

Is Your DC Power System Up to Snuff?

Jim Edmondson, AE5JE

I made some interesting discoveries while investigating low power output on one of my HF radios. While I knew that some of these issues could be important, I did not realize the magnitude of the problem. My Kenwood TS-890S exhibited low power output on several bands. This was most noticeable on 15M and especially 6M when measuring forward power using an accurate external power meter. When set to 100W, I measured 80 - 90 W on 15M and only 60 - 70 W on 6M. The other bands were >90W. Some power loss due to reflected power was expected since my antennas are not 1:1 SWR and I was not using a tuner. Since I bought this radio used, I downloaded a service manual and looked into possible reasons for the low power.

After some input on the TS-890S groups.io forum, I took a more detailed look at my DC power system. I use an MFJ-4035MV linear power supply to power my rigs and station accessories. I set the power supply to deliver 13.8V. The MFJ and a LiFePO4 battery connect to a automatic switch (more on that later) via 10-ga zip cord. The "switch" trickle charges the battery and switches to battery power if utility power is lost. From there a 10-ga zip cord powers a fused distribution block. All DC connections are via Anderson-type power poles.

Most modern 100W HF rig spec sheets will state that the rig will output 100 +/- a few watts at 13.8V when set to full power. Also, the spec sheet will state that the rig can operate at 13.8 +/- 15% DCV. This is equivalent to a range of 11.73 — 15.87 DCV. It is important to realize that these voltages should be measured at the rig's DCV input terminals (or possibly at the final power amplifier). When I measured the voltage at the rig, I found it to be 11.25V at key down when the power supply was set to 13.8V. The voltage at the rig was almost 0.5V below spec and the drop in my distribution system was 2.55 V! I never anticipated this result as I was using large gauge wire and the manufacturer's power cable.

As shown in the table below, 10-ga (my zip cord) and 12-ga (manufacturer's power cable) are sufficient to carry full rig power ($\leq 20A$). The table below was excerpted from this [webpage](#) and shows amp capacity to cause various wire temperatures (ampacity). I excerpted gauges commonly used gauges in DC wiring systems. The temperature ranges are based on what the insulation types (PVC or PE) can withstand due to ohmic heating in the cable. These conditions are for wires in open air, not crowded into a chase or conduit. Using an [online calculator](#), I determined that the voltage drop in 10' of 10- or 12-gauge the wire would be 3 — 5% or 0.4 — 0.7V. My first order of business was to get rid of the lengthy manufacturer's cable and its unnecessary fuses / fuse holders, which could cause additional voltage drop at the contacts. I made up a new 5' x 10-ga cable to go from the distribution block to the rig to replace the ~10' x 12-ga manufacturer's cable with in-line fuses.

AWG Wire Gauge Ampacity Chart				
AWG	Diameter (mm)	Copper Ampacity (60°C)	Copper Ampacity (75°C)	Copper Ampacity (90°C)
8	3.264	40	50	55
10	2.588	30	35	40
12	2.053	20	25	30
14	1.628	15	20	25
16	1.291	10	13	18
18	1.024	7	10	13
20	0.812	5	7	9

While the voltage drop in the wire was much larger than I expected, the automatic power switch dropped over 0.6V under key down conditions (~20A). This is despite the fact that spec is 0.3V drop at 40A. Even worse, the distribution / fuse block dropped ~1V. I value the ability to seamlessly change to battery power if the utility power goes down. Also, this reduces the stresses on the equipment due to power flipping off and on as often happens with power interruptions.

Besides the large out-of-spec voltage drop of the switch, I did not like that the switch only trickle-charged the battery. After a power event, I would have to manually charge the battery to keep it ready. While the voltage drop of the distribution box was huge, the easy fuse replacement, blown fuse indicators and compact wiring setup make it very convenient.

For the above reasons, I replaced the switch with an Epic PwrGate from West Mountain Radio. This unit has a spec voltage drop of only 0.05V at 40A. It is also a full multi-stage battery charger for lead acid, gel and LiFePO4 batteries. The max current for first-stage charging current and many other parameters can be set by the user. It also has an input for solar panel battery charging in the event of a prolonged power outage. Finally, the Epic PwrGate has a USB connection through which you can use a "terminal" program on your PC, to monitor the power supply and battery voltages, charging current, etc. in real time.

Even with the improved automatic switch and reduced wire lengths, the power at the rig was about 12V or slightly above the minimum spec voltage for the rig. I was not willing to live without the switch and the convenience of the distribution block. I do need to better understand why the block voltage is so large. Perhaps cleaning the contacts with Deoxit would help or maybe the internal connections use small gauge wire – work for another day.

In order to boost voltage at the rig, I increased the power supply output from 13.8V to 14.5V. This provides about 12.8V at the rig during key down, comfortably above the 11.73V minimum rig voltage spec. At the same time, the power supply voltage is well below the maximum voltage spec for ham radio equipment of 15.87V (13.8V + 15%). This means that when the rig is not key down, even full power supply voltage is safe for low current drawing accessories. Additionally, West Mountain Radio recommends boosting the power supply voltage to assure full battery charging. All in all, these improvements and adjustments worked out to be a good solution.