CTIA

Wireless Subscriber Station Certification Program

Method of Measurement for Radiated RF Power and Receiver Performance

Cellular Telecommunications & Internet Association Method of Measurement for Radiated RF Power and Receiver Performance

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CTIA Certification Program

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Section 1: Introduction

1.1 Purpose:

This Test Plan defines the methodology and procedures to be followed in the laboratory evaluation for conducting Radiated RF Power and Receiver Performance measurements on wireless subscriber stations.

This Test Plan is part of a CTIA Certification Program as described in a separate document entitled CTIA Terminal Unit Certification Program Management Document. This document contains criteria, in addition to laboratory performance tests, that must be met for CTIA certification.

1.2 Scope:

This Test Plan details specific hardware, software, laboratory techniques, test methodology, test procedures and technical criteria used during a CTIA product evaluation. This Test Plan does not include the test requirements or test methodology for other aspects for evaluating terminal equipment or technologies. Where applicable, other Test Plans exist or will be prepared for inclusion into the CTIA Certification Program.

This Test Plan gives a practical methodology for the accurate testing of wireless subscriber stations to ensure that they meet current industry standards.

1.3 Applicable Documents:

The baseline standards for the Certification Program's test plans are listed below. CTIA will incorporate revised industry standards, as they become available. As additional programs are added additional standards will be referenced. All referenced standards may cross reference additional standards.

Recommended Minimum Standard for 800 MHz Dual Mode Narrowband Analog Cellular Subscriber Units. TIA/EIA/IS-90, January 1993, Telecommunications Industry Association.

Mobile Station - Base Station Compatibility Standard for 800 MHz Analog Cellular. TIA/EIA/IS-91, October 1994, Telecommunications Industry Association.

Recommended Minimum Performance Standards of 800 MHz Cellular Subscriber Units. TIA/EIA/IS-19-B, May 1988, Telecommunications Industry Association.

800 MHz Mobile Stations Authentication Test Procedure. Rev. 3.1, July 1998. CTIA.

Cellular System Mobile Station-Base Station Compatibility Standard. EIA/TIA Interim Standard, EIA/TIA IS-553, June 1996, Telecommunications Industry Association.

Recommended Minimum Performance Standards for Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations. TIA/EIA-98-B, August 1998, Telecommunications Industry Association.

Recommended Minimum Performance Requirements for 1.8 to 2.0 GHz Code Division Multiple Access (CDMA) Personal Stations. J-STD-018, September 1995, Telecommunications Industry Association.

Mobile Station–Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular Systems. TIA/EIA/IS-95-A, May 1995, Telecommunications Industry Association.

TDMA Cellular/PCS - Radio Interface - Mobile Station - Base Station Compatibility. TIA/EIA/IS-136-A, October 1996, Telecommunications Industry Association

TDMA Cellular/PCS- Radio Interface - Minimum Performance Standard for Mobile Stations. TIA/EIA/IS-137-A, July 1996, Telecommunications Industry Association.

Cellular Mobile Telephone Equipment Specifications, Preliminary, Advanced Mobile Phone Service, Inc.

TIA/EI -136-A, Telecommunications Industry Association, Standards and Technology Department, 2001 Pennsylvania Ave. NW, Washington, DC 20006.

ANSI/IEEE Std 149-1979, IEEE Standard Test Procedures for Antennas, IEEE, Inc., 1979, p. 100.

Mobile Station (MS) conformance specification, *GSM 11.10-1(ETS 300 607-1)*

Electromagnetic compatibility and Radio Spectrum Matters (ERM) for radio communications equipment, *EN 300 339*

Radio Equipment and Systems (RES); Electromagnetic compatibility (EMC) for Digital Enhanced Cordless Telecommunications (DECT) equipment, *ETS 300 329*

Radio Equipment and Systems(RES); Electromagnetic compatibility(EMC) for European Digital Enhanced Cordless telecommunications(DECT) equipment, *ETS 300 342-1*

1.4 Certification Test Plans:

Detailed laboratory test procedures and technical requirements for certification are contained in the following documents. Test plans provide detailed information regarding the type of test equipment typically used to perform the evaluation (i.e., manufacturer, model, and firmware release). See appropriate test plans for a detailed description of each test performed.

- *Test Plan for 800 MHz AMPS & Cellular/PCS TDMA Dual Mode Wireless Subscriber Stations*
- *Test Plan for 800 MHz AMPS & Dual Mode AMPS/NAMPS Wireless Subscriber Stations*
- *Test Plan for 800 MHz AMPS & Cellular/PCS CDMA Dual Mode Wireless Subscriber Stations*
- *Test Plan for 800 MHz AMPS Analog Wireless Subscriber Stations*
- *800 MHz Mobile Station Authentication Test Procedure*

1.5 Test Overview:

This Test Plan presents the individual test procedures bulked by type of test and/or technology (Transmitter, Receiver, AMPS, CDMA, TDMA, & GSM).

1.6 EUT - The Cellular Subscriber Station:

Devices for test are to be supplied with all required peripherals and accessories, in accordance with the Program Management Document for CTIA Mobile Station Certification Programs. This includes:

Table 1.2 - EUT Peripherals and Accessories

Mobile Units	Transportable Units	Handheld Units	Other
1. Transceiver Unit 2. Handset/Cradle 3. Hands-free speaker and microphone 4. All interconnecting and power cables 5. EUT mounting hardware 6. Test Interface Adapter (TIA)	1. Transceiver Unit and Carrying Case 2. Handset/Cradle 3. Rechargeable Batteries 4. Power Cables (Charging and battery adapter) 5. Antenna and Adapter 6. Test Interface Adapter (TIA)	1. Transceiver Unit 2. Rechargeable Battery and Battery Charger 3. Antenna Adapter 4. Power Cables (charging and car adapter) 5. Mobile/car adapter apparatus (including hands-free equipment) 6. Test Interface Adapter (TIA)	1. Transceiver Unit 2. Antenna Adapter 3. Power cables 4. Test Interface Adapter (TIA) 5. Appropriate ancillary equipment required for normal operation of the EUT.

In addition, any auxiliary equipment which is available as part of the product, either for installation or as an option, should be supplied.

1.7 Subscriber Unit Test Interface (TIA) Requirements:

Detailed requirements for the Test Interface Adapter (TIA) are defined in TIA/EIA Interim Standard, TIA/EIA/IS-137-A, TDMA Cellular/PCS - Radio Interface - Minimum Performance Standard for Mobile Stations, Section 8, Mobile Station Test Interface. These requirements represent an attempt to standardize the test interface, including access to all points required for testing. This allows automatic tests to be carried out, specify audio impedances, and Equipment Under Test (EUT) control codes for manual testing.

No laboratory attempt will be made to “kludge” patches for any test requiring internal test point connections. Physical access to the relevant test points in the subscriber set, and clear instructions must be provided from the manufacturer.

The TIA, together with appropriate documentation and labeling, must be supplied with each unit submitted for testing. The TIA, including all associated connectors and cables, must operate without degrading the performance of the EUT.

The cables supplied to connect the TIA and the unit under test must be of sufficient length to permit the physical separation of the TIA from the EUT in environmental testing (approximately 5 to 6 feet).

The connectors supplied for connection of the TIA and/or the EUT to the test equipment must be standard connectors (N-type, BNC [recommended for 800 MHz only] or SMA). If specialized or proprietary connectors are used, adapters must be provided.

Additional criteria may be added to the TIA requirement if deemed necessary by the testing laboratory.

1.8 Subscriber Unit Documentation:

All documentation associated with the installation and operation of the equipment shall be supplied in accordance with the CTIA Program Management Document-Mobile Station Certification Programs. This includes:

- User guides or manuals
- Programming instructions
- Installation guides or manuals
- Service manuals, including manual control of EUT from TIA and/or keypad
- Identification of the IF frequencies used in the receiver.
- Diagram of the Test Interface Adapter, giving details of the pin connections.
- Submission checklist (Appendix B: Test Result Reporting).

A telephone number and contact person at the manufacturer shall also be supplied to provide backup, and to answer technical or operational questions.

1.9 Test Equipment and Software:

The “core” test equipment used during the evaluation will be identified in each individual Test Procedure/Section. Core test equipment may be substituted if test equipment equivalency can be confirmed. Should this occur, such change shall be noted in the Test Report. Equipment shall be calibrated to standards traceable to NIST.

1.10 Test Environment:

All tests as described in this Test Plan will be performed at a CTIA Authorized Test Laboratory (CATL) for CTIA Certification. Personnel performing the test will be experienced in the testing of mobile communications equipment with respect to radiated power measurements. Special instructions where needed for operation of EUT, will be provided by the manufacturer.

Manufacturers will work directly with a CATL (of their choice) to have equipment tested. All tests will be performed at test facilities accredited to ISO/IEC Guide 17025.

1.11 Failure Criteria:

Failure during the tests may occur as:

a) ***Failure to Meet a Required Parameter/Specification*** - If this condition is observed, a reasonable check of the unit shall be carried out to ensure that no catastrophic failure has taken place. If the unit under test is functional, the tests shall be continued and failures reported in the Test Report, and/or the second test sample substituted when reasonable.
b) ***Serious Failure*** - This shall include failure to function, physical failure, burning, etc. If such failure occurs, the tests will be stopped and the second test sample substituted for the balance of the tests.

All failures of any type will be noted in the Test Report. Where deemed appropriate by the testing laboratory, interim failures will also be reported for recommended action. Repairs or alterations to the EUT will not be made unless specifically instruction to do so by the manufacturer/client. Such work is not considered within the scope of testing to this procedure.

For certification purposes, tests different from those shown in this Test Plan will only be conducted upon instruction by CTIA. Certain tests are conducted for informational purposes only.

1.12 Test Reports:

The test report will provide the results of the tests, and will include:

1. The type, serial number and description of the equipment tested.
2. FCC ID Number and Software Revision.
3. The date of the tests.
4. The person who performed the tests.
5. The laboratory facility used for the tests.
6. The reference Test Plan to which the units were tested.
7. The test results, identifying each set of results for each individual procedure.
8. A list of where the unit did not meet the specified criteria (failures).
9. Data and plots.
10. Contact Point.
11. Chamber characterization data and date of last characterization.

The Certification Test Report will not normally provide any analysis of why the unit might have failed any test, and will not suggest any modifications to correct the problem.

Two copies of all Certification Test Reports will be delivered to CTIA. Requests for additional copies should be made through CTIA.

Specific test results will only be released to the submitting manufacturer. CTIA will maintain complete confidentiality of specific test results. Upon satisfaction of the CTIA Certification Program Manager that all Certification Program requirements have been met, a unit will be added to the CTIA List of Certified Mobile Stations. This list is made available to the industry and the general public.

Neither public nor industry notifications will be made upon the failure of a unit to meet Certification Program Requirements. Specific test data results will not be released without the written approval of the submitting manufacturer.

Section 2: Scope of Measurements

Good antenna performance is critical to the effective operation of a cellular or PCS device in today's networks. As devices become smaller antenna performance is often compromised. Achieving an efficient antenna in a small size and over both cellular and PCS frequency bands is a difficult task. A comprehensive and accurate characterization of antenna performance will enable cellular/PCS carriers and device manufacturers to determine how well devices will work within the constraints of a specific cellular network design.

Generally, peak EIRP (Effective Isotropic Radiated Power) is not a good indication of mobile performance in the field. For example, if the radiation pattern of the device's antenna system is highly directive, the peak EIRP would be high (since the antenna gain is high in one direction), while coverage is poor in other directions. In a cellular environment it is best to maximize the spatial coverage of the antenna system so the user does not have to point the antenna in one particular direction to get good call performance. Further, the human head can alter the shape and peak value of the EUT radiation pattern and hence radiated power pattern. Losses due to the head can vary significantly with frequency, device size, and the antenna design implemented. From a field performance perspective, measurement of the average and peak EIRP on a head model is more meaningful than measurement of peak EIRP in free-space conditions.

Receiver performance is considered as important to over all system performance as is Transmitter performance. The downlink, or subscriber unit receive path. is integral to the quality of the device's operation. Poor receiver radiated performance will cause the user of the subscriber unit to hear a low quality voice signal. This also causes the subscriber unit to loose the base station signal resulting in abrupt termination of the call. This test specification requires spherical effective radiated receiver sensitivity (Receiver Total Isotropic Sensitivity) to be measured. A frequent cause of poor sensitivity on a single channel, or a small number of channels, is due to receiver in-band noise, or spurious signals from the transmitter itself being radiated back into the receiver. The receiver sensitivity will be measured with the transmitter set to the maximum power output allowed by the particular EUT and technology combination.

The procedures defined herein will verify acceptable test chambers for measurements in both cellular and PCS (if applicable) bands; measure terminal EIRP and receiver performance for digital cellular/PCS, and analog cellular; measure mobile performance in free-space and with a simulated head/head and torso.

2.1 Device Measurements--Transmitter:

The radiated RF performance of the Equipment Under Test (EUT) is measured by sampling the radiated transmit power of the mobile at various locations surrounding the device. A three-dimensional characterization of the 'transmit' performance of the EUT is pieced together by analyzing the data from the spatially distributed measurements. Data points taken every 15 degrees in the Theta (θ) and in the Phi (Φ) axes are sufficient to fully characterize the EUT's far field radiation pattern and total radiated power. This accounts for a total of 277 measurements for each measurement antenna polarization.

2.2 Device Measurements--Receiver:

The receiver performance of the Equipment Under Test (EUT) is measured utilizing Bit Error Rate (BER) or Frame Errasure Rate (FER). This test specification uses the appropriate digital error rate (as measured by the subscriber unit) to evaluate effective radiated receiver sensitivity at each spatial measurement location. A three-dimensional characterization of the receiver performance of the EUT is pieced together by analyzing the data from the spatially distributed measurements. Data points taken every 30 degrees[1] in the Theta (θ) and in the Phi (Φ) axes are sufficient to fully characterize the EUT's receiver pattern. All of the measured sensitivity values for each EUT test condition will be integrated to give a single figure of merit referred to as Total Isotropic Sensitivity (TIS).

Some digital technologies and/or EUT's may not allow the measurement of digital error rate without special procedures for controlling the EUT. In this case, external cables and manual test commands may be applied to the EUT for setup purposes only. All such cables must be removed and the EUT operated in stand-alone self contained battery powered mode during the data collection process.

2.3 Device Measurements--General:

Two acceptable methods of scanning the EUT are proposed. (1) The "conical" cut method, whereby the EUT rotates on its long axis and the measurement antenna is moved to several locations over head for each rotation. (2) The measurement antenna remains fixed and the EUT is rotated about two axes in sequential order, typically referred to as a "great circle" cut method. Section 2.5 Great Circle Test Method describes the great circle cut method, and Section 2.4 Conical Cut Test Method describes the conical cut method.

In both methods, the angle of elevation in the long axis of the EUT is referred to as the Theta angle, and the azimuth angle of the EUT is referred to as the Phi angle. The axis of turntable rotation will measure along the Theta axis for the great circle cut method, and along the Phi axis for the conical cut method. Although the data is gathered in a different order, the resultant data from both methods is processed in the same manner. The measurement antenna should be capable of measuring in two polarizations; horizontal and vertical. These two polarizations may be measured simultaneous with the EUT rotation or with sequential rotations. A separate rotation in the Phi plane with the EUT vertically orientated may be scanned for easy visualization of the more traditional H-plane radiation pattern.

Measurement makes use of the calibration data obtained from Appendix D: Test Site Calibration to normalize measurements of RF power radiated by the EUT performed over a spherical surface with the EUT's antenna centered at the sphere. A Base Station

[1] The use of a 30 degree spatial separation increment is preliminary. An investigation is underway to determine the loss in overall accuracy vs. the 15 degree spatial separation increment used in the transmitter tests. The agreed goal of the receiver test is to find TIS with an accuracy of 2dB or better with a certainty of 95%.

Simulator is used to setup calls to the EUT and to request reports of signal strength that the EUT is measuring on the 'receive' frequency of the call. These two measurements may be taken individually or together as part of a single set of sampling scans. Data is collected and stored during the measurement step for delivery with the test report for each device tested.

Measurements will be made in a (1) "free-space" configuration whereby the EUT will be placed directly on a turntable, and; (2) "simulated-use[2]" configuration whereby the EUT will be placed against a simulated head/head and torso phantom meeting the characteristics defined in Appendix E: Simulated Head Design and Construction. Measurements will be performed with the antenna of the EUT extended and retracted (if applicable) in these two test configurations. Refer to Appendix A:Test Set-up Configurations for illustration of a "free-space" configuration. "Simulated-use" configuration will place the EUT against a simulated head/head and torso phantom with the simulated head/head and torso placed atop the turntable.

Different measurement results may be obtained between positioning the EUT on the left or right ear of the phantom. Measurement variability may also be attributed to the level of fluid in the phantom; especially when the phantom is positioned horizontally (Great Circle Cut). To minimize measurement uncertainties, air bubbles in the phantom should be eliminated by completely filling the phantom with fluid. Special care should be taken when performing Great Circle Cut measurements on the phantom to ensure the center of rotation is indeed about the EUT in each measurement axis.

Tests shall be conducted on all possible EUT configurations (i.e., battery pack configurations, housing schemes) unless it is demonstrated that there is negligible impact to performance with the different options. It is the responsibility of the manufacturer to define which options represent the "baseline" configuration and to provide adequate supporting data that validates assumptions for reduced testing of the remaining options. At a minimum, a complete set of measurements is required for the baseline EUT configuration.

2.4 Conical Cut Test Method

Appendix A: Test Set-up Configurations shows a diagram of the conical cut measurement method. The conical cut method requires the ability of the measurement antenna to be rotated in the Theta plane (overhead) of the EUT. Thirteen conical cuts are required to capture data every 15 degrees from the EUT; with the top (0 degrees) and bottom (minus 180 degree) cuts being at only one Phi angle. Typically, the EUT will remain affixed to a turntable during the entire measurement process. The measurement antenna will be positioned in at a starting Theta angle. The EUT will then be rotated around the full 360 degrees of Phi rotation. The EUT then be moved to the next Theta angle, and the process repeated.

[2] The simulated-use configuration applies to handheld portable units only.

Measurements of the radiated transmit power and receiver sensitivity should be recorded in both vertical and horizontal polarizations simultaneously to reduce measurement uncertainties due to EUT repositioning. The EUT will report the power it measures in the receive-band by sending a message to the Base Station Simulator (for technologies that support this function).

2.5 Great Circle Test Method

Appendix G: Great Circle Measurement Orientation Diagrams shows diagrams of some of the Great Circle (Theta rotation) cuts. Twelve Theta rotation cuts are measured while rotating the EUT in the Phi plane (end-over-end) in 15 degree increments over the entire 360 degree Theta rotation range. The composite of the Theta cuts provides a three-dimensional view of the antenna pattern and performance. Some reference Theta rotation cuts are measured as described in the table below. The full list of Theta rotation cuts is: T0, T15, T30, T45, T60, T75, T90, T105, T120, T135, T150, & T165.

Table 2.3-1: Great Circle Cut Designations

Cut Designation	Description
T0	0-degree Cut: the plane normal to the faceplate of the EUT and parallel with the long dimension of the phone
T45	45-degree Cut: the plane at 45-degrees clockwise from the normal to the faceplate of the EUT and parallel with the long dimension of the EUT
T90	90-degree Cut: the plane normal to the narrow dimension of the EUT and parallel with the long dimension of the EUT
T135	135-degree Cut: the plane at 45-degrees counterclockwise from the normal to the faceplate of the EUT and parallel with the long dimension of the EUT

Refer to Appendix G:Great Circle Measurement Orientation Diagrams for graphic illustrations for the four reference measurement orientations. The other listed orientations are in-between the reference orientations respectively. For most turntable configurations, it is generally convenient to place the EUT horizontally to measure the Theta rotation cuts. Jigs that are fabricated using a low loss, low dielectric constant material may be constructed to assist in positioning the EUT on the turntable so that it remains stable during the measurements.

Measurements of the radiated transmit power and receiver sensitivity should be recorded in both vertical and horizontal polarizations simultaneously to reduce measurement uncertainties due to EUT repositioning. The EUT will report the power it measures in the receive-band by sending a message to the Base Station Simulator (for technologies that support this function).

The figure shown in Appendix A: Test Set-up Configurations illustrates the measurement configuration for the Great Circle cut method[3]. The EUT is oriented to measure the T0 cut in this illustration.

2.6 Traditional H-Plane Measurements:

A single H-plane cut at bore-sight will be measured by orienting the long dimension of the EUT vertically. Signal strengths will be recorded while rotating the EUT in 6 degree increments over the entire 360 degree azimuthal range. Measurements of the radiated transmit power can be recorded in both vertical and horizontal polarizations simultaneously. Received signal strength will be reported by the EUT to the Base Station Simulator.

The figure show in Appendix A: Test Set-up Configurations illustrates the measurement configuration for the H-plane cut. Note: the **vertically oriented** measurement antenna should be connected to the cable feeding the Power Splitter/Base Station Simulator for this orientation.

[3] If the laboratory is equipped with a suitable three-dimensional positioner, then this may be used to improve results and reduce measurement time over taking twelve E-plane cuts. This type of measurement method would be the Conical Cut method as described in Section 2.4 Conical Cut Test Method

Section 3: Test Procedure – Radiated Power

Evaluations herein will be conducted in locations meeting the requirements specified in Appendix C: Test Site Characteristics & Quiet Zone Accuracy. Test sites shall be calibrated in accordance with the procedures specified in Appendix D: Test Site Calibration. Calibration data shall be included in the final test report of the EUT (Equipment Under Test). Unless otherwise noted, all evaluations will be performed in 'conversational' mode, at maximum transmit power.

Products supporting multiple air-interface technologies will be tested in accordance with all relevant test procedures. Test results will be provided for each test performed in the format defined in Appendix B: Test Result Reporting.

3.1 Analog TIA/EIA/IS-91A:

The measurement site and EUT shall be configured as specified in Appendix A: Test Set-up Configurations. The power radiated by the EUT shall be measured using a calibrated and accurate RF measuring instrument (e.g., *Spectrum Analyzers/Measurement Receivers/Power Meter).*

Using the parameters in Table 3.1-1 for the Analog Control Channel, and related parameters for the mobile station, page the EUT and direct it to a voice/traffic channel.

Table 3.1-1: Analog Base Station Parameters

Parameter	Setting
Type	AMPS/NAMPS
Band	800
System	B
Channel	334
SID	1234
VMAC	0
DCC	1
Initial AVC	991
Base Station Power	-50 dBm

Tests shall be conducted for three different frequency pairs across the Cellular Bands, as defined in Table 3.1-2. Efficiency may be gained by performing handoffs to each frequency pair while the EUT is positioned at each measurement coordinate. Handoffs can be accomplished using the Base Station Simulator thereby eliminating the need to disturb the test configuration or adjust the EUT. The test site/chamber shall be calibrated for these frequencies, and calibration data provided in the report.

Table 3.1-2 TIA/EIA-91A Test Frequencies

Band	Channel Pair	Designation	Frequency (MHz)
Cellular A	991	CH_1-TX	824.04
Cellular A	991	CH_1-RX	Not Applicable
Cellular B	384	CH_2-TX	836.52
Cellular B	384	CH_2-RX	Not Applicable
Cellular B	799	CH_3-TX	836.52
Cellular B	799	CH_3-RX	Not Applicable

Radiated power measurements will be recorded in the "free-space" configuration on all applicable frequencies with the EUT antenna configurations extended and retracted, if applicable.

For handheld portable units, radiated power measurements will be repeated on all applicable frequencies, and with all antenna configurations, with the EUT placed against a simulated head/head and torso phantom to simulate the effects a human head would have on the antenna performance.

A diagram with the example procedural flow is shown in Appendix H: Example Flow Diagram for the Device Measurement Procedure for Each Cut. This diagram describes the procedure for cycling through all frequencies and all azimuthal positions for a single antenna configuration and great-circle antenna pattern cut. It must be repeated when a different cut and/or antenna configuration is required. It also must be repeated for characterizing the effects of the simulated head/head and torso.

3.1.1 Criteria – Analog Radiated Power

Radiated RF Power shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2Calculating Spatially Averaged Quantities. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Table 3.1.1-1: Analog Minimum Radiated Power Level Requirements

Device Power (Class)	Free-Space Radiated Power Extended/Retracted	Simulated Head Radiated Power Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

Note: RF Power measured conductivity shall comply with the power levels specified in relevant industry standard(s).

3.2 CDMA TIA/EIA/IS-98B and ANSI-J-STD-008:

The measurement site and EUT shall be configured as specified in Appendix A: Test Set-up Configurations. The power radiated by the EUT shall be measured using a calibrated and accurate RF measuring instrument (e.g., *Spectrum Analyzers/Measurement Receivers/Power Meter)*. Note: see Appendix F.4 CDMA: for CDMA TIA/EIA/IS-95 power measurement considerations.

Using the parameters in Table 3.2-1 for the CDMA Pilot Channel, and related parameters for the mobile station, page the EUT and direct it to a voice/traffic channel.

Table 3.2-1: CDMA Base Station Parameters IS-95B

Parameter	Setting
Type	CDMA
Band	800
Channel (Reg.)	283 *
SID	1234*
NID	65535*
Service Option	2
Rate	Full
Pilot Channel	-7 dBm
Traffic Channel	-15.6 dBm
Power Control	Always Up
Path Loss	See table 4.1-1

Table 3.2-2: CDMA Base Station Parameters – J-STD-018

Parameter	Setting
Type	CDMA
Band	1900
Channel (Reg.)	25 *
SID	1234*
NID	65535*
Service Option	2
Rate	Full
Pilot Channel	-7 dBm
Traffic Channel	-15.6 dBm
Power Control	Always Up
Path Loss	See table 4.1-1

*Note: * Registration channel, SID/NID are service provider specific*

Tests shall be conducted for three different frequency pairs across the bands supported by the EUT (i.e., cellular and/or PCS), as defined in Table 3.2-1. Efficiency may be gained by performing handoffs to each frequency pair while the EUT is positioned at each measurement coordinate. Handoffs can be accomplished using the Base Station

Simulator thereby eliminating the need to disturb the test configuration or adjust the EUT. The test site/chamber shall be calibrated for these frequencies, and calibration data provided in the report.

Table 3.2-3 TIA/EIA/IS-95B Test Frequencies

Band	Channel Pair	Designation	Frequency (MHz)
Cellular A	1013	CH_1-TX	824.7
Cellular A	1013	CH_1-RX	869.7
Cellular B	384	CH_2-TX	836.52
Cellular B	384	CH_2-RX	881.52
Cellular B	777	CH_3-TX	848.31
Cellular B	777	CH_3-RX	893.31
PCS A	25	CH_4-TX	1851.25
PCS A	25	CH_4-RX	1931.25
PCS B	600	CH_5-TX	1880.00
PCS B	600	CH_5-RX	1960.00
PCS C	1175	CH_6-TX	1908.75
PCS C	1175	CH_6-RX	1988.75

Radiated power measurements will be recorded in the ”free-space” configuration on all applicable frequencies with the EUT antenna configurations extended and retracted, if applicable.

For handheld portable units, radiated power measurements will be repeated on all applicable frequencies, and with all antenna configurations, with the EUT placed against a simulated head/head and torso phantom to simulate the effects a human head would have on the antenna performance.

A diagram with the example procedural flow is shown in Appendix H: Example Flow Diagram for the Device Measurement Procedure for Each Cut. This diagram describes the procedure for cycling through all frequencies and all azimuthal positions for a single antenna configuration and great-circle antenna pattern cut. It must be repeated when a different cut and/or antenna configuration is required. It also must be repeated for characterizing the effects of the simulated head/head and torso.

3.2.1 Criteria – CDMA Radiated Power

Radiated RF Power shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2Calculating Spatially Averaged Quantities. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Table 3.2.1-1: CDMA Minimum Radiated Power Level Requirements

Device Power (Class)	Free-Space Radiated Power Extended/Retracted	Simulated Head Radiated Power Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

Note: RF Power measured conductivity shall comply with the power levels specified in the relevant industry standard(s).

3.3 TDMA TIA/ANSI-136:

The measurement site and EUT shall be configured as specified in Appendix A: Test Set-up Configurations. The power radiated by the EUT shall be measured using a calibrated and accurate RF measuring instrument (e.g., Spectrum *Analyzers/Measurement Receivers/Power Meter capable of averaging across burst).* Note: TIA/EIA-136 is a non-constant envelope TDMA technology; as such the power must be averaged over the active time slots only (see Appendix F.1 TDMA TIA/ANSI-136:).

Using the parameters in Table 3.3-1 for the Digital Control Channel, and related parameters for the mobile station, page the EUT and direct it to a voice/traffic channel.

Table 3.3-1: ANSI-136 Base Station Parameters

Parameter	Setting
Type	Digital
Band	Cellular/PCS
System	B
Channel	700
SID	1234
DMAC	2
DVCC	128
Time Alignment	0
Time Slot	1 (or 1+4)
Rate	Full
Access Burst	1
Initial DTC	991
Base Station Power	-50 dBm

Tests shall be conducted for three different frequency pairs across the bands supported by the EUT (i.e., cellular and/or PCS), as defined in Table 3.3-2. Efficiency may be gained by performing handoffs to each frequency pair while the EUT is positioned at each measurement coordinate. Handoffs can be accomplished using the Base Station Simulator thereby eliminating the need to disturb the test configuration or adjust the EUT. The test site/chamber shall be calibrated for these frequencies, and calibration data provided in the report.

Table 3.3-2 ANSI-136 Test Frequencies

Band	Channel Pair	Designation	Frequency (MHz)
Cellular A	991	CH_1-TX	824.04
Cellular A	991	CH_1-RX	869.04
Cellular B	384	CH_2-TX	836.52
Cellular B	384	CH_2-RX	881.52
Cellular B	799	CH_3-TX	848.97
Cellular B	799	CH_3-RX	893.97
PCS A	2	CH_4-TX	1850.04
PCS A	2	CH_4-RX	1930.08
PCS B	999	CH_5-TX	1879.95
PCS B	999	CH_5-RX	1959.99
PCS C	1998	CH_6-TX	1909.92
PCS C	1998	CH_6-RX	1989.96

Radiated power measurements will be recorded in the ”free-space” configuration on all applicable frequencies with the EUT antenna configurations extended and retracted, if applicable.

For handheld portable units, radiated power measurements will be repeated on all applicable frequencies, and with all antenna configurations, with the EUT placed against a simulated head/head and torso phantom to simulate the effects a human head would have on the antenna performance.

A diagram with the example procedural flow is shown in Appendix H: Example Flow Diagram for the Device Measurement Procedure for Each Cut. This diagram describes the procedure for cycling through all frequencies and all azimuthal positions for a single antenna configuration and great-circle antenna pattern cut. It must be repeated when a different cut and/or antenna configuration is required. It also must be repeated for characterizing the effects of the simulated head/head and torso.

3.3.1 Criteria – ANSI-136 Radiated Power

Radiated RF Power shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2Calculating Spatially Averaged Quantities. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Table 3.3.1-1: ANSI-136 Minimum Radiated Power Level Requirements

Device Power (Class)	Free-Space Radiated Power Extended/Retracted	Simulated Head Radiated Power Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD
Class IV	TBD	TBD

Note: RF Power measured conductivity shall comply with the power levels specified in the relevant industry standard(s).

3.4 GSM-1900 J-STD-007 & ETSI PCS 11.10:

The measurement site and EUT shall be configured as specified in Appendix A: Test Set-up Configurations. The power radiated by the EUT shall be measured using a calibrated and accurate RF measuring instrument (e.g., Spectrum *Analyzers/Measurement Receivers/Power Meter capable of averaging across burst).* Note: GSM-1900 is a constant envelope TDMA technology. See Appendix F.2 GSM-1900 -- J-STD-007 for power measurement considerations.

Using the parameters in Table 3.4-1 for the Broadcast Control Channel, and related parameters for the mobile station, page the EUT and direct it to a voice/traffic channel.

Table 3.4-1: GSM-1900 Base Station Parameters

Parameter	Setting
Type	GSM
Band	1900
Channel	700
Time Slot	1
Rate	Full
Access Burst	1
Base Station Power	-50 dBm

Tests shall be conducted for three different frequency pairs across the bands supported by the EUT, as defined in Table 3.4-2. Efficiency may be gained by performing handoffs to each frequency pair while the EUT is positioned at each measurement coordinate. Handoffs can be accomplished using the Base Station Simulator thereby eliminating the need to disturb the test configuration or adjust the EUT. Test site shall be calibrated for these frequencies, and calibration data provided in the report.

Table 3.4-2 GSM-1900 Test Frequencies

Band	Channel Pair	Designation	Frequency (MHz)
PCS A	512	CH_1-TX	1850.20
PCS A	512	CH_1-RX	1930.20
PCS B	661	CH_2-TX	1880.00
PCS B	661	CH_2-RX	1960.00
PCS C	810	CH_3-TX	1909.80
PCS C	810	CH_3-RX	1989.80

Radiated power measurements will be recorded in the ”free-space” configuration on all applicable frequencies with the EUT antenna configurations extended and retracted, if applicable.

For handheld portable units, radiated power measurements will be repeated on all applicable frequencies, and with all antenna configurations, with the EUT placed against a simulated head/head and torso phantom to simulate the effects a human head would have on the antenna performance.

A diagram with the example procedural flow is shown in Appendix H: Example Flow Diagram for the Device Measurement Procedure for Each Cut. This diagram describes the procedure for cycling through all frequencies and all azimuthal positions for a single antenna configuration and great-circle antenna pattern cut. It must be repeated when a different cut and/or antenna configuration is required. It also must be repeated for characterizing the effects of the simulated head/head and torso.

3.4.1 Criteria – GSM-1900 Radiated Power

Radiated RF Power shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2Calculating Spatially Averaged Quantities. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Table 3.4.1-1: GSM-1900 Minimum Radiated Power Level Requirements

Device Power (Class)	Free-Space Radiated Power Extended/Retracted	Simulated Head Radiated Power Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

Note: RF Power measured conductivity shall comply with the power levels specified in the relevant industry standard(s).

Section 4: Test Procedure -- Receiver Performance

Evaluations herein will be conducted in locations meeting the requirements specified in Appendix C: Test Site Characteristics & Quiet Zone Accuracy. Test sites shall be calibrated in accordance with the procedures specified in Appendix D: Test Site Calibration. Calibration data shall be included in the final test report of the EUT (Equipment Under Test).

Products supporting multiple air-interface technologies shall be tested in accordance with all relevant test procedures. Test results will be provided for each test performed in the format defined in Appendix B: Test Result Reporting.

Receiver Performance measurements may be made simultaneously with tests performed in Section 3: Test Procedure – Radiated Power. For measurements not made in conjunction, test setups and frequencies defined in this section should be used.

Total Isotropic Sensitivity (TIS) will be fully measured on three (3) channels (low, middle and high) as described in Section 3:Test Procedure – Radiated Power for the frequency bands supported by the EUT. All of the remaining intermediate channels must be evaluated for relative sensitivity. This is to be done by comparison of the 3 fully measured channels with the intermediate channels measured. Since some digital technologies have a very large number of intermediate channels, some channels may be omitted from actual testing provided there is no more than 500KHz between any two successive intermediate channels. All or any combination of intermediate channels may be evaluated, as long as the maximum separation rule is followed. Refer to Appendix I: Total Isotropic Sensitivity for details on TIS.

Handheld units[4] must be evaluated in the head adjacent talk position against a phantom as described in Appendix E: Simulated Head Design and Construction. Devices other than handheld units must be evaluated in the free space configuration. A base station simulator appropriate for the air-interface is required for these tests and will be used to report the digital error rate found by the EUT. The EUT will be placed in an active call on the specified test channel(s), and in the specified test conditions. The RF power level of the base station simulator will then be adjusted to achieve the desired digital error rate at each measured location on the sphere. The digital error rate from the EUT will be extracted from the base station simulator. A sufficient number of bits or frames will be sampled such that the confidence interval in digital error rate is 95% or better. Since the process of measuring effective radiated receiver sensitivity is typically less accurate than measuring transmitter radiated power, this test specification allows for a relaxation in the spatial separation to 30 degrees in the Theta (θ) and in the Phi (Φ) axes for TIS[5]; as noted in Section 2.2 Device Measurements--Receiver:.

[4] Refer to Section 1.6EUT - The Cellular Subscriber Station: for definition of handheld units.

[5] The use of a 30 degree spatial separation increment is preliminary. An investigation is underway to determine the loss in overall accuracy vs. the 15 degree spatial separation increment used in the transmitter tests. The agreed goal of the receiver test is to find TIS with an accuracy of 2dB or better with a certainty of 95%.

4.1 Analog TIA/EIA/IS-91A:

Receiver sensitivity measurements, as recommended in this specification, are not presently supported in AMPS. Accordingly, test methods for analog receiver sensitivity are not specified. On definition of an accurate test method, this section will be revisited.

4.1.1 Criteria -- Analog

This section will be revisited on adoption of an accurate test method.

4.2 CDMA TIA/EIA/IS-98B and ANSI-J-STD-008:

Receiver Sensitivity measurements will be conducted using the *Base Station Simulator* to determine the EUT's receiver sensitivity by reporting the forward-link power[6] resulting in a Frame Error Rate (FER) of 3.0%. Refer to Appendix A: Test Set-up Configurations for set-up illustrations in the free-space configuration.

Using the set-up parameters defined in Section 3.2 CDMA TIA/EIA/IS-98B and ANSI-J-STD-008:, page the EUT and direct it to a voice/traffic channel ensuring the EUT is transmitting at maximum power. With a digital voice/traffic channel established, invoke a FER Measurement.

FER measurements shall be obtained with the RF power level of the call simulator adjusted so as to achieve the desired digital error rate (3.0% +/- 1.0%) at each measured location on the sphere. A minimum of 1000 frames should be observed. The RF level resulting in the targeted sensitivity values for each EUT test condition will be integrated pursuant to Appendix B.2 Calculating Spatially Averaged Quantities to give a single figure of merit referred to as Total Isotropic Sensitivity (TIS).

TIS will be fully measured on 3 channels (low, middle and high) as described in Section 3: Test Procedure – Radiated Power for the frequency bands supported by the EUT.

Measurements will be repeated on all or any combination of intermediate channels, provided that the maximum separation rule is followed.

Procedure for measuring relative sensitivity on intermediate channels:

a) Move the EUT and chamber positioner(s) to the location & polarization resulting in the best radiated sensitivity measured for the closest, in frequency, fully measured channel, now used as a Reference Channel.

b) Increase the RF signal level of the digital call simulator by 10dB over that used at the same spherical spatial location for the respective Reference Channel.

c) Using the digital call simulator, measure the appropriate digital error rate for this test condition. The measured digital error rate must not exceed that found on the reference channel.

[6] Determining the precise Base Station Simulator power is critical as this is what thew EUT measures.

Handheld units[7] must be evaluated in the head adjacent talk position against a phantom as described in Appendix F: Power Measurement Considerations. Devices other than handheld units must be evaluated in the free space configuration.

4.2.1 Criteria -- CDMA Sensitivity

Receiver Sensitivity TIS shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2.3 Total Isotropic Sensitivity. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Relative sensitivity on intermediate channels test results shall be provided in a file format equivalent to that specified in Appendix B.1Measurement Data Files Radiated Power:

Table 4.2.6-1 CDMA RX Sensitivity Requirements

Device Power (Class)	Free-Space RX Sensitivity Extended/Retracted	Simulated Head RX Sensitivity Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

4.3 TDMA TIA/ANSI-136:

Receiver Sensitivity procedures will utilize the same spherical measurement procedure as specified for the Transmitter power measurements in Section 3: Test Procedure – Radiated Power. Measurement however must be obtained while the EUT is in a test mode, and not in the normal call processing mode of operation. Therefore, the specific set of commands necessary to place the EUT in "loop back mode" must be obtained from the manufacturer in order to begin testing. A list of the test mode commands is specified in TIA/EIA-136-270A, section 8. To place the EUT in loop back mode for the digital RX sensitivity test, the following commands may be used in the order specified by the terminal manufacturer:

Table 4.3-1: Commands for digital loop back Bit Error Rate (BER) Test

Command	Description
TIA/EIA-136-270 SUSPEND	Terminate the normal mode and enter the test mode
TIA/EIA-136-270 INIT	Initialize the transceiver
TIA/EIA-136-270 LOAD-SYNTH (LOAD-SYNTH HYPERBAND)	Set the synthesizer to the channel (channel and band) specified by the byte(s) following the command
TIA/EIA-136-270 SET-ATTN	Set the RF power attenuation to the value specified by the byte following the command

[7] Refer to Section 1.6EUT - The Cellular Subscriber Station: for definition of handheld units.

Command	Description
TIA/EIA-136-270 DCCH-DGTS	Switch to DCCH digital mode with slot assignment specified by one byte following the command
TIA/EIA-136-270 TDMAON	Synchronize to the forward traffic channel and set the DVCC and data format as specified by the first and second byte (respectively) following the command

There are two methods for setting up the EUT in digital loop back BER. The manufacturer and test facility shall determine the best method to use in order to minimize the test time, and maximize reproducibility. The methods are assigned in the order of preference:

a) Remote programming of test mode parameters via data cable. If available, the manufacturer shall provide the cable and application, which will allow the test facility to remotely program the EUT. Once the proper mode and channel has been selected, all equipment external to the EUT shall be removed prior to performing the RX sensitivity test.

b) Keypad programming of test mode parameters.

Using the set-up parameters defined in Section 3.3 TDMA TIA/ANSI-136: direct the EUT to a voice channel ensuring the EUT is transmitting at maximum power. With a digital voice channel established, invoke a BER Measurement.

Once the EUT is in digital loop back BER mode for the specified channel, the base station power will be lowered until a 3% BER (+/- 0.1%[8]) is measured by the base station when the number of bits measured is 100 kilo-bits. Prior to the final measurement(s) to achieve a 3% BER, the measurement device can use a minimum of 10 kilo-bits to determine if base station power is low enough.

Typically, the maximum deviation in RX level measurements from peak to null of any one channel does not exceed 30 dB. Therefore, the test facility may only raise the base station power 30 dB above the first 3% BER measurement level in order to reduce the number of BER measurements required. However, some measurements of EUTs may exceed 30 dB from peak to null when in the presence of a simulated head. If the base station power must be raised to greater than 30 dB above the last sensitivity (reference) level, then the sensitivity should be considered negligible for that location.

TIS pursuant to Appendix B.2 Calculating Spatially Averaged Quantities will be fully measured on the 3 channels (low, middle and high) as described in Section 3: Test Procedure – Radiated Power for the frequency bands supported by the EUT.

Measurements will be repeated on all or any combination of intermediate channels, provided that the maximum separation rule is followed.

[8] Further investigation of this error margin may cause to either increase or decrease.

Procedure for measuring relative sensitivity on intermediate channels:

d) Move the EUT and chamber positioner(s) to the location & polarization of resulting in the best radiated sensitivity measured for the closest, in frequency, fully measured channel, now used as a Reference Channel.

e) Increase the RF signal level of the digital call simulator by 10dB over that used at the same spherical spatial location for the respective Reference Channel.

f) Using the digital call simulator, measure the appropriate digital error rate for this test condition. The measured digital error rate must not exceed that found on the reference channel.

Handheld units[9] must be evaluated in the head adjacent talk position against a phantom as described in Appendix F: Power Measurement Considerations. Devices other than handheld units must be evaluated in the free space configuration.

4.3.1: Criteria – ANSI-136 RX Sensitivity

Receiver Sensitivity TIS shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2.3 Total Isotropic Sensitivity. Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted. The reported RF level that produces a 3% BER for each channel shall be less than or equal to the levels noted below.

Relative sensitivity on intermediate channels test results shall be provided in a file format specified in Appendix B.1Measurement Data Files Radiated Power:

Table 4.3.1-1 ANSI-136 RX Sensitivity Requirements

Device Power (Class)	Free-Space RX Sensitivity Extended/Retracted	Simulated Head RX Sensitivity Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

[9] Refer to Section 1.6EUT - The Cellular Subscriber Station: for definition of handheld units.

4.4 GSM-1900:

Receiver Sensitivity procedures will utilize the same spherical measurement procedure as specified for the Transmitter power measurements in Section 3: Test Procedure – Radiated Power. Refer to GSM 05.05 and GSM 11.10 for procedures and criteria for the setup of loop back mode. The base station simulator shall place the EUT into Loop back mode.

Using the set-up parameters defined in Section 3.4 GSM-1900 J-STD-007 & ETSI PCS 11.10: page the EUT and direct it to a voice/traffic channel ensuring the EUT is transmitting at maximum power. With a digital voice/traffic channel established, invoke a BER Measurement.

Once in loop back mode, the base station power is lowered until a 2.44% (+/- 0.1%[1]) RBER is measured by the base station when the number of samples measured is 10 kilo-bits.

Typically, the maximum deviation in RX level measurements from peak to null of any one channel does not exceed 30 dB. Therefore, the test facility may only raise the base station power 30 dB above the first 3% BER measurement level in order to reduce the number of BER measurements required. However, some measurements of EUTs may exceed 30 dB from peak to null when in the presence of a simulated head. If the base station power must be raised to greater than 30 dB above the last sensitivity (reference) level, then the sensitivity should be considered negligible for that location.

TIS pursuant to Appendix B.2 Calculating Spatially Averaged Quantities will be fully measured on the 3 channels (low, middle and high) as described in Section 3: Test Procedure – Radiated Power for the frequency bands supported by the EUT.

Measurements will be repeated on all or any combination of intermediate channels, provided that the maximum separation rule is followed.

Procedure for measuring relative sensitivity on intermediate channels:

g) Move the EUT and chamber positioner(s) to the location & polarization resulting in the best radiated sensitivity measured for the closest, in frequency, fully measured channel, now used as a Reference Channel.

h) Increase the RF signal level of the digital call simulator by 10dB over that used at the same spherical spatial location for the respective Reference Channel.

i) Using the digital call simulator, measure the appropriate digital error rate for this test condition. The measured digital error rate must not exceed that found on the reference channel.

Handheld units[10] must be evaluated in the head adjacent talk position against a phantom as described in Appendix F: Power Measurement Considerations. Devices other than handheld units must be evaluated in the free space configuration.

4.4.1: Criteria – GSM 1900 RX Sensitivity

Receiver Sensitivity TIS shall be reported using the Figure of Merit for industry analyzes, as specified in Appendix B.2.3 Total Isotropic Sensitivity Reports shall include results for free-space and simulated-use configurations (if applicable) across all channels measured with the EUT antenna extended and retracted.

Relative sensitivity on intermediate channels test results shall be provided in a file format specified in Appendix B.1Measurement Data Files Radiated Power: The reported RF level that produces a 2.44% RBER for each channel shall be less than or equal to the levels noted below.

Table 4.4.1-1: GSM-1900 RX Sensitivity Requirements

Device Power (Class)	Free-Space RX Sensitivity Extended/Retracted	Simulated Head RX Sensitivity Extended/Retracted
Class I	TBD	TBD
Class II	TBD	TBD
Class III	TBD	TBD

[10] Refer to Section 1.6 EUT - The Cellular Subscriber Station: for definition of handheld units.

Appendix A: Test Set-up Configurations

A.1 Test Set-up – Free Space:

The Equipment Under Test (EUT) will be placed in a test chamber meeting the characteristics defined in Appendix C: Test Site Characteristics & Quiet Zone Accuracy and calibrated in accordance with Appendix D: Test Site Calibration.

Place the EUT atop a non-conductive turntable at a distance no less than 3 times the EUT transmitting frequency's wavelength from the measurement antenna. Adjust the elevation of the measurement antenna to be at boresight with the center of the EUT.

Using a simulated base-station, the EUT will be placed into a call and measurements performed in the E and H planes.

Figure A.1-1 Device Measurement Test Configuration – Great Circle Cut

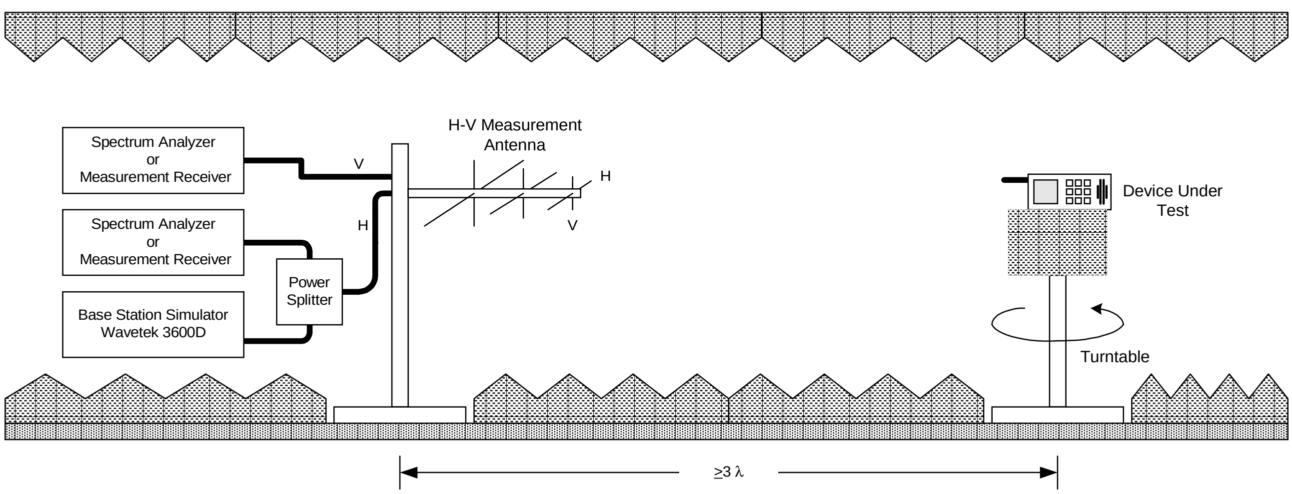


Figure A.1-2 Device Measurement Test Configuration – Traditional H0 Cut

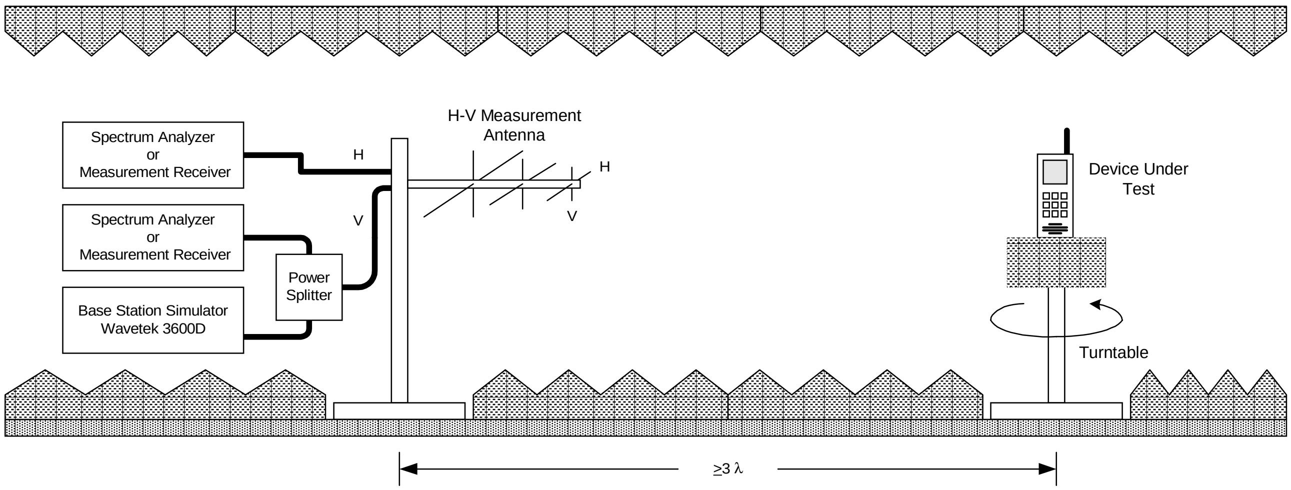
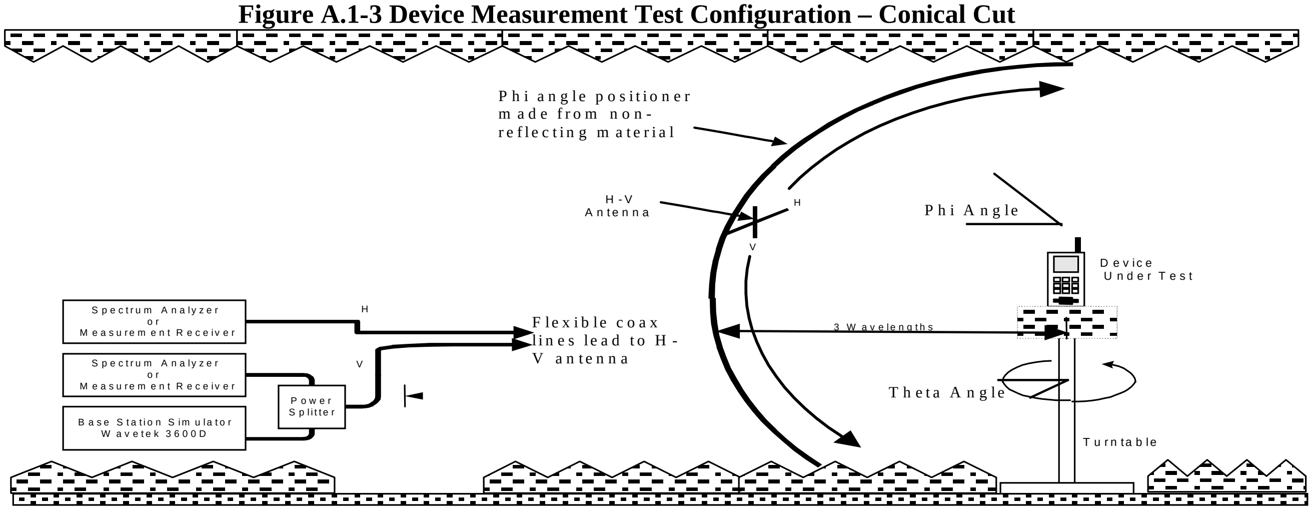


Figure A.1-3 Device Measurement Test Configuration – Conical Cut



A.2 Test Set-up -- Simulated Head/Phantom

Using the same Test Set-up procedures defined for free-space; place the EUT against a simulated head/head and torso phantom meeting the characteristics defined in Appendix E: Simulated Head Design and Construction. Position the EUT as illustrated in Figure E.1-1: Inclination Angle Statistics, with an angle of 65 degrees. The EUT position on "SAM" phantom is also illustrated in Appendix E.4 Definition of the EUT Position on "SAM" Phantom.

Place the simulated head/head and torso phantom atop a non-conductive turntable at a distance no less than 3 times the EUT transmitting frequency's wavelength from the measuring antenna. Adjust the elevation of the measurement antenna to be at boresight with the center of the EUT.

Using a simulated base-station, the EUT will be placed into a call and measurements performed in the E and H planes.

Appendix B: Test Result Reporting

Test reports and files will be provided as described in this section. Deliverables consist of a calibration file (Appendix D) and measurement data files for each EUT characterized.

Data will be reported so correlation with field performance can be determined with confidence. Pass/Fail criteria will be specified after sufficient analysis of the measured data has been conducted.

B.1 Measurement Data Files Radiated Power:

Measurements should be performed on at least three units calibrated using production level factory equipment and procedures. The mean and standard deviation in the performance levels should be assessed. Requirements for average and peak EIRP with head blockage have not been defined.

Data shall be supplied in a format accessible (i.e., readable) for additional examination and computation as outlined in Table B.1-1. For dual-band products, files shall be provided for (6 different frequency pairs) × (2 different antenna configurations, if applicable) × (2 different obstructions).

For single-band products, files shall be provided for (3 different frequency pairs) × (2 different antenna configurations, if applicable) × (2 different obstructions).

For great-circle cuts, each file shall contain measurements for 12 cuts × (2 transmit polarizations + 1 receive polarization). Based on samples measured every 15 degrees of rotation for each cut, approximately 540 measurements are recorded in each file.

Table B.1-1 Example Measurement Data File Format

Date of Measurement:	24 Aug 2000
Device Mfr/Model:	Acme 2000
TX Frequency:	CH_i-TX
RX Frequency:	CH_i-RX
Antenna [Retracted, Extended]:	Extended
Obstruction [Free Space, Simulated head/head and torso]:	Free Space

θ (degrees)	**Vertical TX EDRP (dBd)**				**Horizontal TX EDRP (dBd)**			
	ϕ=0	**ϕ=15**	**•••**	**ϕ=165**	**ϕ=0**	**ϕ=15**	**•••**	**ϕ=165**
0	28.1	28.1	•••	28.1	28.1	28.1	•••	28.1
15	28.1	28.1	•••	28.1	28.1	28.1	•••	28.1
30	28.1	28.1	•••	28.1	28.1	28.1	•••	28.1
• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •
345	28.1	28.1	•••	28.1	28.1	28.1	•••	28.1

θ (degrees)	**Vertical RX Sensitivity (@3% BER)**				**Horizontal RX Sensitivity (@3% BER)**			
	ϕ=0	**ϕ=30**	**•••**	**ϕ=150**	**ϕ=0**	**ϕ=30**	**•••**	**ϕ=150**
0	-112	-112	•••	-112	-112	-112	•••	-112
30	-112	-112	•••	-112	-112	-112	•••	-112
60	-112	-112	•••	-112	-112	-112	•••	-112
• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •	• • •
330	-112	-112	-112	-112	-112	-112	-112	-112

B.2 Calculating Spatially Averaged Quantities

Three figures of merit will be used to calculate the spatially averaged radiated EIRP and sensitivity[11]. Results from these figures of merit are for informational purposes and will not be used by the CTIA to pass or fail a device at this time. The objective is to use the following figures of merit to observe trends in performance over different products.

The spatially averaged effective radiated power and sensitivity values shall be derived from the measurement data. The spatial average is calculated as a sin-theta weighted ($\sin(\theta)$) average over all elevation angles. Uniform weighting is also used to average over all azimuths. "Sin-theta weighted average" is an averaging scheme that puts more

[11] Certain equations (particularly the limits of summation in the near-horizon equations) maybe changed slightly once the sampling increment is finalized (e.g., 30 degrees vs. 15 degrees) since there may not be sample points at the exact border of a 45 degree or 22.5 degree window around the horizon.

emphasis on horizon data than zenith and nadir and is appropriate for use when samples are taken uniformly in theta and phi.

Note that N and M may be different for the transmit and receive measurements.

B.2.1 Total Radiated Power

Assuming that a complete sphere is measured with N theta cuts and M phi cuts, then the Total Radiated Power may be calculated as follows.

Total Radiated Power:

$$TRP = \frac{\pi}{2NM}\sum_{i=1}^{N}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| \quad \text{[Equation B.2.1-1]}$$

B.2.2 Near-Horizon Partial Radiated Power

Assuming that a complete sphere is measured with N theta cuts and M phi cuts, then the Near-Horizon Partial Radiated Power may be calculated as follows.

Power radiated over ±π/4 near the Horizon:

$$HRP_{\pm\pi/4} = \frac{\pi}{2NM}\sum_{i=\frac{N}{4}}^{\frac{3N}{4}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| \text{ for conic cuts} \quad \text{[Equation B.2.2-1]}$$

$$HRP_{\pm\pi/4} = \frac{\pi}{2NM}\left[\sum_{i=\frac{N}{8}}^{\frac{3N}{8}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| + \sum_{i=\frac{5N}{8}}^{\frac{7N}{8}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right|\right] \text{ for great-circle cuts}$$

[Equation B.2.2-2]

Power Radiated over ±π/8 near the Horizon:

$$HRP_{\pm\pi/8} = \frac{\pi}{2NM}\sum_{i=\frac{3N}{8}}^{\frac{5N}{8}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| \text{ for conic cuts} \quad \text{[Equation B.2.2-3]}$$

$$HRP_{\pm\pi/8} = \frac{\pi}{2NM}\left[\sum_{i=\frac{3N}{16}}^{\frac{5N}{16}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right| + \sum_{i=\frac{11N}{16}}^{\frac{13N}{16}}\sum_{j=1}^{M} EiRP(\theta_i,\phi_j)\left|\sin(\theta_i)\right|\right] \text{ for great-circle cuts}$$

[Equation B.2.2-3]

B.2.3 Total Isotropic Sensitivity

Assuming that a complete sphere is measured with N theta cuts and M phi cuts, then the Total Isotropic Sensitivity may be calculated as follows.

Total Isotropic Sensitivity:

$$TIS = \frac{2NM}{\pi \sum_{i=1}^{N} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right|} \quad \text{[Equation B.2.3-1]}$$

where EIS is the radiated effective isotropic sensitivity measured at each direction and polarization.

B.2.4 Near-Horizon Partial Isotropic Sensitivity

Assuming that a complete sphere is measured with N theta cuts and M phi cuts, then the Near-Horizon Partial Isotropic Sensitivity may be calculated as follows.

For sensitivity considered over ±π/4 near the Horizon:

$$NHPIS_{\pm\pi/4} = \frac{2NM}{\pi \sum_{i=\frac{N}{4}}^{\frac{3N}{4}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right|} \quad \text{for conic cuts [Equation B.2.4-1]}$$

$$NHPIS_{\pm\pi/4} = \frac{2NM}{\pi \left\{ \sum_{i=\frac{N}{8}}^{\frac{3N}{8}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right| + \sum_{i=\frac{5N}{8}}^{\frac{7N}{8}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right| \right\}}$$

for great-circle cuts [Equation B.2.4-2]

For sensitivity considered over ±π/8 near the Horizon:

$$NHPIS_{\pm\pi/4} = \frac{2NM}{\pi \sum_{i=\frac{3N}{8}}^{\frac{5N}{8}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right|} \quad \text{for conic cuts [Equation B.2.4-3]}$$

$$NHPIS_{\pm\pi/4} = \frac{2NM}{\pi \left\{ \sum_{i=\frac{3N}{16}}^{\frac{5N}{16}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right| + \sum_{i=\frac{11N}{16}}^{\frac{13N}{16}} \sum_{j=1}^{M} \left[\frac{1}{EIS_{\theta}(\theta,\phi)} + \frac{1}{EIS_{\phi}(\theta,\phi)} \right] \left| \sin(\theta_i) \right| \right\}}$$

for great-circle cuts [Equation B.2.4-4]

B.3 Measurement Data File –Conducted RF Power

RF Power levels shall be measured using a direct couple method for each EUT reported. Measurements should be made in accordance with the relevant CTIA test plan as specified in Section 1.4 Certification Test Plans:

Table B.3-1 Example Measurement Data File Format

Test	**Criteria (dBW)**		**Channel**		
	Min	Max	#1	#2	#3
TX Power @ Level 0 (dBW)					
•					
•					
•					
TX Power @ Level (lowest setting)					

B.4 3-D Plots

Plots shall be submitted for each EUT reported.

B.5 Calibration Data File (Quiet Zone and Path Loss)

Placeholder for quiet zone and path loss measurements. Table D.2-1 and D.3-1 illustrate the data file format.

Appendix C: Test Site Characteristics & Quiet Zone Accuracy

This section describes an efficient procedure for ensuring sufficient quiet zone accuracy of the test site by characterizing the measurement accuracy of an anechoic chamber, and the associated measurement equipment. This procedure is recommended to characterize variations in field measurements caused by reflections within an anechoic chamber.

C.1 Equipment required:

Details on the symmetry antenna can be found in Appendix J: Symmetry Pattern.

1. Anechoic chamber to be characterized. For the purpose of these tests, this chamber must be large enough to allow the measurement antenna to be at least 3λ from the EUT and the test site must be free of all interference.
2. Cellular-band sleeve dipole probe antenna with less than ±0.1 dB of asymmetry[12] in the azimuth plane pattern.
3. Cellular-band reference loop probe antenna with less than ±0.1 dB of asymmetry in the azimuth plane pattern.
4. PCS-band sleeve dipole probe antenna with less than ±0.1 dB of asymmetry[13] in the azimuth plane pattern.
5. PCS-band reference loop probe antenna with less than ±0.1 dB of asymmetry in the azimuth plane pattern

Note: It is necessary that the above antennas be optimized for the respective frequencies as indicated in C.2.

6. Low dielectric constant, low-loss column (e.g. Styrofoam) for positioning the probe antennas
7. Measurement antenna(s) (e.g. calibrated horn or dipole used during antenna measurements)
8. Network analyzer or signal generator/measurement receiver

C.2 Test Channels:

Channels to be used to test for quiet zone accuracy

1. Cellular-band: 384 (836.52 MHz)
2. PCS-band: 999 (1879.95 MHz)

[12] The asymmetry specification for purposes of this measurement may be stated more specifically as the pattern shall not deviate from a perfect circle by more than ±0.1 dB. A sleeve dipole is recommended since the cable and feedpoint may be arranged in such a way that interactions with the measurement are minimized. The gain and efficiency of this antenna is immaterial since the measurement seeks to determine deviations in the measured antenna pattern caused by reflections within the measurement chamber.

[13] The asymmetry specification for purposes of this measurement may be stated more specifically as the pattern shall not deviate from a perfect circle by more than ±0.1 dB. A sleeve dipole is recommended since the cable and feedpoint may be arranged in such a way that interactions with the measurement are minimized. The gain and efficiency of this antenna is immaterial since the measurement seeks to determine deviations in the measured antenna pattern caused by reflections within the measurement chamber.

C.3 Measurement Procedures:

Reference Pattern Measurement

1. Place the band-appropriate vertically polarized sleeve dipole (probe antenna) at the center of the dielectric column, which is centered atop the antenna positioner located in the anechoic chamber. Center the sleeve dipole precisely on the antenna positioner's axis of rotation, and ensure that the antenna is exactly vertical. The center of the probe antenna should be at the center of the quiet zone.
2. Place the measurement antenna in the vertically polarized position a distance greater then 3 times the wavelength meters away from the probe antenna. Adjust the elevation of the measurement antenna to be at boresight with the center of the probe antenna.
3. Attach a signal source to a coaxial cable feeding the probe antenna and set the frequency to the appropriate channel. Set the amplitude to a level appropriate for the measurement receiver. Connect a measurement receiver to the measurement antenna. Ensure that all coaxial cables are dressed to minimize effects upon the measurement results.
4. Rotate the probe antenna and record the signal received by the measurement antenna at every 2 degrees of azimuth.
5. Record the measurement results to a file that can be imported into a Microsoft Excel spreadsheet.
6. Record test parameters including: (a) the distance between the measurement and probe antennas, (b) cable losses and other losses associated with the measurement setup, and (c) power of the signal source at the probe antenna connector.
7. Repeat steps 1 through 6 above using the band-appropriate horizontally polarized reference loop antenna as the probe antenna.

Note: The vertically polarized sleeve dipole and horizontally polarized reference loop antennas may be combined into one assembly, thus allowing the two data sets to be taken conjointly.

Offset Pattern Measurements

Note: the following procedure applies for both the vertically polarized sleeve dipole and horizontally polarized reference loop antenna offset pattern measurements.

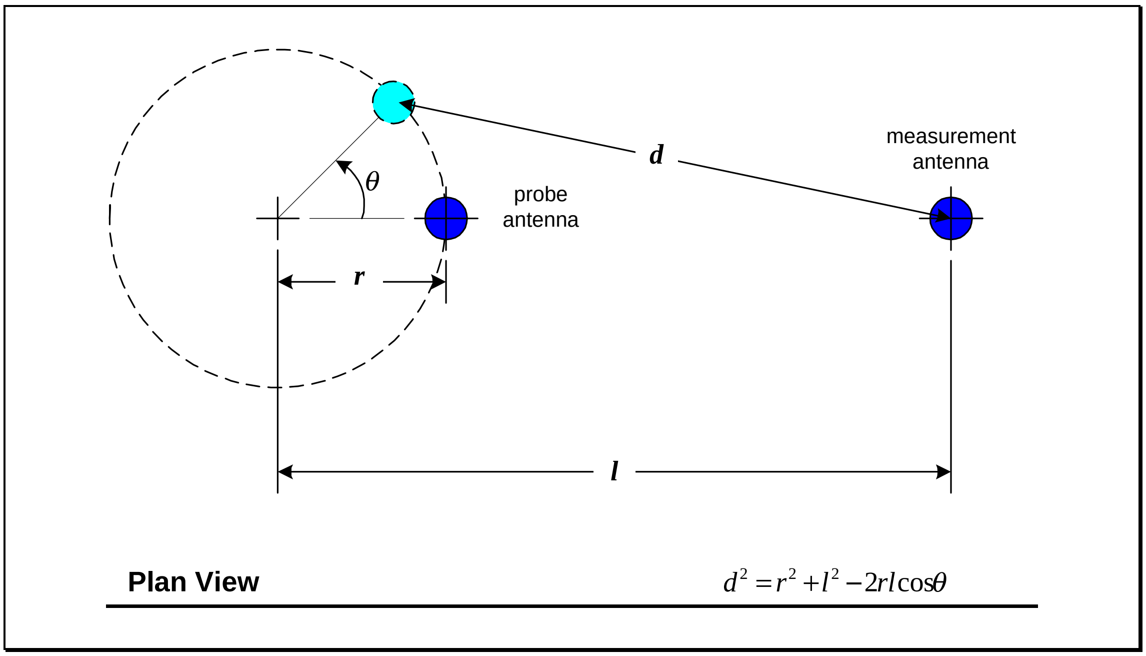
1. Offset the probe antenna from the center of the positioner's axis of rotation by 6 inches, ensuring it is exactly vertical. Repeat steps 2 through 6 described in the Reference Pattern Measurement.
2. Repeat the previous step with the probe antenna offset 3 inches from the axis of rotation.
3. Elevate the probe antenna ±6 inches and repeat steps 1 and 2.

C.4 Analysis:

1. Plot the dipole and loop antenna reference patterns using polar coordinates and having a resolution of 0.25 dB or better. These patterns should appear to be perfectly circular (less than ±0.1 dB of variation)
2. Adjust the offset pattern measurements to correct for distance variation using the equation for the Law of Cosines (see below).
3. Overlay a plot of the corrected offset patterns onto the reference pattern plot.
4. The adjusted offset patterns should not vary more than ±0.5 dB from the reference pattern.

Law of Cosines Adjustment Method

For coplanar antennas, the Law of Cosines may be used to determine the distance between antennas as one is rotated about a center axis. For minor differences in elevation, the Law of Cosines should still be of sufficient accuracy for our analysis. Refer to the following figure to aid in understanding this discussion. Note that this illustration is a view from the perspective of looking down on vertically oriented antennas from above.



- Let ***l*** be the distance measured between the axis of rotation and the measurement antenna
- Let ***r*** be the measured distance that the probe antenna is offset from the axis of rotation.
- Let θ be the rotation azimuth of the probe antenna where 0-degrees is the point where the probe antenna is closest to the measurement antenna and 180-degrees is the point where the probe antenna is farthest away from the measurement antenna

- Let ***d*** be the calculated distance between the probe antenna and the measurement antenna. Then ***d*** may be calculated from the Law of Cosines as follows:

$$d^2 = r^2 + l^2 - 2\, r\, l \cos\theta \quad \text{[Equation C.4-1]}$$

- Adjust the measured signal power to account for distance variation using the following equation:

$$P_{adj} = P_{meas} - 20 \log (d/l) \quad \text{[Equation C.4-2]}$$

where P_{adj} and P_{meas} are in decibels.

Note that parameter ***r*** and ***l*** must be carefully measured and recorded to enable accurate application of this technique.

Appendix D: Test Site Calibration

D.1 Method:

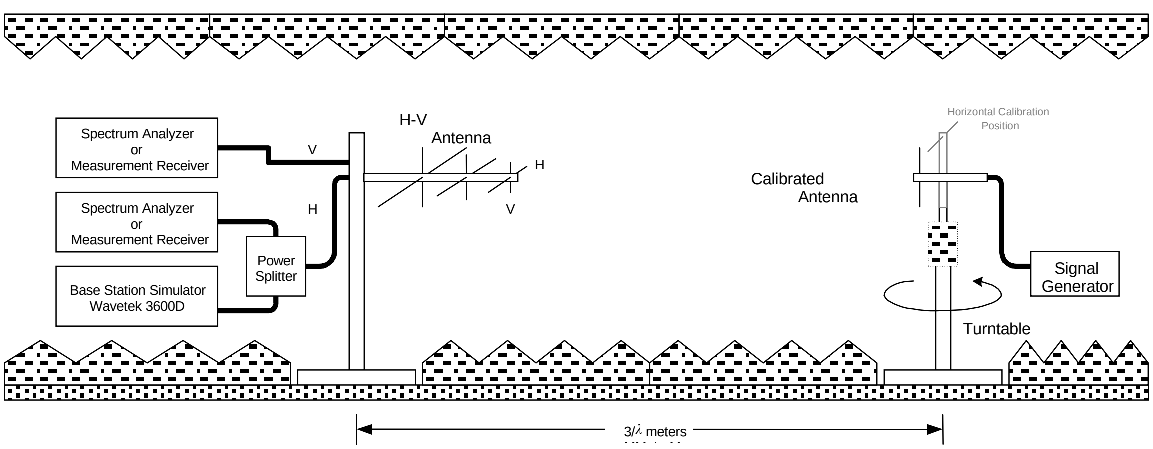
Calibration is used to determine system losses and gains so they may be normalized out of the device measurement data. A common substitution method is used for this purpose.

D.2 Calibration:

Test site Calibration uses a substitution method whereby the Equipment Under Test (EUT) is replaced by an antenna with calibrated gain/loss characteristics at the frequencies of measurement (viz. the *Calibrated Substitution Antenna*). A *Signal Generator* is used to drive the Substitution Antenna at a known power level. A *Spectrum Analyzer* or *Measurement Receiver* is used to measure the power of the radiated signal coupled out of the antenna to be used during the EUT measurement step (viz. the *Measurement Antenna*). Refer to Figure D.2-1 for the recommended test configuration for the Calibration step.

Place the band-appropriate vertically polarized sleeve dipole (measurement antenna) at the center of the dielectric column, which is centered atop the antenna positioner located in the test chamber. Center the sleeve dipole precisely on the antenna positioner's axis of rotation and ensure that the antenna is exactly vertical. The center of the probe antenna should be at the center of the quiet zone.

Figure D.2-1 Calibration Test Configuration



The *Measurement Antenna* elevation is adjusted so it is at boresight with the *Calibrated Substitution Antenna*. The power into the *Calibrated Substitution Antenna* is measured at each frequency. The power at the input terminals of the *Spectrum Analyzers* (or *Measurement Receivers*) connected to the horizontal and vertical element of the *Measurement Antenna* is recorded at each frequency.

The measurement will be repeated with the *Calibrated Substitution Antenna* polarized both vertically and horizontally at each frequency. The path loss (difference between the power into the calibrated antenna and the power received at the spectrum analyzer) will be calculated from this data for every frequency and polarization to be tested. The path loss should also be adjusted to account for the calibrated substitution antenna's gain/loss in dBd for the frequency of measurement. The table below shows how this data might be recorded.

Table D.2-1 Example Calibration Data Record

Band	Frequency (MHz)	Measured Signal Strength (dBm)		Sig Gen Power (dBm)	Substitution Antenna Gain (dBd)	Path Loss (dB)	
		Analyzer H	Analyzer V			Vert	Horz
Cellular	CH_1-TX	-90	-90	0.0	0.5	90.5	90.5
Cellular	CH_1-RX	-99	-99	0.0	0.5	99.5	99.5
Cellular	CH_2-TX	-96	-96	0.0	0.5	96.5	96.5
Cellular	CH_2-RX	-95	-95	0.0	0.5	95.5	95.5
Cellular	CH_3-TX	-89	-89	0.0	0.5	89.5	89.5
Cellular	CH_3-RX	-92	-92	0.0	0.5	92.5	92.5
PCS	CH_4-TX	-90	-90	0.0	0.5	90.5	90.5
PCS	CH_4-RX	-99	-99	0.0	0.5	99.5	99.5
PCS	CH_5-TX	-96	-96	0.0	0.5	96.5	96.5
PCS	CH_5-RX	-95	-95	0.0	0.5	95.5	95.5
PCS	CH_6-TX	-89	-89	0.0	0.5	89.5	89.5
PCS	CH_6-RX	-92	-92	0.0	0.5	92.5	92.5

Path loss may be calculated using the following equation:

$$PL = P_{sig\ gen} + G_{subst\ ant} - P_{sp\ an} \qquad \text{[Equation D.2-1]}$$

where,

PL ≡ Path Loss (in dB)

$P_{sig\ gen}$ ≡ Power delivered by the Signal Generator to the Substitution Antenna (in dBm)

$G_{subst\ ant}$ ≡ Gain of the Substitution Antenna (in dBd)

$P_{sp\ an}$ ≡ Power measured by the spectrum analyzer in a 30 kHz (or greater) bandwidth (in dBm)

The losses between the *Measurement Antenna* and the *Base Station Simulator* (including cable and power splitter losses) should be matched to within ±0.1 dB so the path losses calculated from the horizontal measurements may be used directly. Otherwise, these differences should be accounted for when making downlink measurements based on mobile signal strength reports.

During the calibration process, it may be desirable to rotate the *Calibrated Substitution Antenna* and plot out the antenna pattern to ensure that the pattern looks reasonable and that the relative orientation of the two antennas is such that the peak lobe is measured for the horizontally polarized case. Cables connecting the *Calibrated Substitution Antenna* to the *Signal Generator* should be dressed in such a way that the impact upon the measurements is negligible.

The same cable configuration and equipment used during Calibration should also be used during the EUT measurement phase so that the calibrations will directly apply.

The recommended frequencies for the measurements are provided in Table 4.1-2. These have been selected to test at the band edges and near the center of each band. Significant variations in EUT performance due to antenna, filtering or circuit design should be apparent using this technique.

D.3 Calibration Data File:

Data shall be supplied in a format accessible (i.e., readable) for additional examination and computation as outlined in Table D.3-1.

Table D.3-1 Example Calibration Data File Format

Date:	24 Aug 2000						
Cal Antenna:	EA-1234						
Band	**Frequency (MHz)**	**Measured Signal Strength (dBm)**		**Sig Gen Power (dBm)**	**Substitution Antenna Gain (dBd)**	**Path Loss (dB)**	
		Analyzer V	**Analyzer H**			**Vert**	**Horz**
Cellular	CH_1-TX	-90	-90	0.0	0.5	90.5	90.5
Cellular	CH_1-RX	-99	-99	0.0	0.5	99.5	99.5
Cellular	CH_2-TX	-96	-96	0.0	0.5	96.5	96.5
Cellular	CH_2-RX	-95	-95	0.0	0.5	95.5	95.5
Cellular	CH_3-TX	-89	-89	0.0	0.5	89.5	89.5
Cellular	CH_3-RX	-92	-92	0.0	0.5	92.5	92.5
PCS	CH_4-TX	-90	-90	0.0	0.5	90.5	90.5
PCS	CH_4-RX	-99	-99	0.0	0.5	99.5	99.5
PCS	CH_5-TX	-96	-96	0.0	0.5	96.5	96.5
PCS	CH_5-RX	-95	-95	0.0	0.5	95.5	95.5
PCS	CH_6-TX	-89	-89	0.0	0.5	89.5	89.5
PCS	CH_6-RX	-92	-92	0.0	0.5	92.5	92.5

The *Calibration Step* shall be performed:

1. If any equipment used in the evaluation has been replaced, repaired, upgraded, or calibrated.
2. If the anechoic chamber has been repaired, or otherwise altered.
3. If the equipment within the chamber has been altered or moved from its original location.
4. If there is any question as to the whether the past calibration data is acceptable for the current measurement.

Appendix E: Simulated Head Design and Construction

E.1 Simulated Head Reference Information:

This section provides recommendations for constructing a simulated head/head and torso to be used for antenna testing. References are provided relating to typical handset usage. The book titled *Mobile Antenna Systems Handbook* by K. Fujimoto and J.R. James[14], shows data that was collected on the inclination angle at which subscribers typically hold mobile phones while in conversation (Figure B-1). The most likely angle is around 60 degrees from vertical. This is the recommended value for antenna testing using a simulated head/head and torso.

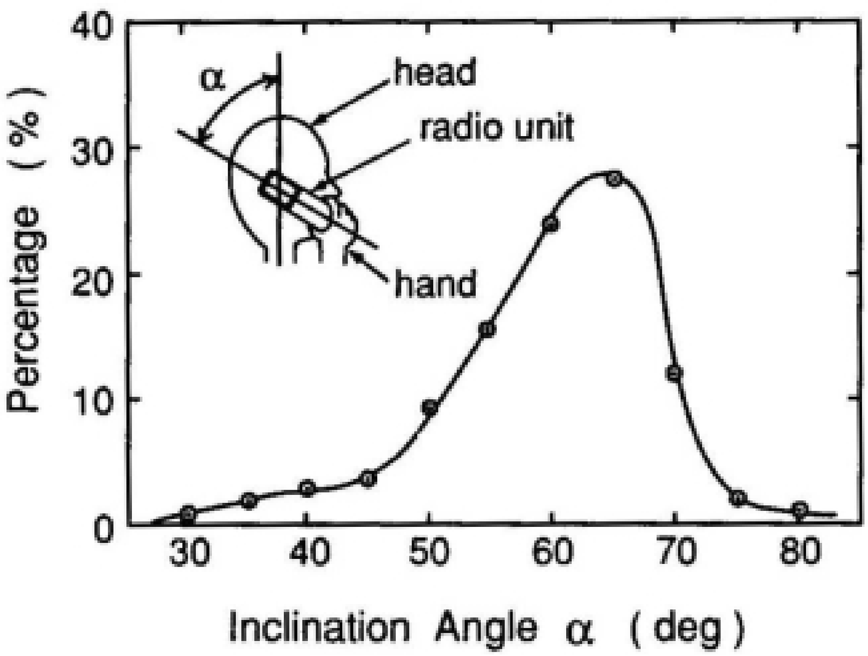


Figure E.1-1 - Inclination Angle Statistics (from K. Fujimoto and J.R. James)

[14] K. Fujimoto and J.R. James, *Mobile Antenna Systems Handbook*, Norwood, MA: Artech House, Inc., 1994, pp. 221, 227.

E.2 IEEE SCC34 "SAM" Anthropomorphic Simulated Head Reference Information

The IEEE SCC34 "SAM" anthropomorphic head model has proven to be the standard phantom used for measuring the RF parameters of handsets and is the phantom recommended for the evaluations specified in this test plan[15]. The SAM phantom is referenced in the FCC Supplement C as the preferred simulated head/head and torso for SAR testing.

Figure E.2-1 shows the IEEE SCC34 "SAM" anthropomorphic head model. The details of its construction and EUT positioning are given in IEEE Std 1528-200X Draft 6.1 dated November 14, 2000. The IEEE document gives details on two positions, while this document requires that the EUT be tested only in the "cheek" or touch position.

In summary, it consists of a 2mm thick fiberglass shell in the shape of a 90th percentile adult male head with dimensions and shape as published by the US Army [Gorden et al., 1989]. The distance between the pinna back and the head, have been adopted as the standard for RF performance testing of handsets.

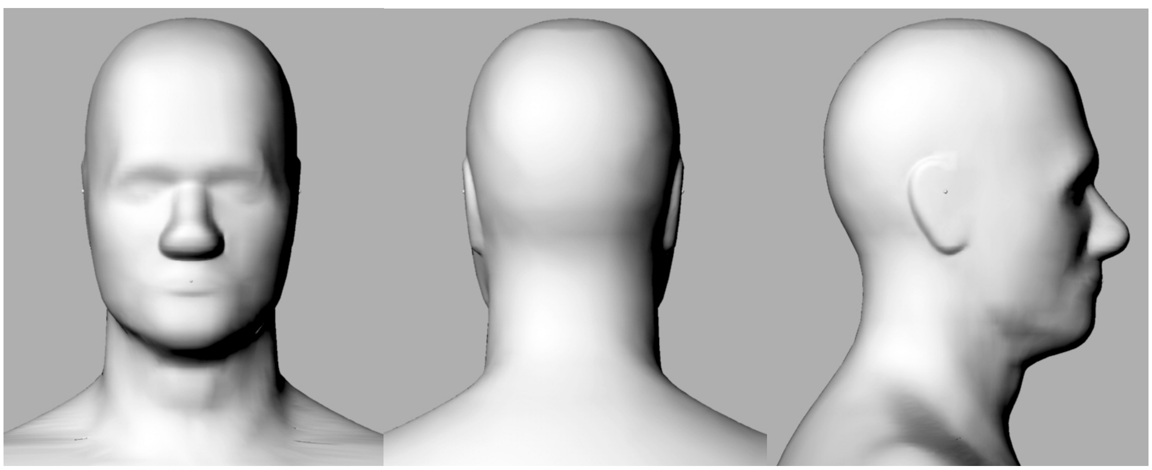


Figure E.2-1, IEEE SCC34 "SAM" anthropomorphic head model.

[15] The availability of this phantom may be limited due to large demand and a limited number of suppliers. While not recommended, an alternative phantom may be used. Since there may be differences between phantoms, a difference in EIRP is expected and should be addressed when reporting test results. Contact CTIA for details on alternative phantoms.

E.3 Simulated Head Fluid Recipes:

Recipe I ("Head" tissue according to the data provided by C. Gabriel at 900 MHz):

Recipe II ("Head" tissue according to the data provided by C. Gabriel at 1900 MHz):

Table E.3-1: Recipe I & II, Head Tissue 900MHz & 1900 MHz

Elements	900 MHz	1900 MHz
Water	42.5%	45.0%
Sugar	55.6%	53.9%
Salt (NaCl)	0.8%	------
HEC (Hydroxyethylcellulosis)	1.0%	1.0%
Bactericide (Dowicil™ 75)	0.1%	0.1%

Note: the desired relative dielectric constant is 41.5 and desired conductivity is 0.90 S/m at 835 MHz.

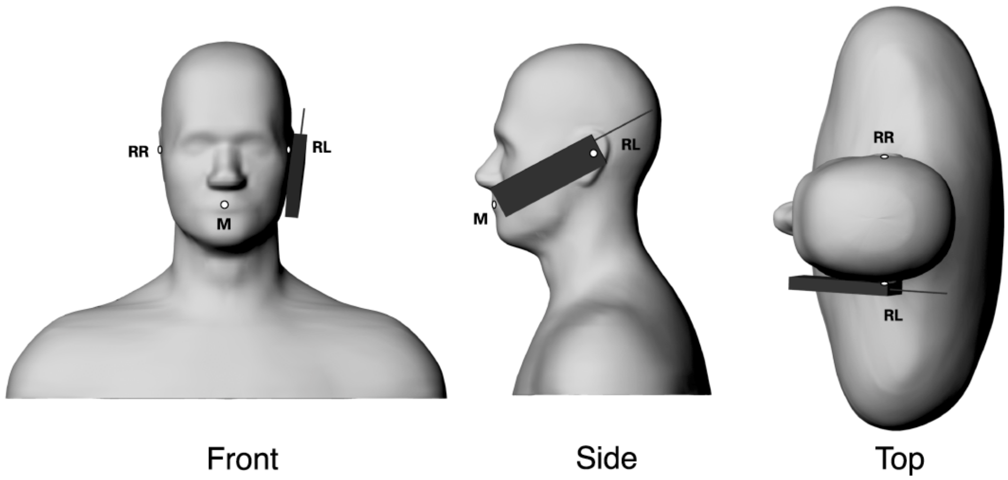
The desired relative dielectric constant is 40.0 and desired conductivity is 1.40 at 1900 MHz. The above recipe will not achieve these values, yet is the recommended recipe because other recipes that would come closer to the desire value use 2-(2-butoxyethoxy) ethanol (DGBE) which is harmful to most plastics, including fiberglass.

Companies such as Schmidt and Partners market these recipes commercially. Also, research into tissue simulation fluids is ongoing. Refer to the most recent IEEE standards and FCC requirements for SAR for the most up-to-date recommendations for tissue simulation fluids.

E.4 Definition of the EUT Position on "SAM" Phantom

1. Position the device with the vertical center line of the body of the device and the horizontal line crossing the center of the ear piece in a plane parallel to the sagittal plane of the phantom ("initial position"). While maintaining the device in this plane, align the vertical center line with the reference plane containing the three ear an mouth reference points (RE, LE and M) and align the center of the ear piece with the line RE-LE
2. Translate the mobile box towards the phantom with the earpiece aligned with the line LE-RE until the EUT touches the ear. While maintaining the device in the reference plane and maintaining the EUT contact with the ear, move the bottom of the box until any point on the front side is in contact with the cheek of the phantom or until contact with the ear is lost.

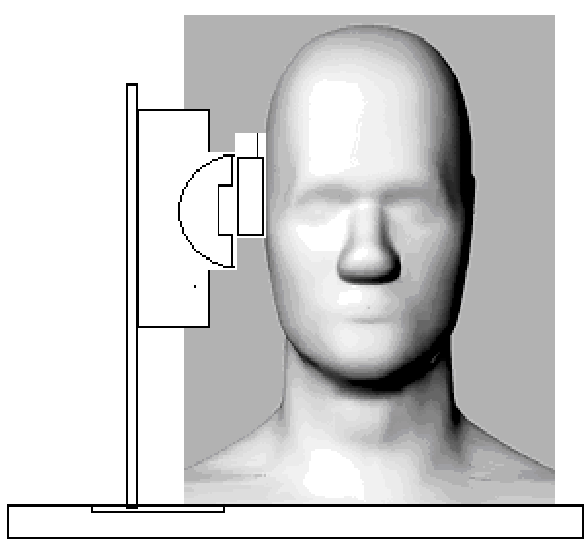
Figure E.4-1 EUT Positions on "SAM"



E.5 Definition of Handset Placement Fixture

A fixture constructed of material with minimum influence on the RF characteristics will be used to hold the EUT against the simulated head[16]. Such a fixture may be constructed as in figure E.5-1. The fixture shown is made of expanded polystyrene (Styrofoam™) and low dielectric plastics (Fiberglass™). The primary goal of the fixture is to allow the accurate positioning of the EUT, while also being transparent and non-reflective to RF. A minimum amount of plastics are used, while the material that is closest to the EUT is expanded polystyrene because of its excellent dielectric and physical properties.

Figure E.5-1 EUT Holding Fixture



[16] Research into the use of a simulated hand is ongoing and may be included as the preferred fixture in the future.

Appendix F: Power Measurement Considerations

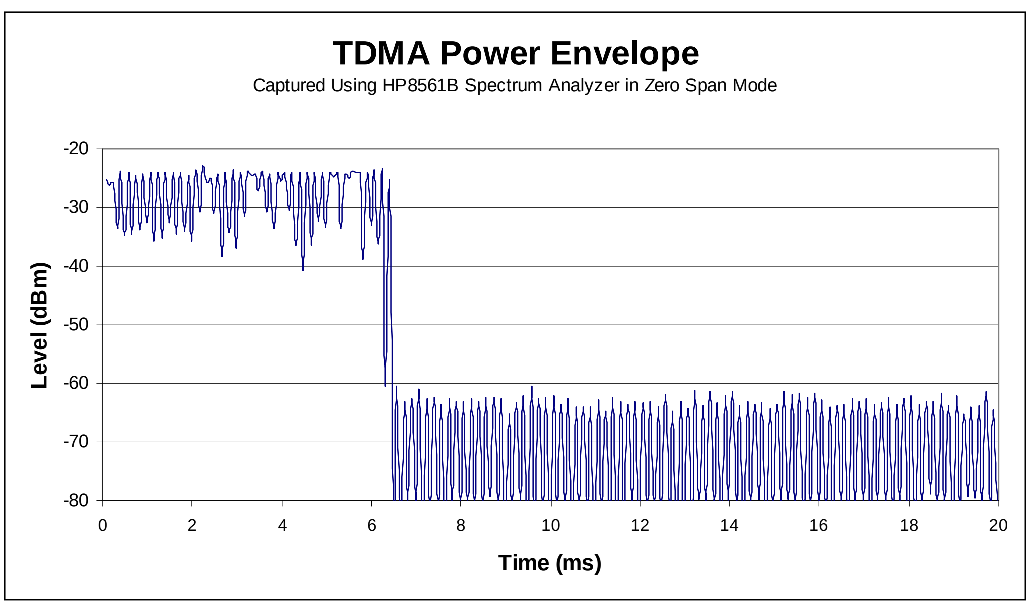
F.1 TDMA TIA/ANSI-136:

TIA/EIA-136-270-A specifies that the mean burst power shall be measured over at least 140 consecutive symbols between symbol number 6 and symbol number 162. Refer to Section 3.2.1.2.2 of TIA/EIA-136-270-A for additional information.

TIA/EIA-136 uses a non-constant envelope modulation (π/4-DQPSK) that is slotted into 6 timeslots. Two of the 6 timeslots are active during a call (e.g. 1+4, 2+5, 3+6). Each timeslot is 162 symbols long and is active for 6.67 ms. The carrier is turned off during the inactive timeslots (≅. 13.33 ms). The first 3 symbols of the active timeslot are used as guard time and the transmit carrier of the mobile station must be off. Symbols 4 through 6 are used for power ramp-up for the mobile station to come up to full transmit power. When an Abbreviated Slot Format is used, the last 22 symbols are also used for guard time and the transmit carrier for the mobile station must be off. When Normal Slot Format is used, the last 22 symbols contain data and carrier is on. Refer to Section 2 of TIA/EIA-136-121-A for further details.

For the purposes of characterizing antenna performance, it is acceptable to trigger on the rising edge of the power bursts at the measurement receiver and average over the central 85% of one or more bursts to estimate the average digital power. The chart below shows a typical spectrum analyzer trace when set to zero span and triggered on the video signal's rising edge. Resolution/Video Bandwidth was set to 300 kHz and Sweep Time was set to 50 ms. Averaging over the first 73 samples results in an average power estimate of –28 dBm.

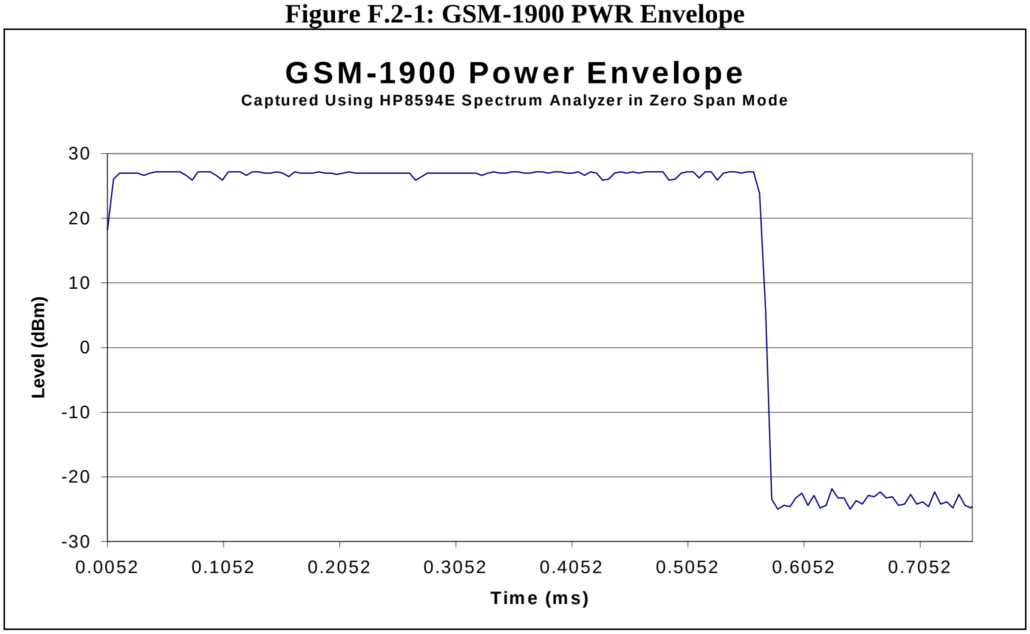
Figure F.1-1: TDMA PWR Envelope



F.2 GSM-1900 -- J-STD-007

GSM-1900 uses a constant envelope modulation (GMSK) that is slotted into 8 timeslots. For the purposes of characterizing antenna performance, it is acceptable to trigger on the rising edge of the power bursts at the measurement receiver and average over the central 85% of one or more bursts to estimate the average digital power. The chart below shows a typical spectrum analyzer trace when set to zero span, and triggered on the video signal's rising edge. Resolution/Video Bandwidth was set to 300 kHz and Sweep Time was set to 8.02 ms. Averaging over the first 73 samples results in an average power estimate of –27 dBm.

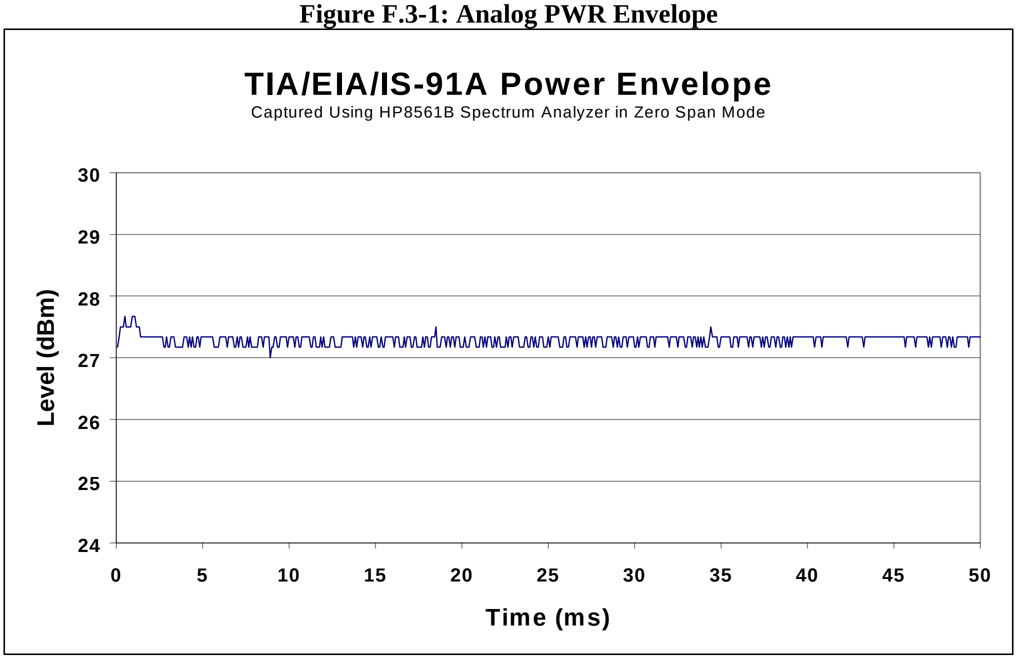
Figure F.2-1: GSM-1900 PWR Envelope



F.3 Analog -- TIA/EIA/IS-91A

TIA/EIA/IS-91A uses a constant envelope modulation (FSK). For the purposes of characterizing antenna performance, it is acceptable to trigger on the rising edge of the power transition at the measurement receiver. The chart below shows a typical spectrum analyzer trace (for 30 kHz analog channel) when set to zero span and triggered on the video signal's rising edge. Resolution/Video Bandwidth was set to 30 kHz and Sweep Time was set to 50 ms. Averaging over the entire 50 ms trace results in an average power estimate of 27.3 dBm.

Figure F.3-1: Analog PWR Envelope



F.4 CDMA:

When using the Tek CMD-80 Digital Radio Communication tester, go to "Power Control", "Max Output", this will accomplish the "always up" condition. Other pieces of test equipment (HP 8924) may be used to perform same function of sending up-bits for power control decisions.

Appendix G: Great Circle Measurement Orientation Diagrams

The following diagrams are provided to illustrate the orientation of the Device Under Test with respect to an antenna used to measure the dominant polarization. Orientations for the four E-Plane cuts specified by this document are illustrated. The EUT is rotated horizontally to characterize the E-Plane pattern across a plane intersecting the EUT faceplate at the specified angle.

Figure G-1 Device Orientation – E0 Cut

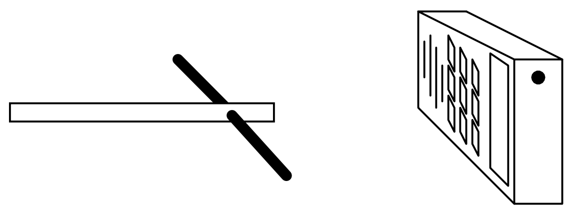


Figure G-2 Device Orientation – E45 Cut

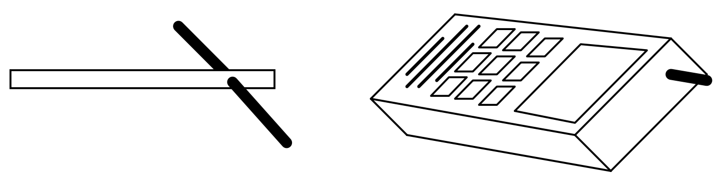


Figure G-3 Device Orientation – E90 Cut

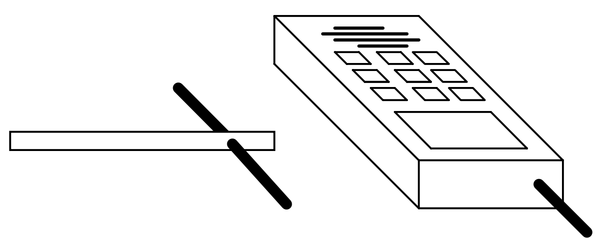
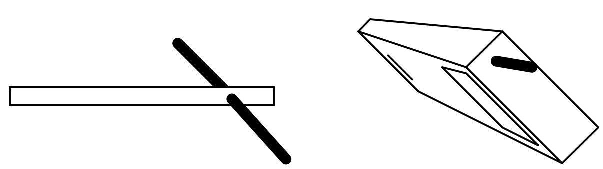
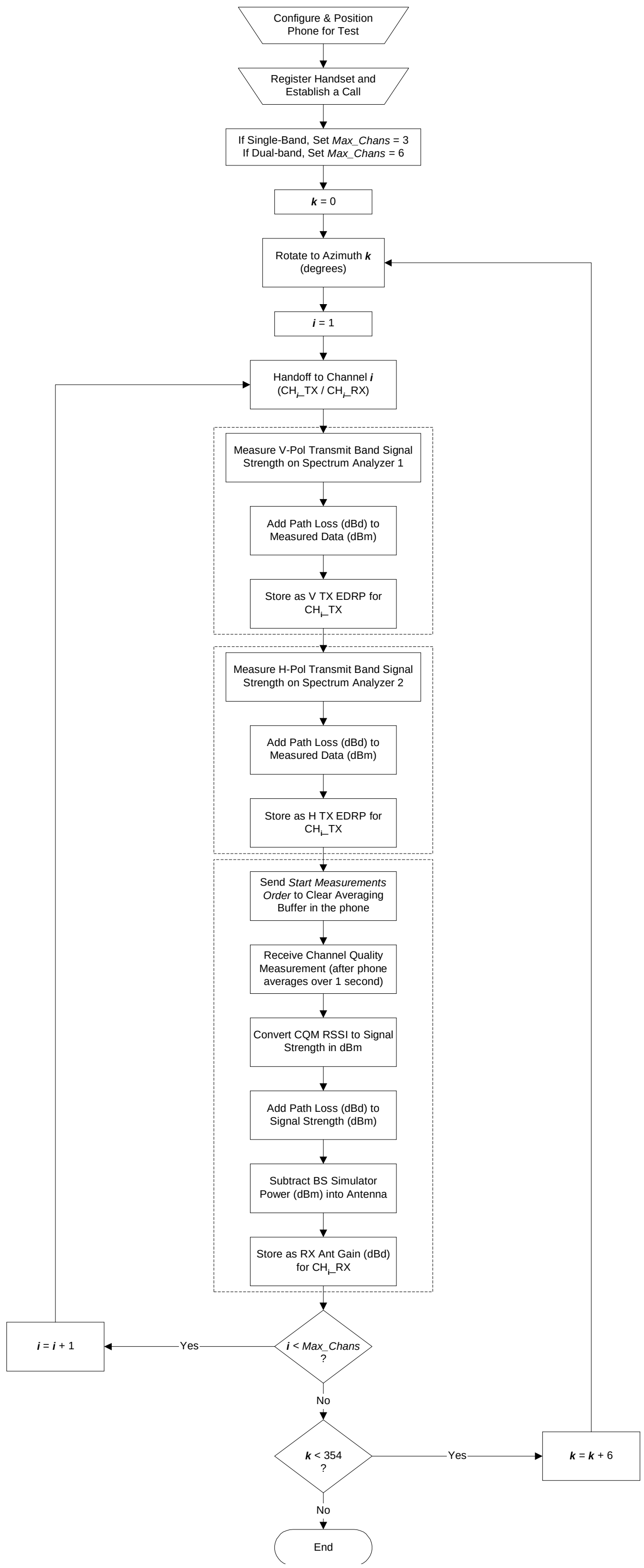


Figure G-4 Device Orientation – E135 Cut



Appendix H: Example Flow Diagram for the Device Measurement Procedure for Each Cut

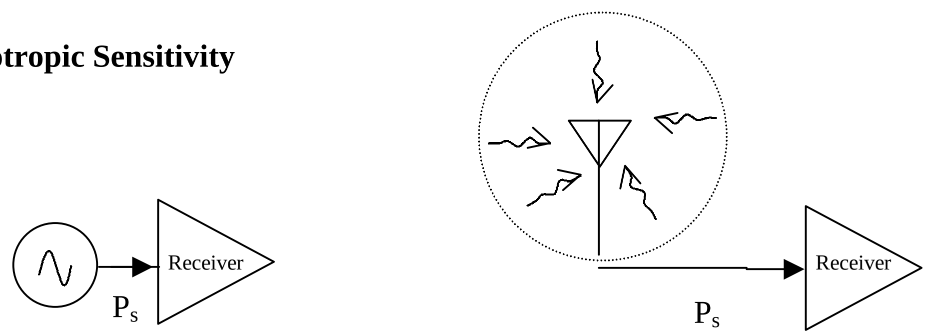


Appendix I: Total Isotropic Sensitivity (Informative)

This section specifies a way of reducing a complete spherical pattern of receive-sensitivity data to a single figure of merit, and to give some meaningful examples of this process. The basic principal applied is to compare the EUT's performance to that of a receiver with a perfect (100% efficient) antenna.

These derivation yields results to apply to real chamber measurements of receive sensitivity.

Total Isotropic Sensitivity



Conducted sensitivity measurement (left) and TIS (right)

Definitions

Assume plane waves of equal power and equal phase incident on the EUT from every direction, and further assume that at each direction, plane waves of equal power in each of the two polarizations (E_θ and E_ϕ) are incident. Now assume the uniform power in all of these waves is simultaneously adjusted so that the power available to the EUT's receiver from the EUT's antenna when immersed in them is the power required for the receiver to operate at its threshold of sensitivity (e.g., a specifiec bit error rate). If the EUT is now replaced with an ideal isotropic antenna with equal gain in each polarization in every direction, the power available from the ideal isotropic antenna from this same uniform incident field is the Total Isotropic Sensitivity[17], TIS.

Define the Effective Isotropic Sensitivities, EIS, as follows:

$EIS_\theta(\theta,\phi) =$ Power available from an ideal isotropic, theta-polarized antenna generated by the theta-polarized plane wave incident from direction (θ,ϕ) which, when incident on the EUT, yields the threshold of sensitivity performance.

[17] This is an sensible definition because it compares the EUT's antenna/receiver system to a perfect, 100% efficient antenna that responds equally to either polarization.

$EIS_\phi(\theta,\phi) =$ Power available from an ideal isotropic, phi-polarized antenna generated by a phi-polarized plane wave incident from direction (θ,ϕ) which, when incident on the EUT, yields the threshold of sensitivity performance.

EIS is the pattern quantity that is actually measured in the chamber, by recording power required at each angle and polarization to achieve sensitivity. It is measured by including the same path-loss factor that is used in the chamber to yield EIRP for a transmitting antenna. Note that the EIS terms are defined with respect to a single-polarized ideal isotropic antenna, but the TIS is defined with respect to a dual-polarized ideal isotropic antenna. This is a convenience to make calibration in the chamber correspond with the calibration done for EIRP. That is to say, the same numerical path loss terms that are generated when calibrating a chamber to yield EIRP patterns for a transmit test will yield EIS patterns for a receive test as defined here (based on single-polarized isotropic references). TIS is based on a dual-polarized isotropic comparison, because real-world EUTs and propagation are dual-polarized. Proper choice of integration kernels will be seen to reconcile this apparent difference.

In general,

$$EIS_x(\theta,\phi) = \frac{P_S}{G_x(\theta,\phi)} \qquad (1)$$

where P_s is the conducted sensitivity of the EUT's receiver and $G_x(\theta,\phi)$ is the gain relative isotropic (in polarization x) of the EUT's antenna (in this case, including mismatch and ohmic losses) in the direction (θ,ϕ).

Calculation of Received Power

Assume a spherical surface centered on the EUT, and calculate the incoming power in the uniform spherical wave described in the definition of TIS. In general, the power flowing into any closed surface can be calculated by integrating the real part of the Poynting vector[18] over that surface:

$$P_{available} = \frac{1}{2} \oiint_S \mathrm{Re}(\vec{E} \times \vec{H}) \cdot d\bar{s}$$

where *S* is the spherical surface on which the electric and magnetic fields are evaluated. For purposes of this discussion, the sign convention is chosen so that a positive power indicates a net power flow into the closed spherical surface.

Assume that the spherical surface *S* has a sufficiently large radius r that the far-field approximation can be applied. Then, upon separating the integration kernel into terms for each of two orthogonal linearly polarized components of incoming wave, we have[19]

[18] See, e.g., Stutzman & Thiele, *Antenna Theory and Design*, first edition, 1981, page 9, equation 1-34; or Balanis, *Antennas*, x edition, 19xx, page 36, equation 2-9.
[19] This is an analogous development to equations 2-12 and 2-12a on page 38 of Balanis.

$$P_{available} = \frac{1}{2\eta_0} \oiint_S (E_\theta^2(r,\theta,\phi) + E_\phi^2(r,\theta,\phi)) ds$$

where r is the radius of the spherical surface of integration, η_0 is the intrinsic impedance of free space, and $E_x(r,\theta,\phi)$ are the magnitudes of the two components of electric field on the surface *S*. Finally, substituting for the differential element of area, ds, we have

$$P_{available} = \frac{1}{2\eta_0} \oiint_S (E_\theta^2(r,\theta,\phi) + E_\phi^2(r,\theta,\phi)) r^2 \sin(\theta) d\theta d\phi \quad (2)$$

As defined above, the TIS is the power that an ideal isotropic radiator would receive from an incoming spherical wave with equal power in each polarization from every direction, such that the same incoming wave would cause the EUT to operate at sensitivity. Define E_{TIS} to be the magnitude of each of the linearly polarized components of this wave,

$$E_\theta(r,\theta,\phi) = E_\phi(r,\theta,\phi) = E_{TIS}$$

Then equation 2 becomes, for this case,

$$P_{available} = \frac{1}{2\eta_0} \oiint_S 2E_{TIS}^2 r^2 \sin(\theta) d\theta d\phi = \frac{4\pi E_{TIS}^2 r^2}{\eta_0}$$

This is the total power carried in such an incoming wave. However, the power actually received from this same incoming wave by any antenna is

$$P_{received} = \frac{1}{2\eta_0} \oiint_S (G_\theta(\theta,\phi) E_{TIS}^2 + G_\phi(\theta,\phi) E_{TIS}^2) r^2 \sin(\theta) d\theta d\phi$$

where $G_x(\theta,\phi)$ are the antenna's component gains in each polarization as in equation 1.

This can be further simplified to

$$P_{received} = \frac{E_{TIS}^2 r^2}{2\eta_0} \oiint_S (G_\theta(\theta,\phi) + G_\phi(\theta,\phi)) \sin(\theta) d\theta d\phi$$

The ideal isotropic dual-polarized antenna envisioned in the above definition of TIS would have a total gain in every direction of 1 (that is, 0 dBi). Therefore, its component gains in each polarization in every direction are 0.5 (that is, -3 dBi), and the power it would receive from this incoming wave (by definition, the TIS) is

$$P_{received} = TIS = \frac{E_{TIS}^2 r^2}{2\eta_0} \oint\!\!\oint_S (\frac{1}{2} + \frac{1}{2}) \sin(\theta) d\theta d\phi = \frac{2\pi E_{TIS}^2 r^2}{\eta_0} \quad (3)$$

For the specific case of the EUT, the power delivered by its antenna to its receiver when immersed in this incoming wave is, *by definition*, the receiver's sensitivity power, P_S , so that

$$P_S = \frac{E_{TIS}^2 r^2}{2\eta_0} \oint\!\!\oint_S (G_\theta(\theta,\phi) + G_\phi(\theta,\phi)) \sin(\theta) d\theta d\phi \qquad (4)$$

Furthermore, we can rearrange equation 1 so that

$$G_x(\theta,\phi) = \frac{P_S}{EIS_x(\theta,\phi)}$$

Substituting into equation 4 yields

$$P_S = \frac{E_{TIS}^2 r^2}{2\eta_0} \oint\!\!\oint_S \left[\frac{P_S}{EIS_\theta(\theta,\phi)} + \frac{P_S}{EIS_\phi(\theta,\phi)} \right] \sin(\theta) d\theta d\phi$$

This can be rearranged to yield

$$\frac{E_{TIS}^2 r^2}{\eta_0} = \frac{2}{\oint\!\!\oint_S \left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)} \right] \sin(\theta) d\theta d\phi}$$

Substituting this into equation 3 yields

$$TIS = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)} \right] \sin(\theta) d\theta d\phi} \qquad (5)$$

Results for a few Special Cases

Assume that the receiver, environment, and antenna are all at the same temperature, e.g., 290K.

Case 1: The EUT employs a 100% efficient, single-polarized, ideal isotropic radiator: For example, assume the EUT's antenna is an ideal, theta-polarized isotropic antenna. By definition, $EIS_\theta(\theta,\phi)$ is then P_s for every angle, and $EIS\phi(\theta,\phi)$ is infinite at every angle. Then equation 5 becomes

$$TIS = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{P_S} + \frac{1}{\infty}\right] \sin(\theta)\, d\theta\, d\phi} = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{P_S} + 0\right] \sin(\theta)\, d\theta\, d\phi} = \frac{P_S\, 4\pi}{\oint\!\!\oint_S \sin(\theta)\, d\theta\, d\phi} = P_S$$

In other words, TIS of a 100% efficient, ideal isotropic, single-polarized antenna is just the sensitivity power, P_s.

Case 2: The EUT employs a 100% efficient, dual-polarized, ideal isotropic radiator: $EIS_\theta(\theta,\phi)$ is then $2P_s$ for every angle, and $EIS\phi(\theta,\phi)$ is also $2P_s$ at every angle. (Recall that the EIS is defined with respect to a single-polarized isotropic, and a dual-polarized isotropic antenna must have half the gain in each polarization of a corresponding single-polarized isotropic antenna.) Then equation 5 becomes

$$TIS = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{2P_S} + \frac{1}{2P_S}\right] \sin(\theta)\, d\theta\, d\phi} = \frac{P_S\, 4\pi}{\oint\!\!\oint_S \sin(\theta)\, d\theta\, d\phi} = P_S$$

Again, a 100% efficient, ideal isotropic antenna has a TIS that is equal to the conducted sensitivity of the receiver, P_s.

Case 3: The EUT employs a 50% efficient but otherwise ideal, single-polarized isotropic antenna. $EIS_\theta(\theta,\phi)$ is then $2P_s$ for every angle (the antenna is a 3-dB attenuator, degrading the receiver noise figure by 3 dB, so twice the power is required to get the same performance), and $EIS\phi(\theta,\phi)$ is infinite at every angle. Then equation 5 becomes

$$TIS = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{2P_S} + \frac{1}{\infty}\right] \sin(\theta)\, d\theta\, d\phi} = \frac{4\pi}{\oint\!\!\oint_S \left[\frac{1}{2P_S} + 0\right] \sin(\theta)\, d\theta\, d\phi} = \frac{2P_S\, 4\pi}{\oint\!\!\oint_S \sin(\theta)\, d\theta\, d\phi} = 2P_S$$

So a 50% efficient antenna has a TIS equal to the conducted sensitivity degraded by 3 dB (i.e., twice as large).

This supports two general conclusions. First, the lower limit (best achievable value) for TIS is simply the conducted sensitivity of the EUT's receiver, P_s. This TIS is achieved with a perfectly matched, 100% efficient antenna. Second, the TIS of a real antenna will be the conducted sensitivity of its receiver degraded by the mismatch/efficiency loss of the antenna.

Conversion to Summations of Discretely Sampled Pattern Data

For simplicity, the summations will be derived separately for the two cases where the EIS data are taken using conic cuts and great-circle cuts. It is assumed in both cases that the measurement points are distributed uniformly in theta and phi.

Conic Cuts: For reference, the Z axis (theta=0 axis) is the long axis of the EUT in a free-space test or points straight up out of the top of the phantom's head in a phantom test. A conic cut is defined as a scan of phi from 0 to 360 degrees while theta is fixed at a given value. A series of conic cuts from theta = 0 (probe antenna at zenith) to 180 degrees (probe antenna at nadir) captures an entire spherical pattern.

$M =$ number of samples per conic cut
$N =$ number of conic cuts to form the spherical pattern
$i =$ index for each conic cut, i ranges from 1 to N
$j =$ index for each sample in a conic cut, j ranges from 1 to M

Then the theta and phi intervals are

$$\Delta\theta = \theta_i - \theta_{i-1} = \frac{\pi}{N}$$

$$\Delta\phi = \phi_j - \phi_{j-1} = \frac{2\pi}{M}$$

At this point, a choice must be made as to how samples taken at the edges of intervals are to correspond to the intervals themselves in approximating the integration. For simplicity, we will choose that the EIS measured at the beginning of a phi interval will represent that entire interval. This will have the effect of discarding the redundant measurement taken at phi=360 degrees. The most correct way to do this would probably be to utilize a trapezoidal rule for approximating the integration, but previous tests done with conic cut data have indicated that the difference in results is not significant.

Substituting the appropriate differentials into equation 5, the summation that approximates the TIS integration in this case is then

$$TIS = \frac{4\pi}{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)}\right]\sin(\theta_i)\frac{\pi}{N}\frac{2\pi}{M}}$$

$$\text{or } TIS = \frac{2NM}{\pi\sum_{i=1}^{N}\sum_{j=1}^{M}\left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)}\right]\sin(\theta_i)} \qquad (6)$$

Great-Circle Cuts: For reference, the Z axis (theta=0 axis) is the long axis of the EUT in a free-space test or points straight up out of the top of the phantom's head in a phantom test. A great-circle cut is defined here as a scan of theta from 0 to 360 degrees while phi is fixed at a given value. A series of such great-circle cuts from phi= 0 to 180 degrees captures an entire spherical pattern. Note that this coordinate system is defined with respect to the device under test (or the phantom), and may not necessarily correspond with the coordinate system of the specific positioning equipment used to obtain the pattern data.

$M =$ number of great-circle cuts to form the spherical pattern
$N =$ number of samples per great-circle cut

$i =$ index for each sample in a great-circle cut, i ranges from 1 to N
$j =$ index for each great-circle cut, j ranges from 1 to M

Then the theta and phi intervals are

$$\theta_i - \theta_{i-1} = \frac{2\pi}{N}$$

$$\phi_j - \phi_{j-1} = \frac{\pi}{M}$$

Again, a choice must be made as to how samples taken at the edges of intervals are to correspond to the intervals themselves in approximating the integration. We will choose that the EIS measured at the beginning of a theta interval will represent that entire interval. This will have the effect of discarding the redundant measurement taken at theta = 360 degrees.

The summation that approximates the TIS integration of equation 5 in this case is then

$$TIS = \frac{4\pi}{\sum_{i=1}^{N}\sum_{j=1}^{M}\left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)}\right]\left|\sin(\theta_i)\right|\frac{2\pi}{N}\frac{\pi}{M}}$$

$$\text{or } TIS = \frac{2NM}{\pi\sum_{i=1}^{N}\sum_{j=1}^{M}\left[\frac{1}{EIS_\theta(\theta,\phi)} + \frac{1}{EIS_\phi(\theta,\phi)}\right]\left|\sin(\theta_i)\right|} \qquad (7)$$

The absolute value of sin(θ) must be used in this case, because we have performed the unnatural mathematical act of sweeping theta through 360 degrees. Equation 7 can be seen to apply also to the case of conic cuts (cf. equation 3), so can be used for both measurement schemes.

Appendix J: Symmetry Pattern Antenna (Informative)

The pattern symmetry requirement specified in Appendix C should not be misinterpreted as an absolute accuracy requirement. A requirement of +/-0.1 dB for antenna pattern measurements taken in the cellular and PCS bands would be very challenging to accomplish. To clarify pattern symmetry, and provide context for selecting its value, the following is provided for informational purposes only.

Symmetry Pattern vs. Absolute Accuracy:

The absolute magnitude accuracy in this specification is +/-1.0 dB for the ERP pattern measurements. Given this specification, consideration must be given to the many items in the complete error budget that contribute to this final overall accuracy. Examples of these are the ultimate accuracy of the instrument used to measure absolute power during the calibration process (e.g., a power meter), known gain accuracy of the calibration reference antenna, quiet zone accuracy (i.e., ripple or reflection in the chamber), and connector repeatability. Many of these error contributions can be made quite small at these frequency ranges. For example, connector repeatability is controlled by proper maintenance and torque of the connectors. Three-dimensional pattern integration of the calibration antenna can yield very precise directivity references. In the case of measuring highly non-directive devices, the two largest single contributors to the error budget are usually the ultimate accuracy of the power measurement instrument, and the quiet zone accuracy (ripple) in the anechoic chamber.

To obtain the +/-1.0 dB overall accuracy desired, a substantially better quiet zone uncertainty of +/-0.5 dB ripple or less (since it is one term of several in the error budget), has been specified. To quantify the quiet zone accuracy, a verification tool (i.e., the omnidirectional dipole or loop source) substantially better than the +/- 0.5 dB ripple level discerned, therefore, should be used. Thus, the omnidirectional test antennas used for chamber validation (not necessarily for chamber calibration) are required to have patterns that are symmetric to +/- 0.1 dB. This level of pattern symmetry is achieved rather easily with an electric dipole rotated about its axis, and can be achieved with some care with the uniform-current (Alford) loops described in this section. (Reference can also be made to, e.g., "Loop Antennas with Uniform Current," Proc. IRE, vol. 32, pp. 603-607, October, 1944.)

Pattern symmetry is measured with an antenna centered precisely on the axis of rotation of the positioner. An anechoic chamber with a very low reflectivity is not required to verify a nominally omnidirectional antenna's pattern symmetry. In other words, a chamber qualifying under the specified ripple/reflectivity levels is not required to prove that an omni test antenna is indeed, omni. If an antenna with a perfectly symmetric omni pattern is precisely on the center of rotation, even if there is a substantial reflector in the chamber, a perfectly uniform pattern can be observed. This is because the signals on both the direct and reflected paths remain constant as the antenna is rotated. So as long as an “omni” antenna starts out more or less omni, it can be qualified for pattern symmetry in a chamber that might not meet the +/-0.5dB quiet zone uncertainty.

It is important to note this specification calls for pattern SYMMETRY of +/-0.1 dB -- NOT absolute gain accuracy. In fact, for the chamber validation (not calibration) phase, gain is not needed at all -- only verification of the pattern symmetry. Furthermore, the +/-0.1 dB symmetry requirement is not arbitrary; it follows directly from the desire for +/-1.0 dB absolute accuracy.

To summarize, this specification does not require validation antennas with a gain accuracy of +/-0.1 dB. Rather, the antenna pattern symmetry should be +/-0.1 dB -- which is achievable and quantifiable. This specification also calls for an overall measurement accuracy level of +/-1.0 dB, which is also achievable with current chamber technology.

For additional information on the symmetry antenna, contact CTIA Certification Program staff.

Appendix K: Change History

Date:	Revision	Section(s)	Description	Changed By
10/12/00	0.1	All	Create Baseline format from EIRP Ad-Hoc contributions	T. Jeffries (CTIA)
10/17/00	0.1	All	Editorial changes and comments submitted for possible acceptance.	C. Martin (SBC)
10/18/00	0.2	All	SBC-TRI comments accepted. Global change of ERP to EIRP.	T. Jeffries (CTIA)
10/18/00	0.2	Section 2	Introduction on the need for simulated-use configuration	
		Section 3	Clarification on when to test for simulated-use	
10/18/00	0.3	All	Modified E/H plane cut methods, phantom choice primarily	P. Moller (Motorola)
10/24/00	0.3	B.2	Include equation for Spatially Averaged	S. Harbin (SBC)
10/24/00	0.3	Section 3	EIRP criteria for TDMA	S. Harbin (SBC)
10/30/00	0.4	Section 4.2	CDMA Receiver Sensitivity Test	T. Erickson (Qcomm)
10/31/00	0.4	3.4	EIRP for GSM-1900	C. Martin (SBC)
10/31/00	0.4	4.3 & 4.4	Receiver Gain procedures for ANSI-136 & GSM-1900	C. Martin (SBC)
11/1/00	0.5	Section 2	Clarification on Great Cut	P. Moller (Motorola)
11/01/00	0.5	Appendix C	Definition Loop Probe Antennas	P. Moller (Motorola)
11/01/00	0.5	Appendix E	Included E.4, EUT Position on “SAM”	P. Moller (Motorola)
11/01/00	0.5	All	General Edits	T. Jeffries (CTIA)
11/7/00	0.6	Section 3	Redefined Radiated Criteria	T. Jeffries (CTIA)
11/17/00	0.6	Section E.5	Definition of HS Placement Fixture	T. Jeffries (CTIA)
11/28/00	0.6A	All	General Edits	C. Martin (Cingular)
01/08/01	0.6A	All	General Edits	C. Martin (Cingular)
2/15/01	0.6B	Appendix E	Alternative phantom footnote and EUT fixture	P. Moller (Motorola)
3/1/01	0.7	Section 4	Added In-between Chan Test & Total Isotropic Sens	P. Moller (Motorola)
3/1/01	0.7	Appendix B	Added TIS & updated TRP equations	E. Krenz (Mototola)
3/1/01	0.7	Section 4	Revised TDMA & GSM test methods	C. Martin (Cingular)
3/1/01	0.7	All	General Edits	T. Jeffries (CTIA)
4/5/01	0.7A	Appendix C	Clarification antenna symmetry	E. Krenz, P. Mollller (Motorola)
5/7/01	0.7-B	All	Editorial changes	T. Jeffries (CTIA)
5/7/01	0.7-B	Appendix I	TIS definition and information	E. Krenz (Motorola)
5/7/01	0.7-B	Appendix J	Symmetry Pattern information	E. Krenz (Motorola)
5/7/01	0.7-B	All	Technical Clarification and Edits	P. Chery, K. Bednasz, M. Isley, R. Sadler (Ericcson)
5/24/01	1.0	All	Editorial Changes – Official Release Draft Ver. 1.0	T.Jeffries (CTIA)