How Mobile Network Operators Use Tektronix Real-Time Spectrum Analyzer

CUSTOMER EXAMPLE

Tektronix®

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com

Introduction

Field service organizations for mobile communication of network operators are using Tektronix USB-based real-time spectrum analyzer for daily work, hundreds of technicians in different service regions are responsible to keep the health of the mobile communication infrastructure (GSM, UMTS and LTE). This includes basic maintenance work as well as system level troubleshooting. System level problems could be related to a hardware fault of the base station itself or it may be caused by an interfering signal coming from external sources.

The main advantages for network operators to use Tektronix USB spectrum analyzers is the portability of the devices (form factor and weight), its price/performance ratio and real-time capabilities. Ideally technicians need one tool that is capable of trouble-shooting not just radios, but also cables, filters and antennas. The following sections describe more in detail how the RSA306 is being used in the field.

The DPX Real-Time Spectrum

When investigating noise or interference a good starting point to look at the signal of interest is the Digital Phosphor spectrum real-time display (DPX). The purpose of the DPX engine is to overcome the time gaps between consecutive acquisitions which are normally present in digital systems like oscilloscopes and spectrum analyzers. Like a classic spectrum analyzer, it shows amplitude vs. frequency information. In addition, the pixels in the display have added color which indicates how often RF energy is being measured at that pixel. The DPX measurement also allows to specify a decay function, providing a phosphorescent effect which mimics the effect of displays found in old CRT based instruments. It adds the dimension of periodicity to the display, showing how often a signal is actually present in the span of interest. This form of real-time spectrum display lets users see what the receiver sees, and provides greater insight into what exactly is happening over the span of interest.

Figure 1 shows a typical LTE base station signal (downlink) at 1800 MHz (E-UTRA Band 3) with an overall channel bandwidth of 20 MHz, it contains control, reference and synchronization signals along with user traffic. Due to the nature of the DPX display, different signal types can be distinguished, even if they are masked by each other. Therefore an experience user can easily detect unusual signal behavior like the presence of an interfering signal.

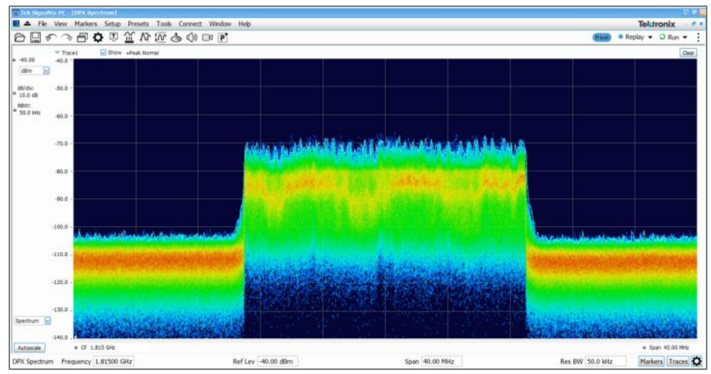

FIGURE 1 - DPX view of an LTE downlink signal at 1800 MHz with 50 kHz RBW

Another discovery tool that is regular used by field service is the analog audio demodulation feature of SignalVu-PC. This may seem a bit strange, but when listening to a digital communication signal like GSM, the presence of an interfering signal would disturb the expected audio pattern.

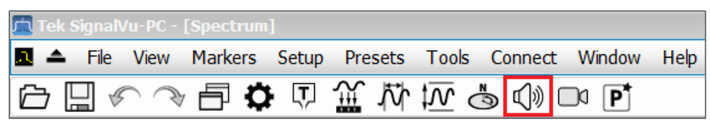

FIGURE 2 - Audio demodulation feature of SVPC

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com

Basic Spectrum Measurements

In order to obtain proper network functionality, basic signal parameters like frequency, bandwidth and power must be verified. Those measurements are either done Over The Air (OTA) with an antenna or directly via cable at a test port of the base stations remote radio head.

Figure 3 shows an LTE signal OTA capture, the "Time Overview" display on the right side shows power within the acquisition bandwidth vs. time and the corresponding spectrum is shown on the left side. Markers were placed manually to determine signal power and bandwidth. The channel navigation toolbar at the bottom of the display allows users to quickly select the desired signal standard and channel frequency. In this case channel 1300 at 1.815 GHz is selected which is the center frequency of the LTE downlink channel used by Telecom - total frequency range of the allocated band is 30 MHz from 1805 to 1835 MHz (blue region).

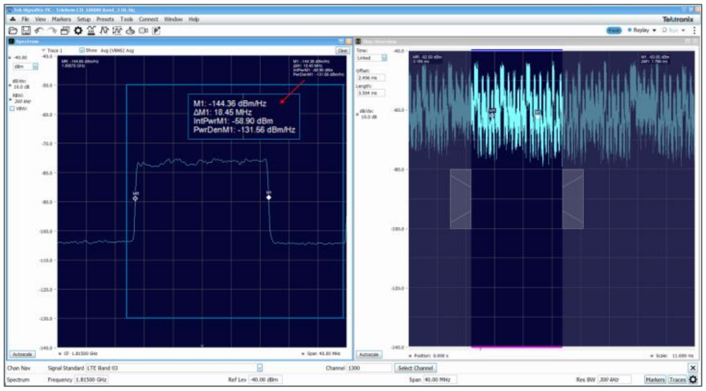

FIGURE 3 - BW measurement with markers

The "Occupied Bandwidth" (OBW) measurement also displays bandwidth and power, but with the difference that the signal is automatically detected. Here an occupied bandwidth of 18.5 MHz was measured within a 20 MHz channel.

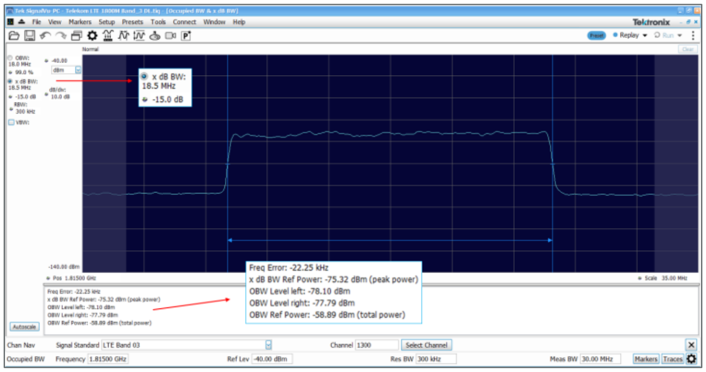

FIGURE 4 - Automated OBW measurement

Measuring the bandwidth is important since other radio services are directly located at adjacent frequency bands. As can be seen on the picture below, the allocated frequency ranges of different network operators are very close together. The same importance applies to the amplitude, insufficient power results in poor signal coverage while too much power would disturb other base station cells.

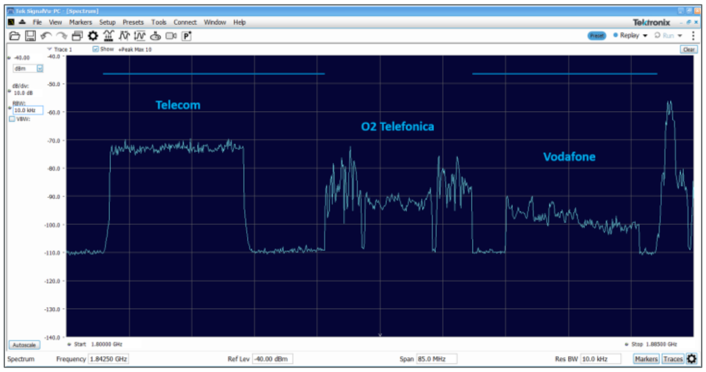

FIGURE 5 - LTE downlink bands at 1800 MHz

User defined setups are used to easy set up the software for a specific measurement task. Frequently used setups can be marked as favorite and recalled quickly with the preset button.

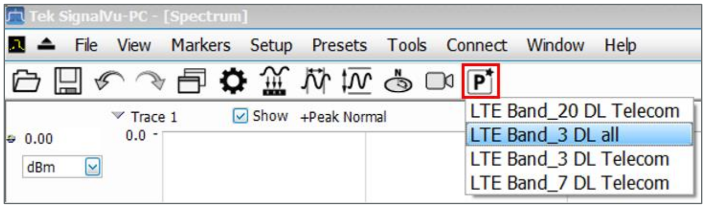

FIGURE 6 - Favorite preset button

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com

Advanced Analysis

In addition to the basic measurements, standard presets are available for further signal analysis.

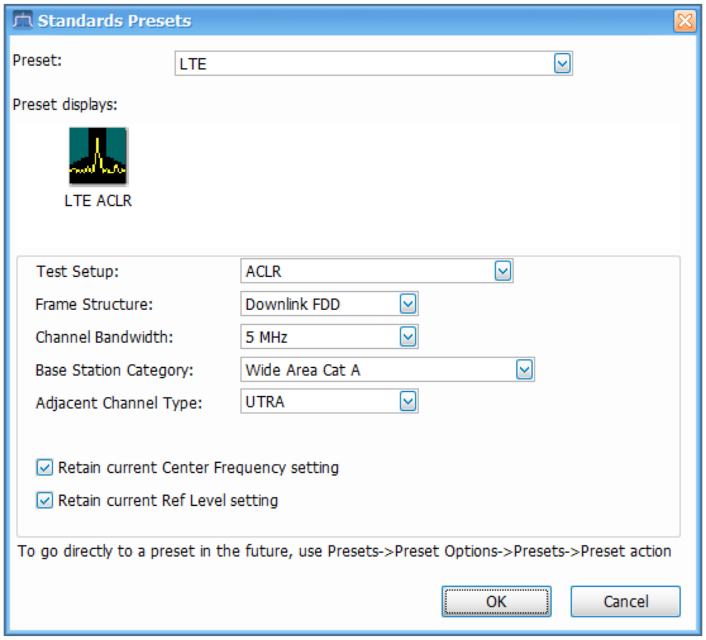

FIGURE 7 - LTE Preset Menu

The selected ACLR (Adjacent Channel Leakage Ratio) setup opens a display that measures power within the centered communication channel of 5 MHz and also the power within the unused adjacent channels. The power ratio between the main channel and the adjacent channels indicates how much energy leaks into the adjacent channels. Too much power leakage results in inefficient system operation, horizontal display lines show if limits are violated.

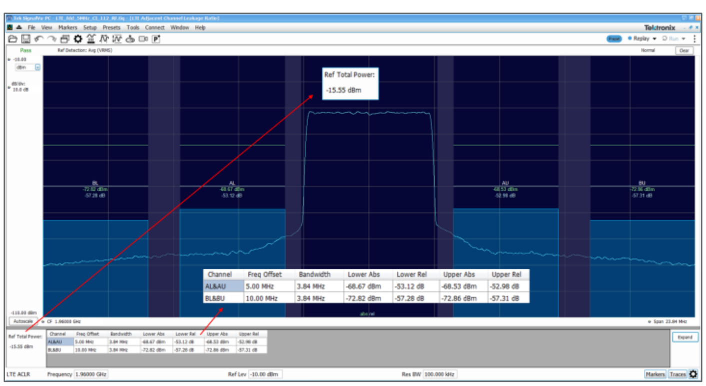

FIGURE 8 - ACLR measurement of a 5 MHz LTE signal

Every 5 ms the LTE base station sends out two synchronization signals which are located in the center of the channel, each has a bandwidth of 915 kHz and a duration of either 72 or 83 us. The signals are called Primary and Secondary Synchronization Signal, PSS and SSS. User Equipment (UE) is using these signals to synchronize to the network in time and frequency, it also gets the networks cell ID out of it. SignalVu-PC automatically detects the synchronization signals and shows its constellation diagram along with cell ID information. Once this is done, the software can measure the power of dedicated reference signals whose position in the radio frame is cell ID dependent. The reference power is also shown in the constellation display, the UE would use it to calculate signal quality which helps the network for cell handover decisions.

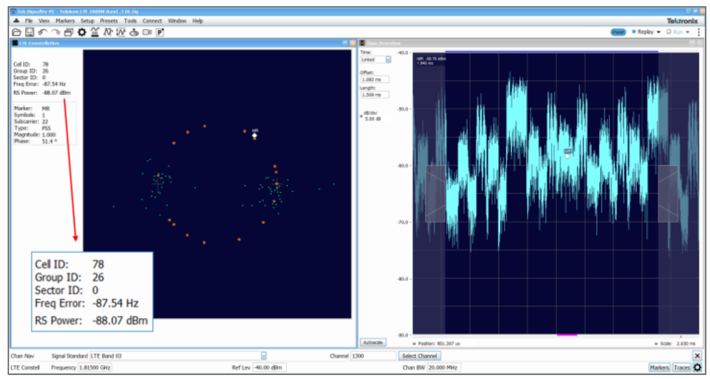

FIGURE 9 - LTE constellation diagram of PSS and SSS (left)

An important display to look at signal behavior vs. time is the Spectrogram which shows the spectrum history, where the latest spectrum is located at the bottom and color represents the signal amplitude. The picture below shows an LTE radio sub frame of 1 ms with synchronization signals located in the center, followed by a wider broadcast signal.

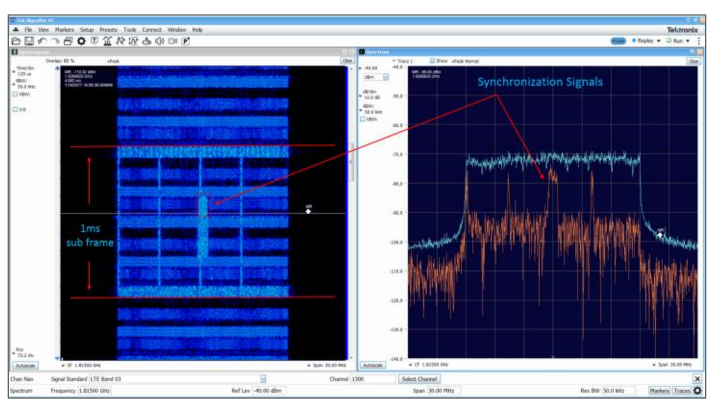

FIGURE 10 - Spectrogram (left) of LTE radio frame and corresponding Spectrum

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com

Tracking Generator Measurements

Since spectrum analyzers receive and measure a signal, they can be considered as passive instruments. As such, spectrum analyzers, by themselves, are not able to make cable and antenna measurements that require known signals to be applied to a particular device or network under test in order to measure the output or response.

There are two main types of test equipment used for making these stimulus-response measurements. The traditional type of test equipment is an RF or scalar network analyzer. The other option is a spectrum analyzer with a tracking generator. A vector network analyzer is typically required if exceptional accuracy is needed, but in most other cases a spectrum analyzer and tracking generator arrangement is an excellent solution. This is particularly true with the advent of low-cost high-performance USB-based spectrum analyzers.

The tracking generator operates by providing a sinusoidal output to the input of the spectrum analyzer. By linking the sweep of the tracking generator to the spectrum analyzer, the output of the tracking generator is on the same frequency as the spectrum analyzer, and the two units track the same frequency. As shown in Figure 11, the return loss bridge is the subsystem that allows reflections of the generated signal to be detected by the spectrum analyzer.

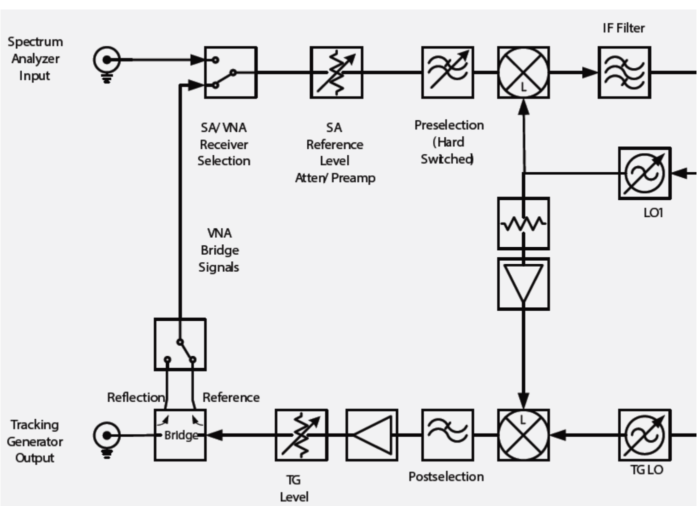

FIGURE 11 - RSA500A / 600A Series Spectrum Analyzer block diagram

Return Loss and VSWR

These measurements are based on the principle that some parts of a signal are reflected due to mismatches in impedance between cables, antennas, connectors or other components. The ratio of the input signal to the reflected signal is called the voltage standing wave ratio or VSWR. This ratio can also be measured in dB, and expressed as return loss.

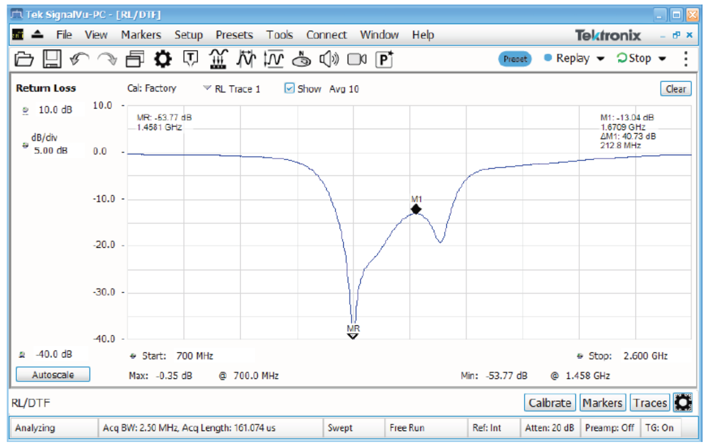

FIGURE 12 - Return loss vs. Frequency of a bandpass filter

Cable Loss

Signals dissipate energy as they travel through cables and components. But by how much? This insertion loss or cable attenuation in transmission lines impacts the overall performance of RF systems and should be factored into VSWR analysis. In extreme cases, cable loss can mask antenna degradation or even outright failures.

Tracking Down Faults

If you've determined that return loss and associated VSWR or cable loss are out of spec, the next step is to find possible locations for the fault – or faults – in the transmission system. Here's where the distance to fault (DTF) measurement is used to troubleshoot the system and identify or pinpoint the location of a fault or discontinuity.

Co-Located Antenna Testing

In many wireless applications, different systems are co-located on towers and other structures. In such situations considerable care must be given to antenna placement, regardless of whether they are part of the same system or not. It's important to maintain an adequate level of isolation in order to keep intermodulation products from being created on the transmission side or to avoid noise desensitization in the receivers.

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com

Summary

With the introduction of USB-based real-time spectrum analyzers from Tektronix, field service technicians now have the right tool for measuring basic signal parameters and identifying short-duration signals in a noisy, crowded spectrum. With the advanced DPX technology, users can see RF characteristics that are practically invisible to a conventional spectrum analyzer.

Due to its form factor and weight, the RSA306B has the best portability, it's directly powered via USB and covers a frequency range from 9 kHz to 6.2 GHz. The RSA500A / RSA600A models are either battery or AC line powered and its frequency coverage is from 9 kHz to 7.5 GHz. Additional standard options include an integrated GNSS receiver and a tracking generator for antenna and cable testing. All models have a real-time bandwidth of 40 MHz. Powerful features such as signal record and playback and mask search are available.

FIGURE 13 - RSA500A Series USB Spectrum Analyzer with Panasonic Tablet

The free SignalVu-PC software covers common spectrum analyzer measurements as well as real-time spectrum analysis. Additional options are available with costs, all can be tested for 30 days. Get more information at tek.com/spectrum-analyzer.

Hardware

Spectrum Analyzer	**RSA306B**	**RSA503A / RSA507A**
Tablet - Panasonic FZ-G1	Opt. CTRL-G1	Opt. CTRL-G1
Tracking Generator (TG)	-	Opt. 04
Software		
SignalVu-PC	free	free
LTE Downlink RF measurement	Opt. SV28	Opt. SV28
TG Vector Measurements - RL, VSWR, DTF, CL	-	Opt. SV60
Accessories		
Calibration kit - 7/16 DIN(f)	-	CALOSL716F
Calibration kit - 7/16 DIN(m)	-	CALOSL716M
Phase-stabilized cable - N(m) to 7/16(f)	-	012-1748-00
Phase-stabilized cable - N(m) to 7/16(m)	-	012-1750-00

FIGURE 14 - Typical Device Configurations

References:

Cable and Antenna Measurements Using Tektronix USB Spectrum Analyzers

(ES) Equipements Scientifiques SA - Département Tests & Mesures - 127 rue de Buzenval BP 26 - 92380 Garches
Tél. 01 47 95 99 45 - Fax. 01 47 01 16 22 - e-mail: tem@es-france.com - Site Web: www.es-france.com