Agilent
HSDPA RF Measurements for User Equipment

Application Note

Agilent Technologies

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Introduction

High speed downlink packet access (HSDPA) is a new packet-based service in the Third Generation Partnership Project (3GPP) Wideband-Code Division Multiple Access (W-CDMA) radio format. Designed to provide higher data throughput on the downlink, it was first introduced in Release 5 of the 3GPP specifications. HSDPA employs adaptive modulation and coding to continually reconfigure the downlink, optimizing data throughput for each user depending on the instantaneous quality of the link. The new service is backwards-compatible with 3GPP Release 99 and can be used in conjunction with other services to the same user equipment (UE). Voice and data applications developed for W-CDMA Release 99 can still be run on the upgraded Release 5 networks, and the same radio channel will support W-CDMA and HSDPA services simultaneously.

The changes that HSDPA introduces have test implications in many different areas, including the radio frequency (RF). New UE transmitter and receiver characteristic requirements and a whole new section for UE HSDPA performance requirements have been added to the Release 5 and Release 6 RF conformance test specifications.

This application note explains the meaning and the purpose of the new RF conformance tests for HSDPA-capable UE. The test solutions from Agilent for the different stages of HSDPA UE research and development (R&D) and manufacturing are also introduced.

To get the most from this application note, you should have knowledge of the basic concepts of HSDPA technology. This information is available in the application note "Concepts of High Speed Downlink Packet Access: Bringing Increased Throughput and Efficiency to W-CDMA" (literature number 5989-2365EN). You also should have a good understanding of W-CDMA concepts and measurements.

Please note that a complete listing of the 3GPP specifications mentioned in this application note is provided in the *Reference Specification Documents* section of this note. Other references that appear in brackets [] are listed in the section *Other References*.

Why Test HSDPA User Equipment?

Although HSDPA is primarily a baseband or signaling extension to W-CDMA, many aspects of the new service require specialized testing.

The main aspects of HSDPA technology that have implications for physical layer testing of the UE are the following:

- The new uplink high speed dedicated physical control channel (HS-DPCCH) increases the peak-to-average power ratio (PAR).
- The uplink HS-DPCCH is not usually transmitted continuously and can be offset in time from the dedicated physical control channel (DPCCH).
- The new 16QAM format in the downlink high speed physical data shared channel (HS-PDSCH) has less margin for UE receiver impairments than does QPSK.
- Decoding the downlink high speed data shared channel (HS-DSCH) involves complex new functionality.
- Accurate channel quality reporting is crucial to overall system performance.
- Without correct detection of the high speed shared control channel (HS-SCCH) downlink control information, HSDPA communication is not possible.

Each of these areas of change and the implications for testing are next discussed briefly.

HS-DPCCH increases uplink peak-to-average power ratio (PAR)

The biggest change on the uplink is the addition of the high speed dedicated physical control channel (HS-DPCCH).

The standard Release 99 W-CDMA uplink signal, which consists of the dedicated physical data channel (DPDCH) and the DPCCH, can have a peak-to-average power ratio (PAR) at 0.1% from about 3.1 dB to about 3.6 dB, depending on the signal configuration. The new code channel (HS-DPCCH) can add up to ~1 dB to the PAR (at 0.1%) of the uplink signal [1].

Because the HS-DPCCH is not usually transmitted continuously, the PAR increases only when the acknowledgement/negative acknowledgement (ACK/NACK) or the channel quality indicator (CQI) fields are transmitted. The exact increase in the PAR depends on the beta factors $ß_c$, $ß_d$, and $ß_{hs}$, which correspond to the relative power levels of the uplink DPCCH, DPDCH, and HS-DPCCH.

A higher PAR can increase the distortion generated by the transmitter, and particularly by the power amplifier, resulting in higher out-of-channel interference and poorer modulation quality. So that Release 99 power amplifiers will work correctly with this higher PAR signal, the maximum output power requirement is reduced when the HS-DPCCH is on.

Figure 1 illustrates how PAR increases when the ACK/NACK or the CQI fields in the HS-DPCCH are transmitted, and how the maximum composite average output power is reduced to compensate for this increase.

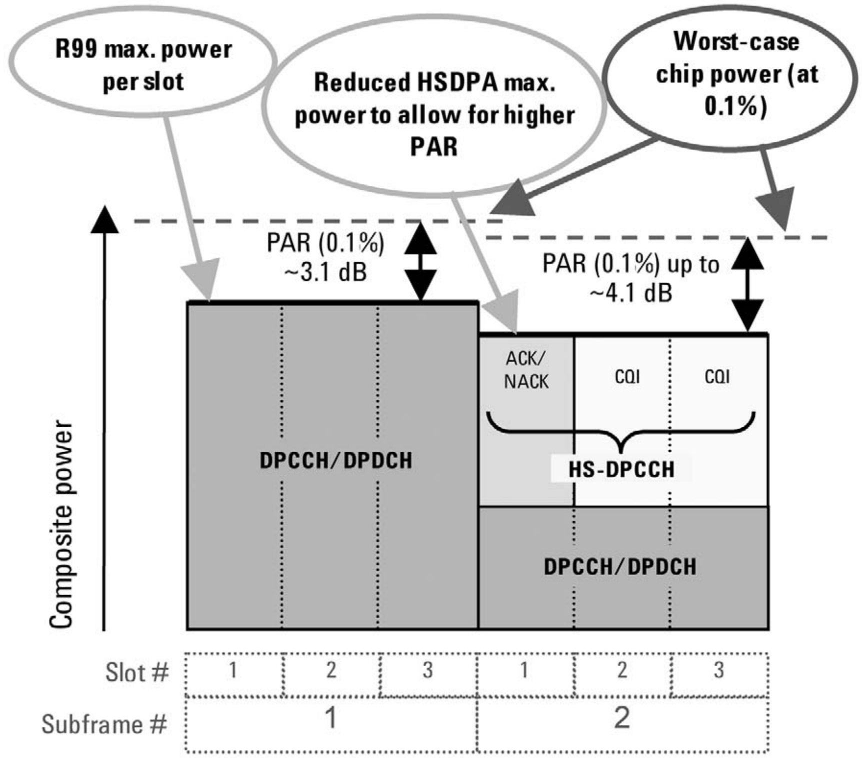

Figure 1. HS-DPCCH increases uplink peak-to-average power ratio (PAR).

Note that even though the PAR at 0.1% of the HSDPA signal versus the R99 signal increases only to ~1 dB, the overall probability of higher PAR is significantly greater [1]. This means that the maximum output power reduction must be larger than the PAR increase at 0.1% in order to meet the same adjacent channel leakage ratio (ACLR), spectrum emissions mask (SEM), and error vector magnitude (EVM) performance.

Simulations have shown that a 1:2 dB relationship between the PAR increase at 0.1% and the maximum output power reduction is necessary to avoid degradation of ACLR, SEM, and EVM [1, 2, 3]. The difference between the maximum output power reduction and the PAR increase explains the fact that in Figure 1 the resulting worst-case chip power level (at 0.1% probability) for the signal with the HS-DPCCH is lower than that of the signal with just the DPDCH/DPCCH, once the power reduction has been applied.

These changes affect testing. In addition to verifying that the UE meets the new maximum output power requirements, you will need to perform out-of-channel interference tests, such as SEM and ACLR, as well as modulation quality measurements to ensure that the UE operates correctly at the reduced maximum output power with the higher PAR signal.

The uplink HS-DPCCH is not usually transmitted continuously and can be offset in time from the DPCCH

As noted earlier, the HS-DPCCH is not usually transmitted continuously and can be offset in time from the DPCCH. Turning the HS-DPCCH on and off can cause power steps of up to 7 dB, depending on the beta factors.

The HS-DPCCH is a shared channel and therefore is fixed in time relative to the common pilot channel (CPICH). The DPDCH and DPCCH, however, can be shifted in time in 0.1 slot increments. In the generic example of power versus time shown in Figure 2, observe that the HS-DPCCH is not aligned in time with these other channels. Additionally, the CQI relative power (∆CQI) differs from the ACK/NACK relative power (∆ACK or ∆NACK). So that the accuracy of the power steps can be verified in such cases, a new test of the power-versus-time mask has been added to the specifications.

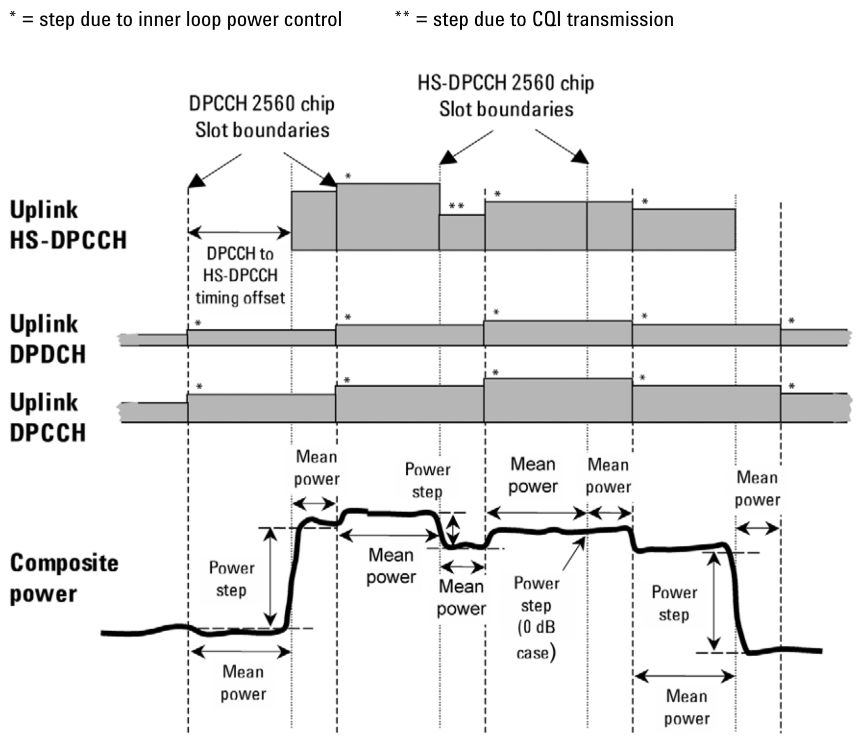

Figure 2. Transmit power template during HS-DPCCH transmission (ref: 3GPP TS 25.101 figure 6.6).

If the HS-DPCCH is not time-aligned with the DPCCH/DPDCH, the 7 dB power step may occur during transmission of the DPCCH/DPDCH slot. Such an occurrence introduces the potential for phase transients or other distortions during the slot transmission, which then degrade the signal quality and impact the ability of the Node B (base station) to demodulate the DPCCH/DPDCH when the HS-DPCCH is transmitted. New modulation accuracy requirements being developed by the 3GPP could address this issue.

16QAM in the downlink HS-PDSCH has less margin for Rx impairments than does QPSK

The HSDPA downlink physical data channel, which is known as the high speed physical data shared channel (HS-PDSCH), may use either standard QPSK modulation or the new 16QAM.

Figure 3 shows that 16QAM has a smaller margin of error than does QPSK, so symbol detection is more susceptible to distortion and noise. For this reason, you will need to evaluate the effects of RF receiver impairments on the 16QAM signal. To enable this, a requirement for reception of 16QAM channels at the maximum input level has been added to the specifications.

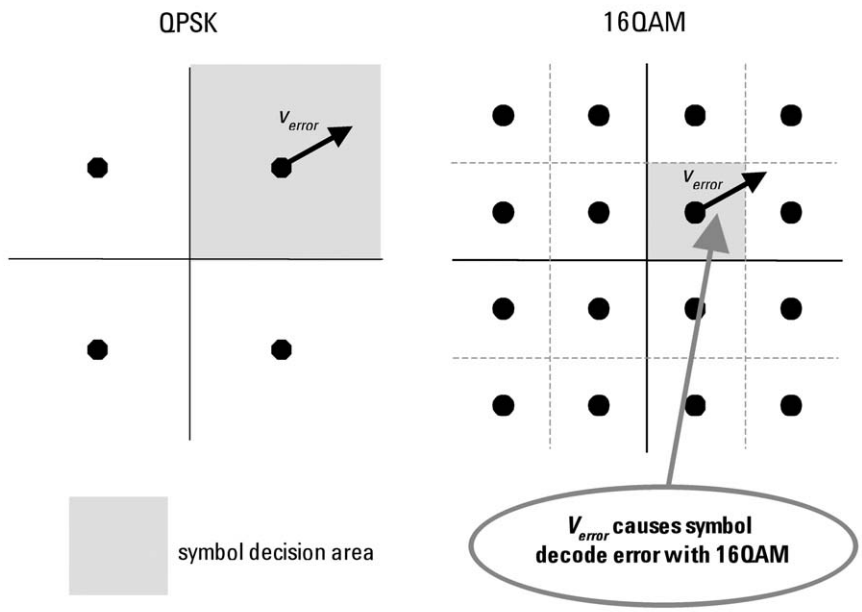

Figure 3. 16QAM has a smaller error margin than QPSK.

The issues raised thus far in this discussion pertain to the RF. However, the new features and functions that HSDPA adds mainly affect the baseband. Therefore, a good portion of the Layer 1 testing that is required to evaluate HSDPA functionality and performance in UE concerns the baseband functions.

Decoding the downlink HS-DSCH involves complex functionality

Decoding the HSDPA downlink data transport channel—known as the high speed data shared channel (HS-DSCH)—makes use of complex new functionality in the UE, as suggested in Figure 4.

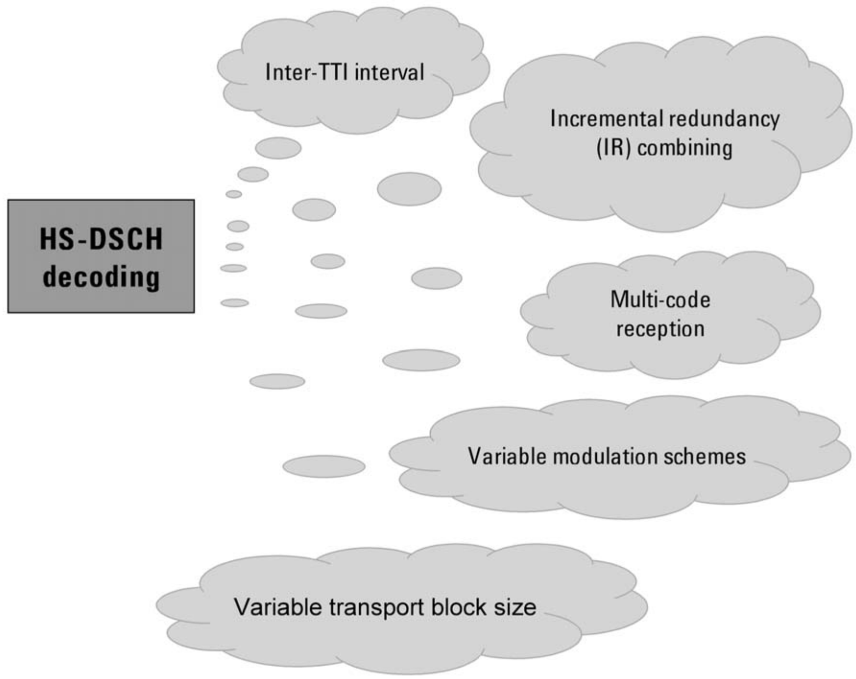

Figure 4. Decoding the downlink HS-DSCH involves complex functionality.

Techniques are employed such as multi-code reception and incremental redundancy (IR), which combines different sets of bits received during retransmissions of the same data block. The latter is part of the hybrid ARQ (HARQ) functionality introduced in HSDPA. Additionally, UE must deal with a variable inter-transmission time interval (inter-TTI), a variable number of code channels, two different modulation schemes, and a variable coding scheme that includes a variable transport block size used to determine the instantaneous throughput.

To verify HS-DSCH decoding performance in UE, the specifications have added a Demodulation of HS-DSCH conformance test with multiple test scenarios. However, because HS-DSCH decoding is so complex and involves such a large number of variables, you may want to test this functionality even more thoroughly earlier in the process of design and verification.

Accurate CQI reporting is crucial to overall system performance

The ability to report the channel quality indicator (CQI) is also part of new UE baseband functionality. This functionality is completely separate from the HS-DSCH decoding process. The UE must be able to derive a CQI value based on the instantaneous channel conditions and report that value to the base transceiver station (BTS).

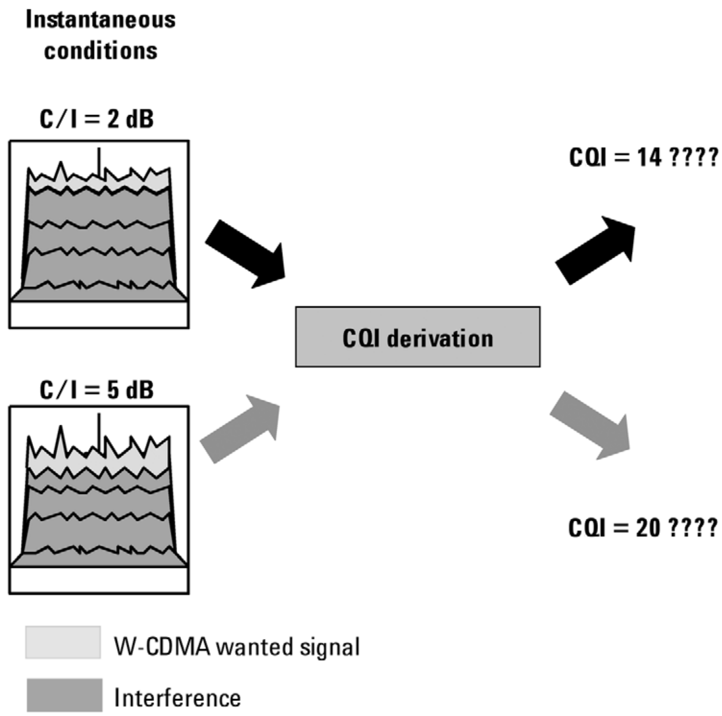

Figure 5. New CQI derivation algorithms are needed in the UE.

Accurate CQI reporting is crucial to overall system efficiency. Inaccurate estimates of channel quality result in either more retransmissions due to errors or less efficient use of the channel's capacity—and both of these decrease the user's throughput. More retransmissions also decrease the left-over capacity for HSDPA transmissions, and less capacity in turn reduces the overall system throughput.

The specifications now require tests that verify the accuracy of CQI reporting. You may also find that additional tests are necessary in the R&D process during development and verification of the CQI derivation algorithms.

Without correct HS-SCCH detection, there is no HSDPA communication

Before the UE can decode HSDPA downlink traffic data in the HS-DSCH, it must first recognize the control information sent by the BTS and carried by the downlink high speed shared control channel (HS-SCCH). In other words, if the UE cannot detect the HS-SCCH control information, it will not be able to decode the payload data on the HS-PDSCH and data throughput will cease.

Verifying the performance of HS-SCCH detection is, therefore, an important test. For this reason, an HS-SCCH detection test has been added to the specifications.

HSDPA UE RF Conformance Tests

To address the challenges introduced by HSDPA, a number of HSDPA-related tests have been added to the UE RF conformance tests (3GPP TS 34.121) in Release 5 and Release 6. Note that there are five new transmitter tests required in 34.121 Section 5:

- Maximum Output Power With HS-DPCCH (34.121 5.2A)
- Transmit ON/OFF Power – HS-DPCCH (34.121 5.7A)
- SEM (34.121 5.9A)
- ACLR (34.121 5.10A)
- EVM (34.121 5.13.1A)

One new test of receiver characteristics is required in 34.121 Section 6:

- Maximum Input Level for HS-PDSCH Reception Using 16QAM (34.121 6.3A)

A whole new section, HSDPA Performance Requirements (34.121 Section 9), covers three main test areas:

- Demodulation of HS-DSCH (34.121 9.2)
- Reporting of CQI (34.121 9.3)
- HS-SCCH Detection Performance (34.121 9.4)

General Test Configuration and Metrics

Before explaining the individual tests in detail, let's discuss some of the general aspects of HSDPA conformance testing, focusing on the most common downlink test configuration parameters and metrics.

General downlink test configuration

The downlink test configuration is similar for all the new HSDPA tests (transmitter, receiver, and performance requirements). It consists of the following channels:

- W-CDMA standard channels
- orthogonal channel noise simulation (OCNS) channels
- HS-DSCH and HS-SCCH

Among the W-CDMA standard channels, the basic W-CDMA control channels—primary common pilot channel (P-CPICH), primary common control physical channel (P-CCPCH), synchronization channel (SCH), and paging indicator channel (PICH)—are required to establish and maintain a connection. A dedicated physical channel (DPCH) is configured as the downlink 12.2 kb/s reference measurement channel (RMC).

Six OCNS channels are transmitted to account for the energy transmitted to other users in a real BTS (see 3GPP TS 34.121 table E.5.5).

Depending on the test, the HS-DSCH configuration is either established as a fixed reference channel (FRC) or based on a CQI value. Both of these configurations will be described in more detail later in this application note.

Most of the tests use one HS-SCCH, with the exception of the HS-SCCH detection performance test, which uses four HS-SCCHs.

It is important to note that all tests are based on a static configuration of the HS-DSCH, so adaptive modulation and coding (AMC) is not used in the system simulator (SS). No tests rely on the direct use of the received CQI report to dynamically configure the downlink HS-DSCH, because specifying UE performance independent of the test system's behavior has proven to be too complicated. Thus the true throughput performance of the UE—that is, the throughput performance that the UE would achieve in a real HSDPA system with AMC—is not tested.

With the exception of the Demodulation of HS-DSCH test, no tests require HARQ functionality in the SS. In other words, for most tests, the SS sends no retransmissions based on the received ACK/NACK report.

Table 1 lists the most general downlink signal configuration for single-link (non-diversity) scenarios. For simplicity these parameters reflect the minimum requirements from 3GPP TS 25.101 in the specifications, not the relaxed test requirements from 3GPP TS 34.121 that take into account test system uncertainty. Refer to 3GPP TS 34.121 annex E.5.1 and E.6.2 for more information on the general test configuration of the downlink physical channels.

Channel	**Level vs. I_{or}**	**Notes**
P-CPICH	–10 dB	S-CPICH is off (DTX)
P-CCPCH & SCH	–12 dB	Time multiplexed
PICH	–15 dB	
DPCH	Test specific	12.2 k RMC
HS-SCCH-1	Test specific	HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (HS-PDSCHs)	Test specific	
OCNS	Remainder	6 channels: 34.121 table E.5.5

Note: The HS-SCCH and the HS-DSCH shall be transmitted continuously (in every TTI) with constant power, but only be allocated to the UE under test during the appropriate TTIs.

Table 1. General single-link (non-diversity) downlink test configuration parameters (based on 3GPP TS 34.121 table E.5.1).

Note that the channel power levels are defined relative to I_{or}, which is the signal as it leaves the SS. The absolute I_{or} power level depends on the test.

In general, only one HS-SCCH (HS-SCCH-1) is transmitted to the UE. No signaling is scheduled, and no power is radiated on HS-SCCH-2, HS-SCCH-3, or HS-SCCH-4, although these channels are signaled to the UE as present.

The HS-DSCH (HS-PDSCHs) power level is the total for all the codes that are part of the HS-DSCH.

Values for individual test configuration parameters that differ from the general values shown here are given later in the separate test sections of the application note.

Fixed reference channels

Fixed reference channel H-Sets (FRC H-Sets) are the HSDPA equivalent of the reference measurement channels (RMC) used for W-CDMA. The FRC H-Sets define the HS-DSCH configurations most often used for HSDPA conformance testing.

The term “fixed” refers to the static nature of the modulation and coding of these channels. As indicated earlier, AMC is not used because of the difficulty in isolating the performance of the SS from that of the UE.

There are five FRC H-Sets (FRC H-Set 1 to 5) defined in Release 5. Another FRC H-Set (FRC H-Set 6) has been added in Release 6. For some of the tests, such as Demodulation of HS-DSCH, the UE category determines which FRC H-Set to use:

- FRC H-Set 1 for UE of HS-DSCH category 1 and 2
- FRC H-Set 2 for UE of HS-DSCH category 3 and 4
- FRC H-Set 3 for UE of HS-DSCH category 5 and 6
- FRC H-Set 4 for UE of HS-DSCH category 11
- FRC H-Set 5 for UE of HS-DSCH category 12
- RC H-Set 6 (added in Release 6) and FRC H-Set 3 for UE of HS-DSCH category 7 and 8

Performance requirements, and thus FRC, have not yet been defined for UE categories 9 and 10. Also, note that FRC H-Sets 1, 2, 3, and 6 each have two configurations, QPSK and 16QAM.

Table 2, taken from the specifications, gives the parameters and values for FRC H-Set 3. As shown in this example, an FRC provides the complete HS-DSCH configuration, including modulation, coding parameters, inter-TTI interval, and number of HARQ processes.

Parameter	**Unit**	**Value**	
Nominal avg. inf. bit rate	kb/s	1601	2332
Inter-TTI distance	TTIs	1	1
Number of HARQ processes	Processes	6	6
Information bit payload (N_{INF})	Bits	3202	4664
Number code blocks	Blocks	1	1
Binary channel bits per TTI	Bits	4800	7680
Total available SMLs in UE	SMLs	57600	57600
Number of SMLs per HARQ proc.	SMLs	9600	9600
Coding rate		0.67	0.61
Number of physical channel codes	Codes	5	4
Modulation		QPSK	16QAM

Table 2. FRC H-Set 3 (ref: 3GPP TS 34.121 annex C.8.1.3).

The most critical parameter of an FRC H-Set configuration is the nominal average information bit rate. In the case of FRC H-Set 3 (QPSK), the nominal average information bit rate is 1601 kb/s. This value is obtained by dividing the information bit payload by the length of the TTI (2 ms) and multiplying the result by the number of parallel HARQ processes divided by 6. The nominal average information bit rate in kb/s turns out to be (3202/2)*(6/6) = 1601 kb/s. This figure represents the maximum throughput that can be achieved with the FRC H-Set channel configuration if all the data blocks are received correctly at the first transmission.

Similar tables for all the FRC H-Sets are provided in the Appendix.

Relationship between t-put R and BLER

The most common metrics used in HSDPA receiver and performance requirement testing are throughput rate (t-put R) and block error rate (BLER).

Because HSDPA is an asymmetric service, you cannot loop the payload data back on the uplink for bit error rate (BER) analysis in the test system. The only data that can be "looped back" are the ACK/NACK and CQI data. Thus the only way to measure BER is to extract the payload data directly from the UE. Although BER is not an HSDPA conformance requirement, it can be useful in R&D as a sensitive measure of receiver performance.

Most HSPDA receiver and performance tests instead specify the minimum requirements in terms of information bit t-put R, which is calculated from the ACK/NACK report and is related to BLER.

Both t-put R and BLER rely on a count of the number of blocks received successfully and the number of blocks not received successfully. In general, receipt of an ACK signifies a success, while receipt of a NACK is considered a failure. If the UE does not correctly identify the signaling from the HS-SCCH, or if it does not detect control information on the HS-SCCH that is consistent with its UE capability, neither ACK nor NACK will be transmitted in the corresponding HS-DPCCH subframe. This unexpected response, known as statistical discontinuous transmission (statDTX), is also considered a failure and should occur only infrequently.

Note that the expected DTX ACK/NACK fields, also known as regular DTX (regDTX), correspond to downlink DTX TTIs and are considered normal UE behavior. Figure 6 illustrates the difference between statDTX and regDTX.

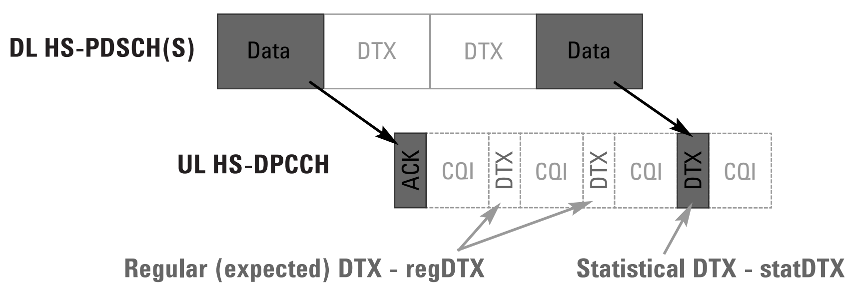

Figure 6. A statDTX is an unexpected DTX response.

In general, BLER is defined as the ratio of unsuccessfully received and decoded blocks to the total number of information blocks sent.

$$BLER = \frac{(NACK + statDTX)}{(NACK + statDTX + ACK)}$$

Equation 1. BLER

T-put R is defined as the sum (in kilobits) of the number of information bits successfully received during the test interval, divided by the duration of the test interval (in seconds). T-put R is a more intuitive indicator of the UE's HSDPA performance than is BLER, as t-put R provides the effective data rate for a fixed channel. For more details, see 3GPP TS 34.121 annex F.6.3.1.

$$t\text{-}put\ R = \frac{ACK \times N_{INFO}}{test\,time}$$

Equation 2. T-put R

If the nominal average information bit rate is known, then BLER can be directly related to t-put R. In this case, BLER can be mapped unambiguously to t-put R for any single FRC, as Equation 2 shows.

$$t\text{-}put\ R = (1 - BLER) \times Nom.\ Average\ Inf.\ Bit\ Rate$$

Equation 3. Relationship between t-put R and BLER

The t-put R minimum requirements thus can be translated to BLER minimum requirements for any single FRC. For example, for FRC H-Set 3 (QPSK), t-put R = (1/BLER) x 1601 kb/s.

HSDPA Transmitter Conformance Tests

Several tests of the transmitter characteristics have been added in the specifications to account for the addition of the HS-DPCCH in the uplink:

- Maximum Output Power with HS-DPCCH (34.121 5.2A)
- Transmit On/Off Power – HS-DPCCH (34.121 5.7A)
- SEM with HS-DPCCH (34.121 5.9A)
- ACLR with HS-DPCCH (34.121 5.10A)
- EVM with HS-DPCCH (34.121 5.13.1A)

The new HSDPA transmitter tests are mainly variations of R99 W-CDMA tests and are used to verify whether the transmitter can handle the addition of the uplink HS-DPCCH. Recall that the HS-DPCCH increases the PAR of the uplink signal, is not transmitted continuously in most cases, and can be offset in time from the DPCCH. These aspects of the HS-DPCCH pose some challenges for the transmitter.

The following HSDPA transmitter conformance tests must therefore be performed with the HS-DPCCH:

- Maximum Output Power test, similar to the standard R99 W-CDMA Maximum Output Power test, but with relaxed output power requirements to enable continued use of R99 power amplifiers with the higher PAR signal
- new power-versus-time mask to verify the accuracy of the uplink power steps when the bursted HS-DPCCH is transmitted (note that the actual test is called "Transmit On/Off Power – HS-DPCCH" in the specifications)
- SEM test and an ACLR test, similar to the standard R99 W-CDMA SEM and ACLR tests, to verify that the transmitter is operating correctly at the reduced maximum output power with the higher PAR signal
- EVM test to verify that the transmitter is operating correctly at the reduced maximum output power with the higher PAR signal. This test should also verify the impact of large HS-DPCCH power steps in the middle of DPCCH/DPDCH slots on the DPCCH/DPDCH signal quality

Figure 7 illustrates the concept of HSDPA transmitter testing. An SS performs the measurements and analysis.

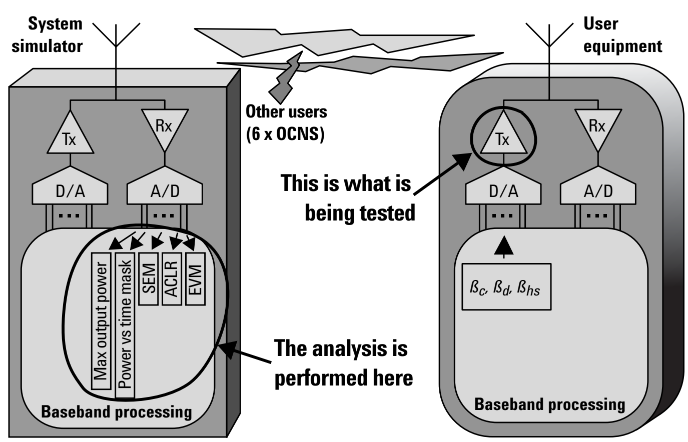

Figure 7. An SS is used to test the transmitter and process the results.

The common aspects of these tests are discussed next, followed by a more detailed explanation of each individual test.

Connection setup

Figure 8 shows the connection setup for the HSDPA transmitter tests. A call is established using the SS. The measurement can be performed by the SS or by a separate tester.

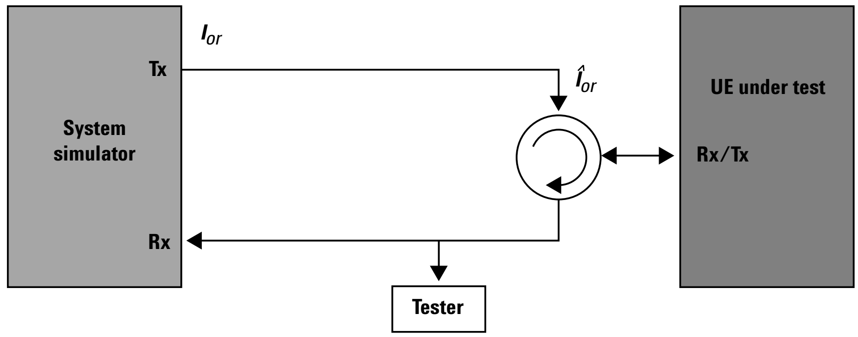

Figure 8. Connection setup for new HSDPA transmitter tests (ref: 3GPP TS 34.121 figure A.20).

In the diagram, I_{or} is the signal as it leaves the SS, and $\hat{I}_{or}$ is the signal as received by the UE. Because the HSDPA transmitter tests do not use fading, I_{or} and $\hat{I}_{or}$ here are the same.

Test-specific downlink parameters

Table 3 complements the general downlink test configuration table (Table 1) presented earlier. Here, only the downlink channel configuration test parameters that are specific to the HSDPA transmitter tests are shown.

Downlink channels	Level vs. I_{or}	Notes
DPCH	–9 dB	12.2 k RMC
HS-SCCH-1	–8 dB	HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (HS-PDSCHs)	–3 dB	FRC H-Set 1

Table 3. Test-specific downlink parameters for HSDPA transmitter tests (based on 3GPP TS 34.121 table E.5.10).

For these tests, the downlink HS-DSCH is configured as FRC H-Set 1 regardless of the UE category, since FRC H-Set 1 uses an inter-TTI of 3, which all the UE support.

The power levels selected for the DPCH, HS-SCCH-1, and HS-DSCH must be high enough to keep the UE's DTX reporting ratio very small and to ensure that the radio link is maintained during the test.

Note that this downlink signal is needed to establish and maintain an HSDPA connection at an inter-TTI interval of 3, but the specific details of the downlink signal configuration are not important for the purpose of transmitter testing and should not affect the results.

Uplink test configuration

All five HSDPA transmitter tests use a similar uplink configuration, which is defined in 3GPP TS 34.121 appendix C.10. One of the objectives of the tests is to verify that HSDPA operation does not interfere with standard operation. For this reason, all the HSDPA tests use a DPCCH and a DPDCH, configured as a standard uplink 12.2 kb/s RMC, in addition to the HS-DPCCH.

In general, a single HS-DPCCH configuration is chosen for all UE categories to limit the number of variables without affecting the results. For example, an inter-TTI interval of 3 is selected because it is supported by all UE categories, even though many are capable of receiving blocks more frequently. A 50% (0.5 slot) time offset between the DPCCH and the HS-DPCCH is used for all tests because this time offset is required for some tests, even though it is unimportant to others.

The code power ratios between the channels in the uplink test configuration depend on which of the six sets of beta factors defined in 3GPP TS 34.121 table C.10.1.4 are used.

In order to simplify the Maximum Output Power, ACLR, and SEM tests, the HS-DPCCH is configured to have continuous power for these tests, as illustrated in Figure 9. Note that these tests are all performed at maximum power.

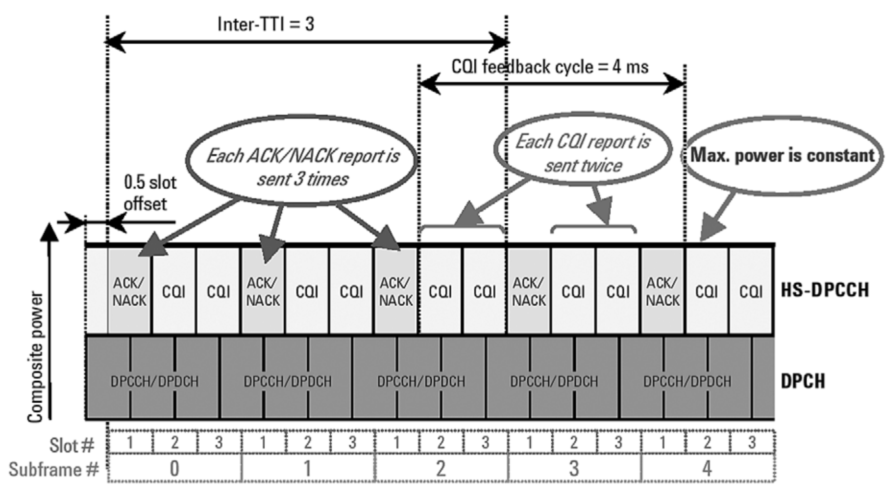

Figure 9. Generic uplink test signal is used for the maximum output power, SEM, and ACLR tests.

The inter-TTI is 3, so the ACK/NACK repetition factor (N_acknack_transmit) is set to 3 to avoid DTX ACK/NACK fields. The CQI feedback cycle (k) is arbitrarily set to 4 ms and the CQI repetition factor (N_cqi_transmit) is set to 2, which avoids DTX CQI fields.

The powe-versus-time (HSDPA Transmit On/Off Power) test uses a more complex uplink signal with discontinuous HS-DPCCH power. As of September 2005, the uplink signal for the EVM test remains undefined but will probably use an HS-DPCCH with a power step.

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

In Release 5 and Release 6, the maximum power specification of the UE transmitter is reduced to allow for the increase in PAR that results from the addition of the HS-DPCCH.

The procedure for the Maximum Output Power with HS-DPCCH test (34.121 5.2A) is almost identical to the procedure for the standard W-CDMA Nominal Maximum Output Power test (34.121 5.2). The main difference is that, for the new HSDPA test, the uplink test signal is based on the DPCCH + DPDCH + HS-DPCCH configuration shown earlier. The test is repeated using the six sets of beta factors given in 3GPP TS 34.121 table C.10.1.4 and shown in Figure 10.

β values from: 34.121 table C.10.1.4 → Requirements from: 34.121 table 5.2A.2

Sub-test	β_c	β_d	β_c/β_d	β_{HS}	Power Class 3 Power (dBm)	Power Class 3 Tol (dB)	Power Class 4 Power (dBm)	Power Class 4 Tol (dB)
1	1/15	15/15	1/15	2/15	+24	+1/-3	+21	+2/-2
2	12/15	15/15	12/15	24/15				
3	13/15	15/15	13/15	26/15	+23	+2/-3	+20	+3/-2
4	15/15	8/15	15/8	30/15				
5	15/15	7/15	15/7	30/15	+22	+3/-3	+19	+4/-2
6	15/15	off	15/0	30/15				

Figure 10. Beta factors (based on 3GPP TS 34.121 table C.10.1.4) and requirements (based on 3GPP TS 34.121 table 5.2.A.2) for the HSDPA Maximum Output Power test.

The reduction of the power requirements depends on which set of beta factors is used, as described in 3GPP TS 34.121 table 5.2.A.2, also shown in Figure 9. To simplify the requirements and minimize the impact of power reduction on the system, the following two-breakpoint solution is used:

- for beta factors $\beta_c/\beta_d << 1$ (specifically $1/15 \leq \beta_c/\beta_d \leq 12/15$), there is no maximum output power reduction
- for beta factors β_c/β_d closer to 1 (specifically $13/15 \leq \beta_c/\beta_d \leq 15/8$), the maximum output power reduction is 1 dB
- for beta factors $\beta_c/\beta_d >> 1$ (specifically $15/7 \leq \beta_c/\beta_d \leq 15/0$), the maximum output power reduction is 2 dB

As of September 2005, the details of the test procedure are still being finalized by 3GPP RAN.

Transmit On/Off Power – HS-DPCCH (34.121 5.7A)

Power-versus-time (officially called Transmit On/Off Power – HS-DPCCH in the specifications) is an important transmitter test that verifies the accuracy of the power steps caused by the addition of the HS-DPCCH. The transmit power template for this test is given in Figure 11. The test is based on a 50% overlap between the DPCCH and the HS-DPCCH timeslots.

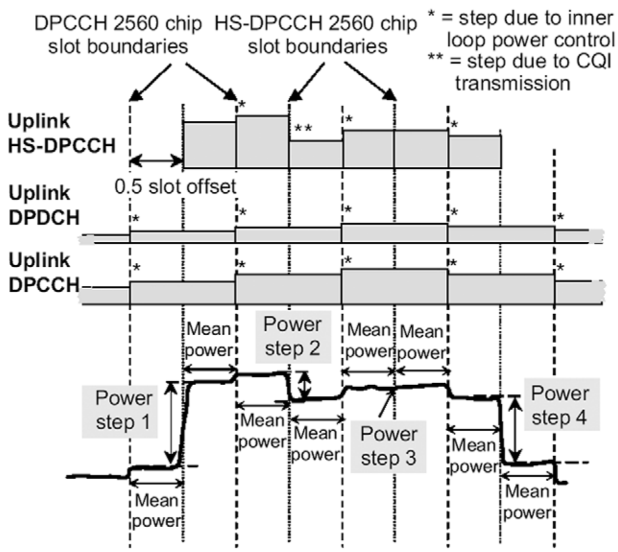

Figure 11. Transmit power template during transmit on/off power – HS-DPCCH measurements (ref: 3GPP TS 34.121 figure 5.7A.2).

The test considers both the changes in power due to inner loop power control—indicated by an asterisk (*) in Figure 11—and the changes in power due to differences between the relative ACK/NACK and CQI power levels—indicated by two asterisks (**). However, only the accuracy of the latter are measured. The power steps in the ACK/NACK and the CQI boundaries are defined in 3GPP TS 34.121 table 5.7A.2.

The nominal power step due to transmission of ACK/NACK or CQI is defined as the difference between the nominal mean power of any two adjacent power evaluation periods. The HS-DPCCH timeslots are not aligned with the DPCCH timeslots, hence the power evaluation periods are shorter than one timeslot and can be defined in two ways:

- a period that starts with a DPCCH slot boundary and ends with the next HS-DPCCH slot boundary
- a period that starts with an HS-DPCCH slot boundary and ends with the next DPCCH slot boundary

The length of any two adjacent power evaluation periods equals 2560 chips. In all cases the evaluation of mean power must exclude a 25 ms period before and after any DPCCH or HS-DPCCH slot boundary.

According to 3GPP TS 34.121 table 5.7A.2 of the specifications, this test is repeated using the beta factors defined in 3GPP TS 34.121 table C.10.1.4 for sub-tests 5 and 6, which are the most challenging sets in the table.

ACLR and SEM with HS-DPCCH (34.121 5.9A and 5.10A)

ACLR is the power from the carrier that shows up in adjacent and alternate 5 MHz channels. SEM is similar to ACLR but the measurement bandwidth is 30 kHz close in and 1 MHz further out. Measurement display examples for these tests are shown in Figure 12 and 13.

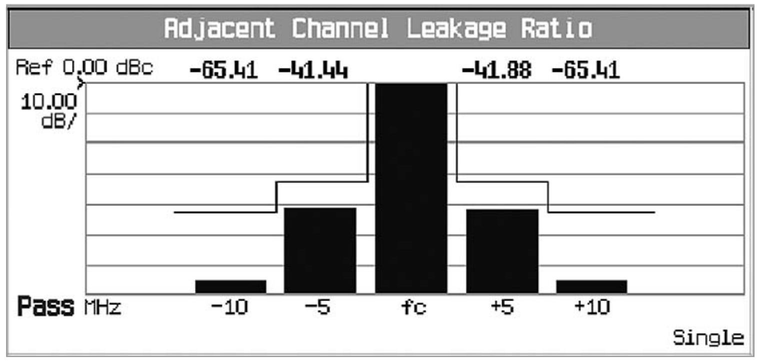

Figure 12. The test procedure for the new HSDPA ACLR test is essentially the same as the R99 ACLR test.

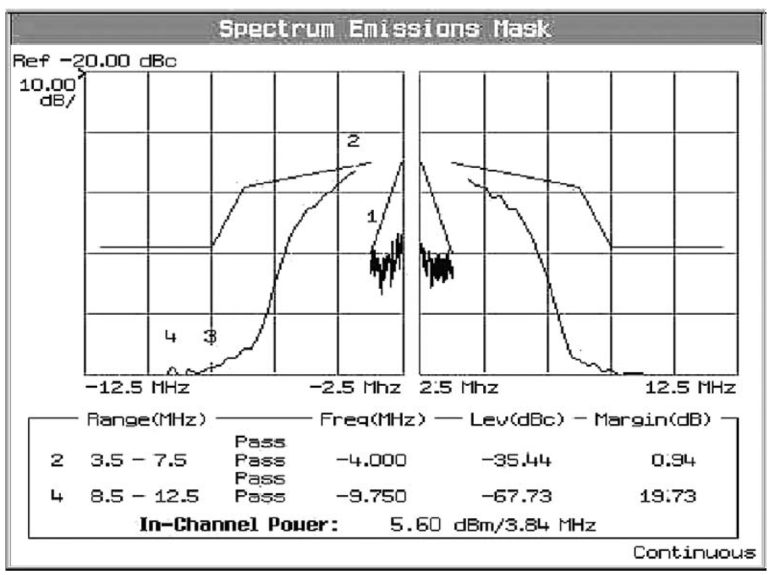

Figure 13. The test procedure for the new HSDPA SEM test is essentially the same as the R99 SEM test.

It’s important that you test the new reduced maximum power requirement along with EVM, ACLR, and SEM at the same maximum power since these measurements will degrade if a problem exists with the power amplifier in the UE.

The test procedures for ACLR and SEM differ from those of R99 in only one significant way: the HSDPA uplink test signal configuration based on the DPCCH + DPDCH + HS-DPCCH configuration shown previously in Figure 9.

EVM with HS-DPCCH (34.121 5.13.1A) and phase discontinuity

The requirements for EVM and phase discontinuity for uplink transmissions with the HS-DPCCH are still being developed by 3GPP (as of September 2005).

One of the biggest challenges for HSDPA transmitters is to ensure that the UE is transmitting the DPCCH + DPDCH correctly when the HS-DPCCH turns on or off during the DPCCH slot. A possible source of error is the AM to PM distortion caused by having a 7 dB step change in power during a DPCCH slot. If this power step occurs near the UE maximum power level, distortion of the output phase may result, making demodulation by the BTS very difficult. The 3GPP is considering a proposal to evaluate how much phase discontinuity is acceptable during the DPCCH/DPDCH slot.

Although the requirement for EVM has not yet been finalized, you can use the existing W-CDMA phase discontinuity measurement to give an indication of whether the performance of a particular UE design is likely to be susceptible to HS-DPCCH power steps.

Under the current W-CDMA requirements, non-HSDPA phase discontinuity is determined by measuring the change in phase between any two adjacent timeslots. Phase transients of up to 30 degrees are allowed only at DPCCH/DPDCH slot boundaries. EVM is measured for each timeslot, excluding the transient periods of 25 μs on either side of the nominal timeslot boundaries. The frequency, absolute phase, absolute amplitude, and chip clock timing used to minimize the error vector are chosen independently for each timeslot. The phase discontinuity result is defined as the difference between the absolute phase used to calculate EVM for the preceding timeslot and the absolute phase used to calculate EVM for the succeeding timeslot.

The existing phase discontinuity requirement applies only for 1 dB changes in power between the slots caused by inner loop power control. However, the power steps caused by HS-DPCCH transmission can be up to 7 dB. Figure 14 shows displays of the phase discontinuity measurement for two UEs with very different output phase performance versus 1 dB power steps.

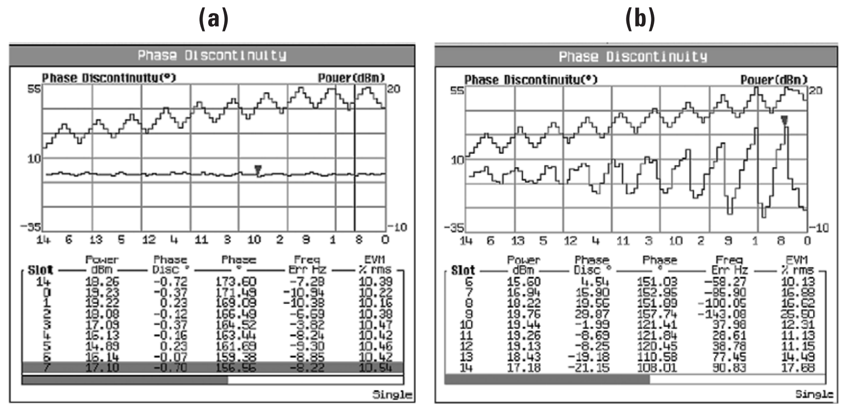

Figure 14. Measuring phase discontinuity can provide an indication of susceptibility to HS-DPCCH power steps. (a) UE with very stable output phase versus 1 dB power steps, and (b) UE with very poor output phase versus 1 dB power steps.

In Figure 14b, which corresponds to the UE with poor output phase performance, notice that the phase transients caused by the power steps are up to 30 degrees per dB of power step.

The scenario only gets worse for power steps that are greater than 1dB. For example, if the phase transients occur at 10 degrees per dB of power step, a 7 dB change in power could cause a 70 degree phase shift, in turn causing the DPCCH and DPDCH to swap symbol positions mid slot. The resulting signal would be very difficult to demodulate accurately.

New requirements are under investigation for handling a possible phase discontinuity caused by HS-DPCCH transmission during the DPCCH slot as well as possible phase steps larger than 30 degrees at the DPCCH slot boundaries when the DPCCH and HS-DPCCH are time-aligned and the power changes by up to 7 dB.

HSDPA Receiver Conformance Test (34.121 6.3A)

There is only one new receiver conformance test, Maximum Input Level for HS-PDSCH Reception with 16QAM (34.121 6.3A). See Figure 15.

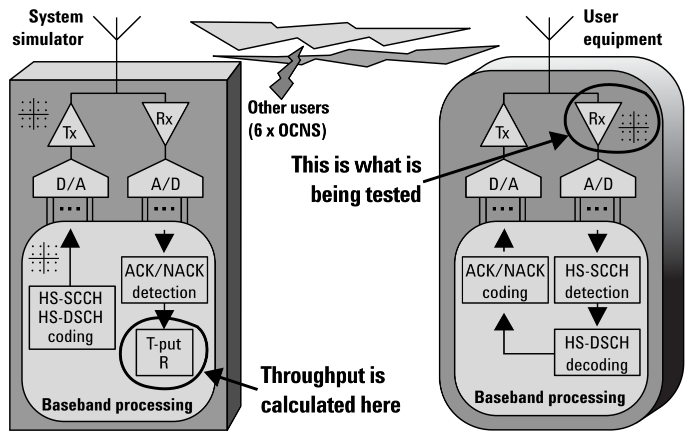

Figure 15. Maximum Input Level for HS-PDSCH Reception with 16QAM verifies UE ability to demodulate a 16QAM downlink channel.

Similar to the existing Maximum Input Level test based on a QPSK data channel, this new test verifies that the UE is capable of demodulating a high power, 16QAM downlink channel. The test was added because symbol detection for 16QAM is more susceptible to distortion and noise than is QPSK detection, so RF impairments can have a bigger effect on the quality of the 16QAM channels.

The minimum requirement for this test is specified in terms of t-put R, which was described earlier in this application note.

Connection setup

As Figure 16 shows, the connection setup for Maximum Input Level for HS-PDSCH Reception with 16QAM is identical to the setup used for all basic W-CDMA receiver characteristics tests. Note that because no fading is used for the receiver tests, I_{or} is equal to $\hat{I}_{or}$.

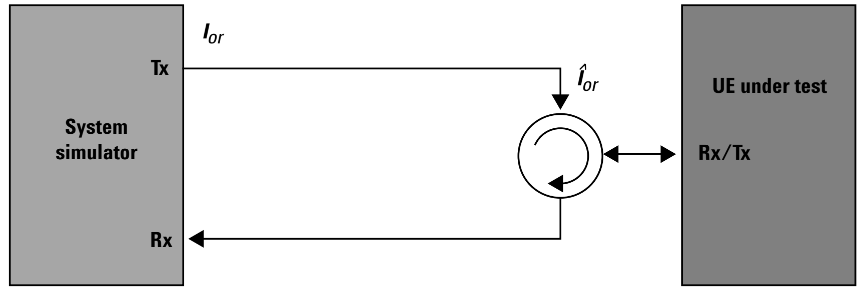

Figure 16. Connection setup for Maximum Input Level for HS-PDSCH Reception with 16QAM is identical to that of W-CDMA receiver tests (ref: 3GPP TS 34.121 figure A.3).

Test-specific downlink parameters

The information in Table 4 complements our earlier discussion of general downlink test configuration test parameters. Here only those downlink parameters that are specific to the receiver test Maximum Input Level for HS-PDSCH Reception (16QAM) are shown. For simplicity the table gives the minimum test requirements from 3GPP TS 25.101, not the relaxed test requirements from 3GPP TS 34.121, which take into account test system uncertainty.

Channel	Level vs. I_{or} (= $\hat{I}_{or}$ @ –25 dBm)	Notes
DPCH	–13 dB	12.2 k RMC
HS-SCCH-1	–13 dB	HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (4 HS-PDSCHs)	–3 dB (total)	FRC H-Set 1 (16QAM)

Table 4. Test-specific downlink parameters for Maximum Input Level for HS-PDSCH Reception with 16QAM (based on 3GPP TS 34.121 tables 6.3A.1 and 6.3A.2).

For this test, the HS-DSCH is configured as FRC H-Set 1 (16QAM configuration), which has an inter-TTI interval of 3. This is the easiest FRC H-Set to configure, and it works with all UE categories that support 16QAM. (This test is not required for UE categories 11 and 12, since these categories support QPSK only.) The HS-PDSCH power is the total for all four codes that are part of the FRC H-Set 1 (16QAM). The most important H-Set parameters for this test are the 16QAM scheme and the nominal average information bit rate.

FRC H-Set 1 (16QAM) Parameters	Unit	Value
Nominal average information bit rate	kb/s	777
Modulation		16QAM
Inter-TTI distance	TTIs	3

Table 5. Critical FRC H-Set 1 (16QAM) parameters for Maximum Input Level for HS-PDSCH reception with 16QAM (based on 3GPP TS 34.121 annex C.8.1.1).

Minimum requirements

To pass this test, t-put R must be higher than 700 kb/s. The nominal average information bit rate for FRC H-Set 1 (16QAM) is 777 kb/s. Therefore, t-put R = (1/BLER) x 777 kb/s. As a result, the minimum requirement of a t-put R > 700 kb/s is equivalent to a BLER < 10%.

Details of the test procedure

The actual test procedure for Maximum Input Level for HS-PDSCH Reception (16QAM), based on 3GPP TS 34.121 clause 6.3A.4.2, is the following:

- A generic HSDPA call is set up as described in 3GPP TS 34.108 clause 7.3.6.3 using the downlink configuration for this test described previously.
- The UE is commanded to output the required uplink power (20 dBm for power class 3 and 18 dBm for power class 4). The power is kept to a ±1 dB tolerance.
- T-put R is calculated from the ACK, NACK, and statDTX sent by the UE on the uplink HS-DPCCH.

The length of this test is defined in 3GPP TS 34.121 annex F.6.3 table F.6.3.5.1. The minimum number of transport blocks for 95% confidence is 467, so the test time is 467*2 ms* inter-TTI (3) = 2.8 seconds.

HSDPA Performance Requirement Tests

The specifications define three performance requirements test sections for HSDPA:

- Demodulation of HS-DSCH (34.121 9.2)
- Reporting of CQI (34.121 9.3)
- HS-SCCH Detection (34.121 9.4)

Connection setup

Figure 17 gives the generic connection diagram for single-link performance of all HSDPA performance requirement tests. Fading profiles and AWGN may be provided by the SS itself or by external faders and AWGN sources if the SS is not available. Note that fading is not required for the Reporting of CQI under AWGN Propagation Conditions test.

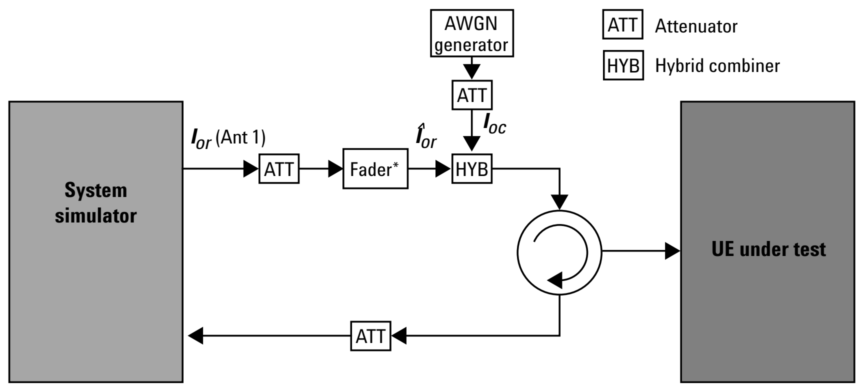

Figure 17. Connection setup for all HSDPA performance requirements tests for single-link performance (ref: 3GPP TS 34.121 figure A.16).

The specifications require that HSDPA performance also be evaluated under open-loop and closed-loop diversity scenarios. Performance will vary from the single-link case, so different test parameters and minimum requirements are specified for diversity conditions. The conformance test measurement setup, illustrated in Figure 18, is similar to that of the single-link test, but now the SS has to simulate a cell with both a normal antenna and a diversity antenna. Two faders (one for each antenna) are required. Fading profiles and AWGN may be provided by the SS itself or by external faders and AWGN sources if the SS is not available. Note that fading is not required for the Reporting of CQI under AWGN Propagation Conditions test.

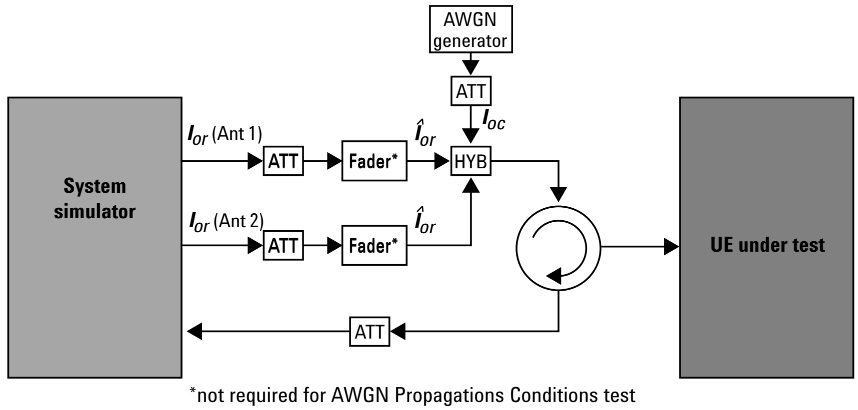

Figure 18. Connection setup for all HSDPA performance requirement tests for open-loop and closed-loop diversity (ref: 3GPP TS 34.121 figure A.19).

During the test, the uplink connection remains a single link. In closed-loop mode this link carries the information from the UE that is used to control the relative power and phase of the downlink antennas. The SS must be able to respond to the closed-loop link instructions from the UE.

Release 5 conformance test specifications describe open-loop and closed-loop diversity scenarios only for the Demodulation of HS-DSCH test, but the Release 6 specifications also include open-loop and closed-loop diversity for the Reporting of CQI tests, and open-loop diversity for the HS-SCCH Detection performance test.

Demodulation of HS-DSCH (34.121 9.2)

Now let's turn to the Demodulation of HS-DSCH performance requirement test.

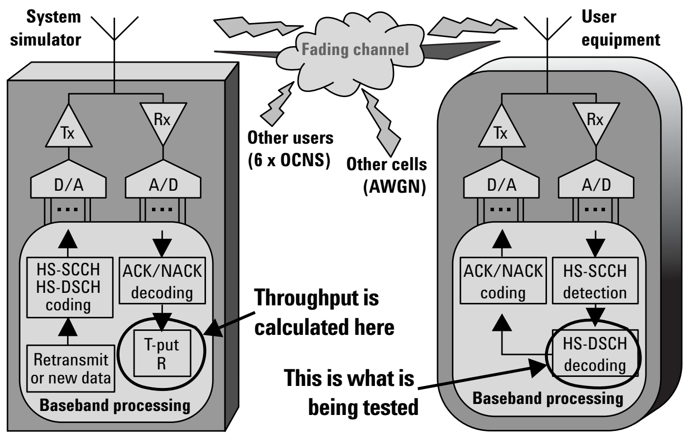

Figure 19. Demodulation of HS-DSCH verifies the HS-DSCH decoding performance of the UE.

Demodulation of HS-DSCH is the equivalent of the demodulation performance requirement tests for W-CDMA dedicated channels. For HSDPA, this test evaluates the HS-DSCH decoding performance of the UE, particularly its most challenging aspects: multicode channel reception and the IR-HARQ combining scheme. Other aspects of decoding, such as the minimum inter-TTI capability of the UE, are also tested.

Demodulation of HS-DSCH specifies minimum requirements in terms of t-put R, which is calculated from the ACK/NACK reports sent by the UE. This test is the only one that requires retransmissions from the SS, which are used to test the HARQ functionality of the UE. The SS uses the ACK/NACK report from the UE to determine when a block must be retransmitted or a new block transmitted. Note that the test must be performed under propagation conditions that include both AWGN and multi-path fading.

Test-specific downlink parameters

The minimum requirements for the Demodulation of HS-DSCH test vary depending on the UE category and the different test scenarios. Release 5 has 99 different downlink test combinations with different t-put R requirements—and this is just for single-link performance! There are even more if you consider open-loop and closed-loop diversity scenarios.

The 99 possible downlink test combinations are a result of the following:

- Eight possible UE categories map onto five possible FRC H-Sets (FRC H-Set 1 to 5). FRC H-Sets 1, 2, and 3 have both QPSK and 16QAM versions.
- Each applicable downlink configuration is tested against four fading profiles.
- Each combination of FRC and fading profile can have up to four t-put R requirements, depending on the signal and noise levels.

Release 6 includes even more downlink configurations and minimum requirements that need to be considered:

- Requirements for two more UE categories have been added, making 10 possible UE categories that map onto 6 possible FRC H-Sets (FRC H-Set 1 to 6). FRC H-Sets 1, 2, 3, and 6 have both QPSK and 16QAM versions.
- Enhanced (that is, more demanding) t-put R requirements have been added for UE with advanced receiver architectures

The information in Table 6 complements our earlier discussion of general downlink channel test configuration parameters. This table, however, shows only those downlink parameters that are specific to the Demodulation of HS-DSCH test and which correspond to single-link performance in Release 5. It does not include all of the test parameters for open-loop and closed-loop diversity scenarios or for the enhanced requirements and additional UE categories in Release 6. For still greater simplicity, the table shows the minimum requirements from 3GPP TS 25.101, not the relaxed test requirements from 3GPP TS 34.121 that take into account test system uncertainty.

Signal	Level vs. I_{oc} @ –60 dBm	Notes
$\hat{I}_{or}$	0 dB or 10 dB	Typical or very good geometry factor

Channel	Level vs. I_{oc}	Notes
DPCH	–5 dB	12.2 k RMC
HS-SCCH-1	–7.5 dB or –8.5 dB	HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (HS-PDSCHs)	–3 dB or –6dB (total)	FRC H-Set 1 to 5

Fading profiles	Notes
Multi-path PA3, PB3, VA30, VA120	Pedestrian A 3 km/h, Pedestrian B 3 km/h, Vehicular A 30 km/h, Vehicular A 120 km/h Ref: 25.101 table B.1B

Table 6. Test-specific downlink parameters for Demodulation of HS-DSCH single link performance in Release 5 (based on 3GPP TS 34.121 clause 9.2.1.2).

One of the most important parameters for this test is the signal-to-noise ratio ($\hat{I}_{or}$ /I_{oc}), known as a cell’s geometry factor. This ratio tells us how much of a cell is above the surrounding noise. As shown in Table 6, typical (0 dB) geometry factors or very good (10 dB) geometry factors are defined for Release 5 single-link performance. Another important parameter is the relative HS-DSCH (or HS-PDSCH) power level. The HS-DSCH is configured as one of the FRC H-Sets, depending on the UE category. The HS-PDSCH power is the total for all the codes that are part of the FRC H-Set.

Four different fading profiles are used in the Demodulation of HS-DSCH test:

- ITU pedestrian A speed 3 km/h (PA3)
- ITU pedestrian B speed 3 km/h (PB3)
- ITU vehicular speed 30 km/h (VA30)
- ITU vehicular A speed 120 km/h (VA120)

These scenarios correspond to profiles with four to six paths and Doppler spectrum. You can find more details on these fading profiles in 3GPP TS 34.121 table D.2.2.1A or 3GPP TS 25.101 table B.1B.

Mapping UE categories onto FRC H-Sets

Figure 20 shows how UE categories are mapped onto FRC H-Sets. Release 5 of the 3GPP specifications provides the minimum throughput requirements for UE categories 1 to 6 and 11 to 12. Release 6 adds the minimum requirements for UE categories 7 and 8.

Tested in Release 6

Tested in Release 5

Based on: 25.306 table 5.1a

HS-DSCH category (FDD)	Min. Inter-TTI interval	Max. Tr. Blk. Size	Max. # of codes
Category 1	3	7298	5
Category 2	3	7298	5
Category 3	2	7298	5
Category 4	2	7298	5
Category 5	1	7298	5
Category 6	1	7298	5
Category 7*	1	14411	10
Category 8*	1	14411	10
Category 9	1	20251	15
Category 10	1	27952	15
Category 11	2	3630	5
Category 12	1	3630	5

Based on: 25.101 A7

FRC H-Set	Inter-TTI Interval	# of HARQ proc.	QPSK Configuration		16QAM Configuration	
			# of inf. bits	# of codes	# of inf. bits	# of codes
FRC H-Set 1	3	2	3202	5	4664	4
FRC H-Set 2	2	3	3202	5	4664	4
FRC H-Set 3	1	6	3202	5	4664	4
FRC H-Set 6 *	1	6	6438	10	9377	8
Not Defined						
FRC H-Set 4	2	2	3202	5	N/A	
FRC H-Set 5	1	3	3202	5	N/A	

*Use FRC H-Set 6 for best channel conditions (Pedestrian A and lowest AWGN setting). Otherwise use FRC H-Set 3.

Figure 20. Mapping between UE category and FRC H-Set (based on 3GPP TS 25.306 table 5.1a and 3GPP TS 25.101 annex A7).

Note that the most capable UE, intended to support 15 HS-DSCH codes and the highest transport block size (that is, the highest theoretical throughput), will not be developed until later releases of the specifications, if at all. The reason for this delay is that the radio conditions under which UE categories 9 and 10 can deliver additional performance over and above categories 7 and 8 are very rare and not likely to be encountered in commercial networks.

The UE categories shown in the far-left column of Figure 20, which are taken from the UE category table in 25.306 table 5.1a, are listed along with most of their defining parameters. Because of space constraints, however, the total IR buffer size parameter has not been included. The FRC H-Set table on the right shows the corresponding parameters for the different FRC H-Sets. These parameters are the inter-TTI interval and number of HARQ processes, the number of codes for the HS-DSCH, and the number of information bits in a transport block, which for an FRC is equal to the size of the transport block.

In general, the parameters of an FRC H-Set are designed to match and stress the HS-DSCH decoding capabilities of the corresponding UE category. For example, FRC H-Set 3, which is the FRC H-Set assigned to UE categories 5 and 6, has an inter-TTI interval of one and six HARQ processes, which are the minimum inter-TTI interval and maximum number of processes that these UE categories can process.

The UE parameters listed in Figure 20 define the maximum theoretical throughput that each UE category allows. This maximum theoretical throughput is given in Figure 21 for each UE category. It is calculated by dividing the maximum HS-DSCH transport block size for a category by the TTI length (2 ms) and dividing again the result by the minimum inter-TTI interval. The higher the minimum inter-TTI interval, the lower the number of parallel HARQ processes allowed, which results in a lower throughput.

Based on: 25.306 Table 5.1a | Based on: 25.101 A7

Tested in Release 6	Tested in Release 5	HS-DSCH category (FDD)	Maximum theoretical throughput	FRC H-Set	Nominal Average Information Bit Rate (QPSK configuration)	Nominal Average Information Bit Rate (16QAM configuration)
✓	✓	Category 1	1.216 Mbps	FRC H-Set 1	534 kbps	777 kbps
✓	✓	Category 2	1.216 Mbps	FRC H-Set 1	534 kbps	777 kbps
✓	✓	Category 3	1.824 Mbps	FRC H-Set 2	801 kbps	1166 kbps
✓	✓	Category 4	1.824 Mbps	FRC H-Set 2	801 kbps	1166 kbps
✓	✓	Category 5	3.649 Mbps	FRC H-Set 3	1601 kbps	2332 kbps
✓	✓	Category 6	3.649 Mbps	FRC H-Set 3	1601 kbps	2332 kbps
✓		Category 7	7.205 Mbps	FRC H-Set 6/ H-Set 3*	3219 kbps/1601 kbps	4689 kbps/2332 kbps
✓		Category 8	7.205 Mbps	FRC H-Set 6/ H-Set 3*	3219 kbps/1601 kbps	4689 kbps/2332 kbps
		Category 9	10.125 Mbps	Not Defined		
		Category 10	13.976 Mbps	Not Defined		
✓	✓	Category 11	907 kbps	FRC H-Set 4	534 kbps	N/A
✓	✓	Category 12	1.815 Mbps	FRC H-Set 5	801 kbps	N/A

*Use FRC H-Set 6 for best channel conditions (Pedestrian A and lowest AWGN setting). Otherwise use FRC H-Set 3.

Figure 21. Maximum theoretical throughput value for each UE category and nominal average information bit rate for each FRC (based on 3GPP TS 25.306 table 5.1a and 3GPP TS 25.101 annex A7).

The maximum theoretical throughput represents the throughput that could be achieved in the downlink if the maximum number of codes, the minimum inter-TTI interval, and the maximum transport block size were always used to serve this UE only—and if no retransmission of data were ever required (in other words, if all blocks were received correctly by the UE the first time the blocks were transmitted).

Figure 21 also gives the nominal average information bit rate for each of the different FRC H-Set configurations. This bit rate is perhaps the most important parameter of the FRC H-Set, as it defines the maximum throughput that would be possible using the fixed channel configuration if all the data blocks were received correctly the first time they were transmitted. As previously noted, the nominal average information bit rate can be calculated from the number of information bits in a block and the number of HARQ processes (shown in Figure 19).

The number of HARQ processes, rather than the inter-TTI interval, is used to calculate the nominal average information bit rate because some FRC H-Sets have TTI patterns that result in a lower-than-expected number of HARQ processes when only the inter-TTI interval is considered.

Notice that the nominal average information bit rate is always lower than the maximum theoretical throughput allowed for the corresponding UE category. This is the case because the maximum theoretical throughput would be possible only if the maximum transport block size for that UE category were used at every downlink HS-DSCH transmission.

Although performance requirements could be defined using FRC H-Sets that match the maximum throughput for each UE category, by the time fading is taken into account, the error rates would be so high they would make this an unrealistic scenario in which to define or measure performance. As a result, the nominal average information bit rates in the FRC H-Sets used for testing each UE category are typically less than half of what the UE might be capable in perfect radio conditions. Even so, as we will see later, the expected BLER when testing using these less stringent FRC H-Sets is still very high—up to 97.6%!

Downlink configuration of HARQ transmissions

Table 7 shows the expected behavior of the SS in response to an ACK/NACK, as described in the Demodulation of HS-DSCH conformance test specifications. Here the objective is to simulate the behavior of the Node B. Upon receiving an ACK, the SS must send a new block of data. Upon receiving a NACK, however, it must send a retransmission using the next redundancy version (RV), up to the maximum number of HARQ transmissions allowed. Upon receiving a DTX, the SS must retransmit the same block of data using the same RV previously transmitted for that HARQ process. The RV defines the exact set of bits that are selected during rate-matching (puncturing) to be sent over the air at the time of any one transmission. Thus different RVs represent different puncturing schemes.

HS-DPCCH ACK/NACK field state	Node B emulator behavior
ACK	ACK: new transmission using first redundancy version (RV)
NACK	NACK: retransmission using the next RV (up to the maximum permitted number or RVs)
DTX	DTX: retransmission using the RV previously transmitted to the same HARQ process

Table 7. Expected behavior of the SS in response to an ACK/NACK (ref: 3GPP TS 34.121 table 9.2.1.2).

Table 8 shows additional HS-DSCH configuration parameters for the Demodulation of HS-DSCH test. At the most, four HARQ transmissions are allowed, so three retransmissions are allowed. The RV sequence to follow is also specified and depends on the FRC modulation format. For QPSK configurations, RV = 0 is always sent in the first transmission of a block. The RVs 2, 5, and 6 are sent in subsequent retransmissions. For 16QAM configurations, RV = 6 is used for the first transmission and RVs 2, 1, and 5 in subsequent retransmissions. In an FRC all the coding and modulation parameters (except for the RV parameter) are fixed, so the number of bits that are sent over the air is always the same. The only difference between transmissions of the same block using different RVs is which set of bits is sent.

Other HS-DSCH configuration parameters	Value	Notes
Maximum # of HARQ transmissions	4	3 retransmissions allowed
Redundancy/constellation version (RV) sequence	{0, 2, 5, 6} {6, 2, 1, 5}	QPSK configurations 16QAM configurations

Table 8. Additional downlink HARQ configuration parameters (based on 3GPP TS 34.121 table 9.2.1.3).

The simplified graphic in Figure 22 shows the interaction between the SS and the UE during the Demodulation of HS-DSCH test. This example uses FRC H-Set 1 (QPSK), which has two processes and an inter-TTI interval of three.

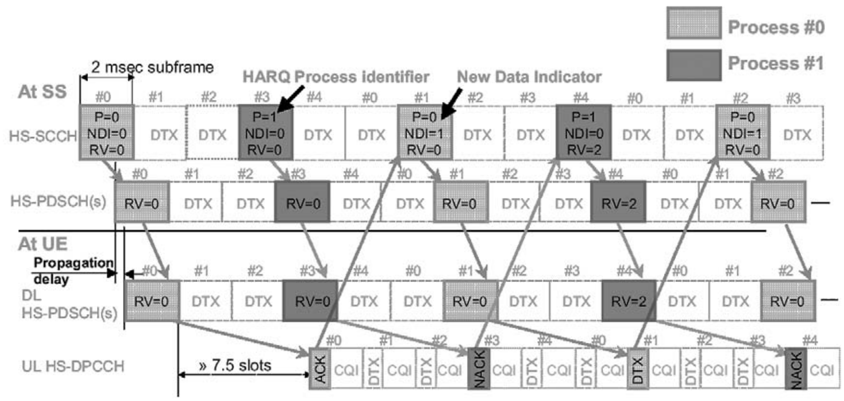

Figure 22. Simplified example of the interaction between the SS and UE during the demodulation of HS-DSCH test.

The downlink HS-SCCH indicates that new data is being transmitted from the SS by toggling the new data indicator (NDI) value between 0 and 1 within the same HARQ process (see 3GPP TS 25.321 clause 11.6.1.3). Thus, for a retransmission, the NDI value stays the same while the RV changes to the next in the sequence. To keep this example simple, we allow a maximum of two HARQ transmissions per block, rather than the four transmissions that are allowed for the actual Demodulation of HS-DSCH test. The RV sequence is {0, 2}.

Note that if a NACK is received for the first block sent for process #1, the SS answers by maintaining the NDI as 0 and changing the RV from 0 to 2. This response indicates that the original data block is being retransmitted using a different RV.

Details of the test procedure

The actual procedure for the Demodulation of HS-DSCH test (based on 3GPP TS 34.121 clause 9.2.1.4) is the following:

- A generic HSDPA call is set up as described in 3GPP TS 34.108 clause 7.3.6.3 using the downlink configuration shown earlier with the required FRC H-Set. The information bit data for the FRC must be pseudo-random and must not be repeated before 10 different information bit payload blocks have been processed. For example, if FRC H-Set 3 (QPSK) is used then the pseudo-random sequence must be at least 10 x 3202 bits long.
- The SS transmits and retransmits according to the uplink ACK/NACK report sent by the UE.
- T-put R is calculated from the ACK, NACK, and statDTX sent by the UE on the uplink HS-DPCCH.

The test length is determined by either the fading cycle or the number of samples required to get a statistically meaningful result—whichever takes the longest time. Test lengths for the different test scenarios are defined in 3GPP TS 34.121 annex F.6.3 tables F.6.3.5 and vary between 4.1 and 164 s.

Minimum requirements

Table 9 shows the minimum requirements established in Release 5 for FRC H-Set 1, 2, and 3 (QPSK configuration) for a typical macro cell geometry factor ($\hat{I}_{or}/I_{oc}$ = 0 dB) and the corresponding BLER.

Typical macro cell geometry factor

Minimum requirements are no indication of real-life performance with AMC

Minimum requirement T-put R for $\hat{I}_{or}/I_{oc}$ = 0 dB

Propagation conditions	Ec/Ior (dB)	FRC H-Set 1 (QPSK) 2 processes Nom. Avg. Inf. Bit Rate = 534 kb/s	FRC H-Set 2 (QPSK) 3 processes Nom. Avg. Inf. Bit Rate = 801 kb/s	FRC H-Set 3 (QPSK) 6 processes Nom. Avg. Inf. Bit Rate = 1601 kb/s	BLER (%)
PA3	–6	65 kb/s	x 1.5	x 3	87.8
PB3	–6	23 kb/s	x 1.5	x 3	95.7
	–3	138 kb/s	x 1.5	x 3	74.2
VA30	–6	22 kb/s	x 1.5	x 3	95.9
	–3	142 kb/s	x 1.5	x 3	73.4
VA120	–6	13 kb/s	x 1.5	x 3	97.6
	–3	140 kb/s	x 1.5	x 3	73.8

Table 9. Minimum requirements for a typical macro cell geometry factor and corresponding BLER (based on 3GPP TS 34.121 table 9.2.1.4).

In general, the minimum throughput requirements for an FRC are quite low in comparison to the nominal average information bit rate. This results in very high BLER figures. For example, Table 9 shows that for a typical macro cell geometry factor, BLER varies between 73 and 97.6%. These percentages suggest that, for these specific test parameters, we can expect inefficient communication between the SS and the UE with lots of retransmissions.

Note that minimum requirements are no indication of the real-life performance of the UE, since the minimum requirements do not take into account AMC (adaptive modulation and coding), which is one of the techniques that overcomes fading and enables higher data rates in real-world operation. If AMC were used during testing, the downlink channel would no longer be a fixed reference. Instead, the downlink HS-DSCH configuration would adapt to the varying channel conditions created by a fading profile, resulting in better throughput performance. However, as we noted earlier, AMC is not used during testing because it would be hard to isolate the performance of the SS from the performance of the UE.

Note also that even though the minimum t-put R requirements vary among the different FRC H-Sets, the corresponding BLER requirements for FRC H-Sets 1, 2, and 3 coincide. For example, the minimum requirement using the PA3 fading profile and Îor /Ioc = 0 dB is t-put R = 65 kb/s for FRC H-Set 1 (QPSK), t-put R = 65 x 1.5 = 98 kb/s for FRC H-Set 2 (QPSK), and t-put R = 65 x 3 = 195 kb/s for FRC H-Set 3 (QPSK). These different t-put R requirements all correspond to the same BLER of 0.88. At the root of the Demodulation of HS-DSCH performance test lies the expectation of a certain BLER for all transmitted blocks. Since the number of blocks transmitted per second varies by FRC H-Set with the number of HARQ processes being used, the nominal throughput will vary, too, but BLER will not.

Figure 23 shows the relationships among the maximum theoretical throughput for a UE category, the nominal average information bit rate for the corresponding FRC H-Set, and the minimum requirements for that FRC H-Set. This particular example covers UE categories 5 and 6, the corresponding FRC H-Set 3, and the minimum requirements for this FRC H-Set with a very good geometry factor (10 dB) and the PA3 fading profile.

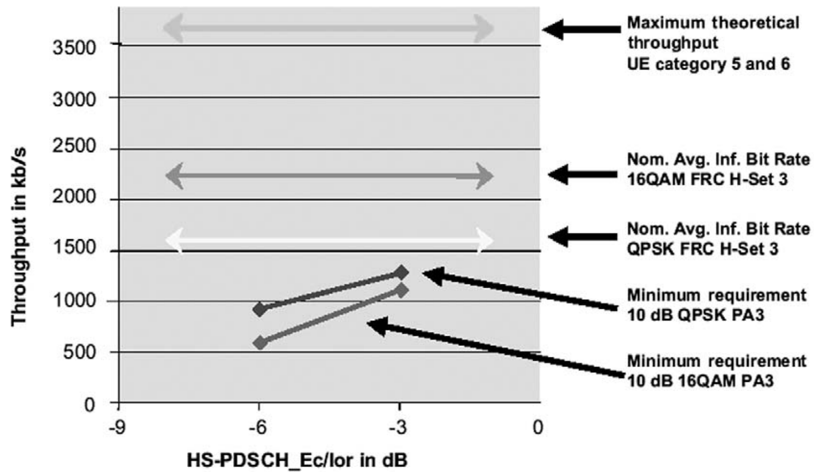

Figure 23. This example shows the relationship among maximum theoretical throughput, nominal average information bit rate, and minimum t-put R requirements for a UE category (based on 3GPP TS 34.121 tables 9.2.1.4 and 9.2.1.6).

A UE category can achieve its maximum theoretical throughput only at specific instances when the varying channel conditions are good enough to support the maximum transport block size for that UE category. So the maximum theoretical throughput is really the theoretical peak throughput for that UE category. In terms of testing, since fading is used, it does not make sense to use a nominal average information bit rate that is very close to the maximum theoretical throughput for the UE category. Even for very good geometry factors, the result would be numerous retransmissions and performance so low as to be pointless to measure. In general, the FRC parameters are chosen to stress the HS-DSCH decoding functionality of the UE according to its category, while keeping the minimum requirements as high as possible.

Despite these objectives, the minimum requirements typically are still much lower than the FRC nominal average information bit rate. Again this is a result of using test cases that reproduce variable channel conditions (fading) but use fixed downlink HS-DSCH configurations (thus no AMC). As we mentioned earlier, the low minimum requirements are not representative of real UE performance with AMC. The extent to which real life performance improves over these test requirements depends on the quality of the AMC algorithms in the Node B.

The requirements based on the 16QAM signals are not necessarily higher than their QPSK equivalents. This is because the test is done under fading and noisy conditions where 16QAM does not perform as well as QPSK. 16QAM achieves its potential only when the cell conditions are most favorable—which is not very often. In the actual operation of the system, QPSK or 16QAM is selected dynamically to match the instantaneous channel conditions and not as a fixed modulation scheme. These minimum requirements therefore do not provide an indicator of real-world performance.

Reporting of CQI (34.121 9.3)

The next category of HSDPA performance requirements tests is the Reporting of CQI (34.121 9.3). Two different tests are included under this heading: Reporting of CQI under AWGN Propagation Conditions (34.121 9.3.1) and Reporting of CQI under Fading Propagation Conditions (34.121 9.3.2). Although these tests have similar purposes, some differences exist in their procedures.

Reporting of CQI under AWGN Propagation Conditions (34.121 9.3.1)

This test evaluates the accuracy of the CQI reporting under stable propagation conditions.

The test procedure has two parts, each of which uses a different metric to evaluate a specific aspect of the reporting accuracy.

During the first part of the procedure, illustrated in Figure 24, the median and the variance of the reported CQI are calculated from multiple CQI reports. Since stable AWGN propagation conditions are used, a low variance is expected.

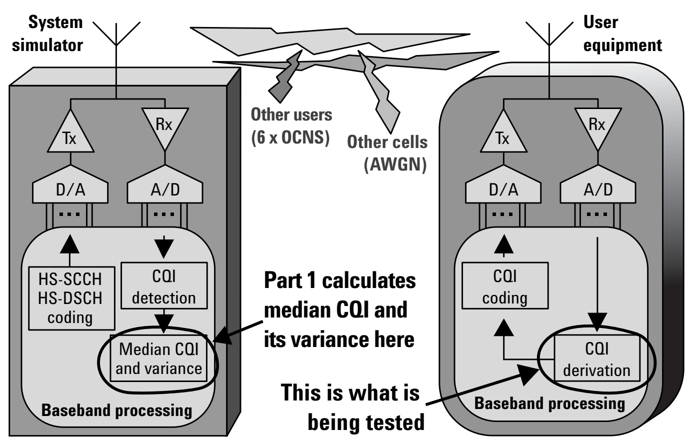

Figure 24. The first part of the Reporting of CQI under AWGN Propagation Conditions test calculates median CQI and variance.

Note that the CQI derivation function is not a measure of the HS-DSCH decoding performance of the UE but rather an estimate of the received channel conditions. As such, it assesses the signal to noise ratio, and the configuration of the HS-DSCH has no direct bearing on the CQI reports. The configuration of the downlink HS-DSCH has been chosen arbitrarily and is fixed; thus, it does not change dynamically in accordance with the uplink CQI report and no AMC is applied.

During this first part of the test, and for the AWGN levels defined, the UE attempts to report the HS-DSCH configuration that would result in a 10% BLER. Because this is not a precise process, some tolerance is accepted in the reports in the form of an allowed variance.

The second part of the Reporting of CQI under AWGN Propagation Conditions test verifies that when the same channel conditions (that is, the same AWGN levels) are used and when the HS-DSCH is configured according to the previously calculated median of the CQI reports, the resulting BLER as measured by the SS will be very close to the nominal figure of 10%. See Figure 25.

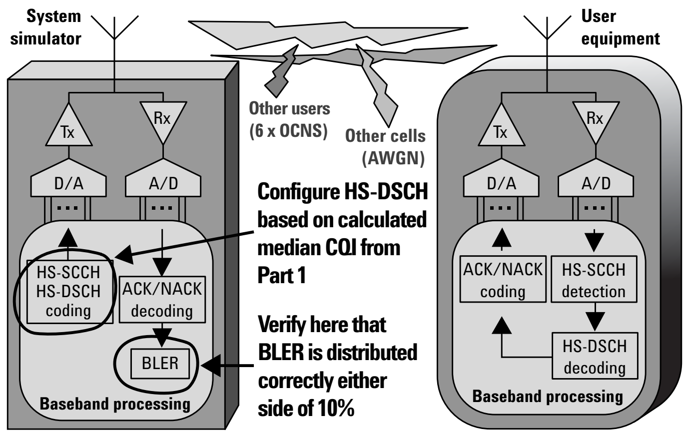

Figure 25. The second part of the Reporting of CQI under AWGN Propagation Conditions test measures BLER distribution for HS-DSCH configured around the median CQI.

This assessment of CQI accuracy is done by first measuring the BLER of the HS-DSCH, configured according to the median value of the reported CQI calculated in part 1. This result should be about 10%. However, rather than indicate a pass or fail based on a near-10% tolerance, the test requires a further measurement using a different HS-DSCH configuration. The intent of this additional measurement is to move the BLER to the other side of 10%. So if the first measurement was < 10%, the second measurement is made using a harder configuration (that is, a configuration with a higher order modulation scheme or less coding gain) that corresponds to median CQI + 2. If the first measurement was ≥ 10%, the second measurement is made using an easier configuration (that is, a configuration with a lower order modulation scheme or more coding gain) that corresponds to median CQI - 1. Thus the sense of the CQI reporting is verified around the 10% threshold, while the actual BLER results are not significant.

We will look in detail at the step-by-step procedure for the Reporting of CQI under AWGN Propagation Conditions test later in this section.

Test-specific parameters

Table 10 shows the downlink channel configuration test parameters that are specific to the Reporting of CQI under AWGN Propagation Conditions test. This table complements the general downlink test configuration table previously discussed. For simplicity, Table 10 includes only those parameters that correspond to the single link performance specified in Release 5. The numerical values used in the table represent the minimum requirements from 3GPP TS 25.101, not the relaxed test requirements from 3GPP TS 34.121 that take into account test system uncertainty.

Signal	Level vs. I_{oc} @ –60 dBm	Notes
$\hat{I}_{or}$	0 dB, 5 dB, or 10 dB	Typical, good, or very good geometry factor

Channel	Level vs. I_{or}	Notes
DPCH	–10 dB	12.2 k RMC
HS-SCCH-1	–10 dB	TTI signalling pattern: "...XOOXOO..." HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (HS-PDSCHs)	–3 dB total	Configuration based on CQI = 16, median CQI, median CQI + 2, or median CQI – 1

Table 10. Test-specific downlink parameters for Reporting of CQI under AWGN Propagation Conditions single link performance in Release 5 (based on 3GPP TS 34.121 table 9.3.1.1).

The most important parameter for this test is the signal-to-noise ratio or cell geometry factor ($\hat{I}_{or} / I_{oc}$). Since no fading is used in this test, the UE reports on stable channel conditions that are represented by the different geometry factors: typical (0 dB), good (5 dB), or very good (10 dB).

The HS-DSCH is configured for this test according to several CQI values. In the first part of the test, the HS-DSCH is arbitrarily configured for CQI = 16, as this value does not affect the test results (that is, the reported CQI median and variance). For the second part of the test, the HS-DSCH is configured according to the previously calculated median CQI and either the median CQI + 2 or median CQI – 1.

The six-subframe HS-SCCH-1 signaling pattern for this test is defined as "...XOOXOO...," wherein "X" indicates a TTI in which the HS-SCCH-1 uses the identity of the UE under test, and "O" indicates a TTI in which the HS-SCCH-1 uses a different UE identity. Therefore, blocks intended for the UE under test appear every third TTI only, which all UE support.

Table 11 shows additional test configuration parameters that are important for this test. Note that the uplink CQI feedback cycle is 2 ms and the CQI repetition factor is 1, so a new CQI report is sent by the UE every subframe.

Other configuration parameters	Value	Notes
CQI feedback cycle	2 ms	CQI transmitted every 2 ms
CQI repetition factor	1	CQI report is never repeated

Table 11. Additional test parameters for Reporting of CQI under AWGN Propagation Conditions (based on 3GPP TS 34.121 table 9.3.1.1).

Figure 26 shows how the parameters that are linked to a certain CQI value can be used to define the whole downlink HS-DSCH configuration. Each CQI value corresponds to a particular transport block size, number of HS-PDSCHs, modulation scheme (QPSK or 16QAM), reference power adjustment Δ, virtual IR buffer size N_{IR}, and RV = 0.

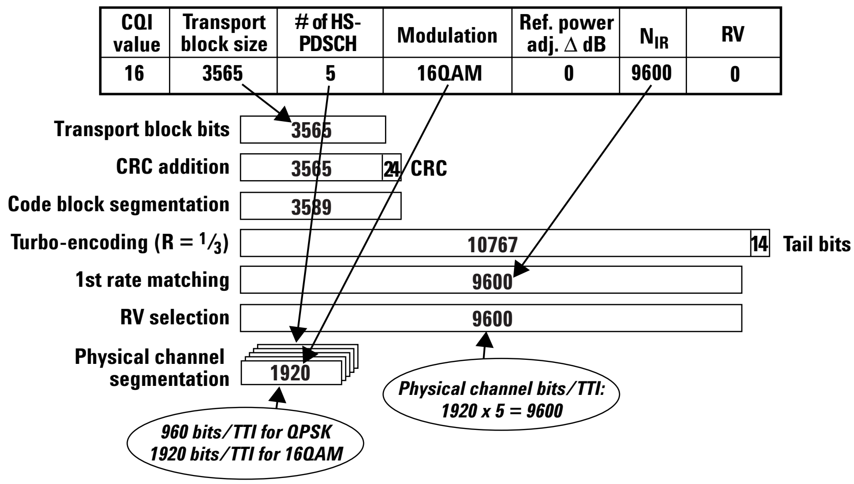

Figure 26. The downlink HS-DSCH configuration for the Reporting of CQI tests is based on a CQI value linked to specific parameters.

The modulation scheme defines the number of bits in each HS-PDSCH subframe (960 bits for QPSK and 1920 bits for 16QAM). Therefore, if the number of HS-PDSCHs and the modulation scheme are known, you can determine the total number of physical channel bits per subframe or TTI. The virtual IR buffer size and the transport block size define the rest of the downlink HS-DSCH coding.

The reference power adjustment Δ is used to adjust the HS-PDSCH E_c/I_{or} setting when the HS-DSCH is configured, but otherwise the HS-DSCH power remains constant during the test.

The example in Figure 26 shows the HS-DSCH configuration for CQI = 16, which was arbitrarily chosen as the HS-DSCH configuration for the first part of the Reporting of CQI under AWGN Propagation Conditions test. For UE categories 1 to 6, CQI value 16 corresponds to a transport block size of 3565 bits, 5 HS-PDSCHs, 16QAM, Δ = 0, NIR = 9600 bits, and RV = 0.

Details of the test procedure

The first part of the Reporting of CQI under AWGN Propagation Conditions test procedure (based on 3GPP TS 34.121 clause 9.3.1.4.2) consists of the following steps:

- A generic HSDPA call is set up as described in 3GPP TS 34.108 clause 7.3.6.3 using the downlink configuration discussed previously. The HS-DSCH is configured according to a CQI value of 16. The SS keeps this downlink configuration regardless of the CQI reports sent by the UE.
- The downlink transmission is carried out until 2000 CQI reports from the UE have been collected.
- A CQI frequency distribution is calculated from these 2000 CQI reports, and then the median CQI value is calculated. The median CQI is defined as the CQI value at or crossing the 50% distribution threshold from the lower CQI side.
- The CQI frequency distribution is used to study the variance of the reported CQI. To pass this first part of the test, the reported CQI value must be within the range of ± 2 of the median CQI value 90% of the time. That is, 1800 or more of the reported CQI values must lie within the median CQI – 2 value and the median CQI + 2 value.

Figure 27 provides an example of the frequency distribution for 2000 CQI reports. The reported median CQI can be determined from this information by creating the CQI cumulative frequency distribution and determining the lowest CQI value that crosses the 50% median point. In order words, for 50% of the reports (or 1000 reports) the CQI value is below or at the median. In this case the median is 13 (50% of the CQI reports have a value of 13 or lower).

Note that this example was created to illustrate the test procedure and it does not represent the real behavior of a UE.

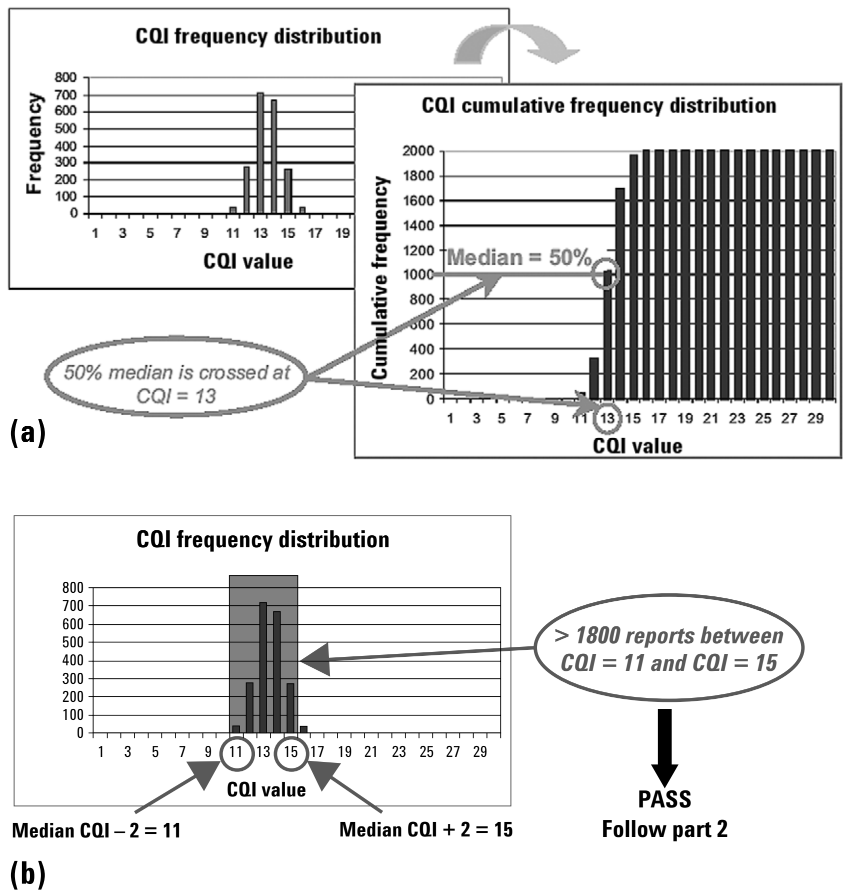

Figure 27. The CQI frequency distribution and CQI cumulative frequency distribution are used to determine (a) the median and (b) the variance of the CQI reports.

Once the median CQI has been calculated, the CQI frequency distribution is examined again to determine whether the variance of the CQI reports falls within the expected limits. Of the 2000 CQI reports, more than 1800 must fall within a range of 5 CQI consecutive values (from a value of median CQI – 2 to a value of median CQI + 2). In Figure 27b, most of the CQI values shown in the CQI frequency distribution chart fall between 11 and 15. Since the median CQI is 13, the UE passes the first part of the test.

Now the UE must undergo the second part of the test procedure, which verifies that the HS-DSCH, configured according to a CQI value just above or below the reported median CQI, gives a BLER that is on the “correct side” of 10%, as described next.

The second part of the test (based on 3GPP TS 34.121 clause 9.3.1.4.2) proceeds as follows:

- The HS-DSCH is configured according to the median CQI value calculated during the first part of the test. The SS keeps this downlink configuration regardless of the CQI reports sent by the UE.
- BLER is calculated based on the ACK/NACK reports for 1000 blocks.
- If BLER is less than 0.1, the HS-DSCH is configured according to a value of median CQI + 2 and BLER is calculated again for another 1000 blocks. The purpose of this step is to verify that when a more difficult HS-DSCH configuration is used, the BLER will be at or above the 10% reference used for the UE's calculation of the CQI report.
- If BLER is greater than 0.1, the HS-DSCH is configured according to a value of median CQI + 1 and BLER is calculated again for another 1000 blocks. The purpose of this step is to verify that when an easier HS-DSCH configuration is used, the BLER will be below the 10% reference used for the UE's calculation of the CQI report.

To summarize briefly the complete test procedure for CQI reporting under static (AWGN) conditions:

- Measure the median CQI using a specific AWGN level.
- Verify that the CQI variance is within limits.
- Measure the BLER using an HS-DSCH configured for the median CQI.
- Verify one of the following:
- If the measured BLER at median CQI is < 10%, verify that using a harder HS-DSCH configuration produces BLER ≥ 10%.
- If the measured BLER at median CQI is ≥ 10%, verify that using an easier HS-DSCH configuration produces BLER < 10%.

Remember that the absolute CQI reports are of no consequence in this procedure. We are concerned only with the CQI variance and the measured BLER using HS-DSCH configured at or near the median CQI.

Reporting of CQI Under Fading Propagation Conditions (34.121 9.3.2)

This test evaluates the accuracy of the CQI reporting under multi-path propagation conditions. It requires the UE to track the real time variation in channel conditions. Because the propagation conditions are not stable, the reported CQI values will likely vary considerably. Therefore, the variance of the CQI reports is not used as a metric, as it was in the first part of the previous (AWGN propagation conditions) test.

For the Reporting of CQI under Fading Propagation Conditions test, the median CQI is calculated from multiple CQI reports and is used to configure the HS-DSCH. As in the previous test, the configuration of the downlink HS-DSCH is fixed and so does not change dynamically in accordance with the uplink CQI report. Once again, no AMC is applied.

The fading propagation conditions test examines two different events representing two different instantaneous channel conditions. Event R1 represents the instantaneous channel conditions that are reported by the UE with a value equal to the calculated median CQI.

Event R2 represents the instantaneous channel conditions that are reported by the UE with a value equal to the median CQI + 3. Therefore, event R2 corresponds to better perceived channel conditions than does event R1.

To verify that the UE is correctly reporting the CQI during non-constant channel conditions, the BLER is calculated independently for event R1 periods (when CQI is reported as the median CQI) and for event R2 periods (when CQI is reported as the median CQI + 3).

As noted previously, the BLER for HS-DSCH blocks received during event R2 channel conditions should be lower than the BLER for blocks received during event R1. This is true because event R2 represents better instantaneous channel conditions, thus resulting in a lower rate of error. Remember that the HS-DSCH configuration does not change during the test. Therefore, the variations of BLER follow exclusively the variations of the instantaneous channel conditions.

Figure 28 illustrates the general test process. The exact test procedure will be described later.

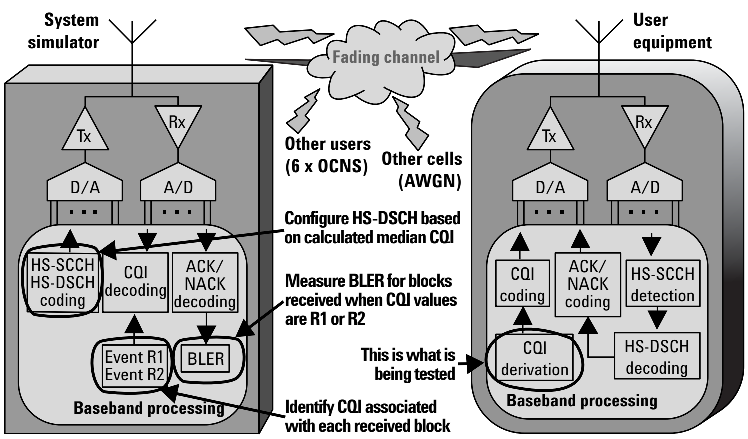

Figure 28. Reporting of CQI under Fading Propagation Conditions tests the accuracy of CQI reporting under multi-path propagation conditions.

Test-specific parameters

Table 13 shows the downlink channel configuration test parameters that are specific to the Reporting of CQI under Fading Propagation Conditions test. This table complements the general downlink test configuration table discussed earlier. For simplicity, Table 11 includes only those parameters that correspond to single link performance in Release 5. The numerical values shown here are the minimum requirements from 3GPP TS 25.101, not the relaxed test requirements from 3GPP TS 34.121 that take into account test system uncertainty.

Signal	Level vs. I_{oc} @ –60 dBm	Notes
$\hat{I}_{or}$	0 dB or 5 dB	Typical or good geometry factor

Channel	Level vs. I_{or}	Notes
DPCH	–6 dB	12.2 k RMC
HS-SCCH-1	–8.5 dB	TTI signalling pattern: "...XOOXOO..." HS-SCCH-2, 3, 4 are off (DTX)
HS-DSCH (HS-PDSCHs)	–8 dB or –4 dB total	Config. based on CQI=16 or median CQI

Fading profile	Notes
Multi-path case 8	Ref: 25.101 Table B.1C

Table 13. Test-specific downlink parameters for Reporting of CQI under Fading Propagation Conditions single link performance in Release 5 (based on 3GPP TS 34.121 table 9.3.2.1).

Reporting of CQI under Fading Propagation Conditions differs from the AWGN propagation conditions test mainly in the fact that the fading propagation conditions test must be performed using both multi-path fading and AWGN. The signal-to-noise levels used correspond to typical (0 dB) or good (5 dB) geometry factors. The multi-path fading profile is multi-path case 8, which consists of two paths. This fading profile is used only for the Reporting of CQI test. Refer to 3GPP TS 25.101 table B.1C for more details on this fading profile.

Note that to set up a channel on which the median CQI can be calculated, the HS-DSCH is first configured arbitrarily based on CQI = 16. Then it is configured according to the calculated median CQI.

Table 14, shows additional test configuration parameter that are important for this test. As with the Reporting of CQI under AWGN Propagation Conditions test, the uplink CQI feedback cycle is 2 ms and the CQI repetition factor is 1, so a new CQI report is sent by the UE every subframe.

Other configuration parameters	Value	Notes
CQI feedback cycle	2 ms	CQI transmitted every 2 ms
CQI repetition factor	1	CQI report is never repeated

Table 14. Additional test parameters for Reporting of CQI under Fading Propagation Conditions (based on 3GPP TS 34.121 table 9.3.2.1).

Details of the test procedure

The procedure for the Reporting of CQI under Fading Propagation Conditions test, based on 3GPP TS 34.121 clause 9.3.2.4.2, consists of the following:

- A generic HSDPA call is set up as described in 3GPP TS 34.108 clause 7.3.6.3 using the downlink configuration shown earlier. The HS-DSCH is configured according to a CQI value of 16. The SS keeps this downlink configuration regardless of the CQI reports sent by the UE.
- The downlink transmission is continued until 2000 CQI reports are collected from the UE. A frequency distribution is calculated for the reported CQI values and then the median CQI is calculated.
- The downlink HS-DSCH is configured again, this time according to the calculated median CQI. The SS keeps this downlink configuration regardless of the CQI reports sent by the UE.

BLER is calculated for two different events:

- For 1000 blocks transmitted during event R1 instantaneous propagation conditions (when the reported CQI value is equal to the median CQI value calculated earlier). The BLER for event R1 must be lower than 60%.
- For 1000 blocks transmitted during event R2 instantaneous propagation conditions (when the reported CQI is equal to the median CQI + 3). The BLER for event R2 must be lower than 15%.

Figure 29 illustrates the procedure to calculate BLER for events R1 and R2. In this example, the median CQI has already been calculated and it is 17.

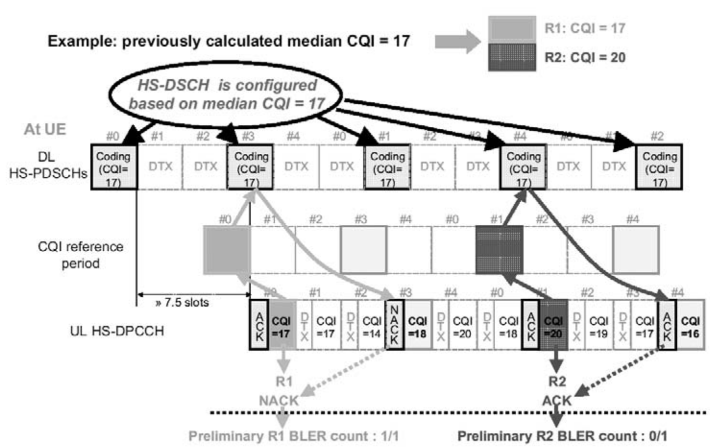

Figure 29. BLER is calculated for events R1 and R2.

The key to understanding the Reporting of CQI under Fading Propagation Conditions test lies in understanding both the definition of CQI found in the specifications (see 3GPP TS 25.214 clause 6A.2) and the means of correctly associating the physical events with the reports from the UE.

According to the specifications, the CQI is derived for a 3-slot reference period ending one slot before the start of the first slot in which the reported CQI value is transmitted. For the purposes of the BLER calculation, the associated HS-PDSCH subframes are the subframes that start their transmission during these reference periods.

Event R1 occurs when the CQI report associated with a transmitted HS-PDSCH subframe has the same value as the previously calculated median CQI (17 in this case). The ACK/NACK report must be collected for 1000 of these events and the BLER must be calculated. In Figure 28, for example, event R1 occurs only once. The ACK/NACK report for the associated HS-DSCH block is a NACK, so the preliminary BLER count for event R1 in this example is BLER = 1/1.

Event R2 occurs when the CQI report associated with a transmitted HS-PDSCH subframe has the same value as the previously calculated median CQI + 3 (20 in this case). The ACK/NACK report must be collected for 1000 of these events and the BLER must be calculated. In Figure 28, event R2 occurs also only once. The ACK/NACK report for the associated HS-DSCH block is an ACK, so the preliminary BLER count for event R2 in this example is BLER = 0/1.

The minimum requirements for this test (BLER < 60% for R1 and BLER < 15% for R2) are based on the expectation discussed earlier that the BLER for event R2 will be much lower than the BLER for event R1. The blocks associated with event R2 are transmitted during better link conditions, according to the CQI report—that is, the reported CQI value for event R2 is higher than the reported CQI value for event R1.

HS-SCCH Detection Performance (34.121 9.4)

The third and final category of the HSDPA Performance Requirement Tests that we will examine is the HS-SCCH Detection Performance test (34.121 9.4). The purpose of this test is to ensure that the UE is capable of correctly decoding control information from the HS-SCCH intended for that UE.

Although this test is probably the least complex of the performance requirement tests, it is arguably the most critical, since HSDPA transmissions cannot be established if HS-SCCH detection in the UE does not work properly.

The minimum requirements for this test are based on the probability of event E_m, defined as $P(E_m)$, which is declared when the UE is signaled on the HS-SCCH-1 but DTX is observed in the corresponding HS-DPCCH ACK/NACK field.

The test must be performed under propagation conditions that include both AWGN and multi-path fading. Figure 30 gives an overview of the test process. The test procedure will be detailed later.

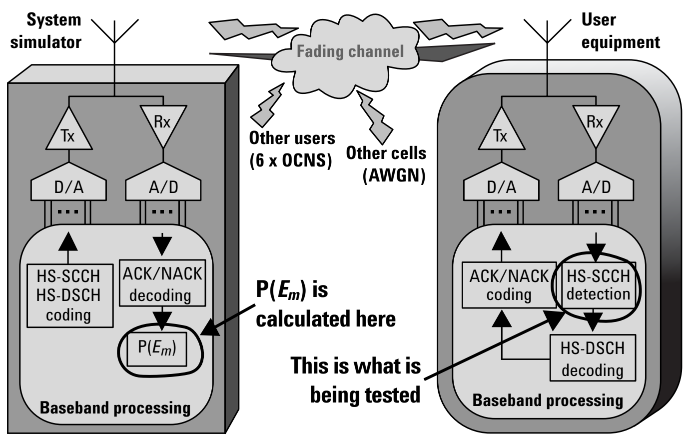

Figure 30. The HS-SCCH Detection Performance test verifies that HS-SCCH detection in the UE is working properly.

Test-specific downlink parameters

Table 15 gives downlink channel configuration test parameters that are specific to the HS-SCCH detection performance test. This table complements the general downlink test configuration table shown earlier. For simplicity, Table 12 includes only those parameters that correspond to single link performance in Release 5. The numerical values given here are the minimum requirements from 3GPP TS 25.101, not the relaxed test requirements from 3GPP TS 34.121 that take into account test system uncertainty.

Signal	Level vs. I_{oc} @ –60 dBm	Notes
$\hat{I}_{or}$	0 dB or 5 dB	Typical or good geometry factor

Channel	Level vs. I_{or}	Notes
DPCH	–8 dB	12.2 k RMC
HS-SCCH-1	–9, –9.9, or –10 dB	Carries the DUT UE identity TTI signalling pattern: "...XOOXOO..."
HS-SCCH-2, 3, 4	Undefined	Carry 3 other identities
HS-DSCH (HS-PDSCH)	–10 dB	Configuration based on CQI = 1

Fading profile	Notes
Multi-path PA3, VA30	Pedestrian A 3 km/h, Vehicular A 30 km/h Ref: 25.101 Table B.1B

Table 15. Test-specific downlink parameters for HS-SCCH Detection Performance single link performance in Release 5 (based on 3GPP TS 34.121 tables 9.4.2, 9.4.3, and E.5.4).

For the HS-SCCH Detection Performance test, four HS-SCCHs are sent to the UE, each with a different UE identity. HS-SCCH-1 carries the UE identity (1010101010101010), while each of the three other HS-SCCHs carries one of the remaining three identities. Only the HS-PDSCH associated to HS-SCCH-1 is left active, while the HS-PDSCHs associated with the other three HS-SCCH are DTX.

As in the Reporting of CQI tests, the six-subframe HS-SCCH-1 signaling pattern for this test is defined as "...XOOXOO...," wherein "X" indicates a TTI in which the HS-SCCH-1 uses the identity of the UE under test, and "O" indicates a TTI in which the HS-SCCH-1 uses a different UE identity. Thus, blocks intended for the UE under test occur only every third TTI, which all UE categories support.

The HS-DSCH configuration should not affect the results of the test. Therefore, the HS-DSCH is configured arbitrarily based on CQI = 1, which corresponds to 1 HS-PDSCH, QPSK modulation, and the smallest transport block size. This is the simplest HS-DSCH configuration to decode.

The test is performed for different combinations of cell geometry factors ($\hat{I}_{or}/I_{oc}$), HS-SCCH-1 power levels, and fading profiles.

Two fading scenarios are used: ITU pedestrian A speed 3km/h (PA3) and ITU vehicular speed 30km/h (VA30). These scenarios correspond to profiles with four to six paths and Doppler spectrum. Refer to 3GPP TS 34.121 table D.2.2.1A or to 3GPP TS 25.101 table B.1B for more details on these fading profiles.

Details of the test procedure

The test procedure for HS-SCCH Detection Performance is based on 3GPP TS 34.121 clause 9.4.2.2.2 and consists of the following:

- A generic HSDPA call is set up as described in 3GPP TS 34.108 clause 7.3.6.3. The downlink configuration includes four HS-SCCHs and the HS-DSCH configuration is based on a CQI value of 1.
- The SS transmits and retransmits according to the uplink ACK/NACK report sent by the UE.
- P(E_m) is calculated from the ACK, NACK, and statDTX sent by the UE on the uplink HS-DPCCH. P(E_m) is defined as the ratio between the number of failures and the total number of blocks measured. For this test, A statDTX is considered a failure, and an ACK or a NACK is considered a success. Therefore P(E_m) = statDTX / (NACK + statDTX + ACK).

The test length is determined by either the fading cycle or the number of samples required to get a statistically meaningful result, whichever results in the longest time. The actual test length for the different scenarios (in 3GPP TS 34.121 annex F.6.1.8 table F.6.1.8) is currently undefined.

Minimum requirements

StatDTX should occur much more infrequently than ACK or NACK. For this reason, the minimum requirements for P(E_m) are on the order of 1% (from 0.01 to 0.05, depending on the fading profile and test parameters), which is at least one order of magnitude smaller than the minimum BLER requirements for other tests (from 0.1 to 0.97, depending on the actual test, UE category, fading profile, and test parameters).

Agilent HSDPA solutions

The rest of this application note describes HSDPA UE test solutions from Agilent for early design verification, conformance test, and manufacturing test. These are illustrated in Figures 31 and 32.

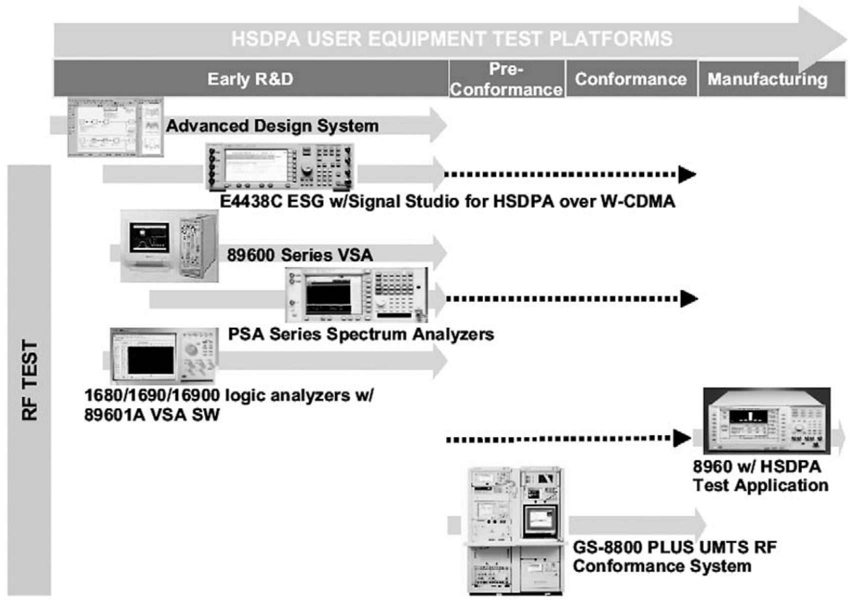

Figure 31. Agilent has solutions for RF testing of HSDPA-capable UE from early design verification through manufacturing.

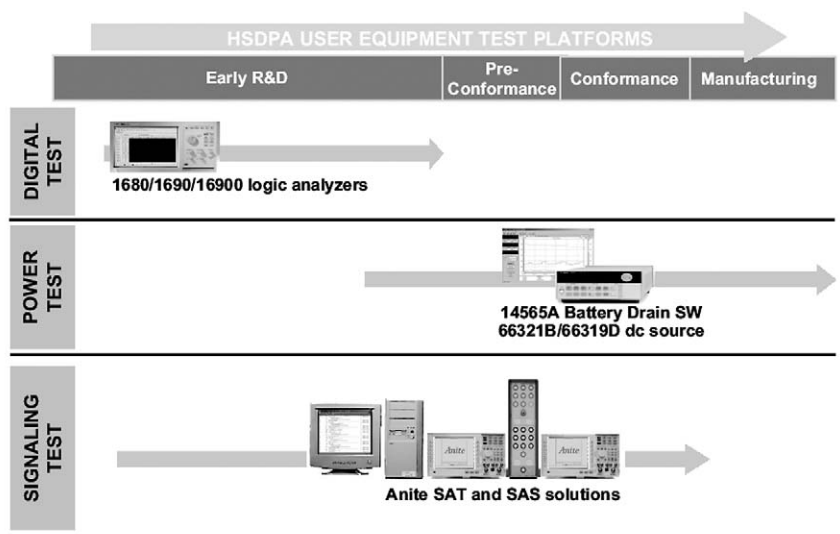

Figure 32. Agilent offers equipment for other areas of HSDPA UE testing.

Tools for early design verification: ADS W-CDMA Design Library

Agilent's Advanced Design System is a powerful electronic design automation software system. It offers a complete, front-to-back, high-frequency design, simulation, layout, and verification solution in a single, integrated design flow. The W-CDMA Design Library for ADS makes it possible to develop and verify 3GPP designs rapidly.

The W-CDMA Design Library for the ADS 2004A release has both an HSDPA-coded uplink source and an uplink receiver for the HS-DPCCH. The uplink BTS receiver is particularly useful during the process of simulating and verifying the HSDPA functionality in the UE during early design verification. The receiver can be used to decode the ACK/NACK and CQI responses from the UE, which are necessary to calculate BLER and other performance requirement metrics.

Signal Studio for HSDPA over W-CDMA

Signal Studio for HSDPA over W-CDMA makes it easier to create HSDPA waveforms for use with the E4438C ESG vector signal generator. The software provides convenient access to transport- and physical-layer parameters, enabling the generation of W-CDMA based HSDPA test signals specifically designed for receiver BLER analysis. The common W-CDMA control channels are included in the software for use in synchronizing with the device under test.

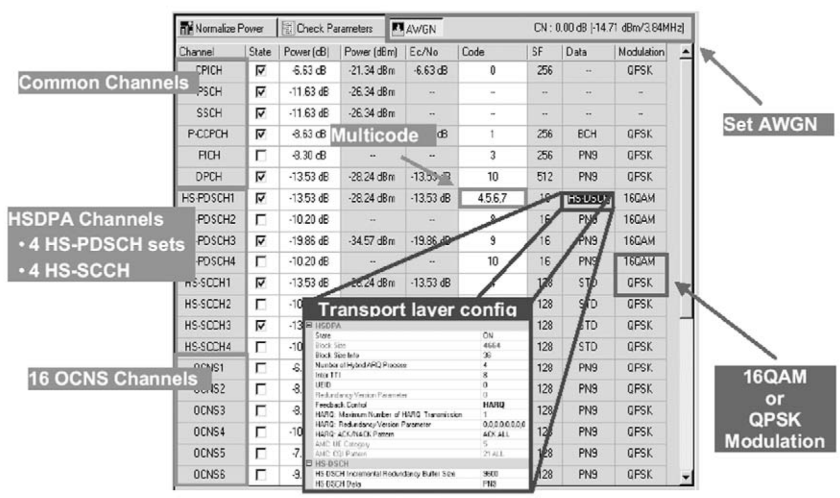

Figure 33. Signal Studio for W-CDMA over HSDPA is designed specifically to provide test signals ideal for performing receiver BLER measurements on the HSDPA channel.

To isolate different receiver subsections during testing, the data payload can be either physical layer coded only, or physical and transport layer coded. The transport layer adds CRC bits, code block segmentation, turbo encoding, rate matching, interleaving, and constellation rearrangement before the data is sent to the physical layer. The CRC bits are calculated in real-time for each transmitted packet to allow BLER testing to be performed. The physical layer spreads and scrambles the data and then maps it to one or more QPSK or 16QAM constellations.

Signal Studio for HSDPA over W-CDMA software is easily configured to simulate realistic operating conditions. For example, you can determine whether a mobile receiver can correctly identify which HSDPA transmission to demodulate by generating up to four HS-SCCH channels at the same time, each with its corresponding HS-PDSCH set. Each HS-SCCH and HS-PDSCH set can be configured differently, including the UE identity, data type, power levels, and spreading code.

The AMC and HARQ HSDPA functionality also can be tested. Each downlink packet to be transmitted can be encoded with different parameters or a different modulation type according to a user-definable AMC or HARQ report that simulates the response from the mobile.

HSDPA capabilities in 89601A VSA Software

The 89601A VSA software with W-CDMA/HSDPA (option B7U) or with the 3G bundle (Option B7N) can perform in-depth modulation quality measurements on W-CDMA signals with HSDPA channels.

Figure 34 shows a measurement display of a W-CDMA uplink signal with an HS-DPCCH. In this display you can see the signal code domain power (upper left) and spectrum (lower left), the composite EVM constellation (upper center) and metrics (lower center), and the HS-DPCCH symbol constellation (lower right) and symbol EVM metrics (upper right).

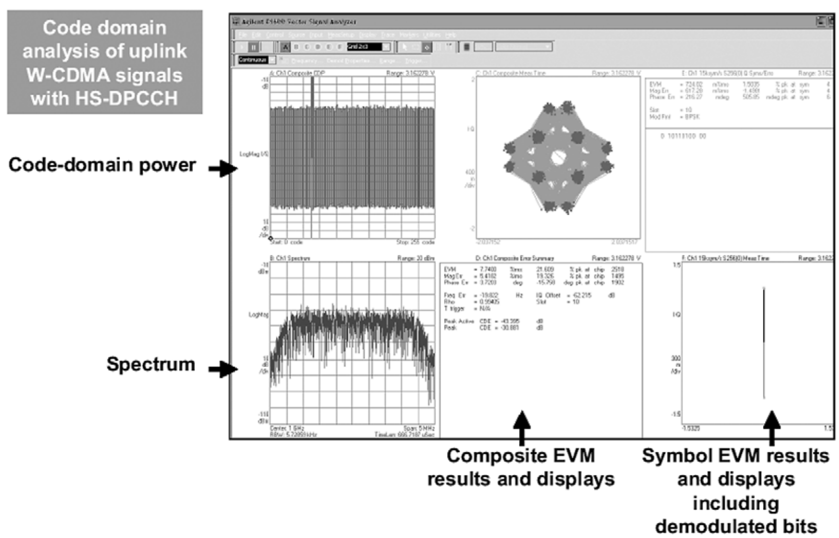

Figure 34. The 89601A VSA software can perform code-domain analysis of W-CDMA signals with HSDPA channels.

The 89601A VSA software can analyze signals from a variety of interfaces, including ADS, all the Agilent spectrum and vector signal analyzers, and the 1680, 1690, and 16900 logic analyzers.

HSDPA personality for PSA spectrum analyzer and VSA transmitter tester

The HSDPA measurement personality (Option 210) adds HSDPA measurements to the W-CDMA measurement personality (Option BAF) for the Agilent E4440A PSA spectrum analyzer and the E4406A VSA transmitter tester.

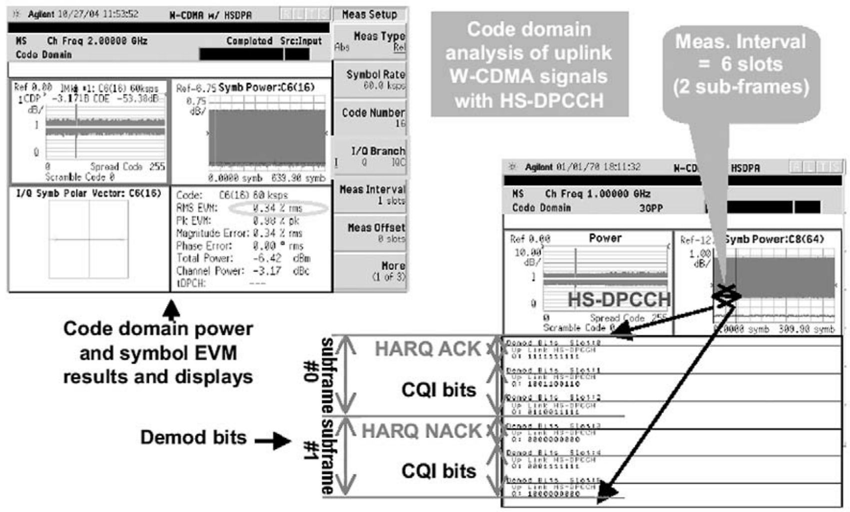

Figure 35. The HSDPA measurement personality provides code domain analysis of uplink W-CDMA signals with HS-DPCCH.

The two measurement displays in Figure 35 each show a W-CDMA uplink signal with an HS-DPCCH. The display on the left shows the code domain power for the signal (upper left) as well as the HS-DPCCH symbol power versus time and the composite chip power versus time (upper right), the HS-DPCCH symbol constellation (lower left), and the symbol EVM metrics (lower right).

The display on the right shows the code domain power for the uplink signal (upper left) as well as the HS-DPCCH symbol power versus time and the composite chip power versus time (upper right), and the demodulated bits (bottom). The demodulated bits display provides the coded HARQ ACK/NACK and CQI bits over the measurement interval, which in this example is set to 2 subframes.

Manufacturing test solutions: HSDPA test application for 8960 series test set

The E1963A W-CDMA mobile test application with Option 403 HSDPA test mode offers targeted capability for W-CDMA/HSDPA, production test engineers who are developing test plans to manufacture W-CDMA/HSDPA devices. Used with Agilent's 8960 series one-box test set, it provides the industry's most complete test functionality for 3GPP TS 34.121 transmitter (Section 5) and receiver characteristics (Section 6) testing. Fast measurements and options for UE connectivity give flexibility for test plan development and the assurance that designs will meet technology standards.

The E1963A test application is also used by design engineers to speed the validation of their designs so that they can get products to market in the least amount of time.

Both frequency division duplex (FDD) and radio bearer (RB) test modes are available on this software. The FDD test mode provides a basic HSDPA forward physical channel signal that is ideal for efficient parametric testing focused on the RF transmitter and receiver. The RB test mode provides the same parametric test capability but adds the protocol required to bring the call up.

Other key features include

- a new and completely functional MAC-hs layer that provides ACK/NACK/DTX support along with analysis of the CQI values reported by the UE
- generation of the standard W-CDMA control channels, a dedicated W-CDMA channel configured as the 12.2 kb/s RMC, and the HSDPA channels.
- support for FRC H-Sets 1 through 5 in both QPSK and 16QAM configurations

The transmitter measurements supported by the test application include channel power, ACLR, and SEM, along with a graphical burst-by-burst display of the UE's output power. These measurements, coupled with a flexible trigger for HSDPA, provide industry leading transmitter measurement capability that enables you to isolate transmission trouble within three distinct zones within the subframe.

The test application supports receiver and performance requirement metrics including BLER and t-put R in kb/s, ACK/NACK count, statDTX count, and median CQI. The measurement display in Figure 36 illustrates this capability.

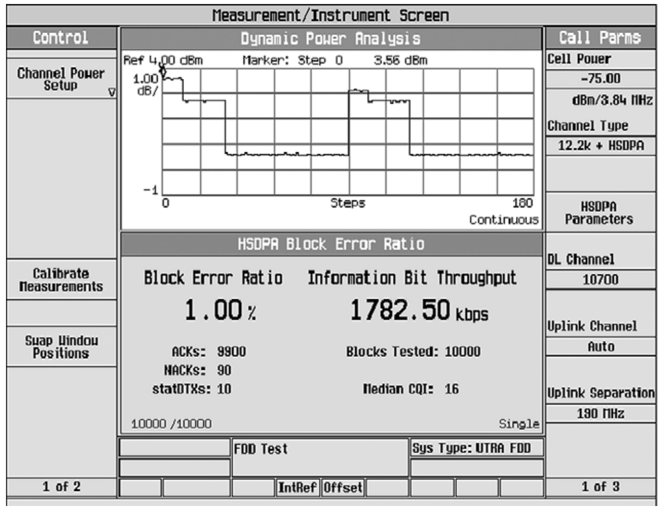

Figure 36. The W-CDMA test application with HSDPA test modes for the 8960 test set supports essential HSDPA tests.

Power supplies and software for battery drain analysis

Agilent 66319B/D and 66321B/D single- and dual-DC output high performance power supplies provide fast transient output response with an advanced, built-in DSP-based digitizing measurement system. When these power supplies are combined with the 14565A device characterization software, they create a solution for recording, viewing, and analyzing battery drain current over periods from microseconds to weeks in duration.

For testing digital wireless devices, the 66319B/D and 66321B/D power supplies provide the following functions:

- replace the main battery (single- or dual-output) and power adapter (dual-output)
- emulate battery characteristics through fast output response and programmable output resistance
- minimize transient voltage drop over long wiring resulting from the pulsed current drain
- provide source/sink capability on the main output for testing and calibrating battery charger circuitry
- accurately measure battery current drains for all operating modes (off, sleep, standby, and active modes)
- capture, visualize, and analyze current drain waveforms down to 15.6 μs resolution (with 14565A software)
- record long-term battery drain up to 1,000 hours; visualize and analyze results by either data log or CCDF display (with 14565A software)

Pre-conformance and conformance RF test solutions

The GS-8800 is an RF design verification system for multiple radio technologies. It supports W-CDMA, HSDPA, GSM, GPRS, EGPRS, cdma2000, 1xEVDO, and AMPS on a single hardware (8960 series) and software platform.

Based on this platform, the GS-8800 plus is a W-CDMA/HSDPA RF conformance system that supports the 3GPP TS 34.121 UE RF conformance test cases in Release 5. The GS-8800 plus enhances the standard system with baseband processors and other instruments used in conformance testing. These are located within the dotted lines in the block diagram shown in Figure 37.

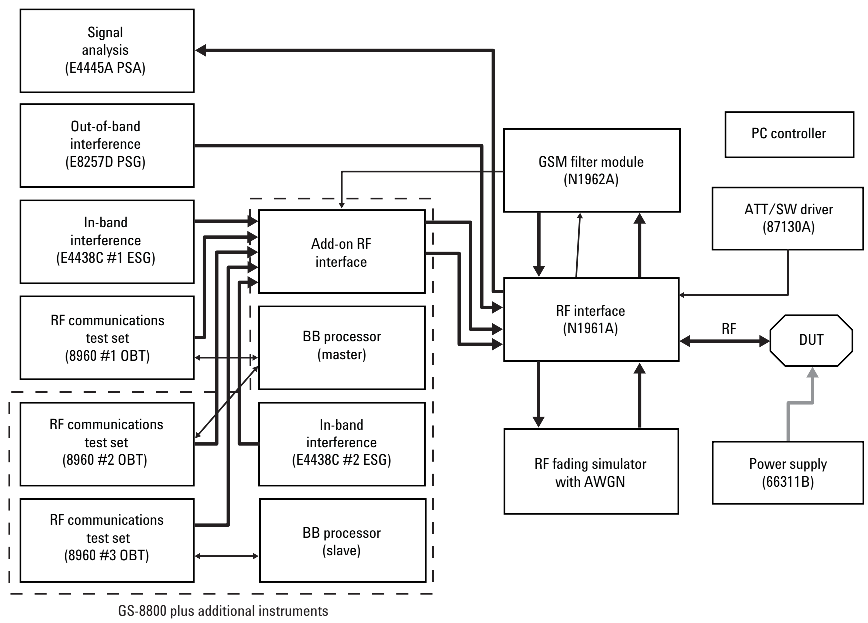

Figure 37. GS-8800 standard and plus systems.

Two configurations are available for GS-8800 plus system. The first is the plus1 system for W-CDMA/HSDPA RF pre-conformance testing. The system is called "pre-compliance" because it limits test coverage to those cases that require only one 8960 test set in the system.

A second configuration, the plus2 system, is an RF conformance test system for W-CDMA and HSDPA. The system includes open loop and closed loop diversity test cases. See Figure 38.

GS-8800 TS 34.121 HSDPA tests

Section	Test description	
5.2A	Maximum output power with HS-DPCCH	Standard system
5.9A	Spectrum emission mask with HS-DPCCH	Standard system
5.10A	Adjacent channel leakage power ratio (ACLR) with HS-DPCCH	Standard system
5.13.1A	Error vector magnitude (EVM) with HS-DPCCH	Standard system
6.3A	Maximum input level for HS-PDSCH reception (16QAM)	Standard system
9.2.1	Demodulation of HS-DSCH - single link performance	plus 1 (plus system)
9.2.2	Demodulation of HS-DSCH - open loop diversity performance	plus 2 (plus system)
9.2.3	Demodulation of HS-DSCH - closed loop diversity performance	plus 2 (plus system)
9.3.1	Reporting of channel quality indicator - AWGN propagation conditions	plus 1 (plus system)
9.3.2	Reporting of channel quality indicator - fading propagation conditions	plus 1 (plus system)
9.4	HS-SCCH detection performance	plus 1 (plus system)

Figure 38. The HSDPA test cases supported by the GS-8800 standard, plus1, and plus2 systems.

Development, conformance, and interoperability signaling test solutions

The Anite SAT Test System provides functional verification of HSDPA UEs and a complete Release 5 development test system. The Anite SAT system consists of multiple test units (up to 12) with an industry-standard PC controller. The test units are connected to the PC controller by a LAN interface. Each test unit comprises an Agilent 8960 wireless communications test set and an Anite add-on module, the Anite Baseband Processor (ABP). Multiple test units provide support for simulation of multiple cells and allow testing of handover procedures. The RF paths are combined by means of a power splitter/combiner. Other channel impairments such as co-channel or adjacent channel interferers can be introduced using an external directional coupler or power splitter/combiner.

For HSDPA testing, this solution includes both MAC and RLC functionality in accordance with 3GPP TS 25.321 and TS 25.322, respectively. The following components of the MAC architecture are implemented:

- MAC-hs, which manages flow control, scheduling and priority control, per-user HARQ processes, and transport format/resource combination selection
- MAC-d, which implements transport channel switching, C/T multiplexing, and flow control with transport channel routing to MAC-hs

RLC entities can be activated in transparent mode, unacknowledged mode, or full acknowledged mode and routed to logical channels as needed.

The Anite SAT Test System can be controlled in three ways:

- A C/C++ programmable API allows you to write test programs or simulation scenarios in C/C++ using Anite's full Programmer's Toolset (PT) for W-CDMA and HSDPA. In addition to the functions of the test system itself, you have access to the underlying facilities of the host computer such as file and I/O systems. You can, for example, develop programs to control external equipment, to control the UE under test, or to store and retrieve large amounts of test data.
- A test case manager uses Anite's Conformance Toolset (CT) to run conformance test scripts for both W-CDMA and HSDPA.
- For HSDPA, a graphical user interface (GUI) is available to allow control via MAC-hs/RLC or baseband for development testing.

The Anite SAS system is a 2-12 cell signaling test solution for Interoperability Test (IOT) using 8960 with ABP. It is controlled by a GUI that allows channels to be activated and deactivated. Test configurations can also be stored and reloaded. The system can be used to create complex cell or network simulations to enable thorough interoperability testing.

Summary

Several aspects of HSDPA technology affect UE functionality and performance. The HSDPA conformance tests that have been added to Release 5 and Release 6 of the 3GPP specifications address the main areas that require testing.

New transmitter tests verify that the UE meets the reduced maximum output power requirements when the HS-DPCCH is added, and that the uplink ACLR, SEM, and EVM performance at this reduced maximum output power does not degrade significantly. A power versus time mask has been introduced to verify the accuracy of the power steps caused by the addition of the HS-DPCCH.

A new receiver test verifies that the UE can demodulate high-power downlink channels with 16QAM.

The new HSDPA performance requirements tests cover three main areas that address some of the most challenging aspects of the new HSDPA functions:

- HS-DSCH decoding (including the multi-code demodulation capability and the HARQ functions—such as the IR combining—that take place during the decoding process)
- CQI reporting
- detection of the HS-SCCH

To meet a wide range of development needs, Agilent provides HSDPA solutions that test UE from early design verification through manufacturing.

Appendix

FRC H-Set 1 definition

Parameter	Unit	Value	
Nominal avg. inf. bit rate	kb/s	534	777
Inter-TTI distance	TTIs	3	3
Number of HARQ processes	Processes	2	2
Information bit payload (N_{INF})	Bits	3202	4664
Number code blocks	Blocks	1	1
Binary channel bits per TTI	Bits	4800	7680
Total available SMLs in UE	SMLs	19200	19200
Number of SMLs per HARQ proc.	SMLs	9600	9600
Coding rate		0.67	0.61
Number of physical channel codes	Codes	5	4
Modulation		QPSK	16QAM

Note: The HS-DSCH shall be transmitted continuously with constant power but only every third TTI shall be allocated to the UE under test.

Table 16. FRC H-Set 1 definition (ref: 3GPP TS 25.101 table A.25).

FRC H-Set 2 definition

Parameter	Unit	Value	
Nominal avg. inf. bit rate	kb/s	801	1166
Inter-TTI distance	TTIs	2	2
Number of HARQ processes	Processes	3	3
Information bit payload (N_{INF})	Bits	3202	4664
Number code blocks	Blocks	1	1
Binary channel bits per TTI	Bits	4800	7680
Total available SMLs in UE	SMLs	28800	28800
Number of SMLs per HARQ proc.	SMLs	9600	9600
Coding rate		0.67	0.61
Number of physical channel codes	Codes	5	4
Modulation		QPSK	16QAM

Note: The HS-DSCH shall be transmitted continuously with constant power but only every third TTI shall be allocated to the UE under test.

Table 17. FRC H-Set 2 definition (ref: 3GPP TS 25.101 table A.26).

FRC H-Set 3 Definition

Parameter	Unit	Value	
Nominal avg. inf. bit rate	kb/s	1601	2332
Inter-TTI distance	TTIs	1	1
Number of HARQ processes	Processes	6	6
Information bit payload (N_{INF})	Bits	32024664	
Number code blocks	Blocks	1	1
Binary channel bits per TTI	Bits	4800	7680
Total available SMLs in UE	SMLs	57600	57600
Number of SMLs per HARQ proc.	SMLs	9600	9600
Coding rate		0.67	0.61
Number of physical channel codes	Codes	5	4
Modulation		QPSK	16QAM

Table 18. FRC H-Set 2 definition (ref: 3GPP TS 25.101 table A.27).

FRC H-Set 4 definition

Parameter	Unit	Value
Nominal avg. inf. bit rate	kb/s	534
Inter-TTI distance	TTIs	2
Number of HARQ processes	Processes	2
Information bit payload (N_{INF})	Bits	3202
Number code blocks	Blocks	1
Binary channel bits per TTI	Bits	4800
Total available SMLs in UE	SMLs	14400
Number of SMLs per HARQ proc.	SMLs	7200
Coding rate		0.67
Number of physical channel codes	Codes	5
Modulation		QPSK

Note: This FRC is used to verify the minimum inter-TTI distance for UE category 11. The HS-PDSCH shall be transmitted continuously with constant power. The six sub-frame HS-SCCH signaling pattern shall repeat as follows: ...OOXOXOOOXOXO..., where 'X' marks TTI in which HS-SCCH uses the identity of the UE under test and 'O' marks TTI, in which HS-SCCH uses a different identity.

Table 19. FRC H-Set 2 definition (ref: 3GPP TS 25.101 table A.28).

FRC H-Set 5 definition

Parameter	Unit	Value
Nominal avg. inf. bit rate	kb/s	801
Inter-TTI distance	TTIs	1
Number of HARQ processes	Processes	3
Information bit payload (N_{INF})	Bits	3202
Number code blocks	Blocks	1
Binary channel bits per TTI	Bits	4800
Total available SMLs in UE	SMLs	28800
Number of SMLs per HARQ proc.	SMLs	9600
Coding rate		0.67
Number of physical channel codes	Codes	5
Modulation		QPSK

Note: This FRC is used to verify the minimum inter-TTI distance for UE category 12. The HS-PDSCH shall be transmitted continuously with constant power. The six sub-frame HS-SCCH signalling pattern shall repeat as follows: ...OOXXXOOOXXXO..., where 'X' marks TTI in which HS-SCCH uses the identity of the UE under test and 'O' marks TTI, in which HS-SCCH uses a different identity.

Table 20. FRC H-Set 2 definition (ref: 3GPP TS 25.101 table A.29).

FRC H-Set 6 definition

Parameter	Unit	Value	
Nominal avg. inf. bit rate	kb/s	3219	4689
Inter-TTI distance	TTIs	1	1
Number of HARQ processes	Processes	6	6
Information bit payload (N_{INF})	Bits	6438	9377
Number code blocks	Blocks	2	2
Binary channel bits per TTI	Bits	9600	15360
Total available SMLs in UE	SMLs	115200	115200
Number of SMLs per HARQ proc.	SMLs	19200	19200
Coding rate		0.67	0.61
Number of physical channel codes	Codes	10	8
Modulation		QPSK	16QAM

Table 21. FRC H-Set 2 definition (ref: 3GPP TS 25.101 table A.30).

Acronym Glossary

3GPP – Third Generation Partnership Project

16QAM – 16 quadrature amplitude modulation

ABP – Anite Baseband Processor

ACK – Acknowledgement

ACLR – Adjacent channel leakage ratio

ADS – Advanced Design System

AMC – Adaptive modulation and coding

AWGN – Adaptive white Gaussian noise

BER – Bit error rate

BLER – Block error rate

BTS – Base transceiver station

CQI – Channel quality indicator

CT – Conformance toolset

DPCCH – Dedicated physical control channel

DPCH – Dedicated physical channel

DPDCH – Dedicated physical data channel

DTX – Discontinuous transmission

EVM – Error vector magnitude

FDD – Frequency division duplex

FRC – Fixed reference channel

GUI – Graphical user interface

HARQ – Hybrid automatic repeat request

HSDPA – High speed downlink packet access

HS-DPCCH – High speed dedicated physical control channel

HS-DSCH - High speed data shared channel

HS-PDSCH – High speed physical data shared channel

HS-SCCH – High speed data shared channel

IOT – Interoperability test

IR – Incremental redundancy

ITU – International Telecommunications Union

MAC – Medium access channel

NACK – Negative acknowledgement

NDI – New data indicator

OCNS – Orthogonal channel noise simulation

PAR – Peak-to-average power ratio

P-CCPCH – Primary common control physical channel

P-CPICH – Primary common pilot channel

PICH – Paging indicator channel

PT – Programmer's toolset

QAM – Quadrature amplitude modulation

QPSK – Quadrature phase shift keying

R&D – Research and development

RAN – Radio access network

RB – Radio bearer

regDTX – Regular discontinuous transmission

RF – Radio frequency

RLC – Radio link control

RMC – Reference measurement channel

RV – Redundancy version

SCH – Synchronization channel

SEM – Spectrum emissions mask

SS – System simulator

statDTX – Statistical discontinuous transmission

t-put R – Throughput R

TS – Technical specification

TTI – Transmission time interval

UE – User equipment

W-CDMA – Wideband code division multiple access

Reference Specification Documents (www.3gpp.org)

3GPP TS 25.101 V.6.9.0
UE Radio Transmission and Reception (FDD)

3GPP TS 34.121 V.6.2.0
Terminal Conformance Specification. Radio Transmission and Reception (FDD)

3GPP TS 25.211 V.5.7.0
Physical Channels and Mapping of Transport Channels onto Physical Channels (FDD)

3GPP TS 25.212 V.5.a.0
Multiplexing and Channel Coding (FDD)

3GPP TS 25.213 V.5.6.0
Spreading and Modulation (FDD)

3GPP TS 25.214 V.5.b.0
Physical Layer Procedures (FDD)

3GPP TS 25.306 V.5.c.0
UE Radio Access Capabilities

3GPP TS 25.308 V.5.7.0
HSDPA Overall Description

3GPP TS 25.321 V.5.c.0
Medium Access Control (MAC) Protocol Specification

3GPP TR 25.858 V.5.0.0
High Speed Downlink Packet Access Physical Layer Aspects

3GPP TR 25.877 V.5.1.0
High Speed Downlink Packet Access: Iub/Iur Protocol Aspects

3GPP TR 25.950 V.4.0.0
UTRA High Speed Downlink Packet Access

Additional References (www.3gpp.org)

[1] 3GPP R4-021607, *UE maximum output power with HS-DPCCH*, Nokia

[2] 3GPP R4-030796, *ACLR requirements under HSDPA operation*, Sony Ericsson Mobile Communications

[3] 3GPP R4-031037, *PAR increase of UE transmit signal with HS-DPCCH*

Related Information

Information on Agilent's HSDPA solutions: **www.agilent.com/find/HSDPA**

Concepts of High Speed Downlink Packet Access: Bringing Increased Throughput and Efficiency to W-CDMA, application note, Agilent literature number 5989-2365EN

Designing and Testing 3GPP W-CDMA User Equipment, application note 1356, Agilent literature number 5980-1238E

HSDPA in the Agilent Technologies 8960 Wireless Communications Test Set, application note, Agilent literature number 5989-3444EN

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