

AM-band, VHF and shortwave receivers in particular often produce audio signals that are a terrible mess of weird squawks, squeals, and other objectionable noises. Today, the growing number of electronic devices is making the cacophony louder and messier than ever before. Fortunately, many of the interference problems that you might experience can be fixed, or at least reduced significantly in severity.

Interference is usually produced by one of two sources: local radio- and TV-station signals and other electronic devices. Signals from AM, FM, and TV stations are quite powerful, and can be troublesome for receiver owners in their immediate vicinity. Unfortunately, in many areas of the country, residences are located quite close to such stations—in a few areas even shortwave stations are located near homes. Let's discuss the problems caused by local transmitters first.

Radio-Station Interference. Typical problems from local transmitters include blanketing, desensitization, harmonic generation, and intermodulation. Let's define each of these in turn.

First we'll deal with blanketing. Blanketing occurs when a very strong local signal completely washes out radio reception all across the band. It generally affects only the band that the signal is found in. The offending signal can either be received throughout the band, or at numerous discrete points.

Another problem is desensitization. Desensitization appears as severely reduced receiver sensitivity due to the presence of a strong local signal. Desensitization can occur across a wide frequency range and is not restricted to a single band. You might not hear the offending signal on your receiver unless it's tuned to the station's frequency.

Yet a third problem is harmonic generation. If the signal is strong enough to drive the RF amplifier of the receiver into nonlinearity, then the receiver may internally generate harmonics of the strong signal. For example, if you live close to a 780-kHz AM broadcast-band signal source, and the receiver overloads from its transmissions, then you might be able to pick up the signal at twice the frequency (1,560-kHz), three

times the frequency (2,340-kHz), and so on up throughout the shortwave bands. Note that the radio station is not generating harmonics (which would violate FCC regulations). The receiver is just responding inappropriately to the received signal.

Last, there's the possibility of intermodulation. This problem occurs when two signals of different frequencies (say, f_1 and f_2) mix together to produce a third frequency (f_3). The two initial frequencies involved might be (and probably are) the assigned fundamental

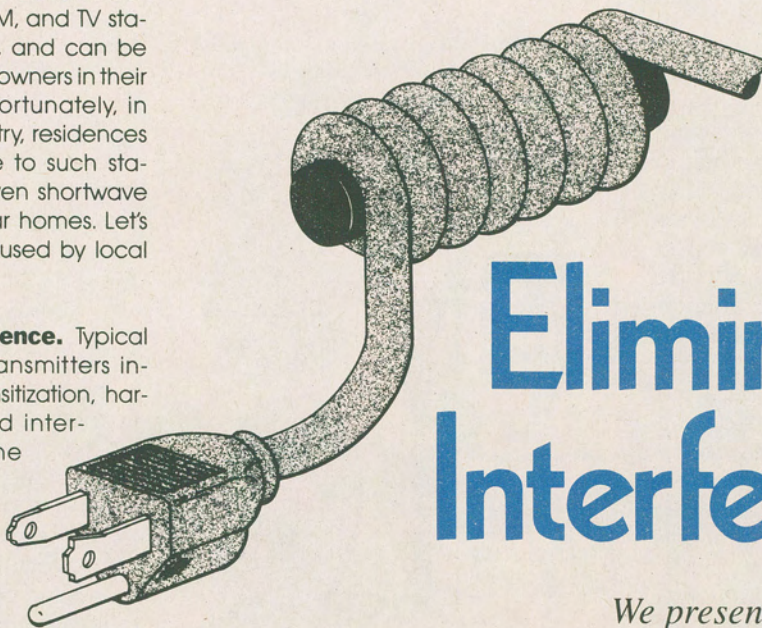
operating on 21,390 kHz (in the 15-meter band). Both stations are operating normally, but at least one is close enough to overload your receiver and produce nonlinearity in the RF amplifier. When the second harmonic of 10,120 kHz (*i.e.* 20,240 kHz) mixes with the 21,390 kHz signal, one resulting frequency is:

$$21,390 - 20,240 = 1,150 \text{ kHz}$$

which is right in the middle of the AM-broadcast band.

If there are many signals generated

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Eliminating Interference

We present a guide to reducing or eliminating interference to any RF receiver.

frequencies of legitimate radio stations, or their harmonics. The third signal is sometimes called a "phantom signal." The frequencies mix due to nonlinearity in some component in the receiver or antenna. The nonlinearity can be due to receiver overload, improper receiver design, or some other source (legend has it that rusted downspouts and corroded antenna connections can act as nonlinear PN junctions). As they say in the new science of Chaos Theory: "...nonlinearity can arise throughout nature in subtle ways."

The possible values for the new frequency can be found from:

$$f_3 = mf_1 \pm nf_2$$

where m and n are integers, although not all possibilities are likely to occur in any given situation. Suppose one local ham is operating on 10,120 kHz (in the new 30-meter band), and another is

in your locality, an extremely large number of possible intermodulation combinations can arise. In my hometown there is a hill, right in the middle of a densely populated residential neighborhood, on which there are two 50-kilowatt FM-broadcast stations; a 5-kilowatt AM-broadcast station; scores of VHF and UHF landmobile-radio base-station or repeater transmitters; and an assortment of paging systems, ham operators, a medical telemetry system, and the microwave towers of an AT&T long-lines relay station—all within a city block or two. Only a few unassisted radio receivers work well in that neighborhood!

There are two approaches to overcoming these problems. First, either reject or somehow selectively attenuate the offending signal (or one of the signals in the case of an intermodulation problem). That is done using a wave-

trap placed between the antenna and the rig. Second, add a passive pre-selector to the front-end of the radio receiver between the antenna line and the antenna input of the receiver.

Wavetraps. Let's discuss three wavetrap circuits that can be used from the AM band up through VHF/UHF frequencies. The circuit in Fig. 1 is an LC wavetrap based on inductors and capacitors. There are two forms of LC resonant circuit shown in Fig. 1. In series with the signal path is a parallel resonant circuit (L2/C2). Such circuits have a very high impedance at the resonant frequency, so they will attenuate signals of that frequency trying to pass through the line between J1 and J2. However, the impedance at all other frequencies is low, so those frequencies will pass easily from J1 to J2. A pair of series resonant circuits are shunted across the line on both ends of the signal path. Series resonant LC circuits have a low impedance at the resonant frequency, and a high impedance at all other frequencies, so they shunt only the offending signal to ground.

The wavetrap of Fig. 1 can be built using either fixed inductors and variable capacitors, or vice-versa. It can be built either for one fixed frequency, or as a variable wavetrap that can be tuned from a front-panel knob to attenuate the offending signal.

Figure 2 shows the circuit of a similar type of wavetrap, but this one is built with varactor diodes. They are used as variable capacitors because their junction capacitance varies with the applied reverse-bias voltage. Thus the circuit is tuned by properly setting V_T . In the circuit of Fig. 2, only series resonant circuits are used.

Wavetraps built from LC circuit elements are useful well into the VHF re-

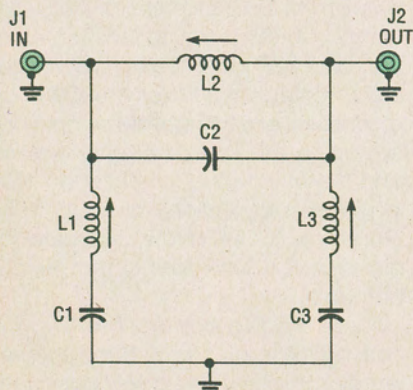


Fig. 1. This is a wavetrap using one series resonant and two parallel resonant tank circuits.

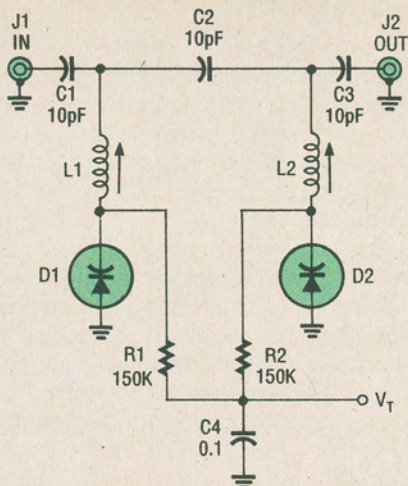


Fig. 2. This voltage-tuned wavetrap takes advantage of the variable junction capacitance of the two varactor diodes.

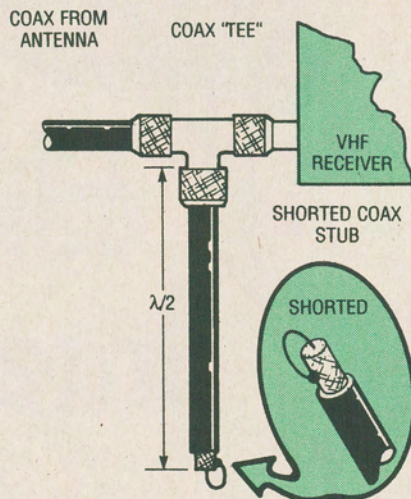


Fig. 3. This half-wavelength shorted-stub form of wavetraps can be used to attenuate a specific frequency. The length of the stub determines the frequency.

gion. In fact, many video and other electronics stores sell wavetraps similar to the one in Fig. 1 that are built especially for the FM-broadcast band (88 to 108 MHz). Those are good sellers because nearby FM-broadcasting stations are frequent sources of interference to VHF television receivers.

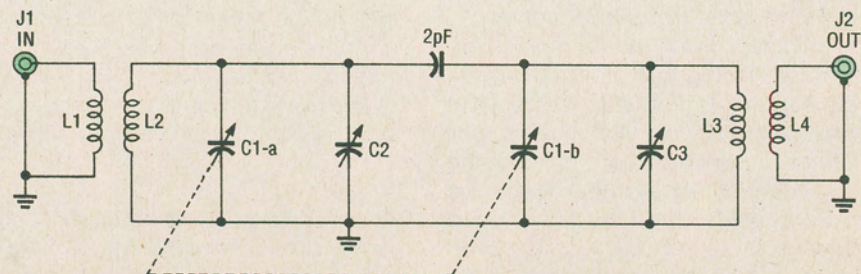


Fig. 4. This passive LC preselector circuit is handy because, unlike wave traps, it is variable.

Another VHF/UHF wavetraps is shown in Fig. 3. That type of wavetraps is called a half-wavelength shorted stub. One of the properties of a transmission line is that it will reflect the load impedance every half wavelength along the line. When the end of the stub is shorted, a "virtual" short-circuit will also appear every half wavelength along the line. The stub length determines the frequency that is shorted. The length of the stub can be found from:

$$L = 492V/f$$

where L is in feet and f is in megahertz. The V term is the velocity factor of the transmission line. For common coaxial lines the value of V ranges from 0.6 (for cable with a polyethylene inner insulation) to 0.82 (for cable with polyfoam insulation).

For example, assume that we need to eliminate the signal from a local FM broadcaster at 88.5 MHz. The shorted stub is made from ordinary coax ($V=0.66$), and must have a length of:

$$(492)(0.66)/88.5 = 3.669 \text{ feet}$$

(or 44-inches).

The half-wavelength shorted stub is connected in parallel with the antenna input on the receiver. In the case shown in Fig. 3, the stub is connected to the receiver and antenna transmission line through a coaxial "tee" connector. Of course, although UHF connectors are shown, the actual connectors that you use must match your receiver and antenna. Also, it is possible to use 300-ohm twinlead for the stub rather than coax, provided it is used as the transmission line as well.

The other approach to solving the problem is to use a passive preselector ahead of the receiver. Again, the pre-selector is inserted directly in the transmission line between the receiver's antenna input and the antenna. Figure 4 shows a typical circuit for this type of preselector. The tuning is controlled by resonant pairs C1-a/L2 and C1-b/L3,

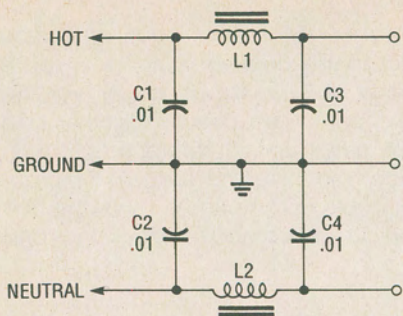


Fig. 5. An LC line-noise EMI filter can effectively prevent noise produced by TV's, VCR's, computers, and other pieces of electronic gear from reaching your household wiring.

which are trimmed by C2 and C3, respectively. The circuit should be built in a closed, shielded metal box.

The Russians, VCR's, and TV's. The world is a terrible place for sensitive radio receivers: a lot of pure crud (in addition to the programming material itself!) comes over the airwaves from a large variety of electronic devices. There are also some renegade transmitters out there. For example, in the HF shortwave spectrum you will occasionally hear a "beka-beka-beka" pulsed signal that seems to hop around quite a bit. It will suddenly appear on your favorite listening frequency, and then go to another. That signal is an "over the horizon backscatter" (OTHB) radar system in the USSR. It is called the "Russian Woodpecker" by North American SWL's and hams. Unfortunately, the very nature of the pulsed signal causes it to spread out over several megahertz—wiping out large segments of the spectrum. That's a problem you can do little about, so let's look at some interfering signals that we can affect.

A lot of homes are equipped with light dimmers. These devices are based on Triacs that cut the AC sinewave off twice per cycle, which produces a harmonic-rich sharp waveform. These devices can cause your receiver to produce a sound similar to "frying eggs" well into the shortwave band.

If you suspect a light dimmer is causing interference confirming your diagnosis is simple: turn off the light. If the noise stops when the light is turned off, then the dimmer is at fault.

Although it is possible to install LC line-noise filters at the dimmer, that approach is not always feasible. It would be better to either remove the dimmer and replace it with an on-off switch, replace the dimmer with a special model that is designed to suppress ra-

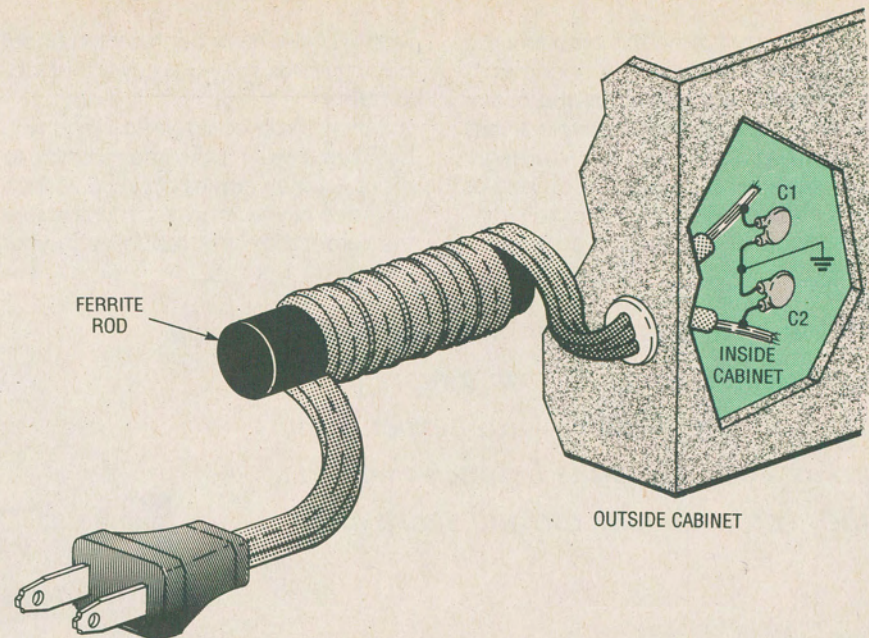


Fig. 6. This ferrite-rod line-cord EMI filter is another effective means of keeping noise from entering your home's wiring.

dio noise, or keep the light turned off when using the receiver.

Another radiation source is the common videotape recorder (or VCR). All VCR's contain a number of radiation-producing circuits, including a 3.58-MHz color-subcarrier oscillator. Don't get me wrong, they are magnificent entertainment products, and I own one, but I also own SW- and ham-radio receivers and can always tell when a popular movie is on TV: Lots of people tape the movie (legalities notwithstanding), so I receive a load of trash at around 3.58-MHz (right in the middle of the 80-meter amateur-radio band) till the movie is over.

Your TV can also be the cause of poor radio reception. A TV set contains at least two major interference producers: a 60-Hz vertical-deflection system and a 15,734-kHz horizontal-deflection system. The horizontal system includes a high-powered amplifier driving a high-voltage "flyback" transformer and a deflection yoke. As you tune up and down the shortwave band, you will hear "little birdies" caused by the horizontal-deflection signal every 15,734-kHz, which are the harmonic signals of the TV's horizontal signal.

One quick solution to interference from VCR's and TV's is a line-noise filter. Those "EMI filters" should be placed in the power line coming from the offending device. They work much of the time because the power line of the VCR or TV acts as the greatest radiator of the interference. The EMI filter should be in-

stalled as close as possible to the body of the offending device.

The filter in Fig. 5 uses LC elements to form a low-pass filter network that is placed in series with the AC power line. Most readers should consider buying a ready-made line filter from a distributor (even Radio Shack offers models suitable for most applications). **Homebrew EMI filters are potentially dangerous if built incorrectly.** If you still want to make your own filter, it should be placed inside a heavy-duty metal cabinet. Also make sure you use capacitors and inductors that are rated for continuous application of AC power.

Another possible solution is the filter shown in Fig. 6, which can be made for any appliance that has ordinary zip lead as the power cord. The wire should be wrapped around a 3/8 to 1/2-inch ferrite rod (Amidon Associates, 12033 Otsego Street, North Hollywood, CA 91607), and then taped to keep it in place. The filter should be mounted as close as possible to the TV or VCR chassis. The optional bypass capacitors (C1 and C2), which are placed inside the equipment cabinet should be .01- μ F 1600-WVDC ceramic discs.

Many communities today are wired for cable-TV. Cable systems transmit a large number of TV, FM-broadcast, and special-service signals along coaxial-transmission lines. They operate on frequencies of 54-MHz to 300-MHz in 36-channel systems and 54-MHz to 440-MHz in 55-channel systems. Whenever

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a large number of signals get together in one system, intermodulation is a possibility, and that means signals outside of the official spectrum can be generated. The problem is that signals leak out of the cable TV system, and interfere with your receiver. The only thing that you can do legally is to complain to the cable operator and insist they eliminate the interference. Fortunately, the FCC is your ally: by law, the operator must keep the signals home!

Other Culprits. It is likely that most American homes today are equipped with microwave ovens. They use a magnetron tube to produce several-hundred watts of microwave power on a frequency of approximately 2,450-MHz. The high voltage applied to the magnetron is typically pulsating DC. It is that pulsating DC that causes "hash" in radio receivers. Although better-quality microwave ovens are equipped with EMI filters, many are not. However, most manufacturers or servicers of microwave ovens can install EMI filters inside the oven. Alternatively, one of the EMI filters we've shown can be used.

The proliferation of personal computers has greatly increased the amount of noise in the radio spectrum. The noise is caused by the digital pulses generated by their internal circuits. Older machines, which use internal clock frequencies of 1 to 4.77 MHz (like the original IBM-PC), wipe out large portions of the AM and shortwave bands. If you doubt that, try using an AM radio near a computer! Later-model computers (XT-turbo, AT, etc.) use higher clock frequencies (e.g. 8, 10, 12, 16, 25, or 33 MHz), and they can wipe out the VHF bands—including the FM-broadcast band—as well.

Most of the noise produced by the computer is radiated through the power line or from the keyboard cable. In the latter case, make sure that a shielded keyboard cable is used. Power-line noise can be stopped by using the EMI filters discussed earlier.

Printers or, more commonly, printer cables are another source of noise. If the cable between the computer and the printer is not shielded, then replace it with a shielded version. Otherwise, you might want to consider a ferrite clamp-on filter bar such, as the Amidon 2X-43 or equivalent. ■