Keysight Technologies
Procedures to Verify and Locate Interference

Using N934xC/B Handheld Spectrum Analyzers

Application Note

Introduction

Wireless communication systems often share or reuse frequency spectrum. As a result, wireless systems are prone to interference. Interference can have many causes, however here we will explore interference that is created by wireless systems operating properly or improperly. In wireless communication systems, interference is commonly created by: one signal infringing on another, operating system components such as transmitters operating improperly, or the communication system itself triggering interference in sensitive equipment. Since all wireless communication systems are vulnerable to the effects of interference, the ability to quickly and accurately measure frequency spectrum in and around the wireless system is an essential step in restoring system integrity. This application note looks at the process and techniques for measuring and locating wireless interference using a handheld, portable spectrum analyzer.

Sources of Interference

Regulatory agencies and standards organizations define wireless operation and protocols within each frequency band. The cause of interference stems from intentional or unintentional signals, or radiators, infringing on the wireless communication system's specific operating frequency band, causing the wireless system to no longer operates as expected.

Interference from unintentional radiators include electrical equipment and mechanical machinery such as switching power supplies, clock and control signals, ignition motors, home appliances including microwave ovens, photocopiers, printers, fluorescent and plasma lighting, and power lines. Unintentional radiators can produce either broadband noise or potentially modulate the radio signals propagating in the surrounding environment. Environment conditions such as lightning and precipitation static can degrade system performance and potentially damage electronic components. However, the majority of radio interference is generated from other wireless systems operating with faulty transmitters and repeaters or from systems that are intentionally attempting to disrupt communications.

Interference from intentional sources include radio transmissions from other wireless systems including broadcast radio and television, cellular, satellite, radar, mobile radio, and cordless phones.

Using a Handheld Spectrum Analyzer to Confirm Interference

Once it has been reported that the system is not operating as expected and it is suspected that the root cause of the problem is interference entering the receiver of the system, the next step is to confirm the existence of wireless signals in the frequency channel of operation. This is typically done using a spectrum analyzer, such as the N9344C, N9343C, N9342C, or N9340B handheld spectrum analyzer (HSA).

The discovery process may involve uncovering the type of signal including duration of transmission, number of occurrences, carrier frequency and bandwidth, and lastly the physical location of the interfering transmitter.

For the HSA to measure the same signals and interference that the system receiver is capturing, the spectrum analyzer should be connected into the receive path or directly to the system antenna. Figure 1A shows a block diagram of a wireless system with the HSA connected to a directional coupler placed between the antenna and the transceiver.

Many wireless systems, including cellular base stations and radar stations, will have directional couplers installed along the cables connecting the transceiver to the system antenna. As shown in Figure 1A, some directional couplers will have two sample points for monitoring the signals coming from the transmitter or arriving to the receiver. After the spectrum analyzer is connected to the coupler, the signals and interference can be observed during normal system operation.

For radios that do not provide access between the transceiver and the antenna, the HSA can be directly connected to the system antenna or connected to an external antenna with the analyzer placed in the area near the transceiver as shown in Figure 1B.

Steps for confirming interference identification and location

1. Report that a reduction in the system performance is observed
2. Confirm the existence of wireless interference using a spectrum analyzer
3. Determine the type of interference by knowing about other wireless signals in the environment
4. Determine the location of the interference using a spectrum analyzer with a directional antenna
5. Correct or remove the source of interference

Using a Handheld Spectrum Analyzer to Confirm Interference (continued)

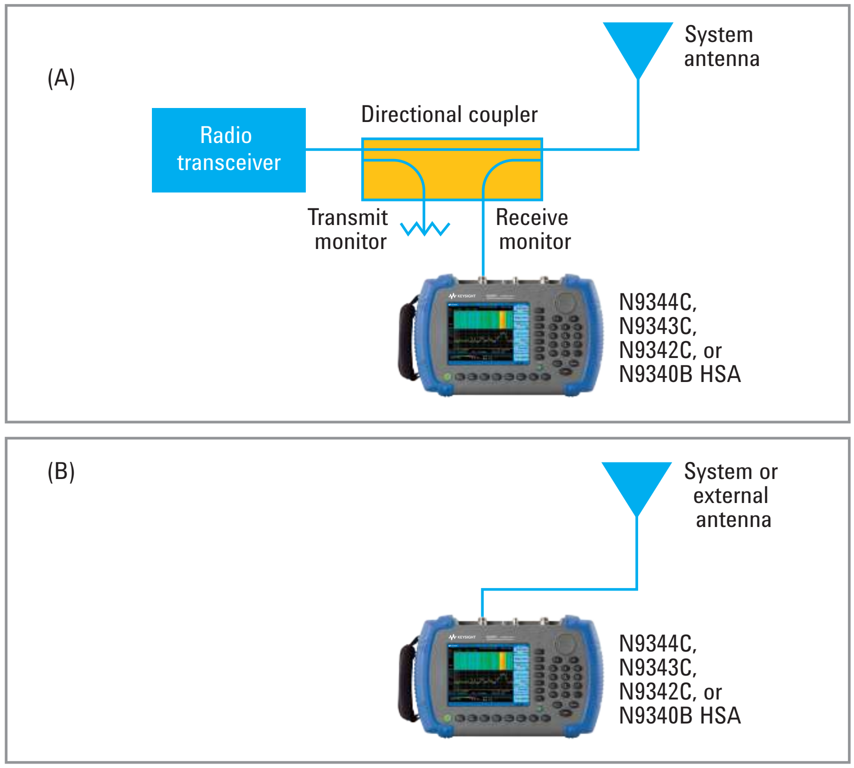

Figure 1. Spectrum analyzer configurations for measuring wireless interference (a) using a directional coupler and (b) using direct connection to the antenna

During the discovery process, using an omni-directional antenna allows signals from all directions to be measured from the surrounding environment. Omni-directional type antennas include the rubber-ducky and whip antennas.

Hint:

Using an omni-directional antenna allows signals from all directions to be measured from the surrounding environment.

If possible, turning off the system transmitter allows the spectrum analyzer to measure in-band and co-channel interference with the lowest noise floor settings. In this case, it is assumed that any nearby out-of-band and adjacent channel transmitters have signal levels low enough so that the spectrum analyzer front-end is not overloaded.

Intermittent signals are often the most difficult to measure. The radio performance occasionally suffers from interference at what may seemingly be random times of the day. For cases when the interference is pulsed or intermittent, the HSAs can be configured to store the maximum trace values over many sweeps.

To illustrate, consider the lower channel of a GSM 850 signal that is only transmitting during a few time slots resulting in a measured waveform that displayed breaks in the envelope.

Using a Handheld Spectrum Analyzer to Confirm Interference (continued)

(Figure 2.) Placing the N934xC/B in "maximum hold" mode, the instrument will fill in the gaps after several sweeps.

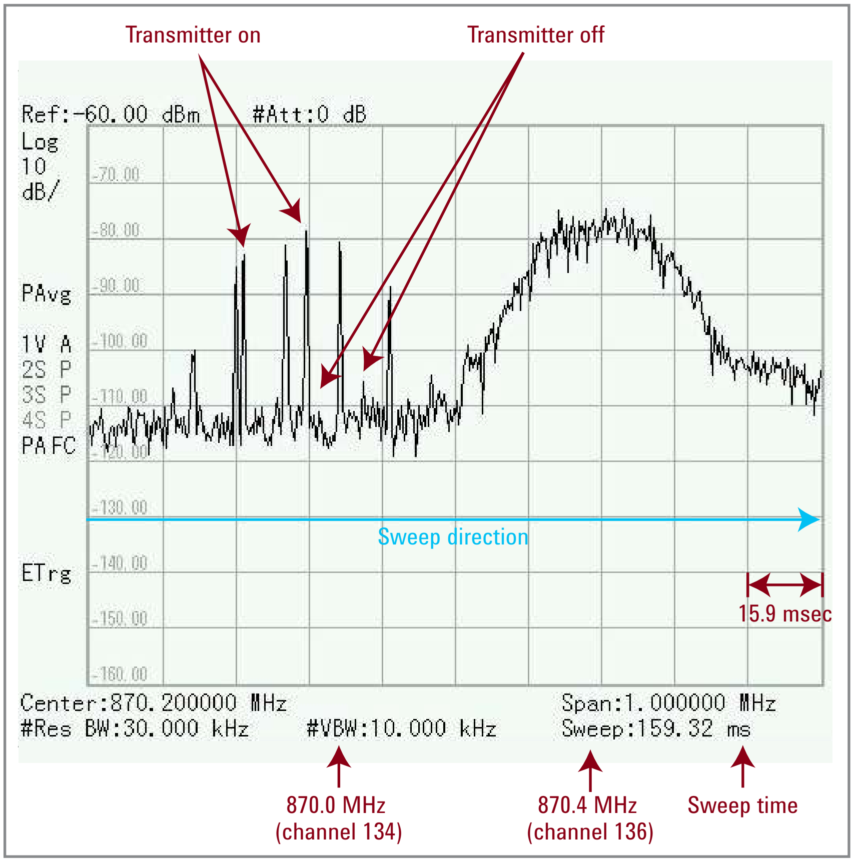

Figure 2. Over-the-air measurement of a GSM 850 downlink transmission using the Keysight N934xC HSA with attached antenna

The {Max Hold} selection is found under the [TRACE] menu on the Keysight HSAs and the results for the GSM 850 signal using the maximum hold is shown in Figure 3. It is now apparent from Figure 3 that the signals in the two channels have a similar spectrum and power distribution.

Using a Handheld Spectrum Analyzer to Confirm Interference (continued)

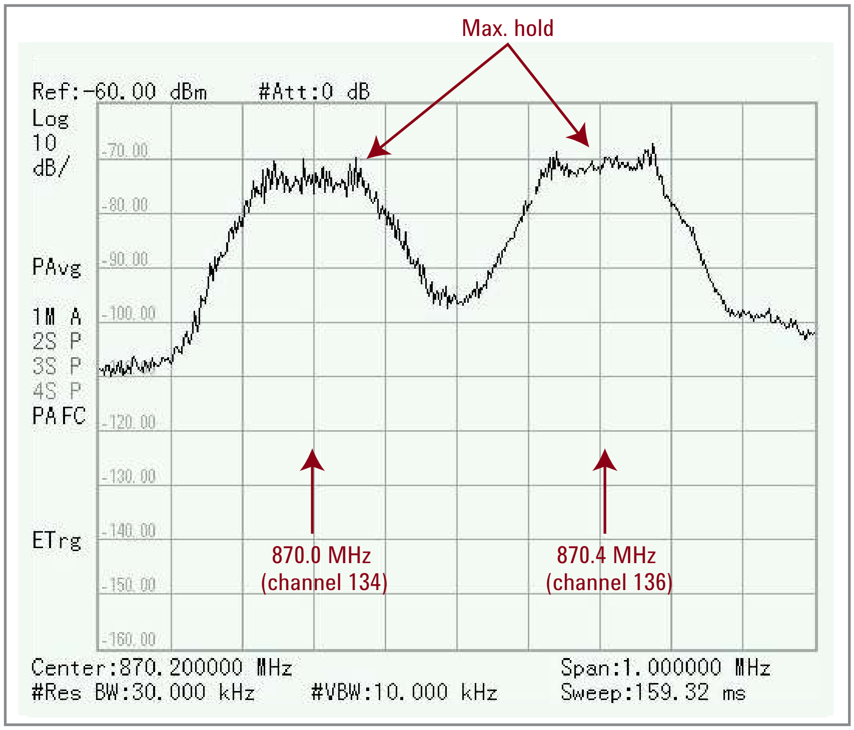

Figure 3. Over-the-air measurement of a GSM 850 downlink transmission using the Keysight N934xC HSA with the trace "Maximum Hold" selected

The trace option on the Keysight HSAs allow up to four different traces to be displayed. The multiple traces can include combinations of Max Hold, Min Hold, stored memory, and active measurements with different detection options including the default "positive peak". Additional information regarding detection modes can be found in the Keysight application note 1286-1, 8 *Hints for Better Spectrum Analysis* (literature number 5965-7009E).

Another useful display option on the Keysight HSAs is the spectrogram. A spectrogram is a unique way to examine frequency, time, and amplitude on the same display. The spectrogram shows the progression of the frequency spectrum as a function of time where a color scale represents the amplitude of the signal. In a spectrogram, each frequency trace occupies a single, horizontal line (one pixel high) on the display. Elapsed time is shown on the vertical axis resulting in a display that scrolls upwards as time progresses.

Using a Handheld Spectrum Analyzer to Confirm Interference (continued)

Figure 4 shows a spectrogram of a signal with a transmitter that is intermittently active. In the figure, the red color in the spectrogram represents the frequency content with the highest signal amplitude. The spectrogram may provide an indication to the timing of the interference and how the signal bandwidth may change over time. The spectrogram can be stored to the internal memory of the Keysight HSAs or onto an external USB flash drive.

The spectrogram can record 1,500 sets of spectrum data with an update interval that is set by the user. The HSAs will automatically create another trace file to save continuously beyond 1,500 sets. For example, on the N9344C sweeping across the full 20 GHz frequency span, the sweep time would be 0.95 seconds. In this case, in one single trace file, the user can set the spectrogram to store data over 48 minutes using an update interval of 1 second or up to 5 days using an update interval of 300 seconds. The spectrogram display is activated using the {SPECTROGRAM} selection under the [MEAS] menu.

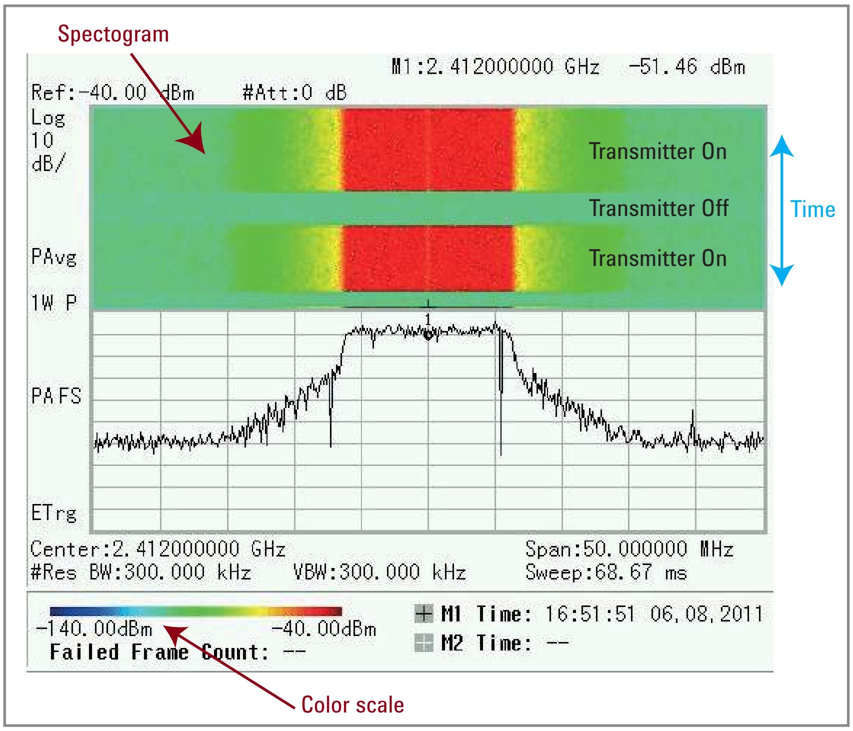

Figure 4. Dual display option showing a spectrogram and the frequency spectrum of a signal with intermittent transmission

Determining Interference Type

Once the interference is observed using an HSA, understanding the type of signal, such as WiFi, cellular, or other, may be helpful in estimating the interferer's location. For example, a wireless equipment operator maintaining a cellular network may observe an "out of spec" transmission from an adjacent frequency channel. Knowing that the type of interference is from another cellular system may provide clues that a nearby repeater may be improperly transmitting energy into the adjacent bands. (For more information on this subject, refer to *Interference Classifications and Measurements*, application note 5990-9075EN.)

Locating the Interference Source

The last step in the discovery process is locating the source of the interference. At this point, it is preferred that a directional antenna be connected to the spectrum analyzer as these high gain antennas provide pointing capability within the wireless environment. Directional antenna types include yagi and patch antennas. Antenna gain of 5 dBi (decibel isotropic) or higher is recommended for this application. For example, Keysight's N9311X-508 directional antenna provides a 5 dBi gain over the frequency range of 700 MHz to 8 GHz.

Hint:

By combining directional measurements from several locations around an environment, it may be possible to triangulate an approximate position for the interfering transmitter.

Observing the amplitude of the signal on the spectrum analyzer as the directional antenna is moved around the environment could potentially point to the physical location of the interference when the measured signal amplitude is at a maximum. Unfortunately multipath reflections in the surrounding environment could reduce the pointing accuracy so it is important to make the measurement from as high as possible such as on rooftops or tall buildings. Cellular base station (BTS) antennas are usually configured with sectorized antennas having a narrow beamwidth and using a measurement configuration as shown in Figure 1A may provide an approximate direction (sector) for the interference.

The exact location of the source usually requires driving or walking around a smaller area with the HSA and directional antenna looking for the maximum signal amplitude. Once the source of the interference is located, the final step is to correct or remove the offending transmitter.

Conclusion

Given the numerous sources that can trigger interference and hamper the proper operation of a wireless communication system, the Keysight N9344C, N9343C, N9342C, and N9340B HSAs are valuable tools. Their features provide the ability to quickly confirm the existence of wireless interference, determine the type of interference, and, in conjunction with a directional antenna, identify the location of the interference. That data allows the source of the interference to be corrected or removed to restore the system to its optimal performance level.

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