SAR EVALUATION REPORT

For

GR8 Communications, Inc.

9862-B Main St
Fairfax, VA 22031

FCC ID: RFYSCH700SERIES

2003-08-18

This Report Concerns:	Equipment Type:
☒ Original Report	Cellular Phone

Test Engineer:	Eric Hong _Hong_
Report No.:	R0306021S
Test Date:	2003-08-11
Reviewed By:	Hans Mellberg
Prepared By:	Bay Area Compliance Laboratory Corporation 230 Commercial Street Sunnyvale, CA 94085 Tel: (408) 732-9162 Fax: (408) 732 9164

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SUMMARY

The US Federal Communications Commission has released the report and order "Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996 [1].

The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 mW/g as recommended by the ANSI/IEEE standard C95.1-1992 [6] for an uncontrolled environment (Paragraph 65). According to the Supplement C of OET Bulletin 65 "Evaluating Compliance with FCC Guide-lines for Human Exposure to Radio frequency Electromagnetic Fields", released on Jun 29, 2001 by the FCC, the device should be evaluated at maximum output power (radiated from the antenna) under "worst-case" conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

This report describes the methodology and results of experiments performed on wireless data terminal. The objective was to determine if there is RF radiation and if radiation is found, what is the extent of radiation with respect to safety limits. SAR (Specific Absorption Rate) is the measure of RF exposure determined by the amount of RF energy absorbed by human body (or its parts) – to determine how the RF energy couples to the body or head which is a primary health concern for body worn devices. The limit below which the exposure to RF is considered safe by regulatory bodies in North America is 1.6 mW/g average over 1 gram of tissue mass.

The test configurations were laid out on a specially designed test fixture to ensure the reproducibility of measurements. Each configuration was scanned for SAR. Analysis of each scan was carried out to characterize the above effects in the device.

There was no SAR of any concern measured on the device for any of the investigated configurations.

1 - REFERENCE

[1] Federal Communications Commission, \Report and order: Guidelines for evaluating the environmental effects of radiofrequency radiation", Tech. Rep. FCC 96-326, FCC, Washington, D.C. 20554, 1996.

[2] David L. Means Kwok Chan, Robert F. Cleveland, \Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields", Tech. Rep., Federal Communication Commission, O_ce of Engineering & Technology, Washington, DC, 1997.

[3] Thomas Schmid, Oliver Egger, and Niels Kuster, \Automated E-_eld scanning system for dosimetric assessments", IEEE Transactions on Microwave Theory and Techniques, vol. 44, pp. 105{113, Jan. 1996.

[4] Niels Kuster, Ralph K.astle, 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] CENELEC, \Considerations for evaluating of human exposure to electromagnetic fields (EMFs) from mobile telecommunication equipment (MTE) in the frequency range 30MHz - 6GHz", Tech. Rep., CENELEC, European Committee for Electrotechnical Standardization, Brussels, 1997.

[6] ANSI, ANSI/IEEE C95.1-1992: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, The Institute of Electrical and Electronics Engineers, Inc., New York, NY 10017, 1992.

[7] Katja Pokovic, Thomas Schmid, and Niels Kuster, \Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies", in ICECOM _ 97, Dubrovnik, October 15{17, 1997, pp. 120-24.

[8] Katja Pokovic, Thomas Schmid, and Niels Kuster, \E-field probe with improved isotropy in brain simulating liquids", in Proceedings of the ELMAR, Zadar, Croatia, 23{25 June, 1996, pp. 172-175.

[9] Volker Hombach, Klaus Meier, Michael Burkhardt, Eberhard K. uhn, and Niels Kuster, \The depen-dence of EM energy absorption upon human head modeling at 900 MHz", IEEE Transactions on Microwave Theory and Techniques, vol. 44, no. 10, pp. 1865-1873, Oct. 1996.

[10] Klaus Meier, Ralf Kastle, Volker Hombach, Roger Tay, and Niels Kuster, \The dependence of EM energy absorption upon human head modeling at 1800 MHz", IEEE Transactions on Microwave Theory and Techniques, Oct. 1997, in press.

[11] W. Gander, Computermathematik, Birkhaeuser, Basel, 1992.

[12] W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Numerical Recepies in C, The Art of Scientific Computing, Second Edition, Cambridge University Press, 1992.Dosimetric Evaluation of Sample device, month 1998 9

[13] NIS81 NAMAS, \The treatment of uncertainity in EMC measurement", Tech. Rep., NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, 1994.

[14] Barry N. Taylor and Christ E. Kuyatt, \Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Tech. Rep., National Institute of Standards and Technology, 1994. Dosimetric Evaluation of Sample device, month 1998 10

2 - TESTING EQUIPMENT

2.1 Equipments List & Calibration Info

Type / Model	Cal. Date	S/N:
DASY3 Professional Dosimetric System	N/A	N/A
Robot RX60L	N/A	F00/5H31A1/A/01
Robot Controller	N/A	F01/5J72A1/A/01
Dell Computer Optiplex GX110	N/A	N/A
Pentium III, Windows NT	N/A	N/A
SPEAG EDC3	N/A	N/A
SPEAG DAE3	08/26/02	456
SPEAG E-Field Probe ET3DV6	08/26/02	1604
SPEAG Dummy Probe	N/A	N/A
SPEAG Generic Twin Phantom	N/A	N/A
SPEAG Light Alignment Sensor	N/A	278
SPEAG Validation Dipole D-1800-S-2	11/6/01	BCL-049
SPEAG Validation Dipole D900V2	9/3/02	122
Brain Equivalent Matter (800MHz)	Daily	N/A
Brain Equivalent Matter (1900MHz)	Daily	N/A
Muscle Equivalent Matter (800MHz)	Daily	N/A
Muscle Equivalent Matter (1900MHz)	Daily	N/A
Robot Table	N/A	N/A
Phone Holder	N/A	N/A
Phantom Cover	N/A	N/A
HP Spectrum Analyzer HP8593GM	6/20/02	3009A00791
Microwave Amp. 8349B	N/A	2644A02662
Power Meter HP436A	4/2/02	2709A29209
Power Sensor HP8482A	4/2/02	2349A08568
Signal Generator RS SMIQ O3	2/10/02	1084800403
Network Analyzer HP-8753ES	7/30/02	820079
Dielectric Probe Kit HP85070A	N/A	N/A
Hewlett Packard HP8566B Spectrum Analyzer	7/23/02	None
Hewlett Packard HP 7470A Plotter	7/23/02	None
A.H. System SAS0200 Horn Antenna	7/23/02	None
Com-Power AB-100 Dipole Antenna	7/23/02	None
Agilent E4419b	4/8/02	GB40202891
Agilent E4412a	4/8/02	US38486529

2.2 Equipment Calibration Certificate

Please see the attached file for detailed information.

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:	1604
Place of Calibration:	Zurich
Date of Calibration:	August 26, 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	*N. Vetter*
Approved by	*Pravic Katja*

Schmid & Partner Engineering AG

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

Probe ET3DV6

SN:1604

Manufactured:	July 30, 2001
Last calibration:	September 7, 2001
Recalibrated:	August 26, 2002

Calibrated for System DASY3

ET3DV6 SN:1604   August 26, 2002

DASY3 - Parameters of Probe: ET3DV6 SN:1604

Sensitivity in Free Space

NormX	$1.73\ \mu V/(V/m)^2$
NormY	$1.68\ \mu V/(V/m)^2$
NormZ	$1.72\ \mu V/(V/m)^2$

Diode Compression

DCP X	93	mV
DCP Y	93	mV
DCP Z	93	mV

Sensitivity in Tissue Simulating Liquid

Head	900 MHz	$\varepsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\%$ mho/m
Head	835 MHz	$\varepsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\%$ mho/m

		Boundary effect:	
ConvF X	$6.5 \pm 9.5\%$ (k=2)		
ConvF Y	$6.5 \pm 9.5\%$ (k=2)	Alpha	0.36
ConvF Z	$6.5 \pm 9.5\%$ (k=2)	Depth	2.82

Head	1800 MHz	$\varepsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\%$ mho/m
Head	1900 MHz	$\varepsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\%$ mho/m

		Boundary effect:	
ConvF X	$5.5 \pm 9.5\%$ (k=2)		
ConvF Y	$5.5 \pm 9.5\%$ (k=2)	Alpha	0.50
ConvF Z	$5.5 \pm 9.5\%$ (k=2)	Depth	2.46

Boundary Effect

Head   900 MHz   Typical SAR gradient: 5 % per mm

	1 mm	2 mm
Probe Tip to Boundary		
SAR_{ba} [%] Without Correction Algorithm	11.1	6.6
SAR_{ba} [%] With Correction Algorithm	0.4	0.6

Head   1800 MHz   Typical SAR gradient: 10 % per mm

	1 mm	2 mm
Probe Tip to Boundary		
SAR_{ba} [%] Without Correction Algorithm	12.3	8.1
SAR_{ba} [%] With Correction Algorithm	0.1	0.1

Sensor Offset

Probe Tip to Sensor Center	2.7	mm
Optical Surface Detection	1.3 ± 0.2	mm

Receiving Pattern (ϕ), $\theta = 0°$

f = 30 MHz, TEM cell ifi110
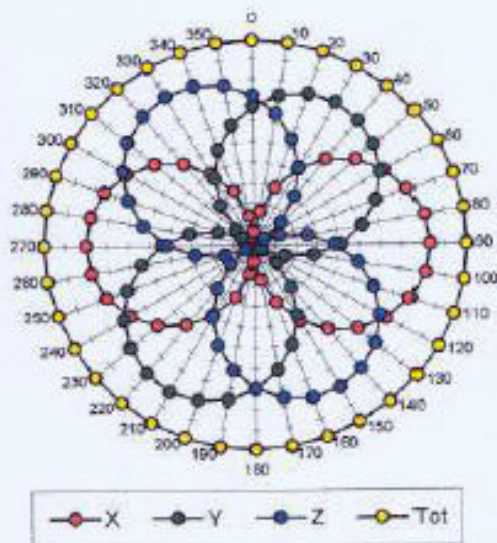
f = 100 MHz, TEM cell ifi110
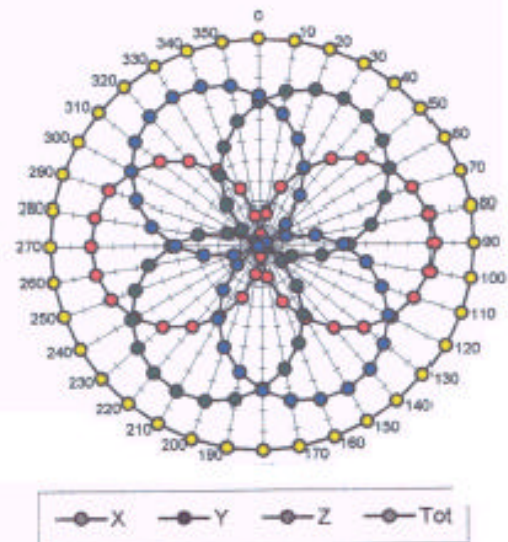
f = 300 MHz, TEM cell ifi110
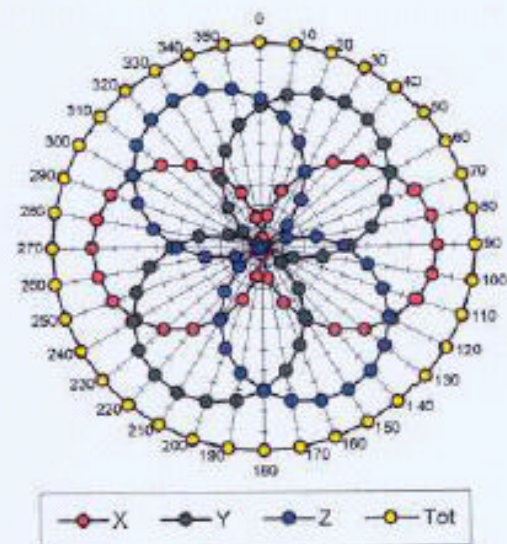
f = 900 MHz, TEM cell ifi110
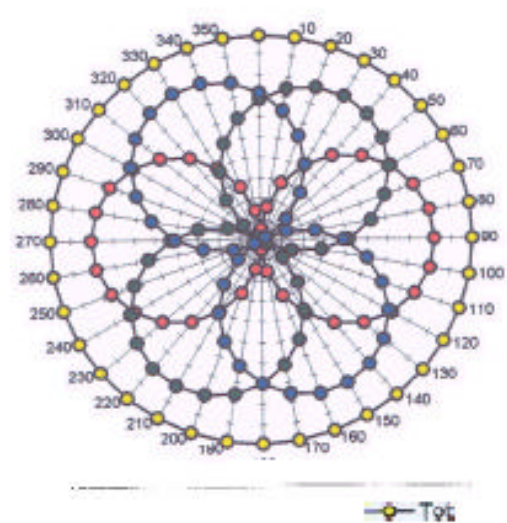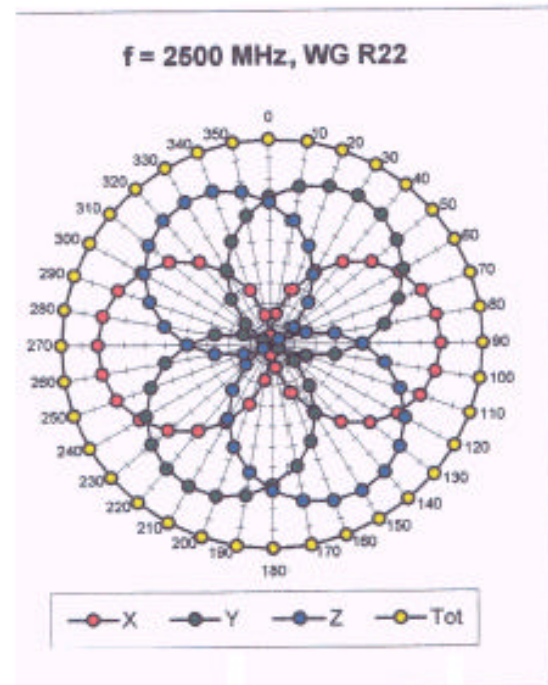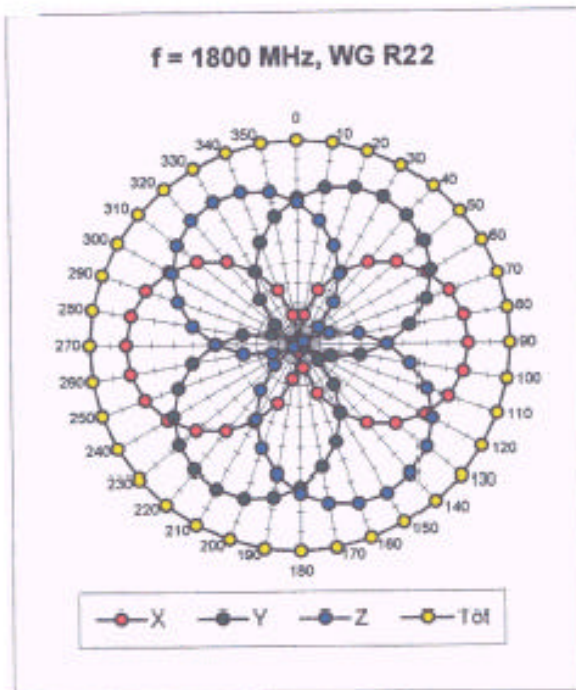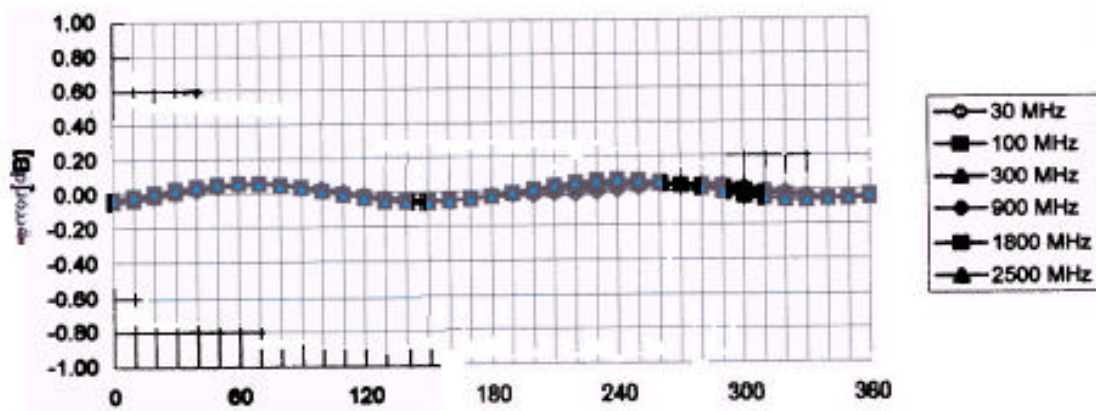
ET3DV6 SN:1604   August 26, 2002

f = 1800 MHz, WG R22

f = 2500 MHz, WG R22

Isotropy Error (φ), θ = 0°

Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)
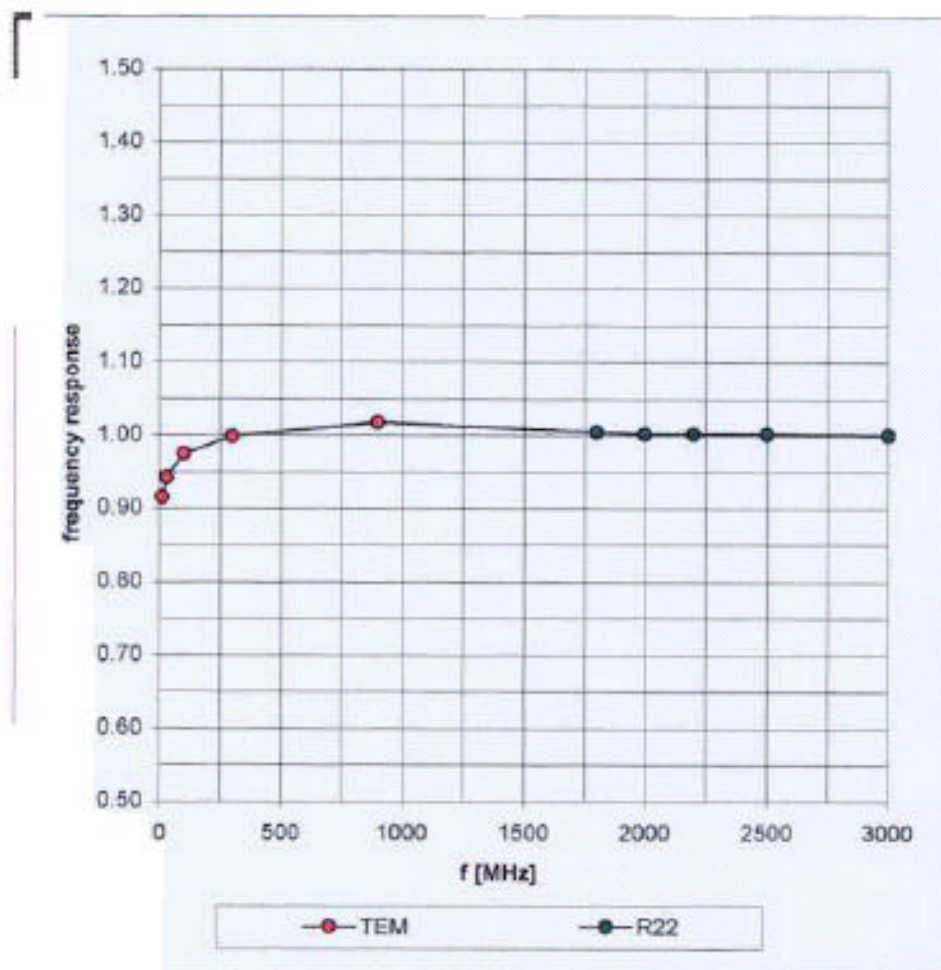
ET3DV6 SN:1604   **August 26, 2002**

Dynamic Range f(SAR$_{brain}$)
(Waveguide R22)
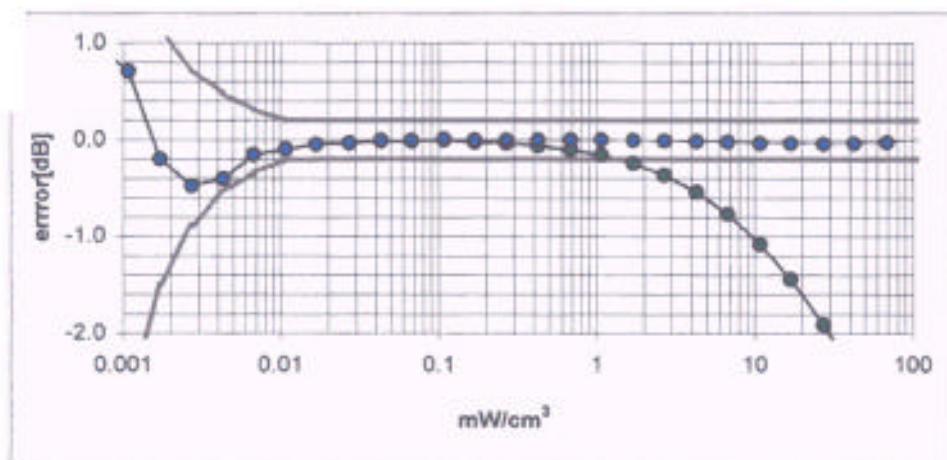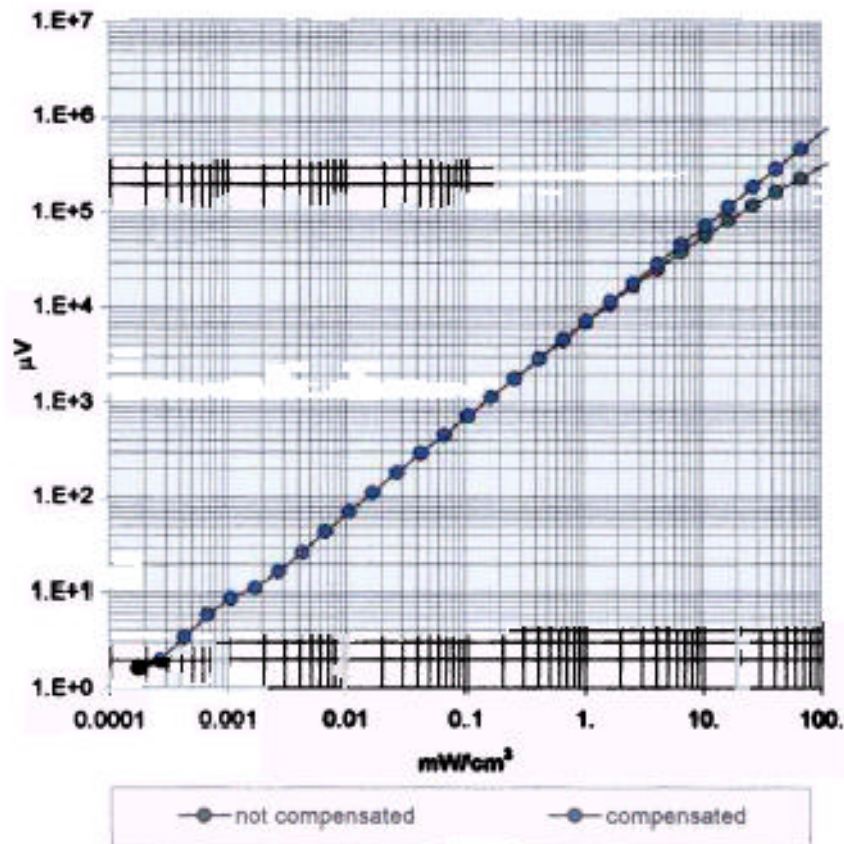
Conversion Factor Assessment

f = 900 MHz, WG R9 (head)   f = 1800 MHz, WG R22 (head)
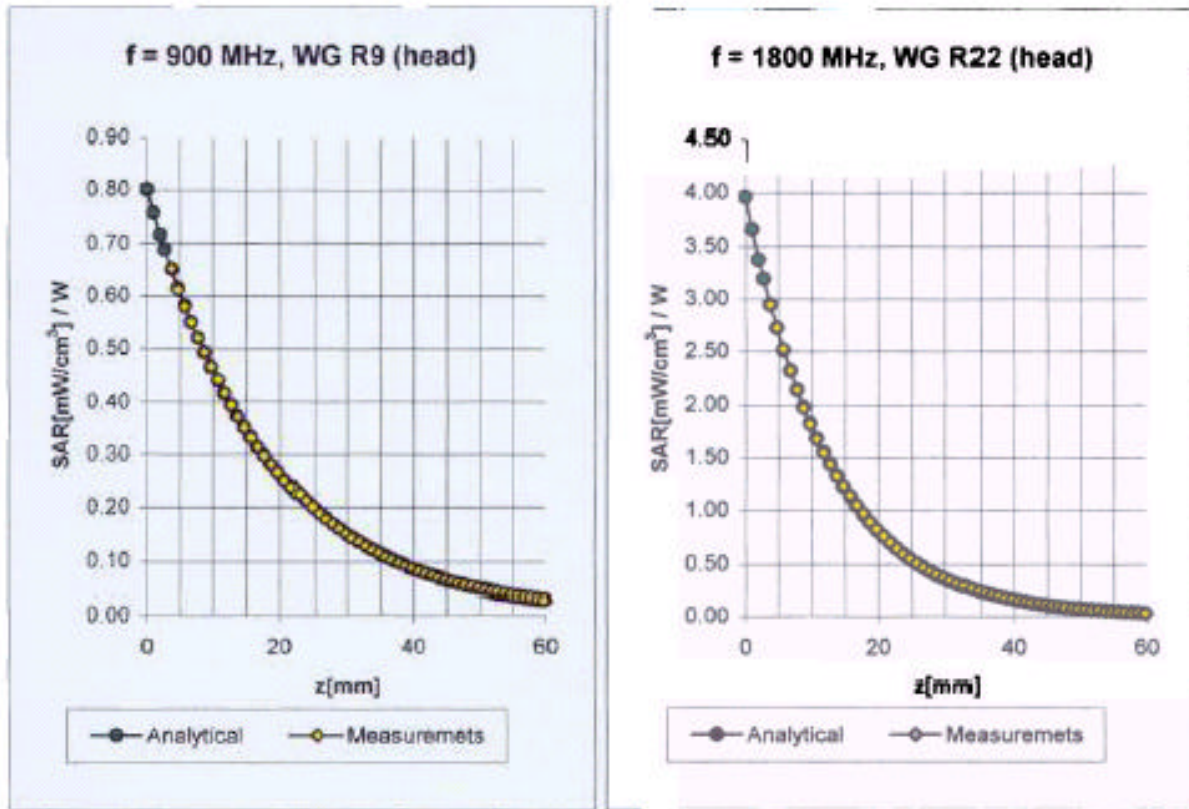
Head	900 MHz		$\varepsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\%$ mho/m
Head	835 MHz		$\varepsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\%$ mho/m
	ConvF X	6.5 ±9.5% (k=2)	Boundary effect:	
	ConvF Y	6.5 ±9.5% (k=2)	Alpha	
	ConvF Z	6.5 ±9.5% (k=2)	Depth	

Head	1800 MHz		$\varepsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\%$ mho/m
Head	1900 MHz		$\varepsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\%$ mho/m
	ConvF X	5.5 ±9.5% (k=2)	Boundary effect:	
	ConvF Y	5.5 ±9.5% (k=2)	Alpha	0.50
	ConvF Z	5.5 ±9.5% (k=2)	Depth	2.46

Conversion Factor Assessment

f = 800 MHz, WG R9 (head)
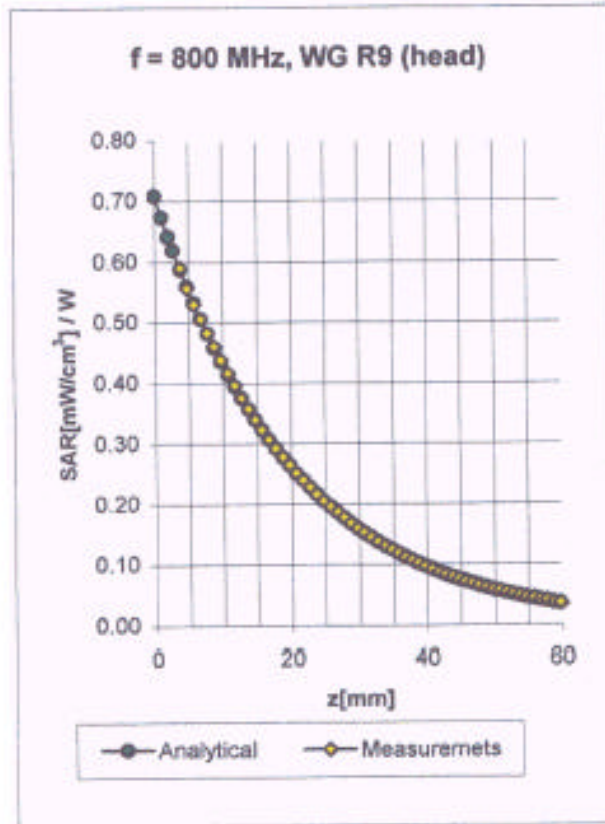
Head	800 MHz	$\varepsilon_r = 41.5 \pm 5\%$	$\sigma = 0.88 \pm 5\%$ mho/m

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

Deviation from Isotropy in HSL
Error (θ,φ), f = 900 MHz
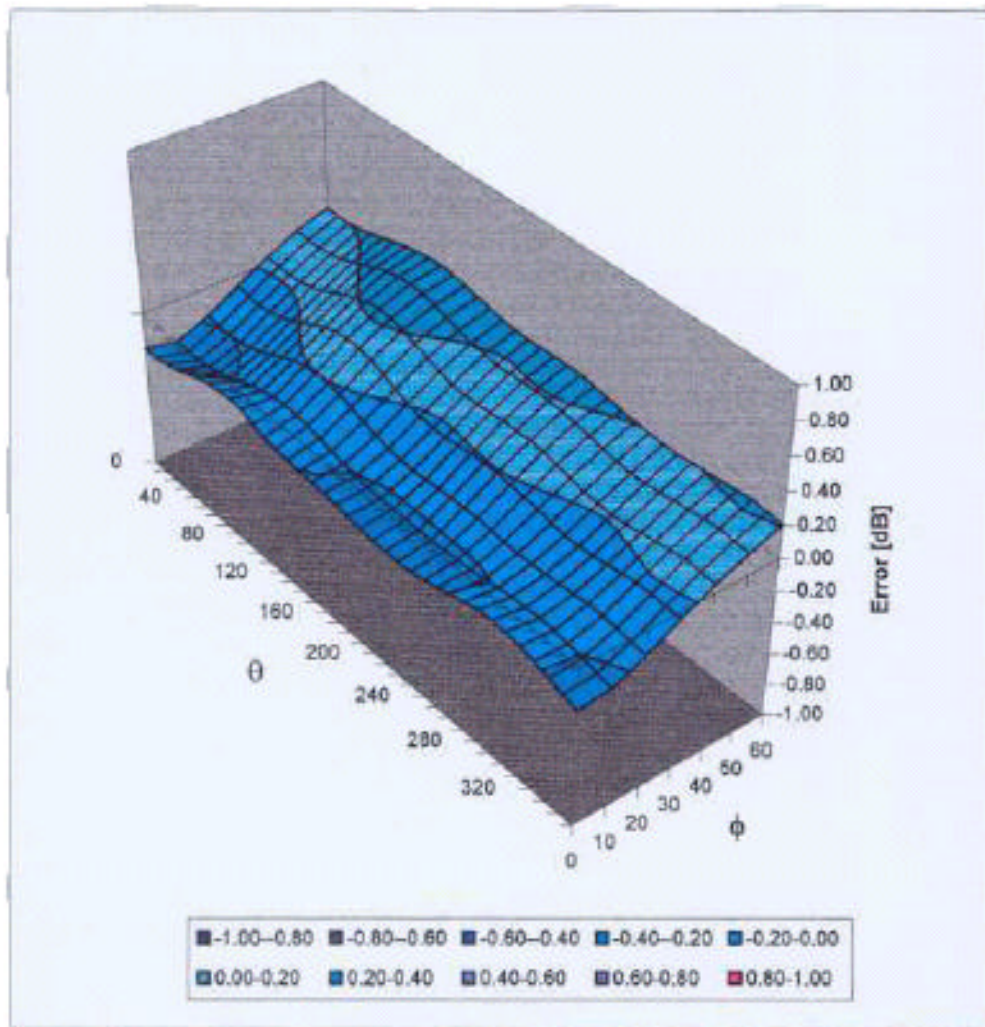
Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

Additional Conversion Factors
for Dosimetric E-Field Probe

Type	ET3DV6
Serial Number:	1604
Place of Assessment	Zurich
Date of Assessment:	October 4, 2002
Probe Calibration Date	August 26, 2002

Schmid & Partner Engineering AG hereby certifies that conversion factor(s) of this probe have been evaluated on the date indicated above. The assessment was performed using the FDTD numerical code SEMCAD of Schmid & Partner Engineering AG. Since the evaluation is coupled with measured conversion factors, it has to be recalculated yearly, i.e., following the re-calibration schedule of the probe. The uncertainty of the numerical assessment is based on the extrapolation from measured value at 900 MHz or at 1800 MHz.

Assessed by

Page   of 2   October 4, 2002

Conversion factor (± standard deviation)

835 MHz	ConvF	$6.4 \pm 8\%$	$\varepsilon_r = 55.2 \pm 5\%$ $\sigma = 0.97 \pm 5\%$ mho/m (body tissue)
1900 MHz	ConvF	$4.9 \pm 8\%$	$\varepsilon_r = 53.3 \pm 5\%$ $\sigma = 1.52 \pm 5\%$ mho/m (body tissue)

835MHz Head Liquid Validation

frequency	e'	e''
815000000.0000	39.3888	19.2166
817000000.0000	39.3629	19.2171
819000000.0000	39.3587	19.2424
821000000.0000	39.3674	19.2915
823000000.0000	39.3925	19.3180
825000000.0000	39.4390	19.3690
827000000.0000	39.4160	19.3642
829000000.0000	39.4457	19.4129
831000000.0000	39.4342	19.4159
833000000.0000	39.5071	19.4927
835000000.0000	39.5960	19.4820
837000000.0000	39.5633	19.4927
839000000.0000	39.5418	19.5112
841000000.0000	39.5748	19.5131
843000000.0000	39.6470	19.5121
845000000.0000	39.6768	19.5794
847000000.0000	39.6819	19.6237
849000000.0000	39.6963	19.5558
851000000.0000	39.7247	19.5869
853000000.0000	39.7687	19.5958
855000000.0000	39.7720	19.6442
857000000.0000	39.7807	19.5826
859000000.0000	39.7776	19.5935
861000000.0000	39.7704	19.5422
863000000.0000	39.7447	19.4944
865000000.0000	39.6822	19.4335
867000000.0000	39.6411	19.4674
869000000.0000	39.6770	19.3645
871000000.0000	39.6046	19.3477
873000000.0000	39.5656	19.3652
875000000.0000	39.5374	19.3196
877000000.0000	39.4478	19.2475
879000000.0000	39.4233	19.2205
881000000.0000	39.4076	19.1863
883000000.0000	39.3323	19.1486
885000000.0000	39.2833	19.1280
887000000.0000	39.2281	19.0712
889000000.0000	39.1469	19.0367
891000000.0000	39.0309	18.9815
893000000.0000	39.0044	18.9761
895000000.0000	38.9800	18.9275
897000000.0000	38.9068	18.9102
899000000.0000	38.8438	18.8698
901000000.0000	38.8108	18.8369
903000000.0000	38.7279	18.8126
905000000.0000	38.6703	18.7937
907000000.0000	38.5802	18.8260
909000000.0000	38.5324	18.7732
911000000.0000	38.4567	18.7924
913000000.0000	38.5072	18.7763
915000000.0000	38.4300	18.7623

$\sigma = \omega \varepsilon_o \varepsilon'' = 2 \pi f \varepsilon_o \varepsilon'' = 0.90$
where $f = 835 \times 10^6$
$\varepsilon_o = 8.854 \times 10^{-12}$
$\varepsilon'' = 19.4820$

835MHz Body Liquid Validation

```
frequency   e'      e''
 815000000.0000    55.3225    21.0528
 815800000.0000    55.3139    21.0531
 816600000.0000    55.3483    21.0465
 817400000.0000    55.3319    20.9157
 818200000.0000    55.3228    20.9216
 819000000.0000    55.3245    20.9224
 819800000.0000    55.3103    20.9152
 820600000.0000    55.3123    20.0271
 821400000.0000    55.3156    20.0182
 822200000.0000    55.3098    20.9140
 823000000.0000    55.2949    20.9043
 823800000.0000    55.2862    20.9064
 824600000.0000    55.3732    20.9018
 825400000.0000    55.2721    20.9079
 826200000.0000    55.2593    20.8844
 827000000.0000    55.2471    20.8777
 827800000.0000    55.2388    20.8642
 828600000.0000    55.2275    20.8484
 829400000.0000    55.1985    20.8513
 830200000.0000    55.2074    20.8472
 831000000.0000    55.2433    20.8337
 831800000.0000    55.1890    20.8252
 832600000.0000    55.2322    20.8185
 833400000.0000    55.1852    20.7858
 834200000.0000    55.2140    20.8171
 835000000.0000    55.2175    20.7122
 835800000.0000    55.2067    20.7023
 836600000.0000    55.1814    20.6745
 837400000.0000    55.2497    20.6918
 838200000.0000    55.2102    20.5914
 839000000.0000    55.1385    20.5773
 839800000.0000    55.1889    20.6945
 840600000.0000    55.1457    20.6504
 841400000.0000    55.1886    20.5967
 842200000.0000    55.1391    20.4831
 843000000.0000    55.1318    20.3227
 843800000.0000    55.1286    20.2372
 844600000.0000    55.1142    20.2854
 845400000.0000    55.1988    20.1353
 846200000.0000    55.1345    20.1145
 847000000.0000    55.1244    20.0142
 847800000.0000    55.0609    20.0457
 848600000.0000    55.1150    20.0546
 849400000.0000    55.1163    20.1813
 850200000.0000    55.0811    20.3254
 851000000.0000    55.0885    20.4183
 851800000.0000    55.0923    20.4632
 852600000.0000    55.0554    20.5446
 853400000.0000    55.0113    20.4623
 854200000.0000    55.0292    20.4527
 855000000.0000    55.0487    20.4236
```

$$\sigma = \omega \varepsilon_o \, \varepsilon'' = 2 \pi f \varepsilon_o \, \varepsilon'' = 0.96$$
where $f = 835 \times 10^6$
$\qquad \varepsilon_o = 8.854 \times 10^{-12}$
$\qquad \varepsilon'' = 20.7122$

3 - EUT DESCRIPTION

Applicant: GR8 Communications, Inc.

Product Description: CDMA Cellular Phone

Product Model Number: SCH-770

FCC ID: RFYSCH700SERIES

Serial Number: None

Maximum RF Output Power: 25.50dBm

RF Exposure environment: General Population/Uncontrolled

Applicable Standard   FCC CFR 47, Part 22

Application Type: Certification

4 - SYSTEM TEST CONFIGURATION

4.1 Justification

The system was configured for testing in a typical fashion (as normally used by a typical user).

4.2 EUT Exercise Procedure

The EUT exercising program used during SAR testing was designed to exercise the various system components in a manner similar to a typical use. The EUT was tested by pushing the PTT bottom during the testing.

4.3 Equipment Modifications

No modification(s) were made to ensure that the EUT complies with the applicable limits.

5 – CONDUCTED OUTPUT POWER MEASUREMENTS

5.1 Provision Applicable

According to FCC §22.913 (a), the ERP of mobile transmitters and auxiliary test transmitters must not exceed 7 watts.

5.2 Test Procedure

The RF output of the transmitter was connected to the input of the spectrum analyzer through sufficient attenuation.

5.3 Test equipment

Hewlett Packard HP8564E Spectrum Analyzer, Calibration Due Date: 2003-08-01.
Hewlett Packard HP 7470A Plotter, Calibration not required.
A.H. Systems SAS200 Horn Antenna, Calibration Due Date: 2004-05-31
Com-Power AB-100 Dipole Antenna, Calibration Due Date: 2003-09-05

5.4 Test Results

Modulation Type	Channel	Frequency (MHz)	Output Power in dBm	Output Power in W	Limit (W)
	Low	825.30	24.33	0.271	7
CDMA	Middle	835.92	25.00	0.316	7
	High	848.22	25.50	0.355	7

Please refer to the following plots.

ATTEN 40dB   MKR 24.33dBm
RL 30.0dBm   10dB/   825.30MHz
                                          GR8 COMMUNICAT
                                          SH-770   L.C

MKR
825.30 MHz
24.33 dBm

CENTER 825.30MHz   SPAN 20.00MHz
*RBW 2.0MHz   VBW 3.0MHz   SWP 50.0ms

ATTEN 40dB   MKR 25.00dBm
RL 30.0dBm   10dB/   835.92MHz
                                          GR8 COMMUNICAT
                                          SH-770   M.C

MKR
835.92 MHz
25.00 dBm

CENTER 835.89MHz   SPAN 20.00MHz
*RBW 2.0MHz   VBW 3.0MHz   SWP 50.0ms

ATTEN 40dB   MKR 25.50dBm
RL 30.0dBm   10dB/   848.22MHz
                                          GR8 COMMUNICAT
                                          SH-770   H.C

MKR
848.22 MHz
25.50 dBm

CENTER 848.19MHz   SPAN 20.00MHz
*RBW 2.0MHz   VBW 3.0MHz   SWP 50.0ms

6 - DOSIMETRIC ASSESSMENT SETUP

These measurements were performed with the automated near-field scanning system DASY3 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9m) which positions the probes with a positional repeatability of better than ±0.02mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The system is described in detail in [3].

The SAR measurements were conducted with the dosimetric probe ET3DV6 SN: 1577 (manufactured by SPEAG), designed in the classical triangular configuration [3] and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in [7] with accuracy of better than ±10%. The spherical isotropy was evaluated with the procedure described in [8] and found to be better than ±0.25dB.

The phantom used was the \Generic Twin Phantom" described in [4]. The ear was simulated as a spacer of 4 mm thickness between the earpiece of the phone and the tissue simulating liquid. The Tissue simulation liquid used for each test is in according with the FCC OET65 supplement C as listed below.

Ingredients	Frequency (MHz)									
(% by weight)	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (Nacl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton x-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.5	56.7	41.5	55.2	41.5	55.0	40.0	53.3	39.2	52.7
Conductivity (s/m)	0.87	0.94	0.90	0.97	0.98	1.06	1.40	1.52	1.80	1.95

6.1 Measurement System Diagram
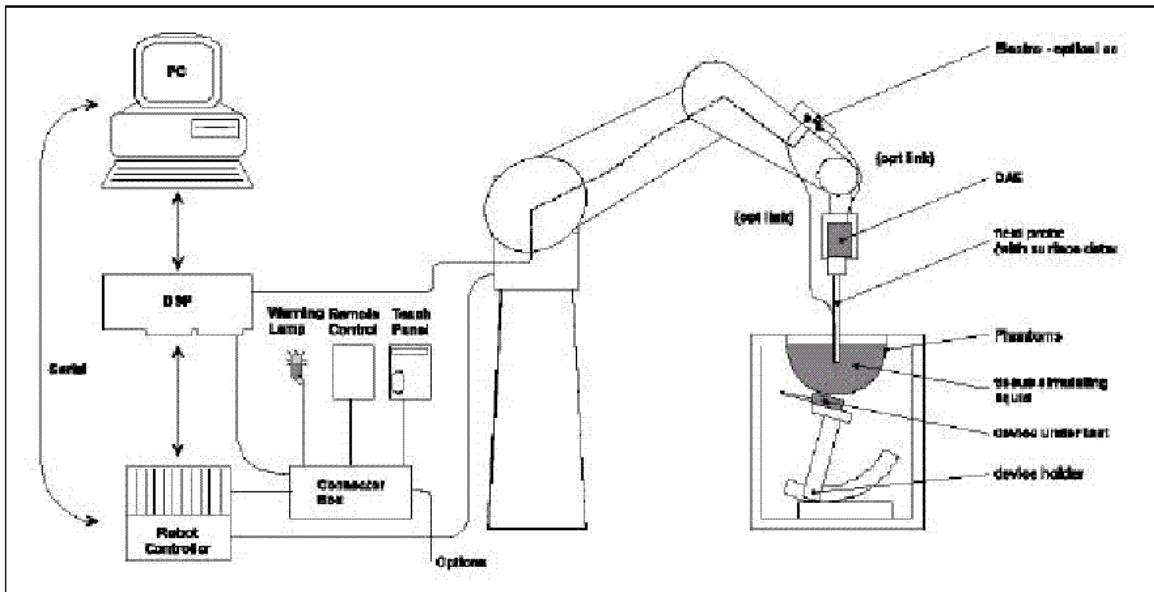
The DASY3 system for performing compliance tests consist of the following items:

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software.
2. An arm extension for accommodating the data acquisition electronics (DAE).
3. A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
4. A data acquisition electronic (DAE), which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
5. A unit to operate the optical surface detector, which is connected to the EOC. The Electro-optical coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the PC plug-in card. The functions of the PC plug-in card based on a DSP is to perform the time critical task such as signal filtering, surveillance of the robot operation fast movement interrupts.
6. A computer operating Windows 95 or larger
7. DASY3 software
8. Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.
9. The generic twin phantom enabling testing left-hand and right-hand usage.
10. The device holder for handheld EUT.
11. Tissue simulating liquid mixed according to the given recipes (see Application Note).
12. System validation dipoles to validate the proper functioning of the system.

6.2. System Components

ET3DV6 Probe Specification
Construction Symmetrical design with triangular core
Built-in optical fiber for surface detection System
Built-in shielding against static charges
Calibration In air from 10 MHz to 2.5 GHz
In brain and muscle simulating tissue at
Frequencies of 450 MHz, 900 MHz and
1.8 GHz (accuracy ± 8%)
Frequency 10 MHz to > 6 GHz; Linearity: ± 0.2 dB
(30 MHz to 3 GHz)
Directivity ± 0.2 dB in brain tissue (rotation around
probe axis)
± 0.4 dB in brain tissue (rotation normal probe axis)
Dynamic 5 mW/g to > 100 mW/g;
Range Linearity: ± 0.2 dB
Surface ± 0.2 mm repeatability in air and clear liquids
Detection over diffuse reflecting surfaces.
Dimensions Overall length: 330 mm
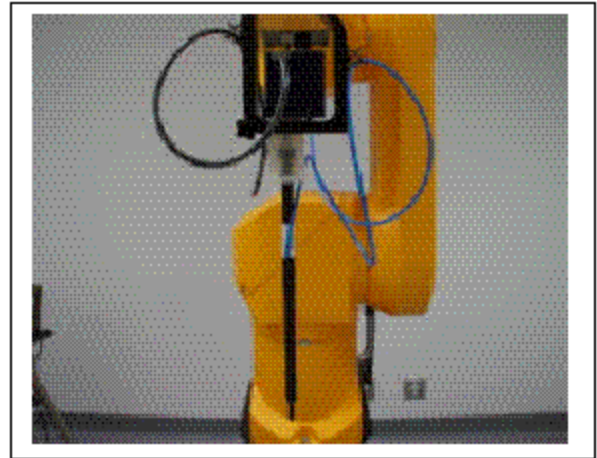Tip length: 16 mm
Body diameter: 12 mm
Tip diameter: 6.8 mm
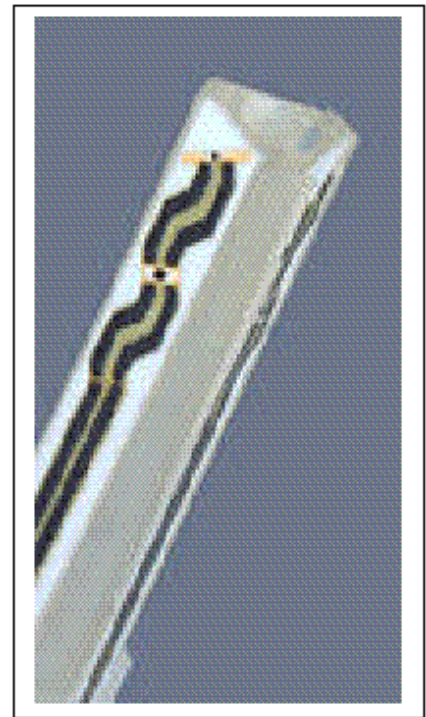Distance from probe tip to dipole centers: 2.7 mm
Application General dosimetric up to 3 GHz
Compliance tests of mobile phones
Fast automatic scanning in arbitrary phantoms

Photograph of the probe

The SAR measurements were conducted with the dosimetric probe
ET3DV6 designed in the classical triangular configuration and
optimized for dosimetric evaluation. The probe is constructed using
the thick film technique; with printed resistive lines on ceramic
substrates. The probe is equipped with an optical multi-fiber line
ending at the front of the probe tip. It is connected to the EOC box on
the robot arm and provides an automatic detection of the phantom
surface. Half of the fibers are connected to a pulsed infrared
transmitter, the other half to a synchronized receiver. As the probe
approaches the surface, the reflection from the surface produces a
coupling from the transmitting to the receiving fibers. This reflection
increases first during the approach, reaches maximum and then
decreases. If the probe is flatly touching the surface, the coupling is
zero. The distance of the coupling maximum to the surface is
independent of the surface reflectivity and largely independent of the
surface to probe angle. The DASY3 software reads the reflection
during a software approach and looks for the maximum using a 2 nd
order fitting. The approach is stopped when reaching the maximum.

**Inside view of
ET3DV6 E-field Probe**

E-Field Probe Calibration Process

Each probe is calibrated according to a dosimetric assessment procedure described in [6] with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in [7] and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, and in a waveguide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium correlates to temperature rise in dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

Data Evaluation

The DASY3 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe Parameter: -Sensitivity $\text{Norm}_i, a_{i0}, a_{i1}, a_{i2}$
                        -Conversion Factor   ConvFi
                        -Diode compression point Dcp_i
Device parameter: -Frequency   f
                        -Crest Factor   cf
Media parameter: -Conductivity   ó
                        -Density   ñ

These parameters must be set correctly in the software. They can either be found in the component documents or be imported into the software from the configuration files issued for the DASY3 components. In the direct measuring mode of the multi-meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$Vi = Ui + (Ui)^2 \; cf \, / \, dcp_i$$

With   Vi   = compensated signal of channel i (i =x, y, z)
       Ui   = input signal of channel i (i =x, y, z)
       cf   = crest factor of exciting field (DASY parameter)
       dcp_i = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:
$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

H-field probes:
$$H_i = \sqrt{Vi} \cdot \frac{a_{i0} + a_{i1}f + a_{i2}f^2}{f}$$

With   Vi   = compensated signal of channel i (i =x, y, z)
       $Norm_i$ = sensor sensitivity of channel i (i =x, y, z)
               ìV/ $(V/m)^2$ for E-field probes
       ConF = sensitivity enhancement in solution
       a_{ij} = sensor sensitivity factors for H-field probes
       f   = carrier frequency [GHz]
       Ei   = electric field strenggy of channel i in V/m
       H_i = diode compression point (DASY parameter)

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \text{Square Root } [(E_x)^2 + (E_y)^2 + (E_z)^2]$$

The primary field data are used to calculate the derived field units.

$$SAR = (E_{tot})^2 \quad ó/(ñ \quad 1000)$$

With   SAR = local specific absorption rate in mW/g
       E_{tot} = total field strength in V/m
       ó   = conductivity in [mho/m] or [Siemens/m]
       ñ   = equivalent tissue density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid.

The power flow density is calculated assuming the excitation field as a free space field.

$$P_{pwe} = (E_{tot})^2 / 3770 \text{ or } P_{pwe} = (H_{tot})2 \quad 37.7$$

With P_{pwe} = equivalent power density of a plane wave in mW/cm3
       E_{tot} = total electric filed strength in V/m
 H_{tot} = total magnetic filed strength in V/m

Generic Twin Phantom

The Generic Twin Phantom is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users [9][10]. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allows the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot.
Shell Thickness 2 ± 0.1 mm
Filling Volume Approx. 20 liters
Dimensions 810 x 1000 x 500 mm (H x L x W)
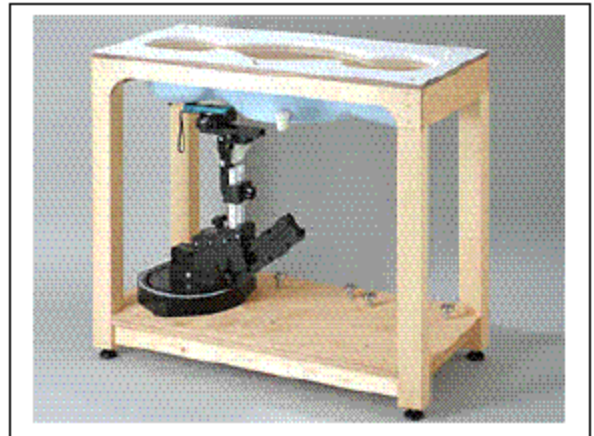
Generic Twin Phantom

Device Holder

In combination with the Generic Twin Phantom V3.0, the Mounting Device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatedly positioned according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

* Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produced infinite number of configurations [10]. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.
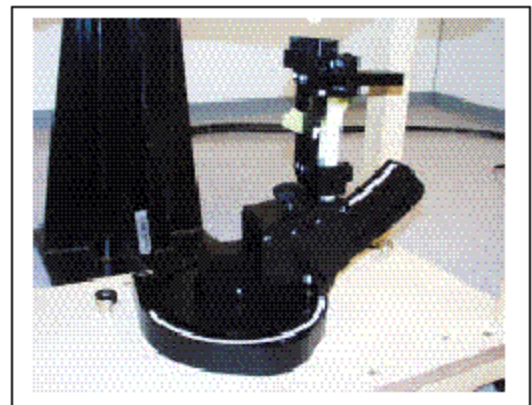
Device Holder

6.3 Measurement Uncertainty

The uncertainty budget has been determined for the DASY3 measurement system according to the NIS81 [13] and the NIST1297 [14] documents and is given in the following Table.

Measurement Uncertainty Analysis per IEEE P1528-2002								
Description	Section	Reported Variance (%)	Probability Distribution type	Divisor	Ci (1g)	Ui (1g)	Vi	welc/satt series term
Probe Calibration	E.2.1	4.80	N	1	1	4.80	1.00E+09	5.30842E-07
Axial isotropy	E.2.2	4.70	R	1.732	0.707107	1.92	1.00E+09	1.35563E-08
Hemispherical isotropy	E.2.2	9.60	R	1.732	0.707107	3.92	1.00E+09	2.35957E-07
Boundary effects	E.2.3	8.30	R	1.732	1	4.79	1.00E+09	5.27377E-07
Linearity	E.2.4	4.70	R	1.732	1	2.71	1.00E+09	5.4225E-08
System Detection Limit	E.2.5	1.00	R	1.732	1	0.58	1.00E+09	1.11124E-10
Readout Electronics	E.2.6	0.00	N	1	1	0.00	1.00E+09	0
Response time	E.2.7	0.00	R	1.732	1	0.00	1.00E+09	0
Integration time	E.2.8	0.00	R	1.732	1	0.00	1.00E+09	0
RF Ambient conditions	E.6.1	3.00	R	1.732	1	1.73	1.00E+09	9.00106E-09
Probe positioning mechanical tolerance	E.6.2	0.40	R	1.732	1	0.23	1.00E+09	2.84478E-12
Probe positioning wrt phantom shell	E.6.3	2.90	R	1.732	1	1.67	1.00E+09	7.8596E-09
Extra/inter-polation & integration algorithmsfor max SAR evaluation	E.5.2	3.90	R	1.732	1	2.25	1.00E+09	2.57079E-08
Test sample positioning	8, E.4.2	6.00	R	1.732	1	3.46	1.00E+09	1.44017E-07
Device holder distance tolerance	E.4.1	5.00	N	1	1	5.00	1.00E+09	0.000000625
Output power and SAR drift measurement	8, E.6.6.2	5.00	R	1.732	1	2.89	1.00E+09	6.94526E-08
Phantom uncertainty, shell thickness tolerance	E.3.1	4.00	R	1.732	1	2.31	1.00E+09	2.84478E-08
Liquid conductivity, deviation from target values	E.3.2	5.00	R	1.732	0.64	1.85	1.00E+09	1.16522E-08
Liquid conductivity, measurement uncertainty	E.3.3	5.00	N	1	0.64	3.20	5	20.97152
Liquid permitivity, deviation from target values	E.3.2	5.00	R	1.732	0.6	1.73	1.00E+09	9.00106E-09
Liquid permitivity, measurement uncertainty	E.3.3	5.00	N	1	0.6	3.00	5	16.2
								689
Probe isotropy sensitivity coefficient	**0.5**							
Combined Standard Uncertainty						12.65	%	
Expanded Uncertainty, 95% confidence		**k=**	**2.004**			25.34	%	

7 - EVALUATION PROCEDURE

7.1 SAR Evaluation Procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the SAR value at a fixed location above the ear point or central position was used as a reference value for assessing the power drop.

Step 2: The SAR distribution at the exposed side of the head was measured at a distance of 3.9 mm from the inner surface of the shell. The area covered the entire dimension of the head or EUT and the horizontal grid spacing was 20 mm x 20 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

Step 3: 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 under the following procedure:

1. 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 measuring point is 1.2 mm. The extrapolation was based on a least square algorithm [11]. 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.

2. The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three onedimensional splines with the "Not a knot"-condition (in x, y and z-directions) [11], [12]. The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

3. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

Step 4: Re-measurement of the SAR value at the same location as in Step 1. If the value changed by more than 5%, the evaluation was repeated.

7.2 Exposure Limits

Table 1: Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands. Wrists. Feet and Ankles
0.4	8.0	20.0

Table 2: Limits for General Population/Uncontrolled Exposure (W/kg)

Whole-Body	Partial-Body	Hands. Wrists. Feet and Ankles
0.08	1.6	4.0

Note: Whole-body SAR is averaged over the entire body, partial-body SAR is averaged over any 1 gram of tissue defined as a tissue volume in the shape of a cube SAR for hands, writs, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

Population/Uncontrolled Environments are defined as locations where there is the exposure of individual who have no knowledge or control of their exposure.

Occupational/Controlled Environments are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure (i.e. as a result of employment or occupation).

Population/uncontrolled environments Partial-body limit 1.6W/kg applied to the EUT.

7.3 Simulated Tissue Liquid Parameter Confirmation

The dielectric parameters were checked prior to assessment using the HP85070A dielectric probe kit. The dielectric parameters measured are reported in each correspondent section:

7.4 SAR Measurement

The SAR measurement was performed with the E-field probe in mechanical detection mode only. The setup and determination of the forward power into the dipole was performed using the following procedures.
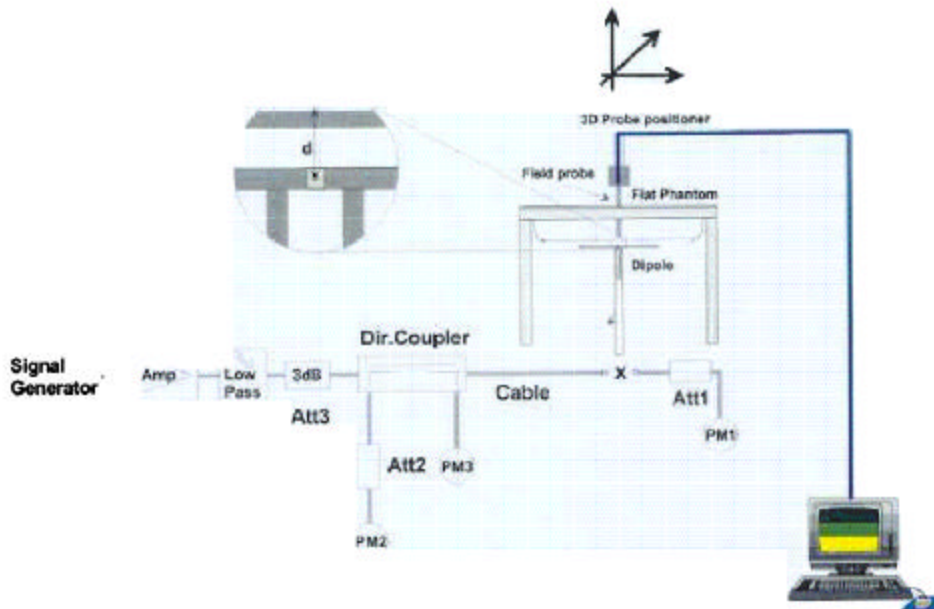
First, the power meter PM1 (including attenuator Att1) is connected to the cable to measure the forward power at the location of the dipole connector (X). The signal generator is adjusted for the desired forward power at he dipole connector (taking into account the attenuation of Att1) as read by power meter PM2. after connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter PM2. If the signal generator does not allow adjustment in 0.01dB steps, the remaining difference at PM 2 must be taken into consideration. PM3 records the reflected power from the dipole to ensure that the value is not changed form the previous value. The reflected power should be 20dB below the forward power.

The SAR measurements were performed in order to achieve repeatability and to establish an average target value.

7.5 System Accuracy Verification

Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of ±10%. The validation results are tabulated below. And also the corresponding SAR plot is attached as well in the SAR plots files.

IEEE P1528 recommended reference value for head

Frequency (MHz)	1 g SAR	10 g SAR	Local SAR at surface (above feed point)	Local SAR at surface (v=2cm offset from feed point)
300	3.0	2.0	4.4	2.1
450	4.9	3.3	7.2	3.2
835	9.5	6.2	14.1	4.9
900	10.8	6.9	16.4	5.4
1450	29.0	16.0	50.2	6.5
1800	38.1	19.8	69.5	6.8
1900	39.7	20.5	72.1	6.6
2000	41.1	21.1	74.6	6.5
2450	52.4	24.0	104.2	7.7
3000	63.8	25.7	140.2	9.5

Validation Dipole SAR Reference Test Result for Body

Validation Measurement	SAR @ 0.025W Input averaged over 1g	SAR @ 1W Input averaged over 1g	SAR @ 0.025W Input averaged over 10g	SAR @ 1W Input averaged over 10g
Test 1	0.222	8.88	0.112	4.48
Test 2	0.221	8.84	0.111	4.44
Test 3	0.222	8.88	0.112	4.48
Test 4	0.220	8.80	0.111	4.44
Test 5	0.223	8.92	0.113	4.52
Test 6	0.222	8.88	0.115	4.60
Test 7	0.221	8.84	0.114	4.56
Test 8	0.222	8.88	0.114	4.56
Test 9	0.223	8.92	0.113	4.52
Test 10	0.222	8.88	0.112	4.48
Average	0.2218	8.872	0.1127	4.51

7.6 Liquid Measurement Result

Simulant	Freq [MHz]	Parameters	Liquid Temp [ºC]	Target Value	Measured Value	Deviation	Limits [%]
Head	835	ε_r	21.0	41.5	39.6	-4.6	±5
		σ	21.0	0.90	0.90	0	±5
		1g SAR	21.0	9.5	9.81	3.26	±10
Body	835	ε_r	22.0	55.2	55.2	0	±5
		σ	22.0	0.97	0.96	-1.03	±5
		1g SAR	22.0	8.872	9.167	3.33	±10

ε_r = relative permittivity, σ = conductivity and ρ=1000kg/m^3

Liquid Forward Power for Head = 105 mW
Liquid Forward Power for Body = 120 mW

System Validation 835 MHz Head liquid (Ambient Temp = 23 Deg C, Liquid Temp = 21 Deg C, 08/11/03)
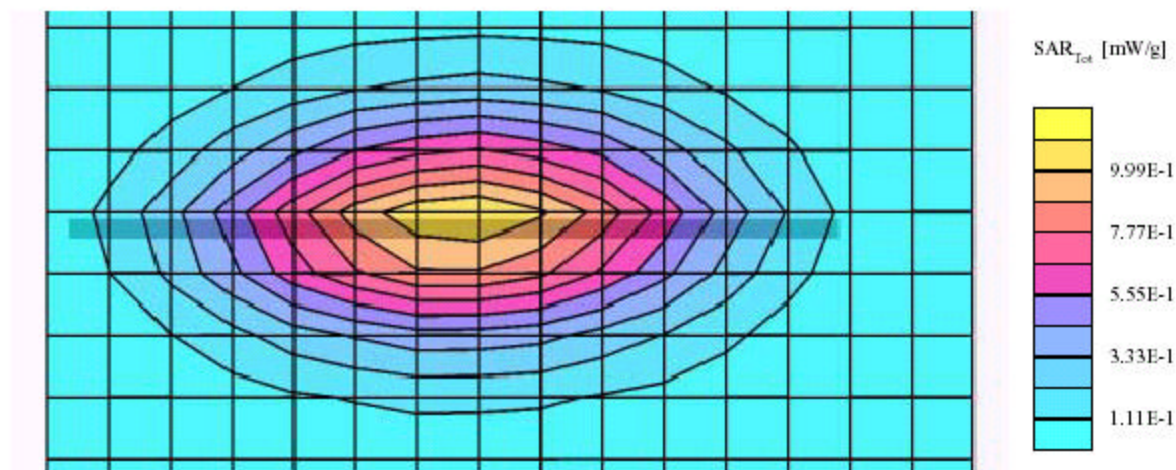
SAM Phantom; Flat Section; Position: (90°,90°); Frequency: 835 MHz

Probe: ET3DV6 - SN1604; ConvF(6.50,6.50,6.50); Crest factor: 1.0; 835 (Head) MHz: $\sigma = 0.90$ mho/m $\varepsilon_r = 39.6$ $\rho = 1.00$ g/cm^3

Cube 5x5x7: SAR (1g): 1.03 mW/g, SAR (10g): 0.646 mW/g, (Worst-case extrapolation)

Coarse: Dx = 12.0, Dy = 12.0, Dz = 10.0

Powerdrift: 0.01 dB

System Validation 835 MHz Body liquid (Ambient Temp = 23 Deg C, Liquid Temp = 22 Deg C, Forward Power = 21 dBm, 8/11/2003)

SAM Phantom; Flat Section; Position: (90°,90°); Frequency: 835 MHz
Probe: ET3DV6 - SN1604; ConvF(6.40,6.40,6.40); Crest factor: 1.0; 835 (Body) MHz: σ = 0.96 mho/m ε_r = 55.2 ρ = 1.00 g/cm³
Cube 5x5x7: SAR (1g): 1.10 mW/g, SAR (10g): 0.597 mW/g, (Worst-case extrapolation)
Coarse: Dx = 12.0, Dy = 12.0, Dz = 10.0
Powerdrift: -0.00 dB