Lab Notes

Prepared by the ARRL Laboratory Staff

Troubleshooting Electrical Noise

Many devices can generate electrical noise. Much of this noise relates to the distribution of the ac power we take for granted in our homes. This month, ARRL Laboratory Supervisor Ed Hare, KA1CV, offers some pointers about locating power-line noise.

Q I would like to listen to weak signals on my HF station, but there is an S9 noise on almost all frequencies. The noise is pretty bad on 160 meters, but I can sometimes hear it on 10 meters, too. The sound is a raucous buzz that varies in intensity. Sometimes it has a higher, varying pitch that sounds much like my electric drill. How can I find the source of this noise?

A That sounds like *two* sources. They are probably devices that are connected to the ac-power lines. Each could be anything from a home electric appliance to power-line equipment or hardware.

Q That covers a lot of territory. Can you narrow the search a little?

A It's difficult to name a source from the sound alone, but there are some easy diagnostic rules you can apply. Buzzing sounds usually result from an electrical arc or spark. An arc intensifies at the positive and negative voltage peaks of the 60-Hz ac voltage waveform, at a 120-Hz frequency. Higher, variable-pitch sounds often come from variable-speed electric motors. The pitch varies with motor speed.

If the noise strength varies with the weather, the source is usually outdoors, exposed to the elements to one degree or another. So, if the problem goes away (or gets worse) during wet weather, think of the power lines first. If the noise varies with the time of day, it usually relates to activities of people.

Note the sound pattern of a noise. Drills, sewing machines, kitchen mixers, heating pads and other devices have characteristic operating patterns that you can hear. Think of home appliances, fluorescent light fixtures, neon signs or factory equipment that operates when a business opens, etc.

These are not iron-clad rules, but they form a good starting point. In some cases, electrical noise indicates a dangerous condition that needs correction, such as an arc inside a home appliance.

Q I should find it! Where do I begin?

A The source is most likely close to you; so let's begin at home. First, let's check your radio—just to be sure. Disconnect the antenna. If possible, use a battery to power the radio or test the radio at a distant location. If the noise goes away, the radio is fine. For portable radios without removable antennas, move the radio (at least a block, perhaps a mile). If the noise strength varies with location, the radio is okay.

Q Whew! The noise went away; I was worried that my radio was broken. What should I do next?

A Let's check your house. First, find a battery-operated AM-broadcast receiver. Tune the radio to a clear frequency and make sure that you can hear the noise on the radio. If so, go to your breaker panel or fuse box. (If you don't normally reset breakers or replace fuses, get a qualified person to help.) Listen to the radio as you switch each of the circuits off and then on. If the noise suddenly disappears as you switch a circuit off, the source is something on that circuit. Next, unplug devices on that circuit, one at a time. When the noise comes and goes with your action, you have located the noise source. The device may not be malfunctioning, but have it checked out by a qualified service person to be sure.

Q I found an old electric clock that seems to make noise sporadically. Is it worth fixing?

A Probably not. The noise indicates an intermittent electrical connection inside the clock, which may be unsafe. Only qualified service personnel should repair consumer equipment. For example, installing capacitors unsuited for use on ac lines could create a fire hazard. Professional repair would cost more than an inexpensive clock is worth—unless it has great sentimental value.

Q That eliminated the worst noise, but I still hear a number of other noises from time to time. Where else can I look?

A You may have two or more noisy devices in your house. You may also hear noise sources at your neighbors' houses. Pay attention to activity in your neighborhood. For example, does the noise appear when your neighbors are outside, perhaps using their electric bug "zapper"? Maybe you hear noise when another neighbor uses an old fluorescent light in the basement. If you see no suspects, try some direction finding (DFing) and investigation.

Q I don't know anything about DFing; don't I need special equipment?

A DFing is a specialty, but its application to electrical noise is fairly simple. You can begin DFing by walking around with a portable AM/SW/VHF AM receiver! (You need an AM receiver because most FM receivers reject electrical noise.) Fortunately, most portable VHF scanners and some ham H-Ts tune the aircraft bands, which use AM instead of FM.

You will need to do a bit of walking or driving. Some electrical noise can propagate for miles! When the power lines radiate noise, standing waves can form on the power-line "antenna." The resulting amplitude peaks and valleys may occur far from the source.

Fortunately, most electrical noise is broadband and usually stronger at lower frequencies. Although you may hear noise on an AM-broadcast receiver miles from the source, you usually won't hear it on VHF until the source is nearby. You can use this to advantage. See **Figure 1**.

You can use the AM broadcast band, or 160 or 80 meters, to locate the neighborhood of the noise. Because you can hear some of the noises on 10 meters, those sources must be nearby. Once you have located the general area, tune the radio higher in frequency. Find a frequency where the signal is weak, and start moving around. As long as the signal becomes stronger, you are approaching the source. Keep tuning to higher frequencies. When you can hear the signal on VHF, you are quite close to the source. To continue, use a directional antenna, or get the receiver very close to each house in the area. (An article describing a directional antenna and aircraft-band receiver appeared in September 1992 *QST*.) [1]

You can pinpoint a house with a VHF receiver by collapsing the receiver's whip antenna to a few inches and placing it near the power meter of each house—with the permission of the occupant, of course. (This may be marginally effective in apartment buildings, too, but not as reliable.) If you do locate a specific house, you will need to repeat the troubleshooting steps from your own home.

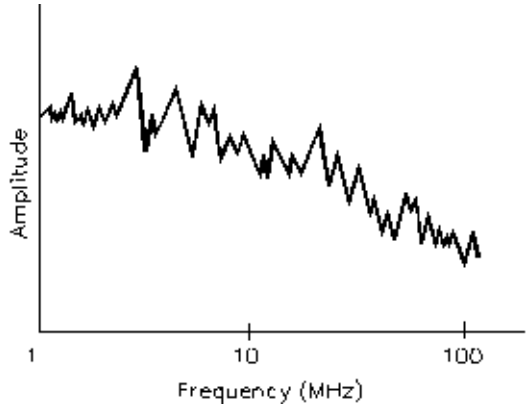

Figure 1—The amplitude of electrical noise varies as a function of frequency.

Q I found two sources—an aquarium heater and a food blender—in neighboring houses. The first neighbor is willing to buy a new heater. What kind should he buy?

A There are no lists of quiet appliances. Take your portable receiver to the pet store and listen to several operating heaters to determine which is least noisy. Most new appliances radiate less noise than those made many years ago.

Q Thanks. What can I do about the food blender? The service shop people say it works fine.

A An external ac-line filter may reduce the noise. The filter plugs into an ac outlet, and the appliance plugs into the filter. The *blender*

will still be noisy, but your location should be much quieter because the filter keeps the noise from being conducted onto the power-line, which can act as an antenna, radiating the noise.

An ac-line filter can also help prevent ac noise from *entering* an appliance via the ac line. It may make a stereo, or station receiver, perform better *if noise is being conducted on the ac line*.

Note that a *surge* filter is probably *not* an ac-line filter. Ac-line filters are often available at electrical supply houses and other retail outlets. Industrial Communications Engineers (ICE) is one manufacturer of commercial ac-line filters. [2] **Figure 2** shows an ac line filter.

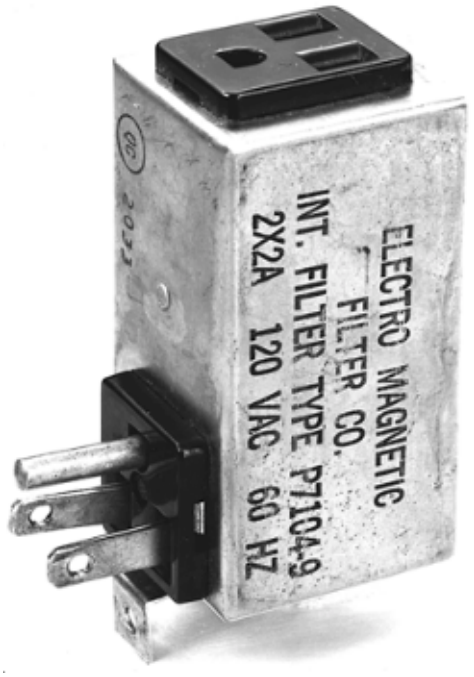

Figure 2—Commercial ac-line filters can reduce interference to or from an electrical appliance.

Q That's better! I hear no noise on 40 meters and higher frequencies, but 80 meters still has a moderately strong, steady buzzing that goes away on rainy days. Is that a bad power line? Should I contact the power company?

A The noise is affected by weather, so it's outdoors and probably something connected to the power lines. (If the noise only appeared at night, I would suspect a street lamp. Their starting circuits can become noisy as they cycle on and off trying to start a bad lamp. Many street lamps use gas-discharge bulbs, which can cause noise.)

Although most high utility power distribution systems generate some noise, FCC regulations prohibit them from interfering with communications. If power-company equipment is the noise source, the utility company must correct it. (They are *not* responsible for interference caused by their customers, however.) In theory, you could report the problem to the utility company and expect them to correct it. In practice, however, the experience with each utility varies quite a bit. Even those with the necessary personnel and equipment to diagnose the problem may have a long waiting list for corrections.

In most cases, it's best for you to locate the problem for them. A combination of the techniques we've discussed can often identify a specific pole. First, track the problem to a neighborhood using the AM-broadcast band, then switch to VHF to get close. Once you are close, you may be able to *hear* or *see* the arc! A careful inspection with a set of binoculars may prove productive.

Q I've narrowed the search to a city block. What can I do from here?

A Call the utility repair people and leave the solution to them. In many cases, defective or cracked pole hardware causes electrical noise. Hardware and live lines occasionally fall from poles during repairs or when someone strikes a pole. Leave this danger to those trained to deal with it!

The utility companies usually have sophisticated equipment and a trained RFI investigator who identifies the problem pole. With that done, the repair office dispatches a crew to make the repairs.

Q Okay, I won't touch the poles, but I'm curious. What kind of things can go wrong?

A Cracked or dirty insulators can permit arcing from a line to the pole. Wire ties that secure lines to insulators can come loose, resulting in a strong arc. Ground wires can fail with an intermittent open, or with small arcs where the wire fastens to the pole.

In most cases, the power companies recognize these problems and can correct them easily. Few people realize, however, that *any* loose hardware on a pole is suspect.

A crew may check out a pole and declare that everything looks good except for a loose bolt holding two cross braces together. These braces do not connect to the line, so the crew does not consider them a problem. Nonetheless, the strong electric field near the high-voltage wires induces current into all nearby conductors. When those conductors are firmly bonded or separated by insulation, all is well. Otherwise, a small spark can develop between the conductors and radiate a *lot* of RF energy. If the service folks tighten that loose bolt, the noise might stop.

Q I want to buy a house that is near high-voltage lines. Do you think I'll have noise problems?

A You might—or might not. Older lines are more prone to problems than newer lines Age causes deterioration and newer hardware is designed with electrical noise in mind. Lines that the utility has upgraded from lower-voltage duty also have more problems, as a rule.

It's best to take your portable receiver to the site on a clear, dry day and give a listen. Talk to the neighbors, too. Ask about their TV reception. Slowly rolling, intermittent black lines appearing on all TVs indicate power-line noise.

Q Is there more to learn?

A Oh, yeah! We have only touched on electrical noise—source location, a few simple cures and working with the power company. My favorite book on the sub-ject is the *Interference Handbook*, by William Nelson, WA6FQG. Nelson is a retired RFI troubleshooter for Southern California Edison Company with many years of experience. ARRL's *Radio Frequency Interference How to Find It and Fix It* covers a wide range of interference topics. Whole chapters explain power-line interference and how to work effectively with your neighbors. I also recommend *Transmitter Hunting: Radio Direction Finding Simplified*. See the *ARRL Publications Catalog* elsewhere in this issue for information about ordering these publications.

Thanks to Harry Thomas, KA1NH, and Jody Boucher, WA1ZBL, for their contributions to this article.

Notes

[1]W. Leavitt, W3AZ, "A Line-Noise 'Sniffer' that *Works,*" *QST,* Sep 1992, pp 52-55.

[2]Industrial Communications Engineers, PO Box 18495, Indianapolis, IN 46218-0495; tel 317-545-5412.