WHITE PAPER

Investigate Interference Issues in the Field with RTSA

KEYSIGHT

The exciting transition to 5G networks also brings an opportunity for interference issues to arise. People-to-people communications as well as machine-to-machine communications can cause interference in your network. If you do not address interference issues properly, critical complications will arise. These complications may affect autonomous driving systems, internet of things (IoT) devices, security or public safety networks, radar navigation, and more.

Interference is everywhere, regardless of the network you operate on — and traditional interference analysis is not always the most reliable. Avoiding complications and detecting elusive interference signals in the field requires real-time spectrum analysis (RTSA). This whitepaper will discuss sources of radio frequency (RF) and microwave (MW) interference, traditional interference analysis pitfalls, and how RTSA helps address interference issues before they become a problem.

Sources of RF and MW Interference

Your network's performance is always limited by noise level, regardless of the network type, and interference signals create noise. When interference impacts network performance, a provider's quality of service (QoS) degrades. Lack of QoS equates to interruptions, downtime, lost money, and more serious issues such as failure to deliver mission-critical data. This highlights the importance of interference management to improve QoS.

To manage interference, you must understand where interference comes from. Below, we will cover two examples of interference sources:

- Internal interference in LTE networks
- External interference in satellite ground stations

To learn about additional interference challenges and how to address them, read the Application Note, "Overcoming RF & MW Interference Challenges in the Field".

1. LTE networks

Typically in LTE, a mobile device at the center of a cell has access to the full spectrum. Mobile devices do not require much power transmission to achieve full capacity and throughput.

A mobile device at the edge of the cell, however, can experience interference from an adjacent cell. This may cause the mobile device to transmit more power. At that time, the whole spectrum is not available for use. Only a fraction of the spectrum is available which means full throughput becomes impossible. The noise generated by each mobile device is called internal interference.

This internal interference can disrupt initial 5G deployments, slowing a provider's time to market. Networks using non-standalone (NSA) mode for 5G deployment leverage existing 4G LTE networks. In NSA mode, a 5G-enabled mobile device transmits and receives data on a 5G channel. If 5G coverage is limited, the mobile device switches to LTE. This allows service providers to offer reliable 5G capabilities sooner. Unfortunately, if the LTE network experiences interference or disruption in NSA mode, so does the 5G network.

In this case, LTE providers use power control as a form of interference management. The base station provides the full spectrum at the center of the cell, but at a lower power. At the same time, it allocates less of the spectrum to users at the edge of the cell but delivers more power, as depicted in Figure 1. By doing this, the network operator minimizes interference at the edge and still provides good QoS to edge users.

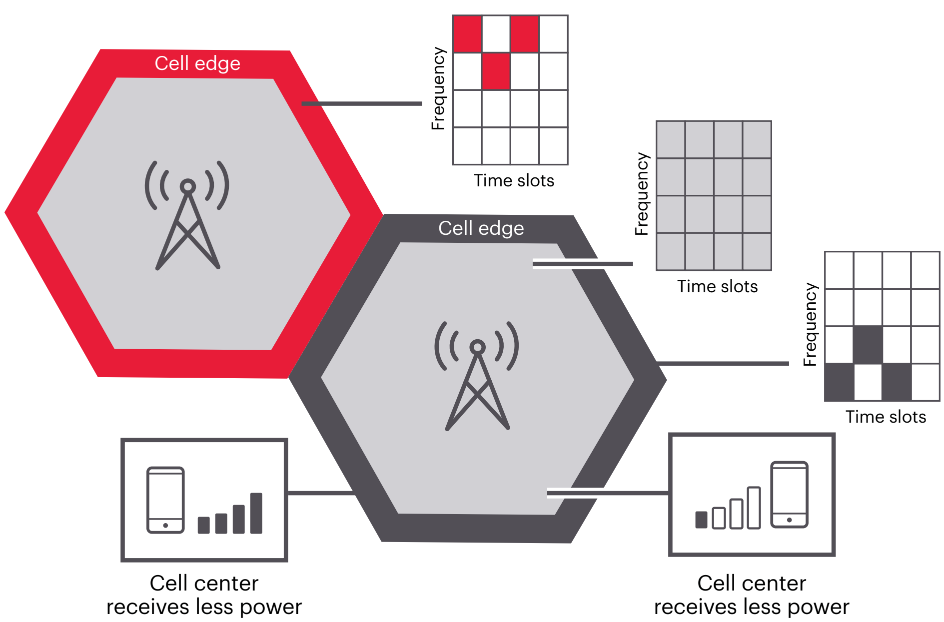

Figure 1. LTE power control and resource block allocation

2. Satellite ground systems

5G radio systems operate in the 3.7 to 4.2 GHz spectrum. This directly overlaps with C-Band satellite downlink transmission frequencies that TV and radio channels use. When a 5G base station or mobile device gets close to a satellite earth station, it can generate external interference as shown in Figure 2. This can be detrimental as the C-Band is needed for emergency and disaster communications, especially in rural and marine areas lacking physical infrastructure.

Regulatory guidelines for cellular planning exist to combat such interference. However, regulating bodies cannot ensure that all 5G waveforms maintain their predicted range. This is where network operators use interference management to verify emission levels and performance limits during deployment.

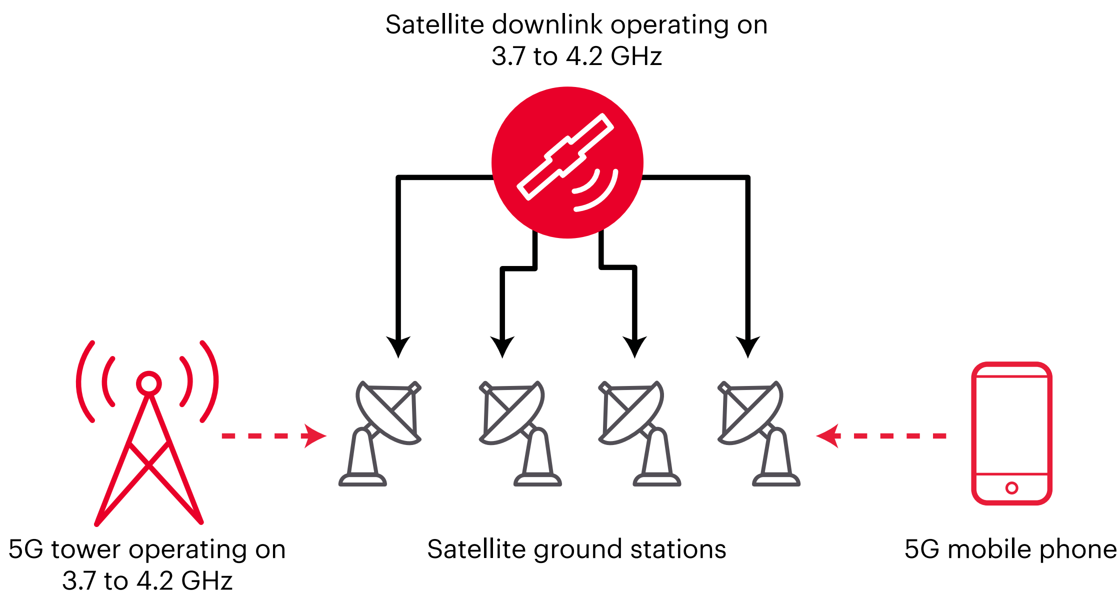

Figure 2. 5G radio tower and mobile phone interfering with satellite ground station communications

Shortcomings of Traditional Interference Analysis

Dealing with interference issues presents many challenges. Typically, capturing and analyzing interference in a steady signal using traditional interference analysis is easy. For a signal such as a continuous waveform (CW) signal, the interference appears at all times.

In the digital communication world, analyzing interference signals gets more difficult because signals tend to appear in bursts and pulses and are traffic-dependent. Since these signals have shorter duration, they are more difficult to detect. Or, the interference signal may depend on network traffic levels; interference appears during rush hour but not at night.

Let's compare the advantages and disadvantages of two traditional analyzer types: swept-tuned and snapshot FFT analyzers.

Swept-tuned (also known as superheterodyne) analyzers

In traditional swept-tuned spectrum analysis, a ramp generator sweeps the local oscillator (LO) over the frequency range of interest using a fixed resolution bandwidth (RBW) filter. Front-end preselectors help to block out-of-band noise to improve receiver dynamic range and sensitivity. Since the ramp generator sweeps at a fixed rate, it precisely controls the sweep time over a frequency span. Swept-tuned analyzers sweep very fast over very large frequency spans; however, when the RBW:SPAN ratio is too small, the analyzer sweeps very slowly.

Advantages	Disadvantages
Fast sweep over wide frequency span	Can miss intermittent signals
Excellent dynamic range and sensitivity	Slow when RBW:SPAN ratio is too small
Precise sweep time control	

Although the swept-tuned analyzer has several advantages, its biggest disadvantage is that it misses signals that appear outside its moving viewpoint, as shown in Figure 3. Such signals may include intermittent and wide-band digitally modulated signals. This characteristic makes the swept-tuned analyzer ineffective for transient, digital interference signal hunting.

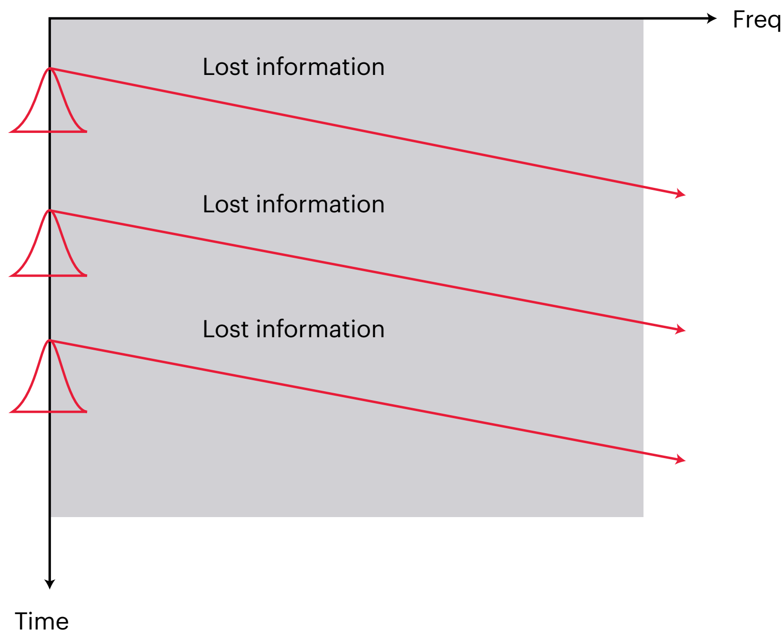

Figure 3. A swept-tuned analyzer misses data events that occur outside the RBW

Snapshot FFT (Fast Fourier Transform) analyzers

A snapshot FFT analyzer gathers a complete block of time-domain samples and computes the frequency domain spectrum. It performs a block down conversion at the front end, with the intermediate frequency (IF) and the analog-to-digital converter (ADC) sample rate determining the block size. Since it performs block conversion, it fully captures the signal within the block, or information bandwidth, enabling further analysis like digital demodulation.

In FFT-based signal analysis, the processing speed or calculation time becomes the limiting factor. Instead of continuously sweeping the LO, like the swept-tuned analyzer, the LO steps through the frequency span. If the instrument does not have high-speed processing, gaps occur between each block of time domain data, and the instrument misses any events that occur in the gaps, as shown in Figure 4.

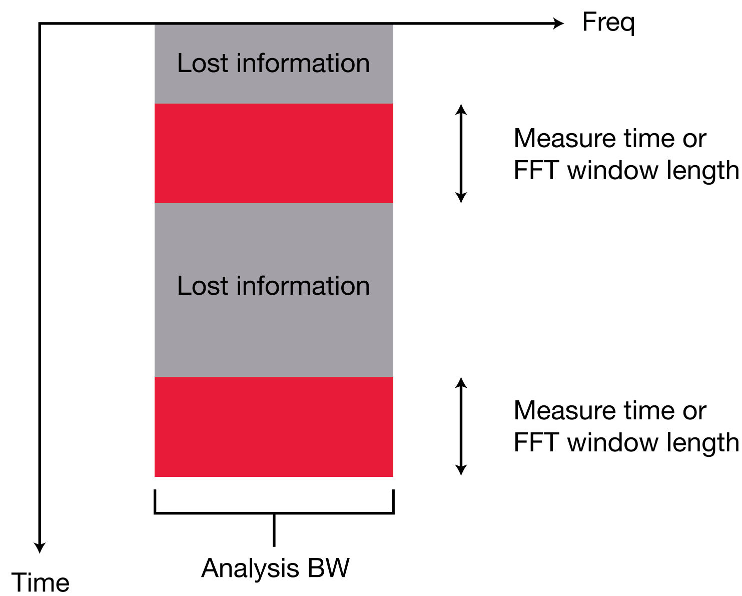

Figure 4. An FFT-based analyzer misses events that occur between time data sample blocks

Advantages	Disadvantages
Captures all signal content within information bandwidth	Relatively slow with very large bandwidth
Can perform digital demodulation	Unpredictable dead time
Fast update speed at narrow RBW	Cannot precisely control sweep time

Unlike the swept-tuned analyzer, the snapshot FFT analyzer performs digital demodulation easily. Furthermore, it can capture elusive signals, but it does have a drawback. The signal must occur within the bandwidth sweep. This can be tricky with an FFT analyzer as its dead time (time between the end of one sweep and the start of the next sweep) is unpredictable, making sweep time difficult to control. The FFT is running on CPU, which has inherent and undefined software latencies.

After each sweep, the snapshot FFT analyzer stitches the information together. But if the interference signal occurs during the dead time between sweeps, while the analyzer is processing and stitching data, it misses the signal.

Real-Time Spectrum Analyzers

When chasing an elusive signal, several important attributes should be considered: when the signal occurs, how long it lasts, where it occurs within the spectrum, and how large or small it is. Understanding these attributes requires a signal analyzer capable of performing real-time spectrum analysis (RTSA). With RTSA, you avoid the disadvantages that come with traditional interference analysis, like dead time between sweeps, depicted in Figure 5. Also known as gap-free FFT analyzers, real-time spectrum analyzers are architecturally similar to snapshot FFT analyzers. The difference is that RTSA uses a circular memory buffer to make sure it captures all of the data and eliminates dead time, as seen in Figure 6. As long as the FFT engine keeps up with the buffer, it does not miss the signal. The analyzer samples, processes, and parallelly computes the data at the same time.

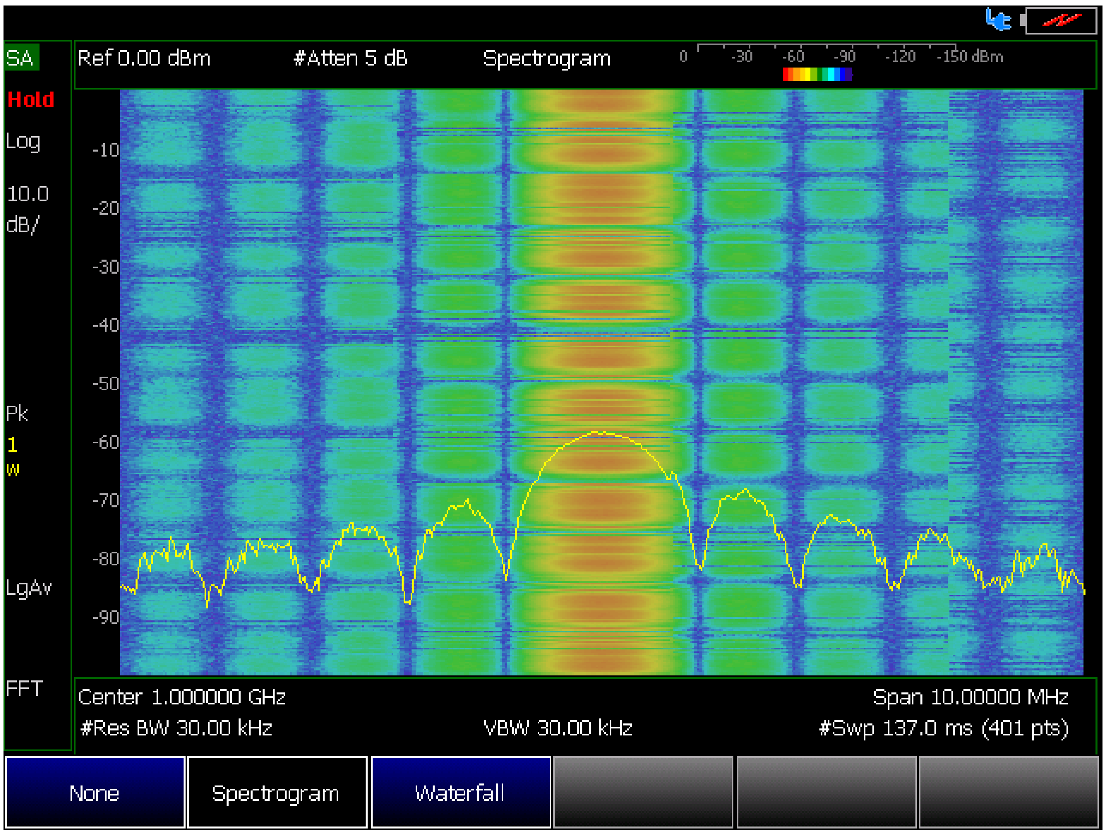

Figure 5. A signal captured using traditional spectrum analysis mode with dead time between updates

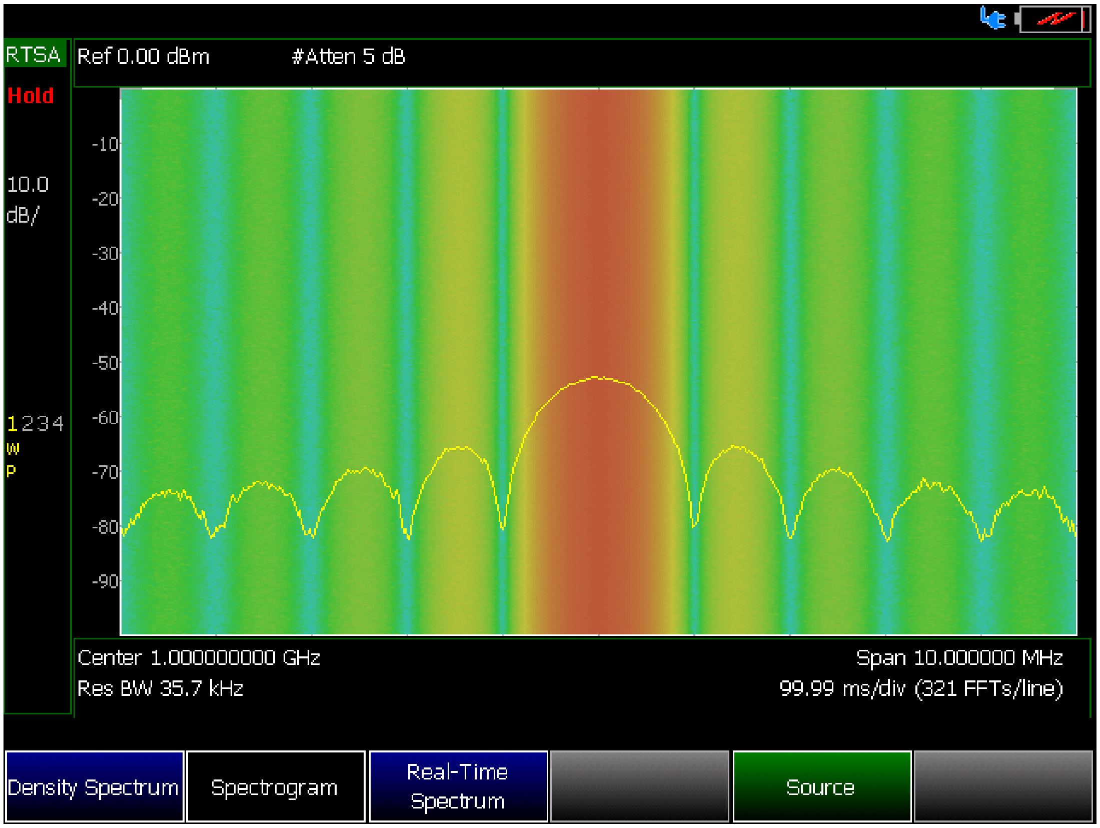

Figure 6. A signal captured using RTSA mode with gap-free results

Those who use real-time spectrum analyzers to detect elusive signals want to know the shortest duration of an event that they can dependably observe. The key instrument specification for this duration is probability of intercept (POI). POI is the minimum amount of time that a signal occurs where a user can still observe the signal with 100% probability and accurately measure it. The signal must be a specific amount above the instrument's noise floor. The core of FFT-based processing relies on the same attributes that ultimately determine a 100% POI: sampling rate, or FFT size, windowing function, window size, overlap processing, and noise floor.

RTSA does have some shortcomings, though. It has limited real-time bandwidth. This means that when tuned to a particular center frequency, the LO tuning stays fixed, and the receiver parks at a particular span. If a signal frequency moves beyond this real-time bandwidth, then you will not see the signal on the real-time display. So, though the real-time bandwidth is relatively small, within that bandwidth you capture the signals fully within the tuned frequency spectrum.

Additionally, since RTSA has fixed LO tuning, the signal to be detected may not be located at the center frequency. Therefore, the detected signal level may not be as accurate in RTSA as when using a traditional spectrum analyzer.

Interference Detection in the field with FieldFox and RTSA

One of the most challenging interferences to detect in the field on a digital wireless network is co-channel interference. Co-channel interference occurs when a signal is on the same frequency as the carrier signal, or within its channel bandwidth, and synchronized with the baseband frames. Detecting and troubleshooting this type of interference is difficult because the carrier signal masks the interfering signal, shown in Figure 7. Hunting co-channel interferers with traditional analyzers requires operators to turn off the carrier transmitter, which disrupts normal communication services. For some, this is not a viable solution.

To see examples of other RTSA measurements FieldFox makes, watch the webinar, "Counter Interference with Over-the-air Signal Characterization".

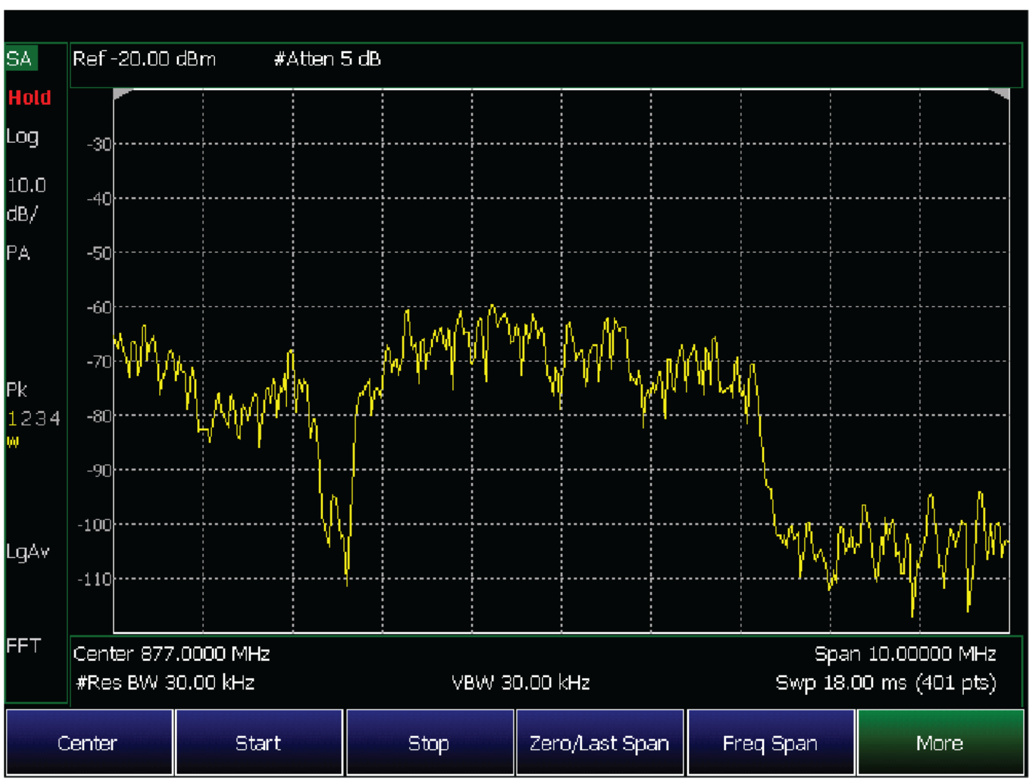

Figure 7. A signal captured using FieldFox's traditional SA mode where the carrier signal masks the interfereing signal

A FieldFox handheld analyzer, equipped with RTSA, detects the smallest interfering signals in the field, including co-channel interference — without turning off the carrier signal. The RTSA density display is a spectrum measurement used to show the frequency of occurrence. The color-coded display shows trace intensity and the user has the option to add a persistence function to focus attention on more recent events as older data fades away. The density display shows frequency, power, and signal occurrence within a given time, making it easy to detect multiple signals in the same channel. See Figure 8.

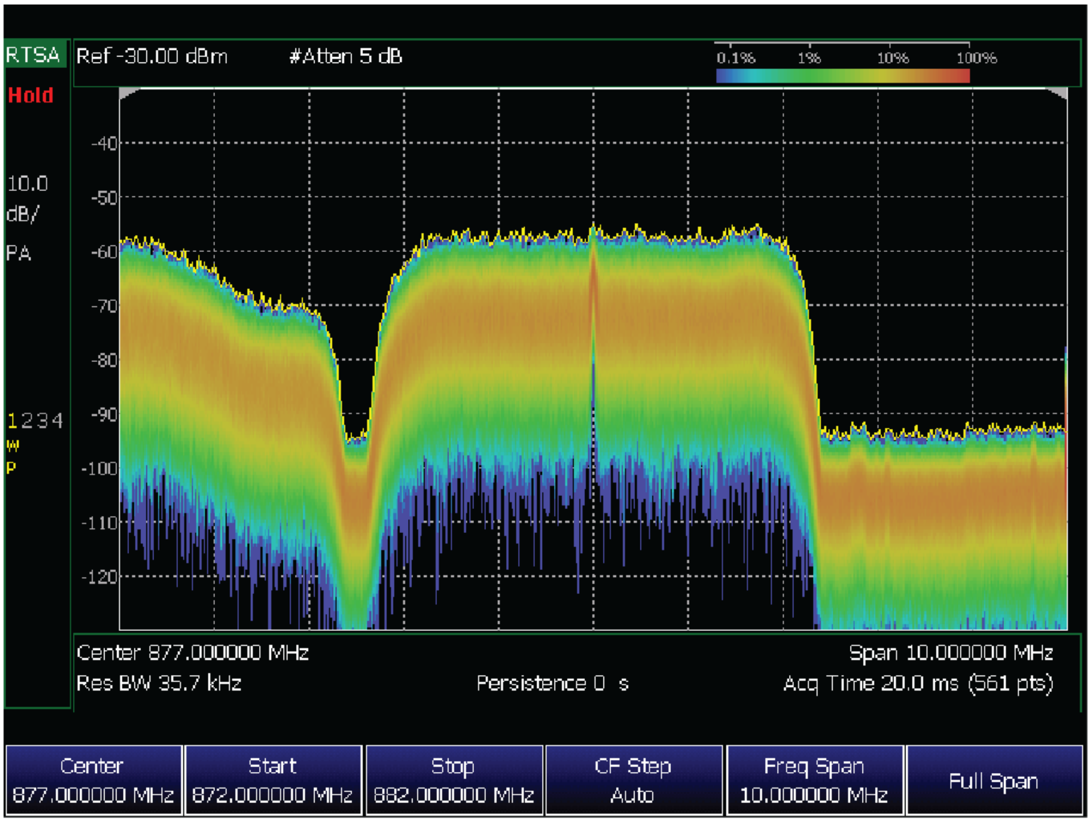

Figure 8. A signal captured using FieldFox's RTSA density display where the interfering signal is seen in the middle of the screen

In addition to interference detection and RTSA, FieldFox supports routine maintenance, in-depth troubleshooting, and anything in between — all with precise microwave and millimeter-wave measurement capabilities. FieldFox is the industry's most integrated handheld analyzer, configurable to be a cable and antenna tester, a network analyzer, a spectrum analyzer, a signal source, and more. With a maximum real-time bandwidth of 100 MHz, FieldFox captures most 5G signals, boasts a best-case POI performance of 5.52 μs, and captures signals as narrow as 47 ns. Visit the FieldFox webpage to find out more.

Figure 9. FieldFox B series handheld analyzers

Conclusion

With 5G on the horizon, 5G-enabled devices and IoT networks will not only be susceptible to interference, but they will also create it. Traditional interference analysis will no longer suffice with bursty, pulsing, narrow interference signals. To maintain a high QoS and ensure reliable network performance, real-time interference management is critical. RTSA facilitates interference management by enabling network operators to detect and troubleshoot elusive interference signals in the field. For these reasons, an RTSA-capable analyzer, like FieldFox, is an invaluable tool to keep in a field kit.