TROUBLE-SHOOTING SYSTEM 14V TYPE B ALTERNATOR SYSTEM ON BEECH, CESSNA, GRUMMAN, MAULE, ETC

By: Femi G. Ibitayo

BETTER TROUBLE-SHOOTING TECHNIQUE

A more systematic approach to trouble-shooting (TS) alerts the mechanic to the conditions of the field circuit breaker, alternator switch, alternator controller, and alternator's field. This approach to trouble-shooting looks at the condition of the pre-controller, controller, and post-controller components.

	Page
How the system works, general	1
Trouble-shooting the 14V type B system	2
How the system works with the R15V00 Rev A	3
Specific problems & trouble-shooting table	4

Pre-Controller Condition: Check the condition of the alternator switch, the field circuit breaker, or the wiring from the Alt Bat to *pin* A on the controller is open.

Voltage Regulator (Controller) Are the voltages on pins I, A, S and F according to the test data on page 4? If not, solve the problem with information on these pages.

Alternator Field Condition: Are the field resistances measured from the airframe ACU connect-or and at the alternator according to the data on pages 2 and 4? If not, use the information on these 4 pages to solve the problem.

Most electrical charging system problems are easily solved by using a systematic trouble-shooting approach with an understanding of Ohm's law (basic electricity).

Figures 1 and 2 are setup in the standard Cessna wiring configuration where the voltage regulator (alternator controller) and the over-voltage sensor are separate. Figure 3 shows the system with the R15V00 Rev A installed as a replacement for both units. Figures 1 and 2 provide a base understanding of the way the system operates. ***Skip to pages 3, 2, and 4 if you have or are mainly interested in a system with the R15V00 Rev A already installed.*** *While these notes apply to aircraft other than Cessna's, we can provide TS notes specific to Beech and Grumman.*

How the System Works

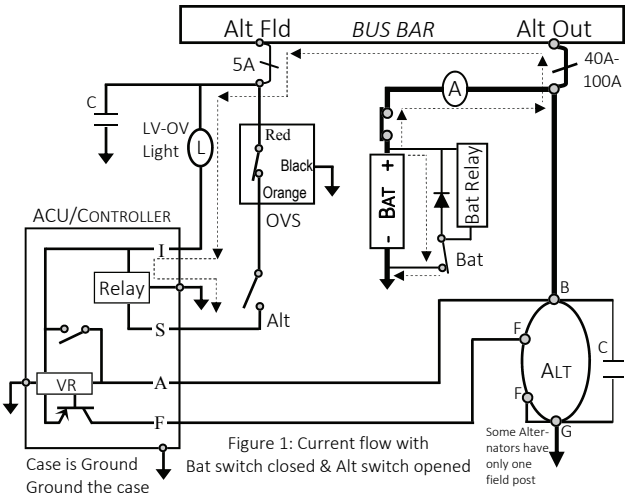

Figure 1: Current flow with Bat switch closed & Alt switch opened

Figure 1. Closing just the Bat switch causes the battery relay to close. The closed battery relay applies the battery voltage to *pin A* of the alternator controller (ACU, controller, regulator) and the Bus. With voltage on the bus and the Alt switch off, the LV-OV light comes on, indicating that the alternator is off-line. The light comes on because current flows from the battery through the light and the controller's low current path to ground. When there is no power on pin S because the Alt switch is open, pin I has a lower voltage than the bus. This potential difference causes current to flow through the light and the light comes on.

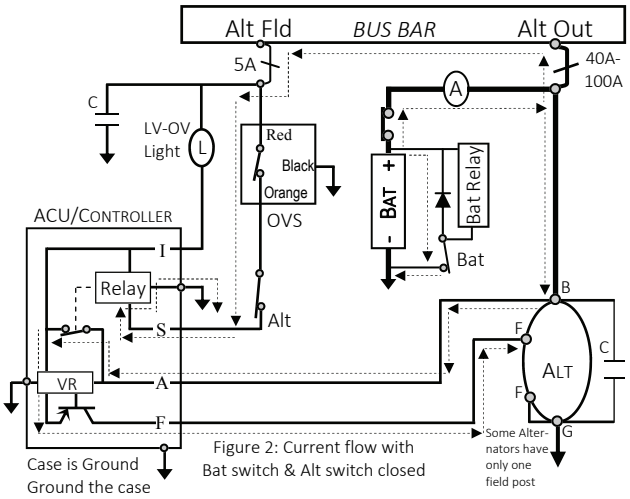

Figure 2: Current flow with Bat switch & Alt switch closed

Figure 2. With the battery voltage applied to the bus, closing the Alt switch applies battery voltage to *pin S* through the Over Voltage Sensor (OVS). The OVS' output controls a relay inside the alternator controller. With power applied to *pin S,* the relay's normally open (NO) contacts closes and connects *pin A* and *pin I*. Connecting pins I and A causes the voltage at pin I and the Bus to be the same, meaning no potential difference exists between the two sides of the LV-OV light. The lack of potential difference means no current flow through the light and the light goes or stays off.

Now current flows from the Bat terminal on the Alternator through pin A to the voltage regulator to the field of the alternator. Pin A serves as the remote voltage sense point and the true power input of the controller. This arrangement avoids the voltage drop problems that is prevalent in systems that have their power input come through the Alt switch, Field circuit breaker, and OV Relay. In this system the primary function of the OV Sensor is to turn off the Controller by opening its OV relay if the system experiences OV fault. The OV Sensor is built-in R15V00 Rev A as shown in **Figure 3**.

The system still functions as describe for Figures 1 and 2. The difference is that OV Sensor inside the R15V00 Rev A operates in the same manner as the one outside. Not having the OV Sensor outside simplifies the system wiring.

When the engine is running, with power on *pin S*, current flows from the alternator's Bat terminal through the controller's voltage regulator to the alternator's field. The regulator keeps the bus voltage constant (around 14V) by controlling the alternator's field current. It increases the field current with increase in system load and decreases it, with a decrease in the system load.

If the bus voltage exceeds about 16V, the internal OVS will open the OV relay contact between pins A and I (the VR input) thus remove power from *pin S* and turning off the controller and the alternator. If the voltage on pin S is below 9V or so, on most controllers the internal OV relay will not energize and connect pins A and I.

An Alternator Controller with built-in OV Sensor/Protector

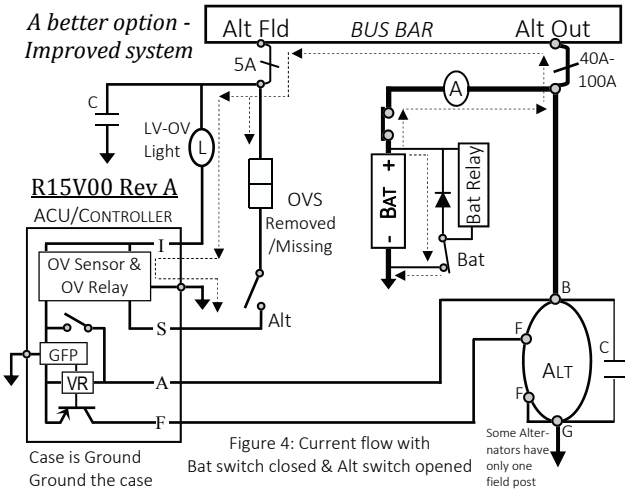

Figure 4: Current flow with Bat switch closed & Alt switch opened

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TROUBLE-SHOOTING SYSTEM 14V TYPE B ALTERNATOR SYSTEM

Checking the condition of the Alternator Charging System

1. If the Master switch is a split type, turn on the Bat switch, turn off the Alt Sw ,and measure the indicated voltages. The LV/OV light in the cockpit should be on.

Check Point	Bus	Pin I	Pin A	Pin S	Pin F
Measure⇒					
Expect ⇒	12-13V	1-6V	12-13V	0-0.5V	0-0.2V

<u>If pin I has bus voltage on it:</u>
Look for a short between pins A & I (internal or external to the controller). Disconnect the controller, a resistance of 0-1K between pins A & I indicates a damaged controller.

<u>If pin I has no voltage on it:</u>
Verify that there is battery voltage on pin A. If there is confirm that pin I is not grounded. If pin I is not grounded, there is a probable open circuit in the controller or regulator between pins A & I.

2. If the Master switch is a split type, turn on the Bat switch, turn on the Alt Switch and measure the indicated voltages. The LV-OV light in the cockpit should be off.

Check Point	Bus	Pin I	Pin A	Pin S	Pin F
Measure⇒					
Expect ⇒	12-13V	12-13V	12-13V	12-13V	10.5-12V

<u>If pin I has no voltage on it:</u>
Look for an open circuit between pins A & I (internal or external to the controller or regulator). With greater than 9V on pin S, the internal N.O. contact of the OV relay inside the controller or regulator, should close, connecting pins A and I.

<u>If pin A has no voltage on it:</u>
Verify that the wire from the alternator's BAT post to pin A of the controller or regulator is connected/secure. Pin A is the power input and voltage sense input for the controller or regulator.

<u>If the pin I voltage is significantly less than bus voltage</u>:
Look for bad LV-OV light, broken wire from LV-OV light, grounded pin I or damaged controller.

<u>If the pin A voltage is less than that of the Bus or Alt BAT:</u>
Look for corrosion on the alternator's BAT terminal, socket for pin A on the airframe ACU connector, or high resistance in the wire (from ALT Bat to pin A). This may cause fluctuating charge meter or bus voltage, and OV nuisance tripping (i.e. alternator dropping off-line).

<u>If pin F has no voltage on it:</u>
Verify that there is no short from the alternator's field or field wire to ground. The ground shielding might be shorting the wire.

<u>Field voltage is equal to the bus voltage (V_B):</u>
The voltage on pin F (V_F) should be 0.5-2V less than the bus'. If the V_F is equal to the V_B, check and verified that the alternator field is 3-7Ω. If it is open, the alternator output will stay around 12V and keep dropping, showing that it is off-line. If it is much greater than 8Ω or is open, it will affect how the charging system work.

A better option - Improved system

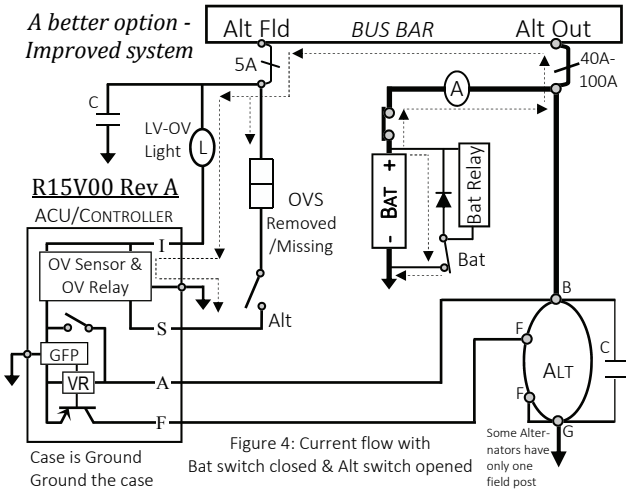


Figure 4: Current flow with Bat switch closed & Alt switch opened

<u>If the pin S voltage is less than bus' but not 0 Volt:</u>
Look for a grounded pin S or damaged controller. Disconnect pin S from the controller, measure the voltage on its wire or terminal, it should read the same as the bus'. If it is still greater than 0 volt but less than 8V, check the Alt switch or breaker.

Field resistance

3. Disconnect/Remove the connector on the ACU. Measure the resistance (on/from the airframe side of the connector) at the identified points.

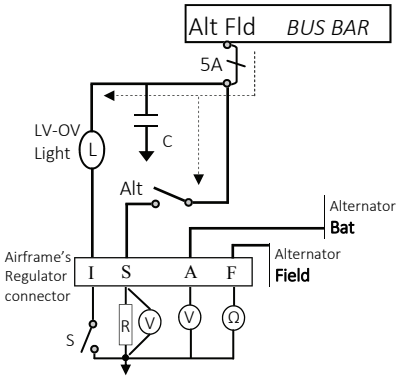
<u>The normal Alt field resistance is 3-6Ω.</u>
Field resistance outside this range may indicate problems with the alternator. Field resistance below 0.5Ω indicates a short to ground, while higher than 7Ω indicate dirty/problemed brushes or open field.

Check Point	Fld-Gnd	Fld-Gnd	PIN A-ALT BAT	BUS TO ALT BAT
Measure⇒				
Expect ⇒	3-6Ω	3-6Ω	0.0-0.1Ω	0.0-0.02Ω
	At ACU	At ALT	Check wires & connections	

<u>Checking the LV-OV light (for correct operation):</u>
Turn on the master switch (BAT & ALT). Ground (indicated by the S switch) pin I, the LV-OV light comes on. Remove the ground, the LV-OV light should turn off.

With the master switch on, the voltage on the alternator BAT post, pin A, and pin S should be the same. Turn off the master switch.

Check the pin F resistance. It should read 3-6Ω.



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HOW THE SYSTEM WORKS

Figure 1A. Closing just the Bat switch causes the battery relay to close. The closed battery relay applies the battery voltage to *pin A* of the alternator controller (ACU, controller, regulator) and the Bus. With voltage on the bus and the Alt switch off, the LV-OV light comes on, indicating that the alternator is off-line. The light comes on because current flows from the battery through the light and the controller's low current path to ground. When there is no power on pin S because the Alt switch is open, pin I has a lower voltage than the bus. This potential difference causes current to flow through the light and the light comes on. *When the LV-OV light is on, the Trouble-Shooting Light (TSL) on the unit comes on red*.

Figure 2A. With the battery switch closed and battery voltage applied to the bus, closing the Alt switch applies battery voltage to *pin S* . With power applied to *pin S,* the internal OV relay's normally open (NO) contacts closes and connects *pin A* and *pin I*. Connecting pins I and A causes the voltage at pin I and the Bus to be the same, meaning no potential difference exists between the two sides of the LV-OV light. The lack of potential difference means no current flow through the light and the light goes or stays off. *With the Alt and Bat switches on, the LV-OV light is off, and the TSL on the unit will turn green.*

Now current flows from the Bat terminal on the Alternator through pin A to the voltage regulator to the field of the alternator. Pin A serves as the remote voltage sense point and the true power input of the controller. In this system the primary function of the OV Sensor is to turn off the Controller if the system experiences OV fault. *With the Alt and Bat switches on, the LV-OV light is off, and the TSL on the unit will turn green.*

The problem posed by the whole field current (max about 3.5 Amps) flowing from the alternator's Bat terminal to pin A of the controller, is that abnormal increases in wire, connection, or junction resistances may cause poor voltage regulation and or fluctuating charge meter, panel lights, and bus voltage. For this reason, one recommends that mechanics clean and tighten the airframe alternator controller/regulator connector and the controller connectors every annual inspection.

When the engine is running, with power on *pin S*, current flows from the alternator's Bat terminal through the controller's voltage regulator to the alternator's field. The regulator keeps the bus voltage constant (around 14V) by controlling the alternator's field current. It increases the field current with increase in system load and decreases it, with a decrease in the system load.

If the field of the alternator shorts to ground in the R15V00 Rev A alternator controller the built-in field-to-ground short protection will turn off the alternator's field and cause the TSL on the unit to turn red. When the TSL turns red, the LV-OV light in the aircraft will come on.

Figure 3A. Over Voltage Protection: If the bus voltage exceeds about 16V, the internal Over Voltage Sensor (OVS) will open the relay contacts between pin A and pin I. Doing that will turn off the controller and take the alternator off line.

The R15V00 Rev A alternator controller is self-protected against alternator with a field-to-ground short. Its built-in **field-to-ground short protection** will turn off the alternator's field, turn the trouble-shooting light (TSL) on the unit red, and the LV-OV light in the aircraft on. The TSL is green when there's battery voltage on pins A and S, and by extension current out of pin F.

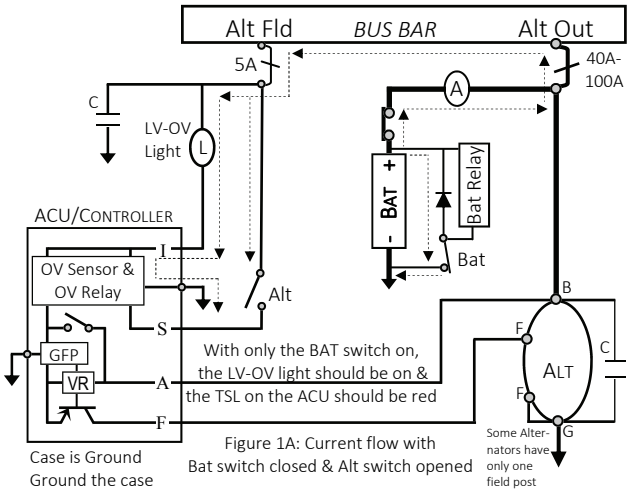

Figure 1A: Current flow with Bat switch closed & Alt switch opened

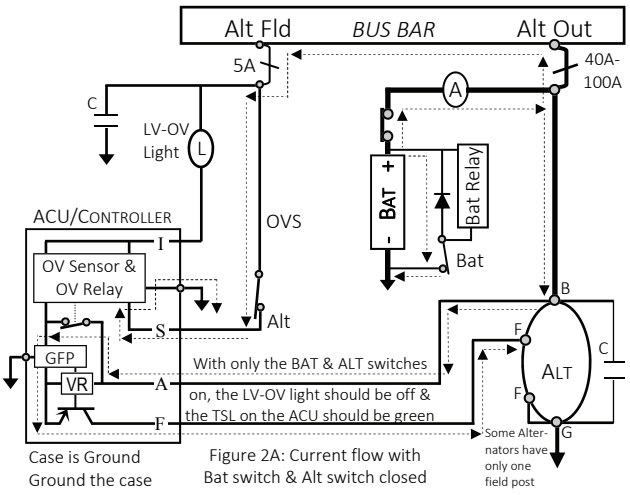

Figure 2A: Current flow with Bat switch & Alt switch closed

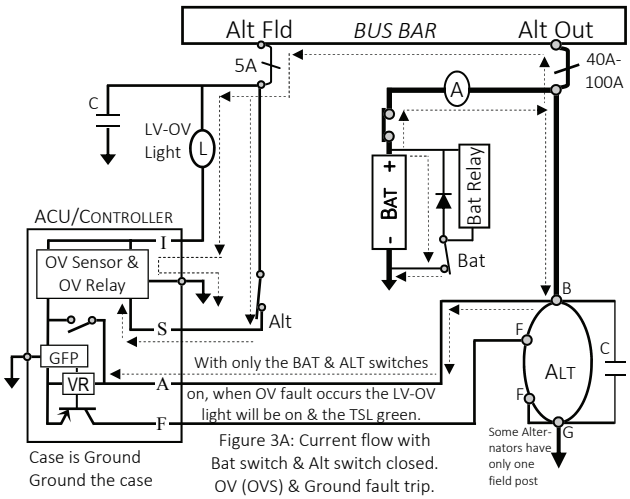

Figure 3A: Current flow with Bat switch & Alt switch closed. OV (OVS) & Ground fault trip.

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TROUBLE-SHOOTING SYSTEM 14V TYPE B R15V00 REV A

Flickering / oscillating ammeter and panel lights.

Check the connections between the Alternator Bat terminal and the pin A input to the controller for high resistance, corrosion, dirt, loose or intermittent connection. The full field current flow from the Bat terminal to pin A, through the controller (regulator) to the field.

Intermittent Over-Voltage trip or Field-to-Ground fault trip.

Watch for field brush bounce that will cause voltage spikes on pin A from the alternator or ground shorted field. These spikes can lead to OV or field-ground short trip in the ACU. Brush bounce problems are not limited to "old" or overhauled alternators.

No voltage regulation or Bus voltage stays at battery voltage (12V)

With the engine off and the Master switch on. Pins I, A, and S should measure Battery voltage, pin F should be 0.5 to 2V less than that.

- If the measured voltages are different, see page 2/4 for probable causes for the problem.
- If the pin F voltage is the same as the bus voltage, look for and correct open circuit or high resistance in the alternator's field or the wire between the field and pin F. The controller might not be properly grounded.
- If the pin F voltage is 0V and pins I, A, S have battery voltage, look for a grounded alternator field or field wire. If the field resistance is correct as shown in step 5 of the installation tests, send the ACU in for test/repair. If there is a field ground fault, repair it or replace the defective alternator.
- If the pin F voltage is correct, verify that the field resistance and the condition of the connections and wires between the ACU and the field are good.

Alternator carries only about half its rated output.

Look for an open stator wire or open diode in the alternator. If one of the 6 rectifier diodes in the alternator is open or one of the three stator wires is broken, the altenator will only carry about half of its rated load. Also, check the shunts (charge or amp meter) and alternator output wires.

Bus voltage drops with load increase

To solve this problem, see *Alternator carries only about half its rated output.* Also check the condition of the wire/connections between pin A and the alternator's Bat terminal.

Bus voltage stays at 13.4-13.8V

Check the condition of the wire/connections between pin A and the alternator's Bat terminal. Make sure that the airframe's connector fits tightly onto pins A and F of the alternator controller or regulator.

LV-OV light does not work, everything else works

Disconnect the ACU/Regulator. Turn on the Bat switch. On the airframe ACU connector ground pin I. The light should illuminate. If it does not, the lamp is defective or the wires to or from it are broken.

An Alternator Controller with a Separate OV Sensor/Protector

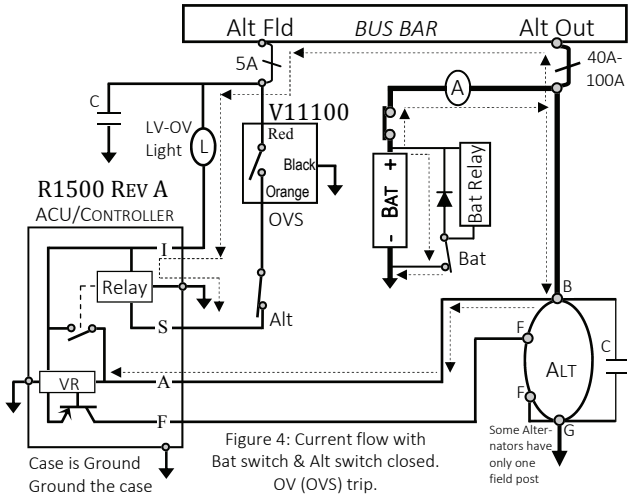

Figure 4: Current flow with Bat switch & Alt switch closed. OV (OVS) trip.

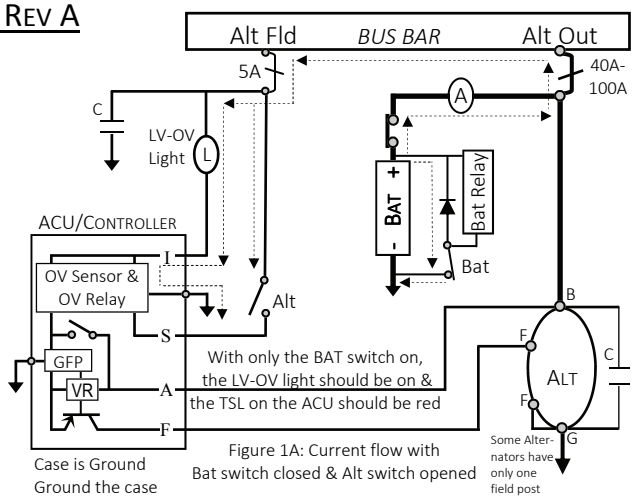

Figure 1A: Current flow with Bat switch closed & Alt switch opened

Except for step 5, take all measurements with the engine off. Take the step 5 voltage from the bus (inside) away from the propellers. It is easier to take the measurements in steps 1 to 4 with the unit unbolted from the firewall, its case grounded to the firewall. This will allow easier access to pins I, A, S, and F, as well as, prevent grounding any of the pins.

1	Check for and replace open, frayed, or broken wires. Clean thoroughly or replace corroded, dirty, or oxidized connections, terminals, contact, or poorly soldered wire junction. *Of particular concern are corroded, oxidized, or loose quick disconnect at pins A, S, and F of the aircraft's voltage regulator mating connector.*			
2	Check for Open or Ground-shorted alternator field. Most 12V alternators have 3-6Ω field resistance. Ground shorted alternator field will damage most Voltage Regulators/ACU. Repair or replace an alternator has a field to ground short, do not connect the ACU to it.			
	Perform and record the following tests with the Master Switch Off			
	Resistance measurement at (engine off)	Measured	Expect	
A	Field resistance at the Alternator (F to Gnd)		3-6	Ω
B	Field resistance at the ACU (F to Gnd)		3-6	Ω
C	FLD switch to circuit breaker resistance		0.1	Ω
D	ALT Output circuit breaker resistance		0.1	Ω
E	ALT BAT to Bus resistance		0.05	Ω
E	ALT BAT to ACU pin A resistance		0.05	Ω
3	With the engine off: Check voltage drops across the Field, Alt switch, Alt field circuit breaker and ACU. High voltage-drop means excessive junction resistance and will lead to many problems like: fluctuation ammeters, charge-meters and panel lights.			
	Perform and record the following tests with the Bat Switch only On			
	Voltage (V) measurement at (engine off)	Measured	Expect	
A	Bus Voltage (Bus to Ground), VBus		12-13	V
B	Pin I Voltage (pin I to Ground), VI, at the ACU		1-6	V
C	Pin A Voltage (pin A to Ground), VA, at the ACU		12-13	V
D	Pin S Voltage (pin S to Ground), VS, at the ACU		0-2	V
E	Pin F Voltage (pin F to Ground), VF, at the ACU		0-3*F	V
F	Alternator post F Voltage (F to Ground), VF		0-3*F	V
4	*Perform and record the following tests with the BAT & ALT Switch On*			
	Voltage (V) measurement at (engine off)	Measured	Expect	
A	Bus Voltage (Bus to Ground), VBus		12-13	V
B	Pin I Voltage (pin I to Ground), VI, at the ACU		12-13	V
C	Pin A Voltage (pin A to Ground), VA, at the ACU		12-13	V
D	Pin S Voltage (pin S to Ground), VS, at the ACU		12-13	V
E	Pin F Voltage (pin F to Ground), VF, at the ACU		10-11.5	V
F	Alternator post F Voltage (F to Ground), VF		10-11.5	V
5	Perform and record the following tests with the Master Switch On			
	Voltage (V) measurement at 1800RPM	Measured	Expect	
A	Bus Voltage (Bus to Ground), VBus		13.8-14.3	V

*F — *greater than 2V if the field resistance is higher than normal.*

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