

## Interference Primer—Part 3

### Telephone Interference

*Just when you thought it was safe to go back in the shack, Ed Hare, KA1CV, ARRL Laboratory Supervisor, is at it again! This time his topic is telephone interference—the bane of every amateur who has to go QRT whenever a telephone rings!—WB8IMY*

The cures for telephone interference are usually fairly easy to understand and implement, but there are often other issues that need to be addressed. Technical issues are really the second half of an interference problem. First and foremost you must deal with personal and political matters. The February and March 1992 *QST* Lab Notes columns discussed the nontechnical side of interference.<sup>1</sup> Read these columns again to refresh your memory. They've been reprinted in the ARRL Technical Department "RFI Package."<sup>2</sup> The "RFI Package" also contains a copy of our new RFI consumer pamphlet plus an up to date "ARRL RFI Resources Directory." The Directory tells you where to buy filters, identifies several EMI-resistant telephones and has a contact list for telephone manufacturers.

Now, let's answer your questions!

**Q:** *I was about two minutes into a QSO with a ham in Outer Elbonia when my doorbell starting bonging like crazy. It was my neighbor Sam, telling me that I was interfering with his new telephone. I tried to tell Sam that it might be the fault of his telephone, but he wasn't convinced. He insisted I was wrong because it's a brand-new model! According to the salesperson, his telephone is the very best one on the market. What's the deal, Mr EMI wizard?*

**A:** We'll have to break the bad news to Sam gently, but let's begin by establishing the fact that interference to telephones is not the fault of the transmitter. A quick quote from the FCC's *Interference Handbook*<sup>3</sup> should explain things clearly: "Telephones, stereos, computers, electronic organs and home intercom devices can receive interference from nearby radio transmitters. When this happens, the device improperly functions as a radio receiver. Proper shielding or filtering can eliminate such interference."

*The FCC doesn't require that telephones include EMI protection and they don't offer legal protection to users of telephones*

that are susceptible to interference. If you show this to Sam, he should realize that the interference is not caused by a problem on your end. Fig 1 pretty much sums up telephone interference at a glance!

This doesn't mean you should leave Sam on his own, though. You want to be on good terms with your neighbors; besides, maybe you'll want to put up a tower someday. Keeping Sam on your side is a good idea!

**Q:** *Fine, but what can I do?*

**A:** If you can reduce the strength of your signal at the telephone equipment or cables, you may reduce the chance that any of your neighbors will experience telephone interference. If practical, try moving your antenna or feed line farther away from (or higher than) his equipment. Using a common-mode choke on the feed line may help. (See Fig 2).

**Q:** *Well, I must confess that I've been interfering with the telephones in my own home, too. I remember your advice to make sure my own house is clean. Should I start here?*

**A:** You betcha! There are several good reasons to start in your own home. If you own your telephone wiring, you have the flexibility to try many different troubleshooting steps easily. If there are problems with Sam's telephone wiring system, however, you'll probably want to call a professional (often your local telephone company) to do the actual repairs. By performing repairs on Sam's wiring, you may be held liable for any problems that occur—even if the problem is with his toaster.

If you lack experience, you may want to hire local experts for your own wiring, too. Before you start troubleshooting your system, check with your local regulators. There may be state or local requirements that must be met.

There's another good reason to start with your own house: You'll be able to demonstrate that EMI cures are not only effective, they're harmless. The next time Sam complains about interference to his telephone, invite him to come over and try *your* telephone instead! By using your telephone when you're on the air, he'll quickly understand that the problem must be on his end.

**Q:** *Okay, I'm ready. Where do I begin?*

**A:** Read the March 1992 "Lab Notes" column and review some of the trouble-

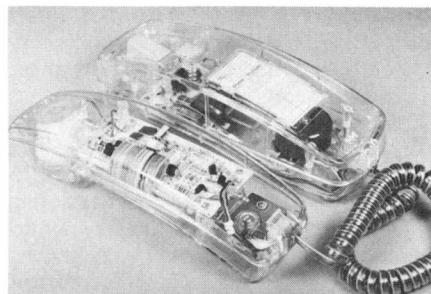


Fig 1—A transparent telephone allows us to see the internal circuitry. Not much shielding here. In fact, if we could see our phones with RF rather than visible light, this is what most telephones would look like!

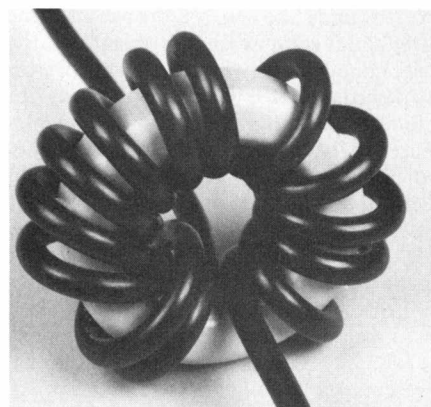


Fig 2—A common-mode choke for coaxial transmission lines. A similar technique is used to wind common-mode chokes for telephone wiring or ac-line cords. Use #75 ferrite material to suppress HF signals and #43 to suppress VHF.

shooting techniques. You can also learn quite a bit about troubleshooting telephone EMI problems from the troubleshooting and telephone chapters of the ARRL book *Radio Frequency Interference—How to Find It and Fix It*.<sup>4</sup>

Rule number one: Simplify the problem! If your home telephone system consists of eight two-line outlets with a telephone in each room, two answering machines, a modem and a fax machine, it may take quite a while to get it all straightened out. Simplifying the problem saves lots of time and headaches!

Most cases of interference stem from more than one cause. If you start with a systematic approach to troubleshooting—debugging and fixing the problems one at a time—you can usually resolve the inter-

<sup>1</sup>Notes appear on page 69.

ference quickly. Disconnect all but one telephone. Cure the EMI bugs (usually with the proper application of filters), then begin adding other devices one at a time, curing each EMI problem as you go. With any luck you'll complete the process with an EMI-free system. If not, at least you'll identify the specific equipment that's not immune.

In modern installations, telephone companies often install a phone jack where the wiring enters the house. This jack makes it easy to unplug the rest of the house wiring and substitute a telephone in its place. If you have access to an EMI-resistant telephone (refer to the ARRL "RFI Package"), you can try that phone at the service entrance (*drop*). If the EMI-resistant telephone doesn't pick up interference at that point, you've eliminated the telephone-company system as a possible culprit.

In many cases, the telephone company is responsible for their lines only up to the point where they attach to the customer's wiring and equipment.

**Q:** *Uh, oh! I plugged in my EMI-resistant phone and I still hear interference. What does this mean?*

**A:** It sounds like this is a problem for the telephone company. For example, the telephone-company lightning arrestor may be defective. Defective arrestors can act like diodes, rectifying any nearby RF energy (just like the crystal radios many of us built when we were kids). Telephone-line amplifiers or other electronic equipment may also be at fault. Leave the telephone-company equipment to the experts. There are important safety issues that are the sole responsibility of the telephone company.

In your case, the EMI-resistant telephone is probably responding to the audio that's present *after* the "diode" as a result of RF rectification. Once the RF has been detected and turned into audio, it *cannot* be filtered out because the interference is at the same frequency as the desired audio signal. This principle applies whether rectification occurs in the telephone company system, your house wiring or a defective telephone or answering machine in your home.

**Q:** *Well, I got the phone company repair personnel out here. They found a defective lightning protector. After they replaced it, I plugged my EMI-resistant telephone into the service entrance and it sounded fine. As soon as I reconnected the house wiring, the interference returned. What now?*

**A:** Replacing the arrestor wasn't a waste of time. Lightning arrestors are notorious for contributing to telephone EMI. This is especially true when the protector has done its job a few times! The fact that it's rectifying RF is one indication that it needed to be replaced anyway.

By plugging your EMI-resistant telephone in at the service entrance and finding no problems, you've proven that the EMI-resistant telephone and the phone system

are clean. When the problem reappears after you reconnect the house wiring, the house wiring itself is the prime suspect.

A careful inspection of the wiring may reveal the source of the problem. Years of exposure in damp basements, walls or crawl spaces may have caused deterioration. Be suspicious of splices that are corroded or badly discolored. Metal corrosion can form a fairly efficient diode, especially if dissimilar metals make contact. If you find this type of corrosion, correct the problem by repairing the splices.

In many cases, homeowners have installed their own telephone wiring, often using substandard wiring. If you find sections of telephone wiring made from two-conductor zip cord, 300-ohm television twin lead, or some other mystery cable, replace it with standard twisted-pair wire. Radio Shack, among others, sells several types of telephone wire. The best telephone wiring systems use twisted-pair, balanced wiring to minimize pickup of external electromagnetic fields. If this system becomes unbalanced in some way, perhaps by one of the wires developing a short circuit to a nearby conductor, the amount of RF picked up by the wiring will increase. Keep your eyes open for this type of problem when examining your existing twisted-pair wiring.

Don't forget to consider hidden, unexpected connections to the telephone line. If your telephone line is hard-wired to your automated alarm system, for example, you really haven't simplified the problem completely—there's still something hooked up to the line!

**Q:** *Bingo! I'd forgotten about the alarm system. When I disconnect the telephone line from the alarm box, my EMI-resistant telephone works fine in every house outlet. Why did the alarm system cause the problem?*

**A:** Well, I can't be sure without seeing the schematic. My guess is that the RF was being conducted down the telephone line and rectified by a solid-state device in the alarm system. The resulting audio signal was then placed back on the line. This effect is not uncommon with alarm systems, answering machines, fax systems and modems.

**Q:** *I have a service contract, so I called the alarm company. After a bit of discussion (which included a lot of pointing at the FCC Interference Handbook), the service installer agreed that he should fix the problem. Neither of us knows where to begin, though. Any ideas?*

**A:** You'll sometimes find that a manufacturer or utility company is willing to responsibly address an interference problem, but lacks the experience and training necessary to apply the correct solutions. You may need to apply your skills (and those of your ARRL Section Technical Coordinator or local RFI committee)

to help their personnel understand the technical issues.

Start by installing a commercially available telephone EMI filter on the alarm system line. Several companies advertise these filters in *QST*. A list is also included in the Technical Department "RFI Package."<sup>2</sup> If the unwanted RF energy is being conducted into the alarm system by the telephone wiring, this filter will block the energy from the components that are detecting the RF signal. As you can see in Fig 3, these modular filters are attractive—your family or neighbors probably won't object to them on aesthetic grounds.

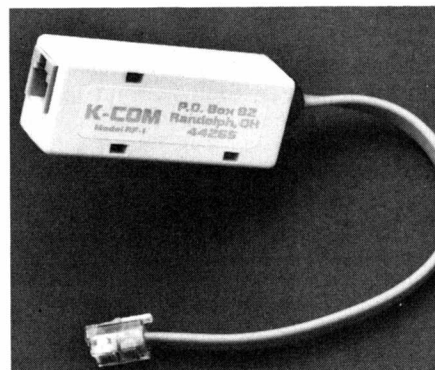


Fig 3—A typical modular telephone EMI filter.

If the telephone filter doesn't work, try installing a common-mode choke on the ac-line cord that supplies power to the alarm system. It may also be necessary to use a differential-mode ac line filter (the commonly available "brute force" filter) on the ac-line cord as well.

If all else fails, it may be necessary to modify the alarm system. This is another job for the experts. Suggest that the repair person contact the manufacturer.

These methods apply to any device connected to the telephone system: your alarm, modem, answering machine and so on. Ac-line-connected devices are much more prone to interference. After all, they offer two possible paths for the RF to enter: through the phone line *and* the ac line. In extreme cases, check any other wiring that connects to the susceptible device, including alarm system wiring and computer cables.

**Q:** *Great! The filters worked. I'll plug in all my goodies and go back to happy hamming!*

**A:** Whoa! Don't jump to conclusions! In addition to the gremlins you have uncovered so far, you may *still* have susceptibility problems with some of your telephones or your answering machine. Plug them in one at a time and see what happens.

**Q:** *The first two telephones worked, but my high-tech bells-and-whistles telephone hears my 40-meter signal just fine! It's my most*

**expensive telephone! Why is it defective? And why just 40 meters? What should I do?**

A: There are two types of telephones that seem to be most susceptible: the inexpensive ones that have virtually no shielding or filtering, and the expensive ones that have many solid-state devices rectifying RF signals. Of course, telephones that fall between these two categories have problems, too!

There may be several reasons why your gee-whiz telephone is particularly susceptible to interference from your 40-meter signal. For example, internal resonances in the telephone circuitry may allow more 40-meter RF energy to reach the susceptible component inside the telephone. However, in this case, it's more likely that the telephone wiring in your home is resonant on 40 meters. The telephone wiring, its associated grounds and any other equipment connected to the system form a large antenna. Like any antenna, this system has high- and low-impedance points. If the telephone happens to be located at one of these nodes (either high- or low-impedance) it may be subject to quite a bit of RF energy.

**Q: Wow! What can I do about it?**

A: Try a commercially available in-line modular telephone filter. These should be installed on the telephone line, as close to the telephone as possible, or on the handset. Telephone EMI filters are made by several different manufacturers and come in several varieties. The ARRL Laboratory Engineers have received reports from the field that the effectiveness of these filters varies from installation to installation, possibly dependent on the exact nature of resonances, impedances and system reactances. Many of these factors are hard to predict, so be prepared to experiment with several different manufacturers' filters in difficult cases.

You may also need to break up the resonances in the telephone wiring. Several manufacturers sell telephone EMI filters that can be installed at strategic points to detune the resonances. This is similar to the effect of using insulators to break up the guy wires on a tower to prevent them from resonating at amateur frequencies.

**Q: I thought I was finished until I got to my answering machine. When I hooked it back up, every telephone in the house had interference again. It sounds awful! What should I do?**

A: It's just a coincidence that your answering machine is doing this. It could just as easily have been one of your telephones—but it *does* give me a chance to give you two answers to one question (heh, heh!). Yours is a situation in which one susceptible device is detecting the RF energy and putting the resultant audio signal back on the telephone line.

You should do the same things to the answering machine (or any other ac-line-connected telephone device) that you did to the alarm system. Install a telephone line filter and don't forget to add a common-mode choke and a brute force ac-line filter on the answering machine line cord. This should clear up most cases of interference to these devices.

**Q: It sure did... but I need to bother you again! I have one telephone that's a real bear to fix. I've tried several different filters to no effect. Should I take it apart and put some filters inside?**

A: No! The manufacturer is responsible for the proper operation and repair of the telephone. The ARRL encourages all people who have an interference problem to contact the manufacturer of the susceptible device through the Electronic Industries Association, 2001 Pennsylvania Ave NW, Washington DC 20006. This helps ensure that the manufacturers (and their national association) are aware of the interference problems their customers are experiencing. Remember: interference that isn't reported officially doesn't exist! (Our "RFI Package" includes a report form—please use it!) Some manufacturers supply filters free of charge. We've even heard reports of major telephone manufacturers giving refunds for defective telephones.

Some consumer devices are so susceptible they can't be filtered externally. If the manufacturer is unable to help, the best solution might be to give the telephone to someone who lives far away from your transmitter and purchase an EMI-resistant telephone to replace it!

**Q: What about my cordless telephone? It seems to pick up interference no matter what I do. Is there anything that will cure the problem?**

A: The FCC does not intend Part 15 devices to be protected from interference. These devices usually have receivers with very wide front-end filtering, making them very susceptible to interference. A cordless telephone is a Part 15 device. It's an unlicensed transceiver that shares the spectrum with other users and services on a noninterference basis. There should be a label on the telephone, or a paragraph in the owner's manual, that explains that the telephone must not cause interference to other services, and must tolerate any interference caused to it.

It's worthwhile to try a telephone filter on the base unit and properly filter its ac-line cord. (You might get lucky!) The best source of help is the manufacturer, but they may point out that the Part 15 device is not protected from interference. These types of problems are difficult to fix after the fact. The necessary engineering should be done when the device is designed.

**Q: Well, that did it. Now my family can use the telephone while I'm on the air. My**

**teenagers thank you. I guess it's time to pay Sam a visit. Any last-minute words of wisdom?**

A: Don't forget *money* issues. Telephone companies often charge to come out and repair wiring. Repairing consumer electronic equipment usually isn't free, and telephone EMI filters require a bit of wallet-digging, too! You and Sam should discuss these issues up front, before you order filters or call the service department. You're *not* responsible for purchasing filters or repairing defects in your neighbor's house wiring. If you want to be neighborly and buy a filter for Sam, that's your choice. However, doing so may set a precedent. If you live in an apartment building where there are hundreds of telephones to contend with, you may have to reevaluate your generosity!

Telephone interference is like any other EMI problem—it usually can be cured by properly applying good troubleshooting techniques and effective filters.


#### Notes

<sup>1</sup>"Lab Notes," *Interference Primer—Part 1, QST*, Feb 1992, p 73. Also, "Lab Notes," *Interference Primer—Part 2, QST*, March 1992, p 81.

<sup>2</sup>The ARRL Technical Department "RFI Package" can be obtained by sending a 9- x 12-inch SASE with three units of First-Class postage to the ARRL Technical Department Secretary. Include your request for the "RFI Package".

<sup>3</sup>A copy of the FCC's *Interference Handbook* can be obtained by sending a 9- x 12-inch SASE with three units of First-Class postage to the ARRL Regulatory Information Branch. Include your request for the *FCC Interference Handbook*.

<sup>4</sup>*Radio Frequency Interference—How to Find It and Fix It* is available from your local dealer or directly from ARRL HQ. See the ARRL Publications Catalog elsewhere in this issue for ordering information.

We welcome your suggestions for topics to be discussed in *Lab Notes*, but we are unable to answer individual questions. Please send your comments or suggestions to: Lab Notes, ARRL, 225 Main St, Newington, CT 06111. 

## Strays



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In New York, the Troy ARA and the Rip Van Winkle ARS recently awarded Dave Watrous, WD2K, both certificates. Expecting to attend a regularly scheduled meeting, Watrous walked into a restaurant to find a pizza party being given in his honor!

### I would like to get in touch with...

amateurs who work for the British Oxygen Co Inc or any of the BOC Group's divisions. David Lain PhD, KA3ZKB, 9065 Guilford Rd, Columbia, MD 21046-1801.