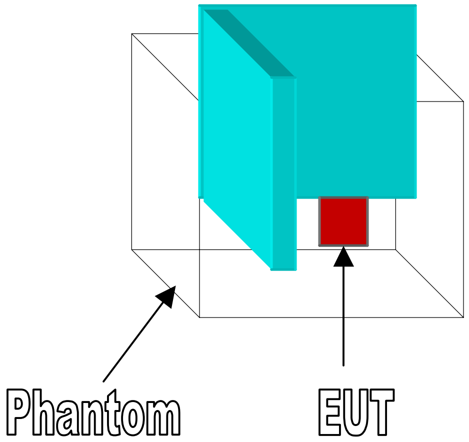
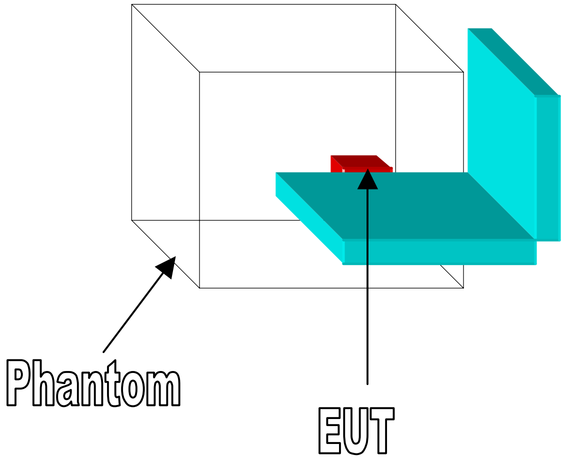
Appendix C

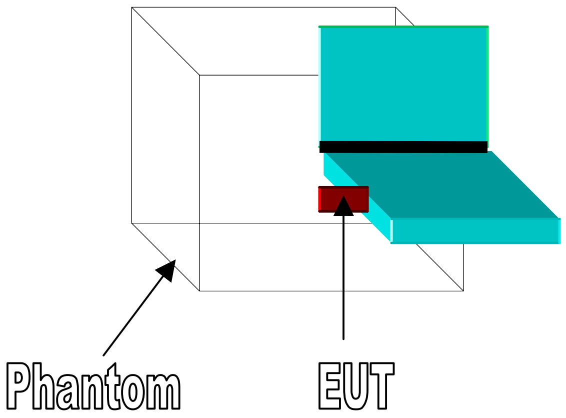
Device test positions:



Lap Position: back of laptop PC touching phantom.



#1 Bystander Position: 1.5 cm separation from EUT to phantom.



#2 Bystander Position: back of laptop PC touching phantom.

Tissue Recipes:

The following recipes are provided in percentage by weight. Approximately 8 liters of liquid are needed to fill the flat phantom and approximately 9 liters are needed to fill the SAM head phantom.

2450MHz Head:

53.74% distilled water
22.59% DGBE
22.59% triton X-100
0.98% salt
0.1% bactericide

2450MHz Body:

73.3% distilled water
12.88% DGBE
12.88% triton X-100
0.84% salt
0.1% bactericide

Material Parameters:

2450MHz head liquid 10/07/02, 21.9°C:

Freq. (MHz)	Rel. Perm.	Condy (S/m)
2450	39.02	1.756

2450MHz body liquid 10/07/02, 21.9°C:

Freq. (MHz)	Rel. Perm.	Condy (S/m)
2412	51.7	1.956
2442	51.52	1.960
2472	51.16	2.006

Environment

Humidity: 45% _ 5 %

Test Equipment

Instrument description	Supplier/Manufacturer	Model	Serial No.	Calibration (date)
Bench top Robot	Mitsubishi supplied by Indexsar	RV-E2	Serial No.	N/A
SAM Phantom	Upright shell phantom made by Antennessa digitized and mounted by Indexsar	SAM	04/02 FT08	N/A
2450MHz Head Tissue Simulant	Cetecom Inc.	2450 Head	S/N: 6	07/24/2002
2450MHz Body Tissue Simulant	Cetecom Inc.	2450 Body	S/N: 7	07/24/2002
2450MHz Dipole	IndexSAR – IEEE 1528 design	IXD-245	10	07/02/2002
Netwok Analyzer	Agilent	8753ES	US39172511-	04/04/2002-
RF Amplifier	Vectawave	N/A	N/A	N/A
Power Meter	Rohde and Schwartz	NRVD	836875/020	5/2002
Power Sensor	Rohde and Schwartz	URV5-Z2	836029/034	5/2002-
Power Sensor	Rohde and Schwartz	URV5-Z2	836029/035	5/2002-
SAR Probe	IndexSAR	IXP-050	S/N 0106	7/10/2002
Probe amplifier	Indexsar	IXA-010	S/N 043	N/A-
Thermometer	Control Company	4039	20410549	Due 11/20/2002

IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP – 050

S/N 0106

10th July 2002

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INTRODUCTION

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N 0106) 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, boxes and spheres) 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 calibration procedure, the probe is placed in a calibration 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 or 1800 MHz) is inserted horizontally into the bracket attached to a second belt (Figure 1). The dipole also can 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, the spherical isotropy of the probe can be 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. When it is necessary to place the probe in liquid, a rectangular box made from PMMA (200mm internal width, 200mm internal height and 100mm internal depth; wall thickness 4mm) is filled with the appropriate liquid and positioned on the stand so that the probe tip is positioned within the liquid (Figure 1). The box is positioned so that its outer surface is 2mm from the dipole. The procedure follows that described in Ref [2]. Section A.5.2.1.

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 the DCP values are typically 0.10V (or 20 in the voltage units used by Indexsar software, which are V*200).

3. Optimizing channel sensitivity factors in air

The first step of the calibration process is to calibrate the Indexsar probe to a W&G EMR300 E-field meter in air. The principal reasons for this are to balance the channels in air and to obtain air factors that are used in subsequent steps of the calibration procedure. It should be noted that the air factors are not separately used for normal SAR testing.

The probe and a 900 MHz standard dipole are positioned in the calibration jig as outlined in the section above. With the Indexsar probe located in air, individual channel output voltages are recorded as probe and dipole are rotated. An ‘air factor’ is applied to each of the probe’s three channels in order to equilibrate the peak magnitudes of each channel. 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):

$$\begin{aligned} E_{air}{}^{2}\ (\text{V/m}) = \quad & U_{linx} * \text{Air Factor}_{x} \\ & + U_{liny} * \text{Air Factor}_{y} \\ & + U_{linz} * \text{Air Factor}_{z} \qquad (2) \end{aligned}$$

It should be noted that the IXP-050 probes are optimised for use in tissue simulating liquids and do not behave isotropically in air.

4. 900 MHz Liquid Calibration

The second phase of calibration requires the channel output voltages of the Indexsar probe to be measured in a box filled with 900 MHz simulated brain liquid, balanced to optimise the probe isotropy. Later, the conversion factors are determined either using a waveguide or by comparison to a reference probe that has been calibrated by NPL.

The box of liquid is placed on the stand as described above and as pictured in Figure 1. Channel outputs for the different orientations of probe and dipole are recorded and entered into a spreadsheet. These measurements are multiplied by the previously determined air factors. Another factor, referred to as the 'liquid factor' is also applied to the measurements of each channel. The magnitude of the liquid factor for each channel is selected so as to optimise the isotropy of the probe (i.e. balance the peak magnitudes of the three channels) in the liquid. The following equation is used (where output voltages are in units of V*200):

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

An automated optimisation program balances the channel factors and then performs an optimisation to minimise the probe isotropy across the whole range of angles of presentation of the source field. A 3D representation of the spherical isotropy for probe S/N 0106 is shown in Figure 3.

The rotational isotropy is also determined. With the dipole at 90° to the probe axis the rotational isotropy for probe 0106 at 900 MHz is +/- 0.09 dB. Note that waveguide measurements were used to determine rotational isotropy at higher frequencies (Fig. 5).

The NPL reference probe is then measured in exactly the same way in the same set-up. The average readings for all angles of rotation are then placed into the spreadsheet of the probe being calibrated. This adjusts the magnitude of the calibration factors until they are similar to the NPL reference probe.

The final step of the 900 MHz calibration requires the measurement of SAR decay in a generic, spherical phantom and fitting the measured data to one of the two following analytical predictions of the decay profile:

1. SAR decay curve modelled using a 200mm diameter sphere energised by a balanced dipole in a 'benchmark configuration' developed as part of an Eureka Project [4] or SAR decay curve modelled by Flomerics [5] using a sphere and a balanced dipole in a similar test configuration.

2. SAR decay curve in a liquid-filled upright waveguide obtained from the procedure described in Ref [2], Section A.3.2.2.

To measure SAR decay via method 1, the probe is inserted through the neck of a spherical phantom filled with simulant liquid, and the tip is positioned at the inside surface of the flask. A suitable balanced dipole is aligned with the probe tip and placed a specific distance from the outer surface of the sphere (depending on whether comparison is made with calculated results from [4] or [5]). As the probe is progressively withdrawn along the centre line of the sphere, E-field measurements are taken. A multiplier is applied to the liquid factors so as to equilibrate the resultant decay function with the modelled results (as shown for waveguides in Figure 6).

For method 2, the probe calibration is carried out using waveguide cells as 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.

The liquid dielectric parameters used for the probe calibrations are tabulated at the end of this document. The final calibration factors for the probe are listed in the summary chart on the next page:

GSM RESPONSE

To measure the GSM response of the probe and amplifier, the probe is held vertically in a cube phantom 30mm from the side of the cube at which the balanced dipole is presented. The dipole is oriented vertically (parallel to the probe axis) for tests at 900MHz.

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 GSM. 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 1 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 GSM setting. The results are entered into a spreadsheet. Using the spreadsheets, the GSM power is calculated by taking 9dB from the measured CW power.

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

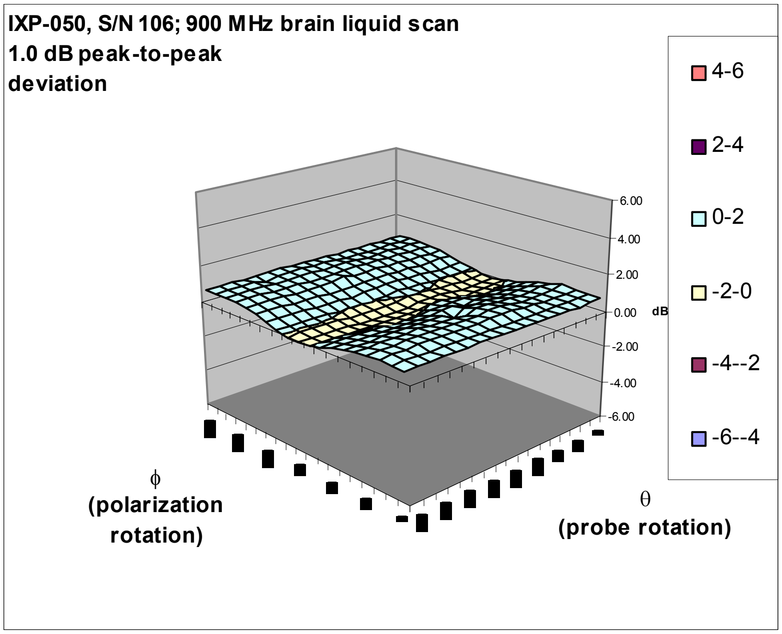
$$\text{SAR (W/kg)} = E_{liq}^{2}\ \text{(V/m)}\ * \sigma\text{(S/m)} / 1000 \qquad (4)$$

Where σ is the conductivity of the simulant liquid employed.

Using this procedure, the results obtained for the GSM response are shown in Figure 6. Additional tests have shown that the GSM response is similar at 1800MHz and is not affected by the orientation between the source and the probe.

The example shown in Figure 7 indicates that the particular plus amplifier combination probe tested correctly reflect the power level of pulsed GSM signals without the need for any specific scheme of correction. For other probes a correction is needed to the linearisation factor for each channel of the probe. Where appropriate, this is indicated in the summary page of calibration factors for each probe.

SUMMARY OF CALIBRATION FACTORS FOR PROBE IXP-050 S/N 0106



(simple, spreadsheet representation of surface shown in 3D in Figure 3 below)

Spherical isotropy (+/- dB)	0.50

X factor	**Y factor**	**Z factor**	
145	214	131	Combined
405	405	405	Air
0.359	0.528	0.324	Air/liq
20	20	20	DCP

8	8	8	DCPs for GSM
20	20	20	DCPs for CDMA/CW

f (MHz)	Axial isotropy (+/- dB)		Conversion factors				Conversion factors				
	BRAIN	BODY	BRAIN				BODY				
			factor	X	Y	Z	factor	X	Y	Z	Notes
835	0.16	*0.16*	0.95	0.341	0.502	0.308	*1.14*	*0.409*	*0.602*	*0.369*	1)
900	0.09	*0.09*	1.00	0.359	0.528	0.324	*1.2*	*0.431*	*0.634*	*0.389*	2), 4)
1800	0.20	0.25	1.50	0.538	0.792	0.486	1.80	0.646	0.950	0.583	3), 4)
1900	0.22	0.25	1.60	0.574	0.845	0.518	1.80	0.646	0.950	0.583	3)
2450	0.24	0.16	1.95	0.466	0.686	0.421	2.50	0.597	0.879	0.539	3), 4)

extrapolated values in italic

Notes

1) From validation measurement with 835MHz dipole and fluid
2) Probe calibration factors from substitution against NPL-calibrated probe (Probe IXP-050 S/N 0071 ; NPL Cal Report No: EF07/2002/03/IndexSAR)
3) From waveguide determination
4) Checked using validation geometry with dipole and box phantom

PROBE SPECIFICATIONS

Indexsar probe 0106, 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 0106	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 0106	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 0106	CENELEC [1]	IEEE [2]
Over range 0.01 – 100 W/kg (+/- dB)	0.125	0.50	0.25

Isotropy (measured at 900MHz)	S/N 016	CENELEC [1]	IEEE [2]
Axial rotation with probe normal to source (+/- dB) at 835, 900, 1800, 1900 and 2450 MHz	Max. 0.25 (see summary table)	0.5	0.25
Spherical isotropy covering all orientations to source (+/- dB)	0.50	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.

[4] Stevens, N. *et al*., Comparison of the numerical and experimental evaluation of the SAR employing a spherical benchmark configuration. *To be published*.

[5] Maggs, J., Modelling of the E-field distribution within a lossy spherical phantom energised by balanced dipole sources. *Flomerics, unpublished*.

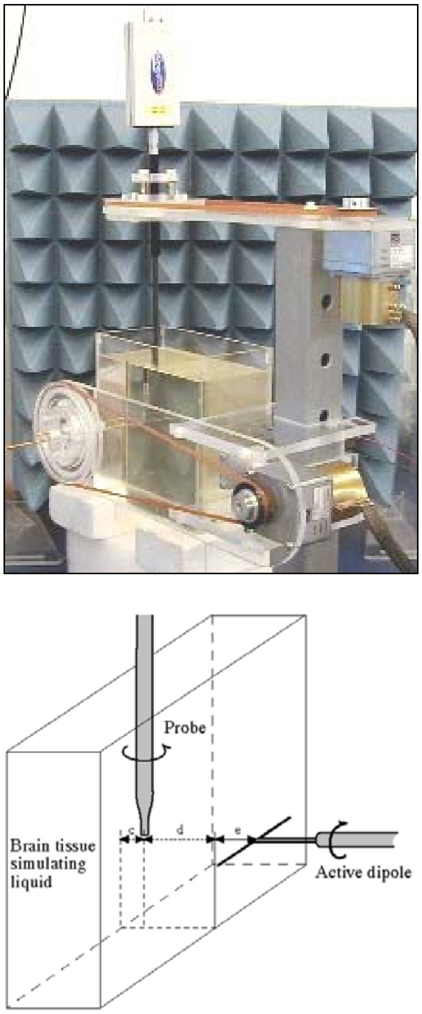


Figure 1. Calibration jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

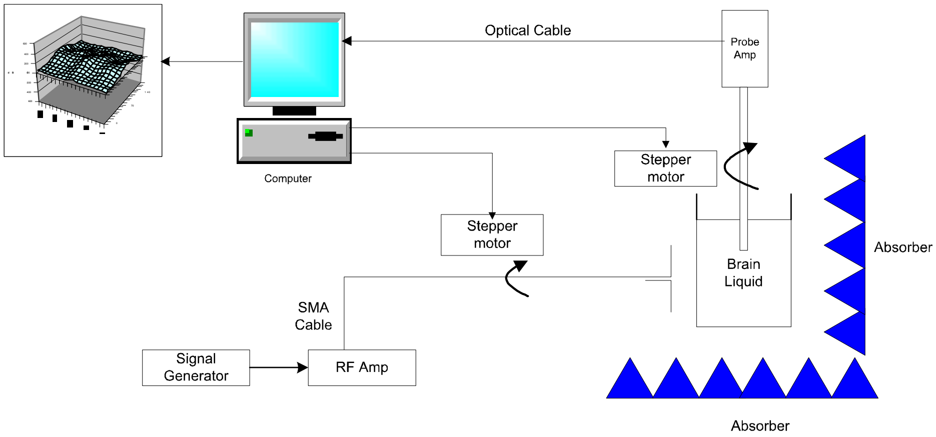


Figure 2. Schematic diagram of the test geometry used for isotropy determination

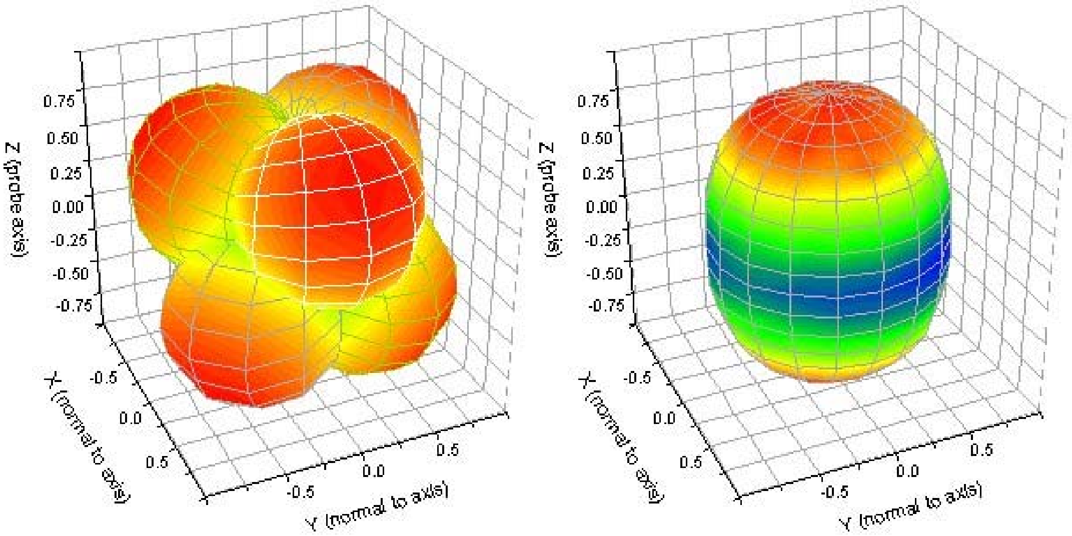


Figure 3. Graphical representation of the probe response to fields applied from each direction. The diagram on the left shows the individual response characteristics of each of the three channels and the diagram on the right shows the resulting probe sensitivity in each direction. The colour range in the figure images the lowest values as blue and the maximum values as red. For the probe S/N 0106, this range is (+/-) 0.50 dB. The probe is more sensitive to fields parallel to the axis and less sensitive to fields normal to the probe axis.

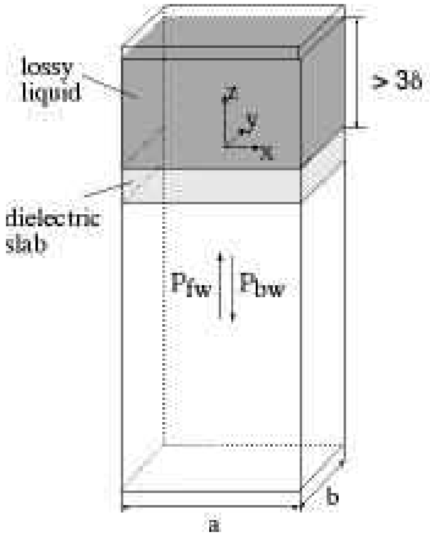
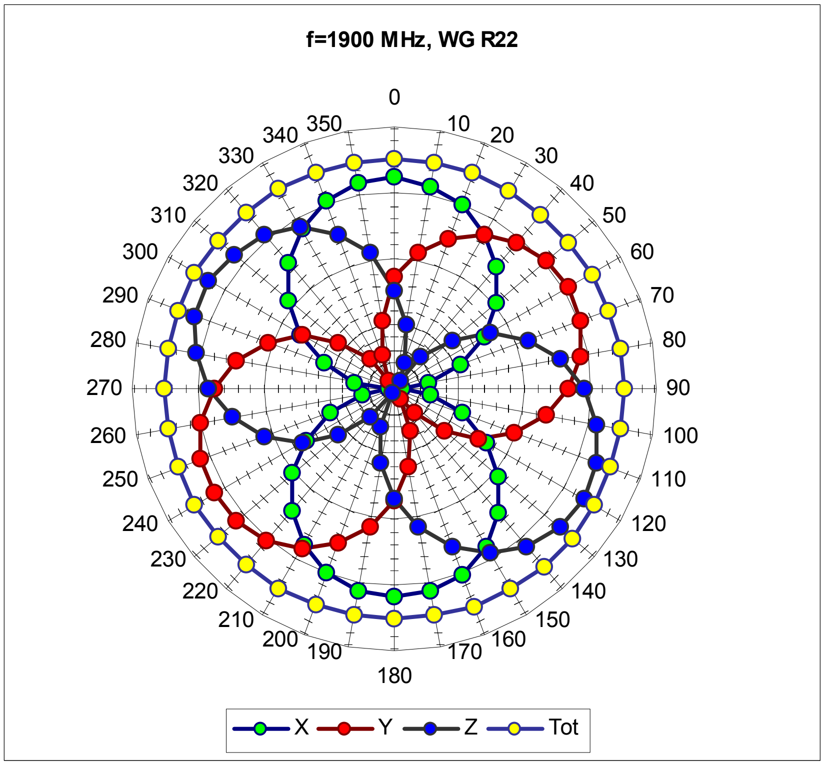


Figure 4. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)



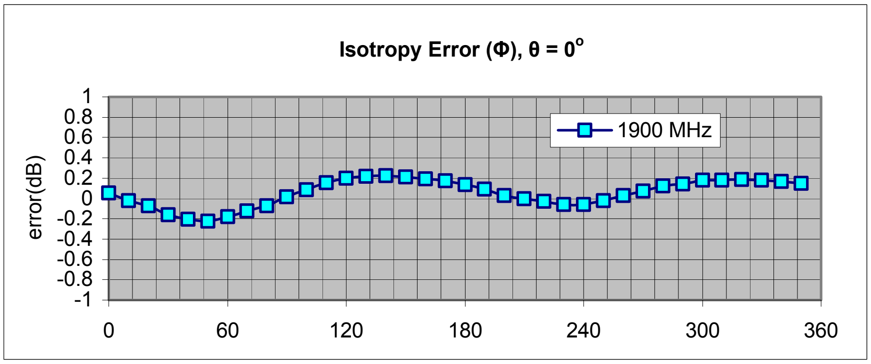
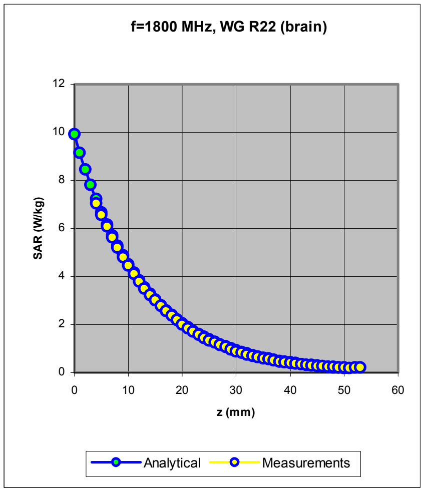
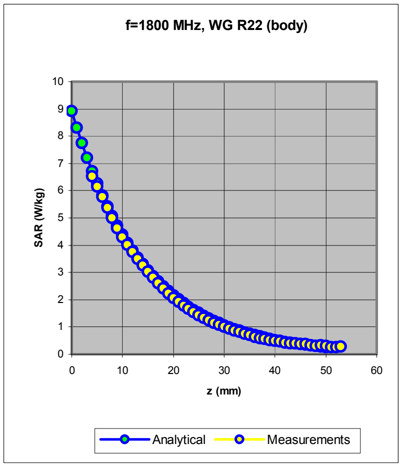
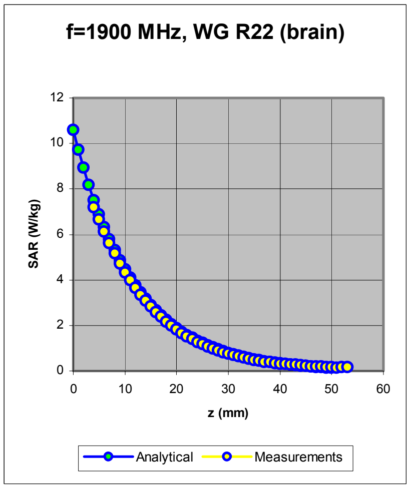
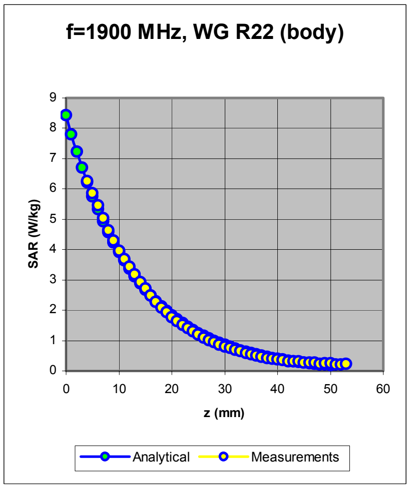


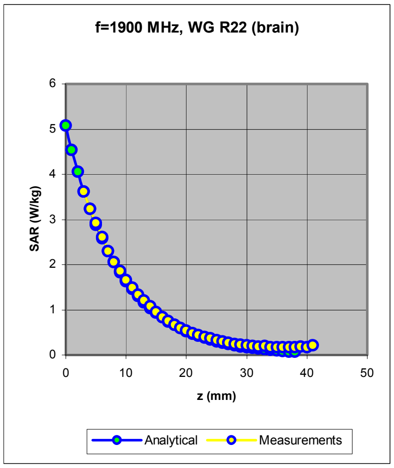
Figure 5. Example of the rotational isotropy of probe S/N 0106 obtained by rotating the probe in a liquid-filled waveguide at 1800 MHz. Similar distributions are obtained at the other test frequencies (1800 and 2450 MHz) both in brain liquids and body fluids (see summary table)


f=1800 MHz, WG R22 (brain)
SAR (W/kg)
0
2
4
6
8
10
12
z (mm)
0
10
20
30
40
50
60
Analytical
Measurements


f=1800 MHz, WG R22 (body)
SAR (W/kg)
0
1
2
3
4
5
6
7
8
9
10
z (mm)
0
10
20
30
40
50
60
Analytical
Measurements


f=1900 MHz, WG R22 (brain)
SAR (W/kg)
0
2
4
6
8
10
12
z (mm)
0
10
20
30
40
50
60
Analytical
Measurements


f=1900 MHz, WG R22 (body)
SAR (W/kg)
0
1
2
3
4
5
6
7
8
9
z (mm)
0
10
20
30
40
50
60
Analytical
Measurements


f=1900 MHz, WG R22 (brain)
SAR (W/kg)
0
1
2
3
4
5
6
z (mm)
0
10
20
30
40
50
Analytical
Measurements

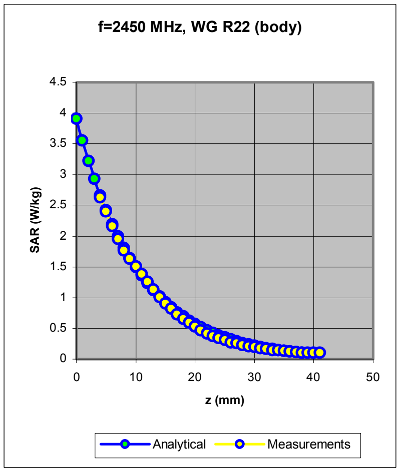

f=2450 MHz, WG R22 (body)
SAR (W/kg)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
z (mm)
0
10
20
30
40
50
Analytical
Measurements

Figure 6. 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.

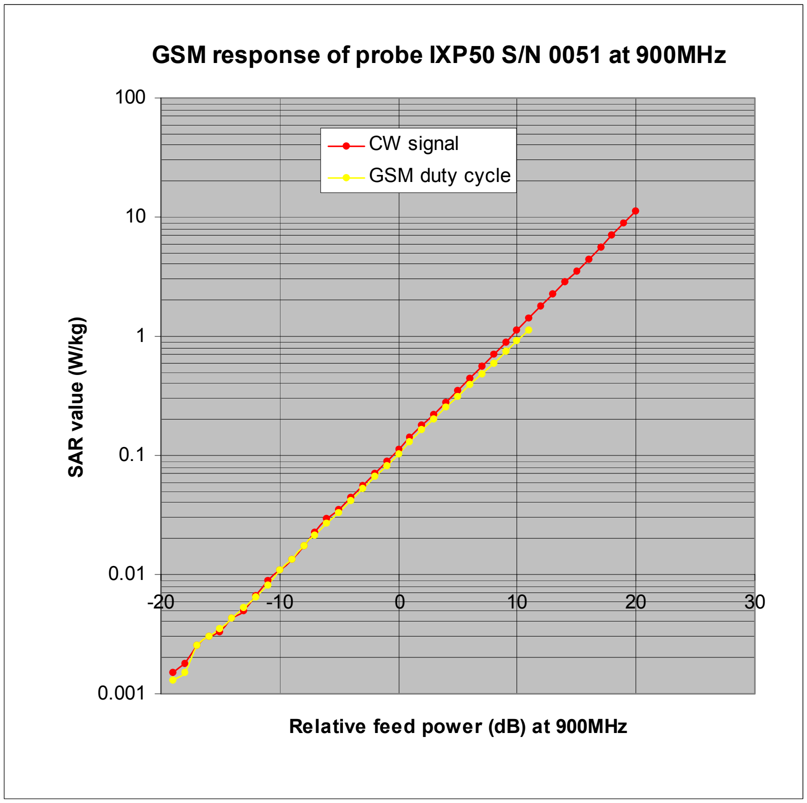


Figure 7. The GSM response of representative IXP-050 probe at 900MHz.

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	42.85	0.90
900 MHz BRAIN	41.95	0.96
1800 MHz BRAIN	39.19	1.34
1800 MHz BODY	51.62	1.37
1900 MHz BRAIN	38.82	1.46
1900 MHz BODY	51.38	1.47
2450 MHz BRAIN	37.65	1.88
2450 MHz BODY	55.28	1.92

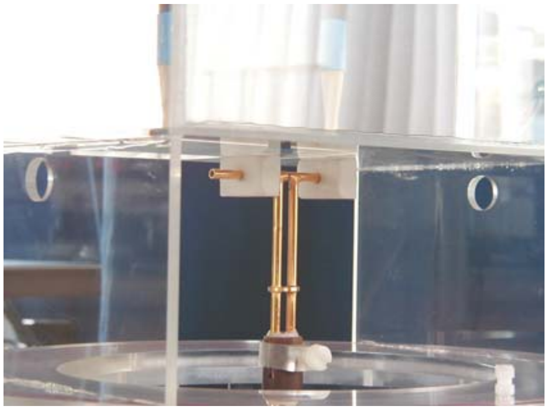
Report No. IXS 0211
July 1st 2002

INDEXSAR
Validation Dipoles
Type IXD-245

Performance measurements

S/N: 2450-01

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 form 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 1/40th 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. SAR Measurement

SAR validation checks using the dipoles can be performed with the box-phantom located on the SARA2 phantom support base on the SARA2 robot system. Tests may be conducted at a feed power level of 0.25W. However, the actual power level should be recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The results can then be compared with Table 8.1 in [1]. Brain liquids should be used so that measurement results can be compared with the (computed) reference values tabulated in IEEE 1528.

3. 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 below:

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.

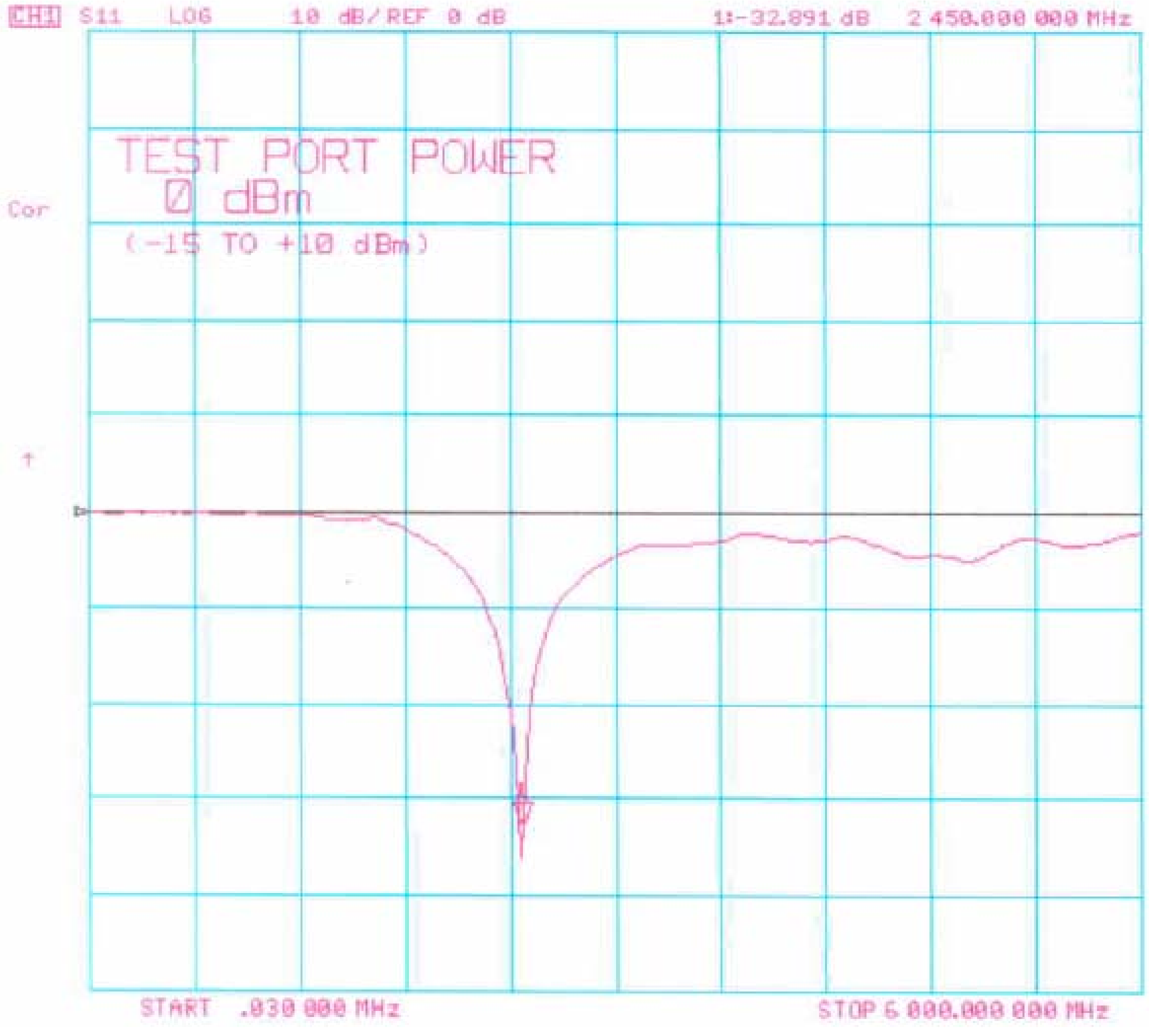
Please note that, because of their construction, the dipoles are short-circuited for DC signals.

4. Performance Measurement

The dipoles are individually tested at their nominal frequency to ensure that they exhibit a return loss of less than -20dB when used with brain or body liquids.

The dipoles are designed to have low return loss ONLY when presented against a lossy-phantom at the specified distance. If the user has a Vector Network Analyser (VNA) it is best to perform a return loss measurement on a specific dipole when it is in a measurement-location against a box phantom. If this is not the case, the return loss should be measured with the dipole positioned at the specified distance from a suitable container of lossy liquid. The distances specified in the standards are 15mm from the lossy liquid (900MHz and below) and 10mm from the liquid (1500MHz and above). The Indexsar foam spacers (described above) should be used to ensure this condition during measurement.

Representative S11 plots for the dipole with nominal frequencies of 2450MHz are shown below.



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. Reference

[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.