HEWLETT® PACKARD

CDPD testing

HP 8921A
Option 502/3 or 602/3

Testing CDPD
RF characteristics

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When it comes to purchasing test equipment for CDPD, many service providers ask these questions.

- ***Why do I need CDPD test systems?***
- ***How do I know my system is working properly, or working at all?***
- ***How can I verify that my infrastructure's RF parameters conform to CDPD system specifications?***
- ***How can I maintain my CDPD system with minimal investment and training ?***

Since many of today's CDPD systems are not heavily loaded, there is very little customer feedback on system performance. In an AMPS voice system, customers can perceive the quality of service by simply listening and talking. In CDPD, the physical link parameters such as sensitivity may be affected by RF performance. A combination of error correction, auto-retry, message spooling and other protocol actions make it more difficult to casually perceive how well the infrastructure is performing. A reliable way to accurately judge system performance is to test the RF performance parameters given by the CDPD system specifications 1.1.

Testing is important because CDPD systems will ultimately become more encumbered due to the recent growth of horizontal application software and the advent of efficient wireless Internet access. In addition, a hybrid system consisting of CDPD and Circuit-Switched Cellular will create ubiquitous coverage which will again increase system usage. Thus, service providers may want to ensure their infrastructure will be operating at its optimum levels to ultimately enhance revenues.

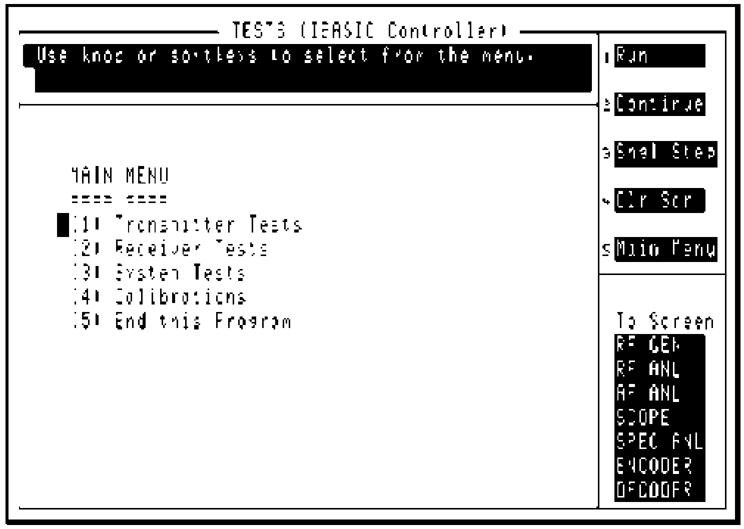
Hewlett-Packard has taken the RF parameters of CDPD system specifications 1.1 and created precise tests to accurately measure these important criteria. Utilizing the HP 8921A platform, the CDPD Cellular Adapter conducts measurements using a simple menu driven user interface. This is beneficial because new technicians will be able to make measurements rapidly and accurately, becoming effective immediately. In addition to these benefits, service providers may couple the HP 8921A with optional connected modules to perform AMPS, TDMA or CDMA RF measurements all in ONE test set.

Hewlett-Packard is a world wide leader in the design and manufacturing of Test and Measurement equipment and is committed to working with Service Providers in developing new measurement solutions *like* CDPD for the cellular industry and other access technologies.

CDPD Tests:

Discussed in this white paper are the objective, method and benefit of the parametric measurements that the new CDPD test set offers.

Additionally, this paper describes the Packet Data Units that are reported by the Hewlett-Packard CDPD test set and provides information on calibration procedures.



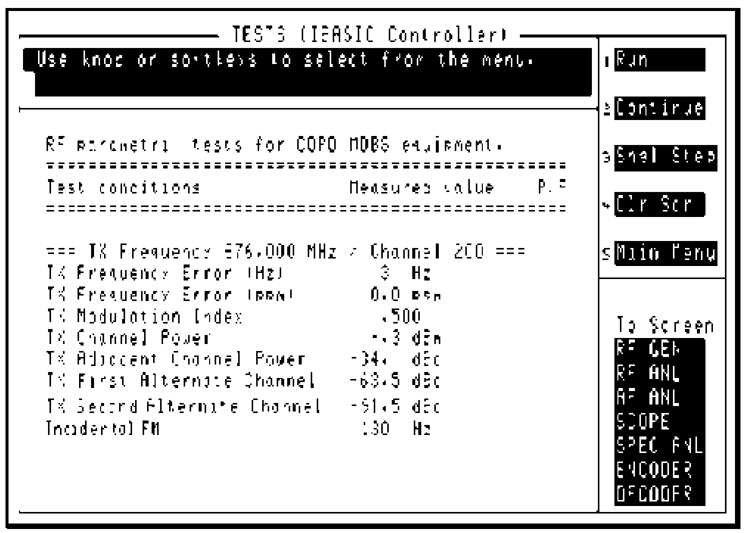
Transmitter Test

TX Frequency Error

Objective: To determine the center frequency of a CDPD modulated signal and report the difference from the desired channel center frequency.

Method: Digital Signal Processing. The algorithm measures the average peak positive and average peak negative frequency deviations of the modulated signal and computes the center frequency. Unlike a frequency counter, this method is insensitive to the amount of time this signalspends at peak plus or peak minus.

Benefit: Improved accuracy compared to a frequency counter. For 0.5 GMSK modulated signals, this method measures the carrier center frequency more accurately than a frequency counter. With this method, data induced frequency error is substantially eliminated.



TX Modulation Index

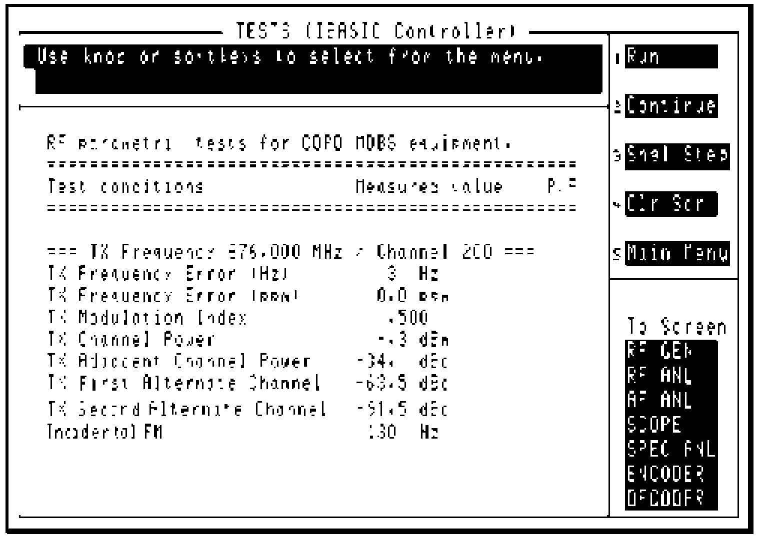
Objective: This measurement displays FM modulation index.

Method: Digital Signal Processing. The algorithm measures the average peak positive and average peak negative frequency deviations of the modulated signal and divides the difference by the data rate (19,200). This measurement method achieves an accuracy of better than 0.1%.

Benefit: Much higher accuracy as compared to conventional FM discriminator measurement method as noise effects are averaged out. The CDPD specification requires 1% accuracy. Measurement error 10 times less than the specification is commonly required to assure accuracy. Conventional measurement techniques (HP 8901A Modulation Analyzer) can achieve only 1% measurement accuracy which does not provide sufficient margin.

Incidental FM

Objective: Incidental FM is the amount of frequency fluctuation riding on the positive and negative deviations of the modulated waveform. This measurement is a modulation waveform quality indicator and not specified in the CDPD 1.1 standard.



Method: This value indicates the RMS frequency fluctuations when the modulated signal is at its peak deviation during runs of 3 or more consecutive 1’s or 0’s. DSP is used to measure peak deviation of the CDPD GMSK modulated signal.

Benefit: Incidental FM directly correlates to quality of modulation. Although incidental FM is not given in the CDPD specification, it can be useful as a predictor of potential component failure. For example, high incidental FM can be caused by bad oscillator phase noise or GMSK modulator distortion.

TX Power

Objective: This measurement displays the total power of the signal at the Test Set’s RF IN/OUT port.

Method: For signals greater than 100 mW, the RF IN/OUT port uses a peak detector to measure total broadband power from 400 kHz to 1 GHz. The measurement has accuracy equivalent to a conventional power meter for single signals.

Benefit: Assures accuracy of transmitter’s actual power output. The HP 8921A accuracy specification is 0.5 dB. Spectrum analyzers typically can achieve only 2 dB accuracy.

TX Channel Power

Objective: This measurement displays the power in a 30 kHz bandwidth, centered around the frequency specified by the given channel.

Method: Utilizing the more sensitive Antenna Port, signals of less than 100 mW are measured as specific channels. However, the current software does not support measurements in a multi-signal environment.

Benefit: Measures total power within entire 30 kHz spectral bandwidth of signal. Rejects signals outside the 30 kHz filter bandwidth. No accuracy specification is given for this mode. Typical accuracy in *1 dB after calibration.

Adjacent Channel Power, Alternate Channel Power

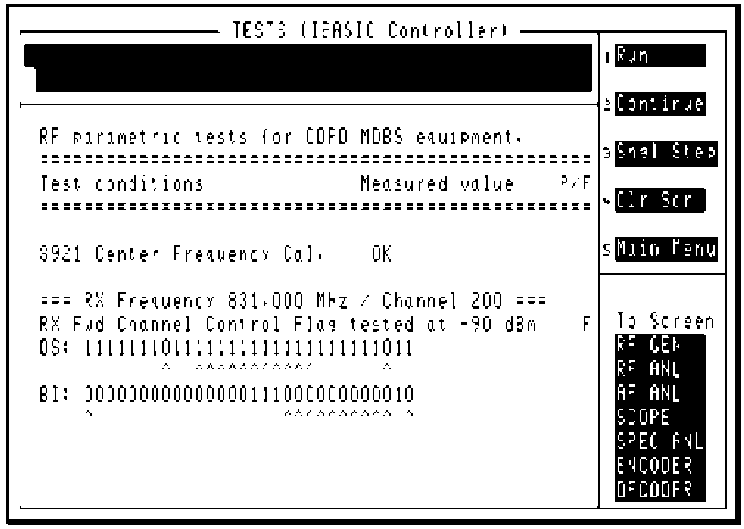
Objective: These tests measure the amount of power present in 30 kHz bandwidth centered around a frequency ±30 kHz (+adjacent channel) or ±60 kHz (1st alternate channel) ±90 kHz (2nd alternate channel) offset from the transmitted channel.

Method: Measures total power within 30 kHz bandwidth centered on the adjacent and alternate channels.

Benefit: Indicates the power levels effecting adjacent and alternate signals which may interfere with accurate transmission on these channels.

Receiver Test

RX forward channel control flag



Objective: The control flag is a series of bits that report the current Busy/Idle and Decode Status of the MDBS. The forward channel control flag bit pattern is different between the different MDBS manufacturers.
This test identifies the bit pattern and determines if it is within the acceptable limits required to reliably sense Busy/Idle and Decode status change. In addition, this test confirms base station and mobile compatibility.

Method: The Forward channel control flag bit stream is decoded by the HP 8921A and checked for adherence to the standard. Bits that are different from the standard are highlighted.

Benefit: Ensures the base station is generating correct control flag bits.

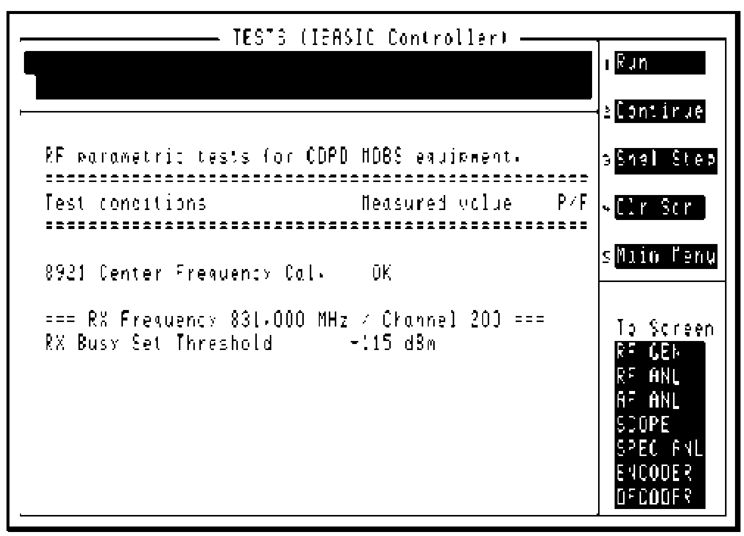
RX Busy Set Threshold (set and measure)

Objective: This test verifies that the transmitter's Busy/Idle flag is set and cleared properly when a specified set level of bursted reverse channel signal is fed into the receiver.

Method: The HP 8921A outputs an RF level given by a user selectable parameter on the reverse channel. The analyzer portion of the HP 8921A then decodes the forward channel control flag and checks status of the Busy/Idle bit. If it shows busy status, then the test passes.

Benefit: Rapid, independent verification of the system set RF level for the busy set threshold. This allows you to be confident your MDBS reverse channel can respond to a set RF level.

RX Busy Set Threshold (iterative)



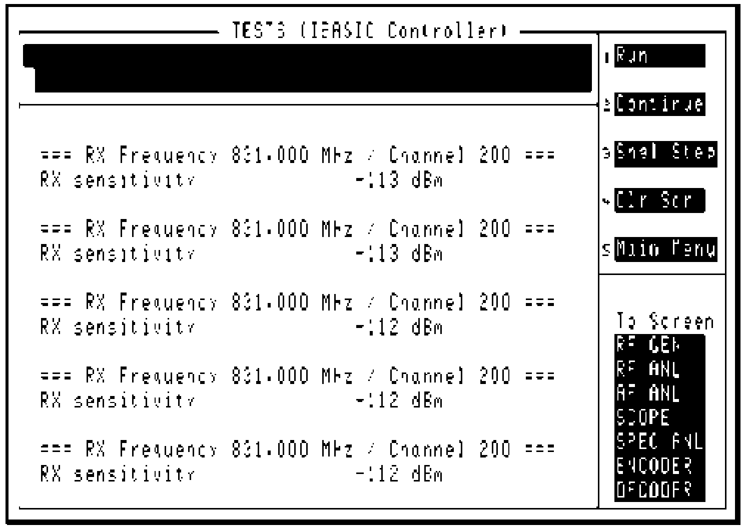
Objective: This test varies the signal level into the receiver to determine the exact level needed to toggle the reverse channel's receiver Busy/Idle Flag to Busy.

Method: This measurement finds the RF level of the MDBS reverse channel Busy/Set threshold using a binary search scheme.

Benefit: Allows user to find the actual system level of the Busy/Idle threshold automatically.

RX Sensitivity (set, measure, and iterative)

Objective: This test verifies that the Block Error Rate for the reverse channel receiver is ≤5% at a specified signal level. The iterative method performs the same test but searches to determine the actual RF level that gives Block Error Rate of 5%



Method: The receiver RF sensitivity is the minimum received signal strength in dBm at the receiver's antenna input terminals and at a nominal frequency of the receiver which when demodulated will produce data blocks with a specified Reed-Solomon Block Error Rate. The Block Error Rate is defined as:

$$\text{Block Error Rate} = \frac{\text{Block sent-correctable received}}{\text{Blocks sent}}$$

With the set-and-measure method, the user sets the RF level at which the test is performed and the measurement returns a "pass" if block error rate is better than 5%. The iterative test uses a binary search scheme to find the actual RF level at which the block error rate exceeds 5%.

Benefit: Rapid, independent verification of the system RF sensitivity using block error rate as given by the CDPD 1.1 standard. This allows you to be confident your MDBS reverse channel has the sensitivity to adequately receive distant mobiles.

Sniffer Threshold (Set and Measure and Iterative)

Objective: This test verifies proper operation of the Sniffer function. The set and measure method verifies the Sniffer will shut down the CDPD forward channel transmitter when an AMPS signal comes on the same channel at a given RF level

Method: The HP 8921A RF signal generator inputs an unmodulated signal at a given level to the Sniffer port. In the set and measure method, this level is given by a user defined parameter. For the iterative test, this level is adjusted iteratively to find the actual level for sniffer activation.

Benefit: Allows provider to determine the sensitivity of sniffer receiver. This is critical for assuring that CDPD will not interfere with AMPS traffic.

Sniffer Activation Time

Objective: This test measures the time it takes the CDPD transmitter to stop transmitting after the Sniffer port receives a signal of a specified level.

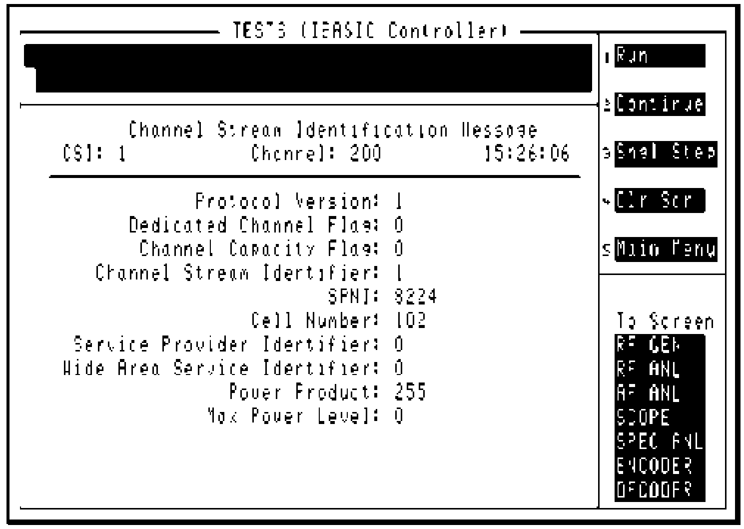
Method: The HP 8921A inputs an RF signal of sufficient level to the Sniffer port. Concurrently, a timing measurement begins on the envelope of the forward channel CDPD transmitter. The time for the RF envelope to turn completely off is then measured and reported.

Benefit: This is important because to operate correctly, the MDBS must vacate the channel when AMPS activity is detected within 40 msec as required by the CDPD standard. Ultimately, the activation timing test verifies CDPD compatibility with the AMPS system. If the CDPD transmitter takes more than 40 ms to go down, AMPS traffic may detect interference.

Channel Stream Identification Protocol Data Units

(CSI PDU)

This data tells the Mobile End Station **(MES)** which Mobile Data Base Station (MDBS) it is communicating with, and reports a number of additional CDPD system parameters associated with that MDBS.



Protocol Version:

This is the version or Radio Resource Management protocol being used.

Dedicated Channel Flag:

This indicates whether the channel can be used for frequency hopping. A value of 1 indicates that the current RF channel is dedicated for CDPD use (non-hopping). A value of 0 indicates the channel stream may be changing RF channels in a frequency hopping CDPD system.

Channel Capacity Flag:

This indicates whether the channel stream possesses sufficient spare capacity to support new M-ESs. If the MDBS indicates that the channel stream is full, the M-ES wishing to register should seek another channel stream. However, M-ESs already registered are not required to seek a new channel stream. A value of 1 indicates the channel stream is full.

Channel Stream Identifier:

This field contains the CSI of the channel stream currently carried on the forward channel. This number, between 1 and 63, can be used to identify the individual MDBS radios in a cell

SPNI:

The high-order 16 bits of the Cell ID field are the Service Provider Network Identifier of the Service Provider Net work providing service in the current cell. Each service provider has a single, unique identification number that is used to identify all of their cells.

Cell Number:

The low order 16 bits of the Cell ID field are the Cell Number. The Cell Number is unique within all cells/sectors of one Service Provider Network. Multiple channel streams on the same cell/sector may be assigned the same Cell ID.

Service Provider Identifier:

The Service Provider Identifier uniquely identifies a licensed facilities based cellular Service Provider providing CDPD services.

Wide Area Service Identifier:

A Wide Area Service Identifier identifies a network of service providers that have a cooperative agreement to provide CDPD service over a large geographic area.

Power Product:

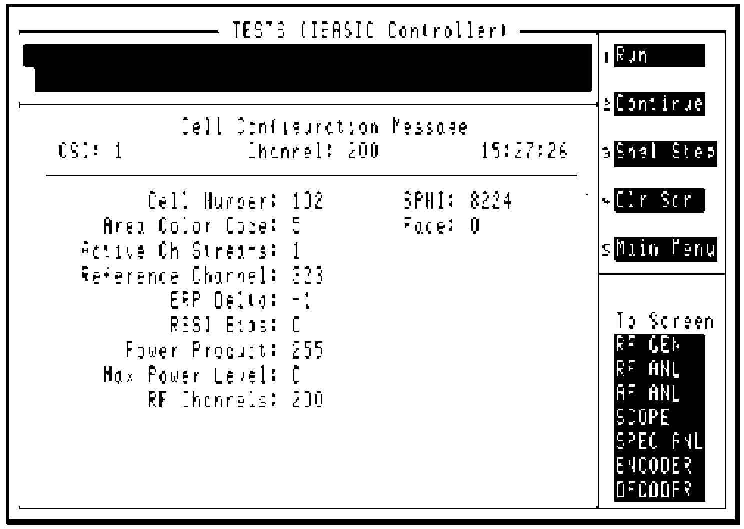
The Power Product is a value transmitted by the MDBS to the M-ES. The M-ES uses this, along with the received signal strength of the forward channel and the maximum allowed power level, to determine how much power to transmit to provide an adequate signal to the MDBS's receiver on the reverse channel. The power product will vary between cells to adjust for cell area size, MDBS's transmitted power, and geography affecting signal strength.

Maximum Power Level:

This is an unassigned value between 0 and 10 representing the maximum power level an M-ES can use for reverse transmission. The 0-10 levels are mapped to absolute power values.

Cell Configuration Protocol Data Units (CCPDU)

This test decodes and displays the CC PDU information from the MDBS transmitter. The CC parameters provide information to the M-ESs to allow channel hopping and to transfer between cells. Information is provided for the current or for an adjacent cell.



Cell Number:

Unique cell ID that includes the Service Provider Network Identifier. This number identifies the cell where the MDBS is located.

Area Color Code:

Denotes the area color code of that cell to facilitate the M-ES to identify cells supported by different MD-ISs.

Active Channel Streams:

This number defines the number of active channel streams in a cell. Zero indicates no CDPD is active in that cell, and 7 means that there are 7 or more channel streams in that cell.

Reference Channel:

A valid RF channel number referring to a continuously keyed channel in a defined cell that can be used in the best cell selection by the M-ES. The reference channel's signal level is used by the M-ES to determine the best cell to transfer to when moving from one cell to another. This value will be in the range of 1 to 1023.

ERP Delta:

This value defines the difference in the nominal effective radiated power between the reference channel and the CDPD channels in that cell. The expected signal strength of a CDPD channel in a cell is calculated by subtracting the ERP delta value from the received signal strength indication.

RSSI Bias:

(Received Signal Strength Indicator) This value allows the service provider to alter when an M-ES transfers its connection to an adjacent cell. By offsetting (biasing) the receiver signal strength indicator value, the mobile will transfer to another cell earlier or later than it normally would with an unbiased RSSI measurement. The number is a signed 2's compliment value in dB, and is derived using the following channel powers:

RSSI Bias (dB) = Adjacent Cell Channel (dBW)-Current Channel (dBW)

Power Product::

This same quantity is broadcast as part of the channel stream ID message.

Maximum Power Level:

This same quantity is broadcast as part of the channel stream ID message.

RF Channels:

This is a list of all RF channels in that cell that can be used for CDPD. Channels marked with a "D" such as 107D, are dedicated CDPD channels.

SPNI:

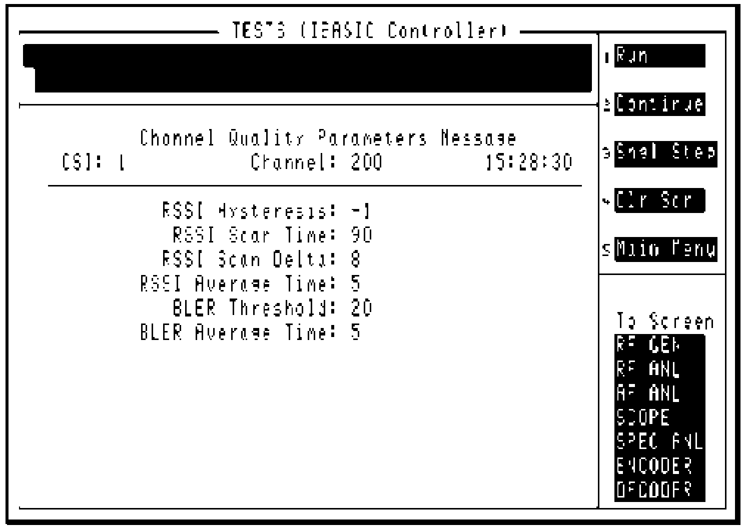
The high-order 16 bits of the Cell ID field are the Service Provider Network Identifier of the Service Provider Network providing service in the current cell. Each service provider has a single, unique identification number that is used to identify all of their cells.

Face:

This value tells if the associated cell is a facing sector of the current cell. The value is set to 1 for facing cells.

Channel Quality Parameters Protocol Data Units (CQPDU)

This information coveys Quality Assessment parameters associated with the current channel.



RSSI Hysteresis:

This is the Received Signal Strength Indicator (RSSI) hysteresis value for the current channel. When there is a heavy volume of traffic along a boundary of two cells with equal power levels, best channel selection may cause unnecessary flip-flops between the cells. This parameter provides a hysteresis effect during the best channel selection and avoids superfluous channel reacquisition.

RSSI Scan Time:

This is the maximum time (in seconds) that may elapse before the M-ES Received Resource Management Entity (RRME) must initiate the channel scan procedure. Channel scanning is ` used to determine the best cell to use, based on the RSSI of the channels from adjacent cells. A value of 0 indicates the RSSI scan time function is disabled.

RSSI Scan Delta:

This value defines the upper and lower ranges for the variation of the RSSI value of the current channel. This is the change in average RSSI that shall cause the M-ES RRME to initiate the channel scan procedure. A value of 0 means the RSSI scan threshold function is disabled.

RSSI Average Time:

This value (in seconds) defines how long the average RSSI of the MDBS must exceed the RSSI Scan Delta value before the M-ES RRME takes action to change channels.

BLER Threshold:

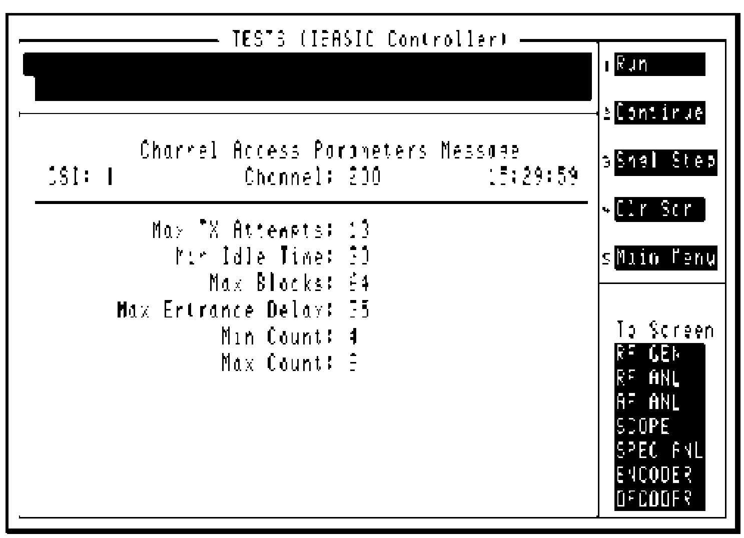
This is the Block Error Rate (BLER) threshold for the current channel (expressed as percent). It is defined as the ratio of the number of uncollectible blocks compared to the total number of blocks received. Ultimately, if the block error rate exceeds the threshold value, this can render the channel unusable.

BLER Average Time:

This value sets the length of time (in seconds) over which the Block Error Rate measurement is averaged.

Channel Access Parameters Protocol Data Units (CAP PDU)

The channel access parameters message contain parameters related to the operation of the MAC layer. These parameters define the operational characteristics of multiple M-ESs sharing a given channel stream and the error-recovery procedures carried out by the MAC layer.



Maximum TX attempts:

This is the maximum number of times an M-ES may attempt to obtain CDPD service with that MDBS. A transmission attempt is either the sensing of the Busy/Idle flag, or the actual transmission of a burst. If the maximum number of transmission attempts is exceeded, the M-ES shall abort the transmission attempt.

Min Idle Time:

After a successful transmission of a burst, the M-ES is required not to access the reverse channel for a minimum period defined by the minimum idle time.

Max Blocks:

This is the maximum number of blocks that a full-duplex M-ES can send in one burst.

Max Entrance Delay:

After finding that the forward channel Busy/Idle status is busy, this is the maximum amount of time (in microslots) that the MES must wait before checking the status again. A counter is incriminated each time the Busy/Idle status is checked, and is compared to the Max TX Attempts setting.

Min Count:

If there is a collision in the reverse channel transmission detected by the decode failure flag, the M-ES backs off for a number of microslots selected within a uniformly distributed random number.

Maximum Count:

When in the BACK Off state, The M-ES's count value is incremented each time the Busy/Idle flag is checked and found to be set to Busy. This is the maximum count value allowed before a new count is started.

Calibration

Cable loss

Objective:

This test is used to calibrate and store cable loss measurements for the test cables you are using to connect the HP 8921A to your base station.

Method:

Swept measurement across the cellular band using the HP 8921A's internal RF tracking signal generator as a source and internal HP 8921A spectrum analyzer as an RF level sensor.

Benefit:

Improves the accuracy of transmitter power measurements and receiver sensitivity measurements by allowing the software to account for the unwanted loss of cables used to connect the HP 8921A to the base station.

Power Measurement Calibration

Objective:

This calibration is only needed for the TX Channel Power (frequency selective power measurement) which is the power measurement method when available TX signal levels are below 20 dBm (100 mW). If your TX signal is below this level, then you must use the TX Channel power measurement by editing Parameter #4 to select ANT IN port. The channel power measurement is made by a Digital Signal Processing technique in the CDPD Cellular Adapter. The channel power measurement range is relative and not initially tied to an absolute power reference. This calibration is necessary to reference the channel power measurement to a known absolute reference. The calibration must be performed at the temperature you wish to make measurements at.

Method:

The Test Set's internal RF signal generator is used as an absolute power standard and input to the TX Channel Power DSP, The software records the difference between the known input signal level from the signal generator and the measured signal level from the DSP and stores this in nonvolatile memory as a calibration factor.

Benefit:

Assures the accuracy of the TX Channel power measurementcapability which is used when TX power levels are less than 100 mW.

GMSK Deviation Calibration and Center Frequency Calibration

Objective (deviation):

To assure accuracy of the HP 8921A's RF signal generator whendeveloping a 0.5 GMSK modulation

Objective (center frequency):

This procedure removes any RF Generator DCFM offset caused by the modulating signal from the cellular adapter.

Method:

The modulated signal is compared to known accurate references internal to the test set and calibration factors are stored in memory.

Benefit:

Assures accuracy of the CDPD signal generator.

References

CDPD System Specification
Release 1.1, January 19, 1995

Cellular Digital Packet Data
The Artech House Mobile Communications Series
Muthutham by Sreetharm
Rajiv Kumar

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