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VLM-14 & VLM-14PM Voltmeter/Loadmeter Installation and Operation

Notice

The VLM-14 Voltmeter/Loadmeter System is not FAA approved and is not offered for use on any certificated aircraft. Do not order this product with an intent to install on a type certificated aircraft before you contact the local offices of the FAA for guidance and a commitment to assist you with a field approval.

Instructions in magenta are not applicable to the VLM-14PM version of this product.

1.0 FEATURES

1.1 Expanded Scale Voltmeter: The VLM-14 voltmeter/loadmeter features an expanded scale voltmeter reading from 10.0 to 15.0 volts DC and marked with colored operational arcs with the following significance:

1.1.1 The range of 10.0 to 10.5 volts is colored red. The only time system operating voltage falls into this range is alternator out, battery only operations. Voltage readings at 10.5 volts and below are indicative of a totally depleted battery.

1.1.2 The range of 10.5 to 13.0 volts is colored yellow. The only time system operating voltage falls into this range is alternator out, battery only operations. Battery only operations will begin at some point less than 13.0 volts. A battery will deliver all of its useful energy in the range of 12.5 down to 10.5 volts where the battery is considered depleted.

1.1.3 The range of 13.0 to 14.5 volts is colored green. An alternator that is carrying 100% of system loads will sustain the system voltage in this range. 13.0 volts voltage is too high for the battery to deliver any energy into the system but too low to significantly charge the battery. Therefore, normal system voltage with an operable alternator will tend toward the top of the green arc in the 14.2 to 14.4 volt range.

1.1.4 The range of 14.5 to 15.0 volts is colored yellow. Sustained charging of a lead-acid battery in this range may be detrimental to the battery's service life.

1.1.5 The voltmeter is red-lined at 15.0 to indicate regulator mis-adjustment or failure. A reading of 15.0 volts or more is justification for shutting down the alternator system and investigating the cause.

1.1.6 The voltmeter's calibration is set by screwdriver adjustments on the etched circuit board (ECB) assembly.

1.2 Alternator Loadmeter: An ammeter is scaled by the size of a remotely mounted 50 mV ammeter shunt so that the loadmeter reads in percentage of the alternator's rated output. The scale plate is marked in LOAD % from zero to 100 and marked with colored operational arcs with the following significance:

1.2.1 A red line at 0% indicates that the alternator is probably off-line.

1.2.2 A yellow arc in the 0-5% range suggests that while the alternator is delivering energy to the system, there might be a problem with power distribution -or- some needed electrical accessories may be turned off.

1.2.3 A green arc marks the range of 5 to 80% of alternator load. This is the normal operating range for a properly sized alternator.

1.2.4 A yellow arc marks the range of 80 to 100%. An alternator may operate in or above this range for a short period of time after engine start depending on state of charge of the battery and demands on the system by

electrical accessories.

1.2.5 A red line marks the upper end of the scale at 100% which represents the alternator's rated full output capabilities. Again, short term operation at or above this level is normal but sustained operation above 80% is indicative of an undersized alternator with respect to system demands -or- some failure in the system that warrants investigation.

1.3 Low Voltage Warning Light: The VLM-14 system includes a panel mounted light emitting diode (LED) driven by a low voltage sensor and flasher circuit on the ECB assembly.

1.3.1 The calibration setpoint for the low voltage warning is factory set at 13.0 ± 0.2 volts. This setpoint was selected as a value too high for a lead-acid battery to deliver energy into an electrical system and too low for an alternator to significantly charge a lead-acid battery. The interpretation of this light suggests that if the light is dark, the alternator must be carrying current system demands and whatever energy the battery contains is not being tapped for system operations.

1.3.2 If the light is flashing, system bus voltage has fallen below 13.0 volts meaning the alternator is (1) shut off, (2) severely overloaded, (3) or failed to the degree that it's totally shut down or at least unable to carry present system loads. System voltages below 13.0 volts will begin to put some demand on the battery's stored energy to make up the difference between system demands and alternator capability.

1.3.3 The LED warning light supplied with the VLM-14 system is a sub-miniature, high intensity device especially designed for ease of mounting near or amongst instruments in front of the pilot.

1.4 Essential Bus Voltmeter Auto-Switch: A relay on the ECB assembly is wired to select either main or essential busses as feedpoints for the voltmeter circuit. This feature is significant if the aircraft is wired according to recommendations in the AeroElectric Connection where the essential bus gets a normal feed from the main bus via a silicon diode.

1.4.1 When the alternator is operating normally, the main bus should be operating at a voltage level established by the setpoint of the alternator's regulator. The essential bus will be operating at approximately 0.6 volts less than the main bus due to the expected voltage drop in a silicon power diode. Under normal operating conditions, the autoswitch relay is energized from the main bus which transfers the voltmeter monitoring lead to the main bus.

1.4.2 During alternator out operations, it is recommended that the main bus be shut down by opening the alternator field switch, battery master contactor and closing the alternate feed switch to power the essential bus directly from the battery.

1.4.3 With the main bus powered down, the low voltage warning light will cease to flash, eliminating potential distraction of the pilot. The voltmeter autoswitch relay will transfer voltage monitoring functions from the main bus to the essential bus so that battery condition will be displayed on the voltmeter during alternator out operations.

1.5 Alternator System Diagnostics: Diagnosis of an alternator problem can only be accurately conducted if the alternator's operating field voltage is known. For most aircraft, this voltage can only be measured while standing behind a rotating propeller with a voltmeter.

1.5.1 If the builder wishes to take advantage of this feature, a special wire is routed from the ECB assembly out to the alternator's field connection. A press-to-test button will energize a second relay on the ECB assembly causing the voltmeter to become disconnected from the bus and instead it becomes an alternator field voltage meter.

1.5.2 Due to the wide range of voltages on the alternator field, the bus voltmeter cannot be used in an expanded scale mode. While the press-to-test button is held, the voltmeter's measurement range is 0-15 volts. Therefore, field voltage readings conform to the following chart:

Instrument Reading	Field Voltage
10.0	0
11.0	3
12.0	6
13.0	9
14.0	12
15.0	15

1.6 Transient Voltage Suppression: The VLM-14 ECB assembly mounts a transient voltage suppressor (TVS) that will clamp off low energy transients generated by switching inductive circuits. CAUTION . . . this is NOT overvoltage protection and does not provide a remedy for a failed alternator regulator. The TVS clamps off small transients that an OV protection system cannot respond to while the OV protection system captures a runaway alternator . . . a condition that a TVS diode cannot mitigate.

2.0 INSTALLATION

2.1 Etched Circuit Board Assembly: The ECB Assembly may be mounted one of two ways. The board has 4 corner mounting holes which may be used with spacers and 4-40 thru screws to attach the ECB to a bracket or sheet metal surface. Alternatively, the installer may elect to use self adhesive Velcro strips supplied with the kit.

2.1.1 Location and mounting methods for the ECB assembly should consider the fact that voltmeter calibration potentiometers on the ECB may require periodic adjustment. If the board is mounted solidly using corner holes, then pick a location that will allow access to the adjustment screws without dismounting the board.

2.1.2 Mounting the ECB with the Velcro strips permits pulling the ECB down for voltmeter adjustment if the wires leading to the ECB are suitably bundled. The ECB is supplied with two Velcro strips already attached. The primary reason is to provide nearly total coverage of the solder side of the ECB for protection from inadvertent contact with conductors. If the surface you plan to use for Velcro mounting is narrow, one mating Velcro strip is sufficient for holding the ECB in place. However, if the surface is sufficiently wide, installing both mating strips is preferred.

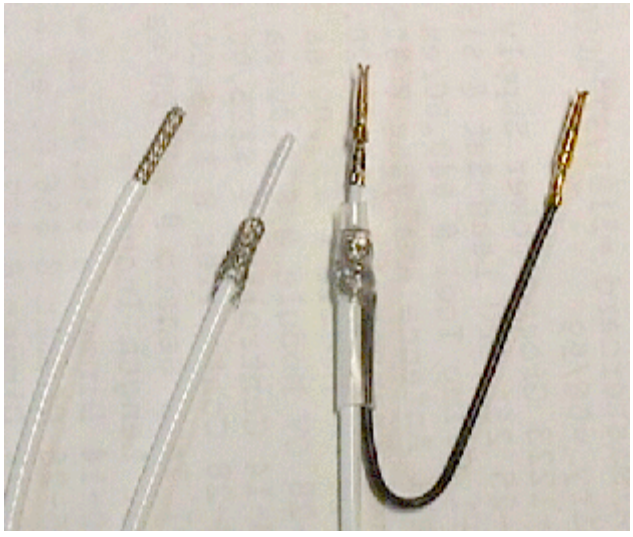
2.1.3 The bonding qualities of adhesive used for Velcro mounting is time dependent. Clean the surface where the ECB is to be mounted using lacquer thinner or acetone to make sure it's grease free. Peel the protective backing from the mating Velcro strips and press firmly into place. When using both Velcro strips, leave a 1/4" longitudinal gap between them (see back side of ECB). You can press the ECB onto its mating Velcro strips right after they're installed but allow 24 hours for the adhesive to reach full strength before de-mating.

2.1.4 Velcro mounting and appropriate cable bundling allows ready dismounting of the ECB for access to calibration screws as needed while reducing restrictions on places where the ECB might be mounted.

2.2 Low Voltage Warning Light: The light emitting diode warning light assembly comes with a length of single conductor shielded wire already mounted to the light. The lamp is a 1600 MCd lamp shortened to widen the viewing angle and provide a frosted projection "screen" for the face of the indicator.

2.2.1 The lamp's small size is conducive to picking a mounting location right in front of the pilot . . . even if the lamp needs to be tucked between existing panel hardware. Use a #30 drill to locate and pilot the LED's mounting hole. Drill out to finished size with a 25/64 (.391) drill. Install lamp fixture leads-first through the mounting hole and secure with nut from the back side. Tie off leadwire behind the panel so that inadvertent tugs on the lamp's leadwires don't break the fixture. A large tie-strap is included with the lamp assembly will allow you to secure the lamps leadwire to a nearby instrument. Peel the cover from adhesive backing on LV WARN placard and affix to panel adjacent to the low voltage warning indicator.

Note:
A crimp style D-sub connector is supplied with the kit. Sockets supplied with the connector are gold-plated, open barrel parts like the figure below. You will need a Radio Shack 276-1595 crimping tool. Use the larger of the two pockets on this tool and follow instructions on the back of the package. If prefer you may substitute a solder type, 15-pin, female D-sub connector from a local supplier. You may also wish to purchase a rear-release extraction tool for these pins (R-S276-1426) in case you put a pin into the wrong hole and need to remove it. D-sub connectors are widely use in many aviation products . . . these tools are good additions to your toolbox.



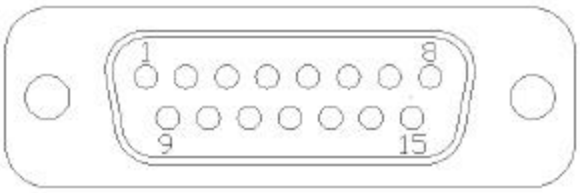
2.2.2 Attaching the shielded wire to the D-sub connector takes a little "maneuvering". Strip 3/8" of outer jacket from the shielded wire and push the shield braid back over the top of the outer jacket.

2.2.3 Strip the center conductor approx 0.07" and crimp female D-sub pin on center conductor. Strip 3/4" insulation from 22AWG pigtail wire and wrap around the exposed shield. Solder wire to shield (yes, the insulation on the wire supplied will withstand soldering temperatures). Place

heatshrink over solder joint and extending back about 1/2" as shown. Dress pigtail around as shown and install another D-sub pin.

2.2.4 In this and following steps, references will be made to numbered pin locations in the ECB's D-sub connector. Looking into the wiring side of the D-sub connector, pins are numbered as shown below:

The center conductor plugs into pin 15 of the connector, shield pigtail goes into pin 12.



Wiring Side View of D-sub Connector

2.3 Alternator Diagnostics Press-to-Test Switch: The push button supplied can be mounted in any convenient place accessible to a person seated in the cockpit. Since this button is used only for diagnostics in case of alternator troubles, it may be mounted out of sight if you wish.
Use 22AWG wire to extend pins 1 and 2 from the D-sub connector to solder lugs on the push button. Heatshrink tubing is supplied to cover the exposed terminals after wires are soldered on.

2.4 Alternator Loadmeter Shunt: An ammeter shunt appropriate to the size of your alternator should be mounted on the firewall in a location convenient to installation in the alternator's B-lead. If you're using the AeroElectric Connection recommended B-lead fuse at the starter contactor on the firewall, then the loadmeter shunt will mount adjacent to the starter contactor and be wired into the lead between the alternator and the B-lead fuse. 24AWG fuse links extended with red and black 20AWG wire are supplied with the kit. Route these wires to the cockpit and splice into the instrument harness using butt-splices supplied. The red shunt lead (closest to the alternator) splices to the white wire in the instrument harness and continues on to pin 3 of the instrument. The black shunt lead (closest to the b-lead fuse or breaker) splices to the green instrument harness wire and continues to pin 1 on the rear of the instrument.

2.5 Panel Instrument: The dual pointer voltmeter/loadmeter mounts in a standard 2-1/4" aircraft instrument mounting hole. Wiring to the rear of the instrument is accomplished with a short instrument harness supplied with the kit. Red and black wires should be used for the voltmeter function. The red instrument harness wire goes to pin 4 on the D-sub connector and pin 4 on the rear of the instrument. The black instrument harness wire goes from pin 3 on the D-sub connector to pin 5 on the rear of the instrument. An internal lighting kit is supplied for the panel instrument. Remove the plastic plug button found on the rear of the instrument. The internal lighting fixture installs
in the open hole.

2.6 Ground Wiring: Install 22AWG wires in pins 11, 10 and 9 of the D-sub connector and extend to the instrument panel ground bus. For convenience, all three wires may be crimped into a single terminal for attaching to a ground bus. If you're using the AeroElectric Connection's "forest-of-tabs" instrument panel ground bus, terminate each wire separately and ground to 3 independent ground tabs.

2.7 Essential Bus Wiring: Install 22AWG wires in pins 13, 6 and 7 of the D-sub connector and extend to a 3 to 5 amp fuse or breaker on the essential bus.

2.8 Main Bus Wiring: Install a 22AWG wire in pin 8 of the D-sub connector and extend to a 3-5 amp fuse or breaker on the main bus. If your airplane does not have a diode isolated essential bus, wire pins 6, 7, 8 and 13 to the main bus.

2.9 Field Voltage Monitor Wiring: A 470-ohm isolation resistor assembly is installed as close as practical to the alternator. If your alternator has a threaded stud field terminal, the free wire of the resistor assembly may be fitted with a ring terminal appropriate to the size of the field terminal and simply share the stud with the existing wire between the alternator and the field terminal of the regulator. If your alternator's field terminal is a fast-on tab, then the isolation resistor assembly's free wire and the regulator's field wire may be crimped into a single terminal.

3.0 System Checkout

3.1.1 With battery master switch ON, alternator field switch ON, and engine not running the voltmeter should be reading battery voltage somewhere below 13.0 volts.

3.1.2 The low voltage warning lamp should be flashing.

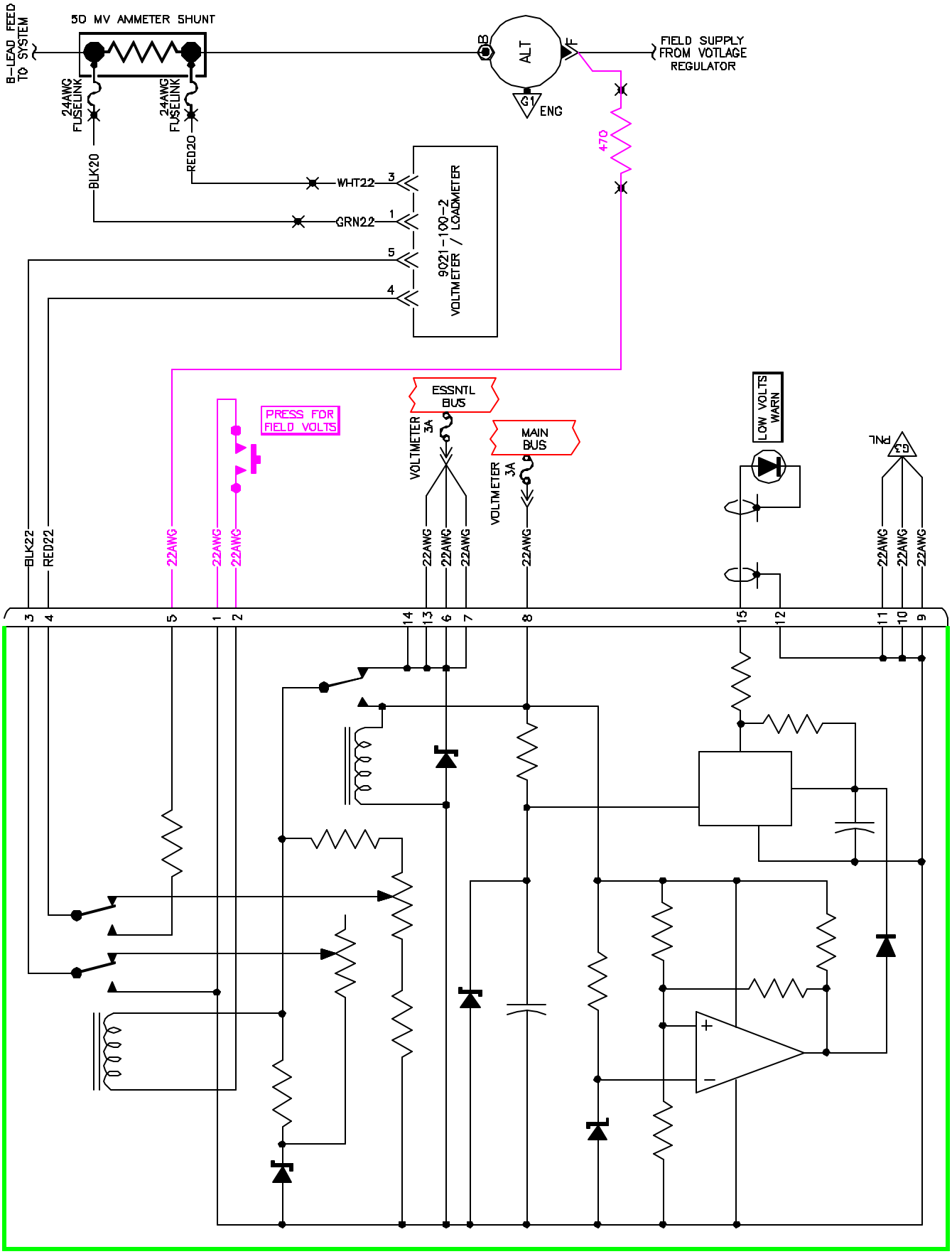
3.1.3 Momentarily depress the alternator system diagnostic button. The voltmeter should indicate between 13 and 14 volts on the instrument (9 and 12 volts in real life).

3.1.4 With engine running, the voltmeter should read somewhere in the green arc. This reading will be the regula-

tor setpoint for your alternator.

3.1.5 The low voltage warning lamp should be dark.

3.1.6 The loadmeter should read some value depending on the system loads and state of charge for the battery.


B-LEAD FEED TO SYSTEM
50 MV AMMETER SHUNT
24AWG FUSELINK
24AWG FUSELINK
BLK20
RED20
B
ALT
F
G1
ENG
FIELD SUPPLY FROM VOTLAGE REGULATOR
470
WHT22
GRN22
3
1
5
4
9021-100-2 VOLTMETER / LOADMETER
PRESS FOR FIELD VOLTS
ESSNTL BUS
MAIN BUS
VOLTMETER 3A
VOLTMETER 3A
LOW VOLTS WARN
PNL
G2
BLK22
RED22
22AWG
22AWG
22AWG
22AWG
22AWG
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3.1.7 Momentarily depress the alternator system diagnostic button. The voltmeter should read less than 14.0 volts on the instrument (12 volts in real life). As engine RPMs increase, field voltage should go down. Daytime cruising flight may require field excitation of less than 3 volts (11 volts indicated on the instrument)

The following steps apply only to aircraft fitted with a diode isolated essential bus . . .

3.1.8 Turn battery master switch and alternator field OFF. Voltmeter should read bottom of scale.

3.1.9 Loadmeter should read bottom of scale.

3.1.10 Low voltage warning light should be dark.

3.1.11 Close essential bus alternate feed switch. Voltmeter should read battery voltage somewhere in the yellow arc below 12.5 volts.

4.0 Conditions for Continued Airworthiness

4.1 Loadmeter Calibration: The loadmeter requires no periodic calibration. Repair or replacement is made on condition of failure.

4.2 Voltmeter Calibration: The voltmeter should be checked each annual inspection for accuracy over the range of the instrument as follows:

4.2.1 Use a regulated, adjustable power supply to power up the essential bus with the ship's battery and alternator OFF. Monitor voltage from the power supply with a digital multimeter capable of displaying nearest 0.01 volt at 14.00 volts of reading.

4.2.2 Set the power supply for a multimeter reading of 11.00 volts.

4.2.3 If the VLM-14 panel instrument does not read exactly 11 volts, adjust the LO volts potentiometer on the ECB assembly (the one nearest the D-sub connector) until the instrument reads 11 volts.

4.2.4 Adjust the power supply for a multimeter reading of 14.00 volts.

4.2.5 If the VLM-14 panel instrument does not read exactly 14 volts, adjust the HI volts potentiometer (the one furthest away from the D-sub connector) until the instrument reads 14 volts.

4.2.6 Repeat steps 4.2.2. through 4.2.5 until no further adjustment is necessary.

4.2.7 Adjust the power supply for multimeter readings of 10.00 to 15.00 volts in 0.50 volt increments. Observe reading of VLM-14 panel instrument for each power supply setting. The panel instrument must agree with the multimeter to within ±0.1 volt.

4.3 Low Voltage Warning Calibration:

4.3.1. Move power supply and multimeter to the ship's main power distribution bus. The VLM-14 voltmeter should accurately display voltage from this new source.

4.3.2. Adjust power supply slowly downward from 14.0 volts and observe the setting where the LO VOLTS WARNING lamp begins to flash. This voltage shall be 13.00 ± 0.20 volts.

5.0 LVM-14 Installation Kit Contents

Qty	P/N	Description
1	9021-100-1	Voltmeter/Loadmeter Instrument
1	9021-200-1	Instrument Harness Assembly
1	9021-201-1	Field Tap Isolation Resistor Assy
1	9021-101-1	Etched Circuit Board Assy
1	S604-15F	Connector, 15-Pin D-sub Crimp w/ Open Barrel Pins
1	DH15	Housing, 15-Pin D-sub Connector
2	2/3 x 3"	Self Adhesive Velcro Hook-Strip
2	S905-24-8	24AWG, #8 Stud, Fuselink with extended leadwires
2	S816RS	22-18AWG Butt Splice
1		Large Nylon Tie-Strap
1	9021-305-1	LV Warn Placard
1	9021-204-1	LED Lamp Assembly
1	S705-1	Push Button
1	9021-704	Instruction Manual
5"	S817-12	Heat Shrink - .12" Dia.

6.0 Materials Needed but not Supplied With This Kit:

20AWG Tefzel wire as required to extend fusible links from

loadmeter shunt to instrument harness.

22AWG Tefzel wire as required to complete wiring to 15-pin D-sub connector

One each, 50 mV Loadmeter shunt sized to the alternator's rated output. For example: a 60 amp alternator requires an S903-60 Loadmeter Shunt.

4 ea 6-32 thread instrument mounting screws with heads and/or color to match panel scheme.

If the installer elects to mount the ECB assembly by its corner holes, the installer will have to supply 4 each screws, spacers, lockwashers and nuts to attach the ECB assembly to its metal mounting surface.

If the LVM-14 is being installed with a two-alternator system, the installer may wish to add a loadmeter sized to the second alternator and a double-pole, double-throw toggle switch to permit the loadmeter to monitor either alternator as shown in the last page to these instructions..

7.0 Alternator System Diagnostics Using the LVM-14

7.1 When an alternator quits alternating, good data is useful in making an accurate diagnosis of the problem. If you don't know what the alternator field voltage is doing when the system is failed or misbehaving, you're not ready to put a wrench to the airplane. There are few mechanics who know about what you're going to learn here . . . still fewer willingly stand behind running propellers to gather the needed information. So consider this: Referring to the wiring diagram in this LVM-14 kit, you can see where a 470-ohm, 1-watt resistor is spliced into the alternator field voltage sense lead. The resistor serves as a current limiting device to isolate the sense lead wire from the field wire and eliminate the need for a fuse to protect the test wire. The resistor also prevents a shorted sense lead wire from upsetting normal alternator operations.

7.2 If the alternator field voltage is zero when the output is zero, then the regulator or associated wiring has failed.

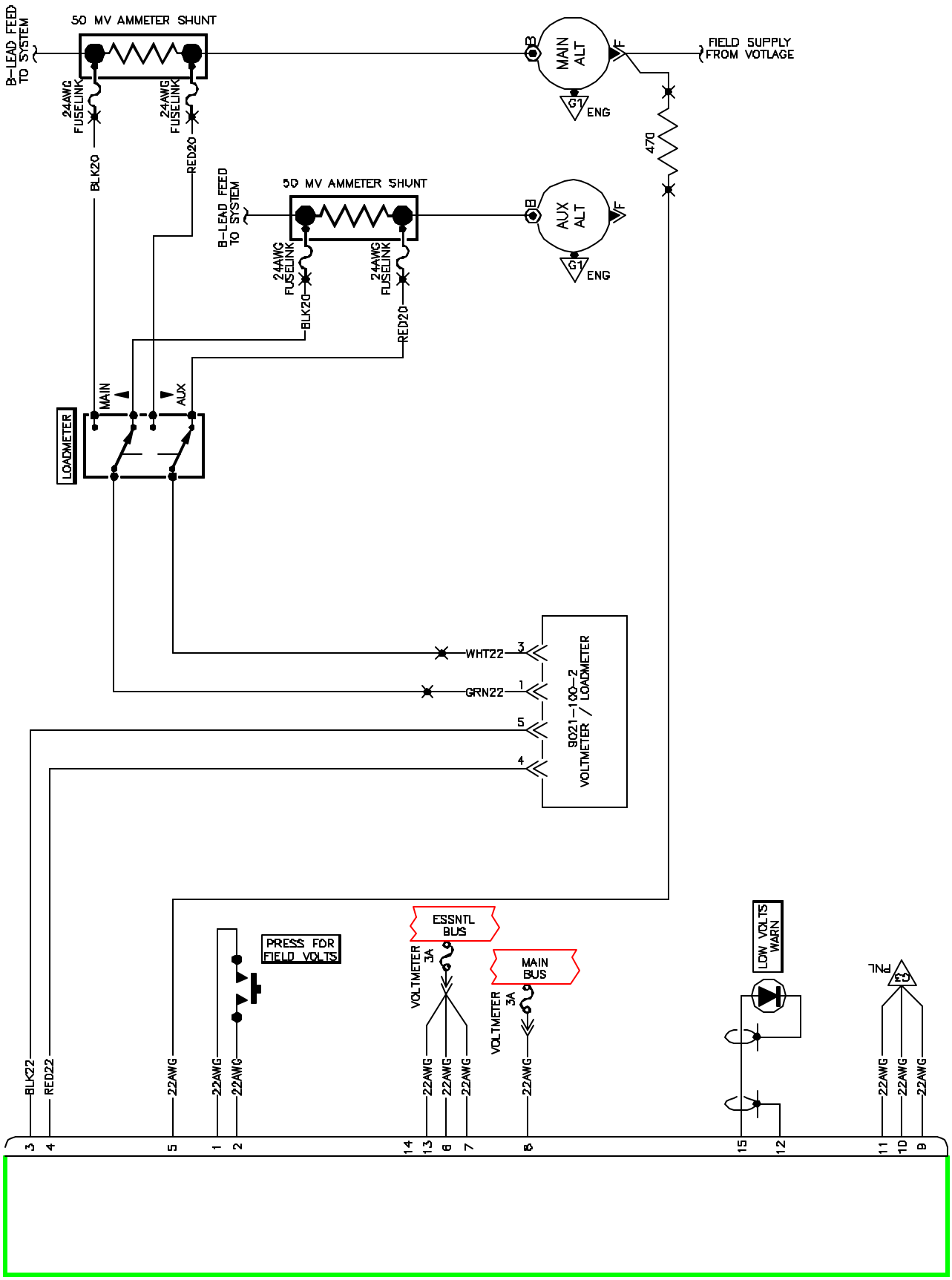
7.3 If the alternator field voltage shows some fairly healthy reading on the order of 10 volts or more and alternator output is zero, the alternator has failed.

7.4 If the alternator has become unstable . . . loadmeter is jumpy, panel lights flicker . . . watch the field voltage and compare it with loadmeter readings. If the field voltage and loadmeter readings swing up and down together, then the regulator has become unstable. Check for increased resistance in regulator field supply wiring and components. Breakers, switches, overvoltage relays, and connectors are all contributors to regulator instability when their resistance ages upward a few milliohms.

7.5 If the loadmeter swings UP while the field voltage is swinging DOWN, then the alternator has some unstable connections inside . . . perhaps worn brushes?

7.6 If field voltage is high, does not drop significantly when engine RPM increases but bus voltage seems normal under light load and sags under heavy loads, then the alternator may have one or more diodes open/shorted.

7.7 While operating with full system loads, carefully observe the engine RPM where alternator field voltage peaks: i.e. begin at idle RPM with all loads ON--if your bus voltage is lower than the regulator setpoint, then the alternator is turning too slow to support present loads. Now, adjust engine RPM carefully to observe engine speed where field voltage stops rising. At this time, the bus voltage should be at the regulator setpoint. The engine RPM is your *minimum speed for regulation* at full load. If your system is working properly and pulley ratios are appropriate, engine RPMs should be equal to or LESS than required to sustain flight.


B-LEAD FEED TO SYSTEM
50 MV AMMETER SHUNT
24AWG FUSELINK
BLK20
RED20
MAIN ALT
B
F
G1
ENG
FIELD SUPPLY FROM VOTLAGE
470
AUX ALT
LOADMETER
MAIN
AUX
WHT22
GRN22
9021-100-2 VOLTMETER / LOADMETER
BLK22
RED22
22AWG
PRESS FOR FIELD VOLTS
ESSNTL BUS
MAIN BUS
VOLTMETER 3A
LOW VOLTS WARN
PNL