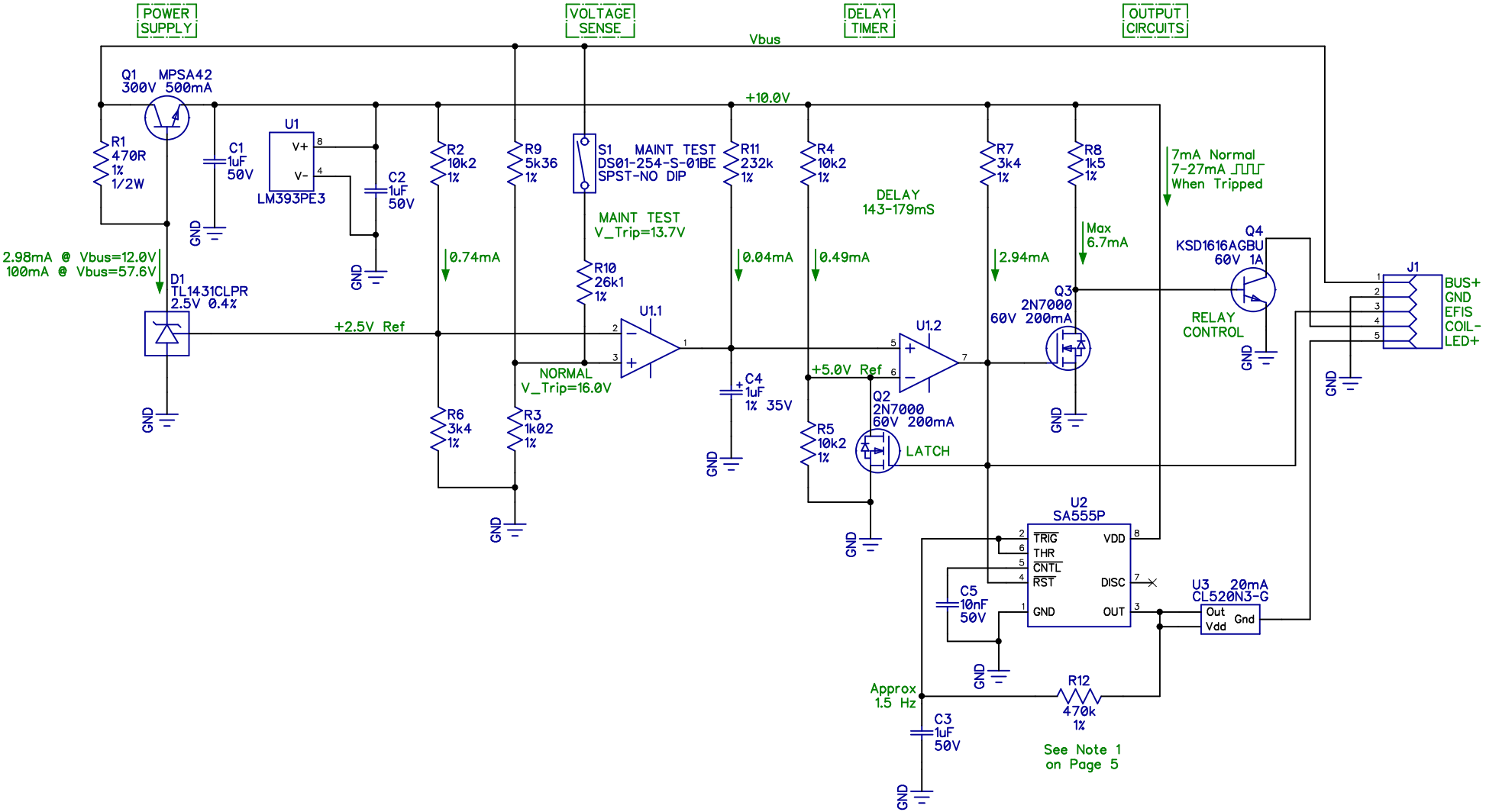
SCHEMATIC DIAGRAM:



ALL RESISTORS 1/4W EXCEPT WHERE INDICATED.

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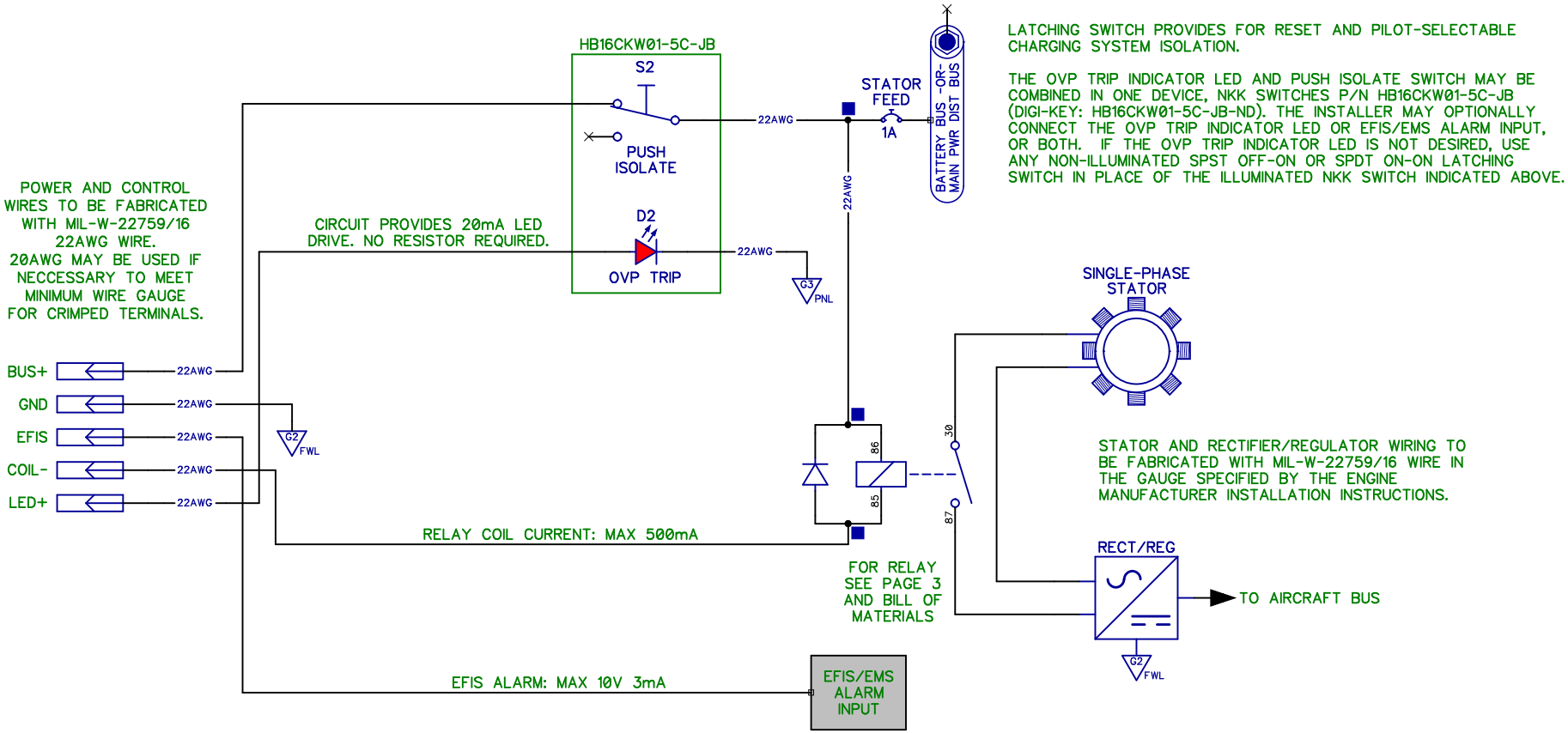
THE DUAL-COMPARATOR VOLTAGE SENSE AND TIMING SCHEME SHOWN ABOVE IS BASED ON A DESIGN BY ROBERT L. NUCKOLLS III, POSTED ON THE AERO-ELECTRIC LIST INTERNET FORUM. IF YOU RE-DISTRIBUTE THIS DESIGN, PLEASE CREDIT HIM IN ACCORDANCE WITH THE TERMS OF THE CREATIVE COMMONS BY-NC-SA LICENSE.

WIRING PLAN (SINGLE PHASE STATOR):



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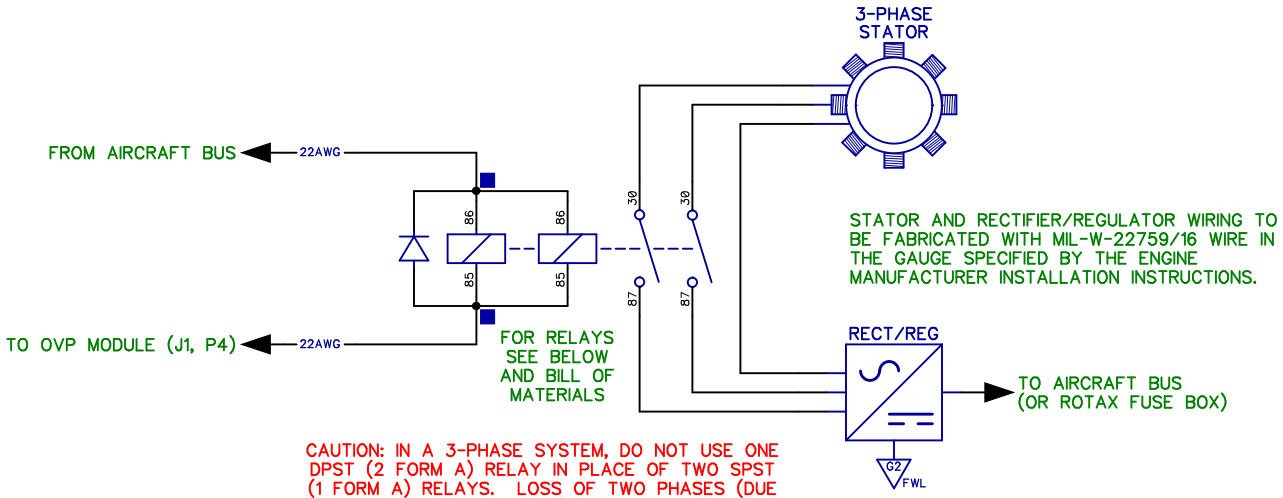
■ = ALL WIRES TERMINATED ON COMMON STUD/PIN

G3 PNL = INST PANEL GROUND

G2 FWL = FIREWALL GROUND

WIRING PLAN (DIFFERENCES FOR 3-PHASE STATOR):



CAUTION: IN A 3-PHASE SYSTEM, DO NOT USE ONE DPST (2 FORM A) RELAY IN PLACE OF TWO SPST (1 FORM A) RELAYS. LOSS OF TWO PHASES (DUE TO A SINGLE RELAY FAILURE) WILL REDUCE CHARGING SYSTEM OUTPUT TO ZERO, WHILE LOSS OF A SINGLE PHASE (FAILURE OF ONE OUT OF TWO RELAYS) WILL IN SOME CASES MAINTAIN REDUCED CHARGING CAPABILITY.

SUGGESTED RELAYS:

RELAY PART NUMBERS (CIT RELAY & SWITCH):
A2M1ASQ12VDC1.6D (METAL BRACKET)
A2F1ASQ12VDC1.6D (PLASTIC BRACKET)

40A SPST-NO (1 FORM A) AUTOMOTIVE RELAYS. THESE RELAYS HAVE AN INTEGRAL DIODE ACROSS THEIR COILS WITH THE CATHODE AT PIN 86. THE POSITIVE SUPPLY TO THE COILS **MUST** BE CONNECTED TO PIN 86 AND OVP MODULE OUTPUT CONNECTED TO PIN 85. REVERSED POLARITY WILL BLOW THE FUSE SHOWN IN THE DIAGRAM ON PAGE 2 AND MAY DAMAGE THE INTEGRAL DIODE.

IF OTHER RELAYS ARE USED WHICH LACK INTEGRAL COIL SUPPRESSION DIODES, AN EXTERNAL DIODE MUST BE ADDED, PARALLEL TO THE RELAY COILS, TO PROTECT CIRCUIT COMPONENTS (AS SHOWN IN THE DIAGRAM ABOVE). IF THESE RELAYS ARE USED, THE EXTERNAL DIODE SHOWN ABOVE AND ON PAGES 2 & 4 IS NOT REQUIRED.

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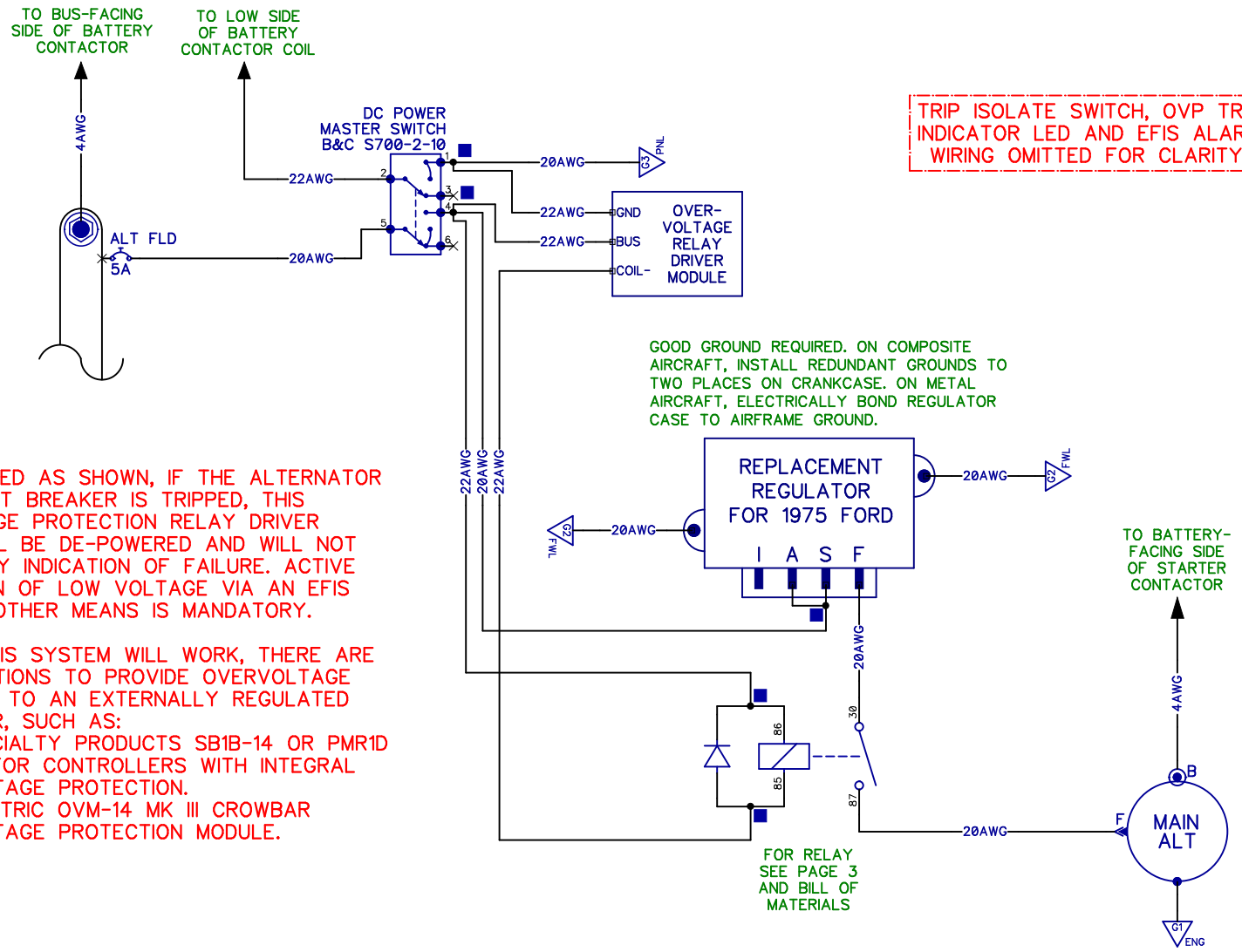
■ = ALL WIRES TERMINATED ON COMMON STUD/PIN

G2 FWL = FIREWALL GROUND

WIRING PLAN (DIFFERENCES FOR EXTERNALLY REGULATED ALTERNATOR):



NOTES:

1. WHEN WIRED AS SHOWN, IF THE ALTERNATOR FIELD CIRCUIT BREAKER IS TRIPPED, THIS OVERVOLTAGE PROTECTION RELAY DRIVER MODULE WILL BE DE-POWERED AND WILL NOT PROVIDE ANY INDICATION OF FAILURE. ACTIVE NOTIFICATION OF LOW VOLTAGE VIA AN EFIS ALARM OR OTHER MEANS IS MANDATORY.

2. WHILE THIS SYSTEM WILL WORK, THERE ARE SIMPLER OPTIONS TO PROVIDE OVERVOLTAGE PROTECTION TO AN EXTERNALLY REGULATED ALTERNATOR, SUCH AS:
- B&C SPECIALTY PRODUCTS SB1B-14 OR PMR1D ALTERNATOR CONTROLLERS WITH INTEGRAL OVERVOLTAGE PROTECTION.
- AEROELECTRIC OVM-14 MK III CROWBAR 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

NOTES:

1. If an OVP TRIP LED is not desired, do not populate C3, C6, R12, U2 and U3, and use a non-illuminated PUSH ISOLATE switch (see S2 & D2 options in Bill of Materials).

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.)

3. In a stator-based charging system, it would seem logical to switch the regulator's output (a single wire) rather than its input (two wires in a 3-phase system). This circuit 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 up to a 30A load at a relatively high DC voltage (as during an overvoltage event) are physically larger, have significantly higher coil current and are costlier than the relays specified. Finally, replacement automotive relays are readily available from auto parts and general merchandise retailers everywhere.

WARNING: With this Overvoltage Protection Module installed, it is MANDATORY that the electrical system have ACTIVE NOTIFICATION of low voltage. This can be done using an EFIS alarm or via discrete circuitry. If the PUSH ISOLATE switch connected to the OVP Module is pushed without the pilot's knowledge, the charging system will be disconnected and the ONLY indication to the pilot will be a LOW VOLTAGE alarm. Failure to correct this condition in an aircraft with an electrically dependent engine can result in engine failure due to battery depletion.

WARNING: When installed in an aircraft powered by a Rotax 9-Series iS engine, activation of the Overvoltage Protection Module in flight, whether via an automatic trip or via pilot manipulation of the PUSH ISOLATE switch, constitutes an urgent condition. When the OVP Module is in a tripped state, 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 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 engine management or ignition system operation.

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BILL OF MATERIALS:

Reference	Qty	Manufacturer	Manufacturer P/N	Digi-Key P/N	Description	Mounting	Package
COMPONENTS:							
C1, C2, C3	3	TDK Corporation	FG18X7R1E105KRT06	445-173261-1-ND	Ceramic capacitor, 1uF, 10%, 25V, X7R	TH	2.5x4.0mm
C4	1	Kyocera AVX	TAP105J035SCS	478-TAP105J035SCS-ND	Solid Tantalum Capacitor, 1uF, 5%, 35V	TH	2.5x4.5mm
C5	1	Vishay Beyschlag	K103K15X7RF53L2	BC5134-ND	Ceramic capacitor, 10nF, 10%, 50V, X7R	TH	2.6x4.0mm
D1	1	Texas Instruments	TL1431CLPR	296-TL1431CLPRCT-ND	Shunt voltage reference IC, 2.5V, 0.4%, 100mA	TH	TO-92
Q1	1	Diotec Semiconductor	MPSA42	4878-MPSA42CT-ND	NPN bipolar junction transistor, 300V, 0.5A	TH	TO-92
Q2, Q3	2	Diotec Semiconductor	2N7000	4878-2N7000CT-ND	N-channel MOSFET, 60V, 200mA	TH	TO-92
Q4	1	onsemi	KSD1616AGBU	KSD1616AGBU-ND	NPN bipolar junction transistor, 60V, 1A	TH	TO-92
R1	1	Yageo	MFR50SFTE52-470R	13-MFR50SFTE52-470RCT-ND	Resistor, axial, 470 ohms, 1%, 1/2W	TH	2.4x6.3mm
R2, R4, R5	3	Yageo	MFR-25FTE52-10K2	13-MFR-25FTE52-10K2CT-ND	Resistor, axial, 10.2k ohms, 1%, 1/4W	TH	2.4x6.3mm
R3	1	Yageo	MFR-25FRF52-1K02	13-MFR-25FRF52-1K02CT-ND	Resistor, axial, 1.02k ohms, 1%, 1/4W	TH	2.4x6.3mm
R6, R7	2	Yageo	MFR-25FTE52-3K4	13-MFR-25FTE52-3K4CT-ND	Resistor, axial, 3.4k ohms, 1%, 1/4W	TH	2.4x6.3mm
R8	1	Yageo	MFR-25FTE52-1K5	13-MFR-25FTE52-1K5CT-ND	Resistor, axial, 1.5k ohms, 1%, 1/4W	TH	2.4x6.3mm
R9	1	Yageo	MFR-25FBF52-5K36	5.36KXBK-ND	Resistor, axial, 5.36k ohms, 1%, 1/4W	TH	2.4x6.3mm
R10	1	Yageo	MFR-25FTE52-26K1	13-MFR-25FTE52-26K1CT-ND	Resistor, axial, 26.1k ohms, 1%, 1/4W	TH	2.4x6.3mm
R11	1	Yageo	MFR-25FRF52-232K	13-MFR-25FRF52-232KCT-ND	Resistor, axial, 232k ohms, 1%, 1/4W	TH	2.4x6.3mm
R12	1	Yageo	MFR-25FTE52-470K	13-MFR-25FTE52-470KCT-ND	Resistor, axial, 470k ohms, 1%, 1/4W	TH	2.4x6.3mm
S1	1	Same Sky (CUI Devices)	DS01-254-L-01BE	2223-DS01-254-L-01BE-ND	Switch, slide, DIP, SPST, 1-position, 25mA, 24V	TH	3.42x9.9mm
U1	1	Texas Instruments	LM393PE3	296-49723-ND	Dual general purpose linear comparator	TH	DIP-8
U2	1	Texas Instruments	SA555P	296-9682-5-ND	Timer/oscillator IC, 100kHz	TH	DIP-8
U3	1	Microchip Technology	CL520N3-G	CL520N3-G-ND	Linear constant current LED driver, 20mA	TH	TO-92
RELAY OPTIONS:		See Note 1					
K1, (K2)	1 (2)	CIT Relay & Switch	A2F1ASQ12VDC1.6D	2449-A2F1ASQ12VDC1.6D-ND	Automotive relay, SPST, 40A, 12V w/coil diode, plastic bracket	n/a	n/a
K1, (K2)	1 (2)	CIT Relay & Switch	A2M1ASQ12VDC1.6D	2449-A2M1ASQ12VDC1.6D-ND	Automotive relay, SPST, 40A, 12V w/coil diode, metal bracket	n/a	n/a
SWITCH / LED OPTIONS:		See Notes 2 & 3					
S2+D2 (combined)	1	NKK Switches	HB16CKW01-5C-JB	HB16CKW01-5C-JB-ND	Pushbutton switch, SPDT, ON-ON, red LED illumination	n/a	n/a
S2 only	1	NKK Switches	HB16CKW01-C	HB16CKW01-C-ND	Pushbutton switch, SPDT, ON-ON, not illuminated	n/a	n/a
D2 only	1	CreeLED, Inc.	C503B-RAN-CA0C0AA1	C503B-RAN-CA0C0AA1-ND	LED, red, 5mm	TH	T-1-3/4, 5mm
D2 (bezel / holder)	1	Sparkfun Electronics	COM-11147	1568-1212-ND	LED holder, 5mm, chrome	n/a	n/a
ENCLOSURE:		See Note 4					
Box	1	Bud Industries	PN-1330-MB	377-2152-ND	Box, polycarbonate, gray, w/cover, 2.060"L x 1.986"W x 1.379"H	n/a	n/a
Screws	2	n/a	n/a	Source locally	M3-0.5 x 5mm self-tapping or machine screws	n/a	n/a
Grommet	1	Essentra Components	GRO025121A	RPC1957-ND	Grommet, rubber, 0.156" ID x 0.250" OD x 0.125" panel thickness	n/a	n/a

Link to Digi-Key parts list: https://www.digikey.com/en/mylists/list/YMHQ6V79OL

Link to purchase printed circuit board: https://oshpark.com/shared_projects/biZ8Hkrx

See notes, next page.

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BILL OF MATERIALS NOTES:

1. For alternator field or single phase stator control, one relay is required. For 3-phase stator control, two relays are required.

2. Any identical-function switch may be substituted for S2 (PUSH ISOLATE).

3. If a non-illuminated switch is used for S2 (PUSH ISOLATE), then a separate LED can be used for D2 (OVP TRIP indicator). For good brightness, suggest the LED listed in the Bill of Materials, mounted directly in front of the pilot.

5. If a weather-sealed relay installation is desired, the following skirted relays, sealed sockets and terminals may be used in place of those indicated in the Bill of Materials:
   - Available at https://www.customconnectorkits.com/
   - Aptiv (formerly Delphi) 12065686 Metri-Pack 630 sealed relay socket

- Aptiv Metri-Pack 630 crimped terminals: 12020156-L (20-18AWG), 12066614-L (16-14AWG), 12033997-L (12-10AWG)
- Aptiv 12052834 connector position assurance lock (locks relay into socket)

- Song Chuan
  896H-1CH-D1SW-001-12VDC
  50A automotive relay
  (12V coil with diode)

- Alternative relay available at
  https://www.digikey.com/short/8w7fd075
  CIT Relay & Switch A2S1ASQ12VDC1.6D
  40A automotive relay (12V coil with diode)

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THEORY OF OPERATION:

1. The main element of the circuit is U1, 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 to ground).

2. Supply voltage for the circuit is provided by a linear voltage regulator composed of D1, a TL1431 2.5V precision voltage reference, and Q1, an MPSA42 NPN pass transistor. Current through D1 is limited by resistor R1 (normally about 3mA at Vbus = 12V, maximum 100mA at Vbus = 57V). Capacitor C1 provides stability. Feedback to the TL1431's adjust pin is provided by the R2-R6 resistive voltage divider, so that 2.5V appears at the adjust pin when the supply rail is at 10V. This divider also provides a 2.5V reference voltage to the inverting input of comparator U1.1.

3. The voltage divider composed of resistors R9 and R3 scales down bus voltage such that when the bus is at 16V, then 2.5V will appear at the non-inverting input of U1.1. Any voltage higher than this will cause the comparator's output to turn off, allowing capacitor C4 to begin charging through resistor R11.

4. The voltage divider composed of resistors R4 and R5 provides a 5V reference voltage to the inverting input of comparator U1.2. The time constant of C4 charging through R11 from a 10V supply provides a delay of approximately 160mS before comparator U1.2 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.

5. Under normal bus voltage conditions, comparator U1.2's output transistor is on and the comparator's output is pulled to ground. This does several things:
   (a) The active-low reset pin of output oscillator U2 is pulled low, preventing the oscillator from working.
   (b) The EFIS/EMS alarm output is pulled low.
   (c) The gate of N-channel MOSFET Q2 is pulled low, turning it off. With Q2 off, the comparator is permitted to operate normally.
   (d) The gate of N-channel MOSFET Q3 is pulled low, turning it off. Resistor R8 supplies current to the base of NPN transistor Q4, turning it on, which energizes the relay coil(s).

6. When U1.1's output goes high and C2 charges to greater than 5V (more than 160mS elapses), U1.2's output goes high, activating the overvoltage protection:
   (a) MOSFET Q2 is turned on, creating a latched condition by pulling the comparator's reference input to ground.
   (b) MOSFET Q3 is turned on, pulling the base of Q4 to ground, turning it off and de-energizing the relay coil(s).
   (c) The EFIS/EMS alarm output is pulled high (current limited to 3mA by R7).
   (d) The reset pin of oscillator U2 is pulled high, turning it on. The oscillator generates a 1.5Hz square wave output, which feeds through U3, a 20mA constant-current LED driver IC. This flashes the OVP TRIP indicator LED on the instrument panel.

7. The instrument panel mounted PUSH ISOLATE switch provides pilot control of the charging system and serves as a reset switch for the circuit. Latching the PUSH ISOLATE switch down cuts off power to the OVP Module and de-energizes the relay(s). Unlatching the PUSH ISOLATE switch re-powers the Module.

8. Maintenance Test switch S1 on the Module circuit board is used to test the OVP Module during aircraft condition inspections in accordance with the Instructions for Continued Airworthiness (page 9). When the switch is closed, the voltage at the non-inverting input to U1.1 (the bus voltage sense comparator) is adjusted by R10 to a value just below what would be expected with the charging system turned on. When the engine is started in this condition and the charging system is activated, the OVP Module will trip, thus verifying calibration and operation of the Module.

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INSTRUCTIONS FOR CONTINUED AIRWORTHINESS:

At each condition inspection, test operation of the Overvoltage Protection (OVP) Module as follows:

1. With the engine off, open or remove any cowling panels requred to provide access to the OVP Module.
2. Remove the cover from the OVP Module enclosure and turn ON the MAINT TEST switch (located in the center of the module circuit board), placing the module in maintenance test mode.
3. Turn ON the DC POWER MASTER switch. If the OVP Module is wired to an EFIS alarm input, wait for the EFIS to complete its boot sequence.
4. Press and release the PUSH ISOLATE switch on the instrument panel to latch it down.
5. Using normal procedures, start the engine and activate the charging system.
6. Observe that the OVP TRIP indicator LED and/or EFIS alarm are not active.
7. Press and release the PUSH ISOLATE switch to unlatch it and activate the OVP Module.
8. Observe that the OVP TRIP indicator LED and/or EFIS alarm become active.
9. If active notification of low voltage is installed, verify that it indicates a low voltage condition.
10. Press and release the PUSH ISOLATE switch to latch it down.
11. Observe that the OVP TRIP indicator and/or EFIS alarm deactivate (low voltage condition will persist).
12. Shut down the engine and turn OFF the DC POWER MASTER switch.
13. Press and release the PUSH ISOLATE switch to unlatch it and arm the OVP Module for future flights.
14. Turn OFF the OVP Module's MAINT TEST switch, returning the module to normal operation, then reinstall the cover on the module enclosure.
15. Reinstall any cowling panels that were removed in step 1.
16. Make an airframe logbook entry to record accomplishment of this procedure.

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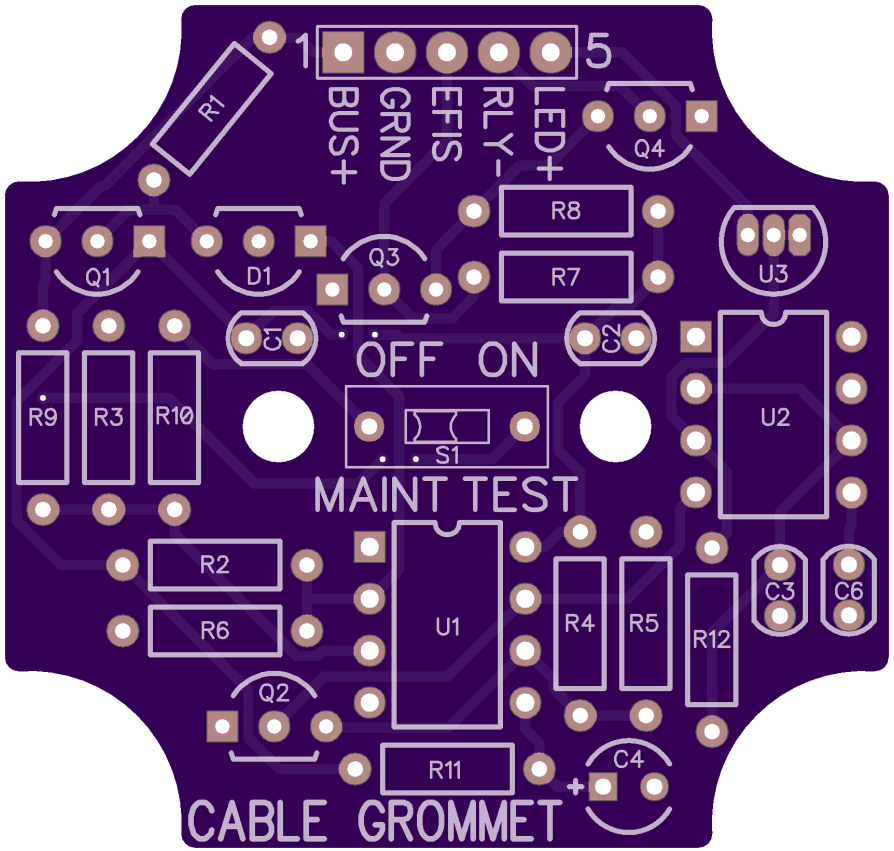
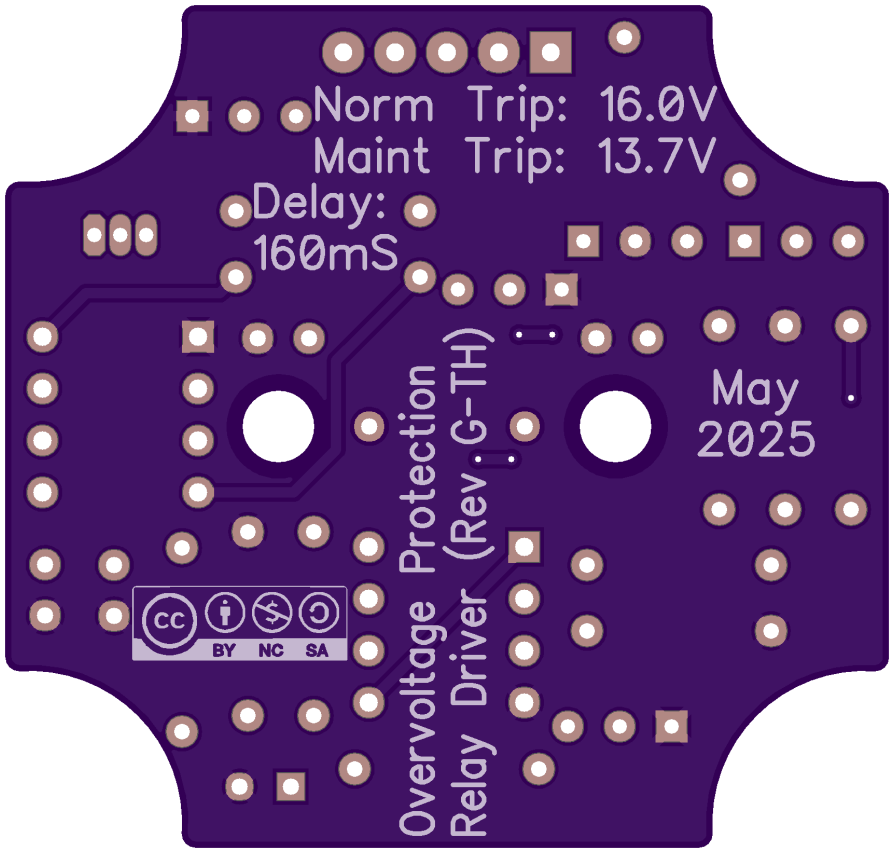
PRINTED CIRCUIT BOARD:





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ASSEMBLY & INSTALLATION

The instructions below assume that you're looking at the circuit board as shown in the left image on page 10. If you're a soldering novice, don't worry; soldering through-hole components is not a difficult skill to learn. The first five minutes of this video -[http://y2u.be/6rmErwU5E-k]- are a good tutorial. The most important things to take from the video are: 1. Heat the pad and the part, then feed in solder. 2. Keep the iron tip clean.

1. Install the resistors (Rxx). One at a time, bend each resistor's legs at 90 degrees, close against the 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.
2. Install the comparator (U1) and oscillator (U2). Orientation of these 8-pin devices is critical. They have a small round dimple or dot molded into their 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 parts are 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 piece of tape to hold each part 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 and trim the remaining legs.
3. Install the voltage reference (D1), transistors (Q1-Q4) and LED driver (U3). 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 two legs and trimming. When soldering the LED driver (U3), be very careful to avoid shorts between its closely spaced pads.
4. Install the capacitors (Cxx). Only C4 (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 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.
5. Install the switch (S1). Insert the switch into the holes in the circuit board so that the "ON" legend is to the right. Solder one leg, check that the switch is fully seated and upright, then solder the other leg and trim.
6. Solder MIL-W-22759/16-22 wires of the necessary length to the through-hole pads on the board, one each for BUS, GROUND, COIL-, EFIS and LED.
7. Drill the grommet hole in the enclosure. To avoid tear-out or cracking of the enclosure, suggest starting with a small diameter twist drill, then drilling to final size with a 1/4" step drill. Drill the hole in the side wall opposite to connector J1, adjacent to the "CABLE GROMMET" legend on the printed circuit board. Leave sufficient space above the circuit board so that the grommet and wires do not contact the circuit board or components.
8. Deburr the hole and insert the rubber grommet, then feed the wires through the grommet. Mount the board in the enclosure with two M3-0.5x5mm self-tapping screws. Attach the enclosure lid with the included machine screws.
9. Mount the enclosure securely and make electrical connections in the aircraft. Be sure the wires are well-supported near the module enclosure so they cannot pull against their solder pads. Do not connect the module directly to the battery, as it continuously draws about 43mA and may slowly deplete the battery during periods of disuse. It should be powered from the main bus, after the battery contactor.

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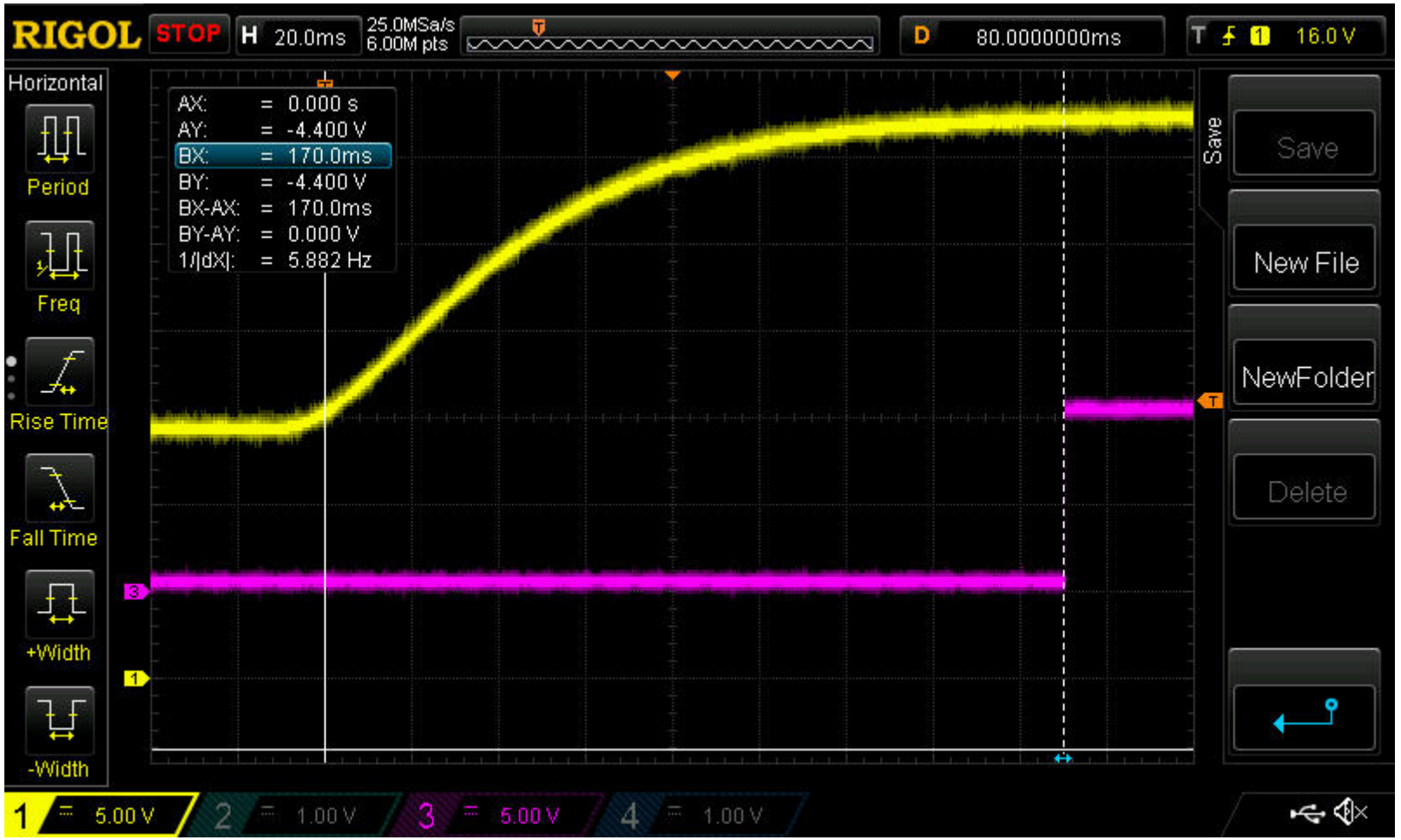
OVP MODULE PERFORMANCE:



Yellow trace shows input voltage starting at 14V and rising to 32V.
Purple trace shows alarm output to EFIS. Module trips 170mS after input exceeds 16V.

Title: Overvoltage Protection Relay Driver Module for Single or 3-Phase Stator Based Charging Systems or for Alternator Field Control	**Rev:** G2-TH
	Size: 11x8.5
Date: 08 May 2025	**Drawn by:** EP
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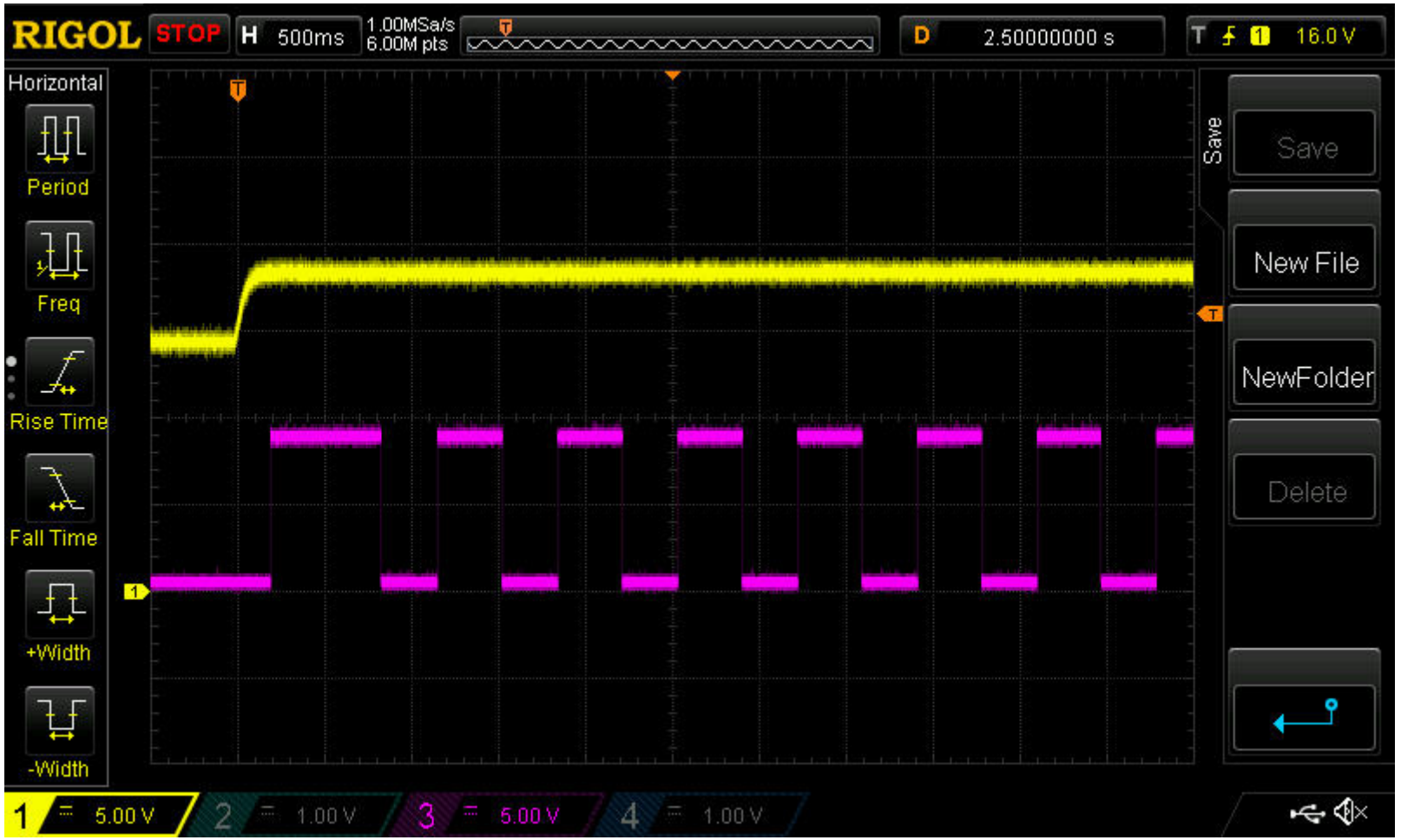
OVP MODULE PERFORMANCE:



Yellow trace shows input voltage starting at 14V and rising to 20V.
Purple trace shows output to warning LED once module has tripped.

Title: Overvoltage Protection Relay Driver Module for Single or 3-Phase Stator Based Charging Systems or for Alternator Field Control	**Rev:** G2-TH
	Size: 11x8.5
Date: 08 May 2025	**Drawn by:** EP
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