Certification Report on

Specific Absorption Rate (SAR)
Experimental Analysis

Intel

Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter
WCF2011BM

Test Date: February 2003

ITLB-WM3B2100-MPCI CARD-3984

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APREL Laboratories

Experimental Analysis SAR Report Supporting Class Two Permissive Change

Subject: **Specific Absorption Rate (SAR) Hand and Body Report**

Product: Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 inside Dell laptop chassis model number PP02X

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories PP02X

Model: PP02X

Client: DELL Computers

Applicant: Intel Corporation
2300 Corporate Center Drive
Thousand Oaks, CA 91320

Manufacturer: Dell Computer Corporation
One Dell Way
Round Rock, TX 78613

Project #: ITLB-WM3B2100-MPCI Card-3984

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Applicant:	Intel Corporation
Manufacturer:	Dell Computer Corporation
FCC ID:	E2K24CLNS
Equipment:	Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 inside Dell laptop chassis model number PP02X
Model:	PP02X
Standard:	FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X. The analysis was carried out in accordance with the requirements of FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation in accordance with Supplement C and, using methodologies contained within IEEE P-1528. The Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X was evaluated for compliance to the RF exposure requirements contained in section 2. "Applicable Documents". The Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X was assessed for SAR at the **maximum available power level** of 17.8dBm while operating with the duty cycle set at 100%.

The Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X utilizes a Mini PCI 802.11b module. The Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X has been assessed for body, bystander, and direct contact SAR, using **TWO** differing types of internal antenna.

Intel provided APREL laboratories with two production models of the DELL laptop chassis model number PP02X. Each PP02X model incorporated a different type of internal antenna which represents the final version of production units. Both of the sample DELL laptops chassis model number PP02X's use the same hardware, and electronics, where the only difference is the antenna used. The antennas used were manufactured by Hitachi and Neweb and for the purpose of this report represent two separate test case scenarios.

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For the purpose of the SAR analysis executed and subsequent report the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside Dell laptop chassis model number PP02X will be called the DUI (Device Under Investigation).

The Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X were evaluated for both body exposure and direct contact SAR (extremities) at low (ch#1), middle (ch#6) and high (ch#11) for the frequency range of 2412MHz to 2462MHz. Tests were executed at zero separation distance, for direct contact SAR (extremities) and, at a separation distance of zero mm for body analysis.

The conservative 10g average for direct contact SAR analysis for the DUI operating with the Neweb antenna was found to be **0.54 W/kg for the peak RF output power of the low channel (ch#1, f=2412MHz)** at the vertical position of DUI. For body SAR analysis the conservative 1 g SAR was found to be **1.28 W/kg for the peak RF output power of the Low channel (ch#1, f=2412MHz)** at the vertical position of the DUI.

The conservative 10g average for direct contact SAR analysis for the DUI operating with the Hitachi antenna was found to be **0.53 W/kg for the peak RF output power of the low channel (ch#1, f=2412MHz)** at the vertical position of DUI. For body SAR analysis the conservative 1 g SAR was found to be **1.20 W/kg for the peak RF output power of the Low channel (ch#1, f=2412MHz)** at the vertical position of the DUI.

Evaluation data and graphs are presented in this report. All analysis conducted and documented in this report were performed while the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X.

For the purpose of the SAR assessment the AC power source was used, and the conservative SAR position and frequency for each of the Test Case Scenarios was reassessed using the battery supply. It was found that the conservative SAR presented in this report was measured while using the AC supply.

Based on the measured results and on how the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X will be marketed and used, it is certified that the product meets the requirements as set forth in the specifications, for the RF exposure environment contained within this report for a **class two permissive change**.

The results presented in this report relate only to the samples evaluated.

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) for a sample Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X while operating with two different types of antenna. These tests were conducted at APREL Laboratories facility located at 51 Spectrum Way, Nepean, Ontario, Canada.

2. APPLICABLE DOCUMENTS

The following documents are applicable to the evaluation performed:

1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

2) ANSI/IEEE C95.1-1999, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

3) ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

5) IEEE P-1528 Draft "Recommended Practice for Determining the Peak Spatial Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communication Devices: Experimental Techniques."

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3. TEST CASE SCENARIOS

Intel provided APREL Laboratories with **TWO**-sample DELL laptops chassis model number PP02X that hosted the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 for the purpose of the SAR evaluation. The evaluations performed on the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X were to establish the conservative SAR value for both 1 and 10g while transmitting at full power.

The DUI (device under test) is the DELL laptop chassis model number PP02X which uses the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100.

Test Case Scenario 1

Dell Latitude With Neweb Antenna

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Test Case Scenario 2

Dell latitude With Hitachi Antenna

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4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-010, s/n 163
- ALIDX-500 Dosimetric SAR Measurement System
- APREL flat Phantom F1, Part # P-V-G8 (overall shell thickness 2mm)
- APREL 2.45GHz Dipole
- APREL RF Amplifier
- Hewlett Packard Signal Generator Asset
- Gigatronics Power Meter
- Gigatronics Power Sensor
- Hewlett Packard Dual Directional Coupler

Table 2: Instrumentation

Instrument	Calibration Due	Asset Number/Serial Number
E-010 Probe	May 2003	163
ALIDX-500	March 2003	N/A
APREL Flat Phantom	N/A	APL-001
APREL UniPhantom	N/A	APL-085
APREL 2450MHz Dipole	CBT	N/A
APREL RF Amplifier	CBT	301467
HP-Signal Generator	September 2003	301468
Gigatronics Power Meter	September 2003	301393
Gigatronics Power Sensor	April 2003	301394
HP Directional Coupler	October 2003	100251

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5. SET UP

5.1 ALIDX-500 Measurement System

The image below shows the laboratory along with the ALIDX-500 Measurement system.

The ALIDX-500 Dosimetric SAR Measurement System was developed jointly with APREL Laboratories and IDX Robotics for use within wireless development and the compliance environment. The system consists of a six axis articulated arm, and controller for precise probe positioning (0.05 mm repeatability). Custom software has been developed to enable communications between the robot controller software and the host operating system.

An amplifier is located on the articulated arm, which is isolated from the custom designed end effector and robot arm. The end effector provides the mechanical touch detection functionality and probe connection interface. The amplifier is functionally validated within the manufacturers site and calibrated at NCL Calibration Laboratories. A Data Acquisition Card (DAC) is used to collect the signal as detected by the isotropic e-field probe. The DAC manufacturer calibrates the DAC to NIST standards. A formal validation is executed using all mechanical and electronic components to prove conformity of the measurement platform as a whole.

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The ALIDX-500 has been designed to measure devices within the compliance environment to meet all recognized standards. The system also conforms to standards, which are currently being developed by the scientific and manufacturing community.

The course scan resolution is defined by the operator and reflects the requirements of the standard to which the device is being tested. Precise measurements are made within the predefined course scan area and the values are logged.

The user predefines the sample rate for which the measurements are made so as to ensure that the full duty-cycle of a pulse modulation device is covered during the sample. The following algorithm is an example of the function used by the system for linearization of the output for the probe.

$$V_i = U_i + U_i^{\,2} \cdot \frac{cf}{dcp_i}$$

The APREL E-Field probe is evaluated to establish the diode compression point.

A complex algorithm is then used to calculate the values within the measured points down to a resolution of 1mm. The data from this process is then used to provide the co-ordinates from which the cube scan is created for the determination of the 1 g and 10 g averages.

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Cube scan averaging consists of a number of complex algorithms, which are used to calculate the one, and ten gram averages. The basis for the cube scan process is centered on the location where the maximum measured SAR value was found. When a secondary peak value is found which is within 60% of the initial peak value, the system will report this back to the operator who can then asses the need for further analysis of both the peak values prior to the one and ten-gram cube scan averaging process. The algorithm consists of 3D cubic Spline, and Lagrange extrapolation to the surface, which form the matrix for calculating the measurement output for the one and ten gram average values. The resolution for the physical scan integral is user defined with a final calculated resolution down to 1mm.

In-depth analysis for the differential of the physical scanning resolution for the cube scan analysis has been carried out, to identify the optimum setting for the probe positioning steps, and this has been determined at 8mm increments on the X, & Y planes. The reduction of the physical step increment increased the time taken for analysis but did not provide a better uncertainty or return on measured values.

Prior to the measurement process the operator can insert the parameters for which the physical measurements are made, defining the X, Y, and Z probe movement integrals. For the FCC compliance process both OET 65 “Supplement C” and the IEEE draft standard “P-1528” were used to define the measurement parameters used during the assessment of the device.

The final output from the system provides data for the area scan measurements, physical and splined (1mm resolution) cube scan with physical and calculated values (1mm resolution).

The overall uncertainty for the methodology and algorithms the ALIDX500 used during the SAR calculation was evaluated using the data from IEEE P-1528 f3 algorithm:

$$f_3(x, y, z) = A \frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2} \cdot \left(e^{-\frac{2z}{a}} + \frac{a^2}{2(a + 2z)^2} \right)$$

The probe used during the measurement process has been assessed to provide values for diode compression. These values are calculated during the probe calibration exercise and are used in the mathematical calculations for the assessment of SAR.

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5.2 Validation

A full system validation was run prior to the SAR testing. The methodology used for the system validation was taken from IEEE P-1528 section 7 (where applicable). Further details of the tissue used during the system validation are provided in section 6.3 Simulated Tissue. The results from both of the system validations are provided in Appendix C Validation Results.

The image below shows the setup used for the system validation.

NOTE:

To fully evaluate the 2 Test Case Scenarios it was necessary for APREL to execute two system validation exercises over a period of 48 hours.

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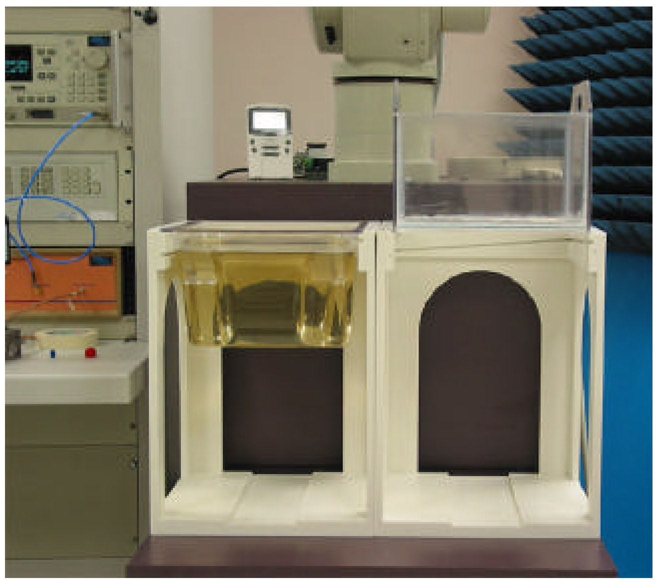
5.3 Body & Bystander Analysis

Measurements were made on each of the Test Case Scenarios using the APREL Universal Phantom, on the low, mid, and high channels. Each Test Case Scenario was assessed for front, back, and vertical. The separation distance used was 0mm for the conservative SAR assessment. The results from this exercise are presented in section 6 test results.

The image below shows part of the setup used for body measurements.



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5.4 Simulated Tissue

The recipes used to make the simulated tissue were as presented in OET Supplement C.

The density used to determine SAR from the measurements was the recommended 1.0 kg/m^3 found in Appendix C of "Supplement C OET Bulletin 65, Edition 01-01".

Dielectric parameters of the simulated tissue material were determined using an Anritsu 37347A Vector Network Analyzer, and the APREL Dielectric Probe.

For both system validations the tissue was calibrated at 2450 MHz.

Table 3: Properties for Tissue used in Validation 1 executed 27th Feb 03

BODY Tissue	APREL	Target Value	D (%)
Dielectric constant, ε_r	50.13	52.7	5
Conductivity, σ [S/m]	2.04	1.95	4
Tissue Conversion Factor,	5.6	-	-
Tissue Temperature (ºC)	22	-	-

Table 4: Properties for Tissue used in Validation 2 executed 28th Feb 03

BODY Tissue	APREL	Target Value	D (%)
Dielectric constant, ε_r	50.13	52.7	5
Conductivity, σ [S/m]	2.04	1.95	4
Tissue Conversion Factor,	5.6	-	-
Tissue Temperature (ºC)	22	-	-

Table 5: Tissue Calibration Instrumentation

Instrument	Calibration Due	Asset Number/Serial Number
Anritsu VNA	CBT	301382
APREL Dielectric Probe	CBT	-

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5.5 Methodology

1. The test methodology utilized in the analysis of the Test Case Scenarios complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.

2. The E-field is measured with a small isotropic probe (output voltage proportional to E^2).

$$SAR = \frac{\sigma \left|\mathbf{E}\right|^2}{\rho}$$

3. The probe is moved precisely from one point to the next using the robot (10 mm increments for wide area scanning and 8 mm increments for zoom scanning in the X, Y directions) and (5.0 mm increments for the final depth profile measurement in the Z direction).

4. The probe travels in the homogeneous liquid simulating human tissue (body).

   Section 5.4 contains information about the properties of the simulated tissue used for these measurements.

5. The liquid is contained in a manikin simulating a portion of the human body with an overall shell thickness of 2 mm.

6. The DUI is positioned with the surface under investigation against the phantom with no separation distance for an initial conservative analysis.

7. All tests were performed with the highest power available from the sample DUI under transmit conditions.

More detailed descriptions of the test method are given in Section 6 where appropriate.

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6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter was integrated by APREL Laboratories following the guidelines specified by Intel. The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter was then set to transmit, using the software, which was supplied by Intel, with a 100% duty cycle. During the SAR measurement process a spectrum analyzer was setup to measure the radiated power.

The two test case scenario Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X have been developed to operate with both AC and, battery supplies. The DUI was analyzed and power measurements were made on the Tx output port for the DUI in both battery and AC use. The power measurement exercise showed that **no measurable difference could be made** when comparing battery and AC power modes.

The DUI then had a further assessment executed while transmitting using the AC supply over a period of 40 minutes. During this period power measurements were made to assess any measurable drift. Table six contains the results from this exercise.

<u>Note</u>

The power measurements taken were conducted and measured using a power meter, and broadband power sensor for both Test Case Scenarios.

Table 6: Conducted power measurement before and after the scanning

Type of Exposure	Scan Type Equivalent	Power Readings (dBm)		ΔP_{TX} (dB)
		Initial	**After 40 Minutes**	
Direct Contact Exposure	Area	17.8	17.8	0
	Fine/Zoom	17.8	17.8	0
Body Exposure	Area	17.8	17.8	0
	Fine/Zoom	17.8	17.8	0

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6.2. SAR MEASUREMENTS

1) RF exposure is expressed as Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points. SAR is expressed as RF power per kilogram of mass, averaged in 10 grams of tissue for the extremities and 1 gram of tissue elsewhere. The equation below is a representation of how SAR can theoretically equate.

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

2) The DUI was put into test mode for the SAR measurements via test software supplied by the manufacturer running on the host platform. This control software set the DUI channel and operating TX mode/frequency.

3) Tables 7, and 8 provide the details in tabular form of the full measurement analysis (Test Case Scenarios), which was performed on the DUI. Appendix A provides contour plots of the SAR measurements super imposed on the DUI.

4) Area/Zoom scans were performed for the low, middle and high channels of the DUI. These scans were repeated for the top, bottom and vertical positions of the DUI. The DUI was operating with maximum output power and a duty cycle of 100%. The DUI was placed up against the phantom during the test process. The phantom shell thickness is 2 mm overall.

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6.3. DIRECT CONTACT SAR

All subsequent testing for the direct contact SAR was performed on three channels (low: 2412MHz, middle: 2437MHz, high: 2462MHz) at all three positions. The results are presented in the following tables.

1) The device had an initial area scan executed to establish the location of the maximum peak SAR. A calculated resolution of 1 mm was used to determine the location for the peak SAR.
2) The device was then explored on a refined 32 mm grid (Cube, Zoom Scan) in three dimensions (X, Y & Z) measuring at 8 mm integrals X & Y and 5 mm integrals in the Z plane so as to create a physical measured point matrix. The system then runs a series of complex algorithms, which completes the matrix of calculated and measured values equivalent to a 1 mm resolution in the X, & Y planes.
3) The software runs a series of Lagrange functions to provide the data for the Z plane, which is inserted into the matrix.
4) To complete the calculated matrix (1 mm resolution) a fourth-order polynomial extrapolation is used to compute the surface values and the 1 and 10-gram averages are then calculated.
5) Where two (or more) peaks with similar values are measured the location of the peaks is recorded. A refined grid is then created to asses each peak location individually, and the maximum value from the assessment is used to record conservative SAR for this report.
6) **For Test Case Scenario 1** the highest conservative SAR value averaged over 10 grams for the direct contact exposure analysis (back of DUI) was found to be 0.54W/kg at the low channel 2412MHz (Table 7).
7) **For Test Case Scenario 2** the highest conservative SAR value averaged over 10 grams for the direct contact exposure analysis (back of DUI) was found to be 0.54W/kg at the low channel 2412MHz (Table 8).

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6.4. BODY EXPOSURE

All subsequent testing for the direct contact SAR was performed on three channels (low: 2412MHz, middle: 2437MHz, high: 2462MHz) at all three positions. The results are presented in the following tables.

1) The device had an initial area scan executed to establish the location of the maximum peak SAR. A calculated resolution of 1mm was used to determine the location for the peak SAR.
2) The device was then explored on a refined 32 mm grid (Cube, Fine Scan) in three dimensions (X, Y & Z) measuring at 8 mm integrals X & Y and 5 mm integrals in the Z plane so as to create a physical measured point matrix. The system then runs a series of complex algorithms, which completes the matrix of calculated and measured values equivalent to a 1 mm resolution in the X, & Y planes.
3) The software runs a series of Lagrange functions to provide the data for the Z plane, which is inserted into the matrix.
4) To complete the calculated matrix (1mm resolution) a fourth order polynomial is used to extrapolate the surface values and the 1 and 10-gram averages are then calculated.
5) Where two (or more) peaks with similar values are measured the location of the peaks is recorded. A refined grid is then created to asses each peak location individually, and the maximum value from the assessment is used to record conservative SAR for this report.
6) **For Test Case Scenario 1** the highest conservative SAR value averaged over 1 gram for the direct contact exposure analysis was found to be 1.28W/kg at the low channel 2412MHz (Table 7) for the DUI located in the vertical position.
7) **For Test Case Scenario 2** the highest conservative SAR value averaged over 1 gram for the direct contact exposure analysis (back of DUI) was found to be 1.20W/kg at the low channel 2412MHz (Table 8).

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Table 7: Test results - 1 g and 10 g SAR values for the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X Test Scenario 1 Neweb antenna

Assessment Type	Position Separation mm	Channel	Channel Number	Frequency MHz	1g SAR W/kg	10g SAR W/kg
Body	**Vertical (0)**	**Low**	**1**	**2412**	**1.28**	**-**
Body	Vertical (0)	Mid	6	2437	1.12	-
Body	Vertical (0)	High	11	2462	1.23	-
Direct	**Vertical (0)**	**Low**	**1**	**2412**	**-**	**0.54**
Direct	Vertical (0)	Mid	6	2437	-	0.49
Direct	Vertical (0)	High	11	2462	-	0.52
Body	Keyboard Down (0)	Low	1	2412	0.69	-
Direct	Keyboard Down (0)	Low	1	2412	-	0.37
Body	Left (0)	Low	1	2412	0.53	-
Direct	Left (0)	Low	1	2412	-	0.47
Body	Keyboard Up(0)	Low	1	2412	0.17	-
Direct	Keyboard Up(0)	Low	1	2412	-	0.16

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Table 8: Test results - 1 g and 10 g SAR values for the Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X Test Scenario 2 Hitachi antenna

Assessment Type	Position Separation mm	Channel	Channel Number	Frequency MHz	1g SAR W/kg	10g SAR W/kg
Body	**Vertical (0)**	**Low**	**1**	**2412**	**1.20**	**-**
Body	Vertical (0)	Mid	6	2437	1.00	-
Body	Vertical (0)	High	11	2462	1.20	-
Direct	**Vertical (0)**	**Low**	**1**	**2412**	**-**	**0.53**
Direct	Vertical (0)	Mid	6	2437	-	0.45
Direct	Vertical (0)	High	11	2462	-	0.53
Body	Keyboard Down (0)	Low	1	2412	0.58	-
Body	Keyboard Down (0)	Mid	6	2437	0.57	-
Body	Keyboard Down (0)	High	11	2462	0.53	
Direct	Keyboard Down (0)	Low	1	2412	-	0.27
Direct	Keyboard Down (0)	Mid	6	2437	-	0.27
Direct	Keyboard Down (0)	High	11	2462	-	0.24
Body	Left (0)	Low	1	2412	0.23	-
Direct	Left (0)	Low	1	2412	-	0.11
Body	Keyboard Up(0)	Low	1	2412	0.18	-
Direct	Keyboard Up(0)	Low	1	2412	-	0.16

Executed 28th Feb 03

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7. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 10 grams, was found to be on **Test Case Scenario 1** while the device was in the **vertical** position, where the conservative SAR was measured on the **low channel 2412MHz at 0.54 W/kg** (direct contact SAR for the exposed extremities – hands, wrists, feet and ankles). The overall margin of uncertainty for this measurement is **±17.9%** (Appendix D). The SAR limit given in the FCC 96-326 Safety Guideline is 4.0 W/kg for direct contact exposure for the general population.

The maximum Specific Absorption Rate (SAR) averaged over 1 gram, was found to be on **Test Case Scenario 1** while the device was in the **vertical** position, where the conservative SAR was measured on the **low channel 2412MHz at 1.28 W/kg** (Body SAR). The overall margin of uncertainty for this measurement is **±18.3%** (Appendix D). The SAR limit given in the FCC 96-326 Safety Guideline is 1.6 W/kg for body exposure for the general population.

Considering the above, this unit as tested, and as it will be marketed and used, is found to be compliant with the FCC 96-326 requirement.

Tested by: Yingzhi Chen   Date: 27th February, 2002

Tested by: Yingzhi Chen   Date: 28th February, 2002

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Appendix A

TEST GRAPHIC PLOTS

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Tel. (613) 820-2730
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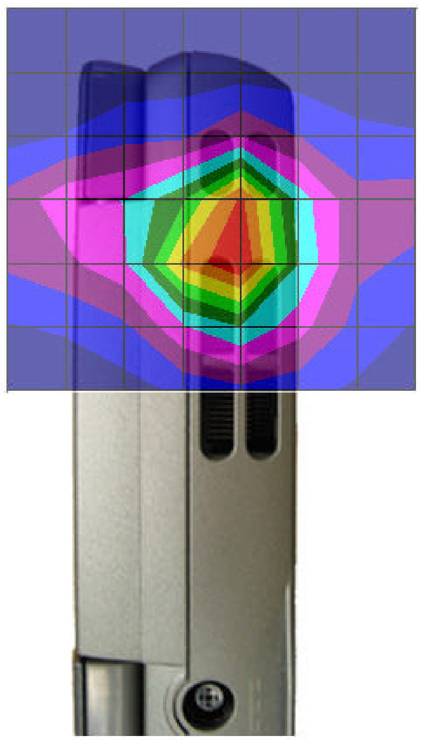
GRAPH 1

Direct contact SAR (10g)
Vertical
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.54**	**0**

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SAR DATA REPORT

SAR DATA REPORT LATITUDE#1 SCAN07-1

START : 27-FEB-03 01:39:03 PM
END : 27-FEB-03 01:44:58 PM
CODE VERSION : 4.12
ROBOT VERSION: 4.08

PRODUCT DATA:
TYPE : DELL LATITUDE #1
FREQUENCY : 2412 MHZ
ANTENNA TYPE : NEWEB
ANTENNA POSN. : INTERNAL

MEASUREMENT DATA:
PHANTOM NAME : APREL-UNI
PHANTOM TYPE : UNIPHANTOM
TISSUE TYPE : MUSCLE
TISSUE DIELECTRIC : 50.130
TISSUE CONDUCTIVITY : 2.040
TISSUE DENSITY : 1.000
CREST FACTOR : 1.000
ROBOT NAME : CRS

PROBE DATA:
PROBE NAME : 163
PROBE TYPE : E FLD TRIANGLE
FREQUENCY : 2450 MHZ
TISSUE TYPE : MUSCLE
CALIBRATED DIELECTRIC : 50.130
CALIBRATED CONDUCTIVITY : 2.040
PROBE OFFSET : 2.500 MM
CONVERSION FACTOR : 5.600
DIODE COMPRESSION PT : 76.0 MV
PROBE SENSITIVITY : 0.580 0.580 0.580 MV/(MW/CM^2)
AMPLIFIER GAINS : 20.00 20.00 20.00
CHAN. OFFSET (MV) : 2.38 1.71 -1.53

SAMPLE:
RATE: 6000 SAMPLES/SEC
COUNT: 1000 SAMPLES
NIDAQ GAIN: 5
SCAN TIME: 166.7 MSEC

COMMENTS:
VERTICAL, 0MM

AREA SCAN - MAX LOCAL SAR VALUE AT X=25.0 Y=-19.0 = 1.01 W/KG
ZOOM SCAN - MAX LOCAL SAR VALUE AT X=33.0 Y=-27.0 Z=0.0 = 3.19 W/KG
MAX 1G SAR AT X=25.0 Y=-19.0 Z=0.0 = 1.28 W/KG
MAX 10G SAR AT X=26.0 Y=-20.0 Z=0.0 = 0.54 W/KG

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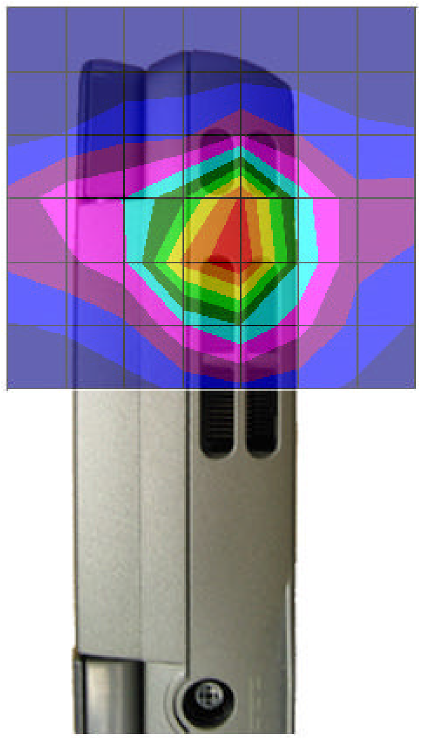
GRAPH 2

Body SAR (1g)
Vertical
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (^{o}C)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.28**	**0**

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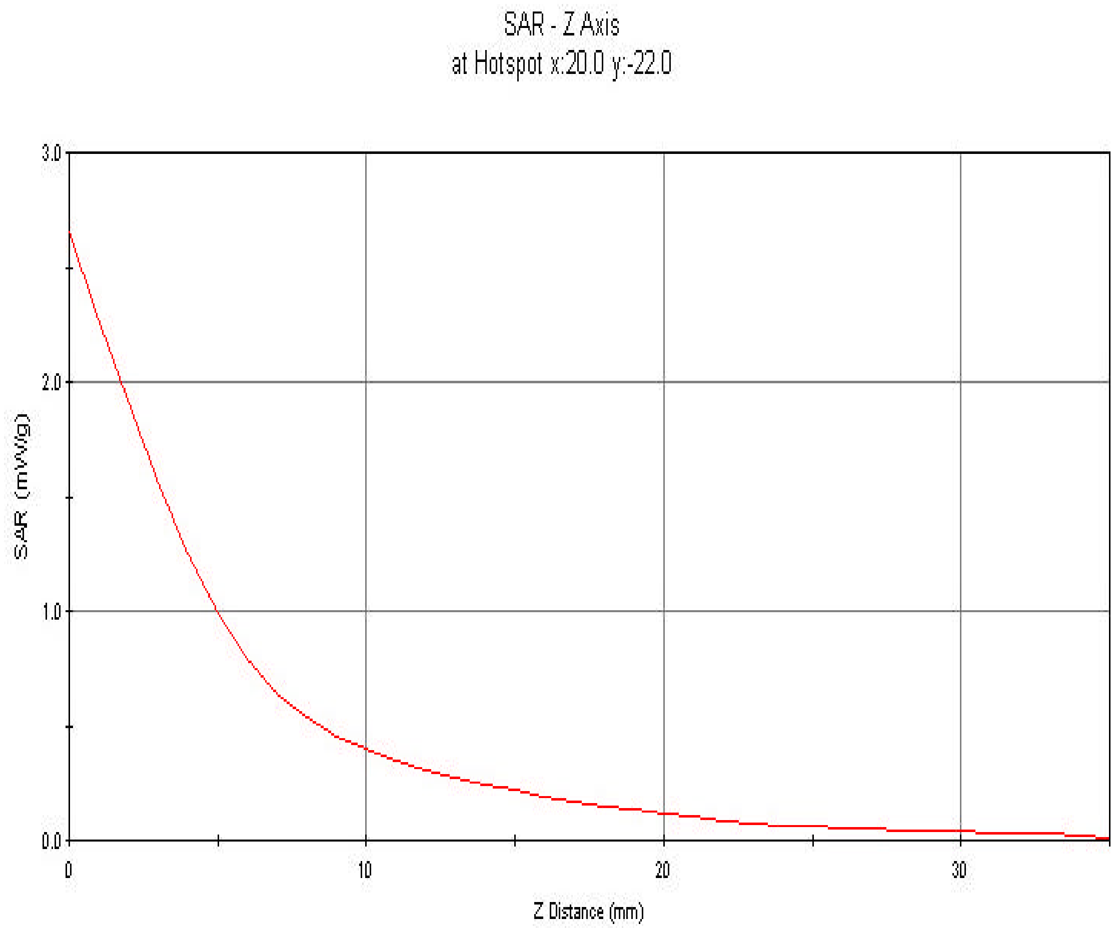
Z AXIS PLOT FOR GRAPHS 1 AND 2



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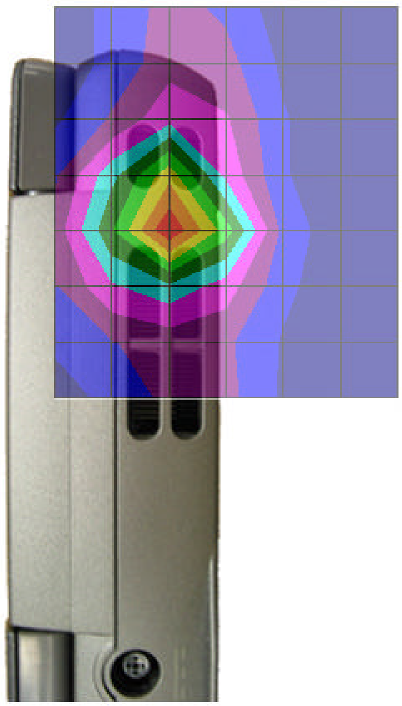
GRAPH 3

Body SAR (1g)
Vertical
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.12**	**0**

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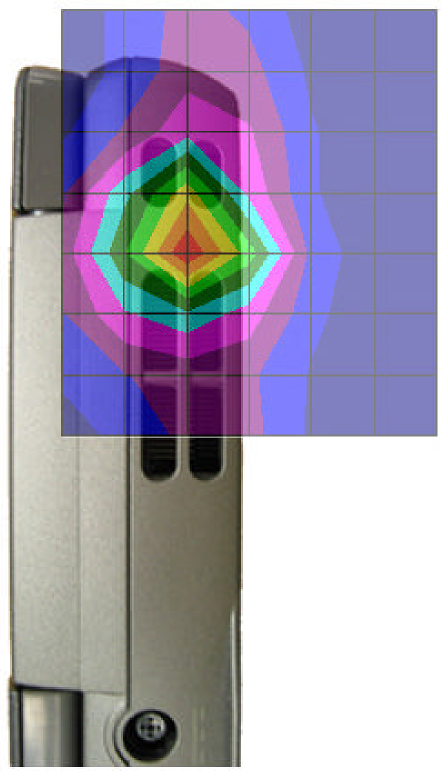
GRAPH 4

Direct Contact SAR (10g)
Vertical
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.49**	**0**

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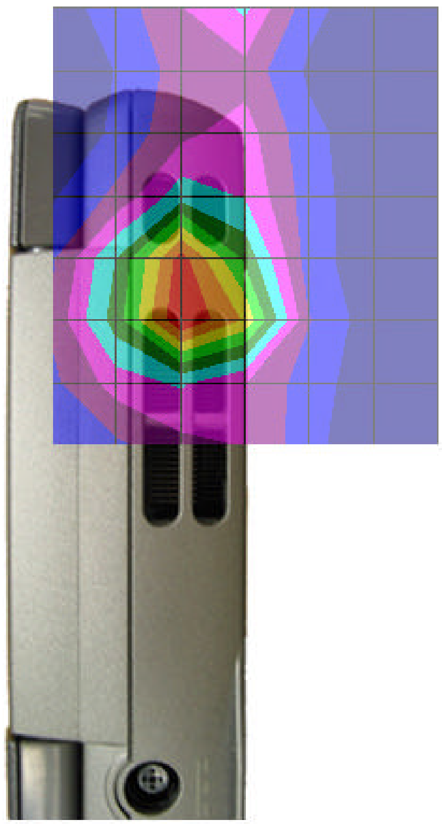
GRAPH 5

Body SAR (1g)
Vertical
Distance 0 mm
High Channel
Frequency: 2462 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (°C)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.23**	**0**

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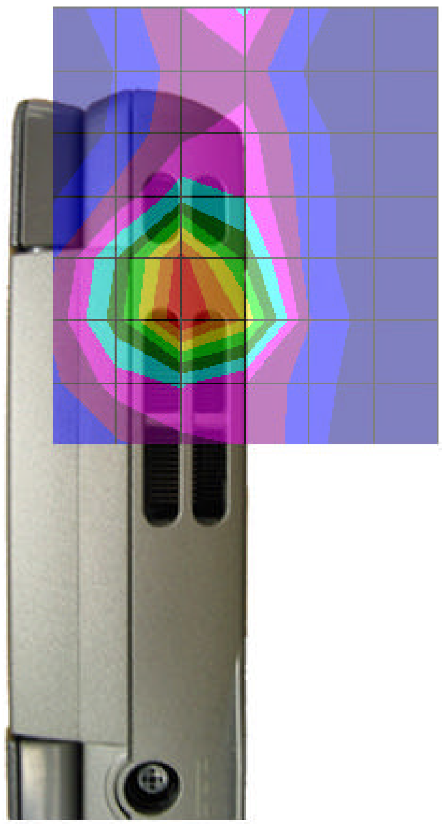
Graph 6

Direct Contact SAR (10g)
Vertical
Distance 0 mm
High Channel
Frequency: 2462 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.52**	**0**

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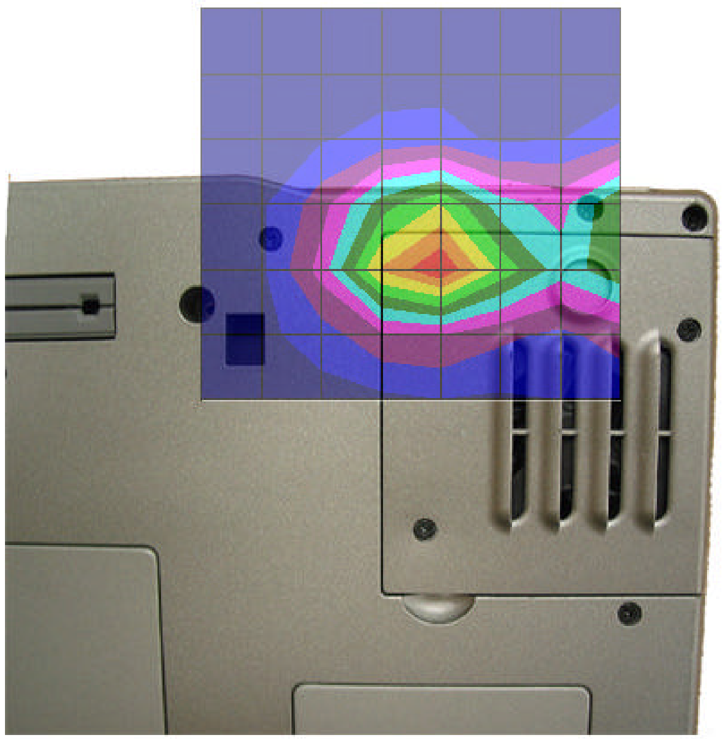
GRAPH 7

Body SAR (1g)
Keyboard Down
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.69**	**0**

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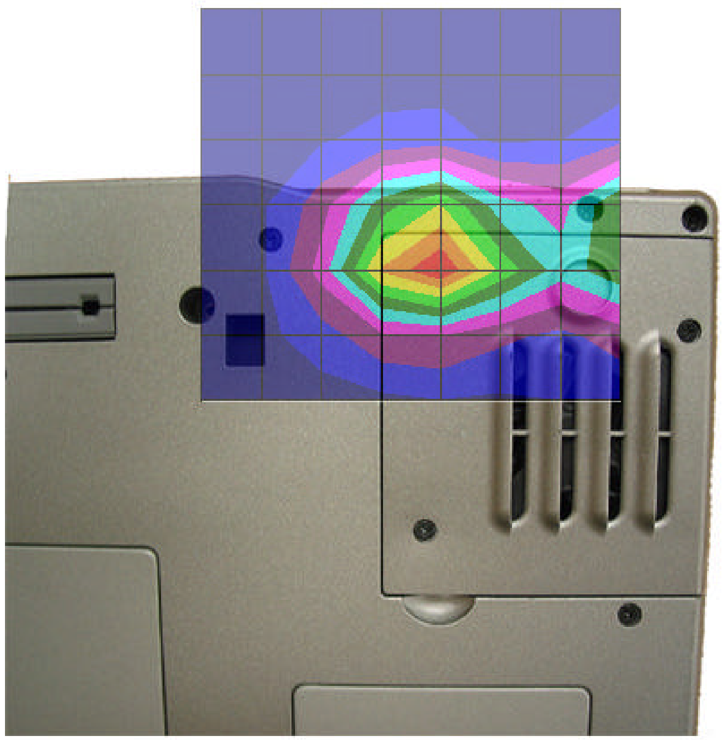
GRAPH 8

Direct Contact SAR (10g)
Keyboard Down
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.37**	**0**

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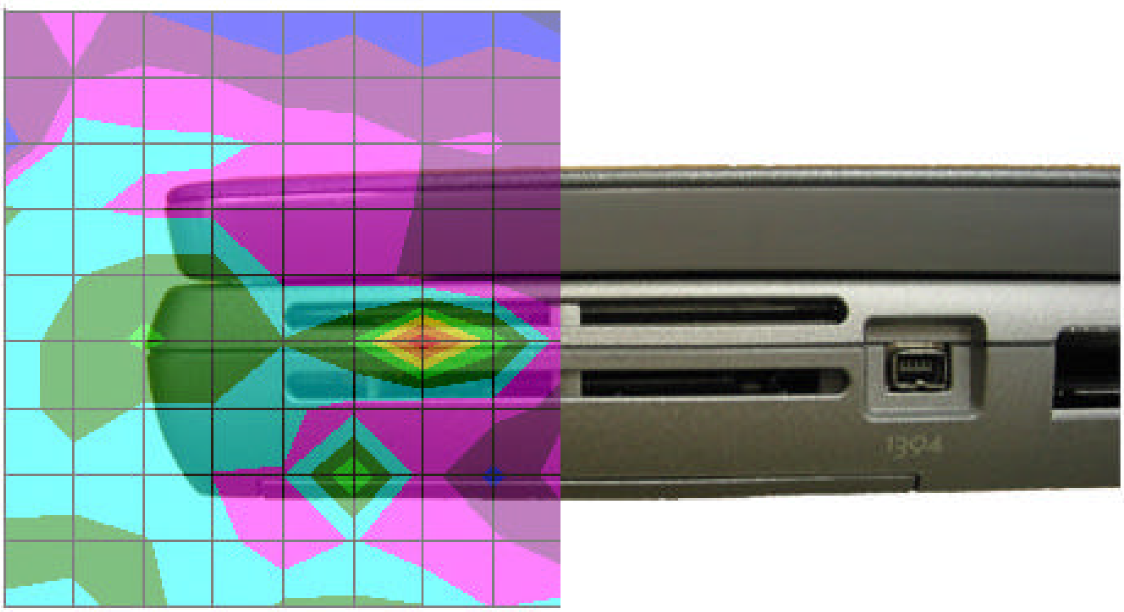
GRAPH 9

Body SAR (1g)
Left Side
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.53**	**0**

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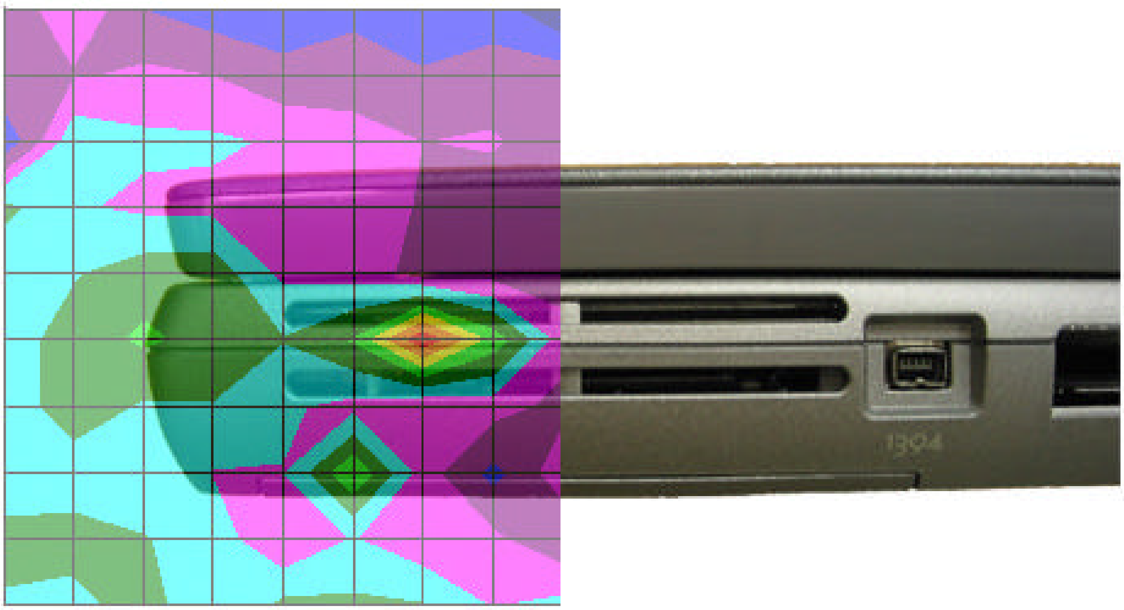
GRAPH 10

Direct Contact SAR (10g)
Left Side
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.47**	**0**

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GRAPH 11

Body SAR (1g)
Keyboard Up
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1

Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.17**	**0**

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GRAPH 12

Direct Contact SAR (10g)
Keyboard Up
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 1

Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
27/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.16**	**0**

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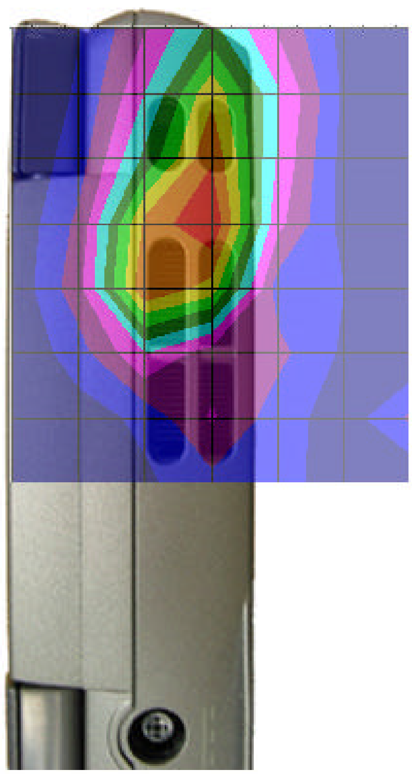
GRAPH 13

Direct contact SAR (10g)
Vertical
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.53**	**0**

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SAR DATA REPORT

SAR DATA REPORT LATITUDE#2 SCAN01

START : 28-FEB-03 03:07:42 PM
END : 28-FEB-03 03:13:38 PM
CODE VERSION : 4.12
ROBOT VERSION: 4.08

PRODUCT DATA:
TYPE : DELL LATITUDE #2
FREQUENCY : 2412 MHZ
ANTENNA TYPE : HITACHI
ANTENNA POSN. : INTERNAL

MEASUREMENT DATA:
PHANTOM NAME : APREL-UNI
PHANTOM TYPE : UNIPHANTOM
TISSUE TYPE : MUSCLE
TISSUE DIELECTRIC : 50.130
TISSUE CONDUCTIVITY : 2.040
TISSUE DENSITY : 1.000
CREST FACTOR : 1.000
ROBOT NAME : CRS

PROBE DATA:
PROBE NAME : 163
PROBE TYPE : E FLD TRIANGLE
FREQUENCY : 2450 MHZ
TISSUE TYPE : MUSCLE
CALIBRATED DIELECTRIC : 50.130
CALIBRATED CONDUCTIVITY : 2.040
PROBE OFFSET : 2.500 MM
CONVERSION FACTOR : 5.600
DIODE COMPRESSION PT : 76.0 MV
PROBE SENSITIVITY : 0.580 0.580 0.580 MV/(MW/CM^2)
AMPLIFIER GAINS : 20.00 20.00 20.00
CHAN. OFFSET (MV) : 2.38 1.71 -1.53

SAMPLE:
RATE: 6000 SAMPLES/SEC
COUNT: 1000 SAMPLES
NIDAQ GAIN: 5
SCAN TIME: 166.7 MSEC

COMMENTS:
VERTICAL, 0MM

AREA SCAN - MAX LOCAL SAR VALUE AT X=20.0 Y=-22.0 = 0.95 W/KG
ZOOM SCAN - MAX LOCAL SAR VALUE AT X=20.0 Y=-22.0 Z=0.0 = 2.64 W/KG
MAX 1G SAR AT X=21.0 Y=-22.0 Z=0.0 = 1.20 W/KG
MAX 10G SAR AT X=19.0 Y=-22.0 Z=0.0 = 0.53 W/KG

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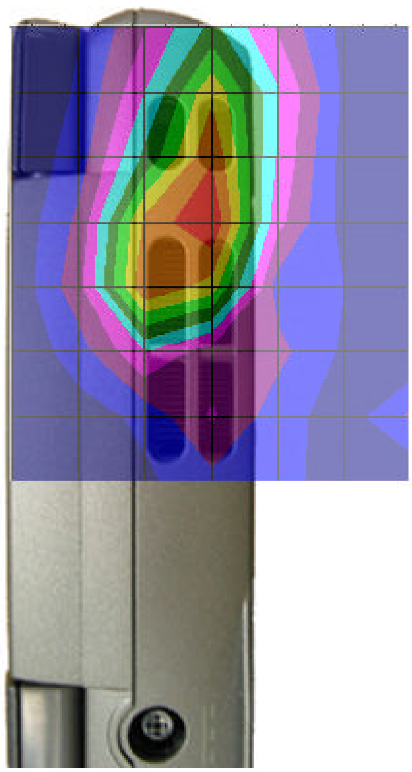
GRAPH 14

Body SAR (1g)
Vertical
Distance 0 mm
Low Channel
Frequency: 2412 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.20**	**0**

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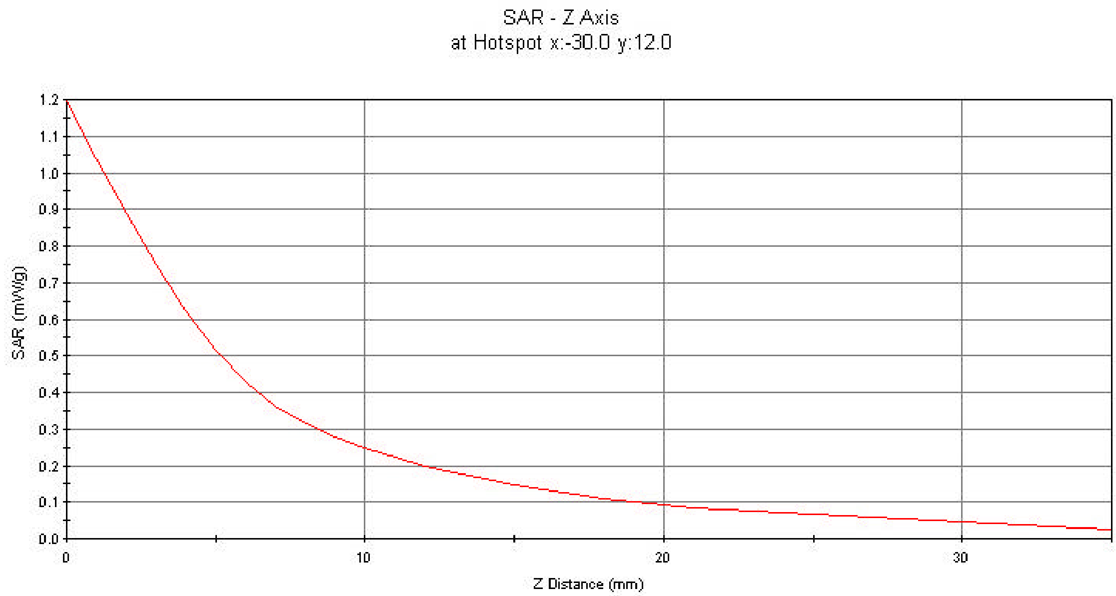
Z AXIS PLOT FOR GRAPHS 13 AND 14



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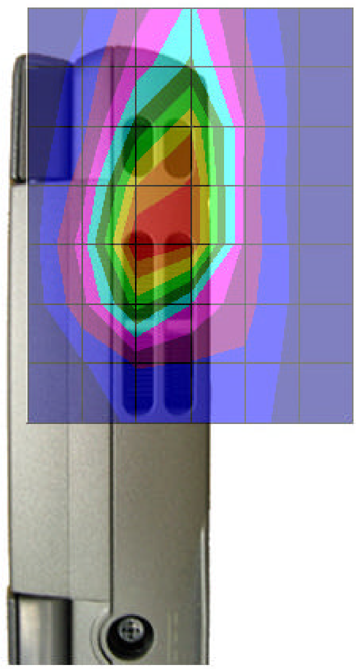
GRAPH 15

Body SAR (1g)
Vertical
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.00**	**0**

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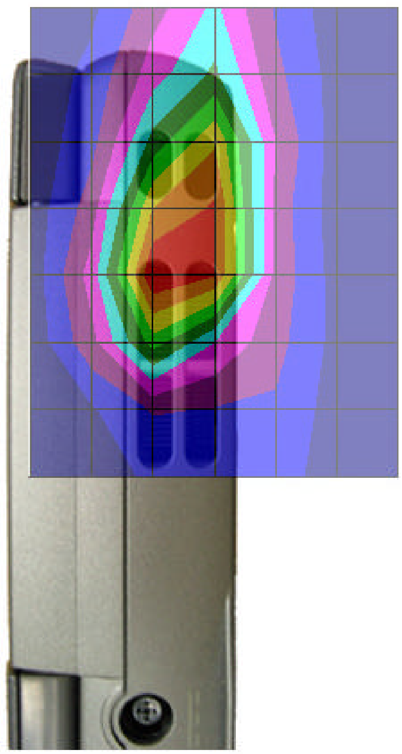
GRAPH 16

Direct Contact SAR (10g)
Vertical
Distance 0 mm
Mid Channel
Frequency: 2437 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.45**	**0**

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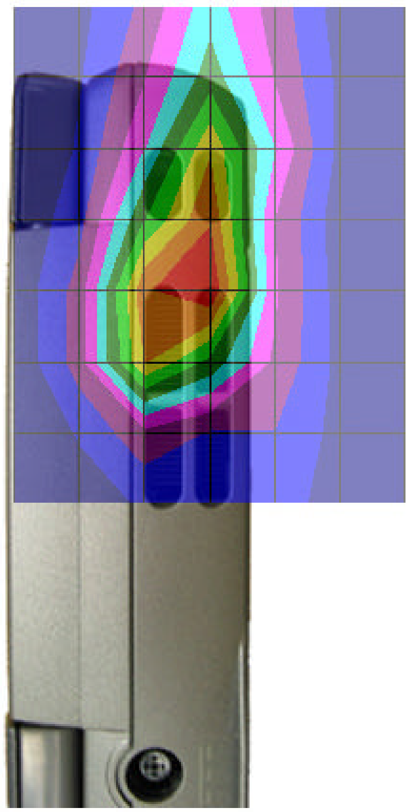
GRAPH 17

Body SAR (1g)
Vertical
Distance 0 mm
High Channel
Frequency: 2462 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**1.20**	**0**

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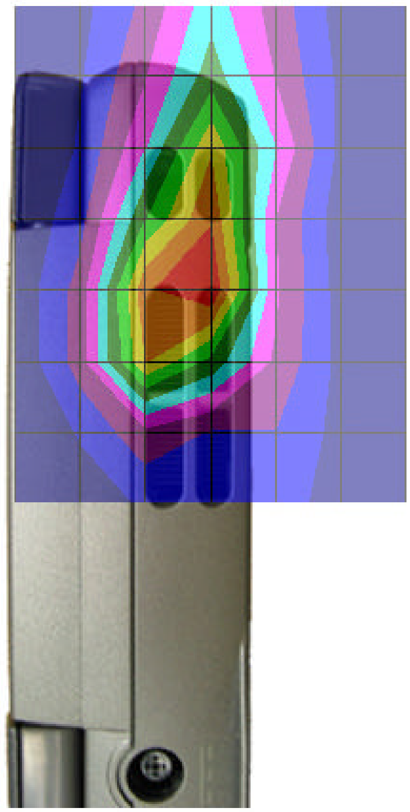
Graph 18

Direct Contact SAR (10g)
Vertical
Distance 0 mm
High Channel
Frequency: 2462 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.53**	**0**

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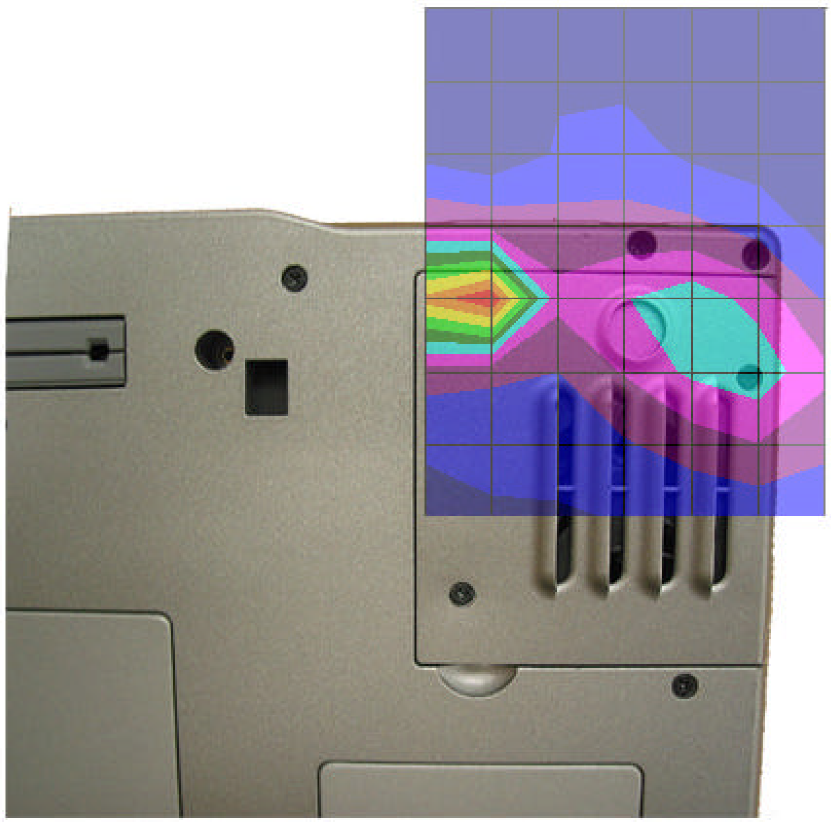
GRAPH 19

Body SAR (1g)
Keyboard Down
Distance 0mm
Low Channel
Frequency: 2412 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	1g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.58**	**0**

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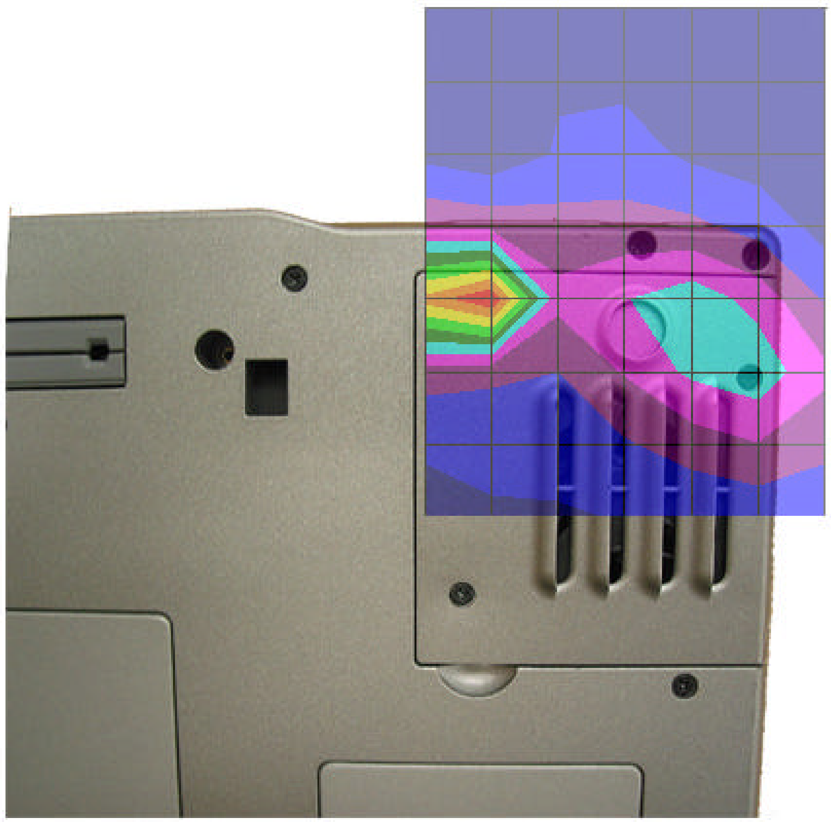
GRAPH 20

Direct Contact SAR (10g)
Back Side Up
Distance 0mm
Low Channel
Frequency: 2412 MHz
Test Scenario 2



Date	Dielectric Constant ε_r	Conductivity σ [S/m]	Probe Con/F	Tissue Temp (ºC)	10g SAR (W/kg)	Power Drift
28/03/03	**50.13**	**2.04**	**5.6**	**21**	**0.27**	**0**

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Appendix B

Setup Pictures

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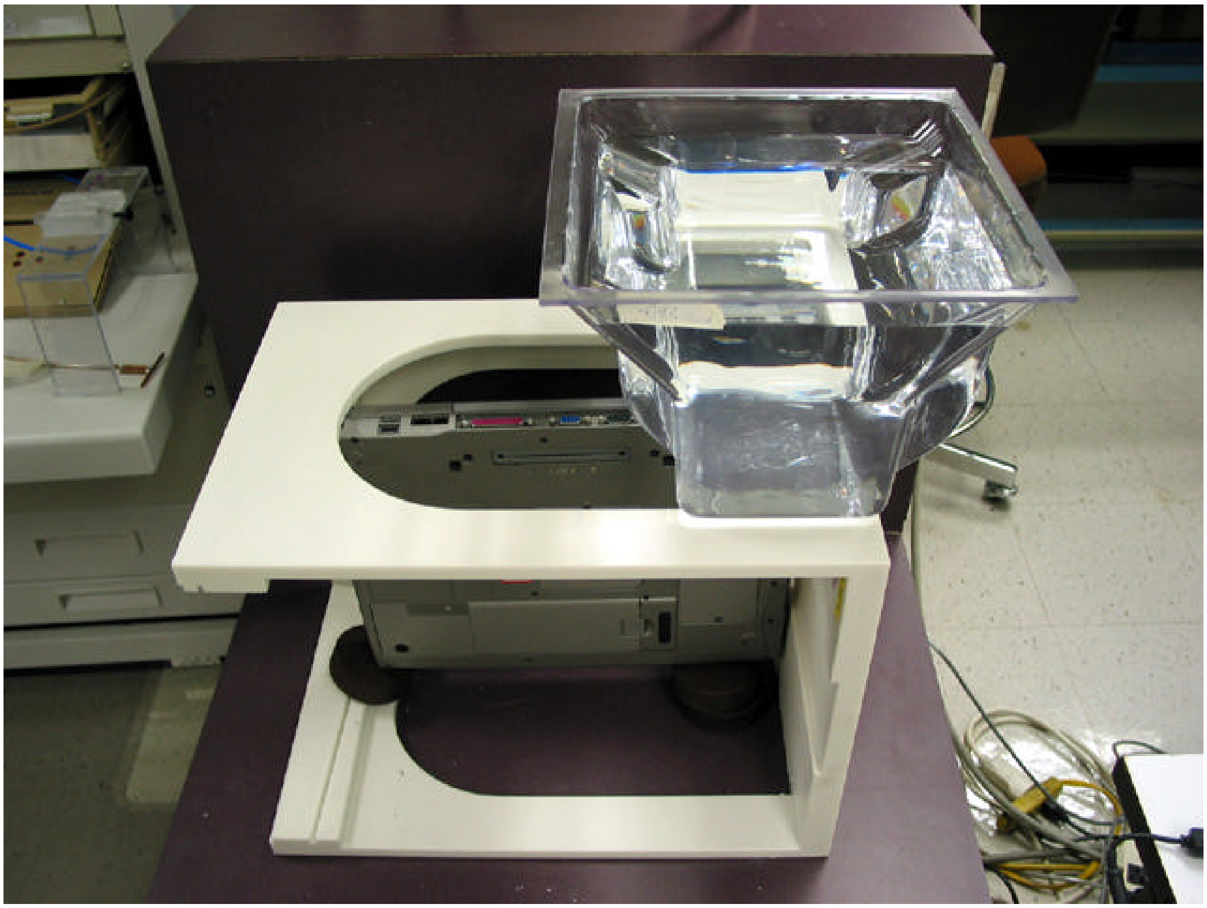
PICTURE 1

Test Scenario 1 Neweb Antenna
DUI in Vertical Position



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PICTURE 2

Test Scenario 1 Neweb Antenna
DUI in Vertical Position

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PICTURE 3

Test Scenario 1 Neweb Antenna
DUI keyboard Down Position

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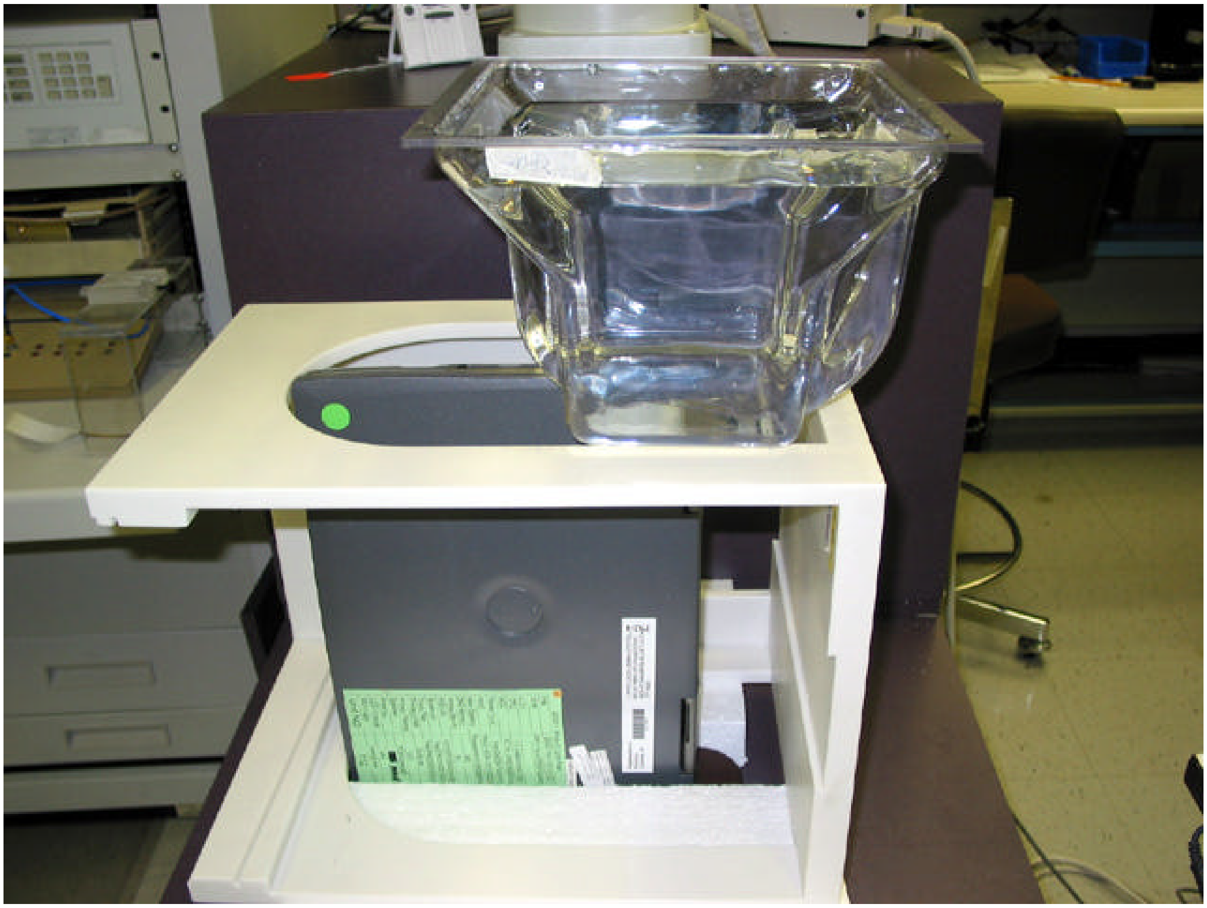
PICTURE 4

Test Scenario 1 Neweb Antenna
DUI Left Position



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e-mail: info@aprel.com

PICTURE 5

Test Scenario 1 Neweb Antenna
DUI keyboard Up Position

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PICTURE 6

Test Scenario 1 Neweb Antenna
DUI keyboard Up Position

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Appendix C

Validation Scan Results

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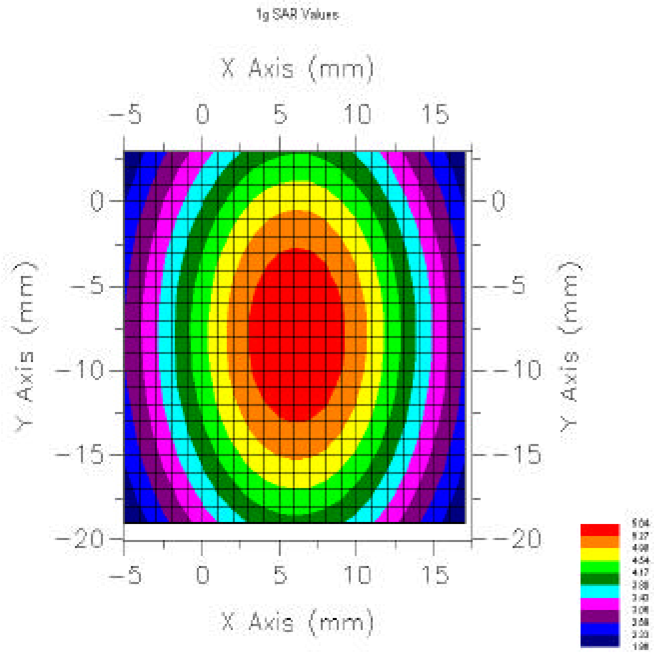
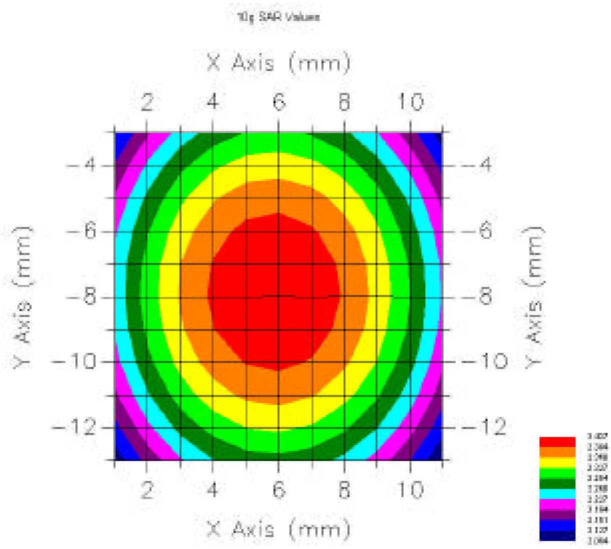
VALIDATION SCAN 1





Date:27th February 2003
Frequency: 2450 MHz
Tissue Type: Muscle
Conversion Factor: 5.6
Input Power to Dipole: 0.1 W (Normalized to 1W)
Distance from Dipole to Tissue: 10 mm
Tissue Depth: 15 cm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
54.0	52.4	+4.0

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
24.3	24.0	+1

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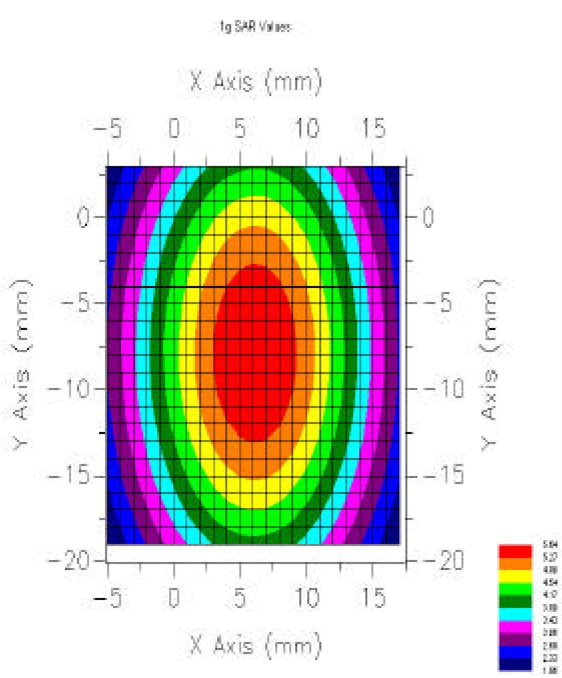
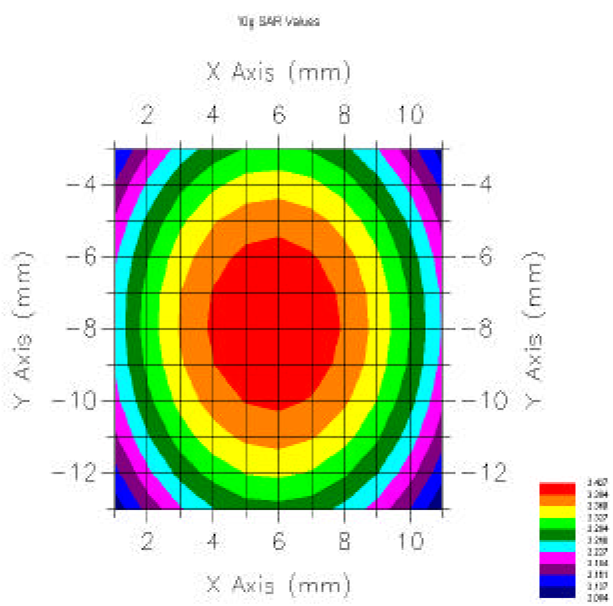
VALIDATION SCAN 2





Date: 28th February 2003
Frequency: 2450 MHz
Tissue Type: Muscle
Conversion Factor: 5.6
Input Power to Dipole: 0.1 W (Normalized to 1W)
Distance from Dipole to Tissue: 10 mm
Tissue Depth: 15 cm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
54.2	52.4	+4.0

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
23.1	24.0	-3

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APPENDIX D: UNCERTAINTY BUDGET

Intel Mini PCI Type 3A 802.11b Wireless LAN Adapter model WM3A2100 located inside DELL laptop chassis model number PP02X

Source of Uncertainty	Description (Annex)	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g)	Standard Uncertainty (10-g)	v_i^2 or v_{eff}
Measurement System									
Probe Calibration	E1.1	3.5	normal	1	1	1	3.5	3.5	
Axial Isotropy	E1.2	3.7	rectangular	3	$(1\text{-cp})^{1/2}$	(1-cp)1/2	1.5	1.5	
Hemispherical Isotropy	E1.2	10.9	rectangular	3	cp	cp	4.4	4.4	
Boundary Effect	E1.3	1.0	rectangular	3	1	1	0.6	0.6	
Linearity	E1.4	4.7	rectangular	3	1	1	2.7	2.7	
Detection Limit	E1.5	1.0	rectangular	3	1	1	0.6	0.6	
Readout Electronics	E1.6	1.0	normal	1	1	1	1.0	1.0	
Response Time	E1.7	0.8	rectangular	3	1	1	0.5	0.5	
Integration Time	E1.8	1.7	rectangular	3	1	1	1.0	1.0	
RF Ambient Condition	E5.1	3.0	rectangular	3	1	1	1.7	1.7	
Probe Positioner Mech. Restrictions	E5.2	0.4	rectangular	3	1	1	0.2	0.2	
Probe Positioning with respect to Phantom Shell	E5.3	2.9	rectangular	3	1	1	1.7	1.7	
Extrapolation and Integration	E4.2	3.7	rectangular	3	1	1	2.1	2.1	
Test Sample Positioning	E3.1.3	4.0	normal	1	1	1	4.0	4.0	11
Device Holder Uncertainty	E3.1.2	2.0	normal	1	1	1	2.0	2.0	8
Drift of Output Power	Section 5.6.2	0.0	rectangular	3	1	1	0.0	0.0	
Phantom and Setup									
Phantom Uncertainty (shape and thickness tolerance)	E2.1	3.4	rectangular	3	1	1	2.0	2.0	
Liquid Conductivity (target)	E2.2	5.0	rectangular	3	0.7	0.5	2.0	1.4	
Liquid Conductivity (meas.)	E2.2	2.0	rectangular	3	0.7	0.5	0.8	0.6	
Liquid Permittivity (target)	E2.2	4.0	rectangular	3	0.6	0.5	1.4	1.2	
Liquid Permittivity (meas.)	E2.2	2.0	rectangular	3	0.6	0.5	0.7	0.6	
Combined Uncertainty			RSS				9.1	9.0	
Combined Uncertainty **(coverage factor = 2)**			Normal (k=2)				18.3	17.9	

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Appendix E

Probe Calibration Certificate

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NCL CALIBRATION LABORATORIES

Calibration File No.: C-P-0265

C E R T I F I C A T E OF C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 2.45 GHz

Manufacturer: APREL Laboratories
Model No.: E-010
Serial No.: 163

Calibration Procedure: SSI/DRB-TP-D01-032
Project No: Probe Cal Internal

Calibrated: November 5th 2002
Recalibration required: November 4th 2003
Released on: November 5th 2002

Released By: ______________________________

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INTRODUCTION

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-010 163.

REFERENCES

SSI/DRB-TP-D01-032 E-Field Probe Calibration Procedure
IEEE P-1528 *DRAFT* "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"
SSI-TP-014 Tissue Calibration Procedure

Conditions

Probe 163 is a working released probe.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5 °C
Temperature of the Tissue: 21 °C +/- 0.5 °C

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CALIBRATION RESULTS SUMMARY

Probe Type: E-Field Probe E-010

Serial Number: 163

Frequency: 2450 MHz

Sensor Offset: 2.4 mm

Sensor Length: **2.5 mm**

Tip Enclosure: **Glass***

Tip Diameter: **7 mm**

Tip Length: **40 mm**

Total Length: **290 mm**

*Resistive to recommended tissue recipes per IEEE-P1528

SENSITIVITY IN AIR

Channel X: 0.58 ìV/(V/m)^2
Channel Y: 0.58 ìV/(V/m)^2
Channel Z: 0.58 ìV/(V/m)^2

Diode Compression Point: 76 mV

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SENSITIVITY IN BODY TISSUE

Frequency: 2450 MHz

Epsilon: 52.7(+/-5%) **Sigma:** 1.95 S/m (+/-10%)

ConvF

Channel X: 5.6

Channel Y: 5.6

Channel Z: 5.6

Tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Boundary Effect:

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.6mm.

Spatial Resolution:

The measured probe tip diameter is 7 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

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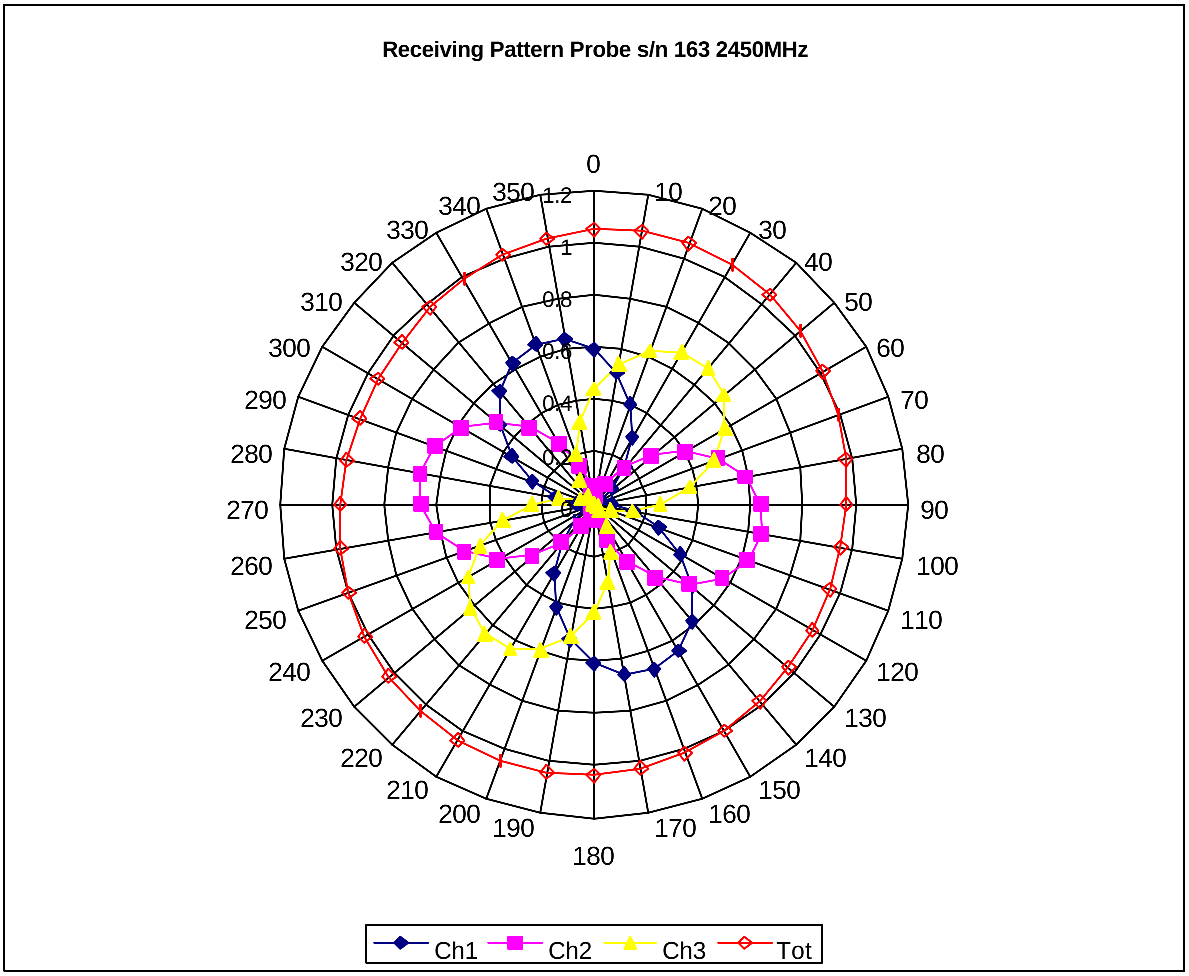
RECEIVING PATTERN 2450 MHZ (AIR)



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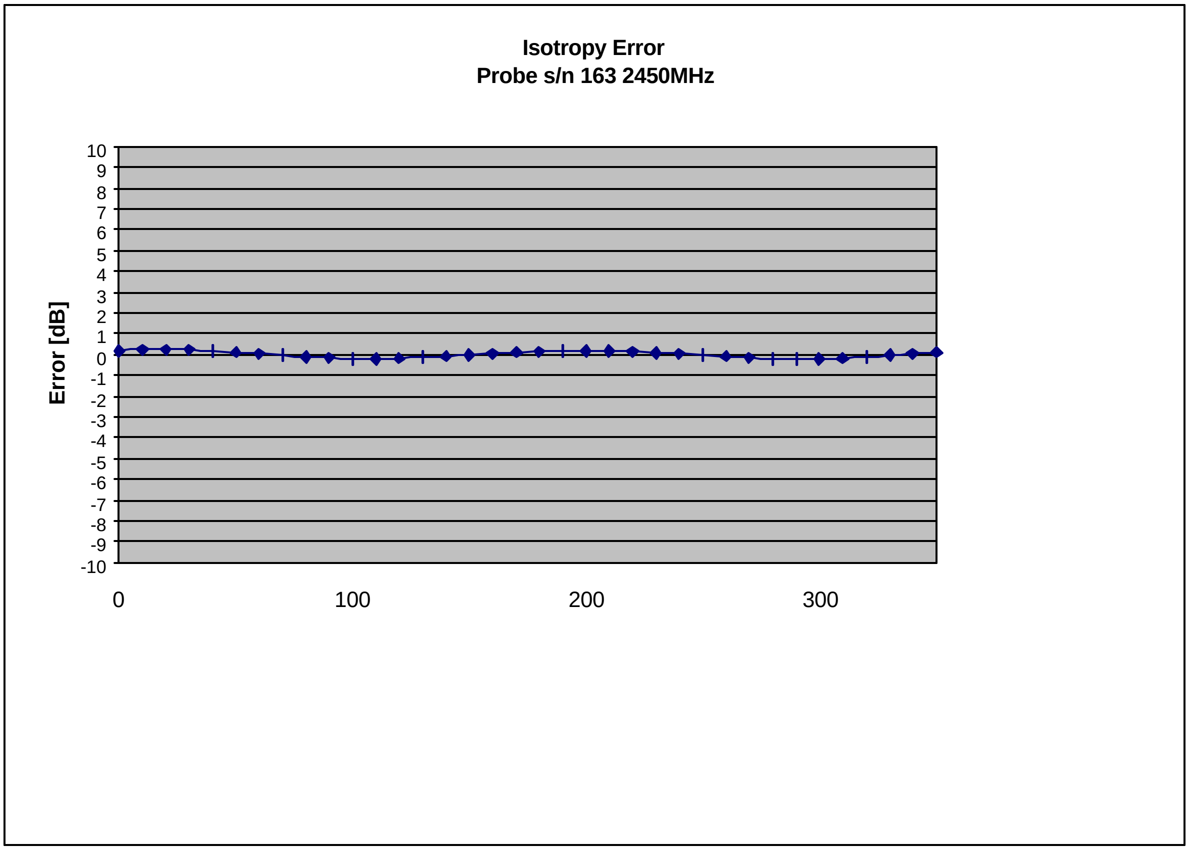
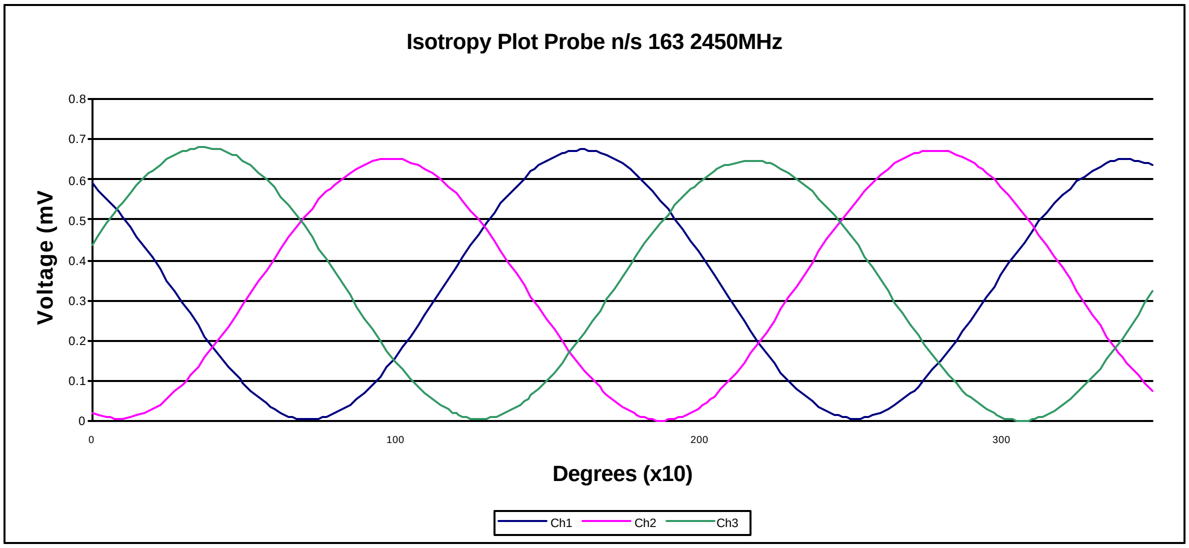
ISOTROPY ERROR 2450 MHZ (AIR)





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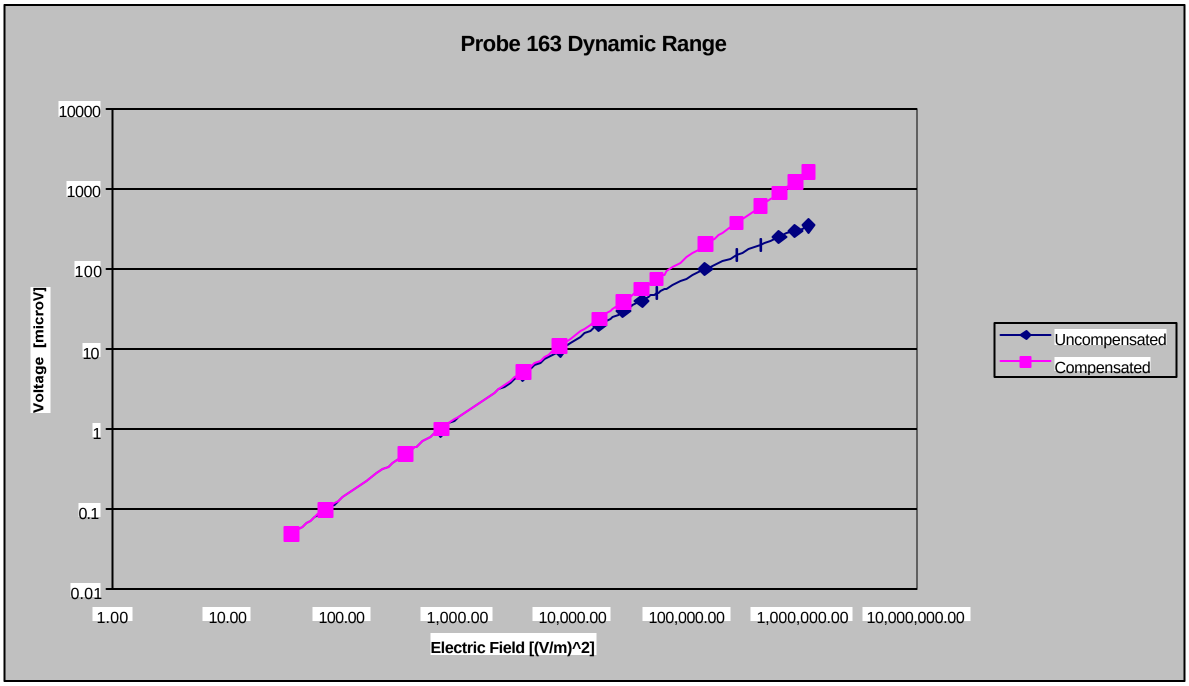
DYNAMIC RANGE



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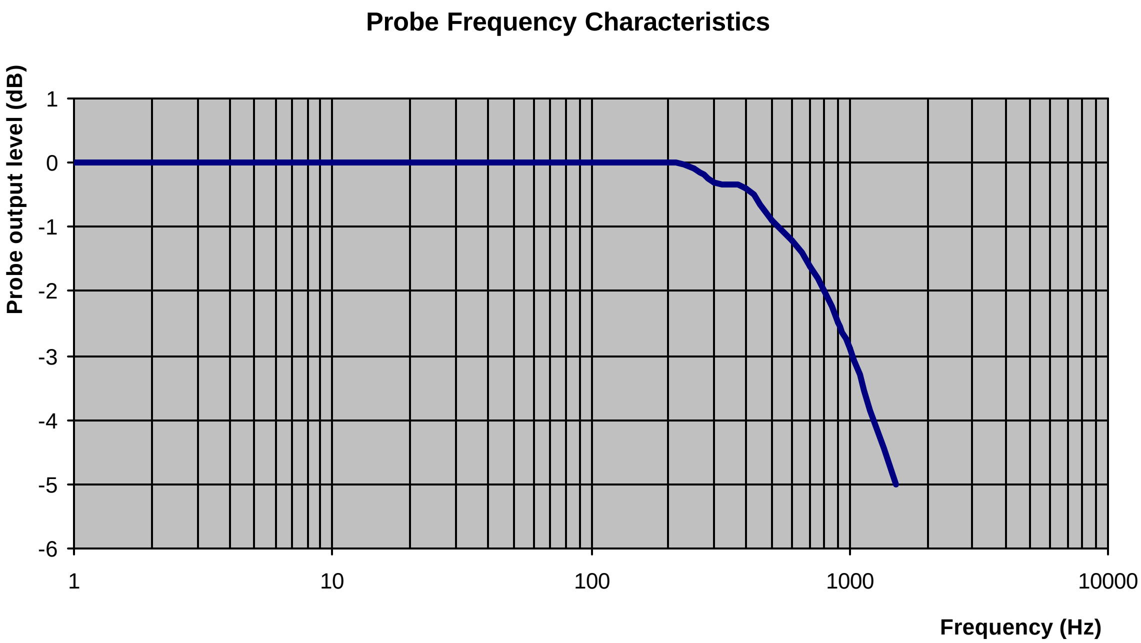
Video Bandwidth



Video Bandwidth at 500 Hz 1 dB
Video Bandwidth at 1.02 KHz: 3 dB

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CONVERSION FACTOR UNCERTAINTY ASSESSMENT

Frequency: 2450 MHz

Epsilon: 52.7 (+/-5%) **Sigma:** 1.95 S/m (+/-10%)

ConvF

Channel X: **5.6** **7%(K=2)**

Channel Y: **5.6** **7%(K=2)**

Channel Z: 5.6 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 MΩ.

Boundary Effect:

FOR A DISTANCE OF 2.6MM THE EVALUATED UNCERTAINTY (INCREASE IN THE PROBE SENSITIVITY) IS LESS THAN 2%.

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TEST EQUIPMENT

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2002

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Appendix F

Dipole Calibration Certificate

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NCL CALIBRATION LABORATORIES

Calibration File No: DC-0265
Project Number: Internal

CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

APREL Validation Dipole

Manufacturer: APREL Laboratories
Part number: D-2450-S-1
Frequency: 2.45 GHz
Serial No: ALCD-10

Customer: APREL

Calibrated: 15 November 2002
Released on: 14 November 2003

Released By: ____

NCL CALIBRATION LABORATORIES

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7. CALIBRATION RESULTS SUMMARY

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

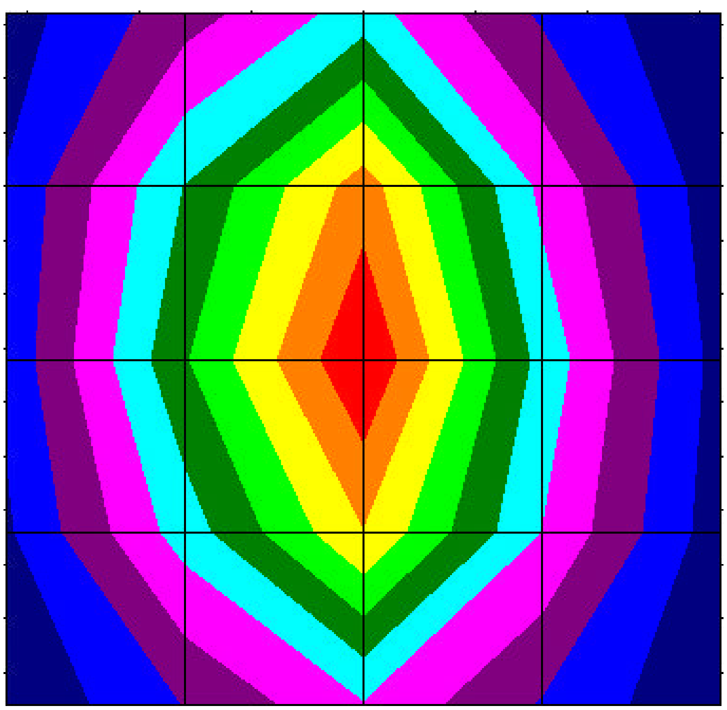
Length: 51.7 mm
Height: 30.8 mm

Electrical Specification

SWR: 1.181U
Return Loss: -21.4 dB
Impedance: 46.175

System Validation Results

Frequency	1 Gram	10 Gram	Peak
2.45 GHz	52.45	22.91	102.91



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8. INTRODUCTION

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018. The results contained within this report are for Validation Dipole ALCD-10 at 2.45 GHz. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the IEEE mechanical specification. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALIDX-500, along with the APREL Reference E-010 130 MHz to 26 GHz E-Field Probe Serial Number 163.

9. REFERENCES

SSI-TP-018 Dipole Calibration Procedure
SSI-TP-016 Tissue Calibration Procedure
IEEE P-1528 *DRAFT* “Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques”

Conditions

Dipole ALCD-10 was a new Dipole taken from stock prior to calibration.

Ambient Temperature of the Laboratory: 24 °C +/- 0.5 °C
Temperature of the Tissue: 20 °C +/- 0.5 °C

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10. DIPOLE CALIBRATION RESULTS

Mechanical Verification

IEEE Length	IEEE Height	Measured Length	Measured Height
51.5 mm	30.4 mm	51.7 mm	30.8 mm

Tissue Validation

Head Tissue 2450 MHz	Measured
Dielectric constant, ε_r	39.2
Conductivity, σ [S/m]	1.82
Tissue Conversion Factor,	4.61

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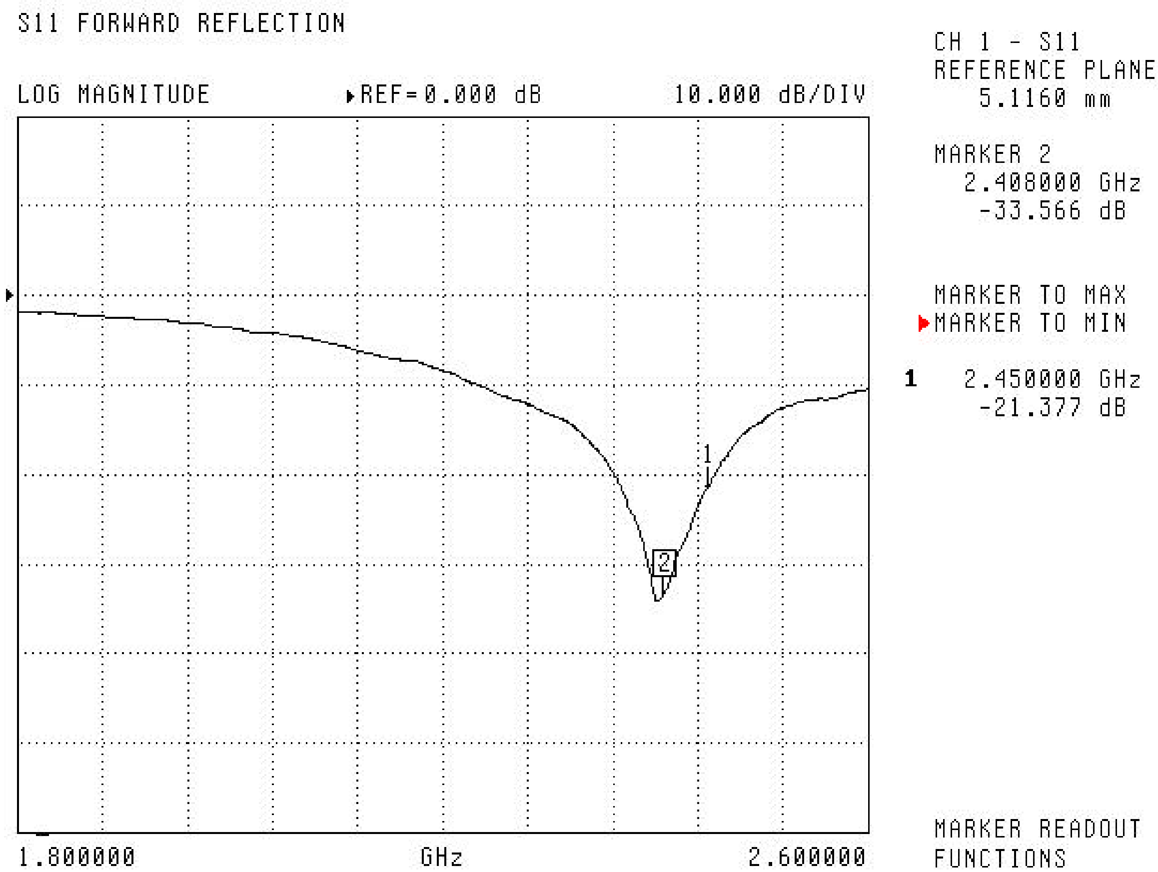
Electrical Calibration

Test	Result	*IEEE Value*
S11 R/L	-21.4	-21 dB
SWR	1.181U	-
Impedance	46.175 Ω	

The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss



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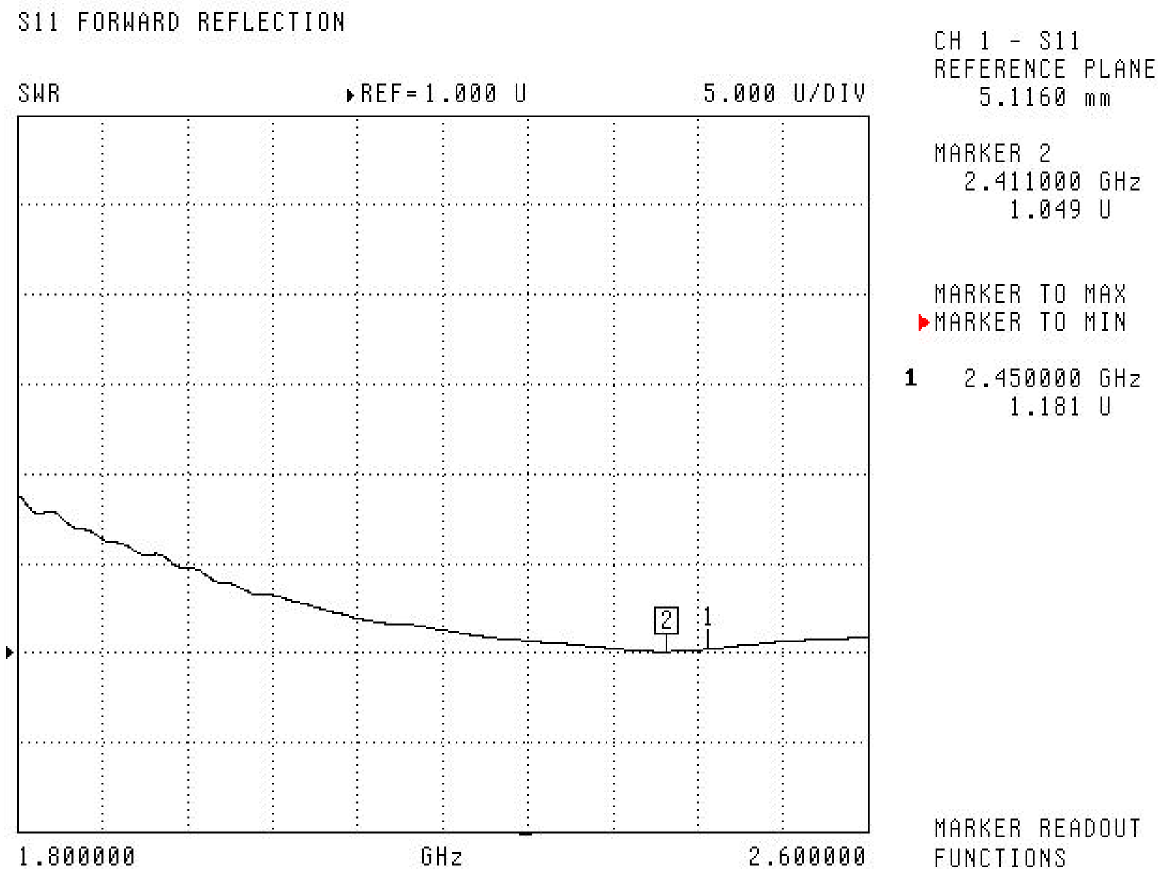
SWR



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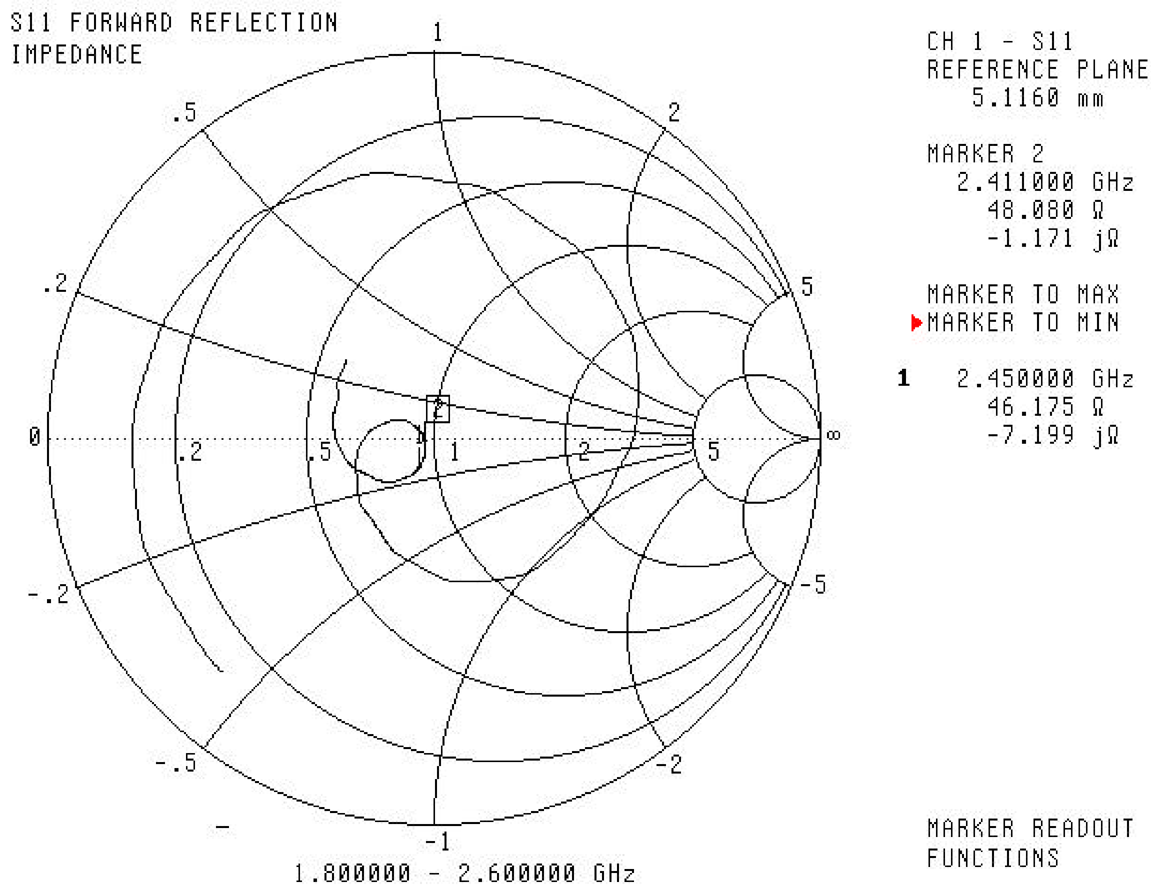
Smith Chart Dipole Impedance



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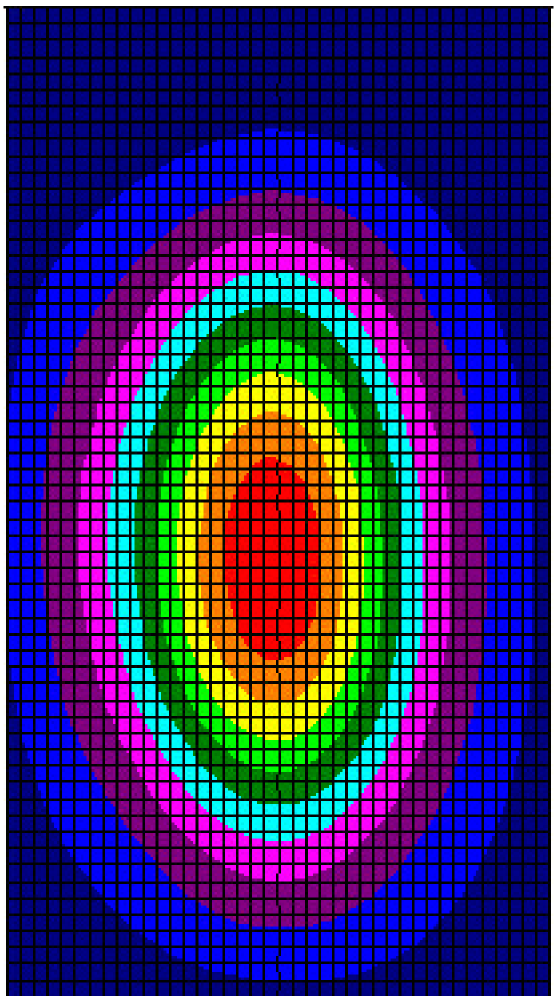
System Validation Results Using the Electrically Calibrated Dipole

Frequency	1 Gram	10 Gram	Peak Above Feed Point
2.45 GHz	52.45	22.91	102.91

The following Graphic Plot is the splined measurement result for the course scan.



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11. TEST EQUIPMENT

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