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Lab Notes

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ELECTRONIC TROUBLESHOOTING

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Q: Someone just gave me a collection of used amateur equipment, but some of it doesn't seem to be working right. I've built a few kits, and understand electronics fairly well, but don't know much about troubleshooting. Should I try to fix this stuff myself?

A: In ham jargon, a collection of used equipment is known as "junque." The pseudo-French spelling is employed to remind us that there is treasure in some of the older equipment we discover from time to time.

You don't need to be an engineer to fix electronic equipment! In fact, some of the engineers I've known were not good troubleshooters. Nearly anyone who is familiar with basic electronic theory can learn troubleshooting techniques and fix many types of electronic failures. To troubleshoot, you simply follow logical, step-by-step procedures to arrive at a solution.

You *do* need to be able to read a schematic diagram and understand basic circuit functions. More importantly, you need to understand basic safety rules! Some of the voltages found in electronic equipment are lethal. Refer to the important information in the 1995 *ARRL Handbook* safety and troubleshooting chapters.

Q: What sort of test equipment will I find useful?

A: Let's start with the basics. If you do a lot of troubleshooting, you'll need a good multimeter for voltage, resistance and current measurements. Modern multimeters can sometimes include such frills as capacitance and inductance meters, and even transistor testers. An oscilloscope can be useful for looking at RF, audio or digital waveforms. A power supply is handy when you need to power the equipment under test, or as a troubleshooting substitute for a defective power supply. If you're troubleshooting old tube-type rigs, a tube tester will help diagnose defective vacuum tubes.

Many electronic problems are sensitive to heat—a unit may work well when it is first turned on, then fail as it warms up. A heat lamp and cold spray[1] may help isolate these thermal problems. First, use the heat lamp to warm the circuitry quickly (don't overdo it!). When the failure occurs, use the cold spray to cool down components one at a time. When the circuit suddenly starts working again, you've found the bad part.

Q: I own most of the test equipment you describe, so I guess I'm ready. Where should I begin?

A: Start by reading through the owner's manual. Make sure you understand the equipment and how it is supposed to work. Does the owner's manual contain a schematic? Even better, can you get a *service* manual for the unit? There are a number of sources for manuals. The most logical is the original equipment manufacturer. The June 1992 issue of *QST* featured a "Lab Notes" column that described a number of companies that sell reproductions of older equipment manuals.

Try the easy things first (if they are real easy, try them twice!) Check the obvious: it would be a shame to spend hours of troubleshooting only to discover a bad fuse.

Q: Are there any general guidelines to follow?

A: Perhaps the most important rule is to *simplify the problem!* If you're troubleshooting a complex system, perhaps an entire amateur station, it may be difficult to determine why no RF is coming out if you have a number of units hooked together in complex ways. In this case, start by testing *only* the transceiver, preferably into a dummy load. If it tests okay, start adding things back one at a time. The problem will diagnose itself pretty quickly. This principle can be applied at many points in the troubleshooting process.

Most failures are catastrophic. It is rare that a circuit will half work. An amplifier stage is usually dead or working, a digital circuit works, or is stuck in one state. Many problems have *multiple* causes, and the problem won't be fixed until you find them all.

Q: Okay, enough preliminary chatter. When do I get to take something apart?

A: Right now! Assuming that you've obtained a schematic, have run through the preliminary diagnosis, and are certain that the problem isn't something obvious, it's time to take the unit apart.

Take notes while you're unscrewing chassis plates and disconnecting cables and wires. You'll need to remember how to put it all back together. If you have to order a part that takes a month to arrive, you may forget which cables or screws went where. If you own a camcorder, use it to make a video record of your work.

Q: Well, the back is off and I have my voltmeter at the ready. What's next?

A: Put the voltmeter down! Before you begin making measurements, spend about 15 minutes looking the unit over from stem to stern. Think of it this way: You're preparing to spend a few hours diagnosing a complex unit. About half of the problems I've seen over the years have exhibited a *visible* symptom—a broken wire, a burned resistor, a loose connector or a cold solder joint. It is much more efficient to find the problem visually, if you can. In 15 minutes, you'll be able to look at every component, wire and connector.

Q: I found a broken wire and repaired it, but the unit still doesn't work. What else can I do?

A: This demonstrates an earlier point—many problems involve multiple causes. The next thing you need to do is to isolate the problem to a single circuit. You're not an experienced troubleshooter, so I recommend one of the systematic approaches to troubleshooting—signal tracing or signal injection.

Let me give you an example. We'll use the block diagram of an AM broadcast receiver shown in Figure 1. Before we can trace a signal, we need to create one. Tune the receiver to 1 MHz and set up a signal generator to provide a 50-µV signal, amplitude modulated with a 1-kHz tone. (The *ARRL Handbook* has a test-equipment chapter that will explain how a signal generator functions.) Feed the generator output to the antenna jack.

Then, use a signal tracer to follow the test signal through the receiver, starting at the input and working toward the output. When you find the stage where the signal disappears, you're *very* close to the problem. In Figure 1, if the IF (intermediate-frequency amplifier) stage was defective, you would find the signal at point "A," but not at point "B."

Q: Wait a minute. What is a signal tracer?

A: A signal tracer gives an audible or visible indication of the presence of a signal. Several different types of test equipment can function as signal tracers. An oscilloscope can be used to visually measure a number of different signal types. A diode RF detector can be used with an audio sound system to detect and listen to a signal. The same detector can sometimes be used with a voltmeter to follow a signal through a system. Refer to the *Handbook* for more information.

Q: What about signal injection?

A: Signal injection is the opposite of signal tracing. You inject a signal at various stages in the system, starting at the output and working your way toward the input. You may need to select different frequencies for each stage. In the block diagram shown in Figure 1, you would begin by injecting an audio signal at the output of the AF (audio frequency) amplifier. You should hear sound coming from the receiver's speaker. You would then move the AF signal to the input of the AF amplifier. If the AF amplifier is functioning, you would still hear the sound. You should then use a modulated signal at the frequency of the IF amplifier. Inject that signal at the output of the IF amplifier. If you hear sound, move to the input. If the IF amplifier is defective, you would hear sound when you inject a signal at point "B," but the sound would disappear when you inject a signal at point "A."

Q: Well, I found a defective AF amplifier in my receiver. What should I do now?

A:Start with voltage readings. If your schematic includes voltage readings, compare those in your circuit against those in the schematic. Any variance greater than about 20% is cause for concern. Refer to the sample circuit shown in Figure 2. If the collector voltage is near 0 V, I would suspect a shorted transistor, or open resistor (R4). This symptom could also be triggered if R2 was open. (This is where general electronic knowledge can pay off, by suggesting what types of component failures can cause what symptoms.)

You may need to test each of these components. By using a modern voltmeter that uses only a few millivolts to measure resistance, it should be easy to measure the components in-circuit. In more complex circuits, especially those using inductors, some components may need to be removed before testing.

Watch out for multiple failures. If R4 is open, there is a good possibility that the failure was caused by a short circuit in Q1. These types of problems are common in electronic circuits.

Q: I discovered that the +12 V was missing entirely. When I checked a few other places in the radio, it was missing there, too. Is my power supply bad?

A: Bingo! Actually, I goofed; I should have told you to check the power supply first. Power supplies often need to supply and dissipate quite a bit of energy. This makes power supply failures fairly common.

Q: I got the radio working. Is it time to do an alignment?

A: Beware the urge to align radio circuits! Most equipment does not require such adjustments on a regular basis. The most common reason a circuit needs alignment is because someone else botched it the first time. If frequency-determining components have been changed in the RF or IF amplifiers, if the circuits are fairly old or have been subject to severe environmental conditions, or if someone "tightened all the loose screws" in those little cans (the IF transformers), the unit needs to be realigned.

Q: I think I'll pass on the alignment for now. The rig is working so I guess it's time to put it all back together, right?

A: Not so fast! First, make a final visual inspection. You want to check the quality of your work. Look at solder joints, double check the replaced parts, make sure there are no pinched or burned wires. Once again, power it up and look for signs of trouble. Operate the rig for a while and let it get good and warm. Once you're satisfied that it's good to go, round up your screws and bolts. Even after the last screw is in place, check the unit one more time.

Q: Thanks for the tips. I was able to fix some of the equipment. Others looked too far gone to warrant any serious attention. But there was one H-T that I'd love to fix, but it has layers of small parts in hard-to-find places. I couldn't make any headway with that one. Is it time for a professional?

A: When my H-T broke, I sent it away for repairs. Some repairs are best left to the pros. The factory repair staff has experience with their products and can usually fix them efficiently.

(1) Freeze spray is distributed by GC Thorsen, PO Box 1209, Rockford, IL 61102; tel 800-443-0852 (call for nearest distributor). It is also sold by most electronic-component distributors.

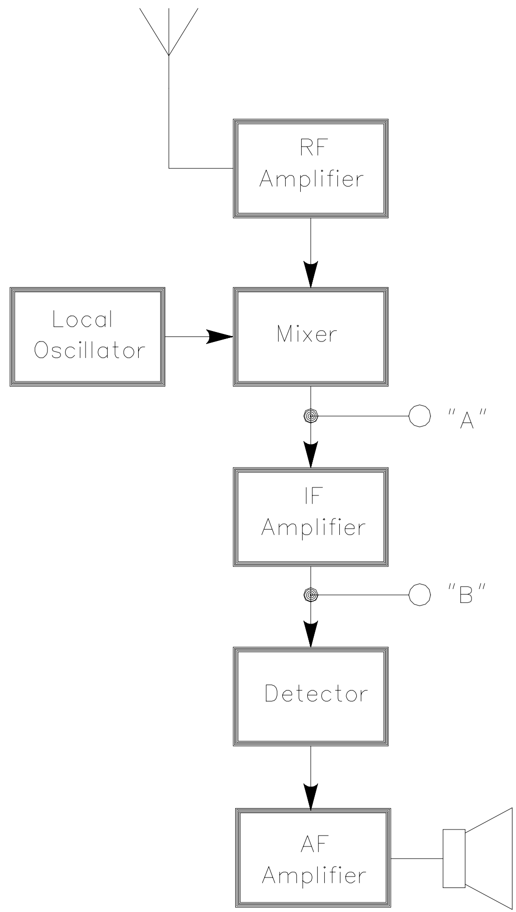

Figure 1—A simplified block diagram of an AM broadcast receiver.

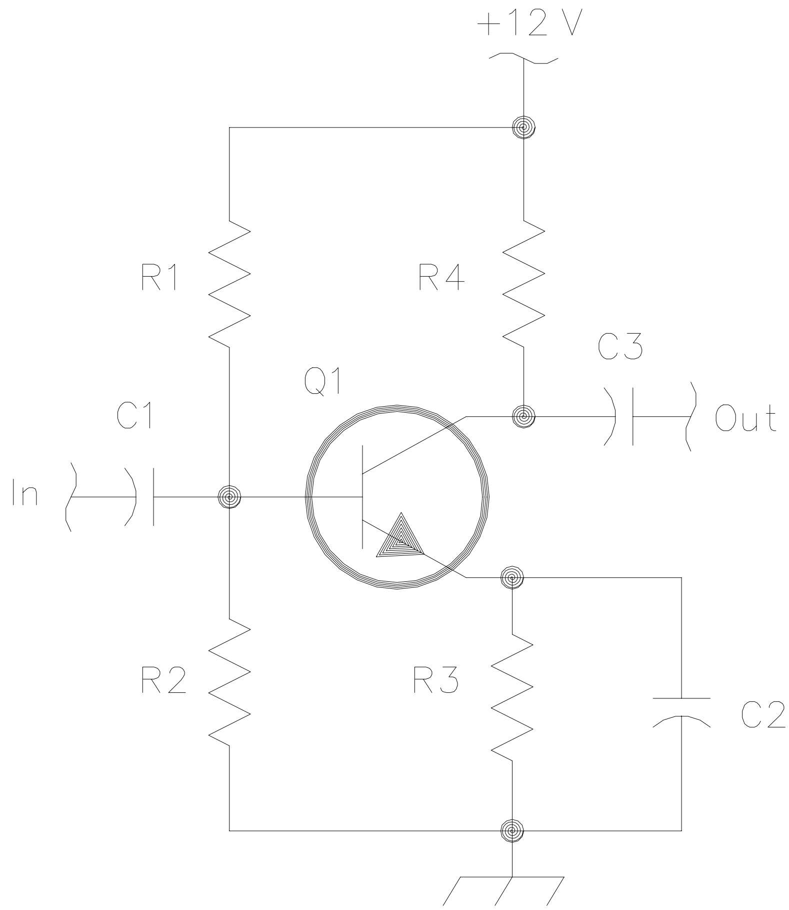

Figure 2—A one-transistor audio-frequency (AF) amplifier stage.

“Live” Troubleshooting

When you’re tracing signals through an active circuit, remember that dangerous voltages exist inside most electronic equipment. Even solid-state gear often has 117 V ac at the input side of the power supply. Some equipment uses circuitry that can put 117 V on the chassis. Simply turning off the power is not enough; some components can store a charge for a surprisingly long time. If you’re not *certain* that you’re qualified to work on live circuits, leave this to the professionals.