

# Testing HSPA+

## Application Note

### Products:

R&S®SMW200A	R&S®FSW
R&S®SMU200A	R&S®FSQ
R&S®AMU200A	R&S®FSV
R&S®SMBV100A	R&S®FSU
R&S®CMW500	
R&S®TS8980	

High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) optimize UMTS for packet data services in the downlink and uplink, respectively. Together, they are referred to as High Speed Packet Access (HSPA).

Within 3GPP Release 7, 8, 9 and 10, further improvements to HSPA have been specified in the context of HSPA+ or HSPA evolution.

This Application Note describes how HSPA+ features can be tested using Rohde & Schwarz instruments.

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The following abbreviations are used in this Application Note for Rohde & Schwarz test equipment:

- The R&S®SMW200A vector signal generator is referred to as the SMW.
- The R&S®SMU200A vector signal generator is referred to as the SMU.
- The R&S®SMATE200A vector signal generator is referred to as the SMATE.
- The R&S®SMJ100A vector signal generator is referred to as the SMJ.
- The R&S®SMBV100A vector signal generator is referred to as the SMBV.
- The R&S®AMU200A vector signal generator is referred to as the AMU.
- The R&S®SMW200A, R&S®SMU200A, R&S®SMATE, R&S®SMBV100A and R&S®SMJ100A vector signal generators are referred to as the SMx.
- The R&S®FSQ signal analyzer is referred to as the FSQ.
- The R&S®FSV spectrum analyzer is referred to as the FSV.
- The R&S®FSW spectrum analyzer is referred to as the FSW.
- The R&S®FSU spectrum analyzer is referred to as the FSU.
- The R&S®FSV, FSQ, FSV, FSW and FSU are referred to as the FSx.
- The R&S®CMW500 radio communication tester is referred to as the CMW.
- The R&S®TS8980 RF Conformance Test System is referred to as the TS8980.

# 1 Introduction

UMTS High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) networks worldwide are operated in order to increase data rate and capacity for downlink and uplink packet data. While HSDPA was introduced as a Release 5 feature in 3GPP (3rd Generation Partnership Project), HSUPA is an important feature of 3GPP Release 6. The combination of HSDPA and HSUPA is often referred to as HSPA (High Speed Packet Access).

However, even with the introduction of HSPA, evolution of UMTS has not reached its end. **HSPA+** brings significant enhancements in 3GPP Release 7, 8, 9 and 10. The objective is to enhance performance of HSPA-based radio networks in terms of spectrum efficiency, peak data rate and latency, and to exploit the full potential of W-CDMA operation. Important features of HSPA+ are:

## 3GPP Release 7

- Downlink MIMO (Multiple Input Multiple Output)
- Higher order modulation for uplink (16QAM) and downlink (64QAM)
- Continuous packet connectivity (CPC)
- Enhanced fractional DPCH (F-DPCH)
- Improved layer 2 support for high downlink data rates
- Enhanced CELL\_FACH state (downlink)

## 3GPP Release 8

- Combination of MIMO and 64QAM
- CS over HSPA
- Dual cell HSDPA (also called dual carrier HSDPA)
- Improved layer 2 support for high uplink data rates
- Enhanced CELL\_FACH state (uplink)
- HS-DSCH DRX reception in CELL\_FACH
- HSPA VoIP to W-CDMA/GSM CS continuity
- Serving cell change enhancements

## 3GPP Release 9

- Dual cell HSUPA (also called dual carrier HSUPA)
- Dual band HSDPA
- Dual cell HSDPA + MIMO
- 2ms TTI uplink range extensions
- TxAA extensions

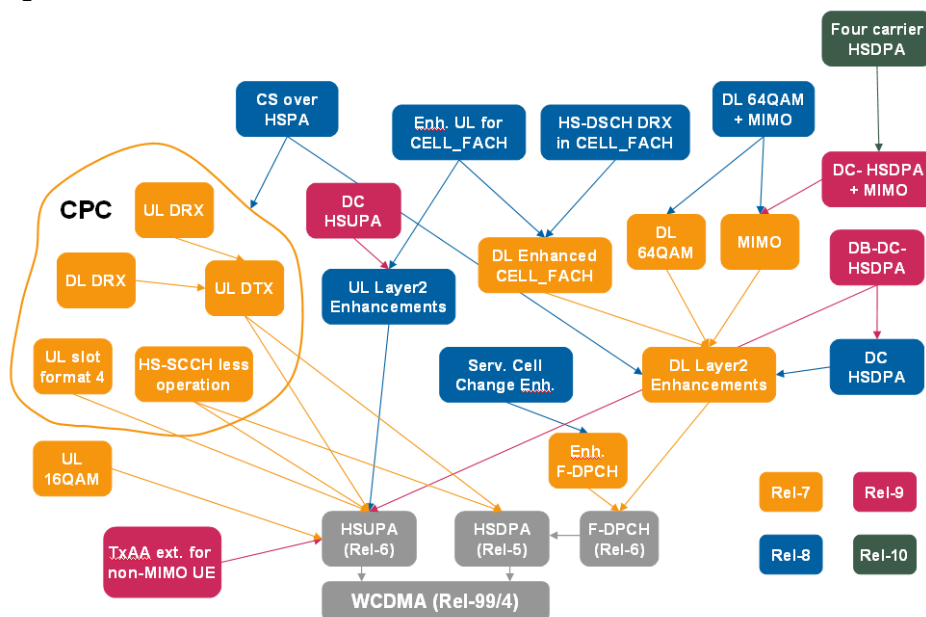
## 3GPP Release 10

- Four-carrier HSDPA

This Application Note describes how to test these features using Rohde & Schwarz equipment. This includes the generation of test signals as well as signal analysis and signaling tests.

For detailed information about HSPA+ and its features, please read the Rohde & Schwarz White Paper "HSPA+ Technology Introduction" [1].

Fig. 1 shows how the individual HSPA+ features relate to one another.



**Fig. 1 HSPA+ feature landscape.**

## 2 HSPA+ Signal Generation

The HSPA+ features build upon the W-CDMA and HSPA settings in the SMx. This paper therefore first defines the basic settings for the SMx before providing descriptions of the individual HSPA+ features.

Up to Release 10, up to four baseband signals and up to four RF paths are needed. These can be handled with one SMW (with two additional RF sources like SGS) or two instrument like SMU or even four instruments like SMBV.

All screenshots in this section show the SMW. Handling in the SMU and SMBV may look different. Important differences are mentioned in the corresponding sections directly.

### 2.1 Basic settings

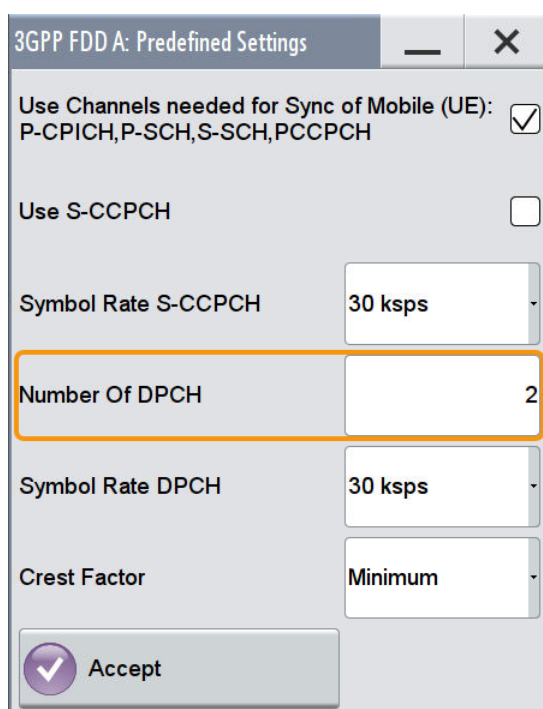
The first step on the SMx is to consider the desired carrier frequency for the RF signal, and then to select the "RF On" check box.

In the SMW next step is to set in the **System Configuration** the wanted number of basebands and the routing to the RF.

#### 2.1.1 Generation of an example HSPA+ downlink signal

The SMx and AMU signal generators make it very easy to generate the signals needed for the various tests. Because HSPA and HSPA+ add high-speed data channels to conventional UMTS W-CDMA signals (in accordance with 3GPP Release 99), the signal generation is illustrated based on the example of an HSPA+ signal that consists of W-CDMA data channels, HSPA+ channels and control channels. This basic example is then followed by descriptions of the feature-specific settings.

First, "3GPP FDD" is selected in "Baseband A" to open the main menu, where all further settings can be made. The "Link Direction" parameter is set to "Downlink/Forward", after which the base station settings are defined in the lower portion of the dialog box. In this area, the synchronization and control channels can be enabled by selecting "Predefined Settings" followed by "Use Channels needed for Sync of Mobile (UE): P-CPICH, P-SCH, S-SCH, PCCPCH". The desired number of data channels for the W-CDMA signal (DPCHs) can also be defined here; in this example it is set to 2.



3GPP FDD A: Predefined Settings

Use Channels needed for Sync of Mobile (UE): ☒ P-CPICH, P-SCH, S-SCH, PCCPCH

Use S-CCPCH ☐

Symbol Rate S-CCPCH 30 kps

Number Of DPCH 2

Symbol Rate DPCH 30 kps

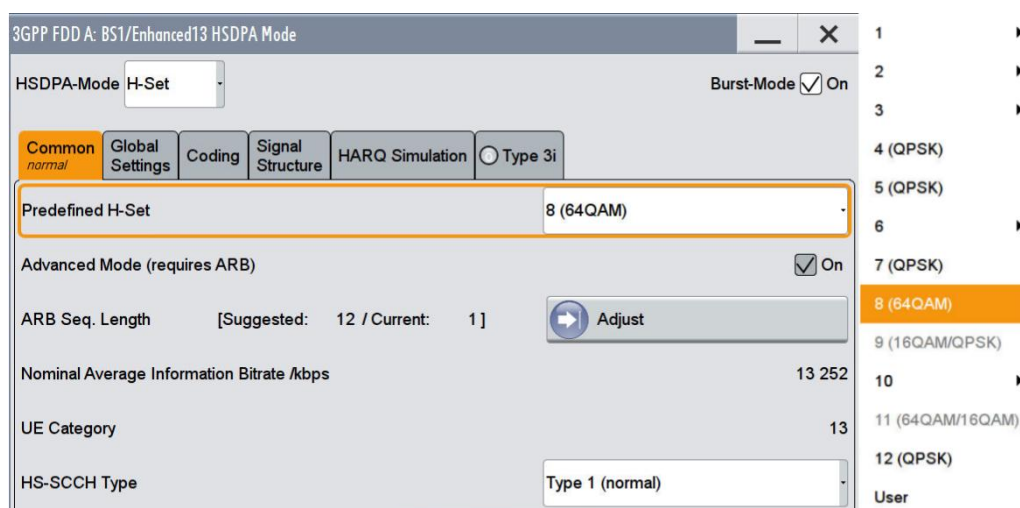
Crest Factor Minimum

☒ Accept

**Fig. 2** Predefined settings for the W-CDMA signal.

The base station is then configured by selecting "BS1". This opens a dialog box with the existing control channels and DPCHs prefilled in the Channel Table. The HSPA+ channels just have to be added.

This is done by selecting a not used row in the channel table (scroll down; the preceding lines are reserved for control channels) and setting Channel Type HS-SCCH. This channel type is the HSDPA downlink control channel that is used to define the HSDPA data channels. "Enhanced/HSDPA Settings" is then selected in the **HS-SCCH** row to open a new dialog box (Fig. 3). By changing the "HSDPA Mode" field from "Continuous" to "H-Set", it is then possible to define the various settings for the HS-DSCH.



3GPP FDD A: BS1/Enhanced HSDPA Mode

HSDPA-Mode H-Set Burst-Mode ☒ On

Common Global Settings Coding Signal Structure HARQ Simulation Type 3i

Predefined H-Set 8 (64QAM)

Advanced Mode (requires ARB) ☒ On

ARB Seq. Length [Suggested: 12 / Current: 1] Adjust

Nominal Average Information Bitrate /kbps 13 252

UE Category 13

HS-SCCH Type Type 1 (normal)

1 2 3 4 (QPSK) 5 (QPSK) 6 7 (QPSK) 8 (64QAM) 9 (16QAM/QPSK) 10 11 (64QAM/16QAM) 12 (QPSK) User

**Fig. 3** Selecting a predefined H-Set.

Selecting "H-Set Configuration > Predefined H-Set" opens a list of the predefined H-Sets in 3GPP TS 25.101 [5] that contain the settings for the various tests. By selecting the desired H-Set (in this example, H-Set 8), the appropriate data channels are added without requiring any additional configuration. However, it is also possible to define individual parameters to meet specific test requirements. The defined channels are now displayed in the channel table and simply have to be enabled.

If there are any overlapping channels in the code domain, the software displays this in the last column of the table and, if desired, can automatically adapt the spreading codes of the individual channels. This is done by clicking on one of the red indicators displayed on the screen, and then selecting "Resolve Domain Conflicts".

Clicking "State > On" then enables the baseband signal.

The total power of the individual W-CDMA channels should be 0 dB relative to the defined level. If the level is greater, clicking "Adjust Total Power to 0 dB" in the main menu normalizes (reduces) the power of all channels to the reference level of 0 dB.

### 2.1.2 Generation of a multi-carrier signal

There are three basic methods for generating signals with two different carrier frequencies:

- Using two RF paths and combining them in the RF range
- Overlaying the two individual signals in the baseband and using a single RF path
- Generating a waveform file and playing it back on multiple carrier frequencies

If two RF outputs are to be used, the desired carrier frequencies for the two RF signals can be set directly in the upper portion of the screen, and the baseband settings can then be made individually.

To use a single RF output on the generator, the center frequency must first be set for the two carrier frequencies. Once the specific settings have been made, a frequency offset must then be set in the "Baseband A" and "Baseband B" blocks. For most of the applications described here, the offset between the two carriers is 5 MHz (the distance between two adjacent W-CDMA channels). Accordingly, an offset of +5 MHz is set in baseband B, for example (or an offset of  $\pm 2.5$  MHz can be set in each of the two basebands).



Baseband Offsets				Misc	
	Frequency Offset /Hz	Phase Offset °	Path Gain /dB	Custom Digital Mod...	ARB...
Baseband A	5 000 000.00	0.00	0.000	Multicarrier CW...	Frequency Offset
BB Input A	0.00		0.000	5.000 000 00 MHz	Phase Offset
BB Input B	0.00		0.000	0.00 deg	Path Gain
Baseband B	0.00	0.00	0.000	0.000 dB	Signal Routing
				route to path B	route to path A
				route to path A and B	

Fig. 4 Setting the frequency offset (left SMW, right: SMU).

The two baseband signals are then combined. This is done by clicking the "Baseband B" block and selecting "route to path A". Fig. 5 shows the resulting changes on the user interface.

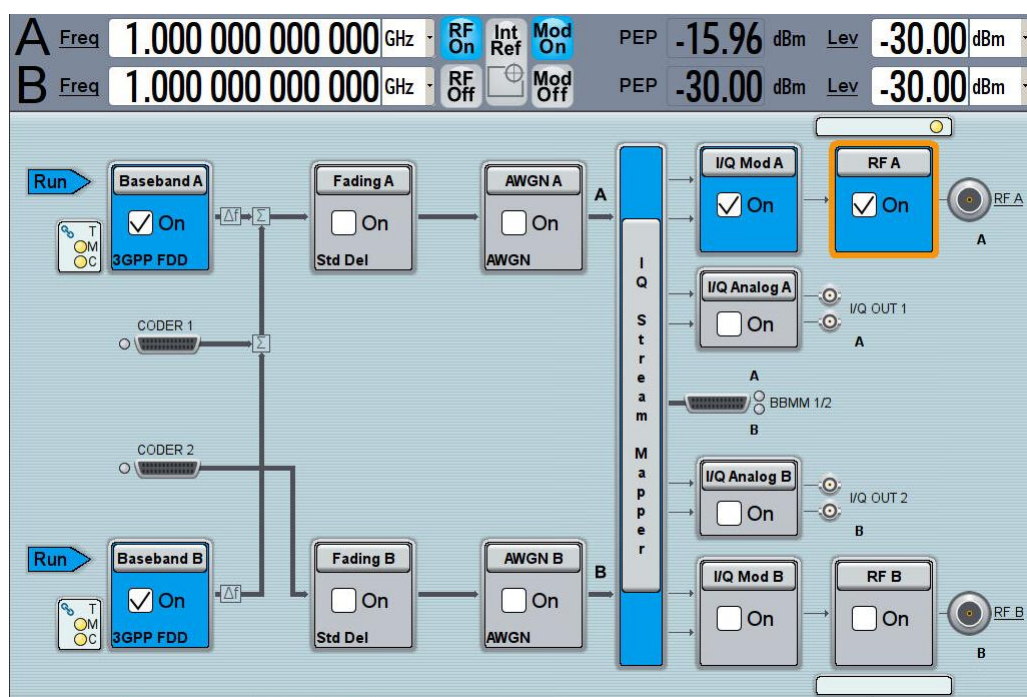


Fig. 5 SMW user interface with combining of the two signals in the baseband.

In both cases, the basebands must start at the same time. This is ensured via synchronizing the basebands. If the system configuration in the SMW is used (like 2 x 1 x 2), the basebands are synchronized automatically.

Otherwise, the trigger settings must be adjusted so that the baseband signals are synchronized. In baseband A, this is done by selecting "Trigger/Marker" and then "Mode > Auto". In baseband B, on the other hand, "Mode" is set to "Armed Retrigger" and "Source" is set to "Internal (Baseband A)".

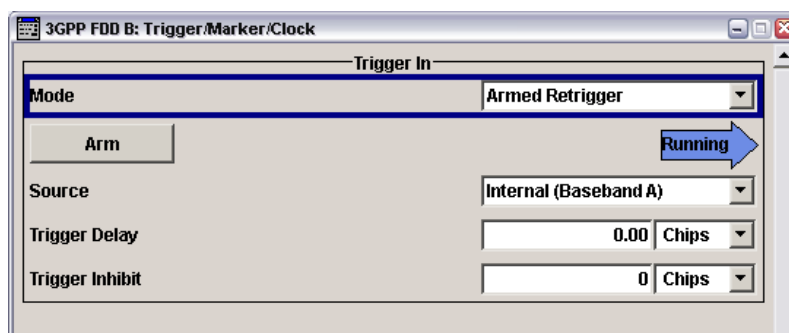


Fig. 6 Trigger settings.

After the changes have been made in baseband B, the signal is restarted in baseband A by setting the baseband state to "Off" and then back to "On". This will synchronize the two basebands.

The signal can also be generated by using two signal generators, each with one baseband and one RF output. In this case, the same basic settings are made in both instruments, which are then synchronized using a common reference and a single trigger for the baseband. This is done by connecting a BNC cable from the "Ref Out" output on the first instrument to the "Ref In" input on the second instrument, and by connecting the "Marker 1" output on the first instrument to the "Trigger 1" input on the second instrument.

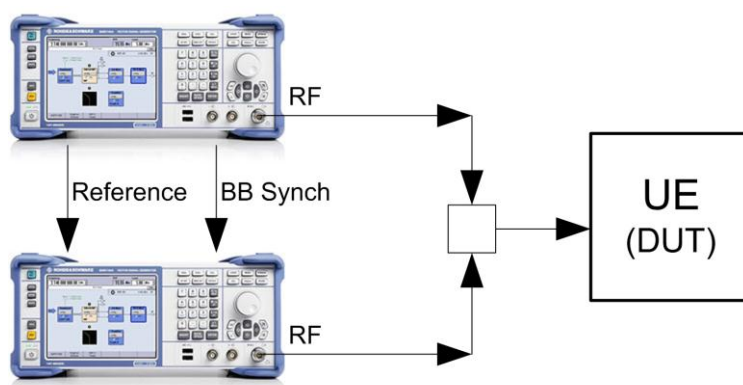


Fig. 7 Example test setup with two SMBVs.

To synchronize the basebands, Marker 1 is defined as "Chip Sequence Period (ARB)" in the trigger settings for baseband 1 (in the first instrument); see Fig. 8. In baseband 2, on the other hand, Mode is defined as "Armed Retrigger" and Source is defined as the external trigger originating from baseband 1; see Fig. 9. For some tests also both basebands have to be synchronized on one external trigger.

The "Clock" settings in the second instrument must also be defined with "Source > External" to ensure that the two instruments remain synchronous.

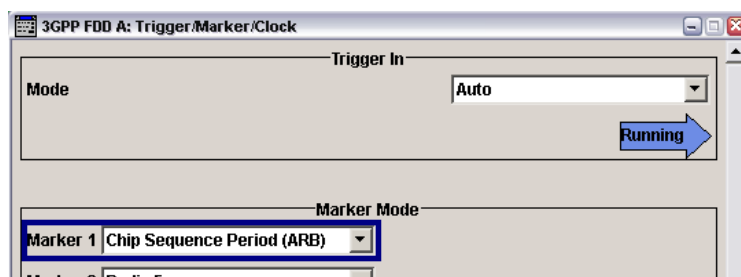


Fig. 8 Trigger settings for BB1.

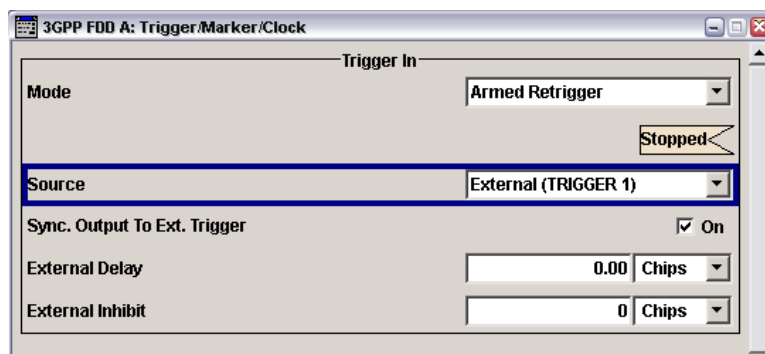


Fig. 9 Trigger settings for BB2; triggered by BB1.

Some signals consist of up to four individual components (for example, 4C-HSDPA). To generate these signals, one SMW can be used. Otherwise either two dual-path instruments (two SMUs) or four single-path instruments (e.g. four SMBVs) are interconnected using the above configuration.

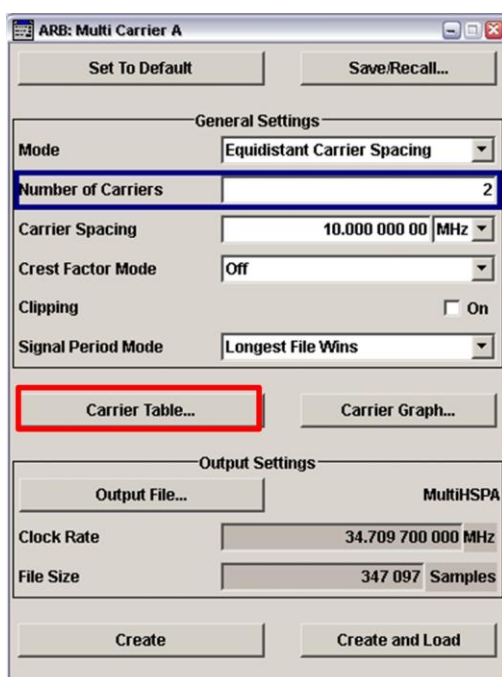
The third option of generating a signal consisting of multiple carrier frequencies makes use of the signal generator's multicarrier functionality and can be performed using one single-path instrument.

In this case, the desired signal is set in the baseband and then saved by clicking on "Generate Waveform File", after which it can be played back at the various frequencies. For this the ARB function is selected in the baseband block, as shown in Fig. 10



Fig. 10 ARB functionality on the signal generator.

In the dialog box that appears, click "Multi Carrier" to open a further dialog box for generating a multicarrier signal, as shown in Fig. 11.



*Fig. 11 ARB multicarrier functionality.*

Settings such as the number of carrier frequencies and their offset to one another can be made here. Clicking the "Carrier Table" button opens the "Multi Carrier Table" dialog box as shown in Fig. 12 for making the individual carrier settings.

ARB Multi Carrier Table A

Number of Carriers: 2

Carrier Table Assistant

Carrier State: ☒ On

Carrier Start: 0 Stop: 1

Gain Start: 0.00 dB Step: 0.00 dB

Phase Start: 0.00 deg Step: 0.00 deg

Delay Start: 0 ns Step: 0 ns

Input Waveform File...

SingleCarrierHSPA

Apply Assistant Settings

	State	Carrier Freq [MHz]	Gain [dB]	Phase [deg]	Delay [ns]	File	Info	!!!
0	On	-5.000 000	0.00	0.00	0	d:/SingleCarrierHSPA	Info...	
1	On	5.000 000	0.00	0.00	0	d:/SingleCarrierHSPA	Info...	

Fig. 12 Multi Carrier Table.

The table at the bottom of this dialog box provides an overview of the current settings for the individual carriers. This can be modified by clicking a specific table entry, or the "Carrier Table Assistant" can be used to modify several carriers at once. In this case, the indices of the first and last carrier to be modified are entered and the desired settings are defined. The "Input Waveform File" button can be used to load the previously generated ARB file. Once all settings are defined, clicking "Apply Assistant Settings" updates the corresponding entries in the table with the new settings.

Once the "Multi Carrier Table" is closed, the "Output Settings" section of the "Multi Carrier" dialog box can be used to define where the multicarrier signal being generated is to be saved. Finally, "Create" or "Create and Load" is clicked to generate the signal. The signal can then be loaded and started in the ARB dialog box.

Please note the following restrictions for both of the methods mentioned above, which use the combination of the signals in the baseband:

- The total bandwidth of the sum signal must not exceed the maximum base bandwidth of the instrument being used. This is 120 MHz or 160 MHz for the SMW, 80 MHz for the SMU and 120 MHz for the SMBV, for example.
- The levels of the individual carriers should be as close to one another as possible, since otherwise a signal with low power would be lost in the quantizing noise.
- It will no longer be possible to fade the individual signals independently from one another, as required by 3GPP TS 25.101 [5], for example.

## 2.2 HSPA+ in the SMx

The SMU-K83 option for the SMW and the SMU-K59 option for the SMU, SMATE, SMJ, SMBV and AMU signal generator allows the internal generation of standard-compliant HSPA+ signals as well as the generation of multicarrier and multisegment signals in line with 3GPP Releases 7 to 10.

Additionally, WinIQSIM2™ software provides a convenient way of creating any standard-compliant waveform with all the included standards using the arbitrary waveform generators functionality. WinIQSIM2™ HSPA+ support is realized using software option K283 (SMW) or software option K259 (SMx) on the respective signal generator.

The supported features include correct MIMO coding, new HSPA+-specific channel parameters as well as channel coding (H-Sets). This enables the test engineer to thoroughly investigate the performance of HSPA+ receivers, no matter whether the physical layer tests are to be performed at the component level (power amplifiers, filters, etc.) or on complete receivers in base stations or mobile phones. Signals for demanding diversity and MIMO tests are intuitively generated. The K83/K283 for the SMW and K59/K259 options for SMx support HSPA+ downlink and uplink signal generation.

Overview of W-CDMA/HSPA+ options in SMW		
<b>K42</b>	Digital Standard 3GPP FDD	
<b>K83</b>	Digital Standard 3GPP FDD HSPA/HSPA+, Enhanced BS/MS Tests	Needs K42

**Table 1: Overview of W-CDMA/HSPA+ options in SMW**

Overview of W-CDMA/HSPA+ options in SMx		
<b>K42</b>	Digital Standard 3GPP FDD	
<b>K43</b>	3GPP FDD Enhanced MS/BS Tests, incl. HSDPA	Needs K42
<b>K45</b>	Digital Standard 3GPP FDD HSUPA	Needs K42
<b>K59</b>	Digital Standard HSPA+	Needs K43 and/or K45

**Table 2: Overview of W-CDMA/HSPA+ options in SMx**

Fig. 13 and Fig. 14 show the basic test setups for receiver tests on user equipment (downlink) and base transceiver stations (uplink).



Fig. 13 Basic downlink test setup.

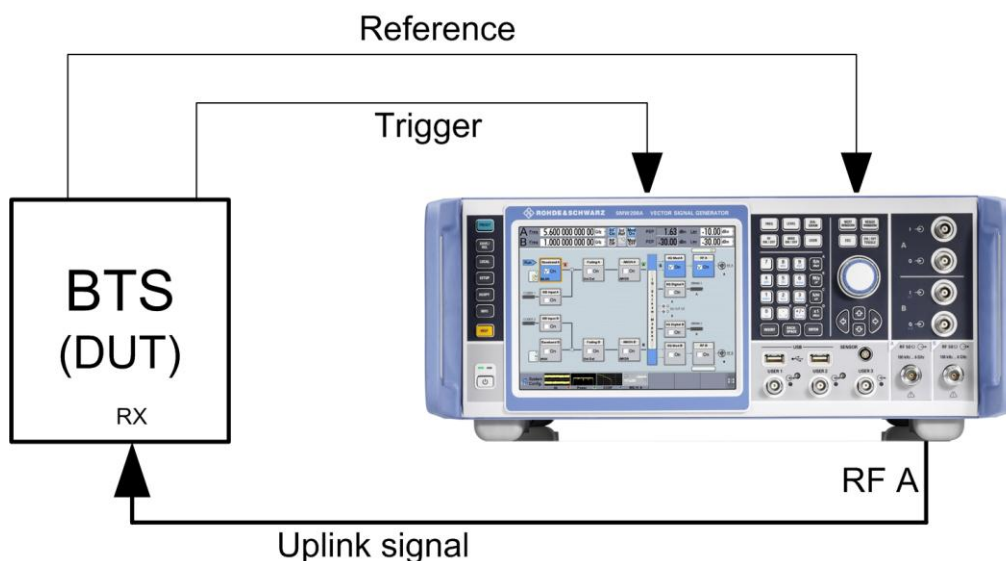


Fig. 14 Basic uplink test setup.

## 2.3 3GPP Release 7

### 2.3.1 64QAM (DL) signal generation

In order to support 64QAM testing [5][10], a fixed reference channel has been introduced. H-Set 8 is specified as the reference test channel for HSPA+ test cases. The H-Set 8 parameterization and coding chain is based on 15 codes with 64QAM modulation. Six hybrid ARQ processes are used, and HS-DSCH is continuously transmitted. Fig. 15 illustrates the possibility to select 64QAM downlink signals in the SMU channel type setting. K83/K59 additionally supports the orthogonal channel noise (OCNS) mode.

Note that user-defined H-Set configuration is possible, i.e. either H-Set 8 can be used or individual parameter settings may be configured, effectively creating a user-defined H-Set.



The SMx also supports Test Model 6 in accordance with 3GPP TS 25.141 [2]. Test Model 6 defines a certain number of channels (including 8 HS-PDSCH using 64QAM) at specified power levels, which is used to test code domain error requirements of a base station components supporting 64QAM modulation in the downlink.

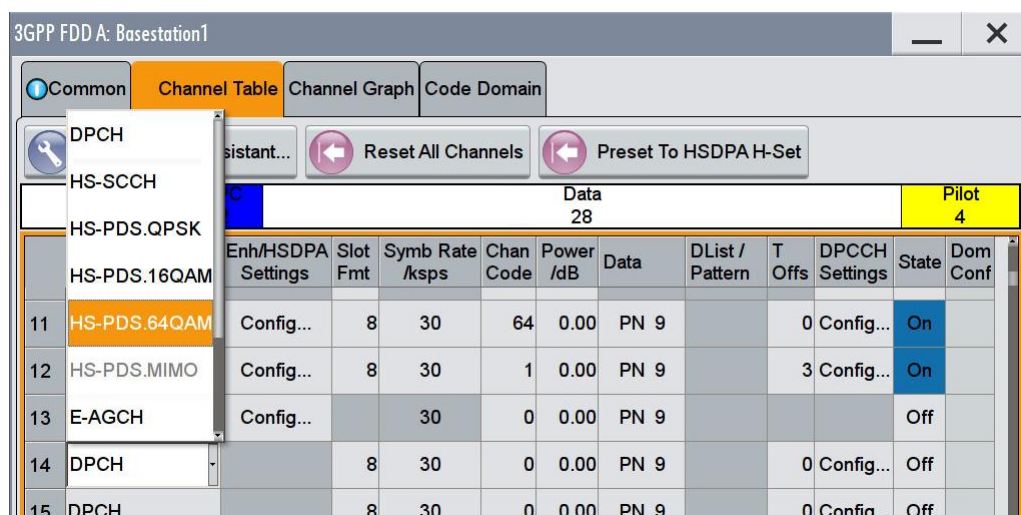


Fig. 15 SMx support for 64QAM operation.

### 2.3.2 16QAM (UL) signal generation

In order to support 16QAM testing (4PAM modulation on I and Q), a fixed reference channel has been introduced [2][6]. **FRC8** is specified as the reference test channel for HSUPA test cases at the base station receiver. Fig. 17 shows the signal generator user interface providing the 16QAM signal by four E-DPDCH codes, two of which use spreading factor 2 and two of which use spreading factor 4 in accordance with 3GPP specifications.

Again, it is possible to set individual parameters according to the specific testing needs.

A fixed reference channel is selected by clicking "HSUPA FRC" in the "E-DPCCH Settings" section. This opens a new dialog box (see Fig. 16), where it is possible to set either one of the FRCs defined in [2] or a user-defined reference channel. Clicking "On" enables the FRC and adapts the E-DPCCH and E-DPDCH channels accordingly.



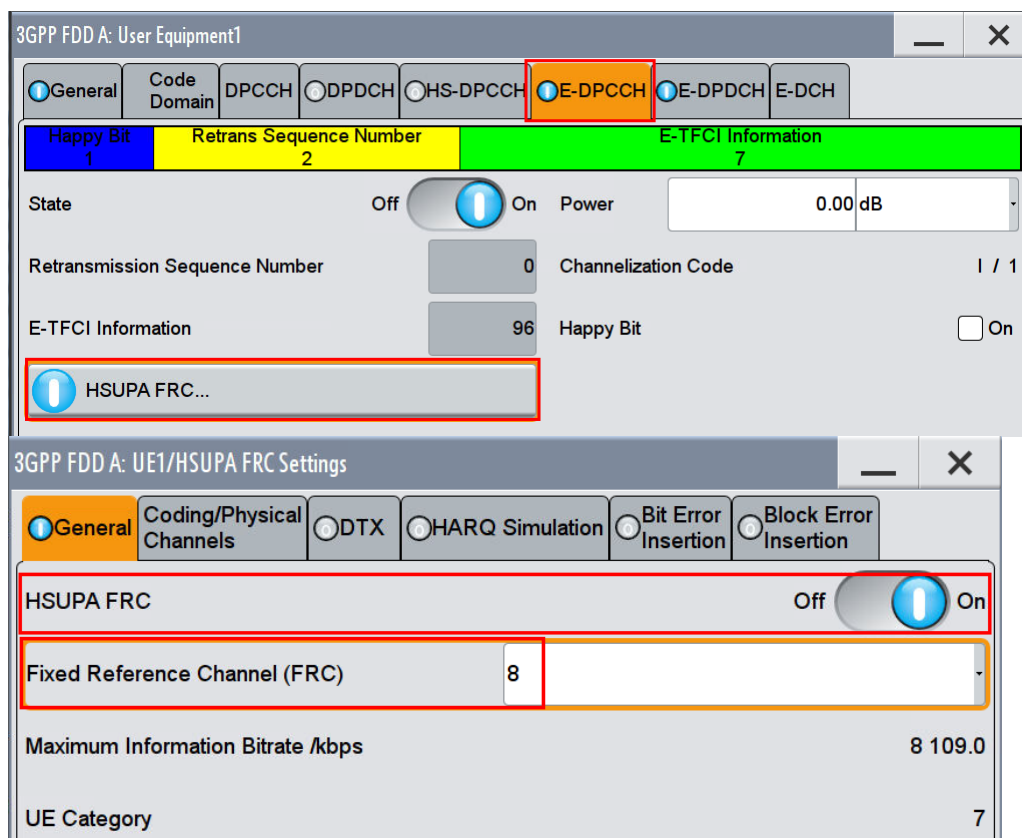


Fig. 16 HSUPA FRC settings.

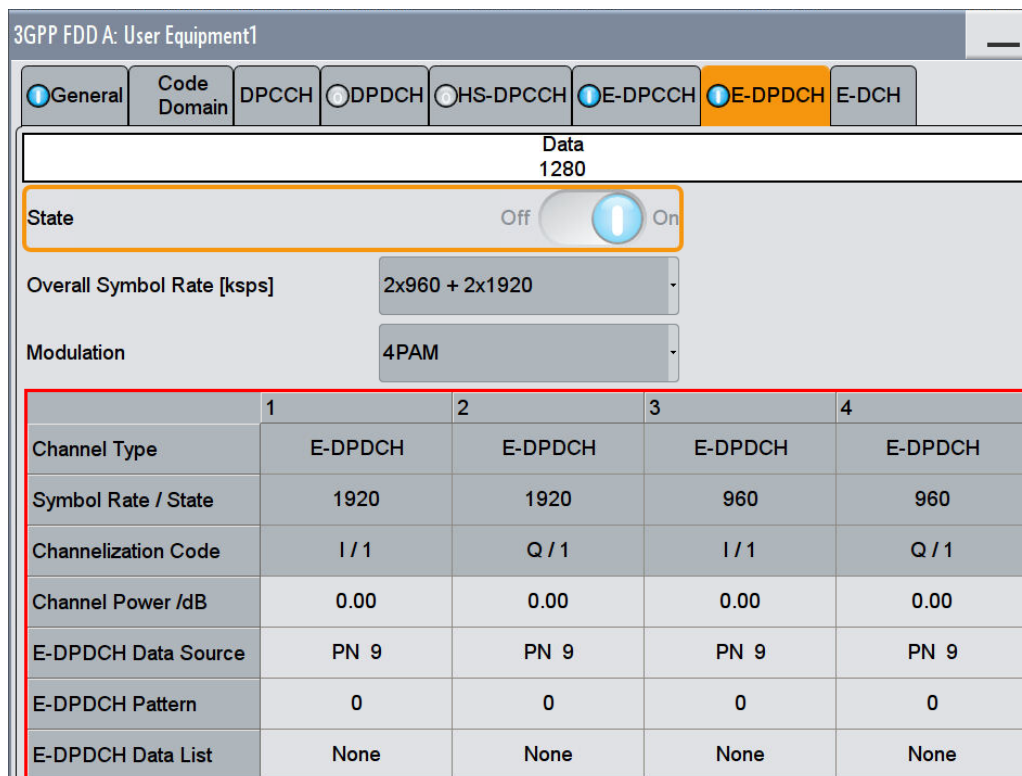


Fig. 17 16QAM UL signal generation.

### 2.3.3 MIMO operation

In order to support MIMO operation, changes to the HSDPA downlink control channel have become necessary, i.e. the HS-SCCH. There is a new HS-SCCH Type 3 for MIMO operation (see Fig. 18). HS-SCCH Type 3 includes signaling of precoding weights as specified by 3GPP [11]. H-Set 9 is specified as the reference test channel for HSPA+ test cases [5][10]. The H-Set 9 parameterization and coding chain is based on 15 codes with two different modulations, 16QAM and QPSK, for primary and secondary transport blocks, respectively. Six HARQ processes per stream are used, and HS-DSCH is continuously transmitted. Again, a user-defined H-Set configuration is possible.

As of 3GPP Release 7, MIMO offers dynamic switching between dual stream and single stream data transmission. Single stream effectively represents a fallback solution to Tx diversity mode in those cases where propagation conditions do not allow MIMO transmission. The "Stream 2 Active Pattern" parameter allows the generation of a user-defined sequence for single and dual stream transmission.

The image displays two screenshots of the '3GPP FDD A: BS1/Enhanced12 HSDPA Mode' configuration window, specifically the 'MIMO Settings' tab.

**Top Screenshot:**

- HSDPA-Mode:** H-Set
- Burst-Mode:** ☒ On
- Common MIMO Settings:**
  - Predefined H-Set:** 9 (16QAM/QPSK)
  - Advanced Mode (requires ARB):** ☒ On
  - ARB Seq. Length:** [Suggested: 6 / Current: 1] **Adjust**
  - Combined Nominal Average Information Bitrate /kbps:** 13 652
  - UE Category:** 15
  - HS-SCCH Type:** Type 3 (MIMO)

**Bottom Screenshot:**

- HSDPA-Mode:** H-Set
- Burst-Mode:** ☒ On
- Common MIMO Settings:**
  - Precoding Weight Pattern (w2):** 0
  - Stream 2 Active Pattern:** 1

3GPP FDD A: BS1/Enhanced12 HSDPA Mode

HSDPA-Mode: H-Set Burst-Mode ☒ On

Common MIMO MIMO Settings Global Settings **Coding** Signal Structure HARQ Simulation

	Stream 1:	Stream 2:
HS-PDSCH Modulation	16QAM	QPSK
Binary Channel Bits Per TTI (Physical Layer)	28 800	14 400
Transport Block Size Table	Table 1	Table 1
Transport Block Size Index	37	42
Information Bit Payload (TB-Size)	17 568	9 736
Coding Rate	0.610	0.676
Virtual IR Buffer Size (per HARQ Process)	28 800	28 800

Fig. 18 SMx support for MIMO operation.

To generate this type of signal, MIMO mode is first selected for both basebands in the basestation settings (section **Common**), as shown in Fig. 19. At the same time, baseband A is set as "Antenna 1 Of 2" and baseband B as "Antenna 2 Of 2" (or vice versa).

3GPP FDD A: Basestation1

**Common** Channel Table Channel Graph Code Domain

State Off ☒ On

☒ Scrambling Code (hex) 0000

Time Delay 0 Chips

☐ S-CPICH As Phase Reference

☐ OCNS Mode Standard

2nd Search Code Group 0

Page Indicators/Frame 18

**Diversity / MIMO** Antenna 1 Of 2

Open Loop Transmit Diversity ☒ On

Fig. 19 Selecting the MIMO mode.

The same settings must be made for both basebands. The "Save/Recall" function makes it easy: Simply configure baseband A and then use Save/Recall to save the settings to the instrument. Then it is simply a matter of selecting baseband B and using the Save/Recall button again to apply the saved settings. Finally, in the BS1 settings for baseband B, "Diversity/MIMO" should be set to "Antenna 2 Of 2". Note that the second antenna transmits only the P-CPICH (with "P-CPICH Pattern" for antenna 2) or S-CPICH and the selected HS-PDSCHs.

The two basebands must also be synchronized as described in 2.1.2.

The SMW signal generator can be equipped with four signal generators and a sixteen-channel fading simulator. The SMU signal generator can be equipped with two signal generators and a four-channel fading simulator. This would require adding hardware options B14 and B15 as well as software option K74, which allows testing of 2x2 MIMO receivers using one box. With this solution, you operate the entire functionality from one convenient user interface, without having to calibrate or synchronize your setup. The fading simulator makes it possible, for example, to simulate the extended ITU fading profiles [12] with correlation between the channels. The same fading and baseband functionality is available with the AMU baseband signal generator and fading simulator. Fig. 20 illustrates the user interface operating a HSPA+ 2x2 MIMO signal, including multipath fading.

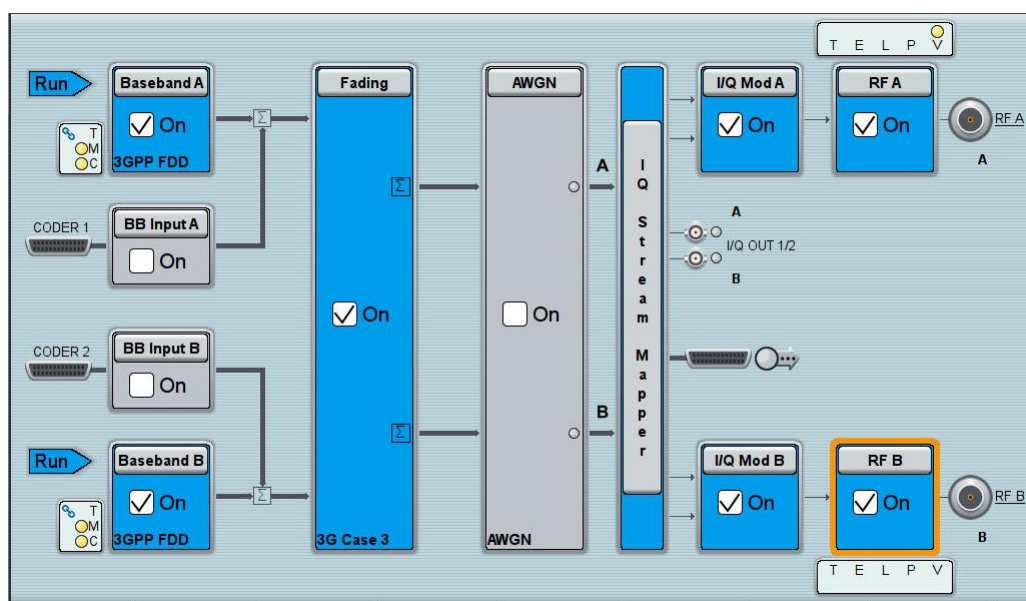


Fig. 20 SMW user interface generating a 2x2 MIMO signal, including multipath fading. The System Configuration is 1 x 2 x 2.

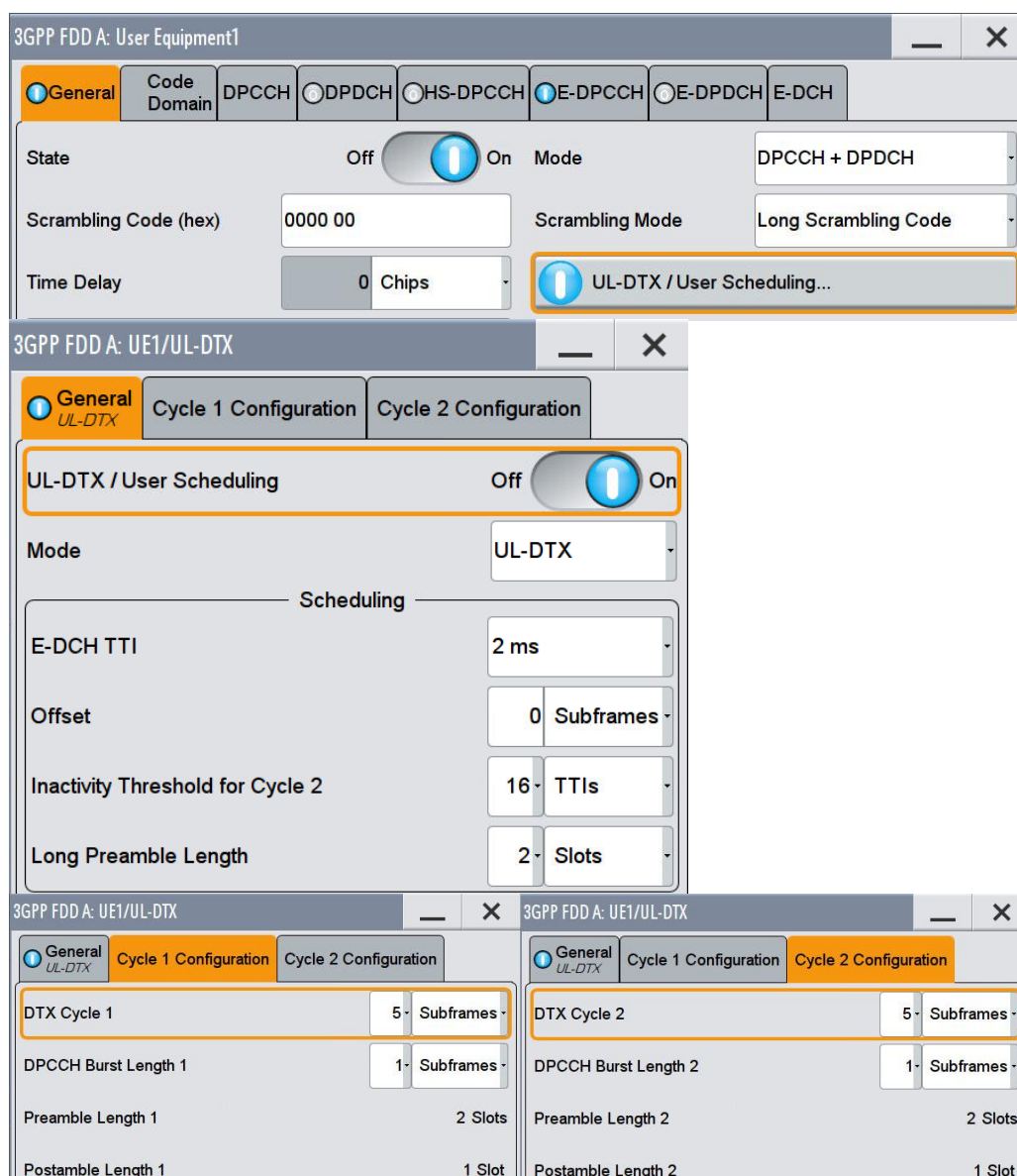
## 2.3.4 CPC

### 2.3.4.1 HS-SCCH less operation

CPC functionality has been added that specifically supports the HS-SCCH less operation mode, i.e. physical channel settings in HS-SCCH and HS-DPSCH for "HS-SCCH-less operation" (incl. HS-SCCH Type 2) can be selected. H-Set 7 is specified as the reference test channel for HSDPA+ test cases [5][10]. H-Set 7 consists of one HS-PDSCH, and its parameterization and coding chain is based on one code with QPSK modulation and one HARQ process. A user-defined H-Set configuration is also possible for HS-SCCH less operation.

### 2.3.4.2 UL-DTX

UL-DTX (i.e. the non-continuous transmission of the uplink DPCCH in cases where the uplink data transmission is missing) can be configured under "UE1 > UL-DTX", however "DPCCH+DPDCH" mode must first be enabled for UE1.



**Fig. 21 Uplink DTX settings.**

This dialog box provides the settings necessary to configure the start offset, the threshold time for switching to UE-DTX cycle 2 and the DPCCH activity patterns for both UE-DTX cycle 1 and 2. It is possible to determine the frequency of the DPCCH bursts and the length of the DPCCH bursts (without pre- and postamble), and to configure the length of the longer preamble for the UE-DTX cycle 2.

### 2.3.4.3 Uplink DPCCH slot format 4

As shown in Fig. 22, K-83 and K-59 supports the new slot format 4 for the uplink DPCCH. It contains only six pilot bits and four TPC (Transmit Power Control) bits in order to reduce DPCCH transmit power. FBI (Feedback Information) and TFCI (Transport Format Combination Indicator) bits are not sent.

Fig. 22 Support for the uplink slot format 4.

### 2.3.5 Enhanced fractional DPCH (F-DPCH)

As seen in Fig. 23, various slot formats can be selected for the F-DPCH. These differ with respect to the position of the TPC information within the respective slot, as defined in [5].

DTX				TPC		DTX						
8				2		10						
	Channel Type	Enh/HSDPA Settings	Slot Fmt	Symb Rate /ksp	Chan Code	Power /dB	Data	DList / Pattern	T Offs	DPCCH Settings	State	Dom Conf
16	F-DPCH		3	15	6	0.00			0	Config...	On	
17	DPCH		8	30	0	0.00	PN 9		0	Config...	Off	

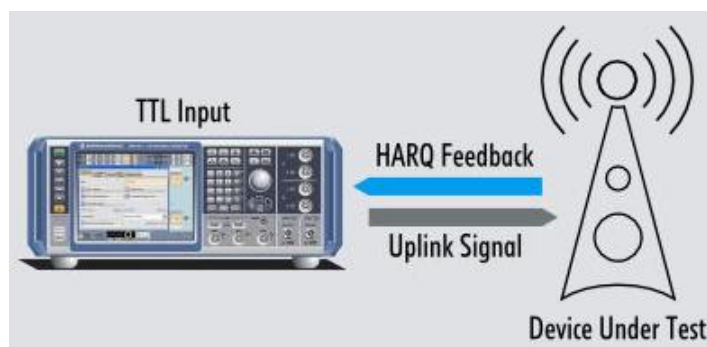
Fig. 23 Setting the F-DPCH.



### 2.3.6 HARQ feedback for uplink 16QAM

Hybrid Automatic Repeat Request is a mechanism to allow the receiver (NodeB) to request that packets be resent by the sender (UE) if these packets could not be received error free in the first place. Incorrectly received coded data blocks may be stored at the receiver, and the two blocks may be combined when the retransmitted block is received. While two independently decoded transmissions might not decode without errors, it is possible that combining the erroneously received transmissions will provide enough information to decode them correctly.

To test this complex mechanism at the device under test (NodeB), the Rohde & Schwarz SMW, SMU, SMJ, SMATE and AMU signal generators offer a TTL input connector that allows the receiver feedback to be taken into account as illustrated in Fig. 24. Based on the received feedback, the generator decides in real time to transmit new data or to retransmit the last packet.



**Fig. 24** Uplink HARQ feedback operation.

Please note that HARQ feedback is not supported by SMBV and WinIQSIM2.

The HARQ feedback settings can be made in the "UE1 > E-DPCCH Settings > HSUPA FRC" dialog box, as shown in Fig. 25.

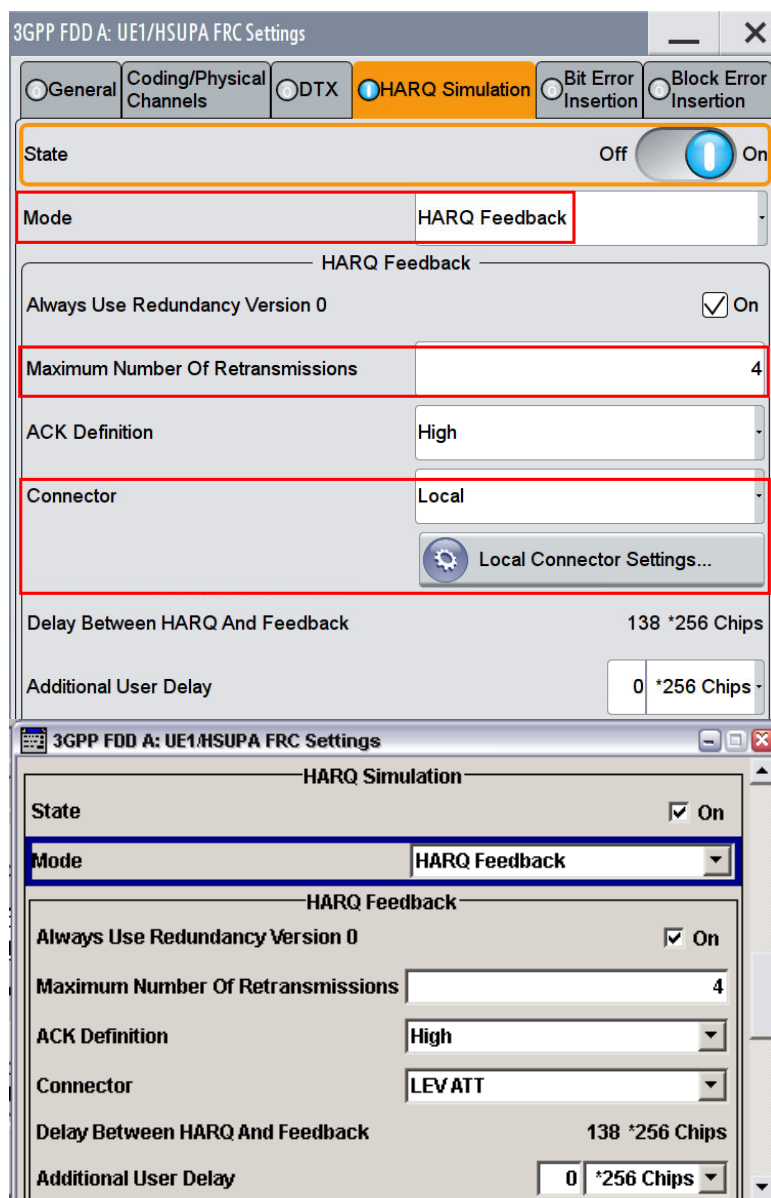


Fig. 25 HARQ settings (upper: SMW, bottom: SMU).

The connector can be set in the SMW via “Local Connector Settings”. In the SMU “LEV ATT” is the default connector.



## 2.4 3GPP Release 8

### 2.4.1 Combination of MIMO and 64 QAM

As described in 2.3.3, the individual parameters for the two MIMO streams can be selected by the user, which makes it possible to generate the combination of MIMO and 64QAM (H-Set 11). The modulation schema can be set separately for the two streams. Note that the modulation schema on the second stream must never be a higher order than what is used on the first stream.

Fig. 26 shows how the parameter settings can be made separately for the two streams.

	Stream 1:	Stream 2:
HS-PDSCH Modulation	64QAM	64QAM
Binary Channel Bits Per TTI (Physical Layer)	43 200	43 200
Transport Block Size Table	Table 1	Table 1
Transport Block Size Index	36	37
Information Bit Payload (TB-Size)	26 504	26 976
Coding Rate	0.614	0.624
Virtual IR Buffer Size (per HARQ Process)	43 200	43 200

Fig. 26 SMx support for 64QAM in both MIMO streams.

### 2.4.2 DC-HSDPA

DC-HSDPA (Dual Cell HSDPA, or Dual Carrier HSDPA) represents the simultaneous transmission on two carrier frequencies (the serving cell and the secondary serving cell). This requires the generation of two different baseband signals, which are then combined as described in 2.1.2.

#### Downlink DC-HSDPA settings

In order to support DC-HSDPA testing, a fixed reference channel has been introduced. H-Set 12 is specified as the reference test channel for HSPA+ test cases [5][10].

The H-Set 12 parameterization and coding chain is based on 1 code with QPSK modulation. Six hybrid ARQ processes are used, and HS-DSCH is continuously transmitted.

The new H-Sets 1A, 3A, 6A, 10A and 12A have also been introduced, which expand the single cell signals for DC-HSDPA applications.

As before, the parameters can either be defined individually, or a predefined H-Set can be used. The P-CPICH, P-CCPCH, P-SCH, S-SCH and PICH channels must also be enabled. After this is completed for baseband A, the settings are saved and then applied to baseband B using the "Save/Recall" function. On baseband B, channels P-CCPCH, P-SCH, S-SCH and PICH are disabled because they are transmitted only in the serving cell.

The signal can then be output on two RF channels, or combined and output in the baseband (see Section 2.1.2).

### **Uplink DC-HSDPA feedback settings**

DC-HSDPA brings changes to the uplink signal as well, because the HS-DPCCH must now transmit CQI information and ACK/NACK for both carrier frequencies. For base station tests, the uplink signal is enabled in the "HS-DPCCH Settings" section (see Fig. 30). Note that "Release 8 and Later" must be set under "Compatibility Mode" and the support for the secondary cell must be enabled. To do so, set "1" in "Secondary Cell Enabled" and "Secondary Cell Active". Here, all together feedback signals for two cells are generated. This makes it possible to set whichever HARQ responses are needed from the UE.

The "HARQ-ACK" parameter can be set for a TTI, where "A/N" feedback refers to the transmission of an ACK to the serving cell and transmission of a NACK to the secondary serving cell. It is also possible to add any needed CQI and PCI feedback and their timing to the respective TTIs. The number of table entries is set above the table, in the "Number of Table Rows" field. Clicking "Adjust ARB Sequence Length" adjusts the length of the generated ARB sequence to match the (recommended) length that is calculated from the parameters "Inter TTI Distance (Interval)", "HARQ-ACK Repeat After" and "PCI/CQI Repeat After".

3GPP FDD A: User Equipment1

General Code Domain DPCCH DPDCH **HS-DPCCH** E-DPCCH E-DPDCH E-DCH

HARQ-ACK (Slots) 1 CQI (Slots) 2

State Off ☒ On Power 0.00 dB

Compatibility Mode Release 8 and Later

Start Delay 101 \*256 Chips MIMO Mode ☐ On

Inter TTI Distance (Interval) 5 Subframes

Channelization Code Q / 64

Slot Format 0 (15kps)

Secondary Cell Enabled 1

Secondary Cell Active 1

Fig. 27 HS-DPCCH settings. One additionally cell is supported.

HARQ - ACK

Number of Rows 3 HARQ-ACK Repeat After 3 Intervals

	HARQ-ACK From Interval	HARQ-ACK To Interval	HS-DPCCH 1 HARQ-ACK 1	HS-DPCCH 1 HARQ-ACK 2	HS-DPCCH 2 HARQ-ACK 3	HS-DPCCH 2 HARQ-ACK 4	Pow Offs /dB
0	0	0	A/A				0.0
1	1	1	A/N				0.0
2	2	2	D/A				0.0

Fig. 28 HS-DPCCH ACK settings for two cells.

PCI / CQI

Number of Rows 3 PCI/CQI Repeat After 3 Intervals

	PCI/CQI From Interval	PCI/CQI To Interval	HS-DPCCH 1 PCI/CQI 1 Type	HS-DPCCH 1 PCI/CQI 1 Content	HS-DPCCH 1 PCI/CQI 2 Type	HS-DPCCH 1 PCI/CQI 2 Content	HS-DPCCH 2 PCI/CQI 3 Type	HS-DPCCH 2 PCI/CQI 3 Content	HS-DPCCH 2 PCI/CQI 4 Type	HS-DPCCH 2 PCI/CQI 4 Content	Pow Offs /dB
0	0	0	Comp CQI	Config...							0.0
1	1	1	DTX								
2	2	2	DTX								

3GPP FDD A: ME1 PCI/CQI

PCI/CQI 1

PCI / CQI Type Composite CQI

CQI 1 10

CQI 2 2

Fig. 29 HS-DPCCH CQI settings for two cells.



**Fig. 30 HS-DPCCH settings. Adjust the sequence length**

For additional information regarding signal generation for DC-HSDPA, refer to the Application Sheets [3] and [4].

## 2.5 3GPP Release 9

### 2.5.1 DC-HSUPA

DC-HSUPA requires DC-HSPDA in the downlink, and therefore uses the same principle for the uplink data channels. Therefore, two different signals are set in the baseband in the same way as described in 2.4.2.

Once "Uplink/Reverse" has been selected as the link direction in baseband A, the dialog box for UE1 can be opened; see Fig.16. This dialog box is used to make the settings for the E-DPCCH and the E-DPDCH, as described in 2.3.2.

"Save/Recall" is then used to copy the settings to the second baseband. In this case, the HS-DPCCH must be disabled again, because feedback for DC-HSDPA is transmitted only in the serving cell (both downlink streams are confirmed simultaneously).

The signal can then be output on two RF channels, or combined and output in the baseband (see Section 2.1.2).

### 2.5.2 Dual band DC-HSDPA

Dual band DC-HSDPA follows the same principle as DC-HSDPA, except that the two signals are not transmitted on carrier frequencies inside the same band. Instead, the carrier frequencies lie in different frequency bands. Only specific combinations are permitted for this, as described in 3GPP TS 25.101 [5].

To generate this type of signal, it is sufficient to follow the steps described in 2.4.2 and then to modify the carrier frequencies accordingly. The large distance between the frequency bands and the limited modulation bandwidth of the instruments (120 MHz or 160 MHz for SMW, 80 MHz for SMU and 120 MHz for SMBV) may make it impossible to combine the two signals in the baseband. The two signals must be mixed separately on the respective carrier frequencies, and thus must also use two separate RF outputs.

## 2.5.3 Combination of DC-HSDPA and MIMO

### Downlink settings

When combining DC-HSDPA and MIMO, a total of four different baseband signals must be generated in the downlink. This is done either with one SMW (use system configuration setting 2 x 2 x 2) or by using two signal generators, each with two basebands. The two instruments are synchronized externally, and their RF outputs are connected; see 2.1.2.

### Uplink DC-HSDPA MIMO feedback settings

For uplink tests, it is sufficient to generate a single baseband signal. "MIMO Mode" can be enabled in the uplink signal for DC-HSDPA (see Fig. 33), which allows up to four transport blocks to be confirmed simultaneously in the HS-DPCCH.

Fig. 31 HS-DPCCH settings. One additionally cell and MIMO is supported.

HARQ - ACK							
Number of Rows		3		HARQ-ACK Repeat After		3 Intervals	
	HARQ-ACK From Interval	HARQ-ACK To Interval	HS-DPCCH 1 HARQ-ACK 1	HS-DPCCH 1 HARQ-ACK 2	HS-DPCCH 2 HARQ-ACK 3	HS-DPCCH 2 HARQ-ACK 4	Pow Offs /dB
0	0	0	AA/AN				0.0
1	1	1	NA/AN				0.0
2	2	2	D/AN				0.0

Fig. 32 HS-DPCCH ACK settings for two cells and MIMO.

PCI / CQI

Number of Rows: 3    PCI/CQI Repeat After: 3 Intervals

	PCI/CQI From Interval	PCI/CQI To Interval	HS-DPCCH 1 PCI/CQI 1 Type	PCI/CQI 1 Content	HS-DPCCH 1 PCI/CQI 2 Type	PCI/CQI 2 Content	HS-DPCCH 2 PCI/CQI 3 Type	PCI/CQI 3 Content	HS-DPCCH 2 PCI/CQI 4 Type	PCI/CQI 4 Content	Pow Offs /dB
0	0	0	A (Dual TB)	Config...							0.0
1	1	1	DTX								
2	2	2	DTX								

3GPP FDD A: ME1 PCI/CQI0

PCI/CQI 1

PCI / CQI Type: A (Dual TB)

CQI 1: 10

CQI 2: 2

PCI: 0

Fig. 33 HS-DPCCH settings for DC-HSDPA with MIMO

## 2.5.4 TxAA extension for non-MIMO UEs

This feature allows the MIMO schema described in 2.3.3 to be used for UEs with only one antenna. As a result, the settings described above can be used here for downlink tests. The "Stream 2 Active Pattern" parameter (see Fig. 34) must be set to "-", which specifies that only the first stream will ever be sent.

3GPP FDD A: BS1/Enhanced12 HSDPA Mode

HSDPA-Mode: H-Set    Burst-Mode: ☒ On

Common MIMO MIMO Settings Global Settings Coding Signal Structure HARQ Simulation

Precoding Weight Pattern (w2): 0

Stream 2 Active Pattern: -

Fig. 34 TxAA setting: stream two is disabled.

## 2.6 Release 10: Four-carrier HSDPA

### Downlink settings

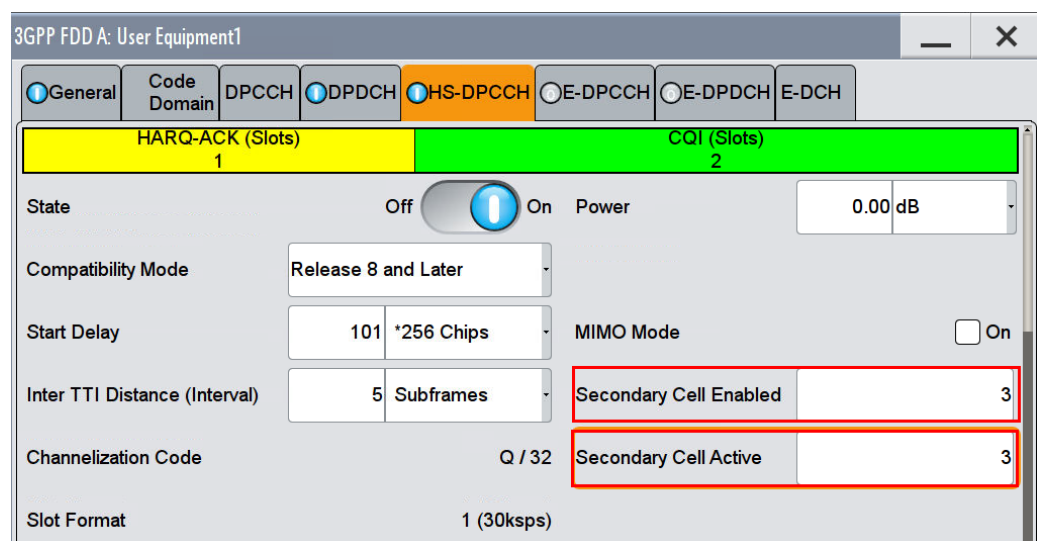
Four-carrier HSDPA follows the same principle as DC-HSDPA (see 2.4.2), except that up to three secondary serving cells are used in addition to the serving cell.

In cases where the individual carriers lie too far apart or need to be independently faded, or where the power differences between the individual signals are too great, one SMW with four baseband and four RF paths, or two signal generators, each with two basebands, or four single-path generators to generate the various signals are required.

### Uplink DC-HSDPA feedback settings

The uplink settings are the same like in DC-HSDPA (see 2.4.2), but up to four ACK and CQI information are transmitted. For this two HS-DPCCH's are transmitted, each supports two downlink carriers.

To do so, set "3" in "Secondary Cell Enabled" and "Secondary Cell Active".



**Fig. 35 HS-DPCCH settings. Three additionally cells are supported.**

### 3 HSPA+ signal analysis

This chapter illustrates how to add HSPA+ measurement functions to the FSU, FSQ, FSG, FSP, FSV and FSW analyzer families in line with the 3GPP specifications for FDD mode. Measurements can be performed on (sub-)systems as well as on individual components – such as amplifiers – that may have to meet more stringent requirements. All measurements can be remotely controlled. The results and demodulated data bits can be transferred via Ethernet LAN (100 Mbps) or via the IEEE bus – an ideal solution in production.

The FS-K72 application firmware provides the basic functionality needed for W-CDMA base station testing. This firmware can be extended to encompass HSPA (high speed packet access) for base station testing using FS-K74, and also to encompass user equipment testing using FS-K73.

Rohde & Schwarz offers a dedicated firmware option to analyze HSPA+ signals for the FSU, FSQ, FSG and FSP. The options FS-K74+ and FS-K73+ offer 64QAM downlink analysis and 16QAM uplink analysis, respectively. This includes automatic detection of signals, including the relative code domain error measurement. FS-K74+ and FS-K73+ run on top of the existing options for W-CDMA, HSDPA and HSUPA signal analysis.

For the FSV, the FSV-K72 (BTS measurements, DL) and FSV-K73 (UE measurements, UL) application firmware already includes HSPA+ analysis possibilities.

For the FSW, the FSW-K72 (BTS measurements, DL) and FSW-K73 (UE measurements, UL) application firmware already includes HSPA+ analysis possibilities.

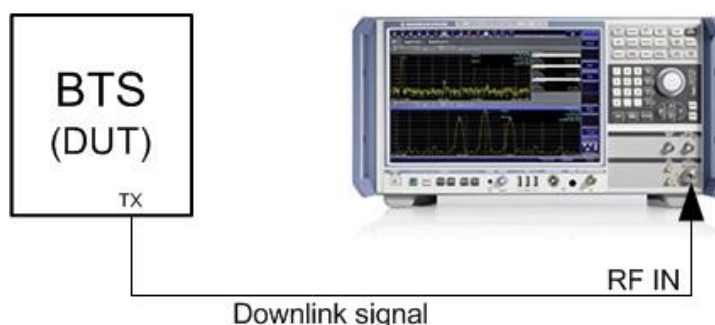
For both FSV and FSW, the additional FS-K74+ and/or FS-K73+ option are not required.

Overview of FSx options for WCDMA/HSPA+		
<b>FSW</b>	FSW-K72	3GPP (W-CDMA) BS (DL) Analysis, incl. HSDPA and HSPA+
	FSW-K73	3GPP (WCDMA) UE (UL) Analysis, incl. HSUPA and HSUPA+
<b>FSV</b>	FSV-K72	3GPP BS (DL) Analysis, incl. HSDPA and HSDPA+
	FSV-K73	3GPP UE (UL) Analysis, incl. HSUPA
<b>FSx</b>	FS-K72	3GPP BTS/Node B FDD Application Firmware
	FS-K73	3GPP UE FDD Application Firmware
	FS-K73+	3GPP HSPA+ UE Application Firmware
	FS-K74	3GPP HSDPA BTS Application Firmware
	FS-K74+	3GPP HSPA+ BTS Application Firmware

**Table 3:** Overview of FSx options for W-CDMA/HSPA+



Fig. 36 and Fig. 37 show the basic test setups for base stations and user equipment.



**Fig. 36 Basic test setup for base station TX.**



**Fig. 37 Basic test setup for user equipment TX.**

General RF measurements, including channel power, ACLR, occupied bandwidth or spurious emissions can be performed independently of the options listed above.

### 3.1 64 QAM downlink and 16 QAM uplink analysis

Fig. 38 provides an example measurement for a code domain power measurement on a 64QAM downlink signal with 16 active channels. Active and inactive channels are marked in different colors. Inactive channels (noise, interference) are displayed with the highest spreading factor.

The channel table (see Fig. 39, right side) lists all channels detected in the signal and their most significant parameters.

Note that the primary scrambling code being used must be set for all measurements so that the signal can be correctly identified. The Autosearch function ("Code Domain Analyzer > Scrambling Code > Autosearch") permits automated detection.

The summary table (see Fig. 39, left side) shows the main parameters for the total signal at a glance (e.g. total power, frequency error and error of chip rate), as well as the parameters for the marked code channel, such as modulation type (64QAM), timing offset, code power and average relative code domain error. Three different measurements are stipulated in the 3GPP specifications for determining the modulation quality:

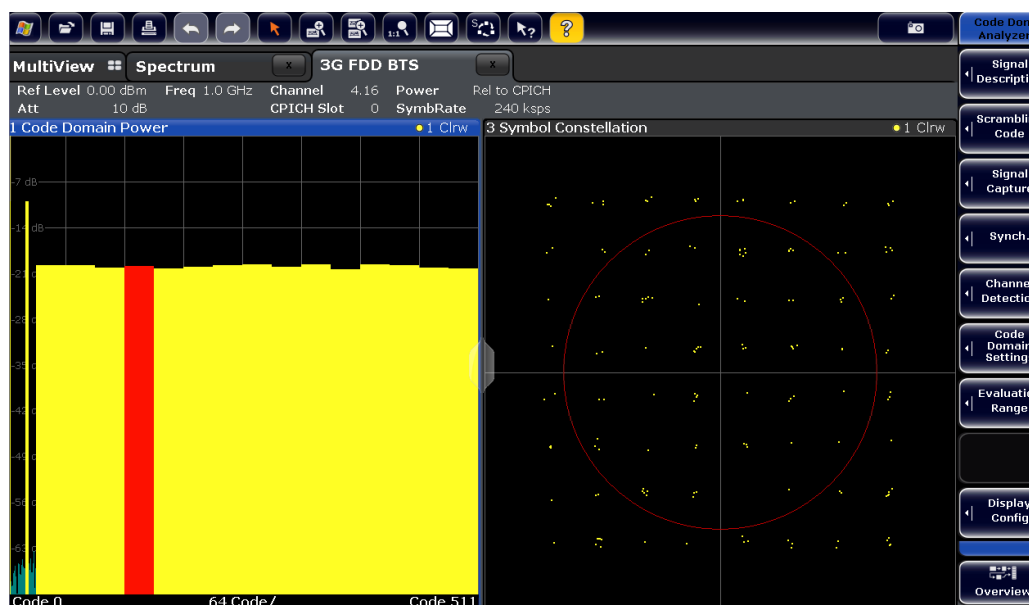
- EVM (error vector magnitude)
- Peak code domain error
- Average relative code domain error

The code domain power measurement offers an in-depth analysis for a W-CDMA signal with several active channels. The composite EVM measurement returns a modulation error value for the total signal, whereas the symbol EVM function yields the individual vector errors of the active channels.

To obtain the peak code domain error (PCDE), the vector error between the measured signal and the ideal reference signal is determined and projected to the codes of a specific spreading factor. With FS-K72, the spreading factor for the PCDE measurement can be selected by the user.

FS-K74+/K73+, FSV-K72/K73 and FSW-K72/K73 provide relative code domain error (RCDE) measurements, i.e. they determine the ratio of the mean power of the error vector projection onto a selectable code to the code's mean power in the composite reference waveform.

The average RCDE is calculated over all 64QAM-modulated channels, and per 3GPP TS 25.104 [6], it must not exceed -21 dB.



**Fig. 38** Code domain power measurement of a 64QAM signal and its constellation diagram.

Ref Level	0.00 dBm	Freq	1.0 GHz	Channel	5.16	Power	Rel to CPICH
Att	10 dB			CPICH Slot	0	SymbRate	240 ksps
2 Result Summary							1 Clrw
General Results (Frame 0, CPICH Slot 0)							
Total Power						-30.46 dBm	
Carrier Freq Error						7.77 Hz	
Chip Rate Error						-0.01 ppm	
Trigger To Frame						5.598310 ms	
IQ Offset						0.06	
IQ Imbalance						0.03 %	
Avg Power Inact Chan						-106.51 dB	
Composite EVM						0.67 %	
PK CDE(15 Ksps)						-64.60 dB	
Rho						0.999959	
No of Active Channels						18	
Avg RCDE(64QAM)						-31.82 dB	
Channel Results (Ch 5.16)							
Symbol Rate						240 ksymb/s	
Timing Offset						0 Chips	
No of Pilot Bits						0	
Channel Slot No						0	
RCDE						-31.80 dB	
Modulation Type						64QAM	
Channel Power Abs						-54.42 dBm	
Channel Power Rel						-20.22 dB	
Symbol EVM						5.62 % PK	
Symbol EVM						2.57 % rms	
3 Channel Table							
Chan Type	Ch.SF	PwrAbs [dBm]	PwrRel [dB]	State	Mod Type	SymRate [ksps]	Tot [Ch]
CPICH	0.256	-34.20	0.00	ON	QPSK	15	0.00
PSCH		-34.20	-0.00	ON	NONE	0	0.00
SSCH		-34.20	-0.00	ON	NONE	0	0.00
PCCPCH	1.256	-34.20	0.00	ON	QPSK	15	0.00
HSPDSCH	1.16	-54.02	-19.82	ON	64QAM	240	0.00
HSPDSCH	2.16	-53.94	-19.74	ON	64QAM	240	0.00
HSPDSCH	3.16	-54.30	-20.09	ON	64QAM	240	0.00
HSPDSCH	4.16	-54.12	-19.92	ON	64QAM	240	0.00
HSPDSCH	5.16	-54.42	-20.22	ON	64QAM	240	0.00
HSPDSCH	6.16	-54.18	-19.98	ON	64QAM	240	0.00
HSPDSCH	7.16	-53.98	-19.77	ON	64QAM	240	0.00
HSPDSCH	8.16	-53.81	-19.60	ON	64QAM	240	0.00
HSPDSCH	9.16	-54.27	-20.06	ON	64QAM	240	0.00
HSPDSCH	10.16	-53.91	-19.70	ON	64QAM	240	0.00
HSPDSCH	11.16	-54.57	-20.37	ON	64QAM	240	0.00
HSPDSCH	12.16	-53.88	-19.67	ON	64QAM	240	0.00
HSPDSCH	13.16	-54.02	-19.81	ON	64QAM	240	0.00
HSPDSCH	14.16	-54.39	-20.19	ON	64QAM	240	0.00
HSPDSCH	15.16	-54.44	-20.24	ON	64QAM	240	0.00
CHAN	5.128	-44.21	-10.00	ON	QPSK	30	0.00

Fig. 39 Result summary table and channel table of the 64QAM signal.

Accordingly, Fig. 40 illustrates a code domain power measurement of a 16QAM uplink signal with two active channels on the I- and the Q-branch respectively, and includes the constellation diagram.

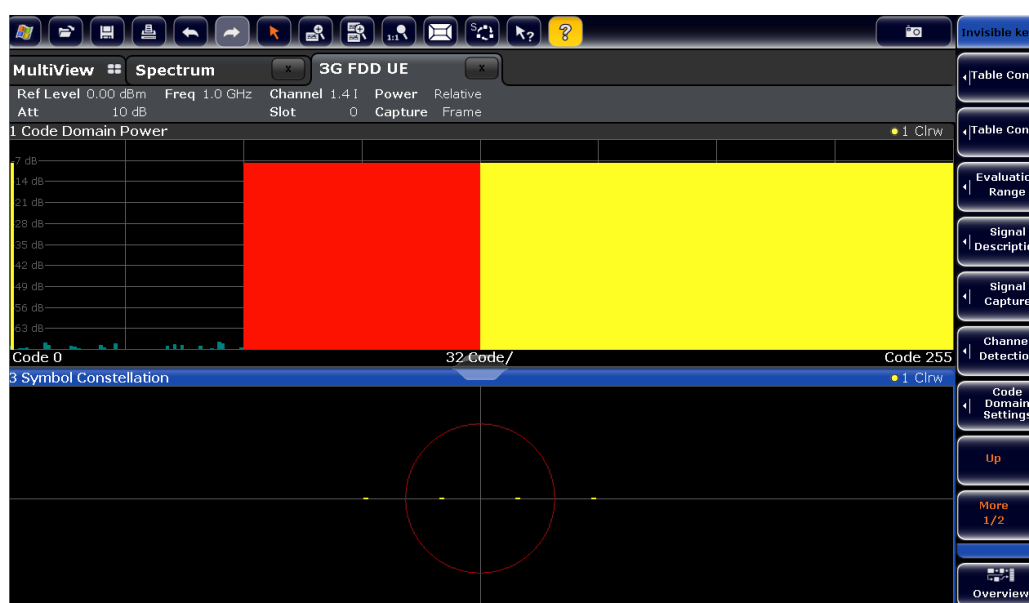


Fig. 40 Code domain power measurement on a 16QAM signal and its constellation diagram (4PAM modulation on the I- and the Q-branch, respectively).

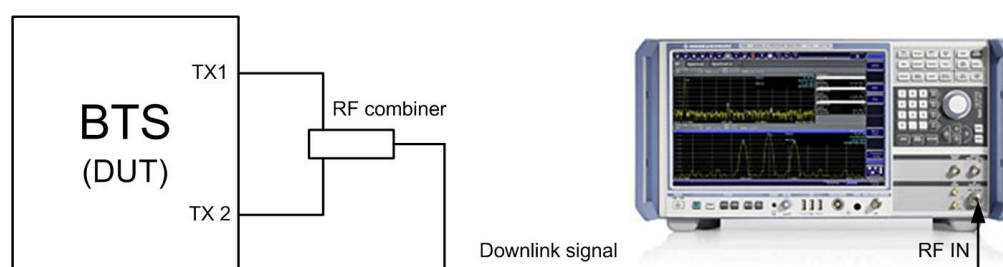
## 3.2 MIMO analysis

### 3.2.1 Time alignment analysis

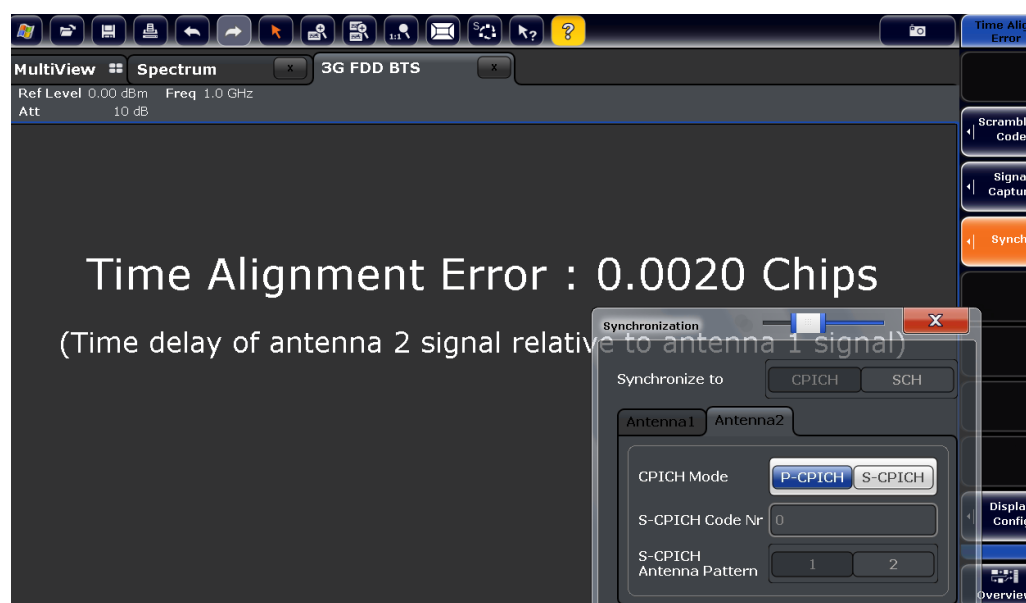
One important requirement for the NodeB transmitting HSPA+ MIMO signals is to achieve a specified time synchronicity of the MIMO signal via the two transmit antennas.

In 3GPP TS 25.104 [6] for downlink MIMO, the specification text reads:  
*In Tx Diversity and MIMO transmission, signals are transmitted from two antennas. These signals shall be aligned. The time alignment error in Tx Diversity and MIMO transmission is specified as the delay between the signals from the two diversity antennas at the antenna ports. The time alignment error in Tx Diversity or MIMO transmission shall not exceed  $\frac{1}{4} T_c$ .*

As a result, the absolute requirement is approximately 65  $\mu\text{s}$ , which can easily be measured with an FSU, FSQ, FSG or FSP using the HSPA+ software options FS-K72 or the FSW-K72, as illustrated in Fig. 41 and Fig. 42.



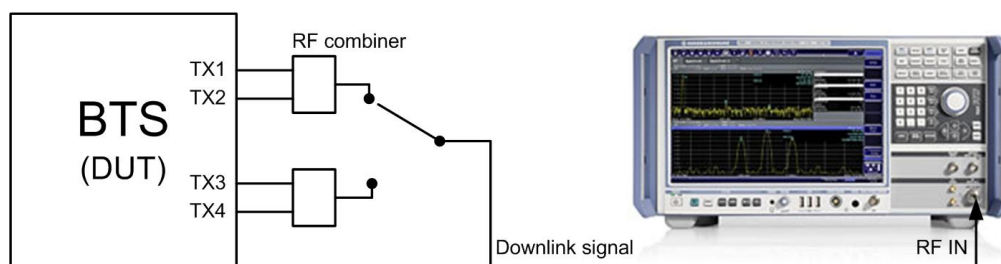
**Fig. 41** Time alignment error measurement of a MIMO signal.



**Fig. 42** Time alignment error measurement of a MIMO signal with the FSW.

Fig. 42 also shows the setting that measures the pilot signals used for both antennas.

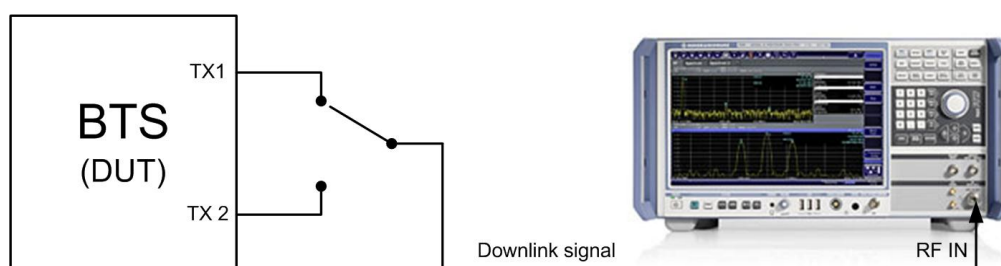
When DC-HSDPA and MIMO are combined, this measurement is performed separately for each of the two carrier frequencies, as shown in Fig. 43. 3GPP TS 25.104 [6] specifies that the time alignment error for DC-HSDPA with MIMO must be no greater than  $\frac{1}{2} T_c$  (instead of  $\frac{1}{4} T_c$ ).



**Fig. 43** Time alignment error measurement on a DC-HSDPA signal with MIMO.

### 3.2.2 Single antenna measurement

MIMO measurements are performed on each antenna sequentially. Fig. 44 shows the test setup.



**Fig. 44** Test setup for a single antenna MIMO measurement.

In this case, HS-PDSCH channels with either QPSK or 16QAM in both streams are detected and demodulated automatically. This is done by setting MIMO mode and selecting the antenna to be tested. See Fig. 45 for an example. In this example, a 2x2 MIMO system with 16QAM in both streams was measured at the first antenna. The displayed constellation (see Fig. 46) resulted from the convolution of the 16QAM constellation with itself, and therefore consists of 49 constellation points (9 constellation points would result for QPSK). This means that EVM measurements are possible for these signals, as well. However, because information is available from only one antenna, the received signal cannot be decoded and the bit stream cannot be displayed.

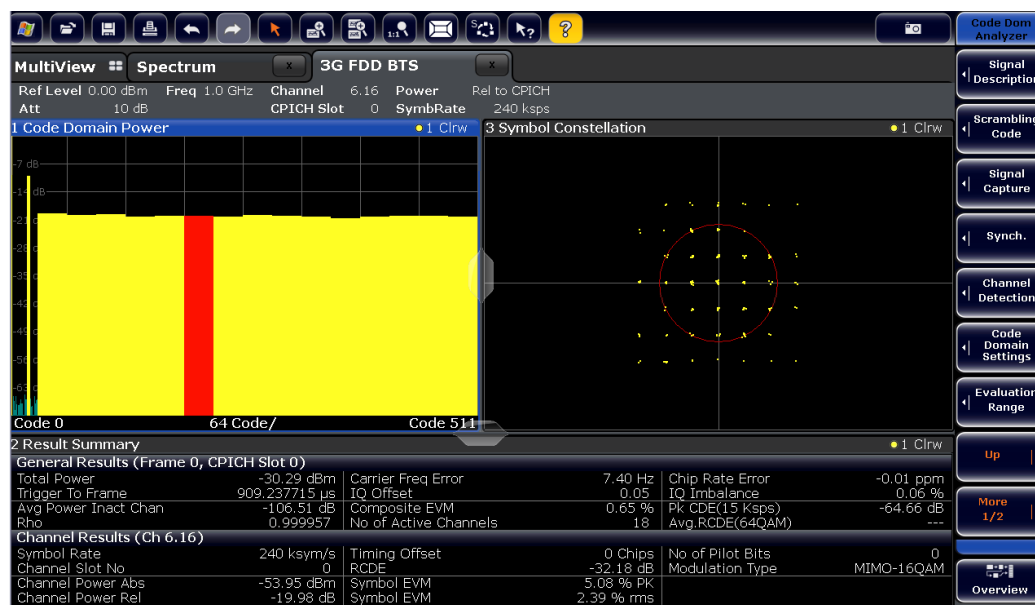


Fig. 45 Single antenna MIMO measurement, showing code domain and constellation diagram.

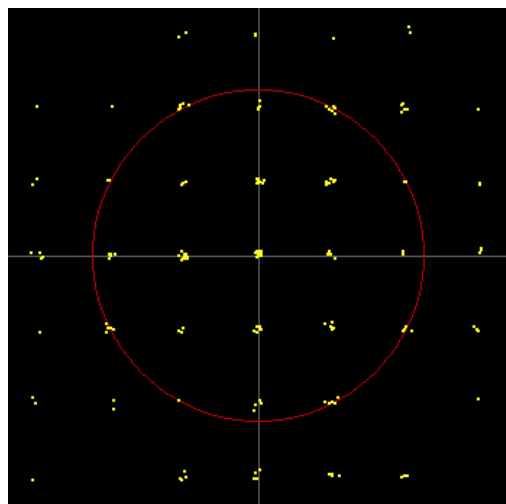


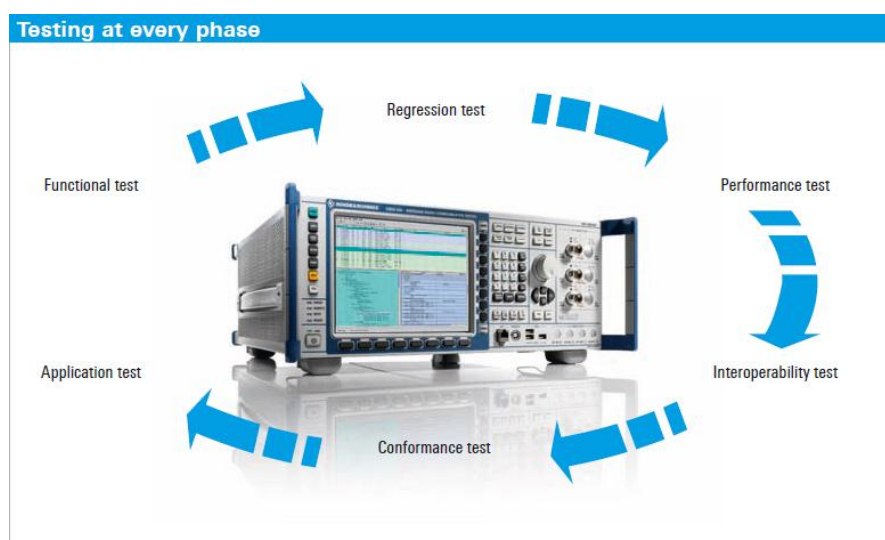
Fig. 46 Constellation diagram for 16QAM x 16QAM MIMO (after convolution: 49 constellation points).

## 4 HSPA+ with the CMW500

The CMW can be used as a protocol tester (message analysis) as well as a radio communication tester (call box, RF test).

In addition to W-CDMA, the CMW offers other radio communication standards, including LTE (FDD and TDD), GSM, CDMA2000, 1x-EV-DO and so on. This makes it possible to test InterRAT scenarios, such as W-CDMA handover to GSM or LTE.

Equipped with powerful hardware and various interfaces to wireless devices, the CMW can be used throughout all phases of HSPA+ device development – from the initial module test up to the integration of software and chipset, as well as for conformance and performance tests of the protocol stack of 3GPP standard-compliant wireless devices, see Fig. 47.



**Fig. 47 Consistent hardware and software concept for all device development phases.**

CMW500 HSPA+
<b>Release 7</b>
<b>HSPA+ Feature</b>
Downlink MIMO
HOM 64 QAM Downlink
HOM 16 QAM Uplink
CPC
F-DPCH
Improved Layer 2 support for downlink

CMW500 HSPA+
<b>Release 7</b>
<b>HSPA+ Feature</b>
Enhanced CELL_FACH state (downlink)
<b>Release 8</b>
<b>HSPA+ Feature</b>
Combination of MIMO and 64QAM
CS over HSPA
Dual cell HSDPA
Improved Layer 2 support for uplink
Enhanced CELL_FACH state (uplink)
HS-DSCH DRX reception in CELL_FACH
HSPA VoIP to W-CDMA/GSM CS continuity
Serving cell change enhancements
<b>Release 9</b>
<b>HSPA+ Feature</b>
Dual band HSDPA
Dual cell HSDPA + MIMO
TxAA extensions

**Table 4: Overview of HSPA+ features in CMW500**

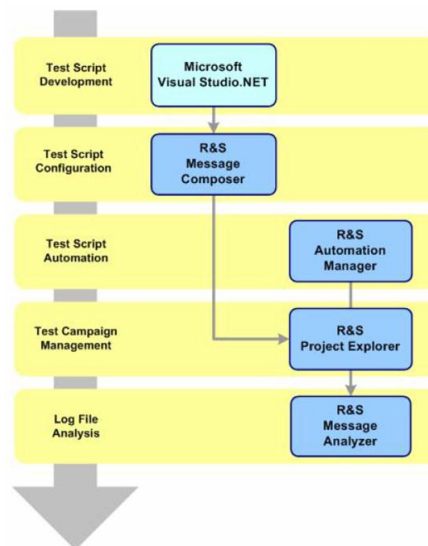
## 4.1 HSPA+ in the CMW protocol tester

The CMW protocol tester provides developers of UE protocol stacks with a specification-conforming reference implementation of the air interface. The comprehensive functions of the programming interfaces and the highly detailed representation in the analysis tools can be used to quickly detect discrepancies in the DUT protocol stack.

The widely used MLAPI interface provides the C++ programming interface to the protocol tester, allowing users to run pre-defined example or reference scenarios and also to develop and modify their own scenarios. As a result, test case creation is significantly simplified and accelerated. The very same tool chain as known from the well established CRTU-W protocol tester environment is available and can be reused.



The Message Composer allows users to compose send and receive constraints, whereas the Message Analyzer provides the means to analyze results and export constraints. The TestSuite Explorer defines configurations and manages suites, while the Project Explorer defines sequences and executes and manages the results. Finally, MS Visual Studio is available for developing and building test scenarios, while the Automation Manager provides full automation during the execution of all test cases and scenarios with minimal or no human interaction. The workflow is illustrated in Fig. 48.



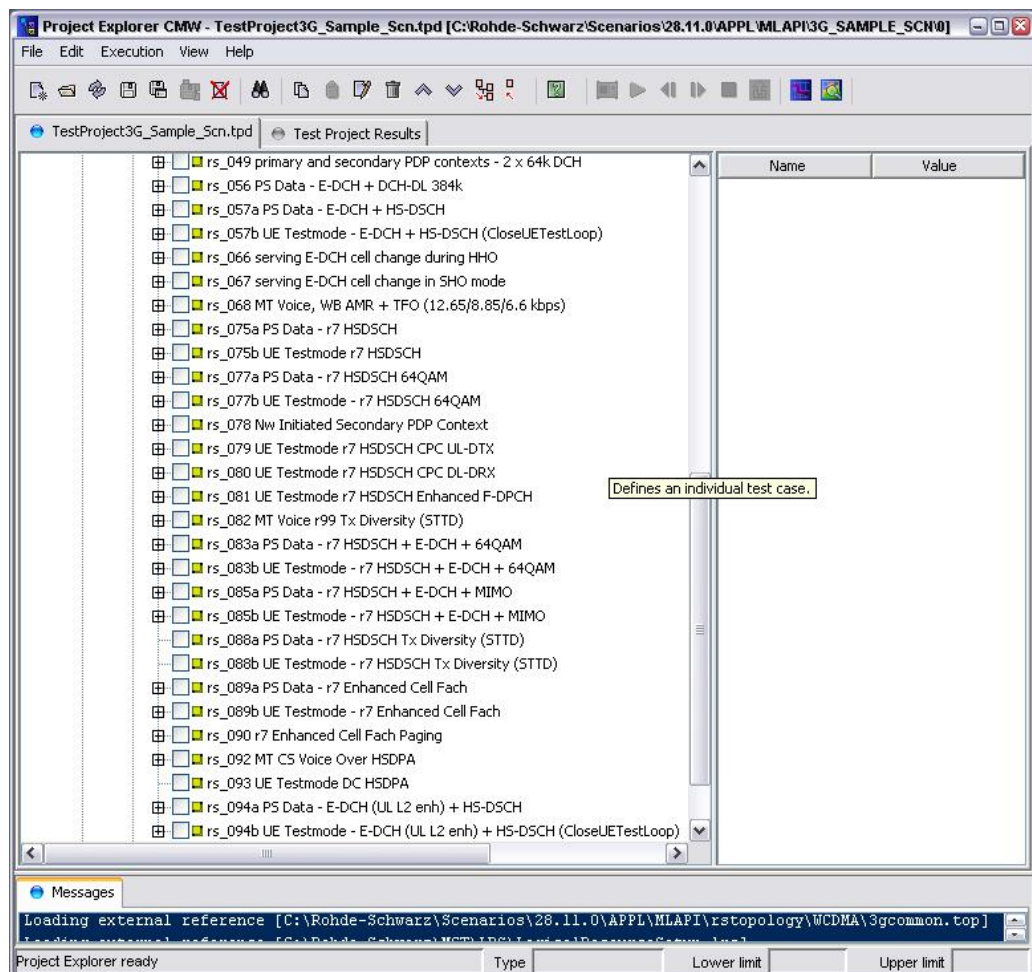
**Fig. 48** Test case development workflow.

The CMW protocol tester supports a very large number of test cases (TCs). Registered users can view a summary of the currently available TCs on the **CMW Customer Web** at <https://extranet.rohde-schwarz.com/>.

#### 4.1.1 HSPA+ E2E throughput test

In addition to message analysis, the main test requirement using the two features is to determine the throughput capabilities of the device under test (DUT), ideally allowing an E2E application to run a specific service of interest. The above illustrated tool chain and the HSPA+ functionality offer an ideal environment to assess the DUT performance, including E2E testing.

Fig. 49 shows available example scenarios to test HSPA+ functionality. Using these scenarios, the CMW protocol tester generates internal arbitrary data after setting up the appropriate radio bearer with the DUT.



**Fig. 49 Project Explorer with 3G test cases for HSPA+ testing.**

After the test case is started successfully, the throughput can be evaluated by starting the Protocol Testing Monitor (PTM), for example (see Fig. 50). The logging capabilities of the protocol tester and the message analyzer permit a detailed investigation of the message flow, making it easy to identify loss of performance due to incorrect behavior and/or protocol errors, for example.

In addition to the throughput performance at RLC level, it is essential to identify the E2E capabilities of the device under test. This is necessary in order to understand the performance of a specific service at IP level.

This happens similar to the internal radio bearer set-up, however in this case no internal data is generated. IP data has to be provided from a suitable application. The Data Application Unit (DAU, see 4.3) provides a convenient method for E2E-Testing.

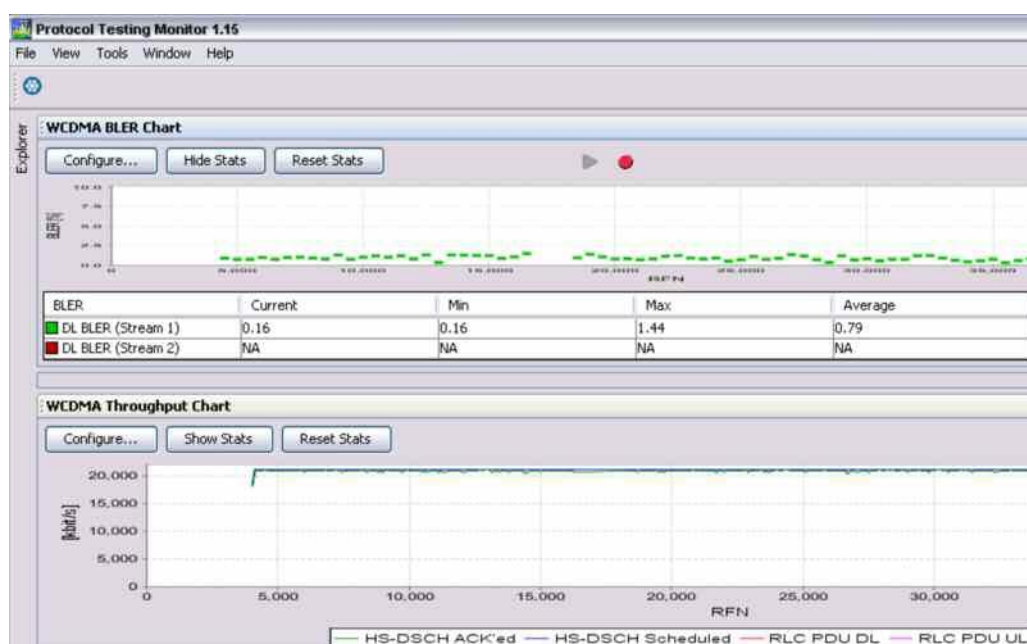


Fig. 50 3G BLER and throughput measurement with the protocol tester.

#### 4.1.2 Running HSPA+ MLAPI scenarios and parallel UL measurements

As mentioned above, the CMW can be used as both a protocol tester and an RF tester.

It is even possible to install both protocol testing and RF testing software options, and consequently to run RF measurements in parallel to a MLAPI test scenario started in the protocol environment. The CMW radio communication tester offers a multi-evaluation mode for performing RF measurements as illustrated in Fig. 51 (see next section 4.2).

This is particularly useful when testing the 64QAM and improved layer2 feature out of the HSPA+ feature set, because it allows users to analyze the throughput and at the same time monitor whether basic Tx operation of the DUT is still running within 3GPP-specified limits.

## 4.2 HSPA+ in the CMW RF tester ("call box")

When used as an RF tester, the CMW consists of a generator for the W-CDMA downlink. It can play back ARB files generated using an external tool, such as WinIQSim or Matlab. An online generator is also available as an option. It permits rapid reconfiguration of the signal and dynamic elements, such as the transmit power control (TPC).

## Transmitter tests (TX)

Measurements on the TX side of the DUT are made possible with the *W-CDMA Multi Evaluation* option (see Fig. 51).

The overview screen provides all measured results and scalar values for the essential measurements: UE power, error vector magnitude (EVM) root mean square (RMS) power, carrier frequency error and occupied bandwidth (OBW). Because measurements results are based on the same set of data, the individual results relate to each other, thus facilitating troubleshooting and debugging..

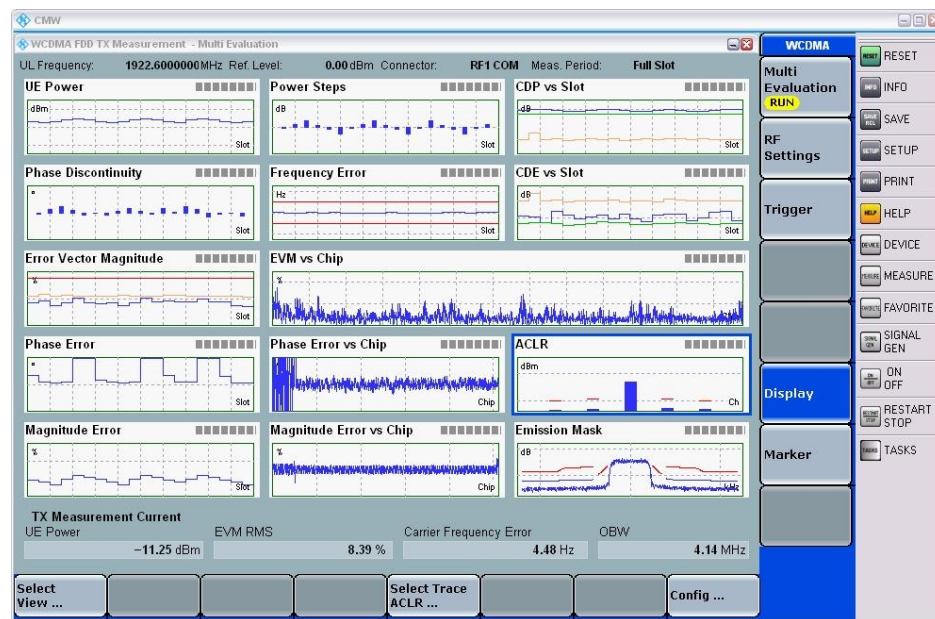


Fig. 51 Multi-evaluation mode of RF uplink measurements.

The overview display in multi-evaluation mode can be adapted to the individual testing needs. For example, it may be necessary to closely monitor only two measurement results, or just one measurement result with a comparison of maximum and average values. The overview display can be configured to meet individual needs.

## Signaling and receiver tests (RX)

The CMW also provides signaling. The "W-CDMA signaling" firmware application (option KS400) allows users to emulate a UTRAN cell and to communicate with the UE under test. The UE can synchronize to the DL signal, register to the circuit switched (CS) domain and attach to the packet switched (PS) domain. A connection can be set up for the CS domain. In addition to the signaling mode, a reduced signaling mode is supported. It allows users to set up a connection without any registration, attach and layer 3 signaling. As a result, modules supporting only layer 1 and 2 can be tested.

This means that RX tests, such as BER or ACK/NACK measurements (BLER, throughput), can be performed in test mode on the DUT.

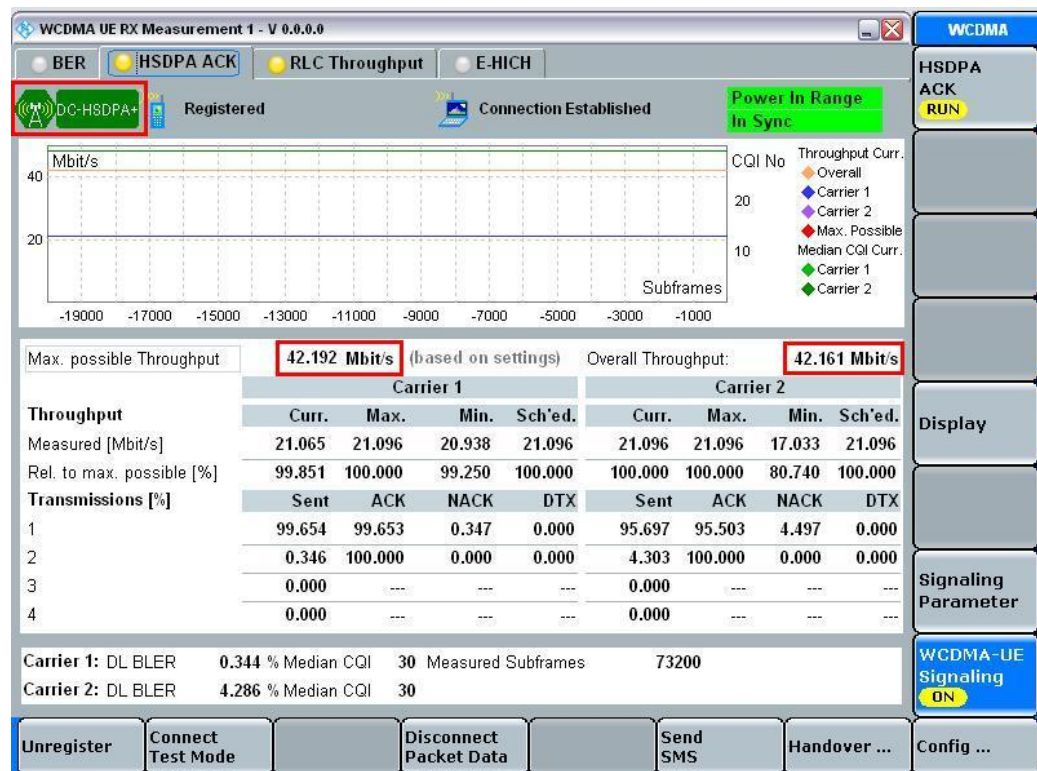


Fig. 52 HSDPA ACK/NACK test of a DC-HSPA+ signal at 42 Mbit/s.

The CMW supports all H-Sets from 1...12 [5][10] as predefined settings. The settings can also be configured individually by selecting "User Defined" (option KS411). A wizard is also available. It automatically matches the settings to a scenario based on the UE category. For example, the scenario "Maximum Throughput" provides an easily configured test of the maximum data rates. The CMW configures the settings automatically. The user does not have to make any changes.

End-to-end data tests can be performed using the DAU (see the next section).

### 4.3 Data Application Unit (DAU) for CMW

The "Data Application Unit" (option B450A) makes it possible to test data transfer via TCP/IP or UDP/IP. It allows users to run Internet Protocol (IP) services on the CMW, such as file transfer and Web browsing. The DAU provides a common and consistent data testing solution on the CMW for all supported radio access technologies.

The DAU is required when testing End-to-End (E2E) IP data transfer as well as when using the instrument for protocol testing (U-plane tests). Together with the DAU, IP-based measurement (option KM050) applications allow users to test and measure the properties of the IP connection, such as network latency or performance. The measurements support Internet protocols IPv4 (option KA100) and IPv6 (option KA150 on top of KA100).



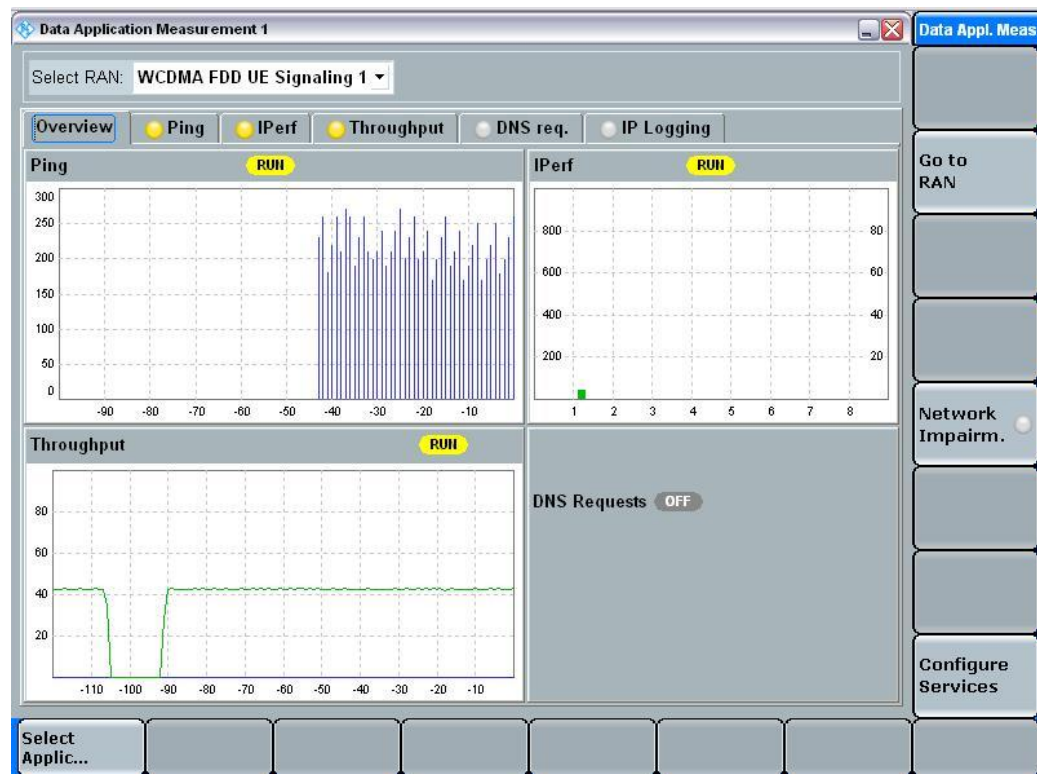


Fig. 53 Overview of the tests in the data application unit. PING, IPPerf and Throughput at a glance.

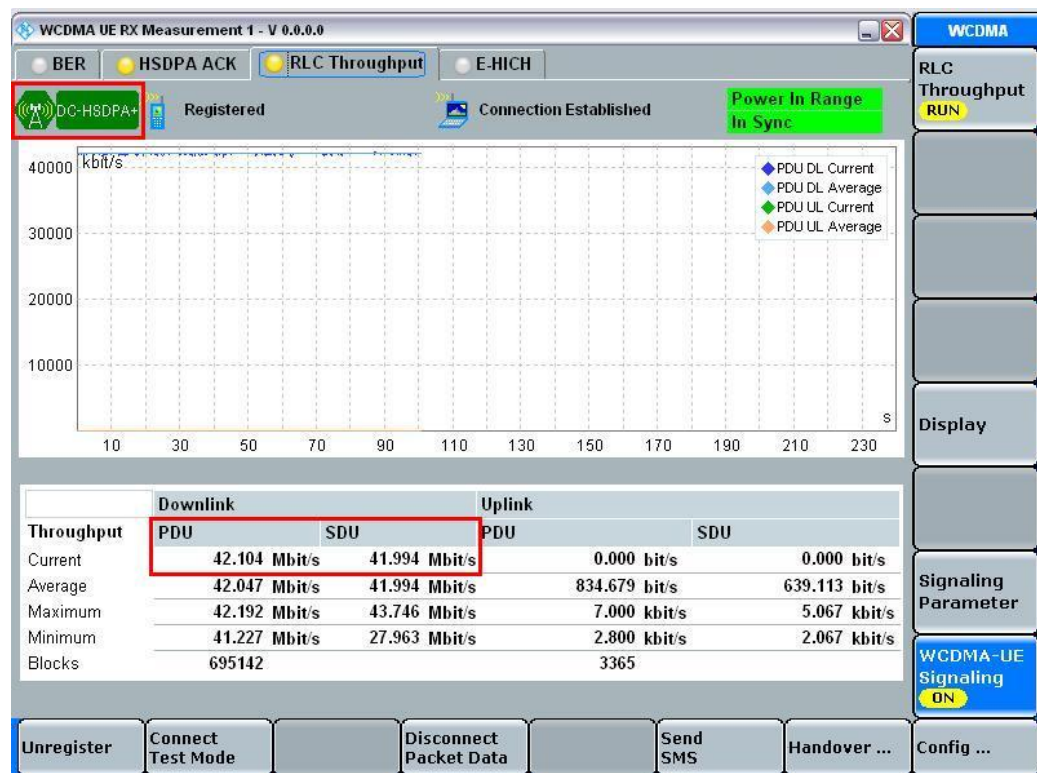


Fig. 54 RLC throughput test of a DC-HSPA+ signal at 42 Mbit/s using the DAU.

## 4.4 Channel simulation – fading

In order to simulate the channel attributes for receiver tests, the CMW can be connected to the AMU via optional digital IQ interfaces. The baseband signals in the AMU are faded, and MIMO (e.g. 2x2) and AWGN are added. The two RF paths can be faded independently of one another (e.g. for DC-HSPA+). The AMU has predefined fading profiles for W-CDMA in accordance with specification [2][5]. The fading parameters can also be changed separately.

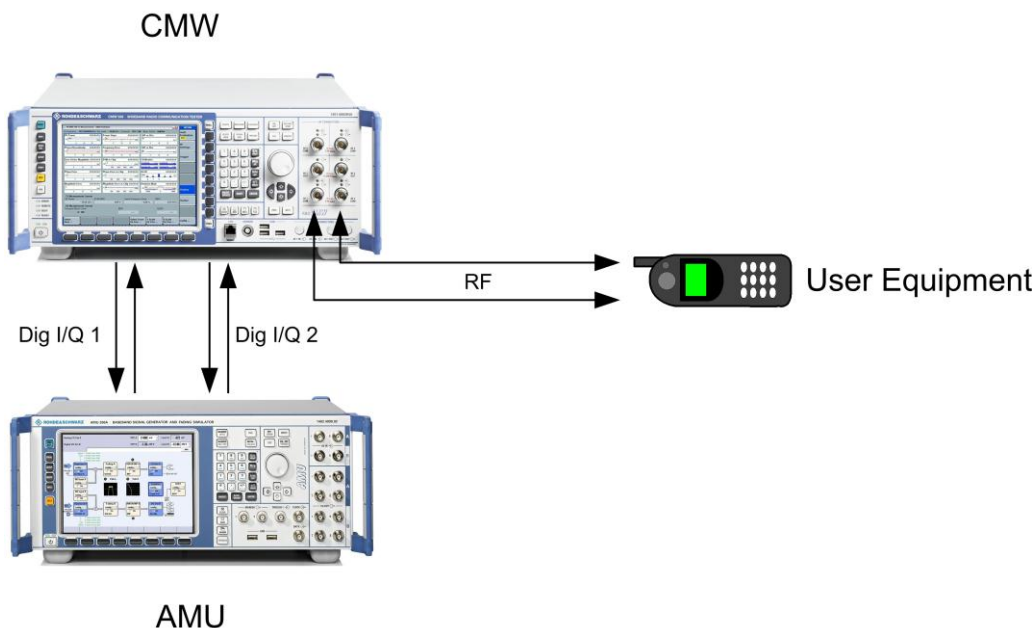


Fig. 55 Test setup for channel simulation with the CMW and AMU (two-channel with MIMO).

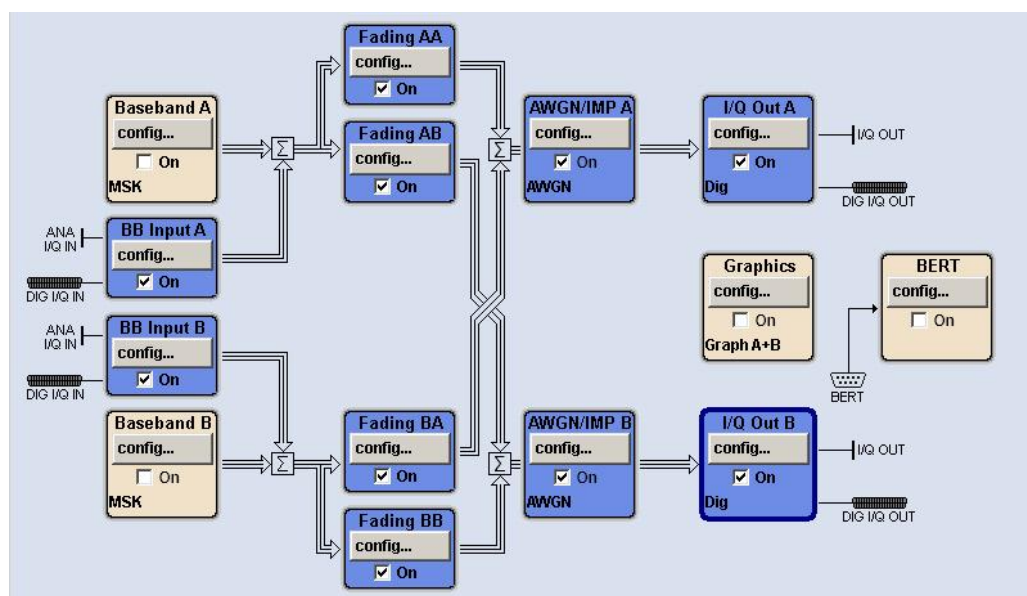


Fig. 56 Block diagram in AMU with 2x2 MIMO, fading and AWGN.

## 5 RF conformance test system TS8980

UEs have to pass various test phases during their development. In the early phase of R&D, the different components of the UE like baseband and RF part are tested independently from each other.

During this time radiocom testers, signal generators (SG) and signal analyzers (SA) are used typically in non-signaling test environments in order to investigate RF receiver and transmitter characteristics of the UE. Pure baseband tests can be done by using simulation and verification using the IQ-interface of the UE which is connected to the IQ-interface of channel emulators, SA and SG. As soon as a logical and physical call setup can be established, further tests on UE prototypes can be performed with the help of a signaling unit (SU) fitted to a radiocom tester like CMW.

Chipset and UE manufacturers will apply differing test specifications. There are internally defined specs which are based on knowledge and prior experience. This is a main part of the test area. Other tests are derived from i.e. the 3GPP test specifications like [TS 34.121]. As maturity of a UE design increases, more testing conditions are added. “House” test specifications as well as [TS 34.121] contain HSPA test scenarios with fading and interference conditions. Additionally, extreme test conditions with varying environmental factors like supply voltage, humidity and temperature are defined for a UE.

Automated test systems like TS8980 with onboard components of SU, SG and SA are able to provide the widest range of such testing conditions. In a pre-conformance context, the user friendly flexibility to change testing parameters like effects of fading and interference as well as tools to find the real design limits in an automated and hence repeatable way are essential. After all, no flaw should pass unnoticed before entering the final stage to market: UE RF certification.

The type approval or certification of UEs according to GCF, PTCRB or a given set of Network Operator test plans is the next phase. GCF and PTCRB requirements typically consist of a subset of otherwise unchanged tests from the 3GPP test specifications.

Network Operator RF test plans usually consist of two types of tests

1. those based on 3GPP with extensions and/or tighter limits, based on an operator's own experience
2. completely new tests as defined
  - a) to protect other services (like Digital TV, ATC Radar, Geolocation services)
  - b) ensure UE performance is not unduly compromised in the vicinity of such other services.

Reproducible and precise measurements are crucial for type approval test systems like the TS8980FTA. Apart from basic accuracy, built-in functions for user-guidance on and/or full automation of calibration is a pre-requisite for a test system to function as an arbiter of UE performance.

Validated certification test case packages for HSPA+ include DC-HSPA, 64QAM DL, CPC, 16QAM UL, Enhanced CELL-FACH, Receiver Types 3 and 3i, and R7 MIMO.





**Figure 57: The test system TS8980FTA**

The TS8980 family of test systems offers the most complete coverage in the industry for applications in W-CDMA and LTE test. TS8980 is used by all leading test houses, first-rate chipset and UE manufacturers, and major network operators.

UTRA and E-UTRA Conformance test in line with GCF and PTCRB as used by labs accredited for certification of mobile devices are complemented by a very broad range of acceptance test packages as defined by many of the leading Network Operators.

The CONTEST graphical user interface gives control over test case execution, automation of DUT, Climatic chamber, DC supply and other external devices. The GUI also comes with a brace of functions for DUT management and standard-compliant result reporting as well as internal and external data base control for result handling, documentation and storage.

Margin Search routines and Performance Evaluation modes allow to evaluate the headroom a DUT has vs certification-level PASS criteria or vs user-specified minimum values.

For more R&D-related work, specific Layer-1 verification packages may be run. RF test for LTE and W-CDMA may be combined with RRM conformance for LTE/W-CDMA, Performance Analysis for LTE/W-CDMA and Location-based services test plans.

Available validated test case packages for HSPA+ are

- 64QAM
- CPC
- Enhanced CELL
- 16 QAM UL
- Type 3
- MIMO R7
- Type 3i
- Dual Carrier

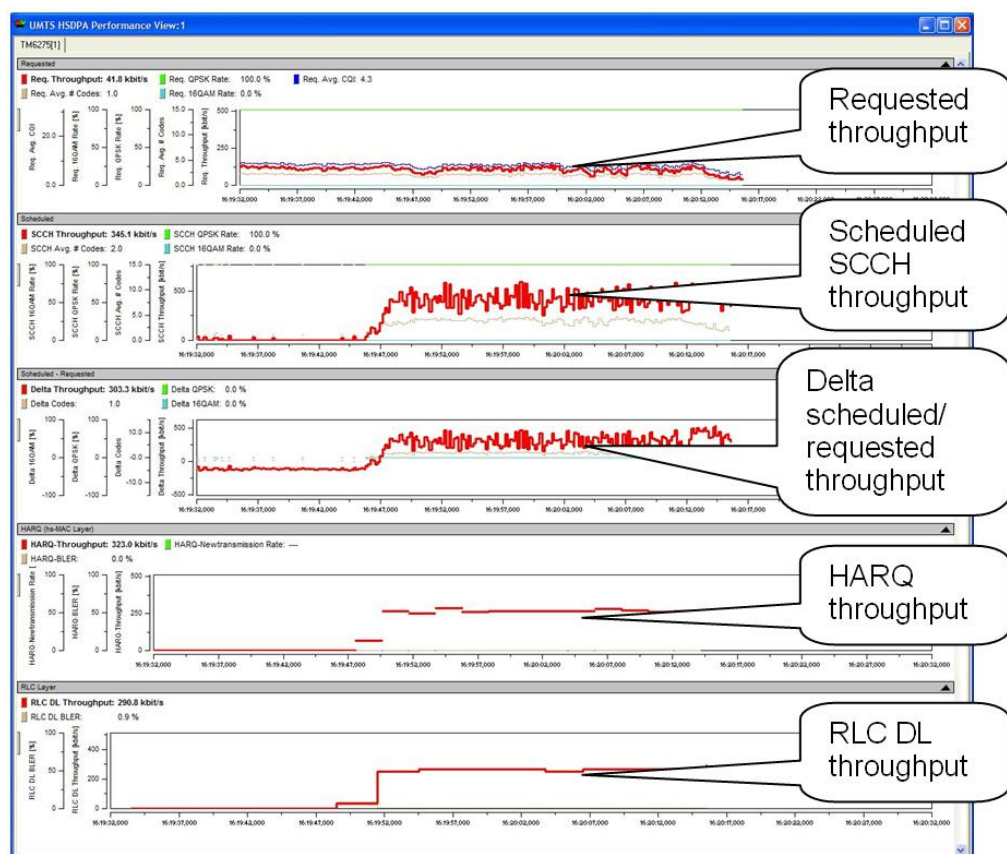
## 6 Drive test solutions

ROMES4 is the universal software platform for the Rohde & Schwarz network optimization systems. In combination with other test and measurement equipment, such as wireless communications scanners and test mobile phones, it provides solutions for all essential tasks involved in coverage measurements, interference identification and performance measurements in wireless communications networks.

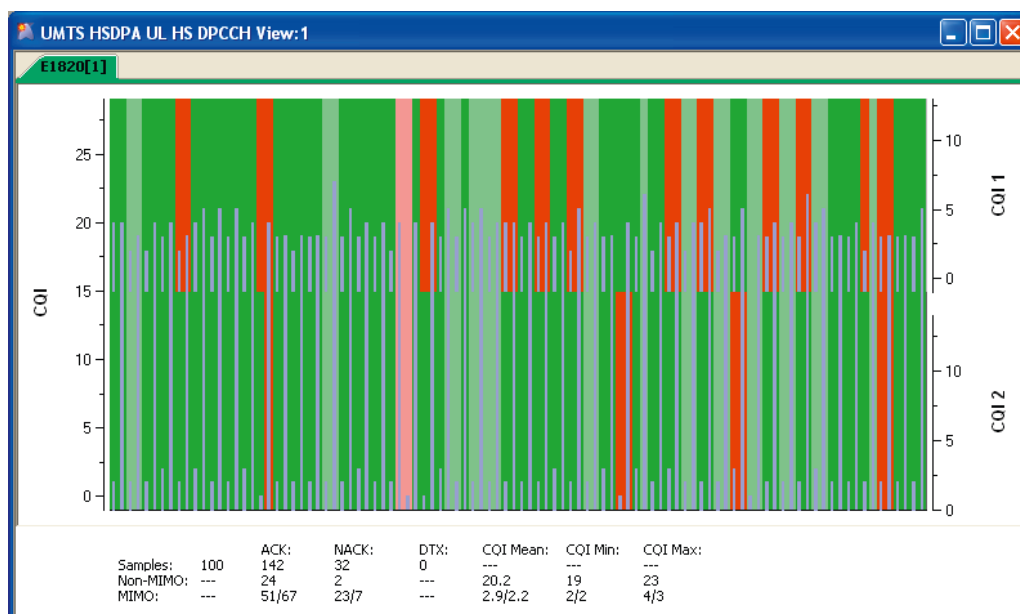
Besides pure recording and visualization of test parameters, data is processed instantly and statistics are calculated in realtime. At present, the GSM/EDGE, WCDMA/HSPA+, CDMA2000® 1xEVDO Rev. A, WLAN (IEEE 802.11b, g), WiMAX™ (IEEE 802.16e), LTE, DVB-T, DVB-H and TETRA technologies are supported.

ROMES4 offers over 15 HSPA(+)-specific "views", which quickly and clearly show all important parameters, thus providing a rapid assessment of the performance.

To optimize an HSPA(+) network, the user observes the data throughput as well as the channel quality (CQI). A low CQI results from a small block size and a low-order modulation. The throughput rates of a network can be optimized by increasing the two values.



**Fig. 58** Throughput view for W-CDMA/HSPA(+).



**Fig. 59 Channel quality indication (CQI) view.**

ROMES fully supports HSPA+ dual cell, which allows a downlink throughput of up to 42 Mbps.

For more information about ROMES and the supported test telephones, refer to the ROMES product brochure [9].

## 7 Appendix

### 7.1 Abbreviations

3GPP	3rd Generation Partnership Project
ACK	Acknowledgement
ARQ	Automatic Repeat Request
BCCH	Broadcast Control Channel
CCCH	Common Control Channel
CPC	Continuous Packet Connectivity
CPICH	Common Pilot Channel
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
DCCH	Dedicated Control Channel
DL	Downlink
DPCCCH	Dedicated Physical Control Channel
DPDCH	Dedicated Physical Data Channel
DRX	Discontinuous Reception
DTCH	Dedicated Traffic Channel
DTX	Discontinuous Transmission
D-TxAA	Double Transmit Antenna Array
E-AGCH	E-DCH Absolute Grant Channel
E-DCH	Enhanced Dedicated Channel
E-DPDCH	Enhanced Dedicated Physical Data Channel
E-RGCH	E-DCH Relative Grant Channel
FACH	Forward Access Channel
F-DPCH	Fractional Dedicated Physical Channel
FDD	Frequency Division Duplex
HARQ	Hybrid Automatic Repeat Request
HSDPA	High Speed Downlink Packet Access
HS-DPCCH	High Speed Dedicated Physical Control Channel
HS-DSCH	High Speed Downlink Shared Channel
HSPA	High Speed Packet Access
HS-PDSCH	High Speed Physical Downlink Shared Channel
HS-SCCH	High Speed Shared Control Channel
HSUPA	High Speed Uplink Packet Access
IP	Internet Protocol
MIMO	Multiple Input Multiple Output
NACK	Negative Acknowledgement
PAM	Pulse Amplitude Modulation
PCCH	Paging Control Channel
PCH	Paging Channel
PCI	Precoding Control Indication
P-CPICH	Primary Common Pilot Channel
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
PCH	Paging Channel
PDU	Protocol Data Unit
PICH	Paging Indicator Channel
PRACH	Physical RACH

RACH	Random Access Channel
RAN	Radio Access Network
RAT	Radio Access Technology
RF	Radio Frequency
RRC	Radio Resource Control
RV	Redundancy Version
S-CCPCH	Secondary Common Control Physical Channel
S-CPICH	Secondary Common Pilot Channel
TDD	Time Division Duplex
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
VoIP	Voice over IP
WCDMA	Wideband Code Division Multiple Access

## 7.2 Literature

- [1] Rohde & Schwarz: **HSPA+ Technology Introduction**, Application Note 1MA205, February 2012
- [2] 3GPP TS 25.141; **Base Station (BS) Conformance Testing (FDD)**, Release 10
- [3] Rohde & Schwarz: **Generating an Uplink Dual Cell HSDPA Test Signal**, Application Sheet 1ZKD-26;
- [4] Rohde & Schwarz: **Generating a DL Dual Cell HSDPA Test Signal**, Application Sheet 1ZKD-27;
- [5] 3GPP TS 25.101; **User Equipment (UE) Radio Transmission and Reception (FDD)**, Release 10
- [6] 3GPP TS 25.104; **Base Station (BS) Radio Transmission and Reception (FDD)**, Release 10
- [7] 3GPP TS 25.211; **Physical Channels and Mapping of Transport Channels onto Physical Channels (FDD)**, Release 10
- [8] Rohde & Schwarz: **Software Manual FS-K72/K74/K74+**
- [9] Rohde & Schwarz: **ROMES4 Drive Test Software**, Product Brochure
- [10] 3GPP TS 34.121-1; **User Equipment (UE) Conformance Specification; Radio Transmission and Reception (FDD); Part 1: Conformance Specification**, Release 10

- [11] 3GPP TS 25.214; **Physical Layer Procedures (FDD)**, Release 10
- [12] ITU ITU-R M.1225, **Guidelines for Evaluations of Radio Transmission Technologies for IMT-2000**, 1997.
- [13] Rohde & Schwarz: **Higher Order MIMO Testing with the R&S®SMW200A Vector Signal Generator**, Application Note 1GP97, April 2013

## 7.3 Additional Information

This application note is subject to improvements and extensions. Please visit [our website](#) to download new versions. Please send any comments or suggestions about this application note to

[TM-Applications@rohde-schwarz.com](mailto:TM-Applications@rohde-schwarz.com)

## 7.4 Ordering Information

Ordering Information		
Vector Signal Generator		
<b>SMW200A</b>		<b>1412.0000.02</b>
SMW-B13	Baseband Main Module, one I/Q path to RF	<b>1413.2807.02</b>
SMW-B13T	Baseband Main Module, two I/Q paths to RF	<b>1413.3003.02</b>
SMW-B10	Baseband Generator with ARB (64 Msample) and Digital Modulation (realtime), 120 MHz RF bandwidth	<b>1413.1200.02</b>
SMW-B10x	1st RF Path	
SMW-B20x	2nd RF Path	
SMW-K511	ARB Memory Extension to 512 Msample	1413.6860.02
SMW-K512	ARB Memory Extension to 1 Gsample	1413.6919.02
SMW-K522	Baseband Extension to 160 MHz RF bandwidth	1413.6960.02
SMW-K42	Digital Standard 3GPP FDD	1413.3784.02
SMW-K62	Additive White Gaussian Noise (AWGN)	1159.8511.02
SMW-B14	Fading Simulator	1413.1500.02
SMW-K71	Dynamic Fading	1413.3532.02
SMW-K71	Enhanced Fading Models	1413.3584.02
SMW-K74	MIMO Fading	1413.3632.02

<b>SMU200A</b>		<b>1141.2005.02</b>
SMU-B9	Baseband Generator with ARB (128 Msamples) and Digital Modulation (realtime)	1161.0766.02
SMU-B10	Baseband Generator with ARB (64 Msamples) and Digital Modulation (realtime)	1141.7007.02
SMU-B11	Baseband Generator with ARB (16 Msamples) and Digital Modulation (realtime)	1159.8411.02
SMU-B13	Baseband Main Module	1141.8003.04
SMU-B102 / B103 / B104 / B106	1st RF Path	1141.8x03.02, x depending on frequency range
SMU-B202 / B203	2nd RF Path	1141.9x00.02, x depending on frequency range
SMU-K42	Digital Standard 3GPP FDD	1160.7909.02
SMU-K43	3GPP FDD Enhanced MS/BS Tests, incl. HSDPA	1160.9660.02
SMU-K45	Digital Standard 3GPP FDD HSUPA	1161.0666.02
SMU-K59	Digital Standard HSPA+	1415.0001.02
SMU-K62	Additive White Gaussian Noise (AWGN)	1159.8511.02
SMU-B14	Fading Simulator	1160.1800.02
SMU-B15	Fading Simulator Extension	1160.2288.02
SMU-K71	Dynamic Fading and Enhanced Resolution	1160.9201.02
SMU-K74	MIMO Fading	1408.7762.02
<b>SMBV100A</b>		<b>1407.6004.02</b>
SMBV-B106	RF 9 kHz – 6 GHz	1407.9703.02
SMBV-B10	Baseband Generator with Digital Modulation (Realtime) and ARB (32 Msample), 120-MHz RF BW	407.8907.02
SMBV-B55	Memory Extension for ARB to 256 Msamples	1407.9203.02
SMBV-K42	Digital Standard 3GPP FDD	1415.8048.02
SMBV-K43	3GPP FDD Enhanced MS/BS Tests, incl. HSDPA	1415.8054.02
SMBV-K59	Digital Standard HSPA+	1415.8219.02
SMBV-K62	Additive White Gaussian Noise (AWGN)	1415.8419.02
<b>Signal Generator</b>		
<b>SGMA RF Source</b>	<b>SGS100A</b>	<b>1416.0505.02</b>



<b>Signal analyzers</b>		
<b>FSW</b>	<b>Up to 8, 13, 26 GHz</b>	<b>1312.8000Kxx</b>
FSW-K72	3GPP (W-CDMA) BS (DL) Analysis, incl. HSDPA and HSPA+	1313.1422.02
FSW-K73	3GPP (WCDMA) UE (UL) Analysis, incl. HSUPA and HSUPA+	
<b>FSQ</b>	<b>Up to 3, 8, 26, 40 GHz</b>	<b>1313.9100.xx</b>
FS-K72	3GPP BTS/Node B FDD Application Firmware	1154.7000.02
FS-K73	3GPP UE FDD Application Firmware	1154.7252.02
FS-K73+	3GPP HSPA+ UE Application Firmware	1309.9274.02
FS-K74	3GPP HSDPA BTS Application Firmware	1300.7156.02
FS-K74+	3GPP HSPA+ BTS Application Firmware	1309.9180.02
<b>FSV</b>	<b>Up to 3, 7, 13, 30, 40 GHz</b>	<b>1307.9002.xx</b>
FSV-K72	3GPP FDD BS Analysis	1310.8503.02
FSV-K73	3GPP UE (UL) Analysis, incl. HSUPA	1310.8555.02
<b>Radio Communication Tester</b>		
<b>CMW500</b>	<b>Radio Communication Tester</b>	<b>1201.0002K02</b>
CMW-S550M	Baseband Interconnection	1202.4801.14
CMW-S590D	RF Frontend	1202.5108.03
CMW-B590A	RF Frontend 2	1202.8707.02
CMW-B300A	Signaling Unit Wideband (SUW), for WCDMA / LTE,	1202.6304.02
CMW-KP40x	Protocol Stack Option WCDMA	
CMW-KC40x	Test Cases WCDMA	
CMW-KF45x	WCDMA HSPA+ MLAPI Scenarios	
CMW-KM40x	WCDMA, TX Measurement, Uplink	
CMW-KS40x	WCDMA Signaling/Network Emulation	
<b>Drive Test</b>		
<b>TSMW</b>	<b>Universal Radio Network Analyzer</b>	<b>1503.3001.03</b>
<b>ROMES4</b>	<b>Drive Test Software</b>	<b>1117.6885.04</b>
<b>Systems</b>		
<b>TS8980</b>	<b>RF Test System</b>	<b>1510.6002.02</b>
<b>TS8980FTA</b>	<b>Conformance Test System</b>	<b>0999.1902.86</b>
<b>TS8980IB</b>	<b>RF ConformanceTest System</b>	<b>0999.1902.84</b>
<b>TS8980S</b>	<b>Pre-Compliance Test System</b>	<b>0999.1902.82</b>

If using the R&S® WinIQSIM2™ with SMBV or SMU to generate standard signals, you must include the appropriate K2x option, where x refers to the standard to be used as defined in this table. For example, to generate HSPA+ signals with WinIQSIM2, you need option K-259.

xx represents the various frequency ranges (e.g. 1155.5001.26 up to 26 GHz).

**Note: Available options are not listed in detail. Please contact your local Rohde & Schwarz sales office for further assistance.**

### About Rohde & Schwarz

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

### Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system



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