TCC
Copenhagen

DANAK
Reg. Nr. 416

SAR Compliance Test Report

Test report no.:	DTX09210-EN	**Date of report:**	December 12, 2003
Template version:	2.0	**Number of pages:**	19
Testing laboratory:	TCC Copenhagen Nokia Danmark A/S Frederikskaj DK-1790 Copenhagen V Denmark Tel. +45 33 29 29 29 Fax. +45 33 29 20 01	**Client:**	Nokia Danmark A/S Frederikskaj DK-1790 Copenhagen V Denmark Tel. +45 33 29 29 29 Fax. +45 33 29 20 01
Responsible test engineer:	Leif Funch Klysner	**Product contact person:**	Anders Sv. Nielsen
Measurements made by:	Daniela Stenhoff		
Tested device:	RH-28		
FCC ID (USA):	QTKRH-28	**Industry Canada ID:**	661AD-RH28
Supplement reports:	-		

Testing has been carried out in accordance with:

47CFR §2.1093
Radiofrequency Radiation Exposure Evaluation: Portable Devices

FCC OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01)
Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

RSS-102
Evaluation Procedure for Mobile and Portable Radio Transmitters with Respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields

IEEE P1528/D1.2, April 21, 2003
Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques

Documentation: The documentation of the testing performed on the tested devices is archived for 15 years at TCC Copenhagen.

Test results: **The tested device complies with the requirements in respect of all parameters subject to the test.** The test results and statements relate only to the items tested. The test report shall not be reproduced except in full, without written approval of the laboratory.

Date and signatures: 12/12/2003

For the contents:

Ruben Hansen
Team Leader

Leif Funch Klysner
SAR Test Engineer

CONTENTS

1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Period of test	10/15/2003 – 10/21/2003
SN, HW and SW numbers of tested device	IMEI 004400/25/172111/2, HW 0403, SW 01.85, DUT# 233087
Batteries used in testing	BL-5C, DUT# 232928 & DUT# 232929
Headsets used in testing	HDS-3, DUT# 232400 HDB-4, DUT# 231980
Other accessories used in testing	MMC card, DUT# 232882
State of sample	Prototype
Notes	

1.2 Maximum Results

The maximum measured SAR values for Head configuration and Body Worn configuration are given in section 1.2.1 and 1.2.2 respectively. The device conforms to the requirements of the standard(s) when the maximum measured SAR value is less than or equal to the limit.

Bluetooth was active during all measurements.

1.2.1 Head Configuration

Mode	Ch / f (MHz)	EIRP	Position	SAR limit (1g avg)	Measured SAR value (1g avg)	Result
GSM 1900	518/1851.4	30.4 dBm	Left, Tilt Without MMC card	1.6 W/kg	0.76 W/kg	PASSED

1.2.2 Body Worn Configuration

Mode	Ch / f (MHz)	EIRP	Separation distance	SAR limit (1g avg)	Measured SAR value (1g avg)	Result
GPRS 1900	518/1851.4	30.4 dBm	1.5 cm	1.6 W/kg	1.11 W/kg	PASSED

1.2.3 Maximum Drift

Maximum drift during measurements	-0.28 dB

1.2.4 Measurement Uncertainty

Extended Uncertainty (k=2) 95%	± 29.1 %

2. DESCRIPTION OF THE DEVICE UNDER TEST

Device category	Portable
Exposure environment	General population/uncontrolled

Modes and Bands of Operation	GSM 850	GSM 1900	GPRS (GSM)	BT
Modulation Mode	GMSK	GMSK	GMSK	
Duty Cycle	1/8	1/8	1 or 2/8	
Transmitter Frequency Range (MHz)	824.2 – 848.8	1850.2 - 1909.8	824.2 – 848.8 1850.2 - 1909.8	2400.0 – 2483.5

Outside of USA and Canada, the transmitter of the device is capable of operating also in GSM1800, which is not part of this filing.

2.1 Picture of the Device

2.2 Description of the Antenna

The device has an internal PIFA antenna. (Plannar Inverted F Antenna)

3. TEST CONDITIONS

3.1 Temperature and Humidity

Period of measurement:	10/15/2003 to 10/21/2003
Ambient temperature (°C):	22.0 ± 1
Ambient humidity (RH %):	45 ± 10

3.2 Test Signal, Frequencies, and Output Power

The device was put into operation by using a call tester. Communication between the device and the call tester was established by air link.

The device output power was set to maximum power level for all tests; a fully charged battery was used for every test sequence.

In all operating bands the measurements were performed on low, middle and high channels.

Power output was measured by a separate accredited test laboratory on the same unit as used for SAR testing.

4. DESCRIPTION OF THE TEST EQUIPMENT

4.1 Measurement System and Components

The measurements were performed using an automated near-field scanning system, DASY 3 software version 3.1d, manufactured by Schmid & Partner Engineering AG (SPEAG) in Switzerland. The SAR extrapolation algorithm used in all measurements on the device was the ‘worst-case extrapolation’ algorithm.

The following table lists calibration dates of SPEAG components:

Test Equipment	Serial Number	Calibration interval	Calibration expiry
DASY3 DAE V1	339	12 months	04/2004
E-field Probe ET3DV6R	1431	12 months	04/2004
Dipole Validation Kit, D835V2	476	24 months	02/2005
Dipole Validation Kit, D1900V2	5d026	24 months	02/2005

Additional test equipment used in testing:

Test Equipment	Model	Serial Number	Calibration interval	Calibration expiry
Signal Generator	SME 03	829444/023	36 months	10/2006
Amplifier	ZHL-42W	E012903	-	-
Power Meter	NRVD	833696/030	12 months	04/2004
Power Sensor	NRV-Z51	843275/004	24 months	12/2004
Call Tester	4400 M	0411216	-	-
Vector Network Analyzer	8753 ES	MY40001091	12 months	09/2004
Dielectric Probe Kit	HP85070B	US33020403	-	-
Double Ridged Horn Antenna	BBHA9120-LF	BBHA 9120 LF-A/105	-	-

4.1.1 Isotropic E-field Probe SN 1431

Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., butyl diglycol)
Calibration	Calibration certificate in Appendix A
Frequency	10 MHz to 3 GHz (dosimetry); Linearity: ± 0.2 dB (30 MHz to 3 GHz)
Optical Surface Detection	± 0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces
Directivity	± 0.2 dB in HSL (rotation around probe axis) ± 0.4 dB in HSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Dimensions	Overall length: 330 mm Tip length: 16 mm Body diameter: 12 mm Tip diameter: 6.8 mm Distance from probe tip to dipole centers: 2.7 mm
Application	General dosimetry up to 3 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

4.2 Phantoms

The phantom used for all tests i.e. for both validation testing and device testing, was the twin-headed "SAM Phantom", manufactured by SPEAG. The phantom conforms to the requirements of IEEE P1528/D1.2, April 21, 2003 (as established by sub committee SCC-34/SC-2).

Validation tests were performed using the flat section, whilst Head SAR tests used the left and right head profile sections. Body SAR testing also used the flat section between the head profiles.

The SPEAG device holder (see Section 5.1) was used to position the device in all tests whilst a tripod was used to position the validation dipoles against the flat section of phantom.

4.3 Simulating Liquids

Recommended values for the dielectric parameters of the simulating liquids are given in IEEE P1528/D1.2, April 21, 2003 and FCC Supplement C to OET Bulletin 65. All tests were carried out using liquids whose dielectric parameters were within ± 5% of the recommended values. All tests were carried out within 24 hours of measuring the dielectric parameters.

The depth of the liquid was 15.0 ± 0.5 cm measured from the ear reference point during validation and device measurements.

4.3.1 Liquid Recipes

The following recipes were used for Head and Body liquids:

800MHz band

Ingredient	Head (% by weight)	Body (% by weight)
Deionised Water	39.74	55.97
HEC	0.25	1.21
Sugar	58.31	41.76
Preservative	0.15	0.27
Salt	1.55	0.79

1900MHz band

Ingredient	Head (% by weight)	Body (% by weight)
Deionised Water	54.88	69.02
Butyl Diglycol	44.91	30.76
Salt	0.21	0.22

4.3.2 Verification of the System

The manufacturer calibrates the probes annually. Dielectric parameters of the simulating liquids were measured every day using the dielectric probe kit and the network analyser. A SAR measurement was made following the determination of the dielectric parameters of the liquids, using the dipole validation kit. A power level of 250 mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The validation results (dielectric parameters and SAR values) are given in the table below.

System verification, head tissue simulant

f [MHz]	Description	SAR [W/kg], 1g	Dielectric Parameters		Temp [°C]
			ε_r	σ [S/m]	
835	Reference result ± 10% window	9.64 8.68 to 10.6	41.5	0.89	N/A
	10/17/2003	9.72	42.1	0.91	22 ± 1
1900	Reference result ± 10% window	41.6 37.4 to 45.8	38.6	1.46	N/A
	10/16/2003	44.0	38.7	1.49	22 ± 1

System verification, body tissue simulant

f [MHz]	Description	SAR [W/kg], 1g	Dielectric Parameters		Temp [°C]
			ε_r	σ [S/m]	
835	Reference result ± 10% window	10.1 9.1 to 11.1	54.0	0.96	N/A
	10/21/2003	9.72	53.5	0.94	22 ± 1
1900	Reference result ± 10% window	42.4 38.2 to 46.6	51.2	1.59	N/A
	10/20/2003	42.8	50.7	1.58	22 ± 1

Plots of the Verification scans are given in Appendix A.

4.3.3 Tissue Simulants used in the Measurements

Head tissue simulant measurements

f [MHz]	Description	Dielectric Parameters		Temp [°C]
		ε_r	σ [S/m]	
836	Recommended value ± 5% window	41.5	0.90	N/A
	10/17/2003	42.1	0.91	22 ± 1
1880	Recommended value ± 5% window	40.0	1.40	N/A
	10/16/2003	38.8	1.47	22 ± 1

Body tissue simulant measurements

f [MHz]	Description	Dielectric Parameters		Temp [°C]
		ε_r	σ [S/m]	
836	Recommended value ± 5% window	55.2	0.97	N/A
	10/21/2003	53.5	0.94	22 ± 1
1880	Recommended value ± 5% window	53.3	1.52	N/A
	10/20/2003	50.7	1.56	22 ± 1

5. DESCRIPTION OF THE TEST PROCEDURE

5.1 Device Holder

The device was placed in the device holder (illustrated below) that is supplied by SPEAG as an integral part of the Dasy system.

Device holder supplied by SPEAG

A Nokia designed spacer (illustrated below) was used to position the device within the SPEAG holder. The spacer positions the device so that the holder has minimal effect on the test results but still holds the device securely. The spacer was removed before the tests.

Nokia spacer

5.2 Test Positions

5.2.1 Against Phantom Head

Measurements were made in "cheek" and "tilt" positions on both the left hand and right hand sides of the phantom.

The positions used in the measurements were according to IEEE P1528/D1.2 April 21 2003 "Recommended Practice for Determining the Spatial-Peak Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques".

Photo of the device in "cheek" position

Photo of the device in "tilt" position

5.2.2 Body Worn Configuration

The device was placed in the SPEAG holder using the Nokia spacer and placed below the flat section of the phantom. The distance between the device and the phantom was kept at 1.5 cm using a separate flat spacer that was removed before the start of the measurements. The device was oriented with its antenna facing the phantom since this orientation gave higher results.

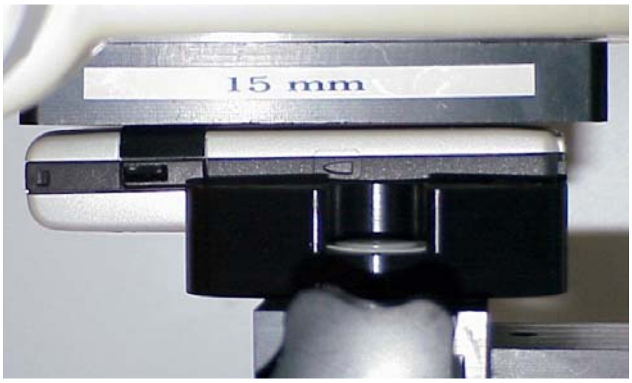


Photo of the device positioned for Body SAR measurement. The spacer was removed for the tests.

5.3 Scan Procedures

First coarse scans were used for determination of the field distribution. Next a cube scan, 5x5x7 was performed around the highest E-field value to determine the averaged SAR value. Drift was determined by measuring the same point at the start of the coarse scan and again at the end of the cube scan.

5.4 SAR Averaging Methods

The maximum SAR value was averaged over a cube of tissue using interpolation and extrapolation.

The interpolation of the points was done with a 3d-Spline. The 3d-Spline comprised three one-dimensional splines with the "Not a knot" -condition [W. Gander, Computermathematik, p. 141-150] (x, y and z -directions) [Numerical Recipes in C, Second Edition, p 123].

The extrapolation was based on least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in the first 30 mm in all z-axis, a fourth order polynomial was calculated. This polynomial was then used to evaluate the points between the phantom surface and the probe tip. The points, calculated from the phantom surface, were at 1 mm spacing.

6. MEASUREMENT UNCERTAINTY

Table 6.1 – Measurement uncertainty evaluation

Uncertainty Component	P1528 Sec	Tol. (%)	Prob Dist	Div	c_i	u_i (%)	v_i
Measurement System							
Probe Calibration	E2.1	±4.8	N	1	1	±4.8	∞
Axial Isotropy	E2.2	±4.7	R	√3	$(1-c_p)^{1/2}$	±1.9	∞
Hemispherical Isotropy	E2.2	±9.6	R	√3	$(c_p)^{1/2}$	±3.9	∞
Boundary Effect	E2.3	±8.3	R	√3	1	±4.8	∞
Linearity	E2.4	±4.7	R	√3	1	±2.7	∞
System Detection Limits	E2.5	±1.0	R	√3	1	±0.6	∞
Readout Electronics	E2.6	±1.0	N	1	1	±1.0	∞
Response Time	E2.7	±0.8	R	√3	1	±0.5	∞
Integration Time	E2.8	±2.6	R	√3	1	±1.5	∞
RF Ambient Conditions - Noise	E6.1	±3.0	R	√3	1	±1.7	∞
RF Ambient Conditions - Reflections	E6.1	±3.0	R	√3	1	±1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	±0.4	R	√3	1	±0.2	∞
Probe Positioning with respect to Phantom Shell	E6.3	±2.9	R	√3	1	±1.7	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5.2	±3.9	R	√3	1	±2.3	∞
Test sample Related							
Test Sample Positioning	E4.2.1	±6.0	N	1	1	±6.0	11
Device Holder Uncertainty	E4.1.1	±5.0	N	1	1	±5.0	7
Output Power Variation - SAR drift measurement	6.6.3	±10.0	R	√3	1	±5.8	∞
Phantom and Tissue Parameters							
Phantom Uncertainty (shape and thickness tolerances)	E3.1	±4.0	R	√3	1	±2.3	∞
Liquid Conductivity Target - tolerance	E3.2	±5.0	R	√3	0.64	±1.8	∞
Liquid Conductivity - measurement uncertainty	E3.3	±5.5	N	1	0.64	±3.5	5
Liquid Permittivity Target tolerance	E3.2	±5.0	R	√3	0.6	±1.7	∞
Liquid Permittivity - measurement uncertainty	E3.3	±2.9	N	1	0.6	±1.7	5
Combined Standard Uncertainty			RSS			±14.5	187
Coverage Factor for 95%			k=2				
Expanded Standard Uncertainty						±29.1	

7. RESULTS

The measured Head SAR values for the test device are tabulated below.
Bluetooth was active during all measurements.

850 MHz Head SAR results

Mode and Band	Position		SAR, averaged over 1g (W/kg)		
			Ch 132 825.0 MHz	Ch 190 836.6 MHz	Ch 247 848.0 MHz
GSM 850	Power level		24.9 dBm	25.1 dBm	24.4 dBm
	Left	Cheek	0.670	**0.721**	0.696
		Tilt		0.473	
	Right	Cheek		0.623	
		Tilt		0.401	
GSM 850	Left, cheek Without MMC card		0.669	**0.740**	0.686

1900 MHz Head SAR results

Mode and Band	Position		SAR, averaged over 1g (W/kg)		
			Ch 518 1851.4 MHz	Ch 661 1880.0 MHz	Ch 804 1908.6 MHz
GSM 1900	Power level		30.4 dBm	30.5 dBm	30.3 dBm
	Left	Cheek		0.550	
		Tilt	0.645	**0.683**	0.634
	Right	Cheek		0.463	
		Tilt		0.653	
GSM 1900	Left, Tilt Without MMC card		**0.758**	0.727	0.642

The measured Body SAR values for the test device are tabulated below.
Bluetooth was active during all measurements.

850 MHz Body SAR results

Mode and Band	Body-worn location setup	SAR, averaged over 1g (W/kg)		
		Ch 132 825 MHz	Ch 190 836.6 MHz	Ch 247 848 MHz
GPRS 850	Power level	24.9 dBm	25.1 dBm	24.4 dBm
	Headset HDS-3	0.844	0.895	0.778
	Headset HDB-4	**0.991**	0.926	0.899
GPRS 850	Headset HDB-4 Without MMC card	**1.02**	0.779	0.857

1900 MHz Body SAR results

Mode and Band	Body-worn location setup	SAR, averaged over 1g (W/kg)		
		Ch 518 1851.4 MHz	Ch 661 1880 MHz	Ch 804 1908.6 MHz
GPRS 1900	Power level	30.4 dBm	30.5 dBm	30.3 dBm
	Headset HDS-3	1.10	0.961	0.878
	Headset HDB-4	**1.11**	1.01	0.901
GPRS 1900	Headset HDB-4 Without MMC card	1.11	0.994	0.893

Plots of the Measurement scans are given in Appendix B.

APPENDIX A: VALIDATION SCANS

See the following pages.

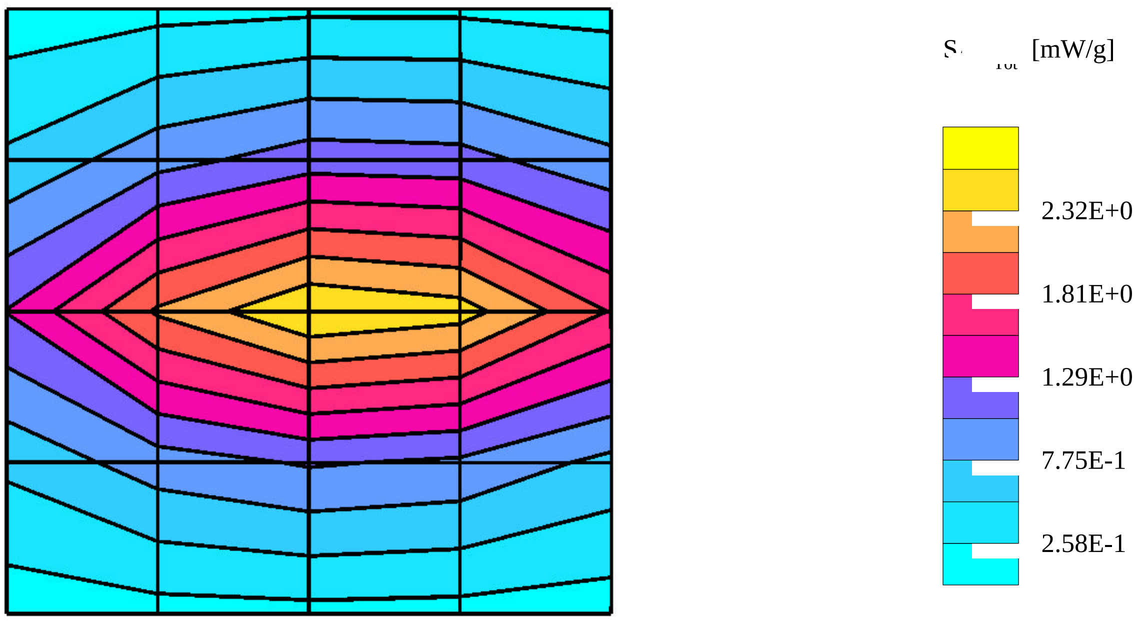
10/17/03

Dipole 835 MHz

Continous Wave, 835 MHz; Crest factor: 1.0

Phantom: SAM Low Band; Section:
Medium Name: Head 835 MHz (SAM): σ = 0.91 mho/m ε_r = 42.1 ρ = 1.00 g/cm^3
Probe: ET3DV6R - SN1431; ConvF(6.20,6.20,6.20)
Cube 5x5x7: SAR (1g): 2.43 mW/g, SAR (10g): 1.59 mW/g, (Advanced extrapolation)
Antenna out: Dx = 20.0, Dy = 20.0, Dz = 10.0
Powerdrift: -0.07 dB
Temperature (°C) = 22 ±1

Filename: Head - 17,10,03 - 2

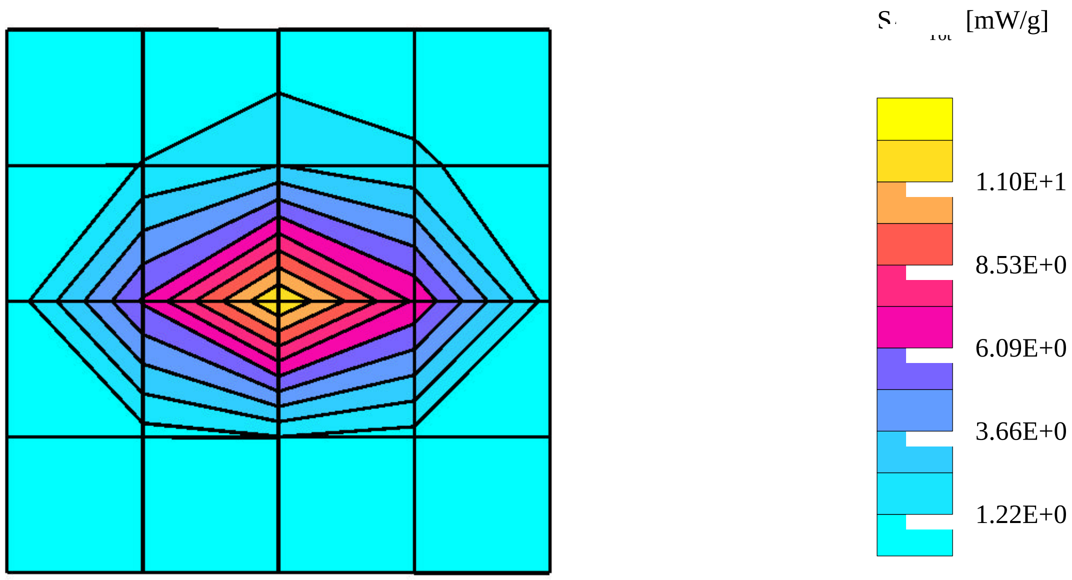


Dipole 1900 MHz

Continous Wave, 1900 MHz; Crest factor: 1.0

Phantom: SAM High Band; Section:
Medium Name: Head 1900 MHz: σ = 1.49 mho/m ε_r = 38.7 ρ = 1.00 g/cm^3
Probe: ET3DV6R - SN1431; ConvF(4.70,4.70,4.70)
Cube 5x5x7: SAR (1g): 11.0 mW/g, SAR (10g): 5.72 mW/g, (Advanced extrapolation)
Antenna out: Dx = 20.0, Dy = 20.0, Dz = 10.0
Powerdrift: 0.10 dB
Temperature (°C) = 22 ±1

Filename: Head - 16,10,03 - 1



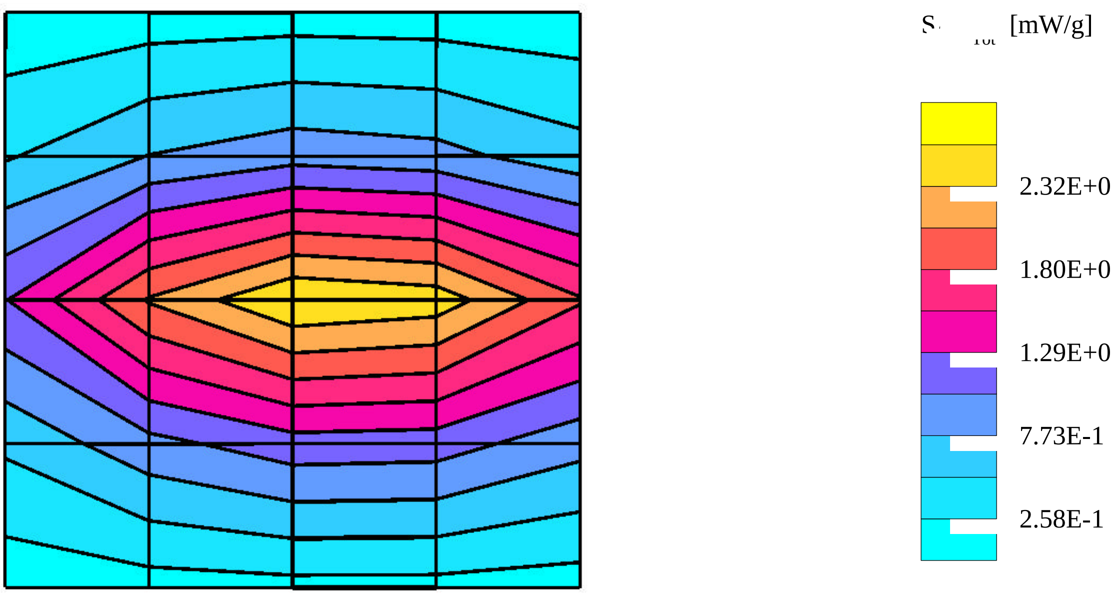
10/21/03

Dipole 835 MHz

Continous Wave, 835 MHz; Crest factor: 1.0

Phantom: SAM Low Band; Section:
Medium Name: Body 835 MHz (SAM): σ = 0.94 mho/m ε_r = 53.5 ρ = 1.00 g/cm³
Probe: ET3DV6R - SN1431; ConvF(6.00,6.00,6.00)
Cube 5x5x7: SAR (1g): 2.43 mW/g, SAR (10g): 1.62 mW/g, (Advanced extrapolation)
Antenna out: Dx = 20.0, Dy = 20.0, Dz = 10.0
Powerdrift: 0.00 dB
Temperature (°C) = 22 ±1

Filename: body - 21,10,03 - 1

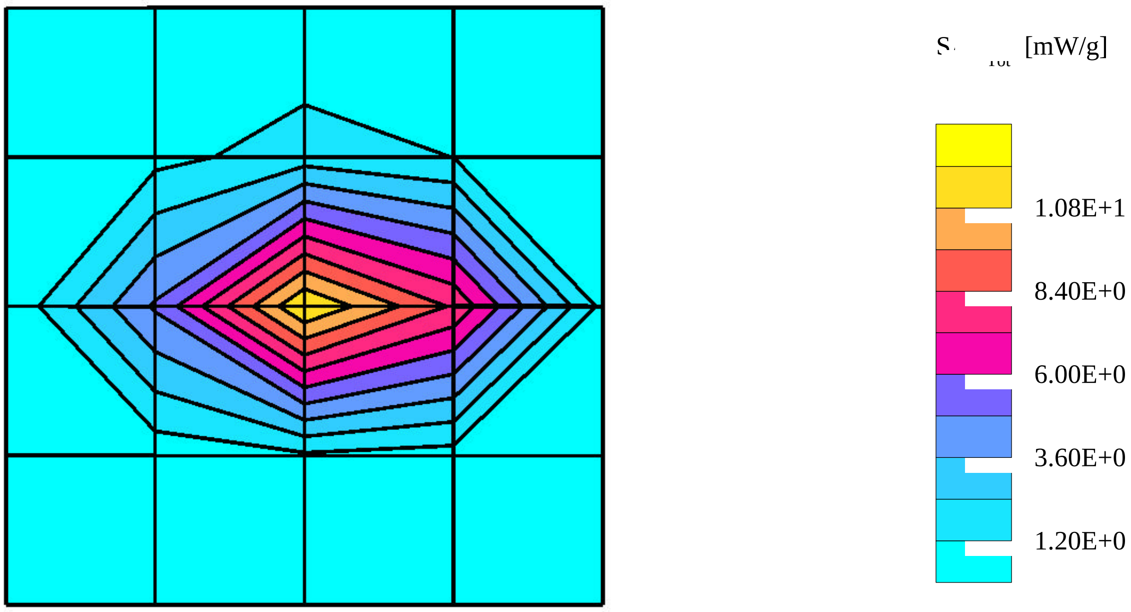


Dipole 1900 MHz

Continous Wave, 1900 MHz; Crest factor: 1.0

Phantom: SAM High Band; Section:
Medium Name: Body 1900 MHz: $\sigma = 1.58$ mho/m $\varepsilon_r = 50.7$ $\rho = 1.00$ g/cm^3
Probe: ET3DV6R - SN1431; ConvF(4.40,4.40,4.40)
Cube 5x5x7: SAR (1g): 10.7 mW/g, SAR (10g): 5.61 mW/g, (Advanced extrapolation)
Antenna out: Dx = 20.0, Dy = 20.0, Dz = 10.0
Powerdrift: 0.13 dB
Temperature (°C) = 22 ±1

Filename: body - 20,10,03 - 1



APPENDIX B: MEASUREMENT SCANS

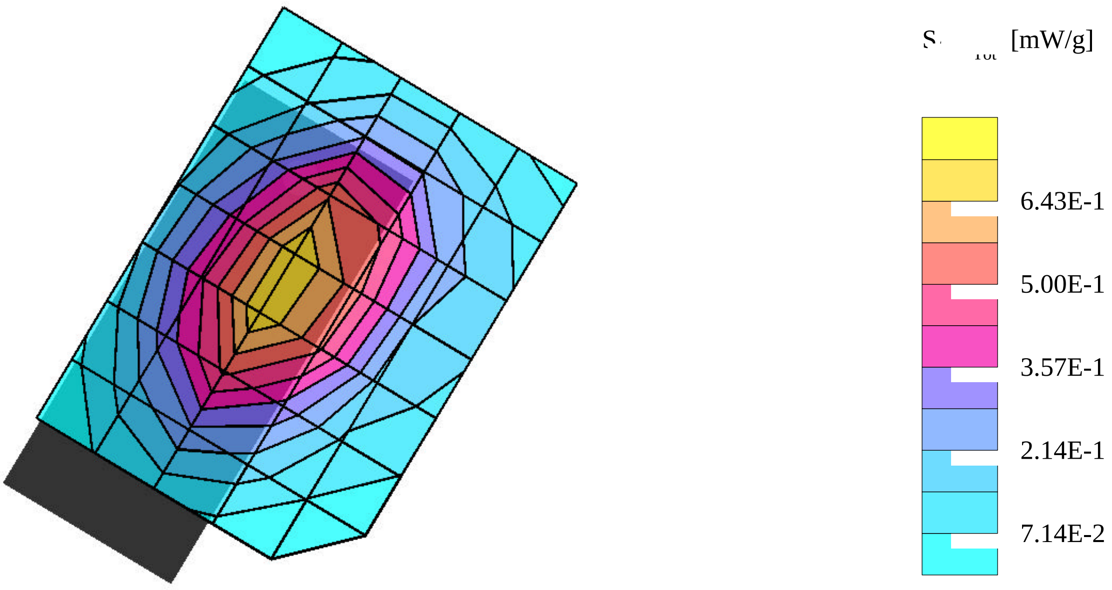
See the following pages.

RH-28

Mode: GSM; CH 190 = 836.6 MHz; Crest factor: 8.0

Phantom: SAM Low Band; Section: Left Hand
Medium Name: Head 835 MHz (SAM): σ = 0.91 mho/m ε_r = 42.1 ρ = 1.00 g/cm³
Probe: ET3DV6R - SN1431; ConvF(6.20,6.20,6.20)
Cube 5x5x7: SAR (1g): 0.721 mW/g, SAR (10g): 0.477 mW/g, (Worst-case extrapolation)
Antenna out: Dx = 15.0, Dy = 15.0, Dz = 10.0
Powerdrift: -0.06 dB
Temperature (°C) = 22 ±1

Filename: SAM touch left 850 MHz Ant in CH 190



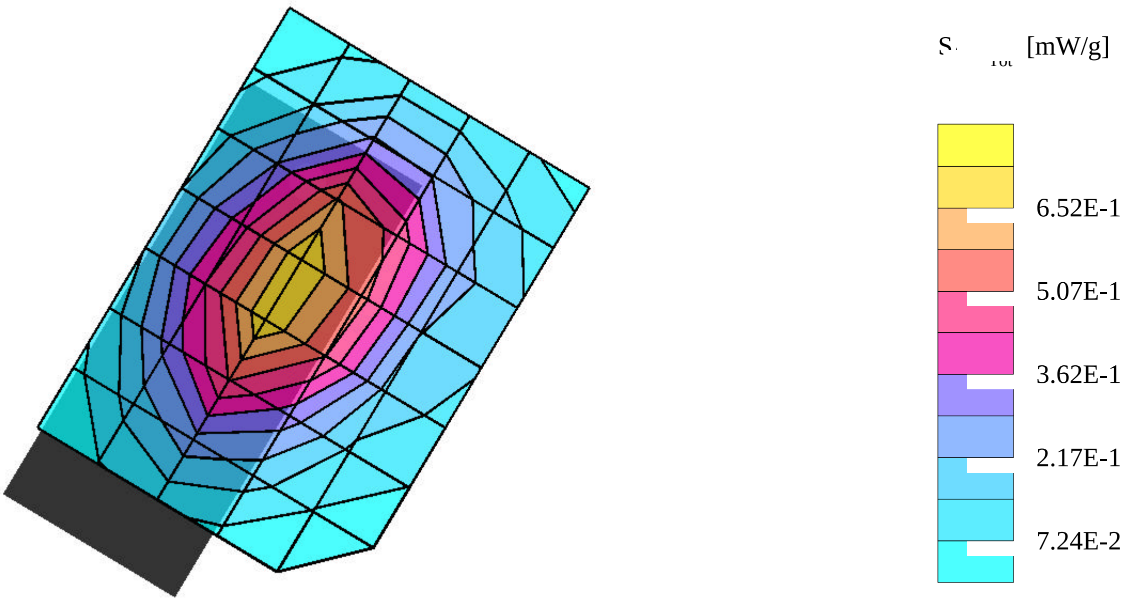
10/17/03

RH-28

Mode: GSM; CH 190 = 836.6 MHz; Crest factor: 8.0

Phantom: SAM Low Band; Section: Left Hand
Medium Name: Head 835 MHz (SAM): $\sigma = 0.91$ mho/m $\varepsilon_r = 42.1$ $\rho = 1.00$ g/cm^3
Probe: ET3DV6R - SN1431; ConvF(6.20,6.20,6.20)
Cube 5x5x7: SAR (1g): 0.740 mW/g, SAR (10g): 0.489 mW/g, (Worst-case extrapolation)
Antenna out: Dx = 15.0, Dy = 15.0, Dz = 10.0
Powerdrift: -0.08 dB
Temperature (°C) = 22 ±1

Filename: SAM touch left 850 MHz Ant in CH 190 no MMC card



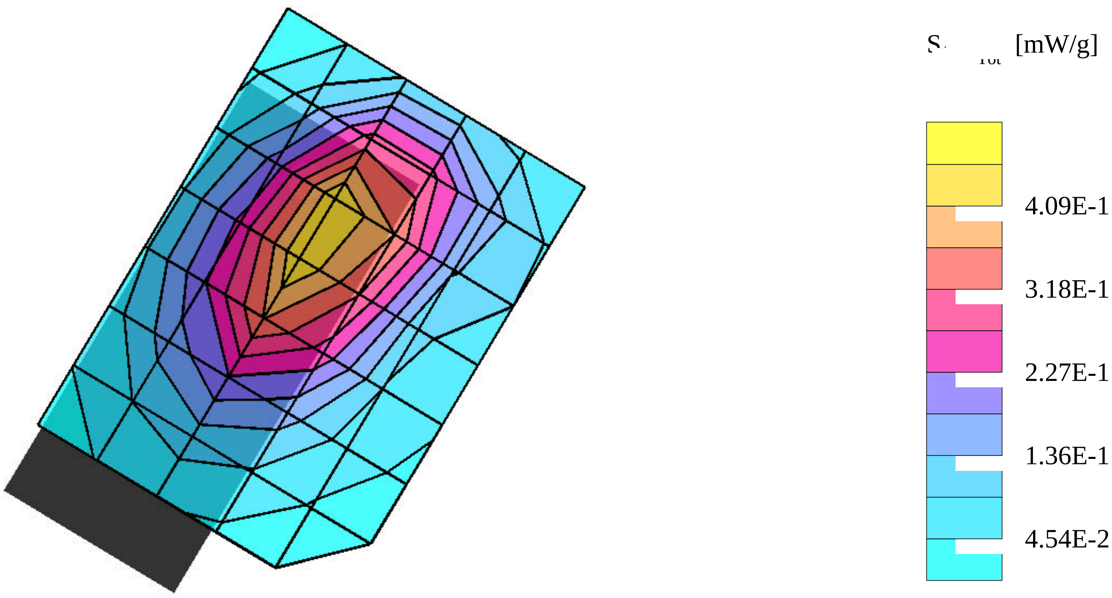
10/17/03

RH-28

Mode: GSM; CH 190 = 836.6 MHz; Crest factor: 8.0

Phantom: SAM Low Band; Section: Left Hand
Medium Name: Head 835 MHz (SAM): σ = 0.91 mho/m ε_r = 42.1 ρ = 1.00 g/cm^3
Probe: ET3DV6R - SN1431; ConvF(6.20,6.20,6.20)
Cube 5x5x7: SAR (1g): 0.473 mW/g, SAR (10g): 0.298 mW/g, (Worst-case extrapolation)
Antenna out: Dx = 15.0, Dy = 15.0, Dz = 10.0
Powerdrift: 0.03 dB
Temperature (°C) = 22 ±1

Filename: SAM plus15° left 850 MHz Ant in CH 190



RH-28

Mode: GSM; CH 190 = 836.6 MHz; Crest factor: 8.0

Phantom: SAM Low Band; Section: Righ Hand
Medium Name: Head 835 MHz (SAM): σ = 0.91 mho/m ε_r = 42.1 ρ = 1.00 g/cm³
Probe: ET3DV6R - SN1431; ConvF(6.20,6.20,6.20)
Cube 5x5x7: SAR (1g): 0.623 mW/g, SAR (10g): 0.416 mW/g, (Worst-case extrapolation)
Antenna out: Dx = 15.0, Dy = 15.0, Dz = 10.0
Powerdrift: 0.17 dB
Temperature (°C) = 22 ±1

Filename: SAM touch right 850 MHz Ant in CH 190