Inbound rfi

Tired of having your shortwave, CB and ham radios knocked out by incoming noise? Most hams and CBers are familiar with the dangers of radio-frequency interference to nearby stereos, television sets and music radios. But what about interference to your own SWL, CB or ham operations? What can you do about it? Here's the lowdown on rfi in reverse from an amateur radio operator who has fought the problem for years.

by Karl T. Thurber Jr., W8FX/4

How many times have you started to operate your ham transceiver, CB set or shortwave receiver, ready for fun and possibly even to snare some choice DX, when your enjoyment is short-lived because of man-made or atmospheric noise that jams the signals you expected to hear when you turned on your equipment?

It's happened to all of us at one time or another, and it's a frustrating experience. But there *are* some things you can do to minimize this kind of disruption.

Here's the complete story on the different kinds of interference you may be bothered with, how to identify and zero-in on different kinds of interference and some simple remedies you can try to give both your ears and your nerves a break.

Kinds of interference

There are literally hundreds of types of interference that can crimp your operating. Rfi sources can range from motor static, atmospheric noise, contact arcing, and loose power line hardware, to tv-set sweep generator buzz and errant harmonics.

Figure 1 shows a representative listing of the most common forms of interference you are likely to encounter. To effectively cope with rfi, you have to understand where and how it's generated and transmitted. Once you recognize the nature of the interference you're experiencing, you can try to find and eliminate the source. Let's take a look at some of the rfi sources listed in figure 1.

Switching and discharge rfi is caused by electric motors in household appliances; passing automobile ignition systems, fluorescent lights; contacts on telephone dials, thermostats and electric blankets; and faulty power-line equipment, to name some of the most common sources. This type of interference is characterized by its raspy, buzzy, or "clicky" sound.

Harmonic-type rfi can be caused by such culprits as strong local transmitters, various kinds of radiation from nearby fm, tv, and shortwave receivers; and even from corroded connections in house wiring and antenna systems (which can *rectify* and *re-radiate* harmonics, even though the original signals are themselves "clean").

One of the most common and persistent forms of harmonic rfi is known as "ITV," and is caused by your own and neighbors' tv-set *horizontal sweep oscillator*. It operates on a low 15,750 cycles, but can act as an efficient "jammer" as high as 15 or 20 MHz, sometimes higher.

Harmonic-type interference can be hard to recognize, since it often sounds like "ordinary" signals.

Other types of rfi you may encounter are cross-modulation or "beating together" of strong signals such as broadcast, fm or tv channels to produce unusual frequency combinations that can wreak havoc with your equipment. Fortunately, this type of rfi is fairly rare.

Another kind of rfi, of sorts, is simple *atmospheric noise* known by amateurs as "QRN", a shorthand "Q-code" abbreviation, which can override even the strongest signals during periods of intense thunderstorm activity. Although this isn't rfi, strictly speaking, we'll discuss how to minimize the effects of "QRN" later on.

Before you can do much about pinpointing and tracking down electrical interference, you need to be able to identify it. Switching-type rfi is usually easy to spot, as it normally follows the operating pattern of the equipment that generates it.

For example, household motors can be audibly correlated with the noise they produce in your receiver, telephone dialing clicks stand out clearly, fluorescent lights may emit a buzzing sound, and ignition noise is present only when a vehicle passes by.

Power line static is not so easy to detect, but it often gets worse in very dry or very wet weather and may change its pattern in periods of high winds.

Harmonic-type rfi can also be hard to spot, although you can try a little "stubby pencil" work, using a frequency allocation chart and a hand calculator, to check out the many possibilities.

Atmospheric noise, on the other hand, is easily distinguished by the way in which it "peaks and wanes" as electri-

cal storm activity approaches and passes by.

With a little effort, you can eliminate most kinds of interference—once you know the source. The first thing you should do is to determine whether the interference is entering your equipment through the power line or is coming in via your antenna. To do this, you need to disconnect the antenna from the receiver at its antenna terminals and short the terminals to ground.

You'll find with well-shielded receivers and transceivers that the noise *usually* enters via the antenna. However, if you find that it's coming in via the power cord, installing a "brute force" ac power line filter should do the trick.

The filter can either be built right inside the receiver's cabinet or be mounted in a small metal "mini-box" attached to the back panel of the set. For best results, the filter case and receiver cabinet should be grounded to the "third wire" of your home's electrical wiring system and also to a cold-water-pipe connection or ground-rod.

If you find that the noise is entering through the antenna, the most common situation, try all your antennas and, if you have a rotatable beam antenna, rotate it to try to determine from which direction the interference is coming.

To get a fix on the source, you can use several methods. Probably the easiest is to use a multi-band portable receiver that covers the frequency ranges you're interested in. A combination am/fm/sw receiver will usually sample enough of the rf spectrum for our purposes.

You can carry the receiver around with you to look for spots where the interference peaks for a sort of rfi locator. An "S" meter on the receiver is helpful to get a more accurate check on the noise's signal strength; CB walkie-talkies can also be used for this purpose.

If it turns out that the interference is coming from some distance, you can use your auto radio and/or mobile CB set to track down the general area of interference, stepping out of your vehicle with the portable for more precise "sleuthing."

If your suspicions lead you to utility power lines, you will find that this kind of noise can be very difficult to precisely locate and impossible for you to cure youself.

If driving around suggests that power company poles are the culprits, you can sometimes localize the source by observing nearby power lines and poles through binoculars for cracked insulators, rubbing ground cables, tree limbs on the wires, etc.

A light tap on the suspected pole may change the pattern of interference, allowing you to confirm its source. You shouldn't try to take any corrective action yourself, however—it's much too dangerous!

Common rfi sources

Here are some of the prevalent types and sources of radio frequency interference experienced by CBers, amateur radio operators and shortwave listeners.

Switching discharge types of rfi

Automobile ignition
Electric motors
Defective powerline equipment
Oil burners
Belt static
Arc welders
Traffic lights
Fluorescent lamps
Thermostats
Telephone dials
Neon signs
Home laundry equipment
Electric fences
Kitchen mixers
Blenders
Hair dryers
Loose hardware on power poles
Electric shavers
Light switches
Furnaces
Doorbells
Lawn mowers
Fish tanks
Electric light dimmers

Harmonic kinds of rfi

Horizontal sweep circuit in home tv sets
Calculators
Ultrasonic cleaners
"Non-linear rectification" and reradiation of signals caused by corroded hardware and wiring such as in antenna systems, pipes, masts and towers, and home gutter-work (downspouts)
TV-set if (intermediate frequency) harmonics

Radio frequency leakage

Diathermy radiation
Oscillator radiation from nearby sw, bc, fm, and tv sets
Regenerative receivers (such as in some garage-door openers and toy CB sets)
High-frequency industrial heating equipment
Direct radiation from strong nearby transmitters (CB, amateur, etc.)

Other kinds

Atmospheric noise or static (QRN)
Cross-modulation (caused by strong local signals mixing together to produce combination "third" frequencies)

Note that some rfi sources can produce interference in more than one category. Also, interference can be transmitted to your receiver either directly, through your antenna, or via the power lines to your equipment.

Most power companies have departments that specialize in rfi detection and elimination, and a call to them with some specifics about the interference should do the trick without any need for you to climb the poles.

If your sleuthing indicates that the interference may be coming from within your own home, you can again use the small portable to search out the interference source, looking critically at thermostats, washing machines, tv sets, and almost all other household gadgets and appliances.

Or, you can use a small six inch rfi probe, made by stripping the shield braid off the end of a piece of coaxial cable, at the end of a long length of coax connected to your receiver, as shown in figure 2.

Route it throughout your house, outdoors, too if necessary, "probing" for the exact source of interference, working in tandem with a friend monitoring your receiver. Another way to check out household rfi is to pull your circuit breakers, thereby isolating circuits, until the interference disappers.

If you find that it disappears when you do this, you can go around unplugging individual appliances until the offender is found. Suspect anything and everything as the source of your rfi, but be sure that before you blame neighbors and the power company for interference problems, your own house is in order!

Of course, if your neighbors are cooperative, and if you suspect a neighboring house, you can pull its circuit breakers and check the electrical and electronic appliances in similar fashion.

If you find that the source of rfi is outside your home, you must exercise some psychology in eliminating the interference. People don't like being told that their appliances, tv sets, and tools are defective and are causing interference with your operations—though they are likely to be the first to complain about your CB or amateur operations. *Be tactful!*

Power companies are usually quite cooperative, and most have at least one mobile "rfi van" crammed with receivers and antennas that can be of real value to you in tracking down power-line rfi sources that are far removed from your home. The use of their equipment will sometimes reveal that the real source of interference isn't in the power lines themselves, but in a home, shop or factory, feeding rfi *into* the lines.

Since rfi violates Federal Communications Commission radiation rules, the FCC holds the ultimate "cards" on getting action in persistent cases. But it's far better to try to solve rfi problems on a local, individual basis.

FCC resources are limited, and you will almost certainly be delayed in solving your interference problems if you pin your hopes on FCC assistance. The key

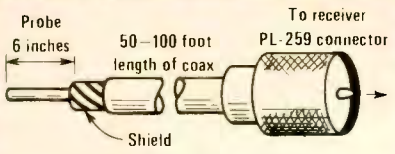


Figure 2: Try this simple rfi probe

Construct this simple rfi probe from a 50 to 100-foot length of RG-58/U or RG-59/U coaxial cable. Strip back about six inches of the outer plastic cover and the braided shield to expose the center conductor wire. That center wire is used as the rfi sensor. Connect the other end to a PL-259 connector or whatever kind will mate to your receiver's antenna terminals. The probe is used to pinpoint rfi sources within your house or apartment. It is connected to your receiver which is tuned to the frequency where interference sounds strongest. Move the probe about to track down and identify the rfi bad actor. A small multiband portable radio would be handy in the search. A handheld CB walkie-talkie also could be used. Another way to track down household rfi is to pull fuses and circuit breakers successively until you find the house wiring circuit carrying the interference. Channel Master's model 5270 ($17) noise detector is called The Sleuth and is designed to track down automibile noise sources. It's used in the car like the home-made device described here is used in the house.

to successful rfi elimination is tracking it down yourself; "Seek and ye shall find!"

Remedies you can try

Once you've located the source, the rfi battle is half won. It's usually far more effective to try to cure interference on a case-by-case basis at the source rather than at the receiving end.

While we can't get into all possible kinds of rfi cures in this short article, suffice it to say that many kinds of appliances, fluorescent lights and "switching" type interference can be reduced or eliminated with a small capacitor (.005 to .1 mfd) connected across the sparking terminals, motor commutator, switch contacts or power line.

A bypass capacitor from either side of the ac line to ground also helps. Securely grounding the appliance often works wonders; you will find many appliances which should be grounded for safety, not to mention rfi reduction, just aren't. A heavy, direct wire to a cold-water pipe ground may help, too.

Shielding and filtering are often required to eliminate interference from rf-producing equipment; "brute force" line filters such as shown in figure 3 can be highly effective if the interference is conducted through the power line.

If it's tv set sweep harmonics that are giving you problems, a couple of bypass capacitors across the set's power cord (near where it enters the set) usually helps in reducing "sweep" interference, as does installation of either a twin-lead trap across the tv antenna terminals as shown in figure 4, or a commercial high-pass filter in series with the antenna lead. (Note: many major set manufacturers will provide free of charge a high-pass filter for rfi reduction if you contact them stating the particulars and requesting the filter.)

From a practical standpoint, *short-duration* interference, such as that from electrical drills and saws, as well as from microwave ovens, may be "more trouble than it's worth" to attempt to eliminate; you may simply decide to live with such interference.

Also, you may want to think twice before purchasing some devices that are notorious rfi generators. For example, the ordinary household light dimmer produces tremendous interference that is very difficult, if not impossible to eliminate.

Making the most of it

Assuming you've done all you can to reduce or eliminate rfi at the source, your final task is to use your receiving equipment to best advantage to overcome any noise or interference remaining.

It's a good idea to install an ac line filter, such as that shown in figure 2, in the power line to your equipment as a matter of standard procedure. This will not only help you with inbound rfi but will help assure that any rf your own CB or amateur transceiver produces won't get into the ac lines and cause problems for others.

A good *noise blanker* (NB) or *automatic noise limiter* (ANL) on your receiver or transceiver, preferably both, are especially important, not only because they can help eliminate any residual man-made noise, but they will also reduce the annoying static crashes caused by atmospheric interference—something you can't do anything about at the source.

An audio *clipper/filter* circuit connected to the speaker leads is also helpful in reducing strong static crashes and sharp man-made noise peaks, and a *selective audio filter* is an especially good bet to narrow the set's if passband and reduce the annoying effects of audible "beats" cause by reception of tv set sweep harmonics.

Your ántenna system itself has some bearing on the amount of noise your receiver will pick up. Generally speaking, a *horizontal* dipole antenna fed with coaxial cable minimizes reception of man-made noises, while a *vertical* antenna tends to accentuate noise pick-up. If you live in a very high-noise area, think twice before you install and use a vertical antenna!

A coaxial lightning arrestor installed in your transmission line will offer more than lightning protection.

The tiny spark gap these devices contain are just right to drain off small accumulations of static electricity which are produced on your antenna near storm areas, and which would otherwise tend to produce a "frying" noise in your equipment and could even build up to the point of damaging your receiver's "front end" rf stage.

We haven't been able to cover rf interference in any great depth here; whole books have been written about this difficult subject. If you're stumped with an rfi problem, try the *ARRL Radio Amateur's Handbook*, or one of the several excellent, specialized Tab Books or Howard Sams publications on rfi. Back issues of amateur magazines such as *CQ*, contain in-depth articles about noise.

An excellent publication covering the whole spectrum of rfi is the Federal Communications Commission's own booklet on interference, *How To Identify and Resolve Radio-Television Interference Problems*. You can have your own copy of this complete, easy-to-read book, avail-

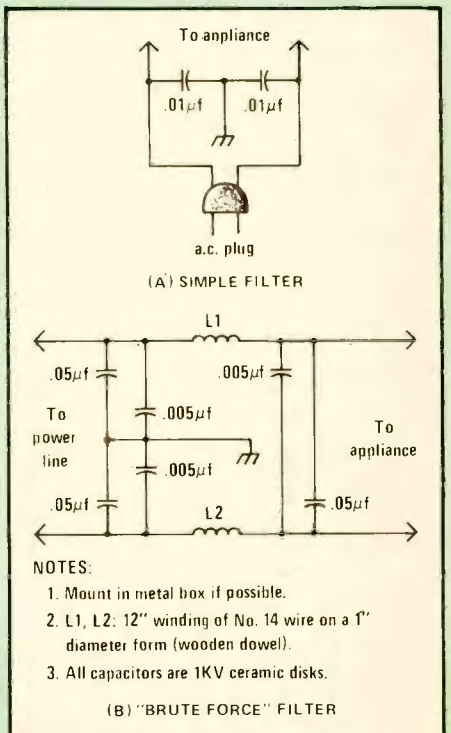
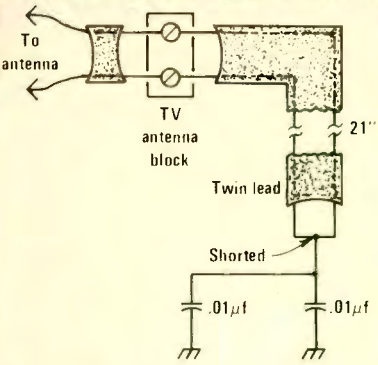


Figure 3: Two rfi filters you can build yourself

The quickie ac line filter (a) is effective in reducing mild rfi pollution from small appliances, tv sets, fluorescent lights and motors. For coping with stronger interference, the brute-force filter (b) will do the trick. Such ac filters can be purchased at Radio Shack stores nationwide or other local radio supply houses. Filters you build for yourself should be mounted as close as possible to the source of interference, and grounded to the third wire of your home wiring system. Also, install a filter at your SWL listening post or ham and CB station console to eliminate rfi which might leak into your gear from the power line.



NOTE:

Do not eliminate the bypass capacitors. They are needed for safety reasons. All capacitors are 1KV ceramic disks.

Figure 4: ITV stub

A shorted stub across your tv set's antenna terminals can help to eliminate annoying buzz-saw harmonics from your set's 15,750 hertz horizontal oscillator. Here's how to build such a stub. A piece of 300-ohm tv lead-in twinlead wire is cut to a length of exactly 21 inches and the far end, away from the tv set connection, is shorted together and grounded. If tv signals are reduced, try shortening or lengthening the stub. A high-pass filter installed at your set's antenna terminals also can be very effective in reducing interference as well as helping to insulate your set against tvi from CB or ham transmitters. An excellent high-pass filter is available from R.L. Drake Co., 540 Richard St., Miamisburg, OH 45342.

able from *Modern Electronics*, 14 Vanderventer Ave., Port Washington, NY 11050, for $1 plus 25¢ postage and handling.

The FCC book is especially good since it lists addresses of most electronic appliance manufacturers. It also tells you how to register an official rfi complaint with the FCC if your best efforts otherwise fail.

Work around it

While you can tolerate some noise and interference and can often work around it, it's better to get rid of as much as you can in order to make listening and communicating a great deal easier and more enjoyable.

Experiencing interference, you need to identify just *what* is causing the interference, take its "electronic fingerprints," and track it down. It's best to try to cure man-made noise at the source, and if you can't, there are several things you can do to our equipment to help filter out what noise you will have to live with.

We'll never get rid of all "inbound rfi" but you can certainly do a good job or "riding herd" on it!