Installing the Compudigital Power Supply Conversion Kit in your Kenwood TS-930S

John Young, W3AFC, with input from Dave Phillips, KB7JS

In my Compendium of Repair for the Kenwood TS-930S, I outline the steps needed to repair the power supply in your Kenwood TS-930S transceiver by modifying the original Automatic Voltage Regulator (AVR) board and installing a Phoenix Contact Quint industrial-grade switching power supply. Depending upon the price paid for the Quint, this may be the cheapest way to restore your radio. It is, however, somewhat labor-intensive and time-consuming, and you may have to play the "watch and wait" game on eBay for a good deal on a Quint. Or you could get started on your radio right away with brand new parts.

For a price of only $199, Jeff Hilliard (k6iok), the owner of Compudigital, offers a complete kit for upgrading your power supply. The kit contains everything you need: A brand-new 20/26-amp Quint power supply, a new replacement board for the AVR, mounting hardware, wire connectors, and a set of instructions. In addition, Jeff posts instructional videos on his website, www.k6iok.com. This is what you will receive:

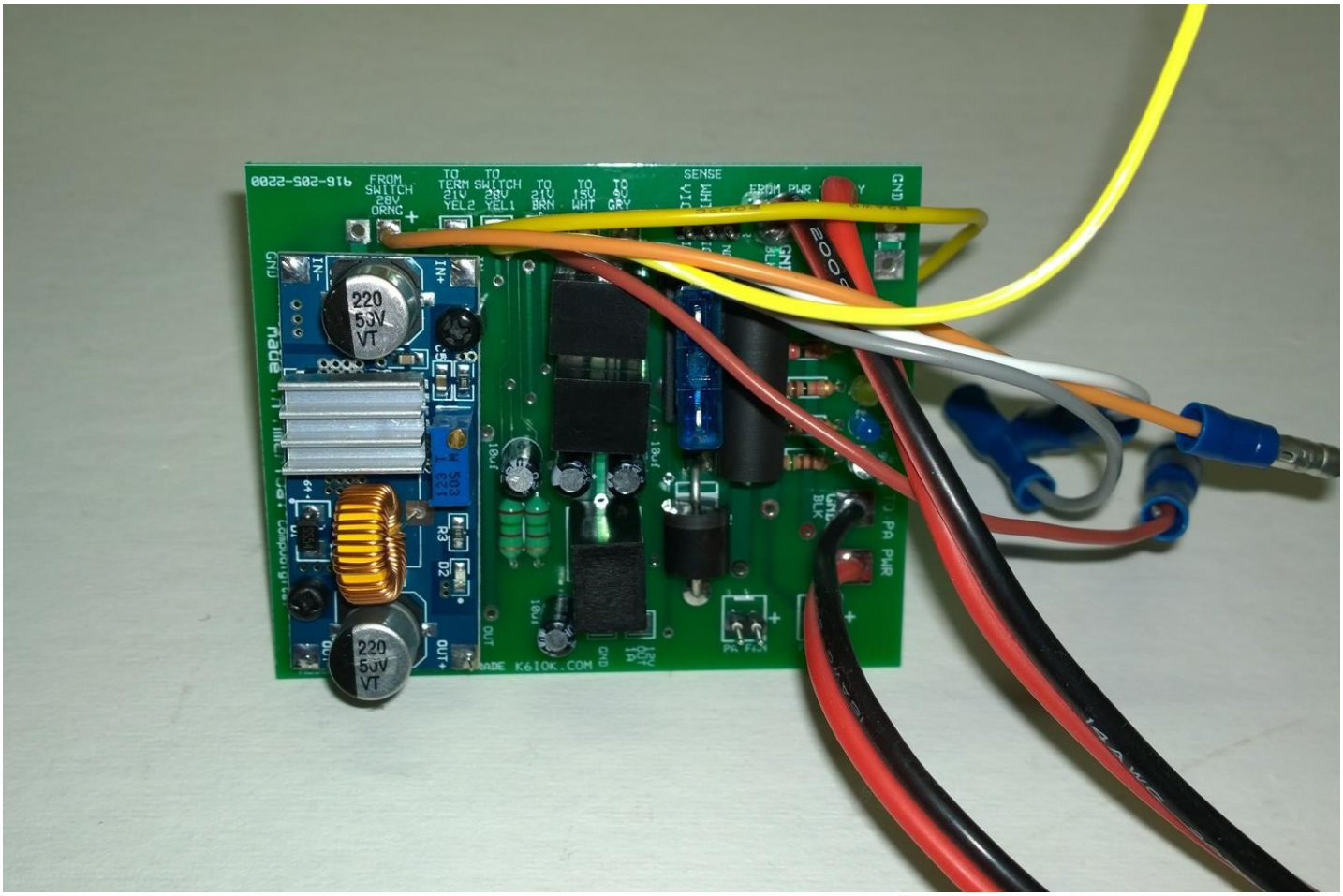
This kit works perfectly whether you have an older 930S with the "28-volt only" AVR board, or the later model with the split 28/21.7-volt system. In the older 930S, the voltage division is purely resistive. There's a bank of resistors behind the Low-Pass Filter (LPF) and four more in the fan housing. They are fed as a group by the 28 volts from the AVR board to produce sub-voltages of 23, 21, 18, and 9V. The actual voltages needed for the radio are 28, 21, 15, and 9V. The 930S will work perfectly with the lower voltages, as explained by Dave Phillips, KB7JS:

"The AVR regulates the 40V DC line from the input bridge rectifier and produces regulated 28V. In early models of the TS-930, this is the one purpose in life for the AVR. Reference voltages were then derived from the 28 V line through voltage dropping resistors housed in an aluminum box behind the Low Pass Filter cage. These resistors provided 23V, 21V, 18V, 15V, and 8V. The 23, 15, and 8-volt lines are used only in the Digital Unit. The 23V line drives an inverter power supply to create the negative voltage drive for the display. I discovered on my first 930 upgrade that the 21V line works fine for this, so the 23V line is not needed.

The resistor bank provided a tremendous amount of heat, so it was eliminated in later revisions of the TS-930, and the AVR was modified to add a regulated output for the 21 V reference. The remaining voltage dropping resistors were then moved inside the PS Fan Cage to provide 23V and 15V from the 28V line, and 8V from the 21.7 V line."

Unfortunately, the later model's 21.7-volt system produces a lot of heat too. It uses a 2SD843 Toshiba 7-ampere power transistor whose output is set by a Zener diode connected to the base. The metal tab of the transistor is the collector, so it must be insulated from the radio's chassis by a pad. This reduces the thermal transfer efficiency, resulting in a large amount of undissipated heat. Whenever I modify a newer radio with that transistor, I replace it with a 5-amp LM2596S DC-DC converter board because it produces almost no heat. In fact, at the loads presented by the 930S' digital board and receiver circuits (about 1.7 amps) it remains cool.

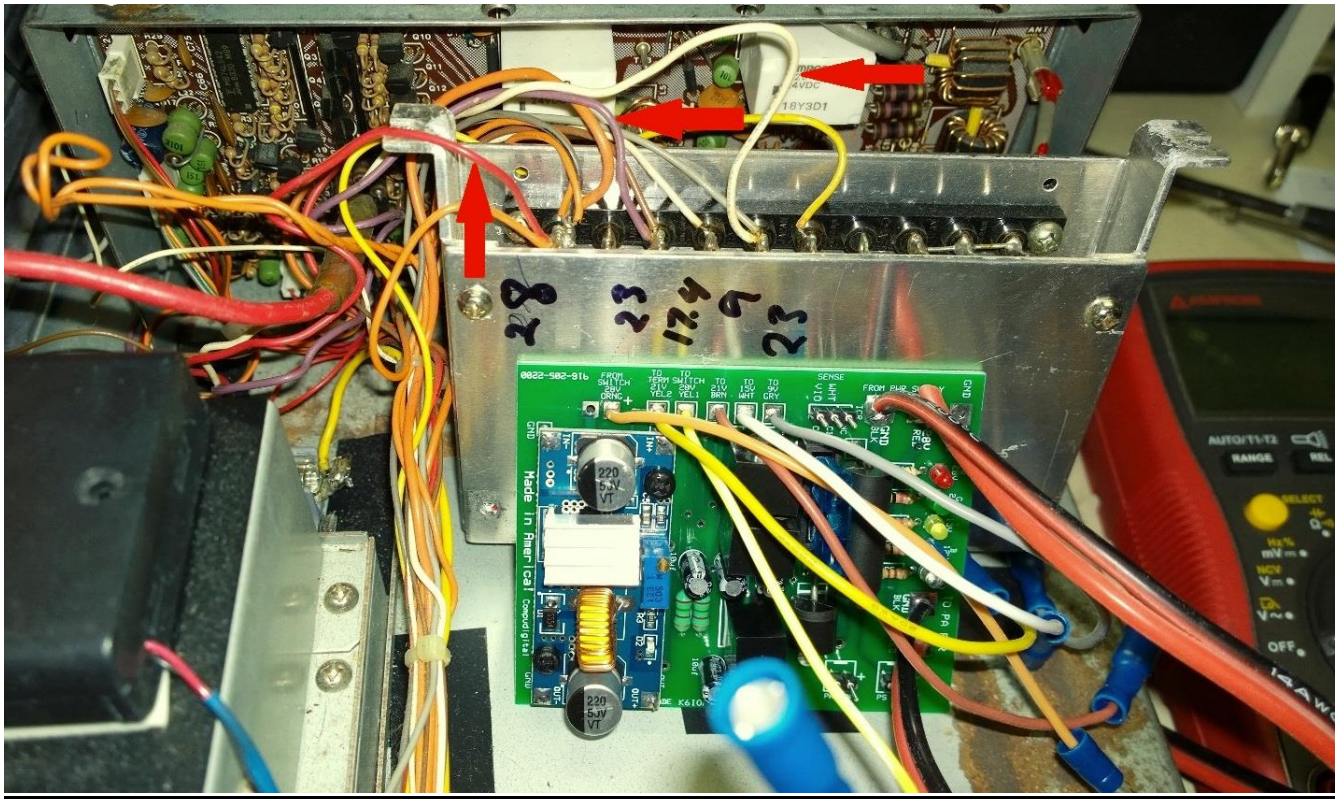
This is a close-up of the Compudigital replacement AVR board. This board supplies ALL the voltage outputs needed for your radio, including the heavy 28-volt lines for the PA and the "sense" circuit voltages that the rig uses to provide the B+ and Ic readings for your panel meter as well as the rig's PA protection circuits. There's even a 12V output in case you need to install lower-voltage PA drivers, like 2sc1969's. The various voltages created by the OEM power supply can be replaced by the 28, 21, 15, and 9-volt outputs shown below. This board also produces reduced-voltages (9V) for the PS and PA fans at the connectors at the bottom right side in the picture. The board contains an automotive-style fuse, making separate fuses for the PA and receiver circuits optional.



The fan pin connectors are not keyed as they are in the original AVR board. This allows one to set each fan to blow out or in, but I feel it's best to have the PS fan blowing out, and the PA fan blowing in against the heat sink.

I installed the kit in my rusty but trusty "test bed" 930S that was donated by Luis Velasquez, K4BTA. I had already converted this radio by installing a new 20/26-amp Quint and modifying the original AVR board. It's an older low serial number radio with the dropping resistor system.

Before removing the connections, I mapped them out as shown in this photo. This allowed me to track the wires and their voltages. For instance, the 9V tap below connects to both the grey wire, and the white one that runs to the dropping resistors located in the PS fan housing. When you install the Compudigital kit, you can cut away the white wire, as well as the red and purple wires to those resistors, leaving you with the orange, yellow, white, brown, and grey wires shown on the board and described in Jeff's instructions. The disposable wires are marked with red arrows in the photo below. Once you cut them, you can remove the wires and the resistors in the fan housing, and the resistor bank shown below.

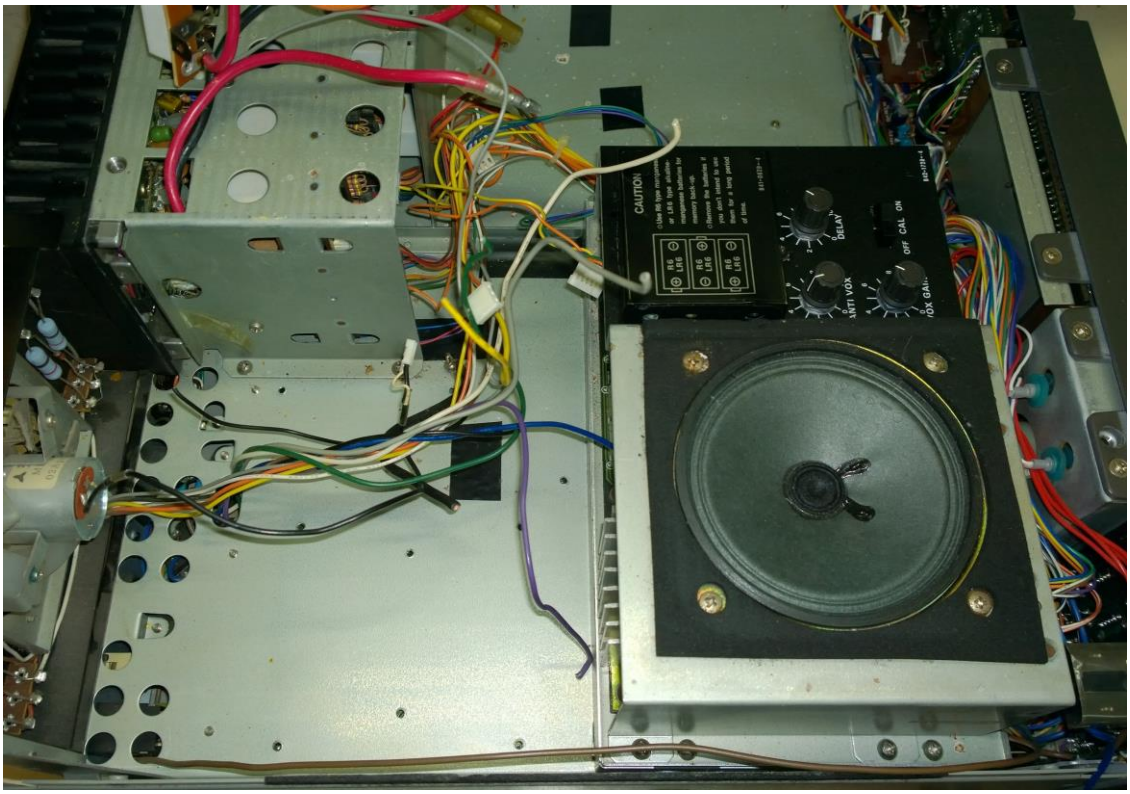


<u>Removing the old power supply and making space</u>

Many of you will be installing this kit in a radio with the OEM power supply still installed, so you will need to remove it to make room for the new Quint. A complete procedure for this can be found in the Compendium. However, I feel some additional information is warranted here. I should mention at this point that I mounted both my Quint and my Compudigital AVR board differently than the way Jeff shows in his video.

Before you begin the task of removing your old power supply parts, please STOP and read this. Use a magnetic screwdriver and keep track of <u>every</u> screw or piece of small hardware that you remove. Here's why. With the old power supply parts removed, you will see openings in the chassis. They were created when Kenwood punched out the main chassis to create mounting tabs for supporting the various circuit boards and other parts. Most of these are directly above the foil side of the Signal Unit. <u>It's very easy for one of the small screws that hold down the AVR board mounting flange or the capacitor bank to slip unnoticed down through one of these slotted holes and get wedged out of sight between the metal chassis and the circuit foils</u>.

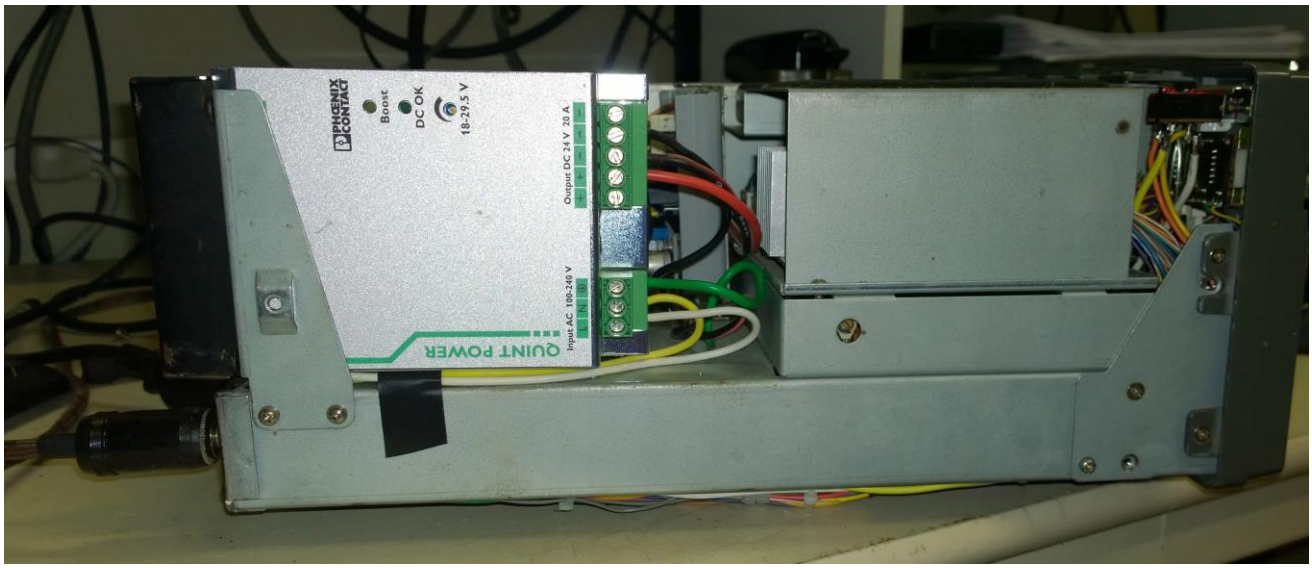
If that happens it will almost certainly fry something on your signal board the moment you turn on your radio. ***All your money and effort will be wasted***, and your radio will be rendered worthless unless you can find someone to repair the board. Even if you notice the missing screw, you may have to loosen or remove your Signal Unit to get it out, which is a HUGE hassle. Trust me, it happened to me once. <u>Before you continue, cover all those holes with tape</u>.



Mounting your Quint

My philosophy is to mount the Quint as close to the PS fan assembly as possible to maximize the air flow through it. This also leaves more room on the opposite side. If you are re-using the original PS fan, you can mount the Quint so that the fan DC terminals are right up against the rear grill. I use a small thin rubber pad to prevent shorting, but electrical tape works well also. Just make the pad as small as possible because you want as much airflow through the Quint as possible. It's an industrial-grade power supply that relies on vertical mounting to allow updraft of air through the housing. Mounted horizontally without a fan, it CAN get hot. If you don't believe me, unplug your power supply fan when you're done, and with the top cover on, operate your rig for 15 or 20 minutes. Then remove the top and touch the Quint's case.

Depending upon your model number, you also may have to re-route your AC power wires so that they aren't in the way. This is how I routed mine. The tape keeps them from slipping out when I have the case off.

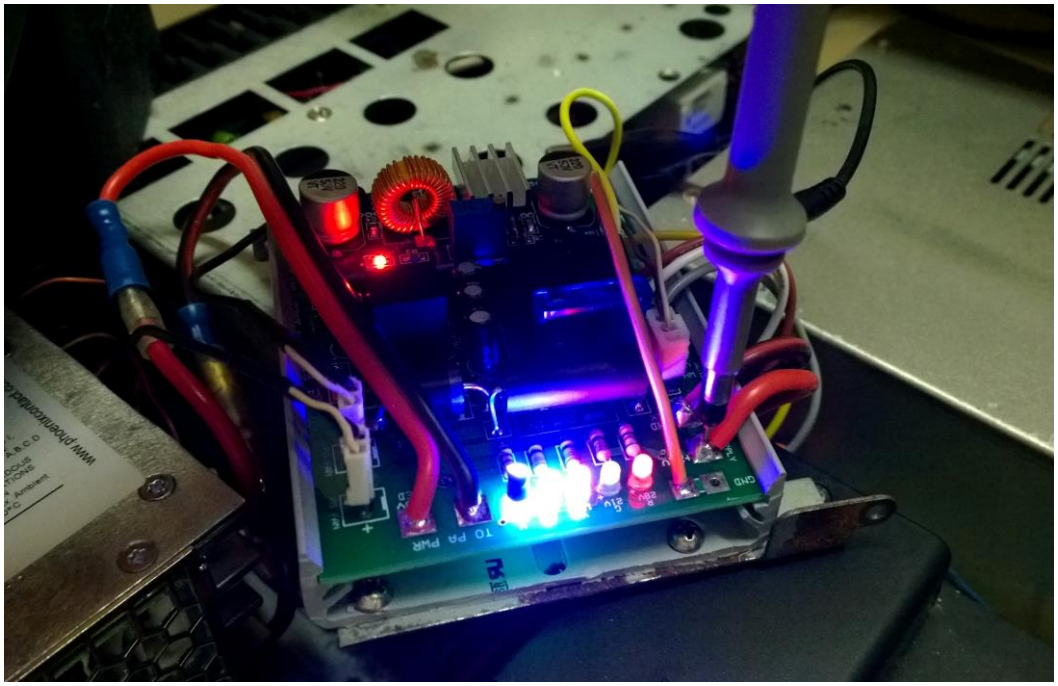


There's actually a method to my madness. Once you re-install the lower case of your radio, it will be easy to reach the terminals and the voltage adjustment screw if necessary. The new AVR board supplied with Jeff's kit has supply wires that easily reach the DC output terminals, and this setup places the Quint's intake and cooling fins directly in the PS fan's airflow. Plus, I think it makes the installation look factory.

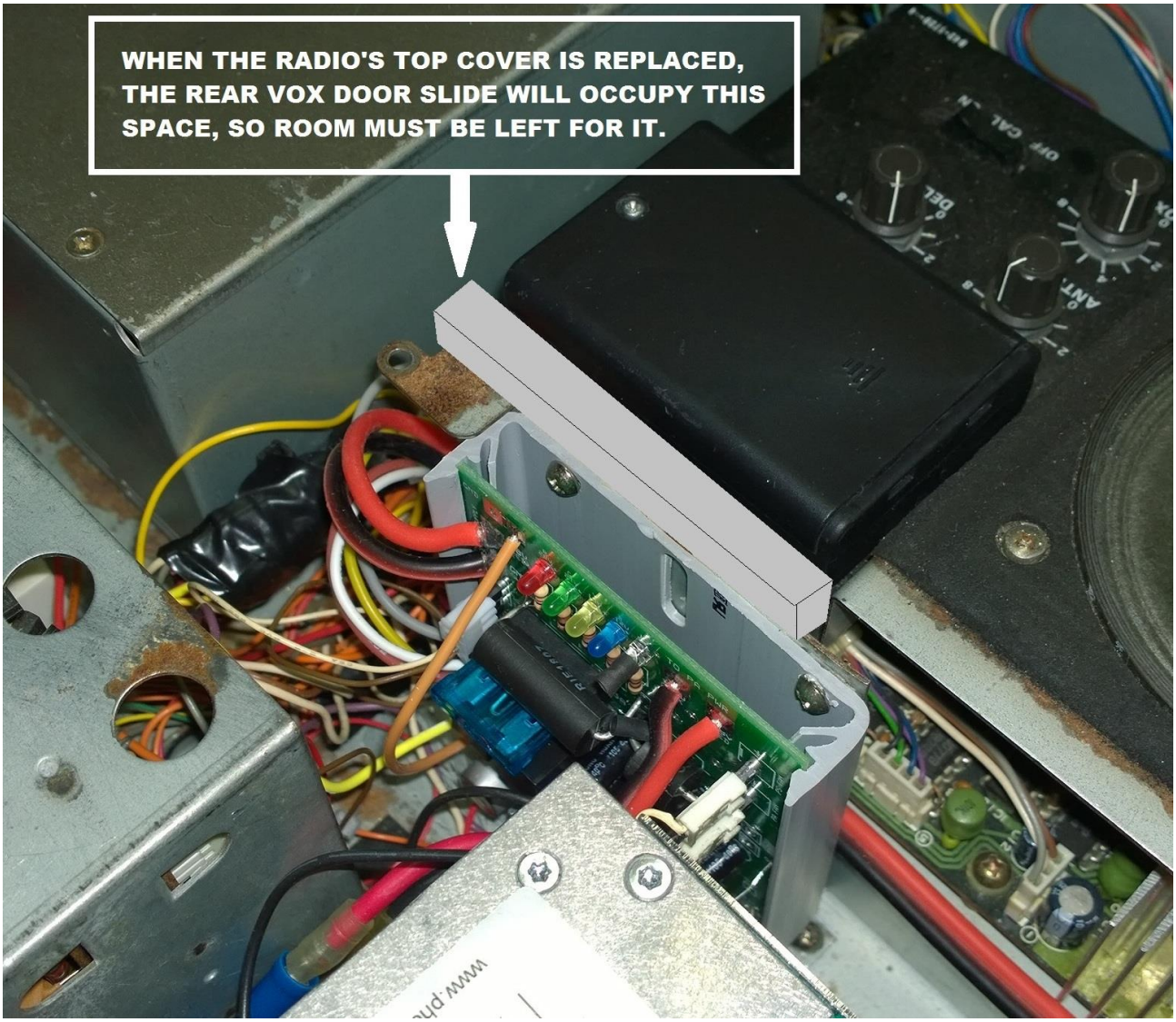
I use an Evercool 70mm x 70mm x 10mm ball-bearing muffin fan for the PS which is a good substitute for the stock fan. It has the same approximate current draw, and it uses the same holes too. More info can be found in the APPENDIX.

Mounting the New AVR Board

As mentioned earlier, I have a habit of doing things differently. Rather than follow Jeff's instructions, I used the old AVR board bracket, drilling the TYCO board track that Jeff provides so that it can be mounted to the bracket. But DO follow Jeff's instructions and test the board before you install it in your rig. If you've decided to bypass the DC switching and use the front panel switch for AC only you can simply leave the test jumper described in Jeff's instructions in place (See APPENDIX about that). This is also a good time to make sure your Quint voltage is set to 28 volts.

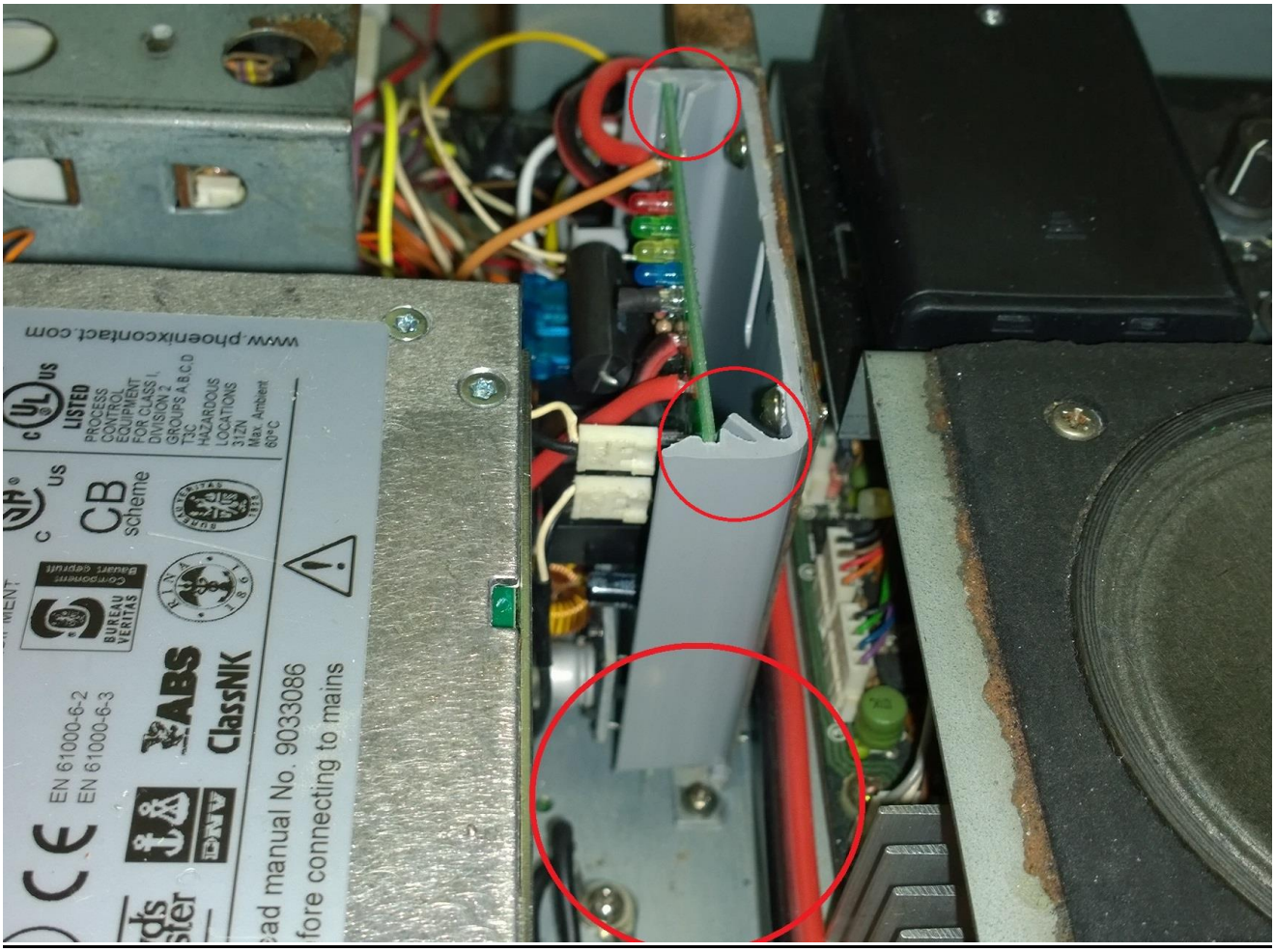


The first time I did this mod, I saw that long tab with the hole in it on the AVR mounting bracket and thought it would be an ideal way to hold down the bracket. I could use one of the existing holes in the chassis that were used by the capacitor bank. And, it placed the new board in the perfect spot for the fan cables to reach their pin headers. Unfortunately, that placed the board and bracket too close to the VOX controls bracket. When I tried to replace the top cover, it wouldn't go on. So, I flipped the bracket around as shown below, moving it about 3/8-inch away from the VOX bracket. That's better than using the tab from a stiffness perspective, but you may have to remove some material from the corner of the TYCO mount to tighten the screw. My method works well but it only uses one screw because the other one doesn't line up. Unless you have your signal unit out already for some other work, I wouldn't risk drilling a second hole.

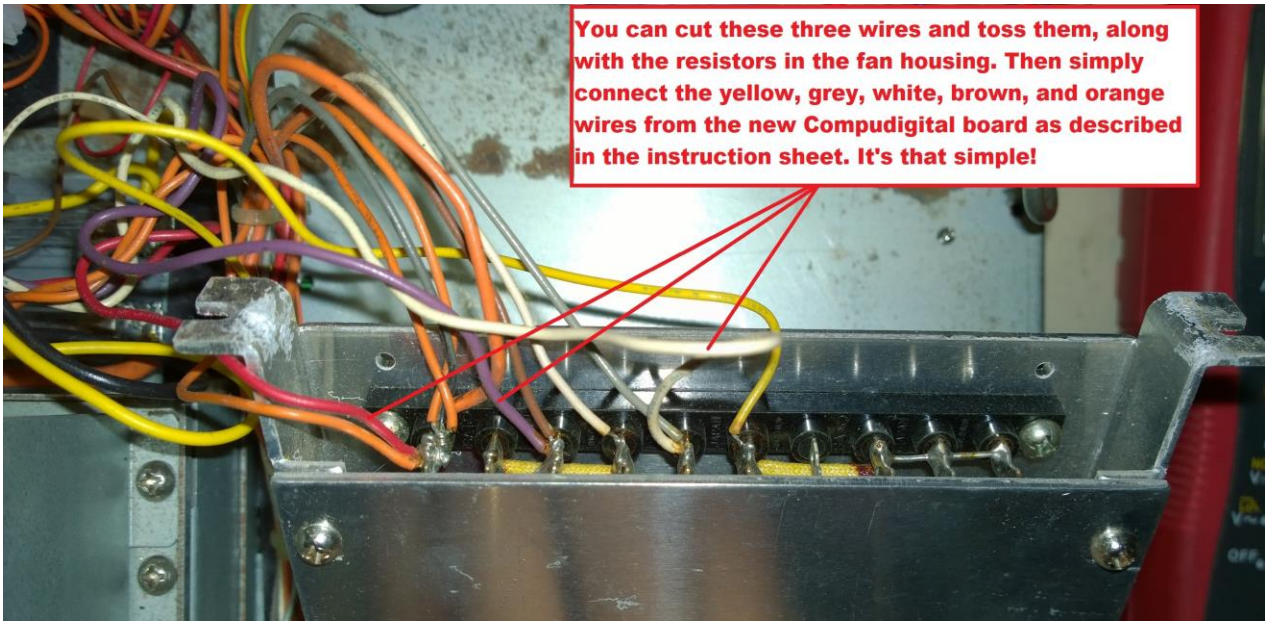


If you feel the need to secure the other side of that bracket, you could make a support by mounting an angle bracket that reaches over to that long tab to the side of the autotuner housing using super-strong double-sided foam tape. My board holds securely enough with just one screw so I probably won't bother

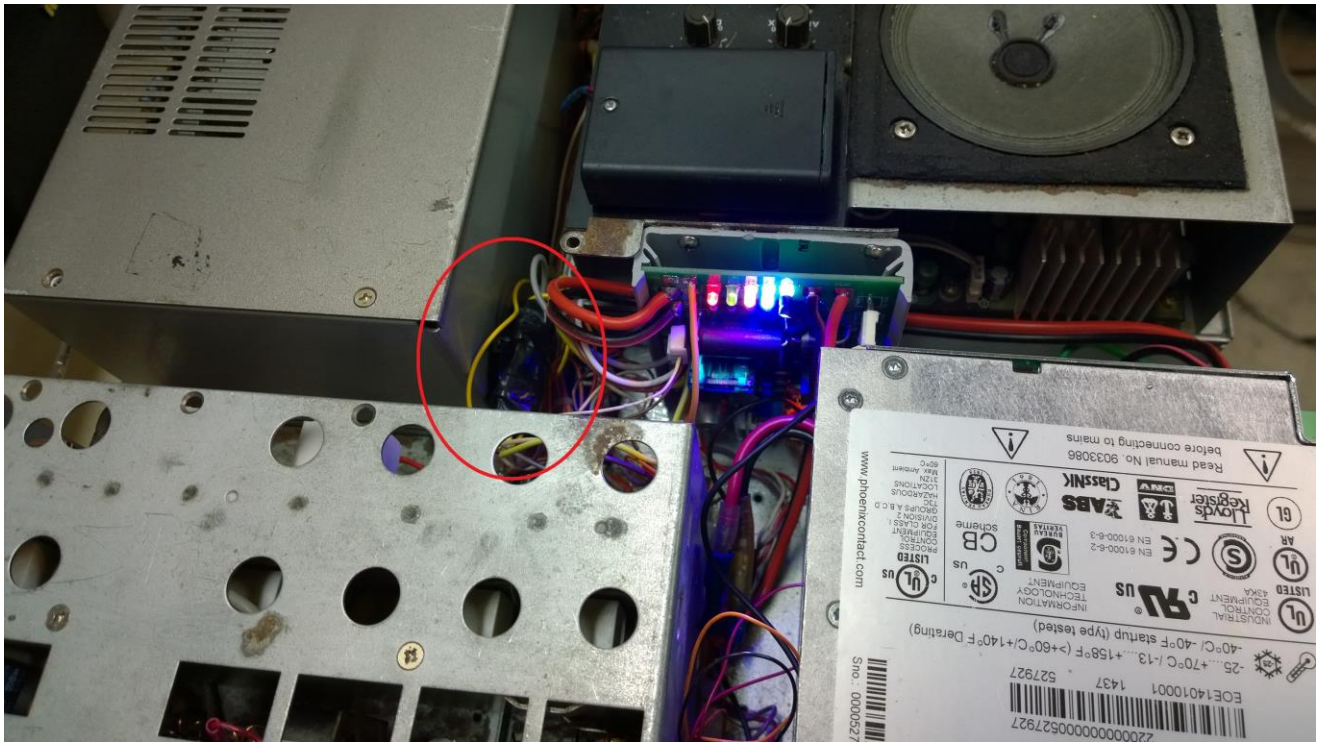
The picture on the next page shows where I trimmed the TYCO board. I also had to trim some material from the inner slide on the TYCO board because it hit a few of the solder joints on the new AVR board (red circles)



Once you've mounted your AVR board to your liking, the rest is easy. For evaluation purposes, I used the kit exactly as supplied by Compudigital, including the large push connectors. Since some of the low voltage wires in the Kenwood are very fine, I tinned them before I crimped them. When I relocate the board to my everyday 930S, I plan to use either direct soldering, or smaller, soldered butt connectors.



After I made my crimps and tested the radio, I wrapped the connectors with electrical tape and tucked them alongside the autotuner. If you use smaller butt splices or direct-connect, you won't have such a large bundle. Some butt splices have heat-shrink tubing and built-in solder that melts when you shrink the tubing. I may give them a try.



With the cover reinstalled, you'll notice a soft blue glow from the vents. I think it's cool, but since there will no longer be heat coming from that vent, you could simply cover the vent from underneath. The blueish tint around the display is there even with the rig turned off. It's not caused by the new AVR board.

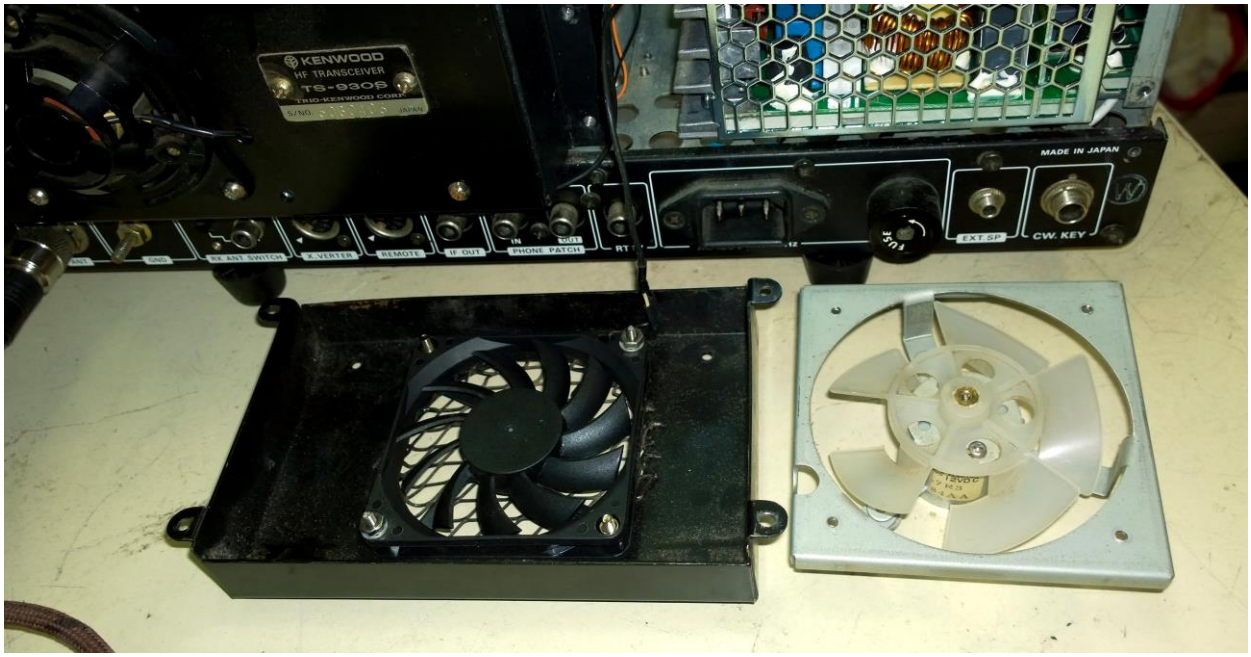
So far, my test bed radio has been cruising along without a hitch for over a month and it really does run cool to the touch. I can even keep my QST magazines on top of it! And most importantly, it's just as quiet as it was before the conversion (See Appendix).

APPENDIX

Using different fans with your TS-930S

Sooner or later one or both of your OEM fans will fail. From my experience, it's usually the bearing behind the blade, allowing the blade to hit somewhere. The Kenwood fan is a very efficient design that distributes air over a wider area than most, but it also produces a lot of lateral stress. The trick is to find a model that is the correct size, and electrically equal to the original so that if you use them together, they will run at about the same speed and noise level. I bought five or six different brands from Amazon until I found one that I liked. It's the Evercool model EC701HH12CA.

This is a 70mm x 70mm x 10mm slim ball-bearing fan. It's a three-wire design but you can just re-pin your 2-pin connector to use the red and black leads or keep your Kenwood pigtail and wire it to the red and black leads at the fan. If you use this fan, it will be completely contained within the OEM fan housing, and you can put the Quint right up against the housing. Your Quint and the radio will run STONE cold.

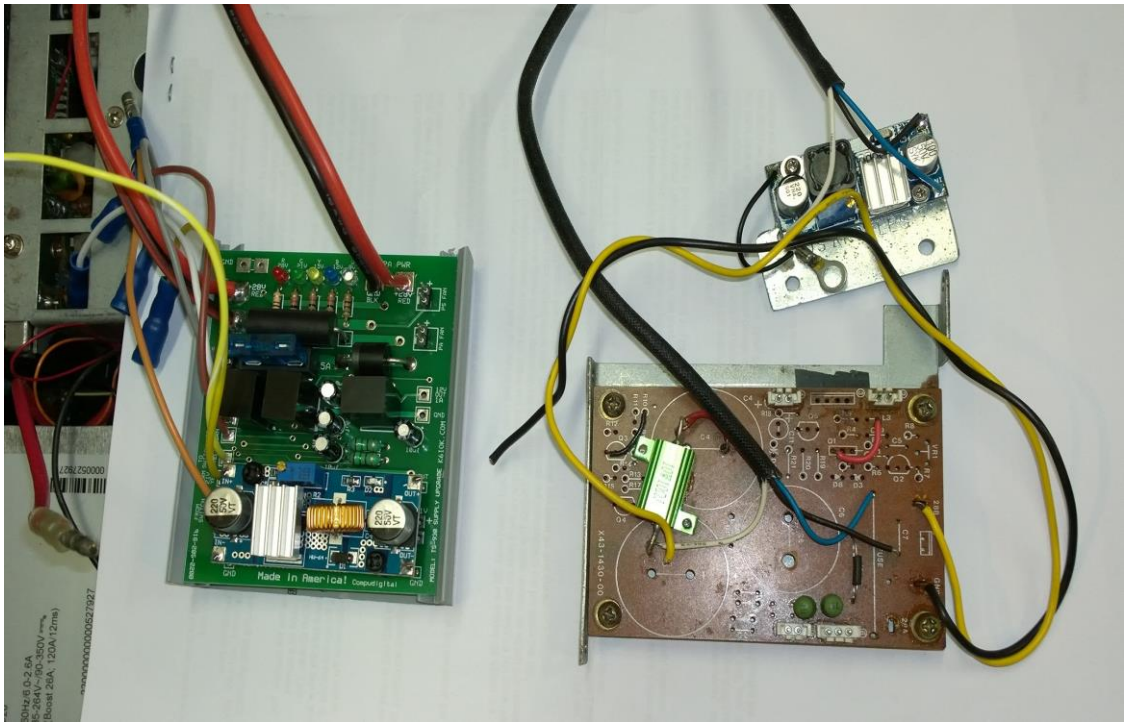


I show the Kenwood fan next to the Evercool to show the difference in the blade designs.

And THIS is how close you can mount your Quint. Super cooling for your new power supply!

Size Comparison between the Original AVR Board and the Compudigital Board

This pic shows how compact the Compudigital board is. The buck converter on my setup was mounted to one of the holes in the big Quint's heat sink. The 0.05 ohm sense resistor is separate with my setup and it's mounted to the chassis. It's included on Jeff's board.



A word about power switching

Kenwood used an unusual switching scheme in the TS-930S. Apparently concerned about back EMF from the transformer power supply, they used a switch with separate contacts to simultaneously switch the neutral side of the AC line, and the 28-volt DC output from the AVR board. The AC lines are grey, and the DC lines are orange and yellow. Once you convert your radio over to a modern power supply like the Quint, you can simply eliminate the DC switch circuit. Some HAMs then bridge the two sets of contacts on top of the front switch to improve the current-carrying capability of the front switch.

Eliminating the DC switching system has pros and cons. By directly connecting the DC output, you remove a potential failure point and a possible AC hum source. The con side is that the DC voltage from the large 20/26-amp doesn't drop to zero instantly under the modest load imposed by the 930S signal processing boards. As a result, when you turn off your rig after the conversion, you will notice a slight delay before the audio ceases and the radio goes dark.

I've timed it, and it's less that a second – about 0.9 seconds, according to a digital stopwatch. But some OPS might find that annoying. That phenomenon doesn't happen with the smaller 10/15-amp Quint.

Noise

There's a lot of discussion in the forums regarding noise generated by switching power supplies. Some have stated that they would rather rebuild their old factory power supply rather than use a "switcher". Dave Phillips and I have studied this issue at great length. While Dave's lab is equipped with far more sophisticated equipment than mine, I can attest that the Quint is extremely quiet. These supplies are used in traffic signal cabinets and other locations where clean DC is a must. The photo below shows the AC component of the 20/26-amp Quint at the DC terminals with the output voltage set to 28.5V. Note that the RMS ripple is less than 22mV. The peak is 48mV. I don't have a 930S in my shack with the original power supply, but Dave plans to conduct comparative noise tests if one comes his way. That may take some time since most TS-930S rigs that come to him for repair have blown power supplies.