**Rohde & Schwarz Products: CMU200, CMU-K64**

# How to do Measurements according to TS 34.121 in presence of the HS-DPCCH with the R&S® CMU200

## Application Note 1CM62

With the extension of the 3GPP FDD system to include HSDPA, the HS-DPCCH has been added as a new code channel in the uplink. This Application Note describes the transmitter measurements provided by the CMU200 to perform the transmitter measurements defined in TS 34.121 in presence of the HS-DPCCH. CMU200 receiver measurements according to TS 34.121 that measure the throughput and the CQI reporting are described.

**ROHDE & SCHWARZ**

# Contents

# 1   Motivation

In Release 99, the measurements which are defined in TS 34.121 chapter 5 (Transmitter Characteristics) are made with a reference measurement channel 12.2 kbps. This RMC defines one code channel on the I-branch (DPDCH) and one code channel on the Q-branch (DPCCH) which are both continuously transmitted (except for compressed mode cases).

With Release 5, there is an additional code channel for the uplink, the HS-DPCCH. This code channel is on the Q-branch in case of the RMC 12.2 kbps and in the case of a Signalling Radio Bearer (SRB). It is not continuously transmitted which results in power transients which are not due to inner loop power control. Furthermore, the HS-DPCCH slot boundaries are not necessarily aligned to the slot boundaries of the DPCH which means that there may be power transients within the inner loop power control period.

The properties of the HS-DPCCH pose new challenges for the UE transmitter design. This document is intended to provide help with determining the transmitter and receiver characteristics of a  Release 5 UE by means of the R&S CMU200. The transmitter characteristics are measured by means of the Power, Modulation, Code Domain Power and Spectrum measurements, whereas the receiver characteristics are measured with the throughput measurement, the CQI measurement, and the HS-DPCCH logging tool.

This application note assumes basic knowledge of HSDPA technology as outlined in the application note [3]. A complete reference of the CMU200 software options CMU-K61/.../-K69 is found in [4].

# 2   Preconditions

Hardware Option CMU-B21v14, B56, B68 is installed.

Software Option CMU- K64, K65, K66 and at least one signalling band (K61…K63, K67…K69)
Base SW >= V3.80

K68: SW  >= V3.80

# 3   Call Setup

- In the Network tab, select Packet Switch Domain On before Registering the DUT
  (*Connection Control / Network --> Packet Switch Domain: ON)*

- In the HSDPA section, select the appropriate UE category (CQI or User defined mode) or the appropriate HSET  (Fixed Reference channel mode) for the DUT
  (*Connection Control / BS Signal --> HSDPA HS-DSCH --> UE category: xx)*
  (*Connection Control / BS Signal --> HSDPA HS-DSCH --> Channel Configuration Type [CQI, Fixed Ref. Channel, User Defined]).*

- Select the HSDPA Test Mode call.
  *(Connection Control / BS Signal --> Packet Switched --> HSDPA Testmode [SRB + HSDPA,RMC + HSDPA])*

- In the measurement tab, select the HS-DPCCH trigger. This trigger makes sure that all measured slots contain the desired part of the HS-DPCCH.
  *(Connection Control / Trigger --> Measurement Trigger Source: HSDPCCH)*

- In the Physical Channel section, choose the DL DPCH timing offset in order to get the desired timing offset between the DPCH and the HS-DPCCH (denoted T_DPCH_HS-DPCCH).
  *(Connection Control / BS Signal --> Downlink Physical Channels --> DL DPCH Timing Offset: 1..149)*

  T_DL_DPCH_Offset is the offset between the PCCPCH and the DL DPCH in symbols of SF256 (range 0..149).
  The timing offset between the DPCH and the HS-DPCCH in units of an SF256 symbol can be calculated by:

  T_DPCH_HS-DPCCH = (((170 – T_DL_DPCH_Offset) mod 30) + 101) mod 10

  Examples:
  1. T_DL_DPCH_Offset = 0 leads to an offset of 256 chips between the UL DPCH and the HS-DPCCH. This is the default setting of the CMU200.

  2. T_DL_DPCH_Offset = 1 will align the slot borders of the UL DPCH and the HS-DPCCH. This setting is not supported in V3.80 but will be supported in a later CMU200 SW Release.

  3. T_DL_DPCH_Offset = 6 leads to an offset of 5*256 chips between the UL DPCH and the HS-DPCCH. That means that the HS-DPCCH slot border cuts the DPCH slot halfway. This setting is used in this application note.

- In the UE Signal Tab, select the $\beta-$ factors used for the sub test
  *(Connection Control / UE Signal --> UE Gain factors --> HSDPA Test Mode: [$\beta_c$, $\beta_d$, $\Delta_{ACK}$, $\Delta_{NACK}$, $\Delta_{CQI}$]*

- *Select a* CQI Feedback Cycle appropriate for the test.
  *(Connection Control / BS Signal --> HSDPA HS-DSCH --> CQI Feedback Cycle [Off, 2ms, 4ms, 8ms, 10ms, 20ms, 40ms, 80ms, 160ms])*

- Register the UE. The message "PS:Attached" appears.

- Go into a Packet Switched Call.
  *(Connection Control / Connection --> Connect UE(PS))*


**Properties of the HSDPA Test Mode Example shown in this application note**


- The HSDPA Call is made with an SRB 3.4. An HSDPA Test Mode with an SRB 2.5 + RMC 12.2 kbps is also available on the CMU200.

- T_DL_DPCH_Offset = 6 is used. The start of an HS-DPCCH slot is therefore in the middle of a DPCH slot.

- The Gain Factors used are $\beta_c$ = 11, $\beta_d$ = 15, $\Delta_{ACK}$ = $\Delta_{NACK}$ = 5, $\Delta_{CQI}$ = 2. This is the default setting of the CMU200. The Gain Factors are defined in [2].

# 4 TX Measurements according to TS 34.121

## Maximum Output Power with HS-DPCCH (TS 34.121 5.2A)

- Start the Maximum Power Measurement:

  *(Menus -> Power --> Application --> Maximum Power)*

In order to guarantee that the measurement period contains at least partially a transmitted HS-DPCCH, use the HS-DPCCH trigger. This trigger makes sure that the DPCH slot used as the measurement period contains the start of an HS-DPCCH subframe in which an Ack or Nack is expected.

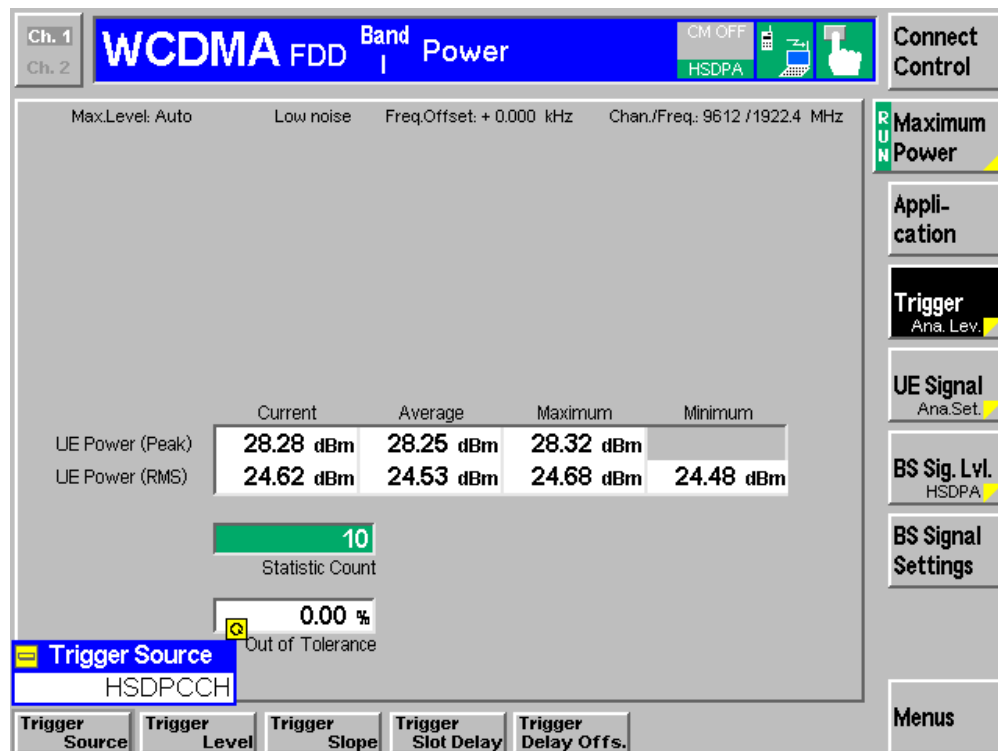- *(Ana. Lev./ Trigger --> Trigger Source: HSDPCCH)*



Figure 1: Maximum Output power

## HS-DPCCH (TS 34.121 5.7A)

The CMU200 features a Code Domain Power vs. Time measurement which is appropriate for the HS-DPCCH measurement defined in TS 34.121 5.7A. This Code Domain Power vs. Time measurement is available via Remote Control in V3.80 and will be implemented in the user interface for manual use in a later CMU200 SW release. The CMUgo PC application provides a comfortable user interface to the Remote Control interface.

The CDP vs. Time measurement records 470 symbol power values each for the total UE power and for the code channel powers of the DPCCH, HS-DPCCH and the relevant DPDCHs. A symbol has the length 256 chips. The power value sequence starts with the measurement trigger set by the user, for example the HS-DPCCH trigger already described in the Call Setup chapter.

- *(Ana. Lev./Trigger --> Trigger Source: HSDPCCH)*
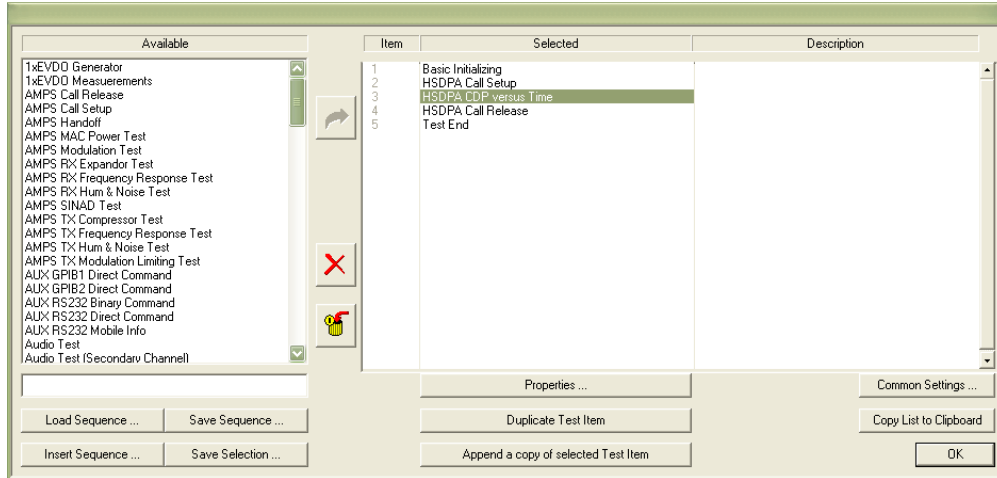


Figure 2: CMUgo Application

Figure 3: CDP vs. Time Selection


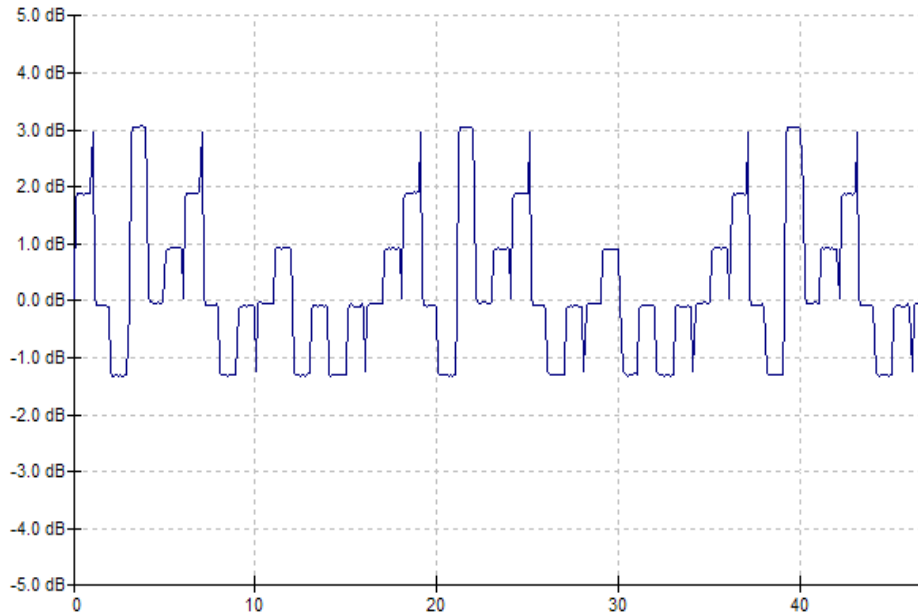
Figure 4: UE Power vs. Time for 47 slots

The total UE power diagram shows the UE power over 47 slots with a measurement value for every 66.7 µs or 256 chips. The reference is the RF Target Level given in the result window (0.0 dBm in the example shown in figure 4).

The measurement defined in TS 34.121 5.7A defines the measurement periods as the time between the HS-DPCCH power transients and the DPCH power transients if the HS-DPCCH and the DPCH are not aligned. With the HS-DPCCH trigger, the CDP vs. Time measurement starts at the DPCH slot which contains the start of an Ack/Nack slot in the HS-DPCCH subframe.

Here is an example of how the CDP vs. Time total power results can be used for the HS-DPCCH measurement:

With a DL DPCH Timing Offset of 6*256 chips as defined in 5.7A.4.1, the HS-DPCCH slot borders are in the middle of the DPCH slot. Therefore, power transients occur after every five 256 chip symbol. The CDP vs. Time measurement delivers a power value for every 256 chip symbol. Thus the CDP vs. Time results can be used for the measurement in 5.7A.4.1 if five succeeding values are averaged starting with the first symbol power value of the measurement as shown in table 1. The 470/5 = 94 averaged values can then be used as power values for the measurement periods defined in TS 34.121 5.7A.

In the example the HS-DSCH scheduling for the DUT is XXXOOOXXXOOO... meaning that the DUT is scheduled in 3 adjacent subframes and not scheduled in the next 3 adjacent subframes.

| Average the total UE power values with the indices | HS-DPCCH section | Remark |
|---|---|---|
| 0,1,2,3,4 | CQI or DTX | Depending on the CQI Feedback Cycle used |
| 5,6,7,8,9 | Ack/Nack | The HS-DPCCH trigger makes sure that Ack or Nack is found at this position |
| 10,11,12,13,14 | Ack/Nack | |
| 15,16,17,18,19 | CQI or DTX | |
| 20,21,22,23,24 | CQI or DTX | |
| 25,26,27,28,29 | CQI or DTX | |
| 30,31,32,33,34 | CQI or DTX | |
| 35,36,37,38,39 | Ack/Nack or DTX | |
| 40,41,42,43,44 | Ack/Nack or DTX | |
| 45,46,47,48,49 | CQI or DTX | |
| 50,51,52,53,54 | CQI or DTX | |
| 55,56,57,58,59 | CQI or DTX | |
| 60,61,62,63,64 | CQI or DTX | |
| 65,66,67,68,69 | Ack/Nack or DTX | |
| 70,71,72,73,74 | Ack/Nack or DTX | |
| 75,76,77,78,79 | CQI or DTX | |
| 80,81,82,83,84 | CQI or DTX | |
| 85..469 | - | Five succeeding power values are averaged |

Table 1: Symbol Averaging for the HS-DPCCH Measurement

## Annex: HS-DPCCH Code Power versus Time

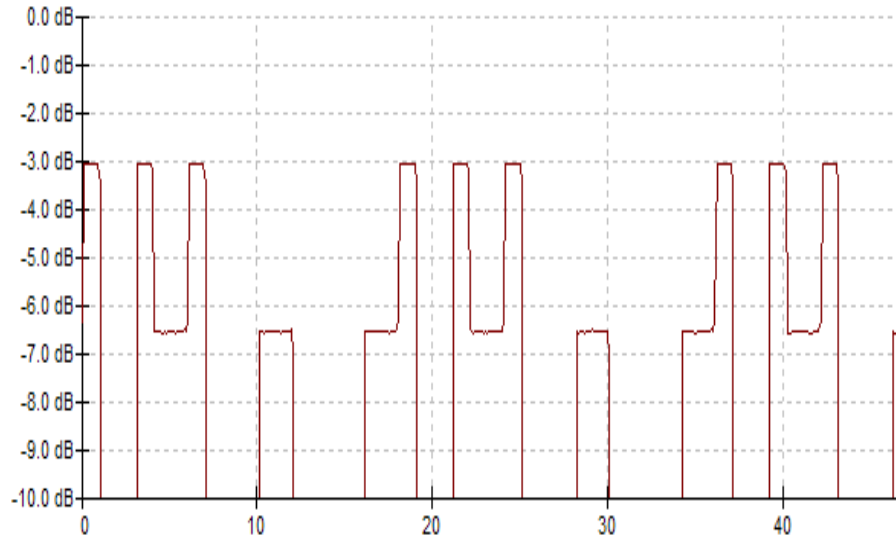*DL Channel: 10562, Attenuation(In/Out) 0.0 / 0.0 dB, RF Target Level 0.0 dBm*



Figure 5: HS-DPCCH Power vs. Time for 47 slots

Figure 5 shows an example of the CDP vs. Time measurement for the HS-DPCCH. The power reference is the total UE power. The HS-DSCH scheduling for the DUT is XXXOOOXXXOOO... and $\Delta_{ACK} = \Delta_{NACK} = 5$. Therefore the HS-DPCCH power is -3dB/total when an Ack or Nack is sent. This happens three subframes in a row before the DUT is not scheduled for the next three subframes. For the CQI, $\Delta_{CQI} = 2$ and a Feedback Cycle of 4 ms is used, so that the CQI is sent every two subframes resp. every 6 slots.

### Spectrum Emission Mask with HS-DPCCH (TS 34.121 5.9A)/ Adjacent Channel Leakage Power Ratio with HS-DPCCH (TS 34.121 5.10A)

- Start the Spectrum Emission Mask:
  *(Menus -> Spectrum --> Application --> Emission Mask)*

- Start the Adjacent Channel Leakage Power Ratio:
  *(Menus -> Spectrum --> Application --> ACLR Filter)*

Two effects generate adjacent channel power:

1. Modulation errors may be introduced because the HS-DPCCH is a new code channel in addition to the DPCCH and the DPDCH. The crest factor is increased.

2. Power switching transients will be introduced when the HS-DPCCH changes its power during a DPCH slot.

Thus, the presence of the HS-DPCCH makes the SEM and ACLR requirements in chapter 5 of TS34.121 harder to meet.

Both measurements, ACLR and SEM, measure the in-band power and the power in adjacent and alternate frequency bands. The power measurements for the different bands take place at different times. In order to make sure that the transmit power of the DUT is the same for all these measurements, the use of the HS-DPCCH trigger is advised. This trigger guarantees that all measurement periods contain the same HS-DPCCH section.
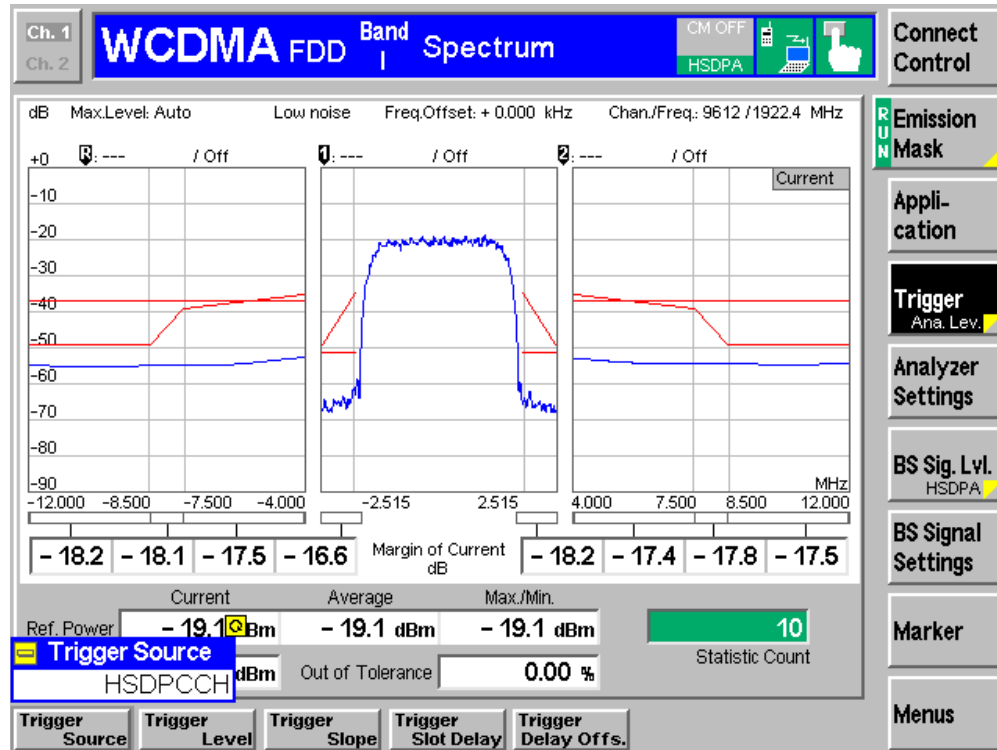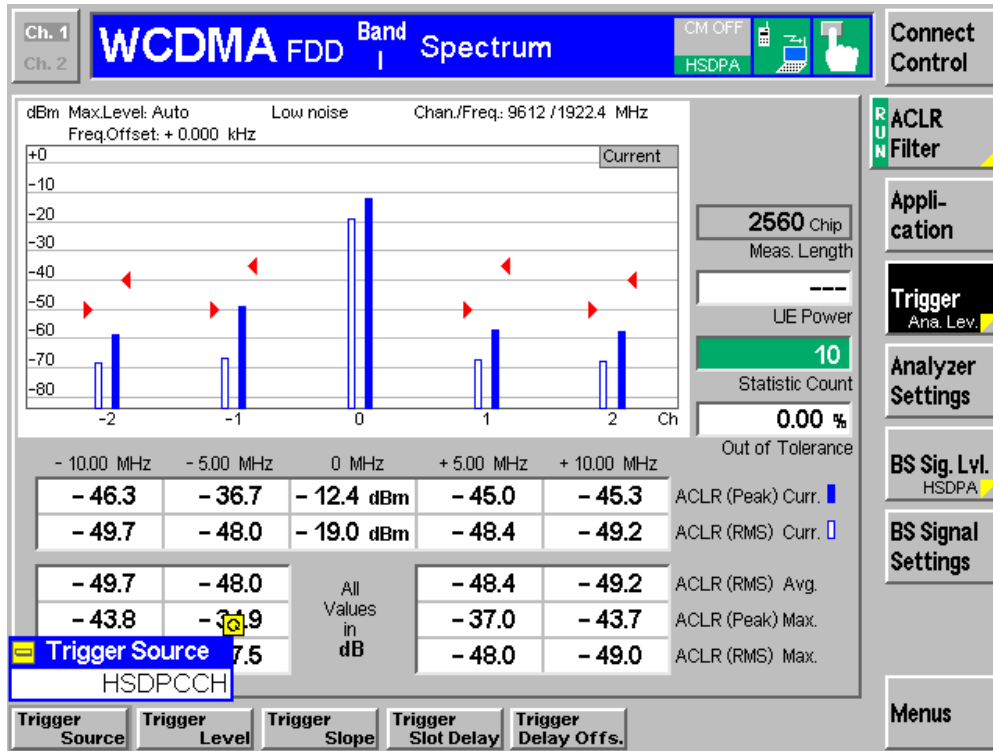


Figure 6: Spectrum Emission Mask

Figure 7: Adjacent Channel Leakage Power Ratio

## Error Vector Magnitude with HS-DPCCH (TS 34.121 5.13.1A)

- Start the Error Vector Magnitude Measurement
  *(Menus -> Modulation --> Application --> EVM WCDMA)*

In Release 99, power transients only occur at the DPCH slot borders due to the inner loop power control. This changes in Release 5. The figures 8, 9, and 10 show the effect of a power rise after the first five SF256 symbol in the slot. An EVM, magnitude and phase error surge appears.

The HS-DPCCH trigger in case of the modulation measurements always marks the DPCH slot that contains the start of a HS-DPCCH subframe in which a valid Ack or Nack is expected. Change the Trigger Slot delay to select a different DPCH slot with the respective parts of the HS-DPCCH subframe.

- Start the Error Vector Magnitude Measurement
  *(Menus -> Modulation --> Application --> EVM WCDMA)*

- Start the Magnitude Error Measurement
  *(Menus -> Modulation --> Application --> Mag. Error WCDMA)*

- Start the Phase Error Measurement
  *(Menus -> Modulation --> Application --> Phase Error WCDMA)*
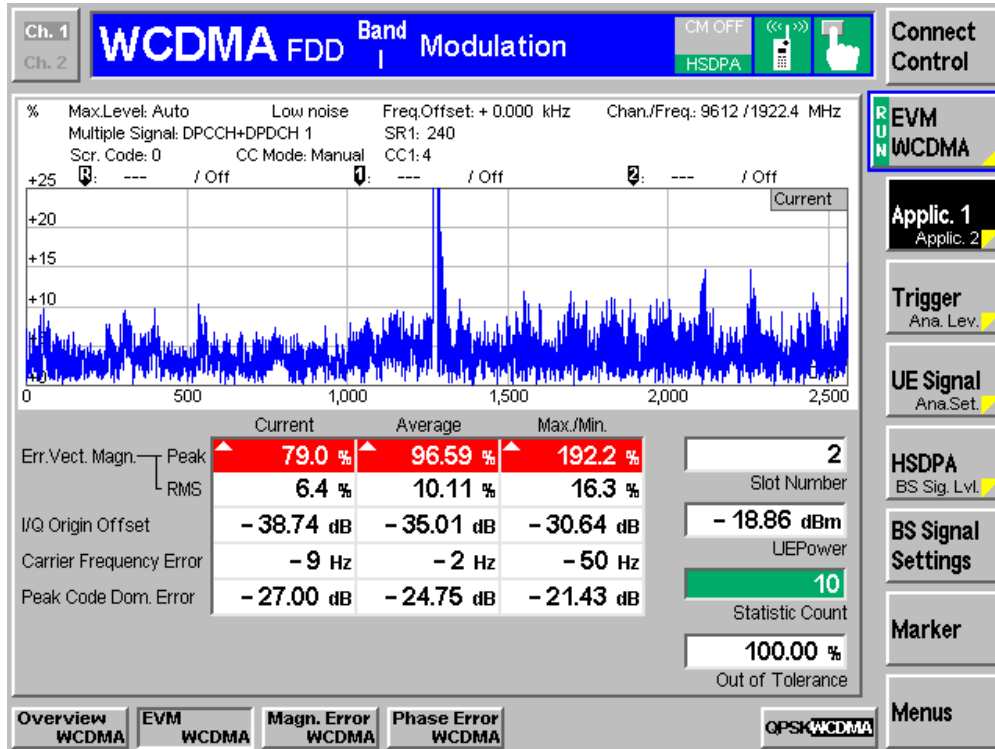
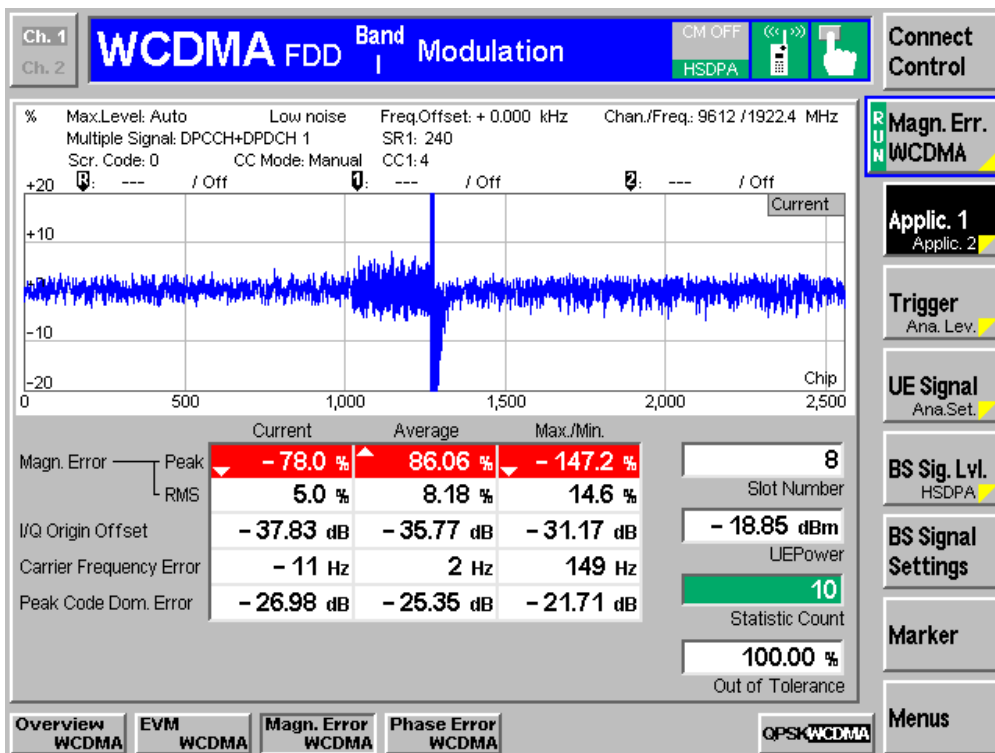Figure 8: EVM in presence of the HS-DPCCH



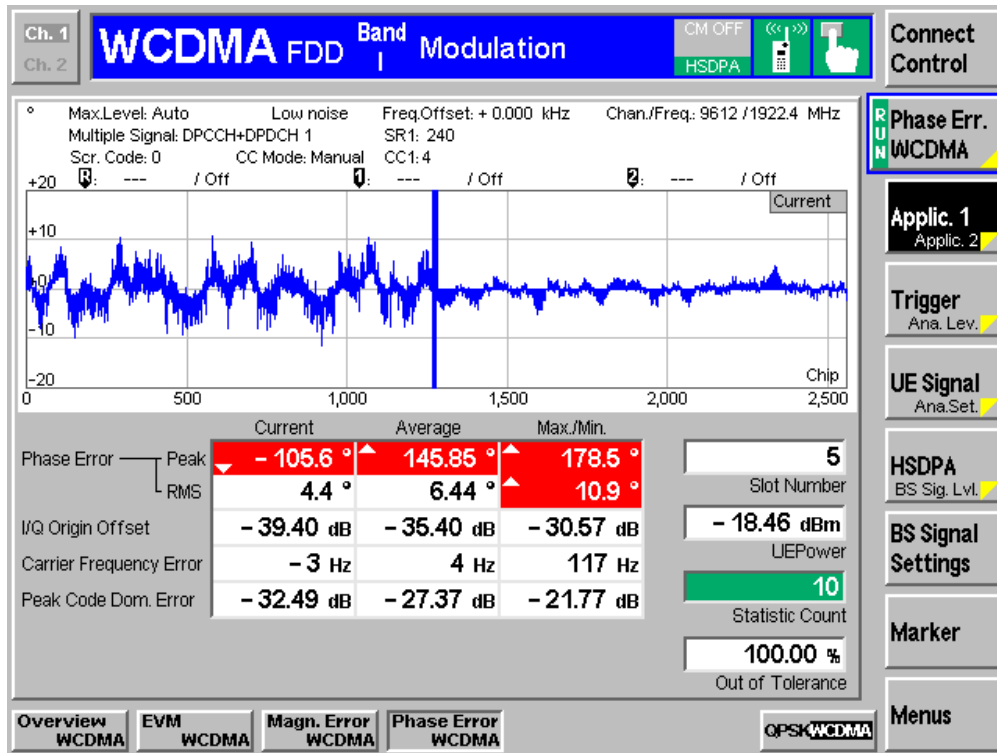Figure 9: Magnitude Error in presence of the HS-DPCCH

Figure 10: Phase Error in presence of the HS-DPCCH

# 5   Additional Tx Measurements provided by the CMU200

### Code Domain Power with HS-DPCCH

- Start the Code Domain Power Manual Measurement
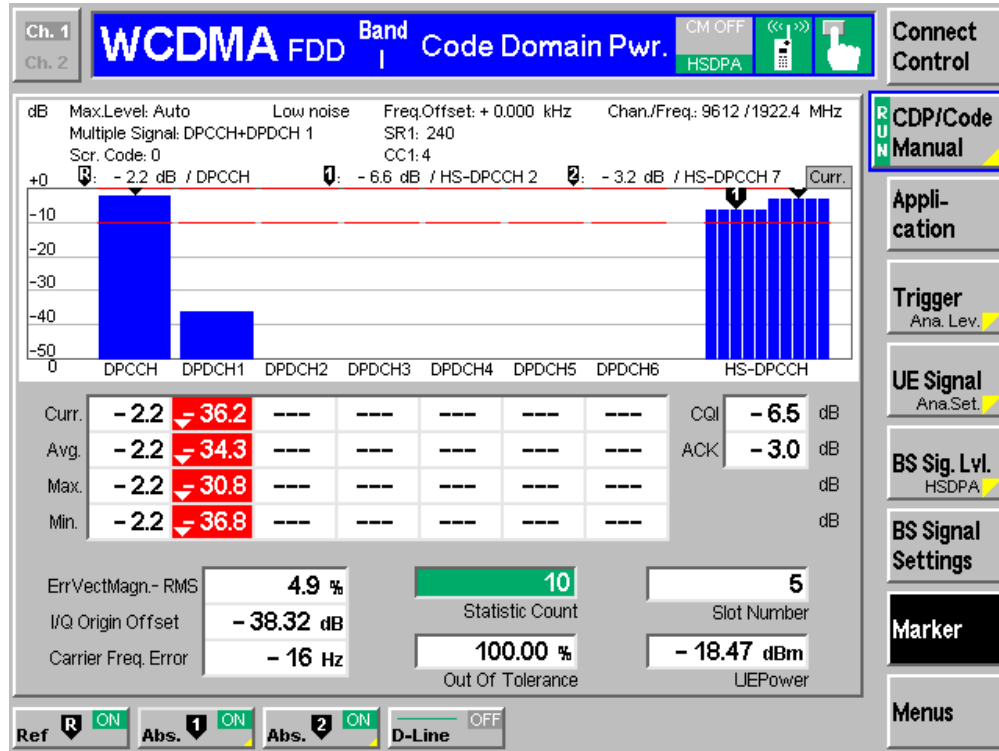  *(Menus -> Code Domain Power --> Application --> CDP/Code Manual)*

Figure 11: Code Domain Power Manual

The measurement diagram in Figure 11 shows the DPCCH, the DPDCH and the HS-DPCCH. The power reference is the total uplink power measured over one DPCH slot.

The DPCCH and DPDCH powers are constant over the measurement period. Therefore, one power bar is shown for these channels. In Figure 11, the DPDCH power is low. No data is transmitted over this channel in the measurement period because the Radio Bearer is a Signalling Radio Bearer which only contains a DCCH. This is a logical channel mapped on the DPDCH which is used to transport signalling information. The residual power is I/Q cross talk from the HS-DPCCH as the DPDCH and the HS-DPCCH have the same code number. According to TS 25.213 the code numbers for the SRB 3.4 are as described in table 2.

| Physical Channel | I/Q branch | Code Number | Remark |
|:---:|:---:|:---:|:---:|
| DPCCH | Q | 0 | |
| DPDCH | I | 64 | SF/4, SF = 256 for SRB 3.4 |
| HS-DPCCH | Q | 64 | Max. Number of DPDCH = 1 |

Table 2: Uplink Code Allocation for the HSDPA Test Mode

The Code Domain Power measurement for the HS-DPCCH is split into ten bars which represent the powers of the ten HS-DPCCH symbols in the DPCH slot.

In general, there will be m = 0..10 Ack/Nack symbols and k = 10 -m CQI symbols shown in the results, if the CQI is present in the current subframe. M and k depend on the DL DPCH timing offset. The HS-DPCCH trigger marks the DPCH slot which contains the first Ack/Nack symbol of the HS-DPCCH subframe. This HS-DPCCH subframe carries the response to HS-PDSCH subframe scheduled 7.5 slots earlier. That means that either Ack or Nack symbols will be present (no DTX), if the DUT reacts correctly on the Harq process scheduling by the CMU200. The following slots of the HS-DPCCH subframe can be seen by configuring the trigger slot delay *(Ana. Lev./Trigger --> Trigger Slot Delay: 0..14)*

In figure 11, the HS-DPCCH bars 1 to 5 show the power of the last CQI symbol of the preceding HS-DPCCH subframe. The bars 6 to 10 show Ack/Nack symbols. The Ack and CQI power fields below the diagram show the averaged power over all CQI resp. Ack/Nack symbols in the DPCH slot. If no CQI or Ack/Nack symbols are present, or if the symbol power is below a threshold (DTX case), no result is shown.

The Ack/Nack power in this field is referred to the total UE power in the DPCH slot while the Ack/Nack symbols are present. The same applies to the CQI power. Thus, in figure 11, the CQI power is referred to the first half of the DPCH slot while the Ack/Nack power is referred to the second half.

# 6   Rx Measurements according to TS 34.121

## Measurement of Receiver sensitivity (TS 34.121 9.2.1 and 9.4)

- Start the Throughput Measurement
  *(Menus -> Receiver Quality --> Application --> HSDPA Ack)*

The CMU200 provides a receiver sensitivity measurement by counting the Acks, Nacks, and DTXs for a specific Harq process or for all Harq processes. The throughput is calculated from the number of Acks and the size of the transport blocks transmitted.

For the measurements defined in TS 34.121

- 9.2.1  Demodulation of HS-DSCH Single Link Performance
- 9.4      HS-SCCH Detection Performance

an external fading simulator like the R&S®SMU200 with fading option must be used for the fading profile.

Figure 12 shows an example of this measurement. A redundancy version (RV) sequence {0,2,5,6} has been chosen.

In order to force errors in the UE receiver, the HS-PDSCH power has been lowered to -12 dB compared to the P-CPICH. The first transmission is always received with a CRC error in the UE. The UE sends a Nack to the CMU200. The CMU200 then uses redundancy version 2 for the

second transmission of the transport block. The  UE receiver is then able to combine the first and second transmission successfully in 92.149 % of all  second transmissions. The remaining 7.851 % of second transmissions still cause  a CRC error in the UE receiver. A third transmission with redundancy version 5 is needed in these cases.

The L1 Harq protocol cares about retransmissions without higher layers interaction. In this example there are no wrongly detected transport blocks. The use of 2nd and 3rd transmissions however reduces the throughput.

The results show 0% DTX, so there are no HS-SCCH detection errors.
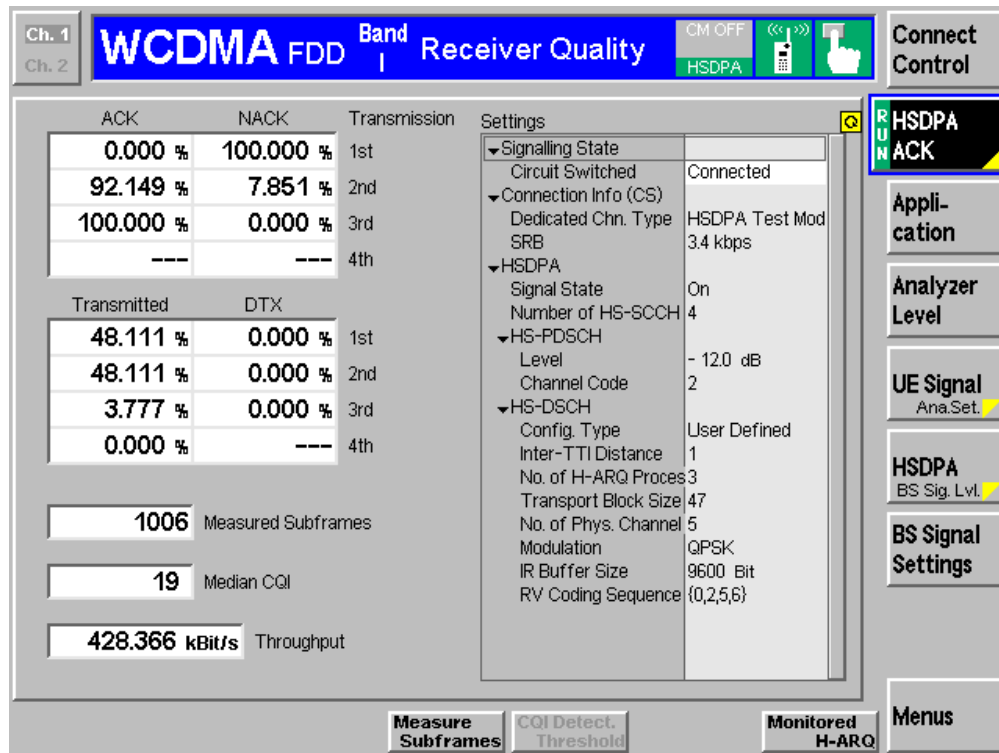


Figure 12: Throughput measurements with HS-PDSCH power = -12dB/P-CPICH

### Reporting of CQI with AWGN propagation conditions (TS 43.121 9.3.1)

• Start the CQI Measurement
 *(Menus -> Receiver Quality --> Application --> HSDPA CQI)*
 *(Connection Control / BS Signal --> HSDPA HS-DSCH --> Channel Configuration Type --> CQI)*
 *(Connection Control / BS Signal --> HSDPA HS-DSCH --> CQI Channel Configuration --> CQI Table Index [Coformance Test])*
 *(Connection Control / BS Signal --> Downlink Physical Channels --> HS-PDSCH --> CQI*
 *Measurement Offset [-6.0 dB .. + 13.0 dB])*

The Channel Quality Indicator is sent by the UE to indicate to the network which data rate it can handle with a block error rate of about 10%. The CQI is an index to a table of transport formats. This table is specific to the UE category. Two conditions are tested in the CQI test:

1. More than 90% of the reported CQIs (except DTX) must be in the interval [median CQI -2, median CQI + 2]

2. If the HS-PDSCH BLER  using the transport format indicated by the median CQI is less than or equal 10%, the HS-PDSCH BLER  using the transport format indicated by the median CQI +2 must be greater than 10%
If the HS-PDSCH BLER  using the transport format indicated by the median CQI is greater than 10%, the HS-PDSCH BLER  using the transport format indicated by the median CQI -1 must be less than or equal 10%.

The CQI Feedback Cycle used will influence the number of DTX shown in the result diagram, but will not influence the Pass/Fail verdict.

The parameter CQI Measurement Offset $\Gamma$ influences the result of this test. The UE estimates the power of the CPICH in order to calculate the CQI. The UE shall assume that

$$P_{\text{HS-PDSCH}} = P_{\text{CPICH}} + \Gamma + \Delta \ [\text{dB}]$$

$\Delta$ is the Reference Power Adjustment to be found in the CQI Table specific to the UE category. It is given for each CQI value. The parameter $\Gamma$ can be used to the balance power offsets between the CPICH and the HS-PDSCH. It can also be used to control the operating point of the HSDPA link in the mode CQI -> FollowCQI. A  CQI Measurement Offset $\Gamma$ of +1.0 dB will increase the CQI reported by the UE by 1, resulting in higher data rate on the HS-PDSCH but also potentially higher HS-PDSCH-BLER.
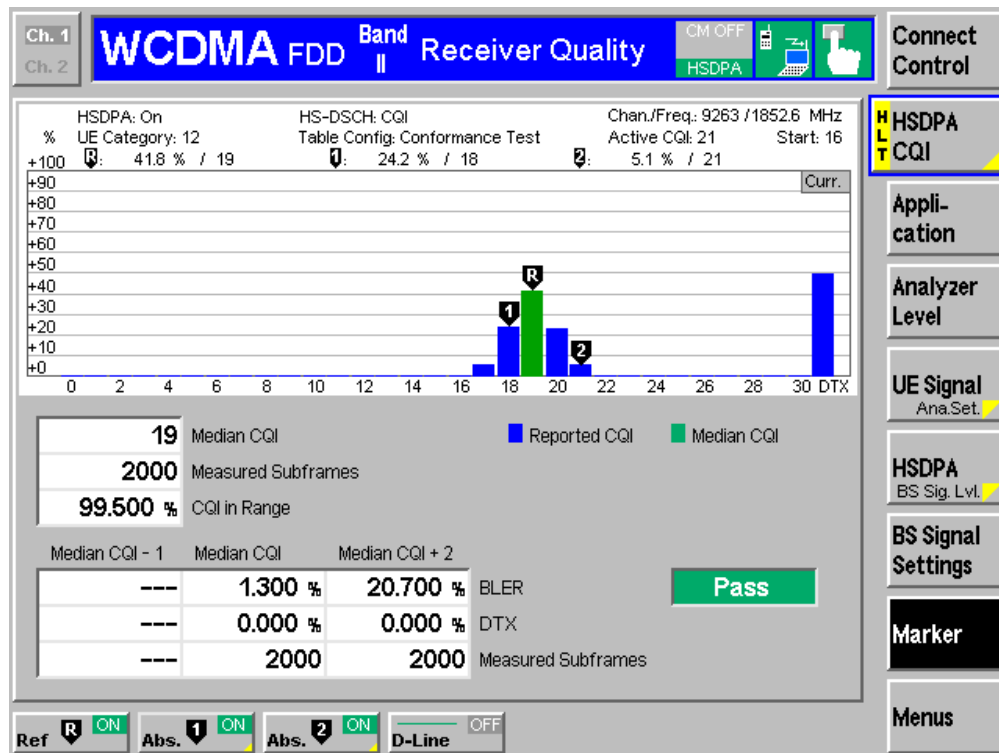


Figure 13: CQI Conformance Test

# 7 Additional Rx Measurements provided by the CMU200

## HS-DPCCH Logging functionality

- Start the HS-DPCCH Logging
  *(Menus -> Receiver Quality --> Application --> HS-DPCCH Logging)*

This functionality can be used to track the HS-DPCCH in order to verify the response to the Harq process scheduling by the CMU200. The logged HS-DPCCH data may also be compared to logging data from the UE.

The Log contains the Ack/Nack and CQI data for 60 consecutive HS-DPCCH subframes. The log starts with subframe 0 of the next system frame or with the StartSFN.
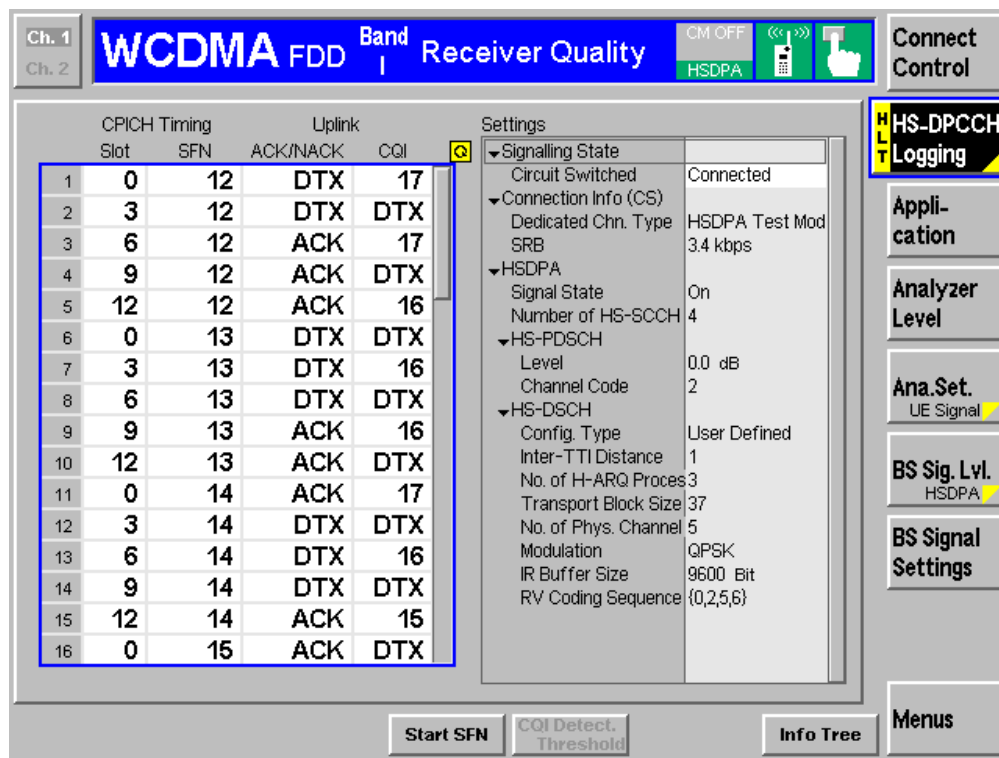
Figure 14: HS-DPCCH Logging

# 8 Additional Information

This application note is updated from time to time. Please visit the website 1CM62 in order to download new versions.

Please contact TM-Applications@rsd.rohde-schwarz.com for comments and further suggestions.

# 9   References

**[1]**  3GPP TS 34.121; Terminal conformance specification; Radio transmission/reception (FDD) (Release 6)

**[2]**  3GPP TS 25.213; Spreading and Modulation (FDD) (Release 5)

**[3]**  Application Note 1MA82; HSDPA Test and Measurement Requirements, Rohde & Schwarz

**[4]**  CMU Operating Manual; Software Options CMU-K61/.../-K69, 1115.4962.12-08, Rohde & Schwarz

# 10 Ordering Information

| | | |
|---|---|---|
| R&S® CMU200 | UNIVERSAL RADIO COMMUNICATION TESTER | 1100.0008.02 |
| R&S® CMU-B21 | HW OPTION FOR CMU200: UNIVERSAL SIGNALLING UNIT (3GPP CAPABLE) | 1100.5200.14 |
| R&S® CMU-B56 | HW OPTION FOR CMU200: 3GPP SIGNALLING UNIT FOR CMU-B21/VAR14 | 1150.1850.14 |
| R&S® CMU-B68 | HW-OPTION FOR CMU200 LAYER1-BOARD (3GPP/FDD, DL+UL) | 1149.9809.02 |
| R&S® CMU-PK60 | SW OPTION FOR CMU200: WCDMA-SIG.: 3GPP/FDD/UE,TX-TEST GENERATOR, BAND 1+2+3+4+5+6 | 1159.3355.02 |
| R&S® CMU-K64 | SW-OPTION FOR CMU200: HSDPA 3GPP/FDD/UE, REL.5 | 1157.3970.02 |
| R&S® CRT-Z3 | 3G UICC/USIM TEST CARD TEST SIM CARD FOR UMTS | 1139.1005.02 |