Case Study

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Uncovering Interference at a Co-Located 800 MHz P25 Public Safety Communication System

RTSA Spectrum Analyzer Key to Uncovering Hard-to-Find Cause

Overview

RF communication systems have become a critical part of modern life. These systems range from tiny Bluetooth® devices to nationwide, high-speed data systems to public safety critical infrastructure. Because these communication systems share common RF spectrum, interference between them is inevitable. Interference between systems can range from intermittent outages that can cause dropped calls to complete blockage of communication. Resolving these issues requires testing of the system with a test RF receiver or spectrum analyzer to detect and locate the source of interference within the system.

Challenge

A public safety organization in northern Nevada was experiencing intermittent receive interference alarms on its 800 MHz P25 public safety communications system. An ordinary swept-tuned spectrum analyzer was used in an attempt to locate the interfering signals, however, none were found. After determining it was not a software issue, it was decided that the cause of the issue was likely to be an interfering signal with short duration or even a hopping signal that was being missed by the spectrum analyzer. A spectrum analyzer with real-time spectrum analysis (RTSA) was needed to be utilized to look for any interfering signals.

Solution

Anritsu's Field Master Pro™ MS2090A solution with real-time spectrum analyzer option was selected to locate the interfering signal (Figure 1). The Field Master Pro MS2090A has an optional real-time mode that can accurately measure the amplitude of a single spectrum event as short as 2 μs, and detect a single event as short as 5 ns. As the interference was undetectable with a standard swept-tuned spectrum analyzer, the real-time option offered the best possibility to find the interference source.

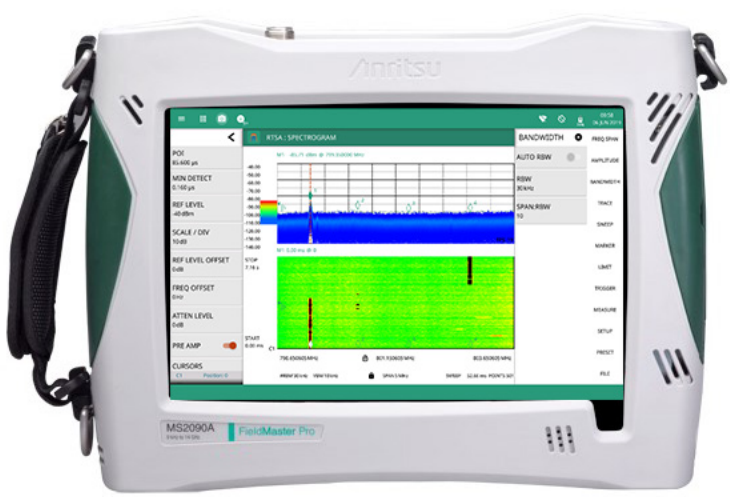

Figure 1. Anritsu Field Master Pro MS2090A with optional RTSA.

- The P25 system was co-located on a hill top site with television and FM broadcast transmitters. Great care was required when making RF measurements to prevent overloading the instrument receiver front end.
- When performing interference testing in multi-transmitter locations like this, it is not uncommon to see 0 dBm signal levels at the front end of a spectrum analyzer using a standard whip antenna. The interfering signals that were being hunted on the system could be as small as -110 dBm. A 0 dBm signal at any frequency within the analyzer's front end range would prevent detecting these small signals, as the input attenuation required to prevent front end over load would result in a consequent high noise floor. Several measurement techniques were employed to ensure all interference would be located quickly and accurately.
- The first action was to perform a survey of the overall site spectrum environment. Using a broadband whip antenna (providing coverage from 500 MHz to 3 GHz) connected to the unit, the spectrum from 9 kHz to 1 GHz with 30 dB input attenuation was observed (Figure 2).

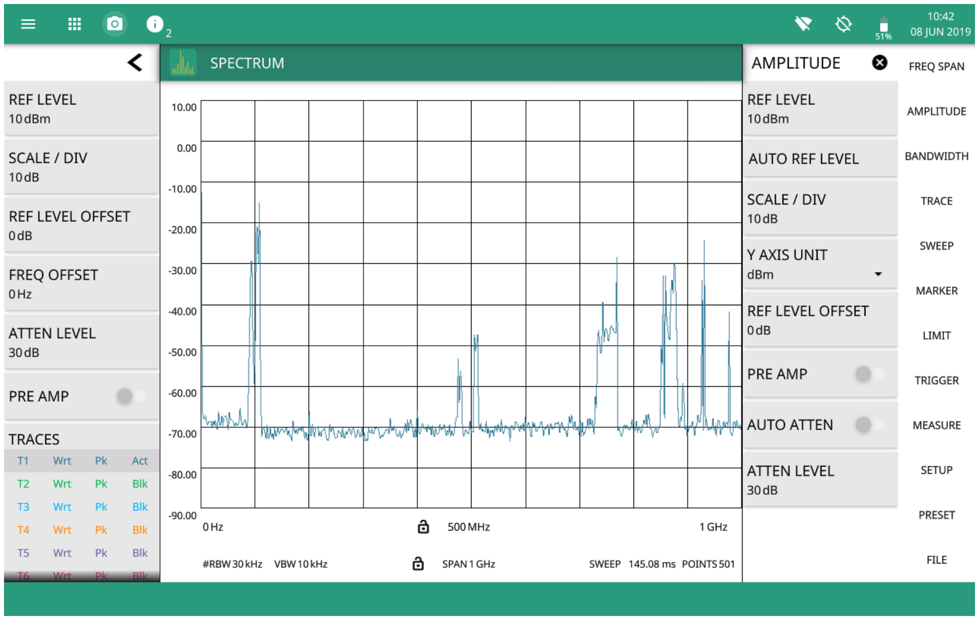

Figure 2. Broadband site survey highlighting high power FM broadcast signals at 100 MHz. The P25 transmitter suffering from intermittent interference can clearly be seen around 800 MHz.

- To reduce the television and FM broadcast power incident at the instrument RF input, a high-pass filter was inserted between the antenna and RF input. This would enable the use of less input attenuation in the analyzer. Switching the spectrum analyzer input attenuator by ±5 dB it was confirmed that no change in the measured signals was seen. This is a common technique to validate no over-load of the analyzer RF front end. (Figure 3)

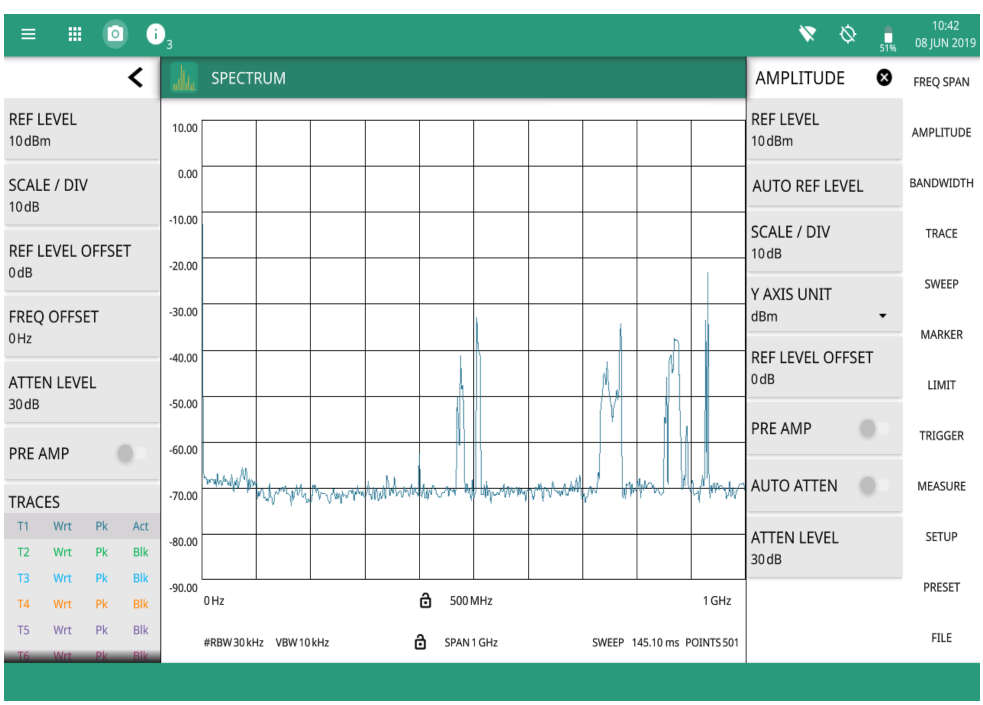

Figure 3. The site survey with a high-pass filter on the RF input, eliminating the high power FM transmitter signals.

- Next, the Field Master Pro MS2090A was connected to the system receiver test port with a 800 MHz bandpass filter plus the high-pass filter to further isolate the P25 signal. This allowed the analyzer have the same sensitivity as the P25 receive system (Figure 4).

Figure 4. The Field Master Pro MS2090A connected to the P25 system receiver RF test port with the high-pass filter in line.

- The Field Master Pro MS2090A was put into RTSA mode and markers were set on the system's 4 receive frequencies. This verified that incoming traffic could be seen. Initially in RTSA mode, both real-time and spectrogram views were used to try to catch brief interfering signals. This facilitated monitoring for correlation between wanted signal traffic and potential interfering products. (Figure 5)

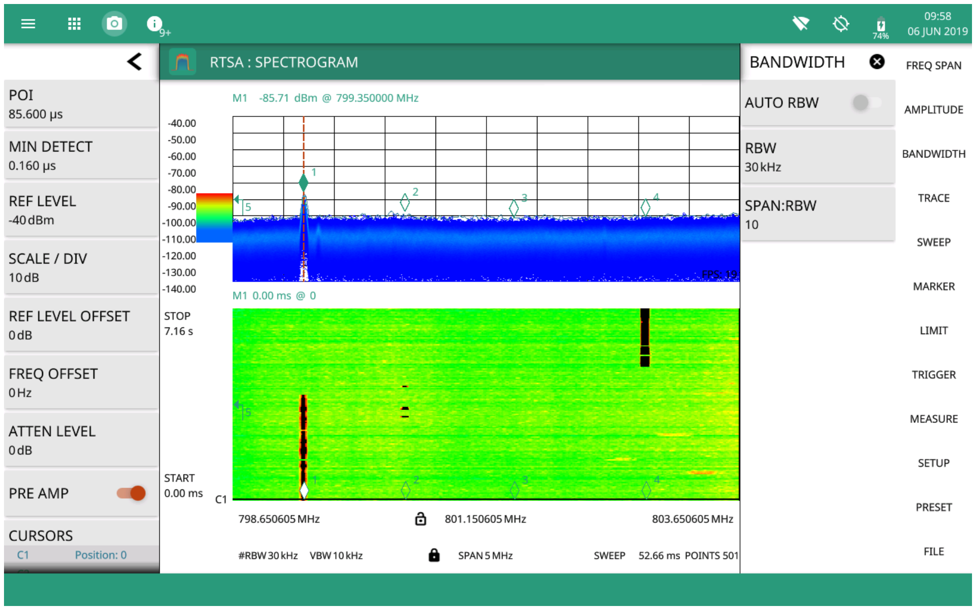

Figure 5. When no interference was present, the activation of P25 traffic is clearly seen as dark lines in the spectrogram.

- Occasionally, the entire noise floor would jump up to -60 dBm, above the incoming P25 signal level. This was captured as dark horizontal lines in the spectrogram trace that covered the full P25 spectrum. The Field Master Pro MS2090A has a probability of intercept as low as 2.05 µs so that even these very short duration bursts of interference were captured. (Figure 6)

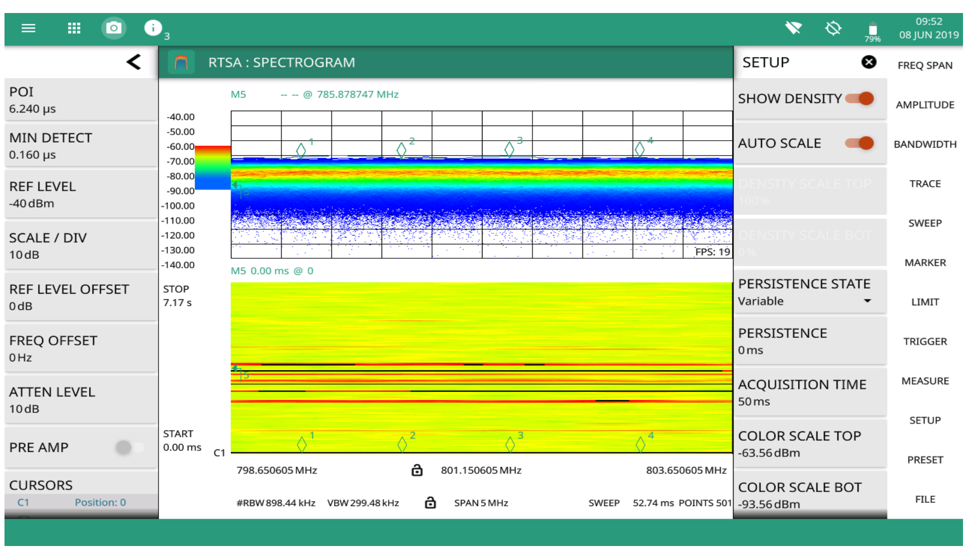

Figure 6. The dark horizontal lines in the spectrogram trace highlight short bursts of high interference signals that covered the full P25 frequency plan. These interfering signals had a power level in excess of -60 dBm, greater than the wanted P25 signals.

- The Field Master Pro MS2090A was switched to standard spectrum analyzer mode to capture traces with and without interference to understand the level of the increasing noise floor.

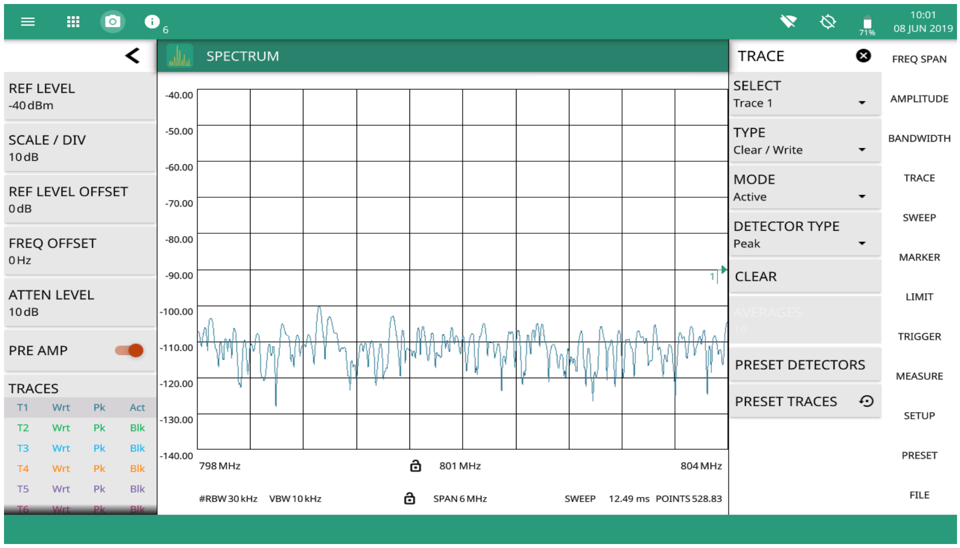

Figure 7. This shows the analyzer noise floor when no interference was present. The sensitivity of -110 dBm is in line with typical P25 radios performance.

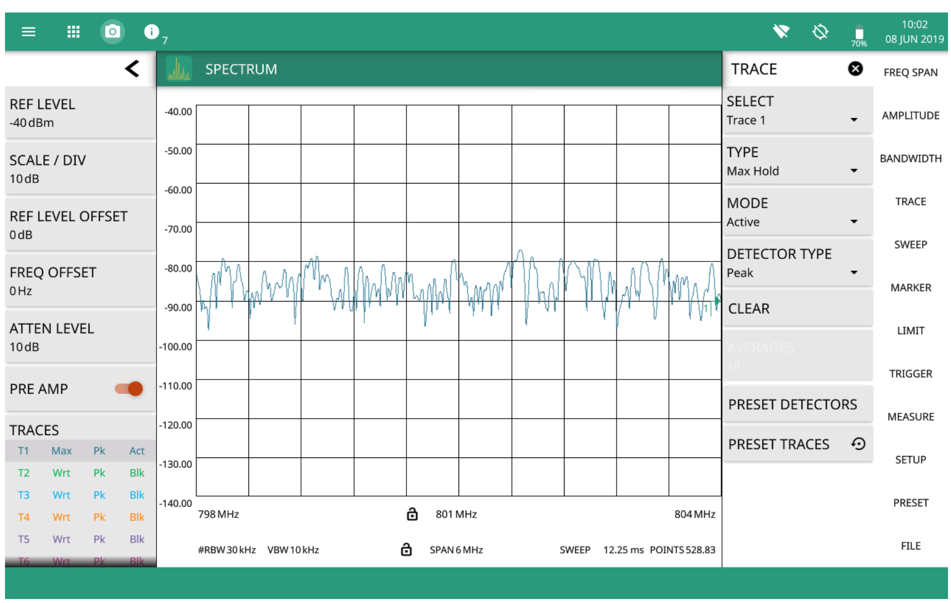

Figure 8. In standard spectrum analyzer mode, it is necessary to use the trace max hold feature to build up an image of the noise resulting from the bursts of interference.

- Since it was established that there was interference onsite, a directional antenna was attached to the Field Master Pro MS2090A in order to walk the site to hone in on the exact source of interference. Often log periodic antennas are used for direction finding as they offer wide frequency coverage. However, the directional pattern is a compromise compared to Yagi antennas. Direction finding antennas may need to have a low PIM specification to prevent the antennas from generating interfering signals on their own from the very high RF fields present at broadcast sites.

- When direction finding, it is best to start with the antenna aimed towards the ground to see the spectrum display with little interference, then bring the antenna to horizontal and slowly rotate 360 degrees. Rotate the antenna from vertical to horizontal to see if there is a peak in the polarization. In this case, the signal peaked when aimed at a broadcast tower and it was not polarization sensitive. There were, however, numerous metal buildings in the area and it needed to be confirmed that the direction was not from a reflection. Walking around the tower at a 30 meter distance, the direction finding was repeated. In all cases, the interference maximum was with the antenna pointed towards the tower, and levels increased further when the antenna was aimed toward the top of the tower.

Figure 9. Using a Yagi antenna to search for the source of the intermittent interference.

- Using this technique, the noise interference was determined to come from a broadcast tower located 50 meters from the P25 antennas. This mountain-top tower supported a number of broadcast transmitters with numerous antennas so the RF fields close to the tower were very high up. After experiencing significant winter weather, it was discovered that a safety climbing cable running from the ground to the very top of the tower had broken away from its insulated mounts. With high wind, this caused the cable to bang up against the tower causing passive intermodulation (PIM) and set off alarms in the P25 receiver monitoring system. It is well documented that incidental contact by movement between dissimilar metal conductors that are physically and electrically close to transmitter antennas and high RF fields will result in passive intermodulation (PIM) products and cause erratic impulse noise on receivers near the site.

During a return visit to the site at a later date, when there was no wind, it was noted that there were no alarms triggered in the P25 monitoring system.

Figure 10. The safety climbing cable, shown having broken free from its isolating tower mount (left) and the loose metal chain (right) were both causes of PIM when being blown against the tower structure by wind.

When hunting for interference, reflections from buildings and vehicles can cause multipath and erroneous direction readings. It is best to take direction readings from a number of vantage points to be sure of the source of the interference. There were two hill tops at this site. When retesting from a hill top 1 kilometer away from the shared P25 and broadcast tower site the only interference source came from the direction of the P25 and broadcast site, providing further evidence that the true cause of the interference had been identified.

Figure 11. Revalidating the source of the interference from a distant location.

Conclusion

Where other solutions had failed, the Field Master Pro MS2090A with real-time spectrum analyzer option was able to detect the source of an intermittent interfering signal at a 800 MHz P25 communication site. With RTSA spans up to 110 MHz (option dependent) and 2.05 μs POI, the Field Master Pro MS2090A provides capability for broadcast FM, Land Mobile Radio, cellular and full ISM band interference monitoring – making it the ultimate signal analysis and interference capture tool.

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