One-Wire Alternator Conversion

By Lynn French

This article is mirrored from EAA.org with comments by Bob Nuckolls -(BN-)

As part of my engine control system installation, I converted my alternator from internal to external regulation. As you may know, internal regulation is fairly standard these days in the automotive world. Although internally regulated alternators are fairly reliable, they still have a failure mode that is not acceptable for use in aircraft. This failure mode occurs when the regulator fails internally and puts the alternator in full output mode regardless of battery charge. This leads to over voltage and eventual (if not instant) battery failure— not good for electronics.

What's worse, even if you were aware that the alternator was overcharging, you would not be able to shut it down by removing the field voltage via fuse or breaker. The only recourse would be to turn off the master—provided you have the alternator wired into your system correctly or have a separate breaker in your panel for the alternator output that can be turned off. So, it is usually recommended to install externally regulated alternators in aircraft. This not only eliminates the type of failure mode caused by internal regulators, but also allows the use of over voltage shutdown circuits that will interrupt the field voltage to the alternator and shut it down automatically before damage occurs.

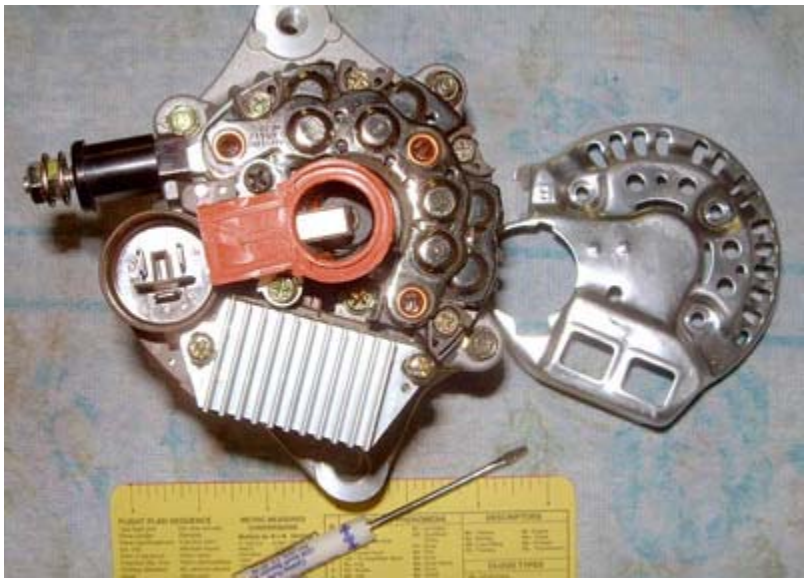
So why not just purchase an off-the-shelf, externally regulated aviation alternator? Because they run about $500 from the popular aviation suppliers! As experimenters, we can make one with a little time using an $80 standard one-wire Denso alternator from our local parts store or off eBay. Besides, whether the alternator costs $500 or $80, the bearings of either one will last the same amount of time and will most likely be the first thing to go.

The original thought for this process was provided in a back issue of *CONTACT! Magazine*. As I investigated three or four different Denso alternators, it appeared that the design was different than what was discussed in the magazine, so I developed a conversion for this type of alternator using what I learned from reading *CONTACT!* The majority of Denso alternators are internally identical with regard to their regulators. What I'll outline here requires some modification to the alternator itself, but primarily it circumvents the internal regulator.

There are basically two things that need to be done to make this work:

1. Modify the internal regulator of your Denso alternator so that it in essence becomes a connection point to route your new external field voltage to the brushes. The internal electronics are bypassed.

2. Modify one of the brush connection points so it is removed from the alternator B+ output terminal and is instead connected to the alternator chassis ground.



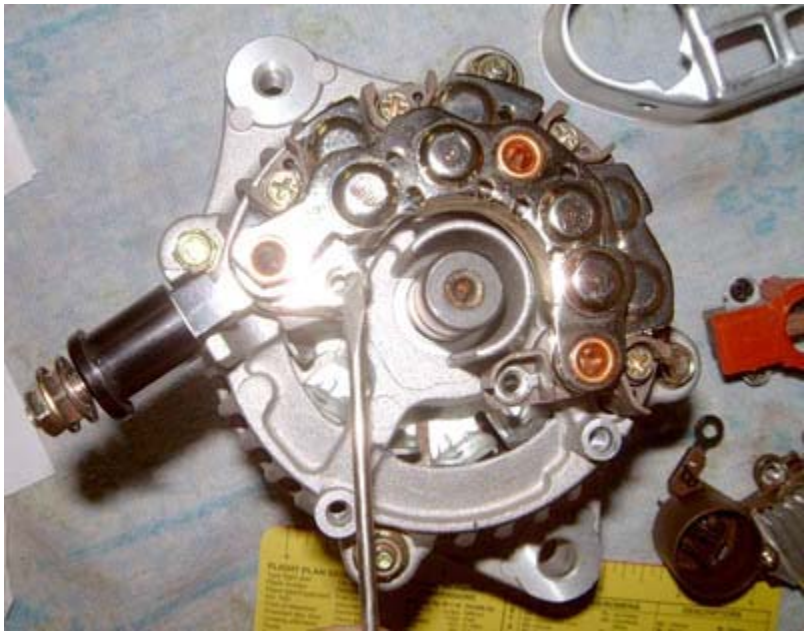
One-wire alternator, end cover and armature removed. Note the three-prong connector that's integrated into the regulator.

The regulator modification

Since most of the one-wire alternators I investigated still have the three-prong round connector installed (usually they just have a plastic plug covering the hole), we are going to use this connector just like you would any other standard regulator (two or three wire) for connecting the field voltage from the external regulator to one side of the brushes. I believe this process is the same as described in the previously mentioned *CONTACT!* issue. A picture is worth a thousand words, so I'll do my best to provide you with both.

Standard regulator, available from many parts stores.

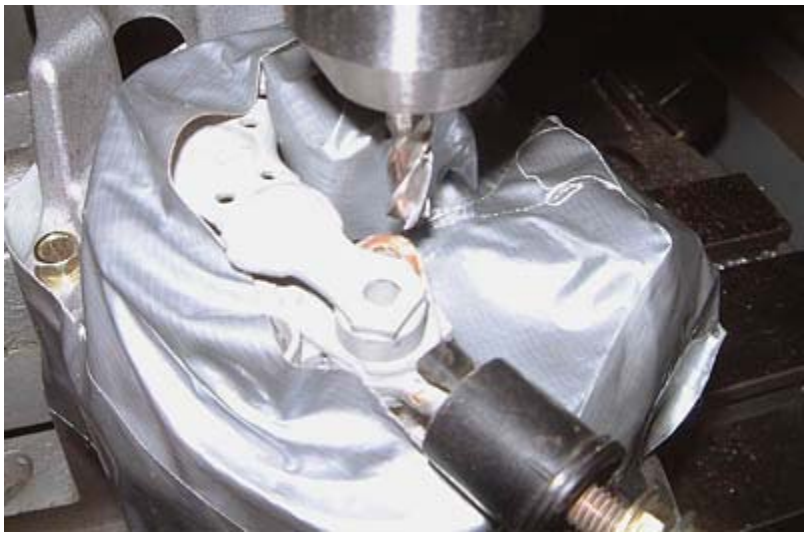
By observing the following photos, you can begin to understand that all the internal circuits of the regulator are bypassed. Use the standard harness connector from your salvage yard or parts store to plug into your alternator's connector. The next step connects the other side of the brushes to your alternator chassis (ground) to complete the field circuit.



With brushes and regulator removed, we can see the attachment tab that will need to be isolated. The reason for this is that this attachment connects one side of the brushes to the main alternator B+ terminal—the one sticking out the lower left side. We don't want this. The external regulator will feed one side of the brushes while the opposite side of the brushes will be connected to ground, as seen in the following photos. The brushes transfer the field current to the commutator ***(slip rings –BN-).*** *The field current is determined by the regulator and controls output voltage.*

Changing the connection point on the other side of the brushes

As you disassemble your alternator, observe how one side of the brushes is actually attached to a copper tab that is part of the same assembly that the alternator's B+ output terminal is attached to. (See above photo.) We don't want this. Instead of being attached to the battery, we want this side of the brushes attached to ground. To do this, we will remove the existing copper mounting tab and drill/tap a separate hole in the end bell (or chassis if you prefer) to which the brush terminal will be affixed. But before we get out the Dremel, remove the brush mounting screw; locate and mark a hole on the chassis of the alternator so you will know where to drill and tap the new mounting hole.



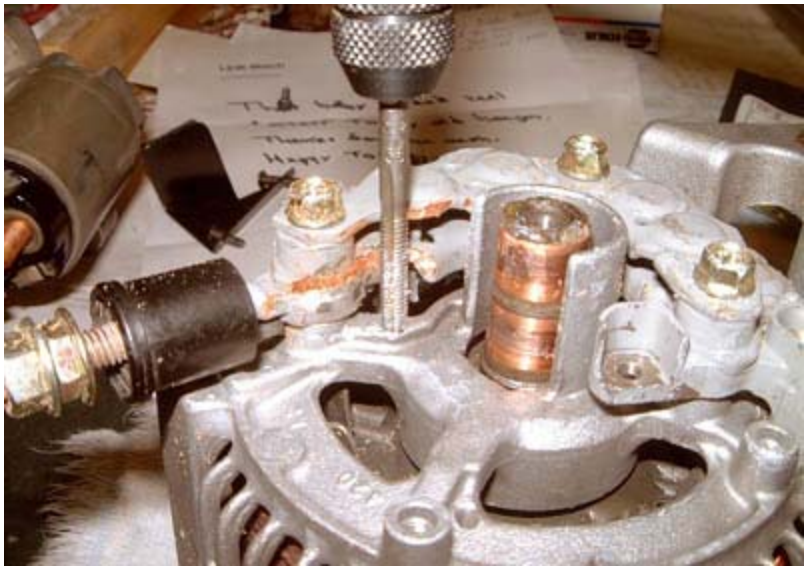
Although this image shows how Lynn used a mill to machine away the copper attachment, a handheld Dremel works fine, too.

It would probably be a good idea to remove the end bell assembly from the alternator to help avoid getting any copper or foreign matter down into the unit, which might cause problems later. Upon completion of this step, make sure that the alternator is thoroughly cleaned.

With the copper portion of the tab removed, the plastic nut retaining pocket is next. But first, make a mark down through this nut pocket, into the chassis, to accommodate the next photo.

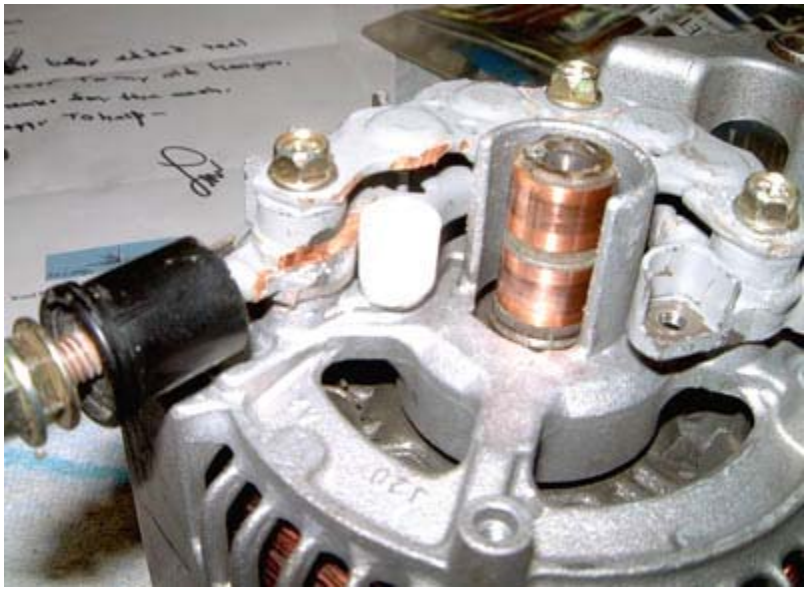
Now that you have located where you need to drill the new attachment hole (as shown in the photo above), remove the brushes and regulator. Using your Dremel, remove the existing tab as shown below. Ensure there is enough clearance so that when the brushes

are installed, there is no concern that vibration will allow their connection to come in contact with this point.



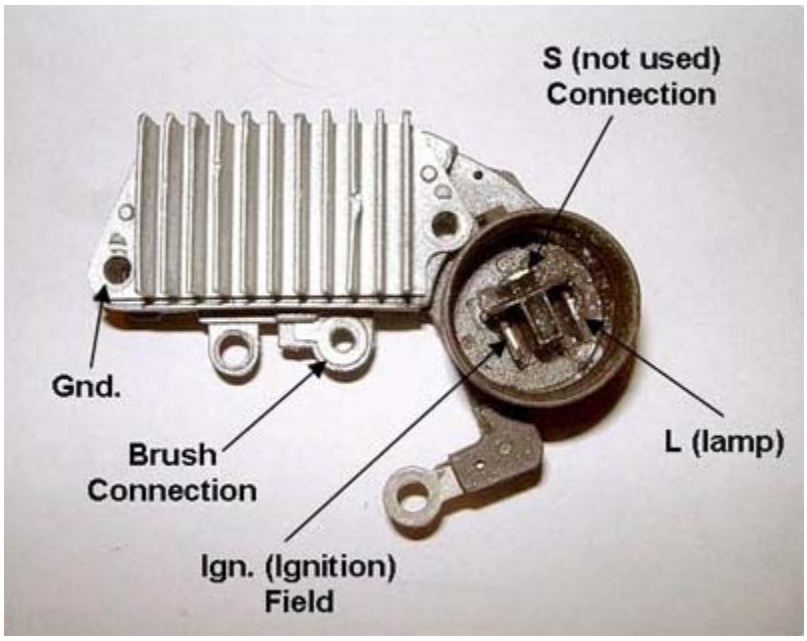
Using the mark from the previous photo, drill and tap a hole for the new attachment. Most of the alternators seen by Lynn use metric screws, so you might want to follow suit. The new attachment will be used to bond this side of the brushes to chassis ground rather than the output B+ terminal as before.

Once the old attach point has been removed and clearance provided, drill and tap a hole into the end bell for the new attachment screw. You will then need to fabricate a standoff spacer with a hole drilled through it that will serve as the new “shelf” that the brush terminal will sit on. I made my standoff out of Delrin and used a blob of J-B Weld underneath it to help provide a level base. You can now reassemble the alternator.

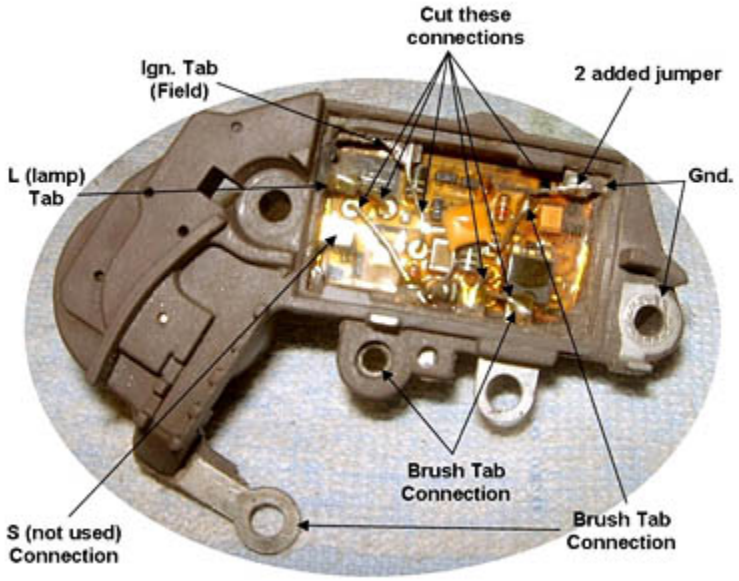


A Delrin standoff is machined to fit around the attachment hole and provide the same

mounting height as the previous arrangement did. Lynn recommends J-B Weld to hold it in place.



Here is the top side of the regulator with the various tabs and connections labeled. The external connector is wired to the standard automotive regulator. The ign./field terminal is the only connection needed.



Now for the regulator: This shows the internal regulator turned upside-down with the bottom cover removed to access the innards. The various terminals and connection points have been located. You will need to cut all of the connections away from the circuit board; it's no longer used. Rewiring is then required so the attachment tabs are re-routed to the brushes and the external connector properly.

Summing up
A standard $18 external regulator from your local parts store is now mounted on the firewall to control the field of the alternator. I think I used a VR-66 ***(VR-166 is the right number . . . there are dozens of equivalent regulators. If it LOOKS like the picture, it IS the right part! –BN-)*** made by Standard. On composite aircraft, be sure the regulator case is grounded. I would also take the time now to install a crowbar over-voltage protection module on your external regulator.

If everything was done correctly, you should be able to plug in the round connector from the external regulator into the alternator, reattach the B+ wire and see a rock solid output of around 14.5 volts when in operation.

A side benefit to this conversion is that it allows you to choose from a broad array of alternator sizes and weights. The internal regulator that we modified in the above procedure is pretty much common across a broad array of Denso alternators. This component is now only a connection point; there is nothing to fail, so if you need to change the alternator, simply remove it from the old one and install it in the replacement. Also, since the end bell of the alternator is now a custom part, I made up a second alternator to serve as a spare. When needed, I will replace the unit with the spare and then keep the end bell off the old one to install on the new one (or repair the old one). ***(Slick idea! –BN-)*** Of course, as a backup plan in an emergency, there is nothing preventing you from simply installing an unmodified, one-wire alternator as a temporary replacement. Just don't plug in the round connector and accept the added risk until you can get the proper replacement installed.

The stock O-200 alternator weighs in at well more than 10 pounds with an output of 35 amps and costs more than $600. With this conversion, I am using a mini one-wire alternator that is rated at 55 amps, weighs 5.6 pounds, and costs less than $80. Another note is that, of course, alternator output is determined by the rpm of its armature. I set up my pulley sizes to run the alternator at the slowest speed possible and still provide the charging needs of my aircraft. The bearings and brushes will last longer if you are not running the alternator at unnecessary speeds. ***(Not necessary or even prudent. Higher RPM improves output at ramp and taxi RPMs, improves cooling and reduces field current. An alternator in an airplane will NEVER see the number of operating hours that same alternator would experience in an automobile. The notion of extending service life by slowing the alternator down is not supported by the physics. The modern alternator runs happily at 10,000 RPM or more in cruise. This gives you 3,000 or so RPM at ramp and taxi RPMs and a substantial output. –BN-)***

I would also like to say that I am very pleased with this alternator's mounting system. It has evolved into a universal mount that will accommodate almost any popular alternator by simply changing spacers in the upper and/or lower attachments.

(Nicely done Lynn! Thank you for researching and sharing this information with the OBAM aviation community. –BN-)