Taking Charge of Alternator Problems

Photos Courtesy of Kelly Aerospace Power Systems 2001

Single Engine Alternator Charging System Troubleshooting

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If you've ever had an "out-of-box failure" of a replacement alternator then you need no description of the frustration you felt when that happened. If you haven't had that experience then no description will do it justice. Technical Reps and Warranty Administrators develop this same sense of frustration when a returned "out-of-box failure" unit tests to specifications.

Aircraft charging systems occasionally present a real troubleshooting challenge. As Tech Service Reps, we would like to minimize your frustration and ours by offering the following insights for solving commonly encountered problems. Given the complexity of the charging system, the information presented in this article will be necessarily brief. We will focus on the "high spots" of alternator troubleshooting. Other related components and some of their effects will also be addressed.

Throughout the years, we've received numerous calls requesting technical assistance with charging system problems. About the time we think we have heard it all something new comes along. The old adage that "You can never know it all" certainly applies to alternators! The only consistent factor is that two basic scenarios exist. The first scenario is "It was working OK and now it isn't," and the second scenario is "I just installed it and it doesn't work." This second scenario can be much more insidious and difficult to troubleshoot, especially if you are uncertain as to the failure mode that caused you to change the component in the first place.

At a risk of pointing out the obvious, your first step should always be to verify that the alternator was correctly installed. Is everything properly routed and secure? With belt-driven units, is the belt tension proper? These questions and others equally apply to units that "fail" soon after installation.

"If all else fails, read the directions"

Manufacturers frequently include installation instructions and some even include a test report packaged with the unit. Occasionally, parts dispatchers remove this information so as to include them in the customer's file. Sometimes these papers actually end up being discarded with the thought of "helping" the mechanic by removing extraneous tags, etc. If you deal with a dispatcher in your organization, ask if you can look over any information that came with the unit. If a manufacturer's bench test report shows that the unit came off their production line operating properly, then it's not likely any fault lies with the replacement unit. If you are the one who actually opened the box and you are sure there are no directions or test reports included, look for other contact information such as the manufacturer's telephone or fax number on the box or data plate, even a web site or email address. In many cases, the manufacturer has a toll-free number to call for technical assistance.

Spend a few moments reviewing installation instructions and performance criteria (see Figure 1). This exercise may prevent you from removing a good replacement unit and installing yet another potentially misdiagnosed "out-of-box failure." Confirming how the installation is to be performed correctly,either through written instructions or with coaching by a Technical Service Representative, can likely save you that "out-of-box failure" experience and get your customer back in the air sooner.

Figure 1: Technical documentation – a valuable source of instruction, product performance data, and manufacturer's contact information.

System similarities & differences

There are three basic types of alternators used on general aviation aircraft: the Ford style, the Chrysler style, and the Prestolite style. The basic principle remains the same for all three models: the alternator's job is to produce AC and convert it to direct electrical current before leaving the device. In so doing, the alternator provides the direct current required by the aircraft instrumentation and equipment.

Distinctions between these models are minor. The greatest difference lies in the wiring configuration of the voltage regulator and the alternator. In some installations, the current-controlling element of the voltage regulator is in series between the A/C bus (direct current) and the alternator field (F1). Only one field terminal will appear on the back of the alternator, with another being internally grounded. Alternators with single-lead brush racks will always be wired in this manner. In other installations, the current-controlling element is located between the alternator field (F2) and ground. In these installations, the alternator will have two field terminal connections available. Alternators with two-lead brush racks can be wired either way.

Grounding of field terminals

One common technical assistance request is diagnosing a newly installed alternator that doesn't work. Most Prestolite-style alternators have two field terminals: one must be grounded directly or through the regulator. Some airframe manufacturers install a very small metal tab going from the F2 terminal to the brush holder screw. Better look close, though; given a well-used alternator, if you don't know it's there, you'll never see it (see Figure 2).

Identifying the failure mode/isolating the cause

Now back to the first scenario: "The alternator was working OK and now it isn't." Presuming that an alternator bearing failure is not involved, that connections all check OK, and correct belt tension has been confirmed for those belt-driven

"Radio Noise"

It's well known that charging system components can affect radio communication in the form of noise. Failing diodes or a bad stator will normally generate a whine in the headset that will vary in pitch with the R.P.M. of the engine. Radio noise falsely attributed to leaking diodes or a partial short in the stator can be one of the hardest problems to track down and solve. Given a new manifestation of radio noise, one of the easier checks is for alternator wires situated too close to the antenna cables. Alternators inherently make some electrical noise and if wiring has recently been re-routed too close to antenna cables, the radio will pick it up. If you have shielded wiring going to or from the alternator, make sure both ends of the shield are properly grounded and that you have good continuity to the airframe. It's also advisable to inspect the connections at the battery. These connections should be perfectly clean, bright and tight. Often overlooked is the connection of the ground strap from the engine to the engine mount. These connections tend to corrode over time and you cannot see the corrosion without taking the ground strap off. If both ends of the connection are clean and tight and the problem persists, then unfortunately everything else has to be checked. Be certain to look closely before deciding all is OK; the problem of corrosion can be very subtle. It only takes about 0.2 ohms resistance on the ground plane to cause radio noise (and a variety of other problems). A friend had an older airplane with the battery mounted in the rear. He had radio noise, slow cranking R.P.M., apparent alternator problems, and several other electrical problems. It was recommended that he run a dedicated ground wire from the battery to the firewall. When he did, all his electrical problems went away. Over the years, the aluminum skin of the aircraft had oxidized where it was overlapped and riveted, putting too much resistance in his ground plane. Regrettably, all solutions are not this simple. Once all potential sources of radio noise have been investigated and eliminated, you may have a genuine avionics problem. Your local avionics shop will have to be consulted for further investigation and diagnosis.

Figure 2: Example of a ground strap on the field for a Prestolite-style alternator. These can be easy to overlook, perhaps the reason a mechanic had marked this one.

units, then use your multimeter to check and see if there is resistance on the alternator field. If the field is open, then the culprit is a bad rotor or brushes. If the field checks OK (generally 3 to 25 ohms), the next step would be to make sure voltage is getting to the field. If not, then it's the regulator or the wiring. Determine whether or not voltage is getting to the regulator; if so, then the regulator most probably is the culprit. If everything is checking as it should, by default, things continue pointing to the alternator as the source of the trouble. There is one more test to make before you remove it from the engine — use an analog ohmmeter to check the resistance between the output terminal and ground (a digital ohmmeter won't work). This is a reverse polarity test so you have to ground the positive probe and contact the negative probe on the terminal. The reading should be between 30 and 50 ohms; a lower reading than this indicates the stator or diodes are gone, and the alternator must be repaired or replaced.

Low current output

The next most common variant of the "It was working OK" scenario is low current output (this can cause a technician to consider changing careers!). As with most other problems, there can be several reasons for the manifestation of low current output — the most frequent one being a shorted or burned stator.

A failed diode is the next most-common suspect immediately following a suspected stator. With a failed diode, you will likely experience radio noise. Modern diodes are much more reliable and durable than those used even just ten years ago, having a much higher mean-time-to-failure life expectancy. Core units returned to our shop have had the stator shorted and burned with fully functional diodes; however, this is the exception instead of the rule. The point is that diodes today can handle the stress of stator failure better than ever. Still, it's not advisable to reuse diodes that have survived a stator failure due to induced stress, coupled with a high probability of damage and subsequent loss of durability.

Another possible cause of low current output is a partially shorted rotor. In this case, the wires in the rotor coil short to each other but not to ground. This lowers the resistance of the coil, thus lowering the magnetic flux of the rotor and the output of the alternator.

Brushes are yet another culprit that can certainly contribute to low current output. Be certain to inspect the brushes. Are they worn? Are they making positive contact with the slip ring on the rotor? Most alternator manuals give minimum lengths for brushes. If you happen to disassemble an alternator for any reason and it's been in service for a while, always measure the brushes.

For gear-driven alternators, the last and certainly ugliest suspect for low output is the one that your customer really doesn't want to hear about: "The coupling gear is slipping." As you may already know, the reason your customer doesn't want to hear about this is that in many cases, the replacement cost of a coupling gear is two or three times the replacement cost of an alternator. Coupling gears have rubber inserts that act as a torsional buffer; the inserts are designed to shear to prevent damage to the engine in case the alternator stops suddenly (for example, if something gets inside the alternator and locks it up). The rubber material of the insert tends to harden with age and heat and will eventually allow the two halves of the gear to slip. A good indication that the coupling gear is responsible for low alternator output is when the system works fine with light electrical loads but the amperage and/or the voltage starts dropping as you add additional load. Engine manufacturers' service bulletins explain how to test coupling gears for minimum slip torque. Also, if you are experiencing high voltage with low output, this can be caused by leaky switches and circuit breakers. If these components have never been replaced, then now is the time to consider doing so.

Pulsing ammeter

Another "first scenario" common complaint is an oscillating or pulsing ammeter needle. Like all other troubleshooting problems, knowing where to start looking for solutions will conserve your time and temper. Usually this problem is caused either by the field circuit breaker, the alternator switch, or both. However, the regulator over voltage sensor might also be bad. To diagnose the problem, turn the electrical system on without starting the engine and measure the voltage coming off the output terminal of the alternator. Next, measure the voltage on the input (power) wire of the regulator and compare the two readings. If there is more than one-half (0.5) volt difference between these readings, then, as you recall from our earlier comments, either (1) the circuit breaker is

Figure 3: Just as overworn brake pads grind brake rotors, brushes that have gone too long and been worn too far cause irreparable harm to mating slip rings.

defective; (2) the alternator switch is defective; or (3) the over voltage sensor is bad. *Note: You could have any combination of the three.* At this point, check the input voltage of the circuit breaker and compare it with the output voltage. Again, if there is more than one-half volt difference, the circuit breaker must be replaced. Then perform the same input-voltage versus output-voltage test on the alternator switch. There cannot be more than one-half volt difference or the switch must be replaced. Voltage differences inside the switch or circuit breaker originate at the contacts. When they lose the dielectric grease they are packed with, they arc and pit and oxidize on the contact surface. These compromised surfaces eventually lose the ability to properly conduct current. The outcome is very much like magneto breaker points that have been run a long time. Although it is rare, one last possible cause of an oscillating or pulsing ammeter is the regulator itself. There are some early regulator designs that operate on such a low frequency that they will cause the ammeter needle to pulse at low RPM with a moderate load. If you have one of these regulators you have two choices: (1) live with it; or (2) upgrade to a newer, high frequency regulator.

Figure 5: Insulated wire used as the brush retainer prior to re-installation of the brush block. Bare wire can scratch the slip ring when removed to release the brushes

"Nuisance tripping"

The final problem we'll discuss could fall in either of our two scenarios: an alternator that drops off line for no apparent reason. A simple cycling of the alternator switch temporarily corrects the problem. For obvious reasons, this is frequently referred to as "nuisance tripping." The first thing to check for is a poor connection in the remote sense or field wires. Some regulators are very sensitive to ambient electrical noise and any intermittent condition will cause the system to trip off line. If connections are confirmed as good and the problem persists, then look at the alternator itself. Even the slightest scratch on the slip ring of the rotor can cause nuisance tripping. Inspect the brushes for excessive wear; especially note if the copper wire is showing, and if it is then the brushes must be replaced (see Figure 3). When the brushes are too short, the brush spring may no longer maintain proper pressure for brushes-to-slip ring contact. Before reassembly, the alternator slip ring must be resurfaced. Don't ruin your good work on the slip ring (see Figure 4); use a piece of plastic or plastic-insulated wire (you can even use a toothpick) as a brush retainer in the brush block (see Figure 5). Bare metal wire can scratch the slip ring when it's pulled out of the brush block to release the brushes once reassembly is complete. It doesn't take very much arcing between the brushes and the slip ring to trip some systems off line and even a tiny scratch can initiate or perpetuate the "dropping off line" problem. If you've looked at the alternator and are confident that it's not the source of the problem, it is very probable that the regulator overvoltage circuit or separate overvoltage sensor is failing. Some systems have no overvoltage protection at all, some have regulators with overvoltage protection built in, and others have a separate overvoltage sensor. Make sure you know which you have before replacing them.

Figure 4: How your slip ring should look when you are ready to reinstall the rotor.

Figure 6: One manufacturer's technical service contact information.

This has been a very basic survey of single engine electrical system troubleshooting. Just remember one thing: if you can't figure out what's wrong don't hesitate to call a manufacturer's Technical Service Representative. They probably can save your time and frustration, your customer's money and both you and your customer a few gray hairs! AMT

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