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# Tests of Power Amplifiers for Single-Channel and Multi-Channel TD-SCDMA Base Stations

## Application Note 1MA103

This Application Note describes how to perform measurements on power amplifiers for TD-SCDMA base stations to specification TS 25.142 using Rohde & Schwarz generators, power meters and signal/spectrum analyzers. The TD-SCDMA application firmware for Rohde & Schwarz generators and analyzers as well as their outstanding performance facilitate efficient and rapid measurements.



## Contents

1	Overview .....	3
2	TD-SCDMA Signal Overview .....	3
	TD-SCDMA signal structure (frames and timeslots).....	4
	DwPTS and UpPTS .....	5
3	Test Setups .....	6
4	Conventions for Instrument Settings .....	7
	Rohde & Schwarz generators and analyzers .....	7
	Power Meter R&S®NRP .....	7
5	Generating Test Signals.....	8
	Single-carrier signals.....	9
	Single-carrier signal with 8 code channels per slot active: .....	9
	Single-carrier signal with 10 code channels per slot active: .....	11
	Single-carrier signal with 1 code channel per slot active: .....	13
	Multi-carrier signals .....	15
	Generation of a phase-coherent two-carrier TD-SCDMA signal (R&S®SMU with two baseband units only):.....	15
	Generation of a phase-coherent four-carrier TD-SCDMA signal (ARB mode): .....	16
6	TD-SCDMA Transmit Measurements .....	18
	Power meter measurements.....	18
	Output power (TS 25.142 chap. 6.2) and gain.....	18
	Input return loss/input VSWR .....	19
	Power meter setup:.....	19
	Measurements with spectrum analyzer/signal analyzer.....	20
	Code domain power measurements: modulation accuracy (TS 25.142 chap. 6.8.1) and peak code domain error (TS 25.142 chap. 6.8.2) .....	20
	Gating of analyzer for spectrum measurements:.....	23
	Output power (TS 25.142 chap. 6.2):.....	24
	Quick power measurement in spectrum analysis mode using the time domain power function.....	25
	Crest factor measurement .....	26
	Adjacent channel leakage power ACLR (TS 25.142 chap. 6.6.2.2) .....	28
	Multi-carrier ACLR (TS 25.142 chap. 6.6.2.2).....	29
	Spectrum emission mask (TS 25.142 chap. 6.6.2.1).....	31
	Power versus Time (Transmit ON/OFF power TS 25.142 chap. 6.5).....	33
7	Glossary .....	36
8	References.....	36
9	Additional Information .....	36
10	Ordering information .....	37

### 1 Overview

To perform measurements on power amplifiers for TD-SCDMA base stations compliant with TS25.142[10], the large dynamic range required in pulse mode operation is a special challenge for development and test engineers. This Application Note describes how to perform these measurements using Rohde & Schwarz generators, power meters and signal/spectrum analyzers. The TD-SCDMA application firmware for Rohde & Schwarz generators and analyzers as well as their outstanding performance facilitate efficient and rapid measurements.

### 2 TD-SCDMA Signal Overview

Time Division Synchronous Code Division Multiple Access (TD-SCDMA) designates a mobile radio transmission method for 3G mobile communications developed by the China Wireless Telecommunication Standard group (CWTS, see <http://www.cwts.org> for details). The same frequency is used for transmissions in both directions with Time Domain Duplexing (TDD). Each resource (frequency, code and timeslot) can be used simultaneously by several base stations or user equipment, provided the scrambling codes differ. The standard is similar to the 3GPP TDD proposal, but with greater emphasis placed on GSM compatibility and with a chip rate limited to 1.28 Mcps. TD-SCDMA is included in the 3GPP Universal Terrestrial Radio Access (UTRA) as the UTRA-TDD option, called 1.28 Mcps TDD or Low Chip Rate (LCR) TDD. TD-SCDMA is a mobile radio standard in which available bandwidth is shared among subscribers according to frequency (FDMA), time (TDMA) and code (CDMA).

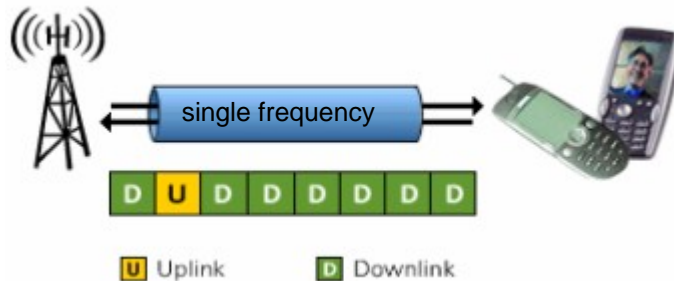


Fig. 1: Principle of TD-SCDMA channel access with TDMA in TDD mode

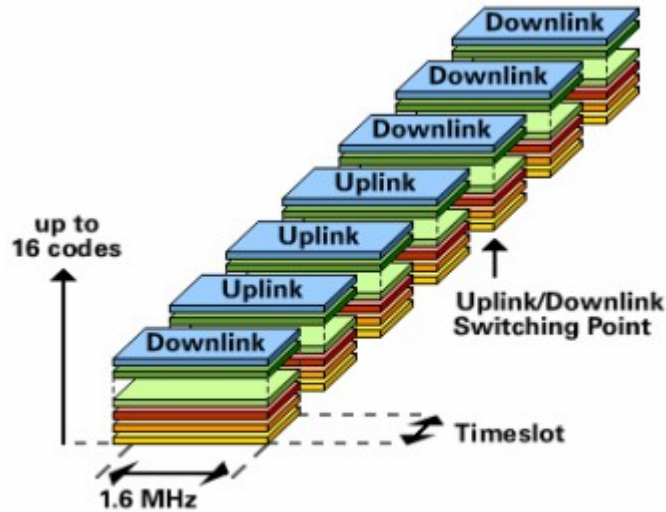


Fig. 2: Principle of TD-SCDMA code division multiple access

## TD-SCDMA signal structure (frames and timeslots)

The TD-SCDMA signal is organized in frames of 5 ms length. Each frame comprises seven traffic timeslots (TS0 to TS6, each 0.675 ms) and two special timeslots (DwPTS and UpPTS) for synchronization.

TS0 is always allocated to the downlink, TS1 to the uplink. The other timeslots are divided between the two directions of transmission. The switching point which separates the uplink slots from the downlink slots is variable.

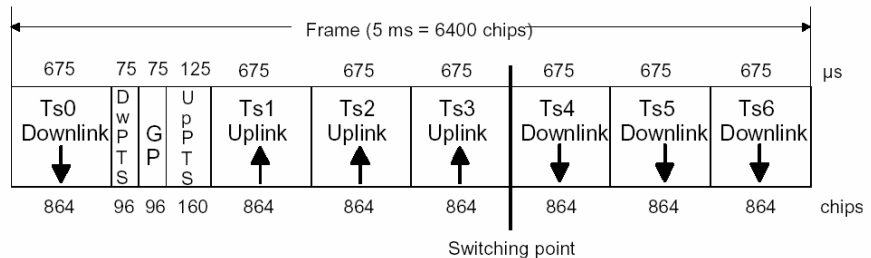


Fig. 3: Structure of a TD-SCDMA frame

For testing base station power amplifiers, the downlink slots are relevant. According to TS 25.142 [10] – e.g. Table 6.2.A in chapter 6.2.4.1.2, the switching point is located between TS3 and TS4. TS4, 5 and 6 are to be activated on the signal generator.

### DwPTS and UpPTS

In the downlink pilot timeslot (DwPTS), the base station sends one of 32 possible 64-chip SYNC codes.

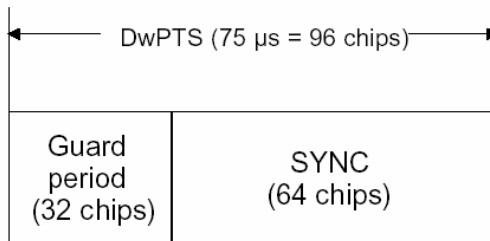


Fig. 4: DwPTS structure

The user equipment synchronizes to the base station using the same synchronization code (SYNC code), which also defines the value range for the scrambling code and the basic midamble code.

The uplink pilot timeslot (UpPTS) is sent by the user equipment to initiate a call with the base station and is therefore not relevant when testing TD-SCDMA base station power amplifiers.

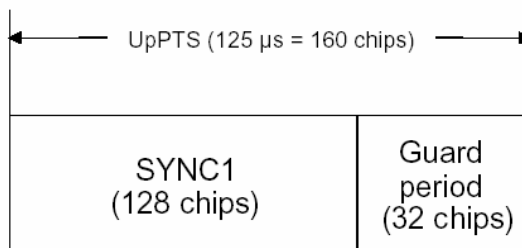


Fig. 5: UpPTS structure

See [1] – Chapter "Digital Standard TD-SCDMA: TD-SCDMA Signal Structure" for more detailed information.

### 3 Test Setups

The test setup shown in Fig. 6 is used for all the measurements described in this Application Note. An R&S®SMU or R&S®SMJ serves as a signal source and an R&S®FSU/FSQ or R&S®FSP carries out the signal analysis. An (optional) bi-directional coupler is used to couple out the forward and reflected signals at the input of the power amplifier under test.

To calculate the amplifier's VSWR, input power and reflected power are measured by sensor 1 and 2.

To measure the power amplifier's output power and gain (= (output power)/(input power)) with the maximum achievable accuracy, power sensor 3 is required. Although the absolute power measurement accuracy of an R&S®FSU or R&S®FSQ is excellent for a spectrum analyzer (0.3 dB absolute accuracy), the accuracy of a power meter, especially that of the R&S®NRP power meter, will always be better.

The marker 1 output (frame start) from the signal generator delivers the trigger signal to the analyzer and the power meter. All measurements can be carried out in sync with the TDMA frame.

The R&S®NRP-Z21 sensors can be used without the power meter base unit as standalone measuring instruments and connected directly via R&S®NRP-Z4 USB adapters to a controlling PC; the trigger signal must be fed to every power sensor via the BNC connectors of the R&S®NRP-Z4 USB adapters.

The analyzer's and signal generator's time bases are locked by feeding the generator's reference output signal to the analyzer's reference input.

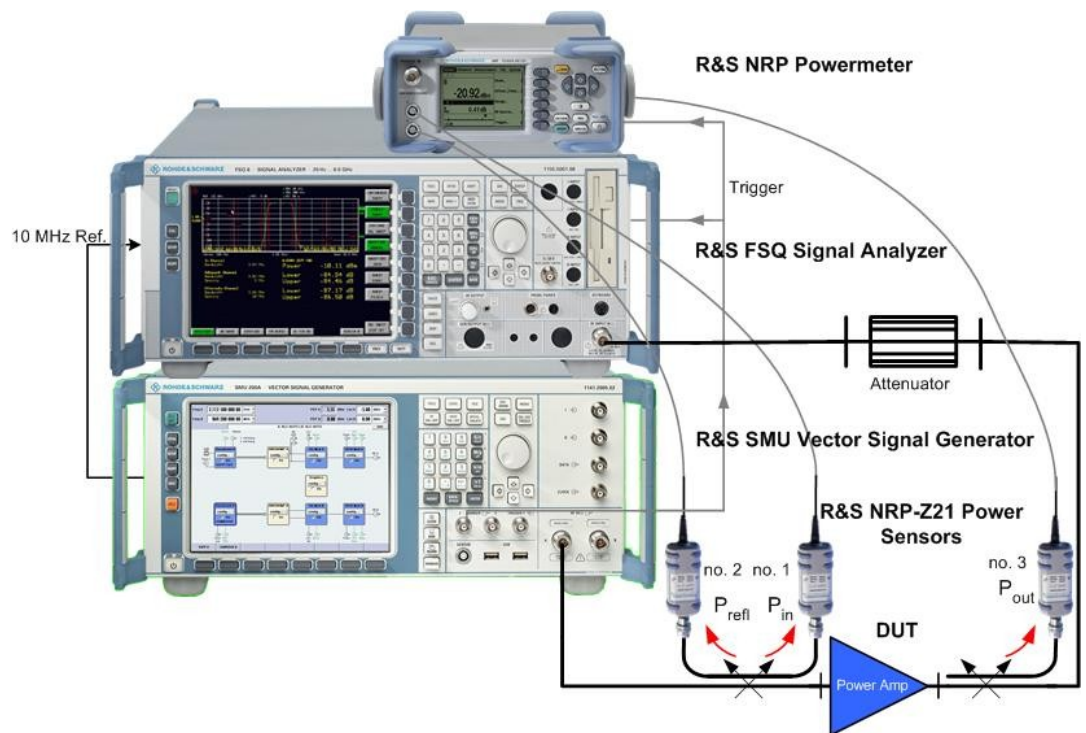


Fig. 6: Proposed test setup with optional power sensors

## 4 Conventions for Instrument Settings

### Rohde & Schwarz generators and analyzers

The following conventions of notation are used when referring to settings on Rohde & Schwarz generators and analyzers. Key strokes are in bold italics and softkey strokes in normal italics:

Convention	Description	Example
<b>&lt;Key&gt;</b>	Press a key on the front panel	<b>FREQ</b>
<i>&lt;Softkey&gt;</i>	Press a softkey	<i>MARKER -&gt;PEAK</i>
<b>&lt;Key&gt;</b> : <i>&lt;Softkey1&gt;</i> : <i>&lt;... &gt;</i> : <i>...</i>	In a sequence of key strokes or softkey strokes, a colon is used as a separator	<b>MARKER:</b> <i>MARKER -&gt;PEAK</i>
<b>&lt;nn unit&gt;</b>	First enter the value using the numerical keypad, then complete the entry with the unit	<b>12 kHz</b>
<b>&lt;nn ENTER&gt;</b>	First enter the value via the numerical keypad, then complete the entry with the Enter key.	<b>TDS BS: SETTINGS:</b> <b>SCRAMBLING CODE 1:</b> <b>ENTER</b>
( <i>&lt;Comment&gt;</i> )	Comments are enclosed in round brackets.	<i>(enter required frequency)</i>

Table 1: Conventions of notation for settings on R&S generators and analyzers

### Power Meter R&S®NRP

The conventions are as above, with the important difference that numerical entries are made with softkeys and terminated with the **Menu** key. Values in square brackets are not settings to be made, but results or information for the user.

Example:

**PRESET:PRESET**  
**FREQ:[A]:[50MHz]**  
**DEL/TRIG 1: 2.12:UNIT[GHz]: Menu**

In the example, the UNIT softkey is used to toggle between the units "MHz" and "GHz".

### **5 Generating Test Signals**

A suitable input signal is essential to test a base station amplifier. It can be provided by an appropriate TD-SCDMA base station unit (without PA module) or preferably a signal generator. Compared to a base station, the R&S<sup>®</sup>SMU or R&S<sup>®</sup>SMJ signal generators provide outstanding signal quality, significant greater flexibility and shorter setting times (especially with remote control by computer).

The R&S<sup>®</sup>SMU or R&S<sup>®</sup>SMJ settings to generate TD-SCDMA downlink test signals in line with TS 25.142 are described below. Specifically, these signals are:

- Single-carrier TD-SCDMA test signals with different numbers of active code channels as stated in TS25.142. Except for the multi-carrier ACLR measurement, one of these signals is a prerequisites for all measurements described below
- A phase-coherent two-carrier TD-SCDMA test signal (R&S<sup>®</sup>SMU, with two baseband units only, 8 active code channels/slot)
- A phase-coherent four-carrier TD-SCDMA test signal (ARB mode, 8 active code channels/slot); this test signal is a prerequisite for the multi-carrier ACLR measurement

The R&S<sup>®</sup>SMU-K50 or R&S<sup>®</sup>SMJ-K50 digital standard TD-SCDMA generator option is a prerequisite.

**Note:**

Only the generator settings that are specifically relevant to TD-SCDMA are described. Also, the frequency and the appropriate level must be set on the generator to obtain the rated amplifier output power.



### Single-carrier signals

According to TS25.142 there are 3 different types of test signals defined for the Transmitter tests. In each case timeslots 0, 4, 5 and 6 are to be set active. The number of active code channels in timeslots 4, 5 and 6 differs depending on the specific transmitter test. The following configurations are required:

- 8 code channels active per timeslot 4, 5 and 6
- 10 code channels active per timeslot 4, 5 and 6
- 1 code channel active per timeslot 4, 5 and 6

The regarding signal generator operating sequences are described in the following:

### Single-carrier signal with 8 code channels per slot active:

#### **MENU**

*BASEBAND A CONFIG:*

*TD-SCDMA...:STATE ON:ENTER*

*Reset All Cells*

*Predefined Settings:*

*Number of Dedicated Channels 24: ENTER*

*Accept:ESC*

*Adjust Total Power to 0 dB*

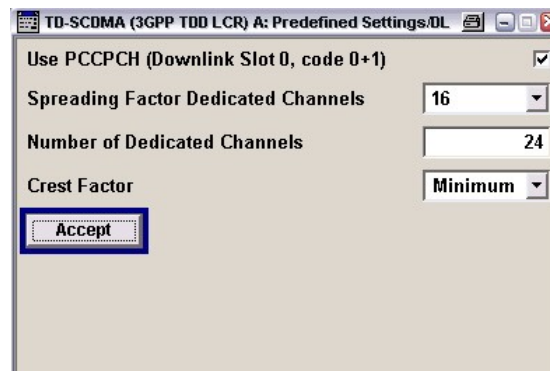


Figure 7: R&S<sup>®</sup>SMU/SMJ user interface (Predefined Settings/DL)

The generator now outputs a TD-SCDMA signal for which the downlink slots 0, 4, 5 and 6 are active as well as the downlink pilot timeslot (DwPTS). 8 code channels are active per slot 4, 5 and 6 (24 in total). In slot 0 the Primary Common Control Physical Channels 1 and 2 (PCCPCH1, PCCPCH2 are active)

The crest factor of the signal is approx. 6.6 dB. See Fig. 15 on page 27.

Check the frame structure in the menu:

## TD-SCDMA Power Amplifier Tests

Cell1:ENTER

make any changes required.

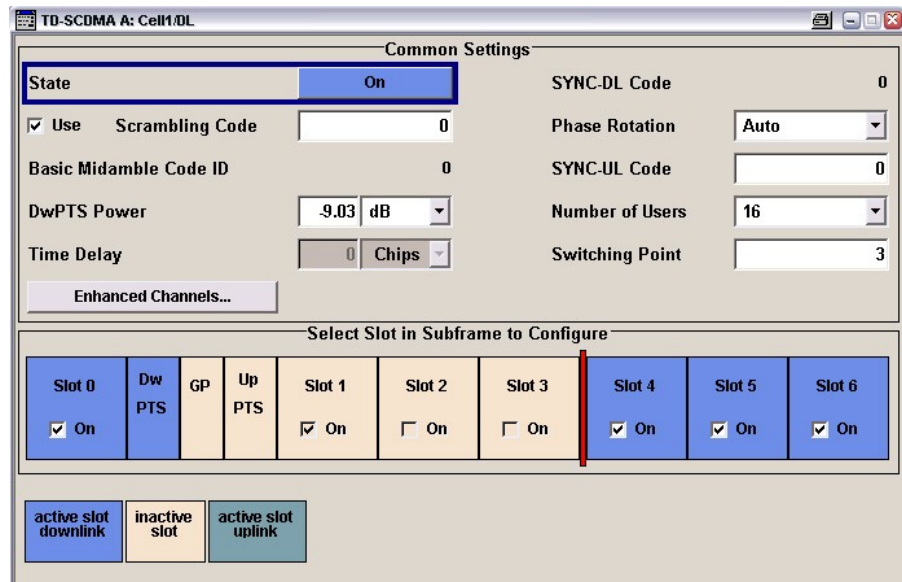


Fig. 8: R&S<sup>®</sup>SMU/SMJ user interface (TD-SCDMA, cell1, common settings)

Details of the slot structure (in this case slot 4) can be obtained with:

SLOT4:ENTER

Channel Type	Enhanced	Crt.User/Mid.Shift	Slot Fmt	Sprd. Fact.	Sprd. Code	Power /dB	Data	DList / Pattern	DPCCH Settings	State	Do. Cfl.
0		1/120	0	16	1	0.00	PN 9			Off	
1		1/120	0	16	2	0.00	PN 9			Off	
2		1/120	0	16	1	0.00	PN 9		Config...	Off	
3		1/120	0	16	1	0.00	PN 9		Config...	Off	
4		1/120	0	16	1	0.00	PN 9			Off	
5		1/120	0	16	1	0.00	PN 9		Config...	Off	
6	Off	1/120	0	16	1	-9.03	PN 9		Config...	On	
7	Off	1/120	0	16	3	-9.03	PN 9		Config...	On	
8		1/120	0	16	5	-9.03	PN 9		Config...	On	
9		1/120	0	16	7	-9.03	PN 9		Config...	On	
10		1/120	0	16	9	-9.03	PN 9		Config...	On	
11		1/120	0	16	11	-9.03	PN 9		Config...	On	
12		1/120	0	16	13	-9.03	PN 9		Config...	On	
13		1/120	0	16	15	-9.03	PN 9		Config...	On	
14		1/120	0	16	1	0.00	PN 9		Config...	Off	
15		1/120	0	16	1	0.00	PN 9		Config...	Off	
16		1/120	0	16	1	0.00	PN 9		Config...	Off	

Fig. 9: Configuration of slot 4 (or 5, or 6); in each case, 8 data channels (DPCH) with a spreading factor of 16 are active

**Single-carrier signal with 10 code channels per slot active:**

***MENU***

***BASEBAND A CONFIG:***

***TD-SCDMA...:STATE ON:ENTER***

***Reset All Cells***

***Predefined Settings:***

***Number of Dedicated Channels 30: ENTER***

***ACCEPT ESC***

***Adjust Total Power to 0 dB***

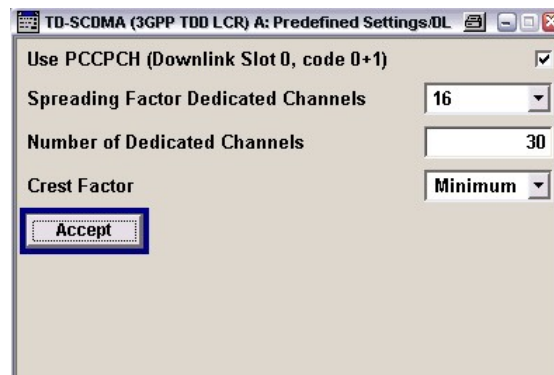


Figure 10: R&S<sup>®</sup>SMU/SMJ user interface (Predefined Settings/DL) setting up 10 code channels per downlink slot (30 in total)

The generator now outputs a TD-SCDMA signal for which the downlink slots 0, 4, 5 and 6 are active as well as the downlink pilot timeslot (DwPTS). 10 code channels are active per slot 4, 5 and 6 (30 in total).

The crest factor of the signal is approx. 4.7 dB.

Check the frame structure in the menu:

***Cell1:ENTER***

Increase the power of the DwPTS timeslot (default value -10dB) by at least 1 dB for synchronization purposes of the analyzer.

## TD-SCDMA Power Amplifier Tests

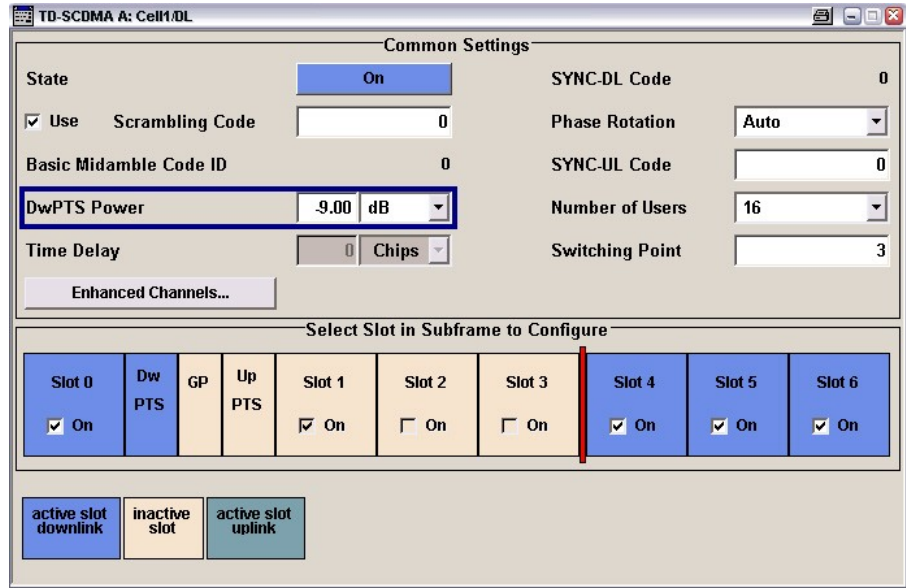


Figure 11: R&S<sup>®</sup>SMU/SMJ user interface (TD-SCDMA, cell1, common settings), DwPTS Power increased by 1 dB

Details of the slot structure (in this case slot 4) can be obtained with:

`Cell1:SLOT4:ENTER`

State		Code Domain...											Channel Graph...		
On															
Data 44			Midamble 144										Data 44		Guard 16
	Channel Type	Enhanced	Crt.User/ Mid.Shift	Slot Fmt	Spr. Fact.	Spr. Code	Power /dB	Data	DList / Pattern	DPCCH Settings	State	Do. Cfl.			
0	P-CCPCH 1		1/120	0	16	1	0.00	PN 9			Off				
1	P-CCPCH 2		1/120	0	16	2	0.00	PN 9			Off				
2	S-CCPCH 1		1/120	0	16	1	0.00	PN 9		Config...	Off				
3	S-CCPCH 2		1/120	0	16	1	0.00	PN 9		Config...	Off				
4	FPACH		1/120	0	16	1	0.00	PN 9			Off				
5	PDSCH		1/120	0	16	1	0.00	PN 9		Config...	Off				
6	DPCH QPSK	Off	1/120	0	16	1	-10.00	PN 9		Config...	On				
7	DPCH QPSK	Off	1/120	0	16	2	-10.00	PN 9		Config...	On				
8	DPCH QPSK		1/120	0	16	3	-10.00	PN 9		Config...	On				
9	DPCH QPSK		1/120	0	16	4	-10.00	PN 9		Config...	On				
10	DPCH QPSK		1/120	0	16	5	-10.00	PN 9		Config...	On				
11	DPCH QPSK		1/120	0	16	6	-10.00	PN 9		Config...	On				
12	DPCH QPSK		1/120	0	16	7	-10.00	PN 9		Config...	On				
13	DPCH QPSK		1/120	0	16	8	-10.00	PN 9		Config...	On				
14	DPCH QPSK		1/120	0	16	9	-10.00	PN 9		Config...	On				
15	DPCH QPSK		1/120	0	16	10	-10.00	PN 9		Config...	On				
16	DPCH QPSK		1/120	0	16	1	0.00	PN 9		Config...	Off				

Fig. 12: Configuration of slot 4 (or 5, or 6); in each case, 10 data channels (DPCH) with a spreading factor of 16 are active

### **Single-carrier signal with 1 code channel per slot active:**

#### ***MENU***

***BASEBAND A CONFIG:***

***TD-SCDMA...:STATE ON:ENTER***

***Reset All Cells***

***Predefined Settings:***

***Number of Dedicated Channels 3: ENTER***

***ACCEPT:ESC***

***Adjust Total Power to 0dB:Enter***

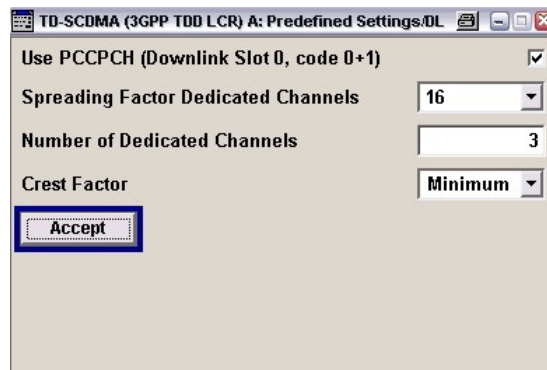


Figure 13: R&S<sup>®</sup> SMU/SMJ user interface (Predefined Settings/DL) setting up 1 code channel per downlink slot (3 in total)

Adjust output power for active data channels:

***Cell1:SLOT4:ENTER***

Adjust the power of the active data channel from -3.01 dB to 0 dB

## TD-SCDMA Power Amplifier Tests

Data 44		Midamble 144						Data 44		Guard 16	
Channel Type	Enhanced	Crt.User/Mid.Shift	Slot Fmt	Sprd. Fact.	Sprd. Code	Power /dB	Data	DList / Pattern	DPCCH Settings	State	Do. Cfl.
0	P-CCPCH 1	1/120	0	16	1	0.00	PN 9			Off	
1	P-CCPCH 2	1/120	0	16	2	0.00	PN 9			Off	
2	S-CCPCH 1	1/120	0	16	1	0.00	PN 9		Config...	Off	
3	S-CCPCH 2	1/120	0	16	1	0.00	PN 9		Config...	Off	
4	FPACH	1/120	0	16	1	0.00	PN 9			Off	
5	PDSCH	1/120	0	16	1	0.00	PN 9		Config...	Off	
6	DPCH QPSK	Off	1/120	0	16	1	0.00	PN 9	Config...	On	
7	DPCH QPSK	Off	1/120	0	16	1	0.00	PN 9	Config...	Off	
8	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	
9	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	
10	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	
11	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	
12	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	
13	DPCH QPSK		1/120	0	16	1	0.00	PN 9	Config...	Off	

Fig. 14: Configuration of slot 4 (or 5, or 6); in each case, 1 data channels (DPCH) with a spreading factor of 16 is active; power of active channel adjusted to 0 dB

Repeat power setting of active channel for slots 5 and 6.

The generator now outputs a TD-SCDMA signal for which the downlink slots 0, 4, 5 and 6 are active as well as the downlink pilot timeslot (DwPTS). 1 code channel is active per slot 4, 5 and 6 (3 in total).

The crest factor of the signal is approx. 3 dB.

### **Multi-carrier signals**

The multi-carrier test signal required depends on the specification of the multi-carrier power amplifier. The Rohde & Schwarz generators provide the following two options:

#### **Generation of a phase-coherent two-carrier TD-SCDMA signal (R&S® SMU with two baseband units only):**

If there are two baseband units in the R&S® SMU, a phase-coherent two-carrier TD-SCDMA signal can be generated with the assistance of the TD-SCDMA application firmware.

Signal generator operating sequence (8 code channels active in slot 4, 5 and 6):

#### **MENU:**

*BASEBAND B CONFIG:*

*FREQ OFFSET: 1.6 MHz*

*SIGNAL ROUTING: ROUTE TO PATH A*

*TD-SCDMA...:STATE ON*

*Predefined Settings: Number of Dedicated Channels 24: ENTER*

*ACCEPT:ESC*

*TRIGGER/MARKER:TRIGGER IN/MODE:ARMED/RETRIGGER  
:SOURCE:INTERNAL(BASBAND A)*

*BASEBAND A CONFIG:*

*TD-SCDMA...:STATE ON:*

*Predefined Settings: of Dedicated Channels 24: ENTER*

*ACCEPT*

***RF/A-MOD:ON***

### **Generation of a phase-coherent four-carrier TD-SCDMA signal (ARB mode):**

TD-SCDMA multi-carrier signals (except the two-carrier signal above) require the generator's arbitrary waveform (ARB) function. The example below illustrates the generation of a four-carrier TD-SCDMA signal. Other configurations with a different number of carriers or different carrier spacings are set analogously. To keep the crest factor of the sum signal down, a code spacing that is as large as possible is selected (→32) for the four TD-SCDMA carriers. This four-carrier TD-SCDMA signal (8 code channels active in slot 4, 5 and 6) is required as a test signal for the multi-carrier ACLR measurement described in Chapter 6.

Signal generator operating sequence.

#### ***MENU***

*BASEBAND A CONFIG:TD-SCDMA...:STATE ON*

*: Predefined Settings:  
:Number of Dedicated Channels 24: **ENTER**  
:ACCEPT: **ESC**  
  
:Generate Waveform File: \d(data)\tds\_0  
:Cell1: Scrambling Code: 32  
  
:Generate Waveform File: \d(data)\tds\_1  
:Cell1: Scrambling Code: 64  
  
:Generate Waveform File: \d(data)\tds\_2  
:Cell1: Scrambling Code: 96  
  
:Generate Waveform File: \d(data)\tds\_3*

#### ***ESC***

*ARB...:MULTICARRIER...:Number of Carrier: 4  
:Carrier Spacing: 1.6 MHz  
:Crest Factor Mode: Minimize  
: Signal Period Mode: Longest File Wins  
:Carrier Table: 0:State ON: File: \ tds\_0  
                  :1:State ON: File: \ tds\_1  
                  :2:State ON: File: \ tds\_2  
                  :3:State ON: File: \ tds\_3  
  
                  Create and Load  
  
:ARB...:State: ON*

To trigger the connected measuring instruments (spectrum analyzer or power meter), the signal generator's marker 1 output must be set to the restart signal. In this case, the restart signal provides a frame trigger signal to start the frame.

*:ARB:...:Trigger/Marker...:Marker Mode: Marker 1 Restart*



## ***TD-SCDMA Power Amplifier Tests***

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Using the ARB function, the generator now outputs a four-carrier TD-SCDMA signal. Each of the carriers has a frame structure like the single-carrier TD-SCDMA signal described above and the carriers are synchronized.

The four carriers are symmetrical about the selected carrier frequency ( $f_c$ ), the offsets being +/- 800 kHz and +/- 2.4 MHz. This must be taken into account when frequency settings are made on the spectrum or signal analyzer.

For code domain analysis, the appropriate scrambling code (see below) must also be set on the analyzer if the carriers are to be demodulated correctly:

TD-SCDMA carrier	$f_c - 2.4$ MHz	$f_c - 0.8$ MHz	$f_c + 0.8$ MHz	$f_c + 2.4$ MHz
Scrambling code	0	32	64	96

Table 2: Carrier frequencies and scrambling codes for the four-carrier TD-SCDMA signal described above

Note:

The crest factor of the four-carrier TD-SCDMA signal described previously is about 8.1 dB measured with the R&S®FSQ at a bandwidth of 20 MHz. This relatively small value for a four-carrier TD-SCDMA signal is obtained by means of different scrambling codes with large code spacing and the *minimize crest factor* setting in ARB mode.

To set a specific crest factor, use the "multicarrier CW" mode. In this mode, it is possible to generate a multi-carrier signal with a total bandwidth similar to an unpulsed TD-SCDMA signal and then set a specific crest factor (function: "Target Crestfactor"). See [1], chapter " Multicarrier Continuous Wave".

### 6 TD-SCDMA Transmit Measurements

One of the single carrier TD-SCDMA test signals described in chapter 5 is required for the measurements below apart from multi-carrier ACLR measurements, which require the four-carrier test signal.

#### Power meter measurements

##### Output power (TS 25.142 chap. 6.2) and gain

Use the 8 channel test signal described in chapter 5 for these tests.

Accurate power measurement at the amplifier output is critical. The amplifier must deliver the requested nominal power and meet the specifications, for example for ACLR, at exactly that power. Even though modern spectrum analyzers such as the R&S®FSP, R&S®FSU or R&S®FSQ have an excellent absolute-power measurement accuracy (0.3 dB), a power meter will always be the first choice for best accuracy. The R&S®NRP with the R&S®NRP-Z11 or R&S®NRP-Z21 sensor is particularly well-suited for measurements on 3GPP signals. Up to four sensors can be connected to the power meter. The R&S®NRP-Z11(-Z21) sensors have a very high dynamic range of 90 dB. Modulation-dependent errors (due to the amplitude variation of the TD-SCDMA signal) are negligible. A typical measurement uncertainty can be as low as about 0.1 dB.

Measure gain at nominal output power (nominal gain) when amplifying one or more TD-SCDMA signals. Measuring with a network analyzer which uses low-level sine signals may give misleading results. To achieve maximum accuracy use high performance directional couplers in combination with a power meter (see Fig. 6 on page 6).

Gain is calculated from the following formula:

$$\begin{aligned} \text{Gain/dB} = \\ & \text{output power level(dBm)} - \text{input power level (dBm)} = \\ & \text{power level indication}_{\text{Sensor 3}}(\text{dBm}) - \text{power level indication}_{\text{Sensor 1}}(\text{dBm}) \end{aligned}$$

Note: This is just the basic formula. Variable coupling losses and the insertion loss of couplers also have to be taken into account.

In addition to nominal gain, gain variation within the transmit band and the out-of-band gain have to be measured too. Both can be measured with the test setup in Fig. 6.

### Input return loss/input VSWR

Good input matching which means high input return loss or low VSWR is essential if the power amplifier is to have specific gain and a flat frequency response.

The magnitude of the input return loss is measured by the power meter with two sensors and a bi-directional coupler (see figure 6 on page 6, sensors 1 and 2). A bi-directional coupler with a high directivity (e.g. NARDA model 3022) in combination with R&S®NRP-Z11/Z21 power sensors ensures sufficiently low measurement uncertainties.

The input return loss is calculated from the following formula:

$$\text{Input return loss (dB)} = \text{input power level (dBm)} - \text{reflected input power level (dBm)} = \text{power level indication}_{\text{Sensor 1}}(\text{dBm}) - \text{power level indication}_{\text{Sensor 2}}(\text{dBm})$$

### Power meter setup:

Time gated mode (T'Gate) is recommended due to the TDMA structure of the signal. The correct setting for measurement channel A of the R&S®NRP power meter is described below. Set channels B or C analogously.

Operating sequence for the power meter:

**PRESET:PRESET:** **↵ Menu:[Sensor]:** **:Mode:** T'GATE

**Start of Gate:** 2.98:UNIT:[ms] **:↵ Menu**

**End of Gate:** 4.99 [ms] **:↵ Menu**

**ESC:ESC:Trigger:**A External **↑:↵ Menu**

**FREQ:[A]:[50MHz]:DEL/TRIG 1:** 2.12 :UNIT:[GHz]:**↵ Menu**

**ESC:Offset** xx<sup>1</sup>dB:Global

**ESC**

The power meter now measures the power integrated over slots 4, 5 and 6.

---

<sup>1</sup> Enter an offset xx corresponding to the coupling loss at the measurement frequency introduced by the directional coupler used (see Fig. 6).

### **Measurements with spectrum analyzer/signal analyzer**

#### **Code domain power measurements: modulation accuracy (TS 25.142 chap. 6.8.1) and peak code domain error (TS 25.142 chap. 6.8.2)**

Use the 10 channel test signal described in chapter 5 for these tests.

The power amplifier may not take the base station's transmit modulation parameters (modulation accuracy and peak code domain error) outside specified limits. Degradation can be caused by compression to which the power amplifier is especially susceptible at the rated output power. The requirement for the base station is a modulation accuracy (EVM) of  $\leq 12.5\%$  and a peak code domain error of  $\leq -28$  dB. These two measured values plus others are displayed in the result summary of the code domain power analysis performed by the analyzer.

Operating sequence for the analyzer:

#### ***PRESET***

***AMPT:NEXT*** *Offset xy dB* (enter an offset according to the connected attenuator)

***Ref Level: yz dB*** (set a ref level of 10 dB above the nominal power of the amplifier)

***FREQ: yy MHz*** (enter required frequency)

***(MORE): TDS BS***

***ADJUST REF LVL***

The signal analyzer now performs the code domain analysis on slot 0 (default setting):

# TD-SCDMA Power Amplifier Tests

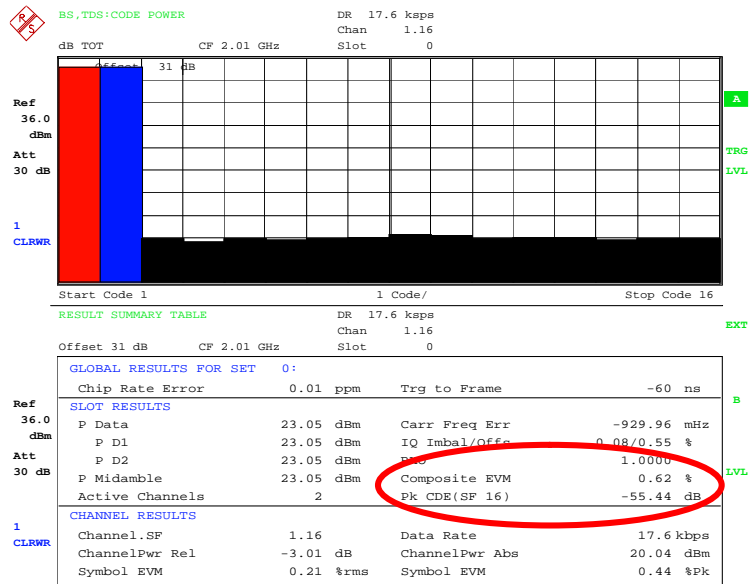


Fig. 15: Default setting for the code domain analysis with the code domain power displayed at the top and the result summary at the bottom (for slot 0)

The code channels P-CCPCH1 and P-CCPCH2 are turned on; all other code channels are turned off.

Under slot results, the result summary also includes the frequency error, the composite EVM (modulation accuracy) and the peak code domain error for slot 0. The symbol EVM (RMS and Pk value) for code channel 1 is shown under channel results.

## TD-SCDMA Power Amplifier Tests

### Measurement on slot 5:

Code domain analysis can also be performed on one of the other slots by selecting its slot number.

Analyzer operating sequence (measurement on slot 5, starting from the previous setting):

**SETTINGS:CAPTURE SETTINGS:SELECT SLOT: 5: ENTER**

Ten data channels, each with a spreading factor of 16, are active. Compared with slot 0, the power is 7 dB higher (see the power displays for P data , P 01, P 02 and P midamble).

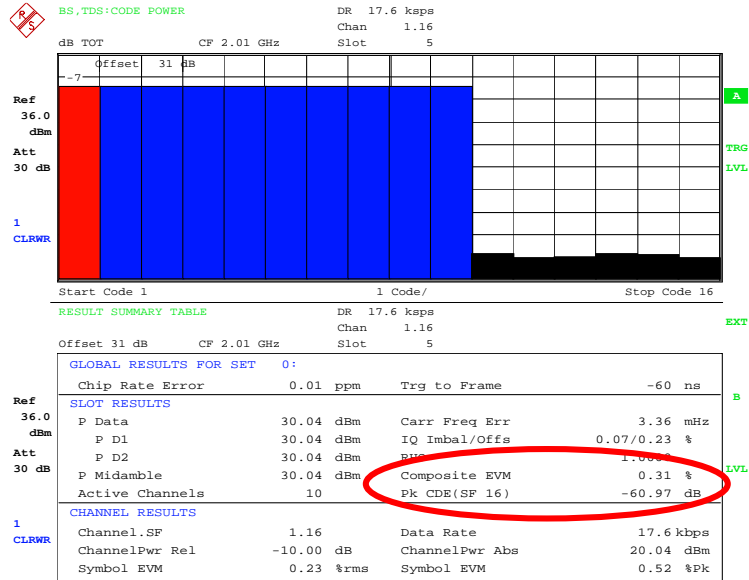


Fig. 16: Default setting for the code domain analysis with the code domain power displayed at the top and the result summary at the bottom (for slot 5)

### Gating of analyzer for spectrum measurements:

TD-SCDMA signals are burst signals. To obtain stable results when spectrum measurements are made on burst signals, acquisition of measurement data can only be acquired when the slots are active. This is achieved by gating the analyzer. The analyzer sweeps or measures only when the slots are active.

Within the TD-SCDMA application firmware, the trigger/gate settings are set by default to measure slots 4 to 6 for all spectrum measurements such as power, ACLR, multi-carrier ACLR, spectrum emission mask, occupied bandwidth, power vs time and signal statistics. The default settings are as follows:

**Trigger:Gate Settings**

**Trigger External:Polarity POS**

**Gate Delay: 2.975 ms**

**Gate Length: 2.015 ms**

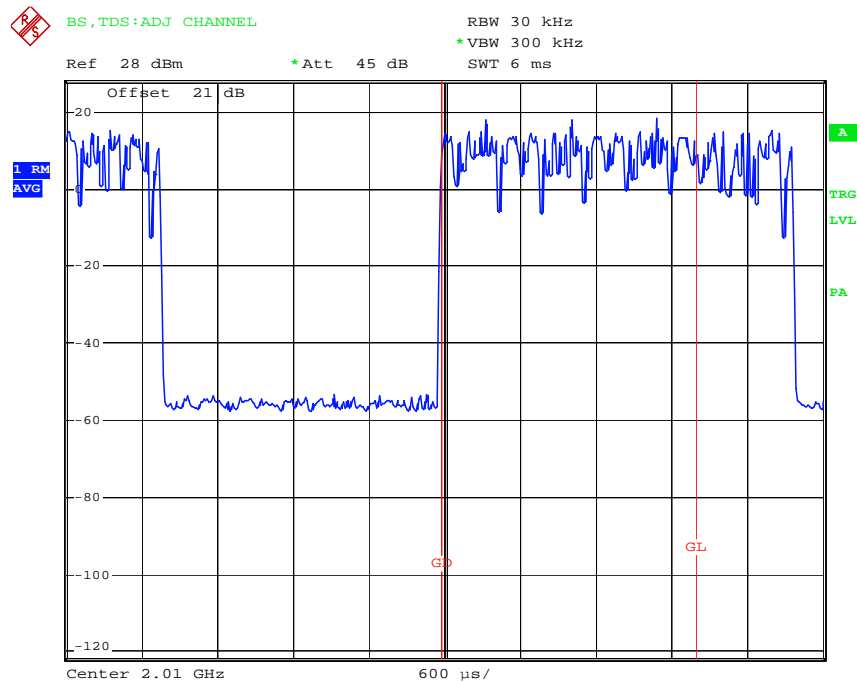


Fig. 17: Gate settings for TD-SCDMA (default setting)

To change to another slot adjust *START SLOT* and *STOP SLOT* within the *ADAPT TO SIGNAL* menu. All spectrum measurements as stated above are then carried out for that slot (or slots).

### Output power (TS 25.142 chap. 6.2):

Use the 8 channel test signal described in chapter 5 for this test.

If no power meter is available, the measurement can be performed with the analyzer instead of the power meter. The power measurement provided by the TD-SCDMA application firmware performs a gated channel-power measurement by means of integrating the power in the frequency domain.

Operating sequence for the analyzer:

#### **PRESET**

**AMPT:NEXT** Offset *xy* dB (enter an offset according to the connected attenuator)

**Ref Level:** *yz* dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** *yy* MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS:** POWER

**ADAPT TO SIGNAL:** AUTO LEVEL & TIME

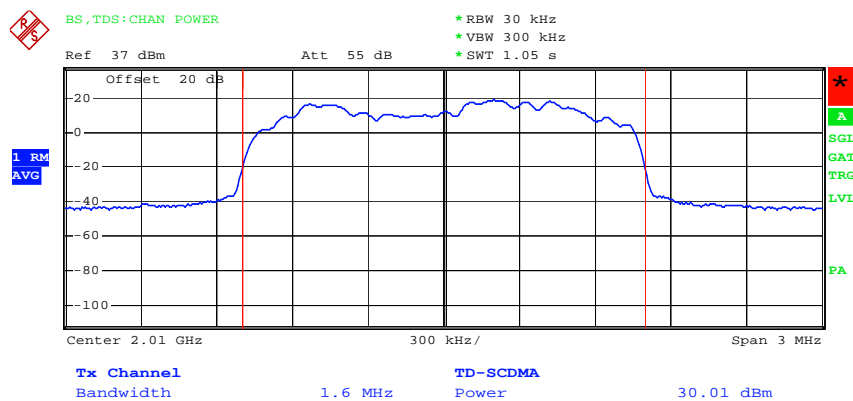


Fig. 18: Power measurement provided by the TD-SCDMA application software (integration in the frequency domain) at a spreading factor of 16 in slots 4, 5 and 6

**Note:** The ripple in the spectrum is due to the constant midamble with a test signal required by TS25.142 e.g. Table 6.1A in chap. 6.2.4.1.2. With a spreading factor of 16 it has a length of 144 bits and is relatively long in comparison with the pseudo-random data bits (2 x 44 bits). By comparison, for spreading factor 1, the length of the data bits is 2 x 704 bits and the resulting spectrum has nearly no ripple.



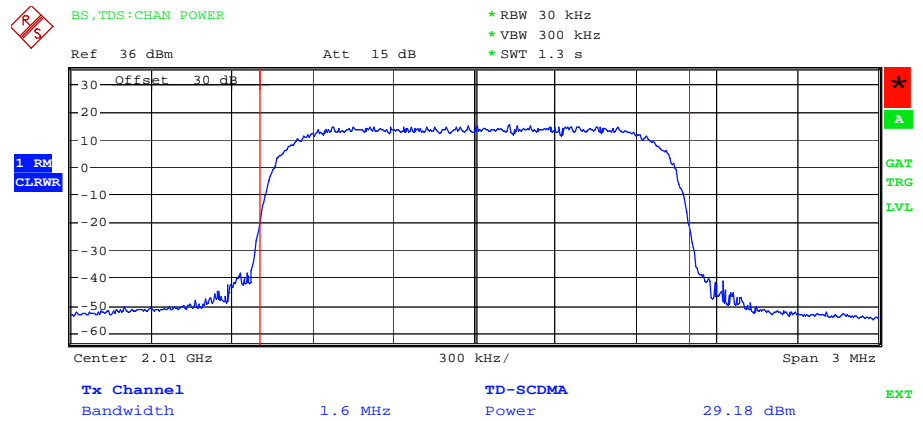


Fig. 19: Flat and symmetrical spectrum for a spreading factor of 1 in slots 4, 5 and 6

## Quick power measurement in spectrum analysis mode using the time domain power function

As a further alternative, the power in slots of interest can also be determined in spectrum analysis mode with a zero span measurement (time domain power measurement). The measurement times are significantly reduced compared with measurements based on integration in the frequency domain.

Operating sequence for the analyzer:

### PRESET

**AMPT: NEXT** Offset xy dB (enter an offset according to the connected attenuator)

**Ref Level:** yz dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** yy MHz (enter the required frequency)

**SPAN:** ZERO SPAN

**TRIGGER:** EXTERN: POS

**SWEEP:** SWEEPTIME MANUAL 6 ms

**BW:** RES BW MANUAL 10 MHz

**MEAS:** TIME DOMAIN POWER

**START LIMIT** 2.98 ms

**STOP LIMIT** 4.99 ms

**TRACE:** DETECTOR: RMS

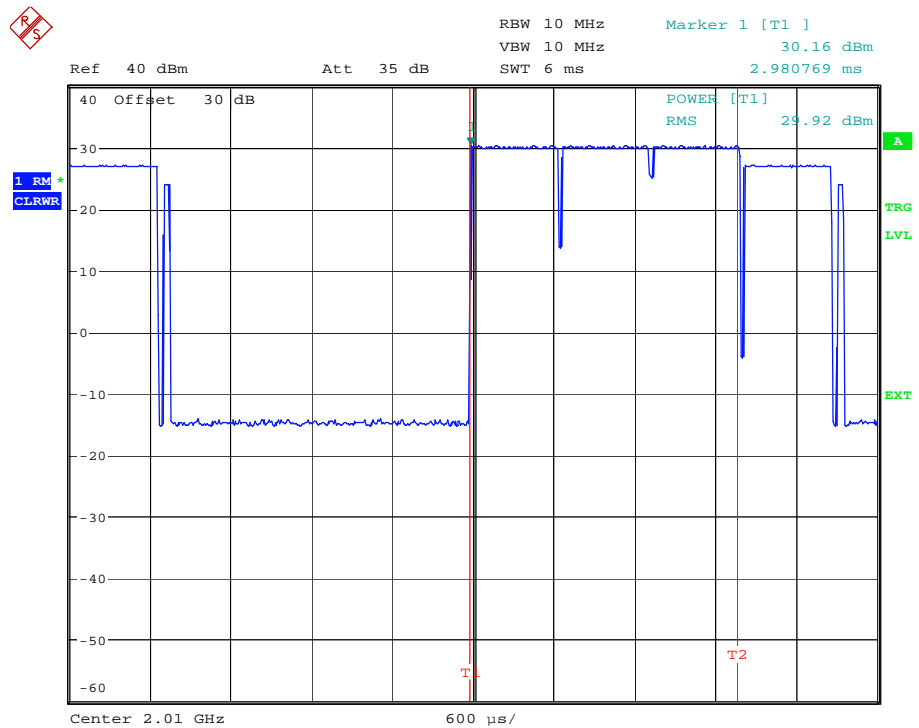


Fig. 20: Power measurement using the time domain power function in the spectrum analyzer mode

## Crest factor measurement

Crest factor measurement is not stipulated in TS 25.142. Its main purpose is to check the test signal or the amplifier output signal. A change (reduction) in the crest factor of the amplifier output signal relative to the signal at the amplifier input indicates amplifier compression.

Rohde & Schwarz analyzers provide crest factor measurement as part of the Complementary Cumulative Distribution Function (CCDF) measurement. The CCDF curve is a plot of relative power versus probability. In the TD-SCDMA application firmware, the CCDF measurement is gated and only performed on selected slots. In the default state, these are slots 4, 5 and 6.

## TD-SCDMA Power Amplifier Tests

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Operating sequence for the analyzer:

**PRESET**

**AMPT:NEXT** Offset *xy* dB (enter an offset according to the connected attenuator)

**Ref Level:** *yz* dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** *yy* MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS: SIGNAL STATISTICS** ↓ ↓ : CCDF

**ADAPT TO SIGNAL: AUTO LEVEL & TIME**

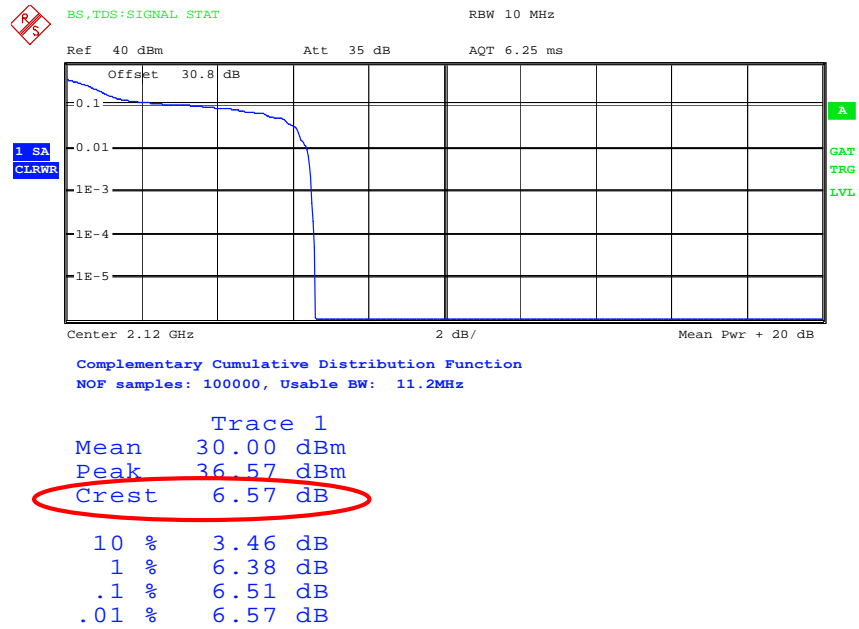


Fig. 21: Crest factor display as part of the CCDF measurement of the TD-SCDMA application firmware (8 channel test signal)

### Adjacent channel leakage power ACLR (TS 25.142 chap. 6.6.2.2)

For base stations, TS25.142 specifies an ACLR of >40 dB in the adjacent channel and an ACLR of >45 dB in the alternate channel. The ACLR of the base station power amplifier must be higher.

Use the 8 channel test signal described in chapter 5 for this test.

#### Performance of the R&S®SMU with R&S®FSU/FSQ

Using the analyzers noise correction function R&S®SMU with R&S®FSU/FSQ, ACLR values of typ. -66 dB in the adjacent channel, and -80 dB in the alternate channel are obtained, providing a more than sufficiently large margin for the values to be tested.

Operating sequence for the analyzer:

#### PRESET

**AMPT:NEXT** Offset xy dB (enter an offset according to the connected attenuator)

**Ref Level:** yz dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** yy MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS:** ACLR

**ADAPT TO SIGNAL:** AUTO LEVEL & TIME

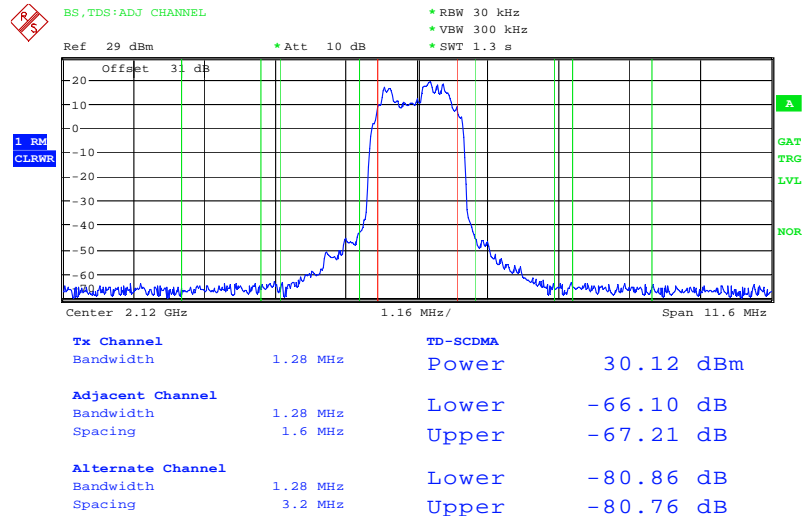


Fig. 22: Typical ACLR performance of the R&S®SMU with R&S®FSU/FSQ

### Performance of the R&S<sup>®</sup>SMU with R&S<sup>®</sup>FSP

An adequate margin for the power amplifier's ACLR values can also be achieved with the R&S<sup>®</sup>SMU with R&S<sup>®</sup>FSP, typical values being -63 dB in the adjacent channel and -74 dB in the alternate channel.

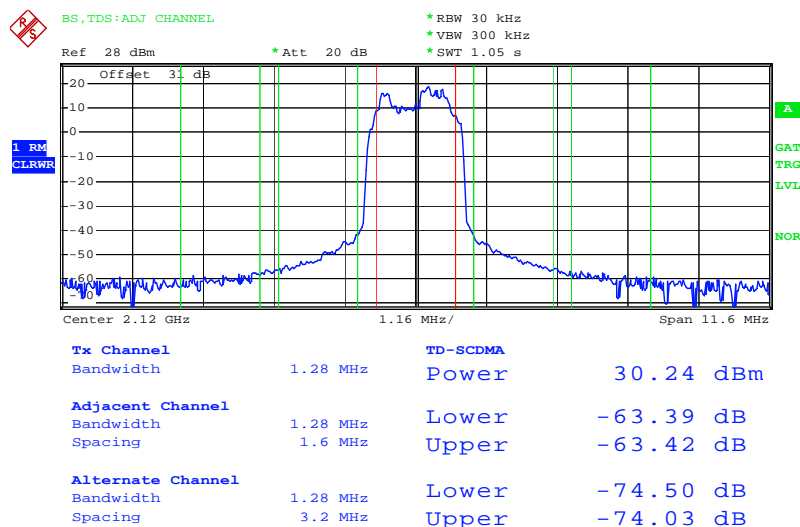


Fig. 23: R&S<sup>®</sup>SMU and R&S<sup>®</sup>FSP ACLR performance

### Multi-carrier ACLR (TS 25.142 chap. 6.6.2.2)

Power amplifiers for multi-carrier base stations have to meet particularly stringent requirements. According to TS 25.142, the ACLR limits of 40 dB (in the adjacent channel) and 45 dB (in the alternate channel) must be met by the carriers above and below the carriers in use.

To set up a suitable test signal (four-carrier signal) on the R&S<sup>®</sup>SMU or R&S<sup>®</sup>SMJ see chapter 5, page 16.

Operating sequence for the analyzer:

#### PRESET

**AMPT:NEXT** Offset xy dB (enter an offset according to the connected attenuator)

**Ref Level:** yz dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** yy MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS:** ACLR

**ADAPT TO SIGNAL:** AUTO LEVEL & TIME

## TD-SCDMA Power Amplifier Tests

Additional setting on the R&S®SMU for optimal ACLR with multi-carrier signals:

**MENU:IQ-Mod:IQ-Settings:Internal Baseband:Baseband Gain: -3 dB.**

As a consequence, an R&S®SMU with R&S®FSU/FSQ achieves a typical ACLR performance of approximately 67 dB in the adjacent channel and 68 dB in the alternate channel.

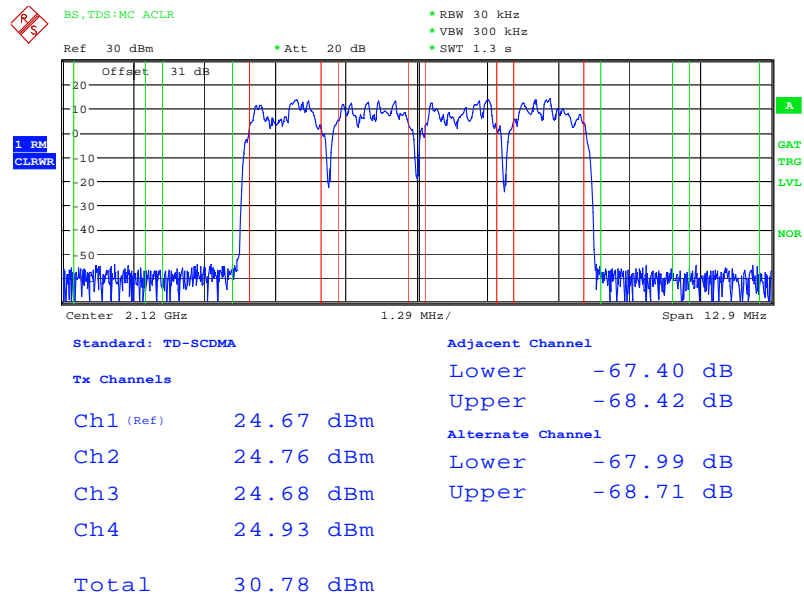


Fig. 24: Typical performance of an R&S®SMU with R&S®FSU/FSQ for adjacent channel measurements on a four-carrier TD-SCDMA signal

### Spectrum emission mask (TS 25.142 chap. 6.6.2.1)

Use the 8 channel test signal described in chapter 5 for this test.

For some regions, TS25.142, chap. 6.6.2.1 stipulates a spectrum emission mask for single-carrier transmitters. This mask is illustrated schematically below. The limit lines depend on the maximum output power of the base station. There must be sufficient margin between the base station power-amplifier's spectrum emission curve and the limit lines.

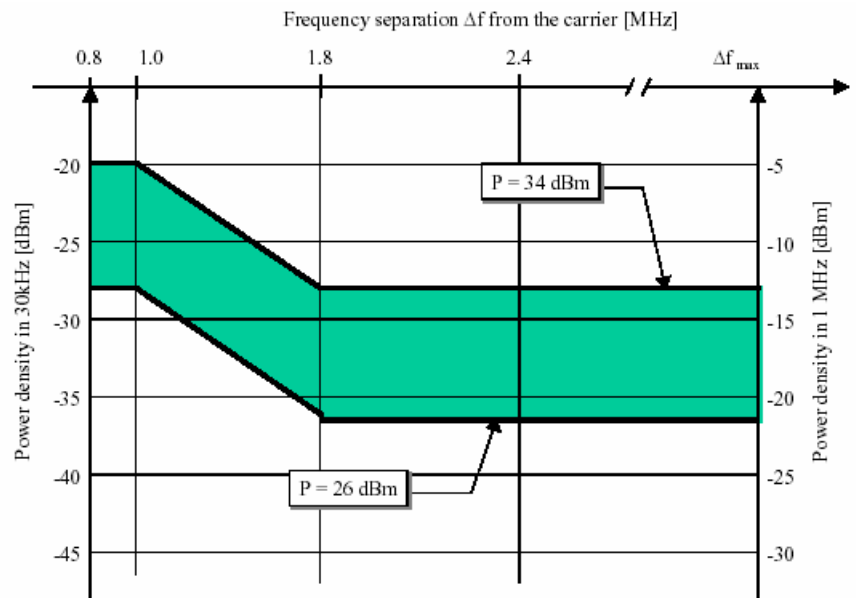


Fig. 25: Diagram showing the spectrum emission mask for TD-SCDMA base stations

To assess power emissions, the analyzer measures the signal power up to 2.3 MHz with a 30 kHz filter and from 2.3 MHz to 4 MHz with a 1 MHz filter. The curve obtained is compared with the limit line specified in TS 25.142 chap. 6.6.2.1 which depends on the base station's power (in this test setup the power amplifier's specified power).

Operating sequence for the analyzer:

#### **PRESET**

**AMPT:NEXT** Offset xy dB (enter an offset according to the connected attenuator)

**Ref Level:** yz dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** yy MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS: SPECTRUM EM MASK**

**ADAPT TO SIGNAL: AUTO LEVEL & TIME**

## TD-SCDMA Power Amplifier Tests

The typical performance of the spectrum emission mask measurement for the R&S<sup>®</sup>SMU with R&S<sup>®</sup>FSU/FSQ or R&S<sup>®</sup>FSP at an amplifier output power of 30 dBm is shown in the two measurement diagrams below, including:

- The spectrum of the TD-SCDMA signal over slots 4 to 6
- The limit line complies with TS25.142 chap. 6.6.2.1.2 (table 6.4 A, output power: 26 dBm to 34 dBm)
- Information about limit-line violations (Pass/Fail information; in this case: Pass)

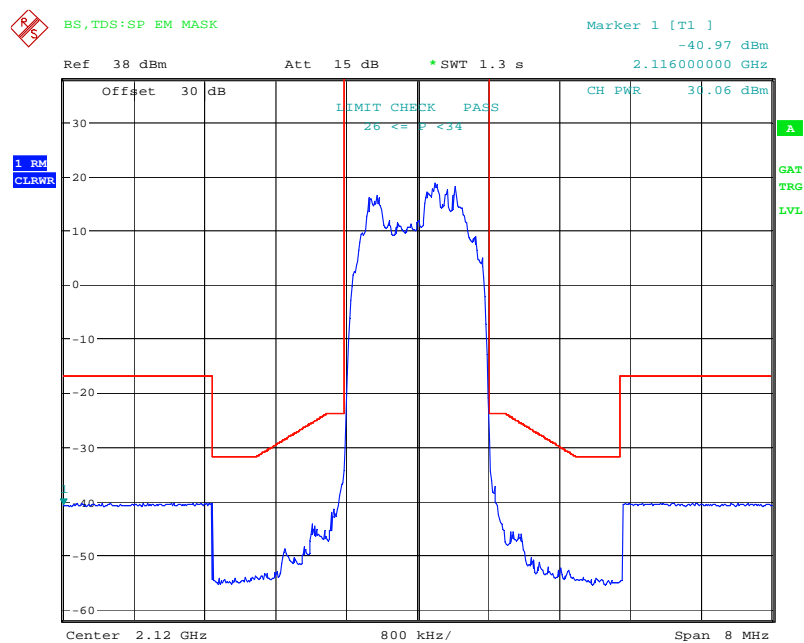


Fig. 26: Demonstration of the dynamic range for the spectrum emission mask measurement at 30 dBm using the R&S<sup>®</sup>SMU with R&S<sup>®</sup>FSU/R&S<sup>®</sup>FSQ



# TD-SCDMA Power Amplifier Tests

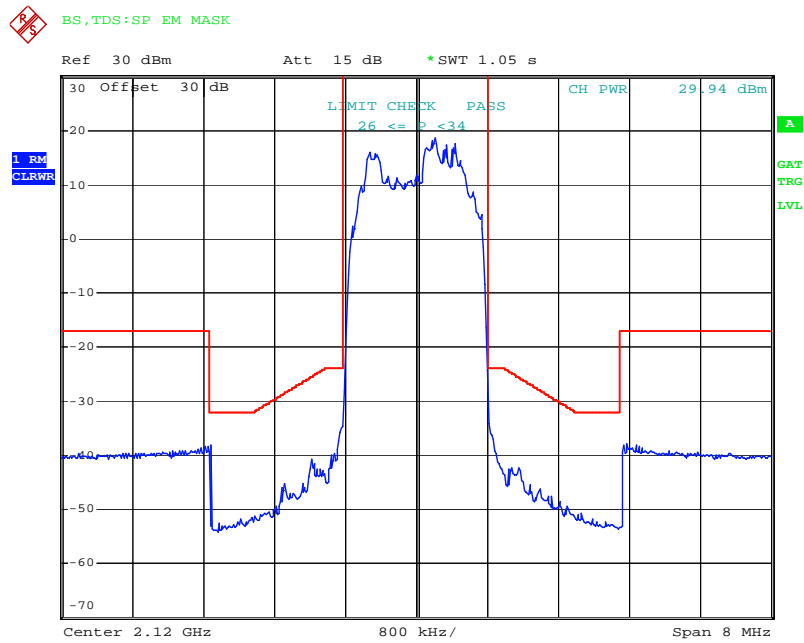


Fig. 27: Demonstration of the dynamic range for the spectrum emission mask measurement at 30 dBm using the R&S<sup>®</sup>SMU with R&S<sup>®</sup>FSP

## Power versus Time (Transmit ON/OFF power TS 25.142 chap. 6.5)

Use the 8 channel test signal described in chapter 5 for this test.

TS 25.142 chapter 6.5 stipulates an extreme dynamic range for this test. During the transmit OFF period, an absolute level of -82 dBm (measured with the 1.28 MHz bandwidth) must not be exceeded.

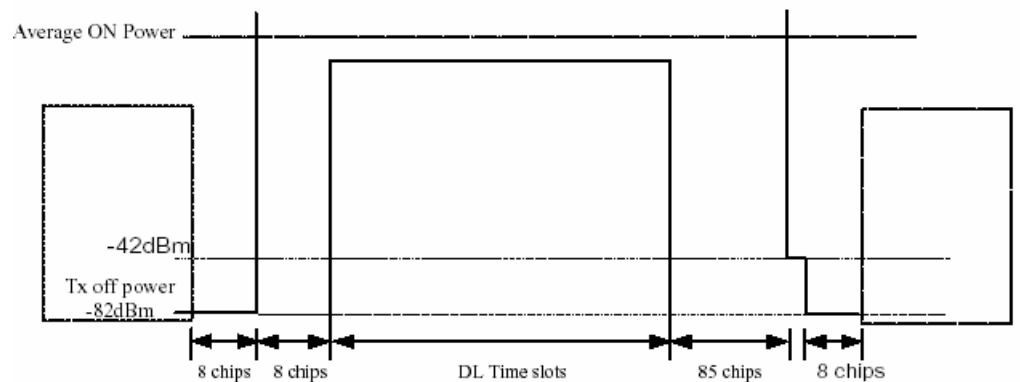


Fig. 28: Transmit On/Off template in line with TS25.142 chap. 6.5.2

For an output power of +30 dBm, for example, this means a dynamic range of 112 dB at a measurement bandwidth of 1.28 MHz.

## ***TD-SCDMA Power Amplifier Tests***

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To achieve this, base station power amplifiers must have special design features, for example to turn off the amplifier's output signal. Measures must be taken to prevent the amplifier's input noise being amplified and fed to the output during the OFF period. (The noise from the signal generator used as the drive source is also suppressed in the OFF period as it would otherwise have a negative effect on the dynamic range that could be obtained.)

Rohde & Schwarz signal analyzers provide a high dynamic measurement mode<sup>2</sup> for the power versus time measurement. A preliminary measurement is used to determine the reference level of the selected ON timeslot (in the default state, slots 4, 5, 6). Using the reference level determined with *Auto Level&Time*, the power during the OFF time is measured keeping the attenuation as low as possible and with the preamplifier turned on. Each measurement is averaged over 100 subframes (default setting of the high dynamic measurement mode).

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<sup>2</sup> The option R&S®FS-K25 "Electronic Attenuator and 20 dB Preamplifier" is required to obtain the maximum dynamic range in this case

## TD-SCDMA Power Amplifier Tests

Operating sequence for the analyzer:

### PRESET

**AMPT:NEXT** Offset *xy* dB (enter an offset according to the connected attenuator)

**Ref Level:** *yz* dB (set a ref level of 10 dB above the nominal power of the amplifier)

**FREQ:** *yy* MHz (enter required frequency)

**MORE:MORE** TDS BS

**MEAS: POWER VS TIME:HIGH DYNAMIC**

**ADAPT TO SIGNAL: AUTO LEVEL & TIME**

**START MEAS**

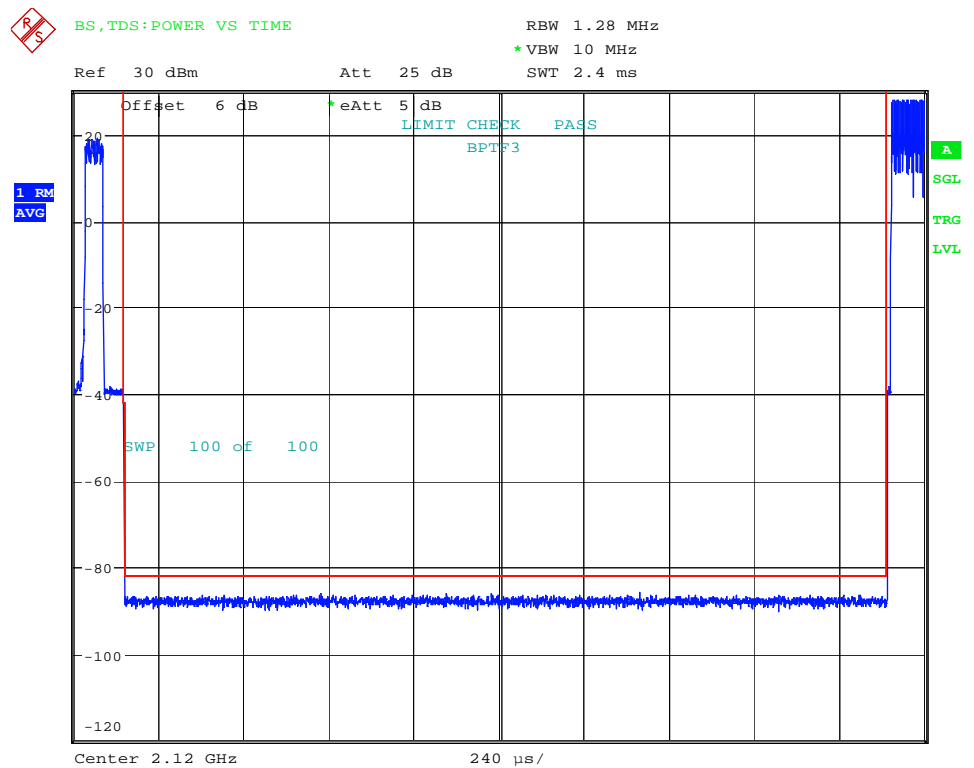


Fig. 29: Power vs time measurement with the R&S<sup>®</sup>FSU/Q; dynamic range at 25 dBm on the amplifier output

## 7 Glossary

ARB	Arbitrary
ACLR	Adjacent channel leakage power ratio
BS	Base station
CCDF	Complementary distributive distribution function
CWTS	China Wireless Telecommunication Standard group ( <a href="http://www.cwts.org">http://www.cwts.org</a> )
DL	Downlink
DwPTS	Downlink pilot timeslot
GP	Guard period
Mcps	Mega chips/s
PA	Power amplifier
TS1,TS2	Timeslot 1, 2
TDD	Time division duplexing
TD-SCDMA	Time division synchronous code division multiple access
UpPTS	Uplink pilot timeslot
UMTS	Universal mobile telecommunications system
UTRA	UMTS Terrestrial radio access

## 8 References

- [1] Operating Manual R&S<sup>®</sup>SMU Vector Signal Generator 1007.9845.32-09-I
- [2] Operating Manual R&S<sup>®</sup>SMJ Vector Signal Generator 1403.7458.32-04-IN
- [3] Software Manual R&S<sup>®</sup>FS–K76 TD–SCDMA Base Station Test Application Firmware 1300.7304.44-03
- [4] Operating Manual R&S<sup>®</sup>NRP Power Meter 1144.1400.12-04-
- [5] Data Sheet R&S<sup>®</sup>SMJ100A Vector Signal Generator PD 5213.5074.22
- [6] Data Sheet R&S<sup>®</sup>SMATE Vector Signal Generator PD0758.1893.22
- [7] Data Sheet R&S<sup>®</sup>SMU200A Vector Signal Generator PD 0758.0197.22
- [8] Application Firmware R&S<sup>®</sup>FS–K76 1300.7304.44-03
- [9] ETSI TS 125 105 V7.1.0 (2005-12)
- [10] ETSI TS 125 142 V7.1.0 (2005-12)

## 9 Additional Information

Please send any comments or suggestions about this Application Note to [TM-Applications@rsd.rohde-schwarz.com](mailto:TM-Applications@rsd.rohde-schwarz.com).

## 10 Ordering information

### Power meter and options

R&S® NRP	Power Meter	1138.3004.02
R&S® NRP-Z11 Diode Power Sensor	200 pW to 200 mW 10 MHz to 8 GHz	1138.3004.02
R&S® NRP-Z21 Diode Power Sensor	200 pW to 200 mW 100 MHz to 18 GHz	1137.6000.02
R&S® NRP-Z3	USB Adapter with trigger port	(active) 1146.7005.02

### Signal analyzer, spectrum analyzer and options

R&S® FSP3	9 kHz to 3 GHz	1093.4495.03
R&S® FSP7	9 kHz to 7 GHz	1093.4495.07
R&S® FSP13	9 kHz to 13 GHz	1093.4495.13
R&S® FSP-B25	Electronic Attenuator, 0 dB to 30 dB, 5 dB steps, integrated preamplifier for FSP3 and FSP7	1129.7746.02
R&S® FSU3	20 Hz to 3.6 GHz	1129.9003.03
R&S® FSU8	20 Hz to 8 GHz	1129.9003.08
R&S® FSU26	20 Hz to 26.5 GHz	1129.9003.26
R&S® FSQ3	20 Hz to 3.6 GHz	1155.5001.03
R&S® FSQ8	20 Hz to 8 GHz	1155.5001.08
R&S® FSQ26	20 Hz to 26.5 GHz	1155.5001.26
R&S® FSU-B25	Electronic Attenuator and 20 dB Preamplifier (3.6 GHz)	1044.9298.02
R&S® FS-K76	3GPP TD-SCDMA BTS Application Firmware	1300.7291.02

### Vector signal generator and options

R&S® SMU200A	Vector Signal Generator	1141.2005.02
R&S® SMU-B102	RF Path A: 100 kHz to 2.2 GHz	1141.8503.02
R&S® SMU-B103	RF Path A: 100 kHz to 3 GHz	1141.8603.02
R&S® SMU-B104	RF Path A: 100 kHz to 4 GHz	1141.8703.02
R&S® SMU-B106	RF Path A: 100 kHz to 6 GHz	1141.8803.02
R&S® SMU-B9	Baseband with ARB (128 Msample)	1404.1501.02
R&S® SMU-B10	Baseband with ARB (64 Msample)	1141.7007.02
R&S® SMU-B11	Baseband with ARB (16 Msample)	1159.8411.02
R&S® SMU-B13	Baseband Main Module	1141.8003.02
R&S® SMU-K50	Digital Standard TD-SCDMA	1161.0966.02
R&S® SMU-B31	High-Power Output	1159.8011.02
R&S® SMU-K250	Digital Standard TD-SCDMA (with WINIQSIM2™)	1408.6314.02
R&S® SMJ100A	Vector Signal Generator	1404.4507.02
R&S® SMJ-B103	RF Path B: 100 kHz to 3 GHz	1403.8502.02
R&S® SMJ-B9	Baseband with ARB (128 Msample)	1404.1501.02
R&S® SMJ-B10	Baseband with ARB (64 Msample)	1403.8902.02
R&S® SMJ-B11	Baseband with ARB (16 Msample)	1403.9009.02
R&S® SMJ-B13	Baseband Main Module	1403.9109.02
R&S® SMJ-K50	Digital Standard TD-SCDMA	1404.1660.02
R&S® SMJ-K250	Digital Standard TD-SCDMA (with WINIQSIM2™)	1404.1316.02

For additional information about power meters, signal generators, spectrum analyzers and signal analyzers, visit the Rohde & Schwarz website [www.rohde-schwarz.com](http://www.rohde-schwarz.com).



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