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Report On

Specific Absorption Rate Testing of the
Option NV
GX0301 Globetrotter GT Max PCMCIA Card

FCC ID: NCMOGX0301

Document 75901921 Report 01 Issue 1 August 2007

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DATED 17th August 2007

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SECTION 1

REPORT SUMMARY

Specific Absorption Rate Testing of the
Option NV
GX0301 Globetrotter GT Max PCMCIA Card

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Specific Absorption Rate Testing of the Option NV GX0301 Globetrotter GT Max PCMCIA Card to the requirements of FCC standard Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01) of 1.6 W/kg.

Objective	To perform Specific Absorption Rate Testing to determine the Equipment Under Test's (EUT's) compliance with the specification/Test Plan, for the series of tests carried out.
Applicant	Option NV
Manufacturer	Option NV
Manufacturing Description	Globetrotter GT Max PCMCIA Card
Model Number	GX0301
Power Class	GSM 835 MHz Class 4 GSM 900 MHz Class 4 DCS 1800 MHz Class 1 PCS 1900 MHz Class 1
GPRS Class	Class B
GPRS Multi-slot Class	12 (4Dn; 4Up; Sum5)
WCDMA Frequency Band	FDD1 (1922.4 to 1977.6 MHz) FDD2 (1852.4 to 1907.6 MHz) FDD5 (826.4 to 846.6 MHz)
WCDMA Power Class	FDD I/II/V Power Class 3 (+24dBm)
Serial Number(s)	GE 2474A04R
IMEI Number(s)	004401440468128
Hardware Version	2.0
Software Version	2.7.0
Host 1 Manufacturer & Model	HP Compaq nc 6320
Host 1 Country of Manufacture	China
Test Specification/Issue/Date	FCC Publication Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01)
Start of Test	25th July 2007
Finish of Test	26th July 2007
Related Document(s)	IEEE STD 1528: 2003. IEEE Std C95.1-2005. ICNIRP Vol. 74, No. 4, 494-522, 1998. ETSI TS 134 121-1 V7.4.0. FCC OET SAR Measurement Procedures for 3G Devices – CDMA 2000 / Ev-DO – WCDMA / HSDPA b(Rev. 1 - June 2006). FCC OET Interim SAR Procedures for Release 6 HSPA Devices – Preliminary Draft, 06/06/2007. SAR Report_7layers_6620_632_FCC_Body_850_1900_WCDMA II_V_Globetrotter GT_3

1.2 BRIEF SUMMARY OF RESULTS

This test report covers partial testing for HSUPA/HSDPA as per the client's request. Limited body SAR testing was performed on FDD Band II and V only.

A brief summary of the tests carried out in accordance with FCC standard Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01) is shown below.

The maximum 1g volume averaged SAR found during this Limited Assessment

Max 1g SAR (W/kg)	0.829
The maximum 1g volume averaged SAR level measured for all the tests performed did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 1.6 W/kg. Level defined in Supplement C (Edition 01-01) to OET Bulletin 65 (97-01).	

1.3 TEST RESULTS SUMMARY

1.3.1 System Performance/ Validation Check Results

Prior to formal testing being performed a System Check was performed in accordance with OET 65 Supplement C (Edition 01-01) [5] and the results were compared against published data in Standard IEEE 1528-2003 [4]. The following results were obtained: -

Date	Dipole Used	Frequency (MHz)	Max 1g SAR (W/kg)	Percentage Drift on Reference	Max 10g SAR (W/kg)	Percentage Drift on Reference
31/07/2007	900 MHz	907.5	11.01*	1.96%	7.12*	3.22%
31/07/2007	1900 MHz	1883.6	40.99*	3.26%	21.68%	5.74%

*Normalised to a forward power of 1W

WCDMA FDD V BODY Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the GX0301 Globetrotter GT Max PCMCIA Card (Serial No.: GE 2474A04R) in HSDPA and HSUPA Modes (Host Laptop: HP Compaq nc 6320)

Position		HSPA Mode	Channel Number	Frequency (MHz)	Max Spot SAR (W/kg)	Max 1g SAR (W/kg	Max 10g SAR (W/kg)	SAR Drift (%)	Area scan (Figure number)
Card Spacing From Phantom	Host Laptop Position								
11mm	0mm Rear Facing	HSDPA Sub-test 2	4132	826.4	0.370	0.450	0.284	-1.30	Figure 5
11mm	0mm Rear Facing	HSUPA Sub-test 5	4233	846.6	0.560	0.688	0.425	0.270	Figure 6
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)									

WCDMA FDD II BODY Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the GX0301 Globetrotter GT Max PCMCIA Card (Serial No.: GE 2474A04R) in HSDPA and HSUPA Modes (Host Laptop: HP Compaq nc 6320)

Position		HSPA Mode	Channel Number	Frequency (MHz)	Max Spot SAR (W/kg)	Max 1g SAR (W/kg	Max 10g SAR (W/kg)	SAR Drift (%)	Area scan (Figure number)
Card Spacing From Phantom	Host Laptop Position								
11mm	0mm Rear Facing	HSDPA Sub-test 1	9262	1852.4	0.680	0.829	0.511	4.02	Figure 7
11mm	0mm Rear Facing	HSUPA Sub-test 5	9400	1880.0	0.670	0.798	0.484	-0.11	Figure 8

1.4 PRODUCT INFORMATION

1.4.1 Technical Description

The Equipment Under Test (EUT) was an Option NV GX0301 Globetrotter GT Max PCMCIA Card. A full technical description can be found in the manufacturer's documentation.

The wireless portable device described within this report has been shown to be capable of compliance for localised specific absorption rate (SAR) for FCC standard Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01) of 1.6 W/kg.

This report must be read in conjunction with SAR Report_7layers_6620_632_FCC_Body_850_1900_WCDMA II_V_Globetrotter GT_3 issued 16th August 2007. The measurements shown in this report were made in accordance with the procedures specified in Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01).

All reported testing was carried out on a sample of equipment to demonstrate compliance with the above standard. The sample tested was found to comply with the requirements in the applied rules.

1.4.2 Test Configuration and Modes of Operation

There is a flipout antenna with one intended position for use. This test report covers partial testing for HSUPA/HSDPA as per the client's request. Limited body SAR testing was performed on FDD Band II and V. The Option NV GX0301 was tested in a HP Compaq nc 6320 host laptop.

Conducted output power measurements were made in accordance to the 3GPP 34.121 standard. The highest output power reading for HSDPA and HSUPA for the FDD II and V band was identified so that two sub-tests were run in each of the bands. The Anritsu 8815B Radio Communications Analyser which is capable of measuring W-CDMA/HSDPA terminals was used to establish the required test configuration for the GX0301 Globetrotter GT Max PCMCIA Card as per the FCC OET SAR Measurement Procedures for 3G Devices. The HSDPA body SAR measurements were made using an FRC with H-set 1 and a 12.2kbps RMC configured in test loop mode 1. For FDD Band 2, SAR testing was conducted using the HP Compaq nc 6320, which was the worst-case host found in the IMST SAR report. The channel and sub-test which gave rise to the highest conducted output power measurement for HSDPA and HSUPA in each bands was selected to be measured, per the client's request and the results are contained within this test report. The output power measurements are contained within Section 1.3 of this report. The output power readings for HSPA did not exceed the WCDMA readings by 0.25dB and therefore, further measurements were not necessary.
SAR was selectively confirmed for other physical channel configurations (DPCCH & DPDCH_n) according to output power, exposure conditions and device operating capabilities as required. The Anritsu 8815B Radio Communications Analyser was initially configured with default settings and the parameters described in 3GPP TS 34.121 were applied. The channel parameters used for the device are contained in Section 1.4.

The UE is fully compliant with 3GPP standards defining required UMTS spreading factors.

The DPCCH spreading factor is 256 per 3GPP TS 25.213 section 4.3.1.2.1.
The DPDCH spreading factor is dependent on number of DPDCH channels and data range. For a single channel the spreading factor can range from 4 to 256. For more then one DPDCH channel the spreading factor is 4. Further details are defined by 3GPP in TS 25.213 section 4.3.1.2.1.

HS-DPCCH spreading factor is 256. Further details can be found in 3GPP TS 25.213 section 4.3.1.2.2.

SAR testing on the body was conducted on the FDD 5 band in HSDPA Sub-test 2 mode and HSUPA Sub-test 5 mode with the HP Compaq nc 6320 host laptop being used. The rear of the laptop was in contact with the bottom of the flat phantom and therefore there was a 0mm separation distance. The Option NV GX0301 card had a 11mm separation distance from the bottom of the flat phantom. SAR testing was also conducted on the FDD 2 band in HSDPA Sub-test 1 mode and HSUPA Sub-test 5 mode with the HP Compaq nc 6320 host laptop being used. The rear of the laptop was in contact with the bottom of the flat phantom and therefore there was a 0mm separation distance. The Option NV GX0301 card had a 11mm separation distance from the bottom of the flat phantom.

The Flat Phantom dimensions were 210mm x 210mm x 210mm with a sidewall thickness of 2.00mm. The phantom was filled to a minimum depth of 150mm with the appropriate Body simulant liquid. The dielectric properties were in accordance with the requirements for the dielectric properties specified in Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01).

Included in this report are descriptions of the test method; the equipment used and an analysis of the test uncertainties applicable and diagrams indicating the locations of maximum SAR for each test position along with photographs indicating the positioning of the module with respect to the body as appropriate.

1.5 RF POWER OUTPUT – CONDUCTED

1.5.1 Specification

ETSI TS 134 121-1 V7.4.0, Universal Mobile Telecommunications System (UMTS); User Equipment (UE) conformance specification; Radio transmission and reception (FDD).

1.5.2 Method

The conducted RF output power measurements were made at the RF output terminal of the EUT. The EUT was controlled via the Anritsu 8815B Radio Communications Analyser selecting the required modes of modulation and sub-sets. The power measurements below incorporate the path loss that was measured on the day for each device.

1.5.3 Results

Maximum WCDMA FDDV Transmit Power Measurements including Path Loss Device: Option NV GX0301 (S/N: GE2474A04R).

FDD Band V		Frequency		
		826.4	836.4	846.6
3GPP 34.121 Mode	HSPA Sub-test	Conducted Transmit Power (dBm)		
Rel99	12.2kbps RMC	21.51	21.34	21.29
Rel6 HSDPA	1	20.93	20.78	20.77
Rel6 HSDPA	2	**21.06**	20.78	20.78
Rel6 HSDPA	3	21.05	20.88	20.96
Rel6 HSDPA	4	20.45	20.28	20.31
Rel6 HSUPA	1	19.81	20.05	19.96
Rel6 HSUPA	2	18.45	18.28	18.19
Rel6 HSUPA	3	19.21	19.02	18.73
Rel6 HSUPA	4	18.83	19.02	18.87
Rel6 HSUPA	5	19.99	19.97	**20.24**

Maximum WCDMA FDD2 Transmit Power Measurements including Path Loss Device: Option NV GX0301 (S/N: GE2474A04R).

FDD Band II		Frequency		
		1852.4	1880	1907.6
3GPP 34.121 Mode	HSPA Sub-test	Conducted Transmit Power (dBm)		
Rel99	12.2kbps RMC	21.63	21.48	21.09
Rel6 HSDPA	1	**21.31**	21.07	20.65
Rel6 HSDPA	2	21.28	21.13	20.61
Rel6 HSDPA	3	21.30	20.21	20.68
Rel6 HSDPA	4	20.81	20.68	20.18
Rel6 HSUPA	1	20.87	20.37	20.26
Rel6 HSUPA	2	18.96	18.86	17.96
Rel6 HSUPA	3	19.58	19.43	18.88
Rel6 HSUPA	4	19.69	18.85	18.94
Rel6 HSUPA	5	19.48	**20.92**	20.41

1.6 CHANNEL PARAMETERS FOR HSDPA

1.6.1 Fixed Reference Channel H-Set 1

Parameter	Unit	Value	
Nominal Avg. Inf. Bit Rate	kbps	534	777
Inter-TTI Distance	TTI's	3	3
Number of HARQ Processes	Processes	2	2
Information Bit Payload (N_{INF})	Bits	3202	4664
MAC-d PDU size	Bits	336	336
Number Code Blocks	Blocks	1	1
Binary Channel Bits Per TTI	Bits	4800	7680
Total Available SML's in UE	SML's	19200	19200
Number of SML's per HARQ Proc.	SML's	9600	9600
Coding Rate		0.67	0.61
Number of Physical Channel Codes	Codes	5	4
Modulation		QPSK	16QAM
Note: The HS-DSCH shall be transmitted continuously with constant power but only every third TTI shall be allocated to the UE under test			

1.6.2 β values for transmitter characteristics tests with HS-DPCCH and E-DCH

Sub-test	β_c	β_d	β_d (SF)	β_c/β_d	β_{HS} (Note1)	β_{ec}	β_{ed} (Note 5) (Note 6)	β_{ed} (SF)	β_{ed} (Codes)	CM (dB) (Note 2)	MPR (dB) (Note 2)	AG Index (Note 6)	E-TFCI
1	11/15 (Note 3)	15/15 (Note 3)	64	11/15 (Note 3)	22/15	209/225	1309/225	4	1	1.0	0.0	20	75
2	6/15	15/15	64	6/15	12/15	12/15	94/75	4	1	3.0	2.0	12	67
3	15/15	9/15	64	15/9	30/15	30/15	β_{ed}1: 47/15 β_{ed}2: 47/15	4 4	2	2.0	1.0	15	92
4	2/15	15/15	64	2/15	4/15	2/15	56/75	4	1	3.0	2.0	17	71
5	15/15 (Note 4)	15/15 (Note 4)	64	15/15 (Note 4)	30/15	24/15	134/15	4	1	1.0	0.0	21	81

Note 1: Δ_{ACK}, Δ_{NACK} and Δ_{CQI} = 30/15 with β_{hs} = 30/15 * β_c .

Note 2: CM = 1 for β_c/β_d =12/15, β_{hs}/β_c=24/15. For all other combinations of DPDCH, DPCCH, HS- DPCCH, E-DPDCH and E-DPCCH the MPR is based on the relative CM difference.

Note 3: For subtest 1 the β_c/β_d ratio of 11/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 10/15 and β_d = 15/15.

Note 4: For subtest 5 the β_c/β_d ratio of 15/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to β_c = 14/15 and β_d = 15/15.

Note 5: In case of testing by UE using E-DPDCH Physical Layer category 1, Sub-test 3 is omitted according to TS25.306 Table 5.1g.

Note 6: β_{ed} can not be set directly, it is set by Absolute Grant Value.

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SECTION 2

TEST DETAILS

Specific Absorption Rate Testing of the
Option NV
GX0301 Globetrotter GT Max PCMCIA Card

2.1 SAR MEASUREMENT SYSTEM

2.1.1 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.

Schematic diagram of the SAR measurement system

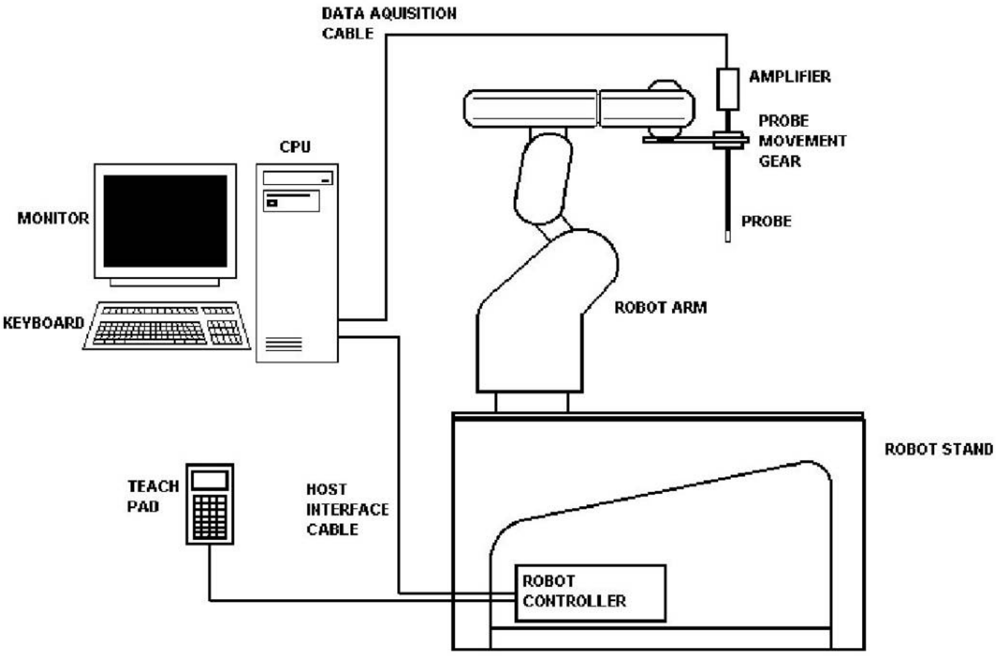


Figure 1

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.

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 0.001mm. 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.

2.1.2 Probe and Amplifier Specification

<u>IXP-050 IndexSAR isotropic immersible SAR probe</u>

The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip.
Probe calibration is described in the following section.

<u>IFA-010 Fast Amplifier</u>

Technical description of IndexSAR IFA-010 Fast probe amplifier
A block diagram of the fast probe amplifier electronics is shown below.

<u>Block diagram of the fast probe amplifier electronic</u>

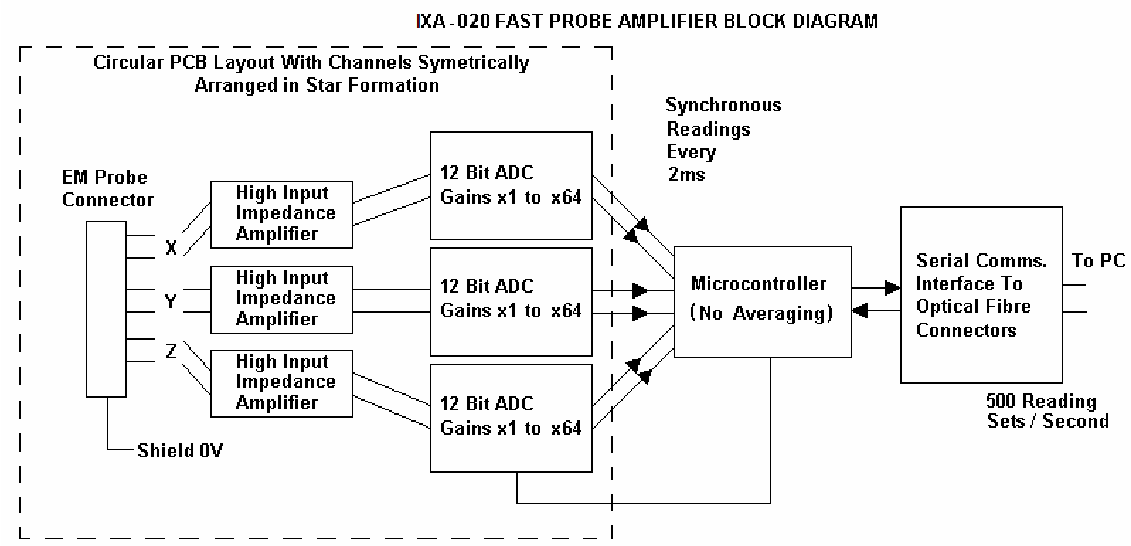


Figure 2

This amplifier has a time constant of approx. 50µs, which is much faster than the SAR probe response time. The overall system time constant is therefore that of the probe (<1ms) and reading sets for all three channels (simultaneously) are returned every 2ms to the PC. The conversion period is approx. 1 µs at the start of each 2ms period. This enables the probe to follow pulse modulated signals of periods >>2ms. The PC software applies the linearisation procedure separately to each reading, so no linearisation corrections for the averaging of modulated signals are needed in this case. It is important to ensure that the probe reading frequency and the pulse period are not synchronised and the behaviour with pulses of short duration in comparison with the measurement interval need additional consideration.

<u>Phantoms</u>

The Flat phantom used is a rectangular Perspex Box IndexSAR item IXB-070. Dimensions 210w 210d 210h (mm). This phantom is used with IndexSAR side bench IXM-030.

The Specific Anthropomorphic Mannequin (SAM) Upright Phantom is fabricated using moulds generated from the CAD files as specified by CENELEC EN50361:2001. It is mounted via a rotation base to a supporting table, which also holds the robotic positioner. The phantom and robot alignment is assured by both mechanical and laser registration systems.

2.1.3 SAR Measurement Procedure

Principal components of the SAR measurement test bench

Figure 3

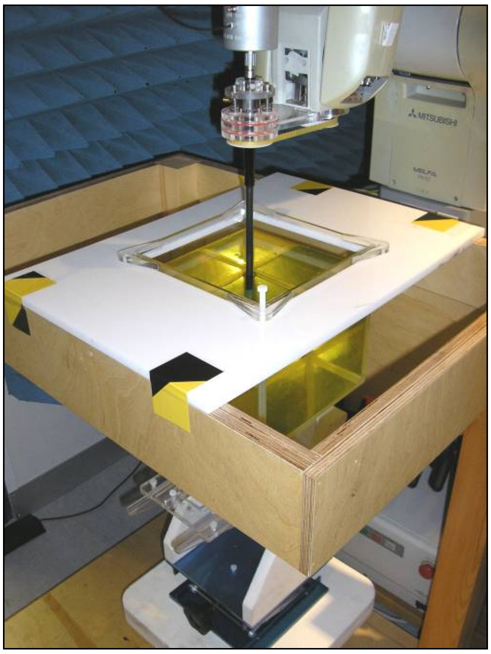


Figure 4

The major components of the test bench are shown in the picture above. A test set and dipole antenna control the handset via an air link and a low-mass phone holder can position the phone at either ear. Graduated scales are provided to set the phone in the 15 degree position. The upright phantom head holds approx. 7 litres of simulant liquid. The phantom is filled and emptied through a 45mm diameter penetration hole in the top of the head.

After an area scan has been done at a fixed distance of 8mm from the surface of the phantom on the source side, a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power drift during measurement to be assessed.

<u>SARA2 Interpolation and Extrapolation schemes</u>

SARA2 software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a general n^{-th} order polynomial fitting routine is implemented following a singular value decomposition algorithm presented in [4]. A 4^{th} order polynomial fit is used by default for data extrapolation, but a linear-logarithmic fitting function can be selected as an option. The polynomial fitting procedures have been tested by comparing the fitting coefficients generated by the SARA2 procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

Interpolation of 2D area scan

The 2D cubic B-spline interpolation is used after the initial area scan at fixed distance from the phantom shell wall. The initial scan data are collected with approx. 115mm spatial resolution and spline interpolation is used to find the location of the local maximum to within a 1mm resolution for positioning the subsequent 3D scanning.

Extrapolation of 3D scan

For the 3D scan, data are collected on a spatially regular 3D grid having (by default) 6.4 mm steps in the lateral dimensions and 3.5 mm steps in the depth direction (away from the source). SARA2 enables full control over the selection of alternative step sizes in all directions.

The digitised shape of the head is available to the SARA2 software, which decides which points in the 3D array are sufficiently well within the shell wall to be 'visited' by the SAR probe. After the data collection, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

Interpolation of 3D scan and volume averaging

The procedure used for defining the shape of the volumes used for SAR averaging in the SARA2 software follow the method of adapting the surface of the 'cube' to conform with the curved inner surface of the phantom (see Appendix C.2.2.1 in EN 50361:2001). This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated and interpolated to less than 1mm spacing and average values are calculated from the phantom surface for the row of data over distances corresponding to the requisite depth for 10g and 1g cubes. This results in two 2D arrays of data, which are then cubic B-spline interpolated to sub mm lateral resolution. A search routine then moves an averaging square around through the 2D array and records the maximum value of the corresponding 1g and 10g volume averages. For the definition of the surface in this procedure, the digitised position of the headshell surface is used for measurement in head-shaped phantoms. For measurements in rectangular, box phantoms, the distance between the phantom wall and the closest set of gridded data points is entered into the software.

For measurements in box-shaped phantoms, this distance is under the control of the user. The effective distance must be greater than 2.5mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 5mm. A value of 6 or 8mm is recommended. This distance is called **dbe** in EN 50361:2001.

For automated measurements inside the head, the distance cannot be less than 2.5mm, which is the radius of the probe tip and to avoid interface proximity effects, a minimum clearance distance of x mm is retained. The actual value of dbe will vary from point to point depending upon how the spatially-regular 3D grid points fit within the shell. The greatest separation is when a grid point is just not visited due to the probe tip dimensions. In this case the distance could be as large as the step-size plus the minimum clearance distance (i.e with x=5 and a step size of 3.5, **dbe** will be between 3.5 and 8.5mm).

The default step size (**dstep** in EN 50361:2001) used is 3.5mm, but this is under user-control. The compromise is with time of scan, so it is not practical to make it much smaller or scan times become long and power-drop influences become larger.

The robot positioning system specification for the repeatability of the positioning (**dss** in EN50361:2001) is +/- 0.04mm.

The phantom shell is made by an industrial moulding process from the CAD files of the SAM shape, with both internal and external moulds. For the upright phantoms, the external shape is subsequently digitised on a Mitutoyo CMM machine (Euro C574) to a precision of 0.001mm. Wall thickness measurements made non-destructively with an ultrasonic sensor indicate that the shell thickness (**dph**) away from the ear is 2.0 +/- 0.1mm. The ultrasonic measurements were calibrated using additional mechanical measurements on available cut surfaces of the phantom shells.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253mm-diameter baseplate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided (procedure detailed elsewhere). This enables the registration of the phantom tip (**dmis**) to be assured to within approx. 0.2mm. This alignment is done with reference to the actual probe tip after installation and probe alignment. The rotational positioning of the phantom is variable – offering advantages for special studies, but locating pins ensure accurate repositioning at the principal positions (LH and RH ears).

2.2 MAXIMUM FDD V HSDPA SAR TEST RESULT AND COURSE AREA SCAN – 2D

SYSTEM / SOFTWARE:	SARA2 / 2.39 VPM	INPUT POWER DRIFT:	0.0 dB
DATE / TIME:	31/07/2007 12:37:35	DUT BATTERY MODEL/NO:	N/A
FILENAME:	75901921-251000-01.txt	PROBE SERIAL NUMBER:	0190
AMBIENT TEMPERATURE:	23.4°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	Option NV GX0301	RELATIVE PERMITTIVITY:	56.57
RELATIVE HUMIDITY:	47.8%	CONDUCTIVITY:	0.992
PHANTOM S/NO:	HeadBox01.csv	LIQUID TEMPERATURE:	22.4°C
PHANTOM ROTATION:	0°	MAX SAR X-AXIS LOCATION:	-3.00 mm
DUT POSITION:	11mm Separation	MAX SAR Y-AXIS LOCATION:	-20.00 mm
ANTENNA CONFIGURATION:	Flipout	MAX E FIELD:	19.58 V/m
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.450 W/kg
AIR FACTORS:	356 / 420 / 424	SAR 10g:	0.284 W/kg
CONVERSION FACTORS:	0.326 / 0.326 / 0.326	SAR START:	0.093 W/kg
TYPE OF MODULATION:	QPSK	SAR END:	0.091 W/kg
MODN. DUTY CYCLE:	100%	SAR DRIFT DURING SCAN:	-1.30 %
DIODE COMPRESSION FACTORS (V*200):	20 / 20 / 20	PROBE BATTERY LAST CHANGED:	31/07/2007
INPUT POWER LEVEL:	21.06	EXTRAPOLATION:	poly4

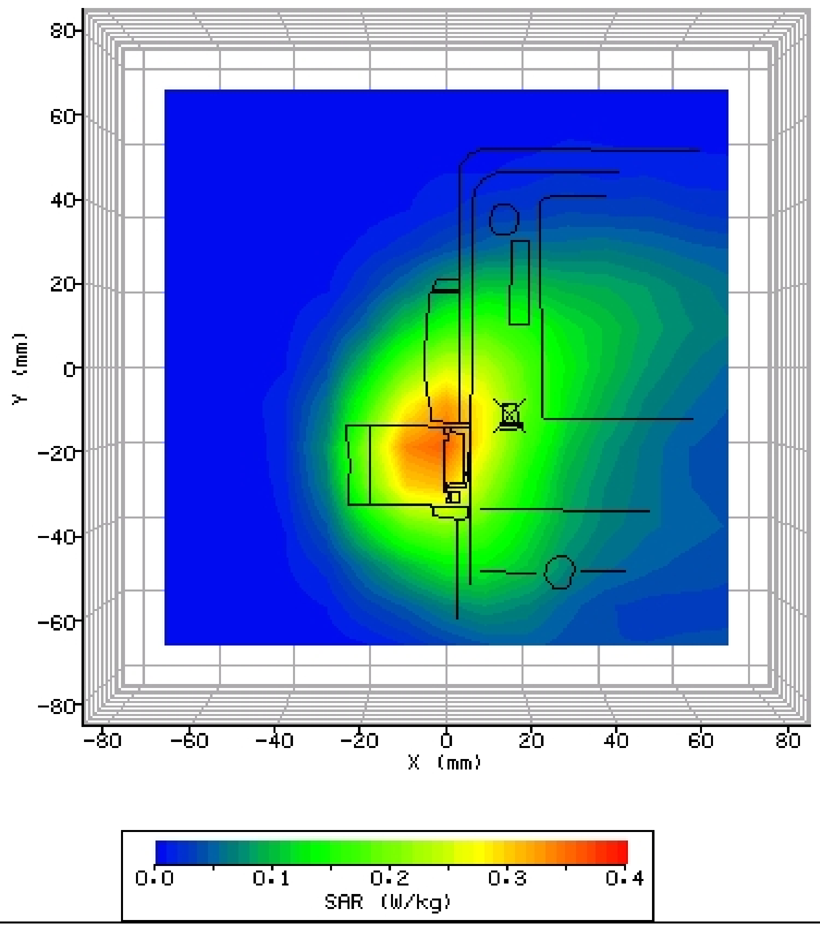


Figure 5: SAR Body Testing Results for the Option GX0301 GT Max PCMCIA Card (Serial No.: GE2474A04R) in 11mm separation distance from bottom of flat phantom; Tested at 826.4MHz (HSDPA

Product Service

Sub-test 2) with Host Laptop HP Compaq nc 6320 in rear facing phantom configuration with 0mm separation distance used.

SYSTEM / SOFTWARE:	SARA2 / 2.39 VPM	INPUT POWER DRIFT:	0.0 dB
DATE / TIME:	31/07/2007 12:37:35	DUT BATTERY MODEL/NO:	N/A
FILENAME:	75901921-251000-02x.txt	PROBE SERIAL NUMBER:	0190
AMBIENT TEMPERATURE:	23.9°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	Option NV GX0301	RELATIVE PERMITTIVITY:	56.57
RELATIVE HUMIDITY:	46.8%	CONDUCTIVITY:	0.992
PHANTOM S/NO:	HeadBox01.csv	LIQUID TEMPERATURE:	22.1°C
PHANTOM ROTATION:	0°	MAX SAR X-AXIS LOCATION:	-3.00 mm
DUT POSITION:	11mm Separation	MAX SAR Y-AXIS LOCATION:	-17.00 mm
ANTENNA CONFIGURATION:	Flipout	MAX E FIELD:	23.95 V/m
TEST FREQUENCY:	846.6MHz	SAR 1g:	0.688 W/kg
AIR FACTORS:	356 / 420 / 424	SAR 10g:	0.425 W/kg
CONVERSION FACTORS:	0.326 / 0.326 / 0.326	SAR START:	0.138 W/kg
TYPE OF MODULATION:	QPSK	SAR END:	0.138 W/kg
MODN. DUTY CYCLE:	100%	SAR DRIFT DURING SCAN:	0.27 %
DIODE COMPRESSION FACTORS (V*200):	20 / 20 / 20	PROBE BATTERY LAST CHANGED:	31/07/2007
INPUT POWER LEVEL:	20.24	EXTRAPOLATION:	poly4

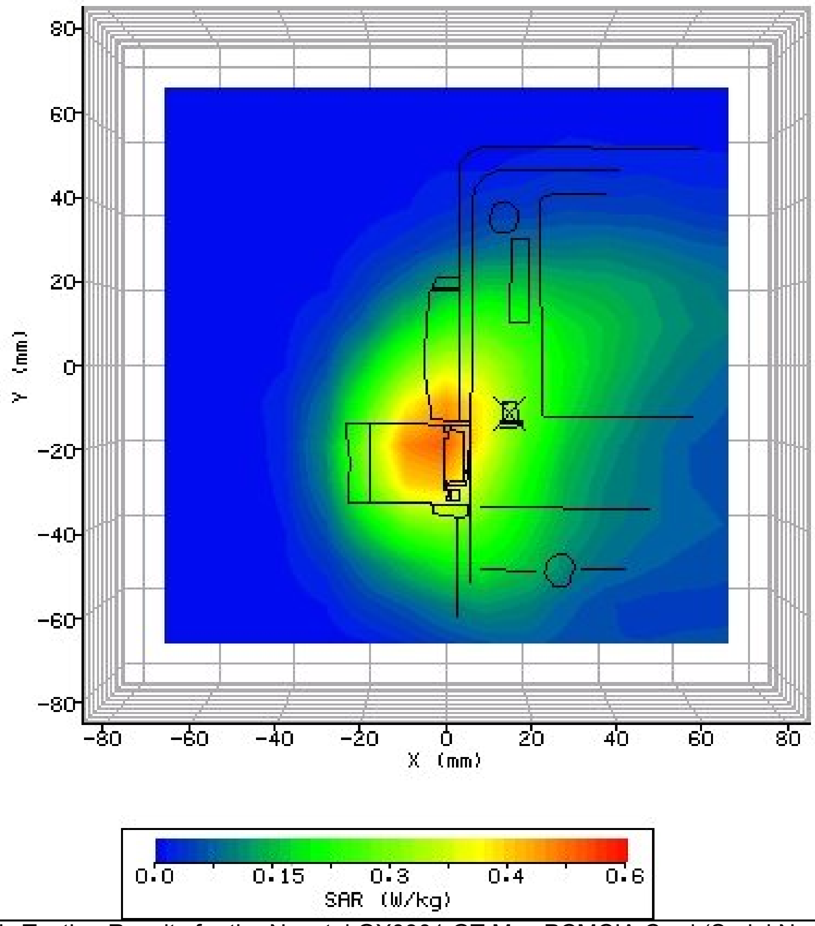


Figure 6: SAR Body Testing Results for the Novatel GX0301 GT Max PCMCIA Card (Serial No.: GE2474A04R) in 11mm separation distance from bottom of flat phantom; Tested at 846.6MHz (HSUPA Sub-test 5) with Host Laptop HP Compaq nc 6320 in rear facing phantom configuration with 0mm separation distance used.

2.3 MAXIMUM FDD II HSDPA SAR TEST RESULT AND COURSE AREA SCAN – 2D

SYSTEM / SOFTWARE:	SARA2 / 2.39 VPM	INPUT POWER DRIFT:	0.0 dB
DATE / TIME:	31/07/2007 15:22:21	DUT BATTERY MODEL/NO:	N/A
FILENAME:	75901921-251000-03.txt	PROBE SERIAL NUMBER:	0190
AMBIENT TEMPERATURE:	23.7°C	LIQUID SIMULANT:	1900 Body
DEVICE UNDER TEST:	Option NV GX0301	RELATIVE PERMITTIVITY:	52.17
RELATIVE HUMIDITY:	44.8%	CONDUCTIVITY:	1.526
PHANTOM S/NO:	HeadBox01.csv	LIQUID TEMPERATURE:	22.7°C
PHANTOM ROTATION:	0°	MAX SAR X-AXIS LOCATION:	9.00 mm
DUT POSITION:	11mm Separation	MAX SAR Y-AXIS LOCATION:	6.00 mm
ANTENNA CONFIGURATION:	Flipout	MAX E FIELD:	21.16 V/m
TEST FREQUENCY:	1852.4MHz	SAR 1g:	0.829 W/kg
AIR FACTORS:	356 / 420 / 424	SAR 10g:	0.511 W/kg
CONVERSION FACTORS:	0.456 / 0.456 / 0.456	SAR START:	0.163 W/kg
TYPE OF MODULATION:	QPSK	SAR END:	0.170 W/kg
MODN. DUTY CYCLE:	100%	SAR DRIFT DURING SCAN:	4.02 %
DIODE COMPRESSION FACTORS (V*200):	20 / 20 / 20	PROBE BATTERY LAST CHANGED:	31/07/2007
INPUT POWER LEVEL:	21.31	EXTRAPOLATION:	poly4

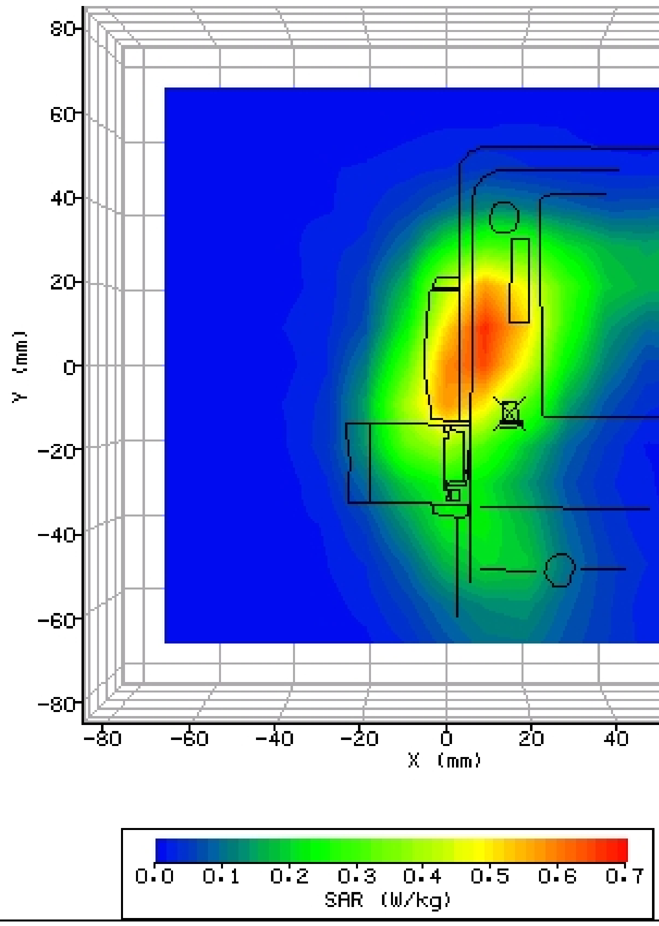


Figure 7: SAR Body Testing Results for the Option GX0301 GT Max PCMCIA Card (Serial No.: GE2474A04R) in 11mm separation distance from bottom of flat phantom; Tested at 1852.4MHz (HSDPA Sub-test 1) with Host Laptop HP Compaq nc 6320 in rear facing phantom configuration with 0mm separation distance used.

Product Service

SYSTEM / SOFTWARE:	SARA2 / 2.39 VPM	INPUT POWER DRIFT:	0.0 dB
DATE / TIME:	31/07/2007 15:54:52	DUT BATTERY MODEL/NO:	N/A
FILENAME:	75901921-251000-04.txt	PROBE SERIAL NUMBER:	0190
AMBIENT TEMPERATURE:	20.4°C	LIQUID SIMULANT:	1900 Body
DEVICE UNDER TEST:	Option NV GX0301	RELATIVE PERMITTIVITY:	52.17
RELATIVE HUMIDITY:	57.2%	CONDUCTIVITY:	1.526
PHANTOM S/NO:	HeadBox01.csv	LIQUID TEMPERATURE:	22.5°C
PHANTOM ROTATION:	0°	MAX SAR X-AXIS LOCATION:	10.00 mm
DUT POSITION:	11mm Separation	MAX SAR Y-AXIS LOCATION:	10.00 mm
ANTENNA CONFIGURATION:	Flipout	MAX E FIELD:	20.90 V/m
TEST FREQUENCY:	1880.0MHz	SAR 1g:	0.798 W/kg
AIR FACTORS:	356 / 420 / 424	SAR 10g:	0.484 W/kg
CONVERSION FACTORS:	0.456 / 0.456 / 0.456	SAR START:	0.160 W/kg
TYPE OF MODULATION:	QPSK	SAR END:	0.159 W/kg
MODN. DUTY CYCLE:	100%	SAR DRIFT DURING SCAN:	-0.11 %
DIODE COMPRESSION FACTORS (V*200):	20 / 20 / 20	PROBE BATTERY LAST CHANGED:	31/07/2007
INPUT POWER LEVEL:	20.92	EXTRAPOLATION:	poly4

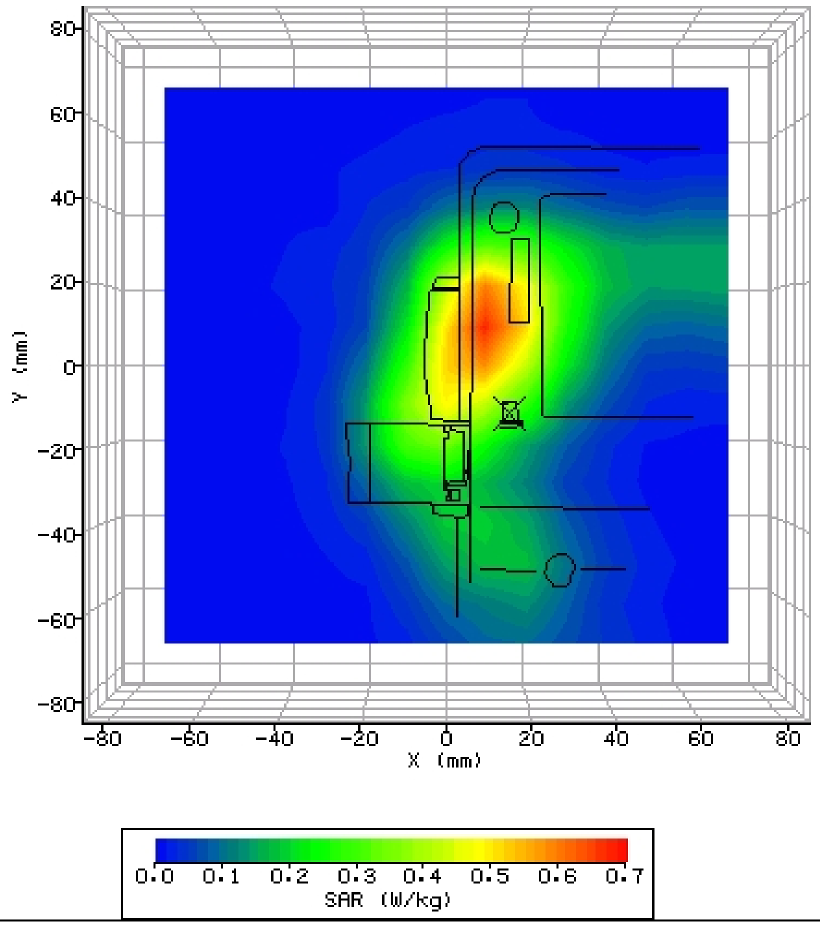


Figure 8: SAR Body Testing Results for the Option GX0301 GT Max PCMCIA Card (Serial No.: GE2474A04R) in 11mm separation distance from bottom of flat phantom; Tested at 1880.0MHz (HSUPA Sub-test 5) with Host Laptop HP Compaq nc 6320 in rear facing phantom configuration with 0mm separation distance used

Product Service

SECTION 3

TEST EQUIPMENT USED

Product Service

3.1 TEST EQUIPMENT USED

The following test equipment was used at TUV Product Service Ltd:

Instrument Description	Manufacturer	Model Type	TE Number	Calibration Dates	
Bench-top Robot	Mitsubishi	RV-E2	156	N/A	N/A
Fast Probe Amplifier	IndexSAR Ltd.	IFA-010	1557	N/A	N/A
Side Bench 2	IndexSAR Ltd.	IXM-030	1571	N/A	N/A
Upright Bench 1	IndexSAR Ltd.	SARA2 system	1568	N/A	N/A
SAR Probe	IndexSAR Ltd.	IXP-050	1556	26/10/2006	26/10/2007
Radiocommunication Analyser	Anritsu	8815B	6200576541	N/A	N/A
Signal Generator	Hewlett Packard	E4422A	61	12/03/2007	12/03/2008
Power Meter	Rohde & Schwarz	NRV	52	17/05/2007	17/05/2008
RF Pre-Amplifier	IndexSAR Ltd.	0.8-3G	2415	N/A	N/A
Bi-Directional Coupler	Krytar	1850	58	27/01/2007	27/01/2008
20dB Attenuator	Narda	766F-10	483	01/06/2007	01/06/2008
Digital Thermometer	Digitron	T208	64	19/10/2006	19/10/2007
Thermocouple	Rohde & Schwarz	K	65	19/10/2006	19/10/2007
835MHz Body TEM	TÜV	Batch 7	N/A	11/07/2007	11/08/2007
1900MHz Body TEM	TÜV	Batch 3	N/A	11/07/2007	11/08/2007
835MHz Head TEM	TÜV	Batch 11	N/A	11/07/2007	11/08/2007
1900MHz Head TEM	TÜV	Batch 2	N/A	11/07/2007	11/08/2007
850 MHz Dipole	IndexSAR Ltd.	IEEE1528	N/A	31/07/2007	01/08/2007
1900 MHz Dipole	IndexSAR Ltd.	IEEE1528	N/A	31/07/2007	01/08/2007
Flat Phantom 2mm Side	IndexSAR Ltd.	HeadBox01	1563	N/A	N/A
200mm Cube Box Phantom (FlatPhantom.csv)	IndexSAR Ltd.	IXB-070	1565	N/A	N/A

3.2 TEST SOFTWARE

The following software was used to control the TÜV Product Service SARA2 System.

Instrument	Version Number	Date
SARA2 system	v.2.3.9 VPM	06/07/2005
Mitsubishi robot controller firmware revision	RV-E2 Version C9a	-
IFA-10 Probe amplifier	Version 2	-

3.3 DIELECTRIC PROPERTIES OF SIMULANT LIQUIDS

The fluid properties of the simulant fluids used during routine SAR evaluation meet the dielectric properties required by EN 50361:2001 & OET Bulletin 65 (Edition 97-01).

The fluids were calibrated in our Laboratory and re-checked prior to any measurements being made against reference fluids stated in IEEE 1528-2003 of 0.9% NaCl (Salt Solution) at 23ºC and also for Dimethylsulphoxide (DMS) at 21ºC.

The fluids were made at TÜV Product Service Ltd under controlled conditions from the following OET(65)c formulae and IEEE 1528-2003. The composition of ingredients may have been modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation:

OET 65(c) Recipes

Ingredients (% by weight)	Frequency (MHz)									
	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	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

IEEE 1528 Recipes

Frequency (MHz)	300	450		835	900			1450	1800				1900		1950	2000	2100		2450		3000
Recipe#	1	1	3	1	1	2	3	1	1	2	2	3	1	2	4	1	1	2	2	3	2
Ingredients (% by weight)																					
1, 2-Propanediol						64.81															
Bactericide	0.19	0.19	0.50	0.10	0.10		0.50													0.50	
Diacetin			48.90				49.20													49.45	
DGBE								45.41	47.00	13.84	44.92		44.94	13.84	45.00	50.00	50.00	7.99	7.99		7.99
HEC	0.98	0.96		1.00	1.00																
NaCl	5.95	3.95	1.70	1.45	1.48	0.79	1.10	0.67	0.36	0.35	0.18	0.64	0.18	0.35				0.16	0.16		0.16
Sucrose	55.32	56.32		57.00	56.50																
Triton X-100										30.45				30.45				19.97	19.97		19.97
Water	37.56	38.56	48.90	40.45	40.92	34.40	49.20	53.80	52.64	55.36	54.90	49.43	54.90	55.36	55.00	50.00	50.00	71.88	71.88	49.75	71.88
Measured dielectric parameters																					
ε'_r	46.00	43.40	44.30	41.60	41.20	41.80	42.70	40.9	39.3	41.00	40.40	39.20	39.90	41.00	40.10	37.00	36.80	41.10	40.30	39.20	37.90
σ (S/m)	0.86	0.85	0.90	0.90	0.98	0.97	0.99	1.21	1.39	1.38	1.40	1.40	1.42	1.38	1.41	1.40	1.51	1.55	1.88	1.82	2.46
Temp (ºC)	22	22	20	22	22	22	20	22	22	21	22	20	21	21	20	22	22	20	20	20	20
Target dielectric parameters (Table 2)																					
ε'_r	45.30	43.50		41.5	41.50			40.50	40.00								39.80		39.20		38.50
σ (S/m)	0.87	0.87		0.9	0.97			1.20	1.40								1.49		1.80		2.40

NOTE – Multiple columns for any single frequency are optional recipe #, reference: 1 (Kanda et al. [B185]), 2 (Vigneras [B143]), 3 (Peyman and Gabriel [B119]), 4 (Fukunaga et al [B50])

Product Service

The dielectric properties of the tissue simulant liquids used for the SAR testing at TÜV Product Service Ltd are as follows:-

Fluid Type and Frequency	Relative Permittivity εR (ε') Target	Relative Permittivity εR (ε') Measured	Conductivity σ Target	Conductivity σ Measured
Head 900MHz	42.0	41.35	0.990	0.977
Body 850MHz	55.0	56.57	1.050	0.992
Head 1900MHz	40.0	39.26	1.400	1.390
Body 1900MHz	53.3	52.17	1.520	1.526

3.4 TEST C.ONDITIONS

3.4.1 Test Laboratory Conditions

Ambient Temperature: Within +15°C to +35°C at 20% RH to 75% RH.
The actual Temperature during the testing ranged from 20.4°C to 23.9°C.
The actual Humidity during the testing ranged from 44.8% to 57.2% RH.

3.4.2 Test Fluid Temperature Range

Frequency	900 MHz	1900 MHz	850 MHz	1900 MHz
Body / Head Fluid	Head	Head	Body	Body
Min Temperature	22.9°C	23.2°C	22.1°C	22.5°C
Max Temperature	22.9°C	23.2°C	22.4°C	22.7°C

3.4.3 SAR Drift

The SAR Drift was within acceptable limits during scans. The maximum SAR Drift, drift due to the handset electronics, was recorded as 4.02% (0.170dB) for all of the testing.

Product Service

3.5 MEASUREMENT UNCERTAINTY

Error Sources	EN 50361 Description (Subclause)	Uncertainty (%)	Probability Distribution	Divisor	ci	ci^2	Standard Uncertainty (%)	Stand Uncert^2	(Stand Uncert^2) X (ci^2)
Measurement Equipment									
Calibration	7.2.1.1	10	Normal	2.00	1	1	5.00	25.00	25.00
Isotropy	7.2.1.2	10.6	Rectangular	1.73	1	1	6.12	37.45	37.45
Linearity	7.2.1.3	2.92	Rectangular	1.73	1	1	1.69	2.84	2.84
Probe Stability	-	2.46	Rectangular	1.73	1	1	1.42	2.02	2.02
Detection limits	7.2.1.4	0	Rectangular	1.73	1	1	0.00	0.00	0.00
Boundary effect	7.2.1.5	1.7	Rectangular	1.73	1	1	0.98	0.96	0.96
Measurement device	7.2.1.6	0	Normal	1.00	1	1	0.00	0.00	0.00
Response time	7.2.1.7	0	Normal	1.00	1	1	0.00	0.00	0.00
Noise	7.2.1.8	0	Normal	1.00	1	1	0.00	0.00	0.00
Integration time	7.2.1.9	2.3	Normal	1.00	1	1	2.30	5.29	5.29
Mechanical constraints									
Scanning system	7.2.2.1	0.57	Rectangular	1.73	1	1	0.33	0.11	0.11
Phantom shell	7.2.2.2	1.43	Rectangular	1.73	1	1	0.83	0.68	0.68
Matching between probe and phantom	7.2.2.3	2.86	Rectangular	1.73	1	1	1.65	2.73	2.73
Positioning of the phone 'Y' Co-ordinate	7.2.2.4	1.5	Normal	1.00	1	1	1.50	2.25	2.25
Positioning of the phone 'Z' Co-ordinate	7.2.2.4	1.73	Normal	1.00	1	1	1.73	2.99	2.99
Physical Parameters									
Liquid conductivity (deviation from target)	7.2.3.2	5	Rectangular	1.73	0.5	0.25	2.89	8.33	2.08
Liquid conductivity (measurement error)	7.2.3.2	15.3	Rectangular	1.73	0.5	0.25	8.83	78.03	19.51
Liquid permittivity (deviation from target)	7.2.3.3	5	Rectangular	1.73	0.5	0.25	2.89	8.33	2.08
Liquid permittivity (measurement error)	7.2.3.3	5	Rectangular	1.73	0.5	0.25	2.89	8.33	2.08
Drifts in output power of the phone, probe, temperature and humidity	7.2.3.4	5	Rectangular	1.73	1	1	2.89	8.33	8.33
Perturbation by the environment	7.2.3.5	3	Rectangular	1.73	1	1	1.73	3.00	3.00
Post-Processing									
SAR interpolation and extrapolation	7.2.4.1	2.4	Rectangular	1.73	1	1	1.39	1.92	1.92
Maximum SAR evaluation	7.2.4.2	2.4	Rectangular	1.73	1	1	1.39	1.92	1.92
Combined standard uncertainty	11.10						Total		123.26
Expanded uncertainty	22.20	% (Using a Coverage Factor of K=2)							
(confidence interval of 95 %)									

Product Service

SECTION 4

PHOTOGRAPHS

4.1 TEST POSITIONAL PHOTOGRAPHS

Figure 9

Top Positional Photograph of the Option NV GX0301 GT Max PCMCIA Card in 11mm separation distance configuration from the bottom of the flat phantom (Host laptop used: HP Compaq nc 6320 – in touch position).

Figure 10

Side Positional Photograph of the Option NV GX0301 GT Max PCMCIA Card in 11mm separation distance configuration from the bottom of the flat phantom (Host laptop used: HP Compaq nc 6320 – in touch position).

Figure 11

Side Positional Photograph of the Option nv GX0301 GT Max PCMCIA Card in 11mm Separation distance configuration from the bottom of the flat phantom (Host laptop used: HP Compaq nc 6320 – in touch position).

4.2 PHOTOGRAPHS OF EQUIPMENT UNDER TEST (EUT)

Figure 12
Front View

Figure 13
Rear View

Figure 14
Front View – In Host Laptop

Figure 15
Side View – In Host Laptop

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

This report relates only to the actual item/items tested.

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation.

Results of tests not covered by our UKAS Accreditation Schedule are marked NUA (Not UKAS Accredited).

ANNEX A

PROBE CALIBRATION INFORMATION

Product Service

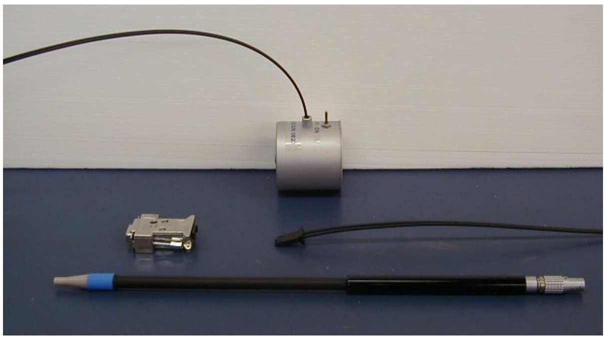
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP – 050

S/N 0190

26th October 2006



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Product Service

INTRODUCTION

This Report presents measured calibration data for a particular IndexSAR SAR probe (S/N 0190) 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. Objectives

The calibration process comprises three stages
1) Determination of the channel sensitivity factors which optimise the probe's overall rotational isotropy in 1800MHz brain fluid
2) At each frequency of interest, application of these channel sensitivity factors to model the exponential decay of SAR in a waveguide fluid cell, and hence derive the liquid conversion factors at that frequency
3) Determination of the effective tip radius and angular offset of the X channel which together optimise the probe's spherical isotropy in 900MHz brain fluid

2. 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).

In turn, measurements of E-field are determined using the following equation (where output voltages are also in units of V*200):

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

Here, "Air Factor" represents each channel's sensitivity, while "Liq Factor" represents the enhancement in signal level when the probe is immersed in tissue-simulant liquids at each frequency of interest.

Product Service

CALCALIBRATION PROCEDURE - Continued

3. Selecting Channel Sensitivity Factors To Optimise Isotropic Response

After manufacture, the first stage of the calibration process is to balance the three channels' Air Factor values, thereby optimising the probe's overall axial response ("rotational isotropy").

To do this, an 900MHz waveguide containing head-fluid simulant is selected. Like all waveguides used during probe calibration, this particular waveguide contains two distinct sections: an air-filled launcher section, and a liquid cell section, separated by a dielectric matching window designed to minimise reflections at the air-liquid interface.

The waveguide stands in an upright position and the liquid cell section is filled with 900MHz brain fluid to within 10 mm of the open end. 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.

During the measurement, a TE_{01} mode is launched into the waveguide by means of an N-type-to-waveguide adapter. The probe is then lowered vertically into the liquid until the tip is exactly 10mm above the centre of the dielectric window. This particular separation ensures that the probe is operating in a part of the waveguide where boundary corrections are not necessary.

Care must also be taken that the probe tip is centred while rotating.

The exact power applied to the input of the waveguide during this stage of the probe calibration is immaterial since only relative values are of interest while the probe rotates. However, the power must be sufficiently above the noise floor and free from drift.

The dedicated IndexSAR calibration software rotates the probe in 10 degree steps about its axis, and at each position, an IndexSAR 'Fast' amplifier samples the probe channels 500 times per second for 0.4 s. The raw $U_{o/p}$ data from each sample are packed into 10 bytes and transmitted back to the PC controller via an optical cable. U_{linx}, U_{liny} and U_{linz} are derived from the raw $U_{o/p}$ values and written to an Excel template.

Once data have been collected from a full probe rotation, the Air Factors are adjusted using a special Excel Solver routine to equalise the output from each channel and hence minimise the rotational isotropy. This automated approach to optimisation removes the effect of human bias.

Figure 5 represents the output from each diode sensor as a function of probe rotation angle. 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, a representative image of which is shown 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.

Product Service

CALIBRATION PROCEDURE - Continued

4. Determination Of Conversion ("Liquid") Factors At Each Frequency Of Interest

A lookup table of conversion factors for a probe allows a SAR value to be derived at the measured frequencies, and for either brain or body fluid-simulant.

The method by which the conversion factors are assessed is based on the comparison between measured and analytical rates of decay of SAR with height above a dielectric window. This way, not only can the conversion factors for that frequency/fluid combination be determined, but an allowance can also be made for the scale and range of boundary layer effects.

The theoretical relationship between the SAR at the cross-sectional centre of the lossy waveguide as a function of the longitudinal distance (z) from the dielectric separator is given by Equation 4:

$$SAR(z) = \frac{4\left(P_f - P_b\right)}{\rho ab\delta} e^{-2z/\delta} \quad (4)$$

Here, the density ρ is conventionally assumed to be 1000 kg/m^3, ab is the cross-sectional area of the waveguide, and P_f and P_b are the forward and reflected power inside the lossless section of the waveguide, respectively. The penetration depth δ (which is the reciprocal of the waveguide-mode attenuation coefficient) is a property of the lossy liquid and is given by Equation (5).

$$\delta = \left[\mathrm{Re}\left\{ \sqrt{\left(\pi / a\right)^2 + j\omega\mu_o\left(\sigma + j\omega\varepsilon_o\varepsilon_r\right)} \right\} \right]^{-1} \quad (5)$$

where σ is the conductivity of the tissue-simulant liquid in S/m, ε_r is its relative permittivity, and ω is the radial frequency (rad/s). Values for σ and ε_r are obtained prior to each waveguide test using an IndexSAR DiLine measurement kit, which uses the TEM method as recommended in [2]. σ and ε_r are both temperature- and fluid-dependent, so are best measured using a sample of the tissue-simulant fluid immediately prior to the actual calibration.

Wherever possible, all DiLine and calibration measurements should be made in the open laboratory at 22 $\pm$ 2.0^{o}C; if this is not possible, the values of σ and ε_r should reflect the actual temperature. Values employed for calibration are listed in the tables below.

By ensuring the liquid height in the waveguide is at least three penetration depths, reflections at the upper surface of the liquid are negligible. The power absorbed in the liquid is therefore determined solely from the waveguide forward and reflected power.

Different waveguides are used for 835/900MHz, 1800/1900MHz, 2450MHz and 5200/5800MHz measurements. Table A.1 of [1] can be used for designing calibration waveguides with a return loss greater than 20 dB at the most important frequencies used for personal wireless communications, and better than 15dB for frequencies

CALIBRATION PROCEDURE - Continued

4. Determination Of Conversion ("Liquid") Factors At Each Frequency Of Interest - Continued

greater than 5GHz. 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 5800 MHz because of the waveguide size is not severe in the context of compliance testing.

During calibration, the probe is lowered carefully until it is just touching the cross-sectional centre of the dielectric window. 200 samples are then taken and written to an Excel template file before moving the probe vertically upwards. This cycle is repeated 50 times. The vertical separation between readings is determined from practical considerations of the expected SAR decay rate, and range from 1mm steps at low frequency, through 0.5mm at 2450MHz, down to 0.2mm at 5GHz.

Once the data collection is complete, a Solver routine is run which optimises the measured-theoretical fit by varying the conversion factor, and the boundary correction size and range.

5. Measurement of Spherical Isotropy

The setup for measuring the probe's spherical isotropy is shown in Figure 2.

A box phantom containing 900MHz head fluid is irradiated by a vertically-polarised, tuned dipole, mounted to the side of the phantom on the robot's seventh axis. During calibration, the spherical response is generated by rotating the probe about its axis in 20 degree steps and changing the dipole polarisation in 10 degree steps.

By using the VPM technique discussed below, an allowance can also be made for the effect of E-field gradient across the probe's spatial extent. This permits values for the probe's effective tip radius and X-channel angular offset to be modelled until the overall spherical isotropy figure is optimised.

The dipole is connected to a signal generator and amplifier via a directional coupler and power meter. As with the determination of rotational isotropy, the absolute power level is not important as long as it is stable.

The probe is positioned within the fluid so that its sensors are at the same vertical height as the centre of the source dipole. The line joining probe to dipole should be perpendicular to the phantom wall, while the horizontal separation between the two should be small enough for VPM corrections to be applicable, without encroaching near the boundary layer of the phantom wall. VPM corrections require a knowledge of the fluid skin depth. This is measured during the calibration by recording the E-field strength while systematically moving the probe away from the dipole in 2mm steps over a 20mm range.

VPM (Virtual Probe Miniaturisation)
SAR probes with 3 diode-sensors in an orthogonal arrangement are designed to display an isotropic response when exposed to a uniform field. However, the probes are ordinarily used for measurements in non-uniform fields and isotropy is not

CALIBRATION PROCEDURE – Continued

5. <u>Measurement of Spherical Isotropy</u> - Continued

assured when the field gradients are significant compared to the dimensions of the tip containing the three orthogonally-arranged dipole sensors.

It becomes increasingly important to assess the effects of field gradients on SAR probe readings when higher frequencies are being used. For IndexSAR IXP-050 probes, which are of 5mm tip diameter, field gradient effects are minor at GSM frequencies, but are major above 5GHz. Smaller probes are less affected by field gradients and so probes, which are significantly less than 5mm diameter, would be better for applications above 5GHz.

The IndexSAR report IXS0223 describes theoretical and experimental studies to evaluate the issues associated with the use of probes at arbitrary angles to surfaces and field directions. Based upon these studies, the procedures and uncertainty analyses referred to in P1528 are addressed for the full range of probe presentation angles.

In addition, generalized procedures for correcting for the finite size of immersible SAR probes are developed. Use of these procedures enables application of schemes for virtual probe miniaturization (VPM) – allowing probes of a specific size to be used where physically-smaller probes would otherwise be required.

Given the typical dimensions of 3-channel SAR probes presently available, use of the VPM technique extends the satisfactory measurement range to higher frequencies.

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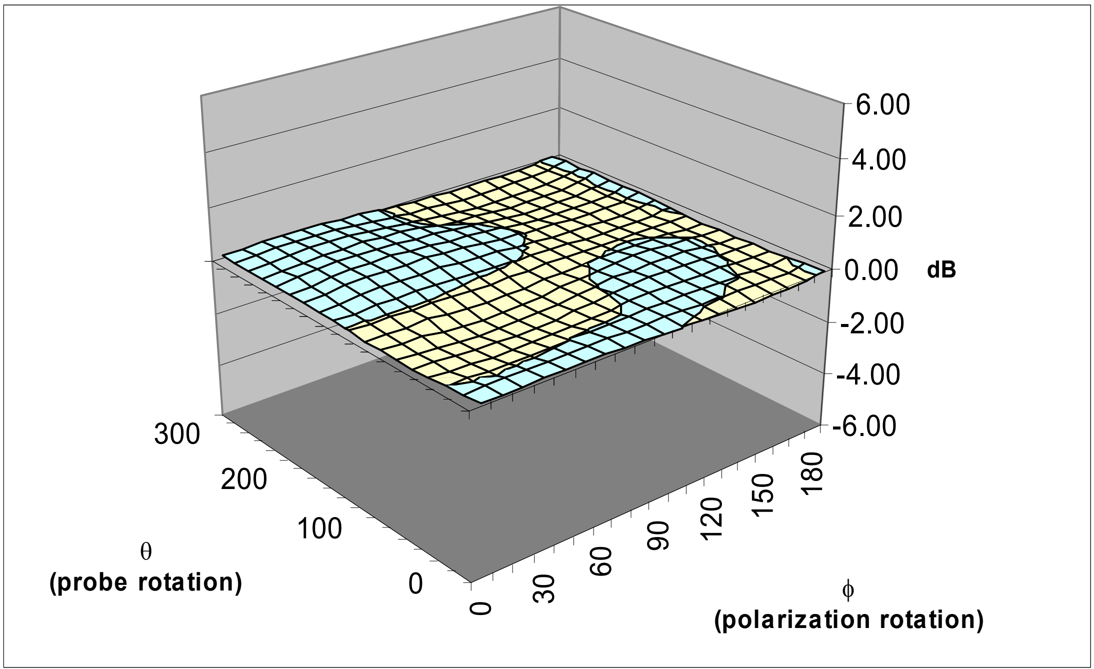
CALIBRATION FACTORS MEASURED FOR PROBE S/N 0190

The probe was calibrated at 835, 900, 1800, 1900 and 2450 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 mm 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. The distance of 2.7mm for assembled probes has been confirmed by taking X-ray images of the probe tips (see Figure 8).

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.



Surface Isotropy diagram of IXP-050 Probe S/N 0190 at 900MHz after VPM
(rotational isotropy +/-0.12dB, spherical isotropy +/-0.29dB)

Probe tip radius	1.25
X Ch. Angle to red dot	-5.0

CALIBRATION FACTORS MEASURED FOR PROBE S/N 0190 - Continued

	Head		Body	
Frequency	**Bdy. Corrn. – f(0)**	**Bdy. Corrn. – d(mm)**	**Bdy. Corrn. – f(0)**	**Bdy. Corrn. – d(mm)**
450	-	-	-	-
835	1.11	1.3	1.17	1.3
900	1.25	1.2	1.16	1.3
1800	1.03	1.4	0.91	1.5
1900	1.00	1.4	0.87	1.6
2100	0.94	1.4	0.73	1.8
2450	0.95	1.4	0.72	1.9

SUMMARY OF CALIBRATION FACTORS FOR PROBE IXP-050 S/N 0190

Spherical isotropy measured at 900MHz	0.29	(+/-) dB

	X	Y	Z	
Air Factors	356	420	424	(V*200)
CW DCPs	20	20	20	(V*200)

Freq (MHz)	Axial Isotropy (+/- dB)		SAR ConvF (liq/air)		Notes
	Head	Body	Head	Body	
450	-	-	0.349	0.342	
835	-	-	0.330	0.326	1,2
900	0.12	-	0.331	0.331	1,2
1800	-	-	0.402	0.437	1,2
1900	-	-	0.411	0.456	1,2
2000	-	-	0.416	0.467	1,2
2450	-	-	0.454	0.516	1,2

Notes	
1)	Calibrations done at 22°C +/-2°C
2)	Waveguide calibration
3)	Transfer calibration against NPL reference probe

PROBE SPECIFICATIONS

IndexSAR probe 0190, 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:

1.1.1 Dimensions	S/N 0190	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		

1.1.2 Dynamic range	S/N 0190	CENELEC [1]	IEEE [2]
Minimum (W/kg)	0.01	<0.02	0.01
Maximum (W/kg) N.B. only measured to > 100 W/kg on representative probes	>100	>100	100

1.1.3 Isotropy (measured at 900MHz)	S/N 0190	CENELEC [1]	IEEE [2]
Axial rotation with probe normal to source (+/- dB)	0.12 Max (See table above)	0.5	0.25
Spherical isotropy covering all orientations to source (+/- dB)	0.29	1.0	0.50

1.1.4 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.
1.1.5 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.

FIGURES

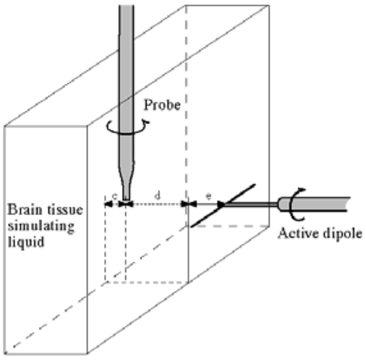


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

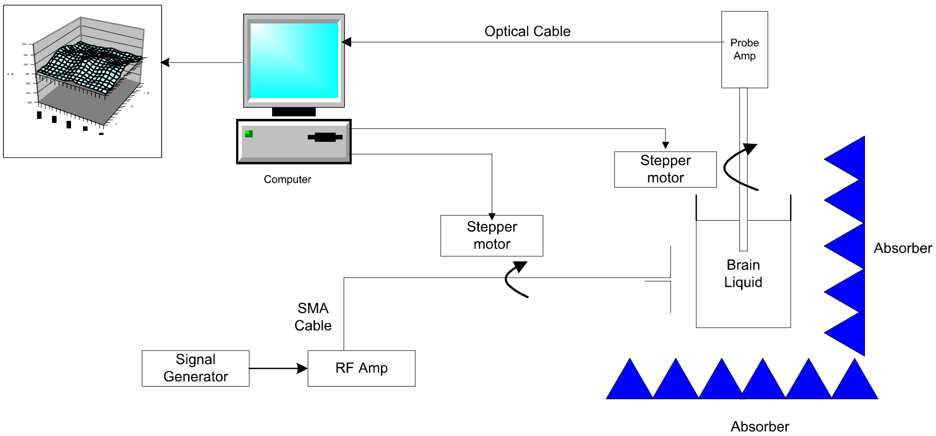


Figure 2. Schematic diagram of the test geometry used for isotropy determination

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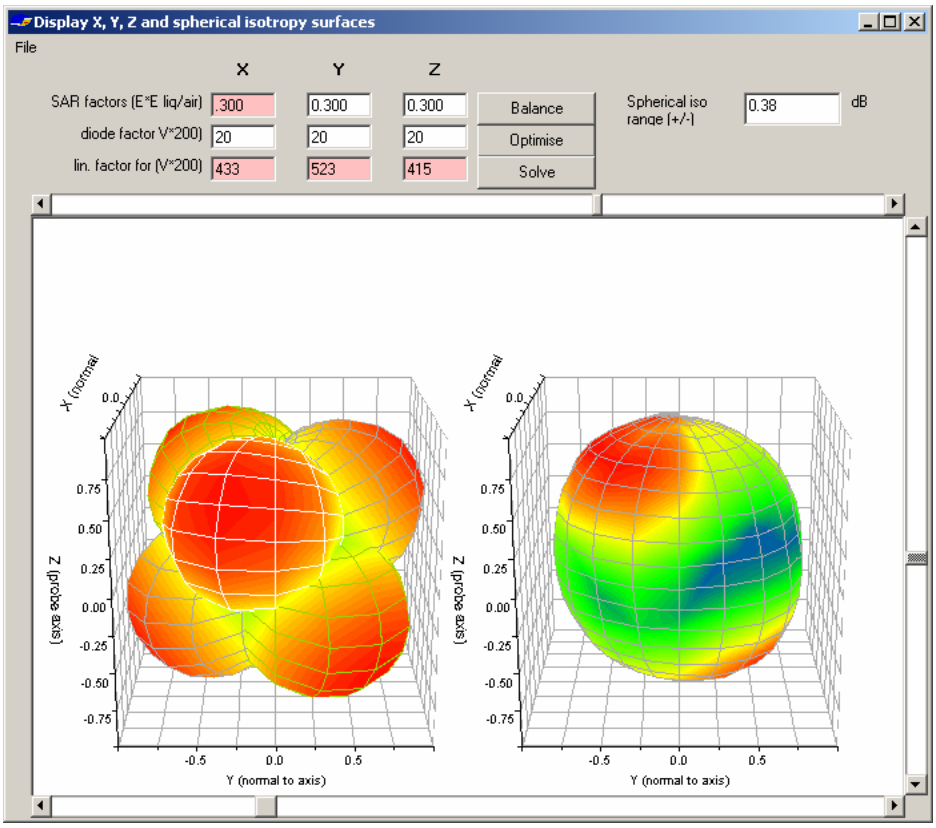

Figure 3. Graphical representation of a probe's response to fields applied from each direction. The diagram on the left shows the individual response characteristics of each of the three channels and the diagram on the right shows the resulting probe sensitivity in each direction. The colour range in the figure images the lowest values as blue and the maximum values as red. For the probe S/N 0190, this range is (+/-) 0.24 dB.

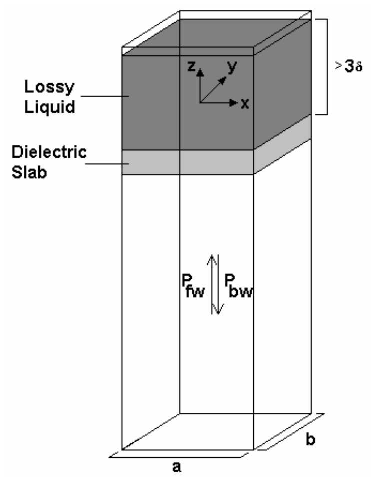

Figure 4. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)

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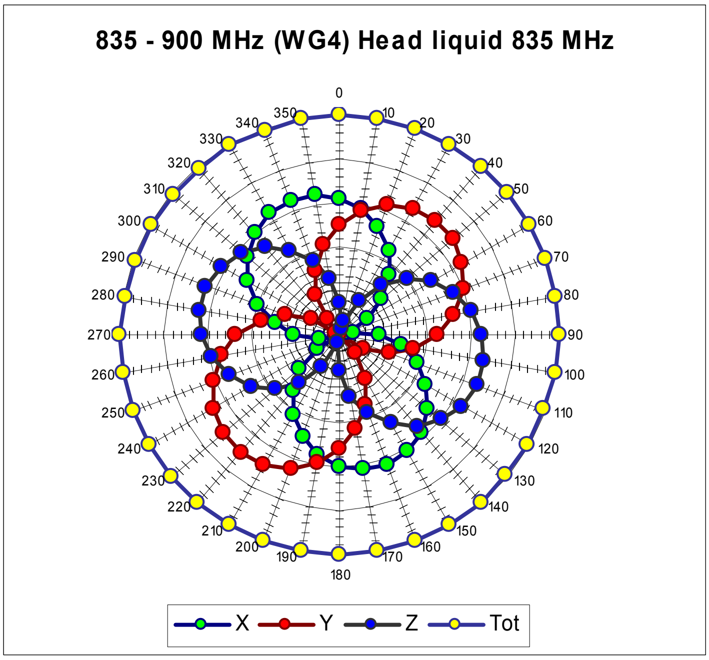


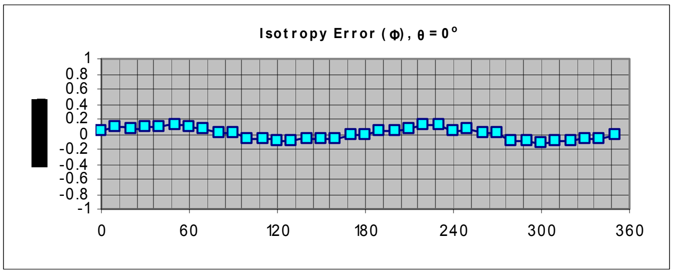
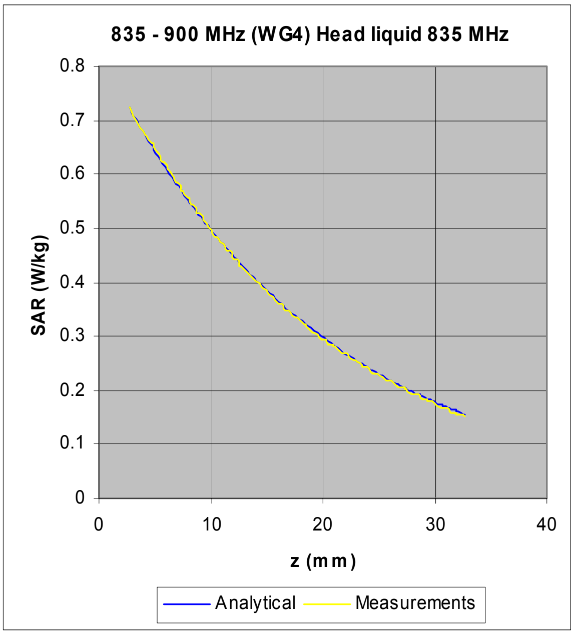
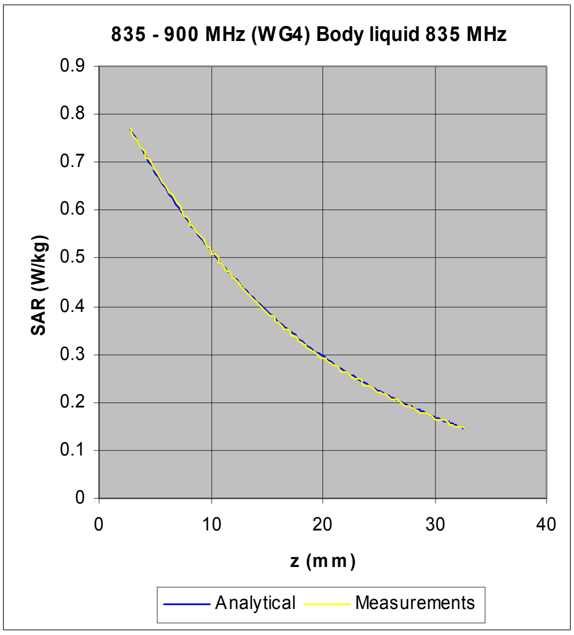


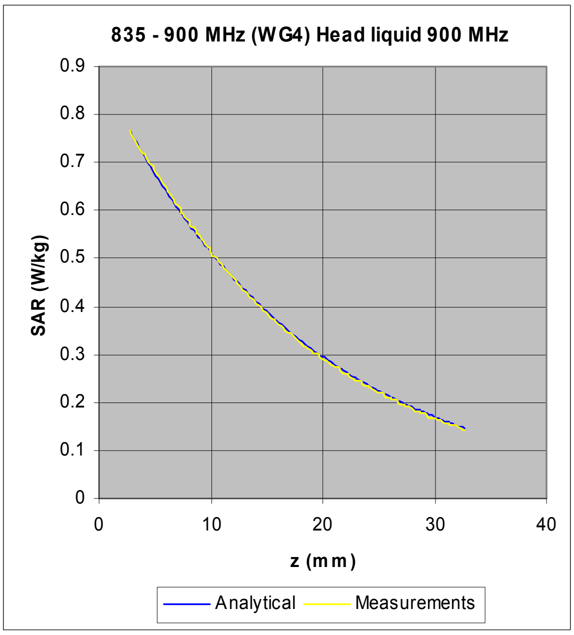
Figure 5. The rotational isotropy of probe S/N 0190 obtained by rotating the probe in a liquid-filled waveguide at 900 MHz.

Product Service

SAR DECAY FUNCTION – Analytical and Measurements







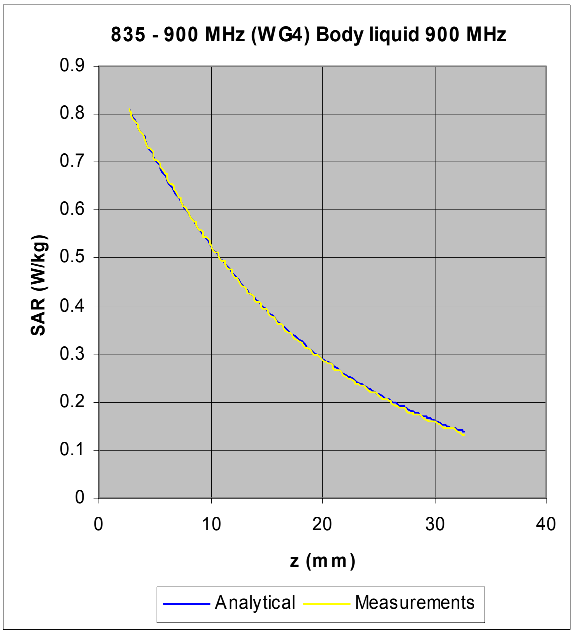
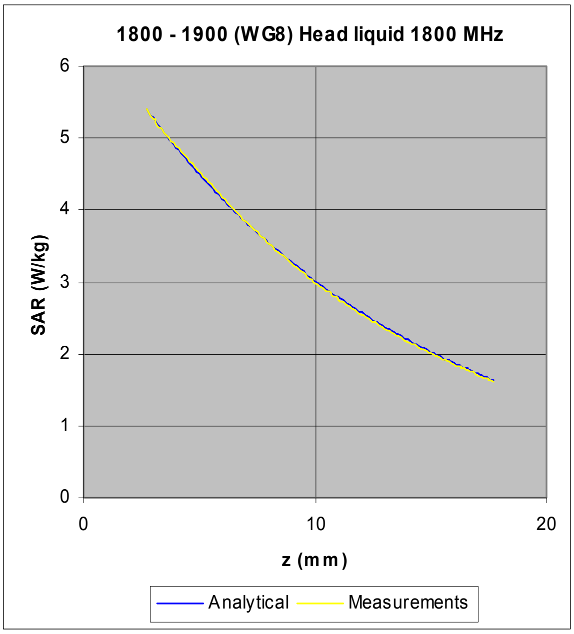
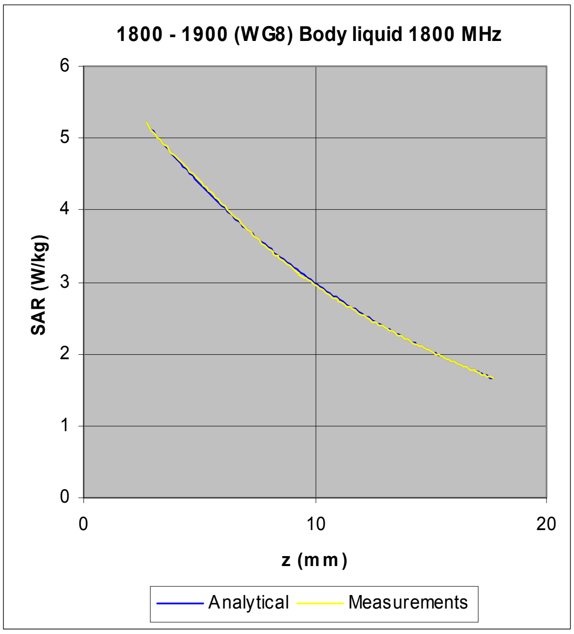
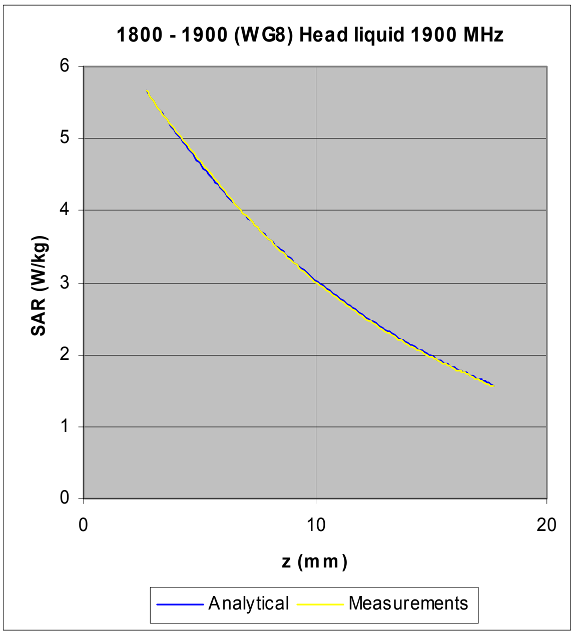


Figure 6a. The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

SAR DECAY FUNCTION – Analytical and Measurements - Continued







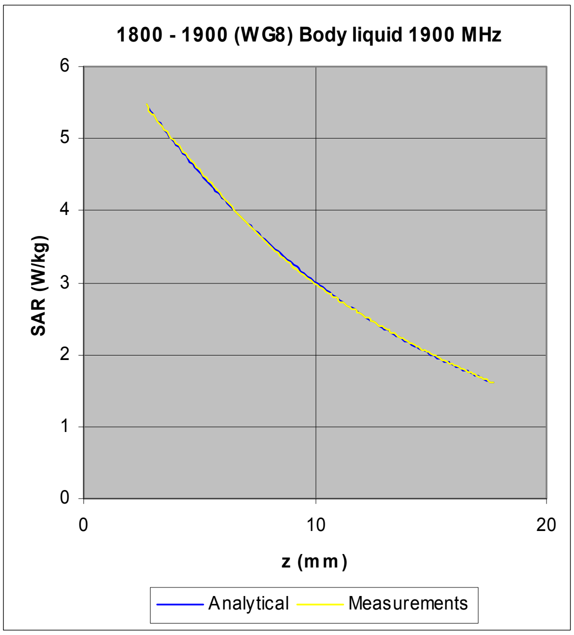
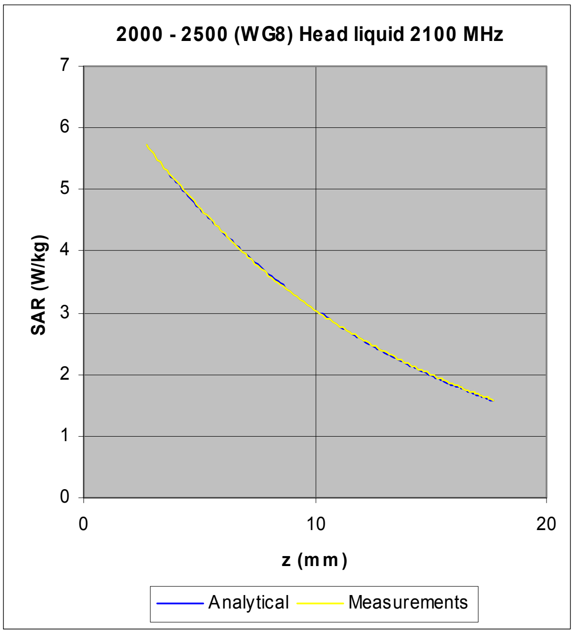
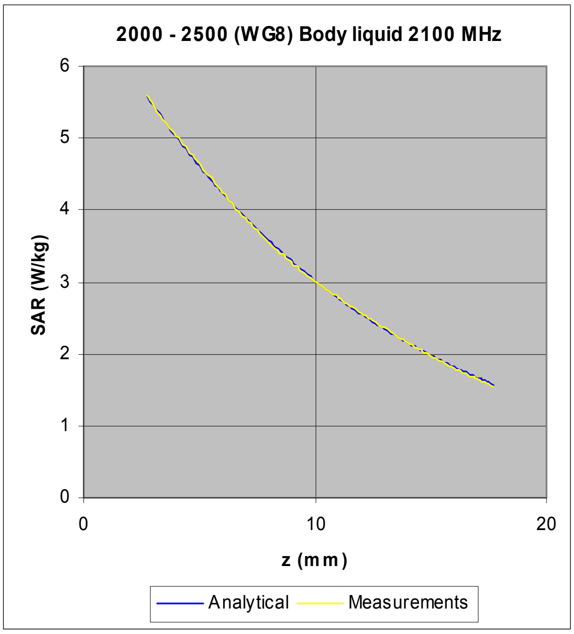
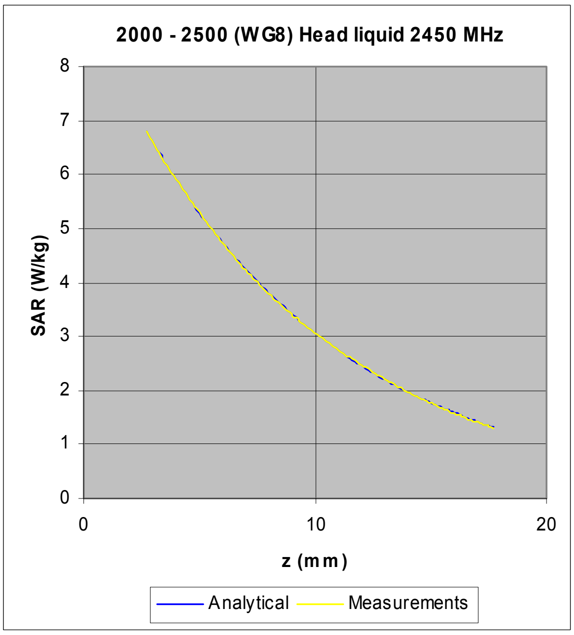


Figure 6b The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

SAR DECAY FUNCTION – Analytical and Measurements - Continued







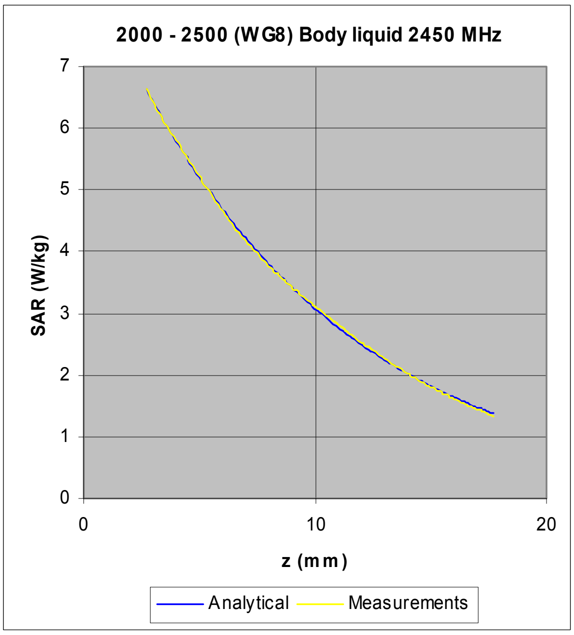


Figure 6c The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

SAR DECAY FUNCTION – Analytical And Measurements - Continued

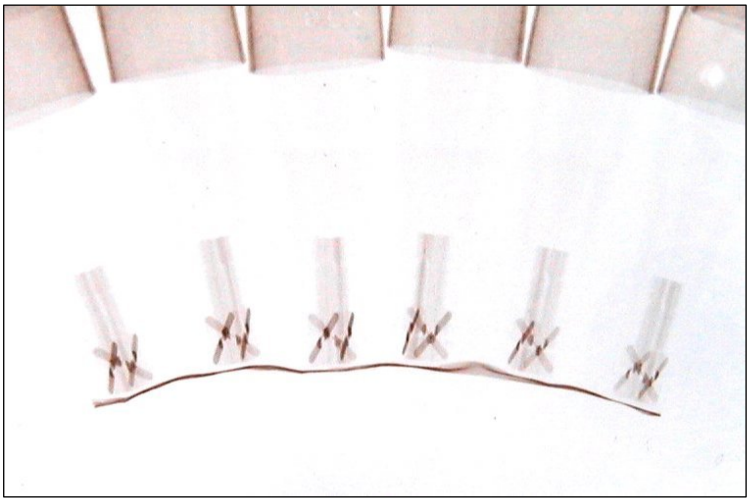


Figure 8: X-ray positive image of 5mm probes

TABLE INDICATING THE DIELECTRIC PARAMETERS OF THE LIQUIDS USED FOR CALIBRATIONS AT EACH FREQUENCY

Liquid used	*Relative permittivity (measured)*	*Conductivity (S/m) (measured)*
450 MHz BRAIN	*44.61*	*0.83*
450 MHz BODY	*56.03*	*0.76*
835 MHz BRAIN	*42.82*	*0.92*
835 MHz BODY	*49.55*	*1.07*
900 MHz BRAIN	*41.98*	*0.98*
900 MHz BODY	*48.82*	*1.13*
1800 MHz BRAIN	*38.95*	*1.35*
1800 MHz BODY	*53.98*	*1.51*
1900 MHz BRAIN	*38.55*	*1.44*
1900 MHz BODY	*53.70*	*1.61*
2100 MHz BRAIN	*40.42*	*1.48*
2100 MHz BODY	*54.62*	*1.68*
2450 MHz BRAIN	*39.04*	*1.85*
2450 MHz BODY	*53.63*	*2.07*