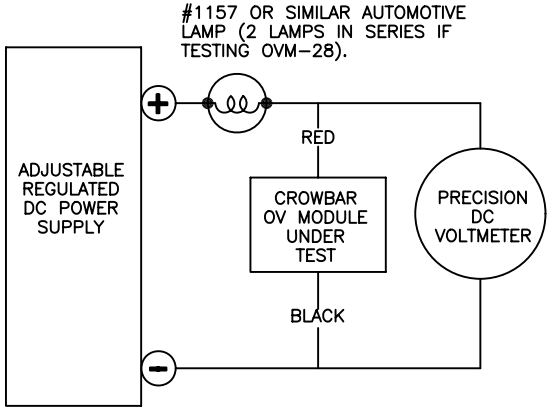
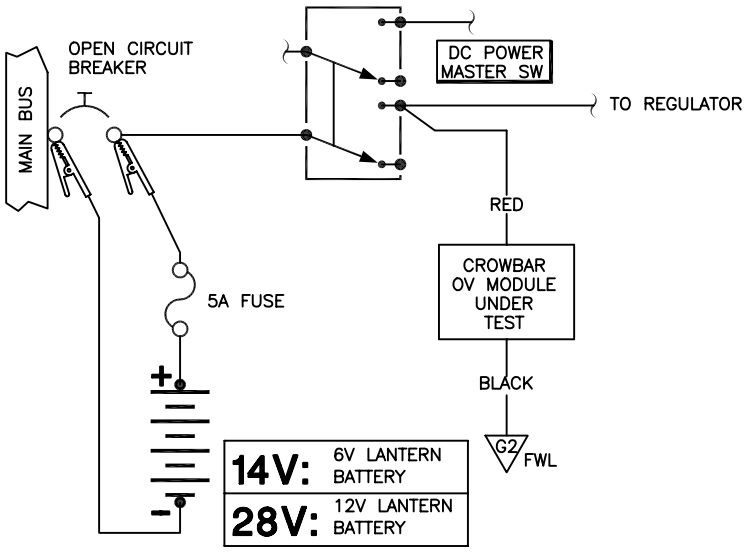
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NOTES:

1. INTERCONNECT DEVICE TO BE TESTED AS SHOWN IN BENCH TEST SETUP TO THE LEFT. THE LAMP BULB IN SERIES WITH THE POWER SUPPLY PROTECTS SUPPLY FROM SHORT CIRCUIT DAMAGE WHEN CROWBAR "FIRES." IF POWER SUPPLY IS INTERNALLY PROTECTED FROM OVERCURRENT, THE LAMP MAY BE ELIMINATED.
2. SET THE POWER SUPPLY FOR 16.3 VOLTS. ADJUST POTENTIOMETER ON OVMODULE SLOWLY UNTIL IT TRIPS CAUSING THE LAMP TO ILLUMINATE OR PLACES A DEAD-SHORT ON POWER SUPPLY. DISCONNECT OV MODULE TO RESET IT. SET POWER SUPPLY VOLTAGE BELOW 16 VOLTS AND RECONNECT OV MODULE. ADJUST POWER SUPPLY VOLTAGE SLOWLY UPWARD AND OBSERVE TRIP POINT. ADJUST POT AS NEEDED TO ACHIEVE TRIP POINT OF 16.3 +/- 0.3 VOLTS (32.6 +/- 0.6 VOLTS ON 28V SYSTEM).
3. THE OV PROTECTION MODULE IS SELF RESETTING IN NORMAL SERVICE. AFTER THE MODULE FIRES, THE BREAKER THAT SUPPLIES POWER TO THE CROWBAR MODULE AND ALTERNATOR FIELD WILL POP THUS REMOVING POWER FROM THE FAILED ALTERNATOR SYSTEM. RESETTING THE CIRCUIT BREAKER WILL RESTORE NORMAL SYSTEM OPERATION EXCEPT IN CASES WHERE THE VOLTAGE REGULATOR HAS FAILED WHEREUPON THE OV PROTECTION MODULE WILL TRIP AGAIN AND SHUT DOWN THE FAILED SYSTEM.
4. THE OV MODULE SHOULD BE TESTED EVERY YEAR FOR PROPER OPERATION. SUGGEST REMOVAL AT EVERY ANNUAL INSPECTION TIME FOR BENCH TESTING AS DESCRIBED IN NOTES 1 THRU 3 ABOVE.
5. AN ALTERNATIVE TEST FOR FUNCTIONALITY ONLY MAY BE CONDUCTED IN THE AIRPLANE. USE A 6-VOLT LANTERN BATTERY (12-VOLT FOR 24V AIRCRAFT) WITH ALLIGATOR CLIP LEADS AND A 5A, INLINE FUSE AS SHOWN IN THE FIGURE BELOW.
6. BEGIN WITH MASTER SWITCH OFF, OPEN THE ALTERNATOR FIELD BREAKER, CLIP THE TEST FIXTURE ACROSS THE BREAKER TAKING CARE TO OBSERVE POLARITY, THEN TURN DC POWER MASTER SWITCH TO ON.
7. THIS TEST SETUP ADDS THE LANTERN BATTERY VOLTAGE TO THE SHIP'S BATTERY VOLTAGE. THIS HIGHER THAN NORMAL VOLTAGE SHOULD TRIGGER THE CROWBAR OV MODULE AND POP THE FUSE IN THE TEST FIXTURE. THIS TEST SHOWS GROSS FUNCTIONALITY OF THE OVM BUT DOES NOT TEST CALIBRATION.
5. NUMBERS IN PARENS () ARE DIGIKEY CATALOG NUMBERS. CALL 1-800-344-4539 AND REQUEST A CATALOG.
6. IF YOU PREFER TO PURCHASE RATHER THAN BUILD, ASSEMBLED AND TESTED OVM-14 AND OVM-28 CROWBAR OV MODULES ARE AVAILABLE FROM B&C SPECIALTY PRODUCTS
NEWTON, KS (316) 283-8000



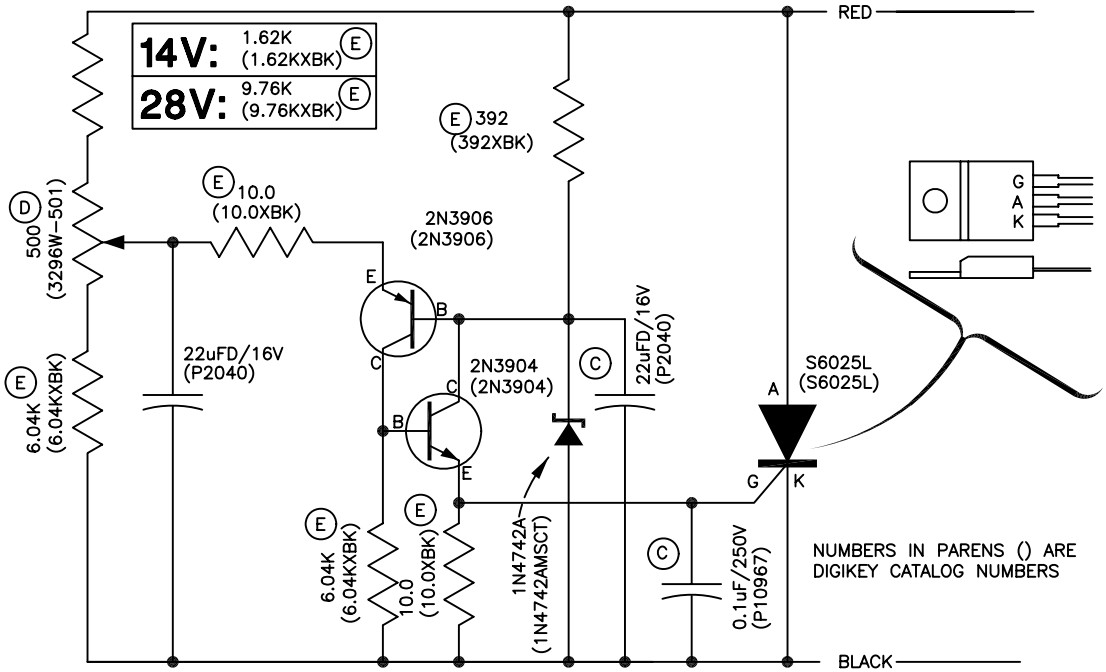
BENCH TEST SETUP



TEST SETUP FOR TESTING ON THE A/C

(See text)

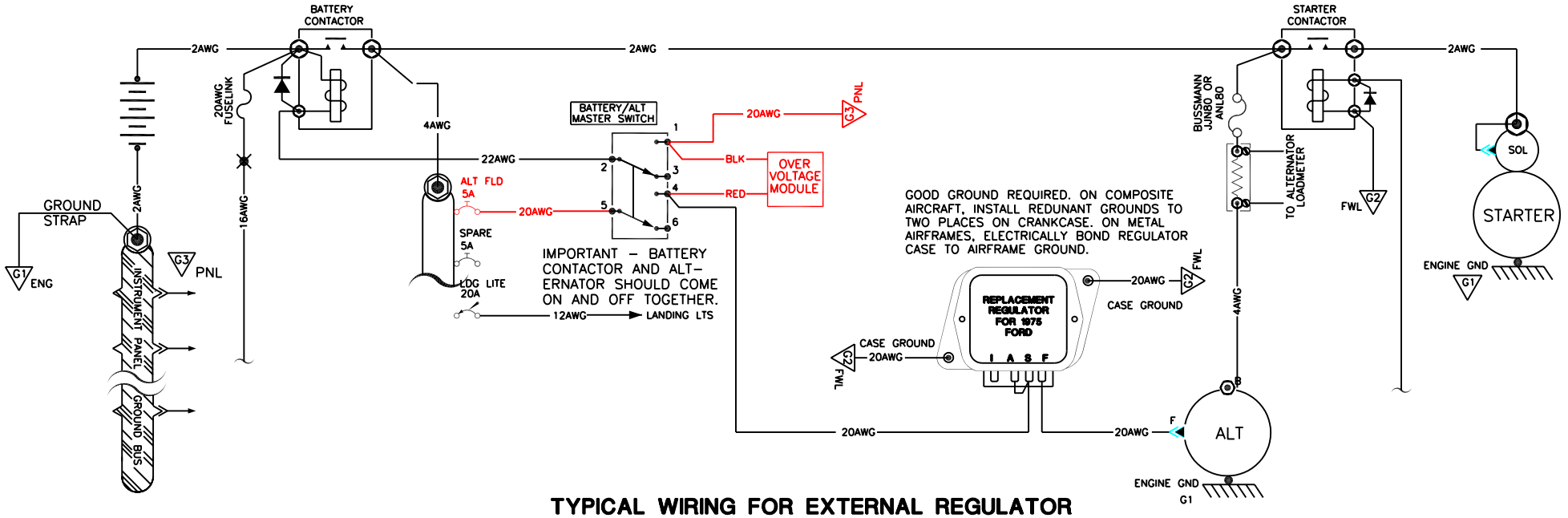
SCHEMATIC AND BILL OF MATERIALS



TITLE	PAGE
CROWBAR OVM	1.0

E REVISED 1/26/6

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TYPICAL WIRING FOR EXTERNAL REGULATOR

The AeroElectric Connection does not recommend the use of internally regulated alternators on aircraft. Wiring for these alternators has been deleted.

TYPICAL WIRING FOR INTERNAL REGULATOR

TITLE: OVM INSTALLATION

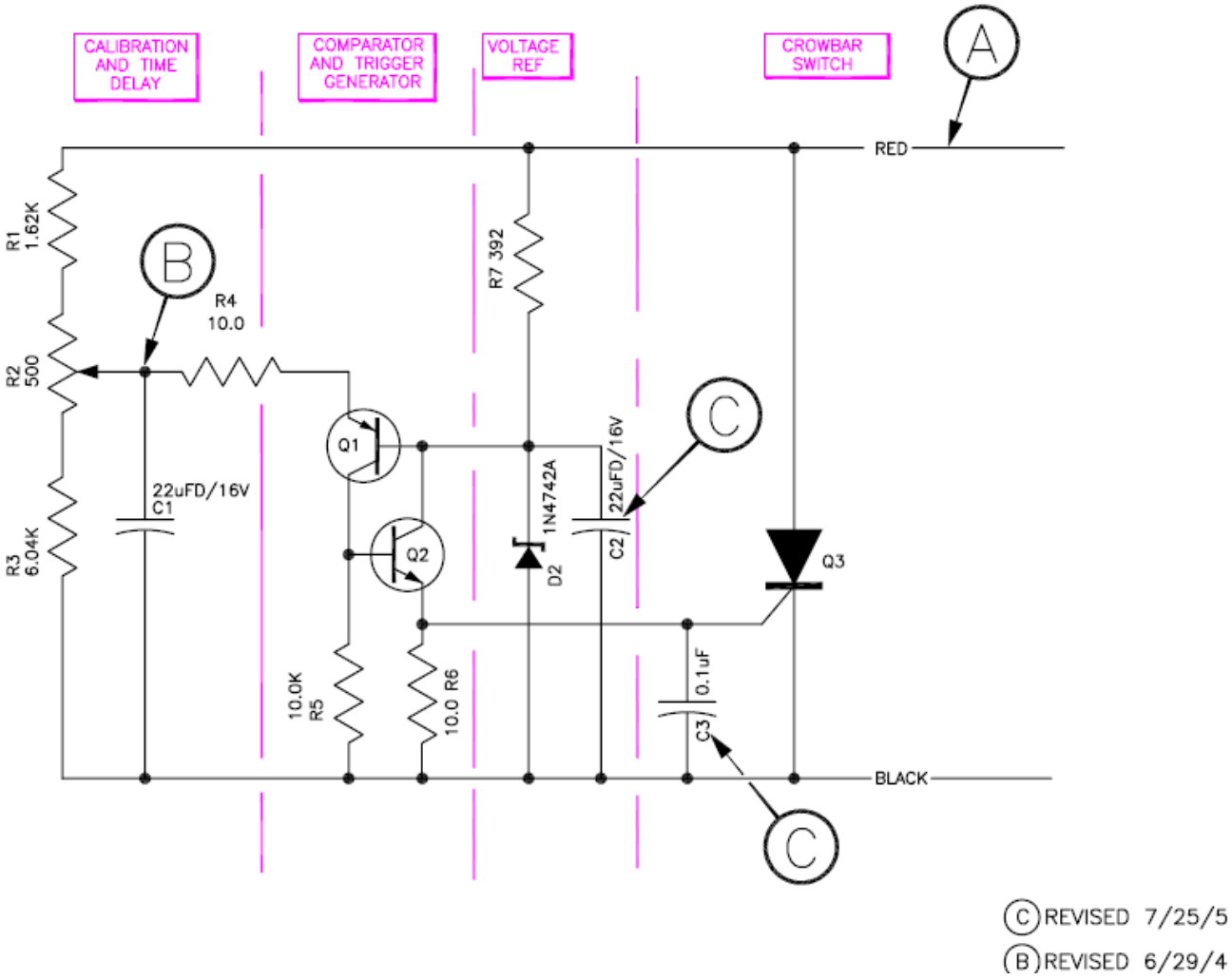
REVISED 6/5/5

PAGE 2.0

DIY Crowbar OV Protection Module

How it works:

The circuit below can be divided into four functional sections. Calibration and time delay, voltage comparator and trigger generator,



voltage reference and a solid state crowbar switch.

Resistors R1 through R3 provide an adjustable voltage divider.

With the potentiometer R2 centered, the equivalent circuit voltage divider is 1870 ohms from bus (A) to the arm of the potentiometer (B) and 6290 ohms from the arm of the potentiometer (B) to ground yielding a voltage multiplier of 0.77

A normal bus voltage (A) in the range of 13.8 to 14.8 volts will produce a voltage range of 10.6 to 11.4 volts across capacitor C1 at “B”.

The voltage divider has a source impedance of 1440 ohms. Combining this source impedance with the 22 uF capacitor (C1) offers a time constant

on the order of 3 milliseconds. This time constant prevents short duration surges from nuisance tripping the OV protection module.

Resistor R7 and zener diode D2 comprise the voltage reference of 12 volts when measured at (C).

The silicone controlled rectifier (Q3) serves as the crowbar switch. This device is normally an open circuit between the bus connection (A) and ground. When fed with a gate trigger pulse at (D) the device turns ON and remains ON until power is removed. The crowbar OV protection module is designed to deliberately open a circuit breaker so in normal operation, power is removed from a triggered crowbar switch within milliseconds of the triggering event.

Capacitors C2 and C3 were product improvements added ad Revision C when a reader discovered and illuminated a tendency of the circuit to nuisance trip under the influence of very narrow, negative going transients in the system.

The “magic” happens in the comparator/trigger section comprised of Q1, Q2, R5 and R6. In the normal operating state, the voltage at the base of Q1 runs 0.6 to 1.4 volts BELOW the emitter of Q1 which is held at 12 volts by voltage reference zener D2. During an OV condition the voltage at B rises. When it passes 12.5 volts, transistor Q1 goes into conduction and it’s collector PULLS UP on the base of Q2 driving it into conduction. The collector of Q2 is tied to the base of Q1 which pulls it DOWN into still harder conduction. This positive feedback causes a rapid increase in the conduction of Q1/Q2 pair causing the charge on C1 to be dumped into the gate of Q3. This rapid, short duration pulse triggers Q3 and initiating the crowbar OV shutdown.

Troubleshooting:

Step 1. Disconnect gate (trigger lead) of Q3 and the junction of Q2 emitter and R6 (Test Point D). Also if diode D1 is installed, remove it (deleted at revision B).

> *Discussion: This will permit some preliminary adjustment and diagnosis of circuit malfunction without tripping Q3 (main crowbar SCR). This also prevents reference voltage from R7/D2 from affecting examination of voltage divider calibration.*

Step 2. Set bench power supply to 10.0 volts (Test Point A). Monitor voltage at the arm of R2 (Test Point B) with respect to ground and adjust R2 so that the voltmeter reads 7.70 volts.

> *Discussion: If you cannot achieve the target setpoint voltage check to see that R1 and R3 are not transposed in the circuit. Also check that the polarity of C1 is proper. Either condition will cause the voltage at “B” to be too low.*

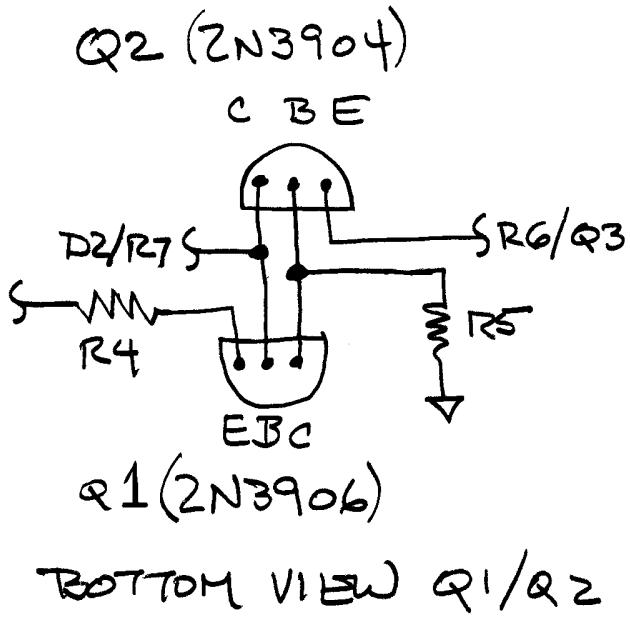
Step 3. Set bench power supply to 14.0 volts. Measure reference voltage at the junction of R7 and D2 (Test Point C). It should be 12.0 ± 0.6 volts. Make note of exact voltage reading.

> *Discussion: If voltage at C is very low but not zero (on the order of 0.6 volts) check for D2 installed backwards*.

Step 4. Confirm voltage at "B", now measures 10.8 ±0.1 volt.

Step 5. Monitor voltage at "B" while you slowly increase supply voltage. At some supply voltage between 16.0 and 16.6 volts, the trigger generator transistors Q1/Q2 should "trip" and voltage at "B" should quickly drop to something on the order of 2 volts.

Discussion: If the trigger generator does not trip, check wiring for the transistors. Wiring of the two transistors is a common wiring error. See adjacent sketch.



Step 6. Momentarily disconnect bench power supply from circuit under test. This will allow the trigger generator to reset.
Repeat Step 5 several times noting supply voltage were the trigger generator trips. Adjust R2 as necessary to achieve a trip voltage of 16.3 volts (32.6 volts for 28 volt system).

Step 7. Reconnect Q3 gate lead disconnected at "D" in Step 1. Set power supply for current limited operation at 1 to 2 amps –OR- conduct the following tests with the #1157 lamp(s) installed in series with the bench test supply.

Step 8. Repeat Step 5 to confirm similar behavior except in this case, the circuit becomes a high-current short across the power supply which causes the power supply to go into a current limited mode –OR- the lamp to illuminate brightly.

Discussion: Failure to trigger and latch the crowbar SCR (Q3) is usually due to wiring errors. Re-check connections to Q3 as depicted in the assembly instructions. If Q3 is wired correctly, try reducing the value of R4 to 10 ohms (reduced from 51.1 ohms in earlier versions).

Other Potential Difficulties:

The occasional crowbar OV protection module will be sensitive to radio transmissions. This difficulty is most often caused by "large" construction techniques. I've rebuilt several owner assembled modules into more compact construction to reduce the antenna effects of long interconnect wires between components. Building the OVM into a metal enclosure grounded to airframe also helps with this case.

On occasion, operating some appliance in the airplane causes the OVM to trip and take the alternator off line. In perhaps 8 years of supplying this product in numbers on the order of 200-300 units, I’ve encountered perhaps 3-5 instances where this problem arose. In all cases, spike suppression techniques normally applied to such devices was left out of the original installation.

-----*****-----

AeroElectric Connection
6936 Bainbridge Road
Wichita, KS 67226-1008
Phone 316-685-8617
Website: aeroelectric.com

"Load Dump" Damage to Alternators with Built-in Regulators

Bob Nuckolls
1 February 2004

AeroElectric-List message posted by: "Ned Thomas" <315@cox.net>

For what it is worth, I had an internally regulated alternator on my RV6A. I had an overvoltage occur and had no way to shut it off except land and turn off the engine. When I smelled the battery acid cooking out I was quite concerned. I was able to land before ruining the battery but even tho I immediately turned off the master when I found the voltmeter reading high, I did find that one of my strobes had fried. After this happened I installed the OV protection recommended by Bob. In the event you do encounter an OV situation you must be able to isolate the alternator. I was lucky, the battery could have blown up...

----- Original Message -----
From: "Clay R" <clayr_55@yahoo.com>

Now I see the following warning on Vans web site on the alternator page. (I think this was added this week)

Warning!

The internally regulated 60 ampere alternator should not be used with overvoltage protection systems. If you open the charging circuit while it is in operation, it will destroy the regulator.

AeroElectric-List message posted by: "Steve Sampson" <SSampson.SLN21@london.edu>

Clay - is anyone looking into this for you? It sounds like plenty of people are getting blown alternators after putting the B&C stuff on.

BACKGROUND

(1) The "B&C stuff" is only a collection of parts described in documents described in the AeroElectric Connection. Let us take care as to how the phenomenon is described with respect to implied cause and effect. ***It's not B&C's architecture but AeroElectric Connection architecture . . . B&C only sells the parts to implement it.***

(2) For years and since day-one of my participation in B&C's development and marketing of alternators, we have preached the doctrine of externally regulated alternators. Examples of this philosophy are found throughout early writings and particularly in chapters on alternators and regulators in the 'Connection. A simple inspection of B&C's offerings from the beginning will show that only externally regulated alternators are offered.

(3) There has been a lot of interest in adapting internally regulated alternators to aircraft because they are so readily available and cheap. Further, they've produced an excellent track record of reliability on cars . . . it seems a shame not exploit that characteristic in aircraft.

(4) The challenge for adapting internally regulated alternators to airplanes has always been making them behave like externally regulated alternators and generators before them. On the instrument panel there is a switch labeled ALT OFF/ON. One expects that operation of this switch will produce the same result whether you're sitting in a 1965 C-172 or a 2004 RV-8.

(5) Most alternators with built in regulators, once given the ON command via the rear-connected control wire will indeed come alive . . . but since this wire was originally intended only as a means for the EFI controller on a car to delay onset of engine loads after starting, there was no requirement for being able to turn the alternator OFF via this same wire. So, the vast majority of automotive take-offs cannot be turned OFF by removing +14v from the control wire via panel mounted switch. This condition was experienced by Mr. Thomas in the anecdote cited earlier.

(6) While the probability of regulator failure in cars is exceedingly low, ***it is not zero***. We've heard anecdotal stories of unhappy, high-dollar events taking place in airplanes after failure of an internally regulated alternator.

(7) With the goal of addressing a desire in the marketplace to utilize off-the-car technology, figure Z-24 was developed to address both ***controllability*** and ***overvoltage*** issues with the lowest practical parts count and without modifying the alternator.

RECENT HISTORY

It seems that there have been a rash of failures of internally regulated alternators installed per Figure Z-24. Let's review the inner workings and shortcomings of the modern, internally regulated alternators. We know that all alternators run best with a battery connected across their output. The battery is an excellent filter for the noise inherent on DC power generated by rectified 3-phase AC power. The battery also provides a flywheel effect . . . a kind of electrical inertia that damps out the frisky nature of an alternator's ability to quicky respond to and control its own output.

A phenomenon labeled by the automotive industry as "load dump" speaks to a characteristic native to the physics of alternator performance. Its existence has been known since the beginnings of alternator use in vehicles . . . but it was only a concern after a proliferation of solid state electronics for fuel injection systems, ignition systems, anti-lock brakes, etc. Should an alternator producing a lot of power be suddenly disconnected from the load, it may generate what would be properly called a surge of voltage exceeding bus voltage by several times. If the load dump is limited to shedding of normal system loads, the battery's electrical inertia will be in place to smooth over the event. However, if the disconnection ***includes*** the battery, no mitigating electrical-mass is present to capture a significant energy transient. In aviation parlance, a "load dump" is rapid shedding of normal system loads. The scenario we are discussing might be more appropriately called a "battery dump".

Unlike relatively low energy spikes characteristic of switching transients on inductive loads, a battery dump event is longer and carries a lot more energy. In the spring of 1998, there was a romance in the OBAM aircraft community with products called transient voltage suppressors (TVS). A school of thought suggested that the electrical system be sprinkled with these little critters to ward off effects of any gremlins of the overvoltage persuasion which may be lurking about the system. The suggested technique was to install a TVS on the power feeder for each vulnerable accessory.

There was an extensive discussion thread. You may review published excerpts of that discussion at:

http://aeroelectric.com/articles/spike.pdf

This was before we began to consider and refine any notions of using internally regulated alternators in OBAM aircraft.

In that thread, I suggested it was much better to (1) identify and mitigate such hazards at their source and/or (2) design accessories to be immune to such hazards. For decades, DO-160 has been an effective guideline for development of robust victims while MIL-STD-704 outlined design goals for output quality of power generation equipment.

Here are but a few of hundreds of relevant documents on the phenomenon to be found on the web . . .

http://www.sto-p.com/pfp/pfp-transients.htm

http://www.onsemi.com/pub/Collateral/CS3341-D.PDF

http://www.audifans.com/archives/1998/08/msg00929.html

. . . do a Google search on "load dump" and "alternator" for a wealth of useful expansion of the topic.

WHAT'S HAPPENING?

The original discussions 4 years ago focused on the need to protect system accessories from the effects of alternator behavior. In the cases before us now, the victim is NOT airframe system accessories being hammered by a skittish alternator. These are cases where the alternator is killing itself . . . or more accurately, killing its own voltage regulator.

If you look over the specifications for modern, solid state regulator chips, you'll find references to protection against load dump conditions built right onto the chip. I believe what we're observing now is a shortcoming of relatively mature automotive take-off alternators with regulators that do not enjoy this kind of protection.

Referring to the group of block diagrams in this document, note that I've illustrated 4 configurations of installation architecture for alternators with built in regulators.

(1) The first diagram is captioned "AUTOMOTIVE" and it illustrates the relationship between battery and alternator in virtually all automotive applications. The battery is ALWAYS connected to the alternator. System loads are controlled via panel switches and/or ignition switch but portions of the power distribution system are ***always hot, even when the vehicle is parked.*** Not desirable on airplanes.

(2) The second configuration is "FIGURE Z-24" referring to an architecture described in the AeroElectric Connection to accommodate two hard-and-fast design goals for using an alternator in an airplane: (a) ***absolute control*** of the alternator operation from the cockpit irrespective of flight condition and (b) protection against the very rare but potentially hazardous and expensive ***overvoltage*** condition.

(3) The third configuration describes an ill-conceived recommendation suggesting deletion of the alternator disconnect and wiring the alternator to the airplane a-la-automotive. Note that while this configuration ***prevents*** the pilot from switching an alternator off while in operation, ***it does not prevent the battery from being taken off line.*** If we disconnect the alternator from the system while leaving the battery on as allowed with Figure Z-24, only the alternator is at-risk for self destruction.

When you leave the alternator connected to the system and shut off the battery master, there is still risk of a battery-dump transient. While system loads will soak up some transient energy and mitigate amplitude and duration of the event, ***now the whole system is subjected to the transient***.

In airplanes like the Baron and Bonanza where alternators and battery master switches are separate, non-interlocked controls, switches can be manipulated in a manner that will produce the same "battery dump" effect that we're discussing. ***So the potential for this effect is not new nor is it unique to the nifty little alternators so popular in the OBAM aircraft community.***

(4) The fourth configuration illustrates an experiment to be conducted which may prove the usefulness of a technique intended to tame the dragon.

A PROPOSED GAME PLAN

(1) If you have Figure Z-24 installed and you're already flying or nearly ready to fly, don't change anything. Although you may never need the protections Z-24 offers, I don't recommend you go flying without it. It is EASY to prevent battery dump damage to the alternator by controlling sequence of operation for the switches.

[a] Battery master is the first switch to come on before cranking the engine and it should stay on until after engine shutdown.

[b] The alternator control switch may be turned on before cranking the engine but it's probably better to leave it off until after the engine is running.

[c] At the end of the flight, shut the engine down before first turning off the alternator . . . .

[d] . . . followed by turning off the battery master switch.

Following suggestions in any of the Z-figures in the 'Connection will provide you with interlocked battery master and alternator control switches wired so as to prevent an alternator from remaining on-line with the battery disconnected.

The battery dump transient is generated by the disconnection of the battery from the alternator b-lead terminal while the alternator is working hard. ***It can't be working hard if the engine is not running***. The warning published by Van's is accurate as far as it goes but misses important points with respect to ***absolute operational control*** of the alternator from the cockpit and ***overvoltage protection***. So, if you don't diddle with the switch while the engine is running, your alternator is not at risk for battery dump damage and you retain both ***operational control*** and ***overvoltage protection***.

(2) If you have yet to select an alternator but need to do it soon, you cannot go wrong with installing an alternator designed for aircraft service. Alternators using external regulation are easily managed for both ***operational control*** and ***overvoltage protection*** by simply opening the field lead. This activity does not generate the battery dump transient we're discussing.

(3) I'm planning to test an alternator with built in regulation on a test stand using a fat TVS device connected as shown in the last block diagram. I'll be making measurements of worst-case transient energies and making sure that the diode we select is adequately sized to the task.

NOTE

> If anyone out there remembers the zener diode that Pelican Aviation used to stick on the back side of their alternators (some STC'd no less!) while calling it "overvoltage protection" please recall that this was neither ov protection nor was it a practical solution to the problem before us now.

After the bench testing studies are complete, I'll be looking for volunteers who are already flying Figure Z-24 alternator control schemes. I will supply a pair of TVS diodes for installation on your airplane. You will be asked to conduct a series of battery dump simulations. After the simulations, you'll be asked to install the second diode and return the first one to me for inspection.

Once we've done the repeatable experiment to demonstrate suitability of the "fix", this paper will be updated to publish the results and Figure Z-24 will be updated appropriately. In the mean time, I'll supply a copy of this paper to Van's in with the hope that it will clarify the issues and forestall some poorly founded modifications to electrical systems in the OBAM aircraft community. Please feel free to circulate this document for both its informative value and potential for critical review.

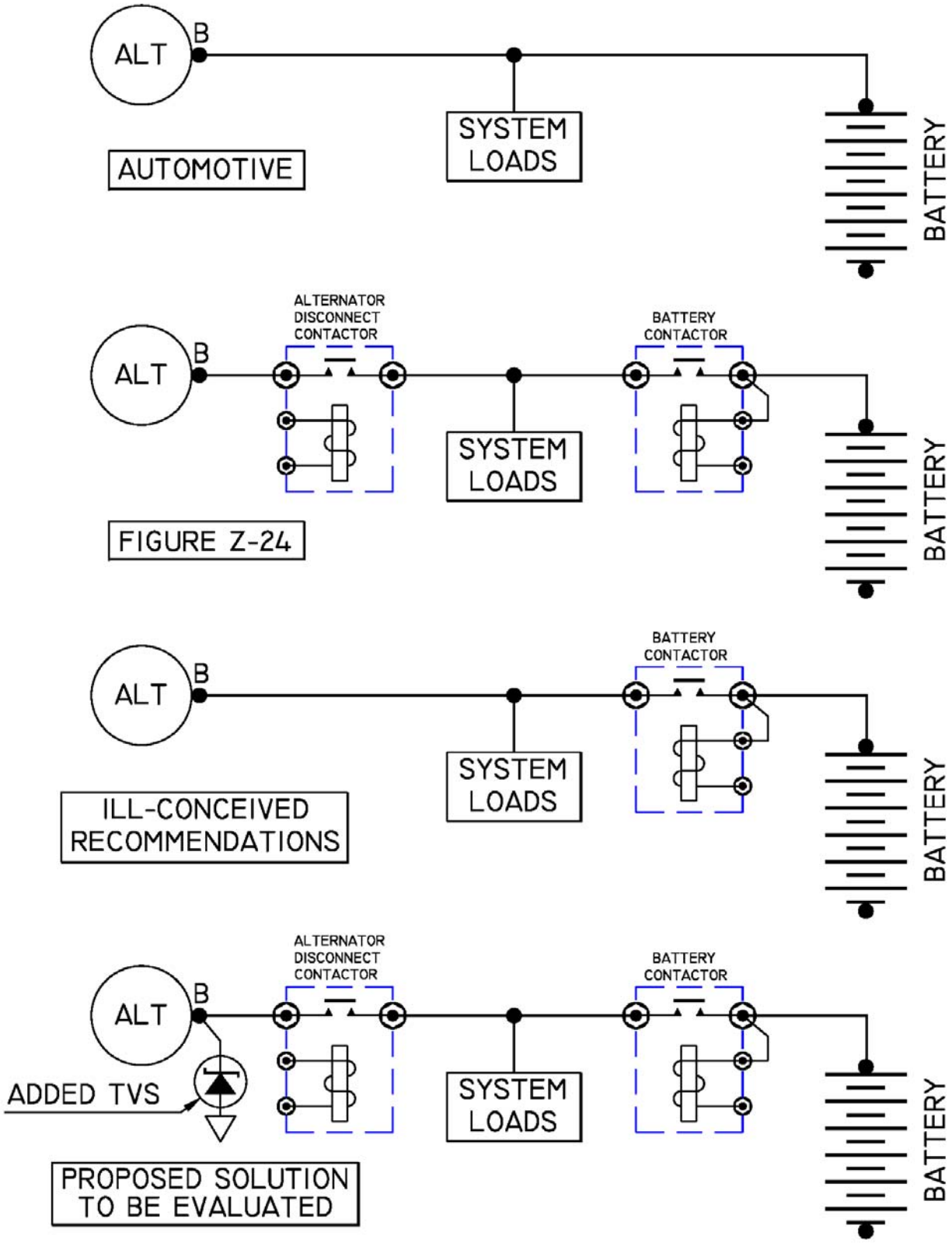
As a closing note to this document, I ran across this paper:

http://www.st.com/stonline/books/pdf/docs/4345.pdf

. . . written by the folks at SGS-Thompson on battery dump mitigation. This paper describes a proposed technique for building battery dump management right into the alternator . . . what a concept! Whether or not this capability will be offered in automotive products suited to airplanes soon is hard to predict. In the meantime, it's a no-brainer to make the alternators we have work quite nicely.

The bottom line folks . . . I believe there is good value in the use of internally regulated alternators on airplanes. However, it's important that we make decisions based upon good science that helps us understand and accommodate their unique characteristics.

Bob . . .


ALT
B
SYSTEM LOADS
BATTERY
AUTOMOTIVE
ALTERNATOR DISCONNECT CONTACTOR
BATTERY CONTACTOR
ALT
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SYSTEM LOADS
BATTERY
FIGURE Z-24
BATTERY CONTACTOR
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SYSTEM LOADS
BATTERY
ILL-CONCEIVED RECOMMENDATIONS
ALTERNATOR DISCONNECT CONTACTOR
BATTERY CONTACTOR
ALT
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ADDED TVS
SYSTEM LOADS
BATTERY
PROPOSED SOLUTION TO BE EVALUATED