HSUPA: 5.76 Mbit/s in the uplink

HSUPA achieves these higher data rates because of the new uplink channels E-DPCCH / E-DPDCH (enhanced dedicated physical control / data channel). In addition, multiple E-DPDCH can transmit in the uplink (multicode). The new control channels in the downlink allow HSUPA to assume a key role by rapidly assigning uplink resources, i.e. the maximum possible transmit power that the UE may currently use [1], [2], [3], [4]. The base station determines the assignment of resources (grants) and conveys this information to the mobile UE on the enhanced uplink absolute grant channel (E-AGCH) and the enhanced uplink relative grant channel (E-RGCH). The hybrid automatic repeat request (HARQ) method, which is already included in HSDPA technology, is also used in HSUPA. The associated reverse channel is the enhanced uplink HARQ indicator channel (E-HICH).

Thoroughly tested with new test software

The new R&S® CRTU-W L1 test software supports HSUPA while high speed downlink packet access (HSDPA) is running simultaneously [5]. The combination of HSDPA and HSUPA is referred to as HSPA (high speed packet access). It is now possible to comprehensively test mobile UE to verify that it complies with the new requirements of packet-oriented connections in WCDMA.

The software includes predefined channel combinations that provide direct access to testing HSUPA chipsets and UE (FIG 1). The two cells of the R&S® CRTU-W protocol tester can be configured as serving cells, cells of serving RLS, or as cells of non-serving RL (see box). Depending on the selected configuration, the parameters of the E-AGCH, E-RGCH, and E-HICH are available.

FIG 1

The basic parameters of the WCDMA cell and channels can be defined in the main menu of the R&S® CRTU-W L1 software.
Details about HSUPA and HSPA

HSUPA is the high-speed expansion for the uplink, which will be introduced with Release 6 of the 3GPP UMTS specification. The use of HARQ and a fast resource assignment mechanism increase spectral efficiency compared with the existing WCDMA method. By reducing redundancy in error correction, the data rate can achieve peak values of up to 5.76 Mbit/s.

HSPA combines the expansions for the downlink (HSDPA) and the uplink (HSUPA). In the future, it will be possible to set up fully packet-oriented connections. The signaling channels of the higher protocol layers can then be transmitted via HSPA channels, making the configuration of dedicated data channels (DCH) unnecessary. This solution paves the way for further optimization of the physical control channels. High data rate and short delay time are essential in time-critical applications (mobile gaming or voice over IP). In addition to the 10 ms frame structure, a 2 ms subframe structure can be optionally used, provided the UE supports this subframe structure. FIG 2 shows the different UE categories. The maximum size of the transport block and the frame structure determine the maximum data rate.

Soft handover for HSUPA is also supported. In this case, the cells in the E-DCH soft handover are classified as serving cells, cells of serving radio link sets (RLS), or cells of non-serving radio links (RL) (FIG 3). A cell of the serving Node B is either a serving cell or a cell of a serving radio link set (RLS).

<table>
<thead>
<tr>
<th>E-DCH category</th>
<th>Max. number of transmitted E-DCH codes</th>
<th>Minimum spreading factor</th>
<th>Transmission time interval (TTI)</th>
<th>Max. number of E-DCH transport block bits that are transmitted in an E-DCH TTI</th>
<th>Data rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>4</td>
<td>nur 10 ms</td>
<td>7110</td>
<td>0.71 Mbit/s</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>10 ms</td>
<td>14484</td>
<td>1.45 Mbit/s</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2 ms</td>
<td>2798</td>
<td>1.4 Mbit/s</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>4</td>
<td>nur 10 ms</td>
<td>14484</td>
<td>1.45 Mbit/s</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>10 ms</td>
<td>20000</td>
<td>2 Mbit/s</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2 ms</td>
<td>5772</td>
<td>2.89 Mbit/s</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2</td>
<td>nur 10 ms</td>
<td>20000</td>
<td>2 Mbit/s</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>2</td>
<td>10 ms</td>
<td>20000</td>
<td>2 Mbit/s</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>2</td>
<td>2 ms</td>
<td>11484</td>
<td>5.74 Mbit/s</td>
</tr>
</tbody>
</table>

FIG 2 HSUPA categories of mobile user equipment. The maximum transmission speed is a key characteristic of the different categories. Support of the 10 ms frame structure is mandatory. The shorter 2 ms subframe structure is specified for only a few categories. If four codes are to be transmitted simultaneously, two of them should have a spreading factor of 2, the other two a spreading factor of 4.

FIG 3 Overview of the HSUPA channel structure.
able. The timing of the HSUPA channels is automatically set in this configuration; the test software supports the 10 ms frame structure and the optional 2 ms subframe structure.

The E-AGCH is used to signal the “absolute grant”, i.e. the maximum transmit power that is currently possible. An enhanced uplink radio network temporary identity (E-RNTI) is transmitted together with the absolute grant to ensure that the UE is unambiguously addressed. As the test software supports the primary and secondary E-RNTI, specific switchover algorithms can be tested in the UE. For a 2 ms subframe structure, activating and deactivating individual HARQ processes can be signaled via the absolute grant scope.

The relative classification of resources (relative grant) is transmitted in the E-RGCH (FIG 4). This channel can contain information for each frame or subframe on how to adapt the current resources by entering different bit patterns (1: up, 0: down, — (DTX): hold). The E-HICH and the E-RGCH are identical in structure. The menu layout is similar to that of the E-RGCH, allowing different bit patterns to be transmitted: 1: ACK, 0: NACK, — (DTX): NACK (in cell of non-serving RLS).

The uniform use of HSPA (see box on page 5) basically makes the use of dedicated physical data channels (DPDCH) unnecessary; nevertheless, measures must still be taken to ensure that the mobile UE does not transmit at more than the required power (closed loop power control). For this reason, the fractional dedicated physical control channel (F-DPCCH) was introduced in the downlink in Release 6; it controls the power of different UE in a time division multiplex method. The R&S®CRTU-W thus also supports the F-DPCCH.

Another benefit of the R&S®CRTU-W L1 test software is its capability to analyze uplink channels. In addition to all data of the DCH transport channels and the physical DPCCH control channel, E-DPCCH information can be recorded and analyzed. The information for the E-DPCCH may be provided as raw bit information, or as evaluated signaling of the individual E-TFCI, happy bit, and RSN fields.

FIG 4 Definition of the HSUPA downlink control channels E-HICH and E-RGCH.

Other means for analyzing the E-DCH are in the pipeline. In the future, the user can either record the bit content directly after demodulation (direct data logging), or after the decoding stage at the E-DCH level.

**Summary**

With the HSUPA expansion, the R&S®CRTU-W L1 test software offers a broad scope of capabilities for testing the Release 6 functionality of mobile phones. The R&S®CRTU-W protocol tester additionally generates the HSUPA downlink channels for monitoring the UE resources and the indicator channel for the HARQ protocol. The new uplink control channel E-DPCCH can be thoroughly analyzed.

Uwe Bäder

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**REFERENCES**

1) 3GPP specification TS 25.211, Physical channels and mapping of transport channel onto physical channels (FDD)
2) 3GPP specification TS 25.213, Spreading and modulation (FDD)
3) 3GPP specification TS 25.214, Physical layer procedures (FDD)
4) 3GPP specification TS 25.306, UE radio access capabilities