Circuit Protection

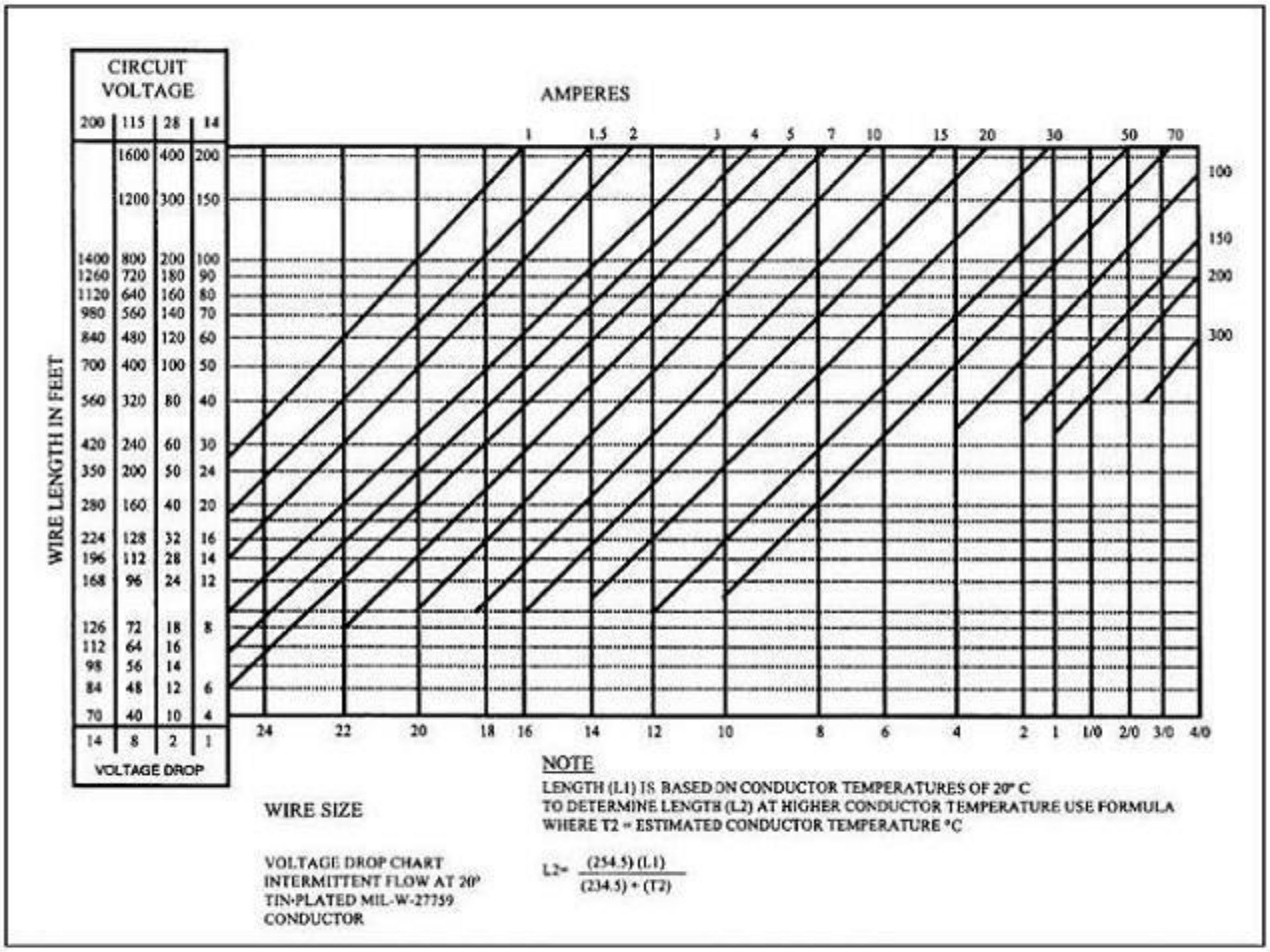
I'll start here by commenting on what others have said time and again. You should primarily protect your aircraft and it's components by protecting the wires with some sort of circuit breaker. IOW, you fuse for the wires, not for the component. The idea is to keep the smoke and sparks inside the wires, and cut off the likelihood for trouble before there's a chance to fry a component or the pilot. Electrical components are rated for a certain amperage load, and usually have a lower operating amperage range . Once you know those numbers, you can choose the proper wire gauge (although most manufacturers tell you what to do) and then determine what sized circuit protector to use to keep the smoke in the wires and the electrons flowing to your widgets.

Wire AN Gauge Copper	**Circuit Breaker amps**	**Fuse amps**
22	5	5
20	7.5	5
18	10	10
16	15	10
14	20	15
12	25/30	20
10	35/40	30
8	50	50

The above table was copied from a Ron Alexander article in SportAir, 1998, but looks to be directly out of AC 43.13-1b, chapter 11.

Wire Sizing Chart

I was reading through AC 43.13-1b chapter 11 about aircraft electrical techniques and came across a chart that helps you choose the appropriate gauge of wire for a particular project. I thought it was pretty interesting. I was set on using #2 welding cable from the battery to the starter and alternator, but according to the chart all I need is #10 !!!



To use the chart, choose your charging/battery system (mine is 14 vdc) and then go down the column to the number of feet of your wire run, then go horizontally across until you come to the diagonal equivalent of your needed continuous amperage, then drop straight down from there and read the gauge wire you need. You should go to the next larger wire, i.e. read to the right. My starter wire run is 14 vdc, goes 12 feet, needs 55 amps. That begets a wire size just shy of ten gauge!!! So I could use relatively light wire up front. Nice that my EVO has the battery up front.

Having had this discussion, perhaps to maximize the cranking ability, it's probably still a good idea to use at least a 4 gauge wire from the battery solenoid to the starter and back. That thing will need some serious cranking amps! So I think there's a bit more to the wire size determination process than just what the chart tells you, but it sure is a good place to start.

Avionics Circuit Protection Requirements (*amperage confirmed from manufacturer)

Essential (Avionics/Aux - St Fuse Block) Bus Components:

	Component	Max Draw	Recommended	Switch	Circuit Protection	Notes
1	Horizon 1 EFIS	4 amp*	1.5 amp*	unit	ST Fuse Block	.5 amp for AHRS and 1.5 amp per screen, 5 amp max. These units are internally

						fused.
2	GRT EIS ?	1 amp*	1 amp*	none	ST Fuse Block ?	
3	GMA-340	2.2 amp*	5 amp*	unit	ST Fuse Block	
4	GNS-480 Main	3.2 amp*	5 amp*	unit	ST Fuse Block	
5	GNS-480 Comm	5.0 amp*	10 amp *	unit	ST Fuse Block	
6	SL-40***	5.2	5 amp*	unit	ST Fuse Block	.27 + 2.1 typical receive and tx, 2 + 3.2 amp max
7	GTX-327	1.8 amp	3 amp*	unit	ST Fuse Block	
8	alt field	5	5 amp	none	ST Fuse Block	
9	ACS ignition	5	5	key	ST Fuse Block	
10	Flap Motor	7 amps	7.5 - 10 amp	grip	ST Fuse Block	
11						
12						

*** for an SL-30, the nav side uses .325 typical, .5 amp max, 2 amp breaker recommended
Total Max Amps Consumed at E-bus: 35.4

W51 Rocker Breaker Components:

	Component	Max Draw	Requirement	Switch	Circuit Protection	Wire Size	Notes
1	Airflow Performance Boost Pump	5*	10 amp*	W51 Rocker Breaker	W51 Rocker Breaker	18	
2	Pitot Heat	7.5 - 15 amp*	10 - 15 amp*	W51 Rocker Breaker	W51 Rocker Breaker	14	
3	Auto Pilot	2.5 amp*	5 amp*	W51 Rocker Breaker	W51 Rocker Breaker	20	Autopilot .5 amp draw Ea. servo 1 amp draw
4	Nav Lights	1.2	5 amp* (1 amp)	W51 Rocker Breaker	W51 Rocker Breaker	18	
5	Strobes	5	5 amp* (7-10 amp)	W51 Rocker Breaker	W51 Rocker Breaker	18	

6	Landing Light	9.2	15 amp	W51 Rocker Breaker	W51 Rocker Breaker	14 - 18	
7							
8							
9							

Total Max Main Bus Amperage Load: 31.2 amps

Other Electrical Components requiring individual circuit protection:

Component	Max Draw	Requirement	Switch	Circuit Protection	Wire Size	Notes
Elev. Trim Servo	.6 amp	1 amp*	Stick Grip momentary	pop up breaker	22	
Dual Plasma III Elect Ign	2.3 amp	5 amp	none	fusible link?	shielded 18 - 22	
Alternator Main Field	55 amp output	30?	Split master	fusible link?	4 - 12	
GRT EIS?	1	1	none	pop up breaker?	22	

Some of the above details are pending. Some of these items may be powered through a stand alone battery bus.

Also not that I haven't specified any wire sizes for the avionics. That's because I am getting the avionics pre-wired, either on the bench by my avionics shop and/or by use of the Approach System Fast Stack Pro-G hub and cable system. More on that later.

Grounding:

I plan on using terminal strips to ground avionics and most other electrical components to the battery (or batteries as it may be). I think that way I will have less chance for trouble with noise and corrosion down the road if I use as many return lines as possible instead of grounding to the airframe. Mark at Team Rocket recommends that the engine be grounded to the engine mount, then ground the engine mount to the battery, and also ground the battery to the wing spar splice plates. I will probably set up this way, but I will most likely still run ground wires to a ground terminal strip whenever possible.

The first ground wire I established was a 12 AWG wire from the battery to the ST Fuse Block negative bus. There are 12 gangs on the negative side of the block, plus a main anchor terminal for the master ground. That terminal is hard to get a wire on because of where I positioned the block, so I connected the main ground wire to the #1 negative ground position on the block. That aux/avionics ground wire is crimped AND soldered to a ring terminal, and is paired with an 8 AWG wire that goes to the right upper corner of the firewall. For a ground feed through the firewall, I removed one of the AN3 bolts from the angle steel in the corner and replaced it with a drilled AN3-7 and a castle nut. This longer bolt has enough length to accommodate the ring terminal on the 8 wire as well as a ring terminal from the massive braided ground strap that will go to the battery. The firewall corner angle steel is primed with a pretty tough coating and it took quite a bit of sanding to get down to the bare metal. If that steel is like any of the other crap that came from the Czech Republic, I'll need to liberally apply some dielectric grease to keep it from corroding.

I haven't finalized the firewall ground because I may end up putting another tray over on the right side. If so, the large white ground wire will have to run a different course. Any of the bolts on that corner angle, including the engine mount bolt, would be a good ground. I chose not to use the engine mount bolt because I would run out of threads if I put a ring terminal on either end of the bolt. I don't want to have to buy a big assed hardened bolt just for that, with so many other choices available already.

For the main DualBus on the left side of the ship, I ran a separate 8 AWG wire from the primary battery on the right side of the ship to the negative terminal on the left side backup battery. From there, I ran a 10 AWG wire up to the DualBus Main Ground Terminal.. Perhaps an 8 gauge wire between the batteries and 10 AWG to the Main Ground Terminal is overkill, but when I hit that starter key, having a good ground connection should NEVER be a problem.

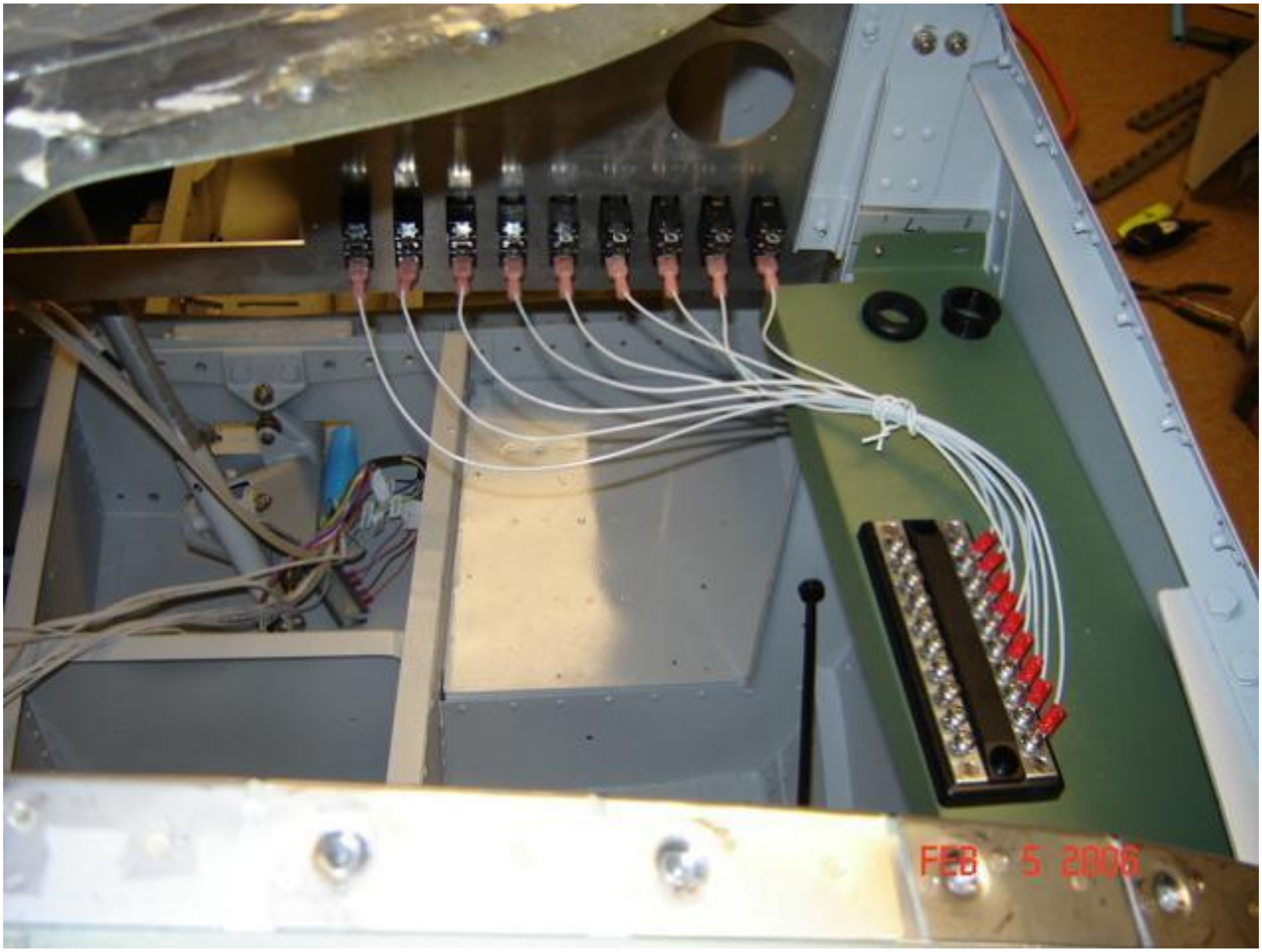
After establishing this ground/return line network, I went around with a multimeter checking many locations to compare the resistance. I think I've created a very nice ground system. Hopefully that will pay off with less intermittent weird problems down the road.

All that is left now is to add another ground from the battery to the wing spar splice plates. I'll probably use a 12 AWG from the battery to the spar plates. It's only about 12 inches, so a massive wire shouldn't be necessary. Actually, I don't think the wing spar splice plate ground is all that necessary, but I'll put it in just for good measure. Perhaps it will make those big gas cans in the wings less likely to go boom.

On the engine side of the firewall, I used about 1.5 feet of braided grounding cable. I bought the raw cable from ACS, and soldered on ring connectors. One end goes on the other side of the 12 AWG wire at the firewall. I cleaned off some paint and put the other end at the closest corner sump bolt on the lower right side of the engine. I think I would have preferred to just use a 12 or 10 AWG wire, but I had the braid already... so I used it.

Main Power Bus - Blue Sea DualBus

For my main power bus, I bought a Blue Sea DualBus terminal strip to power and ground the main aircraft electrical equipment, particularly those things that require a panel switch, and are not "essential" to flight. The DualBus is a simple unit with two rows of 10 each #8 screw terminals, one row for ground and the other for power. The strip handles 100 amps continuous, which is nearly double the output of my alternator.



The pic gives you an idea of what I had in mind for wiring from the DualBus.

A power wire goes from the DualBus to the #1 quick connect .250 tab on the W51 rockers. The #2 tab hooks up to the load (feeds power to the widgets). The #3 tab is not used because these switches will not internally light. The ground return wires will be brought up from the widgets in pair, and grounded to the DualBus. There is one screw at the aft end (top end in the pic) on each side the DualBus terminal strip for a pos and neg wire from the battery (solenoid via breaker and master switch) or ground terminal down low. I will move the power wires shown on the DualBus to the other side and run the ground return wires outboard.

There are two different types of grommets shown near the instrument panel in the picture. One is a plain old rubber grommet from the electrical department at Lowes. The other is a SB 1000-12 Heyco snap bushing that I bought with some other electrical parts from Mouser. It is a .750 ID nylon bushing similar to the rudder cable SB 625-8 Heyco snap bushings provided with the F1 kit. I have several different sizes of rubber grommet, but only the two sizes of snap bushings. The final grommet decision may depend on how big the wire bundles are, and whether or not there are obstacles or a need for a tight turn in the wire.

I ended up not using the green shelf. I found it to be too wide, and it gets in the way reaching into the boot cowl. I moved the Dual Bus to the longeron at the boot cowl panel. The bus sits just inside the lip of the boot cowl for easy access. The ground side was moved to the top. I figured I'd be a lot less likely to shock myself that way. I fashioned a mounting bracket out of .032. I removed 3 rivets from the longeron and riveted the bracket directly to the ship's frame. At the bottom of the bracket, I just glued it using some GOOP. Simple, and no extra holes in the skin.

Essential Bus - Blue Sea ST Fuse Block

The Essential (avionics, or aux) Bus, or "E-bus", powers all the "essentials" of flight. This bus should power the items that work to ensure safety of flight. This bus is primary powered by a line from the Main Bus (in my case more directly from the output side of the battery solenoid. The E-bus is mostly an avionics bus, but it should also power the fuel boost pump. The E-bus will have two ways to get juice, normally through the alternator and the primary battery, but in case of alternator shut down or primary battery failure, the E-bus will have an alternate path that can be switched on to receive power from the secondary backup battery.

The ST* Blade Fuse Block (**PN:** 5026) is a 12 Circuit power center with a built in negative bus is going to be my power AND ground block for the avionics stack and a few essential items. The ST block takes ATO or ATC type blade fuses. The ST block handles 100 amps continuous total, with a maximum of 30 amps at any single fuse.

I bought Smart Glow blade fuses for my fuse block. "When they blow, they glow!" is the slogan. Each fuse has an LED light that illuminates after the fuse burns through. Makes it easy to find the offending culprit to change it out. The only problem is that the Smart Glow fuses don't fit under the clear Lexan cover of the ST Fuse Block, unless you file down the plastic cylinder on top of the fuse that houses the LED and shows the amperage. The fuse bodies are color coded, so knowing the number isn't all that important, once the system is set up. I took a hand file and ground down a sample fuse and did a little test. With just enough clearance under the block cover, the fuse still worked. I blew out a 25 amp fuse on purpose and I can say that the LED's are VERY bright. Only problem with these fuses so far is that they don't come in sizes smaller than 5 amps, so any 3 amp fuses will not glow when they blow.

I mounted the ST block on the right side of the ship in the side wall bay just aft of the instrument panel. The plan is to cover the block with upholstery, but have the block accessible in flight behind a panel. I slightly canted the block so that I can see it better and get fingers on it more easily to change the fuses. The polycarbonate cover does not fit over the Smart Glow fuses, and adds too much thickness, so if I use the glow fuses, I will have to modify them.

I took some scrap .032 and made a mounting bracket for the ST Fuse Block. I used four nut plates and 4 #8 screws to mount it up. The bracket has an offset face in that it turns the face of the ST Block toward the pilot about 50 degrees or so. It's turned just enough that it should make it easier to grab and remove the fuses.

I located a key switch and an eyeball vent in the instrument panel sub frame just forward of the E-bus. I think I'm going to cover this side bay and put an "arm rest" on it. On the front, I think I will make a simple hinged door that swings up to give me access to this entire fuse panel bay.

Depending on how many wires end up clogging the hole through the #2 bulkhead, I may have to make a larger or second hole. Note that the main ground wire to the fuse block does not go to the empty terminal on the right end of the unit yet. I've since installed an 8 AWG to the ground stud. Still need to dimple the side skin and rivet the bracket to position, too. If I can get a buddy to help, I'll buck solid rivets. Otherwise cs pop rivets should work just fine.

The main power feed to the E-bus is from the primary battery solenoid on the left of the forward stick bay through an 8 AWG wire. The alternate/secondary power feed to the E-bus is from the secondary backup PC680 battery through a second battery solenoid on the right side of the ship. The alternate battery source comes to the supply side terminal on the primary battery solenoid through a short independent 8 AWG wire from the supply line side of a secondary battery solenoid.   In the event of primary battery failure (extremely unlikely) or alternator failure, I've installed a separate ON ON toggle switch to ground out either battery solenoid. When one battery solenoid is grounded on, the other is always ungrounded, which means turned off. The master which operates the primary side of the electrical system, including the Main bus gets it's ground from the alternate battery toggle.

Battery Bus?

I don't have plans to install a battery bus per se, but I thought I would discuss it. Instead, I have wires direct from each battery to the dual Electronic Ignitions (EI) and the computer brain of the AHRS, which controls the EFIS and is the primary attitude indicator.

As I have spent a lot of time trying to understand wiring diagrams and the layout of various aircraft electrical systems, I have discovered that perhaps I should add a 3rd bus. If nothing else, since I am having dual electronic ignition, I should at least have a separate battery feed to one side of the ignition direct from the batteries. Also, Grand Rapids Technology recommends that the AHRS guidance module be connected to the battery and never shut down in flight. My primary instruments are being replaced by the Horizon 1 EFIS, so it also will need to have power from the battery bus. I have a dual screen, single AHRS system ordered, with an integrated engine monitor. The engine monitor is planned for continuous viewing on the bottom screen. The second monitor at the bottom of my panel and those engine instruments MAY not be essential for flight. So perhaps I will wire the AHRS guidance system and the top screen direct to the battery bus.

The Battery bus (B-bus) could be just small fuse block, located as close as possible to the battery. It would be powered directly from the battery positive terminal (or from the BAT terminal of the battery contactor) and is "hot" all the time, without a switch. This bus is commonly used for interior lights, clocks, and hour meters. In my case, it will also be used to feed one of the two electronic ignitions for my engine. To protect this hot battery line, I will probably use 12AWG wire and a 16 gauge fusible link.

A power feed from the battery bus also can power the essential bus. In case of alternator failure, the battery can then feed to a switch and subsequently the essential bus to power the EFIS, NAVCOM, transponder, and GPS, as well as the fuel boost pump. Bob Nuckolls has some great ideas about how to set up an alternate electrical line to the essential bus, which includes an in line diode to prevent "back flow" drainage from a secondary battery toward a corrupted alternator.

The B-bus doesn't really need much more than 4 to 6 fuse slots, if even that. I really don't think I need another ST Fuse block here, just a Plain Jane fuse block without any ground terminals. I wasn't planning on any courtesy lights, or an hour meter or clock (those are in the EFIS). This bus would just be an intermediate to the E-bus and may only have that one line, and at least a feed to one side of the ignition. I could just make individual lines and an in line fuse with a switch, or dedicate a line (with fusible link) from the rocker breakers on the panel to the E-bus as an alternate battery feed. I'll have to contemplate that one. A dedicated battery bus is a good idea for future expansion.

I found a couple 4 gang ATC fuse blocks on the web. Two in particular looked workable. I was trying to fit a battery bus in the sidewall bay with the ST fuse block. A 6 gang block was just too large. A 4 gang would be about right. Hella sells some ATC fuse blocks with splash proof lids. One style has the wires coming out the both sides. One style has the block on pedestals and the wires come from underneath. I think what I want to do is use the pedestal style, but I bought both types just in case I decided to change my mind. In fact I bought two of the side wire styles because they would be handy for adding some farkles to my motorcycle.

The Hella pedestal style splash proof fuse block looks like this:


MAR 8 2006
MTA

The fast on quick connect spade terminals aren't pushed on the male spades of the fuse block all the way. Those left three terminals especially do NOT like to come off if you put them all the way on. They do clear the mounting face under the pedestal feet when completely connected. I may, however, give my self some more working room for the wires and put 1/4 or 1/8 inch spacers under the feet when I screw the base down. That will make it easier to get the feed wires to the spades underneath. Also, more than likely, if I use this Hella fuse block B-bus, I will make quite a large hole under the base to accommodate bringing wires through the bulkhead to the spades on the block. Hmmmm.... maybe I should use the side terminals after all. They have a larger footprint, but will be easier to service if necessary... hmmmm...

Still not sure I'm even installing a battery bus.

Odyssey PC680 Battery

The Odyssey PC680 battery is a smallish long storage life and high cranking dry cell 12 vdc battery with many features that are optimal for use in aircraft. On the EVO model F1, this battery easily mounts under the pilot's right knee in a small bay in the floor. The Fuselage3 page shows the mounting tray and location.

I bought M6 bolts for the battery terminals at Auto Zone to replace the little screws that came with the battery.

The marine variations of the Odyssey batteries are identical to the type that I am using.From an great article on marine applications of the Odyssey batteries:

" *The Odyssey Battery is an AGM battery that is very unique and technologically advanced. It was designed to meet the demanding needs of the US Military with respect to heat, cold, shock and vibration, and to last much longer than other batteries. It is currently used in tanks, fighter jets, battle ships, and many other military applications. On top of this it delivers higher cranking power while also being the best deep cycle battery available (two to three times the cranking amperage of other similar sized batteries and the ability to be drawn down to 100% over 400 times). Other attributes include the ability to sit dormant for up to two years and still hold enough charge to start the motor it was intended for. This is very important because we often don't get to use our (planes) boats as much as we would like during the season. The Odyssey battery actually lasts up to 6-10 years which is attributed to it being manufactured with 99.9% pure virgin lead. The US Coast Guard has 500 batteries in 50 Bollinger 87 foot protector class cutters since 1998 without a single failure to date. On top of all this, it* *is maintenance free and will not vent during normal operation due to its patented technology to reuse its internal gases. It is also the only battery to claim an explosion proof design.*

Charging the Odyssey battery is similar to a flooded battery. It is not sensitive to charging like other AGM's and the Gel batteries. In fact, the Odyssey battery has no restrictions on the inrush of current and will recharge in one third the time of a conventional battery. This allows the battery to be utilized with traditional flooded chargers and typically does not require replacing your current charger in many applications. Most marine three stage chargers available today work very well for charging the AGM batteries. "

These batteries kick ass. I'm thinking seriously about changing out my old wet auto batteries for Odysseys when the time comes. I've had the first battery in storage for well over a year , and the voltage hasn't seemed to drop at all. If the service life is half as good as the shelf life, these batteries should take over the industry.

Now that we've decided where some big electrical components are going, lets start to run some wire!

Power Supply Wire Run

The primary battery in my F1 EVO is located under the pilot's left knee on the floor. The secondary battery is under the right knee on the floor. The main bus is under the left boot cowl (so far) so it can easily feed the rocker breakers in the panel, and the starter/solenoid at the firewall. The Essential (avionics, aux) bus is located in the right sidewall bay to the side of the pilot's knee just above the right battery.

For reference, I have been looking at Bob Nuckoll's AeroElectric Connection pages and Randy Pflanzer's set up and wiring diagrams. My application is a dual battery, single alternator F1 EVO, so most dual alternator, rear battery setups won't work for me. But it's a good start to check out those that have come before. Randy's diagrams and wiring set up is VERY well thought through and quite detailed. Of course AC 43-13-1b is helpful, too.

My EVO battery location, per TR's suggestion, is on the floor just in front of the wing spar on each side of the forward stick bay. Tom Martin has placed his single EVO battery in the center bay, forward of the stick bay. After having installed the fuel pump, filter, selector and lines in the forward center bay, I could still have room for one if not two batteries in that compartment. Had I not already made the trays and drilled the belly skins for rivets, I might have considered moving the batteries farther forward into the center bay.

The first big #4 AWG wires go left to right over the top of the batteries through grommets or bushings in the walls of the bays. The wire run to the left is going over the top of the battery at the front end of the battery bay, along the aft side of the #2 bulkhead. I extended the battery hold down arm hinge from the lip of the top of the bay so that I could put a pair of Adel clamps (or screwed zip ties) along the bulkhead to support the wires before going through the wall into the center stick bay. I drilled the location to allow at least a 3/4 opening for big wires to go back and forth. I may need a bigger opening here (and elsewhere), but I started with a 3/4 ID grommet, which requires a 1 inch hole. The wires to the right are going to exit the battery bay directly in front of the negative battery terminal.

The main airframe negative ground return 8 AWG wire comes from an AN3 bolt in the firewall's upper right hand corner, down the back of the instrument panel sub frame (#2 bulkhead) and then through the floor bulkhead direct to the battery negative ground terminal. I also installed an 8 AWG ground wire to the Main Ground Bus (the DualBus terminal strip) from the negative terminal of the primary battery.There is an 8 AWG wire between the negative terminals on the batteries as well, thus creating a rather strong and large ground circuit.

I will also run an extra ground wire to the wing spar splice plates at the rear floor of the battery bay once the wings are installed. As of yet, I don't have anything electrical grounded to the airframe, and I don't plan too. Everything is directly grounded to the batteries, either directly or indirectly through a bus or feeder wire. So I'm not sure grounding to the splice plates is all that necessary. One would think that the wings should be fairly well grounded to the fuselage given the thousands of bolts that are used to keep the wing spars bolted to the canoe. But TR sez I should ground to the splice plates, so I will.

The primary positive power #4 AWG wires go from the primary battery to the "BAT" side of the primary battery solenoid, then branches out from the supply or "line" stud of the battery solenoid. An 8 AWG wire makes a short run to the Main bus (which is just a Blue Sea DualBus terminal strip near the rocker breakers behind the left instrument panel). A separate 4 AWG wire goes from the line side of the primary battery solenoid to the BatterLink ACR isolator. Another 4 AWG feeds from the line side of the primary battery solenoid to the BAT side of the starter solenoid, now relocated to the right side of the ship. An 8 AWG wire branches from there to the E-bus.

The ST Fuse block that is my E-bus actually sits on the side wall just above the rudder cable. So many pos and neg wires have to penetrate the #2 bulkhead to the ST Fuse block to get ground AND power. The large aux power wire as well as a hefty ground wire will go through the 3/4 grommet in the bulkhead to the pos terminal on the fuse block. From there, all the ground and power feeds will traverse back through he bulkhead grommet and then back to the floor, or most likely continue upwards to the avionics. I think I'm going to need a bigger (or additional) hole.

Mark at Team Rocket said that he ran his wires along the forward edge of the #2 bulkhead in a series of 1 inch Adel clamps. I kept all the wires aft of the #2 bulkhead until they reach the instrument panel uprights. This keeps the wires away from fuel lines and my feet.

I reversed the stainless #10 nuts and screws you can see on the #2 bulkhead which hold Adel clamps. You are really supposed to put the screw pan head on the rubber loop side of the clamp. The #10 - #12 Adel clamps are so beefy and the loop is so far from the screw, I don't see any problem with putting the nut (and threaded screw end) on the "working side" of the clamps. Just need to make sure that the threads don't cut into the clamp. Certainly more chance of me hanging my heals up on the nuts compared to a pan head, and I reversed the nuts and screws just to try to keep my heels from getting scuffed by the screw ends.

I did find that the #12 Adel cushion clamps are too small for all the wires that I needed to run. I was running out of room in the clamps before even bringing stick, servo, autopilot, or lighting wires to the front. So I made an order to Spruce and got some #16 and #20 WDG Adel clamps. Good thing I made the battery hold down hinges so far away from the bulkhead!

I used my big step drill to make 7/8 holes from the right knee battery bay, into the center stick bay, and then in roughly the same location into the left knee (aux battery?) bay. On the left side, I will keep the wires as high as possible. I've made another hole from the left knee bay to the forward (pilot) footwell. That hole will feed supply and ground return wires up the left side of the #2 bulkhead. I drilled out a couple existing rivets to allow attachment of #12 Adel clamps. I may not need Adel clamps quite that large, but I'm starting with #12's so I make sure I have more than enough room for the cushion clamps.The existing tooling holes are quite nice for mounting even more Adel clamps for the supply wire runs up the forward (backside) side of the #2 bulkhead.

For the negative ground return wires I used 8 AWG from the negative terminal of the primary battery all the way to the DualBus main ground strip. I also ran a combined ground using 8 AWG to the upper right corner of the firewall, and a short run 10 AWG wire to the ground bus on the ST Fuse Block (aux/avionics supply and grounds).


'Lectric Bob and countless others suggest that you keep the 'fat wires" away from the "skinny" ones. Also, my research suggests that both the starter and alternator wires should run together on one side of the instrument panel and all the other wires, electronic ignition and particularly sensor wires, should go as far away on the firewall as possible. In my case, I relocated the starter to the right side so that the

main power 4 AWG feed goes from the alternator to the starter solenoid supply stud, then through an ANL fuse, then to the battery system. All this runs at the very outside corner of the right side of the firewall. The other "skinny" wires run through the middle and slightly left of center through the firewall. The mid wires decrease in size and voltage from right to left. The rightmost wires are the high voltage ignition cables, then the EGT/CHT sensors, then the very low voltage sensors at the left side. Supposedly, this type of arrangement keeps the little gremlins at bay. Hopefully, I have enough separation and good enough grounding and shielding to keep the noise AND the gremlins out.


Battery Solenoid

I originally purchased a pair of Cole-Hersee model 24115 Continuous Duty 85 amp battery solenoids (relay, contactor, actuator, etc...) from Van's and Wicks.

These things couldn't be simpler to install and operate. You connect the BATT end of the solenoid to the positive terminal on the battery via a big wire with a crimped and/or soldered 5/16 terminal. The other "line" (or "supply") stud of the unit is the same size terminal and that one goes to your main bus or whatever else you want to send switched power.

To operate (close) the normally open circuit, and "turn on the battery", it only takes one wire (well, one simple "circuit", I suppose...). All you have to do is run a wire from the smaller middle post on the battery solenoid, which is a 3/16 terminal, to a switch, and then from the switch to a ground negative source (return line, negative bus). Close the BAT switch, the current at the battery solenoid 3/16 stud goes to ground, the solenoid magnetizes and operates, et VOILA! You got power! Sweet, huh?!

These little gems are going right into the forward stick bay. In the pic to the left, I located the right (secondary) battery solenoid to two factory located rivet holes. It happened to match perfectly with the factory rivet holes, and was a good high location for the solenoid, with plenty of clearance from the control tube and way up off the floor. I installed TWO battery solenoids and they are located in mirror image locations in the forward stick bay.

I need to power the Main and Essential buses from the supply side of the primary battery solenoid. The positive wire (and of course the grounding wire) that goes to the DualBus terminal strip on the left side of the ship is a 4 gauge. More on the DualBus main bus down this page.

I used 18 gauge wire from the battery solenoid 3/16 post to a split master switch that my friend John Watler gave me. The ground for the split master battery switch is supplied through an ALTERNATE BATTERY ON ON toggle switch. The ALT swtich gets it's ground from an 18 AWG to a ground terminal on the E-bus (ST Fuse Block).

After an email on the F1 list describing one builder frying his Garmin radio due to a "spike", I started getting nervous about protecting my avionics from the spikes that supposedly come from the starter, and from a runaway alternator. I do not have an avionics master switch. Not so much because it's a single point of failure, but more so because I'm lazy and don't want to install or use an extra switch.

My EFIS is going to be always on, and so is the electronic ignition. The Garmin stack can just be shut off at the faceplate, so I'm not so worried about those, particularly at startup.

Dual Battery / Alternate Battery Source

Installing a backup electrical system is a good idea in any airplane. Perhaps it's a must if you have dual electronic ignition, as in my F1. There are many ways to arrange redundant or backup electrical systems. Primarily, they are dual alternators or dual batteries or both. I may install a backup alternator on the engine vacuum pump pad down the road. However, I have more faith in the integrity of batteries (especially the Odyssey) over the reliability of an alternator. I have had a few aircraft alternator problems over the years, and feel much more secure in having a charged pair of batteries getting me through a flight. Of course the chances of two alternators failing is quite remote, too, but not as remote as two Odyssey batteries failing.

I was trying to decide on how to setup my dual battery system. First, what batteries to use. I was considering using two smaller batteries (to save weight) and running them concurrently (get it, conCURRENTly?) so I could be sure and start the plane. However, after thinking it through, I decided to sacrifice the weight and install two full sized PC680's. That's another 14.5 pounds up front, which is significant to gross weight, but probably not to CG since the batteries sit so close to the wing spar . Perhaps I should just lose 20 myself to compensate for the weight. I certainly have adipose tissue to spare.

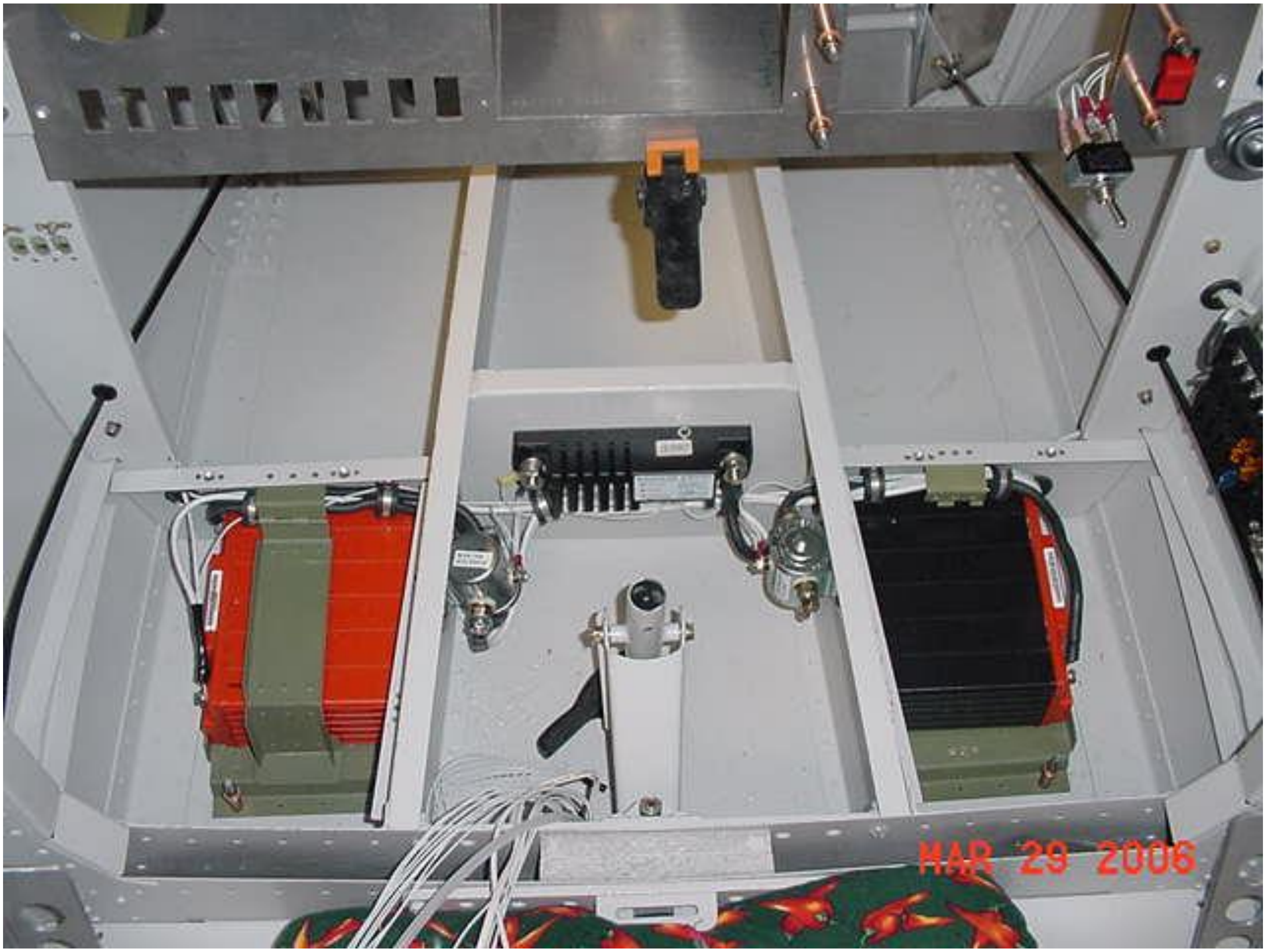
When I wired in my second PC680, I had to take steps to combine the battery power as well as steps to separate the two batteries within the electrical system. When everything is running hunky dory, which should be 99.9% of the time, both batteries should be working together ("combined") and charging from the single alternator via the BatteryLink ACR.

However, when things go bad, like the primary battery gets weak, or the alternator fails, then it is desirable to have a secondary backup battery system, completely separate from the primary electrical source. The BatteryLink ACR isolator and two battery solenoids accomplish this for me. If the primary battery or alternator goes down and the voltage drops below a preset level, the BatteryLink relay opens automatically and the secondary battery system is cut off from the primary charging system. Usually, the only thing the secondary battery is doing is powering one of the two electronic ignitions and the AHRS of the EFIS. The primary system is still powering it's EI, the AHRS and both buses.

Now, to put the backup battery (and backup electrical system) into service: Flip the ON-ON toggle switch on the instrument panel marked "Alternate Battery", and power is fed from the secondary system to the supply side of the primary battery solenoid. When you switch from primary to alternate (secondary backup) battery, the roles of the system reverse: the primary battery is then just powering the AHRS and an EI, and the secondary battery powers both buses. The flow from the secondary battery to the primary battery is cut off, the secondary battery now powers both buses and each battery still feeds the electronic ignition.

Side note: Either battery, or the E-bus, can directy power the EFIS. GRT made it so that the EFIS system automatically chooses the strongest power source hooked to it. The EFIS/EIS system has it's own internal protection, and three separate power feeds. Pretty cool.

The dual battery and BatteryLink ACR ("isolator") in the front of the cabin on the floor looks like this (except later on, I turned the BatteryLink upside down):



The backup secondary alternate battery feed is set up to run one electronic ignition and add one feed to the GRT EFIS's AHRS. That's all the backup battery will do the vast majority of the time. However if needed, the alternate battery backup feed can be switched to power the both the Main and E-bus. There is no switch in my system to shut off either bus, you just have to turn off whatever you don't need by the rocker breaker switches in the instrument panel, or directly at the device you want to shut down.

The main/primary/master battery is on the left side of the ship. The backup/secondary battery is in the mirror image location on the right side of the ship. The plan is to rotate one of these two batteries out of service every other year (with the ELT battery). The fresh battery goes into the right (secondary) side, and the old right side battery goes over to the main battery side on the left, which is the battery used to start the engine. So the best battery is always the backup, and the old battery gets used and abused on the left side of the ship. If the older battery isn't good enough to start the plane, it's not good enough to start a light with, either! I sure want to have the very best battery in the backup slot so I have the strongest battery to power the ignition and the E-bus when I need it the most.

Both batteries are hooked to the bat sides of the solenoids, with jumpers from each to the BatteryLink ACR. The alternator B-lead comes indirectly to the supply side of the primary solenoid. When the master is on and the primary battery solenoid is energized, the alternator can charge both batteries, but it goes through the solenoids. Both buses are also wired to the supply side of the primary battery solenoid with a jumper to the supply side of the secondary battery solenoid. One switch, and ON-ON toggle operates both battery solenoids. Therefore only one battery system can operate the bus at one time.

The batteries are indirectly linked through the BatteryLink ACR. That unit has diodes in it and regulates the flow between the batteries (and the charging system). When the batteries are "combined", the primary battery charges the secondary battery. When not combined, the secondary battery can be completely isolated from everything. The secondary battery is usually automatically charged or disconnected by the BatteryLink ACR. It can be manually removed by a switch on the panel that will open the circuit at the BatteryLink.

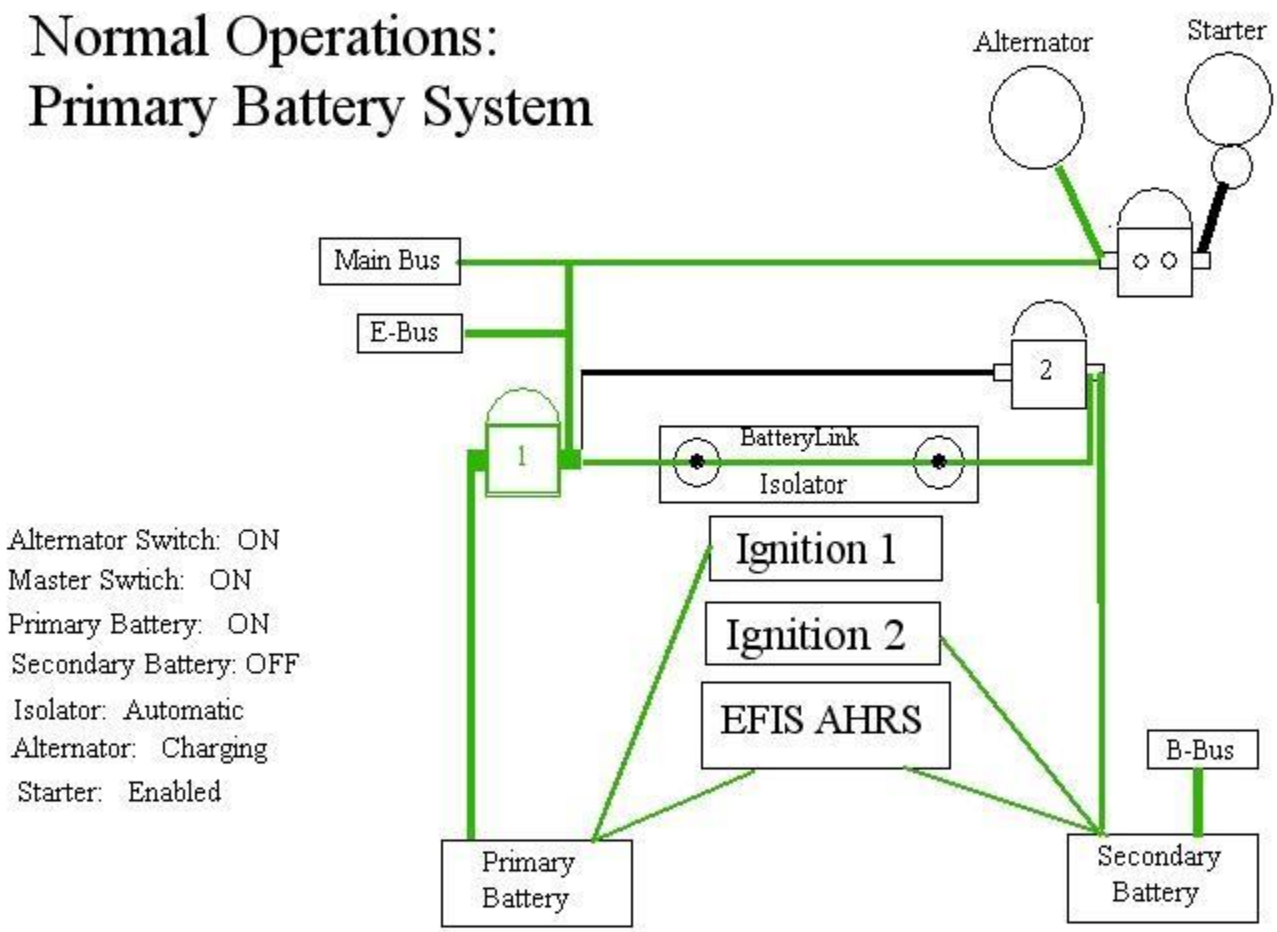
At start up, the split master is turned on. That closes the primary battery solenoid (if the battery switch is set on primary..), but the secondary battery solenoid remains open and the secondary battery is protected/isolated from the system. When you first turn on the electrical system, the BatterLink relay is automatically open for about the first minute of operation. Having the isolator open (off) protects the secondary battery and the BatteryLink isolator during engine start.

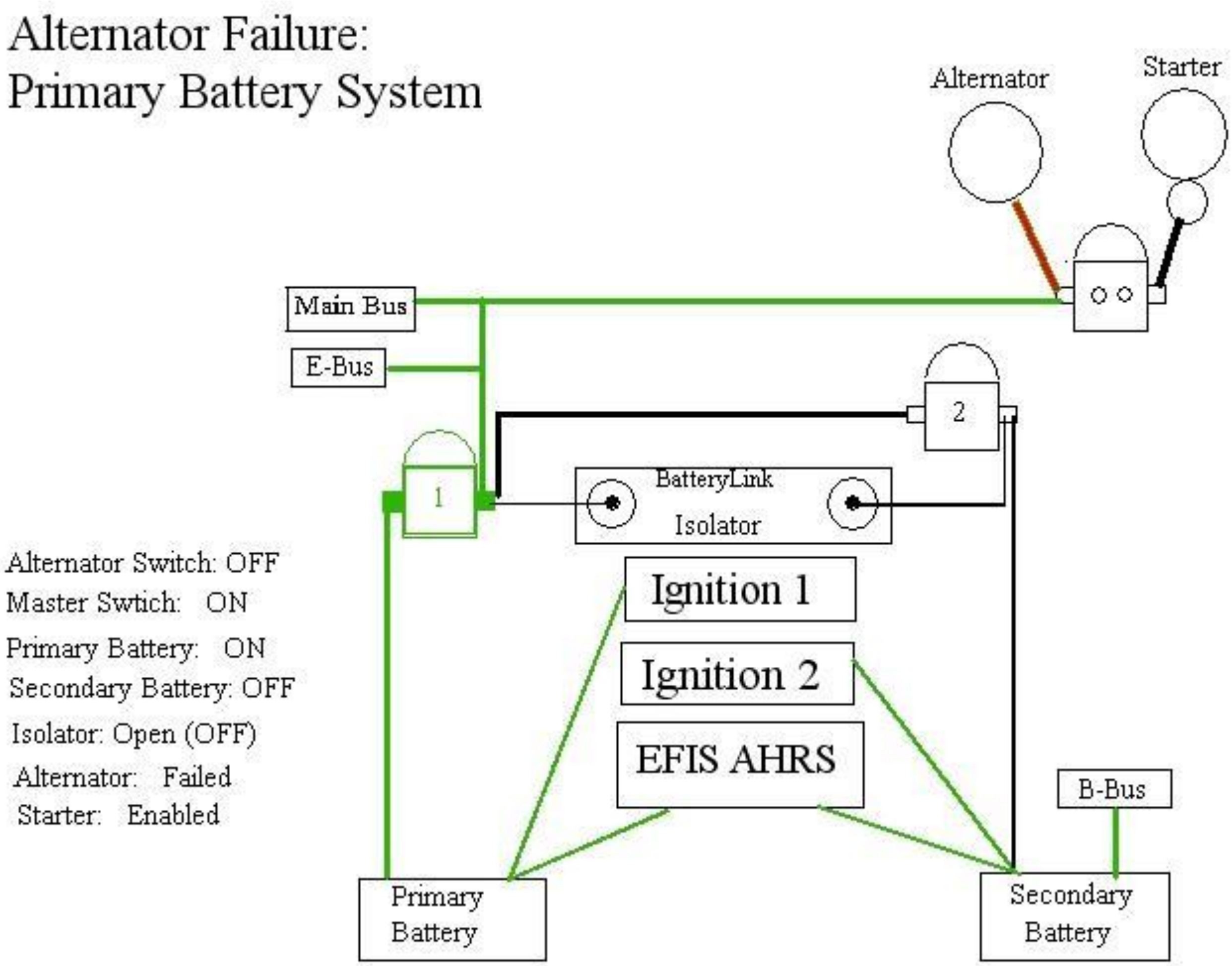
In case of alternator failure, or if one of the batteries discharges for some reason, the isolator senses the discrepancy, and automatically disconnects (opens it's relay) the batteries. That's the purpose of the BatteryLink ACR, it automatically combines both batteries to charge them, or in event of discharge or alternator failure, it disconnects (shuts off) automatically (or you can switch it manually) in order to save whatever energy remains in one battery without transferring the remaining energy to the other battery. More about that below.

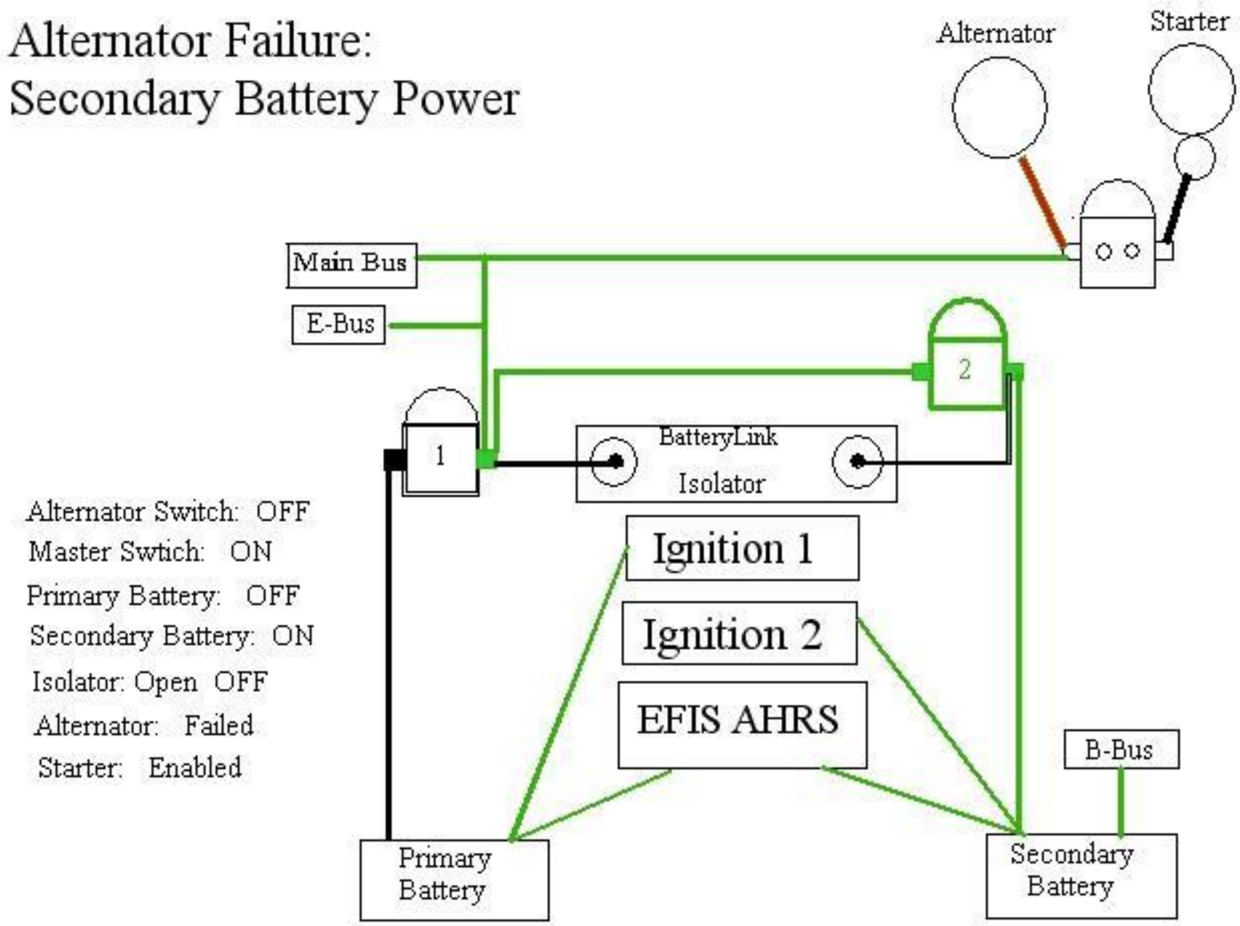
My EFIS will flag me that there is a charging problem. At that point I can choose to continue in the normal primary mode, or switch to the secondary alternate battery to power the buses. Only one battery ever feeds the buses. With the isolator open and the main battery switch on normal (or primary.. haven't decided on nomenclature for placards yet) only the primary battery is supplying the buses. If I switch to BACKUP or SECONDARY or ALTERNATE BATTERY, then only the right side secondary battery is feeding the buses. How do I accomplish this? Well, my ALTERNATE BATTERY toggle is a DTDP ON-ON switch.

Normally, the toggle has PRIMARY ON (or "Normal"). An 18 AWG ground wire from the E-bus ground bus grounds the split master switch, which when switched on, grounds the primary solenoid and closes the primary solenoid relay. If necessary, I can switch the toggle to the other secondary/alternate ON, and that action grounds out the secondary solenoid and UN-grounds the primary solenoid which locks out the primary battery. The ON-ON switch never allows you to have both battery solenoids closed ("turned on") at the same time.

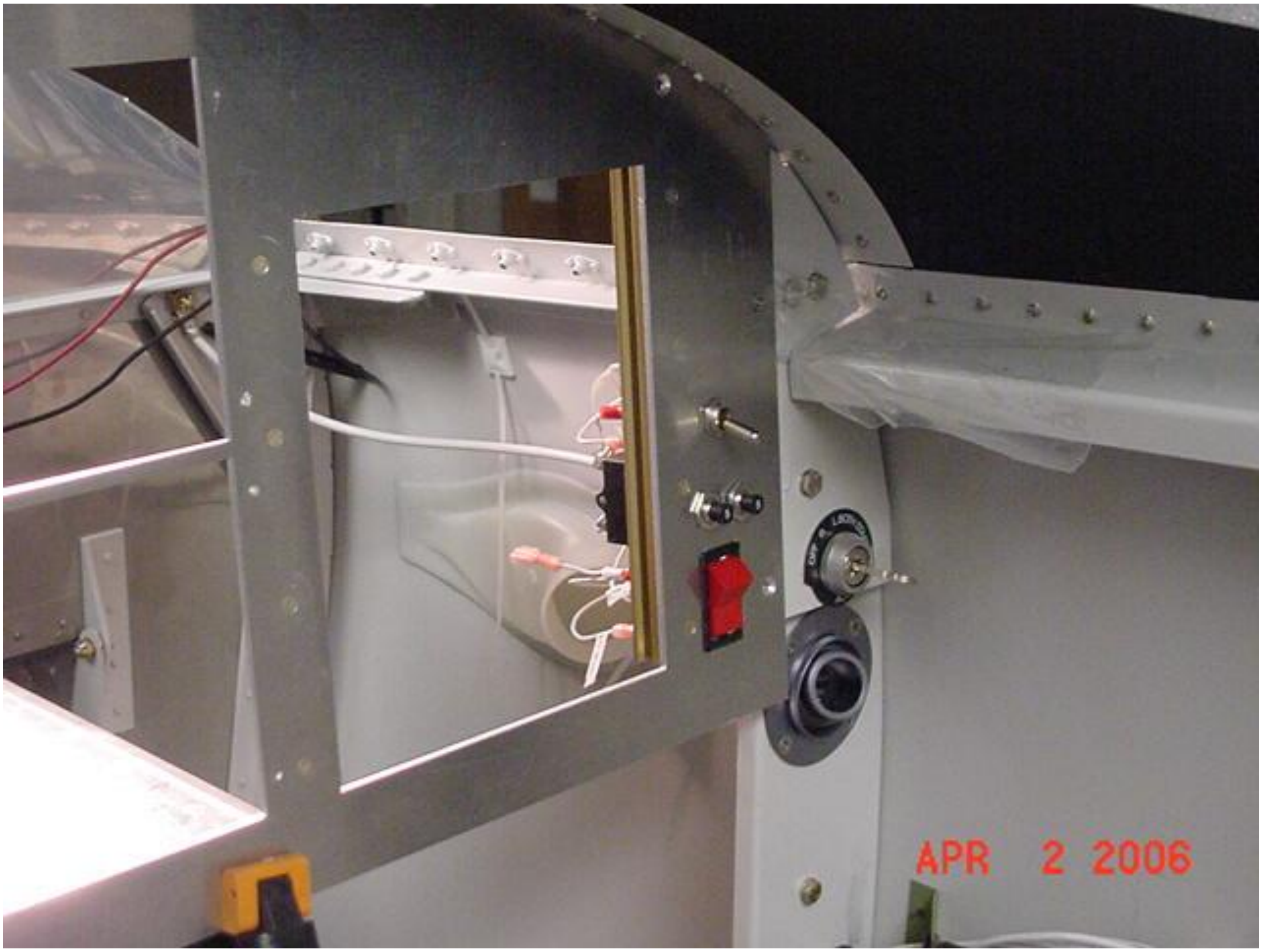
Getting confused? Me too. I'm still working on this system. Hopefully the wiring diagrams below can make some sense out of this thing. I think I'm getting closer to having a single switch alternate electrical source.


Normal Operations:
Primary Battery System
Alternator
Starter
Main Bus
E-Bus
1
2
BatteryLink
Isolator
Ignition 1
Ignition 2
EFIS AHRS
B-Bus
Primary Battery
Secondary Battery
Alternator Switch: ON
Master Swtich: ON
Primary Battery: ON
Secondary Battery: OFF
Isolator: Automatic
Alternator: Charging
Starter: Enabled


Alternator Failure:
Primary Battery System
Alternator
Starter
Main Bus
E-Bus
2
1
BatteryLink
Isolator
Ignition 1
Ignition 2
EFIS AHRS
B-Bus
Primary
Battery
Secondary
Battery
Alternator Switch: OFF
Master Swtich: ON
Primary Battery: ON
Secondary Battery: OFF
Isolator: Open (OFF)
Alternator: Failed
Starter: Enabled



After feeling confident that I had the alternate battery source and battery isolator concepts in hand, I went ahead and installed the ON-ON toggle in the instrument panel. I had to remake a couple of the wires because I put a pair of 5 amp breakers in the panel between the toggle and the master switch.



I could have spread the components out a little, but I wanted them in close proximity to the ignition and master switch. Also, you never know what might come along down the road. I still have a little room above the toggle to install a couple more switches, idiot lights or breakers.

Note that I finally riveted in the Radio Rax rails for my avionics. I'm not really even close to being ready to order the avionics, but I was tired of working around the clekos.

There is an alternate toggle switch diagram next to the split master wiring diagram farther down the page. I set the switch up so that when ALTERNATE (or SECONDARY) BATTERY is selected, the toggle switch, which is a DPDT ON-ON 20 amp switch, the BatteryLink ACR isolator is forced to disconnect the batteries by grounding out the isolator's switch.

<u>Battery Isolator</u>

Since I am planning on a dual Plasma III electronic ignition, I am installing backup battery alternate electrical system. Keep in mind, the "fail safe" built in to the Plasma III is that it will run all the way down to 5 volts. At 5 volts, nearly everything else in the ship has probably stopped working. But the engine keeps firing! And since the electronic ignition works down to such low voltage on such a low power draw, the theory is that you will run out of gas before you run out of electricity to continue to run the engine. Especially with two batteries to work with.

The backup battery might be good for many things, keeping the Plasma III system energized and thereby keeping the engine running in event of an alternator failure is just one. Back up power for the E-bus avionics is another. Also, having extra battery power if you forget and leave the master (with the primary battery) turned on and kill the primary battery is a nice thing if you need to start the engine. Especially if you are at some remote Podunk strip with no open facilities.

Well, I've purchased another Blue Sea item that has just come out for marine use that is used to charge and regulate two battery banks.

The CL-Series BatteryLink™ ACR (Current Limiting) is a battery isolator device with many features:

- Automatically combines battery banks during the charging cycle and isolates under discharge
- Activates from any charging source - alternators, battery chargers, or solar panels
- Senses charge voltages on up to two battery banks
- Meets SAE J1171 - External ignition protection requirements
- Noise free circuitry will not interfere with other devices
- Limits current flow allowing smaller wire size
- Low current draw when closed: <0.2A

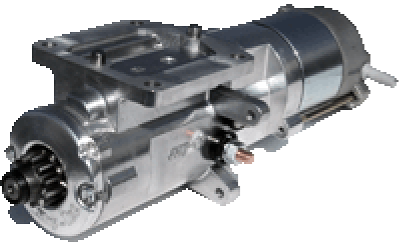
This device is not very complicated, small and light, allows you to reduce wire size, and the unit only costs about $80. Gotta like it! This thing is cool. It automatically shuts off if voltage is too high or too low (and you can set that limit!). It is fused and won't allow current spikes through to the second battery (the left side primary battery in my setup). It allows both batteries to charge to capacity from a single alternator. It has many functions and serves many purposes, the main function being to ISOATE the batteries in event of a charging system failure.

This battery isolator is really a Automatic Charging Relay, and it is not really to be used as a battery combiner for engine starting. But it CAN be used that way. The manufacturer does recommend a separate 1, both, 2 switch to cross feed the batteries when extra starting juice is needed and you want to crank the engine from both batteries.

NOTE: I actually mounted the unit upside down unlike this picture. That puts the "A" terminal of the unit on the left side of the ship, where the primary battery and solenoid are located.

The primary function of the BatteryLink is to charge two batteries through a single charging source. When it does this, it senses the charging and automatically closes it's relay and charges the second battery via the primary battery line (if there is sufficient output from the alternator or battery charger). When the ACR senses the voltage drop to about 13 volts (or the unit senses preset limits of under or over voltage), the relay on the ACR opens automatically and the two battery systems are then disconnected electronically and isolated from one, another. IOW, with the isolator relay opened, there are two separate (more or less) electrical battery systems.

When the relay opens, an idiot light from the unit shuts off, which tells you that the batteries are no longer combined. If the engine is running, and the batteries are not combined, there is a problem (or the BattteryLink is switched off manually).The GRT EFIS, will monitor the electrical system's condition and alert me to a problem, either with volts or amps. At this point, if there is an alternator or primary battery failure, or just an weak charging problem, I'll be alerted by the EFIS, then I get to choose which of the two systems to use for the E-bus and Main bus electrical feed. Each of the 2 LSE Plasma III electronic ignitions is powered by it's own battery line for safety. The engine will run fine on just one ignition (better than two mags!), but runs even better on both ignitions. You can shut one of the ignitions down by pulling the circuit breaker, or switch the key to conserve electricity. It might be desirable to shut one side down in flight to ensure that there is enough voltage output from one or the other battery to get safely to the ground. But since each ignition only consumes about 3 amps, and



the Odyssey batteries are rated at 17 ampere hours, and rarely fail, the likelihood for needing to shut off one of the ignitions is remote. The plane is likely to run out of fuel before it runs out of sufficient voltage to keep the engines turning. Again, especially with two batteries.

So, if there is a primary failure of the charging system in flight, but the batteries are good and strong, you might *not* want to turn anything off but the alternator (via master switch). There might be enough juice in both batteries to give you full function of everything for an entire flight with full fuel. Well, a daytime VFR flight, anyway. At night, I would probably shut off ALL of the lights and every non essential item until the very last minute. That's a judgment call. Perhaps at the last minute the primary system might be switched on to complete the flight with all systems operating. But with two 17 ampere hour batteries, you can run both ignitions and some avionics for a long time.

BTW, you can set up a backup alternate battery system without a battery isolator. I just found this unit to make the setup very simple, with options and conveniences that I thought were VERY cheap and effective.

Starter Solenoid and Starter

The Sky-Tec NL149 inline high torque starter is a bit heavier than the other models of Sky-Tec starters. However, it turns a bit slower (for high compression monster motors... 6.5:1 versus 4.3:1 ratio), perhaps as slow as OEM and maybe even a little slower. But, the starter uses less amps to turn over. The max voltage this baby uses is where their other starters begin to draw... 185 amps! The NL can use as little as 125 amps to crank an engine. That's a good thing. My electrical system (particularly the BatteryLink ACR isolater) can handle this load for very short durations in a snap without getting fried.

My engine has a slightly higher compression ratio than stock, so a high torque starter is a good thing. Also, then engine has dual electronic ignition, so it should be easier to start the engine, even if it doesn't crank as fast.

The Sky-Tec NL starters come from the factory without a dedicated starter solenoid on board, unlike their other starters. I understand that you can mod the starter to make the solenoid that IS on board the NL starter to function as a starter solenoid. But that change creates limitations on how you set up your start system in that you can't use the ACS key starter. So, I'll opt to take the starter as is from the factory and then go ahead and use the ACS rotary key starter switch and the starter solenoid as planned... the old fashioned way, which I already have installed.

I asked the fine folks at Sky-Tec about using 8 gauge wire for my starter. That's reasonable, considering my batteries are in front of my wing spars, not back in the baggage area. If they WERE back in the back, I'd probably be using 2 gauge Bogart cables. Anyway, Rich Chiappe of Sky-Tec fame was kind enough to put up with my rudimentary questions about the NL starter and wiring, and offered a link to his website and an explanation of wire sizing. It particularly related to starters, but looks familiar and the concepts are generally accepted aircraft practices. Rich told me that I should use a figure of 200 PEAK amps for the NL starter. All I had to do was keep that 200 figure in mind, then refer to the chart on his page that showed the acceptable size of wire to handle a load and 1/2 voltage drop per given wire length. The article then suggests that there could easily be another 1/2 volt drop induced by the solenoids. Simply stated, once you figure the length of wire needed from your battery to your starter, use the chart to figure out what gauge wire to use. You want to extrapolate to the next larger wire gauge. Then for safety sake, step up one wire size. Then perhaps step up one more wire size due to the extra 1/2 volt induced by the solenoids. Also, the article suggests not to forget that your supply wires are only as good as the ground wires. Don't forget that the starter (and all those other electric widgets) are only in the middle of the loop (circuit), and that the grounds have to be as good as the supply. So make sure your ground wires are as big as the supply wires.

Based on the information I am using, I could extrapolate to a 10 gauge wire, if I only have to go 5 feet. Then step up to an 8 for safety, then perhaps a 6 for additional induced voltage drop in the system. I already have 4 awg gauge wire to the start solenoid, and was contemplating replacing it with 8. Now I think I'll stick with what I know has worked for others.

The standard aircraft starter solenoid (contactor) is an intermittent duty Cole-Hersee model ES-24021. This unit looks very similar to the battery solenoid except that is has two small terminal 3/16 screws and the body case is Bakelite (or similar insulating material). The starter is normally open and when you switch *positive* current to the unit, the solenoid activates and current is passed from the battery terminal on one side to the starter terminal on the other. I had a little trouble figuring this unit out. There is a big "S" near one of the 3/16 post for "switch" and an "I" near the other, which stands for "illuminate" or "instrument" or just plain "idiot" light. When the solenoid is operated, current is passed to the "I" terminal so that you can hook up an idiot light. That's just in case your starter gets stuck in the "on" position.

**I could get by without this stand alone starter solenoid, but I installed it anyway. I am purchasing a Mattituck TMX IO540, and they come with a new Sky-Tec NL149 inline compact high torque starter. Some Sky-Tec's starters have an on-board in-line starter solenoid. The NL models have an onboard solenoid, but it is not used for starting. Having said that, a little fairy told me that you CAN modify these NL starters and use the onboard solenoid to use as a starter solenoid. The down side is that you cannot use an ACS rotary key switch with start features to operate the NL starter with the solenoid modified for starting. Bummer. But I understand that if you go by the gospel of Bob Nuckolls and use toggles and a push button, the NL starter will work well using it's own on board modified solenoid as a starter solenoid, and that the company will stand by the modified starter! Sweet!

I had a little problem when I was bench testing this little guy. It wouldn't work. Well, duh, no ground. So I clipped a ground from the metal housing (one of the "foot brackets") to the neg battery terminal. Then it worked just fine.

Originally, I was going to put the starter solenoid near the left side of the firewall. In the end, I mounted it on an extruded angle bracket on the right side firewall upright. Drilling the holes was a bit of a bitch with my crude tools, but I got it accomplished. The starter solenoid is just below the corner, as high up away from my feet as I could manage, and just below the brake fuid reservoir in the corner.

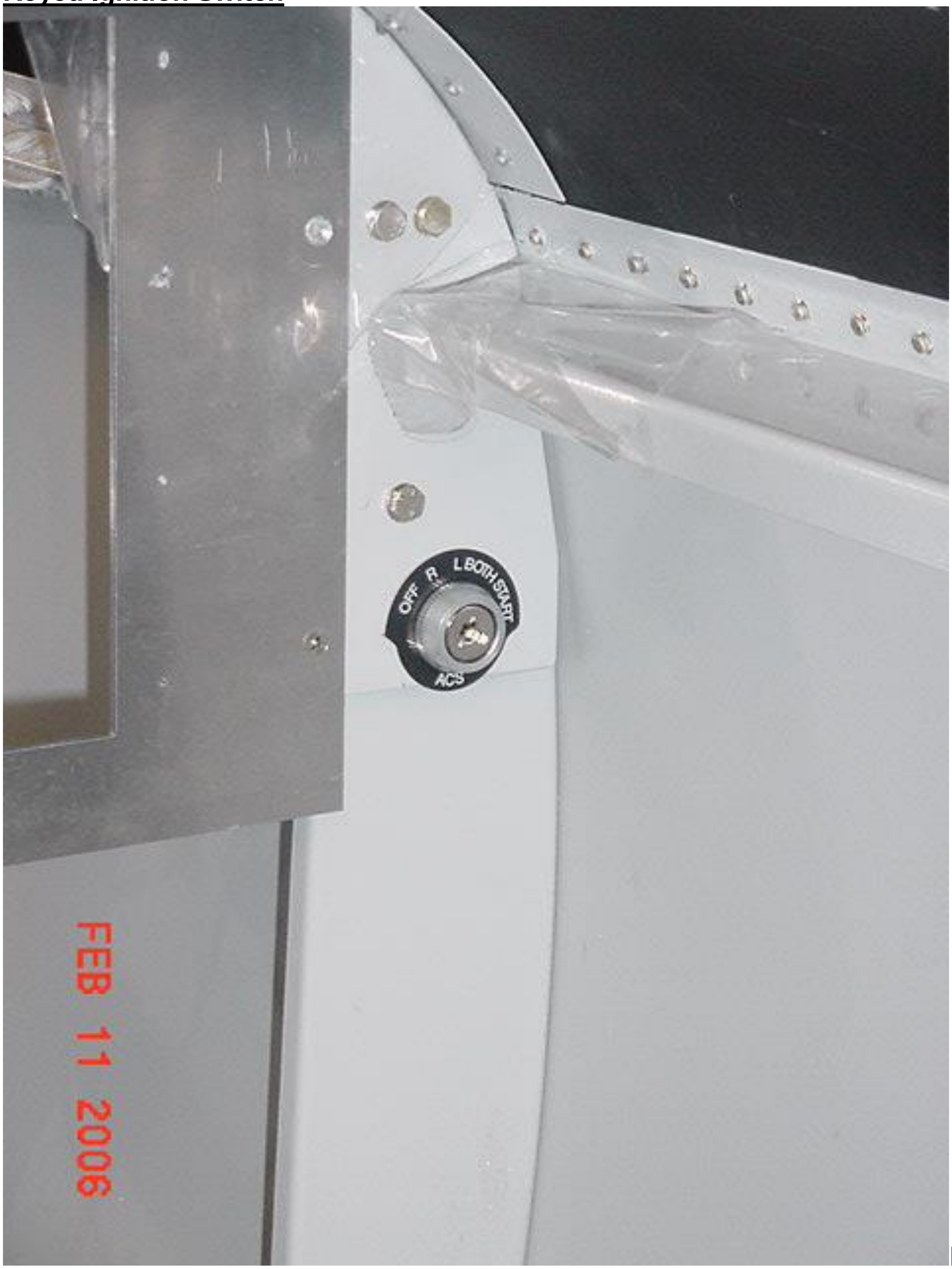
I used 4 AWG gauge wire for the 5/16 terminals on the starter (from the line side of the battery solenoid), but I'll use shielded 20 gauge wire to power the 3/16 "S" terminal (and ground the housing.. maybe). That wire will goes to the keyed starter switch I bought from Van's. I'm not sure I'll use the idiot light. If the GRT EFIS has a connection for it, I'll use it. I've never had a starter idiot (other than the pilot) on other planes and I don't really find this function all that important, especially with the newer generation of flyweight starters.

When used with my ACS keyed ignition switch, this starter solenoid requires a diode from the switch terminal to a ground at the screw/bolt base of the solenoid unit. The diode was included with the ignition set, and the diode was already assembled with the proper ring terminals and the sheathed wire at the proper length. The diode required for the ACS ignition was installed on the starter solenoid per the ignition switch manufacturer's plans.

The power supply wire for the starter solenoid is 4 AWG and comes from the supply side of the primary battery solenoid, not direct to my battery. The wire to the starter is also 4 AWG and has a simple grommet and stainless shield around it through the firewall. One note here: I put the shield and grommet on "the big wires" before crimping on the terminals.

The switch wire is a shielded 20 AWG wire from the ACS keyed ignition switch, as required by the ign switch instructions. The ground sheath is crimped with the ACS keyed ignition ground wire and the power supply wire (also shielded 20 AWG) ground sheath, all screwed to the ground terminal on the back of the keyed switch. The ground sheaths may not need to be attached or grounded.

Keyed Ignition Switch



I was having trouble finding a suitable place for my ACS A-510-2K keyed ignition switch and locks set. I didn't want it in the panel. I wanted it preferably on the right side. I wanted to be able to work the throttle with my left hand and use the key start with my right. Actually, with a dual LightSpeed Plasma III ignition, I don't think I'll really need to catch the engine with the left hand throttle, so I'll probably end up holding the stick back with my left hand to keep the tail down during engine start.

The key switch was going to go in the panel, but the base of the switch is so bulky, it was going to take up a LOT of space. The F1 panel isn't all that big, and finding an appropriate nook was necessary and troublesome. I was going to put it on the bulkhead at the right just below the instrument panel, but thought that I would probably try to stick an eyeball air vent there.

Finally, I was looking at the panel. Wondering what the hell I was going to do with that single open bolt hole between the other four AN3 bolts I was using. Hmmm... nope, can't fit it in there. I was looking at the back of the sub frame and just didn't like ANY location at all. Finally I checked out the area where the special angle shims are used to bolt the bottom of the instrument panel sub frame parts to the bulkhead. That looked like a great place.

Now comes the problem. I brain farted. The 7/8 inch threaded key barrel of the ignition switch was too short, and the base was too wide. I took the bolts out of the angles and removed the R4 shim. Thankfully, the switch placard covers the bolt holes perfectly. The switch sits in the panel at an angle due to the panel support structures, but I was able to work around that. I used my step drills from each side and went all the way up through the pilot hole to 7/8. Stuck the barrel through the hole. Drat, still not enough to make the knurled nut look right. Also, there was some concern about how much support the instrument panel was going to get.

I decided to cut the R4 shim into pieces and place it between the panels ABOVE the other thick aluminum part (which the ignition barrel now goes through). I trimmed two small pieces of the R4 shim, drilled out that tooling hole between the other support bolts, and used two opposing R4 shims there to support the panel. I put an AN3 -7 through there and bolted it up. It pulled the panel right back against the sup frame, worked beautifully. Between the single shimmed AN3 bolt and the steel barrel of the ignition switch, I think the right side of the instrument panel will be supported beautifully.

You can see in the pic that the bolt isn't exactly centered in the angle shim. Well, I can live with that. I actually used the original bolt holes I drilled in the shim, and then trimmed the part to fit.

What you cannot see is that there is a reverse twin sandwiched in between the panels directly behind the R4 shim (as TR planned, just not in the factory location). That squares up the panel, bolt, and nut so that everything fits flush.

Not so, for the ignition switch. It sits at an angle. How to remedy that? Well, you could shim between the panel and the body of the ignition switch. That's not too hard. I thought about gluing up a series of .032 sheet, or just mill down a nice thick piece of 1/8 aluminum. What I chose to do, was shave off the knurled nut that locks down the barrel to the face of the instrument panel. I had to grind down the nut anyway, because the barrel didn't fit far enough through the panel. I had to trim it back half way through the knurled half of the nut. So I just ground the nut at an angle.

Some things worth noting about this switch... First off, it requires shielded wire on all connections. 22 gauge is probably OK, but I'm going to use 20 gauge shielded individual wires. The instructions recommend grounding each wire to the airframe. I may bundle the shields together, put a ring terminal on them and ground them to the ground wire at the back of the ignition switch. Don't know yet whether that is Kosher or not, but makes sense to me. As long as it's a good ground, it should work (I guess), and a ground to the battery should be best.

This ACS ignition switch comes with a diode that you place on the starter contactor to protect the electrical system. The diode comes ready to install with the proper terminals sized to fit the common type starter solenoid.

The ignition switch power and starter wires are 20 AWG, with the ground sheath being crimped and combined to the 18 AWG ground wire. The power and ground go to the #1 position for pos and neg on the ST Fuse Block. A 5 amp ATC blade fuse is used for the ignition switch power.

Split Master Switch

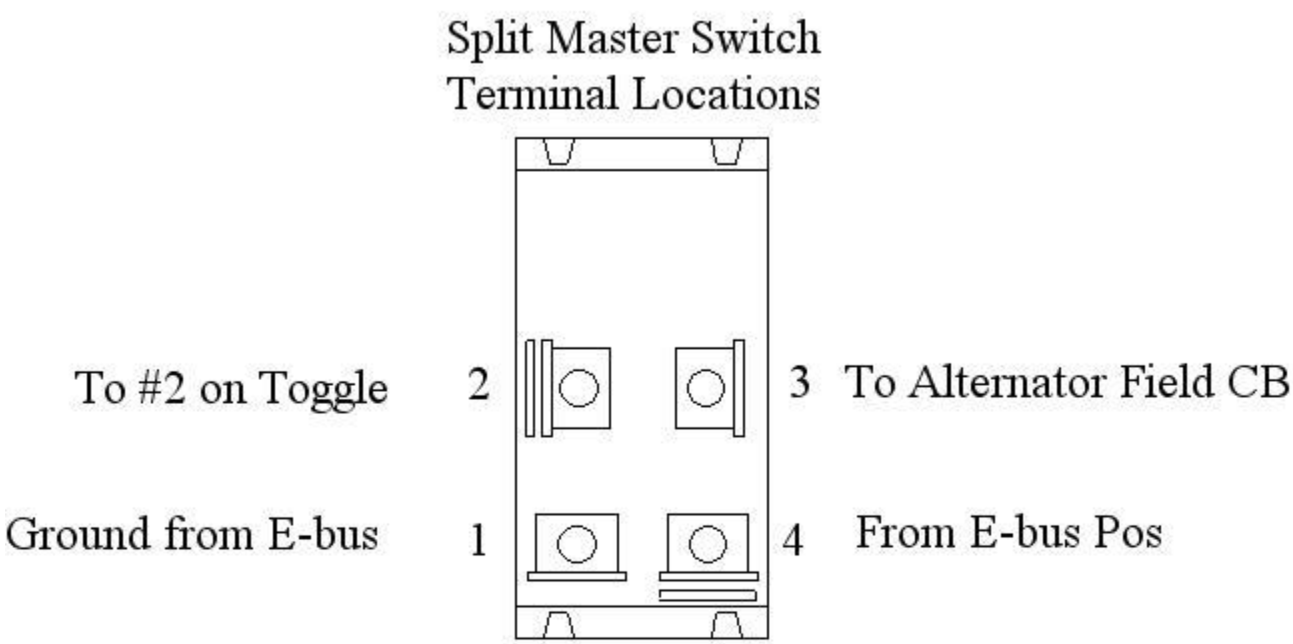
My buddy John Watler provided me with a Cessna style Carling S-1994-1-1 split rocker switch commonly used on aircraft. Don't tell Bob Nuckolls that I'm using it, he would be disappointed. I think his writings on the AeroElectric Connection have convinced me that we all need to be really careful with these switches. As I understand it, that is because if you turn off the alternator in flight at cruise RPM, and have a weak battery and electrical system, more than likely the surge created when you spool up the alternator juice again will fry some of your electric goodies. So 'Lectric Bob sez only shut off the alternator in flight if it is an emergency,a nd leave it off. If you need take it off line, you should not bring it back on line, at least not without operating like you have a parked, dormant plane (no, or low, rpm and everything electrical shut off). Or I suppose if you turn it back on, you should have everything going full blast to suck up the excessive electricity. Don't know about you, but I'll just try not to make this blunder. In order to NOT turn the alternator off in flight (without shutting off the battery too), Bob has actually recommended super gluing the two red rockers together. I think what I will do is just take a tiny sheet metal screw and screw the two rockers together. Bob Nuckolls recommends a pull-able breaker for use if you absolutely have to take the alternator off line in flight.

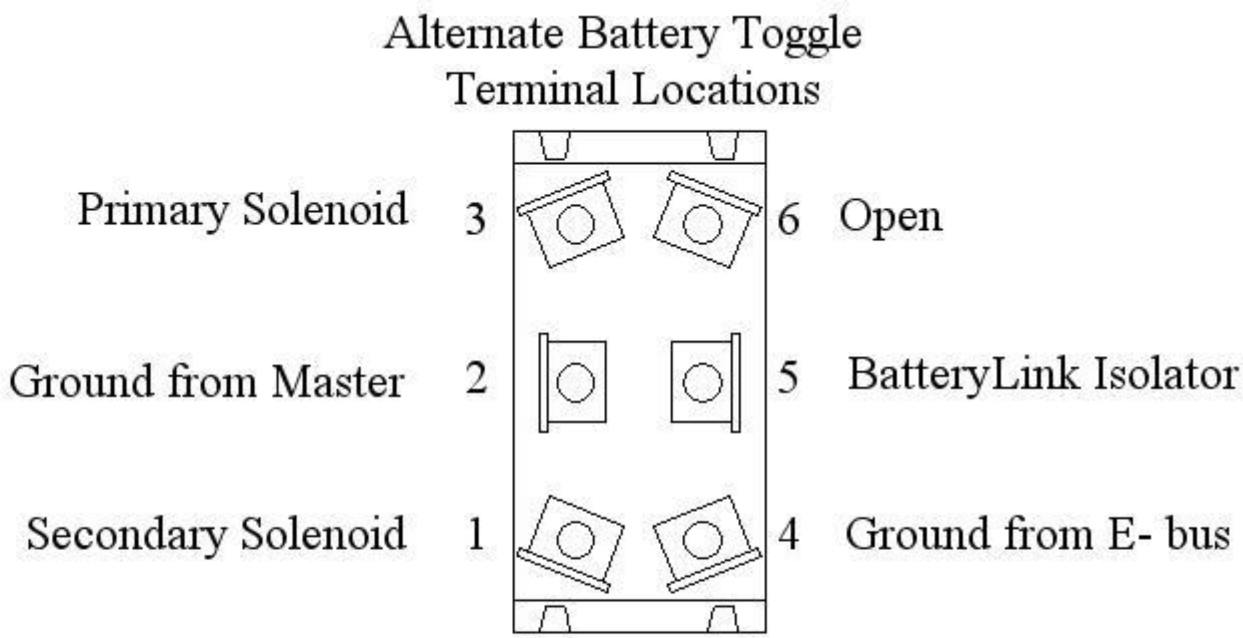
Since John was kind enough to provide the switch (and laser cut my instrument panel), I figured the least I could do is use the darn thing. Unfortunately, the switch has no instructions or wiring diagram. After a web search, even Carling doesn't have that information on their website, so I emailed them about how to wire it. They were clueless and said they had no idea how Cessna had them set up this switch. It's not all that complicated, but it took a little bit of trial and error to figure out which connection goes where.

For the rest of you, Bob Nuckolls would prefer that you just use a single rocker with double poles that always turns both battery and alternator on and off at the same time. I may modify the switch to operate that way, but it will have the traditional "split look" that's been all the rage since the 60's. I'm just used to that kind of switch, and I think I will be less likely to forget to shut it off.

I chose to put the split master in my panel. There was a small area just to the left of the keyed ignition switch, so I put the master there where it would be handy. I also put a couple related battery and ignition breakers up the panel's left side above the master switch.

The supply wires for the battery split master switch are 18 AWG and go from the primary battery solenoid supply to the right side of the switch, through the Alternate Battery ON ON switch, then to the #2 ground terminal on the ST Fuse Block.



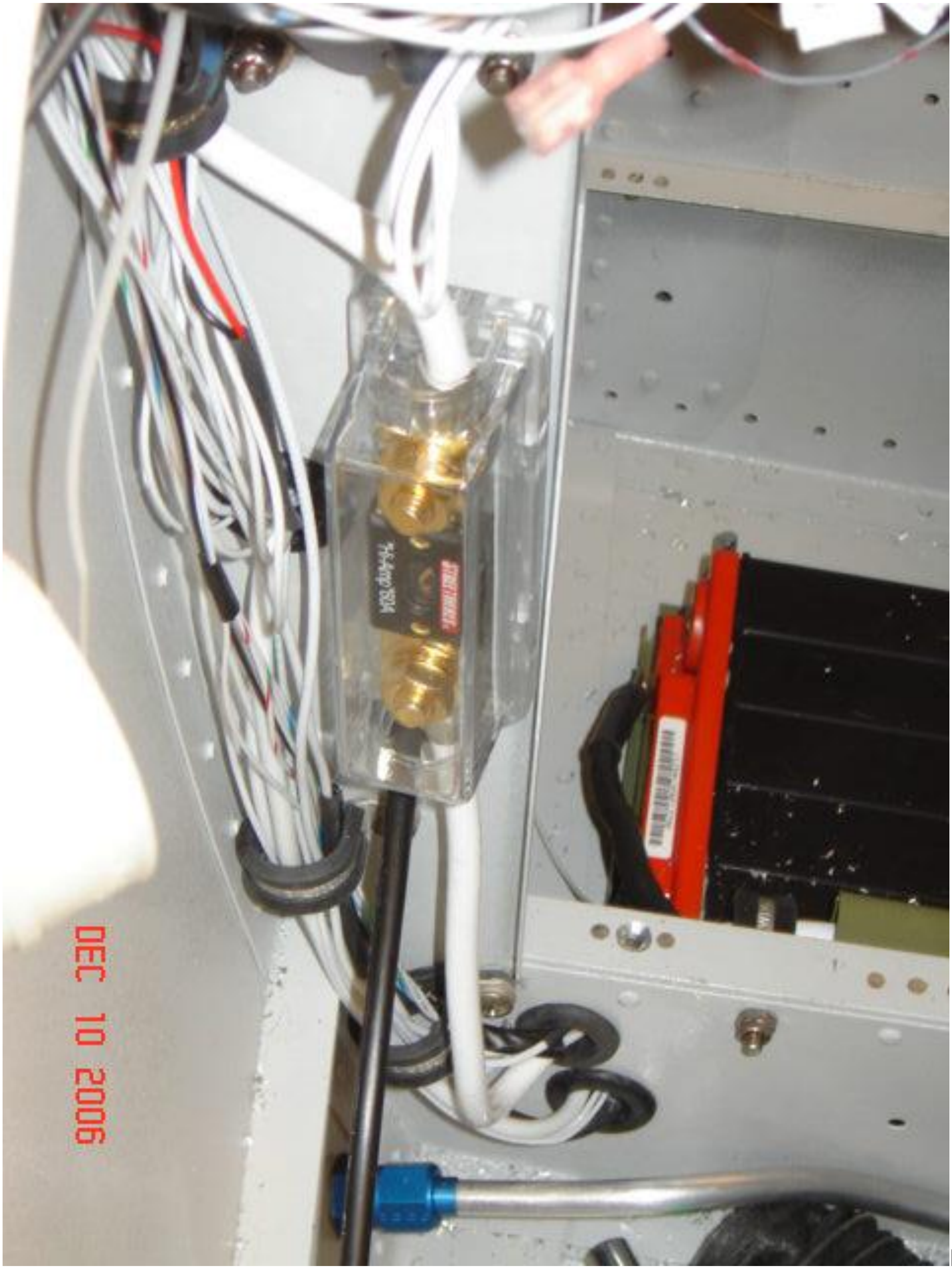


Alternator Protection and Field Breaker

I'm not sure exactly what kind of alternator my TMX-IO-540 has. Supposedly it is 55 amp output, internally regulated, and manufactured by Mitsubishi. Other than that, I have no idea what I'm getting. So, I haven't really been able to get much alternator wiring completed in advance. In the mean time, I did install a Cessna style split master and have it up and running for battery power. On the alternator side, I'm really at a loss on how to wire it. I've searched the net and looked at many wiring diagrams.

I have learned a few things. What most of you know is that it takes a little bit of battery power (about 2+ amps) to excite the alternator "field" to get it to start charging the electrical system (actually reverse the chemical processes in the battery). Once the engine is turning after the alternator has been excited, the field makes it's own required 2 amps (and then some) to sustain operation and propagate alternator output to the ship.

At this point, I'm contemplating not using a separate pullable breaker for the 5 amp alternator field, I'm just going to blade fuse it, at the ST Fuse block. I was concerned about putting the fuse after the switch, but I think the switch is rated 10 amps, so the fast acting 5 amp fuse is probably going to fry before either the switch or the 18 AWG wire. I will probably use a fusible link.



In the mean time, I purchased a 60 amp pop up breaker from Wicks. *I didn't use it*. Instead, I used a 60 amp ANL fuse and holder. If the alternator or internal regulator goes a little wonky, with an ANL fuse I won't get nuisance trips. If the alternator goes hog wild, well, the ANL fuse will burn through and I won't have cause to reset it in flight.

The pic shows the clear plastic holder, and you can see the 9/16 gold nuts that hold the Streetwise ANL-60 fuse (made for those booming audio systems). I drilled a new hole (AN3 bolt) and set the holder just above the rudder cable on the forward side of the right #2 bulkhead.

Since the single "power wire" goes to the starter solenoid at the firewall, then the starter wire and alternator "B-Lead" immediately go through the firewall, there wasn't a convenient place to protect the alternator by itself after the solenoid. So both the starter and alterntor are protected by the 60 amp ANL circuit protector. That doesn't really do much for the starter, but it doesn't really hurt anything either. As suggested by another builder, having just one big fat wire going to the firewall makes more sense than two (for each the alt and start). Less weight, less cost, less chances for (unlikely) failure. And when the starter is turning the alternator isn't working, and vice versa.

ANL Current Limiter

For the Alternator line (B-lead), I chose to use an ANL current limiter (fuse). 'Lectric Bob recommends that IF you want to try to protect the ship's electrical system from a catastrophic alternator power surge (extremely unlikely), you can place an ANL fuse inline on the B-lead toward the battery end. In my case, the B-lead will only go to the primary battery, not the secondary.

I placed the ANL fuse holder and a 60 amp ANL fuse between the alternator B-lead and the battery. I bought the Streetwise 60 amp ANL fuse and the "wafer fuse holder" on Amazon. com for about $24 shipped.

My ship will have the B-lead go from a battery, through the ANL fuse to the BAT terminal on the starter solenoid. Then a separate 4 AWG wire will go from there through the firewall to the alternator. If the ANL fuse never gets a chance to protect the ship's electrical power, at least I will have a simple way to disable the plane, just take the ANL fuse out, kind of like a key.

Fusible Link

I asked Mark Frederick about circuit protection and how to hook up the alternator. His response, and similarly from others, was that nothing will shut off an alternator and protect the system better than a fusible link. I wasn't even sure what a fusible link was, so I did a little research. Mark recommended an "automotive specific" fusible link, but did not offer anything other than to say "Honda". Auto parts stores sells fusible links in various sizes.

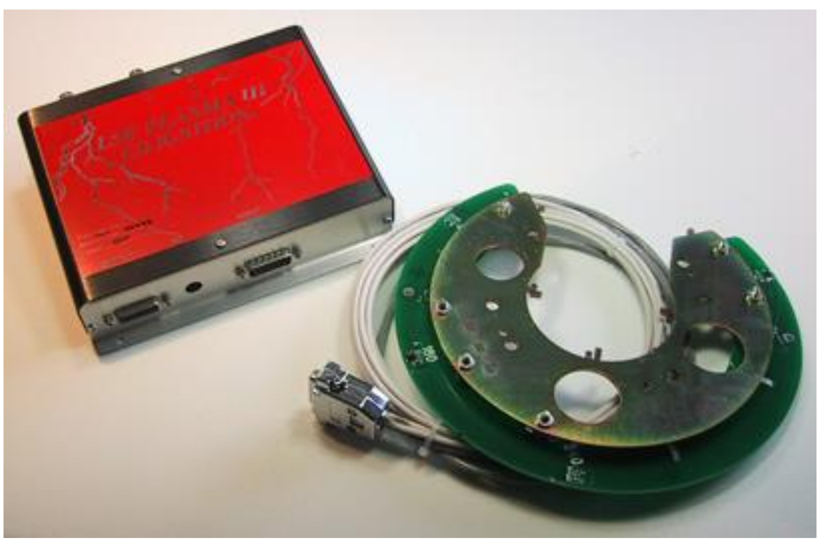
An interesting tidbit on circuit protection from Bob Nuckolls, copied from an email response on the AeroElectric Digest:

"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 the 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."

Lightweight electrical systems are described by Bob Nuckolls in "appendix Z", and a comic book on how to make a fusible link is described on the AeroElectric Connection. It looks as though the alternator circuit breaker plan may be trashed and a fusible link crimped inline just off of the battery terminal on the alternator b-lead. Now we're getting somewhere!

Another item that I find interesting is that a fusible link can be created by installing a wire that is 4 AWG steps smaller than the wire it is protecting. Very common would be a 22 AWG link to protect an 18 AWG wire run, or a 24 AWG link to protect a 20 gauge wire. Now I just need to figure out what size to use for an alternator B-lead. Seems those wires are about 4 or 8, 8 being my preferred choice since I already have 12 AWG wire, and no splices large enough for a #4 wire.

I ordered a few little items from B&C Specialty. My order included a little fusible link kit. Now if I feel I need a little added protection on some wires in the 18 - 20 gauge range, I have the means to fabricate four fusible links. I don't think this fusible link kit is appropriate for a 4 gauge B-lead.



Electronic Ignition

I ordered my TMX IO-540 with a dual LightSpeed Plasma III ignition. Mattituck offers no details on how they plan to install, set up and deliver the engine with the ignition pre-installed and the engine test run. They do, however, build hundreds of engines every year, and I'm sure they know what they are doing. So what I have to do, it be prepared to install the electronic controller(s) and wire up the units to my electrical system after I hang the engine.

Dual electronic ignitions offers improved performance over magnetos, but at a potential cost. Magnetos generate their own spark without battery power. The Plasma III has to have a battery source and at least 5 volts to keep it running (6.5 volts at start up). If a wire breaks, or the alternator quits and the juice runs out, the engine stops.

The LSE Plasma III is engineered so that it operates down in a voltage range where other electrical gadgets won't operate. The idea is that the electronic ignition is the last thing to go, voltage-wise. Since it operates on only 5 volts (at around 3 amper hours when the battery is at about 13 volts) you probably will run out of fuel before the battery(s) actually give out. In hopes to increase the likelyhood for this scenario to never gets a chance to happen, the safe money is on putting a back up power source (battery in my case) in the electrical system, and run two ignition systems independently from separate sources.

The Plasma III installation manual recommends a 5 amp pullable breaker. I bought two 5 amp pullable breakers, and drilled them into the panel just above the split master. That puts them close to the split master and ignition switch where you might logically want to find them. I have just enough room in the panel above the split master to stack the pullable breakers on the instrument panel.

Since I have a rotary key ignition switch, I have to change the way I wire the key unit and the Plasma control unit. You wire the Plasma control units direct to the battery, with shielded #18 single conductor wire. No multiple conductor cables here, each of these wires have to ALL be individually shielded single conductor wires. And the ground braids have to be attached at both ends

For the rotary key switch, the Plasma III controllers have a separate D-sub connector that you have to solder in a sort of ''P-lead'. That grounded shield wire goes from the CDI units (Plasma III controllers) and the center conductor attaches to the L and R terminals of the rotary switch (terminals 1 & 2). The shield is grounded to the ground terminal (#5) in the middle of the ACS key switch).

I'm trying to prepare the ship for the arrival of my engine. It's hard to stay ahead when you don't have all the parts in hand. All I can do is read and try to get a couple simple things ready in advance. The Plasma III looks a little complicated to get too far ahead. More when the engine and ignition is on the mount....

My engine is assembled and ready to ship from Mattituck, NY., so I decided to proceeded a little farther in preparation of getting the Plasma III in hand. I decided to use two 5 amp pullable circuit breakers in the panel above the master switch.

I wanted the breakers to be nearby in case I needed to shut them off. Also, all the switches over on my right are different types and it would be hard to get confused and switch the wrong thing.

Of course the idea of putting the breakers side by side was to correspond with left and right ignitions. Although in reality, the ignitions are usually set up on the engine to be top and bottom. But the designation of R and L still exist and that's the conscript I will adhere to.

Now I just need the actual Electronic Ignition controllers in hand to begin the wiring. The Plasma III uses shielded wire everywhere, and ideally, the trick would be to make the wire runs with one continuous grounding sheath (braid) on each wire. I've had to splice them in the past, which is no big deal, but I'm going to see if I can make them continuous this time.

Elevator Trim Servo

The F1 kit comes with a Ray Allen T3 electric elevator trim servo. Unfortunately, there's no wire, relays, switches, or speed modules with the kit. I went ahead and bought those additional parts direct from Ray Allen (and Aircraft Spruce).

The trim servo goes in front of the trim tab in the bottom of the left elevator. You have to route the wiring from there, over the HS, and into the empennage, then up to the control stick bays in the front of the cabin. I put in corrugated plastic conduit from the last bay of the emp all the way to the stick bays. That makes the runs easier. The conduit will also be used to run any additional wires for the tail light, tail strobe and possibly a VF bullet cam.

The trim servo has 5 very small wires. I think I will need at least two connections, one in the trim tab and one in the tail. At the forward end, all the wires will get ring terminals and be fastened to a terminal strip located in the front stick bay. The loose ends of the wires need some type of connector that may occasionally be separated. I think I will get a Dsub mini connector or an interlocking connector with crimpable pins. It could end up being a soldering job, but I'll just have to see what is available. I have done both soldered and crimped pins before, so either isn't really a problem.

I decided to use a 5 pin MOLEX plug. I bought several pairs at the local Electronics Depot. They aren't that great, but they'll do. I'm glad I bought the Ray Allen 5 wire cable from them specifically for this job. Also, I ordered a Ray Allen relay deck to turn my up and down hat switches on my grips to properly operate the servo. I also bought a second relay deck just in case I ever put aileron trim on the plane, or have use for similar switching. The relays are only rated at 1 amp, so they aren't going to power anything major. The relay decks may end up switching two wires that have typical relay blocks (automotive type) so that there is adequate protection of the wires and components.

I crimped on my Molex plugs to the short T3 servo pigtail with some shrink wrap around the bundle. I cut about 3 feet of 5 wire cable and ran it though the tooling hole near the TE of the trim tab. I figured that heck, the servo is right next to the hole, and why bother drilling another hole, I'll just use what's there. So the wire run will go from the tooling hole along the inner lower edge of the elevator rib, back to the rear of the elevator pivot tube and down into the empennage deck. I am going to leave a lot of slack and I will attach another Molex locking plug connector at or under the empennage deck. Then I'll run another run of cable through the light blue corrugated conduit that I ran from the tail spring bay all the way up to the stick bay, and that will terminate with ring terminals at a long terminal strip.

Control Stick Grips

I bought a CH Products control stick grip a long time ago for the front (pilot) seat. I am going to go ahead and use it (for now), but it feels a lot like a gaming grip with very small buttons that have very short throws and very light feel. Neither is that good when you are getting bounced around in the air. But it's paid for, so I'm putting it in (maybe). I can always move it to the back seat and get a different grip for the front.

The CH grip has 8 functions. The wiring is 22 gauge. There are 11 wires, so I am going to need a large terminal block or a terminal strip. Since I am not sure that I am going to like the grip, and I may change it out, I want to be able to pull the grip and all the wires out. I can't just change the aluminum tube, because I am running the wires out the bottom of the aluminum tube through the steel stick tube receptacle. So I have decided that what I will try to do is use a terminal strip with very small screws and ring connectors. In order to aid removal and the placement of the terminal strip out of the way in the bay, each wire will be cut to a different length. The idea of a terminal strip will also make hooking in the lesser wiring from the rear seat stick fairly easy. I'll be labeling all the wires along the way with my portable label making machine which I bought at Staples.

The switches on this grip are not particularly heavy duty. They are only rated at like 50 mA for 24 volts. So use of a relay is in order on most of these hookups. I don't pretend to understand electricals, but I'm going to be very careful with what loads go to these switches. I was going to use the left and right buttons for flaps, the hat for trim, the trigger for PTT, and the index button for either flip flop on channels or autopilot on and off. I think in order to accomplish these things, I may need to use multiple relays. That's going to be a pain in the ass. More time and cost, and more chances for equipment failure. I may end up dumping this grip and getting a more traditional heavy duty grip like the $150 B8 grip that Spruce sells, which has switches rated at 30 amps!!!!

For the rear seat, I bought a Ray Allen G101 single button push to talk foam grip. Nothing fancy, to be sure. Comes unassembled. I pitched out the short 24 ga wires and used my milspec 22 gauge. I'm going to leave a loop inside the stick and then put faston terminals just outside the stick. That way, I can just disconnect the two wires from the stick and remove the tube and grip fairly easily.

I don't think the rear seat copilot is ever going to get a chance to land. If they do, either the pilot will operate the flaps, or the copilot just won't get to use any. With the EVO wings, you can get by pretty well without them, even in a pinch.

Relay Deck

Even if I change grips, I will still need to wire in a Ray Allen relay deck to change the hat button action to work the elevator trim. The reason you need one of these is that the motor on the servo is operated and reversed by reversing the polarity of the current. Neg/Pos runs one direction, Pos/Neg runs the other. So the relay deck changes the momentary switch into an electrical reverser.

I also purchased a relay deck for the flap motor wiring, which operates by the same electrical reversal.

The pic of the REL-1 and the SPD-1 modules are a little deceiving. They both have a scad of color coded wires dangling out from their little black bodies. That's not a bad thing. I thought perhaps you had to plug into them, or open them and insert wires. Nah, just crimp connectors on them and move on.

Servo Speed Control

A few builders have noted that in cruise it would be best if the elevator servos were slowed down so you could get smaller increments of change. At the other end of the spectrum, in the landing pattern, having the servos moving as fast as they will go, to help offset the pitch change due to the flaps is very helpful.

You can get a Ray Allen speed control module and adjust how slow the servo operates. You can even switch it on or off. That way you either get your choice of slow or full tilt boogey. I purchased one of these little guys, and will install it, but don't know if I'll use it. I'm not sure I have an extra switch open on the grip for it, perhaps I'll use the right hat to turn it on and off, since I don't plan on having aileron trim.

I ended up stacking these two relays pictured above and wiring them together to use to power my trim servo. I found a wiring diagram online to wire my CH
Products stick grip to BOTH relays and put a Speed Deck relay cut off toggle switch.

In cruise, very minute trim changes are required. When landing and lowering the flaps, big and fast trim changes are required. I put a SPDT toggle between the Speed Deck and the Relay Deck. Now I can switch between full speed on the servo, or use the speed relay and adust the servo speed down to reduce the amount of movement in cruise. Nice!

The two relays shown above are stacked together and wired together on top of the "Bow Tie Bracket" that I made in the stick bay. The relays are protected by a 1 amp fuse on the E-Bus and the wiring is milspec #22.

ELT Cable and Annunciator

My ACK Model E-01 ELT is sitting where builders of the standard F1 model put their battery. It is on the left side of the ship back behind the baggage compartment in the empennage. My battery is going under my left knee in front of the CG. So I only need ONE tray behind the baggage area, and the ELT is already fastened to it.

The ELT comes with "phone cord" and that will run forward to the Annunciator in the panel. Just as easy to run it on the floor with all the other rear electricals. The ELT cable is just a typical residential telephone cable. It has the normal telephone ends on it. What you get for the cable run to the annunciator is essentially a telephone extension chord. Nothing wrong with that at all. Should make life fairly easy.

Only problem I had was getting the RJ-11 type phone plug going through my plastic conduit along the floor. It wasn't too bad. But the cable is very flexible and the plastic plug is rather bulky. Glad I didn't already have a mess of wires in the conduit.

I just took my dremel and did surgery on the conduit to create an access for the phone cable.

What you see in the pic is not the final arrangement of the ELT end of the cable, it's just set in there until I can figure out how I'm going to run the wires from the end of the conduit in the footwell bay up front to the instrument panel. Once I start running wires up front, I'll support and secure the cable and the conduit.

I did not have a location cut in my panel for the ELT annunciator. I thought that I would leave it out until I installed all the avionics, then see where there is room for it. Eventually, I just put it in line with and over the top of the Garmin stack. There just wasn't room top dead center in the instrument panel. It may look a little awkward where I put it, but it WILL be conspicuous.

Don't forget that not only does the ACK main unit take 8 D cell batteries (ONLY Duracell MN 1300 approved), but the annunciator also take a 6 volt cameral battery. If you use the specified lithium cell in the annunciator, it is good for 7 years, and a regular alkalyne battery is good for 4 years. I found the alkalyne battery at Walmart, so that's what I bought. Nice to know that I can get a replacement just about anywhere that has a camera department.

Tail Light

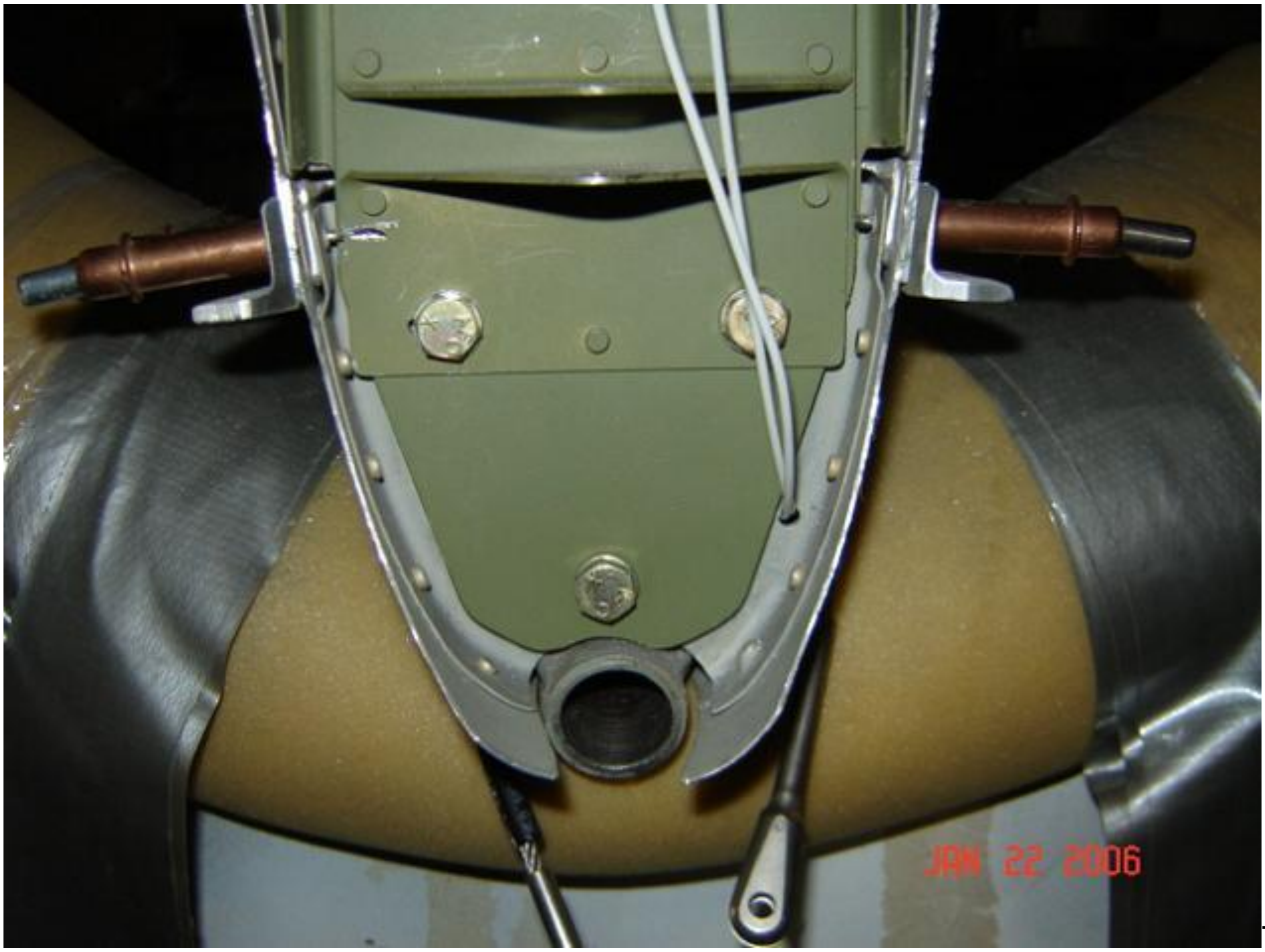
I was going to get a tail strobe, but decided to be cheap. I also thought that I'd save all those flying behind me, which will be about everyone, the strobe flash in their eyes. HAH! So I ordered the Whelen A555AV14 from Spruce for about $90. It is the horizontal mount "Grimes" type 25 watt incandescent tail light. It consumes 2 amps @ 14vdc, so according to my table above, I only need to use 22 gauge wire. I have 22 gauge wire, but chose to use 18 gauge milspec wire.

The wire run is from the lower rudder fairing through the #12 bulkhead. The negative ground wire will terminate at a grounding terminal strip up near the battery, and the positive power wire will go straight to the W51 Rocker Breaker in the instrument panel.

I drilled a hole big enough for 4 #18 sized wires next to the VF down at the lower right of the tail spring weldment. Behind the scenes in the pic below, the wires do not go THROUGH the tail spring weldment, but between the weldment and the side skin. There is a small area between the weldment and the skin just large enough to allow the wires to pass though easily.

Depending on what kind of pigtail comes with the light, if any, I may try to use spade connectors at the light. I'll know more when I get the part. However I run the wire, the only break will be at the light pigtail. I will leave a loop of wire in the tail spring bay "just in case".

All the wire I'm using in my Rocket is aircraft mil spec multi strand wire. I bought some in bulk at OSH and SNF, and ordered some from SteinAir and Wicks as well. I decided to run two each 18 gauge wires back through the emp and out the tail bulkhead for the tail light.



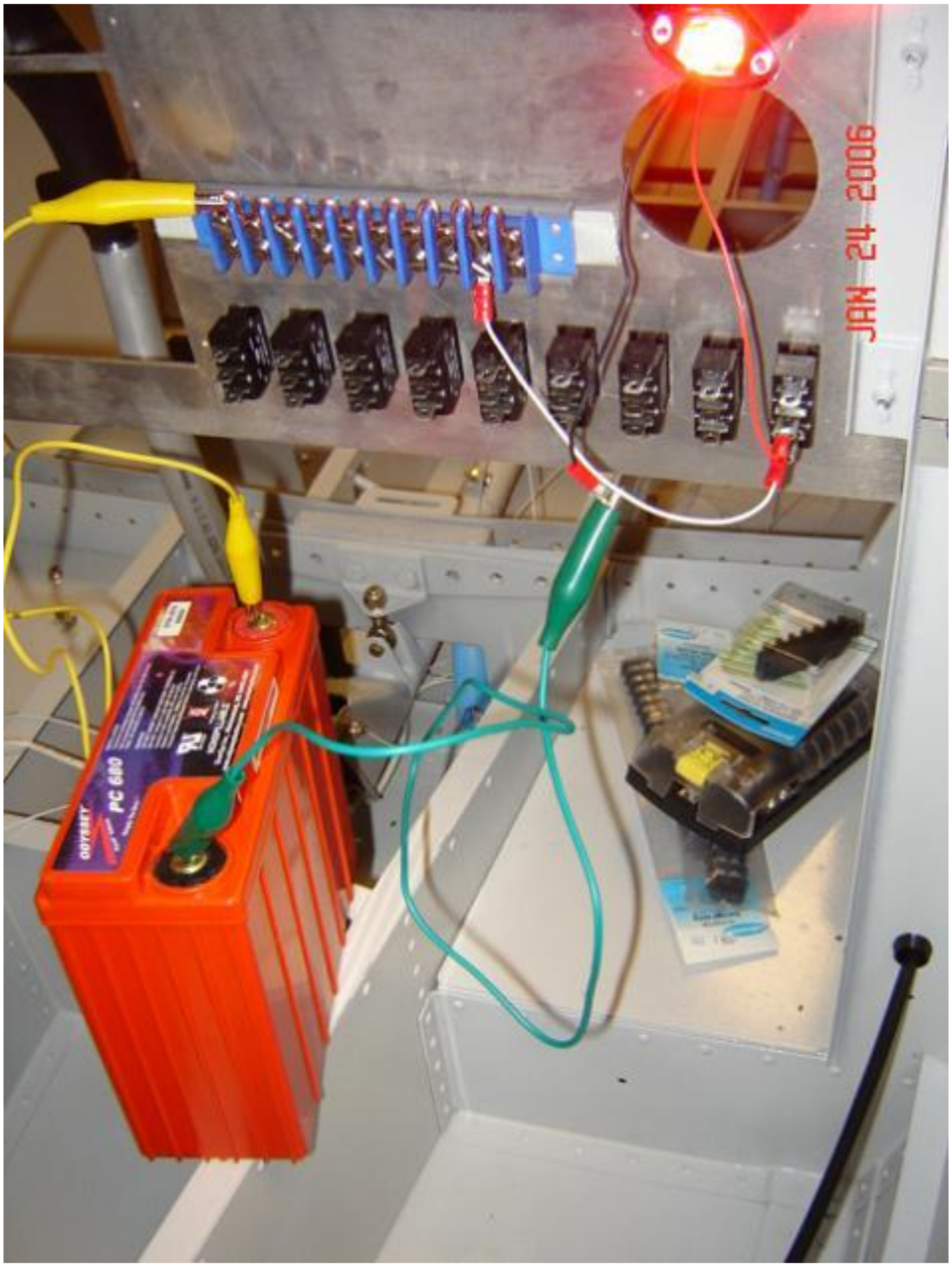
This location allows you to take the wire directly into the lower rudder fairing. I could either go straight through, or loop up and over the lip below the bottom rudder bracket.

The A555 light comes with a funky connector, but they also give you a mating pigtail. I'm just going to crimp a splice connector onto the pigtail. The connector and

W51 Instrument Panel Rocker Breakers

I purchased many Tyco W51 Rocker Breakers for my instrument panel. They are made to be a switch, not just a breaker pretending to be a switch. They are illuminated and can handle 50vdc. Much to my chagrin, I've found that 12vdc is not enough to light the neon in the rockers that I have in stock. After a couple emails to Tyco (Potter Brumfield) I finally found out that I have the wrong model rocker. I tried to re-order the correct rocker model that lights for vdc current, but NO ONE sells them. So I am stuck with the unlit W51's or I have to change plans.

The W51's snap into the instrument panel beautifully. They have 3 fast on .250 blade connectors on the back. I snapped the entire row of breakers in the panel just for ooooh and aaaaahs and then set my battery in to play. Also, to start getting an idea of how to organize the terminal strips (that I'm using as bus bars). I'm going to need a lot of room for terminal strips, and I'm trying to stay away from the area above the switches in the panel just in case I was to put instruments or a glove box in there.



The terminal strip is just taped up there. In the end I'm going to make a shelf on the sidewall of the bay just under the boot cowl halve. I need a rack for a main bus and a ground strip. Then near the battery, I'm going to need the same thing. And then additionally, I'm going to put in a Blue Sea fuse panel for the accessories. Organizing the wiring layout is going to take some time and thought.

Unfortunately I ordered the wrong rocker breakers from Mouser.com a long time ago. What I have are 125 vac rockers and I need the 50vdc rocker breakers if I want lighted switches. Man, those babies are impossible to come by. Took me a week of emailing just to find out that I had the wrong product and then another to find that the correct model was even "available". Regrettably, there are no 20 amp rocker breakers in the 50 vdc series, only -5, -10, and -15. The correct part numbers are: W51-ABA3B2-5, -10, -15. There are also cross overt numbers available through other vendors, and those numbers are: 7-1423673-0, 7-1423673-1 ,7-1423673-2 . No one seemed to want to use the cross over numbers, no one had the DC rockers in their catalog, and only a couple companies were even interested in trying to get a price and order them for me.

I did find one company using a bastardized version of the cross over numbers, but they require me to order a minimum of 200 pieces of each size before they special order the rockers. Don't think so.

The latest news is that NO ONE that I have contacted has the correct W51 rockers in 50vdc in stock. I finally had to ask TYCO for sales records of who they may have sold them to (if anyone at all) just so I can find SOMEONE who is willing to sell me the correct part. Oh, I CAN buy the rockers, but I've been told by a couple companies that I have to buy 200 of each size, and I can expect a 50 day wait for them to be produced. That would be $2300 and 2 months wait. I don't think I want to try to unload that kind of inventory on eBay. Sheesh, wish I would have paid more attention to this foul up a year ago when I started planning the panel this way. I may have to just install a row of rockers with separate breakers or fuses after all. Drat.

The good news and not so good news. I can use the W51's I have, but they just won't illuminate. So the decision is whether or not to use what I have, and just skip wiring the #3 tang for the light, or jump to a different program. I have found other rocker breakers, but the same problems applies - no one sells them in small quantities at 50vdc rating... there just isn't a market for them. Aircraft Spruce sells an unlit rocker switch that will go right in the panel cut outs, so I can do that, but I'm no better off. I can get lighted rockers, but I'd have to either dremel the crap out of the panel or have a new one burned. Crap. Best laid plans and all that.... OK, I'm going with the W51's that I have. They'll just be unlighted.

I'm happy to report that I screwed up some wiring when installing some of the "aux gauges" to the EFIS. I reversed polarity when I changed the orientation of the Main Dualbus in the left boot cowl. Anyway, the point of this confession is that I had an opportunity to do a basic test of the rocker breakers. They certainly do their job! Good to know that they will help keep the smoke in the wires where it belongs.

<u>TruTrak Autopilot Servos</u>

The <u>TruTrak</u> Autopilot (TT AP) pitch servo is back by the ELT at the elevator bell crank. I almost forgot about needing to wire it. And it needs a BUNCH of wires.

When you purchase the servos from TruTrak, you get a kit of 9 pin and 25 pin connectors, but no wire. The electrical hook up is fairly simple to the servos, all you have to do is run 7 or 8 wires to the 9 pin connector and solder the 20 to 24 gauge wires in. That was a fun little project.

I ball parked where my pitch (elevator) servo wires were going to run, cut off 8 strands of #20 wire to approx length and striped and soldered in the ends. Per the instructions, you only need 2 each (power and ground) #20's on the 9 pin connector, and the rest of the wires can be #24. I didn't have any 22 or 24 gauge, so I just ran #20. That makes the bundle heavier and thicker, but what the heck. I was able to get it the 8 wires (one pin is not used on the pitch servo) to the stick bay, and it's what I had on hand. #20 is also easier to crimp onto ring terminals (but it barely fits the solder pins on the connector).

My electrical and avionics plan uses several terminal strips. For the auto pilot and trim servos and the control sticks, the terminal strips will locate in the forward stick bay. That's going to be a lot of terminals, but I'm not sure at this point exactly where the TT AP head is going to locate. So the idea is to put an 8 or 10 terminal strips into the stick bay. Then later, way down the road when I actually have my TT AP head in hand, the wire run for the 25 pin connector should be pretty easy. Not an ideal situation, and it increases potential for problems, but I think it will work beautifully. All of the TT AP's use the same connectors and wiring, so even if I change models of TT AP, I'm still good to go. And that is another good thing about using terminal strips, you can rearrange the wire connections on the strip if need be.

The roll (aileron) servo is a relatively short run of wires, only about 2 - 3 feet, from under the right passenger floor to the forward stick bay.

I haven't permanently mounted any terminal strips yet. I'm leaving some slack in the wires and leaving myself somewhat open for moving parts around to accommodate each other. I haven't really decided yet how to run the wires from under the passenger floor through the control torque tube bay through the spar pass through to terminate in the forward stick bay. I'm just about done routing the aft wiring for the plane (except perhaps radio coax), so once I have a better idea what all has to go where, then I can better decide how to bundle and route it all together.

BTW, instead of using my battery operated tape labeler, I decided to just mark each servo wire with an indelible marker. I may label them based on the manufacturers wiring diagrams later, but for now, the wires just have one to 9 hash marks about 6 inches from the ends. KISS.

So far, soldering the 9 pin connectors with 20 gauge wire was a fun little project.

I changed out the aileron servo from a "B" servo to a "C" servo. Nice to know that even after 3 years, TruTrak swapped them out merely for the cost of shipping. The "C" servo has a little stronger pull. While I was at it, I bought a "torque enhancer" to even further increase the strength of the pull. I did not install the TE on the servo, but have it in stock in case there is a strength issue with the autopilot turning the airplane. The elevator servo is OK being a weaker "B" servo.

Left Floor Wiring

The cabin floor started looking like a spaghetti bowl, so I started cleaning things up a bit. I'm a little closer to having the battery ready to put in, as well as the contactor and perhaps a couple switches and breakers. The wires from behind the wings are pretty well set, there's not much to it. I went back and re-drilled the holes for the static tubing and inserted 1/4 inch ID grommets. I installed 4 mil-spec cushion clamps to hold the bare wire runs. I was going to keep everything in conduit, but that is really inconvenient. So I tried to follow AC 43.13-1b chapter 11 on electrical techniques and routed and supported some wiring. I'm not finished and I'm not sure that it's correct, but here goes....

The pic above is deceiving in that the wire from the two red fast on blade connectors to the conduit is actually about 2 inches over the flap torque tube, and bows back away from the motor arm about an inch. There should be room for the tube and motor to travel without the wires contacting anything. I may go ahead and fasten the wires down to the tube, but the motor is hinged on the arm, and the wires have to bow out quite a bit. I thought it best to just let them traverse the bay up out of the way. I suppose I could route them all the way around the perimeter and then into the conduit. I've emailed Mark Frederick for some advise.

This is not very elegant, but that static tubing is somewhat resistant to tight bends. The zip tie to the conduit really keeps that end from moving. The cushion clamp on the inner wall has a #8 ss screw and an ss nylon stop nut on it. The bundle is up off the floor and away from the wall.

The bundle and static line make a sharp "S" turn through the wall (and rubber grommets). Again, the bundles are not contacting the wall or the floor. This run looks pretty good to me until the aileron tube pass through. The cushion clamp just before that aileron hole is routing the wire bundle (and static line) to go UNDER the aileron tube, then up thought the spar cut out. Up to the front in the control system bay, I still have some organizing to do.

Avionics Harness

I know a guy who knows a guy who wired up a Rocket avionics stack for about $500. Don't know any more than that, except the guy doing the wiring was a retired avionics tech. I've installed radios and headphone jacks with shielded wire, so I know a little about wiring. And I have the tools to make computer type pin connectors. However, when I got an estimate from a panel builder that suggested a HUGE amount of time to install the avionics I have suggested above, I'm thinking it would cost me a fortune to have that puppy wired by a shop. And I still would have a lot of time wiring the avionics when they arrive. When you buy Garmin avionics in particular, the company may not warranty your radios unless they are wired by an approved Garmin avionics tech. So at least a prewire by an avionics tech may be necessary to be warranted. I think in the end, I'll end up buying the units with some prewiring done at the vendors shop.

Since looking into the Approach System Fast Stack cable harness system, I have heard some very good, and some not so good information about the system. There is still a lot of work that goes into wiring the system. The cable connectors and hub save a lot of time, for sure. But what I'm finding out is that I am going to end up doing so much of the wiring myself in advance of installing the avionics stack, the cost benefit is looking less and less attractive. I am installing the components in my electrical system, my EFIS and ignition system and instrument avionics panel "piece meal". By the time I'm ready for the Garmin stack, there may not be all that much extra wiring to consider. And that last bit of wiring can just be handled by the avionics supplier. The $1800 or so spent on the Fast Stack system may go a long way toward the "small" amount of bench wiring required for my panel. Also, Garmin may or may not cover a warranty issue if the stack isn't wired by an approved station. So when you order the radios, might as well pay the shop to "pre-wire" the units, and hopefully that will keep Garmin happy, IF there is an issue.

Bow Tie Bracket

In the stick bay, I had to figure out where to run some electrics and try to keep everything off the floor. I was going to make a bracket to sit on either side of the stick bay, but decided to instead make a bracket to hold the stick grip relays and a barrier terminal strip for the stock grip wires. I fashioned brackets to sit behind my two battery solenoids out of .025, then made a cross member to scew down over the top of them. The barrier strip is very narrow, so I decided to trim it down and give myself some more clearance from the movement of the stick and some mroe working room. Turned out that the cross member looks like a big bow tie. I put nutplates in the brackets. Now I can unscrew the bow tie and remove the relays and barrier strip without removing the battery solenoids. I works very well in my hangar, I'm anxious to see if it all works together in service.

Secondary EFIS Power Relay

The GRT EFIS and AHRS allow you to have THREE electical sources to power it. I decided to install a secondary relay that turns the secondary battery on to the EFIS and AHRS when the master switch is on. You cannot turn off the EFIS. If there is a power source to the EFIS, it detects it and powers up. So I couldn't just hook up the secondary EFIS power wires direct to the battery, or the EFIS would be on all the time. So instead I ussed a 30/40 amp automotive relay and jumped power behind the power from the master (positive) and the E-bus ground. I put a 1 volt fuse in the E-Bus and ran power/ground wires to the relay from the battery.

The EFIS system and AHRS can use 3 sources of power. The draw is about a total of 1 amp. The EFIS is internally fused, but GRT does recommend a 1 amp fuse on the power line. The EFIS will detect power sources through all of the three power leads. It chooses the strongest one and draws current from that source. Pretty cool. The problem was that I wanted independant power sources, but also want the EFIS to choose to get power from whatever source it chooses. If I just switched the secondary power source, I would get a warning message on the screen for low power on the secondary source. I could shut the warning off (like I did for the tertiary power), but actually I ALWAYS was to be monitoring BOTH batteries. And you can't just run the secondary wire direct to the battery. It would keep the EFIS on all the time. So I hooked a relay to the master switch. The problem with that arrangement is that if for some unknown reason I have to switch the master switch completely off, I would have NO instruments (except a wet compass). Theoretically with the dual battery system I have, I can run either battery with or without the alternator. I can't think of a situation where the Master BAT switch would need to be off, but I may go ahead and make another toggle switch to take battery power direct from one of the batteries to the EFIS. Perhaps that would be a tertiary source of EFIS power (rather than a third battery).

Flap Relays

I used a pair of standard automotive 30/40 amp relays to switch power from the left and right buttons on the CH Products stick grip. The current required by the flaps is more than the switches can handle, so a relay was a must. You can buy fancy schmancy gizmos to operate the flaps using any stick grip, but for 4 dollars, just a pair of relays that ground out with a push of the button is hard to beat. The flaps are wired with #18 milspec wire and presently have only a 5 amp fuse in the E-Bus. 7 (or 7.5) amp fuse is recommended. I'm going to use the 5 for now and see how I get along.

More to come!