RV-7 Electrical System

9/23/07

This electrical system is derived from Figure Z-13/20 as featured in revision 11 of the Aeroelectric Connection, plus some influence on the aux battery arrangement from Figure Z-30.

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 very small (3.3Ah VRLA) 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 devices on the aux bus (EFIS, AHRS, and electronic ignition) for 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. I am designing a small board that will be very similar in functionalty to the AEC9005 LVW/ABMM module, with a few small differences spelled out in the notes below. This board will monitor the bus voltage and pull in the aux battery charging relay only when the engine is not being cranked (to avoid taxing the aux battery) and when bus voltage is greater than 13V (indicating that at least one alternator is online).

I evaluated using a diode to charge the aux battery, as recommended by Lightspeed Engineering, but I am not confident in the battery's ability to reach full charge using that method. I likewise considered designing a constant-current charging circuit to manage the aux battery and prevent it backfeeding into the main bus, but since I have never really enjoyed designing switch-mode power supplies I decided that a solution using a voltage monitor and relay would be easier to understand and troubleshoot.

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 main and E-bus fuse blocks, voltage regulators, aux battery and associated relays, and other devices will be located in the cabin area.

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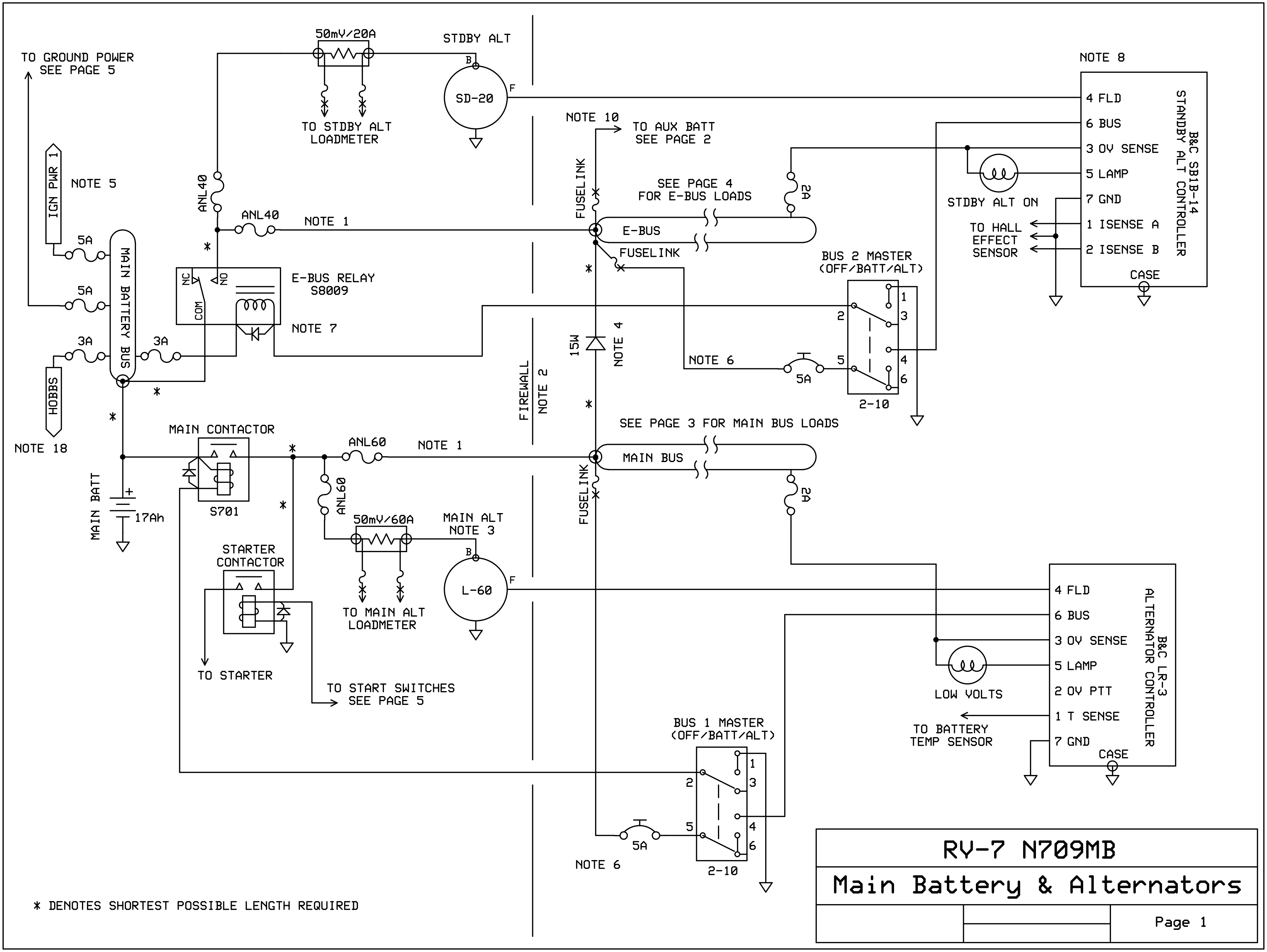

TO GROUND POWER SEE PAGE 5
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STDBY ALT
SD-20
TO STDBY ALT LOADMETER
NOTE 8
4 FLD
6 BUS
3 OV SENSE
5 LAMP
7 GND
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2 ISENSE B
CASE
B&C SB1B-14 STANDBY ALT CONTROLLER
STDBY ALT ON
TO HALL EFFECT SENSOR
NOTE 10
TO AUX BATT SEE PAGE 2
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SEE PAGE 4 FOR E-BUS LOADS
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2A
IGN PWR 1
NOTE 5
ANL40
ANL40
NOTE 1
5A
5A
3A
3A
MAIN BATTERY BUS
E-BUS RELAY S8009
NC
NO
COM
NOTE 7
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NOTE 18
BUS 2 MASTER (OFF/BATT/ALT)
2-10
NOTE 6
15W
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ANL60
NOTE 1
MAIN BUS
MAIN BATT
17Ah
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TO MAIN ALT LOADMETER
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TO STARTER
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6 BUS
3 OV SENSE
5 LAMP
2 OV PTT
1 T SENSE
7 GND
CASE
LOW VOLTS
TO BATTERY TEMP SENSOR
BUS 1 MASTER (OFF/BATT/ALT)
2-10
NOTE 6
* DENOTES SHORTEST POSSIBLE LENGTH REQUIRED
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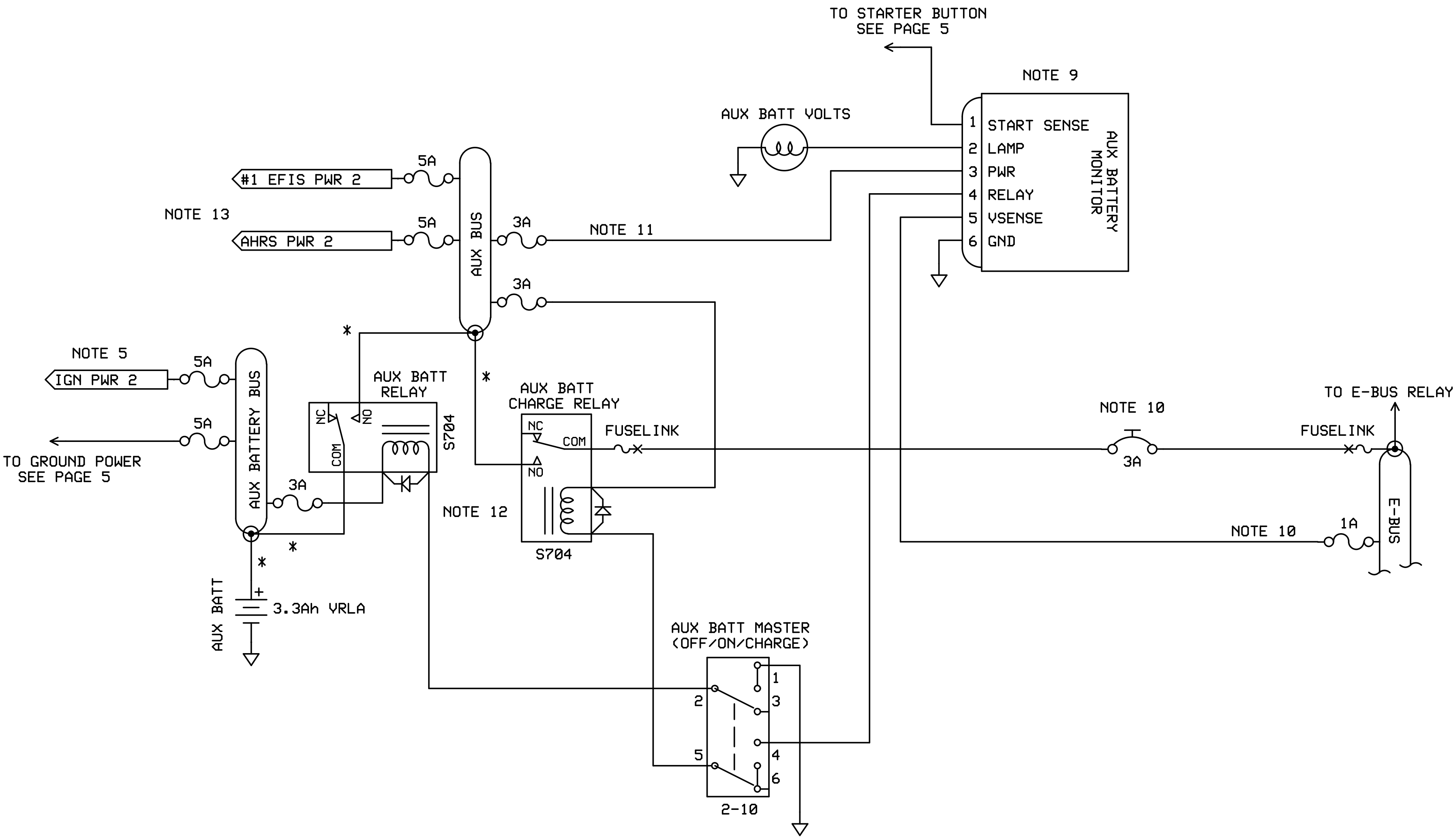
Main Battery & Alternators
Page 1



* DENOTES SHORTEST POSSIBLE LENGTH REQUIRED

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Auxilliary Battery		
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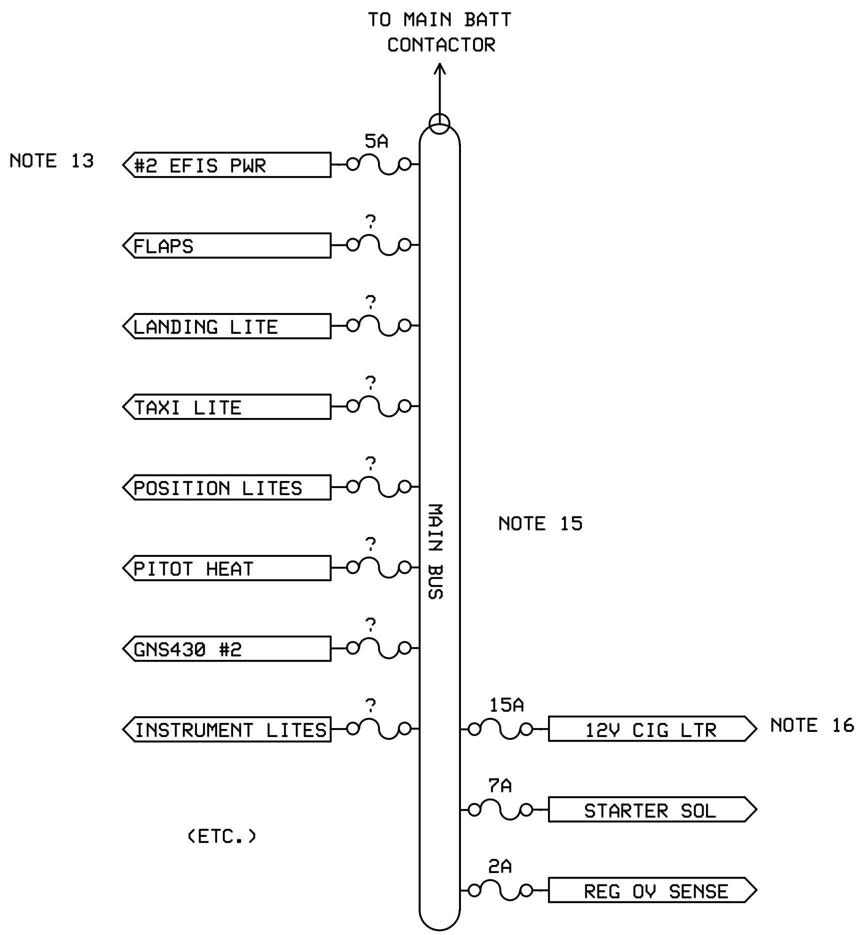

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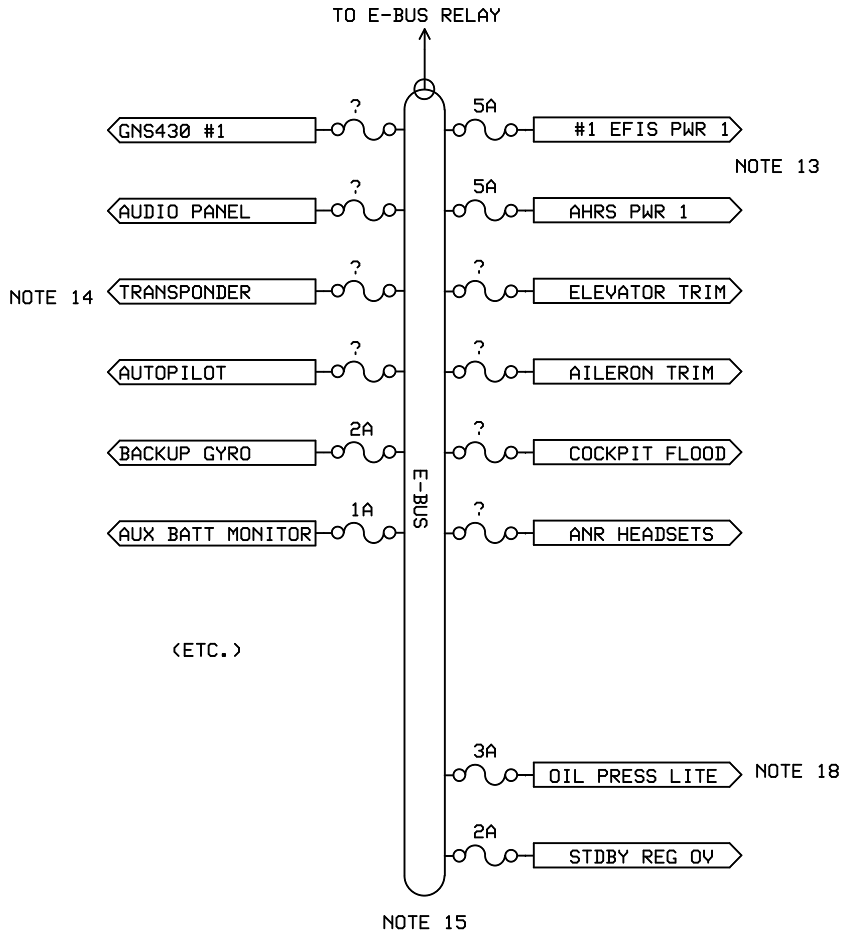
Main Bus Loads



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Endurance Bus Loads		
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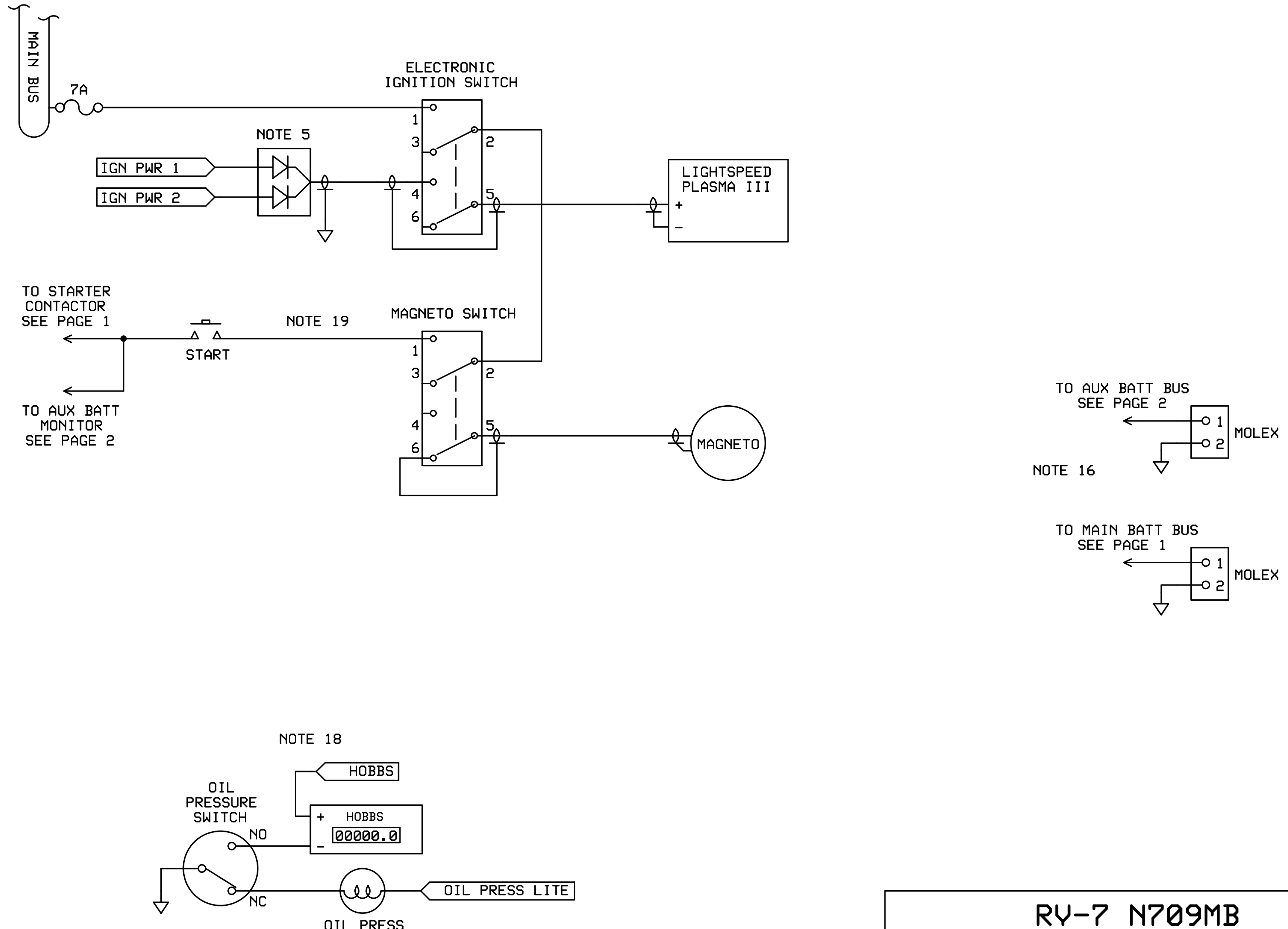

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Miscellaneous

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 an "AUX 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: This module is something I'm designing for my own use, but I will share the design on my website when it's finished. It is very similar to the AEC9005 Low Voltage Warning / Aux Battery Management module, with a few differences:

a) The aux battery charge relay can't be closed if there is voltage on the board's START SENSE pin. This ensures the aux battery will be isolated when cranking the engine. I may decide this feature isn't necessary but I've drawn it for now to show my thinking.
b) The board can drive a lamp, not just an LED. The annunciator lights I've chosen can use either an incandescent bulb or a 12V LED, so I wanted to have the option of using either one.
c) The board has separate pins for power and bus voltage sense. This lets it be powered from one bus and monitor a different bus - see Note 11.

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 bus protect both ends of this relatively long, somewhat fat wire.

Note 11: The aux battery management board is powered from the aux bus, and monitors the E-bus to determine when to close the aux battery charge relay. This means that the "AUX BATT VOLTS" light will illuminate whenever the aux battery relay is closed and the E-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.

Note 12: I've shown S704 relays for both the aux battery relay and the aux battery charge relay, since current through both of these should be well under 20A.

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 bus, 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: I will put two Molex connectors out of sight under the panel, for charging the main and aux batteries. These connectors will run straight to the main and aux battery busses. The intent here is to allow a small battery charger or battery maintainer to be connected for recharging, not for a ground power cart to be used to jump-start the airplane - 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: The ignition switches are connected in such a way as to prevent energizing the starter contactor unless both ignitions are turned on. This is to avoid accidentally engaging the starter until ready for engine start.

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