APPLICATION NOTE

Overcoming RF & MW Interference Challenges in the Field

Using Real-time Spectrum Analysis (RTSA)

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 both commercial and aerospace defense (A/D) wireless communication networks. Uncover the drawbacks associated with traditional interference analysis and get an in-depth introduction to RTSA and why this type of analysis is required to troubleshoot interference in today's networks with bursty and elusive signals.

KEYSIGHT TECHNOLOGIES

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Introduction

With the increase of wireless technologies in communication networks, one inherent challenge is interference. Regardless of the type of network, performance is always limited by the noise level in the system. This noise can be generated internally and/or externally.

The level of interference management determines the quality of service. For example, uplink noise level management of an LTE network can dramatically improve 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.

In order to detect demanding signals and troubleshoot network issues, a real-time signal analysis (RTSA) capability is necessary for field test. 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, 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 are transmitting at the same time, this creates a much higher noise level on the downlink (direction from the base station or base station to the mobile). The higher noise level on the downlink at the mobile antenna triggers the mobile to increase its output power to overcome the higher noise level. In turn, this leads to increased uplink (direction from mobile to BTS) noise level at the base station antenna. The higher level of noise at the BTS antenna will reduce cell site capacity. These examples are considered to be network internal interference.

In addition to internal interference, external interference is becoming more and 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 a noise-limited network. It has frequency reuse of 1, which means every cell site uses the exact same frequency channel. In order 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 CQI (channel quality indicator) 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, and it is a key input for the base station to schedule bandwidth and determine the throughout delivered to mobile. The interference is an aggregation of noise generated inside the cell site and interference coming from external transmitters. If there is external interference on the downlink, it will drive CQI lower, and will drive more 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.

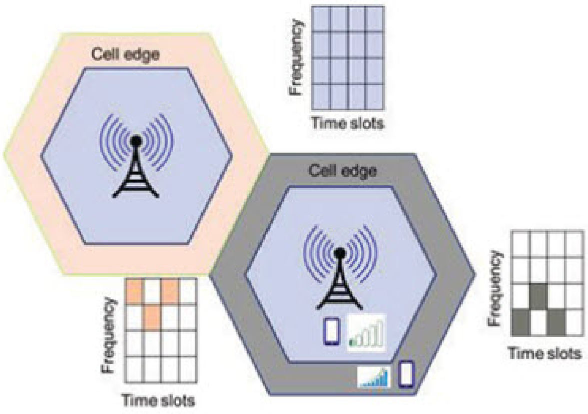


Figure 1a - LTE power control and resource block allocation

Precise power control plays a very important 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 sufficient 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, and allocates fewer resource blocks (subcarriers) at the edge of the cell, 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 are used to synchronize the mobile with the cell and to start decode system information. If there is narrowband interference close to the center of the LTE channel, it can have a major impact on the mobile's synchronization process; sometimes it can even block the whole cell. For example, some analog 700 MHz FM wireless microphones can easily block an LTE cell; these wireless microphones are banned by the FCC.

Microwave backhaul interference issues

About 50% of the world's base stations are connected 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 really comes from areas discussed below.

Reflection and refraction

In a mobile network, microwave radios are widely used for point-to-point connections. The radio can be deployed in an urban area and when its transmission path is blocked, the signal will be bounced back and can cancel a portion of the energy towards the remote receiver, or the signal could be bent to change directions (which is called refraction). Both cases will create 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 will occur. These bands are very close to the frequencies used by 802.11n or 802.11ac WLAN, and we start to see interference between these two systems. For example, when WLAN operates near a 5.8 GHz microwave radio, it could raise the power level at the microwave radio receiver, misleading the microwave radio to think that it needs to reduce its transmit power on the link, and in turn the radio does not transmit sufficient power to maintain the actual signal level needed, so an outage occurs.

5G signal and potential interference

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

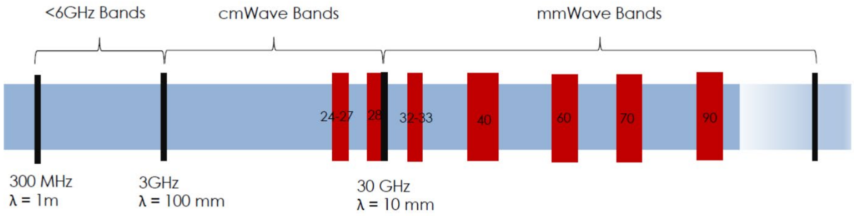


Figure 2b – 5G frequency bands and spectrum allocations

For the first time, the millimeter wave frequency band will be used for terrestrial communications and will present unique challenges in deployment. The 3GPP standard 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 will vary 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 that the 5G network is completely operating on its own; from air interface point of view, the UE/mobile exchanges both control and traffic information on the 5G network only. While SA mode takes all the advantages that 5G can provide, it is the most expensive way to build a 5G network. On the other hand, 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 can transmit and receive traffic on a 5G data channel and if 5G is not able to provide adequate coverage, the UE can fall 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 the LTE network is interfered or disrupted in NSA mode, so is the 5G network.

Aerospace/Defense (A/D) and Public Safety Interference Issues

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

These technologies are effective to fend off external interferences, but they also make field troubleshooting far more difficult than ever. New tools and measurement techniques are required to effectively maintain aerospace and defense communication systems.

Public safety/two-way radio interference issues

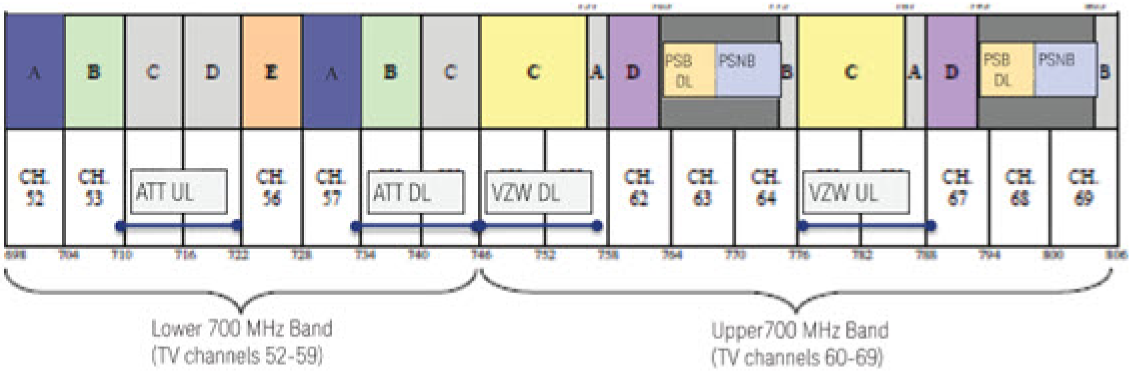


Figure 3 - 700 MHz band public safety narrow band and broadband channel assignment

There are two major issues in public safety radio systems. One is adjacent channel interference and the other 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. If the duplexer or diplexer is not tuned properly, a base station will generate adjacent channel interference among operating channels, and this will reduce the coverage area.

Because a public safety transmitter is operating at a higher power level, if its power amplifier is saturated, intermodulation products will be produced, and its harmonics can easily land on adjacent bands. If these harmonic products land on LTE control frequencies (see Figure 2), network services will be disrupted.

Satellite ground station interference issues

Satellite communication systems are commonly deployed in aerospace and defense networks. One of the trends happening 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.

Higher frequency will significantly reduce beam size. It requires more precise antenna alignment, and mis-alignment could introduce co-channel interference and adjacent channel interference. Multi-beam frequency reuse allows adjacent areas to share the same frequency plan and polarization. If the system is not properly optimized, it could generate strong co-channel, adjacent channel and cross polarization interference.

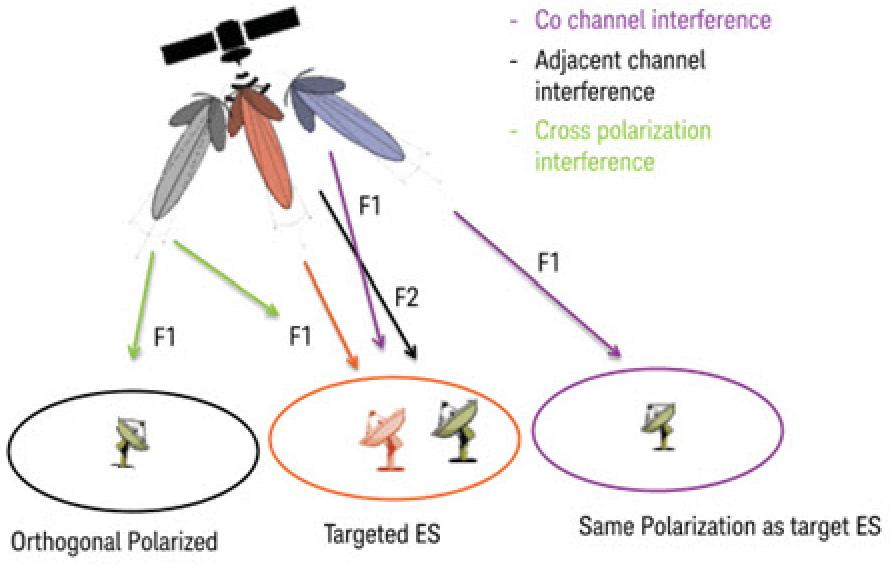


Figure 4 - Interference types in satellite ground station operation

The problems with traditional interference analysis

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

If there are interference issues in the network, a system performance monitoring tool will report issues such as the uplink noise floor rising without significant traffic, connection failures, signal-to-noise ratio is too high, etc. The next step is to detect where the interference is coming from. Traditionally a spectrum analyzer with a directional antenna is the tool of choice to detect and locate the interference.

Traditional swept tuned and FFT spectrum analyzers are very effective for detecting a relatively constant signal, or max hold can be used to detect intermittent signals. Because traditional analyzers either have a large dead time where no data is being captured during a retrace, or the dead time is unpredictable, their effectiveness starts to be challenged while dealing with random bursty signals, narrow pulses like RADAR, or a signal whose duration is based on network traffic conditions.

Given the ever-growing 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 are facing two challenges to detecting interference: one is that interference under investigation is much more bursty due to time division multiplex nature of digital wireless signals; and the another is the spectrum analzyer 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 the most challenging signals; it is called gap-free spectrum analysis or real-time spectrum analysis (RTSA).

Spectrum analyzer receiver architecture overview

In order to better understand the capability of RTSA, it is important to look into the traditional spectrum analyzer receiver architechure, and its advantages and disadvantages.

Swept tuned receiver

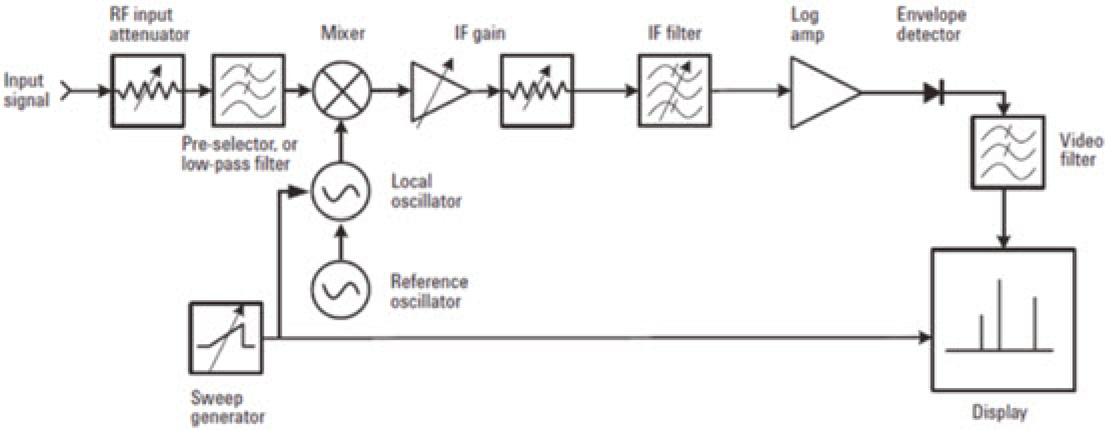


Figure 5 - Super-heterodyne spectrum analyzer/swept-tuned spectrum receiver

A super-heterodyne spectrum analyzer is also called a swept-tuned spectrum analyzer. Heterodyne means to mix; in this system the RF input signal mixes with the LO signal to translate the input signal from a higher frequency to a lower frequency, the IF (intermediate frequency). Signal magnitude is detected by an envelope detector, and displayed as a vertical point.

In order to control the display of the horizontal / frequency axis, a ramp/sweep generator is used to control the movement, and it also tunes the LO to the expected frequencies. The LO tuning rate can be controlled by setting the sweep time and frequency span. The front end of a spectrum analyzer is equipped with signal conditioning circuits, which are attenuators and pre-selectors (low pass filters). The role of these circuits is to make sure 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 super-heterodyne receiver has excellent dynamic range.

Since the ramp generator sweeps at a fixed rate, it can control sweep time precisely over a frequency span. By controlling the sweep rate, it enables the receiver to sweep a very large span at a faster rate than a fast fourier transform (FFT) analyzer.

The biggest disadvantage of a super-heterodyne receiver is that it can miss intermittent signal contents, especially wideband digitally modulated signals. Another problem is that the sweep time can get dramatically longer at narrow resolution bandwidth (RBW).

Snap shot FFT receiver

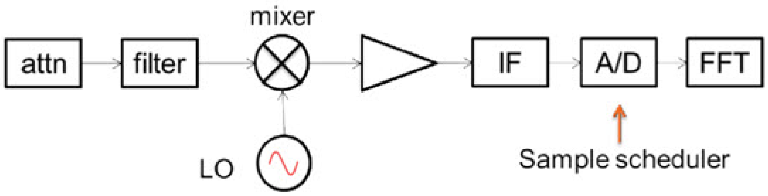


Figure 6 - Snap shot FFT spectrum analyzer

Snap shot FFT analyzer/receiver is designed to handle wide band signals. It has a block conversion at the front end, and the IF bandwidth and ADC sample rate decide the block conversion size. Instead of continuous tuning of the local oscillator (LO), the LO steps through the frequency span. After the LO tunes to the right frequency, the receiver samples data through the analog-to-digital converter (ADC), converts them into I/Q (in-phase and quardrature) IQ pairs, puts data into proper FFT time frames, converts time domain frame into FFT spectrum data, and finally sends spectrum results to the display and then starts to acquire data again. This is a serial operation, so it has a period of time between screen updates when signals will be missed at the input. This duration is called dead time, and the length of the duration is unpredictable.

Since it is a block conversion, any signal within the block or information bandwidth will be fully captured for further analysis, such as a digital demodulated signal. Snapshot FFT is ideal for analyzing wideband digital signals; it can reproduce digital receiver behavior based on its signal specification, for example LTE signal test.

Since the FFT engine is not able to finish its operation within a specific time frame, it is impossible to precisely control the FFT receiver sweep time. If the signal bandwidth is larger than the information bandwidth of the receiver, signal stitching is required, and it can result in missing part of the wide band signal contents.

Real-time spectrum analzyer (RTSA)

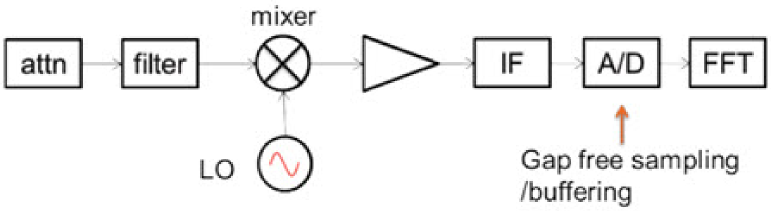


Figure 7 - Real-time spectrum analyzer

A real-time spectrum analyzer is an FFT analyzer without dead time. The receiver is parked at a frequency span of interest, which is 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, RTSA is limited by its bandwidth. When the receiver tries to measure signals beyond its real-time bandwidth, the LO has to be tuned, and at this time, it is no longer real-time or gap-free.

Since RTSA has no tuning, the signal to be detected may not be located at the center frequency, and its detected signal level may not be as accurate as when using 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 snap shot 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. At a given bandwidth, there is no signal missing. It is ideal to detect elusive signals.

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

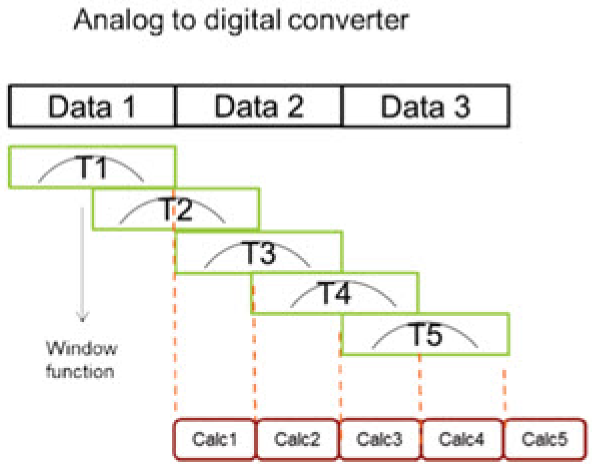


Figure 8 - RTSA signal processing flow

Above is the signal flow of RTSA. First of all, 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 the efficiency.

Instead of processing raw data one frame at a time, RTSA actually re-arranges the raw data frame (data 1, data 2, data 3…) to new FFT frames (T1, T2…). Starting from T2, it takes a portion of a sample from T1 and combines it with new data, a portion from data 2 to form T2 and T3 does the same to take a portion of sample from previous T2, and a portion of new samples from data 2. This is called overlapping FFT, and it guarantees that a signal that occurs at the edge of data 1 and data 2 will be properly positioned to the center of the next FFT, to make sure the signal is properly detected.

The reason to move the signal to the center of the frame is to prevent windowing from filtering out the useful signal at the edge of the data frame / time record. For illustration purposes, we've 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, one shows a receiver which has dead time between updates, and no FFT overlapping, while the other capture shows RTSA with overlapping FFT.

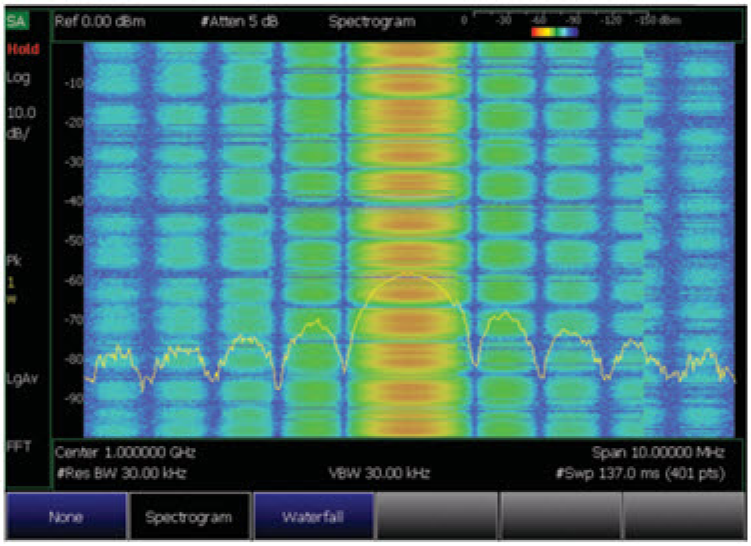

Ref 0.00 dBm #Atten 5 dB
Center 1.000000 GHz
#Res BW 30.00 kHz
VBW 30.00 kHz
Span 10.00000 MHz
#Swp 137.0 ms (401 pts)

Figure 9 - No FFT overlapping, with dead time between updates

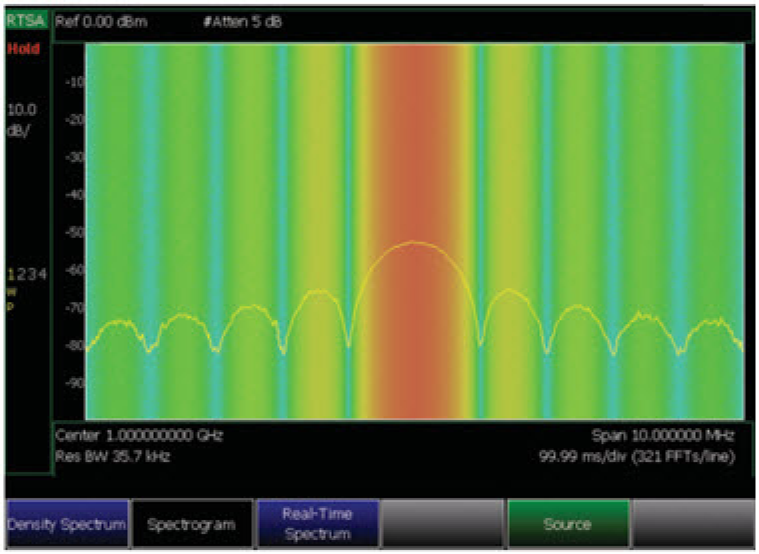

Ref 0.00 dBm #Atten 5 dB
Center 1.000000000 GHz
Res BW 35.7 kHz
Span 10.000000 MHz
99.99 ms/div (321 FFTs/line)

Figure 10 - FFT overlapping with no gap capturing

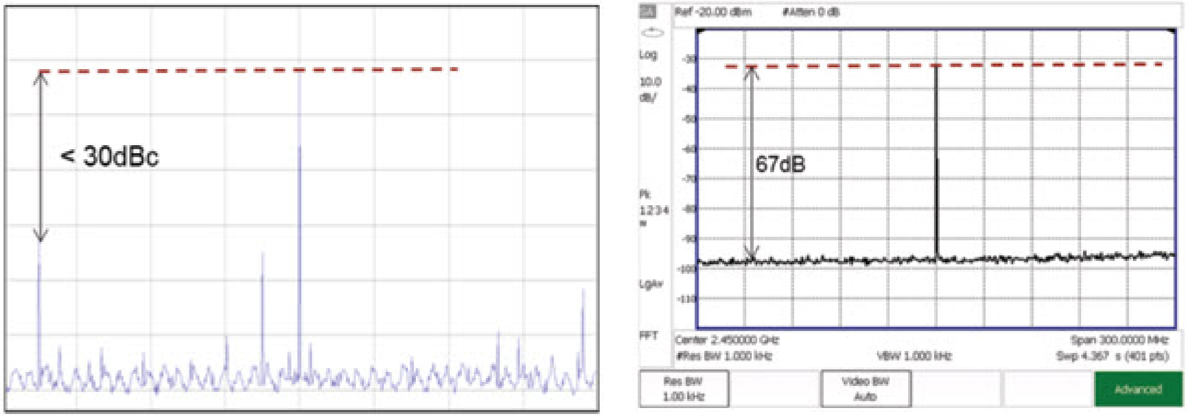
RTSA key performance indicators

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

Another specification is called minimum signal duration for 100% probability of intercept (POI). It is the minimum duration of the signal of interest if it is to be detected with 100% probability and measured with the same amplitude accuracy as that of a CW signal. In order to detect narrow pulse signals in frequency domain properly, it requires a large RBW to make sure the signal falls into the size of the RBW, and the large RBW means a small window size in 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 (resolution bandwidth /RBW) and overlapping to reliably detect signals of interest.

The primary purpose to use RTSA in the field is to find interference, so dynamic range and input related spurious performances are key specifications. 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 test, there are many over-the-air signals surrounding the receiver. If front end performance is not robust enough to handle sophisticated over-air-signals, RTSA will have a hard time discerning the signal of interest from self-inflicted spurs.



Center 2.450000 GHz
#Res BW 1.000 kHz
VBW 1.000 kHz
Span 300.0000 MHz
Swp 4.367 s (401 pts)

RTSA lacking of front end signal conditioning

Fieldfox RTSA with proper frontend signal conditioning

Figure 11 - Input related spur and dynamic range comparison

In Figure 10 the left picture shows a low cost, not well designed RTSA. You can see the input signal can create a lot of spurs, some of them are just 30 dB down from the real signal. This can cause the user to investigate these phantom interferers and miss the real threat.

On the other hand, a well-designed RF chain can significantly improve dynamic range and the ability to detect potential interference. For example, on the right-hand picture, FieldFox has super clean spurious performance-for the same settings, you don’t see any visible spur on Fieldfox which makes it very effective to do field interference troubleshooting.

RTSA dramatically improves efficiency to root out interference issues

Two types of interference are most challenging in the field. One is co-channel interference, and another is uplink interference. In this section, we will examine both types of interference, and explore how RTSA can help 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 dig a little bit deeper. In order to have a major impact on digital wireless systems, not only do interfering signals need to be on the same frequency, but they also need to be synchronized with the baseband frames. Digital systems treat non-synchronized interferers as noise, which may not have a major negative impact on system performance.

The figures below demonstrate the impact of co-channel interference. These measurements were done on a lab test system to show the concept, since a constellation cannot be easily obtained in a field test. The top figure shows LTE signal quality without co-channel interference. We can 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 QAM. Sync channels and broadcasting channel modulation forms a circle as shown in Figure 11. 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 are indistinguishable from the traffic channels as shown in Figure 12. This will prevent the mobile from synchronizing with the network, and the call will eventually drop.

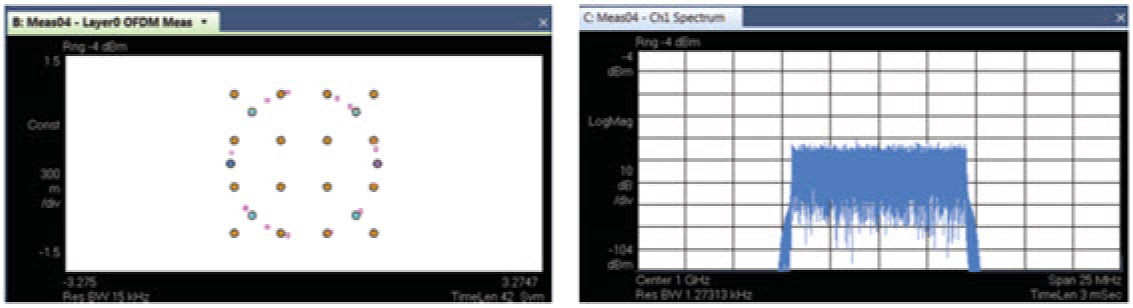


Figure 12 - Constellation and spectrum of 16 QAM LTE without interference

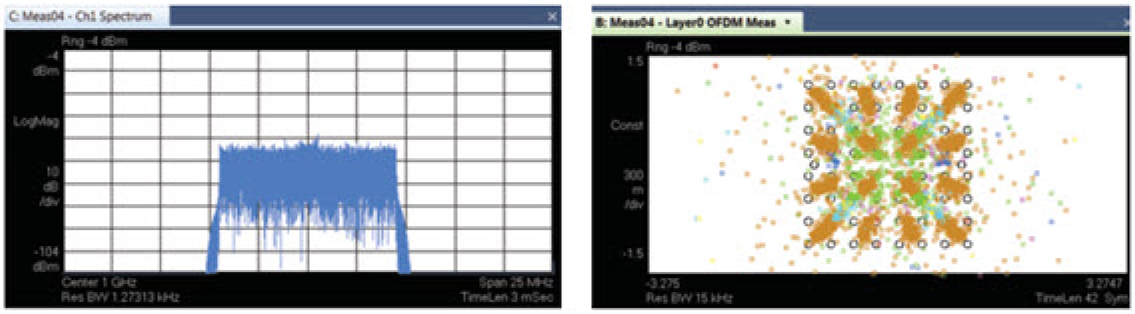


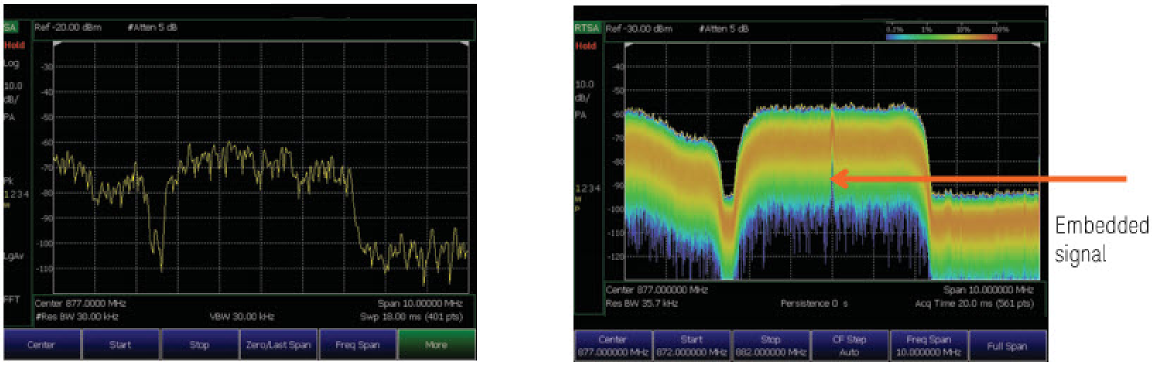
Figure 13 - 16 QAM LTE signal under co-channel interference condition

Typically, co-channel interference impacts the network quality the 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 doesn't know this is due to downlink co-channel interference.

Co-channel interference detection and troubleshooting is the most challenging task for communication network operators, because interferers can be hidden underneath the serving frequency signal. Typically, the user has to turn off the carrier transmitter to find if any other signal appears in the same frequency channel, and then locate them to eliminate or reduce the impact. It is very intrusive and disrupts normal communication services. Under many circumstances, turning off serving transmitters is not a viable solution.

The RTSA density display is a spectrum measurement enhanced to show frequency of occurrence. The display is coded using color to show trace intensity, and a persistence function can be added 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 different signal-level distribution from the serving carrier, the display makes it a lot easier to detect multiple signals in the same channel. Figure 13 shows a W-CDMA signal with a 2-way radio FM signal buried inside the same channel. A spectrum analyzer is not able to find the hidden signal without turning off the serving carrier, whereas the RTSA density display makes it fairly easy to spot the intruder.



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

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

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

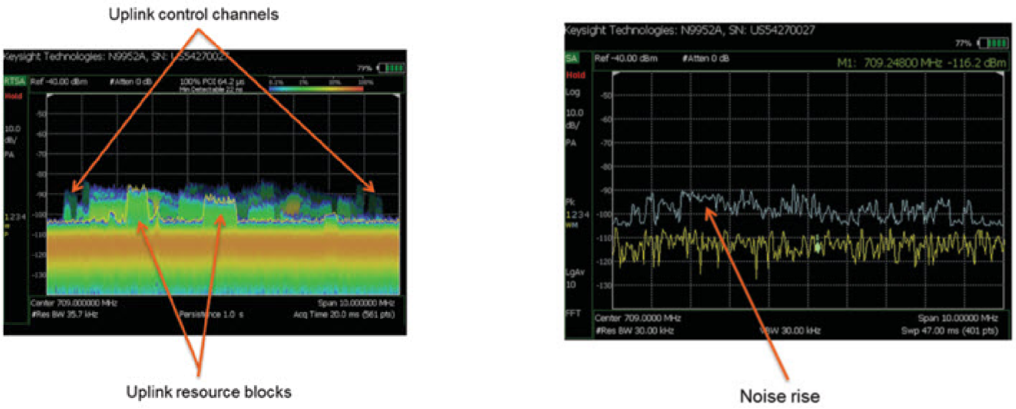
Figure 14 - Comparing co-channel interference detection with traditional spectrum analyser

RTSA expands signal intelligence from 2 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

An LTE network is like most broadband wireless systems, its capacity and performance are uplink noise limited. This is because all cell sites and mobile devices operate on the same frequency, making controlling noise coming from inside and outside of the network crucial.

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



RTSA is able to see various uplink RB assignments
Which helps to evaluate congestion of eNB.
Interferences can be quickly identified.

Traditional spectrum analyzer can detect accumulative noise
floor rise to predict loading of eNB, but cannot make a distinction
if the rise of noise is caused by traffic or interference.

Figure 15 - LTE uplink channel operation

In Figure 14, RTSA is able to scan LTE uplink resource block (RB) assignments. The persistence setting enables a user to observe the frequency of RB allocations, providing a very good indicator of network congestion. If a non-LTE signal shows up in the band, it can be quickly spotted. A traditional spectrum analyzer is only able to show a cumulative noise floor rise. Any external interference occurring is buried in the rise of the noise floor, so it is very difficult to rely on this tool to detect interference.

This is important, for example, because narrow-band interference can often knock down an LTE system. 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, physical uplink control channels like a random-access channel (RACH), Hybrid automatic repeat request (HARQ), and channel quality indicator (CQI) are carried by subcarriers at the edge of the channel shown in Figure 15. If any interference, for example a 700 MHz wireless microphone, happens to be in these two areas, it will create interference in the network operation, or potentially block the service for the entire cell site.

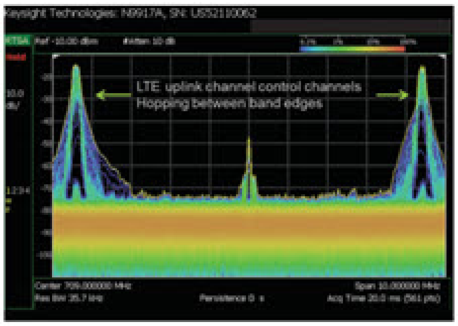


Figure 16 - Uplink control channel assignment

What needs to be fixed to mitigate or eliminate interferences

Interference can be the manifestation of network component failures. In fact, more than 50% of interferences are caused by malfunction of RF subsystems or components in the network (Figure 16).

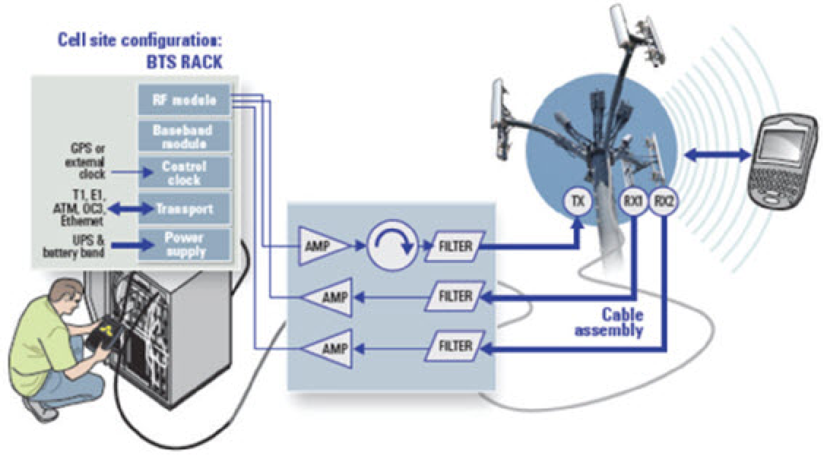
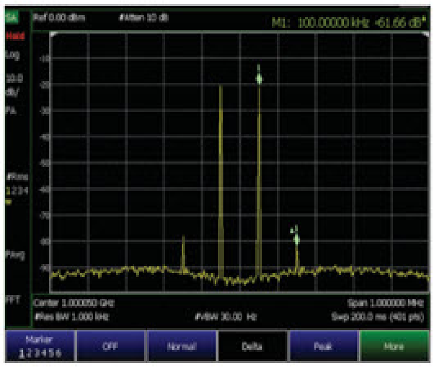


Figure 17 - Key RF subsystems in a cell site – antennas, cables, amplifiers and filters

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 parameter is return loss/voltage standing wave ratio (VSWR). If a transmitter antenna's return loss fails, less energy will be transmitted to the coverage area. This will trigger the mobile to increase its transmitting power, as it thinks it is far from the base station. This in turn will cause noise to rise at the base station receivers, which could be interpreted as external interference by the base station, and could lead technicians to wrong directions for a solution. So, it is strongly recommended to sweep the antenna first if there is any suspicion of external interference.

The cable system also plays a key role to keep the network running. Because feeder lines are exposed to various external environment changes, connectors will get corroded and cables will be bent by external impacts like winds. These changes lead to higher cable loss from first installation, and higher loss will reduce the received power level close to the cell edge. This causes 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.

Low noise amplifiers (LNA) are widely used in the base station receiver chain, typically installed right behind the base station receive antenna. An LNA is very beneficial for improving reverse link coverage, and improving uplink data throughput. But an LNA can be blocked when a mobile is too close to the receiving antenna, like in an indoor system, or when the receiving antenna is installed too close to pedestrian traffic like at downtown streets. A blocked LNA acts like uplink interference, and it also produces intermodulation products (Figure 17), further interfering with the network. The fix of the issue involves selection of an LNA with a higher compression point, use of a band pass filter in front of the LNA, and minimizing LNAs and replacing with a fully power-controlled repeater or base station.



Ref 0.00 dBm
#Atten 10 dB
M1: 100.00000 kHz -61.66 dB
Center 1.000050 GHz
#Res BW 1.000 kHz
#VBW 30.00 Hz
Span 1.000000 MHz
Swp 200.0 ms (401 pts)

Figure 18 - Saturated LNA produces intermodulation signals

Carrying precision into the field

Every piece of gear in a field kit has to prove its worth—and that's 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, locate the source of the problem—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 capabilities: Cable and antenna tester (CAT), spectrum analyzer, real-time spectrum analyser (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 pounds lb (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 can also perform pulse measurements using its spectrum-analyzer mode and a USB peak power sensor.

FieldFox key RTSA specifications 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 probability of intercept (POI), which is the minimum duration of a signal of interest that can be detected with 100 percent probability and measured with the same amplitude accuracy as when observing a CW signal. A FieldFox with RTSA has POI performance of 5.5 µs best case (with 100 MHz span and max RBW) and can detect 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 make this goal, networks are TDMA in nature, so many users can share the same channel. In addition to the bursty nature of signal characteristics, tight frequency reuse is widely deployed to increase overall network capacity. This 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 are getting more and more complex, and they are required to support 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 are not possible with traditional spectrum analyzers.

Interference is a symptom and there are deeper root causes. Hardware failures like problems with the antenna, cable, diplexer/duplexer and low noise amplifier, can and will induce interference in the network. A FieldFox handheld analyzer which 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, is a valuable tool for detecting, locating and fixing interference issues in the field.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

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