/Inritsu

Practical Tips on HSDPA Measurements
MT8222A and MS2721B
BTS Master™ and Spectrum Master™

Introduction

This is a practical High-Speed Download Packet Access (HSDPA) measurement procedures note. The objective of this note is to present measurement tips and procedures which will help a field-based network technician or RF engineer conduct Node B measurements on HSDPA overlay networks.

Upgrading/Deploying HSDPA

The growth of data in communications, and services such as Internet access and large file downloads of audio, video and gaming applications, is prompting a migration away from circuit-switched traffic and toward packet-switched traffic. With this migration underway, end-users are requiring higher data rates and improved Quality of Service (QoS). Operators are demanding greater system capacity.

HSDPA – a cellular network overlay, supported by the UMTS (universal mobile telecommunications system) standard – offers a way to address the need to handle today's ever increasing data rates by effectively upgrading the WCDMA network. HSDPA can also be deployed with WCDMA where WCDMA supports packet-data applications and HSDPA supports data applications. As a 3.5-G mobile telephony protocol, HSDPA improves end-user experience by increasing peak data rates to 14.4 Mbps in the downlink, reducing delay and increasing system capacity by 200 to 300%.

Like other mobile telephony standards, HSDPA will be rolled out in phases. The first phase enables the initial increase in peak data rates. The second phase of HSDPA, currently being specified in the Third Generation Partnership Project (3GPP) release 6, will enhance the uplink with improved coverage for high data rates of up to 28.8 Mbps, improve uplink capacity and reduce uplink delay. It will also introduce antenna array technologies such as beam forming and Multiple-Input Multiple-Output (MIMO) to help increase the transmission power of the base stations sector. The final phase of HSDPA will introduce a new air interface with orthogonal frequency division multiplexing (OFDM) and higher modulation schemes. It is expected to support data rates up to 50 Mbps.

As a cost-effective overlay to current UMTS systems or cost effective HSDPA network deployment, and with the promise to deliver improved capacity, data speeds and performance comparable to current wireless LAN services, HSDPA offers today's network operators a very real competitive edge. With HSDPA now beginning to roll out and network operators pushing for its quick adoption, today's field-based technicians and RF engineers will require suitable equipment to test new HSDPA features.

Understanding HSDPA

HSDPA is considered one of the most significant additions to the Wideband Code Division Multiple Access (WCDMA) radio standard which provides the air interface for UMTS (Table 1). It increases downlink peak data rates and packet data efficiency, making the system more competitive with other high data rate wireless technologies in use today. HSDPA technology is evolved from, and is backwards-compatible with, 3GPP Release 99 WCDMA systems meaning that WCDMA-based voice and data applications can still run on the upgraded networks. In addition, the same radio channel can support both WCDMA and HSDPA services simultaneously.

Feature	HSDPA
Downlink Frame Size	2-ms TTI (3 slots)
Channel Feedback	Channel quality reported at 2-ms rate or 500 Hz
Data User Multiplexing	TDM/CDM
Adaptive Modulation and Coding	QPSK & 16-QAM mandatory
Hybrid-ARQ	Chase or Incremental Redundancy (IR)
Spreading Factor	SF = 16 using UTRA OVSF channelization codes
Control Channel Approach	Dedicated channel pointing to shared channel

Table 1. HSDPA features.

Upgrading/deploying HSDPA necessitates a number of new requirements, including:
- The addition of new high-speed downlink channels
- Use of 16QAM modulation in addition to QPSK modulation
- Use of code multiplexing combined with time multiplexing
- The addition of a new uplink control channel
- Fast link adaptation using adaptive modulation and coding (AMC)
- Use of hybrid automatic-repeat-request (HARQ)
- Medium access control (MAC) scheduling function moved to Node-B

The primary benefits of HSDPA include:
- Improved end-user experience, which translates into shorter download times through higher bit rates (14-Mbps peak rate) and reduced roundtrip time over the air interface.
- Increased system capacity. Depending on the deployment scenario, this increase can range from two to three times that of WCDMA 3GPP release 99. HSDPA increases capacity via shared-channel transmission, and the use of link adaptation, fast scheduling, fast retransmission and 16QAM.
- Wide-area mobile coverage without requiring any extra spectrum/carrier for data applications.

HSDPA Architectural Changes

The HSDPA frame structure consists of a radio frame that is 2 ms in length. For comparison, each 10-ms WCDMA frame contains five HSDPA sub-frames (Figure 1). The shorter frame size allows user data transmissions to be assigned to one or more physical channels for a shorter duration. As a result, the network can readjust its resource allocation in time as well as in the code domain.
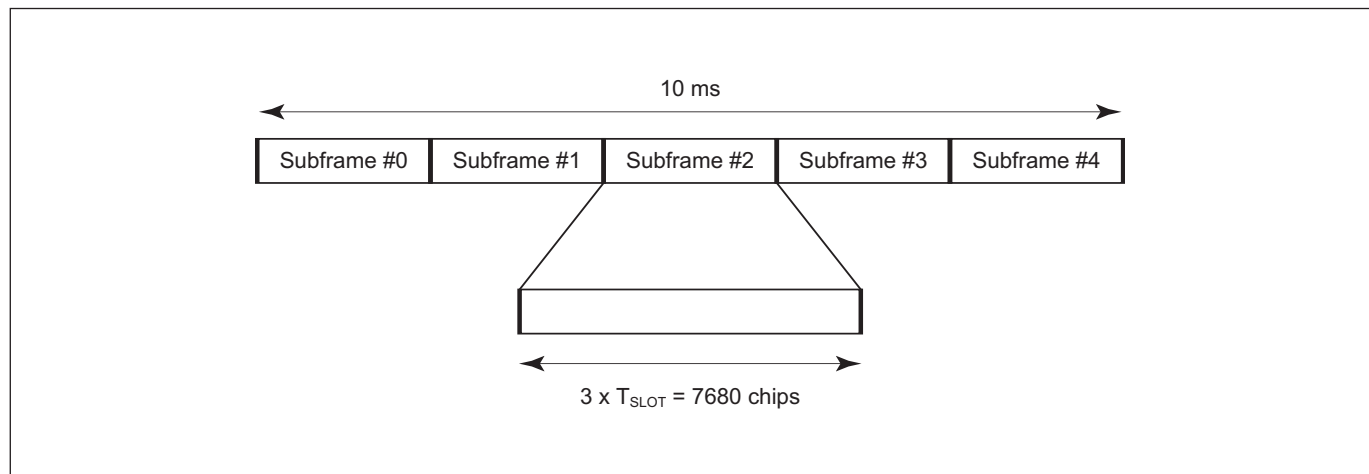

Figure 1. Shown here is the HSDPA frame structure.

While HSDPA provides double the network capacity of the WCDMA network, and increases its download speed five fold, it also requires a number of major architectural changes which impact the physical channels, modulation and coding. HSDPA, for example, introduces two new physical channels: the High Speed Physical Downlink Shared Channel (HS-PDSCH) and the High Speed Physical Control Channel (HS-DPCCH) (Figure 2). HS-PDSCH provides the transport mechanism for new logical channels introduced by HSDPA. It carries the actual data, uses adaptive modulation and is power controlled by the Node B. HS-DPCCH is an uplink control channel which carries signaling and channel quality information from the User Equipment (UE) to Node B, which in turn uses this information to perform the adaptive modulation and coding for HS-PDSCH (Figure 3).
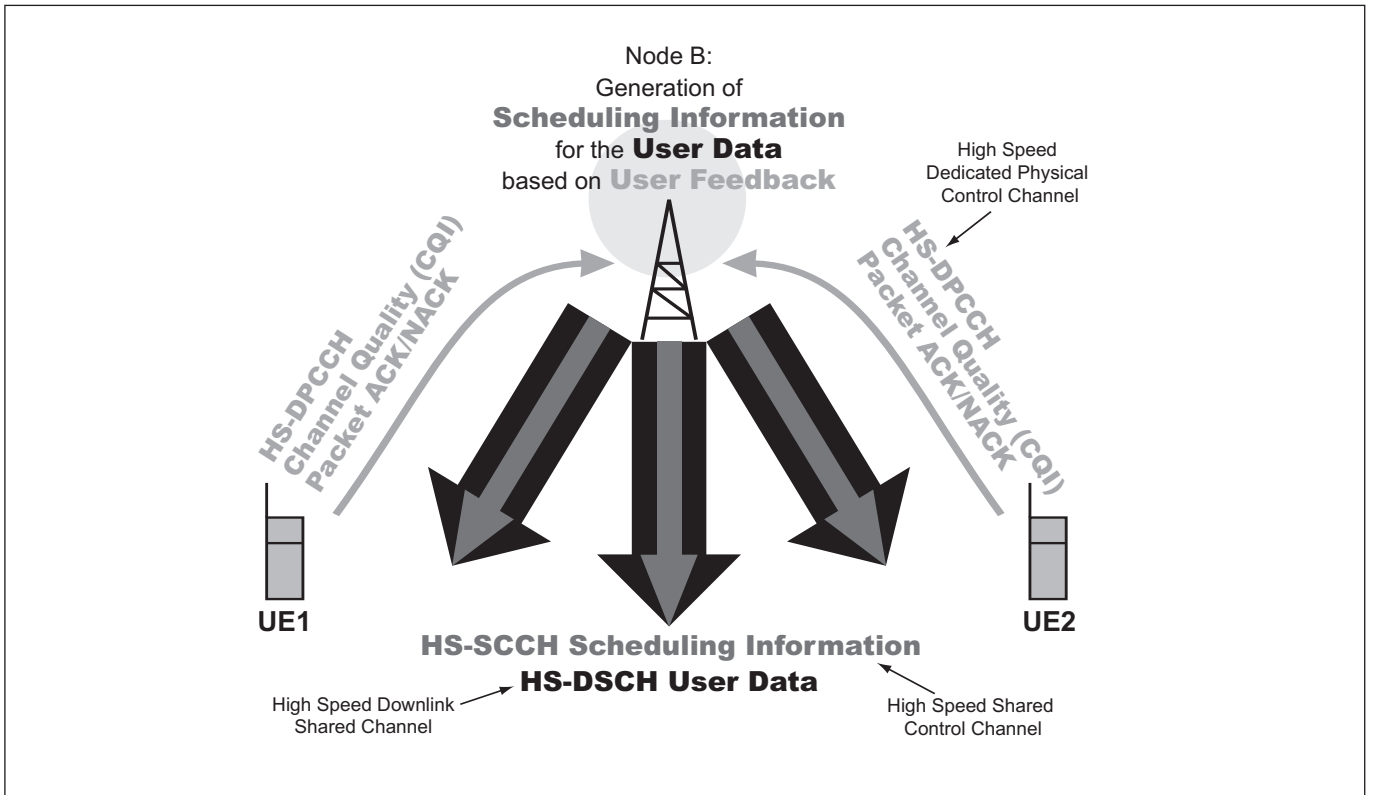
Figure 2. The overall HSDPA scheme and new channels are illustrated in this figure.

HSDPA channels transmit user data via dedicated channels (code multiplexing) as well as via time multiplexing whereby several users share the same channel. When one user is not using an available resource it is made available to others. With this approach, a large number of users can efficiently use the same time-multiplexed channel and available radio network resources.
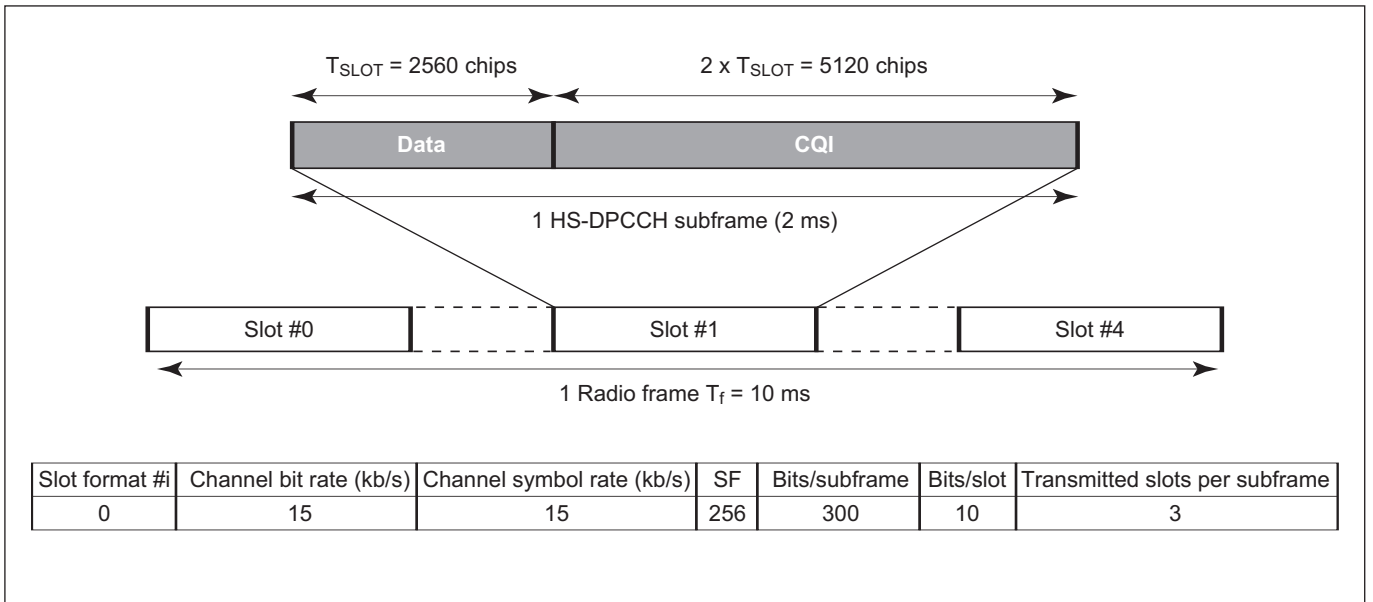

Slot format #i	Channel bit rate (kb/s)	Channel symbol rate (kb/s)	SF	Bits/subframe	Bits/slot	Transmitted slots per subframe
0	15	15	256	300	10	3

Figure 3. Shown here is the HS-DPCCH structure

The new logical channels introduced by HSDPA include: the High Speed Downlink Shared Channel (HS-DSCH) and the High Speed Shared Control Channel (HS-SCCH). HS-DSCH provides the logical transfer mechanism for data transported on HS-PDSCH as well as enhanced support for interactive, background and streaming radio access bearer (RAB) services in the downlink (Figure 4).
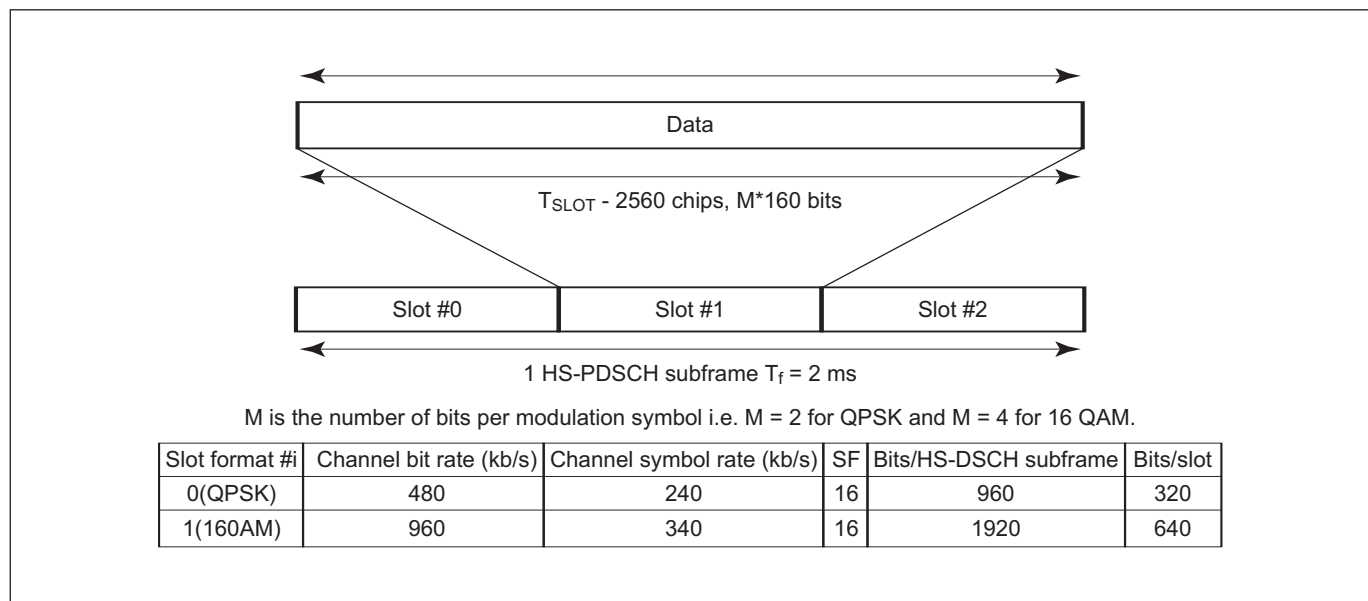

Slot format Table:

Slot format #i	Channel bit rate (kb/s)	Channel symbol rate (kb/s)	SF	Bits/HS-DSCH subframe	Bits/slot
0(QPSK)	480	240	16	960	320
1(16QAM)	960	340	16	1920	640

Figure 4. Shown here is the HS-PDSCH structure.

HS-SCCH, is a downlink signaling channel that provides information regarding timing and coding - such as channel code set, modulation scheme, transport block size, and UE identity - to the UE (Figure 5). This data enables user equipment to decode received data by "listening" to HS-DPCH in an optimized way, at the right time and with the correct codecs. It also allows a connection to be made without wasting precious radio resources.
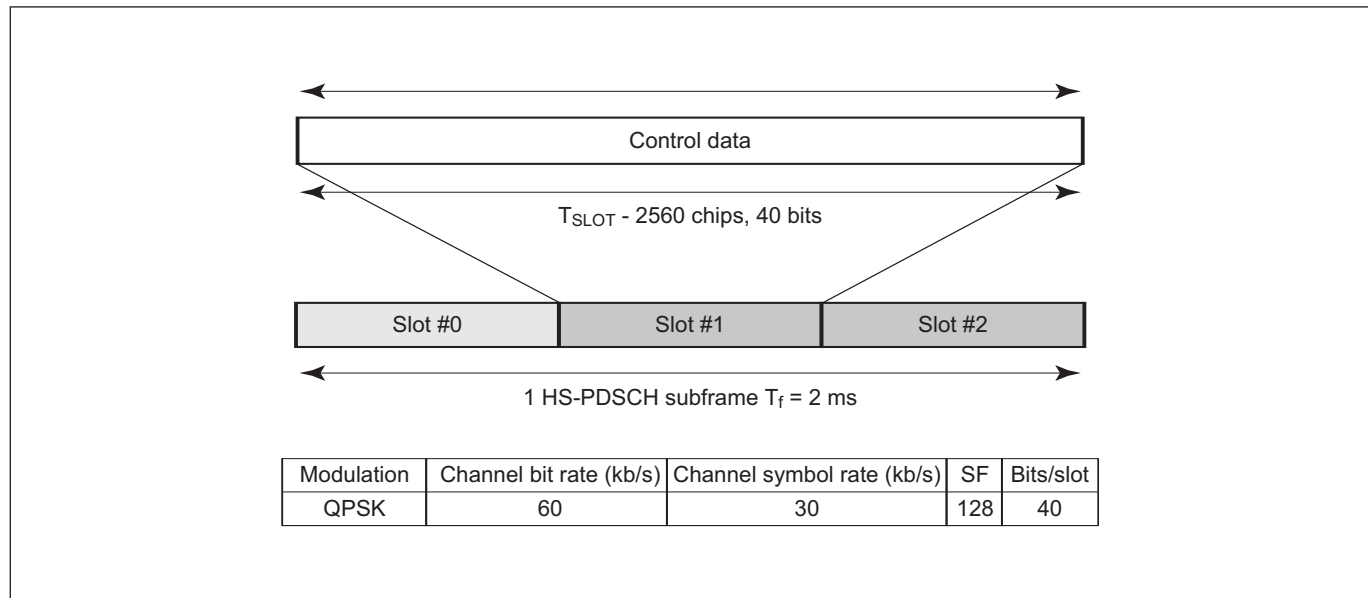

Modulation	Channel bit rate (kb/s)	Channel symbol rate (kb/s)	SF	Bits/slot
QPSK	60	30	128	40

Figure 5. Shown here is the HS-SCCH structure.

To support the features facilitated by the new HS-DSCH transmission (with minimal impact on the existing radio interface protocol architecture), HSDPA introduces a new MAC sub layer known as the high-speed MAC (MAC-hs). It takes care of the transport block scheduling, channel allocation and the transport format selection. It also handles the adaptive modulation and coding (AMC), fast packet scheduling mechanism and HARQ. Residing in the base station, the MAC-hs allows the functional split between layers and nodes from WCDMA 3GPP release 99 to remain intact.

AMC represents a major change for HSDPA. Here the UE actively feeds back information about the channel conditions which can then be used by Node B to determine the modulation and coding scheme. For each Transmit Time Interval (TTI), UE feedback is taken into account. The best possible modulation and coding is then chosen and the highest possible transmission rate obtained.

With these architectural changes, a smooth upgrade from WCDMA to HSDPA is possible. They ensure HSDPA operation in environments where not all cells have HSDPA functionality.

HSDPA Transmission

HSDPA is based on a "fat-pipe", shared-channel transmission. Since it can rapidly adapt to changes in the radio environment and fast retransmission of erroneous data, the corresponding functionality must be placed close to the air interface.

HSDPA is characterized by the following key features:
- Shared channel transmission
  With shared-channel transmission, some channel codes and the transmission power in a cell are seen as a common resource which can be dynamically shared between users in the time and code domains. The result is a much more efficient use of available codes and power resources.

  HS-DSCH is mapped on a shared-code resource that consists of up to 15 codes. The spreading factor is fixed at 16 (Figure 6). The number of codes supported by the terminal/system, operator settings and system capacity determines the actual number of utilized codes.
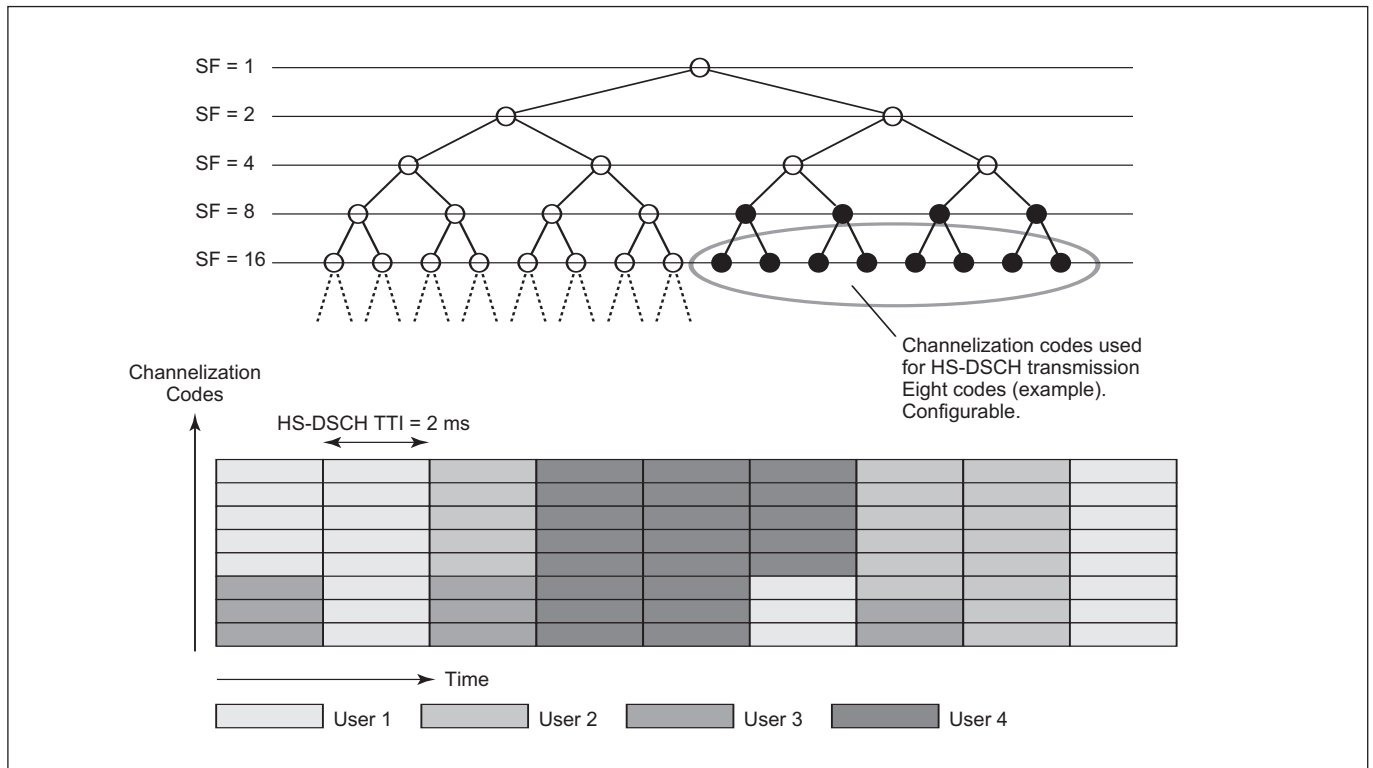

Figure 6. HS-DSCH code and time structures

- Higher-order modulation
  In addition to quadrature phase-shift keying (QPSK) modulation, HS-DSCH can also use 16QAM to provide higher data rates. While 16QAM features twice the peak rate capability of QPSK, enabling it to more efficiently use bandwidth, it also requires better radio channel conditions than QPSK.

- Short transmission time interval (TTI)
  Channel codes from the shared code resource are dynamically allocated every 2 ms or 500 times per second. With a short TTI, the roundtrip time is reduced and the tracking of channel variations is improved. Although time is the primary way of sharing the "fat-pipe" resource among users, it is also possible to share resources in the code domain by using different subsets of the total HS-DSCH channel code set.

- Fast link adaptation

  Fast link adaptation, using AMC, adjusts transmission parameters to instantaneous radio conditions. When channel conditions permit, it enables the use of high-order modulations. HS-DSCH transmission relies on rate adjustment to compensate for rapidly varying radio conditions in the downlink. While keeping transmission power constant, it adjusts the data rate by changing the channel-coding rate. This method of rate adaptation or link adaptation is more efficient than power control for services that tolerate short-term variations in the data rate. To further increase peak data rates, HS-DSCH can use spectral-efficient 16QAM modulation when channel conditions permit.

- Fast scheduling

  Fast-scheduling determines to which UE the shared channel transmission should be directed at any given moment. Note that the objective is to transmit to users with favorable radio conditions. The scheduler determines overall HSDPA performance. For each TTI, the scheduler decides which users will receive the HS-DSCH transmission. It also works closely with the link adaptation mechanism to determine which modulation and how many codes should be used; resulting in the actual end-user bit rate. Instead of sequentially allocating radio resources among users, capacity can be increased significantly using channel-dependent scheduling.

- Fast HARQ

  HARQ is a technique that combines feed-forward error correction (FEC) and ARQ methods. It saves information from previous failed attempts to be used in future decoding. As compared to AMC which uses explicit measurements to set the modulation and coding format, HARQ is an implicit link-adaptation technique. It uses link-layer acknowledgements (ACK/NACK) for re-transmission decisions. While AMC provides for the coarse data-rate selection, HARQ provides the fine data-rate adjustment based on channel conditions.

Understanding HSDPA Measurements

Verifying HSDPA performance requires field technicians to measure many different types of parameters. Note that an applicable band pass filter must be used to eliminate out of band signals that can cause mixer saturation. HSDPA measurements that can be made with BTS Master MT8222A and Spectrum Master MS2721B include:

- Carrier Frequency is defined as the selected transmitter operating center frequency, entered by the user or calculated from the signal standard, and channel number, entered by the user.

- Carrier Feedthrough measures the amount of unmodulated signal that is leaking through the transmitter. The WCDMA 3GPP specification does not specify Carrier Feedthrough measurement.

- Code Domain Power (CDP)

  CDP displays how much of the channel power is in each (code channel) (Figure 15). Power is normalized to the channel power, so if a code reads – 10dB, it means that the code is 1/10th of the channel power. Colors are applied according to the following:

Parameter	Description	Color	Viewable on Display
CPICH	Common Pilot Channel	Red	All CDP views
P-CCPCH	Primary Common Control Physical Channel	Magenta	All CDP views
S-CCPCH	Secondary Common Control Physical Channel	Cyan	All CDP views
PICH	Paging Indicator Channel	Green	All CDP views
P-SCH	Primary Sync Channel	Navy Blue	Control Channels
S-SCH	Secondary Sync Channel	Blue	Control Channels
Traffic	WCDMA Traffic	Yellow	All CDP views
Noise	Noise	Grey	All CDP views
HS-PDSCH	High Speed Physical Downlink Shared Channel	Orange	HSDPA Screen and CDP Screen when the WCDMA/HSDPA option is installed

Note that in the WCDMA/HSDPA specification the P-SCH and S-SCH are not assigned spreading codes and therefore do not appear in the CDP display. They have special non-orthogonal scrambling codes and are on 10% of the time.

- CDP Table

  Code Domain Power Table displays the active Orthogonal Variable Spreading Factors (OVSF). Each individual code is color coded using the same format as CDP (Code Domain Power Display), each code will display the spreading factor, code number, status, symbol EVM, modulation type, relative power and absolute power.

- Channel Power

  Channel power is the total power transmitted in the 3.8 MHz WCDMA channel specified. Channel power measures the Node B/base station transmitting power (within the bandwidth of 3.84 MHz) and is displayed in dBm and Watts. For Over The Air (OTA) measurements, the channel power will vary as the signal path from the Node B transmitter to the BTS Master MT8222A and Spectrum Master MS2721B varies.

- Scrambling Code

  In the WCDMA specification, the scrambling code can be from 0 to 511. It is the base station ID and is used for de-scrambling. If the number of the scrambling code is known, its value can be entered. The test set can then decode that particular signal and display the CDP. If the scrambling code is unknown, BTS Master and Spectrum Master can be set to auto scrambling so that the test set can find the scrambling code number by the searching algorithm. It can then lock on to the strongest code to decode and display the CDP of the signal.

- Spreading Factor (OVSF Codes)

  According to the 3GPP standard, the spreading factor can vary from 4 to 512. BTS Master and Spectrum Master can be set to a maximum spreading factor of 256 or 512.

- Frequency Error

  Frequency error is the difference between the received center frequency and the specified center frequency. This value is tied to the external frequency reference accuracy and is typically only useful with a good external frequency reference.

- Codogram

  When codogram is selected the screen displays the changes in code power levels over time.

- Noise Floor

  Noise Floor is the average power of inactive codes in the code domain, displayed in the CDP measurement display.

- Threshold

  The Active Channel Threshold Level can be set to indicate which code channels are considered active. Any code channels exceeding this power level are considered active traffic channels. Any code channels below this power level are considered inactive (or noise). A horizontal red line on the screen represents the threshold level. BTS Master and Spectrum Master can set this level automatically based on the received signal. The user can also opt to manually enter a value in the threshold setup menu.

- Occupied Bandwidth is calculated as the bandwidth containing 99% of the total integrated power within the transmitted spectrum around the selected center frequency.

- Error Vector Magnitude (EVM)

  EVM is the ratio, in percent, of the difference between the reference waveform and the measured waveform. EVM metrics are used to measure the modulation quality of a transmitter. The 3GPP standard requires the EVM not to exceed 17.5% when the base station is transmitting a composite signal using only QPSK modulation and not to exceed 12.5% when the base station is transmitting a composite signal that includes 16QAM modulation,

- Symbol EVM (@EVM) is defined as the EVM for a single code channel.

- Peak to Average Power is the ratio of the peak power and the RMS power of the signal calculated over one frame interval and is displayed in dB.

- Peak Code Domain Error (PCDE)

  PCDE takes the noise and projects the maximum impact it will have on all OVSF codes. PCDE is the maximum value for the code domain error for all codes (channels) - both active and inactive. Note that in the 3GPP standard to address the possibility of uneven error power distribution in WCDMA, the EVM measurement has been supplemented with PCDE. The 3GPP standard requires the PCDE not to exceed -33 dB at a spreading factor of 256.

- Ec is defined as the chip energy for PCPICH and is determined by multiplying CPICH by the chip time.

- Ec/Io is the value of the pilot power compared to the total channel power. Ec/Io is displayed in text only and OTA measurement displays.

- Pilot Dominance is the strength of the strongest pilot compared to the next strongest pilot in the same channel. This value should be >10 dB to make good Over The Air measurements.

- Total Power is the channel power (the sum of the power of all the scrambling codes); also called Io. It is displayed in dBm.

- CPICH Abs Power is the energy over one chip of the Common Pilot channel Power displayed in dBm.

- P-CCPCH Abs Power is the absolute Primary Common Control Physical Channel power displayed in dBm.

- S-CCPCH Abs Power is the absolute Secondary Common Control Physical Channel power displayed in dBm.

- P-SCH Abs Power is the absolute Primary Sync Channel power displayed in dBm.

- S-SCH Abs Power is the absolute Secondary Sync Channel Power displayed in dBm.

- PICH is the Paging Indicator Channel Power.

- HSDPA Power versus Time Display
  To display how the code is varying over time, select the code and set the time. In the CDP view, HSDPA signals are displayed in orange. Note that the BTS Master and Spectrum Master each provide a rolling 48-sample display, which allows the engineer to check how level the power levels stay over time.

- Tau
  Tau measures the time delay from the input trigger to the "start of a slot."

- Multipath
  Multipath refers to a signal that bounces off buildings or other obstructions and reaches the mobile from different paths. Multipath power is the total combined multi-path power from multiple multi-path signals of the strongest pilot. This should be >0.2 dB to make good Over The Air measurements.

- Constellation
  The symbol constellation for the selected code is displayed (16 QAM or QPSK) in the HSDPA view. It provides a way to tell, for example, if outside noise distortion or other artifacts are diminishing the signals.

Making HSDPA Measurements

The Anritsu BTS Master MT8222A and Spectrum Master MS2721B can measure HSDPA Node B transmitter performance in one of two ways, either:
- Over The Air (OTA) with an antenna.
- Via Direct Connection of BTS/Spectrum Master to Node B equipment.

Set-Up

Regardless of whether the measurement will be taken Over The Air or via a Direct Connection making HSDPA performance measurements with BTS Master/Spectrum Master requires some initial set-up. First, MT8222A/MS2721B must be configured for WCDMA/HSDPA mode as follows:
1. Select the Shift key, then the Mode (9) key.
2. Use the directional arrow keys or the rotary knob to highlight WCDMA/HSDPA Signal Analyzer. Press the Enter key to select.

Next, BTS Master/Spectrum Master must be configured to tune to the frequency being output by the base station. The user can either enter the center frequency of the channel or select the signal standard and channel which allows BTS/Spectrum Master to automatically set the frequency. If the applicable information is not stored in the unit, Master Software Tools may be used to create the signal standard and then subsequently download it into the unit.

To enter the center frequency:
1. Press the Freq function hard key.
2. Press the Center Freq soft key.
3. Enter the desired frequency using the keypad, the arrow keys or the rotary knob. If entering a frequency using the keypad, the soft key labels will change to GHz, MHz, kHz and Hz. Select the appropriate units key. Selecting the Enter key has the same affect as selecting the MHz soft key.
4. Press the Enter key to set the Center Frequency. The current setting is shown on the left side of the display.

To select a signal standard:
1. Press the Freq function hard key.
2. Select the Signal Standard soft key.
3. Using the Up/Down arrow keys or the rotary knob, highlight a signal standard and press Enter to select. When a signal standard is selected, the center frequency for the first channel of the selected standard is automatically tuned.
4. Select the Channel soft key and use the Up/Down arrow keys, the keypad or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display. The current settings are displayed on the left side of the screen.

Additional Configuration

Additional procedures for configuring BTS/Spectrum Master for the HSDPA measurement include:

- Power Offset For Compensating External Loss
  To obtain accurate results, the external attenuation should be compensated using power offset. In power offset mode the compensation factor is in dB. The external attenuation is caused by using an external cable or external high power attenuator. To set the Power Offset:
  1. Press the Amplitude function hard key.
  2. Press the Power Offset soft key. Use the keypad, the arrow keys or the rotary knob to enter the desired offset value.
  3. Press the Enter key to set the Power Offset. The value entered is displayed on the left side of the screen.

- Scrambling Code Set-up
  BTS/Spectrum Master MS2721B can set up a scrambling code automatically or manually. In Auto mode the unit automatically locks on to the strongest scrambling code in the signal. To automatically set the Scrambling Code:
  1. Press the Set-up function hard key.
  2. Press the Scrambling Code soft key to select Auto.

  In Manual mode the desired code is manually entered and the unit looks only for that specific scrambling code. To manually set up a Scrambling Code:
  1. Press the Set-up function hard key.
  2. Press the Scrambling Code soft key to select Manual. Use the keypad, the arrow keys or the rotary knob to enter the desired Scrambling Code, as shown on the left side of the screen.
  3. Press the Enter key to set the Scrambling Code.

- Maximum Spreading Factor Set-up
  The number of chips per data symbol is called the Spreading Factor. In this case, the lower the spreading factor the higher the data rate. According to the 3GPP standard, the spreading factor can vary from 4 to 512 and the maximum spreading factor is either 256 or 512. BTS/Spectrum Master can be set to 256 or 512 maximum spreading factors. To set up the maximum spreading factor:
  1. Press the Set-up function hard key.
  2. Press the Max Spreading Factor soft key to select either 256 or 512.

- S-CCPCH Spreading Factor, S-CCPCH Code and PICH Code Set-up
  In the 3GPP specification, two optional control channels are provided for S-CCPCH and PICH. These codes can have different spreading codes and spreading factors. In BTS/Spectrum Master the S-CCPCH spreading factor and S-CCPCH and PICH codes can be manually entered following these steps:
  1. Press the Set-up function hard key.
  2. Select the S-CCPCH Spread soft key and manually enter the desired spreading factor.
  3. Select the S-CCPCH Code soft key and manually enter the desired spreading code.
  4. Select the PICH Code soft key and manually enter the desired spreading code.

  For the most accurate results, manually enter the S-CCPCH spreading and S-CCPCH and PICH codes before taking the measurement. The default values for the S-CCPCH spreading factor and S-CCPCH and PICH codes are 256, 3 and 16, respectively.

- External Reference Frequency Setup
  To obtain the best frequency accuracy measurements, it is important to use an external reference frequency attached to BTS/Spectrum Master Ext Ref In connector or GPS. Most Node B equipment has a reference frequency available on a BNC connector. To configure the BTS/Spectrum Master to use an external reference frequency:
  1. Press the Set-up function hard key.
  2. Press the Select Reference Frequency soft key to display a list of the available reference frequencies:

1 MHz	4.9152 MHz
1.2288 MHz	5 MHz
1.544 MHz	9.8304 MHz
2.048 MHz	10 MHz
2.4576 MHz	13 MHz
4.8 MHz	19.6608 MHz

  3. Use the Up/Down arrow keys, or the rotary knob, to highlight the applicable reference frequency on the list. Press the Enter key to set the reference frequency.

  As BTS/Spectrum Master locks to the source, the Reference Freq value is displayed in the user settable parameters to the left of the display.

- GPS

GPS gives accurate frequency error measurements which comply with the 3GPP frequency error measurement. To configure BTS/Spectrum Master to use GPS:

1. Install the Anritsu GPS antenna to the GPS antenna connection on the BTS/Spectrum Master connector panel.

   One antenna now available from Anritsu that is suitable for this purpose is the 2000-1410 Magnet Mount GPS Antenna with 5 m (15 ft.) cable. Note that the GPS antenna connection on BTS/Spectrum Master is fitted with a reverse BNC connector to help prevent damage to the GPS circuitry. There is a DC voltage present on this connector. Never connect anything other than the Anritsu GPS antenna to this port.

2. Press the Shift, then System keys, to open the system options.
3. Press the GPS soft key to open the GPS menu.
4. Press the GPS On/Off soft key to turn the GPS feature on or off. When GPS is first turned on, the GPS icon below will be displayed in red:

   When the GPS receiver is tracking at least three satellites, the GPS icon will change to green as shown:

   Note that it may take as long as three minutes for the Ref Freq status to change to GPS High Accuracy in the Status menu displayed on the left side of the screen.

5. Press the GPS Info soft key to view the number of tracked satellites, latitude, longitude, altitude, and UTC timing information, etc...

   Note that to reset the GPS, press the Reset soft key. The green GPS icon with a red cross

   appears when GPS satellite tracking is lost. This occurs after being active (tracking three or more satellites).

   Within three minutes of satellite acquisition, the reference oscillator will have an accuracy of less than 25 PPB (parts per billion). The OCXO internal standard accuracy is ±0.3 PPM. The correction factor applied to the internal OCXO allows the instrument to maintain GPS frequency accuracy for three days, even when the instrument is obstructed from receiving signals from the GPS satellites. In order to acquire data from the GPS satellites, the user must have line-of-sight to the satellites or the antenna must be placed outside with out any obstructions.

   Once GPS High Accuracy is achieved, the internal reference is adjusted and will hold this adjusted value even when GPS satellites can no longer be received. This status will be indicated by "Internal High Accuracy" showing in the Status menu displayed on the left side of the screen. This improved frequency accuracy of better than 50 ppm will hold up to three days. Note: When the GPS feature is not enabled, the reference source will display either "Internal Standard Accuracy" or a user selected external reference frequency in the Status menu on the left side of the screen.

- Threshold Set-up

The threshold level is an advanced setting that can be set to indicate which codes are considered active. In the CDP screen the threshold level is indicated by a horizontal dotted red line. Any code channels exceeding this power level are considered active traffic channels and any code channels below this power level are considered inactive or noise. To manually set the threshold level:

1. Press the Set-up function hard key.
2. Select the More soft key.
3. Select the Threshold soft key and select either Auto or Manual.
4. If Manual is selected, select the Manual Threshold soft key and enter a value, followed by the enter soft key. Note that the threshold can only be set in Codogram or CDP modes. The default threshold level is -30 dB.

- Filtered Versus Unfiltered Power

In BTS/Spectrum Master, the ACLR measurement uses the filtered channel power to determine the ACLR values and is listed as filtered on the display. In all other screens the unfiltered channel power is displayed as channel power.

With the initial set-up complete, you are now ready to begin making HSDPA measurements.

Making Direct Connect Measurements

To demodulate the HSDPA signal connect the power amplifier of the Node B equipment to the RF In connector of BTS/Spectrum Master using a coupler or attenuator (Figure 7). Note that the maximum input damage level of the RF In port is +43 dBm. To prevent damage always use a coupler (sniffer port) or high power attenuator if connected directly to the power amplifier output.

Making Over The Air Measurements

The OTA method is considered the most preferable means of making HSDPA Node B measurements as it offers a more cost-effective, time-efficient approach to testing. Using the OTA test, technicians can execute a diagnostic test in less than five minutes without even getting out of their vehicles, although the vehicle should be parked close to the site. The OTA test enables field technicians to examine real-time traffic loading and power distribution, as well as to quickly see if the capacity already in place at the site is being utilized efficiently. Also, it provides field technicians with the ability to monitor hard to reach pole-top base stations.

If you chose to measure HSDPA performance Over The Air with an antenna, first ensure that BTS/Spectrum Master is not connected to Node B equipment (Figure 8). Next, connect the appropriate frequency band antenna to the BTS/Spectrum Master RF In connector. Set up the Scrambling Code, either automatically or manually, as per Scrambling Code set-up instructions on page 9.

WCDMA/HSDPA RF Measurements

HSDPA RF measurements include: Spectrum, Adjacent Channel Leakage Ratio (ACLR) and Spectral Emission

Figure 7. Illustrated here is the connection required to make HSDPA measurements using Spectrum Master via direct connection to Node B.

Figure 8. Making HSDPA measurements Over The Air requires the set-up shown here.

Mask. When making HSDPA RF measurements, you must first connect BTS/Spectrum Master to Node B equipment as shown in Figure 7. To make this connection, follow the direct connect procedure specified in this page. Then:

- Band Spectrum
  The Band Spectrum measurement screen displays the selected band spectrum of ten channels. The cursor can be moved to select the desired channel using the directional arrow keys or the rotary knob. The Channel Number can also be directly entered using the numerical keypad. Selecting the Channel Spectrum after you select a channel using the cursor will display the measurements for the selected signal.

  For Band Spectrum measurements:
  1. Select the Shift key, then the Mode (9) key.
  2. Use the directional arrow keys or the rotary knob to highlight WCDMA/HSDPA Signal Analyzer. Press the Enter key to select.
  3. Press the Freq function hard key.
  4. Press the Signal Standard soft key and select the applicable WCDMA standard.
  5. Press the Measurements function hard key and the RF Measurements soft key.
  6. Press the Band Spectrum soft key to display the band spectrum.
  7. Move the cursor, using the directional arrow keys or the rotary knob, to select the desired channel. The Channel Number can also be directly entered using the numerical keypad.
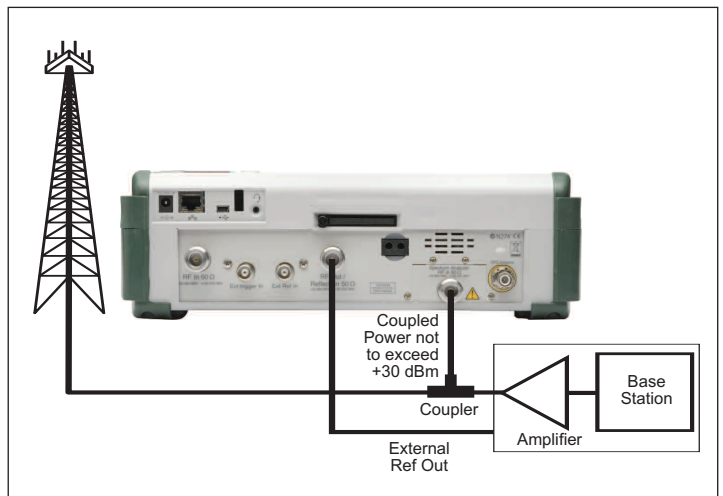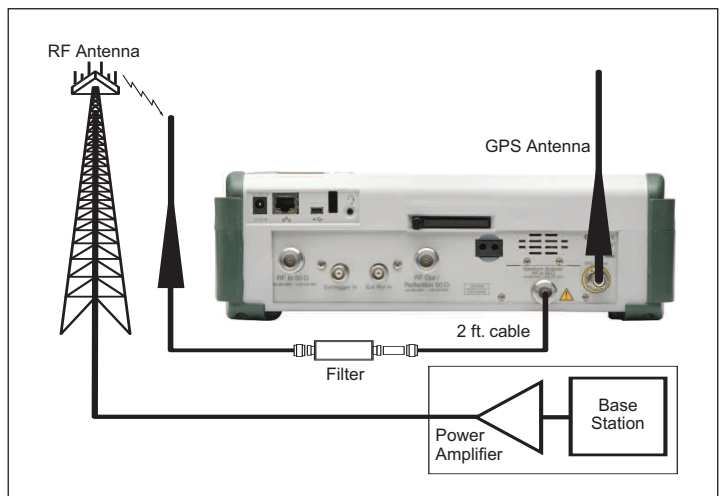
- Channel Spectrum

  The channel spectrum screen displays the selected channel signal and the following measurements: channel power in dBm and Watts, occupied bandwidth, and peak to average power. When Channel Spectrum is selected, the unit automatically displays the measurements for the selected signal.

  To measure channel spectrum:

  1. Follow Steps 1-3, from Band Spectrum procedure.
  2. Press the Center Freq soft key and enter the desired frequency manually, or press the Signal Standard soft key and select the applicable standard.
  3. Select the Channel soft key and use the Up/Down arrow keys, the keypad or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display.
  4. Press the Setup function hard key.
  5. For the most accurate frequency measurements, press the Select Reference Frequency soft key to display a list of the available reference frequencies. Select the desired reference frequency as explained in the External Frequency Reference Set-Up on page 9, or activate the GPS (if equipped), and synchronize the BTS/Spectrum Master to High Internal accuracy as explained in page 10.
  6. Press the Measurements function hard key.
  7. Press the RF Measurements soft key.
  8. Press the Channel Spectrum soft key to activate the spectrum measurement (Figure 9). The red dot on the soft key indicates it is selected.
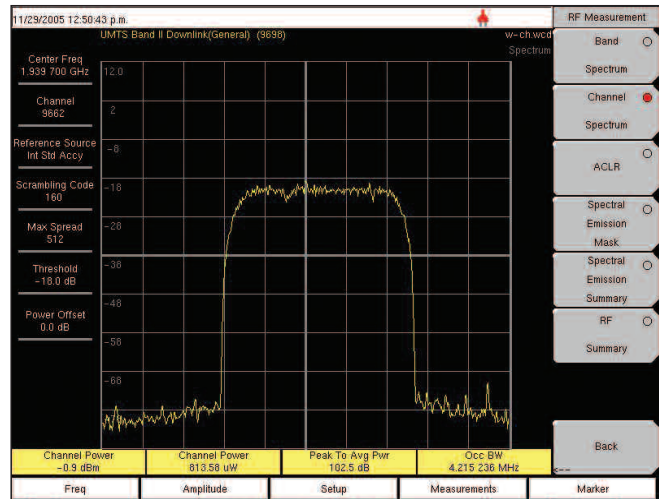
Figure 9. RF measurement example.

Using the Band Spectrum cursor, select the desired channel. The unit will automatically display the measurements for the selected channel when the Channel Spectrum key is selected.

- For ACLR Measurements:

  Adjacent Channel Leakage Ratio (ACLR) is defined as the ratio of the amount of leakage power in an adjacent channel to the total transmitted power in the main channel and is displayed in tabular format under the bar graph. The 3GPP standard specifies one main channel and two adjacent channels. The ACLR screen displays the main channel power and the power of two adjacent channels on each side as a bar graph. The channel spacing is -10 MHz, -5 MHz, +5 MHz and +10 MHz. The channels are color coded. The 3GPP standard requires the adjacent channel power leakage ratio to be better than 45 dB at 5-MHz offset and 50 dB at 10-MHz offset.

  The BTS/Spectrum Master can also make ACLR measurements for multi-channel systems by measuring the main channels and the adjacent channels, from one to four channels. The ACLR screen can display up to 12 channels total. The default value for each channel is 5MHz and the channel width can be set manually from 3.84 MHz to 5.4 MHz. In the ACLR measurement mode the filtered channel power is used to determine ACLR values and is listed as filtered on the display.

  To make ACLR measurements for one main channel, two adjacent channels:

  1. Follow Steps 1-5, of the Channel Spectrum procedure.
  2. Press the Measurements function hard key.
  3. Press the RF Measurement soft key.

     Note that in BTS/Spectrum Master, the ACLR measurement uses the filtered channel power to determine the ACLR values and is listed as filtered on the display. In all other screens the unfiltered channel power is displayed as channel power.

  4. Press the ACLR soft key to activate the ACLR measurement (Figure 10). The red dot on the soft key indicates it is selected. Using the Band Spectrum cursor, select the required channel and press the ACLR soft key. The BTS/Spectrum Master will display the measurement.
  5. Press the ACLR soft key again and select one main channel and two adjacent channels.
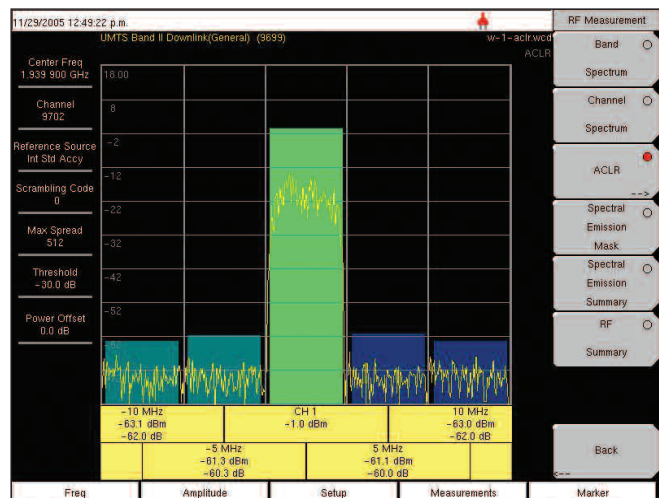

Figure 10. ACLR measurement example.

- Multi-Channel ACLR

  To measure multi-channel ACLR:
  1. Follow Steps 1-8, of the ACLR measurements (Figure 11).
  2. Press the ACLR soft key again and select the number of main and adjacent channels. For this example four main channels and four adjacent channels are selected.

     Note: The channel width can be set manually from 3.84 MHz to 5 MHz by pressing the ACLR soft key and Channel Width soft key.

- Spectral Emission Mask:
  The Spectral Emission Mask displays the selected signal and mask, as defined in the 3GPP specification. The mask varies depending on the input signal. BTS/Spectrum Master also indicates if the signal is within the specified limits by displaying PASSED or FAILED. The emission mask is also displayed in tabular format with different frequency ranges, along with whether or not the signal PASSED/FAILED in that region. The 3GPP specification specifies four masks depending on the base station output power:
  - P ≥ 43 dBm
  - 39 ≤ P < 43 dBm
  - 31 ≤ P < 39 dBm
  - P < 31 dBm

  1. Follow Steps 1-3, of the ACLR measurements.
  2. Press the Spectral Emission Mask soft key to activate the Spectral Emission Mask measurement (Figure 12). The red dot on the soft key indicates it is selected.
  3. Press the Spectral Emission Summary soft key to display the Spectral Emission Summary table (Figure 13). The red dot on the soft key indicates it is selected.
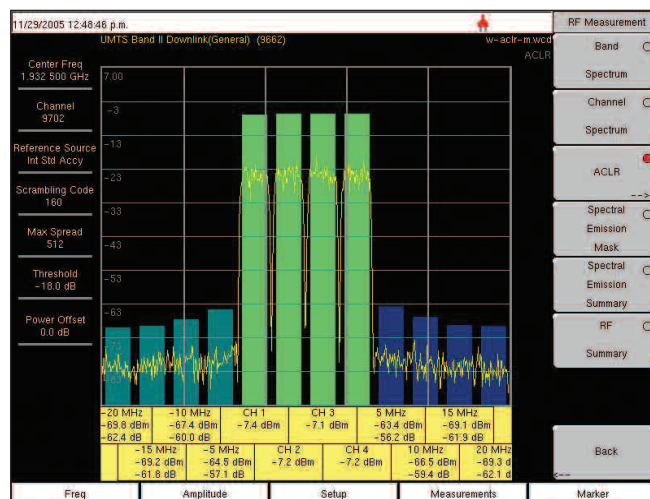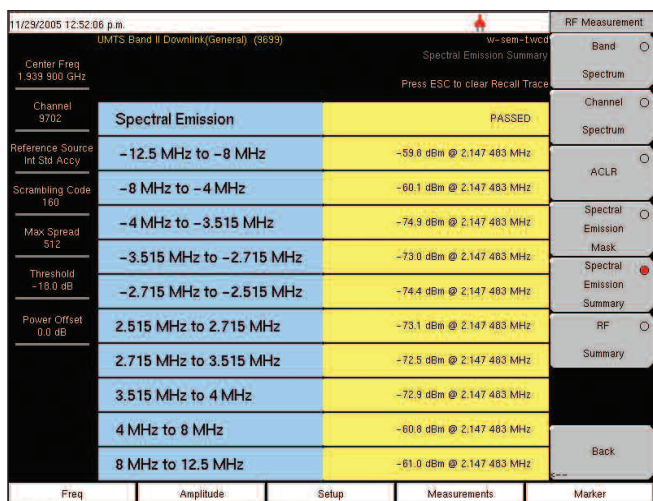

Figure 11. ACLR Multi-channel Measurement Example

12. Spectral emission mask measurement example
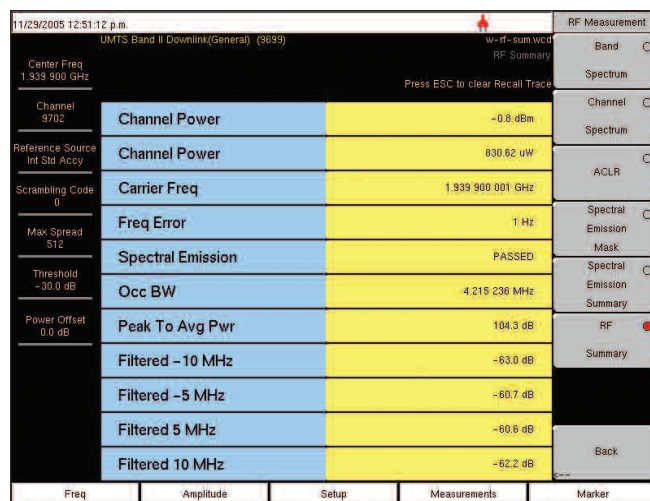

13. Summary screen example.

Figure 14. RF Summary example.

Note that BTS/Spectrum Master displays an RF Summary screen with all the critical transmitter performance measurements listed in tabular format, without demodulating the HSDPA signal (Figure 14). The parameters featured in the RF summary table are Channel Power in dBm and Watts, Carrier Frequency, Frequency Error, Spectral emission PASS/FAIL criteria, Occupied Bandwidth, Peak to Average Power, and ACLR at -10 MHz, -5 MHz, 5 MHz and 10 MHz channels.

Demodulating HSDPA

Demodulation is the process whereby the changes imposed on the carrier at the receiver are removed to reveal the message at the receiver. BTS/Spectrum Master demodulates HSDPA signals by connecting directly to Node B equipment. Demodulation results can be displayed in a CDP, CDP table, HSDPA, Codogram and Modulation Summary Screen.

In CDP and Codogram measurements, the Zoom function can be activated to zoom in on selected OVSF codes. The Zoom function can be set to start from a particular OVSF code. Press CDP or Codogram twice to activate the zoom function. The arrow in the lower right corner of the soft key indicates a sub menu is available.

To demodulate HSDPA signals using direct connect, follow the procedure listed in the direct connect set-up as described in page 11. Then proceed as follows:

• For CDP Summary Screen:
The CDP display includes spreading factor (OVSF codes) set to 256 or 512 and features a "zoom in" capability in which BTS/Spectrum Master can zoom to 32, 64 and 128 codes. The user can input the zoom code to start the zoom in from the entered OVSF codes. The demodulator also displays CPICH, P-CCPCH, S-CCPCH, PICH, P-SCH and S-SCH power in tabular format. For WCDMA/HSDPA Demodulator, the HSDPA codes are also displayed.

To display the CDP summary screen:
1. Follow Steps 1-4, of the Channel Spectrum section.
2. Press the Scrambling Code soft key to select Auto so that the MS2721B will automatically detect the scrambling code.
3. To accurately make frequency error measurement use external reference frequency or GPS. To activate GPS follow the procedure in GPS section on page 10 and synchronize.
4. Follow this step if external frequency reference is selected. Connect the external reference to the Ext RF Input BNC connector, and follow the external reference frequency set-up on page 9 to lock the BTS/Spectrum Master to it.
5. Press the S-CCPCH Spread soft key to manually set the S-CCPCH spreading. The BTS/Spectrum Master will display the default S-CCPCH spreading factor of 256 in all the views. Set the S-CCPCH spreading factor to show accurate results.
6. Press the S-CCPCH Code soft key to enter the correct S-CCPCH code. The BTS/Spectrum Master will display the default S-CCPCH code of 3 in all the views. Set the S-CCPCH code to show accurate results.
7. Press the PICH Code soft key to enter the correct PICH code. The BTS/Spectrum Master will display the default PICH code of 16 in all the views. Set the PICH code to show accurate results.
8. Press the Threshold soft key to manually set the Threshold level which determines which codes are active. The default value is –30 dB.
9. Press the Measurements function hard key.
10. Select the Demodulator soft key to activate the demodulator menu.
11. Press the CDP soft key to activate the CDP measurement. The red dot on the soft key indicates it is selected.
12. Press the CDP soft key again to activate the zoom function.
13. Press the Zoom soft key to select the appropriate zoom level. The Zoom key toggles between 32, 64 and 128.
14. Press the Zoom Start soft key to manually enter the zoom start code.
15. Press the Back soft key to go back to the CDP measurement. Note that the blue color block on the CDP screen represents the selected zoom codes. The same codes are displayed in the zoom screen (Figure 15).

Figure 15. HSDPA Code Domain Power Measurement Screen with GPS example.

• For HSDPA Summary Screen:
HSDPA displays the spreading factor (OVSF codes) 256 or 512 codes and high speed downlink physical shared channel codes HS-PDSCH. The right or left active codes can be selected using the cursor. The selected code power versus time and constellation are displayed. The demodulator also displays CPICH, P-CCPCH, S-CCPCH, PICH, P-SCH and SSCH power in tabular format.

To display the HSDPA summary screen:
1. Select the Demodulator soft key to activate the demodulator menu.
2. Press the HSDPA soft key to activate the HSDPA measurement. The red dot on the soft key indicates HSDPA is selected.
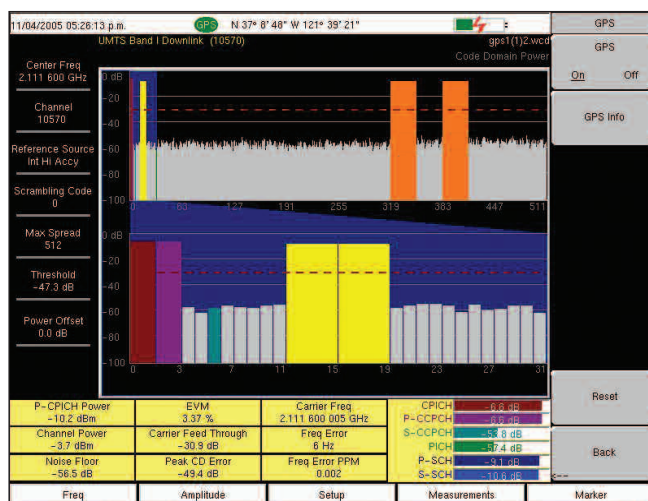3. Press the HSDPA soft key again to display the HSDPA measurement signal parameters.

4. Press the Total Time soft key to set the time or the Single Sweep Time soft key to set the time for the power versus time display. The maximum time is 72 hours.
5. Use the cursor to select the desired code. The code parameters are displayed on the screen.
6. Press the IQ Persistence soft key and use the keypad or rotary knob to set the IQ Persistence to 2. The BTS/Spectrum Master will display the constellation diagram after the first sample, and then update the constellation diagram after the second sample. IQ Persistence can be set as high as 48. When the maximum is reached, the first sample is replaced, and so on. Note that the HSDPA modulation is 16QAM or QPSK (Figure 16).

Markers can be used to read the individual code power, symbol EVM and type of code. Markers can be activated in all the WCDMA/HSDPA measurements by following these steps:

1. Press the Marker function hard key to display the Marker menu.
2. Press the Marker soft key to select the appropriate marker (1-6). The underlined marker number is the currently selected marker.
3. Press the On/Off soft key to activate the selected marker.
4. Press the Marker Table soft key to display the Marker table. The marker table is displayed on the screen below the measurements table (Figure 16).

- For Codogram Summary Screen:
BTS/Spectrum Master's Codogram summary screen displays the code power levels over time via two graphs. The graph on the top of the screen displays all of the selected OVSF codes, while the graph on the bottom displays the selected OVSF zoom codes.

Figure 16. HSDPA with Markers example.

To display measurement results via the Codogram Summary Screen:
1. Follow Steps 1-4, of the Channel Spectrum.
2. Press the Scrambling Code soft key to select Auto so that the MS2721B will automatically detect the scrambling code.
3. Press the Select Reference Frequency soft key to display a list of the available reference frequencies and select the desired reference frequency to get accurate frequency measurements. As explained in the External Frequency Reference set-up on page 9.
4. Press the S-CCPCH Spread soft key to manually set the S-CCPCH spreading. The BTS/Spectrum Master will display the default S-CCPCH spreading factor of 256 in all the views. Set the S-CCPCH spreading factor to show accurate results.
5. Press the S-CCPCH Code soft key to enter the correct S-CCPCH code. The BTS/Spectrum Master will display the default S-CCPCH code of 3 in all the views. Set the S-CCPCH code to show accurate results.
6. Press the PICH Code soft key to enter the correct PICH code. The BTS/Spectrum Master will display the default PICH code of 16 in all the views. Set the PICH code to show accurate results.
7. Press the Threshold soft key to manually set the Threshold level which determines which codes are active. The default value is –30 dB.

Figure 17. Codogram Measurement Screen example

8. Press the Measurements function hard key.
9. Select the Demodulator soft key to activate the demodulator menu.
10. Press the Codogram soft key to activate the Codogram measurement.
11. Press the Codogram soft key to activate the zoom function and to set the time for the measurement.
12. Press the Zoom soft key to select the appropriate zoom level. The Zoom key toggles between 32, 64 and 128.
13. Press the Zoom Start soft key to manually enter the zoom start code.
14. Press the Total Time or Single Sweep Time soft key to set the required time.
15. Press the Back soft key to go back to the Codogram measurement (Figure 17). The blue color block on the Codogram screen represents the selected zoom codes and the same codes are displayed in the zoom screen. Save the data before making any measurements, otherwise the data will be lost.
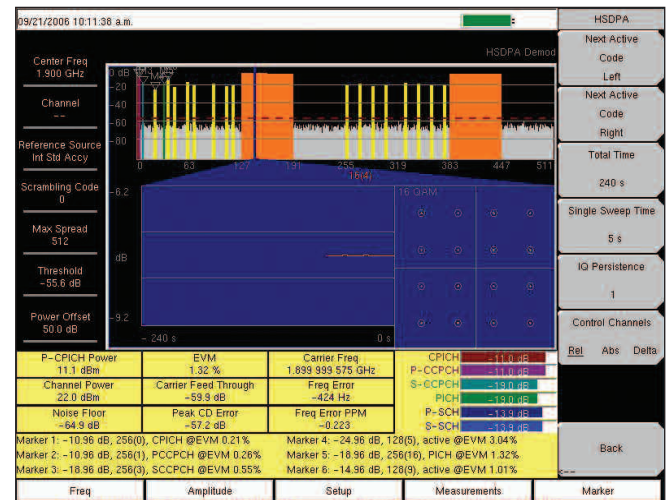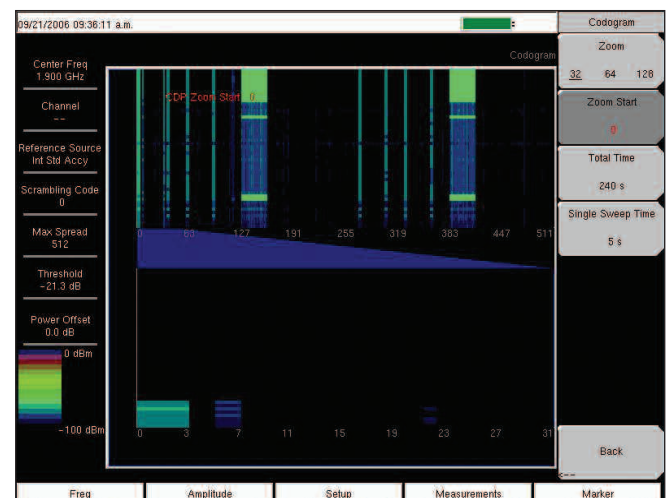
Over The Air Test

There are two measurements in the Over The Air measurement section, Scrambling Code and Multipath.

- Scrambling Code

  The Scrambling Code screen displays six strongest scrambling codes as bar graphs and underneath the bar graphs the scrambling code number, CPICH, Ec/Io, Ec pilot dominance related to the strongest scrambling code and OTA total power are displayed in the table format.

  In Scrambling code measurement the Scrambling Code can be set to Auto to automatically measure and display the six strongest scrambling codes, or Manual, to look for the set scrambling codes.

  The Scrambling Code measurement screen can be locked by pressing the Code Lock On/Off soft key. The Display Unit soft key can be used to display the Scrambling Code bar graph by selecting CPICH or Ec/Io. The default display is CPICH. The Sort By soft key can display the scrambling codes sorted by Power or Code.

  Procedure:
  1. Select the Shift key, then the Mode (9) key.
  2. Use the directional arrow keys or the rotary knob to highlight WCDMA/HSDPA Signal Analyzer and press the Enter key to select.
  3. Connect the appropriate antenna to the RF In connector to make OTA measurements.
  4. Press the Freq function hard key.
  5. Press the Center Freq soft key and enter the desired frequency manually, or press the Signal Standard soft key and select the applicable WCDMA standard.
  6. Select the Channel soft key and use the Up/Down arrow keys, the keypad, or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display.
  7. Press the Measurements function hard key.
  8. Select the Over the Air soft key.
  9. Select the Scrambling Code soft key to activate the Scrambling Code measurement.
  10. Select the Scrambling Code soft key again to display the Scrambling Code soft key menu.
  11. Press the Scrambling Code soft key and select Auto to automatically detect the six scrambling codes (Example figure 18).

      NOTE: Press Reset to activate the OTA measurement in a different location for accurate results.

  12. To only look for specific scrambling codes, press the Scrambling Code soft key to highlight Manual, then use the Manual Code soft key to select the specific code and the On/Off soft key to turn the selected code on or off. The Code Lock soft key locks the code, so that the code will not change with each update.

Figure 18. OTA measurement example.

- Multipath

  The Multipath Power screen displays the Primary signal (strongest Pilot) as bar #0 and up to the six strongest multipath components of that primary signal as numbered bar graphs (1-6) and underneath the bar graphs the multipath number, Tau (msec), Tau (chips), Distance (meters or feet), RSCP (Received Signal Code Power) dBm and Relative Power (dB) are displayed in the table format.

  In Multipath power measurement the Scrambling Code can be set to Auto to automatically measure and display the strongest scrambling code and it's multipath components, or Manual, to look for a set scrambling code.

  Procedure
  1. Press the Measurements function hard key.
  2. Select the Over the Air soft key.
  3. Select the Multipath soft key to activate the Multipath measurement.
  4. Select the Multipath soft key again to display the Multipath soft key menu.
  5. Press the Scrambling Code soft key and select Auto to automatically detect the strongest scrambling code.
  6. To look for specific scrambling code, press the Scrambling Code soft key to highlight Manual, then use the Manual Scrambling Code soft key to select the specific code.
  7. Select the Vertical Display soft key to change the graphs vertical scale between RSCP (Absolute power) and Relative Power, the vertical scale chosen will be underlined.
  8. Select the Horizontal Display soft key to change the graphs horizontal scale between chips and msec, the horizontal scale chosen will be underlined.
  9. Select the Distance soft key to choose the units to be displayed for distance in the table, m (meters) or ft (feet), the choice will be underlined.
  10. Press the Back key to return to the previous Over The Air Menu.

Figure 19. Multipath measurement example.

Pass/Fail Mode

BTS/Spectrum Master provides a Pass/Fail mode. In this mode, it saves the five test models, or test conditions for base station conformance testing, specified in the 3GPP standard (TS 125.141) for quick and easy measurements. After selection of a test model, the BTS/Spectrum Master displays test results in tabular format with clear PASS or FAIL indications that include min/max threshold. Using Master Software Tools, a custom test list can be created and downloaded into the BTS/Spectrum Master. All critical parameters can be selected for pass/fail testing, including each individual code power level, the spreading factor and symbol EVM.

To activate the Pass/Fail mode:
1. Follow Steps 1-7, of the Over The Air Test.
8. Press the Pass/Fail Mode soft key to display the pass/fail mode menu. Press the Select Pass/Fail Test soft key and select the applicable Test Model to activate the measurement (Example figure 20).
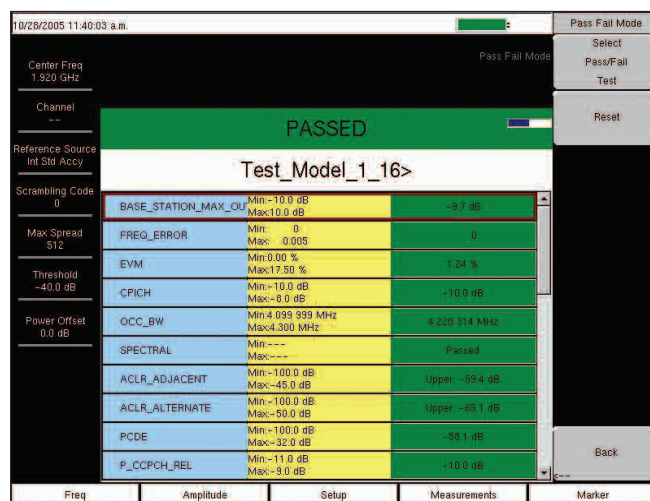

Figure 20. Pass/Fail mode example screen.

Code Table List

The code table list displays all of the codes which are active and color coded similar to CDP. It displays, for example, code number, type, CDP (in dB), and the code's Symbol EVM as well as its modulation type. The user can scroll through the codes contained in the list.

Procedure

1. Select the Demodulator soft key to activate the demodulator menu.
2. Press the CDP Table soft key to activate the CDP Table measurement. The red dot on the soft key indicates CDP Table is selected.
3. Use the scroll wheel to scroll up and down the CDP Table (Example Figure 21).

Figure 21. CDP table example.

Conclusion

Anritsu's BTS Master and Spectrum Master provides HSDPA measurement capabilities which enable field-based network technicians and RF engineers to quickly, efficiently and cost-effectively conduct Node B measurements. BTS Master and Spectrum Master's support for RF measurements, demodulation and OTA measurements is essential for ensuring that any performance problems are detected early enough to minimize service disruptions.

/Anritsu

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