Finding Radio Frequency Interferers

By Steve Thomas

Finding the source of radio frequency interference is a critically important activity as the number of emitters inexorably increases. These emitters are not only licensed and unlicensed transmitters but also many kinds of unintended emitters. Finding an interfering emitter is often more art and creative thinking than science. This paper is intended to help you be successful.

For purposes of finding an interferer it really doesn't matter what kind of emitter you are seeking. As long as you remain open to having anything be the source of interference you should be successful. However, if you get fixated on finding something that looks like a transmitter with an antenna attached, you may end up frustrated and unsuccessful. The interferer may look like a transmitter, but it can just as easily look like a FAX machine, a floor buffer, tower lighting, a rusty fence, a corroded tower, a worn-out electric blanket, an elevator – just about anything that has a motor or can corrode or arc.

All interference is ultimately a receiver issue. An undesired signal that gets through the receiver's filters can cause interference. That being said, sometimes there is nothing that can be easily done in the receiver system to solve the problem. If the interfering signal is on the receiver frequency, it will get through.

However if the signal is at some other frequency, there probably is a solution that can be engineered to reduce or eliminate the interference. The key is to properly identify the source of the inference so proper measures can be taken to harden the receiver against that sort of problem. The section of this paper on mitigating interference goes into some of the measures that can be taken. But, don't work blindly. Identify the real source of the problem so you aren't just wasting time and money.

Identifying Interference

As strange as it may sound, the first step to solving an interference issue is actually determining that there really is interference. Sometimes there are other issues at play that cause a communications system to work less than optimally but don't actually involve an outside signal. There was a case in which the dropped-call rate on one sector of a cell site skyrocketed. A technician was dispatched to the site to fix the problem. He was paying attention to the site as he arrived and discovered that a building had been constructed that blocked that sector.

To identify the interfering signal, unless it is completely obvious, the first step is to see what signals are reaching the receiver through the antenna port. Most cellular systems and some land mobile systems are built with a test port to allow this sort of testing without taking a receiver out of service. If there is nothing unexpected getting into the receiver through the antenna port, there probably is either another means of entry into the system or the investigation at the antenna input didn't cover a broad enough frequency range. A signal at one of the receiver's IF frequencies can sometimes cause trouble since the input filters may not thoroughly suppress such signals. So, when you are looking at signals coming in the antenna, don't just look at the receiver frequency but rather go much wider so you include all IF frequencies employed by the receiver. If you don't know those frequencies, ask the receiver manufacturer or a technical expert within your organization. Common IF frequencies are 455 kHz, 10.7 MHz, 70 MHz and 140 MHz, although this list should in no way be considered complete.

Although most receiver issues involve signals coming into the antenna port, there are other ways for interfering signals to cause problems. Once you are satisfied that nothing unusual is getting into the receiver through the antenna port, you need to broaden the search to include signals conducted into the receiver through the power supply wiring and radiated into the receiver through directly through gaps in the receiver's shielding. To do this testing use a spectrum analyzer with an antenna appropriate for the frequency range to be investigated. Look for signals that are large compared to the signals being received. Small signals should be sufficiently suppressed by the receiver's shielding.

Signals conducted into the receiver by power supply wiring can be investigated by setting the antenna so it is parallel to the power supply wiring or by using a current probe that clamps around the wiring. Conducted emissions from switching power supplies can be a big problem for medical ultrasound equipment causing artifacts on the ultrasound display. The frequencies employed by switching power supplies are generally in the same range as are used for imaging by the ultrasound equipment itself. RF signals can also be conducted into equipment via the power wiring. Garden variety current probes aren't very useful for such measurements since they aren't designed to work at high frequencies. There are broadband current probes on the market that work up to 1 GHz. One source is A. H. Systems, Inc. (www.ahsystems.com).

Characterizing the interfering signal

You have the best chance of successfully solving an interference problem when you know something about the type of signal you are chasing. You will generally be faced with two types of signals: discrete and noise-like.

A discrete signal is one that generally has a central carrier and probably is modulated with some form of AM or FM. The interference could be NTSC TV for example since often closed-circuit video systems aren't particularly well shielded or installed. Being able to recognize different types of signals on the spectrum analyzer is very helpful when you are hunting for interference.

Noise-like signals may be real noise, such as arcing or sparking, or signals such as CDMA that have noise-like characteristics. You will usually be able to recognize a man-made noise-like signal by its restricted bandwidth and generally sharp edges as shown in the example of a CDMA signal in figure 1. Another sort of man-made signal you will encounter is GSM, shown in figure 2. The GSM signal can be recognized by its Gaussian shape.

One interesting thing to be aware of for all noise-like signals is how the display of the signals responds to changes in the instrument's resolution bandwidth (RBW). The displayed amplitude of noise drops as the RBW is reduced. The same thing happens when viewing noise-like signals. For AM signals the amplitude of the signal remains constant as the noise floor changes when the RBW is adjusted.

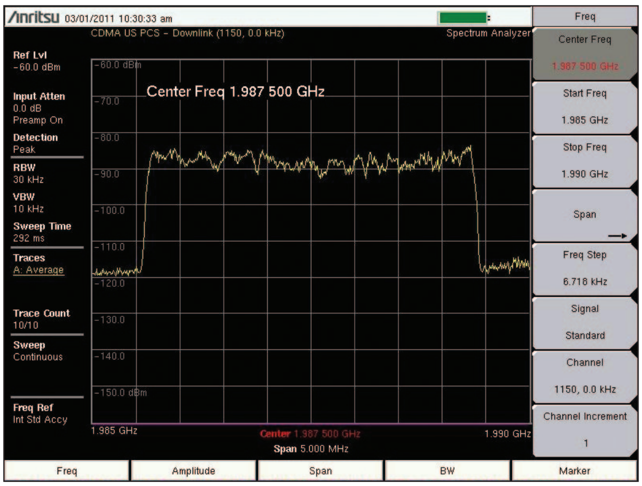

Figure 1. A CDMA signal

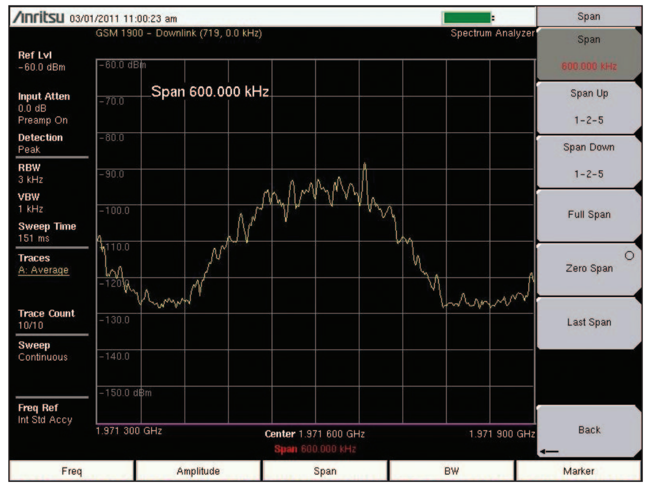

Figure 2 GSM Signal

An AM/FM/SSB demodulator is very handy when you are trying to identify an analog modulated signal. You can listen to the signal and often can figure out exactly what it is. Pagers and land-mobile signals transmit a Morse code ID every 10 minutes they are active. If you don't understand Morse code, record the ID and have someone who does tell you what it says. That will give you the call sign of the station.

In the United States you can then look it up on the FCC universal licensing system at http://wireless2.fcc.gov/UlsApp/UlsSearch/searchLicense.jsp. This database includes just about every class of licensee except for commercial broadcast. You will get the name and address of the license holder, although you may discover that the data is not up-to-date since the license details often aren't modified to reflect changes of ownership. Nevertheless it is a good place to start.

There are several trace modes that can be helpful when attempting to characterize an interferer. Max hold and trace averaging are generally the most useful. By using max hold you can see signals that popped up even once, a useful tool when you are first working to determine if there is actually an interferer.

Trace averaging shows you the overall conditions over time. Used in conjunction with peak hold you can quickly detect signals. Add a min hold trace to the display and you can see signals that are continuously present on the min hold trace, the worst case interference level on the max hold trace as well as the average conditions on the average trace.

In figure 3, the blue trace shows a signal in the middle of the screen and two very large signals nearby that are potential interferers. There are other signals at the edges of the display that we are concerned about at the moment, although that could change.

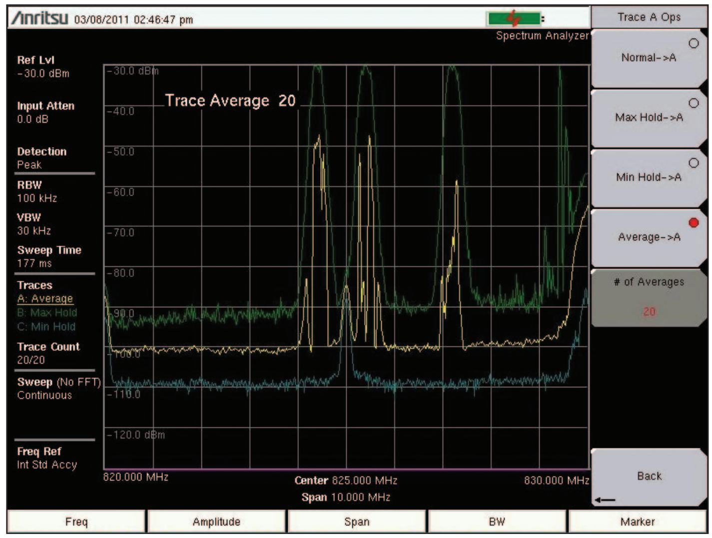

Figure 3. Three traces showing potential interferers

Finding the Interferer

Depending on how intermittent the interfering signal is, this part can be fairly easy or extremely slow and tedious. Use a directional antenna to do the direction finding. To keep yourself from getting confused, it is best to plot the direction to the interferer on a map. Almost any road map or topographical map will do the job. You can also use interference mapping in the Interference Analysis option in Anritsu handheld spectrum analyzers to do the plotting within the instrument as shown in figure 4. You can use software supplied with the option to create a geo-tagged map from Google Maps (or other map sources) that covers the geographic area in which you are interested.

After you have taken enough measurements (and it may only take two) that you have two bearing lines that cross, go to the location where the lines cross and look around. The source of the interference may be obvious at that point, or you may need to do another round of direction finding to localize the source.

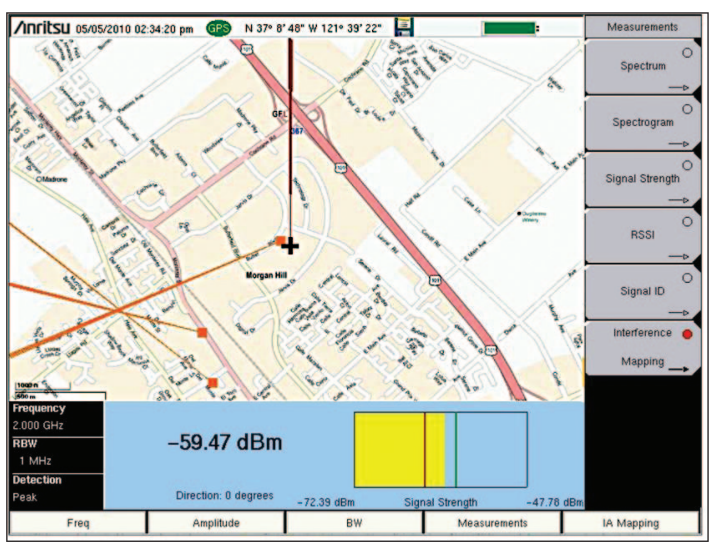

Figure 4: Interference Mapping

Direction finding in the presence of multipath

When hunting for interference multipath can be a big issue. If you are in a city with tall buildings you may not get a direct signal from an interferer until you are very close. One method to hunt under those circumstances is to simply follow the largest signal. In a busy city this is easiest to do on foot. At an intersection aim your directional antenna down each of the streets while watching the signal level. Go down the street with the strongest signal. Repeat at each intersection. When you get a radical change in direction you know that you are close, especially if the signal level has been rising with successive measurements. Once you are close, you can use traditional direction finding techniques to locate the interferer.

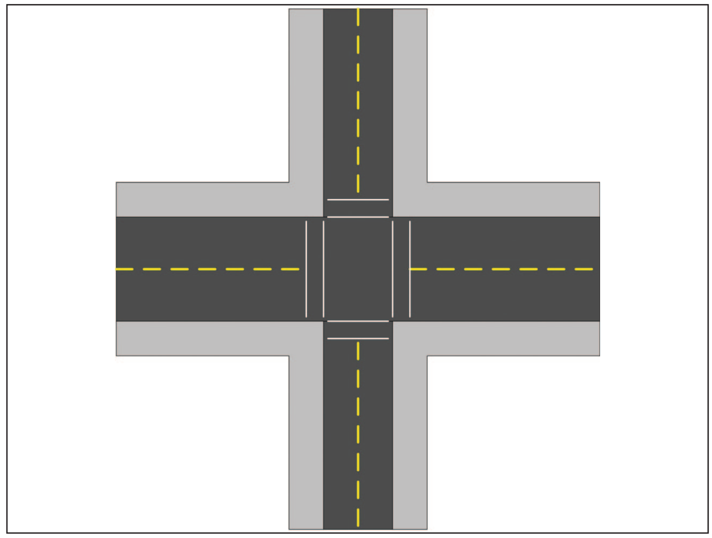

Figure 5

Intermittent Interferers

If the interferer is intermittent, using the spectrogram display is a good way to provide you the continuity of measurement so you can see if the signal is getting stronger as you are tracking down the interferer. In the example shown here, intermittent high-amplitude signals appear at several frequencies at approximately 824 MHz. With the spectrogram display shown in figure 6 it is easy for the eye to integrate the signals and see that the signals at slightly different frequencies are occurring at the same time. That knowledge can be a real help when you are hunting for an interferer. On the spectrogram display amplitude changes are shown as color variations. The most recent trace is at the bottom of the display with previous traces above it.

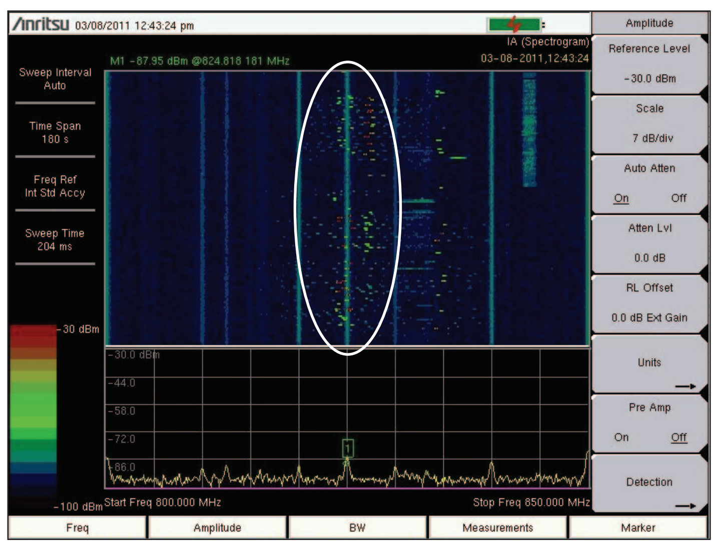

Figure 6: Intermittent signals

One particularly insidious source of interference is an improperly installed cell phone booster, also called a bi-directional amplifier or BDA. These devices have two antennas, one installed in a location that gets a good signal from the cell site, and one indoors that sends and receives signals from local handsets. To work properly the antennas need to be installed far apart to keep feedback between the two antennas from occurring. When feedback occurs, a good quality booster will automatically turn off. Cheaper ones don't have such protection and can oscillate and spew interference on roughly the frequency of the cell site. The signal may move around in frequency and be pretty dirty as feedback conditions change with building occupancy and other factors. Figure 7 shows the signal from just such a device. This particular device plagued a cellular provider for months before they tracked it down since the user turned it on only occasionally, but when it was on it would cause many dropped or blocked calls in one sector of the site.

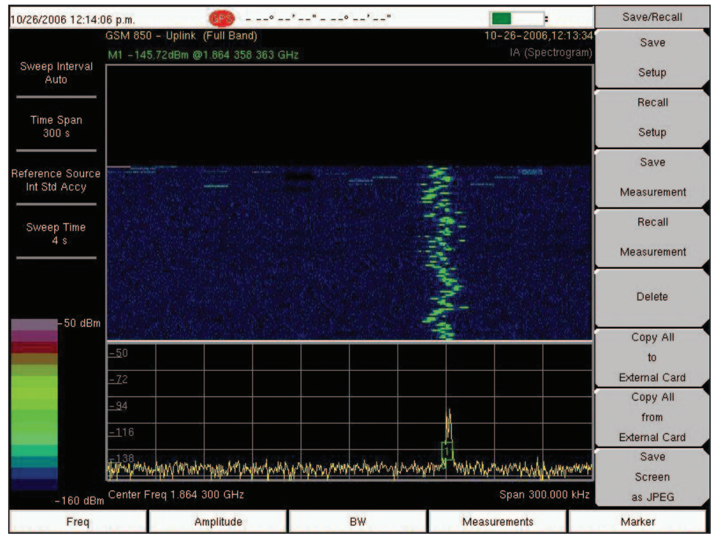

Figure 7: An oscillating cellular booster.

Mitigating Interference

Once you have found the source of the interfering signal, the next step is to figure out how to keep it from causing further interference. There are two basic approaches. The first is to harden the receiver so it rejects the interference. This works for signals that are off frequency. Hardening may take the form of filtering designed to reduce the signal amplitude, better shielding of the receiver and better grounding of shielding that already exists.

The second approach is to get the signal turned off or reduced in amplitude enough that the receiver can tolerate the interference that is left. How this is done depends entirely on the source of the signal. It may involve changing to a different antenna or the receiver.

If the receiver is receiving intermodulation products that fall within the receiver's passband, the cure to the problem generally has to take place at the source of the intermodulation. It is possible that intermodulation is taking place within your receiver, in which case the cure may be additional filtering or attenuation to knock down one or both of the signals causing the intermodulation.

Intermodulation occurring outside the receiver and antenna system can be caused by environmental diodes such as rusty fences, rain gutters, metal picnic tables – basically anything that has different metals and their oxides in contact with each other. These problems can be very time consuming to find since they may occur only under certain, very specific, conditions. Perhaps the right amount of humidity and just the right temperature puts the metals in just exactly the right contact with each other that they form diodes. Introduce large signals into the metals from nearby transmitters (nearby may be a few miles for high power broadcast stations) and harmonics of the signals are generated by the action of the diode. Multiple signals and their harmonics will then mix together to form even- and odd-order intermodulation products.

Once you think you have found the precise location of the environmental diode, try changing anything about the diode – wiggle a fence wire and see if the signal changes. Spray the suspected location with water, press the pieces closer together or pull them apart. If the signal changes, you have found the source. You may be able to cure the problem by removing rust, insulating the offending pieces or other remedies depending on the situation up to replacing the offending item.

If the source of the interference is a transmitter, you may need to be diplomatic to get the problem resolved. If diplomacy doesn't work, and you believe the transmitter isn't operating properly, you may need to get the licensing authority such as the FCC involved. If the interference is to first responders such as police and fire departments, the FCC can be very responsive to help solve such problems. Otherwise, carefully document what you have found and provide the information to the FCC local enforcement office. They have the legal authority to help solve interference problems to licensed emitters and will do the best they can to resolve the issue. In most other countries there will the equivalent function in some governmental organization.

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