Using R&S FSW for Efficient Measurements on Multi-Standard Radio Base Stations

Application Note

Products:

- R&S®FSW

This application note introduces the Multi-Standard Radio Analyzer function of the R&S FSW and shows how it performs the measurement on multi-standard radio transmitters. It reveals interactions caused by co-existence of signals using different cellular standards and localizes the root cause.
With an example of a base station signal consisting of three radio access technologies (GSM/WCDMA/LTE FDD) it shows how easy interactions can be found. The R&S FSW is the ideal tool for troubleshooting tasks with its combination of a large bandwidth and the versatile Multi-Standard Radio Analyzer in one measurement instrument.

ROHDE&SCHWARZ

Application Note

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1 Introduction

RF engineers working with Multi-Standard Radio Transmitters face a challenging task. Complex signals from different Radio Access Technologies (RAT) are generated and transmitted using common hardware. On the one hand the transmitter and especially the output power amplifier needs to be power efficient and deliver high RF power at lowest possible DC power consumption. Furthermore the hardware needs to transmit TDMA signals like GSM or TD-SCDMA with high power on / power off ratios, CDMA like signals such as with 3GPP WCDMA and OFDM signals like LTE signals simultaneously. Each of these signals is already challenging. But transmitting these signals with a common signal path creates additional challenges. The signals must not influence each other to avoid degradation of an individual RAT.
This combination of different signals also requires advanced measurement instruments which are able to analyze and localize problems caused by interaction between the different signals.

This application note introduces the Multi-Standard Radio Analyzer (MSRA) of the Signal and Spectrum Analyzer R&S FSW and explains the differences between the MSRA and the Multi-View function, which is sometimes also named Multi-Standard Radio Analyzer. Using a practical example the operation of the R&S FSW is shown using a multi-standard radio signal with some impairments generated by a signal source (R&S SMU or R&S SMBV).
It shows how easy it is to find the root-cause of the impairment using the R&S FSW. Finally some additional features like handling long sequences or speeding up the measurement with the R&S FSW MSRA are explained.

2 Multi-Standard Radio Analyzer of the R&S FSW

The Multi-Standard Radio Analyzer (MSRA) is a standard feature of the R&S FSW . It enables the analysis of different signals within a frequency band up to 160 MHz. The R&S FSW captures all signals within the complete band in one shot. The MSRA can demodulate and measure each of these signals individually using the captured data and applying the appropriate analyzing function in the different channels like GSM (FSW-K10), 3GPP WCDMA (FSW-K72), cdma2000 (FSW-K82), LTE (FSW-K100/104) etc. That way the MSRA can correlate the different signals for special events. For example: by looking at an event in one signal like a high EVM at a specific symbol it is possible to find the reason by evaluating the other signals in the MSRA channel at the same time instant.

Figure1 shows a scenario of a multi-standard radio signal comprising two WCDMA signals and two GSM signals in a total bandwidth of 16 MHz..

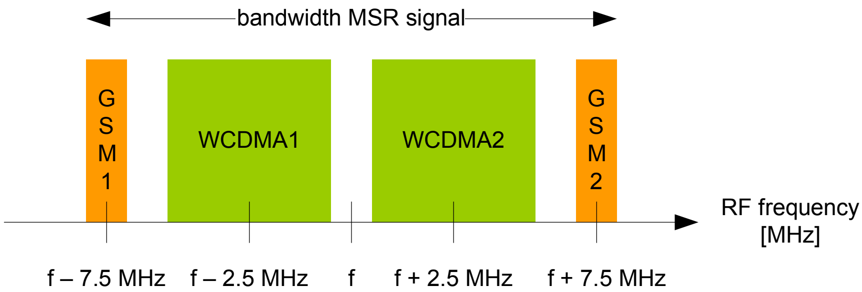

Figure 1: Example of a signal with 2 GSM and 2 WCDMA carriers

The R&S FSW captures the complete 16 MHz in a single shot. Subsequently it filters and resamples the signals according to the set channel parameters. It then applies the respective measurement application for each signal. The measurement results for each signal are displayed in a separate window on the R&S FSW screen.
As the origin of the measurement in the different channels is a common data set, time correlation between the different channels is possible. The R&S FSW can capture up to 200 Mega Samples of signal data. Using this large memory the likelihood capturing a rare event is increased.

R&S FSW Multi-View and Sequencer mode
An alternative method to evaluate multi-standard radio signals is to measure the different signals sequentially. This method is sometimes also called Multi-Standard Radio Analyzer. Using this approach all measurement results of the different transmit signals are also available. The R&S FSW with its Multi-view capability can display all test results simultaneously.
However, the difference is, that no time correlation between the different transmit signals is available and the influence between the different signal is hard or even impossible to find. This method is also available with the R&S FSW in the Multi-View mode. The advantage of the Multi-View method is, that the signal analyzer can also perform measurements on signals spread over a wider bandwidth than the maximum analysis bandwidth. However, an R&S FSW equipped with 160 MHz analysis bandwidth covers the bandwidth of today's cellular base transmitter stations.

3 Using R&S FSW to Troubleshoot MSR Base Stations

An MSR base station transmits the RATs used in a country or a region through a single transmitter. For example in Europe this may be a combination of GSM, 3GPP WCDMA and LTE, where the GSM signals are typically located at the band edges of the operator bandwidth and 3GPP WCDMA and LTE signals are in-between. In other regions configurations may differ depending on the Radio Access Technologies used. The starting point to perform a measurement on a multi-standard radio signal with the R&S FSW is to capture the complete transmit signal using the MSRA mode with the appropriate center frequency, level and analysis bandwidth.
The following measurement example demonstrates the procedures to measure on a MSR signal. It uses a signal generated by R&S signal generators with a EVM glitch on the WCDMA carrier at a specific symbol. In practice the signal could be measured at any stage of a base station transmitter, e.g. in the base-band section or in the output amplifier. With traditional means the reason for these kind of glitches are hard and time consuming to find. The example shows how easy it is with the MSRA in the R&S FSW.

The R&S SMU or R&S SMBV generator is configured to generate a signal with a combination of two GSM signals, a 3GPP WCDMA signal and a LTE signal using an ARB file.

Measurement setup

The measurements are performed using the following instruments and accessories:

- The R&S FSW with application firmware R&S FSW-K72: 3GPP FDD BTS Measurements and R&S FSW-K10 GSM Measurements
- A Vector Signal Generator:
  R&S SMU (with options R&S SMU-K240 Dig. Std. GSM/EDGE, SMU-K242 Dig. Std. 3GPP FDD, SMU-K255 Dig. Std. EUTRA)
  or
  R&S SMBV (with options R&S SMBV-K240 Dig. Std. GSM/EDGE, SMBV-K242 Dig. Std. 3GPP FDD, SMBV-K255 Dig. Std. EUTRA)
  (The vector signal generator is referred to as SMx in the example.)
- 1 coaxial cable, 50Ω, N connector
- 1 coaxial cable, 50Ω, BNC connector

To set up the instruments

1. Connect the "RF output" of the SMU or SMBV to the RF INPUT connector of the R&S FSW.
2. Connect the "Marker1" output of the SMU or SMBV to the TRIGGER INPUT connector on the front panel of the R&S FSW.
   Note:
   The use of a trigger is not mandatory with the MSRA. It is used in this application note for reasons of clarity. Without a trigger all timing values within the application note would be different.

Preparation

The waveform with the multi-standard radio signal is available on the R&S FSW hard drive under:
`C:\R_S\Instr\user\Waveforms\MSRA_GSM_WCDMA_LTE_GSM.wv`
The `Readme.txt` file in the same folder provides a description of the signal.

The waveform file contains a signal with four carriers with three Radio Access Technologies (see table below).

Frequency	RAT	Description of Signal
994.9 MHz	GSM	Normal burst, Slot2, TSC2, ramp time 0.2 symbols, 4 frames
997.5 MHz	WCDMA	Test Model1_64 Channels, 1 frame
1002.5 MHz	LTE FDD	Test Model 1_1_5MHz, 4 frames
1005.1 MHz	GSM	Normal burst, Slot2, TSC2, ramp time 0.2 symbols, 4 frames

► Copy the file from the R&S FSW using a USB stick

Settings on the R&S SMU or SMBV

1. Press the PRESET key to reset the instrument.
2. Set the frequency to 1 GHz.
3. Set the output level to 0 dBm.
4. Switch the RF on.
5. Press the DIAGRAM key, select “ARB…” and then select "Load Waveform" to load the signal data from the provided file MSRA_GSM_WCDMA_LTE_GSM.wv from the USB stick.
6. Select the "Trigger/Marker" menu and set "Marker1" to "Restart". Press the ESC key to close the dialog box.
7. Switch the "State" button to "ON" to activate the waveform.

Settings on the R&S FSW

1. Press the PRESET key on the R&S FSW.
2. Press the MODE key and select the "Multi-Standard Radio Analyzer" tab. Confirm the message which asks if the MSRA mode shall be started.
3. Set the "Center Frequency" to 1 GHz.
4. Set the reference level to 10 dBm.
5. Press the TRIG key and select "External Trigger 1" to use the external trigger from the SMU or SMBV.
6. Press the MEAS CONFIG key, select “Data Acquisition” and change the “Analysis Bandwidth" to 16 MHz.

As the R&S FSW is set to continuous sweep mode by default, data acquisition is started with each trigger event. The MSRA Master tab displays the spectrum of the multi-standard transmitter signal (see figure 2).

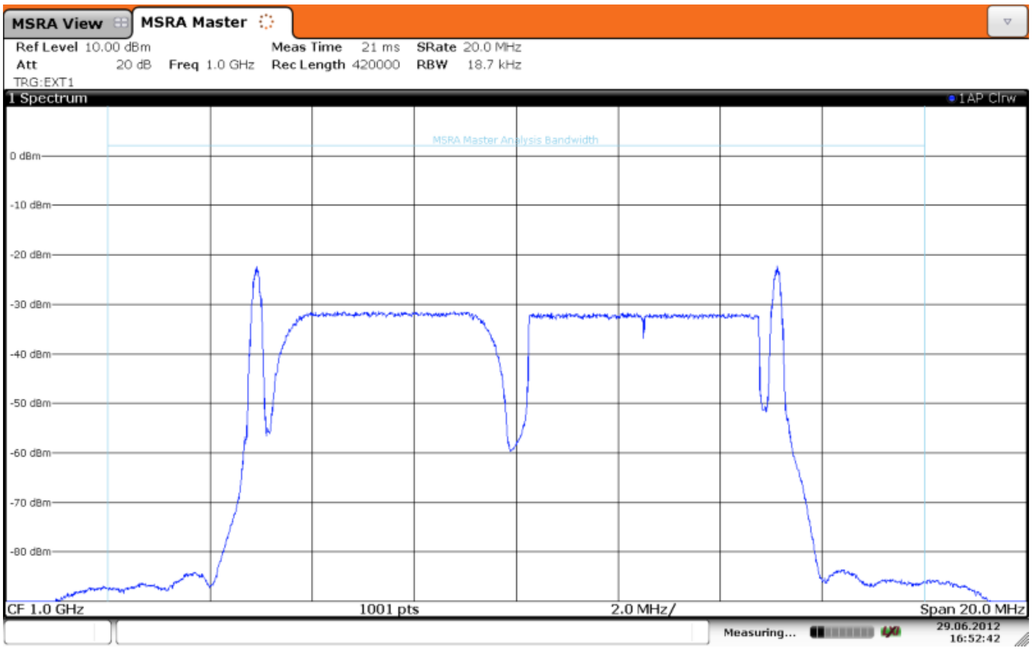

Figure 2: Spectrum Display in the MSRA mode showing the GSM/WCDMA/LTE/GSM carriers

To analyze the GSM signal at 994.9MHz

Activate an GSM measurement channel to analyze the GSM signal:

1. Press the MODE key and select the "GSM" button.
2. Set the center frequency to 994.9 MHz.
3. Adjust the GSM slot setup to match the signal provided by the generator (GSM, Slot 2 active):
   Press the MEAS CONFIG key, select the "Slot Scope" soft key and set the "Slot to measure" to number 2. Change to the "Slot tab" and set the "Slot 0" to "Off" and the "Slot 2" to "On".
4. As it is a multi-carrier scenario a multi-carrier filter needs to be applied:
   Press the MEAS CONFIG key, select the "Meas Settings" soft key and switch the "Multi Carrier BTS" toggle switch to "On".
5. Reduce the amount of data to be analyzed as the signal sequence from the generator is limited in their length:
   Press the SWEEP key, select the "Capture Time" soft key and set the value to 10 ms and then select the "Statistic Count" soft key and set the value to 1.

The GSM measurement application obtains an extract of the data captured by the MSRA Master for the first carrier on 994.9 MHz. The part of spectrum of the captured data the GSM measurement application analyzes is marked by vertical cyan lines in the MSRA Master window (see figure 3, top window).

To analyze the WCDMA signal

Activate a 3GPP FDD WCDMA measurement channel to analyze the WCDMA signal:

1. Press the MODE key and select the "3GPP FDD BTS" button.
2. Set the center frequency to 997.5 MHz
   The R&S FSW feeds the 3GPP FDD BTS application with the set of the data captured by the MSRA Master for measurement on the 3GPP WCDMA channel.
3. Select the "MSRA View" tab to see spectrum of the captured data on top of the screen and the measured GSM and 3GPP WCDMA signals in parallel below.

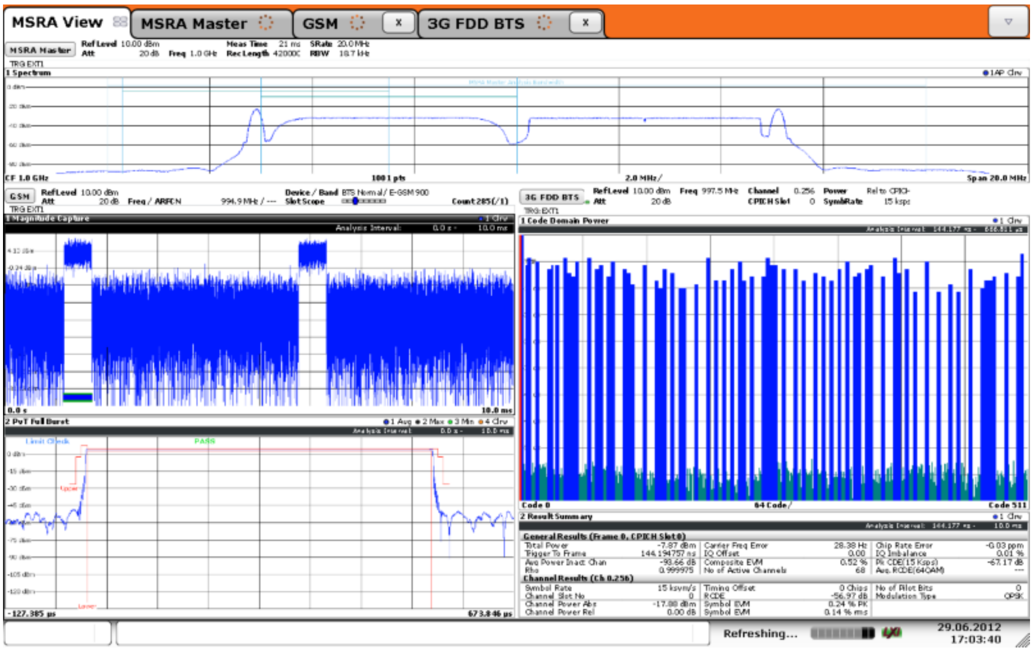

Figure 3: MSRA View for GSM and 3GPP FDD BTS applications

4. Tap the "3GPP FDD BTS" tab to display 3GPP WCDMA results.
5. Display the composite EVM of the WCDMA burst:
   a. Press the MEAS CONFIG key, then select the "Display Config" soft key.
   b. Scroll through the result display buttons until you see "Composite EVM", then drag the button to the diagram area of the display.
   The "Code Domain Power" display is replaced by the "Composite EVM" display.
   c. Select the red cross at the top of the result display list to close the SmartGrid mode.
6. To optimize the scaling of the diagram display, press the AUTO SET key and select "Auto Scale Window" (see figure 4).

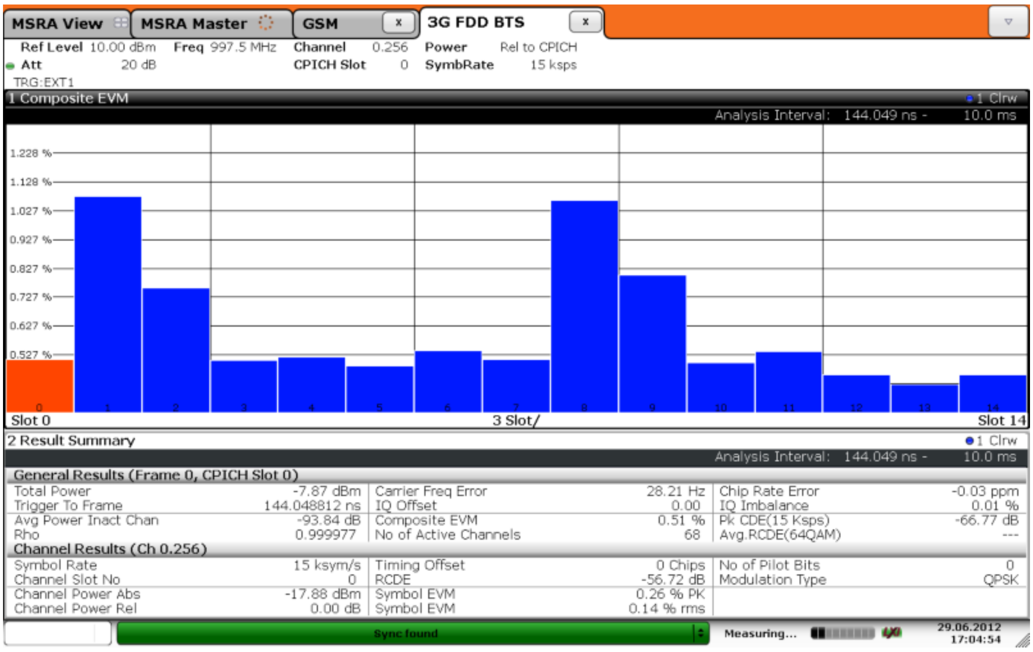

Figure 4: Composite EVM diagram of the WCDMA signal

The slots 1, 2, 8, and 9 show a significant higher EVM than the other slots.

7. Analyze the Chip EVM in these slots:
   a. Press the MEAS CONFIG key, then select the "Display Config" soft key.
   b. Drag the "EVM vs Chip" button over the "Result Summary" beneath the "Composite EVM" display to replace it.
   c. Tap the red cross at the top of the result display list to close the SmartGrid.
   The EVM vs Chip is displayed for slot 0.

8. Take a closer look at slot 1, which has a high EVM:
   a. Select the "Evaluation Range" soft key and set the "Slot" to 1. Slot 1 is highlighted in red color in the Composite EVM display.
   b. Tap the "EVM vs Chip" window to set the focus on it. The EVM for the individual chips in slot 1 is displayed. Note the analysis interval displayed in the window title bar, which indicates that the result displayed in the "EVM vs Chip" window was captured in the time interval 666.8 µs to 1.333 ms (referred to the absolute time of the I/Q data captured).
   c. Press the PEAK SEARCH key to place Marker1 on the chip with the highest EVM in slot 1. Marker1 indicates that chip number 1878 has the highest EVM.
   d. With the Analysis Line feature from the toolbar it is possible to mark the same moment in time in every active application. Press the Analysis Line “AL” button of the toolbar and position the orange Analysis Line on the peak in the EVM trace at the time 1.156ms.

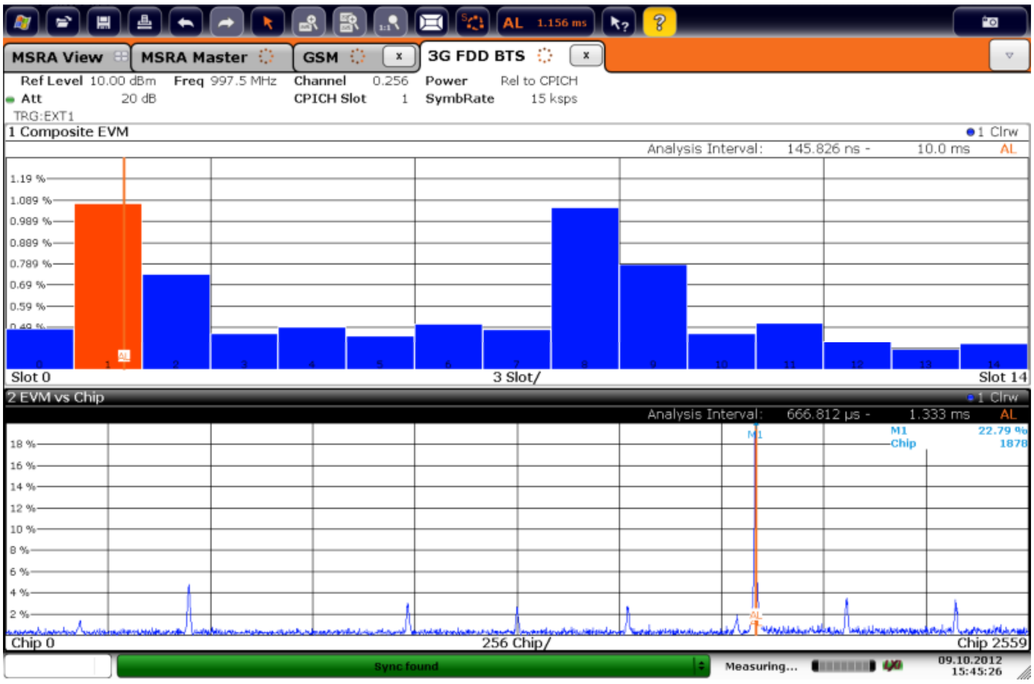

Figure 5: Determining the chip with the highest EVM in a WCDMA slot and set Analysis Line there

To determine time correlations in the MSR signal

With the help of the Analysis Line which is set to the absolute time at which the particularly error occurred, the MSRA can be used to find correlating events within other carriers at the same time. Start the investigation by analyzing the GSM signal at 994,9 MHz.

1. Select the "GSM" tab.
2. In the Magnitude Capture Display the orange Analysis Line is positioned at the rising edge of the first GSM slot
3. As well in the Pvt Full Burst Display the orange line is visible at the rising edge.

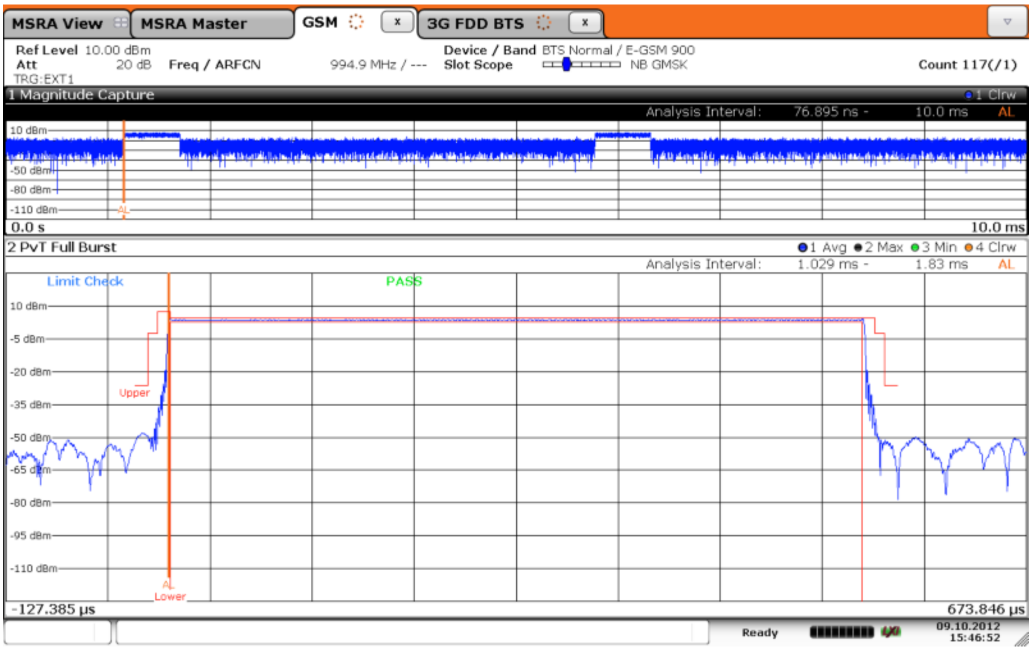

Figure 6: Correlating event marked with Analysis Line on the GSM burst: The rising edge of the signal!

So it is evident that the rising edge of the first GSM burst occurs at the same moment in time when the WCDMA symbol has a high EVM!

Conclusion of the measurement example

In the R&S FSW MSRA mode it is very easy to find interaction between different carriers, since the analysis is performed on a common set of I/Q data. This is especially easy to detect in the MSRA View, which displays the captured data and the specific application results in parallel on one screen (see figure 7).

Figure 7: MSRA View of MSR signal with time correlations

4 Additional Features of the MSRA Mode

Capturing and analyzing long data sequences

The R&S FSW MSRA can capture very long signal sequences (up to 200 Mega Samples). In order to examine particular areas, each measurement application within the MSRA supports a "Capture Offset" setting (see TRIG menu or "Data Acquisition"/ "Signal Capture" dialog box).

In the "MSRA Master" tab, the vertical cyan lines in the "Magnitude" result display indicate which time interval of the signal data is being analyzed by the different applications.

In this example 40 ms have been captured. The GSM application starts the analysis at a Capture Offset of 16 ms (4 divisions with 4.0 ms/div).The 3GPP FDD BTS application starts the analysis at a Capture Offset of 20 ms (5 divisions) (see figure 8).

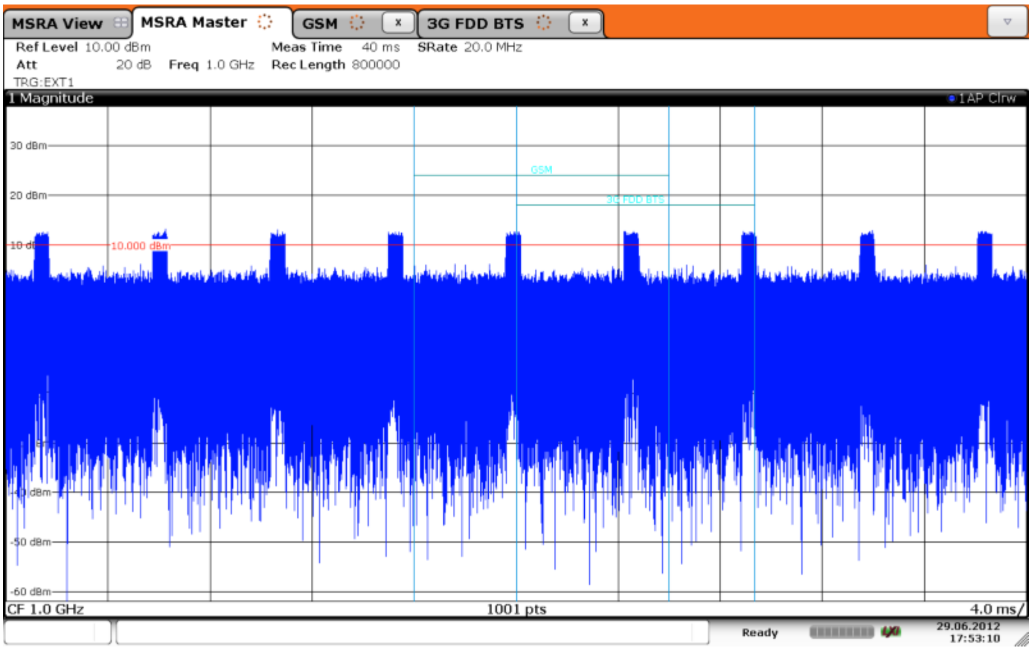

Figure 8: MSRA Master Magnitude View shows with cyan lines the I/Q data used from the application in the dimension of time

Reconfiguring the device under test, whilst FSW is analyzing the signal

Let's assume a test procedure requests to analyze a complex signal from an MSR Base Station. The overall test time for this task is not only depends on the speed of the signal analyzer, but also on the time which the base station needs to set up the appropriate test scenarios.

Normally those test scenarios are performed with remote control programs. For remote control the Multi-Standard Radio Analyzer supports a unique feature:

The status bit #9 (MSRA Capture Finished) in the `STAT:OPER` register is set when the I/Q data capturing is done. The data is available and further analysis in the different MSRA measurement applications start. The important point is that the captured I/Q data is not changed during these analysis steps. Even if the "Capture Offset" is changed in order to analyze the long sequence, the stored I/Q data remains the same. Therefore, this status bit can be used to start the re-configuring of the base station for the next test step. That way the setup of the base station can be performed in parallel to the analysis inside the R&S FSW. This may save valuable test time!

5 Literature

[1] Application note from R&S: Measuring Multi-Standard Radio Base Stations 1MA198

6 Ordering Information

Designation	Type	Order No.
Spectrum Analyzer	R&S®FSW8	1312.8000.08
Spectrum Analyzer	R&S®FSW13	1312.8000.13
Spectrum Analyzer	R&S®FSW26	1312.8000.26
Spectrum Analyzer	R&S®FSW43	1312.8000.43
Analog Modulation Analysis for AM/FM/φM	R&S®FSW-K7	1313.1339.02
GSM/EDGE/EDGE Evo/VAMOS Measurements	R&S®FSW-K10	1313.1368.02
Vector Signal Analysis	R&S®FSW-K70	1313.1416.02
Analysis of 3GPP FDD Base Station Signals incl. HSPA+	R&S®FSW-K72	1313.1422.02
Analysis of TD-SCDMA Base Station Signals	R&S®FSW-K76	1313.1445.02
CDMA2000® BS Measurements	R&S®FSW-K82	1313.1468.02
1xEV-DO BS Measurements	R&S®FSW-K84	1313.1480.02
EUTRA/LTE FDD Downlink Measurement Application	R&S®FSW-K100	1313.1545.02
EUTRA/LTE TDD Downlink Measurement Application	R&S®FSW-K104	1313.1574.02

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