RV-7 Electrical System

9/30/07

This electrical system is derived from Figure Z-13/20 as featured in revision 11 of the Aeroelectric Connection, plus an aux battery.

This airplane is being built for cross-country travel and will be used for occasional IFR. My minimum electrical equipment list includes a Garmin GNS430 GPS/nav/comm, one EFIS screen and its associated AHRS/air data computer, a two-axis Trutrak autopilot, aileron and elevator trim, minimal cockpit lighting, and a single backup electric gyro instrument. An E-bus load analysis yields an approximate minimum current draw of 9A, and up to 15A when the comm is transmitting. This dictates the use of a relay to energize the E-bus alt feed path, and requires the use of an SD-20 aux alternator instead of an SD-8.

In addition to the above, the airplane also has one Lightspeed electronic ignition module. The electronic ignition, EFIS display, and AHRS are all sensitive to reduced bus voltage that happens during engine cranking, so I have elected to equip the airplane with a small auxilliary battery to sustain these three devices during engine start. The EFIS and AHRS have built-in diode-isolated secondary power inputs, and I will use half of a bridge rectifier to provide equivalent dual-power-path functionality for the electronic ignition.

In the event that the main alternator fails, I will have the option of powering both the main bus and E-bus from the SD-20, or turning off the main bus (BUS 1 MASTER switch) and continuing the flight indefinitely using only the items on the E-bus. Under the most improbable emergency circumstances (main battery and both alternators failed) I calculate that a fully charged aux battery will sustain the #1 EFIS, AHRS, and electronic ignition for at least 30 minutes. I have also chosen to retain a single magneto to enable non-electronic-dependent flight if required.

Since I have elected to have two alternators and two batteries, I weighed the pros and cons of going to a true dual battery/dual alternator architecture like Figure Z-14, but I wasn't confident using such a small battery in that role. (My aux battery is constrained by the size of location in which I plan to mount it)

Under normal circumstances, all electrical loads will be carried by the main battery (17Ah SLA) and alternators - the aux battery will be contributing nothing, remaining charged for when it's needed for the next engine start. The aux battery will be charged through a diode, similar to the setup recommended by Lightspeed Engineering. This will let the aux battery charge whenever one of the alternators is online, and will prevent the aux battery from backfeeding into the main bus, with no active switching required. The diode will also do the job of dropping the 14.4V alternator voltage down to the ~13.8V float voltage recommended by Panasonic for their VRLA batteries.

I have designed a small voltage monitor board, which simply monitors the voltage on its "Vin" pin. If the monitored voltage is below the set point, the lamp connected to the board will be illuminated. The board has its own onboard diodes that allow it to be powered from two different sources, and the voltage it monitors doesn't necessarily have to be one of its power inputs. I show a few of these little boards used to indicate various things.

For reference, the main battery, main contactor, starter contactor, E-bus relay, and main battery bus will be located on the engine side of the firewall. The aux battery and its relay and fuse block will be mounted beneath the baggage floor, behind a removable panel. The main and E-bus fuse blocks, voltage regulators, and other devices will be located in the under-panel area in the cabin.

- Matt Burch
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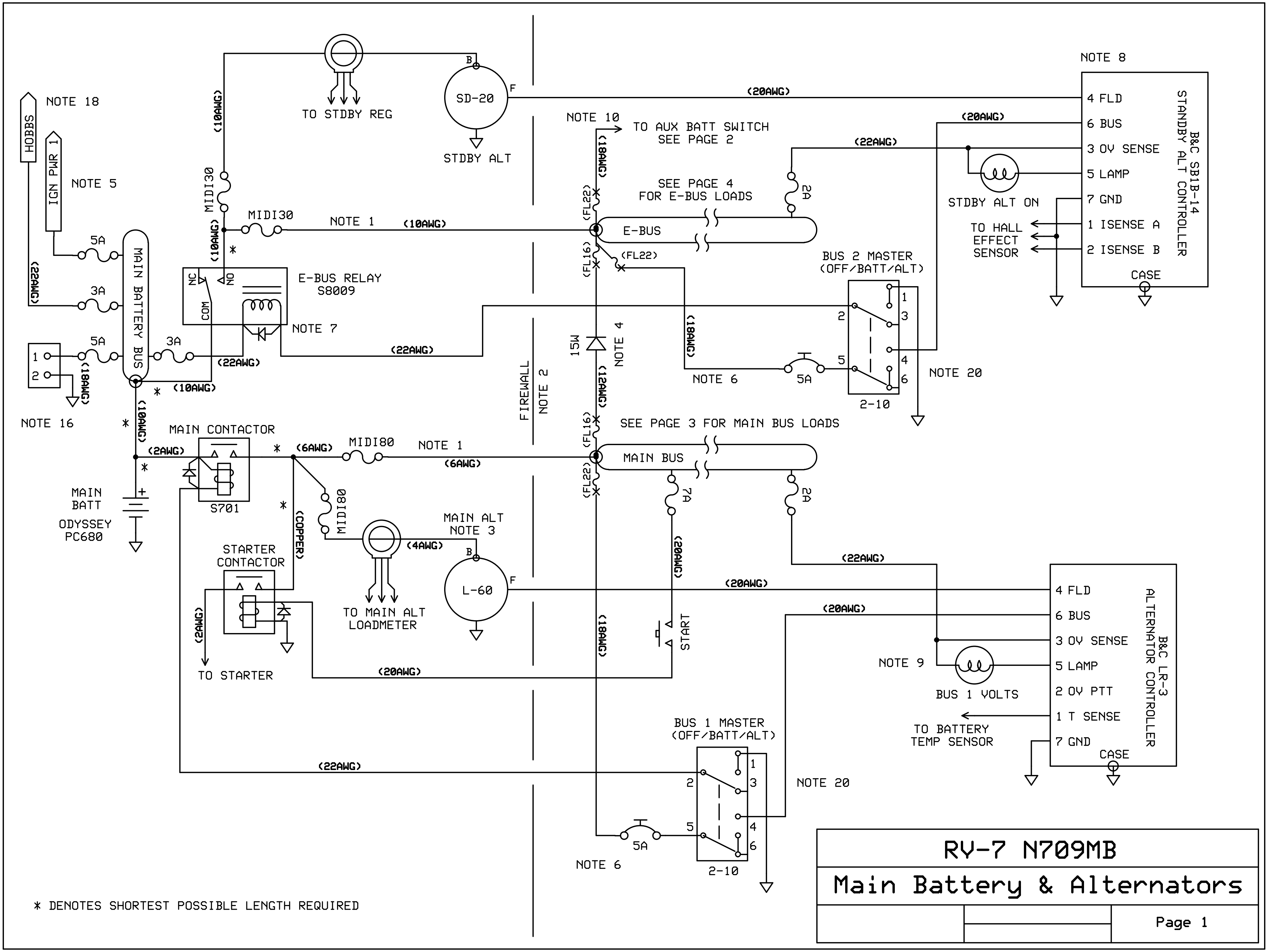
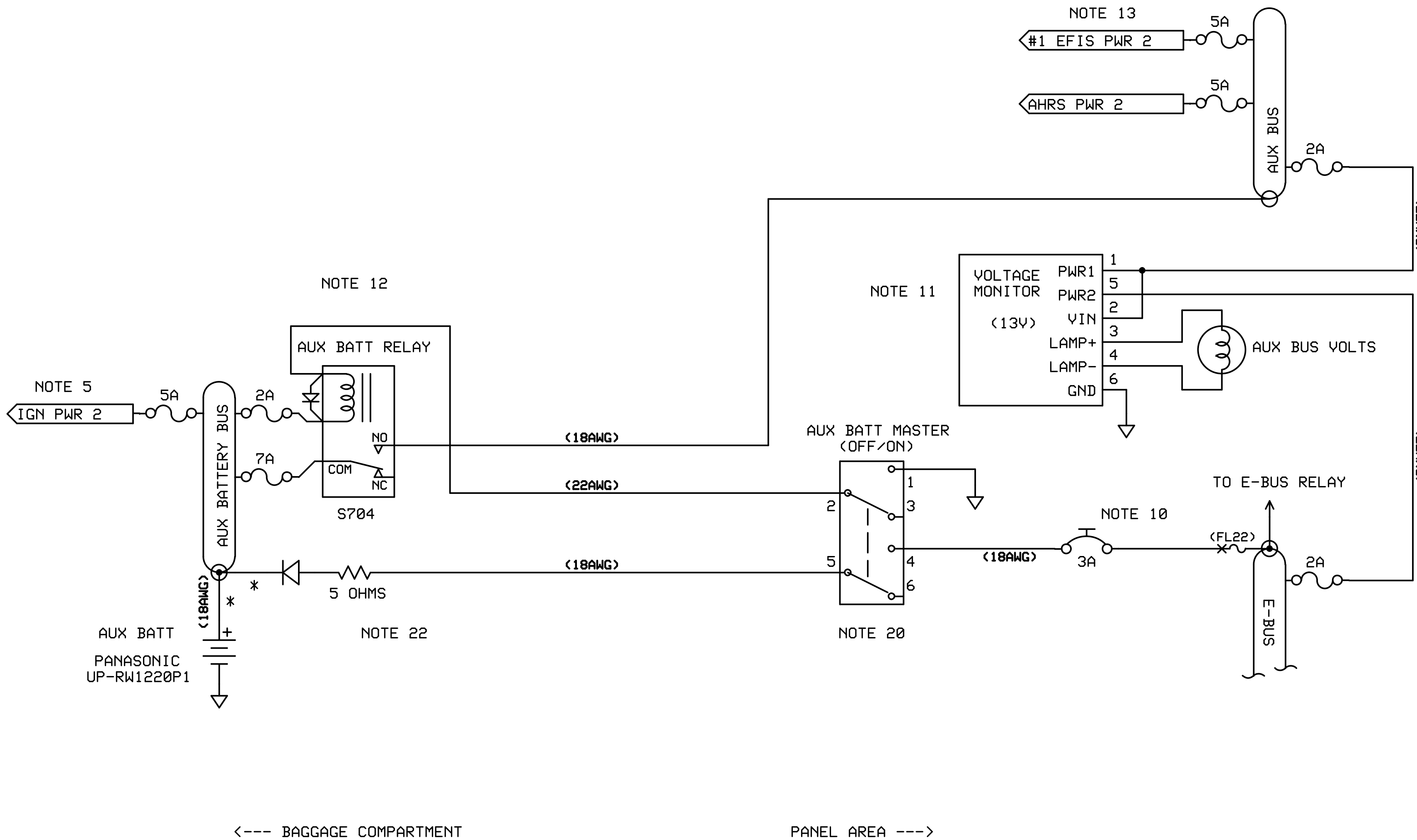

NOTE 18
HOBBS
IGN PWR 1
NOTE 5
MAIN BATTERY BUS
5A
3A
(22AWG)
(10AWG)
(18AWG)
NOTE 16
MAIN BATT
ODYSSEY PC680
(2AWG)
MAIN CONTACTOR
S701
STARTER CONTACTOR
(COPPER)
TO STARTER
MIDI30
NOTE 1
TO STDBY REG
SD-20
STDBY ALT
E-BUS RELAY S8009
NC
NO
COM
NOTE 7
MIDI80
(6AWG)
(4AWG)
MAIN ALT NOTE 3
L-60
TO MAIN ALT LOADMETER
(20AWG)
FIREWALL NOTE 2
NOTE 10
TO AUX BATT SWITCH SEE PAGE 2
SEE PAGE 4 FOR E-BUS LOADS
E-BUS
(FL22)
(FL16)
15W
NOTE 4
(12AWG)
SEE PAGE 3 FOR MAIN BUS LOADS
MAIN BUS
7A
2A
START
BUS 2 MASTER (OFF/BATT/ALT)
NOTE 6
2-10
NOTE 20
STDBY ALT ON
TO HALL EFFECT SENSOR
NOTE 8
4 FLD
6 BUS
3 OV SENSE
5 LAMP
7 GND
1 ISENSE A
2 ISENSE B
CASE
B&C SB1B-14 STANDBY ALT CONTROLLER
NOTE 9
BUS 1 VOLTS
TO BATTERY TEMP SENSOR
2 OV PTT
1 T SENSE
B&C LR-3 ALTERNATOR CONTROLLER
BUS 1 MASTER (OFF/BATT/ALT)
* DENOTES SHORTEST POSSIBLE LENGTH REQUIRED
RV-7 N709MB
Main Battery & Alternators
Page 1



* DENOTES SHORTEST POSSIBLE LENGTH REQUIRED

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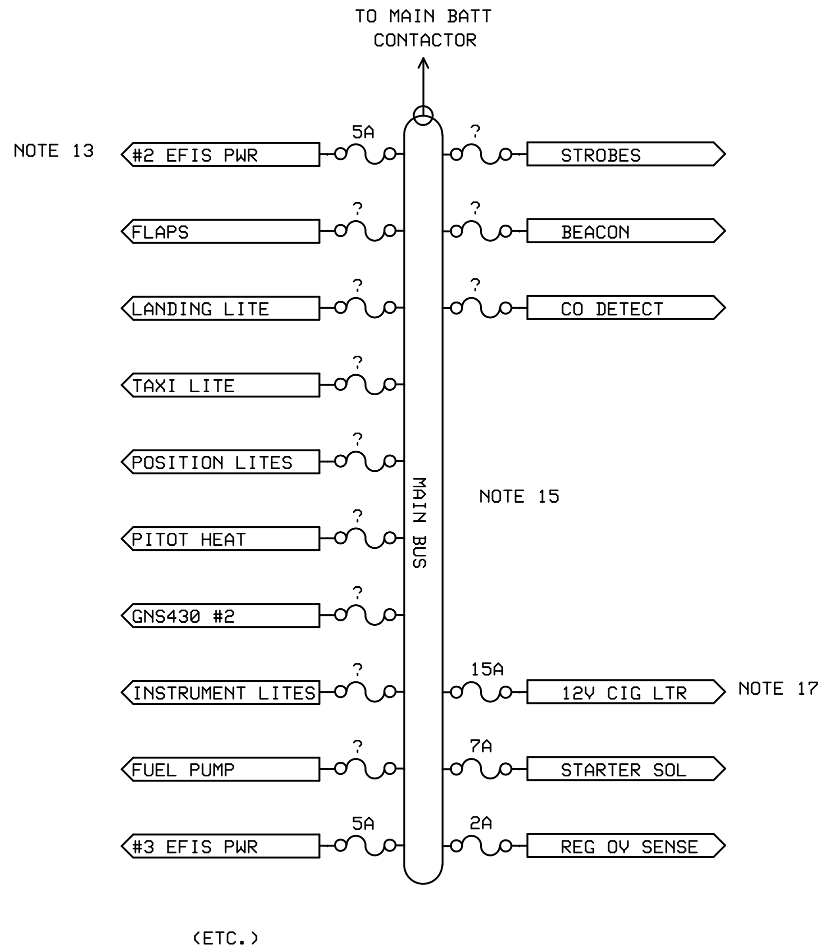
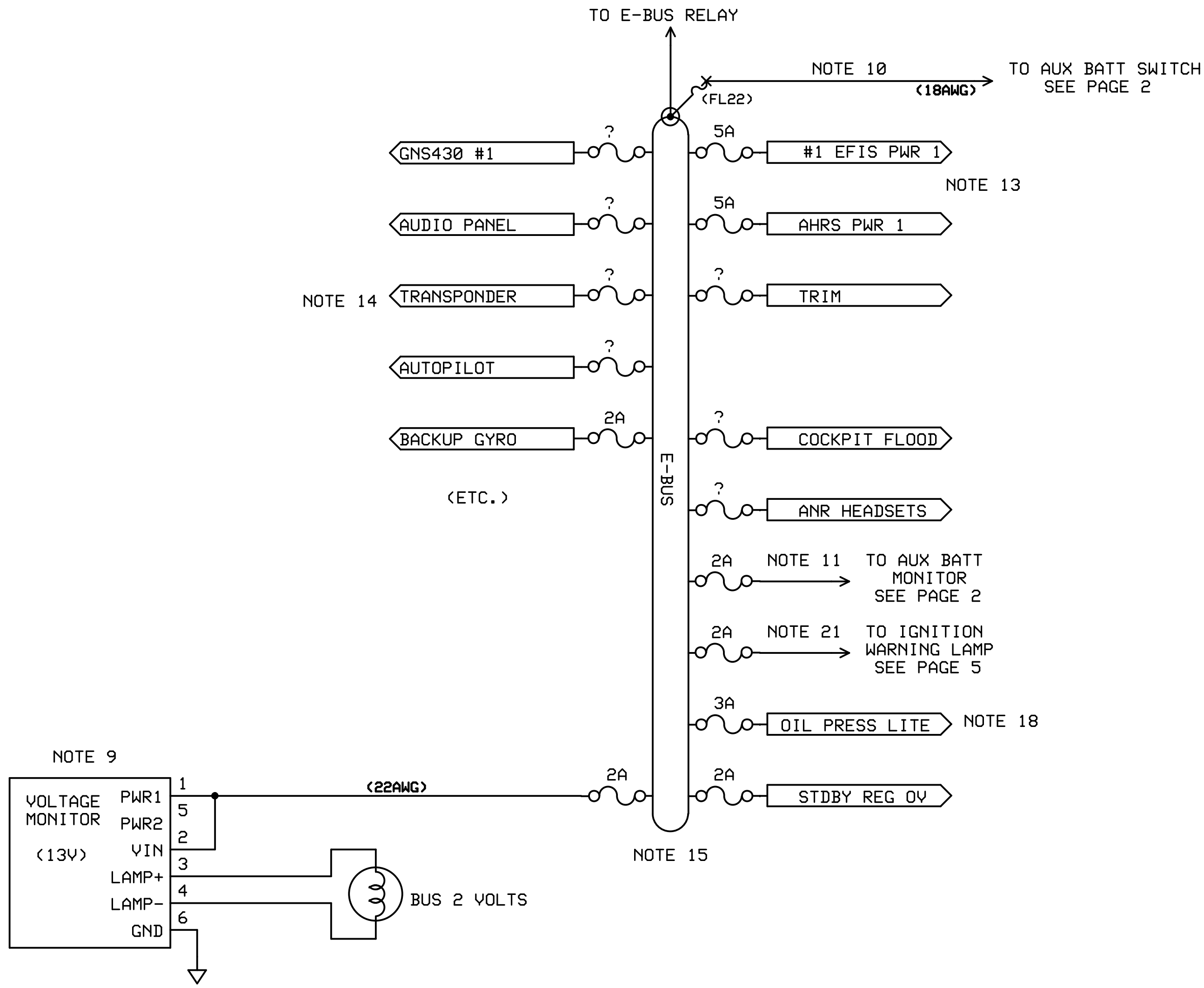
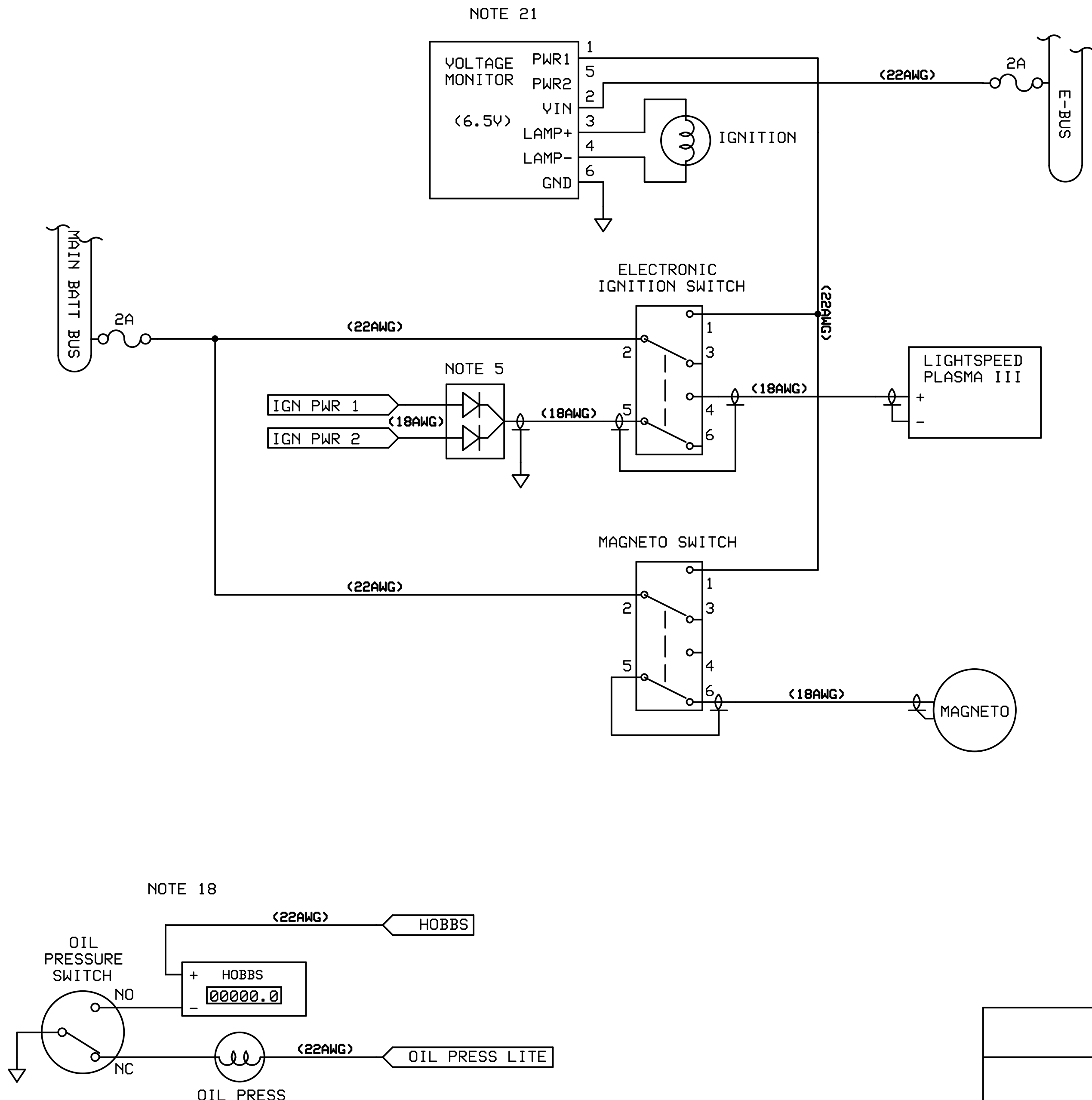
Auxilliary Battery		
		Page 2



RV-7 N709MB		
Main Bus Loads		
		Page 3



RV-7 N709MB		
Endurance Bus Loads		
		Page 4



RV-7 N709MB

Miscellaneous

Notes from the schematic:

Note 1: I've drawn ANL current limiters protecting the fat feed lines from the main and E-bus through the firewall. This isn't shown in the Z figures, but was suggested to me by Tim Hedding at B&C.

Note 2: The firewall is shown only as a reference to indicate whether a particular component will be mounted in the engine compartment or cabin. Relative locations of components and firewall passthroughs will be determined by the practicality of mounting and wire routing.

Note 3: I've shown a 60A alternator, but I will evaluate the use of a 40A alternator once I finalize my equipment list and load analysis.

Note 4: E-bus loads have been sized to keep the continuous current draw below 16A (80% of the SD-20's rated output). This dictates the use of a diode heatsinked to handle 15W for the E-bus feed from the main bus.

Note 5: The electronic ignition can receive power from either the main battery bus or aux battery bus. One half of a bridge rectifier is used to isolate the two power feeds. Per the Lightspeed installation instructions, the ignition module is grounded to the shield of the supply wire, which I've shown continued all the way to the rectifier.

Note 6: Each alternator regulator supply wire incorporates a circuit breaker on the panel, for pilot detection of OV trip events. The wire between bus and breaker is protected by a fusible link.

Note 7: I chose to use the 40A-rated S8009 relay for the E-bus after I learned from a conversation with B&C that the SD-20 can put out slightly more than 20A under certain circumstances. (The S704 relay is rated for 20A). I selected a relay instead of a contactor because of the lower coil current requirement, and because the E-bus relay does not need to support cranking currents.

Note 8: Figure Z-13/20 shows an LR-3 regulator paired with the SD-20 alternator powering the E-bus. I've drawn an SB-1 standby regulator here, because I wanted to retain the ability to have a "STDBY ALT ON" light along with the annunciation of too much current draw that the SB-1 gives you. I could go either way on this however. With my current way of thinking, normal operations will have both the BUS 1 MASTER and BUS 2 MASTER switches in the ALT position, with the main alternator providing all the energy and the SD-20 being online but dormant.

Note 9: The main alternator controller handles the BUS 1 VOLTS lamp, which indicates low voltage on the main bus. The voltage monitor shown on page 4 handles the BUS 2 VOLTS lamp, which indicates low voltage on the E-bus.

Note 10: I chose to bring charge current to the aux battery from the E-bus, not from the main bus, so that the "AUX BATT VOLTS" light won't illuminate when the E-bus relay is closed and the main battery contactor is open. The aux battery should draw almost no current from the E-bus once it recharges after an engine start. Note that the aux battery charging wire is brought out to a low-value breaker on the panel - this is intended to provide some protection against accidentally charging the aux battery too rapidly if it has somehow been seriously depleted (aux battery switch left on). Fusible links from the E-bus and aux battery bus protect both ends of this relatively long wire.

Note 11: The aux battery voltage monitor will illuminate the AUX BATT VOLTS light whenever there is power on the aux bus or E-bus and the aux bus voltage is less than 13V. I drew it this way so there will be a light to remind me not to leave the aux battery switch on after a flight, and I'd also have a positive indication that the aux battery is not getting a charge.

Note 12: The aux battery relay can be energized either by the aux battery or by the E-bus, since the aux battery charge current doesn't pass through the relay. By hooking it up this way, we prevent the possibility of a situation where the aux battery is too depleted to close its own relay and accept a charge.

Note 13: The EFIS display and the AHRS feature internal diodes that let them take power from multiple isolated buses. I have drawn the #1 EFIS and AHRS connected to both the E-bus and aux battery, to keep them online during engine starting. The #2 EFIS is connected only to the main bus, as I can safely fly the airplane with only one functioning display.

Note 14: Since my standby alternator has excess capacity above and beyond my minimum required E-bus loads, I've shown the transponder connected to the E-bus as well.

Note 15: The exact number of fuse positions required for the main bus and E-bus has not been finalized - I've drawn them both as the 20-slot size just for convenience.

Note 16: A Molex connector under the cowling, connected to the main battery bus, will allow a low-rate charger or battery maintainer to be connected through the oil filler door. I decided not to incorporate a high-current ground power receptacle, because I didn't want the weight and complexity. If the main battery is so depleted that it can't crank the engine, I will put it on the charger and wait to go flying instead of trying to jump-start the airplane and fly off.

Note 17: For times when I need to power the electrical system for extended periods on the ground (i.e. maintenance and testing) I will connect my bench power supply through the cigarette lighter plug that goes to the main bus. That will provide up to 15A, enough to run all or most of my avionics.

Note 18: An oil pressure switch connects one side of either the hourmeter or oil pressure warning light to ground. The hourmeter is powered from the main battery bus, so it will count up whenever the engine is running even if all other switches are off. The oil pressure light is powered from the E-bus, so it will light up whenever either the main or E-bus master switches are closed and the oil pressure is too low - this lets it double as another "don't forget to turn off the master" reminder light.

Note 19: (removed)

Note 20: The BUS 1 MASTER switch combines the functions of battery master switch (first position) and main alternator field switch (second position). The BUS 2 MASTER switch combines the functions of E-bus alt feed switch (first position) and standby alternator enable switch (second position). The AUX BATT MASTER switch supplies from the aux battery to the #1 EFIS and AHRS, and allows charging current to flow to the aux battery. For all three switches, the normal procedure would be to put them all "up" before takeoff and leave them there.

Note 21: The voltage monitor that is intertwined with the electronic ignition and magneto switches manages is powered whenever either of the two ignition switches is in the "up" position. It watches the E-bus voltage, and lights the "IGNITION" lamp to warn me if the bus master switches are off but I've left either of the ignition switches on. This "hey dummy, you left the ignitions on after shutdown!" indication tells me the batteries are being drained and/or the magneto is unsafe. The light is extinguished either when the bus master switches are turned on, or if both ignition switches are turned off. None of this makes any connection to the actual electronic ignition power wire or the magneto P-lead, so it should have absolutely no effect on the operation of the aircraft's ignition systems. I may not actually build it this way - I mostly just wanted to see if I could figure a cheap and easy way to remind myself if I leave the electronic ignition turned on after a flight. (well, a checklist is cheaper, but we're all human)

Note 22: The resistor provides some current limiting to keep the battery from charging too rapidly. I'll use a lightweight aluminum-chassis power resistor just so I have no problems with heat dissipation.