

Detecting interfering signals and mitigating them

Interfering signals close to a carrier can be sources of interference that are difficult to detect. Field technicians must be able to identify and mitigate such interfering signals that can be less than 1 kHz apart and have a 60 dB difference in amplitude. The article discusses the type of performance necessary in a test instrument in order to identify interfering signals and track them down to their sources.

By Steve Thomas

As the radio spectrum is becoming more crowded and emerging technologies compete for spectrum space, the ability to detect and identify interfering signals is becoming more important. Add to this the fact that higher data rate technologies generally need better signal to noise/interference ratios to perform properly and you have a situation rife with the potential for exponentially increasing problems. There are multiple approaches to detecting interference. The best case, and sometimes the most difficult, is to track down and eliminate the interfering signal or signals. The second, and generally easier, approach is to filter the signal to reduce the amplitude of the interfering signal. This is helpful in cases of fundamental overload or interference from odd-order intermodulation products. There are several ways that various modulation formats deal with interference.

As part of 802.11(b), several modulation formats are used. The highest throughput formats require the best signal to noise/interference ratio. To maintain a user's connection, an access point will negotiate a reduction to a simpler modulation format when the signal to noise/interference ratio becomes too bad. Because this reduces throughput, users can easily become frustrated with slow data rates, especially if they see download times climbing dramatically because of it. The orthogonal frequency division multiplexing (OFDM) format used in 802.11(a) uses multiple subcarriers. If a particular subcarrier isn't working properly due to interference or multipath distortion, that subcarrier will not be used, lowering throughput, but not as dramatically as is the case with 802.11(b). For interference to cellular telephone communications, moving a handset to another frequency or handing it off to another base terminal station (cell site) is possible. Dropped calls are a common consequence of intermittent interference to a site.

Spectrum competition

New uses coexist with, or replace, existing uses. One current broadband over power line (BPL) field trial, for example, uses the radio spectrum from approximately 4 MHz to 40 MHz using spread spectrum technology that is intended to not unduly raise interference levels for existing users of high-frequency (HF) spectrum. Preliminary field measurements done at one BPL trial showed a broad rise in the apparent noise floor due to the BPL signal (Figure 1). There are also plans under way to employ BPL technology within buildings to distribute broadband signals via the power lines to every power outlet. This in-building solution is much more manageable in terms of interference since the potential for interference should be much better understood within the confines of a single building, as opposed to spectrum use in a large area. As installation of a BPL solution is being planned, a thorough site survey to determine areas of

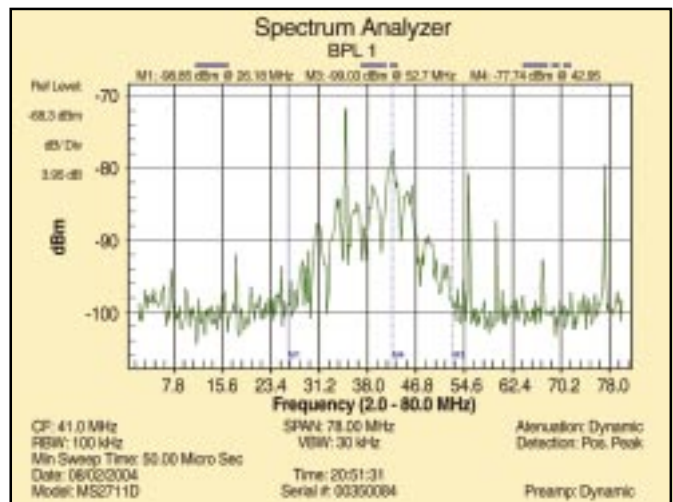


Figure 1. Broadband signal from a trial BPL system.

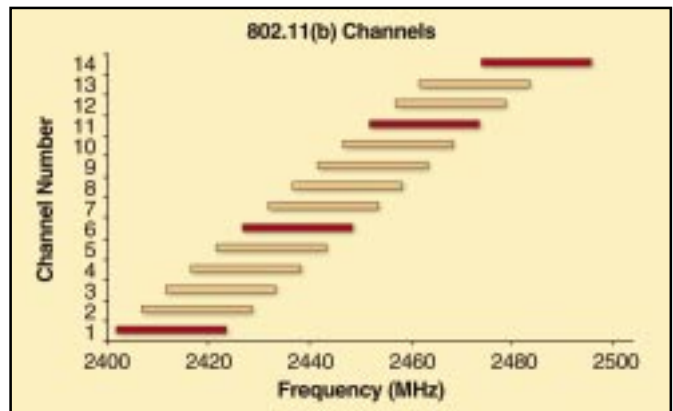


Figure 2. 802.11(b, g) channels.

interference is essential. A handheld spectrum analyzer makes this job simple since it can be easily carried throughout a facility while making measurements, saving measurements as needed for later downloading and analysis.

The measurement shown in Figure 1 was done with a whip antenna. Some technologies compete with themselves. The channels assigned for 802.11(b) and 802.11(g), for example, overlap so badly that there are only three non-overlapping channels available in the

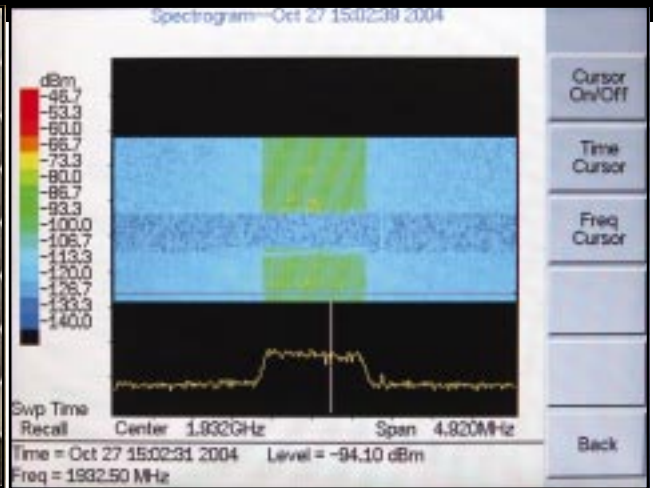
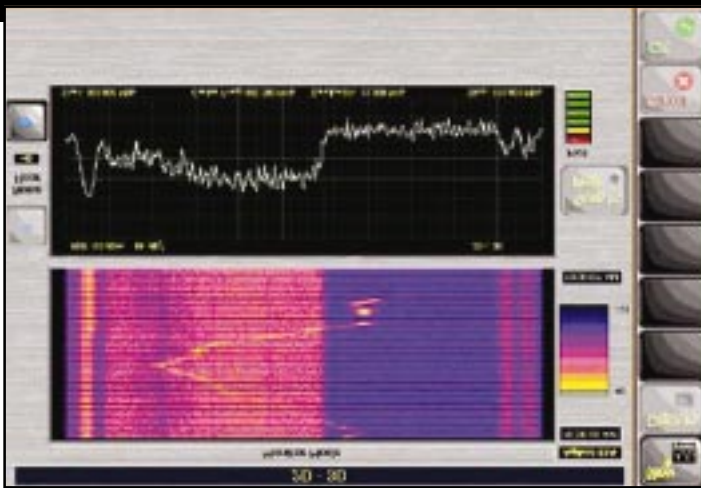


Figure 3. Oasis II Spectrogram.

Figure 4. Interference analysis option for Anritsu Cell Master MT8212B.

United States. In Japan, channel 14 provides a fourth non-overlapping channel (Figure 2). Since Wi-Fi occupies unlicensed areas of the radio spectrum, there is no central body coordinating the channels used by access points. To make the problem worse, many consumer-level access points make it difficult to even determine on what channel they are operating, much less make it easy to change the channel if desired. Higher-end access points have the capability to scan the channels available in the local jurisdiction to determine the best one to use. There have been cases where next-door neighbors were trying to operate consumer-grade 802.11(b) access points on channel 1 and suffered significant interference problems. In one particular instance, one of the users returned three different brands of equipment to the store stating that he couldn't stay connected, when the real problem, of course, was interference.

For enterprise 802.11 installations, a good site survey before installation begins is essential to give the best chance of achieving trouble-free system operation. For 802.11(b) and 802.11(g) installations, be sure to pay attention to the potential of interference from microwave ovens and cordless telephones. Since such devices are used intermittently, being too hasty in declaring a site clean can lead to problems later. Use max hold on the spectrum analyzer to catch intermittent emitters. Frequency-hopping emitters such as near-by Wi-Fi systems also need to be discovered during the site survey so an informed decision regarding available spectrum space can be made. You can also use more sophisticated tools discussed later in this article to visually display all emitters over a period of time.

Interference?

How do you determine if problems are being caused by interference? Abrupt up-and-down changes in throughput can be indicative of intermittent interference while a step reduction in throughput or a reduction in apparent receiver sensitivity often points to a new emitter causing difficulties. Looking at Figure 1, it can be seen that a signal being received in the 30 MHz to 50 MHz range would need to be at least 10 dB to 20 dB stronger to be received with the same signal-to-noise ratio than would be the case if the interfering signal weren't there. This same sort of problem can be caused by broadband phase noise emanations from a nearby transmitter, especially a problem for co-located systems.

Intermodulation in a receiver input or in nearby "environmental diodes" can create interfering signals. An environmental diode can be formed when dissimilar metals touch each other or when corrosion forms between two pieces of the same type of metal. Tracking down such problems is best done with a directional antenna attached to a spectrum analyzer that shows power level at the problem frequency. Channelized communication systems are particularly prone to this sort of problem because the channels are evenly spaced. Intermodulation products up to the ninth order have been known to cause harmful interference problems.

Power line problems can cause significant interference issues. Generally, these problems are most troublesome for HF and very high frequency (VHF) installations. Cracked or dirty insulators on

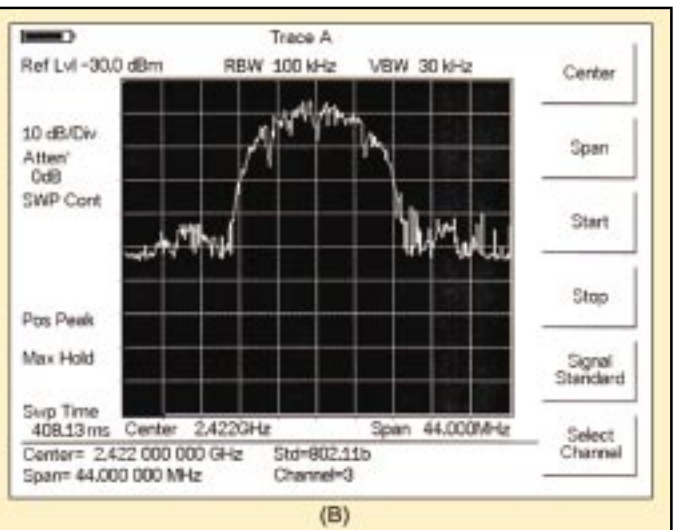
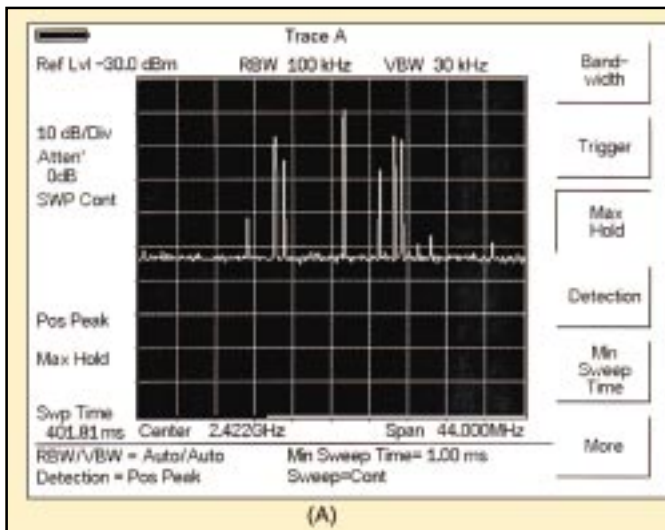


Figure 5a. 802.11b signal with fast sweep.

Figure 5b. 802.11b signal with max hold.

high-voltage lines can generate arcing and corona that can sometimes be extremely strong. Other broken or damaged hardware on a power pole can also potentially generate harmful interference. Directional antennas can be helpful in localizing such problems. Most major power companies have interference mitigation groups in their engineering or operations departments. Experience has shown that many dedicated, busy, and helpful people work in such groups. If you believe you have a case of power line interference, contact your local power company for assistance. You can help them help you by localizing the source of the interference so their time can be best spent determining the precise source of the problem.

Monitoring over time

Often, interfering signals aren't continuous but come and go. These intermittent signals can try the patience of even the most patient and intrepid interference sleuth. Coming to the aid of such people are software and hardware solutions. Oasis II software from Summitek Instruments in Colorado (www.summitekinstruments.com) works with many different spectrum analyzers to create spectrogram displays such as that shown in Figure 3. In addition, the software can use its database of licensed emitters coupled with GPS measured location to determine possible frequency combinations of nearby emitters whose intermodulation products could fall near a given frequency.

Option 25 for the Anritsu Cell Master MT8212B shown in Figure 4 is an example of a hardware solution to the same problem. Measurements made with either the software or the hardware solutions can be automatically saved for later recall.

For some interfering signals, if you look too fast you probably won't see the interfering signal. This is particularly true of frequency-hopping signals such as 802.11(b) or cordless multichannel telephones. For those situations, using a spectrogram can be useful, and using max hold to paint an overall picture of a hopping signal over time can be helpful, as shown in Figures 5a and 5b.

As you are tracking down interference sources, it pays to be alert to patterns in the interference, especially if it is intermittent. Pay attention to time of day, humidity levels, weather, cloud cover and variations in signal strength of the interferer. Power line problems are especially prone to variations in the weather. A cracked insulator may be fine on a dry, sunny day but arc badly during damp weather.

Summary

Interference can come from many sources, some obvious, some subtle. The proper tools can make the job of identifying interfering signals and tracking them to their sources much more manageable. RFD

ABOUT THE AUTHOR

Steve Thomas is a product manager for the Anritsu Company in Morgan Hill, Calif. He currently works in the Field Solutions Business Unit of its Microwave Measurement Division. He has more than 30 years of varied experience in the RF and microwave instrumentation arena including work in noise figure measurement and vector network analysis. He has spent many hours on towers installing and maintaining antenna systems at his amateur radio station, N6ST.