

Specific Absorption Rate (SAR) Test Report
for
Cardionet, Inc.
on the
CardioNet ECG Monitor With Arrhythmia Detection
Model Number: 1001

Test Report: 30225951
Date of Report: March 28, 2002

Job #: 3022595
Date of Test: March 28, 2002

Total No of Pages Contained in this Report: 46.



Warnock Hersey



Tested by:	
Reviewed by:	

Review Date: 3/29/02



emc



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TABLE OF CONTENTS

1.0	JOB DESCRIPTION	3
1.1	Client Information	3
1.2	Equipment under test (EUT)	3
1.3	Test Plan Reference	4
1.4	System Test Configuration	5
1.4.1	System Block Diagram & Support Equipment	5
1.4.2	Test Position	6
1.4.3	Test Condition	7
1.5	Modifications required for compliance	7
1.6	Additions, deviations and exclusions from standards	7
2.0	SAR EVALUATION	8
2.1	SAR Limits	8
2.2	Configuration Photographs	9
2.3	System Verification	15
2.4	Evaluation Procedures	15
2.5	Test Results	16
3.0	TEST EQUIPMENT	19
3.1	Equipment List	19
3.2	Muscle Tissue Simulating Liquid	20
3.3	E-Field Probe Calibration	20
3.4	Measurement Uncertainty	21
3.5	Measurement Tractability	21
4.0	WARNING LABEL INFORMATION - USA	22
5.0	REFERENCES	23
5.0	DOCUMENT HISTORY	24
APPENDIX A - SAR Evaluation Data		25
APPENDIX B - E-Field Probe Calibration Data		34

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

1.0 JOB DESCRIPTION

1.1 Client Information

The 1001 has been tested at the request of:

Company: Cardionet, Inc.
510 Market Street
San Diego , CA 92101
USA

Name of contact: Mr. Gary Thomas
Telephone: 619/243-7530
Fax: 619/243-7700

1.2 Equipment under test (EUT)

Product Descriptions:

Equipment	CardioNet ECG Monitor With Arrhythmia Detection		
Trade Name	CardioNet	P/N.	1001
FCC ID	Not Labeled	S/N No.	11006
Category	Portable device	RF Exposure	Uncontrolled Environment
Frequency Band	824 - 849 MHz	System	CDPD

EUT Antenna Description			
Type	Monopole	Configuration	Fixed
Dimensions	13.5mm (L), 7mm (D)	Gain	0 dBi
Location	N/A		

Use of Product : The Sensor communicates the ECG Arrhythmic information wirelessly to the Monitor which the events are then sent out over a wireless CDPD Network

Manufacturer: Cardionet, Inc.

Production is planned: Yes, No

EUT receive date: March 28, 2002

EUT received condition: Good working condition prototype

Test start date: March 28, 2002

Test end date: March 28, 2002

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

1.3 Test Plan Reference

FCC Rule: Part 2.1093, FCC's OET Bulletin 65, Supplement C (Edition 01-01)

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

1.4 System Test Configuration

1.4.1 System Block Diagram & Support Equipment

The diagram shown below details test configuration of the equipment under test.



The CardioNet Monitoring System consists of two devices the Cardio Sensor and the Cardio Monitor. The Cardio Sensor is a very low power transmitter operating at ISM band (902 - 928 MHz) at 1 mW, Communicates with the Cardio Monitor. The Cardio Monitor in addition to communicating with the sensor, transmits data to basestation at cellular band frequencies (824 – 848 MHz).

No Support Equipment was used. The test sample was operated in a test mode that allows control of the transmitter without the need to place actual phone calls. For the purposes of this test the device is commanded to test mode and manually set to the proper channel, transmitter power level and transmit mode of operation. The device was then placed in the SAR Measurement System with a fully charged battery.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

1.4.2 Test Position

Three test configurations were used to show compliance with the FCC RF human exposure requirements. In all configurations, the 1001 was configured for testing in a typical fashion (as a customer would normally use it). Due to the application and usage of the product, SAR measurements with the human head region are not necessary. Table 1 below describes the setup and condition:

Table 1, Equipment Setup

Configuration	Description
A	<ul style="list-style-type: none"> Antenna in horizontal position, distance from antenna to Phantom = 16.5 mm Simulating close proximity of human body; Back Side touching phantom
B	<ul style="list-style-type: none"> Antenna in horizontal position, distance from antenna to Phantom = 13.5 mm Simulating close proximity of human body; Front Side touching phantom

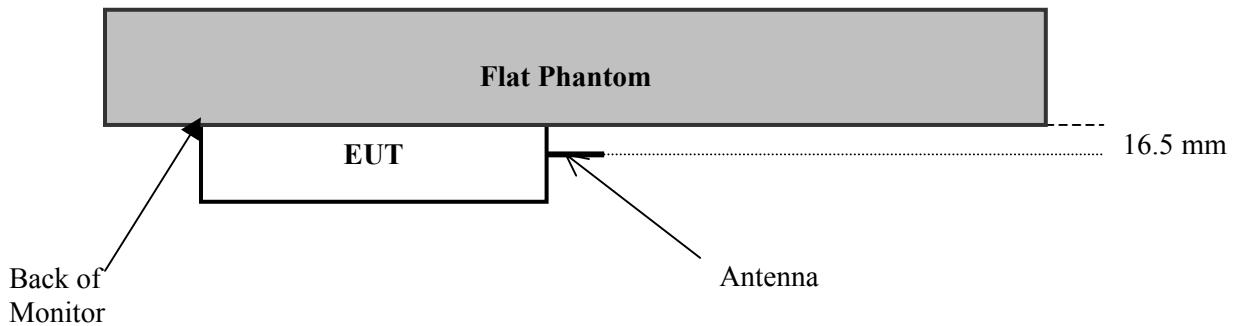


Figure 1: Configuration A Back Side Touching Phantom

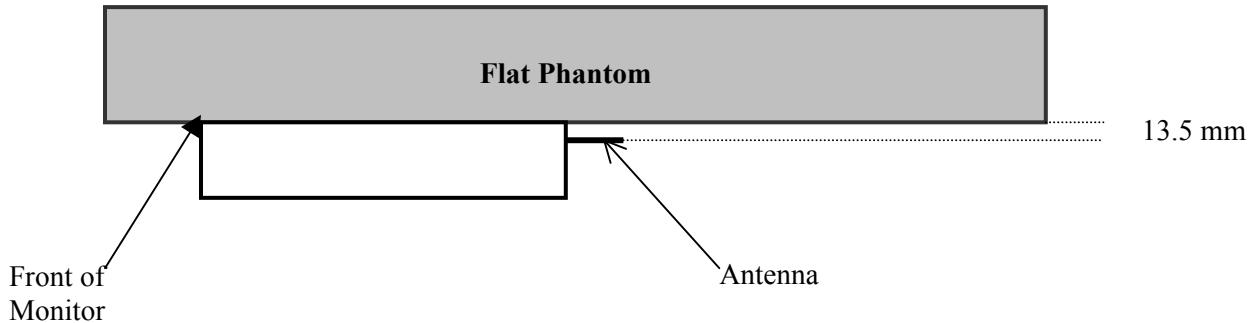


Figure 2: Configuration B Front Side Touching Phantom

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

1.4.3 Test Condition

During tests, the worst case data (max. RF coupling) was determined with following conditions:

EUT Antenna	Fixed length	Orientation	N/A
Usage	Stand-alone	Distance between antenna axis at the joint and the phantom surface:	16.5 mm – Back Side touching phantom 13.5 mm –Front Side touching phantom
Simulating human Body/hand	body	EUT Battery	Unit powered from battery.
Power output	Frequency MHz	Power Output, Watts	Power Output, dBm
	824	0.381	25.8
	835	0.325	25.1
	848	0.227	23.5

The spatial peak SAR values were accessed for lowest, middle and highest operating channels defined by the manufacturer.

Antenna port power measurement was performed, with the HP 435A power meter, before and after the SAR tests to ensure that the 1001 operated at the highest power level.

1.5 Modifications required for compliance

No modifications were implemented by Intertek Testing Services.

1.6 Additions, deviations and exclusions from standards

No additions, deviations or exclusions have been made from standard.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.0 SAR EVALUATION

2.1 SAR Limits

The following FCC limits for SAR apply to devices operate in General Population/Uncontrolled Exposure environment:

EXPOSURE (General Population/Uncontrolled Exposure environment)	SAR (W/kg)
Average over the whole body	0.08
Spatial Peak (1g)	1.60
Spatial Peak for hands, wrists, feet and ankles (10g)	4.00

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

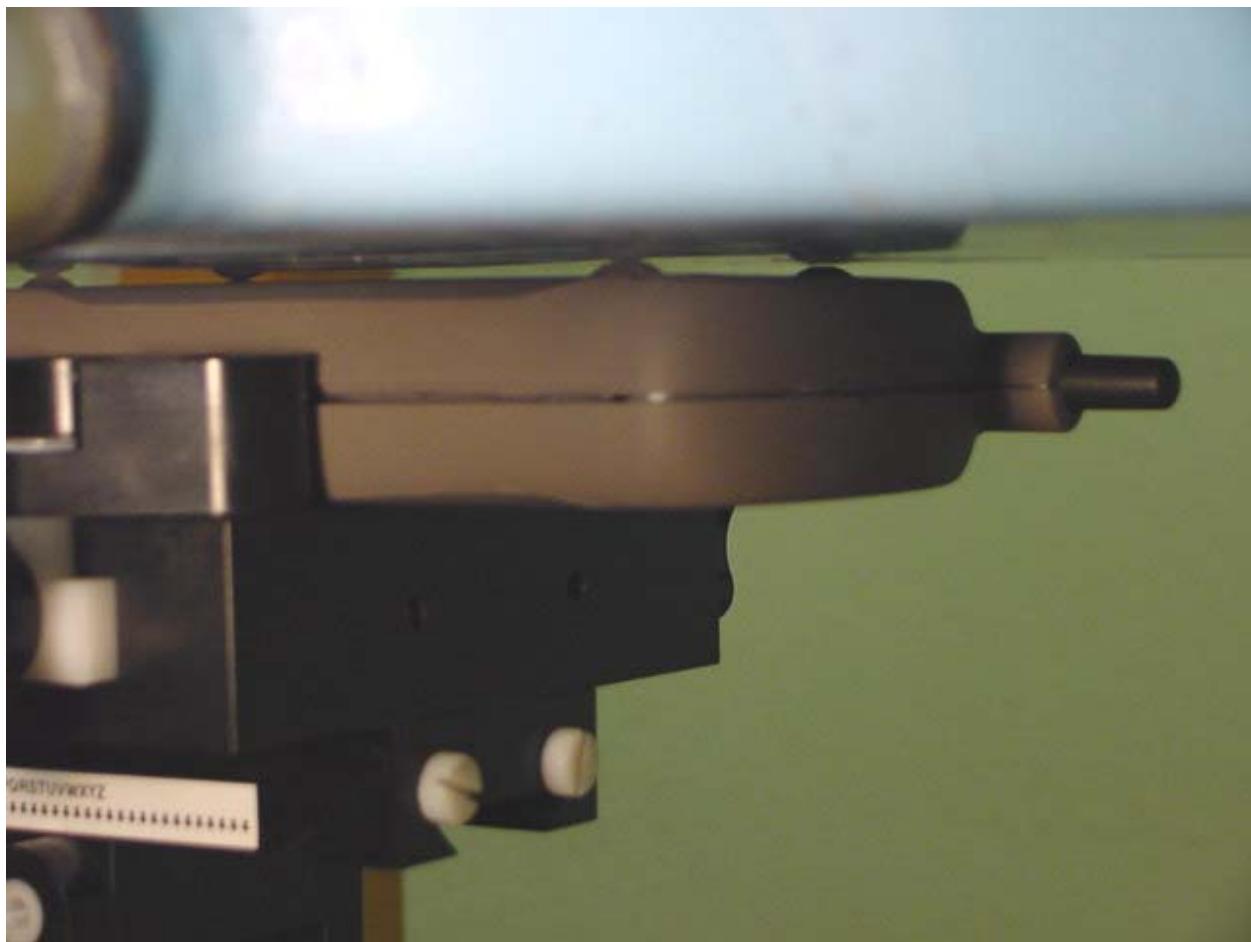
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2.2 Configuration Photographs

SAR measurement Test Setup

(Configuration A)

(Back Side Touching Phantom)



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FCC ID: Not Labeled

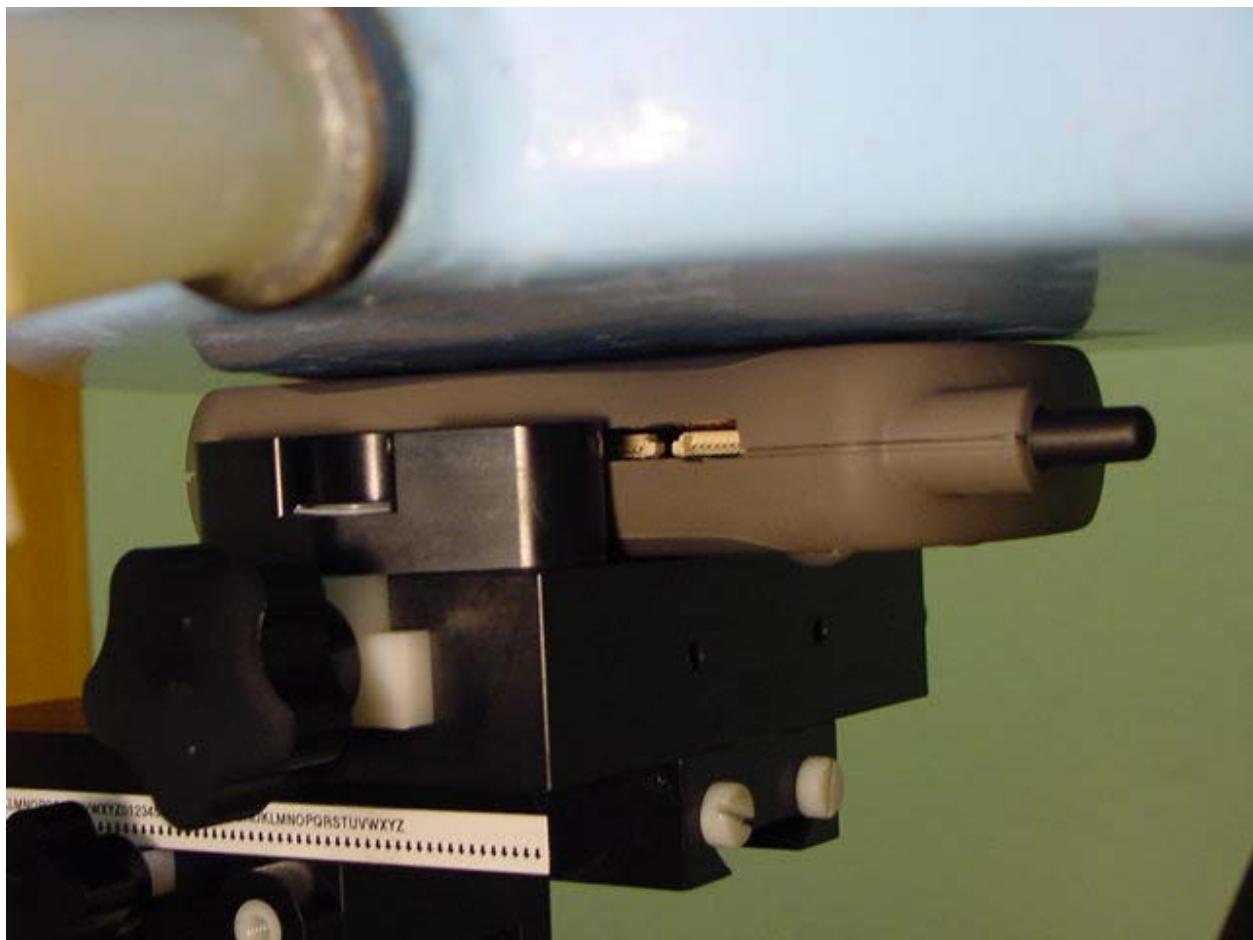
Date of Test: March 28, 2002

2.2 Configuration Photographs (Continued)

SAR measurement Test Setup

(Configuration B)

Front Side Touching Phantom



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.2 Configuration Photographs (Continued)

SAR measurement Test Setup

EUT Cardio Monitor



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.2 Configuration Photographs (Continued)

SAR measurement Test Setup

EUT Cardio Monitor



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.2 Configuration Photographs (Continued)

SAR measurement Test Setup

EUT Cardio Sensor



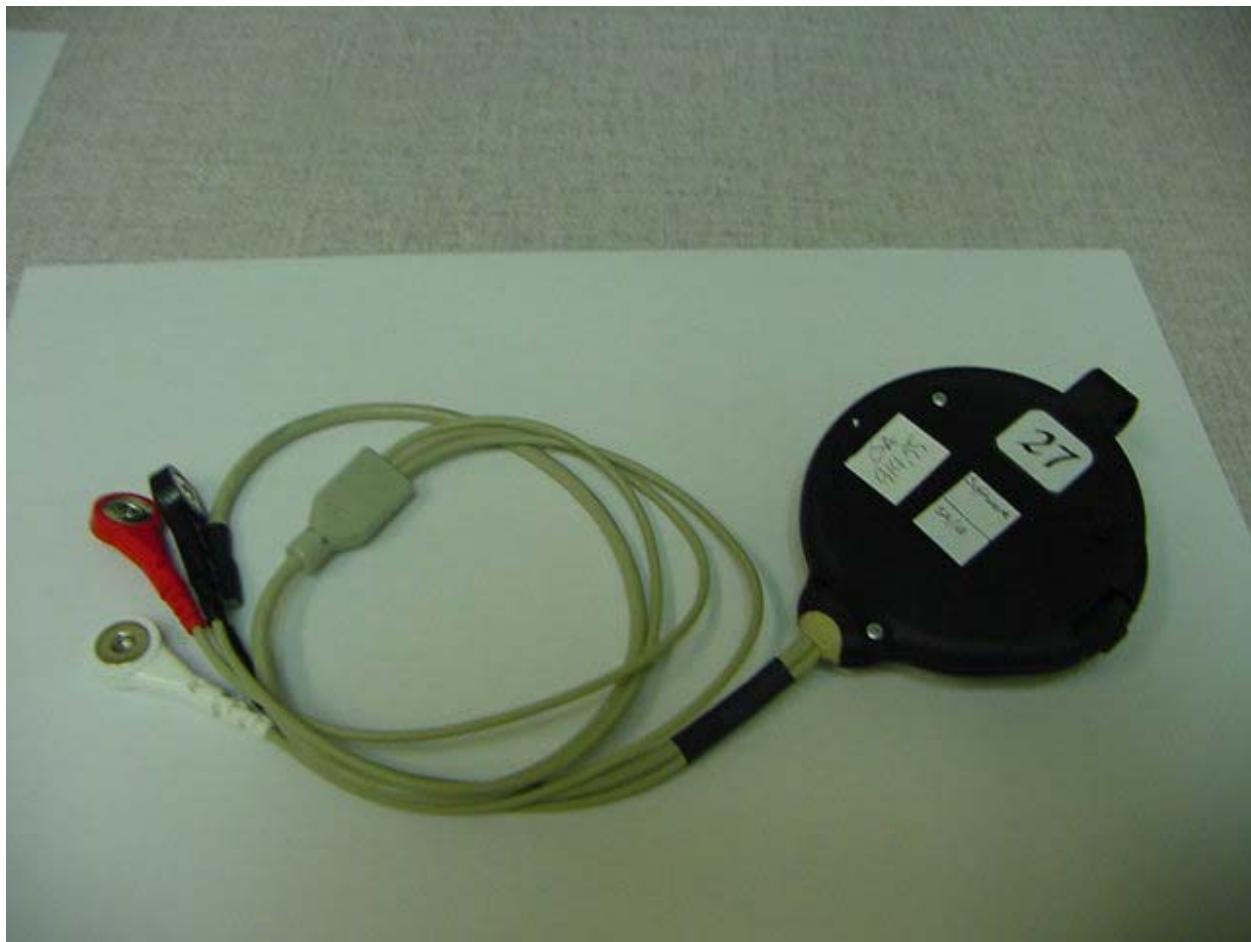
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.2 Configuration Photographs (Continued)

SAR measurement Test Setup

EUT Cardio Sensor



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.3 System Verification

Prior to the assessment, the system was verified to the $\pm 5\%$ of the specifications by using the system validation kit. The validation was performed at 900 MHz.

Validation kit	Targeted SAR _{1g} (mW/g)	Measured SAR _{1g} (mW/g)
D900V2	2.77	2.59

* See plot #8

2.4 Evaluation Procedures

The SAR evaluation was performed with the following procedures:

- a. SAR was measured at a fixed location above the reference point and used as a reference value for the assessing the power drop.
- b. The SAR distribution at the exposed side of the flat Phantom was measured at a distance of 30 mm from the inner surface of the shell. The area covered the entire dimension of the head and the horizontal grid spacing was 20 mm x 20 mm. Based on this data, the area of the maximum absorption was determined by spline interpolation.
- c. Around this point, a volume of 32 mm x 32 mm x 34 mm was assessed by measuring 5 x 5 x 7 points. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure:
 - i) The data at the surface were extrapolated, since the center of the dipoles is 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measurement point is 1.6 mm. The extrapolation was based on a least square algorithm. A polynomial of the fourth order was calculated through the points in Z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.
 - ii) The maximum interpolated value was searched with a straightforward algorithm. Around this maximum, the SAR values averaged over the spatial volumes (1g or 10g) were computed using the 3-D spline interpolation algorithm. The 3-D spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y and z directions). The volume was integrated with the trapezoidal algorithm. 1000 points (10 x 10 x 10) were interpolated to calculate the average.
 - iii) All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
- d. Re-measurements of the SAR value at the same location as in step a. above. If the value changed by more than 5 %, the evaluation was repeated.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

2.5 Test Results

The results on the following page(s) were obtained when the device was tested in the condition described in this report. Detail measurement data and plots, which reveal information about the location of the maximum SAR with respect to the device, are reported in Appendix A.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

Measurement Results

Trade Name:	CardioNet	Model No.:	1001
Serial No.:	11006	Test Engineer:	Suresh Kondapalli

TEST CONDITIONS

Ambient Temperature	23.5 °C	Relative Humidity	55 %
Test Signal Source	Test Mode	Signal Modulation	CW
Output Power Before SAR Test	See Page 7	Output Power After SAR Test	No change
Test Duration	20 Min. each test	Number of Battery Change	New battery for each scan

SAR Test Results for CardioMonitor

Configuration A Back Side touching the Phantom					
Frequency MHz	Operating Mode	Crest Factor	Measured SAR _{1g} (mW/g)	Measured SAR _{10g} (mW/g)	Plot Number
824	CW	1	1.07	0.718	1
835	CW	1	0.929	0.619	2
848	CW	1	0.652	0.436	3

Configuration B Front Side touching the Phantom

Frequency MHz	Operating Mode	Crest Factor	Measured SAR _{1g} (mW/g)	Measured SAR _{10g} (mW/g)	Plot Number
824	CW	1	1.24	0.834	4
835	CW	1	1.08	0.716	5
848	CW	1	0.847	0.561	6

SAR Test Results for CardioSensor

Sensor touching the Phantom					
Frequency MHz	Operating Mode	Crest Factor	Measured SAR _{1g} (mW/g)	Measured SAR _{10g} (mW/g)	Plot Number
915	CW	1	0.0019	0.0011	7

Note: As the SAR measured from the Sensor is very low, the SAR test for the Monitor in the ISM Band was not performed (the power of the Monitor transmitter in ISM band is about the same as Sensor, 1 mW).

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

D900V2					
Frequency MHz	Operating Mode	Crest Factor	Measured SAR_{1g} (mW/g)	Measured SAR_{10g} (mW/g)	Plot Number
900	CW	1	2.59	1.67	8

Note: a) Worst case data were reported
b) Duty cycle factor included in the measured SAR data
c) Uncertainty of the system is not included

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

3.0 TEST EQUIPMENT

3.1 Equipment List

The Specific Absorption Rate (SAR) tests were performed with the SPEAG model DASY 3 automated near-field scanning system, which is a package, optimized for dosimetric evaluation of mobile radios [3].

The following major equipment/components were used for the SAR evaluations:

SAR Measurement System			
EQUIPMENT	SPECIFICATIONS	S/N #	LAST CAL. DATE
Robot	Stäubi RX60L Repeatability: $\pm 0.025\text{mm}$ Accuracy: 0.806×10^{-3} degree Number of Axes: 6	597412-01	N/A
E-Field Probe	ET3DV6 Frequency Range: 10 MHz to 6 GHz Linearity: ± 0.2 dB Directivity: ± 0.1 dB in brain tissue	1576	02/27/02
Data Acquisition	DAE3 Measurement Range: $1\mu\text{V}$ to $>200\text{mV}$ Input offset Voltage: $< 1\mu\text{V}$ (with auto zero) Input Resistance: 200 M	317	N/A
Phantom	Generic Twin V3.0 Type: Generic Twin, Homogenous Shell Material: Fiberglass Thickness: 2 ± 0.1 mm Capacity: 20 liter Ear spacer: 4 mm (between EUT ear piece and tissue simulating liquid)	N/A	N/A
Simulated Tissue	Mixture Please see section 6.2 for details	N/A	03/28/02
Power Meter	HP 8900D w/ 84811A sensor Frequency Range: 100kHz to 18 GHz Power Range: $300\mu\text{W}$ to 3W	3607U00673	08/08/01

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

3.2 Muscle Tissue Simulating Liquid

Ingredients	% by Weight
Sugar	41.76
HEC	1.21
Water	56.0
Bactericide	0.27
Salt	0.76

The dielectric parameters were verified prior to assessment using the HP 85070A dielectric probe kit and the HP 8753C network Analyzer. The dielectric parameters were:

Frequency (MHz)	\boxtimes_r *	\square *(mho/m)	\square **(kg/m ³)
835	53.3	0.93	1000

* Worst case uncertainty of the HP 85070A dielectric probe kit

** Worst case assumption

3.3 E-Field Probe Calibration

Probes were calibrated by the manufacturer in the TEM cell ifi 110. To ensure consistency, a strict protocol was followed. The conversion factor (ConF) between this calibration and the measurement in the tissue simulation solution was performed by comparison with temperature measurement and computer simulations. Probe calibration factors are included in Appendix C.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

3.4 Measurement Uncertainty

The uncertainty budget has been determined for the DASY3 measurement system according to the NIS81 [5] and the NIST 1297 [6] documents and is given in the following table. The extended uncertainty (K=2) was assessed to be 23.5 %

UNCERTAINTY BUDGET				
Uncertainty Description	Error	Distrib.	Weight	Std.Dev.
Probe Uncertainty				
Axial isotropy	±0.2 dB	U-shape	0.5	±2.4 %
Spherical isotropy	±0.4 dB	U-shape	0.5	±4.8 %
Isotropy from gradient	±0.5 dB	U-shape	0	
Spatial resolution	±0.5 %	Normal	1	±0.5 %
Linearity error	±0.2 dB	Rectang.	1	±2.7 %
Calibration error	±3.3 %	Normal	1	±3.3 %
SAR Evaluation Uncertainty				
Data acquisition error	±1 %	Rectang.	1	±0.6 %
ELF and RF disturbances	±0.25 %	Normal	1	±0.25 %
Conductivity assessment	±10 %	Rectang.	1	±5.8 %
Spatial Peak SAR Evaluation Uncertainty				
Extrapol boundary effect	±3 %	Normal	1	±3 %
Probe positioning error	±0.1 mm	Normal	1	±1 %
Integrat. and cube orient	±3 %	Normal	1	±3 %
Cube shape inaccuracies	±2 %	Rectang.	1	±1.2 %
Device positioning	±6 %	Normal	1	±6 %
Combined Uncertainties				±11.7 %

3.5 Measurement Tractability

All measurements described in this report are traceable to National Institute of Standards and Technology (NIST) standards or appropriate national standards.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

4.0 WARNING LABEL INFORMATION - USA

See users manual.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

5.0 REFERENCES

- [1] ANSI, *ANSI/IEEE C95.1-1991: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz*, The Institute of electrical and Electronics Engineers, Inc., New York, NY 10017, 1992
- [2] Federal Communications Commission, “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”, OET Bulletin 65, FCC, Washington, D.C. 20554, 1997
- [3] Thomas Schmid, Oliver Egger, and Niels Kuster, “Automated E-field scanning system for dosimetric assessments”, *IEEE Transaction on Microwave Theory and Techniques*, vol. 44, pp. 105-113, Jan. 1996.
- [4] Niels Kuster, Ralph Kastle, and Thomas Schmid, “Dosimetric evaluation of mobile communications equipment with known precision”, *IEICE Transactions on Communications*, vol. E80-B, no. 5, pp.645-652, May 1997.
- [5] NIS81, NAMAS, “The treatment of uncertainty in EMC measurement”, Tech. Rep., NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, 1994.
- [6] Barry N. Taylor and Chris E. Kuyatt, “Guidelines for evaluating and expressing the uncertainty of NIST measurement results”, Tech. Rep., National Institute of Standards and Technology, 1994.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

5.0 DOCUMENT HISTORY

Revision/ Job Number	Writer Initials	Date	Change
1.0 /3022595	SS	March 28, 2002	Original document

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

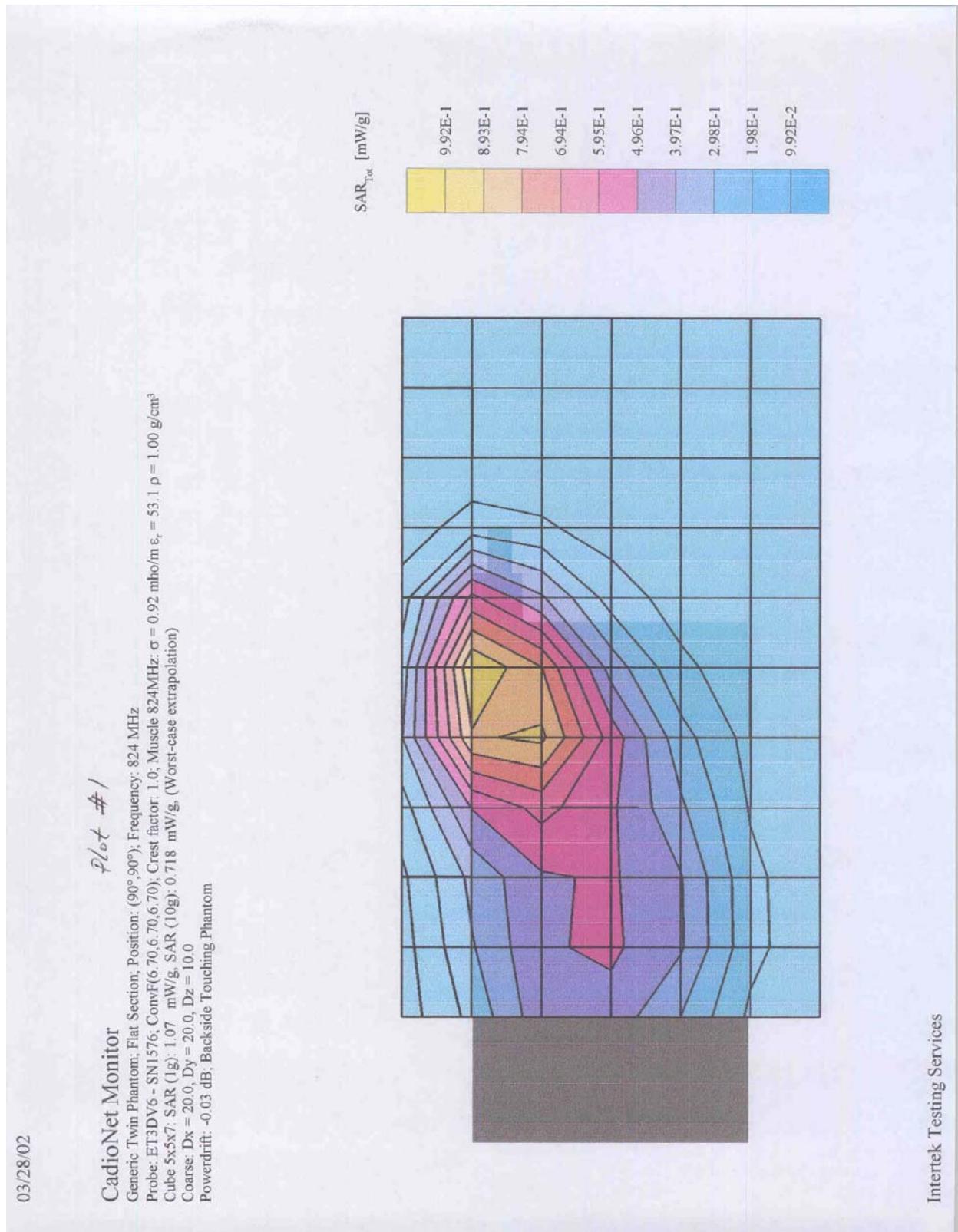
APPENDIX A - SAR Evaluation Data

Please note that the graphical visualization of the phone position onto the SAR distribution gives only limited information on the current distribution of the device, since the curvature of the head results in graphical distortion. Full information can only be obtained either by H-field scans in free space or SAR evaluation with a flat phantom.

Power drift is the measurement of power drift of the device over one complete SAR scan.

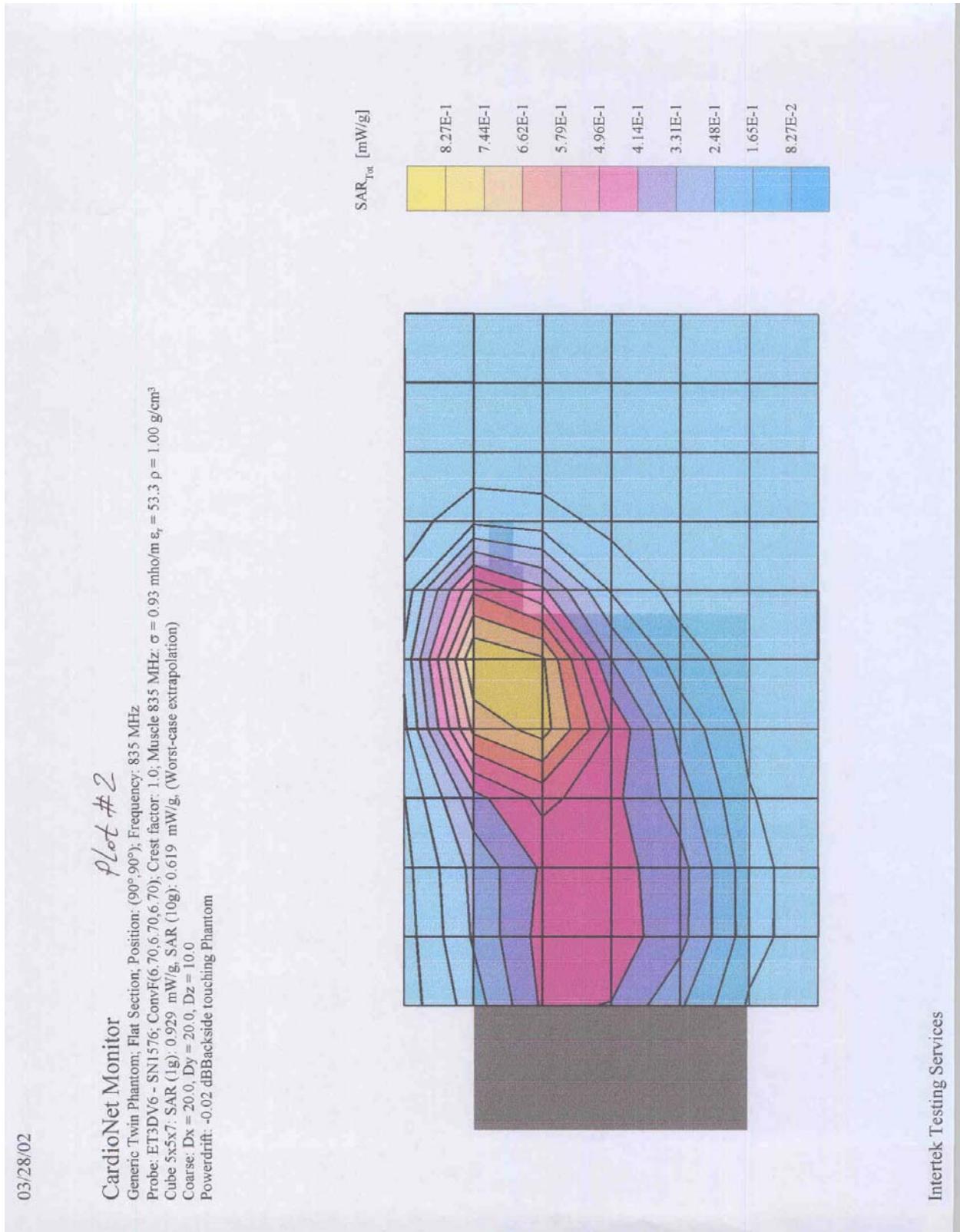
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002



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FCC ID: Not Labeled

Date of Test: March 28, 2002

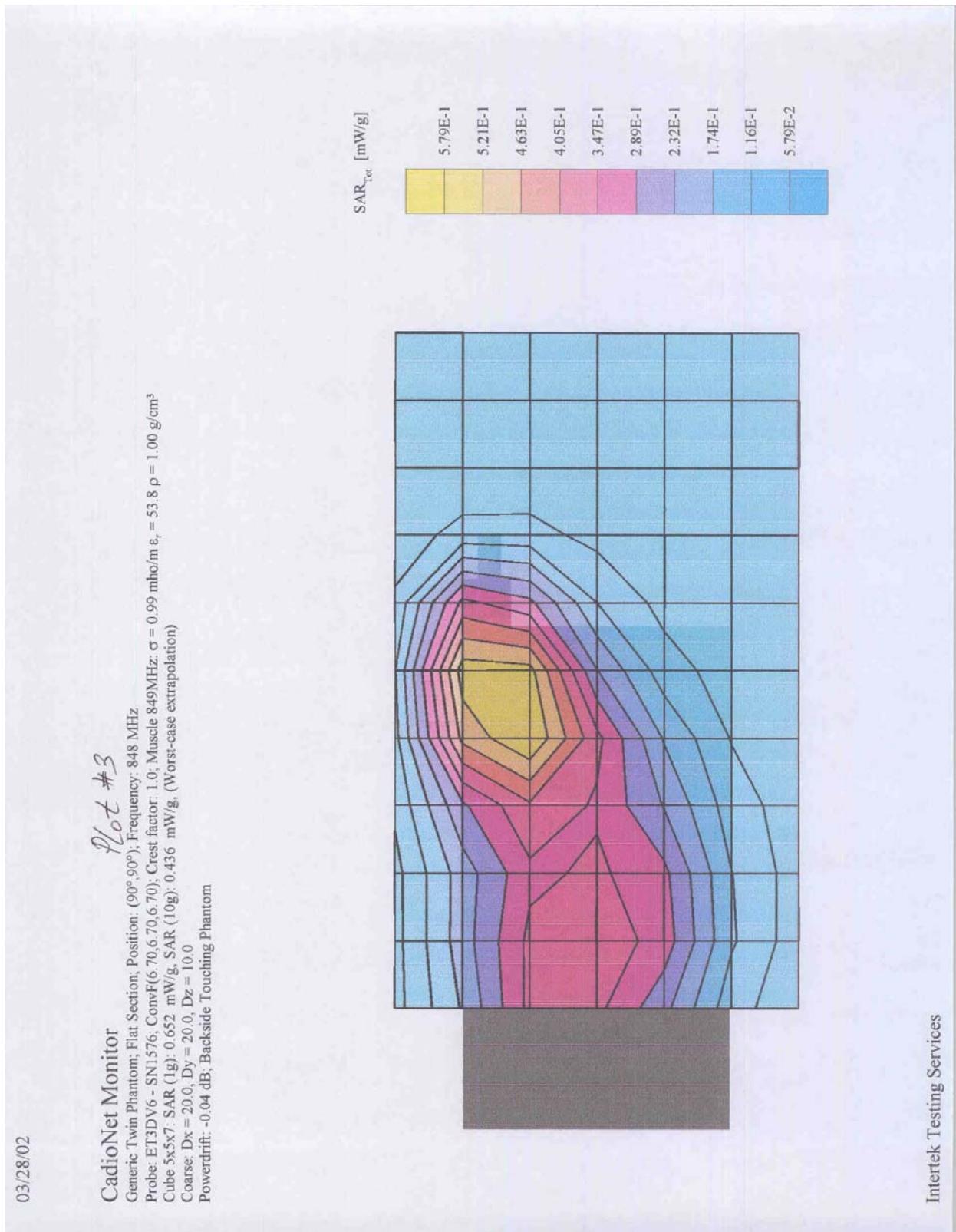


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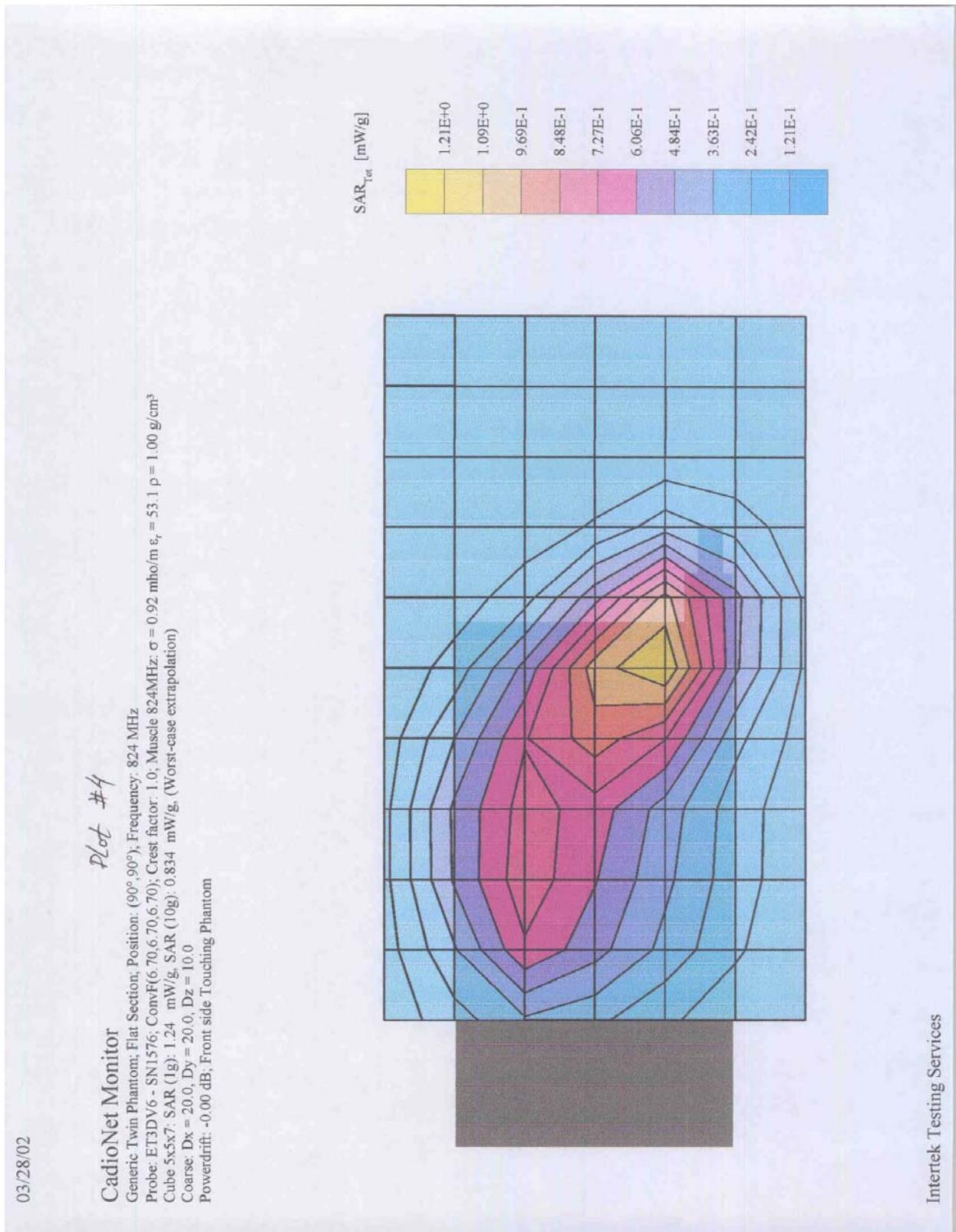
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002



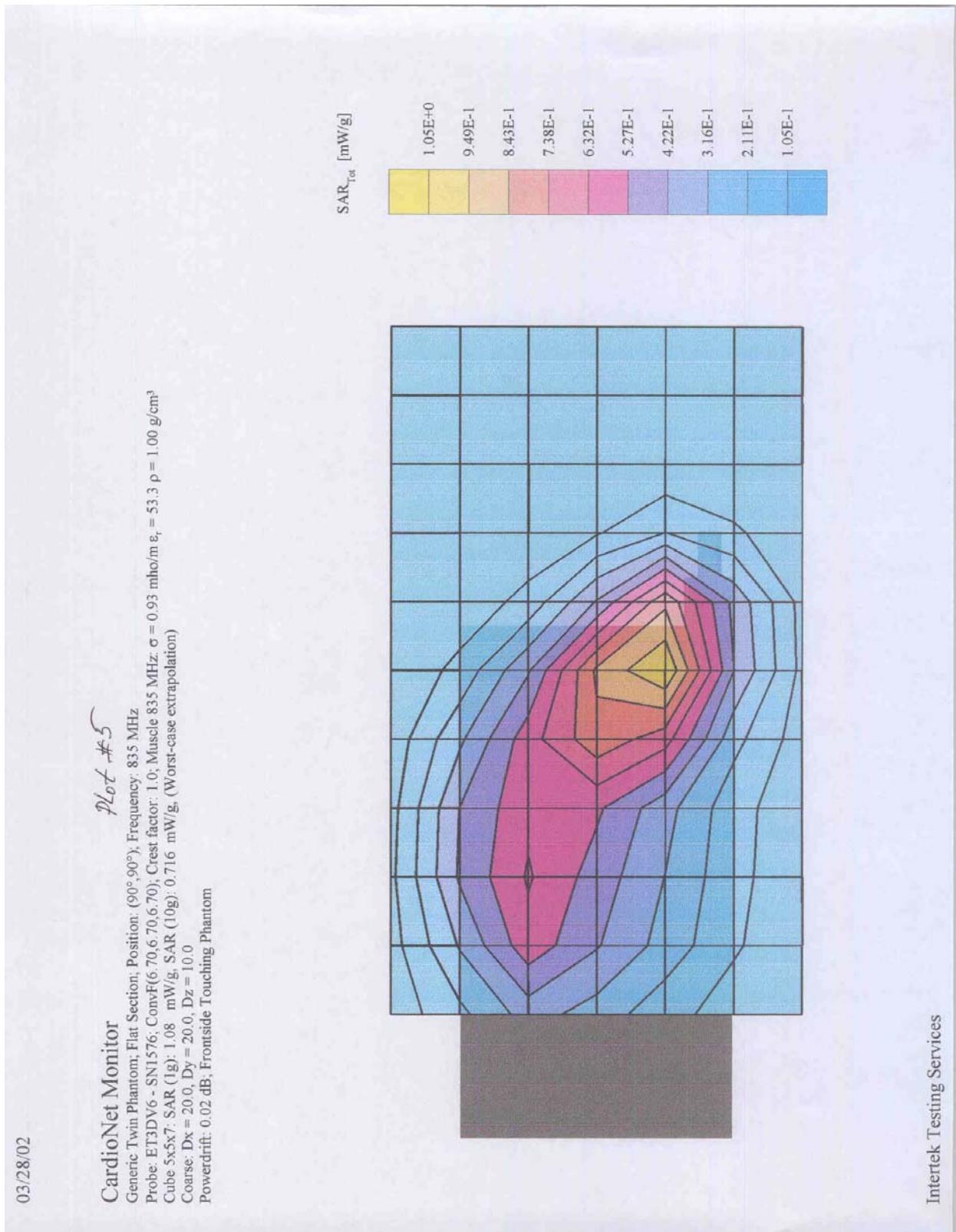
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FCC ID: Not Labeled

Date of Test: March 28, 2002



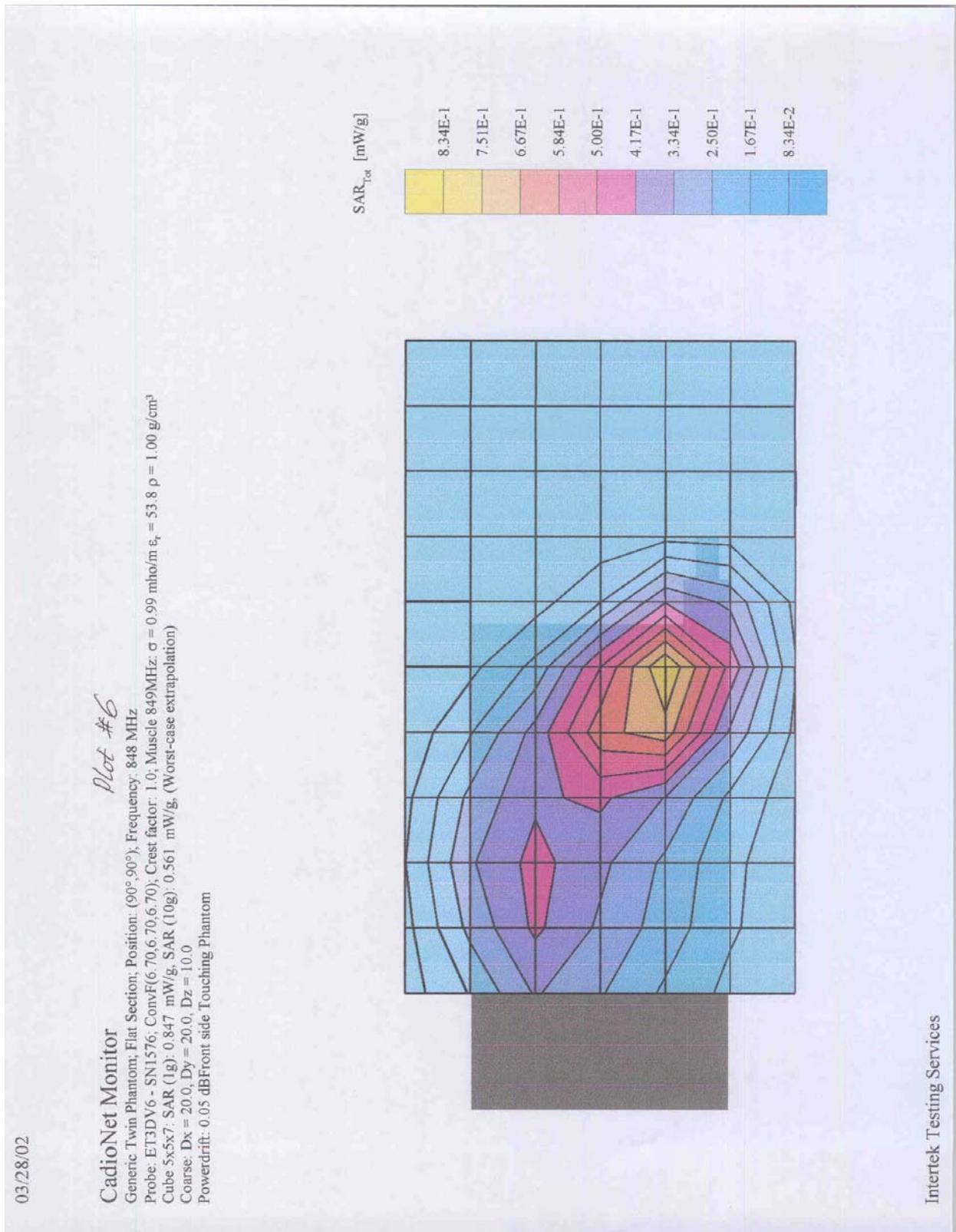
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002



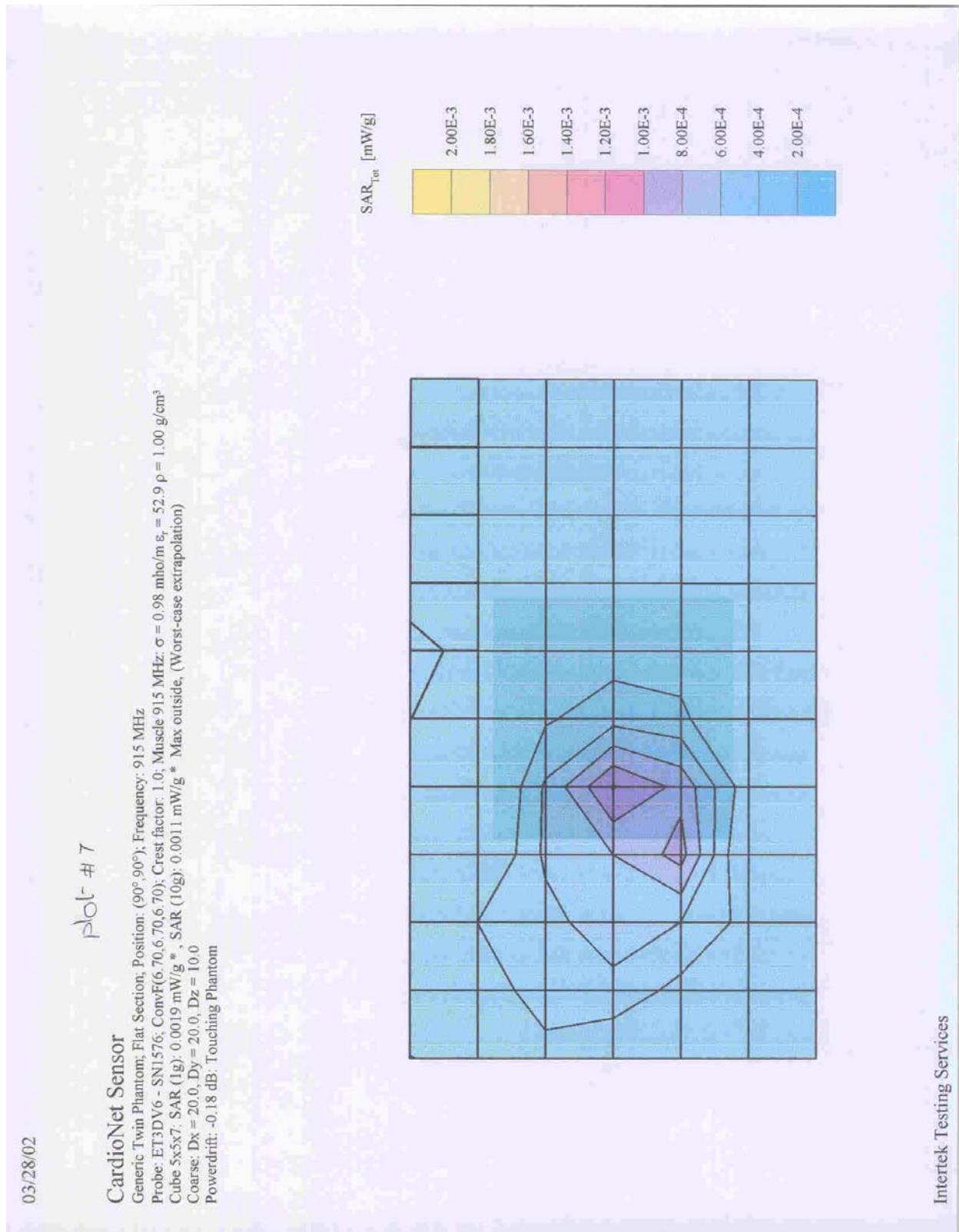
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FCC ID: Not Labeled

Date of Test: March 28, 2002



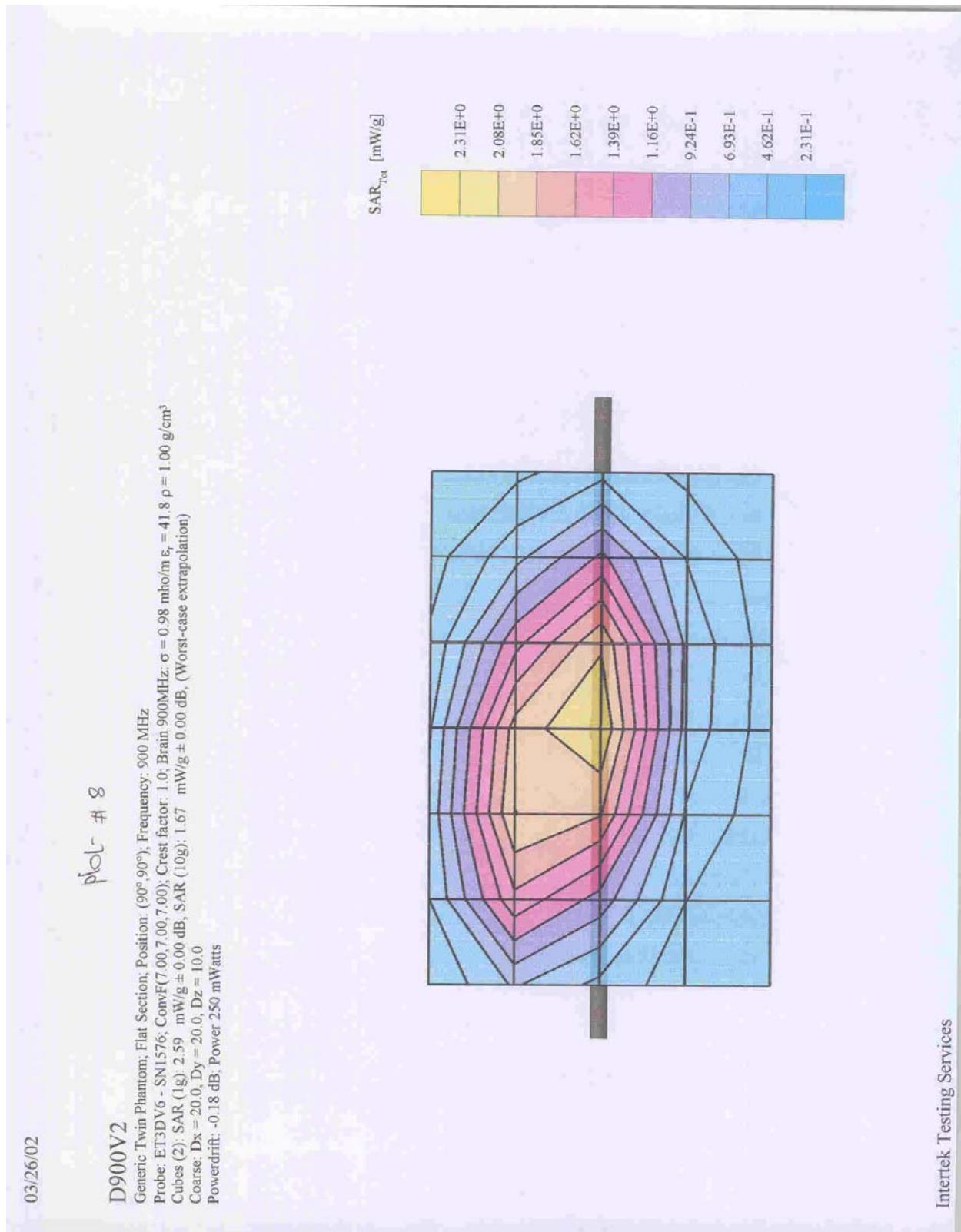
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

APPENDIX B - E-Field Probe Calibration Data

See attached.

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

**Schmid & Partner
Engineering AG**

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

Calibration Certificate

Dosimetric E-Field Probe

Type:

ET3DV6

Serial Number:

1576

Place of Calibration:

Zurich

Date of Calibration:

February 27, 2002

Calibration Interval:

12 months

Schmid & Partner Engineering AG hereby certifies, that this device has been calibrated on the date indicated above. The calibration was performed in accordance with specifications and procedures of Schmid & Partner Engineering AG.

Wherever applicable, the standards used in the calibration process are traceable to international standards. In all other cases the standards of the Laboratory for EMF and Microwave Electronics at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland have been applied.

Calibrated by:

Marc Kötter

Approved by:

N. Kels

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

**Schmid & Partner
Engineering AG**

Zeughausstrasse 43, 8004 Zurich, Switzerland, Telephone +41 1 245 97 00, Fax +41 1 245 97 79

Probe ET3DV6

SN:1576

Manufactured:	April 6, 2001
Last calibration:	April 20, 2001
Recalibrated:	February 27, 2002

Calibrated for System DASY3

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

DASY3 - Parameters of Probe: ET3DV6 SN:1576

Sensitivity in Free Space

NormX	1.77 $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	1.81 $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	1.76 $\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression

DCP X	98	mV
DCP Y	98	mV
DCP Z	98	mV

Sensitivity in Tissue Simulating Liquid

Head	900 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\% \text{ mho/m}$
Head	835 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\% \text{ mho/m}$
ConvF X	7.0 $\pm 9.5\% \text{ (k=2)}$	Boundary effect:	
ConvF Y	7.0 $\pm 9.5\% \text{ (k=2)}$	Alpha	0.30
ConvF Z	7.0 $\pm 9.5\% \text{ (k=2)}$	Depth	2.51
Head	1800 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
Head	1900 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
ConvF X	5.4 $\pm 9.5\% \text{ (k=2)}$	Boundary effect:	
ConvF Y	5.4 $\pm 9.5\% \text{ (k=2)}$	Alpha	0.45
ConvF Z	5.4 $\pm 9.5\% \text{ (k=2)}$	Depth	2.30

Boundary Effect

Head 900 MHz Typical SAR gradient: 5 % per mm

Probe Tip to Boundary	1 mm	2 mm
SAR _{be} [%] Without Correction Algorithm	7.6	4.3
SAR _{be} [%] With Correction Algorithm	0.3	0.5

Head 1800 MHz Typical SAR gradient: 10 % per mm

Probe Tip to Boundary	1 mm	2 mm
SAR _{be} [%] Without Correction Algorithm	9.7	6.6
SAR _{be} [%] With Correction Algorithm	0.2	0.3

Sensor Offset

Probe Tip to Sensor Center	2.7	mm
Optical Surface Detection	1.9 ± 0.2	mm

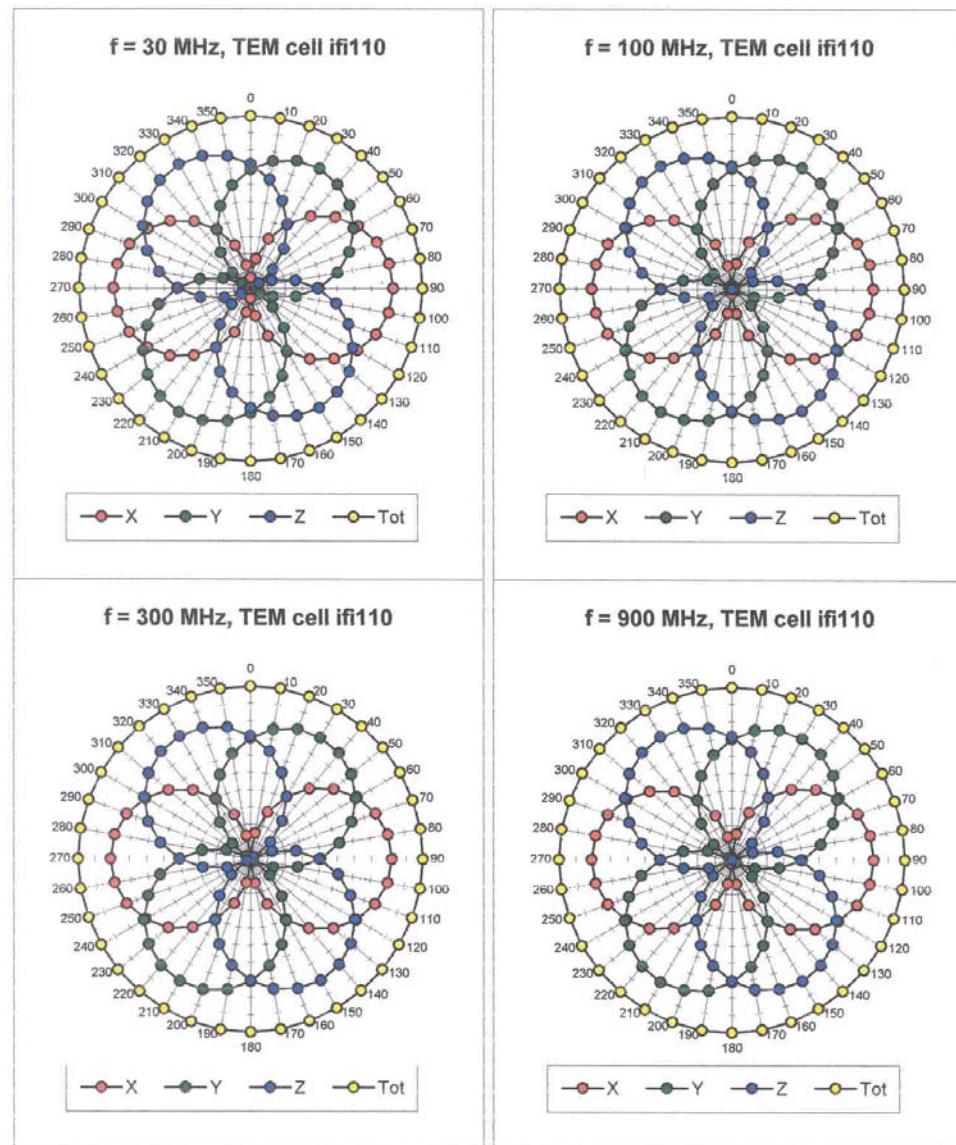
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Receiving Pattern (ϕ), $\theta = 0^\circ$

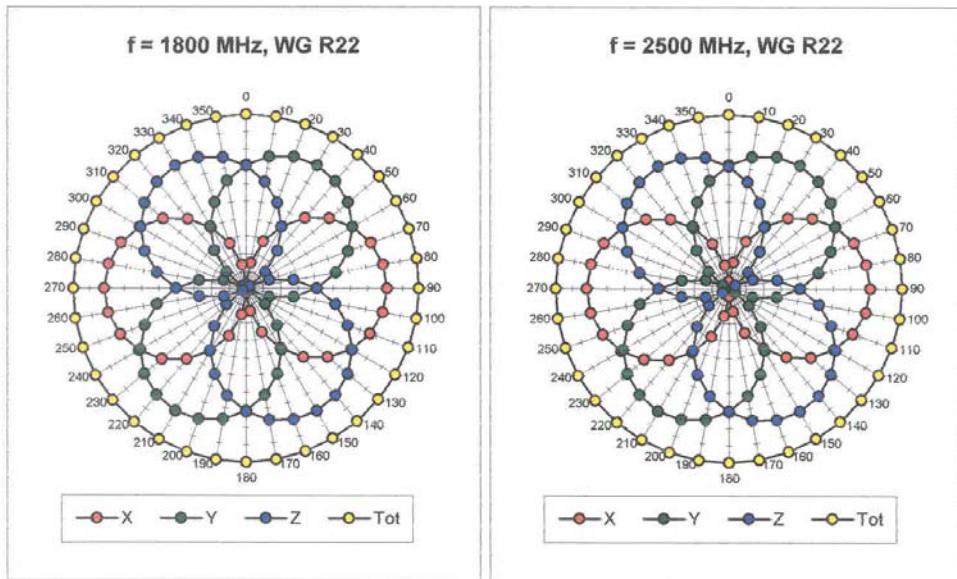


Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

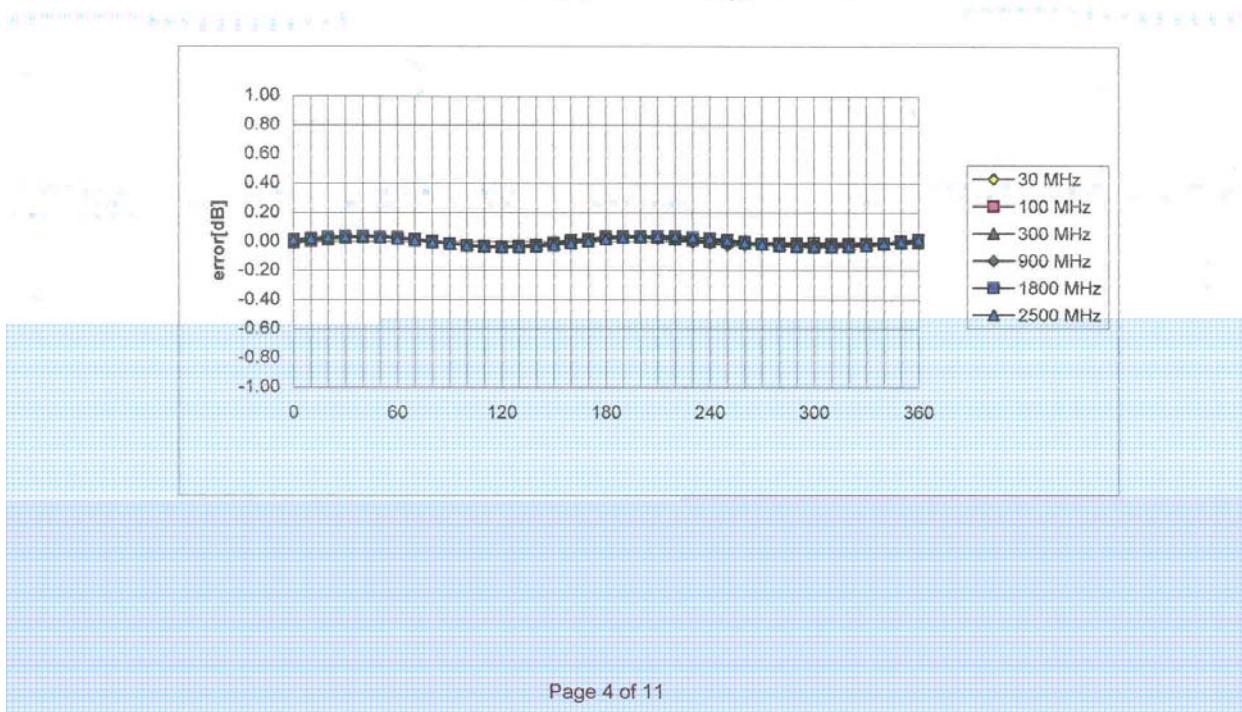
Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002



Isotropy Error (ϕ), $\theta = 0^\circ$



Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

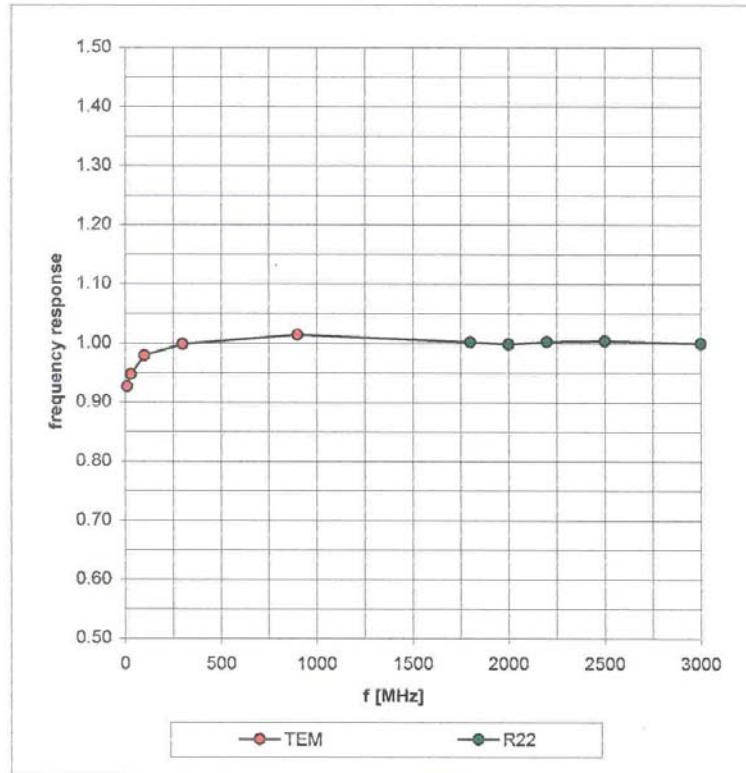
Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)



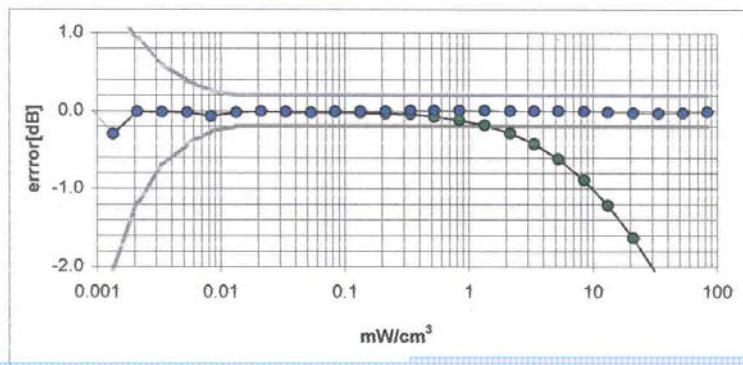
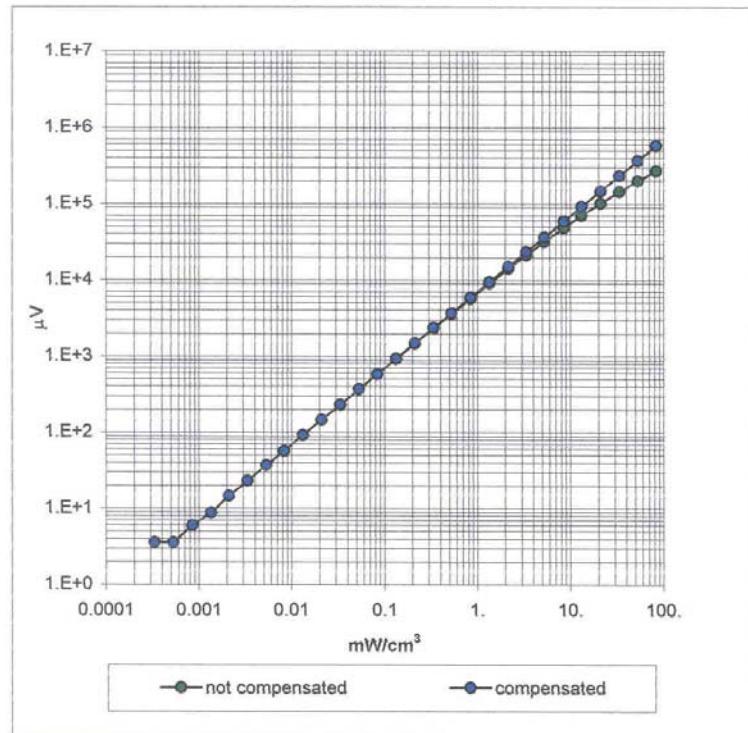
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Dynamic Range $f(\text{SAR}_{\text{brain}})$
(Waveguide R22)



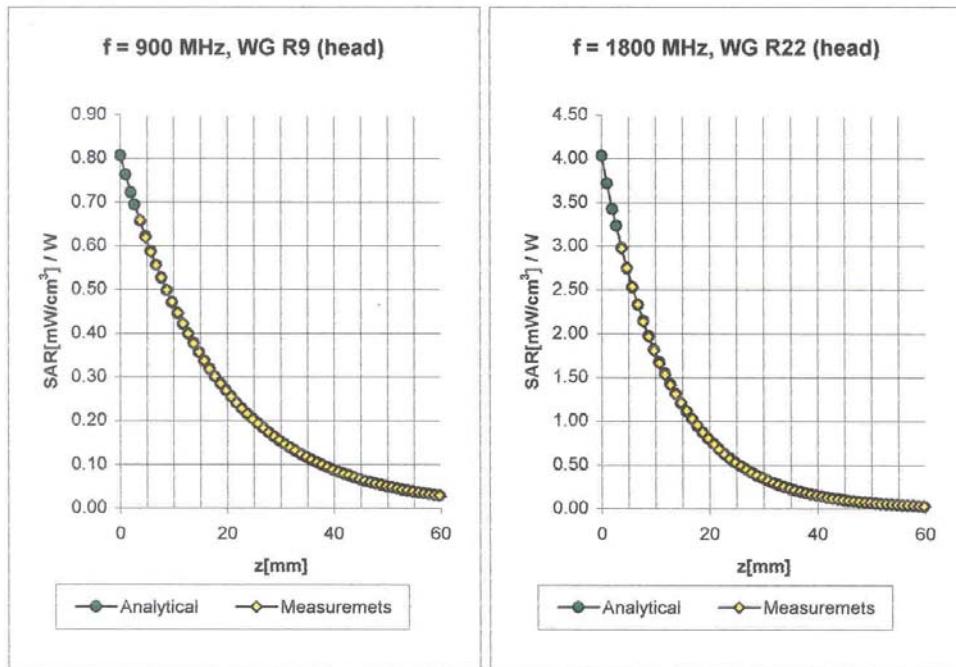
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Conversion Factor Assessment



Head	900 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\% \text{ mho/m}$
Head	835 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\% \text{ mho/m}$
ConvF X	7.0 $\pm 9.5\% \text{ (k=2)}$		Boundary effect:
ConvF Y	7.0 $\pm 9.5\% \text{ (k=2)}$		Alpha 0.30
ConvF Z	7.0 $\pm 9.5\% \text{ (k=2)}$		Depth 2.51

Head	1800 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
Head	1900 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
ConvF X	5.4 $\pm 9.5\% \text{ (k=2)}$		Boundary effect:
ConvF Y	5.4 $\pm 9.5\% \text{ (k=2)}$		Alpha 0.45
ConvF Z	5.4 $\pm 9.5\% \text{ (k=2)}$		Depth 2.30

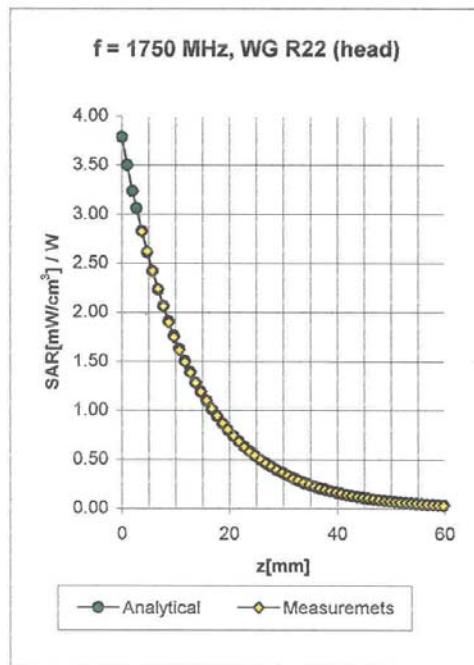
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Conversion Factor Assessment



Head 1750 MHz $\epsilon_r = 40.0 \pm 5\%$ $\sigma = 1.40 \pm 5\% \text{ mho/m}$

ConvF X	5.4 $\pm 8.9\%$ (k=2)	Boundary effect:
ConvF Y	5.4 $\pm 8.9\%$ (k=2)	Alpha 0.45
ConvF Z	5.4 $\pm 8.9\%$ (k=2)	Depth 2.27

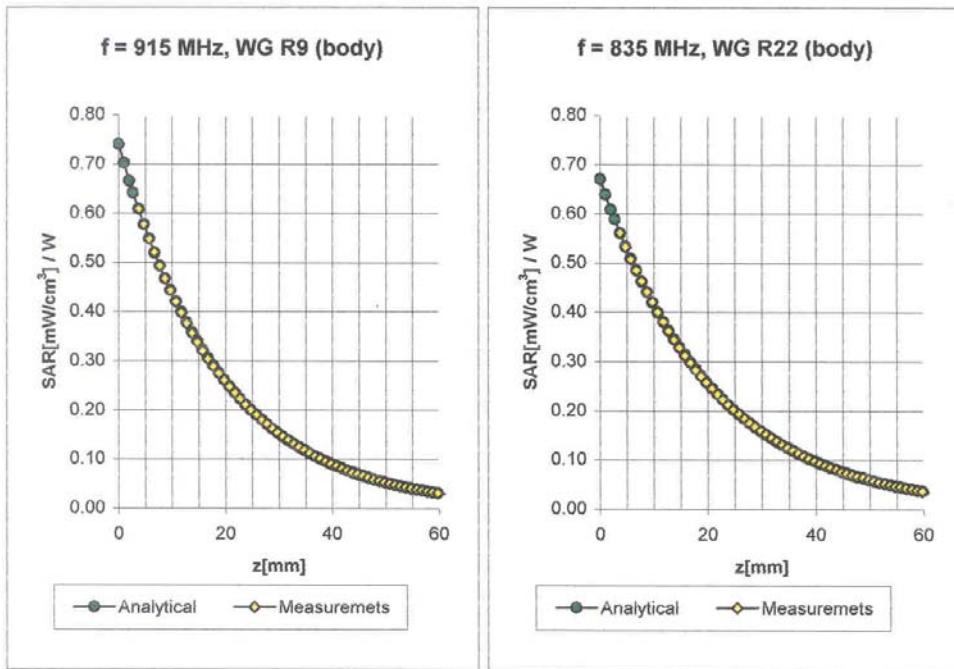
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Conversion Factor Assessment



Body 915 MHz $\epsilon_r = 55.0 \pm 5\%$ $\sigma = 1.06 \pm 5\% \text{ mho/m}$

ConvF X	6.7 $\pm 8.9\%$ (k=2)	Boundary effect:
ConvF Y	6.7 $\pm 8.9\%$ (k=2)	Alpha 0.45
ConvF Z	6.7 $\pm 8.9\%$ (k=2)	Depth 2.01

Body 835 MHz $\epsilon_r = 55.2 \pm 5\%$ $\sigma = 0.97 \pm 5\% \text{ mho/m}$

ConvF X	6.7 $\pm 8.9\%$ (k=2)	Boundary effect:
ConvF Y	6.7 $\pm 8.9\%$ (k=2)	Alpha 0.34
ConvF Z	6.7 $\pm 8.9\%$ (k=2)	Depth 2.37

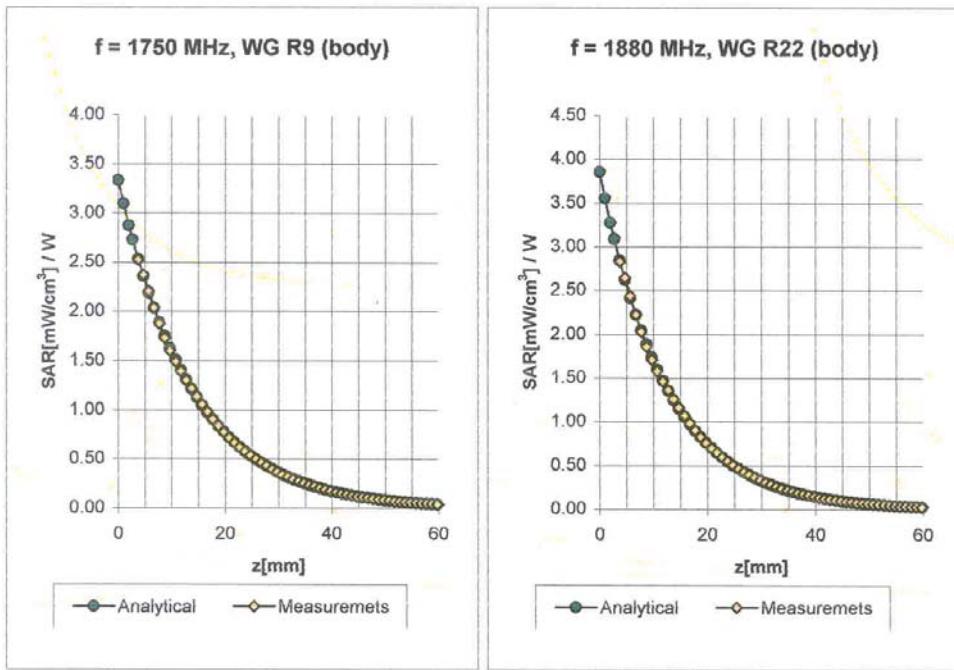
Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Conversion Factor Assessment



Body 1750 MHz $\epsilon_r = 53.3 \pm 5\%$ $\sigma = 1.52 \pm 5\% \text{ mho/m}$

ConvF X	5.1 $\pm 8.9\%$ (k=2)	Boundary effect:
ConvF Y	5.1 $\pm 8.9\%$ (k=2)	Alpha 0.51
ConvF Z	5.1 $\pm 8.9\%$ (k=2)	Depth 2.31

Body 1880 MHz $\epsilon_r = 53.3 \pm 5\%$ $\sigma = 1.52 \pm 5\% \text{ mho/m}$

ConvF X	4.8 $\pm 8.9\%$ (k=2)	Boundary effect:
ConvF Y	4.8 $\pm 8.9\%$ (k=2)	Alpha 0.63
ConvF Z	4.8 $\pm 8.9\%$ (k=2)	Depth 2.10

Cardionet, Inc., Model No: 1001
FCC ID: Not Labeled

Date of Test: March 28, 2002

ET3DV6 SN:1576

February 27, 2002

Deviation from Isotropy in HSL

Error (θ, ϕ), $f = 900$ MHz

