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APREL Laboratories

Experimental Analysis SAR Report

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 PP05L

Model: PP05L

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

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

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories PP05L

Project #: ITLB-DELL-Single Band Mini PCI Type 3a-3976

Prepared by: APREL Laboratories
51 Spectrum Way
Nepean, Ontario
K2R 1E6

Approved by ______________________________ Date: _________________
Stuart Nicol
Director Product Development, Dosimetric R&D

Submitted by ______________________________ Date: __________________
Jay Sarkar
Technical Director of Standards & Certification

Released by ______________________________ Date: __________________
Dr. Jacek J. Wojcik, P. Eng.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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 PP05L
Model:	PP05L
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 inside Dell laptop chassis model number PP05L. 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 inside Dell laptop chassis model number PP05L 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 inside Dell laptop chassis model number PP05L was assessed for SAR at the **maximum available power level** of 17.8dBm while operating with the duty cycle set at 100%.

The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter is an internally located unit tested with an internal Hitachi antenna. The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter has no body worn applications and can only function while located within the Dell laptop chassis model number PP05L. The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter has been developed as an OEM module, which shall be integrated within the Dell laptop chassis model number PP05L by the laptop manufacturer. The Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter was integrated by APREL for the purpose of the analysis.

The Dell laptop chassis model number PP05L is a production model, which has a set of integrated antennas. The antennas are not visible to the user. The Dell laptop chassis model number PP05L as tested incorporated a low power Bluetooth module (<1mW), along with the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter operating at the 802.11b standard. Activation codes were provided to APREL for the purpose of this analysis, which enabled the engineer to set the operational parameters of the SAR assessment (frequency and Tx power).

51 Spectrum Way Tel. (613) 820-2730
Nepean, Ontario, K2R 1E6 Fax (613) 820 4161
e-mail: info@aprel.com

For the purpose of the SAR analysis executed and subsequent report the Dell laptop chassis model number PP05L, which incorporated the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter operating at the 802.11b standard and Bluetooth module will be called the DUI (Device Under Investigation).

The Dell laptop chassis model number PP05L incorporating the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter was 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, a 10mm separation distance for body analysis. Further analysis was made of the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter while the Bluetooth device was transmitting, at the low mid, and high channels. The results of this additional analysis are presented in this report.

The conservative 10g average for direct contact SAR analysis (hand/extremities) was found to be **0.50 W/kg for the peak RF output power of the low channel (ch#1, f=2412MHz)** for the left side of the Dell laptop chassis model number PP05L at 0 mm separation. A further analysis was performed while the Bluetooth device was transmitting synchronously with the 802.11b module and the conservative 10g average was found to be **0.87 W/kg at the mid channel (ch#6, f=24737MHz)**.

For body SAR analysis a separation distance of 5 mm from the left side of the Dell laptop chassis model number PP05L was assessed where the conservative 1 g SAR was found to be **1.16 W/kg for the peak RF output power of the Mid channel (ch#6, f=2437MHz)**. A further analysis was performed while the Bluetooth device was transmitting synchronously with the 802.11b module and the conservative 1g average was found to be **0.94 W/kg at the low channel (ch#1, f=2412MHz)**.

Evaluation data and graphs are presented in this report. All analysis conducted and documented in this report were performed while the DUI was connected to an external power supply. It was found that while the Dell laptop chassis model number PP05L was operating using both the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter operating at the 802.11b standard, and Bluetooth module the conservative SAR measured was found to be lower. APREL conducted an additional analysis at the frequency and position where the maximum SAR was found while the host was running from the internal power source (battery), and it was found that the conservative SAR did not increase.

Based on the measured results and on how the Dell laptop chassis model number PP05L 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.

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

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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51 Spectrum Way Tel. (613) 820-2730
Nepean, Ontario, K2R 1E6 Fax (613) 820 4161
e-mail: info@aprel.com

1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) for a sample WM3A2100-PP05L mobile PC (Laptop) incorporating an Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter 802.11b standard, and Bluetooth module. These tests were conducted at APREL Laboratories facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

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."

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

3. TEST CASE SCENARIOS

Intel provided APREL Laboratories with the Dell laptop chassis model number PP05L for the purpose of the SAR evaluation. The evaluations performed on the Dell laptop chassis model number PP05L mobile PC (DUI) were to establish the conservative SAR value for both 1 and 10g while operating with the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter operating at the 802.11b standard. Further evaluations of the DUI were made while the Bluetooth and 802.11b modules were transmitting.

No independent evaluation of the Bluetooth module was made by APREL.

To further support the grant application all transmit scenarios were assessed where both the 802.11b and Bluetooth modules were set to transmit synchronously and the DUI was assessed while using the Hitachi antenna. This analysis was performed to show compliance within all normative user situations.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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 8 (where applicable). Further details of the tissue used during the system validation are provided in section 6.3 Simulated Tissue. The results from the system validation are provided in Annex A Measurement Results.

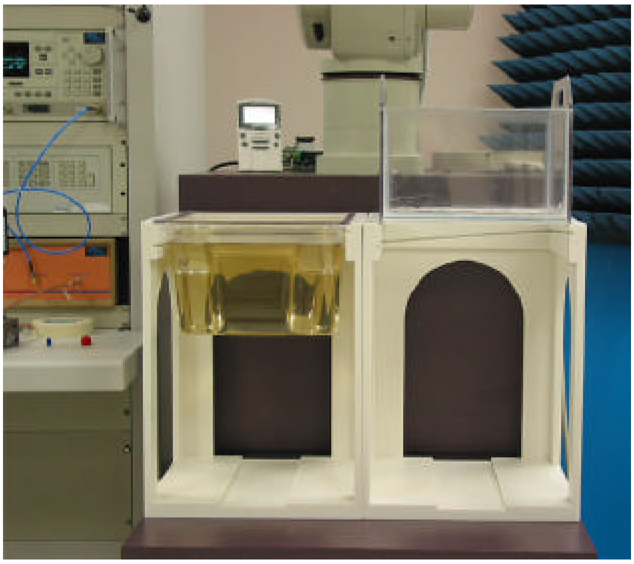
The image below shows the setup used for the system validation.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

5.3 Body & Direct Contact Analysis

Measurements were made on the test DUI using the APREL Universal Phantom, on the low, mid, and high channels. The DUI was assessed with the LHS of the DUI placed against the phantom. The initial separation distance used was 0mm for the conservative SAR assessment. A secondary assessment was executed on the device at the position and frequency for the conservative value at a distance of 5mm from the phantom. The results from this exercise are presented in section 6 test results.

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



51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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.

Table 3: Properties of the Tissue

BODY Tissue	APREL	Target Value	D (%)
Dielectric constant, ε_r	50.46	52.7	4
Conductivity, σ [S/m]	2.03	1.95	4
Tissue Conversion Factor,	5.6	-	-
Tissue Temperature (°C)	20	-	-

Table 4: Tissue Calibration Instrumentation

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

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

5.5 Methodology

1. The test methodology utilized in the analysis of the DUI 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).

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

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.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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 WM3A2100-PP05L which incorporated the Intel Pro/Wireless 2100 WLAN Mini-PCI Type 3A Adapter has been developed to operate with both AC and, battery. The device was analyzed with the AC cord attached, and the position, and frequency, for which the conservative SAR was found was reassessed using the battery. The values recorded in table 5 represent the assessed drift while the DUI was attached to the AC power supply. The reassessment using the battery power source found a lower SAR value. All values presented in this report, represent the conservative measured SAR while connected to the AC source.

Note

The power measurements taken were conducted and measured using a power meter, and broadband power sensor.

The device was set to transmit for a period of 30 minutes (exceeded scan time) and conducted power measurements were made at 5-minute intervals to gauge power drift. Over the course of the 30-minute period no power drift was measured.

The same process was executed as above while the Bluetooth device was set to transmit and the power was assessed, no power drift was measured.

Table 5: Conducted power measurement before and after the scanning

Type of Exposure	Scan Type	Power Readings (dBm)		ΔP_{TX} (dB)
		Before scanning	After scanning	
Direct Exposure	Coarse	17.7	17.7	0
	Fine	17.7	17.7	0
Body Exposure	Coarse	17.7	17.7	0
	Fine - body	17.7	17.7	0

51 Spectrum Way Tel. (613) 820-2730
Nepean, Ontario, K2R 1E6 Fax (613) 820 4161
e-mail: info@aprel.com

6.2. SAR MEASUREMENTS

1) RF exposure is expressed as a 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 testing software supplied by the manufacturer running on the DUI to control the channel and operating TX mode/frequency.

3) Table 6 provides the details in tabular form of the full measurement analysis, which was performed on the DUI. Appendix A provides contour plots of the SAR measurements on the DUI. A digital image of the DUI test configuration is presented with the contour plot superimposed for visualization purposes.

4) Wide area scans were performed for the low, middle and high channels 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.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

6.3. DIRECT CONTACT SAR

All subsequent testing for the direct contact SAR (user's hand exposure) was performed on three channels (low: 2412MHz, middle: 2437MHz, high: 2462MHz) at the optimum position - with the DUI facing up at 0mm separation distance. The results are presented in Table 6 below.

1) The DUI 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 DUI 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 (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) **The DUI while running with the 802.11b** found the highest conservative SAR value averaged over 10 grams for the direct contact exposure (user's hand exposure) analysis to be 0.50W/kg at the low channel 2412MHz (Table 6). **Analysis made on the DUI while running both the 802.11b and Bluetooth modules** found the highest conservative SAR value averaged over 10 grams for the direct contact exposure analysis (user's hand exposure) to be 0.87W/kg at the mid channel 2437MHz (Table 7).

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

6.4. BODY EXPOSURE

All subsequent testing for body SAR was performed on three channels (low: 2412MHz, middle: 2437MHz, high: 2462MHz) at the optimum position - with the DUI facing up at 0mm and 5mm separation distances. The results are presented in Table 6 and below.

1) The DUI 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 DUI 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) **The DUI while running with the 802.11b** found the highest conservative SAR value averaged over 1 gram for the body exposure to be 1.16W/kg at the mid channel 2437MHz with a 5mm separation distance (Table 6). **Analysis made on the DUI while running both the 802.11b and Bluetooth modules** found the highest conservative SAR value averaged over 1 gram for the body exposure to be 0.94W/kg at the low channel 2412MHz with a 5mm separation distance (Table 6).

51 Spectrum Way Tel. (613) 820-2730
Nepean, Ontario, K2R 1E6 Fax (613) 820 4161
e-mail: info@aprel.com

Table 6: Testing results - 1 g and 10 g SAR values for the WM3A2100-PP05L

Assessment Type	Channel			Module	1g SAR Limit: 1.6W/Kg	10g SAR Limit: 4.0W/Kg
	L/M/H	Channel #	Freq (MHz)			
Direct Contact	**Low**	**1**	**2412**	**802.11b**	**-**	**0.50**
Direct Contact	Mid	6	2437	802.11b	-	0.18
Direct Contact	High	11	2462	802.11b	-	0.47
Direct Contact	Low	1	2412	802.11b	-	0.69
Direct Contact	**Mid**	**6**	**2437**	**Both**	**-**	**0.87**
Direct Contact	High	11	2462	Both	-	0.67
Body* **	**Mid**	**6**	**2437**	**802.11b**	**1.16**	**-**
Body***	High	11	2462	802.11b	0.70	-
Body* **	**Low**	**1**	**2412**	**Both**	**0.94**	**-**
Body***	Mid	6	2437	Both	0.74	-
Body***	High	11	2462	Both	0.88	-
Body Underside DUI UP	**Low**	**1**	**2412**	**Both**	**0.30**	**-**

*** Test was performed on 5.0mm separation distance.

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

7. CONCLUSIONS

The conservative measured Specific Absorption Rate (SAR) averaged over 10 grams, measured on the low channel 2412MHz for **the DUI transmitting with the 802.11b module assessed for direct contact SAR, is 0.50 W/kg** (direct contact SAR for the exposed extremities – hands, wrists, feet and ankles). The overall margin of uncertainty for this measurement is ±**17.8% (**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 conservative measured Specific Absorption Rate (SAR) averaged over 1 gram, measured on the mid channel 2437MHz for **the DUI transmitting with the 802.11b module assessed for Body SAR at a separation distance of 5mm is 1.16 W/kg**. The overall margin of uncertainty for this measurement is ±**18.1%** (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: ________________________ Date: 14 January, 2003

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

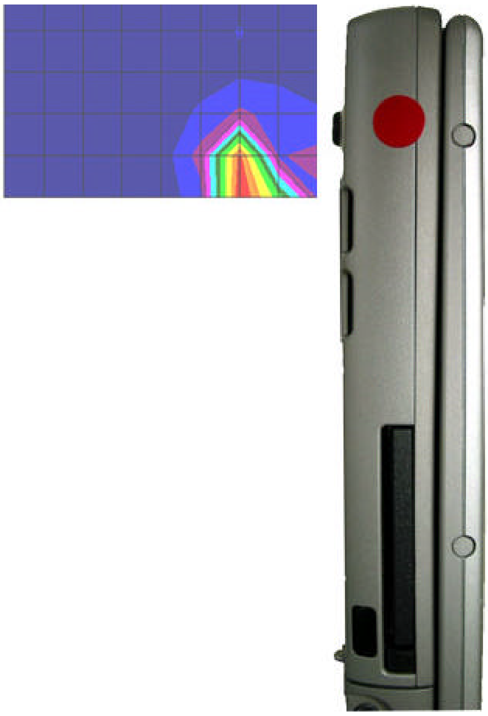
Appendix A

TEST GRAPHIC PLOTS

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

GRAPH 1 (NO BLUETOOTH)

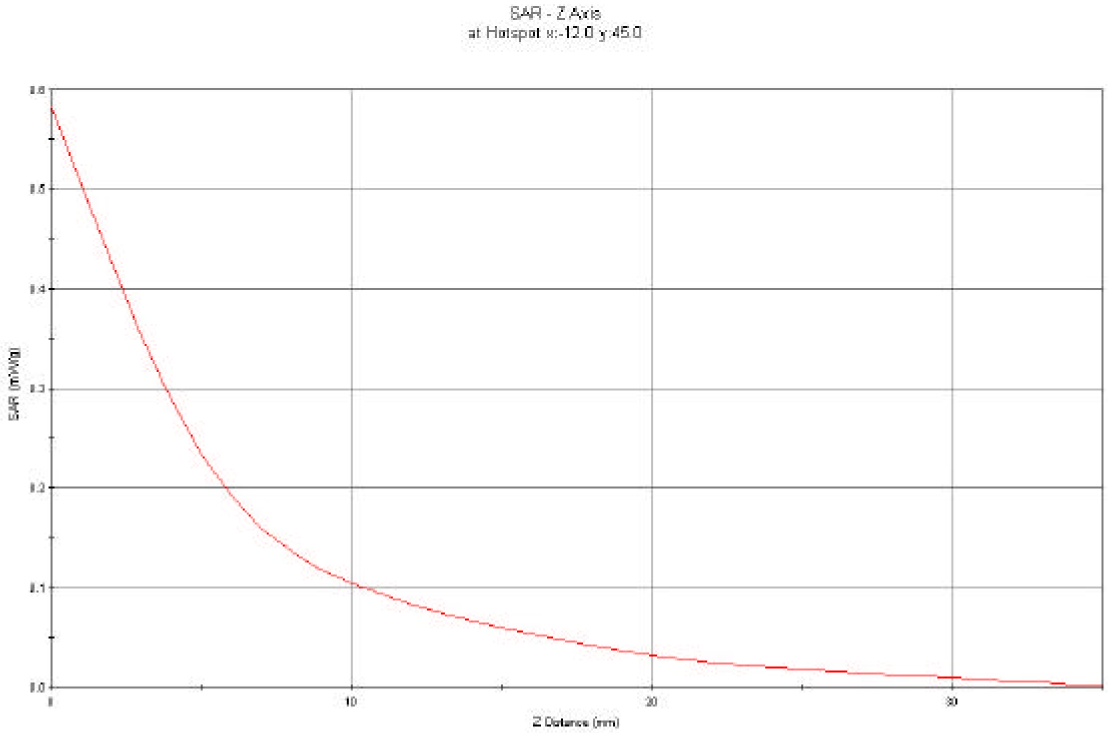
Direct contact SAR (10g)
LHS
Distance 0mm
Low Channel
Frequency: 2412 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.50**

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

Z-AXIS PLOT FOR GRAPH 1



51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

SAR DATA REPORT DELL SCAN04

START : 14-JANUARY-03 11:27:00 AM
END : 14-JANUARY-03 11:33:19 AM
CODE VERSION : 4.12
ROBOT VERSION: 4.08

PRODUCT DATA:
TYPE : DELL LAPTOP#2
FREQUENCY : 2412 MHZ
TRANSMIT PWR : 1 W
ANTENNA TYPE : CENTER FED
ANTENNA POSN. : INTERNAL

MEASUREMENT DATA:
PHANTOM NAME : DELL PHANTOM2
PHANTOM TYPE : UNIPHANTOM
TISSUE TYPE : MUSCLE
TISSUE DIELECTRIC : 50.460
TISSUE CONDUCTIVITY : 2.030
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 : 50.360
CALIBRATED CONDUCTIVITY : 1.95
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) : 2.40 1.42 1.52

SAMPLE:
RATE: 6000 SAMPLES/SEC
COUNT: 1000 SAMPLES
NIDAQ GAIN: 5
SCAN TIME: 166. 7 MSEC

COMMENTS:

AREA SCAN - MAX LOCAL SAR VALUE AT X=20.0 Y=-25.0 = 1.12 W/KG
ZOOM SCAN - MAX LOCAL SAR VALUE AT X=36.0 Y=-9.0 Z=20.0 = 13.50 W/KG
MAX 1G SAR AT X=22.0 Y=-26.0 Z=0.0 = 1.33 W/KG
MAX 10G SAR AT X=25.0 Y=-28.0 Z=0.0 = 0.50 W/KG

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Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
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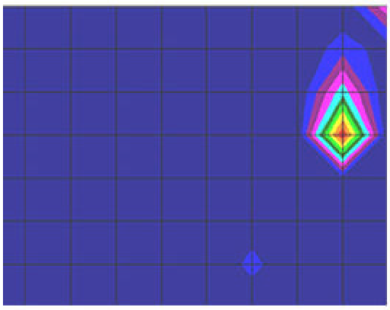
GRAPH 2 (NO BLUETOOTH)

Direct contact SAR (10g)
LHS
Distance 0mm
Mid Channel
Frequency: 2437 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.18**

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Nepean, Ontario, K2R 1E6
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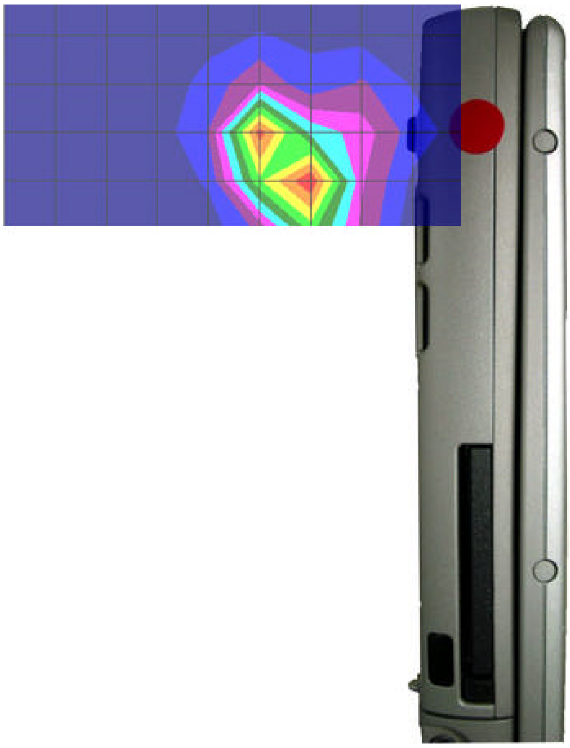
GRAPH 3 (NO BLUETOOTH)

Direct contact SAR (10g)
LHS
Distance 0mm
High Channel
Frequency: 2462 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.47**

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Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
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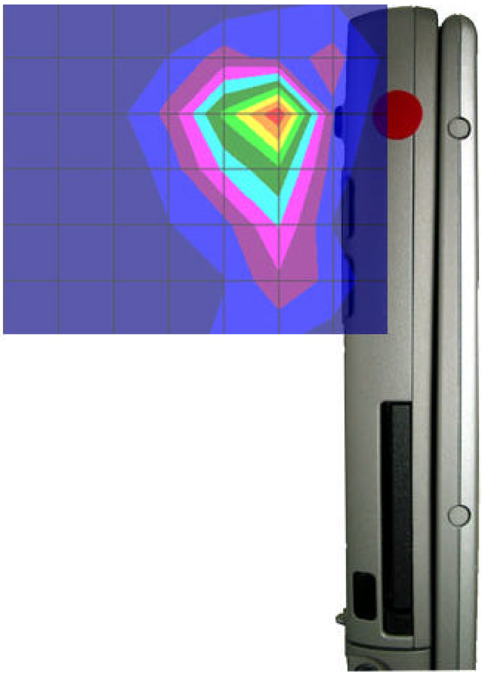
GRAPH 4 (802.11b BLUETOOTH)

Direct contact SAR (10g)
LHS
Distance 0mm
Low Channel
Frequency: 2412 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.69**

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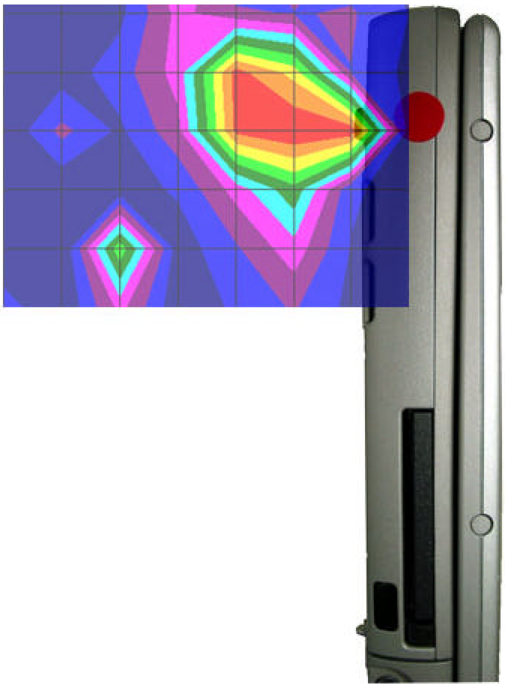
GRAPH 5 (802.11b BLUETOOTH)

Direct contact SAR (10g)
LHS
Distance 0mm
Mid Channel
Frequency: 2437 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.87**

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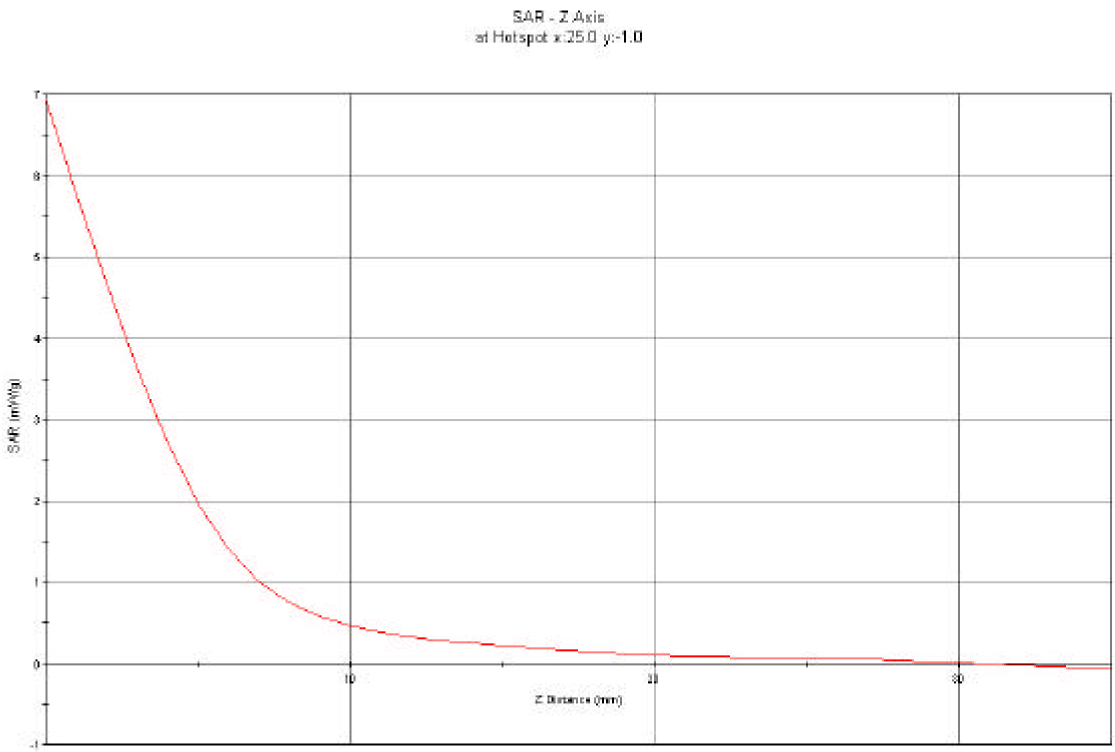
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

Z-AXIS PLOT FOR GRAPH 5



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e-mail: info@aprel.com
Tel. (613) 820-2730
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SAR DATA REPORT DELL SCAN07

START : 14-JANUARY-03 04:33:18 PM
END : 14-JANUARY-03 04:39:23 PM
CODE VERSION : 4.12
ROBOT VERSION: 4.08

PRODUCT DATA:
TYPE : DELL LATITUDE
FREQUENCY : 2412 MHZ
ANTENNA TYPE : CENTER FED
ANTENNA POSN. : INTERNAL

MEASUREMENT DATA:
PHANTOM NAME : DELL PHANTOM2
PHANTOM TYPE : UNIPHANTOM
TISSUE TYPE : MUSCLE
TISSUE DIELECTRIC : 50.460
TISSUE CONDUCTIVITY : 2.030
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 : 50.360
CALIBRATED CONDUCTIVITY : 1.95
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) : 2.40 1.42 1.52

SAMPLE:
RATE: 6000 SAMPLES/SEC
COUNT: 1000 SAMPLES
NIDAQ GAIN: 5
SCAN TIME: 166. 7 MSEC

COMMENTS:

AREA SCAN - MAX LOCAL SAR VALUE AT X=18.0 Y=0.0 = 1.47 W/KG
ZOOM SCAN - MAX LOCAL SAR VALUE AT X=25.0 Y=-1.0 Z=0.0 = 6.93 W/KG
MAX 1G SAR AT X=24.0 Y=-1.0 Z=0.0 = 2.47 W/KG
MAX 10G SAR AT X=20.0 Y=-2.0 Z=0.0 = 0.87 W/KG

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e-mail: info@aprel.com
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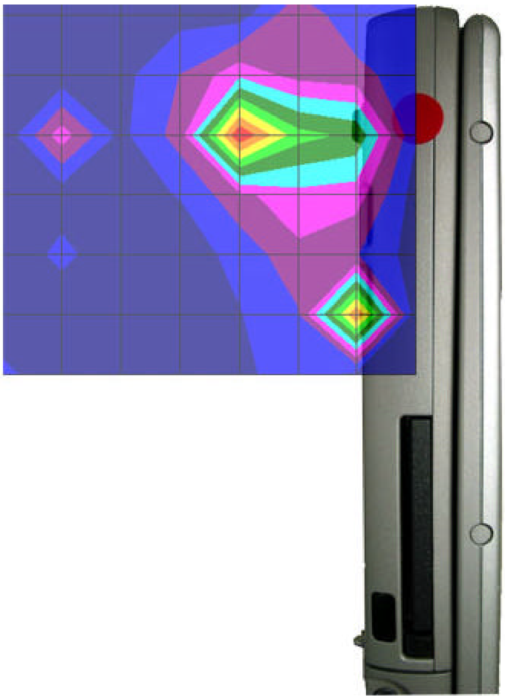
GRAPH 6 (802.11b BLUETOOTH)

Direct contact SAR (10g)
LHS
Distance 0mm
High Channel
Frequency: 2462 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (ºC)	Probe Conversion Factor	10g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.67**

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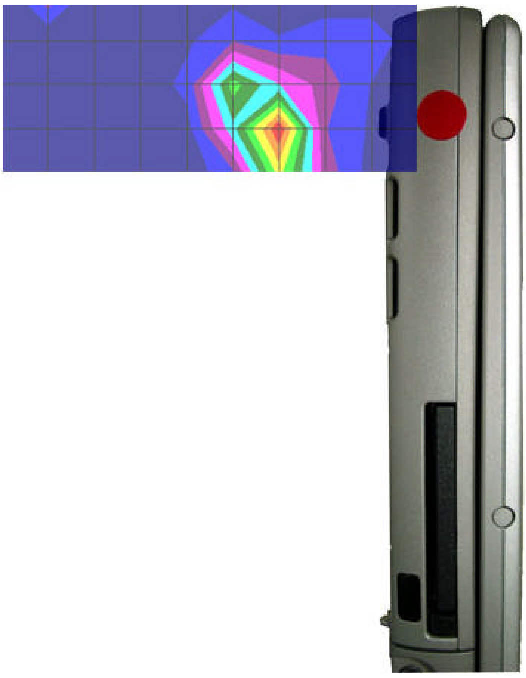
GRAPH 7 (NO BLUETOOTH)

Body SAR (1g)
LHS
Distance 5mm
Mid Channel
Frequency: 2437 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	1g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**1.16**

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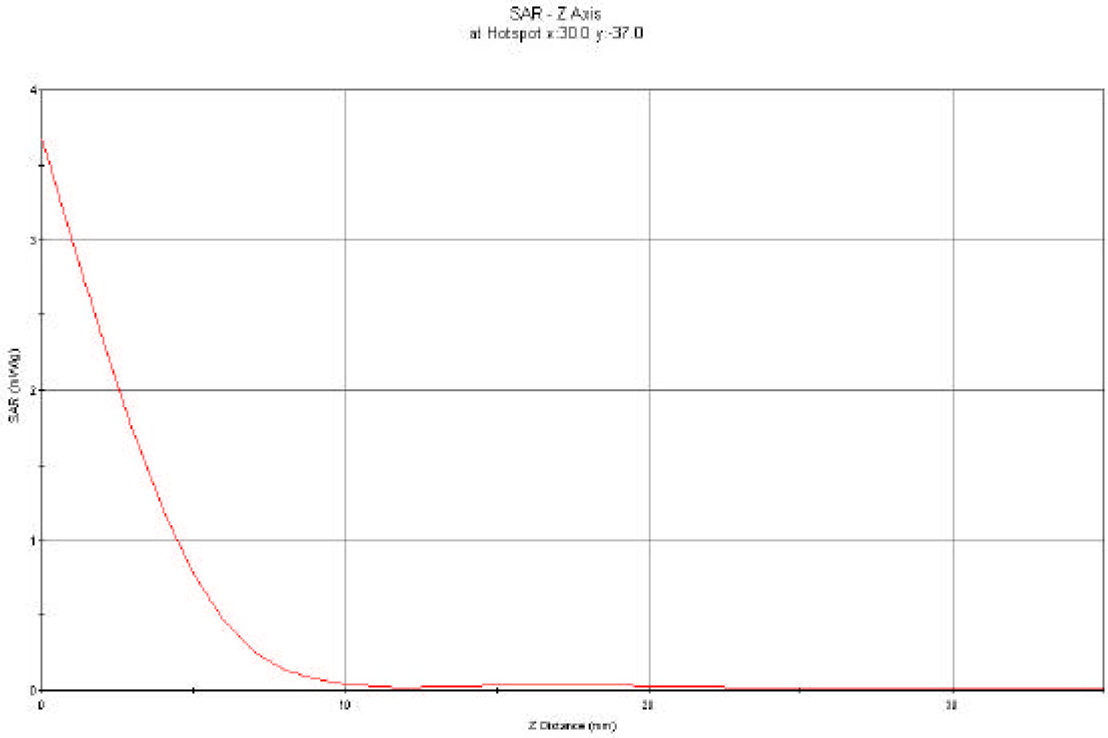
Z-AXIS PLOT FOR GRAPH 7



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SAR DATA REPORT DELL SCAN05-2

START : 14-JANUARY-03 12:07:53 PM
END : 14-JANUARY-03 12:14:25 PM
CODE VERSION : 4.12
ROBOT VERSION: 4.08

PRODUCT DATA:
TYPE : DELL LAPTOP#2
FREQUENCY : 2412 MHZ
TRANSMIT PWR : 1 W
ANTENNA TYPE : CENTER FED
ANTENNA POSN. : INTERNAL

MEASUREMENT DATA:
PHANTOM NAME : DELL PHANTOM2
PHANTOM TYPE : UNIPHANTOM
TISSUE TYPE : MUSCLE
TISSUE DIELECTRIC : 50.460
TISSUE CONDUCTIVITY : 2.030
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 : 50.360
CALIBRATED CONDUCTIVITY : 1.95
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) : 2.40 1.42 1.52

SAMPLE:
RATE: 6000 SAMPLES/SEC
COUNT: 1000 SAMPLES
NIDAQ GAIN: 5
SCAN TIME: 166. 7 MSEC

COMMENTS:

AREA SCAN - MAX LOCAL SAR VALUE AT X=14.0 Y=-21.0 = 1.05 W/KG
ZOOM SCAN - MAX LOCAL SAR VALUE AT X=30.0 Y=-37.0 Z=0.0 = 3. 68 W/KG
MAX 1G SAR AT X=14.0 Y=-21.0 Z=0.0 = 1.16 W/KG
MAX 10G SAR AT X=13.0 Y=-19.0 Z=0.0 = 0.46 W/KG

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e-mail: info@aprel.com
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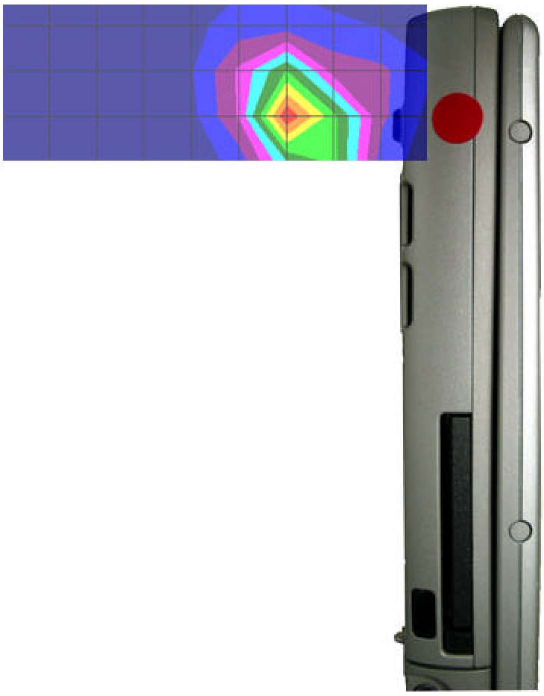
GRAPH 8 (NO BLUETOOTH)

Body SAR (1g)
LHS
Distance 5mm
High Channel
FREQUENCY: 2462 MHZ



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	1g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.70**

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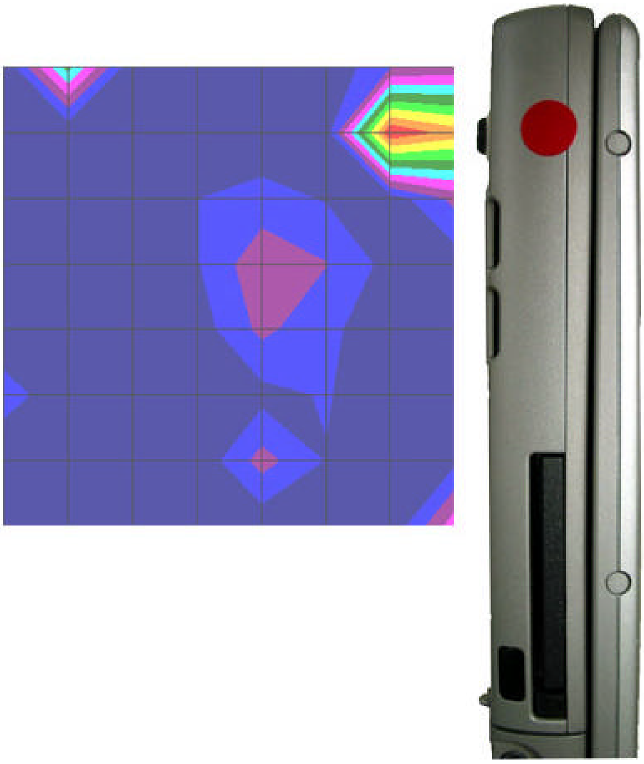
GRAPH 9 (802.11b and BLUETOOTH)

Body SAR (1g)
LHS
Distance 0 mm
Low Channel
Frequency: 2412 MHz



Dielectric constant εr	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	1g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.94**

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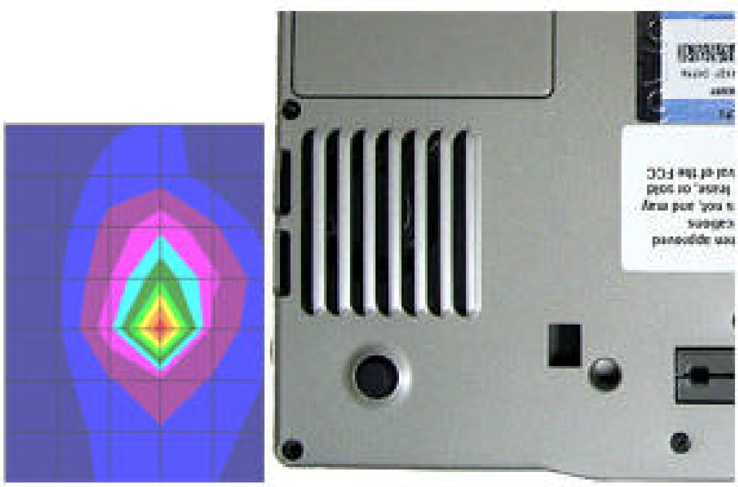
GRAPH 10 (802.11b and BLUETOOTH)

Body SAR (1g)
Body Underside DUI UP
Distance 0mm
Low Channel
Frequency: 2412 MHz



Dielectric constant ε_r	Conductivity σ [S/m]	Tissue Temperature (°C)	Probe Conversion Factor	1g SAR (W/kg)
50.46	**2.03**	**21**	**5.6**	**0.30**

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Appendix B

PICTURES OF THE EVALUATION SETUP

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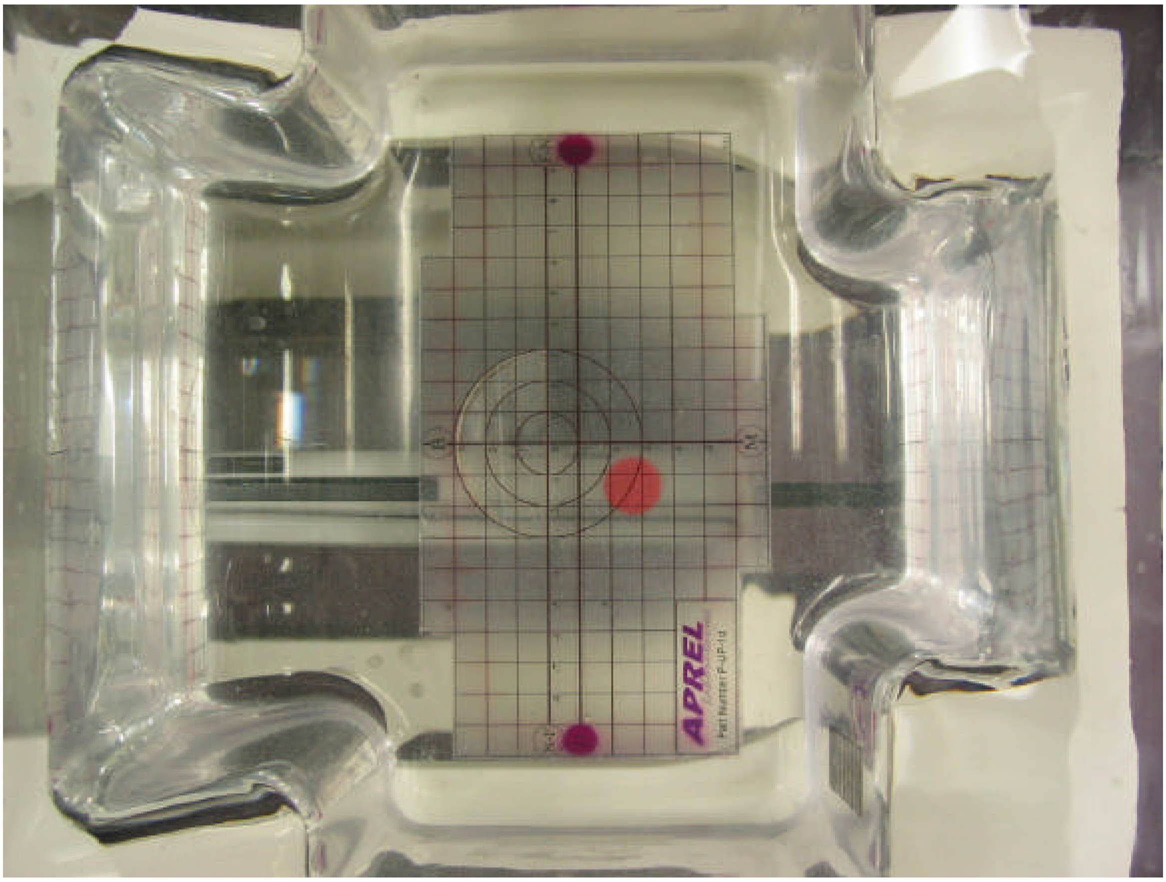
PICTURE 1

DEVICE LHS UP



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PICTURE 2

DEVICE LHS UP FRONT VIEW

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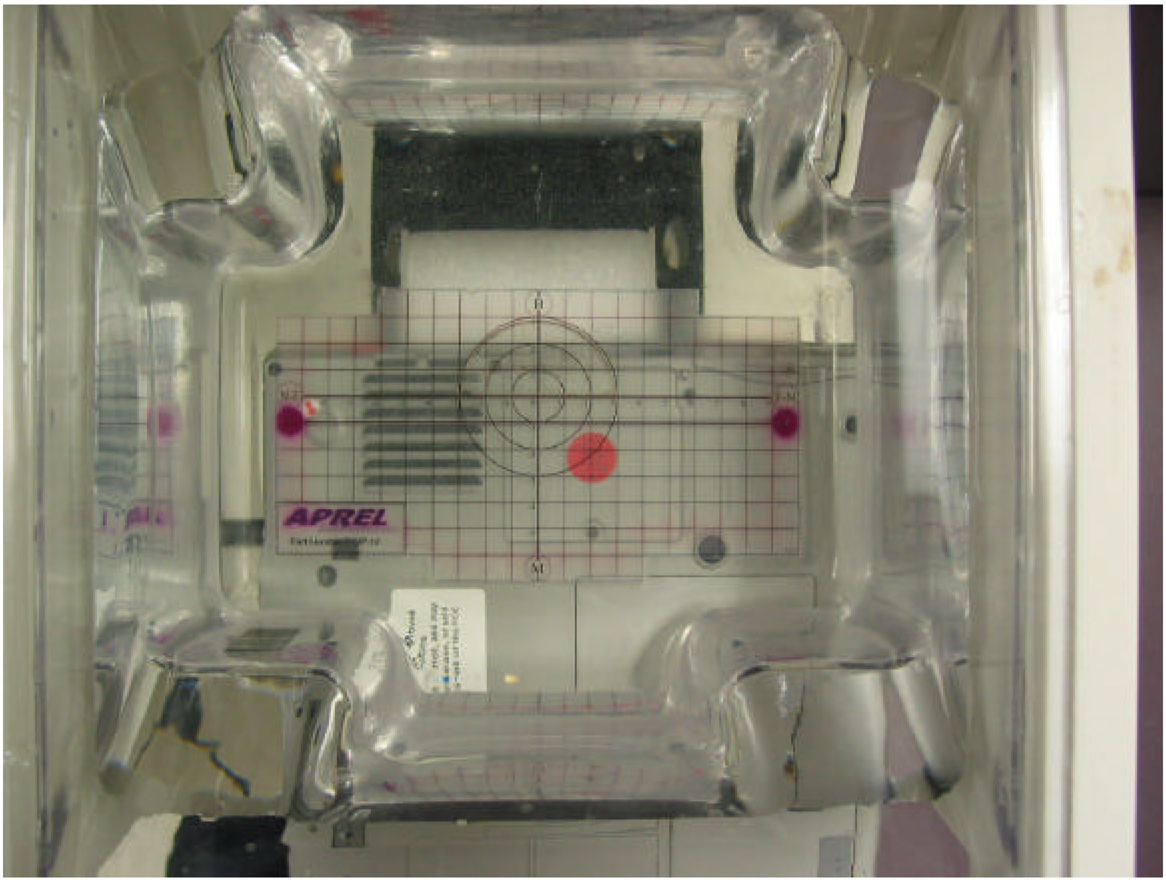
Picture 3

Device Under-side Up



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APPENDIX C: VALIDATION SCAN

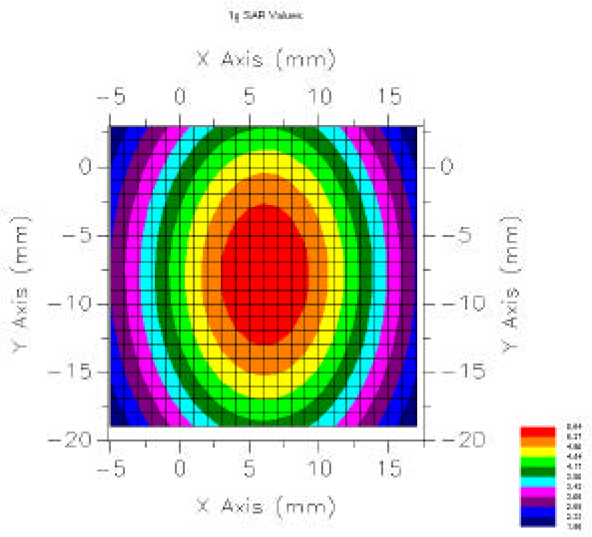

Figure 5. Contour Plot of 1 gram Validation Scan

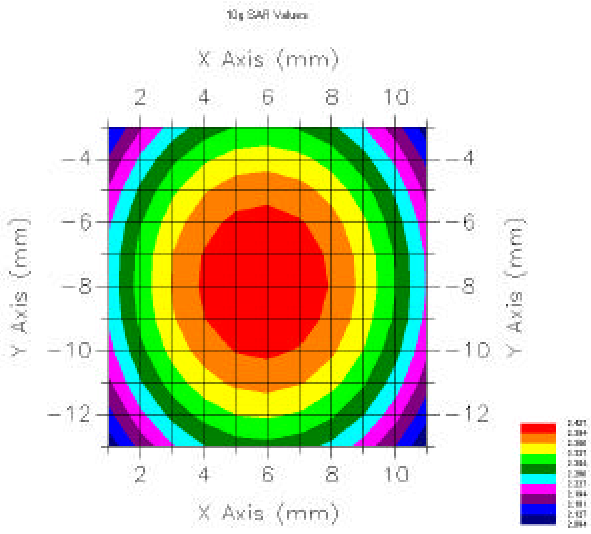

Figure 6. Contour Plot of 10 gram Validation Scan

Frequency: 2450 MHz
Tissue Type: Muscle
Conversion Factor: 5.6
Input Power to Dipole: 1 W
Distance from Dipole to Tissue: 10 mm
Tissue Depth: 15 cm

Measured 1 Gram SAR (W/Kg)	Target 1 Gram SAR (W/Kg)	Delta (%)
52.67	52.4	0

Measured 10 Gram SAR (W/Kg)	Target 10 Gram SAR (W/Kg)	Delta (%)
22.8	24.0	5

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e-mail: info@aprel.com
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APPENDIX D: UNCERTAINTY BUDGET

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	4.0	rectangular	3	0.7	0.5	1.6	1.2	
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				9.2	9.0	
Combined Uncertainty **(coverage factor = 2)**			Normal (k=2)				18.4	18.0	

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

Appendix E
Probe Calibration Certificate

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

NCL CALIBRATION LABORATORIES

Calibration File No.: C-P-0265

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.

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: ______________________________

NCL CALIBRATION LABORATORIES
51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6
Division of APREL Lab.
TEL: (613) 820-4988
FAX: (613) 820-4161

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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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Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
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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 ì V/(V/m)^2
Channel Y: 0.58 ì V/(V/m)^2
Channel Z: 0.58 ì V/(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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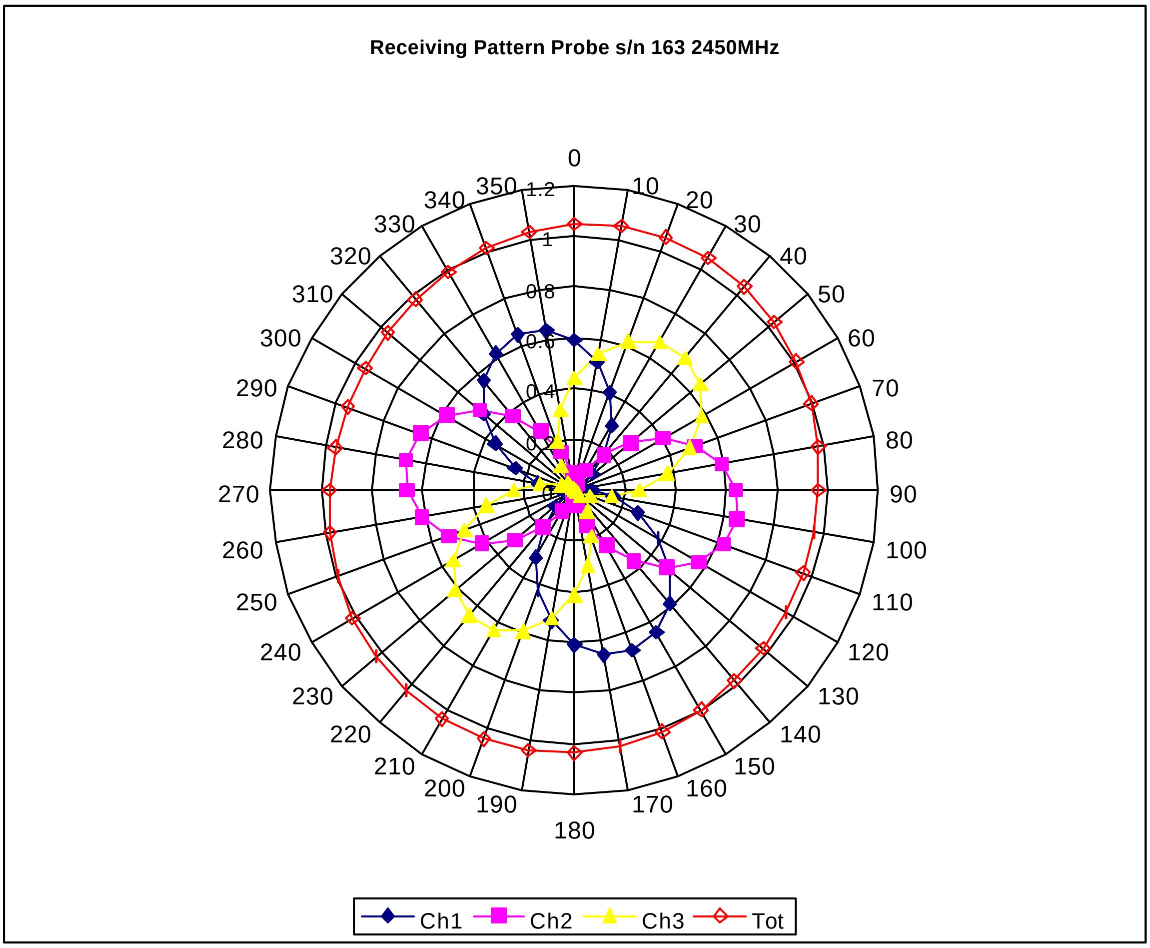
RECEIVING PATTERN 2450 MHZ (AIR)



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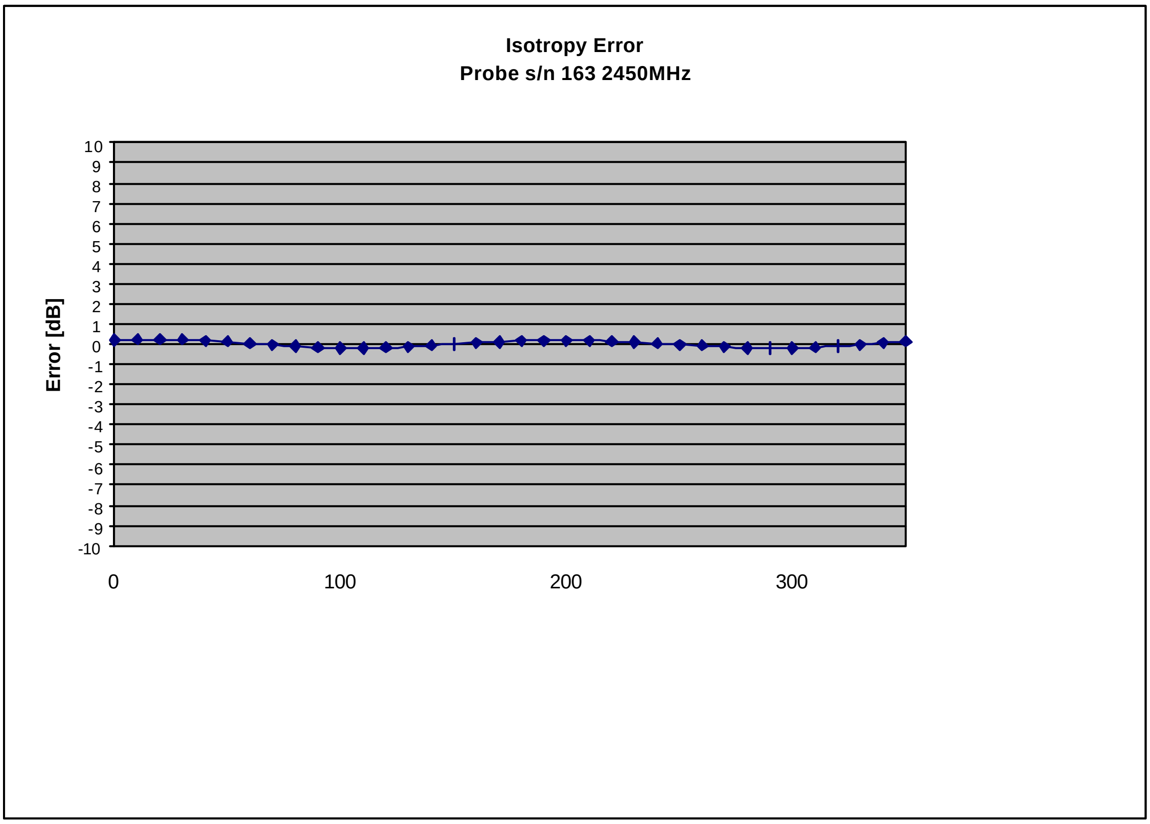
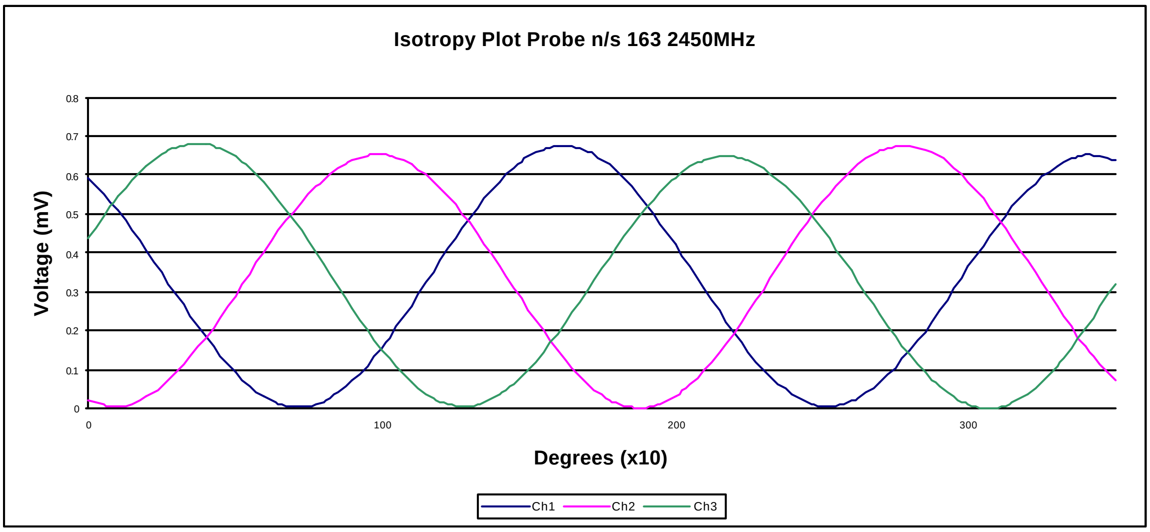
ISOTROPY ERROR 2450 MHZ (AIR)





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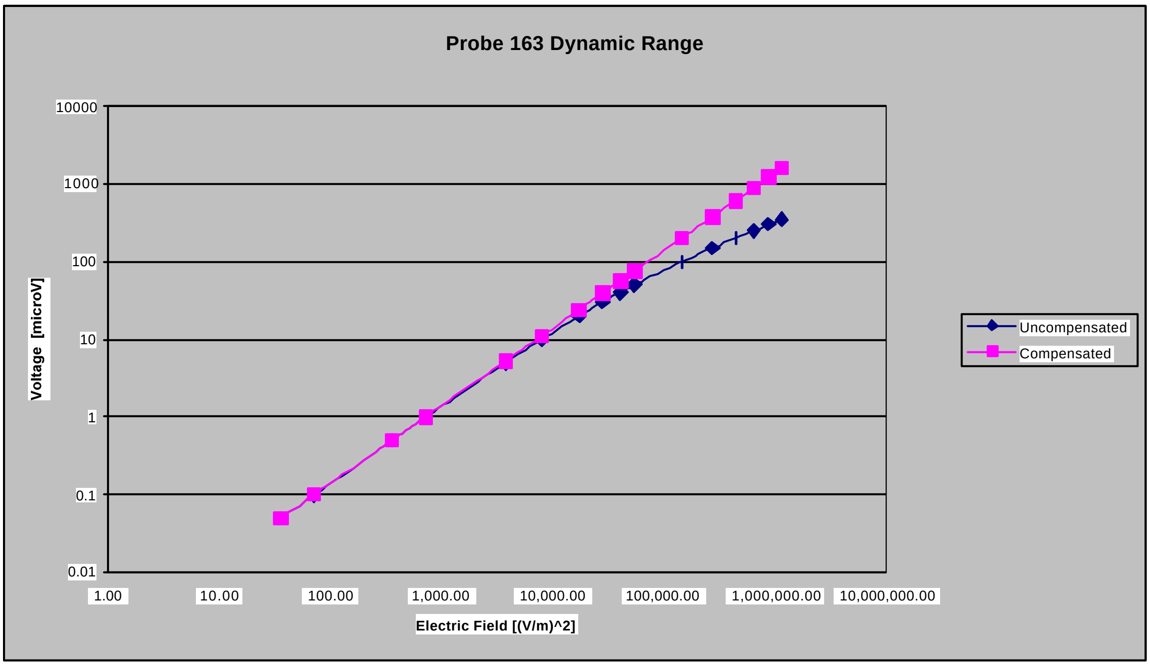
DYNAMIC RANGE



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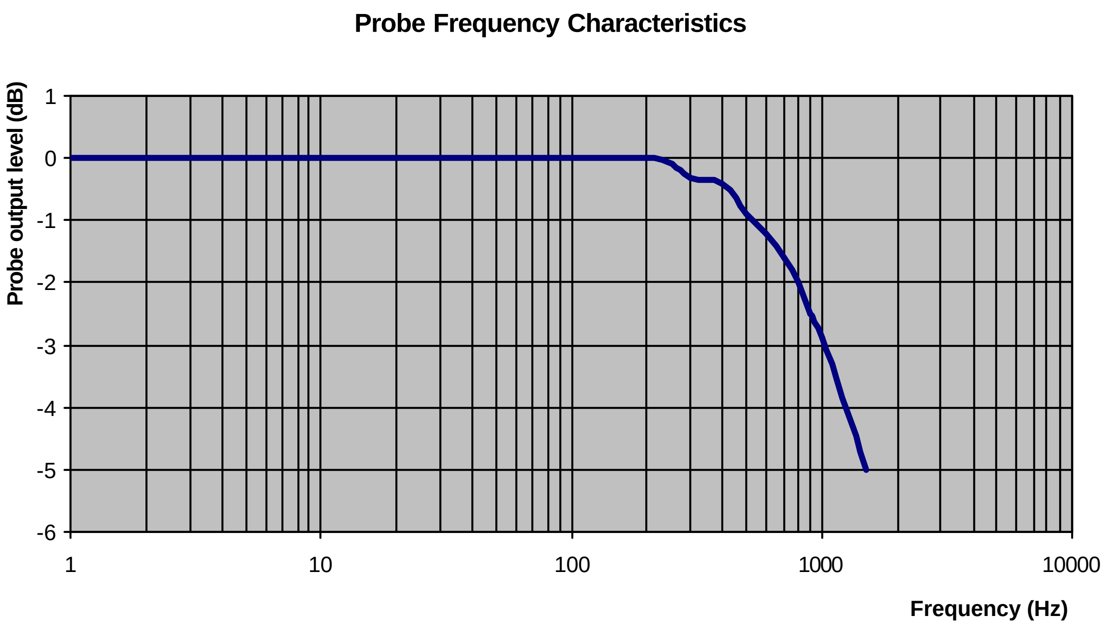
Video Bandwidth



Video Bandwidth at 500 Hz 1 dB

Video Bandwidth at 1.02 KHz: 3 dB

51 Spectrum Way
Nepean, Ontario, K2R 1E6
e-mail: info@aprel.com
Tel. (613) 820-2730
Fax (613) 820 4161

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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