Universal Radio Communication Tester R&S®CMU 200

HSDPA – accelerator for WCDMA

HSDPA[1], the expansion of WCDMA[2] in third-generation mobile radio, increases transmission rates in data links from base stations to UMTS user equipment to more than 10 Mbit/s. Such high transfer rates allow fast loading of videos to mobile radio equipment, for example.

This article examines new principles that are being applied to expand a defined mobile radio standard in this way, and which requirements they place on T&M equipment.

Faster with HSDPA

WCDMA FDD (frequency division duplex) was designed for a useful data rate of 384 kbit/s, or 2 Mbit/s if the multiple code method is used. If the chip rate on the air interface remains unchanged (3.84 Mchip/s), up to 14.4 Mbit/s can additionally be transmitted in HSDPA channels in the downlink. This is feasible because of the highly sophisticated communications principles applied in the lower layers (physical layer and MAC layer) of the two communicating partners, i.e. the base station and the mobile radio user equipment.

The key elements of this new standard are as follows:

- Intelligent use and reduction of frames for information units from 10 ms (15 timeslots) to 2 ms (three timeslots).
- Optional use of a higher-level modulation mode (16QAM).
- Fast and optimized adaptation of modulation, channel coding and power in the downlink (adaptive modulation and error coding) to meet current radio channel conditions.
- Continuous and fast feedback of the reception quality in the user equipment (channel quality indication – CQI).
- Short response times have been defined in the physical layer of the mobile radio user equipment. During this time, the equipment acknowledges whether an HSDPA data packet was "understood" (ACK/NACK process).
- Information retransmission with changed coding (incremental redundancy): The mobile radio user equipment intelligently superimposes fragments that were received at different times (soft combining) and thus tries to decode the complete information.
- Division of the transmission subframes into parallel processes that are controlled independently of each other (hybrid automatic repeat request – HARQ).

HSDPA expands the channel structure of the previous WCDMA system (FIG 1). User equipment for HSDPA processes up to four control channels (HS-SCCH) in addition to the known physical channels of a WCDMA cell in the down-

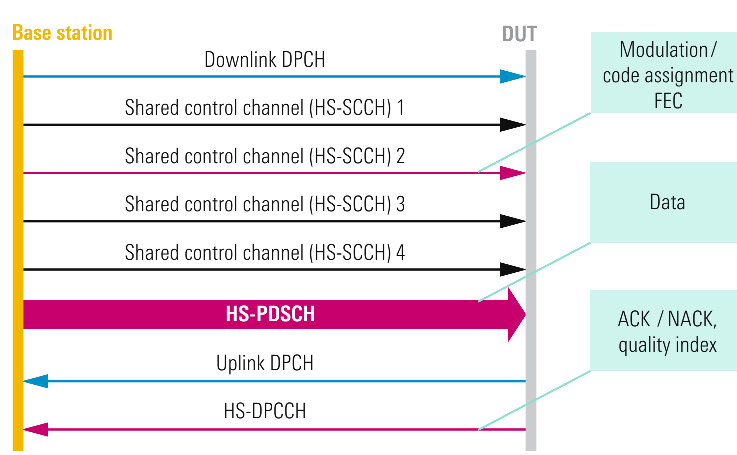

FIG 1 Channel structure of the physical channels with HSDPA.

1) High-speed downlink packet access.
2) Wideband code division multiple access.

HS-DSCH category	Max. number of HS-DSCH codes that can be received	Min. inter-time transmission interval	Max. number of bits in an HS-DSCH transport block during an HS-DSCH TTI	Total number of soft channel bits
1 (1.2 Mbit/s)	5	3	7298	19200
2	5	3	7298	28800
3	5	2	7298	28800
4	5	2	7298	38400
5 (3.6 Mbit/s)	5	1	7298	57600
6	5	1	7298	67200
7 (7 Mbit/s)	10	1	14411	115200
8	10	1	14411	134400
9 (10 Mbit/s)	15	1	20251	172800
10	15	1	27952	172800
11 (QPSK only)	5	2	3630	14400
12 (QPSK only)	5	1	3630	28800

FIG 2 Categories for HSDPA mobile radio user equipment.

link. Each channel contains information about which user equipment (user equipment identity – UE ID) is addressed by the HSDPA transmission and where the data packet that is transmitted a few moments later can be found in the code domain. Plus, the control channel describes the modulation and coding that are used and indicates whether this information is new or a repetition of a previously transmitted packet.

The carriers for the coded and modulated payload are the HS-PDSCH channels, each of which physically occupies the same space in the code domain since they are spread with a fixed factor (SF = 16). A base station can distribute a maximum of 15 HS-PDSCH channels during a transmission to one or more units of user equipment.

The transmission of the control channels and of the associated data channels requires three timeslots each, i.e. 2 ms. It should be noted that the data identifier on the HS-PDSCH channels starts with the third timeslot of the HS-SCCH channel, so there is a time overlap. Thus, the receiver in the mobile radio UE must start processing data even before it receives all the control information it requires.

The 3GPP standard divides mobile user equipment into different categories on the basis of HSDPA performance (FIG 2). The categories indicate which transport block size the equipment offers (a quantity for the maximum information data rate), whether the equipment supports 16QAM, the maximum number of HS-PDSCH channels the equipment can handle and how often the equipment is able to process HSDPA packets consecutively (minimal inter-time transmission interval – TTI).

As you can see from FIG 1, a new HS-DPCCH physical control channel has also been added to the uplink, i.e. the transmission from mobile radio UE to base station. This is the channel on which the mobile radio UE confirms whether it "understood" an HSDPA packet (acknowledged) or not (not acknowledged) so that the packet will be repeated if necessary. Moreover, the mobile radio UE continuously assesses the quality of the transmission path and cyclically transmits this information to the base station as a quality index (CQI) on this channel. Having this information, the base station can quickly define a favourable configuration for the downlink. The response time of an addressed mobile radio UE is precisely specified: no more than 5 ms after a message has been received (FIG 3).

HSDPA with the R&S®CMU200

If the R&S®CMU-K64 software option is added to a Universal Radio Communication Tester R&S®CMU200 (featuring WCDMA functions), the tester can handle HSDPA signal generation and evaluation. At the generator end, you will find ready-to-use scenarios (fixed rate channel test, CQI test, etc) and configuration elements (e.g. parameter sets for HSDPA tests). These scenarios are derived from 3GPP documentation

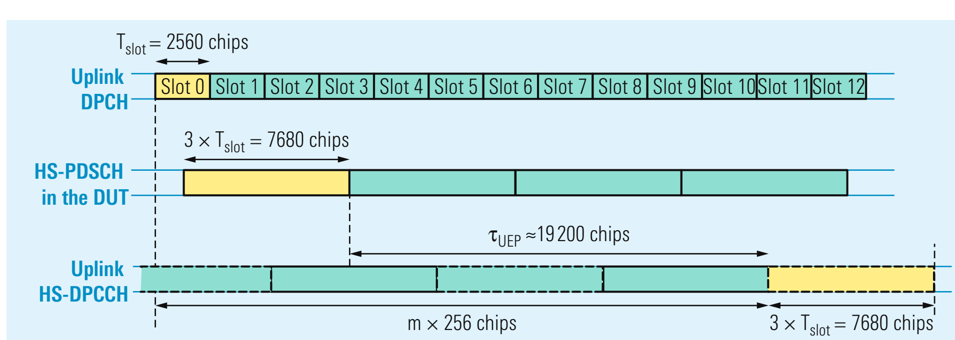

FIG 3 Time correlation in the uplink and downlink (ACK/NACK processing time in the DUT ≈ 5 ms).

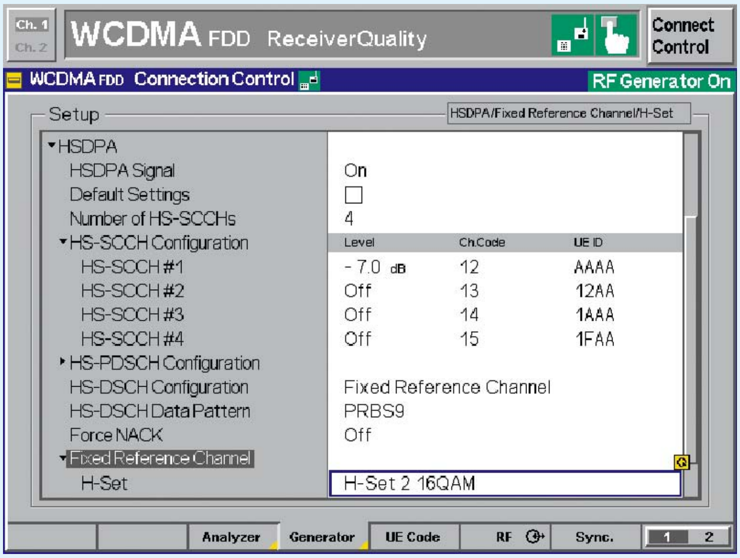

**FIG 4
Section of the HSDPA generator menu.**

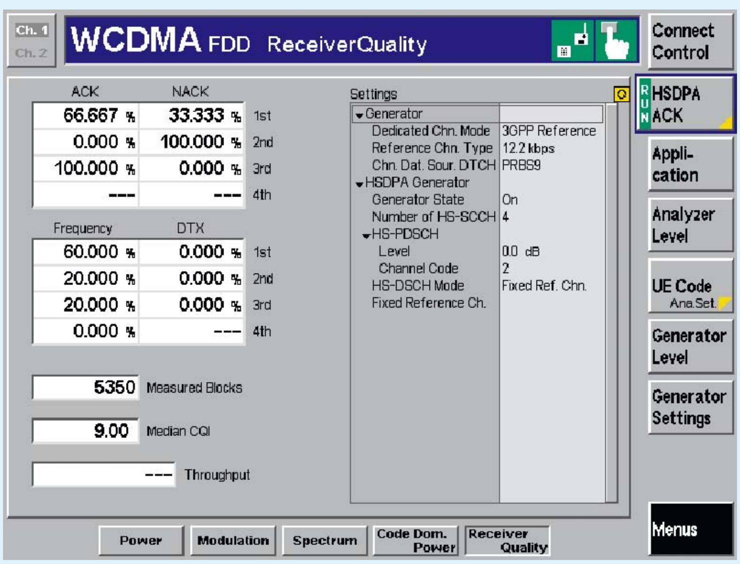

**FIG 5
Section of the HSDPA receiver quality menu.**

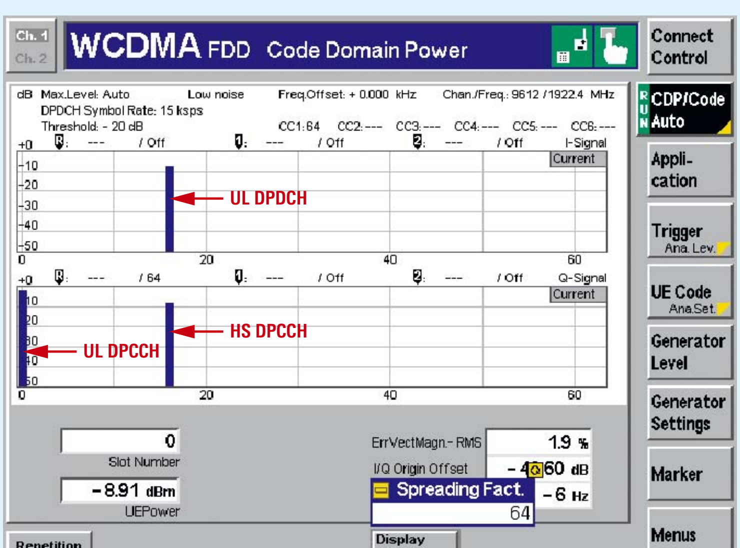

**FIG 6
Code domain measurement in the uplink: DCCH, DPDCH and HS-DPCCH.**

for minimum DUT requirements (3GPP TS 25.101) or, to some extent, from existing measurement procedures for RF conformance tests (3GPP TS 34.121).

For expert users, the R&S®CMU 200 user interface offers downlink parameters that can be configured manually or via remote control. You can thus define basic parameters such as level and code channel, but also modulation mode (QPSK or 16QAM), number of HSDPA channels, transport block size, response in the case of retransmission and much more (FIG 4).

The R&S®CMU-K64 software option in the receive section of the R&S®CMU 200 includes evaluation of the HS-DCCH uplink channel. The tester decodes both the ACK / NACK fields and the CQI information, which it assigns on-screen to the matching transmission in the downlink. Within the instrument, the receiver in the R&S®CMU 200 forwards the control data to the transmitter, thus defining the characteristics of the next downlink transmissions. The complex and time-critical interaction between transmitter and receiver on the tester end must run smoothly to ensure dynamic testing. This is the only way to evaluate the quality of operations such as retransmissions for various test signals and to measure data throughput, for example (FIG 5).

In addition to the HSDPA-specific tests described above, the required expansion of the existing RF test technology in the uplink is also worth mentioning. The modulation and code domain evaluation in the R&S®CMU 200 functions correctly irrespective of whether the additional uplink HS-DPCCH channel is present or not and evaluates the quality of the transmitter in the DUT (FIG 6).

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