Excerpts from the Archive.digest
AEROELECTRIC LIST
http://www.matronics.com/rv-list/

Courtesy of:
Matronics Email Lists
c/o Matt Dralle
PO Box 347
Livermore, CA 94550-7227

Frequently Asked Electrical Questions posted to:
The AeroElectric List
and answered by
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"Imagination is more important than knowledge. It is a miracle that curiosity survives formal education"
Albert Einstein

Hell, there are no rules here-- we're trying to accomplish something.
Thomas A. Edison

Too often we enjoy the comfort of opinion without the discomfort of thought. ~
John F. Kennedy

Experience and common sense cannot be replaced with policy and procedures.
R. L. Nuckolls III

There is a great difference between knowing and understanding:
you can know a lot about something and not really understand it.
C.F. Kettering

"In theory there is no difference between theory and practice. In practice there is."
Yogi Berra

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Selected messages through Jan 2003. Edited by Louie Holt, RV8, Florida.

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1. ALTERNATORS

Alternator Load Anaylsis

> Bob . . .I had asked about how to do a load analysis? I have listed all loads and breaker sizes. Some things are on periodically, some all the time. On your CD of the Lancair IV electrical there is a page with the 2 busses and place for names and loads. It is filled in with info for the Lancair. Is there a blank copy of that same form?

A Actually, I'm working on an article for Sport Aviation on this topic. Yes, the forms I show in those diagrams are an example and a blank for doing your own system. The notion is that you need to categorize load conditions for all flight modes. You need to fill in currents that represent continuous running loads . . . transient loads like transmit, landing gear motors, etc are included but noted as intermittent and then not included as part of the totals.

What you need to convince yourself of is that the alternator has plenty of oomph to carry worst case loads and STILL have about 20 to 25% of its capacity left over to recharge the battery. Of course, you do a separate analysis for each system if you have a dual system. Perhaps two more analyses for a situation where one alternator of a dual system is down and you've closed the cross-feed contactor to keep both buses up. And last, an analysis for an essential bus to show what things are on for normal ops and what loads are on only during battery only ops . . . again, it's an exercise to KNOW how much you can depend on limited resources of electrical energy under various operating conditions.

Of course, it's insufficient to just add up the breakers . . . .breaker size is only loosely related to running loads. You need to get out the data for the equipment you plan to install and look up the rated loads or actually measure it with an ammeter on your airplane. I'll see if I can get a blank form published this evening that folks can use to facilitate the analysis tasks on their projects. Bob . . .

Load Analysis

A I've yet to see a single engine airplane homebuilt that won't run well on a 40A machine. The largest full-up, night-ifr running load I've calculated so far is 27A which leaves 13A for battery support. Bob:

>   Using the above logic, the Z appendix drawings that call for awg 4 or 5 wire for the alternator output seems to be more than required. Assuming even a 100% increase in load for a short battery charging period, would not awg 8 be adequate?   Do you recommend the larger wire and 80 amp in line fuse to protect against a potential battery feed short in this wire?

A   4AWG was a one-size-fits all that was mated with the terminals supplied in our b-lead fuse kit of some years past. It wasn't that 4AWG was necessary, just that it didn't hurt anything and will mate with the hardware in the kit. 8AWG would be fine too. I'm going to be taking the b-lead fuse kit off the website catalog and replacing it with ANL current limiters and the appropriate mounting base. When this is done, customers will supply their own terminals to attach to the mounting base and can size the alternator b-lead accordingly. Bob . . .

Load Anaylsis

> Bob,   where or how do I find the current requirements for the different items on my electrical diagram. Most items give a breaker size only that I can see. Radios must use much less when receiving than when sending, for instance. Any direction on this matter? >Jim

A   This information should be available from the manufacturer of the item or calculated from it's rating. For example, a 55W landing light bulb would draw 55(w)/13(v)=4.2Amps.   A 100W pitot tube will need 100/13 = 7.7A   Or you get the data from the manufacturer's literature for the product. Radios, pumps, etc should have information in the tech manual about how much the device draws under various operating conditions. Bob . . .

Load Analysis, Electric Heat

> Hi, Im building an RV-8 and there is a problem getting heat to the rear cockpit so im installing an electric heater which draws 25 amps. I would like to wire the heater through the landing/taxi switches so that the heater cannot be on when the lights are turned on to avoid over loading the alternator and possibly blowing the current limiter at night close to the ground. Do you have any suggestions as to what switch I should use or is the idea not feasable. thanks for your time, I have sure enjoyed your book.

A   The idea is feasible but not necessary. First, unlike generators, alternators are inherently current limited in their ability to put be loaded severely beyond rated capacity. When an alternator becomes overloaded, the bus voltage simply sags down to the point were the battery makes up the difference. Sooo . . . an alternator is not capable of blowing it's own properly sized b-lead protection. Should the condition you're concerned about come to pass, your low-voltage warning light should begin flashing to let you know that some loads need to be shed.   Bob . . .

Re: Load Analysis,   light watts/amps ratings

>Maybe this is nit-picky for the purpose of load analysis, but if I want to determine how many amps a 100 W landing light will draw, do I use 12 V or 14 V in the equation? If I assume it's

rated at 12 V, then it will draw 8.33 A. Whereas if it's rated at 14 V which would be the norm for a car or airplane when the alternator's working, it will draw 7.14 A which is enough difference to be worth noting. Is there an industry standard for how bulbs are rated?

A Oh, sorta . . . take a peek at this catalog of lamps. Note that lamps for 14 volt vehicles are rated at 12.0 12.8 and 13.0 volts.
http://www.lighting.philips.com/nam/product_database/pdf/mini_seal.pdf
Have no idea why the variable nor why they choose any particular value. It's nice that they DON'T rate them at 13.8 or 14.0 volts because with larger lamps in particular, you don't want to install wiring so large that the voltage drop to the lamp is near zero . . . Note that the 4509 lamps found on lots of single engine aircraft is rated at 100W at 13.0 volts. When in doubt, go to the engineering data. Keep a copy of that lamp catalog .pdf file I cited above. I've had a number of paper equals to it for years and now I have one on my hard drive . . .Bob . . .

Re: Load Analysis Flap motor amps?

> Anybody know approx how many amps Vans flap motor draws? I know it's only an intermittent load, but I'm just curious for fuse and relay sizing...

A I've not measured it but I've been told that it maxes out at 5A full load. Further, the way it's used in the RV's doesn't begin to load it up severely. Bob . . .

S In the VANS supplied wiring loom they protect the flap circuit with a 5 Amp breaker so clearly it is pulling less than that. Steve

S I looked it up on the comapany's web site one day and if memory serves correctly the current draw was around 3A with a 100lb load. Should be less than that for an RV.

Re:Load Analysis, Ray Allen trim servos

> The Lancair manual says that the trim system is 5amps. Is this for the whole trim system?

A The Ray Allen servos draw less than 0.5A full load. And, yes, much to my dismay they do wire their product with ()#*$%)(U(%Z too small a wire. I've had numerous discussions with them at their booth at OSH and over the phone. Seldom have I encountered such a lack of understanding and unwillingness to accommodate from a supplier of parts to the OBAM market. To install it in your airplane, you can ignore the wire size they use. Further, it's a good idea to question anyone's recommendations for breaker size unless they're willing and able to explain the rational for the recommendation.

First, I wouldn't recommend wiring anything in your airplane with less than 22AWG wire. We recently included 24 AWG in production wire bundles and the folks on the production line have nothing good to say about it. 22AWG is the practical lower limit for size strictly from viewpoint of working with the wire. If you use 22AWG a 5A breaker is obviously appropriate for protection of the wire. However, based on current draw of the actuator and the use of some smaller wires in the system I recommend a 1A fuse.

Don't mean to imply that anyone would have "trouble" with properly installed wire of any size. Just because the device is fitted with unusually small lead wires from the factory in no way

obligates the builder to use the same size wire to extend the leads for remainder of the installation. Bob . . .

Re: Load Analysis; Facet Electric fuel pump ?

What is the current draw on a Facet fuel pump?

S I have a Facet , the inrush current on switch-on is 1.2 Amps, it stabilises on 0.9 Amps during continouse run (wet). I do not know, what your pumps type is, mine is a Facet 40108. Hope it helpes Werner

S The 478360 draws 1 amp max. The 40108 draws 1.4 amps max. Regards Craig
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Re: Alternator fuse

>Bob, For the 40 amp alternator is the 80 amp fuse the right size to use or should I look for a 60 amp? Dave Ford

A The JJS/JJN series fuses are very fast acting and were deliberately oversized for alternator b-lead applications to prevent nuisance tripping. An JJS/JJN-80 fuse is fine for alternators from 35 to 60A. Given low cost availability of the ANL series limiters and in light of their VERY robust overcurrent carrying behavior, you'll want to size the limiter closer to the rated output of the alternator. ANL limiters are available in a variety of sizes which you can check out by downloading this data sheet. http://www.bussmann.com/library/bifs/2024.pdf
Note these devices are designed to clear HARD faults in the hundreds of amperes . . . exactly the type of fault to be expected in the alternator b-lead circuit. B&C stocks the ANL40 and ANL60 parts. Bob . . .

Re: ANL Sizing

> Bob: I'm planning on using the B&C 40 Amp alternator. I notice that in the B&C catalog it says that the 40 Amp ANL is appropriate for use with up to a 40 Amp alternator. Is this correct, or should I use the 60 Amp ANL?

A 40 is fine. Bob . . .

Re: Maxi Fuse for Alternator B lead

> Hi Bob, I am looking for a way around the $40 fuse set up. I found the Maxi Fuse holder with a 60amp fuse, It comes with an 8-10awg wire. Can this setup be used reliably or am I asking for trouble? My concerns are that I will be running the 4awg wire from the alternator and then reducing to the 8-10awg wire to connect to the starter contactor. Have I restricted the load carrying capabilities to the smaller wire? Is that bad? The person that I talked to said that if it

comes with a 60amp fuse it will certainly handle it. It made sense but I thought I should get your opinion.

A Go for it. Keep the wire gage constant. Install the MAX60 and holder as close as practical to the starter contactor. Extend the other lead of the fuseholder with the same size wire and run it to the alternator b-lead. This is not quite as robust as the b-lead fuse kits or ANL limiters . . . but I think it will probably perform well for you. Bob . . .

Proposed E-bus loads using Z-13

I've been thinking about scrapping the idea of having pitot heat on my E-bus and going with the SD-8 rather than the SD-20 for the second alternator. I wonder if folks could comment on using the SD-8 with the following tentative load requirements. All information on current comes from manufacturers' specs or from panel planner, although I used the same number for the typical and maximum loads when only one number was given. My proposal:

	Typical	Maximum
UPS SL-15 Audio Panel	.35	1.5
UPS SL-30 Nav/Com		
Com Receiver (continuous?)	.27	2
Com Transmitter (continuous?)	2.1	3.2
Nav Receiver	.325	.5
UPS SL-70 Transponder	.5	1.4
TruTrak Autopilot (1 axis on)	2	2
RC Allen Electric AI	1.2	1.2
Electric Turn Coordinator	.35	.35
VM-1000 Engine Instruments	.3	.3
EI Fuel gauge	.1	.1
Panel & Reading Lights (guestimate)	.2	.2
Totals	7.695	12.75

I could substitute the UPS GX-60 GPS/Com for the SL-30 with about a .2 amp increase, but I figured I would have my battery-operated handheld GPS on board. Plus, I can live without the GPS heading information because the TruTrak has its own DG. So the typical load on the SD-8 would be just under 8 amps, right near its rating, and the maximum load (if everything happened at once I guess) would approach 13 amps, which is more than the alternator can handle. Three questions: 1) Could I run this load on the SD-8 with the battery contactor open to save the battery for the landing phase? 2) If the advice would be to run this with the battery contactor closed, how fast would the battery draw down? 3) Would you advise against this? If so, why, and what alternative would you suggest? Thanks in advance, Dan

A .35A continuous draw for the audio panel seems high. Also the 2.1A value for the transceiver . . . Transceivers are just receivers except when the mic button is pushed so I would expect the standby current to be on the order of .2 to .5A for any transceiver. The autopilot will be pretty low unless you're in turbulence so all-in-all, the list you have presented looks comfortably doable. If at any time one is running battery/SD-8 combination, watch take a peek at the voltmeter (or have lv warning on the e-bus too). If you can't keep the bus high enough to unload the battery while en route . . . shut some things off. I think you'll find that the SD-8 is really an SD-10. It's got some headroom over the advertised 8A rating. Even if you CAN'T keep the bus voltage up, then only the difference between SD-8 capability and loads will come from the battery. If that's only an amp or two, you still have tremendous endurance.

You can't hurt it. The output simply sags and the battery takes up the slack. These are transient conditions that do not figure into the total energy requirements to get where you're going.

> Three questions: 1) Could I run this load on the SD-8 with the battery contactor open to save the battery for the landing phase?

A This is the normal mode of operation for main-alt-out conditions.

> 2) If the advice would be to run this with the battery contactor closed, how fast would the battery draw down? 3) Would you advise against this? If so, why, and what alternative would you suggest?

A Contactor open until airport in sight. Then close the contactor to run whatever goodies are deemed necessary or desirable to complete the flight. Bob . . .

S Re: Maxi Fuse for Alternator B lead
>>In a message dated 1/10/02 you said " Install the MAX60 and holder as close as practical to the starter contactor." Now you are confusing me (not hard to do BTW). I thought the idea was to always locate the wire protector (fuse) as close as possible to the source of current, in this case the alternator. What have I missed?

A The alternator is NOT the source of current that opens this fuse . . . Alternators are physically incapable of putting out much more than their design limit with respect to current (not so for voltage . . . you can get 100V+ from a runaway alternator). The current source that might antagonize the alternator b-lead is the BATTERY . . . good for 700-1500 amps in a fault condition through fat wires. Hence, the alternator b-lead protection goes at the end of the wire opposite the alternator connection. Consider that the alternator b-lead breaker has always been right at the bus even on the spam cans. Bob . . .

Re: current limiter in b-lead

Bob, Your new Fig. Z-22 shows an ANL current limiter in the b-lead when using a Skytec starter. I assume this wire run would only go from the alternator to the built-in starter solinoid and thus be fairly short.(Reference your fig. Z-14, rev.8) Would the circuit protection still be necessary and if so at which end to protect which device/length of wire?

A Yeah . . . we're concerned about shorted diodes in the alternator . . . here the source of power that blows the fuse is the battery.

>> Without a PM starter system doesn't your circuit protection get put near the normal starter solenoid?

A Yes, because the b-lead needs protection from battery. With the PM starter, the b-lead

is so short (rear of alternator to fat terminal on starter) that it's more a matter of mechanical convenience as to how the fuse is installed. For this application, I think I'd stay with the fast JJN/JJS series fuses covered with heat shrink . . . this combo is a bit easier to work with in the small space and closer quarters behind the starter and alternator. Bob . . .

Alternator Switch

>> Bob: Sorry if I'm the 10,000th guy to ask this, but on page 11-20 of your book you advise using a 2-3 switch to control battery master contactor AND alt. field current simultaneously, but you don't say why. It always made sense to me to be able to disconnect the alt. field coil separately in order to avoid wasting power into it when the alternator fails and you're running off the battery only. The Z-1 schematic shows the same switch.

A   Most of the folks building MODERN single engine airplanes have an essential bus that is powered independently of the main bus. If the alternator fails, one wants to shut down the main bus which takes care of the alternator field loads -AND- battery contactor. If there's a need to keep the main bus up via the battery contactor, then you can pull the alternator field breaker while leaving the DC power master switch ON. This is most often done during maintenance ops on the ground to minimize battery loads.

Another option is to wire the DC POWER MASTER with an S700-2-10 switch - two pole, three position, progressive transfer. With this switch, one can emulate the features of the mystical-magic split-rocker switch that's found on many certified ships and too many homebuilts. The lower position is OFF, first position is BATTERY only, the second position adds the ALT FIELD. This is the switch shown in the latest incarnations of the 'Connections power distribution diagrams at: http://aeroelectric.com/articles/Rev10/z10.pdf

>Are you depending on the B&C voltage regulator to not power the field coil when the alt. dies?

A   Nope, it's all done with switches as described above. Bob . . .

Alternator Relays and Starter Contactors

>Why do we still use remote starter solenoids with modern PM starters that have a solenoid built in? Anybody seen a modern car that had a second, remote solenoid? Nope. If the starter solenoid were to stick, you could just kill the master solenoid to deactivate it.

A   The built in starter contactors have VERY high inrush currents on the order of 30A or more. You CAN use them as the sole control for starter operations but it's very hard on your starter engagement switch. See http://aeroelectric.com/articles/strtctr.pdf

>About internally-regulated alternators: In looking at the wiring diagrams in my Aeroelectric Connection book, I see that Bob recommends putting a relay in series with the output B-lead so that the unit can be isolated from the rest of the wiring. Why? If you cut the power to the field terminal, how can the alternator put out anything? Is it so that in case the internal regulator shorts out somehow and full-fields the unit, it can still be isolated?

A   The little wire going into the back of internally regulated alternators does not supply field current. It's only a control lead to the electronics of the regulator. There are failure modes in most internally regulated alternators that CANNOT be controlled externally . . . hence the need for a disconnect relay in the b-lead.

> Also, what's the wisdom of putting a fuse in the B-lead? I thought that an alternator can only put out as much current as it's rated for, since at that point it reaches maximum magnetic flux.

A The fuse is to protect the system and wiring from shorted diodes in the alternator which can produce a hard fault to ground good for many hundreds of amps and much smoke. It's and increasingly rare event with modern alternators . . . but I wouldn't bet the rate is zero. The limiter is cheap insurance. Bob . . .

Re: Protection for alternator field circuit and ammeter

>Drawing Z24 shows how to add an OV protection module for an internally regulated power supply. It requires the use of a 5A circuit breaker and also of a fuselink attached to the main connection of the main bus. The question: Can we replace the fuselink by using one of the outputs on the main bus protected by a larger fuse (say 15amps)? I would like for sure the breaker to let go before the fuse.

A Some 5A breakers will open a 15A fuse. Fuses are MUCH faster than breakers. This is why I prefer the fusible link in this slot.

>On another subject, I will be using an ampere-meter, but I don't know where to connect the shunt. Some of the Z diagrams indicate where to install a load-meter which would provide load information for the alternator only when it is functioning.

Yup . . .

> An ampere-meter provides + and - amperes to/from the battery (I suppose). With a dual-battery/battery bus installation, it seems there is no single place where it would make sense to put the ampere-meter. If I install it between the battery contactors and the alternator/main bus, it won't measure the load for the ignitions/fuel pumps/essential bus when on alternate feed to e-Bus.

A Loadmeters only read 0 to some value either in AMPS full scale (or in the case of the ones I sell, 0-100% of alternator output). See:
http://www.aeroelectric.com/Catalog/instrmnt/loadvolt.jpg
. . . . If you're down to battery only operations, the need for an ammeter (which was small to begin with) goes to zero . . . you should plan in advance and KNOW what things you can leave running in order to achieve what ever endurance you've chosen for yourself with battery only operations. For myself, a "30-minute 'emergency' battery" is just that . . . a battery that is incapable of preventing an emergency in all cases. A lightly loaded battery of known condition will allow you to comfortably use all fuel aboard so that if you're going to have an "emergency" it ain't gonna happen 'cause the panel went dark. Given that the loads under battery only ops are predicted, the ammeter is unnecessary. It is, however, a useful tool for assessing the health of the alternator and trouble shooting the system when things are not behaving as you wish. Bob . . .

Re: Question on Dual Alt/Single Battery

>> I am planning on using the SD-20 so I can have a little more juice in the event of main alternator failure (to cover pitot heat, for example.) How should Z-13 be modified to wire in the SD-20 instead of the SD-8?

A How about a variation on Z-14. Use S704-1 relays for a low current (30A) cross-feed, and as the battery relay for a small (6 a.h. or so) battery to stabilize the SD-20 when the cross-feed is open. Use the Aux Bus as you would the E-bus and put all the main-alt-out en route loads on the Aux Bus. You wouldn't close the cross-feed during cranking in this case so a single pole, single throw cross-feed switch would suffice. Bob . . .

Alternator, capacitor

>> As long as you are using the same MFD rating, you should use a higher voltage rating to keep voltage spikes from destroying the capacitor.

A "spikes" of the capacitor destroying variety don't exist in our systems. All capacitors have a short duration "surge" rating that exceeds their rated operating voltage by about 25% but even this capability is seldom tested in our systems. In fact, it is the capacitor's duty to FILTER off what some folks refer to as "spikes" and other sources of noise.

> The physical size may be the deciding factor as you might have a limited space. I would use the best cap with the right MFD but as at least 3 to 10 times the voltage rating for longevity as the nominal rating of the device, (12 volts?)

>I'm confused and wanted to check on the required voltage rating for the electrolytic filter cap for the Rotax (and other permanent magnet alternators). Rotax call for a 25V cap. Most of the schematics in appendix Z also call for a 25V cap. Note 20 say's the voltage requirement ranges from 15V to 50V. The 47,000uFd cap B&C sells (PN S251D479) and recommends for Rotax is rated at 16V. Is a 16V capacitor acceptable in this application?

A You betcha! The general rule of thumb for selecting the capacitor size for a pm alternator is 1,000 uF per amp of output . . . but having one larger than this can't do anything but make the output smoother and quieter. Soooo . . . 10,000 uF or larger is okay for an SD-8, 18,000 or larger is appropriate to the 912/914 Rotax. 47,000 will work for any of them and is a practical upper limit for physical size . . . bigger capacitors are harder to mount, more expensive and will add only marginally to performance.

The biggest stress on capacitors of this type is RIPPLE CURRENT (the noise that is inherent in the output of PM alternator) . . . increasing the voltage rating is of no assistance in making the capacitor last longer . . . in fact, for the same size capacitor in uFD, the device's internal impedance will go UP with voltage rating which in turn adds to internal heating. All other things being equal, buy capacitors with smaller diameter and longer cases . . . small diameters are easier to find clamps for and easier to mount. Smaller diameters also dump out internal heat better. Aluminum electrolytic capacitors are life limited critters. I'd replace them about every 200 hours of operation for best performance. Bob . . .

Alternator Internal Regulator

> I was sure hoping someone knew what could cause the voltage regulator to go out on the ND internal regulated alternator. Repair shop said I may have shorted out the alternator light circuit which in turn can cause the regulator to fail. I did mount my relay using one of the existing three bolts that appear to run through the back of the alt but they are not connected to anything I am aware of. I used a smaller lighter high amp relay instead of the big contactor. Any thoughts would be most welcome.

A Use of an automotive alternator with built in regulator has some risk associated with it. There ARE failure modes within the regulators that may precipitate uncontrollable voltage run-away. By-in-large, the warning light driver built into these products are not terribly useful . . . the ONLY all inclusive warning system for monitoring alternator performance should be a low voltage sensing system that lights up for bus voltage below 13.0 volts. Ignore the built in lamp circuit.

I presume the "relay" you cited is for the external ov protection. If I interpret your words correctly, you have mounted a relay right on the back of the alternator. This is not recommended. This subjects the relay to much higher vibration levels from the engine than it would experience if mounted on the firewall.

I gotta be honest with you folks . . . I have published work-arounds for letting you "get by" with internally regulated alternators . . . I DON'T RECOMMEND THEM. When we design new systems for aircraft, I really lean on my compatriots to reduce if not eliminate relays in the system. Relays, especially those that carry heavy current -AND- get vibrated are some of the poorest performance devices in the airplane. This is why our latest and greatest Mach 2.5 GPS guided target has NO RELAYS in the power distribution system. I'd really like to see the automotive alternators get modified to use external regulation. Bob . . .

Alternator

>> Bob , any thought on why the alternator would not shut down even after the field was cut. It went to 28 volts. I have an order with you for the Over voltage protection that's for sure. Richard

A Sure . . . it's because MANY if not ALL automotive alternators have failure modes that can BYPASS the effects of any control circuits for a normally operating alternator. This is why we've always suggested that really nice automotive products be modified for external regulation and ov protection so that we can be sure of performance in a failed regulator situation. You'll also need an alternator disconnect contactor to go with your ov module . . . the ov module is capable of shutting down an externally regulated alternator with no assistance. An INTERNALLY regulated alternator needs to be physically disconnected from the bus in an OV condition. See: http://aeroelectric.com/articles/bleadov.pdf Bob . . .

Alternator: Diode

>> Bob, What is the indication of a shorted or open diode in the alternator ? My lights are "flickering" and the volt-ammeter is showing +/- 5volts-3amps movement. thanks, JerryB

A Jerry, This is a common problem and it's generally not associated with an alternator problem . . . although it could be worn brushes. But first: My favorite diagnosis tool for this condition is a $15.00 generic Ford regulator with 24" clipleads on the B, F and ground terminals. Unhook the alternator's F terminal from ship's wiring and temporarily hook the test regulator right to the back of the alternator.

Alternatively, hook a wire from the alternator's b-lead (main power output terminal) to the regulator's field power input lead. Leave the alternator switch off or pull the alternator field breaker. If the alternator comes up stable then this is the most likely scenario: A regulator is a servo system. It looks at the bus and steers the field current of an alternator to maintain the desired bus voltage set point.

The regulator gets its information about bus voltage through the same pathway as the field supply current.

On some production airplanes, this pathway has upwards of 20 ohmic joints (wire crimps, closed contacts in switches, solder joint, mated contacts in plugs, etc.) in addition to perhaps 5-10 feet of 20AWG wire with a resistance of about 10 milliohms per foot. Aging of the ohmic joints raises their electrical resistance. No single joint contributes a lot but all totaled up, the supply circuit resistance can exceed 100 milliohms. Now, field current will vary normally between .5 and 4 amps depending on RPM and system loads. With a 4 amp load and 100 milliohms of resistance in the regulator's sense lead, the regulator's best guess about bus voltage may be in error by 400 millivolts or more. Worse yet, as the regulator INCREASES field current in an attempt to raise bus voltage, part of the true increase is masked by an INCREASED LOSS of voltage along the sense lead due to field current. This causes the regulator to lag behind reality and in extreme cases, induces a bus voltage chasing mode with symptoms much as you have described.

TWO FIXES:

(1) change the regulator out for one that has voltage sense leads that are independent of the field supply current. This has to be done by at least a 337 effort and at worst, an STC.

(2) do a total refurbishment of all items in the field supply pathway starting with the breaker and carrying it all the way to the regulator. This includes all connectors, switches, ov relays, etc., etc. Many owners have reported that replacing the master switch fixed the problem. In fact, changing one of many parts contributing to the problem reduced the resistance enough to make the system stable again. However, the problem will return in spite of a reasonably good master switch because the switch and all the rest of the components continue to age - driving total resistance past the lower limit for stability. If you replace EVERYTHING, the system should stay stable for another 20 years or so. This problem is worst in older airplanes and is a function of age. Total refurbishment brings the resistance back down to as-new levels. If the regulator experiments don't help, then the mostly likely problem is alternator brushes. Diode failures don't generally cause system instability . . . they just degrade the altenrator's ability to deliver maximum rated output. Bob . . .

Alternator: ANL Current Limiter

>> Bob, In place of the 80 amp fuse, B & C recommended a C905-40 current limiter with # 8 AWG wire between the alternator and the starter contactor. Do you think this is an equally good solution? Joel Harding

A ----Just got off the phone with folks at B&C . . . they're now stocking the ANL series current limiters (a cross between a fat fuse and fusible link) for another program. Their p/n for

the 40A limiter is C905-40. I agree with them that this is a good substitute for the in-line fuse we've been selling for some years. We've agreed to change the offering in B&C catalog on my website. Bob . . .

Alternator: ANL & Fuse

>> I'm obviously missing something, here. But is a 40A current limiter equal to an 80A fuse?

A Well, kinda sorta . . . Recall that the 80A fuse is FAST and it was selected as a good compromise for ALL alternators 60A and below. The ANL series current limiters are like fusible links and not subject to tripping out under small overloads like the fuse. I've just posted an article on the topic which you're all welcome to read at:
http://www.aeroelectric.com/articles/anl/anlvsjjs.html Bob . . .

Alternator: b-lead fuseable link

>I have the B&C specialties 80 amp inline fuse for the alternator big wire, is there any problem with attaching one end of this directly to the alternator post, instead of making a short section of wire between it and the alt? Kevin in WA RV 9A

A The fuse needs to go at the OTHER end of that wire. The energy source that is a threat to that wire is the BATTERY . . . not the alternator. Those fuses are not terribly structural . . .it would be best to have wires attached to both ends even if the end away from the alternator is a short one.
Bob . . .

Alternator

>>Bob, I'm having a problem with my new electrical system installation that perhaps you'll help me with - at my level of knowledge I'm not even sure what the appropriate trouble shooting steps would be. I've installed your ovm and relay. I have a Rotax engine with PM alternator that does about 13 amps. I have been testing the electrical system and it appears to work ok - strobes flash, fans run, starter turns engine, etc... however Here's the problem, When I run the starter and release the key the alternator breaker pops. So long as I hold the key in the start position everything is fine. I can reset the breaker a couple of times without turning the master off/on but eventually the master switch has to be cycled to allow setting the breaker. I have the master wired per your diagrams so that it operates the battery contactor and the alternator control relay simultaneously. I have a warning light as per your diagram to show when the breaker trips the relay has disconnected the alternator from the power bus). Please reveal the answer to this puzzle, if possible. If not, please suggest a diagnostic approach that will lead to the answer. Bill

A Bill, How old is your ovm? Does it have red/black or yellow/black wires? If red/black it may be suffering from a rare but pesky nuisance tripping problem. If you'd like to send it to me, I'll update it at no charge and return it to you. If it's the later version (yel/blk) I may need to see it anyhow. Something may be wrong with it.

Note: (The OV module in question was returned for evaluation. It was performing to specifications, however the device was updated to a newer configuration and returned to service. - Unfortunately, the upgrade did not fix the problem. Subsequent conversation revealed that the airplane was wired per AeroElectric Connection drawings EXCEPT . . . on advice of Rotax the spike catcher diode was left off of the ACS OFF-L-R-Both-Start keyswitch. In point of fact, had the diode been included per ACS recommendations, the system would probably have demonstrated the same problem. I recommended that a diode be added across the starter contactor's coil per drawings in the book whereupon we received the following e-mail:)

>>Bob, I installed a diode on the starter contactor (actually it's the one that came with the ACS switch (I had not installed it because Rotax said the Clum contactor didn't need one)) and the ovm tripping problem is now history. Whew!! I'm not sure I understand how ovm tripping and the starter diode fit together; perhaps you could enlighten me. Regards. Bill

A Good news to hear my friend. The answer is simple. Starter contactors (because of their intermittent duty, heavy current draw) are significant sources of inductive kick during a de-energizing operation. We supply diodes on ALL of the contactors we sell . . . either added on (as in the case of our S701-1 and -2 continuous duty contactors) or built in like the S702-1 starter contactor).

The ACS starter switch had an official government AD published against it a few years back that required rebuilding the switch's starter control contacts -AND- adding a diode at the switch. Problem was, the way the diode was wired into the circuit, it has ZERO effectiveness in catching the starter contactor's spike.

The diode needs to go across the coil of the contactor just as you've accomplished on your airplane. With out the diode, there is no place for the spike to go but across the starter switch terminals and some portion of it winds up propagating out into the system. It's not much of a hazard to other equipment but it can nuisance trip SCR crowbar OV modules. We had a problem with a similar circuit on the A-36 Bonanza a few weeks ago . . . this is what prompted the modification to my design . . . HOWEVER, if the offending spike is big enough (as was yours) . . . there's no practical way to make my crowbar ignore it. This leaves only one solution . . . snub it off at the source . . which is what we've done. Rotax should be made aware of the quality of their advice. Bob . . .

Alternators

>>3-phase stator windings in alternators can be connected in "Star" or "Wye" (Delta). If star-connected, the ends of the windings are joined at a single neutral point.

A Star and Wye are the same connection, while Delta is the "other" format . . .

> Due to harmonics, this point is really not neutral,

A This connection was used on early automotive alternators as an output to tell the regulator that the alternator was spinning and had a modicum of field excitation. This is the "stator" lead that runs between some alternators and their associated regulators. This output is sometimes used to close a field supply relay. The alternator is initially excited through the idiot light circuit with just enough field current to get some stator output - not enough to begin delivering energy to the system but enough to close the field relay.

This system has the advantage of automatic disconnect of field excitation when the alternator is not spinning. The down side of early designs was that if the idiot lamp burned out, the alternator wouldn't come on line. Later cars added a resistor across the lamp to supply initial excitation current irrespective of lamp condition. In some airplanes, this terminal is watched by a simple voltage comparator to see that the alternator has both motion and excitation to keep an idiot light turned off. I designed several of these devices for both Beech and Cessna about 30 years ago.

There are some alternator designs that have 9 rectifiers in their diode array as opposed to the more common 6. I've not taken the time to understand the exact physics of how these benefit the output but if an automotive manufacturer with a need for hundreds of thousands of alternators sez it's a good thing to do, you can probably take that proposition to the bank. The nominal DC output voltage from this terminal is 1/2 of bus voltage but it may have waveform peaks that exceed bus voltage thereby offering an opportunity to pipe a few more amps of output to the system.

> and according to one text on automobile alternators, if the neutral is brought out and rectified, the alternator can produce 10% more power from ~3,000rpm and up - at the expense of slightly more ripple in the alternator voltage.
>So, can this extra power be captured in commercially-available alternators - B&C's L-40, for instance - making it a 44A alternator ? Is the Star neutral accessible in this alternator, or has it already been tapped and rectified ?

A You can ask B&C how their ND alternators are wound. I probably knew at one time but it has been about ten years since I had one apart and don't recall. I would counsel come caution about modifying a perfectly good alternator . . . there is risk of reducing reliability as a result of inexperience with the task . . . 10% isn't much to gain for your efforts. 95+ percent of my readers are doing full up IFR airplanes with 30 amps or less running loads. This leaves you with 25% or more overhead from a 40A alternator with no risk of degrading a demonstrably bullet-proof alternator. Bob . . .

Alternators

>Am I missing something in your schematics ? I don't see a resistor across the alternator light in your schematics. Will the alternator in your schematics start if the idiot light is burned out ?

A No, this was purely an AUTOMOTIVE problem with early designs (read pre 1970). Our regulators do not depend on the neutral connection nor do they depend on continuity through the lamp for functinality.

OV Module

>>I am utilizing the crowbar overvoltage module and relay that you show in your schematic Z-7. Where is the best place to mount the module, relay, and capacitor? Can these units be installed in the engine compartment, or would they be better-off behind the inst. panel?

A they will live well any place you'd like to mount them. The capacitor should be on the firewall so that the alternator can feed power to the starter contactor through the shortest length of wire.

>For the 16 awg fusible link, can the link be sleeved with the materials from your fusible link kit? I bought one for the other 2 links, but it states that i should contact you about other sizes.

A Yes, that link is on the firewall and out of the cabin. You sleeve it with the fiberglas-silicone sleeving.

> I would think that I could leave the wire unprotected since it will be mounted to a little shelf on the firewall, with nothing else very close to it. What do you think?

A You mean no sleeving? The sleeving is to protect other wires that might be bundled with it. If not tied into a bundle, then mount the relay next to the starter contactor. Bring 12AWG from rectifier/regulator to the relay. Use 16AWG jumper from relay to starter contactor. You can omit sleeving if the burning of 16AWG won't affect anything else. Bob . . .

Alternators: Internal - External Regulator

>> I'm considering a 60 Amp Nippon alternator in my newest RV-6A (IFR, all electric's) aircraft. I'd like to use an off-the-shelf automotive unit with an internal regulator and an external over voltage protection unit. I'm hesitant of this approach (Vs the certified aircraft approach with external regulator and OV protection) because I don't fully understand all the possible limitations and safety considerations of an in-the-alternator regulator in an IFR aircraft. With your experience in the aviation community, I'm hoping that you may be able to shed some light on the following questions: >
>1. Are there any weather or altitude related limitations of using an alternator with in an internal regulator? Will flying into heavy rain effect the operation of the alternator any more than the certified approach?

No

>2. To your knowledge, are there any reliability issues with alternators utilizing internal regulators? Is the meantime between failures (MTBF) better or worse than the certified approach? Are there any inherent failure modes that might be worse than those found in the certified approach?

An alternator with a built in regulator is probably MORE reliable than one with an external regulator . . .More compact, less wiring, lower parts count. However, internal regulators generally do not include ov protection to guard against a small but potentially hazardous condition.

>3. What are the FAA's arguments supporting external regulators or against >internal regulators?

If the FAA had an opinion on this topic, it would have no more validity than another opinion based on physics and logic. Bob . . .

Alternator: Nippondenso

>> I was ready to bolt up the Deere version of the alternator, and decided against it. The closer I get to flying this thing, the harder it is to go with product that is not coming from an established outfit.

A   If it's a factory original ND alternator, I'd have NO problems with bolting it to an airplane. Compared to the 1960's certified junk flying on most P/C/B/M airplanes, the ND is a modern miracle. Bob....

Alternator: Breaker

>>When it came close to time to start putting wires in my RV-8, I bought Van's wiring kit, figuring it would be a good way to get off ground zero.   Their scheme puts fuse protection in the form of either switch circuit breakers or circuit breakers, on a switch console by the front pilot's right arm. I had decided to replace most of these per your suggestion of automotive type fuse blocks, and toggle switches, but worked myself into a conundrum as to what to do with their 35A circuit breaker in the #8 wire from the alternator.

A   I recommend tying the alternators power output (commonly refered to as the "b-lead") directly to the starter contactor on the firewall via an in-line fuse and not bring the noisiest wire in the airplane into the cockpit.

>>I was about to run it 'backwards' through one of the Normal Bus fuses, thereby feeding the Normal Bus, when I ran into a problem in that the yellow Fast On wire terminals I got from AeroElectric won't go on this #8 wire.

A   This wouldn't have worked anyhow. You need to rate b-lead protection at least 20% greater than alternator output . . . a 60A alternator will put out 70+ amps when it's cold. I presume your alternator is at LEAST a 35A machine . . . and if Vans provided a 35A breaker to go with it, then you'll have a breaker DESIGNED to nuisance trip just like the b-lead breakers in tens of thousands of spam-cans.

>>In the process of deciding to go back to Van's 35A circuit breaker, I began wondering what good the circuit breaker was doing on the cockpit end of the alternator's output wire. Have since decided its function is to protect the alternator's
output wire, since if it shorts to ground the main source of juice will be from the battery rather than the alternator.

A   The source of energy that will burn the b-lead is the BATTERY. An alternator is incapable of delivering large fault currents . . .the machine's magnetics simply won't allow it. The b-lead protection is most likely going to open in response to shorted diodes in the alternator with the second most probable cause being a b-lead feeder shorted to ground. If you don't bring this wire through the firewall, then the probability of this event goes down sharply.   I prefer the in-line fuses like those sold on our website catalog. They're easy to install and if the fuse ever opens, it will be a result of a badly damaged and therefore disabled alternator.

>>Is this correct? But after the 35A circuit breaker opens, the alternator will still be feeding pretty significant amount of energy to the short.

A You can dead short a fully fielded alternator and get only 20-30 percent more than its rated output and then only while it's cold. As the critter warms up, the output will go down.

>>The alternator current goes through this 35A circuit breaker, over to the Normal Bus fuse block stud, and then another #8 wire goes to the Starter Relay battery terminal. So this scheme also leaves this wire from the fuse block to the Starter Relay unprotected.

A These wires generally don't require protection beyond careful installation and maintenance to make sure they don't rub on airframe and short out. Study the distribution diagrams in the back of the book along with the notes.

>>Another thing I thought I would run by you is while looking for info on why Van's put the alternator circuit breaker where they did, I found their reasoning for providing separate switch circuit breakers for Strobe and Nav Lights, and also separate switch circuit breakers for Taxi and Landing lights. I had already decided to use your scheme for combining Strobes and Nav on one 2-3 switch, and Taxi and Landing lights on another. They say to put Strobes and Nav on separate circuits, so if you get into a condition like fog maybe, you can shut off the Strobes to keep them from blinding the pilot.

A A 2-3 switch? This would turn both on and off together. The two pole switch would allow you to power them from separate circuits but not control them separately. By using a 2-10 switch (progressive transfer of the two sides) you can have the first position bring on strobes and the second position bring on nav lights. Same thing with landing/taxi. Some builders put in a 2-10 switch and wire so that the first position is taxi and second position adds landing light. In any case, you need to install fuse blocks with enough slots to give every device in the airplane its own bus feed.

>>I am going to stay with your combination scheme, since my main use will be Strobes in daylight to keep from getting run over. If I really screw up and get into a condition where the Strobes are blinding me, I'll shut everything off since in those conditions the only thing likely to keep somebody from running over me will be somebody's radar.

A Agreed

>>Their reasoning on separate Landing and Taxi lights is that some times bulbs fail shorted. This will take out a common fuse, leaving no lights at all for landing. Again I'm staying with your combination scheme, since I think bulbs failing shorted is a rare event, or I may run the Taxi and Landing light circuits through their own fuses after
the switch. I don't intend to fly at night, but if I screw up and get caught flying in the dark, and a shorted light bulb has taken out both Landing and Taxi lights, I can probably find a lighted runway.

A Never seen a bulb fail shorted . . . but I suppose it could happen . . . none the less, this shouldn't be an issue because protected circuits on fuse blocks are cheap. I try to build a new system with at least 20% spares on each bus for future additions. There's NO ECONOMY in having too few fuses. Bob . . .

Re: Alternator warning light

>Bob, I am looking for a simple circuit that will cause a light to come on when the alternator stops charging, similar to the L lead function in automotive voltage regulators (my aircraft regulator has no L lead). Do you know of one?

A Sure. Go to our website at http://www.aeroelectric.com Click on: "Article Reprints, Newsgroup Threads, CAD Drawing Downloads" Under the section on How To Articles click on: "Click here for the schematic on a do it yourself low voltage monitor." This device is the very best way to get timely active notification of any charging system failure that renders the alternator incapable of carrying ship's electrical loads. All of the parts are available from Digikey for about $10.00 I recommend you avoid any of the automotive approaches for driving an idiot light. First, without having a schematic of how the sensor works, I can't tell if it will catch all failures . . . Second, the proposed circuit will nicely drive a high intensity red led that's small enough to mount right in front of you on the panel where you cannot miss it . .it flashes too. . .Bob . . .

S >> Bob - Have you a LED solution to the standard filament lamp? Obviously the life of a LED is better, not to mention heat dissipation, power consumption and mechanical strength. Mike Gray

SA Mike, All you need to convert any incandescent circuit to an LED, is a current-limiting resistor in series - and LEDs exist that even have them built-in. For instance, go to <http://www.digikey.com/scripts/us/dksus.dll?KeywordSearch> and look up "160-1046". 23 cents is all it costs! You can also get little panel-mount LED holders, they're pretty cheap too, I've got tons of extras I've had laying around here for years that I'll never use (if you ever come through MLB, stop by), but you may as well include them in your order from DK, they're pretty cheap too. -John R. P.S.: The digiKey part number for the afore-mentioned panel-LED-mount is MP52-ND.

Alternator: Diodes

>> What's the diode on the back of b&c alternator commonly used on small lycomings (belt driven). My buddy has one that broke. Where can I get a replacement, and what effects will I see if I run without it?

A B&C dosen't ship their alternator with any diodes on the back, nor do they recommend any. There was an kit (the name escapes me) that used to ship an alternator with a zener tied from b-lead to ground on the back of their alternator and called it "over voltage protection" . . . totally out in left field. Gordon? Are you listening? Tell them what happened to your diode . . .
If the diode is missing from your friend's installation, tell him he doesn't need it. If he really WANTS one, he can install a 1N4745 zener . . . but it will disappear again when a surge from the alternator exceeds 16 volts. Many folk have seen those diodes and added them. It's the Cessna shielded alternator wire syndrome . . . many builders have wired their airplanes like a 172 and shielded alternator wires because 100,000 Cessnas did it. Shielding alternator wires is of no value.

>Also, what's a typical current draw from a complete set of nav lights? My buddy went with breakers on the panel (?) and only has a 5A unit dedicated for it. That's only 60+W which doesn't seem like enough. The breaker pops after about 5min run time. I am guessing that if he really had a wiring problem, it would pop immediately.

A   2A per bulb. If he has two white lights (integrated tip and "tail" lights on wingtips, then is draw is 8A . . .he needs a 10A breaker and should wire the system with 16AWG wire. If he has only one white light, then a 7A breaker and 18AWG will suffice. Bob . . .

Alternators, Re: 16 AWG fusible link?

>>Bob, I need to fabricate a 16 AWG fusible link to protect the 12 AWG line between the battery and the SD-8 Standby Alternator control relay. This is as shown on your "All Electric Airplane on a Budget" drawing. The "comic book" on your web site that deals with fusible links specifically says that the instructions only apply to 22 or 24 AWG fusible links, and to contact you if a larger one is needed. So, what do I need to know to make a 16 AWG fusible link?

A   Opps! You caught me with one foot in a bucket and the other one in the mud. That's supposed to be a 20AWG fuse link. Rational: Many RV-8 builders are putting the battery in the back which necessitates a long run from the SD-8 to the battery. I wanted to give the SD-8's regulator the best practical chance to take advantage of the battery's low internal resistance and to have a good notion of what the battery voltage was at the far end of the feeder.

Soooo . . . the 12AWG feeder, while oversized for the alternator's output, supplied an electrically rigid connection of the SD-8 regulator to a tail mounted battery. In an airplane with a front battery (SD-8 feeder a couple of feet long) you can drop the SD-8 feeder to 16AWG and protect with 20AWG fusible link. If you have a long SD-8 feeder, go 12AWG feeder and stay with 20AWG fuse link. Use a yellow butt splice to grab the 12AWG . . . strip the 20AWG about an inch and fold it triple where it enters the wire grip. I'll put an explanation to this effect in the Revision 11 Z-notes . . . thank's for the head's up! ..Bob
----

Alternators, Re: Pull-up for B&C regulator

>>Bob,   Took me a while to get around to it, but I did finally get around to hanging a 200-ohm pull-up resistor between terminals 3 & 5 of the B&C regulator. It worked like a charm. With the Master on and battery voltage showing about 12.2, my Lo Volts alarm now blinks like crazy. Your diagnosis and my guess were obviously correct -- there was simply too much residual current flowing in the high (off) state to turn off my optoisolator. Thanks for the help. All seems to be working fine now. Jim Cameron Lancair Super ES, N143ES

A   Pleased to get the feedback and equally pleased to hear that it's working as desired.

Alternator , Fusible Links and battery choices.

>> Hi Bob, Just to clear up a few things that are nagging at me from the list. I plan an RV3 with 40A and SD8 alternators, dual E.I.'S, 12 AHr battery (if I can find) behind seat, and Z13 architecture.

A   Good choice. Make the battery decision last. An RG battery needs only a shallow tray to capture the footprint and a holddown strap(s) capable of 200+ pounds tensile strenght. A couple of velcro straps with 6" or more overlap will exceed this by a large margin.

>Re alternator feeds: There was a recent discussion about an RV8 with the battery in frount Vs the back. A 12AWG alternator feed and a 20AWG fusible link were recommended with battery in back. What wires does "alternator feeds" constitute and does this apply to both alternators? I notice on Z13 that 12AWG is used on SD8 but 18AWG is used on the 40A so does this only apply to SD8?

A Each alternator has it's own situation with respect to system interface and performance as it relates to wires sizes and lengths. The SD-8 is an 8A rated, 10A capable machine. It should be attached to the system with protection rated at no less than 10A continuous duty operation. If lead lengths are short, 16AWG wire would suffice. Since the regulator should be close to the alternator -AND- because the regulator senses bus voltage through the same leadwire that delivers power to the system, I like to control voltage drop along this wire when the battery is located some distance from the regulator as in the situation you are considering. This is why I show heavier, 12AWG wire. This selection dates back to the earliest days of popular use of the SD-8 . . . long and vari-eze airplanes with alternator in tail, battery up front and both power and ground wires bringing power to the front with as much as 25-30' round trip. PROTECTION of this wire can still be rated as if it were used in a tractor aircraft with battery up front . . .16AWG and 20AWG fuselink works if you're interested in taking advantage of what the fuselink offers. This could be a 10A fuse or breaker as well.

>Re fusible links and the E.I.'s: You've stated that one justification for fusible links is they are more reliable/longer lived than fuse blocks. All that would be on a battery bus is the hobbs and the two E.I.'s. Would you recommend eliminating the bus and just using 22AWG fusible links and 18AWG wire for these three items?

A This is an option but it makes you stack a lot of terminals on a single stud but if they all fit on the hot-side stud of your battery contactor, you can do this. I had one builder worrying about the single feedline between contactor and battery bus fuse block as being single point of failure for both ignitions. True but relatively easy to build the same reliability for this short piece of wire as say, the attachement of wings to the fuselage. I think he ended up putting a fuse-link feed on one ignition and then running all the rest of the battery bus items from the fuse block . . . a good example of actions taken in consideration of risk and physics as opposed to worship at the altar of hangar tales and wizened ol' salts who assure you that, "you'd better stick to the way we've always done it no matter what you think."

>Re contactor location: With the battery in back, a lister stated that the battery contactor needed to be in back also. But Z13 only specifies that the battery contactor be within 6 inches of the battery bus (or presumably the fusible links to the E.I.'s and the hobbs if no bat bus). There is nothing about how close the battery is to the contactor. I conclude that the battery contactor should be on the firewall and not next to the battery. Is this correct?

A I should mark those leads with (*) too . . . I think I mention it in the text of the book. Battery contactors need to be located as close as practical to the battery and the battery, bus if you have one, should be as close as practical to the contactor.

>Re cheap Vs expensive batteries: On the list there are enthusiastic proponents of both (e.g. the $30 garden tractor Vs the $74 Odysey). I think I've seen you say there's nothing wrong with the cheap one. As a practical matter wouldn't you be inclined to change out the cheap one twice as often, say each year, as the Odysey, every 2 years?

A Sure. And what's the risk of trying the cheapest battery you can lay your hands on? As

long as I'm dealing with RG technology I'd buy a cheapie and test it at the end of a year. If it has performed well for the past year and still presents an acceptable capacity, hey . . . the cheapie is a good deal. If not, then upgrade. I see a lot of builders agonizing over battery choices like they would for an STC on a certified ship. Make the wrong choice here man and you're stuck with a certified error carved into stone. In homebuilts we're free to TRY anything for which we've considered and mitigated risks and determine which products are suited to the way we use our airplanes. Leave enough room for a 24 a.h. footprint for your battery tray. Start out with the cheapest battery you can lay your hands on in an RG technology. If you don't like it, making a new tray to fit a different battery is no big deal. Bob . . .

Re: "idiot light" wiring for a Delco Shunt wound generator

>> Does anyone know how to wire a generator warning light on a Delco shunt wound generator with a three terminal (Bat, Arm, Field) mechanical regulator? This is on Continental E series engine if that has any bearing on the type involved. I have an Ammeter on >the panel but would like to have a warning annunciator too. >Thanks, >Gary

A Make your warning light totally independent of the power generating source. You need a light that flashes any time the bus drops below 13.0 volts irrespective of whether your source is generator or alternator. You can brew your own per:
http://aeroelectric.com/articles/lvwarn/9021-610.pdf
. . . or get one of these when they pop up on the website in a few days . . .
http://aeroelectric.com/temp/MVC-081X.JPG
http://aeroelectric.com/temp/MVC-082X.JPG
....or build one from your own acquisition of parts using a bare etched circuit board and instructions that will be made available as a partial kit. The warning lights associated with virtually every alternator or generator installation will NOT annunciate all system failure modes . . . the low volts warning light WILL. Bob . . .

Alternator: Re: Actual Loads

>Bob, In evaluating the real current loads in various operating conditions, I have measured current draw for each of the radios and instruments that I have. There are a few items that I do not have data for and cannot readily measure until everything is installed and operating. Referring to your Z-11 schematic, what continuous (or average)current do you expect in the line from the Main Power Bus to the pin 6 of the Alternator Controller: and for the Lo V Warn to pin 5 of the Controller?

A Pin 6 is field supply. Since the B&C alternators are originally rated as 40 or 60A devices with the field powered up internally, they will become 43 and 63A devices with the field supplied externally. If you're using any other brand of EXTERNALLY excited alternator, then figure on a max of 3A going into pin 6 on the regulator which will happen under the very rare cases of maxed out alternator performance due to loading, low RPM or both. Under normal conditions, a B&C with the supplied pulley and typical loads for VFR/IFR flight, field current will be 1 to 1.5 amps.
Pin 5 is a sense lead that draws about 50 milliamps as I recall. Bob . . .

Alternator: B-Lead Fuse

> Hi Bob! I just wanted to thank you for the great seminar this past weekend, I definitely learned a lot about my systems, and am going to take your advice and go with the fuse blocks. I do have some questions that have come up, and need some clarification as well-
> 1) I will be running a single 95 amp rated alternator, dual battery system in my Velocity with my SVX motor- with the over voltage protection; the device that I get from you, trips the power fuse on the B lead- is that correct and not the field breaker? You said that I should probably get a 150 amp fuse for the B lead- I didn't see one on the B&C web site, but I would figure that it can be special ordered- would 150 be too large?

A	If you use a FUSE like the JJS/JJN series devices we used to sell, then you need to oversize them to keep from nuisance tripping on the output of an alternator. You can probably pick up a JJN-150 or JJS-150 fuse from a local electrical contractor supply house.
	Alternatively, the ANL-100 current limiter would also be suited. We have holders for the ANL limiters and I think B&C either has or would get a 100A device for you. Give them a call.

> they say that they are good for a lot more than their rated capacity (then why not rate them that way?).

A	ANL devices are intended to be used in power distribution bus structures where hard fault currents can be expected to be 10X the rating of the device. See http://www.aeroelectric.com/articles/anl/anlvsjjs.html
	There are LOTS of different kinds of fuses with different opening characteristics depending on the intended service. I used JJN/JJS fast devices early on because of availability and when B&C started using and stocking them for their product line, it seemed a good idea not to stock two different kinds of parts that could be used for similar tasks. Hence the changeover as the article above will describe.

> So then the alt field current is never tripped out to shut off the alternator, just the power coming out of it is prevented from making it to the bus?

A	Here's a copy of an earlier post on ov protection for alternators with built in regulators

>> Hi, Bob. I know the answer to this must be in the Connection somewhere, but I have been unable to find it. Regarding fig. Z-24, O/V protection with an internally regualted alternator:
> 1. What is the need for the O/V contactor? Can't the Crowbar module just cause the alternator field breaker to pop?

A	Alternators with built in regulators don't get field power through the control wire going into the back . . . there are failure modes INSIDE the alternator that cannot be controlled from outside. Hence the need to physically disconnect the alternator's b-lead from the rest of the airplane.

> 2.   Why is there a fusible link between the buss bar and switch, with the breaker after the switch? Why not just a 5 Amp breaker off the main buss?

A	Because if the main bus is a fuse block -AND- it's remotely mounted for convenience of installation and maintenance then it's also remote to the panel where the 5A breaker needs to go. This puts a longer-than-6-inches hot wire between the fuse block and the breaker that is best protected with a fusible link.

> Sorry if these are questions you have answered lots of times. I would like to keep the number of contactors to a minimum, and would also like to understand the system.

A To eliminate the extra contactor, go to an externally regulated alternator.
------------------- End of repost ----------------------------

2)So, OK, no breakers then, and 3 busses
--- a battery (always on) bus for things like map light, clock power, radio memory ect...
--- an essential bus that will stay on (with a contactor?)in the event of alt failure to keep the essentials going.
--- a main buss for everything else.

Thing is, with my overly outfitted panel, I have a lot of circuits- if it is all right , I will list them for you and get your opinion on what bus they should be on.......

BATTERY BUS:
cabin light
map light
12v jack
radio memory
stereo memory
transponder (clock function from the Garmin unit)

ESSENTIAL BUS
EFIS One (yea- I already sent my deposit- I'll keep my fingers crossed) might not need this one on the essential bus, but it doesn't use too much power)
Transponder power
Strobes
Panel lights
alternator field

A - Alternator field is ALWAYS on the MAIN bus.

CDI head
NAV Com/ localizer RX
Audio panel/marker RX
engine gauges (I'm using electronics international electronic units)

A Why would shutting down the engine guages while en route be a bad thing to do?

Engine control module (doesn't get more essential than that one)

A This guy goes on the battery bus

Fuel pump

A Battery bus

Aux fuel pump

A Battery bus

Pitot Heat

A Main bus

GPS COM

A Everything below on the MAIN bus

AND THE REST
WX500 sensor
JP fuel scan
elev. trim
Ail. trim
elev. AP servo
Ail. AP servo
Dynon EFIS (has it's own battery backup built in)
Gear Pump
AUX radiator cooling fans
CD/DVD player
Nav lights
taxi light
landing light

A Your e-bus should be able to get down below 3 amps for the en-route battery only endurance mode. Once you have the airport in sight, bring the main bus back up to use all those other goodies if they're really handy . . . but by then, your comfortable arrival should NOT be an issue even if the battery goes dead.

> Good thing I have 95 amps available I suppose..........

A Thats about 65 amps more than you'll ever need. The biggest full-up IFR load I've ever seen on a homebuilt was 27 Amps.

> OH, and could you give me the info on those fancy French contactors- might just spend the $$ if the power looks like it will be close......

A Dave S. Are you listening in? Who makes those low-holding current contactors? I seem recall that AirTechnics handles them here in town. . .

(Re: Low power contactor, Bob asked for the source of the low power contactor. It is made by Kilovac, which was bought by Tyco-and thus the site is harder to navigate. The model that you would want is the EV200AAANA. This is $67.61 from onlinecomponents.com , which is one of the distrubutors. Nice unit, but it may need cooling as it is encased in resin. I plan to put the fuse, ANL current limiter, capacitor for cutting noise from the PM alternator, and two regulators for the two alternators all in one aluminum box with some air flow. Found this on Kilovac's website at http://www.kilovac.com/general.news.item.asp?id=330

A This isn't the device I'd seen earlier but it offers similar characteristics for a lower price. Here's the datasheet on the EV200 http://www.kilovac.com/pdf/kilovac/high.voltage/pdf/ev200.pdf Bob . . .)

> Thanks Bob, You have an absolutely great seminar, that should be required attendance for every homebuilder with an electrical system!

A Thank you! Bob . . .

A Follow-up
Just got a note from Todd at B&C. He says they stock the ANL in an 80A rated device. Given the robust nature of these critters, I think an 80A would be okay for your 95A alternator. I found some ANL100 fuses on Amazon.com for $12.00 each at:
http://www.amazon.com/exec/obidos/ASIN/B00004Y3RM/summitpost-20/103-6569411-3501455

Did a little more searching and found a smaller alternative to the ANL series fuses. Dubbed the MEGA/SEA series you might consider a fuse holder like this:
http://www.bluesea.com/catalog_.pdf/fuseblocks/pg_7.pdf

matching fuses are shown a bit further down the same page. Bob . . .

Alternator: Re: B- Lead In-line fuse or to the panel?

> Should the 70amp (or should it be 80 amp?) fuse between the 60amp alternator & the main battery contactor (and the 30 amp fuse between the 20 amp alternator & the aux battery contactor) be an In Line fuse? Or should you run the wire back to the fuse panel?

A B-leads from alternators need to stay off the panel. This is what's shown on all of our power distribution diagrams. If you use JJN/JJS series fuses for alternator b-lead protection then use an 80A fuse for a 60A alternator. See
http://www.aeroelectric.com/articles/anl/anlvsjjs.html
and http://www.aeroelectric.com/articles/fusvsbkr.html If you want to go the ANL current limiter route, the device can be selected for the same size or even a little smaller than the alternator's rated output.

>What is the "Transient Suppressor" found on the Lancair Schematic? Is it typical to install this?

A It's pink elephant insurance. Used to sell them and at one time, they were a hot item of discussion on the various list servers. See: http://www.aeroelectric.com/articles/spike.pdf I even included one as part of the loadmeter/voltmeter system I sold a short time back. Bottom line is that I've never been able to capture an electrical gremlin that would be expected to trigger one of these devices. For a time in the late 60's we experimented with various active spike catching circuits on the single engine Cessnas. We came up with some pretty nifty circuits but the bottom line was that even then, we could never identify the existence much less a source of spikes that was worth building a spike catcher for. I don't think I'd bother to include one in a new design. Bob . . .

Alternator: Re: Internally Regulated Alternator Adjustment?

> Answering my own question here: apparently my Hitachi (unknown model nr.) internally regulated alternator requires battery voltage on its "S" terminal to regulate at 14.2 volts. With no connection to "S", its output rises to 15 volts. Perhaps the "S" means "sense". It certainly doesn't mean "start" in the case of this alternator.

A	This usually means "Switch" . . . other alternators will use "IGN" on the terminal with the same function. Sorry I missed asking you how you had connected leads to the back of the alternator when this thread started. I just assumed you had a diagram describing how to use the alternator. The reason the output voltage jumps up should the alternator get started is because there is a one-diode drop in an internal connection between b-lead and the "S" terminal. The regulator thinks it's seeing bus voltage when in fact, there's a .7 volt error that causes the regulator to boost alternator output by that amount.

>For alternator starting, I found that some current must be injected into the "L" terminal. With no connection there, my alternator wouldn't come on line below 2400 (engine) RPM. In my installation, I feed it from the same source that feeds the "S" connection but through a 20-ohm resistor.   "L" stands for "lamp" terminal -- the idiot light on the dash. In some 70s automotive designs, the lamp supplied the alternator starting current and when the lamp burned out the alternator wouldn't start (except by residual magnetism).

A	Correct. In many early automotive installations, should the alternator warning light bulb burn out, the alternator wouldn't start up. This was a sort of double-whammy against the car owner 'cause he not only lost indication of a failed alternator, the failure of the 50-cent lamp might force failure of the alternator as well. Later cars added a resistor across the bulb to prevent lamp failure from killing the alternator too. 20-ohms is a bit low. During the time that your bus is hot but the alternator is not turning, circuitry inside the regulator is pulling down on that 20 ohm resistor as if it were a lamp. 20 ohms on 12v produces 600 mA of current on a lamp driver transistor sized for perhaps a 100-200 mA lamp. This may not be a bid deal for the transistor but I think you'll find that the alternator comes on line nicely with a 50-75 ohm resistor as well and would certainly reduce risk of overheating the regulator's lamp driver transistor. Bob . . .

Re: Alternator capacity/loading ....

James E. Clark wrote: My partner and I have a recently completed RV6 with Van's 35A alternator. When flying, all (electrically) works fine ... no smoke escapes and all items work as expected. :-) BUT ...If after landing (or engine at idle during landing), I have on strobes (Whelen - 7A), landing light + taxi light (55 watts each and thus about 5+5 A = 10 amps) and nav lights (<5A ??) , the voltage DROPS from 14+ to < 12 and I (appropriately so) get low voltage warning and a big drain on the battery. I awitch them off and battery starts getting about a 10 A or so charge and voltage goes back to 14+. QUESTION(S): My suspicion is that this alternator is not producing anything near rated
>output at the lower RPMs.

A	Still need to know about pulley size. Many builders have opted for oversized pulleys based on Van's recommendations. The notion was that the alternator will last longer at slower

speeds.
This is sort of true . . . but the reason turns out to be more a problem with rotor balance taking out bearings than a function of rapid wear out at higher alternator RPM.

B&C leaves the small pulleys on and balances the rotors to very tight requirements. By and large, these alternators have a good chance of running the lifetime of the airplane and certainly the lifetime of the engine. Best yet, the small pulley gives you nice output at ramp idle and taxi speeds. The biggest difference is probably pulley size. . . If I recall correctly, Van pioneered the "oversized" pulley to slow down alternators that wouldn't last well on airplanes. B&C took the opposite approach . . . find out why the bearings failed and see if that problem could be fixed without having to slow down the alternator. Balancing the rotors turns out to be the REAL solution thus preserving alternator performance at low engine RPMs. Bob . . .

S James, I had a similar problem on my 6A with Van's 35 amp alternator. It was fine for the first 250 hrs, then I got a low voltage warning in flight. I don't have an ammeter, only a voltmeter. I reduced the load, by switching off the wig-wag landing lights, & got my normal charging voltage back. I estimated that the alternator was putting out about 12 amps. Someone later told me that it was probably a diode failure in the alternator, & that it is fairly common for Van's rebuilt car alternators to last only a few hundred hours. I assume that if a 35 amp alternater will put out x% of 35 amps at engine idle, then a 12 amp alternator will put out x% of 12 amps at idle, so your low voltage at idle could be partial alternator failure like mine. I never did get the alternator fixed, as Oshkosh was the following week & I replaced it with a B&C 40 amp unit. Should have spent the big bucks in the first place! Regards, Chris

S Limited output from the Van's supplied 35 amp kit. Do you have anodized mounting hardware ? (at one time this was supplied in the kit and it may not have changed) From a previous post I sent explaining limited output from a known good alternator:

1. The mounting bracket is anodized (Blue on this one) and is a near perfect insulator. Except for minor scratches, produced when bolting the bracket to the engine and bolting the alternator to the bracket, it provides Zero ground return. The frame of the alternator is the big current ground return and Must be grounded to the engine as is the starter motor. The minor scratches soon corrode and become insulators. I chose to run a heavy (#6) ground strap from the frame of the alternator to the frame of the starter using plated aviation grade connectors with 5/16ths holes clamped by the respective pivot and mounting bolts. I could have removed the bracket and removed an appropriate amount of anodizing from it; alodined and or coated with silicone grease; and then remounted and safetied, but the ground strap was easier and a more resilient method, in my opinion. Hope this is a clue to the problem, Gary
----

Re: OVM Installation

>OK, I have the overvoltage module now....1) As I read the instructions for an external regulator it looks like I can wire this to the regulator "in" line that is controlled by the alternator switch and then ground it locally at by the voltage regulator. Is this correct?

A Essentially. You can wire the OVM into the system at any convenient place DOWNSTREAM of the circuit breaker that supplies either field excitation power (external regulator) or alternator control power (internally regulated).

>2) Why is it necessary to wire the alternator to a resettable circuit breaker? Is it only to reset for

nuisance tripping? or is there another reason why I would want to have the over voltage turned back on?

A Yes, to allow resetting for nuisance trips. OBAM aircraft are famous for situations that might trigger the OV module. Eventually, we track them down and fix them. If it were my airplane, the 5A breaker for OVM system would be on the panel as shown in all of the switch panel layouts we've published. Bob . . .

S >My understanding is that the circuit breaker is what kills power to the alternator field on an over voltage condition as determined by the OV module (crowbar). When the OV module "sees" voltage rise on the alternator field supply wire above a preset level and for a specific time interval as determined by the OV module, the controlling transistor gates the SCR on(both components are in the OV module), providing a dead short between the alternator field supply line and ground, or the same thing as would happen if this wire were to short to a rib- the breaker pops, removing voltage from the alternator and eliminating the source of the OV condition, and also dumping the inductive spike from the alternator windings harmlessly to ground- I may not have explained it quite right, but the concept is pure brilliance and you have the honorable Mr. Knuckolls to thank! I don't have the book open before me, but the wiring you suggest sounds correct. I believe the feed for the OV module can be connected direct to the downstream side of the circuit breaker.

A Your understanding is correct. I stole the idea from the design of power supplies for large main-frame computers common to the 80's . . .Bob

S >" My understanding is that the circuit breaker is what kills power to the alternator field on an over voltage condition."

>Hmmm. My understanding is different. As wired in my plane, the OV module shorts the breaker as you say. However, when the circuit breaker pops it kills the voltage to the field of the contactor which is connecting the alternator output (B lead) to the battery, thus removing the offending voltage from the system whether or not the alternator field is receiving power internally to the alternator itself.

A Internally and externally regulated alternators ARE slightly different in the way that the OVM tames a runaway alternator. For internally regulated machines, the external B-lead contactor is not necessary. Bob . . .

Re: Alternators; Controllers

>Bob: I will be doing the Z-14. Do you recommend the new ABMM for this electrical system? > If you use B&C alternator controllers, low voltage warning and ov protection for both busses is built in. You don't need the aux battery management feature. If you use generic regulators, you'll need to add ov protection and lv warning for both systems.

>

Alternator controllers: meaning the two LR3's

A yes . . .

> They asked me what shunt I wanted. Read an article months ago about shunts. I thought from this article that a 100 amp shunt was recommended. This EI Volt/AMP gauge does not come with any specific shunt, so when they asked, I said the 100/50 shunt. Your Z-14 shows the 60/50, & 20/50 shunt's respectively. Are you saying the shunt has to match the alternator and the gauge? Have not really looked at the gauge close enough to know.

A if you have a "loadmeter" calibrated in percent of alternator output such as the one we used to sell, then the shunt has to be sized to the alternator . . . I.e. a 20A alternator needs a shunt that delivers 50 m.v. to an instrument that reads full scale with 50 m.v. applied. In the case of your ammeter, it reads out in absolute amps . . .therefore the shunt has to be size to the full scale capability of the instrument. If you're going to switch the single instrument between two different alternators, then the instrument's scale needs to be fixed . . . in this case, 100A full scale . . . and the same size shunt would be used with both alternators. So, when reading output of the main alternator, you need to know that 60A is 100% of full output, and full output of the aux alternator is 20A . . . you would do percentage of full capability mentally. Bob . . .

Re: Alternators; OV Protection for Internally Regulated "One Wire" Alternator?

> I have been looking in my Aeroelectric book at Z-24 and it appears to me that the way the OV crowbar works is by creating a "short" on the alternator field control breaker which is connected to the alternator disconnect contactor. I guess the OV crowbar just trips the 5 amp breaker? Is this basically a correct way of looking at this?

A yes. for info on internal workings and for testing info on crowbar ov module see http://www.aeroelectric.com/articles/crowbar.pdf

> Since I have an internally regulated alternator that has no external field wire I am thinking that the alternator disconnect contactor can get its control voltage from the bus thru the circuit shown in Z-24.

A yes

> It will just >not have the field wire from the alternator to the alternator disconnect contactor.

A correct . . . the little wire going into the back of most internally regulated alternators is for control only . . . it does not carry field excitation current and therefore is able to effect shutdown of a runaway alternator. Since you have the "one wire" alternator, you still use figure Z-24 . . . you just don't have a connection from the contactor coil to the alternator control pin. Bob . . .

Re; Alternator; circuit breakers

> I didn't realize that you were recommending OV protection for the SD-8. Is B&C also recommending it now? Six years ago, we were still saying that the OV/LV sensor would be adequate because an OV condition would happen slowly enough for the pilot to see the flashing light and turn off the SD-8 before any damage was done.

A Yup. B&C has an install kit for PM altenrators that includes a filter capacitor, ov module,

control relay and light fixture. It's their p/n 504-1 and wired per Z-17. Bob . .

Re: Load Analysis; List of current consumption figures

> I seem to remember someone asking about the amount of current consumed by various bits of equipment. I've just stumbled upon this page:

http://aircraftexpense.com/eloadindex.htm

which contains a *very* comprehensive list of aeroplane equipment and its current consumption.

A	Too bad folks who took considerable time to compile this list didn't include running current values along with the peak current values. Running current is what's needed for load analysis, peak current often just sizes wire and fuses. Bottom line is, get out your volt-ammeter (you all DO have one of these . . . no?) and confirm ANY data you might get from printed literature after your system is up and running. Bob . . .

Re: Alternator; Z-13 questions

>I'm configuring my RV-8 as an "all electric plane on a budget". The battery will be aft mounted for weight and balance considerations. I have the following questions.

>1) What size current limiter and ammeter shunt is suggested for a 40 amp alternator, Z-13 shows the values for a 60 amp alt.

A	40A for both devices.

>2) When mounting the battery in the rear of a metal airplane, it was suggested to me by a friend to ground the battery (-) to a local stout longeron, then to reconnect to that same longeron for the firewall ground forest of fast on tabs. I am leaning towards a common ground and running a seperate 2awg wire forward to the firewall to avoid ground loops. Your thoughts?

Bringing all fat feeders to the common ground point is never a bad decision electrically. It depends on how much one agonizes over the weight of 8' of 2AWG at 4 oz per foot for a total of 2#. History of electrical systems in aviation have suggested that structural parts of the airplane are best designed for holding the airplane together and depending on them for electrical pathways too is problematical. To be sure a couple hundred thousand airplanes HAVE used structural members for electrical tasks but if one is weighing perceptions of relative goodness between two choices, my personal approach would be to keep electrical and structural systems independent of each other as much as practical.

I would use local grounds for lights in wings, strobe power supplies and pitot heaters. These are not high current systems and they are neither strong antagonists nor potential victims for noise issues.

>5) In Z-13, there is a fuse between the Battery bus and the E bus switch and an additional fuseable link between the switch and the e bus. Why both?

The wire between battery bus and e-bus can be powered from EITHER end. The purest would deduce that some form of protection needs to be applied at each end of the

feedpath. Since the e-bus alternate feed switch is relatively close to the e-bus, fault risks to the e-bus end are low . . . I'd probably not put a fuse or fuselink in at the e-bus end. I've had some builders assign one of the e-bus fuse slots as an power INPUT connection for the alternate feedpath. If you've got a fuse slot open, this wouldn't be a bad thing to do. You install the same size fuse at the e-bus end as you do for the battery bus end. Bob . . .

Re: Alternators; Wiring VM1000 for dual alternator installation

>I'm wiring my RV-8 with Z-13. My ammeter will the embedded in the Vision MIcrosystems VM-1000 display. My questions are:

>1) What would be the consequence if I connected the leads from both ammeter shunts to the VM-1000? Since both alternators would be operating at different times wouldn't the display just show the current from which ever alternator was switched on? No doubt I'm missing something, please poke holes in my logic.

A the VM1000 uses hall effect sensors, not shunts. You can connect the three wires so that both sensors are powered up all the time but you need a switch in the signal lead to swap the instrument between sensors.

>2) For those who have used a primary and an E bus and a display like the VM-1000, where in the circuit did you wire the voltmeter? Any reason to have a voltmeter on the main bus as well as the E-bus? OOps, that's a dumb question, I think I just answered it myself. Current is very important to system health, but knowing if the voltage falls below alternator output (#1 or #2) is all that really matters, yes? Having said that, my logic is that putting a single voltmeter accross the pnl ground plane to the started contactor would do the job. Fire away, what am I missing?

A since the VM-1000 doesn't help you get from point A to point B, I'd put it on the main bus and let it go dark during battery only ops. One might argue that you need a voltmeter on the endurance bus 'cause it's the battery's "gas gage" but if you've done your load analysis versus battery size -AND- you do reasonable periodic maintenance on the battery, then there is zero concern for getting airport in sight battery only, even if your alternator crapped 5 minutes after departure. Your engine isn't going to quit running because it isn't being monitored. If there are things the VM-1000 can do for you en route, they are very short duration activities that can be covered by momentarily turning the master switch on. Bob . . .

Re: Alternators; sizing of current limiters on the B lead

>Bob I am doing the Z14 system. I have a 60 amp main alt and a b&c 20 amp on the second system. How do I size the current limiters on the B lead. ANL60 and ANL20?

A The ANL devices have fusing characteristics that approach fusible links in terms of time-to-open at various, intermediate current levels. Since the purpose of a b-lead fuse is to protect the system against HARD fault (read 500-1000 amps) due to shorted diodes in alternator, the actual size of the protection is not terribly critical. The ANL limiters are made by a number of companies but not all companies make all sizes. Bussman (see: http://www.bussmann.com/library/bifs/2024.pdf

. . . does make a pretty good spread in the low current range An ANL-35 or ANL-30 would be fine for the SD-20, an ANL-50 or ANL-60 for the 60A machine would do too. B&C stocks ANL-40 and ANL-60 which are the sizes used on their STC'd kits. If push came to shove, I'd have no heartburn with an ANL-40 on the SD-20 alternator.

The SD-20 b-lead can also be protected adequately with the big-dog cousin to the ATC plastic fuses. Theres a critter called the MAXIFUSE (see:

http://www.bussauto.com/pdf/maxifuse.pdf

A MAX30 in a single fuse inline holder (available from many automotive parts stores along with the fuse) would be fine on the SD-20 as well. Probably less expensive and easier to install than an ANL limiter and base. Bob . . .

Re: Alternators; Option for alternator B-lead fuse

>   Bob, I would like to get your opinion on the use of a fuse holder similar to the following for alternator b-lead protection forward of the firewall:

http://www.crutchfield.com/cgi-bin/S-08KCpdYV9zh/ProdView.asp?s=0&cc=01&g=716&id=morephotos&pi=1&i=575CPPFH4&display=L#morephotos

>These are commonly used in car stereo installations and are designed to go under the hood, near the battery. My plan is to have it mounted to the engine mount using adel clamps near the starter contactor. 40 Amp fuses are available (for my 40 amp B&C alternator.) The one drawback I can see is that the attachment of the wires is done with a set screw rather than a clamped connection. My alternative is to use a Bussmann JJS/JJN type fuse as shown in your book.

A Hardware for automotive guitar-driven rock-crushers, as you have noted, do not feature gas-tight connections so prized by those who deliver solderless hardware to the aerospace industry. The JJS/JJN series fuses can be purchased through local electrical supply houses. You might also consider miniature versions of the ANL series fuses. If you have a high speed connection, download this catalog and check out the MIDI series fuses from Littlefuse:

http://aeroelectric.com/temp/Littlefuse.pdf

There's a MAXI version of the small plastic fuses. See:

http://aeroelectric.com/temp/maxifuse.pdf

This device would be suitable for small alternator b-lead protection. I'd have no heartburn with using a MAX40 fuse in the b-lead of a 40A machine. Automotive parts stores carry in-line fuse holders for this plastic super-fuse. See:

http://aeroelectric.com/temp/MAX_InLine.pdf

The options offered above are much superior to the device you cited. Bob . . .

Re: Alternator; Connection

>I'm trying to source the B-crimp style terminals used in connectors for B&C (and similar) alternator field connections. I've tried everywhere from Radio Shack to Digikey.. I'm probably

searching using the wrong name.. Can you advise a name, P/N and/or source? Wayne

A You're talking about the un-insulated brass terminals that go inside a nylon housing that fits the back of the alternator. Looks like this:

http://www.aeroelectric.com/temp/41194.pdf

except fitted with a barb on the back side to retain it in the connector housing. I used to carry those and in fact, I think I gave my inventory to B&C when all the parts business moved up there. I don't recall now where I found them. They were all strung together for automatic feed into a crimping machine. They were unplated brass as I recall.

I wouldn't have any heartburn with going directly onto the tabs at the back of the alternator with a single PIDG Faston installed on the field wire. The PIDG terminals are plated and made from harder metal. Electrically and mechanically a much better terminal. Bob . . .

Re: Alternators; Unstable charging system . . .

> I felt pretty certain that if you recommended hooking the regulator right to the back of the alternator, and then followed the appropriate connection you knew things would settle down nicely. Well, they did just that! The ammeter was rock steady to the charging side, and the voltage read a solid 14.4 Now the follow up to get these same results once the voltage regulator is reinstalled, and not hanging off the alternator. The other thing I noted was that when hooked up in this manner the alternator side of the split master was not working, but I'm sure you knew that would happen. Let me know what's next, and thanks!

A Okay, this experiment was important to tell us that the components were okay and that you didn't have a flaky regulator or bouncing brushes in the alternator.

I'd start at the bus (did I ask whether you're using fuseblocks or breakers?) and check to see that you have good terminals, at least 20AWG wire all the way to the regulator's "A/S" terminals. If the regulator is mounted on the firewall, grounding isn't an issue for the regulator . .and seldom does grounding affect stability . . . only voltage setting.

Also, you mentioned that the "alternator side of the split master was not working" . . . I'd bet that MOST of your circuit resistance is happening in that switch. I have a plastic bag full of perfectly good looking split-rocker switches that were sent to me after putting in a new one cured a bouncy ammeter complaint. This has occurred in countless certified ships and a few OBAM aircraft. This doesn't mean that the split-rocker is necessarily a "bad" product (it's made by Carling and uses the same guts as the S700 series toggle switches B&C sells).

Regulators are sensitive to small amounts of resistance in the lines between bus and regulator. I had one builder who mounted his regulator within a few inches of the bus, tied the A/S terminals directly to the breaker with short, single, solid wire and put his alternator control switch in series with the field wire. He added crowbar ov protection to the breaker and ended up with a combination that would probably be stable over the lifetime of the airplane.

In older production Cessnas, I think I counted 20 some odd crimps, connections and spring-pressure maintained metal-metal contacts between bus and regulator. As all of these joints age, they add resistance to the circuit. At some point in time, the system becomes unstable with symptoms you have observed.

Thousands of spam-can owners have paid out $millions$ to ignorant mechanics who replaced EVERYTHING BUT aged/compromised wiring before finally renewing the bus-to-regulator components. In many cases, owners have reported that replacing only the spilt-rocker "fixed" the problem. Indeed this single component can be a major contributor of total loop resistance.

But consider that if NEW loop resistance was on the order of 50 milliohms and had climbed to 100 milliohms with the switch contributing 25 ohms of de-stabilizing resistance. Replacing the switch drops total down to 75 milliohms and the regulator is happy again . . . but not for as long as it would be when replacing ALL sources of age/service related resistance in the bus-to-regulator pathway.

The obvious, elegant solution in original design is to incorporate a regulator that separates voltage sense wires from field current supply wires. The LR-3 does just that. Any new regulators I design will have separate sense wires too.

Does this suggest that the OBAM community should rip out all their three-terminal switchers and bolt on the LR-3? Not at all. The automotive style regulators have for the most part given good value but they DO have special characteristics that only one mechanic in 1000 understands. In the spam-can world, ignorance is shoveled out at $thousands$ per non-idea, in the OBAM aircraft world, we've managed to keep those costs MUCH lower . . . and much of it happens right here on the AeroElectric List. Bob . . .

Re: Alternators; SD 20 Alt Failure

The pictures can be viewed at:
http://www.aeroelectric.com/Pictures/SD-20A.jpg
http://www.aeroelectric.com/Pictures/SD-20B.jpg

PRELIMINARY investigation suggests that (1) there are no casting flaws and (2) that in this particular case, there was not a single crack but a series of three independent failures for each of the three corners that broke off . . . the 4th had been overstressed and broke off with relatively low force bending applied with pliers.

Let's be cautious with loose speculation . . . keep in mind that thousands of these alternators are in service over a service history of 9 years or better. There have been only three casting failures reported to B&C over this period of time. There is a working hypothesis as to root cause which will be developed and either confirmed or rejected. This is a high priority investigation and the results will be posted here and reported to the FAA as soon as credible data are available.

Bob . . .

Re: Alternator and electronic ignition

Leonard, First verify that the miss is caused by the alternator by disabling the alternator and running just off the battery. Then if the problem does appear to be the alternator, check alternator output and voltage as mentioned below. I will bet that the alternator has a bad diode and thus is not outputting full power (current and voltage). Also with a bad diode the alternator will output a lot of "AC ripple" which is basically noise. This noise can be misread by the electronic ignition as a signal to fire the coil, which would cause a miss.

The best way to check AC ripple is with a scope, however a multimeter will work as well. Turn the meter to AC voltage and connect positive lead to B+ on alternator, and negative to alternator body. You should read less than 400mV, a rough number, of AC voltage. If the voltage is high, most likely you have a bad diode. Also check your grounds again, a bad engine ground could also cause some hiccups with electronic ignitions. Trampas

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Re: Alternators: Crowbar OV protection

>A fuse, hmm, good idea. My plane has a 60 amp alternator, and had a 40 amp breaker installed, due to, I suppose the previous owner not wanting to change the breaker when he upgraded the alternator. But that 40 amp breaker has never popped. So if I install a 60 amp fuse, the only way it would ever melt would be from a problem that I wouldn't want it back from anyway.

A I'm not sure we're together here. The fuse I was referring to in my earlier post would have replaced any kind of 5A FIELD breaker that you might be worried about . . . never saw a fuse fail to open when hard faulted. The fuse you're talking about is in the alternator b-lead (output). See Figure 17-2 and associated text on page 17-7 of the 'Connection.

The fact that you've never seen this breaker open says only that you have yet to generate the perfectly normal condition that will open it. If you choose to "fuse" this lead then consider the discussion in these threads:

http://www.aeroelectric.com/articles/fusvsbkr.html

and in particular the second half where I was taken to task for under-sizing a fast acting, JJN/JJS series b-lead fuse that we no longer offer nor recommend.
http://www.aeroelectric.com/articles/fusvbkr2.html

The device of choice is the ANL60 or even an ANL35. If you look at the fusing characteristics of these devices at

http://www.aeroelectric.com/articles/anl/anl.pdf

you'll see that you're unlikely to nuisance trip these devices on a 60A alternator on the coldest day. Irrespective of the circuit protection you choose for the b-lead, there is no bearing on the choice of configuration or operation of the ov protection system. The b-lead fuse protects the rest of the system from a hard fault inside the alternator while the ov protection system wards off effects of a failed regulator. Bob . . .

Alternator

>Actually in my case its only a problem when the battery has a VERY low charge (barely enought to start). Thats when I cannot turn on the ALT once engine is running. Turn on the ALT first and then start everythings fine. Turning anything on after the ALT is working, no problem. The only problem is turning the ALT on after the engine is running and the battery charge is very low.

A Okay, this suggests that either (1) your engine is VERY difficult to start and/or (2) your battery is in VERY sad shape. We've all seen airplanes cranking out on the ramp that take multiple attempts of 10 second cranking intervals to finally get the engine going . . . if at all.

The starter and battery in all cranking systems are in a huge OVERLOAD mode with respect to how the rest of the vehicle's systems perform.   It sounds as if there's insufficient battery voltage left after cranking to get your alternator to come on line. This is probably not a fault of the alternator or regulator. The normal cranking scenario should require no more than a few percent of a battery's capacity leaving plenty of snort for things to come on line and a MINIMAL energy replacement task when the alternator clocks in on the job.

Load and capacity testing of your battery is in order. Fine tuning of engine characteristics that make it hard to start is another useful activity. Bob . . .

Re: Alternator:: ANL 20n current limiter source

> Was planning to place a final order to collect remaining needs for my electrical system and saw that the B&C site doesn't offer ANL 20 current limiters. I figured this would be the right one for my #2 alternator, the SD-20. If not, would I do harm by substituting an ANL 40?

A   An ANL40 would be fine there. Alternatively you could use an automotive in-line fuse holder for a "fat fuse" . . . there is a line of plastic plug in fuses that are big brothers to the ATC plastics that fit the fuseblocks. Many automotive stores stock the Bussman HHX or something similar.

http://www.bussauto.com/pdf/inlinefuseholder.pdf

You can also buy fuses down to 20A for this holder at the same store . . . I'd put a 30A fuse in it.

>On a similar topic, the information from Continental says that the alternator that comes with the engine (IO-550) provides 70 amps. Should I order an ANL 60 or an ANL 70 for the primary alternator?

ANL60 from B&C would be fine here. The ANL series limiters are VERY robust compared to fuses and the potential overload on an "undersized" limiter is not an issue. Bob . . .

Re: Alternators: Both Z-13 alternators on at same time

> Hi Bob, Just have a desire to further my education. Per Z-13, what happens if I inadvertently turn on my SD-8 while my main alternator is running? Would this be an expensive lesson with lots of smoke? Do I need to set the voltage on one a bit less than the other? Thanks.

A   Nope. No damage will occur. The alternator with the higher setpoint will attempt to hog the load . . . if this happens to be the smaller SD8 alternator, it will put out up between 8 and 10 amps before the bus sags enough to wake up the larger alternator whereupon it will take up the slack.

Now, UNLIKE the SD-20 which is DESIGNED to operate TOGETHER with the larger alternator in a Z-12 configuration, you DON'T want to set the SD-8 for a lower voltage and run it all the time. Unless you have the special circuitry like that built into the SD-20/SB-1 combination to alert you when the main alternator fails, running the SD-8 all the time would mask the event if your system was lightly loaded. Bob . . .

Re: Alternator: Architecture questions for an RV7

>Bob, I am building an RV 7 using all B&C electrical products, including the 60A alternator and 20A vacuum pad mounted alternator and SB1-14 and LR3C-14 voltage regulators. The architecture includes a separate battery master switch and individual alternator field switches. (I am using one of your main bus/essential bus architectures with dual alternators, diode feed to

the essential bus and alternate switched path to the essential bus. This arrangement is as shown in skeleton figure 17-2 of your Aero Electric Connection manual rev 10 dated Nov 2001).

A First, why are you installing two big alternators? How do you plan to use this airplane and how is it going to be equipped? For this combination of alternators, Figure Z-14 is the system of choice for folks who NEED this much engine generated power.

>I have what seems like a trivial question: If I have a main bus fault for example, is there any importance as to the order of opening/closing the battery master and essential bus switches. If not why can't the essential bus alternative feed switch be replaced by a direct connection? If I close the essential bus feed switch by accident whilst the battery master switch is still closed are there any implications?

A "Faults" to the bus are so rare as to be unworthy of procedural consideration. The philosophy of the architecture in Figure 17-2 (and Z-11) is to provide

(1) an alternative feed path for power to electrically powered items that will essentially insure comfortable arrival at airport of intended destination and

(2) provide a way to reduce en route loads during battery only operation to a value that compliments goal (1) cited above.

If you have two engine driven power sources in the form of 40+ and 20A machines, en route energy conservation is not an issue. Therefore, it seems more practical to consider figures 17-5 and Z-14. But first things first, why have you selected this particular pair of alternators?

>If I open the battery master switch without opening the alternator field switches first, will this have any detrimental effect on the alternators?

A If wired per any of the Z-figures with a 2-10 master switch, this issues is mute. The switch is configured to bring the alternator on last and off first. Unless you've specifically designed and tested your proposed system for alternator only performance, operation without a battery is an iffy proposition and not recommended.

>Are there any other circumstances when using your voltage regulators and alternators that can damage either of them by incorrect operation of the battery master switch and/or the individual field switches. For example, by opening a field switch with the engine running and the battery master switch closed ? I should perhaps mention that I am asking this question because there are dire warnings in some Automobile maintenance manuals, and indeed on an American Web site dealing with some marine installations, that an engine must on no account be run without the battery being connected else alternator damage may ensue as a result of a rise of output voltage to 100V or so. But this advice may not apply to your arrangements ?

A It sure does . . . that's what drove the configurations described in Appendix Z.

> I plan to use the battery temp sensors on both regulators. This option is not shown on the SB1-14 regulator. Is this available and if so are the connections to pins 1&6 as per the LR3C-14

A No, the temperature sensor is useful in very few situations and not recommended unless you plan to spend long legs of a trip at 25,000 feet on oxygen where you might cold-soak a battery.

> I want to keep my instrument panel as neat as possible! I have standardised all my warning and indicator lights as high intensity LEDs with internal dropping resistors. Can I use one of

these in place of your supplied low voltage warning filament lamp on the LR3C-14?

A Yes, see http://www.aeroelectric.com/temp/LV_Led.jpg

> I am also planning to be able to test all the warning lamps on my panel with a single push to test button, applying a ground or 12v as appropriate. For the alternator warning lights I was planning on using a relay to temporarily disconnect the low voltage warning light from pin 5 on the regulator and connect to ground therefore placing 12v from the main bus across the light to test its operation. Is this ok?

A If you're using LEDs throughout, I wouldn't bother about PTT. The life of an LED is so high that you're MUCH more likely to loose functionality of an annunciator for reasons that are not tested by your PTT system. Keep the parts count down and check list shorter by leaving this low-value feature off. Bob . . .

Alternator: No Electric Starter/System Ques

> Bob, in a thread while I was away over Christmas, you answered the following question thus:
> >MAIN ALTERNATOR OUTPUT > >1. ? Without a starter contactor will the output of the main 50 amp alternator go to the 60-anl on the firewall and then to the post of the Main Bus Fuse Block?
> Yes, but mount the ANL-60 as close to Main Bus as practical.

> That interested me since in another context I had been wondering about ANL location. I was puzzling why in Z-24 the ANL was shown downstream of the internally regulated alternator isolation contactor. My thinking was that by having it close to the alternator it would blow if anything (including the isolation contactor) ran amok downstream. What is the advantage of having it at the main bus end ?

A The ANL limiter (fat fuse) is there to protect the alternator b-lead wire . . . the source of energy that places this wire at risk is NOT the alternator but the battery. An alternator is incapable of putting out enough current to open its own b-lead protection while the battery is capable of fat-wire faults approaching 1000 amps. So, while selecting the SIZE of the protection device is driven by alternator output capability, selecting LOCATION is associated with the risk source . . the BATTERY.

On some occasions, we have fat wires that can source a fault from either end . . . in which case, you might have a limiter at both ends of the same conductor. However, I've never encountered a situation like this for small aircraft. Bob . . .

Re: Alternator: OVM
> I have Bob's OVM-14 Over Voltage Protection module for my internally regulated alternator installed in my plane. What's the easiest way to test it & verify I've installed it correctly?

A Testing is best accomplished on the bench but there's a technique described in: http://www.aeroelectric.com/articles/crowbar.pdf
for testing in the airplane too. Bob . . .
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2. ANTENNA

Antenna: GPS connector

>My GPS antenna has a screw on type female end. My coax cable has a BNC female end. How do I connect the two? Is there some fancy male/male TNC/BNC connector? Ross Mickey RV6A

S From: "James E. Clark" <jclark@conterra.com> Yes, there is such a "cable". One came with our antenna and is about 6-8" long. Seemed to have been a "stock" cable as opposed to one that was custome made. James

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Antenna

>> Bob, Sorry, I should have mentioned that my fuselage is aluminum. Would you use the same technique that you described for graphite? Also, the inside surface is primed, so should that be removed where the skin and doubler touch?

A That does make a difference. I presume the doubler is riveted to the skin and perhaps includes a formed flange that picks up a riveted joint in something more substantial than the skin. You can leave ALL surfaces of the doubler primed for corrosion protection. Rivets swell in properly sized holes with enough force to insure good electrical
connection to the airframe. I would clean off insulating material on both sides of all layers of the sandwich around the mounting holes to an area about 1/2" in diameter. This is important for antennas that have multiple fasteners holding the antenna base to the aircraft.

Some antenna manufactures suggest cleaning all of the surface under an antenna base to insure electrical bonding. The large area is low pressure and certainly not gas-tight tight junction between antenna and airplane. The only place where practical bonding takes place is around the fasteners and only if they're torqued up nice and tight. If your antenna base comes with 8-32 mounting hardware, I'd drill out for 10-32 hardware, clean well for all metal under head of screw, around holes on all surfaces, and use internal tooth lock washers under inside nuts. Torque to 12-15 in/lbs. If your antenna is a single whisker mounted on a ceramic insulating bushing, only the ground for the coax shield is of any concern for bonding . . . here a terminal on a #8 screw with good cleaning of the area around the hole
will suffice. Torque to 7-9 in/lb. Same techniques apply for graphite airplanes except that I wouldn't recommend the ceramic bushing style antenna. Bob . . .

Re: DIY ATC antenna

> >Cheers, Is there, do you suppose, an excuse for producing your own robust ATC Transponder antenna? I have installed several on WW II rebuilds and admire the simple

elegance of a hundred-dollar item by the time it feels metal against its skin. Any thoughts out there?   Thompson?   Anyone? Ferg A064

A   It's certainly not difficult to build an antenna that's heftier than the skinny-monopole antennas found on most small airplanes. The bizjets use "shark fin" style antennas that are indeed more robust . . . their price is equally more robust.

Here's the "top dog" of transponder anntennas: http://www.comant.com/ci100.html This guy retails for about $225 depending on the connector you want. If anyone wants a puppy like this, I can order it for you. The underdogs on the totem pole are like our ANT-1: http://www.aeroelectric.com/Catalog/antenna/antenna.html#ant-1 Which we sell for about as low as anyone in the industry. I've seen this critter in several catalogs at $99. That's what prompted me to add them to my catalog.

I talk about hand-crafted transponder antennas in the 'Connection. The goal is to get 2.8" of radiator outside the skin connected to the center conductor of your feedline with a minimum of exposed conductor in terms of both surface and length inside the skin. Intuitively the antennas illustrated above have ZERO exposed conductor inside the skin. I have a design for a transponder antenna that is carved out of a solid chunk of brass . . . antenna, radiator and feedpoint network are all one piece of material. A coax connector would thread into a hole in the base and solder to a small capacitor that in turn solders to a notch in the base section of the radiator.

Okay, so it's EASY to build a very robust antenna IF you have access to the tools. Bottom line is that there are few ways an amateur builder (or even a professional) could go about it that would yield a good return on investment for the effort. $225 for "top dog" seems like a lot of money but would you be willing/able to put an hour or two of precision machining time into a do-it-yerself effort? I've been to factories that do this kind of thing and indeed, their out-the-door-cost of antenna like "top dog" are something on the order of $10-20. But they have to make the initial investment in tools and skills that can only be recovered by building thousands of antennas. They also have to endure the assistance of government in looking out for the best interests of their customers.

Bob Archer's efforts in low tech labor approach to "protected" antennas is a good example of how some tomato-juice can materials and some knowledge can pay off. Once you stick the critters out in the air stream and weather, it's another task on top of the first. I've got some ideas I'm fiddling with and will probably publish some articles on them. But for now, if it were my airplane, I'd stick an ANT-1 on the belly and write off occasional replacement as dues paid to have the "pleasure" of owning the airplane. Bob . . .

Antenna: placement for RV-8

>> Can you tell me how much the splitter costs? (Sidenote: does Bob Archer have a website? I looked in the Yeller pages and only found an e-mail address and phone number). Is there any disadvantage to using this device? There must be a downside or I can't see why anyone would use a second antenna.....I suppose maybe there's a failure mode in the splitter that could leave you with no antenna for either comm, or possibly toast one of your radios if it doesn't work right?

S   >*** The latter. A relay connecting two transmitters can have a failure mode where one COM radio transmits directly into the other COM radio. zzzZZAP!

A   You can use a pair of double-pole, double-throw relays and a splitter with good port-to-port isolation that has no such failure modes . . .You can have a relay failure that

reduces one of the transceivers to a receive-only mode.
Common guys, the holy-grail of no-whiskers-on-my airplane is fraught with potential for loss of utility for the system that depends on reasonable antenna performance. I had a builder a few years back mount all his whiskers on inspection plates so that when the ship was sitting out on the line for a week at OSH, blank plates could be used to present a aura of technical sophistication. Whatever a comm antenna represents in the way of esthetics, its effect on airplane performance is all but unmeasurable. Bob . . .

Antenna: COAX

A RG400 and RG142 are electrically equal to each other. They differ only mechanically in that RG142 has a solid center conductor. My personal preference is 400 but I wouldn't throw away a fine piece of 142. The connectors we sell work on both cables. Bob . . .
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3. AVIONICS

Avionics: Books

Try Avionics Troubleshooting & Repair by Eric Mahler. Aside from the title, this book is really more of an installation guide than anything else, as it goes by the premise that most avionics problems are actually installation issues and, among other things, shows you how to check and perfect those connections. Andy, Builder's Bookstore http://www.buildersbooks.com
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Avionics: Radio noise

>>I had a radio problem that sounds similar to yours. My transmissions were understandable on the ground (but not clear), but once airborn - while I could hear others perfectly clear, it was rare that anyone could understand me. I checked Antennas, connectors, etc all to no avail. Thinking the radio transmission might be overpowered by cockpit noise I even sprung $60 for a high noise environment microphone. No noticeable difference. One day an A&E type was at our little airport working on one of the FBOs plane so I mentioned my problem to him. He went out to the
airplane, pulled my Terra 760 from its rack, took out a small screwdrive stuck it in a hole in the side and turned it approx 1/2 turn and told me to try it. It now works fine. It turns out the "mic gain" was turned up too high and was overmodulating the carrier wave causing "splatter" resulting in distortion. By turning down the gain it eliminated the overmodulation and now EVERYONE can understand me. Don't know if it would have bearing on your problem, but thought I would mention it. Bob may have some thoughts on this as a possible cause of your problem. Ed Anderson
----

Avionics, Master

>> This is an interesting topic for me. If DO160 requires qualified electronic equipment to cope with all the voltage dips, surges and spikes on the electrical supply, then what specification dictates that the generation system should not deliver voltage dips, surges and spikes of even greater magnitude. This is surely a function of the generator AND the regulator working together, not to mention the magnitude of the load switching and speed changes.

A MOST problems are a function of system design, NOT performance of hardware selected. The worst performing regulator, generator/alternator and battery combination will not in and of themselves combine to make an untenable electrical system. A battery in good condition is the great mediator. Further, DO-160 speaks to emissions of potential noise sources too. Alternators, starter generators and regulators are all subject to scrutiny under DO-160. Some TSO documents for starter generators will also speak to allowable noise from a generator. MIL-STD-704 also speaks to the kinds of perturbation limits which one should design to in fabricating an electrical system. By-in-large, its EASY to control the ugly things generated by appliances connected to the system; we generally design them out by: (1) use of modern RG batteries changed out when capacity drops below some service level (but never less than 50%). http://aeroelectric.com/articles/battest.pdf
http://aeroelectric.com/articles/rg_bat.html
http://aeroelectric.com/articles/bat_thd.pdf (2) keeping leadwires between battery, starter and alternator as short as practical and no less than 4AWG wire . . . 2AWG if battery is remotely located from engine (light, piston power a/c; larger wires and batteries would apply to turbine powered aircraft). (3) using single point ground system for all sensitive systems. Remote grounding is suited only for devices which are not strong antagonists nor victims of noise (lamps, pitot heaters, little trim motors, strobe power supplies, etc.). (4) use of spike suppression diodes on large energy storage devices (contactors and solenoid valves are biggest sources). See: http://aeroelectric.com/articles/spike.pdf
http://aeroelectric.com/articles/s704inst.jpg
http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg
http://www.aeroelectric.com/Catalog/switch/s701-2.jpg

If you've done these four simple things, your electrical system is going to be as quiet and friendly as as the present technology will allow. Further, it will be WAAAAayyyyyyy under the kinds of things that DO-160 prescribes for allowable stresses. Bob . . .

Avionics: Audio

>I want to have a jack in my aircraft to provide power for the noise cancelling feature on my David Clark headset. The battery pack takes six AAs, so I need 9V from my 12V electrical system. Can I just measure the current, assume it's constant, and put a resistor in series with the jack to make the headset see 9V?

A The task is easy to do. This circuit is similar to the small dimmer we sell which you can see at: http://www.aeroelectric.com/Catalog/lighting/dim5-14.jpg   The schematic for this device is shown in the installation instructions at:
http://www.aeroelectric.com/Catalog/lighting/9013_ins.pdf   You can get parts from most electronics suppliers.   An LM317T, a 380 Ohm, 1/4 watt resistor. Substitute a 2400 Ohm, 1/4 watt resistor for the 910 Ohm reistor. A couple of capacitors rounds it out,   . . 10uf @ 25 volts is in the ballpark. Just put a short circuit across pins 1 and 4 of the assembly, eliminate the potentiometer, and volia! you've got a precision 9v regulator with excellent bus noise rejection. If you wanted to order the DIM5-14 from B&C without the potentiometer, you can put your own

resistor in the connector between pins 1 and 4 to set the output to 9 volts. Since 2400 is needed and 910 is already in place, you would add a 1500 ohm resistor between pins 1 and 4 of the DIM5-14's connector. Bob . . .

Avionics: Book?

>>Modern Aviation Electronics by Albert Helfrick. > >
http://www.amazon.com/exec/obidos/ASIN/013097692X/sbw/
Especially since you ask about relatively old technology (VOR, DME, XPDR), this would be a good introduction for you. I have the 1984 edition, but a 1994 edition is now available.

>>A newer book by Helfrick supposedly covers satellite technology, glass cockpit, and datalink as well. I haven't seen it: > http://www.amazon.com/exec/obidos/ASIN/1885544103/sbw/

Avionics, Re: Turning off avionics during a hot mag check

>> Turning them off for a mag check sounds like advice from an avionics shop that makes it's living replacing the swirches you wear out with all that cycling.

A Most switches die of old age and/or get corroded for lack of use. Every switch made is rated in the tens of thousands of cycles at full load . . . none of them ever make it that far in a single engine airplane and it's not because they were cycled too much . . .

> The mags are an isolated system with no connection to the electrical system other than >airframe ground and even if the mag drop is severe it's still no worse than changing the throttle or prop cycling for testing the voltage regulator.

A True . . .

> It is >good practice to have them off during engine starting as voltage varies widely.

A What are the physics that makes this a "good practice?"

>> It is also good to switch them off before the master on shut down because when the master is shut down the alternator can put out very high voltages this is called load dump in the automotive world.

A In the automotive world, "load dump" is a battery disconnect while the alternator is working hard to recharge a discharged battery. See: bottom of first column on page 4 of http://aeroelectric.com/articles/spike.pdf

Load dump in the aircraft world is a situation where a load or combination of loads are simultaneously removed from the bus. In bizjets we see "load dump" when 200A air conditioner compressors or 100A de-ice heaters are shut off . . . the biggest load dump I've been able to deliberately generate in a Bonanza was to shut off landing, taxi, a/c and pitot heat switches all at once. With the current voltage regulators I measured a "bump" of less than 1.5 volts on the 28v bus that lasted for about 10 milliseconds before the regulator recovered.

When you shut the alternator off, it quietly goes to sleep. No muss, no fuss and certainly no spikes. Now, there are some folks who have experienced unstable alternator operations during shutdown because they have separate battery and alternator switches . . . if the battery goes off first, then the alternator looses the benefit of electrical inertia offered by the battery. SOME alternator/regulator combinations don't like this and bus voltage may become erratic . . . until the alternator is also shut down . . . but it's still not hazardous to electro-goodies. This is why all of our power distribution diagrams call for either a 2-5 or 2-10 switch to control battery and alternator in the SAME switch.

> If the aircraft can be started with the master off (some can) AND there is a switch labeled alternator AND that switch (which controls the alternator's field exitation) is turned off before the master on >shutdown then all the avionics will live longer if their switches are simply left on.

A Again, I am not aware of any transient condition that justifies these assertions. I've had all kinds of test equipment on airplanes over the years looking for gremlins and dragons . . .so have the folk who crafted DO-160 qualification testing. As always, if anyone has identified, measured and documented a hazard as yet undiscovered, I'd sure like to hear about it and I know a bunch of guys on the DO-160 committee that would like to know about it too . . .
Bob . . .

Avionics: TSO Requirements

I did some checking on TSOed equipment. My certified Bellanca does NOT have any TSOed equipment. Surprised? Shouldn't be as TSOs only started in 1947 and is NOT the only way to get appliances that are approved for flight.

Here is Joe Norris' EAA peer re-viewed statement...

"Equipment does not need to be manufactured to a TSO, even for IFR flight. A TSO (Technical Standard Order) is a guideline issued by FAA for the manufacture of a component. It is a method of compliance with the regulations regarding performance and accuracy, and as such can be used by a manufacturer to streamline the approval process for a particular component. A TSO is not THE ONLY means of compliance. In fact, so long as the equipment in your aircraft meets the requirements spelled out in FAR 91.205 (as required by your operating limitations) and can be proven (through flight or ground testing) to perform within the required tolerances, you're good to go.

TSOs are relatively new." (They were first set-up in 1947 and heavily revised in 1980.) "There are literally hundreds of aircraft flying today, both type certificated and experimental, that don't have a single TSOed radio or instrument installed. TSOs were developed to aid in the manufacturing of aviation products, not as an approval for installation."

Hope this helps. Let me know if you have further questions.

Joe Norris, EAA Aviation Information Services, EAA Aviation Center, Oshkosh, WI,
888-322-4636, extension 6806, jnorris@eaa.org

Avionics: Handheld GPS Approaches Legal?

>While NDB, DME, RNAV, ILS and GPS approaches my may brilliantly performed using a handheld GPS, one had better have the "equipment appropriate to the facilities to be used" on board. RIght?

I always remember the motto "SKIN, TIN, TICKET" and I add HOUSE. If I have an accident while flying an NDB approach without an ADF receiver I suspect that even if I save my skin, my ticket and possibly my home will be in jeopardy. FAA will scoff up my ticket and lawyers will take everything else while my insurance man shakes his head and smiles.

A You have an accident and all those things are at risk anyhow. The fact that you choose to be a dutiful observer of whatever rules are in place has little effect on the willingness of folks who would readily attack your character and resources if it enhanced their own careers or financial condition . . .

Bob . . .

Avionics: Re: ICOM A200 getting Turn & Bank Gyro sound

>I have just finished installing my ICOM A200 with DRE 244e intercom. My electrical system is configured with toggle switches, main bus with blade fuses and a common ground on the firewall where all ground wires run to. While sitting in the cockpit and enjoying John Denver's CD, I could hear my Electric Turn & Bank Gyro creating an anoying whirl in the headset. I pulled the fuse on the gyro and the noise went away. I did install the pilot's headphone & mic jacks on the subpanel close to the gyro, but am lost at what may be
the culprit.

A There are a lot of turn coordinators that are being manufactured under the guidelines in effect at the time of their original entry into the aviation market . . . at least 25 and perhaps 35-40 years ago. We were not as sensitive to effects of magnetic radiated noise then.

First, find a 12v battery. You might have to make it up using a couple of 6v lantern batteries from Walmart . . . get cheap ones unless you have a lantern that can use them. Use the batteries to power up the turn coordinator independently of the aircraft power and see if the noise goes away. If it does, then the noise is electrically coupled via the aircraft power bus to other devices in the system. The fix is a noise filter like:
http://aeroelectric.com/articles/filter/filter.html

If the noise only goes down but you can still hear it, then you may have a coupling mode that includes BOTH conducted electrical -AND- magnetic. If the noise does not go away entirely on separate battery power, then you'll need to add a shield to the outside of the turn coordinator case. A strip of thin magnetic material (like gutter flashing from the lumber yard) that is wrapped two or three times tightly around the outside of the case and held on with tye-wraps will usually do the job.

You can make up a cylinder of coiled material and put the tye-wraps on loosely so that the i.d. of the cylinder is just larger than the T/C case. Take the connector off and slip the cylinder over the T/C from behind. Snug the tye-wraps down to close the cylinder down on the instrument. You may find it useful to put a strip of double sided tape along the end of the shielding strip's inside surface so that it can get a good friction grip on the instrument. This allows you to twist the coil of sheet metal down tightly from the outside and get a good fit before putting the final tensioning tugs on the tye-wraps.

Avionics: Re: Connector for Electric Artificial Horizon

>Hi Folks, Getting ready to install the RC Allen electric artificial horizon. It looks like the electrical connection is via a 4 pin mini-DIN connector labeled MS3116E8-4S or equivalent. Does anyone know of a good mail order source for such things? I'd appreciate any info and

any peculiarities people have uncovered in dealing witrh these units. Thanks in advance. Bill Yamokoski

A The folks at http://www.skirrow.org/Classic%20Technology/connectors.htm say they have this connector in stock for $6.30. By the way, the last character in the part number is an "S" not a "5" Bob . . .

Avionics: TruTrak Autopilot

> I have a TruTrak DFC250 autopilot system in my Lancair ES, and as far as I'm concerned, it's the best thing since the pop-up toaster. It flies the plane better than I can (no comments, please!), including climbs to pre-selected altitude, turn anticipation on multi-leg flight plans, etc., etc. Much superior to the S-Tec system I put in my first ES. Jim Cameron Lancair Super ES N143ES

Avionics: Re: IFR GPS for homebuilts

>Hello Fellow Builders, I have touched on this subject before and I would very gingerly like to raise it again. Below is the URL for an article on AVWEB (taken from Aviation Consumer) that discusses in some detail the subject of installing / upgrading to an IFR capable GPS in a type certificated aircraft. The sidebar and the letters responding to the article are also of value. http://www.avweb.com/articles/ifrgps/index.html It is evident that there is considerable effort / paperwork involved in such an installation / upgrade. (Unfortunately the article fails to reference AC 20-138 that also pertains to this subject.) Here is my interest. I have a Garmin GNS 430 and an Apollo SL-30 in the instument panel of my plane under construction. I also have a separate CDI >and a select switch to send either GNS 430 or SL-30 data to that CDI. When it comes time to have this airplane inspected / certified by the FAA what hoops will I have to jump through to attain IFR enroute, terminal, and approach capable certification / approval for my amateur built experimental plane?

A Fly off the hours needed to get your airplane cut loose on the world. When that's signed off, go out and fly a bunch of different approaches at as many facilities and exercising the full gamut of techniques using your equipment as installed. Demonstrate to yourself that it works as it is supposed to. Make a notation in the log what you've done and call it fit to fly.

There's a lot of paperwork for certified ships but my sources here tell me that once you've got your basic hours flown off in a homebuilt, nobody has much of an interest in what you do with it after that (unless you INVITE them to have an interest).

When it comes to satisfying ANYBODY that you, your airplane and the equipment installed are qualified to go bore holes in the fog, you need to be your own worst critic. A rubber stamp has yet to make anything work better. Bob . . .

Avionics: Re: Panel mounted power jacks for hand-helds

>I have a portable GPS that I plan to use in my Q200. I want to wire a 12V power outlet somewhere on the panel but want to use something better than a cigarette-lighter socket for the connection. I thought one of those airline Empower sockets would work well but I can't find anywhere to buy one. Anyone know a source for the sockets - I think they're ARINC 628? Dave

A Unless you're trying to achieve some commonality with the sockets on an airliner (don't think they'd be too happy about having you plug your hand-held into a power jack on a big iron bird), find something easy at Radio Shack. Consider mounting a 274-1576 mounted on your panel and a mating 274-1573 plug on the end of your power cord to the hand-held. A more robust combination is a 274-002 on the panel and a 274-001 on the cord. If you what something REALLY stout, put a 274-013 on the panel and tip the cord with a 274-011. Bob . . .

Avionics: Re: Bendix King Handheld KX99

>>I have made the sin of shutting off the battrey master before shutting the engine (912 Rotax). my handheld transceiver KX-99 (Bendix King) which was powered form the the plane battrey, could not be switched on again. The local Radio Engineer is telling me that the Audio Synthesizer Board gone bust and the price of the new one from the States $740! I bought this handheld brand new 4 years ago for $550. Any good ideas and cheaper solutions Guys? Please Help! Ahmed Eskander

A Do you have separate battery and alternator switches? Was the alternator still ON when you switched the battery OFF? One of the problems with hand-helds is that they're not INSTALLED in the airplane and not subject to the same rigors of DO-160 testing as panel mounted stuff. If I were going to tie any hand helds into ship's power, I would probably use a Radio Shack 270-030 noise filter downstream of a small fuse (1A) and then put a couple of 1N4745, glass zener diodes across the output feeding the radio. The filter will take off the short duration gremlins that most radios don't care about. The zeners would function like the crowbar ov protection system used on the Grummans some years back . . . ov conditions of long duration would fail the diode shorted (without allowing the output to rise above 16 volts) and open the fuse. Bob . . .

Avionics, ELT AK450 by Ameri-King & IDC

Just a minor point - to install a standard RJ-11 modular phone plug, you do have to strip off the outer cable sheath, but you don't have to strip the individual wires. The tools just strip the sheath. And yes, you have to wonder what they were thinking to require a *crossover* four conductor cable on the ELT. Not an uncommon thing for the larger RJ-45 connectors used in data applications, which come in straight through and crossover (reversed) configurations. But this is a one-of-a-kind non-standard use of this type of cable and I'll bet a lot of ELT remote controls have been miswired as a result. Gotta go check mine :-) Curt

S I bought the AK450 by Ameri-King ELT because of it's price, using ordinary off the shelf batteries, and the feature of having a panel mount control. The RJ11 cable that came with it was 25' long and to save a little weight I just bought a 10' RJ11 cable. When testing I found that the panel mount control wouldn't work. I called the factory and told them what was happening and what I did and asked for some trouble shooting advice. His answer was to send it in. I asked him if the cable I put in might be causing the problem and his answer was "send the unit in". He refused to give me any help whatsoever. Thinking the cable might be the cause I thanked him for "all his help" and went back to trouble shooting. What I found was that the cable connectors aren't wired the same as a telephone cable. They're opposite. The simple fix was to purchase a $10 crimper, some connectors, and in ten minutes the problem was fixed. I won't be dealing with that company again. Darrel

SS Caution: it's the AmeriKing that reverses the wires. Check to be sure the ACK does also. They are different companies. I have owned both at various times. ACK's antenna didn't last 3 months in the elements before the chrome began falling off the loading coil. The AmeriKing has a nice SS whip antenna, but the unit itself locked up in the "on" position every time I tried to test it..2 trips back for customer "service." Now I just don't test it anymore; I know it will turn on, and if I ever really need it, I won't care whether I can turn it off :-) Bill B

SSS ACK ELT I've just taken a look at the manual for the ACK E-01 ELT, and it says "The RCPI unit is connected to the ELT unit via means of RJ-11 standard type modular connectors...the interconnecting cable may be shortened or a longer cable of up to 150 feet may be used if required." No details about how you do this, even though there is a great amount of detail on many other areas of installation. I take this to mean that the wires are straight through, and that it must be the AmeriKing unit that has the crossover pinouts.

SSSS I have also had experience with both the ACK and AmeriKing ELTs, and I echo your comments. MY ACK antenna is still rusty, but after many frustrating hours of troubleshooting, I found a fix for the locked "ON" remote head on the AmeriKing. Apparently the little wires inside the female "phone" connector don't stick up enough to provide consistent contact with the male part of the connector. This lets you turn it on from the remote head, but not back off. The fix is to take a pair of fine tweezers, reach into the female connector on the head, and bend the wires up higher. When the male end is inserted, the wires make positive contact and you can turn it on and off at will. I also had to cut the extension wire and put a new end on it. The wire has a little ridge on one side. I used the ridge to keep the polarity straight and crimped a new end on with the special tool (borrowed from a friend). Good luck, Danny Kight
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Avionics, Re: Wiring two Comm units

>> Bob; What is the accepted standard -if any- for wiring two COMM trancievers in an aircraft. The Audio out portion is simple but how do you wire the mic and PTT switches so as to use the main unit but be able to cross over to the second unit when required. I would install PTT switches on both pilot/co-pilot sticks and a simple vox intercom (probably the intercom inside primary radio - Microair 760SFL-8.33) It would of course be simple to mount a DPDT switch to clunk one to the other but is there a more elegant way?

A Don't think so. That's the way it's been done since the first airplane received it's second radio. I wired a Cessna with three transmitters using a 4-pole version of our S700-2-10 switch in a miniature version. Placing jumpers in proper places on the back of the switch gave me a three position, miniature toggle that would move the microphone to the desired transmitter. The

transmitter select switch of most audio panels does this same thing albeit with a rotary device as opposed to a toggle. Bob
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Avionics: Navaid servo

> I agonized for months about where to put the Navaid servo and associated hardware. Most builders locate them under the rear passenger footwells which is really under the pilot's seat. This is logical and would work well but doesn't provide for easy access when making adjustments or troubleshooting the servo. Since the servo is a mechanical widget with lots of gears and electronics it just made sense to me that I'd need to get at fairly frequently. Accessing the floor area is a real hassle: you must remove about 30 screws, the crotchbelt which is cotter keyed, the seat back, and the front floor assembly. While agonizing I stumbled across RV-8 builder Ray Lynn's installation... forward of the main spar carry-through. (http://vondane.com/rv8a/tt&i/index.htm#navaid) Nope, I can't take credit for this concept. With the servo located forward of the F-804 main spar you can get it after just removing the right cabin console cover. BTW, if you use this technique make sure you trim the console cover so that it does not mount under that little triangular right front seat pan bracket. I manufactured the servo mount from scrap pieces of .063" aluminum and .063" angle — very handy stuff. The servo much be raised a bit so clear the screws on the bottom, so I included mounting rails on each end to raise it up. Note that one vertical side must be shorter than the other to compensate for the lower longeron it's mounted to. Since you can't get in there to buck driven rivets, the two vertical sides are attached to the floor with blind rivets. I used Pop rivets on the inboard side and CherryMax on the outboard side. The only reason I used the CherryMax is that I need a longer reach to go through the longeron and the Pop rivets I had on hand did not have enough grip range. I attached the control rod to the main control yoke with a special piece my buddy Randy Griffin made from stainless steel. you could easily make one from 1/8" aluminum though. In all this installation works very well. I was able to quickly do the set-up adjustments, which require access to the inside of the box, while sitting in the pilot's seat. If I ever need to go back in it's only six screws away. BTW, if you're considering NOT installing the Navaid I highly suggest you reconsider. For $1,450 you get a single axis autopilot that will track whatever signal you feed it (VOR, GPS, Loran), a wing leveler, and a turn coordinator. The first time you set a course in your GPS, push the Smart Coupler to "course" and get the green LED, and feel the Navaid lock in on the course you will think it's magic. It will even make the turns for you at your waypoints!

Avionics: PRODUCT: Meyer Aviation Headsets

> Through a friend I found out about a guy in Michigan that takes David Clark headphone parts and assembles them into a unique headset solution. If you're looking for a true linear frequency response high-fidelity headset, and one that also provides the most passive noise reduction available, then look no further. John Meyer (Meyer Aviation) can offer you two paths. First, he can take your standard David Clark's and convert them to true hi-fi by replacing the drivers. For this he charges $50 for mono sets and $75 for stereo sets. But the real treat is the second option: get a set of his custom headsets. His specialty is to begin with David Clark's H10-56 helicopter cups and frame, and build up the best in every respect. What most folks don't realize is that the DC helicopter headsets begin with a larger (and heavier) headset cup with more sound absorbing insulation. Regular DC models, with the gel seals, provide 23 db of passive noise reduction whereas the helicopter models provide 27. Now that may not sound like much

but remember that sound pressure levels require a doubling of energy for a 3 db increase. Or conversely, for a 3 db reduction you need to cut the acoustic energy in half. Anyway, the custom headsets feature the helicopter cups, his high-fidelity drivers, his own electret mic element (the standard H10-56s have a dynamic mic), and all the usual comfort goodies such as the gel seals. These are the best headsets I've ever used. Not only do they come close to comparing to home hi-fi headphones fidelity-wise, but I don't even notice the extra weight. And the extra quiet provided by the superior passive noise reduction is immediately apparent — just put them on and you'll notice it right away. I recently installed a PS Engineering PCD7100 intercom with CD player and the fidelity is fabulous. There really is no comparable product available, all the current offerings from Lightspeed for example do not have true linear frequency response. Check the specs for the frequency response of their drivers and you'll see it's rolled off in the bottom and top ends to optimize voice reproduction - not what you want for high fidelity reproduction. David Clark's normal products do the same thing.

By the way, if you call David Clark and talk to any of the product managers they are fully aware of John and what he is doing. Actually they unofficially refer people to him and recommend his solution for those interested in what he has to offer. See his web site for further info... www.dipple.com/jmeyer or call him at 616-896-9858.

Avionics: PRODUCT: King Antenna Adapter by Lervold

Many of us carry a handheld com radio as a backup in case our electrical system goes down or our com goes out. What most pilots don't have however is a way to quickly and easily get access to their external antenna. The rubber ducky antenna on most handheld coms just doesn't provide much range for either send or receive. Simply coupling it to an external antenna will let it perform nearly as well as your in-panel unit. In designing my electrical system, and searching for a way to quickly and easily access my belly mounted com antenna, I started asking questions. One obvious strategy is to install a simple antenna cable splitter. Then, in the event of a panel com failure, just connect a piece of coax cable with BNC connectors both the the splitter box and the antenna connector on the radio. The problem with this however is that whenever you split an electrical signal you lose 3 db which is 50% of the power/energy. This loss would be present all of the time whether the handheld was connected or not. Hmm, not good. In spite of poring over all the avionics supply catalogs I just could not come up with a better solution.

When the time came to buy my avionics I asked Dewey at Pacific Coast Avionics what the best solution was. He said "Oh, you need a King KX-99 antenna adapter". Okay. Turns out it's a little box that interrupts the antenna cable whenever a plug is inserted and connects your handheld. Perfect! This little device, while not cheap at around $75, is a little box and a special cable. The small lightweight cable has a 1/8" mini-plug on one end, which goes into the box, and a BNC on the other that connects to your handheld unit. When the mini-plug is inserted it disconnects the main com radio and connects the handheld... voila, no signal loss. All you need to do is mount this in a reachable location while in flight and keep your handheld radio and the special cord within reach. Note the part number on the picture and just order it from your local avionics supplier. Thanks Dewey!

Avionics: Re: GNS 430 Current Draw

Brian, I've measured the current draw of my GNS 430 of the combined Nav and Com lines at

2.13 amps on a 12 volt supply. Regards, Richard Dudley

Subject: RE: GNS 430 Current Draw

>>Be advised that that number should increase when transmitting. Transient loads for transmitters are generally ignored in the load analysis for sizing alternators and batteries. Transmitter energy requirements are generally under 1% of the total system requirements and are therefore not a factor.

Avionics: Subject: Navigation Select Switch

>> I plan to have both VOR and an IFR capable GPS in my panel. I would like to be able to display the track info from both on a OBS instrument (probably the Narco 122D/GPS.) I need some sort of switch to select VOR or GPS and an annunciator to show which is selected. I also would like to use the same switch and display so my NAVAID autopilot can track either a VOR or GPS course. What have others used? I am open to all suggestions. Charlie Brame>

S	Hello Charlie, I have a Garmin 430, an UPS AT (Apollo) SL-30, and a Navaid AP1 autopilot in my panel. Regarding selection / annunciation, my Garmin 106A CDI has built in lights that tell what is feeding it. For the GPS input from the GNS 430 it says "GPS". For the VHF nav input from the GNS 430 it says "V/LOC". For the SL-30 input it reads "NAV". In addition the input selector push button to choose between the GNS 430 and the SL-30 is split horizontally and illuminated so that when the GNS 430 is selected that part of the button is lit up and reads "GNS430". When the SL-30 is selected that part of the button is lit up and reads "SL-30". So there should not be much confusion about what is feeding the CDI. Also whatever is feeding the CDI is also feeding the Navaid Autopilot. There are a lot of things to be switched when shifting from one to the other and the many shifting relays are in a Northern Airborne Technologies relay box. If you want more details please let me know. 'OC' Baker
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Avionics: switching nav inputs

>> "I have a similar question: In my Europa XS aircraft, the panel is equipped with an Apollo SL-30 Nav/Comm, a Garmin 195 GPSMAP, a MD200-306 Indicator for track and glideslope and a Navaid autopilot. I need a switch to select the indicator and the autopilot input between the Nav and the GPS. Pacific Coast Avionics sell an Eaton Annuciator Switch for GPS/NAV, but I have no specific information about it and don't know if it handles the data given by the SL-30 and the GARMIN 195 correctly. Pacific Coast Avionics don't reply to emails asking for more information. Does anyone know the Eaton Annuciator Switch for GPS/NAV or even have any experiences? Or is there a better solution for this switching task?
 Thanks in advance for all replies! Alfred Buess Europa HB-YKI "

S	Hello Alfred, Please see my earlier response to Charles Brame and David Buckwalters additional cautionary comments. I would like to emphasize on principle that many signals must be changed / transferred in the switching scenario that you are attempting. It is very unlikely that the switch itself would be capable of changing all those items. Instead the switch would activate

a box containing several relays which would do the actual switching. A detailed knowledge of the signals involved, their compatibility, and the inner workings of the relay box (such as a Northern Airborne Technologies RS16-001) is required. I'm sorry that it is not easier / simpler to do. I hired a professional to wire my panel. 'OC' Baker,
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Avionics: Navigation Select Switch

> I have the SL30, MD 200, TruTrak AP and Garmin 196 GPS. TruTrak said that the 196 could provide current track info to the AP, but not the ARNIC (?) data needed to provide multi-leg guidance --IE GPSS. So the best I can do is look at the GPS see on course is 315`, for example, manually dial that into the TruTrak and tell in to head in that direction. Effective, but not very efficent considering the equipement I have. What would you guys do if you had these components to maximize their usefulness? Thanks, >Larry
>BowenAero.com

S Larry - You are correct that the 196 doesn't output the ARINC 429 data needed to provide GPSS information to the Tru-Trak, but it does output RS-232 data that will allow the autopilot to fly GPS track. This means you can track a courseline, but it won't intercept a new courseline, such as a new waypoint in your flightplan. If you have a Tru-Trak Digiflight or Digitrack system, you won't be able to couple in the SL-30 analog nav deviation information. If you have a DFC system, you can put in the analog deviation info.

S Alfred - This would be the most sensible setup with the equipment you have. A double pole switch will work fine for this application. Get a good quality switch from Bob Nuckolls' web site or an electronic supply house. >David,

>Thank you very much for your helpful explanation! I have the Smart Coupler to use the Garmin 195 data for the Navaid >autopilot. Following the KISS principle, I think I will hook up the MD-200 only to the SL-30 and not to the Garmin. The >Navaid will be fed either with GPS data via the Smart Coupler or with Nav data from the SL-30. A double pole switch should allow to choose one of the two sources. Or do you see any problems with this concept? >Alfred Buess
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Avionics: Re: Navigation Select Switch

> >In the pure analog world, you'll to switch between 14 and 18 wires from the indicator to the two radios. This take a 18 pole, double throw switch . . .> Could this be an application for those old computer printer switches? They switch 25 inputs to either of 25 outputs.

A Don't know why this wouldn't work. Bob . . .

Avionics: Re: computer printer switches

> >In the pure analog world, you'll need to switch between 14 and 18 wires from the indicator to the two radios. This take a 18 pole, double throw switch . . . Could this be an application for those old computer printer switches? They switch 25 inputs to either of 25 outputs.

>It might not work if it was for a printer, but old RS.232 serial communication devices needed most of the 25 wires switched in an A-B switch - except pin-7 which usually is common for RS-232 connections, and was connected from the input to both of the outputs. Bear in mind that these switches are designed for low power signal (+/- 12 V few mAmps). They will not carry or break any significan amount of power.

A There are two varieties. Some use solid state, silicon switches that look like an array of chips on a pc board. The ol' hammer-n-tongs approach uses a two-position switch at up to 25 poles operated by a simple knob on the front panel. The later types have totally isolated, hard-switched channels that would be well suited to handling an array of analog signals between nav receivers and a remote mounted CDI/GS/OBS head. Bob . . .

Avionics: Re: encoder error

> Anyone know why a new encoder would consistently report an altitude 500' low? I figure the 500' would mean that I wired it up wrong to the transponder,but it appears to be correct. Does the adjustment screws have this much corrective ability. Which one do I turn, the Hi or the Lo, and which way? Thanks again, Scott in Vancouver

A Let the tech who does your pitot static test do this. The HI/LO pots are interactive. Turning one affects the setting of the other. There is a procedure for doing this at the time your system is tested. If it's ALWAYS 500' off then it's unlikely that the system is miswired or broke. It simply needs some magic tweaking by someone who has the equipment to bring it into agreement with your altimeter. If you don't plan to have it check soon but want to use the system, adjust only the LO pot. Bob . . .

Avionics: Dual Comm Audio Wiring

>How can I wire my airplane to use 2 comm radios without going to the expense of an audio panel? David Domeier

A Sure, see this drawing. http://aeroelectric.com/temp/DualCommAudio.pdf
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Avionics: Re: Headset/ Mic Jack insulation

> Hello, I wanted to know if the anti rotation tang on my jacks, need to be cut off if I'm using the insulated washers?

A I think they do . . . You don't want them to "bite" into the washer. Bob . . .

Avionics: Re: PTT wiring

> Looking for suggestions on how to and what kind of wire to use to wire the PTT's on the

sticks of my RV-7. Any tricks to providing for the slack at the bottom of the sticks to allow movement without interference or fatiguing the wire? Thanks, Neil McLeod

S Neil, Use a good quality switch, 22ga wire and place a small connector that will fit in the control tube. Try a Dean's connector. This is used for radio control models and can be purchased at Tower Hobbies. Peter

A Use a relay to carry power and use stick grip switches to control relay.

> d) This results in about 7 wires (from memory) I could use a heavier gauge wire but it might be very hard to get it all in, and also I worry it would put 'friction' in the stick movement. So my questions are: 1) Would you consider using these fine wires in such an application just up and down the stick to a barrier block near by? (Then thicker wire as you discussed.)

A I wouldn't use barrier strips (threaded fasteners . . . UGH!). A d-sub connector would be a good way to make the transition from tiny-wires to handy-wires, something like http://www.aeroelectric.com/articles/macservo/macservo.html In the next to the last image, tiny-wires are running out to the servo, handy-wires run to the rest of the system. In this case, tiny-wires might run up your control stick, handy-wires run from an UN-modified d-sub mounted to a bracket near lower end of the control stick. Bob...

S But commercially, "Superflexible" means Mogami (sold in the US by Marshall Electronics) used by the audio/video industry. It finds its way into top-end headphone cables and microphone cables. For a cheap solution, steal some good quality CD headphones. Cut the cords off for you airplane and give the headphones back to your teenager for Xmas. Say they're the new "cordless" type. Eric M. Jones
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Re: Avionics; Wiring headset jacks

> Bob, in the shop note you say, that you use 3 wire shielded, and the shield itself is connected on both (?) sides to the Mic LO, did you use the 3 wire because of wiring both mic's to only 4 ports? (You used the shielding instead of one wire).

A The shop notes are one example of suitable wiring as it applies to the 760VHF that has one PTT and two mic inputs for the pair crew stations. This means I have three active wires departing the radio and the need for one ground return. I had some 3-conductor shielded and the drawing illustrates a technique for using wire on hand for this task.

Here's a wirebook I did for a 430/340 combo in the AGATE Bonanza a few years ago.
http://aeroelectric.com/temp/gns430.pdf
Bob . . .

Re: Avionics; Mic wiring (QuickShot)

Well, here I go helping people to vois their warranty. There is a book called Quick Shot. It is a avionics installation reference manual for most intercoms, audiopanels, navcom, cam, ADF, GPS, HSI, Loran, Glideslope, transponder, etc. These are pinouts of connectors, not circuit

drawings. Cost for binder and pages is $60.
Quick Shot, Edmo Distributors Inc., 800 235-3300 OR
QS products, Lakeland Fl 33811, 941 616-6187
http://www.qsproducts.com/
http://www.chiefaircraft.com/Aircraft/Books/QuickShot.html
http://qsproducts.com/how2get1.html

Re: Avionics; Unswitched Audio Inputs

> snip I am wiring my own panel with a UPSAT SL15M audio panel with 2 unswitched audio inputs. I have an AOA, EDM900, TruTrak Autopilot, and a Davtron that all need to be connected to an unswitched audio input.

PS Engineering said, "Use a dropping resistor from 100 to 460 ohms on each feed and hook two up to each input".

UPSAT said, "It can't be done, pick two".

TruTrak said, "Just hook all 4 up, it won't hurt a thing". Anyone else care to cast a vote!!! Thanks, Mike Lancair ES

S Mike, Here's a past exchnge on this topic from the AeroElectric list: (Basically a poor man's audio panel) Stan Blanton

A >> See some new drawings I just posted at:
>> http://www.aeroelectric.com/articles/audio/760v1.pdf
>> http://www.aeroelectric.com/articles/audio/760v2.pdf
>> http://www.aeroelectric.com/articles/audio/760v3.pdf
>> http://www.aeroelectric.com/articles/audio/760v4.pdf
>>
>> These four drawings show how to do stereo with the Microair (or any other transceiver).

>Is this amplifier (p. 2.4) expandable in parallel using the same value components for other inputs such as engine monitors, fuel monitors, MB lights etc. or would all of the component values have to be adjusted?

A You can add additional inputs to as many as you need. The component values assume that all audio sources are in the same ballpark for output voltage. If you have a lot of different sources, you might want to put a screwdriver adjustment gain control in the input circuit of each source.

>Does each warning tone source need its own set of resitor/capacitors?

Yes . . .

>Could this be used (with some of the sources switched) as a poor man's audio panel driving an intercom other than that included in a Microair?

You can use this basic amplifier configuration with any combination of radios/music sources/intercom systems. Bob . . .

Re: Avionics; Multiple GPS feeds

> Can a GPS antenna feed more than 1 GPS device?
>Trutrak Flight Systems says no, Garmin says yes.
Which is it and anybody have experience doing this?
Specically I want to feed GPS signal to my Digitrak autopilot and GTX 327 transponder. I have a GPS 35 receiver as recommended by Trutrak Flight Systems. Steve

S Actually, GPS devices that support a serial interface typically support the NMEA data stream protocol. The NMEA protocol defines a continuous stream of data that the GPS provides. Although the GPS is not "required" to provide all of the data types defined by the NMEA. For instance, a GPS-35 receiver as Scott mentions is a complete GPS unit that provides an NMEA data stream. However, you can't program in a course or waypoints like you can on a panel or handheld GPS. Thus the GPS-35 has no clue where you want to go, only which way you're going. As such, it cannot provide cross track error information which is part of the data stream definition. Thus a GPS-35 cannot drive a Navaid autopilot even with the smartcoupler because it has no course information to determine if your off track.

But I digress . . . The NMEA is a data stream and is not a request protocol as Scott mentions below. This data stream is a one way communication from GPS to whatever is connected at the other end. Some GPS's can be configured to send different optional data types, but this is not done by a device requesting information. The data continually streams out of teh receiver, and the autopilot/transponder/moving map just sucks it up. Thus it is possible to hook up this one way data stream to more than one device as Garmin indicated. As such, a single GPS receiver CAN drive the NMEA data stream to more than one device. However, If the discussion with TruTrack was relating to hooking up multiple GPS antenna's, then the answer to that is no, you can't hookup a single antenna to more than one receiver. Todd Houg

-----Original Message----- From: Scot Stambaugh

S Steve, The GPS 35 is a complete 12 channel GPS receiver, not just an antenna. once power is applied, it finds satellites and gathers a longitude and latitude position coordinates as well as developing a error metric and a number of other variables that it can offer to whatever devise it is connected to, such as a Trutrak A/P or a Chelton Flight Systems EFIS or Control Vision's Anywhere moving map package. The interface to the GPS 35 is a RS-232 two way serial connection that reports the various information to the above instruments. RS-232 is intended to be a point-to-point protocol, which means one unit on each end of the cable. Since the above mentioned units assume that there is only one device on the other end of the cable it only sends the information that is requested of it. So, consider this situation. If you have one GPS 35 and you connect it to the Trutrak and also the GTX 327. The GTX 327 may only request Lat/Lon information and never ask for any of the other data that the unit makes available, but the Trutrak wants to also request position error data for example. What could happen is the Trutrack would send a command to the GPS requesting a position error message and the GPS promptly replies. The GTX 327 is connected to the same wire and gets the position error message same as the Trutrak but one of two things will happen. The design engineer for the GTX 327 assumed that this would always be a point-to-point connection and that all messages are for him only and would attempt to decipher the "position error" message as Lat/Lon. It would either get confused and declare an error, or worse, it would somehow convince itself that the data string is a Lat/Lon and treat it as such. Now everything is hosed.

Now, onto your original question, GPS antenna signals should be able to be split and

shared between GPS receivers but the signal is not real strong. It dissipates over long cable runs and should be carefully managed when adding additional loads to it such as making it drive two GPS's. You can purchase GPS amplifiers for long cable runs or just to boost the signal but you need to know what your doing because if you don't need to boost the signal that much and you give the GPS receiver too much signal that will cause signal distortion. A reduction in signal power to the GPS receiver will usually result in a difficultly for the receiver to detect and acquire as many satellites. This increases position error and can cause signal loss conditions more often. Sorry for the long dissertation. I am in a similar situation, with a GPS 35 driving my CFS EFIS-2000 and needing (but not wanting) a second GPS 35 to drive my Anywhere map PDA system as a backup. good luck, scot
----

Re: Avionics: Cheap blind encoder.

> Companion encoder question: Panel will have a transponder and a GNS430. Both require input from an encoder. Can the two units be paralleled to the same encoder (two wires from each encoder pin) or does the typical installation have two encoders?

A You can drive multiple loads with one encoder but you need an array of diodes to avoid cross-coupled problems between loads. One manual speaks of open collector outputs which are active pull down only devices and that the pull-up for logic "hi" is expected to come from the transponder (signal load). This means that isolation diodes would have to be included in the data lines for each device that expects to get altitude data with the cathode facing the encoder.

These diodes prevent the data lines from being pulled to ground by a transponder or GPS that is powered down. I've published an exemplar diagram at

http://aeroelectric.com/temp/Encoder.pdf

The neatest way to install this raft of diodes is to lay out a simple etched circuit board with d-sub connector to bring wires onto and off the board. For driving two loads, there's a total 27 wires . . . a single 37-pin D-sub would do it.

I've seen some "professional" installations where the diodes were simply butt-sliced into the wire bundles and covered with heat-shrink. I guess some DER signed off on this somewhere.

Be sure to check if the devices that need altitude data for built in diodes. If they're already present, then you can simply eliminate the diodes show in the drawing and wire direct. Bob . . .

S Bob, appreciate for the diode diagram. BTW, the GNS430 install manual makes mention of the need for diodes with some encoders and transponders, but doesn't mention which ones. Here's the notation: "Some transponders and other altitude encoder receivers do not have internal isolation diodes to prevent the unit form pulling the encoder lines to ground when the unit is off. These units require a diode added to the installation harness for each encoder line. The anode should be connected on the receiving unit's side and the cathode should be connected onthe encoder side. A set of diodes is required for each unit without internal diodes. The 400 Series unit includes internal diodes for isolation of the encoder lines." For anybody needing the manual, it is on the web at http:/www.garmin.com/manuals/143.pdf. No link on the Garmin website, but it's there. I supppose another approach might be to simply purchase a second encoder for $175. Wire one to the transponder, the other to the 430.

A Thanks for the confirmation of my midnight analysis last night. It's pretty easy to test your transponder or GPS for the existence of diodes. Hook a 9v battery in series with a 10K

resistor and hook the (+) end of this test fixture to one of the altitude data input pins and the (-) end to signal ground. Measure the voltage at the data input pin with a digital voltmeter (very high input impedance). It should read battery voltage. If diodes are not present it will read substantially lower. Bob . . .

Re: Avionics; Stick It-Your-Ear Headsets

Aviation Consumer recently reviewed the Panther and the Auri-Comm by Quiet Technologies
http://www.quiettechnologies.com

The Auri-Comm differs from the Panther in that it uses expanding foam inserts (like industrial ear defenders) instead of custom molded earpieces, and uses an ultralight boom mike and stereo earpieces instead of the mono earpiece and intra-canal mike of the Panther. It's also cheaper when the cost of the custom molding is included.

Aviation Consumer preferred the Auri-Comm over the Panther for several reasons:
0. quieter, less fussy fitting
1. better sound quality, both transmit and receive
2. more comfortable
3. more rugged
4. less sensitive to cord microphonics (move the cord around and the sound of the movement is transferred directly to your ear), the seal is not broken when you eat or move you jaw, and the microphone does not pick up body noises like the Panther. Shaun
----

Re: Avionics: Marker Beacon Antenna Lead

> Still wondering what is required for a marker beacon antenna lead. Charlie

A   Marker beacon is a very strong, 75 MHz signal that can be handled on ordinary shielded wire that might otherwise be considered a VERY poor grade of coaxial cable. If you must go out to the wingtip to get some radio-transparent "skin" then you could use ordinary single conductor shielded wire and exposed 40" of center conductor at far end. Tape to inside of tip fairing as "spread out" as the inside surface and volume will allow. Bob . . .

Re: Avionics; Power Connection

> Can you recomend some type of connector (both male and female) in the power cord and female in the plane, so thatI can plug into "connector/jack" while in the airplane and use the cig plug when in my car.

A   I have accessory power connectors in my cars that bypass that butt-ugly cigar lighter jack. There's no reason you can't have tight fitting, reliable connections for DC power in both the car -AND- the airplane.

Likely candidates are the 274-010 and 274-013 pair of connectors from Radio Shack. See   http://aeroelectric.com/temp/274-010.jpg and

http://aeroelectric.com/temp/274-013.jpg

These are metal-shell parts intended originally for microphone cable connectors. They're designed for a bizillion mate/de-mate cycles. The plug locks into the jack to prevent inadvertent disengagement. The pair of connectors is about $8.50 Consider a sheet metal bracket under the dash of your car wired to a fused source of +12V that mounts a couple of the jacks. A similar installation would work in your airplane as well.

These will not "work loose" . . . and are more compact that the cigar lighter socket/plug combination. Bob . . .

Re: Avionics; System reliability

>>>Uhhh, has anyone else had this thought: sounds like an awful lot of people are building IFR RV's out there with all these Dynons being ordered. This is a good thing, if true.

> > Frankly that is the last place I would put one, in an IFR RV. That is a bad thing IMO if true.

>I don't know much about Dynon's system. However, I do know a lot about component design and system design. There are a lot of dead guys behind the evolution of many designs in aviation, airframes and systems. One does need to be quite humble to where the certified industry has evolved to over the years. It is very easy to chuck rocks at their "antiquated" methodology, and jump to new stuff. No problem with VFR, but altogether different for IFR.

>That being said, I am certainly not saying we should not use new technology. I only caution those who do make leaps of technology to be very, very aware of how small changes to a design, system, etc., usually have unforeseen consequences. These unforeseen consequences can be nasty, and I've never seen a design change that didn't have surprises. It is quite easy to point to accidents caused by mechanical gyro failures and conclude we just need to replace them with something else. Keep in mind, in doing this "analysis", that the area under the cumulative time in use of vacuum gyros combined with electric TC/TB (for example) is huge, while the total time the newcomers (Dynon) have is quite limited, probably one millionth as much time. Something to think about - the temptation to believe that a design change will be an overall improvement is overwhelming, but experience tells otherwise. Systems like Dynon's are clearly where the future is, but expect turbulence and dead guys along the way. Alex Peterson Maple Grove, MN RV6-A N66AP 337 hours

A This is yet another, perhaps more compelling reason for one to conduct and satisfy the FMEA (failure mode effects analysis) I described earlier on the AeroElectric-List. This same train of thought supports the discussion we had last week on knock sensors and choosing a system upon which you and folks you value will place a degree of trust.

See why arguments for breakers versus fuses are shallow to the extreme? In some systems, (especially those with microcircuits and software) there can be thousands of potential failure points that have nothing to do with whether or not a breaker/fuse opens or does not open.

By conducting the FMEA and having others review it with you, you can sort ALL potential failures into two piles

(1) "@#$!@#!!, is that thing broke again! I'm getting tired of replacing it. I think I'll upgrade to the high dollar part." and

(2) "My momma told me there might be days like this. Hope I live to tell my grandchildren about it?"

When a failure falls into pile (2), you have two choices there as well:

(1) never depend on that device as a source hangar tales fodder . . . like stay out of clouds even though you do have a full-up panel of gyros and one vacuum pump or

(2) have a truly reliable back- up for the thing (e.g. adding a third, spill proof gyro adds no reliability if it's power source is common to the rest of the gyros).

When you bolt that all-in-one gee-whiz display to your airplane, consider that it contains thousands of transistors, an LCD screen that requires an oscillator to stay alive and keep the crystals shook up, etc. etc. Ten years and 1000 systems from now, these products may indeed amass a service record that rivals a B&C L40 alternator . . . or they may not. Are you offering your airplane and cargo as a "research" tool for the folks selling the product?

I've had builders worry a lot about landing gear extension-retraction systems. Weight, dollars and parts-count driven reliability are sacrificed to improve the builder's confidence in a perceived level of reliability through redundancy. I thought the gear system on the Beech Sierra was pretty elegant. Hydraulic pressure holds gear up. No doors. Very few moving parts. Emergency extension involves opening a door on floor under pilot knees. Open valve. Gear falls down and locked. With any gross failure of system integrity, gear falls down and locked.

I'll suggest the handy switch, lights, motor and pump are the SECONDARY gear operating system optimized for pilot convenience. The valve on the floor was the PRIMARY gear operating system guaranteed to work every time.

I think you will find there are similar approaches to the same order of system reliability for panel instrumentation. Full-up dual on the order of twin EFIS and a Z-14 electrical system are obvious solutions but just about assure a doubling of cost.

An alternative altitude readout, airspeed indicator, rate-gyro-stabilized and radio-aided wing leveler, hand-helds in the flight bag, etc. don't add much to your budget or panel space requirements and may well be the "valve on the floor" approach to backing up that full-color gee-whiz that works really nice . . . most of the time. Let's do everything we can to safely and sanely assist these new kids on the block . . . one or more of them will architect a piece of aviation's future. At the same time, here's to having nothing but Harry Potter adventures to read to the grand-kids for excitement. Bob . . .

Re: Avionics: Audio Lo wire

> I guess the best thing for me to do under the circumstances is to insulate the phone jacks (mic jacks are already insulated) and to take the audio low wire to aircraft ground. This may prove to have some noise in the system but since there is no audio low wire in the intercom, I see no alternative.\

A Audio lo on virtually every piece of avionics is the same as power ground for that piece of avionics. The pins may be labled gnd, common, signal ground, audio ground, audio lo, etc, etc. but if you take an ohmmeter and ring then out you'll find that they all come together. In the absence of anything labeled specifically for audio grounding purposes, use power ground AT the CONNECTOR for that accesssory. Bob . . .

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4. BATTERIES

Re: Recombinant Gas Batteries

> In the literature Bob appears to recommend the RG batteries. The problem is that I have searched both B&C and AircraftSpruce but can't find the RG batteries. Please help. Walter

A "Recombinant Gas" (RG) is also "Starved Electrolyte" is also "Glass-Mat-Technology", is also "Vented Sealed Lead Acid" (VLSA), and sometimes called "Maintenance Free" but can become confused with flooded batteries having glued on caps to make them "Maintenance Difficult" . . . they are oft referred to in error as "Gel-Cell" batteries in honor of the first series of "Immobilized Electrolyte" batteries of some 40 odd years ago.
By and large, ANY lead-acid battery offered today other than flooded batteries for use in vehicles will be the more modern technology product irrespective of what name the sales person recognizes.

See the following sites for a tip-of-the-iceberg view of available products and some additional information on battery technologies.

http://www.hepi.com/
http://www.concordebattery.com/
http://www.panasonic.com/industrial/battery/oem/chem/seal/index.html
http://www.mywebplace.com/yuasaspec.html
http://www.sbw.org/batcap/
http://www.batteryweb.com/optima.cfm
http://www.batteryweb.com/powersonic12vsla.cfm
http://www.4unique.com/battery/battery_tutorial.htm
http://www.4unique.com/battery/batteries.htm

If your heart is really set on a "gel-cell" battery, you can get 'em here:

http://www.batteryweb.com/sonnenschein.cfm

. . . and to top it off my friends, here's a seller that delivers much elephant-hocky about products he doesn't even know the proper name for much less understand how they work.
http://www.emesystems.com/batcharg.htm
Happy new year. Bob . . .

Re: Small RG batteries

>>Does anyone know anything about the Exide Powersport Sealed RG batteries? I just picked up a 14BS for my non-starter equiped PM magnet alternator VariEze. The battery is a 12Ah unit that looks like it will keep my one electronic ignition and MicroAir com radio going for far

longer than I have fuel. The battery looks like just a small version of the batteries produced by Concorde. Anyone have any input? The reason that I am asking is that I had gotten the impression that other RG batteries come fully charged, but this one you add acid, and then seal it, to never add water again. Is that normal with the RG's?

A Just because it's "sealed" doesn't make it an RG battery . . .and this is no exception. Now that you have it, I'd run it until it's capacity drops to 6 a.h. or so but next time get a REAL RG battery. Do you carry any additional ballast weight up front in addition to the battery? If you need the low weight, consider the NP12-12 at http://www.mywebplace.com/yuasaspec.html If you carry any ballast and can replace it with USEFUL weight, go on up to the NP18-12. The later battery is made by about everybody. Make sure it's a VRLA (vent regulated lead-acid) or RG (recombinant gas) technology. Bob . . .

Battery: Recharging, Jump Starting

A A few days ago, someone expressed concerns about using a ramp battery cart to jump start an airplane when the ship's really dead, Dead, DEAD battery was still connected across the ground power jack. A couple of days ago, I put a 3A load on one of my portable instrumentation batteries (32A.H. Panasonic RG battery). This is a fairly new battery. I've deep discharged it perhaps 4 times in the past year, otherwise, it has sat on the shelf after spending a day on a 14.2 volt power supply to charge it.

After I unhooked the load . . . the battery voltage was about 100 millivolts. It slowly rose to about 3 volts after a minute or two. I set up a 40A power supply for 12.5 volts and connected it across the dead battery. The current rose initially to about 10A. The power supply was set up to maintain 12.5 volts at the dead battery's terminals and I watched as the "charge" current climbed slowly. It stabilized at 15A in about 10 minutes and has held constant after that time. Given that a battery delivers significant energy at 12.5 volts or below, I think this experiment justifies the statement I offered a few days ago that a dead battery in the airplane does not present a significant load to a battery cart that is soon expected to put out hundreds of amps to crank an engine.

Now, obviously if one connects a ground power cart set up for 14-15 volts, the dead battery will request more charging current. After I saw that the battery charge rate was not going to increase further at the 12.5 volt "bus" I increased the power supply's output to 14.5 volts and the charge current rose to just over 22 amps. This indicates that the dead battery represents littlemore than a nuisance drain on any common form of ground power used to service airplanes.

I left the battery on charge with the 40 amp bench supply set for 14.2 volts. After about 10 minutes, the charge current had risen to over 30A . . . a short time later, the power supply went into current limit mode (just like an alternator would if you tried to "overload" it). I didn't hang around to see how long it took for the thing to drop below 40 amps but I suspect it wasn't very long . . . it's only a 32 a.h. battery and 40A would totally recharge it in under one hour. The point is that as the battery's chemistry began to wake up after being flogged into unconsciousness, internal resistance of the battery begins to recover to a normally low value. This is exactly the phenomenon that has lured unwary and ignorant pilots of spam cans into believing that just because the ammeter laid over nicely after start-up, that all was well with their electrical system.

After launching into the blue (or grey) the battery recharge current keeps climbing (if the battery were cold, the climb rate would be slower and may peak out at a lower value) but the pilot is already busy with other things. Adding ship's loads to battery recharge loads maxed out the alternator. Hundreds if not thousands of times in the history of alternators on small airplanes, the 60A b-lead breaker opens and the pilot is unaware of loss of alternator because he has no active notification of low bus voltage and he presses blissfully on until the panel goes dark.

This bench demonstration of battery performance further re-enforces my personal notion that you need to be wary of launching with a battery that is known to be in a discharged state. Upsizing the capabilities of b-lead protection is a BIG step forward in avoiding unhappy events. However, situations like this are few and far between on most airplanes . . . when you find your alternator maxed out, remember that it's under an extra-ordinary stress that is seldom demonstrated . . . just keep an eye on it. If you're launching into the grey, I'd really recommend ground charging the battery to full capacity before launch. Just because it's a "good" battery doesn't help if a need to put the spurs into it arises when it's already out of breath. Bob . . .

Battery Article

>Knew I'd seen this somewhere.... http://www.landiss.com/battery.htm - Jerry Kaidor (jerry@tr2.com)

A A well written and documented piece . . . I'm going to contact the author for permission to .pdf the thing and keep it posted on our website. Bob . . .

Batteries, dual

> Bob, I'm looking at your z11_v1.pdf/z11_v2.pdf files and have a couple of questions:
>1. How is the ignition wired in these schematics? I'm assuming dual electronic ignitions are used and that either battery can supply voltage to both ignition systems. Are two switches required? Why not power both off the essential buss?

A No, one ignition runs from the main battery bus, the other ignition runs from the aux battery bus.

>2. Why not use a double pole, center off switch for the essential buss alternate feed? This would enable the second battery to be selected if, for some reason, the first one failed.. OR, better yet, diode couple the two battery sources together for the essential buss feed.....

A Why make it so complicated? What's the likelihood of loosing an alternator and both batteries on a single flight? In fact, if you pay even rudimentary attention to battery maintenance in the form of periodic capacity checks or yearly swap out, loss of battery probability goes to near zero. This leaves wiring as the next most vulnerable featurs in the system. It's best not to have the two ignition systems share anything . . . not even a battery selector switch. Keep it simple.

>3. How is the auxiliary battery charged? I'm assuming That the Aux Master switch has to be turned ON whenever the MASTER is ON.

A Sure . . . for all normal operations both battery switches are on. The only time you turn them off is when you don't have engine driven power source (also a very rare event with ND alternators).

> Doesn't this setup make the overall process a bit more ergonomically complicated? So many switches to remember what each does... And to remember to shut off least the battery goes dead.....

A What would you do different? What I've proposed is no more switches for ignition and fuel pumps than you would have if you only had one battery. I counsel against making them anything but simple ON/OFF switches that control power from one battery to one appliance.

The only thing that's added is an aux battery master that is always on anytime the DC power master is on EXCEPT while in flight and after you've lost an alternator. Figure Z11 shows an optional aux battery management (low voltage monitor module) that will automatically close your aux battery contactor any time the bus is above 13.0 volts. The ONLY time this happens is if you have a properly functioning alternator. So as long as the low voltage light is OUT, it doesn't matter where your aux battery master switch is placed. If the light comes on, pilot actiona are always the same Bob . . .

Batteries

>>Bob, I am considering using a lighter battery in my RV8, and putting it in the front baggage compartment, on the right side floor. I have people telling me I shouldn't do this because lead acid batteries can explode, blowing acid all over. I have heard of this happening in cars, when the jumper cables are hooked up backwards, but not otherwise. Can this happen in normal conditions - runaway charging system etc.? Are some battery types more prone to this? I know that ni-cads can experience thermal runaway, can lead acid types? Does it make any difference - thin plates, thick plates, gel, sealed etc.? What do you all think?

A John, Start with an article I did for Aviation Consumer 6 years ago which you can find at: http://www.aeroelectric.com/articles/battery.pdf Then know that battery explosions are extremely rare. The modern RG battery has so little enclosed vapor space that an internally generated explosion would result in a meager Psssstttt from the battery vent. Now, you can fabricate an excellent battery fueled bomb in your airplane by enclosing a battery in a tight box and putting other electrical goodies inside with it. At least one Glasair owner I know of lived to tell the tail of loud noises and evil smells from the tailcone of his airplane. An RG battery out in the open is not a dragon to be reckoned with.

Install an RG battery any where you like. Right side up, on end or laying down. It doesn't matter. Put it in a tray and hold it down with some webbing and velcro. Two 1" x 6" velcro patches are good for holding a 17 a.h. battery down under 15+ g's of loading. You'll need a 17 a.h. recombinant gas battery which can be purchased from a variety of battery specialty shops. Handle these like any other lead-acid battery. Bus volts no less than 13.8 - 14.2 is about ideal - no more than 14.6 Bob . . .

Batteries

>>Bob, How much of a real-world difference in cranking power is there between the 17 ah batteries and the RG-25, which puts out 25 ah? I have a RG-25 in my RV-6 and in cold conditions I find the battery barely sufficient to crank a cold engine. I have been told that the

Sky-Tec starter is a very high-draw starter compared to other starters (like the B&C). I found that leaving a small ceramic space heater in the cockpit overnight the day before a flight makes a world of difference in cranking power.

A Well, one has half again more energy storage capacity than the other. Sooooo . . . all other things being equal you can run e-bus goodies 1.5x as long with the bigger battery. Now, if you're clever and willing to carefully select the list of goodies needed to get the airport in sight sans alternator, then 17 a.h. can save considerable pounds and $ over the larger feller.

Cranking ability is almost a separate issue. There are 1.5 a.h. batteries with enough snort to crank an engine. Only enough energy to do ONE cranking cycle but the initial cranking RPMs are quite good. Some certified ships upsized the flooded battery from a more common 24 a.h. to 32 a.h. to offset losses in long wiring when the battery was located back in the tail.

There are three secrets to success with small batteries. Keeping resistance in the cranking path small, low resistance and figuring out ways to reduce the resistance in your ships fat wire wiring. A large battery of the same technology will have a lower resistance than a smaller . . . but in terms of overall performance, some models of Piper would be about 20 pounds ahead of the game to mount a 17 a.h. battery on the firewall and trash the 35 a.h. battery installation in the tail.

If you're suffering lackluster cranking with a new RG battery of any capacity, I'd certainly look at intervening wiring and contactors first. Don't overlook the ground path too. You can use a voltmeter to measure the positive and negative path drops during engine cranking. The ground path should be well under 0.8 volt. The positive path should be under 1.5 volts. Or build a millivoltmeter as discussed in the article in the chapter on grounding in the AeroElectric Connection. Here we're looking for path resistances on the order of 1.6 milliohms in the ground path and 3.5 milliohms in the positive path. What size wire is used to do all the cranking path current in your airplane and where is the battery located? Deducing and fixing the cause excessive path loss is the minimum weight, minimum dollar approach to a solution. Bob . . .

Batteries, electronic ignition

>Dear Mr. Nuckolls: You were kind enough to speak with my partner, Don Herzstein this morning about the power distribution system we are planning for our Cozy Mk IV with an IO 360 engine. I have attached my circuit diagram for the system for any comments you would be kind enough to make.
>1. We have two of Klaus' electronic ignitions and really do want the redundancy.

A No problem . .. just tie a second battery on the system with it's own battery master switch and contactor . . .

>2. Were planning to use two 12 AH SLA batteries (in parallel for starting) but they didn't have the cranking power and we are replacing them with unit(s) which have better starting output.

A A pair of 17's is your best bet.

>3. We will probably use two of the same battery for parallel applicaions although with the isolation it is probably not necessary.

A No "isolation" beyond the opening of the aux battery contactor during alternator out operations is necessary or advisable.

>4. Will monitor each battery (either on bus or isolated) with a battery condition meter but will have to manually put a battery on the bus to charge.

A No "monitoring" necessary. If your bus voltage is 14.2 to 14.6 volts then the batteries are happy. If bus voltage drops below 13.0 then the batteries are at-risk for discharge. Go to plan-B for alternator out operations. New battery in main, move main to aux and pitch the aux battery every year to insure freshness and critical capacity. This is a SIMPLE concept that offers reliablity unheard of in the spam cans . . . No extra pilot or mechanic's duties. Bob . . .

Re: Mag/Ignition VS Electronic/Electronic ignition

> Bob, The engine I'm buying from Bart Lalonde allows me to obtain a duel electronic ignition system at basically the same price as a system with 1 mag and 1 electronic ignition. I believe the dual electronic ignition system would be marginally more efficient, certainly easier and more fool proof to change plugs, and has a certain aesthetic appeal to me. I also plan on the B&C alternator and voltage regulator and doing your design for the wiring. So, cost aside, does either system have a clear and/or compelling advantage over the other from a failure mode analysis viewpoint? >Thanks, Rick Fogerson

A I presume that by "either system" you're referring to elect/mag versus elect/elect ignition systems. I suggest that when an engine is supplied with mags (and the rebate for leaving them off is poor to none) that the builder take off one mag and put an electronic ignition on. Store the take-off mag in a dry environment and when the first mag fails, put the take-off mag back on the engine. When the second mag fails, then buy a second electronic ignition to replace it.

There's nothing wrong with a magneto as a backup to the electronic ignition . . . it's very unlikely that the magneto will ever be called to do hard work while airborne. As long as you paid for the things, you might as well get your money's worth out of them.

Yes, 95% of your performance improvement will come from installation of the first electronic ignition. Biggest benefit is 10x to 100x more reliability, easier starting and cost of plugs. Fuel savings over the lifetime of the airplane will be disappointingly small unless you spend a LOT of time cruising at low manifold pressures (8000' plus). Since your situation isn't going to force magnetos upon you, I'd go for the the whole (dual) enchilada. If it were my airplane, I'm not sure I'd worry much about adding a second battery. I'd go for the all-electric-airplane-on-a-budget approach and feed both ignition systems from the battery bus. Bob . . .

Battery

>>I am building a Glastar with an autoconversion. The engine is the all aluminum Nissan V-6 rated at 190 hp. I have it mounted on the airplane after running it on a test stand. The big problem I have is the two batteries for weight and balance will be going behind the first bulk head which is about 10 ft plus from the firewall. I want all the redundancy I can get so two RG batteries. I'm not sure what is the best way to go. In Contact Magazine, a homebuilder was using separate leads from his two batteries to his hot bus for his ignition and fuel. I've seen your drawing but I am a little confused as how I should proceed with the batteries that far away.

Questions like a copper conduit for the 2AWG wire to the firewall? Redundancy power for the computers, (I will be using a backup computer for ignition and a a/c nozzle into the intake for backup fuel) etc. >Do you have any specific wiring diagrams for my above situation? I assume I should be able to get all I need from the ones you have published in "The AeroElectric Connection". I was a farm boy turned Dentist but I'm no engineer.

A (1) Two 17 a.h. RG batteries located together behind seats. Each has it's own battery master contactor and feeds a single 2AWG wire that comes forward to the starter contactor.

(2) A fuseblock mounted at each battery provides an always-hot bus for each half of the goodies necessary to keep the engine running. ELECTRICALLY DEPENDENT ENGINES SHOULD BE POWERED DIRECTLY FROM ALWAYS HOT BATTERY BUSSES, NOT THROUGH THE BATTERY MASTER/BUS BARS SYSTEM.

(3) Ground each battery separately through its own 4AWG leadwire between battery (-) to firewall ground stud.

(4) No conduit necessary or even helpful in a metal airplane. Not much different than Figures Z-1 and/or Z-2 implemented as I've described above. Bob . . .

Re: battery brands

>Hello Bob Would you please comment on what brands are actual RG design? For example the Odyssey? Do you have a favourite for price/performance? Thanks >Peter

A Just about any lead-acid battery you buy today is going to be an RG/VSLA/Starved-Electrolyte technology. Gel-Cells are rare but they're still out there . . . you have to look for them. If you subscribe to the notion of good preventative maintenance on a battery . . .See http://aeroelectric.com/articles/battest.pdf
. . . then you can get good value from about ANY battery that will crank your engine. This means that irrespective of the battery's electrical size, it must have terminals that accept bolted-on, 4AWG wires and it must be able to dump out 300+ amps at 8.5V when new.

My personal favorites are the 17-20 a.h. class batteries by Hawker, Powersonic, Panasonic, Yuasa, and dozens of others. These batteries are typically 3" x 6" x 7" in size, cost $50-120. You can find them in almost any "Batteries-Are-Us" store front in addition to hundreds of websites. Further, if you subscribe to (1) yearly change out or (2) periodic capacity testing, you're free to explore the less expensive offerings in comfort that you'll NEVER suffer a battery failure. Bob . . .

Re: Batteries, Concorde vs Odyssey

> Thanks to all who replied on and off-list to my battery question from yesterday. After a review of the spec's for both Concorde's and Odyssey's offerings, I'm still confused on which battery will provide the best cranking performance. The problem is that the two manufacturers do not publish directly comparable performance specifications.

Here's some data: Data at 32F:

The Concorde RG-25 provides 1254 cranking amps after 0.3 seconds and 250A after 15 seconds at 32F.

The RG-25 XC provides 536A after 0.3 seconds and 375A after 15 seconds. (interesting that it provides much less up-front power than its sibling but significantly more power at the end of 15 seconds).

The Odyssey PC 680 provides 300A after 30 seconds, but no initial output amperage is given.

At higher temperatures (74F for the Concordes, and 80F for the Odyssey), the data is:

RG-25 - 1278A at 0.3 seconds, 508A after 15 seconds.

RG-25XL - 846A at 0.3 seconds, 597A after 15 seconds.

PC-680 - 680A after 5 seconds. No data for 15 or 30 seconds.

It is more difficult to compare the PC-680 and the RG25XC, but my eyeball analysis says the PC-680 may have an advantage in starting performance. Some other things to consider are that the PC-680 is 9 pounds lighter than the RG25XC and 8 pounds lighter than the RG-25. The PC-680 is a 16AH battery, and the others are 25AH. Depending on the retailer, the Concordes are generally less expensive than the PC-680.

A Unless you're planning some engine that is VERY hard to start, cranking shouldn't be an issue for you. Your battery's most important task is to back up the alternator. An RG battery of almost any pedigree will crank engines well down to a fraction of their original capacity. If you subscribe to the notion that it's a good thing to carry sufficient battery capacity to utilize ALL fuel aboard with just the e-bus running, then you're going to replace batteries before they even begin to exhibit poor cranking. What architecture are you considering for your electrical system? Bob

----

Re: Batteries; bus location

>Bob, I'm wiring my airplane as discussed in all electric on a budget. This is a Harmon Rocket where the battery is in the back (baggage compartment). On your diagram you have a battery bus for hot equipment connected to the battery contactor by a 14 AWG wire noted not to exceed 6 inches. This would mean that I will need multiple wires going from the bus (presumably located close to the battery) all the way to the front of the airplane to supply my clock, essential bus, electronic ignition (single mag airplane)etc. Is there an alternative such that I can have a single wire going to the front to a battery bus adjacent to the main and essential buses?

A Some people have located their battery bus remote from the battery but it's not recommended. If you do remote mount it, then include an in-line fuse at the battery for the bus feed. Problem is that you now have an always hot wire of considerable length protected at greater than 5A. The FAA wouldn't allow it for crash safety reasons. If it were my airplane, the battery bus goes right next to the battery. Bob . . .

> Is this because a shorted wire would cause a considerable arc when protected above 5A? (potential fire hazard?) My e-bus alt feed switch is located near my master, (left side of panel) resulting in a 5' long wire protected at 15A by an in-line fuse at the battery. (batt is FWF, right side, e-bus fuseblock is under right side of panel- forgetting to kill the e-bus makes this "hot" wire 3' longer). IIRC, you have mentioned in the past to locate this switch near the batt, I assume for this reason? Any other way to reduce this risk? I'd really rather not re-locate the switch... Thanks as always Mark

A The original concept for an e-bus was to get these loads down into the 2-3 amp range so that you could get airport in sight, battery only and then turn the main bus back on. A 5A feeder to the e-bus was adequate for most systems. With the advent of All-Electric-on-a-Budget, adding gyros to the e-bus has pushed the alternate feedpath to less comfortable levels for crash safety. I've got a client who wants to incorporate the e-bus into a certifiable design and his DER is most comfortable with a remote relay as shown in:

http://aeroelectric.com/Page_Per_System/Power_Distribution/Heavy_E-Bus.pdf

This operates as a sort of mini-battery relay for e-bus loads only. The relay draws only 100mA (about 1/7th that of a contactor) and still gives the pilot a way to shut off all long hot leads preceding a potentially airplane-bending arrival.

This diagram will become Figure Z-32 in the next revision to the 'Connection. ...Bob

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Re: Batteries; Military-style Ground Power Plug

> I'm installing the military style, three pin ground power plug. I'm using Fighre 4 from Bob's article on ground power plugs as a guide. My question centers around the contactor. I have one with three terminals, two large ones and a single small one. It appears externally similar to the S701-1 contactor otherwise.

>1) Do I install a diode from the small terminal to the large terminal on the contactor that will connect to the large center pin of the plug?

>2) Will the red wire of the OVM-14 module go to this same terminal?

>3) I assume that the black wire of the OVM_14 will go to the small terminal. Correct?

>4) The large terminal marked "BAT" will connect to the battery contactor and the unmarked large terminal will connect to the center pin of the plug. Right??

>Thanks for the help. Bill

A No, a 3-terminal contactor cannot take advantage of the small, sequenced energizing/de-energizing pin in the connector. You need a 4-terminal device so that you have access to both ends of the contactor coil.

This is why we stock the 4-terminal device. It can substitute for a 3-terminal contactor as supplied with jumper . . . but will serve in the unique situations requiring 4-terminals by removing the jumper. Bob . . .

Re: RG Battery Pack Purchase

> I just bought that battery myself. It was interesting to read the fine print and look at the graphs of the batteries in that general amp-hour range. For anyone who hasn't done that yet, it may come as a bit of a shock that "17 AH" does not mean you can suck 17 amps of current for an hour while you find an airport. Typically the rating is based on 20 hours. If you intend to drain current from the battery for an hour, you need to limit yourself to about 1/2 the rated AH rating (about 8 amps in this case).

A Exactly. Batteries have a characteristic called internal impedance. It's a parasitic resistance that throws away energy in the form of heat in response to load on the battery in accordance with the dictates of Watts = Amps x Volts and Volts = Amps x Ohms. Substituting the second equation into the first for volts we get Watts = Amps x Amps x Ohms or Watts = Amps(Squared) x Ohms. This shows that doubling the load on your battery makes for a 4x increase in energy tossed off as heat by internal impedance. All batteries are characterized by their manufacturers. Download http://www.aeroelectric.com/temp/lc-rd1217p.pdf on the Panasonic 17 a.h. battery. Run up the 4 hour line to 10.5 volts and you can see that some load between 1.7 and 4.5 amps can be supported for this period of time.

It would be nice if they had plotted in more data but suffice it to say, there's a REASON that I hound folks for keeping the e-bus loads LOW. If you truly cannot get the e-bus loads down on the order of 3A then a bigger battery or second alternator should be considered. That 4-pound SD-8 installation looks pretty good . . . no? Bob . .

Re: Batteries; Aux Battery Management Module

> I want to install an alternate battery in my Dragonfly. Are the AEC 9005-101 and 201 what I need to do that. Best regards, Bart

A You don't NEED the aux battery management module to install a second battery. Simply add a contactor, battery and battery bus along side the first battery and an aux battery master switch on the panel. What IS HIGHLY RECOMMENDED is active notification of alternator failure. This should be a flashing light and/or alarm tone in your headset.

If you already have the low voltage warning system then you don't need an AEC9005-101. If you still need the low voltage warning, then I suggest you either acquire the AEC9005-101 or build it's equal. If you purchase the AEC9005, then it comes with an additional feature for automatically managing the aux battery contactor if you wire it as shown on page 7 of the instructions. You can download a copy of the instructions at:
http://www.aeroelectric.com/Catalog/AEC/9005/9005-701B.pdf
Note that you will also need an S700-2-10 switch from B&C at www.bandc.biz Bob . . .
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5. CIRCUIT BREAKERS

Circuit Breakers

>> Cheers, Our (canada) ministry of transport mails out amendments to the Aeronautical Information Periodical (rules and regs) quarterly, accompanied by the ASL - Air Safety Letter - which comments on recent accidents and enlarges upon common beliefs and practices as they relate to Air safety. The most recent edition, #1/2001, carries an article by Mike Murphy of the Air Passenger Safety Group within the ministry. It's about "The Deliberately Weak Link in the Electrical Cahin..." - the circuit breaker. This carefully crafted three pages describes the device, its purpose, its ramifications (hello SR111?) and it's positive dangers when involved with teflon covered wire. You don't want to miss it. Details from me - I have a Microsoft Word version and a text version and might be able to steer you to a website one as well. I found out my Air Force, my employer of 35 years and I all misused the little b.....r. >Ferg A064

A Ferg, I found the article and a number of related links. In reviewing the article I didn't pick up any concerns about "teflon" covered wire. See http://www.cadmus.ca/Circuit%20Breakers.htm Mil-W-22759 wire or it's commercial replacements (Raychem Spec 55 etc) are not mentioned as strong trouble makers in the article. The trade name for Mil-W-22759/16 wire is "Tefzel" . . . a cousin to teflon but much tougher and resistant to cuts and abrasion than teflon. In fact, the biggest heartburn seems to be over Kapton wire.

The article does raise the excellent point about not messing with breakers in flight . . . which is a good idea no matter what kind of wire you're using. Better yet, use fuses which operate much faster than breakers.

Looking over the following links I find a cross reference of wire types in service on various aircraft. http://www.cadmus.ca/wiretypes.htm Bob . . .

Re: Switch-breakers . . .

>Could you elaborate on this? At first thought, a toggle switch that is also a circuit breaker seems attractive. What am I missing? >Thanks. >Robert Miller

A Circuit protection is used to tap a bus and distribute power to a useful location. If you have a row of switch-breakers on the panel, now you've created a bus behind the panel that is probably in addition to the ones already a part of fuse blocks. If you're using breakers throughout the system, then the inclusion of switch-breakers forces you to fabricate a bus on the right side for the non-switching breakers and another bus on the left side for all the switch breakers.

Fuseblocks keep the busses off the panel and provide you with an convenient, compact, low parts count, bolt-on alternative to the high parts count, costly, laborious and real estate hungry breaker panels. See also http://aeroelectric.com/articles/fuseorcb.html It's not that a switch-breaker is an inherently evil device . . . but its use forces design issues counter productive to the fabrication of low cost, failure tolerant, easy to maintain systems. Bob . . .

Circuit breakers

>I have an RV-8 and am working on the electrical subpanel. I messed up and went with circuit breakers. I now see the advantage of working with a fuse box. My question is....I have 2 PotterBrumfield W23's,then 4 W58's, then 2 W23's. The tabs for the W23's and W58's are different. How can I hook them together? What size wire to use for the power line? My highest CB rating is 15amp. Ed Perry

A Take a look at any certified ship with circuit breakers and you find that they're all the same style and have threaded fasteners on the back to support a strip of brass or copper drilled with holes at intevals matching the breaker spacing. If you're going to use breakers effectively, uniformity is real important. Your only alternative is to take individual wires from each breaker to a bolted junction that lets you fan out the bus feeder to each breaker through SHORT lengths of wire . . . this drives up the parts count and clutter behind the panel but I don't know of any other way to do it. Have you considered changing over to fuseblocks? Bob . . .

ANLs

>Bob or anyone: Can someone explain or refer me to any source of information that would explain ANLs and how they work. Thanks. Harry Crosby

A Sure. Take a peek at the new articles listed in the What's New box at the top of this page: http://aeroelectric.com/articles.html Bob . . .

Re: Circuit breaker substitution

>>Bob, Just wondered what your thoughts are on substituting 7.5 amp breakers for the 5 amp field breakers for the main and SD8 alternators since I already have a couple of 7.5 breakers on hand. Dave Ford

A I've not tested the our crowbar ov modules with the larger breaker. When one of these gizmos triggers, the current flowing in the crowbar module can exceed 300 amps for the milliseconds that it takes to open the breaker. The time constant for a 7.5A breaker will be longer than for 5A . . .Having said that, know that we tested our crowbar circuits with a series of repetitive trip cycles. I suspect that in a real ov situation needing a single trip cycle, the critters will be okay. The risk is that should the ov module be overloaded, it becomes a permanent short instead of a transient short. The risk is to the ov module and not to the system. Bob . . .

Breakers vs. fuses on the battery bus . . .

> >I am using circuit breakers (don't stone me for this) and I wonder how to incorporate this into the z4 drawing. The drawing says to keep the 10AWG wire to the aux/main battery busses 6" or less. There is no way to do this with that wire coming to the CB panel approx 2 ft. from the firewall.

A This shouldn't be a problem . . . battery busses are right next to the battery . . . whether you use fuses or breakers is immaterial. The bizjets have LOTS of breakers that are NOT in the cockpit . . . battery busses are one of them.

> Also the main/aux pwr bus has a 4AWG wire feeding each of these. These feed wires do not have protection. Is that because they are oversized to begin with and short in length the way they are utilized in the diagram? If these wires were 2.5 ft in length would that change the rational? Could I size these feed wires more closely to the load requirement?

A These wires don't need protection because they are main feeders that tend to burn clear as opposed to hard faulting to ground. In areas where there is mechanical risk of hard faulting, we simply provide extra care in routing and protecting the wire. They should be sized for the full output rating of your alternator that feeds that particular bus. An SD-20 main feed could drop to 10AWG, but I'd leave the other one at 4AWG. Bob . . .

.

Re: Fuses/CB's

>Hi Bob,   Another question for you...on fig. Z-14 on the main power bus, you show mostly fuses and then there's a 5A CB for the ALT FIELD. Why the CB instead of a fuse? Sounds like it makes sense, but I'm curious to hear the real rationale!

A	The alternator system shuts down by means of a crowbar ov module that will deliberately short the field supply line to ground - expecting the upstream fault protection to open up and remove power from the alternator. Don't want to do this with fuses. Crowbar OV modules can be nuisance tripped so this is the one place where I use a circuit breaker.

> Also you have a CB for the hyd pump...This seems to make sense too, since there isn't actually an on-off switch for the pump and it would be nice to have "override" control. Is this the rationale for the hyd pump CB? Are there any other systems that you would think would be nice to have this control over, ie use a CB over a fuse even tough you are going primarily with fuses?

A	I drew that before B&C was handling the ANL limiters. I wasn't intending that to be any kind of controller . . . the pump motor has a high inrush and the JJS/JJN type fuses were inappropriate to protecting this kind of feeder. The ANLs are just the ticket. Even if you use a breaker for the pump, I wouldn't put it on the panel . . . one of the goals of clean system design is to keep those kind of current carrying conductors away from the panel. I did have one Glasair builder mount his pump circuit breaker low on the right side kick panel so he could reach it if he stuck a contactor. This should be a rare event and if it happens, you can treat it just like an alternator out event. Kill the main bus to shut off the pump. Continue to intended destination and turn the main bus on long enough to cycle the gear . . . or leave it off and use the primary gear extension system (the manual one that ALWAYS works) to lower the gear.

>Also how exactly do you wire the CB off the fuse block? Your diagram only shows the CB connected to the fuse block, ie no connecting wire from the fuse block to the CB???

A	Opps . . . that should be drawn like the alternator field breaker in figure Z-11 . . . a fusible link at the fuseblock extends the bus up to a breaker mounted beside the DC POWER MASTER switch. Need to fix that! Bob . . .

Subject: Re: CB vs Fuses

>> My bad experiences with fuses have been the old ceramics from European autos and 5 X 20 glass fuses (also European). I believe the ACT blade types are superior....but hey...there's still no switch. I'll probably have a few fuses in places where I don't also need a separate switch. I also have used self-resetting solid state fuses; these should be carefully applied.

A	The only fuses I've seen that succumbed to vibration were the glass and ceramic cartridge devices in the smaller ratings and of the fast-blow variety. The fusible portion of the device was so fine in the 3A or smaller sizes that they would part the solder joint under the end cap with severe vibration. This is why you didn't see a cartridge fuse of less than 5A used in very many places on airplanes. The plastic fuses in all sizes are not so afflicted.

> Electrohydraulic-Magnetic circuit breakers are best for operating in difficult environments and packed panels. They don't heat load and nuisance trip. They are small and have rockers or toggles and lots of >features. These are going into my Glastar. http://www.pocosales.com/ or http://www.cbibreakers.com/ look up CBI Hy-Mag B-frame circuit breakers. >http://www.etacbe.com/n_america/e-t-a/etacbeframeset.html check model series 8330

A These are indeed fine circuit breakers . . . we've looked at breakers with similar performance characteristics in certified aircraft for years . . . but only in special cases where the extra fast response of magnetically tripped breakers was found useful or necessary . . . They are used less than 1% of the time in the GA fleet. To state they are "best" for your application implies an increased risk of problems by using any lesser product. I'll suggest that 50 years of experience in the GA fleet has demonstrated that this is not the case. I don't recommend fuses as "better" than breakers for the purpose of protecting the wires but I would say that they are equal to breakers in this regard at a fraction of the cost. Bob . . .

Switch-breakers

“Also, switch-breakers are not advised . . . I wish they had never invented those things. They have a very limited utility on airplanes. ...Bob,”

>Would you expound on this viewpoint a little further?

A Circuit protection is used to keep wires from burning should they be subject to overload. Circuit protection should be as close to the distribution bus as practical. Fuseblocks have the bus bar built into the fuseblock assembly . . . hard to get the fuse any closer to the bus . . . also hard to get the bus any more protected/enclosed. Circuit breaker panels build bus bars right on the backs of the breakers.

Generally speaking, power distribution centers are remote from pilot controls. Fuse blocks can and should be out of sight, out of mind behind the panel somewhere. Breaker panels are most often displayed proudly on the panel but there's no practical reason to use up panel space with breakers . . . a breaker panel could just as easily be located out of sight, out of mind also.

When you select a switch/breaker for installation in your airplane, you have a device that's more
expensive than a switch, doesn't look like the rest of your switches and forces you to extend the power distribution system to a point behind the instrument panel in front of the pilot. There are now concerns for treating the feedwire from your REAL power distribution bus to the switch-breaker as if it were a bus bar. Further, a switch breaker's performance as a switch will never equal that of a device designed to be a switch.

Risks to this wire are low but what is the advantage in using a switch/breaker? Fuseblocks do EXACTLY the same job in conjunction with low cost, all look alike switches. Other than the single, 5A alternator field breaker used upstream of a crowbar ov module, I can find no practical justification for the use of breakers and/or switch/breakers in a modern, emergency-free electrical system design. Bob . . .

Re: Why breaker for alternator field?

> I'm building a two alternator two battery system, but will use a very small battery for the B&C SD20, regulated with the LR3. I have several questions:
> 1. Why have a 5 amp breaker for the alternator field? I would prefer a toggle switch and a fuse, sized to twice the maximum explected field current. A fusible link could be used instead, or even a Raychem Polyswitch rated 5 amps such as the RUE500-UD at $0.79 from DigiKey.

A Overvoltage protection in the form of crowbar circuits deliberately open the field supply protection. there are situations where ov nuisance tripping can occur when in fact no ov condition exists and until we can built the ultimate, know-it-all ov protection system, this is ONE circuit that I recommend be a circuit breaker and mounted in reach of pilot as illustrated in the switch panel layouts I published earlier this month. Fusible links are used when you have a single leadwire to protect where it is VERY unlikely that it will ever see a serious fault and/or where the
ultimate in circuit reliablity is needed. You would never use a fusible link upstream of a crowbar module expecting it to be the reacting device in case of ov condition.

> 2. Each alternator-the SD20 and the Jabiru flywheel mounted PM unit-can put out 20 amps max. Would a 16 gauge fusible link be reasonable rather than an ANL30?

A Probably, but . . .

> Or, parallel two RHE1000-ND 10 amp PolySwitches, each of which trip at 18 amps and cost $1.10 each. I'm afraid the wimpy 5 amp/hr Panasonic sealed lead acid battery might not be able to trip the ANL30, which costs much more anyway.

A The fusible link is as robust as an ANL limiter. If you don't want to use the ANL then get an inline fuseholder from an automotive parts store that will accommodate the MAXIfuses . . . big brothers to the ATC series fuses that fit our fuseblocks. A 30A maxifuse would be just about right. Please ditch the polyfuses. These are NOT suited to aircraft power distribution system fault management.

> 3. I will be combining the PM alternator connection of Z-13 with the dual bus dual alternator architecture of Z-14, except it will be adjusted to avoid crossfeed during starting, and the crossfeed relay and the aux battery contactor will be small units with 88 ohm coils. Both alternators will have low voltage indicators. On the PM alternator, since it will be used during normal operations, should the output go to the battery side of the main contactor as in Z-12, or to the output side as on all the other diagrams?

A Output side. . .

> 4. I will be dividing my loads between the two busses. I suppose that I should divide the essential loads between them, but it would be less confusing to have all the avionics on one bus, lights on the other. The crossfeed relay keeps both busses alive, unless one bus has a short to ground. Divide the essential loads?

A I'd treat the second bus as an "essential" bus . . . when you have fully redundant power generation systems with crossfeed capability, you don't need to have an "essential" bus that can be isolated for battery only operations. Bob . . .

Re: Circuit Breakers; OV tripping

> Bob, After a new ov module (yellow lead) and new (rebuilt) alternator, the OV circuit breaker continues to trip right after the engine starts. My plane is wired per Z-2, only I have an auto type ignition instead of magnetos. Please help...I'm desperate. I am about to tear everything out and start from scratch...

A Are you sure you don't have an ov condition? Do you have a voltmeter in the airplane? Try disconnecting the ov module, turn off all radios, start engine with alternator switch OFF and engine at ramp idle. With then turn on all heavy loads like landing lights, taxi lights, pitot heat, and THEN turn on alternator while watching the voltmeter. If it goes above 15 volts, under these conditions, you have a problem with the alternator . . shut down immediately.

If it doesn't go above 15 volts, then increase RPM to about 2000 while watching voltmeter. Again, if it goes above 15 volts, you've got an alternator problem - shut down immediately. If the voltage is still okay, start switching off the loads one at a time while watching voltmeter. If you get down to no loads and the bus voltage is still normal (13.8 to 14.6 volts) then we've confirmed that the alternator is okay.

Do you have the alternator ON while cranking or do you turn it on after the engine is running?
Bob . . .
----

6. COAX

Coaxial cable

>Bob, I remember a statement, I believe was yours, that RG400 was not necessary for our applications - and that it was too expensive. Now I'm in the market for coax for radios and antennas and would like to know your present thinking on the subject. I notice that your web site no longer carries RG58.

A Never did carry it. RG-58 is an obsolete spec for a wire designed in WWII . . . PVC and Polyethylene. We haven't used it in production airplanes in the past 15 years or so. RG-400 is my favorite (stranded center conductor) but RG-142 is equal in performance (solid center conductor).

> Also, I see that ACS sells RG-58C/U (for non certificated planes) quite a bit cheeper than Van's RG-58C. Can it be said that either one of these are adequate for experimentals or that one is better than the other?

A Personally, wouldn't use RG-58 in either new or replacment construction . . .

> And finally, do the same BNC coax connectors fit the cables mentioned?

A   Yes they do. Bob . . .
------

50 Ohm Impedance

>. Re: 50 ohm.   Exactly what does it mean when coax is described as 50 ohm impedence? Also, I found a 90 degree BNC male/BNC female connector at RS, which works perfectly for belly mount antennas. I am (appropriately) skeptical of most RS stuff, but how important is a fitting like this for optimum radio operation?

S	50 ohms is the "resistance" seen by radio frequencies (HF, VHF and UHF) when "looking" into a 50 ohm cable (of infinite length - thus the need to terminate it with a "50 ohm" antenna). It is NOT what you would measure with an (DC current) ohm meter.
	Actually the cable can be viewed as a combination of an infinite number of small capacitors and coils whose resistances to radio frequencies combine into the 50 ohms over a wide frequency range. The "ohm" rating of a coax cable is determined by a relation of the diameters of the inner conductor and the outer conductor (shield) and the material separating the two, if I'm not mistaken. Bottom line, you cannot determine the radio frequency "ohm" rating of a cable by using an ohm meter. Finn
----

Re: Coax Cable Routing

>> Could someone please advise: Should coax cable for communication antenna be routed together with electrical wires?

A	They can be . . .

>Would the electrical cables interfere with transmitting or receiving? The electrical cables are: flap motor power, nav, tail and taxi lights, fuel level, strobe power (14 volts, not the high side) and push to talk. Thanks in advance.

No . . .Bob . . .

Re: Coax bulkhead fittings

>Bob / et al, Are the coax bulkhead fittings supposed to be isolated from the metal airframe to prevent multiple ground paths or are they supposed to be grounded at their attachments? I am installing the coax for my VOR/LOC/GS antenna in the top of my VS and I'm planning on a couple of bulkhead fittings to facilitate maintenance. I could use regular male/female connectors with standoffs if necessary. Thanks, Ralph Capen

A	It's only in very special cases where it's necessary or advisable to isolate bulkhead fittings from the airframe. I wouldn't worry about it. Bob . . .

Re: Coax; Right Angle BNC

> Gang, A few months ago somebody asked about crimp-on right angle female BNC connectors. Bob mentioned using a right angle adapter. Has anyone yet found a source for a decent crimp-on right angle?

A	There are a number of sources . . . but none that I know of that will install with the tool we sell. AMP 225974-2 is a suitable part that sells for $22.00 qty of 1. The hand tool that installs it is about $400.00. If it were my airplane, I'd install a cable male connector, mate it with a right angle adapter and shrink a chunk of double walled tubing over the interface to make it permanent. . . . the po' boy's right angle connector. Bob . .

S	What about the Amphenol 31-334, available from Newark as PN 39F1443 for $28.92? It needs the Amphenol CTL-1 tool, which Mouser lists for about $50. Is this connector comptiable with the RCT-2 tool that B&C sells? I suddenly developed an interest in 90 deg coax connectors tonight, as I just discovered that my avionics installation leaves a bit less room for the RG-400 coax than I had hoped. So, I spent a little while flipping pages of an old Newark catalog and found:
	90 deg BNC 50 ohm jack plug - part number 89F2919 - $18.11 - TYCO ELECTRONICS
http://www.newark.com/NewarkWebCommerce/newark/en_US/support/catalog/productDetail.jsp?id=89F2919
	90 deg BNC crimp on jack plug (UG-306)- part number 39F071 - $17.39 - AMPHENOL
http://www.newark.com/NewarkWebCommerce/newark/en_US/support/catalog/productDetail.jsp?id=39F071
	90 deg BNC crimp on jack plug (UG-306A)- part number 39F1071 - $12.62 - AMPHENOL
http://www.newark.com/NewarkWebCommerce/newark/en_US/support/catalog/productDetail.jsp?id=39F1071

Questions - should there be enough performance difference between the crimp on connector vs the jack plug to make this a consideration?   I've got to connect to COM, NAV, G/S and GPS antennae. I've searched the web, but I can't find what the difference is between a UG-306 and a UG-306A connector (other than about $5). Can anyone shed any light on this? Thanks,
  Kevin Horton	RV-8 (finishing kit) Ottawa, Canada
http://go.phpwebhosting.com/~khorton/rv8/

Re: Coax; RG400

> Bob, others, Does anyone know the spec of attenuation in dB per foot for RG400 coax? My Ryan TCAD systems wants to have 3dB of attenuation +/-0.5dB, so I have to cut the coax to length accordingly. Currently, my coaxes are about 12' long, but I cut them before I knew this.

A	RG-400 and RG-142 are same attenuation which runs 20db/100ft at transponder frequencies. See http://aeroelectric.com/temp/coaxloss.pdf This says that you need 15 ft pieces. Bob . . .

Re: Coax; RG400

>Bob, I have lots of experience with RG-8 and RG-58, etc. but none with the RG400 which has two coax screens. Now that I'm connecting the coax to antenna elements (by the usual 'picking' coax screen to get at insulator and central wire), can you please tell me how to connect each screen? That is one, both or either to ground element?

Treat them as a single shield. Insulation is sufficiently heat resistant to soldering shield end directly to antenna element.

Here's a series of photos I did for a Shop Notes posting that I've not yet taken time to post. http://www.aeroelectric.com/temp/Antenna Bob . . .

Re: Coax, Antenna; Hand held COM

>Can a hand held com radio antenna be spliced into the aircraft com antenna cable?

A   Sure. My personal favorite is to bring the comm antenna coax into reach of the pilot. Put a connector splice in the coax using connectors like . . .

http://www.aeroelectric.com/Catalog/antenna/antenna.html#s605cm

http://www.aeroelectric.com/Catalog/antenna/antenna.html#s605cf

If you make the comm antenna coax feeder about 3' too long and coil the excess under the seat, then you can simply open this junction and run the antenna coax up to your hand held. Perhaps the ideal alternative is a second comm antenna dedicated to the hand held.

Or . . . you can build an adapter like that shown in

http://www.aeroelectric.com/articles/commtap/commtap.html

Bob . . .

Re: coax squisher

> A friend let me borrow a ratcheting type coax crimper. It is made for RG type cable 6,58,59,62,141,142 and has hex crimps .324", .256", .213", and .068" (pin). Will this work adequately for the RG-400 wire and BNC male connectors I got from B&C?

A   Yup, .213 and .068 are the dies for that connector.   Bob . . .

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7. CONNECTORS

Re: Polarized Connectors.

> Would these Radio Shack polarized connectors be suitable for wing root disconnects? (p/n

274-151 male, 274-154 female at $.99 each) They are rated at 20 amps and cannot be connected the wrong way, and as the name says are interlocked.

A There are a gob of products out there that are fairly suitable to this task. The only down side of ALL of them is their 7-strand, automotive wire with PVC insulation.

Re: Molex Type Connector Question

> > Bob or other knowledgeable person: I am planning my RV-6 slider instrument panel to be removable for service and I am considering the use of Molex connectors to facilitate separation of the wire bundles between the panel mounted switches, lights and instruments and the fuse blocks and all the other stuff mounted behind the panel. My wiring scheme is basically per Figure Z-11. I would use the detent lock style connectors with receptacles mounted in the subpanel and free hanging plugs. I have the following questions and will appreciate any helpful comments and suggestions:
> 1. Are these connectors acceptable for experimental aircraft use?
> 2. Is this a reasonable plan?
> 3. Are there any "gotchus" I should know about? Thanks in advance and for your continued good natured support of people with dumb questions like this. Harry Crosby

S Harry: I am using Molex style Amp connectors exclusive in my airplane. So far, no problems but the airplane is only 4 years old and has only flown 1,000+ hours. It has only been to to the Arctic Circle once, coast to coast 5 times, to the highest airport in North America, and also to the lowest. There were no wire splices used in construction of my airplane. Molex style connectors were used in their place. One thing I did was to have as few connections as possible. Every connection is a potential failure point. With that said, only add connectors where needed. My harness stays with the airplane. (RV-6 slider) The switches are removable from the panel and the radio stack stays in the airplane. The instruments all come out individually and the panel is removable but no wires come with it.

If you use Molex style connectors, purchase extra contacts along with the contact removal tool. There are several different size contacts and several different styles that are not interchangeable. I prefer to use in line or in harness connectors instead of having a receptacle mounted in a piece of metal. It is extra work to install the receptacle into a mount. Do it if you think it is worth the extra work. Gary A. Sobek

S Yes, the Molex connectors are acceptable. But, I'd recommend the Amphenol plastic Circular Connectors. (do a search on these at www.digi-key.com) They don't cost much more than the Molex connectors and they have a very positive twist lock feature. I wired my Velocity instrument panel using the Molex's before someone showed me the Circular Connectors. I replaced them and am very happy with the change.

A I agree. If you need multi-pin connectors, the circular plastic Tyco/AMP connectors are much easier to work with than the Waldom/Molex and they use superior contact materials. See page 146 of the Digikey Catalog at: http://info.digikey.com/T021/V5/145-147.pdf The Series 1 connectors use formed pins capable of more current than the Series 2. Series 1 pins can be installed with the B&C's BCT-1 crimp tool.
http://www.aeroelectric.com/Catalog/tools/tools.html#bct-1 My personal favorites are the Series 2 that use the same machined (or formed) pins as D-sub connectors. You can install and remove these pins with the same tools as D-subs. B&C RCT-3 crimp tool at:

http://www.aeroelectric.com/Catalog/tools/tools.html#rct-3 and DSE-1 extraction tool at: http://www.aeroelectric.com/Catalog/tools/tools.html#dse-1 A typical Series 1 connector can be viewed at: http://catalog.tycoelectronics.com/TE/docs/pdf/9/14/167419.pdf A Series 2 is at: http://catalog.tycoelectronics.com/TE/docs/pdf/1/30/215031.pdf Bob . . .

Solder, 63/37 alloy

>> Bob, Help. I've been hinting in various e-mails that I'd like to buy some 63/37 solder. You'd mentioned a "long time ago" that you had some and were actually looking for some small spools to wind small batches on.

A You're making this too complicated. The 63/37 from Radio Shack will do fine. Or, you can order the Cadillac stuff from Allied Electronics http://www.alliedelec.com under their catalog #833-5130 This will get you a pound of the same solder that has been used on my bench for over 20 years. It's .031" Resin 44 by Kester. It will cost you about $11 and shipping.

>When I "googled" Ersin, it gave a link to www.multicore.com (in England), which listed Krydon.com as a distributor - called: 500 pound minimum! And they stock "Multicore", not Ersin.

A Multicore is the company, Ersin is one of their trade names for fluxes. See: http://www.kellysearch.com/company.asp?corporate-key=80133930 http://www.audioasylum.com/audio/tweaks/messages/7078.html I checked some Multicore sources . . . they're higher priced than Kester for similar stuff. Go for the big "K" from Allied. Bob . . .

Firestop for firewall

>> Bob and all those others with greater experience than I, help please!.....Built all those nice holes thru the firewall, ran a plethora of wires, then put stainless covers on them with nice rubber grommets. However, there is still "air space" that would allow hot air, CO, or whatever into the cockpit. What does the world suggest I go stick these things full of? Be gentle please.
>
>Criteria.....ability to 'work it in', reasonable temperature resistance, 'permanent' softness in case I need to rework it for more/fewer wires in the future, reasonably neat and nice looking. Oh, yeah, must be able to handle metric and imperial sized holes.....I've seen high temp red silicon (?) used, but the end product always looks messy. Mike

A See: http://www.firestopit.com/sealants.htm
http://www.firestopit.com/silicone_sealant.htm
http://www.envirograf.com/products/product060.html
http://www.uniquefirestop.com/fill_kit.htm
Bob . . .

S Re: That "hole filling goopy stuff"..... One more time... Windshield adhesive tape... comes in a roll like caulk. Looks like black caulk, stays flexible, is resistant to oil, gas, H2O2, will cure warts, will stick to your plane. Find it at any non-FAA approved autobody supply stores. Made

by 3M etc.

Re: D-sub Hi Density Pins?

> I'll be the one to ask. I'm familiar with D-sub connectors, but what are high-density pins? Why & where are they used instead of low-density? I'm assuming low density pins are the stamped sheet metal ones, correct?

A Look on the back of your computer . . . the video cable connector is the same physical size as the serial data connector. The serial data is 9-pin; the video cable is 15-pin. The pins are described as 20 and 22 AWG rated pins. Both sizes are available in machined (preferred) and open-barrel, sheet metal. Here's a drawing on a 20AWG standard density d=sub (sometimes called the "109-series" for the spacing between pins.
http://catalog.tycoelectronics.com/TE/docs/pdf/7/68/213867.pdf
Here's a 22AWG high density part (90-series).
http://catalog.tycoelectronics.com/TE/docs/pdf/0/59/221950.pdf
Actually, there's also a "50-series" micro-miniature but hopefully we won't see any of these showing up on airplanes! Bob . . .

Connectors, D-subs

>> > I could use some simple guidance here - assuming one correctly applied pin on both sides of the connector, how much current can I safely pass through one of them before needing to split the power connection between two pins? or Three? or Four?

A For the target project, I derated D-sub pins to 4A. For larger current requirements, I parallel whatever is necessary to keep individual pin loading to 4A or less. To parallel two pins, you need to swamp out the small variation in resistance from pin to pin. It's seldom satisfactory, for example, to simply short an array of pins together at the back of the connector and expect current through the array to distribute evenly across the array.

Taking a cue from past tasks where I needed to parallel multiple transistors in a power control circuit (we added small value ballast resistors in series with the emitter lead of each transistor) I reasoned that we can short all the pins together at the connector on one half (in this case the etched circuit board side). For the mating connector, each pin gets a 22AWG wire about 10" long. The array of wires is joined to a common butt-splice. The other side of the butt splice carries on with the size of wire appropriate for the circuit's total current.

The approximately 10 milliohms of wire resistance offered by each pigtail has the same effect as the ballast resistors in an array of paralleled transistors. Tiny variations in resistance from pin-to-pin a insignificant compared to the value of the ballast resistance.

> Why not keep power on good ole AMP/Molex >connectors?

A The D-sub connector is compact. You can get very high quality gold plated pins for them. They're easily worked with low cost tools . . . even if you use the machined pins. The AMP Mate-n-Lock and Molex connectors don't come in right angle PC mount versions. Their contact density is much lower than the D-sub. I don't think you can get them in greater numbers than 12 contacts per plug/socket.

If you're building a product where you'd like to mix high current (10A+) wires in with small signal wires,
the AMP/MOLEX solutions will either have you paralleling conductors in the small pins -OR- having to upsize the
connector just because you have one or two wires out of the total that carry heavy current.

The D-sub solution offers a fair selection of connector sizes (9, 15, 25, 37, 50) and a large range of connector
configurations that let you deal seamlessly with panel mount, ecb mount and cable mounted versions. You can easily intermix micro-amp signal and control with some rather hefty power wiring with a single technology. There are some new circular connectors from AMP that use the same pins as the D-sub . . . these too might be considered for similar treatment . . . I'm not sure if AMP offers any ECB mount versions yet . . . and it's unlikely that there will ever be a right-angle ECB version.

All things considered, in spite of the ugly hole you have to cut to mount a D-sub, the availability of low cost, high quality pins and inexpensive tooling combine to make them attractive for a broad range of applications. Bob . . .

> I used to think that splitting power connections was not good practice because if one line/connector fails you would not know about it until the remaining connectors started to overheat. Is this wrong?

A This has been the standard saw . . . but let's suppose you have four bolts holding the spar-stub on your wing to the carry-thru. How do we know when one of them is not carrying it's intended load? There are lots of places where we depend on reasonable care and workmanship to insure that a single point of failure isn't going to happen. I don't see any difference between multiple load paths in structure and multiple load paths in wires. Know what you're trying to accomplish and do it right. The most flack I've fielded on this notion was from folks worried about putting multiple strands of wire into a butt splice. In one case, I'm putting 7 strands of 22AWG into a butt splice. I showed them how to strip the ends of the bundle. Wrap a rubber band around the bundle very tight so as to prevent slippage of individual strands. Then, I pointed the ends of the strands at the observer and asked? If you had not just witnessed that these wires came from 7 strands of 22AWG, how would you know by looking at the end that it wasn't a single strand of, say a single 10AWG?" The answer was, of course, "no way I can know."

"Okay, once we put these wires into a splice and put the gas-tight squash on it . . . and no strands were allowed to slip, what's the likelihood that any one strand isn't properly connected? Let's go a step further, tug on each of the 7 strands and see if you can pull them out without breaking the wire." After that, it was simply a matter of using the right tool to install D-sub pins on other ends and push them into a connector. Then I asked, "Has anyone ever seen a properly installed wire on a D-sub loaded to 4A or less cause failure in the mated pins?" "Nope" was the answer there too. Bottom line was that all the "what-if" concerns were washed away with knowledge of the task and the craftsmanship to do it. Hmmm . . . suppose we depend on the same skills to install wing and prop bolts? Bob . . .

Solder Sleeves and Heat Guns

> DigiKey sells a similar 3M product in any quantity. These heat shrink solder splices have a tin plated brass barrel in them that hold a solder disc. In qty of 10 they are $0.49 to $0.77 each depending on size. See http://www.digikey.com/ Page 550 in catalog. To go directly to the

catalog page click this: http://info.digikey.com/T011/V4/550.pdf

A Just got my samples of this product. These are splices only. They wrap a cylinder of solderable material in a high temperature heat shrink. There is a solid pellet of solder inside the cylinder at the center. There are retention tangs punched through the cylinder wall to sort of grab the stripped ends of the wires to hold them in place while heat is applied. I've posted a teardown photo of this product at: http://www.aeroelectric.com/articles/3Msplices.jpg

The SMALLEST of these devices is suitable for splicing wires no smaller than about 18AWG; the largest that I took apart for the photo would be good for much bigger wires but takes one hellofa heatgun to do the job. These things have 3M's name on them so I have to believe they're fairly suited to some tasks. Given that they cannot replace a solder sleeve for attaching pigtails to shielded wire -and- that they only replace a crimped butt splice, I wouldn't recommend these for use in your airplane.

>>Radio Shack sells solder strips that you can use to wrap around the pigtail and the sleeve or wire you are connecting to. Just put a piece of heat shrink over it and hit with heat gun until the solder melts. I used this method for installing pigtails on all my shielded wires an it worked well.
>Kevin in WA RV 9A

A Solder comes in lots of fancy forms . . . the CRITICAL thing about solder is ALLOY ratio (63/37 best 60/40 quite usable), alloy PURITY (you can only be sure with name brands that offer products to stringent specs) and FLUX (Again the name brands that cater to high-dollar markets). Good solder from Kester, Ersin, or any other brand where spool is labled with a QPL or MIL-S-571 label is not hard to find and relieves one of any concerns for quality and suitability to the task. Bob . . .

Solder Sleeves

>>Bob, do you know of a source of these types of sleeves that have pig-tails already attached?

A There are lots of folks who handle Raychem products. Download these documents from Raychem's website which are selection guide, data sheet and installation guide for this genre of products.
http://interconnect.raychem.com/pdf/h54683.pdf
http://interconnect.raychem.com/pdf/h54681.pdf
http://interconnect.raychem.com/pdf/h54682.pdf then click on this link to find a distributor near you:
http://interconnect.raychem.com/indexf.html

I buy from A.E. Petsche who has warehouses all over the country. I buy in full boxes of 100
pieces. They don't sell small quantities. John at http://www.terminaltown.com/ used to offer small quantities but he's trying to sell out his business and isn't taking orders.

You can do your own impersonation of solder sleeve with the technique I published at: http://www.aeroelectric.com/articles/pigtail/pigtail.html

I only use solder sleeves for my customers that demand and/or expect them. I terminate about as many shield pigtails with the poor-man's technique as with solder sleeves. Bob . . .

Re: Solder Sleeves

> HI Bob, >I have used these before without any problems. The words of wisdom I have is maybe you are concetrating the heat too much on the sleeve, Have you tried with no tip on the heat gun or putting your heat gun further away from the sleeve? the trick is to heat it up slowly. And the plastic will melt or deform slightly but not more than that.

A Wondering what kind of solder sleeves you're talking about. The devices we use and sell in our kits feature a ring of sealant at both ends of a heat shrinkable sleeve. There's a ring in the center of flux coated solder. As the heat builds up in the sleeve, the outer jacket and end seals soften and shrink first. The ends are oft closed to minimum diameter before the solder begins to flow in the center. The only time I've had problems was with a gun that didn't put out enough heat. One needs to do the install with a single application of heat . . . if you take the heat away and try to come back, I think you'll find that the characteristics of the heatshrink are altered and it won't pull down around the solder joint even if you do get the solder to flow inside.

The heatgun I use is rated at 1200W. I hold the solder sleeve 1/2" off end of the nozzle. I used to use a concentrator but after the concentrator got lost, I found that it didn't seem to make much difference. As long as the insulation on your wire isn't getting cooked, you're not putting on too much heat. Bob . . .

Connectors

>> My problem is I have too many wires for too few places. For instance, there are three aircraft ground positions on the monitor (1, 17&18) but 21 shields for those three spots plus the airframe ground. There are 8 signal grounds for one spot (#14). My thinking is to put a wire in 1, 17, 18 and 14 with a ring terminal on the end. Then ring terminals on the other wires and bolt them together. Naturally to the correct spot. Cover with heat shrink tubing. As you can see my electrical mind is dangerous. Will a #18 do at the monitor side?

A I get this question several imes a month. There's a relatively painless way to handle the termination f multiple shield grounds into a few pins of a connector. I went to the workbench with my camera and produced the following addition to Bob's Shop Notes: http://www.aeroelectric.com/articles/pigtail/pigtail.html Bob . . .

S Bravo! Nice little tutorial on a subject I see butchered often in the field! Where can I get those Raychem terminations? My local electronics distributor doesn't carry the Raychem line. And by expensive did you mean $1 ea? $5 ea? or like Military cost over run expensive? -Bob A&P IA

A Download these documents from Raychem's website which are selection guide, data sheet and installation guide for this genre of products.
http://interconnect.raychem.com/pdf/h54683.pdf
http://interconnect.raychem.com/pdf/h54681.pdf
http://interconnect.raychem.com/pdf/h54682.pdf then click on this link to find a distributor near you: http://interconnect.raychem.com/indexf.html Hold onto your wallet when you call them . . . I just bought a box of 100 SO96-2-55-22-90 soldersleeves for $120.00
Bob ....

Connectors, Wing Root

> I saw a thread the other day where you were commenting why have a break in the wire at the wing root since the wings would rarely be removed, just a 8" loop of spare wire. My thought is that barrier strips just inside the fuselage would make a practical way of separating the wiring on an occasinal basis. However, I see no approach like that anywhere in your book. Do you think this a poor idea?

A I work really HARD to avoid any kind of threaded fastener in wiring . . . if you need wing root disconnects, consider a white nylon product from Amp (mate-n-lock) or Waldom/Molex. Cessna started using mate-n-locks in production harnesses in the mid 60's and for all I know, they still do use them. They've got a good track record.

> Grounding a simple wire - say a nav light. So I crimp an eyelet on the end of the wire. Now what sort of bolt should I bolt it to say a wing rib with? Brass?

A Clean up all the metal surfaces, and bolt down solid. I like to use #8 hardware. Once torqued down nice and tight, paint it.

> And finally corrosion, if you combine a copper wire, a brass bolt and an aluminum rib, does this not set up corrosion issues?

A Stay with tinned terminals held against clean aluminum and by cad plated steel bolts. This combination has an excellent track record and it can only get better if you keep the moisture off it. Corrosion happens when moisture gets between the differential alloys . . . this is why it's important to put enough pressure on the torqued down parts to provide "gas tight" connection. That's why I don't like to use #6 and smaller hardware to ground things . . . you can't torque a small fastener very hard. I've had some builders put their grounds down with AN3 (10-32 hardware) torqued to the high end of the range for 40,000 psi steel bolts (25 inch pounds). Some folk have mistaken this for electrical overkill in grabbing the airframe with a terminated wire, others have properly understood it to be mechanical protection against corrosion. The better the squash, the more impervious to moisture. Download AC43-13 from my website and check out chapter 6 section 1. Paragraph 6.2 talks about combinations of conditions conducive to corrosion. Availability of fluids and oxygen are required components that cannot get into the joint when nicely mated up. Bob . . .

Connectors, Shield Termination

> I'm getting ready to install a 4-place intercom and the info on how to terminate the cable shields is a real help. Also read the article on wire stripping, but I still have a challenge I'm trying to work through. With 2 and 3 conductor 22 gauge shielded Tefzel cable: (1) is there an efficient way to remove the outer (very thin) insulation jacket without nicking the braid, and similarly (2) is there a clean and quick way to trim the shield braid to the 1/4" or so needed to attach a pigtail without damaging the insulation of the multiple inner conductors? Any help would be greatly appreciated. THANKS! Regards, John Hall (Anchorage, AK)

A Sure, I'll show you how I do it when I have a couple dozen radio harnesses to build. But hold your nose for this one when I say "neat doesn't count for much." I know this goes against

the grain of builders who think in terms of building furniture but here goes. . .
Download these pictures:
http://www.aeroelectric.com/temp/Shield1.jpg
http://www.aeroelectric.com/temp/Shield2.jpg
http://www.aeroelectric.com/temp/Shield3.jpg
http://www.aeroelectric.com/temp/Shield4.jpg
http://www.aeroelectric.com/temp/Shield5.jpg

Here I show that it's not necessary to gather all those pesky strands neatly and "undamaged" into the fold before soldering. If you can "rip" off the outer jacket even if it tears off most of the shielding, you can see from the pictures how the remaining strands can be wound around the inner conductors in preparation for attaching the shield's leadwire. After the heatshrink cools off, nobody but you will know how horribly you treated those poor, itty-bitty wires. A little heatshrink hides a lot of "sins" . . .Bob . . .

Mini Connectors MAC Grips

> I used some Deans R/C model connectors on my MAC grips and thought other people might be interested in using these in tight spots. I included the link below and some ordering information. They are probably available at any hobby shop that carries radio-controlled cars/planes. I mail-ordered mine thru Omni Models 1-800-342-6464.
2-pin F46670 $1.39
3-pin F46671 $1.49
4-pin F46674 $1.85

A Gary, thanks for the heads up on this. Omni Models has a website and a brief search of their offerings turned up some interesting possibilities. Check out:
http://www2.omnimodels.com/cgi-bin/woi0001p.pgm?Q=1&I=WSDM3005
This is an example of hundreds of variations on a theme in 0.1" spaced, 0.025" square posted connectors common throughout the electronics industry. With this small spacing and in-line design, they're fairly easy to work with for tight spot, low current applications like the control wheel switch harnesses. Many of these connectors do not positively lock to each other when mated so a piece of suitably sized heatshrink over the mated pairs is in order. Bob . .

Connectors, Tiny wire

> Is it practical to use phone or computer-network type jacks and connectors (RJ-45?) to deal with these tiny wires? Or aren't they hearty enough?

A I've considered these products for a number of years. When you look at some of the nasty environments that they seem to survive in, it seems that they might be okay for airplanes. I've seen telephones in plating shops (moist, corrosive atmospheres), machine shops (oily dust) and outdoors (moist, temperature cycles and dust), etc.
I think there's a TSO'd ELT that uses RJ connectors and ordinary telephone wire as part of the installation. Sooo . . . I wouldn't discourage you from trying it. I'm considering it for black-box to black-box wiring for serial data cables and for very low power and control requirements . . . in these cases, connections to wires are always made with crimp tools onto flat-bundles. Mating connectors are always soldered to etched circuit boards. I think the risks are low and in some

cases, convenience is high. Bob . . .

Re: BNC crimp connectors

> I have used only the solder type BNC connectors, because for aircraft, stranded center conductor coaxial cable must be used. All the crimp-type BNC connectors that I have been able to find have a smaller diameter hole for center conductor. Anyone know of the part number/manufacturer of the crimp-type that will work??? > Wayne

S Wayne, I have used crimped BNC connectors from Aeroelectric and Digi-Key with RG-400 that has stranded center connector. The Digi-Key part number is All64-ND and the Aeroelectric part is the only one they list. They both use a crimp tool that is sold by Aeroelectric. Regards, Richard Dudley -6A FWF

Connectors: Re: Soldering 14AWG wires w/o cold solder joint . .

> One thing I haven't seen mentioned: most solder training includes the admonition to first prepare the joint so that mechanical integrity is supplied by the joint, not the solder. The solder should only supply electrical continuity. A side benefit is that you will have a much easier time making a good electrical connection with the solder.

A Kinda, sorta true but mostly BS. It is true that solder is not as "structural" as the materials it commonly joins. Nowadays, solder is both the structural -AND- electrical member in most electronic assemblies for holding surface mount parts to etched circuit boards. Solder sleeves are another good example of the dual role (structure/conductive) capabilities of solder.
When you twist two clean wires together, they are now capable of conducting electrical current across the joint about as well as they ever can. The effects of environment would eventually degrade that condition if left open to atmosphere. Solder provides a gas tight exclusion of the environment that maintains the original quality of the joint within. Reasonably clean materials to be soldered will be quite cooperative when soldering . . . even when solder is the structural component of the joint, as long as you're using the material within it's well known limits.

>My experience has been that whether you transition from stranded to solid at the solder or at the crimp, you still have a stress riser. If no strain relief is supplied and/or the wire isn't held stable after leaving the connector, it is likely to break.

A See articles on terminals at: http://www.aeroelectric.com/articles/rules/review.html and http://www.aeroelectric.com/articles/terminal.pdf You are correct . . .Crimping a terminal on a wire makes it just as "solid" in the joint as solder does. Without proper support of the wire just outside the solid to stranded transition, soldered and crimped wires are both equally vulnerable to flexure stress and failure. That's the magic of a PIDG terminal . . .Bob . . .

Re: Connectors; Wing Root

> As the builder of a trailerable aircraft with removable wings this issue is very important so I would appreciate your comments on what type connectors are suitable for very frequent use. Best regards, Rob

A Understand. Just published a suggestion for wing root connectors at http://www.aeroelectric.com/articles/wingwire/wingwire.html These connectors are quite robust, easy to find, and very accommodating to multiple mate-demate cycles. One could lap-solder the joints in the wires instead of using butt-splices which are fairly expensive. Heat shrink over the joints would finish the splice.

Molex and mate-n-lock white nylon connectors would work fairly well and are easy to replace if they get flaky with age. If you want to go first class, AMP Series III, CPC connectors. Take a peek at the versions with high current Series XII contacts that would do a nice job of handling pitot heat and high-wattage landing light circuits. See http://www.mouser.com//index.cfm?handler=fra_pdfset&pdffile=431 Bob . . .

Re: Connectors; AMP CPC or Equivalent

> Bob and Gang, Discussion of connectors raises an interesting thought; don't think I've ever seen a good article on multi-wire plug connectors, and the selection of a particular type for a particular application. Electronics guys know the details because they've worked with them for years. The rest of us pick up a Digi-Key catalog or similar, find a jaw-dropping selection, and groan.

A Engineers navigating connector-wilds aren't much happier about it. Connectors are like laundry soap . . . so many choices, so few outstanding reasons for selecting any particular technology. Every year or so, some starry-eyed sales rep would drop a new connector catalog on my desk claiming that THIS product finally answered the needs for everyone and was the greatest connector since they began slicing bread . . .

Task 1 for a connector is to make non-permanent connections between one or more strands of wire. Attachment to the wire can be solder, crimp, or mass-termination (like ribbon cables munched onto a 50 wires in a single stroke). Considerations are (1) do you really NEED a connector there? (2) how many strands of wire? (3) what sizes of wire? (4) any extraordinary environmental concerns? (5) any extra ordinary mechanical concerns?

> Need examples? When does one use a Molex connector vs a D-sub?

A D-subs are the first connector I consider for any new application. Check out this picture: http://aeroelectric.com/temp/power_dist.jpg This is a "tall" picture . . . so scroll down to see the bottom half. This is an all solid state, power distribution box that routes energy from ground power jack and up to two batteries to 5 different busses in the vehicle. External power input can be as high as 40A continuous . . . yet, if one knows how to make it work, all can be handled though the 20AWG pins of d-sub connectors. This box USED to be about 10" long, 4" thick 5" wide, full of relays and wired up with supper-whizzy connectors. The connectors alone on the previous version cost more than the whole bill of materials for the new version.

Here you can see how the solder-right-to-the-board features of D-sub connectors has a profound reduction of labor to install. In this case, although subjected to up to 30g acceleration and short term radiant heating, the D-sub was entirely suited mechanically to the task. The mil-spec, gold-plated pins were no worse (or better) than the gold-plated pins on MUCH more expensive connectors.

> Why are (most?) D-sub pins gold plated?

A I wouldn't say most . . . you can buy tin-plated connectors in D-sub. Gold is preferred because is does not corrode . . . electrical integrity of mated pins is not nearly so likely to degrade with age and use. Gold plated pins are relatively cheap for D-subs because of the huge volume in this particular product. By-the-way, the same 20AWG pin is used in AMP CPC Series II connectors like: http://dkc3.digikey.com/PDF/T031/0192.pdf use the same pins as a D-sub . . . so you have two low-cost connector opportunities to use the same tools and a common part number for pins.

> Is connector selection as simple as observing an amperage rating, or is there more to it?

A I you were wiring anything but voltages up to 28vdc, there might be voltage rating issues but in our market, ANY connector will suffice that can carry the current and accommodate the quantity of wires. If you need to carry more than 4A continuous per pin, consider the CPC Series I connectors in the same catalog can accommodate up to 14AWG wires. Except for firewall penetrations, the AMP CPC connectors for systems teamed with CPC and/or D-subs for avionics would be my connectors of choice. They are low cost, tools are reasonably priced, gold plated pins are available for both styles. Excellent values for our projects.

> Why a choice of metal or plastic backshells?

A Plastic is less expensive and lighter. 90% of my applications use plastic. There are almost never interference issues that justify the metal or conductive plastic backshells. If the connector is used under the cowl, metal backshells are probably advised.

> The automotive world uses plastic connector shells that lock when mated; why don't we use similar connectors in our airplanes? Or do we, and where do you get them?

A Mate-n-Lock/Molex style connectors have been used on many single engine airplane beginning in the 60's. Does a Molex shell offer any wire support, or does it strictly depend on the insulation crimp of the little sheet copper pin? That's it. No bundle support. Only the insulation grip on each strand. I was skeptical when I first laid eyes on them but in retrospect, they seem to have performed well for decades in spite of no back shell support and non-gold pins. Before Internet access reduced the need, my library used to have about 5 feet of shelving dedicated to connectors. Your consternation is understandable. I think you'll find that the two connector series I cited will do a good job for your project 98% of the time. Bob . . .

S Re: MIL spec connectors >Does anyone know of a good place to buy MIL Spec connectors that dont cost a fortune. I need one that can handle aobut 24 wires at 18g. I want to put in line with a exisiting harness.

A What is the "magic" you expect for having purchased mil-spec? Unless you have a customer with some hard over requirement for spec'd connectors, consider the AMP CPC connectors on pages 191-192 of current Digikey catalog. If you gotta have holy-watered connectors, contact Aeroelectric Connector in Torrance, CA (310) 618-3737 and give them a part number.

Consider the MS3470 series connectors at http://www.aero-electric.com/26482_2.htm pick your inserts from http://www.aero-electric.com/26482s2_cont_insert.htm Consider too

that tools to install/extract pins will be needed. Bob . . .

Re: Connectors, Sealed

I've been using some Deutsch IPD connectors. They're sealed, use high quality solid pins and sockets, and are easy to buy in small quantities from www.laddinc.com. The DTM series are good up to 7.5 amps, DT up to 13 amps. These are both plastic connectors. They also have round connectors in both plastic and aluminum. Dave in Wichita
----

Re: Connectors; Ring-terminal sizes needed?

Mark, FWIW

- My B&C L-60A alternator B lead stud is 1/4"
- The ANL fuseholder in which I have a L-60 fuse has 5/16" terminals
- My fuse blocks from Aeroelectric have #10 studs
- My 24/48 tab groundblock from Aeroelectric has a 5/16" bolt

-----

>May I add B&C 5 amp circuit breaker to this list?

Most are #6 screws. There are a few that are #8 Bob . .

Re: Connectors; d-Sub variation for the solder-challenged

This isn't my 1st choice (I have way too much experience soldering), but for those who choose d-Sub connectors & don't want to solder or crimp, I just noticed these in a wiring trade publication. Similar wire terminations seem to be reliable in industrial environments.

http://www.phoenixcon.com/subcon/

Charlie

Re: Connectors; banana plugs.

>Would radio shack know what to sell me if I ask for "banana plugs"?

A Yes, they'll know. They're also shown in the Radio Shack catalog as shown in the clip at:
http://aeroelectric.com/temp/RS_Banana_Plugs.jpg

The 1576/1573 pair of connectors simply provide a convenient means for plugging a multimeter into a cockpit mounted test jack to measure field voltage. Figure Z-23 describes the airplane wiring. You'll need to make an extension cable with banana plugs (or what ever mates with your multimeter) on one end and a 274-1573 plug on the other.

Alternatively, one could simply mount a pair of 274-725 banana jacks on the panel (Item 23 down lower on the clip cited above) and use test leads with banana plugs on both ends to effect the connection between multimeter and the electrical system. However one chooses to do this, it affords the troubleshooter a vital piece of information needed to diagnose alternator system problems BEFORE pulling the cowl.

>It's probably there but I can't find in your book the purpose of the 5A C.B. in the alt. field wire.

A If you use a modern, crowbar ov protection system, the system DEPENDS on a convenient means for interrupting the field supply in case of an ov event. This is described in terms of hardware in:

http://www.aeroelectric.com/articles/crowbar.pdf
http://www.aeroelectric.com/articles/bleadov.pdf

and described operationally on page 6-7 of the book.

Since it is possible to get nuisance trips of the OV system, it's the one breaker that I would include on the panel of my airplane even when I'm using fuse blocks to protect the rest of the system.

>Also, does it need to be in plain view so you can see immediately if it trips or can I put it out of the way but still accessable by touch in-flight?

A I like to put them in same row as switches. See
http://aeroelectric.com/temp/Switches.pdf

>And if I haven't strained your patience too far, the Radio Shack P/N for the 1N4005 diode. One responded with 276-1141 and another with 276-1105

A The 276-1141 is a 3A diode like those we pre-install on the contactors which you can see at:

http://www.bandc.biz/S701-2.html

and

http://www.bandc.biz/S701-1.html

The 1A diodes would work fine here but they're smaller and not no robust. The 3A devices are mechanically a better choice. It would work but is pretty fat for use on the S704 coil terminals.

The 276-1105 is as near as I can tell, a bogus number. I plugged it into the search engine on Radio Shack's website and it came up empty. Refering to my Radio Shack catalog, I find this listing:

http://aeroelectric.com/temp/RS_Diodes.jpg

Here's the full range of 1A, 3A and 25A bridge rectifier diodes suited for use in the various applications depicted in the website articles and pages of the 'Connection. Bob . . .

Re: Connectors; Large Elec Connection - AN vs Brass Bolt?

>bob.nuckolls@cox.net writes:

The resistance of plated steel hardware is significantly higher than the copper alloys recommended for current carrying hardware supplied in our grounding kits. If the bolt simply supplies pressure to hold current carrying components together, then the AN hardware is okay. When the bolt has both assembly -AND- current carrying responsibilities, it should be brass. Bob . . .

>Good Morning Bob, Just curiosity sparked by my sailing days, how would bronze bolts fare? If I recall, bronze is stronger than brass and should be capable of handling a higher torque. What would the electrical characteristics be?

A Copper, brass and bronze will exhibit tensile strengths on the order of 50K, 100K and 200K psi for each material. Conductivity will be 100%, 28% and 13% for the various alloys. So, it's a trade off . . . Fat copper bolts for strength or VERY fat bronze bolts for conductivity. Iron and steel are on the same order as bronze for conductivity.

Brass hardware is readily available and a reasonable compromise. Even so, conductivity is not likely to become an issue in most airplanes until you step up to 100A plus systems with lots of electric heat or air conditioning loads that can be high and sustained. But steel hardware with high electrical loading IS a concern. The only electrical fire I ever started was the result of mis-applied steel hardware in the conduction path. Bob . . .

S Actually the Ultimate tensile strength for the three red metals mentioned are:

UNS C11000 electrolytic copper (full hard) 48 KSI (48,000 psi), (full soft) 32 KSI
UNS C360 Free cutting brass (full hard) 68 KSI, (full soft) 49 KSI
UNS C932 Bearing Bronze (83% Cu) 35 KSI
UNS C1018 cold rolled steel (commercial grade bolts) 64 KSI, AN bolts 100 - 140 KSI

As you can see from the mechanical properties of these materials that both copper and brass have reasonably good mechanical strength with good electrical conductivity. Bronze has poor mechanical strength and poor conductivity. Chris Stone

A I went back to see where I dug up the earlier numbers. I see that my bronze strength was acquired by clicking on the wrong box . . . Beryllium Copper.

Yup, bronze is not so nearly robust a stuff but I don't think they would make bolts out of bearing/bushing material.
http://www.precisionsteel.com/intro5.cfm?Properties=True&ProductType=BronzeA
suggests that we can heat treat to something on the order of 98Kpsi although one would probably have to special order such parts. I suspect bronze marine hardware is not nearly so robust.

Cy's point was rather profound . . . these are, after all, not structural parts . . . however I will suggest they are single points of failure for the system. A quick look at recommended torque values for brass hardware has most authors coming down at just under low-carbon steel fasteners. 5/16-18 threaded hardware (supplied with B&C ground busses) can certainly be torqued to 100 lb-in which should cover us well for both electrical concerns about fastener conductivity and mechanical concerns for terminal crush. Bob . . .

S You made me curious so I looked it up - the following are in units of micro-ohm-cm if I deciphered the table correctly:

Copper wire - 1.7
Aluminum (pure) - 2.8
Brass - 6.21, or about 4 times the resistance of copper
Steel - 15 to 45 with harder (stronger) materials having the higher numbers

A note in Mark's Handbook says bronze alloys can have 25 to 85% of the conductivity of copper with tensile strengths up to 130,000 psi, just as Bob said. I was surprised to see how poorly steel conducts electricity. The resistance of steel is 10 to 30 times that of copper. Aluminum is a poorer conductor than copper per unit volume, but better per unit weight - hence the use of aluminum for electrical transmission wires and some aircraft battery cables. Gary

Casey

Re: Connectors: Pins
>Can the pin shown on the B&C web site (Part # S604P) be used for AMP CPC connectors? Or are the pins shown on page 566 of the mouser catalog the same as the B&C pins?
>http://www.bandcspecialty.com/cgi-bin/ez-catalog/cat_display.cgi?24X358218
>http://www.mouser.com/catalog/615/566.pdf

A Yes, the CPC series 2 connectors use the same pins as the crimp D-Subs. The "20DM" (Dsub Military) pins in the Mouser catalog are the same as what's offered by B&C. Bob . . .

Connectors:

>What thoughts on using anderson powerpoles?

A I believe this is the series of connectors B&C supplies with the SD-8 installation kit. The full range of products is viewable at:
http://www.andersonpower.com/products/pp/pp.html#
These have a pretty good record on B&C's products. If you really gotta have a connector somewhere, these should be considered. Of course, they are specific to high current applications and I've only seen wire-bundle to wire-bundle mating sets. Bob . . .

Re: Connectors: Removing Molex KK Pins
> Does anyone have a good (read: cheap) source for the extractor tool used to remove Molex KK series pins? These are the pins used in King/Narco radio connectors.

A I've made dozens of extraction tools for various tab-retained connector pins by cutting down a pocket screwdriver as shown here:
http://www.aeroelectric.com/Pictures/extraction_tool.jpg
You need to grind gently so that the shank doesn't get so hot that it melts the plastic handle. Bob . . .

Re: Connectors: DsubSourceSought

> Having thoroughly fouled up my first wiring attempt, wires too short & too small to crimp properly, I'm looking for a source for a new female Dsub connector that goes on the back of my Garmin 320A transponder's installation tray. The existing connector is labeled ITT 0208 DBMA25S.

A I don't think that connector is anything special. The part shows up in the itt-cannon catalog which you can download at:
http://www.aeroelectric.com/temp/DSubCatalog98.pdf
See page 183. These connectors tend to be pretty generic across manufacturers.

Compare the connector you have with a 25S d-sub from Radio Shack. There are some series d-subs with short shells that take special pins. But for the most part, I've had good luck substituting connectors from other suppliers. See if the Radio Shack shell will fit your installation. If so, throw away the sheet metal pins that come with it and substitute the machined pins. Bob . . .
----

8. CONTACTORS

Master Contactor

>> My airplanes alternator output (B lead) is wired to the same post on the master contactor as the battery cable. This does not conform to Bob's and most other diagrams which show the alternator supply wired to the switched side of the contactor. Are there any negative implications with this arrangement? Dick

A Yes . . . when the master switch is OFF, you want everything (except equipment intended to run from the always hot battery bus) to be COLD . . . that's what the word "master switch" means. What are the advantages of NOT doing this? Bob . . .

Re: solenoide wiring

>Hi Bob or others, I'm wiring my airplane and I have a question. I look at differents wiring schematic's and saw they generally put the wire from battery contactor on the left side of the solenoide, (view when installed on the firewall). Is that a must? I've a space problem and i'd prefer to put it on the right side of my four branchs starter contactor. Is that possible to reverse it. >Daniel

A If you have a 4-terminal contactor like our S701-1 (see http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg) You can interchange the fat terminals even tho the one on left may be marked "BAT" . . . in fact, both sets of terminals are interchangeable. If you have a 3-terminal contactor, the you MUST use the "left hand" fat terminal as the battery feed. Bob . . .

Contactor

> Is the purpose of the fusible link to act like a fuse? If so why not just install an inline fuse?

A fuses are fine too . . . just not as robust . . . especially when mounted out on the engine.

>Next question is, I ordered the Starter contactor that Van's sells. I cannot find the documentation for it. It has 4 posts that are oriented straight out. from left to right they are Big, small, small, Big. I saw your starter contactor in the catalog and it says that you can run a starter engaged light from one of the posts. Can I do the same with this one and what should the connections be? I'm guessing from left to right Battery, ignition, ?, Starter. Am I close?

A Are there no markings on the contactor at all? If not, I suspect the part is a generic, 4-terminal contactor that may or may not be intermittent duty and optimized. If it's a generic contactor, you have two fat terminals that control starter current, two little terminals that power up the coil. Be sure to add a diode across the coil http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg The labels in this photo are for building a 4-terminal battery master contactor. To convert to starter contactor remove jumper. Connect right hand small terminal ("to master switch") to ground. Apply power from starter button or switch to left hand small terminal (banded end of diode). Either fat terminal can go to starter. Other fat terminal goes to battery contactor. Starter engaged light needs to hook to the fat terminal that powers the starter . . . what your watching for is a stuck contactor which keeps the starter powered up after the contactor's coil is de-energized. Bob
---

Contactor, Master/Starter Relay

>I have Vans master and starter relays. Does it matter which way the power goes through them? (as in right to left or left to right?) >Thanks, Norman Hunger >RV6A Delta BC

A No, the main power terminals on the starter contactor are independent. If you have a 3-terminal battery contactor, one should be marked "BAT" or "B" . . . this one would go to the battery. If you have a 4-terminal battery contactor, you can wire the main terminals in any configuration you like. Be sure to add spike catcher diodes in the coil circuits. These are illustrated in pictures of our products in the parts catalog and in our wiring diagrams. Bob . . .

Contactor, Master

>> My master relay / contactor is very warm or maybe even hot. It's nearly hot enought to scorch my finger. So, is this normal ? I've measured the coil current at 0.7 amps. David Stafford

A If you multiply 0.7A * 14 volts we get right at 10 watts of heat to be dissipated from the surface of the contactor. A device with this surface area and power dissipation can be expected to rise about 40 degrees C (70 F) above ambient. Assuming a 70 F room, the surface of the contactor will top out in the neighborhood of 140-150F . . . NOT something you'd want to put your finger on but a LONG way from damaging to components of the contactor which will operate at 200F or better. Bob . . .

Contactors and Spike Catchers

>> Bob: does the little silver band on the spike catcher diodes on your battery and alternator

contactors go towards the positive or negative coil terminal? Am I correct that to use the contactor for an alternator contactor, I must remove the jumper wire? Thanx, Rion

A Yes . . . the banded end of any diode used as a spike catcher must attach to the + terminal of the contactor coil. The S701-1 contactor is supplied with a diode and jumper to make it installation-ready for use as a battery contactor. You are correct that to use this device as an alternator disconnect contactor, the jumper would be removed.
Bob . . .

Contactor

>>Bob, Putting the starter contactor in the engine compartment will dictate that a load style ammeter must be used. I do prefer the +_ auto type, but am willing to forgo that for system simplicity.

A Understand . . . but I think the loadmeter when combined with a voltmeter (which you need anyhow for battery only operations) will give you a clearer picture of system condition.

>> It also results in an un-fused hot wire going through the firewall (master contactor to starter contactor). What type of firewall feed thru do you recommend? A hole in thin stainless with a grommet on it to protect a heavy current carrying always hot wire (when the master contactor is closed) doesn't meet my long term safety requirements.

A Been done for decades on hundreds of thousands of airplanes. Running a main feeder through a grommet that's properly shielded on the engine side is pretty rudimentary technology. I'd add a layer of fire-putty over the grommet shield on the engine side. The bonanza uses a 90-degree flanged elbow with about 1" i.d. to bring most wires through the firewall. The elbow is on the engine side of the firewall. A piece of firesleeve and two stainless steel clamps are used to close the open end of the transition tightly around the bundle. This technique has been tested in Bad Jack's house of horrible tortures and shown to take 2000 degrees open flame for a long time.

> If the alternator fuse is in the engine compartment, what are your preferences concerning how it is mounted?

A As an in-line fuse with wires attached to both ends and heat shrink over the whole. Our b-lead fuse kit is supplied with all the necessary heat shrinks.
You CAN put the starter contactor inside . . . and bring the alternator b-lead through instead of the always hot feed to the starter contactor . . . the b-lead fuse is to protect the b-lead from BATTERY current . . . not alternator current. Bob . . .

Contactor, Starter

>Hey everyone ! I had to say "hold everything here" when I saw this . My confusion on this is directed to Bob : Is'nt one of the potential failure modes of the start contactor to fail (welded contacts) in the closed position? This would result in the starter being engaged when there is actually no voltage present at the "I" terminal & hence no illumination of the Starter Engaged

annunciator . This is the major reason I thought I wanted the annunciator . Otherwise I know the starter is engaged if the prop is turning ! It seems to me that the pic-up point for the annunciator should be the high current terminal that gets power when the heavy contacts are closed . I realise the voltage (for a 12 v sys) would be maybe 6 or 8 v during cranking so a lower rated annunciator lamp rating might be needed but @ least then I would know to turn off my batt master B4 my starter self destructs . Please clarify . Chris

A When you take one of these contactors apart and study the way the main terminal contacts are bridged to engage the starter, the "I" terminal has to be closed too . . . the moveable contact inside is like a three-legged stool. Most 12v lamps are entirely adequate to the task for annunciation - especially if you are watching for the light to go out when you release the start button. Bob . . .

>> So... is there anything wrong with putting the indicator light on the starter side contact? Especially if it were an LED, which would draw an insignificant amount of current away from the starter (with dropping resistor of course)? -John

A that would work too . . Bob

Re: Starter solenoid - Internal diodes

>>Hi All, I've heard about starter solenoids wich have a diode included against electric arcs. It seems they are very different from the conventual STANCOR contactor that we can buy and find everywhere. Does anybody know a trademark name for this type of product and where I can purchase one of it ? >Vincent.

A It's a toss up. Many of the off-the-shelf automotive contactors I've researched have a diode installed. If they do, they'll be marked on the box or somewhere on the device that a diode is included. The S702-1 contactor offered from our website does include the built in diode.

If you have an automotive contactor that is not so marked, then it's easy to take advantage of the superior characteristics of the product by adding your own diode. A 1N5400 series device (3A, 50V or more) is just fine. Radio Shack sells them here in states for about $1.25 in a package of 2 diodes. These are the same diodes we include externally on our S701-1 contactors which you can see at: http://www.aeroelectric.com/Catalog/switch/s701-1I.jpg
I'd go to the car-parts store and look at all the offerings of starter contactors. If they look like: http://www.aeroelectric.com/Catalog/switch/s702-1I.jpg . . . then check the box and/or markings on the base of the device to see if the word "diode" is mentioned. If you find one so marked, fine and dandy. If you can't find one at the first store, I'm not sure I'd spend much time looking . . . adding the diode is cheap and easy. Bob . . .

Re: Starter relay location

>> Does the starter relay need to be mounted on the firewall? I was thinking of mounting it next to the master relay on the battery tray in the aft area of my RV-8 and then running the 2awg up front thru the firewall to the starter. The Van's diagram shows a #2awg running from the master relay thru the firewall to the starter relay and then to the starter. Is there a performance issue with keeping the starter relay close to the starter? David

A Putting the starter contactor on the firewall gives you a place to tap the system for feedpath to the main bus -AND- a place to attach the feedpath from the alternator b-lead so that it can avoid attachment to the main bus. Bob . . .

Re: Starter Contactor or Not

>> Bob, I reread your 1998 article about starter solenoids. The B&C Starter solenoid described may draw up to 35A momentarily on engagement, but I am using a SkyTec (skytecair.com) unit. A representative of SkyTec says that their solenoid draws 20A momentarily (50 millisecs) and then holds with 10A. The company recommends that experimental aircraft use a starter switch on a 15A circuit with 14 gauge wire directly to the starter solenoid instead of a separate starter contactor. Do you see a problem with this approach so long at the switch is 20A DC rated and protected with a diode?

A Give it a try. If you don't get the results you would like with respect to performance, then you can easily change it later.

>This approach has another seeming advantage. The B lead from the alternator could follow a very short path from the right front of my Lycoming O-320 to a fuse on a bracket under the crankcase to the the front left side starter lug where the #2 wire from the battery connects.

A If you're using the ANL current limiters, this makes it a tad harder to mount the base under the engine. . .

> I would tap the battery wire somewhere in the cabin for the primary bus.

A Please don't do this. Bring the appropriate feed wire either from the starter hot terminal or the switched side of the battery contactor. If it were my airplane, I would still use the external battery contactor as shown on the drawings. Bob . . .----
----

Re: Loss of Batt Contactor in Fig Z-12

>Hi Bob, In numerous places you say "alternators don't run well without a battery"...What exactly does this mean for Z-12 architecture if you lose your battery contactor? Can I assume that in Z-12, the primary B&C 60A alt. and backup SD-20 alternator would both be useless under this failure scenario and you would be left with only your essential bus powered off the battery?

A Yes. That is why the All Electric Airplane on a Budget architecture is so attractive. The SD-8 is inexpensive, light, bypasses the battery contactor and supplies enough snort to run LOTS of goodies. Now, just because the battery contactor fails to do the designed function doesn't mean the alternator(s) quit.

Remember, an alternator needs a source of field voltage which is the same bus that the alternator powers. IF . . . you hit the bus with a high inrush load (landing light, certainly a hydraulic pump, etc) with no battery to fill in the gap for a few tens of milliseconds, the bus could sag sufficiently to starve the field supply which drops the bus voltage which starves the field supply even more. The effect is precipitous. The alternator quits and without a battery, it doesn't come back. Even if the alternator says on line, loss of battery always degrades stability of the voltage regulator and the bus voltage jumps around more. Filtering action of the battery is lost too and the bus become noisier. Sooooo . . . if one has managed to get an STC to put an SD-20 on a certified ship like a C210 or Bonanza, the next thing I would do is get an STC to add an aux battery.

Once you go the dollars and weight to put the SD-20 on an amateur built aircraft, I'd go for the extra battery too . . .whether it's an aux battery in parallel with the main battery al la Z-12 or a dual-battery/dual-alternator installation like Figure Z-14 (even if the second battery is small like we discussed earlier).

>If that is indeed the case, wouldn't the slightly more complicated and marginally more expensive Z-14 be MUCH more reliable/redundant as either alternator would be capable of running off either battery in case of a failed contactor... Worded another way: If you're already planning a dual alternator (B&C 60A + SD-20) system, is there any reason to go with the Z-12 architecture over the Z-14 architecture if you can live with the small increases in added weight, cost and complexity of Z-14...

A You got it.

>On another note, I plan on having initially one electronic ignition and one mag...eventually possibly going to dual electronic ignition after using the mags I already have. Would adding an aux battery & bus (to power the second electronic ign) to Z-12 be a relatively easy modification or do you think it would make more sense to just start out with the dual alt/dual batt/split bus Z-14 system?

A If you don't mind the dollars and weight budget, the Z-14 or Z-14A architecture will provide the highest margin of comfort. But if you're going to use up both mags before you put a second electronic ignition on, you may be very close to selling the airplane before you need to upgrade the system . . . perhaps Z-13 has a good chance of supplying your needs for many hundreds of hours. When the second electronic ignition goes in, add a small aux battery al la Z-30.
Don't get me wrong, the SD-20 is a fine piece of machinery but if you're making $tradeoffs$ between what useful goodies you're planning to put on the panel and the ability to shovel lots of electrons, maybe your best return on investment would be with the smaller second alternator.
Bob . . .

Contactor, Starter

>> I purchased the Starter Contactor and the 20A Sealed Relay from your website, but I'm unsure which terminals to use for both of these items (I can figure that the big ones on the Intermittent Relay are form the battery and to the starter, but does it matter which one is which?) Which one of the little ones to use for the Starter Switch?

A The two large terminals of the starter contactor are interchangeable. These carry current from battery to starter motor when the button is pushed. The solenoid coil of the starter contactor is internally connected to the contactor's mounting base . . . so one connection to the coil is achieved via attachment to grounded, metallic structure. The "S" terminal is 10-32 thread and receives power to energize the contactor via the starter switch. The "I" terminal is 8-32 thread and is optionally used to supply power to a STARTER ENGAGED indicator light. Most builders ignore this terminal.

> I have the same kind of questions regarding the little relay as well.

A The two large tabs of the relay are interchangeable and are connected to the switching contacts inside the relay. The two small tabs are also interchangeable and supply power to the solenoid coil that will energize the relay. Bob . . .

Contactor, Master

>>Most, if not all, aircraft electrical systems put the starter (and its solenoid) in series with the master solenoid. The master solenoid is required to carry a huge load that is otherwise far beyond its need and, in addition, becomes just another voltage drop on the way to the starter. Why is it done this way? Thanks, Glenn Giere

A The contactor most likely to stick is the starter contactor. Running the starter current through a battery master contactor or switch gives you a way to shut things down if the starter contactor DOES stick. Further, the idea of a battery master is to disconnect ALL major current carrying pathways in an airplane. Items we wire to an always hot battery bus are generally loads of 5A or less (which I like to protect with VERY fast fuses). Bob . . .

Circuit protection for big wires

>I'm building an RV-8 with an aft mounted battery. I note that the electrical system schematics in Bob's Appendix Z don't show any circuit protection on the big wires going to the starter contactor, and to the main fuse block. Both those wires will be quite long in my installation, and I'm concerned about the lack of protection. I have visions about a major smoke in the cockpit triggered by something chafing one of those cables, or a post crash fire triggered by arcing from the broken, but still live cables. I'm seriously considering mounting the starter contactor aft, beside the main contactor, next to the battery. That way the cable going to the starter will only be live during a start. That still leaves the long cable going to the main fuse block. Would it be practical to either make a large capacity fuselink, or install a large CB or fuse in that line? I would rather deal with an inflight short by seeing everything go black, and then selecting the essential bus alternate feed, than scrambling to throw the battery master in the middle of a major smoke in the cockpit event. Comments?

A The interesting thing about FAT wires in an airplane is that while they carry the greatest energy and potential for current flow, they represent the least hazard with respect to electrical faults.   It's very difficult to create a hard fault on one of these wires. Study the wire's pathway through the airframe. What items of structure or loose systems might come to bear on one of these wires with sufficient force to compromise its insulation and produce a hard short? If the possiblity of such a scenario exists, it's easier to design out the possibility than to provide fusible protection for the wire.

If a fault does develop, it's most likely a "soft" fault that causes some arcing (battery wires rubbing the edge of a lightening hole is a good example) that simply burns away the area it touches without bringing down the system. Over 200,000 airplanes have been built in this country without fusible protection of the FAT wires. Like wing struts, propeller shafts, flight controls . . . it's relatively easy to product very low probability of failure by design.

Another reader suggested that the battery contactor should be a hot-side control as opposed to cold-side control. A little study will show that it doesn't make any difference which side of the contactor is switched. A severe fault on the feedline downstream of the contactor will load the battery to a point perhaps low enough to cause the contactor to open. When it does, battery voltage comes back up and the contactor recloses. This sets up a scenario for "buzzing" of the battery contactor which almost always results in a welding of the contactor. It's really easy to protect he wire from faults to the degree that fuses and/or breakers are not necessary.

>>I have visions about a major smoke in the cockpit triggered by something chafing one of those cables, or a post crash fire triggered by arcing from the broken, but still live cables.

A If it's an impending crash that you're preparing for, ALL SWITCHES OFF is a good thing to do before coming into contact with the earth.

>I'm seriously considering mounting the starter contactor aft, beside the main contactor, next to the battery. That way the cable going to the starter will only be live during a start.

A If you do this, you'll lose the advantage of tying alternator b-lead power feeds to the starter contactor and avoid bringing the noisiest wire in the airplane into the cockpit for attachment to the bus along with your audio system and radios. The power distribution diagrams in Appendix Z have evolved over more than 12 years of refining ideas and philosophies on owner built and maintained (OBAM) aircraft. I won't say that they're infallible nor would I suggest that we won't deduce good reasons for changes in the future. Given the rich database of history about fat wires in little airplanes and our understanding of the designed in failure modes of certified airplanes (see Chapter 17 of the AeroElectric Connection) I would counsel caution about major departures the philosophies presently illustrated by those drawings. Bob . . .

OV Contactor wiring

>>Bob: Another question which will illustrate how blindly we electrical novices follow your notes to the letter: I bought the 4 terminal B-lead OV contactor from B&C as illustrated in your posting "OV Protection For Built-in Regulator". Your posting shows no jumper from one of the coil (small) leads to one of the large leads as is present on my contactor from B&C. I assume I remove the jumper. Correct? Mike

A You are correct. We install the jumper to make the contactor function as-purchased as though it were a 3-terminal battery contactor. When used in other applications such as B-lead OV protection, crossfeed contactors and others, you remove the jumper to return it to a 4-lead device. The diode stays on. Bob . . .

Contactors

Bob,
> > 1. On your revised (10-28-00) fig. Z-14 you have changed the wiring for the sky-tec starter and starter contactor. I recall some discussion of this on the rv-list but could you please review the issues and reasons?

A This change is to accommodate a problem unique to Sky-Tec and other permanent magnet motor starters. Voltage generated by the motor as it spins down causes a delayed disengagement of the pinion gear if the starter is wired like B&C and others with wound field motors. Adding the relay in the system as shown in Figure Z-14 takes care of this problem.

> > 2. On the same dwg. you have an altrnator ov disconnect contactor. Why is this needed?

A This is needed if you want to run an alternator with a built-in regulator. The disconnect contactor provides a way to unhook a runaway alternator from your system in the event of regulator failure. Bob . . .

Contactor, battery, bus

>>Bob, I have three questions: Re: Wiring Diagram Z-8 (Aeorelectric

>1) Why are'nt you using a fusible link (18AWG) or other form of protection between the battery contactor and the battery bus on Fig. Z-8 ? (p Z-16 of 4/00 edition)

A The battery bus is located right AT THE BATTERY. Short feeders (6" or less) don't require separate protection because (1) like a fusible link, they don't represent a large smoke/fire hazard and (2) being short and relatively open to inspection, they don't have a high probability of fault.

>2) What is the purpose of the fusible link (20AWG) betwen the essential bus and the battery bus? (does'nt the 7A fuse on the Batt. bus provide the needed protection?

A You need to protect a wire from ALL sources of overload. That wire has a potential source from BOTH ends. I used a fusible link at the e-bus end to avoid using up fuse slot on the fuse block . . . obviously, you could do that in lieu of the link, a link would be okay at the battery end as well. If you've got the spare fuse slots, use them instead. If you're running short, use links.

>3) Where does the IN4005 diode on the PM Alternator control relay (shown in a photo on your web site) attach on the Z-8 diagram?

A The anode (non banded end of the diode) goes to the same terminal on the relay as the black (-) lead from the OVM. The cathode (banded end) goes to the same relay terminal as the red/yel (+) lead of the OVM. Bob . . .

RE: starter contactor

>Hi Bob, I'm confused again. I've got a solenoid right on my starter. Some guys told me that I

don't need starter contactor in that case and I've just to bring the battery cable (from Battery contactor) right on the big starter's stud and to plug the solenoid connection right on the start's pole of the ignition switch. Is that true.

A You CAN use built in contactors included on MOST starters but you may not want to. See: http://aeroelectric.com/articles/strtctr.pdf ...If you DO use a built in contactor and the starter is a wound field device (like B&C) then you can make your starter engagement switch last a whole lot longer by adding a buffer relay as shown in Figure Z-22 of the AeroElectric Connection. If you have a PM motor starter (like Skytech) then the buffer relay is REQUIRED to prevent starter run-on and to protect the starter switch's contacts.

>In the wirings diagram, I saw that the main buss is wiring from the starter contactor. Where did I take my feed if I do not have a starter contactor, on the starter stud?

A Of the switched side of the battery contactor . . . but if it were my airplane, it would have an auxiliary contactor like our 702-1 that has no heavy inrush currents, draws about 4 amps while energized, has built-in arc suppression diode on coil and provides a hand location on firewall for power distribution and b-lead feeds when the battery is located remotely from the engine. See: http://www.aeroelectric.com/Catalog/switch/switch.html#s702-1 Bob . . .

Re: Contactor confusion

>> Hi Bob: I have a B&C master contactor and a four terminal starter contactor of the type that has two small terminals labeled "S" and "I." After rereading your book and several of your articles I got curious about the internal connections on these devises and started checking with my multimeter and found that I measure essentially zero resistance through the coils of both devises where your book and related articles says there should be somewhere between 4 and 15 ohms (all diodes and connections removed). Can you help me understand what is going on here? Both devises pull in properly when I apply 12 volts across the coil terminals.

A The diodes shouldn't make any difference when measureing these devices with a multi-meter. What kind of multi-meter are you using? Some of the lower cost, analog devices don't have a good low ohms capability. For example, I have an old "pocket" mulitmeter that reads 1000 ohms at midscale on the lowest resistance setting. This means that 4-ohms and 15-ohms would look like zero ohms on the instrument.

>Also, what is the "I" terminal on the starter contactor connected to? Van's suggested wiring diagram shows an optional lightweight starter hookup that has a jumper from the "I" terminal on the contactor to the starter solinoid. Any idea what that is for (I am using your Z-1, now Z-11 wiring but am unsure how to treat the Sky-Tec starter on my new engine)? Thanks for your continuing support and patience with these probably dumb questions.

A The "I" terminal is essentially a second power output terminal that becomes hot when the contactor is energized. See http://www.aeroelectric.com/Catalog/switch/switch.html#s702-1 and http://www.aeroelectric.com/Catalog/switch/S702Wire.jpg The "I" terminal was used on automobiles to boost ignition coil primary current during cranking. This terminal could very well be used as Van suggests . . . it will serve the same function as the starter-run-on buffer relay shown in figure Z-22 of the book . . . The "I" terminal has been used by some builders to drive a STARTER ENGAGED light on the panel. Bob . . .

Contactors, Current Limiters on Z22

> Hi Bob, >Just a few quick questions: 1) Do all the Z diagrams use S704-1 for starter contactors and S701-1 for Battery Contactors?

A Yes. However, we call out those numbers as minimum-effort acquisitions of two of many parts suited to the task.

>2) Z-22 (Permanent Magnet "run-on") says "size B-lead ANL limiter to Alternator and AWG to match". For a B&C 40 amp would that be ANL 60 and 6 AWG?

A We needed to upsize earlier JJS/JJN series fuses with respect to their alternators because of very fast response of the fuses. ANL limiters are much more robust as described in . . .http://aeroelectric.com/articles/anl/anlvsjjs.html . . . and are picked with ratings closer to the output of alternator. Therefore a 40A alternator gets an ANL40, the 60A alternator gets an ANL60
Bob . . .

Contactors, Re: Battery Solenoid Question

>>To clarify.....I attached my battery solenoid directly to the airframe using the two slots in the metal bracket. OHM meter shows continuity between the aircraft frame and the center post of the battery solenoid. Seems to me the center post on the solenoid should only be grounded when the battery side of the master switch is ON. Wire to battery side of master switch checked good..... battery switch OFF.... no continuity between wire and aircraft ground....battery switch on.... good continuity between wire and aircraft ground. Attached ground wire to center post of battery solenoid and still no current out the other side of the solenoid. Therefore, I'm not getting any power to the panel. This is my second battery solenoid. I must be doing something wrong.... ???? Suggestions and comments welcomed. I am Baffled....

A Just talked to Jack on the phone. It may be that his "fat" terminals are reversed on the contactor. 3-terminal contactors use one of the fat terminals as one of coil connections . . . ya gotta have battery power to the right one or you get symptoms like those described above. Bob . . .

Subject: B&C Starter Contactor Question

>> The B&C starter contactor has the two smaller studs, one marked "S" and the other "I". Am I correct in thinking the "S" is wired to the starter switch >. .

A Yes.

>and the "I" to firewall ground?

A No, the "I" terminal is an artifact left over from early days of 12v cars where they ran a 6v coil in series with a resistor to bring "points close" current down to appropriate levels. The "I" terminal was used to bypass the resistor during cranking to provide a hotter spark while the battery was heavily loaded by the starter motor.

>Would the "I" also go to the "starter engaged" light?

A It could. You need to put a fuse or fusible link right at the starter contactor and run a lead off to the cockpit to illuminate the lamp.

> Am I also safe in assuming that the starting current can be wired to run through the contactor in either direction?

A Yes

> Finally, some of the diagrams in the "Connection" refer to "case ground" in reference to the starter contactor. Does this mean grounding of the contactor case, and not grounding to the engine crankcase?

A Either would work but the handiest way to cover this requirement is to mount the starter contactor on a metalic firewall. The "S" terminal is one end of the contactor's coil, the other end is attached to the mounting base. If you have a composite firewall or the contactor needs to mount on a non-grounded surface, then a separate wire from contactor mounting flange to the firewall ground bus is in order.

Further, if you have our S702-1 contactor, there is a diode built into the contactor assembly to shunt away the inductive spike from the coil. If you have one of B&C's STC'ed contactors you'll need to add a diode from "S" to mounting flange. Use a 3A device from Radio Shack (about $1 for blister pak of 2). Banded end of diode goes to "S", other end goes to flange. Bob . . .

Subject: Re: Battery Contactor Question

>> Today I attempted to power up the core of my electrical system by turning on the battery switch and closing the battery contactor. My intent was to then connect the the main and essential busses and periferal circuits. The system is wired IAW the "Connection" using the B&C contactor. As soon as the switch was closed the 22AWG wire from the grounding bus and thru the switch to the terminal at the upstream side of the diode (away from the band) heated up. The contactor did not close. The + side of the battery is connected to the large terminal by the diode and the - terminal goes to the grounding bus. My limited knowledge leaves me stumped, and I would appreciate any input.>Lance

A Hmmm . . . sounds like the diode is bad or marked backwards (rare but it has happened). Temporarily remove the diode and see the contactor operates normally. If so, get a new diode from Radio Shack (3A rated at any voltage) and install it on the contactor per http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg If this fixes it, I'd like to get the original diode back for analysis.

Bob . . .

R Bob, thanks for the timely response. I removed the diode, turned on the battery switch, and....Voila! The contact clunked shut and the halogen lamp I had hooked up lit up the basement. I will send you the diode and hook up another. I quess what they say about the only stupid question is the one you don't ask is true. Lance

----

Re: contactors

>Bob, how does one distinguish an intermittent (starter) contactor from a continuous (master) contactor? Thank you. Ken

A Intermittent duty devices have lower coil resistance . . .on the order of 3-4 ohms. Continuous duty devices will be 10-16 ohms. Bob . . .

Re: Diodes on relay coils

>> I have your book and seem to remember a while back an article on the website about diodes on relay's coils to save the points. I want to install the diodes on a bosch relay (#0 332 002 150) I have for my hyd gear motor but in all the diagrams for the diodes no part #'s are listed or sizing of diode is shown for the diode on the coil of the relay. It is a 12volt system.

A You may want to review http://aeroelectric.com/articles/spikecatcher.pdf

>> I looked at the digikey website and found there is a $#%# load of diodes can you help with what size ?? I seem to remember an article on installing these on the website also a while back but looked today and could not find it.

A The diode rating is not critical but mechanical robustness is something to consider. I favor the 3A devices in the 1N5400 series devices (sold by Radio Shack in blister paks of 2 for about $1). Any voltage rating is fine. You can see these device and a typical installation at: http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg Bob . . .

Re: Bosch relay

>Bob and all, I am building an RV-8 with a Ray Allen G-7 stick grip. I'm planning on using Bosch automotive relays for flap control and autopilot servo disconnect. Any reason not to use these relays? What is the difference between the 330-070 and the 330-073? Thanks for any help. Ted .

A The only data I could find quickly on the -070 and -073 doesn't show any difference in them. Either appears suited to the task. Bob . . .

Re: Battery contactor diode

>Does the diode for the battery contactor need to be enclosed in heat shrink tubing? I understand the reason for the starter contactor.

A Doesn't have to but it doesn't hurt either. See http://aeroelectric.com/Catalog/switch/s701-1l.jpg for how we attach a 1N5400 series diode to the continuous duty contactor. Our starter contactors are supplied with a built in diode. If you're particular contactor doesn't have the diode built in, you'll need to add one externally between the "S" terminal (cathod-banded end of diode) and the contactor's mounting base (anode end) of diode. Bob . . .

Re: Battery Contactor Question

Bob, In my starterless, B&C dynamo'ed, day VFR only VariEze, it seems like the standard battery contactor is overkill. They are designed to handle a lot of continuous amps and burn a fair amount of power in the windings. I am considering substituting another relay to do the job. Maybe a power window relay from an early 70's Ford pickup? I think its rated at something like 60A max - I am trying to find its continuous duty rating. The napa-echlin part number echar200. Can you suggest another part number that would be a better choice? Or maybe a rationale for using the standard contactor?

A It doesn't even need to be that big. The little 1" cube SPDT relays rated at 20A or better would be fine. See our S704-1 at
http://www.aeroelectric.com/Catalog/switch/switch.html#s704-1
Lots of folks stock relays of this genre' Bob . . .

Battery Switch

Goto http://store.summitracing.com and search on SUM-G1432

This switch sells for $20 and is sufficiently rated to serve as a battery disconnect switch in a light
aircraft.

A I've had several builders replace the finger operated lever on similar switches with a belcrank arm. An auto parts choke/throttle control kit was adapted to the bell crank and mounted on the panel to provide a push-pull master battery switch. This is especially suited to airplanes with small or no alternator where you don't want to throw away an amp of keep-closed power and also don't want to buy the much more expensive, low-holding current contactors. Bob . .

Re: Solenoid Wire Size

> Dear Bob and list members, One of the biggest variables I've noticed in the various manuals and wiring aids is the wire size called out for the starter contactor. Bob's diagrams have them sensibly small, Bingelis would have fatter wires; my own kit manufacturer recommends 12 ga.

for both relays and the field circuits! My question is, what kind of current draw does one typically see to activate the starter solenoid? Many thanks, Jeffrey Steenson ABQ, NM

A See http://www.aeroelectric.com/articles/strtctr.pdf Some designers try to mitigate effects of starter solenoid inrush currents using fatter wires to maintain the snappy solenoid engagement with 20+ amps inrush. I prefer to use the B&C approach to always using a good quality starter contactor in series with the starter and wiring the starter's built in solenoid as shown in the Z-drawings. In this case, starter button current is about 4A. You can't do this with PM motor starters so Figure Z-22 becomes an attractive option where starter button current drops to about 100 mA. Bob . . .

Re: Contactors

>> Bob, I've positioned my battery and contactors so that they can be connected short, shrink wrapped lengths of your B&C brass bus bar stock. Any idea of the AWG equivelent of this brass stock? Should I double it up?

Single layer will be fine.

>On a similar note, I notice that drawing 11a shows 18AWG for the starter contactor, but 22 awg for the other contactors. Why is this?

Starter contactors draw about 5X the current Bob . . .

Re: S-701 Master (Battery Contactor)

> Hi Bob, A friend of mine which is an electrical automotive mechanical said me that it was better to install your master switch S-701-1 upside down. Is that true?

A Rotating contactors to compensate for g-loading in flight is one of those bogus ideas that have been floating around for a long time. Install them in what ever way makes the best sense for getting them hooked up. Bob . . .

Re: Contactors, Diodes

>I really want to understand where the diode goes on a relay. Which senario is correct. It goes from the small terminal which is switched to 12v, or to ground?

A The MECHANICAL positioning depends on the particular contactor or relay. For example: http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg shows how we attache the diodes to a contactor wherein both terminals of the energizing coil are brought out to small terminals on the side. The diode always goes across the contactor or relay coil. When you use a contactor with a coil lead connnected internally to the "BAT" terminal then the diode has to run between the "BAT" terminal (banded end) and the single small coil terminal.

For many starter contactors, the coil is internally connected to the contactor base . . . this means that the diode has to run between the small coil terminal (banded end) and the base. The contactors we offer all come with diodes installed on outside as in picture above or installed internally as with our S702-1 http://www.aeroelectric.com/Catalog/switch/s702-1l.jpg

Here's an example of how a diode can be installed on the smaller, S704-1 relay http://www.aeroelectric.com/articles/s704inst.jpg

The rating of the diode is insignificant. Any silicon rectifier diode will do the job electrically on any contator or relay. For smaller tasks 1N4000 series devices (1A rated) are handy. For larger tasks, I prefer the 1N5400 series for their mechanical robustness. Both diodes are available from Radio Shack. Bob . . .

Re: Contactors; Mechanical Latching Battery Disconnect

> Hi Bob, Sorry to belabor this. I'm not real clear on how to do what you are suggesting... I thought it important to be able to isolate the battery. It is located behind the occupants in the tail cone. Currently the Battery disconnect is in front of the occupants under the panel. That leaves the battery lead running under one of the occupants arms. It just seemed to make sense that one should be able to cut the power from this main battery lead in the event it were to short out in the cabin.

Sure . . there's a BATTERY MASTER contactor right at the battery. Open the battery master switch and everything but the battery bus goes cold. You have a battery bus right at the battery location too. Low current feeds (FAA likes to see 5A or less, I'm comfortable with 7A if fused, not breakered) drive directly from the battery bus. If you have higher current needs, then a mini-contactor, or fat-relay (like the S704 or it's solid state equal) is used to make feeds larger than 7A cold right at the bus. Your e-bus alternate feed comes from the battery bus, your engine dependent needs come from the battery bus.

Battery contactors and all other controls for more than 5A feeders should unhook right at the battery. It would be best if anything larger than 5A did not venture more than a few inches from the battery location before it hits a pilot controlled disconnect.

See this hypothetical:

http://aeroelectric.com/temp/batbus.pdf

Here I show a battery bus and a battery contactor right next to the battery. A FAT wire comes off the contactor to the starter contactor and main bus. A battery bus can drive:

.... a 1A protected lead of any length to a clock . . .

. . . a 1A protected lead to the hour-meter.

. . . a 3A protected lead to a switch for a Kettering ignition.

. . . a 7A protected lead gets a local disconnect relay for the e-bus alternate feed that's burdened with big transmitter and/or perhaps gyros. This could be a 10A feeder. The point is that long, always hot wires protected at over 5A need pilot controlled disconnect in close proximity to the bus.

. . . if you're fuel injected and need a hi-pressure squirter fused at 10A, it gets a relay too.

. . . a 1A courtesy light can go as far as needs be with no special concerns.

This is what I'd have to do to sell this or a similar system to the FAA . . . it has to do with crash safety. Always hot wires from the battery are either pilot controllable or limited to 5A or less. I've seen them allow breakers but fuses are MUCH faster and offer even greater safety. We've got a lot of builders who have built some pretty hefty e-busses . . . with bigger than 5A feeders for the alternate feed path. If it were my airplane, I'd use the local disconnect relay as shown for a budget of about 100 mA to keep the relay closed. Or better yet, a solid state relay with a 10 mA budget.

If I understand your hypothetical, you were going to have a LONG, FAT feeder from the battery coming forward to the battery contactor. This WOULD function but it's not recommended.

Battery bus is a fuse block like http://www.aeroelectric.com/Catalog/ckrtprot/fuseblks.jpg or a row of breakers tied together with a strip of brass just like the rows of breakers in every certified airplane. You mount the fuse block or mini-breaker panel right next to the battery with shortest practical leads for the always- hot feed between battery and bus. Bob . . .

Re: Contactors; 3 terminal contactor diode placement?

>I utilized a continuous duty 3 terminal contactor for my battery disconnect and was wondering how to place a diode? Thanks, Ned

A banded end of diode gets a 5/16 terminal and shares one of the fat terminals that goes off to battery (+). The other end of the diode goes to small terminal. Bob . . .

Re: Contactors; Starter Contactor Mounting

> I've got the starter contactor mounted on the firewall. It is what Bob calls a "Type I", nounted with the cap up. One of the airport crowd came by and suggested that it should be mounted 'upside down'. The idea apparently is that gravity will assist the spring in breaking contact and helping prevent starter engagement after the engine is running.

Ol' mechanic's tale that's been fertilized too
much for decades . . .

>I've used this contactor for 18syears in this position and don't think this is a concern. I've seen them mounted both ways and wonder if there is a preferred way.

Nope . . . but be aware that this style contactor
http://aeroelectric.com/Pictures/s701-1l.jpg
is increasingly difficult to find in a high-pressure, intermittent-duty style best suited for starter contactor service.

If you're using continuous duty versions of this contactor -AND- in light of exemplar service experience, there's no pressing reason to change from what you've been doing. However, the continuous duty contactors used in this position are more likely to stick or weld shut . . . this has nothing to do with direction of gravity.

If you ever stick this contactor, you might consider replacing with this intermittent duty style: http://aeroelectric.com/Pictures/s702-1l.jpg which is about as bullet-proof a starter contactor as you can buy.

>Also, is it possible to add a "starter engaged" light (probably be an LED) powered by a small wire on the terminal running to the starter? Or will the high current fry a piece of 22 AWG wire in that location? The particular contactor has three terminals.

Sure. If you want to use an LED, you'll need to put a resistor in series with it. Mount this resistor AT THE CONTACTOR end of the wire. This impedance jump at the source end will protect the wire. Also, put a diode in parallel with the LED with banded end (cathode) of diode tied to plus side (anode) of LED. LED's are relatively robust for forward transient currents but rather fragile for reverse transients. The diode (1N4005 or similar) combined with your 330 ohm resistor at the feed-end of the wire will protect the LED. Bob . . .

Contactors

> Bob - thanks for that. In that case I will get a S701-1. But for my education, why cant I use the VANS 3 terminal unit? Surely it is internally wired as in the top right of the attached diag. with the coil between the third terminal and the case which is grounded to the firewall? Doesnt energising the coil, terminal to case pull the contactor in, and vica versa? (If the diag. does not go through matronics, it is yours and labelled - 'OV protection for built in regulator 1.0' It appears to have the filename 'bleadov.pdf' which I suspect is your name for it.)

A To use a contactor with coil internally connected to the BAT terminal, you need to pull to ground to close the contactor . . . like for the battery master. Your alternator control leads is a pull up to bus to turn the alternator on. To satisfy both of these conditions, you would have to have a 3-pole DC PWR master wired like:

http://www.aeroelectric.com/temp/sampson.gif

By going to a 4-terminal contactor, you can make both alternator AND contactor operate by pulling up to bus with one pole of a two pole master switch. Bob . . .
----

9. DIODES / RESISTORS

Re: spike eating diodes again

>

>Hello Bob, It appears that a significant portion of the questions that you receive deal with the spike suppression diodes. You have my understanding and sympathy if you feel that we acolytes are beating a dead horse, but still I'd like to give that poor beast a few more whacks.

A Hmmm . . . if he's still twitching, whack away . . .

>I have gleaned two fundamentals regarding connecting the spike suppression diodes from your teaching:

>1) The diode goes across the coil of the contactor.

A Yes

>2) The cathode end of the diode (the one with the bar in the diagrams and the one with the stripe / bar / darkening on the diode itself) connects to the positive end of the contactor coil.

A Correct

>Now I'd like to describe a local circuit diagram:

A) Envision a three terminal battery master contactor. One contactor large terminal is connected by heavy AWG wire to the plus terminal of the battery. This same contactor terminal is also connected internally to one end of the contactor coil inside the contactor.

B) The other large terminal on the battery master contactor is connected by heavy AWG wire to the input side of the airplane's starter contactor.

C) The one small terminal on the side of the battery master contactor is connected internally to the opposite end of the contactor coil from A) above. This small terminal is also connected externally by wire to the battery master switch. When the battery master switch is closed it completes a circuit to ground, current then flows through the contactor coil and the contactor coil magnetic force moves the slug which closes the contact points between the two large terminals.

A Correct so far . . .

>D) The circuit diagram in question has a spike suppression diode connected from the small terminal of the master battery contactor directly to ground. The cathode (bar) end of the diode is on the terminal end of this connection to ground.

A I presume your talking about somebody else's wiring diagram. What you describe is a situation similar to an airworthiness directive issued against the classic OFF-L-R-BOTH-START keyswitch offered by Aircraft Spruce and others. The AD was INTENDED to replace starter switch contacts badly burned by the inductive effects of the starter contactor and add a diode for the purported task of mitigating the inductive kick from the contactor and improved on switch contact longevity. The AD calls for putting a diode ACROSS THE SWITCH contacts.

Take a peek at: http://www.aeroelectric.com/nodiode.jpg

Here's an oscilloscope trace of the inductive kick across a contactor coil when no diode is present. I had to rig a very fast switching mechanism so that contact spreading velocity was too high for a fire to form between the opening contacts . . . Voltage across the coil rises quickly reaching more than 300 volts in about 300 microseconds.

Take a peek at: http://www.aeroelectric.com/doncoil.jpg

Here you see how the diode stops the intensive negative going swing of the inductive spike because electron flow of the spike puts the diode in a FORWARD conducting mode.

Now look at: http://www.aeroelectric.com/donswtch.jpg

Here, the diode is across the switch, just like the FAA says you should do it. Note that the collapsing field in the contactor coil is taking the terminal negative, just like it did in the first picture you looked at . . . this puts the diode in a REVERSE current mode . . . no current flows.

Note in this figure how we can see where the fire lights up between the poor switch contacts. We can also see where the fire finally goes out after about 1.2 milliseconds. The remaining field collapse still takes the spike to over 300 volts.

>Now the local circuit described in A) through D) above appears to me to violate the two criteria given in 1) and 2) above because the diode is not across the coil and the cathode (bar) end of the diode is attatched to the negative end instead of the positive end of the coil. I am further

concerned because it appears to me that the plus terminal of the battery is constantly connected to ground through the contactor coil wire and the diode.

A The situation you describe is the same as for the starter contactor example shown in the figures above. The diode is in the WRONG place to do its job. Your perceptions and suspicions are well founded with the exception of the last sentence. Note that with a diode across the battery master switch contacts and with the switch open, the small terminal of the contactor coil rises to battery voltage. This puts the diode in a reverse bias mode and no current flows.

>So here are my questions:
>AA) Will the circuit described in A) through D) above provide proper spike suppression protection for the battery master switch?

A No . . .

>BB) If the circuit described in A) through D) above will not provide proper spike protection what connection of the diode and small terminal will provide the proper protection?

A None . . . ya gotta put a BIG terminal on one end of the diode and tie it to the battery side of the contactor . . . I.E. get the diode properly wired across the coil.

>CC) Will the circuit described in A) through D) above have any adverse affects on the intended or desired circuit operation?

A Battery contactors don't store a lot of energy. Likelihood of experiencing observable wear and tear on the battery master is problematical . . . intermittent duty starter contactors draw a LOT more current and store more energy, hence the situation that brought the FAA cavalry galloping over the hill to save us from an enemy they didn't understand.

>Separate, but related question: Of these two diodes listed below which one is preferred for spike suppression and why?
>DD) Type 1N5400, Cat No 276-1141, 3 Amp, 200 Amp Surge, 50 Peak Inverse >Voltage.
>EE) Type 1N4001, Cat No 276-1101, 1 Amp, 30 Amp Surge, 50 Peak Inverse Voltage.

A Take your pick . . . ANY diode does the job with respect to physics of the task. The electrical stresses on a diode in this application are tiny. I PREFER the 1N540x series diodes because they have bigger leads and a mechanically more robust design. You can see how we put the diodes on in.
http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg
http://www.aeroelectric.com/Catalog/switch/s701-2.jpg
Note these diodes ARE the 1N540x series devices. You can get these from Radio Shack in blister paks of two diodes for about $1.
The starter contactor shown at . . .http://www.aeroelectric.com/Catalog/switch/s702-1l.jpg . . . doesn't have a visible diode . . . the contactors we buy have the diode already built in.
Bob . . .

S From: John, Subject: Re: spike eating diodes again

>> That doesn't make any sense - if you want to stop contact arcing, you put a _capacitor_ across the contacts, not a diode... you put the diode across the coil to clamp the reverse EMF. This is SOP, no, required engineering practice - and the FAA doesn't know about it?!?

A A capacitor across the coil behaves like the capacitor across the points in the tried and well worn Kettering ignition system we drove for about 70 years. Here the task was to mitigate arcing at the points WITHOUT restraining the magnitude of the voltage swing. All the capacitor does is give the voltage rise a shallower slope so that the points (slow, cam operated) have a chance to open and break the arc . . . from that point on, the field continues to collapse in the coil and you get the full effect of that collapse at the coil's secondary winding when the spark lights the fire in a cylinder.

A capacitor COULD have a similar beneficial effect for switch contacts. In fact, if you use a capacitor and resistor in series (so that the capacitor doesn't dump high inrush to the switch contacts as they close) you could very readily protect the contacts on switch that controls a battery or starter contactor. This is discussed in detail in chapter 6 of the AeroElectric Connection.

Reverse or counter EMF is that voltage generated by the RISE of magnetic field in the coil that causes coil current to ramp up in the classic mirror image of an R*C curve except in this case it's an L/R curve. The diode is not a participant in the routing of current flow while the switch is closed/closing and the current is rising. Counter EMF in magnetic circuits is always less than applied voltage.

The diode only goes to work when the circuit is broken and the collapsing magnetic field is trying to maintain current the energized current flow. This isn't counter EMF but an unrestrained forward EMF that works hard (300+ volts!). Unless routed off to do harmless work by warming up some diodes and wire, will start a fire across the switch contacts and burn away some metal. The photos I published show that this effect is achieved in grand style with a diode across the contactor's coil.

Perhaps somebody in the FAA understands this but I've never met them. Whoever did the AD on the ACS keyswitch obviously didn't understand it either.

>BTW, _is_ a capacitor across the switch a good idea? I don't think it's really necessary if you've got the clamping diode, but I guess it wouldn't hurt (unless you consider it another "point of failure" item where the risk outweighs the benefit).

A Don't need the cap if you have the diode. The cap and series resistor are bigger and more expensive than a diode and the diode is much easier to install and mechanically more robust. Once the diode is in place, there's nothing for the capacitor to do. Back before I fully understood these things, I thought it would be cool to make the points in my '57 Chevy last forever by putting a diode across the coil. Sure 'nuf . . . no arcing . . but the engine didn't run either.

That's when I built my first transistorized Kettering system with a rewound GM coil and a three 2N174 germanium power transistors. Point current dropped to 1 amp purely resistive and the capacitor went away. The problem then became one of keeping the points working good. When the fire went away, the natural ability to burn away oil film went away too. A brand new set of points would get flaky and had to be cleaned periodically because the o-ring in my distributor shaft wasn't keeping the greasy stuff out of the points compartment. Not all that glitters is gold . . .

>Anyway, thanks for pointing out the obvious about the diode, I'll have to check mine (it's got an external diode wired across two contacts, I'll have to check which ones)... I had assumed it would be wired correctly across the coil not the switch...

A You got it. . .Bob . . .

S >> >>Bob wrote: the points in the tried and well worn Kettering ignition system we drove for about 70 years. Here the task was to mitigate arcing at the points WITHOUT restraining the magnitude of the voltage swing. All the capacitor does is give the voltage rise a shallower slope so that the points (slow, cam operated) have a chance to open and break the arc

SR *** Not exactly. If I remember correctly, the capacitor and the ignition coil form a resonant circuit, producing high-amplitude oscillations at the primary of around 10 kHz during spark discharge. Take the capacitor out, the engine will run very poorly - if at all. So it's not just there to protect the points.

A same-o, same-o . . . with the capacitor out the coil collapse rate was a function of it's self resonant frequency . . . much higher than with a capacitor added. Voltage rate of rise would be so fast that a fire would form between the points that never went out until stored energy in the coil was used up. . . . energy stored in the coil would be expended burning points and none made it to the spark plug. If you add too much capacity, rate of rise is slowed too much (resonant frequency too low) and spark performance suffered.

"Protecting the points" and maximizing the energy fed to the spark plug were hand-in-hand benefits of choosing the right size capacitor for the task. Bob . . .

Re: Heatsink for diode - 1.5A dimmer

>>Bob, Looking at the picture of your 1.5a dimmer... why is it that the one I bought from Vans Aircraft is much smaller and has a tiny heat sink? It is also a 1.5a dimmer.

A it may be a switching type controller. They run cooler but have a potential for noise.

>If I cannot find a heat sink, could I make a simple one from a 0.064" aluminum sheet (bent as a U)? What size would be appropriate?

A Hmmm . . . I've built heatsinks but the biggest problem is to get good thermal conductivity between the multiple layers needed to fabricate a array of "fins" . . . I'd rather you used a heatsink from B&C. Bob . . .

Spike catching diodes

>1) Does the diode always get installed so that it provides a connection between the solenoid switch terminal and some other part of the circuit?

A the diode should be installed such that it is across the coil of the contactor (solenoid) as shown in all of our drawings.

>2) Does it matter which other part of the circuit that the diode connection goes to? I see on Tony's diagram that the diode connection is made to the plus or input side of the relay. I see

that on your sketch you show the diode connection going to ground. Which is correct / better?

A . . . across the coil are the magic words. Depending on how the contactor gets it's power to energize, one side of the diodemay or may not be connected directly to ground. For the starter contactors we sell, the diode is built into the contactor and just happens to have the arrow connection (anode) of the diode connected to ground. On battery contactors . . . the anode eventually gets to ground but it's through the battery master switch.

The one thing that can be said about the diode installation in ALL situations is that the anode (arrow head end) always connects to the (-) end of the coil, the cathode (bar end) always connects to the (+) end of the coil.

>3) When diagramming this diode connection which is the proper direction for the diode triangle to be pointing? I see on Tony's diagram that the diode triangle has the base connected to the solenoid switch terminal. I see on your sketch that you have the point of the diode triangle connected to the solenoid switch terminal (and the base of the triangle connected to ground).

>4) When the switch has been closed for some time is there supposed to be any current flow through the diode?

A No, current only flows for a few milliseconds AFTER the switch controlling the contactor opens.

>5) Which way is the current from the collapsing coil field supposed to flow through the diode when the switch is opened? In the direction that the diode triangle is pointing or opposite to the direction the diode triangle is pointing?

A When the contactor is first energized, electrons supplied by thepower source come from ground and out of the (+) connection of coil connection. When the power source is interrupted, the collapsing magnetic field makes the coil a source of electrons as opposed to load for electron flow. The effect is to attempt to maintain flow in the same direction as the excitation force; the (+) terminal still produces a strong electron flow which drives the terminal negative as shown in the many oscilloscope traces of the article I cited. Electrons flow through a diode in opposition to the direction the arrow points in the diode's symbol. So, in the short interval after the switch opens, energy that would otherwise drive the (+) terminal several hundred volts in a negative direction are clamped off by diode and rendered harmless.

>6) When one has a diode in hand how can one tell by looking at its markings which end the triangle is pointing towards?

A The banded end of the diode is the cathode (bar end) of schematic symbol. A little study of the photos of battery and cross feed contactors in our website catalog should produce a re-enforcing view of how these devices are used. Bob...

Resistors

>I don't know if this will help you but I recently needed a precision 9.5 ohm resister to repair a multimeter that got zapped and ran into the same problem of having to buy $60 bucks worth to get one. I worked around it by using a $2.00 subminiature 20 ohm potentiometer set to the proper resistance and sealed with epoxy.

A Potentiometers make mediocre fixed resistors . . . and very poor precision resistors. The "adjustable" part of a pot is a wiper than moves over the surface of a resistive element. The contact pressure, surface condition, etc have a profound effect on the series resistance that is a part of the wiper's connection with the body of the pot. For example, you needed 9.5 ohms and probably got that value when you adjusted it the first time. Part of that 9.5 was contact resistance of the wiper . . . it might have accounted for several ohms of the total resistance. As the pot aged and felt the effects of the environment, the body of the pot might be expected to be quite stable but the wiper's contact resistance cannot.

If you expected 1% tolerance (+/- 9.5 milliohms) and the contact resistance at set-time was 2000 milliohms, it's easy to see how a normal variation of several hundred milliohms of contact resistance can blow away the accuracy of the set-point.

When used as a voltage divider where contact resistance is washed out by keeping the wiper's current load very small, an adjustment can be quite stable . . .

Digikey will sell you a bag of 5 precision resistors for $1. Since the lowest value you can get in the jelly-bean variety precision resistors is 10.0 ohms, you need to parallel the 10.0 ohm resistor with a 191 ohm resistor to get 9.50 ohms. You have to throw away 80% the resistors you buy but they only cost $2 total. This combination of stable devices can be expected to be very close to 9.50 ohms for a VERY long time. Bob . . .

------

diode

> Will a 10 amp. diode unit do the job for the e-bus application? I happen to have one it is what you describe in almost every respect. The exception is that the cube has no facet at the + connect corner. Having brought the diode unit into much better light I now see a part number; KBPC3510.

A That's a 35A 1000v device. Quite suitable. The larger current rated devices will have slightly lower voltage drop at the low currents we operate them. Bob . . .

Fw: Diodes; Spike-catcher failures

Here's a thread that's been going on the Velocity builder's list server. Food for thought for all!

---- Original Message -----It is obviously common practice to use diodes and Transient voltage suppressors (TVS) to kill the backward inducted current from devices with coils (relays, motors, etc.) to protect the contacts in switches and relys from arcing. Have we also considered the consequences of these little jewels failing; especially failing in a shorted condition; which, I believe is the most likely failure mode.

I had installed a TVS (a P6KE27DICT TVS from Digikey rated 27v 600W) across the coil on a battery contactor. It has been there for a year or two and has worked well as I cycled the gear or whatever. Also in testing circuits I have many times closed the contactor by touching an alligator clip from battery - to the ground terminal of the coil for momentary closing, and was pleased to note that there was little or no arcing. Until the other day, when I went to do that and got a bunch of sparks. What! I put it on again and realized quickly that I had a dead short and things were getting hot in a hurry. The TVS had failed shorted.

In a typical circuit, the battery switch on your panel closes that contactor coil circuit to ground. A shorted TVS, or diode, makes that an unprotected short to ground, and I'd think could smoke some #22 awg pretty fast. What's wrong with this picture? Are we assuming that these things don't fail?

Similarly; a shorted diode that you have across your trim motor relay would cause the trim to run all the way to one extreme and stay there. Can you fly and land your plane with full up or down trim? Could be be real tough, especially if you haven't trimmed the trim spring to allow full travel in the opposite direction with some hard pulling on the stick.

I have a bunch of the 1N4001 diodes that I planned using across small relays. I think a diode across a contactor needs a higher current rating, but how high? And how does one determine the rating required. Us electronically challenged nuclear engineers, educated mostly before the advent of semiconductors, want to know. Thanks, Al

S Al, You are correct, this had been a problem and has resulted in problems with general and commercial aircraft. I could not find my notes for an IA conference in early 90's but did find info in notes from a conference this year. AD 90 03 19 R1 required all spike suppression devices to be removed from a commercial transport because of fire in the heater elements that was caused by the spike diode that shorted the relay to ground. The FAA will not allow any electrical system to be installed in an aircraft that has a spike suppression device across the coil of a relay that is connected to a high current power source. The key is "HIGH CURRENT".

On low-current systems it is still ok but as you noted this type of system will almost always bypass the circuit breaker and burn something up. If using a spike suppression device, try to use a transorb (Mosorb), try 1N6284A/ 1.5kE36A, Motorola. Cost less than $1 and works much much faster. Remember, low current only. Johnny Thompson XLRG N5UP

S It would be informative to connect the shorted diode to a piece of 22 ga mil spec wire then apply 13 volts and see which melts first. I'll bet the diode burns open before the insulation is damaged.

S Well; I did just that. Based on two tests, you lose your bet 50% of the time. I first did the test on the TVS that had failed short the other day. Recall that it had heated pretty seriously before I opened the circuit. I put it between two 10" lengths of #22 wire and applied 12 volts. The TVS opened in less than a second and not much else happened.

I then failed a 1N4001 diode by passing a pulse of forward current exceeding its rating. I then connected 12v in the other direction. The results were dramatic. The diode and its leads were the first things that got red hot; followed quickly by the #22 wire becoming red hot and essentially vaporizing all of the tefzel insulation. A couple seconds more (at least it seemed that long) and the insulation began melting on my #18 wire jumper; at which point I gave quick tug on the alligator clips which pulled the diode apart.

My Conclusion: DO NOT put a diode across a relay where the relay coil is in a circuit that closes to ground. In fact; look closely at any circuit where you have used diodes to increase the life of the contacts in a switch or relay and consider the consequences of a shorted diode.

Possible solution: My son (who is not electronically challenged, and makes his living designing microprocessors and other circuits, suggests the following:

There are two other "snubbing" approaches you can use which won't have a single point failure.

1) Diode and resistor in series. Resistor value would be chosen to match resistance of coil. Unlike the purely resistive snubbing which would place additional drain on the battery, the diode will prevent the current from flowing through the resistor in normal mode. The resistor protects your circuit in the event of a diode failure, and still allows the relay to operate. In snubbing mode, the current flows through the resistor and the diode.

2) Resistor and capacitor in series. With this approach, the capacitor is chosen to "absorb" the energy from the coil. However, the circuit will now resonate. The resistor is added to dampen the resonance. Choosing the values of both the R and C would depend on the inductance of the coil, which is something you probably don't know. So, there would be some trial and error involved with choosing values. I think approach #1 will work very well.

S Sounds right to me. The resistance of the battery contactor coil is about 15 ohms. Put a 15 ohm resistor in series with the diode, and the current in the rare event of the shorted diode would be less than an amp. Keep the resistor in the open air where it can dissipate some heat. Typical 15 A relays have coil resistance of about 150 Ohms. Put in a 150 Ohm resistor with your diode and shorted current is limited to less than 0.1 amps. Not enough to drive your trim motor.

Anyway; it makes sense to me not to risk myself and my plane in an effort to prolong the life of the contacts in a relay. Failure of the relay is likely to be inconsequential. Best, Al

----

Re: Diodes; Assy

>I need to order a D25 Diode assembly. I ordered a bunch of parts from B&C, but they were unable to supply the diode. Do I order it directly from you?

A No, I don't sell parts any more. You can use a Radio Shack 276-1185 . . .

Re: diodes

> > The diode needs to be rated for 15v or more and be capable of carrying the same current that it takes to energize the contactor (1 to 5A) for a few milliseconds. About any diode rectifier is electrically suited to the task. 1N400x series are fine but they are rather small, sometimes glass devices that are fragile compared to the 1N540x series devices that are always 1/4" diam plastic and 20AWG leads.

If you look at the diodes we supply on the S700 series contactors at http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg and http://www.aeroelectric.com/Catalog/switch/s701-2.jpg . . . you can see how the mechanically more robust 3A diodes lend themselves to the task. ANY diode you can find will work electrically . . .chose for convenience of application.

>Sorry to bring this back up, but the vagueness of "ANY diode" has left my head spinning as I look at page 468 of the Digikey catalog (Sept-Dec 2002). There's a selection of 1N540x diodes

(bridge rectifiers?), the variation being the "max peak reverse voltage." It ranges from 50V to 1000V. Can I assume that 50V is sufficient? Is this voltage what you meant by "rated for 15v"? They all cost the same (32 cents), but does "going big" equate to being conservative? Or should I really just throw a dart at the page and choose one that way?

A The very best way to get confused is pull down a catalog with too many choices. Go to Radio Shack and ask for a "3A diode". They only stock three numbers: 276-1141, 50-volt; 276-1143, 200-volt; and 276-1144, 400-volt and any of them will work fine. Two in a blister pack for about $1.25 Bob . . .

Re: Diodes: Lighting, Forward Voltage Drop (Wig-wag)

>2. I am concerned about the voltage drop using the bridge rectifier causing a reduction in brightness of the lamps. I believe the Connection says that these diodes have a forward voltage drop of about .6V. My own measurements show this drop to be about .8V when used in my E-bus setup. This is using the diode I got from B & C. I picked up a similar diode from the Shack, pn 276-1185, and it lists the forward voltage drop as 1.7V. Is this at the full 50V? Is the drop linear with respect to input voltage? Does it vary with current? Most importantly, does this small voltage drop result in a noticeable loss of light at the lamp?

S >Try this. Have a friend set in his car 1/2 mile away on a dark road and have him turn on his headlights ten times in a row for about 5 seconds each time.

S Now Bob....Jeff got to this argument late, so let me rehash--

If you run Radio Shack diode, pn 276-1185 with a current of 5 amps, you wind up with 0.85 Volts drop. At 16A you get 0.94V. The forward voltage drop Vf is not linear and goes up with temperature and current (not voltage) and is maximum at max current. I don't think Radio Shack sells any 1.7Vf parts, but you can measure this with any meter.

Reasonable people differ on this but I think it is there is a lot to be said for using Schottky diodes in this application. At 5 amps the Vf is only 0.32V, at 16 A it is 0.35V.

Now why would anyone care about such small Vf differences? Well, it's because the electricity you use in an airplane or by a battery OR by an airplane battery(!) is expensive stuff indeed. And the use of power Schottkys is the engineering standard in battery operated systems, and where power loss is critical. Contemporary designers don't use p/n diodes in low-volt power applications.

How much power is lost? There are a lot of ways to paint it but Powerloss=IV(forward). So for 16A you lose 16x0.94Watts=15 Watts. This is dissipated as heat so you'll need a big heatsink. For the Schottky you'll lose 16X0.35=5.6 Watts so you need only a very small heatsink if any at all. And yes it is easy to see the difference in lamp brightness.

I don't know how you calculate the energy costs in an airplane, but the ultimate cost of using P/N diodes (especially in a bridge) has got to be significant. So use Schottkys. Buy mine or get your own. Regards, Eric M. Jones

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Re: diodes

> Bob ... can you remind me why there are so many diodes on the various contactors? I'm building the 'all electric' airplane and don't really know why they are there. Regards, David

A See http://www.aeroelectric.com/articles/spikecatcher.pdf

The S701-1 contactor from B&C is fitted with a single spike catcher as shown at:

http://www.bandc.biz/S701-1.html

The S701-2 contactor is for crossfeed service and needs two additional diodes for steering power from either hot bus to the close the contactor. Hence it has three total as seen at:

http://www.bandc.biz/S701-2.html

Bob . . .

Diodes:

>PS Is it worth putting diodes in the circuit or are the motors just too small?

A PM motors do not behave like relay and contactor coils. No diodes are necessary. They're useful on any relays, contactors and solenoids that are employed in your system. Bob . . .

Re: Diodes

>3) What does the diode on the starter solenoid do? The solenoid I bought (from Wicks, I think) came without one. What's the spec for the diode? What pins to install it between?

A See http://www.aeroelectric.com/articles/spikecatcher.pdf ANY rectifier diode 1A or larger, 50V or larger is fine. Check out 276-1141 rectifiers from Radio Shack. Two to a package for about $1.25. If the starter contactor looks like:

http://www.aeroelectric.com/Pictures/s702-1l.jpg

then see this for wiring info:

http://www.aeroelectric.com/Pictures/s702wire.jpg

Diode would go from "S" to base on the contactor. Banded end of diode to "S"

Bob...

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10. FUSES

Fuse, on the bus wire?

>> Bob- I understand the need to protect the Alt B lead at the battery [protection is given to the wire to keep the battery from becoming an arc welder if the wire shorts]

A Actually, the greatest risk to that wire is from shorted diodes inside the alternator . . . for short runs of HEAVY wire, there is little risk of the wire itself getting shorted to ground.

>why isn't the lead from the batt contactor to the buss similarly protected?

A For the same reason as cited above. The large feeders are not at much risk of shorting in a way that puts the wire in jeopardy. We go to extra pains on installation to support such conductors and minimize risks but they are already very small. There are hundreds of thousands of airplanes that have no "extra" protection of large power distribution feedlines. Bob . . .

Inline Fuse Rating

> If I understand your Figure Z1, I am going to route the B lead from the alternator to the battery side of the Starter contactor. I am running a 35 amp alternator supplied by Van's and I have a few 50 circuit breakers laying around, will this be enough to protect the 4awg wire? Or should I go with a heavier inline fuse? If the fuse what amp?

A No, the 50A breaker is fine. Mount it on a bracked close to the starter contactor.

Fuse link

>> Bob, Your drawings show from the main bus to the master switch alternator side a fusible link then routing through a circuit breaker to the alternator field. Is the double protection necessary or is the fusible link suggested as an option? Dave Ford RV6

A protection for a wire needs to be AT THE BUS. If you're using a fuseblock mounted away from the panel, then there's an unprotected wire that runs from the main bus up to the DC MASTER and ALT FIELD circuit breaker. Using a fusible link at the bus takes care of the short wire, the c/b takes care of the ov protection and downstream wiring. Bob -------

RE: Fuses vs. Breakers exchange

>Interesting discussion. I agree with many of you that the pilot should be FLYING while airborne and should save the MAINTENANCE until on the ground. A properly designed system will allow you to continue the flight without the NEED to change any fuses or reset any cb's. I swerve slightly however, and come down on the side of the cb in the cockpit simply for pilot awareness. The popped cb tells me exactly what the problem is so I can continue the flight COMFORTABLY with that knowledge.

A Spent the whole day today in a "Red Team" meeting where a good customer with a lot of airplanes has his shorts in a bunch. Seems a low-rate but persistent nuisance trip of a warning system will sometimes result in a scrubbed mission or putting an airplane down away from home field. In the later case, passengers and crew of the afflicted airplane have to buy commercial tickets. Technicians and other pilots have to fly commercial to recover the airplane.

I've participated in hundreds of problem-solving efforts over the years involving systems that draw everything from milliamps to hundreds of amps from ship's power. I've witnessed gawd-awful burned up motors, contactors and power supplies. There have been plenty of microprocessors that wandered off to la-la land. I cannot remember one case where the problem to be solved first made its presence known by popping a breaker.

The ones that popped breakers were fixed by the mechanics (they found the shorted wire or hard-fault failed component). The problems that don't pop breakers (aside from wires that came loose) are often the hardest to fix and they greatly outnumber problems that do pop breakers. This is the way most radios fail and it always means a trip to the shop.

I am mystified by any notion of comfort to be derived from knowing or not knowing that a fuse/breaker is open or not open. Many of our new designs on the big ships use remotely controlled breakers driven by flight systems management computers. When a system mis-behaves, we light a lamp anyhow to tell a pilot the thing isn't working. He doesn't know and couldn't care less as to why. We don't have to annunciate "AFT COMPRESSOR RCB OPEN" . . . his pax are already telling him, "it's hot back here!"

Popped breakers were not mentioned in today's meeting either but I have taken notice of an delta-p switch built and certified with 30 year old, very process sensitive technology. Few people have the skill and patience to make this product work well today. It's time to do a simpler, no-moving parts upgrade . . . just like swapping out all those breakers and a bizillion threaded fasteners and lock-washers for the little plug-in block of plastic with only one part . . . and it doesn't move. Bob

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Fuses / Breakers

>>Bob, I have been reading your articles. You make the point in an article about fuses vs breakers that the fuse is there to protect the wire. I was wondering why specially protect the wire? If I put a fuse on the end user (say a radio) that protects the radio. If I size the wire correctly for the load (temperature rise), then the radio fuse would kick in before the wire gets hot, so both are protected. Does that make sense?

A Only in a very limited sense. In airplanes and most DC powered vehicles, the branch circuits are fixed load. Unlike your house, loads at the ends of a wire in your airplnae tend not to change. A branch circuit for your bedroom may never be loaded more than a couple of amps yet the breaker that PROTECTS the 14AWG wire to all the lights and outlets in the room is 15A device designed to keep that piece of wire from catching fire. The fact that a short INSIDE a radio (or bedside lamp) will also open a breaker or fuse doesn't mean that the radio is afforded any useful "protection" . . . after all, it just shorted, went belly up, and took out it's own power source!

The important event here is that the power source went down to protect the intervening wire . . . if something craps inside an accessory and presents a hazardous overload to the power supply wiring, #1 task is to protect wiring. #2 task is to keep the failure from propagating to the rest of the system. Any "protection" afforded the dead appliance is #3 in line and way down on your list of concerns for comfortable operation of your airplane. Bob . . .

Fuses, breakers

> Hi, Bob >Question 1 : While studying Fig Z 16 in Rev 10, I'm not sure I really understand the role or the 5 A breaker in addition to the fuselink between the masterswitch and main bus. I gather this breaker trips when the crowbar module pulls pin 4 to ground in case of overvoltage. It so de-energizes the relay, disconnecting the alternator feeder from the battery contactor and main bus. Is that correct ? But then, why the fuselink at the main bus ?

A Assuming that the bus is a fuseblock mounted remotely from the panel mounted breaker and switches, we need to protect the wire that EXTENDS the bus from fuseblock to breaker. Hence the fusible link. Some folks have tried to use one of the fuse slots in the main bus to replace the fusible link and found that some 5A breakers will open a 30A fuse when the crowbar hits it . . . so the fusible link is much preferred.

>Question 2 : On the same diagram, why does the fuselink at the starter contactor seem to be downstream from the feeder ?

A That's a real fuse in the form of an ANL or JJS/JJN series device. The threat to this wire is not from the alternator but from the battery . . . an alternator is supposed to be incapable of opening its own b-lead protection (Such is not always the case, tens of thousands of certified ships have b-lead breakrs designed to nuisance trip). See:
http://aeroelectric.com/articles/anl/anlvsjjs.html
http://aeroelectric.com/articles/fuseorcb.html
http://aeroelectric.com/articles/fusvsbkr.html

>If this is really so, what protects the feeder between the capacitor and the OV relay ? Or is it that in case of fault on the feeder, the curent flows from thebattery to the faulted point ?

A You got it. Alternators are inherently current limited. They cannot damage their own power output wiring. Bob . . .

Subject: CBs vs Breakers

I did not realize reading Bob's text how compact a blade fuse installation can be. This evening, I wired my fuse panel and I am pretty impressed with the number of wires coming out of it! See: http://mthobby.pcperfect.com/ch601/daypict.jpg 22 circuits, main bus feed, ess bus feed and alternator field (not yet connected). All on a panel 10"X6" that will take 0"X0" of instrument panel space. Michel
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Re: FUSE Alternator Field line protection

>>Bob, In your earlier versions (Z-1) of the Z-11 schematic you showed a 15 amp fuse before the switch and a 5amp circuit breaker after the switch protecting the wiring to the Bus terminal of the LR-3. In the later versions (Z-11) you have changed to a fusible link in place of the fuse with the 5amp circuit breaker in the same position. Would you describe the rationale for the change?

A Sure. Things melt due to current flow with a characteristic that is fairly constant for the material, length and cross-section. It's called the I(squared)*T constant. While you can have a variety of materials and technologies designed to burn open in sufficient time to protect any given wire, you may find that their Isquared*T constants are very different. So, if you hook a 5A breaker and a 5A fuse in series with each other, and short the circuit to a hefty battery, you will find that the fuse always opens before the breaker. Okay, up=size the fuse. A 10A fuse will open before a 5A breaker and in most cases, a 15A fuse will open faster than a 5A breaker. Soooo . . . rather than take up a fuse slot useful for other things, it seemed more practical to

protect that short extension of the bus that runs from fuseblock to OV crowbar breaker with a fusible link wtih an Isquared*T constant MUCH longer than a 5A breaker but still much shorter than the protected wire. Bob . . .

B-Lead Fuse

> Hi Bob! I just wanted to thank you for the great seminar this past weekend, I definitely learned a lot about my systems, and am going to take your advice and go with the fuse blocks. I do have some questions that have come up, and need some clarification as well-
> 1) I will be running a single 95 amp rated alternator, dual battery system in my Velocity with my SVX motor- with the over voltage protection; the device that I get from you, trips the power fuse on the B lead- is that correct and not the field breaker? You said that I should probably get a 150 amp fuse for the B lead- I didn't see one on the B&C web site, but I would figure that it can be special ordered- would 150 be too large?

A If you use a FUSE like the JJS/JJN series devices we used to sell, then you need to oversize them to keep from nuisance tripping on the output of an alternator. You can probably pick up a JJN-150 or JJS-150 fuse from a local electrical contractor supply house.
Alternatively, the ANL-100 current limiter would also be suited. We have holders for the ANL limiters and I think B&C either has or would get a 100A device for you. Give them a call.

> they say that they are good for a lot more than their rated capacity (then why not rate them that way?).

A ANL devices are intended to be used in power distribution bus structures where hard fault currents can be expected to be 10X the rating of the device. See http://www.aeroelectric.com/articles/anl/anlvsjjs.html
There are LOTS of different kinds of fuses with different opening characteristics depending on the intended service. I used JJN/JJS fast devices early on because of availability and when B&C started using and stocking them for their product line, it seemed a good idea not to stock two different kinds of parts that could be used for similar tasks. Hence the changeover as the article above will describe. BOB...

Re: Fuses; Alternator

> I am retrofitting my Q-200 with a B&C 200G alternator. Their drawing calls for a 15a fuse on the engine side of the firewall. What would be a recommended fuse and holder for this application? I didn't find anything in the AEC catalog, maybe I'm just not looking in the right place. The catalog said the ATC fuseblock was not reccomended for continous loads more than 7a.

A The fuse blocks are rated by the manufacturer at up to 30A per slot. For aircraft use we've recommended de-rating to 15A per slot . . . and then only for loads like pitot heat and klieg-lights you may have bolted on for night landings. The single ATC fuse holder at
http://www.aeroelectric.com/Catalog/ckrtprot/ckrtprot.html#ifh-2
is also RATED for much more . . . about 20A as I recall. You could use this with a 15A fuse in it for the 200G alternator. If it were my airplane, I'd wire per figure Z-16 of Appendix Z and use a 20AWG fusible link on the end of a 16AWG or 14AWG feeder . . . the feeder/link combination

shown on Figure Z-16 is appropriate for the larger, Rotax alternator. Bob . . .

Re: Fuses, Grounding; Dumb Questions

> > 1) Grounding: Even though Iam buildingan aircraft with a steel tube fuselage I am planning on running a separate ground cable from instrument panel ground bus directly to the battery.

correct

> > 2) The alternatorFIELDbreakergoeson the panel and the alternatorOUTPUT cirquit protection (probably fusible link in my case)goes near the starter >contactor, correct?

the fuse goes as close a spossible to the alternator, which might in this case be on the firewall close to the starter contactor.

"Fuselink" should not be confused with "fusible link" and the supper fat fuses like the JJN/JJS/ANL series fuses that you will find called out on various wiring diagrams.

Fusible links are described at: http://www.aeroelectric.com/articles/fuselink/fuselink.html
really big fuses (sometimes called current limiters) are illustrated at:
http://www.aeroelectric.com/articles/fuselink/fuselink.html
http://aeroelectric.com/Pictures/clbase.jpg
and
http://www.bussmann.com/library/bifs/1029.pdf

Circuit protection goes as close as possible to the SOURCE of energy that puts the wire at risk. Alternators are physically incapable of tripping their own b-lead protection . . . it's ship's BATTERY that will burn this wire IF you experience mechanical failure or shorted diodes in alternator (both very rare). Sooo . . . b-lead protection is installed at the FAR END of the wire leading from alternator b-lead to wherever it ties to ship's power distribution.

> > 3) When would one want to pull the alternator field breaker to run on battery only?

if you want to shutdown the alternator you pull the breaker, this could be for test reason, or if you supsect the OV did not work or ..... and the breaker is also triggered from the OV module.

OR . . . should the regulator become unstable and the bus voltage is jumping round (like the thread on increased alternator field supply resistance we've been discussing in another thread). The breaker is shown on our wiring diagrams as the ONLY breaker in a fuse-block equipped airplane because the CROWBAR OV protection needs the breaker. It's not included just because you "might want to pull the field breaker" . . . the latest versions of Z-drawings show the S700-2-10 progressive transfer switch that mimics the infamous split-rocker switch and allows you to move the DC PWR MASTER switch to a mid, battery only operating position. Bob . . .

Fuse Blocks

>To this end, I have come across the 15710 Series Rear Terminal ATC Fuse Block by Bussmann Auto which I feel would be ideal for my purpose. It's properties including modular

construction, dual buss option, rear access etc can be seen at
http://www.bussauto.com/pdf/rta.pdf
>

S I've seen the Bussmann info on those fuse holders too and thought they looked nice. Recently, I saw them in a Watek, Inc. catalogue and they were priced at $32.04 (Qty 1-9), $27.24 (10-49), $24.03 (50-99). They sell the terminals too. I'd like one for a 4WD vehicle I'm working on. If there is enough interest, I'd be willing to order a group of them along with the terminals and make them available to others. The one they listed in the catalogue is a 20 position dual bus unit. One input stud feeds 14 of the positions and the other input stud feeds the other 6 positions. www.waytekwire.com Dave Swartzendruber
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11. GROUNDING

Grounding

> I know that most metal airplanes are wired so that only one wire goes out to the component, say a landing light. The current completes the path via the airframe. My problem is that I've been priming my parts prior to to riveting and thus I don't have a good metal to metal contact throughout my aircraft. What do you guys think? For the guys priming like I am, are you planning on using a two wire system. Any thoughts will surely be appreciated. >Thanks, >Jerry

S AC43-13B Chapter 11 illustrates the procedure for making a grounding point. When I got the skins clecoed to the ribs and spar on the wings I opened up the alignment hole in the main spar at the outboard end that the string was passed through to accept a number 10 screw. I made a grounding point at this location as per 43-13. A resistance reading with a digital ohm meter from the grounding point to the most inboard rivet on the spar, in fact to any rivet on the wing, was 0.1 ohm. Vince Welch
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Grounding

>> I am putting in the wiring to the wings. I will have a nav. light, landing light and a strobe (with the power supply in each wing-tip). I plan to ground everything together in the wing-tip and additionally use the ground wire in the Power supply cable to connect the wingtip ground to the firewall grounding block (B&C's version).

A Don't run extra "ground" wires from one place in the airplane to other places in the airplane. In metal airplanes, devices such as pitot heaters, lamps, strobe power supplies, little trim motors, etc may be grounded to airframe locally with no risk of becoming either victim or antagonist with respect to noise.

> In reading chapter 16 it appears I should also use shielded cable from the power supply to the lamp and, since I have fiberglass wingtips, I will ground the shield to the lamp housing.

A Unless the installation instructions tell you something different, I would ground the power supply to strobe shields at both ends . . . to the strobe mounting screws and to the metal fixture under the strobe lamp assembly.

>> What about the shield from the power supply to the switch? Do I ground it at both ends or just one and, if so, does it matter which?

A Shielding this wire is of no particular benefit.

>Finally, I had planned to run all these wires through the same conduit as my mike and earphone cables. They would run together for about three feet. Separating them will be difficult but I can do it if necessary. I am not sure if I need to because it is the "switch to strobe power supply" wire, not the "power supply to strobe lamp" wire. Any help you could offer would be appreciated.

A They may run together in bundles or conduits without risk of coupling noises between systems. Make sure your microphone and headset jacks are insulated from the airframe by means of non-conductive mounting bracket or insulating washers like:
http://www.aeroelectric.com/Catalog/wiring/wiring.html#s890-1 Bob . . .

Grounding

>>I am building an RV6 and have already installed the Vans location for the battery and engine ground studs per Vans on the firewall in front of the battery with the Vans supplied 8" #2 cable from the battery neg. I recently purchased your single point ground block and wanted to put that nearer to the instrument panel for instrument grounds and run an approximately 20" ground strap or #2 cable to the already installed firewall stud. 1) Am I compromising anything doing this?, 2) Will this be an adequate grounding system?

A Local ground for the battery is fine . . . but the ground block should be on the firewall so that it shares the ground stud with battery (-) connection and the crankcase jumper. What you propose would work but it's not the way the system was designed for optimum performance . . . the idea is to bring everything together insofar as it's possible to a single point on the firewall. What you propose will probably work and it will be an improvement over what's flying around in most certified ships today. A remotely mounted ground block should be isolated from local ground . . . mount it on a piece of wood or phenolic . . . a fat ground strap is not necessary . . . #10 wire would be big enough to connect it to the firewall. Bob . . .

Ground bus "clones"

>>Bob: I read your book on ground busses. I thus find the need to install a ground bus behind the instrument panal on my RV 6A. The ground bus I made contains eight (8)-8/32 brass screws soldered to brass stock. I also soldered two(2)-10/32 brass screws to hold the ground bus in the aircraft and act as the connection point for the ground wire terminal end. The battery

ground is approx 3 feet away. I plan to use this ground bus to ground the instruments, gauges, etc. on the instrument panal.

A I would REALLY like for you to consider using the forest-of-tabs ground buses offered in our website catalog from B&C . . . these devices give you a separate, non-loosening attachment for each ground wire in your system . . . no single failure takes out more than one system. Further, the fast-on tab is far superior to the threaded fastener in terms of connection integrity.

>>(1) Is it feasible to use 8 gauge wire from the battery ground point on the firewall to the ground bus? (I have 8 gauge in stock)

A Starter cranking current flows in this wire. It should be 4AWG at least. Consider using welding cable from local welding supply store or 4AWG Tefzel from B&C . . . they have LOTS in stock.

>>(2) Is the ground bus system I devised a feasible method to ground the instrument panal, thus elimate a future grounding problem? (I would hate to depend on the rivets on the aircraft to serve as a GOOD ground)

A Actually, rivets are one of the MOST dependable means for achieving both mechanical and electrical attachment of two pieces of metal. Consider that a rivet is installed in a close slip fit hole and when driven to proper height, swells up in the hole making a gas tight connection between the riveted materials. Given that an airplane is assembled with thousands of rivets, I'd take the rivets over a bolted connection ANY day. Some folk have worried about rivets not making good connection because their parts are all painted with corrosion protection before assembly . . . keep in mind that the compression strength of aluminum alloys start at about 30,000 psi and go up from there. Compression strength of zinc chromate is somewhere on other of peanut butter. I don't care how much zinc chromate was in the hole before you bucked the rivet. . . there is NO zinc chromate in the hole after you buck the rivet.

The ground bus should get its ground to the firewall by clamping up action of the 5/16" brass bolt provided with the kit. This bolt is attached point for the battery (-) lead -AND- the engine-to-firewall ground strap. If everything behind the panel grounds to the ground block then the only thing that really depends on ground-block-to-firewall connection are the items locally grounded like landing lights, pitot heater, nav lights and strobe power supply . . . Further, the integrity of ground-block-to-airframe connection is quite good because of the multiple threaded fasteners used to install the ground block.

Bob . . .

Bonding

>>Could not find anything in Bob's book or Archives on Control Surfaces electrical bonding and/or static wicks for these homebuilts. Anybody has ideas as to its value or lack of in particular to operating IFR. Thanks Michel Boucher

A It doesn't hurt to put a bonding strap across the hinge joints of control surfaces. This applies only to metal
or carbon fiber machines. If you're building a glas/expoxy machine, don't bother . . . there's nothing conductive to

which you can attach the bonding straps. I would not worry about bonding control cables. Bob . . .

Re: "How to safeguard your avionics"

>> On their "safeguard your avionics" page, http://www.aea.net/R1/Secure/guide2.pdf On this page they say to make sure the airframe static wicks and grounding straps are in good condition. Are static wicks necessary in slower (<200mph) aircraft? With respect to avionics, how do they help? If they are needed, how do you go about determining position and quantity?

A Static wicks are a performance issue . . . not a safeguard issue. Depending on paint, speed and atmospheric conditions you can build a static charge on the airplane that will begin to bleed off in random fashion with so much local current in the discharge that it creates an interfering noise in receivers. There are no 100% rules for the numbers and placements of static wicks. Further, static wick performance can vary widely from manufacturer to manufacturer . . . for awhile at Raytheon, we had to do receiving inspection on every wick that came in the door to insure a minimum performance level. The ultimate solution for number and placement of wicks on some RAC/Beechcraft products was hard won after a lot of cut-n-try flight testing.

By-and-large, don't worry about them until you find that you need them. Flying in snow, is the most difficult situation to endure. If your radios are still receiving well then you will not need them. If the prop tips start glowing blue and you get little fuzzy lighting streamers around the edges of the windscreen, then it's a pretty sure bet that you've got a problem that can probably be helped by installing wicks. Bob . . .

Grounding

q Bob N. and/or others, I have about 20 ground connections located on the left side of my panel. The grounds are from the engine instruments, their lights and misc warning lights. Can these ground wires be consolidated at the left side (i.e. close by the instruments and lights) and then run one large wire (12 ga) back to the common ground block which is located on the opposite side of the aircraft? Will there be ground loop or interference problems with this arrangement. The wires would be consolidated at the left onto a terminal board of some sort.

A Not generally a good idea. First there is the possiblity for interaction between systems sharing the ground wire but more importantly, you have lots of goodies depending on one piece of hardware. Why didn't you put the ground block on the firewall and tie your engine bond strap and battery minus cables to a common bolt along with grounds for all the panel mounted goodies? How do you connect all the ground up on the right side of the airplane?
Bob . . .

Grounding : "Gnd" Terminal in Slick Magneto

>Bob: The Slick magnetos, in the O-360 A1A that I purchased from Van's, have a terminal labeled "gnd". How is it wired? I've seen engines where nothing is connected to it. In others the

P lead shield is wired to it.

A That's what it's for.

> I saw one where the "gnd" terminal was connected to 'single point ground'.

A Nein, nein!!!! There should be a fat, braided jumper between the crankcase and the single point ground on the firewall. See chapter 5 of the AeroElectric Connection. The ground terminal on a magneto is for p-lead shields only. Bob . . .

Grounding, Magnetos, Re: P Lead Shielding

>Bob: I have a conventional "key" ignition switch. The switch installation instructions recommend that the P Lead shields be grounded to the "nearest structure". Your book says to ground the shield only at the magneto. But that's using toggle switches. What do you recommend and why?

A Shielding works to mitigate coupling of magneto noise in two ways: (1) the presence of a grounded conductor between the antagonist (p-lead) and potential victims (other wires in the wire bundle). This breaks the electrostatic coupling of fast rise-time voltages across insulators. (2) any current flowing in a wire creates a magnetic field which can couple noise to adjacent conductors - UNLESS a companion current flow of the same magnitude flows in the opposite direction in close proximity to the noisy wire . .in this case we use the shield as the return path for the offending signal.

IF you tie the p-lead shield down at both ends, you kill the effectiveness of the shielding in controlling magnetic coupling of p-lead noises and at the same time to turn the shield into it's own version of a magnetic noise radiator because it shares some of the alternator grounding duties with the bond strap that should be the ONLY path that attaches a crankcase to the airframe. It doesn't matter what kind of switch you use. I've seen several noise problems go away in airplanes when the ground jumper on the cabin end of the p-lead shield was removed. Bob . . .

Re: Grounding strobe power pack

>Bob: I have located the strobe power pack just behind the back wall of the baggage compartment and was wondering if it might cause any noise-related problems if I were to ground the ground lead right there instead of running a wire all the way back to the firewall "forest of tabs" that I've used for everything else up to this point. Thanks, >Scott in Vancouver

A No, landing lights, taxi lights, strobe power supplies, and pitot heaters can get local grounds. IF, in the relatively rare case you do get some noise from the strobe supply, it's a 99.5% bet that it's conducted noise that is easily filtered at the power supply. Bob . . .

Re: multiple wire paths in composite aircraft

>Bob, > >A couple years ago I did an experimental study of 22759/16-#4 vs. #4 welding cable, #2 welding cable, and 3/4" soft copper conduit... Using a regulated voltage source, I measured current and voltage drop through various lengths of these materials, and here are some of the results:
>#4 22759/16: 0.137 lbs/ft, 0.245 mOhms/ft
>#4 Welding cable: 0.170 lbs/ft, 0.230 mOhms/ft
>#2 Welding cable: 0.275 lbs/ft, 0.148 mOhms/ft
>3/4" copper tubing: 0.416 lbs/ft, 0.066 mOhms/ft

>I've gone back and forth a bit on using the 3/4" copper for a ground conduit (in a Velocity), but now have decided to do it for sure, and running the potentially noisy stuff inside it (Alternator B-lead, mag lead, electronic ignition power, strobe power, fuel pump power)... I'm also using thickwall 5/8" teflon tubing to run additional sensor cables (shielded of course), it is a breeze to pull additional cables through either conduit!

A Consider running all wires through the same copper conduit. Otherwise, be sensitive to potential for ground loop problems between systems that both use ground wires but live in separate bundles.
Bob . . .

Heads Up - Ground Strap Problem

> I had a problem with my electrical system shortly after I began flying my RV-6. The ground strap that ran from the engine to my firewall ground bus came loose at the crimp on the engine side. Probably because of engine vibration or a loose crimp. The result was that when I attempted to start on a subsequent flight, I noticed that my starter was not as crisp as it had been. I also smelled an odor like burning rubber so I shut down and discovered the problem. When the ground strap came apart, the ground became the carb heat cable and the mixture control cable. The carb heat cable was deformed badly by the heat and the insulation on the mixture control cable was melted. So two new control cables and a second ground strap were ordered. I also soldered all crimps as a backup.

Lesson learned: have a backup ground on your engine to prevent damage to your control cables. I noticed that I have two engine grounds on my RV-4, I don't know why I missed the second one on my RV-6!   Pat Hatch

A Better yet, do a better job on the original ground. What kind of wire were you using for the ground strap? This should be a very flexible, 2AWG equivalent welding cable or flat braid that runs from a brass bolt (to a single point ground block) on firewall to a hefty bolt on the crankcase . . . See chapter on grounding. Your experience has been repeated many, many times by lots of folks over the years. It happened twice in 6 months on the airport I owned by two of my mechanics. Redundancy is not a good substitute for craftsmanship. Multiple grounds only invite noise problems. Bob . . .

Re: A bunch of questions on shielding / grounding

>Hi Bob - > I think I understand most of the rules of shielding / grounding, but I've got some specifics, perhaps you could help with them... First a review of the rules as I think I understand

them, please correct me anywhere I'm mistaken:
>1) high-current power lines are best used with the shield being power return, to reduce magnetic EMI.

A Shielding (in the usual sense of braided copper overlay) has no benefits with respect to magnetic isolation. I built a prop synchronizer once that took advantage of a very strong magnetic field OUTSIDE a shielded spark plug wire. Shielding serves only to break capacitive coupling between adjacent conductors. The best attenuation technique for keeping magnetically coupled noises from propagating is to keep the noisy wires away from potential victims. That's why I like to take the alternator b-lead to the starter contactor out on the firewall and not even bring it into the cockpit.

>2) If RF is potentially involved, the shield should be grounded for an electrostatic RF shield, and only at the source end. In such case if protection from magnetic coupling is also needed, twisting the two power lines is desirable (but don't use the shield for power return, as it could carry the RF)

A Shielding as a means of containing RF is valid only when the conductor is a nicely matched transmission line . . . like coax cable used for antennas. Fortunately too, the only time we pipe RF around the airplane IS on coaxial cables attached to reasonably matched antennas. This containment of energy is a totally different mode of propagation from electrostatic coupling of fast rise time voltages between parallel conductors.

>Now here's a couple specifics... >1) a Navaid Devices autopilot servo is mounted on a canard pusher, and so has to go about 16 feet... the wires include (2) 18# for power, and (1) 24# for control. I plan to use an 18#/shielded for power and return, and a separate 20#/sh or 22#/sh for the signal, with the shield grounded at the source (instrument panel) (24# just seems too small for anything, especially 16ft when the original app is probably only expecting 4ft or so)
>Or, could I use 18#twisted-pair/shield all combined together? It probably is best not to, as I think it would actiually take less space for the separate wires (and be easier to pull through the duct) since they aren't twisted, and probably better for shielding the control signal (heard about weird things happening on the AP whenever the radio is transmitting, but that's probably the input wires not the output control signal - do you know?)

A Run all wires to and from the servos as a twisted group and don't worry about shielding them. If the servo is sensitive to RF, it's because the servo has some serious, internal design deficiencies and shielding will have marginal if any beneficial effects. In some cases, shielding a non-transmission line signal wire has increased a systems sensitivity to RF rather than decrease it. The RF-Wall has to be at the device's connections to the outside world and should not DEPEND on shielded wire because shielded wire is not dependable in this regard.

>2) I have a JPI for CHT/EGT monitoring, and a Grand Rapids for everything else, but it can also do EGT/CHT... since they both use the type-J and type-K thermocouple wiring and load the sensors negligibly, I am told they can share the same sensors. Question - how do I splice them >together? Or should I?

A Not sure what your question is here. Have you studied the chapter on thermocouples in the book?

>3) Does electronic ignition noise (RF) ever make it's way back through the power wiring for the electronic ignition? My unit just uses a single 18#/sh, is that good enough? Or should I use

18#pr/sh?

A If it gets out, it will be because the noise is propagating down the center conductor and out into your power distribution system This will require a filter of some variety right at the ignition system . . . again, shielding the wire will be of little if any benefit.

>4) I also have a Weldon electric boost pump - Everyone around here uses 16#pr/shielded, but that seems like overkill, even for 16ft... would 18# be good enough?

A How much current does it draw? Size the wire for the power handling task. Again, if it's a noisy pump, you're going to need a noise filter at the pump. Ditch the shielded wire.

>5) I'm running all the noisy stuff (strobe power, boost pump power, electronic ignition power, as well as alternator B-lead and magneto P-lead) through a 10-ft copper nduit - will that attenuate any RF enough at the end so that I can use single-conductor shielded power lines for these power lines, rather than shielded twisted-pair? I know that this will likely "depend on the installation", but I'm just curious in your experience with running copper conduit in a glass plane (I recall you did that at least once), if it was still a known problem, or clearly a non-issue, or still an unknown. >Thanks much for the lesson!

A Hmmm . . . don't think you've read the chapter on noise. Had a guy call me on phone about 10 years ago and gave me a description much like yours. He'd shielded and filtered the bejabbers out of everything. He then asked my advice as to what else he needed. I asked if he had a noise problem. He said, "No, I haven't flown the airplane yet." I had to advise him that he'd spent a lot of time, dollars, weight and worry about things which were probably not going to be problems. And, if they were, they need to be tackled one at a time per the philosophy described in the chapter on noise. Suggest you review that chapter and let's start this conversation over again. Bob . . .

Re: A bunch of questions on shielding / grounding

> OK, Bob, I'll start over... I was paraphrasing, in my own words, what I had read in chapters 5 and 16, and as related to my application. I will try to get to the heart of my remaining questions (part of it I have since figured out, both with your help and some additional careful reading), and I will mention the page numbers (mostly from Chapters 5 and 16)... hopefully that should make it clear what I'm asking, even if I don't use exactly the right words!

>First, remember that I am building a canard-pusher (Velocity) and have long 16' runs. I am running all the antennas down the pilot-side duct, and a 10' by 3/4" copper conduit ground down the co-pilot side, in which I will run the noisy and/or fat wires. For the engine sensor wires (8 thermocouple pair unshielded, and 10 more #22STP (shielded twisted-pair) as per manufacturer instructions), I am running a 5/8" Teflon PTFE tubing, so all wires can be easily removed or added.

A I'd run these down the conduit too.

>So, here is what I said before, and what further questions I have: >Rule 1: For fat wires, magnetic EMI (as I call it) is usually the big issue as I understand it. (This is also your item (2b) on page 16-8.) According to pages 5-8 ("A conduit-shielded bundle which uses the shield for its ground connection has very small magnetic shields around it") and 5-9 ("Single-conductor shielded wire may be considered for things like compass lights, instrument floods, pannel dimmer rheostats, etc. Use the shield as the return conductor!"), I can minimize magnetic EMI

either by using the shield as a return conductor, or by twisting the ground and power leads around each other. Okay, once you run things down the conduit wherein the conduit is also ground return for everything aft, the coaxial conductor benefits for reducing radiated magnetically coupled noises is covered. Closely paralleled current flows, twisted pair paralleled current flows and coaxial paired current flows are all strong attenuators of magnetic field radiation as a result of any of those currents.

A I think you've got it well covered.

>In your reply, you said: "Shielding (in the usual sense of braided copper overlay) has no benefits with respect to magnetic isolation. I built a prop synchronizer once that took advantage of a very strong magnetic field OUTSIDE a shielded spark plug wire. Shielding serves only to break capacitive coupling between adjacent conductors. The best attenuation technique for keeping magnetically coupled noises from propagating is to keep the noisy wires away from potential victims."

>>But I'm talking about the power/ground circuits, not a spark plug type situation. Perhaps I didn't make that clear? Also, although I know that using single-conductor shielded wire inside a ground conduit does not provide any extra magnetic shielding advantages, it is more compact (I believe) to run such smooth wire rather than lumpy twisted wire, and is much eaiser to pull through the conduit. The power/ground pairs where I propose to employ this method include: Fuel pump(#16), autopilot servo power(#18), electronic ignition power(#18), Strobe power (#18), and navlight power(#18), which will accompany the alternator field lead(#18), alternator B-lead(#8) and magneto P-lead(#18/sh) all in the copper conduit.

>(I just realized now, that very likely I really don't need *any* of those shields for ground return inside the conduit, if I use the conduit itself as the ground return - I was focusing on single point grounding up front, but you clearly have stated in the book that having a second ground block in the engine area is OK. So, if I only put pwer wires in the conduit where the ground return circuit is the conduit itself, do I still have to twist them? I don't think so,

A You are correct. Once magnetically contained within the conduit, no additional treatment such as twisting and/or shielding is necessary . . . EXCEPT p-leads from mags DO have very fast rise-time voltages on them and they WILL benefit from shielding. All of these wires can come down the same tube.

>Rule #2: Shielding, for shielding's sake (and not to provide a return path for a power circuit), is only good for limited RF protection, and practically none from capacitive coupling in long parallel lines. I interpreted RFI as being all fast-rise-time signals, and that that protection was significant. Am I mistaken on both counts? In your reply, reason for routing the noisy wires there, I was hoping it would help...in any event, it can't hurt, can it?

A Only rare cases of RF coupling does shielding hurt. In all other cases it can range from benign benefits to profound as long as the rules for ground-loop avoidance are observed.

>As for my specific questions, I've got them pretty much handled - As for the fuel pump, it is around 5 amps so #16 seems like waaay overkill for 14 ft... the problem was, I think, that there were several pump failures locally where the installation was blamed (and warranty therefore voided), and #18 was picked for the culprit, and #16 for the solution. Since I'm running it through the conduit anyway, I'll forget about the shielding and just run #18 and check the voltage at the pump... it looks like we're talking about 0.45 Vdrop for #18 instead of 0.28 Vdrop for #16 - I can't imagine that would be a problem.

A I agree. Do you know what kind of words the supplier used with respect to "improper installation" for which they claimed damage to the product? I can't imagine that low voltage would do anything to a pump other than degrade its performance. It would be interesting to hear their rational.

>I guess it really is pretty simple:
>1) Fat wires are magnetically noisy, which can be counteracted by keeping the power/ground pairs together, or power contained within the ground return

A Yup.

>2) Capacitive coupling will still be a problem even with shields; the only way to avoid that is to keep the noisy wires well-separated from the sensitive ones (mostly audio, or radio antennas).

A I've seen p-leads reside in friendly proximity with audio leads . . . as long as the p-leads get airframe grounded at engine end only. Antenna coaxes should be completely benign with respect to co-location issues when you use modern coax (RG-142/400).

>3) RF noise (or audio noise, for that matter) on power lines is best handled by filters at either the source or the destination depending on symptoms, but only if necessary.

A Yup.

>4) For audio circuits, first keep them away from fat wires; second use twisted pair; third if shielded, connect shielding only at one end (intercom or radio). . . . unless specifically shown to be something different in the manufacturer's installation instructions.

>I do have one new question: should I put my (not-terribly-sensitive-but-could-be) engine sensor wires in the co-pilot duct next to the conduit with the fat and/or noisy wires, or should I put them in the pilot duct with the antenna coax (RG400)? The only problems I anticipate are the autopilot servo wires, and since all problems so far (on other planes) have been demonstrated only during radio transmission, I will keep those away from the antenna cables. I'm just wondering about the others at this point.

A I think you have a greater chance of having trouble by having two routes for wires running down both sides of fuselage than by bringing them all down the same side. "sensitive" wires could be outside the conduit but I'd still run everything down the same side.

>I hope this makes more sense. At least, I *think* I'm making progress! Shielding and grounding has been a "black art" for me as well, for too long, and I hope this exchange will illuminate things more than confuse them further.

A You understand more than what I deduced from your original post. You're on the right track. Bob .

Subject: Re: A bunch of questions on shielding / grounding

>> The issue with multiple ground paths is called ground loop. The voltage of the ground wire at the ground terminal of a high current /high noise device will not necessarily be 0 volts. This is so because when that device is using a lot of power, the same amount of current is being

carried by both the power and ground leads. The current being carried in the wires will raise the voltage at the ground connection of the device, and lower it at the 12V connection. If a device uses 10A of current, and its wired using the same size wire for both power and ground, the voltage drop caused by the wire's resistance will be shared by both leads. If you have 0.1ohm total resistance (to make the math easy), then the total voltage drop is 1V, .5v on the ground and .5V on the V+.

No problem so far. However, if another device has its own power and ground wires, but ALSO has a short ground path to the power hog, the power hog will also start moving around the ground potential for the more delicate/sensitive device. Its no big deal for light bulbs, and electric motors, because they won't have their performance affected significantly. But it could cause you headaches in your intercom (pun intended). That changing ground potential would be just as bad as wiggling the V+ lead by the same amount. No amount of filtering or shielding will fix this.

The question with where to ground an antenna's coax is a slightly different one. The reason is that antennas are transmitting at (and optimized for) a frequency where some motor or alternator induced noise will have little effect. So, if you have a dipole with a ground plane, the feed line's shield obviously needs to be connected to that ground plane and (with the coax connector) to the radio chassis. If the ground plane is shorted to the ground of a power hog (because you have a metal plane for ex), there may not be much you can do about it, but it probably won't cause you any problems. BTW, the ground plane doesn't really need to be at the same ground as the battery (no need to run a ground wire from the battery to the ground plane in a plastic airplane), because the ground plane is just being used to 'fool' the antenna into thinking it has a bottom half (for a dipole). From the high frequency, EM standpoint, they look the same. mp

A Ground loops don't generally figure strongly in coax cable runs on metal airplanes . . and never on plastic airplanes. The most critical circuits are engine instrumentation and audio systems. With the single point ground system described in the 'Connection, ground loops are never an issue. The biggest potential problem with running wire bundles down opposite sides of the fuselage in a canard-pusher is the potential for having differential current flows down each side that creates a magnetic field in the cockpit that can have profound effects on the fluid compass. Had a builder several years back that ran a conduit down one side and a vacuum line down the other. He decided that the vacuum line could double as the fat wire conductor to the engine compartment. Circulating currents in these two pathways were so strong that his compass pointed perpetually to some value like 112 degrees and decidedly nose down. Compass worked find if he turned all electrics off. The advantage of putting all fore/aft pathways right together is that such magnetic fields are impossible both external to the conduit/wire bundle and highly attenuated with respect to coupling between various systems that share the bundle. This isn't really a ground loop issue but one of controlling magnetic radiation and inter-system magnetic coupling. Bob . . .

Re: bunch of questions on shielding / grounding

>>The p-lead should be grounded to the mag (engine) only. The high frequency (engergy) pulses that come up the center conductor of the p-lead are coupled to its shield because of the length of the parallel run of the conductors (coaxial). If you connect the p-lead shield to some other ground at the panel, this coupled noise gets injected into the ground at that point. This ground noise can be picked up by any piece of equipment that is also grounded to the same

place. There is no possible benefit from grounding the p-lead to the panel. That's my understanding, anyway.

A Pretty close. Again, we're looking for the attenuating effects of magnetic radiation by keeping currents on inside conductor equal to and opposite in direction as currents on outer conductor. If the wire "floats" at the panel end while the engine is running, the currents MUST be balanced. If you ground the shield at the panel end too, then there is almost assuredly a difference in current flows on the two conductors . . . I've had several p-lead noise problems get cured when the panel ground recommended by several DIY books was removed. A further benefit is that should an engine ground strap be unconnected, you don't want starter looking for a ground on your p-lead shields. Had two cases of wire-bundle burning happen on spam cans when mechanics did just that . . tried to crank the engien through the p-lead shields. Bob . . .

RE: A bunch of questions on shielding / grounding

>> In your response you said that it would be better not to have multiple paths. This seems counterintuitive. Would you please explain briefly why you recommend not having wires on both sides of the fuselage (it isn't too late for me to re-route the antenna coax on my Europa). >Best regards, Rob Housman

A Coaxes are not part of the discussion. They can be routed separately but in a properly configured ground system, they can be easily routed with other wires as well. Folks who have experienced a "fix" to a noise problem by separating wire bundles are only mitigating the effects of poor architecture in the first place. Attention to detail on those little "racetracks" of electron races goes a long way to avoiding root cause of noise problems that won't require mitigation or cure. Bob . . .

Re: Battery Ground Wire

>-- I'm starting to wire my RV-6a and am considering running the negative battery cable (#4)to one of the lower engine mount bolts and a cable from the engine to the engine mount instead of drilling another hole in the firewall for a copper or brass bolt and 2 wires, one battery - firewall, one firewall - engine mount. Is this sound electrical practice?

A Engine mounts and associated hardware should be used to hold the engine in the airplane and should not be part of the electrical system. If an engine mount is supplied with electrical bonding jumpers around the shock mounts, I would remove them. Engine needs for electrical connection are best satisfied with a single, hefty bonding strap from crankcase to single point, brass grounding bolt on the firewall that shares connection with the single point ground for system components and if practical, the (-) terminal of the battery. If it were my RV-6, only the nav lights, landing lights, pitot heat and strobe power supply would ground to airframe locally . . . everything else goes to the magic ground on the firewall. Bob . . .

Re: ground strap path

> Bob and gang, Why do we use a *braided* ground strap anyway? Is there any electrical

difference between a braided strap and a #2 wire? Or is it merely a question of mechanics, ie, the strap is more flexible when used in a short length?

A Super flexible and very resistant to breakage due to engine vibration. Welding cable would work good too. Try to "bend" a window and it breaks, yet strands of glass fiber are quite flexible. Many tiny strands are much better than fewer, heavier strands . . . Bob . . .

> Somebody mentioned a ground point next to the base of the Lycoming oil filler neck. Found it, and looks like it was designed for the purpose.

A We had a thread on this about 10 days ago. Several folks identified attach holes on the accessory case and/or crankcase that seem to be better places to ground a high current conductor. I'd look for 5/16" or larger threaded fastener. Bob . . .

Re: Grounding, Block

> I am using the B&C Ground Block, however, the space on the engine site where it is best placed, does not correspond to the space on the cabin side. They need to be offset by a foot. So, I have riveted the two sides into the most appropriate place for the application on the respective sides of the firewall. Is that OK or do I need to wire them together with 2AWG?

A The idea was that all cranking currents would be carried by no part of the airframe or any components that held it together. Hence, the 5/16" brass bolt intended to connect cockpit side grounds with engine compartment grounds. It wouldn't hurt anything to run a fatwire jumper between them . . . Bob . . .

Re: Grounding; all the wires from my panel

> I have a bunch of individual ground wires coming from panel, 20+. Do I really need to run each one to a faston tab connected to my B&C ground bus on the inside of the firewall? Or can I somehow combine them on the panel and have a fat wire tie them to the airframe ground?
>Thanks, Mike Easley Colorado Springs

A "Need" is hard to define with certainty. It is good practice" to run each wire to the single point ground out of consideration for potential noise problems -and- overall system reliability. Bob . . .

Re: Grounding

Ah, grounding. Few subjects evoke more emotion than this one. Few subjects are misunderstood more than this one. Most electrical engineers don't know anything about this subject, although they claim they do (because the must...they are electrical engineers). Most electrical engineers don't actually design circuits where good grounding practice makes a difference, so who can blame them. Best thing you can do is read GROUNDING AND

SHIELDING TECHNIQUES by Ralph Morrison. Since, you probably won't do that, I will try to pass along what I have taken from the book and hopefully it will confuse you enough to purchase this excellent text.

First off, a shield is a Faraday cage. Similar to your aluminum bird. The Faraday cage actually works bonded or not...For more information on faraday cages you may have to take a Physics 300 level course on the subject. The book the University of Washington uses is Electrodynamics but I don't have a source for this one. For instance, if your airplane receives a lightning strike you will be fine whether it is "grounded" or not. Anyway, bonding on two ends is bad. Here is why:

It is very difficult to actually keep all current off of your airframe. In fact, the best thing you can do is just assume that there will be current on the airframe and use wiring techniques that work irregardless. Should you connect a shield at two points along the airframe, you will very definitely be driving that shield, actually putting noise into your wires.

Here is the best way to ground any electrical circuit that you want to keep switching noise (strobes, switches, mags, electric ignition) off of.
(BY THE WAY PLEASE READ GROUNDING AND SHIELDING TECHNIQUES by Ralph Morrison....I DID. I just looked on Amazon.com and they have them in stock.)

1) Identify four ground busses. I used, Avionics PWR, Shield, Switches and noisy ground, Airframe.
2) All the above ground busses are connected to the battery in exactly the same point. I used a copper plate on the firewall near the battery. Except the airframe ground, a wire of appropriate gauge is attached to the copper plate. NEVER SHALL THESE WIRES EVER MAKE ELECTRICAL CONTACT AGAIN.
3) Run the wires to isolated (e.g. not electrically in contact with the airframe) to distribution blocks (terminal blocks).

SHIELD BLOCKS: Never connect these to anything that will conduct current. These are reserved for shield drains only. Now I only care about shield drains that are in the avionics. On the strobe wires, you are just trying to keep the noise in the cable and not out (as in avionics wiring) so just bond the strobe drains to the airframe (note: very large noise eminators, like powerful PWM motor cables will actually put current into the shield wire, this is why you bond them, and you don't want this crap in your signal shield drains so keep them separate).

AVIONICS PWR BLOCKS: These blocks are reserved only for the power returns of your avionics. This means in my airplane: SL30NAV common, SL30 Comm common, PMA7000M power common, GNC300XL common, GTX327 common, Mid Continent CDI common.

SWITCHES AND NOISY GROUND: These blocks are used to return a bunch of switched and unimportant current to the copper plate keeping the bulk of the crap off of the airframe. On this block, I would return nav/cabin lights, gyro commons, basically all the stuff that is fairly noise immune. Things that are typically noise immune are also noise generators.

AIRFRAME: Since it is not convenient to run every power ground to the above set of terminal blocks, it is appropriate to return things like nav lights or strobe power supply to the airframe. However, you are now going to have current induced into the airframe. This is fine as long as you follow the convention above. As soon as you connect a return from the avionics or an intercom shield to the airframe, you will now hear the switching noise of the components you just hooked into the airframe. Worse you may not hear what this noise is doing to your avionics ability to "hear" radio signals.

I have absolutely no noise in my intercom under any power situation in my airplane. My dent puller (http://www.electroimpact.com/edr.asp) eats 32k joules in 1.2ms, switching upto 10kV using a spark gap (super fast 10 nano second switch). This 10kV sitting no 40uF caps is completely dissipated in 10us. No LM324s die as a result nor does the embedded controller that handles all the timing. I did the research on this stuff when I had trouble with my Dent Puller and ended up reading and more importantly understanding the book mentioned above.

Todd

PS for a copy of my shematics see the free downloads link on my website www.rvwoody.com
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Re: Ground Loop

> I have heard about "ground loop". Who can tell me more or indicate where are the things I have to read ? Michel

S In the context of airplanes, the goal when installing radios, intercoms, and entertainment systems is to NOT hear alternator whine, strobe squeal, electric gyro brush noise, and magneto pulses in your headphones (or have others hear these noises in your radio transmissions). An installation which has the audio contaminated with these undesirable noises is said to have "ground loops" (the most likely cause), while one where the audio is "clean" does not.

In most metal airframes, the airframe itself is used as a conductor for the minus side of the power distribution. Each device has a short minus wire which is grounded locally, or some devices (like strobe power packs) ground through the case. In non-metallic airframes, you have to explicitly run minus supply wires to these remote devices.

You get to choose if each of these runs all the way back to the battery minus terminal (radial grounds), or if you run a heavy ground bus from the battery minus terminal, and then ground the remote devices to this (ground tree). As far as keeping noise out of the audio, the former is preferable, but not absolutely required. In a metal airframe, you don't get that choice.

If the current flowing to/from these remote devices happens to have frequency components in the audible range (alternator ripple, strobe power supply, gyro brushes, magneto Primary leads), and there is some way for these currents to "couple" into the audio wiring, then you would hear the noise mixed with whatever audio you are listening to... The goal when installing is to prevent "coupling" between the noise currents and the audio system.

Both airframes and copper ground trees are slightly resistive, and the current flowing to/from the various devices causes a voltage drop along the airframe/ground tree wiring. In a well designed ground distribution system, the ground drops may be only a few tens of milliVolts (mV), but that is enough to contaminate the audio if these drops are allowed to "couple" into the audio wiring. In the worst case, the ground drops might be as high as hundreds of mV.

A bad example of this is in my Cessna 182, where a 60A alternator is mounted on the engine, and the battery is mounted in the aft end of the fuselage (for weight distribution). The alternator puts out 60A of audible ripple current, which flows from the ground stud of the alternator, through the ground strap to the engine crankcase, through the engine, through another ground strap across the rubber engine mount to the motor mount cradle, to the fire wall, along the fuselage under the cabin floor to the aft fuselage, to the battery ground strap, and finally into the minus terminal of the battery.

Imagine taking two very long clip leads; connect one to the alternator frame, and the other to the battery minus terminal. Bring the other two ends of the clip leads into the cabin, and connect them to the tip and barrel of a standard aviation headset which you are wearing. Now start the engine and make sure the alternator is charging.

The total ground voltage drop between the clip leads (alternator all the way to the battery minus) will be plainly audible in the headset. Obviously, the ground drop is large enough to create a voltage signal level almost as big as what would normally be driving the headsets.

So how do you prevent the noise sources from "coupling" into the audio system? Some people think that the coupling is inductive or capacitive, and that "shielding" is key to eliminating contaminated audio. Others think that "filtering" the noise sources is the key, but both of these methods are only secondary, and rarely fix the underlying problem.

The primary cause of audio contamination is allowing the audio system to connect to the airframe power ground (or ground wiring) at more than ONE location (violating the principle of "single point ground"). If the audio system connects into the current carrying ground system at multiple places ("ground loop"), the ground voltage drops that exist between the multiple grounding points can add in series with the audio signals, just like the clip leads/headphone test above.

Mic audio level is only a few hundred mV, so it is easy to get a few tens of mV of alternator ripple between the radio stack and the airframe point where the mic jack is "grounded" if you don't take steps to prevent the mic jack sleeve from coming in contact with the airframe.

The correct way to wire your audio is to have a completely separate ground wire between each disparate audio item, and then cross tie this whole "floating audio ground" to the airframe (in a metal airframe) or to the power ground bus (in a non-metallic airframe) in just exactly ONE place... This avoids having the power ground drops appearing between a radio output and its headphone jack, for example.

This requires some mechanical ingenuity. For example, when mounting mic and headphone jacks, you have to use insulating shoulder washers to keep the threaded sleeve from touching the airframe. Since they are not locally grounded, an additional ground wire from each jack has to run back to the intercom/audio panel... Usually, I use shielded wire for all of the jack wiring, where the shield is used for the jack sleeves, and the conductors inside are used for PTT, Mic Tip, R and L headphone.

Okay, so we now understand "single point ground", but what happens in the radio stack? It turns out that all of the standard avionics (King, Garmin, UPSat, Narco, uAir) connects the audio and power grounds internally to the case of each radio, which contacts the tray, which is grounded by virtue of the rack being fastened into the rails in the panel, which is in turn connected to the airframe structure. You get no choice about this, you are stuck with it, especially in a Cessna or Mooney. If you are creating the panel yourself, then maybe you can control things.

When installing your radios/audio panel into a metal aircraft, the radio rack stack becomes the defacto single point ground for the entire audio/avionics suite. When you make your audio wiring harnesses, you have to take this into consideration. The best you can do is not allowing any of the remotely mounted parts of the audio system from contacting the airframe locally. This is why the cabin speaker needs to have two wires running from it to the audio panel, one of which is grounded at the rear of the audio panel. Why each mic and headphone jack brings its sleeve all the way to the rear connector of the audio panel/intercom, etc, etc.

In a non-metallic airplane, you could use the instrument panel as a ground plane for all of the radios/audio stuff, and purposefully keep the alternator and strobe currents out of the panel area. Don't ground the electric gyros to the panel (ie run the gyro minus lead more directly to the battery minus).

This raises some interesting problems. For example, suppose you have a nice clean audio system (no whine or squeals), and you want to add a CD player/AM/FM entertainment system that you want to power from the aircraft power. Your stack is full, so you have to mount the CD system someplace else, like in the center console. The CD system has an "audio ground" and it has a "power ground" pin. Where do you tie these?

First, take an Ohmmeter, and measure between the CD system's audio and power ground pins, and the case. There is a 99% probability that the cheapskate who designed it tied both of these to the CD system's case, which poses the following dilemmas: When you screw the CD system into the console (assuming a metal mounting structure), for better or worse, you have now tied the CD system to a ground removed from the one that the rest of all your radio stack is tied to. If there is a big preexisting ground drop in the airframe between the radio stack and the center console, then you are screwed, because there is nothing you can two with the as yet unconnected CD system audio and power ground wires which will undo this.

The only hope is to "isolate" the CD system by using some sort of insulating mounting which keeps it from grounding through its case. Now you still have two "ground" wires to hook up. The only place where these can be connected without violating the "single point ground" for the entire audio system is to tie the power ground to the rails of the radio rack (same place as where the radios are presently grounded), and tie the audio ground to the audio panel. Space permitting, you are way better off mounting the CD system in the center radio stack where it doesnt matter if its case touches the rails.

So, in summary: When wiring a metal airframe, use the airframe as the ground return path for all non-audio stuff. Mount all of your radios/audio panel/intercom/entertainment in the radio stack. Connect the power grounds from all the avionics to a single point electrically connected to the rack assembly. Connect all of the audio grounds to the rear of the audio switching panel. Tie all sleeves from remotely-mounted isolated mic/headphone jacks to the intercom which in turn should be grounded only to audio switching panel. Any other piece of audio equipment should be "floated" locally, its power ground tied to the radio racks, and its audio ground brought up to the switching panel.

When wiring a non-metallic airframe, connect all of the non-audio stuff to a network of ground wires where ultimately each item has a path back to the minus terminal of the battery. Since some of these paths may be shared, the current carrying capacity of the ground wires has to be considered. When wiring all of your avionics/audio items, tie all grounds (both power and audio) to a single point located on or near the radio rack(s). Tie just ONE single jumper wire from the radio grounds to the power ground bus.

Mike Mladejovsky, PhD EE

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12. IMPEDANCE

Impedance ?

>Could somebody please explain impedance to me. I understand resistance/ ohms, current, amperage,voltage, A/C, D/C, single phase, relays, capacitors,transformers, and seem to know enough to be dangerous to myself and others in many different types of electrical componentry. I have wired houses and troubleshoot machine tools and various charging systems with reasonable sucess. I own numerous multimeters, and understand wiring diagrams, but the impedance concept still eludes me. I can usually keep the smoke inside most of my electronics(on a good day..some smoke has escaped I admit). Thanks, Dave Leonard

S Dave - Sure, I'll give it a try. Others Listers have given good descriptions, but I think you may be unaware of the dynamics of AC circuits, which include radio, TV, household current, and any other non-DC electricity. Impedance is AC resistance, or CHANGING resistance. Got it? No? Well, let me try again, with "think about it" examples: one for a COIL, and one for a CAPACITOR.

COIL:

Rule 1) A coil resists CHANGES in current (amps).

Rule 2) It does this by taking time to CHANGE its magnetic field.

Rule 3) Bigger coils, bigger resistance to current CHANGES.

A coil is a wire, and has (near) zero resistance ... eventually. A disconnected coil has no magnetic field.

A) When suddenly connected to a 12V battery, the coil INITIALLY has a 12V drop across it, with no current flowing - effectively a LOT of resistance (12V/0A = infinite ohms). However, the coil begins to draw current, building up its magnetic field as it does, storing its energy in the magnetic field. Eventually the battery will be effectively shorted out (0V) by the coil, and drawing all the current the battery can deliver - effectively NO resistance (0V/100A = 0 ohms).

B) Now disconnect the coil, and the current is INITIALLY high (100A in the above example), and the resistance is also VERY high (thin air). The coil will resist any change in current - it still wants to pump 100A! You might wonder where it gets the energy for this - why, from the coil's magnetic field, of course! How can it get 100A across thin air? By increasing the VOLTAGE to spark levels. IMPORTANT: While a coil does resist CURRENT changes, the coil's voltage is free game - ANY voltage will do! NOTE: Apply voltage to a coil and the current eventually changes from zero to something. Voltage changes before the current does.

CAPACITOR:

Rule 1) A capacitor resists CHANGES in voltage.

Rule 2) It does this by taking time to CHANGE its electric field.

Rule 3) Bigger capacitors, bigger resistance to voltage CHANGES.

A capacitor is two metallic plates real close together, but not touching. They're insulated from each other, and have (near) infinite resistance ...eventually. A disconnected capacitor may or may not have electric field between its plates.

A) When suddenly connected to a 12V battery, the discharged capacitor INITIALLY has a 0V drop across it, which suddenly draws all available current - effectively NO resistance (0V/100A = 0 ohms). IMPORTANT: While a capacitor does resist VOLTAGE changes, the capacitor's current is free game - ANY current will do! That battery REALLY wants 12V across that capacitor! The capacitor begins to charge up, building up its electric field as it does, storing its energy in the electric field. Eventually the capacitor will be charged up to 12V, and drawing no more current from the battery - effectively a LOT of resistance (12V/0A = infinite ohms).

B) Now disconnect the capacitor, and the voltage will remain at 12V, because the resistance is still VERY high (thin air).

C) If you suddenly short the capacitor, it will resist any change in voltage - it still wants to hold 12V! You might wonder where it gets the energy for this - why, from the capacitor's electric field, of course! How can it get 12V across a short? By increasing the CURRENT to very high levels.

NOTE: Apply voltage to a capacitor and the current eventually changes from something to zero. Current changes before the voltage does.

These are the two DC states - on, and off. It's what happens in between that matters - and how fast. That's the AC part. For a single change in voltage (or current), the "resistance" changes, then settles into some new value.

NOTE: If you are constantly CHANGING the voltage (or current) input, then the "resistance" depends upon HOW FAST you're changing. The RESISTANCE in Ohms depends upon exactly WHEN you measure the circuit, and is rather irrelevant anyway, 'cause it's gonna change!

`The IMPEDANCE will depend upon the frequency of the changes (usually a smooth sine wave). For a coil, you can change the voltage (up & down) as fast as you want, it will gradually increase or decrease the current depending upon the average voltage over time. This is why coils are good for noise elimination - spikey alternator juice in one side, smoother current changes coming out the other.

For a capacitor, any change in voltage is "resisted" - the capacitor tries to draw or inject current into the circuit to steady the voltage. This is also used in noise reduction - put one between a bus feed and ground, and it will really, really try to keep the bus at a steady voltage, absorbing and returning current as necessary to prevent voltage changes.

Speaking of capacitors - a coax cable is kinda like a capacitor: that long wire just a fraction of an inch from its shielding - not quite two parallel plates, but still close enough, especially at RF frequencies. If you know the FREQUENCY of the AC that you're sending down the wire, then you can figure out how much "resistance" you will have. UHF and VHF are at certain frequencies, and the coax is setup to have approximate "resistances" at those frequencies - this is so radio and antenna manufacturers know what to design their equipment for. (Higher frequencies = higher resistance, etc.) That's why it's called impedance, so you don't confuse it with simple DC resistance. They both resist (or impede) electrical flow. Impedance is also measured in Ohms, but only for a given frequency (rate of voltage/current changes - i.e. 100Mhz = 100,000,000 changes per second.)

I am not familiar specifically with aero electrical systems - so feel free to correct me as necessary, especially if I recommended any no-no's (like the noise reduction stuff.) I hope I haven't overdone it on my first post. Great list guys - keep up the work. I'll be joining you soon ... Vince Orton

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13. INSTRUMENTS

Ammeter: Re: Where should I put it ?

> Bob, I'm using a variation of Figure Z-11, without a starter. Where would be best place to put the internal shunt ammeter? Since there are two feeds off the battery, I'm a little confused. Sam

A I presume you're talking about a minus-zero-plus type ammeter designed to read battery discharge-charge levels like automobiles of old and Cessnas of late. If you want to use this instrument, you have to bring fat, high current wires to the panel . . . an interference issue we try to avoid. You also have to wire the bus-to-battery feed so that it carries both discharge current from battery to bus and charge current from alternator to battery. This requires that you connect the alternator b-lead to the bus inside the cockpit . . . another fat wire unnecessarily brought inside to accommodate an instrument. If you'd like to use this instrument, you need to pitch Z-11 and get out the wiring diagram for a C-172. Otherwise, I'd recommend replacing it with a remotely shunted, alternator loadmeter style instrument. Bob

S Re: One wire alternater

> Bob, I am using a Ford engine and I would like to use a one wire alt, internally shunted-60-0-+60 ammeter. I have always liked those because it shows whether the charging systems are keeping up or not. Please feed me the pros and cons of this setup. Thanks. N801BH.

A This ammeter cannot be used in a low noise, simple architectures is described in Appendix Z of the 'Connection. There are better ways to "show whether the charging systems are keeping up or not." Before you carve this decision into stone, I'll suggest you review the 'Connection for the concepts that support these "non-standard" approaches to wiring an airplane . . . especially the chapters on noise and reliability. The zero-center-ammeter just doesn't fit any of these architectures . . . which isn't a bad deal because it's really EASY to know if your charging system is keeping up or not. Just install a low volts warning light as described http://www.aeroelectric.com/articles/lvwarn/LVWarn-ABMM.html and http://www.aeroelectric.com/articles/lvwarn/9021-620.pdf and offered pre-assembled at http://www.aeroelectric.com/Catalog/AEC/9005/9005.html Ammeters and voltmeters are DIAGNOSTIC devices that are easily missed or ignored if something is wrong with the system. -0+ ammeters make it difficult to build a low-noise system. Active notification of low voltage cannot be ignored and will annuniciated the need for initiating "plan-B" within seconds of the failure. Bob . . .

Re: Van's lighted gages

<< just wondering if anyone knew how many watts or amps the light bulbs draws in the vans lighted instruments (Fuel presser, oil press&temp, volts and amps, tack) there is not any info on there web page. >>

S Don't know about the others (but I'd bet they are all the same) but the lights in Van's voltmeter draws 60 ma with from a 12 volt battery. Should be pretty close to 50 ma at 14 volts. I checked the lights in several other manufacturers instruments and they also drew 50 to 60 ma at 12 volts. Hope this helps. Harry Crosby

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Ammeter fluctuates

> >I have an RV-4 that has a 35 amp alternator installed. The ammeter fluctuates all the time even with all electrical equipment turned off. I had the alternator tested and it works as advertised. I replaced the voltage regulator and still have the same problem.

A What do you mean my "fluctuates" . . . does the ammeter simply deflect toward discharge and sits motionless at some reading or does it wiggle around? How large are the excursions? Are we talking about a reading on the order of 2-3 amps or is it larger? I presume further that you're talking about a minus-0-plus battery ammeter. Bob . . .

S Do you have the white and red, split master/alternator switch? If you do, this is one case where you get what you pay for. Even a T-210 comes with this garbage and the ammeter in the one we owned used to dance rythmically accompanied by a simple tune in our headphones. It was just high-resistance in the switch contacts. Changing it fixed it right up.... Scott In Vancouver

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RE: Ammeter - how useful?

> > some engine monitors I'm considering come with a voltmeter, which I see a use for. Is there any compelling reason to try to add an ammeter to an already crowded panel? Thanks in advance, Rick Fogerson, RV3 wings, Boise, ID

A Agreed . . . the reason one does a load analysis of the ship's system (ability to LOAD the bus versus ability of the alternator to CARRY the bus) is to show that when everything is working as designed, no positioning of panel controls will create a shortage of power. As long as bus voltage is where it belongs you know the alternator (even it it's crippled with an open diode or the something is preventing the regulator from providing full field voltage) is presently carrying all the loads presently turned on.

May I suggest the following order of priority for electrical system instrumentation?

(1) active notification of low voltage backed up by ov protection - this tells you that the bus voltage is within a operational window that makes for very high probability of comfortable completion of flight.

(2) accurate voltmeter with 0.1 volt resolution. This is you first best clue that something is amiss.

(3) alternator loadmeters are invaluable tools for diagnosing problems when the voltmeter raises the first red flag. I.e., will the alternator willingly pick up a load in spite of it being too low? This means the regulator is misadjusted or bad. Does the bus voltage sag as loads are increased? Here's where you could use . .

(4) alternator field voltmeter. This is a feature included in our VLM-14 volt-loadmeter product. If bus voltage is sagging and the alternator is receiving less than full field, then the regulator is bad . . . if the alternator is full fielded and the voltage is low, the alternator is probably bad.

When the low voltage light comes on or you get an ov trip, you can always get out the tools to make measurements for (2), (3) and (4) when you get on the ground. Sooooo . . . I'll suggest the minimum instrumentation is covered in (1) and anything else you choose to add will only make your relationship with the machine more convenient. Bob . . .

Re: Low Voltage Warning

> 1. I plan to use the B & C Alternator Controller with a B & C alternator. Does the lamp attached to pin 5 indicate OV or low voltage? If it indicates OV, is there a provision for indicating low voltage? [that's 2 questions in 1]

A The lamp will flash any time the bus voltage drops BELOW 13.0 volts. If you have OV protection, you don't need an indicator specific to an OV problem . . . within milliseconds of OV onset, the system is shut down and the LV light begins to flash a few seconds later.

> 2. If the controller does not provide for low voltage warning, then I refer to your 9021-610 "Schematic Diagram - Low Voltage Warning". Is there a convenient way to add a "test" switch to check for functioning of the LED when the voltage is normal?

A Sure, just shut the alternator off. It doesn't hurt to do this in flight but it shouldn't be necessary either. The light will begin to flash as soon as you turn the master on and before the engine is started. This provides for automatic preflight testing of the circuit when the light goes out after the alternator comes on line. But if you have a B&C controller, you don't need the critter in 9021-610. Bob . . .

Re: Electrical System Instrumentation

>Hi Bob, I am putting together a Murphy Super Rebel and am a month or so away from starting the Engine Installation/ Panel and Wiring. The majority of the panel goodies have been selected and on hand. I am trying to wrap up instrumentation for the 9 cyl 400 HP M-14PF Radial. My question for you concerns instrumentation for the electrical system of the SR. I know I want a digital voltmeter and I would like it to be a 2.25 round. Both Electronics International and Davtron make such an animal and both can be toggled between Volts and Amps. A Davtron Model, the M475VAA has dual shunts and can read voltage and two current flows. It can measure alternator output and charge and discharge of the battery. It has a three position toggle switch. Volts/ +,- Battery Amps/Alternator amps.

A	I highly recommend external shunt ammeters for two reasons (1) they keep high current leads out of the cockpit and (2) they can be used to monitor more than one current by means of an ammeter selector switch and multiple shunts. I'd go with the Davtron but put the shunts in each of the two alternator output leads . . . if you have a good voltmeter then a battery ammeter is less than useful compared to the pair of alternator loadmeter functions. Bob . . .

Hall Effect Ammeters

> > Bob, What about those ammeters that use a "current sense" transducer - the ones that look like a donut that you pass the main cable through and the current is measured indirectly via the induced magnetic field - do you have any experience with those?

A	Those are hall effect transducers. These are described in the book on page 7-15. They work fine. Rocky Mountain and others use them for current measurement. They're electronic devices with some drift and calibration issues. They're also not as rugged as a shunt. I use them routinely for flight test instrumentation where I can push a pin out of a plug, run the wire through the sensor and put the pin back in the plug. Here's a link to a company that makes several sizes that I keep handy for my quick-n-dirty instrumentation tasks: http://www.west.net/~escor/

Re: Instrument Lighting

>> Bob, Is there a preferred architecture for instrument lighting? In a given panel, there may be a combination of many small incandescent lamps in instruments while for those without internal lamps, there are several alternatives such as post lights or even inserts between the instrument and the panel. In addition, modern avionics such as UPS and Garmin have dimmer imput that apparently monitors the dimmer buss and responds as the voltage of the buss is changed. These units are programmable for the "offset" and "slope" of the response.

A My least favorite task on the GP-180 program at Learjet was to architecture the panel dimming control system. The airplane had a broad mix of incandescent, plasma, led, fluorescent, and EL lighting on the panel. Pilots who fly $multimillion$ airplanes like all the illumination to move up and down together on whatever control is used to set intensity. The end result for that airplane was a couple of dimming controllers with individual, programmable outputs that could be tailored to the lighting technology they powered. These things cost over $1500 each in 1983.

I advise builders to make space for at least 4 dimmer potentiometers in their panel. At the outset, install only one and hook all the dimming loads to a single dimmer. It will be months after the airplane flies that you will begin to have a sense of what lighted items need different or special attention. If you need to add more controls, you'll be able to do it in a manner that makes them look like they belong there. If you carve your dimmer panel into stone and need to add controls later . . . well . . .

The alternative is to spend a LOT of time with a blackout blanket over the canopy working on the dimming system in the shop . . . If it were my airplane, I'd concentrate on getting it flying. Save the enhancements for winter time projects when you can't fly much anyhow.

>There may be as many as twenty or more lamps and/or dimmer accesses that could be in parallel. Among the questions I have are:

>1. Should these all be in parallel with the wiring protected by a single fuse, loosing all if a short occurs in one and the problem of troubleshooting to isolate the offending circuit. Or should they each be fused , a cumbersome prospect: or possibly use in-line fuses on each? Or, should some sort of priority "zoning" be used with each zone having its own fuse?

A This isn't done . . . common shorts during production caused a LOT of damage to dimmers at Beechcraft on the Bonanza and Baron lines about 25 years ago. I designed a short-proof dimmer that would simply shut down when overloaded. Once all the shorts are fixed, the dimmer would operate normally. Our dimmers are similarly short proof.

>2. The other aspect of all these lights is the physical connection of all the wires or zoned paralleling of wires. I can imagine using many butt splices and bundling leads from nearby instruments and tying together the butt splices and eventually arriving at the buss.

A You can use a D-sub connector to build a minibus immediately adjacent to the instruments being lighted. Fixture wires can be brought to this common point close by the instruments so that an array of many lights can be neatly wired and powered through a single dimmed power and ground wire running from the panel to the dimmer. See: http://aeroelectric.com/articles/minibus/minibus.html ....Bob . . .

Re: dimmer question

>> Bob, Just a question about how your dimmers work in terms of dissipating power. What exactly does the heat sink do? Is it dissipating extra energy when the dimmer is turned down, or up?? (excuse my excessive ignorance...) One of the things I'm wondering on the subject of panel dimming is do I need a panel lights On/Off switch (more clutter and an extra failure point)

or can I just wire up the dimmer to the lights and during the day turn the dimmer all the way down to minimize power draw from it?

A In the early days of panel illumination, power to the lamps was controlled by simple rheostat . . . a panel mounted, knob adjustable power resistor. Full clockwise rotation reduced the resistance to zero and the lamps were fully illuminated. Rotation CCW increased resistance and intensity goes down. Simple and at that time, not terribly expensive because rheostats were common catalog items in many sizes.

The problem with rheostats are several fold. First, they DO get hot . . . energy that is not fed to lamps is used up in the rheostat and shed in the form of heat. The rheostat's total resistance needed to be adjusted to accommodate the number of lamps in the circuit. Often, there was no ideal catalog item so compromises were made in performance. In some cases, aircraft companies designed and ordered special rheostats with features not available off-the-shelf. The price went up.

The dimmers we sell are "smart rheostats" . . . they still dump off unneeded eneregy in the form of heat. However, instead of being constant resistance devices they are constant voltage devices with the smarts to hold output constant based on control knob position and irrespective of bus voltage fluctuations. Anohter advantage of the current design is that heat is dumped off remote from the panel control. Further, the panel control can now be a miniature potentiometer . . . much more panel friendly.

I recall riding in a Cessna 310 one night where the panel around two dimmer rheostats (each about 3" in diameter and 1.5" deep behind panel) ran so hot that you could not hold your finger on the panel material around the knob. The two rheostats used up about 20 square inches of panel space . . . now we can put each control pot in less than 1 square inch of space and heat comes off the panel.

When the lamps are turned all the way up, very little power is dissipated in the dimmer assembly (max amps times about 1 volt drop = low watts). When the lamps are turned all the way down we have a little more energy dumped (minimum amps times 10 volts of drop = a bit more power). Maximum heat is generated when the lamps are at some medium intensity where there is significant current at about 7-8 volts of drop = most watts). The dimmers we sell are designed to stop dimming when the lamps are just above dull red glow . . . and emitting least usable amount of light. This happens at about 4 volts. If we took the control all the way down to minimum for the dimmer regulator, there would a significant amount of control rotation that produced no visible changes in light output . . . poor design. The power consumed by the dimmer system at minimum intensity is very small compared to the output of your alternator. Life of bulbs at 4 volts is measured in centuries . . . so adding a switch to control them is of no practical benefit. Having said all that, it's important to note that even at minimum intensity operation, your full up Christmas display of panel lighting can be large compared to the energy it takes to run really useful things like radios. This is why we recommend the e-bus be loaded with single lamp illumination sources like our map light or a single flood lamp in the overhead. It's possible to SEE quite well with very little energy devoted to panel illumination. Bob . . .

Oil Switch

>> I know this has been a topic before and I have searched the archives but didn't find the answer. I have two of the oil switches from B&C. I would think that I would get continuity between the common pole and the normally closed pole, but I don't on either switch. I am

testing them on my bench with a meter. What am I not seeing here?? Jerry Calvert

>> Jerry they are supposed to close under pressure. When you have oil pressure the switch closes and applies 12 Volts to a Hobbs meter and it starts counting the time you have run the engine. Of course there are switches that are closed until you apply oil pressure and then they open. I bought one that does both so I can incorporate it into my system. One side will run the hobbs meter when I have oil pressure and the other side will either turn a light on to let me know that the Master Switch is still on after the engine has shut down, or I can hook it up to a buzzer that will let me know that the Master Sw is still on. Howard

>> Oil Switch problem resolved! Paul Messinger suggested testing the oil switch continuity with a light and 12v battery. The ohm meter doesn't have enough voltage to get through the slight oxidation on the contacts. This suggestion wins the prize! The 12v testing method proves that the normally closed contact is definately closed in the natural state. Thanks Paul.

Flap motor control

>> Robert, I too am using the electric flap motor w/ just a momentary toggle switch. I am using a small magnet glued inside of the flap and on the inside of the fuselage I have mounted 3 reed switches (like the ones you get for a window in a home security system), each positioned for 10,20,30 degrees of flaps. At the panel where you mount the toggle switch you can wire in 3 LEDs and resistors or 3 filament type indicator lamps and as the flaps move through each position it will light up to tell you what position your flaps setting is in. I am working on my motor mount for my 601XL. Hope this helps. Bob N601XL

Exhaust Gas Indicator

> > Hi Listers, does anyone know of a schematic for building a CO exhaust indicator display? I wondered if a normal ox sensor could be used to drive an LED display? er.msn.com

A Common wisdom says automotive oxygen sensors won't survive the lead in a 100LL engine's exhaust. A couple of years ago, at an RV fly-in in Burlington CO, a pilot brought in a really nice Falco. I was looking over his craftsmanship under the cowl and noticed what looked like an oxygen sensor screwed into a boss on his exhaust stack on one side. When asked about it, he told me it was indeed a plain vanilla oxygen sensor that he'd been using for at least 200+ hours to give him a more accurate leaning tool. There's a whole raft of information and products out there for the automotive markets . . . some of these speak to the evils of "leaded fuel" . . . but it might not cost you much to find out for yourself. Of course if your project flys with mogas, you're home free. Bob

S Hi Bob, I have a homemade Air/Fuel indicator (Oxygen ratio sensor) using 10 LEDs to indicate relative richness or leaneness of mixture. I have 115 hours of 100LL on it and it still works just fine. I too had heard that an O2 sensor exposed to leaded gas would die in a few minutes to a few hours. Simply not true. HOWEVER, apparently, leaded gasoline does contaminate the sensor to the point that it loses its ability to respond quickly enough to change (milliseconds) to control an automobile Fuel management system and prevent those bad exhaust emissions. So for its intended purpose in an automobile, its essentially correct that leaded gas will degrade it. But, if you simply want to use an O2 sensor in your exhaust to provide and indication of relative fuel mixture, it will work fine using 100 LL for hundreds of hours. I sent John a schematic of this simple LED Air Fuel Indictor. Best Regards Ed

A Ed, if you'd like to have your work posted in the technical articles archives on aeroelectric.com, you would be welcome to send me a copy too . . .

S Hi Bob, I have attached a quick and dirty schematic of the circuit. The only note I forgot to place in the diagram was depending on what type LEDs you use the 500 Ohm voltage dropping resistor may not be needed. I use the minature T-1 (3mm) diffused LEDs. Also, if you use the Bar mode of the chip the dropping resistor may not be needed. If the LED's look dim remove the resistor or short around it. Its precision is as good as the care in calibration. It is of course a relative Air/Fuel mixture indicator (indicator - because of course, it does not measure air/fuel ratio but infers it from the oxygen content of the exhaust gas and has a very non linear curve) rather than an absolute. Generally the outer limits of the curve lean and rich are what most are interested in. However, once calibrated and you get use to using it, it is quite a useful low cost, little circuit. Parts cost approx $10-15 depending on what and where you get it. I use a couple of 1 1/2 volt dry cells with a potentiometer to vary the voltage between 100mv and 1000mv to fine tune and check it out. Best Regards Ed

S Bob . . .Sounds like John wants to roll his own, but for those that are interested Iceman sells a system using an automotive O2 sensor. See: http://www.dica.ca/iceindex.htm

S Take a look at
http://www.dakotadigital.com/Detail.cfm?Category=140&PartNumber=ODY-13-2

for another option in the States. Cheers, ~Warren

S www.jcwhitney.com jc whitney air/fuel ratio gauge a bar graph mounted in a round 2 1/16 gage pn 81ts5401x... $35.95 and oxygen sensor for above is 81ts5403t .... $49.95 but any standard automobile ox sensor will work with this gauge.... jerry

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Vans Tachometer Transducer

I am posting this message as I feel that others may find this hint helpful if they are trying to hook an electronic engine monitor up to their engine. I am using a Grand Rapids Engine Information System engine monitor in my RV6A. My plane has an O-360 Lyc with dual mags. The EIS has a single mag input for the tach function, a connection to the P lead on one of the mags. The problem arises in that when you are doing a mag check, you will only get a tach reading when the mag that is connected to the EIS is hot. When you ground this mag, you lose your tach, and so it is hard to judge if you are getting a uniform mag drop. Van's catalog offeres a transducer that connected to the Tach drive on a Lyc and fed a signal to their electronic tach. Obviously, since this is a mechanical take-off, it will show the RPM regardless of the mag selected. I bought one of the transducers and with the help of a couple of RV-list folks, confirmed the correct wire connections (red +12vdc, black ground, white signal). The transducer puts out 8 pulses per revolution, and each pulse goes from ground to +12vdc. This makes it perfect to interface with the EIS, which allows you to select from 0.5 to 10 pulsed per revolution and needs a pulse that is at least 9 volts above ground. The transducer is very well made and has no real friction to it. I assume that it is either an optical or hall effect sensor. I assume that this will last very well. Mel

A Beechcraft went to all-electric engine gaging on the Bonanzas and Barons about 1983. I was at Electro-Mech then (the last job I had before joining LearJet and working with Bruce Shauger on the Piaggio). Beech put out a request for quotes on tach transducers and we won the job. It was a simple hall effect device mounted in proximity to a series of tiny bar magnets spun on an aluminum disk driven by the tachometer drive pad on the engine. I suspect that the device Vans sells is similar technology. If one has access to a lathe, it wouldn't be difficult to build a device compatible with any tach. The shift to this technology for tachometer data was very positive for Beech (and I presume most others) and the design has proven pretty much bullet-proof over the years. I can strongly recommend it. Bob . . .

Fuel Gauge calibration

>I am using VDO fuel gauge senders and ISSPRO fuel gauges. I have found that they work, but do not reflect full movement like I would like them to, i.e., it reads 1/8 when empty, and pegs the meter when full. I have found they read much better if I put a 22 ohm resistor in series with the sender, making empty read just off the E mark, and making full read right on the F mark. ("Empty" and "full" positions are determined by actually rotating the tanks at this point - I want to get them reading ok just before I will be putting them in the wing.) My question is if there is anything wrong with doing this, and if not, should the resistor be placed at the sender or at the gauge, and are there any ideas about a rugged mount for adding a series resistor?

A Not at all. A really good gaging system has potentiometers on it to do just what you've discovered works for you. I'd put it inside the airplane. You can cut the resistor's leads to 1/4" each end (use 1/2 watt or bigger for mechanical robustness) and just lap solder the wires to the resistor leads. Put small pieces of heatshrink over solder joints and a large piece over the whole assembly.

>Also, there are minor differences between sender and gauge combinations - is this normal? I was extra careful to make sure the senders were installed all exactly the same way.

A You'll just have to check and see. I've seen some pretty good float transducers and some pretty bad ones. Whatever you need to do to fool the thing into working right is perfectly justifiable and practical. Bob . . .

Re: Low fuel warning

>> I'm well into the wiring stage on my Kitfox Series 5. The fuel feeds from the two wing tanks into a centrally mounted header tank positioned behind the co-pilots seat. I feel it would be prudent to fit a low fuel warning unit to the header tank in case of a tank finger filter blockage, air lock etc. My question: Does anyone now of a simple way of doing this? er.msn.com

A You can build a float/magnet assembly that will actuate a reed switch when fuel falls below a specified level in the tank. My personal favorite is a reflective liquid level sensor like: http://www.newark.com/psearch/Description.jsp?sku=96F1247 I've designed several variations on this theme. Thousands are flying around in Beech (Raytheon) aircraft. You just stick it through the tank wall at the height of the liquid you want to detect. There are some manufactured reed switch/magnet assemblies like: http://www.newark.com/psearch/Description.jsp?sku=92F4695 I think the polysulfphone critters live well in gasoline. Bob . . .

>>Here's another place for the same idea...http://www.ppavionics.com/LFL.htm

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Lights

<< Bob, I can echo the advice from Mr. Bartrim. I built the landing lights for my RV-6 in a similar manner. J.C. Whitney offers plain round 3" reflectors that take an H-3 halogen bulb for about $3 each. I got 100 watt H-3 bulbs from them also, but at $7 each, it would be slightly cheaper to get them at the local auto parts store. The most intimidating part, forming the lenses, turned out to be a piece of cake. I used 1/16" lexan and heated it with my wife's 1600 watt hairdryer. It bends easily after you warm it up good. The mounting brackets for the reflectors are made from scrap sheet and angle aluminum. Total cost for both my landing lights was about $30. Danny

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Trim

>> Matte Draille also sells a speed adjustable servo thru Matronics, called " The Govenor" it also has relays for multiple switches (pilot/co-pilot). Van's also sells it in his catalog. Tell me more about it. Is it better than the one from Mac? I have the one from Mac already and I am under the impression that I have to wire it up with two relays. Is there a better way?

A You can read about it here: http://www.matronics.com/governor/index.htm It's a solid state replacement for relays that ADDS the ability to set trim speed with a screwdriver adjustment. Bob . . .

Trim

>> Rob W M Shipley. glassman@tns.net I need to reduce the speed at which my MAC servo moves the aileron trim on my RV9 elevator. 9 volts looks about right and I was wondering if there is a simple solid state package that could supply this. Any ideas? > >Rob.

A Sure. Our little half amp dimmers have been used for this purpose. Instead of adjusting voltage to a light bulb, you can set the voltage to a more desirable, lower voltage with the dimmer. You can see the dimmer product at:
http://www.aeroelectric.com/Catalog/lighting/lighting.html#dim5-14

You can download instructions for installing the dimmer at: http://www.aeroelectric.com/Catalog/lighting/9013_ins.pdf This document also illustrates the wiring diagram for the dimmer which you can use as a guide for fabricating your own voltage adjustment device . . . the parts needed to do this are available at Radio Shack.

If you wanted a really compact assembly, the little DIM5-14 assembly can be fitted with a potentiometer right on the board and eliminate the outboard potentiometer used as the panel control for dimming. Many airplanes suffer from poor trim speed selection over the full range of the airspeeds. Designers have little choice when it comes to off-the-shelf actuators to operate trim systems and they seldom take the time to optimize the mechanical gain between the selected trim actuator and the trim tab . . . It's not uncommon for builders to find that the trim system is too fast in cruising speed to accurately trim the airplane. I designed the first multi-speed trim system for the Lears about 20 years ago that allowed full speed ops in the approach/departure phases but slowed it down by about a factor of 4 during cruise. Pilots loved it. Bob . . .

Panels

>>Bob Nuckolls mentioned an outfit that'll make custom engraved panels for switches and whatnot. I think he said they're laminated plexiglass, engraved from behind. Is that written up somewhere?

A My personal favorite source of engraved panels is offered by Werner Berry who has a website at: http://www.aeroengraving.com/ Bob . . .

Trim indicator

>> Bob, I will probably use acme threads, (like in a vise) I am guessing but should have around 1.5 to 2 inches of travel. I have not made the tab yet . Just trying to think about what I need. I have thought about using a mechanical fuel gauge sender and gauge. The only other way I know of is to use a potentiometer with arm. What kind of gauge is available? I thought maybe someone you knew had already been through this process of making a low cost trim and indicator. I know you are busy. You have been kind enough already in replying. I will come up with something. Thanks for everything.

A No problem, that's what where here for. I think your forces are going to be SOoooooo small that something like 1/4-20 all-thread would suffice. 2" would give you 40 turns . . . too many to let you use a 10 turn potentiometer direct drive . . . getting a pot attache to the far end of the "acme" can be difficult too. You could install a small gear at the output of your screwdriver gear box to effect a 4:1 reduction to a 10-turn pot. See parts at the top of this page:

http://info.digikey.com/T012/V4/507.pdf

For an indicator, I'd recommend an LED bar graph display. See data sheet on chip to drive display at: http://www.national.com/ds/LM/LM3915.pdf

You can use one or more of these devices cascaded (see data sheets) to drive one or more led arrays that would light up a bar graph to indicate tab position. See: http://info.digikey.com/T012/V4/713.pdf Bob . . .

Oil Pressure Idiot Light?

> I seem to remember that Hobbs meters usually run off an oil pressure switch. Would there be any point to hooking the Hobbs switch up to a big red warning light? Or are these switches calibrated such that when they go on, the engine has already blown? - Jerry

A Unless you've purchased a high-dollar, "aircraft" pressure switch, the device is probably automotive and will transfer contacts in the 4-10 psi range. The switch we sell is just such a device. I recommend that it be wired as shown in: http://www.aeroelectric.com/Catalog/switch/oilpwarn.pdf where a light a perhaps a buzzer annunciates low oil pressure. The BIGGEST value of this light and noise maker is to avoid walking away from the airplane with the master or essential bus alternate feed switches left on.

Of course, the other side of the switch operates the hourmeter . . . it's reasonable to assume that if the light is OFF, the other side of the switch is closed and the hourmeter is powered. This doesn't guarantee that it is running. The hour meter is powered directly from the battery bus while the light/buzzer is powered from the e-bus . . . the hour meter fuse could be open and you wouldn't know it. Bob . . .

R.C. Allen electric artif horizon

<<. My expensive R.C. Allen electric artif horizon works like crap. I was careful to run it about once a month during the year I had it in my panel during construction. You have to pull the cage knob to make it "center." Then it works fine for a few minutes but then rolls over and down and has to be reset. I noticed last night that the cage knob is not quite flush with the instrument. I'll fix that this morning and see if it helps. If not, then it's going back to the Gyro House!>>

S When you bought the gyro, did you have it set for 8 degree panel tilt? If not, I suggest sending it to RC Allen for adjustment.

Fuel gauges

>>I recently bemoaned the failure of a fuel gauge due to the installation of the sender in backwards. Further study confirms that the senders were mounted differently. One has 0 ohms at empty and the other has 100+ at empty. As I mentioned, I have Mitchell gauges and on calling their company number, they have gauges that work with both high and low resistance at empty. They have offered to let me exchange the gauge at only the cost of shipping so I should soon have both needles moving the same direction when empty or full. Good customer service deserves a pat on the back from all of us. Bob Kellar rkellar@mediaone.net

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Ammeter

>>Speaking of ammeters ... I am planning on using the Grand Rapids engine monitor and I asked them if I could use an auxiliary input as an alternator load meter with an appropriate current shunt. I got this answer back: "We are looking into a current sensor that will allow an aux input be used to display current. Uses a hall effect sensor (no shunt required). Expected cost is $40 or so..." Is there any reason why I wouldn't want a hall effect sensor instead of a shunt?

A A shunt is more rugged and generally more precise and stable with temperature. Hall effect devices are used regularly with great success. They're easier to install as you don't have to break into and put terminals on the wire you're instrumenting. From a practical perspective, either has it's advantages and limitations. So I guess your choice should be driven by compatibility and convenience issues. If GRI's engine monitor is set up to use hall effect, it probably cannot use a shunt so the answer here is pretty simple. Bob . . .

Wonky Ammeter

>I would like your help diagnosing a condition with the ammeter on my RV-6A. I have the B&C voltage regulator. I have the B&C Specialty L-40 alternator. All is wired up according to diagram Z-1 from Bob's "Aeroelectric Connection," except that I'm using an ammeter and a voltmeter ...

or at least I'm trying to. I am using Van's ammeter and a Van's 40 amp external shunt. Soon after starting the engine, the ammeter reads a few amps on the discharge side. It comes positive when the engine revs get above 1200 or so. When I turn on the transponder, electric boost pump, etc., the ammeter goes to discharge (maybe -20 amps) then comes back positive.

A If you're using a (-)zero(+) type ammeter then you've had to make some major changes to Figure Z-1 that will make diagnosis of your problem difficult without seeing exactly how you have changed things.

>If I turn on the radio, the ammeter goes to maximum discharge (greater than 40 amps) and stays there even if I turn the radio off again. But not always. Sometimes when I leave the radio on, the ammeter swings back to the positive side after being pegged at - 40 amps. The ammeter also always reads maximum discharge when I key the microphone.

A Hmmmm . . . doesn't sound good. The meter may be mechanically sticking at full scale after being whanged too hard. This can't happen without some kind of error in how it's wired.

>I had other troubles with the ammeter reading, but "fixed" those by moving one of the leads on the Radio Shack diode between then essential bus and the main bus. The diode has three "out" terminals. The ammeter reads in a more bizarre fashion if I use the other "out" terminals.

A The diode between the main bus and essential bus should have no effect on how ammeter behaves. . .

>The voltmeter shows steady voltage of between 12 and 14 volts when engine RPM comes up from idle. The battery is always charged.

A 12-14 is not very "steady" . . . depending on how your alternator is belted, you should get a bus voltage of no less than 13.5 at just above ground idle RPM . . . this voltage should not change more than a few tenth's of a volt depending on what you have turned on.

>I can fly OK without the ammeter working, so have labeled it "INOP" for the first 26 hours of flight, but now is the time to fix it. Here are some ideas that have been floated by me: >1. The ammeter is wired backwards to the shunt. I should reverse the wires from the gauge to the shunt. I can't see this as correct, though. If wired backwards, it should just read "discharging" when charging, etc.

A Correct.

>2. The shunt is the wrong size. The great needle deflections are caused by the fact that I'm using the wrong shunt. If I had the right shunt the needle on the ammeter would be just a little one side or the other of zero and I would be a happy man. I don't buy this suggestion, either.

A Agreed.

>3. The voltage regulator looks funny and should be replaced with one like everybody else uses. I like my B&C and don't want to use a Ford voltage regulator.

A There are thousands of B&C regulators out there in happy service of their users . . .

>4. The voltage regulator is OK, but is wired incorrectly in some way.

A The voltage regulator also should have no effect on what appears to be rather bizzare behavior of your ammeter.

>5. There is something wrong with the shunt and I should replace it. (The shunt looks like such a simple device that it should either work or not work.) I welcome your thoughts. I think that the

diode is to blame, but can't figure out why. Like the ammeter shunt, it is so simple that it should either work or not work. I wish (not for the first time on this project) that I had taken some electrical tech courses in high school or college so I could figure out what's going on here.

A If you've "Used Z-1 except . . ." then we need to know what the exception is. Send me a wiring diagram that shows what you've done. Bob . . .

S Stephen wrote: You should not remove the diode because it is used to supply current to the devices connected to the essential bus in normal operation. The purpose of the diode is to allow current to flow from the main bus to the essential bus (during normal operation) but not in the reverse direction

S OK, here' s a question. The diode has a forward drop of .6 - .7 volts. Now, that's a lot of voltage for a lead-acid battery. If there is an emergency battery on the essential bus - that is being kept charged through that diode - it will be in a constant state of half (or less than half) charge. Because the main bus will rise only to the value needed to keep the main battery charged. ...Or is there something I don't understand here?

A Jeeesshhh guys . . . buy ya books and buy ya books and we're having these kinds of discussions? . . . may I recommend some remedial reading? http://aeroelectric.com/articles/Rev9/ch17-9.pdf

In particular, check out the description of figure 17-2 that begins on page 17-7. The very minor modification to the classic cookie-cutter spam-can electrical system (Fig 17-1) combined with preventative maintenance of the ship's battery would make the vast majority of dark-n-stormy-night stories about electrical system problems a ho-hum deal.

All those gidgets and gadgets have specific roles to play and with characteristics that have been deduced suited to the task. It sounds like the posting that started this thread is mostly centered in a mis-application of a battery ammeter in a system architectured like Figure 17-2 (or Appendix Z, Figure Z-1) . . . which will not support the battery ammeter installation (because of b-lead fusing out on the firewall). The diode has nothing to do with battery maintenance for either a main or standby battery . . . it's only used to insure that any time the main bus is up, the e-bus is up and that the e-bus can NEVER be loaded by the main bus. Bob . . .

S The voltage drop across a diode that is forward biased is a function of thecurrent flowing through the diode but .6 volts drop is a typical value. The AeroElectric Figure Z1 schematic (my copy is vintage April 2000) does not incorporate an emergency battery for backup of the essential bus but instead relies on a manual switch to connect the primary battery to the essential bus (and bypass the diode) in the case of alternator failure. Since the voltage regulator for the alternator would be set to keep the voltage at somewhere between 13.8 to 14.2 volts in normal operation and the charging voltage for a 12V battery should be around 14 volts, you would be correct that if an emergency battery was installed, it would require a different scheme to keep it properly charged.

A IF an auxiliary battery is necessary (we don't put "emergency" batteries in our airplanes because our airplanes do not suffer electrical emergencies . . .then check out figure 17-6 of . . .http://aeroelectric.com/articles/Rev9/ch17-9.pdf

If you needed a dozen batteries in your airplane, you can install as many as necessary by simply adding a battery, battery contactor, battery master switch and a battery bus assigned to that battery's specific tasks. Again, diodes have no role to play other than to trap the spike from the contactor coil's collapsing magnetic field . . . and this is most aimed at saving the switch that controls the contactor . . .

With the rising interest in removing things that suck from modern airplanes, the lightweight vacuum pump pad alternators all but eliminates the need for a second battery in 95+ percent of all the amateur built airplanes under construction. Bob . . .

Electric gyros

>>I'm seriously considering going with an all electric panel (14v system). The high cost and long lead time to get new gyros are a problem though. Are there any particular places I should or should not buy overhauled gyros from? Any good or bad types/models of gyros? Any other considerations? >Thanks,

A Consider punching the panel for a DG but not purchasing it until later. You get really GOOD heading info from a GPS receiver. I think one could learn to do most of what's necessary to comfortably navigate without a DG. It's possible that some new, all electronic DG replacement products will be available by the time you REALLY need them . . .and for a whole lot less than the cost of a slaved gyro. Bob . . .

Low fuel warning

>Hi Bob, I enjoyed the seminar this weekend (except for the cold ;-)). Lots of useful information from you and others in attendance. You mentioned briefly an idea to build a low fuel sensing device using an LED and receiver. You might want to check out Pillar Point Avionics, Inc. They have exactly what you described. I didnt mention it earlier because I thought it worked on a differant principle. The web site is http://www.ppavionics.com . Also, the company that makes an under glareshield EL light strip is Aeroenhancements at >http://www.aeroenhancements.com/. >Lee Clements

A Lee, Correct on both counts. Thanks for the links. I'm forwarding them to the AeroElectric-List too so that other folks can check them out. Bob . . .

Instruments

>> I am building the switch panel for my Europa at the moment and I was wondering why the turn coordinator has a separate switch in some aircraft.   My Comanche has one, but my C150 didn't. I can't think of a valid reason why I should fit one.

A Older T/C instruments used brush type DC motors . . . very low current but non-the-less . . . subject to brush wear. However, most of the failures of these instruments to come on line happen when you first power up . . . a commutator that sits for long periods of time not being used tend to corrode and loose contact with the brush. Given the low current, low torque nature of these motors, they are most likely to fail from dis-use than from gross wearout.

I'd run one of these guys all the time and overhaul it every 200 hours or 4 years, which ever comes first. Modern T/C instruments have brushless motors and solid state inverters to drive them. There is no value in leaving this kind of instrument shut down with some notion of "saving it until I need it most". You need to KNOW when this guy has died and letting it run all the time (like 99% of all type certificated aircraft) is the best bet. Remember, your making bets against a double failure in the same given 4-hour flight. When you're dealing with a vacuum system, you have a single failure that can bring down both gyro instruments. The probability of double failure is probably pretty high on TC aircraft compared to OwnerBuildAndMaintained (OBAM) aircraft. TC aircraft owners put of EVERY bit of maintenance they can for as long as they can 'cause the checkbook takes a heavy hit whenever anyone legally works on the airplane.

You guys can and should consider preventative maintenance activities that would shock the C-172 owner. You can do it yourself for a fraction of the cost and benefit from system reliability two to ten times better than the what the SpamCan drive enjoys. Something as important as the turn coordinator should have its own circuit protection, as should most components of your panel. I've published thousands of words on this topic. An excellent synopsis of all these works can be found in chapter 17 of The AeroElectric Connection. Bob.....

Re: Ammeter Shunt

>>My ammeter shunt is connected directly to the starter relay, which places it at 12 volts. How does one protect it against being accidentally shorted to ground? It is a big lump of metal connected essentially directly to the battery. Even if the 4 terminals could be covered there is still the body of it.

A Ammeter shunts have been around almost since the first generators and batteries were stuck on airplanes. It's the very BEST way to get an accurate measurement of a large current REMOTE from the display instrument. And yes, they generally ride at 14 or 28v above airframe ground.

>Is it possible to use a huge piece of shrink tube over the whole thing? >Does shrink tube come that big? How about fabricating a cover over the whole thing?

A You can do this but I wouldn't worry about it. I've had builders worry about long exposed bus bars across the back of their instrument panels. I suggest they crawl under the instrument panel for a looksee. The goal is to design hazardous conditions out of the installation, then you don't have to worry about protecting against them.

>I don't want to connect it in the battery ground lead because then the ammeter has to have capacity to read the full starter current, which makes it inaccurate at the normal much lower currents. I hope somebody has already solved this.

A Sure have . . . in hundreds of thousands of certified airplanes that have a lot of similarly exposed, heavy current conductors. 99.9% of problems with wiring come from worn out materials and/or poor workmanship aided and abetted by equally poor maintenance. It's very easy to design out potential failures associated with an exposed ammeter shunt or any other difficult to enclose conductors. BTW, don't forget to fuse the itty bitty wires leading away from the shunt . . . Either 5A fuses or 24AWG fusible links driving 20AWG leadwires . . . the later would be my personal choice. Bob . . .

Dimmer

> All, A few weeks back I wrote about a problem that I had with the Van's stock panel dimmer (ES DIMMER, LAMP 1.5A). I installed per the directions only to find that when I keyed my com transmitter all the lights in the cockpit that were hooked up to the dimmer would go out. Clearly RF was getting into my little dimmer. A little research and some helpful direction from the list and I was able to solve the problem.

My dimmer circuit board actually had the layout for adding two capacitors but the holes were empty. A schematic was actually available on page 222 of "18 Years of the RV ator". Unfortunately the values suggested in this drawing are wrong. The capacitor value needed for the one that's attached to the LM317 actually needs to be 0.001 micro farad at 25 volts and not 0.1 as suggested.

I will put the details and pictures on my site tomorrow. The fix works like a champ. The lights don't even flicker now. - Jim Please check out: http://www.homestead.com/RV8A/files/ for the details.

Re: Ammeter Shunt Problem

> > This is intended as a heads up for those considering the Electronics International volt/ammeter and are wiring their RV per Bob Nuckolls's wiring diagrams where the ammeter shunt is in the alternator output, such as Figure Z-9. I wired my RV-6 this way and had a problem. The first thing I did when I started wiring was to install the voltmeter side of the VA-1A volt/ammeter to the emergency bus so that I could monitor bus voltages as I progressed with the wiring project. When I was finishing wiring, I hooked up the shunt on the firewall and as soon as I did I began to notice strange things. Intermittently, I started to notice that the voltmeter was reading upwards of 20 volts! Now with 12-volt batteries how could this be possible? Stranger yet was when I started flying, all indications were normal. It was only when the engine was shut down that I got the strange indications. I began to consult with one of the engineers at Electronics International, Ron, and we finally got to the root of the problem. I finally determined that the problem was the shunt not being powered, i.e., when there is no voltage across the shunt, the instrument is outside its dynamic range and will not operate properly--plus it is finding a ground through the alternator. This could be a problem under the following scenario: say you are flying along and lose your alternator. No problem, you shut down the alternator and batteries and make sure the emergency bus is powered, right? Well, when you check the emergency bus voltage you are going to find erroneous readings--again, because of the shunt is not being powered. This could be a problem as you attempt to monitor your batteries while you look for a place to land.

A Don't you plan to have enough KNOWN and/or PROVEN capacity on board to make it to airport of intended destination? The voltmeter on the E-bus is a nice thing to have but I would hope it is something that one can easily do without.

>Well, there is a solution. Maybe this is not the most elegant one, but it is a solution. I wired a DPDT switch to isolate the shunt when the alternator is not operating. So now you have to remember to turn the shunt "OFF" when experiencing alternator failure, or when you want to check battery voltages on the ground prior to starting.

A This is a disappointing feature in the design of their product. Was there no mention of it in their installation manual? If I were to offer such a product to the marketplace, it would be a requirement that ammeter and voltmeter functions be totally independent of each other and non-interactive.

>Hope this helps somebody down the road. By the way, I love the EI voltmeter, I also have had it in my RV-4 for the past 12 years; however, the shunt is wired in the battery circuit, thus I never saw the problem in the -4. Bob, care to weigh in?

A When you use their product in the classic spam-can architecture (borrowed from the 1948 Chevy) then I'm sure the device performs as the manufacturer suggests it should. As soon as you depart from this architecture and for example, want to switch between a variety of shunts and/or switch to measure a variety of voltages on various busses, there comes a time when a certain combination of switch positions yields erroneous results. Too bad. With some simple attention to internal architecture, the product could have been so much more . . . Bob . . .

Re: Compass location and perturbations

>> Hi Bob, For space reasons, our vertical card compass will be located on the panel. Our intention is to install it below the artificial horizon, where the DG would be, if we had one. Thus our visual scan will remain conventional. But, in this particular location, can this compass be perturbated by the near by gyros or other electrical stuff ? If so, is there any "classical" remedy to the situation ? Thanks in advance, Gilles

> I also mounted my compass in the panel on an RV6A - it was substantially affected by the electric turn coordinator . To get out of this I wrapped the turn coordinator with Mu (Greek-sounds like mew) Metal which you can get from Aircraft Spruce or one of the compass manufacturers . This eliminated the major problem - there is still some minor problem from the dimmer rheostat which is also close to it. If you can, keep it away from the electric gyros and any electrical device which is liable to generate a magnetic field.

A Mu-metal is the optimal material for magnetic shielding but it's expensive, rare and not the easiest stuff to work with. Try gutter flashing metal available from lumber yards and big-box stores. Cut a strip width equal to the depth of the instrument and long enough to go around the instrument three times. Coil a cylinder of the strip held loosely with long tye wraps. Slide over the instrument and snug the tye-wraps down. I've used this technique perhaps a dozen times in 30 years with a high probability of successful interference mitigation. Bob . . .

Re: dual low voltage indicator

> Bob, Is there a circuit that will monitor dual independant busses and indicate low voltage on each buss? I have B&C 40A and SD8. SD8 has of course its own regulator & relay with optional steady light triggered by inactive relay to indicate low voltage (not enough voltage to pull relay?) or aux. alt. off.   Don't yet have regulator for B&C alt. I know LR3B will indicate LV but I was wondering if there is a circuit made or a schematic of one that maybe I could put together to monitor 2 busses and give visual indication by flashing light if one or the other gets to a certain level.

A   Dave, You could build two of these: http://aeroelectric.com/temp/LVW-ABMM.pdf   using this diagram, http://www.aeroelectric.com/articles/lvwarn/9021-620.pdf and one of these fixtures (or equal) http://www.aeroelectric.com/articles/lvwarn/LVWarn-ABMM.html Bob...

Fuel level optical sensors?

> http://www.ppavionics.com/products.htm   They sell it have them in my header tanks for my glastar, work great! The principal upon which these things function was first brought to my attention when I was about 16 years old. Delco batteries were fitted with a special battery cap called "The Delco Eye" . . . it was simply a piece of plastic rod, cut to a 90-degree cone on the far end an mounted to a filler cap. If battery water was low, ambient light entering the cap end of the rod was reflected back causing the cap's center to appear bright - meaning add water. When submerged in liquid, the center was black.

A   I built some sensors using photocells and light bulbs to do some fuel sloshing studies in a Baron about 25 years ago. A few years later, we used the same principal to design and fabricate a whole line of low-liquid level sensors at Electro-Mech that are now used in dozens of places on RAC products. It's solid, no-moving parts, dead-nuts calibration for alerting one to levels in a tank. Bob . . .

RE: Oil Temp probe?

>How do you wire up an Oil Temp probe on a Lycoming? It has 2 white unmarked wires comming out of the probe. My EIS manual says that I should have one as a sensor and 1 as ground, but I imagine that the probe is nicely grounded as it's a large brass part screwed into the crankcase. So how can I tell which wire is the sense vs ground? it reads about 12K across the 2 leads.

S   Andy, I believe it is just a thermistor and is not polarity sensitive. I randomly picked one to ground and it works as it should. Chris Heitman Dousman WI

A I agree. Bob . . .

Re: Reliability of Electric Gyros?

> I've followed the thread on the RC Allen gyros, as I was also planning their electric attitude and heading indicators for my panel. I've not heard good things about these gyros, not on this website, not on other websites, and not from a certain kit manufacturer. Does anyone know of a source of information on the reliability of these things?

A Talk to instrument overhaul shops . . . they see lots of all brands of gyros come over their work benches and can give you a better feel for how a product is performing in the marketplace . . . but consider their answers too. I once asked an a/p about the serviceability of the low-dollar contactors we sell on our website . . . these are direct descendants of the RBM Controls contactors used on over 100,000 Cessnas and others for decades. The guy said, "Man! I replace a lot of those. I don't think they're nearly as good as the ones used on the Beech Bonanza (Cutler-Hammer 6041H series . . . 10X the price)." Looking around his shop and the ramp outside, Cessnas being worked on and waiting to be worked on outnumbered all other brands by 3 or 4 to 1 . . . His perception of reliability was skewed by the disproportionate volumes of customers. In fact, the low-dollar contactors, while not as hefty as the mil-spec style are an excellent value.

One can cast about the web and get all kinds of positive and negative opinion about any product . . . all of which is meaningless unless you have data relative to the numbers of owners who are experiencing satisfactory service life. You won't get this from talking to owners, you won't get it talking to manufacturer's . . . you might get some useful information talking to people who work on the products and airplanes that carry them. Bob . . .

Re: Instruments; cycling voltmeter and ammeter

> I have about 16 hours on my RV-4 and have a question.=A0 My voltmeter and ammeter cycle between 13-14.5 V on the voltmeter and between 5-10 amps every 1/2 second or so.=A0 The volt meter rapidly rises from 13 volts to 14.5 volts and back almost like the voltage is rising, gets too high, cuts out, drops below 13 volts, kicks back in, rises to 14.5 volts, cuts out......=A0 It just rapidly cycles up and down.=A0 I have tried adjusting the voltage regulator lower but does not seem to help the cycling.....

> I have a 35 amp Van's supplied alternator, a Van's supplied $35ish voltage regulator, and an Aeroelectric overvoltage protection device.

A This sounds like a classic voltage stability problem that can jump up when there is too much resistance in the wiring and components between a voltage regulator and where it ties to the bus.

Just for grins, try making a temporary connection from the input of your regulator right to the b-lead of the alternator. Use a nice fat 18AWG or 16AWG wire. Disconnect the regulator's input lead that gets power from the bus and splice it to the test wire. Attach the other end of the wire to the alternator b-lead. Turn off ALL electronic gizmos. Start the engine and check the voltmeter. If the voltage looks okay, then try turning things on to vary the load while you watch the voltmeter. There's a good chance that the voltage will be steady.

If this is true, then you need to "refurbish" all wiring/components between the bus and the regulator. This is a very common problem on some models of single engine Cessnas where there can be as many as 20 joints in the wiring between bus and regulator. As these age and increase in resistance, the system can become unstable in exactly the manner you have described. Bob . . .

Re: Instruments; Alternator Shunts:

>To: EI re volt/amp gauge. I am beginning to install and wire up my instrument panel for a Lancair ES. I will be running an all electric airplane, i.e. 60A/20A alternators. What is the correct shunt for these alternators? Lancair sent me the volt/amp gauge with the external shunt 60A/100mv. I have seen where yo can install a switch so as to read either the 60A alt, or the 20A alt system. With the current shunt, I believe this means that at full amp load, 60amp system, a full deflection on the gauge would occur. Flip the switch and now full deflection would mean a 20amp load. So with that in mind, unless there is specific required shunt, if I get the 60A/50mv shunt, would this mean that the gauge would indicate a full load of 60amps with a half deflection on the gauge? If so, then anything further would indicate a load of more than 60A/20A respectively as the gauge went toward a full deflection. Is this something I would want to be aware of should I temporarily exceed? Do you have the electrical schematics for wiring a switch so as to read either system? What kind of amperage rating is on this gauge? I will be installing in the future a Dynon EFIS -10, which has a function of reading volts/amps. Until then I'll have to use the switch method, or even do both if that is possible so as to have a back up if either gauge was to fail.

Thanks, Ed Silvanic

S From: "EI Tech Support" <Sales@Buy-Ei.com> Subject: RE: amp/volt gauge/ shunts and wiring Date: Fri, 21 Feb 2003 10:17:10 -0800

Ed - Thank you for your email. I am unaware of a voltammeter that will read correctly from two different shunts that have different shunt values. As far shunts are concerned, there are no "correct" or "incorrect" shunt values. The only concern is that you select a shunt that will accommodate your generator or alternator. In your case, you have 60 Amp and 20 Amp alternators. You will need to select at least a 60 Amp shunt to accommodate both.

There are two possible installations that come to mind when I picture your system. If the two alternators feed into one line that goes to the bus, you can get away with installing one shunt in the line after both alternators. If, however, the two alternators are parallel and feed into separate lines that both go to the bus, you will need two shunts. Electronics International's

Voltammeter's will not read from two different shunts that have different shunt values. A possible solution to the second installation would be to install two S-50 shunts and one VA-1A-50. Both shunts have the same value and the instrument will read both of them. You could then install an RSVA-2 switch to select between the two systems. You could also install a third shunt in your battery lead and install an RSVA-3 switch.

The shunts I mentioned retail for $35. The switches are each $100. The instrument retails for $342. If you have any questions, or if I can be of any assistance, please don't hesitate to contact me.

Tyler Speed

Electronics International Inc.

63296 Powell Butte Highway

Bend, OR 97701

Phone: (541) 318-6060

Fax: (541) 318-7575

Web: <http://www.buy-ei.com/> www.Buy-Ei.com

Re: Instruments; Hall Effect Ammeters]

> I can confirm that a hall effect sensor is included in the MicroMonitor kit. This one is impressed with the name "MICRO SWITCH, Freeport, Ill. U.S.A.". It is also inked with a number '9948' followed by 'CSLA1CE'. I wonder what the Mircoswitch/Honeywell relationship is. Looks like it is a 75 amp device vice the 'f' version 100 amp rating. Bernie C.

"Robert L. Nuckolls, III" wrote: The MicroMonitor uses a hall effect device. The last time I saw one installed they were using a Honeywell product. You can browse the complete line of Honeywell current sensors at

http://content.honeywell.com/sensing/prodinfo/current/

check out the CSLA1CF open loop sensor at

http://catalog.sensing.honeywell.com/printfriendly.asp?FAM=current&PN=CSLA1CF

and a closed loop sensor at

http://catalog.sensing.honeywell.com/printfriendly.asp?FAM=current&PN=CSNA111-500

Didn't find anyone other than MicroMonitor taking advantage of this technology in a product. Bob . . .

Re: Instruments; volts vs amps

> If your panel only provided room to display readings for either volts or amps (but not both), what would you all recommend displaying and why?

A Ammeters and voltmeters are useful only when things are NOT going well. Things WORK most of the time so a simple low volts warning light accurately set to operate below 13.0 volts is the primary flight instrument for failure warning. If you are in flight when the light comes on, the existence or absence of a voltmeter or ammeter of any kind is not an issue because you're going to switch immediately to "plan-b" . . . now, if you want something to watch and worry about during plan-b operations, you need a voltmeter on the e-bus. However, if it's your standard practice to conduct good preventative maintenance on the airplane's battery, then you KNOW that the battery is going to get you on the ground comfortably. Therefore, I'll suggest that any airplane can be quite safely operated with neither voltmeter or ammeter on the panel.

When you get on the ground, a voltmeter or ammeter on the panel will only serve to confirm what you already know . . . the alternator is down for some reason. The most useful troubleshooting voltmeter is one that measures FIELD voltage on an externally excited alternator. If you install this capability, wire it like the VLM-14 system we used to sell, you can diagnose your system per paragraph 7.0 of http://aeroelectric.com/temp/9021704F.pdf and KNOW what you need to replace before you pull the cowl off the airplane.

Now, if you have a handy hole in the panel just dying to be filled with something, perhaps a voltmeter (analog preferred) with a push-button switch-over to read field voltage would have the greatest overall utility in ownership and repair of your airplane. But maybe that 2-1/4" hole would have more usefulness if you stuffed a 760VHF transceiver in it.

Some will argue long and hard about the virtues of voltmeters, loadmeters and -0+ battery ammeters . . . all of these things are fine instruments that have some degree (but never enough) utility in troubleshooting your airplane . . . none of these helps you fly the airplane in the most logical manner. Even a voltmeter on the e-bus to serve as "battery gas gage" will only serve to tell you something you probably already know . . . whether or not you've paid attention to battery maintenance homework. Bob . . .

Re: Instruments; HOWTO K and J Thermocouples soldering

>Hello Folks, I need your experience, we prepared jesterday the CHT and EGT probes on my engine (4 each) to connect to a rotary switch. Preparing is one thing, but we found it nearly impossible to solder this exotique materials to the switch. There must be another way doing this, what kind of solder, temperature, torches/iron do we need to get a proper connection and what else do we have to consider doing this job?

A I've found that several good tin/lead solders I have around the shop will solder type J wire . . . I use metcal irons with 700 degree tips for this. I haven't had a chance to try K wire yet.

A technique that ALWAYS works is to "tin" or coat the end of the wire to be soldered to you switch with silver solder. Ordinary tin-lead solder will then alloy with the new coating and make a satisfactory joint to your switch or other component. Bob . . .

S The application note for the Analog Devices AD594 describes how to solder both type J and type K thermocouples with three rosin core solders. These are 95% tin-5% silver; 95%tin-5%antimony; and 90%tin-10% lead. The first one is available at radio shack, and I have used it successfully to solder the ends of the thermocouple wire together. It should work just as well to solder to the switch terminals. So don't worry about soldering the TC wires for things like CHT measurements. Welding is only needed for EGT heat levels. Jim Foerster

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Re: Instruments; Panel Lettering:

A I make panels like that for a dollar or two every so often by printing the artwork onto a piece of paper, laminate it in my office laminator (Sam's Club $70), center-punch hole centers on panel through placard, cut holes with punches, spot facers and/or step-drill, stick placard down over holes with photographic dry-mount (large sheets of double sided sticky tape), cut holes in placards with Xacto knife and mount parts.

Here are a few examples:

http://aeroelectric.com/temp/panela.jpg

http://aeroelectric.com/temp/panelb.jpg

http://aeroelectric.com/temp/panelc.jpg

Some of these panels are several years old and have stood up against quite a bit of handling stresses. You can lay out such panel placards using any of the CAD programs on the CD offered from my website for either $10 for hard CD or free if you download

http://aeroelectric.com/CD/AEC8_0.zip

FUTURA, TECHNIC, and VELVET-L (on the CD) are good panel labeling fonts. One builder resized the published layout at

http://aeroelectric.com/temp/Switches.pdf

in a copy machine, cut out the one he liked, had it laminated and stuck it onto his panel.

This is a labor intensive but very low material cost approach to panel placard building. It's so easy that if you don't like the way it came out first time, or it gets damaged, it's easy to revise and/or replace. Bob . . .

S Re: Panel markings Better yet, check out www.frontpanelexpress.com Randy

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Re: Instruments; Ammeter Shunts, Two Busses, Switches

>I have an EDM900 on my panel with a single readout for amps. I want to be able to check the amps for both busses. I have a 70 amp alternator and the B&C 20 amp. The EDM900 came with a 100 amp shunt. Do I need any special or "matching" shunt to use on the 20 amp alternator or will the B&C 30 amp, for example, work fine?

A A "shunt" is a precision, zero-temperature coefficient resistor designed for tolerable heat rise with LARGE currents flowing through it. Years ago, a sort of standard was adopted for sizing shunts such that when a current equal to their rating was impressed upon them, the voltage drop would be 50 mV. This was a compromise between keeping the ENERGY lost in the shunt to some reasonable value and industry ability to fabricate instruments that would read full scale at 50 mV.

If you want your instrument to read out in absolute amps, then you will need to use the same shunt for both measurements . . . in this case, 100A shunts for both systems . . .

Now, given that your instrument reads a full scale "100" with 50 mV applied offers an opportunity to scale the instrument differently. If you use a 70A shunt on the big alternator, then the instrument will read 100 when the alternator is delivering 100% of its capacity. It follows then that you install a 20A shunt in series with the other alternator and again, the instrument will read "100" when that alternator is running at max capacity.

Intuitively, this makes more sense to me when you want one display to read multiple energy sources . . . it's more useful to know how much of the source capacity you've used (got left) than to know how many amps are being drawn from the device. Further, it allows a single instrument to read energy sources of different size using the same scale factor. 100% of capacity is just as meaningful on an SD-8 alternator as it is on a 120A fire breather.

> There are two wires feeding the EDM900 for amps. My plan was to get a DPDT switch and feed the EDM from either shunt. Do I need to switch both wires from the shunts or just one?

A BOTH!!!! Switching just one will get you blown fuses . . . you ARE planning to fuse your ammeter leads . . . aren't you?

> JPI shows two possible installations of the shunt, charge/discharge or load. It seems the charge/discharge is the best way because you get more info, but....

A How is the charge/discharge reading richer in information than a loadmeter?

> I don't know where to put the shunt. I have a fat #2 wire running from my master contactor (in the rear) to my starter contactor (forward of the firewall). From the lug on the starter contactor I have a #4 wire running back through the firewall to my main buss. I also have the main alternator tied to the starter contactor lug. The JPI installation manual says to put the shunt between the master contactor and the bus. Do I need to run my alternator feed directly to the bus? Or is there another place I can put the shunt? I'm sure I don't want to cut my #2 wire feeding the starter. Any ideas?

A Sure, check out the wiring diagrams in Appendix Z. I'll suggest that a charge/discharge battery ammeter is no more "useful" than an alternator load meter. ANY and ALL electrical system instrumentation is useful only as a diagnostic tool . . . and I think we're agreed that diagnostics are best left for the maintenance hangar. If you have ov protection, a low voltage warning light and battery(ies) sized and maintained for guaranteed endurance sans alternator, then the airplane is perfectly operable with no additional instrumentation.

If things are not going right, presence of the instruments on the panel are of no value to you as a pilot unless your battery is four years old. Voltmeters are then quite useful to gage the enthusiasm with which you exercise mental butt-kicking on your hurried decent to the nearest airport. If it were my airplane and I had both panel space, budget and enthusiasm for installing electrical system diagnostics on the panel . . . the 100A JPI would be switched between alternators - each fitted with shunts sized to the machine.

A voltmeter would read the e-bus (or aux/main buses if you are doing Z-14) and be fitted with a switch so that I could also read field voltage of either alternator. That way, while on taxi to the hangar, I could flip a few switches and know exactly what needs to be fixed/replaced before I shut the engine down. A convenience at best . . . you can make the same measurements with your shop equipment when you're ready to pull the cowl. Bob . . .

Re: Instruments; Ammeter shunts

> Bob-- Got your book. Have read the section on ammeters/shunts several times. But, I just don't understand the mechanics of the shunt. If the shunt reduces the voltage to say 50 M.V.for the ammeter, how does it still then carry battery voltage to ground? Seems I'm missing a fundamental or two.

A A shunt is simply a precision resistor capable of carrying a lot more current that the panel instrument. When ammeters were first installed in vehicles, they were usually a "battery ammeter" with discharge-0-charge markings on them These instruments had FAT wires coming to big terminals on the back. ALL of the current that the instrument was measuring passed through the instrument.

The nice thing about a shunt is that it carries the vast majority of the current to be measured. Panel instruments designed to work with shunts are intended to operate as VOLTMETERS with a full scale deflection of 50 millivolts.

If you want your instrument to be a 100A full scale device, then you need a shunt resistance of 0.05v/100a = 500 micro-ohms. If you want a 10A full scale instrument, then the shunt becomes 0.05v/10a = 5 milliohms.

The ammeter has nothing to do with battery voltage nor does it "reduce voltage" . . . it does what all resistors do: presents a voltage drop that is proportional to the current flowing in the resistor. The 10A and 100A ammeter hypothetical cases above could be used at any system voltage. ...Bob

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Re: Instruments; Hall sensor problem???

>I believe that the Hall sensor setup for the VM 1000 is designed to show alternator output and not the system load directly. Until you run your engine (and the alternator) you won't see anything but "0" on the "amps" display. Larry Ford

A One can slip the hall sensor over any wire in the airplane you wish to monitor . . . but larry is right, if you've installed it over the alternator b-lead, it will function as an alternator loadmeter and will read zero unless the alternator is functioning.

Some builders have installed it on the battery feed wire and use it as a battery ammeter in which case I believe it will properly sense and display both (+) and (-) current flows. Bob . . .

S Actually, it will not properly display both (+) and (-) current flows. The Hall sensor will sense both directions, but the data processing unit and display are made to show any (-) current flow as zero (0). I'm not sure why they did it that way. Perhaps because the analog part of their display is laid out to display only positive current. I think I would have made it so that the digital part of the display would show the negative current even if the analog part just stopped at zero. That would give you more options on how you chose to use their equipment. Dave in Wichita

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Instruments: Shunts:

S A shunt isn't designed as a current limiter or regulator in any way. Its only purpose is to provide a means for MEASURING current through a section of a circuit. It is instrumentation, only. Ideal instruments shouldn't effect the behavior of the system being measured. The ideal shunt/ammeter would cause 0 voltage drop in the circuit, but 50mV is acceptable,

Current limiters are designed to only work when there is some kind of malfunction on the bus. I don't believe they would be good to use as another form of regulation. Matt-

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Instruments: Shunts

> Jim Sower wrote: I knew ammeters had a shunt. Are you saying that I could remove the shunt from the meter on the panel and remote it all the way back to the firewall (Velocity) and run a pair of 26 gauge wires back to the panel and connect directly to the movement (or something analogous to this with an off-the-shelf calibrated shunt)? That might solve the problem if the "movement" of the current meter was any good or I could obtain an easily installable substitute.

A That's what a shunt does for you. Let's you measure current in a remote location on tiny wires irrespective of how much current is being measured/monitored.

S Ah-ha! The confusion becomes clear! Jim, ammeters with internal shunts are actually not the standard practice here, or at least not in homebuilts (I don't know what certified ships use - Bob?), and for the exact reason you describe - it's a pain to run the wiring. You would normally use a shunt (essentially a simple current-to-voltage converter) located in the exact spot you want to measure, and NOT run huge 4AWG or similar wires up behind your panel. And yes, you can then run a much smaller and lighter wire pair up to the meter.

B&C has a whole page of shunts of various sizes at:

http://www.bandcspecialty.com/cgi-bin/ez-catalog/cat_display.cgi?15X358218

Then you use an ammeter designed for an external shunt, which is really just a voltmeter with a typical range of 0-50mV. The face of the "voltmeter" is painted with a scale calibrated to the correct range, which you need to know. You pick your shunt to match your meter, not your "expected" current flow - when the shunt has 50mV across it, your meter should show full-scale, and that full scale (suppose it's 40A) needs to be correct! That's why B&C has so many sizes available.

You might want something bigger than 26AWG though; 22AWG might be more appropriate. Bob, do you have a recommendation on maximum resistance in the wiring to an ammeter? I don't remember what these meters have as an internal coil resistance so I can't do the math on errors associated with wiring resistance. Since I've gone digital I don't even have one to measure.

Basically, Jim, you want the wiring to the meter to have a very small resistance compared to the wiring inside the meter, which is the coil that creates the electromagnet and moves the needle. This will make the meter more accurate. The more resistance the wire has, the greater the relative voltage drop across it compared to the meter's needle, and the less accurate the meter will be. If you care. Regards, Chad

A Yup, that's the big ADVANTAGE of a shut . . . you can keep fat wires out of the instrument environment yet do measurements on huge current values on small wires (26 is pretty small and not fun to work with - 22AWG is recommended as the smallest practical airframe wire). Now, if you increase the ammeter extension wires to 20AWG, then you can take advantage of the fusible link kits now offered by B&C where you get some silicone jacketed, fiberglas sleeving, some but splices and 24AWG (sometimes hard to find) wire for use as shown at:

http://www.aeroelectric.com/articles/fuselink/fuselink.html

Virtually ALL ammeters of any quality are DESIGNED to work with EXTERNAL shunts. These instruments have a 50 mv full scale movement and can be marked to depict ANY desired full scale value in amperes while in fact, the REAL current flowing through the instrument is perhaps at most a few milliamps. This was the sum and substance of on of the earlier replies in this thread.

> Output from the alternator runs about 10" through 8- or 10-gauge cable and passes through a 1.5" x 1.5" x 0.5" metal box with 1/4" terminals on each side and a mounting flange (I'm told this is a fusible link)

A Is this a commercially produced unit? Do you know what it really contains? I've seen builders shun the rather fat ANL limiters and bases in favor of building an automotive mini-ANL into their own enclosure thusly:

http://www.aeroelectric.com/articles/Thread/Figure_2.gif

I DON'T recommend this. The metal box is usually grounded to the firewall. The mechanical integrity of the insulating washers is at risk here. They are relatively thin and not robust. This assembly puts very small clearances between fat wires carrying lots of current adjacent to hard-ground enclosures. I couldn't certify this arrangement. This is one case where those-who-know-more-about-airplanes-than-we-do make sense.

Yes, the ANL+base combo is pretty honky. If you just gotta have a smaller part, consider the Littlefuse MIDI style or some of the Bussman miniature high current fuses but when fabricating a base, bandsaw out a piece of Delrin or phenonic, drill holes for brass fuse studs and for mounting base to airframe. Counter bore holes for fuse studs so that heads of screws are under-flush to bottom surface.

see http://www.aeroelectric.com/articles/Thread/Figure_3.gif

After installing studs, pot the counter-bore with expoxy to capture screw head and insulate the screw from electrical contact. Hex headed screws are really good here . . . lets the epoxy get a good grip on it. Also, steel is probably okay since your ring terminal that carries current on and off the fuseholder is bolted right against the fuse tab . . . the bolt will carry only a tiny percentage of total current flow. It would be better that the alternator b-lead were replaced with a hunk of 4AWG running from b-terminal through a shunt, b-lead fuse and then to starter contactor. Bob . . .----------

Re: Instruments: Thermocouples

A All of these discussion should be academic. REAL thermocouple wire is not hard to get nor is it expensive in the small quantities needed to wire the average SE aircraft. See:

http://www.omega.com/toc_asp/subsectionSC.asp?subsection=H06&book=Temperature

for a gaggle of thermocouple wire products. May I recommend the TT series wires and 20AWG stranded as particularly robust and easy to use. Of there are other combinations to choose from. There's a part-number-builder on each catalog page for wire that will tell you what a small quantity of each kind of wire will cost. For example, TT-J-20S in 25' coil is the grand sum of $32 plus shipping. The same insulation in a 24 gage stranded wire is $27. K-wires are similarly priced. Check out the rest of Omega's website for a wealth of free reference literature on thermocouples and other technologies. Bottom line is that what ever technology you use to deduce temperatures based on a thermocouple will DEPEND on a reference junction somewhere in the system. For panel mounted instruments, this reference is INSIDE the instrument. Bring T/C wires all the way up to the instrument if you expect to achieve specified performance for that instrument. Bob . . .

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14. LED'S

LED

>Dear Bob, (This is an edited copy of an email I sent to B&C late last week): I have recently fitted a LR3B-14 Voltage Regulator in a Long-Ez rebuild. Nice unit, well made, etc. However having substituted a 12V rated LED (620 ohm resistor included) for the LoVolt warning lamp supplied so as to provide some conformity/aesthetic appeal to the warning lights system, I find that the LED remains on, albeit rather dimly, when the bus voltage is 14.2 Volts or more.

A The lamp driver circuit was designed to power a lamp having a normal load of at least 80 milliampers and to have no visible light at 5 ma. The 5 ma "leakage" comes from a collector-base resistor on the lamp driver that will cause the bulb to illuminate in case the LR-3 looses all connections to the bus (of course the lamp needs to enjoy its own connection to +14 . . . don't share a supply with either of the LR-3 power input leads).

To run an LED, you need to parallel the led with a 180 ohm resistor. This will raise the threshold of illumination for the lamp to something on the order of 8 milliamperes. Then select a series resistor that will produce 50-30 ma at 11.5 volts drop (220 to 390 ohms) when the lamp is lit. This combination of resistors should take care of normal ops . . you might want to make sure that the lamp comes on steady when both +14 supplies are removed from the LR-3. Bob . . .

Re: LED Annunciator Panel

>Bob, Do you have a wiring diagram for an annunciator panel using LED's?

A An annunciator panel is pretty customized to the task. You need some lamps to light up when they get a ground, others that light up when hit with +14V. Still others may need both lead wires to connect to the device that drives them.

>Something with a ptt button etc.?

A If you use LEDs . . .press to test isn't very useful. It's complex to implement and given the life of LEDs, not worth the effort.

> Which LED's will be visible in daylight,

A All the new bright LEDs are capable of sunlight viewability . . .

>but dimmable at night?

A . . . all LEDs are dimmable.

> Can you just use a simple pot for the dimmer switch?

A Yes . . . but since you need to control at least two and sometimes more LED sources for dimming, most systems just use a bright/dim switch.

>Any other suggestions?

A It's not difficult to do but it can be tedious. You first need to define what conditions are to be annunciated and how the power and control is to be supplied to each lamp. Bob . . .

Re: USING LEDS

> >Folks, I am looking at using a couple of LEDs to indicate things like fuel pump on, pitot heat on, maybe low fuel or oil pressure. Most LEDs seem to like 2-5volts. So how do I provide that voltage electrically - a step down device to a 5v mini bus? In line resisters to each?

A Red LEDs are about 2v, Whites are almost 4v with other colors in that range. All can be operated with a simple resistor in series to set rated operating current for operation at any voltage greater than the minimum required for the device. See http://www.aeroelectric.com/articles/leds3.pdf

Bob . . .

S Re: USING LEDS To make it even simpler, Radio Shack offers assemblies of red, green, and orange LEDs (276-270, 276-271, 276-272, respectively) that have the resistor installed internally so all are rated at 12VDC (16VDC max). Best regards, Rob Housman

S By coincidence, I was looking at a Kitplanes article on this just yesterday... came from the September 2000 issue. The short answer is a resistor of at least 600 ohms is right for a single LED in a 14V electrical system. If you have several LEDs is series, the resistor value drops. Frank.

Re: LED Wiring

> Bob, In your LED wiring diagram, you have a 220 ohm resister in both parallel & series with the LED. The 12 volt LED's purchased from RS have only a 220 ohm resister in series with the LED. Why the difference? Do I need to put a resister in parallel with the Radio Shack 12V LED before I use it as a low volts warning light?

A We need to make the LED emulate an incandescent lamp which will NOT illuminate at the very current levels that flow in this annunicator circuit in the OFF state. Without the parallel resistor, the LED glows dimly even when the bus voltage is normal. Bob . . .

Re: LED Dimmer Switch

> Bob, I am trying to hook up an LED warning panel for main & aux alternator failure, x-feed on, starter on & low oil pressure warn. I have tried hooking up an LED warning panel using LEDs with parallel & series 220 ohm resters instead of lamps. I used the Zener Diode 1N4745A

as the dimmer, but get no ruduction in the LED brightness. Any suggestions on where I am going wrong?

A You probably have the zener backwards. It sounds like you've got it wired such that the zener is FORWARD biased wherein the voltage drop is about the same as an ordinary diode . . . 0.7 volts. Reversing the zener causes the voltage drop to increase to the value of the zener's rating. In the case of a 1N4745, the rating is 16 volts. This will drop ALL of your applied voltage and the LED will be dark. Try zeners over the range of 1N4735 (6.2v) to 1N4739 (9.1 volts) to find the one that provides the desired dimming characteristic. Bob . . .

>I have tried a couple of Zeners and the 9.1volt with a 220 ohm resister in series with it appears to work for a single LED. However, when I put more than one LED with 220ohm resistors in parallel to the LED then none work. (When I bypass the Zener, they work, but at a dimmer level). Is there some special trick to making multiple LED's dim?

A Each LED needs its own resistor. You cannot parallel LEDs. Further, depending on whether your group of LEDs are pulled up to +14v or pulled down to ground, you need separate dimming control zeners and a two pole switch to handle the full array of annunciator leds. See http://aeroelectric.com/temp/LED_Dimming.gif Bob . . .

> Thanks, I was putting another resister in parallel with each LED in addition to the series resistor.

A Oh. That was only necessary for making the LR3 Regulator believe it was driving a light bulb. The LR3 is a pull-down type switch for the LED output. So, if you want to dim this LED along with other LEDs of the pull-down variety, you would put a resistor in parallel ONLY with the LED for the LR3, all others run barefoot. Bob . . .

S LED's don't function like light bulbs. They are diodes that just happen to emit light. It takes a 'threshold' voltage to forward bias or light the diode (varies with the design/color of the LED) and the diode will use a fixed amount of current to be 'converted' to light. The series resistor is sized to supply the needed voltage/current to the LED depending on supply voltage. Less than 'threshold' voltage means that the LED doesn't glow. If the voltage is raised very much above the theshold, current begins to rise (remember it's a diode, not a resistive load) and the excess current destroys the diode.

LED 'brightness' is varied by pulsing the DC supply voltage with a varying pulse width. The pulse frequency is high enough that the human eye doesn't notice it, kind of like TV or movie pictures. Constant DC voltage = max brightness; as the 'on' time percentage of the DC voltage decreases, the LED looks dimmer to the human eye. Think about strobe lights from your Disco days. :-) The faster the strobe flashes, the brighter the room looks.

LED dimmers are available & plans for building your own are available, but either way you are looking at more money/work/complexity than a zener or reostat to change the voltage. Charlie

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LED Primer:

1) LEDs will emit light if their voltage is above some small voltage, usually a couple of volts. Incandescent lamps when you think about it, behave the same (but for very different reasons).

2) LEDs lifetimes are nearly infinite if not pushed too hard; there are LEDs that have been on continuously for thirty years and counting. LEDs will be common household lamps in the next few years. Plug-in replacement lamps for most applications are available or easy to craft yourself. They are not extremely efficient (lumens/watt), but they are small, cool, and last almost forever.

3) LEDs are brighter and dimmer depending on the current through them. (Forget pulse-width modulation...that's usually not the way it's done). If you increase the voltage to them, the current through them increases and they get brighter. If you reduce the resistance the same thing happens. Don't exceed the recommended maximum current. Most common LEDs work well at 20 milliamps. For the mathematically inclined: V(supply)-V(led)R(in series) x I(led).

4) Using LEDs in parallel: Incandescent lamps (and many other things) INCREASE resistance when they're on so the hot lamp gets less of the current. This is good. But LEDs (and many other things) decrease resistance when they're on so all the current wants to go through one LED. This is not good; one LED's current will quickly spiral up, leading to things not working. To prevent this, you only have to give each little LED its own little resistor.

5) If you want to dim parallel LEDs (each of which may be on or off) then it is easiest to change the voltage to the LEDs. Bob's zener+bypass switch or any voltage regulator works well. Regards, Eric

----

Re: LED Dimmer Switch

>Bob, I thought the LR3 just grounded the low volt warning light contact when the voltage dropped.

A That's right. In the common vernacular of electro_speak this is a "pull-down" activation of the lamp.

>So, you're saying that when I hook the LED with a 220ohm resister in parallel & one in series to the LR3, that it will not behave like it does on my breadboard (where I have the other LED's hooked up to the same power bus)? Do I need to run a separate power line to the LR3 indicators separate from the other 6 LED's I have hooked up? Or can they all share the same power line?

A Since power is in the "pull up side" of the "pull-down" activate lamp, it is possible to run all the LEDs from a single power source as illustrated in my sketch.

>When I include one LED with a parallel resistor and the others without, on the dim setting (through the zener) only those that do not have a resistor light up. The result is that the LR3 warning light remains dark even when I connect it to ground. If instead of connecting it to ground on the breadboard, it is connected to the LR3, will it work in this configuration?

A Hmmm . . . you're beginning to get a glimpse into the perverseness of behavior of LEDs when you try to treat them like voltage driven devices. A red led has about 2.0 volts across it at all intensities and its light output varies with current. Lets try this for the LR3 wiring: http://aeroelectric.com/temp/LED_Dimming2.gif

>(for example, if in your diagram, one of the LED's had a resister in parallel with the LED and the others didn't, the one with the parallel resistor doesn't do it's job).

A Yup, the original suggestion wouldn't tolerate dimming. Let's see if this works better. Bob . . .

LED's: Dimming LED's and incandesent bulbs with AeroLectric

For a circuit which allows using LED's and standard incandesent bulbs on the same B&C dimmer see Randall Henderson's web page at http://www.edt.com/homewing/rhproject/cabinlts.html. For LED's, Randall uses a 4.7V Zener diode to offset the 4V minimum output voltage of the dimmer, allowing the LED's to be completely dimmed when the incandesant bulbs are getting the "keep warm" voltage. Regards, Roy

A Randall did a nice job integrating LEDs into his cockpit lighting scheme . . . I'm impressed. Bob . . .

Re: LED position lights redux

> I believe the formula for conversion of the LED intensity from mcd to Lumens is(current in ma x mcd = lumens). This is what I have seen listed in several suppliters specs? Typical bright white LED was @20mA(mcd rating)=3000 Lumens.

A Check out;

http://www.electro-optical.com/whitepapers/candela.htm Here's a nice link to folks who work in LED technologies http://www.ledtronics.com/pages/downloads/light_measurement_terms.pdf

Here's a site that specializes in replacing incandescent lamps with LEDs . http://www.theledlight.com/ and some discussions on the physics of light measurement

http://www.theledlight.com/lumens.html who also offers to source some killer leds at:

http://www.theledlight.com/led-specs.html   another lucid discussion of quantifying light

http://www.intl-light.com/handbook/intens.html

Re: LEDs

> I am about to order some LEDs. Roughly how many mcd do I need for the following:

>1. For a red flood for the cabin if all else fails so I can see in dim >light?

>2. A white one to provide some light in the baggage compartement to find something in the dark when the plane is parked?

S   I000 mcd = 1cd is approximately as much light as from 1 regular candle. Jerzy

----

Re: LED's; parallel resistor used with LR-3?

> Bob, I found in the archives a reference where you recommended a 220 ohm resistor to be used in parallel with an LED when used to replace the incandescent bulb in the LR-3 Low voltage warning circuit. Then I also have a sketch you posted for someone not too long ago showing the same   thing only in this case you recommend a 470 ohm resistor for the parallel resistor.

A   470 ohm series resistance will give you about 21 mA of lamp current. 220 raises it to 45 mA. The high intensity red lamps I use really get your attention at 45 mA!

>Is it 220, 470, or does it matter? I don't know how much current the LR-3 sinks in the OFF state so I'm not sure how to calculate what it should be.

A   The LR-3 pulls down at about 2 mA in the off state. Putting a 220 ohm resistor across the LED and then a 220-470 ohm resistor in series with the lamp/led combo will get it lit up in good shape. You need the 220 across the lamp to keep it dark while off-state leakage is present.

>For what it's worth, Greg Toman suggests a 1K resistor to be used with his engine monitor warning light if replaced with an LED, but his circuit may not sink the same amount of current as the LR-3....so maybe that's a moot point.

A   This would give you about 10 mA on most lamps. This will get you quite a bit of light too . . .Bob . . .

Re: LEDs

> I am looking for the brightest LED annunciator lights that would be viewable in direct sun light. If these devices are not available for direct sunlight, I would like the next best option. A 45 degree viewing angle would be preferred but could accommodate smaller angle as necessary. Hopefully several colors would be available. Source would be 14 Volt and dimmable as dictated by ambient light. Any help would be appreciated

A See http://www.flamecorp.com/pdf_files/aml_1.pdf page 44 shows some LED custom annunciators. Bob . . .

Re: LEDs, voltage and current

> My understanding is the resistor is to get the voltage down to tolerable levels for the LED.

A Close, but not quite. If the LED is rated at 3.6v, that's pretty much what it will pull unless overdriven - and then it won't last very long at all. What the resistor actually does is limit current - in fact, they are known as "current-limiting" resistors in this circuit - but you could put any kind of current limiter there, it's just that resistors are the cheapest - but you have to size them properly.

You see, the LED is highly non-linear WRT current - it will "require" very close to 3.6v over a wide range of current - anything from less than 1 milliamp to 100 milliamps or more... less current and it's dim; more current and it's brighter (up until it burns out) - but the voltage stays pretty much the same over the range I mentioned. It's your job to calculate the resistor value that will allow just the right amount of current through - not enough resistance, and the current goes up and reduces the life of the LED; too much resistance, and it may be dimmer than you want.

The calculation is simple - the available voltage is 13.8v (typical main bus voltage) minus the 3.6 volt that the LED will use... so you've got 10.2v across the resistor (or resistors if you like, but there's no good reason in this case to use more than one) - and you want no more than 20mA to pass through it... ohm's law says E=IR or E/I=R... 10.2/.02 = 510 ohms.

Any higher resistance will mkae the light dimmer; any lower resistance and you will be exceeding the rated current, possibly reducing the LED's life. Actually, with your proposed 94 ohms resistance, the current will be (E/R=I) or 10.2/94 = 0.11, or 110 milliamps - not a good idea... they will get pretty hot, and expected life will definitely be reduced. Not only that, but the power dissipated in each resistor (P=I 2*R) will be 47*.11*.11, or over 1/2 watt, requiring each resistor to be 1 watt rating - relatively large!

> The long lead should be positive. THe LEDsI have are rated at 3.6 volts at 20 mA. I used 47 ohm resitors ...one on each side of the LEDs with the circuit being... 12 volt battery positive > switch > 47 ohm resistor > Positive lead on led>.... >Negative lead on led > + led >- led >+led > - led > 47 ohm resistor > negative ground.

A A single 510-ohm resistor will get you the proper current, and will only dissipate less than a quarter-watt, so a half-watt resistor would be the proper choice. Why do you want to use two resistors?

S P.S.: Digikey has brighter LEDs with lower cost - but it does require a bit of searching, they have so many! Here's an interesting one, 441-1008-ND on page

http://dkc3.digikey.com/PDF/T033/1199.pdf

Actually, this one is mounted in a wedge base for use with standard automotive light sockets (although you'll probably never need to replace it) - and it even apparently contains its own current-limiting resistor (it has a 12-volt rating)!

Powering LEDs

Remember before running off to build some led lights, that leds are DIODES and they cannot be put in parallel, without a current limiting resistor. The reasonable way to make an led assembly is to put several leds in series with ONE limiting resistor. For example-- if the power supply is 14.5V and the individual led Vf (voltage drop) is 2 volts, you can string seven of these leds in series with a series resistor (in this case E=IR; pick the current; 0.5V/.020A=25 ohms).

This string (whose length is limited only by the available drive voltage) can conveniently be put into a parallel-connected assembly (whose width is limited only by the available current). Remember to calculate the power dissipated in the resistor (I x I x R; in this case .02 x .02 x 25=.01W). The dissipated power in a single led operated from 14.5V at .02A would be about 30X as much. This often fools first timers. Squash the notion that leds need to be pulsed to change their intensity. This errant notion comes from the way digit displays are lighted by microprocessors. It is also electrically very noisy. Regular leds behave pretty much like regular filament lamps to changing voltage.

One more thing to watch for! Leds usually have a poor reverse voltage withstand, usually only 4-5 volts. So you can easily blow them up by reverse voltage or ESD static. I don't know what Jim Weir was thinking. It must be hard to come up with an article every month. Regards, Eric M. Jones

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LED’s

You can run LEDs in series or parallel. There is a short, sweet summary of the pros and cons of series vs. parallel LEDs at:

http://www.bivar.com/eLetter/driving-la.htm

By the way, it's simple math, but there's a neat calculator for this formula at:

http://ourworld.compuserve.com/homepages/Bill_Bowden/led.htm

It's more complex than others in that it handles multiple LEDs but if you're planning on chaining it's a neat tool. Regards, Chad

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LED’s

Scott--Actually LEDs are rated at a couple of volts. They don't do anything at lower voltages. Above a couple of volts, the produce light depending on how much current flows through them. Ohm's Law E=IR is applicable here with just a little jiggering. Voltage across the device is equal to the Current (I)through it times the Resistance (R). Since the LED automatically drops couple volts all the time (let's call it Vf), the voltage we're looking at is really E minus Vf. Then the formula is: (E-Vf)=IR

Everything else with a small amount of algebra follows from this. Remember a few small details---

1) LEDs don't change color as voltage changes. Incandescents do!

2) LEDs are diodes and diodes don't like parallel hook-ups. If you want parallel LEDs you have to limit the current through each LED with a little resistor.

3) The series resistor wattage is I x I x R. Don't forget 25 milliamps is 0.025 Amps.

4) Buy LEDs from eBay if you can.

5) There is almost no upper voltage limit. LEDs work fine at voltages where the resistor becomes the problem. For a 20 milliamp LED operated at 10 kilovolts you just use a 500k ohm 200W resistor($75).

If you plan to power an LED from 14.5V, it will work at 16V and still work at a few volts. Regards, Eric M. Jones www.PerihelionDesign.com

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15. MAG / EI

Re: Magnetos and Electronic Ignition

>> I just hung my XP 0360 engine and am going to start the finish wiring soon. I am set up with a left magneto for the bottom cylinders and a lightspeed EI for the top cylinders. How do I tell if there is an impulse coupler on the left magneto?

A If you took a magneto off the other side, compare with the one you left on. The mounting base thickness for an impulse coupled mag is taller/thicker. Engines are generally supplied with either an impulse coupled mag on the left side -or- a dual point, "shower-o-sparks" mag in the left side. If one has to choose between impulse coupled and shower-o-sparks, get the later. It's a bit more complicated but a superior performing mag for engine starting. Bob...

Mag wiring

> I'm a little confused about how to properly wire my slick mags... I assume the p lead terminal goes between the splined lock washer and the fiber washer. Right?

S The mags I installed didn't have a fiber washer. The only purpose I can see for this washer is to act as an insulator in case the terminal gets bent down against the mag case. I would question the ability of the fiber washer to withstand the torque of the nut without crushing. However, if you determine that the washer is up to the task, then yes, install the terminal between the fiber washer and lock washer.

> Also, why is this stud flat on one side?

S To prevent the stud from turning when you tighten the nut.

> Does the mag case work as engine ground?

S Yes.

> and is there a specific screw I'm supposed to use for this ground?

S There should be a threaded hole in the mag case very close to the stud. Connect the shield to this hole with a screw (should have been included in the mag installation kit.)

> Or, do I run it to the firewall ground block?

S No.

> Ignorance sure ain't bliss.

That's what we're here for. As the Beatles once said, "I get by with a little help from my friends."
Bill

Magneto: Re: LASAR ignition wiring

>How does one wire the p-leads for a LASAR ignition? I want to use toggle switches for each magneto and a push-button starter. The blue and green wires from the LASAR low voltage control harness do not appear to be shielded and do not go directly to a magneto, instead they

go to the controller box. I realize that each magneto needs to be grounded to be "off," but how does one do this with a LASAR?

> >

A How did you come into the hardware? No installation manual? Bob . . .

>The hardware came with my new Lycoming O-320 from Van's. The instructions (service letter SL1-96) are for hacking into a certified ship's existing ignition system and refer to splicing into the existing p-leads which are connected to a key switch (ensuring that shielding on the p-lead does not ground p-lead at splice and removing the jumper wire in the key switch for the right mag).

S From John Huft (RV8 Pagosa Springs, CO 28 hours flying with LASAR): "The blue and green wires are simply grounded to turn the mags off, and left open to turn the mags on. The magic box senses the ground and turns the mags off. There is not the usual noise on these wires, because they are not P-leads at all. You can cut these wires to whatever length is convienent. The cables from the magic box to the mags are pre-prepared, and are not to be messed with."

A Found a copy of the service bulletin at http://www.unisonindustries.com/pdf/marketing_literature/SL1-96(F).pdf

It's pretty clear that the ignition control leads are configured so as to be transparent to the ignition switch as to whether the ignition system is magneto or LASAR.

>Therefore, I plan to hook the green and blue wires to #3 terminals on seperate single-pole switches, and a panel ground wire to each terminal #2, and leave each terminal #1 open so that the down position is "off."

A That ought to do it. Here's some stuff I found about local aviation writer's LASAR installation on his Cherokee 180 in Earl Long's facility at Dead Cow International . .

http://www.avweb.com/articles/lasar1/

http://www.avweb.com/articles/lasar2/

Bob . . .

Re: Ignition; Bus

>Bob, My thoughts on the dual electronic ignition was to put one ignition on the battery bus and the other on the essential bus, if the wire from the battery contactor to the battery bus broke, I would still have an electronic ignition that would work. If both ignitions were put on the battery bus, would opening the essential bus alternate feed switch restore the battery bus?

A	E-bus alternate feed switch has nothing to do with the battery bus. Battery bus is always hot irrespective of the position of any switch.

>The alternator field c.b., in figure Z-11, what is the purpose of the fuselink when the wire has a 5a c.b. protecting it?

A	The 5A breaker is remotely located from the main bus. There is a wire segment between the main bus and the breaker that is not protected. Any protection we put there needs to have a time constant much longer than the breaker so that an ov trip doesn't open the upstream protection.

>With the dual alt/single battery design (figure Z-12,) should I connect the aux alt on/off switch to the same bolt as the master switch?

A	Yes, if you're using fuse blocks, you'll need to remote the field breakers for both alternators and use fusible links from the main bus feed bolt.

HOWEVER . . . Figure Z-12 is not recommended for new design. Note that the main busses drive breakers. This is recommended for adding a second alternator to an existing system like on a Bonanza or C-210 . . . or a homebuilt that's already configured with breakers and 1960's architecture system. If you're starting from scratch, you can do better.

>Finally, the essential bus is shown connecting to the main bus via a bolt, there is only one bolt on my 20 amp fuse block that I bought from B&C. Should I also connect this bus via the single bolt?

A	Yes, the bolt is long enough to stack multiple terminals on it. Bob . . .

Re: Magneto; Tach P-lead feed

> As I understand it, a tach feed from a mag P-lead will work regardless of whether the mag is "On" or "Off." A mag is turned "Off" by grounding it, so the P-lead connection at the mag should continue to provide tach info. The only problem (according to the VM-1000 folks) is that there may be minor erratic tach indications if the mag has an impulse starter.

A	Don't think so. A mag driven tach looks for the "low" voltage mirror image of the spark that appears across OPEN points of the mag switch. Closed switch, no spark, no signal to tach.

> Another option is a transducer that fits on the mechanical tach port on a Lycoming. Van sells the transducer for $60 (part #IE VTACHGEN2) or $67 if you have a vacuum pump (part #IE

VTACGEN12.)

A This is the very best way to go. Bypass the ignition systems entirely. I designed tach transducers for the Bonanzas and Barons when they went to 2" instruments back in the 80's . . built a hall effect transducer that screwed right onto the tach drive fitting of the engine. Bob . . .

Re: Ignition; EI Install - Firewall Penetration

> My feeling is "wassabigdeal?!" I'm not ABOUT to cut a 1" hole in my firewall when I could get away with a much smaller pass-through just for the wire. I'll be chopping my connector off.

http://rvproject.com/images/2003/20030713_lightspeed_harness.jpg

That's a photo of what the 15-pin connector looks like when you take the housing off, as it comes from LightSpeed.

http://rvproject.com/images/2003/20030713_lightspeed_schematic.jpg

That's a crappy photo of the schematic that comes with the LightSpeed system...but you've got a reference if you get stuck. I understand why Klaus doesn't want to support myriad problems when people cut off his connector and screw up installing a new one.

By the way, the 15-pin connector housings are available from Mouser...part # 156-1415 (receptacle) or 156-1416 (plug), and the crimp pin/socket contacts are on page 603 of the online catalog as well.

http://www.mouser.com/catalog/614/603.pdf

Dan

A yup . . . good ol' d-sub. cutoff and replacement is a piece of cake. Go with machined pins, throw away the saddle-clamp strain-relief and replace with silicon tape wrap sufficient to provide very snug fit in the exit hole of the backshell like this:

http://aeroelectric.com/Catalog/avionics/760harn.jpg

Crimped on d-subs have to be the easiest connectors in the world to work with. Wouldn't hesitate for a second to chop one off and replace it. Bob . . .

Re: Ignitions; Questions

> Bob, I am building an RV7 (in England) with a Lycoming IOF-360 (FADEC, The FADEC comes with its own battery to power the FADEC in case of main electrical systems failure. I am planning to use your excellent architecture in Appendix Z to your manual with B&C Alternators etc. As this is my first stab at aircraft electrics I have some silly questions that you have probably answered a thousand times!

>1. Why are the Alternator B leads connected to the Starter contactor? If they were connected to the Battery contactor (output side) there would be one less bolted connection (and hence less resistance)?

A Main bus power is taken from the handiest place nearest the bus. If the battery is in the tail, then the starter contactor is best place. If battery is up front, then either starter contactor or battery contactor can be considered.

>2. Is there any issue with someone turning on the Aux Alternator bus feed switch with the Main Alternator running ok, and if not, why not just have both running all the time and therefore remove the requirement to switch on the Aux alt in case of main alt failure?

A That is exactly what happens in certified ships. Figure Z-12 is not recommended for new design. It's an easy fix to add a second alternator to an existing airplane. This this case, both alternators are ON but the aux alternator regulator is set for about 1 volt below normal bus voltage. Soooo . . . with the main alternator working, the aux alternator relaxes.

If the main alternator quits, the bus voltage sags, the aux alternator comes alive automatically. The SB-1 reglator is fitted with a circuit to illuminate an "AUX ALT LOADED" warning light and flash it if the aux alternator output is higher than 20A . . . reduce load until light stops flashing.

>3. I understand your logic regarding the use of a Diode (rather than a switch) between the main and essential bus. Really stupid question: Why have the diode at all and have the essential bus permanently fed through the battery bus (keeping the e-bus alternative feed switch of course to isolate on close down)?

A You want two, relatively independent feed paths for the e-bus. Minimize the probability of single failure taking this bus down.

>4. Have thought long and hard regarding your ideas on cct breakers vs fuses, not quite made my mind up yet - like the idea of being able to pull cct breakers if equipment plays up (but could of course put in a switch on the panel!)You show a mixture of Switches and cct breakers on Appendix Z, any particular reason (fuses on battery bus and breakers on main power bus)?

A Nope, the Z-figures are illustrative of options . . . they are not intended to depict details of any particular system. Once you're satisfied with a particular architecture, then exactly what runs from each bus, whether you use breakers or fuses, and selection of switches are all personal decisions. What devices in your proposed system have even a remote possibility of failure in a way that encourages you to interrupt power by pulling a breaker?

>5. I completely agree with your logic regarding old fashioned dual avionics/master switch. Is there any real issue regarding spikes on start up and so should I have switches for all equipment that does not have its own internal switches (there would be lots!) or is this an old wives tale and should I not worry and connect all my non essential, not switched, equipment directly to the main power bus.

A Can't speak for you but it doesn't worry me . . . I know that it's easy to build a system totally free of hazards to any product designed to live in airplanes (or any other vehicle). Bob . .

.

Re: Magnetos; Slick mag P-lead continuity

> I just want to confirm that it's normal for a Slick magneto to have internal continuity between the P-lead and GND terminals.

A yes. the p-lead is actually in parallel with the same winding that the points work against to time the spark. This is a very low resistance winding which will be closer to zero ohms when the points are closed. This is why it takes a special "ohmmeter" to time a magneto. The buzzer in the old timing lights created a relatively high frequency AC excitation signal that was more discriminating of point opening than the ordinary DC ohmmeter.

>I hooked up my mag switch (18AWG shielded wire, shield=ground terminal, center conductor=P-lead, 1-3 switch) and was surprised when I did a continuity test across the terminals...there's continuity regardless of the mag switch position. I guess this makes sense, that the switch is simply >short-circuiting/grounding some internal mag circuit (I'm obviously not too familiar with the internals), but I want to sanity check this before I plod along unknowingly with an always-hot or always-cold mag.

A Your points may be closed. If you can slowly rotate the magneto and watch the ohmmeter closely, you may perceive some change of resistance as the shaft turns . .but it will always be a low resistance. Bob . . .

Re: Magneto; Switches

There is an error in Figure Z-27. The intent was to show how to interlock the ignition switches to disable a non-impulse coupled magneto when paired with an electronic ignition. Here's the corrected drawing:

http://aeroelectric.com/articles/Appendix_Z_Drawings/Z-27_r11.pdf

Thanks for the heads-up. You're the first to catch this problem . . . Bob . . .

Re: Starter/mag switch

>Hi Bob and list, I'm using two switches for my ignition, one for the left mag and starter (double pole) and an other switch for the right electronic ignition. I'm upgrading to an all electric panel with a Grand Raids Tech. EIS and doing away with the tach cable.

> What do you think about the idea of using a triple pole switch for the left mag and starter and add a circuit to switch to the EI tach info when the mag is off?

A not sure about the "twice the rpm" statement but yes, most electronic tachs work best while watching only one of two mags at a time. A third pole on one mag switch can be used to swap tach sensing to the opposite mag when it is in the OFF position. It doesn't matter which mag you do this with. Bob . . .

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16. Motor Control

Re: speed reduction trim

>Bob, Do you have a schematic for a speed reduction device for the trim servos that I can build or is it something that I have to buy such as the Governor Mk III is a speed reduction and switch multiplexer for the MAC Trim series of aircraft trim servos from Matronics?

A You can use an LM317 regulator from Radio Shack to build an adjustable power supply that will provide the necessary, lower voltage for slower operation. Are you talking about MAC linear actuators? These only draw a few hundred milliamps and can be easily controlled by the smallest plastic device (LM317T). You can find data on the device along with hookup info at: http://www.national.com/ds/LM/LM117.pdf

Matt's product is another alternative. Also, in a few weeks, the B&C catalog on our website will offer the full range of dimmers as two channel, adjustable power conditioners. You can see a prototype of the 1.5A controller at: http://aeroelectric.com/temp/apc15-14a.jpg and http://aeroelectric.com/temp/apc15-14b.jpg A closeup view of the board is found at http://aeroelectric.com/temp/apc15-14c.jpg

In the closeup view you can see the two potentiometers that set output voltage. These can be used as a two-channel controller where one might need hi and low speed trim speed adjustment. It can also be used as a single channel device to provide clean, regulated power to accessories that require some voltage less than 14v to operate.

These will probably sell for the same price as their dimmer counterparts . . . the two surface mounted potentiometers on the power conditioner cost about the same as the panel mounted potentiometer and knob for the dimmer. When the products are being offered for sale, you'll be able to download a copy of the installation instructions which will show how to hook it up for the various tasks. Bob . . .

Re: speed reduction

>> I downloaded this information, purchased the LM317T regulator and proceeded to build the speed reducer, since I only need a reduced speed I only installed a 130 ohm resistor from pin 3 to pin 2. On the bench this gave me about 10.5 volts output. The problem is that by putting this device in line it is only good for one direction as it does not work with the current flow reversed. So I just tried a 10 ohm resistor in line and it also reduced the voltage from 14.5 to around 10.5 on the bench. At this point I installed this resistor in line on my planes MAC servo and did not see and differance in acutation time.

A Reversing the motor requires that you reverse it's leadwires. One lead is + extend, the other is + retract. Regulation of voltage for the purpose of controlling speed needs to be done before the switch that controls direction, i.e. your speed control needs to look like a bus having some reduced voltage . . . it goes in the line between the aircraft bus and the trim switch. If 10 ohms of resistance produces a 3.0 volt drop, then your motor is drawing 0.3 amps or 300 milliamps. Motors used in most actuators are permanent magnet devices who's speed is roughly proportional to applied voltage. The motor has no way of knowing if the voltage is reduced via resistor or adjustable regulator. With the regulator, the voltage is constant irrespective of motor current (changes with load on the actuator). With a simple series resistor speed control, the speed regulation with motor load is poor because as the motor slows due to increasing load, the current goes up. Voltage drop increases across the fixed resistor causing the motor to slow down still more.

>> ran my servo on a 9v teeny battery during testing and I couldn't tell much difference either. So I suspect you need to be down at some lower voltage to cut speed at least in half which is what I think most folks want. My suggestion is to fly and try. I think faster is better. When I roll out on final, it is too slow. When I am at high cruise it is a little quick but easily manageable. Hence I have never fiddled with it. To me the only challenge was to learn the tenth of a second "blip" it takes to trim at cruise. On the other hand I love gadgets, and someday may put a two position micro switch in just so my guest pilots can play with it.

A Control of trim speed is a common problem on a lot of airplanes. The wider the speed range btween cruise and approach to landing, the worse the problem. You want runaway speeds to be limited in cruise so you deliberately reduce motor supply voltage until trim action is so benign that the pilot can perceive and react to it fast enough to prevent problems. This makes for a system that runs too slow during the approach phase.

To the best of my knowledge I designed the first tightly regulated trim speed controllers for bizjets that first flew on the Lear Model 55 prototype about 1980. The system had two speeds, one about 4 times faster than the other for use in takeoff/approach and cruise phases of flight.

Our soon to be offered Adjustable Power Conditioners were fitted with two potentiometers so that one might have independently controlled high and low speed settings. The transfer from low to high speed operation might be controlled by a microswitch on the flaps that select low speed operation when flaps are fully retracted and high speed as soon as the flaps come off the up-stop.

Without knowing about this servo (therefore excusing me from any responsibility for my comments whatsoever), I'm wondering if perhaps pulse width modulation is the proper way to slow this guy down? Pulse width modulation is just another item in the bag of tricks that allows the motor speed to be controlled with a switch that is duty cycle switched (that's how I did it on the Lear). The motor doesn't care. If you need only one reduced speed and motor current is stable, the a resistor might do. If you need to have a stable voltage source irrespective of motor load changes, then something like what you are building (like our APC) works better. If you want to close the loop on motor speed control and hold it very constant over wide ranges of bus voltage and motor load, then more smarts and duty cycle switching is attractive. The trim actuator won't care which one you use. Bob . . .

Re: motor speed control

> > > I ran my servo on a 9v teeny battery during testing and I couldn't tell much difference either. So I suspect you need to be down at some lower voltage to cut speed at least in half which is what I think most folks want.

> > Without knowing about this servo (therefore excusing me from any responsibility for my comments whatsoever), I'm wondering if perhaps pulse width modulation is the proper way to slow this guy down? (Yep, your parts count just went way up, too.)

>I think so to. I have been watching this thread and I suspect that lowering the voltage on a shunt dc motor just lowers the available torque - doesn't necessarily change the unloaded speed. The only speed drop one gets is from the reduced available torque. PM field dc motors look like a shunt dc motor with a fixed field voltage (also current and flux). As I recall, changing the speed on a requires a change in the field - which one can't do with a PM field. So the only way to lower the speed and keep the torque up is to use a PWM power supply.

A A PM or (shunt wound motor with fixed field) is very sensitive to applied voltage . . . in fact, motor speed is almost directly proportional to applied voltage. If you'd like to dig into the details of motor performance, here is one of dozens of good links on the subjet; http://www.pittmannet.com/pdf/220000ALL.pdf

Torque is directly proportional to armature current. Armature current is equal to applied voltage minus counter emf (directly proportional to speed) divided by motor resistance . . . usually a very low number. A pm motor has an counter emf constant, let's say our sample motor is 4 volts per thousand RPM. Let's assume further that the motor has an resistance of .5 ohms. Sooooo . . . if we lock the shaft (zero rpm) and put 14 volts to the motor, we can expect a stall current of 14/0.5 or 28 amps. This would also be very close to the inrush current for getting this motor started.

Okay, turn the shaft loose and let's suppose we measure a no-load current of 1.0 amp. We know that 1 amp drops 0.5 volt across the internal resistance so counter-emf must be 13.5 volts. The no load speed is, therefore, 13.5/4 = 3.375 KRPM. Now, let's have our motor drive the flaps down and we measure a max current of say 6 amps. Okay, 6A times 0.5 ohms says counter emf is now 14 - 3 or 11 volts. 11/4 = 2.75 KRPM.

Now, let's drop the bus to 10 volts. The flaps are going to take the same TORQUE to lower irrespective of how fast you drive them. So, to maintain the same current (and 3.0 volts of I*R drop) the counter emf MUST drop to 10 - 3 or 7.0 volts. The new flap motor speed is 7/4 = 1.75 KRPM. The motor is doing the same work but at 1.75/2.75 = 63% of the full bus voltage speed. Want a motor that has better speed regulation? Try the same calculations using 0.2 ohms resistance with the same counter emf factor. Bottom line is that a motor's speed can be controlled by ANY means that adjusts it's perceived applied voltage. Duty cycle (or pulse width modulation) switching is no different than turning down the knob on a power supply. Bob . . .

Resistors: Re: blower speed control

> I have a cabin heat blower fan which draws 4.9 amps at 13v. I'd like to create a "slow" switch setting where it would run at about half speed. Whats the best way to do this? Put a resistor in the circuit for the slow speed? What size resistor? Regards, John

A The simplest way is to emulate the speed controls used on cars . . . add a resistor in series of the appropriate size to achieve desired speed reduction. This may be difficult to do in advance of final installation so one can hedge their bets by using an adjustable resistor. You can purchase such a device from Digikey as described at http://info.digikey.com/T023/V5/0675-0679.pdf I think the AVT50-3 would be a safe bet. Wire it up per . . . http://www.aeroelectric.com/temp/2speed.gif When the installation is completed and the system can be powered up, adjust slider on resistor to get desired low speed. Bob . . .

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17. PRIMER, ELECTRIC

Fuel Primer

>in regards to the fuel primer , what do you mean by primary system failure? is this where you would be using a fuel flow meter with the vane paddles in it ? they do warn to have a bypass in a system like this. i have used two different types of electric primers that i put together , worked great and were cheap. if you want i could tell you how i did it ....marty

A Some years ago(I believe I may have written about the idea in my first issue of the AeroElectric Connection) I suggested that builders consider a backup fuel delivery system. I opined that it was pretty easy to do . . . in fact, lots of certified airplanes are already fitted with a rudimentary backup system.

DataPoint 1. I've read dozens of hangar flying stories over the years where a pilot suffered a variety of normal fuel delivery system failures (broken throttle linkage, stuck float in carb, plugged fuel lines, etc) and managed to nurse his airplane to a comfortable landing by stroking the primer pump.

DataPoint 2. I connected these stories with a system I observed on the Beech Skipper (BE-77) in which I took my primary training. To prime the engine, one pressed in on the key while cranking. This closes an extra set of contacts in the key switch opening a solenoid valve that routes fuel from the downstream side of the boost pump to the primer lines. This made sure that the cranking motor was turning as raw fuel was fed to the engine. This improves vaporization efficiency because the engine is ingesting air while fuel is flowing.

DataPoint 3. The so called fuel injected engines found on airplanes is very rudimentary when compared with modern EFI systems on automobiles but is technically elegant with respect to complexity. They simply deliver a calibrated pressure flow of fuel to a nozzle located just outside the intake valve of each cylinder.

DataPoint 4. I've noted that some engines don't prime all cylinders, to make the backup delivery system work, you'd want to have fuel delivered to every cylinder. Other primers dump fuel into the carburetor which is fine.

Proposal.....Borrowing from the electrically controlled primer system found on the BE-77 and perhaps other airplanes, how about putting a valve in the primer line that allows calibration of primer fuel flow to some rate commensurate with 60-70% power. A needle valve would work. Arrange to supply power to the boost pump and open the solenoid valve by the proper placement of switches in the cockpit. If one wanted to take redundancy to a logical limit, I'd put a separate finger strainer in a tank and supply the primer system with it's own electric pump. Now, should one find himself airborne with no way to get fuel to the engine through the normal delivery path, you would shut off the normal delivery system (valves closed, pump off, mixture to idle cutoff) and flip the primer switch on. The throttle then becomes a mixture control. Adjust throttle for best running engine. The reasoning here is that a simple enhancement to a stock primer system would provide an on-purpose backup to the normal fuel delivery system.

Several years after I first proposed this system, a Long Ez driver e-mailed me to say that his airplane suffered a frozen fuel selector valve and the handle broke off with the valve in a position that wouldn't allow delivery of useful fuel. The calibrated primer back system did the job and he continued flight for over 30 minutes to an uneventful landing at an airport. Bob . . .

Primer

> Iam told that you have an electric primer system.

A Ed, I don't have a "system" for sale but I've written in my book about my own fondest wishes for a primer system. The Beech BE-77 Skipper was my training airplane when I learned to fly. It had an electric primer system consisting of a simple electric valve in a line that tee'd off the downstream side of the electric boost pump. An extra contact in the ignition switch would close when pushed in while holding the key in the START position. This dumped fuel into the primer system while the engine was drawing air during cranking. For an airplane with a carburetor priming line, it was ESSENTIAL that fuel enter the engine while cranking so that it was drawn into the induction system rather than dribble out the carburetor air duct.

Having read dozens of stories about pilots who limped their airplanes with compromised fuel delivery to safe landings with repeated strokes on a primer pump, I theorized that the primer system might be enhanced as follows:

Install a 4-port primer system that dumps fuel into the manifold right outside the intake valve for each cylinder. Plumb it up with an electric valve tapped into the pressure side of your boost pump . . . better yet, provide a separate pump plumbed directly to a tank that you plan to empty last during the course of normal flight operations. The enhancement comes from adding a needle valve in the line that you calibrate on the ground for a fuel flow rate in the 55-65% power range for your engine.

Now, if you loose primary fuel flow, you may pull the carb back to idle-cuttoff mixture, shut of the primary fuel flow system, turn on the primer and then adjust throttle (which has now become a mixture control) for smoothest running engine.

The electric valve is available from Aircraft Spruce. The pump is your garden variety FAWCET solid-state pump. You'd need to track down a needle valve from a hydraulic systems parts supplier. It needs to be a small one . . . take a look at some of the larger valves available from aquarium supplies stores used to set up air flows. (Be sure to safety the valve position after you've set it for proper fuel flow). In the past 13 years since I first published that idea, two builders have told me that the system worked to save their bacon AND the airplane when a failure occurred in their primary fuel delivery systems. Bob . . .

Re: Electric Primer

>The A Spruce catalog there is an electric primer that describes a solenoid with a spring and plunger. Does this arrangement replace a traditional type primer the same way - i.e., would the switch be operated the same as in throw the switch for 2-3 seconds, and one "squirt" is delivered, let go, then throw the switch again, etc.? So would it be wired as a momentary switch? Also, the electric primer is cheaper by at least half of the traditional ones, and you can leave the primer lines on the other side of the firewall. Seems like a no brainer - is there any reason to use the traditional primer? Gary Liming

A Figure Z-1 and Z-11 show how to wire this with a single S700-2-50 switch. The Beech Skipper used this technique and other undoubtedly do too. It would be my choice. Bob . . .

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18. RELAYS

Relays, landing light

>>Wondering what type of relay to use for a 100 W landing light (controlled from Infinity stick grip)? I was looking at a relay in Radio Shack yesterday rated for 10 A @12 VDC. This would be enough for the continuous currrent draw of a 100 W bulb, but due to the inrush current I seem to recall 'Lectric Bob recommending toggle switches rated for at 20 A. Assuming the same applies to a relay (??), can anybody recommend a good source for such a critter? I prefer a double pole single throw since I plan to power both the landing and taxi lights (on separate circuits) with a single button on the stick grip. >Thanks,

A Radio Shack stocks a 20-30A relay that might be billed as a headlight or horn relay. It's about a 1" black plastic cube and may also have a mounting bracket on it. It's a close cousin to our S704-1 relays you can see at: http://www.aeroelectric.com/Catalog/switch/switch.html#s704-1 If it were my airplane, this is the relay I'd use. Bob . . .

S Re: landing light relays? You might want to check Jameco Electronics, they have a large assortment of relays at very good prices. They also have sockets with the diode already mounted. Here is the ones I used for my flap relays, they have 12v 40 amp contacts.

https://www.jameco.com/cgi-bin/ncommerce3/ProductDisplay?prmenbr=91&prrfnbr=

4058&cgrfnbr=722&ctgys=503;523;722;

Re: relay source?

> I'm looking for a source of relays similar to the S704-1 sold by on Bob's web site. See: http://www.aeroelectric.com/Catalog/switch/switch.html#s704-1 I'm looking for a couple of 12v, 4 amp relays that use Fast-On tabs. I need one that is normally open, single pole, and one that is normally closed, double pole.

A The S704 has normally closed contact so it can be used as a normally closed. Radio

Shack's 900-2394 is a similar product. I'm not aware of any double pole products in this type of package. If all you need is 4A, take a look at Radio Shack's 275-214 (4PDT - 5A) and 275-218 (DPDT - 10A) products. These may have extra poles for your task but they are easily ignored. These have tabs that can probably be wired using narrow fast-ons. I'd have to measure the tabs to be sure. Bob . . .

Relays

>>Re: relay for fuel pump

>>I am using the Fawcet (non-fuel injected) pump. I did look at your web site and thought those might be more than I needed. I really didn't see anything in your book (although I got a lot of other information from it!) Thanks for you help.

A No problem. That little guy doesn't need much current. How about switching it directly and leaving the relay out? If you DO use a relay, something LIKE the S704-1 is nice because it has the handy push-on spade terminals . . . even if it is a bit over-rated. Bob . . .

Re: relay contact ratings

> One more ignorant question about relay ratings...do the same rules apply to selecting appropriate relay contact ratings as with toggle switches? For example I think Bob recommends a toggle switch rated at 20 A for a 100W landing light due to inrush. Is the same true for relays, or will a 15 A relay provide sufficient service life?

A You need to read the article at: http://www.aeroelectric.com/articles/swtchrat.pdf and then pretty much go buy any switch you want to do any task you want. By-in-large, the life of switches in airplanes has little if anything to do with their ratings. If you find it interesting to worry about ratings, I would not dissuade you from addressing your worries - but I'd rather you didn't worry about them at all. All those "rules" people are fond of citing don't mean much for the machines we're building. Bob . . .

Re: Use of Relays??

>Hi all, I have two Fawcet fuel transfer pumps and one aux. EFI fuel pump. I am wondering if I would be wise to use the toggle switches on the panel to close relays which supply power to the pumps? I ask as I have read about switch failures in the past and I wonder if reducing the amount of load going through each switch would help with this problem. Be gentle, electronics is still a black art to me..... :-)

A But did the story tellers know why the switch failed? I've observed over the years that most switches fail of old age and dis-use . . . not from electrical stresses. Relays are among the least reliable of switching devices due to their mechanical complexity and the need for winding solenoid coils from very fine, SOLID wire and a few other sundry features unique to relays.

With all other things being equal, the most reliable systems are those with the lowest parts count. Parts count includes ALL parts . . . screws, lockwashers, internal springs, terminals, pieces of wire, moving contacts, etc, etc. The ultimate reliability in a fuel delivery system has the fewest possible parts and an operating mode that is most TOLERANT of a failure of any single system component. It is good to look at higher failure probability components like switches and pumps because they are the most complex in terms of pieces and the most highly stressed cause they have to do WORK under less than ideal conditions. But this doesn't eliminate the need to consider power sources, skill in applying terminals to wires and configuring the system so that if something doesn't work as you originally intended, you have a plan of action for comfortable completion of the flight. I'll suggest a review of chapter 17 may be useful to you . . .Bob . . .

Re: Relays; Switch Reliability

> For an application like this, I would suggest the Perfect Cubes, which are solid state devices that Eric Jones is building. I have been testing these units the past couple weeks, and have found their performance to be great. They draw very little current to turn them on, so your switches should last for a long time with little degradation. The cubes themselves, being solid state, will far outlast any relay. Just something to think about. I'm using these for my taxi lights (11A), landing lights (11A), pitot heat (7A), Navs (5A), and strobes (7A). I'm using Eric's larger units called the Powerlink JR on my gear up and down (35A) and my avionics busses (15A and 22A). No relays in my plane :) (well, hopefully someday)

Eric is also working on a larger unit, called a Powerlink, that will hopefully be able to replace the stardard battery contactors and handle 200A+. I have a prototype, and hope to test it soon. Eric has some other cool products too, like the super diodes, a wig wag flasher, and is working on LED bulbs. All kinds of cool electronic gadgets that should make our planes safer.

Contact: Eric M. Jones emjones@charter.net

Solid state devices will always win when it becomes a battle of dependability, especially where vibration is a concern. Also, the solid state devices have thermal shutout protection modes that no switch or relay have. The sizes and weight are also much less for the solid state devices. The cube (20A) is about the size of a dice, the powerlink jr (35A) is the size of a domino.

In my design I haven't chosen to implement this, as they aren't 100% proven yet, but in the future, you won't even need fuses or circuit breakers with these devices and their protection modes.....if they draw too much current, they trip out until the current reaches a normal level. This would be a highly simplified system without CB's or fuses, and a lot less weight, AND no pilot thought/action required. Until they are proven and I have some hours on them, I chose to go a more traditional route....

http://www.lancaironline.net/pix/shannon-jan03/panel_cbs

http://www.lancaironline.net/pix/shannon-jan03/panel_perfect_cube_2

with mounting the cubes DIRECTLY to the circuit breaker, as their tab is a Vin terminal also. Shannon

A A 7A "rated" toggle or rocker switch would run for thousands of cycles in any of these applications. Bob...

Re: Relay; trim

> Bob I am in the proces of creating a pitch trim rely deck. Can't use MAC to much load. I was reading you download about this Pitch trim page 4.2. The elevator trim on the Velocity has a 3amp draw and 5a breaker so i have a good idea of the size of the relays. Any suggestion on whose to use?

A The S704-1 relay shown on our website catalog is suited to this task and can be wired per diagram you cited. http://www.aeroelectric.com/Catalog/switch/s704-1l.jpg

> Also have a question on the spike diodes you use in the diagram I assume 12v but what oHm and amp size would you suggest. If you have a description that goes whit that diagram how can I get it?

A Don't have a bill of materials for this. Any diode you can put your hands on will work. 1N4000 series devices mounted like http://www.aeroelectric.com/articles/s704inst.jpg this picture shows how to put the diode on when used as an alternator disconnect relay . . . using this relay as pitch-trim relay would be wired similarly. Bob . . .

Re: Relays; Pilot Controlled Battery Disconnect -

A Sorry to take so long to get back to this . . . been busy. Download

http://aeroelectric.com/temp/v1a.pdf

http://aeroelectric.com/temp/v2.pdf

http://aeroelectric.com/temp/v3.pdf

. . . trim with scissors and use transparent tape to put these three drawings together into a larger, easier to read document. This illustrates a technique for installing control relays adjacent to the battery bus when switched loads are protected at greater than 7A . . . FAA would like to see these relays for loads greater than 5A . . . it's problematical. We're talking about crash safety and I'm reasonably certain that the 5A convention was pretty much pulled out of a hat . . .

They are "comfortable" with both 5A fuses and 5A breakers. Breakers are so much slower than fuses as to represent at least an order of magnitude greater hazard with respect to how much energy can be dumped into a fault before the protection operates . . . given that truly modern airplanes use fuses, I'd be comfortable with hardwired battery bus lines of 7A or less and only install relays for 10 and larger feeds. I'm going to add this technique to the 'Connection at Rev 11. Bob . . .

Re: Relays; PTT

> I would like both the pilot and the co-pilot to have PTT buttons and when one pushes theirs it cuts the other person off from talking. Im just wanting your expertise in finding a couple nice tiny (but inexpensive) relays (preferably something I can solder in line and just cover with heat shrink) that will work with the currents we have here.

A Tiny relays and soldering in-line are mutually incompatible features. Tiny relays mount to etched circuit boards and very non-robust terminals. Years ago, the relay of choice for what you're wanting to do was Potter-Brumfield 4PDT KHA series relays. They're cheap from Digikey (cat #PB142), and can either be soldered to directly with wires and heat- shrink or you can install them in a socket (Cat #PB144) and hold relay in place with spring wire bail (Cat #PB146).

I've added a first-come/first-served PTT relay circuit to the last page of AEC instructions for installation of 760VHF . . . this would work with any other radio too. See: http://www.aeroelectric.com/Catalog/avionics/760imB.pdf

Bob .

Relays:

You're the second builder in the past week to note the acres-of-relays technique to achieve some ill-conceived benefit in designing an aircraft electrical system.

See http://www.aeroelectric.com/Pictures/TooManyRelays.jpg

There is no foundation in physics or even demonstrated practice for taking this blanket approach to potential interference control. Further, it illustrates a serious lack of understanding on the part of the designer. Worse yet, it increases weight, complexity, cost of ownership and reduces reliability. Bob . . .

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19. STARTERS

Re: Lightweight starters...

>> I'm a bit confused about the lightweight starters currently available. It was my understanding and general impression that most RV builders were getting the Skytech starter because it was the lightest, best all-around starter. But I've heard a few less than positive things about Skytech's track record recently. I looked at the Magnaflite starter, which appears to be a new motor bolted on to the old "Bendix drive"....it's roughly comparable in price to a Skytech, is 0.1 pounds lighter, and makes the claim that it has more torque than "any other lightweight starter out there". I haven't looked at the B&C unit but if I recall correctly it was heavier and more expensive than the Skytech. So, is the Skytech getting a lot of use simply because Vans sells it (both separately and on their new Lycomings) or is there something I'm missing?

A B&C produced the first successful lightweight starter design. It's been STCd for longer than I care to remember and enjoys strong user support. Robinson Helicopter has used nothing but B&C starters for about 15 years and they're very happy with the decision. B&C has participated in dozens of conversations with Lycoming and Continental about supplying volume quantities to support their engine production. In every case (until a few months ago) both Lycand Cont thought they could do better. Lyc has gone through several iterations of sub-contracted and outside starters (including Skytech) over the past 10 years. None have matched the performance and reliability of the B&C starter. Continental tested a B&C starter on their new IO-240 and pronounced the starter "indestructible" after 5000 starts in the test cell. Then they proceeded to attempt a clone of the B&C design which proved to be a poor business decision. Seems their clone has dropped too much metal in too many engines. I belive they're currently negotiating with B&C for the starter they tested.

Virtually all competition to the B&C starters use PM motors . . . lighter, cheaper and easier to build. I was involved in Bill's deliberations to consider offering a PM motor version of his design. After several months of consideration, we agreed that it would add no performance value. PM motors have some performance downside . . . most notability the higher inrush current and steeper current vs. RPM curves characteristic of a parallel wound motor. Bill was unwilling to give up superior system integration issues and elected to stay with the wound field design. Further, B&C designs use all ball bearing construction and no plastic structural parts or gears. B&C starter pinion gears are directly engaged with the ring gear by a solenoid.

Many folks report satisfactory performance from other starters. In the bigger picture, B&C's track record with Robinson stands in sharp contrast with attempts by both Lyc and Cont to do better for less money. Yeah, the B&C starters are more expensive but they've got more stuff in 'em and they're harder to build. I'll suggest that trials in the marketplace have proven B&C starters to be good value. Bob . . .

Starter contactor

>>Bob, I am using a starter contactor that has a fourth terminal that is normally used to power a 12 volt ignition circuit during cranking on an automobile. This terminal is isolated from either the

starter or battery terminals when the contactor is not energized. It is my plan to use this terminal to drive the starter solenoid, allowing the starter contactor to serve both the role of eliminating the "always hot" 2AWG wire to the starter and also isolate the starter motor from the starter solenoid when the start switch is opened. Are you aware of any reason why this configuration may not work, and do you know if this contact can handle the current loads for the starter solenoid?

A I think that would work okay.

>>Switching topics, in your drawings for essential buss wiring, you show the use of a diode bridge to isolate the essential buss from the main buss. I note that you feed the power from the main buss to the essential buss by a single connection to one of the "AC" terminals on the diode bridge. This puts all the current through a single diode in the bridge. Why not connect the feed the power from the main buss to both "AC" terminals on the diode bridge and thus, through two diodes in parallel? Would this not improve the current handling capacity of the bridge as well as reduce the

voltage drop across it?

A Voltage drop in diodes is a matter of the physics of creating an electronic check valve . . . it's a relatively constant voltage irrespective of size of diode or the current being passed through it. Paralleling two diodes will not decrease voltage drop in any material way. Further, diodes connected in parallel do not share a load well. It wouldn't hurt to use two diodes in parallel as long as your current draw does not exceed the rating of ONE diode . . . Bob . . .

Re: Fig Z-14 SKY-TEC Starter Wiring Change

A A few weeks ago I published a diagram that speaks to a run-on problem exhibited by starters with permanent

magnet motors. These motors generate considerable power as a permanent magnet generator as they spin down after the

starter button is released. This output power can cause the pinion gear solenoid to dwell in the ENGAGED position

for up to several seconds. The obvious solution was to drive the starter solenoid/ contactor coil directly trough the start push button or switch . . . cars do it, why not airplanes?

You can find an article I wrote on the characteristics of modern starter solenoids and contactors at http://www.aeroelectric.com/articles/strtctr.pdf

In this piece I talk about why these two-stage devices have very high current draw in the first few milliseconds

after you push the starter button. Unfortunately, this quite normal characteristic is hard on all but the most robust

of starter switches and pushbuttons. To mitigate this problem, B&C has recommended (and I agree) that a separate, intermittent duty starter contactor be used to accommodate the special operating characteristics of modern starter engagement solenoids. Power is fed to the solenoid by way of a short jumper between the main power terminal for the starter and the solenoid winding terminal (usually a push on spade). B&C ships their starters with this jumper installed. Our wiring diagrams show the jumper and use of an external starter contactor for cockpit control of starter engagement. A problem arises when a permanent magnet motor is substituted for the wound-field motor. These motors are pretty efficient generators during the few seconds it takes for the motor to spin down after the engine starts. The voltage that comes back OUT of these motors tends to keep the engagement solenoid energized for several seconds after the pilot releases the starter button. B&C starters do no do this . . . they still use wound field motors for reasons that we won't discuss here. Only permanent magnet products have this problem. In the published drawing at http://www.aeroelectric.com/errata/z14.pdf you'll see where inordinate stresses on the starter switch have been mitigated by a small "boost" relay (our S704-1 is suitable for this application). Bob...

S I called the Skytec tech support and spoke to a fellow about the two wirings. He said the preferred way is the way Bob suggests but because they wanted to sell this starter to the certified crowd, they had to make it compatible with the conventional installation of these aircraft. I had my plane wired with the traditional starter contactor and tore it out. I like the relay method better. Ross

S In the 10-28-00 revision of Fig Z-14 is shown a diode between ground and the starter-run relay terminal connected to the starter solenoid. This appears to me to handle the collapsing magnetic field of the solenoid coil upon release of the ignition key from the start position. However, I don't see a diode across the coil of the starter-run relay the to do the same to minimize arcing at ignition switch contacts. Is it possible that the diode shown was actually intended to be across the starter-run relay coil instead of as it is shown. If not, then would it not be beneficial to add another diode (not shown) across the starter-run coil as is consistently shown for the battery contactor coil, aux battery contactor, and alternator contactor?

A The energy stored on the S704-1 relay (or any similar) is so low that it does not represent a threat to the starter switch. The relay energizes with about 100 milliamperes of coil current where the smallest inrush of even the recommended intermittant duty contactors (like our S702-1) is on the order of 4-5 amps. One could add a diode on that coil. See: http://www.aeroelectric.com/articls/s704inst.jpg for how we do it when that relay is used as an alternator disconnect relay for PM alternators. Bob....

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20. STROBES

Strobes

>> I have the A600-PG/PR wingtip assembly and the HDA,CF power pack. I want to alternate between the left and right strobes. Is this how I wire it? Left strobe in socket 3 or 4. Right strobe in socket 2. Jumper pins 1 and 2 in socket 1 (trigger). What is the proper size wire for the HDA,CF power +,- runs? It is a 12 V system. What is the proper way to wire the forward and tail position lights? Can I use a common ground at the wing tip, tie the two positive leads together at the wing and run one wire to a switch and power supply? What would be the proper size wire for this combination? Ross

A You can ground the power supply locally in a metal airplane. The system probably draws and average current of less than 5A but it does have a peak current draw at the end of each flash that would benefit from slightly larger wire. 20AWG is fine.

>What is the proper way to wire the forward and tail position lights? Can I use a common ground at the wing tip, tie the two positive leads together at the wing and run one wire to a switch and power supply? What would be the proper size wire for this combination?

A 20AWG wire throughout fed with 7A fuse/breaker. You can ground each light locally and bring the trio of wires together wherever convenient. I think I'd bring them all three together at a blue (14-16AWG) terminal right at the position lights switch. Bob . . .

Aeroflash strobes

>OK. But I have a question here. Say I'm wiring the position lights, which each take 5 amps. Should I run 16AWG back to a T, then use 20AWG to each light?

A Astute question. This is the one case where one has to account for the TOTAL load of multiple small loads. Each lamp runs at about 2A. The total is 6A. This means that the breaker/fuse should be about 7A. If you have a 7A protection, then the ENTIRE system should be wired for 7A loads irrespective of the fact that each branch is loaded to only 2A. Bring 20AWG wires all the way from each lamp to the back of your nav lights switch. Crimp all three wires into a single blue terminal at the switch. See; http://aeroelectric.com/articles/multiplewires/multiplewires.html

>I'm still trying to figure out what to use for various joints. Is there a permanent joint for RG58?

A Sure. Look over the products at:

http://www.aeroelectric.com/Catalog/antenna/antenna.html

http://www.aeroelectric.com/Catalog/tools/tools.html#rct-2 and article at:

http://aeroelectric.com/articles/bnccrimp.pdf

http://aeroelectric.com/articles/coaxconn/coaxconn.html

>What should I use to join the nav lights in the wing root? Knife splices seem a little inconvienient when the wing is removed and reinstalled.

A If it were my airplane, I'd wire the wings with 10' hunks of wire hanging out the root. When the wings are installed, put a service loop of about 6" slack at the root and route wires on into the fuselage to the panel. IF and when you need to remove your wings (I'm renting airplanes that are 40 years old that probably have never had the wings removed) then cut the wires and go back together with butt-splices or next best think is knife-splices.

If your airplane gets routinely trailered and you HAVE to repeatedly open the wire bundles, then consider: or the white plastic Waldom/Molex or Tyco/AMP Mate-n-Lock with terminals applied like: http://aeroelectric.com/articles/matenlok/matenlok.html

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Strobes

>>I'm building a RV9 and plan to install Bob Archer wingtip antennas. A comm in one tip and the nav in the other tip. I'll also have wheelen strobe/position lights in the tips powered by a single power supply in the fusalage. I'm concerned about interference from the strobe/nav lights. Can the wires for the lights and the antenna be run together in the same conduit? Should I order the "shielded" versions of the lights or maybe just use shielded wire from the power supply? I plan to use the RG400 shielded cable for the antennas, is this enough protection? I've heard from one pilot on the RV list that has a similar setup with no problems but would like more opinions on the subject. >Cliff

A I've never seen a problem with noise coupled between properly installed antenna coaxes and wiring to other systems. Bob . . .

Strobes, Power Supply Wires

>>Bob wrote: "Use an ohmmeter to see if the power ground wire actually connects to the power supply case. If it DOES, and your airplane is all metal, then take the power ground to local ground along with the shields." Bob, just to clarify this, is the local power ground used INSTEAD of the firewall ground or IN ADDITION to it.

A If your airplane is metal -AND- the strobe supply has a low resistance (less than 10 ohms) connection between the negative power supply lead -and- the case, then ground the power supply locally. Taking the (-) leadwire elsewhere when it was already connected firmly to local ground via case bolts would CREATE an unnecessary and potentially pesky ground loop. In the targets business, we always design our major electrical/ electronic components with separate case and power grounds. Cases are always grounded locally along with shields to ward off noises coming in from outside. Power grounds are taken to a single point common, usually inside the power distribution box. Bob . . .

Strobes

>Is it necessary to run a shielded power line to a Whelen 3 bulb power supply?

A   No

>Do you think it is appropriate to mount this 2.1 lbs box on the belly skin?

A   I'd fabricate a shelf that attaches to internal structure. The problem with attaching anything to skin is the labor and downtime involved in repairing skins that have become cracked due to vibration and extra loads attached to them.

>The Whelen manual mentions shielded wire but it doesn't spell out what systems will need one.

A   The only wires that need to be shielded in the stobe system are those that run from power supply to flash tube fixtures. Their install kits used to come with the appropriate wire for this task. Bob . . .

Strobes, remote vs. local supply?

>I was planning on separate power units mounted in the wing tips and tail, thus allowing the high-voltage lines to be as short as possible and as far away from the avionics and radios as possible. The Strobe guy only sells the single, centrally mounted power units. Is my phobia about high-voltage noise unfounded or should I stick with my plan for remote mounted power units and just pay the cost and weight penalty? One other penalty of the separate power units is that the strobes will not be synchronized to each other. Not sure if this is a concern but looking for opinions and god knows these lists are great place to gather opinions;~)

A   There are tens of thousands of airplanes flying with single power supplies driving multiple, remote lamp fixtures that are giving excellent service. People who do have noise problems generally don't follow good installation practices with respect to the use of shielded wiring. Bob . . .

Re: Light Flashing Circuit

> > I have been considering constructing my own microcontroller based lamp flashing system for my RV. I was thinking about putting some filament warming logic in the system to cut down on those high inrush currents that are generated because the filament is cold.

A The mass of a high power lamp filament is so great that it does not have time to cool into the realm of high inrush before the next pulse comes along in your wig-wag circuit. So only the initial surge at first turn-on is really significant. The only place I've found keep-warm to be really useful is to improve the life of 1950's technology sealed-beam lamps originally incorporated in most certified ships. Modern halogens have very high inrush too . . . but they're so much more robust than the certified products, keep warm isn't worth the effort. If it were my airplane, modern automotive halogens would be used on the wings and keep-warm circuits chucked into the trash can along with the sealed-beams.

> > Also how would a halogen bulb and an incandescent bulb differ in their reaction to this system?

A Both are incandescent lamps. Originally lamps ran in a mostly nitrogen atmosphere. Operating temperature was a trade off between light output and life . . . tungsten evaporates at normal lamp operating temperatures. As the lamp ages, it becomes thinner and more fragile, the inside of the glass becomes clouded with a film of condensed tungsten. Here's an interesting history of the incandescent lamp.

http://inventors.about.com/gi/dynamic/offsite.htm?site=http://invsee.asu.edu/Modules/lightbulb/meathist.htm

Halogens came along and figured out a way to make tungsten vapors re-deposit on the filament. The result was to allow the lamp to operate at higher temperatures without sacrificing life. The bulb's efficiency goes up at higher operating temperatures and the life is extended as well.

In the interest of low cost of ownership, minimized parts count and ease of installation, lamps like http://aeroelectric.com/4352.jpg are particularly attractive to me. These 55W critters work nicely in leading edge installations and may well run the lifetime of the airplane.

Walk down the isles any automotive parts store and see if they've got your lamp on the shelf. P/N is unimportant. Your looking for a high-beam or dual beam lamp with 55W or greater power per bulb. The one I illustrated is a #4352. It is the only one I've found with the very low vertical profile. Unfortunately, it was used on very few cars and is not a high-volume favorite. Makes them a bit pricey as headlamps go - about $20. Except for the fact that this lamp will outlast the contemporary "aviation" qualified lamps one might be inclined to look for another part . . . but if you're looking to install a leading edge lamp, this is the part of choice.

For small, round or semi-round fixtures, take a look at off-road fixtures offered in places like Walmart and other automotive parts outlets. These can be had with 55W replaceable lamps not unlike those used on headlights of cars. They're pretty cheap too. Saw a pair of compact bumper mount fixtures that would easily fit into the space commonly reserved for wingtip installations. You can buy a set, hook them to your car battery after dark and see what kind of light output you get and what the pattern looks like. Keep in mind that you don't really need gobs of light

to find the runway or make a good landing. Just 'cause a 767 blows the retinas off the eyeballs at 5 miles doesn't mean that's a good thing for an RV. Bob . . .

Re: Strobes

>> There are certainly much cheaper power supplies that you can use with the aeroflash or whelen strobe tubes if you don't want to build a custom mount. I chose to use the Nova Electronics XPAK 904 - this is one of the links Bob posted: http://www.strobe.com/products/xpak.htm

The 904 has bascially the same specs as the whelen cometflash 413 that drives three strobe heads. I purchased my 904 from http://www.strobesnmore.com for $159 dollars compared to $350+ for the whelen unit. There's detailed information in the RV-List archives, just search on XPAK. I hooked it up to my Whelen lighting units and they're extremely bright! It exceeds the 20 Joules per flash requirment that Bob mentions.

A Good data points! Thank you. Bob . . .

Re: Strobe "reconditioning"

> I have a Whelen strobe light power supply that I haven't powered up in many years. I have heard that the capacitors in strobe supplies "weaken" after long periods of inactivity, and have to be slowly trained up to normal voltage. Can anyone advise me on how to do this?

A Hook up the 14 volt supply leads to a 6v battery. Leave the strobe head(s) disconnected. After 10 hours or so, apply full 12v for another 10 hours. Then you can hook up heads and see how it works. Bob . . .

S I went out to the www.whelen.com and the warning is still there....WARNING: Strobe light power supplies are meant to be used, not to remain in an inactive state. Use them at all times, this will improve their proper functioning. Any strobe light power supply that has been out of service for a long period of time is subject to failure because the electrolytic condenser loses the polarity formation. A strobe light power supply not having been used for one year or longer is vulnerable to failure. If this is the case, it is recommended to start operating the system on a voltage that is reduced by 25 percent for 10 to 15 minutes before putting the power supply into normal service. This will prevent overheating of the condenser while they reform. If the power supply, after a long period of non use, is operated at full voltage immediately, there is an excellent possibility that the condenser will become overheated.

S I spoke with Whelen about this this very subject last week. The person I talked with, Jeff Argersinger, told me that it was only a concern if the unit was one of the older "DF" dual flash units as opposed to the newer "CF" comet flash units. The CF units first appeared in the early to mid 90's. Supposedly the newer units have better capacitors. Stan

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Switches; Re: Switch on a strobe line?

> I'm installing a 4 head strobe pack and would like to be able to turn off two of the strobes while leaving the other 2 on. Can I use a conventional toggle swich in line with the bulbs, or does the high voltage make that unworkable?

A Why would you want to do this? You need to switch high voltages that should be as confined as practical inside a shielded environment, shortest practical wires and routed away from other avionics and instrumentation wiring. If there's a really good reason to make yourself less noticeable to others while flying, I'd put a relay near the power supply to open the trigger lead of the controlled strobe head. Operate the relay from a remote switch on the panel. The three wires from power supply to flash tube are ground, trigger and high voltage. The trigger signal is also high voltage but very low energy. Discontinuing this signal will stop the tube from flashing. Bob .

Re: Strobes; Grounding shield on RV's?

> Bob, I'm interested in getting the strobe wire shield grounding philosophy clarified.. understand you recommend for composite aircraft to ground the shielding to the strobe head body, whereas on a metal aircraft to leave the shield at the strobe head end unconnected. Is that correct?

A Yes.

>Now, on the RV series, of course most of the wing is metal BUT the wingtip is fiberglass so the strobe body is not mounted directly on the metal airframe. So what do you recommend in this case?

A Ground the base of the strobe head to the shield . . . Bob . . .

Re: Strobes; shield grounding question

>Bob (Nuckolls) wrote: Ground to the power supply mounting bolt. Shields are ALWAYS system specific and will tie to some feature on a system connector or to the case. They never get pigtails to a remote ground point . . .

>

>My understanding is that shields should only be connected on one end to prevent introduction of ground loops through the shield. It doesn't matter which end of the shield is grounded as it

only serves to block radiation of FRI from the enclosed wires to other systems. Do you concur with my recollection or do I need some retraining? Bob (Lee)

A Shields use purely as electro-static coupling breaks between adjacent wires needs to be grounded at one end only. Adding a ground at the other end will not make it work better and it MIGHT cause a new problem with ground loop induced noises.

Some installers use shields as ground returns in addition to electro-static shielding. This the case, installation wiring diagrams are explicit as to where you hook the shields. For example, I show headset and microphone wiring carried on shielded single and trio wires in the installation manual I did for the Microair 760VHF . . . the radio would probably work fine and noise free had these circuits been simply wired with open, twisted wires and no shielding. In this case, getting the wires already assembled in a twisted mini-bundle with a shield was a convenience. The shield is useful to insure concentricity of the bundle's magnetic fields for reduced susceptibility to noise in addition to providing a ground return for the remote component . . . its benefits as an electro-static shield are not necessary nor utilized in this case.

Check out the headset and microphone wiring in http://aeroelectric.com/Catalog/avionics/760imB.pdf

where you'll see that shield termination at both ends of the run are quite explicit.

The short story is that there is no single, hard rule for use of shielded wire and terminating the shield. Unless the schematic shows otherwise, hook up one end only and as depicted on the diagram. If it wants you to hook up both ends, it should be equally explicit. And whether or not the designer intended the shielding to work as electrostatic de-coupling, electromagnetic

de-coupling, or just as another wire in the bundle . . . you'll have to ask because it cannot always be deduced by dissecting the wiring diagram. Bob . . .

Re: Strobes: noise

> I have a whooping noise in my headsets witch is louder on the ground. In flight it`s barely noticable except for who receives my transmissions. Where to start?

A First, run strobes from a pair of 6v lantern batteries by powering it up right at the strobe supply. If noise goes away, this says that the noise is CONDUCTED on the +14v power line coming out of the strobe supply. You can try a filter of the variety shown at:

http://www.aeroelectric.com/articles/filter/filter.html

A simpler alternative is to mount a fat capacitor like http://www.aeroelectric.com/Pictures/s251_3.jpg

next to the power supply and wire it across the incoming power (observe polarity). These caps can be ordered from B&C at http://www.bandc.biz or call 316.283.8000   This will take a bit of cut-n-try but it IS a problem that can be cured. Bob . . .

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21. SWITCHES

Avionics Master switches

I just ran across this article on avionics master switches...It seems to disagree with Bob's analysis of the need for them..and being one to stir thepot..here it is: http://www.avweb.com/articles/avmaster.html I tend to believe they are unnecessary myself, liking Bob's logic....higher parts count.. single point failure, etc.. Dave. a man with a '72 Bellanca Viking with no avionics master..

A When I could find e-mail addresses, I've written a number of authors asking for specifics as to the magnitude and source of transients that exceed the capabilities of the radio to deal with it. Never had an answer from any one of them. The general flow of these articles is to first instill a lot of concern for the uncertainties based on divine revelation.

For example, the article you cited says:

"Your panel of state-of-the-art avionics might represent one-quarter or one-third of the total value of your (TRUE) aircraft. To invest this kind of money and not have proper protection doesn't make economic sense or even common sense." Hmmmm . . . I guess "protection" is a "common sense" issue, not a scientific issue. The article goes on to say:

"You might think that you could just turn on and off the radios individually before and after starting the aircraft and wouldn't have a need for an avionics master switch, but that's only half-true. You may be able to turn on and off the navigation and communications equipment, but how about the intercom, fuel computer, glideslope receiver, marker beacon, altitude encoder, HSI, flight directorwell the list goes on. None of those units normally have an on-off switch. Their designers assume that the installing agency knows what they are doing and will provide spike protection."

Here the author chooses to ignore or is completely ignorant of the fact that the "installing agency" has no responsibility whatsoever with respect to protecting any aircraft accessory from system gremlins real or imagined. The installer is obligated by regulation and ignorance to follow the instructions that come with the product. Our guardian angles with clubs are quick to bless installations in accordance with approved documentation . . . right or wrong. Any installer with the brass to do something original either faces an uphill battle to convince the "angels" that the science is correct and that the deviation is a good thing . . . when tradition and ignorance are so pervasive, why bother?

These articles also fail to mention the hundreds of products with solid state innards that are routinely attached to the main bus of tens of thousands of airplanes and amassed millions of failure-free flight hours. It's easier to ignore the efforts of capable designers and chalk the apparent success up as "a universe of accidents looking for someplace to happen."

Dr. Tom's credentials are impressive . . . he owns "one of the finest radio shops on the West Coast", has the blessings of the FAA for functioning as a DER and even earned a PhD in nuclear physics. . . . Hmmmmm . . . won't belabor the obvious question there.

The article wraps up with: "If you have modern solid-state avionics (nav/comms, DME, GPS, fuel flow computer, etc.) then in my opinion an avionics master switch is a must. The few dollars you try to save by not installing one will return to haunt you in repair bills, guaranteed."

Hmmm. . . "guaranteed" . . . These articles have been around for decades and they'll persist as along as there are consumers ready to buy into the advertising hype. They never contain any data or specifics as to the threats or weaknesses in the design of potential victims.

As a sideline datapoint, I've been working with a number of folks at Raytheon who are considering the next generation glass cockpit products for inclusion into light aircraft. These systems are far more complex and potentially fragile than any piece of avionics produced to date . . . but all are tested to DO-160 to DEMONSTRATE an ability to withstand anything the airplane might throw at it . . and nature too. People have agonized for years about "spikes" from starter motors . . . you ought to see what we do to provide immunity from most effects of lightning. Now that's a SPIKE! Bob . . .

S FWIW - just as a sidebar - the ole' reliable 727 did indeed have avionics masters installed. Our company routinely kept those in the 'ON' position. The brand new state-of-the-art A320 with more avionics and computers than anyone can count, doesn't have any avionics master switches. I don't know what sort of electrical spikes are caused when the generators kick in during engine start (at about 53% of N1 rotation speed, the generator suddenly assumes the full load of the electrical busses), but the mechanical jolt is violent enough to actually make the engine pods shake, and the impact can be felt in the flight deck! And I couldn't count the number of times a year that the electrical system bounces around from engine-generator power, to Auxiallary-gen power, to ground power, to nothing (the worst case is when the ground plug falls out of the socket 2 minutes before pushback and everything suddenly goes black - then someone hurredly plugs it back in and all the lights and bells and whistles come on doing self-tests while the pilots frantically fumble through the flight computer pages to ensure that none of the data has been lost or corrupted!!! joy oh joy!).

All without any 'master switch' protection at all. -- Grant Corriveau Montreal

S I might point out that IF you follow ALL the electrical design suggestions that Bob recommends AND have equipment that was DESIGNED to current 160 requirements you need not worry about electrical damage. However I have some electronics from major mfgrs that was manufactured in 1999 (designed years before that)that does not meet 160. Further some appear to not have suitable protection for devices across the input bus that are rated for 18V max.

Those with spam cans that have older electronics and factory stock electrical charging systems should consider the use of an avionics master and/or turn off everything during starting and shutdown. The origins of the ""requirement"" for avionics master switches is not clear. However FBO's found that they had fewer equipment problems in the 50"s and 60" with rental acft if there was a avionics master and if it was used.

Personally I like a single switch for power control and have a second one in the very unlikely event of failure. This is a personal preference not due to worrys. I have included proper spike transient supression at the source in my acft similar to what Bob suggests and use the Avionics master for personal choice only. My conclusion is that a properly designed electrical system does not need the additional cautions of avionics off during start up and shutdown.

However I have yet to see a spam can built before 1990 that had a good electrical design. Paul Messinger

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Re: Keyswitch

>I know the ACS type keyswitch doesn't really provide hard security, but it does have a psychological barrier I would like to retain.

A . . . in addition to lack of security, they're fat, expensive, not more robust than toggle switches and inconvenient (how many time have you strapped in and found the keys are still in your pocket?) Further, only low dollar airplanes take advantage of this "protection" . . . twin engine airplanes don't fly with two keys., Hence, I'll suggest that the notion of protection is a myth . .

> In your book, though, you state those switches "contribute to occasional engine kick-back with possible damage to engine and/or starter." This is a different issue from whether or not a key is used to turn the switch, but of the way the contacts work. What is this kick back, and what is it about the switch contacts that causes it?

A I've not been able to "prove" this but analysis suggests that during an aborted cranking operation, the prop is still in motion when the right-mag disabling contacts open . . . IF the right mag chooses to deliver what ever spark it can produce at this time and it lights the fire in one cylinder . . . you get a kickback. Another anecdotal data point is that I've not heard of a single kickback incident with toggle ignition switches. Bob . . .

Switch, Battery/Alternator Master

>Bob, I notice in your diagrams you always have a Battery/Alternator Master Switch, and inline with the Alternator leg is a 5A breaker. Why not omit the Alternator portion of the Master switch and just use a push/pull breaker, and pull the breaker if you want to disconnect the alternator?

Dave Morris

A Back in the "good 'ol days" when airplanes were getting their first generators, batteries and a few lights, the battery master and generator control switches could be and were separate switches. This is because a generator will start and run by itself whether or not a battery was on line to go with it. When alternators came along, they needed (and still do need) a battery to get them to come up reliably. Further, alternators do not run well without a battery on line. None the less, it was desirable to have some degree of independent control of the battery and alternator insofar as system performance requirements would permit. This is when the split-rocker master switch was conceived. This switch has acquired almost magical attributes . . . I've seen the red-rocker enshrined in prominent locations on the panels of many homebuilts even when all other switches were a different style.

A little study of the split rocker shows us that the battery can be on by itself, but the alternator cannot. The same functionality is provided by our DP3T, on-on-on toggle switch (S700-2-10). Lower position is ALL OFF, mid position is BAT ONLY, upper position is BAT+ALT. It's true that you could replace the S700-2-10 with an S700-2-3 and turn on BOTH devices with a single throw of the DC master switch. It's a rare in-flight condition that the alternator NEEDS to be off. If you're doing some battery-only ground maintenance, then you could pull the breaker. We recommend the S700-2-10 as an alternative to the split-rocker switch to provide equivalent functionality.

Bob . . .

Re: Switches, master, e-bus

A Okay, let's talk about operations. If the low voltage light comes on, BATTERY MASTER - OFF, E-BUS ALT FEED - ON. If you want to reduce this, you can run the E-BUS ALT FEED in the on condition in normal flight so if the low voltage light comes on you have only one switch to turn off. This is easy to safeguard since the low voltage warning light drives off the main bus . . . it will flash at you until the main bus goes cold.

>Bob, if you leave the E-BUS ALT FEED on during normal operations I assume you would read full system voltage on the E-BUS. Not that it is needed as you say, but is that correct.

A Yes . . . in fact, some builders have put their only voltmeter feed on the e-bus knowing that the time they REALLY need it is during battery only ops . . .They have the option of knowing further that the main bus is 0.7 volts higher and doing the mental calculation to arrive at the alternator setpoint . . . or as you have accurately stated, closing the e-bus alternate feed will raise the e-bus closer to the main bus. Bob . . .

Re: Pin numbers of S700-2-10 on Z-23 & Z-24

> > Bob, Regarding figures Z-23 and Z-24, is there a typo on the pin numbers for the S700-2-10 switch? I looked through the archives and couldn't find any mention of errors, so if it's correct, please explain what's different that reverses the pin 2 and pin 5 logic between these drawings

A Good eye. I thought I'd caught all those. Numbering shown in figures Z-23 and Z-24 are incorrect. I got wrapped around a manufacturing differences axle a few years ago when I discovered that my S700-2-10 switches were assembled opposite the Microswitch equivalents. Note the view of switch in Figure 11-11 versus switch view in Z-16. The columns are switched.

Figure 11-11 is Microswitch; figure Z-16 is S700-2-10. I had published some variations on switch terminal numbering based on switches I was holding in my hand at the time not realizing there were two configurations. Sooooo . . . you've found a couple of artifacts in my wiring symbols that represent confusing times.

I determined that the schematics could be left constant with respect to terminal numbers if I simply pointed out the difference between the two switches. I illustrated the S700-2-10 right on the drawing. The Microswitch product has reversed column numbers molded into the plastic switch housing. I've marked the switches in Figures Z-23/24 for correction. Thanks! Bob . . .

Re: Guitar switch suitable for electric flaps ?

>> Hi Bob and all, What would you think of the use of a 5 position lever rotary switch for our electric flaps motors ? The setups I've seen use conventionnal rotary switches and a cranked lever on the shaft to provide a positive locking effect for each flap position. Nevertheless the whole device is rather bulky behind the panel. Any advice about using a switch such as this one http://www.electro-nc.com/e2_m.pdf

A I presume you're interested in having the switch provide input for 5 positions of flaps. Cessna did the most practical "servoed" flap control system for small aircraft. They rigged a Bowden control cable between the flap mechanism and the flap switch assembly. Microswitches that operate the flap motor are mounted on a plate that is rotated under a cam that's operated by the flap control handle. Moving the handle would depress one of the two switches which causes the flap motor to run. As the flap moves, the switch plate is moved to follow the command cam until the operated switch is released and the flaps stop. This arrangement gives you basically infinite number of flap positions although the handle is fitted with a couple or three detents. See if you can find a Cessna single engine airplane fitted with this system. A local maintenance shop should be able to show you a parts catalog and maintenance manual description of the system.

The switch you've cited COULD be used as you suggest but it takes some intervening electronics to make it work. Most flap systems are so benign with respect to effect and handling qualities that the notion of more than up, half, down positions doesn't seem very useful. The nice thing about a totally manual system with a spring loaded, center off switch is that you still have infinite number of flap positions and a reliable, SIMPLE, low parts count system. Bob . . .

>The Cessna arrangement is nice and simple , but the kit manufacturer supplies the servo device with a linear pot and limit switches as a standard. > >

A If the feedback potentiometer is built in, then the hardest part of a servoed flap system is done. Did they include any kind of sample electronics? Further, if you go automatic servo positioning, have you considered the hazards for electronics failure where you get un-commanded flap motion? You might want to consider two switches. One to drive flaps up and down with center being spring loaded off. Then a second switch to select the three flap extension positions. The servo amplifier would be active only in the extend operation causing flaps to stop at the desired location while holding the command switch down. Holding the command switch up will simply drive flaps to their full up position. This system would be incapable of simple electronics failure that would produce un-commanded motion. Also, the Cessna style mechanical feedback could still be applicable to your project . . . the potentiometer would still be used to drive a flap position indicator. Bob . . .

Switch, master

>> I'm working off Figure Z-8 and have come across a few questions. Main Battery Master Switch (2-3) Is this a double pole double throw switch?

A Later versions of that drawing call out a 2-10 . . . double pole, three position, ON-ON-ON function. This allows the single switch to mimic the function of the nearly sacred split rocker master switch. Bottom position - ALL OFF, mid position - BATTERY ONLY, upper position, BATTY and ALTERNATOR ON.

>With this set up does the master have to be on to engage the starter?

A Yes . . . the master switch needs to have control of ALL aircraft power except for the e-bus alternate feed.

>If adding a ground power receptacle, does it wire into the hot side of the master contactor?

A Yes, I prefer this connection because it allows you to charge a battery without having any other power applied to the aircraft.

>Auxiliary Alternator off/on - is this a single pole single throw switch to >be mounted on the panel?

A Yes.

>Are avionics masters not done anymore? The "need" for the avionics master was misunderstood from day-one . . . we didn't know much about solid state electronics when transistors first started to show up in airplane radios. See: http://aeroelectric.com/articles/avmaster.pdf The avionics master was born in the mid 60's, long before we learned how to build robust solid state systems an quantify the gremlins that were supposed to be lurking around every bush waiting for a vulnerable transistor to come along. See: http://aeroelectric.com/articles/do160.html

>This diagram indicates that there will be two alternator load meters. Are they the same wired in parallel? (in my case a RMI Monitor)

A No, run BOTH alternators through the same sensor. You'll only need to run one alternator at a time so the same sensor can read either or both alternators simultaneously, it doesn't know and doesn't care.

>Does the voltage regulator and the LR-3 go in the engine compartment?

A Wherever you want to put it for best accessability.

>How are folks mounting that honkin capacitor?

A Adel clamps.

Switches: Mag

>> Bob, I searched the active search engine but found nothing directly related to question, although I am sure I read something very close on the list..... I have two drawings. One drawing is from the ACS starter switch wiring diagram and the other drawing is your Appendix Z general wiring diagram which I wired my RV-4 after. The ground lug on the mag(s) is connected to the wire sheath on the special wire(ground woven wire around a center insulated wire). On the other end at the ACS switch do I connect the ground sheath(from both mag wires) to the "G" lug on the ACS switch also ??

A There are a variety of methodologies for wiring the mags suggested over the years . . . ALL are functional in terms of controlling the ignition system. Several themes have problems with respect to noise mitigation and potential for damage to wiring at a future date:

>> I also have a local ground wire going from the ACS ground lug to a local ground.

A LOTS of certified ships are wired this way . . . This means that your shields are grounded to the airframe at both ends. The engine end gets grounded through the crankcase-to-firewall jumper, the switch end gets grounded to panel structure. This puts a conductive pathway in parallel with the crankcase to firewall jumper and reduces the effectiveness of the shields as mechanisms to reduce propagation of p-lead noise.

The hazard to wiring comes from future maintenance errors wherein the crankcase to firewall ground strap is inadvertently left disconnected but you attempt to crank the engine. The starter tries to find a ground through the p-lead shields (or any other shielded wires to the engine that are similarly mis-used) and the several hundred amps burns up the shielded wires and damages any wires bundled with them. Had a mechanic at our airport do this twice on two different airplanes!

>> Is this correct or do I float the ACS end of these grounds ?? The wiring diagrams seem at odds here.

A Wired as shown in Figure Z and other drawings I've produced, the system functions as intended. I've had a couple of builders reduce or eliminate magneto noise in their radios by disconnecting the local ground at the switch. Wiring in this manner also prevents the shields from being called upon to do duty for which they are not designed and causing damage to the airplane.

>> Also, I did a first engine start tonight and I have a dead mag. When the switch is placed on the "L" position the engine quits. It runs on the "R" position and the "both" position. I got some tracing to do here.....I have a standard left mag impulse coupling (goes clank when I spin the prop...) Any suggestions on tracing the bug ? The timing seems spot on on 25 degrees on both mags...one firing a slight prop bump from the other when I use the buzz box.

A Just because the mag times doesn't mean it's a good mag. Try disconnecting the p-lead right at the left mag, start the engine and see if it runs on "L" position (R-mag grounded). If so, the problem is in the wiring. If the engine quits, the mag is bad. Bob . . .

Switches, circuit breakers

>> Bob, This is an IFR "all electric" single battery concept (Figure Z-8, Aeroelectric Connection) with a 40A ND with internal regulator backed up with a B&C SD-8 alternator and s704-1 relay. Crowbar OV protection is used on each. Regarding the ELECTRICAL charging and power BUS distribution switches and circuit breakers, this is my understanding: 1) 5A circuit breakers will be mounted on the panel for each alternator and it is this breaker that will trip, if and when the crowbar OV module activates. And also, one could use the primary alternator's CB to momentarily reset the alternator while leaving the main battery switch ON.

A Alternators do not require "resetting" . . . further, if you use the S700-2-10 progressive transfer switch as a DC POWER MASTER, the first position turns on battery only, the second position brings up the alternator. The alternator can be shut off any time and still leave the battery on line.

>2) There will be one toggle switch to turn on/off the SD-8 alternator, and another independent switch (e-bus alternate feed) to supply power to the essential bus should the MAIN BAT switch be turned OFF. Based on this, the use of the AUX ALT does not limit you to using only those items wired to the the ESSENTIAL BUS. It would be appropriate to put the two switches side by side as it seems they would normally be used together.

A No problem with that. There is no harm in having ALL switches on at the same time. There is only advantage in selectively closing switches depending on the nature of the failure. Some have asked if they can run the main and aux alternators together for some "added capacity" and the answer is yes . . . can't imagine why you would ever need to do this but it can be done.

>3) If the MAIN BAT was turned OFF, and the AUX ALT turned ON, the SD-8 would charge

the battery.

A Yes . . . and run goodies on the e-bus should the alternate feed switch happen to be closed also.

>4) By manipulating a combination of switches and circuit breakers, one could substitute the use of the SD-8 in place of the primary alternator while using the MAIN bus. Of course, the battery would probably drain if it was left in this state.

A Correct . . . but the drain on the battery would be reduced by the approximately 10Amps that the SD-8 will deliver. If you were close to the intended destination and wanted to leave the main bus up for the approach, there's not a thing wrong with adding the SD-8 output to extend the battery life.

>First, am I right with these statements and can you think of any switches or circuit breakers that I've overlooked? The way I see it, these are the ONLY circuit breakers on the panel. Secondly, what acronyms do you typically use for labeling these circuit breakers and switches on the panel?

A Correct, only two breakers are advised. I'd call them MAIN ALT and AUX ALT Bob . . .

Switches for duel alternators

>>Bob, I have an all electric 6A with a LD-40 and SD-8. Would there be any benefit to wiring the switch that puts the SD-8 on line so that the LD-40 is cut off at the same time so that they can not be both sending juice to the essential bus at the same time? If so, how is this wired and what switches would you use?

A No, there is no harm to having both alternators on line at the same time. "Interlocking" is more complex and offers single points of failure for both alternators.

>> Also, do you recommend putting a cover over the switch that turns on the SD-8 and the switch that turns on "battery only" essential bus power? Or, perhaops using one of those switches that have to be pulled on to be turned on?

A The All Electric Airplane on a Budget concept has been pretty well thrashed with respect to failure modes. If you can find a way to increase reliability by taking some things OUT (reduced parts count) or if you perceive a failure mode that needs the attention of redesign, let's talk about it. For the moment, there are no changes I can recommend. Bob . . .

Switches

>> Hi Bob, Using the 2-5 switches for mags, left/starter. I have rang out the switch and find it does not match the Aeroelectric Figure Z1 which I am using on my RV-6. The drawing shows 2-3 and 5-6 in the off position, while I have measured 1-2 and 5-6 when off (switch down). Drawing shows 4-5 and 1-2 in the on position, I measure 2-3 and 5-6 on (switch centered), with 2-3 and 4-5 in the start (momentary, up) position, breaking the 5-6 connection. What am I missing?

A Sounds like you have a 2-50 switch . . . not a 2-5. The 2-50 has progressive transfer. With the toggle in the anti-keyway (full down) position, it's just like a 2-5 with connections between 2-3 and 5-6. Moving to the mid position transfers only the left (rear view) switch transfers making contact between 1-3 and leaving the 5-6 contact alone. Moving to the keyway (full up momentary) position transfers the right switch making 5-6 go open and closing the 4-5. This switch is described as DP3T on-on-(on). The schematic symbol for a 2-50 switch is depicted in Figure Z1 for the FUEL BOOST ON/OFF/PRIME switch.

On the other hand, a 2-5 switch (the one you're supposed to be using on the mags), With the toggle in the anti-keyway (full down) position, it connects 2-3 and 5-6. Moving to the mid position transfers both switches to an intermediate off postion (no terminals connected to each other). Moving to the keyway (full up momentary) position transfers both switches making the 1-2 and 4-5 pairs. This switch is described as DP3T on-off-(on). The schematic for a 2-5 is depicted in Figure Z1 for the right and left magneto switches. If you purchased 2-5's and got 2-50's instead, B&C will exchange them for you . . . you'll also get a credit for price difference. Bob . . .

Switches, control grip

>Does anybody have part numbers for switches that are used in control grips? >Lonnie

A There are dozens . . . you need to decide if you want toggles, rockers, slide switches, push-buttons, etc. Where are you buying your grip? If from Infinity, it can be ordered with a combination of switches that meet your needs. If you're building from scratch, you need to research the realm of affordable miniature switches. Start at: http://www.ckcorp.com/download.shtml down in the lower half of this index you'll find listings for 7000 and 8000 series switch catalogs that will give you an excellent starting point for selecting and procuring the switches you need.

Bob . . .

Switches, PTT Grounding

>> Bob,   The wiring diagram for my PM1000 intercom has the PTT switches grounded at the mic jacks. Is this required or will remote grounds be satisfactory? >John

A remote grounds will probably work . . . I like to return them to the mic jack . . . the rule of thumb for reducing the ability of a wire to be a victim of noise is to have every outbound electron in close proximity to the inbound electrons and all ground returned to the connector of the appliance. That's why I draw the headset, microphone and PTT leads the way you see them in our Microair 760VHF installation drawings. You can try anything you want and if it works, then it's okay. I KNOW that the wiring I suggest is always okay. Bob . . .

Switches

>>Bob: Are the toggle switches used for a left mag, right elec ignition special swithces or just SPST? Pushbutton starter.

A You can use plain vanilla toggles . . . If your right mag doesn't have an impulse coupler, I prefer to use DPST (S700-2-3 in our catalog) and wire the second poles in series with the starter push button (See S710-1) such that the starter cannot be engaged unless the left mag is ON and the right mag is OFF.

See exemplar diagrams in Appendix Z download at:
http://www.aeroelectric.com/errata/R9Z_0400.pdf

Bob . . .

Switch, Key

>>I'm trying to go with the theory of no single point failures but I still want a key switch. Can I have the regular key switch on my panel (I have bought the conventional one fron Van) and duplicate all the functions with hidden switches?

A Not sure what the problem is here. If you have a key switch installed and wired up, I don't see any value in adding more switches . . . my primary objection to key switches are:

(1) expensive compared to alternatives.

(2) big . . . they take up room on panel and don't really look like they're part of the rest of the airplane's electrical system controls.

(3) no protection from theft . . . anyone who understands how they work will not be deterred in the slightest for getting the airplane running AFTER they've gained access to the cockpit.

(4) about half the time, I find that the keys are still in my pocket after I get belted in . . . keys are a pain in the whatsit. Bob . . .

Switch, Key

>>Hi Norman: I am going to use VAN's standard key switch on the panel. I will then use a SPDT or a DPDT switch (which ever one is required) that will allow me to choose the key switch for start or REMOTE START which will be a push button on the control stick. I am using the Infinity Grips and will use the right hand thumb switch for remote starting. That way I can keep the right hand on the stick and hold the stick back (RV-8) while I start the engine. Once the engine is started, simply flip the toggle switch back to the Key Sw. position and you will have no problem of hitting the pushbutton and engaging the starter while flying.

A Why not simply wire them in parallel with each other and eliminate the remote start select switch . . . or better yet, wire up the starter to the stick grip and just ignore the starter contacts on the key-switch. However, if you're going to plan on an air-start capability (with very limited usefulness and much potential for hazard to hardware) then I'd recommend removing the key-switch entirely and using toggle switches wired to disable the starter any time the right mag is on. I've never flown an airplane yet where the prop doesn't continue to windmill at normal flying speeds. If you're loosing power pump, then simply restoring fuel flow gets the engine back. If you think there's real risk of a prop stopping in flight, then there is risk of kickback by having the right mag enabled during cranking with a starter. Placing the right mags TOGGLE switch in the OFF position to enable the starter negates the risk.

If you're going to full electronic ignition, then you need two toggle switches anyhow and it doesn't matter if both ignitions are on during cranking . . . so the key switch becomes even less useful . . .Bob.....

Switch, Key

>>Bob, To follow this thread a step further do you have any thoughts on ways to secure the airplane. I don't intend to use a key start switch, but would like some way to disable the airplane and at least make it more time consuming to try and steal it. What about some kind of remote switch like use on car doors etc.? Jim

A When I owned the airport, there was a J-3 in our rental fleet that had no door locks and toggle switch mags. The airplane was housed in open pole barn facilities and vulnerable to theft. The BEST way to secure this kind (or any other kind) of aircraft is with a piece of hardened chain (covered with leather or plastic sleeve to avoid scratching) wrapped around the propeller blades and secured with a really good lock. The whole rig cost me less than $25 and I can guarantee you that nobody wants to try and fly an airplane with that kind of "unbalance" in the prop.

It's so obvious just walking up to the airplane that a potential thief won't even bother to wreck your doors to get inside . . . unless it's radios he wants. Can't help you much with that issue other than to use radios that install in trays, dismount with an allen wrench, and you can take them with you. Bob . . .

Switches . . .

>>Bob, Your comment about leaving the alternator switch ON with the battery OFF triggers a

question. What's wrong with that scenario? I had planned to have separate master battery (with a contactor) and alternator switches. Charlie

A This used to be practical back in the generator days . . . a generator will come and run fairly well self-excited and without a battery on line. When alternators came along, the practice of two independent switches was modified to accommodate most alternator's need for (1) initial battery excitation to get the system into operation and (2) most alternators don't run well without a battery on line.

This is where the legendary "split rocker master switch" was born. Its magical powers are invoked by most users of certificated aircraft and many builders three decades later. In fact, a simple two pole switch can be used to bring the alternator on and off together (use the field breaker to open field excitation for extended battery-only ground operations) -OR- use our S700-2-10 switch to provide the low cost equivalency of the split rocker . . . the 2-10 can be wired for OFF-BAT ONLY-BOTH operation. Bob . . .

Switches

Here is a web address for Greenlee Punches. About midway down the page you will find "keyed" punches.

< http://www.greenlee.textron.com/download/archive/gfl-02-13.pdf >

Switches, trim / flap run-a-way

>> My Cessna with a S-TEC 60-2 autopilot had a very simple electric pitch system that was fault tolerant. Instead of the single DPDT switch usually shown on schematics I have seen they used two separate SPDT switches placed right next to each other. You had to move BOTH levers simultaneously to produce a trim movement. As each wire from the trim motor was connected to the common terminal of a switch there was no single wire that could be shorted to either power or ground that could produce a trim movement. This was true of wires upstream or downstream of the switch. If a switch stuck in one position the movement would still stop when the other switch returned to neutral. All conceivable single failure modes resulted in either no trim or in a blown breaker. What's wrong with that?

A This is almost exactly the system used on KingAirs . . .Bob . . .

Switches and noise

>>I am planning my panel for my RV-4, and can fit most everything on the panel if I locate my

toggle switches below my radio "stack" (SL-40 and SL-70). Do the switches themselves, and I am thinking specifically of the alternator field switch, constitute a source of radio noise, and if so, is it the distance from the antenna or the receiver or both that is of concern? I am going to try and follow your book, using an internally regulated alternator with the crowbar overvoltage protection gizmo, but if the switches themselves are a source of noise if my installation is less than perfect, then I can mount them elsewhere and run the extra wire. (Preferably, just the noisy switches.)

A Most radio wiring comes out the back of the trays while switch panel wiring is generally bundled together and

carried way to the side of the panel routed along the back side of the panel. Switches are not active emitters of noise and no worse conductors of noise than the wires that connect them. Just bundle wires from switches and radios separately. Bob . . .

Re: switch question

>>I have your aeroelectric connection book that suggests that I use an off-start/on switch for the right mag and a off/on/start for the left mag. I have wired my RV-6 IAW your figure Z-1. Note 2 states that the switches should be a Microswitch p/n 2TL1-5.

A Those switches are now available from B&C as the S700-2-5 toggle switch . . . MUCH less expensive than Microswitch parts. See the website catalog at http://www.aeroelectric.com/Catalog/BCcatalog.html Bob . . .

Toggle Switch Installation

One of Lectric Bob's Shop Notes addresses Toggle Switch Installation. His suggestion for cutting a hole for the body is to use a 15/32" spotfacer fitted with a 1/8" pilot drill. I am sure that this tool works well. However, in calling one major tool company I found that technical person was not familiar with spotfacers. A call to a local tool supplier located a source of 15/32" spotfacers for about $30. The same supplier had a Black & Decker 15/32" "Bullet Drill" for $8.95 (marked down from $12). The bullet drill has a 15/32" body with a cutting end that looks very much like the spotfacer's in Bob's photo. It has an integral pilot about 5/32". I tried it on the .060 aluminum of the instrument panel at about 600 rpm in my drill press. It cuts like a gem making a very clean hole an creating a minimal burr. Richard Dudley

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Re: switch ratings - AC to DC

>>Bob, I have your S700 type switches and intend to run my Whelen position lights through one switch, but am concerned that I may be overloading it. The switch states 15A @ 125 VAC. I read through the chapter on switches, but it doesn't give a conversion to direct current. Is

there a formula?

A No but there's an article at: http://aeroelectric.com/articles/swtchrat.pdf . . . that speaks to this issue.

> My Whelen's are the type that has the white lights molded/integrated with the position lights. My plan is to fuse 12.5A and run a 16 awg to the switch. From the switch will exit two 16 awg wires (one pidg connector), one going out each wingtip (via CPC at wing root) to a terminal strip. From the (single) wire, I will power both the colored light and the white (tail) light. Does this sound reasonable? Whelen specifies 4A for the position light, but they don't mention the requirement for the white tail light of the integrated unit. Considering it is of smaller diameter wire, it will be less than four (4) ampers.

A Why 12.5A???? These lamps are about 2A each, 4 lamps comes to 8A so a 10A fuse is plenty. The 4A figure quoted by Whelen is apparently for the pair of bulbs in each fixture. Check out the article cited above. Bob . . .

Switches, Flap position

> > I've flown airplanes from C-150 to A-36 Bonanza and I cannot imagine that it would be an uncomfortable situation to NOT have a panel mounted flap position indicator OR precise control over flap position. Nevertheless, we find it nice to have preselected positions, especially with such a marked change between the 30 and 40 degrees down positions. No switch fumbling, no waiting and watching the flaps to ensure the desired position. A little less workload while in the pattern. Nice when getting into tight places.

A Sure . . . but that doesn't mean we should give up "resistance to hazard" for "nice." Nothing gets everybody straight up in their chairs faster than attaching any kind of motor to a flight control surface. I've been involved in design and certification efforts on perhaps two dozen such programs such as pitch trim, spoiler control, flap control and roll trim control on several biz-jets. In virtually every case, the electronics to do control is easy . . . the electronics to be the watch-dog over control functions invariably doubled or tripled the amount of electronics in the system. In the case of pitch trim for the Lears (circa 1980-82) the majority field returns for repairs involve monitor circuits . . . the control circuitry was very simple and robust; the monitor circuitry more complex and prone to failure.

Whether the flaps deploy or not would not change the outcome of the approach in the vast majority of landings (how often do YOU plan to put your airplane down on 1000' of runway? Those are the only times I have full flaps out earlier in a stabilized approach and then I KNOW the flaps are working before descending very low). Keep in mind that your resources for stored energy on the airframe comes in two forms, fuel and altitude above the ground. As soon as you throw out ANY flaps, you're squandering stored energy. If all goes well (as it does in the vast majority of cases) it doesn't matter. But I personally object to the notion of milking out 10 degrees of flap at a time beginning on the downwind leg. I don't want to throw away any energy resources in the form of altitude until my comfortable arrival is assured whether or not the engine is running.

I'd suggest you concentrate on getting your project airworthy with the simplest systems that will do the necessary tasks. IF you find shortcomings based on your experience with the airplane, add whatever remedies are called for later. Without proper monitoring for fail safe operation, the flap control system you've described should cause a profound INCREASE in workload . . . for flight conditions at airspeeds above the white arc and for operations below 200' AGL, I would have to flip another switch in my head to watch for and be ready to react to failure in the flap system. I couldn't certify this system in a factory built airplane without a LOT of work to accommodate all failure modes (which admits that not EVERYTHING a bureaucrat makes you do is useless). Bob . . .

Switches, Cessna-type flap

> My boss and RV-6A builder/pilot made a Cessna-type flap switch. Works great, he's been flying for about 4 years now with no problems. I don't have a picture of it in the panel but there's a description with diagram of how it works in our Chapter 33 newsletter from last August. See it at: http://groups.yahoo.com/group/eaachapter33/files/2001_Newsletters/08_Lipp isch_aug2001.PDF Hope this helps. --Markl

S >By the way, it appears in this system the builer used only 2 limit switches and 2 diodes. Questions for Bob and all : Is it the way to go, or are relays mandatory ? I've seen in catalogs that some limit switches are rated at 5 amps.

A Recommend the Microswitch V3 or V5 series switches. These are small and relatively rugged compared to smaller devices. You'll find that they're easier to work with and will last longer than the smaller switches irrespective of their "ratings" . . . As I recall, the Cessna system uses the v3/v5 style devices.

S Further, can we safely dispense with limit switches ?

A Depends on your actuator and how much trust you place in the followup system to stop the motor in the right place EVERY TIME. Actuators we were putting in the airplane when I was at Cessna had free-running followers at the ball screw limits. As long as the flaps are rigged so that full-stroke operation of the actuator doesn't put anything into a bind, one pair of switches will suffice. If your actuator doesn't have this non-binding mechanical limit, then leaving limit switches out runs the risk of driving the system into mechanical limits. Can your system tolerate this condition? Will something bend, break or bind in a manner that puts the flight at risk? Bob . . .

S One thing that Cessna does is place the limit switches in the wing at the actuator and the "follower" switches at the flap switch. Besides the safety aspects of having a redundant shut-off at the travel limit the actuator-mounted switches are more accurate. You don't really care whether a 20-degree setting results in 19 or 22 degrees, but you do care that "up" is very accurate. The follower switches control intermediate positions and the limit switches control the end points. At least I think that's what they had in mind. Gary

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Re: Switch for dimming light

>> I'm upgrading my panel and adding an annunciator for my GPS. The lights will require dimming. Unfortunately, I cannot add another instrument to my dimmer. I would like to place a small switch under the instrument for day\night operation. I think what I need is a Zener diode, but I'm uncertain as to which of the many in the Mouser catalog to get and how to wire it to the switch. I could probably figure it out if I had one in my hand, but any suggestions would be appreciated.

A You'll need to experiment with this. Do you have access to a variable DC power supply? Set in a dark hangar for 10-15 minutes until your eyes dark-adapt. Adjust the voltage to the annunicator power to get desired intensity. Then SUBTRACT that voltage from 14 to get the size of zener you need. Also, while it's running from your power supply, measure the worst case current required at that voltage level so that we can calculate the power handling requirement for the zener . . . it may take something larger than a 1W device. Bob . . .

Switches, wiring

>> Bob, all When wiring a switched item is it better to run power to the item and switch the ground, or run power to the switch then to the item Jim Robinson

A Come off the bus via circuit protection through the switch and then to the powered Item. Ground with solid wire to either (1) single point ground on firewall or (2 - if you have a metal airplane) local grounds for strobes, nav lights, landing/taxi lights, and pitot heat. Bob . . .

Subject: Re: Connecting S700-1-3 switches

>I would like to know if it matters where we connect the 12V and the load on a SPST switch.

I used to connect the 12V on the center contact, but the lighted switches I initially installed mandated connecting the 12V on the lower contact and the load on the center contact (so the ground could be attached to the upper contact for the light).

A You can wire them any way you wish to achieve the desired functionality.

>I would like to change the switches this evening for the ones I just received from B&C. Can I use the same wiring configuration (12V on lower contact and load on the center one)? I would like this because this way, there woul'dnt be voltage on the upper contact when the switch is turned off (these are really SPDT switches sold as SPST). >Thanks for the prompt reply!

A No problem. I double checked the switch description on our website just to be sure and do find that the S700-1-3 switch is listed as P/N S700-1-3 Single Pole, Two Position, ON-ON Switch. We do suggest this switch for single-ON applications since it's the same price as a true single position switch and it avoids stocking two different parts.

Bob . . .

Re: Master switch wiring

>> On Z-11 the master switch is a two position switch (Off-Bat-Alt) and on Z-12 and others it is a single position switch throwing both alt and bat. This makes sense to me if you have redandant alternators.

A It's not critical for any architecture. The 2-3 switch is less expensive and if you have crowbar ov protection, the associated circuit breaker can be pulled for rare instances of needing to run the battery during ground maintenance with the alternator disabled and even rarer instances of needing to disable the alternator in flight.

If you want to get fancy and don't mind the extra cost of the ON-ON-ON switch, then you can do the OFF, BATT-ONLY, BAT-ALT functionality shown on Z-11 and most of the other drawings.

>> However, on Z-11 the breaker for the alt field is on the right of the switch (with a fuseable link on the left) and on Z-12 the breaker is on the left. I have not been able to find an explanation of the difference in the book.

A There is no difference functionally, if you use fuseblocks, a leadwire from bus terminal to the panel where the master switch is located along with the alt field crowbar breaker would like some protection . . . fusible link works well here as it is MUCH slower protection than the circuit breaker and will not nuisance trip if the OV system crowbars the breaker. Current in a series circuit is the same everywhere, it matters not which comes first, master switch or field breaker.

> Is >this just a way of showing there are different ways of wiring the same thing, or is there some other thinking behind the difference?

A Just seeing if you're paying attention and willing to formulate the question. You passed the test! Bob . . .

Re: Push to Start Button Circuit

>>I recently aquired an RV-3A with an 160 HP, IO-320. It had the Prestolite starter in it, a push to start button wired through the master switch lighting/nav light ciruit with a 5 A CB. After the first start, during subsequent hot starts the 5A breaker would pop. I replaced the Prestolite starter with a Skytec and checked the circuit breaker panel and found a loose main power supply wire. I tightened all connections and replaced the 5A CB with a new 7A CB and serviced the battery. After doing this, the new 7A CB popped during the first attempt at a cold start. Upon resetting the CB, the battery contactor chattered when the MS was activated. I verified that the battery was charged and then replaced the battery contactor. The next start went

without a hitch. However, upon trying a hot start, the 7A CB popped again. I was able to get the engine started after about 20 minutes and about 5 resets of the CB. The wiring appears to be 16 - 18 ga, which should support a 10A CB. However, I'm puzzled as to why the starter button to the starter solenoid would draw more than a few amps. I'm inclined to think that either there's too much resistance in the starter button contact or perhaps in the starter solenoid. Any thoughts on how to proceed would be appreciated.

A Your experience is understandable and predicable. See http://aeroelectric.com/articles/strtctr.pdf

Your circuit breakers seem to be pretty fast . . .lots of 7A breakers will stay closed for the short period of time your starter contactor is drawing 20+ amps. A starter contactor boost relay like Figure Z-22 or an external contactor like our S702-1 would both be good fixes. Bob . . .

Re: Push to Start Button Circuit

Bob, I believe I found the problem. First, the starter contactor turned out to be for a 6v system and the hot wire from the battery contactor to the starter contactor was in bad shape. It had broken strands in the bundle where it was crimped and the insulation had obviously overheated. The damage to the wire was only on the side toward the firewall and was not visible from the cockpit side. RV-3's don't provide much access! I installed new wire and a new contactor to be sure. Haven't had time to try starting the engine yet, but I'm confident the mystery has been solved. Thanks for your thoughts.John Warren

A Another thing to check on is whether or not your contactor has a built in spike catcher diode. If not, be sure to add one externally. The intermittent duty contactor can really EAT starter buttons. Bob . . .

Re: Push to Start Button Circuit - Follow Up

>Speaking of Start buttons, what do you all think about using a momentary SPST switch as a start button? I have the push button with guard from Aeroelectric, however I'm thinking it would be kind of neat to use one of those red switch guards that flips up when you use the device... Seems I would have to drill it out a bit to fit the push button inside, so I am considering going to a spring loaded switch inside the guard.

A That's been done. I've also seen a customer use 2-5 series switches so that the starter is engaged by raising one of the mag switches to the full up position. This combines ignition and starter functions into two switches. Bob . . .

Re: Switches and diodes

> Hi, Bob. I am putting a system together for my RV-9A. I am using a Geo alternator with built-in regulator and your crowbar O/V protection. I will have electronic ignition on the left, and a mag on the right. (Only because Smartplugs do not like leaded fuel....)

> 1. Why not use a 2-3 switch for the right mag, since no center off position is needed or wanted?

A   You do need an OFF position, this is when the magneto is ON. I chose to make both switches the same style so that when you are in cruising flight or parked, the normal position for BOTH switches is the same. Obviously, one could use a 1-3 in the right mag slot but with dissimilar positions of the switch for cruising flight. It's a human factors thing.

> 2. Using a 2-50 switch for the left (electronic) ignition and start switch, should I put a diode across the start contacts as shown? Or put one across the actuator coil on the contactor?

A   diodes always go across the coil. Do you have one of my diagrams that still shows it across the switch? See http://aeroelectric.com/articles/spikecatcher.pdf

> 3. It doesn't show a diode on the B-lead Overvoltage contactor. Should I use one?

A   Yes. I plan to add one at the next update. Bob...

Switches; Re: Air Operated Squat Switch

>   Does anyone have any of the air pressure type squat switches around that they could get some numbers off of for me.

A   "squat" switches . . . these are normally ordinary basic switches that sense when the aircraft's weight is on the wheels. Squat switches are used to prevent gear retraction, dump cabin pressure, etc.

> Specifically I need to know what the switch pressure set point should be (to open or close the switch at a given airspeed) in either PSI, mbar or in. H2O???? Maybe someone here knows how to figure this out??? Thanks in advance!

A   Sounds like you're asking about an airspeed sensing switch (for landing gear warning?). If so, you're interested in a switch that changes state at about 50 to 70 knots or a static-total pressure differential of .04 to .08 PSI.   Digikey has some switches rated to operated over this range at: http://info.digikey.com/T023/V5/0988.pdf   Check out the PSF-102 series which appear to have hose barbs that will let you plumb the switch into the pitot static system to read IAS pressure for about $14 each. Bob . . .

>   Hi Bob, Thanks for the quick response....And yes you were right on the money as to my

intentions! In the response below, you mentioned the .04 to .08. Is there a formula for this?

A I was giving you numbers in PSI . . . a formula that works pretty good though 150kts or so is;

P = (Vsq)/1467 where P is dynamic pressure inches of water,

V is velocity in Kts. You need to square the velocity value.

> The pressure switch you recommended, PSF-102, (which is the exact one I was looking at by the way!) says that it has "Adjustable set points from 0.1" to 100.0" H20" This is outside the range you gave me (.04-.08) for the equivalent 50-70 knot airspeed range... so I'm a little confused!

A The .04 - .08 was PSI and would have covered an airspeed range of 40 to 70 MPH, or 43 to 60 Knots.

> Bob . . .I'm still confused. Whats the conversion of Inches of water to PSI?

A See http://www.convert-me.com/en/convert/pressure PSI * 27.68 = in-H20

> Using the forumla P (inches of water) = V (Kts) squared/1467 for 40kts & 70kts, P would be 1.09. & 3.34 inches of water. The nearest to that would be: PSF102 384-1017-ND with a H2O range of 2 to 17. Is this the one we want?

A Note that the catalog listing has three columns of pressure range for each device. The far left column is In-H2O which shows that the second device has an adjustment range of 0.5 to 2.0 In-H2O and .018 to .072 PSI. This device would give you 17 to 54 Kts trip point. The next device (384-1017) covers 2-15 In-H2O for a range of 54 to 148 Kts adjustment range. Bob . . .

S Re: Low fuel pressure switch? >Could something like this be use to detect fuel levels? If you built a T into the fuel line and attach a tube then the fuel level in that tube would do the same thing?

A Fuel weighs about 3/4 that of water. Soooooo . . . if you wanted to operate a switch at say 3" of fuel level in a tank this translates to 2.25" of water. So a 384-1016 or 1017 switch seems to have some possibilities for this. You would need some signal conditioning to filter the effects of slosh . . . or perhaps plumb the switch to a standpipe with very small holes in it. A similar technology was played with about 30 years ago. A diaphragm built into the bottom of a tank was fitted with contacts to close when the column weight of fuel was above a certain level. It worked but had poor service life . . . nobody had figured out how to do the switch contacts to make them last. It's 30 years later and things are probably much better in this regard . . . it's probably worth trying and the risks are low. Bob . . .

Switches: Re: runaway trim

> Does anyone know what the failure modes are for runaway trim? i.e. stuck switch ? motor malfunction? I plan to have a three position momentary switch, up,off,down, and a N.O. pushbutton switch right next to it. To add trim you will push the button (this will provide power to the aforementioned 3 position switch) and then you move the 3 position switch in the appropriate direction. Rick

A That's how the big guys do it. Design so that it takes two independent, pre-flight testable failures to effect a runaway trip. This can be a simple "trim enable" switch operated in conjunction with a trim up/dn switch. The King Airs split their two-pole, double-throw switch into two halves, which can BOTH be operated with the thumb to get desired trim . . . failure of either half doesn't stick the trim in a runaway condition. I published a diagram a few weeks ago for a master trim disconnect system that would shut down all trim systems + autopilot servos. This is a very common feature in larger GA aircraft and bizjets. It's usually a little red button on yolk or stick that unlatches a relay. In any case, you want to make sure that your trim system authority has no more range and effect than what is needed for operations. I'm aware of a Kitfox accident where a stuck trim switch put the tab to an extreme position that was almost twice the trim force needed to operate the airplane over full range of speeds and CG . . . Even at that, it wasn't a great amount of force had the pilot been expecting it but the onset of effects were so fast that the pilot didn't react in a useful way . . . pilot got out okay but it totaled the airplane. Bob . . .

Re: Switches; S700-2-1

A Never had any call for them . . . it's the same price as a 2-3 but few designers like to put OFF in the middle on an airplane panel. How about down is OFF, center is WIG/WAG and up is ON? You can do this with a 2-10 wired per the SECOND drawing just added to the file at http://aeroelectric.com/articles/WigWag/WigWag.pdf

> Hm...that still doesn't really accomplish my goal of having independent circuit protection for each light and keeping the system down to two components (one switch + one SSF-1). Thanks for putting that drawing together, it's definitely a helpful reference. Out of curiosity, what's the purpose of the full wave diode rectifier...sorry, I'm new. 8

A The rectifier keeps you from having to purchase a more expensive switch but the 2-10 switch also drives you to a single power source. Download the drawing again and check out the third drawing. This shows how a four-pole switch can do what you want. Allied Electronics has this device from Honeywell-Microswitch. You might check the Allied listings at www.allied-elec.com

> Perfect. Even nicer that down is OFF. Thanks much! Dan

Re: Switches; Wig-Wag

> I have been looking at Bobs schmatics for Wig-Wag and I was wondering if it is feasable on the third layout to split the 4LT1-10 switch into tow 2-10 switches, one for taxi and one for landing lights. The idea is to be able to have both lights on, just the taxi light, wig-wag or off with only two switches. I prefer not to use three switches as on the first layout to save panel room.

> As I see it only when BOTH switches are at the center will wig-wag work. If the taxi switch is up then it will be on, no matter what position the landing lt switch is at and visa-versa. I came to this conclusion based on Note #1 that states both 2 & 3 pins of the SSF-1 flasher must be loaded to a lamp in order for it to actually flash. The only reason I am looking at seperating the taxi and landing light is that I have a tail dragging RV-6 that I am assuming I will have to adjust the taxi light different then the landing light. The second assumption I am making is that I will need to turn off the landing light on the ground since it will be pointing up and may blind other pilots. Are these valid assumptions?

A You betcha. What you propose will work. I've added the option to the collection of drawings at: http://aeroelectric.com/articles/WigWag/WigWag.pdf   Bob . . .

Re: Switches: keyway question

> Sorry if the answer to this is obvious... When drilling your panel for toggle switches, is the keyway slot generally ignored? I mean...maybe if you have the panel laser cut you could have the keyway notch integrated into the cutout, but when drilling your own 15/32" holes there doesn't seem to be a good way to do this. Does simply using a lock washer of some sort prevent switch rotation?

A Ignore the keyway for cutting panel and then use anti-rotation washer that comes with switch. Hole layout for using these washers is shown on page 6 of: http://content.honeywell.com/sensing/prodinfo/tr/catalog/tl_series.pdf

Note that tab on anti-rotation washer may be on the OPPOSITE side from switch keyway so the anti-rotation hole may need to be BELOW the main clearance hole. Bob . . .

Re: Switches; MicroSwitch vs. Carling

A Over the years, AeroElectric Connection drawings have depicted a mixture of progressive transfer switches by Honeywell-MicroSwitch and Carling (who makes the S700-Series switches stocked at B&C. Until all the documentation can be updated to resolve differences between the two brands see the benchmark document at:

http://www.aeroelectric.com/articles/Carling_Micro/Carling_Micro.pdf

These differences have left a few pitfalls for generating new drawings from the archives of old drawings. One has to be careful lest artifacts of both switch brands get intermixed.   Just such a snafu occurred when instructions for the LV_Warn/ABMM modules were crafted. For those of you who have received LV_Warn Modules from the first production batch, B-revision instructions have been posted at:

http://www.aeroelectric.com/Catalog/AEC/9005/9005-701B.pdf

The second production batch is being finished now and will be shipped tomorrow with Revision B instructions. Bob . . .

>Ok, I see that. I was already considering a fuselink, but some or your writings (page 10-4)seemed to discourage them in the current ranges we are talking about here. Re-reading it, I see you addressed PM alternators. While I'm looking at Z-16 - what is the purpose of the 22AWG fuselink in series with the 5a breaker? Isn't that redundent redundent?

A Fuseblock (and bus) may be mounted somewhat remotely from the panel and the 5A field breaker. If you EXTEND the bus with a wire up to the breaker, it should be protected. If you use a FUSE in the fuse block, then because of the much faster response time of a fuse, a 15A fuse might open faster than a 5A breaker . . . so we use a fusible link with a time constant that is greater than a breaker to protect that wire segment. Bob . . .

Re: Switches; De-Rate Mini Switches?

> Hello List, This is my first post. I am building a 12 Volt system and want to >incorporate Alco Ultra-Mini Toggle switches wherever possible but I need advice: The catalog says the switches are rated for 6 amps at 125 V AC and 4 amps at 28 V DC: Can I assume they are rated for 8 amps at 14 V? AC 43-13 requires de-rating factors to be applied to switches (factors vary according to voltage & type of load): Do you apply the same de-rating factors?

A Be wary of AC43-13 and in particular any sense you may have that what's offered is in any way a REQUIREMENT for you as the builder of an airplane. AC43-13 contains some really good information but it's rife with little pockets of junk science and outright errors.

Everything AC43-13 purports to do for system reliability is ALWAYS predicated on increasing longevity through quality enhancement, little tricks-of-the-trade like de-rating certain parts, and a reverence for things "certified" for both hardware and the people who are allowed to work on airplanes. No place in AC43-13 or any other holy-watered document will you see a discussion of architecture that produces system reliability by way of a failure tolerant design.

Take peek at the article on switch ratings at:
http://www.aeroelectric.com/articles/swtchrat.pdf

I wouldn't discourage you from your quest to build with small switches but keep in mind the following considerations as physical size goes down in a switch.

(1) assuming most switches have about the same on-resistance, smaller switches will run warmer at the same current levels thus exacerbating degradation of contacts during the ON times. Loads like landing lights and pitot heaters are best handled by a relay (like S704-1 on our website) which is in turn controlled by a miniature switch.

(2) if you have magnetos and choose to be rid of the Jurassic key-switch, then be aware of voltage breakdown limitations on the small switches in their OPEN position. I would be wary of a miniature toggle switch's ability to stand off the several hundred, fast rate-of-rise volts that are present on p-leads of a mag. After some years in service, a miniature switch may acquire enough contaminates to be vulnerable to this kind of stress even though it worked fine upon

initial installation. The result would be a rough running mag that is being sapped of spark energy by arcing at the switch. If you're contemplating electronic ignition, this isn't a concern.

Choose good quality switches. Brands like C&K or Cuttler-Hammer and ALCO are mechanically more robust than miniature switches of unknown pedigree found in many parts catalogs.

Finally, plan ahead. Should you find at some time in the future that your choice of switches produced less than satisfactory performance, will surgery to your panel be a major or minor effort? Bob . . .

S >No, the rating at 14V would be essentially the same as 28V. The switch ratings are based on two factors: the steady state current handling capacity of the contacts and, when switched from on to off, the ability to break the current carried by the switch and quench the internal arc caused by opening the switch contacts. The ratings you quote indicate that the physical current handling capacity is 6 amps steady state - which limits the 125VAC rating. The reason the DC rating is less is due to the second limitation. With AC, the current goes through zero 120 times per second,which serves very nicely to quench the arc when switching a load off. With DC, the current is continuous so the contacts have to open wide enough to cause the internal arc to quench. Bottom line - do not use this switch for more than 4A continuous at 14 VDC. Dick Tasker

A Good answer . . . I agree. Bob . . .

S >What about putting a diode across the contacts? Would that help with the transients? How would this diode be attached? Gary

A No help here. It's not a 'transient' . . . when contacts FIRST open, the air gap is measured in nano-inches . . . any voltage level will form an arc in this gap. The secret is to increase contact mass (to take heat out) and increase spreading velocity (to stretch arc so fast it doesn't have time to heat things up) and increase air gap for opened switch. All of these things are physically limited when you miniaturize a switch. Bob . . .

S >Will the S704-1 relay work for an Infinity grip starter switch setup?

A sure. relays can be used to boost the current handling ability of any switching device. That's what starter and battery contactors do too. You wouldn't want to put 200+ amp rated switches on your control panel for these tasks. Bob . . .

Re: Switches; Push to Start

>Last question: B&C sells two push to start sw's. An S895-1 with bare terminals and according to B&C a 501-200-1 with soldiered wires, veristor across the terminals, and potted in back. I'm not familiar with the latter and wanted your opinion of it.

Use the first one. It comes with no MOV installed. The MOV's turned out to be a bad idea . . . at least not as good as using a diode across the contactor. The part number with MOV installed is part of an STC'd kit that Bill sells. It should probably be modified but it's so much hassle . . .well, we've all heard that story before. Bob . . .

Re: Switches; Buffering loads on stick grip switches . . .

>Comments/Questions: Hello Bob....I've been trying to find an alternative to the very expensive Stick grips available. I bought a gaming stick called "Seitek" and it looks promising. I pulled it apart and isolated the stick from the base unit. The stick has several small microswitches and a "coolie hat" switch. It looks very space-age! I don't kid myself that these small devices could switch my high current items like trim motors, but perhaps with the correct relays installed....? Hence my question; What is a good relay selection to install between these (milliamp?) switches and the actuator to do the heavy lifting. Functions I'd want to switch are;

>1) PPT (perhaps the small microswitch is enough alone for this function)

Probably so.

>2) 4-way trim

>3) Air brake up and down

I've uploaded a set of exemplar drawings that show how to control permanent magnet motors with relays at

http://aeroelectric.com/temp/PM_Motor_Relays.pdf

The common theme throughout these drawings are the pair of single pole, double throw relays that control motor power. Note that in the relaxed state, the normally closed contacts put a dead short across the motor. This is a very useful technique for reducing coasting of the motor after power is removed. Energizing one relay or the other puts (+) power on alternate leads of the motor to control direction. Obviously, the relay's contacts must be sufficiently rated for satisfactory service life depending on the motor load. MAC servos draw perhaps 200 mA . . . ANY relay will handle this load. Our S704-1 relays will handle up to 30A . . . and their package/terminal configuration makes them attractive for installation and wiring irrespective of how much you load the contacts.

Hope this helps. Bob . . .

Limit Switches

See www.motionsystems.com for actuators that freewheel at both extremes of their travel. They're used on the Glasair's for flap and electric trim actuators. Bruce www.glasair.org

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Switch, flap shaped toggle

>Do you know who makes either the whole switch or just the bat handle adapter for this?

A You don't even WANT to know what this switch costs for a Bonanza.

How about building one?

You start with a toggle switch that operates on a pinned shaft as opposed to ball-n-socket pivot. Microswitch products are one example of this kind of switch. Next, carve a flap shape out of a piece of aluminum. If I were going to make a lot, I'd have the things NC machined. If I needed one, less than 30 minutes or so with a band-saw, belt sander and little chunk of 5/8" alum sheet would get the job done too. See:

http://www.aeroelectric.com/articles/FlapSwitch/FlapSw1.jpg

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22. TOOLS

Crimpers

>I have a question about a couple of your crimpers. I have a Garmin GPS/Comm that I am installing and wanted to know if your RCT-3 Machine pin crimper will work. The radio has 2 plugs, the first is a 37 pin D-sub and the other is a HD-26 D-sub. All of the wires are 22 AWG except the power lines and they are 18 AWG. Will this tool work?

A The RCT-3 will install both standard (20AWG) and high density (22AWG) pins. 18AWG power wires can be used but you need to clip off 7 strands of wire in order to get the 18AWG wire to fit a 20AWG pin. This does not degrade the effectiveness of the joint and still lets you take advantage of the lower voltage drop in the heavier 18AWG wire.

>I have a Greenlee ratchet crimper and wondered if your RCT-1 is the same or if it crimps differently for aviation purposes. Sounds like a dumb question but I don't want to risk my aircraft for a dumb mistake. The people around here recommend the AMP Pro Crimper II, what do you think?

A Not familiar with the Greenlee product you cite. Amp Pro-Crimper II tools are for the open-barrel, sheet metal pins. If you try to put a 20AWG wire on an 18AWG wire with this tool, you'll get a compromised electrical joint. Further, the insulation will be too large for a good grip by the tabs on a 20AWG pin. If it were my airplane, I'd discard the sheet metal pins and substitute machined pins installed with the RCT-3. If your radio was supplied with sheet metal pins, you need our bct-1 tool. I have not tried this tool with the smaller high density sheet metal pins . . . my gut feeling is that I probably wouldn't use these pins or this tool in my project. Bob . . .

Crimper

>> Bob, Have rec'd your crimping tool and it is impressive (once I figured out how to unlatch it - either the latch is hidden intentionally or my fingers are too fat).

A Unlatch? . . . was there something jammed in the tool that prevented you from closing it all the way?

>Anyway, a couple of questions - 1. Any guidelines on the use of the adjustment (I guess) star wheel?

A Never had a reason to mess with it. In fact, I've not taken time to deduce when and if it needs to be adjusted. I did pull tests on the tools as received and found them satisfactory.

>2. This question has to do with the situation where, for example, you want a wire to go from a fuse to a terminal on instrument #1, then continue on to a second instrument, and you are using Fast-On terminals. Looks like there are 2 possibilities; jamb two wires into the Fast-On at Instrument #1, or use a butt splice somewhere between the fuss and instrument #1.

A Either is fine. For example, you can put up to four 22AWG wires into a red terminal. Multiple conductors can be connected into all of the crimped terminals. The trick is to make sure that the stripped ends of all conductors stay even with each other as the bundle is inserted into the terminal. I cut a rubber band to make a "hog tie" strand of rubber. Even up the ends of the bundle and then wrap about 10 turns of rubber band around it about 1" from the end. This high tension, high friction capturing of the bundle strands makes sure that they don't slip out of alignment as you work them into the terminal.

>Would appreciate you feelings about the best way to proceed, or (knowing you) another dozen or say ways to accomplish the same thing. If we're going the 2-conductors-into-one-terminal route, some guidance on terminal size for 2 conductors would help.

A The total cross section of wire needs to be within the ratings of the terminal. Every 3AWG steps in wire doubles or halves the cross section of copper. So, if you have a red terminal good for 18-22AWG, we can deduce that three strands of 22AWG are equal to

19AWG, the 4th strand takes in into the neighborhood of 18AWG. Similarly for a blue splice (14-16AWG) you could put six 22AWG wires into one end of a blue splice.

Crimpers, Wirestrippers - Best ?

>>Light Plane Maintenance magazine did a survey of crimpers and wirestrippers in its Feb 2000 edition. Among ratcheting crimpers with switchable die sets, LPM favored the Ideal Crimpmaster, with AMP and Paladin also mentioned. Are there other equally good or better crimpers (except for expensive Mil-Spec tools) ? Among cheap non-ratchet crimpers, LPM found one and only one good crimper - the AMP Super Champ. LPM said that the market was flooded with no-name junk crimpers.

A I've sold a $40 3-pocket PIDG tool for about 5 years which you can view at http://www.aeroelectric.com/Catalog/tools/tools.html#rct-1 and order from B&C at: http://www.aeroelectric.com/Catalog/BCcatalog.html

This tool is most satisfactory for the installation of insulated terminals with aviation style wire grips as well as the automotive all-plastic terminals (for use on your lawnmower).

>Among wire strippers, LPM found the Buchanan Ultra Stripper to be the best. However, I can't find this wirestripper anyplace. Is there another hand-held non MIL-Spec wirestripper just as good - or better ?

A My personal favorite is made by Ideal Industries and sold by Allied and Newark Ideal's p/n is 45-187. Unfortunately, I'm aware of no low cost equals to this fine tool. They're about $160. See:
http://search.newark.com/part_detail.phtml?PART%5FID=250&VID=250&10005=58F551....Bob . . .

Heat gun

BTW, my 20 year old Ungar heat gun went belly up last weekend right in the middle of a hot job. None of the electronics supply houses were open so I resigned myself to buying something at Home Depot. I thought I'd find one of those electric flame throwers weighing in at 10 pounds and used to thaw pipes and peel paint. I was pleasantly surprised to find a Milwaukee heat gun that was lighter and smaller than my Ungar. It features an adjustable power control to set heat output . . . my old gun stopped off airflow to raise heat. This neat tool actually controls power to heater with a circuit similar to a light dimmer. The price was a pleasant $40. I'll put a photo of the tool on the pigtails article after I've had a chance to try the 3M splice products. Bob . . .

Crimp tool

>> bob, i just got your d-sub crimp tool from b and c and want to know where the crimp should be on the pin. my crimps come out on the very end crimping about 3/32 or less. should i hold the pin back a little or is this ok?

A No, it's not okay. I used to check and modify those tools as needed. B&C told me a few weeks ago that the tools seemed to be putting the crimp in the right place. I'm now finding out that their assessment was incorrect. You can either return the tool for replacement or modify it yourself as shown at: http://www.aeroelectric.com/articles/techbits/rct3mod.jpg

>>also where can i buy solder sleeves?

A Check out the solder sleeve data on Raychem's website at: http://interconnect.raychem.com/pdf/h54683.pdf

http://interconnect.raychem.com/pdf/h54681.pdf
http://interconnect.raychem.com/pdf/h54682.pdf then click on this link to find a distributor near you: http://interconnect.raychem.com/indexf.html Bob . . .

Crimpers

> Fast-On Terminal Crimping. I bought an Amp Pro-Crimper II, tool part # 58433-3, w/ die part # 58423-1, some time ago to handle my crimping requirements for ring and fast-on terminals. It's description says "Insulated terminals & splices (PIDG, Plasti-grip)". It has worked great so far except, imagine my surprise and consternation when I

noticed the little '*' and read that it is "not for use with PIDG FASTON receptacles". I called AMP and they confirmed the information and said I have to use another crimper (cost & aggravation, etc). My questions. How can you get adequate crimping performance for ring terminals, splices, AND fastons out of the crimper you sell when AMP does not? What do you recommend I do for the many faston crimps needed for implementing AeroElectric (your) guidance?

Tools, Re: AMP HDP-22 Pin Crimper

> My Apollo UPS ACU connector uses AMP high density pins HDP-22 (.030) AMP p/n 748333-4. The $10 crimp tools do not form the crimp into a "nice .040 inch diameter required for easy insertion and more importantly easy removal.

> AMP recommends the following Crimp Tools.

> AMP Certi-Crimp p/n 90430-1

> AMP Pro-Crimper II p/n 90800-1

> These are very expensive tools $250-$450. Does anyone have an equivalent alternative or be willing to lend or rent the AMP tool.

S *** Check out the aeroelectric web site. There's a link to B&C Specialties. THEY have the proper tool. It costs about forty bucks. Does a beautiful job. - Jerry

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Tools, Re: Where to get tefzel wire strippers

>> Bob, I appreciate the latest article on wire strippers. Could you give us the brand and possible source for the 'dull' machined die stripper in the illustration of the good one? Sometimes its best just to pay the freight and get something that does it right for your lifetime. Jim

A Sure. Go to
http://www.newark.com/find/searchResults.jsp?action=0&First=0&QText=58f551

click the "buy" box and take it from there . . .Bob . . .

SS You can get the same stripper cheaper here: http://www.alliedelec.com

Search for Mfg. part no.: 45-187. Cost is $147.31 ($19.77 less than Newark).

I discovered this after ordering one from Newark :<(The stripper works great - never a nicked strand! It's a joy to use a tool that works exactly as it should. Chris Heitman

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Re: flaring tubing

Here is an interesting link on flaring:
advancement.cnet.navy.mil/products/web-pdf/tramans/bookchunks/14256_ch36.pdf and

http://www.geocities.com/MotorCity/Track/1943/gentip2/gentip2.html

Mike Nellis - http://bmnellis.com Georgetown, TX

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power supply

>Sounds like a great way to go, where did you find the power supply?

A Radio Shack's website at http://www.radioshack.com now sells the Samlex SEC1223 for less that I used to buy it wholesale. Go to their website and enter 910-3916 as a search term. I think the description is in error. It's really a 13.8 volt, 23A switchmode power supply. I sold about two dozen of them from our website catalog a coupld of years ago and gave a few away at weekend seminars. 23A will run EVERYTHING in your airplane as long as you don't turn pitot heat on too . . . It's on sale right now for $89.00 . . .Snap 'em up guys, this is a good price for that much snort in a power supply. Bob . . .

Re: Multimeter TC Amps?

> My meter is rated to a max of 2 amps, if I'm reading this right. I guess it's time to invest in a 'real' meter.

S Nah. Just invest in a resistor. Suppose you want to measure 20A, and your meter has a 0-.2 Volt scale: You want to stick a resistor in series with your UUT (Unit Under Test) such that a current of 20A will generate .2V across the resistor. Ohms Law says that R = E/I, or .2/20, or 0.01 ohms. Now, that's a pretty small resistor. You won't pick that up at the Radio Shack. What you can pick up, however, is some thin wire. Say, some 24gauge "magnet wire". You find the copper table in the Amateur Radio Handbook (or in some other electrical reference). This will tell you the ohmage of your wire in ohms per 1000'. It's easy to figure out the exact length of wire you need for the resistance you want. It won't be all that long, for such a small ohmage. Such a resistor is called a "current shunt" in the metering trade. I found a copper table on the Web here:

http://www.physics.montana.edu/edl/documents/edlpages/copperwiretable.htm - Jerry)

Mulitimeters,

> Bob, would you be able to write us a short idiots guide to how to use a digital multimeter, covering things like when to have power on a circuit under test, and when not to. Any precautions about changing modes on the multimeter, and how to measure volts, amps and ohms across a component. And where not to put a probe.

A Good idea. I'll consider that as a good topic for either an article or a new chapter to the book. In the mean time, take a look at these links I found on the 'net.

http://www.kaitousa.com/usingamultimeter.htm

http://www.boatsafe.com/nauticalknowhow/electricity2.htm

http://mechatronics.mech.nwu.edu/mechatronics/design_ref/tools/multimeter.html

The most common error . . . and possibly what happened to your meter . . . is putting voltage into the probes of an instrument set up to measure current. Depending on the current capabilities of the voltage source, you might get a really BIG current flow that in the old days, toasted your multimeter (I've done this several times in my younger days). Nowadays, modern instruments are protected with fuses so the risks are less. I use so many different models that I try to check twice where the range switch is set before hooking things up to make sure that habits acquired with one instrument don't become a hazard to other instruments. Bob . . .

Tools, wire strippers

Hi Bob; Dave here. A long time reader of "The Connection", and a big fan of your tips, insight, and techniques. Just re-read your "Wire Stripping . . . Facts and Myths" article. Having "done my time" with a variety of strippers, I'm at the point where I'd like to invest a bit in one of the "high dollar" tools you mention. Some level of grip / stroke automation would be nice, to address those 'one handed' operations behind a panel, etc. Do you have a recommendation? I do mostly stacks, so something in the range of 16 to 26 AWG would probably be about right.. If there are interchangeable dies for larger sizes, that would be great! And, I'm not into "prestige", so a "best bang for the buck" is what I'm hoping for. Anything you sell through AeroElectric? I'd appreciate any advice and referrals...

A My personal favorite is the Ideal 45-187 which is fully described at http://www.idealindustries.com/ They are sold at http://www.alliedelec.com/cart/partlookup.asp enter "45-187" as manufacturer's part and hit "submit" Bob . . .

Re: Tools; soldering iron question

> In my prior post, I expressed the need for a fuse for my voltage converter, when I had an idea. I am using my voltage converter for various things, but one thing I'm using it for is to run a soldering iron. It is a 120V iron and I have 220V supply. Is there a solution that combines voltage conversion and variability of supply? My limited knowledge of electricity leads me to believe that because the iron is a pure resistor, it should be possible to construct a way to both convert voltage and vary the current to provide a way to vary the heat of the iron. Thanks a lot.

A Try a 1A, 600 volt diode in series with the iron. This will feed it with 1/2 the energy it would get if plugged directly into a 220v line and just what it needs to believe it's seeing a 120v source.

I use diodes in the line cords of some my "killer" irons to put them into a lower temperature "standby" condition. Without the diode, they get too hot between tasks. Bob . . .

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23. Voltage/Reg

Regulators

>How superior are solid state regulators to relay type regulators?

A ohhh . . . probably not more than 2000% better . . .Bob

Voltage Regulator: Terminal Connections

>Hi Bob, Sorry to bother you again but I'd like some information that I cannot seem to find on your site. 1) I purchased a "bubble pack" voltage regulator that has four terminals which are marked: I,A,S, & F. What are these terminals and where should they go on my plane. The present regulator has only 2 connections one directly to the Field of the alternator and the other to the master switch. I think this is one of the cheap regulators that came with Van's kits in the late eighties. I'm still fighting the pulsating volt and amp variations. I have gone over all the connections as you suggested but so far no joy. and also had the alternator checked by a local alternator shop and all is OK on their test equipment. This leaves the regulator as the last item.

A Figure Z-2 of the downloadable set of diagrams available from http://www.aeroelectric.com/errata/R9Z_0400.pdf will show you this wiring. "F" goes to field of alternator. "I" is not used. "A" and "S" are tied together and run to your field breaker via the DC power master switch. Be sure to get a good ground of the regulator's base to the aircraft.

>>2) The other problem is a "whine" in my headsets. It only seems to be audible at low (taxi) speeds but is quite annoying. I am certain that it is coming from the alternator and it may clear when I can get the pulsating voltage solved.

A Do you have a single point ground system as described in the 'Connection? Are your headset and microphone jacks insulated from the airframe? Bob . . .

Voltage Regulator . . .

>>Bob, I just got off the phone with Scott at Varga Enterprizes in Chandler, AZ. I was discussing a problem with the voltage regulator in our PA28-151. The old, original unit was replaced with a Lamar unit #B00373-1, some years ago. It was replaced again in June of 1998. The problem that we have been encountering is, the load meter oscillates back and forth like a metronome. The needle deflects full scale with the "low voltage" light flickering as it reached to low end of the scale. We have replaced, in the last 2.5 years, the alternator, battery, all of the aluminum wiring associated with the charging system, the load meter itself, and the master switch. At the last annual, (last week) our mechanic placed a "jumper" wire on the alternator to bypass the VR and, the oscillations stopped. We are, and have been, of the opinion, that the problem is with the VR. Scott says that you are the World's "guru" when it comes to the world of aircraft electrical systems. Have you any insight that you might be able to share with us

regarding this situation? Would appreciate any help. Warren McIlvoy, President

A Waren, Just as an experiment, have your mechanic hook a wire from the alternator's b-lead (main power output terminal) to the regulator's field power input lead. Leave the alternator switch off or pull the alternator field breaker.

If the alternator comes up stable then this is the most likely scenario: A regulator is a servo system. It looks at the bus and steers the field current of an alternator to maintain the desired bus voltage set point. The regulator gets its information about bus voltage through the same pathway as the field supply current. On some production airplanes, this pathway has upwards of 20 ohmic joints (wire crimps, closed contacts in switches, solder joint, mated contacts in plugs, etc.) in addition to perhaps 5-10 feet of 20AWG wire with a resistance of about 10 milliohms per foot.

Aging of the ohmic joints raises their electrical resistance. No single joint contributes a lot but all totaled up, the supply circuit resistance can exceed 100 milliohms.   Now, field current will vary normally between .5 and 4 amps depending on RPM and system loads. With a 4 amp load and 100 milliohms of resistance in the regulator's sense lead, the regulator's best guess about bus voltage may be in error by 400 millivolts or more. Worse yet, as the regulator INCREASES field current in an attempt to raise bus voltage, part of the true increase is masked by an INCREASED LOSS of voltage along the sense lead due to field current. This causes the regulator to lag behind reality and in extreme cases, induces a bus voltage chasing mode with symptoms much as you have described.

TWO FIXES:

(1) change the regulator out for one that has voltage sense leads that are independent of the field supply current. This has to be done by at least a 337 effort and at worst, an STC.

(2) do a total refurbishment of all items in the field supply pathway starting with the breaker and carrying it all the way to the regulator. This includes all connectors, switches, ov relays, etc., etc.

Many owners have reported that replacing the master switch fixed the problem. In fact, changing one of many parts contributing to the problem reduced the resistance enough to make the system stable again. However, the problem will return in spite of a reasonably good master switch because the switch and all the rest of the components continue to age - driving total resistance past the lower limit for stability.   If you replace EVERYTHING, the system should stay stable for another 20 years or so. This problem is worst in older airplanes and is a function of age. Total refurbishment brings the resistance back down to factory-new levels. Let me know how this works out for you.

Bob . . .

>> Just thought that I would update you on this problem. We did change some of the wiring between the electrical bus and the voltage regulator with no success. My mechanic bypassed the alternator circuit breaker and the meter stood still. We replaced the circuit breaker today and, for now, the problem has stopped. Thanks for all you insight in this matter. Warren

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Re: B & C Regulator

<<From: Robert   I have had a host of electrical problems with N161GS. The first were caused by an avionics tech cross wiring the two alternators and regulators. However after that the problem was traced to a regulator that didn't regulate. B & C insisted that this was due to latent unspecified damage to the regulator and could not possibly be due to a design/performance defect in their unit. Sounded like a cop-out to me but they charged me to repair their defective unit. Now a couple months later I read in Flying magazine an editor's story about his B & C regulator that - guess what - did not regulate and the voltage ran away, to 30 v as I recall the article. Sounds like we have a design problem with the B & C units and that some external protection is warranted: the internal system is just too unreliable. Could anyone suggest a non-B & C solution?

A   The history of these devices is long and successful. LR-1 regulators flew the closed course mission on Voyager and by the time the around-the-world mission launched in Dec '86, we'd made some upgrades to the LR-2 series devices which flew around the world. I don't know the exact figures but there are certainly thousands of these devices in service in OBAM ships around the world and in several hundreds of certified ships as regulators for the B&C SD-20 standby alternators and their close cousins.

We've had several instances where builders were installing dual alternators and got wires between the two systems intermixed . . . with variable results ranging from benign to catastrophic damage to the regulators.

Be advised that these regulators MUST have a reliable system ground. This is why the regulator is fitted with a ground terminal on the terminal strip in addition to a ground stud on the case.

In a metal airplane, these two pathways are usually redundant to a ground path that is created through the mounting bolts when the regulator is mounted on the firewall. If the regulator is mounted on a non-metalic or otherwise insulated surface, it is important that ground-path integrity be assured with diligent use of the ground terminals cited above. If ground is lost, the regulator looses it's ability to monitor bus voltage and make the right choices with respect to alternator control and the system can go into overvoltage. The problem is compounded because the crowbar ov protection system depends upon good ground to open the field supply breaker.

Re: Warning lights with the LR-3

>> Bob, I was planning on wiring separate lights for over- and under-voltage conditions and would like to know how to do this with the LR-3 regulator. In your schematics (e.g., Z-13), pin 3 on the controller is labelled "OV sense." I assume this means "over-voltage sensor." This pin is routed through the same light as pin 5, and both go through a warning light. In this configuation, does the warning light function as both a low-voltage and over-voltage indicator? Is it steady for one condition and flashing for the other?

A   No. OV sense is for internal use by the regulator only. The only function of the warning light is to annunciate low voltage. There is no need to annunciate Over Voltage . . . within tens of milliseconds of an OV event, the alternator is shut down which translates immediately to a low voltage situation.

>What is the role of pin 2("OV PTT") which is left open in the schematic?

A That can be connected to the bus to force a trip of the OV protection. We used to show a push to test button on the diagrams but people were getting into the habit of "testing" that circuit on every flight. This is unnecessarily hard on the circuit breaker. You can use this pin to test the system every annual . . . or perhaps every oil change. Bob . . .

Re: OV Protection module - where?

>> Where and how should we mount the OV-14 protection module? Schematically - anywhere downstream of your ALT FieLD breaker. Should it be attached directly to the breaker and hanging by the wires? Should it be in front of the firewall? How do we fix it in a position?

A Physically, I'd tie it right into a handy wire bundle. Some folks have drilled a small hole in the crimped flat spot on the end away from wires to allow a small tye-wrap or string-tie to secure the far end while tye-wrap or string-tie on other end simply hugs the wires. Exact location is not terribly important. If it were my airplane, I'd place it as close as practical to the field breaker but I have installed them on the under side of a Ford style regulator . . . solder wires to A/S terminals and case ground. Use spot of RTV to attach OVM to bottom of regulator (there's a cavity about 5/8" deep that houses the little critter nicely). Bob . . .

Re: B&C Voltage Regulator

>Bob, please: >While testing the B&C LR3B-14 voltage regulator, using only the airplane's battery, I noticed that terminal 6 (field voltage) on the voltage regulator read approximately 1.6 volts dc when the alternator field switch is set to "off".

A This is normal . . .

>The bus voltage sense terminal was reading 12.6 volts. The voltage lamp was cycling on and off.

A This is also normal . . .

>When I turned the alternator field voltage switch to on, terminal 6 read 12.6 volts. Is this normal?

A Yup . . .

>What is the approximate minimum bus voltage which will turn the over voltage lamp off?

A 13.0 volts +/- 0.2 volts. The light is supposed to flash if your alternator is not working. Bob . . .

Re: adjustable voltage regulator

> I'm a little confused in all the archives--looking for an adjustable voltage regulator for the B&C 40 amp alt. Do I really NEED the LR3B(?) or can I use (which one) a 1975-1994 adjustable Ford regulator (if they really are) with Bob's dual voltage monitor & notification kit? Dave Ford

A There are a number of adjustable automotive regulators I've seen over the years but if you're not interested in the LR3 then how about the generic Ford VR-166? You'll find that this guy runs 14.2 +/- 0.2 volts as installed and will be just fine as-is. Bob . . .

Re: LR3 mounting location?

> Ok, Help I am confused by conflicting information. Where's the "best" place to mount my LR3 voltage regulator. I am building a RV9 (for reference) The B&C instructions say in the cockpit somewhere aft of the firewall. However a search through the archives seems to indicate that it can go anywhere I like (even forward of the firewall). So the question is, should it be aft to be cool in the cockpit, but hard to reach under the dash, or should it be high on the forward side of the firewall where it's easy to get to with the cowl open?

A EVERY manufacturer would like for you to pamper their products as much as practical . . . but thousands of these critters are running fine on the firewall just like hundreds of thousands of their cousins in the world of certified antiquity. Bob . . .

Re: O/V protection again

> Hi, Bob. I know the answer to this must be in the Connection somewhere, but I have been unable to find it. Regarding fig. Z-24, O/V protection with an internally regualted alternator:

> 1. What is the need for the O/V contactor? Can't the Crowbar module just cause the alternator field breaker to pop?

A Alternators with built in regulators don't get field power through the control wire going into the back . . . there are failure modes INSIDE the alternator that cannot be controlled from outside. Hence the need to physically disconnect the alternator's b-lead from the rest of the airplane.

> 2. Why is there a fusible link between the buss bar and switch, with the breaker after the switch? Why not just a 5 Amp breaker off the main buss?

A Because if the main bus is a fuse block -AND- it's remotely mounted for convenience of installation and maintenance then it's also remote to the panel where the 5A breaker needs to go. This puts a longer-than-6-inches hot wire between the fuse block and the breaker that is best protected with a fusible link.

> Sorry if these are questions you have answered lots of times. I would like to keep the number of contactors to a minimum, and would also like to understand the system.

A To eliminate the extra contactor, go to an externally regulated alternator. Bob . . .

Re: O/V protection again

> Bob, That Z11A (duel battery, single alternator) schematic you released a couple of weeks ago is perfect for what I'm doing. Any chance of getting the same in DWG format? John Slade Cozy IV

A goto http://aeroelectric.com/temp with your browser and right-click on Z11A.dwg to download to your hard drive. Bob . . .

Voltage Regulator:

> > This voltage regulator stuff is driving me NUTS!! I just installed a '94 or so Ford unit with spades labeled: I S A F. I connected the "F" tab to alternator field, shunted the S and A tabs together (as I understood Bob's instructions) and connected them to the battery via the Alternator (Cessna split) switch. I thought I had the problem solved when I cranked it up and saw 14.5 - 14.7 volts. Then I went to fly and when I turned the engine up, the voltage went to over 16 volts.

S Is the regulator properly grounded?

> Yes. Regulator and fusible link are bolted to baffling (one on each side, with the same bolts).

Ground wire from mounting bolt to ground stud on engine. Don't know how I could ground it better than that. Jim S.

A How did the fusible link get mounted on baffling adjacent to the regulator. Remember that all protective devices are mounted as close to the source of energy that puts the wire in danger. Fuses, breakers and fusible links are generally installed as close to the bus as practical if not actually ON the bus.

You need to measure the voltage AT the regulator. (+) terminal of voltmeter on A-S and the (-) lead on regulator case. This will tell you what the regulator thinks it's seeing in the way of bus voltage. Regulators can respond only to what they see at their terminals. See figure 4-5 in the 'Connection. I suspect you will find that voltage at the regulator terminals is 14.2 to 14.6 while the bus voltage is higher.   Voltage drops in regulator wiring can make it appear that the regulator is malfunctioning. Bob . . .

Re: Voltage/Reg; OV Protection/Internal Regulator

>> Hi Bob (Nuckolls), In your book (page 6-6, diagram 6-4 (The Ultimate Protection, the "Relayless" O.V. Relay)) an OV circuit is shown that does not include an alternator OV disconnect contactor. In figure Z-24 the contactor is shown. Could you please elaborate on the differences? I would guess that the concern is when the alternator field is cut (fuse blows) the alternator may not immediately stop producing power (but since I know nothing about electricity my assumptions are dangerous!)? FYI: my situation is a auto engine (Subaru) with an internally regulated alternator.

A If you have an INTERNALLY regulated alternator, then shutting of the +14 volts going into the control lead is not a 100% sure means of shutting down a working alternator . . . much less a failed one. THEN is when we add the external b-lead disconnect relay.

If your alternator is EXTERNALLY regulated, then opening the alternator field path is certain to corral the runaway charging system and the b-lead relay is not needed. Bob . . .

Re: voltage regulator location

> For a z-13 installation, I have noted on the instructions for both the LR-3 regulator, and the SD-8 regulator, capacitor, relay, & OV module, that these items should be mounted on the cockpit side of the firewall to avoid heat, water, & vibration. I'm real curious as to where most builders install them, and any good or bad experiences. How often might these devices cause smoke in the cockpit?   What about access to adjust the voltage and perform the annual test on the LR-3? Also, I would be running the SD-8 12 ga output wire inside the cockpit to the devices and then back out again to the battery contactor. Any insights will be greatly appreciated.

A EVERY manufacturer of electro-whizzies would like for you to never get his box wet, hot, too-cold, oily, dusty, or badly beat upon . . . if they had a choice. It stands to reason that PROBABILITY of unhappy customers due to environmentally induced problems will be lower.

However, Mr. Bainbridge has elected to play in the same sandbox with the big guys.

Irrespective of his best wishes for his products, they should not require any more pampering that other devices designed for airplanes. All of the devices you've cited have be successfully installed both in the cockpit and under the cowl for 15 to 20 years. Design your system for installation and maintenance ease and simplicity, not for feather-bedding the components. Bob . . .

Re: LR3C-14 low voltage warn light

> I recently had something blow the LR3C-14 field fuse on my purchased when flying RV 6A and the low voltage warning light did not come on. When I rebuild the VFR panel for IFR the fuse will be replaced with a breaker. Can I safely ground terminal 5 to test the light bulb? Assumming the light bulb is good is the LR3C-14 repairable?

A Before the event, did the low voltage light ever flash? If installed correctly, the low voltage light should flash any time the battery switch is ON and the alternator is not supplying power to the bus either because it is turned OFF, failed, or engine not running.

This means the low voltage light gets tested EVERY preflight. Yes, you can ground #5 to test the bulb. After replacing the fuse, did it blow again? Bob . . .

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24. WIRING

Connectors, crimping or soldiering

> What are the rules for determining the correct connector in wiring an airplane?

A Okay. Here are the "rules" by which Bob Nuckolls would wire his own airplane:

RULE 1: First choice for joining/terminating any wires up through 22 through 12AWG are PIDG style terminals as described in http://www.aeroelectric.com/articles/terminal.pdf

using tools like http://www.aeroelectric.com/Catalog/tools/tools.html#rct-1 or better.

RULE 2: Where there is a choice, I would select fast-ons over threaded fasteners in the 22 to 12 AWG range using terminals like
http://www.aeroelectric.com/Catalog/wiring/wiring.html#faston with features as explained in

http://www.aeroelectric.com/articles/faston3.pdf

RULE 3: When I have to live with a treaded fastener then these terminals are in order . . .http://www.aeroelectric.com/Catalog/wiring/wiring.html#s816p

RULE 4: For wires larger than 12AWG, then I would solder and heatshrink joints as described in . .http://www.aeroelectric.com/articles/big_term.pdf Using materials like . . .http://www.aeroelectric.com/Catalog/wiring/s812.jpg which are supplied with double-wall heatshrink for finishing.

RULE 5A: Permanent splicing of single conductors to be accomplished with butt splices like . . .http://www.aeroelectric.com/Catalog/wiring/s816.jpg

RULE 5B: but if it was deemed desirable to break the splice open for future convenience, a knife splice and heat shrink would be used thusly . . .http://www.aeroelectric.com/Catalog/wiring/ksplc2.jpg

RULE 6: When the accessory items are supplied with nylon connectors like AMP Mate-n-Lock or Molex, pins are installed with a tool like . . .http://www.aeroelectric.com/Catalog/tools/tools.html#bct-1 used thusly . . . http://aeroelectric.com/articles/matenlok/matenlok.html

These connectors would only be used as an accommodation for the use of an accessory that comes with them already installed. They are not my connector style of choice for any other applications.

RULE 7A: When working with accessories supplied with D-sub connectors, the first choice of mating connectors is the removable pin variety that will accept machined pins like . .

http://www.aeroelectric.com/Catalog/connect/connect.html#S604 installed with a tool like

http://www.aeroelectric.com/Catalog/tools/tools.html#rct-3 and removed with a tool like . . .http://www.aeroelectric.com/Catalog/tools/tools.html#dse-1

RULE 7B: if for any reason the crimped-pin mating d-sub is not available, then soldering is my

second choice using techniques described in . . .
http://www.aeroelectric.com/articles/dsubs/d_solder.html and tools like
http://www.aeroelectric.com/Catalog/tools/tools.html#s101_1 or better

RULE 7C: If options 7A and 7B are not practical, then the lowest order choice for working with d-subs is open barrel crimped pins installed with a tools and techniques like those described in RULE 6.

RULE 8: Installation of connectors on coaxial cables to antennas are installed per
http://www.aeroelectric.com/articles/bnccrimp.pdf using tool . .
http://www.aeroelectric.com/Catalog/tools/tools.html#rct-2 and wire . .
.http://www.aeroelectric.com/Catalog/antenna/antenna.html#rg-400 and connectors . .
.http://www.aeroelectric.com/Catalog/antenna/antenna.html

RULE 9: A single point ground system shall be established behind the instrument panel with sufficient attach points for all accessories in the cockpit area. In deference to RULE 2, a forest-of-fast-on-tabs ground block similar to . .
.http://www.aeroelectric.com/Catalog/wiring/wiring.html#gndblk The threaded stud on the ground block assembly would penetrate the firewall and be used to terminate battery (-) leads on either side of firewall and the crankcase ground strap on the engine side of the firewall.

In the case of canard pushers with the battery up front, the ground bus would be mounted forward of the instrument panel. If the airplane's firewall is metalic, then a brass bolt and appropriate washers and nuts would be used to provide an engine compartment ground stud and connection of the ground lead to the firewall. A ground strap like . .
.http://www.aeroelectric.com/Catalog/wiring/wiring.html#bbs . . . will be used to connect the crankcase to the firewall ground stud.

Any ground straps provided around the rubber biscuits of an engine mount will be removed. Engine mounts are for holding engines on airplanes and not use for any part of the electrical system.

RULE 10: Tefzel wire used throughout with the exception of cranking circuit fat wires where 4AWG or 2AWG welding cable would be used. An alternative FAT wire could be one of the new copper-clad aluminum wires. These new materials are as solderable and crimpable as pure copper conductors. Caution To get the same electrical performance, you need to use about 2AWG steps larger wire than for copper but the installed wire will still be lighter.

Here endeth the reading of the rules. In parallel universes there are differing rules which may well prove to be as useful or perhaps even better than those cited in Bob's universe. Given what Bob has learned up to and including Sunday, October 27, 2003 the rules cited above are his personal choices for practical, solid techniques using moderately priced materials, and tools. Adherence to these rules is likely to produce an electrical system where (1) component wear-out and failure are the sole causes for maintenance and (2) the wiring can be expected to perform as intended over the lifetime of the airplane.

I've made the statement numerous times and will repeat it here. There is no significant difference in a properly soldered versus properly crimped joint on a wire. Crimping takes specialized tools and less skill; soldering uses very in-expensive tools and takes some practice. I cannot cite any reason for saying that one technique is better than the other with respect to service life in your airplane.   Bob . . .

Wiring , harness workmanship standards

> Hi everyone, I just joined the list and noticed that there is very little talk about workmanship. I am in the business of building wiring harnesses (I am not trying to solicit work) During my visit to sun and fun I stopped at some of the professional panel builders booths and inspected some of the crimping and soldering. Some of the workmanship was great, But I did notice some bad crimps and poor soldering. Below is a link to a workmanship standard that I highly recommend to everyone. I would bet that more panel problems are related to workmanship than equipment failures.   http://www.whma.org/standards.htm

The top mistakes I see are:

1. wrong tooling for crimps. (I have seen ring lungs crimped with vice

grips)

2. improper sevice loops and harness support.

3. nicking of strands when stripping

4. wrong strip length for the terminal being used

5. the crimp just not made properly even with the right tooling.

6. bad solder joints.

7. sloppy harness routing and combing out of the wires.

I would recomend that a sample of each type of crimp that you need to do be made and a pull test be done. It can be done with something like a fish scale.

Make all of your crimps first before inserting the pins into the connector and do a visual inspection of all the crimps. Use magnification if needed. After the pins are inserted into the connector check to see if they are inserted all the way and locked in. I have seen hundreds of pins not inserted all the way.

If possible make a harness board and build the harness off the panel. This makes it easier to inspect and if you had to make another one it would look the same. panels or plane harnesses. See my web site for examples of harnesses www.advanceddesign.com Ron

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Re: Wiring D-Sub Connectors

> Perusing 'lectric Bob's web site for supplies, I find myself with these questions:

>1. Soldering wires to a d-sub, or crimping machined pins and pushing them into a d-sub

connector -- what's the difference? When do I use one and not the other?

A When the product you're installing comes with a solder-type d-sub and you don't have and/or don't want to change to the other style connector, then you'll have to solder it. Either technique is entirely adequate to the task if done with the right tools, skill and understanding.

>2. On the Tools page, does the BCT-1 also crimp the machine pins? If so, I would have no need to buy both the BCT-1 and the RCT-3, right?

A The BCT-1 is for open-barrel sheet metal pins as shown on http://aeroelectric.com/articles/matenlok/matenlok.html The RCT-3 is for machined pins as shown here http://www.aeroelectric.com/Catalog/connect/connect.html#S604

The crimp-pin d-subs sold in many stores like Radio Shack have the open barrel pins. I use the connector housings from Radio Shack when I need to get some in a hurry or on a weekend and

use the machined pins in them . . . but either can be installed in a satisfactory manner. I prefer and usually always use the machined pins in my projects.

>C. I see female fast-on spade terminals, but no male counterparts. Why? I was thinking of using this combo for the occasional connection in the airplane. Is it not recommended?

A It's only been recently that anyone offered a male fast-on in the PIDG style (metal liners in the insulation grip). They've been available in plasti-grip for a long time but I wouldn't use these on my airplane. If you want to make a serviceable splice in two wires I would recommend knife splices like this http://www.aeroelectric.com/Catalog/wiring/ksplc2.jpg Bob . . .

Wire selection

>> Hi Bob, 1) I plan to hook up a 1.5amp interior light with my nav light switch. Does the wire to the 1.5amp light have to handle the full rating for the whole circuit or just the 1.5amps?

A Why hook it to the nav lights circuit? I presume the light will still have its own switch. Are you trying to be sure that the light is out when the nav lights are off? Your hypothesis is correct . . . EVERY wire downstream of a protection device needs to be sized to that device irrespective of the true load. What you could do is come off a 7 or 10A fuse to nav lights switch. Wire lights with 20 or 18 AWG wire. Attach to nav lights switch with 24AWG fusible link that protects 20AWG wire running off to the interior light switch. But it still begs the question, why not give the overhead light it's own switch that gets a good post flight inspection along with all other switches?

>> 2) My panel dimmer only has one outlet. I plan on wiring up 4 items that will not exceed the dimmer rating. What method do you recommend to get power to all 4 items? I was considering

the piggybacks like I used on the shielded wires.

A Use a butt splice to bring as many wires together as needed. In this case, a pair of 22AWG wires into one end of a red splice would connect to three 22AWG wires in the other end. Bob . . .

Wire, Battery

>> Bob, I ordered battery cables from your website last night. Are they 2 guage or 4?

A Our battery jumpers are fabricated from 4AWG welding cable.

>Years ago I ordered a bunch of stuff from Van including two of those spike catching diodes. Are they the same as the ones you mentioned?

A ANY diode you can put your hands on will work as a spike catcher across the coil of a relay or contactor. There are no rectifier diodes made with voltage ratings of less than 50 nor current ratings of less than 1 amp. My personal favorites are the 1N5400 series devices available from Radio Shack for about $1 for a pak of two parts. These feature more robust leadwires and heavier plastic bodies. These are the parts illustrated in our website catalog pictures.

>>Is there any theories out there that one should use crimps on all high vibration enviorment cables and electrical connections? Some one told me that in the Aircraft Standards Handbook it is mentioned to not solder the lugs onto the leads. Help! I'm confused!

A Bottom line is that either solder -OR- crimped terminals offer excellent technologies for jointing wires and terminals. Here are a couple of pieces I've published on my website on this topic. http://www.aeroelectric.com/articles/rules/review.html -- http://www.aeroelectric.com/articles/big_term.pdf

>>If I buy the vacume pad alternator (as backup) and the Aircraft Alternator Control System do I still need a OVM-14 at the vacume pad?

A I would recommend it. Nobody in the alternator business wants to advertise that the probability of over voltage failure is NOT ZERO . . . it may be quite low but it is not zero. I'm helping analyze a VERY expensive incident involving a small alternator, small battery and a series of errors that culminated into many thousands of dollars worth of damage. Please include ov protection on every alternator system and test the ov module every annual.

>>Where is a good source for my main alternator? I want a big honking one. No bigger.......

A You cannot do better than a B&C modified Nipon-Denso alternator. Why so big? The biggest full up IFR running load I've ever encountered was 27 Amps . . . meaning that an L-40 (6.5 pounds) was very much up to the task. This should be the first and last alternator you put on your airplane. Beech/Piper/Cessna and Mooney can only dream about having alternator service records that approach the history of B&C alternators. Bob . . .

Wire , Battery

>> I'm doing the main cables from battery to the relays. I've got a three year old wiring Kit from Van. This has lots of #2 wire (heavy) and the correct size lugs with white rubber boots. My problem is at the battery. I've got one from a jetski and it has 1/4 inch posts. The inner size of Vans lugs are 3/8 so there is a little slop. It goes away with washers and tightening it up but is this allowed?

A It would probably work okay . . . I'd much rather see the right terminal installed.

>Also I would like to put a 45 degree bend "up" on the lug so the cable leaves the battery traveling up. Is this allowed? I test bent one and it still appears solid and fits real well.

A Sure . . . you can form the lugs to accommodate wire routing.

>Do I have to get new lugs to remove the slop?

A Not necessary but recommended

>If I do shouldn't I downsize to #4 wire? (firewall battery)

A The only time you need 2AWG wire in an RV is when the battery is behind the seats. Otherwise, 4AWG is fine for the whole system. Irrespective of where the battery is located, 4AWG jumpers from battery(-) to ground and battery(+) to contactor are fine too. We offer pre-assembled battery jumpers made from welding cable . . . very soft and easy to work with. If it were my airplane, I'd make new battery jumpers with proper sized terminals and fabricate from 4AWG welding cable.

>How many amps is #4 wire rated for?

A Not so much continuous with respect to starting . . .even 2AWG is rated for only 100A continuous. Cranking will draw 200A plus but only for a few seconds. Wire sizing in the cranking circuit is a function of voltage drop and starter performance - wire heating due to momentary overloading of conductors is a secondary issue. 4AWG wire is fine for the whole system as long as you don't have a long run to a remotely mounted battery. If the battery is up front, 4AWG is fine. Bob . . .

Wire

> In crimping multiple wires, I seem to recall that you should only do this with odd numbers, 1, 3, 5 etc. Bob Marshall

S Haven't heard that one . . . numbers of wires doesn't make any difference. Keep in mind that when the wire grip is closed down on the strands, they become a single piece of metal . . . meaning that the joint is gas-tight. Nothing in the way of moisture or corrosive gasses can get in . . . When that much pressure is involved, it matters not how many wires you started with. At school we were taught a way to do this a bit more easily:

1. Strip the wires.
2. Untwist the strands of each wire and fan them out.
3. Lay the fans on top of one another.
4. Apply a little finger pressure to get the strands to interleave.
5. Twist the fans back into a single, larger wire.
6. Insert the new, larger wire into the sleeve of the connector.
7. Crimp.

This is a bit easier if you strip the wire longer than usual. Clip the new, larger wire back to the proper length for the connector. But perhaps Bob will tell us that this compromises the quality of the crimp because twisting the wires by hand doesn't create a bundle of strands packed the right way. Manufactured wire has the strands arranged in an optimum packing pattern which, when crushed by the crimp, forms a gas-tight piece of metal. Strands randomly twisted together by hand may not crush as nicely. Still, I've always had good results with this technique. Steve Williams

A You almost cannot miss getting a good joint as long as all of the strands can be coaxed into position in the terminal's wire grip volume . . . probably the easiest lay-up for acquiring a gas-tight joint is to have all the strands laying perfectly flat and parallel . . . but if twisting them together helps you get all of them in together, I don't think it hurts. When putting a lot of strands in the same crimp, I'll sometimes bundle the conductors using a length of rubber banding to get a really tight grip on the bundle and prevent one conductor from sliding with respect to the others. If all the butt ends of the conductors are even when you bundle them up, then the funnel shaped entry of the better grade terminals (PIDG or Waldom Avicrimp) will guide them into the right spot for crimping. The strip length might want to be a bit longer . . .say half again.

>>I'm using AMP CPC connectors that use #20 MIL pins/sockets (for 20 AWG). I need to run 16 AWG thru so I was going to solder the 16 AWG to two 20 AWG wires that can be crimped in

the pins for the connector. Would I be better off using blue double-crimp butt splices to get the single 16 AWG down to two 20 AWG instead of soldering?

A No, you're on the right track . . . BUT . . . make the 20AWG segments some rather significant length (like about a foot if you can) before you bring them together for joining to the 16AWG. This is to put significant milliohms of wire in series with the two pins . . . much more milliohms than the resistance of the pins themselves. This extra resistance makes sure that the pins share the load. You only need to do this on one side of the connector . . . or perhaps 6" "ballast" resistors on both sides?

>>I was going to switch to the series 1 CPC that has larger pin sizes available but I couldn't find the MIL pins for them so I'm sticking with the series 2 CPC that only accept 20 ga or less. Many a sleepless nite debating about using connectors vs straight wires and what type of connectors and pins. Any better ideas? We use EDAC at work and they have really nice crimped pins but the crimper and pins for the AMP CPC series 2 are the same as D-subs so it's convenient.

A Not a bad choice. I'm building a power distribution system for a new target that will take 40 amps through d-sub pins (10 pins paralleled with 22AWG/12" ballast resistors to force the pins into a load sharing mode.

>>I think it will only be for the one starter relay wire but the fuel pump and electronic ignition wires are also 16 AWG. They only draw 1.5 to 3 amps so I'm not sure why they come with 16 AWG. Could I step these down to 20 AWG and if so, what would be the best way? Fold back the 20 AWG onto itself and use a blue double-crimp butt splice?

A Hmmmm . . . in this case, I'd splice them with 20AWG wires at the appliance and continue on through your connector with a single strand of 20AWG wire on one pin. Ignore the size of wire that comes out of the black boxes . . . wire it up with conductors and other materials rated to the task. Use a blue butt splice and double the 20AWG conductor back on itself. Bob . . .---------

Wire

>>Bob, thanks very much for the answers on multiple conductors into single crimp. It's very reassuring to get some feedback. But I'm still a little confused - I'm sure it's just nit-picking on different techniques but you recommended splicing verses soldering for multiple conductors before. But below, you recommend soldering 16 AWG to two 20 AWG, but splicing from one 16 AWG to one 20 AWG (with the foldback on the wire). I would have guessed the other way around. It seems like either way would work fine but if your experience shows otherwise I'd rather follow your recommendations. Thanks again, Gary

A Check the indentation of the various paragraphs in my reply. One of the readers uses the word "solder" . . . I didn't. There's nothing wrong with solder . . . solder and crimped joints will both make entirely satisfactory joints in conductors. They simply require different tools, materials and skills. There is no difference in their respective service performance. The reference to "foldback" speaks to an occasional need to increase the number of strands inside the wire grip area of a crimped joint to bring the stranding up to a volume the terminal was designed for. The reference to foldback was made in a discussion about dealing with the OVERSIZED leadwire provided on one of products to be installed. A fuel pump that needed less than 3 amps to run was fitted with a 16AWG leadwire. Are you obligated to carry 16AWG all the way back to the bus? No . . .

You COULD drop all the way down to 22AWG wire . . .in which case, soldering a 22AWG feeder to the 16AWG pigtail would be one way to do it. In this particular case, the connector was rated for 20-22AWG wire. I suggested that a blue butt splice (16-14AWG) could be used but a 20AWG wire in one end would have to be doubled back to increase the amount of copper in the wire grip area . . .Take a peek at this picture.
http://www.aeroelectric.com/articles/22-16sp.jpg

Knife splices make a neat way to joint dissimilar wires. In this case, the fuel pump could be fitted with a blue knife splice, the feeder from the bus could be as small as 22AWG . . . so put a red knife splice on it. Red and blue knife splices will interconnect . . . put a piece of heat shrink over the joint and you're done. Bob . . .

Wire

>> What's the general thoughts of the AMP Waterproof Fusion Tape (Manf #605262-1)? I'm considering it a companion to heat shrink tubing, especially on larger applications like battery cables. I ordered a couple rolls from Newark to check it out and I'm quite impressed. > This is a rubber, stretchable, non-adhesive tape and it sticks to itself quite well. It's an insulator and is removable if necessary. Hell, I even tried it on a leaky garden hose and it worked great! I like this a hell of a lot better than regular adhesive electrical tape. >Unless I hear of any longer-term problems with it I may use it quite a bit for insulating wires and blocks. >Greg

A This kind of product has been around for awhile. We use tons of it at RAC. You can also buy small rolls of it at: http://www.aeroelectric.com/Catalog/slikstik/chem.html#s894 I just talked with Todd at B&C and he's going to look into stocking bigger rolls as well. It's not a TOUGH tape but it is very resistant to heat, oil, ozone, etc. Good stuff to use under the cowl. I also use it to wrap a wire bundle where it exits the backshell of a d-sub connnector. I can use it to build up bundle diameter to fit the backshell exit hole and eliminate the need for any extra strain relief. Bob . . .

Wire

>> A few questions on the 2awg wires. I am using the figure Z-9 diagram for inspiration and my alternator is Van's 35amp. (1) Diagram uses two 2awg wires to connect battery to contactor and also to ground block. Mine will each be 8" in length. I want to order these from B&C, but theirs are 4awg. Will these be ok?

A Sure . . . in fact, on an RV with a battery on firewall, you can use 4AWG throughout.

>(2) Since my alternator is 35 amp, can I substitute 8awg wire for the 4awg wire that goes from the battery contactor to the main bus.

A Yes . .

>(3) Also can I substitute 8awg for the 4awg wire from the starter contactor thru the 80amp fuselink to the shunt and from the other side of the shunt to the alternator? Or would the wire melt before the fuselink would??

A Yes. You CAN substitute a smaller wire and no . . . the fuse will pop only when you have shorted diodes in the alternator . . . a HARD fault that causes hundreds of amps to flow. The fuse will open in milliseconds . . . the wire will get barely warm to touch. Bob . . .

Wire, Sizes

> Bob, you wrote: “Nav lights are an interesting special case. Each light is only 2Amps suggesting that 22AWG would power the light. 25' of 22AWG is .4 ohms giving a voltage drop of 0.8 volts at 2A . . . a tad much. Dropping to 20AWG gives us a drop of 0.5 volts . . . okay. Now, we're tying three loads to one breaker and the wire needs to be rated for TOTAL load . . . in this case 20AWG is still okay attached to a 7A fuse.”

>>Bob, Now I'm confused, but that's not unusual. When you say "rated for TOTAL load" I'm assuming you mean the wire from the power source to the breaker. Each light will then have it's own wire from the breaker to the light fixture. You are not saying that these wires have to be able to carry the load of the other fixtures that have their own wire from the breaker, are you?

A No, I'm saying that the breaker sized to carry 3 loads must be wired with a conductor rated for THAT breaker. This means that three 2-amp loads for a total of 6 amps have to be wired with wire sized to the breaker, not the individual lamps. However, since one generally wants to upsize the wire for voltage drop considerations - ESPECIALLY in a composite aircraft where the wires run a round trip, then the wires will already be OVERSIZED with respect to the breaker size which is not a problem.

>>Example; If the Nav lights were 4 amps each instead of 2 amps, 14 awg would be needed from the power source to the breaker, then 3 dedicated 20 awg wires from the breaker to each individual fixture. Is this correct?

A No, if you had 4A each for total of 12, then you need a 15A breaker which MUST drive wiring rated for 15A is all parts of the circuit. Yes, this would be 14AWG wire - used everywhere in the circuit. You could get a fault at a light fixture location that would be expected to open a 15A breaker . . . you don't want to do that through 20AWG wires. Bob . . .

Wire, Size, Local Ground

>>Bob, By each way I just mean the distance from the power source to the light fixture. I do plan to ground to the airframe and I understand that this will have less resistance than running a dedicated ground wire. For planning purposes I was just assuming that grounding through the airframe had the same resistance as the wiring run. Should I assume that there will be NO resistance and thus no voltage loss by grounding to frame? Or is there some standard resistance value that I should use for planning purposes? Thanks, Cliff

A For practical purposes, ground path resistance in a metal airframe is negligible . . . it's not zero but it's very small compared to power wiring resistance. This assumes of course that one takes pains to clean the aluminum under the terminal and bolt it up right firmly to get a moisture and gas tight joint between ground terminal and airframe. Bob . . .

Wire runs and fuel lines

>Bob, I've been following this list since it's inception and I believe that "The AeroElectric Connection" has actually helped me understand what those electrons do, or are supposed to do. My question is this: I'm building an RV-8 with the full baggage compartment, which leaves only a relatively small area of the firewall for all of the fuel and electrical lines to pass. I've been studying how I might run the various fuel and electrical lines (as well as brake lines), and they're going to be close to one another. Is there any rule of thumb as to how far apart an electrical wire should be from a fuel line in the cockpit (or anywhere else)?

A The heavy iron guys have formulated lots of "rules of thumb" for such separations . . . not sure any of them are based on logic and understanding. Fuel or hydraulic fluids are not susceptible to unhappy stresses from within their various tubes and hoses . . . it's only when the containment is compromised that leaking fluids become an issue. I suppose the standard thinking is that if a wire bundle rubs against a tube carrying flammables, the same actions that opened the fluid line might also rub away insulation thus giving rise to potential ignition.

As a practical matter in little airplanes, the rules of thumb separation values may be difficult to observe. Common logic says that if you're concerned about a potentially antagonistic wire bundle rubbing against a victim fluid line, you can keep it from happening by (1) securing the two systems firmly to each other so that motion between them doesn't occur and (2) including some additional buffer between them . . . like a piece of hose or thin wall plastic tubing over fuel and brake lines before you tie-wrap them firmly together with wire bundles. Heat shrink over the wire bundle might also contribute to physical isolation of the two systems.

Neatly buffered and secured systems will co-exist nicely. It's stuff allowed to wave around in the breeze that offers potential for hazard. Bob . . .

Wire, Conduit reference

You can get tubing in Teflon form, from McMaster-Carr, in many sizes (but don't use the thinwall stuff, it kinks up easily when you try to bend it), if you want the higher resistance to heat and flame. I bought both (Nylon-11 and Teflon PTFE) and did some flame tests, as well as dipping in a 500-degree solder tank... The nylon gets soft and starts to emit some fumes about the same time it actually starts melting, but does not burn; the teflon just sits there and does absolutely nothing except get fairly warm and a little bit softer but nowhere near the point of melting. See: http://www.mcmaster.com/catalog/108/html/0081.html> for a comparison of different kinds of Thermoplastic tubing. I ended up using (2) 8-ft lengths of 5/8" O.D. heavy-wall tubing as conduit in my Velocity; it's great for pulling new cable from the engine to the panel area; I can actually *push* 18-ga cable if the conduit isn't too full!

I also, once upon a time, compared automotive battery cable to welding cable and Tefzel (22759-xx) in a 700+ degree solder pot and also with flame tests; the automotive cable burned immediately, made thick oily smoke and sustained a flame after the source was removed; the Tefzel smelled fairly nasty but would not burn right away (and would not sustain a flame at all); the welding cable gave off kind of a "hot rubbery smell" which wasn't irritationg at all, and would not burn or melt, but did swell just a bit. -John

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Audio Wire Selection

>>Bob, Despite reading (& rereading) your AeroElectric Connection, and looking at your web site I'm unsure as to the best cabling choice to install a 4-person intercom in an all metal A/C. I'm installing an RST-Engineering product (RST-565) and in his manual he (Jim Weir) suggests that RG-174 is fine for connecting the mike audio. I plan on using the insulating washers you sell (P/N S825-1). If I understand correctly these washers will insulate the jacks from the airframe, then the "ground (shell)" connection wire should be run all the way to the forest of tabs on the firewall.

A No, avionics grounds are signal grounds. You wire according to the installation manual diagrams and they will tell you where to ground signals and shields.

>> This would, in effect, require two conductors for phone jacks (+ and -) and three conductors for mike jacks (audio +, audio -, and mike key).

A See http://www.aeroelectric.com/Catalog/wire/wire.html#S906-1-22 The single conductor shielded wire is used on headset jacks. The center conductor carries headset audio out, the shield carries signal ground (shell connection on headset plug) back to the audio system. The 3-conductor wire is useful for microphone jacks. The installation drawings for your system should have specific suggestions for how you wire them up. A good example of headset and microphone jack wiring can be seen in the installation drawings I did for the VHF transceiver we sell. Download http://www.aeroelectric.com/articles/techbits/760v1.pdf and http://www.aeroelectric.com/articles/techbits/760v2.pdf You can see how the diagrams are quite specific as to the utilization of shields.

>>Does the cabling from each phones jack have to be run back to the panel? or can the audio portion be daisy-chained from jack to jack to minimize cabling?

A You may daisy chain and the drawings above show just that. Bob . . .

Wire Bundles

>Is it okay to bundle the P leads / CHT&EGT sensor leads / "B" lead from the alt / and "F" lead to the alt together and pass them thru the same hole in the firewall.

A Sure. ESPECIALLY if you take care NOT to physically ground the p-lead shields at the panel end of their runs . . . only at the engine end. Use the shields to PROVIDE ground for the individual magneto switches as shown on many of our diagrams. Bob . . .

Com - GPS bundle

>can i run com and gps antenna wire together in conduit under seat and baggage compartment? they will be going their separate ways after baggage compartment bulkhead. antennas are over three feet apart. thanks dave pierson

A Yes, the routing you propose poses no special potential for problems . . . except I am concerned about the LENGTH of your GPS antenna coax. At 1500 MHz, you want to keep this as SHORT as possible . . losses at this frequency are high. Bob . . .

Wire Sizes

>>Is #4 for my 40 amp alternator and #2 to the starter okay?

A The 4AWG recommendation came from the fact that most of the the power distribution system is wired with 4AWG or larger for the rest of the high current conductors. The b-lead feed on an alternator can be downsized to 6 or even 8AWG in some cases . . . but it only saves an ounce or two and you have to chase down a short piece of other sized wire and terminals to match . . . adding a couple more feet of 4AWG and matching terminals is an easy thing to do since you need those sizes anyhow. Bob . . .

>>At 250 amps, with 7 feet of cable (don't forget to add the length of the ground cable), 4awg would have a voltage drop of .425 volts, while 2awg would have a .273 volt drop. The difference in voltage delivered to the starter in this case would be .152 volts. I decided to go with 4awg based upon this.   To further support that decision, a while back I did a calculation of the temperature rise that 4awg wire would have in this case, and I recall it to be around 1 degree Fahrenheit per second, which is quite acceptable.

A Good science sir . . . Bob . . .

Wire

>>I am building an RV-4. How do I size the rest of the wiring that I am going to need (landing lights, trim, radios, flaps, etc.)?

A Look up and know the current requirements for each of your planned electrical accessories. Make up a spread sheet either on paper or in your computer that lists electrical loads for each of the gizmos you plan to install. You need to have separate columns for type of operation. They might have headers like Taxi/Day, Taxi/Night, Take/Off and Climb, Cruise Day, Cruise Night, Cruise IFR, and Battery Only Ops.   See what the total continuous draw is for installed equipment under each of these operating scenarios. This is called an electrical load analysis. It's not difficult. You need to look up information in the books that come with your radios or ask questions of folks who have the same stuff installed.

This is the FIRST step in designing your ship's electrical system for it helps you size the alternator, size the battery and plan for getting on the ground comfortably when something breaks. Have you made a list of all the electrical goodies you plan to install? Bob.....

Wiring, battery

>>Mr. Nuckolls, In your book, you recommended using Welding cable instead of #2 wiring because of its many strands and flexibility. Is this still your recommendation? I am building a RV-6a and am also wondering is I could use #4 AWG wire instead of #2 to the starter?

A When you have a battery mounted within two feet of the engine, ALL of the heavy power wiring can be done with 4AWG wire. I'd use TEFZEL everywhere except for the short jumpers from battery to master contactor and battery to ground. There I would substitute short pieces of 4AWG welding cable like: http://www.aeroelectric.com/Catalog/wiring/wiring.html#sbl You can get these from B&C or fabricate them yourself. Bob . . .

Wire and NoOx

>I do have one question based on my industrial power and control days. We used a product called NOXIDE which is a paste used between connectors (lugs) and aluminum bus. Unplated surfaces were abraded and immediately the paste applied and the bolted joint made up. The idea was to inhibit corrosion and oxidation at the joint. Belleville washers were also used.   I will be makng some ground lug connections to the aluminum structure. Do you recommend either a joint paste or Belleville washers or will a simple bolted joint provide long term reliability?

A I've never seen the Bellville washers used in airplanes but intuitively, they seem like a reasonable product to use. By-in-large, all of your hardware suited to aviation connections will be tin plated. This reduces electrolytic potentials between copper and aluminum. The classic approach is to buff the aluminum, wipe the tin plate clean and then bolt up with enough force to actually put a little crush on the copper terminal. I have to belive that NoOx can't hurt and it may be beneficial in these cases. I think a Bellville washer would probably be totally used up by the time you put a crush on the copper so its only purpose would be to help keep tension on a joint that is already loosened up. I.e. in the process of Failing. So I guess my approach would be to leave the washer out and go ahead with the NoOx. Bob . . .

Wiring

>>After working on the wiring this weekend, I've come-up with a few more questions: 1. In the Z-7 schematic, what is the wire AWG connecting the battery contacter to the bus?

A This wire is sized to the alternator's output . . . or how much of it you would EVER expect to use . . . 8AWG is good for 40A and is probably a good middle of the road choice.

>2. What type of diode goes on the battery contacter? I have the one from Aircraft Spruce.

A Any diode you can get your hands on will do electrically. It's very UNcritical. However, our contactors are fitted with 1N5400 series devices which you can buy at Radio Shack in a blister pak of 2 for about $1. These are 3A diodes with a voltage rating of 50 volts or more. They have robust leads that crimp well into the Red (22-18AWG) PIDG terminals. These are the diodes you see illustrated in our parts catalog. The picture for the S701-1 contactor shows a good way to attach the diode.

>3. The picture on your site of the relay has a diode in it, but I don't see the diode in the schematic. Should I install one like the picture shows?

A I put that on 'cause a builder wanted to add diodes to ALL of his relays/contactors and was asking how to do it on the S704-1. That device stores very little energy and what spike it dumps out is zero risk . . . that diode is optional. However, here you need the smaller devices like a 1N4000 series device. 1A rating at any voltage. RS has these too. . ..

>4. What ring terminal would you recommed for a 12 AWG wire to a 1/4" post? I didn't see anything on your website for those sizes.

A The Yellow PIDG terminals are 10-12AWG and the only thing we have in that range is the yellow fast-on receptacles. Terminals in that range are low volume devices and I was waiting until I built up the inventory in smaller sizes first. Now that it's B&C's inventory, we'll have to see. You might e-mail Todd at B&C . . . there might be a small quantity of the right terminals in the laboratory stock that he could accommodate your needs.

>5. Does RG-400 coaxial cable work ok with the special connectors that are put in my radio trays? I want to use it...just want to be sure it doesn't cause any problems because in the manuals, RG-58 is specifically called-out.

A Yes . . . the connectors we stock are originally designed for RG-58 and we've used them many times with the RG-400. Bob . . .

Wiring, Magneto

> > I know I'm supposed to use 18 gauge shielded wires to the P lead on the magnetos   The Zx diagrams in Bob's book show 20 gauge from switch to mags, which is what I used. Let's see if someone knows what current draw the magnetos pull from the 12 volt line. Then we'll know if something heavier than 20 Gauge is warranted. I checked Tony's Firewall Forward, BTW - 16 AWG!!

A Magnetos have NO current draw from the airplane's electrical system. The p-leads are used to literally short out the points in the magneto (simulated failure of the capacitor if you will) in order to make it stop working. The current in this lead is not significant with respect to sizing the wire. 22AWG wire would work, as will anything heavier. The primary thought for somewhat heavier wire like 20 or 18AWG is for mechanical robustness for a lead that connects directly to some portion of the engine.

A couple of builders have purchased the shielded trio wire from our website catalog and simply paralleled all three conductors into single red (22-18AWG) terminals at each end. Bob . . .

Shielding

>By the way, my whole understanding of the purpose of using shielded wire may be faulty. I thought it was that GPS is very noise-sensitive and therefore one would like to keep radiated

energy in the vicinity as low as possible. I just assumed that every unshielded conductor acts like a little antenna broadcasting whatever goes through it, and that its signal would be a problem for the GPS even several feet away. Is the only problem actually between wires that run in close proximity to one another for some distance? I am in fact running all my radio-related wiring in separate bundles.

A Shielded wire has almost no beneficial effects for controlling "radiation" . . . shielding breaks up the CAPACITIVE coupling of fast rise-time voltages between adjacent conductors in airplanes that use airframe ground for the primary power return. In composite airplanes, where the ground must accompany the supply wire to remote loads, there is a small benefit to be gained to reduce MAGNETIC coupling of current variation noise between adjacent conductors by using the shield as a ground return. This absolutely forces concentric equal and opposite magnetic fields around the wire to cancel each other. Similarly, magnetic fields from other antagonists couple equally into both conductors with electrical effects nulled out at the ends of the conductor.

You can get 90% of the SAME effect by bundling inbound and outbound conductors together in parallel bundles and 99% of the same effect by twisting them together (about 1 turn per inch).

If you have the tools, skill and materials to deal comfortably with shielded wire for this application, it's not a bad thing to do . . . but the benefits over other techniques don't justify the effort if you're having to spend a lot of time on it -OR- if there are any concerns for operational integrity due to hassles of the special techniques involved.

Most problems with MAGNETIC radiation involve the whisky compass or alternator whine coupled into audio systems.

>Now that I think about it, people use GPS in all kinds of environments. Is noise really that big a problem? And does noise really mean what I thought it means -- eg a signal emanating from an unshielded DC conductor running to, say, a light bulb?

A No, GPS is 1500 MHz . . . far above the range of system generated noises in your airplane. The strongest potential antagonist to GPS comes from harmonics of local oscillators in your VHF receivers falling on or near the GPS receiving frequencies . . . and this has been rare in practice. Most cases of poor GPS performance can be traced to antenna problems . . .poor design or location on the aircraft.

Except for the minor benefits I've described above, the use of shielded wire in light aircraft is generally limited to P-leads, strobe-head-to-power-supply leads (both fast risetime voltages), and to avionics wiring where the installation instructions call out shielded wire. The biggest noise reduction comes from use of single point grounding (in both metal and plastic airplanes) described in my book. Bob . . .

Wiring: Re: Shielded Wire

> Is it practical or prudent to try to use the sheild on sheilded aircraft as a current carrying conductor (like coax)? Is there a gauge equivalent spec for the material of the sheild?

A I've often used the shield as a ground return for a remotely powered device. This can provide OPTIMUM control of magnetically coupled noise. Just for grins, I took two samples of shielded wire we stock and compared the resistance of the shield and interior conductors. The 22AWG shielded single measured 15 milliohms/foot (about what we would expect from 22AWG wire) and the shield measured 18 milliohms/foot . . . slightly higher than 22AWG wire but not enough greater to call it 23AWG equivalent. A shielded trio of 22AWG wires showed 16 milliohms/foot for the wires and 10 milliohms/foot for the shield (20AWG equivalent).

I once used shielded wire to monitor some super-critical wiring in a power distribution system. The notion was that if a wire were being compromised mechanically due to rubbing or other intrusion, potential faults would have to intersect the shields FIRST. So, I powered up all the shields in series with a relay so that if any one shield came to ground, the relay pulled in and annunicated the potential fault long before a real fault made it through to the center conductor.

Aside from odd-ball situations like this, the only currents I would generally flow on shields are ground returns. Bob . . .

Wiring: Re: Wire Interference Question

>Bob, On the F1 Rocket, the battery, ELT, and battery solenoid are installed in the baggage area under a panel. My TruTrak autopilot servo for the elevator is also installed here. I would also like to install my strobe power unit and the relays/speed controller for my MAC servos in the same area for access reasons. Do you see any problem with having this mix of electrical components within close proximity of one another? Should I separate the wiring runs in any way? I have the following wire bundles into and out of this location:

>1) Battery cables (positive and negative)

>2) Strobe power and two strobe output bundles

>3) Autopilot servo bundle

>4) Trim motor bundle into and out of the controller and relay

>

>As always, your advice is greatly appreciated.

A No special problems to be anticipated here. All these things should live happily together. Bob . . .

Wiring; Ground block question

>RV9 project: After reading your book I'm still confused about grounding. I'd like to mount the groundblock on the subpanel of my RV9 so all the instruments ground wires don't have to be spliced, and then run a large connecting wire back to the main firewall ground bolt. Is this acceptable or is it too many connections and a possible interference problem ?

A This would probably work. It's no worse than certified ships of the past that had no rational plan for grounding. However, the system works best when used as prescribed by mounting on the firewall and extending individual system grounds to a common ground.

> I have the sliding canopy version so once the foredeck skin goes down it's practically impossible to work up under there. By moving the connections up to the subpanel it's easy to remove the panel for future maintenance, modifications, etc.

A Understand. Lots of things about our favorite toys are in the "pretty hard" pile, perhaps even difficult. If it were my airplane, the ground block would go on the firewall. If you can't put a new wire into a connector pin long enough to reach the firewall ground block, then it's a simple matter to solder a lap-joint and cover with heat-shrink. This makes a very low-bulk splice that co-exists very nicely with other wires in a bundle. Bob . . .

Wire Data Document

I've often encouraged folks to acquire and become familiar with catalogs of materials and supplies . . . in addition to helping locate sources for various materials, they are often powerful educational tools. I've run across a .pdf file catalog for wire and wiring supplies that includes a wealth of technical information and I recommend you add this to your library. For a short time, I've posted it at: http://aeroelectric.com/temp/wirecatalog.pdf

Folks running across this post in the archives at some later date may access the on-line version of the catalog at http://www.std-wire.com/ViewCat.htm the on-line version has some advantages in that the table of contents is hyper-linked to various subjects within the rather voluminous catalog (260 pages, 7 Mbtes). If you download the .pdf file, the hyper-links don't work but Acrobat's text search feature works nicely and lets you find a keyword or part number anywhere in the catalog. Bob . . .

Wiring: Re:Bundles

> I have one convenient place to run wires thru the baggage area, and I will be running two coax for xpndr and com antennas, a whelen tail strobe cable (with single central strobe unit - ie, high voltage run), aux battery power for second electronic ignition, MAC electric rudder and elevator trim cables and flap motor controller power and switch. Are there any recommended separation rules of thumb? I could separate two bundles by about 4" or three separated by about an inch. I imagine the strobe, com and xpndr are the noise generators and should be separate from the rest, but should also be separate from each other. Could I get away with bundling any of these together? Gary Krysztopik

A Separation "rules" are generally useful only when the folks who built the systems didn't do their homework for interference emissions and susceptibility. By-and-large, there are few if any concerns for wire bundle separation in light aircraft with the following exception. I wouldn't run avionics bundles in with wires carrying airframe systems power and control. This is not difficult to do because 99% of avionics signal wires are clustered around panel mounted equipment and are easy to route separately from wires that come in from around the airframe to the switch panel. Bob . . .

Re: Thermocouple Switch for Blue Mountain EFIS

> Craig Asked: I'm working on connecting up my EFIS/One from Blue Mountain Avionics into my existing airplane. I'm looking for a special switch (or suggestions), connecting my EGT/CHT sensors to the system. The EFIS has 6 inputs for thermocouples, and I have a 6 cylinder Lyc. So I was gonna put my 3 hottest cylinders, both EGT & CHT (for a total of 6 inputs), and then use a (and this is where I need the help), a 6 way (6PDT on-on switch - if there is such a thing). Then I would switch from my 3 hottest cylinders, which I want to monitor most of the time, and to check the others as needed. If anyone has a better suggestion, let me know. By the way, I've seen Bob's thermocouple information in Chap 14 of the current Aeroelectric Connection.

A IF I were to tackle this task on my airplane, here's how I'd do it: Put the 2 hottest cylinder CHT/EGT thermocouples onto 2 fixed inputs which uses up 4 of the total. Run the other pair of inputs to a 4-pole, 4-position such that thermocouple PAIRS for the other 4 cylinders can be switched to the "roving" inputs to the EFIS. Hopefully the thermocouple wires are 20AWG or smaller. I'd use D-sub connectors with machined pins to make the interface with individual probes and a harness that brings all temperature data into the cabin. The harness needs to be fabricated from the same kind of thermocouple wire as the probe (type J or K). I'd bring the bundle to a small enclosure mounting a two pole, x-position switch for the purpose of selecting one-of-x thermocouples for display. Use another d-sub connector at the rear of the enclosure to bring the probe bundle into the switch and carry the thermocouple signal away to the instrument.

The interior of the switch box can be wired with ordinary copper . . . when both sides of the thermocouple lead are treated with the same "interfering influence", the errors cancel out. Thermocouple wire is used to take the signal from the switch box to the instrument. Grayhill has a suitable, miniature switch that you can purchase from Digikey goto: http://www.digikey.com and enter 71BD30-02-2-AJN as the part number to search. This switch has two decks of two poles each for a total of 4 poles. It has an adjustable stop so that you can limit the throw to 4 positions. Bob . . .

Re: Thermocouple and fast-ons

Kevin says: The EIS 4000 doesn't use any switches, as all thermocouple wires go into the unit, and it can display data from all cylinders at once. The wires from the Fast-Ons to the EIS 4000 are thermocouple wires, i.e. type J or K as appropriate. Looking at one wire, I see the following interfaces in order: Type J wire from thermocouple to male Fast-On tab; male Fast-On tab to female Fast-On tab; female Fast-On tab to Type J wire; Type J wire to male D-sub pin; male

D-sub pin to female D-sub pin (connector attached to the back of the EIS). I can't tell what kind of wire is used from here on in. The parts I'm worried about are those associated with the Fast-On tabs. Everytime we have an interface with dissimilar metals, we'll create a voltage. The voltages at the two interfaces between the Type J wire and the Fast-On tabs will cancel each other out, assuming both interfaces are the same temperature. So I don't see how using Fast-On tabs creates a problem, but I'm certainly no expert, so I could have this all messed up.

A Kevin, My concern with fast-ons is based on the relative hardness of the two materials. Thermocouple wire is quite hard compared to the terminal that's grabbing it and trying to get a gas-tight joint. I prefer the machined pins found available for D-subs and other multi-pin connectors for their 4-quadrant grip on the wire. EIS has been using the fast-ons for years and I must presume they're getting satisfactory service . . . so I'd advise that you follow their instructions and truck on. Bob . . .

Thermocouple wires

> “You need to extend thermocouple wires with thermocouple wire. If you splice to copper at any place other than the instrument reading the thermocouple, then you've created a new cold-junction that is remote from the instrument and therefore unaccounted.”

>Will this work, or do I really need to have a d-sub connector on the inbound (front side)?

You can use any kind of connector you like including butt splices, but the extension wire needs to match the thermocouples you're wiring. Here's a good source for wire. http://www.omega.com/toc_asp/subsectionSC.asp?subsection=H06&book=Temperature

Bob . . .

Re: thermocouple wires

> Have a look at: http://www.rst-engr.com/rst/magazine/egtcht.pdf

It has a pretty good description of how all this works. Matt

A This is a good hammer-n-tongs piece on working with thermocouples but it does not speak to the need for a reference junction. It also speaks about heating effects of galvanic corrosion with some shaky science but by-in-large, the article is factually useful. Have you read the thermocouple section of the 'Connection? You can download it at

http://aeroelectric.com/articles/excerpt.pdf

>However, we can use a short splice of copper (ie: a d-connector) as long as we have thermocouple wires on both sides to cancel the copper connections. If we don't do it this way, we'll get the temperature at the copper connection instead of the temp probe. Did I sum it up correctly?

A Nope.

>Now, the big question: WHY? How does all this stuff work? How does the temp probe actually pick up and transmit temperature, how do the thermocouple wires transmit it, why doesn't copper work, and what is the meter expecting to see? If this is all in The Book or on The Website, I'm more than happy to just go read.

A ANY time you take two different metals and clamp them together, the junction of the two metals will generate a small but predictable voltage depending on the temperature of the junction. See http://www.ferrotec-america.com/3ref1.htm

To make use of this phenomenon, you must (1) account for any and all other junctions of dissimilar materials including extension wire, connectors, switches, etc. and (2) the voltage generated at the junction of interest MUST be compared with a junction of known temperature oft called the "compensating", "cold" or "reference" junction. ANY other junctions introduced into the system must be introduced in pairs so that they cancel each other. One example of this is shown in Figure 14-7 on how to hose your thermocouples by improper use of switch. Figure 14-10 speaks to the issue of "cold" junctions and how they must be treated in order to get accurate measurements should the cold junction be located remotely from the measurement device.

At Cessna in the 60's we had a lot of thermocouple installations wired like view-B in figure 14-10. A thermos bottle fitted with a bored rubber stopper contained a mixture of water and crushed ice. All the thermocouples went into the ice bath and came out on copper wire to the recording instruments. Check over these suggested readings and then let's revisit your project.

Bob . . .

Kroy K3000-PC Shrink Wrap Printer

Here is a URL to look at the Kroy K3000-PC Shrink Wrap Printer. The price has "gone up" some, but now sells for $149 with all you need but the shrink wrap.
http://www.wiremarker.com/k3000_feature.htm

Re: Wiring from scratch : where do you start ?

> Anyone know of a practical coding method for numbering the wires in a logical way ?

S What I have done is to identify each device with an alphanumeric 2-4 letter symbol, and connectors with 3 digit numbers (first being the connector, the second two being the pin number). My labels will consist of a pair of codes, the one nearest the connector/devise being that pin designation, and the one away from the connection/devise indicating where the wire goes. The other end of the wire will have a similar tag. The label will be within 6" of the terminal, hence, wires less than 12" need have only one tag midway.

Examples: Busses are labeled B+ or B- followed by a cap letter such as M for main, E for essential, G for gauges, I for instruments, L for lighting, etc.

Switches and switchbreakersare S01, ..., S34. Fuses are F0n (n=numeric) for panel mounted fuses. The fuse blocks are F10-F14 and F20-F24 for the essential bus, and F30-F39 and F40-F49 for the main bus.

Connectors are 100, 200, etc with the last two digits of that connector being the connector pin number. In the case of the wings, there is a connector at the root and at the tip. The left wing root connector is 701-716, the wingtip connector 740-752.

Avionics (minimal UPS Apollo for now, more later) uses A1 for the SL10 or 15 audio panel, A2 for the MX20, A3c and A3n for the SL30 com and nav sides respectively, A6c and A6g for the com and gps respectively, and A7 for the transponder. Hope this helps. Regards, Doug

A What Doug has described is a means by which reference designators are applied to hardware . . .this is a good thing to do because it lets you put a simple label on a component symbol in the wiring diagram to key it to the bill of materials built up in some nice data base program like Excel or Access . . ..If I understand your question correctly, you're asking about identifying wires. You can be as simple or as complicated as you like. I show a technique for putting labels on wires at: http://www.aeroelectric.com/Catalog/wiring/wiring.html#s817c

and http://www.aeroelectric.com/Catalog/wiring/s817c.jpg

Use the smallest font your computer will generate (typically 6pt) on full sheets of Avery label material. The illustration shows some pretty verbose labels. I'll suggest that a simple numbering of each wire segment with a unique number is sufficient. It's not even necessary that you use the numbers in order or that all numbers in any given sequence be used to label a wire. What you're really trying to do is tie individual wires down to a conductor depicted in your wirebook. You can spend a lot of time putting a name on a wire when a simple number ultimately does as good a job. Bob

----

Re: Teflon vs Tefzel Harness

>There's a local surplus store with a small mountain of teflon insulated wire, from 10 gage to 26, randomly available in standard colors and a rainbow of striped (purple with green, red with

yellow, etc,) Also a bunch of shielded multi conductor, sold by the pound. Is Teflon insulation acceptable, or should I hold out for tefzel?

A For stuff that stays behind the panel, Teflon is fine. Tefzel is the material of choice or something similar like Raychem's Spec 55 wire. These are not as high a temperature rating as Teflon but they're tougher. This isn't really an issue behind the panel and it shouldn't be very much of an issue elsewhere. After all, ANY insulation is at risk if a wire is allowed to rest against hard/sharp segments of structure . . . it doesn't matter what insulation you use, every one will eventually wear through and compromise the circuit. We used nothing but Teflon as high temperature lead-wires on all of Electro-Mech's motor products destined for aircraft installations. I think they still use a majority of Teflon having deduced that high temperature characteristics are more important than abrasion and mechanical stress when your supposed to properly support/protect the wires from such stress in the first place. If you can get as good or better deal in Teflon, especially for cockpit wiring that is well protected, I'd go for it. Bob . . .

RE: Tefzel in colors/source

>> Pacific Coast Avionics 2001 Catalog(sales 503-678-6242) lists colored Tefzel wire in 22awg in 10 colors and several years ago, I also got the same assortment in 20awg. Call to see what is in stock. (also some in 18awg.) $14 per 100 in 2001 catalog... 50 ft min per color. My wire was marked MS22759/16/22   12814. Not super low cost but available! >Paul

A Good data point Paul. Thanks!   Bob . . .

Electrical Bus, brass strip

>1. I need a source for the 60A bus - Copper strap.

A You can buy brass strip from a lot of sources like Home Depot, Lowes, Hobby-Lobby, etc. You need some sheet brass 3/8 to ½ inch wide by .05 to 03 thick depending on width. I've cut bus bars out of brass kick-shields for doors that I've purchased from a hardware store. It's not critical.

If you go breakers, make the alternator breaker a 75A device lest you become victim to the same philosophy that fitted tens of thousands of airplanes with breakers designed to nuisance trip.   See:

http://aeroelectric.com/articles/fuseorcb.html

http://aeroelectric.com/articles/fusvsbkr.html
http://aeroelectric.com/articles/neveragain/neveragain.html

Bob . . .

Subject: Re: AeroElectric Connection Wire Chart Question

>In Figures 8-3 and 8-4 of The Aero-Electric Connection, the wire current capacity appears to be for wire in conduit or bundled, but the text on page 8-9 says "single strand in free air." The question comes from comparison with an old chart (Fig 11-7 1988) in AC 43.13 where those (Aero-Electric) currents plot very close to the wire in bundles curve and far from the single wire curve. Is there a contradiction?

A To quote from the repertoire of Dick Martin's retorts on 1968 television, "You bet your sweet bippy". This, ladies and gentlemen, is a good demonstration of how seemingly reasonable but not quite accurate information can become accepted as fact simply because it's been repeated so often or is written down in some book . . .

It's taken me some time to respond to this because I've been digging around looking for the resources I might have used when chapter 8 was crafted about 10 years ago. (I went to the files and discovered that all of the AutoCAD generated figures for that chapter were drawn in AutoCAD v1.17 it was running on a PC-XT and output to a plodding pen plotter!) I remember duplicating Figure 8-4 from some reference but I'm unable to put my hands on it after all this time.

Suffice it to say, the data shown there IS NOT properly displayed or attributed with respect to significance. Just for grins, I took a piece of 22AWG wire, attached a thermocouple to the outside surface and stuck it on a 10A constant current power supply. Guess what? I got a 38 degree C rise. 5A amps 1/2 the current and dissipates 1/4th the power so we would expect something on the order of a 10 degree C rise.

In retrospect, there are other data points that would have raised the question had I been prompted to consider it. For example, EVERY 22AWG wire in heavy-iron birds are driven by a 5A breaker. It's a matter of routine for wires in these airplanes to disappear into large wire bundles of 1-3" in diameter. One could deduce from this fact alone that a 5A temperature rise for 22AWG wire would have to be more on the order of 10 degree C suited for wire bundles as opposed to the 35 degree C value shown in Figure 8-4.

This is an excellent lesson in how good science is practiced. We need to accept questions on ANY offering of "fact" at ANY time and be willing to defend the answer with good numbers and critical thought.

Readers can correct their books for Figure 8-4 by changing the 35C curve to 10C and drawing another line above it with the same slope and crossing intersection of 22AWG and 10Amps. Label the new line 35C. The old 10C line could be relabeled 3C.

Wire table on Page 8-8, next to last column, scratch out "35" and write in "10". There are other references to temperature rise in the text that can be fixed accordingly. Chapter 8 wasn't on the short list of chapters to be worked on last week but it is now. The chapter has been offering bad data for over 10 years but thanks to the inquisitive mind and willingness of Mr. Brick to ask the question, it's going to get fixed. I thank you sir! ....Bob . . .

Re: Wiring supports in the fuselage

Panduit makes some right-angle wire tie anchors for bulkheads and lightening holes. Check out their part numbers RAMH-S6-D and LHMS-S5-D. The anchor is made of Nylon and can be screwed or riveted to the airframe, a much more permanent installation than a self-adhesive anchor. David

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Re: SEC: UNCLASSIFIED - BATTERIES AND FUSES

>The AEC and AC43.13 provide guidance on wire sizing, switch sizing and the maximum breaker or fuse sizes for a given wire size. What is the best way to optimize fuse selection between the boundaries of nuisance trips and max size fuse for the wire. I have been advised that the rule of thumb is to double the Amps of a lamp, and for other devices choose a fuse 25% greater than the load. Is this wise?

A Kinda . . . yes, a fuse/breaker should be sized for some operating headroom but you don't need to double the rating for lamps. Lamp inrush lasts but a few TENS OF MILLIseconds. PITOT HEAT on the other hand draws 2x or more times running current for several seconds . . . you gotta about double the fuse rating to keep it from nuisance tripping. I'd wire pitot heat with 14AWG and 15A . . . everything else can pretty much be a 10-25% overhead.

>Battery question for Bob, Looking at Fig 17-6, Is there a risk that when both battery contactors are made, if one battery is well charged and the other fully discharged, that a huge inrush to the flat battery may occur, overheating it, warping the plates etc?

>

No. Bob . . .

Wire: Swissair and fire

> The situation got worse with more rapidity than the crew anticipated and they blew away get-on-the-ground-quick time with a combination of troubleshooting efforts and other distractions.

This is essentialy the conclusion reached. The extensive use of kapton insulation brought about discovery that (a) time, (b) moisture and (c) vibration caused the insulation to produce tiny cracks. These created the occasional trip of C/Bs over time. The great danger was in the re-saetting of the c/b, fuse, etc (no matter which). With the resurgence of power small but very hot (1200deg) sparks brought the insulation well above its specs and it became explosive. This has been demonstrated to destroy accompanying bundled circuits or to bring other materials to high temperature - in fact a video in the USN labs shows it blowing a steel plate in two.

Re: Questions on last chapter of Aeroelectric Book

>I finished reading the book and have questions on items 2 and 3 from >page 16-16:

Item 2) - you talk about a brass stud in the firewall to connect the negative terminal of the battery to the engine crankcase. Is this for composite airplanes only or metal ones too?

A Metal too . . . but with rear mounted batteries in a metal airplane, you can ground the batteries to structure locally -OR- run a battery ground to the firewall stud.

>Item 3) - You say to run "DC power & control around the left side of the cockpit". My RV3 will have two batteries in back but the trim cable and throttle and mixture quadrant are on the left side. I think I heard somewhere that power wires should not be run on the same side of fuselage as these flight controlcables for some electrical reason???? Even if that is not the case, it would be harder to run the wires and not conflict with the control cables. What do you think?>

A Don't know why anyone would say this. Wires, controls, plumbing and black boxes have lived in close proximity to each other in the confined spaces of airplanes for years. There are mechanical considerations for installation that are observed to prevent interference with each others functions but I can think of no practical reason why one take pains to avoid sharing spaces. Note 3 suggests that power and signal wiring not share spaces for noise-mitigation . . . but failure to observe this is not an automatic guarantee of noise problems either. It's just something easy to do on initial installation that eliminates a hard-to-track-down-and-fix possibility should a noise problem arise later. Bob . . .

Re: terminal strip for fastons

>> Bob - do you sell a terminal strip for fastons? I cant find them on your web site. I think since I will have to make a joint at the wing root this is my choice method. Assuming a joint (which I know you dislike) anything against this?

A How about this? http://aeroelectric.com/articles/wingwire/wingwire.html

Bob . . .

Microphone wiring

>Bob, I've watched your posts on the RV-List, found them informative and helpful. Your AeroElectric Connection book has been very helpful in planning and wiring my RV-6. The bird

flies like a dream, and so far I've been able to keep the smoke in the wires. Thus far, I've not been able to find a good source of information on the care and wiring of nav-com and intercoms. My plane is equipped with an old King KX170B, Microair 720, with a Sigtronics SPA 400 intercom. I have interconnected them with a simple switching arrangement that allows selecting comm1 (King), comm 2, (MicroAir), both (audio only), nav (audio for ident). My problem is, I've describe my circuitry to a good A&P, and I think I've improperly wired the switches for comm selection. I've used a DPDT miniature toggle to switch the Mic audio and Headset audio to either comm1, or comm 2, with a SPST miniature toggle to either connect or remain open across the headset audio switch lugs of the DPDT switch. The configuration works, and communications are clear, according to all reports I've received during the last year. My A&P tells me that I should have also included the transmitter key line in the switch, using a 3PDT switch, so as to key up the proper transmitter. My gut tells me he's right, but now I'm curious to know why the simpler circuit I've used hasn't caused problems during the last year. Many times I've had both radios tuned to the same frequency, and keying the mike has never created the squeal normally associated with two transmitters using the same frequency at the same time. In fact, the radio not selected will receive the information transmitted by the other. I've used a hand-held radio to double check, and can not detect any keying of the transmitter section of the non-selected radio when the PTT switch is keyed, and I know that the transmit key line is connected to both radios directly. What am I missing?

A If you have confirmed that the non-selected transmitter is indeed passive then you're probably okay. I'm at a loss to explain why you are not having problems . . . the standard practice since day one has been to switch both mic-audio and PTT lines for the selected transmitter. The only thing I can think of is that some modern transmitters I've seen don't need the PTT line to make the transfer from receive to transmit. Microphones should break both the PTT and Mic-Audio lines when the PTT button is relaxed. This allows different microphones to share the same input to the transmitter without interfering with each other.

Many modern amateur transmitters sense the microphone power current draw when a microphone is connected to the audio circuit via the PTT switch and use this to deduce the need to transfer from receive to transmit. I suspect that other manufacturers may be doing the same thing - which makes the separate PTT control lead unnecessary for those radios.

Bob . . .

Re: Wiring, Shielded

>> What's the standard practice for shielded wire? One source says both ends of the shield should go to ground. Another source says only one end should be grounded. Who is right? Does it depend on the situation?

A Shields can be used for

(1) breaking the electro-static coupling mode between adjacent wires where it is generally desirable to ground only ONE end of the shield and/or

(2) part of a signal conduction pathway where BOTH ends of the shield may be connected. In the later case, electro-static shielding is available . . . the shield just does double duty.

Installation instructions for the product should be explicit as to how shields are treated in their particular situation. There are no hard and fast rules for shield termination. It's also true that shields are often mis-used and create un-anticipated problems. When in doubt, talk to the designer and/or service rep for the system you're working with . . . and feel free to dump on them a bit if their instructions are found lacking. Bob . . .

>> OK. Thanks. Does it matter which end? This is the rule no matter what is using the shielded wire -- p-leads, avionics, etc? Larry

A Follow the instructions . . .For example, p-leads on our z-drawings are GROUNDED at the engine end . . . the switch end is use to PROVIDE A GROUND for the switch. Here is an example of a case where the shield is connected at both ends but only one end is GROUND. Same kind of thing happens in the installation drawings I published for our Microair transceiver harness . . .shields are connected at both ends, grounded at the radio and provide grounds for mic/headset jacks.

Your 3-conductor shielded strobe wiring should ground the shield at the power supply end . . . and if the strobe head is mounted on an insulated surface, the shield should provide ground for the shell of the head. If the head mounts on a metal surface, then the shield is left unconnected at the strobe head. If the instructions are not clear, let's talk about it here on the list . . . Bob . . .

S Shielded wire, Electronic Ignitions

> Has anybody here actually checked or measured the characteristics of the power supply current for these ignitions? I recently asked Klaus "Is the ignition power cable a significant source of noise?". With the assumption of shielded wire, his response was "Not significant enough to bother your radios and nav system but possibly significant enough to trigger your storm scope. You want to separate their wiring." Further discussion related that several airplanes were flying with Stormscopes, but it took a lot of shielding, including switches and breakers.

A I am skeptical of this. If you have a "noise" of any kind on a wire, it exists all along that wire including things that it connects to. Many folks are belabored of the notion that shielding of a wire is to reduce its ability to behave like an antenna . . . to launch or capture radiated signals. Hence the Stormscope anecdote.

If a device emits a noise potentially harmful to other systems in the airplane . . . the VERY BEST place to deal with it is by filtering off the stimulus AT THE SOURCE . . . i.e. inside the ignition system. If one is aware of such a noise, and then admonishes a customer to shield wires to mitigate effects of the noise, they are at least obligated to suggest FILTERING as well.

Shielding has only very small effects upon signals that have a potential for radiating from a wire. The notion that some noise coming from the ignition system was conducted by the wire from ignition-to-switch-to-circuit-breaker and simply decided to go no further argues with the physics of noise conduction. If one allows a known noise source to escape their product, one can generally count on that noise propagating throughout the system by CONDUCTION wherein shielding components along the route of travel is irrelevant. Bob...

S Shielded Wire Termination

>Bob, I have a question about shielded wire termination, specifically, do you know of any standard regarding how far to strip back the shielding? I thought it was 3" max, but have been told 6" is OK... I have been in the avionics business for many years, but have had trouble finding anything considered a "standard". Collins install practices says 3" while a NASA doc I found says 4". There is nothing in 43.13... Thanks for your trouble.

A The major benefit of shielding is to break the capacitive coupling mode between adjacent wires where fast rising and/or high voltage antagonists exist. The act of exposing 3-6" per conductor at the connectors is a trivial degradation of the shielding effect. Develop a "standard" that works for you . . . it wil be fine. Bob . . .

S Shielded wire at the wing root

> Bob - I connect this shielded strobe wiring issue to the 'Wiring at the wing root' one. I fully understand your concerns over introducing 3 new joints in each wire but some folk like Rob Houseman with his trailerable aircraft must. In order to reduce the number of joints is it acceptable and effective to ground the strobe cable shield at the wing tip and the power supply, but NOT take the shield connection through the wing root junction?

A That's a tough one to answer because "effectiveness" is a function of measurements and/or studies by folks who know a lot more about it than I do. Give it a try . . . the worst thing that happens is you have a noise issue to resolve later . . . these are generally no big deal. If it works, you're home free.

> Also in an aircraft with a glass tip on a metal structure IF grounding at the tip, is there any need to shield the last 12" of wire into the glass tip. I am assuming no antenna out there, only lights.

A I presume you're talking about the pigtails with connectors that extend out of the fixtures that are generally not shielded. Wouldn't worry about these being exposed . . .If there are no antennas close by, just stick 'em in and see how it plays. Bob . . .

Re: Wiring; Electrical Noise in aircraft wiring

I have been reading the aeroelectric forum for a few months. I have noticed that a lot of the discussions have to do with the mechanics of wiring aircraft, i.e crimping vs soldering, wire sizes, ring terminals, etc. Also, there is a lot of discussion about circuit protection, redundency, reliability, spike suppression, etc.

Occasionaly, there are a few questions about electrical noise, i.e., shielding, grounding, ground loops, bypassing, filtering, especially where it involves audio, intercoms, mic wiring, audio switching panels, entertainment. Usually, what starts the discussion is something like "how do I get the alternator whine/strobe squeal out of my headphones?"

The topic of grounding/shielding is often the least understood, and there is a lot of bad advice that is meted out, here and on other forums. I'll go so far as to say that a lot of avionics vendors, and most avionics installers dont really know what they are doing.

I just happened to be poking around at an Intel Microcontroller site, and found the following application note AN-125, which succinctly discusses this topic:

http://www.intel.com/design/auto/mcs96/applnots/21031302.PDF

"Designing Microcontroller Systems for Electrically Noisy Environments".

Read the app note. Study it. There will be a quiz.... Mike Mladejovsky

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Re: Wiring; Too many wires in conduit

>Is it OK to run the same ground wire for the flasher power supply, landing light, and nav light? I plan to run those wires in the same conduit out to the wing tip. Am I going to be able to also run an antenna cable for my nav in the same conduit, or will there be too much noise from the strobe power supply. The power supply is at the wing tip so there won't be hi voltage wires next to the antenna cable.

A run them all together . . .Bob . . .

Re: Wiring; Firewall Bolt

A BTW, 1/4-20 is a tad light for firewall penetrations by fat wires . .. 5/16 is the lightest hardware recommended and it should be brass. Bob . . .

Re: Wiring; cutting heavy gauge wire, contactor diodes, copper alloys

>1) What's the easiest and cleanest way to cut 2 awg wire?

A See http://www.aeroelectric.com/Catalog/tools/hdc-1a.jpg

and http://www.aeroelectric.com/Catalog/tools/hdc-1b.jpg

and http://www.aeroelectric.com/Catalog/BCcatalog.html

>2) What type of diode(s) should be used on battery/starter contactors? I couldn't find any spec on it in the AEC book. I have a 3-terminal battery contactor (ES 24115 from Van's) and a 4-terminal starter contactor (ES 24021). I've checked the archives and found varying info...1N5xxx or 1N4xxx or other?

A The diode needs to be rated for 15v or more and be capable of carrying the same current that it takes to energize the contactor (1 to 5A) for a few milliseconds. About any diode rectifier is electrically suited to the task. 1N400x series are fine but they are rather small, sometimes glass devices that are fragile compared to the 1N540x series devices that are always 1/4" diam plastic and 20AWG leads. If you look at the diodes we supply on the S700 series contactors at

http://www.aeroelectric.com/Catalog/switch/s701-1l.jpg

and http://www.aeroelectric.com/Catalog/switch/s701-2.jpg

. . . you can see how the mechanically more robust 3A diodes lend themselves to the task.

ANY diode you can find will work electrically . . .chose for convenience of application.

>3) Is there a significant difference between copper alloys 101 & 110...specific case being an .062" or .064" x 1/2" connector between contactors.

A I presume you're talking about material for bus bar stock to substitute for short pieces of wire with terminals . . . 1/2" x .064 of any copper alloy including sheet brasses is fine. I prefer brass because it's easier to work with. Copper is soft and tends to snag a drill. Bob . . .

Re: Wiring; Wire and Screw Sizes Tutorial

AWG-American Wire Gage, Also known as the Brown & Sharpe Wire gage not "gauge", and used in the United States since the 1880s when the prairies were no longer black with buffalo, for ductile metal wires. Each wire manufacturer faced the problem of maximizing a wire-drawing diameter reduction while minimizing the wire breakage. "Process" had a lot to do with this, so many made their own gage.

By our enlightened AWG standards, number 0000 wire is 0.4600 inch in diameter. The diameter of each succeeding size, 000, 00, 0, 1, 2 etc. is 0.890525 times the diameter of the previous size. Wires get smaller as the gage number gets bigger since these numbers simply represent the number of the draw. Brown and Sharpe had the edge in this whole mess because THEY made the measuring instrument too. Cool...... So figuring out any size solid wire is simple. For example; solid 18 AWG is ummm....let's see....0.0808 inches. For stranded wire the exercise is left to the student. Eric M. Jones

S >Gage sizes for guns: Gauge represents the number of lead balls of the diameter of the shotgun bore required to weigh one pound. For example, the diameter of the bore of a 12 gauge shotgun is 0.729 inches; 12 lead balls of this diameter weigh one pound. The sole exception to this is the .410 shotgun, which has a diameter of .41 inches (i.e., .41 caliber) and is actually 68 Gauge. It may be spelled gage for wire, but I've always seen it spelled with a u for shotguns.

Re: Wiring; Large wires

> I noticed that I am missing the wire size between the main bus and the battery contactor. I considered 4AWG just to be on the safe side but I was wondering if there was any need to go with wire that big or if I could get away with something smaller. I am trying to build the system around a 40A alternator but with the capability to go to 60A in the future if I decide to.

A The main bus feeder is sized for alternator load. Since the rest of the airplane's fat wires are 4AWG, you've probably already got enough left over to do the main bus feed with 4AWG too . . . which would be fine.

To drive a 60A bus, you can downsize to 6AWG. 8AWG would be fine for a 40A system . . . unless you're going to add electric toe warmers, I cannot imagine that you'd ever need a 60A machine. Bob...

Re: Wiring; bus feed questions

> I've built my RV-7 electrical system pretty much exactly to Figure Z-11. Everything seems to work great with the exception of something that's been nagging me.

> When I feed the e-bus via the alternate (battery) feed, the turn coordinator spins audibly faster than when I'm running everything off the main bus (feeding the e-bus through the D-25 diode). It's not just slightly...it's *noticeably* faster (higher pitch) when powering the e-bus directly off the battery.

A Have you measured the voltage difference between e-bus and main bus? It IS possible that you've wired the diode assembly such that you have TWO diodes in series thus doubling the voltage drop discussed below. Take a peek at: http://aeroelectric.com/Pictures/s401-25.jpg

> NOTE: this is in my garage running off the battery alone (engine/alternator are not running). I have tested this when powering nothing off the main bus, just feeding to the e-bus, so it's not like there's any real additional load on the battery. So my assumptions are:

>1) The battery contactor, which draws 720-750mA according to a current draw test I did before wiring all this up, is making the difference in load?

>2) I have wired the D-25 diode incorrectly. I was more than a little confused about the orientation of the terminals, since mine didn't match up exactly with Bob's Z-11 diagram. Is it possible to wire it so that it places a load on the system?

A How did your diode differ from Z-11? The e-bus will see a drop across the normal feed diode of .6 to .8 volts which WILL let motors run slower, lights burn dimmer and transmitters put out less power. Closing the e-bus alternate feed will bypass the diode and erase the drop . . . but consider this:

During alternator out operations, e-bus devices are expected to provide useful performance over the discharge voltage range of the battery . . . which starts out at about 12.5 and drops to 10.5 when less than 5% of capacity remains. Now, with the alternator running, main bus voltage will be 13.8 to 14.6 volts. Taking off 0.8 volts for e-bus normal feedpath diode drop runs the e-bus at 13.0 to 13.8 volts . . . 0.5 to 1.3 volts higher than the e-bus will see running battery only. Your tests are battery only, this means that the e-bus starts out with 12.5 - 0.8 or about 11.7 volts when powered through the normal feed path . . .Bottom line is that what you have observed is predictable, understandable and not relevant to how the system operates in the air. Bob . . .

> Have you measured the voltage difference between e-bus and main bus?

The drop is .79 volts.

> It IS possible that you've wired the diode assembly such that you have TWO diodes in series thus doubling the voltage drop discussed below. Take a peek at: http://aeroelectric.com/Pictures/s401-25.jpg

Ah, interesting. I did connect the main bus to a different terminal (the lower left terminal in that photo), as you can see here: http://www.rvproject.com/images/diode_wiring.jpg

> How did your diode differ from Z-11?

I was confused by Z-11 because in the iso view of the diode, it's very clear which terminals are (+), (-) and (wave) (whatever the wave is supposed to mean, I have no idea). The issue I had is that in the actual wiring diagram, it's totally unclear to me *which* of the two (wave) terminals the main bus should connect to. You might want to clarify that to help people in the future, just a suggestion...because unless I missed something it's ambiguous and there are two choices. I chose the "other" one.

Now looking at the jpeg you posted above, I see exactly how you did it. But tell me this...does it matter which (wave) terminal the main bus is connected to, or are they both internally connected? Judging by the diode symbol on the diagram it looks like either one would work fine? (Dan

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Subject: Re: Wire size confusion

>Bob, In my Europa kitplane I have Whelen A600 wingtip strobe and position lights. Due to limited space for the wires in the wings, I'd like to use one single wire in each wing as negative lead for both the strobe and the position lights. The wiring will be such that strobes may be on without the position lights, but the position lights may not be on without the strobes. Is there a problem with this single negative lead system? >Alfred

A Don't do this. The "ground" wire for strobes is carried inside the shielded wire that runs from power supply to strobe tube head. This should be totally independent of any other grounds to other devices. There should ALWAYS be room for the necessary wires and sharing grounds between systems injects single points of failure for all systems sharing the wire.

Bob . . .

Re: Wiring; Suitability of a computer serial mouse wiring harness for aircraft use

Hey Charlie, Check out gary Newsteads site. He did the very same thing. You can check with him for the details

http://www.jlc.net/~fcs/images/avionics/e_aileronsrvo.jpg

http://www.jlc.net/~fcs/images/avionics/e_srvoleads.jpg

http://www.jlc.net/~fcs/images/avionics/e_srvobrkt2.jpg

http://www.jlc.net/~fcs/images/avionics/e_srvobrkt2.jpg

http://www.jlc.net/~fcs/images/avionics/e_srvorouting.jpg

Charlie Kuss wrote:

>Listers, I was pondering how to wire my Ray Allen stick grips today. While rummaging around my odds and ends box, I came across a wiring harness for a computer mouse. Specifically, this mouse is designed to connect to a serial port on a PC style computer. The harness has a very nice 9 pin D-sub female connector and back shell attached. It's wires are rather small gauge but are color coded. The harness does have a nice outer sheath protecting the harness. Best of all, the entire harness is quite thin.

> Does anyone know what gauge wire is used in these devices? I don't have any strippers that go down that small. If the wire gauge is sufficient, I'd like to try using this item to extend the wires from my stick grip out of the control stick. Any suggestions (pro or con) will be appreciated. Charlie Kuss

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Re: Wiring: Copper strap vs. cable for short runs

> I'm putting together a compact little assembly that will contain both the battery and starter contactors as well as the shunt and current limiter. These are mounted together on a panel approximately 3.5 by 7.5 inches, so they are very close together. The problem is, they're so close together that making cables is a problem. I have some eighth inch thick by half inch copper I could make connections with. Is this acceptable? Pros and cons?

A   This is commonly done. In fact, the note codes in Appendix Z drawings suggest the use of "2AWG equivalent strap" between fat terminals of contactors and other items where the runs are short.

S   >Hello Steve, Sounds very robust using 1/8 X 1/2 copper stock. (would make a >very neat job too) What I would look out for is that larger (heavy) components move even when very well secured. Relative motion could break battery posts loose or contactor terminals may break internally. It would be safer to use copper braided conductors to ensure flexible connections that will carry the current you need.

A Battery posts should be wired with the softest practical conductors to reduce stress on lead terminal tabs. We started offering 4AWG build to spec "super flex" battery leads several years ago and B&C still offers them at:
http://www.bandc.biz/cgi-bin/ez-catalog/cat_display.cgi?26X358218

Places where strap is practical would include a cluster of contactors combined with perhaps an ANL limiter and/or ammeter shunts. For example, our drawings show an ANL b-lead current limiter, loadmeter shunt and starter contactor co-located. Copper or brass straps in the contactor- limiter and limiter-shunt gaps is quite practical . . in fact, recommended. 1/8" thick is hard to work with and these straps don't need to be thick. They have a LOT of surface area compared to cross section and don't heat up like wires of equivalent cross section. You can buy brass shapes in hobby shops. The same B&C page I cited above offers 1/2 x .025" brass strips for fabricating bus bars. The same material works fine for jumper straps between large terminals of closely co-located components. If you cut your own straps, 5/8 x .032" might be a better choice but it's not real critical. Bob . . .

S >Try this. It worked very well for a friend and we are going to use it for our short, fat interconnects. Cheers, John

"http://www.conrardyco.com/buss.html

I wanted to show people on the list this product. It is a coated flexible buss bar material. I use it for large power contactors 400 amps +. It is much easier than using wire or bending copper. You cut it to the length you need and drill the hole size that you need. You do not have to use lugs. there part # 505053 is good for a 154 amps. Contact: Erico tel 800-497-4304. I used it to make my contactor panel.

A This stuff is okay but in my opinion, overkill. Brass sheet from the hobby shop is easy to find and reasonably priced. K&S Metals are carried by a half dozen hardware and hobby stores within three miles of my house. Look for this display.
http://www.ksmetals.com/HobbyMerchandisers/metal_center.asp

Bob . . .

Re: Wiring: Cozy questions

>1)I need a firewall ground on both sides of firewall plus a panel ground, right?

A You may not need anything on the firewall. See:
http://www.aeroelectric.com/articles/Appendix_Z_Drawings/z15ak.pdf

Depending on how many things need grounds at the firewall, your rear grounds may be handled by a single brass bolt through the firewall that will ground the firewall sheet and provide a terminal to transition from 2AWG ground wire to a copper-braid bond-strap from firewall to crankcase.

>Shall I connect the two with a nice beefy length of (braided?) cable running down the side of the fuselage, or is a thin cable running up to the panel sufficient (on the grounds that it won't have to take starting currents)?

A Is your battery in the back? If so, it grounds to the brass bolt at the firewall and you take a reasonable feeder ground up front for instrumentation. 6AWG or so is suggested.

>4) The Cozy design calls for the comm antenna coax and the Whelen wingtip strobe cables to run in the same 1" diameter tunnel down the wing. Inevitably, somewhere in the tunnel the cable jackets are going to touch. Am I ensuring strobe noise on my comm or is the cable shielding enough to prevent crosstalk?

A They can happily coexist in same conduit.

>Should I go to additional lengths to separate the two cables? BTW - is the strobe wire pulsed or constant voltage? In other words, which end of the strobe feed wire is the strobe capacitor - power supply end or flashing end?

A It's in the power supply. But the wire from power-supply to strobe is shielded, twisted triple and with very low noise coupling characteristics. Bob . . .

Re: Wiring Diagrams Available

> For those of you with the interest, I posted all the wiring diagrams for my F1 Rocket on my web site today. You can get to them off of the F1 Rocket Project page. You can view them as .PDF files using Adobe Acrobat. Perhaps you'll find them helpful. I don't have them all there yet as I am still undecided on my EFIS and avionics packages.

A Randy, thanks for sharing these with the List . . . you've spent a lot of time putting them together and they're an excellent example of how to document your system. On the standby alternator, you'll need to eliminate the "AUX ON" lamp in series with the BUS feed to SB-1 reglator. Pin 6 is field supply lead for the alternator and should get a hard connection to the bus when the switch is closed.

The other lamp is labeled AUX INOP . . . acttally, this light will illuminate when the aux alternator picks up a load. Normal operations call for both alternator switches to be ON. Aux alternator voltage regulator is set about a volt lower than main alternator set point. When main alternator is doing it's job, aux alternator will simple relax. If the bus voltage sags (due to main alternator failure) the aux alternator will come alive. IF system loads exceed rating of alternator, the light will be flashing. You simply reduce system loads until the light illuminates steady. If the main alternator comes back on line, the aux alternator relaxes again and the light will go out. Bob

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Re: Firewall Penetration

> Bruce, Check out: http://www.epm-avcorp.com/tubeseal.html >Randy F1 Rocket

http://www.epm-avcorp.com/index.html

A Randy, thanks for posting this. I'd forgotten that they finished development of this product and had it up for sale. I've added their web address to my list of manufacturer's data sites. Bob . . .

Firewall Penetration

#1. Don't bother passing a "fat wire" through the firewall. Summitt Racing and many other shops sell a wonderful little insulated stud that is made specifically for that purpose. It's a "bulkhead pass-through", and is a great item. It's a stud surrounded by insulation. The stud is brass and

threaded on both sides, and is the same size stud as the battery studs. Simple, easy and only about $10.00. I know most of my RV building friends are doing the same. That fat #2 wire doesn't like to bend around tight corners. FYI, the ground should just be a similar stud, only bolted through the firewall so that the airframe is grounded also. Try www.summitracing.com. It's part number SUM-G1431.

A Take care lest you put an opening in the firewall that compromises the firewall's protective qualities. The part number referenced above looks like a nylon part that wouldn't last. Bob

S Look at: http://moroso.com/catalog/categorydisplay.asp?catcode=42224 Scroll down to Item #74145

> #2) The wire at Home Depot is most likely plain copper. I don't want to start a war here, but I used good Aviation Tefzel wire throughout my plane. That being said, MANY RV builders are using welding cables with great results. The stuff is very flexible, and easy to use. You have to make your own decision on flammability, and safety of the insulator. Hope this helps!

Cheers, Stein

S There are lots of choices for the penetration itself, I used electrical conduit connectors. The important thing is to have some physical protection to prevent the wire insulation from being cut thru by the stainless firewall and the ability to seal against fumes.

Wiring: Re: Firewall Penetrations

> Stainless steel shields for wire and cable firewall penetrations are readily available (and easy to make) but who sells the asbestos washers and "fire putty" used with them. That "system" is probably significantly safer than the "plastic grommets and high temperature RTV" combination used by many builders but the parts are hard to find. Jack

S Try the following page and search for "fire stop." http://www.mcmaster.com/ John

S The 3M fire barrier caulk (the red stuff) is available at most Home Depot stores in the electrical dept for about $10.00 a tube. This may or may not be what you are looking for but it is the same stuff that's sold by aircraft supply houses for about $25 a tube. You have to look really close to find the stuff as the stores I've visited had it hidden pretty well. The 3M name on the tube is...Fire Barrier CP 25WB+ Caulk. It's latex based. The 3M I.D. # is 98-0400-5379-9. Don't look in the paint section. The only place that I've found it is in electrical section. And, it's usually hidden pretty well. One store had it in the shipping box on the floor level. If you need any more info off the tube drop a note. Bill

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RE: Firewall penetrations . . .

>BOB, I USED THE FOLLOWING AMPHENOL CONNECTORS ON MY ROCKET: MS3102E22-7P (FW BULKHEAD MOUNT RECEPTACLE, ONE #0 GA PIN, BUT ACCOMODATES 2GA ALSO) ABOUT $10, MS3106E22-7S (STARTER CABLE PLUG, ONE #0 GA SOCKET, BUT ACCOMODATES 2GA ALSO) ABOUT $20. THESE ARE SOLDER CUP TERMINATIONS, BUT NO BIG DEAL TO SOLDER WITH THE CORRECT TOOLS.

FOR 4GA WIRE USE MS3102E16-12P FOR THE FW AND MS3106E16-12S FOR THE CABLE. PROBABLY A COUPLE OF DOLLARS CHEAPER FOR EACH THAN THE CONNECTORS ABOVE. I AGREE WITH YOUR ASSESSMENT ABOUT FIRE AND THE PLASTIC FEED THRU. NOT WORTH IT IF YOU BREAK AN EXHAUST STACK OR INJECTOR LINE.

I'D RATHER BE ON THE GROUND WISHING I WAS FLYING, THAN BE FLYING AND WISH I WAS ON THE GROUND. DAN HARMON ROCKET II

A These are certainly better than plastic of any kind but they're die-cast or injection-molded aluminum shells. All of our firewall penetration hardware at RAC is stainless.

Bob . . .

RE: Firewall penetrations . . .

>RAC? Where are you suggesting we get this hardware?

A RAC is Raytheon Aircraft Company . . . the folks who pay most of the bills around here. The connectors suggested below are indeed metal and certainly much better than plastic but they'll only last perhaps a minute or two compared to seconds with plastic.

The firewall penetrations we use on the piston ships at RAC have about a 1" stainless steel tube with a flange that bolts to the firewall. Immediately forward of the firewall, the tube makes a 90-degree bend and continues parallel to the firewall for perhaps 2" and ends with a bead for hose clamp at the end. A piece of fire-sleeve is fitted to the end of the tube. All wires are brought through this fitting. With the final wire in place, the sleeve is stuffed with fire-putty and clamps are added to close the sleeve down around the wires as excess putty extrudes from the sleeve.

This is an excellent barrier to fire that might try to make it into the cockpit via your wire routing. Jack Thurman tested this with "Puff the Magic Dragon" out in Uncle Jack's House of Tortures many years ago. It's relatively inexpensive, easy to fabricate and very accommodating of the need to add or delete wires at a later date. Bob . . .

Re: "Fire Putty"

You can get fire putty from Mcmaster-carr www.mcmaster.com it come in sheets, is cheap and is just what you need. Bill Rounds

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DC Power Supplies

A quick Yahoo search for alternatives to the out of stock Samlex power supply from Radio Shack offered several other sources. This amateur radio supply company has many listed, including two Samlex models. http://www.universal-radio.com/catalog/hamps.html I ordered the Samlex SEC-1223. It came to just under $95 with shipping and should be plenty for bench power. I'm getting ready to dive into panel wiring on my RV-8. Thanks again to Bob and this site. They give a novice like me confidence that I can really do this. Planning dual alt/single batt all-electric panel with B&C light weight starter, L40 and SD-20 alternators and 25 ah RG battery. I'm also using an Aerosport Power 180hp 0-360 with AP fuel injection and one mag/one Lightspeed EI. Firewall mounted battery and swinging either a 3-blade MT or Aerocomposites prop. Ken

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Strobe power supply location

>> I have a single unit Whelen power supply for strobes that I want to locate under the pilot seat aft. Is this a suitable location or will this be a source of noise for antennae, intercom, etc. Dave RV6

A Shouldn't be a problem. Bob . . .

S I'm building a 9A & after checking archives, put the same question to Gus at Vans:

"Don't put the power pack within a couple of feet of the antenna or you are asking for interference, we put it back in the fuse by the bellcrank.The power pack is mounted to a sort of shelf riveted to the F- 907bulkhead and the F-929 rib. A couple of bent flanges stiffen it up. Don't mount it directly to the skin"

Re: Wing Wiring Questions

> Bob, I'm getting ready to run the wires through the wings in my F1 Rocket and I had a couple of questions that I hoped you would be willing to answer. Here is the configuration. I have Sportcraft Antennas in my wingtips along with strobes, position lights, landing lights, and a heated pitot tube midpoint. My questions are:

> 1) Is it okay to run the coax in the tube with the other wires?

A You bet.

>2) Should I run the stobe wires with the others (inside the tube) or should I separate it and run it all by itself?

A they can all run down the same tube.

>3) Is it necessary to run ground wires back to the fuselage (and subsequently back to the ground block) or can I attach the ground wires to the spar? Will I introduce a noise problem by doing so?

A No, ground nav lights, pitot heat and landing lights locally to structure. The strobe fixtures should wire only to the shielded wires that come with the installation kit. I've had some builders ADD a ground wire for the black wire and shield at the fixture end of the strobe lamp feeder that CAUSED problems. Bob .

Re: Diagram Z-14 questions

> Bob, In Figure Z-14, there are 6" or shorter wires recommended between the Battery / Battery Contactor / Battery Bus. Does this mean that the Battery Bus must be a maximum of 12" from the battery? Where are most people mounting their Battery & Bus (in an RV).

A Battery busses should be right next to the battery as should their respective contactors. This is why those leads are flagged as having the shortest practical length.

>In Z-14, The Main battery wire to the Contactor doesn't have the 6" requirement, but the Aux Battery does. Why is this?

A My mistake . . .

>In Z-14, Does the Cross-Feed contactor close automatically when one alternator goes out? If not, can it be made to? Is there any reason not to do that?

A You will have plenty of warning about alternator failure with low voltage warning lights. Depending on where you are at in the flight, you may choose to do nothing but shut down the failed alternator. It's not necessary to close the cross-feed if you are minutes away from a desirable landing.

>If you turn off one alternator, will the Cross-Feed automatically close?

A Not the way it's wired now and leaving it manual gives you no more switches to operate than if you had a single alternator single battery system . . . with an essential bus alternate feed switch.

>Can the Lamp output of the LR-3 module be connected with an LED? Any ramifications?

A I published that drawing in the temp director on the website a couple of weeks ago. I don't know if it got carried over in the server switch.

Just checked and it's gone. Does anyone on the List recall downloading that sketch? It was a hand drawn .jpg file.

>If you turn off (open) the alternator contactor, will the LR-3 Lamp glow?

A it's supposed to.

>I have one 60 amp and one 20 amp B&C alternator using LR-3 regulators. Is the ANL 40 Current Limiter OK for the 20 amp alternator? (your web site only has ANL40 & ANL 60).

A Hmmmm . . . I thought B&C had 30's to go with the SD-20 alternator. I thought that's what they were shipping with the STC'd kits.

>What is an "mov"? Where do I get them?

A Those turned out to be a not so hot idea. Use diodes as described in http://www.aeroelectric.com/articles/spikecatcher.pdf

>Comparing the Lancair schematic & the Figure Z-14 Schematic, why the difference in the CrossFeed Contactor setup? One uses an "mov" with diodes & the other has a different setup

of diodes. What is the functionality of this? Or are they functionally the same?

A The Lancair schematic is an old drawing and may still have an error in the diode interconnection on the cross-feed contactor that was corrected with Figure Z-14.

>Z-14 doesn't have the LR-3 ptt circuit connected (where the Lancair diagram does). Why? (If LED is used, is a ptt not required?)

A PTT is used to actively test the ov trip system. The installation instructions with the LR3 should speak to testing this perhaps once a year or at every oil change but NOT by installation of a switch for the purposes of testing each pre-flight.

I'd mount push buttons easy to access from the pilot's seat but not necessarily on the panel. If your LR-3 is accessible during routine maintenance, you can leave the buttons out and just install a temporary jumper wire to do the periodic but infrequent active tests.

>In reviewing the Lancair schematic, can a diode be used instead of lamps for all annunciation purposes? What is the schematic you would use in place of the one drawn (or is it the same)?

A sure. LEDs need to have a series resistor added to set their operating current. See http://www.aeroelectric.com/articles/leds3.pdf Also see http://www.aeroelectric.com/articles/lvwarn/LVWarn-ABMM.html for some alternative mounting suggestions for LEDs Bob . . .

Re: wire sizes for ES

> Knowing that I am building a Lancair ES, do I have to double the length to find the right gauge wire since I have to run a ground wire?

A I think I understand your question. Yes, when considering VOLTAGE DROP for the device you are powering, you need to account for the total length of wire used to power the device which is generally about 2x the length of wire used in a metal airplane where the device might take advantage of a local ground. Bob..

RE: Wiring Stick connections.

>I was planning to put a) the trim, b) PTT, c) Navaid quick disconnect (power to the servo) through the stick. (Not sure what this might be drawing - 2 or 3 amps max.?)

A Use a relay to carry power and use stick grip switches to control relay.

>d) This results in about 7 wires (from memory) I could use a heavier gauge wire but it might be very hard to get it all in, and also I worry it would put 'friction' in the stick movement.

A Stay with the small wire.

>So my questions are: 1) Would you consider using these fine wires in such an application just up and down the stick to a barrier block near by? (Then thicker wire as you discussed.)

A I wouldn't use barrier strips (threaded fasteners . . . UGH!). A d-sub connector would be a good way to make the transition from tiny-wires to handy-wires, something like http://www.aeroelectric.com/articles/macservo/macservo.html

In the next to the last image, tiny-wires are running out to the servo, handy-wires run to the rest of the system. In this case, tiny-wires might run up your control stick, handy-wires run from an UN-modified d-sub mounted to a bracket near lower end of the control stick.

>2) Do you feel a relay to break the Navaid supply is essential?

A yes

>3) What is the best way to get the wires 'off' the stick. I have seen two approaches: a) Making the longest loop possible and let it hang down as far as possible and then over to a grommet (ensuring full stick movement.) b) Take it first onto spanwise tube connecting the two sticks using just enough wire to allow for full aileron movement and then from as close to the rotation point of that tube onto the structure this time allowing for elevator movement. It seems the endless movement of these wires must be a weakness in any aircraft and I want them to be 'happy' but I do not want to feel that they are there!

A Even if you made these wires 22AWG, you wouldn't "feel" them. The mechanical advantage of stick length above the pivot versus length below the pivot will prevent this. A bigger wire is not less prone to flex-failure . . . rather the opposite is true. See chapter on wire.

At Cessna, about 1968, we did some studies in the experimental shop to show suitability of certain wires to take trim and PTT lines off the control yoke tube onto some point on the airframe. Taking a cue from what we knew about the relative robustness of welding cable with respect to flexing (a bizillion strands of copper cat hair) we looked around for handy-wire with similar characteristics. I seem to recall the lucky supplier was a product called "Spectra Strip" (now part of Amphenol but don't recall if they were back then) had a ribbon cable with exceedingly fine stranding. Seems each conductor was 105 strands of very fine wire used to make up a 26AWG conductor . . . small but still usable. We put tiny PIDG terminals on each strand and tied them off on miniature barrier strips. We set up a test to exercise a control yoke mockup over full cycles of pitch and roll for over a million cycles with no evidence that the wire had degraded in any way.

Now, what does this mean for the average OBAM aircraft builder? Not much I suspect. If you use ordinary 22AWG aircraft wire (19-strand) and make your transition from the stick to airframe with a generous radius (6") and attention to support so that the slack doesn't rub the airframe, I sincerely doubt that you'll experience any difficulties with this wire over the time you own the airplane . . . and let's suppose it DOES break a strand in, say the next ten years . . . how big a deal is it to diagnose and refurbish for another ten-years of service? I think I'd use 22AWG and if possible try to make the transition from moving controls to airframe in a way that tends to twist/untwist a bundle as opposed to flexing it. I'd also try to take as much advantage as possible of machined-pin, d-subs for interconnection but whatever you decided to do, don't spend much time worrying about it. Bob . . .

Re: Suggested wiring circuits.

> Bob, Why have the voltmeter reading voltage from the essential bus after the diode rather than from the battery bus? Thanks as always for enlightenment.

A Depending on your meter, it may draw some small but significant amount of power that would run the battery down if fed from the battery bus. If one want's to steer around doing the mental math of adding diode drop to the reading to know bus voltage, just flip the e-bus alternate feed switch on for a moment. Bob

----

Re: Z Diagrams

>I have a question about differences between wiring diagrams Z 11 and Z 13. One has a fuselink and the 5 A field circuit breaker between the main bus and the master switch. The other has the circuit breaker downstream of the master switch. Does it make any difference one way or the other?

A both figures suggest extending the bus via a vulnerable wire up to the alternator control switch. BOTH systems suggest a 5A breaker in this power lead to accommodate the modus-operandi of crowbar ov protection. Exact location of breaker along the route is not terribly important as long as wires leading up to the breaker are not at risk. Risk is mitigated with the fusible link at the bus. Fusible links are preferred to fuses because they have a very long time constant compared to fuses and breakers . . . so that if the crowbar system operates, only the breaker will open.

>Also, I'm planning a small 4 to 5 A. H. battery to back up my #2 electronic ignition. I will probably locate it somewhere near the instrument panel. Would there be a problem grounding it on the firewall ground, when the main battery is grounded locally in the rear fuselage?

A Ground it to the single point ground on the firewall.

>And the last awe inspiring question of the day is, since there will be a large number of ground wires coming off the back of the instrument panel, does it make sense to combine them all with a multiple tab ground and just run one wire to the firewall ground, to reduce the size of the wire bundle?

A No. Every system should have its own ground wire to the single point ground bus . . . else the single point ground is no longer a single point ground. Bob . . .

Re: Z-Diagrams; Z-12

>Bob, I am building an all-electric RV-6A and currently planning on a dual alternator, single battery electrical system (a-la Z-12), with a D25 Diode assy providing E-Buss primary feed...fuses - not breakers. For overvoltage protection, a crow-bar (OVM-14) driving a B-lead contactor (S701-1)...or do I really need two sets - one for each alternator? I don't really understand how it works - looks like it (OVM-14) would short the circuit that normally provides power to the S-701 (easiest path) causing the S-701 to open....yes/no? Although it looks like the LR-3/SB-1 alternator controllers would be one-stop shopping providing OV protection too?!

A First, note that Z-12 is shown set up with breakers. If you go the fuseblock route, you need to treat your alternator field supply circuit like that shown in Figure Z-11 where there is a fusible link coming off the bus to supply field power to the alternator control switch. This path continues on through a 5A breaker mandated for the crowbar ov protection . . . The second alternator would have its own fusible link and field supply circuit as the first alternator. OV protection is built into the regulators B&C makes. You would not need to add an OVM-14.

>I would prefer the autoswitching as described on pg 17-12. Are these mutually exclusive? OV protection is more critical to me than autoswitching if I have to make a choice - I'm open to education though.....

A Autoswitching happens because the standby alternator is set to regulate at 0.5 to 1.0 volts BELOW normal bus voltage. Normal operation is for both alternator switches to be ON all the time. Should the main alternator fail, bus voltage sags and the #2 regulator brings the #2 alternator on line to support ship's loads. The Alternator Load/Overload light will flash until you reduce ship's load to or below 20A.

>I hope that I've conveyed my intended direction...please validate or provide education.

A All the hardware you need is currently available. Figure Z-12 is most often applied to airplanes that already have breaker panels. You can certainly apply it to a new airplane with fuseblocks provided that you make the small changes described above to add fusible links and alternator field breakers. Bob . . .

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25 Misc

Re: Lighting; Landing/taxi light warm up

>I read somewhere about some sort of resistor that could be used in light circuits to protect incandescent lamps when they were switched on. It would initially have high resistance which would drop quickly when warmed by current flow. The ramp-up to full brightness would not be so slow as to be bothersome but would offer some protection to the lamp's cold filament. Is anyone familiar with this resistor and is it worth the effort to incorporate them into an OBAM electrical system? >Jay Ferguson

See inrush current limiters at

http://dkc3.digikey.com/PDF/T031/0731.pdf

I incorporated one of these into the taxi light on the GP-180 at lear about 20 years ago. I'm unaware of any more applications since. If you're using $high$ "aircraft" lamps, they might be worth the trouble. Use low automotive or industrial halogen lamps and you'll get many times the life without the inrush limiters and far less cost. Bob . . .

S > I guess the only real benefit then would be the longer lasting light bulbs for standard relays and switches. It still seems they would be warranted for the new solid state relays, which is why Eric suggested them, and mainly why I am using them. If you don't think they are warranted for this application, by all means let me know....one part to remove and one less thing to fail.

Life IS a real issue with aviation lamps which tend to be old technology, relatively short lived and expensive when compared to modern automotive and commercial halogen lamps. If it were my airplane and I could live with a leading edge installation, I'd work really hard to get this lamp installed in my leading edges:

http://aeroelectric.com/temp/4352.JPG

It's short, halogen, dual filament and 55w. One of these critters on each wing gives you hi-landing/lo-taxi lighting and four (count 'em) FOUR filaments putting light out the front. Given that these run for YEARS on automobiles without pre-warming or inrush limiting, they should last the lifetime of most airplanes. Bob...

Re: Lighting; How to dim multiple annunciator lights?

> I've started pondering how to control the intensity of several annunciator lights, but I haven't come up with a solution that I like yet. I figure I can't be the first builder with this problem, so there must be several good ideas I haven't thought of yet. I've got four LED annunciators that I need to deal with. All will be unlit most of the time, but they could be illuminated for long periods if they are annunciating a system failure. All of them are driven by a 12V signal when they are in the ON state. I.e 12V = ON, 0V = OFF.

A   Okay, this means that they all share a common ground. To apply equal dimming to the entire array, select a zener diode (1-watt 1N4700 series is fine) that provides the right voltage drop for the dim position. Put this zener in series with the ground for all lamps. Put a bright/dim toggle switch in parallel with the zener. Close the switch for max-bright operation, open for dimmmed operation.

See: http://aeroelectric.com/temp/annun_dim.gif

Bob . . .

Re: Electronics; Course Materials

A   From time to time I've been asked to recommend some texts for electronics neophytes. I taught for a time at Great Lakes. I was impressed with the quality of Navy electronics schools and really enjoyed my tenure there . . . now if it had just paid enough to survive on.

None the less, I've discovered that the Navy has keep up the good work on instructional materials for electronics and other courses. If any of you would like to have your own personal copies of an excellent set of texts . . . right-click on the following series of links and tell your browser where to store these files on your hard drive. Start with the first one and happy learning . . .

https://www.advancement.cnet.navy.mil/products/web-pdf/tramans/fullbook/14173.pdf

through
https://www.advancement.cnet.navy.mil/products/web-pdf/tramans/fullbook/14196.pdf

I may add these to my CD_Rom offering as well.   Bob . . .

Re: Misc; Windows viewable sketches

Just about any cad software can open a dxf file for editing, and those same programs can save to that "universal" drawing file format. If your intent is simply to permit others to view your drawings (as opposed to editing them) AutoCad will do the job. Use the help function and the search term "raster file plotter" to find out how to save an AutoCad file as a graphic. The first paragraph in the help window (in AutoCad 2000) is . ."Plotting to Raster File Formats

The nonsystem raster driver supports several raster file formats, including Windows BMP, CALS, TIFF, PNG, TGA, PCX, and JPEG. The raster driver is most commonly used to plot to files for desktop publishing. " . . . . with further detail to follow. Most of these file types can be opened in Paint.

Another scheme that will permit anyone to view your drawings by using the free Adobe Acrobat Reader is for you to use FinePrint to save the file in Adobe Acrobat's pdf format. Go to www.fineprint.com and download the free version of that program. Best regards, Rob Housman

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Re: Electronics; Prefixes

10nF mylar cap.

> 10nF = .01uF. Radio Shack has them. nano-Farad is a relatively recent term. You won't find in in most catalogs (e.g. Digikey).

1 nano farad is still often written as 0.001 uF

1000 pico Farad (pF) = 1 nano Farad (nF)

1000 nano Farad (nF) = 1 micro Farad (uF aka mFd)

1,000,000 microFarad (uF) = 1 Farad

milliFarad is not used. Or at least I've never (in 50 years) seen it. regards, -john-

A "nano" is 10 to the minus 9th exponent. In the US manufacturers and designers have largely ignored this multiplier preferring to use "micro" (10 to the minus 6) and "pico" (10 to the minus 12) multipliers.

Electronics diagrams from other parts of the world have taken advantage of the intermediate nano multiplier ever since I can remember . . .

1 nF is 1000 pF and .001 mF

So the 10 nF capacitor callout can also be written as .01 mF or 10,000 pF . . . and Radio Shack has had them since day-one. Bob . . .

S Minor nit, Bob.

1nf is 1000pF or 0.001uF (the lower case m is reserved for milli, while lower case u is used for micro) MikeM

Re: Electronics; V=IR problem

>I have an 8 day clock that wants 5V for the internal light. I have a 12v airplane. I know if measure the clock's resistance with an ohm meter I can figure out how big a resistor to put in line with it. Can someone walk me through the equation?

A Light bulbs have a very steep positive temperature coefficient of resistance. The resistance reading you'll get with an ohmmeter will be much lower than actual operating resistance.

You need to attach the clock to a 5v power supply and measure the current with the lamp operating. Then subtract 5v from 14v to get the resistor drop. Your formula is R=E/I so divide the voltage drop by measured current to yield appropriate size resistor. Bob . . .

S V=IR is the start

You want 5 volts across the clock, so measure its resistance. Now you know Vclock and Rclock, so calculate Iclock from equation. Say Rclock is 5ohms, the Iclock would be 1A. Now we know the current through the circuit needs to be 1 Amp, and we need to drop 12-5=7 volts across the other resistor. So, Vres is 7 volts, Iclock=Iresistor=1A, so again, using the equation we can find the R value you need is 7ohms. Size your resistor power by P=I 2 * R, so 1*1*7, or 7watts in the case. Oversize it by a factor of about 2 I'd say to be safe.

Also, you might want to consider 14.4 volts in these calcs instead of 12, depending on how you set up your electrical system.

These are all hypothetical, but should help you get it figured out. Basically, sum of all current in and out of a node is zero, and sum of all voltages around a loop is also zero. Hopefully you can see these laws at work in the above example. Another way would be to just use a small 7805 5v voltage regulator that takes 12 in and would put out enough 5V to run your clock.

S Actually, I've found it difficult to reliably measure the resistance of a lamp directly with an ohmmeter - if it's LED, you won't get a meaningful answer, and if it's incandescent, the cold resistance is different from the hot (lighted) resistance. Also, if there's any electronics in it at all (apparently not, by "8-day clock" I take it to mean it's mechanical, only the light needs electrical), I would not depend solely on a dropping resistor anyway, I'd want a 5.1v Zener in there too.

But, given a mechanical clock, I'd simply first find the current it uses at 5 volts (use a milliammeter and 4 NiCads or NiMHs), then divide that into 9 (14-volt supply - 5-volt desired = 9-volt drop)... Example: let's say you find it uses 50 milliamps (.05A) - you want to drop 9 volts so that would be 9/.05 or 180 ohms. Wattage is I*I*R, or 1/20*1/20*180 in this case... about 1/2 watt so make it a 1-watt resistor and make sure it has a bit of room to breathe. Maybe it would just be better to swap the 5-volt for a 12-volt lamp if possible? -John R.

S Good Evening Richard, I am definitely one of those electrically challenged types, but I have used Zeners for dimming purposes. What is so nice about a Zener is that it drops the voltage to the required voltage regardless of what the load is. I guess I should say; as long as the load is within the capacity of the zener.

The first time I used one was to dim a set of four GPS annunciator lights. Since they were sometimes all on at the same time and other times only one or two were on, a resistor wouldn't work. The zener did the job perfectly. I think it is all just magic! Surely, some of the folks on this list will explain it much better than I can. Happy Skies, Old Bob

S > Bob, that's indeed a great way to independently dim a set of lamps, independent of load... but I think Richard has the opposite requirement - a fixed load that he wants to dependently dim with the master dimmer. A zener won't work for that. -John R.

A A zener has a relatively constant voltage drop. So, Consider a 5v lamp in series with a 9v resistor to run full bright from a 14v supply. At 14v, all lamps will be max bright. Reducing dimming supply voltage by say, 2 volts, will drop the supply to 14v string by (2/14)*100 or 14%. Voltage on the 5v string will go down by 2v as well. (2/5)*100 is 40%. Reducing dimming supply still further to say 9V will have the 14v string about half-bright, the 5v string will be dark. Bob . . .-------

Re: Electronics; courses on aerolearn.com

> Drew- Some of Bob's Aeroconnection courses are available on Aerolearn.com, along with a variety of other electrical and electronic subjects. All courses on Aerolearn are free, and are primarily of interest to Aircraft Maintenance Technicians. You have to register to access the site.

> Mike Rice > Aerolearn.com

Re: Electronics; Learning

>Two of Ten Things to Know about Learning Electronics:

>

>1) Subscribe to an electronics magazine. Buy Forrest Mims' "Engineer's Notebook at your local Radio Shack (The only book you will need for a long time). ---he's online too.

A This is an excellent text. Also look though the used book stores on 'net for anything by Thomas A. Floyd. In particular Electric Circuits Fundamentals (any edition) Excellent teaching style, expensive new ($105) but I've found copies on 'net for under $20.

2) Albert Einstein taught: If you are not interested in something you really can't learn it. Education usually consists of fooling oneself into being interested. This is itself a learned art and usually involves solving some puzzle that you yourself have created.

A The very best are passionate about their craft. Too many graduate from college with the notion that because they regurgitated facts with sufficient accuracy to acquire a diploma, they're going on to be successful . . . doesn't work that way . ..

Re: Misc; Backup Electrical Power

>> I have an idea for a backup electrical system for my RV-7...it involves having about 934 lemons onboard...

http://www.checkoway.com/lemon_battery.html

>What do you think?

Re: Electronics; The book I wish I'd written . . .

A I've been looking for some texts to support an educational activity with some family young folks who have expressed an interest in electronics. I ran across a really nice piece of work in my father-in-law's library and did some Internet research to check availability of more copies. Turns out, Mr. Thomas Floyd has done a lot of books with many current publications offered at over $100 each. The used book market is well stocked with latest and earlier editions for as little as $4.

A few weeks ago, there was some discussion about recommended readings in electronics. I'm prepared to enthusiastically recommend "Electronics Fundamentals - Circuits, Device and Applications" by T.L. Floyd . . . I picked up a second edition for $6. The writing style is excellent but the illustrations are superb. For the price, why not check this one out? Bob . . .

S I have Thomas L. Floyd's Digital Fundamentals and it is pretty good. It is easy to see he cares greatly about teaching the subject. Maybe even better--see Horowitz and Hill's The Art of Electronics. I want to strongly recommend Paul G. Hewitt's "Conceptual Physics" (and its many versions) as a good basis for an electronics education. Physics is fundamental to all science. This is one of those books you can't put down. Paul G. Hewitt is online and answers his emails.

Bob--write your own electronics book. We know you have a lot of free time! Regards, Eric Jones

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Re: Electronics;   aerolearn.com

> This is an outstanding aviation maintenance training resource

I'm glad you like Aerolearn.com, spread the word- it is still free to users.

Mike Rice

Chief Administrative Officer

Northrop Rice Aviation Institute of Technology

1155 W. Arbor Vitae, Suite 115

Inglewood, CA 90301

Phone 310 568-4973

Fax: 310 568-8542

Re: Misc: Cool schematic CAD program

> Just this past week, I downloaded TurboCAD LE, which is free. I've found it easy to use and fully compatable with AutoCAD files. In about 4 hours, I built templates for all the electrical symbols on Bob's drawings and I'm in the process of putting together the wire book for my F1 Rocket. At some point, I'll have these posted on my web site. Randy #95 F1 Rocket http://mywebpages.home.comcast.net/

> By the way, Bob, I was the guy that walked up to you at Sullivan and asked if you knew of any free schematic drawing programs. I had IntelliCAD from your CDROM and had tried to use it to draw up a schematic of my aircraft system by modifying one of your Z diagrams. I never did like it very much as it was not intuitive and had a long learning curve. So I have been on a quest for a better CAD program for schematics ever since. I've looked at 3 or 4 different free or "very cheap" programs and never was impressed with any of them. >

> But last week I found a really sweet program that immediately became my favorite. It's called DesignWorks Lite, and can be downloaded from http://www.designworks4.com with a fully functional version. The program is $39.95 if you register it. (By the way, I have utterly no financial interest in the program.. I just like it!) I tried it and was immediately productive, without reading any help screens or manuals.

S Go to Tucows.com and see their giant list of CAD stuff. (The freeware FreeCAD 8.2 looks good if you want to study mechanical linkages.) Also check .... http://www.freecad.com/ lots of free stuff for CAD.

My favorite is still DesignCad....if only for the reason when you call their free tech support you get fast tech help instantly. The line is never busy because the program is so easy to use. It's very much like AutoCAD but $3000 cheaper. It does 2D or 3D at the push of a button. Cool............... Regards, Eric M. Jones

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Servos

I took a look inside my Ray Allen T4-5 servo that is smaller than you want, but it just has a gear that screws on a brass threaded rod. I think just a small amount of innovation could give you a length of rod what you would like, you would need to install end stops.

Other ideas take a look at model sailboat servos, also model plane landing gear servos for huge scale, look at Hitec RCDs site:

http://www.hitecrcd.com/product_fs.htm

Take a look at servo city, especial sprockets and gears:

http://www.servocity.com/ServoCity/Products/Sprockets__Gears__Chain/sprockets__gears__chain.html

and gearboxes

http://www.servocity.com/ServoCity/Products/Servo_Power_Gearboxes/servo_power_gearboxes.html

fool around at both sites, you may find something you could use Winding a cable or chain, either like a copier or garage door opener? You could check out one of my favorite companies of all time mcmaster carr

www.mcmaster.com

They sell to public with a credit card. open 24 hours a day. Check out Inline electromechanical Actuators, electromechanical actuators, Often if you see something close, it can put you on track. you can get quotes from McMaster on stuff you want. For instance if they offer the exact you are looking for, but in 24 volts, ask for a quote on a 12 volt unit. Often the quote will come back with MFGs name, so you can further investigate. Good Luck Ron Parigoris

S Check out Electrak linear actuators http://www.powerdrives.com/electrak/

I used one of these for my airbrake actuator. Used to be made by Warner Electric but seem to be sold by Danaher now. Electrak 1 go up to 75 pounds. Eletrak 2 go to 250 pounds. I have an Electrak 1 S12-17A8-02 (12V, 4" throw, 75 pound load) that I don't need if you're interested. Dave

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Misc: CAD

> Of the 3 CAD programs on the CD, which is best for printing and which is best if you want to modify? Thanks Matthew M. Jurotich

A I prefer Autocad. You'll need to generate install disks. Have 4 floppies handy and call the "makeset.bat" file. Insert disks as they are called for. Then start with #1 to do a pristine install of LT 1.0 for Windows. It will flawlessly open all the .dwg files I publish, edit and print them. Bob .

Re Joysticks

> Joysticks have gotten a design boost by the interest in computer flight games. About three years ago I started to speculate whether or not computer joysticks could be used instead of the "real kind". Now some of the make-believe kind are almost certainly better than the "real kind". See this for good reason to make a trip to Best Buy today:

http://www.saitekusa.com/usa/prod/cyborg_gold.htm (or many other Saitek

joysticks...but I have my heart set on these beauties!)

Several months ago Thrustmaster (PC game joysticks) introduced a metal, extremely high quality copy of the F-16 HOTAS system for $799.00. You can now buy them for FIVE HUNDRED DOLLARS CHEAPER! In perusing the industrial joysticks I now see more and more "Rugged ABS construction". You really have to believe plastic is a better choice for a joystick anyway (or wood). The very least one should do to the Ray Allen stick and others is to use environmentally-sealed gold contact switches. Watch the current ratings too. Regarding the Ray Allen MAC8--please see my write-up on this device.

www.periheliondesign.com/mac8trim.zip

Regards, Eric M. Jones www.PerihelionDesign.com

Re: Electronics

Here is a chart that lists the dielectric strengths of various common materials. Note that vacuum is one of the lowest (worst) dielectric strengths.

Regards, Matt- N34RD

Dielectric strengths for insulators

Dielectric strength in kilovolts per inch (kV/in):

Material* Dielectric strength

==

Vacuum --------------------- 20

Air ------------------------ 20 to 75

Porcelain ------------------ 40 to 200

Paraffin Wax --------------- 200 to 300

Transformer Oil ------------ 400

Bakelite ------------------- 300 to 550

Rubber --------------------- 450 to 700

Shellac -------------------- 900

Paper ---------------------- 1250

Teflon --------------------- 1500

Glass ---------------------- 2000 to 3000

Mica ----------------------- 5000

Re: Electronics: How do I solder

> Off topic, long and rambling with social commentary..

>I have a toy for my 9 year old boy.. it's a kit, with a PCB, and a another PCB that solders to it. They both have tabs with silver contacts on them,

S You can solder a hundred years and not discover the difference between 60% tin-40% lead and 63% tin-37% lead solders. Most sources give the melting points and that's that. But the real difference in tin-lead solders is far more subtle: 60-40 solder has a small "mushy" temperature range. 63-37 goes from solid to liquid with no mushy range at all (That's called eutectic). The smaller the tin (first digit) the greater the mushy range. This is important if there are gaps to bridge, and there always are.

When soldering sheetmetal or stained glass for example, you really want a large range of mushy so you can stick a whole mess of solder onto the part to fill gaps, so you might use 50-50, which has a liquid temperature of 461F (maybe it's time for a propane torch) and a mushy range of 56F. Why is 63-37 so common? It is shiny and pretty when it solidifies. This makes assemblers proud. It is also great for solder plating PCBs for example. The 60-40 solder solidifies like a wax--first the lead solidifies, then a second later the tin solidifies. This leaves a hazy, frosted surface.

You can also remember:

1) Tin melts at a lower temperature than lead, improves wetability, costs more, and is more flexible.

2) Lead melts at a much higher temperature, is poisonous, costs very little, is stronger but easier to fatigue crack.

3) There is a great difference between solders of the same kind. Ersin is very good, Alpha Metals has found its way into my junk box.

Dave--use 60-40. Regards, Eric M. Jones
