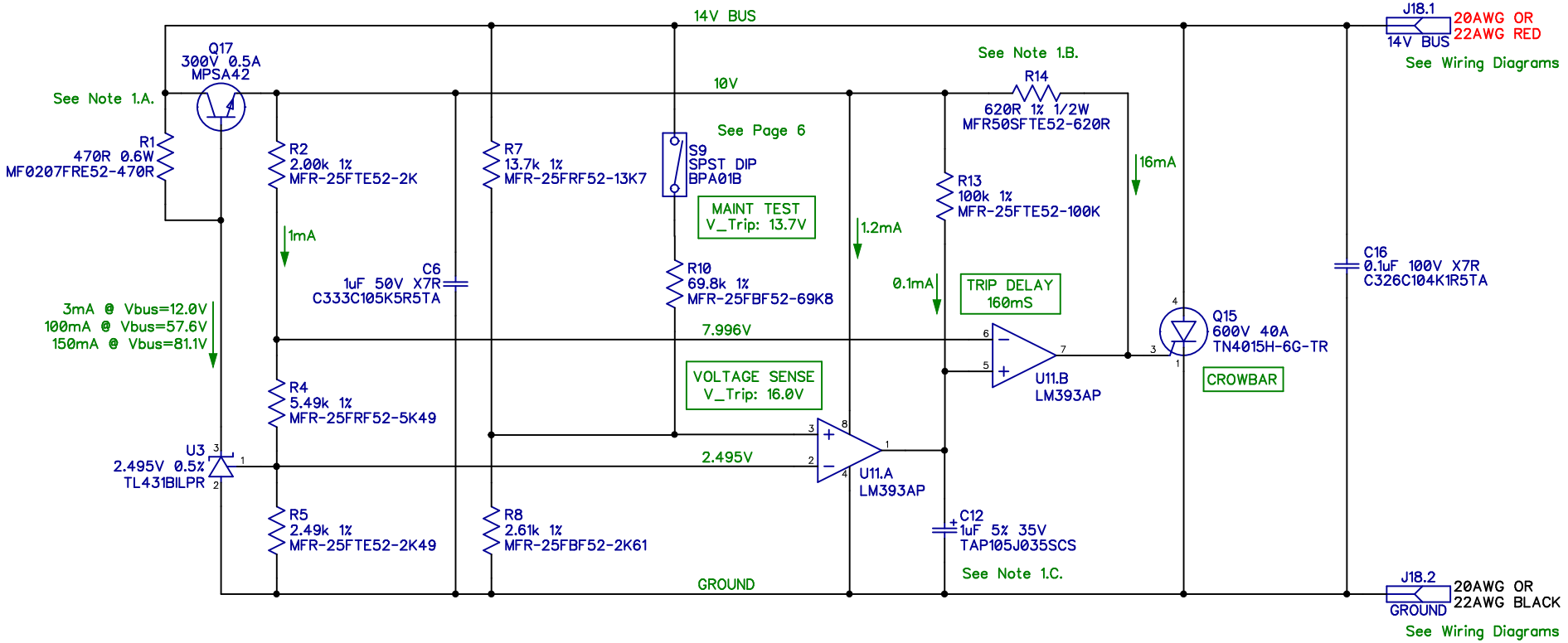
SCHEMATIC DIAGRAM



Title: OVM-14 MkIII Overvoltage Protection Module Original Design by Robert L. Nuckolls III Posted to the AeroElectric-List Forum	**Rev:** 1d **Size:** 11x8.5
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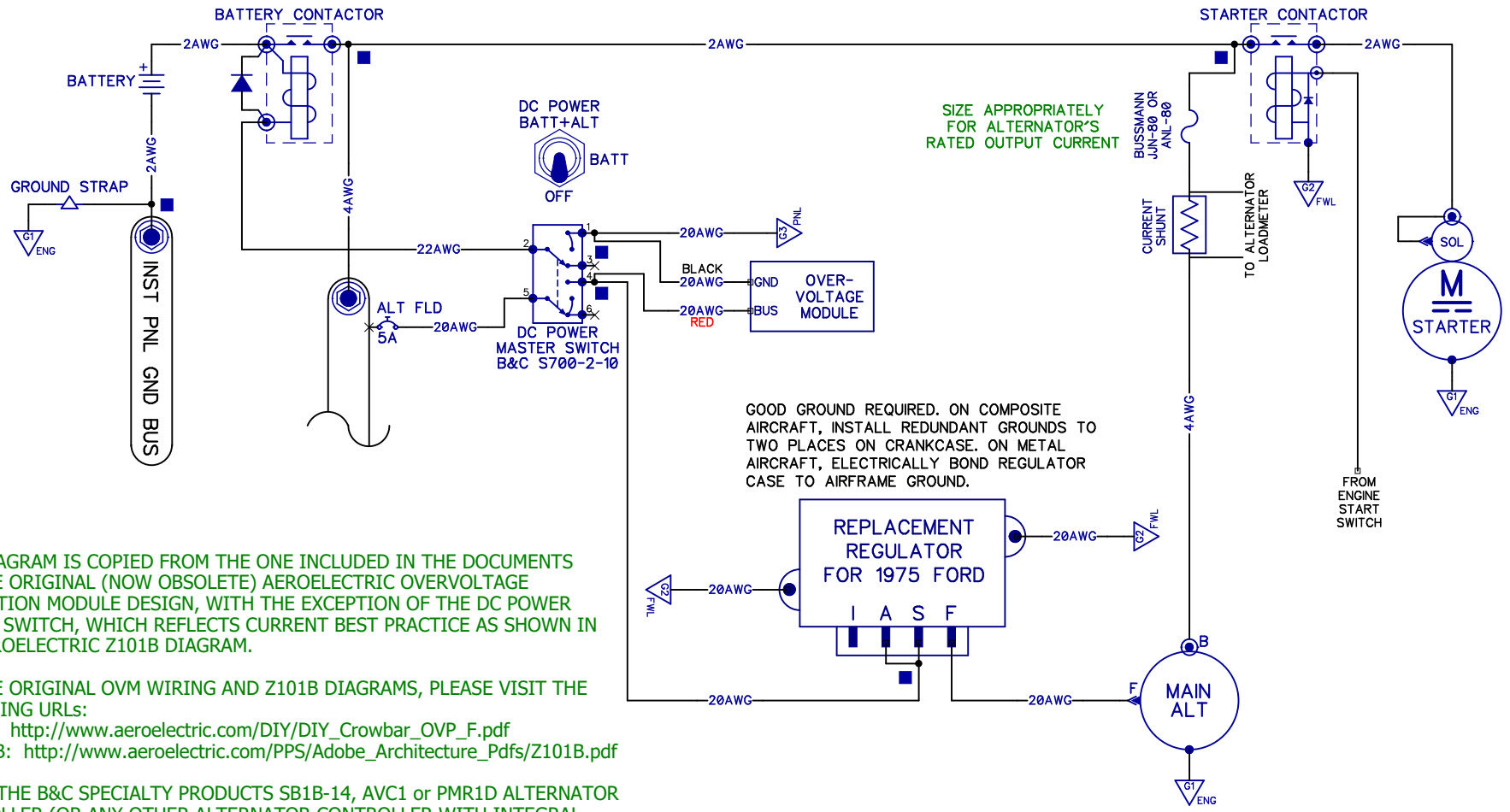
WIRING DIAGRAM: EXTERNALLY REGULATED ALTERNATOR



THIS DIAGRAM IS COPIED FROM THE ONE INCLUDED IN THE DOCUMENTS FOR THE ORIGINAL (NOW OBSOLETE) AEROELECTRIC OVERVOLTAGE PROTECTION MODULE DESIGN, WITH THE EXCEPTION OF THE DC POWER MASTER SWITCH, WHICH REFLECTS CURRENT BEST PRACTICE AS SHOWN IN THE AEROELECTRIC Z101B DIAGRAM.

FOR THE ORIGINAL OVM WIRING AND Z101B DIAGRAMS, PLEASE VISIT THE FOLLOWING URLs:
- OVM: http://www.aeroelectric.com/DIY/DIY_Crowbar_OVP_F.pdf
- Z101B: http://www.aeroelectric.com/PPS/Adobe_Architecture_Pdfs/Z101B.pdf

USE OF THE B&C SPECIALTY PRODUCTS SB1B-14, AVC1 or PMR1D ALTERNATOR CONTROLLER (OR ANY OTHER ALTERNATOR CONTROLLER WITH INTEGRAL OVERVOLTAGE PROTECTION) AS SHOWN IN THE Z101B DIAGRAM ELIMINATES THE NEED FOR A SEPARATE OVERVOLTAGE PROTECTION MODULE.

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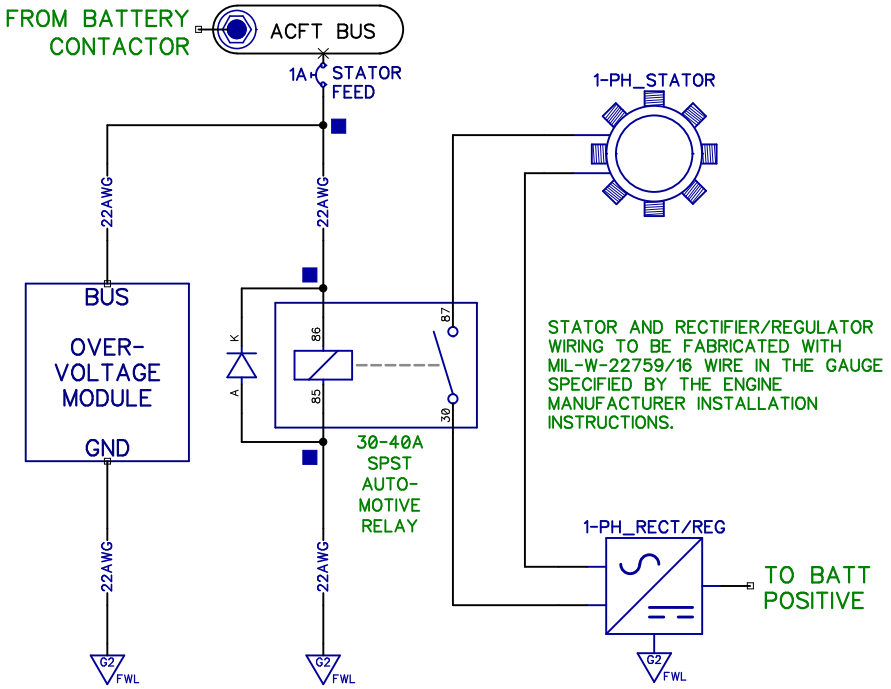
■ = ALL WIRES TERMINATED ON COMMON STUD/PIN

G3 PNL = INSTRUMENT PANEL GROUND

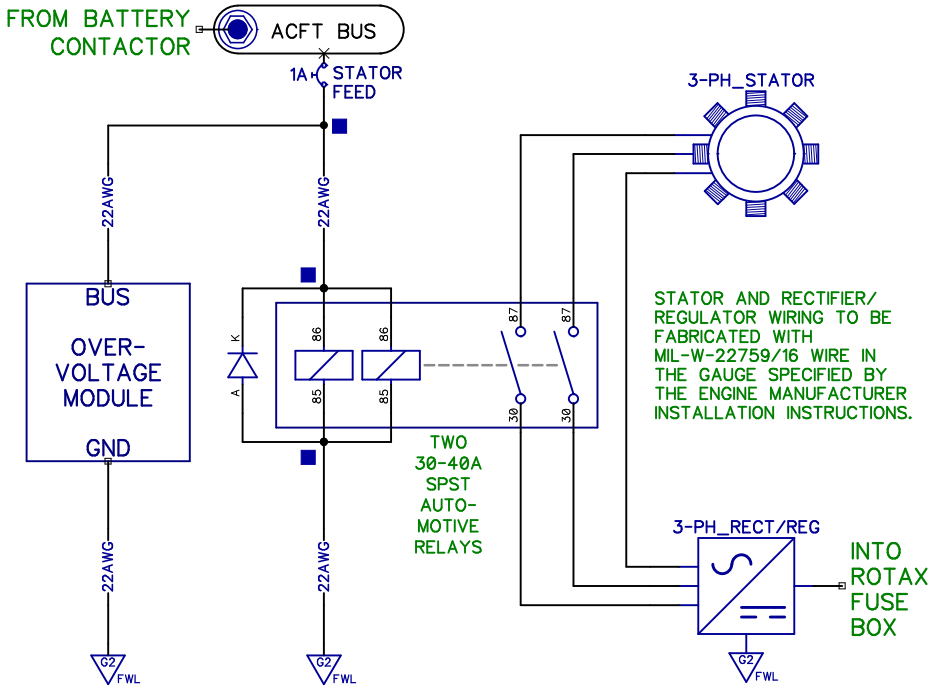
G2 FWL = FIREWALL GROUND

G1 ENG = ENGINE CRANKCASE GROUND

WIRING DIAGRAM FOR SINGLE PHASE STATORS (Rotax 912UL/ULS, 914UL)



WIRING DIAGRAM FOR THREE PHASE STATORS (Rotax 912iS, 915iS, 916iS)



SUGGESTED RELAYS:
THE RELAYS LISTED IN THE BILL OF MATERIALS ON PAGE 7 CONTAIN INTEGRAL BACK-EMF DIODES ACROSS THEIR COILS. IF THESE RELAYS ARE USED, THEN THE EXTERNAL DIODES SHOWN IN THE DIAGRAMS ON THIS SHEET ARE NOT REQUIRED. THE RELAY PIN NUMBERS SHOWN ABOVE MATCH THE SUGGESTED RELAYS. BE CERTAIN TO CONNECT BUS FEED TO PIN 86. POLARITY REVERSAL WILL OPEN THE BREAKER AND MAY DAMAGE THE DIODES.

CAUTIONARY NOTES:
- FOR 3-PHASE SYSTEMS, SWITCH TWO STATOR PHASES WITH TWO SEPARATE SINGLE POLE SINGLE THROW RELAYS IN PARALLEL. DO NOT USE ONE DOUBLE POLE SINGLE THROW RELAY. FAILURE OF ONE SPST RELAY LEAVES TWO PHASES INTACT, WHICH MAY PRESERVE SOME GENERATING CAPABILITY, WHILE FAILURE OF A LONE SPDT RELAY WOULD CUT OFF TWO PHASES, REDUCING GENERATING CAPABILITY TO ZERO.
- ON ROTAX 9-SERIES "iS" ENGINES, APPLY OVERVOLTAGE PROTECTION TO CHARGING SYSTEM "B" ONLY. DO NOT INTERRUPT SYSTEM "A".

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IF MANUAL CONTROL OF STATOR FEED IS DESIRED, THE RELAY COIL POWER MAY BE INTERRUPTED WITH A DC POWER MASTER SWITCH AS SHOWN IN THE ALTERNATOR WIRING DIAGRAM ON PAGE 2. THIS CONFIGURATION IS NOT SHOWN IN ANY ROTAX DOCUMENTATION. SEE WARNINGS ON PAGE 4.

■ = ALL WIRES TERMINATED ON COMMON STUD/PIN

G2 FWL = FIREWALL GROUND

NOTES

1. The following changes were made to the original design (see Note 2) for this module:
   A. Pass transistor Q17 was added and the value of R1 was adjusted from 392 ohms to 470 ohms. This ensures good supply regulation and provides adequate current for voltage reference U3 under all operating conditions while protecting U3 against overcurrent during severe overvoltage events. With these changes, at a bus voltage of 14.2V, R1 power dissipation is reduced from 0.34W to 0.03W.
   B. The value of R14 was changed from 2.49k ohms to 620 ohms and it was connected to the 10V supply instead of the aircraft bus. This ensures adequate current to the gate of Q15 to turn it on (as much as 15mA required) and ensures that the current sink through the output of U11.B is well controlled (absolute maximum rating: 20mA). With this change, voltage reference U3 was unable to regulate properly due to the extra current draw, driving the changes in note 1.A.
   C. Timing capacitor C12 was changed to a 5% tolerance solid tantalum type for better stability over applied voltage, temperature and age.
   D. Voltage divider resistor values were adjusted to achieve the desired 16.0V normal trip and 13.7V maintenance test mode trip. 13.7V was chosen for maintenance test mode to accomodate the typical resting voltage of LiFePO4 batteries (3.4V per cell, 13.6V for a battery with four cells in series).
2. The core circuit in this overvoltage protection module was originally designed by Robert L. Nuckolls III and was posted to the AeroElectric-List Matronics Forum. Please visit the following URL: http://forum.matronics.com/viewforum.php?f=3. Search for "OVM-14 MkIII" to see project history, original schematic and circuit board layout. Read all related threads to ensure a full understanding of system operation and testing. Mr. Nuckolls has not reviewed or endorsed these changes to his original design.
3. For some Rotax 912iS and 915iS engines: On 3 July 2019 Rotax issued Service Instructions SI-912i-024 (for 912iS) and SI-915i-006 (for 915iS) instructing operators to replace the factory-installed TE Connectivity Deutsch DT series connectors (rated for 13A per contact) on the Stator B and Regulator B harnesses with a Rotax-supplied Amphenol "ecomate RM" connector set. That connector set is very costly (approximately $71 from a commercial supplier; $460 from Rotax) and requires special (read: expensive) tooling to crimp its terminals.

   Suggest the following alternative method of compliance for operators of Experimental category aircraft: The Amphenol ATP series connectors are an exact copy of the common TE Connectivity Deutsch DTP series at about half the cost, they are rated to carry 25A per contact, and the installer can use high quality machined contact terminals that crimp with common and affordable tooling (search for iCrimp IWD-12). Replace the Rotax factory-installed Deutsch DT connectors on the Stator B and Regulator B harnesses with Amphenol ATP connectors instead of the Rotax-specified Amphenol "ecomate RM" connectors.

   Link to Amphenol ATP series connector components: https://www.digikey.com/en/mylists/list/F79ZR57U0V
   (Click "+" next to each item to see alternatives.)

WARNING: When installed in an aircraft powered by a Rotax 9-Series iS engine, activation of the overvoltage protection module in flight constitutes an urgent condition. Once the module has tripped, Stator B is isolated from Rectifier/Regulator B, and thus from the Rotax Fuse Box. This prevents the ECU and Fuse Box from switching to the "B" electrical system in the event that the "A" electrical system fails. Engine electrical redundancy is lost, and subsequent failure of the "A" electrical system will result in immediate engine shutdown. If this occurs, close the BATTERY BACKUP switch and restart the engine. Continued engine operation will be supported by battery power only. Land at the nearest suitable airport and repair the "B" electrical system overvoltage condition before further flight.

WARNING: In any aircraft powered by an electrically dependent engine equipped with a single stator or alternator and no second source of electrical power generation, activation of the overvoltage protection module will constitute an urgent condition. The engine will only operate until the battery is depleted below the minimum voltage for ignition system operation.

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THEORY OF OPERATION

1. The main element of the circuit is U11, an LM393 dual linear comparator with open-collector outputs. This device works by comparing its inputs against one another. If its non-inverting input (marked "+") is at a higher voltage than its inverting input (marked "-"), then its output is high (transistor off, pulled to the supply voltage by an external pull-up resistor). If its inverting input is at a higher voltage than its non-inverting input, then its output is low (transistor on, pulling the output pin to ground).

2. Supply voltage for the circuit is provided from the monitored aircraft bus via a linear power supply composed of current-limiting resistor R1, TL431 precision voltage reference U3 and NPN pass transistor Q17. Capacitor C6 provides stability. Feedback to the TL431's adjust pin is provided by the R2-R4-R5 resistive voltage divider, so that 2.495V appears at the adjust pin when the circuit's supply rail is at 10V. This divider also provides a 2.495V reference voltage to the inverting input of comparator U11.A, as well as a 7.996V reference voltage to the inverting input of comparator U11.B.

3. The voltage divider composed of resistors R7 and R8 scales down bus voltage such that when the bus is at about 16V, then 2.495V will appear at the non-inverting input of U11.A. Any voltage higher than this will cause the comparator's output to go high, allowing capacitor C12 to begin charging through resistor R13. The time constant of C12 charging through R13 from a 10V supply provides an approximately 160mS delay before comparator U11.B will trip. This prevents the circuit from tripping and cutting off the charging system in response to short-duration voltage transients in the aircraft's electrical system.

4. Under normal bus voltage conditions, comparator U11.B's output transistor is on and the output is pulled down to ground. This pulls the gate of the crowbar SCR Q15 low, holding it off.

5. When U11.A's output goes high and C12 charges to greater than 7.996V (more than 160mS elapses), U11.B's output goes high, activating the overvoltage protection. Q15's gate is allowed to charge via R14, triggering the SCR. This crowbars the supply, opening the ALT FIELD or STATOR FEED circuit breaker.

NOTE: In a stator-based charging system, it would seem logical to switch the regulator's output rather than its input. This system switches the input wires for two reasons: (1) The ROTAX 9-Series engine installation manuals state that cutting the regulator's connection to the battery while under load can destroy the regulator. Thus, switching the output has the potential to damage a properly functioning regulator in the event of a nuisance trip. (2) Relays with contact ratings adequate to switch as much as a 30A load at a relatively high DC voltage (as during an overvoltage event) are physically larger, have significantly higher coil current and are more costly than the relays specified. Finally, replacement automotive relays are commonly available from auto parts and general merchandise retailers everywhere.

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INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

At each condition inspection, test operation of the overvoltage protection module as follows:

1. Turn OFF the engine.
2. If necessary, remove the upper cowling to provide access to the overvoltage protection module.
3. Turn ON the overvoltage protection module's test switch (S9), placing the module in maintenance test mode.
4. Turn ON the DC Power Master switch, leaving the Alternator switch OFF (for a stator-based system, pull the Stator Feed circuit breaker).
5. Start the engine.
6. Once the engine is running, turn the Alternator switch ON, or close the Stator Feed circuit breaker.
7. Observe that the Alternator Field or Stator Feed circuit breaker trip as soon as bus voltage rises to its normal level.
8. Turn OFF the engine.
9. Close the Alternator Field or Stator Feed circuit breaker.
10. Turn OFF the overvoltage protection module's test switch (S9) to return the module to normal operation.
11. If it was removed, reinstall the upper cowling.
12. Make an airframe logbook entry to record accomplishment of this procedure.

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BILL OF MATERIALS

Reference	Qty	Manufacturer	Manufacturer P/N	Digi-Key P/N	Description	Mounting	Package
C6	1	KEMET	C333C105K5R5TA	399-13915-ND	1uF 10% 50V X7R ceramic capacitor	TH	0.28"x0.16"
C12	1	KEMET	C322C105J5R5TA	399-C322C105J5R5TA-ND	1uF 5% 50V X7R ceramic capacitor	TH	0.2"x0.125"
C16	1	KEMET	C326C104K1R5TA	399-C326C104K1R5TA-ND	0.1uF 10% 100V X7R ceramic capacitor	TH	0.2"x0.125"
J18	1	Wurth Elektronik	638363122002	732-638363122002-ND	1/4" quick connect terminal, 2-position, male	TH	11.5x11.74mm
Q15	1	STMicroelectronics	TN4015H-6G-TR	497-17022-1-ND	SCR, 600V, 40A	SM	TO-263-3
Q17	1	Diotec Semiconductor	MPSA42	4878-MPSA42CT-ND	NPN bipolar juntion transistor, 300V, 500mA	TH	TO-92-3
R1	1	Yageo	MF0207FRE52-470R	13-MF0207FRE52-470RCT-ND	Resistor, axial, 470 ohms, 1%, 0.6W	TH	0.094"Dx0.248"
R2	1	Yageo	MFR-25FTE52-2K	13-MFR-25FTE52-2KCT-ND	Resistor, axial, 2k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R4	1	Yageo	MFR-25FRF52-5K49	13-MFR-25FRF52-5K49CT-ND	Resistor, axial, 5.49k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R5	1	Yageo	MFR-25FTE52-2K49	13-MFR-25FTE52-2K49CT-ND	Resistor, axial, 2.49k ohms, 1%, 0.4W	TH	0.094"Dx0.248"
R7	1	Yageo	MFR-25FRF52-13K7	13-MFR-25FRF52-13K7CT-ND	Resistor, axial, 13.7k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R8	1	Yageo	MFR-25FBF52-2K61	2.61KXBK-ND	Resistor, axial, 2.67k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R10	1	Yageo	MFR-25FBF52-69K8	13-MFR-25FBF52-69K8-ND	Resistor, axial, 68.1k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R13	1	Yageo	MFR-25FTE52-100K	13-MFR-25FTE52-100KCT-ND	Resistor, axial, 100k ohms, 1%, 1/4W	TH	0.094"Dx0.248"
R14	1	Yageo	MFR50SFTE52-620R	13-MFR50SFTE52-620RCT-ND	Resistor, axial, 620 ohms, 1%, 1/2W	TH	0.094"Dx0.248"
S9	1	C&K	BPA01B	CKN10346-ND	Switch, piano, DIP, 1 position, SPST, 0.025A, 24V	TH	4.48x8.15mm
U3	1	Texas Instruments	TL431BILPR	296-TL431BILPRCT-ND	Shunt voltage reference, 2.495V, 0.5%	TH	TO-92-3
U11	1	Texas Instruments	LM393AP	296-6609-5-ND	Differential linear comparator, 2 circuits	TH	8-PDIP
Heat Shrink Tube	2.5"	Qualtek	Q2-Z-1 1/2-01-QB6IN-5	Q2-Z-1 1/2-01-QB6IN-5-ND	Heat shrink tubing, 1-1/2" dia, 2:1 shrink ratio	n/a	n/a
RELAY OPTIONS:							
K1, (K2)	1 (2)	CIT Relay & Switch	A2M1ASQ12VDC1.6D	2449-A2M1ASQ12VDC1.6D-ND	Automotive relay, SPST, 40A, 12V coil w/diode, metal bracket	n/a	n/a
K1, (K2)	1 (2)	CIT Relay & Switch	A2F1ASQ12VDC1.6D	2449-A2F1ASQ12VDC1.6D-ND	Automotive relay, SPST, 40A, 12V coil w/diode, plastic bracket	n/a	n/a

Note: For single-phase stator control, one relay is required. For 3-phase stator control, two relays are required.

Digi-Key Parts List: https://www.digikey.com/en/mylists/list/KSLXG5SQTF

Purchase Printed Circuit Board: https://oshpark.com/shared_projects/pXNz8Ogh

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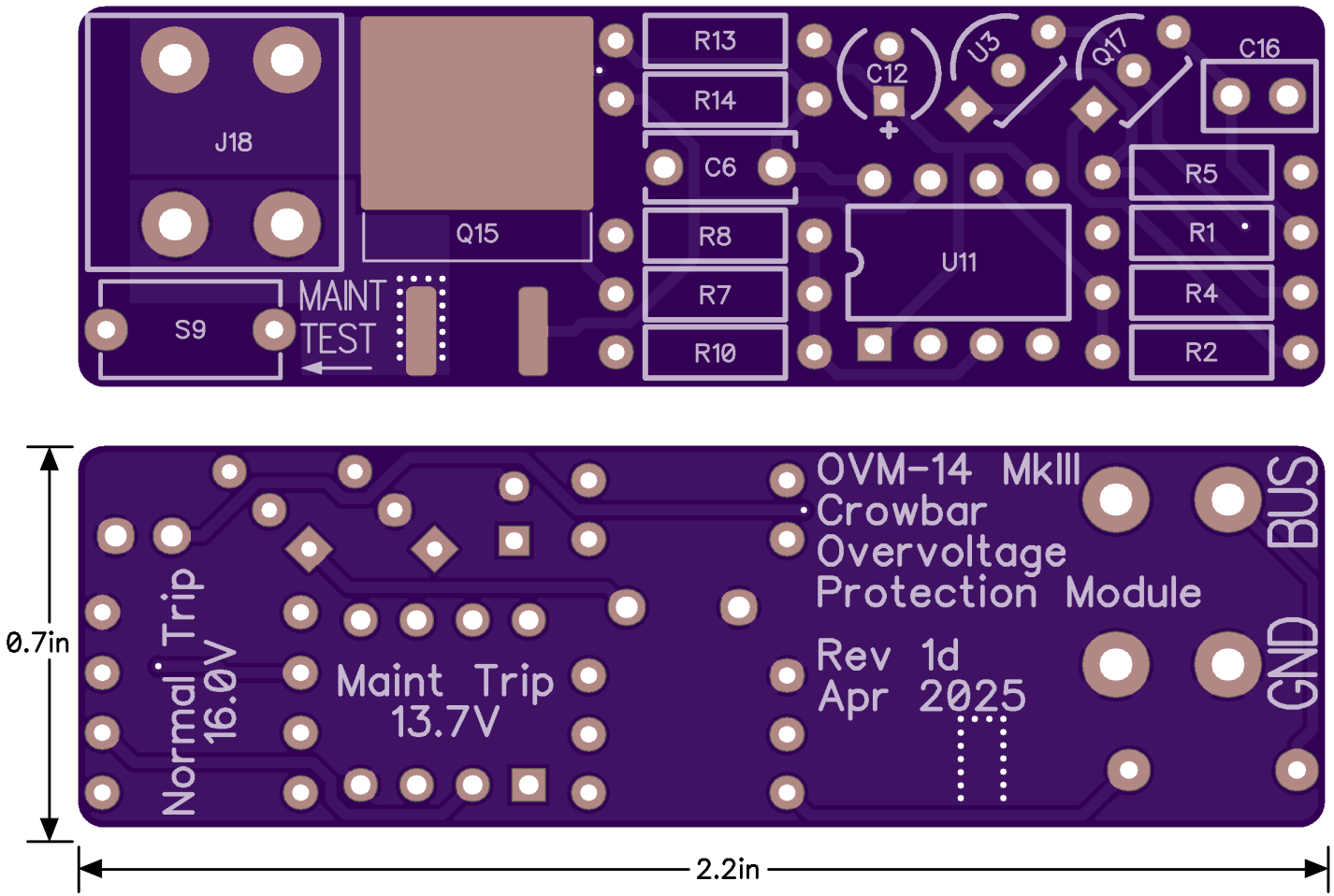
CIRCUIT BOARD LAYOUT



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CIRCUIT BOARD ASSEMBLY

The instructions below assume that you're looking at the circuit board as shown in the top image on page 8.

1. Install the SCR (Q15). Start by melting a small amount of solder onto the lower right pad for Q15. You want to just tin the pad, not deposit a large lump of solder. Next, position Q15 carefully on its three pads, then, while holding it down, touch your iron to the lower right leg, melting the solder under the leg and pinning the part in place. Finish soldering the SCR by using your iron to heat the large tab at the top of the part, then feed solder onto the pad so that it flows under the part (due to the mass of the part and copper on the board, this may take some dwell time with your soldering iron). When the solder forms a fillet at the top of the tab, you're done. Finally, solder down the lower left leg and add a bit more solder to the lower right leg.
2. Install the resistors (Rxx). One at a time, bend each resistor's legs at 90 degrees, close against its body, then insert it into the correct position on the board. On the back side of the board, bend both legs outward slightly to hold the resistor in the holes, then solder the legs in place on the back side of the board. Trim the legs flush, then repeat this process for all resistors. The resistors are not polarized; orientation is not important.
3. Install the comparator (U11). Orientation of this 8-pin device is critical. It has a small round dimple or dot molded into its top surface; this dot indicates the location of pin 1. The printing on the circuit board has a notch at one end and one square solder pad; these also indicate the location of pin 1. Be sure that the comparator is inserted with the dot on the part at the same end as the notch on the board (pin 1 in the square pad). Use a small piece of tape to hold the comparator in place while you turn the board over and solder only one leg. Check that the part is fully seated on the board. If needed, briefly re-melt the leg you just soldered while gently pushing the part into place, then let it cool. Solder/trim remaining legs.
4. Install the voltage reference (D1) and transistor (Q17). Orientation of these parts is easy: just match the flat face on the parts to the markings on the circuit board. Like with the comparator, solder one leg first, then make sure the part is fully seated before soldering the other 2 legs and trimming.
5. Install the capacitors (Cxx). Only C12 (the round, yellow part) is polarized. It has a small "+" printed on one side and the positive leg is shorter than the other. Be sure the positive leg goes into the hole maked "+" on the circuit board. For the other two capacitors, orientation is not important. Like with the resistors, insert the capacitors, bend the legs outward slightly to hold the parts in place, solder the back side, then trim the legs.
6. Install the switch (S9). Insert the switch into the holes in the circuit board so that the "piano key" actuator is to the left, sticking just off the left end of the board. Solder one leg, check that the switch is fully seated and upright, then solder the other leg and trim.
7. Install the 2-position QC connector (J18). Insert the connector with the tabs sticking out to the left, solder one leg, check fitment, then solder the remaining legs. Soldering this part may require significant dwell time with your soldering iron; the part and the copper on the circuit board are heat sinks which can make soldering difficult.
8. Install the heat shrink tubing. Place the tubing over the assembled circuit board so that it's flush with the left end of the QC connector body and switch, then shrink it carefully into place using a heat gun. If you don't have a heat gun, you can use a torch or lighter, but be very careful not to overheat and melt the tubing or burn the circuit board or components.

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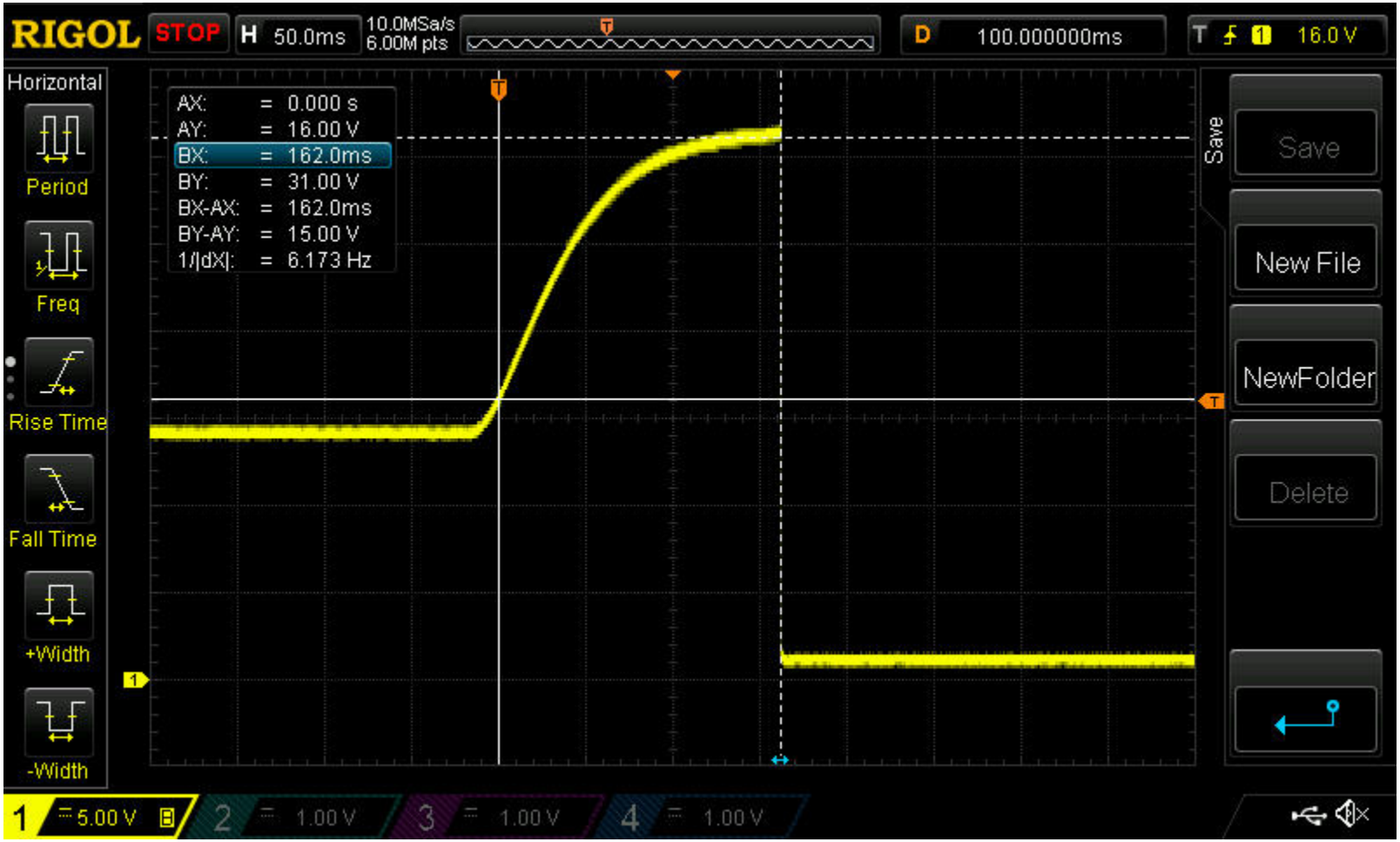
MODULE PERFORMANCE



MODULE POWERED WITH 14V, RISING TO 31V. TRIP OCCURS 162mS AFTER VOLTAGE PASSES 16V.

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