Specific Absorption Rate (SAR) Test Report

for

BENQ Corporation

on the

Q600 Mobile Phone

Model Number: Q600

Test Report: EME-031286
Date of Report: Dec. 5, 2003
Date of test: Nov. 26, 2003

Total No of Pages Contained in this Report: 95

0597
ILAC MRA

Accredited for testing to FCC Part 15

Tested by: Kevin Chen	
Reviewed by: Elton Chen	

Review Date: Dec. 5, 2003

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STATEMENT OF COMPLIANCE

The Q600 handset supplied for Specific Absorption Rate (SAR) testing is a single band Class 0 CDMA2000 850 device.

The BENQ sample device, model # Q600 was evaluated in accordance with the requirements for compliance testing defined in FCC OET Bulletin 65, Supplement C (Edition 01-01). Testing was performed at the Intertek Testing Services facility in Hsinchu, Taiwan.

For the evaluation, the dosimetric assessment system INDEXSAR SARA2 was used. The phantom employed was the head Specific Anthropomorphic Mannequin (SAM) phantom and the box phantom of 2mm thick in one wall. The total uncertainty for the evaluation of the spatial peak SAR values averaged over a cube of 1g tissue mass had been assessed for this system to be ±29.7%.

SAR testing was performed at both the left and right ear of the phantom at the two-handset positions stated in the specification. Testing was performed at the middle frequency of each band and at the top and the bottom frequencies for the position giving greater than 0.8W/kg SAR with a fully charged battery. The sequence used accorded with the block diagram of tests given in section 1.3.1. The Q600 had a helix antenna so that the requirement for testing with antenna extended and retracted was not applicable. The Q600 was only tested the operation mode which provided by client

Any accessories supplied with Q600 have also been tested.

The device was tested at their maximum output power declared by the BENQ.

In summary, the maximum spatial peak SAR value for the sample device averaged over 1g was found to be:

Phantom	Worst Case Position	SAR_{1g}, W/kg
Head Specific Anthropomorphic Mannequin (SAM) phantom	EUT right cheek to the phantom	0.864 W/kg

In conclusion, the tested Sample device was found to be in compliance with the requirements defined in OET Bulletin 65, Supplement C (Edition 01-01) for head and body configurations.

1.0 Job Description

1.1 Client Information

The Q600 has been tested at the request of:

Company: **BENQ Corporation**
No. 157, Shan-Ying Road, Gueishan, Taoyuan 333,
Taiwan

1.2 Equipment under test (EUT)

Product Descriptions:

Equipment	**Q600 Mobile Phone**		
Trade Name	BENQ	**Model No:**	Q600
FCC ID	JVPH1222	**S/N No.**	Not Labeled
Category	Portable	**RF Exposure**	Uncontrolled Environment
Frequency Band	824.7 – 848.31 MHz	**System / Power Level**	CDMA Class 0

EUT Antenna Description			
Type	Helix	**Configuration**	Fixed
Dimensions	25 x 8 mm	**Gain**	2.51 dBi
Location	Embedded		

Use of product: **Mobile Phone Communication**

Manufacturer: BENQ

Production is planned: [X] Yes, [ ] No

EUT receive date: Nov. 25, 2003

EUT received condition: Good operating condition prototype

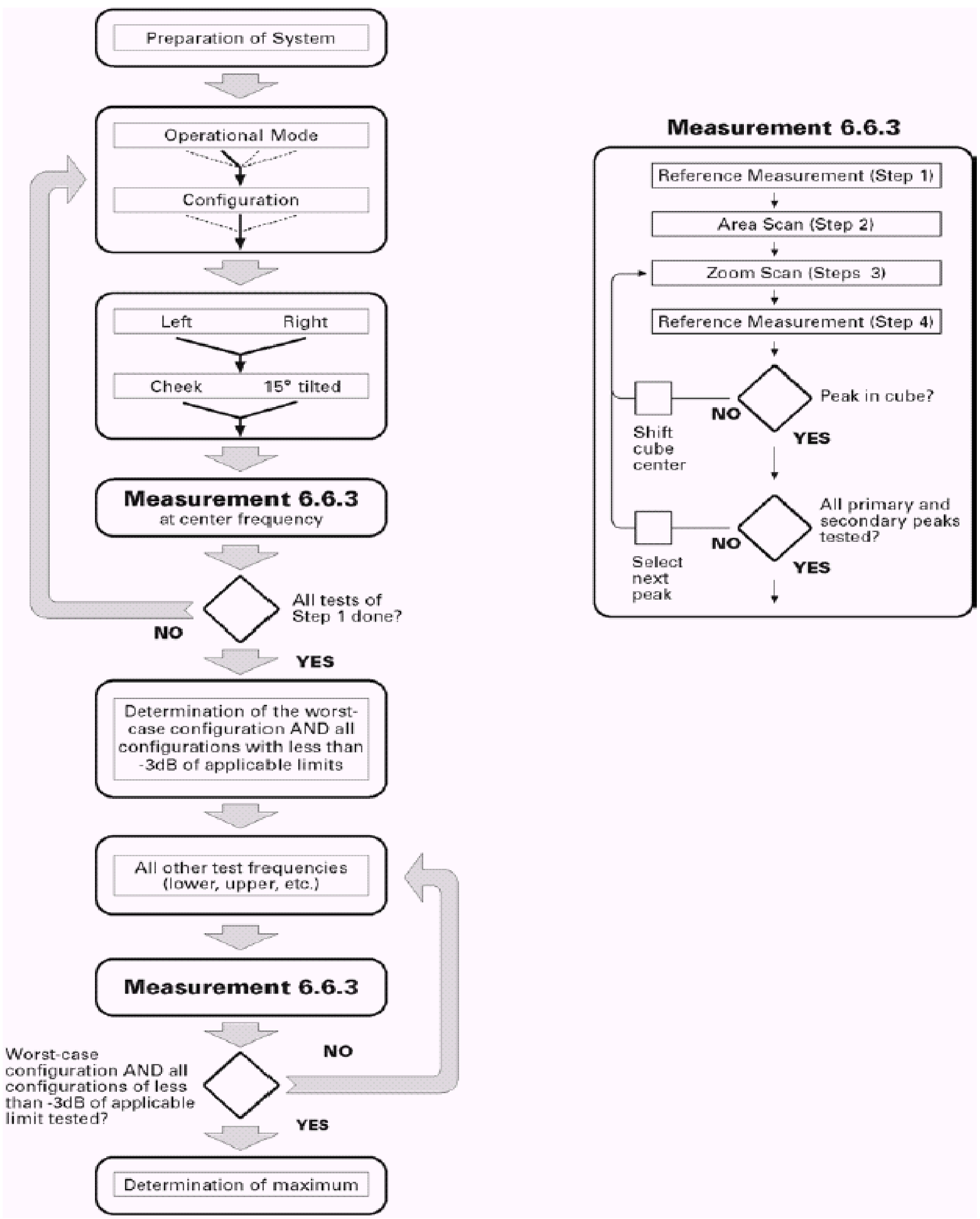
Test start date: Nov. 25, 2003

Test end date: Nov. 26, 2003

1.3 Test plan reference

FCC Rule: Part 2.1093, FCC's OET Bulletin 65, Supplement C (Edition 01-01) and IEEE 1528/D1.2

Block Diagram of the Recommended Practices and Procedures



1.4 System test configuration

1.4.1 System block diagram & Support equipment

Support Equipment			
Item #	**Equipment**	**Model No.**	**S/N**
1	N/A	N/A	N/A

1.4.2 Test Position

See the photographs as section 2.2

1.4.3 Test Condition

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

Usage	Operates with a built-in test mode by client	**Distance between antenna axis at the joint and the liquid surface:**	EUT is touching and tilting the Head Phantom in right and left position, separating the Body Phantom 15 mm in front and rear position from EUT.	
Simulating human Head/ Body	Head and Body	**EUT Battery**	Fully-charged with 3 batteries	
ERP	**Channel**	**Frequency MHz**	**Before SAR Test (dBm)**	**After SAR Test (dBm)**
	Low Channel - 1013	824.7	24.30	24.25
	Mid Channel – 384	836.52	24.14	24.22
	High Channel- 777	848.31	24.06	24.08

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

The conducted output power was measured before and after the test using a power meter and power sensor.

The EUT was transmitted continuously during the test.

1.5 Modifications required for compliance

Intertek Testing Services implemented no modifications.

1.6 Additions, deviations and exclusions from standards

The phantom employed was the upright head phantom and the box phantom of 2mm thick in vertical wall.

2.0 SAR Evaluation

2.1 SAR Limits

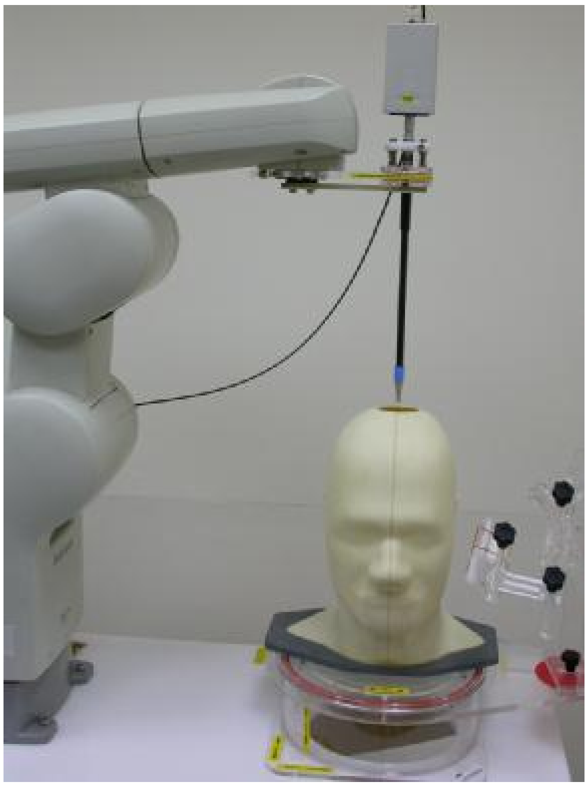
The following FCC limits for SAR apply to devices operate in General Population/Uncontrolled Exposure environment:

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

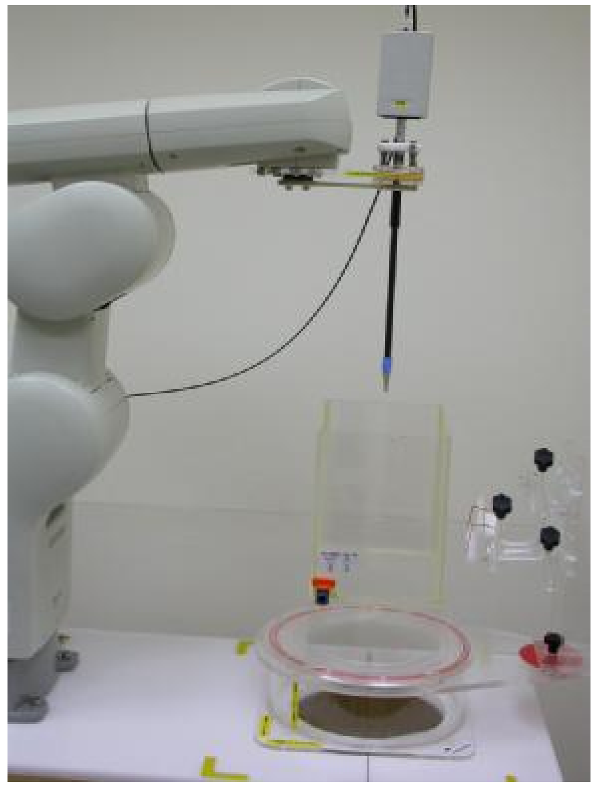
2.2 Configuration Photographs

SAR Measurement Test Setup

Test System



Head

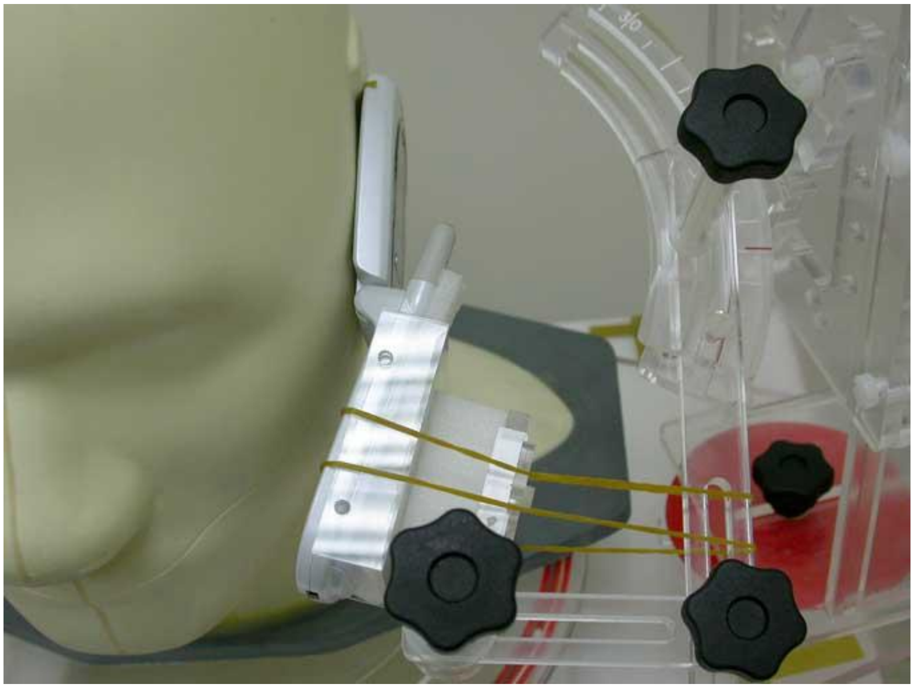


Body

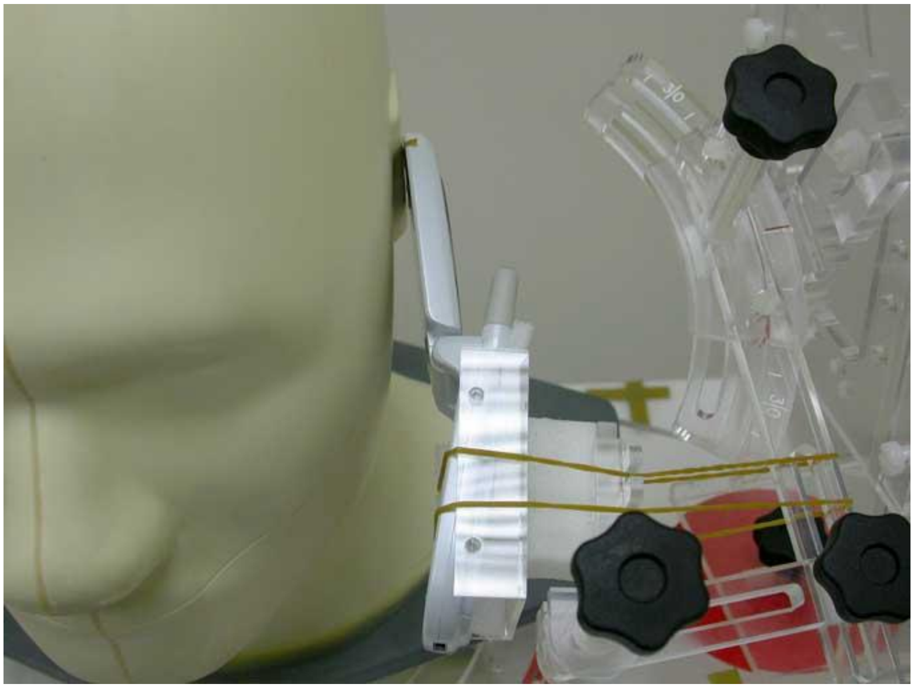
Test System: Head Simulator

SAR Measurement Test Setup

Cheek Position of Left Ear

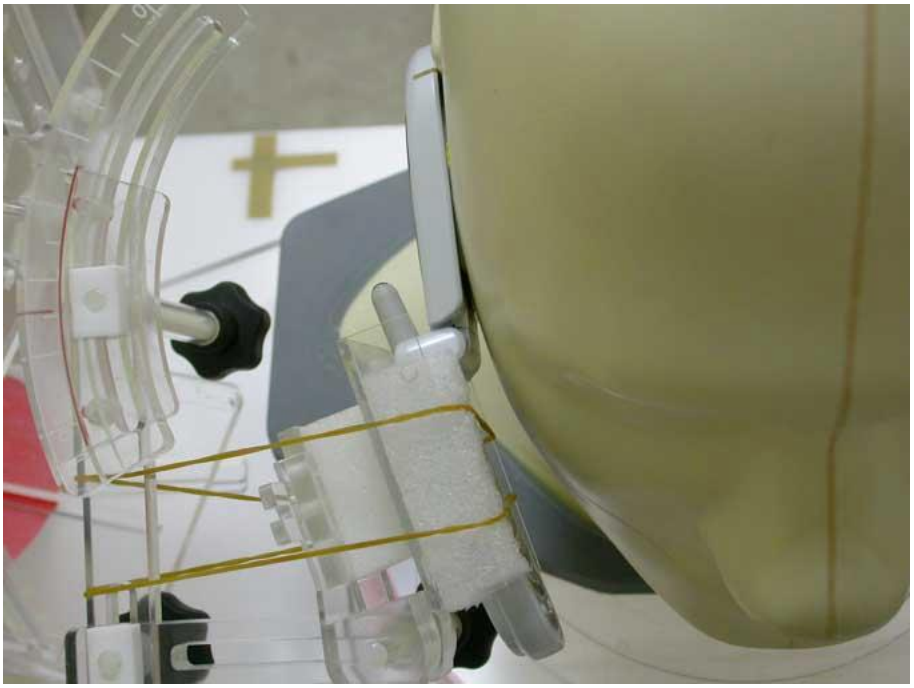


Tilt Position of Left Ear

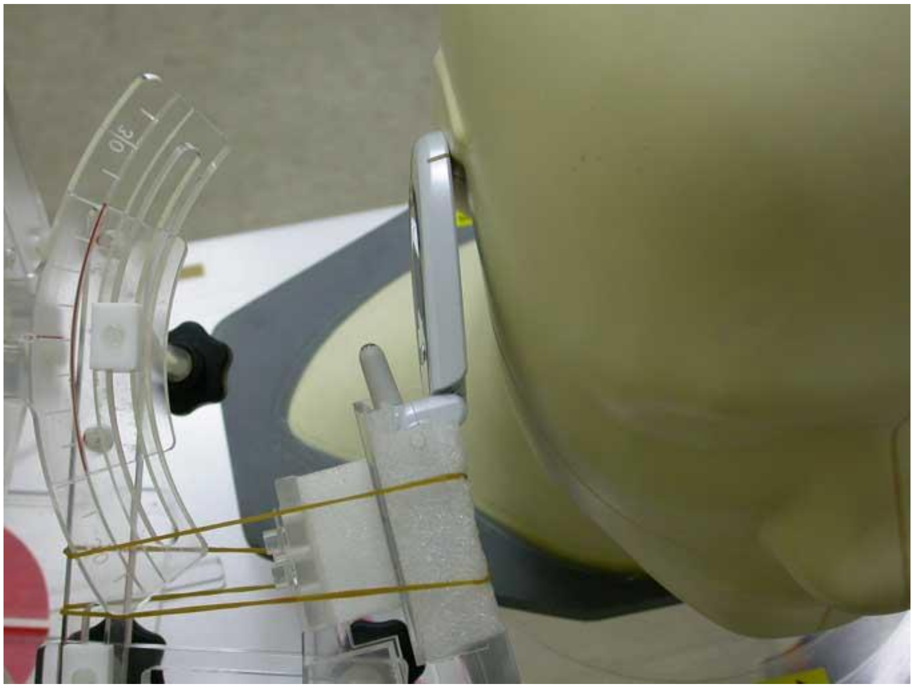


SAR Measurement Test Setup

Cheek Position of Right Ear



Tilt Position of Right Ear

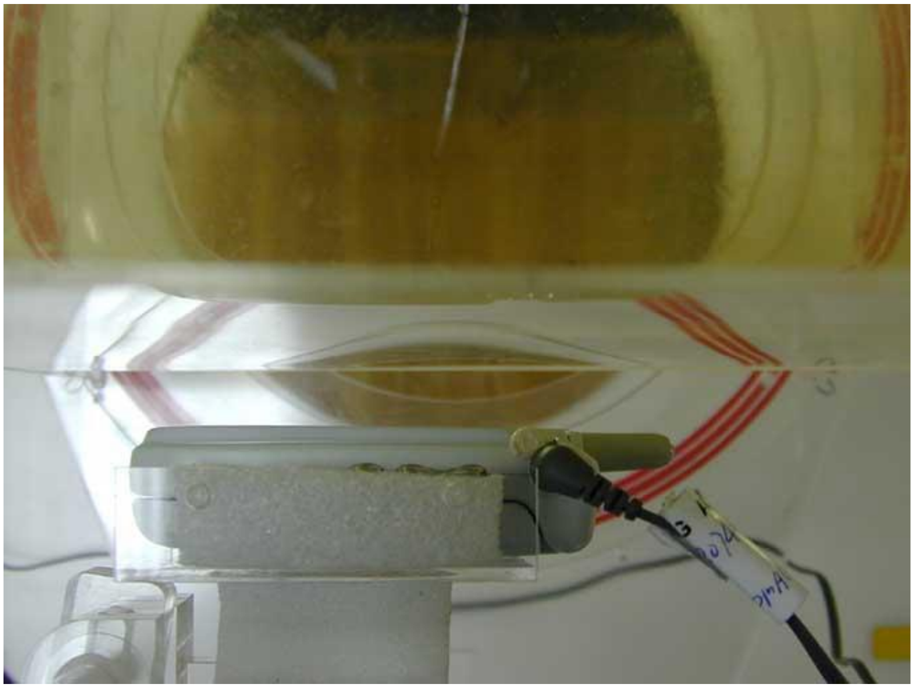


Test System: Body Simulator

SAR Measurement Test Setup

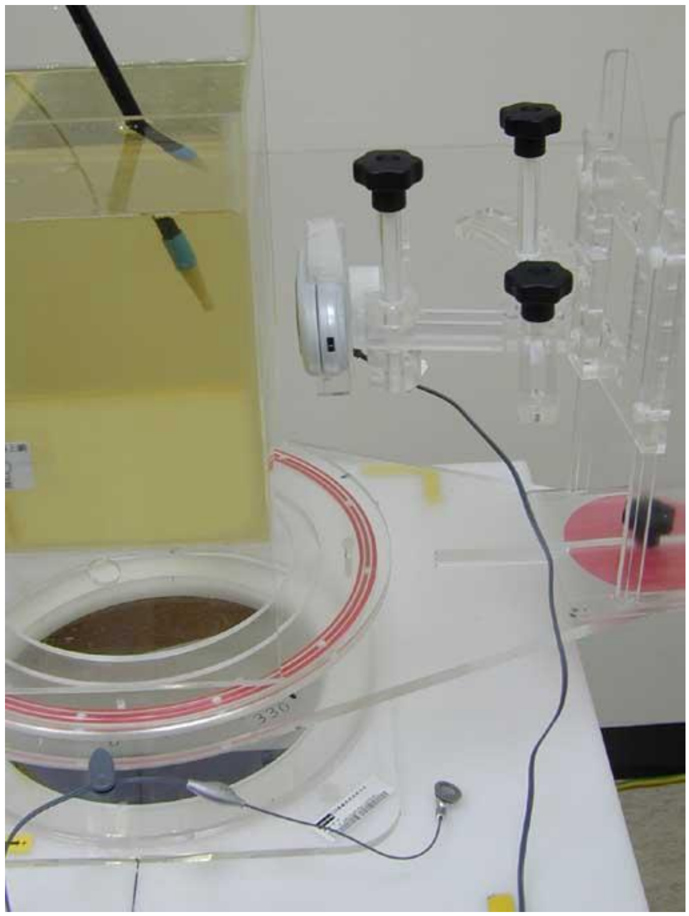
EUT rear to phantom, 15 mm separation

EUT rear to phantom, 15 mm separation– Zoom In

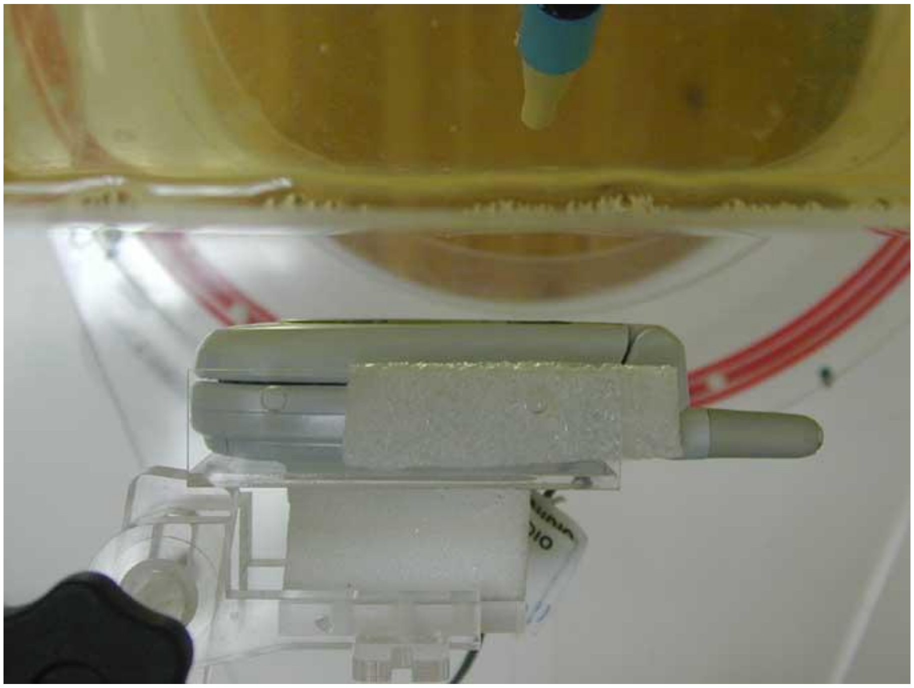


SAR Measurement Test Setup

EUT front to phantom, 15 mm separation



EUT front to phantom, 15 mm separation-zoom in



2.3 SAR measurement system

Robot system specification

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

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

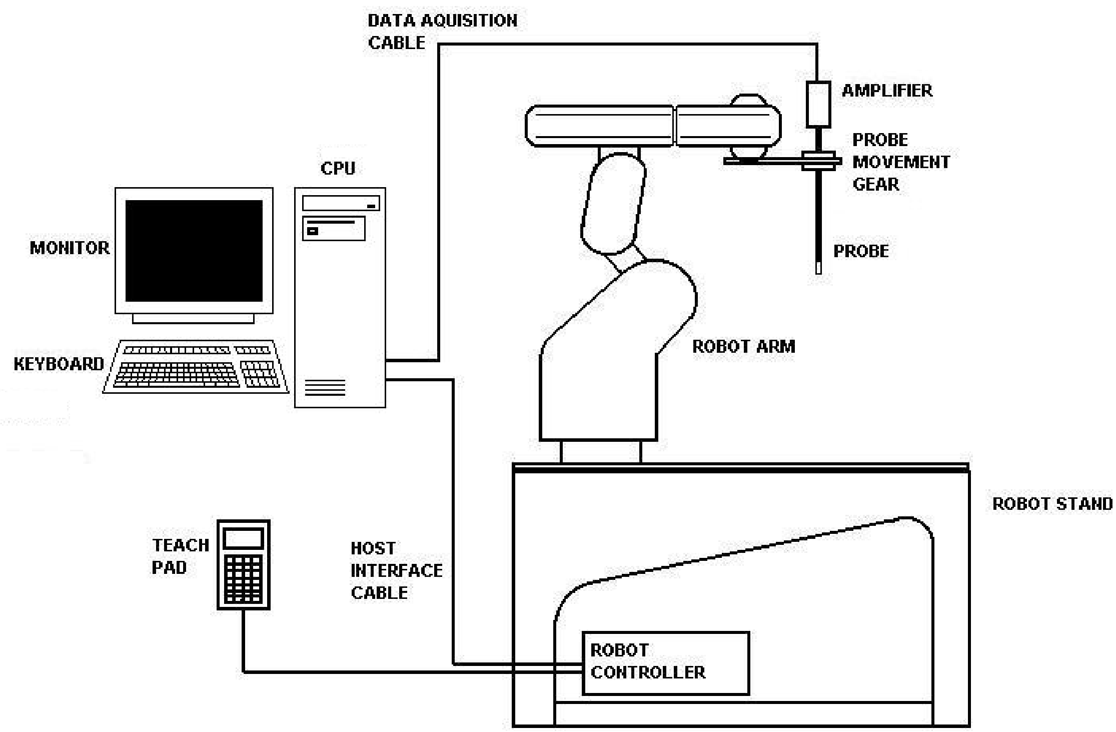


Figure 1: Schematic diagram of the SAR measurement system

The position and digitised shape of the phantom heads are made available to the software for accurate positioning of the probe and reduction of set-up time.
The SAM phantom heads are individually digitised using a Mitutoyo CMM machine to a precision of 0.02mm. The data is then converted into a shape format for the software, providing an accurate description of the phantom shell.

In operation, the system first does an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centred at that point to determine volume averaged SAR level. The first 2 measurements points in a direction perpendicular to the surface of the phantom during the zoom scan and closest to the phantom surface, were only 3.5mm and the probe is kept at greater than half a diameter from the surface.

2.4 SAR measurement system validation

Routine record keeping procedures should be established for tracking the calibration and performance of SAR measurement system. When SAR measurements are performed, the entire measurement system should be checked daily within the device transmitting frequency ranges to verify system accuracy. A flat phantom irradiated by a half-wavelength dipole is typically used to verify the measurement accuracy of a system. When a radiating source is not available at the operating frequency range of the test device to verify system accuracy, a source operating within 100 MHz of the mid-band channel of each operating mode may be used. The measured one-gram SAR should be within 10% of the expected target values specified for the specific phantom and RF source used in the system verification measurement.

Procedures

The SAR evaluation was performed with the following procedures:

a. The SAR distribution was measured at the exposed side of the bottom of the box phantom and was measured at a distance of 15 mm for 900 MHz from the inner surface of the shell. The feed power was 1/4W.

b. The dimension for this cube is 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 5 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.

2.4.1 System Validation result

System Validation (900 MHz Head)				
Frequency MHz	**Operating Mode**	**Target SAR_{1g} (mW/g)**	**Measured SAR_{1g} (mW/g)**	**Deviation (±10%)**
900	CW	10.8	10.512	-2.67

Date / Time:	2003/11/12	**Position:**	bottom of box phantom
Filename:	900system validation	**Phantom:**	HeadBox1-val..csv
Device Tested:	900MHz system validation	**Head Rotation:**	0
Antenna:	900MHz dipole	**Test Frequency:**	900MHz
Shape File:	none.csv	**Power Level:**	24dBm

Probe: 0136

Cal File: SN0136_900_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.261	.261	.261

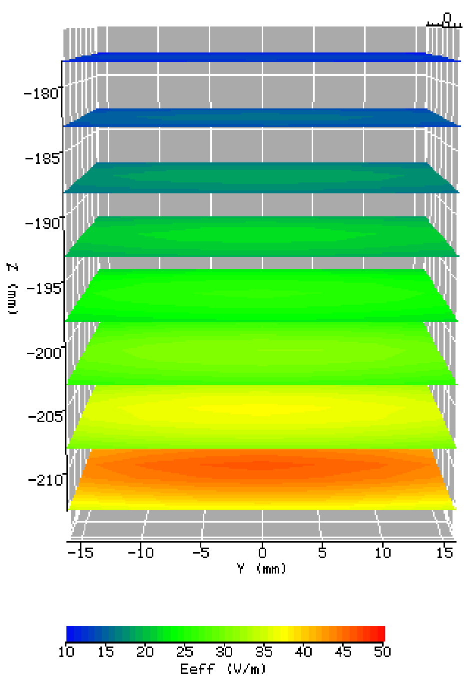
Amp Gain: 2

Averaging: 1

Batteries Replaced: -

Liquid:	15.5cm
Type:	900MHz Head
Conductivity:	0.9855
Relative Permittivity:	41.395
Liquid Temp (deg C):	21.9
Ambient Temp (deg C):	22
Ambient RH (%):	45
Density (kg/m3):	1000
Software Version:	VPM2.0

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):	**Start Scan**	**End Scan**
	0.550	0.552

Change during Scan (%) 0.43

Max E-field (V/m): 46.11

Max SAR (W/kg)	**1g**	**10g**
	2.628	1.697

Location of Max (mm):	**X**	**Y**	**Z**
	1.3	0.0	-221.0

Normalized to an input power of 1W
Averaged over 1 cm^3 (1g) of tissue

10.512W/kg

2.4.2 System Performance Check result

System performance check (900 MHz Head)				
Frequency MHz	**Operating Mode**	**Target SAR_{1g} (mW/g)**	**Measured SAR_{1g} (mW/g)**	**Deviation (±10%)**
900	CW	10.8	10.136	-6.148

Date / Time:	2003/11/25	**Position:**	bottom of box phantom
Filename:	900performance check	**Phantom:**	HeadBox1-val..csv
Device Tested:	900 performance check	**Head Rotation:**	0
Antenna:	900 dipole	**Test Frequency:**	900MHz
Shape File:	none.csv	**Power Level:**	24dBm

Probe: 0136

Cal File: SN0136_900_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.261	.261	.261

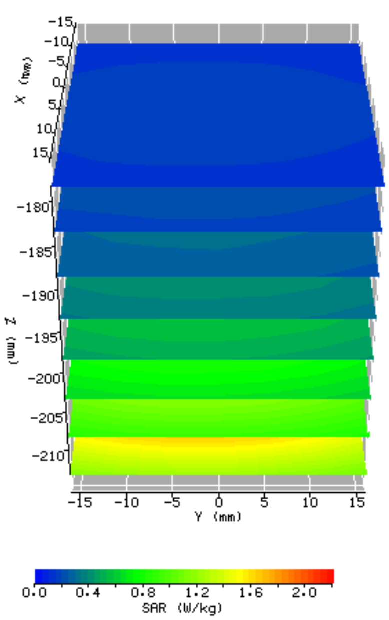
Amp Gain: 2

Averaging: 1

Batteries Replaced: -

Liquid:	15.5cm
Type:	900MHz Head
Conductivity:	0.96641
Relative Permittivity:	40.42005
Liquid Temp (deg C):	22
Ambient Temp (deg C):	22
Ambient RH (%):	45
Density (kg/m3):	1000
Software Version:	VPM2.0

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):	**Start Scan**	**End Scan**
	0.538	0.536

Change during Scan (%) -0.34

Max E-field (V/m): 45.76

Max SAR (W/kg)	**1g**	**10g**
	2.534	1.646

Location of Max (mm):	**X**	**Y**	**Z**
	0.0	-2.7	-221.3

Normalized to an input power of 1W
Averaged over 1 cm^3 (1g) of tissue
10.136W/kg

2.5 Test Result

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

Measurement Results

Trade Name:	BENQ	**Model No.:**	Q600
Serial No.:	Not Labled	**Test Engineer:**	Kevin Chen
TEST CONDITIONS			
Ambient Temperature	22 °C	**Relative Humidity**	50 %
Test Signal Source	Test Mode	**Signal Modulation**	CDMA
Output Power Before SAR Test	See page 7	**Output Power After SAR Test**	See page 7
Test Duration	22 min. each scan	**Number of Battery Change**	3

EUT Position						
Channel (MHz)	**Operating Mode**	**Crest Factor**	**Description**	**Degree / Distance**	**Measured SAR_{1g} (mW/g)**	**Plot Number**
384	CDMA	1	Right Cheek	0°	0.853	1
384	CDMA	1	Right Tilt	15°	0.330	2
384	CDMA	1	Left Cheek	0°	0.864	3
384	CDMA	1	Left Tilt	15°	0.366	4
1013	CDMA	1	Right Cheek	0°	0.775	5
1013	CDMA	1	Left Cheek	0°	0.764	6
777	CDMA	1	Right Cheek	0°	0.652	7
777	CDMA	1	Left Cheek	0°	0.595	8
384	CDMA	1	Front to box phantom	15 mm	0.297	9
384	CDMA	1	Rear to box phantom	15 mm	0.602	10
1013	CDMA	1	Front to box phantom	15 mm	0.222	11
1013	CDMA	1	Rear to box phantom	15 mm	0.401	12
777	CDMA	1	Front to box phantom	15 mm	0.205	13
777	CDMA	1	Rear to box phantom	15 mm	0.516	14

Note: 1. Configuration at middle channel with more than –3dB of applicable limit.

3.0 Test Equipment

3.1 Equipment List

The Specific Absorption Rate (SAR) tests were performed with the INDEXSAR SARA2 SYSTEM.

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

SAR Measurement System			
EQUIPMENT	**SPECIFICATIONS**	S/N #	LAST CAL. DATE
Balanced Validation Dipole Antenna	**900MHz**	0022	09/29/2003
Balanced Validation Dipole Antenna	**1800MHz**	0012	09/29/2003
Controller	**Mitsubishi CR-E116**	F1008007	N/A
Robot	**Mitsubishi RV-E2**	EA009002	N/A
	Repeatability: ± 0.04mm; Number of Axes: 6		
E-Field Probe	**IXP-050**	0136	09/10/2003
	Frequency Range: Probe outer diameter: 5.2 mm; Length: 350 mm; Distance between the probe tip and the dipole center: 2.7 mm		
Data Acquisition	**SARA2**	N/A	N/A
	Processor: Pentium 4; Clock speed: 1.5GHz; OS: Windows XP; I/O: two RS232; Software: SARA2 ver. VPM2.0		
Phantom	**Upright Head Specific Anthropomorphic Mannequin (SAM) phantom, 2mm wall thickness box phantom**	N/A	N/A
	The head and body phantom shell should be made of low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna should be within 2.0 ± 0.2 mm. The phantom should be filled with the required head or body equivalent tissue medium to a depth of 15.0 ± 0.5 cm. Body capacity: 152.5 x 215.5 x 200 (W x L x D) mm^3.		
Device holder	Material: clear Perspex; Dielectric constant: less than 2.85 above 500MHz	N/A	N/A
Simulated Tissue	**Mixture**	N/A	11/25/2003
	Please see section 3.2 for details		
RF Power Meter	**Boonton 4231A with 51011-EMC power sensor**	79401-32482	03/21/2003
	Frequency Range: 0.03 to 8 GHz, <24dBm		
RF Power Amplifier	**INDEXSAR VTL5400**	0302	01/23/2003
	10MHz to 2.5GHz, Gain >30dB		
Directional Coupler	**INDEXSAR VDC0830-20**	0302	05/19/2003
	0.8 to 3 GHz, Max. Power<500W		
Vector Network Analyzer	**HP 8753B** **HP 85046A**	2807J04037 2729A01958	07/04/2003
	300k to 3GHz		
Signal Generator	**R&S SMR27**	100036	09/19/2003
	10M to 27GHz, <120dBuV		

3.2 Tissue Simulating Liquid

3.2.1 Head Tissue Simulating Liquid

For head evaluation test

Head Ingredients Frequency (835 MHz)	
Water	41.45%
Salt	1.45%
Sugar	56.0%
HEC (Hydroxyethyl Cellulose)	1.0%
Bactericide	0.1%

For system performance check

Head Ingredients Frequency (900 MHz)	
Water	40.92%
Salt	1.48%
Sugar	56.5%
HEC (Hydroxyethyl Cellulose)	1.0%
Bactericide	0.1%

The dielectric parameters were verified prior to assessment using the HP 85046A dielectric probe kit and the HP 8753B network Analyzer. The dielectric parameters were:

Frequency (MHz)	Temp. (℃)	e_r / Relative Permittivity			s / Conductivity (mho/m)			r *(kg/m^3)
		measured	target	Δ(±5%)	measured	target	Δ(±5%)	
835	22.0	51.15	41.5	-2.9%	1.952	0.90	0.10%	1000
900	22.6	40.42	41.5	-2.6%	0.966	0.97	-0.41%	1000

* *Worst-case assumption*

3.2.2 Body Tissue Simulating Liquid for body evaluation test

Body Ingredients Frequency (835 MHz)	
Water	52.4%
Salt	1.4%
Sugar	45.0%
HEC (Hydroxyethyl Cellulose)	1.0%
Bactericide	0.1%

The dielectric parameters were verified prior to assessment using the HP 85046A dielectric probe kit and the HP 8753B network Analyzer. The dielectric parameters were:

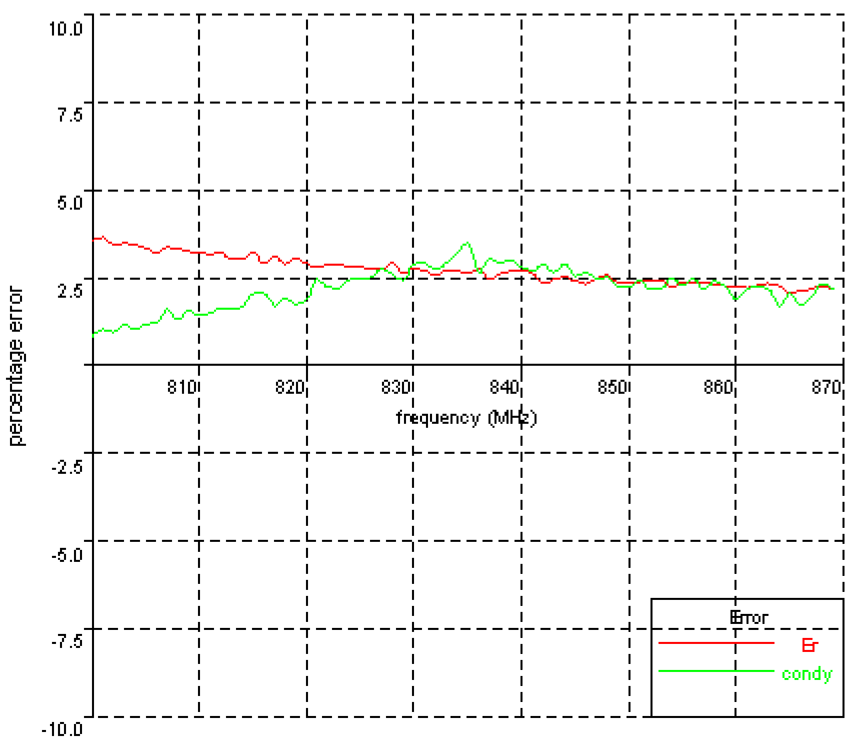
Frequency (MHz)	**Temp. (℃)**	e r / **Relative Permittivity**			s / **Conductivity (mho/m)**			r ***(kg/m³)**
		measured	target	Δ(±5%)	measured	target	Δ(±5%)	
835	23.1	55.393	55.2	-0.350%	0.957	0.97	-1.34	1000

* *Worst-case assumption*

3.2.3 Head liquid test result

For head evaluation test

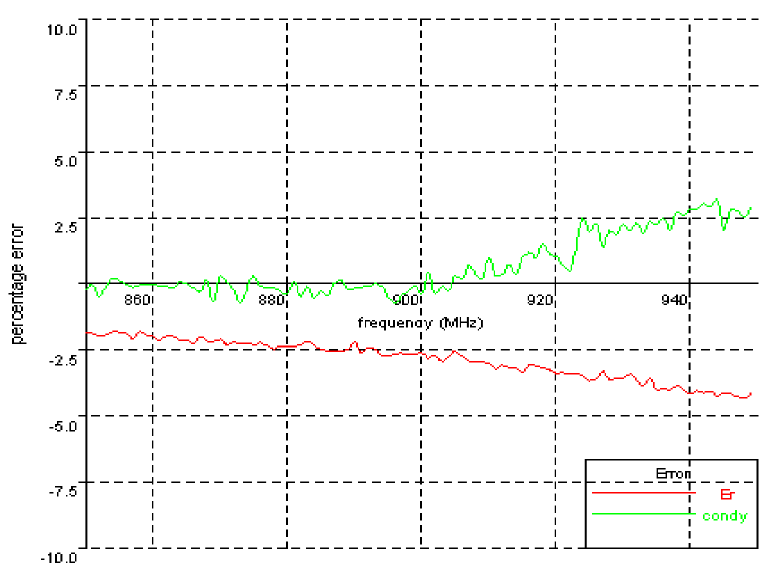
Date: 25 Nov. 2003	Temperature:22.0℃	Type: 835MHz/head (FCC)	Tested by: Kevin
800, 43.1589109993, -0.9048460934		**835, 42.6022824728, -0.9313092193**	
801, 43.2012472011, -0.9065312691		836, 42.6425183369, -0.9247223766	
802, 43.1152603042, -0.9060606583		837, 42.5272174104, -0.9297649215	
803, 43.1204988084, -0.9080472087		838, 42.5830769441, -0.9298034664	
804, 43.0941316927, -0.907019628		839, 42.6248482886, -0.9315618132	
805, 43.0533841765, -0.9083243138		840, 42.6217409372, -0.9306776162	
806, 42.9889412756, -0.9085496837		841, 42.5956787996, -0.9309836882	
807, 43.0485454086, -0.9121340466		842, 42.4732793158, -0.9338404609	
808, 43.0326792317, -0.9098584794		843, 42.5185587198, -0.9327299541	
809, 42.9883331626, -0.912103537		844, 42.5519935501, -0.9361044395	
810, 42.9731156253, -0.9111772934		845, 42.5039070107, -0.9340728868	
811, 42.948403986, -0.9114395792		846, 42.4688769213, -0.9362093858	
812, 42.9569231235, -0.9129662904		847, 42.538263993, -0.9354896529	
813, 42.8752530938, -0.9126780322		848, 42.5694624119, -0.9371214468	
814, 42.8736902908, -0.9135748285		849, 42.4851975723, -0.9357237844	
815, 42.947391569, -0.9168149918		850, 42.4700546355, -0.9366779651	
816, 42.8118463801, -0.9171833873		851, 42.4908683605, -0.9395061497	
817, 42.8870045779, -0.9139157897		852, 42.5013631997, -0.938445543	
818, 42.7921709806, -0.9157873392		853, 42.5049777524, -0.9395470049	
819, 42.8508931378, -0.914553664		854, 42.4355600502, -0.943491147	
820, 42.7894046941, -0.9158149693		855, 42.482347668, -0.9426940341	
821, 42.7383886494, -0.92105801		856, 42.489057943, -0.9455338859	
822, 42.7608925141, -0.9190087564		857, 42.489057943, -0.9437998734	
823, 42.7519351617, -0.9189426501		858, 42.451358205, -0.9469639578	
824, 42.7376318036, -0.9211457185		859, 42.444653201, -0.9468682742	
825, 42.718765907, -0.921313202		860, 42.4374326136, -0.9445156409	
826, 42.6942534328, -0.9218759828		861, 42.4202454534, -0.948317883	
827, 42.6906220974, -0.9240921154		862, 42.4498100759, -0.9499192135	
828, 42.7534483502, -0.9227751184		863, 42.4706138795, -0.9504858956	
829, 42.6290416274, -0.9215034154		864, 42.438704785, -0.9468524379	
830, 42.6729315995, -0.9257067891		865, 42.3678509532, -0.9514640007	
831, 42.6468381601, -0.9260244925		866, 42.3865548664, -0.949672967	
832, 42.5912830379, -0.9244061551		867, 42.40619444, -0.952599566	
833, 42.6404380545, -0.9263125343		868, 42.4357492697, -0.9573767724	
834, 42.6231686771, -0.9289059515		869, 42.4033873042, -0.9572102156	
		870, 42.3461427313, -0.9530972696	



For system performance check

Date: 25 Nov. 2003	Temperature:22.6℃	Type: 900MHz/head (FCC)	Tested by: Kevin

850, 40.7319844067, -0.9141880979	**900, 40.4200478584, -0.9664132872**
851, 40.7135586659, -0.9170352802	901, 40.3336095154, -0.9750356299
852, 40.6891585247, -0.9138703208	902, 40.3785692354, -0.9674981873
853, 40.69756251, -0.9183027276	903, 40.283734859, -0.9708841453
854, 40.7445822936, -0.9223481786	904, 40.3510225137, -0.9702186986
855, 40.7376509183, -0.9229084309	905, 40.4444488743, -0.9762950886
856, 40.7211521697, -0.9225124544	906, 40.3666227335, -0.9759713953
857, 40.6361490875, -0.9225363506	907, 40.287305656, -0.9816003688
858, 40.7424459019, -0.9244514341	908, 40.2758822224, -0.9789423415
859, 40.698976488, -0.9255288833	909, 40.2822439764, -0.9779640409
860, 40.6724336935, -0.9266401074	910, 40.2426883321, -0.9862207029
861, 40.6111105497, -0.9274207365	911, 40.1672035085, -0.9805439722
862, 40.6789450341, -0.9280880086	912, 40.2199631621, -0.9813419726
863, 40.6824045982, -0.9286416671	913, 40.1937327674, -0.9857500648
864, 40.6190913855, -0.9319382758	914, 40.1823358663, -0.9829898668
865, 40.6205719513, -0.9325257206	915, 40.1035523812, -0.9896717696
866, 40.5672128002, -0.9321961604	916, 40.2296349421, -0.9922114342
867, 40.6596576164, -0.9317484099	917, 40.2148077163, -0.9903161222
868, 40.6018069911, -0.9370549492	918, 40.180199593, -0.9961396332
869, 40.5858070602, -0.930167454	919, 40.1521154975, -0.9931030999
870, 40.6356600671, -0.9403735906	920, 40.089949002, -0.9923550742
871, 40.5458047401, -0.9396200526	921, 40.0914102806, -0.9894840071
872, 40.587549855, -0.9378780382	922, 40.0652637247, -0.9878680054
873, 40.5540991536, -0.9343497303	923, 40.074671585, -0.9971559883
874, 40.5739739071, -0.9404025582	924, 40.0401840603, -1.0082051773
875, 40.5405343944, -0.9458990425	925, 39.960051917, -1.0035565477
876, 40.5753716253, -0.9434943648	926, 40.0091362863, -1.0066970361
877, 40.5289640436, -0.9438273349	927, 40.105334323, -0.9985169486
878, 40.4791675635, -0.9449035348	928, 39.9674229346, -1.0054477955
879, 40.518875104, -0.9446682277	929, 40.0003096689, -1.0038828796
880, 40.5223210549, -0.9447338923	930, 39.9939917971, -1.0084945441
881, 40.5093543631, -0.9503790752	931, 40.0642031195, -1.00639264
882, 40.549091515, -0.9460125039	932, 39.9573301864, -1.0097694574
883, 40.5844294156, -0.9509154426	933, 39.8562333049, -1.0062261744
884, 40.5360422721, -0.9476277847	934, 39.9732797723, -1.0111303026
885, 40.4713152949, -0.9512160593	935, 39.7900154084, -1.0103510609
886, 40.4500091389, -0.9510399512	936, 39.8124179193, -1.0134042422
887, 40.454923815, -0.9560105287	937, 39.7948433151, -1.0089300428
888, 40.4534492331, -0.958582168	938, 39.8666420945, -1.0162094485
889, 40.4732746601, -0.9562105969	939, 39.7904122225, -1.0157960479
890, 40.5755198864, -0.9577437147	940, 39.7254278576, -1.0183743353
891, 40.4276404386, -0.9591265683	941, 39.7805071318, -1.0188838783
892, 40.5035336329, -0.9604401901	942, 39.7380640411, -1.0212195072
893, 40.4790846406, -0.9626238049	943, 39.765759328, -1.0203860285
894, 40.3793789201, -0.9625527892	944, 39.6881043054, -1.0237585012
895, 40.3630252717, -0.9599535165	945, 39.7337928328, -1.0124307118
896, 40.4026188839, -0.958935981	946, 39.7143224803, -1.0207054096
897, 40.4125979453, -0.9625992967	947, 39.668899713, -1.0207810256
898, 40.3913227011, -0.9649733864	948, 39.6430287072, -1.018559614
899, 40.3913227011, -0.9678614902	949, 39.7111763723, -1.0223012222
	950, 39.6590118025, -1.0260928353



3.2.4 Body liquid test result

<table>
<tr><td>Date: 25 Nov. 2003</td><td>Temperature:23.1℃</td><td>Type:835MHz/Body (FCC)</td><td>Tested by: Clay</td></tr>
<tr><td colspan="2">800, 55.7950056327, -0.937121643
801, 55.7771518518, -0.9367606563
802, 55.7504295571, -0.9368599784
803, 55.7641993814, -0.9377963372
804, 55.7785825389, -0.9381208197
805, 55.7139740318, -0.9396235224
806, 55.7145832641, -0.9391299137
807, 55.7199308335, -0.9386009061
808, 55.7287320433, -0.9429857422
809, 55.7081923964, -0.9400525781
810, 55.6423822561, -0.9427523593
811, 55.6370412273, -0.9443226306
812, 55.5932136113, -0.943151816
813, 55.56043482, -0.9438861584
814, 55.5557091589, -0.9460891182
815, 55.5624591776, -0.9436459709
816, 55.5869880454, -0.9471560978
817, 55.5099222011, -0.9459365322
818, 55.5303795635, -0.9453523032
819, 55.5487517686, -0.9468107891
820, 55.535025142, -0.9468826208
821, 55.5000204284, -0.9480131661
822, 55.4807784146, -0.9504734985
823, 55.4728242828, -0.9505336002
824, 55.476328707, -0.9516781553
825, 55.5029096161, -0.9520374054
826, 55.4837335032, -0.9525905766
827, 55.4700229432, -0.9526067245
828, 55.4353273893, -0.9546941846
829, 55.4341150187, -0.9533460824
830, 55.404325832, -0.952821459
831, 55.4367978895, -0.9556685575
832, 55.3890900017, -0.9555268747
833, 55.4481385381, -0.9572990265
834, 55.4222475455, -0.9571787613</td><td colspan="2">835, 55.3930704593, -0.9573854172
836, 55.4026276809, -0.9570118906
837, 55.3680696873, -0.9596048505
838, 55.3774208645, -0.9595603983
839, 55.3413051774, -0.960164695
840, 55.4247691445, -0.9595875605
841, 55.3858179182, -0.9636332938
842, 55.3613686665, -0.9614264527
843, 55.3157419505, -0.9639848665
844, 55.2980415286, -0.9648195532
845, 55.3116996173, -0.9643851265
846, 55.350248888, -0.9662386788
847, 55.3147557819, -0.9654083917
848, 55.3424696015, -0.9653958135
849, 55.396757115, -0.9689406334
850, 55.3669880037, -0.9677789206
851, 55.3255989328, -0.9698325813
852, 55.3370259452, -0.9691862541
853, 55.3045996915, -0.9703591649
854, 55.3147465222, -0.9707456116
855, 55.3757341754, -0.9738288084
856, 55.2777740328, -0.9733293818
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862, 55.3054231145, -0.9762572775
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866, 55.3137348167, -0.984291667
867, 55.2628430679, -0.9840034722
868, 55.2752835661, -0.9838658639
869, 55.3100408023, -0.9829299266
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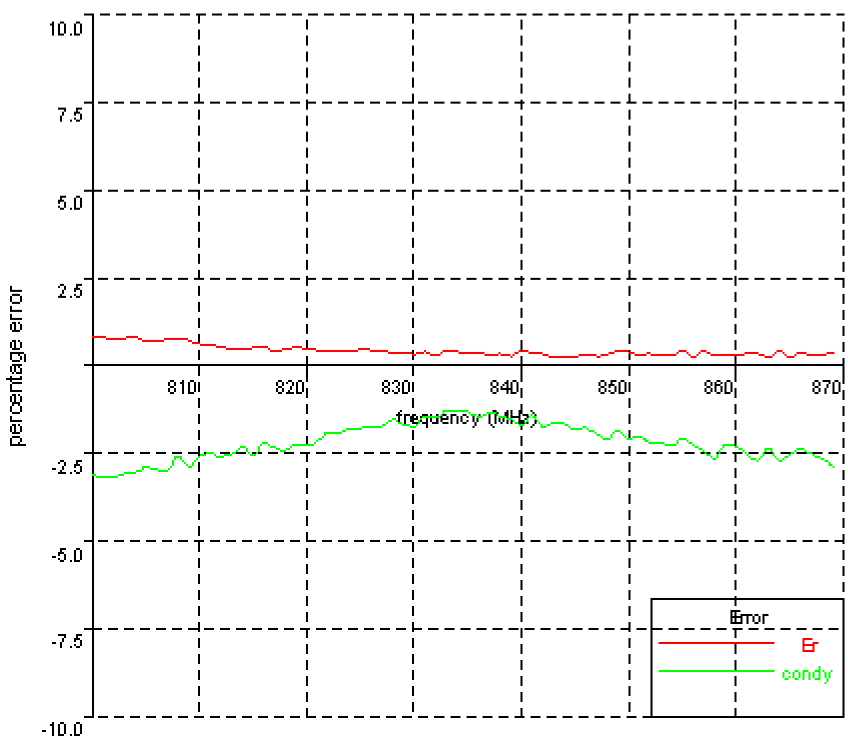


3.3 E-Field Probe and 900 Balanced Dipole Antenna Calibration

Probe calibration factors and dipole antenna calibration are included in Appendix C.

4.0 Measurement Uncertainty

The uncertainty budget has been determined for the INDEXSAR SARA2 measurement system according to IEEE P1528 documents [3] and is given in the following table. The extended uncertainty (95% confidence level) was assessed to be 29.7 %

Table 1 Exposure Assessment Uncertainty

Example of measurement uncertainty assessment SAR measurement

(blue entries are site-specific)

a	b			c	d	e		f	g	h	I
Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1 (1g)	c1 (10g)	Standard Uncertainty (%) 1g	Standard Uncertainty (%) 10g
		(dB)		(%)							
Measurement System											
Probe Calibration	E2.1			2.5	N	1 or k	1	1	1	2.50	2.50
Axial Isotropy	E2.2	0.25	5.93	5.93	R	√3	1.73	0	0	0.00	0.00
Hemispherical Isotropy	E2.2	0.45	10.92	10.92	R	√3	1.73	1	1	6.30	6.30
Boundary effect	E2.3		4	4.00	R	√3	1.73	1	1	2.31	2.31
Linearity	E2.4	0.04	0.93	0.93	R	√3	1.73	1	1	0.53	0.53
System Detection Limits	E2.5		1	1.00	R	√3	1.73	1	1	0.58	0.58
Readout Electronics	E2.6		1	1.00	N	1 or k	1.00	1	1	1.00	1.00
Response time	E2.7		0	0.00	R	√3	1.73	1	1	0.00	0.00
Integration time	E2.8		1.4	1.40	R	√3	1.73	1	1	0.81	0.81
RF Ambient Conditions	E6.1		3	3.00	R	√3	1.73	1	1	1.73	1.73
Probe Positioner Mechanical Tolerance	E6.2		0.6	0.60	R	√3	1.73	1	1	0.35	0.35
Probe Position wrt. Phantom Shell	E6.3		3	3.00	R	√3	1.73	1	1	1.73	1.73
SAR Evaluation Algorithms	E5		8	8.00	R	√3	1.73	1	1	4.62	4.62
Test Sample Related											
Test Sample Positioning	E4.2		2	2.00	N	1	1.00	1	1	2.00	2.00
Device Holder Uncertainty	E4.1		2	2.00	N	1	1.00	1	1	2.00	2.00
Output Power Variation	6.6.2		5	5.00	R	√3	1.73	1	1	2.89	2.89
Phantom and Tissue Parameters											
Phantom Uncertainty (shape and thickness)	E3.1		4	4.00	R	√3	1.73	1	1	2.31	2.31
Liquid conductivity (Deviation from target)	E3.2		5	5.00	R	√3	1.73	0.64	0.43	1.85	1.24
Liquid conductivity (measurement uncert.)	E3.3		1.1	1.10	N	1	1.00	0.64	0.43	0.70	0.47
Liquid permittivity (Deviation from target)	E3.2		5	5.00	R	√3	1.73	0.6	0.49	1.73	1.41
Liquid permittivity (measurement uncert.)	E3.3		1.1	1.10	N	1	1.00	0.6	0.49	0.66	0.54
Combined standard uncertainty					**RSS**					10.5	10.3
Expanded uncertainty	(95% Confidence Level)				k=2					**20.6**	**20.3**

Table 2 System Check (Verification)
Example of measurement uncertainty assessment for system performance check

(blue entries are site-specific)

a	b			c	d	e		f	g	h	I
Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1 (1g)	c1 (10g)	Standard Uncertainty (%) 1g	Standard Uncertainty (%) 10g
		(dB)		(%)							
Measurement System											
Probe Calibration	E2.1			2.5	N	1 or k	1	1	1	2.50	2.50
Axial Isotropy	E2.2	0.25	5.93	5.93	R	√3	1.73	0	0	0.00	0.00
Hemispherical Isotropy	E2.2	0.45	10.92	10.92	R	√3	1.73	1	1	6.30	6.30
Boundary effect	E2.3		4	4.00	R	√3	1.73	1	1	2.31	2.31
Linearity	E2.4	0.04	0.93	0.93	R	√3	1.73	1	1	0.53	0.53
System Detection Limits	E2.5		1	1.00	R	√3	1.73	1	1	0.58	0.58
Readout Electronics	E2.6		1	1.00	N	1 or k	1.00	1	1	1.00	1.00
Response time	E2.7		0	0.00	R	√3	1.73	1	1	0.00	0.00
Integration time	E2.8		1.4	1.40	R	√3	1.73	1	1	0.81	0.81
RF Ambient Conditions	E6.1		3	3.00	R	√3	1.73	1	1	1.73	1.73
Probe Positioner Mechanical Tolerance	E6.2		0.6	0.60	R	√3	1.73	1	1	0.35	0.35
Probe Position wrt. Phantom Shell	E6.3		3	3.00	R	√3	1.73	1	1	1.73	1.73
SAR Evaluation Algorithms	E5		8	8.00	R	√3	1.73	1	1	4.62	4.62
Dipole											
Dipole axis to liquid distance	8, E4.2		2	2.00	N	1	1.00	1	1	2.00	2.00
Input power and SAR drift measurement	8, 6.6.2		5	5.00	R	√3	1.73	1	1	2.89	2.89
Phantom and Tissue Parameters											
Phantom Uncertainty (thickness)	E3.1		4	4.00	R	√3	1.73	1	1	2.31	2.31
Liquid conductivity (Deviation from target)	E3.2		5	5.00	R	√3	1.73	0.64	0.43	1.85	1.24
Liquid conductivity (measurement uncert.)	E3.3		1.1	1.10	N	1	1.00	0.64	0.43	0.70	0.47
Liquid permittivity (Deviation from target)	E3.2		5	5.00	R	√3	1.73	0.6	0.49	1.73	1.41
Liquid permittivity (measurement uncert.)	E3.3		1.1	1.10	N	1	1.00	0.6	0.49	0.66	0.54
Combined standard uncertainty					**RSS**					10.3	10.1
Expanded uncertainty	(95% Confidence Level)				k=2					**20.2**	**19.9**

Table 3 Uncertainty assessment for waveguide probe calibration

	a		b		c	
Uncertainty Component	Tol. (+/-%)	Prob. Dist.	Divisor (descrip)	Divisor (value)	c1	Standard Uncertainty (+/- %)
Waveguide calibrations						
Incident or forward power	1	R	√3	1.73	1	0.58
Refected power	1.00	R	√3	1.73	1	0.58
Liquid conductivity	2.00	R	√3	1.73	1	1.15
Liquid permittivity	2.00	R	√3	1.73	1	1.15
Probe positioning	1.00	N	1	1.00	1	1.00
Field homogeneity	1.00	R	√3	1.73	1	0.58
Field probe positioning	2.00	R	√3	1.73	1	1.15
Field probe linearity	1.00	R	√3	1.73	1	0.58
Combined standard uncertainty		**RSS**				**2.5**
Expanded uncertainty		k=2				4.9

Table 4 Uncertainty assessment for DiLine dielectric property measurement

	a		b		c	
Uncertainty Component	Tol. (+/- %)	Prob. Dist.	Divisor (descrip)	Divisor (value)	c1	Standard Uncertainty (+/- %)
Permittivity measurement						
Repeatability (n repeats)	1	N	1 or k	1	1	1.00
Temperature measurement	0.30	R	√3	1.73	1	0.17
VNA drift, linearity	0.50	R	√3	1.73	1	0.29
Test port cable variations	0.50	R	√3	1.73	1	0.29
Combined standard uncertainty		**RSS**				**1.1**
Expanded uncertainty		k=2				2.1

	a		b		c	
Uncertainty Component	Tol. (+/- %)	Prob. Dist.	Divisor (descrip)	Divisor (value)	c1	Standard Uncertainty (+/- %)
Conductivity measurement						
Repeatability (n repeats)	1	N	1 or k	1	1	1.00
Temperature measurement	0.30	R	√3	1.73	1	0.17
VNA drift, linearity	0.50	R	√3	1.73	1	0.29
Test port cable variations	0.50	R	√3	1.73	1	0.29
Combined standard uncertainty		**RSS**				**1.1**
Expanded uncertainty		k=2				2.1

5.0 Measurement Traceability

All measurements described in this report are traceable to Chinese National Laboratory Accreditation (CNLA) standards or appropriate national standards.

6.0 WARNING LABEL INFORMATION - USA

See user manual.

7.0 REFERENCES

[1] ANSI, *ANSI/IEEE C95.1-1999: 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, 1999

[2] Federal Communications Commission, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Supplement C to OET Bulletin 65, Washington, D.C. 20554, 1997

[3] IEEE Standards Coordinating Committee 34, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", IEEE Std 1528/D1.2, April 21, 2003

8.0 DOCUMENT HISTORY

Revision/ Job Number	Writer Initials	Date	Change
N/A	J.C.	Dec. 5, 2003	Original document

APPENDIX A - SAR Evaluation Data

Power drift is the measurement of power drift of the device over one complete SAR scan.
To assess the drift of the power of the device under test, a SAR measurement was made in the middle of the zoom scan volume at the start of the scan and a measurement at this point was then also made after the measurement scan. The difference between the two measurements should be less than 5%.

plot 1 (1/2)

Date / Time:	2003/11/26	**Position:**	right cheek
Filename:	835ch384rc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	180
Antenna:	helix	**Test Frequency:**	835_ch384
Shape File:	Q600.csv	**Power Level:**	24.14dBm

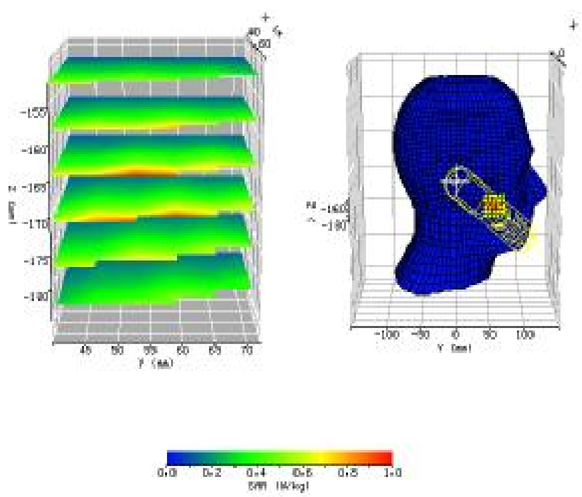
Probe:	0136
Cal File:	SN0136_835_CW_HEAD
Cal Factors:	see table below
Amp Gain:	2
Averaging:	1
Batteries Replaced:	2

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.387	0.384

Change during Scan (%) -0.82

Max E-field (V/m): 31.94

Max SAR (W/kg)

1g	10g
0.853	0.561

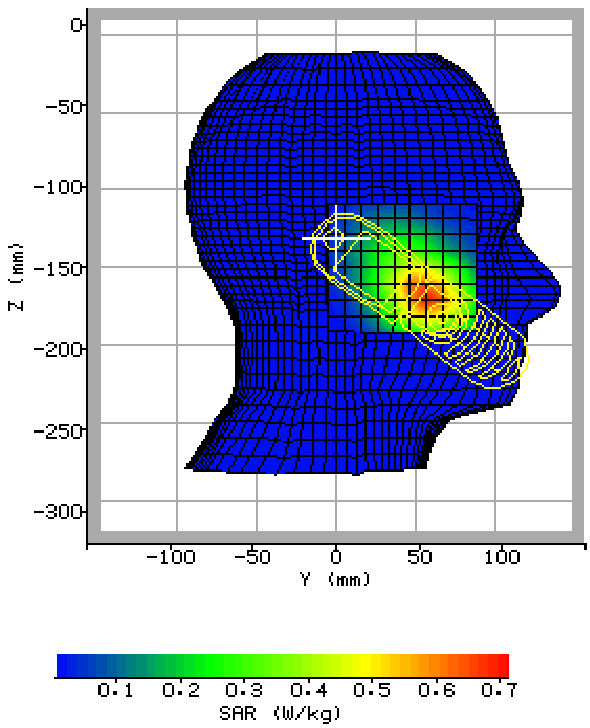
Location of Max (mm):

X	Y	Z
75.6	40.0	-168.0

plot 1 (2/2)

AREA SCAN:

	Min	Max	Steps
Scan Extent:			
Y	-5.0	85.0	9.0
Z	-190.0	-110.0	8.0



plot 2 (1/2)

Date / Time:	2003/11/26	**Position:**	right tilt
Filename:	835ch384rt	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	180
Antenna:	helix	**Test Frequency:**	835_ch384
Shape File:	Q600.csv	**Power Level:**	24.14dBm

Probe: 0136
Cal File: SN0136_835_CW_HEAD

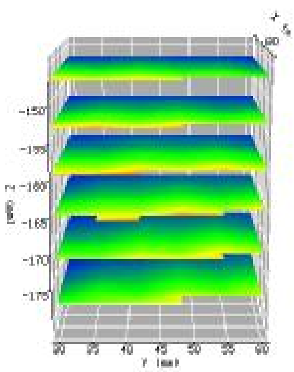
Cal Factors:

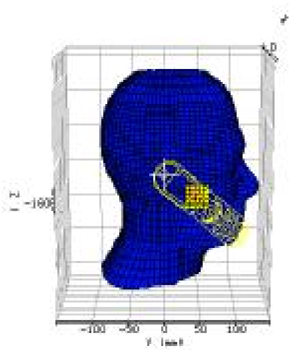
	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

Amp Gain: 2
Averaging: 1
Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1





ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.174	0.177

Change during Scan (%) 1.90
Max E-field (V/m): 19.52

Max SAR (W/kg)

1g	10g
0.330	0.237

Location of Max (mm):

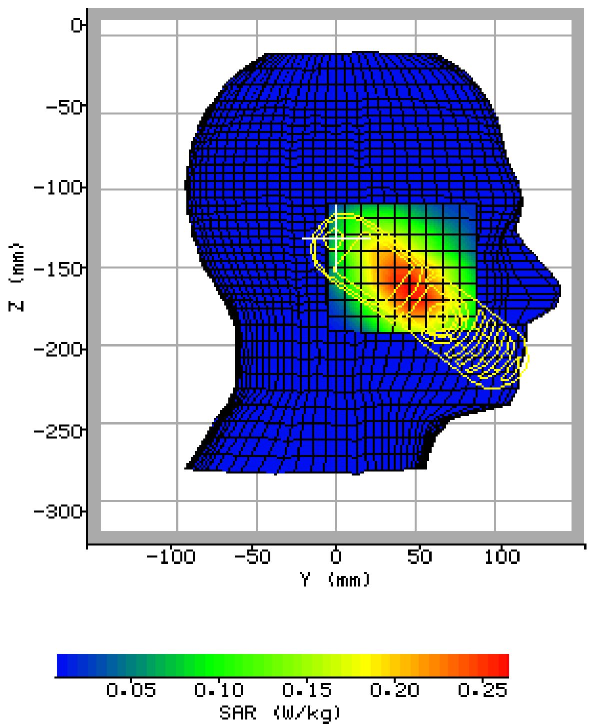
X	Y	Z
75.1	29.0	-165.1

plot 2 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-5.0	85.0	9.0
Z	-190.0	-110.0	8.0



plot 3 (1/2)

Date / Time:	2003/11/26	**Position:**	left cheek
Filename:	835ch384lc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	helix	**Test Frequency:**	835_ch384
Shape File:	Q600.csv	**Power Level:**	24.14dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

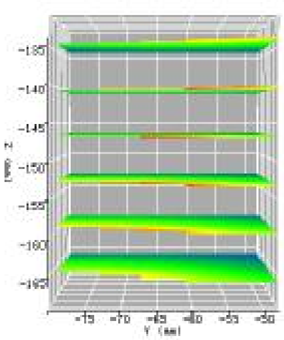
Amp Gain: 2

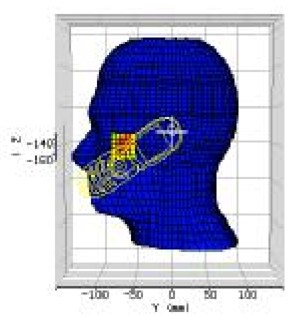
Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1





ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.446	0.451

Change during Scan (%) 1.16

Max E-field (V/m): 30.61

Max SAR (W/kg)

1g	10g
0.864	0.596

Location of Max (mm):

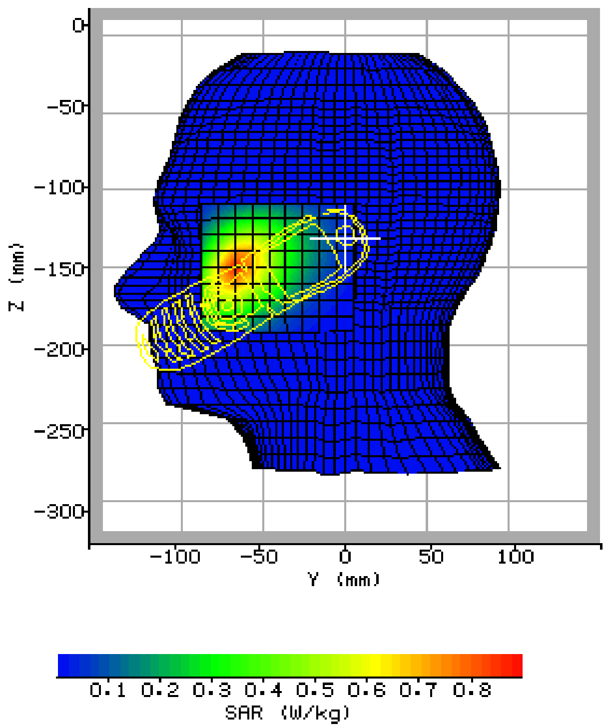
X	Y	Z
64.4	-80.0	-145.7

plot 3 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-85.0	5.0	9.0
Z	-190.0	-110.0	8.0



plot 4 (1/2)

Date / Time:	2003/11/26	**Position:**	left tilt
Filename:	835ch384lt	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	helix	**Test Frequency:**	835_ch384
Shape File:	Q600.csv	**Power Level:**	24.14dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

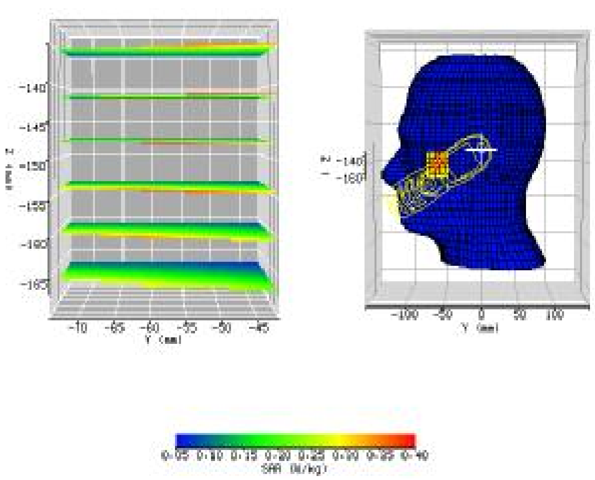
Amp Gain: 2

Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.211	0.212

Change during Scan (%) 0.59

Max E-field (V/m): 20.28

Max SAR (W/kg)

1g	10g
0.366	0.280

Location of Max (mm):

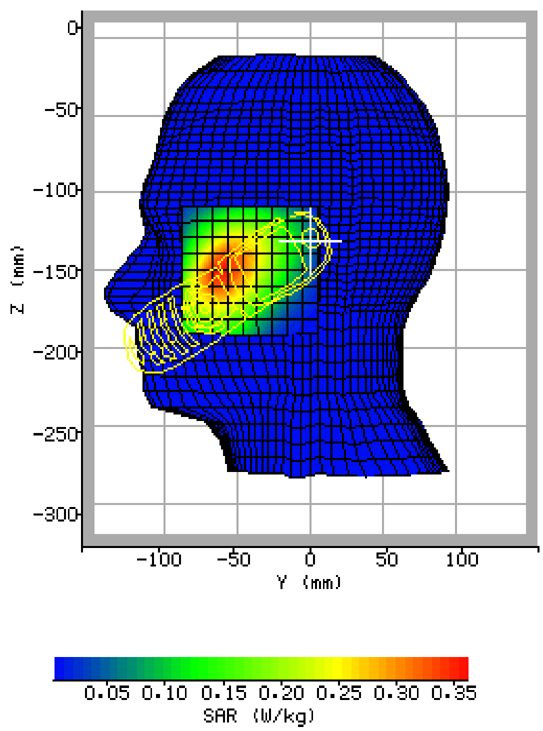
X	Y	Z
68.2	-74.0	-146.7

plot 4 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-85.0	5.0	9.0
Z	-190.0	-110.0	8.0



plot 5 (1/2)

Date / Time:	2003/11/26	**Position:**	right cheek
Filename:	835ch1013rc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	180
Antenna:	helix	**Test Frequency:**	835_ch1013
Shape File:	Q600.csv	**Power Level:**	24.30dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

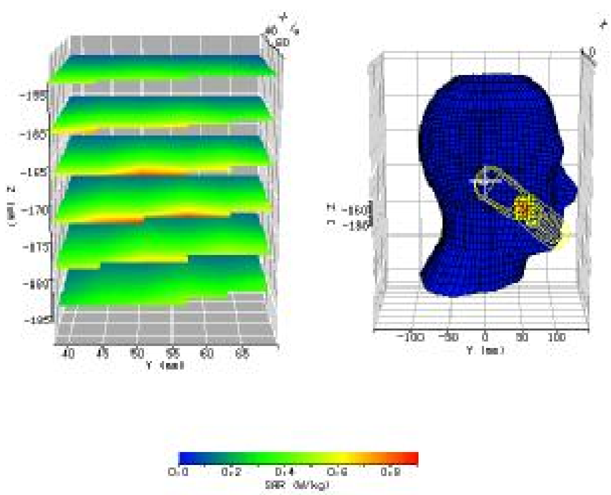
Amp Gain: 2

Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.362	0.351

Change during Scan (%) -3.66

Max E-field (V/m): 30.14

Max SAR (W/kg)

1g	10g
0.775	0.501

Location of Max (mm):

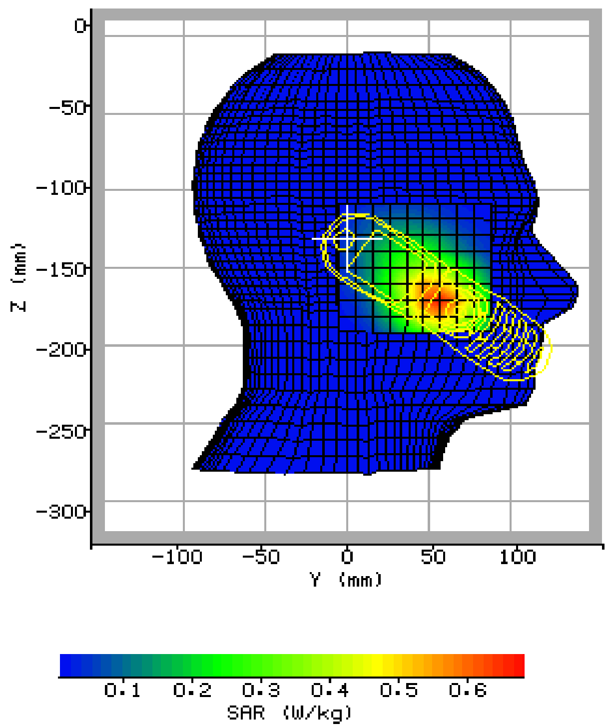
X	Y	Z
75.3	38.0	-171.1

plot 5 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-5.0	85.0	9.0
Z	-190.0	-110.0	8.0



plot 6 (1/2)

Date / Time:	2003/11/26	**Position:**	left cheek
Filename:	835ch1013lc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	helix	**Test Frequency:**	835_ch1013
Shape File:	Q600.csv	**Power Level:**	24.30dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

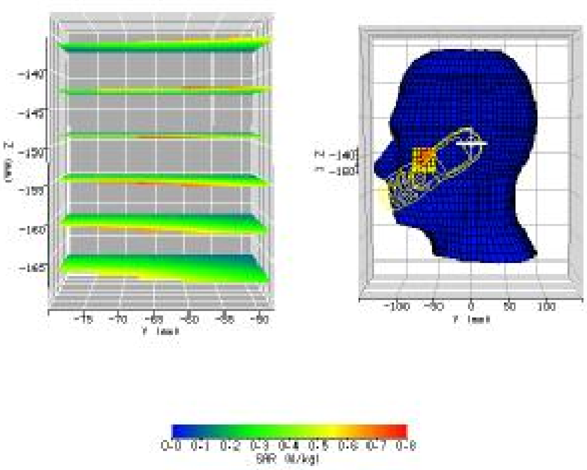
Amp Gain: 2

Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.420	0.410

Change during Scan (%) -2.54

Max E-field (V/m): 28.92

Max SAR (W/kg)

1g	10g
0.764	0.528

Location of Max (mm):

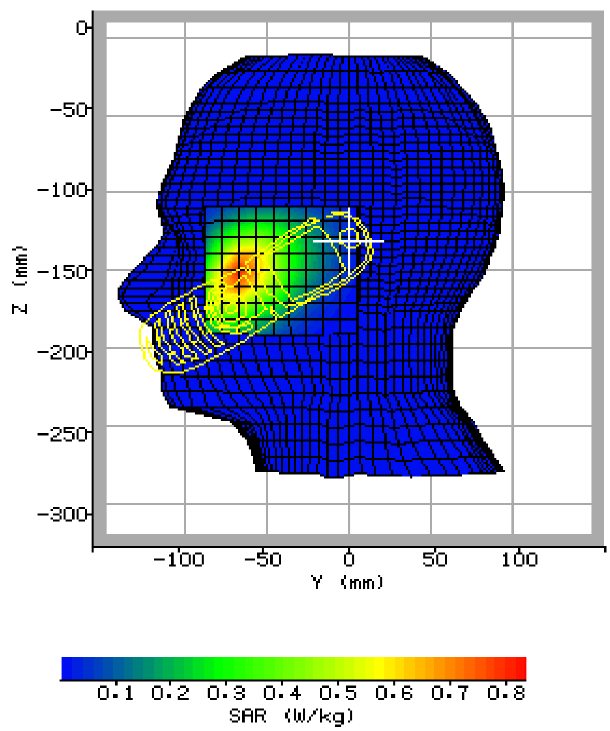
X	Y	Z
64.5	-80.0	-147.7

plot 6 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-85.0	5.0	9.0
Z	-190.0	-110.0	8.0



plot 7 (1/2)

Date / Time:	2003/11/26	**Position:**	right cheek
Filename:	835ch777rc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	180
Antenna:	helix	**Test Frequency:**	835_ch777
Shape File:	Q600.csv	**Power Level:**	24.06dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

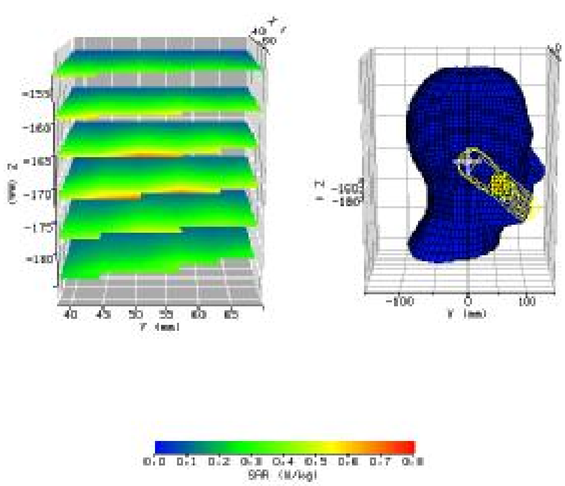
Amp Gain: 2

Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

	Start Scan	End Scan
Spot SAR (W/kg):	0.286	0.276

Change during Scan (%) -3.51

Max E-field (V/m): 27.59

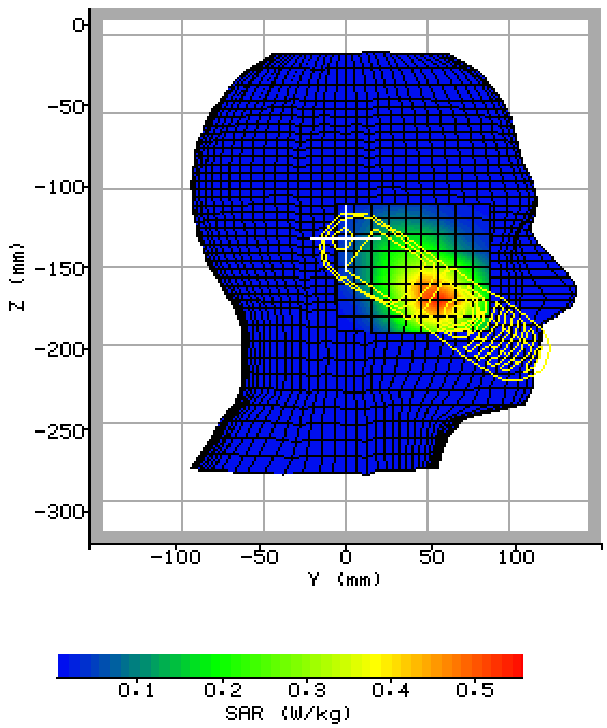
	1g	10g
Max SAR (W/kg)	0.652	0.416

	X	Y	Z
Location of Max (mm):	75.5	38.0	-169.0

plot 7 (2/2)

AREA SCAN:

		Min	Max	Steps
Scan Extent:	Y	-5.0	85.0	9.0
	Z	-190.0	-110.0	8.0



plot 8 (1/2)

Date / Time:	2003/11/26	**Position:**	left cheek
Filename:	835ch777lc	**Phantom:**	HeadFT05.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	helix	**Test Frequency:**	835_ch777
Shape File:	Q600.csv	**Power Level:**	24.06dBm

Probe: 0136

Cal File: SN0136_835_CW_HEAD

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.257	.257	.257

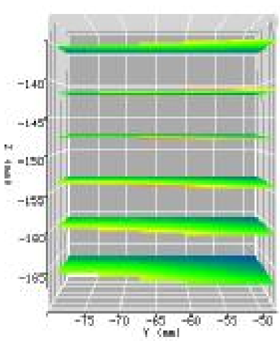
Amp Gain: 2

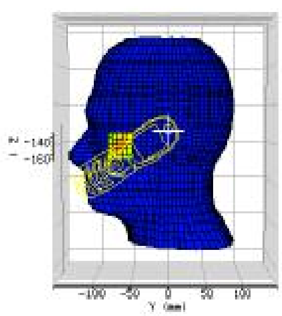
Averaging: 1

Batteries Replaced: 2

Liquid:	15.5cm
Type:	835MHz Head
Conductivity:	0.9313
Relative Permittivity:	42.60228
Liquid Temp (deg C):	21.5
Ambient Temp (deg C):	22
Ambient RH (%):	48
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1





ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.324	0.316

Change during Scan (%) -2.40

Max E-field (V/m): 25.59

Max SAR (W/kg)

1g	10g
0.595	0.410

Location of Max (mm):

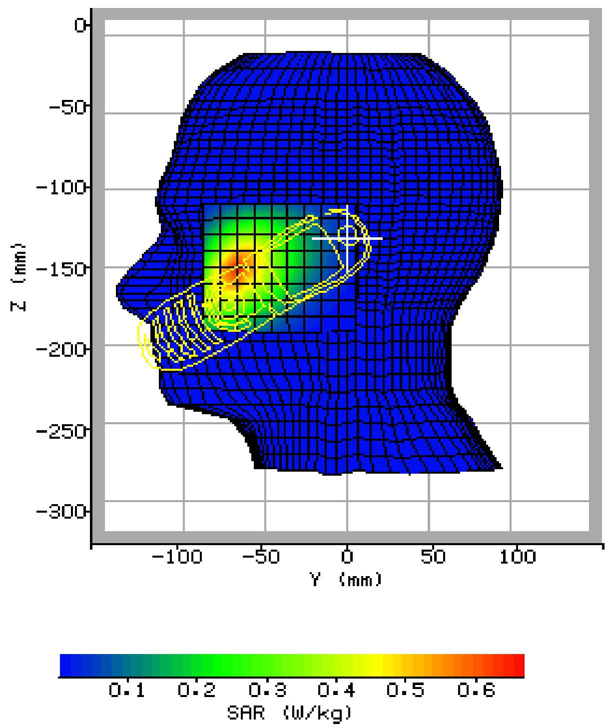
X	Y	Z
64.5	-80.0	-147.8

plot 8 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-85.0	5.0	9.0
Z	-190.0	-110.0	8.0



plot 9 (1/2)

Date / Time:	2003/11/26	**Position:**	front to box phantom
Filename:	835ch384_front15.txt	**Phantom:**	HeadBox2-test.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	Helix	**Test Frequency:**	835MHz_ch384
Shape File:	Q600-front.csv	**Power Level:**	24.14dBm

Probe:	0136
Cal File:	SN0136_835_CW_BODY

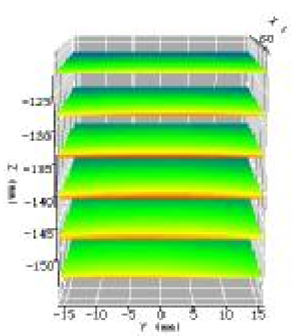
Cal Factors:

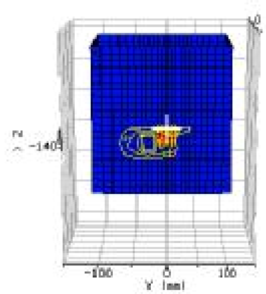
	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

Amp Gain:	2
Averaging:	1
Batteries Replaced:	3

Liquid:	15.5cm
Type:	835MHz Body
Conductivity:	0.9574
Relative Permittivity:	55.3931
Liquid Temp (deg C):	22.7
Ambient Temp (deg C):	22
Ambient RH (%):	43
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1





ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.149	0.146

Change during Scan (%) -1.73

Max E-field (V/m): 18.62

Max SAR (W/kg)

1g	10g
0.297	0.211

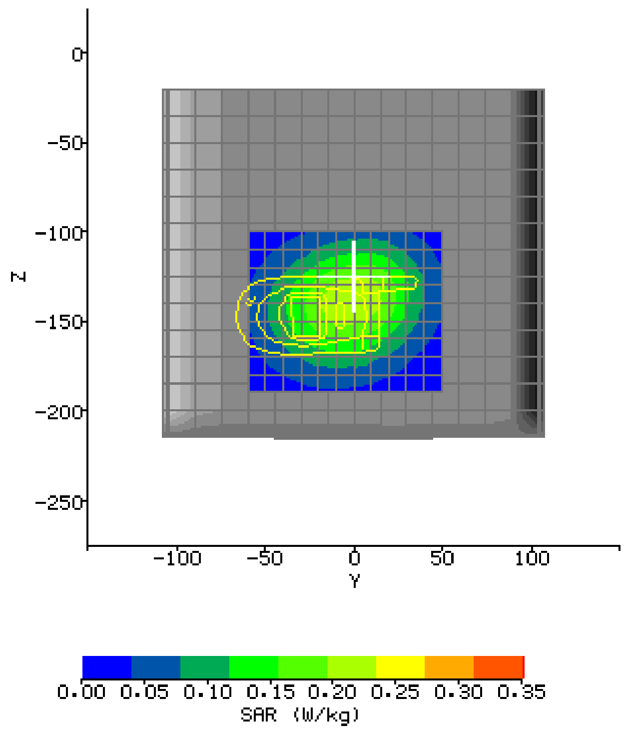
Location of Max (mm):

X	Y	Z
78.1	-16.0	-138.0

plot 9 (2/2)

AREA SCAN:

Scan Extent:		**Min**	**Max**	**Steps**
	Y	-60.0	50.0	11.0
	Z	-190.0	-100.0	9.0



plot 10 (1/2)

Date / Time:	2003/11/26	**Position:**	rear to box phantom
Filename:	835ch384_rear15.txt	**Phantom:**	HeadBox2-test.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	Helix	**Test Frequency:**	835MHz_ch384
Shape File:	Q600-rear.csv	**Power Level:**	24.14dBm

Probe: 0136
Cal File: SN0136_835_CW_BODY

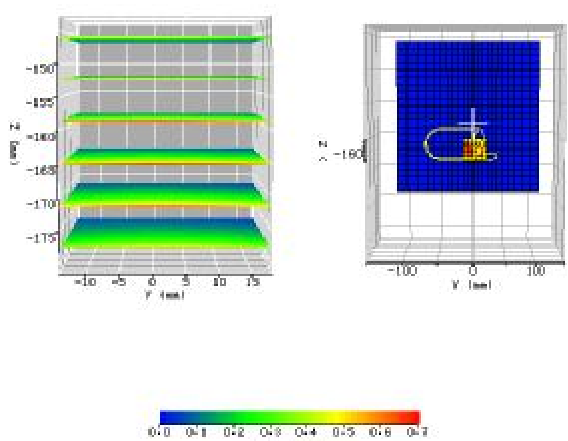
Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

Amp Gain: 2
Averaging: 1
Batteries Replaced: 3

Liquid:	15.5cm
Type:	835MHz Body
Conductivity:	0.9574
Relative Permittivity:	55.3931
Liquid Temp (deg C):	22.7
Ambient Temp (deg C):	22
Ambient RH (%):	43
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

	Start Scan	End Scan
Spot SAR (W/kg):	0.267	0.278

Change during Scan (%) 4.17

Max E-field (V/m): 26.87

	1g	10g
Max SAR (W/kg)	0.602	0.408

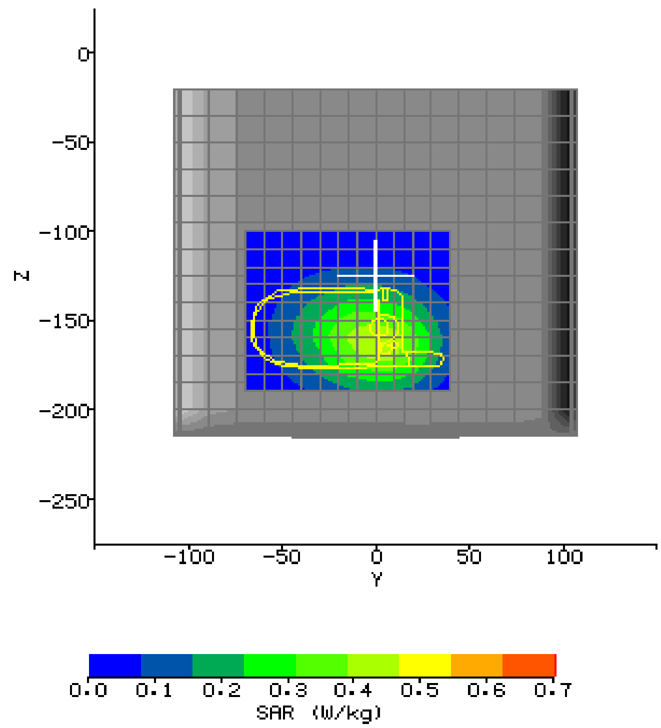
	X	Y	Z
Location of Max (mm):	78.0	-14.0	-160.9

plot 10 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-70.0	40.0	11.0
Z	-190.0	-100.0	9.0



plot 11 (1/2)

Date / Time:	2003/11/26	**Position:**	front to box phantom
Filename:	835ch1013_front15.txt	**Phantom:**	HeadBox2-test.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	Helix	**Test Frequency:**	835MHz_ch1013
Shape File:	Q600-front.csv	**Power Level:**	24.30dBm

Probe: 0136

Cal File: SN0136_835_CW_BODY

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

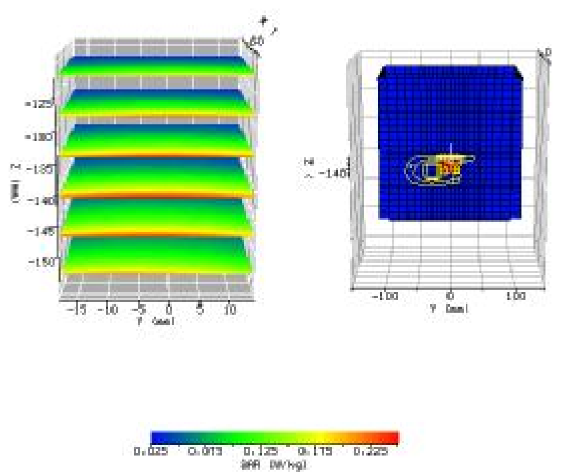
Amp Gain: 2

Averaging: 1

Batteries Replaced: 3

Liquid:	15.5cm
Type:	835MHz Body
Conductivity:	0.9574
Relative Permittivity:	55.3931
Liquid Temp (deg C):	22.7
Ambient Temp (deg C):	22
Ambient RH (%):	43
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.113	0.108

Change during Scan (%) -4.41

Max E-field (V/m): 16.08

Max SAR (W/kg)

1g	10g
0.222	0.158

Location of Max (mm):

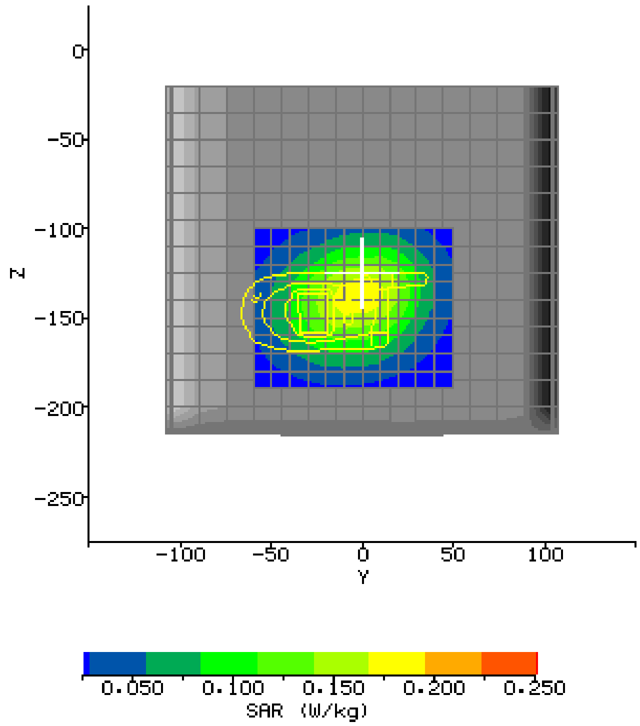
X	Y	Z
78.1	-18.0	-139.1

plot 11 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-60.0	50.0	11.0
Z	-190.0	-100.0	9.0



plot 12 (1/2)

Date / Time: 2003/11/26
Filename: 835ch1013_rear15.txt
Device Tested: Q600
Antenna: Helix
Shape File: Q600-rear.csv

Position: rear to box phantom
Phantom: HeadBox2-test.csv
Head Rotation: 0
Test Frequency: 835MHz_ch1013
Power Level: 24.30dBm

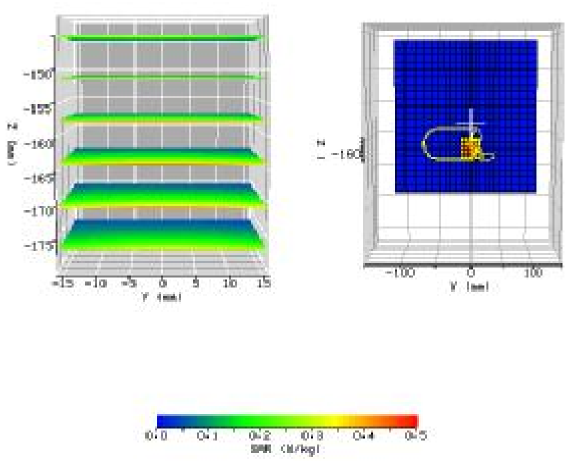
Probe: 0136
Cal File: SN0136_835_CW_BODY

Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

Amp Gain: 2
Averaging: 1
Batteries Replaced: 3

Liquid: 15.5cm
Type: 835MHz Body
Conductivity: 0.9574
Relative Permittivity: 55.3931
Liquid Temp (deg C): 22.7
Ambient Temp (deg C): 22
Ambient RH (%): 43
Density (kg/m3): 1000
Software Version: 0.421N
Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.188	0.182

Change during Scan (%) -3.25

Max E-field (V/m): 21.82

Max SAR (W/kg)

1g	10g
0.401	0.273

Location of Max (mm):

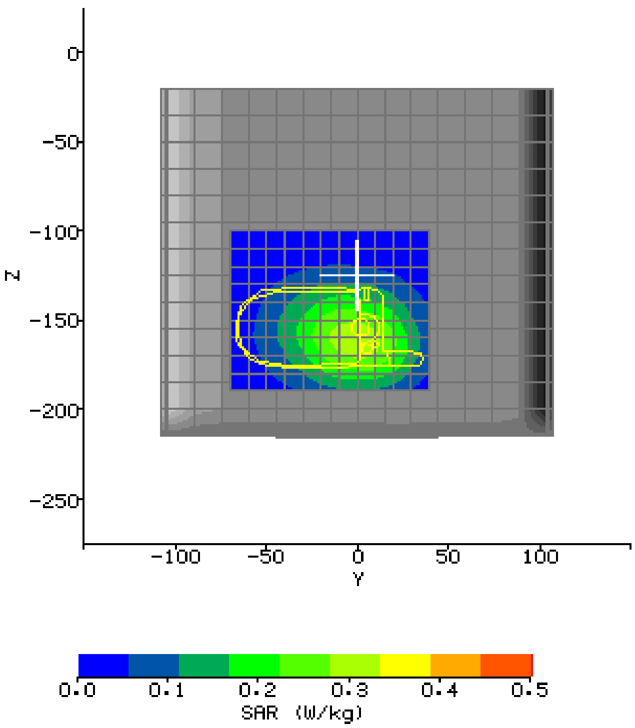
X	Y	Z
78.1	-16.0	-162.1

plot 12 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-70.0	40.0	11.0
Z	-190.0	-100.0	9.0



plot 13 (1/2)

Date / Time:	2003/11/26	**Position:**	front to box phantom
Filename:	835ch777_front15.txt	**Phantom:**	HeadBox2-test.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	Helix	**Test Frequency:**	835MHz_ch777
Shape File:	Q600-front.csv	**Power Level:**	24.06dBm

Probe: 0136

Cal File: SN0136_835_CW_BODY

Cal Factors:

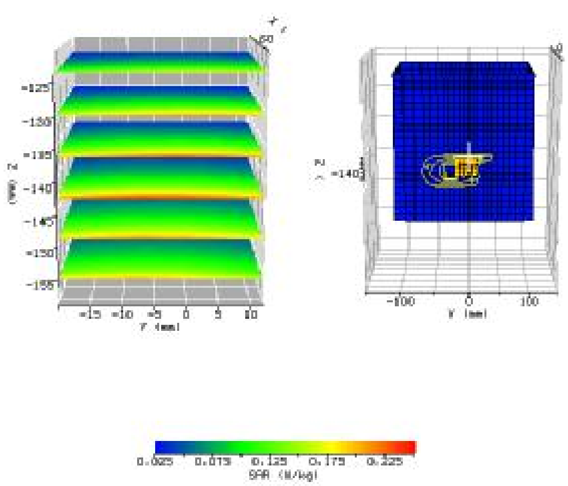
	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

Amp Gain: 2

Averaging: 1

Batteries Replaced: 3

Liquid:	15.5cm
Type:	835MHz Body
Conductivity:	0.9574
Relative Permittivity:	55.3931
Liquid Temp (deg C):	22.7
Ambient Temp (deg C):	22
Ambient RH (%):	43
Density (kg/m3):	1000
Software Version:	0.421N



ZOOM SCAN RESULTS:

Spot SAR (W/kg):

Start Scan	End Scan
0.103	0.100

Change during Scan (%) -1.08

Max E-field (V/m): 15.55

Max SAR (W/kg)

1g	10g
0.205	0.145

Location of Max (mm):

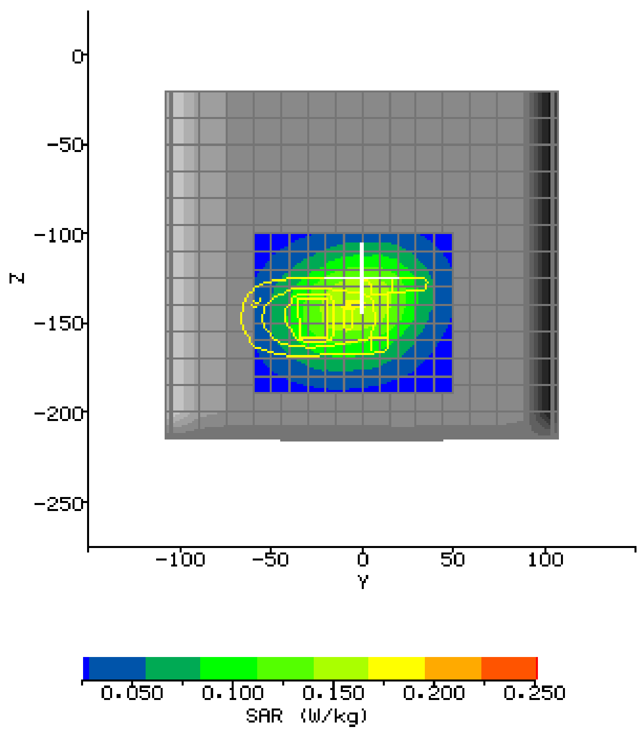
X	Y	Z
78.0	-20.0	-141.1

plot 13 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-60.0	50.0	11.0
Z	-190.0	-100.0	9.0



plot 14 (1/2)

Date / Time:	2003/11/26	**Position:**	rear to box phantom
Filename:	835ch777_rear15.txt	**Phantom:**	HeadBox2-test.csv
Device Tested:	Q600	**Head Rotation:**	0
Antenna:	Helix	**Test Frequency:**	835MHz_ch777
Shape File:	Q600-rear.csv	**Power Level:**	24.06dBm

Probe:	0136
Cal File:	SN0136_835_CW_BODY

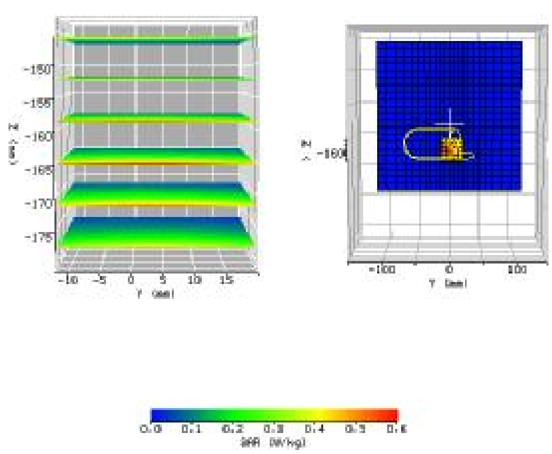
Cal Factors:

	X	Y	Z
Air	490	405	405
DCP	20	20	20
Lin	.272	.272	.272

Amp Gain:	2
Averaging:	1
Batteries Replaced:	3

Liquid:	15.5cm
Type:	835MHz Body
Conductivity:	0.9574
Relative Permittivity:	55.3931
Liquid Temp (deg C):	22.7
Ambient Temp (deg C):	22
Ambient RH (%):	43
Density (kg/m3):	1000
Software Version:	0.421N

Crest Factor=1



ZOOM SCAN RESULTS:

Spot SAR (W/kg):	**Start Scan**	**End Scan**

Change during Scan (%)

Max E-field (V/m): 24.83

Max SAR (W/kg)	**1g**	**10g**
	0.516	0.345

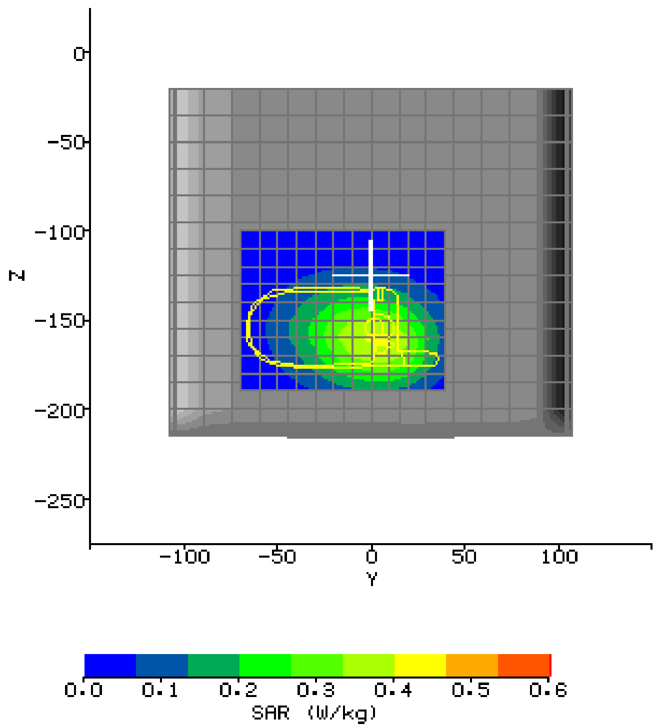
Location of Max (mm):	**X**	**Y**	**Z**
	78.1	-12.0	-163.1

plot 14 (2/2)

AREA SCAN:

Scan Extent:

	Min	Max	Steps
Y	-70.0	40.0	11.0
Z	-190.0	-100.0	9.0



APPENDIX B - Photographs

Accessory


AC ADAPTOR
MODEL:PLM02A-036(A)
P/N:25.10101.021 -1
INPUT:120V~ 60Hz 0.1A
OUTPUT:3.6V 600mA
US LISTED
ITE POWER SUPPLY
CAUTION:
"Risk of electric shock"
"Dry location use only"
MJ

ear phone

APPENDIX C - E-Field Probe and 900MHz Balanced Dipole Antenna Calibration Data

IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP – 050

S/N 0136

10th September 2003

Indexsar Limited
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INTRODUCTION

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N 0136) and describes the procedures used for characterisation and calibration.

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of CENELEC [1] and IEEE [2] standards. The procedures incorporate techniques for probe linearisation, isotropy assessment and determination of liquid factors (conversion factors). Calibrations are determined by comparing probe readings with analytical computations in canonical test geometries (waveguides) using normalised power inputs.

Each step of the calibration procedure and the equipment used is described in the sections below.

CALIBRATION PROCEDURE

1. Equipment Used

For the first part of the characterisation procedure, the probe is placed in an isotropy measurement jig as pictured in Figure 1. In this position the probe can be rotated about its axis by a non-metallic belt driven by a stepper motor.

The probe is attached via its amplifier and an optical cable to a PC. A schematic representation of the test geometry is illustrated in Figure 2.

A balanced dipole (900 MHz) is inserted horizontally into the bracket attached to a second belt (Figure 1). The dipole can also be rotated about its axis. A cable connects the dipole to a signal generator, via a directional coupler and power meter. The signal generator feeds an RF amplifier at constant power, the output of which is monitored using the power meter. The probe is positioned so that its sensors line up with the rotation center of the source dipole. By recording output voltage measurements of each channel as both the probe and the dipole are rotated, data are obtained from which the spherical isotropy of the probe can be optimised and its magnitude determined.

The calibration process requires E-field measurements to be taken in air, in 900 MHz simulated brain liquid and at other frequencies/liquids as appropriate.

2. Linearising probe output

The probe channel output signals are linearised in the manner set out in Refs [1] and [2]. The following equation is utilized for each channel:

$$U_{lin} = U_{o/p} + U_{o/p}{}^{2} / DCP \qquad (1)$$

where U_{lin} is the linearised signal, $U_{o/p}$ is the raw output signal in voltage units and DCP is the diode compression potential in similar voltage units.

DCP is determined from fitting equation (1) to measurements of U_{lin} versus source feed power over the full dynamic range of the probe. The DCP is a characteristic of the schottky diodes used as the sensors. For the IXP-050 probes with CW signals the DCP values are typically 0.10V (or 20 in the voltage units used by Indexsar software, which are V*200).

3. Selecting channel sensitivity factors to optimise isotropic response

The basic measurements obtained using the calibration jig (Fig 1) represent the output from each diode sensor as a function of the presentation angle of the source (probe and dipole rotation angles). The directionality of the orthogonally-arranged sensors can be checked by analysing the data using dedicated Indexsar software, which displays the data in 3D format as in Figure 3. The left-hand side of this diagram shows the individual channel outputs after linearisation (see above). The program uses these data to balance the channel outputs and then applies an optimisation process, which makes fine adjustments to the channel factors for optimum isotropic response.

The next stage of the process is to calibrate the Indexsar probe to a W&G EMR300 E-field meter in air. The principal reasons for this are to obtain conversion factors applicable should the probe be used in air and to provide an overall measure of the probe sensitivity.

A multiplier is applied to factors to bring the magnitudes of the average E-field measurements as close as possible to those of the W&G probe.

The following equation is used (where linearised output voltages are in units of V*200):

$$E_{air}^2\ (V/m) = U_{linx} * \text{Air Factor}_x + U_{liny} * \text{Air Factor}_y + U_{linz} * \text{Air Factor}_z \qquad (2)$$

It should be noted that the air factors are not separately used for normal SAR testing. The IXP-050 probes are optimised for use in tissue-simulating liquids and do not behave isotropically in air.

4. 900 MHz Liquid Calibration

Conversion factors for use when the probes are immersed in tissue-simulant liquids at 900 MHz are determined either using a waveguide or by comparison to a reference probe that has been calibrated by NPL. Waveguide procedures are described later. The summary sheet indicates the method used for the probe S/N 0136.

The conversion factor, referred to as the 'liquid factor' is also applied to the measurements of each channel. The following equation is used (where output voltages are in units of V*200):

$$E_{liq}^2\ (V/m) = U_{linx} * \text{Air Factor}_x * \text{Liq Factor}_x + U_{liny} * \text{Air Factor}_y * \text{Liq Factor}_y + U_{linz} * \text{Air Factor}_z * \text{Liq Factor}_z \qquad (3)$$

A 3D representation of the spherical isotropy for probe S/N 0136 using these factors is shown in Figure 3.

The rotational isotropy can also determined from the calibration jig measurements and is reported as the 900MHz isotropy in the summary table. Note that waveguide measurements can also be used to determine rotational isotropy (Fig. 5).

The design of the cells used for determining probe conversion factors are waveguide cells is shown in Figure 4. The cells consist of a coax to waveguide transition and an open-ended section of waveguide containing a dielectric separator. Each waveguide cell stands in the upright positition and is filled with liquid within 10 mm of the open end. The seperator provides a liquid seal and is designed for a good electrical transition from air filled guide to liquid filled guide. The choice of cell depends on the portion of the frequency band to be examined and the choice of liquid used. The depth of liquid ensures there is negligible radiation from the waveguide open top and that the probe calibration is not influenced by reflections from nearby objects. The return loss at the coaxial connector of the filled waveguide cell is measured initially using a network analyser and this information is used subsequently in the calibration procedure. The probe is positioned in the centre of the waveguide and is adjusted vertically or rotated using stepper motor arrangements. The signal generator is connected to the waveguide cell and the power is monitored with a coupler and a power meter. A fuller description of the waveguide method is given below.

The liquid dielectric parameters used for the probe calibrations are listed in the Tables below. The final calibration factors for the probe are listed in the summary chart.

WAVEGUIDE MEASUREMENT PROCEDURE

The calibration method is based on setting up a calculable specific absorption rate (SAR) in a vertically-mounted WG8 (R22) waveguide section [1]. The waveguide has an air-filled, launcher section and a liquid-filled section separated by a matching window that is designed to minimise reflections at the liquid interface. A TE_{01} mode is launched into the waveguide by means of a N-type-to-waveguide adapter. The power delivered to the liquid section is calculated from the forward power and reflection coefficient measured at the input to the waveguide. At the centre of the cross-section of the waveguide, the local spot SAR in the liquid as a function of distance from the window is given by functions set out in IEEE1528 as below:

Because of the low cutoff frequency, the field inside the liquid nearly propagates as a TEM wave. The depth of the medium (greater than three penetration depths) ensures that reflections at the upper surface of the liquid are negligible. The power absorbed in the liquid is determined by measuring the waveguide forward and reflected power. Equation (4) shows the relationship between the SAR at the cross-sectional center of the lossy waveguide and the longitudinal distance (z) from the dielectric separator

$$SAR(z) = \frac{4\left(P_f - P_b\right)}{r\,abd} e^{-2z/d} \qquad (4)$$

where the density r is conventionally assumed to be 1000 kg/m^3, ab is the cross-sectional area of the waveguide, P_f and P_b are the forward and reflected power inside the lossless section of the waveguide, respectively. The penetration depth d, which is the reciprocal of the waveguide-mode attenuation coefficient, is determined from a scan along the z-axis and compared with the theoretical value determined from Equation (5) using the measured dielectric properties of the lossy liquid.

$$d = \left[\mathrm{Re}\left\{ \sqrt{(p / a)^2 + jwm_o\left(s + jwe_o e_r\right)} \right\} \right]^{-1}. \qquad (5)$$

Table A.1 of [1] can be used for designing calibration waveguides with a return loss greater than 30 dB at the most important frequencies used for personal wireless communications. Values for the penetration depth for these specific fixtures and tissue-simulating mixtures are also listed in Table A.1.

According to [1], this calibration technique provides excellent accuracy, with standard uncertainty of less than 3.6% depending on the frequency and medium. The calibration itself is reduced to power measurements traceable to a standard calibration procedure. The practical limitation to the frequency band of 800 to 2500 MHz because of the waveguide size is not severe in the context of compliance testing.

CALIBRATION FACTORS MEASURED FOR PROBE S/N 0136

The probe was calibrated at 900, 1800, 1900 and 2450MHz MHz in liquid samples representing both brain liquid and body fluid at these frequencies. The calibration was for CW signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The axial isotropy of the probe was measured by rotating the probe about its axis in 10 degree steps through 360 degrees in this orientation.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 2.7 m from the probe tip in the direction of the probe amplifier. A value of 2.7 mm should be used for the tip to sensor offset distance in the software.

It is important that the diode compression point and air factors used in the software are the same as those quoted in the results tables, as these are used to convert the diode output voltages to a SAR value.

DIELECTRIC PROPERTIES OF LIQUIDS

The dielectric properties of the brain and body tissue-simulant liquids employed for calibration are listed in the tables below. The measurements were performed prior to each waveguide test using an Indexsar DiLine measurement kit, which uses the TEM method as recommended in [2].

AMBIENT CONDITIONS

Measurements were made in the open laboratory at 22 $\pm$ 2.0^{o}C. The temperature of the liquids in the waveguide used was measured using a mercury thermometer.

RESPONSE TO MODULATED SIGNALS

To measure the response of the probe and amplifier to modulated signals, the probe is held vertically in a liquid-filled waveguide.

An RF amplifier is allowed to warm up and stabilise before use. A spectrum analyser is used to demonstrate that the peak power of the RF amplifier for the CW signals and the pulsed signals are within 0.1dB of each other when the signal generator is switched from CW to modulated output. Subsequently, the power levels recorded are read from a power meter when a CW signal is being transmitted.

The test sequence involves manually stepping the power up in regular (e.g. 2 dB) steps from the lowest power that gives a measurable reading on the SAR probe up to the maximum that the amplifiers can deliver.

At each power level, the individual channel outputs from the SAR probe are recorded at CW and then recorded again with the modulation setting. The results are entered into a spreadsheet. Using the spreadsheets, the modulated power is calculated by applying a factor to the measured CW power (e.g. for GSM, this factor is 9.03dB). This process is repeated 3 times with the response maximised for each channel sensor in turn.

The probe channel output signals are linearised in the manner set out in Section 1 above using equation (1) with the DCPs determined from the linearisation procedure. Calibration factors for the probe are used to determine the E-field values corresponding to the probe readings using equation (3). SAR is determined from the equation

$$SAR\ (W/kg) = E_{liq}^{2}\ (V/m) * \sigma(S/m) / 1000 \qquad (6)$$

Where σ is the conductivity of the simulant liquid employed.

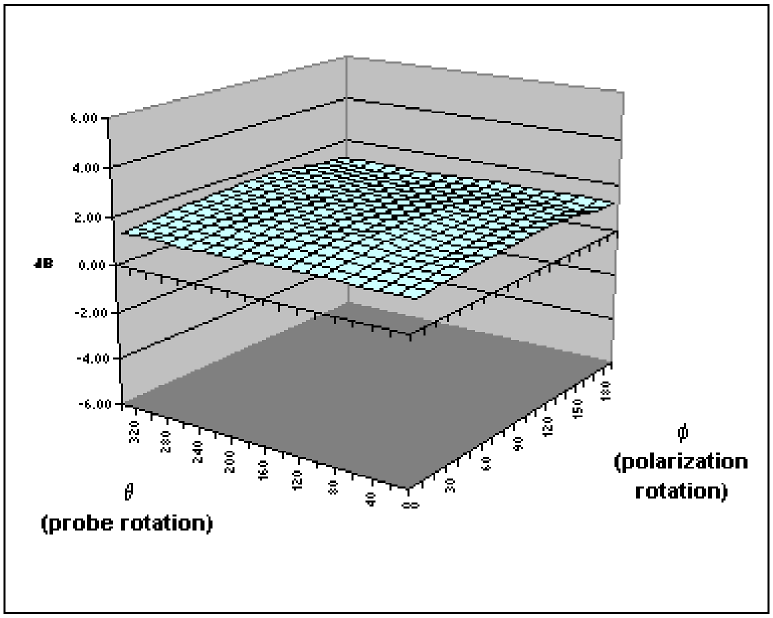
Using the spreadsheet data, the DCP value for linearising each of the individual channels (X, Y and Z) is assessed separately. The corresponding DCP values are listed in the summary page of the calibration factors for each probe.

Figure 7 shows the linearised probe response to GSM signals, Figure 8 the response to GPRS signals (GSM with 2 timeslots) and Figure 9 the response to CDMA IS-95A and W-CDMA signals.

Additional tests have shown that the modulation response is similar at 1800MHz and is not affected by the orientation between the source and the probe.

SUMMARY OF CALIBRATION FACTORS FOR PROBE IXP-050 S/N 0136

Spherical isotropy measured at 900 MHz	0.24	(+/-) dB



	X	Y	Z	
Air factors	490	405	405	(V*200)
DCPs	20	20	20	(V*200)
DSSS	20	20	20	(V*200)
GSM	8	9.5	11.2	(V*200)
CDMA	20	20	20	(V*200)

f (MHz)	Axial isotropy (+/- dB)		SAR conversion factors (liq/air)		Notes
	BRAIN	BODY	BRAIN	BODY	
450					
835	0.05	0.04	0.257	0.272	1,2,3
900	0.05	0.04	0.261	0.282	1,2,3
1800	0.06	0.06	0.315	0.339	1,2,3
1900	0.06	0.06	0.327	0.351	1,2,3
2450	0.05	0.10	0.378	0.405	1,2,3

Notes
1) Calibrations done at 22C +/- 2C
2) Waveguide calibration
3) Checked using box-phantom validation test

(the graph shows a simple, spreadsheet representation of surface shown in 3D in Figure 3 below)

ROBE SPECIFICATIONS

Indexsar probe 0136, along with its calibration, is compared with CENELEC and IEEE standards recommendations (Refs [1] and [2]) in the Tables below. A listing of relevant specifications is contained in the tables below:

Dimensions	S/N 0136	CENELEC [1]	IEEE [2]
Overall length (mm)	350		
Tip length (mm)	10		
Body diameter (mm)	12		
Tip diameter (mm)	5.2	8	8
Distance from probe tip to dipole centers (mm)	2.7		

Dynamic range	S/N 0136	CENELEC [1]	IEEE [2]
Minimum (W/kg)	0.01	<0.02	0.01
Maximum (W/kg) N.B. only measured to 35 W/kg	>35	>100	100

Linearity of response	S/N 0136	CENELEC [1]	IEEE [2]
Over range 0.01 – 100 W/kg (+/- dB)	0.125	0.50	0.25

Isotropy (measured at 900MHz)	S/N 0136	CENELEC [1]	IEEE [2]
Axial rotation with probe normal to source (+/- dB) at 835, 900, 1800, 1900 and 2450 MHz	Max. 0.10 (see summary table)	0.5	0.25
Spherical isotropy covering all orientations to source (+/- dB)	0.24	1.0	0.50

Construction	Each probe contains three orthogonal dipole sensors arranged on a triangular prism core, protected against static charges by built-in shielding, and covered at the tip by PEEK cylindrical enclosure material. No adhesives are used in the immersed section. Outer case materials are PEEK and heat-shrink sleeving.
Chemical resistance	Tested to be resistant to glycol and alcohol containing simulant liquids but probes should be removed, cleaned and dried when not in use.

REFERENCES

[1] CENELEC, EN 50361, July 2001. Basic Standard for the measurement of specific absorption rate related to human exposure to electromagnetic fields from mobile phones.

[2] IEEE 1528, Recommended practice for determining the spatial-peak specific absorption rate (SAR) in the human body due to wireless communications devices: Experimental techniques.

[3] Calibration report on SAR probe IXP-050 S/N 0071 from National Physical Laboratory. Test Report EF07/2002/03/IndexSAR. Dated 20 February 2002.

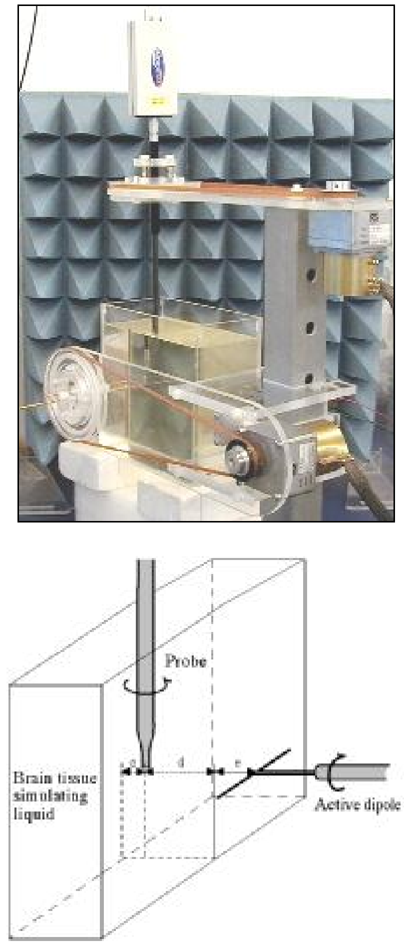


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

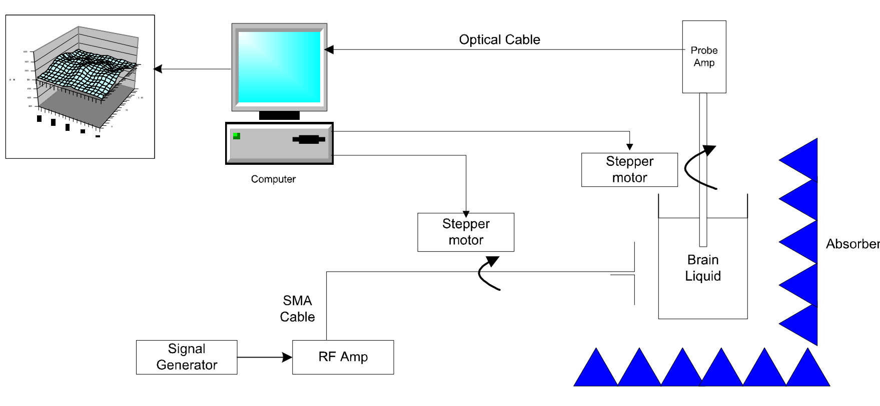


Figure 2. Schematic diagram of the test geometry used for isotropy determination

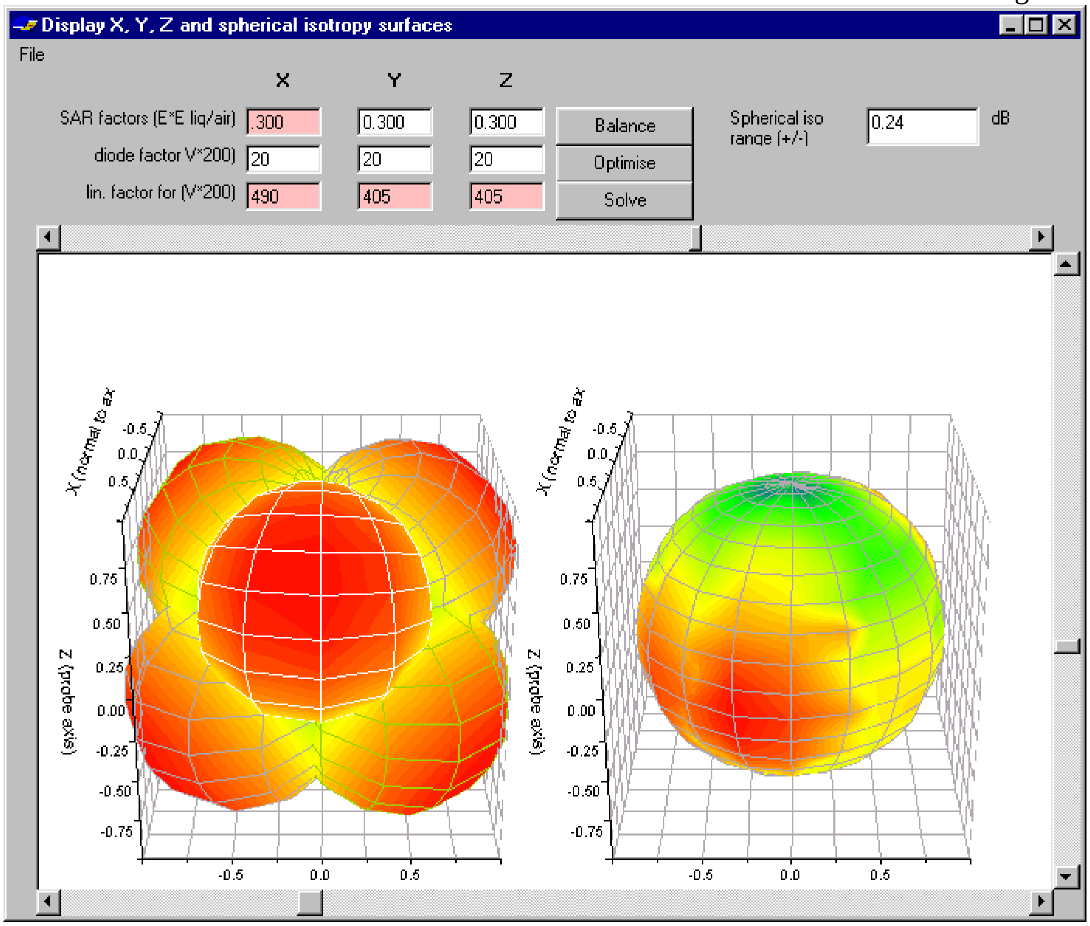


Figure 3. Graphical representation of the probe response to fields applied from each direction. The diagram on the left shows the individual response characteristics of each of the three channels and the diagram on the right shows the resulting probe sensitivity in each direction. The colour range in the figure images the lowest values as blue and the maximum values as red. For the probe S/N 0136, this range is (+/-) 0.24 dB. The probe is more sensitive to fields parallel to the axis and less sensitive to fields normal to the probe axis.

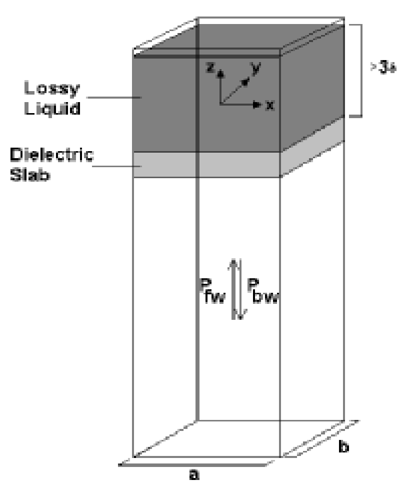
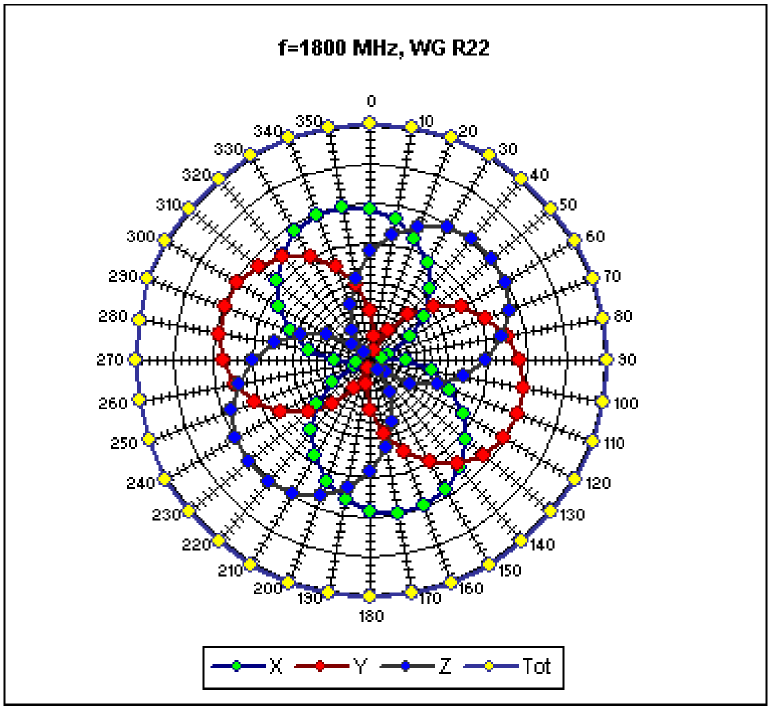


Figure 4. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)

IXP-050 S/N 0136 **18-Aug-03**



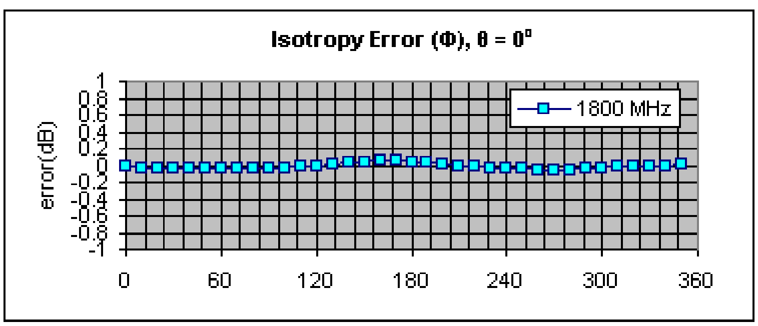


Figure 5. Example of the rotational isotropy of probe S/N 0136 obtained by rotating the probe in a liquid-filled waveguide at 2450 MHz. Similar distributions are obtained at the other test frequencies (1800 and 1900 MHz) both in brain liquids and body fluids (see summary table)

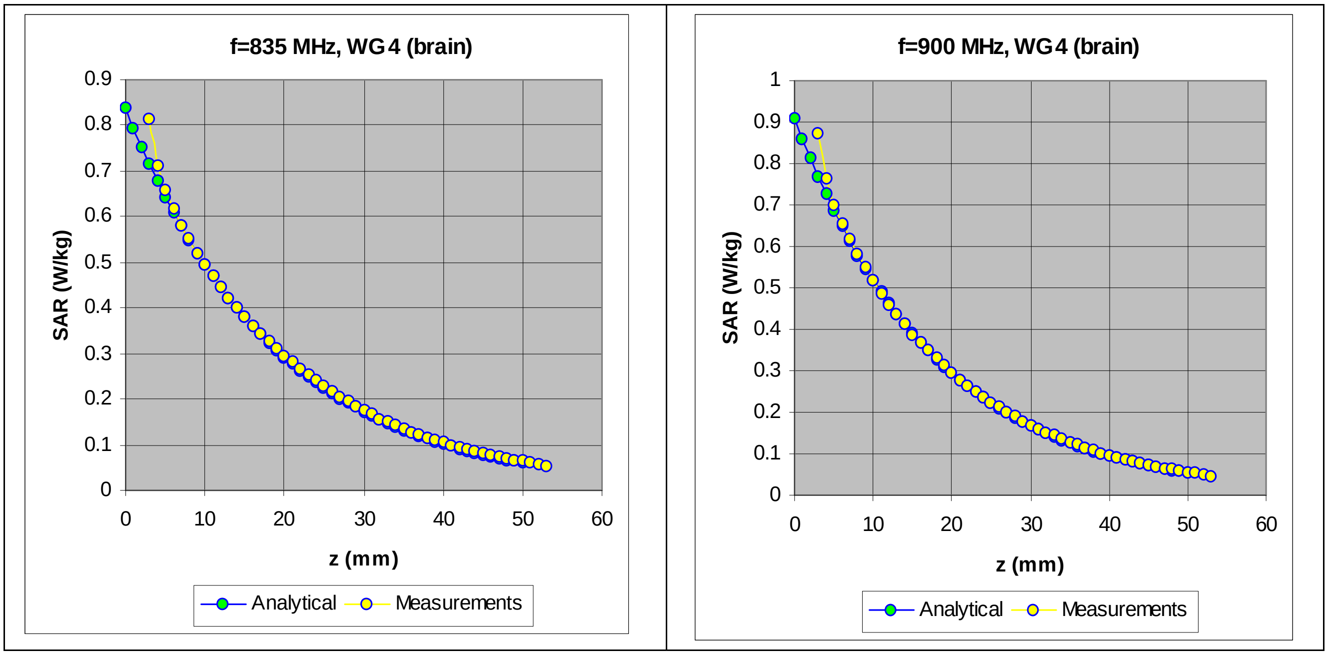


Figure 6. The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

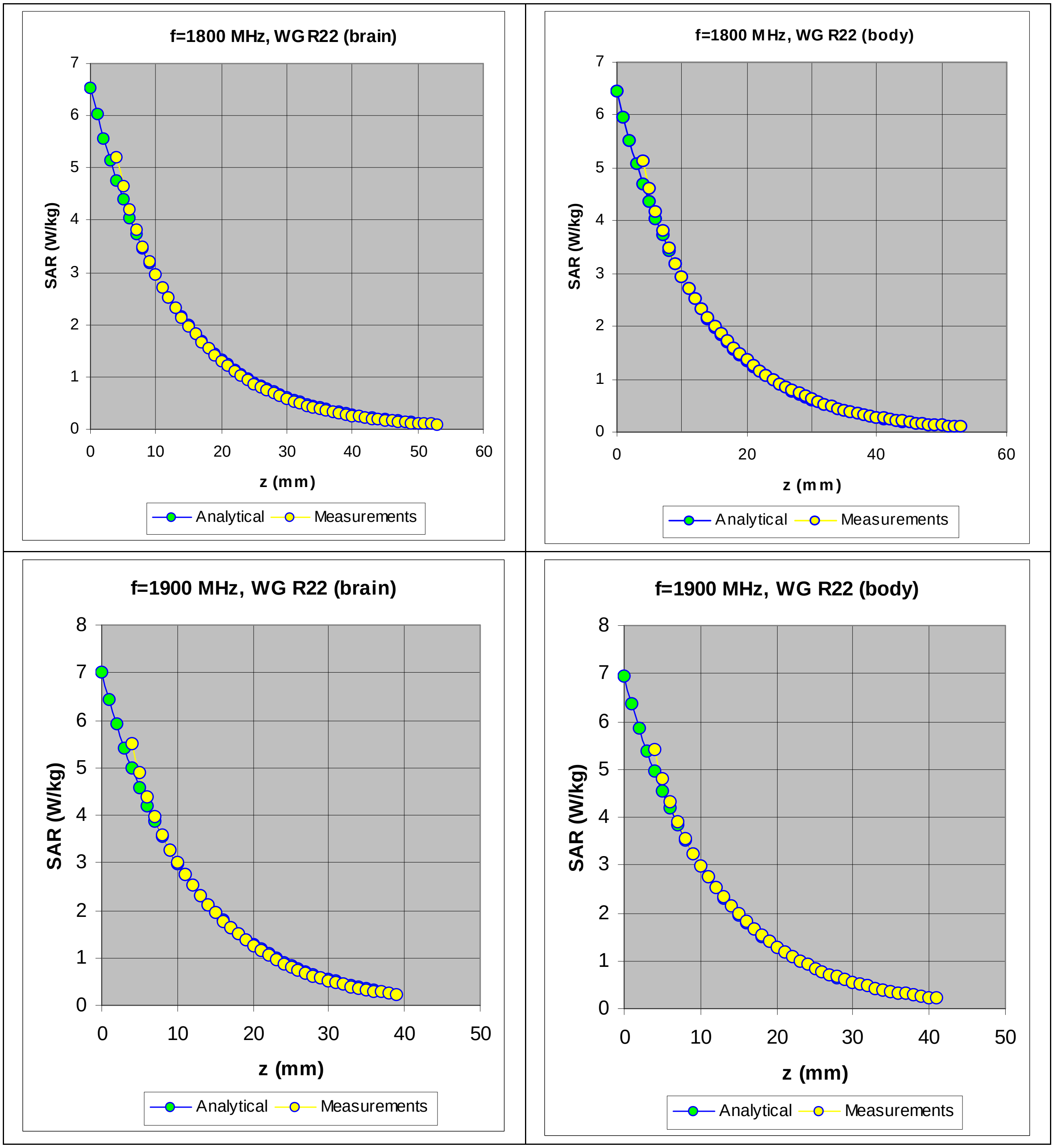


Figure 7. The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

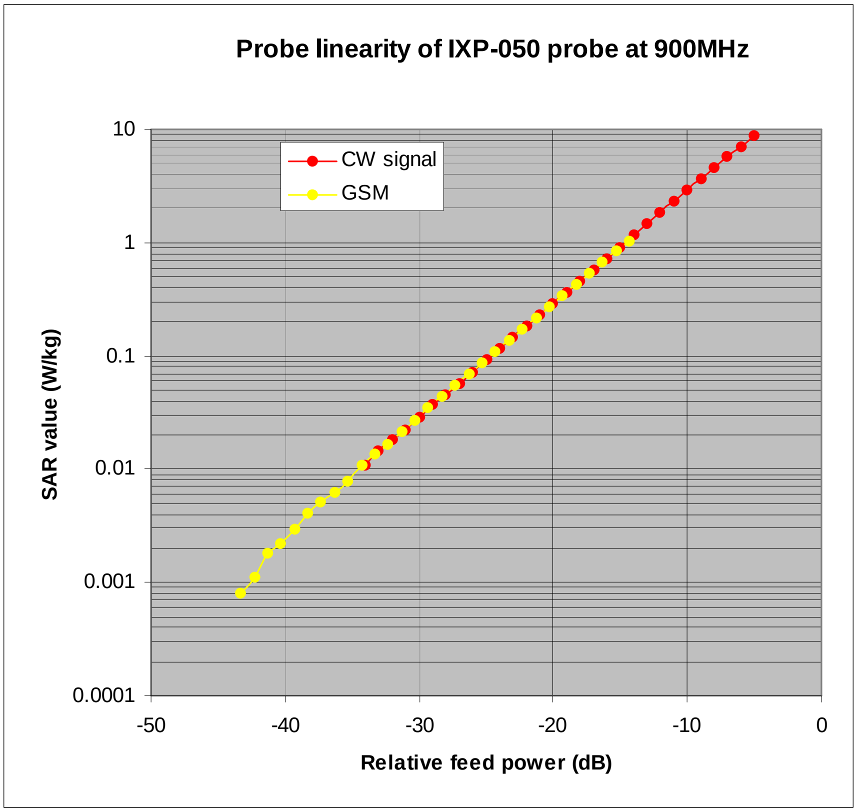


Figure 8. The GSM response of an IXP-050 probe at 900MHz.

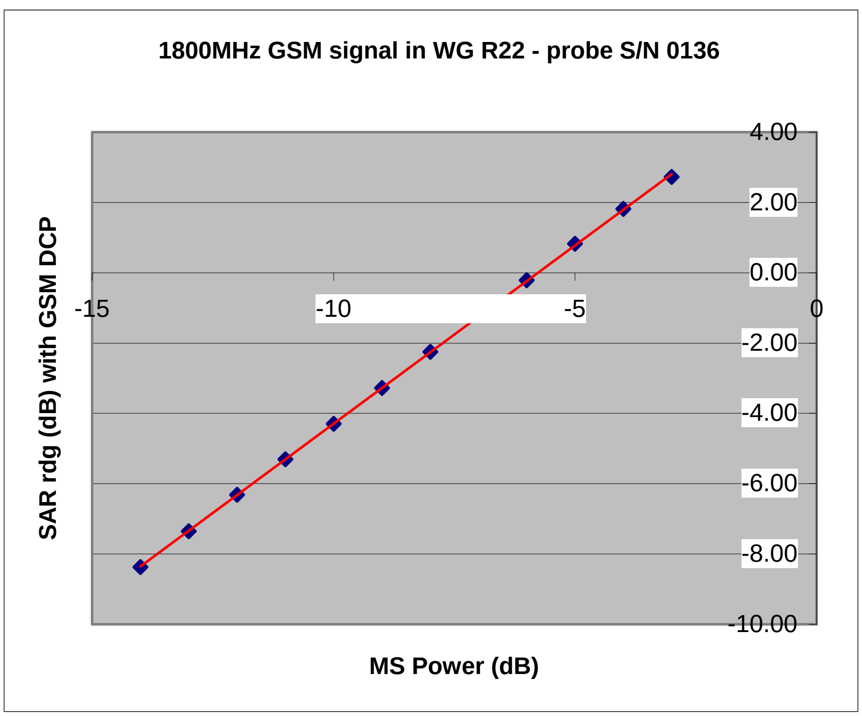


Figure 8a. The actual GSM response of IXP-050 probe S/N 0136 at 1800MHz

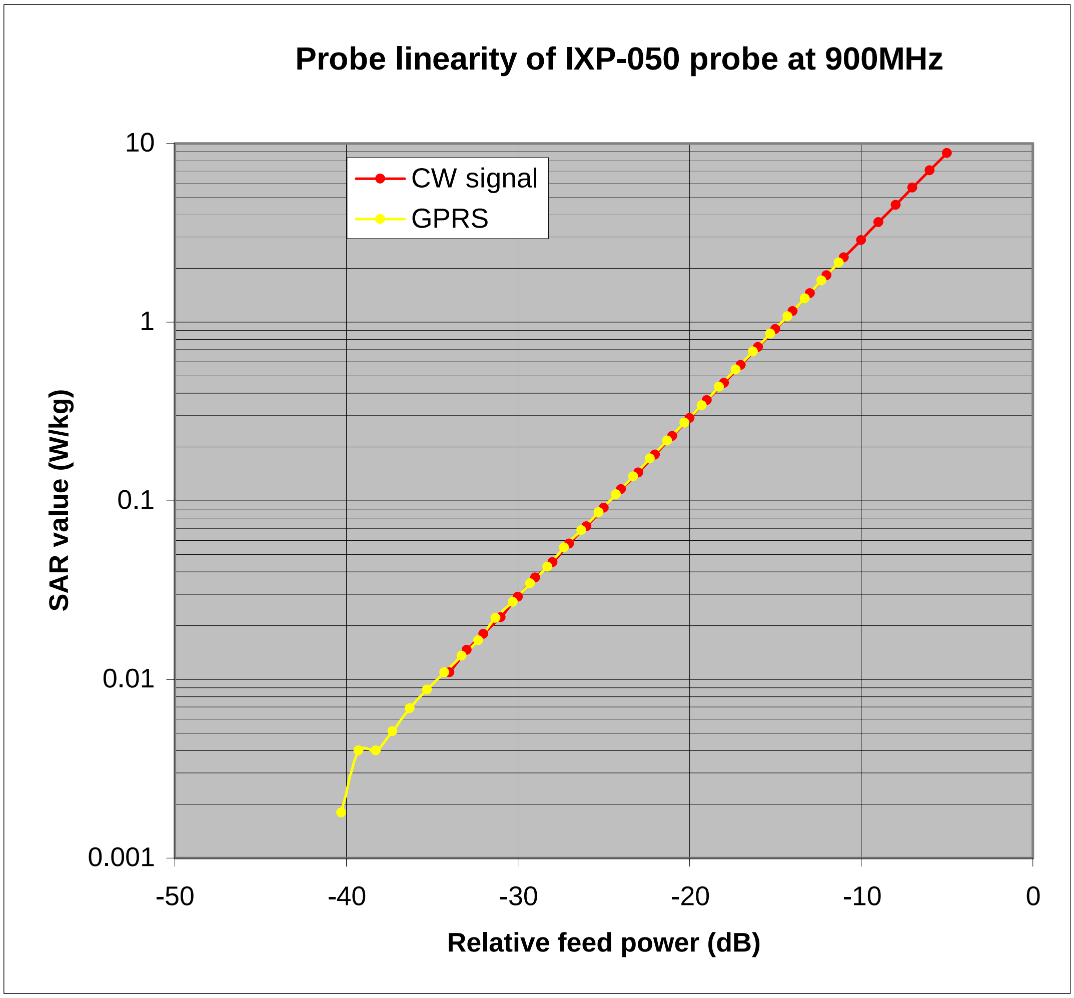
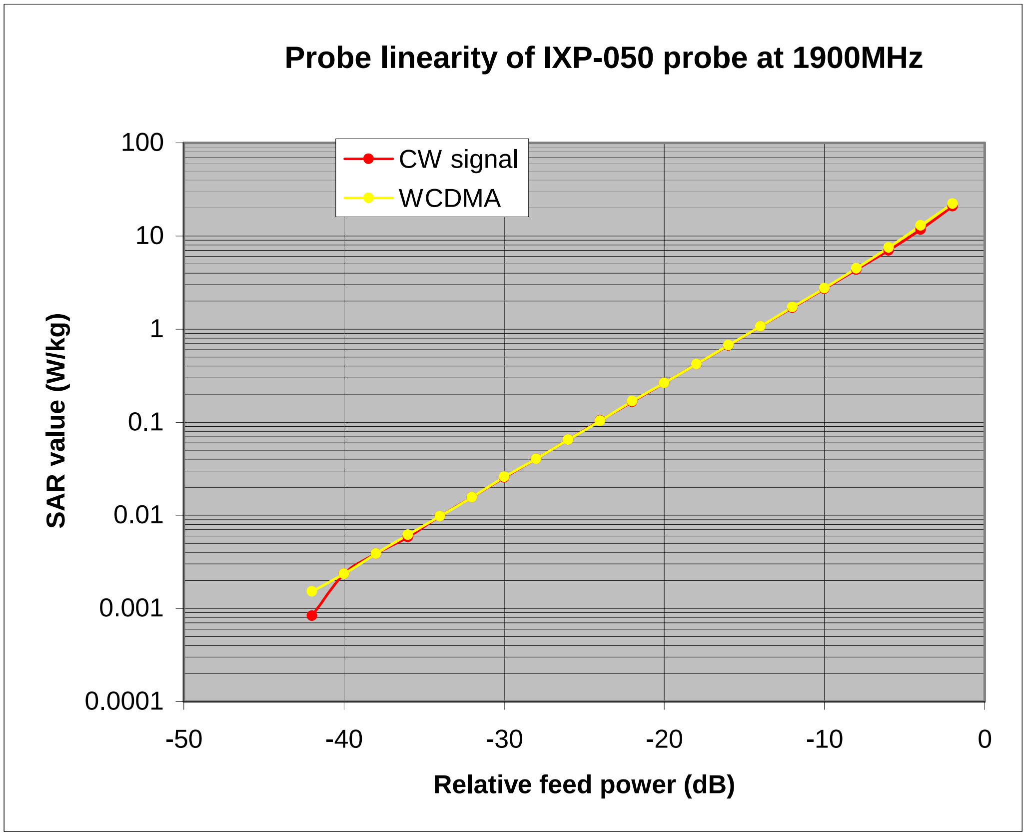


Figure 9. The GPRS response of an IXP-050 probe at 900MHz.



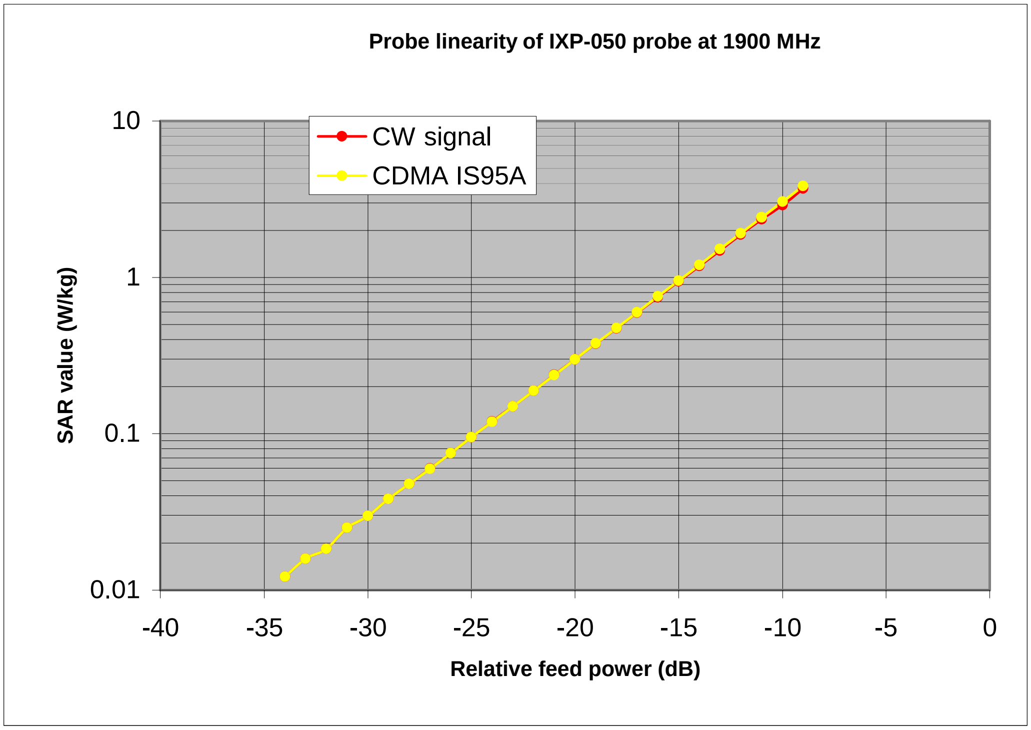


Figure 10. The CDMA response of an IXP-050 probe at 1900MHz.

Table indicating the dielectric parameters of the liquids used for calibrations at each frequency

Liquid used	Relative permittivity (measured)	Conductivity (S/m) (measured)
835 MHz BRAIN	43.18	0.935
835 MHz BODY	59.19	0.992
900 MHz BRAIN	42.47	0.998
900 MHz BODY	58.7	1.056
1800 MHz BRAIN	38.72	1.34
1800 MHz BODY	52.5	1.53
1900 MHz BRAIN	38.31	1.43
1900 MHz BODY	52.06	1.64
2450 MHz BRAIN	38.9	1.87
2450 MHz BODY	52.59	2.08

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e-mail: enquiries@indexsar.com

Calibration / Conformance statement
Balanced Validation dipole

Type:	**IXD-090 900MHz**
Manufacturer:	**IndexSAR, UK**
Serial Number:	**0022**
Place of Calibration:	**IndexSAR, UK**

IndexSAR Limited hereby declares that the IXD series dipole named above has been checked for conformity to the specifications given in the draft IEEE 1528 and CENELEC En 50361 standards on the date shown below.

Date of Calibration/Check:	**29th September 2003**

The dipole named above should be periodically re-checked using the procedures set out in the dipole calibration document. It is important that the cautions regarding handling of the dipoles (given in the calibration document) are adhered to.

Next Calibration Date:	**September 2005**

The calibration measurements were carried out using the methods described in the calibration document. Where applicable, the standards used in the calibration process are traceable to the UK's National Physical Laboratory.

Calibrated By: [signature]

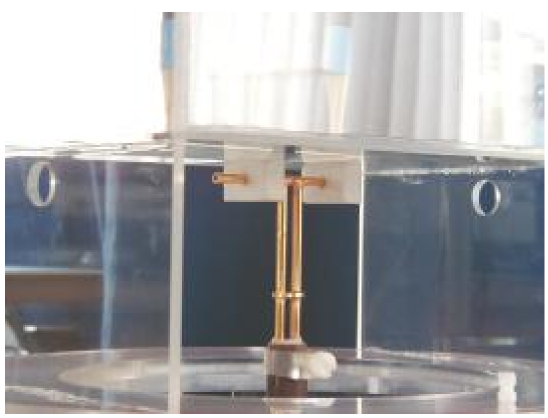
Approved By: [signature]

Report No. SN0022_900
29th September 2003

INDEXSAR
900MHz validation Dipole
Type IXD-090 **S/N 0022**

Performance measurements

- ***MI Manning***



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e-mail: enquiries@indexsar.com

1. Measurement Conditions

Measurements were performed using a box-shaped phantom made of PMMA with dimensions designed to meet the accuracy criteria for reasonably-sized phantoms that do not have liquid capacities substantially in excess of the volume of liquid required to fill the Indexsar upright SAM phantoms used for SAR testing of handsets against the ear.

An HP 8753B vector network analyser was used for the return loss measurements.
The dipole was placed in a special holder made of low-permittivity, low-loss materials. This holder enables the dipole to be positioned accurately in the centre of the base of the Indexsar box-phantom used for flat-surface testing and validation checks.

The validation dipoles are supplied with special spacers made from a low-permittivity, low-loss foam material. These spacers are fitted to the dipole arms to ensure that, when the dipole is offered up to the phantom surface, the spacing between the dipole and the liquid surface is accurately aligned according to the guidance in the relevant standards documentation. The spacers are rectangular with a central hole equal to the dipole arm diameter and dimensioned so that the longer side can be used to ensure a spacing of 15mm from the liquid in the phantom (for tests at 900MHz and below) and the shorter side can be used for tests at 1800MHz and above to ensure a spacing of 10mm from the liquid in the phantom. The spacers are made on a CNC milling machine with an accuracy of $1/40^{th}$ mm but they may suffer wear and tear and need to be replaced periodically. The material used is Rohacell, which has a relative permittivity of approx. 1.05 and a negligible loss tangent.

The apparatus supplied by Indexsar for dipole validation tests thus includes:

Balanced dipoles for each frequency required are dimensioned according to the guidelines given in IEEE 1528 [1]. The dipoles are made from semi-rigid 50 Ohm co-ax, which is joined by soldering and is gold-plated subsequently. The constructed dipoles are easily deformed, if mis-handled, and periodic checks need to be made of their symmetry.

Rohacell foam spacers designed for presenting the dipoles to 2mm thick PMMA box phantoms. These components also suffer wear and tear and should be replaced when the central hole is a loose-fit on the dipole arms or if the edges are too worn to ensure accurate alignment. The standard spacers are dimensioned for use with 2mm wall thickness (additional spacers are available for 4mm wall thickness).

2. Typical SAR Measurement

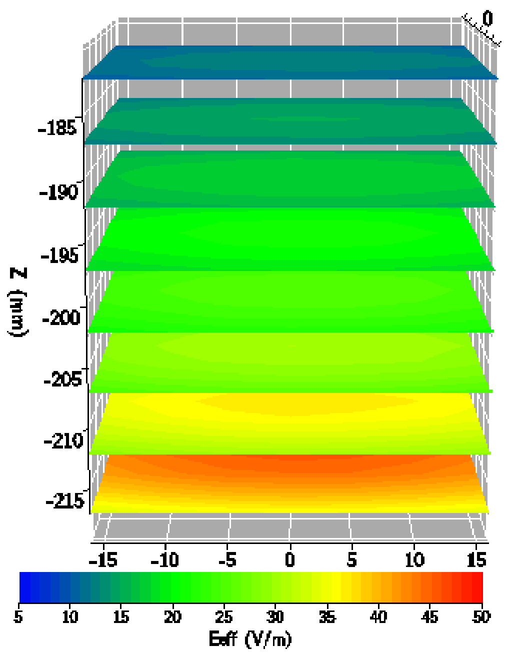
A SAR validation check was performed with the box-phantom located on the SARA2 phantom support base on the SARA2 robot system. Tests were conducted at a feed power level of approx. 0.25W. The actual power level was recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The ambient temperature was $24^{o}C$ +/- $1^{o}C$ and the relative humidity was 67% during the measurements.

The phantom is filled with a 900MHz brain liquid using a recipe from [1], which had the following electrical parameters (measured using an Indexsar DiLine kit) at 900MHz:

Relative Permittivity **42.5**
Conductivity **0.97 S/m**

The SARA2 software version 0.421N is used with an Indexsar probe previously calibrated using waveguides.

The 3D measurements made using the dipole at the bottom of the phantom box are shown below:



The results, normalised to an input power of 1W (forward power) are typically:

Averaged over 1 cm3 (1g) of tissue **10.184 W/kg**
Averaged over 10cm3 (10g) of tissue **6.572 W/kg**

These results can be compared with Table 8.1 in [1]. The agreement is within 10%.

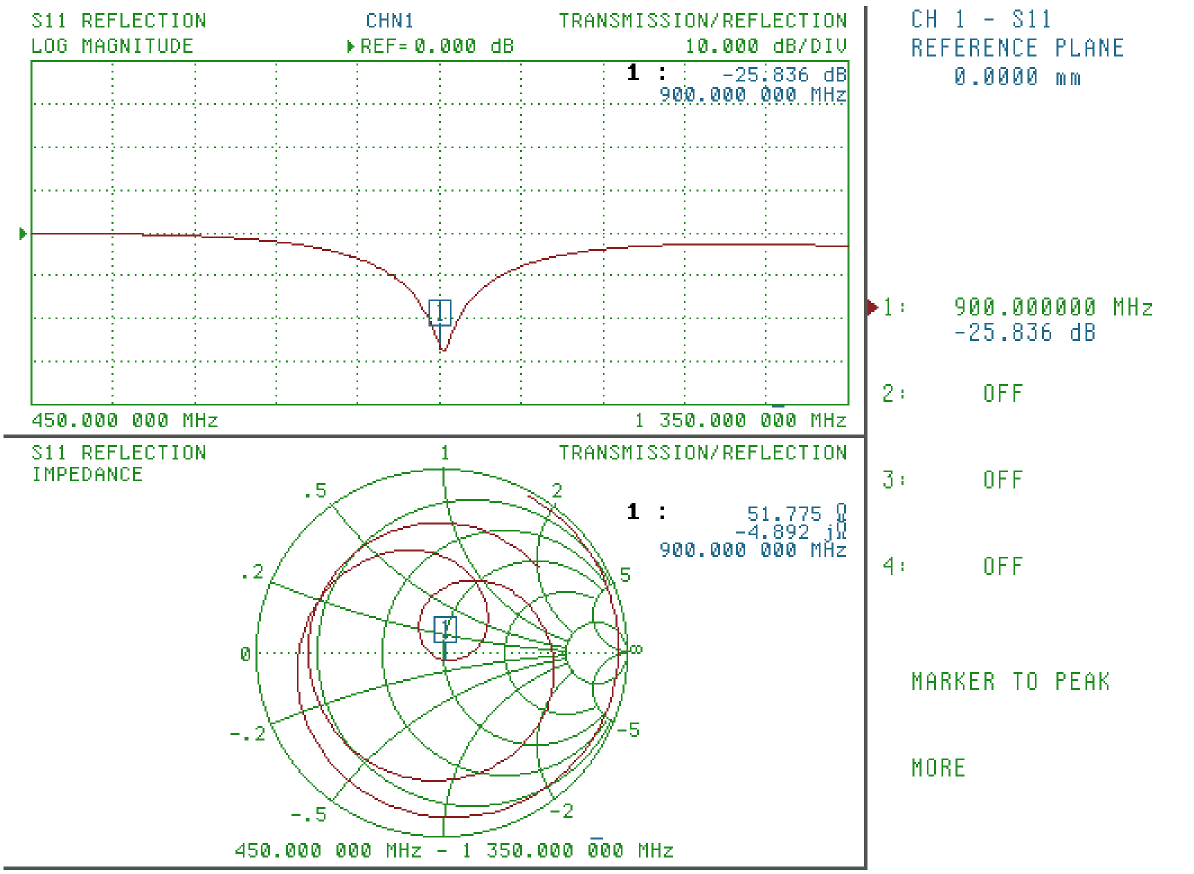
3. Dipole impedance and return loss

The dipoles are designed to have low return loss ONLY when presented against a lossy-phantom at the specified distance. A Vector Network Analyser (VNA) was used to perform a return loss measurement on the specific dipole when in the measurement-location against the box phantom. The distance was as specified in the standard i.e. 10mm from the liquid (for 900MHz). The Indexsar foam spacers (described above) were used to ensure this condition during measurement.

The impedance was measured at the SMA-connector with the network analyser.
The following parameters were measured:

Dipole impedance at 900 MHz Re{Z} = **51.775 Ω**
Im{Z} = **-4.892 Ω**

Return loss at 900MHz **-25.836 dB**



4. Dipole handling

The dipoles are made from standard, copper-sheathed coaxial cable. In assembly, the sections are joined using ordinary soft-soldering. This is necessary to avoid excessive heat input in manufacture, which would destroy the polythene dielectric used for the cable. The consequence of the construction material and the assembly technique is that the dipoles are fragile and can be deformed by rough handling. Conversely, they can be straightened quite easily as described in this report.

If a dipole is suspected of being deformed, a normal workshop lathe can be used as an alignment jig to restore the symmetry. To do this, the dipole is first placed in the headstock of the lathe (centred on the plastic or brass spacers) and the headstock is rotated by hand (do NOT use the motor). A marker (lathe tool or similar) is brought up close to the end of one dipole arm and then the headstock is rotated by 0.5 rev. to check the opposing arm. If they are not balanced, judicious deformation of the arms can be used to restore the symmetry.

If a dipole has a failed solder joint, the dipole can be fixed down in such a way that the arms are co-linear and the joint re-soldered with a reasonably-powerful electrical soldering iron. Do not use gas soldering irons. After such a repair, electrical tests must be performed as described below.

Please note that, because of their construction, the dipoles are short-circuited for DC signals.

5. Tuning the dipole

The dipole dimensions are based on calculations that assumed specific liquid dielectric properties. If the liquid dielectric properties are somewhat different, the dipole tuning will also vary. A pragmatic way of accounting for variations in liquid properties is to ‘tune’ the dipole (by applying minor variations to its effective length). For this purpose, Indexsar can supply short brass tube lengths to extend the length of the dipole and thus ‘tune’ the dipole. It cannot be made shorter without removing a bit from the arm. An alternative way to tune the dipole is to use copper shielding tape to extend the effective length of the dipole. Do both arms equally.

It should be possible to tune a dipole as described, whilst in place in the measurement position as long as the user has access to a VNA for determining the return loss.

6. References

[1] Draft recommended practice for determining the peak spatial-average specific absorption rate (SAR) in the human body due to wireless communications devices: Experimental Techniques.