RFI Management for Field Day

Modern electrical power equipment and many electronic devices and lights generate significant HF interference noise if not carefully managed. This can be a major problem for Field Day. I found that the 1 KW generator/inverter that we use for Field Day for powering the CW station can cause significant noise in the receiver. On 80 and 40 meters, the noise interference could be as high as S9+10 dB with the background noise from an inverted vee antenna at perhaps S7 or so (preamp set ON and receiver sensitivity at max). This seemed to be an important issue to also address as well as inter-station interference issues.

There are many references and sources for RFI/EMI problems. A good source is this slide deck by VE1FA: http://www.halifax-arc.org/pdf/RFI-Lect-2016.pdf. He addresses these problems:

- Grounding
- TX and RX issues & TVI
- Power equipment and AC power line issues
- Modern digital equipment issues
- AC power filter design issues
- Common mode and differential mode issues

Another good source on this problem that specifically targets hams and HF relevant issues is work by Jim Brown, K9YC. His website provides a large number or resources at www.K9YC.com. He has a large slide deck on these issues here: http://www.k9yc.com/GroundingAndAudio.pdf and here: https://www.nccc.cc/pdf/Sep-K9YC-RFI2013.pdf, and a detailed paper here: http://k9yc.com/RFI-Ham.pdf. Some of the key issues and problems he addresses are:

- Bonding and grounding
- Ground myths
- Common mode conduction problems
- Differential conduction problems
- Radiation problems
- Shielding
- Placement of filter issues

The ARRL has a number of relevant publications including “Grounding and Bonding”; “Elimination of Electrical Noise 2nd Edition”; “The ARRL RFI Book 3rd Edition”; and “RFI Pocket Guide”. Some of these also reference K9YC and others.

I found that the problems with my generator/inverter appeared to be dominated by radiation problems and differential conduction problems. Also, placement of filters was important and the correct or important ground issues were often counter-intuitive. Interference can come in a number of forms, and the solution or solutions will be different depending on the type of noise and the configuration of the equipment.

With the generator placed only 75 feet of so from the 80 and 40 meter antennas, I found that attempts to filter the AC power lines from the generator/inverter to the HF rig only made modest changes to the level of interference noise, but when the generator was placed about 200 feet from the 80 and 40 meter antennas, then filtering of the AC power lines was much more effective and it was possible to almost completely eliminate the noise. This indicates that it is likely that radiation coupling from the generator/inverter and/or near field coupling is significant when generator/inverter is fairly close to the antennas, and that I had a combination of radiated and conducted interference noise.

A simple earth ground or improved grounding may address an RFI problem, and it is a good first practice for a generator since it is needed for safety. The ARA has found that a good earth ground at the primary generator is important to reduce RFI. If there is radiation from a piece of equipment or possibly common mode conducted interference, a good ground may mitigate that radiation, but depending on the configuration of the equipment, it may not mitigate the radiation. Also, grounding the chassis or ground system of a piece of equipment will probably not address conducted differential interference. If grounding does not address an RFI problem, then common mode chokes and differential filters may be effective, and physical distance can mitigate radiation directly from the equipment. The ARRL, K9YC and others emphasize proper bonding the grounds of equipment to minimize RFI, but they also clarify that ground bonding connections must be less than about ¼ wavelength to be effective. In the case of Field Day, generators and different operating positions are usually separated by distances that are large compared to a ¼ wavelength, even on 80 and 40 meters. In that case, it is important to prevent noise radiation at the source, and to stop conducted common and differential modes noise near the source with proper filters.

An earth ground at my generator/inverter was found to be unhelpful to reduce the generator/inverter noise, consistent with Jim Brown's comments. An earth ground is still important for safety at a generator, but it was ineffective to reduce HF noise for my generator/inverter. A ground improperly introduced can even increase noise, possibly significantly. This is typically due to ground loops or radiation on a ground connection that in non-zero in length compared to a wavelength. I found that with an AC power filter for differential mode noise located near the HF rig that providing a separate ground to the AC power filter dramatically increased noise which may be counter intuitive. But of course this can introduce a ground loop even if the ground wires are short compared to ¼ wavelength.

This power strip was modified by adding an RFI filter for differential mode noise. Inductors of 15 uH intended for RFI hash suppression and rated at 20 Amps were added between the 1st and the following outlets inline on the “hot” and “neutral” wires. After the inductors, two 0.1 uF capacitors rated at 600 volts were added coupling from “hot” and “neutral” to ground. This arrangement provided about 40 dB suppression of differential mode noise signals in the 3 to 30 MHz range. It should be noted that this arrangement appears as 2 single-ended filters with a common ground wire (green) although the noise addressed is commonly referred to as “differential” mode since the current flows in equal but opposite directions on a signal wire and in this case a ground wire.

VE1FA emphasizes that a good RFI filter will include both common mode and differential mode filters. K9YC emphasizes that common mode RFI filters are often not included in EMI/RFI filters and that common mode RFI can often be a problem. Furthermore, power strips often include surge protectors and electrical impulse protection, but they usually provide little to no EMI/RFI protection. A few power strips do include EMI/RFI filters such as the Tripp Lite Isobar Ultra series.

This picture shows the 1 KW generator/inverter followed by an RF common mode choke with 9 turns of the power cable on two 2.4 inch toroids, and this was followed by an RFI filter for differential mode in the power strip. I found that an earth ground did not appear to have any effect on the noise on 80 and 40 meters in my situation. I also found that in my case, the common mode choke appeared to have little effect on the noise, although it may in some cases. But the filter for differential mode caused the noise to completely disappear on 40 meters and higher frequencies, and it was almost eliminated on 80 meters once the generator was placed about 200 feet from my antennas and operating position. On some frequencies a slight buzz could be discerned, but it did not move the S meter relative to the background noise. Notice that the noise was eliminated without using any earth ground at the generator/inverter, although using a ground is needed for safety and does not damage the elimination of the noise by other means for this case. In other situations a ground or other means may mitigate RFI.

Jim Brown recommends placing common mode chokes and differential filters as close to the generator as possible. This keeps the noise off of the power lines to the equipment and prevents the lines from radiating the noise and coupling into the antennas by radiation. If there is significant residual noise still on the power lines due to stray capacitive coupling past the filters, for example, then locating a second set of filters at the rig or equipment can be effective to reduce residual noise.

Placing noisy generators or other power sources with noisy components as far as is practical from the operating points is important for mitigating electrical noise as well as acoustical noise, and a good ground at the generator is important for safety and is good practice for RFI mitigation. Filters for common mode and differential mode noise are also important to eliminate noise from conducting to the operating equipment over the power cables, and may be needed if there is significant conducted noise, and by placing the filters as close as possible to the power source, radiation from the power cables can also be eliminated.