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SAR Test Report for Motorola portable cellular phone (FCC ID IHDT56ZM1).

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1. Introduction

The Motorola Personal Communications Sector Product Safety Laboratory has performed measurements of the maximum potential exposure to the user of portable cellular phone FCC ID IHDT56ZM1. The Specific Absorption Rate (SAR) of this product was measured. This report details the test setup and equipment as well as the results of those tests.

2. Applicable Regulations

Federal Communications Commission rule §2.1093(d)(2), the ANSI/IEEE C95.1 1992 and the NCRP Report Number 86 specify the maximum exposure limit of 1.6 W/kg as averaged over any 1 gram of tissue for portable devices being used within 20cm of the user in the uncontrolled environment.

3. Description of Test Sample

A prototype unit serial number FC80212B was measured. This unit is identical in physical construction, maximum radiated power levels and antenna structure to units that will be in production. It transmits in the frequency range of 824 to 849 MHz using AMPS and TDMA modes, and 1850 to 1910 MHz using TDMA mode only. The unit was tested at its maximum transmitter power. The unit is equipped with a fixed antenna that serves as both a receive and transmit antenna. The antenna has a single operating position as shown in figure 1.

Figure 1. Front of Phone Showing Antenna

Figure 2 shows the test unit as it is placed onto the phantom. For the purposes of the actual SAR tests the Motorola phantom head is tilted on its side by 90 degrees so that a vertically oriented measurement probe can easily scan an area where the phone is in close contact with the phantom and the SAR will be the highest.

Figure 2. Phone Against Head in Normal Use Position

4. SAR Test Facility

The Motorola test facility utilized for the SAR testing of this product is the Personal Communications Sector Product Safety Laboratory, in Libertyville Illinois. The laboratory utilizes a Dosimetric Assessment System (Dasy™) SAR measurement system manufactured by Schmid & Partner Engineering AG

(SPEAG™), of Zurich Switzerland. This system utilizes a computer controlled six axis robot to move a measurement probe to measure the SAR. A photo of the Dasy™ system with the Motorola phantom is shown in figure 3. Probe serial number 1375 was used for the measurements. It was calibrated at SPEAG™, and has a calibration date June 12, 1998. A copy of the calibration certificate is included as appendix B. Dipole Validation Kit type D900V2, serial number 036 was used to validate the system accuracy at 800MHz. The validation SAR value is 9.56 mW/g normalized to 1 Watt, and the Dasy™ system used for the test phone measured 10.28 mW/g normalized to 1 Watt. This is within the required accuracy, and thus the measured SAR values are considered correct. See appendix C for printout of the validation test from the Dasy™ measurement system. Dipole Validation Kit type D1800V2, serial number 226 was used to validate the system accuracy at 1900MHz. The validation SAR value is 39.9 mW/g normalized to 1 Watt, and the Dasy™ system used for the test phone measured 40.8 mW/g normalized to 1 Watt. This is within the required accuracy, and thus the measured SAR values are considered correct. See appendix D for printout of the validation test from the Dasy™ measurement system.

The measurement methodology is described in IEEE Transactions on Vehicular Technology, vol. 44, no. 3, August 1995, titled Electromagnetic Energy Exposure of Simulated users of Portable Cellular Telephones. The Dasy™ system is operated per the instructions in the Dasy™ Users Manual. A copy of the title page of this manual is included as appendix D. The entire manual is available directly from SPEAG™.

Figure 3. Dasy™ System used for measurements

5. Test Sample Conditions

For the purposes of these tests the subject phone was positioned on the measurement phantom per the instructions in the Motorola users manual for the subject phone. The position used for the tests is the 3-point contact position. In this position the test sample contacts the phantom's ear and cheek and is positioned with a repeatability of better than ±6%. Since the antenna is not located on the center of the phone, the SAR was measured with the phone on both the left and right side talk positions (See figure 2). Due to the construction of the phone, the base of the antenna is 20 mm away from the phantom for the left side head, which is the closest.

The test sample is capable of operation in a test mode that allows control of the transmitter without the need to place actual phone calls. This guarantees that the unit does not change its transmitter power, and that the resultant SAR values will not be affected by external connections. For the purposes of this test the unit is commanded to test mode and manually set to the proper channel, transmitter power level and transmit mode of operation. Since the test sample uses the 1/3 duty cycle of the TDMA system while in digital mode, the crest factor (the ratio between peak and average power) is set to 3 for these tests. When the test sample was tested in analog mode the crest factor was set to 1. The phone is then placed in the SAR measurement system with a fully charged battery. At the end of each test the Dasy™ system measures the drift of the SAR at a fixed point in the phantom so as to ensure that the test sample has not changed in transmitter power. For the purposes of these tests, the transmitter was operated at the highest transmitter output and with the phone on both left and right side talk positions.

6. Method of Measurement

The system is instructed to scan as much of the face of the phone as is in close proximity to the phantom. Using the information gained about the general region of highest SAR, the system then automatically scans a smaller area centered around the location of peak spatial SAR. During this scan the system automatically measures the fall off of electric field strength as the measurement probe is moved away from the inner surface of the phantom in the direction of the local normal to the phantom surface. Using appropriate probe calibration techniques, the SAR in 1 gram of phantom tissue is then calculated. The 800MHZ phantom head, shown in figure 2, was filled with a liquid having relative dielectric constant equal to 43 and conductivity equal to 0.90 S/m. This mixture is a good dielectric equivalent of the gray matter of the human brain. The composition of the liquid mixture is as follows: 42.5% water; 55.6.0% sugar; 0.8% salt, 1% HEC; and 0.1% bactericide. The 1900MHZ phantom head, also shown in figure 2, was filled with a liquid having relative dielectric constant equal to 41 and conductivity equal to 1.71 S/m. This mixture is a good dielectric equivalent of the gray matter of the human brain. The composition of the liquid mixture is as follows: 45.9% water; 53.0% sugar; 0% salt, 1% HEC; and 0.1% bactericide.

7. Measurement Uncertainty

The overall RMS uncertainty of the measurement system is ±12.0%. The breakdown of the individual uncertainties is as follows:

Probe Uncertainty	**±%**
Isotropy error	7.2
Calibration error	3.3
Spatial resolution	0.5

SAR Evaluation	**±%**
Conductivity measurement	5.0
Environmental errors	1.0

Peak SAR Evaluation	**±%**
Probe positioning	1.0
Volumetric averaging	4.2
Device positioning	6.0

8. SAR Test Results

Figure 4 shows the phone overlaid with a typical contour plot. The phone is placed on the phantom's head with the center of the phone's speaker at the center of the ear, and the center line of the phone extends downward to the center of the phantom's mouth. The same orientation and phone position are used for left and right side talk positions.

The maximum SAR level for the Motorola portable cellular phone (FCC ID IHDT56ZM1) in the 800MHz band is 1.45 W/kg and was found on the right side head, and with the phone in analog mode. The highest SAR found in digital mode was 0.53 W/kg. A full data set output of the two test conditions with the highest SAR values from the Dasy™ measurement system is included as appendix A. The test conditions included are indicated as bold numbers in the following table. All other test conditions measured lower SAR values than those included. Note that digital mode SAR data was measured only for the test condition that resulted in the highest analog SAR value. This is because the only difference between analog and digital modes that can impact SAR is the average transmitter power.

	Left side head		Right side head		Conducted Power Output (dBm)	
Channel	Analog	TDMA	Analog	TDMA	Analog	TDMA
991	1.20		1.34		26.5	27.5
384	1.29		**1.45**	**0.53**	26.5	27.5
799	1.08		1.18		26.5	27.5

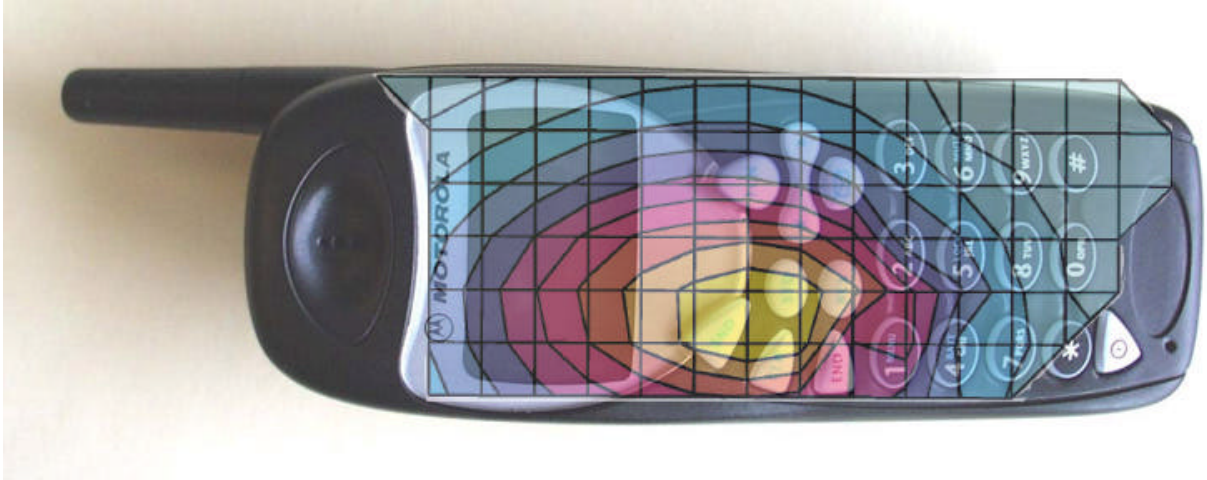


Figure 4. Phone with 800MHz Analog Contour Plot Overlay

The maximum SAR level for the Motorola portable cellular phone (FCC ID IHDT56ZM1) in the 1900MHz band is 0.51 W/kg and was found on the left side head. A full data set output of the test condition with the highest SAR values from the Dasy™ measurement system is included as appendix A. The test conditions included are indicated as bold numbers in the following table. All other test conditions measured lower SAR values than those included. Figure 5 shows the contour plot of the highest test condition overlaid onto a picture of the phone.

	Left side head	Right side head	Conducted Power
Channel	TDMA	TDMA	Output (dBm)
1	**0.51**	0.41	27.5
1000	0.44	0.35	27.5
1999	0.37	0.29	27.5

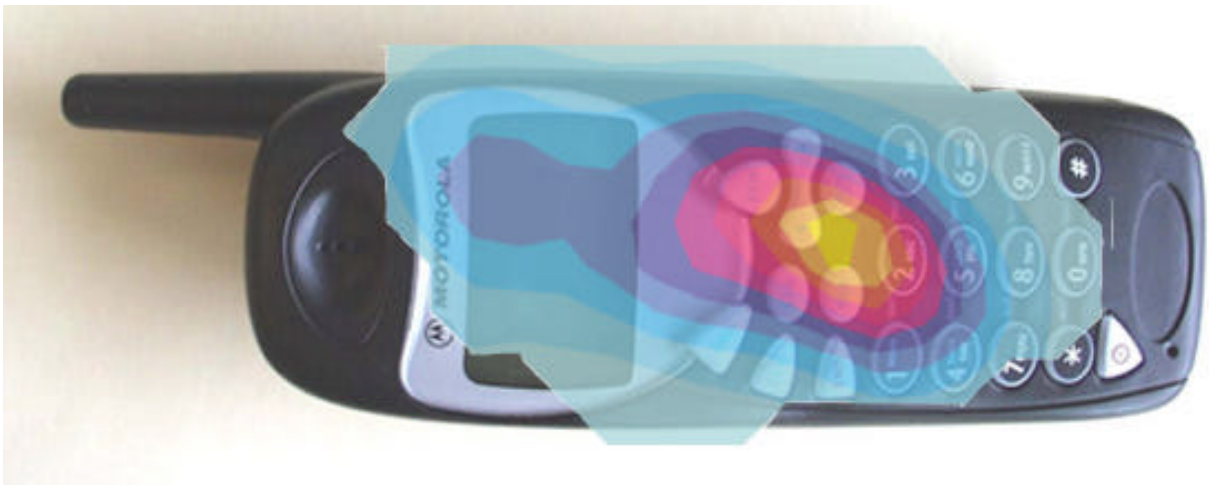


Figure 5. Phone with 1900MHz TDMA Contour Plot Overlay

9. Body Worn Configuration Evaluation

The cellular phone (FCC ID IHDT56ZM1) can be used in a body-worn configuration using the supplied belt clip. We have performed an evaluation to show RF exposure compliance when used with the belt clip. The test sample was tested only in the mode that resulted in the highest SAR value when held against the phantom head. Figure 6 shows the test unit as it is placed onto the phantom.

Figure 6. Phone In Supplied Belt Clip Against Phantom

The maximum SAR level for the Motorola portable cellular phone (FCC ID IHDT56ZM1) in the 800MHz band when used in the body worn configuration is 1.19 W/kg. A full data set output of the test condition with the highest SAR values from the Dasy™ measurement system is included as Appendix B. The test condition included is indicated as a bold number in the following table. All other test conditions measured lower SAR values than those included.

Channel	SAR (W/kg)
991	**1.19**
384	1.17
799	1.01

The cellular phone (FCC ID IHDT56ZM1) can be used with a PCMCIA card connection while in a body worn configuration. The use of the PCMCIA card connection does not affect the transmitter output power and thus will not increase the maximum SAR value.

10. External Antenna Option Evaluation

The Motorola Personal Communications Sector Product Safety Laboratory has evaluated the portable cellular phone (FCC ID IHDT56ZM1) external antenna option for the need to conduct SAR evaluation. Given the design, recommended installation and how the phone operates with this option; when properly installed and used with this option, the phone/option combination satisfies the criteria to be

considered a 'mobile device' as defined in Federal Communications Commission section 47 CFR § 2.1091 titled “Radio frequency radiation exposure evaluation: mobile devices.”

In section § 2.1091, paragraph (b) defines a mobile device as “a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter’s radiating structure(s) and the body of the user or nearby persons.” The portable cellular phone (FCC ID IHDT56ZM1) is intended to be installed into a vehicle such that the phone is physically secured at one location. The installation guide describes the recommended installation of both the phone and the external antenna. The antenna is to be located outside of the vehicle and its location should be such that at least 20 cm of conductive horizontal surface extends in all directions from the center of the antenna. Based on the installation of the transceiver and the antenna, the transmitters radiating structure is more than 20 centimeters from the user. Thus, the portable cellular phone (FCC ID IHDT56ZM1) is a “mobile device” as defined in section § 2.1091 paragraph (b).

Paragraph (c) of section § 2.1091 gives the descriptions of types of mobile devices that are subject to routine environmental evaluation for RF exposure based on frequencies of operation and transmit ERP. The portable cellular phone (FCC ID IHDT56ZM1) operates at transmit frequencies of 824 to 849 MHz and 1850 to 1910 MHz. Accounting for the cable loss and antenna gain of the external antenna option, the phone has an ERP of less than 1.5 Watts at 800 MHz, and less than 3.0 Watts at 1900 MHz. Thus the portable cellular phone (FCC ID IHDT56ZM1) is “categorically excluded from routine environmental evaluation” per paragraph (c), and thus SAR evaluation is not required.

11. Battery Options

The cellular phone (FCC ID IHDT56ZM1) does have two battery options., “AA” and “AAAL”. These battery options do not affect the attachment to the belt clip, and thus do not change the distance from the antenna or phone to the body in the body worn configuration. For the purposes of head adjacent testing the battery chosen was the battery that gave the highest SAR values, in this case a “AAAL” battery was used for the head adjacent testing.

12. Summary

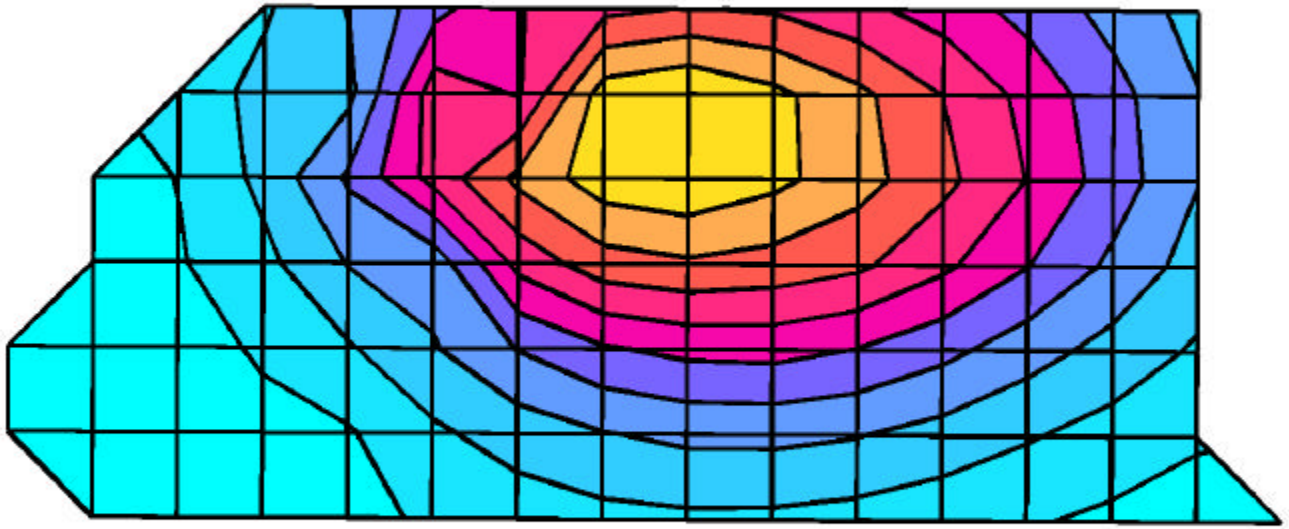
The SAR values found for the portable cellular phone (FCC ID IHDT56ZM1) are below the maximum recommended levels of 1.6 W/kg.

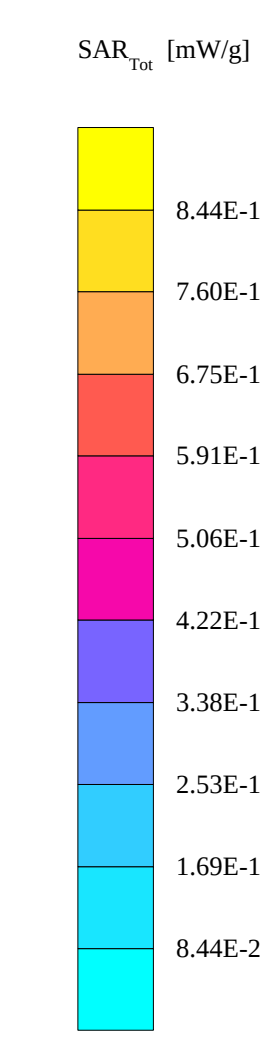
Appendix A

The following pages are printouts from the Dasy™ measurement system of the data against the phantom head.

S/N FC80212B

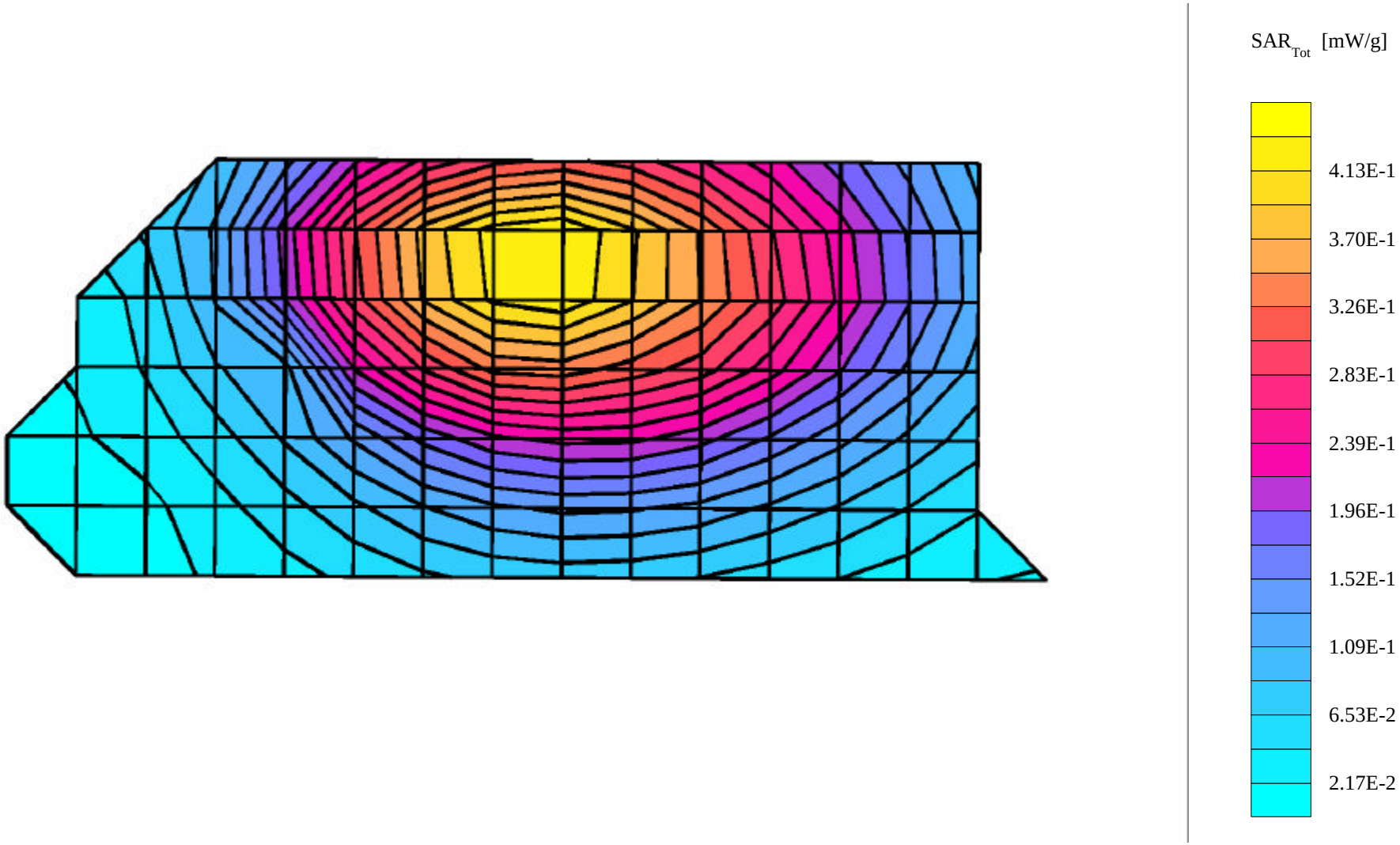
Ch 384/Pwr 2/ JK
TILT RIGHT Phantom; Section; Position: ; Frequency: 837 MHz
Probe: ET3DV6 - SN1375; ConvF(6.59,6.59,6.59); Crest factor: 1.0; Brain 800Mhz: σ = 0.90 mho/m ε_r = 43.0 ρ = 1.00 g/cm^3
Cube 5x5x7: SAR (1g): 1.45 [mW/g], SAR (10g): 1.03 [mW/g], (Worst-case extrapolation)
Coarse: Dx = 9.0, Dy = 9.0, Dz = 10.0
Powerdrift: -0.06 dB





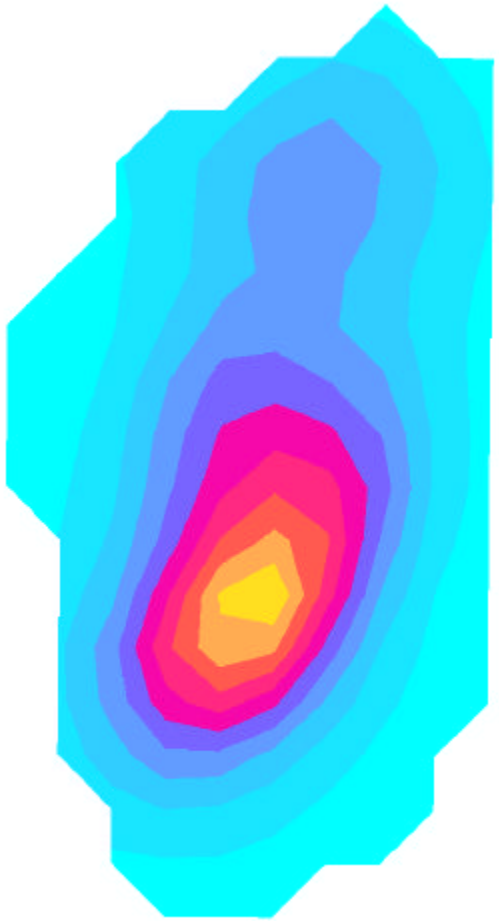
S/N FC80212B

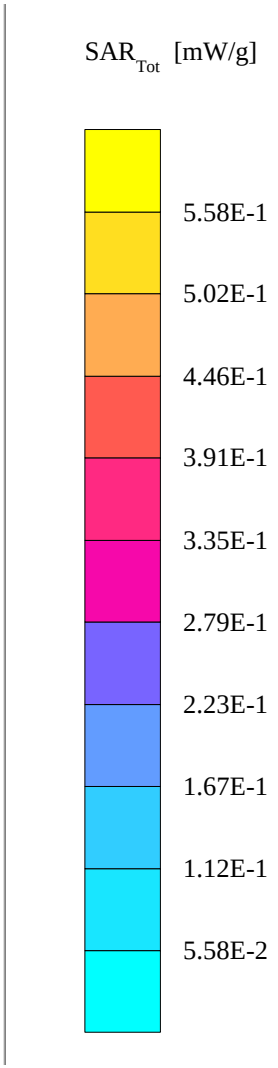
Ch 384/Pwr 2/TDMA Mode/JK
TILT RIGHT Phantom; Section; Position: ; Frequency: 837 MHz
Probe: ET3DV6 - SN1375; ConvF(6.59,6.59,6.59); Crest factor: 3.0; Brain 800Mhz: σ = 0.90 mho/m ε_r = 43.0 ρ = 1.00 g/cm^3
Cube 5x5x7: SAR (1g): 0.729 [mW/g], SAR (10g): 0.525 [mW/g], (Worst-case extrapolation)
Coarse: Dx = 9.0, Dy = 9.0, Dz = 10.0
Powerdrift: 0.07 dB



SN# FC80212B

Ch1/Pwr 2/TDMA/JK
TILT LEFT Phantom; Section; Position: ; Frequency: 1850 MHz
Probe: ET3DV6 - SN1375; ConvF(5.79,5.79,5.79); Crest factor: 3.0; Brain 1900 MHz: σ = 1.71 mho/m ε_r = 41.0 ρ = 1.00 g/cm^3
Cube 5x5x7: SAR (1g): 0.508 [mW/g], SAR (10g): 0.282 [mW/g], (Worst-case extrapolation)
Coarse: Dx = 10.0, Dy = 10.0, Dz = 0.0
Powerdrift: 0.04 dB



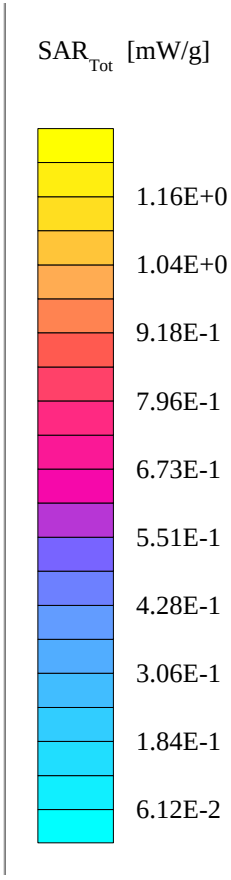


Appendix B

The following pages are printouts from the Dasy™ measurement system of the data in a Body Worn Configuration.

S/N FC80212B

CH 991/BELT CLIP/PWR2/SC
Belt Clip Phantom; Section; Position: ; Frequency: 824 MHz
Probe: ET3DV6 - SN1375; ConvF(6.59,6.59,6.59); Crest factor: 1.0; Muscle 800 MHz: σ = 1.10 mho/m ε_r = 52.0 ρ = 1.00 g/cm^3
Cube 5x5x7: SAR (1g): 1.19 [mW/g], SAR (10g): 0.817 [mW/g], (Worst-case extrapolation)
Coarse: Dx = 10.0, Dy = 10.0, Dz = 0.0
Powerdrift: 0.05 dB



Appendix C

The following page is a copy of the Calibration Certificate for Dasy™ probe serial number 1375.

Schmid & Partner
Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

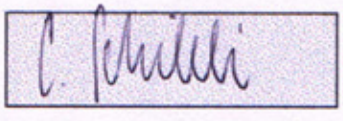
Calibration Certificate

Dosimetric E-Field Probe

Type:	**ET3DV6**
Serial Number:	**1375**
Place of Calibration:	**Zurich**
Date of Calibration:	**July 1, 1999**
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.

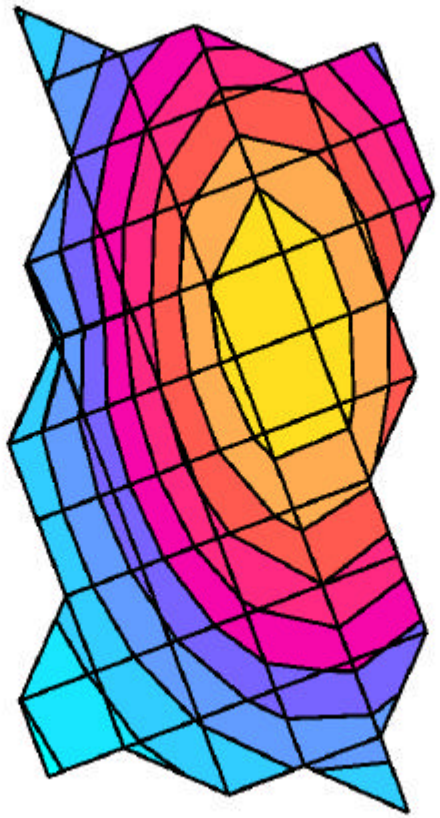
Calibrated by:	
Approved by:	

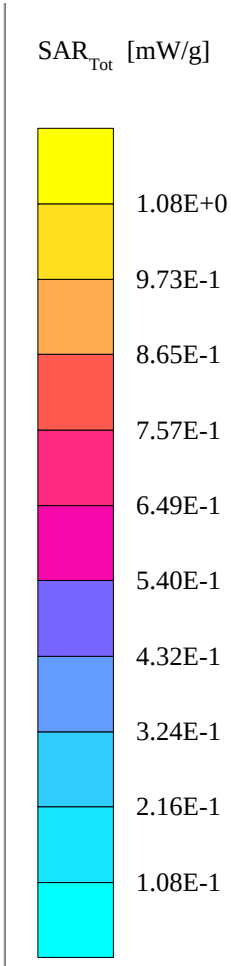
Appendix D

The following page is the printout from the Dasy™ measurement system validation tests.

Dipole 900MHz

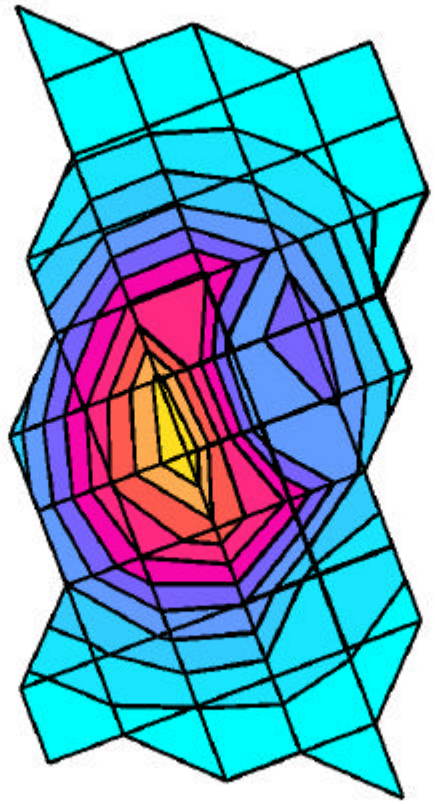
Forward Power : 0.25W
MOT FLAT Phantom; MOTO FLAT Section; Position: (0°,0°); Frequency: 900 MHz
Probe: ET3DV6 - SN1375; ConvF(6.59,6.59,6.59); Crest factor: 1.0; Brain 900Mhz: σ = 0.85 mho/m ε_r = 43.0 ρ = 1.00 g/cm^3
Cube 5x5x7: SAR (1g): 2.57 [mW/g], SAR (10g): 1.67 [mW/g], (Worst-case extrapolation)
Coarse: Dx = 10.0, Dy = 10.0, Dz = 10.0
Powerdrift: -0.07 dB

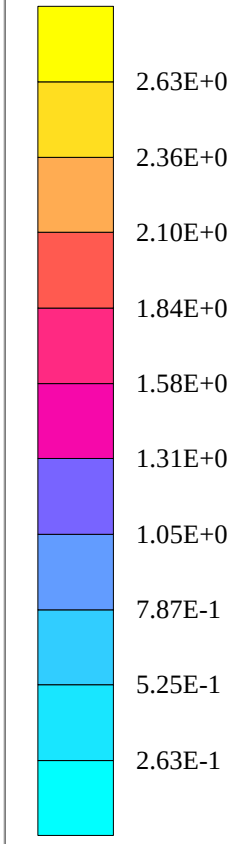




Dipole 1800 MHz

Forward Power : 258mW
MOT FLAT Phantom; MOTO FLAT Section; Position: (0°,0°); Frequency: 1800 MHz
Probe: ET3DV6 - SN1375; ConvF(5.79,5.79,5.79); Crest factor: 1.0; Brain 1800 MHz: σ = 1.71 mho/m ε_r = 41.0 ρ = 1.00 g/cm^3
Cubes (2): SAR (1g): 10.2 mW/g ± 0.03 dB, SAR (10g): 4.99 mW/g ± 0.24 dB, (Worst-case extrapolation)
Coarse: Dx = 10.0, Dy = 10.0, Dz = 10.0
Powerdrift: -0.02 dB





Appendix E

The following page is a copy of the first page of the Dasy™ Users Manual

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Preliminary Manual

DASY3 V1.0b

for Windows 95

March 98 Edition
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