Lab Notes

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Curing Interference to Non-Radio Equipment

The ARRL Laboratory staff is continuing to receive phone calls and letters about interference problems, so this month we will continue our "Lab Notes" series on EMI/RFI. At first glance, interference to non-radio equipment sounds like it should be easy to understand and solve, but, as always, the issues are complex and the solutions are sometimes elusive. In addition to the "personal diplomacy" involved, you and your neighbor must understand the regulatory and technical aspects of the problem.

We have called on our EMI/RFI guru again. Ed Hare, KA1CV, our Laboratory Supervisor and co-editor of our RFI book, will help unravel some of the mystery.

Q: Well, it happened again! Just when I got Sam's television and telephone interference problems under control, my other neighbor, Sally, bought a new stereo system. Just as I fired up on 20-meters, my telephone rang. Sally was very upset! My transmitter was interfering with her new purchase. She says it's all my fault because the stereo system is brand new. I want to help her, but I think I need to understand more about the subject. Can you help?

A: I wish I had a nickel for every time I've heard a similar tale. I'll be glad to offer some advice, but first I want to take you back in time a bit.

We started this EMI/RFI "Lab Notes" series in February and March 1992 *QST*. Those two articles discussed the important personal and technical issues that surround any EMI/RFI problem and told you how to contact a valuable local resource—your ARRL section Technical Coordinator (TC). If you have the back issues, read them. If you gave them away to your local library, or are a new League member (welcome to the hobby!), a reprint is included in the "EMI/RFI Package,"[1] available from the ARRL Technical Department Secretary.

Q: I just sent for the package, but I'm still wondering if the problem really is my fault after all. Should I put a filter on my transmitter?

A: No. Remember, you are interfering with a non-radio device. The FCC's *Interference Handbook 1990 Edition*[2] says "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."

Her stereo is picking up your RF signal. If your transmitter is not putting out illegal spurious signals, your spurious emissions are 30 to 60 dB weaker than your fundamental. This means that these spurs are 1000 to 1,000,000 times weaker than your fundamental signal. The problem is almost certainly not caused by harmonics.

Q: I guess the FCC has let me off the hook, right?

A: You are indeed off the hook, at least as far as the technical and regulatory issues are concerned. But remember, Sally is your neighbor. You may want to offer a helping hand anyway. Amateur Radio is known for its public-service contributions. Applying your technical skills, or those of your TC or local EMI/RFI Committee, to a neighborhood problem is a form of public service. So let's see how we can help.

Q: Well, the ARRL "EMI/RFI Package" arrived in this morning's mail. You didn't tell me it had a pamphlet about interference that was written just for my neighbor! I gave it to Sally and after she read it, she (somewhat reluctantly) agreed that it might not be my fault. She is ready to work with me toward a solution. Where do we begin?

A: Let me start with a stern warning! Do *not* attempt to repair your neighbor's equipment. The problem can often be fixed with the proper application of internal filtering and shielding, but this is something that is best done by the manufacturer. Think of the possible consequences. If you dismantle Sally's new stereo system, you may be setting yourself up for some real problems. You'll probably void her warranty. This means that anything that goes wrong with that system, *ever*, will be your fault as far as she is concerned!

If you work on her system, you may also be breaking the law. Most states have laws that prohibit you from working on your neighbor's electronic equipment (even for free) unless you hold a valid state service license. Your ham license, although a valued document, is no substitute.

Q: Should I tell Sally that there is nothing I can do?

A: No. There is a lot you can do! You can help her contact the manufacturer of the stereo system. The Electronic Industries Association, 2001 Pennsylvania Ave. NW, Washington, DC 20006, tel 202-457-4977 maintains a database of key contact people at each manufacturer.

You may discover that the manufacturer already has some easy fixes available. Some manufacturers even offer to do the work under warranty, or supply free filters.

Once you and Sally have located a manufacturer's representative to repair the stereo, you can help that representative understand the technical issues involved. The manufacturers are usually willing to assume their responsibilities fairly, but they do not always understand the fundamental causes of the problem, nor all the solutions. The ARRL has published an RFI book, *Radio Frequency Interference — How to Find It and Fix It.*[3] Buy a copy and read the chapters on fundamentals and curing audio equipment interference.

You can also make your station available for testing when the electronic service person arrives. Sometimes several things need to be tried before the magic combination is found. If you're not there to put the radio signal on the air, the service person will have no way of knowing whether the cures actually worked.

Q: The manufacturer has agreed to send a service person to investigate the problem. If I'm going to help, I guess I'd better sharpen my skills. I've read the "EMI/RFI Package" and learned a bit about troubleshooting. What's the best way to start?

A: Start by simplifying the problem. Disconnect all inputs to the stereo system, one by one, and see if the interference suddenly goes away. If you disconnect the FM tuner, for example, and the interference stops, you've found a culprit. Now you know where to apply the cure. (Of course, this doesn't apply to a unit that is all self-contained.)

Q: We disconnected everything, including the long audio cable from Sally's stereo TV. The interference is still there.

A: That's unfortunate. Those long cables are prime suspects. They make make a nice long-wire antennas and they pick up a lot of RF. Let's recall an old electromagnetic compatibility (EMC) engineer's adage: Components don't pick up RF energy—wires do! Take a look at the wires that are connected to her amplifier.

Q: Well, the only wires I see are the speaker wires. She has the speakers located about 15 feet from the stereo. Hmmm... the wires are just about the size of my 20-meter dipole. Is that why she gets interference when I operate on 20 meters?

A: Could be! Speaker wires are often 8- or 16-feet long. When you put two of them together, you make an efficient ham-band receive antenna—not something you want to connect to your neighbor's stereo. Try bundling the speaker wires to reduce their

[1]Notes appear on page 65.

effectiveness as an antenna. This procedure has been known to eliminate the interference all by itself.

Q: Well, we moved the speakers and tried bundling the wires. It helped somewhat, but not enough. "CQ DX" is still interspersed with her favorite songs. What's next?

A: You're on the right track. Try this: Disconnect the speaker wires altogether and plug in a set of headphones. What happens?

Q: The interference is gone! However, Sally is understandably reluctant to use her headphones whenever she wants to listen to her stereo. Now what?

A: Well, you've just learned that the RF is being picked up on the speaker wires and being conducted into the amplifier. (The output transistors are possibly rectifying the RF into audio, and the amplifier's internal negative feedback circuitry is conducting it back to the high-gain stages of the amplifier.) Let's start with a common-mode choke.

Q: I think Sally had a different kind of choke in mind—one that involves my neck! What is a common-mode choke?

A: For a detailed explanation, I will refer you to the RFI book. However, I will gladly tell you how to build one (two actually, you will need one for each speaker output). Wrap ten to fifteen turns of speaker wire onto an FT-140-43 ferrite core. (Use an FT-240-43 if the speaker wires are large, and use -73 material for interference from 80- or 160-meter signals.) The common-mode chokes should be installed right at the amplifier. If the system uses amplified speakers, you should install one at each speaker, too.

Another possibility is to try a few commercially available filters. Here are two companies that sell filters specifically designed for audio systems:

Industrial Communications Engineers, POB 18495, Indianapolis IN, 46218-0495, tel 317-545-5412. Model 461 series.

TCE Labs, RR9 Box 243D, New Braunfels TX 78133, tel 800-KILL-TVI. Model SP-1.

Both of these companies have fine reputations, and sell a broad line of other interference-reduction products. Contact them for more information.

Q: I read an old QST article that recommended placing a 0.01 µF capacitor across the speaker terminals. Wouldn't that be a lot easier?

A: *Don't do it!* That was good advice when amplifiers used tubes. Many modern solid-state amplifiers don't work well into capacitive loads. In fact, they can break into a full-power (sometimes ultrasonic) oscillation. This can result in the near-instantaneous destruction of the output module or transistors. And if you think you had a diplomacy problem *before* you blow up her stereo, think what will happen after you let out all the smoke!

Q: Thanks for the warning! Where do I get the right ferrite chokes?

A: The ARRL "RFI Package" contains a list of EMI/RFI materials suppliers. You can also refer to the advertisements in *QST* — there are a few advertisers offering ferrite materials and chokes.

Q: I installed the speaker-lead chokes, and they worked like champs! However, as soon as I hook up the long cable to the TV set, the interference returned. Should I put chokes on that cable, too?

A: Yes. Many interference problems have multiple causes. This is why we simplify the problem into manageable-sized pieces. Try a ferrite common-mode choke at one or both ends of long cable.

Q: The chokes helped somewhat. What else can I try?

A: Now we are getting into the more complicated cures. You many need to use an L/C filter in the input lines as well. The ARRL RFI book contains information about how to buy or build one.

Q: We're going to order a filter. In the meantime, Sally has decided to forgo her stereo TV connection. I guess everything is under control. Am I going to have similar problems if one of my neighbors installs an intercom or alarm system?

A: You might. Many of these devices are not designed with EMC in mind. But you have learned many things from your stereo experiences that you can apply to nearly any non-radio interference problem.

You can make use of those 0.01 µF capacitors, putting them across (or from both terminals to ground) of simple alarm systems, or across input connections to intercoms. You can also install some common-mode chokes on long wire runs. Some people have reported that a single choke for both wires in a twisted pair works best; others have reported that a separate ferrite choke for each wire cured the interference.

In any case, contact the manufacturer through the Electronic Industries Association. This not only assures that you get the best possible source of help, but it also ensures that the manufacturer knows when people are having problems with their systems.

You can also contact me here at ARRL Headquarters to get advice on how to fix an interference problem that has stumped you and your ARRL section Technical Coordinator. Good luck!

Notes

[1]The ARRL Technical Department "RFI Package" can be obtained by sending a large (9 ×12) self-addressed stamped envelope to the ARRL Technical Department Secretary. Include a specific request for the "RFI Package." The package is rather large so three units of postage is appreciated.

[2]A copy of the FCC *Interference Handbook* can be obtained by sending a large (9 ×12) self-addressed stamp envelope to the ARRL Regulatory Information Branch. Include a specific request for the FCC *Interference Handbook*. Three units of postage is appreciated.

[3]*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. QST

New Products

HAND-HELD TRANSCEIVER

◊ Midland International Corp returns to the Amateur Radio field with its model 73-005 2-meter FM hand-held rig. It features an 18-function LCD display, multifunction scanning with pause or busy modes, 20 memories, five custom repeater offsets, rotary knob or direct-entry frequency selection, DTMF tone squelch and continuous tone-coded squelch system (CTCSS), a power output of 0.35-5 watts and extended receive coverage (135-170 MHz). The 6.5-oz radio has a manufacturer's suggested retail price of $449. Consumer Communication Div, Midland, 1690 N Topping, Kansas City, MO 86120; tel 800-MIDLAND (800-643-5263) or 816-241-8500, fax 816-245-1144.

NOISE ELIMINATOR

◊ Amateurs and shortwave listeners will hear their receivers slice through static and atmospheric noise with the NRF-7 general-purpose noise remover and filter kit from JPS Communications. It uses digital signal processing (DSP) to reduce noise and remove multiple audio tones or carriers. It has a linear-phase data filter, deep-skirted CW and SSB filters, selectable CW carrier frequency, a peak filter and an automatic notch filter that typically eliminates unwanted tones in less than 5 ms. The NRF-7 operates on your radio's audio output, has a built-in 2-watt speaker amplifier, a 10-position rotary selector switch and an LED tuning indicator. It operates on 12 V dc with a switch to completely bypass the unit when the power is off. The retail price is $249.95.

Amateurs can connect their radio stations to the telephone system with the RTU-250 radio/telephone interface, a unique two-way phone patch that uses DSP technology. It eliminates false VOX tripping and oscillation in full-duplex circuits, reduces time-consuming set-up, provides hybrid balance with no adjustments and automatically adapts to changing phone-line conditions. The compact desktop unit fits under a standard telephone set and is easily connected to most transceivers. The retail price is $590.

JPS Communications Inc, PO Box 97757, Raleigh, NC 27624-7757; tel 919-790-1011, fax 919-790-1456. QST