RFI Test Report – Tripp-Lite UPS

Manufacturer: Tripp-Lite **Model: SU1000RTXL2UA**
Tested by: Gary Johnson, NA6O **Date: Nov 25, 2020**

Manufacturer's web link:
https://www.tripplite.com/smartonline-120v-1kva-800w-double-conversion-ups-2u-rack-tower-extended-run-snmpwebcard-option-usb-db9-serial~SU1000RTXL2UA

Description: Rackmount UPS, 120 VAC, 1.0 kVA, 800 W, double-conversion (on-line inverter), external batteries supported, networkable.
Purchased from: Amazon, $575
Optional equipment:
External battery, rackmount, BP24V36-2US, $597
Network card, TLNETCARD, $338

Compliance Summary
Recommend for amateur radio stations: Conditional. Extensive filtering and choking required
FCC Part 15 conducted emissions: Specified as Class A (I did not perform testing)
FCC Part 15 labeling: Compliant

System Installation Description
I have two installations utilizing this UPS at my remote HF site, W6SRR. The first system consists of the UPS plus one of the manufacturer's external battery expansion units. It is located in the 20-foot Conex shipping container that serves as our station. The second system belongs to the property owner and consists of the same UPS plus an ad-hoc set of four 6 V, 400 AH AGM batteries in series. It is located just next to our container inside a wooden building. Antennas are right next to our container on a 30-foot tower with 14 feet of projecting mast. The consist is: JK

Navassa 5, Optibeam 40/30m dipole, and half-slopers for 80 and 160m. Very close proximity of the antennas is a worst-case scenario for RFI susceptibility.

RFI on the First System
The first system was installed in our container. Ferrite common-mode chokes were preemptively installed:

- Input cord, 12 turns on 4-inch type 31 toroid.
- Output (load) cords(2 ea): 8-10 turns on 2.4-inch type 31 toroids.
- Ethernet cable: 14 turns 2.4-inch type 31 toroid.

At power-on, broadband RFI was immediately detected on all HF bands, increasing the noise floor by 6-10 dB, and was was especially noticeable on the high bands. Audible signature was 120 Hz buzz. Using a sniffer probe and shortwave radio, the source was pinpointed as being the input line cord. Clearly a single choke was insufficient. An outlet box was assembled, containing a Delta 20DKBG5 EMI filter, and an additional choke on the cord feeding that, 10 turns on a 2.4-inch type 31 toroid. This was sufficient to reduce the noise on all bands back to our baseline.

Experimentally, I proved that common-mode chokes alone are insufficient to cure RFI on the AC line input. Apparently there is a high level of normal-mode noise that needs to be removed, thus the use of a commercial EMI filter proved effective in this case.

We did not test the system with the external battery pack unplugged. The jumper cable to that pack is quite short (about 14 inches) and is made from a tight pair of #6 AWG wires with 75 A PowerPole connectors. Additional battery units can be daisy-chained, and that is the main reason we chose this UPS system in the first place.

RFI on the Second System
The second system was installed with its 500-pound (!) external battery set (4 ea Full River DC400-6). This configuration is not something that the manufacturer supports but the owner decided that the large capacity was needed. Comprehensive RFI filtering was preemptively installed, based on experience with the first system:

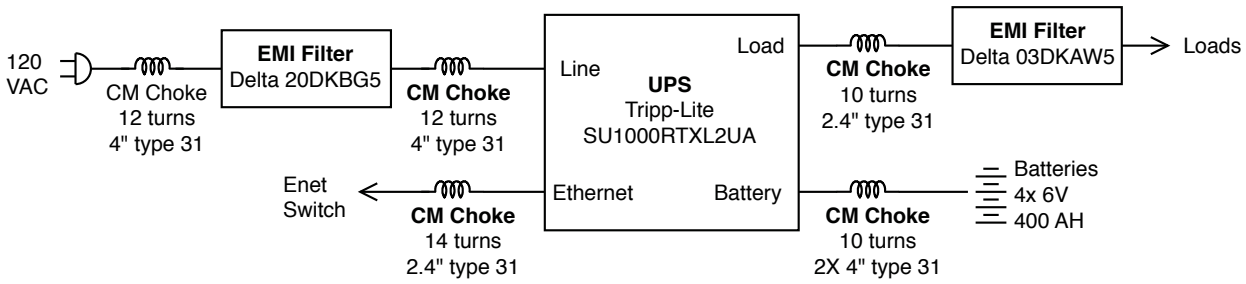
- Input cord, 12 turns on 4-inch type 31 toroid, followed by a custom outlet box containing a Delta 20DKBG5 EMI filter, followed by a final choke similar to the first.
- Output (load) cords: 8-10 turns on 2.4-inch type 31 toroids plus a custom outlet assembly containing a Delta 03DKAW5 EMI filter.
- Ethernet cable: 14 turns on a 2.4-inch type 31 toroid.

At power-on, severe RFI was noted particularly on 80 and 160m, consisting of broadband 120 Hz buzz plus powerful noise carriers every 40 kHz, typical of heavy-duty switching supplies. Noise was S9+5 dB everywhere, and S9+15 on the noise carriers. Broadband buzz was also apparent on higher bands. Clearly this is unacceptable!

Testing proved that the external battery cabling was the source of the radiated noise. Unplugging the battery pack returned everything to the normal baseline noise level. A massive choke was fabricated, consisting of two 4-inch type 31 toroids with 10 turns of #6 AWG paired cable and 75 A PowerPoles. This was plugged into the back of the UPS (very short exposed wire length), then

the batteries were plugged into the choke. Also, excess cable to the batteries was twisted as tightly as possible. This eliminated the severe RFI.

Basic measurements of common-mode current noise were performed with a portable spectrum analyzer and current probe. Installing the large choke reduced the current by at least 25 dB at 3.5 MHz.



One-line diagram of RFI mitigation on the second UPS installation.

Conclusion

After extensive online research, I determined that UPS systems that support external batteries are at best certified as FCC Part 15 Class A (commercial), and never the quieter Class B (residential). This is probably because of the high ripple current in external cabling which the manufacturer has difficulty filtering. Any time such a system is installed near amateur radio antennas, expect an RFI problem. In contrast, small single-box UPS system, such as the 1 kVA units from CyberPower, are in my experience RFI quiet and are unlikely to cause problems. But their runtime is limited.

This fairly expensive Tripp-Lite UPS system required extensive filtering on **all** cables to make it tolerable. The manufacturer's battery packs are well-made, with steel enclosures and short cables. My opinion is that this works reasonably well from an RFI standpoint. If needed, it's possible to fabricate a large, expensive choke similar to what we did for the ad-hoc battery system.

Our site remains fairly noisy due to the presence of numerous commercial VHF, UHF, and microwave links plus residual RFI from the UPS systems and other nearby devices. A lot of money and effort has been expended on filtering and optimal installation wherever possible and yet the noise floor increases with the addition of each new item.

Ferrite Toroids Used

Toroid, 2.4" OD, type 31, Fair-Rite 2631803802
Toroid, 4.0" OD, type 31, Fair-Rite 2631814002

W6TCP holding the high-current battery choke.

The second UPS installation, with all filtering devices visible.