Newcomers and Elmers Net: RFI -- Robert AK3Q 6-7-15

Radio Frequency Interference (RFI) is becoming a bigger and bigger problem, partly due to our hi-tech society
-- how many things now run on wall warts/power cubes? Even larger appliances have switching power supplies which can be a source of noise
-- try listening to AM radio stations during the day; even higher frequencies are affected more and more
-- there are days when I have an s5-7 noise level on 20 meters because of RFI

Sources
RFI can be a real nuisance, and sometimes the source is quite unexpected.
-- almost any electrical device can cause interference; the question is the same for any device—can it be shielded or can the noise be effectively minimized
-- modern convenience items are the worst offenders; plasma TVs; light switch dimmers; wall warts of almost any type; power supplies
-- cell phones, routers, wireless devices of all kinds
--computers, monitors, cordless and corded mice and keyboards; inexpensive electrical devices of almost any kind can be troublesome
-- vacuum cleaners, alarm systems, remote control cameras, and almost any small appliance
-- large appliances are common culprits as well, as are the furnace/ac unit; modern water heaters, heat pumps, refrigerators, and the list goes on
-- When the interference is something like a neighbor's plasma TV you may not be able to do much about it.
-- Fortunately interference is something which often can be fixed over time or with some experimentation, even if it means sacrificing a bit of convenience, such as shutting down your computer or TV system while you enjoy the radio hobby.

Identifying Sources
A pocket AM radio with a fresh set of batteries can reveal a lot of noise sources large and small both outside in the neighborhood and around the house as you walk around
-- The actual sources in the house may come as something of a surprise, especially from devices which appear to be turned off!

-- Wall warts are particularly susceptible to producing hash, and of course we have more of these than ever to charge or power our electronic gadgets.
-- the source of noise may be external, especially when living in highly populated areas.
-- Apartment dwellers have had to put up with noisy neighbors since the beginning of time, but radio enthusiasts are very likely to have (or cause!) interference for which there may be little recourse.
-- Noise introduced within the building's wiring can be quite difficult to overcome, but so too the neighbor's plasma TV which stays on from 6 pm until 2 am!
-- Finding the source of interference into a radio is half of the battle, but once found, may be fairly simple to overcome.
-- Using the AM radio method mentioned above, try to locate sources of noise in your immediate surroundings.
-- If the noise is coming from wall warts unplug them or look at replacing them with units with better shielding.
-- Just make sure you are replacing like-for-like—pay close attention to output ratings as small devices are easy to overload.
-- Try turning off circuit beakers in the house either one by one or all at once and then turn them back on one at a time to find the offending circuits.
-- If you have an alternate power source to run your radio see what happens when everything is turned off—the results may surprise you!
-- As you turn circuits back on you should be able to isolate the problem sources, and from there determine how best to deal with them.
-- Replace dimmer controls with standard light switches, or if you just must have a dimmer control, see if there are better units available or if shielding is possible.
-- Small appliances may need to be unplugged if they produce noise, and the same goes for larger electrical appliances.
-- Sometimes moving plugs to a different outlet can eliminate a noise problem, such as separating the computer or TV from the same wiring that feeds your radio room.
-- Power strips can be offenders as well, especially when switching power supplies or wall warts are plugged in to them.
-- Some cable boxes, DVD players, and TVs may have power-down modes which leave some circuitry on even when "power" is off. This is usually to keep timers going or displays working to show the status of the device.
-- If you find noise is still present when everything is turned off in the normal manner, try unplugging devices from the wall one by one to find the offender.

Ferrite Beads and Toroid Cores

Ferrite is a substance which can really help reduce or eliminate RFI along power cords, speaker wires, mouse cables and video inputs.
-- By placing one or more ferrite beads around a cable, often the offending interference can be stopped.
-- (This is useful if you find your computer speakers are making horrendous noises as you transmit on your HF rig. You may need to put beads on the speaker wires and the power cable, or you may need several)
-- Some ferrite beads come in a housing which allows them to be separated and then fitted over a cord and snapped in place.
-- Ferrite cores are designed so that wires may be wrapped around them multiple times, with each turn acting like an additional bead.

If beads and toroid cores are not enough, another device which may be worth a look is an AC line RFI filter.
-- There are various styles to handle noise and transients and surges for individual lines as well whole-house filters.
-- There are also units designed to work as power strips for computers, stereo and TV equipment. (While these can work well for line noise in many cases, they will not do anything for interference caused by a plasma TV. The source of the noise is the plasma technology itself, not the electronics.)
-- Keep in mind sometimes the biggest noise offender can be the power supply you are using for your radio!
-- While linear power supplies are usually very quiet, switching power supplies can generate a lot of noise. Their lighter weight and smaller footprint sometimes come with a price.
-- Of course not all switching power supplies produce interference—just do not assume your radio power is clean; check it for noise like any other piece of electrical equipment in the house.

Sometimes noise/interference can be minimized by moving your equipment to another room or even just another outlet.
-- Some interference is generated within the power lines, but some is radiated and picked up by sensitive radio gear or along antenna lines.
-- Move the rig as far away from the source of noise as possible, and do the same with your antenna system if possible.
-- Ferrite beads or cores can also help isolate RF or other electrical noise coming in from the antenna, and do not neglect checking your radio/antenna system for loose connections or frayed wires.

Watch Over Your Station!

Although every amateur operator has a vested interest in identifying, controlling, and eliminating man-made sources of noise, we should all remember that noise is a reciprocal issue.
-- using the lowest power we can to get out signals heard is a good start
-- having well-made equipment, testing it, and fixing problems right away is the responsible thing to do
-- We should also go to great lengths to ensure that our stations and test benches are not noise sources relative to any other devices able to pick up RF energy.
-- The less we tolerate noise and interference that might emerge from our own equipment, the more justified we are in insisting that other interests do likewise.

In the end, however, some folks are condemned to live in areas where noise is beyond control; this is where operating skill comes in
-- antenna choice, feed system choice, filtration, noise cancellers, noise blankers, and operator skills can go a long way toward reducing currently unlivable noise to a mere constant irritation

IV. Is It Really Power-Line Noise Or Something Else? (By Terry Rybak, automotive EMC engineer)

A good first step is to eliminate some obvious sources. Although not usually necessary, you can quickly determine if the problem is being generated within the affected device by a simple test. Have the customer remove the antenna connection to the radio in order to see whether the noise goes away. If no change or little change in the noise results, the problem with the receiver or its power supply, or the RFI source may is located near the receiver or connected to the same AC circuit. Typically this is not the case however. I mention it only for situations where you suspect a problem with the customer's radio or television.

Assuming you don't feel this test is necessary, or observe a significant noise drop while performing it, proceed to verify the source is not in the customer's house. The proliferation of electronic devices and electrical appliances can often result in a plethora of confusing and hard to identify sources. Many of these sources are actually the cause of harmful interference. Follow the steps below to determine if the source is in the home:

All steps should be performed while interference is active!

- Go to the main breaker panel or fuse box in the home. Verify the presence of the noise with the battery-powered radio. (Be sure to have your flashlight ready in case the lights go out.)

- If the noise is present and is the same as the interference, shut off all power to the premises by turning off the MAIN circuit breaker or pulling the MAIN fuses. An alternate method is to place the radio next to the meter and, if the noise is present, pull the meter. If the noise on the AM radio stops while the power is off, the source of the interference is within the residence. If the noise continues, you can assume it is coming from a point external to the customer's home.
- Restore the main circuit breaker or fuses or meter.
- If the noise stopped while the power was off, you can locate the circuit supplying the power to the noise source. While monitoring the battery powered AM radio as before, and with the noise present, turn off and on the individual circuit breakers one at a time until the noise stops. Leave off the breaker that stops the noise.
- You must now determine what is on the circuit by going from room to room, if necessary, checking outlets, appliances, and lights for the absence of electricity. The offending noise will be something on this circuit. Turn the breaker back on and wait for the noise to return.
- With the noise back on and using the AM radio to monitor it, return to the area of the noisy circuit and unplug everything on this circuit one at a time until the offending device is found.

Here are some household items commonly found to cause interference:

- Door Bell Transformers
- Electric Blankets
- Electric Blankets
- Heating Pads (of all kinds)
- Recessed Ceiling Light Fixtures
- Furnace Control Circuits
- Refrigerators (Becoming a frequent problem)
- TV Top & Stereo, Amplified Antennas
- Light Dimmers
- Aquarium Heaters
- Screw In Photocells
- Low Energy Compact (screw in) Florescent Lights
- Touch Control Lamps
- Clean Air Machines (table top and furnace type)

These devices, when causing harmful interference, are in violation of Federal Communications Commission rules and regulations and can be a nuisance to the customer and their neighbors. It is important to have the offending device repaired or replaced to ensure normal safe operation. Many sources of radio and television interference are also caused by arcing. The arcing will generate heat and may signal a fire hazard.

If the noise source is not in the customer's home, check with the closest neighbors. The place where the interference is the most intense may indicate the source of the disturbance. If one of the neighbors has a similar problem, ask him, or her, to run the breaker test to try to locate the faulty equipment. A household appliance or electrical device rarely causes interference that extends beyond a few houses on a secondary system.

Note that, if the source is not in the customer's home or a neighbor's home, the noise is originating from a source that is beyond the customer's control. Direction finding techniques may then be used isolate the noise to a particular residence or an area of the utility's power-line system. We'll be exploring some of these techniques in a later section.

How To ID Power-Line Noise

Many electrical devices, such as electrical motors, tools and appliances, can cause interference. The types of interference differ greatly from one electrical device to another. Interference caused by a computer, for example, is not the same as that produced by a household appliance.

Noise that varies with the time of day is related to what people are doing, usually pointing to some electrical device or appliance. Noise from consumer type devices, as opposed to power-line noise, will often come and go with periods of human activity. It will frequently correlate with evenings and weekends. Unless it is associated with climate control or HVAC system, an indoor RFI source less likely to be affected by weather than power-line noise. The importance of maintaining a good and accurate interference log cannot be overstated. Ask the customer to record date, time and weather conditions. Correlating the presence of the noise with periods of human activity and/or weather often provides very important clues when trying to identify power-line noise.

Often Weather Related

If the interference appears and varies in intensity depending on weather conditions (dry or damp weather, or wind), and if the breaker test excludes a source inside the home, the interference may be caused by faulty components associated with the electrical power-lines near the home. Wet weather may temporarily reduce or eliminate the noise by shorting out spark gaps on the power-line. Windy weather may cause the noise to vary or even stop for a while, as loose hardware is affected.

Is There A Smoking Gun?

While there may not be a smoking gun, power-line noise often reveals itself with some important clues. As previously discussed in Section 1, virtually all radio noise originating from utility company equipment is caused by a spark or arcing. The radio noise is only generated during the times when a breakdown and ionization of air occurs, and current flows between two conductors in a gap.

Once an ionized path is established in the gap, current flows at all parts of the cycle where the voltage is higher than the breakdown voltage of the gap. This typically occurs only near the positive and negative voltage peaks -- the times of highest instantaneous voltage. Sometimes, the gap may break down only on one polarity of the waveform.

Because power-lines carry 60 Hz ac, the voltage on them passes through two peaks each cycle (one positive and one negative) and pass through zero twice each cycle. This gives 120 peaks and 120 zero crossings in each second. Power-line noise follows this pattern, generally occurring in bursts at a rate of 120 (sometimes 60) bursts per second. This gives power-line noise a characteristic sound that is often described as a harsh and raspy hum or buzz. Because the peaks can occur twice per cycle, true power-line noise usually has a strong 120-Hz modulation.

Noise occurring in bursts at a rate of 120 bursts per second, and the resulting characteristic raspy buzz or frying sound, is often the first and most obvious clue of power-line interference. It is typically a broad banded type of noise starting at the low end of the radio spectrum. Power-line noise is usually stronger on lower frequencies. It occurs continuously across each band, up through the spectrum to some upper frequency where it will taper off.

A good test for the 120 Hz burst rate for both indoor and power-line noise sources involves an oscilloscope. The oscilloscope should show the bursts occurring every 1/120 seconds, or 8 1/3 ms. Look at the suspect noise from a radio's audio output using the AM mode. Use the wide filter settings and tune to a frequency without a station. Power-line noise bursts should repeat every 8.33 ms. If this is not the case, you probably don't have power-line noise. See Figure 3.

Alternately, you can perform a similar test if the noise pattern is visible on a TV set. The noise occurs in two horizontal groups or bands. Typically these two bands drift slowly upward on the screen. One group is a result of arcing during the positive half of the 60 Hz sine wave. The other group is a result from the negative half of the sine wave.

Note: The slow drift upward is caused by a slight difference in the power-line noise burst rate and the rate at which the TV images are transmitted. The TV images are transmitted at a rate of 59.94 Hz. This is because when television was first developed, a 60 Hz vertical scan frequency was selected so that any power-line noise would remain stationary on the screen, and be less annoying. When the color burst signal was added some years later, the scan frequency had to change to accommodate the color burst signal. Power-line noise occurs at 120 bursts per second. Since the power-line noise burst rate is almost twice the TV rate, two synchronized bands of noise appear on the screen. The slight difference in frequency causes these two bands to slowly drift upward on a TV screen.

It is usually best to perform this test at the lower VHF TV channels and with an antenna (as opposed to a cable hook-up). In addition, the positive and negative power-line noise burst may also have slightly different characteristics. This can cause each half of the cycle to have a slightly different pattern on the screen. As you turn the channel selector to higher frequency channels, the interference should diminish. If the interference can be observed on UHF channels, the source is probably relatively close by. See Figure 4.

What to Look For

As previously discussed in Section 1, corona typically does not cause radio noise. Radio noise is almost always caused by a spark or arc across an air gap. *(There are also many other non-arcing sources, such as lights.)* Any voltage across an air gap can cause radio noise -- even ground wires, neutral wires and wires not directly connected to a power-line.

Typical culprits include broken or loose hardware such as bolts on wood cross arm brackets, a broken lightning arrestor lead wire, inadequate hardware spacing such as a gap between a ground wire and a metal staple, metal tags left on hardware, or metal objects thrown on the power-line. Any metal parts that are not well insulated from, or well connected to, one another may form a spark gap.

A Common "Non-Source"

Note that transformers don't even receive honorable mention in the list of most common power-line noise culprits. Despite their reputation, only a very small percentage of transformers are actually found to be the cause of an RTVI complaint.

Why are they blamed so often for noise they do not actually cause? Let's take a closer look at a typical scenario for some insight:

A customer calls with an RTVI complaint. He'll typically say he has looked long and hard for the cause the problem. He'll also add that he found the source on a transformer pole and that he believes the cause is the transformer. When power company investigator comes to start his investigation, like the customer, he finds the highest level to be at that pole. He too may then conclude the problem is the transformer. The transformer is changed and the problem is gone. Problem solved!

You may now ask the obvious question, "If the transformer wasn't the source, why is the noise gone? The actual reason may be that the source was only loose hardware. The hardware was tightened when the transformer is replaced. Obviously, it is far more economical to only tighten the loose hardware and not change the transformer. There is also added hardware associated with the transformer pole. Remember, the pole will have a driven ground conductor, lightning arrestor, often a down guy and other hardware that can act as an antenna and radiate noise. This can cause a high level of noise that fools the investigator into believing he has found the source structure. He hasn't found the source of the noise, only a better antenna to radiate it.

ARRL Resource Page for RFI
http://www.arrl.org/radio-frequency-interference-rfi

Sounds of RFI
http://www.arrl.org/sounds-of-rfi