Products: Signal Analyzer FSIQ (with option FSIQ-B70 and FSIQ-K72)

Measurements on 3GPP Base Station Transmitter Signals

Application Note

This application note explains the measurements on 3GPP Base Station Transmitter signals according to TS 25.141, using the Signal Analyzer FSIQ with the Code Domain Power application firmware FSIQ-K72.

ROHDE & SCHWARZ

Subject to change – Josef Wolf 08/01 - 1EF44_1E

Contents

1 Overview

With the introduction of a CDMA transmission scheme for the third generation of mobile radio systems new requirements on test equipment arise. The CDMA transmission scheme is already in use and the measurement techniques are well known from the existing IS 95 system. However, due to the variable and higher data rates possible with the W-CDMA system currently specified within 3GPP, the signal structure is more complex compared to IS 95. With the 3GPP system each user can be assigned a different bit rate from 7.5 kbit/s to 2 Mbit/s. This is not the case with the second generation systems.

The conformance test for W-CDMA base station transmitters is described in the 3GPP document TS 25.141. It requires different measurements on Base Station (BS) transmit signals that are only possible to perform by de-spreading the CDMA signal into the different code channels. A dedicated analyzer is necessary to de-spread the signal and measure power of the different code channels, as well as the modulation quality of the whole signal. In addition to these in-band measurements, out of band transmission and spurious measurements are necessary to ensure protection of other W-CDMA channels or other radio systems from interference. Additional measurements not required by the standard are desirable, for example to assure on module level that the whole base station transmitter will work or to troubleshoot non-working modules.

The structure of the W-CDMA signal is explained as far as this knowledge is needed for understanding the measurement. Especially with the in-channel measurement explained in section 3 and 5 the structure of the signal is of importance. In section 4 the out-of-band measurements are discussed. These are spectrum measurements requiring specific functions of the spectrum analyzer.

In chapter 7 the difference between the minimum requirements and the test requirements and their relation to the test tolerances is described. The requirement values used in this document are the test requirements.

2 Structure of the 3GPP W-CDMA Signal

To help understand the measurements in the code domain this section gives a short overview of the W-CDMA Down Link (DL) signal structure.

Structure in Code Domain

Different bit rates for data transmission are implemented in the 3GPP standard by using different spreading factors of the information bits. Spreading Factors (SF) between 4 and 512 are defined. Each SF is assigned a number of code channels. The number of code channels available for a specific SF is dependent on the SF itself. The different code channels can be shown in the so-called code tree (see figure 1).

The different codes with a specific SF are orthogonal (vertical bars in fig 1). The codes of branches in the tree (connected through lines in figure 1) are related to each other, i. e. they are not orthogonal. If one single code channel in a branch of the code tree is occupied, other users cannot use all other codes in the branch.

With a spreading factor of 4 four users are possible in theory. With a spreading factor of 512 the theoretical maximum number of users is 512. However, not all channels can be used for payload. Some channels must be used for network signaling overhead, such as exchanging network information with the users or for initiating a call. For the purposes of this application note, these network signaling channels are referred to as organization channels. The most important organization channels are:

CPICH	Common Pilot Channel (SF 256, position 0)
PICH	Paging indication channel (SF 256, position 16)
PCCPCH	Primary common control physical channel (SF 256, position 1)
SCCPCH	Secondary Common Control Physical Channel
PSCH	Primary Synchronization channel
SSCH	Secondary Synchronization Channel

The PSCH and the SSCH are only transmitted during the first 256 chips of a slot. They are not orthogonal because they are superimposed on the other channels. Therefore they are not assigned to a code position.

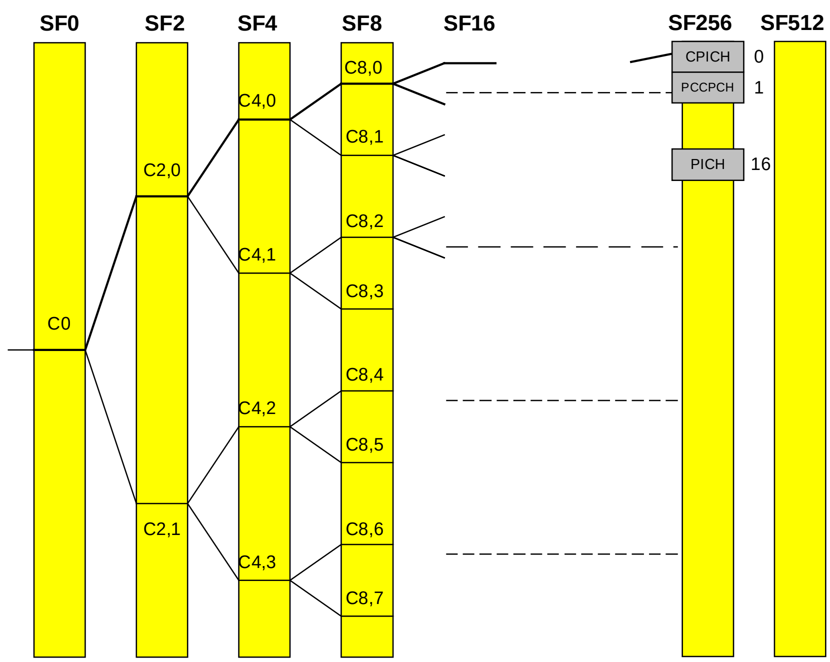


Fig 1 Code Tree of a W-CDMA signal. The organization channels are shown on their position in code class 256 (15 kbps)

Structure in Time Domain

The W-CDMA signal is organized in frames with a length of 10 ms. A frame consists of 15 slots. With the 3.84 MHz chip rate used each slot contains 2560 chips.

The structure and the purpose of the different channels are explained below with respect to their use for transmitter measurements.

Dedicated Physical Channel (DPCH)

A traffic channel for transmission of voice or user data in downlink has the structure shown in figure 2.

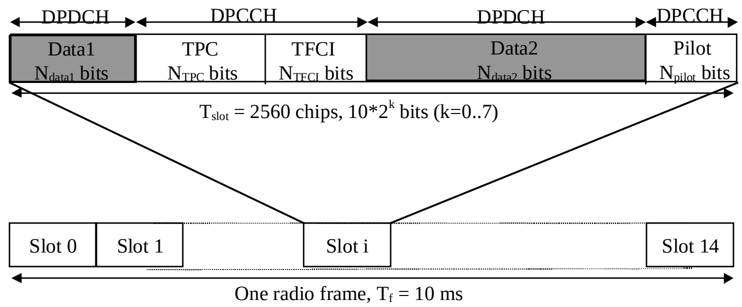


Fig 2 Structure of a W-CDMA traffic channel in time domain

DPCCH =	Dedicated Physical Control Channel
DPDCH =	Dedicated Physical Data Channel
TFCI =	Transport Format Combination Indicator
TPC =	Transmit Power Control
Pilot =	Pilot Symbols

The DPCH contains control and data information. The data portion contains the Dedicated Physical Data Channel (DPDCH), with 4 to 1248 data bits, dependent on the spreading factor of the code channel. Control information includes

- the DPCCH (Dedicated Physical Control Channel) comprising the Pilot symbols,
- the Transmit Power Control (TPC) bits and
- the Transport Format Combination Indicator (TFCI) bits.

The number of pilot bits can vary between 2 and 16. The number of TPC bits is 2, 4 or 8. For higher bit rates more TPC bits are used. An all zero TPC bit pattern stands for a power down command for the mobile station and an all one bit pattern for a power up command for the mobile station.

Common Pilot Channel (CPICH)

To synchronize the mobile station the base station transmits a Common Pilot Channel (CPICH) with a pre-defined symbol sequence. It is transmitted continuously at a fixed power level. Its structure is shown in figure 3.

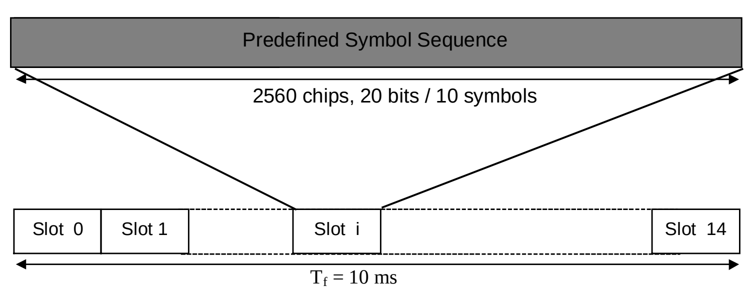


Fig 3 Structure of the Common Pilot Channel (CPICH)

The spreading factor of the CPICH is 256; i. e. the transmission rate is 30 kbps. In the code tree the CPICH is on position 0. By default the CPICH is the phase reference for all other channels in the downlink.

Paging Indication Channel (PICH)

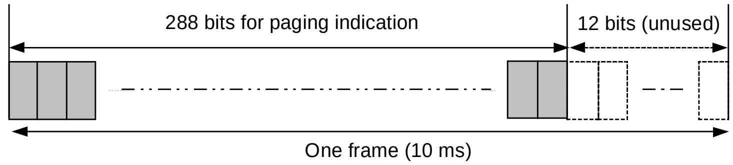


Fig 4 Structure of the Paging Indication Channel (PICH)

The PICH does not contain any pilot or other control channels. If the Paging Indicator in a certain frame is set to "1" it is an indication for mobile stations associated with this page indicator to read a message in the corresponding frame of the associated Secondary Common Control Physical Channel (S-CCPCH).

Synchronization Channel (SCH)

The Synchronization Channel (SCH) is for cell search. It consists of two sub-channels, the Primary SCH (P-SCH) and Secondary SCH (S-SCH). The 10 ms frames of the Primary and Secondary SCH are divided into 15 slots, each of length 2560 chips. Figure 5 illustrates the structure of the SCH radio frame.

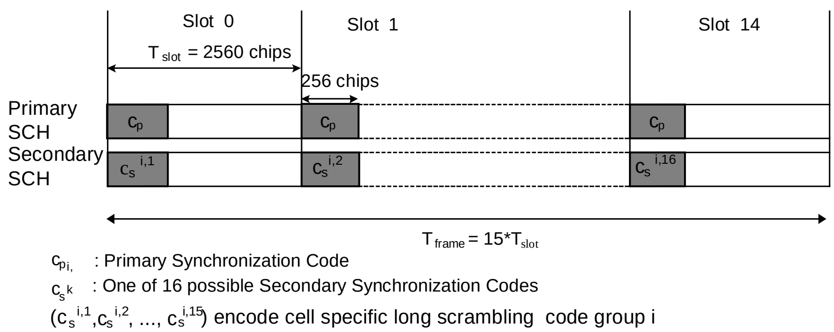


Fig 5 Structure of the Synchronization Channel (SCH)

The synchronization channel is non-orthogonal to the other channels and is only switched on during the first 256 chips of each slot.

The P-SCH is the same in all slots of the frame, where as the S-SCH changes every slot. This enables the mobile to reasonably quickly search for the P-SCH to establish the frame timing, and then use the S-SCH to find the slot timing. The sequence on the Secondary SCH also indicates which scrambling code is used in the cell.

As the SCH is non orthogonal it creates some interference in all other channels. EVM measurement in the presence of the SCH requires special techniques in the test equipment to remove the effects of this distortion.

Primary Common Control Physical Channel (P-CCPCH)

The P-CCPCH is a fixed rate (30 kbps, SF = 256) downlink physical channel used to carry the Broadcast Channel (BCH). The BCH sends system- and cell-specific information to all users. It is always transmitted over the entire cell with a low fixed bit rate.

Figure 6 shows the frame structure of the P-CCPCH. The frame structure differs from the downlink DPCH in that no TPC commands, no TFCI and no pilot bits are transmitted The P-CCPCH is not transmitted during the first 256 chips of each slot. Instead, Primary SCH and Secondary SCH are transmitted during this period (see figure 5).

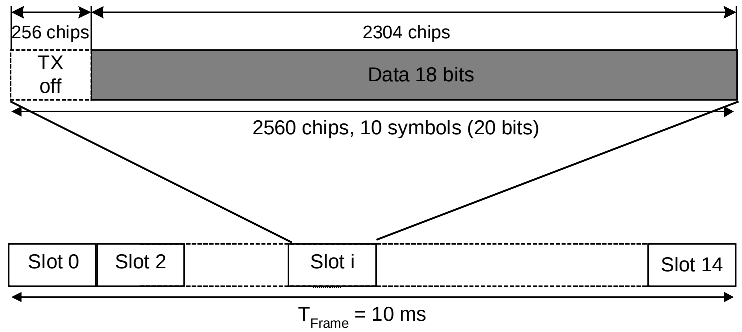


Fig 6 Structure of the Primary Common Control Physical Channel (P-CCPCH)

Secondary Common Control Physical Channel (S-CCPCH)

The S-CCPCH is used to carry the Forward Access Channel (FACH) and the Paging Channel (PCH). FACH and PCH are used to send short messages to the mobile, the User Equipment (UE). The S-CCPCH can use the same set of spreading factors as the downlink DPCH. The frame structure of the Secondary CCPCH is shown in figure 7

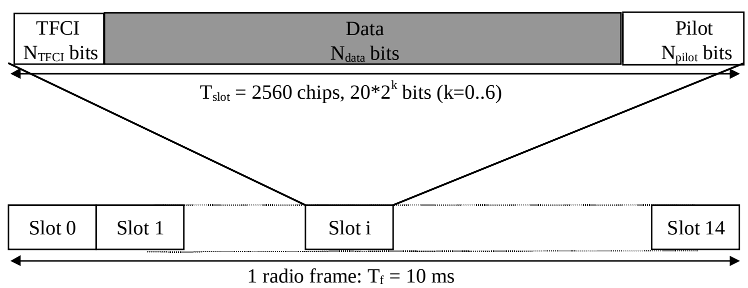


Fig 7 Structure for Secondary Common Control Physical Channel (S-CCPCH)

The parameter k in figure 7 determines the total number of bits per downlink Secondary CCPCH slot. It is related to the spreading factor SF of the physical channel as $SF = 256/2^k$. The spreading factor range is from 256 down to 4.

The main difference between the Primary and Secondary CCPCH is that the transport channel mapped to the Primary CCPCH (BCH) can only have a fixed data rate, while the Secondary CCPCH supports multiple data rates.

PCH - Paging Channel

The PCH is a downlink channel used to broadcast control information into an entire cell, allowing the UE efficient sleep mode procedures.

FACH - Forward Access Channel

The FACH is a downlink transport channel used to transmit short messages to the UE. The FACH is transmitted over the entire cell or over only a part of the cell. The FACH can be transmitted using slow power control.

Code Channel Timing Offsets

The power of each user code channel is controlled on slot basis. Dependent on the transmission quality the mobile station reports, the base station adjusts the power of each individual code channel separately.

To minimize the crest factor of the W-CDMA signal, each code channel can be assigned a timing offset such that the absolute time of a slot is different for each channel. The reference channel is the CPICH. The timing offset can be between 0 and 38144 chips in steps of 256 chips, or nearly a complete frame.

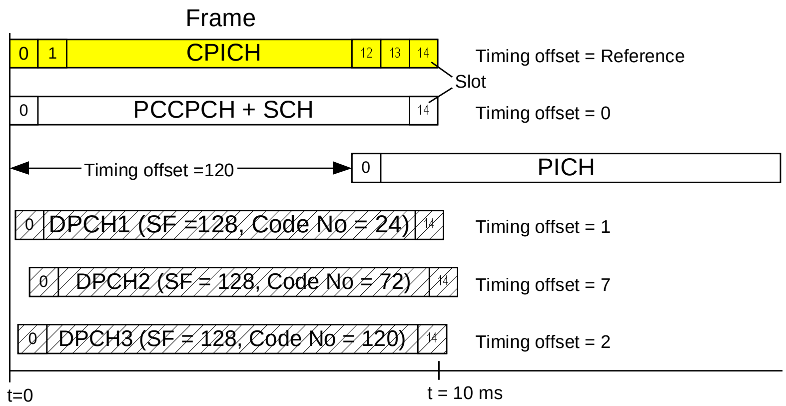


Fig 8 Absolute timing of the code channels of test model 1.

During a CPICH timeslot, the other active channels may belong to a different slot number or even to a different frame number compared to the CPICH. Due to the timing offset two different time scalings can be defined:

- With absolute time scaling the power of all code channels is referenced to the CPICH. With this absolute time reference the slot timing of all other channels do not necessarily match the slot timing of the CPICH.
- With logical time scaling all channels are regarded in respect to their frame number and timeslot number. The logical time scaling corresponds to the absolute time scaling, if the timing offsets are removed and the corresponding timeslots are overlaid.

The FSIQ uses absolute time scaling referenced to the start of CPICH slot 0 for measurements in the code domain. The power in the different code channels is displayed in the raster of the CPICH timeslots.

3 Measurements in Code Domain

The most prominent requirement for in-channel measurements on W-CDMA signals is Code Domain Power analysis. As all channels use the same spectrum, the measurement must be performed by de-spreading the W-CDMA signal into its individual code channels and measuring their individual power and quality.

Test Models

The 3GPP standard TS 25.141 defines four different test models to assure that the results between different base stations are comparable.

Each of these test models contain organization channels listed on page 4 and a number of Dedicated Physical Channels, each using the spreading factor 128 or 256 (corresponds to 30 kbps or 15 kbps transmission rate). Each channel is assigned a specific power level and timing offset. The contents of the different channels of the test models are exactly specified in TS 25.141.

Test model 1 is primarily used for measurement of the out of band spectrum and the maximum output power of the base station. It uses 64 user code channels at 30 kbps (spreading factor 128) randomly distributed across the code space with random power levels and random timing offsets. The intention is to use a signal with a high crest factor to simulate a realistic traffic scenario. If the base station does not support 64 traffic channels, models using 32 or 16 traffic channels are specified.

Test model 1 is used with the following measurements specified in TS 25.141:

- spectrum emission mask
- adjacent channel leakage ratio (ACLR)
- spurious emissions
- transmit intermodulation
- base station maximum output power

Test model 2 is used for the measurement of the output power dynamics with the exception of total power dynamic range. It comprises the organization channels P-CCPCH + SCH, CPICH, PICH, S-CCPCH containing PCH and 3 traffic channels, each with 30 kbps transmission rate.

Test model 3 is used for the measurement of Peak Code Domain Error (PCDE). It contains in addition to the organization channels P-CCPCH + SCH, CPICH, PICH, S-CCPCH containing PCH, and 16 or 32 traffic channels each with spreading factor 256 (= 15 kbps transmission rate), dependent on the capability of the base station.

Test model 4 is used for measurement of Error Vector Magnitude (EVM) and total power dynamic range. It uses the P-CCPCH, SCH and CPICH (optional), only. No traffic channel is active.

Maximum Output Power

For the measurement of the maximum output power test model 1 is used.

Maximum output power of the base station is the mean power level per carrier at the antenna connector as specified by the manufacturer. It is defined as the mean power over certain slots and shall be within 2.7 dB of the manufacturer’s specification.

Measurement of the mean power can be performed in two different ways:

- The FSIQ uses the integrated bandwidth method in spectrum mode to measure the channel power. Using the rms detector the measurement result is very accurate and repeatable. However, there is no relation to specific slots of the W-CDMA signal.
- Using the Code domain power function of the option FSIQ-K72, the power is measured during a selectable slot of the W-CDMA signal. To enable the FSIQ to detect the PICH in test model 1, it supports the selection of the test model to be measured. With the test model selected, the FSIQ knows the code configuration of the test signal in advance. The calculations in code domain are then performed exactly to the specification. The test result is reported as a numeric value in the result summary.

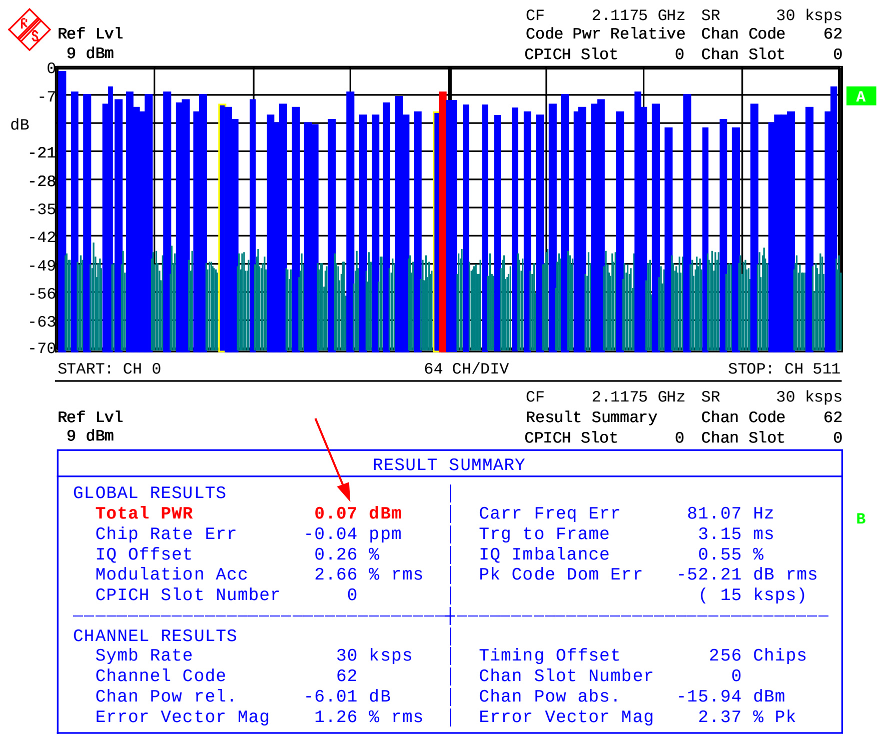


Fig 9 Numeric measurement result for the total power using test model 1 (Total Pwr, arrowed)

In addition to the total power the result summary table shows other useful information characterizing the W-CDMA signal in more detail. Some of the measurement values apply to the whole signal such as the carrier frequency error, chip rate error, modulation accuracy (EVM) and the peak code domain error (PCDE). They are listed in the section GLOBAL RESULTS. In addition to the Global Results, characteristics and test results for a specific code channel are output. These are the symbol rate, the code number, the slot number, the timing offset and the error vector magnitude for the de-spread symbols. These are listed in the CHANNEL RESULTS table.

CPICH Power Accuracy

The purpose of this test is to verify that the CPICH power matches, within the limits given in TS 25.141 (± 2.9 dB), the power signalled from the network to the base station.

With the code domain power analyzer, the power of the P-CCPCH and the P-CPICH must be measured while the base station is transmitting with the maximum power and inner loop power control is disabled. For the measurement of the CPICH power accuracy test model 2 is used.

The CPICH Power can easily be measured with the FSIQ by using the marker. After analyzing the signal in code domain power mode, the marker is set to the CPICH or the P-CCPCH by using the dedicated marker functions (MKR -> CPICH or MKR -> PCCPCH). The marker read out shows the respective power level (see marker output in figure 10).

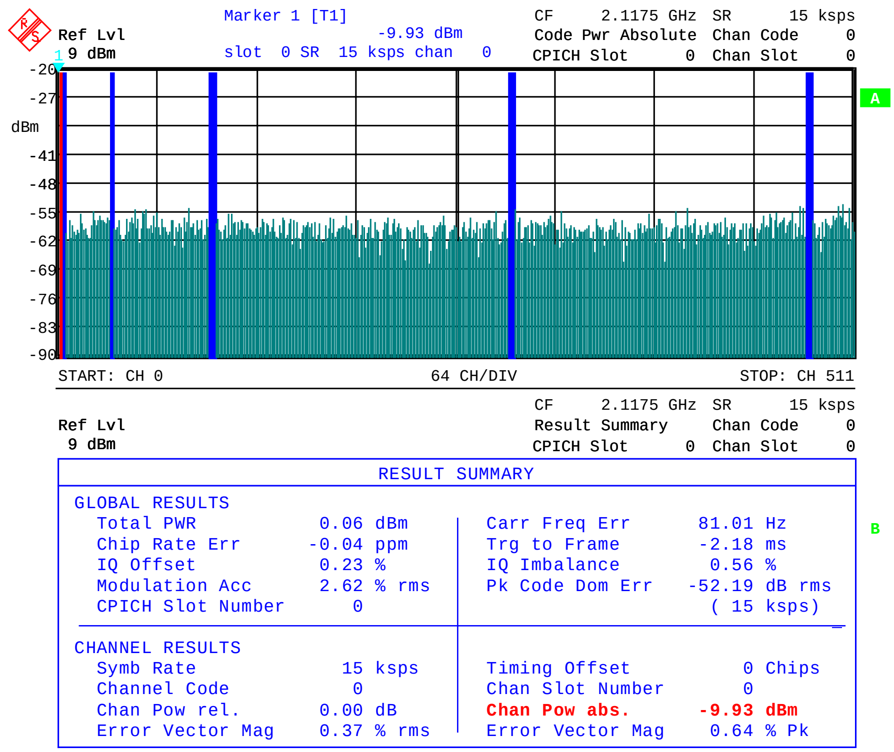


Fig 10 Code domain power display with the marker readout for CPICH power. Test model 2 signal used.

The absolute power is output also in the RESULT SUMMARY in the CHANNEL RESULT section.

Frequency Stability

With the frequency stability measurement the correct frequency of the base station is to be verified. The requirement is a frequency accuracy of 0.05 ppm of the set transmit frequency. The standard only requires that the transmit signal is continuously modulated. No specific channel configuration is stated in the standard.

The FSIQ can measure the frequency error of the base station in any channel configuration. Along with the RESULT SUMMARY the frequency error is always output in the GLOBAL RESULTS table (see figure 10, Carr Freq Err). It is calculated during synchronization to the W-CDMA signal.

However, for highest accuracy the FSIQ needs a high precision external reference fulfilling the high stability requirements. Oven controlled crystal oscillators normally do not provide sufficient stability to meet the requirement. An external reference signal, for example a Rubidium oscillator, is necessary to synchronize the internal reference oscillator of the FSIQ.

Power Control Steps and Combined Power Control Tolerance

Control of output power is important in CDMA systems. To minimize interference with other users the transmitted power in each code channel should be kept at its minimum for a reliable connection. The mobile station therefore sends a power control message (TPC bits, see figure 2) to the base station in each timeslot to request the base station to decrease or increase the transmit power.

The base station needs to adjust the power of an individual code channel in 1-dB steps (optional 0.5-dB steps) dependent on the power control symbol sent by the mobile station. In order to minimize the interference to other users, the transmit power of the base station must be set very accurately. The accuracy of the 1-dB steps is required to be ± 0.6 dB and for the optional 0.5-dB steps the accuracy must be ± 0.35 dB.

After 10 consecutive steps in one direction the error of the relative power is required to be within a 2.1-dB tolerance for 1-dB steps and within a 1.1-dB tolerance for 0.5-dB steps.

Test model 2 is used for testing the power control steps.

The FSIQ evaluates a complete frame for code domain power measurement. Therefore, the measurement of the power control step tolerance and the combined power control tolerance can be measured in a single run.

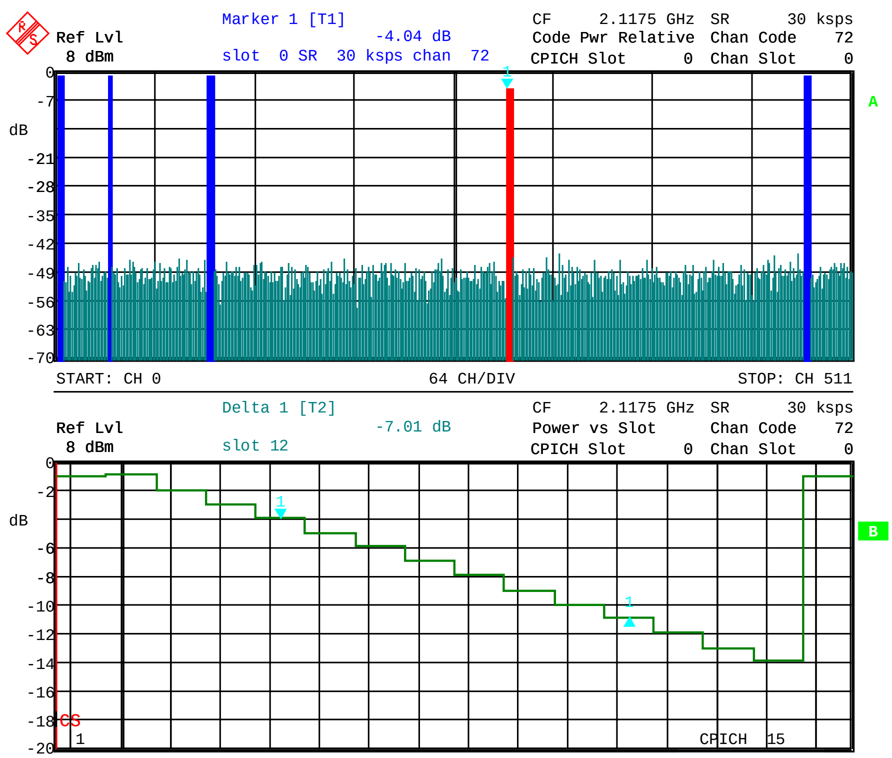


Fig 11 Measurement of the 1-dB power control steps

Using the marker and delta marker function in the time domain display the accuracy of each power step can be measured directly with the delta marker readout. Similarly, the relative power after 10 steps can be measured.

With the time domain display the relation between the CPICH and the code channel under test can be checked. In figure 11 the power of code channel 72 is controlled in 1-dB steps. The steps can be seen to be not aligned with the grid. This is due to the timing offset of channel 72 in test model 2. It is 7 x 256 chips = 1792 chips. The grid is instead aligned to the CPICH slots marked within the x-axis of the grid from 0 to 14. The vertical line marked with CS (Start Slot) shows the start of slot 0 of code channel 72. The timeslot number of the displayed code channel is labeled below the grid (-1 to 15). Switching the display in the lower screen to 'Result Summary' outputs the measured timing offset (see e.g. figure 9).

The code levels shown in the upper part of the display in figure 11 are measured during the timeslot of the CPICH. As only 30% of code channel 72 matches the CPICH slot the power read out by a marker set to code channel 72 is 70% from the previous timeslot and 30 % from the selected CPICH slot number. For accurate power measurement of code channels with a timing offset the time domain display is the right choice.

Total Power Dynamic Range

The total power dynamic range is the difference between the maximum output power and the minimum output power of a base station for the entire signal. It is measured with test model 4. The base station output signal only consists of the CPICH, the P-CCPCH + SCH and the PICH channel.

For testing the total power dynamic range the maximum output power must first be measured. Then, all code channels are set to their minimum power. The total power must be at least 18 dB below the maximum output power.

The total power dynamic range can be measured in the spectrum mode as well as with the Code Domain Power function of the FSIQ. In spectrum mode, the channel power function leads to faster results, as the code power calculation within the FSIQ is not necessary. In code domain mode in addition to the total power measurement, the correct code configuration of the device under test can be checked. For both possibilities the FSIQ offers one-button solutions. The level auto adjust function of the FSIQ frees the user from the need to manually optimize the analyzer input settings.

Power Control Dynamic Range

The purpose of the test is to verify the dynamic range of an individual code channel. The code channel under test is set to its maximum power, and to its minimum power. At its maximum power the code channel must be greater than the total power of the signal –3.2 dB. Its minimum power must be less than the total power –27.8 dB.

The test is performed on traffic channels (DPCH) using test model 2. It uses 3 traffic channels. The DPCH under test is set to its maximum power level. The level of the other DPCHs is reduced to meet the requirement for the DPCH under test to be greater than the total power - 3 dB. Then power of the DPCH under test is set to its minimum power control level. The power of the other code channels remains unchanged. In this configuration the level of the DPCH under test is measured.

If the device under test can be commanded to set the power in 3-dB steps the measurement can be carried out in a single run. If only 1-dB steps are possible a two-pass measurement is necessary, the first pass at the maximum power of the code channel under consideration and the second pass at its minimum power.

Figure 12 shows an example for measuring power control dynamic range by commanding the device under test in 3-dB steps. The Delta Marker readout shows the level of code channel 72 after 9 steps.

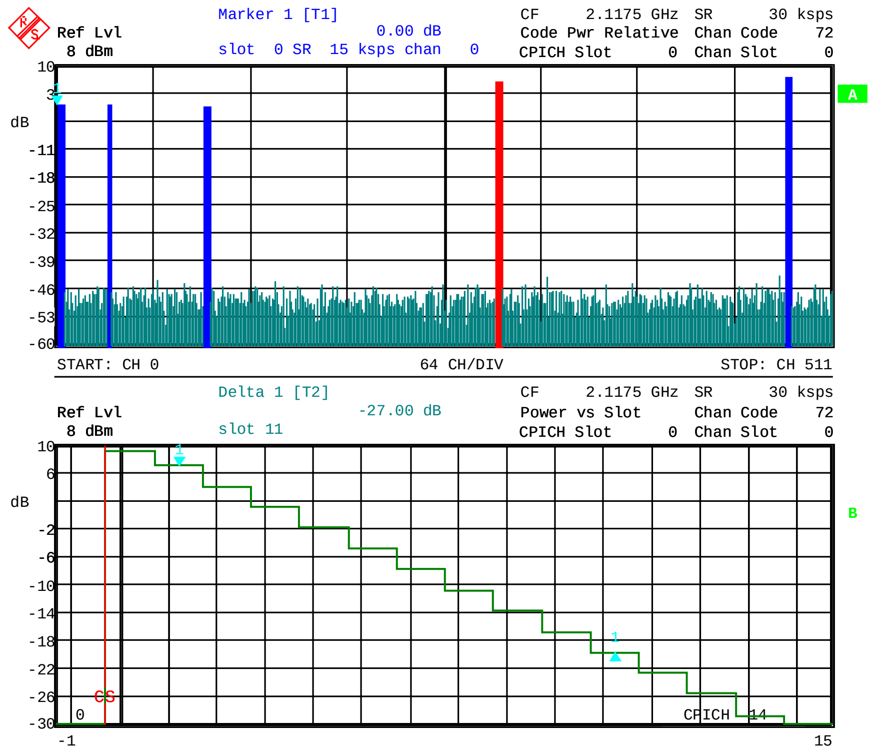


Fig 12 Measurement of the power control dynamic range using 3-dB steps for code channel 72

Measurement of the Transmit Modulation Quality

Modulation Accuracy (EVM)

The Error Vector Magnitude (EVM) is defined as the difference between the measured waveform and the theoretical modulated waveform. An error vector is calculated from the difference of both waveforms for each chip. From the error vectors the Mean Error Vector Power (MEVP) is calculated for a complete timeslot. The MEVP is related to the Mean Reference Signal Power (MRSP) within the same slot. From these two power values the EVM is calculated as follows:

$$\mathrm{EVM}/\% = \sqrt{\frac{\mathrm{MEVP}}{\mathrm{MRSP}}}$$

Test model 4 using the Paging Indication Channel (PICH) and the Synchronization Channels (SCH), only is applied. As the measurement interval is specified to be one timeslot, the EVM result is one numbered value per timeslot. The specification of the EVM is valid over the total power dynamic range.

As the Synchronization Channels in the test signal are not orthogonal to the other code channels, they increase the EVM unless special measures are taken to account for the distortion created by the SCH. When calculating the ideal waveform the FSIQ takes into account the non-orthogonal SCHs. That way both the ideal waveform and the measured waveform have the SCH included. This procedure results in an EVM value that represents the behavior of the device under test rather than the impact of the SCHs.

In general EVM can be measured for any code channel configuration. However, with different code channel configurations to test model 4, a different crest factor of the signal will result. For most realistic signals, e.g. test model 1 or 3, the crest factor will be higher and this will stress the device under test more.

The FSIQ needs the CPICH (optional in test model 4) to be available in the W-CDMA signal in order to synchronize to the W-CDMA waveform. Otherwise any code channel configuration can be used for EVM measurement. This allows for the modulation quality to be tested under various conditions to determine the impact of different loading conditions to the device under test. The following screen-shot shows the EVM measurement using a W-CDMA signal loaded with 32 code channels (test model 3).

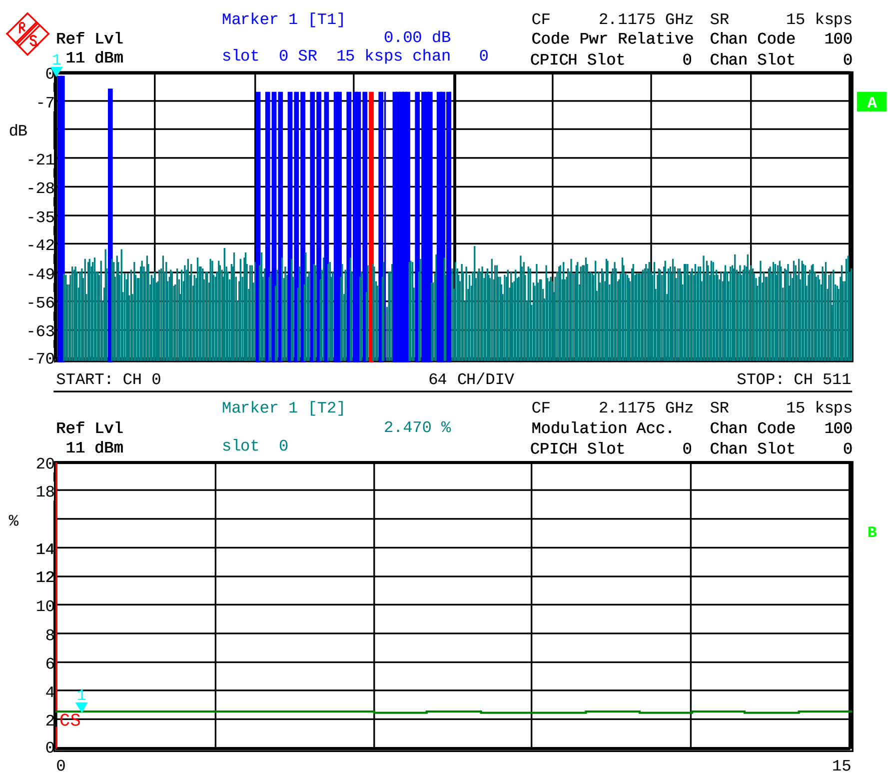


Fig 13 Graphic display of the EVM dependent on the slot number for a complete frame

The EVM for all 15 slots of a W-CDMA frame is displayed graphically in the lower part of the screen. The numbered values for the EVM can be read out easily using the marker.

Alternately the mean value for the EVM over all slots of the analyzed frame can be read in the GLOBAL RESULTS of the RESULT SUMMARY.

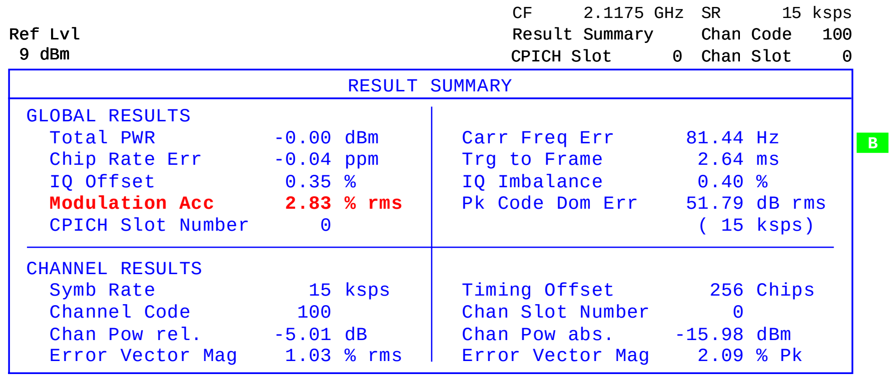


Fig 14 Numeric display for the EVM of the complete frame in the RESULT SUMMARY

Peak Code Domain Error (PCDE)

With the PCDE measurement the difference between the test signal and the ideal reference signal is projected onto the code space at a specific spreading factor. PCDE is a measure for the leakage of occupied code channels into all other channels. It represents the relative power leakage of non-ideal code channels into free code channels. For Peak Code Domain Error (PCDE) measurement test model 3 is used. In addition to the organization channels it uses 16 or 32 traffic channels with a 15 kbps transmission rate each.

The TS25.141 standard specifies that the projection is made onto code channels with spreading factor 256, i.e. 15 kbps transmission rate. The measurement has to be performed on timeslot basis, i. e. for each slot one value or numbered result is calculated. The FSIQ allows the user to select the spreading factor of the code channel for the projection of the error vector. That way the influence on code channels with different spreading factors can be evaluated. A typical test result for PCDE measurement with the Signal Analyzer FSIQ is shown in the following figure.

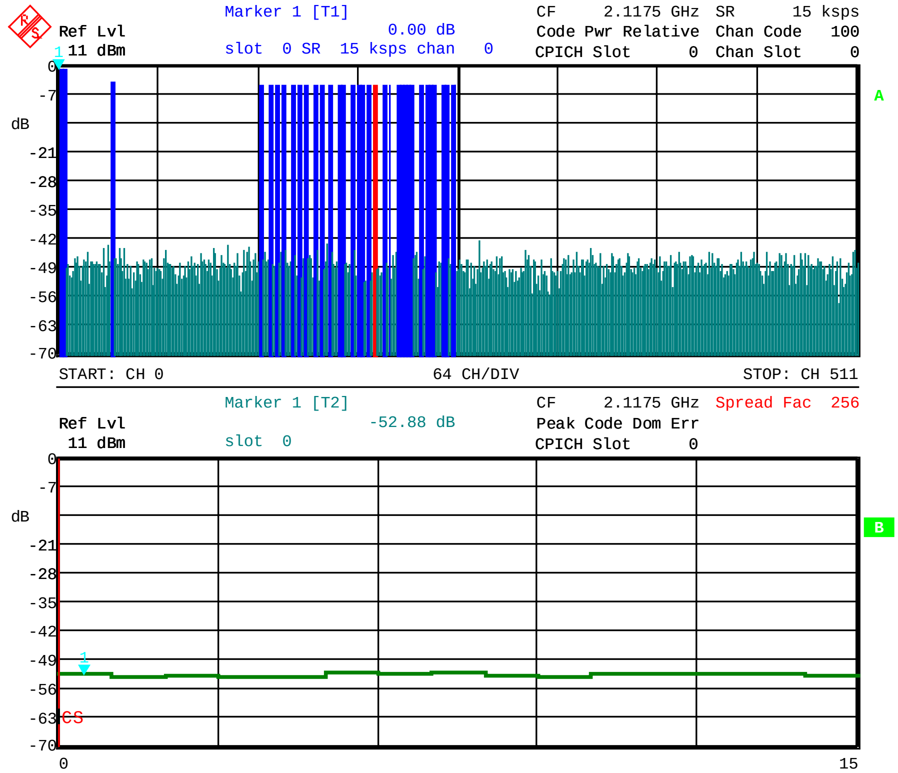
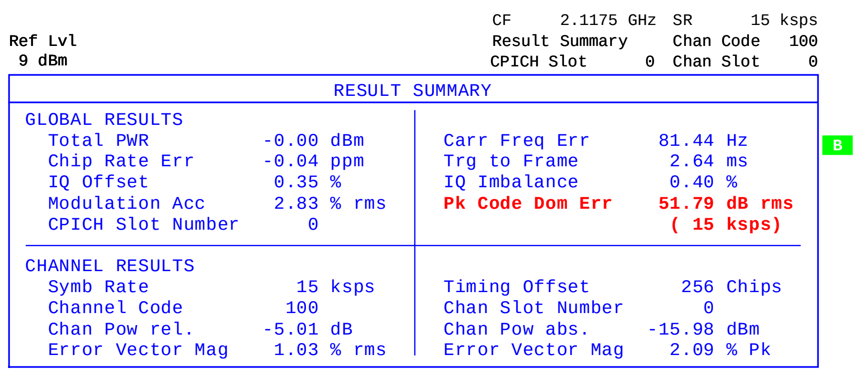


Fig 15 Graphic display of the Peak Code Domain Error using test model 3 dependent on the slot number for a complete frame

In the lower part of the screen the PCDE in each of the 15 timeslots of a W-CDMA frame is output in a trace. Within a timeslot the PCDE is a constant value. The numbered value of the PCDE can easily be read out using the marker. The spreading factor used for the error projection is output on top of the PCDE display (= 256 in figure 15).

Alternately the PCDE for the complete frame can be read out from the GLOBAL RESULTS in the Result Summary (see figure 16).


Ref Lvl 9 dBm
CF 2.1175 GHz SR 15 ksps
Result Summary Chan Code 100
CPICH Slot 0 Chan Slot 0

RESULT SUMMARY

GLOBAL RESULTS

Total PWR	-0.00 dBm	Carr Freq Err	81.44 Hz
Chip Rate Err	-0.04 ppm	Trg to Frame	2.64 ms
IQ Offset	0.35 %	IQ Imbalance	0.40 %
Modulation Acc	2.83 % rms	Pk Code Dom Err	51.79 dB rms (15 ksps)
CPICH Slot Number	0		

CHANNEL RESULTS

Symb Rate	15 ksps	Timing Offset	256 Chips
Channel Code	100	Chan Slot Number	0
Chan Pow rel.	-5.01 dB	Chan Pow abs.	-15.98 dBm
Error Vector Mag	1.03 % rms	Error Vector Mag	2.09 % Pk

Fig 16 Numeric display of the Peak Code Domain Error

4 Measurements in Spectrum Domain

Occupied Bandwidth (OBW)

Occupied Bandwidth (OBW) is a measure of the bandwidth containing 99% of the total integrated power for transmitted spectrum and is centered on the assigned channel frequency. The occupied channel bandwidth shall be less than 5 MHz based on a chip rate of 3.84 Mcps.

For measurement of the OBW test model 1 is used.

The FSIQ measures the OBW using scalar spectrum analyzer mode. By setting up the OBW measurement with the dedicated function provided by FSIQ-K72, the FSIQ uses a pre-defined setting as specified in TS25.141. The total power is measured within a span of 10 MHz.

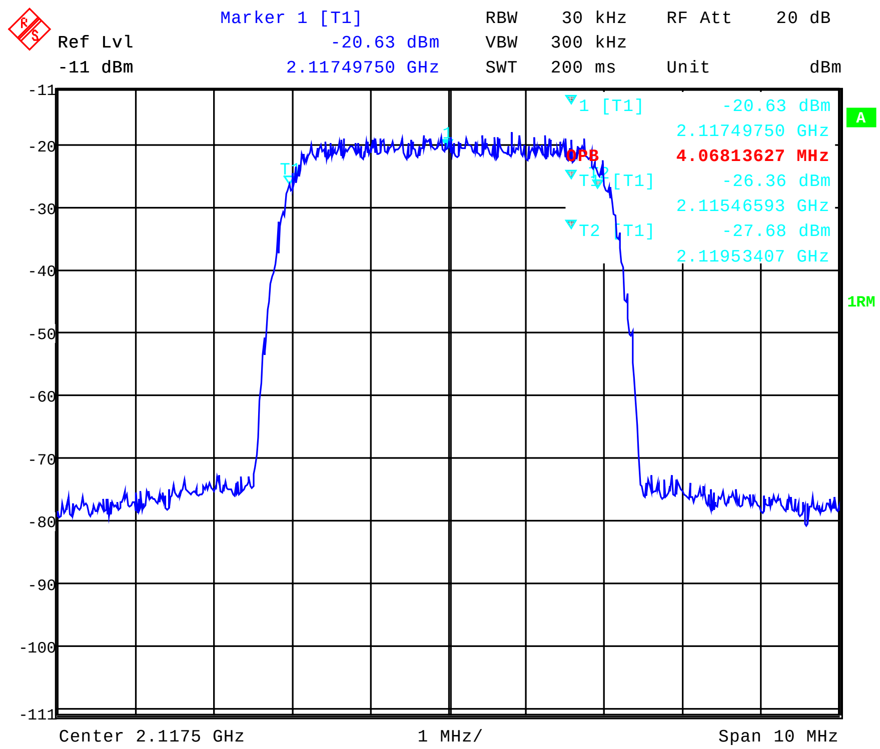


Fig 17 Measurement example for Occupied Bandwidth measurement

The FSIQ first measures the total power by integrating the pixels of the complete trace. The FSIQ then integrates the trace beginning with the start frequency until the power is 0.5 % of the total power. Finally it integrates the trace beginning with the stop frequency until 0.5 % of the total power is reached. The OBW is calculated from both frequencies at the 0.5-% power point.

Spectrum Emission Mask

The Spectrum Emission Mask measurement defines a mask in a 25 MHz span, which must be met by a base station output signal. Close to the carrier a 30 kHz measurement bandwidth is used whereas far off the carrier a 1 MHz bandwidth is used. Test model 1 is specified in TS25.141 for the measurement.

The following figure shows the limits and the associated measurement bandwidths dependent on the frequency offset from the transmit channel:

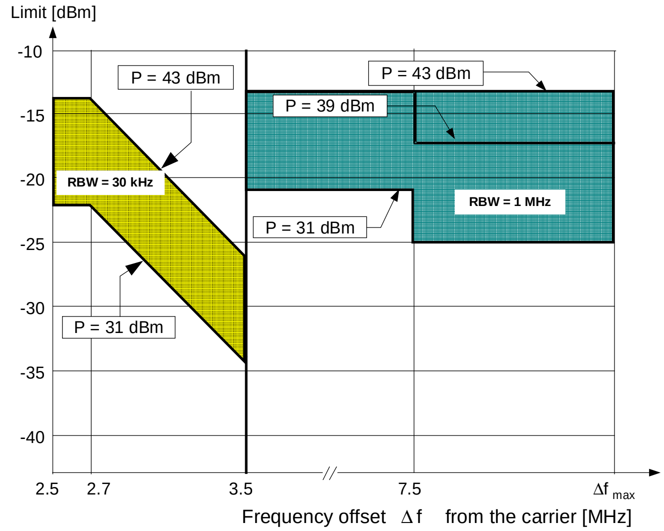


Fig 18 Limits for the spectrum emission mask measurement

The test limits are dependent on the output power of the base station. With most spectrum analyzers, using 4- or 5-pole Resolution Bandwidth (RBW) filters the selectivity of the 1-MHz RBW filter causes leakage of the transmit signal close to the carrier at 3.5 MHz offset. Using a 1-MHz resolution bandwidth, leakage power due to the filter characteristic is measured rather than leakage power due to the signal itself.

The standard TS25.141 therefore allows simulating the 1-MHz measurement bandwidth by using a narrow resolution bandwidth and integration over 1 MHz. This so-called Integrated Bandwidth method (IBW) gives true results for the average power in the 1 MHz bandwidth. However, peak power due to transients cannot be measured correctly.

The FSIQ-K72 automatically detects, based on the input power, what test limit to apply and reports if the test has been passed or failed according to the 3GPP limits. The user also has the option to define which power class limits to test against, or even to define the limits.

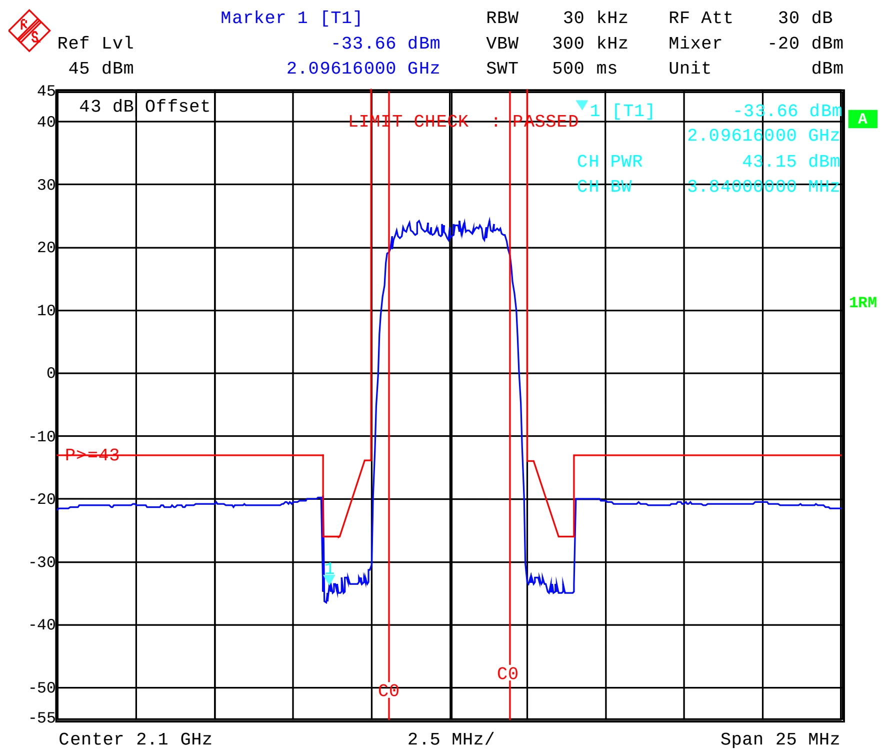


Fig 19 Measurement of the Spectrum emission mask using the FSIQ-K72

Measurement of the Adjacent Channel Leakage Ratio (ACLR)

For Adjacent Channel Leakage Ratio measurement (ACLR) test model 1 is used. ACLR is defined as the ratio of the average power in the transmit channel to the power in the 5-MHz and 10-MHz offset channels, each measured with a 3GPP receive filter (root raised cosine filter, $\alpha = 0.22$ and $f_{chip} = 3.84$ Mcps). The standard states that a true rms voltage or an average power measurement method must be used. The stability of the test result shall be ≤ 0.2 dB at a 95 % confidence level. A favorable method to accomplish this is the use of a rms detector in a spectrum analyzer. It measures the true average power during a settable time frame.

The Signal Analyzer FSIQ provides a pre-defined test routine for ACLR measurement on 3GPP signals using the rms detector. It calculates the required root raised cosine filter by weighting the trace pixels before integrating them for the power in the different channels. The stability of the test result is influenced by the set sweeptime.

When measuring all 5 channels specified in the standard a sweeptime of 500 ms leads to a standard deviation of the ACLR values of 0.1 dB. This corresponds to 0.2-dB stability with a 95 % confidence level.

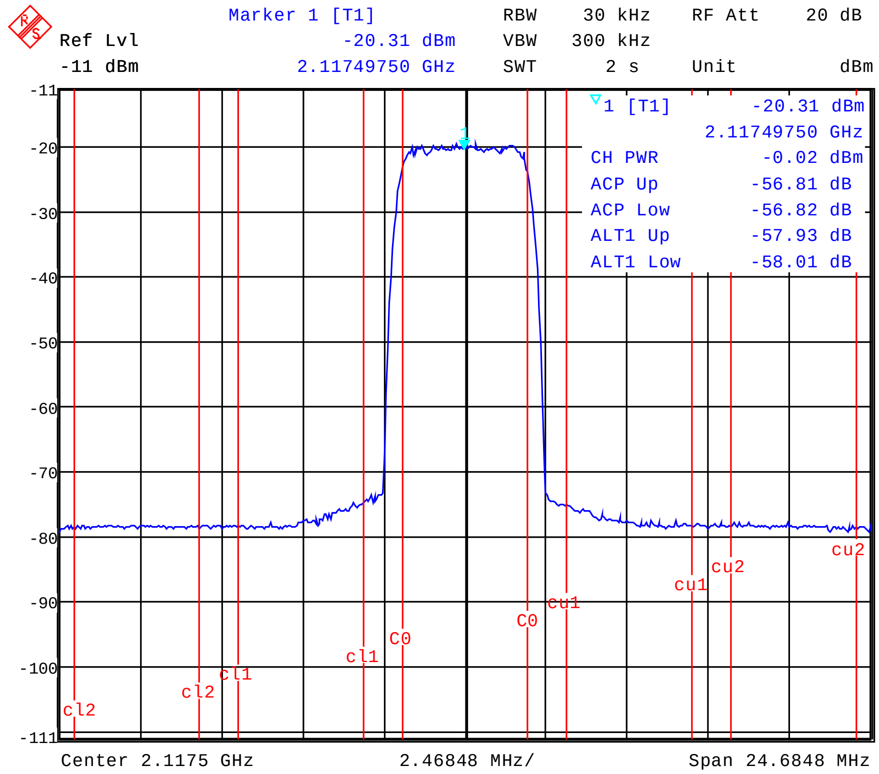


Fig 20 Measurement of the Adjacent Channel Leakage Ratio using the FSIQ

In the 3GPP standard (TS 25.141, Ver. 3.5.0) the following ACLR values are mandatory at the antenna connector of the base station:

Channel offset	ACLR
± 5 MHz	-44.2 dBc
± 10 MHz	-49.2 dBc

For the analyzer not to influence the ACLR value the inherent ACLR should be about 10 dB lower than the specified limits to measure. With 10 dB margin the error introduced by the analyzer is +0.41 dB.

As all stages of the transmitter chain contribute to the total ACLR at the base station output, in general the ACLR values of the different stages need to be lower. This sets higher requirements for the inherent ACLR of the analyzer.

In the 2-GHz frequency range the FSIQ provides an inherent ACLR of -75 dBc in the 5-MHz offset channel at the optimum mixer level1 of about -12 dBm. Taking the 10-dB step-size of the input attenuator into consideration the inherent ACLR is - 71 dBc in the worst case within the mixer level range between -8 and -18 dBm. For higher requirements a 1-dB step attenuator (option FSE-B13) can be added to the FSIQ to meet the optimum level (-12 dBm) of the mixer for any level at the RF input. In the 10-MHz offset channel the respective value is -81 dBc at the optimum mixer level of -3 dBm. The assumed crest factor of the W-CDMA signal is 11 dB for these values.

For details of ACLR measurement using FSE Spectrum Analyzers see [3].

[1] Mixer level = level at the RF connector of the analyzer - RF attenuation

5 Additional Useful Code Domain Measurements

In addition to the measurements required for the conformance test according to TS 25.141 other measurements are very helpful while developing base stations or their modules, and for trouble-shooting.

For a quick check of the organization part of a channel, viewing the bitstream within a slot is very helpful. The FSIQ outputs the detected bitstream for the selected code channel and timeslot.

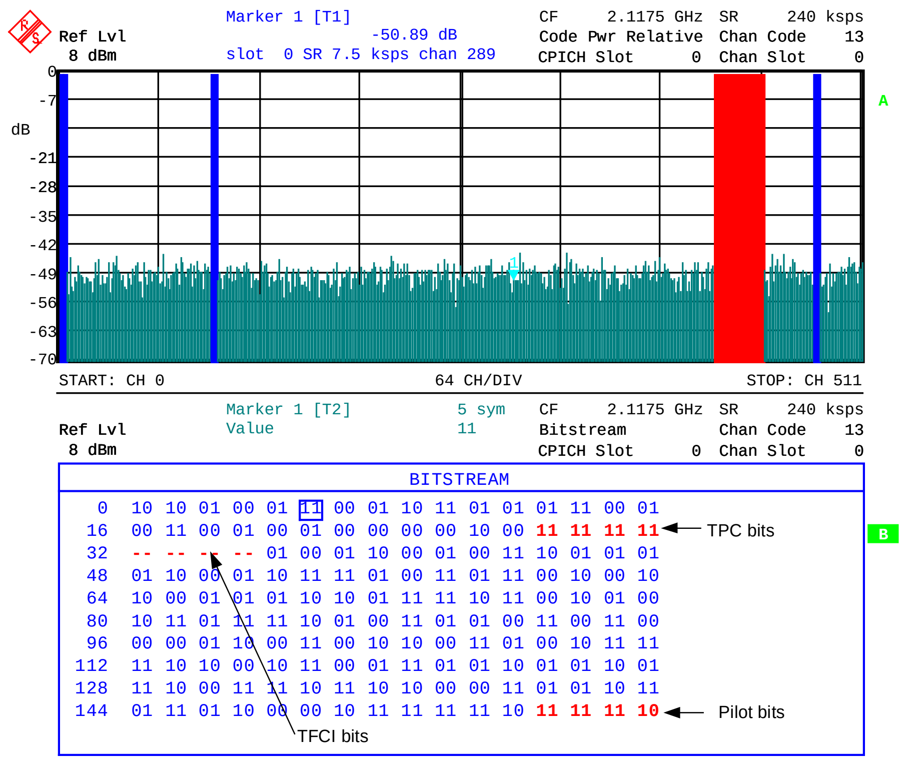


Fig 21 Bitstream Output of the dedicated physical channel 13 using a symbol rate of 240 kbps, timeslot 0

The example in figure 21 shows the bitstream in slot 0 of code channel 13 with a symbol rate of 240 kbit/s. No TFCI bits (Transport Format Combination Indicator) have been transmitted in this channel. Therefore on the positions of the TFCI bits '-' are output as the FSIQ could not detect valid symbols.

Symbol Constellation Diagram

For each channel a constellation diagram of the de-spread symbols can be defined. As a measure of the quality of the specific code channel an EVM at the symbol level is helpful as a numbered value. From both, the impact of a non-ideal transmission block on an individual user channel can be seen.

Figure 22 shows an example for a constellation diagram of code channel 72 marked red in the code domain display. The signal under test has been clipped in baseband in front of the transmit filter.

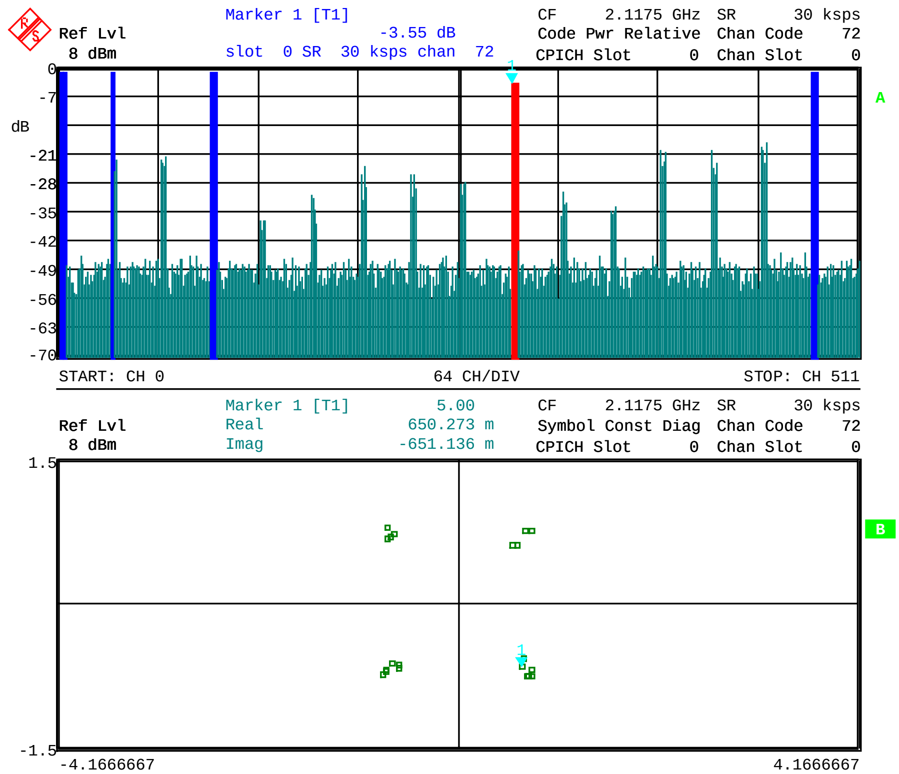


Fig. 22 Constellation diagram of code channel 72 and code domain power of a W-CDMA signal with clipping.

Due to the clipping, energy from the used code channels is spread into inactive code channels. The clipping can be seen more clearly in the symbol constellation diagram. Some of the constellation points show a lower magnitude than expected from an ideal signal.

6 Additional Useful Spectrum Measurements

As the W-CDMA signal is similar to a noise signal, statistical information can be useful during development and trouble shooting. It can for instance be used to determine the headroom that is needed for components or when studying the effects of the baseband clipping.

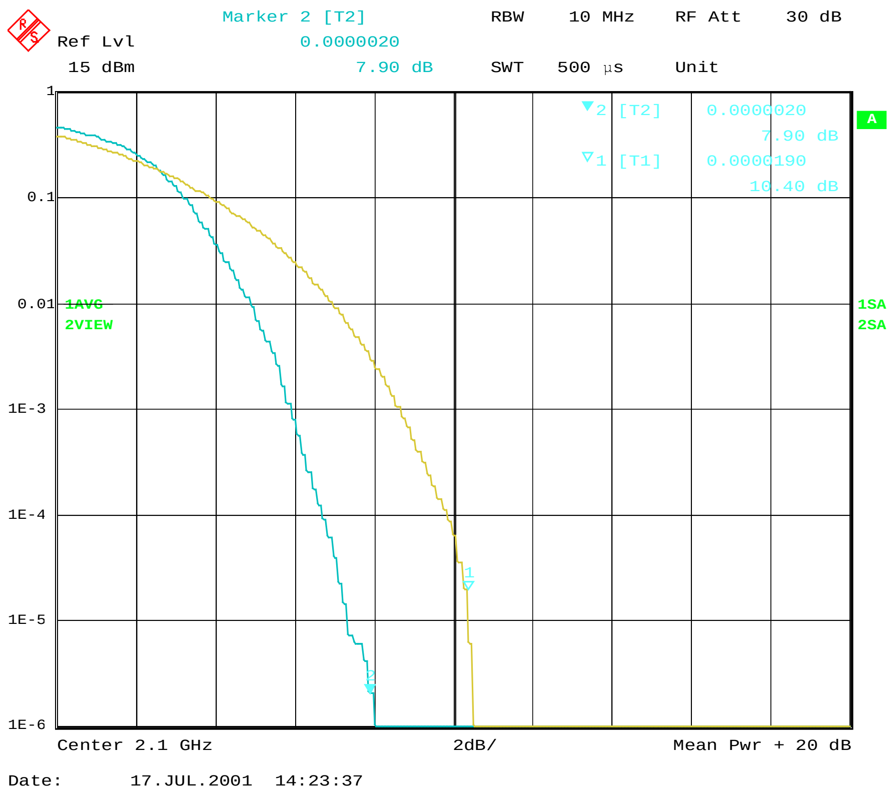


Fig 23 Measurement of the CCDF using the FSIQ

In Figure 23 Test model 1 from TS 25.141 with 64 codes has been measured without clipping as well as clipped in the baseband. Both signals fulfill the 3GPP requirement on PCDE. However, one of the signals has a 2.5 dB lower crest factor, and hence does not stress the transmitter as much.

7 Test Tolerances

In contrast to most mature mobile communication standards, 3GPP has separated the system requirements and the test requirements. The concept makes use of minimum requirements, test requirements and test tolerances.

The minimum requirements are requirements that do not take uncertainties introduced by test and measurement into account and can be seen as system requirements. These requirements are also frequently called core requirements. The test requirements are the minimum requirements related with the maximum acceptable test tolerance. The test requirements contain the values with which the result of a test shall be compared in order to determine the outcome of that test. The test tolerance is either equal to the maximum acceptable test uncertainty or it is set to zero. Requirements that are based on regulatory requirements, such as the ITU-R recommendation SM329-8 on spurious emission, or where the test system uncertainty could not be determined, have a zero test tolerance. If a test system has a higher uncertainty than the maximum acceptable, the test tolerance is reduced by the value by which it exceeds the acceptable uncertainty.

Regardless of how the test system uncertainty is applied in the standard for the test requirements, low test system uncertainties always have the benefit of more stabile and repeatable results. For the requirements with non-zero test tolerance, a lower than specified test system uncertainty, the 3GPP concept provides additional margins for the design.

8 Abbreviations

3GPP	Third generation partnership project
ACLR	Adjacent Channel Leakage Ratio
CCDF	Complementary Cumulative Distribution Function
CPICH	Common Pilot Channel
DCCH	Dedicated Control Channel
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel
DPDCH	Dedicated Physical Data Channel
DTCH	Dedicated Traffic Channel
EVM	Error Vector Magnitude
FACH	Forward Access Channel
ITU	International Telecommunication Union.
PICH	Paging Indication Channel
PCCPCH	Primary Common Control Physical Channel
PCDE	Peak Code Domain Error
PCH	Paging Channel
PSCH	Primary Synchronization channel
SCCPCH	Secondary Common Control Physical Channel
SCH	Synchronization Channel
SSCH	Secondary Synchronization Channel
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control

9 Literature

[1] Technical Specification TS 25.104 V 4.0.0, 3rd Generation Partnership Project (3GPP), Technical Specification Group (TSG) RAN WG4, UTRA (BS) FDD; Radio transmission and Reception

[2] Application Note 1GP39_0E, W-CDMA Signal Generator Solutions by Rohde & Schwarz

[3] Application Note 1EF40_E, Measurement of Adjacent Channel Power on Wideband CDMA Signals

[4] Josef Wolf and Bob Buxton, "Measure Adjacent Channel Power With a Spectrum Analyzer, " *Microwaves & RF*, January 1997, pp. 55-60.

10 Ordering information

Type of instrument

		Ordering number
FSIQ3	20 Hz to 3.5 GHz	1119.5005.13
FSIQ7	20 Hz to 7 GHz	1119.5005.17
FSIQ26	20 Hz to 26.5 (27) GHz	1119.6001.27
FSIQ-B70	DSP and IQ Memory Extension	1119.6747.02
FSIQ-K72	Application Firmware 3GPP Code Domain Power Measurement for FSIQ	1126.4746.02

ROHDE & SCHWARZ GmbH & Co. KG · Mühldorfstraße 15 · D-81671 München · P.O.B 80 14 69 · D-81614 München ·
Telephone +49 89 4129 -0 · Fax +49 89 4129 - 13777 · Internet: http://www.rohde-schwarz.com