

Troubleshooting Radio Frequency Interference Problems



Judging from the volume of related messages on the Syn-Aud-Con listserv, radio frequency interference (RFI) is a major problem in many systems. The quantity and quality of responses concerning RFI problems has been astounding. I thought it would be a good idea to compile all of that useful information into a document that will help others solve these perplexing problems. Pat Brown

You turn on the sound system and you hear a radio station. Now what? Let's lay aside the "magic fixes" and "voodoo methods" and set forth a methodical procedure to deal with the problem.

The key here is to "divide and conquer." It is essential that the problem be localized to one part of the sound system. If more than one problem exists, these tests will help disclose that also. Start with simple tests and proceed to more rigorous ones. Problems range from simple to complex, but more fall into the simple category.

Tools to aid in RFI troubleshooting:

Here are some basic things that you will need for troubleshooting RFI problems. There are MUCH more esoteric gadgets out there which can prove invaluable under many circumstances. But before we pull out the "big guns" let's look at some inexpensive tools that will locate most of the problems.

- Headphone amplifier
- Dynamic microphone
- Mic to line preamp
- Battery-operated Phantom Power Supply
- Ohm meter

Divide and Conquer

Drop the level of the main fader on the mixer. If the RFI drops in level, you have localized it to the front end of the mixer (at least ahead of the main potentiometer). If it does

not go away, unplug the output of the mixer from the rest of the system. If there is still RFI at the output of the system, there is help later in this document. If unplugging the mixer output stopped the RFI, the problem lies in the mixer and/or devices connected to it. Listen to the mixer output through a headphone amplifier (battery powered) and continue on. Shure makes one that has a transformer-balanced input (Model FP12) - highly recommended for this purpose.



*Tools of the trade...
 Headphone amplifier and mic preamp -
 both battery powered (courtesy Shure Bros.)*

Check the Mic Lines

Drop the channel faders on the console one-by-one. If the problem goes away when a specific channel is dropped, you have isolated the problem. If the RFI drops in level a little with each channel, you may have found many problems! It is important to determine whether the RFI is getting into the mic lines (very common) or somewhere else.

Listen to each mic line individually through the headphone amplifier. You may need an external phantom power supply for condenser microphones. If the mic lines are clean through the headphone amp, but have RFI through the mixer, the mixer input may not be grounded properly or may not be RFI immune. See the section on mixer inputs for some other things to try.

Mixer Problems?

Pick the mixer up and turn it. The RFI will either get better, get worse, or stay the same. If this changes the level of the RFI, consult the manufacturer of the mixer.

Too Many Grounds

Using an appropriate outlet tester, check the AC socket that the mixer is plugged into to make sure that it is properly grounded. Disconnect each mic line from the mixer. Using an ohm meter, check for shorts between any of the three conductors and a building ground. The building ground should be accessible on the 3rd prong of the AC outlet that the mixer is plugged into. Mic lines often get “unbalanced” by a conductor getting shorted to conduit, etc. somewhere up the path. They will still work, but will be noisy since there is no common-mode rejection at the balanced input of the device. Electricians often ground audio shields to conduits, jack plates, etc. The only ground on a mic line should be at the mixer! Find the improper grounds and disconnect them.

If you are in doubt at all about the condition of the building electrical ground, have a qualified electrician check it out. It is usually a bad idea to drive a dedicated ground rod for the audio system, as it establishes different ground potentials for different electrical devices in the same building.

Shorted Shields?

Using an ohmmeter, check for shorts between shields of pairs of multiconductor cables. Each pair of a snake cable should be individually shielded, and each shield should be isolated from the other shields. When the outer jacket is removed from a snake cable for wiring purposes, it is important to heat shrink the individual pairs to maintain their isolation. This is a time consuming process, and many installers overlook it. If there are shorts between shields that can't be located at either end, you may need to pull new wire.

Ron Steinberg of Rentcom Communications told of an installation that was an RFI/EMI nightmare. Upon testing the newly installed mic lines, it was discovered that there was no

continuity between the drain wire and the foil shield (an extra layer of Mylar was isolating them). Very unusual, but not impossible. The manufacturer replaced the wire without question. The moral of the story? Assume nothing.

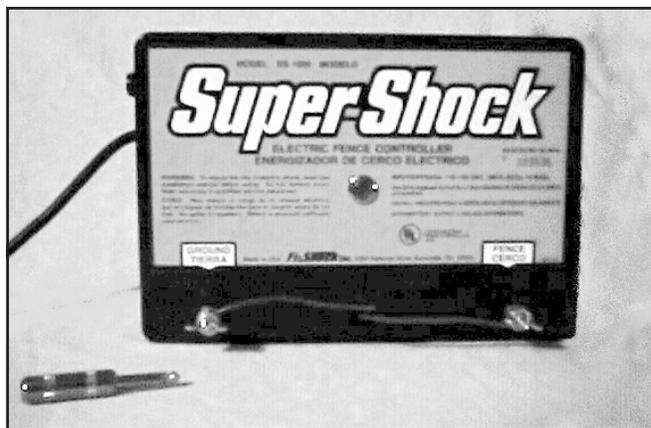
Choir Mic Problems

Are the choir mics causing RFI problems? Most choir mics have a “module” that goes on the end of the line from the mixer. A small diameter cable proceeds from that point to the microphone. On most choir mics, this is an unbalanced line. Such lines should be cut to length, and never coiled up. Unplug the mic line from the module, leaving the module plugged into the mixer. Does the problem go away? No? Unhook the module and plug in a regular dynamic microphone into the mixer through the same mic line. Does the problem go away? You may need to install filters on the mic input to the module. Better yet, consult the manufacturer of the microphone for some remedies. Chances are you aren't the first one that has had this problem.

RFI source

Caution! - The following test should be performed with care in your shop or service department.

Sometimes RFI problems are intermittent. A useful tool is a broadband RFI source that can be used to “infect” a component with RFI. Sounds expensive? Not really. The author uses an electric fence charger for this purpose. These are available from any farm supply store, and are priced from \$50 to \$75. A fence charger is a high-voltage/low current source for powering electric fences. This simple box has an AC cord and two terminals - one is “hot” and the other is ground. Take two pieces of 12 gauge solid copper wire (Romex works well) and connect them to each terminal. Strip back the last .25 inch of insulation from each, exposing the copper conductor. Bend the two wires so that the exposed ends are about one-eighth inch apart. Plug the unit in. You will get a spark at one-second intervals. The spark is a very broadband source of RFI, and

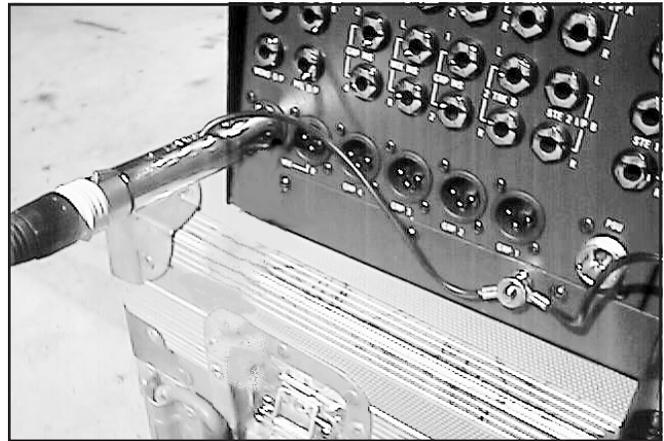


An electric fence charger can be used as an RFI source. See text for guidelines.

interference from it will audible on any radio station and all TV stations - both VHF and UHF. If there is an RF path into your sound system, this will find it! Use caution and common sense here. The shock from these devices is significant (can put a bull on its knees), so make sure that you set it up safely. Also, make sure that any nearby computers or DSP processors are switched off, as the generator may interfere with them. This is EXTREMELY important. The RF energy will obey the inverse-square law, so a location for the generator within 5-10 feet of the mixer should be adequate.

The pulsing “snap” of the spark will be clearly identifiable as you listen to the outputs of the mixer, mic lines, etc. For increased resolution, use an oscilloscope.

If you can keep this out of your sound system, you can keep out anything.



A barrel connector can be used to establish a good chassis ground for a long cable run.

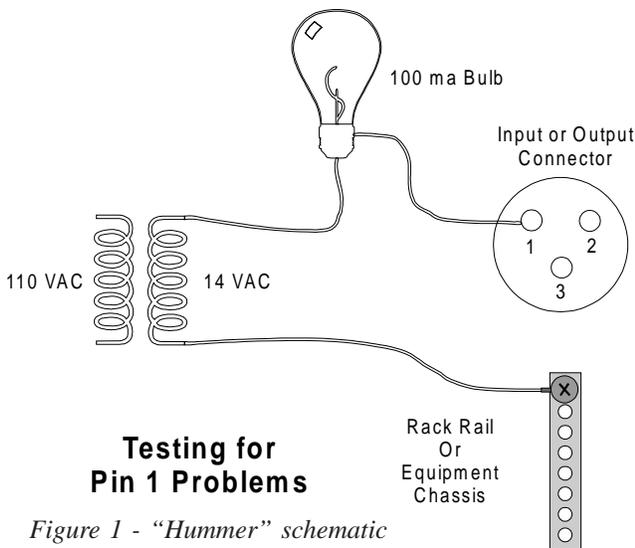


Figure 1 - “Hummer” schematic

Back to Pin 1

Make certain that the mixer is earth grounded on pin 1 of all input and output connectors. This is a VERY common problem that can result in RFI getting into the internal circuitry through the pin 1 connection. One test that will reveal this is the “hummer” test described in our last newsletter. The “hummer” test involves feeding about 100 ma of current into pin 1

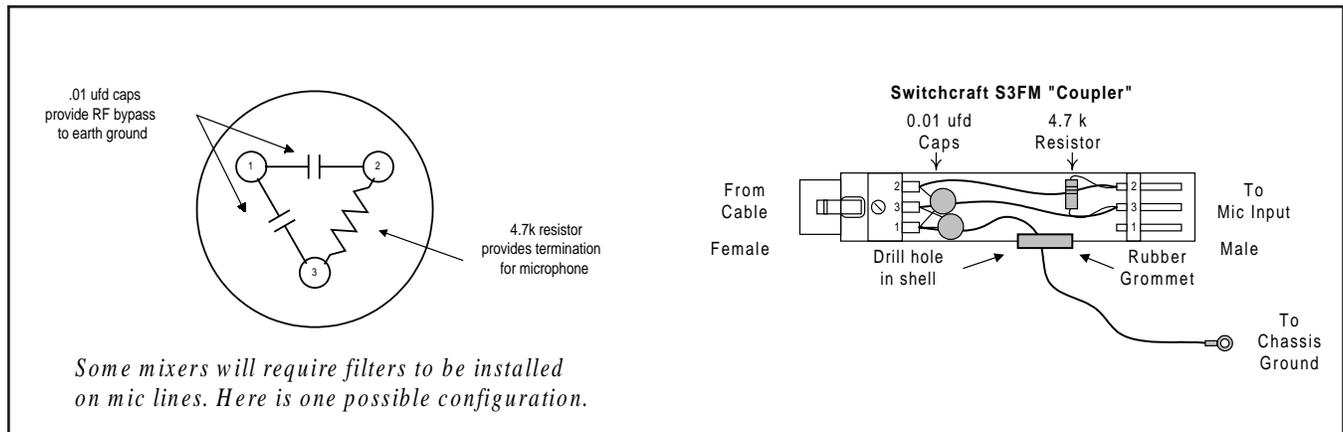
and listening to the mixer output for hum. See figure 1 for a hummer schematic. If your mixer has a pin 1 problem, consider breaking the shields out of the XLR plugs and tying them directly to the mixer case. You may have to scrape a little paint to get to metal, but it is important that the noise currents in the shield go to earth and not onto the circuit board. The procedure is well-documented in the June 1995 AES Journal, with a number of grounding and shielding authorities commenting on the procedure.

Try a different mixer

Before you go to too much trouble, try substituting another mixer for the one that you are using. I keep a small, four channel unit for this purpose. It has transformer-balanced inputs and outputs, and runs off of batteries which keeps it isolated from the building AC and grounds. If your mic lines still have RF when hooked-up to this mixer, your problem is getting more serious. If the problem goes away, you will quickly learn why some mixers cost much more than others. Remember, it’s the stuff on the inside that counts.

Rule out the wire

Substitute a different mic line. I keep a 100’ length of “star quad” cable for making acoustic measurements. Substitute such a cable for your installed mic line. Just lay it out



Some mixers will require filters to be installed on mic lines. Here is one possible configuration.

along the same path and hook the mic to it. If the RFI goes away, you have learned why some wire costs more than others. In sensitive installations, this is a test that you will want to perform before you spec the wire.

Filtering Out RFI

When all else fails, you may need to install some filters on input and output lines. These filters come in several forms. The most readily available (and simplest) are ceramic disc capacitors. These are soldered from pins 2 and 3 to pin 1 (see diagram). The capacitor becomes a low-pass filter that provides a low impedance path for frequencies above its corner frequency to ground. What is the correct value? A common one is 0.01 microfarads. Since the filtering characteristics are dependent upon the circuit impedance, the best thing to do is to start with a small value and increase it until the high-frequency roll-off becomes audible (broad band pink or white noise as a source). A capacitor substitution box works well for this purpose. Be sure to use the same value on each pin. Sometimes it is necessary to achieve a steeper roll-off than a single capacitor can provide. You can accomplish this by using a series inductor (or “choke”) along with the capacitor. These can be acquired at the local Radio Shack. Ferrite beads are also useful as input filters. These can be slipped over a small length of bus wire and placed in series with the signal. RFI filters can get quite complex, and only some simple examples have been listed here. Before you get too elaborate, make certain that you are not attempting to “cover-up” a de-

sign flaw in one of the sound system components. The most practical way to fix such problems is to consult the manufacturer or substitute a different device for the one giving you headaches. Sometimes manufacturers are reluctant to admit that their product(s) have a problem, so prove it to yourself by the substitution method.

When you find yourself resorting to these kinds of methods, the best solution often is to install input transformers on the offending mic lines. Transformers offer the highest RFI immunity and RFI “blocking” capability of all methods discussed. Their sole drawback is cost. Then again, if you are making your fifth trip back to a venue to troubleshoot RFI problems, transformers start to look quite economical!

It is rare, but not impossible, for RFI to get into the system after the mixer. Make certain that you isolate the problem to pre or post mixer immediately. This can save you hours of troubleshooting.

Radio-frequency interference can be a major problem for system installers and designers. The measures contained herein represent ideas contributed by a large group of audio professionals, and should suffice in correcting most RFI problems that are not design flaws in signal processing equipment. When in doubt as to a device’s RFI immunity, **SUBSTITUTE A KNOWN-GOOD DEVICE**. One learns to appreciate very quickly the price and performance of professional-quality equipment in high-RFI environments. *pb*

RFI Troubleshooting Flowchart

Use this chart as an aid in prioritizing your RFI troubleshooting procedure.

