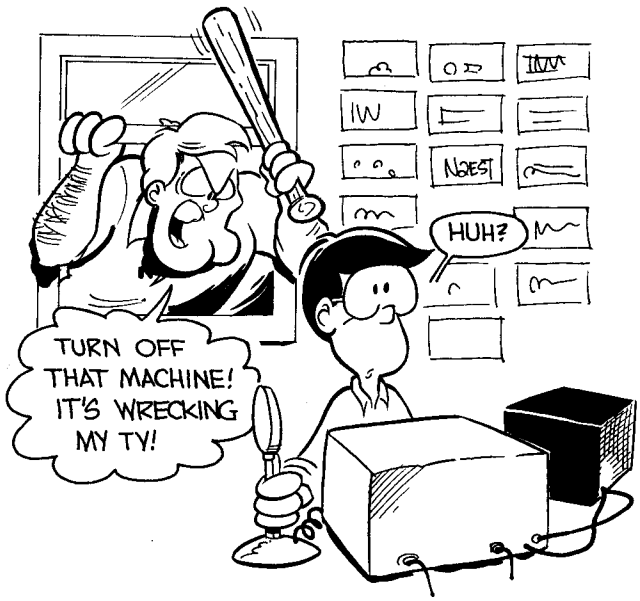


• *First Steps In Radio*

Understanding TV and Radio Interference

Part 14: Ham radio interference to home entertainment devices is a matter we can't dismiss easily. Fortunately, there are simple steps we can take to solve most problems caused by our station equipment.

By Doug DeMaw,* W1FB

In a recent installment of this series we examined radio-wave propagation with respect to the ionospheric layers. We did not cover the effects of radio-frequency energy in the immediate vicinity of our amateur stations — the region where intense levels of RF energy are generally present when our transmitters are operating. It is not uncommon for these strong fields to create interference in nearby TV, AM and FM receivers. This near-field RF energy can also affect the performance of telephones, computers and other electronic devices found in homes.

Our responsibility as hams is to ensure that our radio equipment is not the fundamental cause of RFI (radio-frequency interference) or TVI (television interference). Often, a large part of the interference problem is the fault of the home-entertainment device, rather than the amateur's transmitter. Unfortunately, the neighbor who experiences an interference problem is hesitant to believe his or her apparatus is deficient. Often the complainant will say, "It has to be you! After all, you have that big antenna in your yard!" Such a person might also say, "It can't be my hi-fi system, I paid $1500 for it."

When the home-entertainment device is responsible for the interference problem, we need to put on a diplomat's hat and assume a new role. Animosity solves no problems, so we must try to cooperate with the irate neighbor in solving the dilemma. Let's look at the basic causes of interference, and learn what the usual steps are toward solving the problems.

Keeping Our Stations "Clean"

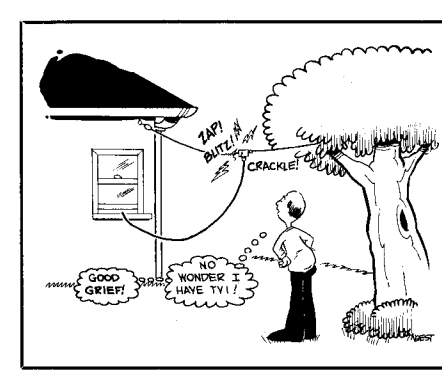
The first responsibility of an amateur operator is to make certain that the transmitter does not radiate harmonic energy. A harmonic is a frequency multiple (odd or even) of the operating frequency. For example, the second harmonic of 3725 kHz is 7450 kHz, the 11th harmonic is 40.975 MHz. The higher-order harmonics fall into the FM and TV bands. If they are strong enough, they can wipe out the TV picture and sound, or blot out an FM station. If these interfering harmonics are radiated by the transmitter directly or via the antenna system, they may be strong enough to cause interference a block or more away!

All transmitters generate harmonic energy. The FCC requires that all commercially made amateur transmitters for the HF bands have all spurious output energy suppressed 40 decibels (dB) or more below the peak power-output level without exceeding the power level of 50 mW. Therefore, if our transmitter puts out 100 W at the desired frequency, all harmonics and other spurious energy must be 10 milliwatts (mW) or less. At VHF, the spurious energy from the transmitter must be at least 60 dB below the peak output power. Proper transmitter design plus suitable harmonic filters can make this possible. Many homemade transmitters do not meet these performance standards, owing to incorrect design procedures and/or a lack of harmonic filtering. The ARRL, however, requires that all published transmitter circuits comply with the FCC regulations before they can appear in *QST*. Similarly, most manufactured transmitting equipment is tested for compliance before it can be advertised in *QST*. These tests are performed at ARRL Hq. in the Technical Department laboratory.

If you have an offensive transmitter, you can add an external harmonic filter to the transmitter. We'll discuss this, and other clean-up measures, later in the article.

Other Interference Causes

It is possible to have a clean transmitter, but your station may still be the cause of RFI or TVI. How can this happen? Let's suppose that somewhere in your antenna or feed line there is a poor electrical joint. In fact, a loose coaxial-cable connector may even be the culprit. A poor solder or mechanical joint can act as a rectifier diode.



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When this happens, the diode-like joint generates strong harmonic currents, and these can be radiated by the antenna. A poor antenna connection may simply "sputter" and arc while you are transmitting, and this will raise havoc throughout the neighborhood.

A poorly conducting joint need not be in the antenna system. It might occur between sections of rain gutter, metal fencing or some other nearby conductor. If a sufficient amount of your RF energy is induced into such objects, they can generate and radiate harmonics.

There is a reverse-interference problem that can result from an unwanted rectifying joint: You may hear all manner of unwanted broadcast band or other commercial signals popping up here and there in the tuning range of your amateur receiver! The poor outdoor joint may be rectifying energy from an AM station. The harmonics caused by this action may fall in the amateur bands.

As an example, suppose there was an AM station near you, and the operating frequency was 1240 kHz. The third harmonic would fall at 3720 kHz — right in the 80-meter Novice band! Of course, you might hear the third harmonic anyway, if the antenna tower of the AM station was very close to your location. This would not mean that the broadcast station had a faulty transmitter. Let's consider a typical 50,000-W AM station. By law, the harmonic signal amplitude must be 40 dB or more below peak fundamental output power, and must not exceed 50 mW. This means that the third harmonic of the AM transmitter must be 50 mW or less in power level. A 50-mW signal from a couple of blocks away can be mighty strong in a ham receiver! In fact, transoceanic amateur QSOs have been made at such power levels.

If any of these problems occur at your station, check for loose joints in the antenna system. If this does not resolve the difficulty, look for poor electrical joints in nearby metal objects. Once the bad joint is found, it's a simple task to clean the mating surfaces and solder them. A jumper wire and two clamps can be used to bond joints in fences and other large conductors.

Interference Preventive Measures

We need to ensure that our transmitters have a clean bill of health, so to speak, before we attempt to solve interference problems in our neighbors' or our own home-entertainment equipment. Caution: If you work on a neighbor's home-entertainment device, you leave yourself open for continuing — or worsening — problems if your cure doesn't work exactly right. Fig. 1 shows the prescribed methods for keeping harmonic energy from reaching the feed line and antenna. FL1 is a low-pass filter. It allows amateur signals to pass through it with little attenuation, but frequencies above, say, 40 MHz are attenuated greatly. This filter should be located as close to the transmitter antenna jack as possible, and it should be connected to a quality earth ground. A suitable earth ground might be several 6-foot copper rods driven into the ground near the ham shack, with about 3 feet between each rod.[1] The rods are bonded together by means of a heavy-gauge conductor, such as the shield braid from RG-8/U coaxial cable. The lead from this ground system to the ham station should be as short and fat as you can make it: The shorter the overall ground lead, the more effective the ground system will be for conducting the harmonic energy to ground. Low-pass filters are widely available on the commercial market. Some amateurs build their own filters from data given in the *ARRL Handbook*.

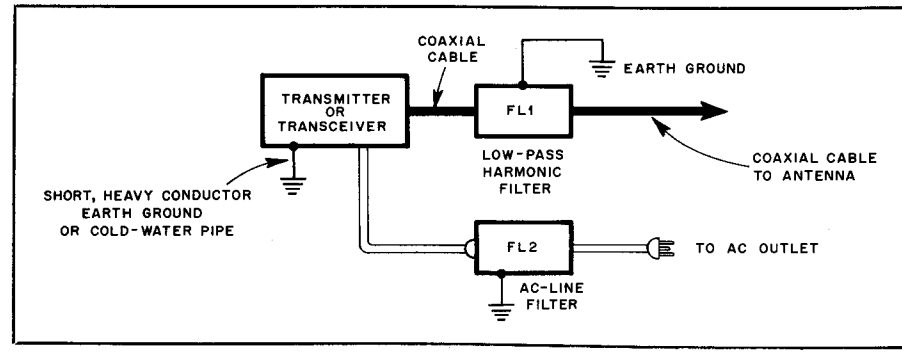


Fig. 1 — Block diagram of an amateur transmitter or transceiver that has a low-pass harmonic filter, plus a brute-force ac-line filter. The filters attenuate harmonic energy to reduce the possibility of TVI and RFI. The ground system should be of high quality (see text), with as short a connecting lead as possible. Frequently, the cold-water pipe system will serve as an effective earth-ground connection.

RF energy at the operating and harmonic frequencies can be conducted along the ac line, then to the power lines for radiation. This unwanted energy may also be conducted into your neighbors' homes and then into their entertainment equipment. It should be standard practice, therefore, to install FL2, an ac-line filter. It will serve also to keep unwanted external noise and RF energy from entering your receiver via the ac line. The *Handbook* has the details for making your own ac filter. FL2 of Fig. 1 should also be located as close to the transmitter as is convenient.

A final word about harmonic radiation is in order. If you mistune the output amplifier of your transmitter (tune it to the wrong frequency), the harmonic output energy level can be quite high. Always tune your transmitter in accordance with the operating instructions. Be sure the amplifier stage is adjusted for correct loading and plate-current dip when using a tube type of output stage. This does not apply to solid-state amplifiers. They are broadband devices, and a harmonic filter is included in the circuit for each operating band.

Dealing with the Neighbor's Problem

Modern solid-state entertainment equipment is more prone to interference than was generally true of vacuum-tube equipment. This is because the transistors and ICs contain diode junctions. These diodes rectify RF energy and cause all kinds of interference problems. Also, many TV and FM receivers have front ends (tuner sections) that are not capable of rejecting non-TV or non-FM frequencies. The amateur signals enter the front end and overload them. This usually blanks out the reception entirely. Interference of this class is referred to as *fundamental overloading*. The most effective cure is the insertion of a *high-pass filter* directly at the tuner of the receiver. (As mentioned earlier, avoid working on a neighbor's home-entertainment device unless you are willing to take responsibility for the modifications you make, and for any future malfunction that could be related to those modifications.) This variety of RF filter allows the TV or FM signals to pass into the receiver, but unwanted energy below the filter frequency (1.8 to 29.7 MHz, for example) is attenuated. A high-pass interference filter (Fig. 2) will not prevent *amateur VHF and UHF* energy from reaching the front end of a TV or FM set, because the filter is necessarily designed to pass all frequencies in that range.

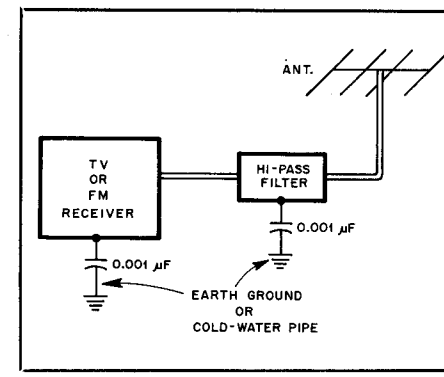
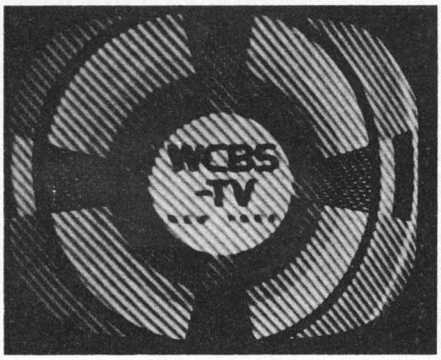


Fig. 2 — A high-pass TVI filter can be attached to the TV receiver near the tuner to prevent fundamental overloading of the TV set from amateur signal energy.

[1]Notes appear on page 37.

How FCC Regulations Affect Our Treatment of RFI-Related Problems

Q. In the eyes of the FCC, who is responsible for RFI?
A. It is the radio amateur's responsibility to ensure that the transmitted signal complies with FCC emission standards regarding the fundamental, harmonics and other transmitted products. If the transmitter is being operated in accordance with FCC regulations, the responsibility of remedying RFI susceptibility in the home-entertainment device lies with the owner of the device.
Q. What is the FCC's view on neighbor relations regarding RFI problems?
A. If a neighbor is experiencing RFI from an amateur's signal on a receiver of good engineering design, and this fact has been made known to the amateur, the FCC may impose quiet hours on the amateur. During these quiet hours, the amateur cannot transmit on the frequencies where the interference exists.
Q. What must an amateur do if faced with a notice of violation?
A. The amateur must reply to the FCC office issuing the notice within 10 days of receipt. If the notice relates to a physical or electrical problem, the amateur must state fully the steps that have been taken to correct the situation. If the notice relates to improper operation of the transmitter, the name of the operator in charge must be given. The FCC will initiate license revocation proceedings should the amateur choose not to respond.



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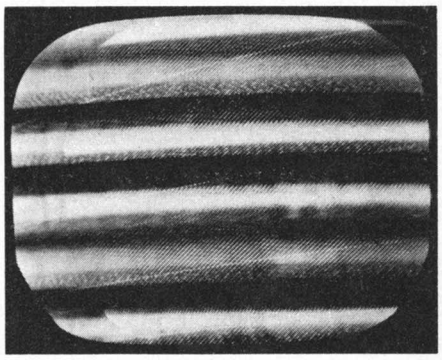

(B)

Fig. 4 — Cross-hatching is shown at A. This is typical of the harmonic interference caused by amateur transmitters. The picture at B shows what sound bars look like on a TV screen.

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High-pass filters are available commercially, or you may want to make your own (less costly!) from information in the *ARRL Handbook. Caution:* Do not install any suppression device inside the neighbor's equipment. Make your installation (with his or her permission) to the equipment cabinet externally. Once you reach inside the "works," you're liable if the neighbor decides you were the cause of a subsequent equipment failure.

Fundamental overloading caused by your VHF or UHF signals must be treated in a slightly different manner. A tunable "band-elimination" filter or "band-reject" filter is generally used in the antenna lead of the TV or FM receiver. This filter is capable of rejecting your VHF or UHF signal, but passes the desired TV or FM energy to the receiver front end. This species of filter contains one or two (depending on the use of Twin Lead or coaxial feed line) tuned, high-Q circuits. They are tuned to the operating frequency of your transmitter, which will result in minimum interference to the TV or FM set. A typical circuit for this kind of filter is shown in Fig. 3. The ARRL literature covers this subject and most other items that relate to interference.[2]

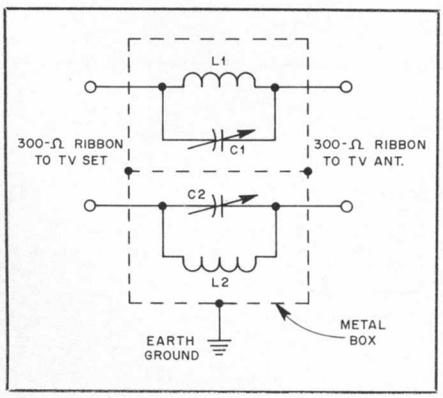

Fig. 3 — A tuned trap, or reject filter, is useful in preventing interference to FM receivers that is caused by amateur VHF or UHF energy. C1 and C2 are adjusted to resonate the traps at the transmitter output frequency.

We need to be aware that some TV set chassis are "hot" with respect to ground. This can cause an arc or even blow fuses when an earth ground is attached to the chassis. I like to stay on the safe side of things by inserting a 0.001-μF disc-ceramic capacitor in series with the ground wire to the TV receiver or filter case. This will prevent sparks from flying! (See Fig. 2.)

Harmonic Interference

Interference from amateur harmonics shows up quite differently in a TV receiver. Rather than blanking out a TV sound and picture system, harmonics cause lines on the TV screen. Diagonal or horizontal bars may appear on the screen. They may be very wide, or they may be spaced close together. Fig. 4 illustrates two kinds of "cross-hatching." Sometimes these bars appear only while you are speaking into your microphone. These are referred to as "sound bars."

It is unfortunate that we amateurs can do nothing at the TV set to cure harmonic TVI. It boils down to going back to our ham stations and starting from "square one." We must improve the harmonic suppression from our transmitters. This requires a great amount of cooperation with the neighbor while numerous checks are made to learn if progress is being made toward eliminating the problem. If the harmonic TVI occurs from operation on only one band, you should consider not using that band until you resolve your problem.

Ac line filters are recommended for use on TV and FM sets when a tough interference problem prevails. It is possible that harmonic energy is entering the TV receiver along the ac line as well as from the antenna system. No possibility should be overlooked when trying to solve TVI or RFI problems.

Harmonic interference to FM radios must be treated in a manner similar to that for TV sets. The symptoms will show up as buzzing or voice sounds superimposed on the FM station that is tuned in. Hams who operate the 6-meter band (50 MHz) are most apt to cause second-harmonic problems to owners of FM (88-108 MHz) receivers, since the second harmonic from any transmitter is usually the strongest.

Hi-Fi Interference

Perhaps the greatest number of interference problems can be related to audio hi-fi gear. This area includes cordless telephones, electronic organs and hearing aids. For the most part, RF energy is conveyed to the equipment via the speaker leads, which are usually quite long. They act effectively as pickup antennas, thereby

routing unwanted energy into the audio equipment. This difficulty is encouraged especially if the speaker wires happen to be the proper length for resonance at your operating frequency. For example, an 8-foot speaker lead would make a perfect resonant pickup antenna for 10 meters.

The most effective cure for RF energy on the speaker wires is the addition of disc ceramic bypass capacitors from each speaker terminal of the hi-fi set to chassis ground (see Fig. 5). This bypasses the RF energy to ground before it can enter the audio circuit via the back door. Another effective preventive measure is to wrap several turns of the speaker lead through a ferrite toroid core, as in Fig. 6. This acts as a choke to RF energy, but does not impair the passage of audio energy to the speakers. Once again, we should also try an ac-line filter to determine if the unwanted energy is entering the hi-fi unit along that route.

The previous methods apply to organs and other units of audio equipment. Hopefully, the required RFI-suppression components will be voluntarily included by the manufacturers in their attempts to meet the RF immunity standards envisioned by Congress when it passed PL 97-259.

Antenna Placement

It should go without saying that an amateur antenna that is close to a neighbor's house or TV antenna is a potential cause of interference. Our objective when installing an antenna should be to keep it as far from adjacent houses as possible. This is no simple assignment for the urban dweller, but physical spacing is important in preventing unwanted coupling to the nearby entertainment devices and their antennas.

Tidbits

We have not discussed interference to CATV systems. This area of difficulty can be, under some circumstances, the worst of the lot. I can recall while living in Newington, Connecticut, that I had no TVI in my own TV sets while operating the HF bands with 1 kW of power. Our TV set used an outdoor rotatable antenna. The miracle of CATV arrived in my neighborhood, and I became a subscriber. Suddenly I had TVI of the first magnitude. All efforts to cure the problem failed until I discovered that the CATV ground system was ineffective. I installed my own ground rods and solved the problem. The best approach to solving CATV difficulties is to enlist the aid of the CATV operator.

The purpose of this article is to provide you with basic information about radio-frequency interference, along with the procedures for curing RFI and TVI. The subject certainly goes much deeper than this. I recommend that you read the interference chapter in the ARRL *Handbook* and the ARRL book *Radio Frequency Interference*.

Glossary

band-elimination reject filter — a specially designed filter that rejects or suppresses a narrow band of frequencies within a wider band of desired frequencies.

decibel — a unit of relative power measurement that is used to express the ratio between two levels of power. It is equal to 10 times the common logarithm of this ratio. The abbreviation for decibel is dB. The abbreviation dBW is referenced to a power level of 1 W. The term dBm follows the same rule, but is referenced to a milliwatt (mW) rather than a watt (W).

fundamental overloading — the unwanted blanking out of the picture and sound of a TV set, caused by large amounts of RF energy from a nearby transmitter fundamental output signal. This condition is not related to harmonic energy from the transmitter, unless the offending harmonic is unusually strong.

high-pass filter — a filter designed to pass all frequencies above a desired one, while rejecting those that lie below the filter-design cutoff frequency.

low-pass filter — a filter designed to reject all frequencies above a desired one, while passing all below the filter-design cutoff frequency.

peak output — RF output power that is averaged over a carrier cycle at the maximum amplitude that can occur with any combination of signals that may be transmitted. More simply, the maximum instantaneous power output from the transmitter.

QRP — from the international Q code meaning "Shall I reduce power?" Also, "Will you reduce power?" This term is commonly used to denote amateur transmitter power levels at or below 10-W dc input to the last transmitter stage or 5-W output. Many hams are QRP operators by choice for the purpose of meeting the challenge of working long distances with very low power.

RFI — radio-frequency interference. Interference to AM and FM radios as well as to various appliances, such as computers, audio systems and telephones.

TVI — interference to television receivers.

Many radio clubs have organized TVI committees. If you become the victim of poor relations with a neighbor because of interference, try enlisting the aid of a local TVI committee. It will function as a go-between for you and the irritated neighbor. Finally, don't forget that failure to attempt a peaceful solution to TVI or RFI may lead to a citation from the FCC. Good luck!

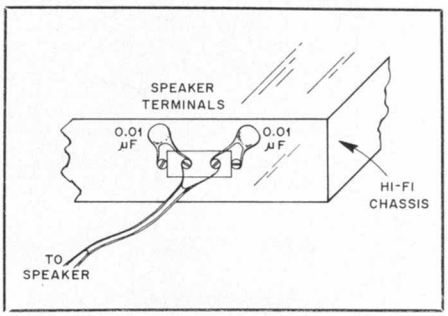

Fig. 5 — Method for reducing unwanted RF pickup by the speaker wires of an audio amplifier. A 0.01-μF ceramic capacitor is connected from each speaker terminal to chassis ground, as shown.

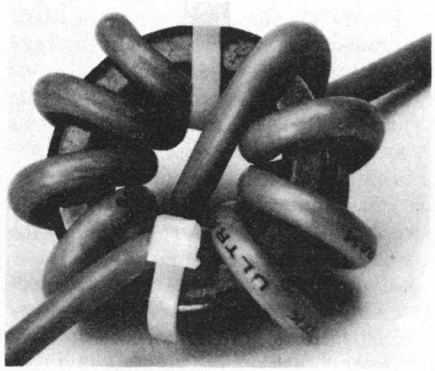

Fig. 6 — Winding the speaker wires on a toroid core can prevent RF energy from entering the circuit of an audio amplifier via the speaker leads. An Amidon FT-140-61 core is suitable if six to eight turns of speaker lead are looped through it.

Notes

[1]m = ft × 0.3048.

[2]C. L. Hutchinson and M. B. Kaczynski, eds., *Radio Frequency Interference* (Newington: ARRL, 1984). QST

Strays

I would like to get in touch with...

☐ anyone with manuals or schematic diagrams for a Knight Star Roamer, a Globe Chief Model 90 transmitter, a Heathkit crystal receiver, Model CR-1, and a BC-454-B ARC 5 military receiver. Shawn Wakefield, KA5UDL, 120 NE Wilshire, Bartlesville, OK 74006.

☐ anyone with information on a VIC 20 computer 24-kbyte RAM Expansion Memory manufactured by MSD, Inc., Dallas, Texas. Rod Chandler, W6VB, 16299 Canelones Dr., Hacienda Heights, CA 91745.

☐ anyone with information on modifying a Kenwood TR-7500 transceiver to work the entire 2-meter spectrum. Dave Stepnowski, KC3AM, 735 W. Birchtree La., Claymont, DE 19703.

☐ anyone with a schematic diagram for a Hooker broadband bilinear amplifier, Model 100 Base. Armand E. Gilone, N4EPM, 1329 Kenlake Ave., Springhill, FL 33526.