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Report On

Specific Absorption Rate Testing of the
Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS

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COMMERCIAL-IN-CONFIDENCE

REPORT ON	Specific Absorption Rate Testing of the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS Mobile Handset Document 75917214 Report 02 Issue 2 June 2012
PREPARED FOR	Sharp Communication Compliance Ltd Azure House Bagshot Road Bracknell Berkshire RG12 7QY
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APPROVED BY	**M Jenkins** Authorised Signatory
DATED	13 June 2012

This report has been up-issued to Issue 2 to include additional information.

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CONTENTS

Product Service

SECTION 1

REPORT SUMMARY

Specific Absorption Rate Testing of the
Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS Mobile Handset

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1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Specific Absorption Rate Testing of the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS Mobile Handset to the requirements of OET Bulletin 65 Supplement C Edition 01-01.

Objective	To perform Specific Absorption Rate Testing to determine the Equipment Under Test's (EUT's) compliance with the requirements specified of OET Bulletin 65 Supplement C Edition 01-01, for the series of tests carried out.
Applicant	Sharp Communication Compliance Ltd
Manufacturer	Sharp Corporation
Manufacturing Description	Mobile Handset
Model Number	CDMA SHI16
Power Class	PCS 1900 MHz Class 1 WCDMA FDD V Class 3 CDMA2000 Class 0
GPRS Class	B
GPRS Multi-slot Class	12
Serial/IMEI Number(s)	004401113852723 004401113852780 004401113852608 004401113851006
Number of Samples Tested	4
Hardware Version	PP1.5
Software Version	D327X / D3131 / D4040
Battery Cell Manufacturer	Sharp Corporation
Battery Model Number	SHI16UAA
Test Specification/Issue/Date	OET Bulletin 65 Supplement C Edition 01-01
Start of Test	23 May 2012
Finish of Test	24 May 2012
Related Document(s)	FCC 47CFR 2.1093 KDB 248227 – v01r02 (Rev 1.2) KDB 450824 – D01 v01r01(Rev 1.1) KDB 450824 – D02 v01r01 KDB 648474 – D01 v01r05 KDB 941225 – D01 v02 KDB 941225 – D03 v01 IEEE 1528-2003
Name of Engineer(s)	Nigel Grigsby

Product Service

1.2 BRIEF SUMMARY OF RESULTS

The measurements shown in this report were made in accordance with the procedures specified OET 65(C) – 2001.

The maximum 1g volume averaged SAR found during this Assessment

Max 1g SAR (W/kg)	0.521
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(C) – 2001 and the results were compared against published data in Standard IEEE 1528-2003. The following results were obtained: -

System performance / Validation results

Date	Dipole Used	Frequency (MHz)	Max 1g SAR (W/kg)*	Percentage Drift on Reference	Max 10g SAR (W/kg)*	Percentage Drift on Reference
22/05/2012	835	835	9.45	-1.18%	6.24	0.36%
22/05/2012	835	835	9.43	-1.31%	6.09	-2.14%
23/05/2012	1900	1900	43.21	8.85%	22.24	8.48%
23/05/2012	1900	1900	35.97	-9.39%	19.05	-7.08%
24/05/2012	2450	2450	49.59	-5.37%	22.61	-5.78%
24/05/2012	2450	2450	47.86	-8.66%	22.52	-6.18%

*Normalised to a forward power of 1W

1.3.2 Results Summary Tables

CDMA2000 Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Ear	Head							
Left	Cheek	777	848.31	0.416	0.358	0.240	1.100	Figure 8
Left	15°	777	848.31	0.273	0.242	0.182	2.500	Figure 9
Right	Cheek	777	848.31	0.485	0.446	0.320	-5.900	Figure 10
Right	15°	777	848.31	0.308	0.274	0.202	-4.600	Figure 11
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

CDMA2000 Body Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Spacing	Direction							
15mm	Front Facing	777	848.31	0.250	0.215	0.151	4.700	Figure 12
15mm	Rear Facing	777	848.31	0.385	0.327	0.226	-0.800	Figure 13
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

WCDMA FDDV Head Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Ear	Head							
Left	Cheek	4232	846.4	0.307	0.270	0.199	-1.300	Figure 14
Left	15°	4232	846.4	0.194	0.174	0.129	0.000	Figure 15
Right	Cheek	4232	846.4	0.361	0.325	0.233	-3.000	Figure 16
Right	15°	4232	846.4	0.200	0.179	0.132	-0.500	Figure 17
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

WCDMA FDDV Body Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Spacing	Direction							
15mm	Front Facing	4232	846.4	0.176	0.150	0.106	-0.800	Figure 18
15mm	Rear Facing	4232	846.4	0.261	0.224	0.156	-0.100	Figure 19
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

PCS 1900MHz Head Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Ear	Head							
Left	Cheek	512	1850.2	0.200	0.172	0.107	-1.100	Figure 20
Left	15°	512	1850.2	0.087	0.072	0.044	0.000	Figure 21
Right	Cheek	512	1850.2	0.157	0.137	0.084	-1.600	Figure 22
Right	15°	512	1850.2	0.056	0.048	0.056	0.000	Figure 23
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

PCS 1900MHz Body Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Spacing	Direction							
15mm	Front Facing	661	1880	0.383	0.315	0.202	-5.100	Figure 24
15mm	Rear Facing	661	1880	0.333	0.273	0.174	-0.700	Figure 25
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

Product Service

WLAN 2450MHz Head Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Ear	Head							
Left	Cheek	6	2437	0.397	0.330	0.179	-3.000	Figure 26
Left	15°	6	2437	0.356	0.294	0.149	1.500	Figure 27
Right	Cheek	6	2437	0.627	0.521	0.254	-0.100	Figure 28
Right	15°	6	2437	0.467	0.356	0.174	0.200	Figure 29
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

WLAN 2450MHz Body Specific Absorption Rate (Maximum SAR) 1g & 10g Results for the Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS.

Position		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)
Spacing	Direction							
15mm	Front Facing	6	2437	0.072	0.055	0.029	2.100	Figure 30
15mm	Rear Facing	6	2437	0.063	0.047	0.023	-4.600	Figure 31
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) & 2.0 W/kg (10g)								

1.4 PRODUCT INFORMATION

1.4.1 Technical Description

The equipment under test (EUT) was a Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS. A full technical description can be found in the manufacturer's documentation.

1.4.2 Test Configuration and Modes of Operation

The testing was performed with standard batteries supplied and manufactured by Sharp Corporation. Each battery was fully charged before each measurement and there were no external connections.

For head SAR assessment, testing was performed with the device in the declared normal position of operation for CDMA2000 800MHz, PCS 1900MHz, WCDMA FDDV and WLAN 2.4GHz frequency bands at maximum power. The device was placed against a Specific Anthropomorphic Mannequin (SAM) phantom as specified in the CENELEC standard EN 62209-1: 2006. The phantom was filled with simulant liquid appropriate to the frequency band. The dielectric properties were measured and found to be in accordance with the requirements for the dielectric properties specified OET 65(C) – 2001. Testing was performed at both the left and right ear of the phantom at both handset positions stated in the applied specification.

For body SAR assessment, the device was tested for typical body-worn operation in accordance with the requirements of OET65(c) with the exception of SAR limits applied, these were obtained from ICNIRP (1998). Flat phantom dimensions are 210mmx210mmx210mm and with a sidewall thickness of 6.0mm. The phantom was filled to a depth of 150mm with the appropriate body simulant liquid. The dielectric properties were in accordance with the requirements specified in Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01). SAR testing was performed with the body of the device placed at 15mm separation from the phantom.

Testing was performed in each position at the frequency that gave the highest output power for each band. No SAR level was found to be within -3dB of the applicable limit (-3dB equates to ≤0.802 W/kg in this instance) therefore no additional testing was required at the remaining frequencies / channels of the bands. WLAN testing was achieved using the devices internal software, customer supplied software and settings supplied by the customer.. The worse case data rate for WLAN testing was obtain from data provided by TUV Product Service determined by the testing of the handset. The worst case was deemed as the data rate which produced the highest level of conducted average power. This was 1Mbps for 802.11b.

Simultaneous transmission SAR testing for Head/Body for CDMA2000 800MHz and WLAN was not required because the antenna separation distance is greater than 5cm and the maximum SAR levels obtained for both transmitters is less than 0.8W/kg.

Simultaneous transmission SAR testing for Head/Body for CDMA2000 800MHz and BT was not required because the antenna separation distance is greater than 5cm and the Bluetooth conducted output power is less than 24mW.

Simultaneous transmission SAR testing for Head/Body for WLAN and BT was not required because the antenna separation distance is less than 2.5cm and the Bluetooth conducted output power is less than 24mW.

Stand alone SAR testing for Bluetooth was not required due to the output power being less than the threshold.

Product Service

The following configurations and procedures for SAR testing were used:

HEAD SAR:

SAR for the head exposure configurations is measured in RC3 with the EUT configured to transmit at full rate using Loopback Service Option SO55.
SAR for RC1 is not required when the maximum average output of each channel is less than 0.25dB higher than that measured in RC3. If SAR for RC1 is required, then SAR is measured on the maximum output channel in RC1 using the exposure configuration that results in the highest SAR for that channel in RC3

BODY SAR:

SAR for the body exposure configuration is measured in RC3 with the EUT configured using TDSO32, to transmit at full rate on FCH with all other code channels disabled.
SAR for multiple code channels (FCH + SCH) is not required when the maximum average output of each RF channel is less than 0.25dB higher than that measured with FCH only. If SAR for multiple code channels is required then SAR is measured on the maximum output channel (FCH + SCHn) with FCH at full rate and SCH0 enabled at 9600bps, using the exposure configuration that results in the highest SAR with FCH only for that channel. When multiple code channels are enabled, the DUT may shift by more than 0.5dB and lead to higher SAR drifts and SCH dropouts.
Body SAR in RC1 is not required when the maximum average output of each channel is less than 0.25dB higher than that measured in RC3. If SAR for RC1 is required, then SAR is measured on the maximum output channel in RC1; with Loopback Service Option SO55, at full rate, using the body exposure configuration that results in the highest SAR that channel in RC3.

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 handset against the body as appropriate.

1.5 FCC POWER MEASUREMENTS

1.5.1 Method

Conducted power measurements were made using a power meter.

1.5.2 Conducted Power Measurements

CDMA2000 800MHz

Head

TUV Sample No.	Mode	Modulation	Frequency	Conducted Carrier Power (dBm)
116	S055, RC1	64-RAY Orthogonal	824.70	23.71
			836.52	23.76
			848.31	**12.79**

TUV Sample No.	Mode	Modulation	Frequency	Conducted Carrier Power (dBm)
116	S055, RC3	64-RAY Orthogonal	824.70	23.66
			836.52	23.71
			848.31	**23.82**

Body

TUV Sample No.	Mode	Modulation	Frequency	Conducted Carrier Power (dBm)
116	TDS032, FCH RC3	BPSK	824.70	23.87
			836.52	23.89
			848.31	**24.00**

TUV Sample No.	Mode	Modulation	Frequency	Conducted Carrier Power (dBm)
116	TDS032, FCH +SCH RC3	BPSK	824.70	23.84
			836.52	23.9
			848.31	**23.98**

WLAN

Mode	Modulation	Frequency	Conducted Carrier Power (dBm) IMEI	Radiated Carrier Power(dBm) IMEI 004401113851006	Peak to Average Ratio (dB)	Corrected Radiated Carrier Power for SAR Report (dBm)
802.11 Mbps	DSSS	2412	18.48	20.71	8.28	12.43
		2437	18.73	20.57	7.54	13.08
		2462	17.90	19.50	7.37	12.13

PCS

Head

TUV Sample No.	Mode	Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
113	Voice	GMSK	1850.2	**19.87**
			1880.0	19.84
			1909.8	19.84

Body

TUV Sample No.	Mode	Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
113	GPRS	GMSK	1850.2	21.12
			1880.0	**21.25**
			1909.8	20.98

WCDMA FDDV

Head

TUV Sample No.	Mode	Modulation	Frequency	Conducted Carrier Power (dBm)
114	RMC	QPSK	826.6	22.31
			835.0	22.30
			846.4	**22.32**

SECTION 2

TEST DETAILS

Specific Absorption Rate Testing of the
Sharp CDMA SHI16 Dual-band CDMA (BC0, BC6) & Tri-band GSM (GSM900/DCS1800/PCS1900) & Dual-band UMTS (FDDI, FDDV) multi mode cellular phone with Bluetooth, WLAN, WiMAX NFC (FeliCa) and GPS Mobile Handset

Product Service

2.1 SARA-C SAR MEASUREMENT SYSTEM

2.1.1 Robot System Specification

The SAR measurement system being used is the IndexSAR SARA-C system, which consists of a cartestian 6-axis robot jig, a dedicated robot controller, a straight IndexSAR probe, an L-shaped Indexsar probe, a fast amplifier, and two phantoms: an upside-down SAM phantom, and a rectangular box phantom,

Figure 1. The L-probe is used in connection with measurements on DUTs held against the SAM phantom, while the straight probe is used exclusively in the box phantom. The robot is used to articulate the probe to programmed positions inside the phantom head to obtain SAR readings from the DUT.

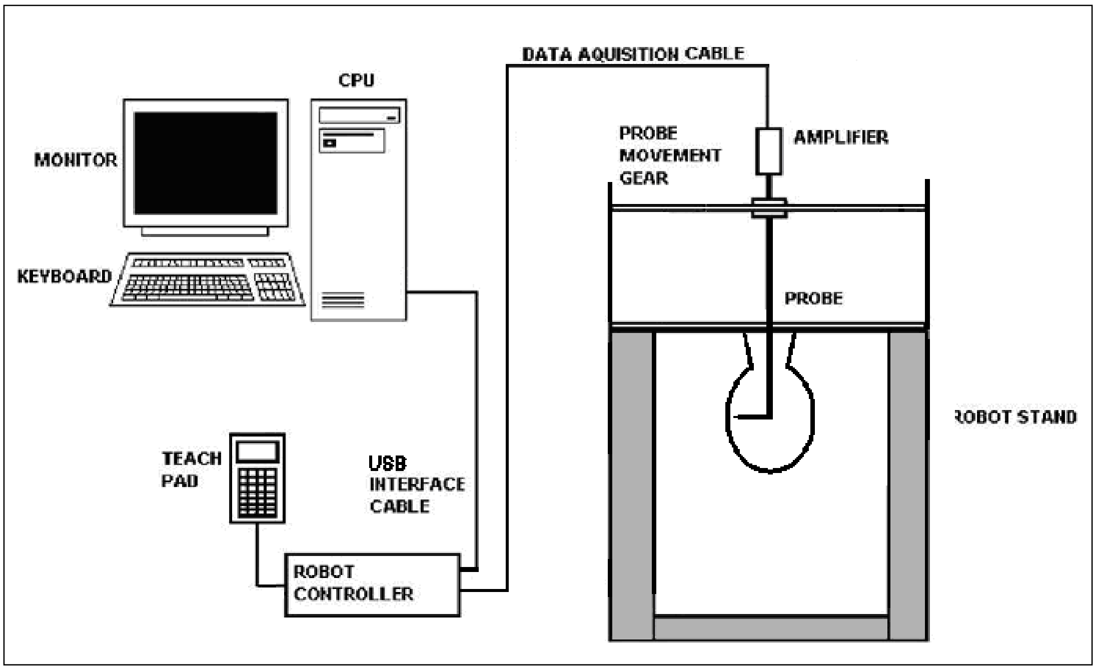

Figure 1 Schematic diagram of the SARA-C measurement system showing the L-probe and upside-down SAM phantom

The system is controlled remotely from a PC, which contains the software to drive 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. Even with this accuracy, registration errors and deformation of the phantom when filled with 7 litres of fluid, can lead to probe placement errors of 1mm or more. For this reason, the L-probes house a 2-axis strain gauge unit, which allow the actual phantom wall position to be sensed to an accuracy of 0.3mm during probe movements.

In operation, the system first does an area (2D) scan within the liquid following the curve of the phantom wall at a fixed distance. 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

IndexSAR isotropic immersible straight SAR probes

Straight 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. The tips come in either 5mm (typically for use up to 3GHz) or 2.5mm (above 3GHz) versions, model types IXP-050 and IXP-025 respectively.

Straight probes are calibrated by NPL in the UK.

Straight probes are used exclusively in the box phantom, to measure SAR from DUTs placed against the phantom base. In SARA2, straight probes were also used in the SAM phantom, but this is forbidden in SARA-C, where L-probes are demanded. NB the reverse is not true: L-probes can be used in the box phantom.

IndexSAR L-probes

The L-shaped probe is so designed to ensure the probe tip can remain perpendicular to the SAM phantom wall during scans. To allow for greater probe articulation freedom, the SAM phantom head has been turned upside down and the probe is inserted through the throat aperture, rather than through a small hole at the top of the head in the old SARA2 SAR measurement system.

Like the straight probes, L-probes also come in the same two tip sizes: IXP-020 (5mm) and IXP-021 (2.5mm).

L-probes are calibrated to national standards in-house by IndexSAR.

L-probes can be used either in the SAM head, or against the side wall of the box phantom.

Product Service

IFA-020 Fast Amplifier

A block diagram of the fast probe amplifier electronics is shown below.

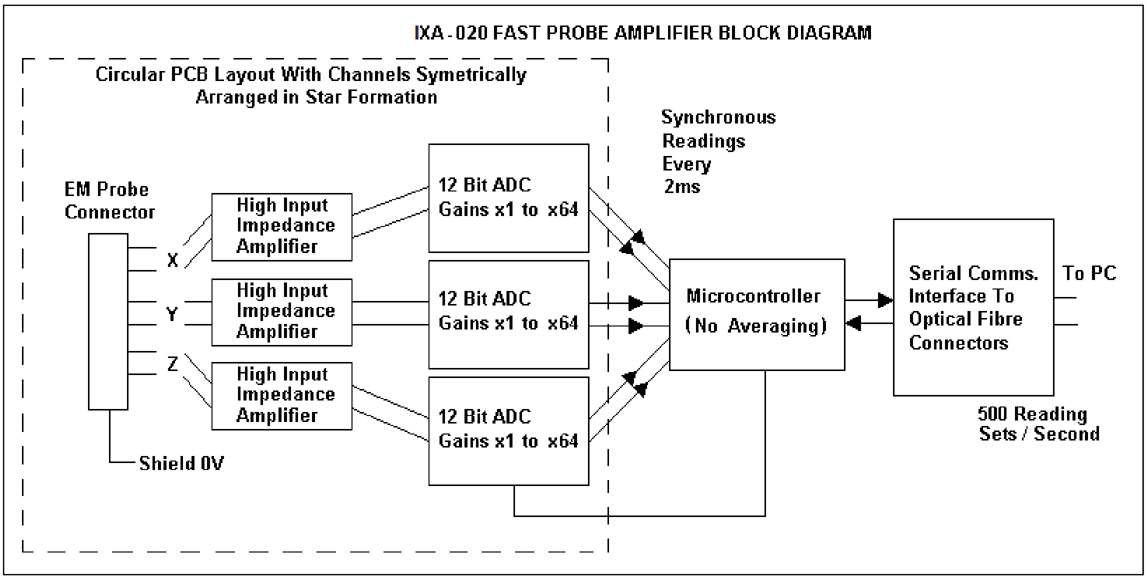

Figure 2 Schematic diagram of the fast amplifier

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 a reading containing data for all three channels is returned to the PC every 2ms. 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.

The fast amplifier sampling rate can be adjusted via the SARA-C user interface from 1.7ms to 2.3ms. When not measuring CW signals, it is important to ensure that this probe reading rate and the modulated signal's pulse repetition rate are not unintentionally synchronised since this can lead to aliasing and a gross reduction in accuracy. For GSM signals, the default amplifier sampling rate of 2ms is entirely satisfactory, whereas changing it to 2.3ms (almost exactly half the GSM frame rate) could mean GSM bursts are always missed.

When aggregating 2ms samples to reduce the stochastic noise, it is equally important to match the number of samples with the longer-term timing structure of the modulation scheme. Taking GSM as an example again, since 120ms is the precise length of a GSM traffic channel multiframe, best practice would dictate that aggregated samples should cover exact multiples of this timescale. In this case, setting the number of samples to be aggregated to 120 (2 multiframes), or 240 samples (4 multiframes) should be ideal. Other signalling protocols would require changing these numbers as appropriate.

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Phantoms

The Flat phantom used is a rectangular Perspex Box IndexSAR item IXB-2HF, dimensions 240 x 190 x 195mm (w x d x h). The base and one side wall are made of FR4 material which has specific dielectric properties and a tightly-controlled thickness. The base is used in tandem with straight probes, measuring either a DUT or a validation dipole, while the side wall is for performing validations with the L-probe. It is also feasible to perform measurements on body-worn devices with the L-probe against the side window, but only if the L-probe is suitably calibrated (ie if the measurement standard demands body and head fluids have the same dielectric properties).

The Specific Anthropomorphic Mannequin (SAM) Upright Phantom is fabricated using moulds generated from the CAD files as specified by CENELEC EN 62209-1: 2006.

2.1.3 SAR Measurement Procedure

Detailed measurement procedures for SARA-C are set out in a separate IndexSAR technical document ("SARA-C Operational Procedures"

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 the 110mm diameter penetration hole in the neck.

An area scan is performed inside the head at a fixed distance of 5mm from the curved surface on the source side. An algorithm presents the user with the location of any local hotspots and allows one to be selected for a follow-up 3D scan, looking at how the signal absorption varies with depth. A comparison between the start and end readings at a fixed distance from the DUT also enables the power drift during measurement to be assessed.

<u>SARA-C Interpolation and Extrapolation schemes</u>

SARA-C software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a proprietary curve-fitting routine is implemented as a weighted average of 3 different polynomial fits. The polynomial fitting procedures have been extensively tested by comparing the fitting coefficients generated by the SARA-C procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

<u>Interpolation of 2D area scan</u>

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.

<u>Extrapolation of 3D scan</u>

For the 3D scan, data are collected on a spatially regular, but conformal, 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). SARA-C enables full control over the selection of alternative step sizes in all directions.

The overall accuracy of the 1g and 10g SAR volume average depends largely on the accuracy with which the probe can be re-positioned in the head. Although the digitised shape of the head is available to the SARA-C software, a better positioning solution is to use strain gauges attached to the L-probe to feel for the actual surface and to base all movements relative to this positive detection. An even more precise, but time-consuming, method is to place the probe tip in positive contact against the phantom wall, then step backwards 0.01mm at a time while monitoring the recorded SAR reading. At the exact moment that the probe detaches from contact, the SAR reading will suddenly fall.

After the data collection, the data are extrapolated up to the shell wall in the depth direction to assign values to points in the 3D array which cannot be measured in practice because of the finite size of the sensor tip. For automated measurements inside the head, the distance of the closest plane from the wall cannot be less than 2.7mm (for 5mm probes) and 1.39mm (for 2.5mm probes), this being the distance of the probe sensors behind the front edge of the probe tip.

Interpolation of 3D scan and volume averaging

The procedure used in SARA-C for defining the volumes used in SAR averaging 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 62209-1: 2006). This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated to the phantom wall, 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, one for 1g and the other for 10g masses, 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.

The default step size 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 EN 62209-1: 2006) is +/- 0.04mm.

Product Service

2.1.4 Head Test Positions

This recommended practice specifies exactly two test positions for the handset against the head phantom, the "Cheek" position and the "tilted" position. The handset should be tested in both positions on the left and right sides of the SAM phantom. In each test position the centre of the earpiece of the device is placed directly at the entrance of the auditory canal. The angles mentioned in the test positions used are referenced to the line connecting both auditory canal openings. The plane this line is on is known as the reference plane. Testing is performed on the right and left-hand sides of the generic phantom head.

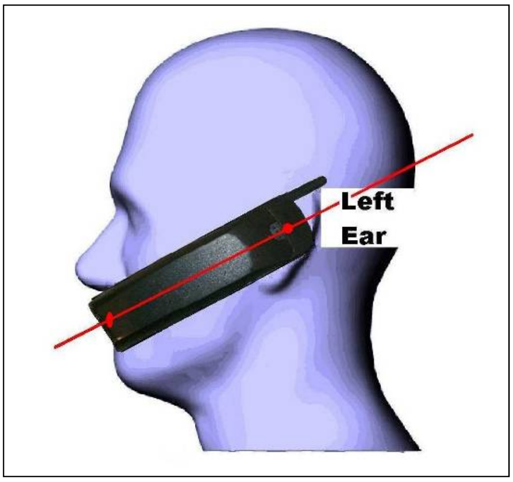

Figure 3 Side view of mobile next to head showing alignment

<u>The Cheek Position</u>
The Cheek Position is where the mobile is in the reference plane and the line between the mobile and the line connecting both auditory canal openings is reduced until any part of the mobile touches any part of the generic twin phantom head.

<u>The 15° Position</u>
The 15° Position is where the mobile is in the reference Cheek position and the phone is kept in contact with the auditory canal at the earpiece; the bottom of the phone is then tilted away from the phantom mouth by 15°.

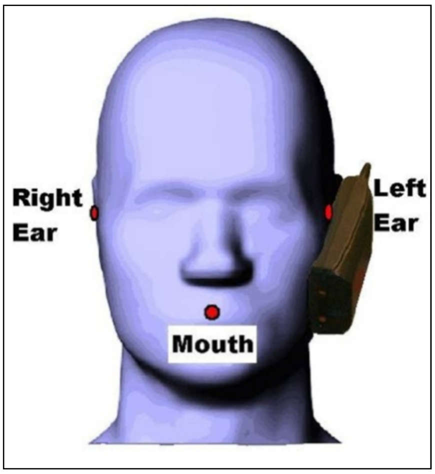

Figure 4 Cheek position

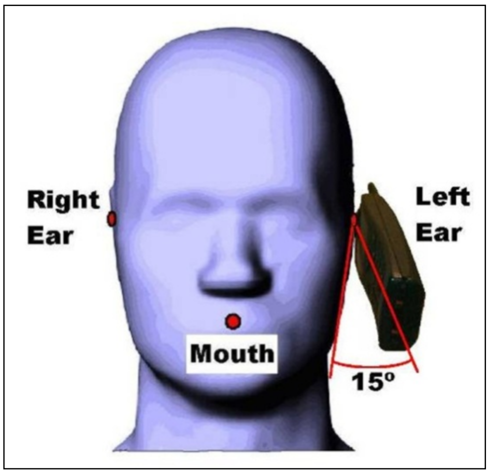

Figure 5 15º Tilt Position

Product Service

2.2 CDMA2000 800MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-07:55:23	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	58.20mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-120.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	19.289
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.358 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.240 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.358 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.362 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	1.100 %

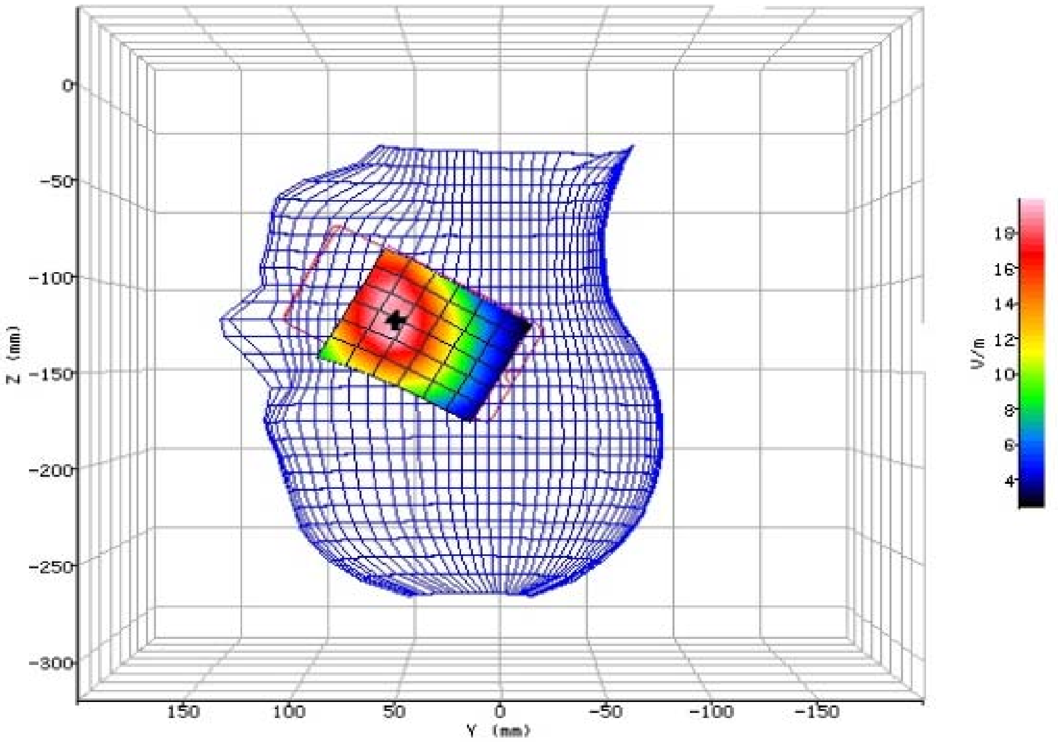

Figure 8: SAR Head Testing Results for the Sharp CDMA SHI16 at 848.31MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-08:13:52	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	48.50mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-128.30mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	15.896
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.242 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.182 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.240 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.246 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	2.500 %

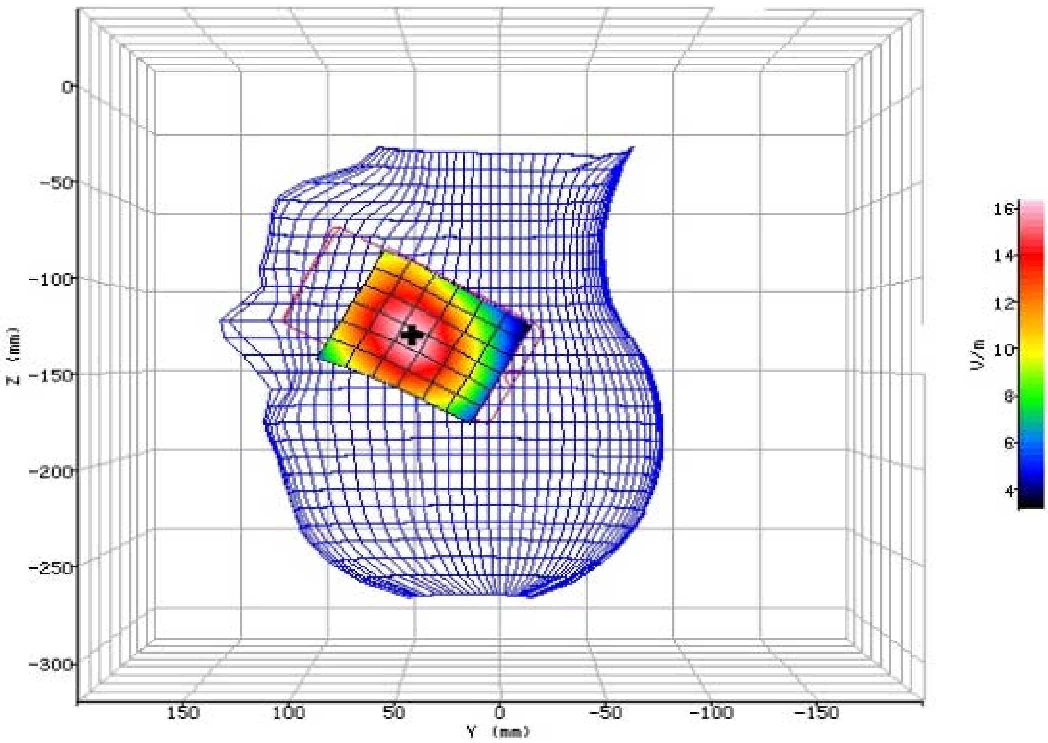

Figure 9: SAR Head Testing Results for the Sharp CDMA SHI16 at 848.31MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-08:51:06	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	57.50mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-111.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.710
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.446 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.320 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.455 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.428 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-5.900 %

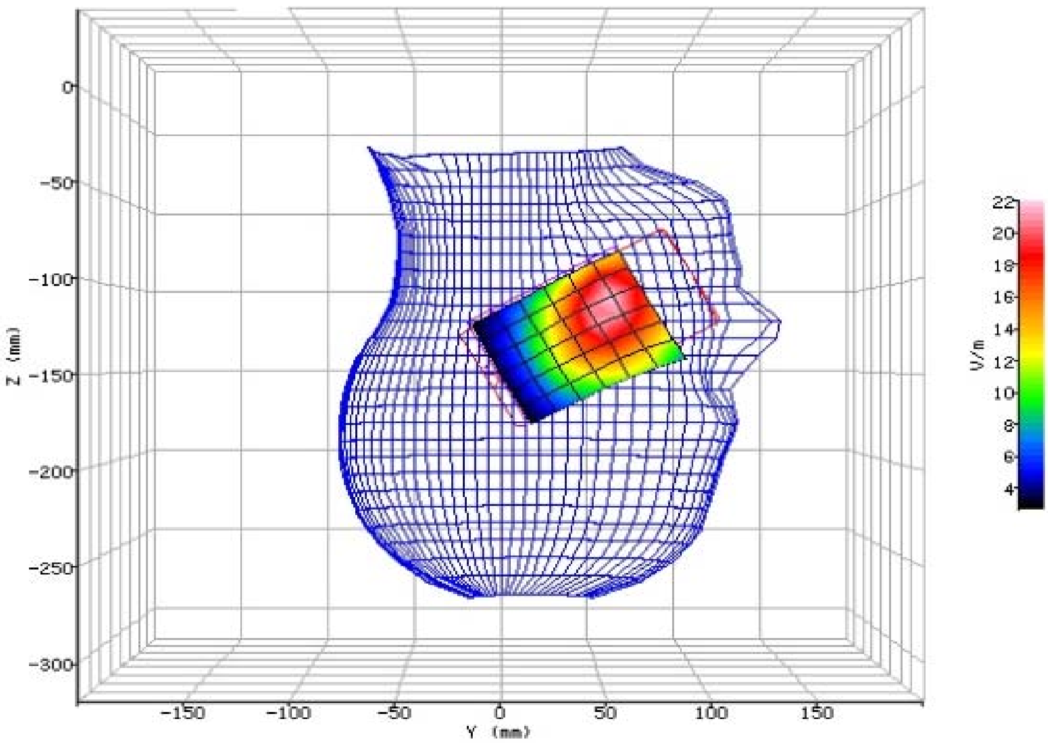

Figure 10: SAR Head Testing Results for the Sharp CDMA SHI16 at 848.31MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-09:09:56	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	47.00mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-120.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	16.663
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.274 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.202 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.285 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.272 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-4.600 %

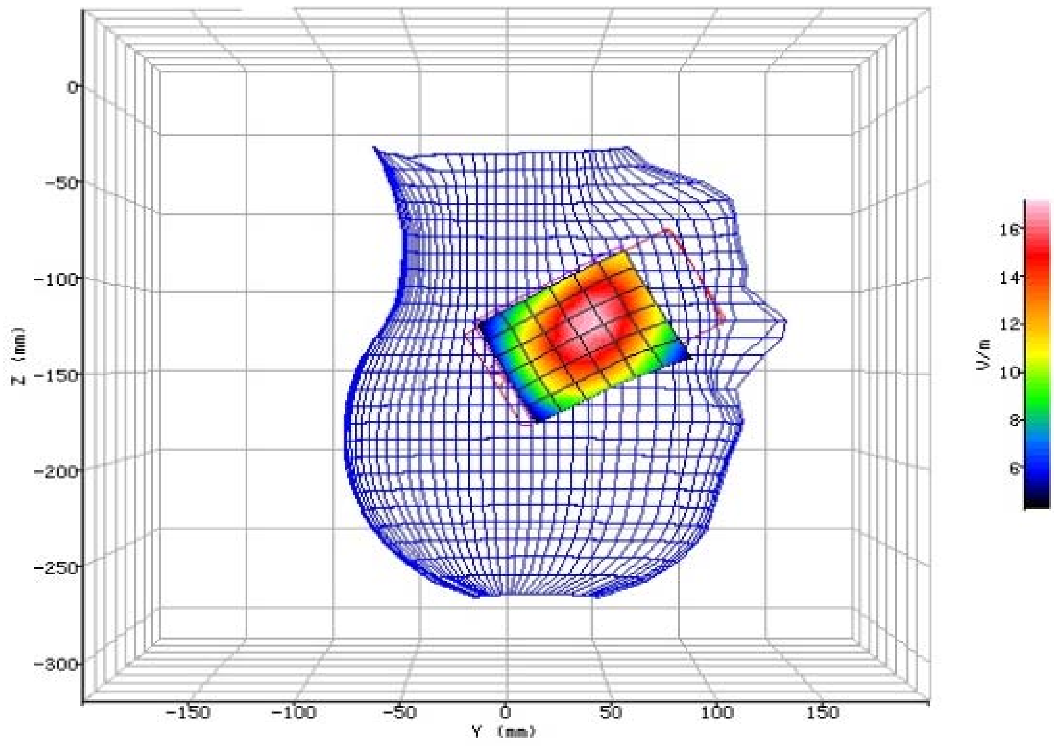

Figure 11: SAR Head Testing Results for the SHI16 Mobile Handset at 848.31MHz.

2.3 CDMA2000 800MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-13:28:05	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	835Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	57.02
RELATIVE HUMIDITY:	46.40%	CONDUCTIVITY:	1.000
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.50°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	42.60mm
DUT POSITION:	15mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-12.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	16.307
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.215 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.151 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.269 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.281 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	4.700 %

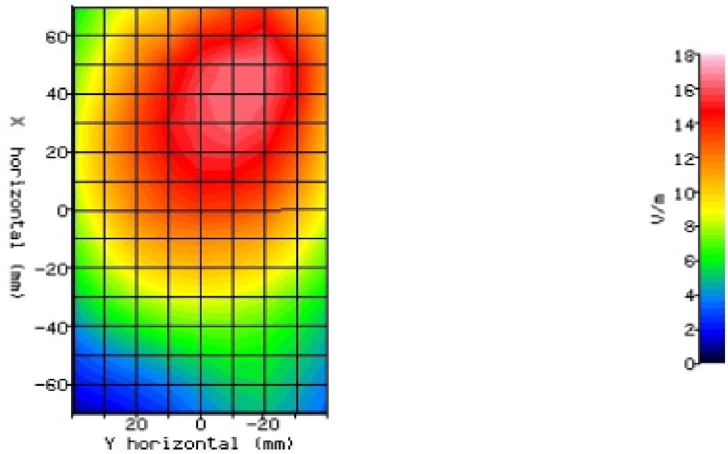

Figure 12: SAR Body Testing Results for the Sharp CDMA SHI16 at 848.31MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-13:43:04	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	835Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	57.02
RELATIVE HUMIDITY:	46.40%	CONDUCTIVITY:	1.000
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.50°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	35.80mm
DUT POSITION:	15mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	2.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.263
TEST FREQUENCY:	848.31MHz	SAR 1g:	0.327 W/kg
TYPE OF MODULATION:	46-RAY Orthogonal	SAR 10g:	0.226 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.430 W/kg
INPUT POWER LEVEL:	23dBm	SAR END:	0.427 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-0.800 %

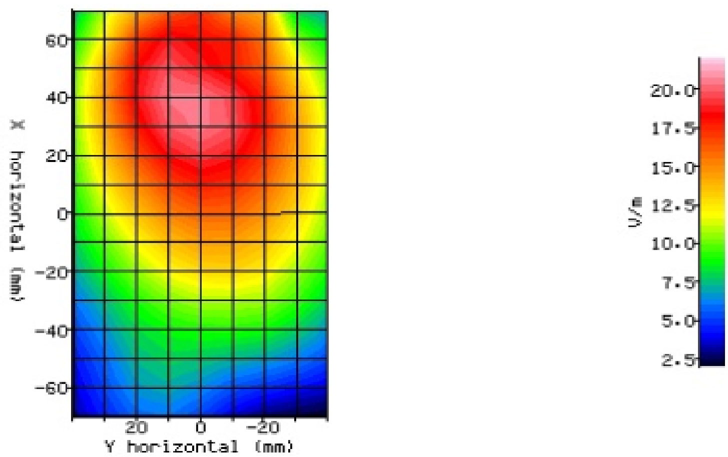

Figure 13: SAR Body Testing Results for the Sharp CDMA SHI16 at 848.31MHz.

Product Service

2.4 WCDMA FDDV HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-10:34:20	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	59.00mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-118.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.510
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.270 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.199 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.303 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.299 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-1.300 %

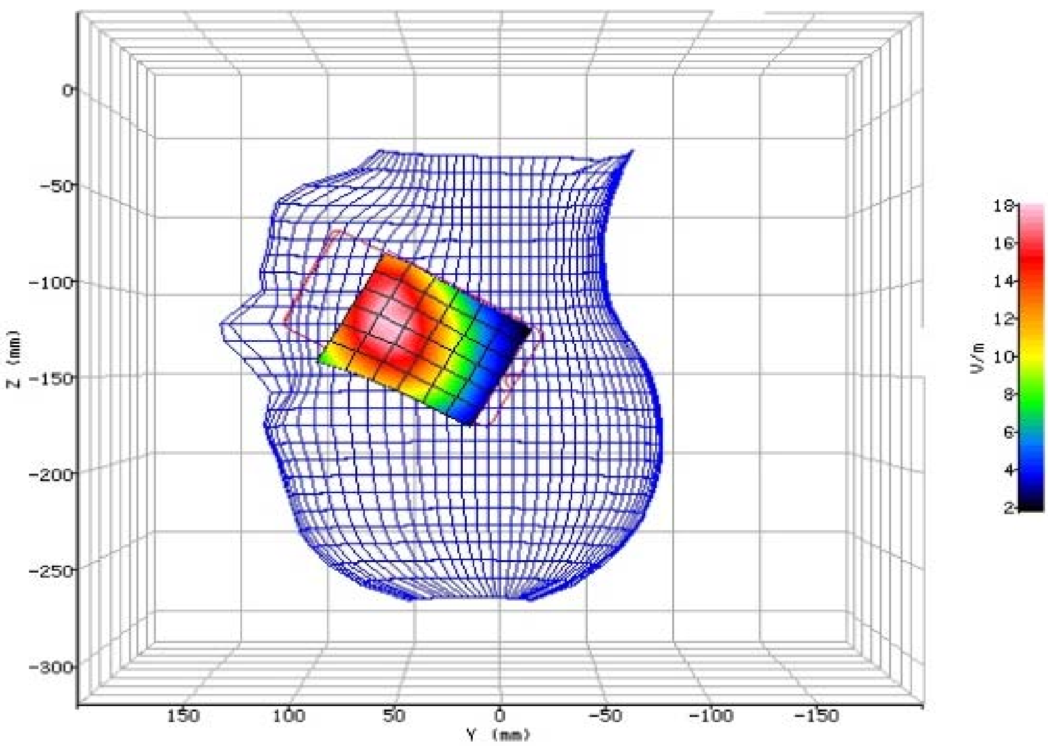

Figure 14: SAR Head Testing Results for the Sharp CDMA SHI16 at 846.4MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-10:59:11	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	48.00mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-131.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	13.492
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.174 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.129 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.177 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.177 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	0.000 %

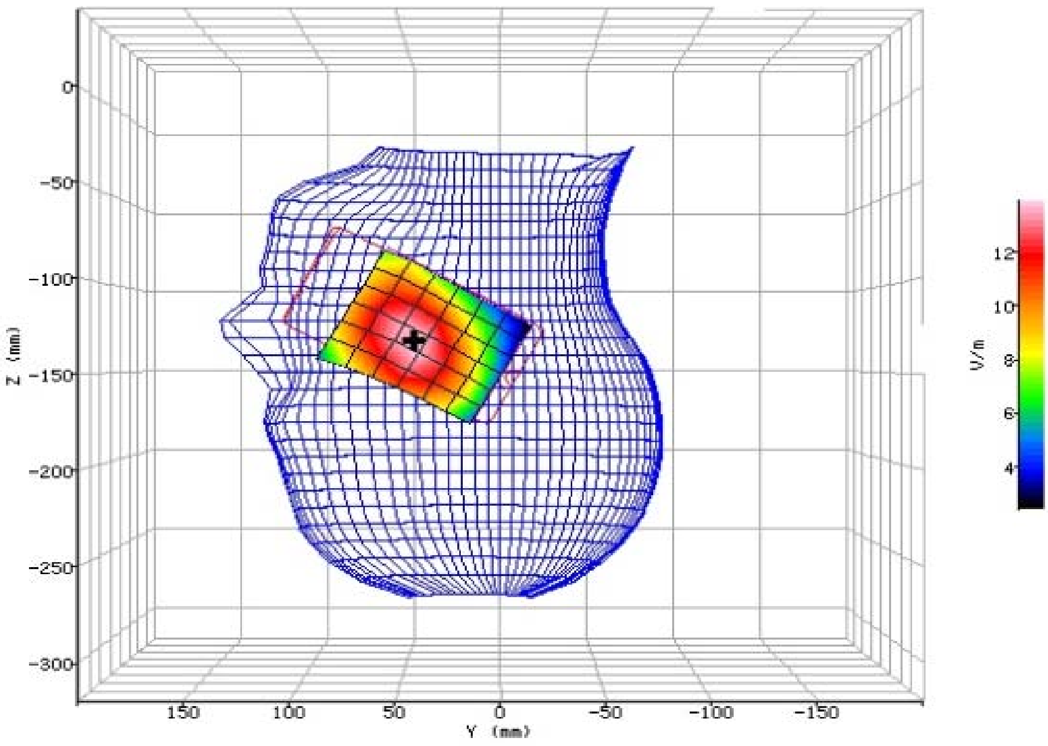

Figure 15: SAR Head Testing Results for the Sharp CDMA SHI16 at 846.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-09:43:08	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	57.80mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-108.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	18.009
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.325 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.233 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.333 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.323 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-3.000 %

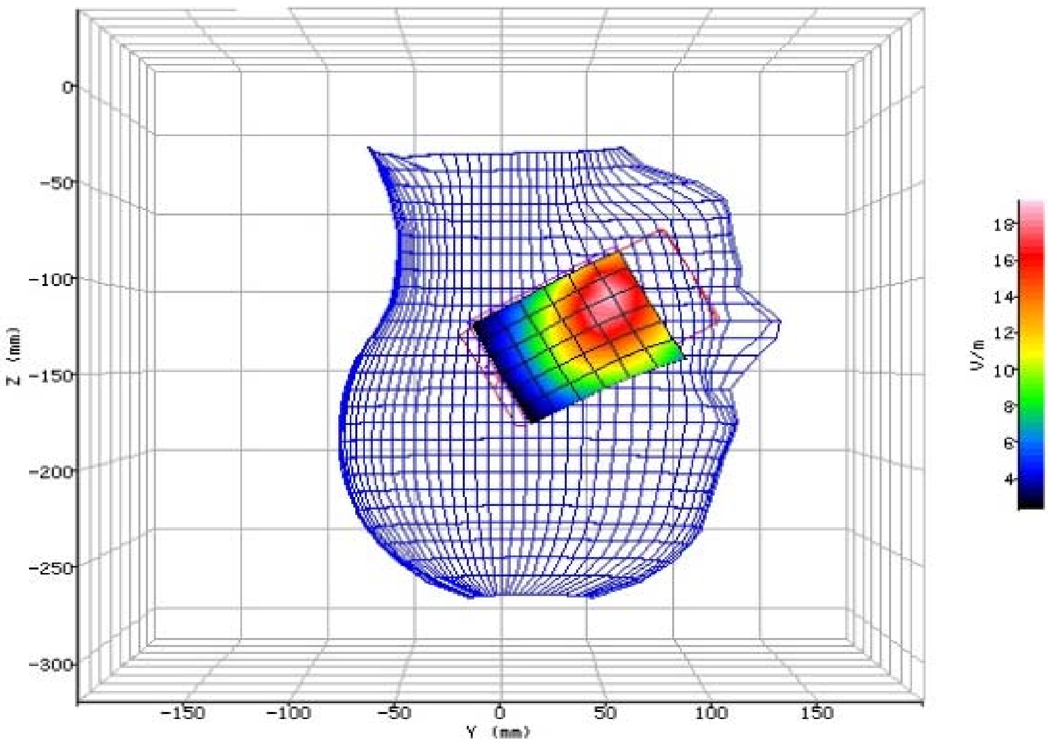

Figure 16: SAR Head Testing Results for the SHI16 Mobile Handset at 846.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-10:03:35	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	23.80°C	LIQUID SIMULANT:	835Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	43.39
RELATIVE HUMIDITY:	47.60%	CONDUCTIVITY:	0.922
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	23.40°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	43.00mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-122.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	13.565
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.179 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.132 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.183 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.182 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-0.500 %

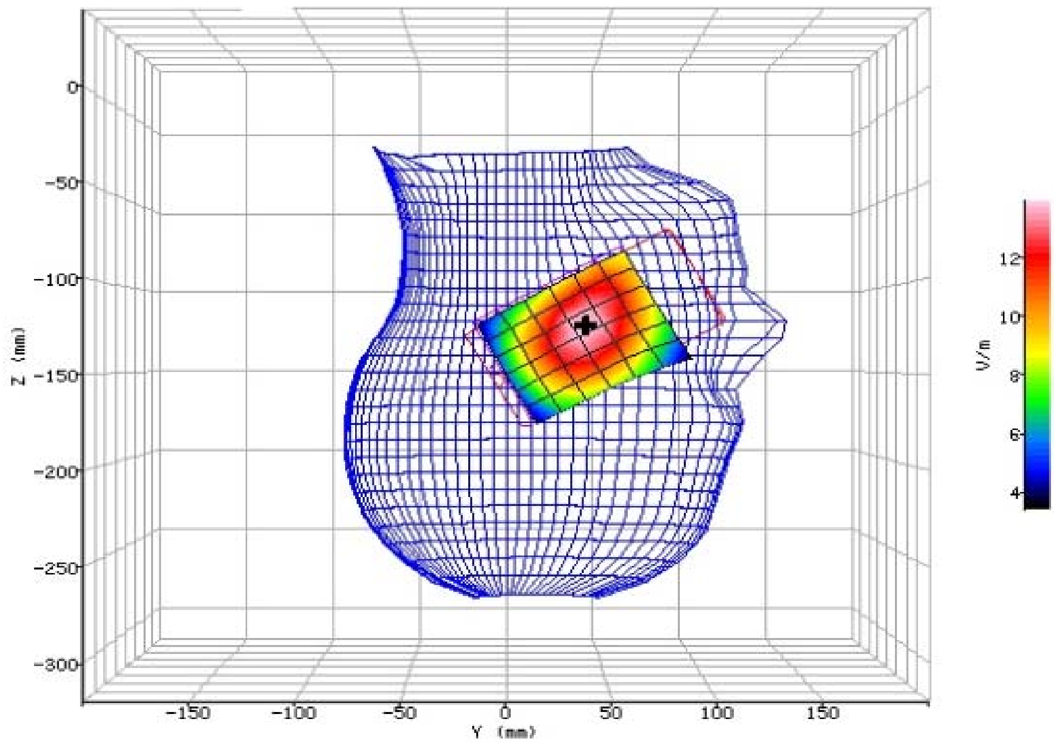

Figure 17: SAR Head Testing Results for the Sharp CDMA SHI16 at 846.4MHz.

Product Service

2.5 WCDMA FDDV BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-12:21:08	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	835Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	57.02
RELATIVE HUMIDITY:	46.40%	CONDUCTIVITY:	1.000
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.50°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	30.00mm
DUT POSITION:	15mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-15.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	13.740
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.150 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.106 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.192 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.190 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-0.800 %

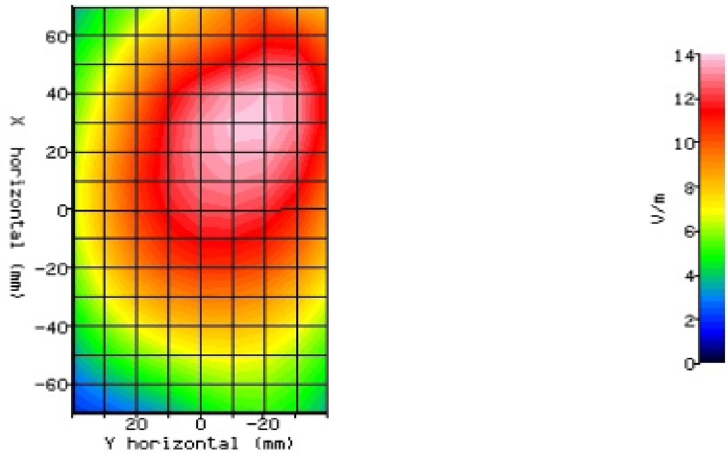

Figure 18: SAR Body Testing Results for the Sharp CDMA SHI16 at 846.4MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	23/05/2012-12:40:57	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	835Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	57.02
RELATIVE HUMIDITY:	46.40%	CONDUCTIVITY:	1.000
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.50°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	36.60mm
DUT POSITION:	15mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	4.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	16.788
TEST FREQUENCY:	846.4MHz	SAR 1g:	0.224 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	0.156 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.291 W/kg
INPUT POWER LEVEL:	24dBm	SAR END:	0.291 W/kg
PROBE BATTERY LAST CHANGED:	23/05/2012	SAR DRIFT DURING SCAN:	-0.100 %

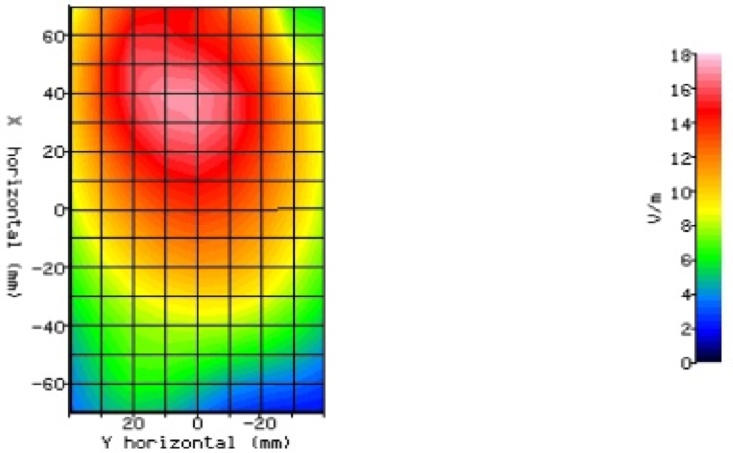

Figure 19: SAR Body Testing Results for the Sharp CDMA SHI16 at 846.4MHz.

Product Service

2.6 PCS 1900MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-07:33:04	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	22.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	40.31
RELATIVE HUMIDITY:	55.80%	CONDUCTIVITY:	1.430
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.20°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	61.60mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-97.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	12.934
TEST FREQUENCY:	1850.2MHz	SAR 1g:	0.172 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	0.107 W/kg
MODN. DUTY CYCLE:	12.5%	SAR START:	0.178 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.176 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-1.100 %

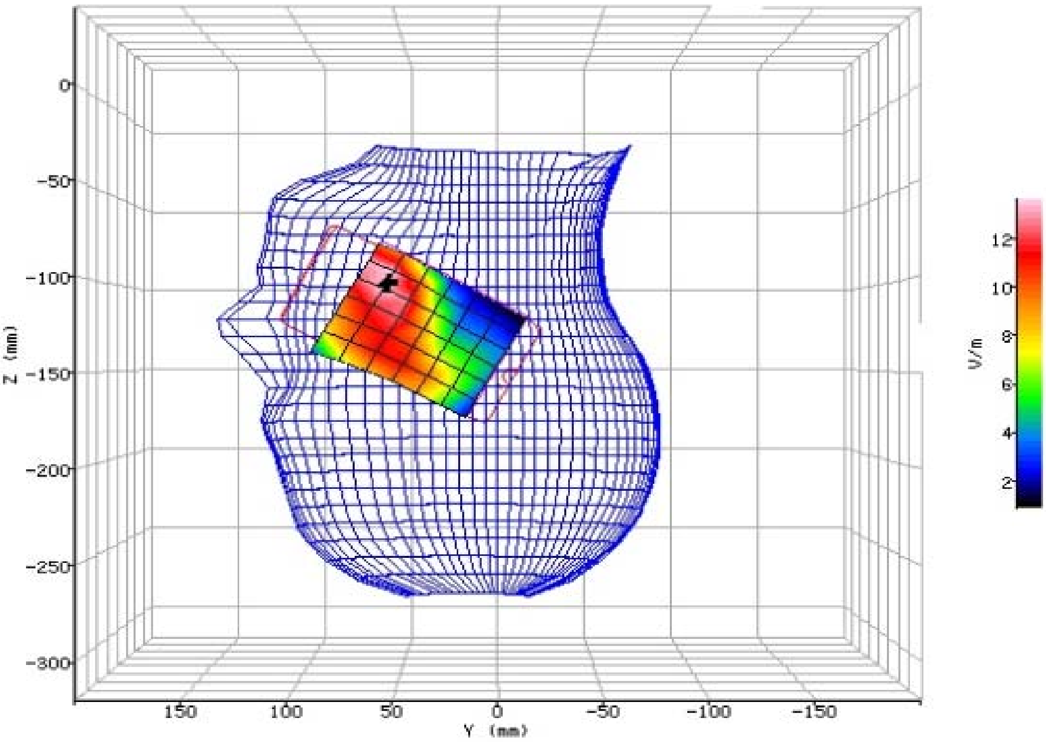

Figure 20: SAR Head Testing Results for the Sharp CDMA SHI16 at 1850.2MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-07:53:35	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	22.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	40.31
RELATIVE HUMIDITY:	55.80%	CONDUCTIVITY:	1.430
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.20°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	61.60mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-153.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	8.313
TEST FREQUENCY:	1850.2MHz	SAR 1g:	0.072 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	0.044 W/kg
MODN. DUTY CYCLE:	12.5%	SAR START:	0.074 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.074 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	0.000 %

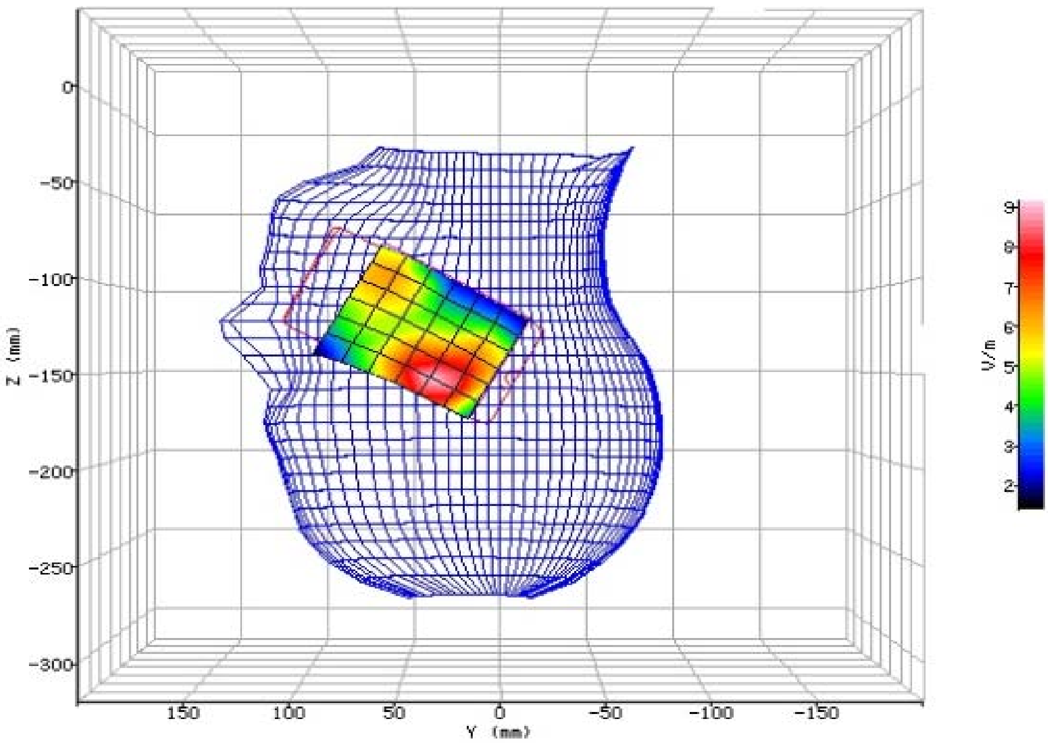

Figure 21: SAR Head Testing Results for the Sharp CDMA SHI16 at 1850.2MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-08:33:06	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	22.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	40.31
RELATIVE HUMIDITY:	55.80%	CONDUCTIVITY:	1.430
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.20°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	58.80mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-104.30mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	12.490
TEST FREQUENCY:	1850.2MHz	SAR 1g:	0.137 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	0.084 W/kg
MODN. DUTY CYCLE:	12.5%	SAR START:	0.187 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.184 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-1.600 %

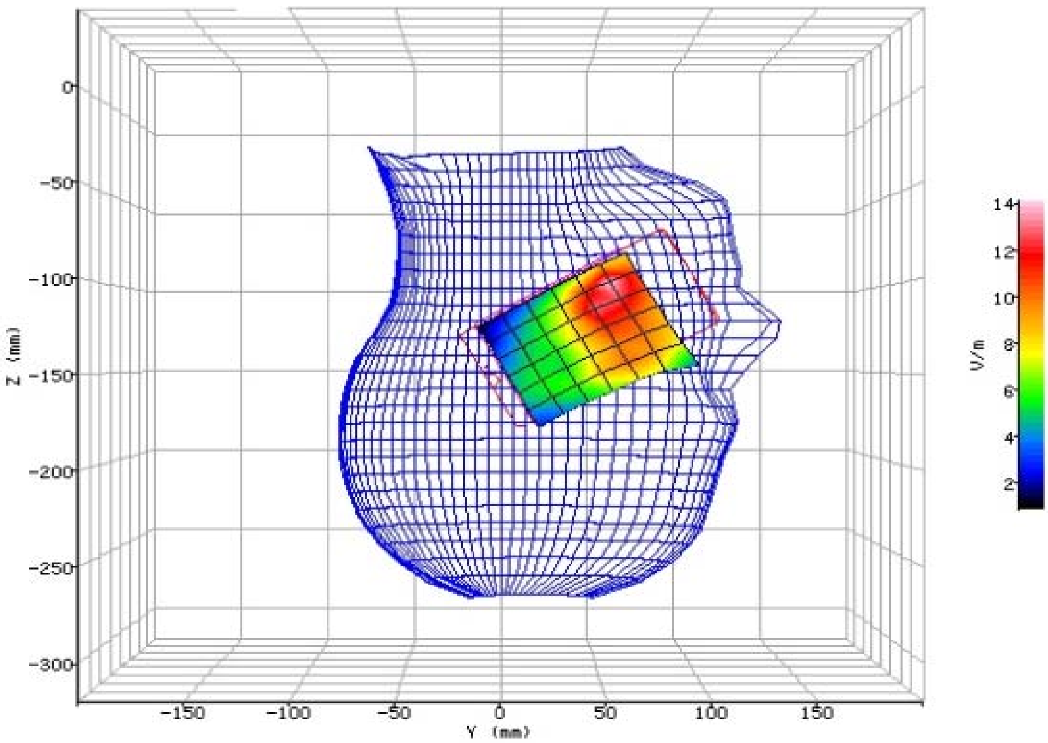

Figure 22: SAR Head Testing Results for the Sharp CDMA SHI16 at 1850.2MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-08:56:38	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	22.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	40.31
RELATIVE HUMIDITY:	55.80%	CONDUCTIVITY:	1.430
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.20°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	18.10mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-134.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	6.869
TEST FREQUENCY:	1850.2MHz	SAR 1g:	0.048 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	0.056 W/kg
MODN. DUTY CYCLE:	12.5%	SAR START:	0.050 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.050 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	0.000 %

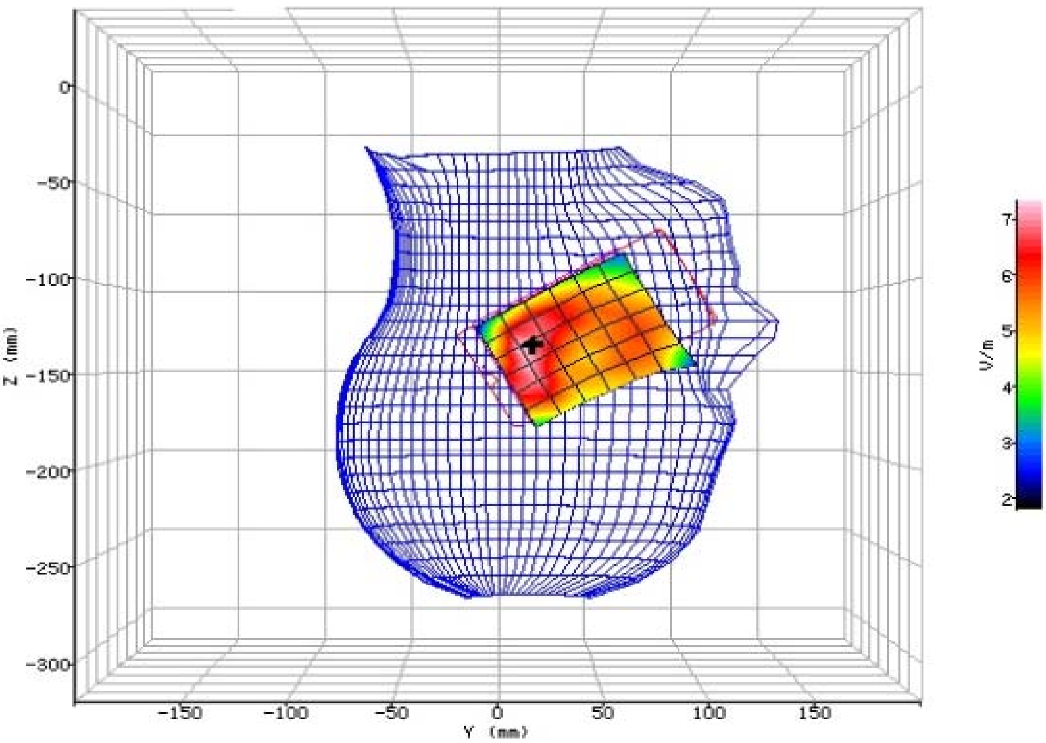

Figure 23: SAR Head Testing Results for the Sharp CDMA SHI16 at 1850.2MHz.

2.7 PCS 1900MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-11:05:07	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	53.94
RELATIVE HUMIDITY:	55.30%	CONDUCTIVITY:	1.580
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	49.80mm
DUT POSITION:	15mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-15.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	16.314
TEST FREQUENCY:	1880MHz	SAR 1g:	0.315 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	0.202 W/kg
MODN. DUTY CYCLE:	25%	SAR START:	0.431 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.409 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-5.100 %

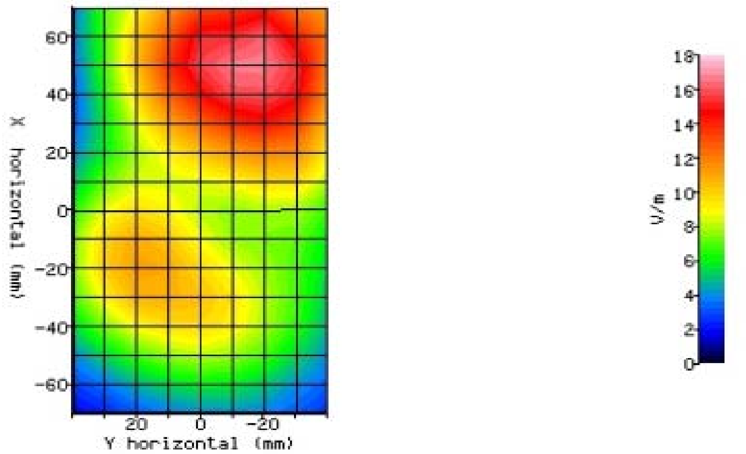

Figure 24: SAR Body Testing Results for the Sharp CDMA SHI16 at 1880MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-11:22:16	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	53.94
RELATIVE HUMIDITY:	55.30%	CONDUCTIVITY:	1.580
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	43.80mm
DUT POSITION:	15mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	4.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	15.090
TEST FREQUENCY:	1880MHz	SAR 1g:	0.273 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	0.174 W/kg
MODN. DUTY CYCLE:	25%	SAR START:	0.375 W/kg
INPUT POWER LEVEL:	30dBm	SAR END:	0.373 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-0.700 %

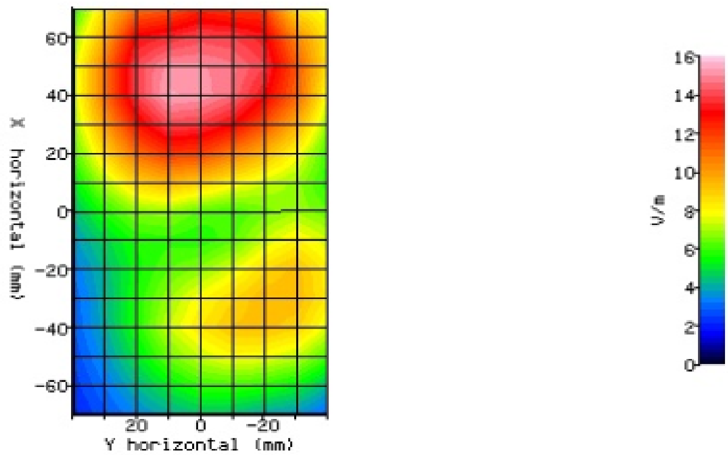

Figure 25: SAR Body Testing Results for the Sharp CDMA SHI16 at 1880MHz.

Product Service

2.8 WLAN 2450MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-15:43:05	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	37.30
RELATIVE HUMIDITY:	54.30%	CONDUCTIVITY:	1.739
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	18.80mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-146.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	12.094
TEST FREQUENCY:	2437MHz	SAR 1g:	0.330 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.179 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.300 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.291 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-3.000 %

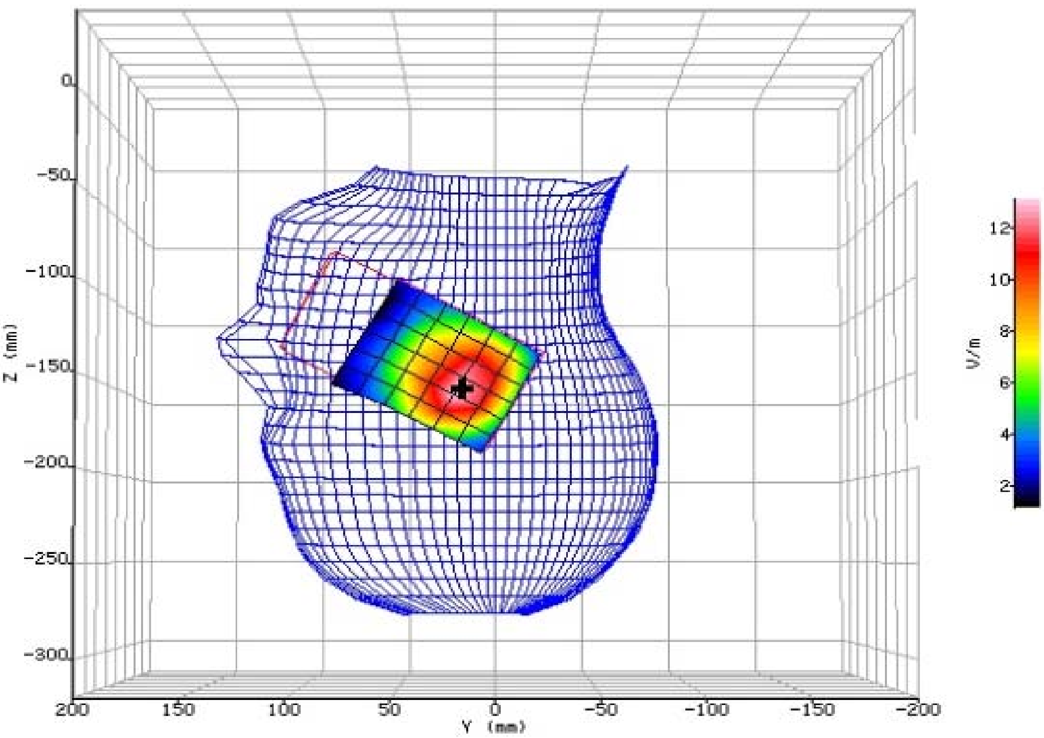

Figure 26: SAR Head Testing Results for the Sharp CDMA SHI16 at 2437MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-16:01:04	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	37.30
RELATIVE HUMIDITY:	54.30%	CONDUCTIVITY:	1.739
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	17.00mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-154.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.546
TEST FREQUENCY:	2437MHz	SAR 1g:	0.294 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.149 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.263 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.267 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	1.500 %

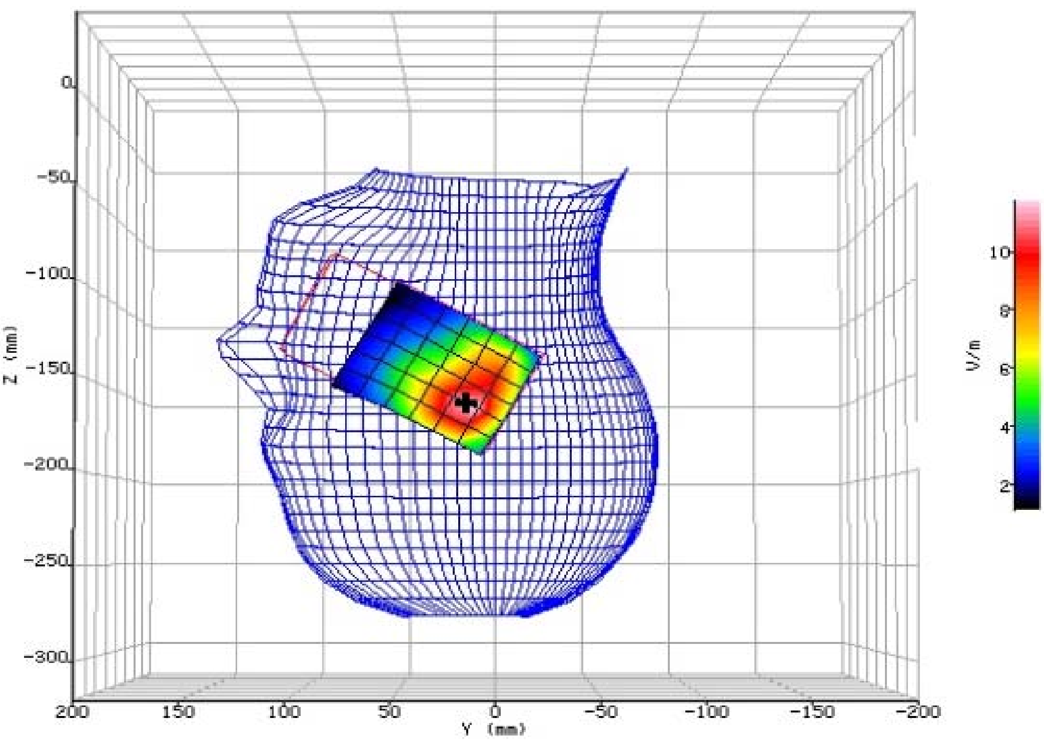

Figure 27: SAR Head Testing Results for the Sharp CDMA SHI16 at 2437MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-16:33:12	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	37.30
RELATIVE HUMIDITY:	54.30%	CONDUCTIVITY:	1.739
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	25.90mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-163.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.408
TEST FREQUENCY:	2437MHz	SAR 1g:	0.521 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.254 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.721 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.720 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-0.100 %

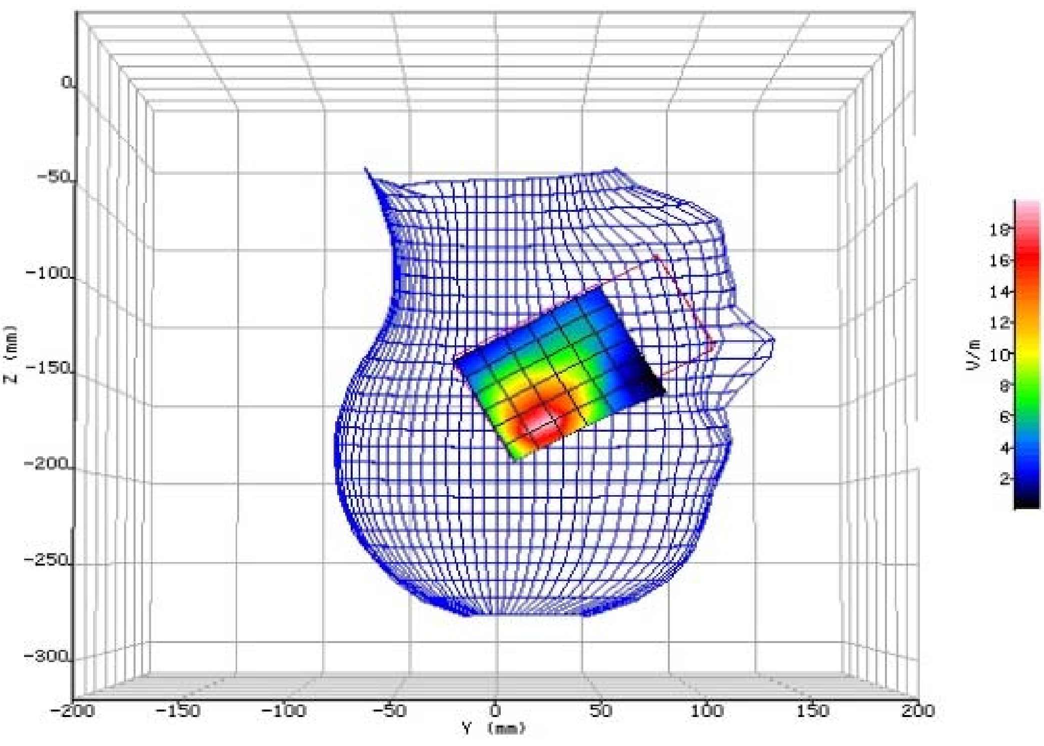

Figure 28: SAR Head Testing Results for the Sharp CDMA SHI16 at 2437MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-16:53:15	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Head
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	37.30
RELATIVE HUMIDITY:	54.30%	CONDUCTIVITY:	1.739
PHANTOM S/NO:	IBX-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	22.90mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-166.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	13.979
TEST FREQUENCY:	2437MHz	SAR 1g:	0.356 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.174 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.491 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.492 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	0.200 %

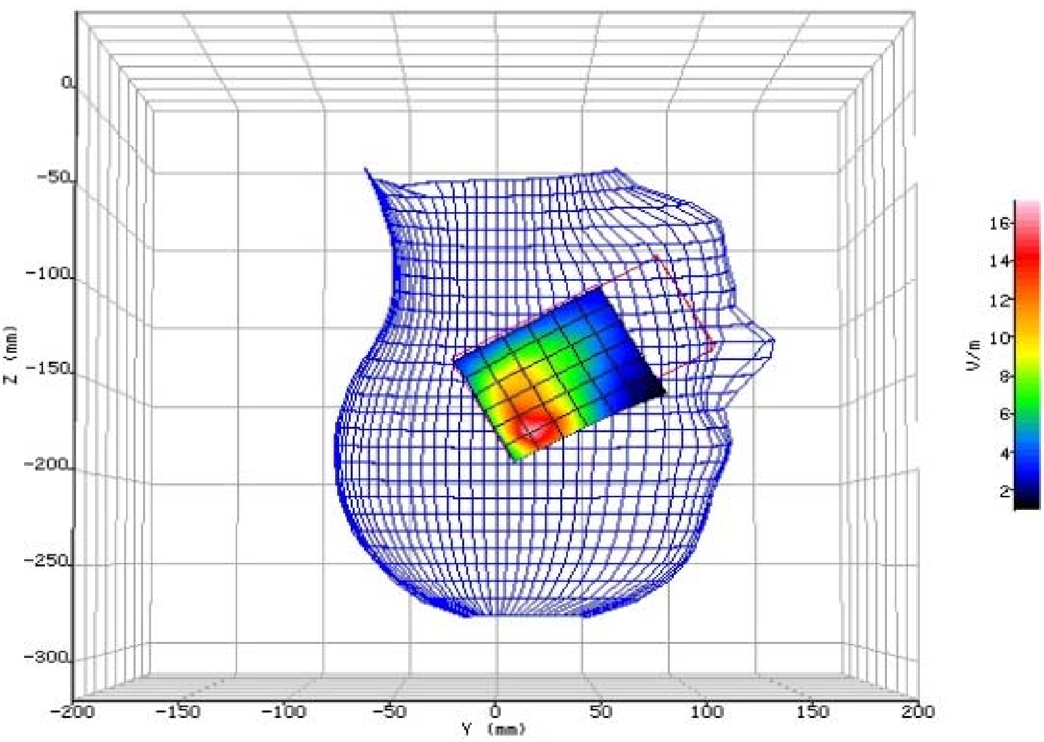

Figure 29: SAR Head Testing Results for the Sharp CDMA SHI16 at 2437MHz.

Product Service

2.9 WLAN 2450MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-17:17:28	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	52.17
RELATIVE HUMIDITY:	48.30%	CONDUCTIVITY:	1.948
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-39.20mm
DUT POSITION:	15mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-28.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.87
TEST FREQUENCY:	2437MHz	SAR 1g:	0.055 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.029 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.081 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.083 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	2.100 %

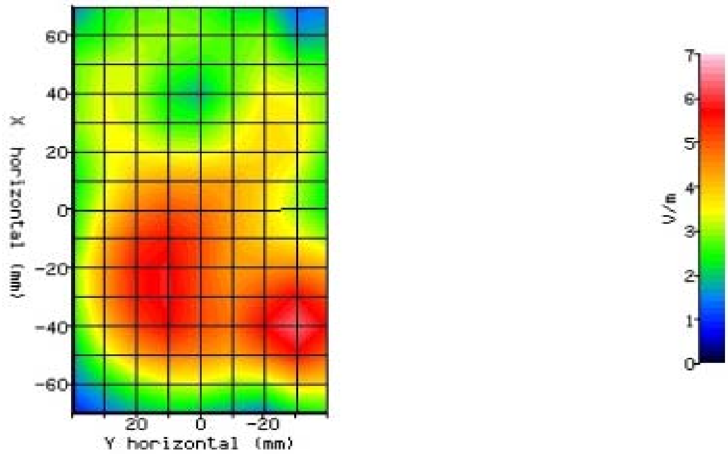

Figure 30: SAR Body Testing Results for the Sharp CDMA SHI16 at 2437MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.07.10	INPUT POWER DRIFT:	0 dB
DATE / TIME:	24/05/2012-17:34:04	DUT BATTERY MODEL/NO:	SHI16UAA
AMBIENT TEMPERATURE:	24.00°C	LIQUID SIMULANT:	2450Body
DEVICE UNDER TEST:	CDMA SHI16	RELATIVE PERMITTIVITY:	52.17
RELATIVE HUMIDITY:	48.30%	CONDUCTIVITY:	1.948
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-42.60mm
DUT POSITION:	15mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	25.30mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.38
TEST FREQUENCY:	2437MHz	SAR 1g:	0.047 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	0.023 W/kg
MODN. DUTY CYCLE:	100%	SAR START:	0.073 W/kg
INPUT POWER LEVEL:	20dBm	SAR END:	0.069 W/kg
PROBE BATTERY LAST CHANGED:	24/05/2012	SAR DRIFT DURING SCAN:	-4.600 %

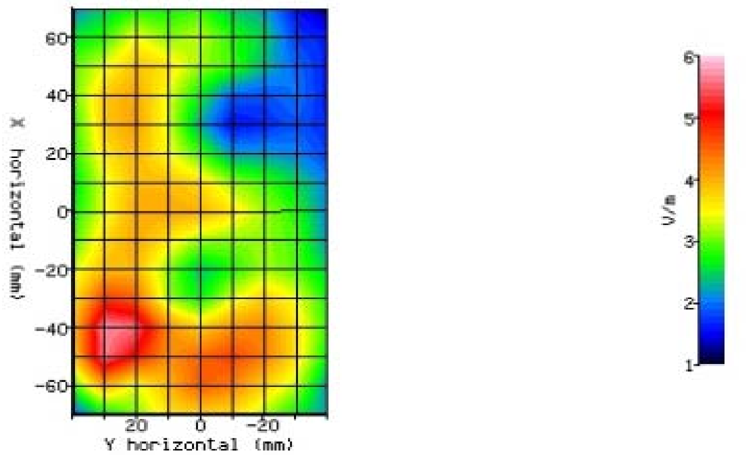

Figure 31: SAR Body Testing Results for the Sharp CDMA SHI16 at 2437MHz.

Product Service

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

The following test equipment was used at TÜV SÜD Product Service Ltd:

Instrument Description	Manufacturer	Model Type	TE Number	Cal Period (months)	Calibration Due Date
Signal Generator	Hewlett Packard	ESG4000A	38	12	23-May-13*
Power Sensor	Rohde & Schwarz	NRV-Z1	60	12	06-Jun-12
Communications Tester	Rohde & Schwarz	CMU 200	442	12	13-Oct-12
Attenuator (20dB, 10W)	Weinschel	37-20-34	482	12	11-Oct-12
Fast Probe Amplifier (3 channels)	IndexSar Ltd	IFA-010	1558	-	TU
Bi-directional Coupler	IndexSar Ltd	7401 (VDC0830-20)	2414	-	TU
Validation Amplifier (10MHz - 2.5GHz)	IndexSar Ltd	VBM2500-3	2415	-	TU
Power Sensor	Rohde & Schwarz	NRV- Z5	2878	12	06-Jun-12
Antenna (Omnidirectional)	Katherin Scala Division	OG-890/1990/DC	2905	-	TU
Dual Channel Power Meter	Rohde & Schwarz	NRVD	3259	12	06-Jun-12
Flat Phantom	IndexSar Ltd	IXB-2HF 800-6000MHz	4074	-	TU
Head Phantom	IndexSar Ltd	IXB-040 Inverted SAM phantom	4075	-	TU
Immersible SAR Probe	IndexSar Ltd	IPX-020	4077	24	17-May-13
Immersible SAR Probe	IndexSar Ltd	IPX-050	1555	24	28-Feb-14
Part of SARAC System	IndexSar Ltd	Cartesian Leg Extension	4078	-	TU
Cartesian 4-axis Robot	IndexSar Ltd	SARAC	4079	-	TU
Part of SARAC System	IndexSar Ltd	White Benchtop	4080	-	TU
Part of SARAC System	IndexSar Ltd	Wooden Bench	4081	-	TU
Signal Generator: 10MHz to 20GHz	Rohde & Schwarz	SMR20	3475	12	20-Dec-12
850MHz Fluid	TUV SUD Product Service	Batch 19	N/A	1	01-Jun-12
1800MHz Fluid	TUV SUD Product Service	Batch 13	N/A	1	01-Jun-12
1900MHz Fluid	TUV SUD Product Service	Batch 7	N/A	1	01-Jun-12
2450MHz Fluid	TUV SUD Product Service	Batch 9	N/A	1	01-Jun-12

TU – Traceability Unscheduled

Product Service

3.2 TEST SOFTWARE

The following software was used to control the TÜV SÜD Product Service Ltd SARA-C System.

Instrument	Version Number	Date
SARA-C system	v.6.07.10	28 February 2010
IFA-10 Probe amplifier	Version 2	-

Product Service

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 OET 65(C) – 2001.

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-Pro-panediol						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])

The dielectric properties of the tissue simulant liquids used for the SAR testing at TÜV SÜD 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
850 MHz Head	41.5	43.39	0.90	0.922
850 MHz Body	55.0	57.02	0.97	1.000
1900 MHz Head	40.0	40.31	1.40	1.430
1900 MHz Body	53.3	53.94	1.52	1.580
2450 MHz Head	39.2	37.30	1.8	1.739
2450 MHz Body	52.7	52.17	1.95	1.948

3.4 TEST CONDITIONS

3.4.1 Test Laboratory Conditions

Ambient temperature: Within +15°C to +35°C.
The actual temperature during the testing ranged from 22°C to 24°C.
The actual humidity during the testing ranged from 46.4% to 55.8% RH.

3.4.2 Test Fluid Temperature Range

Frequency	Body / Head Fluid	Min Temperature °C	Max Temperature °C
800 MHz	Head	23.4	23.4
800 MHz	Body	23.5	23.5
1900 MHz	Head	22.2	22.2
1900 MHz	Body	22.8	22.8
2450 MHz	Head	22.8	22.8
2450 MHz	Body	22.8	22.8

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 -5.9% (1.063 dB) for all of the testing. The measurement uncertainty budget for this assessment includes the maximum SAR Drift figures for Head and/or Body as applicable.

Product Service

3.5 MEASUREMENT UNCERTAINTY

Head SAR Measurements.

Source of Uncertainty	IEEE P1528 Description	Tolerance / Uncertainty ± %	Probability distribution	Div	c_i (1g)	c_i (10g)	Standard Uncertainty ± % (1g)	Standard Uncertainty ± % (10g)	v_i or v_{eff}
Measurement System									
Probe calibration	E.2.1	6.20	N	1	1	1	6.20	6.20	∞
Axial Isotropy	E.2.2	3.50	R	1.73	0.71	0.7071	1.43	1.43	∞
Hemispherical Isotropy	E.2.2	9.60	R	1.73	0.71	0.7071	3.92	3.92	∞
Boundary effect	E.2.3	0.49	R	1.73	1	1	0.28	0.28	∞
Linearity	E.2.4	1.60	R	1.73	1	1	0.92	0.92	∞
Detection limits	E.2.4	4.75	R	1.73	1	1	2.74	2.74	∞
Modulation response	E.2.5	1.20	R	1.73	1	1	0.69	0.69	∞
Readout electronics	E.2.6	0.05	N	1	1	1	0.05	0.05	∞
Response time	E.2.7	0.00	R	1.73	1	1	0.00	0.00	∞
Integration time	E.2.8	1.50	N	1.00	1	1	1.50	1.50	∞
RF ambient conditions - noise	E.6.1	3.00	R	1.73	1	1	1.73	1.73	∞
RF ambient conditions - reflections	E.6.1	3.00	R	1.73	1	1	1.73	1.73	∞
Probe positioner mech. restrictions	E.6.2	1.50	R	1.73	1	1	0.87	0.87	∞
Probe positioning with respect to phantom shell	E.6.3	0.34	R	1.73	1	1	0.20	0.20	∞
Post-processing	E.5	2.00	R	1.73	1	1	1.15	1.15	∞
Test sample related									
Device holder uncertainty	E.4.1	5.1	N	1	0.77	1	3.90	5.10	9.00
Test sample positioning	E.4.2	2.4	N	1	0.96	1	2.30	2.40	9.00
Input Power and SAR Drift	E.2.9	4.7	R	1.73	1	1	2.71	2.71	∞
Phantom and set-up									
Phantom uncertainty (shape, thickness & permittivity tolerances)	E.3.1	2.00	R	1.73	1	1	1.15	1.15	∞
									∞
Uncertainty in SAR correction for deviations in permittivity and conductivity	E.3.2	1.20	N	1.00	1	0.808	1.20	0.97	∞
Liquid conductivity measurement	E.3.3	1.31	N	1	0.78	0.71	1.02	0.93	∞
Liquid permittivity measurement	E.3.3	1.27	N	1	0.23	0.26	0.29	0.33	∞
Liquid conductivity - temperature uncertainty	E.3.4	0.00	R	1.73	0.78	0.71	0.00	0.00	∞
Liquid permittivity - temperature uncertainty	E.3.4	0.00	R	1.73	0.23	0.26	0.00	0.00	∞
Combined standard uncertainty			RSS				10.34	10.84	
Expanded uncertainty (95% confidence interval)			K=2				20.68	21.68	

Product Service

Body SAR Measurements.

Source of Uncertainty	IEEE P1528 Description	Tolerance / Uncertainty ± %	Probability distribution	Div	c_i (1g)	c_i (10g)	Standard Uncertainty ± % (1g)	Standard Uncertainty ± % (10g)	v_i or v_{eff}
Measurement System									
Probe calibration	E.2.1	6.20	N	1	1	1	6.20	6.20	∞
Axial Isotropy	E.2.2	3.50	R	1.73	0.707	0.7071	1.43	1.43	∞
Hemispherical Isotropy	E.2.2	9.60	R	1.73	0.707	0.7071	3.92	3.92	∞
Boundary effect	E.2.3	0.49	R	1.73	1	1	0.28	0.28	∞
Linearity	E.2.4	1.60	R	1.73	1	1	0.92	0.92	∞
Detection limits	E.2.4	4.75	R	1.73	1	1	2.74	2.74	∞
Modulation response	E.2.5	1.20	R	1.73	1	1	0.69	0.69	∞
Readout electronics	E.2.6	0.05	N	1	1	1	0.05	0.05	∞
Response time	E.2.7	0.00	R	1.73	1	1	0.00	0.00	∞
Integration time	E.2.8	1.50	N	1.00	1	1	1.50	1.50	∞
RF ambient conditions - noise	E.6.1	3.00	R	1.73	1	1	1.73	1.73	∞
RF ambient conditions - reflections	E.6.1	3.00	R	1.73	1	1	1.73	1.73	∞
Probe positioner mech. restrictions	E.6.2	1.10	R	1.73	1	1	0.64	0.64	∞
Probe positioning with respect to phantom shell	E.6.3	4.00	R	1.73	1	1	2.31	2.31	∞
Post-processing	E.5	2.00	R	1.73	1	1	1.15	1.15	∞
Test sample related									
Device holder uncertainty	E.4.1	5.1	N	1	0.77	1	3.90	5.10	9
Test sample positioning	E.4.2	2.4	N	1	0.96	1	2.30	2.40	9
Input Power and SAR Drift	E.2.9	-5.9	R	1.73	1	1	-3.41	-3.41	∞
Phantom and set-up									
Phantom uncertainty (shape, thickness & permittivity tolerances)	E.3.1	2.00	R	1.73	1	1	1.15	1.15	∞
Uncertainty in SAR correction for deviations in permittivity and conductivity	E.3.2	1.20	N	1.00	1	0.808	1.20	0.97	∞
Liquid conductivity measurement	E.3.3	1.31	N	1	0.78	0.71	1.02	0.93	∞
Liquid permittivity measurement	E.3.3	1.27	N	1	0.23	0.26	0.29	0.33	∞
Liquid conductivity - temperature uncertainty	E.3.4	0.00	R	1.73	0.78	0.71	0.00	0.00	∞
Liquid permittivity - temperature uncertainty	E.3.4	0.00	R	1.73	0.23	0.26	0.00	0.00	∞
Combined standard uncertainty			RSS				10.78	11.26	
Expanded uncertainty (95% confidence interval)			K=2				21.55	22.51	

Product Service

SECTION 4

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

Product Service

4.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

UKAS
TESTING
0141

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 REPORT

NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

SAR PROBE

IndexSAR

Model: IXP-050

Serial number: 0170

FOR: Indexsar Ltd.
Oakfield House
Cudworth Lane
Newdigate
Surrey
RH5 5BG

DESCRIPTION: An IndexSAR isotropic electric field probe for determining specific absorption rates (SAR) in dielectric liquids. The probe has three orthogonal sensors, and the output voltage of the sensors is converted to an optical signal by a meter unit containing an analogue to digital (AD) converter. Probe readings are obtained using software via the RS232 port. The probe was calibrated with IndexSAR amplifier model IXA-010 S/N 036 belonging to NPL.

IDENTIFICATION: The probe is marked with the manufacturer's serial number 0170

MEASUREMENTS COMPLETED ON: 1 March 2012

The reported uncertainty is based on a coverage factor $k = 2$, providing a level of confidence of approximately 95%

Reference : 2012020074-1 **Page 1 of 7**

Date of Issue : 1 March 2012 **Signed :** B. Loader **(Authorised Signatory)**

Checked by : BGL **Name : Mr B G Loader** **on behalf of NPLML**

NPLC01-0601

MEASUREMENT PROCEDURE

For frequencies at or above 835 MHz, the calibration method is based on establishing a calculable specific absorption rate (SAR) using a matched waveguide cell [1]. The cell has a feed-section and a liquid-filled section separated by a matching window that is designed to minimise reflections at the interface. A TE_{01} mode is launched into the waveguide by means of a N-type-to-waveguide adapter. The power delivered to the liquid is calculated from the forward power and reflection coefficient measured at the input to the cell. At the centre of the cross-section of the waveguide cell, the volume specific absorption rate (SAR^V) in the liquid as a function of distance from the window is given by

$$SAR^V = \frac{4(P_w)}{ab\delta} e^{-2Z/\delta} \tag{1}$$

where

a = the larger cross-sectional dimension of the waveguide.
b = the smaller cross-sectional dimension of the waveguide.
δ = the skin depth for the liquid in the waveguide.
Z = the distance of the probe's sensors from the liquid to matching window boundary.
P_w = the power delivered to the liquid.

For frequencies below 835 MHz, the SAR in the liquid is established by measuring the rate of temperature rise in the liquid at the calibration point. In this case the SAR in the liquid is related to the temperature rise by

$$SAR = c\frac{dT}{dt} \tag{2}$$

where c is the specific heat of the liquid.

Liquids having the properties specified by SAR measurement standards [2, 3, 4] were used for the calibration. The value of δ for the liquid was obtained by measuring the electric field (E) at a number of distances from the matching window. The calibration was for continuous wave (CW) signals, 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 probe was rotated about its axis in 15-degree steps, and the ratio of the calibration factors for the three probe sensors X, Y, & Z were optimized to give the best axial isotropy.

The probe was calibrated with the linearisation and air-correction factors enabled. Comparing the measured values of E^2 in the liquid to those calculated for the waveguide cell allows the ratio, *ConvF*, of sensitivity for (E^2_{LIQUID}) / (E^2_{AIR}) to be determined, as required by the probe software.

The linear response of the probe to continuous wave signals was tested at 1800 MHz over the range 0.12 W/kg to 100 W/kg in accordance with [3].

The spherical isotropy of the probe was tested in head liquid at 900 MHz, in accordance with [3, 5, 6], for probe axial rotation (θ) through 360° and source polarisation (φ) rotation through 90 ° in 15° increments.

ENVIRONMENT

Measurements were made in a temperature-controlled laboratory at 22 ± 1°C. The temperature of the liquid used was measured at the beginning and end of each measurement.

UNCERTAINTIES

The estimated uncertainty in calibration for SAR (W kg^{-1}) is ± 10 %. The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%.

This uncertainty is valid when the probe is used in a liquid with the same dielectric properties as those used for the calibration. No estimate is made for the long-term stability of the device calibrated or of the fluids used in the calibration.

When using the probe for SAR testing, additional uncertainties should be added to account for the spherical isotropy of the probe, proximity effects, linearity, and response to pulsed fields. There will be additional uncertainty if the probe is used in liquids having significantly different electrical properties to those used for the calibration. The electrical properties of the liquids will be related to temperature.

RESULTS

Tables 1 and 2 give the results for calibration in liquid.

These calibration factors are only correct when the values for sensitivity in free-space, diode compression and sensor offset from the tip of the probe, as set in the probe software, are the same as those given in Table 1 and 2.

Table 3 contains the values of the boundary correction factors *f(0)* and *d*.

Table 4 gives the probe linearity and spherical isotropy.

REFERENCES:

[1] Pokovic, KT, T.Schmid and N.Kuster, "Robust set-up for Precise Calibration of E-field probes in Tissue Simulating Liquids at Mobile Phone Frequencies", Proceedings ICECOM 1997, pp 120 – 124, Dubrovnik, Croatia Oct 12-17, 1997.

[2] British Standard BS EN 503361:2001. "Basic standard for the measurement of specific absorption rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz)".

[3] IEEE Standard 1528-2003 "Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques".

[4] Federal Communications Commission, FCC OET Bulletin 65, Supplement C, June 2001, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", David L. Means, Kwok W. Chan.

[5] IEC Standard 62209-1 Ed 1. (2005), "Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices - Human models, Instrumentation, and Procedures – - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)".

[6] IEC Standard 62209-2 Ed 1. (2010), "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)".

Table 1
Sensitivity in Head Simulating Liquids.
SAR probe: IXP-050
S/N 0170

Probe settings for calibration		
Sensitivity in free-space[1]	**Diode Compression**[2]	**Sensor offset from tip of probe**[2]
Lin X =524.99 $(V/m)^2/(V*200)$ Lin Y = 453.82 $(V/m)^2/(V*200)$ Lin Z = 484.81 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z= 20 (V*200)	2.7 mm

Sensitivity in Head Simulating Liquid.

Calibration frequency	Liquid Phantom[3]		Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy
(MHz)	ε′ [3]	σ [3] (Sm^{-1})	$ConvF_X$	$ConvF_Y$	$ConvF_Z$	(dB)
450	41.8	0.88	**0.180**	**0.177**	**0.187**	±0.01
835	40.2	0.93	**0.240**	**0.215**	**0.228**	±0.01
900	39.8	0.97	**0.242**	**0.217**	**0.228**	±0.01
1800	40.0	1.41	**0.277**	**0.299**	**0.295**	±0.05
1900	39.2	1.39	**0.308**	**0.335**	**0.292**	±0.01
2100	40.5	1.46	**0.319**	**0.350**	**0.331**	±0.02
2450	39.1	1.80	**0.308**	**0.342**	**0.325**	±0.02
2600	38.6	1.95	**0.323**	**0.360**	**0.344**	±0.02

Reference : 2012020074-1
Date of Issue : 1 March 2012
Checked by : BCL

NPLCS00-0807

Table 2
Sensitivity in Body Simulating Liquids.
SAR probe: IXP-050
S/N 0170

Probe settings for calibration		
Sensitivity in free-space[(1)]	**Diode Compression[(2)]**	**Sensor offset from tip of probe[(2)]**
Lin X =524.99 $(V/m)^2/(V*200)$ Lin Y = 453.82 $(V/m)^2/(V*200)$ Lin Z = 484.81 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z= 20 (V*200)	2.7 mm

Sensitivity in Body Simulating Liquid.

Calibration frequency	Liquid Phantom[(3)]		Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy
(MHz)	ε' [(3)]	σ [(3)] (Sm^{-1})	$ConvF_X$	$ConvF_Y$	$ConvF_Z$	(dB)
450	55.6	0.98	**0.194**	**0.187**	**0.200**	±0.03
835	56.1	1.02	**0.225**	**0.231**	**0.233**	±0.01
900	55.8	1.05	**0.234**	**0.242**	**0.243**	±0.01
1800	52.3	1.51	**0.305**	**0.320**	**0.321**	±0.02
1900	52.0	1.59	**0.319**	**0.337**	**0.338**	±0.03
2100	51.5	1.63	**0.341**	**0.375**	**0.365**	±0.01
2450	50.5	1.96	**0.342**	**0.383**	**0.367**	±0.02
2600	50.2	2.12	**0.355**	**0.399**	**0.382**	±0.02

Notes.
(1) Measured at 900 MHz
(2) The manufacturer supplied these figures.
(3) Measured at a temperature of 22 ± 1 ^{0}C.

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Date of Issue : 1 March 2012
Checked by : BCL

NPLCS00-08/07

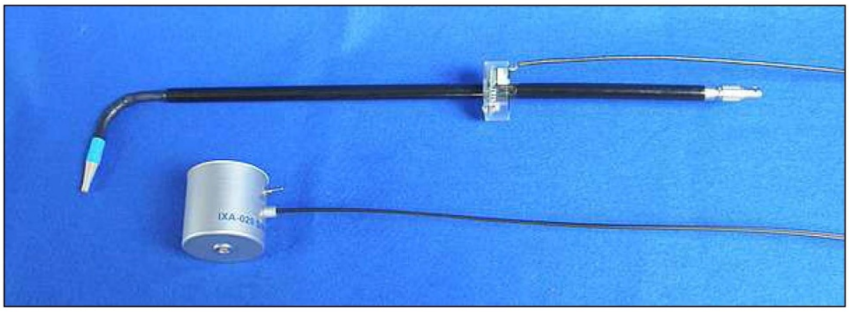
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP–020

S/N L0011

October 2011



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Calibration Certificate 1110/L0011
Date of Issue: 11th October 2011
Immersible SAR Probe

Type:	IXP-020
Manufacturer:	IndexSAR, UK
Serial Number:	L0011
Place of Calibration:	IndexSAR, UK
Date of Receipt of Probe:	N/A
Calibration Dates:	7th April — 18th May 2011
Customer:	TUV

IndexSAR Ltd hereby declares that the IXP-020 Probe named above has been calibrated for conformity to the IEEE 1528 and BSEN 62209-1 standards using the methods described in this calibration document. Where applicable, the standards used in the calibration process are traceable to the UK's National Physical Laboratory.

Calibrated by:	A. Brinklow	**Technical Manager**
Approved by:		**Director**

Please keep this certificate with the calibration document. When the probe is sent for a calibration check, please include the calibration document.

INTRODUCTION

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N L0011) only and describes the procedures used for characterisation and calibration.

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of BSEN 622009-1 [Ref 1] & IEEE [Ref 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 two stages:-

1) Determination of the channel sensitivity factors which optimise the probe's overall spherical isotropy in 900MHz 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

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 mV and DCP is the diode compression potential, also in mV.

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-020 probes with CW signals the DCP values are typically 100mV.

In turn, measurements of E-field are determined using the following equation:

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

Page 3 of 16

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.

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 response to incoming signals of any polarisation position angle ("spherical isotropy"). The setup for measuring the probe's spherical isotropy is shown in Figure 1.

A box phantom containing 900MHz head fluid is irradiated by a vertically-polarised, tuned dipole, mounted at the side of the phantom on the robot's seventh axis. The dipole is connected to a signal generator and amplifier via a directional coupler and power meter. The absolute power level is not important as long as it is stable, with stability being monitored using the coupler and power meter.

During calibration, the spherical response is generated by changing the orientation of the probe sensors with respect to the dipole, keeping the long shaft of the probe vertical and the probe sensors at the same position in space.

Initially, the short shaft of the probe is positioned parallel to the phantom wall with its sensors at the same vertical height as the centre of the source dipole and the line joining sensors to dipole perpendicular to the phantom wall (see Figure 1). In this position, the probe is said to be at a position angle of -90 degrees. During the scan, the probe is rotated from -90 to +90 degrees in 10 degree steps, and at each position angle, the dipole polarisation changes from 0 to 360 degrees in 20 degree steps. The short shaft of the probe thereby starts moving increasingly end-on to the dipole, and after perpendicularity, it carries on until facing in the opposite direction from its starting position, all the time with the centroid of the sensors occupying the same position in space.

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

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 perpendicular distance from 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:

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

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).

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

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°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.

Dedicated waveguides have been designed to accommodate the geometry of an L-shaped probe as it traces out the decay profile. Traditional straight probes measure the decay rate of a vertical-travelling signal above a horizontal dielectric window; for the L-shaped probes, the geometry has had to be changed, and the waveguide now lies horizontally and instead of being open at the end, is capped with a metal plate (see Figure 4). A slot is cut in the top ("b") face through which tissue simulant fluid can be poured, and through which the probe can enter the guide and be offered up to the now vertical waveguide window.

During calibration, the probe is moved carefully until the flat face of the tip 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 into the liquid away from the waveguide window. This cycle is repeated 150 times. The spatial separation between readings is determined from practical considerations of the expected SAR decay rate, and range from 0.2mm steps at low frequency, through 0.1mm at 2450MHz, down to 0.05mm 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.

By ensuring the waveguide cap is at least three penetration depths, reflections 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, 2100/2450/2600MHz 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 greater than 5GHz. Values for the penetration depth for these specific fixtures and tissue-simulating mixtures are also listed in Table A.1.

For 450 MHz calibrations, a slightly different technique must be used — the equatorial response of the probe-under-test is compared with the equivalent response of a probe whose 450MHz characteristics have already been determined by NPL. The conversion factor of the probe-under-test can then be deduced.

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.

CALIBRATION FACTORS MEASURED FOR PROBE S/N L0011

The probe was calibrated at 835, 900, 1800, 1900, 2100 and 2450 MHz in liquid samples representing brain liquid at these frequencies.

The calibration was for CW signals only, and the horizontal axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation.

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 9).

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.

CALIBRATION EQUIPMENT

The Table on page 16 indicates the calibration status of all test equipment used during probe calibration.

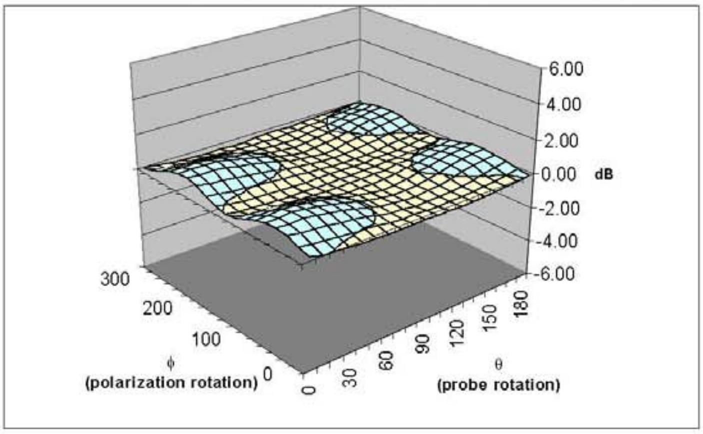
MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA2 measurement system has been published in Reference [3]. Table 10 from that document is re-created below, and lists the uncertainty factors associated just with the calibration of probes.

Source of uncertainty	**Uncertainty value ± %**	**Probability distribution**	**Divisor**	c_i	**Standard uncertainty ui ± %**	v_i **or** v_{eff}
Incident or forward power	5.743	N	1.00	1	5.743	∞
Refelected power	5.773	N	1.00	1	5.773	∞
Liquid conductivity	1.120	N	1.00	1	1.120	∞
Liquid permittivity	1.085	N	1.00	1	1.085	∞
Field homgeneity	0.002	R	1.73	1	0.001	∞
Probe positioning: +/-0.05mm	0.55	R	1.73	1	0.318	
Influence on Probe pos: 11%/mm						
Field probe linearity	4.7	R	1.73	1	2.714	∞
Combined standard uncertainty		**RSS**			**8.729**	

At the 95% confidence level, therefore, the expanded uncertainty is 17.1%

SUMMARY OF CAL FACTORS FOR PROBE IXP-020 S/N L0011



Surface Isotropy diagram of IXP-020 Probe S/N L0011 at 900MHz (axial isotropy +/-0.03dB, spherical isotropy +/-0.58dB, other subsets listed below)

Measured Isotropy at 900MHz	Probe orientation range relative to dipole	(+/-) dB
Spherical Isotropy	±90°	0.58
	±60°	0.54
	±30°	0.32
	±20°	0.22
Axial Isotropy	0°	0.03

Channel Sensitivities				
	X	Y	Z	
Air Factors	69.36	84.92	85.72	$(V/m)^2/mV$
CW DCPs	100	100	100	mV

SAR Conversion Factors/ Boundary Corrections				
Freq (MHz)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	Notes
835	0.265	1.9	1.1	1,2
900	0.273	2.0	1.0	1,2
1800	0.327	1.3	1.3	1,2
1900	0.331	0.9	1.5	1,2
2100	0.350	1.0	1.5	1,2
2450	0.359	0.8	1.6	1,2
Notes				
1)	Calibrations done at 22°C +/-2°C			
2)	Waveguide calibration			

Probe tip radius	0 mm
X Ch. Angle to red dot	0°

PROBE SPECIFICATIONS

Indexsar probe L0011, along with its calibration, is compared with BSEN 62209-1 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 L0011	BSEN [1]	IEEE [2]
Vertical shaft (mm)	510		
Horizontal shaft (mm)	90		
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 L0011	BSEN [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

Isotropy (measured at 900MHz)		S/N L0011	BSEN [1]	IEEE [2]
Spherical	Probe at ±90°	0.58	1.0	0.50
	Probe at ±60°	0.54		
	Probe at ±30°	0.32		
	Probe at ±20°	0.22		
Axial	Probe at 0°	0.03	0.5	0.25

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. Outer case materials are PEEK and heat-shrink sleeving.
Chemical resistance	Tested to be resistant to TWEEN and sugar/salt-based simulant liquids but probes should be removed, cleaned and dried when not in use. NOT recommended for use with glycol or soluble oil-based liquids.

REFERENCES

[1] BSEN 62209-1:2006. Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)

[2] IEEE 1528, 2003 Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

[3] Indexsar Report IXS-0300, October 2007. Measurement uncertainties for the SARA2 system assessed against the recommendations of BS EN 62209-1:2006

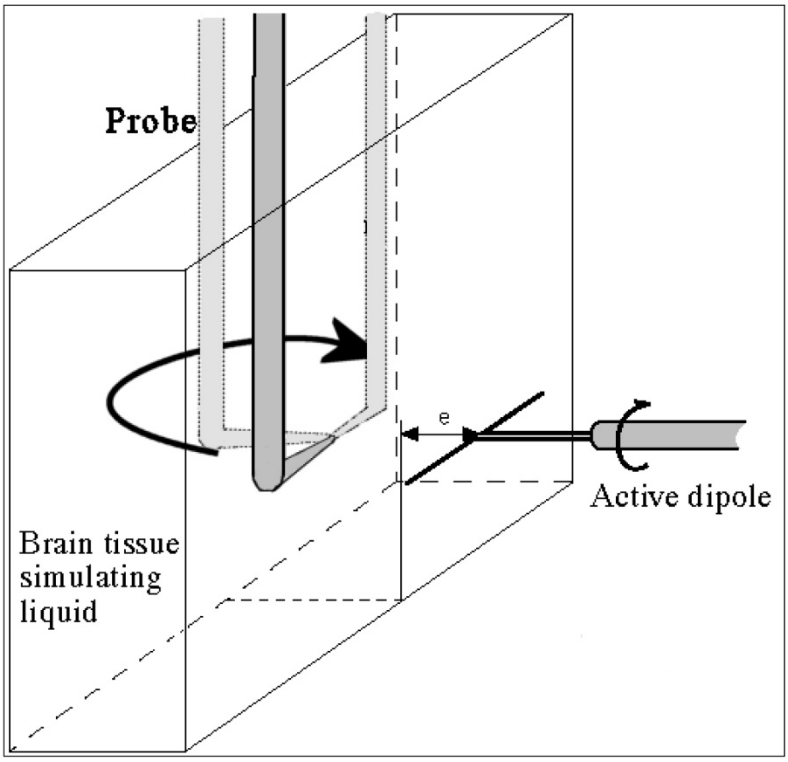


Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

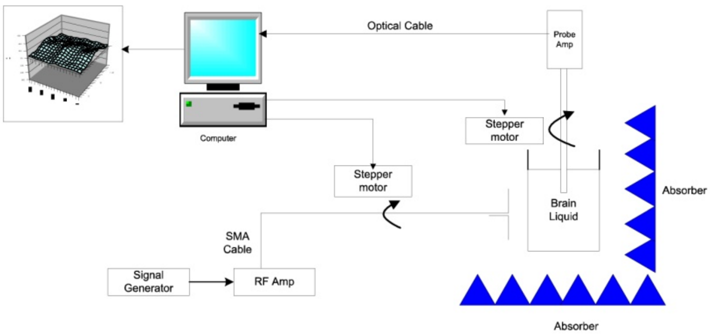


Figure 2. Schematic diagram of the test geometry used for isotropy determination

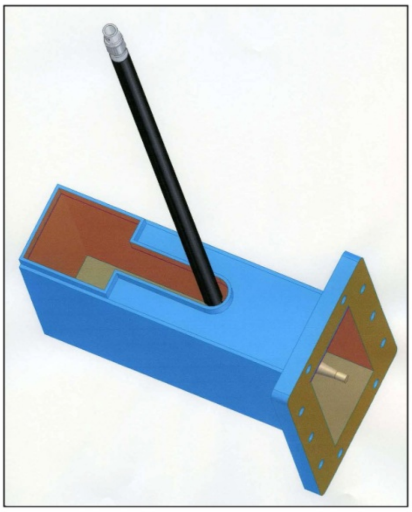


Figure 4. Schematic showing the innovative design of slot in the waveguide termination

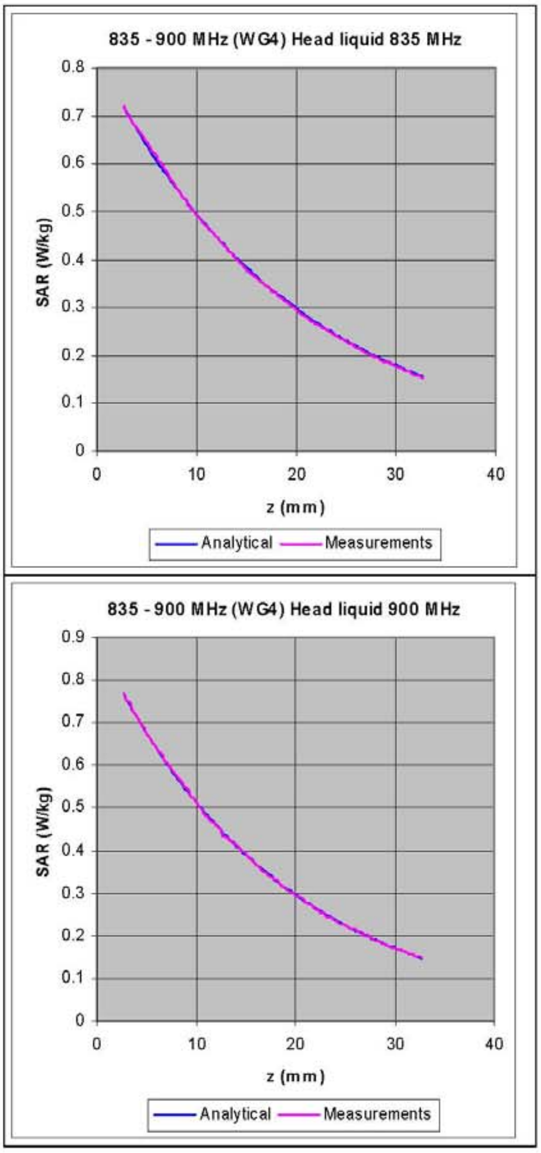
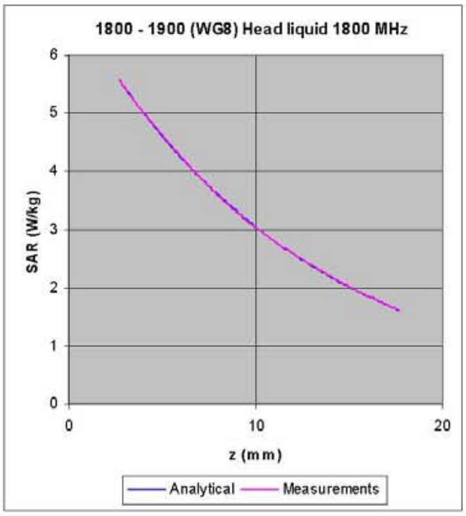
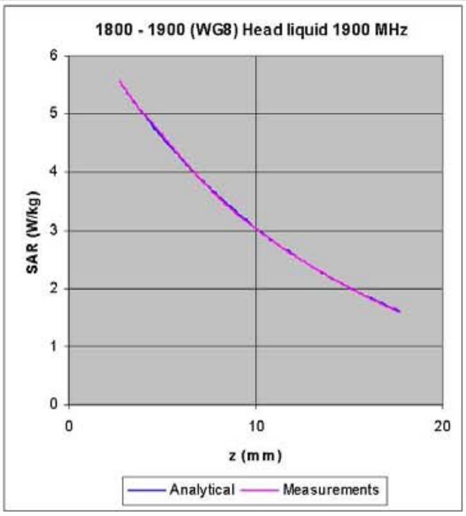


Figure 6. The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.


1800 - 1900 (WG8) Head liquid 1800 MHz
SAR (W/kg)
z (mm)
0
1
2
3
4
5
6
0
10
20
Analytical
Measurements


1800 - 1900 (WG8) Head liquid 1900 MHz
SAR (W/kg)
z (mm)
0
1
2
3
4
5
6
0
10
20
Analytical
Measurements

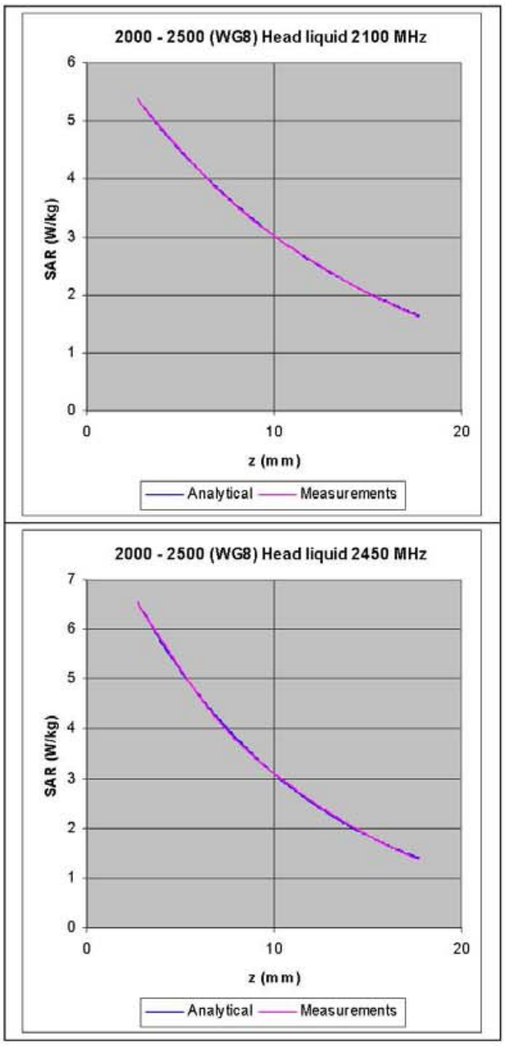


Figure 7. The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

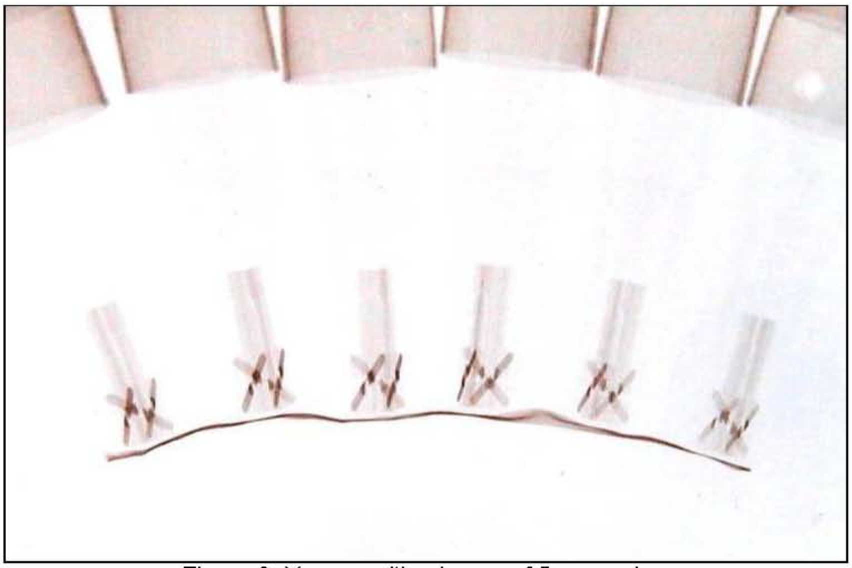


Figure 9: X-ray positive image of 5mm probes

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

Liquid used	Relative permittivity (measured)	Conductivity (S/m) (measured)
835 MHz BRAIN	42.80	0.91
900 MHz BRAIN	40.47	0.95
1800 MHz BRAIN	40.01	1.42
1900 MHz BRAIN	40.08	1.42
2100 MHz BRAIN	41.98	1.38
2450 MHz BRAIN	40.68	1.77

Table of test equipment calibration status

Instrument description	Supplier / Manufacturer	Model	Serial No.	Last calibration date	Calibration due date
Power sensor	Rohde & Schwarz	NRP-Z23	100169	14/09/2010	14/9/2012
Dielectric property measurement	Indexsar	DiLine (sensor lengths: 160mm, 80mm and 60mm)	N/A	(absolute) – checked against NPL values using reference liquids	N/A
Vector network analyser	Anritsu	MS6423B	003102	17/01/2011	17/01/2012
SMA autocalibration module	Anritsu	36581KKF/1	001902	17/01/2011	17/01/2012

Page 16 of 16