

AIRCRAFT Maintenance TECHNOLOGY

The Leading Publication For The Professional Maintenance Team

Reprinted with permission from *Aircraft Maintenance Technology*, May/June 1999

1

Recip Technology

Kelly Aerospace 1999



New Generation Voltage Regulators

Aid troubleshooting

By Kelly Aerospace's Technical Service Group

General aviation aircraft electrical systems may be one of the least understood aircraft subsystems when it comes to maintenance and troubleshooting. A sound understanding of system functional characteristics combined with application of the latest design alternator and voltage control units can significantly compliment diagnostic skills and reduce downtime. The following provides an overview of both the functional and the diagnostic advantages offered by the latest design voltage control units, with an emphasis on system troubleshooting and problem resolution.

High frequency voltage control units

One of the more classic complaints concerning the early solid-state variable frequency, "bang-bang" voltage regulator designs is loosely referred to as the "nervous needle" syndrome. *Nervous needle* describes an ammeter or load meter whose indicator needle seems to vibrate making it difficult to read the current. Another similar complaint is flickering panel lights.

To remedy the problem, a new generation, high frequency regulator should be installed. Because the frequency of these new regulators (1,000 Hz) is well beyond the normal operating frequency of the alterna-

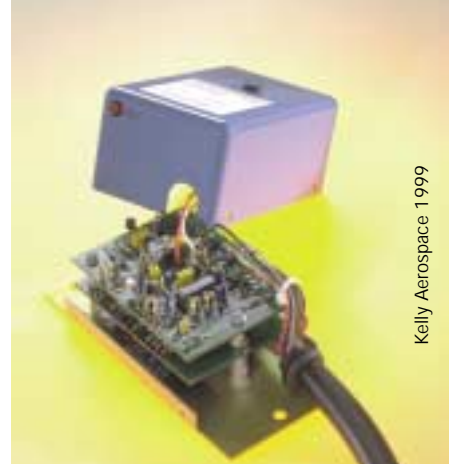
tor, the alternator doesn't follow the individual correction pulses, thereby, providing smoother alternator operation. Once the high frequency regulator is installed, and the "jittery" output current has been removed from the alternator and the battery, belt, and battery service life should be greatly improved.

If a high frequency regulator exhibits a rapidly swinging ammeter needle (sometimes referred to as float), the condition may be due to a high resistance contact (loose connections, corrosion) in the Alternator Control Switch or within the circuit breaker, which is in series with this switch. Using a conductor (jumper-wire), bypass the control switch or the circuit breaker one at a time to see if the situation improves. As always, a good practice is to keep a voltmeter attached to the bus at all times until the system is repaired and returned to service.

Ground fault protection

Another nuisance problem is when a regulator becomes disabled by either a "flying short" (flying shorts are caused by centrifugal force) in the alternator rotor or from a regulator field lead being faulted to ground during installation. In other cases, this field may short to ground from vibration or insulation failure.

When this happens, the power output transistor in the solid-state voltage regulators would probably be damaged beyond repair from the direct short to ground. The



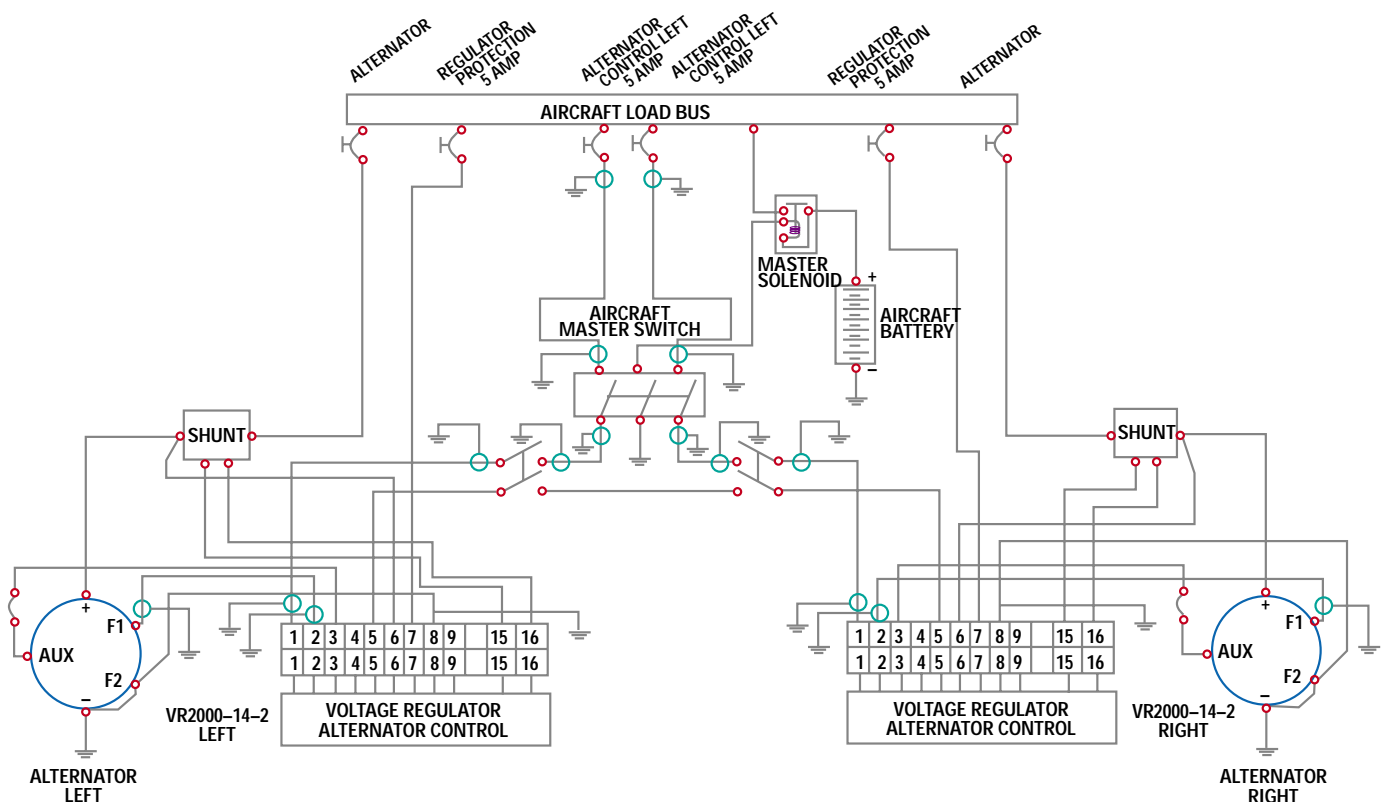
Kelly Aerospace 1999

The Kelly Aerospace VR2000 offers built-in troubleshooting diagnostics to identify electrical system problems, all the while protecting your vital avionics and instruments.

failure mode of the early design regulators is to have the main power transistor suffer a "melt down" and the traces on the PC board burned open. New voltage regulators are now designed with Ground Fault Protection circuitry (GFP) and an annunciator LED mounted on the side of the case to indicate a "ground fault." This provides the maintenance technician with a tool to diagnose this type of failure and immediately identify a ground fault.

If a ground fault takes place either within the body of the alternator or in the aircraft wiring of a plane equipped with a new generation regulator incorporating GFP, the voltage regulator will not be damaged and the GFP circuitry will take the electrical system off-line instantaneously, precluding aircraft wiring or avionics damage. If the

TYPICAL SHUNT PARALLELING SYSTEM



ground fault is intermittent in nature, cycling the alternator switch or master switch each time the fault occurs can restore normal operation of the electrical system.

This is not a permanent solution to the problem. Analysis should be conducted to locate the source of the ground fault and a permanent fix to the problem should be implemented.

The ground fault diagnostic procedure suggests that the system be shut down. The field wire should then be temporarily removed from the alternator field terminal and insulated. Restart the engine and run at the highest speed practical on the ground.

Obviously the alternator cannot build up voltage or produce load current with its field terminal open, but, at this stage, we only want to see if the GFP LED remains off. If it does, since the field lead to the alternator is the only wire disconnected, the alternator itself is suspect. The problem may be a shorted rotor (flying short), a shorted brush, brush holder, etc.

If the LED immediately lights again (either before the engine is started or immediately afterward), the alternator is eliminated as the culprit since it is disconnected and the field lead itself is suspect. Shut down the system and remove the field wire from the harness side of the voltage regulator connector. Again, restart the engine, repeat the above procedure, and record the results. If the LED remains out, the lead wire is shorted to ground somewhere along its length. If on the other hand the LED comes back on, the voltage regulator is suspect and should be removed and tested.

Overvoltage protection

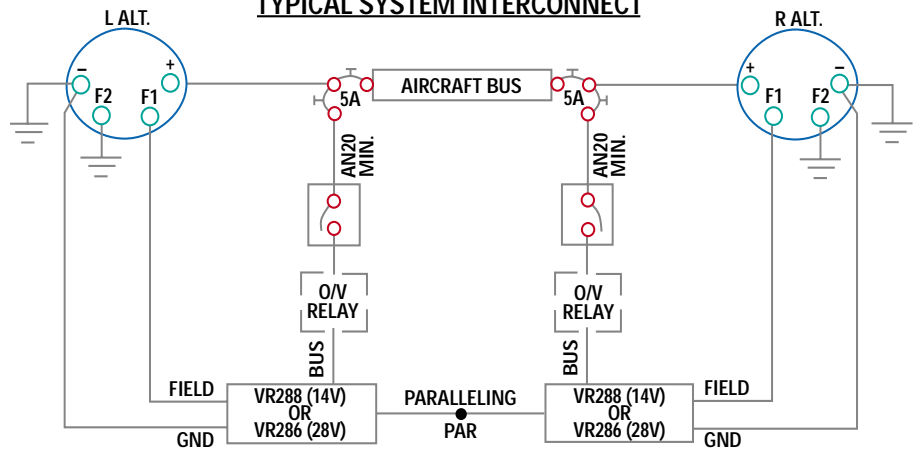
Ground fault protection and overvoltage protection are similar in that both are activated by an intermittent or continuous high voltage surge, which can cause extreme damage to the electrical system and components.

Overvoltage protection provides system shutdown to prevent such damage.

Overvoltage protection circuits in the Electrodelta regulators employ a level of protection for those conditions where too much excitation is provided to the alternator — causing it to “run away.” This creates potentially damaging, excessive, output voltage. This condition is caused by either a shorted output transistor in the voltage regulator or the field wiring shorting to the bus either inside or outside the alternator.

The latest overvoltage protection systems are designed around a temperature compensated reference and an integrated circuit operational amplifier. Employing precision feedback control, it functions as a highly accurate, inverse time constant integrator to perform this function. Since its inception, this device and its function have been steadily improved. Today, it is one of the most reliable circuits in use.

TYPICAL SYSTEM INTERCONNECT



Paralleling

In a system, which utilizes multiple alternators, the voltage regulator paralleling circuit assures each alternator carries its share of the load. Two methods are generally used: Field Paralleling and Shunt Paralleling.

Field Paralleling

Field paralleling may be found in two forms: alternator rotors directly connected together with a single regulator or a separate regulator connected to each alternator. Both of these techniques rely on the assumption that equal power to the alternator shunt field will yield equal output currents. This will only happen at equal alternator speeds. Any significant difference will result in the bulk of the current being carried by the channel — with the lowest line resistance. Also, with the first approach, which ties both alternator rotors to a common regulator, an internal rotor problem on either alternator could disable both alternators. The newer style approach utilizing separate regulators with individual field switches provides a means to isolate the two channels.

Proper feeder cable balance (impedance) is extremely important in all paralleling installations, especially field paralleling. Without paralleling, the system must overcome the imbalance in order to share the load. It is recommended that you set the system up in the manner it will be used in the installation without using simulations, if possible. Make sure each voltage regulator is attached to its own alternator — even if extension leads must be used. That way, bus impedance can be taken into account at the time of initial setup.

Shunt Paralleling

Shunt Paralleling is an improved approach. Installing a calibrated shunt in the output of each alternator and connecting them to individual regulators allows each regulator to evaluate the output current from its own alternator and compare it to the output of the other and equalize it by means of a bus. A further benefit is that the

system is more tolerant to imbalances and has the ability to supply dissimilar power to each alternator. This achieves the desired output current balance.

Specific setup instructions and installation procedures are typically packaged with all voltage regulators. When a system is first installed, it is recommended that the Shunt Paralleling Procedure be followed to set up the system. This will allow basic check out and performance to be accomplished. System performance across the entire speed and load range will be displayed and any deviations annunciated.

Should problems arise in a paralleling system, the first step is to identify what is happening. The problem is usually a failure to parallel or a failure to regulate. First, isolate the two channels and to treat them as two mutually exclusive entities. By attaching a voltmeter to the bus, the voltage may be determined and monitored.

Prior to starting the engine, turn on the master switch, battery switch, and alternator control switch and verify what voltages are observed at the alternator terminals. Battery voltage should be present at both the alternator battery terminal and field terminal. No voltage should be present at the AUX/STA terminal.

If battery voltage is not present at the field terminal of the alternator with the Alternator Control Switch turned on, the voltage regulator may be suspect. Also, check the LED indicator. If it is on, refer back to the ground fault diagnostic technique mentioned earlier. If the alternator and the field wire check out OK, the voltage regulator is suspect and should be checked on the bench.

If the voltages are correct then the next step is to start the engine and bring it up to approximately 20 percent above normal idle speed. Check bus voltage and record the value along with engine speed and alternator load. If the load is zero, check the bus voltage. If it is still reading battery voltage, there may be no field output from the Alternator Control Unit and it now becomes necessary to check the voltage delivered to

the alternator field.

If there is no field voltage check if the LED is lit on the front of the regulator. If the LED is lit, refer to the Ground Fault Diagnostic Procedure for the voltage regulator in question.

Another problem occurs when both channels independently operate correctly, yet fail to parallel properly. This could be either a regulator or a system problem. It is very important to determine which one has occurred. Defective wiring, switches, connections, circuit breakers or even the alternator itself can cause paralleling problems.

Another place to check is the shunt connections to the regulators. These twisted shielded wires should have the shields grounded at the shunt end. Check the connections to make sure that they are not loose or reversed.

Alternator out sensing and indication

In most applications the "Alternator Out" circuit normally experiences little if any trouble. If the indicator light fails to extinguish after engine start with the alternator supplying load current, don't automatically replace the regulator. First check the indicator light for a short to ground.

If the problem is that the lamp remains out even with the engine stopped, check the light bulb or the negative lamp lead for an open connection. Try removing the lamp lead from the regulator and connect it directly to ground to see if the lamp will light. If not, disregard the regulator and concentrate on the lamp, socket or the annunciator assembly.

Another thing to check is the AUX/STA connection in the alternator itself. Check the terminal on the alternator for AC voltage while the alternator is supplying load current.

Using a voltmeter set to RMS and measure the voltage. Normal value expected here, up to 20% of electrical load is approximately 9 volts for a 14-volt system and 18 volts for a 28-volt system. If no output voltage is observed while the alternator is producing output current, remove the alternator and check the internal terminal connection. It may have been disconnected, broken or burned off.

In paralleling systems with two or more power sources, accurate indication of one alternator being off the bus may not be possible with bus low voltage sensing alone. To remedy this, Alternator Out Sensing is used to signal the arrival and departure of each alternator from the load bus. Also, the overall bus voltage may not be significantly different with one alternator off-line. The only place where the lack of participation of an alternator may be rapidly and accurately seen is at the "AUX" or "STA" terminals of the alternators. This stator tap reflects the actual load status of the alternator.

When output current of the alternator

drops near zero, the voltage at the tap does also, allowing the voltage regulator to sense and signal this condition.

Bus low sensing and indication

A "bus-low" condition exists when the voltage on the bus falls below a specified limit such as 12 volts, on a 14 volt system, and 24 volts, on a 28-volt system. This indication is that the aircraft system load exceeds the alternators output and insufficient voltage is available to replenish the battery. Worse, the aircraft may now be using the battery to support the system. Extended "bus-low" operation will deplete the battery. Load shedding may be required to alleviate this bus-low condition.

This system behaves in a manner similar to the *alternator out* circuit with the difference being that the input signal source is usually contained within the regulator with only the input from the lamp remaining outside. However, before replacing the alternator or a regulator, check the lamp circuit in the same way you would with the Alternator Out circuit.

Through the years, we have learned that the key to solving many electrical system problems is education and patience.

If you run into a situation which has you chasing your tail there is expert help available. Please feel free to contact Kelly Aerospace Power Systems Product Support group at 334-227-8306. **AMT**

Lighten Up

With MagnaFlite!

Lightweight, Most Powerful Starter Technology Available Today...

Lycoming selected, customer preferred. Own the lightweight starter selected by the factory.

- ❖ *FAA/PMA approved for most Lycoming Engines.*
- ❖ *Designed exclusively for the aircraft engine applications utilizing the latest in permanent magnet technology.*
- ❖ *Weighs 7.9 lbs.*
- ❖ *Improved cranking power over conventional starters.*
- ❖ *Easy to install with no engine/cowling modifications required.*
- ❖ *Unmatched Warranty.*

Performance and reliability... MagnaFlite.

For more information on Kelly Aerospace or a listing of your nearest Kelly Aerospace Distributor, visit our website at www.kellyaerospace.com or call (877) FLY-KELLY.






KELLY AEROSPACE
Power Systems
 P.O. Box 273 • Fort Deposit, AL 36032
 (877) FLY-KELLY or (877) 359-5355
<http://www.kellyaerospace.com>
 Certified Repair Station #UT2R226L