MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*

914 WEST PATAPSCO AVENUE ! BALTIMORE, MARYLAND 21230-3432 ! PHONE (410) 354-3300 ! FAX (410) 354-3313

October 24, 2002

Novatel Wireless Technologies
Suite 200, 6715 - 8th Street NE
Calgary, AB T2E-7H7

Reference: Merlin G301 PCMCIA Card
FCC ID: NBZNRM-MG301

Dear Mr. Owen Thistle:

Enclosed is the EMC SAR Evaluation Report for the Novatel Wireless Technologies Merlin G301 PCMCIA Card. The Merlin G301 PCMCIA Card was tested in accordance with the measurement procedures specified in FCC OET 65 Supplement C:01-01 and shown to be capable to be in compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1-1992.

Thank you for using the testing services of MET Laboratories. If you have any questions regarding these results or if MET can be of further assistance to you, please feel free to contact me. We appreciate your business and look forward to working with you again soon.

Kindest Regards,
MET LABORATORIES, INC.

Marianne Bosley

Marianne Bosley

Documentation Department

Enclosures: (\Novatel Wireless\EMC12352-FCCSAR.rpt)

DOCTEM-23 Jan 02

Dosimetric Assessment

Test Report

for the

Novatel Wireless Technologies
Merlin G301 PCMCIA Card

Tested And Evaluated
In Accordance With
FCC OET 65 Supplement C:01-01

MET REPORT: **EMC12352-FCCSAR**

October 24, 2002

PREPARED FOR:

Novatel Wireless Technologies
Suite 200, 6715-8th Street NE
Calgary, AB, T2E-7H7

PREPARED BY:

MET Laboratories, Inc.
914 West Patapsco Avenue
Baltimore, Maryland 21230-3432

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PREPARED FOR:

Novatel Wireless Technologies
Suite 200, 6715 - 8th Street NE
Calgary, AB, T2E 7H7

Report Prepared By:

Marianne T. Bosley
EMC ADMINISTRATOR

Report Reviewed By:

Asad Bajwa
TEST ENGINEER

Final Review By:

CHRISTOPHER R. HARVEY
EMC LAB DIRECTOR

Engineering Statement: The measurements shown in this report were made in accordance with the procedures specified in Supplement C to OET Bulletin 65 of the Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment evaluated is capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1-1992.

CHRISTOPHER R. HARVEY
EMC LAB DIRECTOR

SAR EVALUATION
CERTIFICATE OF COMPLIANCE

FCC ID: NBZNRM-MG301
APPLICANT: Novatel Wireless Technologies

APPLICANT NAME AND ADDRESS:		**DATE OF TEST:**	September 18,2002
Novatel Wireless Technologies		**TEST LOCATION**:	MET LABORATORIES INC.
Suite 200, 6715-8th Street NE			914 West Patapsco Avenue
Calgary, AB, T2E-7H7			Baltimore, Maryland 21230

EUT:	GSM/GPRS PCS 1900 PCMCIA Card
Date of Receipt:	June 14, 2002
Device Category:	GSM/GPRS PCS 1900 PCMCIA Card
RF exposure environment:	Uncontrolled
Power supply:	Powered by PC
Antenna:	Detachable (Not operational without antenna)
Measured Standards:	PCS 1900
Modulation:	GMSK
Crest Factor:	GSM = 8
TX Range:	GSM PCS 1900 1850.2 MHz - 1909.8 MHz
RX Range:	GSM PCS 1900 1930.2 MHz - 1989.8 MHz
Used TX Channels:	GSM PCS 1900: low: ch.512, center: ch. 660, high: ch. 810
Maximum RF Power Output:	1.0 W EIRP GSM PCS 1900 (30 dBm)
Maximum SAR Measurement: (Averaged over 1g)	1.292 W/kg PCS GSM Body

This wireless portable device has been tested in accordance with the measurement procedures specified in FCC/OET Bulletin 65 Supplement C (2001) and IEEE Std. 1528-200X (July 2001), and has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE Std. C95.1 - 1992.

I attest to the accuracy of this data. All reported measurements were performed by me, or were made under my supervision, and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them..

I also certify that no party to this application has been denied the FCC benefits pursuant to Section 5.301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 862.

Chris Harvey
Director, EMC Laboratory

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OBJECTIVE

The Merlin G301 PCMCIA Card is a Type II PC card GSM/GPRS (Global System for Mobil communications/General Packet Radio System) wireless modem from Novatel Wireless Technologies that operates in the 900 MHz (GSM), 1800 MHz (DCS) and 1900 MHz (PCS) bands.

The objective of the procedure was to perform a dosimetric assessment of the PCMCIA card in the GSM 1900 standard. The measurements have been carried out with the dosimetric assessment system "SARA2", and were made according to the Supplement C to OET Bulletin 65 of the Federal Communications Commission (FCC) Guidelines [FCC 2001] for evaluating compliance of mobile and portable devices with FCC limits for human exposure in the general population to radio frequency emissions.

INTRODUCTION

In the United States, the most recent FCC RF exposure criteria is documented in the publication OET 65 Supplement C Edition 01-01 [FCC 2001], which sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3kHz to 300GHz.

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. (c) 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. The measurement procedure described in IEEE/ANSI C95.3-1992 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring SAR due to the RF radiation exposure from the Equipment Under Test (EUT).

SAR DEFINITION

Specific absorption rate (SAR) is the biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest. It is a measure of the power absorbed per unit mass and may be spatially averaged over the total mass of an exposed body or its parts.

In mathematical terms Specific Absorption Rate (SAR) is defined as the time derivative (rate) of the incremental energy absorbed by (dissipated in) an incremental mass contained in a volume element of a given density. It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body as given below**.** The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity s and the mass density r of the biological tissue:

$$SAR = \frac{|E|^2 s}{r}$$

SAR is expressed in units of Watts per Kilogram (W/kg)

F = Conductivity of the tissue-simulant material (S/m)

D= Mass density of the tissue-simulant material (kg/m3)

E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relations to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

SUMMARY FOR SAR TEST REPORT

EUT	GSM/GPRS PCS 1900 PCMCIA Card
FCC ID	NBZNRM-MG301
Date of receipt	June 14, 2002
Date of Test	September 18,2002
RF Exposure Category	Uncontrolled
Measured Standard	PCS 1900
Measurement performed by	Liming Xu

Maximum Results Found during SAR Evaluation

The equipment is deemed to fulfil the requirements if the measured values are less than or equal to the limit.

Head Configuration

Phantom Configuration	Test Position	Channel	Power (dBm)	Frequency (GHz)	Max. 1g SAR (W/kg)
NA	NA	NA	NA	NA	NA

Table 1. MAX SAR Head Configuration

Body Worn Configuration

Test Configurations w/ 900mAH Battery	Channel	Power (dBm)	Frequency (GHz)	Max. 1g SAR (W/kg)
Antenna parallel - PCMCIA card parallel to phantom with headset	30	660	1.88	1.292

Table 2. MAX SAR Body Configuration

DESCRIPTION OF TESTED DEVICE

FCC ID	NBZNRM-MG301
Modes of Operation	GSM 1900
Modulation Mode(s)	GMSK
Duty Cycle(s) (=1/ Crest Factor)	Crest Factor = 8
Transmitter Frequency Range	1850.2 MHz - 1909.8 MHz

Picture of EUT

Description of the Antenna

Detachable (Not operational without antenna)

Battery Options

Powered by the host Laptop.

EUT PICTURES

Fig 1 Top View

Fig 2 Bottom View

Fig 3 Front View

Fig 4 With Antenna

Fig 5 Antenna Detached

Fig 6 With Headset and Antenna

TEST CONDITIONS

Environment

Test Environment	Dedicated test area
Ambient temperature	22°C ± 1 °C
Tissue simulating liquid temperature	22°C ± 0.5 °C
Shielded Chamber	Anechoic material strategically positioned to minimize room reflections
Ambient Noise	very low

Test Signal, Frequencies and Output Power

1. The measurements are first performed at the middle channel of the operating band of the EUT. If the SAR value of the middle channel for each test configuration (Left, Right, Cheek, Tilt, Extended, Retracted) is at least 2 dB below the SAR limit, testing at the high and low channels is optional for such test configurations.

2. The PCMCIA Card was set to maximum power level during the all test. Power output was measured before each test.

3. The PCMCIA Card was equipped with a special firmware, which allowed controlling the transmitter from its keypad.

T During SAR testing, the EUT (PCMCIA Card) was operated and controlled by a Rhode & Schwartz CMU 200 Base Station Simulator.

During SAR testing, the EUT (PCMCIA Card) was operated and controlled by an Agilent Base station Simulator.

Other

TEST DETAILS

Tissue Recipes

The following recipe is provided in percentage by weight.

1900 MHz, Body:
41.8% De-Ionized Water
0.2% Salt
58% Sugar
00% DGBE

Material Parameters

Simulant	Freq [MHz]	Room Temp [C]	Liquid Temp [C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
Body	1900	24.4	24.7	χ_r	54	52.3	3.15	+/- 5%
				F	1.45	1.43	1.38	+/- 5%

Table 3: Parameters of the tissue simulating liquid, September 18, 2002

Parameters were measured before and after testing. These values reflect both measurements.

System Validation:

Following equipment is used for the system validation:

Signal Generator (Agilent E4432B)
RF Amplifier (Mini-Circuits ZHL-42)
Dual Directional Coupler (HP 778D)
The HP 8564E Spectrum Analyzer (used for RF power measurement)
Cables, Attenuate and Adapters

The recommended (IEEE Std 1528) set-up was used:

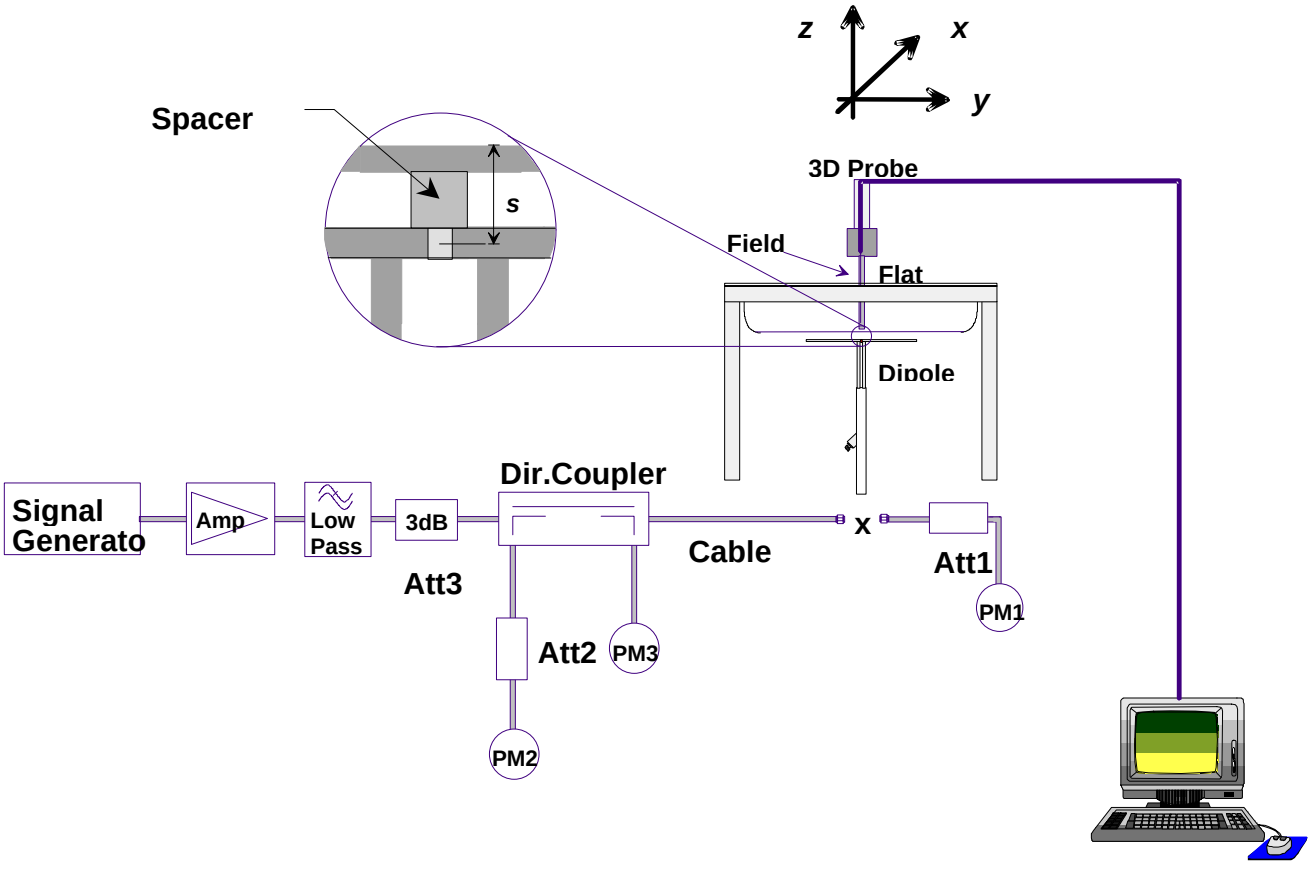


Figure 7. Performance Check Setup Diagram

Performance Checking

Test Position:	Flat Phantom
Test Date:	September 18,2002
Antenna Position:	Balanced Dipole
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH	NA
SAR Drift	<2%
SAR (1g):	36.337

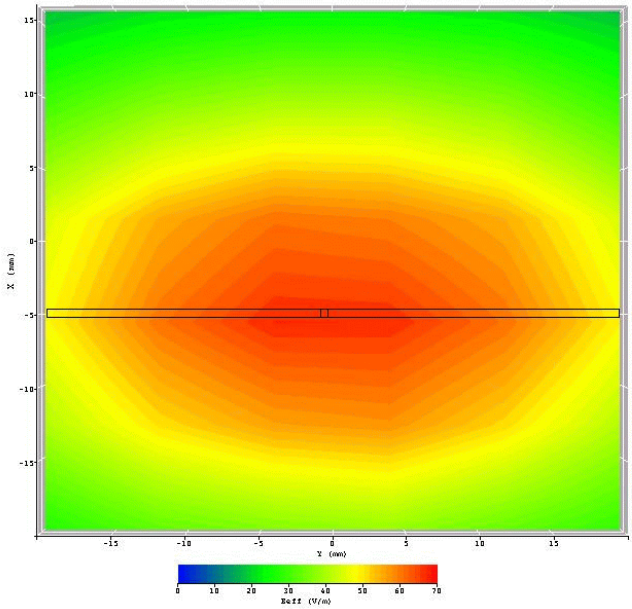


Figure 8. Validation Measurement - 1800 MHz in flat bath

Simulant	Freq [MHz]	Room Temp [C]	Liquid Temp [C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
Body	1800	24.4	24.7	χ_r	54	52.3	3.15	+/- 5
				F	1.45	1.43	1.38	+/- 5
				1g SAR	38.1	36.337	4.628	+/- 10

Table 4. System Validation results Summary.- September 18, 2002

NOTES:

RF forward Power = 0.204 W

Validation was performed within 100 MHz of Operating Frequency.

Test Position:	Flat Phantom
Test Date:	October 18,2002
Antenna Position:	Balanced Dipole
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room	24.5 C
Post Test Room	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH	NA
SAR Drift	<2%
SAR (1g):	36.343

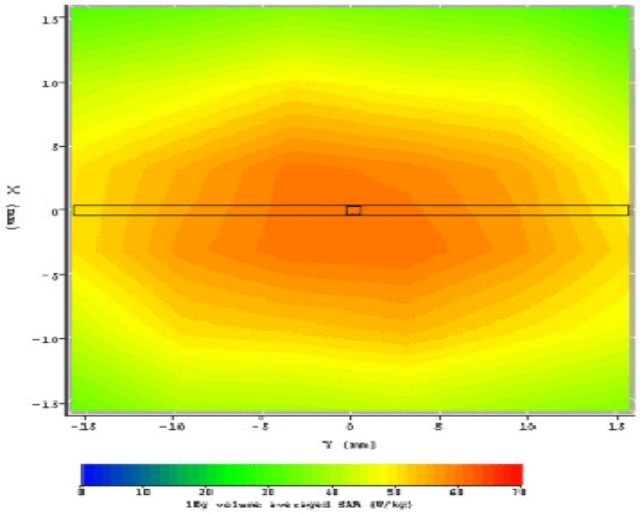


Figure 8x. Validation Measurement - 1800 MHz in flat bath

Simulant	Freq [MHz]	Room Temp [C]	Liquid Temp [C]	Parameters	Target Value	Measured Value	Deviation [%]	Limit [%]
Body	1800	24.5	24.8	χ_r	54	52.4	2.96	+/- 5
				F	1.45	1.44	0.68	+/- 5
				1g SAR	38.1	36.343	4.61	+/- 10

Table 4x. System Validation results Summary.- October 18, 2002

NOTES:

RF forward Power = 0.204 W

Validation was performed within 100 MHz of Operating Frequency.

SAR Results Summary

SAR results for PCS 1900MHz band for PCMCIA card - GSM/GPRS

PCMCIA TEST POSITION	Power (dBm)	CHANNEL	FREQ. (GHz)	Max.1g SAR (W/kg)	SAR 2nd Spot
Antenna vertical and parallel to phantom without headset	30	660	1.880	0.722	0.116
Antenna vertical and parallel to phantom with headset	30	660	1.880	0.758	0.136
Antenna parallel - PCMCIA card parallel to phantom without headset	30	660	1.880	0.76	0.182
Antenna parallel - PCMCIA card parallel to phantom with headset	30	660	1.880	1.292	0.196
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	30	660	1.880	0.47	None *
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	30	660	1.880	0.504	None *

Table 5. SAR Results - 1900MHz

NOTES:

1 The measurements are first performed at the middle channel of the operating band of the EUT. If the SAR value of the middle channel for each test configuration (Left, Right, Cheek, Tilt, Extended, Retracted) is at least 2 dB below the SAR limit, testing at the high and low channels is optional for such test configurations.

2 The above antenna test results represent the maximum SAR values with antenna attached. The device is not operational with the antenna detached.

3 All modes of operation are investigated and worst case are reported.

4	Multiple Hot Spots	None	TSAR was less than 2 dB of the highest peak	TReported
5	Battery Type	Standard	Extended	Both
6	Power Measured	Conducted	TEIRP	ERP
7	SAR Measurement System	SARA2		
8	SAR Configuration	Head	TBody	

9 Before the measurements, the test site ambient conditions were checked performing SAR measurements with the phone powered off.

SAR results for PCS 1900MHz band for PCMCIA card - GSM/GPRS

PCMCIA TEST POSITION	Power (dBm)	CHANNEL	FREQ. (GHz)	Max.1g SAR (W/kg)	SAR 2nd Spot
Antenna vertical and parallel to phantom without headset	30	512	1.85	0.758	0.101
Antenna vertical and parallel to phantom with headset	30	512	1.85	1.154	0.131
Antenna parallel - PCMCIA card parallel to phantom without headset	30	512	1.85	1.204	0.180
Antenna parallel - PCMCIA card parallel to phantom with headset	30	512	1.85	1.208	0.163
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	30	512	1.85	0.596	None *
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	30	512	1.85	0.682	None *

Table 5. SAR Results - 1900MHz

NOTES:

1	The measurements are first performed at the middle channel of the operating band of the EUT. If the SAR value of the middle channel for each test configuration (Left, Right, Cheek, Tilt, Extended, Retracted) is at least 2 dB below the SAR limit, testing at the high and low channels is optional for such test configurations.			
2	The above antenna test results represent the maximum SAR values with antenna attached. The device is not operational with the antenna detached.			
3	All modes of operation are investigated and worst case are reported.			
4	Multiple Hot Spots	None	TSAR was less than 2 dB of the highest peak	TReported
5	Battery Type	Standard	Extended	Both
6	Power Measured	Conducted	TEIRP	ERP
7	SAR Measurement System	SARA2		
8	SAR Configuration	Head	TBody	
9	Before the measurements, the test site ambient conditions were checked performing SAR measurements with the phone powered off.			

SAR results for PCS 1900MHz band for PCMCIA card - GSM/GPRS

PCMCIA TEST POSITION	Power (dBm)	CHANNEL	FREQ. (GHz)	Max.1g SAR (W/kg)	SAR 2nd Spot
Antenna vertical and parallel to phantom without headset	29.8	810	1.909	0.904	0.112
Antenna vertical and parallel to phantom with headset	29.8	810	1.909	0.886	0.131
Antenna parallel - PCMCIA card parallel to phantom without headset	29.8	810	1.909	0.930	0.174
Antenna parallel - PCMCIA card parallel to phantom with headset	29.8	810	1.909	1.048	0.179
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	29.8	810	1.909	0.546	None *
Antenna Perpendicular - PCMCIA card parallel to phantom with headset	29.8	810	1.909	0.640	None *

Table 5. SAR Results - 1900MHz

NOTES:

1 The measurements are first performed at the middle channel of the operating band of the EUT. If the SAR value of the middle channel for each test configuration (Left, Right, Cheek, Tilt, Extended, Retracted) is at least 2 dB below the SAR limit, testing at the high and low channels is optional for such test configurations.

2 The above antenna test results represent the maximum SAR values with antenna attached. The device is not operational with the antenna detached.

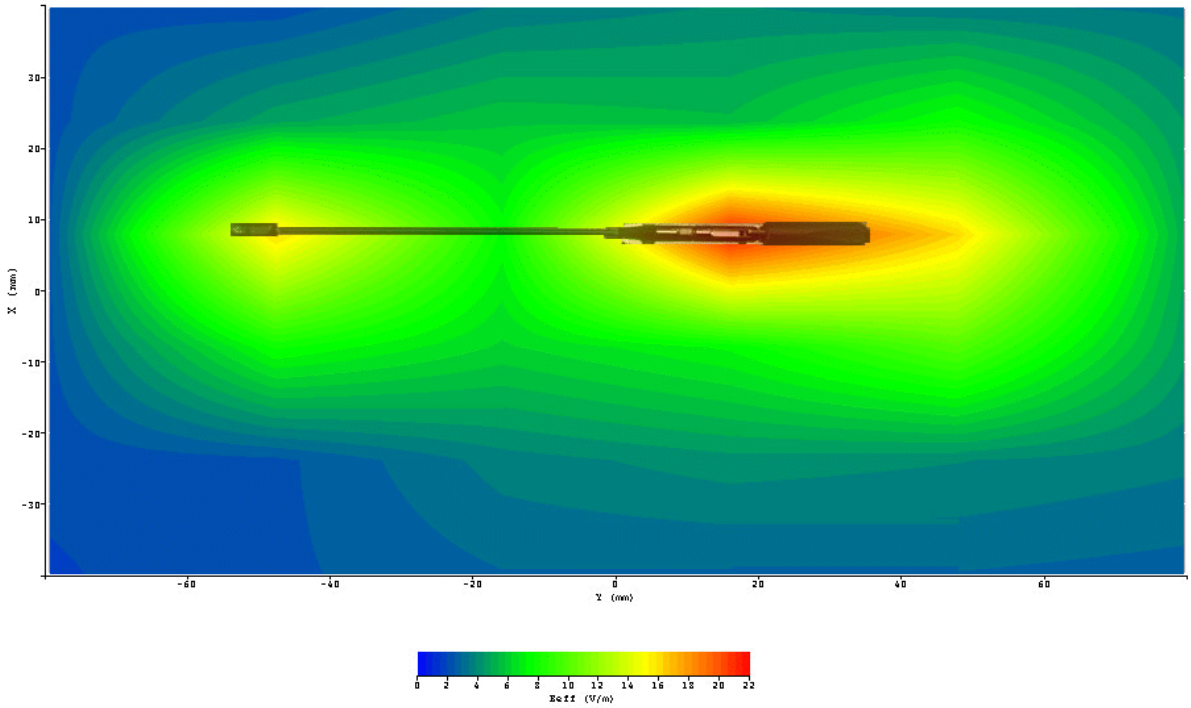
3 All modes of operation are investigated and worst case are reported.

4	Multiple Hot Spots	None	TSAR was less than 2 dB of the highest peak	TReported
5	Battery Type	Standard	Extended	Both
6	Power Measured	Conducted	TEIRP	ERP
7	SAR Measurement System	SARA2		
8	SAR Configuration	Head	TBody	

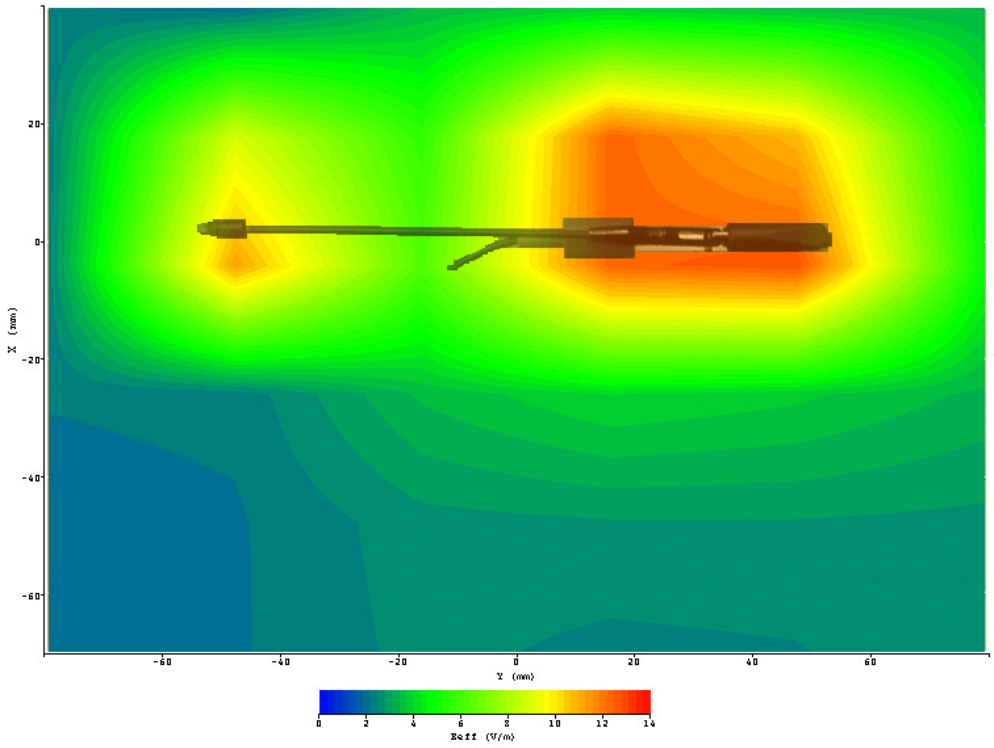
9 Before the measurements, the test site ambient conditions were checked performing SAR measurements with the phone powered off.

SAR DISTRIBUTIONS (AREA SCANS)

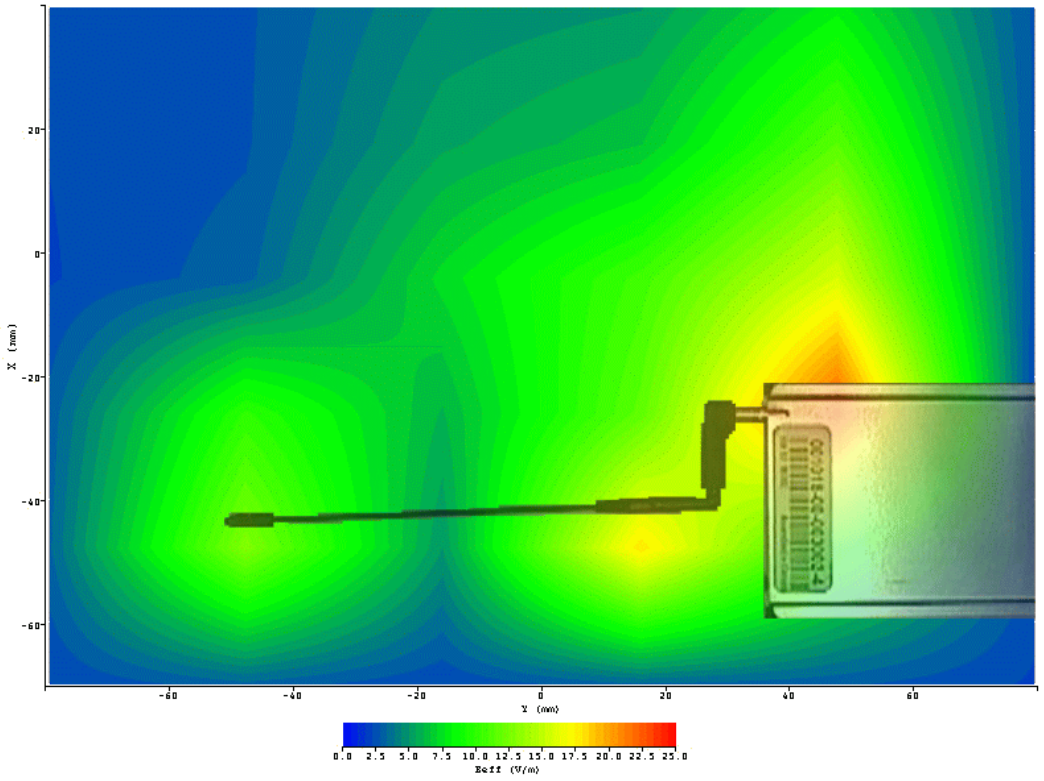
Test Position:	Antenna vertical and parallel to phantom without headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.722 W/Kg



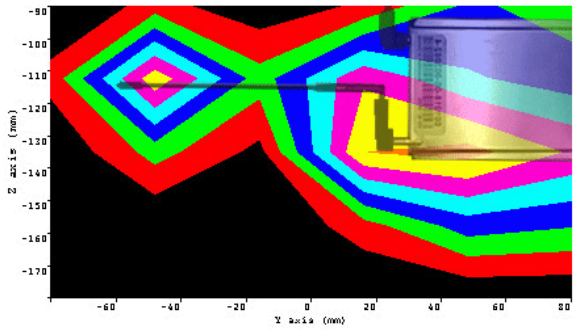
Test Position:	Antenna vertical and parallel to phantom with headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.758 W/Kg

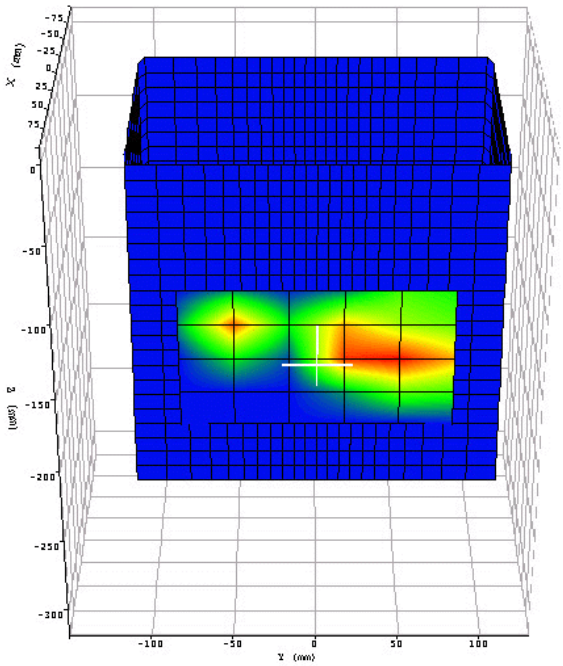


Test Position:	Antenna horizontal and parallel to phantom without headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.760 W/Kg

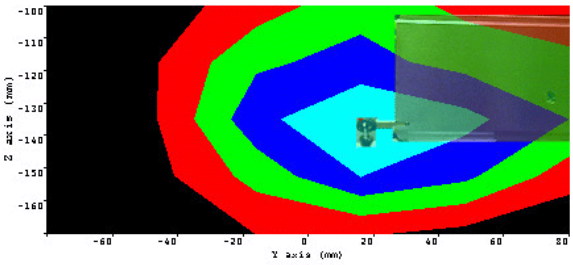


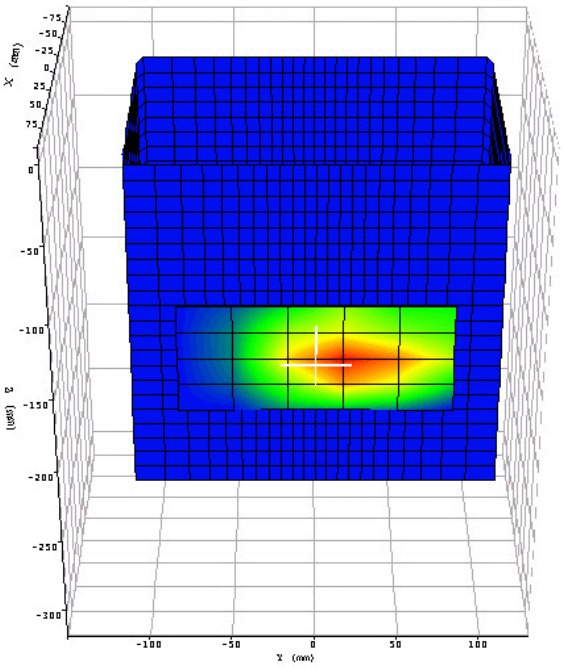
Test Position:	Antenna horizontal and parallel to phantom with headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	1.292 W/Kg



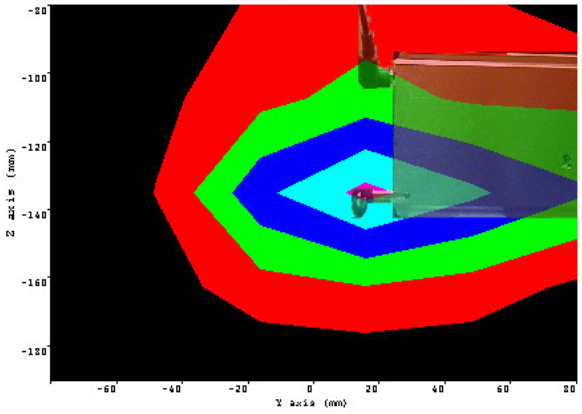


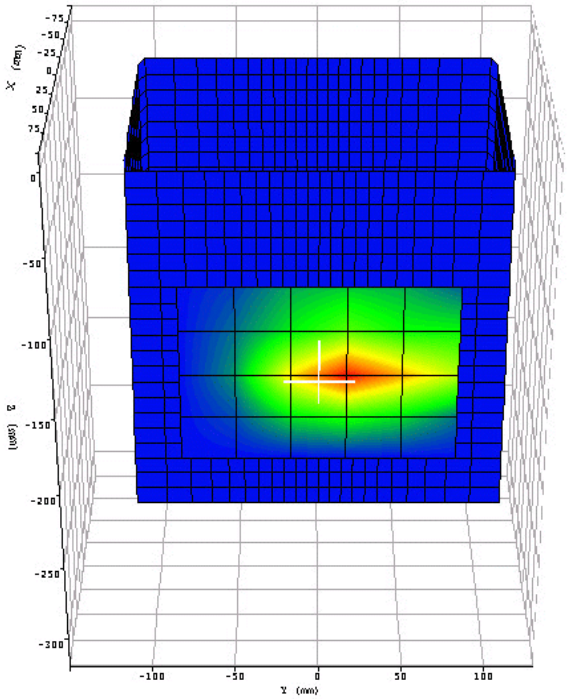
Test Position:	Antenna perpendicular and parallel to phantom without headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.470 W/Kg



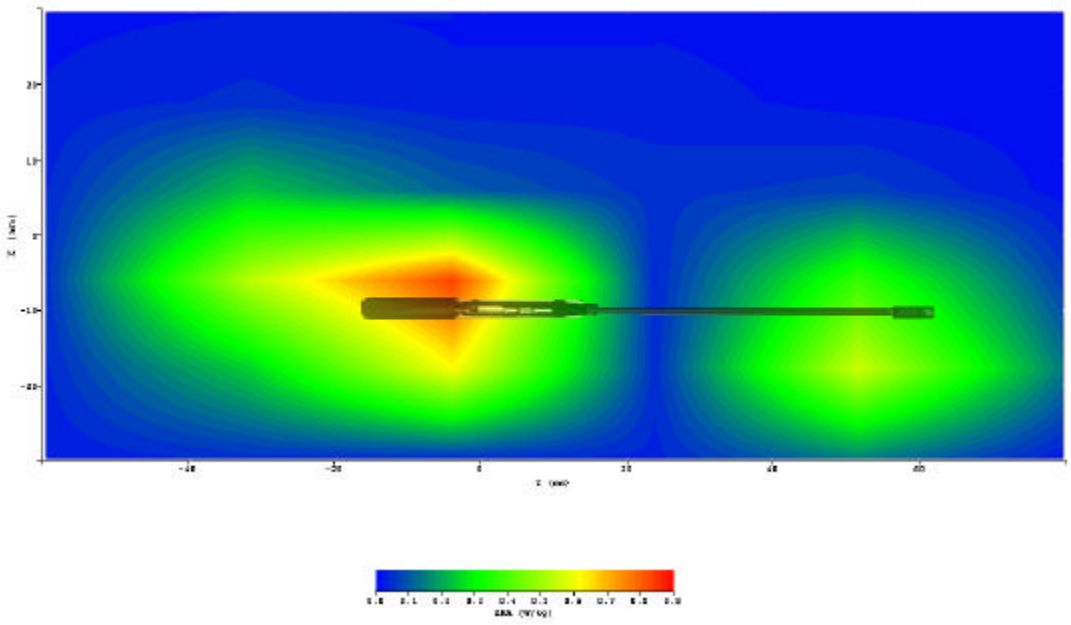


Test Position:	Antenna perpendicular and parallel to phantom with headset
Test Date:	September 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.3; F = 1.43
Pre Test Room Temperature:	24.4 C
Post Test Room Temperature:	24.5 C
Pre Test Simulant Liquid	24.7 C
Post Test Simulant Liquid	24.8 C
CH 660	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.504 W/Kg

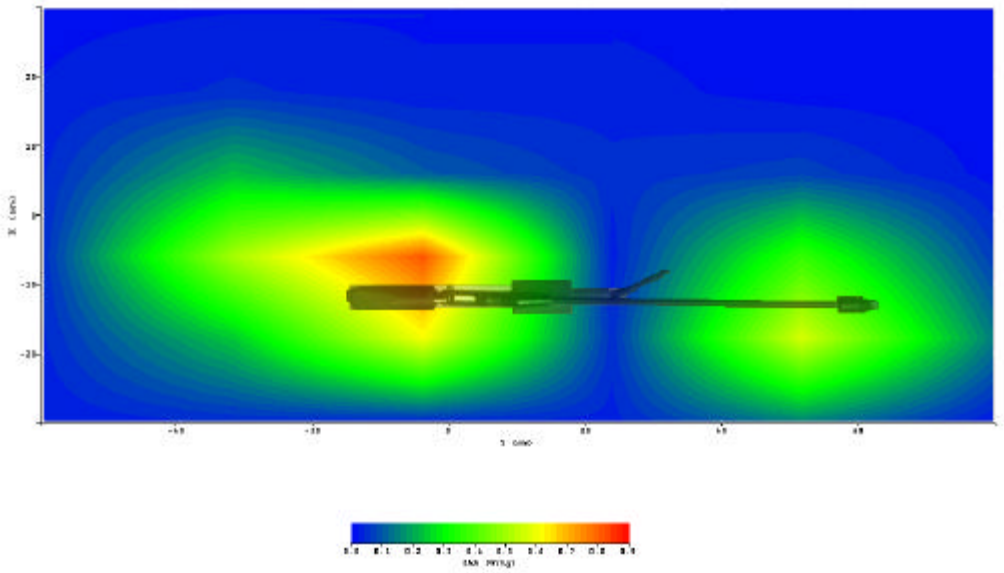




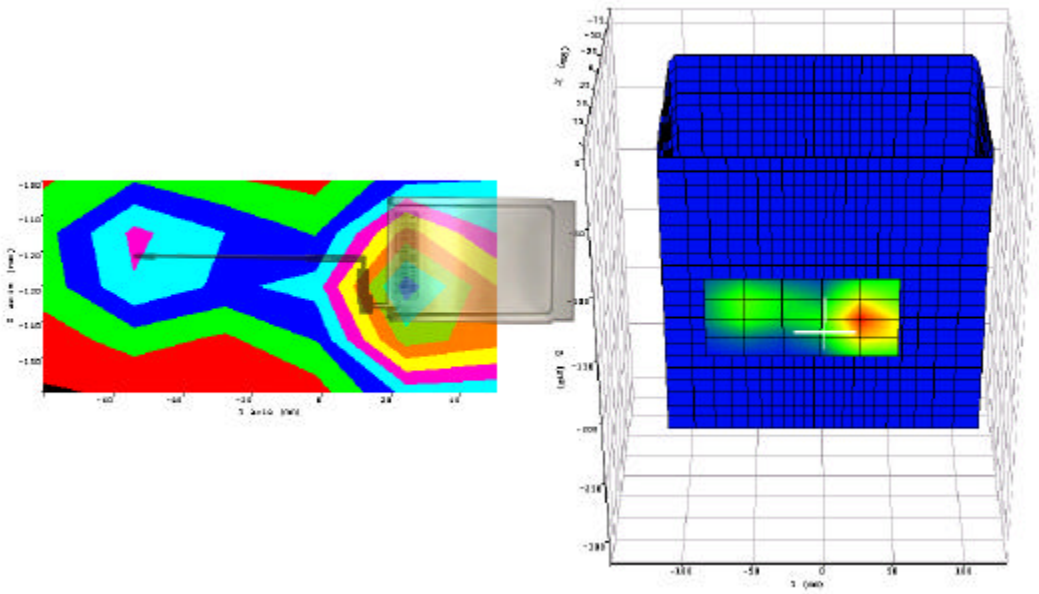
Test Position:	Antenna vertical and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.758 W/Kg



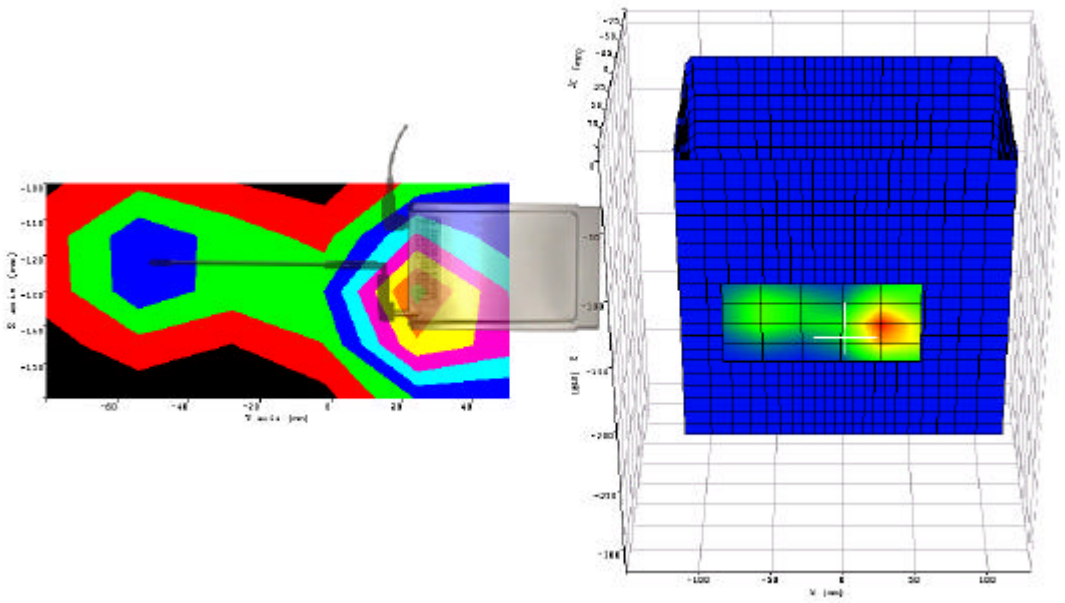
Test Position:	Antenna vertical and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	1.154 W/Kg



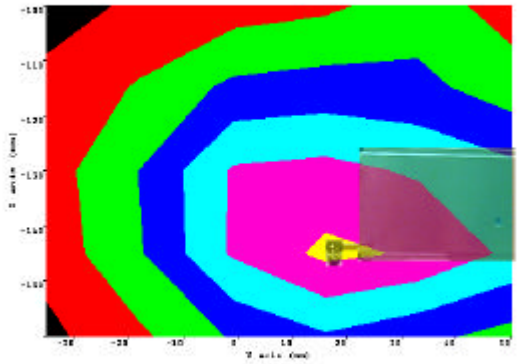
Test Position:	Antenna Horizontal and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	1.204 W/Kg

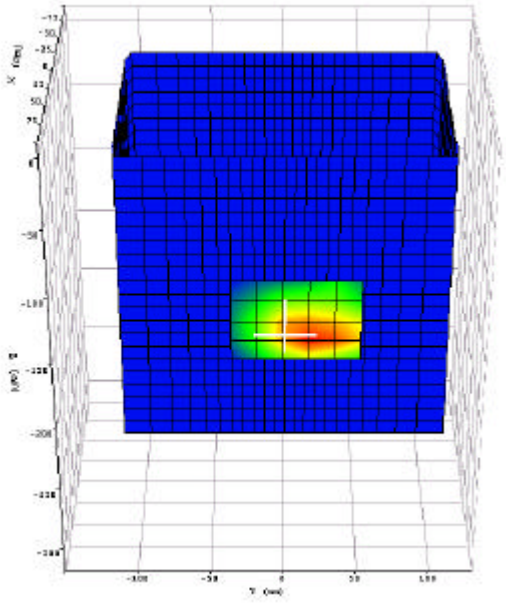


Test Position:	Antenna Horizontal and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	1.208 W/Kg

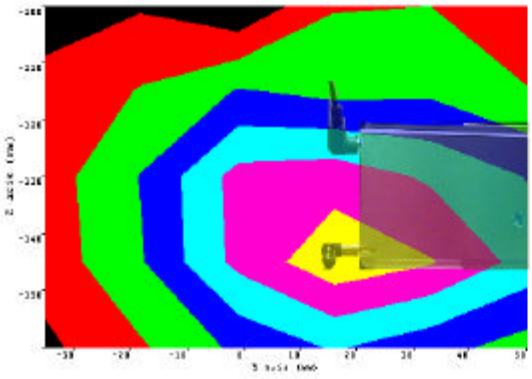


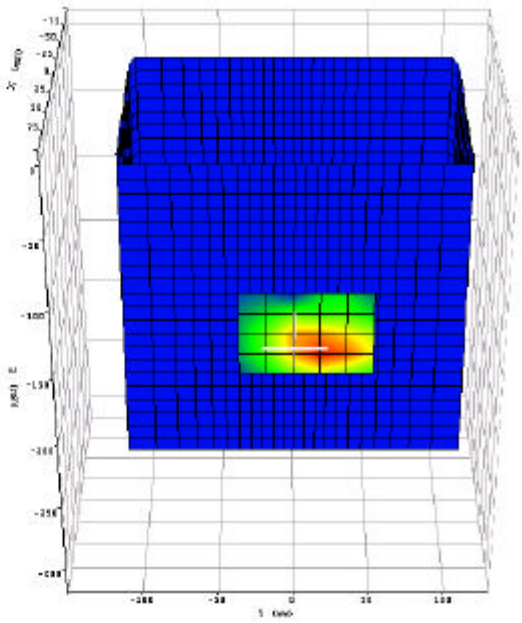
Test Position:	Antenna perpendicular and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.596 W/Kg



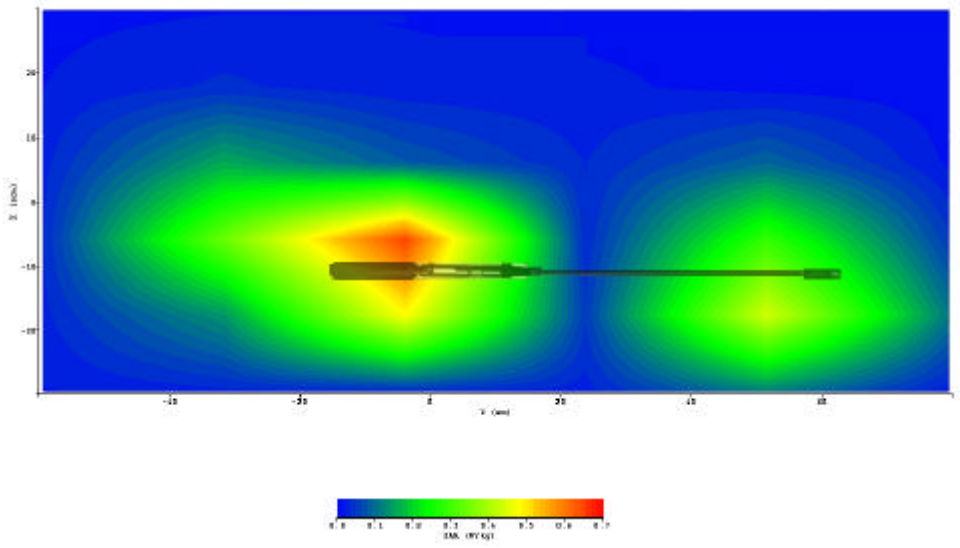


Test Position:	Antenna perpendicular and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 512	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.682 W/Kg

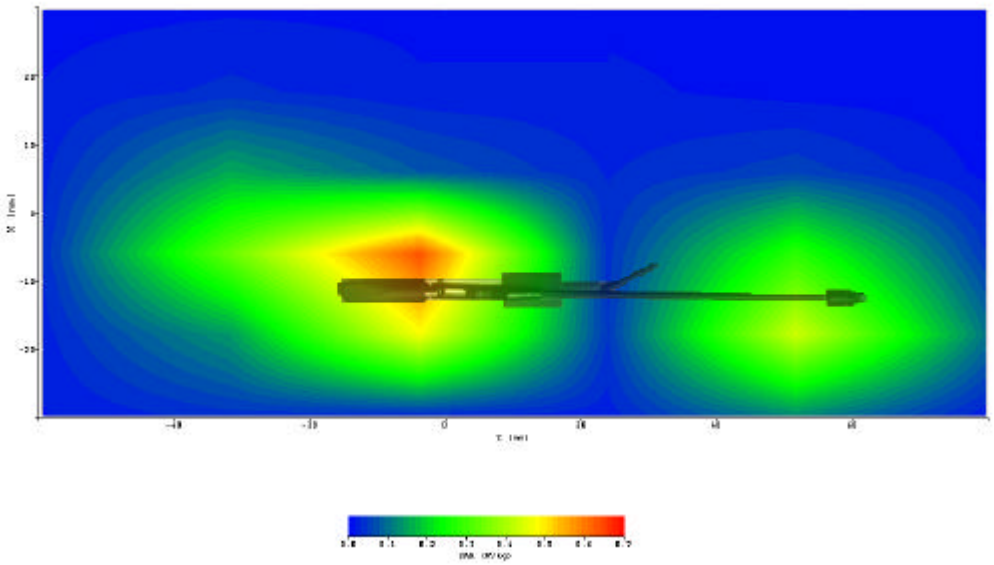




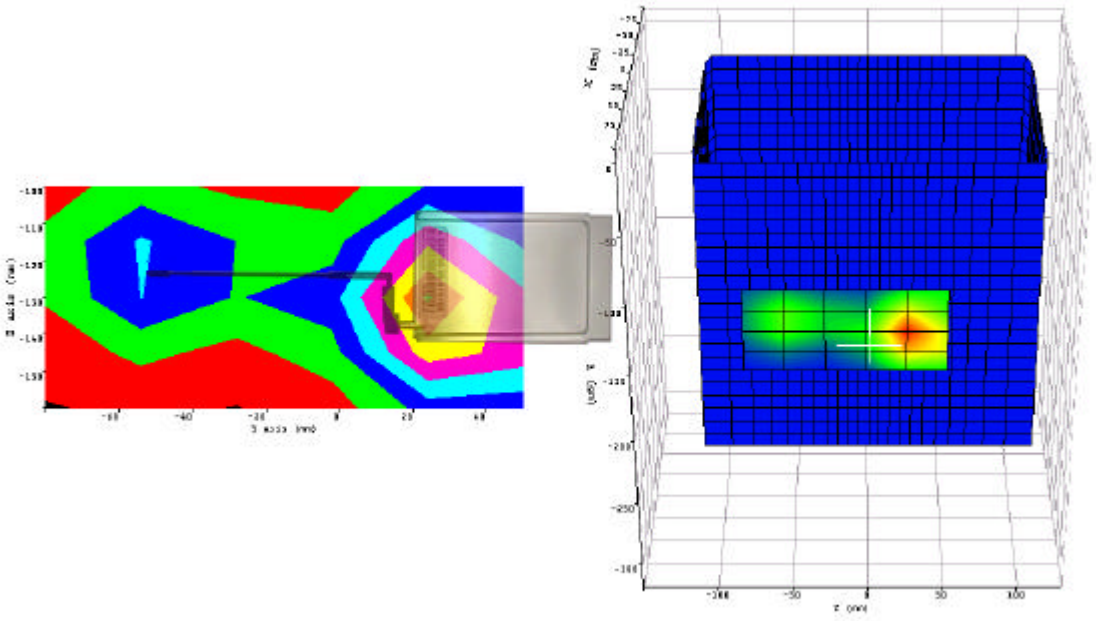
Test Position:	Antenna vertical and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.904 W/Kg



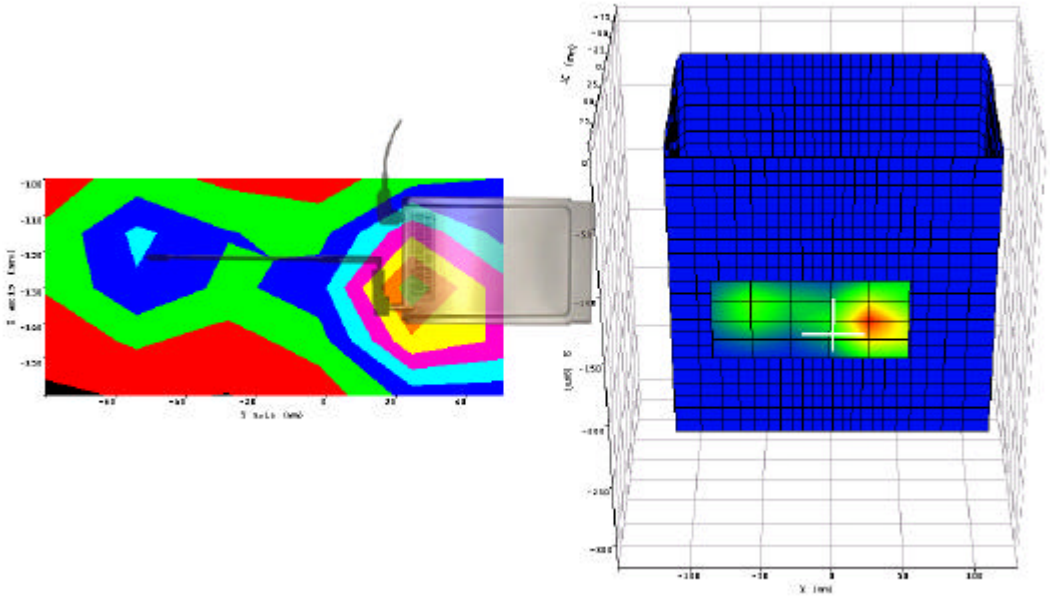
Test Position:	Antenna vertical and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.886 W/Kg



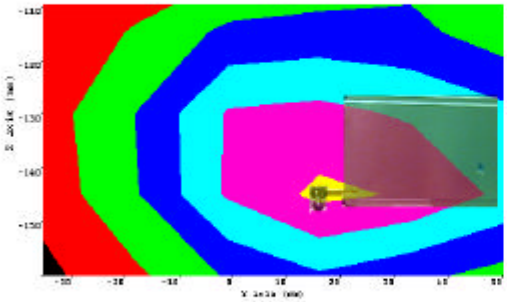
Test Position:	Antenna Horizontal and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.930 W/Kg

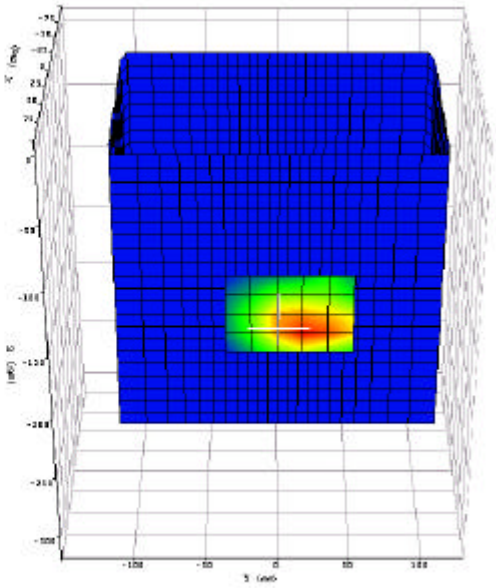


Test Position:	Antenna Horizontal and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	1.048 W/Kg

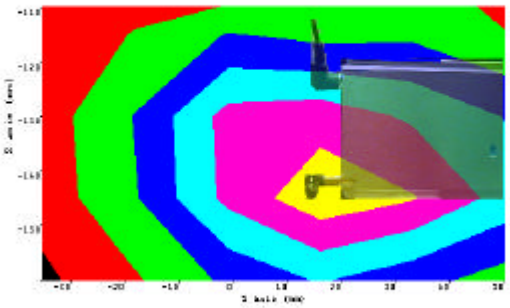


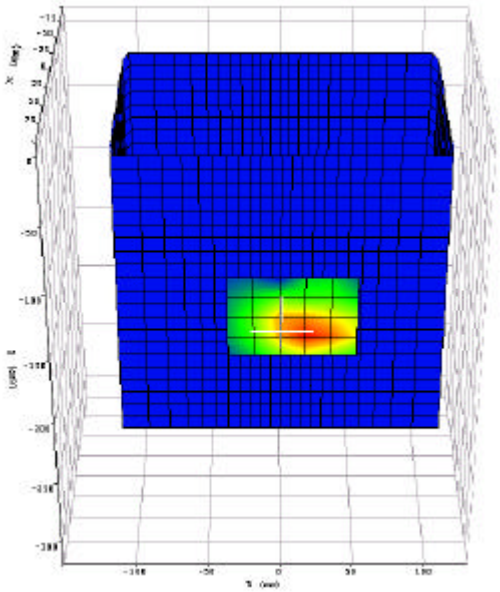
Test Position:	Antenna perpendicular and parallel to phantom without headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.546 W/Kg





Test Position:	Antenna perpendicular and parallel to phantom with headset
Test Date:	October 18, 2002
Antenna Position:	Same as above
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	Body: χ_r = 52.4; F = 1.44
Pre Test Room Temperature:	24.5 C
Post Test Room Temperature:	24.6 C
Pre Test Simulant Liquid	24.8 C
Post Test Simulant Liquid	24.9 C
CH 810	Crest factor=8(GSM)
SAR Drift	<1%
SAR (1g):	0.640 W/Kg





Setup Pictures

There are six test positions employed in the testing as described in the FCC Policy for PCMCIA cards. In each position the card is inserted into a laptop computer.

(The PCMCIA Card's antenna is separated from the flat phantom by 0 cm**)**

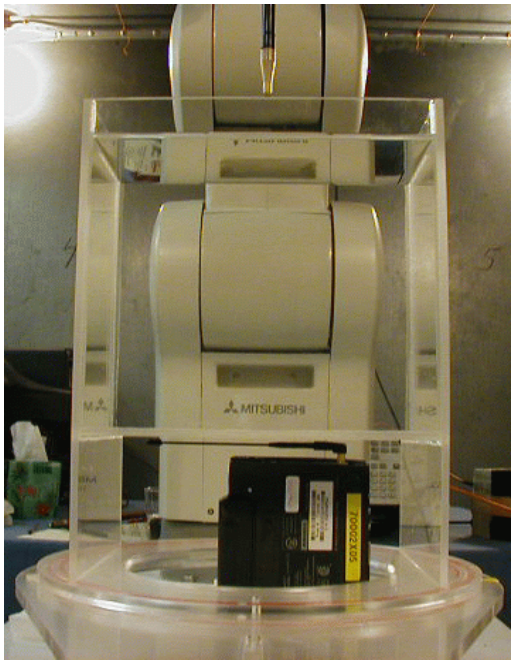


Figure S1. Position #1 - Antenna vertical and parallel to the phantom - PCS 1900 MHz

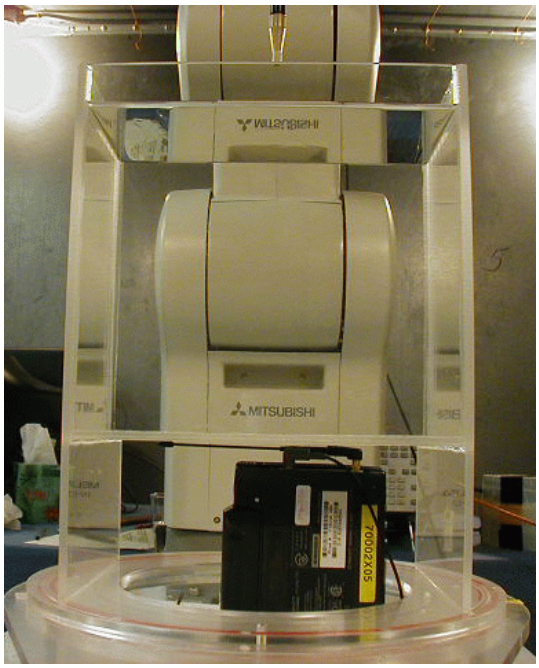


Figure S2. Position #2 - Antenna vertical and parallel to the phantom with headset - PCS 1900 MHz

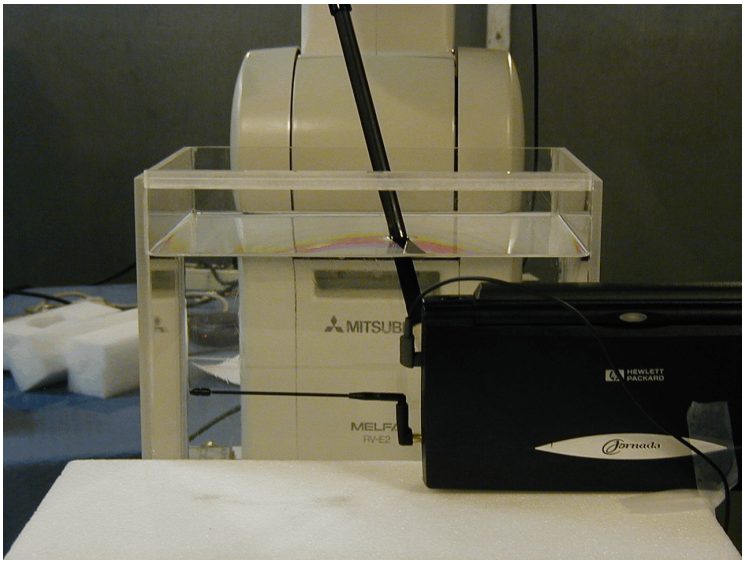


Figure S3. Position #3 - Antenna horizontal and parallel to the phantom without headset -PCS 1900 MHz

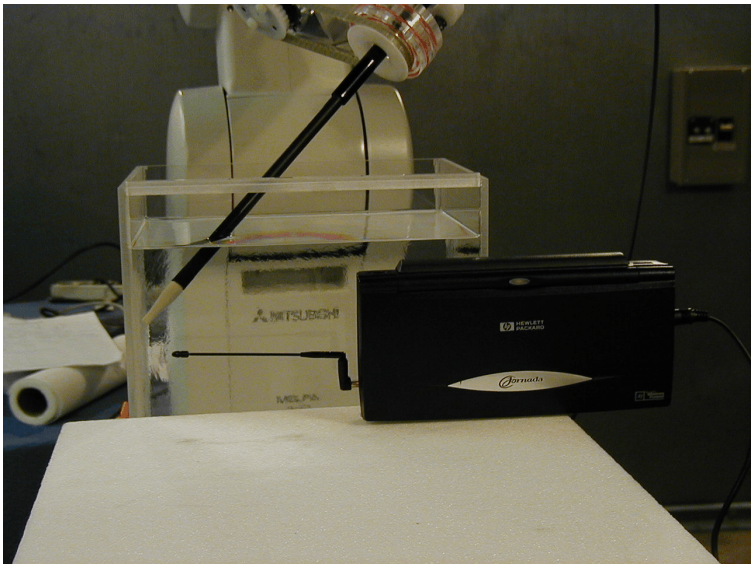


Figure S4. Position #4 Antenna horizontal and parallel to the phantom with headset PCS 1900 MHz

Figure S5. Position #5 Antenna perpendicular to the phantom without headset PCS 1900 MHz

Figure S6. Position #6 Antenna perpendicular to the phantom with headset PCS 1900 MHz

Measurement System

Measurement System - SARA2 System Specification

The SAR measurement system being used is the IndexSAR SARA2 system, which consists of a Mitsubishi RV-E2 6-axis robot arm and controller, IndexSAR probe and amplifier and SAM phantom Head Shape. The robot is used to articulate the probe to programmed positions inside the phantom head to obtain the SAR readings from the EUT.

The system is controlled remotely from a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans.

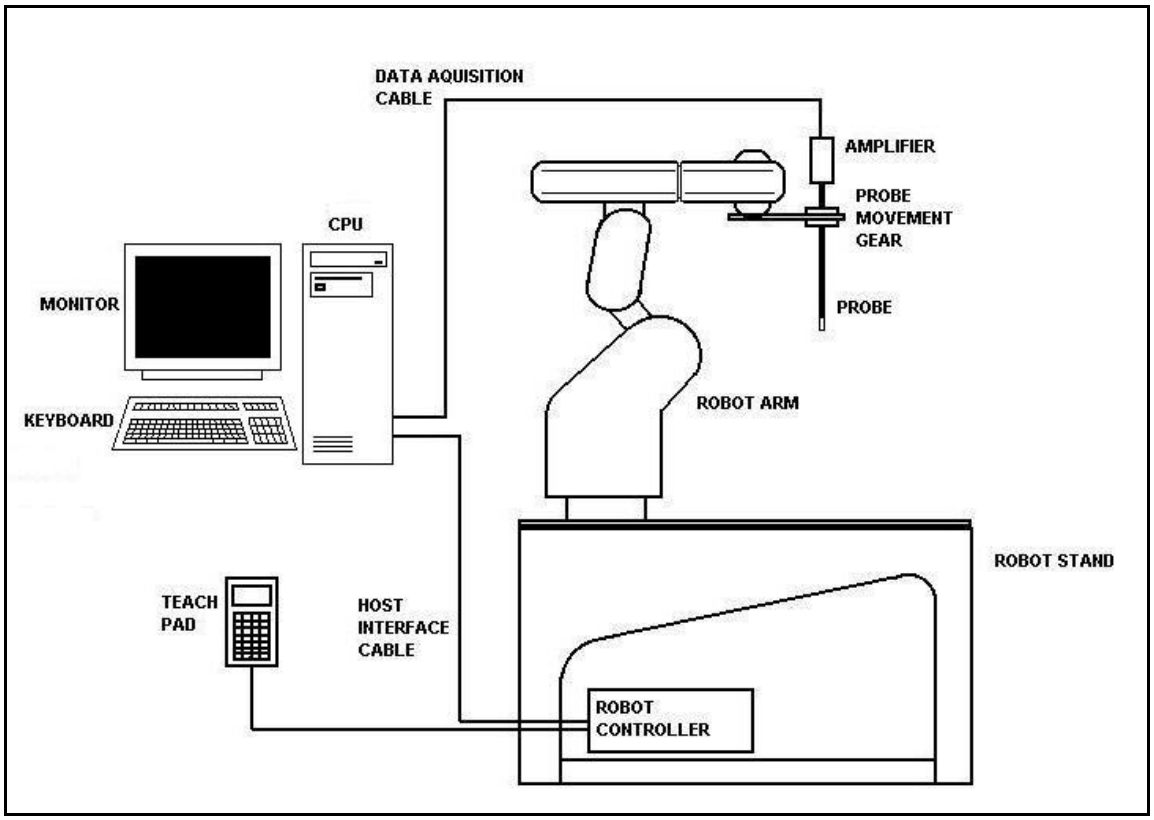


Figure 9. Block Diagram of SARA 2 System

The position and digitized shape of the phantom heads/flat baths are made available to the software for accurate positioning of the probe and reduction of set-up time.

The SAM phantom heads/flat baths are individually digitized using a Mitutoyo CMM machine to a precision of 0.001mm. The data is then converted into a shape format for the software, providing an accurate description of the phantom shell.

In operation, the system first performs an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centred at that point to determine volume averaged SAR level.

Robot/Controller:

Model	**Mitsibishi Movemaster RV-2E 6 Axis Robot**
Repeatability	**+/-0.04mm**
Speed	**Up to 3500 mm/sec**

Data Acquisition (Minimum requirements):

Processor	**Pentium III**
Clock Speed	**700MHz**
Operating System	**Windows 98 or 2000**
I/O	**Two RS232, or One RS232 and One USB**
Software	**SARA2 Ver.xx, IXU-010X Utility Software Ver.xx, Microsoft Excel**
Memory	**10GB Hard drive, CDROM**

IXP-050 IndexSAR isotropic immersible SAR probe

The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip. Probe calibration is described in the Calibration report appendix.

IXP-010 Amplifier

The amplifier unit has multi-pole connector to connect to the probe and a multiplexer selects between the 3-channel single-ended inputs. A 16-bit AtoD converter with programmable gain is used along with an on-board micro-controller with non-volatile firmware. Battery life is around 150 hours and data are transferred to the PC via 3m of duplex optical fibre and a self-powered RS232 to optical converter.

Phantoms:

SAM Twin Horizontal Phantom per IEEE Draft 1528:

The SAM Twin Horizontal is fabricated to the CAD files as specified by FCC OET 65 Supplement C 01-01 and IEEE Draft 1528. It is mounted on a dielectric table which includes mounting brackets for EUT positioners and a shelf for dipole holders. The phantom has three integrated positioning reference points.

SAM Upright Phantom per CENELEC EN50361:

The SAM Upright Phantom is fabricated to the CAD files as specified by CENELEC EN50361. It is mounted on the base table which holds the robotic positioner. The phantom and robot alignment is assured by both mechanical and laser registration systems.

Flat Bath Phantom for testing above 800 MHz:

The Flat Bath Box Phantom is fabricated to the specifications of the OET 65 Supplement C and CENELEC EN50361 standard. It is mounted on a similar rotational base to that of which the SAM upright phantom is attached to. It is positioned in place of the SAM upright head when doing validations or flat bath testing

Phantom Properties:

Phantom Type	Material	Permittivity (g)	Conductivity (F - S/m)
SAM Upright Phantom	Head:polyurethane Resin Base:PVC	<3.15 above 200 MHz	<0.02 below 2 GHz
Box Phantom/holder	Clear: Perspex	<2.85 above 500 MHz	<0.015 below 2 GHz

Table 6. Phantom Properties

Measurement Procedure

Figure 10. Photograph of SARA 2 System

The major components of the test bench are shown in the picture above. A test set and dipole antenna control the handset via an air link and a low-mass phone holder can position the phone at either ear. Graduated scales are provided to set the phone in the 15 degree position. The upright phantom head holds approx. 7 liters of simulant liquid. The phantom is filled and emptied through a 45mm diameter penetration hole in the top of the head.

After an area scan has been performed at a fixed distance of 8mm from the surface of the phantom on the source side, a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power drift during measurement to be assessed.

SARA2 Interpolation and Extrapolation schemes

SARA2 software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a general n^{-th} order polynomial fitting routine is implemented following a singular value decomposition algorithm presented in [4]. A 4^{th} order polynomial fit is used by default for data extrapolation, but a linear-logarithmic fitting function can be selected as an option. The polynomial fitting procedures have been tested by comparing the fitting coefficients generated by the SARA2 procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

Interpolation of 2D area scan

The 2D cubic B-spline interpolation is used after the initial area scan at fixed distance from the phantom shell wall. The initial scan data are collected with approx. 10mm spatial resolution and spline interpolation is used to find the location of the local maximum to within a 1mm resolution for positioning the subsequent 3D scanning.

Extrapolation of 3D scan

For the 3D scan, data are collected on a spatially regular 3D grid having (by default) 6.4 mm steps in the lateral dimensions and 3.5 mm steps in the depth direction (away from the source). SARA2 enables full control over the selection of alternative step sizes in all directions.

The digitized shape of the head/flat bath is available to the SARA2 software, which decides which points in the 3D array are sufficiently well within the shell wall to be 'visited' by the SAR probe. After the data collection, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

Interpolation of 3D scan and volume averaging

The procedure used for defining the shape of the volumes used for SAR averaging in the SARA2 software follow the method of adapting the surface of the 'cube' to conform with the curved inner surface of the phantom. This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated and interpolated to less than 1mm spacing and average values are calculated from the phantom surface for the row of data over distances corresponding to the requisite depth for 10g and 1g cubes. This results in two 2D arrays of data, which are then cubic B-spline interpolated to sub mm lateral resolution. A search routine then moves an averaging square around through the 2D array and records the maximum value of the corresponding 1g and 10g volume averages. For the definition of the surface in this procedure, the digitized position of the head-shell surface is used for measurement in head-shaped phantoms. For measurements in rectangular, box phantoms, the distance between the phantom wall and the closest set of gridded data points is entered into the software.

For measurements in box-shaped phantoms, this distance is under the control of the user. The effective distance must be greater than 2.5mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 5mm. A value of 6 or 8mm is recommended. This distance is called dbe in EN 50361.

For automated measurements inside the head, the distance cannot be less than 2.5mm, which is the radius of the probe tip and to avoid interface proximity effects, a minimum clearance distance of x mm is retained. The actual value of dbe will vary from point to point depending upon how the spatially-regular 3D grid points fit within the shell. The greatest separation is when a grid point is just not visited due to the probe tip dimensions. In this case the distance could be as large as the step-size plus the minimum clearance distance (i.e with x=5 and a step size of 3.5, dbe will be between 3.5 and 8.5mm).

The default step size (dstep in EN 50361) used is 3.5mm, but this is under user-control. The compromise is with time of scan, so it is not practical to make it much smaller or scan times become long and power-drop influences become larger. The robot positioning system specification for the repeatability of the positioning (dss in EN50361) is +/- 0.04mm.

The phantom shell is made by an industrial molding process from the CAD files of the SAM shape, with both internal and external molds. For the upright phantoms, the external shape is subsequently digitized on a Mitutoyo CMM machine (Euro C574) to a precision of 0.001mm. Wall thickness measurements made non-destructively with an ultrasonic sensor indicate that the shell thickness (dph) away from the ear is 2.0 +/- 0.1mm. The ultrasonic measurements were calibrated using additional mechanical measurements on available cut surfaces of the phantom shells. See support document IXS-020x.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253mm diameter baseplate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided (procedure detailed elsewhere). This enables the registration of the phantom tip (dmis) to be assured to within approx. 0.2mm. This alignment is done with reference to the actual probe tip after installation and probe alignment. The rotational positioning of the phantom is variable – offering advantages for special studies, but locating pins ensure accurate repositioning at the principal positions (LH and RH ears).

Uncertainty Assessment -

Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1	Standard Uncertainty (%)	
		(dB)		(%)						sqr
Measurement System										
Probe Calibration	E1.1			10	N	1 or k	2	1	5.00	25.00
Axial Isotropy	E1.2	0.25	5.93	5.93	R	√3	1.73	0	0.00	0.00
Hemispherical Isotropy	E1.2	0.5	12.2	12.20	R	√3	1.73	1	7.04	49.63
Boundary effects	E1.3		4	4.00	R	√3	1.73	1	2.31	5.33
Linearity	E1.4	0.04	0.93	0.93	R	√3	1.73	1	0.53	0.29
System Detection Limits	E1.5		1	1.00	R	√3	1.73	1	0.58	0.33
Readout Electronics	E1.6		1	1.00	N	1 or k	1.00	1	1	1.00
Response time	E1.7		0	0.00	R	√3	1.73	1	0	0.00
Integration time	E1.8		1.8	1.80	R	√3	1.73	1	1.04	1.08
RF Ambient Conditions	E5.1		3	3.00	R	√3	1.73	1	1.73	3
Probe Positioner Mechanical Tolerance	E5.2		0.6	0.60	R	√3	1.73	1	0.35	0.12
Probe Position wrt. Phantom Shell	E5.3		5	3.80	R	√3	1.73	1	2.19	4.81
SAR Evaluation Algorithms	E4.2		8	4.00	R	√3	1.73	1	2.31	5.33
Test Sample Related										
Test Sample Positioning	E3.2.1		10	10.00	R	√3	1.73	1	5.77	33.33
Device Holder Uncertainty	E3.1.1		10	8.00	R	√3	1.73	1	4.62	21.33
Output Power Variation	E5.6.2		5	5.00	R	√3	1.73	1	2.89	8.33
Phantom and Tissue Parameters										
Phantom Uncertainty (shape and thickness)	E2.1		4	4.00	R	√3	1.73	0.5	1.15	1.33
Liquid conductivity (Deviation from target)	E2.2		5	5.00	R	√3	1.73	0.5	1.44	2.08
Liquid conductivity (measurement uncert.)	E2.2		10	10.00	R	√3	1.73	0.5	2.89	8.33
Liquid permittivity (Deviation from target)	E2.2		5	5	R	√3	1.73	0.5	1.44	2.08
Liquid permittivity (measurement uncert.)	E2.2		5	5.00	R	√3	1.73	0.5	1.44	2.08
Combined standard uncertainty					RSS			13.2		
Expanded uncertainty k=2 (95% Confidence Level)				25.9%						

Table7. Uncertainty budget of SARA2

Table 3 includes the preliminary uncertainty budget. The expanded uncertainty is assessed to be 25.9%. This uncertainty includes probe calibration, positioning and evaluation errors, as well as errors of the correct dielectric parameters for the tissue simulating liquid, etc.

END OF REPORT