APPLICATION NOTE

Overcoming RF & MW Interference Challenges in the Field

Using real-time spectrum analysis

KEYSIGHT

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This application note discusses practical strategies to overcome RF and microwave interference challenges in the field using real-time spectrum analysis (RTSA). Learn about the different types of interference encountered in commercial and aerospace and defense (A/D) wireless communication networks. Uncover the drawbacks associated with traditional interference analysis and get an in-depth introduction to RTSA. Understand why RTSA is valuable for troubleshooting interference in today's networks with bursty and elusive signals.

Introduction

Increasing wireless technologies in communication networks bring one inherent challenge — interference. Regardless of the type of network, the noise level in the system always limits performance. Generation of noise is internal or external.

The level of interference management determines the quality of service. For example, uplink noise level management of an LTE network dramatically improves its performance. Proper channel assignment and reuse in an enterprise wireless local area network (LAN) assures the planned connection speed, and optimized antenna location/pattern in a satellite earth station contributes to the reliability of communication under all weather conditions.

A real-time signal analysis (RTSA) capability is necessary for detecting demanding signals and troubleshooting network issues in the field. In this paper, we will look at interference in various networks, discuss RTSA technology and its key performance indicators, and explore applications to troubleshoot RADAR, electronic warfare (EW), and interference issues in communication networks.

Review of RF and MW Interference Issues

Wireless interference challenges

In commercial digital wireless networks, the key challenge is to provide as much capacity as possible within the available spectrum. This design goal drives much tighter frequency reuse and wider channel deployment. Because cell sites are so close to each other, and base stations transmit at the same time, this creates a much higher noise level on the downlink (direction from the base station to the mobile). The higher noise level on the downlink at the mobile antenna triggers the mobile to increase its output power. In turn, this leads to increased uplink (direction from the mobile to the base station) noise level at the base station antenna. The higher level of noise at the base transceiver station (BTS) antenna reduces cell site capacity. These are examples of internal network interference.

In addition to internal interference, external interference is more prevalent now; this is due to tight frequency guard bands between network operators, poor network planning, network optimization, and illegal use of spectrum.

Interference issues in LTE networks

The LTE network is noise limited. It has a frequency reuse of one, which means every cell site uses the same frequency channel. For an LTE network to work properly, it must have a sophisticated and efficient interference management scheme.

On the downlink, LTE base stations rely on channel quality indicator (CQI) reports from the mobile to estimate the interference in the coverage area. CQI is a measure of the signal-to-interference ratio on the downlink channel or on certain resource blocks. It is a key input for the base station to schedule bandwidth and determine the throughput delivered to the mobile. The interference is an aggregation of noise generated inside the cell site and interference from external transmitters. If there is external interference on the downlink, it drives CQI lower and prompts the retransmission of data, which in turn decreases network speed. Downlink interference is one of the most challenging situations to deal with because there is no direct feedback from the base station to indicate that interference is present.

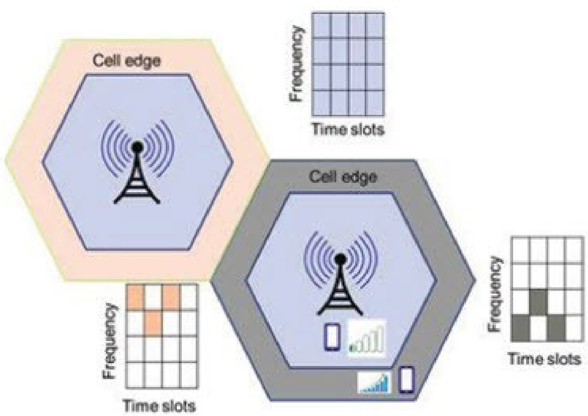


Figure 1. LTE power control and resource block allocation

Precise power control plays a critical role in LTE interference management because the serving cell and neighbor cells share the same frequency channel. The network needs to minimize interference at the edge of the cell, and at the same time, provide enough power to the edge users to get good service quality. An LTE base station provides full-spectrum at lower power in the center of the cell. At the edge of the cell, it allocates fewer resource blocks (subcarriers) but delivers more power (Figure 1). This approach improves overall cell throughput and minimizes the interference.

LTE control channels are located at the center of the channel with a bandwidth of 1.08 MHz regardless of the system's channel bandwidth. Key downlink control channels are the primary sync, secondary sync, and broadcast channels. The primary sync and secondary sync channels synchronize the mobile with the cell and decode system information. Narrowband interference close to the center of the LTE channel majorly impacts the mobile's synchronization process; sometimes it blocks the whole cell. For example, some analog 700 MHz FM wireless microphones easily block an LTE cell. The Federal Communications Commission (FCC) bans these wireless microphones.

Microwave backhaul interference issues

About 50% of the world's base stations connect to backhaul with a microwave radio. With recent developments in Gigabit Ethernet over microwave, it makes microwave radio very attractive as a backhaul option for 4G/LTE deployment.

Just like any radio technology, interference is always part of the network. For microwave radio networks, the primary interference comes from the areas discussed below.

Reflection and refraction

In a mobile network, microwave radios are widely used for point-to-point connections and deployed in urban areas. When something blocks the transmission path, the signal bounces back and cancels out a portion of the energy traveling towards the remote receiver. This type of event is considered reflection. When the signal bends and changes directions, it is refraction. Both cases create a system outage.

Interference on unlicensed bands

In recent years, point-to-point Ethernet microwave links have been widely used for mobile backhaul; they are convenient and lower cost. Point-to-point microwave links operate either on licensed or unlicensed bands such as 5.3 GHz, 5.4 GHz, and 5.8 GHz. In unlicensed bands, more interference-related system outages occur. These bands are very close to the frequencies used by 802.11n or 802.11ac wireless local area networks (WLAN), so interference occurs between these two systems. For example, when a WLAN operates near a 5.8 GHz microwave radio, it raises the power level at the microwave radio receiver. The increase in power level misleads the microwave radio to think that it needs to reduce its transmit power on the link. In turn, the radio does not transmit enough power to maintain the actual signal level required, so an outage occurs.

5G signal and potential interference

5G deployment dramatically expands the frequency bands that wireless communications use. 5G operates in the current cellular frequency band (< 2 GHz), mid-band 3.5 to 4.5 GHz, and the millimeter-wave bands > 24 GHz.

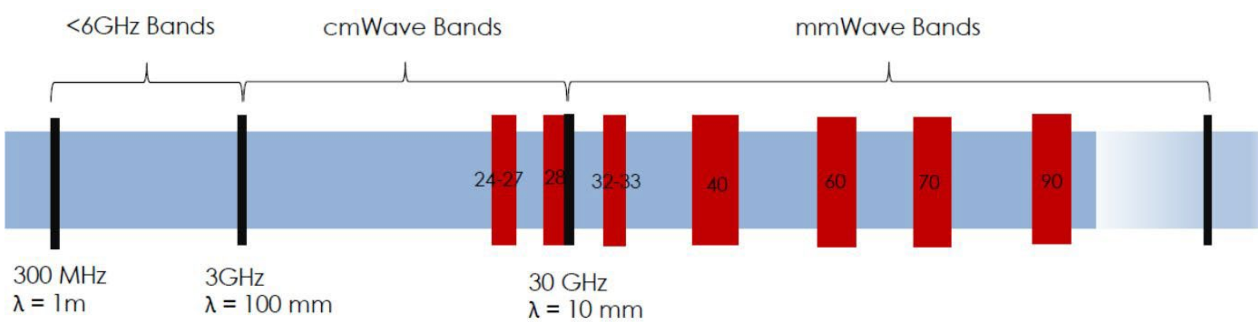


Figure 2. 5G frequency bands and spectrum allocations

For the first time, terrestrial communications use the millimeter-wave frequency band and present unique challenges in deployment. The 3rd Generation Partnership Project (3GPP) standards body refers to sub-6 GHz frequency bands as FR1 (Frequency Range 1) and millimeter-wave frequency bands > 24 GHz as FR2 (Frequency Range 2). 5G channel bandwidth varies from 10 MHz to 400 MHz to provide flexible channel allocation and support for different services like ultra-low latency and mobile broadband communications.

In addition to FR1 and FR2 operating bands, 5G introduces standalone mode (SA) and non-standalone mode (NSA) for deployment. SA mode means the 5G network completely operates on its own; from an air interface point of view, the user equipment (UE) or mobile exchanges both control and traffic information on the 5G network only. While SA mode supports all the advantages that 5G provides, it is the most expensive way to build a 5G network. In contrast, NSA mode deployment leverages existing LTE networks, where LTE is the anchor of the network. The control channel resides on the LTE network, and the UE is 5G enabled. The UE transmits and receives traffic on a 5G data channel, and if 5G cannot provide adequate coverage, the UE falls back to LTE. At the initial stages of 5G deployment, NSA mode is more reliable and allows wireless operators to offer 5G services much earlier than SA mode. Of course, if something interferes or disrupts the LTE network in NSA mode, it affects the 5G network, too.

A/D and Public Safety Interference Issues

Most of the common A/D communication systems are satellite, radar, EW systems, and secure communication (public safety) networks. With the explosive development of wireless technologies in both the commercial and A/D space, more interference enters into A/D systems. A/D systems are moving to higher frequencies, deploying much narrower radar pulses, and implementing highly encrypted digital wireless systems for communication in order to mitigate these challenges.

These technologies fend off external interferences, but they also make troubleshooting in the field far more difficult. Effectively maintaining A/D communication systems requires new tools and measurement techniques.

Public safety/two-way radio interference issues

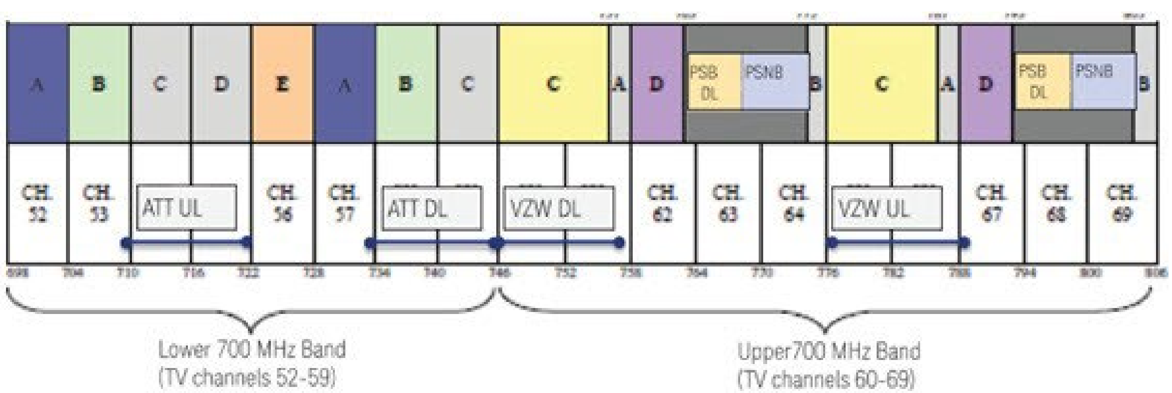


Figure 3. 700 MHz band public safety narrowband and broadband channel assignment

Two significant issues plague public safety radio systems. The first is adjacent channel interference and the second is intermodulation distortion. Typically, public safety radio is a narrow band system with bandwidths like 25/12.5/6.25 kHz, and it transmits at a much higher power than a commercial system. It requires channel rejection in the range of 80 to 100 dB. An improperly tuned duplexer or diplexer causes a base station to generate adjacent channel interference among operating channels, thus reducing the coverage area.

A public safety transmitter operates at a higher power level. A saturated power amplifier causes intermodulation, and its harmonics land on adjacent bands. When these harmonic products land on LTE control frequencies (see Figure 3), disruptions in network service occurs.

Satellite ground station interference issues

Aerospace and defense networks commonly deploy satellite communication systems. One of the trends in this area is to provide high-capacity communication links to the military establishment. There are two primary techniques to increase system capacity, one is to increase the operating frequency from C and Ku bands to Ka bands, and the other is to use multiple beams to deploy frequency reuse.

A higher frequency significantly reduces beam size. It requires more precise antenna alignment. Mis-alignment introduces co-channel interference and adjacent channel interference. Multi-beam frequency reuse allows adjacent areas to share the same frequency plan and polarization. An improperly optimized system creates strong co-channel, adjacent channel, and cross-polarization interferences.

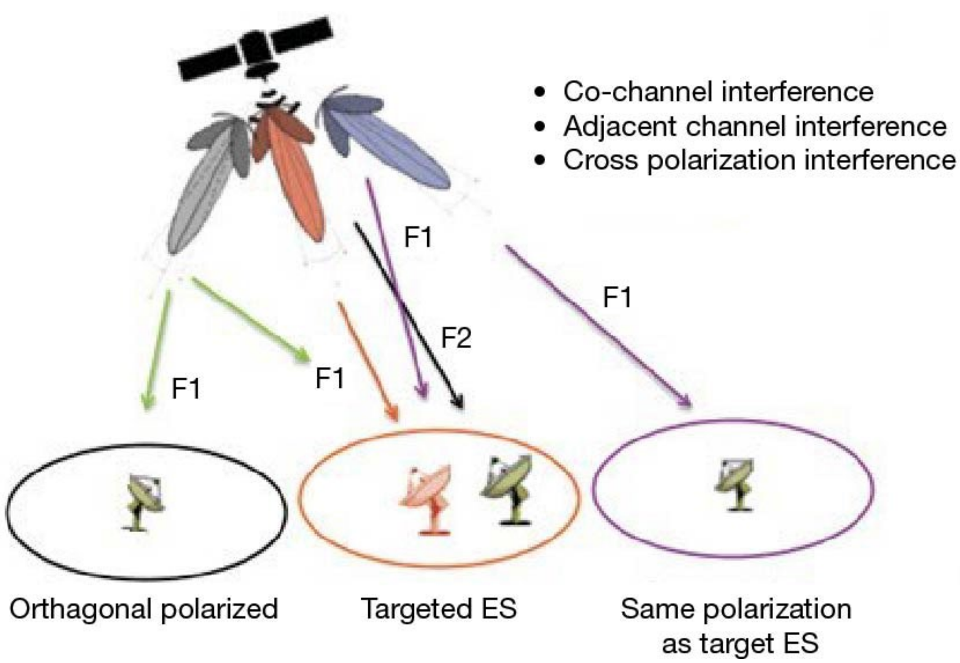


Figure 4. Interference types in satellite ground station operation

Challenges with traditional interference analysis

There are a few ways to classify interference. From the signal-interaction viewpoint, it is categorized as co-channel interference, adjacent channel interference, and intermodulation (passive and active). From the network operation perspective, it is grouped into downlink interference — base station (BS) and mobile station (MS), uplink interference (MS to BS), and external interference.

If there are interference issues in the network, a system performance monitoring tool will report the issues. These issues may be a rise of uplink noise floor without significant traffic, connection failures, a high signal-to-noise ratio, and more. The next step is to detect where the interference stems from. Traditionally, a spectrum analyzer with a directional antenna is the tool of choice to detect and locate the interference.

Traditional swept-tuned and fast Fourier transform (FFT) spectrum analyzers effectively detect a relatively constant signal, or intermittent signals using max hold. Traditional analyzers either have a large dead time where no data capture occurs during a retrace, or the dead time is unpredictable. Because of this, their effectiveness is challenged when dealing with random, bursty signals, narrow pulses like radar, or a signal with a duration based on network traffic conditions.

Given the increasingly bursty nature of wireless broadband networks, it is time to find a complementary tool to improve the effectiveness of spectrum analysis.

Real-Time Spectrum Analyzer (RTSA) introduction

We face two challenges when detecting interference: one is that interference under investigation is much more bursty due to the time-division multiplex nature of digital wireless signals. The second is that the spectrum analyzer has too much dead time, which causes missed signals.

The most effective way to mitigate these challenges is to minimize, and ideally eliminate the dead time present in a traditional spectrum analyzer. A new tool is necessary to detect challenging signals — gap-free spectrum analysis or real-time spectrum analysis (RTSA).

Spectrum analyzer receiver architecture overview

To better understand the capability of RTSA, it is important to look at the traditional spectrum analyzer receiver architecture, and its advantages and disadvantages.

Swept-tuned receiver

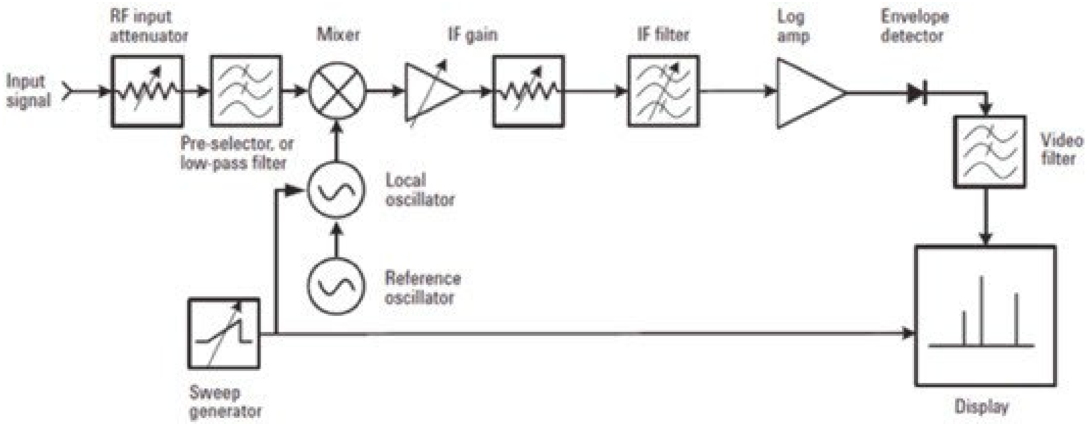


Figure 5. Superheterodyne spectrum analyzer/swept-tuned spectrum receiver

Heterodyne means to mix. In a superheterodyne (also known as swept-tuned) spectrum analyzer, the RF input signal mixes with the local oscillator (LO) signal to translate the input signal from a higher frequency to a lower frequency — the IF (intermediate frequency). An envelope detector detects signal magnitude and displays it as a vertical point.

In order to control the display of the horizontal frequency axis, use a ramp/sweep generator to control the movement tune of the LO to the expected frequencies. Setting the sweep time and frequency span controls the LO tuning rate. The front end of a spectrum analyzer contains signal conditioning circuits — attenuators and pre-selectors (low-pass filters). The role of these circuits is to ensure input signals are at an optimum level before hitting the mixer. Front end pre-selectors help to block out-of-band noise to improve receiver dynamic range and sensitivity. The tuning LO provides a better selectivity of the receiver. It naturally blocks unwanted out-of-band signals, and that is why a superheterodyne receiver has excellent dynamic range.

Since the ramp generator sweeps at a fixed rate, it precisely controls sweep time over a frequency span. By controlling the sweep rate, it enables the receiver to sweep a very large span at a faster rate than an FFT analyzer.

The significant disadvantage of a superheterodyne receiver is that it may miss intermittent signal contents, especially wideband digitally modulated signals. Another issue is that the sweep time is dramatically longer at narrow resolution bandwidth (RBW).

Snapshot FFT receiver

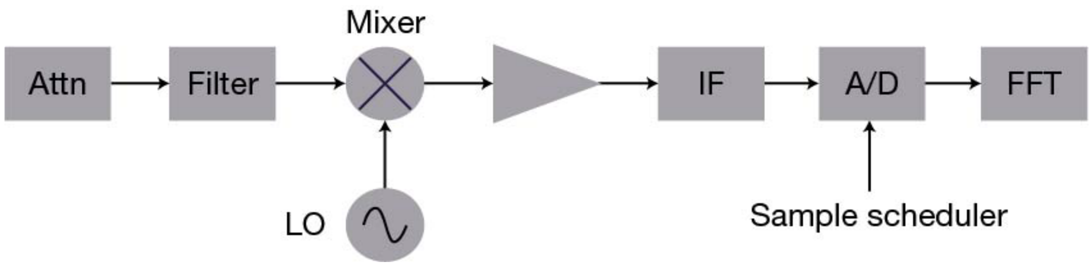


Figure 6. Snapshot FFT spectrum analyzer

A snapshot FFT analyzer/receiver can handle wideband signals. It has a block conversion at the front end while the IF bandwidth and analog-to-digital converter (ADC) sample rate decide the block conversion size. Instead of continuous tuning of the LO, the LO steps through the frequency span. After the LO tunes to the right frequency, the receiver samples data through the ADC and converts it into I/Q (in-phase and quadrature) pairs. Next, the receiver puts data into proper FFT time frames, converts the time domain frame into FFT spectrum data, sends spectrum results to the display, and finally, starts to acquire data again. This is a serial operation, so some signals at the input go undetected when there is time between screen updates. This duration is dead time, and the length of the duration is unpredictable.

Since it is a block conversion, any signal within the block or information bandwidth is fully captured for further analysis, such as a digital demodulated signal. Snapshot FFT is ideal for wideband digital signal analysis. It reproduces digital receiver behavior based on its signal specification — for example, an LTE signal test.

Since the FFT engine cannot finish its operation within a specific time frame, it is impossible to precisely control the FFT receiver sweep time. A signal bandwidth larger than the information bandwidth of the receiver requires signal stitching which results in missing part of the wide-band signal contents.

Real-Time Spectrum Analyzer (RTSA)

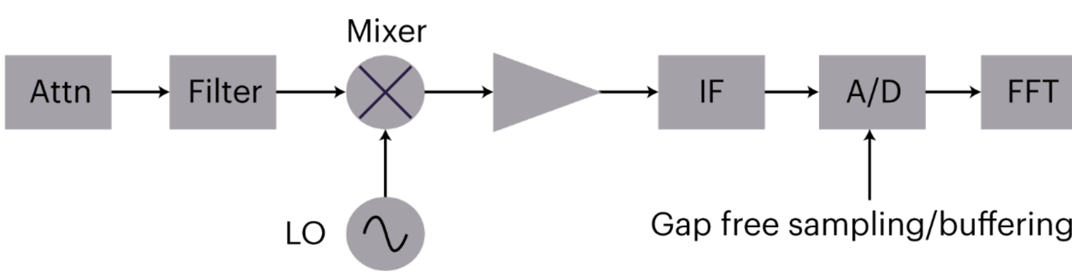


Figure 7. Real-time spectrum analyzer

A real-time spectrum analyzer is an FFT analyzer without dead time. The receiver parks at a frequency span of interest limited by the real-time frequency bandwidth. There is no tuning or stepping. It has a large enough signal buffer, FFT engine, and display engine to process and empty memory before subsequent data frames come in.

Within its capture bandwidth, it detects any transient signals, dynamic signals, and RF pulses.

Nevertheless, bandwidth limits RTSA. When the receiver tries to measure signals beyond its real-time bandwidth, the LO must be tuned. And at this time, it is no longer real-time or gap-free.

Since RTSA has no tuning, the signal may not be located at the center frequency. Additionally, its detected signal level may not be as accurate as measuring with a traditional spectrum analyzer. So, RTSA is not recommended to provide accurate power measurements.

RTSA signal flow and data processing

RTSA is based on FFT processing, but it removes the dead time of a snapshot FFT analyzer. It processes and displays signals faster than the time needed for the ADC to fill up the circular buffer at a given information bandwidth. Of course, the downside is that RTSA is always fix-tuned and bandwidth limited. However, it is an ideal method to detect elusive signals at a given bandwidth as it doesn't miss signals.

In addition to a robust FFT engine and large circular memory buffer, the most important technique of RTSA is overlapping FFT. With overlapping FFT, it is possible for RTSA to reliably detect a narrow pulse with a random duty cycle.

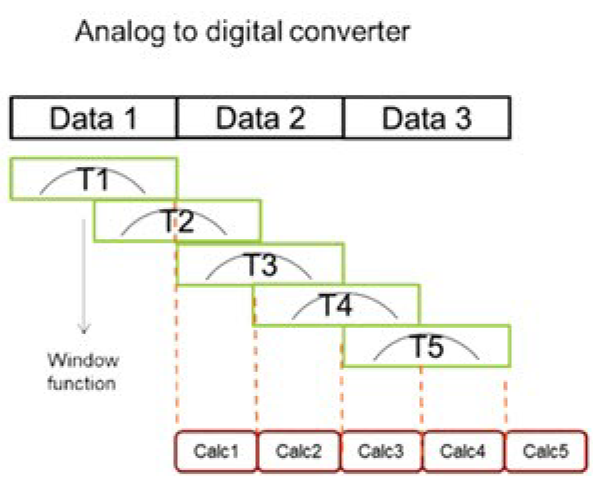


Figure 8. RTSA signal processing flow

Figure 8 is the signal flow of RTSA. First, the ADC samples data from the IF chain and packs them into each data frame. In the case of FieldFox, each data frame includes 1024 samples, which is also the size of the FFT engine. In FieldFox, the FFT size is fixed to improve efficiency.

Instead of processing raw data one frame at a time, RTSA rearranges the raw data frame (data 1, data 2, data 3, …) to new FFT frames (T1, T2, …). To form T2, it takes a portion of the sample from T1 and combines it with new data from data 2. T3 does the same with a portion of the sample from previous T2 and a portion of new samples from data 2. This is called overlapping FFT, and it guarantees that a signal at the edge of data 1 and data 2 is properly positioned to the center of the next FFT, so the signal is detected.

Moving the signal to the center of the frame prevents windowing from filtering out the useful signal at the edge of the data frame or time record. For illustration purposes, we have made FFT calculation and display twice as fast as saving data to buffers.

Overlapping FFT dramatically increases the chance to capture narrow pulses or transient signals. In the screen captures below, Figure 9 shows a receiver with the dead time between updates, and no FFT overlapping. Figure 10 shows RTSA with overlapping FFT.

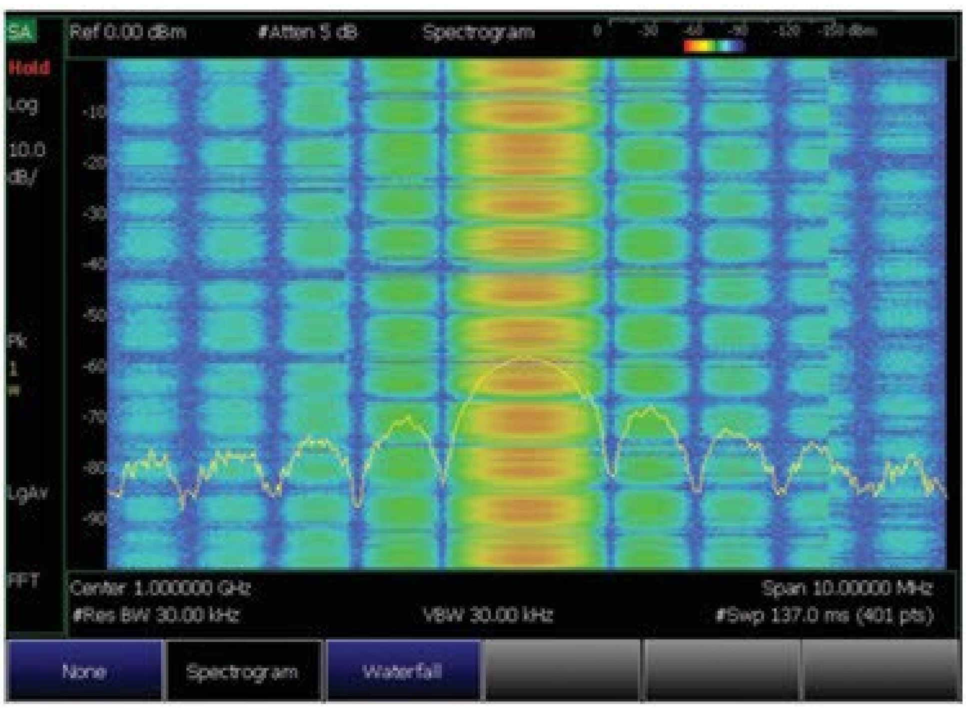


Figure 9. No FFT overlapping; with the dead time between updates

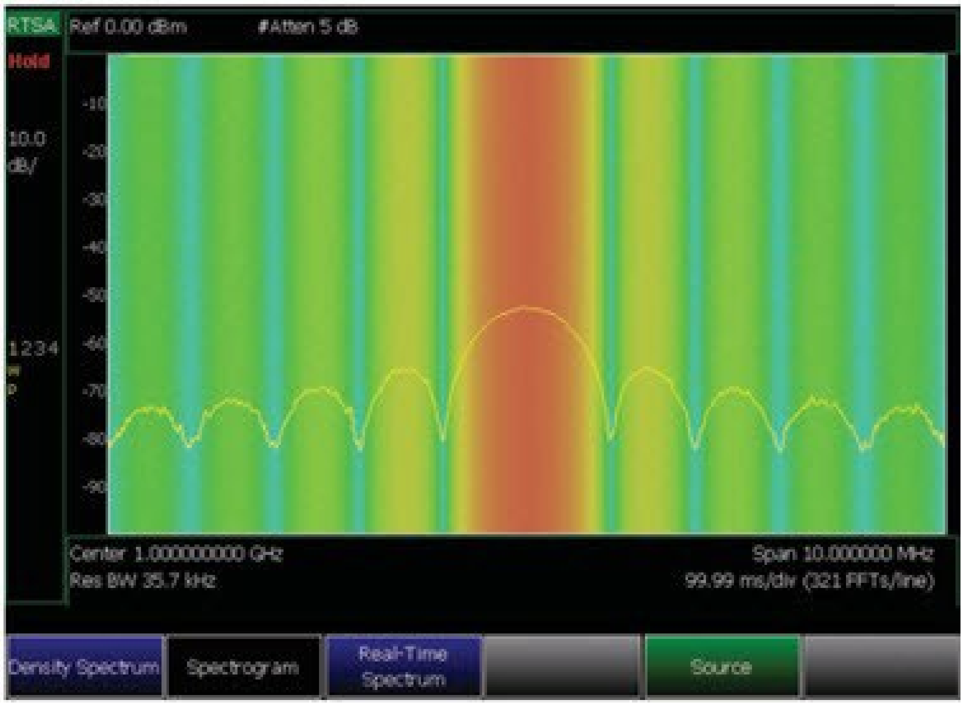


Figure 10. FFT overlapping with no gap capturing

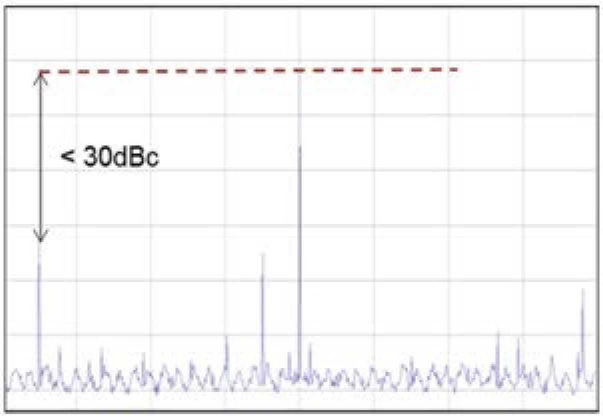
RTSA key performance indicators

In RTSA, there are a few critical key specifications. One is real-time bandwidth, and in general, the larger the bandwidth is, the better. The downside is that large bandwidth requires a large field-programmable gate array (FPGA) to process the data. A large FPGA demands more space and power, so a user must make a trade-off between portability and bandwidth. For most over-the-air applications, 10 MHz bandwidth is adequate, but emerging standards, like 5G, require wider bandwidths.

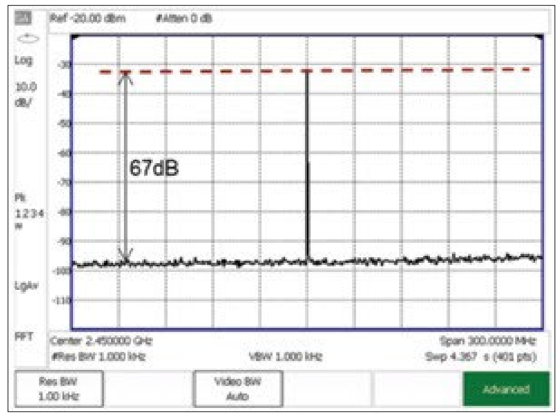
Another specification is called the minimum signal duration for 100% probability of intercept (POI). It is the minimum duration of the signal of interest detected with 100% probability and measured with the same amplitude accuracy as that of a continuous waveform (CW) signal. In order to detect narrow pulse signals in the frequency domain properly, it requires a large resolution bandwidth (RBW). A large RBW is necessary to ensure the signal falls into the size of the RBW, but that means a small window size in the time domain. If the window size is too small, it may miss signals toward the edge of the window; making it harder to distinguish two or more pulses next to each other. In order to reliably detect narrow pulse signals, FieldFox provides auto mode to optimize window size (RBW) and overlapping to reliably detect signals of interest.

The primary purpose for RTSA use in the field is to find interference, so key specifications include dynamic range and input-related spurious performances. Usable dynamic range is the combination of front-end gain compression, pre-amplifier gain, and noise floor of the receiver.

Front-end RF chain and IF chain signal conditioning play key roles to ensure good spurious-free dynamic range (SFDR). For field testing, many over-the-air signals surround the receiver. If front-end performance cannot handle sophisticated over-air-signals, RTSA cannot discern the signal of interest from self-inflicted spurs.



RTSA lacking front end signal conditioning



RTSA lacking front end signal conditioning

Figure 11. Input related spur and dynamic range comparison

In Figure 11, the left image shows a low-cost, poorly designed RTSA. The input signal creates several spurs. Some just 30 dB down from the real signal. This causes the user to investigate these phantom interferers and miss the real threat.

However, a well-designed RF chain significantly improves dynamic range and the ability to detect potential interferences. For example, in the image on the right, FieldFox provides clean spurious performance using the same settings. You do not see any visible spurs on FieldFox, which makes it very effective when troubleshooting field interference.

RTSA dramatically improves efficiency to root out interference issues

In the field, there are two challenging types of interference — co-channel interference and uplink interference. In this section, we will examine both types of interference, and explore how RTSA helps to detect and locate these interferences.

Co-channel interference

Co-channel interference refers to interfering signals that are on the same frequency as the serving carrier or are inside its channel bandwidth. This is a good definition for analog systems, but for digital wireless networks, we need to investigate a bit deeper. In order to have a major impact on digital wireless systems, not only do interfering signals need to fall on the same frequency, but they also need to synchronize with the baseband frames. Digital systems treat non-synchronized interferers as noise, which may not have a major negative impact on system performance.

Figures 12 and 13 demonstrate the impact of co-channel interference. These measurements were performed on a lab test system to show the concept since a constellation is not easily obtainable in a field test. Figure 12 shows LTE signal quality without co-channel interference. We see synchronization channels with binary phase-shift keying (BPSK), physical broadcasting channel with quadrature phase-shift keying (QPSK), and downlink shared channel (traffic channels) with 16 quadrature amplitude modulation (QAM). Sync channels and broadcasting channel modulation form a circle (Figure 12). When a wireless microphone signal (FM) transmits at the center of an LTE channel where both the sync and broadcasting channels are assigned, the constellation gets blurred, and the control channels become indistinguishable from the traffic channels as shown in Figure 13. This prevents the mobile from synchronizing with the network, and the call eventually drops.

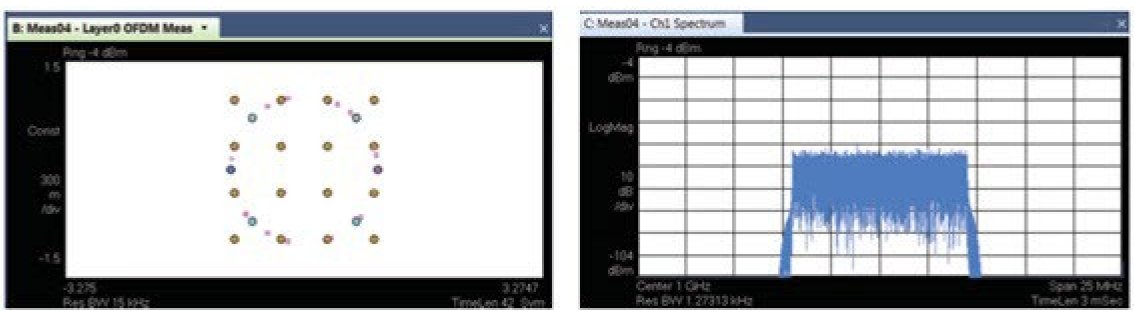


Figure 12. Constellation and spectrum of 16 QAM LTE without interference

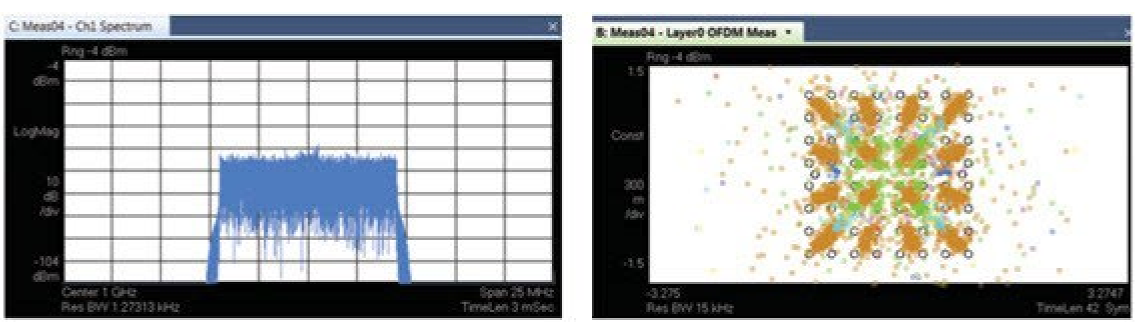


Figure 13. 16 QAM LTE signal under co-channel interference condition

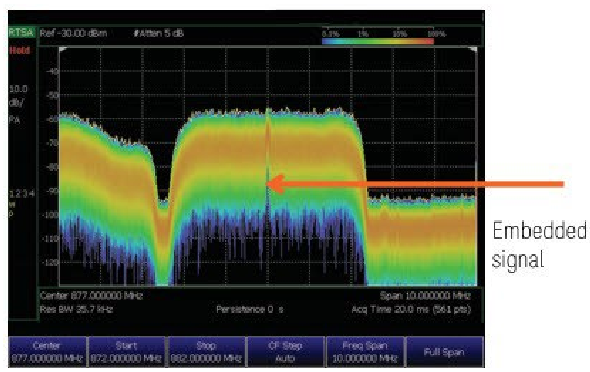
Typically, co-channel interference impacts the network quality most on the downlink. This is because that system has no direct feedback on downlink co-channel interference. For example, when an illegal wireless microphone blasts RF energy into the middle of LTE downlink channel, the mobile only knows that the signal/noise ratio is bad, and it needs to transmit more power on the uplink. The system does not know this is because of downlink co-channel interference.

The most challenging task for communication network operators is co-channel interference detection because interferers hide underneath the serving frequency signal. The user must turn off the carrier transmitter to detect other signals in the same frequency channel and then locate them to eliminate or reduce the impact. This is an intrusive task and disrupts normal communication services. Under many circumstances, turning off the serving transmitter is not a viable solution.

The RTSA density display is a spectrum measurement enhanced to show frequency of occurrence. The display is color-coded to show trace intensity, and the device adds 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. Because interferences have a different signal-level distribution from the serving carrier, the display makes it a lot easier to detect multiple signals in the same channel. Figure 14 shows a Wide-band Code-Division Multiple Access (W-CDMA) signal with a 2-way radio FM signal buried inside the same channel. A spectrum analyzer cannot find the hidden signal without turning off the serving carrier, whereas the RTSA density display makes it easy to spot the intruder.

In traditional SA mode, it is hard to find the interfering signal buried inside the downlink carrier



In RTSA, density display clearly identifies the embedded signal at 877 MHz

The narrowband signal
(center: 877 MHz, bandwidth:12 kHz)

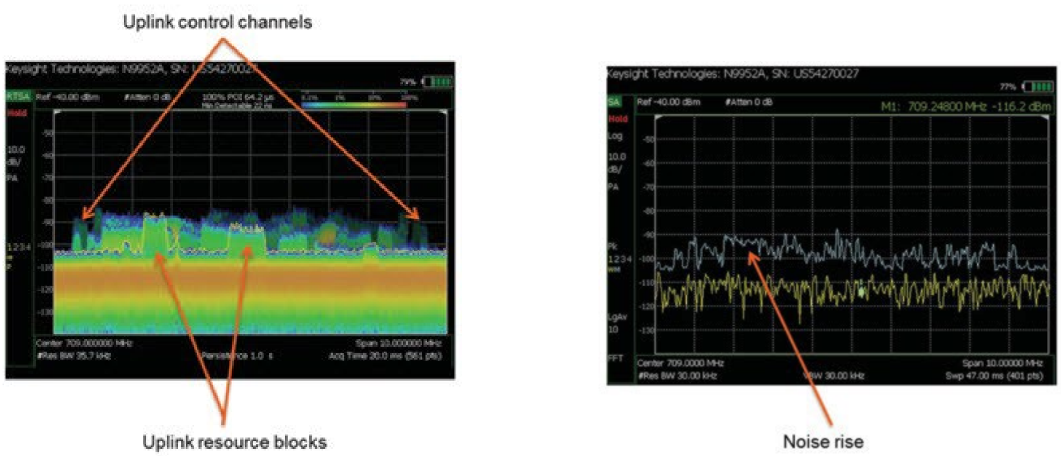
Figure 14. Comparing co-channel interference detection with a traditional spectrum analyzer

RTSA expands signal intelligence from two dimensions of frequency and power level, to the additional dimension of time of occurrences. This capability allows differentiating multiple signals on the same channel.

LTE uplink operation verification and interference

The capacity and performance of an LTE network are uplink noise limited, like most broadband wireless systems. This is because all cell sites and mobile devices operate on the same frequency, making noise control crucial both inside and outside the network.

Gap-free capture and the density display are essential to evaluate digital wireless signals. Gap-free capture allows the analyzer to find the time signatures of a signal, and the density display makes it very easy to examine a signal's power statistic distribution. Timing and signal-level distribution help users to separate various signal types, even within the same network.



RTSA sees various uplink RB assignments which help to evaluate congestion of eNB. Interferences are quickly identified.

Traditional spectrum analyzer detects accumulative noise floor rise to predict loading of eNB, but it cannot determine if the rise of noise is caused by traffic or interference.

Figure 15. LTE uplink channel operation

In Figure 15, RTSA scans the LTE uplink resource block (RB) assignments. The persistence setting enables a user to observe the frequency of RB allocations, providing a good indicator of network congestion. A non-LTE signal is quickly spotted when it appears in the band. A traditional spectrum analyzer can only show a cumulative noise floor rise. The rise of the noise floor conceals any external interference, so it is difficult to rely on this tool to detect interference.

Detecting this interference is important. For example, narrow-band interference often causes an LTE system outage. An LTE control channel on the downlink is in the center 1.08 MHz of its 10 MHz or 20 MHz channel. On the uplink, however, subcarriers at the edge of the channel carry physical uplink control channels like a random-access channel (RACH), hybrid automatic repeat request (HARQ), and channel quality indicator (CQI), (Figure 16). If any interference, like a 700 MHz wireless microphone, happens to occur in these two areas, it creates interference in the network operation or potentially blocks the service for the entire cell site.

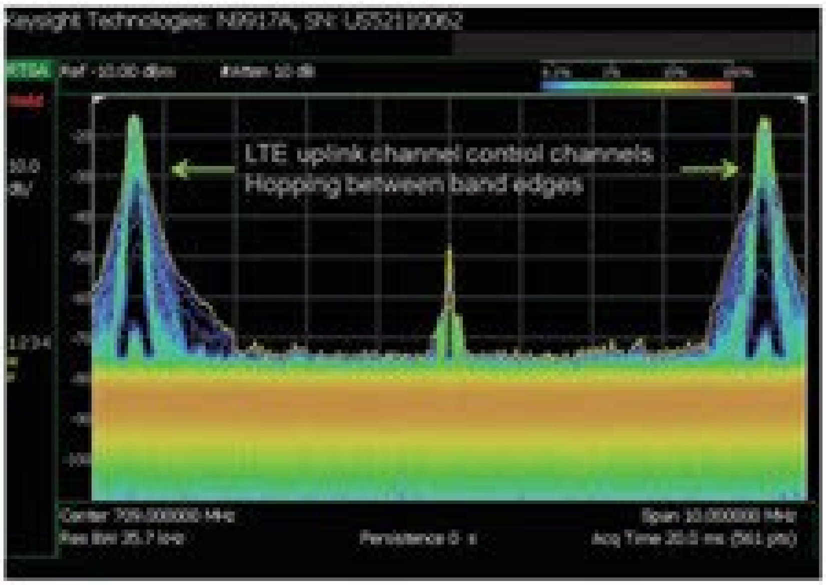


Figure 16. Uplink control channel assignment

Fixes to mitigate or eliminate interferences

Network component failures manifest into interference. Malfunction of RF subsystems or components in the network causes more than 50% of interferences (Figure 17).

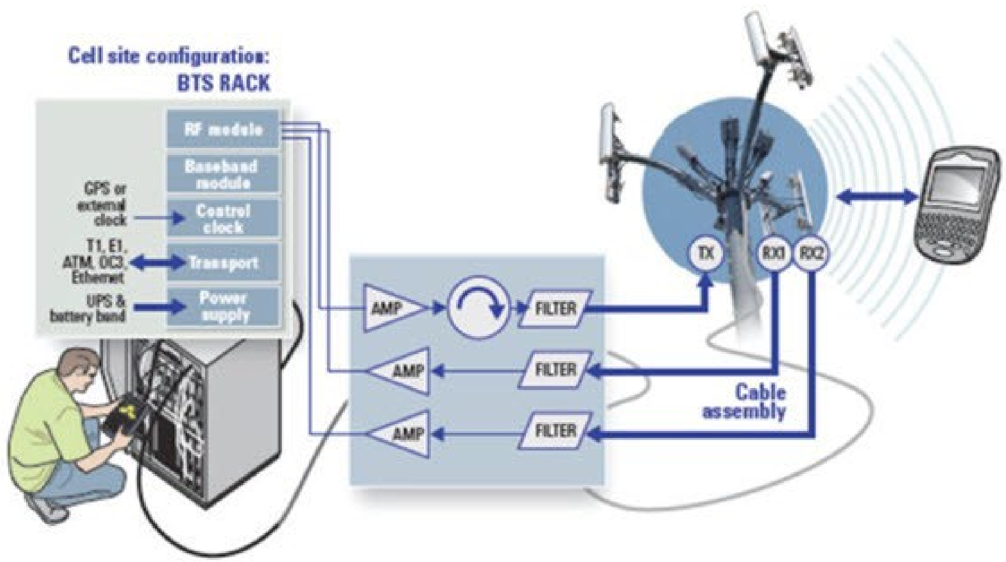


Figure 17. Key RF subsystems in a cell site — antennas, cables, amplifiers, and filters

The antenna is the single most important component in a wireless network. It is the only interface between the physical network and radio waves (over-the-air). The key performance parameters are return loss and voltage standing wave ratio (VSWR). When a transmitter antenna's return loss fails, it transmits less energy to the coverage area. Less energy transmitted to the coverage area triggers the mobile to increase its transmitting power, as it thinks it is far from the base station. This causes noise to rise at the base station receivers, which may be interpreted as external interference by the base station. An incorrect interpretation can lead technicians in the wrong direction for a solution. We strongly recommend sweeping the antenna first if there is any suspicion of external interference.

The cable system also plays a key role to keep the network running. Feeder lines suffer from exposure to various external environment changes — connectors corrode, and cables bend from external impacts like winds. These changes lead to higher cable loss from the first installation, and higher loss reduces the received power level close to the cell edge, causing signal to noise ratio (S/N) deterioration. Routine cable loss measurement against the link budget is a proactive way to avoid interference issues within the network.

The base station receiver chain widely uses low noise amplifiers (LNA) typically installed right behind the base station receiver antenna. An LNA improves reverse link coverage and uplink data throughput. However, when a mobile is too close to the receiving antenna, like in an indoor system, or the receiving antenna is installed too close to pedestrian traffic, like on downtown streets, it may block the LAN. A blocked LNA acts like uplink interference, and it also produces intermodulation products (Figure 18), further interfering with the network. The fix of the issue involves selection of an LNA with a higher compression point, use of a bandpass filter in front of the LNA, and minimizing LNAs and replacing with a fully power-controlled repeater or base station.

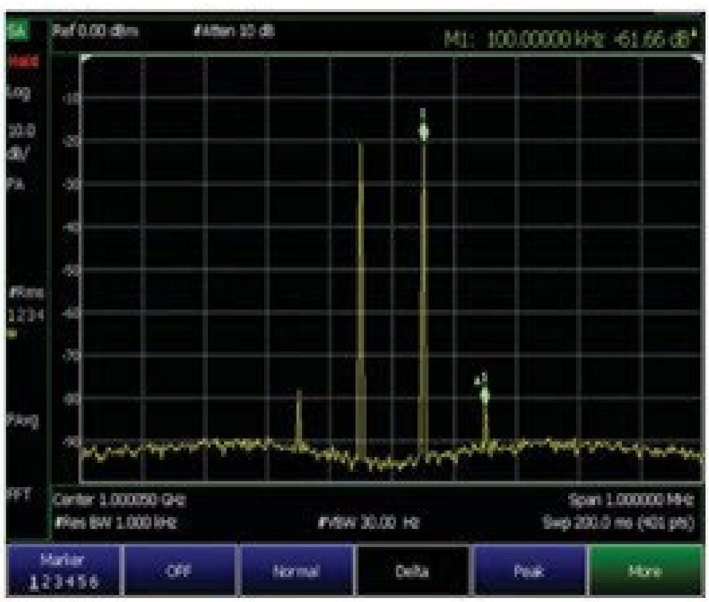


Figure 18. Saturated LNA produces intermodulation signals

Carrying precision into the field

Every piece of gear in a field kit must prove its worth — and that is the driving idea behind Keysight's FieldFox family of handheld analyzers. In applications such as interference troubleshooting, FieldFox analyzers help engineers and technicians quickly detect issues and locate the source of the problem to determine whether it is an interfering signal or faulty component. And, after implementing a fix, verify system performance.

Figure 19. Designed to help field personnel detect, locate, and fix interference problems, rugged FieldFox handheld analyzers with RTSA weigh just 7.35 lbs. (3.34 kg) and provide a battery life of about 4 hours

The analyzers deliver precise microwave and millimeter-wave measurements and possess key attributes that support routine maintenance, in-depth troubleshooting, and virtually anything in between:

- Frequency coverage: 5 kHz up to a maximum of 50 GHz
- Information / real-time bandwidth: 10 / 40 / 100 MHz
- Multiple configurations: Cable and antenna tester (CAT), spectrum analyzer, real-time spectrum analyzer (RTSA), over-the-air digital signal demodulation, I/Q analyzer with recording, power meter, vector network analyzer (VNA), power meter, independent signal source, frequency counter, GNSS/GPS receiver, and more
- Rugged design: Meets MIL-PRF-28800 F Class 2; type tested for IP53 and MIL-STD 810G, Method 511.5, Procedure 1 (explosive environment)
- Field ready: 7.35 lbs. (3.34 kg) and up to 4 hours of typical battery life

A built-in interference analyzer includes the ability to record and playback captured signals. FieldFox also performs pulse measurements using its spectrum analyzer mode and a USB peak power sensor.

The key RTSA specifications of FieldFox are exceptional for field testing. The analyzers fare quite well when assessed versus the key indicators of RTSA performance. Maximum real-time bandwidth is up to 100MHz, which is enough to capture most 5G signals. Another crucial indicator specification is the POI. FieldFox with RTSA boasts a best-case POI performance of 5.5 μs (with a 100 MHz span and max RBW) and detects signals as narrow as 47 ns.

Conclusion

The driving force behind modern communication systems is to provide the highest capacity at a given bandwidth. To achieve this goal, networks are time-division multiple access (TDMA); many users share the same channel. In addition to the bursty nature of signal characteristics, operators deploy tight frequency reuse to increase overall network capacity. Such reuse introduces co-channel interferences inside networks. Gap-free spectrum analysis or RTSA is necessary to enable field engineers and technicians to troubleshoot interference issues.

Radio systems grow more and more complex, requiring support for multiple radio formats. For example, public safety radios need to support 25 kHz / 12.5 kHz / 6.25 kHz channels for both analog and digital modulation. System field engineers need to verify both the spectrum performance of the network, as well as the timing profiles of control and traffic channels. RTSA density display with persistence provides unique insights on signal operation, which is not possible with traditional spectrum analyzers.

Interference is a symptom with deeper root causes. Hardware failures like problems with the antenna, cable, diplexer, duplexer, and low-noise amplifier induces interference in the network. A FieldFox handheld analyzer combines the functions of a spectrum analyzer, RTSA, cable antenna tester, vector network analyzer, and independent signal source. With the addition of a directional antenna, it is a valuable tool for detecting, locating, and fixing interference issues in the field.