Production Measurements on 3GPP WCDMA Femtocells
Application Note

Products:

- R&S®SMBV
- R&S®SMJ
- R&S®SMU
- R&S®FSV
- R&S®FSP
- R&S®FSL
- R&S®FSQ

Femtocells or Home base stations are an important development for cellular networks. This new emerging base station class demands economical test equipment suitable for mass production.
Rohde & Schwarz range of signal generators and analyzers contain models suitable for testing all classes of base station.
With the R&S®SMBV100A Vector Signal Generator and the R&S®FSV Signal Analyzer Rohde & Schwarz supply two instruments which are particularly suited for the fast and cost-efficient calibration and test required for Femtocells.
This application note describes the tests commonly used during the production of Femtocells, focusing on WCDMA, HSPA, and HSPA+ technology. Tests, test plans and hardware setups for Femtocells with and without receiver diversity are detailed. Find hints about the instrument settings and have a look at typical measurement results.
An introduction to simulating GPS / A-GPS signals for testing the GPS receiver of a Femtocell completes the paper.

Application Note

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1 Overview

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This application note describes the tests commonly used during the production of Femtocells, focusing on WCDMA, HSPA, and HSPA+ technology.

As well as "Femtocell", numerous other terms are used to describe the low power base station technology designed for installation and use in a building, for example "Home base station", "Femto base station", and "Home NodeB". For brevity "Femtocell" is used in this application note.
The standardization forum 3GPP (3rd Generation Partnership Project) defines the conformance test requirements for Femtocells in 3GPP TS 25.141. These test requirements are derived from the RF performance requirements stipulated in 3GPP TS 25.104. However, only a few measurements of the large number of tests stipulated in the 3GPP standard are applicable to Femtocell production.

The content of this application note is structured as follows:

- Section 3 shows which tests are commonly used to calibrate and validate Femtocells.
- Section 4 describes hardware test setups for devices with and without RX diversity.
- Section 5 is about customary test plans and how to optimize the test suites.
- Section 6 discusses the test requirements in the standard TS25.141 for the commonly used production tests.
- Section 7 and 8 go more into detail and present measurement results for transmitter and receiver tests.
- Section 9 introduces the GPS / A-GPS option for Rohde & Schwarz signal generators for testing the GPS receiver of a Femtocell.

Rohde & Schwarz offers a wide range of instruments for base station tests on Femtocells:

- For the complete set of conformance tests according to standard TS 25.141 the high end R&S®FSQ Signal Analyzer and the two-channel R&S®SMU Vector Signal Generator and Fading Simulator are essential.
- For fast and cost-efficient calibration and production test of Femtocells the R&S®SMBV100A Vector Signal Generator and the R&S®FSV Signal Analyzer are ideal. They can also be used for research and development applications.
- The mid-range spectrum analyzer FSP, the economic spectrum analyzer FSL, and the mid-range signal generator SMJ complete the portfolio.

Software options for all of these instruments greatly simplify to generating and analyzing standard-compliant signals applicable for Femtocells such as WCDMA, HSPA, and HSPA+.

All screen shots in the following text are made with FSV and SMBV. The user interfaces of the other analyzer and generator types slightly differ.

Application note 1MA139 refers to version 8.7.0 of TS 25.141 [1] and version 8.2.0 of the study item TR 25.820 for Home NodeBs [3].

The following abbreviations are used in this application note for R&S® test equipment:

- The R&S®FSQ Signal Analyzer is referred to as FSQ.
- The R&S®FSV Signal and Spectrum Analyzer is referred to as FSV.
- The R&S®FSP Spectrum Analyzer is referred to as FSP.
- The R&S®FSL Spectrum Analyzer is referred to as FSL.
- The R&S®SMU200A Vector Signal Generator is referred to as SMU.
- The R&S®SMJ100A Vector Signal Generator is referred to as SMJ.
- The R&S®SMBV100A Vector Signal Generator is referred to as SMBV.

2 Calibration and Validation Measurements during Production

Calibration

To meet the stipulated specifications, the calibration procedure measures and adjusts several parameters of the DUT. Calibration plans depend on the type of the DUT (an uncalibrated RF chip needs more efforts than a board using a calibrated RF chip), and differ from manufacturer to manufacturer. Nevertheless there are some typical test items that can be identified.

For TX calibration the following items are commonly measured. Your individual production demands determine which tests you use. All the listed measurements can be made with Rohde & Schwarz instruments.

TX Measurements
Maximum Output Power (total power)
Code Domain Power (CDP)
Frequency
Spectrum (Adjacent Channel Leakage Ratio ACLR, Spectrum Emission Mask SEM)
Modulation Quality (Error Vector Magnitude EVM, Peak Code Domain Error PCDE, Relative Code Domain Error RCDE, Baseband DC-Offset)

Table 3.1: TX Calibration Tests

Particularly spectrum and modulation quality tests are not universally applied.

During RX calibration, the test equipment applies specific uplink signals at the antenna input. For different signal levels and frequencies the test software reads the following items from the DUT:

RX Measurements
RX Signal Strength Indication (RSSI)
Automatic Gain Control (AGC)

Table 3.2: RX Calibration Tests

Before the calibration measurements take place an initial setting is written into the Non Volatile Memory (NVM) of the DUT. During or after calibration, correction parameters are derived from the measured values. Sometimes the test-software interpolates parameters for other frequencies and other levels than the measured ones, or for different temperatures. Finally, at the end of the calibration, the correction parameters are written into the DUT where they replace the initial NVM content.
By this process the TX- and RX-Part of the device is adjusted to operate according to the conformance requirements of standard TS 25.141.

The duration of calibration depends on the number of measurements and the sum of the individual measurement times. A good calibration starts with an optimum initial non volatile memory setting. A good calibration plan has an optimized minimum number of loops and iterations. Rohde & Schwarz provide test solutions optimized for production in terms of measurement and settling times.

If the DUT is an RF chip many of the items listed above have to be adjusted. If the DUT is a board using a calibrated RF chip (or a set), most or all calibration steps listed above may not be necessary.

Validation

Validation makes sure that calibration was successful and that the device operates according to the conformance requirements of standard TS 25.141.
Validation uses the non volatile memory content determined during calibration. After measurement, this time the results are checked against the limits provided by the standard.

Some of the measurements already performed during calibration may be repeated for validation purposes. Typical items for validation are:

TX Measurements
Output Power (Max. Power, Dynamic Range)
Code Domain Power (CDP)
Frequency
Spectrum (Occupied Bandwidth OBW, ACLR, SEM)
Modulation Quality (EVM, PCDE, RCDE)
RX Measurements
RX-Sensitivity (Bit Error Rate BER, Block Error Rate BLER)

Table 3.3: TX / RX Validation Tests

Each measurement is performed once and provides a pass/fail result. The duration of the validation depends on the sum of the individual measurement times. By carefully evaluating and selecting only the measurements that are essential, the test time can be reduced to a minimum.
To achieve the best efficiency, Rohde & Schwarz instruments makes use of:

- Short measurement and settling times due to optimized test equipment
- Testing by parallel and evaluating many results (e.g. OBW + ACLR + SEM) from a single data set
- Simultaneous RX and TX measurements

Simultaneous RX and TX measurements are possible if the receive and transmit parts of your device can work, and be controlled, independently. The hardware test setup you find in section 4 supports RX and TX tests running at the same time.

Some manufactures refer to making **Functional Tests** at the end of the production line. The DUT is made to function as in normal operation. Typical functional tests are a call setup with a test mobile or measurements of the data throughput for HSPA. These tests can often be made using a user equipment modified to serve as an enhanced "golden device".

Such tests are manufacturer specific and fall outside the scope of this application note, which concentrates on calibration and validation measurements. These tests can be performed with just two instruments: a signal generator and a signal analyzer.

3 Hardware Test Setups

Fig. 4.1 shows a production test setup for **DUTs without RX diversity**.

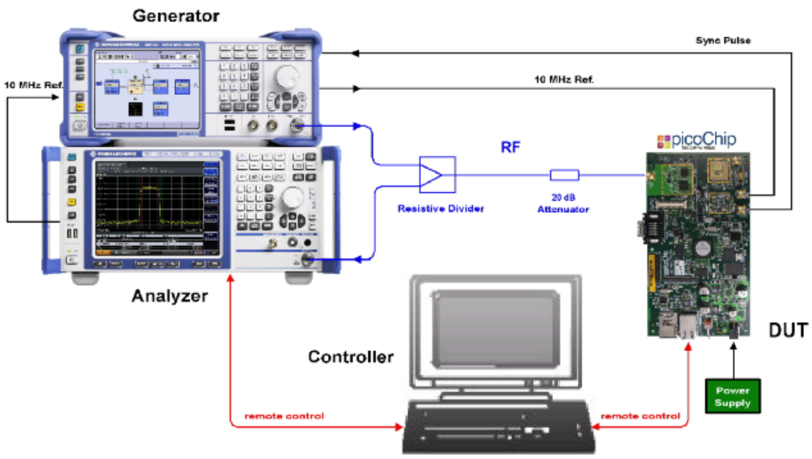

Figure 4.1: Recommended Test Setup for DUTs without RX diversity

The test setup shown in Fig. 4.1 is suitable for all Femtocell production tests mentioned in the previous section and is the same for both calibration and validation.
The test instruments shown are the FSV and the SMBV. The DUT is a typical Femtocell design[1].
Connect the modules via one resistive divider and one attenuator. These inexpensive components have an excellent flat frequency response. The RX / TX path losses are nearly constant within the working frequency band and can easily be compensated.

The TX tests measure the downlink signal from the DUT, which flows in the lower branch of the RF divider to the analyzer. RX tests use the upper branch. The 20 dB attenuator between the divider and the DUT not only reduces the already low level of downlink signal (20 dBm maximum). Moreover it improves the impedance matching which is important to achieve accurate RF input levels for the bit error measurements.

In some publications you may find a transducer in the test setup to avoid TX power reaching the generator. In the setup in Fig. 4.1 the signal power from the DUT at the generator socket is below 0 dBm. The SMBV can cope with this without any consequences. So you can run TX and RX tests simultaneously - without expensive components.

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[1] For more information about the DUT in Fig. 4.1 contact https://support.picochip.com.

A 10 MHz reference clock synchronizes analyzer, generator, and the device under test. If the DUT is the reference source configure the instruments accordingly.

The frequency error of the DUT determined during the TX tests is relative to the 10 MHz clock. This seems to be adequate for production tests. If you need an absolute frequency error indication use a Rubidium or Cesium frequency standard as reference.

Bit error measurements require a synchronisation pulse from the DUT. This could be a signal indicating the Start of the Frame Number SFN (when the frame counter wraps from 4095 to 0) or the start of a Transmission Time Interval TTI. You find details about the timing requirements in [5].

The test program runs on a computer shown as the Controller in Fig.4.1 for both the DUT and the test instruments. Access the Rohde & Schwarz instruments via either the IEEE488 or the LAN interface.

DUTs with RX diversity usually have one common TX / RX connector and a second one for RX only. TS 25.141 specifies measuring the RX inputs separately each time, terminating the unused socket by 50 Ohms. Therefore you need RF switches.

If your DUT can independently enable and disable the RF inputs internally the sensitivity tests can be made without any switching components, see Fig. 4.2.

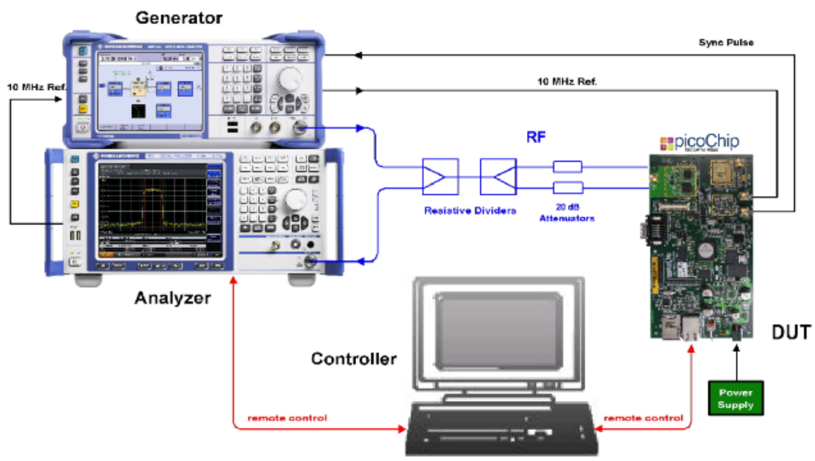

Figure 4.2: Recommended Test Setup for DUTs with RX diversity

Here the RF path is simply split by a second resistive divider. Use the same types for both attenuators, and the same type and length of cables to achieve the same path loss.
In this setup the two RF ports of the DUT are decoupled by more than 40 dB. If this is not sufficient, you may increase the attenuation up to 30 dB in each path.

4 Production Test Suites

The test steps of a production test suite can be divided into RF tests and non-RF tests. RF tests are measuring the TX power, the occupied bandwidth, or the error vector magnitude, for example.
Non-RF tests include checking the power consumption, or measuring the ambient temperature of the chip, for example.
This application notes concentrates on the pure RF tests.

The RF tests consist of several steps:

- Configure the DUT
- Configure the test instruments
- Start a measurement
- Fetch and evaluate the results

Many steps can also be broken into substeps. Steps and substeps can possibly be done in parallel.

Fig. 5.1 shows a commonly used serial test suite. Only RF tests are included.

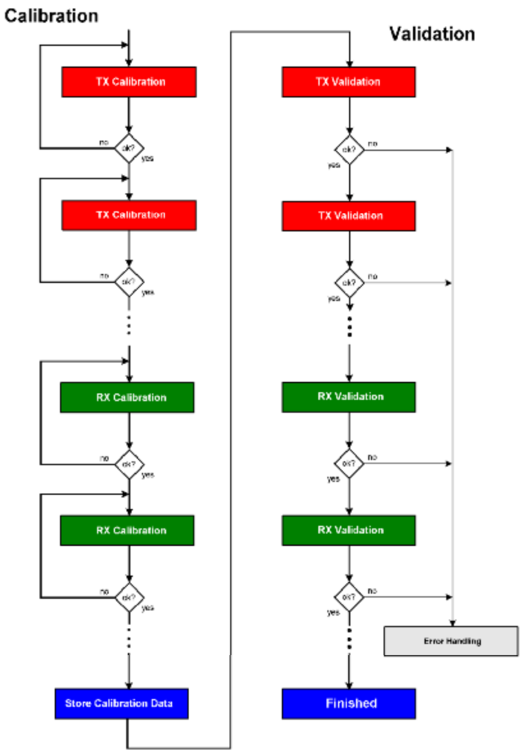

Figure 5.1: Serial test suite

During calibration measurements are repeated until the device is aligned. During validation, each measurement returns pass / fail parameters. TX and RX measurement steps follow one after another.
If it is possible with the DUT to control and configure the TX and RX parts independently, you can reduce the testing time dramatically. Fig. 5.2 shows how measurements can be performed in parallel.

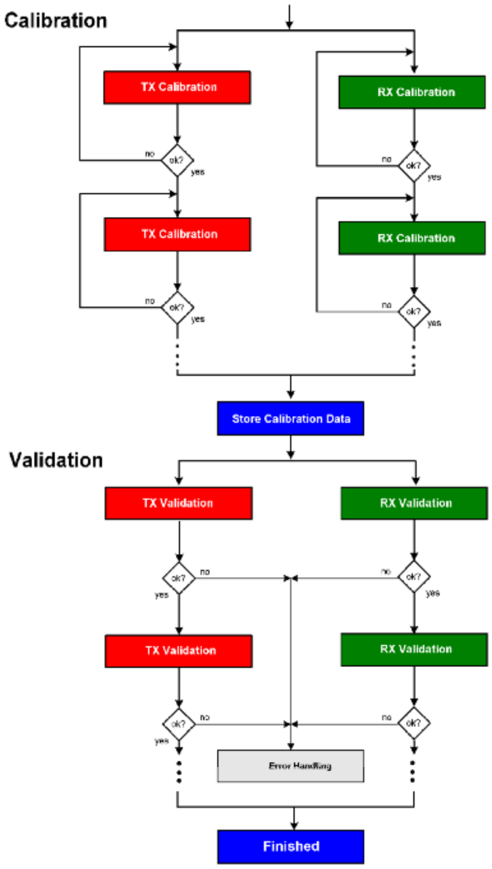

Figure 5.2: Testing TX and RX in parallel

Figure 5.2 shows only the principle. In reality the sum of the RX and the sum of theTX tests as well as the different test steps themselves take different times.
However, if your DUT makes it possible, many TX and RX test steps or test substeps can run almost simultaneously. During a current TX measurement you can already configure the generator for the next task, and start an RX calibration. Perhaps almost all TX measurements can be performed during the validation BER test.

The hardware setups recommended in the previous section are designed to run TX and RX tests in parallel. Check your current test plan and look for opportunities for parallel testing.

5 Femtocell Measurements and the Standard TS 25.141

As 3GPP WCDMA / HSPA(+) base stations, Femtocells have to be compliant with the Standard TS 25.141 including the specific "Home BS" requirements. The standard not only determines the properties to test; it also defines how the measurements are to be performed. The Standard prescribes the hardware setups and the required test signals, the measurement parameters such as filters, bandwidths, sweep times, calculation formulae for EVM and code errors, and the test limits.

The need to meet the requirements is the basis for calibration and validation measurements. Of course, test engineers may apply more stringent limits and additional tests if they wish to.

All the Rohde & Schwarz analyzers and generators mentioned in this application note can be fitted with 3GPP WCDMA, HSPA, and HSPA+ personalities as software options which configure the equipment exactly for the standard TS 25.141. All the necessary parameter settings are taken care of; no need to configure the analyzer to evaluate the TX Adjacent Channel Leakage Ratio (ACLR) or the Error Vector Magnitude (EVM) according to the standard, for example. Once the correct measurement mode is selected in the analyzer, all standard-compliant measurement parameters are loaded automatically. Rohde & Schwarz signal generators offer predefined settings for the real time generation of the TS 25.141 test signals, known as the reference measurement channels.

All the tests in standard TS 25.141 are mandatory for type approval; however only a small subset is applicable for testing Femtocells in production. The tables 6.1 and 6.2 on page 13 show a reduced list containing only these standard tests which correspond to the measurements commonly used for calibration and validation, the tests which are listed in section 3 of this application note[2].

The first column of the tables 6.1 and 6.2 shows the number of the corresponding section in TS 25.141. The second column contains the name of the test in the standard.
The tables 6.1 and 6.2 also show which analyzers and generators are suited for each measurement.

For the TX tests Rohde & Schwarz recommends the FSV as the fastest instrument optimum for production. If your calibration plan contains loops with many TX measurements, this analyzer can reduce your test times dramatically.

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[2] In particular all the spurious emissions tests, all the interferer tests, and all the performance tests with multipath propagation (fading) and AWGN are typically not addressed in production. These tests can of course also be performed by R&S instruments, see [4].

No.	TX Tests	Analyzer			
		FSL	FSP	FSV	FSQ
6.2.1	BS Maximum Output Power	√	√	√	√
6.3	Frequency Error	√	√	√	√
6.4.4	Total Power Dynamic Range	√	√	√	√
6.5.1	Occupied Bandwidth	√	√	√	√
6.5.2.1	Spectrum Emission Mask	√	√	√	√
6.5.2.2	Adj. Channel Leakage Ratio	√	√	√	√
6.7.1	Error Vector Magnitude	√	√	√	√
6.7.2	Peak Code Domain Error	√	√	√	√
6.7.4	Rel. Peak Code Domain Error		√	√	√

Table 6.1: Corresponding TX Tests of TS 25.141

For RX tests (BER measurements) all generators in table 6.1 are equally suited.
The decision which instruments to choose will also be influenced by the future test and performance requirements of your individual applications.

No.	RX Test	Generator		
		SMBV	SMJ	SMU
7.2	Reference Sensitivity Level	√	√	√

Table 6.2: Corresponding RX Tests of TS 25.141

Sections 7 and 8 provide further advice on how to select and perform the measurements required by TS 25.141.

The examples in the following sections use the FSV and the SMBV. The representation of results on the instrument screen and the user interface differ sligthly for other analyzers and generators.

6 Transmitter Measurements

Transmitter tests are measurements on the base station downlink signal. The testing instrument is a vector signal analyzer.

Select the 3GPP FDD BTS option FSV-K72. A column of softkeys appears on the screen offering the following measurement modes:

Code Domain Analyzer	Activates the **code domain** measurement mode.
Power	Activates the channel power measurement, in **time domain** mode.
Ch Power ACLR	Activates the adjacent-channel power measurement, in **spectrum domain.**
Spectrum Emission Mask	Compares the signal power in different carrier offset ranges with the maximum values specified, in **spectrum domain.**
Occupied Bandwidth	Activates the measurement of the occupied bandwidth, **spectrum domain.**
CCDF	Evaluates the signal with regard to its statistical characteristics (Complementary Cumulative Distribution Function)
RF Combi	Activates the RF combination measurement of the ACLR, SEM, and OBW, **spectrum domain.**

Table 7.1 lists the TX measurements commonly used in calibration and validation and shows which analyzer mode is applicable.

No.	TX Test	Measurement Mode	Test Signal
6.2.1	BS Output Power	Time/Code Domain	TM 1, 4, 5
6.3	Frequency Error	Code Domain	TM 1, 4, 5
6.4.4	Total Power Dynamic Range	Time/Code Domain	TM 4
6.5.1	Occupied Bandwidth	Spectrum Domain	TM 1
6.5.2.1	Spectrum Emission Mask	Spectrum Domain	TM 1
6.5.2.2	Adj. Channel Leakage Ratio	Spectrum Domain	TM 1
6.7.1	Error Vector Magnitude	Code Domain	TM 1, 4, 5
6.7.2	Peak Code Domain Error	Code Domain	TM 3
6.7.4	Rel. Peak Code Domain Error	Code Domain	TM 6

Table 7.1: TX-tests, Measurement Modes, and Test Signals for Femtocell base stations tests.

The characteristics of the different modes are described in the following sections, in particular how the analyzer combines measurements in code and spectrum domain.

The test signal column of table 7.1 shows the test signals stipulated by the standard. TS 25.141 specifies 6 test models (TM) with predefined channel combinations and settings to make sure that the measurement results from different base stations can be compared. For Femtocells TM1, TM3, TM5, and TM6 use a reduced number of channels.

Time Domain Power Measurements

TX Test	Measurement Mode	Test Signal
BS Output Power	Time/Code Domain	TM 1, 4, 5
Frequency Error	Code Domain	TM 1, 4, 5
Total Power Dynamic Range	Time/Code Domain	TM 4
Occupied Bandwidth	Spectrum Domain	TM 1
Spectrum Emission Mask	Spectrum Domain	TM 1
Adj. Channel Leakage Ratio	Spectrum Domain	TM 1
Error Vector Magnitude	Code Domain	TM 1, 4, 5
Peak Code Domain Error	Code Domain	TM 3
Rel. Peak Code Domain Error	Code Domain	TM 6

BS Output power

The BS Output Power is measured during calibration as well as during validation. Because one sweep averages over 10 frames the time domain mode provides very accurate and stable measurement results. The analyzer uses an RMS detector and an RRC measurement filter. Figure 7.2 shows a typical result on the FSV screen:

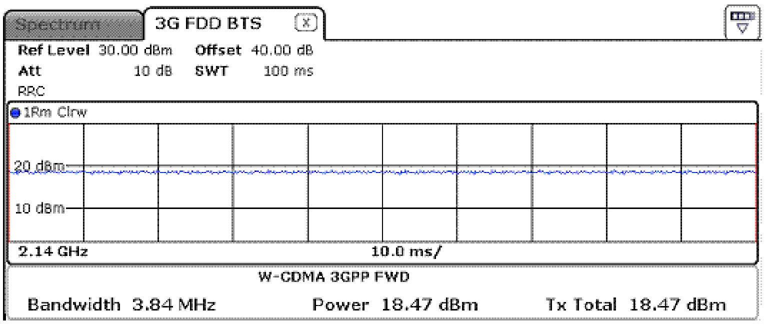


Fig. 7.2: BS power measured in time domain

In addition to the graphical signal representation shown in the upper part of figure 7.2, the numerical result is displayed automatically, too.

Total Power Dynamic Range

The Total Power Dynamic Range is measured during validation.

Check whether the Femtocell can reduce its output power by 18 dB. According to the standard, the dynamic range shall be tested together with the frequency error and the EVM. To reduce the number of test steps you might consider checking the output power in code domain, because the code domain mode provides power, frequency error, and EVM together in one single record.

Note: For high precision power measurements use Rohde & Schwarz NRP-Z power sensors. They can be directly connected to FSV, FSL, FSP and FSQ spectrum analyzers, and are supported by the corresponding firmware. A program is provided for controlling the sensors by PC, see NRP-Toolkit.

Code Domain Measurements

TX Test	Measurement Mode	Test Signal
BS Output Power	Time/Code Domain	TM 1, 4, 5
Frequency Error	Code Domain	TM 1, 4, 5
Total Power Dynamic Range	Time/Code Domain	TM 4
Occupied Bandwidth	Spectrum Domain	TM 1
Spectrum Emission Mask	Spectrum Domain	TM 1
Adj. Channel Leakage Ratio	Spectrum Domain	TM 1
Error Vector Magnitude	Code Domain	TM 1, 4, 5
Peak Code Domain Error	Code Domain	TM 3
Rel. Peak Code Domain Error	Code Domain	TM 6

The code domain mode mainly determines the modulation quality. It is used during both calibration and validation. In code domain measure the total and the code power, the frequency error, the EVM, and the PCDE of QPSK, 16QAM and 64QAM code channels. All these (and many more) results are derived from one single record.

As an example Fig. 7.3 shows a code domain record of a test model 5 signal with 4 HS-PDSCHs (High Speed Physical Downlink Shared Channels).

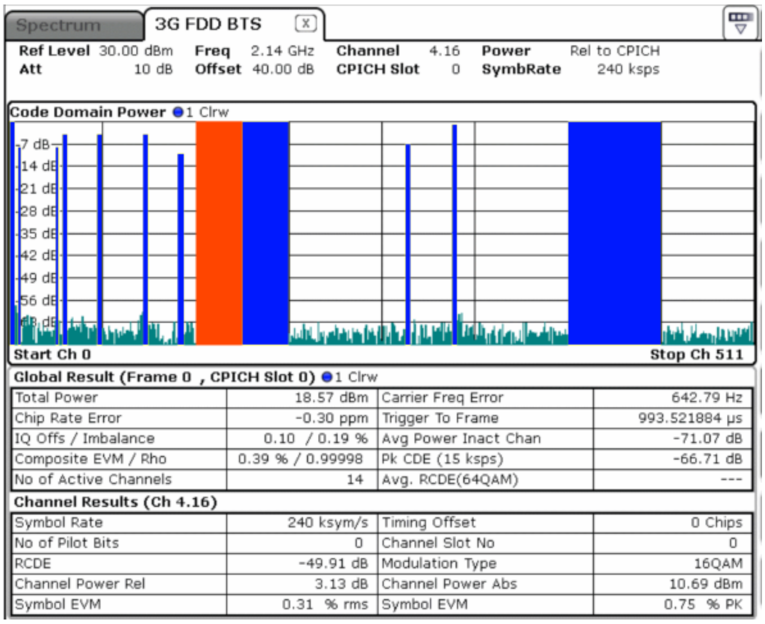


Fig. 7.3: Results derived from one code domain record

In the upper half you see the classical code domain power representation, in the lower half a result summary divided into *Global Results* and *Channel Results*.

- The Global Results report on the total signal. These also contain the measurement results required by the standard :

Total Power	=	BS Output Power acc. to 6.2.1 (for all slots)
Carrier Frequency Error	=	Frequency Error acc. to 6.3
Composite EVM	=	Error Vector Magnitude acc. to 6.7.1
Pk CDE	=	Peak Code Domain Error acc. to 6.7.3
Avg. RCDE (64 QAM)	=	Rel. Peak Code Domain Error acc. to 6.7.4

(The Relative Peak Code Domain Error is only applicable for test model 6 using 64 QAM HS-PDSCH channels.)

These results are required during calibration and validation.
Some additional useful measurement results are shown in the Global Result window. For example, the IQ Offs / Imbalance value allows to calibrate the DC baseband offset.

All values are evaluated according to TS 25.141. All results are derived from a single record.

- The Channel Results provide a detailed characterisation of a single code channel selected by the (red) analyzer marker.

In Fig. 7.3 code channel 4 is selected. It is the first HSDPA data channel HS-PDSCH with spreading factor 16, a symbol rate of 240 ksym/s and 16 QAM modulation. You see as individual parameters e.g. the absolute and relative power of this code channel, the timing offset and so on.

Fig. 7.4 gives an overview which measurement results can be graphically displayed in code domain mode. Watch up to 4 results (in up to 4 subscreens) simultaneously.

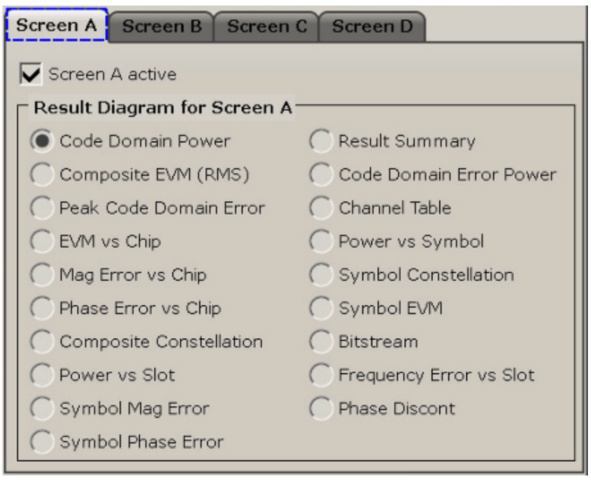


Fig. 7.4: Graphical displays in code domain mode

Fig. 7.5 shows what is behind the measurement results.

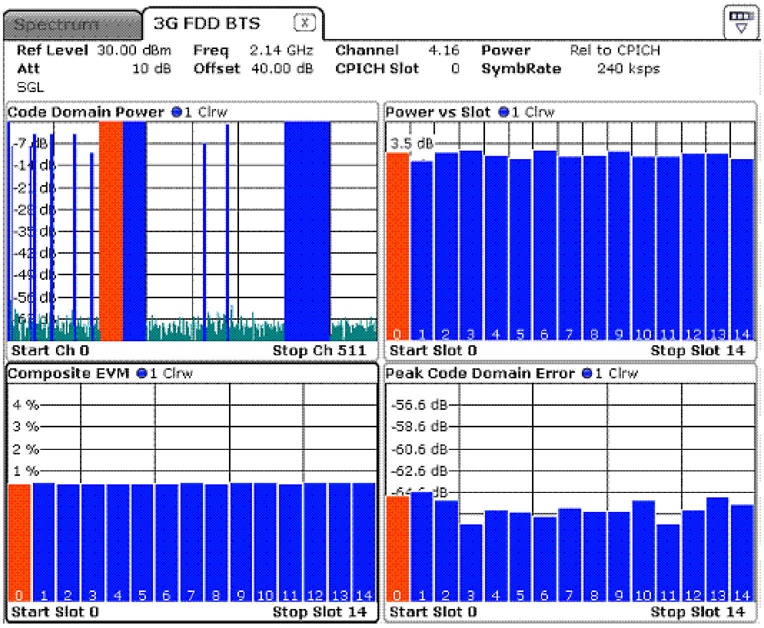


Fig. 7.5: Four Results derived from one code domain record in graphical representation

This screenshot displays measurement results which are relevant for Femtocell testing.

- The upper left window shows the classical code domain power display.
- The upper right window shows the total power versus slot.
- The lower left window shows the Error Vector Magnitude versus slot.
- The lower right window shows the Peak Code Domain Error versus slot.

All the results are calculated from a single record. All values are available via remote control.
You get 15 values for the 15 slots of one recorded frame. For power and EVM average over all slots; for Peak Code Domain Error take the maximum.

Note: Power values are displayed in dBm. Convert the measured values into Watt before averaging.

Power vs. Slot

Whereas the power measurement in time domain integrates over ten frames, the power result in code domain is only based on one frame. If your DUT provides a long term constant RF output power, one code domain snapshot could replace the time domain measurement. If you know the possible RF output power variations, you can alternatively use the code domain power result, applying more stringent limits. Typically, deviations between the time and the code domain results are 0.1 to 0.3 dB.

Composite EVM

The Composite EVM measurement is derived from the error vector between the measurement signal and an ideal internally generated reference signal. The error is averaged over all channels for each slot. Average over all slots according to the standard or take the worst case to be on the safe side.

Peak Code Domain Error
The Peak Code Domain Error shows the maximum of code error for the entire signal (all codes) for each slot. Take the maximum value.

Frequency Error

The frequency error of the DUT signal displayed in Fig. 7.3 is relative to the 10 MHz reference clock applied to the analyzer. This seems to be adequate for production tests. If you need an absolute value use a Rubidium or Cesium frequency standard as reference.

Total power dynamic range

Total power dynamic range checks whether the Femtocell can reduce its output power by 18 dB. According to the standard the dynamic range shall be tested together with the frequency error and the EVM. To reduce the number of test steps you might consider checking the output power in code domain, because this mode provides the output power as well as the frequency error and the EVM in one single record. If your DUT provides a long term constant RF output power, one code domain snapshot could replace the time domain measurement.

According to the standard, the measurements in code domain have to be repeated for different test models, see table 7.1.

Frequency Domain (Spectrum) Measurements

TX Test	Measurement Mode	Test Signal
BS Output Power	Time/Code Domain	TM 1, 4, 5
Frequency Error	Code Domain	TM 1, 4, 5
Total Power Dynamic Range	Time/Code Domain	TM 4
Occupied Bandwidth	Spectrum Domain	TM 1
Spectrum Emission Mask	Spectrum Domain	TM 1
Adj. Channel Leakage Ratio	Spectrum Domain	TM 1
Error Vector Magnitude	Code Domain	TM 1, 4, 5
Peak Code Domain Error	Code Domain	TM 3
Rel. Peak Code Domain Error	Code Domain	TM 6

The measurements in frequency (spectrum) domain could -in principle - be performed by any general purpose analyzer. However, using the 3GPP WCDMA / HSPA / HSPA+ personalities, the measurements are much easier, because the configurations and requirements of the standard are automatically set. The required numerical results, for example the Occupied Bandwidth according to TS 25.141, are directly computed. Moreover the BS signal is checked against predefined limits and a pass / fail verdict is given.
Using a special analyzer mode - the Spectrum Combi[3] - all three spectrum measurements are performed in one record, see Fig. 7.6:

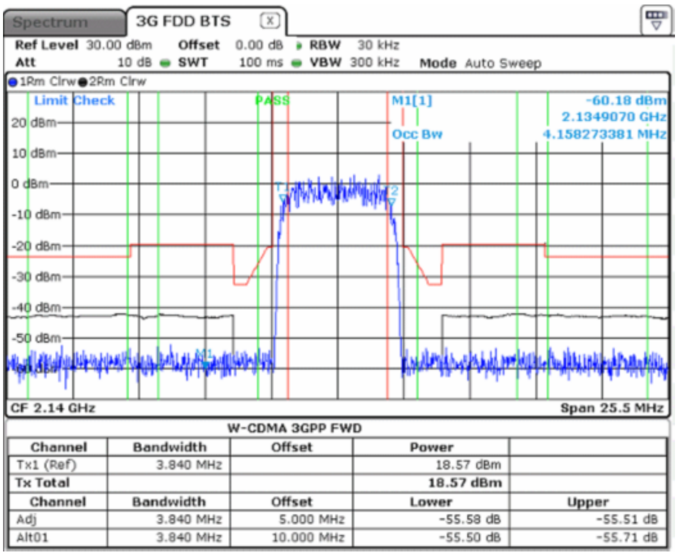


Fig. 7.6: Spectrum Combi Measurement

Fig. 7.6 shows the signal spectrum with the analyzer default setting for 3GPP WCDMA. The limits for the Spectrum Emission Mask are adapted automatically to the carrier power. If you want to apply more stringent limits, define your own user set.

You get numerical results for the Occupied Bandwidth, the TX total power, and the signal strength in the adjacent and alternate channels. To simplify the evaluation of the measurements, the analyzer presents also a pass / fail verdict.

[3] The Spectrum Combi mode is available on the FSV and FSQ; the automatic SEM adaption is currently implemented only for higher output levels than Home BSs provide.

7 Receiver Measurements

	RX Test	Test Signal
7.2	RX Sensitivity	UL RMC 12.2
	RX Signal Strength Indication (RSSI), Automatic Gain Control AGC, etc.	UL RMC 12.2

Receiver tests are measurements using a predefined uplink signal to the Femtocell. According to the standard use the Reference Uplink Channel RMC 12.2 kbps.

For calibration, the uplink signal is commonly used to align the Radio Signal Strength Indicator RSSI or the AGC.

Validation tests check the RX sensitivity by measuring the Bit or the Block Error Rate (BER / BLER). Unlike user equipment, base stations calculate the BER or BLER internally and report the measurement results (single ended BER / BLER). The test result is presented by the base station controlling software.

For details on how to generate the uplink RMC, and how to run Bit or Block Error Rate (BER / BLER) tests on WCDMA base stations, see application note 1MA144, [5].

Fig. 8.1 shows a typical BER representation evaluated by a BS controlling software.

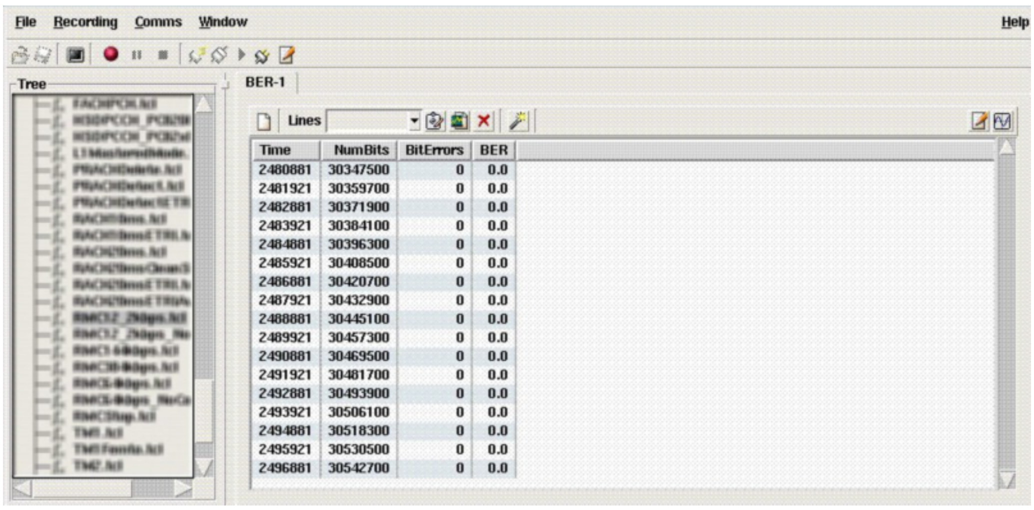


Fig. 8.1: Bit error results

For BER measurements, the generator frame timing has to be synchronized to the Femtocell. This is accomplished by starting the generator at the Start of Frame Number or the start of a Transmission Time Interval.
Once triggered, the generator and the DUT stay synchronized due to the common reference clock.

By default R&S generators use a time delay between the frame start defined by the downlink signal and the frame start of the uplink, of 1024 chips. Depending on the device under test a higher delay could be necessary, see application note 1MA144, [5].

To check correct BER evaluation you can insert a fixed percentage of bit errors into the generator signal. Insert these bit errors on the transport block level, see [5]. If you insert the errors on the physical layer level they are for the most part compensated by the receiver error correction.

Fig. 8.2 shows a measurement result with a BER of 0.1% simulated by the generator.

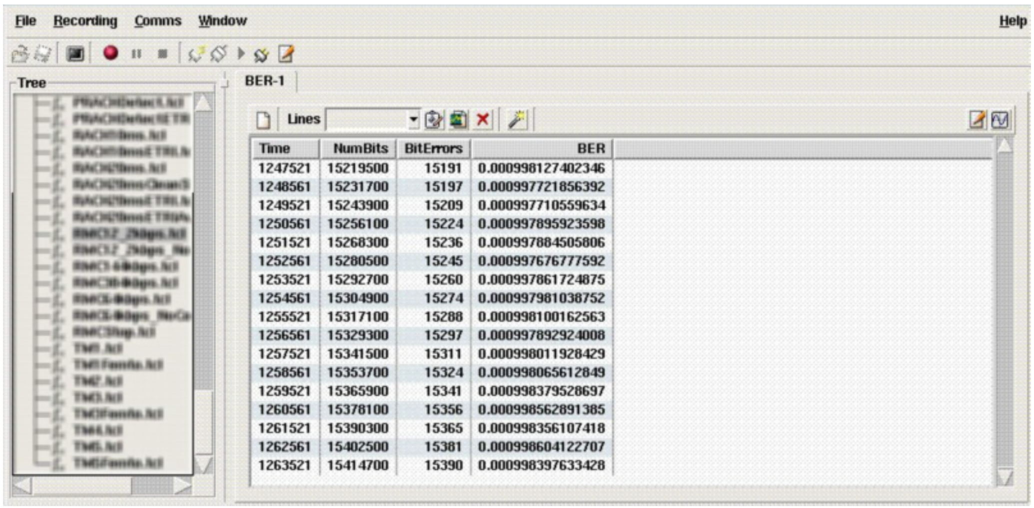


Fig. 8.2: BER measurement with 0.1 % simulated erroneous bits

To get a reliable result the standard requires a testing time of about 20 s. Even if you decide to reduce this measurement duration for production testing, there is adequate time for several transmitter tests in parallel.

8 Simulating a GPS / A-GPS Signal

Some Femtocells are able to determine their location using GPS/A-GPS technology.

To check the GPS function, Rohde & Schwarz signal generators provide real-world GPS signals with real navigation and real almanac data for up to eight satellites. The GPS/A-GPS options can simulate not only fixed positions but also moving receivers.

Fig. 9.1 shows the main menu of the generator, where you can enter the altitude, the latitude, and the longitude.

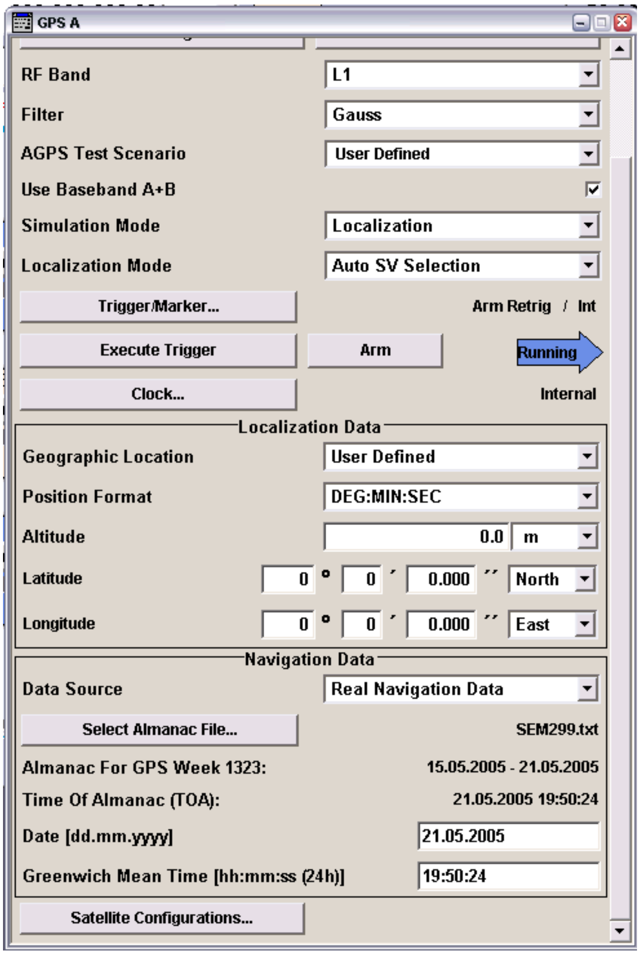
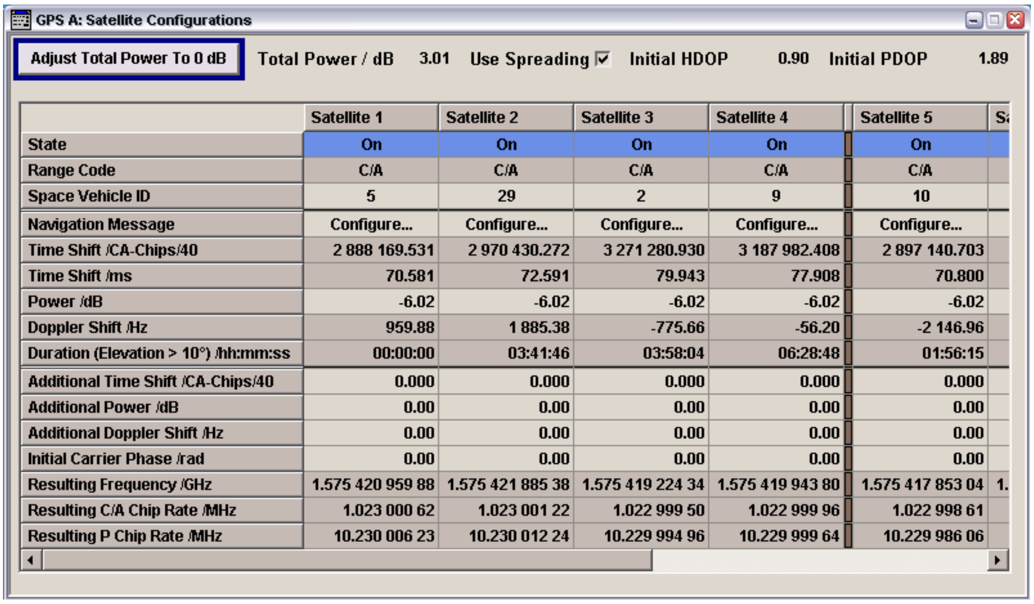


Fig. 9.1: GPS main menu on the signal generator

Fig. 8.2 shows how to configure the satellite parameters:



GPS A: Satellite Configurations

Adjust Total Power To 0 dB | Total Power / dB 3.01 | Use Spreading ☑ | Initial HDOP 0.90 | Initial PDOP 1.89

	Satellite 1	Satellite 2	Satellite 3	Satellite 4	Satellite 5	Sa
State	On	On	On	On	On	
Range Code	C/A	C/A	C/A	C/A	C/A	
Space Vehicle ID	5	29	2	9	10	
Navigation Message	Configure...	Configure...	Configure...	Configure...	Configure...	
Time Shift /CA-Chips/40	2 888 169.531	2 970 430.272	3 271 280.930	3 187 982.408	2 897 140.703	
Time Shift /ms	70.581	72.591	79.943	77.908	70.800	
Power /dB	-6.02	-6.02	-6.02	-6.02	-6.02	
Doppler Shift /Hz	959.88	1 885.38	-775.66	-56.20	-2 146.96	
Duration (Elevation > 10°) /hh:mm:ss	00:00:00	03:41:46	03:58:04	06:28:48	01:56:15	
Additional Time Shift /CA-Chips/40	0.000	0.000	0.000	0.000	0.000	
Additional Power /dB	0.00	0.00	0.00	0.00	0.00	
Additional Doppler Shift /Hz	0.00	0.00	0.00	0.00	0.00	
Initial Carrier Phase /rad	0.00	0.00	0.00	0.00	0.00	
Resulting Frequency /GHz	1.575 420 959 88	1.575 421 885 38	1.575 419 224 34	1.575 419 943 80	1.575 417 853 04	1.
Resulting C/A Chip Rate /MHz	1.023 000 62	1.023 001 22	1.022 999 50	1.022 999 96	1.022 998 61	
Resulting P Chip Rate /MHz	10.230 006 23	10.230 012 24	10.229 994 96	10.229 999 64	10.229 986 06	

Fig. 9.1: GPS satellite configuration

For details of how to convert NMEA 0183 waypoint files for R&S®SMU200A, see Application Note 1MA133 [6].

9 Summary

Testing Femtocells is a challenge for production engineers. High volume throughput demands short testing times and a minimum number of tests. However, the rigorous conformance requirements of the 3GPP standard have to be met. Test equipment must keep the cost of test to a minimum by providing the best tradeoff between the purchase price, running costs, test times, and test reliability.

With the SMBV and the FSV Rohde & Schwarz offer two instruments which are particulary suited for fast and cost-efficient test for Femtocells.

10 Literature

[1] 3GPP TS25.141; Base Station (BS) conformance testing (FDD) V 8.4.0, 2008-09

[2] 3GPP TS25.104; Base Station (BS) radio transmission and reception (FDD) V 8.4.1, 2008-09

[3] 3GPP TR25.820; 3G Home NodeB Study Item Technical Report V 8.2.0, 2008-09

[4] Tests on 3GPP WCDMA FDD NodeBs in Accordance with Standard TS25.141, Application Note 1MA67, Rohde&Schwarz®, 2005

[5] How to Run WCDMA BER/BLER Tests using R&S Vector Signal Generators, Application Note 1MA144, Rohde&Schwarz®, 2009

[6] Convert NMEA 0183 waypoint files for R&S®SMU200A, Application Note 1MA133, Rohde&Schwarz®, 2009

[7] Manual SMBV

[8] Manual FSV

11 Additional Information

Please contact **tm-applications@rohde-schwarz.com** for comments and further suggestions.

12 Ordering Information

SMBV100A VECTOR SIGNAL GENERATOR		
Type	**Designation**	**Order No**
SMBV100A	Vector Signal Generator	1407.6004.02
SMBV-B103 or SMBV-B106	9 kHz to 3.2 GHz 9 kHz to 6 GHz	1407.9603.02 1407.9703.02
SMBV-B10	Baseband Generator with Digital Modulation (realtime) and ARB (32 MSample), 120 MHz RF Bandwidth	1407.8607.02
SMBV-B92	Hard disc	1407.9403.02
SMBV-K42	Digital Standard 3GPP FDD	1415.8048.02

SMJ100A VECTOR SIGNAL GENERATOR		
Type	**Designation**	**Order No**
SMJ100A	Vector Signal Generator	1403.4507.02
SMJ-B103 or SMJ-B106	Frequ. range 100 kHz - 3 GHz Frequ. range 100 kHz - 6 GHz	1403.8502.02 1403.8702.02
SMJ-B9 or SMJ-B10 or SMJ-B11	Basebandgenerator with dig. modulation (real time) and ARB 128 / 64 / 16 MSamples	1404.1501.02 1403.8902.02 1403.9009.02
SMJ-B13	Baseband main module	1403.9109.02
SMJ-K42	Digital Standard 3GPP FDD	1404.0405.02

SMU200A VECTOR SIGNAL GENERATOR		
Type	**Designation**	**Order No**
SMU200A	Vector Signal Generator	1141.2005.02
SMU-B102 or SMU-B103 or SMU-B104 or SMU-B106	Frequ. range 100 kHz - 2.2 GHz Frequ. range 100 kHz - 3 GHz Frequ. range 100 kHz - 4 GHz Frequ. range 100 kHz - 6 GHz	1141.8503.02 1141.8603.02 1141.8703.02 1141.8803.02
SMU-B9 or SMU-B10 or SMU-B11	Basebandgenerator with dig. modulation (real time) and ARB 128 / 64 / 16 MSamples	1161.0766.02 1141.7007.02 1159.8411.02
SMU-B13	Baseband main module	1141.8003.02
SMU-K42	Digital Standard 3GPP FDD	1160.7909.02

FSV SIGNAL ANALYZER		
Type	**Designation**	**Order No**
FSV3	Signal and Spectrum Analyzer 9 kHz to 3.6 GHz	1307.9002K03
FSV7	Signal and Spectrum Analyzer 9 kHz to 7 GHz	1307.9002K07
FSV13	Signal and Spectrum Analyzer 9 kHz to 13.6 GHz	1307.9002K13
FSV30	Signal and Spectrum Analyzer 9 kHz to 30 GHz	1307.9002K30
FSV40	Signal and Spectrum Analyzer 9 kHz to 40 GHz	1307.9002K40
FSV-K72	3GPP BS (DL) Analysis, incl. HSDPA and HSDPA+	1310.8503.02

FSP SIGNAL ANALYZER		
Type	**Designation**	**Order No**
FSP3	Spectrum Analyzer 9 kHz to 3 GHz	1164.4391.03
FSP7	Spectrum Analyzer 9 kHz to 7 GHz	1164.4391.07
FSP13	Spectrum Analyzer 9 kHz to 13 GHz	1164.4391.13
FSP30	Spectrum Analyzer 9 kHz to 30 GHz	1164.4391.30
FSP40	Spectrum Analyzer 9 kHz to 40 GHz	1164.4391.40
FS-K72	3GPP BTS/Node B FDD Application Firmware	1154.7000.02

FSL SIGNAL ANALYZER		
Type	**Designation**	**Order No**
FSL3	Spectrum Analyzer, 9 kHz to 3 GHz	1300.2502.03
FSL6	Spectrum Analyzer, 9 kHz to 6 GHz	1300.2502.06
FSL18	Spectrum Analyzer, 9 kHz to 18 GHz	1300.2502.18
FSL-K72	3GPP FDD BTS Application Firmware	1302.0620.02

FSQ SIGNAL ANALYZER		
Type	**Designation**	**Order No**
FSQ8	FSQ Signal Analyzer 20 Hz to 3.6 GHz	1155.5001.03
FSQ 8	FSQ Signal Analyzer 20 Hz to 8 GHz	1155.5001.08
FSQ 26	FSQ Signal Analyzer 20 Hz to 26 GHz	1155.5001.26
FSQ 40	FSQ Signal Analyzer 20 Hz to 40 GHz	1155.5001.40
FS-K72	3GPP BTS/Node B FDD Application Firmware	1154.700.02
FS-K74	3GPP HSDPA Base Transceiver Station (BTS) Application Firmware	1300.7156.02

About Rohde & Schwarz
Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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