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Report On

Specific Absorption Rate Testing of the
Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS

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REPORT ON	Specific Absorption Rate Testing of the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS Document 759230192 Report 12 Issue 1 June 2015
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DATED	19 June 2015

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SECTION 1

REPORT SUMMARY

Specific Absorption Rate Testing of the
Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Specific Absorption Rate Testing of the SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS to the requirements of KDB 447498 – D01 v05r02 General RF Exposure Guidance.

Objective	To perform Specific Absorption Rate Testing to determine the Equipment Under Test's (EUT's) compliance with the requirements specified of KDB 447498 – D01 v05 General RF Exposure Guidance, for the series of tests carried out.
Applicant	Sharp Communication Compliance Ltd
Manufacturer	Sharp Corporation
Manufacturing Description	Mobile Handset
Serial/IMEI Number(s)	004401115362507 (SAR Test: GSM/WCDMA) 004401115362515 (SAR Test: GSM/WCDMA) 004401115362499 (SAR Test: LTE) 004401115362473 (SAR Test: WLAN) 004401115362432 (Conducted: GSM) 004401115362523 (Conducted: WCDMA) 004401115362440 (Conducted: LTE) 004401115362408 (Conducted: Bluetooth) 004401115362481 (Conducted: WLAN – 2.4GHz)
Number of Samples Tested	4
Hardware Version	PP1
Software Version	C4070 - GSM/WCDMA/LTE/WLAN
Battery Cell Manufacturer	Sharp Corporation
Battery Model Number	SHF31UAA
Test Specification/Issue/Date	KDB 447498 – D01 v05r02 General RF Exposure Guidance
Start of Test	01 June 2015
Finish of Test	04 June 2015
Related Document(s)	FCC 47CFR 2.1093: 2014 KDB 248227 – D01 v02r01 KDB 865664 – D01 v01r03 KDB 865664 – D02 v01r01 KDB 648474 – D04 v01r02 KDB 941225 – D01 v03 KDB 941225 – D06 v02 KDB 941225 – D05 v02r03 IEEE 1528-2013
Name of Engineer(s)	Nigel Grigsby Nicolas Barincou

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1.2 BRIEF SUMMARY OF RESULTS

The measurements shown in this report were made in accordance with the procedures specified KDB 447498 – D01 v05r02.

The maximum 1g volume averaged SAR found during this Assessment

Max 1g SAR (W/kg) Head	0.39 (Measured)	0.48 (Scaled)
Max 1g SAR (W/kg) Body / Hotspot	0.96 (Measured)	1.18 (Scaled)
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.		

The maximum 1g volume averaged Stand-alone Reported SAR found during this Assessment for each supported mode, including highest simultaneous transmission results;

Band	Test Configuration	Max Reported Scaled SAR (W/kg)	Highest Simultaneous Transmission Scaled SAR (W/kg)
GSM/GPRS 850	Head	0.38	1.24*
	Body/Hotspot	**1.18**	
PCS/GPRS 1900	Head	0.45	
	Body/Hotspot	0.42	
WCDMA FDD V	Head	**0.48**	
	Body/Hotspot	1.04	
LTE Band 26	Body/Hotspot	1.14	
WLAN 2.4GHz	Head	0.10	
	Body/Hotspot	0.29	
The maximum 1g volume averaged SAR level measured for all the tests performed (including simultaneous transmission analysis results) did not exceed the limits for General Population/Uncontrolled Exposure (W/kg) Partial Body of 1.6 W/kg. * The highest simultaneous transmission has been calculated using the Bluetooth Body SAR estimation in section 1.3.4 of this report as no 2.4GHz WLAN measurement was taken for the position that yielded the highest stand alone SAR			

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 KDB 865664 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
20/04/2015	835	835	10.33	-1.56%
22/04/2015	835	835	9.54	0.34%
23/04/2015	835	835	9.78	2.81%
24/04/2015	835	835	9.38	-1.38%
21/04/2015	1900	1900	40.46	6.70%
27/04/2015	1900	1900	39.86	-4.66%
30/04/2015	2450	2450	48.04	-6.39%
01/05/2015	2450	2450	51.89	-5.17%

*Normalised to a forward power of 1W

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1.3.2 Results Summary Tables

GSM 850MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Left Cheek	251	848.80	32.16	32.90	0.23	0.27	Figure 6
Left 15°	251	848.80	32.16	32.90	0.09	0.11	Figure 7
Right Cheek	251	848.80	32.16	32.90	0.27	0.32	Figure 8
Right 15°	251	848.80	32.16	32.90	0.08	0.09	Figure 9
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is: ≤ 0.8W/kg when the transmission band is ≤ 100MHz ≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz ≤ 0.4W/kg when the transmission band is ≥ 200MHz							

GSM 850MHz GPRS Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Left Cheek	251	848.80	29.90	30.80	0.29	0.36	Figure 10
Left 15°	251	848.80	29.90	30.80	0.11	0.14	Figure 11
Right Cheek	251	848.80	29.90	30.80	0.31	0.38	Figure 12
Right 15°	251	848.80	29.90	30.80	0.11	0.14	Figure 13
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is: ≤ 0.8W/kg when the transmission band is ≤ 100MHz ≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz ≤ 0.4W/kg when the transmission band is ≥ 200MHz The time slot configuration with the highest source-based time-averaged maximum output power was used for testing, this was 2x time slots.							

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GSM 850MHz GPRS Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position							
10mm	Front Facing	251	848.80	29.90	30.80	0.52	0.64	Figure 14
10mm	Rear Facing	251	848.80	29.90	30.80	0.75	0.92	Figure 15
10mm	Left Edge	251	848.80	29.90	30.80	0.40	0.49	Figure 16
10mm	Right Edge	251	848.80	29.90	30.80	0.50	0.62	Figure 17
10mm	Top Edge	251	848.80	29.90	30.80	0.04	0.05	Figure 18
10mm	Rear Facing	189	836.40	29.90	30.80	0.96	**1.18**	Figure 19
10mm	Rear Facing	128	824.20	29.90	30.80	0.91	1.12	Figure 20

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06

The time slot configuration with the highest source-based time-averaged maximum output power was used for testing, this was 2x time slots.

WCDMA FDDV Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Left Cheek	4132	826.40	23.30	24.20	0.39	**0.48**	Figure 21
Left 15°	4132	826.40	23.30	24.20	0.12	0.15	Figure 22
Right Cheek	4132	826.40	23.30	24.20	0.37	0.46	Figure 23
Right 15°	4132	826.40	23.30	24.20	0.12	0.15	Figure 24

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

KDB 941225 D01 – Testing of the secondary mode was not required - When the maximum output power and tune-up tolerance specified for production units in a secondary mode is ≤ ¼ dB higher than the primary mode or when the highest reported SAR of the primary mode is scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode and the adjusted SAR is ≤ 1.2 W/kg, SAR measurement is not required for the secondary mode.

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WCDMA FDDV Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position							
10mm	Front Facing	4132	826.40	23.30	24.20	0.53	0.65	Figure 25
10mm	Rear Facing	4132	826.40	23.30	24.20	0.84	1.03	Figure 26
10mm	Left Edge	4132	826.40	23.30	24.20	0.43	0.53	Figure 27
10mm	Right Edge	4132	826.40	23.30	24.20	0.52	0.64	Figure 28
10mm	Top Edge	4132	826.40	23.30	24.20	0.04	0.05	Figure 29
10mm	Rear Facing	4175	835.00	23.30	24.20	0.78	0.96	Figure 30
10mm	Rear Facing	4233	846.60	23.30	24.20	0.62	0.76	Figure 31

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06

KDB 941225 D01 – Testing of the secondary mode was not required - When the maximum output power and tune-up tolerance specified for production units in a secondary mode is ≤ ¼ dB higher than the primary mode or when the highest reported SAR of the primary mode is scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode and the adjusted SAR is ≤ 1.2 W/kg, SAR measurement is not required for the secondary mode.

LTE Band 26 Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

15MHz Bandwidth, 1 Resource Block, High Offset.

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position							
10mm	Front Facing	26865	831.50	23.08	24.2	0.53	0.69	Figure 32
10mm	Rear Facing	26865	831.50	23.08	24.2	0.72	0.93	Figure 33
10mm	Left Edge	26865	831.50	23.08	24.2	0.41	0.53	Figure 34
10mm	Right Edge	26865	831.50	23.08	24.2	0.50	0.65	Figure 35
10mm	Top Edge	26865	831.50	23.08	24.2	0.04	0.05	Figure 36
10mm	Rear Facing	26765	821.50	23.08	24.2	0.88	1.14	Figure 37
10mm	Rear Facing	26965	841.50	23.08	24.2	0.52	0.67	Figure 38

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06

KDB 941225 D05 - Largest channel bandwidth standalone SAR test requirements – 4.2.1. The requirements to test other resource block allocations and higher order modulations were not met.

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LTE Band 26 Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

15MHz Bandwidth, 36 Resource Blocks, Middle Offset.

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position							
10mm	Front Facing	26865	821.50	22.25	23.20	0.39	0.48	Figure 39
10mm	Rear Facing	26865	821.50	22.25	23.20	0.62	0.77	Figure 40
10mm	Left Edge	26865	821.50	22.25	23.20	0.31	0.39	Figure 41
10mm	Right Edge	26865	821.50	22.25	23.20	0.38	0.47	Figure 42
10mm	Top Edge	26865	821.50	22.25	23.20	0.03	0.04	Figure 43

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06

KDB 941225 D05 - Largest channel bandwidth standalone SAR test requirements – 4.2.2. The requirements to test other resource block allocations and higher order modulations were not met.

PCS 1900MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Left Cheek	661	1880	28.59	30.50	0.19	0.29	Figure 44
Left 15°	661	1880	28.59	30.50	0.09	0.14	Figure 45
Right Cheek	661	1880	28.59	30.50	0.25	0.39	Figure 46
Right 15°	661	1880	28.59	30.50	0.08	0.12	Figure 47

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

PCS 1900MHz GPRS Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Left Cheek	661	1880	26.35	28.30	0.22	0.34	Figure 48
Left 15°	661	1880	26.35	28.30	0.09	0.14	Figure 49
Right Cheek	661	1880	26.35	28.30	0.29	0.45	Figure 50
Right 15°	661	1880	26.35	28.30	0.10	0.16	Figure 51
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is: ≤ 0.8W/kg when the transmission band is ≤ 100MHz ≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz ≤ 0.4W/kg when the transmission band is ≥ 200MHz The time slot configuration with the highest source-based time-averaged maximum output power was used for testing, this was 2x time slots.							

PCS 1900MHz GPRS Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position							
10mm	Front Facing	661	1880	26.35	28.30	0.16	0.25	Figure 52
10mm	Rear Facing	661	1880	26.35	28.30	0.27	0.42	Figure 53
10mm	Right Edge	661	1880	26.35	28.30	0.18	0.28	Figure 54
10mm	Top Edge	661	1880	26.35	28.30	0.23	0.36	Figure 55
Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g) KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is: ≤ 0.8W/kg when the transmission band is ≤ 100MHz ≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz ≤ 0.4W/kg when the transmission band is ≥ 200MHz Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 The time slot configuration with the highest source-based time-averaged maximum output power was used for testing, this was 2x time slots.								

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WLAN 2412MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

802.11b, 1 Mbps, DSSS

Test Position	Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Scaled Duty Cycle 1g SAR (W/kg)	Area scan (Figure number)
Right Cheek	1	2412.0	15.25	17.00	0.07	0.10	0.10	Figure 56

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

KDB248227 D01 v02 - Testing was not required for OFDM in accordance with Section 5.3.2

KDB248227 D01 v02 - Only one position was tested in accordance with Section 5.3.1

KDB248227 D01 v02 – A duty factor scaling was applied to the scaled SAR in accordance with section 2.2

WLAN 2412MHz Body & Hotspot Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS.

802.11b, 1 Mbps, DSSS

Position		Channel Number	Frequency (MHz)	Measured Conducted Power (dBm)	Tune Up limit (dBm)	Measured 1g SAR (W/kg)	Scaled 1g SAR (W/kg)	Scaled Duty Cycle 1g SAR (W/kg)	Area scan (Figure number)
Spacing	Position								
10mm	Left Edge	1	2412.0	15.25	17.00	0.20	0.30	0.30	Figure 57

Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)

KDB 447498 D01 - Testing of other required channels within the operation mode of a frequency band is not required when the reported 1g SAR for mid-band or highest output power channel is:

≤ 0.8W/kg when the transmission band is ≤ 100MHz
≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz
≤ 0.4W/kg when the transmission band is ≥ 200MHz

Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06

KDB248227 D01 v02 - Testing was not required for OFDM in accordance with Section 5.3.2

KDB248227 D01 v02 - Only one position was tested in accordance with Section 5.3.1

KDB248227 D01 v02 – A duty factor scaling was applied to the scaled SAR in accordance with section 2.2

WLAN DSSS SAR Test Requirements

802.11b, 1 Mbps, DSSS

Test Position	Channel Number	Frequency (MHz)	Area 2D Scan (V/m)
Left Cheek	1	2412.0	5.32
Left 15°	1	2412.0	3.00
Right Cheek	1	2412.0	**5.62**
Right 15°	1	2412.0	3.92
KDB 248227 D01 Section 5.3.1 - Testing of other positions is not required when the measured SAR is ≤ 0.4W/kg:			

WLAN DSSS SAR Test Requirements

802.11b, 1 Mbps, DSSS

Position		Channel Number	Frequency (MHz)	Area 2D Scan (V/m)
Spacing	Position			
10mm	Front Face	1	2412.0	5.95
10mm	Rear Face	1	2412.0	7.79
10mm	Left Edge	1	2412.0	**8.82**
10mm	Top Edge	1	2412.0	6.07
KDB 248227 D01 Section 5.3.1 - Testing of other positions is not required when the measured SAR is ≤ 0.4W/kg:				

1.3.3 Simultaneous Transmission

Position Head	GPRS 850MHz 1g SAR (W/kg) CH 251 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values)	∑ 1g SAR (W/kg)
Left Cheek	0.36	N/A*	N/A
Left 15°	0.14	N/A*	N/A
Right Cheek	0.38	0.10	0.48
Right 15°	0.14	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	GPRS 850MHz 1g SAR (W/kg) CH 251 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.64	N/A*	N/A
Rear Facing	0.92	N/A*	N/A
Left Edge	0.49	0.30	0.79
Right Edge	0.62	N/A*	N/A
Top Edge	0.05	N/A*	N/A
Bottom Edge	**1.18**	N/A*	N/A
Bottom Edge	1.12	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Head	WCDMA FDDV 1g SAR (W/kg) CH 4132 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values)	∑ 1g SAR (W/kg)
Left Cheek	**0.48**	N/A*	N/A
Left 15°	0.15	N/A*	N/A
Right Cheek	0.46	0.10	0.56
Right 15°	0.15	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	WCDMA FDDV 1g SAR (W/kg) CH 4132 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.65	N/A*	N/A
Rear Facing	1.03	N/A*	N/A
Left Edge	0.53	0.30	0.83
Right Edge	0.64	N/A*	N/A
Top Edge	0.05	N/A*	N/A
Rear Facing	0.96	N/A*	N/A
Rear Facing	0.76	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	LTE Band 26, 1RB 1g SAR (W/kg) CH 26865 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.69	N/A*	N/A
Rear Facing	0.93	N/A*	N/A
Left Edge	0.53	0.30	0.83
Right Edge	0.65	N/A*	N/A
Top Edge	0.05	N/A*	N/A
Rear Facing	1.14	N/A*	N/A
Rear Facing	0.67	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 The configuration with 1RB yielded the highest SAR when measured and was therefore used in the simultaneous transmission calculation * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Head	GPRS 1900MHz 1g SAR (W/kg) CH 661 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values	∑ 1g SAR (W/kg)
Left Cheek	0.34	N/A*	N/A
Left 15°	0.14	N/A*	N/A
Right Cheek	0.45	0.10	0.55
Right 15°	0.16	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	GPRS 1900MHz 1g SAR (W/kg) CH 661 (Scaled SAR values)	WLAN 2.4GHz 1g SAR (W/kg) CH 1 (Scaled SAR values	∑ 1g SAR (W/kg)
Front Facing	0.25	N/A*	N/A
Rear Facing	0.42	N/A*	N/A
Right Edge	0.28	N/A*	N/A
Top Edge	0.36	N/A*	N/A
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 * No SAR Measurement was required in this position in accordance with KDB 248227 D01 Section 5.3.1			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	GPRS 850MHz 1g SAR (W/kg) CH 251 (Scaled SAR values	Bluetooth 2.4GHz 1g SAR (W/kg) CH 78 (Estimated SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.64	0.06	0.70
Rear Facing	0.92	0.06	0.98
Left Edge	0.49	0.06	0.55
Right Edge	0.62	0.06	0.68
Top Edge	0.05	0.06	0.11
Bottom Edge	**1.18**	0.06	1.24
Bottom Edge	1.12	0.06	1.18
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Product Service

Position Body	WCDMA FDDV 1g SAR (W/kg) CH 4132 (Scaled SAR values)	Bluetooth 2.4GHz 1g SAR (W/kg) CH 78 (Estimated SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.65	0.06	0.71
Rear Facing	1.03	0.06	1.09
Left Edge	0.53	0.06	0.59
Right Edge	0.64	0.06	0.70
Top Edge	0.05	0.06	0.11
Rear Facing	0.96	0.06	1.02
Rear Facing	0.76	0.06	0.82
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

Position Body	LTE Band 26, 1RB 1g SAR (W/kg) CH 26865 (Scaled SAR values)	Bluetooth 2.4GHz 1g SAR (W/kg) CH 78 (Estimated SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.69	0.06	0.75
Rear Facing	0.93	0.06	0.99
Left Edge	0.53	0.06	0.59
Right Edge	0.65	0.06	0.71
Top Edge	0.05	0.06	0.11
Rear Facing	1.14	0.06	1.20
Rear Facing	0.67	0.06	0.73
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06 The configuration with 1RB yielded the highest SAR when measured and was therefore used in the simultaneous transmission calculation			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg

Position Body	GPRS 1900MHz 1g SAR (W/kg) CH 661 (Scaled SAR values)	Bluetooth 2.4GHz 1g SAR (W/kg) CH 78 (Estimated SAR values)	∑ 1g SAR (W/kg)
Front Facing	0.25	0.06	0.31
Rear Facing	0.42	0.06	0.48
Right Edge	0.28	0.06	0.34
Top Edge	0.36	0.06	0.42
Simultaneous Transmission KDB 447498 D01 Testing was carried out with a 10mm separation distance to meet the requirements of KDB 941225 D06			

Simultaneous SAR measurements were not required as the sum of the 1g SAR measurements did not exceed 1.6 W/kg.

1.3.4 Standalone SAR Estimation

When the standalone SAR test exclusion of section 4.3.1 is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion. The estimated SAR is only used to determine simultaneous transmission SAR test exclusion; When SAR is estimated, it must be applied to determine the sum of 1-g SAR test exclusion. When SAR to peak location separation ratio test exclusion is applied, the highest reported SAR for simultaneous transmission can be an estimated standalone SAR if the estimated SAR is the highest among the simultaneously transmitting antennas (see KDB 690783).

(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]·$[\sqrt{f(GHz)}/7.5]$ W/kg for test separation distances ≤ 50 mm;

where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR

when the minimum test separation distance is <5mm, a distance of 5mm is applied.

Bluetooth Head SAR Estimation

Frequency (MHz)	Maximum Power (mW)	Distance (mm)	Estimated SAR (W/kg)
2480	2.94	5	0.122

Bluetooth Body SAR Estimation

Frequency (MHz)	Maximum Power (mW)	Distance (mm)	Estimated SAR (W/kg)
2480	2.94	10	0.06

1.4 PRODUCT INFORMATION

1.4.1 Technical Description

The equipment under test (EUT) was a Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(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.

For head SAR assessment, testing was performed with the device in the declared normal position of operation for GSM 850MHz, PCS 1900MHz, WCDMA FDDV and WLAN 2.4GHz frequency bands at maximum power. The device was placed against a Specific Anthropomorphic Mannequin (SAM) phantom. 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 in KDB 865665. 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, testing was performed for GSM 850MHz, PCS 1900MHz, WCDMA FDDV, LTE Band 26, and WLAN 2.4GHz frequency bands at maximum power. The device was placed at a distance of 10 mm from the bottom of the flat phantom for all body testing. The Flat Phantom dimensions were 245mm x 195mm x 200mm with a sidewall thickness of 2.00mm. The phantom was filled to a minimum depth of 150mm with the appropriate Body simulant liquid. The dielectric properties were in accordance with the requirements specified in KDB 865665. As the device is capable of hotspot configuration a 10mm separation distance was used to meet the requirements of KDB 941225 D06 Hotspot.

Testing was performed in each position at the frequency that gave the highest output power for each band. For all bands all scaled SAR levels were found to be <0.80 W/kg (KDB 447498 D01) therefore no additional testing was required at the relevant frequencies / channels of the bands. WLAN testing was achieved using the devices internal software, customer supplied software and settings supplied by the customer. SAR was measured for WLAN using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate KDB 248227 D01 v02 Section 5.1. This was 802.11b DSSS 1Mbps. SAR was not required for OFDM as the SAR Test Exclusion criteria for OFDM in KDB 248227 D01 v02 Section 5.3.2 were met.

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

GSM 850

Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
		Average
GMSK - Voice	824.20	31.91
	836.40	31.89
	848.80	32.16
GMSK - GPRS	824.20	29.81
	836.40	29.57
	848.80	29.90

PCS 1900

Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
		Average
GMSK - Voice	1850.20	28.51
	1880.00	28.59
	1909.80	28.58
GMSK - GPRS	1850.20	26.05
	1880.00	26.35
	1909.80	26.25

Product Service

WCDMA FDD V

Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
		Average
WCDMA - 12.2kbps RMC	826.4	23.30
	835.0	23.27
	846.6	23.24
WCDMA - 12.2kbps AMR with 3.4kbps SRB*	826.4	23.28
	835.0	23.29
	846.6	23.26
WCDMA - HSDPA (Subtest #1)	826.4	22.35
	835.0	22.29
	846.6	22.33
WCDMA - HSDPA (Subtest #2)	826.4	21.32
	835.0	21.29
	846.6	21.32
WCDMA - HSDPA (Subtest #3)	826.4	21.15
	835.0	21.15
	846.6	21.08
WCDMA - HSDPA (Subtest #4)	826.4	21.24
	835.0	21.25
	846.6	21.25
WCDMA - HSUPA (Subtest #1)	826.4	22.08
	835.0	22.06
	846.6	22.01
WCDMA - HSUPA (Subtest #2)	826.4	21.72
	835.0	21.64
	846.6	21.63
WCDMA - 12.2kbps RMC WCDMA - HSUPA (Subtest #3)	826.4	21.92
	835.0	21.91
	846.6	21.91
WCDMA - HSUPA (Subtest #4)	826.4	22.37
	835.0	22.36
	846.6	22.41
WCDMA - HSUPA (Subtest #5)	826.4	21.97
	835.0	22.01
	846.6	22.03
* The measured Conducted power for 12.2kbps AMR is <0.25dB higher than 12.2kbps RMC, therefore, testing was carried out using 12.2kbps RMC.		

Product Service

WLAN

Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
		Average
802.11(b) - 2.4 GHz – 1Mbps DSSS	2412	15.25
	2437	15.09
	2462	15.21
802.11(g) - 2.4 GHz - 6Mbps OFDM	2412	9.88
	2437	9.73
	2462	9.89
802.11 (n) - 2.4 GHz – MCS0 OFDM	2412	8.89
	2437	8.92
	2462	8.95

LTE Band 26

Channel Bandwidth (MHz)	Modulation	Resource Block Allocation	Resource Block Offset	Measured Average Output Power (dBm)		
				Low Test Channel (821.5MHz)	Middle Test Channel (831.5 MHz)	High Test Channel (841.5 MHz)
15	QPSK	1	Low	22.99	23.05	22.76
		1	Mid	23.02	22.93	22.86
		1	High	22.97	23.08	22.83
		36	Low	22.22	22.09	21.89
		36	Mid	22.25	22.03	21.91
		36	High	22.2	22.00	21.93
		75	N/A	22.24	22.18	21.89
	16 QAM	1	Low	22.16	22.32	21.99
		1	Mid	22.18	22.21	22.01
		1	High	22.14	22.36	22.08
		36	Low	21.32	21.15	20.91
		36	Mid	21.22	21.09	20.93
		36	High	21.23	21.13	20.96
		75	N/A	21.30	21.24	21.12

Bluetooth

Modulation	Frequency (MHz)	Conducted Carrier Power (dBm)
		Average
GFSK/DH5	2402	4.44
	2441	4.48
	2480	4.69

1.5.3 Standalone SAR Test Exclusion Considerations (KDB 447498 D01)

The 1g SAR Test exclusion thresholds for 100 MHz to 6 GHz *test separation distances* ≤ 50 mm are determined by:

[(*max power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] [√f ($_{GHz}$)]* ≤ 3.0, where

- f ($_{GHz}$) is the RF channel transmit frequency in GHz.
- Power and distance are rounded to the nearest mW and mm before calculation.
- The result is rounded to one decimal place for comparison.
- When the maximum test separation distance is < 5 mm, a distance of 5 mm is applied.

Band	Frequency (MHz)	Max Power		Test Position	Distance (mm)	Threshold	Test Exclusion
		(dBm)	(mW)				
GSM 850MHz	848.8	32.9	1949.84	Head	< 5	359.3	No
GPRS 850MHz	848.8	30.8	1202.26	Head	< 5	221.5	No
GPRS 850MHz	848.8	30.8	1202.26	Body	10	110.8	No
WCDMA FDD V	826.4	24.2	263.03	Head	< 5	47.8	No
				Body	10	23.9	No
LTE Band 26	831.5	24.2	263.03	Body	10	24.0	No
LTE Band 26	821.5	24.2	263.03	Body	10	23.8	No
GSM 1900MHz	1880.0	30.5	1122.02	Head	< 5	307.7	No
GPRS 1900MHz	1880.0	28.3	676.08	Head	< 5	185.4	No
GPRS 1900MHz	1800.0	28.3	676.08	Body	10	92.7	No
WLAN 2.4 GHz DSSS	2412.0	17.0	50.12	Head	< 5	15.6	No
				Body	10	7.8	No
Bluetooth	2480.0	8.0	6.31	Head	< 5	2.0	Yes
				Body	10	1.0	Yes

Product Service

SECTION 2

TEST DETAILS

Specific Absorption Rate Testing of the
Sharp SHF32 Quad-band GSM (850/900/1800/1900) & Dual-band UMTS (FDDI, FDDV) & Dual-band LTE (B1, B26) multi mode cellular phone with Bluetooth, WLAN, SRD(FeliCa) and GPS

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.

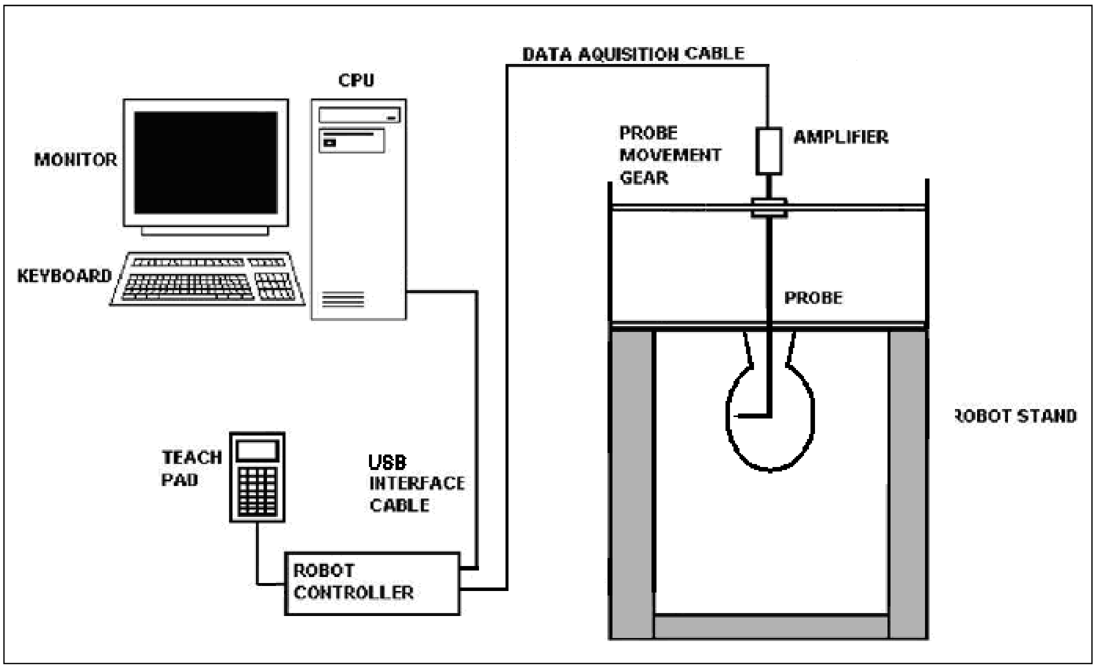

Figure 1 Schematic diagram of the SARA-C measurement system showing the L-probe and upside-down SAM phantom

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.

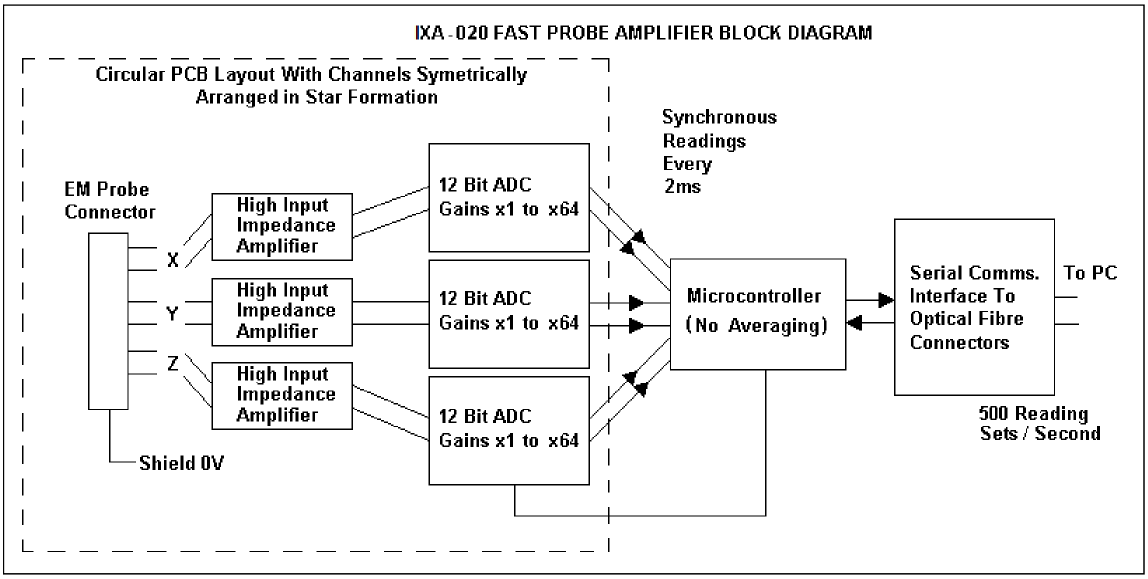

Figure 2 Schematic diagram of the fast amplifier

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.

Product Service

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.

SARA-C Interpolation and Extrapolation schemes

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.

Interpolation of 2D area scan

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

Extrapolation of 3D scan

For the 3D scan, data are collected on a spatially regular, 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.

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.

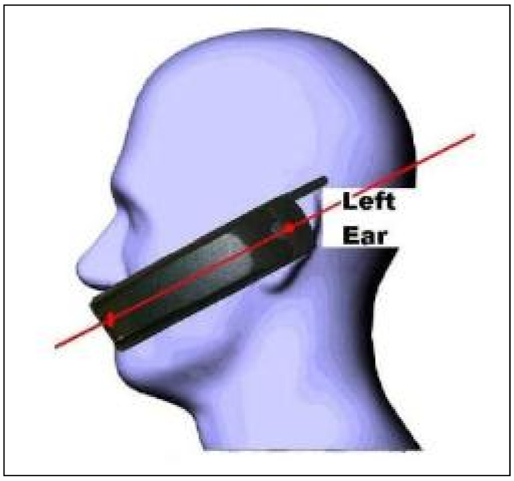

Figure 3 Side view of mobile next to head showing alignment

<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°.

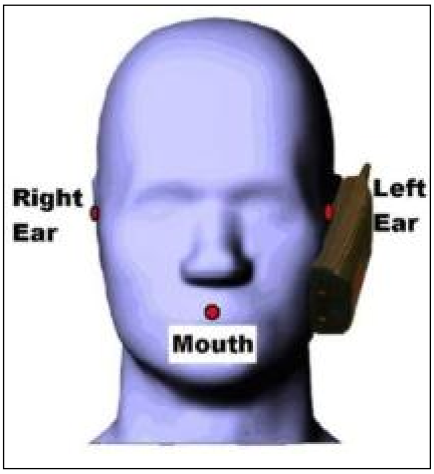

Figure 4 Cheek position

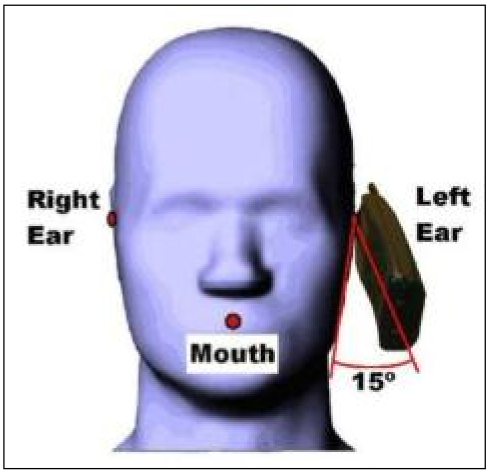

Figure 5 15º Tilt Position

2.2 GSM 850MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-09:57:08	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	84.40mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	51.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.235
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.232 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.262 W/kg
INPUT POWER LEVEL:	32.9dBm	SAR END:	0.255 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	-2.500 %

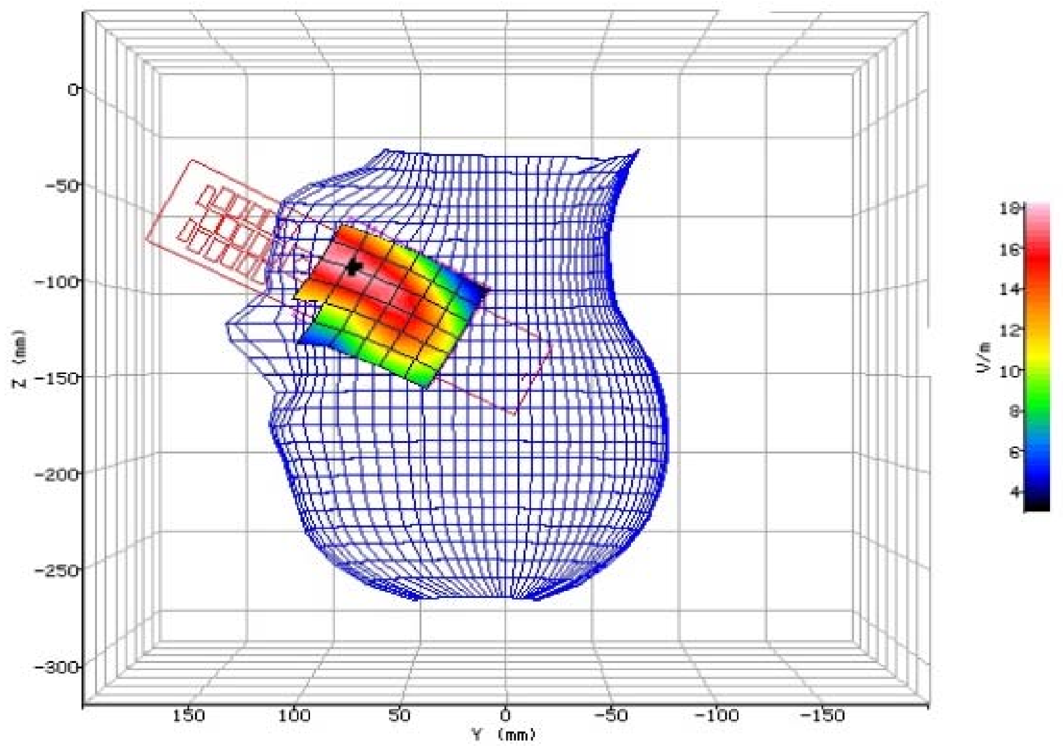

Figure 6: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-10:23:00	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	49.40mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-116.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	9.378
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.094 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.084 W/kg
INPUT POWER LEVEL:	32.9dBm	SAR END:	0.082 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	-2.300 %

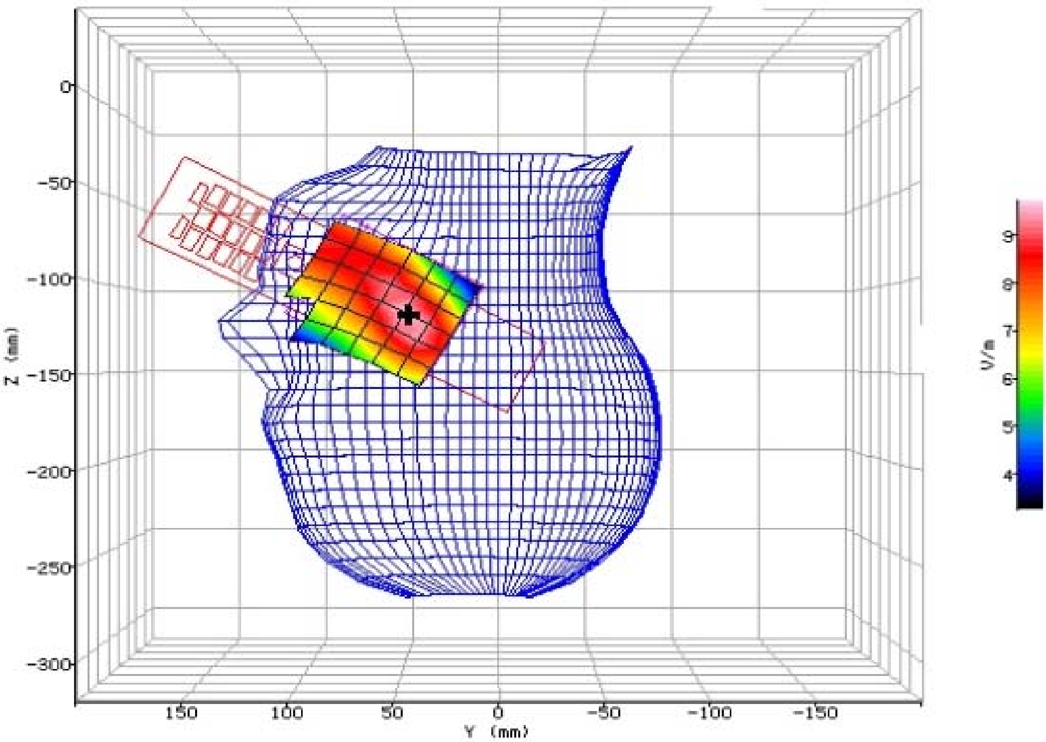

Figure 7: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-11:31:32	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	84.30mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-122.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.079
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.273 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.294 W/kg
INPUT POWER LEVEL:	32.9dBm	SAR END:	0.304 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	3.400 %

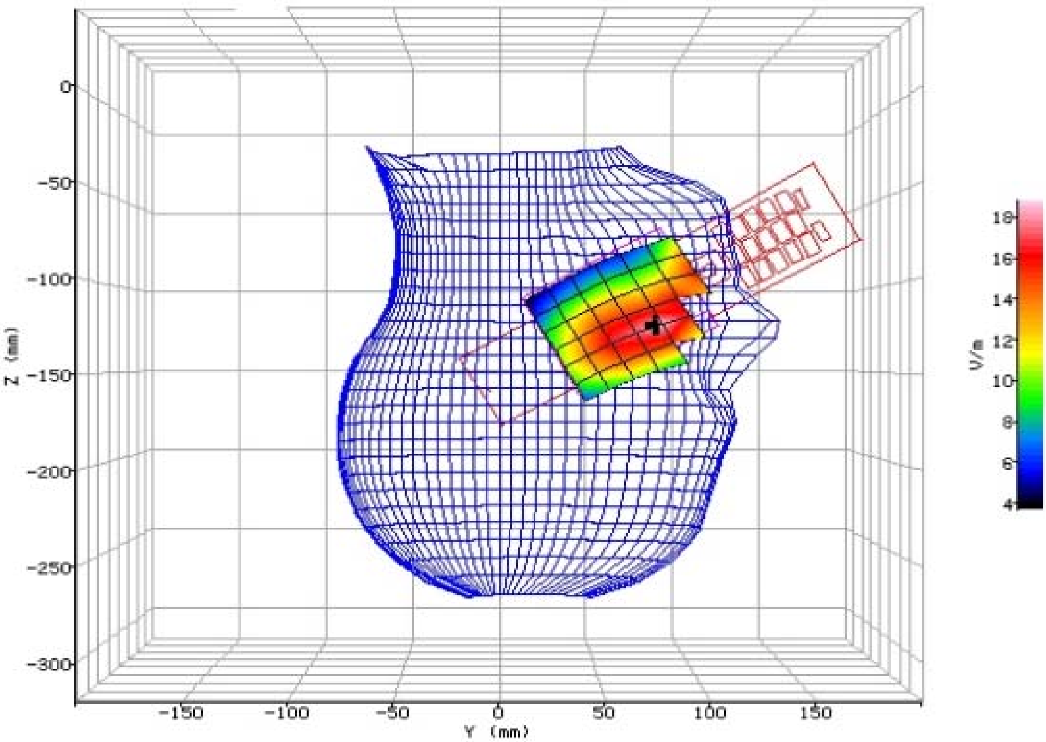

Figure 8: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-12:22:13	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	62.20mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-129.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.309
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.082 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.094 W/kg
INPUT POWER LEVEL:	32.9dBm	SAR END:	0.095 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	0.200 %

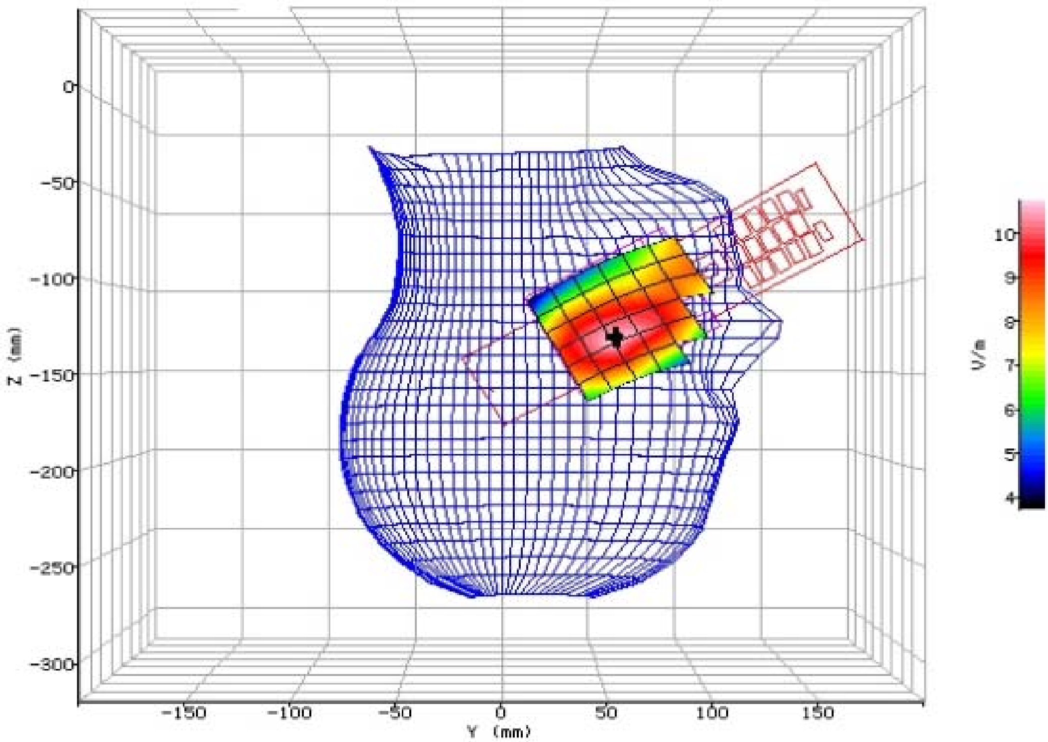

Figure 9: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

2.3 GSM 850MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-14:08:55	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	79.80mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-91.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.519
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.292 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.279 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.299 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	7.000 %

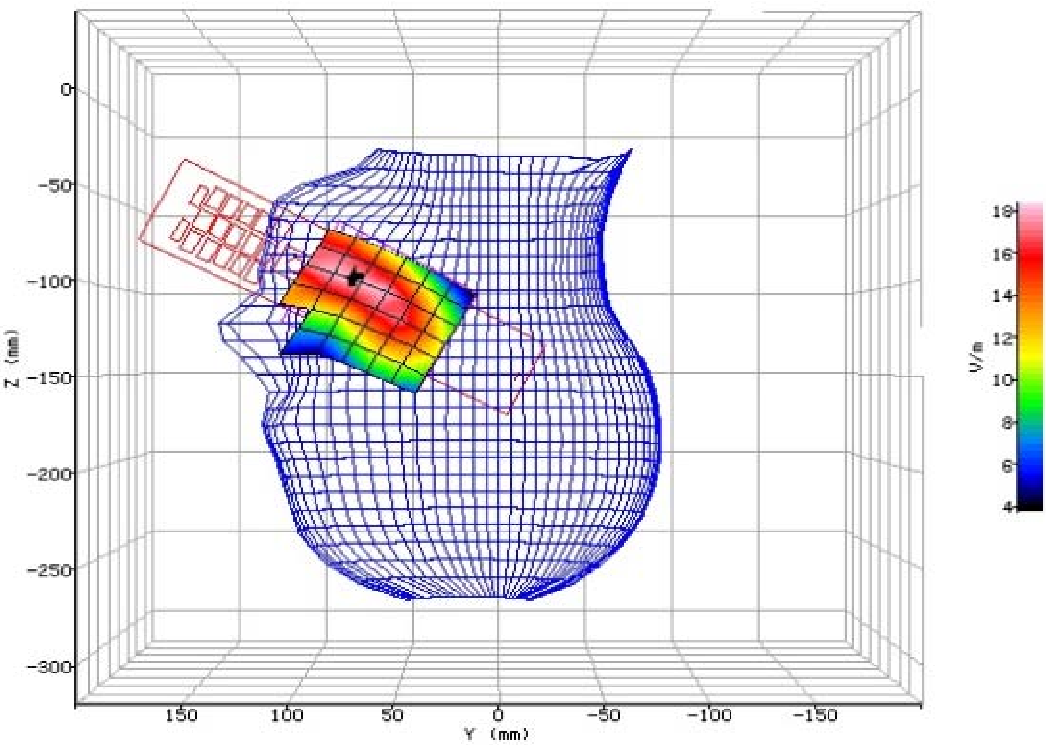

Figure 10: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-14:37:28	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	49.20mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-118.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	9.957
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.106 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.090 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.096 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	6.600 %

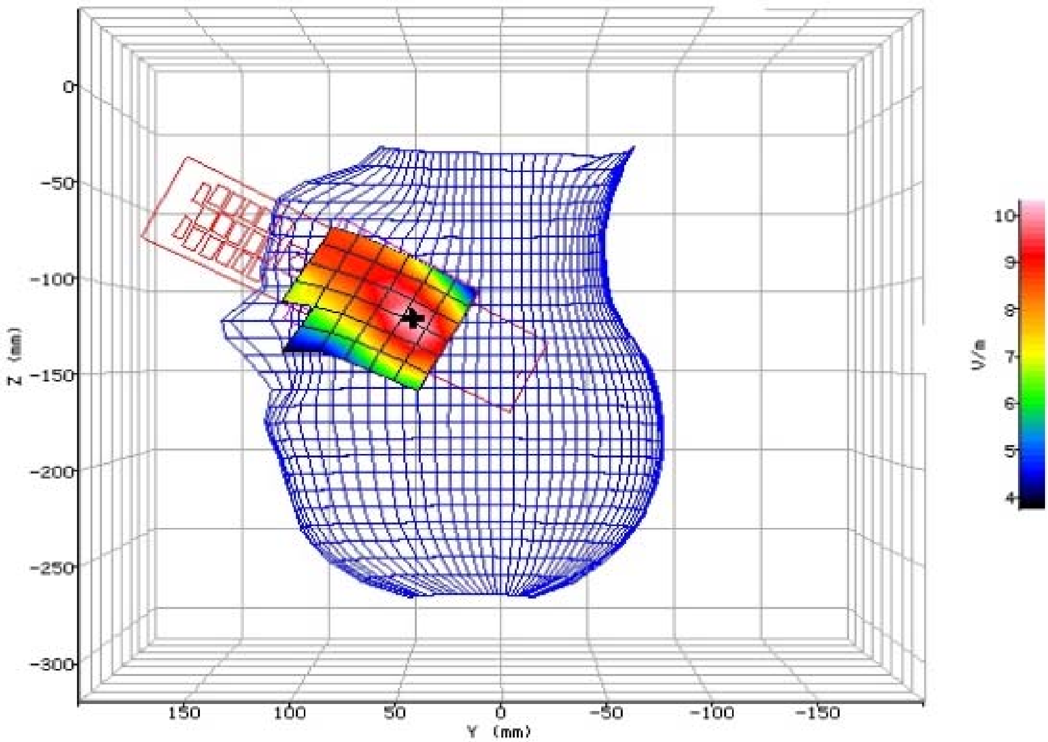

Figure 11: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-12:54:14	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	84.40mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-119.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	19.233
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.310 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.372 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.353 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	-5.200 %

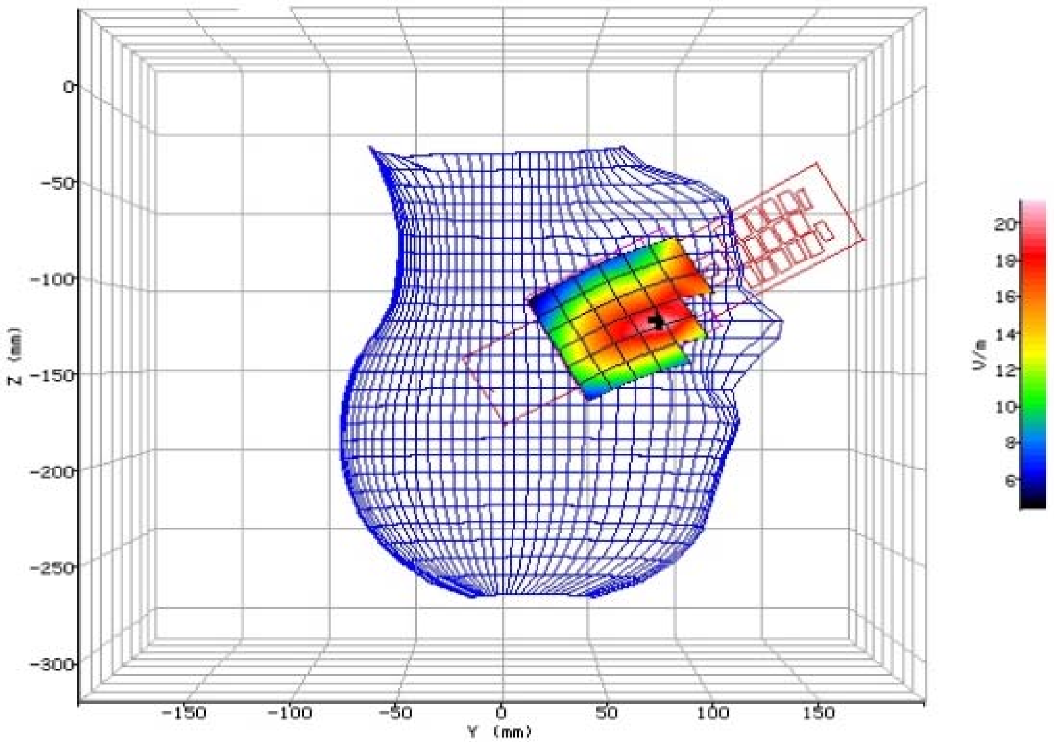

Figure 12: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-13:21:10	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	60.60mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-129.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.827
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.113 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.108 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.112 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	3.600 %

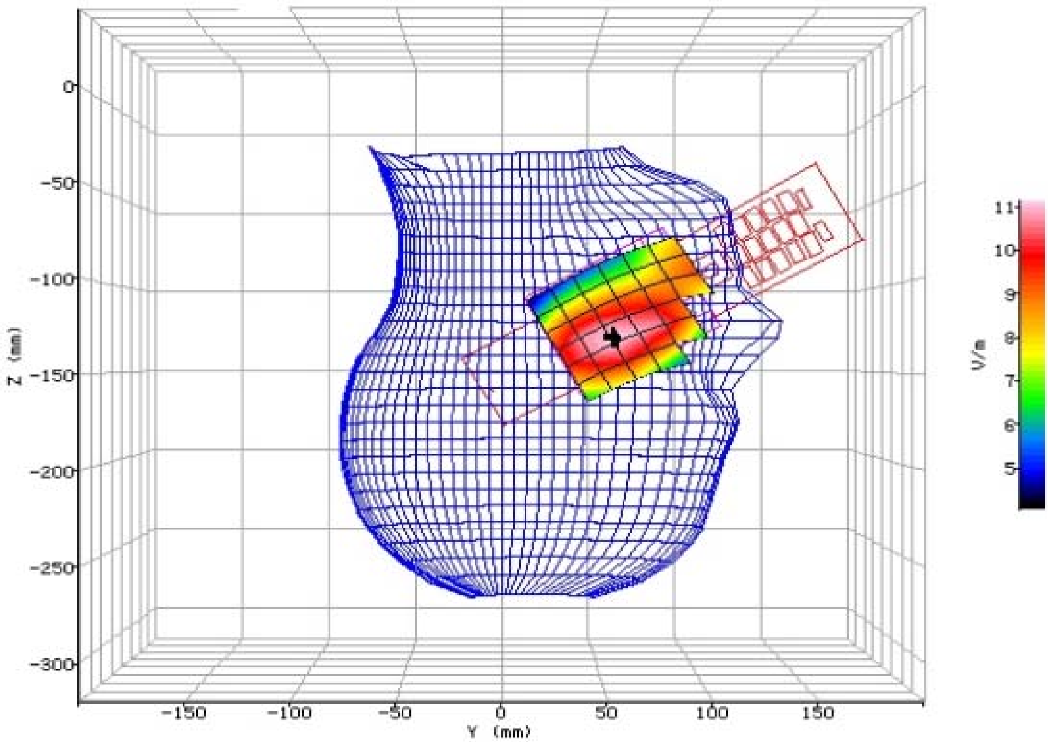

Figure 13: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

2.4 GSM 850MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-15:17:09	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-4.60mm
DUT POSITION:	10mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-1.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	24.787
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.521 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.505 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.532 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	5.500 %

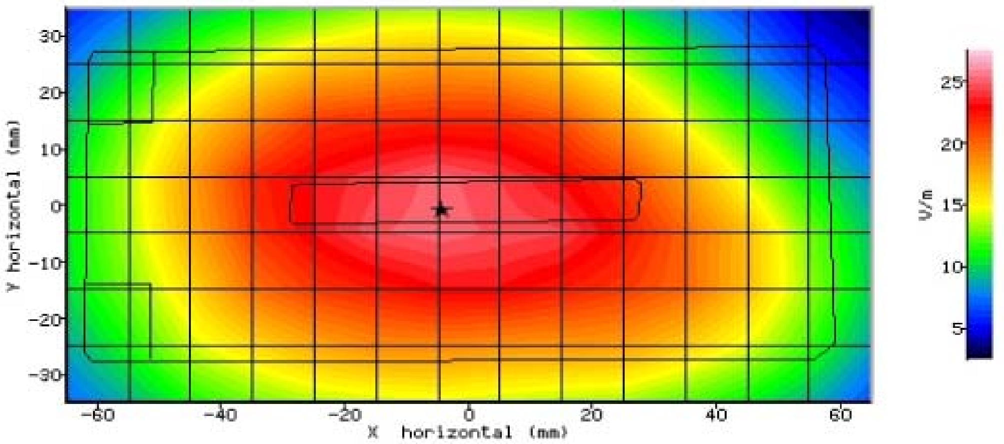

Figure 14: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-15:47:55	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-14.90mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	2.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	27.328
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.745 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.743 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.808 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	8.800 %

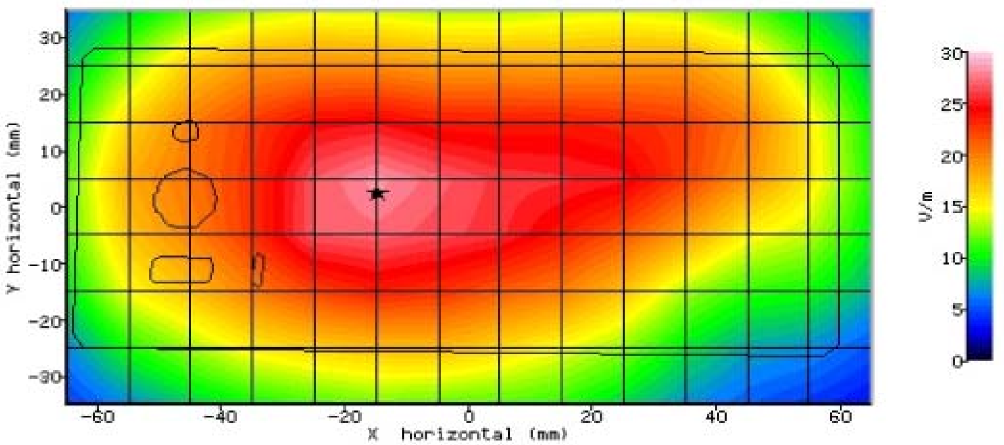

Figure 15: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-16:13:52	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-6.20mm
DUT POSITION:	10mm-Left Edge	MAX SAR Y-AXIS LOCATION:	3.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.146
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.400 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.386 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.385 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-0.400 %

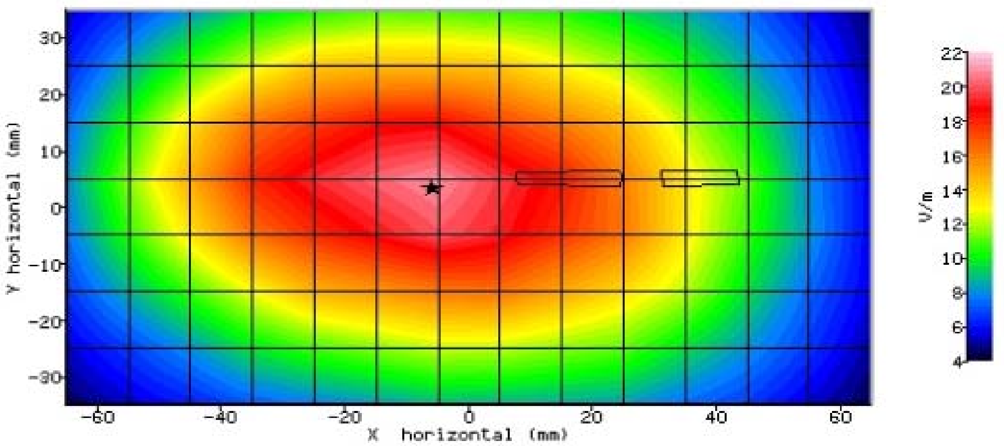

Figure 16: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-16:31:07	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	9.40mm
DUT POSITION:	10mm-Right Edge	MAX SAR Y-AXIS LOCATION:	3.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	22.178
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.497 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.500 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.498 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-0.400 %

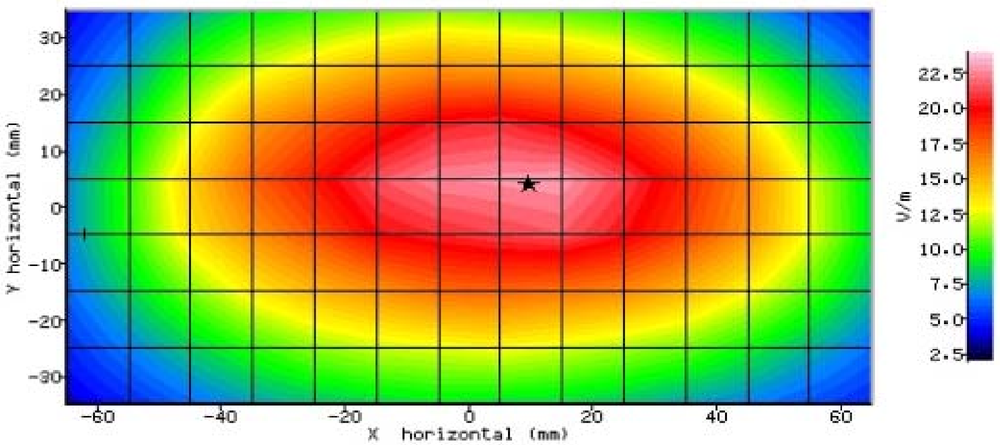

Figure 17: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-16:50:26	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	4.30mm
DUT POSITION:	10mm-Top Edge	MAX SAR Y-AXIS LOCATION:	11.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	8.316
TEST FREQUENCY:	848.8MHz	SAR 1g:	0.044 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.081 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.078 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-2.600 %

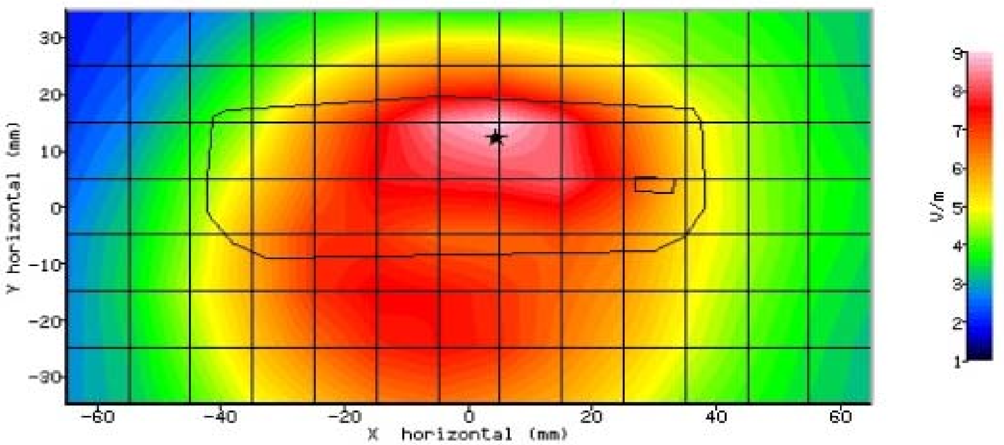

Figure 18: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 848.8MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-13:12:31	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-13.70mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	2.40mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	31.104
TEST FREQUENCY:	836.4MHz	SAR 1g:	0.961 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.947 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	0.880 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-7.100 %

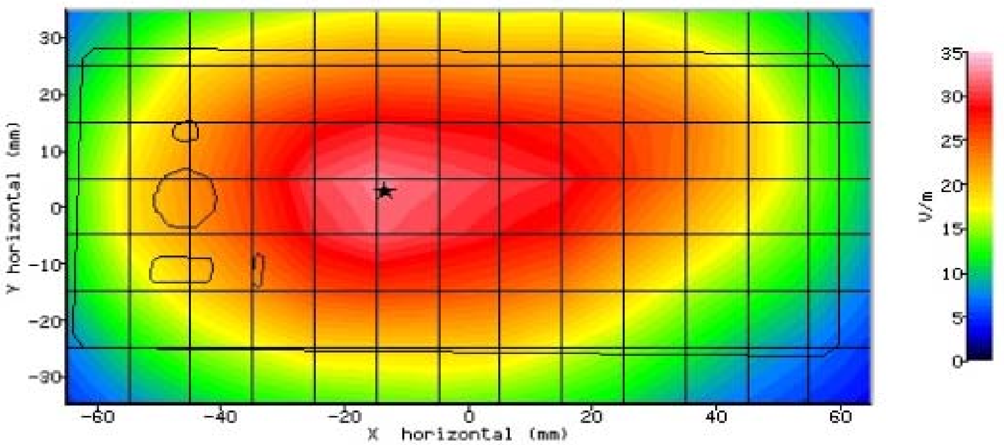

Figure 19: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 836.4MHz.

COMMERCIAL-IN-CONFIDENCE

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-13:31:17	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	47.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-16.70mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	3.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	30.329
TEST FREQUENCY:	824.2MHz	SAR 1g:	0.914 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.923 W/kg
INPUT POWER LEVEL:	30.8dBm	SAR END:	1.001 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	8.500 %

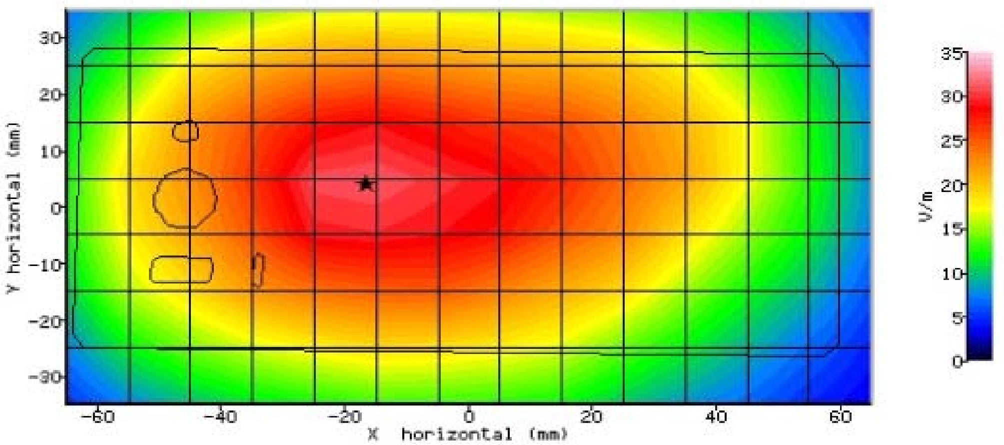

Figure 20: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 824.2MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-16:24:32	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	83.10mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-87.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.902
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.393 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.390 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.384 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	-1.600 %

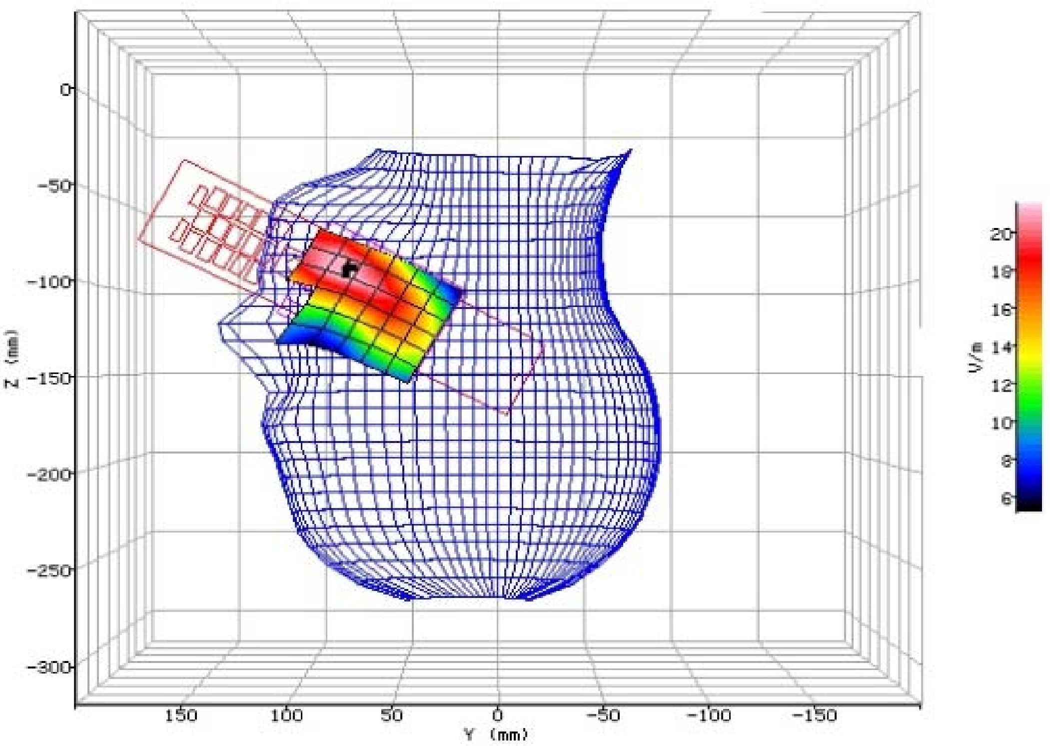

Figure 21: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-09:52:36	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.50°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	51.90mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-113.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.191
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.118 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.118 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.117 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	-0.300 %

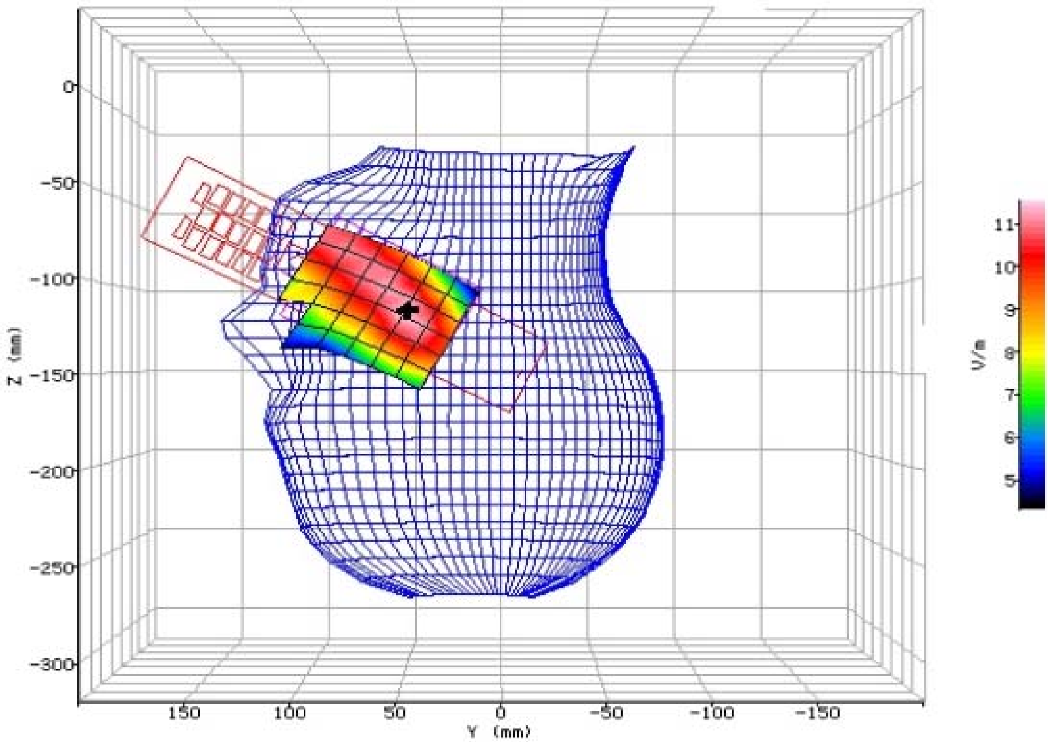

Figure 22: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-10:39:57	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	30.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.90°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	85.90mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-118.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.187
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.374 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.420 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.427 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	1.800 %

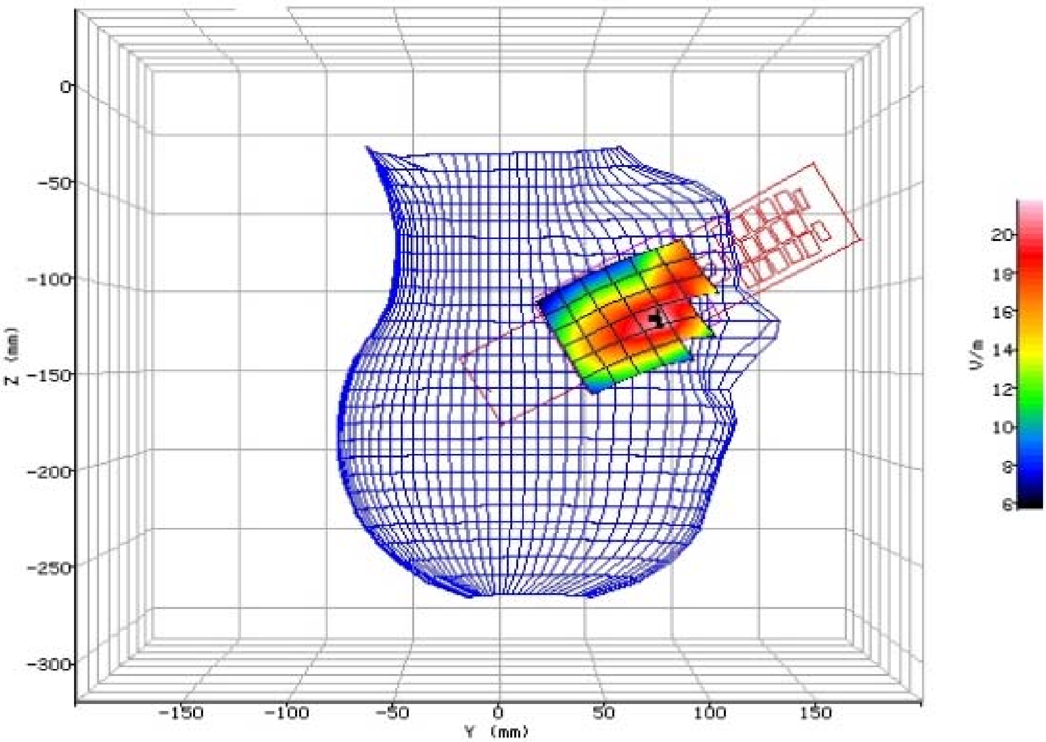

Figure 23: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-11:04:22	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	850 Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	41.84
RELATIVE HUMIDITY:	30.40%	CONDUCTIVITY:	0.893
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.90°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	68.10mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-128.30mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.788
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.119 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.125 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.124 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-0.400 %

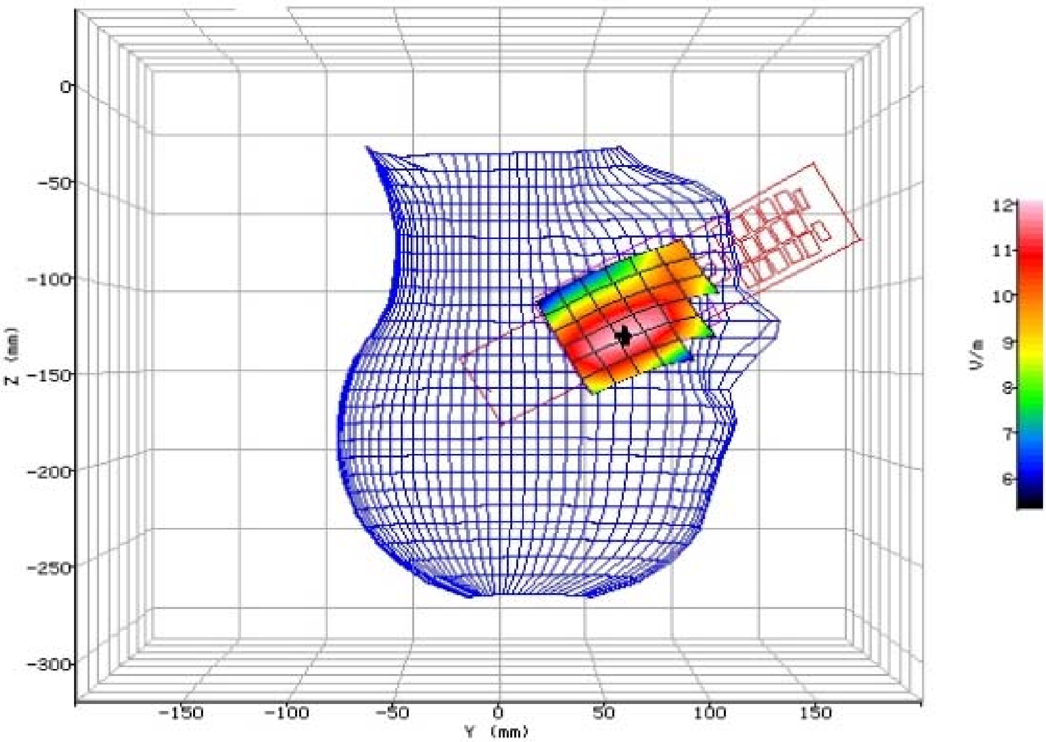

Figure 24: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-09:06:28	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-8.20mm
DUT POSITION:	10mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-3.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	23.275
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.527 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.535 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.519 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-2.900 %

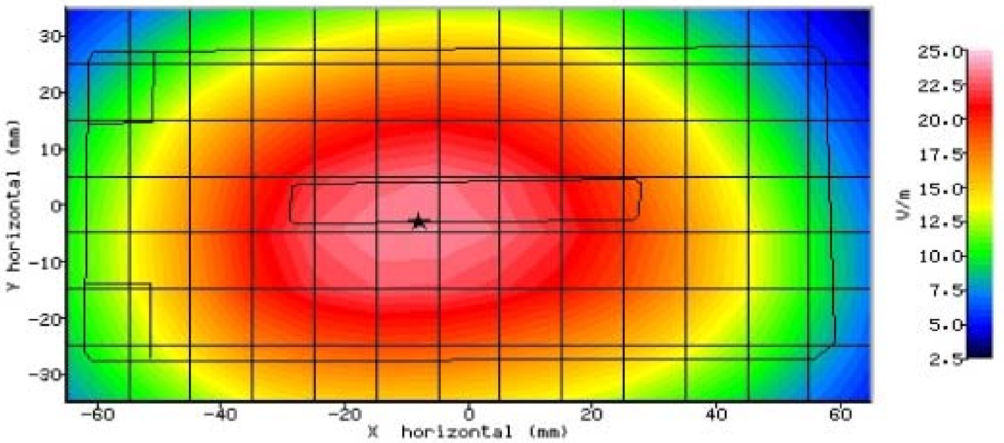

Figure 25: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-09:26:46	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-14.80mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	3.30mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	29.234
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.844 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.835 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.826 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-1.100 %

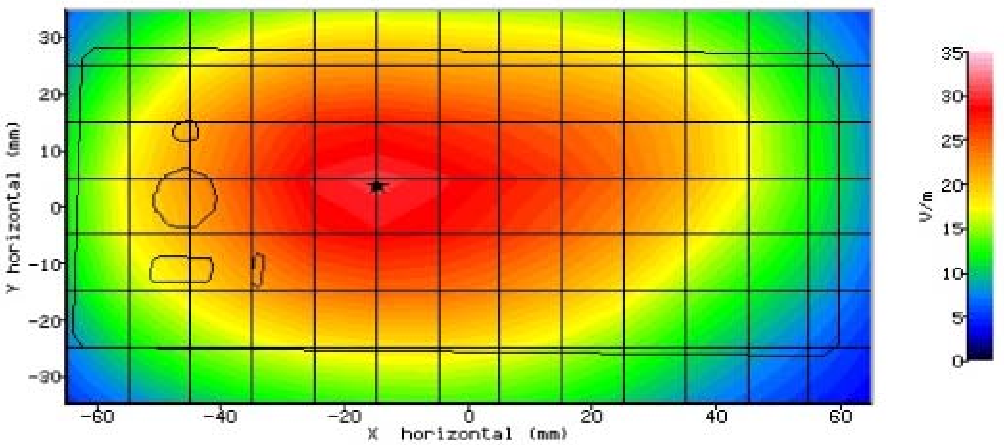

Figure 26: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-10:16:10	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-6.90mm
DUT POSITION:	10mm-Left Edge	MAX SAR Y-AXIS LOCATION:	4.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.642
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.429 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.427 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.424 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.700 %

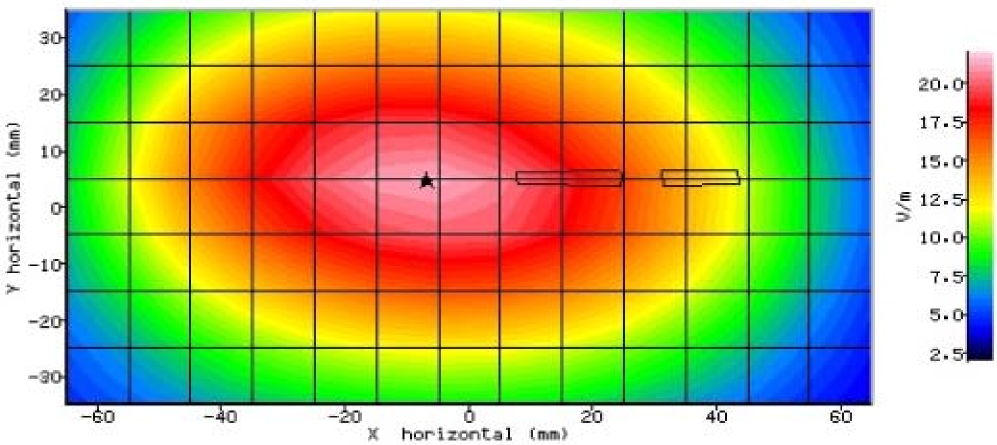

Figure 27: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-10:37:25	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-4.20mm
DUT POSITION:	10mm-Right Edge	MAX SAR Y-AXIS LOCATION:	2.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	22.643
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.516 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.523 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.529 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	1.300 %

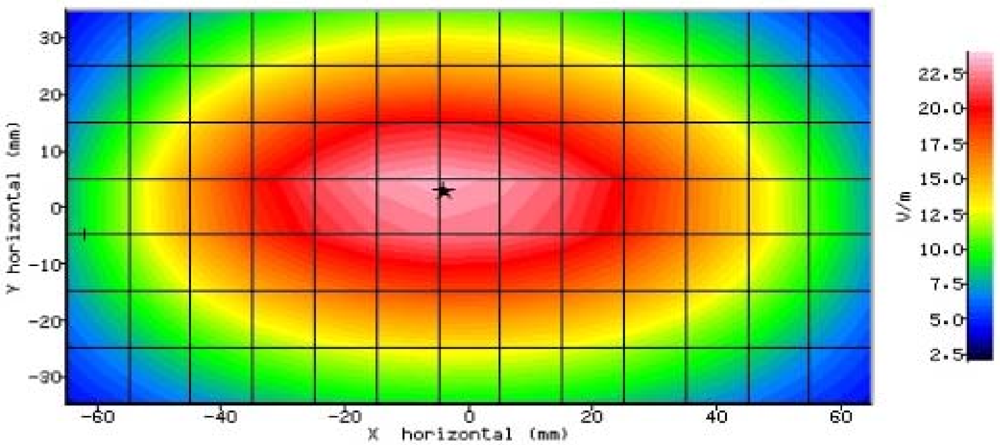

Figure 28: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-10:57:48	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	6.10mm
DUT POSITION:	10mm-Top Edge	MAX SAR Y-AXIS LOCATION:	10.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.981
TEST FREQUENCY:	826.4MHz	SAR 1g:	0.040 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.040 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.039 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.100 %

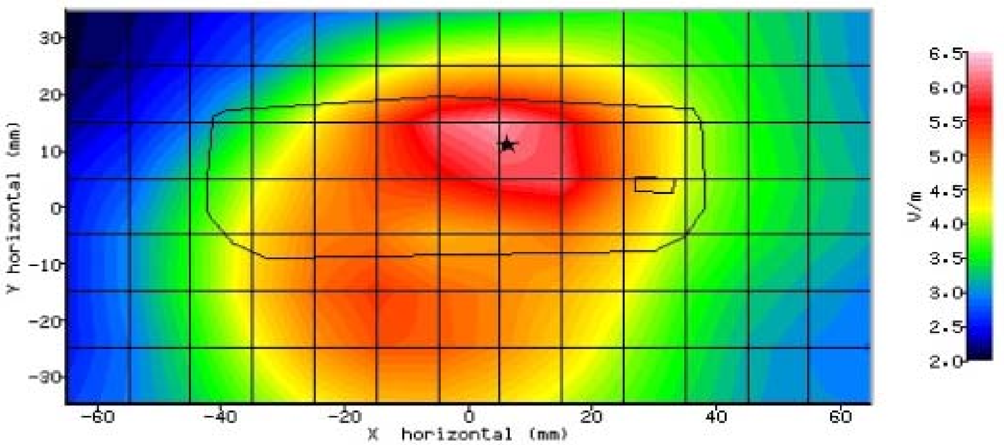

Figure 29: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 826.4MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-11:26:57	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-11.20mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	3.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	28.101
TEST FREQUENCY:	835.0MHz	SAR 1g:	0.781 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.790 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.788 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.200 %

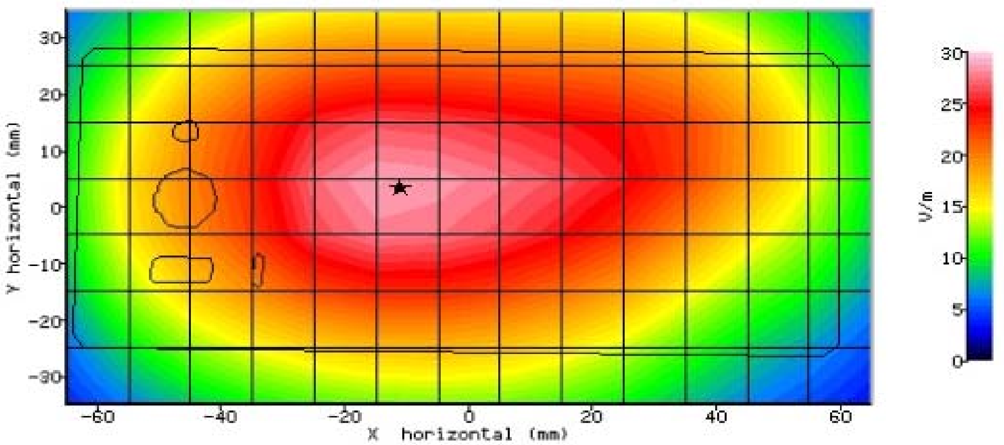

Figure 30: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 835.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-11:50:51	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.30°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	35.80%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-11.00mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	1.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	24.631
TEST FREQUENCY:	846.6MHz	SAR 1g:	0.624 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.628 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.612 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-2.600 %

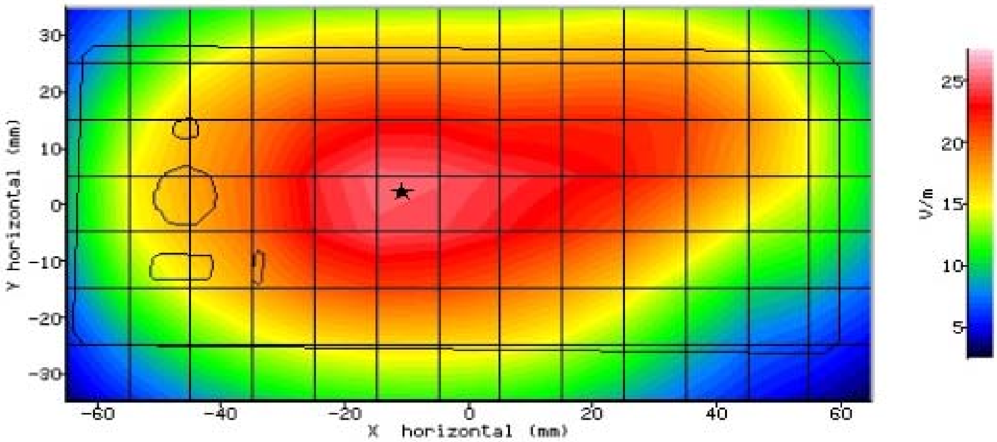

Figure 31: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 846.6MHz.

Product Service

2.7 LTE BAND 26 850MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-14:22:56	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-7.20mm
DUT POSITION:	10mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-2.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	23.189
TEST FREQUENCY:	831.5MHz	SAR 1g:	0.525 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.529 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.510 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-3.600 %

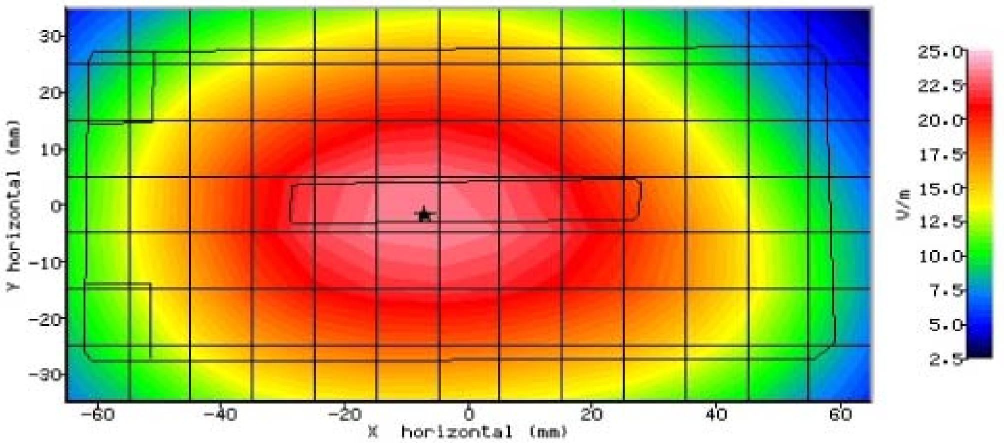

Figure 32: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 831.5MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-14:39:54	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-12.90mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	2.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	27.260
TEST FREQUENCY:	831.5MHz	SAR 1g:	0.723 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.732 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.715 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-2.400 %

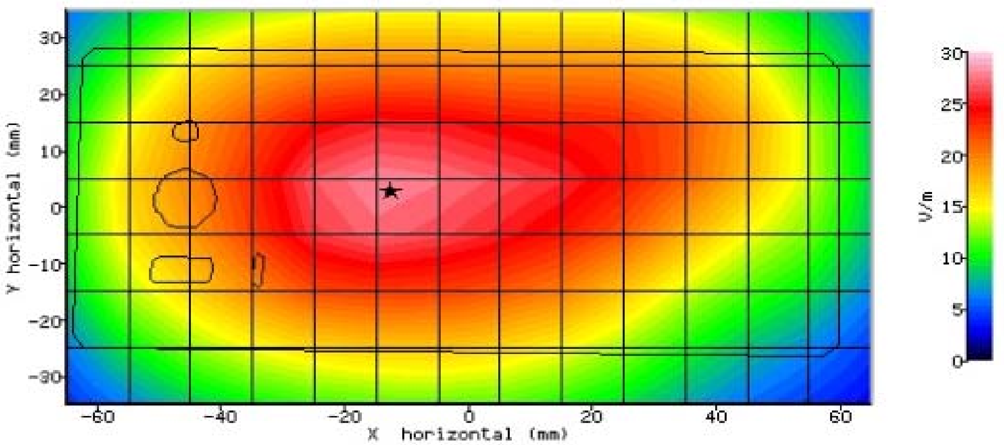

Figure 33: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 831.5MHz.

COMMERCIAL-IN-CONFIDENCE

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-15:04:49	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-5.00mm
DUT POSITION:	10mm-Left Edge	MAX SAR Y-AXIS LOCATION:	2.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	20.051
TEST FREQUENCY:	831.5MHz	SAR 1g:	0.406 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.403 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.401 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.400 %

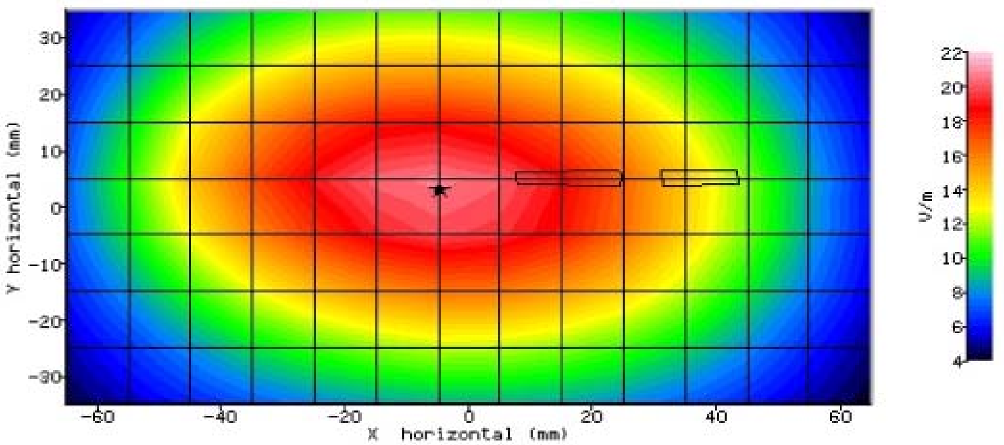

Figure 34: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 831.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-15:23:29	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	3.80mm
DUT POSITION:	10mm-Right Edge	MAX SAR Y-AXIS LOCATION:	2.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	22.028
TEST FREQUENCY:	831.5MHz	SAR 1g:	0.497 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.497 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.497 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.100 %

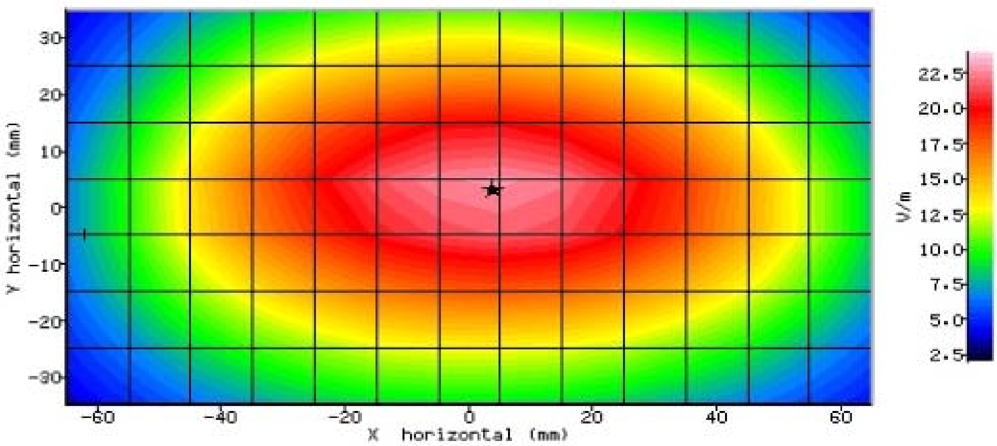

Figure 35: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 831.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-15:41:04	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	8.20mm
DUT POSITION:	10mm-Top Edge	MAX SAR Y-AXIS LOCATION:	9.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	6.212
TEST FREQUENCY:	831.5MHz	SAR 1g:	0.043 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.043 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.043 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.800 %

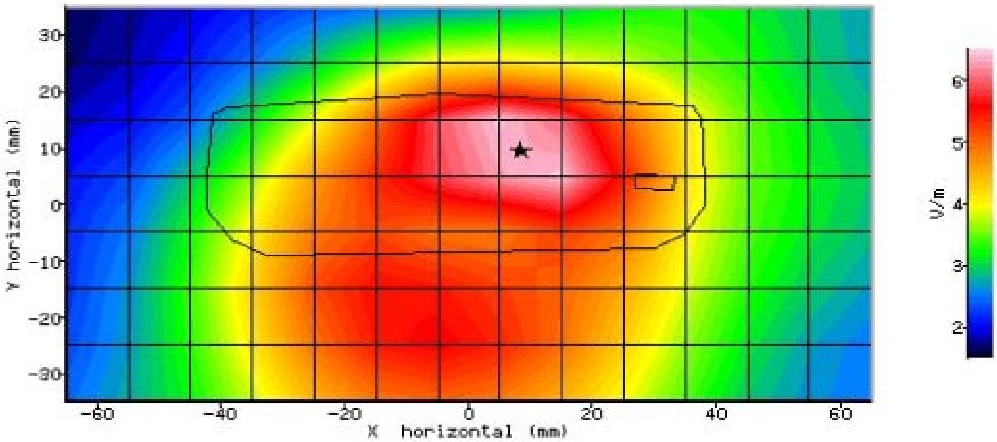

Figure 36: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 831.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-16:06:39	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-11.50mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	1.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	29.729
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.878 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.885 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.806 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-9.000 %

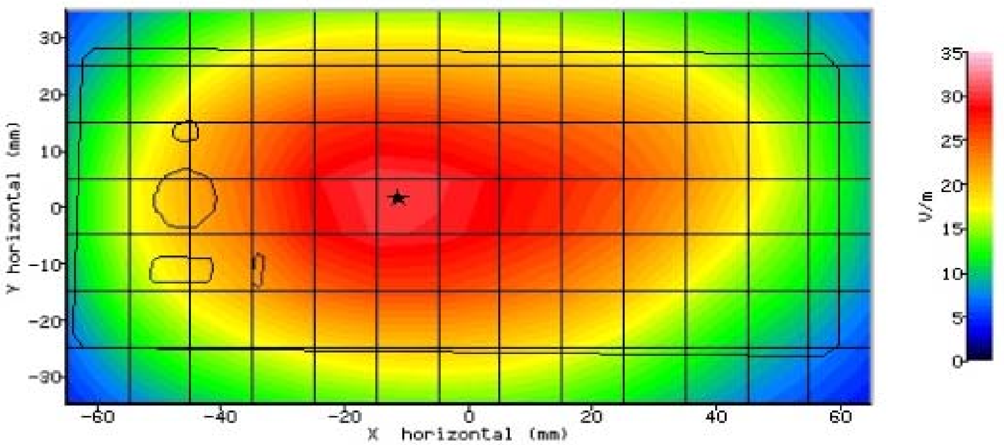

Figure 37: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-16:24:45	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	30.30%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-12.00mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	-1.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	22.770
TEST FREQUENCY:	841.5MHz	SAR 1g:	0.522 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.524 W/kg
INPUT POWER LEVEL:	24.2dBm	SAR END:	0.519 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-0.900 %

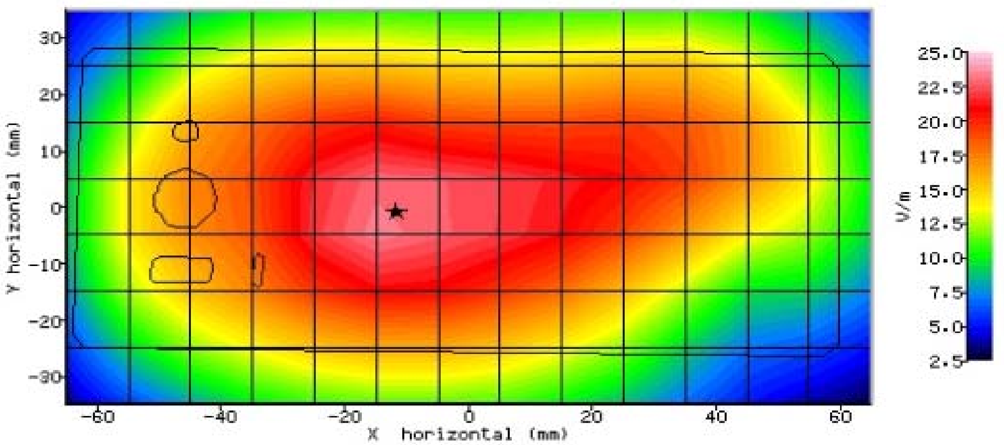

Figure 38: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 841.5MHz.

Product Service

2.8 LTE BAND 26 850MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	04/06/2015-10:43:31	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	39.50%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-8.20mm
DUT POSITION:	10mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-3.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	19.830
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.385 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.384 W/kg
INPUT POWER LEVEL:	23.2dBm	SAR END:	0.372 W/kg
PROBE BATTERY LAST CHANGED:	04/06/2015	SAR DRIFT DURING SCAN:	-3.300 %

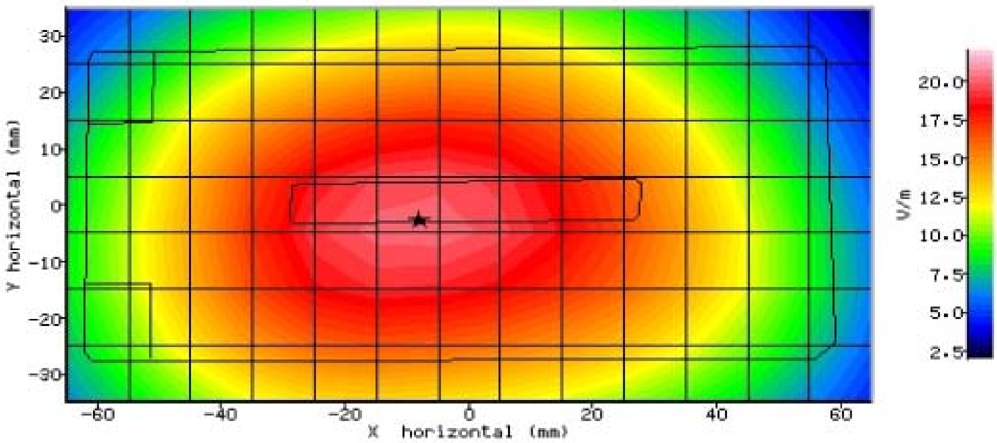

Figure 39: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	04/06/2015-11:02:01	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	39.50%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-13.90mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	5.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	25.099
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.624 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.643 W/kg
INPUT POWER LEVEL:	23.2dBm	SAR END:	0.618 W/kg
PROBE BATTERY LAST CHANGED:	04/06/2015	SAR DRIFT DURING SCAN:	-3.900 %

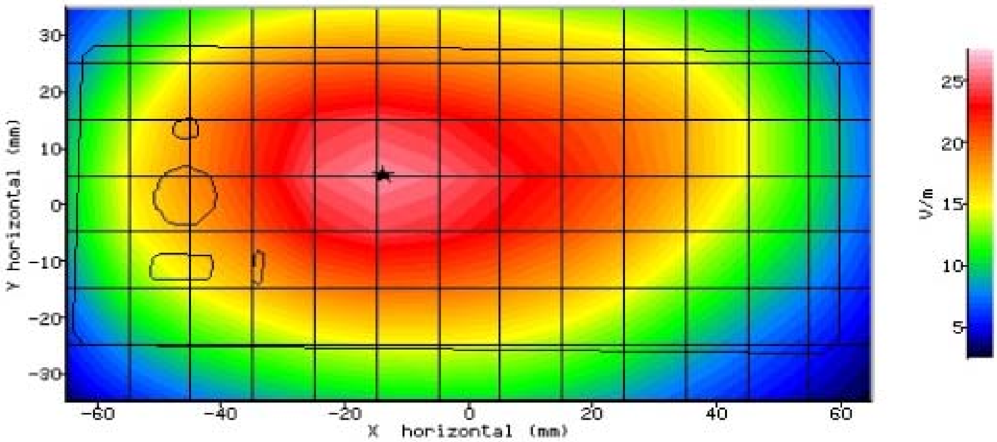

Figure 40: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	04/06/2015-09:45:02	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	39.50%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-7.00mm
DUT POSITION:	10mm-Left Edge	MAX SAR Y-AXIS LOCATION:	4.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	17.457
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.309 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.312 W/kg
INPUT POWER LEVEL:	23.2dBm	SAR END:	0.308 W/kg
PROBE BATTERY LAST CHANGED:	04/06/2015	SAR DRIFT DURING SCAN:	-1.500 %

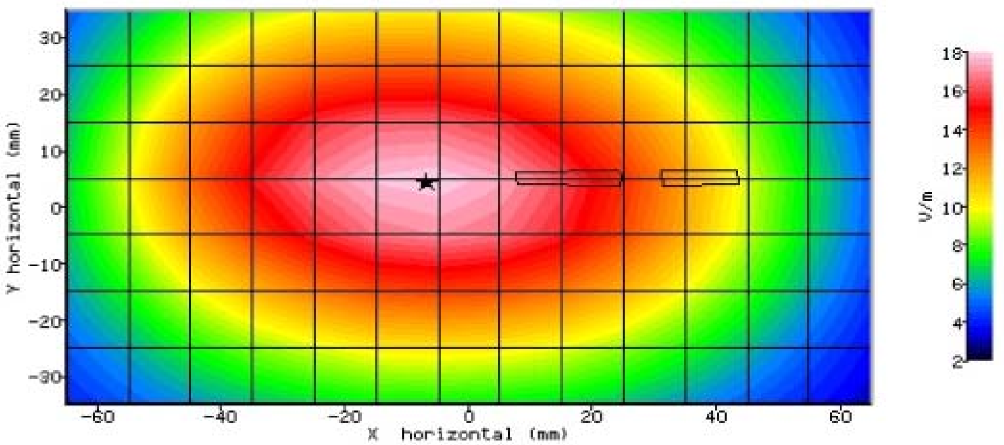

Figure 41: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	04/06/2015-10:03:44	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	39.50%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-7.20mm
DUT POSITION:	10mm-Right Edge	MAX SAR Y-AXIS LOCATION:	1.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	19.452
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.376 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.380 W/kg
INPUT POWER LEVEL:	23.2dBm	SAR END:	0.380 W/kg
PROBE BATTERY LAST CHANGED:	04/06/2015	SAR DRIFT DURING SCAN:	0.000 %

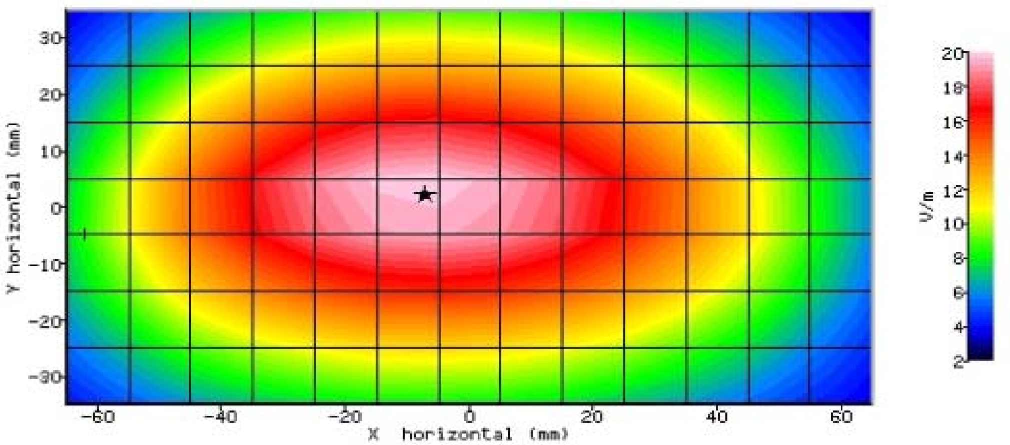

Figure 42: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

COMMERCIAL-IN-CONFIDENCE

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	04/06/2015-10:21:06	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	850 Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.90
RELATIVE HUMIDITY:	39.50%	CONDUCTIVITY:	0.945
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	3.60mm
DUT POSITION:	10mm-Top Edge	MAX SAR Y-AXIS LOCATION:	12.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.158
TEST FREQUENCY:	821.5MHz	SAR 1g:	0.028 W/kg
TYPE OF MODULATION:	QPSK (LTE)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.028 W/kg
INPUT POWER LEVEL:	23.2dBm	SAR END:	0.028 W/kg
PROBE BATTERY LAST CHANGED:	04/06/2015	SAR DRIFT DURING SCAN:	0.800 %

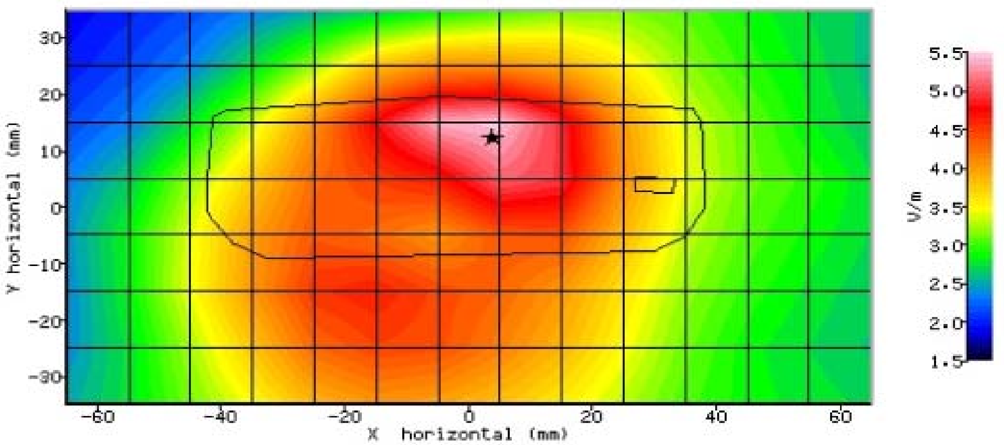

Figure 43: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 821.5MHz.

Product Service

2.9 GSM 1900MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-14:10:41	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	28.90%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	80.10mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-94.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.658
TEST FREQUENCY:	1880MHz	SAR 1g:	0.189 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.218 W/kg
INPUT POWER LEVEL:	30.5dBm	SAR END:	0.208 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-4.500 %

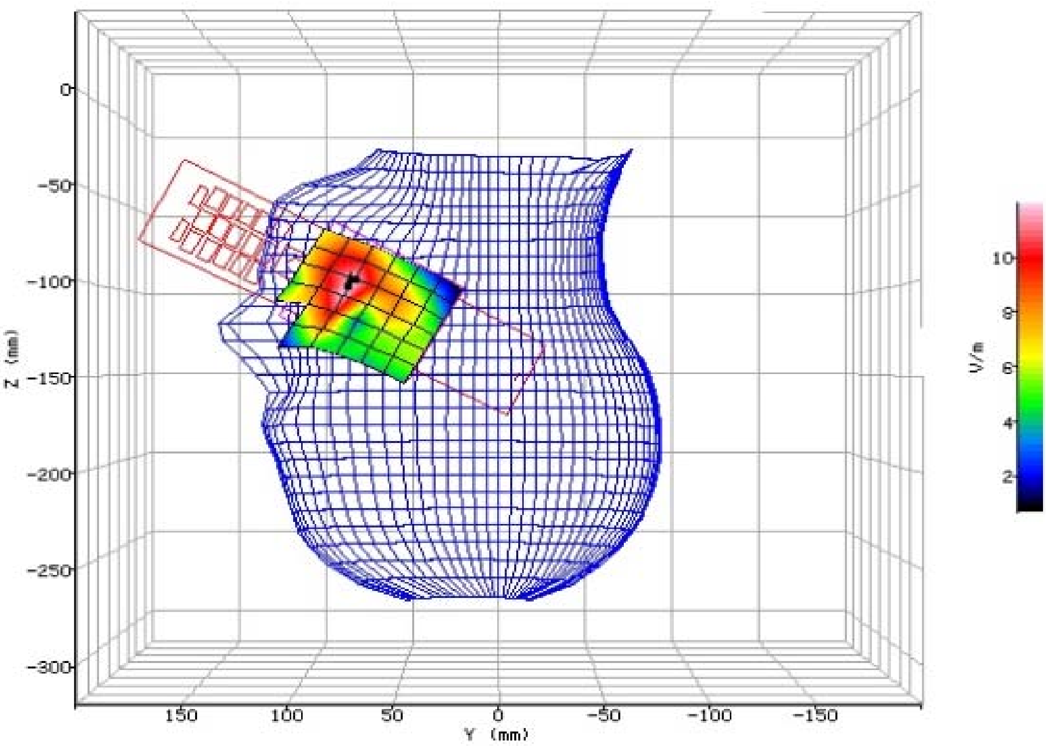

Figure 44: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-15:05:12	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	28.90%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	26.60mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-149.10mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	6.999
TEST FREQUENCY:	1880MHz	SAR 1g:	0.093 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.085 W/kg
INPUT POWER LEVEL:	30.5dBm	SAR END:	0.083 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-2.300 %

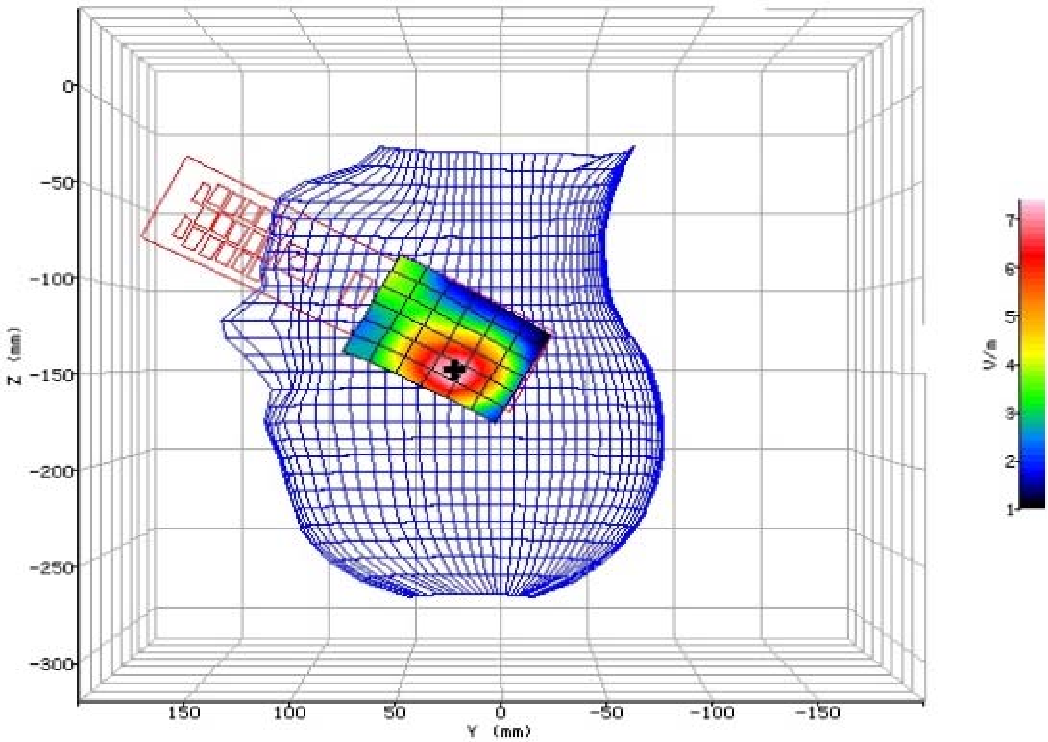

Figure 45: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-15:36:21	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	28.90%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	91.10mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-110.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.064
TEST FREQUENCY:	1880MHz	SAR 1g:	0.245 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.210 W/kg
INPUT POWER LEVEL:	30.5dBm	SAR END:	0.221 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	4.800 %

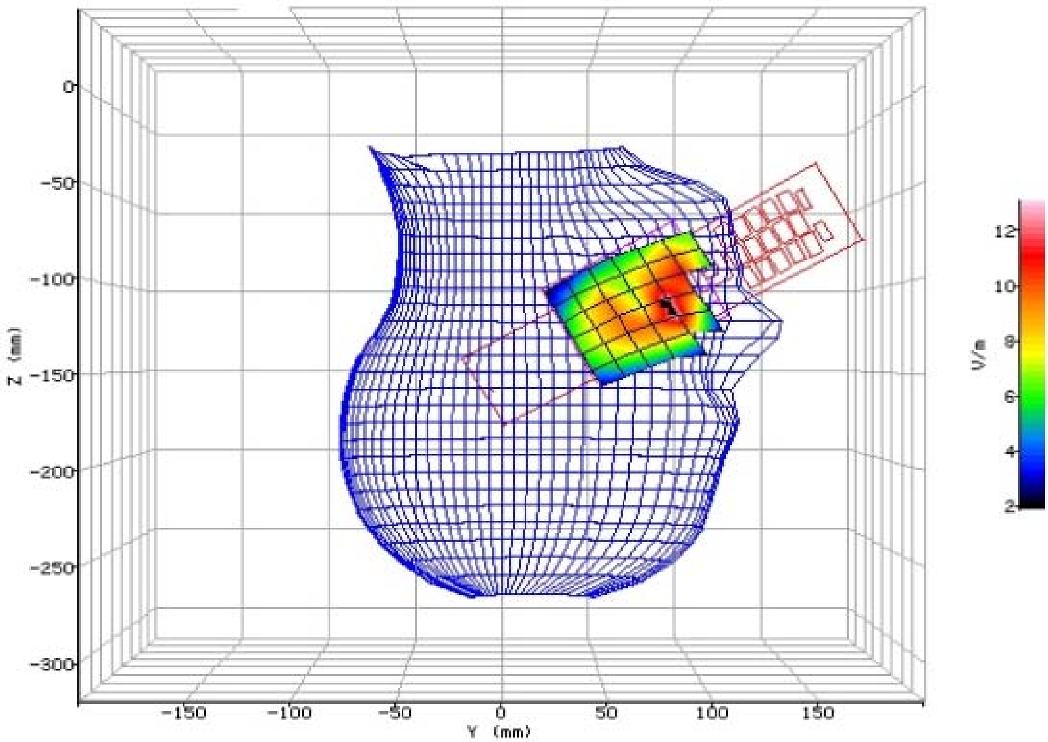

Figure 46: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-16:33:02	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.00°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	28.90%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	21.90mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-141.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	7.518
TEST FREQUENCY:	1880MHz	SAR 1g:	0.079 W/kg
TYPE OF MODULATION:	GMSK (Voice Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	12.5%	SAR START:	0.102 W/kg
INPUT POWER LEVEL:	30.5dBm	SAR END:	0.096 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	-5.200 %

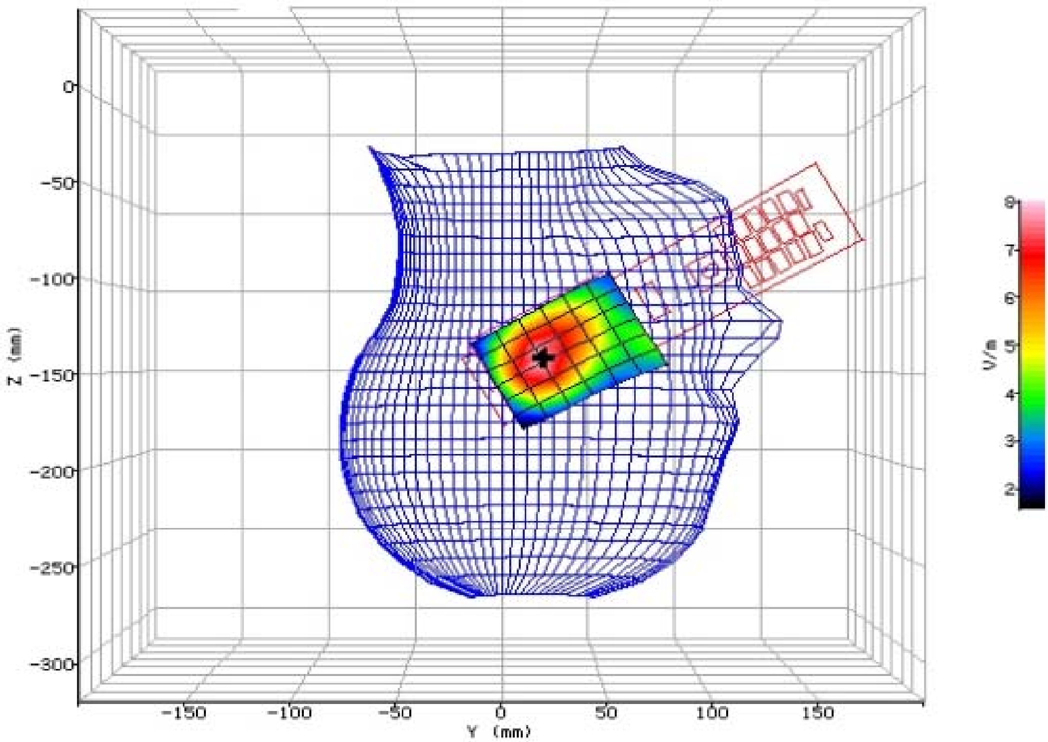

Figure 47: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

2.10 GSM 1900MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-10:59:04	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	31.00%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	82.20mm
DUT POSITION:	Left-Cheek	MAX SAR Z-AXIS LOCATION:	-92.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.688
TEST FREQUENCY:	1880MHz	SAR 1g:	0.218 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.282 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.263 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-6.500 %

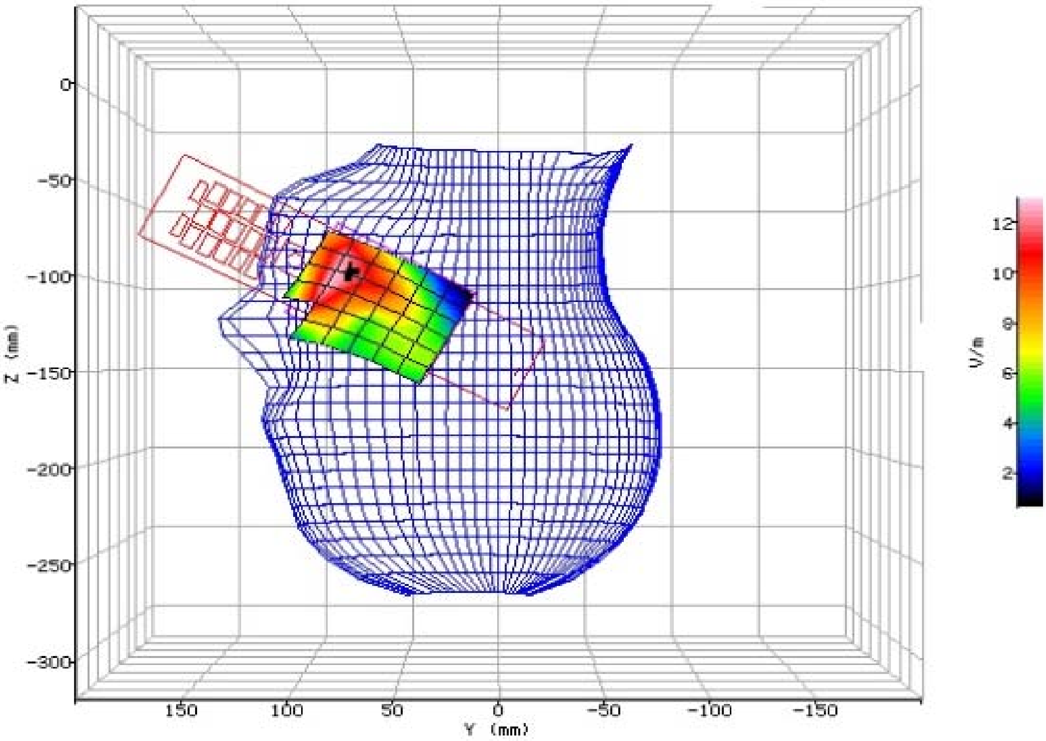

Figure 48: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-11:37:31	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	31.00%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	26.60mm
DUT POSITION:	Left-15°	MAX SAR Z-AXIS LOCATION:	-149.70mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	7.506
TEST FREQUENCY:	1880MHz	SAR 1g:	0.094 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.097 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.092 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-5.000 %

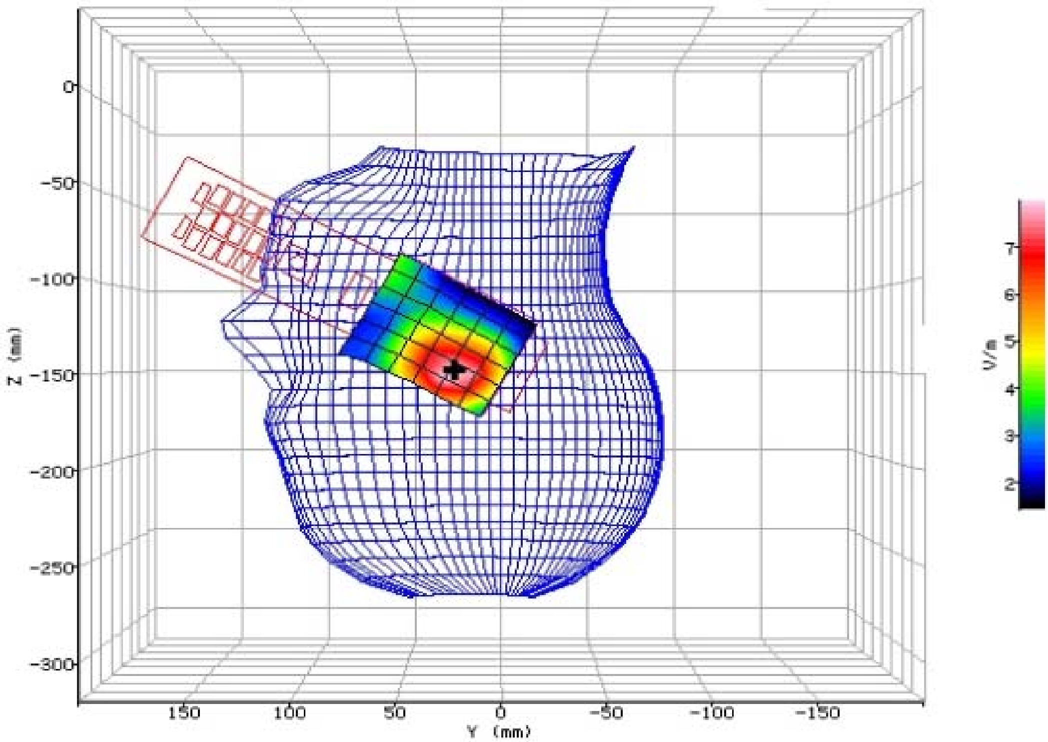

Figure 49: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-08:55:58	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	31.00%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	89.10mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-120.20mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.135
TEST FREQUENCY:	1880MHz	SAR 1g:	0.285 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.183 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.187 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	1.800 %

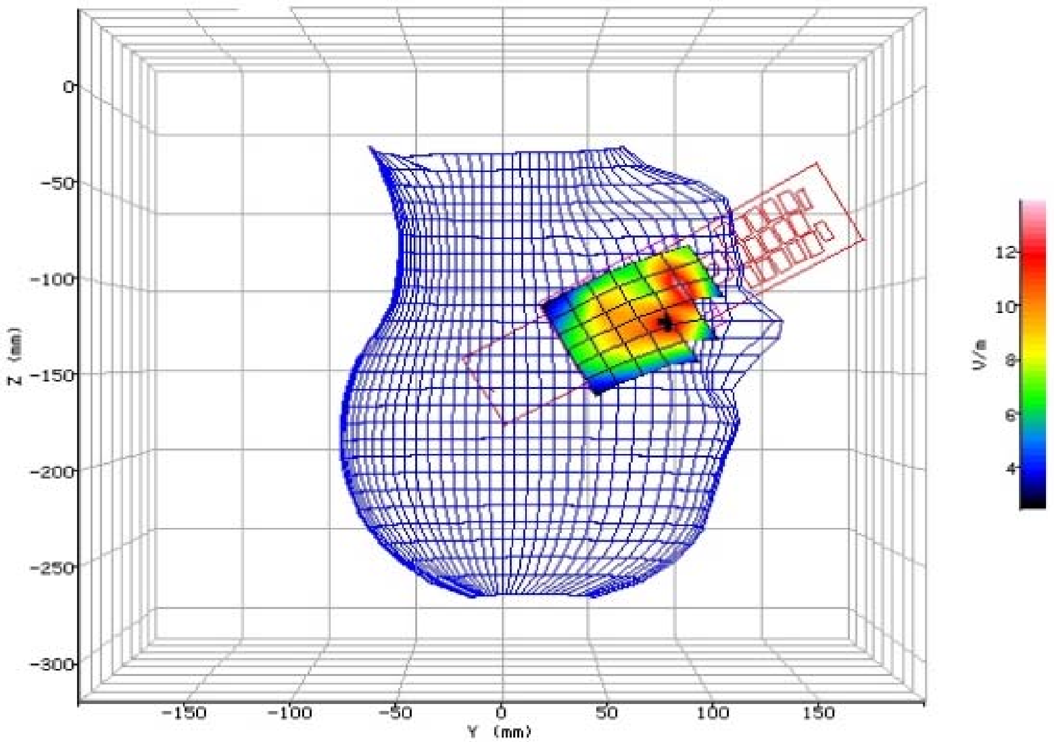

Figure 50: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-10:23:53	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	1900Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	40.75
RELATIVE HUMIDITY:	31.00%	CONDUCTIVITY:	1.448
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.10°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	21.60mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-143.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	7.964
TEST FREQUENCY:	1880MHz	SAR 1g:	0.099 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.104 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.107 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	2.800 %

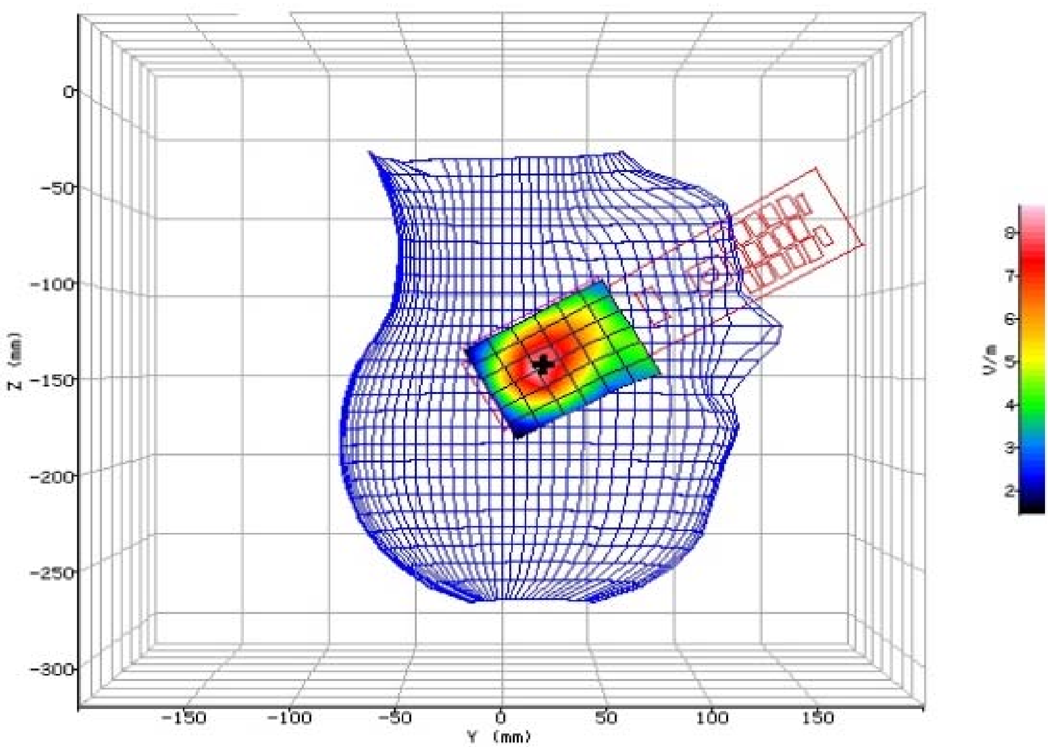

Figure 51: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

2.11 GSM 1900MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-14:21:41	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	54.48
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	1.576
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.00°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-35.60mm
DUT POSITION:	10mm-Front Facing	MAX SAR Y-AXIS LOCATION:	-9.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.397
TEST FREQUENCY:	1880MHz	SAR 1g:	0.163 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.170 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.168 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-1.200 %

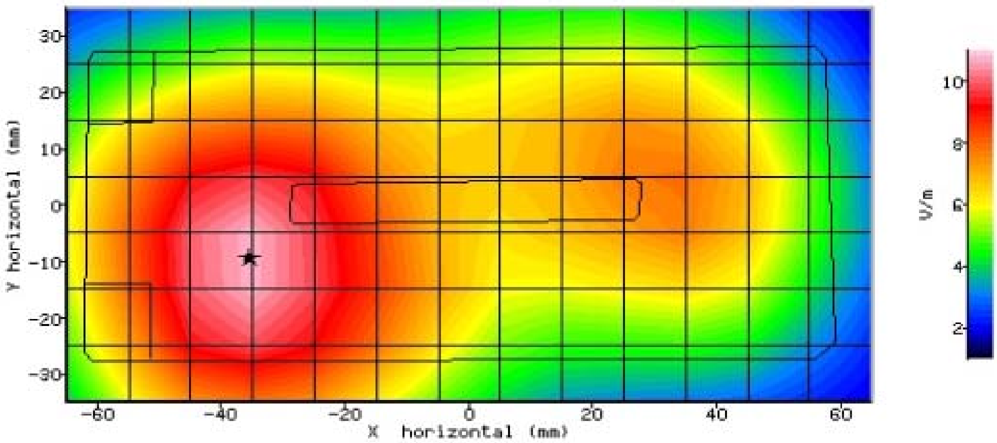

Figure 52: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-14:42:25	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	54.48
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	1.576
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.00°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-36.90mm
DUT POSITION:	10mm-Rear Facing	MAX SAR Y-AXIS LOCATION:	17.80mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	12.902
TEST FREQUENCY:	1880MHz	SAR 1g:	0.268 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.282 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.273 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-3.200 %

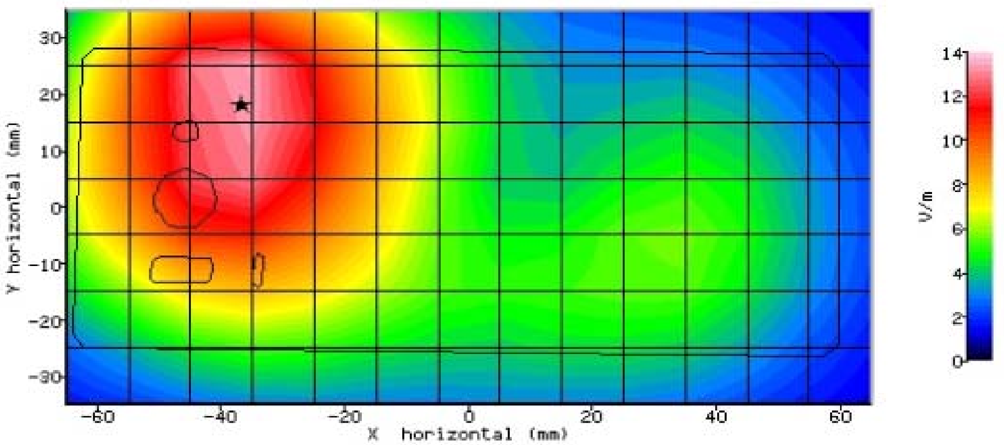

Figure 53: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-15:17:07	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	54.48
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	1.576
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.00°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-35.80mm
DUT POSITION:	10mm-Right Edge	MAX SAR Y-AXIS LOCATION:	-4.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	10.065
TEST FREQUENCY:	1880MHz	SAR 1g:	0.179 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.202 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.189 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	-6.400 %

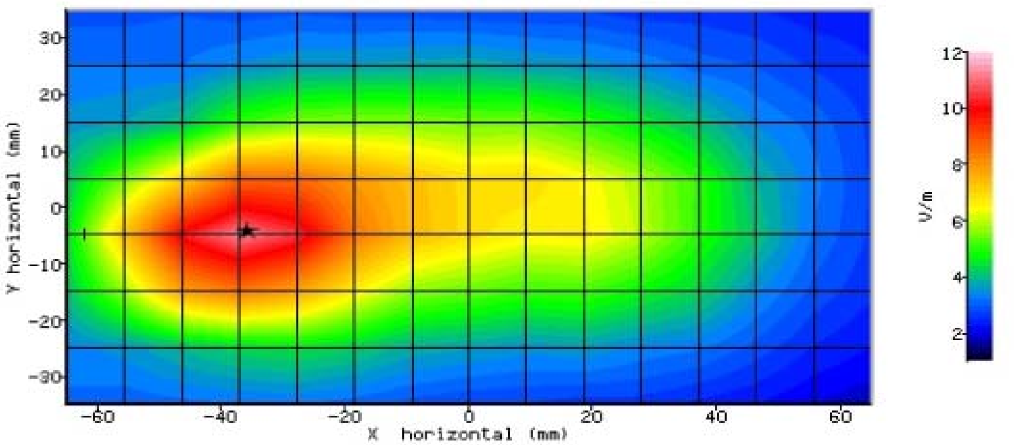

Figure 54: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	03/06/2015-16:02:36	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.20°C	LIQUID SIMULANT:	1900Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	54.48
RELATIVE HUMIDITY:	31.60%	CONDUCTIVITY:	1.576
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.00°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	4.30mm
DUT POSITION:	10mm-Top Edge	MAX SAR Y-AXIS LOCATION:	-3.00mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	11.798
TEST FREQUENCY:	1880MHz	SAR 1g:	0.231 W/kg
TYPE OF MODULATION:	GMSK (GPRS Mode)	SAR 10g:	N/A
MODN. DUTY CYCLE:	25%	SAR START:	0.246 W/kg
INPUT POWER LEVEL:	28.3dBm	SAR END:	0.258 W/kg
PROBE BATTERY LAST CHANGED:	03/06/2015	SAR DRIFT DURING SCAN:	4.800 %

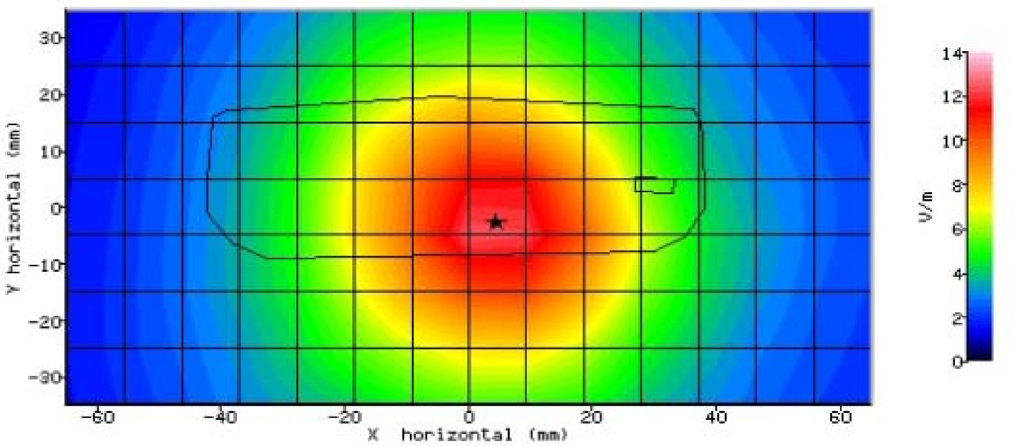

Figure 55: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 1880.0MHz.

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Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	01/06/2015-14:51:02	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	2450Head
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	39.74
RELATIVE HUMIDITY:	29.80%	CONDUCTIVITY:	1.849
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.80°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	84.60mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-98.60mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.594
TEST FREQUENCY:	2412.0MHz	SAR 1g:	0.066 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.070 W/kg
INPUT POWER LEVEL:	17dBm	SAR END:	0.073 W/kg
PROBE BATTERY LAST CHANGED:	01/06/2015	SAR DRIFT DURING SCAN:	4.300 %

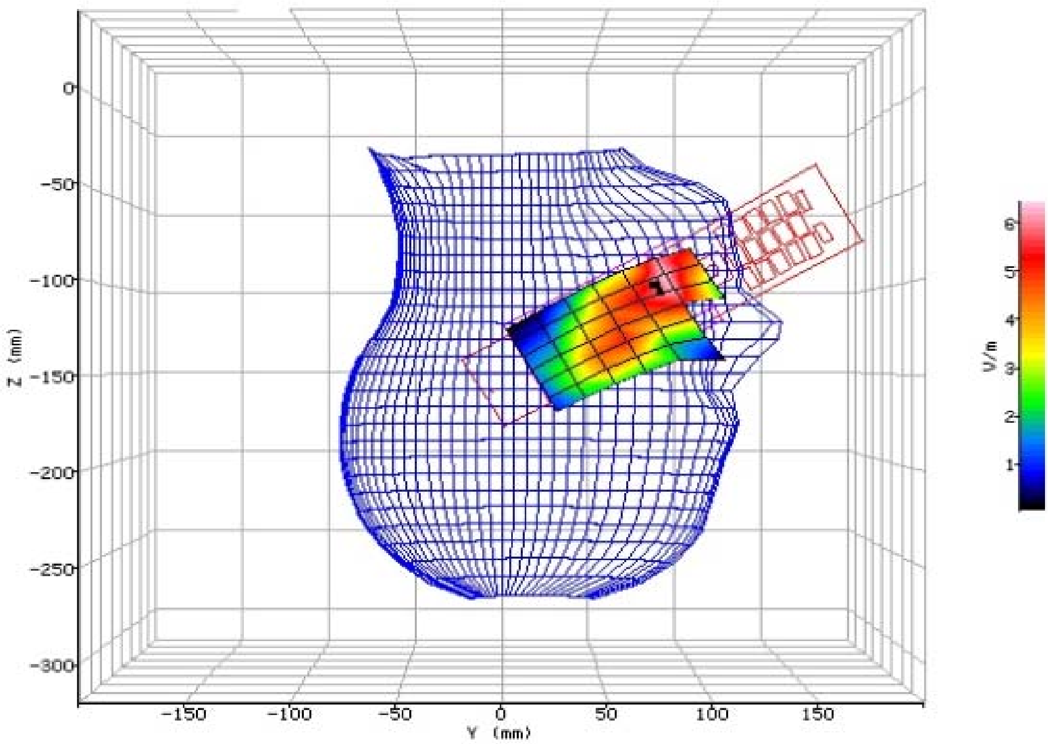

Figure 56: SAR Head Testing Results for the Sharp SHF32 Mobile Handset at 2412.0MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.15	INPUT POWER DRIFT:	0 dB
DATE / TIME:	02/06/2015-13:21:29	DUT BATTERY MODEL/NO:	SHF31UAA
AMBIENT TEMPERATURE:	23.40°C	LIQUID SIMULANT:	2450Body
DEVICE UNDER TEST:	SHF32	RELATIVE PERMITTIVITY:	52.12
RELATIVE HUMIDITY:	49.10%	CONDUCTIVITY:	1.986
PHANTOM S/NO:	IXB-2HF	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR X-AXIS LOCATION:	-26.60mm
DUT POSITION:	10mm-Left Edge	MAX SAR Y-AXIS LOCATION:	5.50mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	8.920
TEST FREQUENCY:	2412.0MHz	SAR 1g:	0.195 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	SAR 10g:	N/A
MODN. DUTY CYCLE:	100%	SAR START:	0.209 W/kg
INPUT POWER LEVEL:	17dBm	SAR END:	0.210 W/kg
PROBE BATTERY LAST CHANGED:	02/06/2015	SAR DRIFT DURING SCAN:	0.700 %

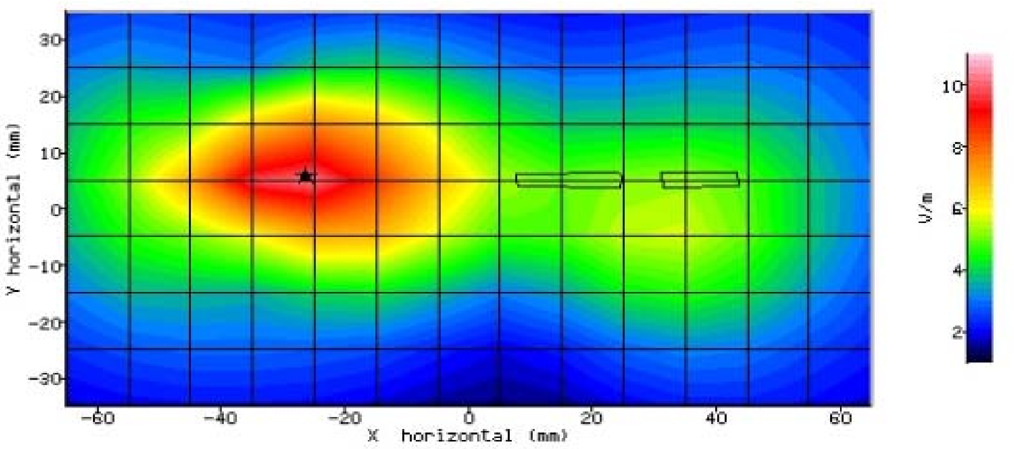

Figure 57: SAR Body Testing Results for the Sharp SHF32 Mobile Handset at 2412.0MHz.

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

The following Test equipment used at TÜV SÜD Product Service:

Instrument Description	Manufacturer	Model Type	TE Number	Cal Period (months)	Calibration Due Date
Signal Generator	Hewlett Packard	ESG4000A	38	12	26-May-2016
10MHz - 2.5GHz, 3W, Amplifier	Vectawave Technology	VTL5400	51	-	TU
Directional Coupler	Krytar	1850	58	-	TU
Power Sensor	Rohde & Schwarz	NRV-Z1	60	12	11-Jun-2015
Signal Generator	Hewlett Packard	ESG4000A	61	12	1-Jul-2015
Thermometer	Digitron	T208	64	12	7-May-2016
Power Sensor	Rohde & Schwarz	NRV-Z1	178	12	19-May-2016
Radio Communications Test Set	Rohde & Schwarz	CMU 200	442	12	13-Jan-2016
Attenuator (20dB, 20W)	Narda	766F-20	483	12	3-Jun-2016
AC Voltage Regulator	Unknown	EM4H520X230X1893	842	-	TU
Ear Positioner with Support	IndexSar Ltd	IXH-050	1578	-	TU
Dipole Positioner/Support (plastic)	IndexSar Ltd	IXH-020	1585	-	TU
Bi-directional Coupler	IndexSar Ltd	7401 (VDC0830-20)	2414	-	TU
Hygromer	Rotronic	I-1000	2784	12	15-Apr-2016
Power Sensor	Rohde & Schwarz	NRV- Z5	2878	12	11-Jun-2015
Antenna (Omnidirectional)	Katherin Scala Division	OG-890/1990/DC	2906	-	TU
Power Meter	Rohde & Schwarz	NRVD	2979	12	19-May-2016
Radio Communications Test Set	Rohde & Schwarz	CMU 200	3035	12	6-Nov-2015
Dual Channel Power Meter	Rohde & Schwarz	NRVD	3259	12	12-Jun-2015
Power Sensor	Rohde & Schwarz	NRV-Z1	3563	12	19-May-2016
Meter & T/C	R.S Components	Meter 615-8206 & Type K T/C	3612	12	24-Sep-2015
SAR 1800 MHz dipole	Speag	D1800V2	3855	36	19-Feb-2017
SAR 900 MHz dipole	Speag	D900V2	3856	36	19-Feb-2017
SAR 835 MHz dipole	Speag	D835V2	3857	36	19-Feb-2017
SAR 2450 MHz dipole	Speag	D2450V2	3875	36	19-Feb-2017
SAR 1900 MHz dipole	Speag	D1900V2	3876	36	19-Feb-2017
Head Phantom	IndexSar Ltd	IXB-040 Inverted SAM phantom	4075	-	TU
Part of SARAC System	IndexSar Ltd	Robot Controller	4076	-	TU
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	Wooden Bench	4081	-	TU

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Instrument Description	Manufacturer	Model Type	TE Number	Cal Period (months)	Calibration Due Date
Part of SARAC System	IndexSar Ltd	5th & 6th Axis Supplementary Controller	4082	-	TU
80mm Tem Cell	IndexSar Ltd		4084	-	TU
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4144	12	7-Nov-2015
Loop Antenna	Solar	7334-1	4215	24	28-Jan-2017
Head Phantom	IndexSar Ltd	IXB-040 Inverted SAM phantom	4254	-	TU
hold handsets against SAM Phantom during testing	IndexSar Ltd	Handset Holder	4257	-	TU
Spacer used to raise body phantom	IndexSar Ltd	Body Phantom Spacer	4258	-	TU
hold handsets against SAM Phantom	IndexSar Ltd	Handset Holder	4263	-	TU
hold handsets against SAM Phantom	IndexSar Ltd	Handset Holder	4264	-	TU
hold handsets against SAM Phantom	IndexSar Ltd	Handset Holder	4265	-	TU
Part of SARAC System	IndexSar Ltd	Wooden Bench	4266	-	TU
Part of SARAC System	IndexSar Ltd	Robot Controller	4267	-	TU
Cartesian 4-axis Robot	IndexSar Ltd	SARAC	4269	-	TU
Part of SARAC System	IndexSar Ltd	White Benchtop	4270	-	TU
Immersible SAR Probe	IndexSar Ltd	IPX-050	4312	24	13-Mar-2017
Immersible SAR Probe	IndexSar Ltd	IPX-050	4313	24	13-Mar-2017
Immersible SAR Probe	IndexSar Ltd	IPX-020	4317	24	20-Mar-2017
Flat Phantom	IndexSar Ltd	IXB-2HF 700-6000MHz	4399	-	TU
Flat Phantom	IndexSar Ltd	IXB-2HF 700-6000MHz	4400	-	TU
SAR Probe	IndexSar Ltd	IPX-020	4443	24	20-Mar-2017
835MHz Head Fluid	IndexSar Ltd	Batch 20	N/A	1	18-Jun-2015
835MHz Body Fluid	IndexSar Ltd	Batch 13	N/A	1	06-Jun-2015
1900MHz Head Fluid	IndexSar Ltd	Batch 8	N/A	1	06-Jun-2015
1900MHz Body Fluid	IndexSar Ltd	Batch 4	N/A	1	06-Jun-2015
2450MHz Head Fluid	IndexSar Ltd	Batch 11	N/A	1	06-Jun-2015
2450MHz Body Fluid	IndexSar Ltd	Batch 7	N/A	1	06-Jun-2015

TU - Traceability Unscheduled

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3.2 TEST SOFTWARE

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

Instrument	Version Number	Date
SARA-C system	v.6.09.08	23 July 2014
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 KDB 865665.

IEEE 1528 Recipes

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

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

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

Fluid Type and Frequency	Relative Permittivity εR (ε') Target	Relative Permittivity εR (ε') Measured	Conductivity σ Target	Conductivity σ Measured
835MHz Head	41.5	41.8	0.90	0.90
835MHz Body	55.2	55.1	0.97	0.99
1900MHz Head	40.0	40.9	1.40	1.45
1900MHz Body	53.3	54.2	1.52	1.57
2450 MHz Head	39.2	37.7	1.80	1.77
2450MHz Body	52.7	50.1	1.95	2.00

Product Service

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 23.0°C to 23.5°C.
The actual humidity during the testing ranged from 28.9% to 49.1% RH.

3.4.2 Test Fluid Temperature Range

Frequency	Body / Head Fluid	Min Temperature °C	Max Temperature °C
835MHz	Head	22.9	23.1
835MHz	Body	23.1	23.2
1900MHz	Head	22.8	23.1
1900MHz	Body	23.0	23.0
2450MHz	Head	22.8	22.8
2450MHz	Body	23.2	23.2

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 7.0% (0.935 dB) for head and 8.8% (1.098 dB) for body. The measurement uncertainty budget for this assessment includes the maximum SAR Drift figures for Head and/or Body as applicable.

3.5 MEASUREMENT UNCERTAINTY

Head SAR Measurements.

Source of Uncertainty	Description	Tolerance / Uncertainty ± %	Probability distribution	Div	c_i (1g)	Standard Uncertainty ± % (1g)	v_i or v_{eff}
Measurement System							
Probe calibration	7.2.1	8.73	N	1	1	8.73	∞
Isotropy	7.2.1.2	3.18	R	1.73	1	1.84	∞
Probe angle >30deg	additional	12.00	R	1.73	1	6.93	∞
Boundary effect	7.2.1.5	0.49	R	1.73	1	0.28	∞
Linearity	7.2.1.3	1.00	R	1.73	1	0.58	∞
Detection limits	7.2.1.4	0.00	R	1.73	1	0.00	∞
Readout electronics	7.2.1.6	0.30	N	1	1	0.30	∞
Response time	7.2.1.7	0.00	R	1.73	1	0.00	∞
Integration time (equiv.)	7.2.1.8	1.38	R	1.73	1	0.80	∞
RF ambient conditions	7.2.3.6	3.00	R	1.73	1	1.73	∞
Probe positioner mech. restrictions	7.2.2.1	5.35	R	1.73	1	3.09	∞
Probe positioning with respect to phantom shell	7.2.2.3	5.00	R	1.73	1	2.89	∞
Post-processing	7.2.4	7.00	R	1.73	1	4.04	∞
Test sample related							
Test sample positioning	7.2.2.4	1.50	R	1.73	1	0.87	∞
Device holder uncertainty	7.2.2.4.2	1.73	R	1.73	1	1.00	∞
Drift of output power	7.2.3.4	7.0	R	1.73	1	4.04	∞
Phantom and set-up							
Phantom uncertainty (shape and thickness tolerances)	7.2.2.2	2.01	R	1.73	1	1.16	∞
Liquid conductivity (target)	7.2.3.3	5.00	R	1.73	0.64	1.85	∞
Liquid conductivity (meas.)	7.2.3.3	5.00	N	1	0.64	3.20	∞
Liquid permittivity (target)	7.2.3.4	5.00	R	1.73	0.6	1.73	∞
Liquid permittivity (meas.)	7.2.3.4	3.00	N	1	0.6	1.80	∞
Combined standard uncertainty			RSS			11.46	
Expanded uncertainty (95% confidence interval)			K=2			22.93	

Product Service

Body SAR Measurements.

Source of Uncertainty	Description	Tolerance / Uncertainty ± %	Probability distribution	Div	c_i (1g)	Standard Uncertainty ± % (1g)	v_i or v_{eff}
Measurement System							
Probe calibration	7.2.1	8.73	N	1	1	8.73	∞
Isotropy	7.2.1.2	3.18	R	1.73	1	1.84	∞
Boundary effect	7.2.1.5	0.49	R	1.73	1	0.28	∞
Linearity	7.2.1.3	1.00	R	1.73	1	0.58	∞
Detection limits	7.2.1.4	0.00	R	1.73	1	0.00	∞
Readout electronics	7.2.1.6	0.30	N	1	1	0.30	∞
Response time	7.2.1.7	0.00	R	1.73	1	0.00	∞
Integration time (equiv.)	7.2.1.8	1.38	R	1.73	1	0.80	∞
RF ambient conditions	7.2.3.6	3.00	R	1.73	1	1.73	∞
Probe positioner mech. restrictions	7.2.2.1	0.60	R	1.73	1	0.35	∞
Probe positioning with respect to phantom shell	7.2.2.3	2.00	R	1.73	1	1.15	∞
Post-processing	7.2.4	7.00	R	1.73	1	4.04	∞
Test sample related							
Test sample positioning	7.2.2.4	1.50	R	1.73	1	0.87	∞
Device holder uncertainty	7.2.2.4.2	1.73	R	1.73	1	1.00	∞
Drift of output power	7.2.3.4	8.8	R	1.73	1	5.08	∞
Phantom and set-up							
Phantom uncertainty (shape and thickness tolerances)	7.2.2.2	2.01	R	1.73	1	1.16	∞
Liquid conductivity (target)	7.2.3.3	5.00	R	1.73	0.64	1.85	∞
Liquid conductivity (meas.)	7.2.3.3	5.00	N	1	0.64	3.20	∞
Liquid permittivity (target)	7.2.3.4	5.00	R	1.73	0.6	1.73	∞
Liquid permittivity (meas.)	7.2.3.4	3.00	N	1	0.6	1.80	∞
Combined standard uncertainty			RSS			11.66	
Expanded uncertainty (95% confidence interval)			K=2			23.32	

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

Product Service

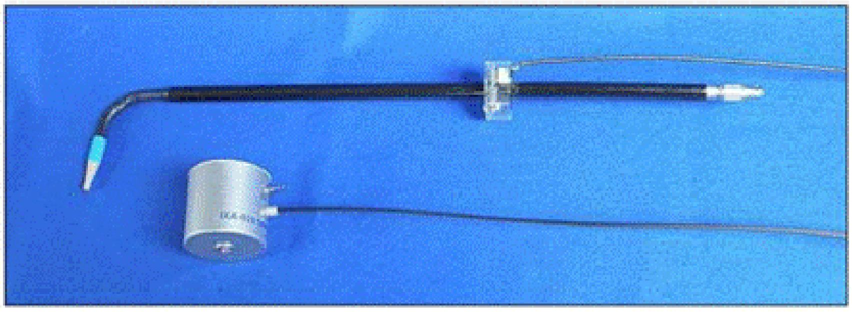
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP–020

S/N L0006

March 2015



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Calibration Certificate 1503/L0006
Date of Issue: 31 March 2013
Immersible SAR Probe

Type:	IXP-020
Manufacturer:	IndexSAR, UK
Serial Number:	L0006
Place of Calibration:	IndexSAR, UK
Date of Receipt of Probe:	10 February 2015
Calibration Dates:	13 – 20 March 2015
Customer:	TUV Sud

IndexSAR Ltd hereby declares that the IXP-050 Probe named above has been calibrated for conformity to the current versions of IEEE 1528, IEC 62209-1, IEC 62209-2, and FCC SAR 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:	[signature]	**Technical Manager**
Approved by:	[signature]	**Director**

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

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INTRODUCTION

L-shaped probes are designed solely for use on the SARA-C SAR-measuring system. They are not designed to work on SARA2 or any other robot-positioning system, but can be positioned manually if software is available to read out SAR measurement values..

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N L0006) only and describes the procedures used for characterisation and calibration.

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of IEC 62209-1 [Ref 1], IEEE 1528 [Ref 2], IEC 62209-2 [Ref 3] and FCC SAR [Ref 4] standards, or equivalent. 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 the following stages:-

1) Determination of the relative channel sensitivity factors which optimise the probe's overall axial isotropy in 900MHz brain fluid.
2) Measure the incidental spherical isotropy using these derived channel sensitivity factors.
3) Since isotropy and channel sensitivity factors are frequency independent, these channel sensitivity factors can be applied to model the exponential decay of SAR in a waveguide fluid cell at each frequency of interest, 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] - [4]. 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.

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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.

For this value of DCP, the typical linearity response of IXP-050 probes to CW and to GSM modulation is shown in Figure 7, along with departures of this same dataset from linearity.

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

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

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

3. Selecting channel sensitivity factors to optimise isotropic response

Within SARA-C, an L-probe's predominant mode of operation is with the tip pointing directly towards the source of radiation. Consequently, optimising the probe's response to boresight signals ("axial isotropy") is far more important than optimising its spherical isotropy (where the direction, as well as the polarisation angle, of the incoming radiation must be taken into account).

The setup for measuring the probe's axial isotropy is shown in Figure 1, and this allows spherical isotropy to be measured at the same time. Moreover, since isotropy is frequency-independent, measurements are normally made at a frequency of 900MHz as lower frequencies are more tolerant of positional inaccuracies.

A box phantom containing 900MHz head fluid is irradiated by a tuned dipole, mounted at the side of the phantom on the SARA2 robot's seventh axis. Note: although the probe is used on SARA-C, it is actually calibrated on SARA2. 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 isotropy response is measured by changing the orientation of the probe sensors with respect to the dipole, while keeping the long shaft of the probe vertical and the probe sensors at precisely the same position in space. Correctly aligning the probe sensors in this way is essential to an accurate measurement of isotropy.

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 passing through 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.

While all relative probe and dipole orientations contribute to the probe's spherical isotropy response, only the subset of measurements made when the probe is exactly end-on to the dipole, contributes to the calculation of axial isotropy. The relative channel sensitivities can be adjusted either to give the most uniform response to all incoming directions and polarisations (spherical isotropy) or just to boresight signals (axial isotropy). Unfortunately, in practice, the two isotropies are not mutually optimisable by the same relative channel gains, so a choice must be made based or the usual mode of operation. That is why Indexsar optimises for Axial Isotropy.

At each probe position/dipole polarisation pair, 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 axial isotropy (see Figure 3). This automated approach to optimisation removes the effect of human bias. These optimised channel sensitivity values can then be applied to the entire dataset as a check on the resulting spherical isotropy, as shown in Figure 4.

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:

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

Here, the density ρ is conventionally assumed to be 1 000 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).

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

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

Wherever possible, all DiLine and calibration measurements should be made in the open laboratory at 22 $\pm$ 2.0°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 2). 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 tip is moved carefully towards the dielectric window until the flat face of the tip is just touching the exact centre of the face. 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 at each separation. 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.

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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 700MHz, 835/900MHz, 1450MHz, 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.

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.

For calibrations at 450MHz, where waveguide calibrations become unfeasible, a full 3D SAR scan over a tuned dipole is performed, and the conversion factor adjusted to make the measured 1g and 10g volume-averaged SAR values agree with published targets.

CALIBRATION FACTORS MEASURED FOR PROBE S/N L0006

The probe was calibrated at 450, 835, 900, 1800, 1900, 2100, 2450 and 2600 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 **Error! Bookmark not defined.** indicates the calibration status of all test equipment used during probe calibration.

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MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA-C measurement system has been published in Reference [3]. Table 17 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}
Forward power	3.92	N	1.00	1	3.92	∞
Reflected power	4.09	N	1.00	1	4.09	∞
Liquid conductivity	1.308	N	1.00	1	1.31	∞
Liquid permittivity	1.271	N	1.00	1	1.27	∞
Field homgeneity	3.0	R	1.73	1	1.73	∞
Probe positioning	0.22	R	1.73	1	0.13	∞
Field probe linearity	0.2	R	1.73	1	0.12	∞
Combined standard uncertainty		RSS			6.20	

At the 95% confidence level, therefore, the expanded uncertainty is 12.4%

SUMMARY OF CAL FACTORS FOR PROBE IXP-020 S/N L0006

Relative Channel Sensitivities (to optimise Axial Isotropy)				
	X	Y	Z	
Air Factors	72.81	90.02	77.16	$(V/m)^2/mV$
CW DCPs	100	100	100	mV

Measured Isotropy at 900MHz	Probe orientation range relative to dipole	(+/-) dB
Axial Isotropy	0° (end-on to dipole)	0.01
Spherical Isotropy	±20°	0.17
	±30°	0.28
	±60°	0.58
	±90°	0.63

SAR Conversion Factors/ Boundary Corrections (Head Fluid)				
Frequency* (MHz)	SAR Conv Factor	Boundary Correction f(0)	Boundary Correction d(mm)	Notes
450	0.298	0.0	1.0	3
700	0.300	1.2	1.1	4
835	0.304	0.8	1.5	1,2
900	0.305	1.0	1.4	1,2
1800	0.373	0.9	1.5	1,2
1900	0.382	0.5	2.3	1,2
2100	0.396	0.6	2.0	1,2
2450	0.423	0.9	1.5	1,2
2600	0.427	1.1	1.4	1,2
Notes				
1)	Calibrations done at 22°C +/-2°C			
2)	Waveguide calibration			
3)	By validation			
4)	By extrapolation			

*The valid frequency of SARA-C probe calibrations are ±100MHz (F<300MHz) and ±200MHz (F>300MHz).

Physical Information	
Sensor offset (mm)	2.7
Elbow – Tip dimension (mm)	84.55

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PROBE SPECIFICATIONS

Indexsar probe L0006, 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 L0006	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 L0006	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 L0006	BSEN [1]	IEEE [2]
Axial	Probe at 0°	0.01	0.5	0.25
Spherical	Probe at ±20°	0.17	N/A	N/A
	Probe at ±30°	0.28		
	Probe at ±60°	0.58		
	Probe at ±90°	0.63		

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.

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REFERENCES

References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

For a specific reference, subsequent revisions do not apply.

For a non-specific reference, the latest version applies.

[1] IEC 62209-1.
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
Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

[3] IEC 62209-2
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)

[4] FCC KDB 865664

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

[6] SARA-C SAR Testing System: Measurement Uncertainty, v1.0.3. October 2011.

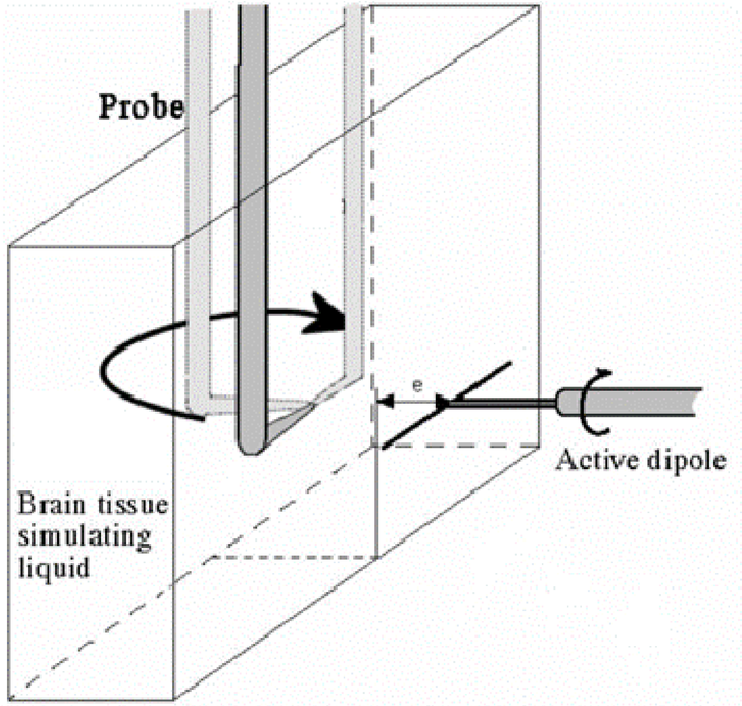

Figure 1 Isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

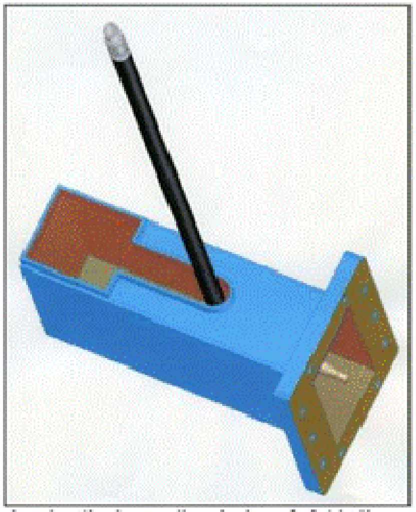

Figure 2 Schematic showing the innovative design of slot in the waveguide termination

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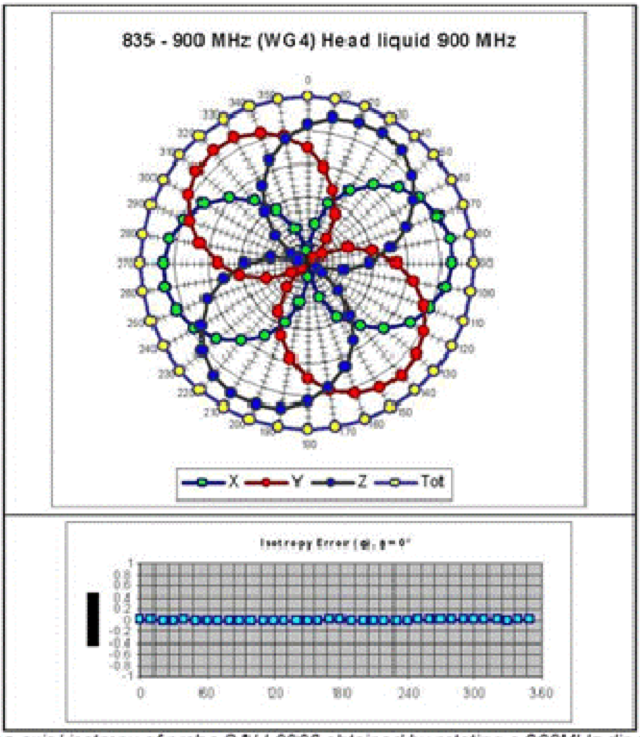


Figure 3 The axial isotropy of probe S/N L0006 obtained by rotating a 900MHz dipole with probe tip aligned with dipole boresight (NB Axial Isotropy is frequency independent)

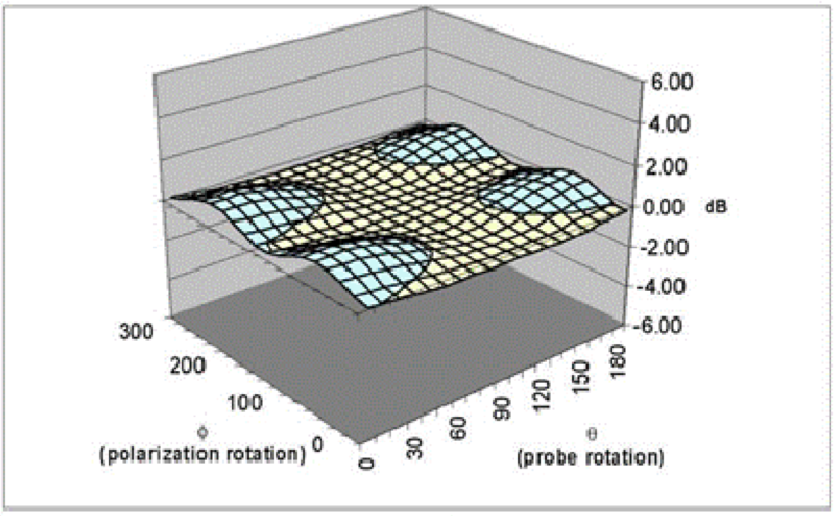


Figure 4 Residual Surface Isotropy at 900 MHz after optimisation for axial isotropy

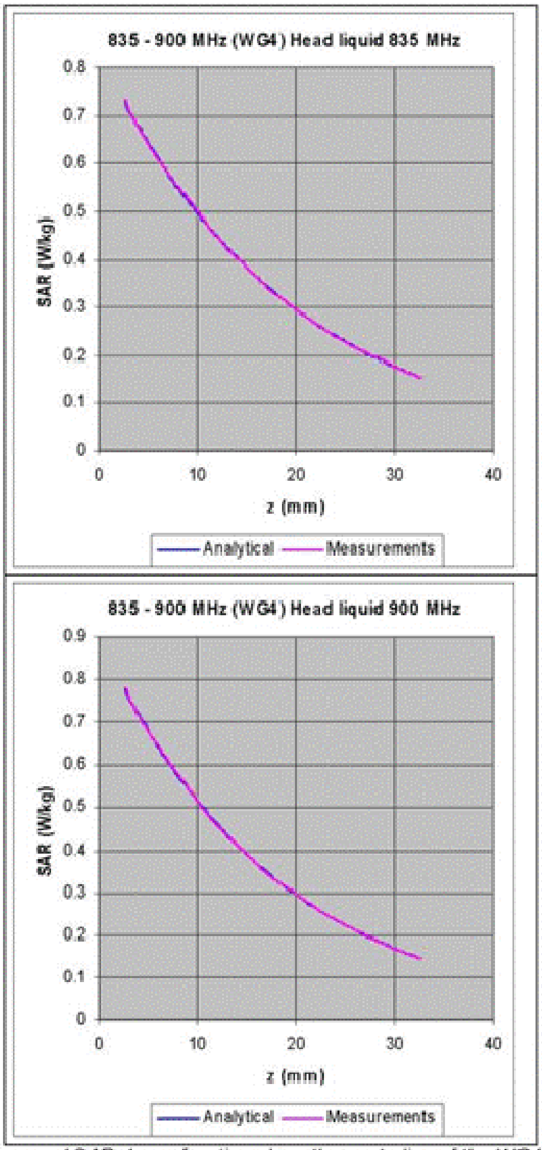
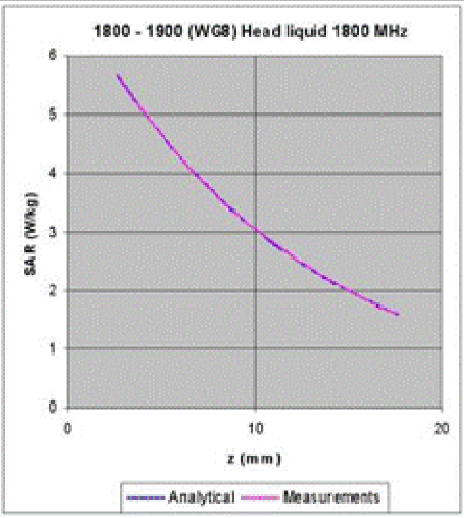
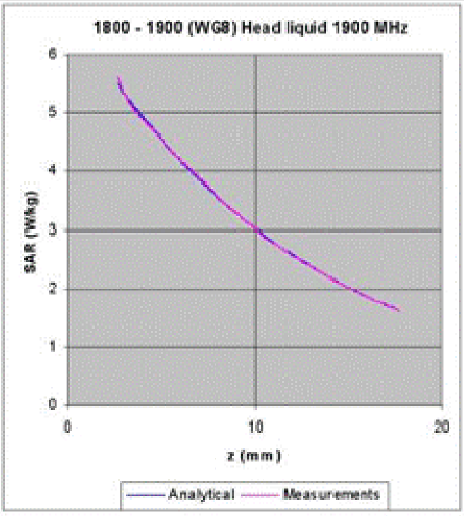


Figure 5 The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.


1800 - 1900 (WG8) Head liquid 1800 MHz
SAR (W/kg)
z (mm)
Analytical
Measurements


1800 - 1900 (WG8) Head liquid 1900 MHz
SAR (W/kg)
z (mm)
Analytical
Measurements

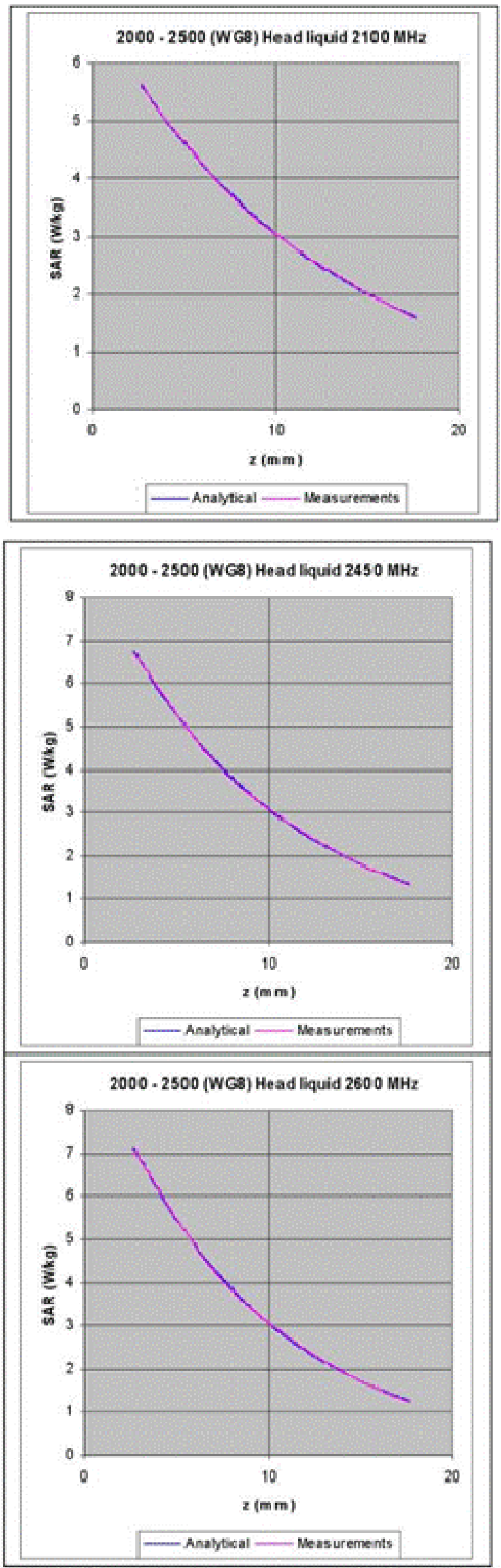
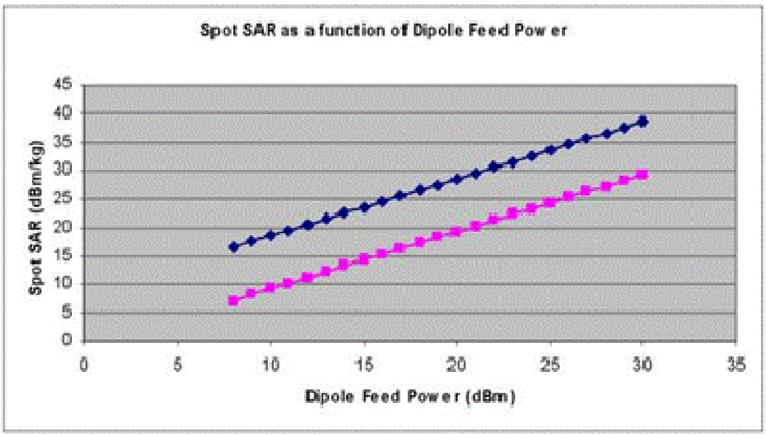


Figure 6. The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.



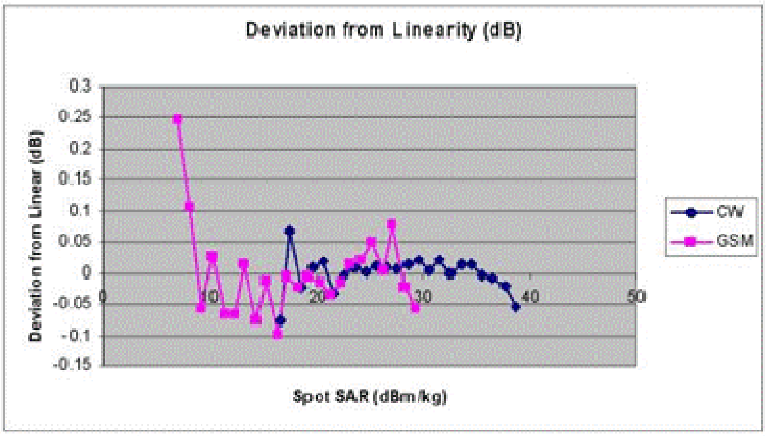


Figure 7: The typical linearity response of 5mm probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of of 8 (ie 9dB) lower than CW. The lower diagram shows the departure from linearity of the same two datasets.

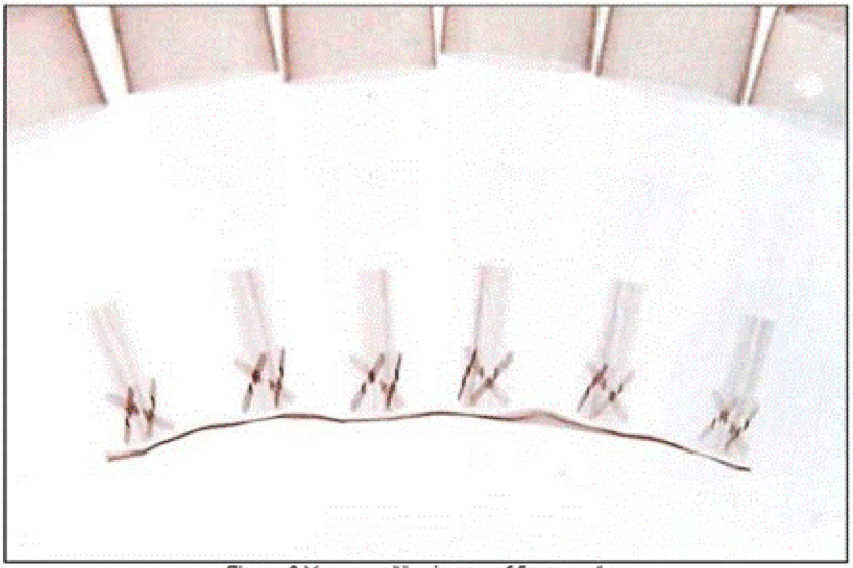


Figure 8 X-ray positive image of 5mm probes

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

Frequency (MHz)	Fluid Type	Measured		Target		% Deviation		Verdict	
		Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
450	Head	44.142	0.845	43.5	0.87	1.5	-2.9	Pass	Pass
835		42.114	0.901	41.5	0.90	1.5	0.1	Pass	Pass
900		41.13	0.961	41.5	0.97	-0.9	-0.9	Pass	Pass
1800		39.719	1.428	40.0	1.40	-0.7	2.0	Pass	Pass
1900		39.744	1.396	40.0	1.40	-0.6	-0.3	Pass	Pass
2100		40.541	1.463	39.8	1.49	1.9	-1.8	Pass	Pass
2450		39.265	1.815	39.2	1.80	0.2	0.8	Pass	Pass
2600		38.715	1.975	39.0	1.96	-0.7	0.8	Pass	Pass

Table of test equipment calibration status

Instrument description	Supplier / Manufacturer	Model	Serial No.	Last calibration date	Cal certificate number	See Annex	Calibration due date
Power sensor	Rohde & Schwarz	NRP-Z23	100063	14/08/2013	10-300287035	1	14/08/2015
Power sensor	Rohde & Schwarz	NRP-Z23	100169	06/08/2014	1400-48811	2	06/08/2016
Dielectric property measurement	Indexsar	DiLine (sensor lengths: 160mm, 80mm and 60mm)	N/A	(absolute) – checked against NPL values using reference liquids	N/A		N/A
Vector network analyser	Anritsu	MS6423B	003102	17/02/2015	RMA20027002	3	17/02/2016
SMA autocalibration module	Anritsu	36581KKF/1	001902	22/01/2015	RMA20021769	4	22/01/2016

TÜV SÜD Product Service

Annex 1

Calibration Certificate of NRP-Z23 power sensor, S/N 100063

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number 10-300287035
Zertifikatsnummer

Unit Data

Item / Gegenstand	Average power sensor
Manufacturer / Hersteller	ROHDE & SCHWARZ
Type / Typ	NRP-Z23
Material Number / Materialnummer	1137.8002.02
Serial Number / Seriennummer	100063
Asset Number / Inventarnummer	

Order Data

Customer / Auftraggeber	IndexSAR Ltd Oakfield House, RH5 5BG Newdigate GB
Order Number / Bestellnummer	-
Date of Receipt / Eingangsdatum	2013-08-08

Performance

Place and Date of Calibration / Ort und Datum der Kalibrierung	Memmingen, 2013-08-14
Scope of Calibration / Umfang der Kalibrierung	Standard Calibration
Statement of Compliance (Incoming) / Konformitätsaussage (Anlieferung)	Measurement results within specifications
Statement of Compliance (Outgoing) / Konformitätsaussage (Auslieferung)	Measurement results within specifications
Extent of Calibration Documents / Umfang des Kalibrierdokuments	2 Pages Calibration Certificate 17 Pages Outgoing Results 17 Pages Incoming Results

This calibration certificate documents, that the named item is tested and measured against defined specifications.
Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2).
Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national / international standards, which realize the physical units of measurement according to the International System of Units (SI).
In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories.
Principles and methods of calibration correspond with EN ISO/IEC 17025. The applied quality system is certified to EN ISO 9001.
This calibration certificate may not be reproduced other than in full.
Calibration certificates without signatures are not valid.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien.
Grundsätze und Verfahren der Kalibrierung entsprechen EN ISO/IEC 17025.
Das angewandte Qualitätsmanagement-System ist zertifiziert nach EN ISO 9001.
Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden.
Kalibrierscheine ohne Signaturen sind ungültig.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Rohde & Schwarz GmbH & Co. KG; Service Operations West

Date of Issue / Ausstellungsdatum	Head of Laboratory / Laborleitung	Person Responsible / Bearbeiter	
2013-08-14	Courage	Ruprecht Schmid	Page 1/2

ROHDE & SCHWARZ GmbH & Co KG · Mühldorfstraße 15 · D-81671 München, Federal Republic of Germany · Telefon (089) 41 29-0 · Telefax (089) 41 29-132 75
Geschäftsführung: Manfred Fleischmann (Vorsitzender), Christian Leicher, Gerhard Geier
Sitz München · Registereintrag: HRA 16 270 · Persönlich haftender Gesellschafter: RUSEG Verwaltungs-GmbH · Sitz München · Registereintrag: AG München HRB 7 534

TÜV SÜD
Product Service

Material Number 1137.8002.02 Serial Number 100063 **Certificate Number 10-300287035**

Calibration Method
Kalibriermethode: NRVC-1109.0930.32

Relative Humidity
Relative Luftfeuchte: 20%-60%

Ambient Temperature
Umgebungstemperatur: (23 $^{+1}_{-1}$) °C

Working standards used (having a significant effect on the accuracy) Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)				
Item Gegenstand	Type Typ	Serial Number Seriennummer	Calibration Certificate Number Kalibrierscheinnummer	Cal. Due Kalibr. bis
Dual Channel Powermeter	NRVD	100862	0114 D-K-15195-01-00 2013-08	2014-11-30
Dual Channel Power Meter	NRVD	828583/0023	0113 D-K-15195-01-00 2013-08	2014-11-30
Vector Network Analyzer	ZVM	835228/0020	0102-DKD-K-16101-2011-08	2013-10-31
Acess Set for Lin. Measurement	NRVC-B2	848997/0028	0085 D-K-15195-01-00 2013-01	2014-06-30
Calibration Kit Type-N ;50 Ohm	85054B	2705A00160	217-01723 [METAS]	2015-03-31
Power Standard	NRVC	836497/0005	0082 D-K-15195-01-00 2013-01	2014-04-30

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Notes
Anmerkungen

Installed options are included in calibration. Depending on installed options, numbers of pages of the record are not consecutive.

TÜV SÜD
Product Service

Annex 2

Calibration Certificate of NRP-Z23 power sensor, S/N 100169

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number Zertifikatsnummer **1400-48811**

Unit data

Item Gegenstand	AVERAGE POWER SENSOR
Manufacturer Hersteller	Rohde & Schwarz
Type Typ	NRP-Z23
Material number Materialnummer	1137.8002.02
Serial number Seriennummer	ID: 1137.8002.02-100169-aj Ser.: 100169
Asset number Anlagennummer	
Recomended Calibration Interval	24 Months

Order data

Customer Auftraggeber	IndexSAR Ltd Oakfield House, Newdigate RH5 5BG Great Britain
On behalf of (where applicable) In namen von (Wenn gewunscht)	
Order number Bestellungnummer	1024R&S
Date of receipt Eingangsdatum	2014-08-06 (YYYY-MM-DD)

Performance

Place and date of calibration Ort u. Datum d. Kalibrierung	Fleet; 2014-08-06 (YYYY-MM-DD)
Scope of calibration Umfang der Kalibrierung	Factory Standard Calibration
Statement of Compliance (Incoming) Konformitätsaussage (Anlieferung)	All measured values are within the data sheet specifications.
Statement of Compliance (Outgoing) Konformitätsaussage (Auslieferung)	All measured values are within the data sheet specifications.
Extent of calibration documents Umfang der Kalibrierdokumentation	2 Pages Calibration Certificate 40 Pages Calibration Results 2 Pages Incoming Report

This calibration certificate documents, that the named item is tested and measured against defined specifications. Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2). Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national / international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories. Principles and methods of calibration correspond essentially with the technical requirements of EN ISO/IEC 17025. The applied quality system is certified to EN ISO 9001. This calibration certificate may not be reproduced other than in full. Calibration certificates without signatures are not valid. The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2). Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien. Grundsätze und Verfahren der Kalibrierung entsprechen im Wesentlichen den technischen Anforderungen der EN ISO/IEC 17025. Das angewandte Qualitätsmanagement-System ist zertifiziert nach EN ISO 9001. Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Kalibrierscheine ohne Unterschriften sind ungültig. Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Rohde & Schwarz UK

Date of issue Ausstellungsdatum	Head of laboratory Laborleitung	Person responsible Bearbeiter
2014-08-06 (YYYY-MM-DD)	Carol Mckenzie	Martin Gill

Page (Seite) 1 of 2

ROHDE & SCHWARZ UK Ltd, Ancells Business Park, Fleet Hampshire GU51 2UZ United Kingdom
Registered in England No. 539607

TÜV SÜD
Product Service

Material number 1137.8002.02
Materialnummer
Serial number ID: 1137.8002.02-100169-aj
Seriennummer Ser.: 100169

Certificate Number **1400-48811**
Zertifikatsnummer

Calibration instruction See first page of calibration results
Kalibrieranweisung
Ambient temperature (23 ± 2) °C
Umgebungstemperatur

Date of receipt 2014-08-06
Eingangsdatum (YYYY-MM-DD)
Relative humidity 20 % - 60 %
Relative Luftfeuchte

This calibration fulfils the requirements of the standard / guideline
Diese Kalibrierung entspricht den Forderungen der Norm / Richtlinie

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial number** Seriennummer	**Calibration certificate number** Kalibrierschein Nummer	**Cal. due** Kalibr. bis
See page 2 of calibration results				

UGB **(Uncertainty guard Band): Measurement uncertainty violates the datasheet limit**

UGB1 **A compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

UGB2 **A non-compliance statement may be possible where a confidence level of less than 95 % is acceptable.**
Die Bestätigung der Nicht-Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Ref.: ILAC-G8:1996 "Guidelines on Assessment and Reporting of Compliance with Specification (based on measurements and tests in a laboratory)"

Notes
Anmerkungen

TÜV SÜD
Product Service

Annex 3

Calibration certificate of Anritsu MS4623B VNA

Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 455875
Email: service.eso@eu.anritsu.com

Date of Issue:	17/02/2015	Certificate N°:	RMA20027002
Customer:	INDEXSAR LTD	Order No:	Contract
Manufacturer:	Anritsu Company		

Model	Serial Number	Description
MS4623B	003102	VNA,10 MHZ-6 GHZ,ACTIVE

Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.

Repair required before calibration	(yes)
Electrical Safety	(yes)
Laser safety class	( )

Authorised Signature

Murray Coleman
Head of Customer Services (EMEA)

Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited.
The attached results relate only to the instrument under calibration.
Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353178)
This Certificate comprises of:
Certificate of Calibration
Cal Report
25 Page(s) of test results

TÜV SÜD Product Service

Annex 4

Calibration certificate of Anritsu 36581KKF/1 auto-cal kit

Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 455675
Email: service.esc@eu.anritsu.com

Date of Issue:	**22/01/2015**	**Certificate N°:**	**RMA20026648**
Customer:	**INDEXSAR LTD**	**Order No:**	**1045ANR**
Manufacturer:	**Anritsu Company**		

Model	Serial Number	Description
MS4623B	**003102**	VNA,10 MHZ-6 GHZ,ACTIVE
36581KKF/1	**001902**	TESTED & CHARACTERIZED TO 6 GHZ

Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.

Within specification before calibration	(yes)
Repair required before calibration	(no)
Electrical Safety	(yes)
Laser safety class	( )

Authorised Signature

Murray Coleman
Head of Customer Services (EMEA)

Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited.
The attached results relate only to the instrument under calibration.
Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353176)
This Certificate comprises of:
Certificate of Calibration
Cal Report
13 Page(s) of test results

Product Service

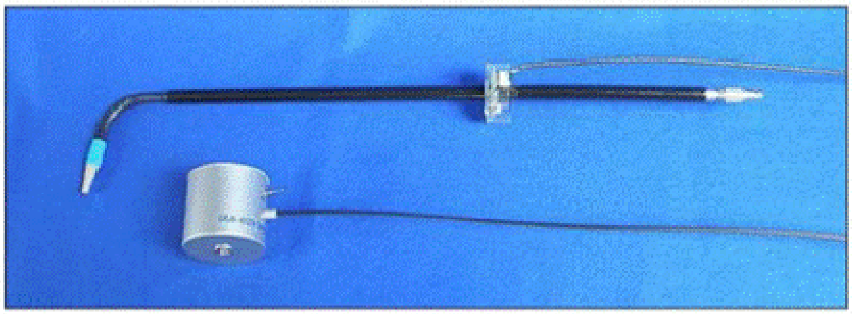
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP–020

S/N L0020

March 2015



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Oakfield House
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Tel: +44 (0) 1306 632 870
Fax: +44 (0) 1306 631 834
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Product Service

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e-mail: enquiries@indexsar.com

Calibration Certificate 1503/L0020
Date of Issue: 31 March 2015
Immersible SAR Probe

Type:	IXP-020
Manufacturer:	IndexSAR, UK
Serial Number:	L0020
Place of Calibration:	IndexSAR, UK
Date of Receipt of Probe:	10 February 2015
Calibration Dates:	13 – 20 March 2015
Customer:	TUV Sud

IndexSAR Ltd hereby declares that the IXP-020 Probe named above has been calibrated for conformity to the current versions of IEEE 1528, IEC 62209-1, IEC 62209-2, and FCC SAR standards, or equivalent, 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:		**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.

Product Service

INTRODUCTION

L-shaped probes are optimised for use on the SARA-C SAR-measuring system. They are not designed to work on SARA2 or any other robot-positioning system, but can be positioned manually if software is available to read out SAR measurement values.

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N L0020) only and describes the procedures used for characterisation and calibration.

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of IEC 62209-1 [Ref 1], IEEE 1528 [Ref 2], IEC 62209-2 [Ref 3] and FCC SAR [Ref 4] standards, or equivalent. 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 the following stages:-

1) Determination of the relative channel sensitivity factors which optimise the probe's overall axial isotropy in 900MHz brain fluid.

2) Measure the incidental spherical isotropy using these derived channel sensitivity factors.

3) Since isotropy and channel sensitivity factors are frequency independent, these channel sensitivity factors can be applied to model the exponential decay of SAR in a waveguide fluid cell at each frequency of interest, 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] - [4]. 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.

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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.

For this value of DCP, the typical linearity response of IXP-050 probes to CW and to GSM modulation is shown in Figure 7, along with departures of this same dataset from linearity.

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

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

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

3. Selecting channel sensitivity factors to optimise isotropic response

Within SARA-C, an L-probe's predominant mode of operation is with the tip pointing directly towards the source of radiation. Consequently, optimising the probe's response to boresight signals ("axial isotropy") is far more important than optimising its spherical isotropy (where the direction, as well as the polarisation angle, of the incoming radiation must be taken into account).

The setup for measuring the probe's axial isotropy is shown in Figure 1, and this allows spherical isotropy to be measured at the same time. Moreover, since isotropy is frequency-independent, measurements are normally made at a frequency of 900MHz as lower frequencies are more tolerant of positional inaccuracies.

A box phantom containing 900MHz head fluid is irradiated by a tuned dipole, mounted at the side of the phantom on the SARA2 robot's seventh axis. Note: although the probe is used on SARA-C, it is actually calibrated on SARA2. 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 isotropy response is measured by changing the orientation of the probe sensors with respect to the dipole, while keeping the long shaft of the probe vertical and the probe sensors at precisely the same position in space. Correctly aligning the probe sensors in this way is essential to an accurate measurement of isotropy.

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

Product Service

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 passing through 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.

While all relative probe and dipole orientations contribute to the probe's spherical isotropy response, only the subset of measurements made when the probe is exactly end-on to the dipole, contributes to the calculation of axial isotropy. The relative channel sensitivities can be adjusted either to give the most uniform response to all incoming directions and polarisations (spherical isotropy) or just to boresight signals (axial isotropy). Unfortunately, in practice, the two isotropies are not mutually optimisable by the same relative channel gains, so a choice must be made based or the usual mode of operation. That is why Indexsar optimises for Axial Isotropy.

At each probe position/dipole polarisation pair, 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 axial isotropy (see Figure 3). This automated approach to optimisation removes the effect of human bias. These optimised channel sensitivity values can then be applied to the entire dataset as a check on the resulting spherical isotropy, as shown in Figure 4.

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:

Product Service

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

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

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

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

Wherever possible, all DiLine and calibration measurements should be made in the open laboratory at 22 $\pm$ 2.0°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 2). 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 tip is moved carefully towards the dielectric window until the flat face of the tip is just touching the exact centre of the face. 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 at each separation. 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.

Product Service

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 700MHz, 835/900MHz, 1450MHz, 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.

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.

For calibrations at 450MHz, where waveguide calibrations become unfeasible, a full 3D SAR scan over a tuned dipole is performed, and the conversion factor adjusted to make the measured 1g and 10g volume-averaged SAR values agree with published targets.

CALIBRATION FACTORS MEASURED FOR PROBE S/N L0020

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 **Error! Bookmark not defined.** indicates the calibration status of all test equipment used during probe calibration.

Product Service

MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA-C measurement system has been published in Reference [3]. Table 17 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}
Forward power	3.92	N	1.00	1	3.92	∞
Reflected power	4.09	N	1.00	1	4.09	∞
Liquid conductivity	1.308	N	1.00	1	1.31	∞
Liquid permittivity	1.271	N	1.00	1	1.27	∞
Field homgeneity	3.0	R	1.73	1	1.73	∞
Probe positioning	0.22	R	1.73	1	0.13	∞
Field probe linearity	0.2	R	1.73	1	0.12	∞
Combined standard uncertainty		RSS			6.20	

At the 95% confidence level, therefore, the expanded uncertainty is 12.4%

SUMMARY OF CAL FACTORS FOR PROBE IXP-020 S/N L0020

Relative Channel Sensitivities (to optimise Axial Isotropy)				
	X	Y	Z	
Air Factors	80.28	89.04	70.68	$(V/m)^2/mV$
CW DCPs	100	100	100	mV

SAR Conversion Factors/ Boundary Corrections (Head Fluid)				
Frequency* (MHz)	**SAR Conv Factor**	**Boundary Correction f(0)**	**Boundary Correction d(mm)**	**Notes**
450	0.272	-	-	3
700	0.272	1.0	1.4	4
835	0.273	0.6	1.7	1,2
900	0.278	0.5	1.8	1,2
1800	0.339	0.6	1.8	1,2
1900	0.355	0.5	2.4	1,2
2100	0.363	0.8	1.6	1,2
2450	0.393	1.3	1.3	1,2
2600	0.416	1.6	1.2	1,2
Notes				
1)	Calibrations done at 22°C +/-2°C			
2)	Waveguide calibration			
3)	By validation			
4)	By extrapolation			

The valid frequency of SARA-C probe calibrations are ±100MHz (F<300MHz) and ±200MHz (F>300MHz).

Physical Information	
Sensor offset (mm)	2.7
Elbow – Tip dimension (mm)	84.11

Product Service

PROBE SPECIFICATIONS

Indexsar probe L0020, 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 L0020	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 L0020	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 L0020	BSEN [1]	IEEE [2]
Axial	Probe at 0°	0.01	0.5	0.25
Spherical	Probe at ±20°	0.16	N/A	N/A
	Probe at ±30°	0.28		
	Probe at ±60°	0.58		
	Probe at ±90°	0.75		

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.

Product Service

REFERENCES

References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

For a specific reference, subsequent revisions do not apply.

For a non-specific reference, the latest version applies.

[1] IEC 62209-1.
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
Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

[3] IEC 62209-2
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)

[4] FCC KDB 865664

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

[6] SARA-C SAR Testing System: Measurement Uncertainty, v1.0.3. October 2011.

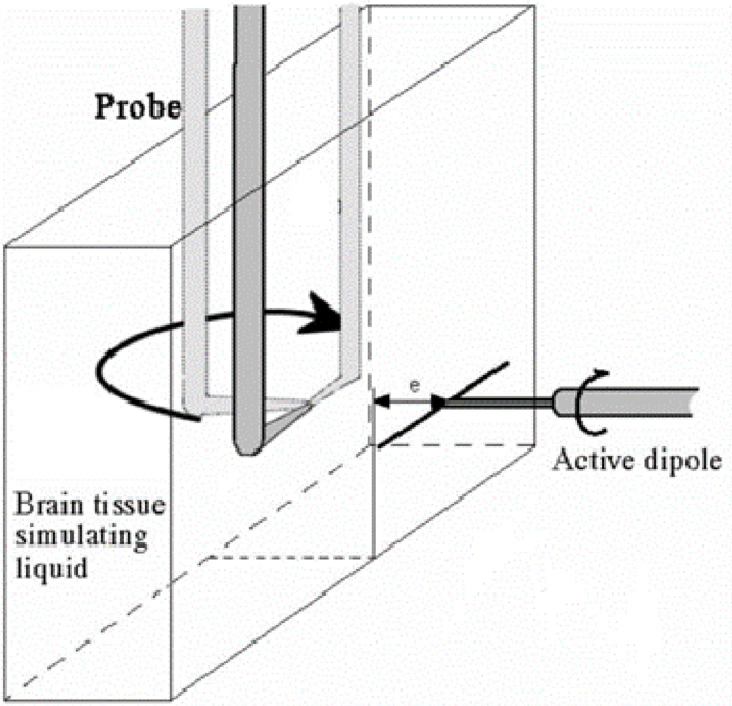


Figure 1 Isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

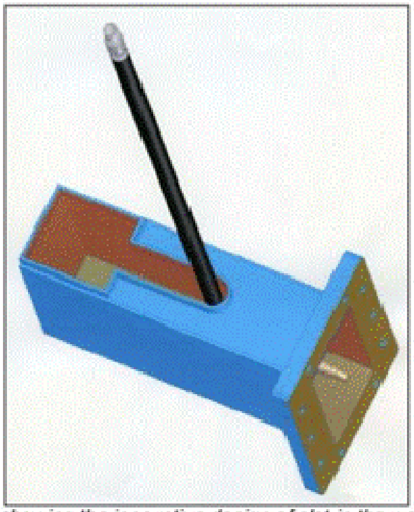


Figure 2 Schematic showing the innovative design of slot in the waveguide termination

Product Service

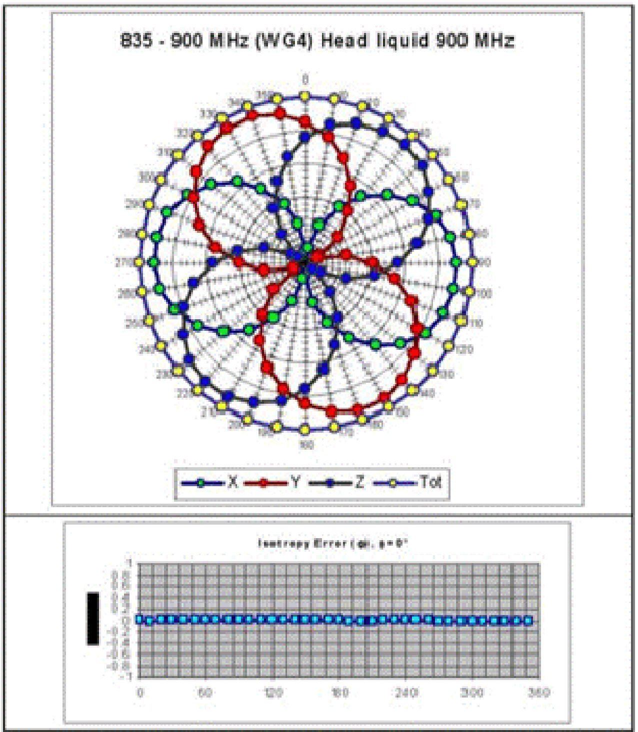


Figure 3 The axial isotropy of probe S/N L0020 obtained by rotating a 900MHz dipole with probe tip aligned with dipole boresight (NB Axial Isotropy is frequency independent)

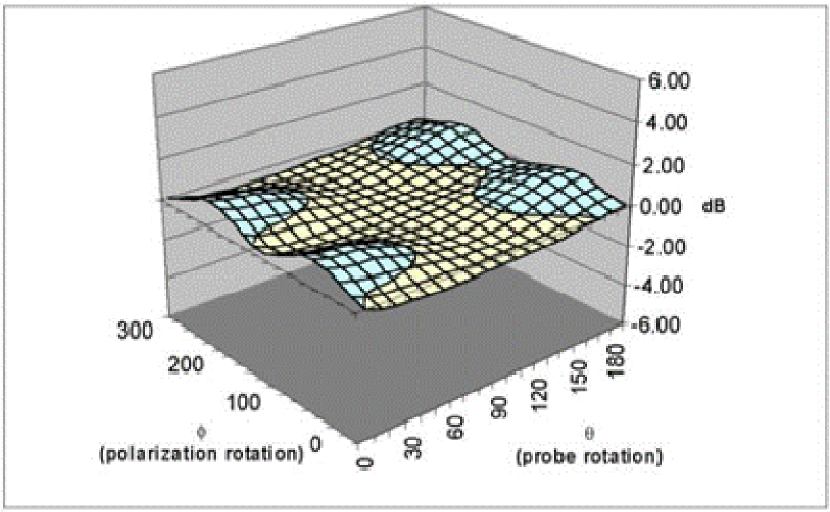


Figure 4 Residual Surface Isotropy at 900 MHz after optimisation for axial isotropy

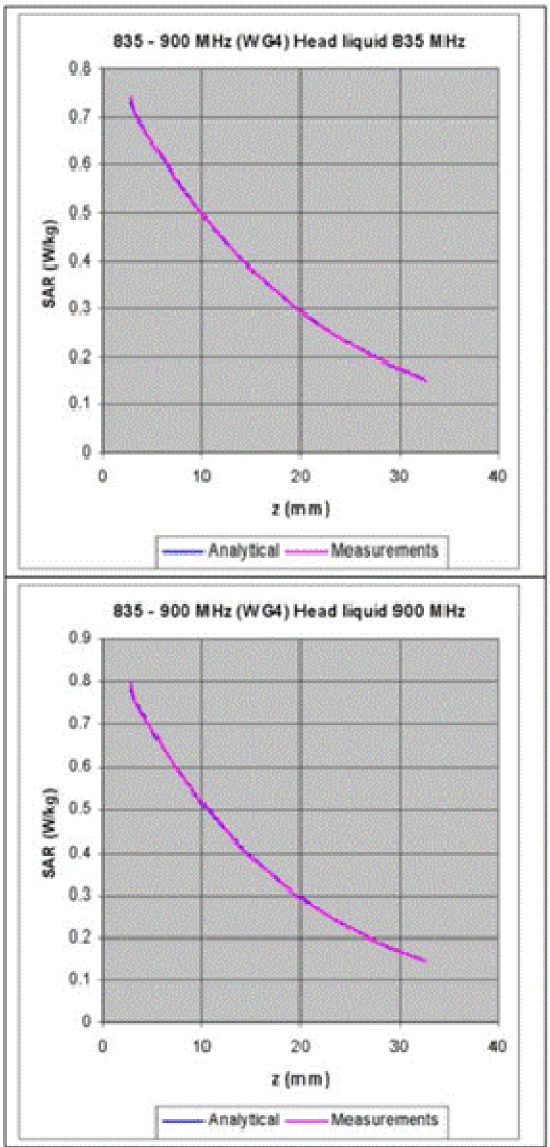
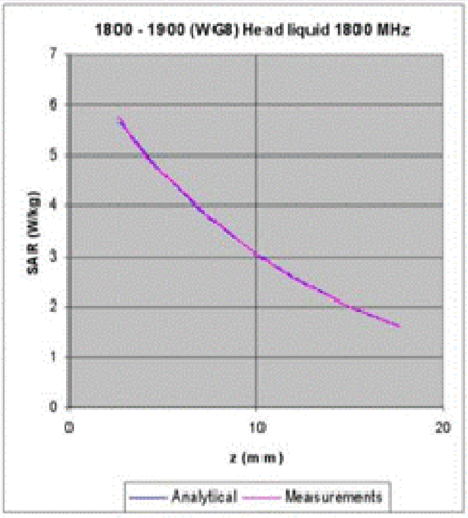
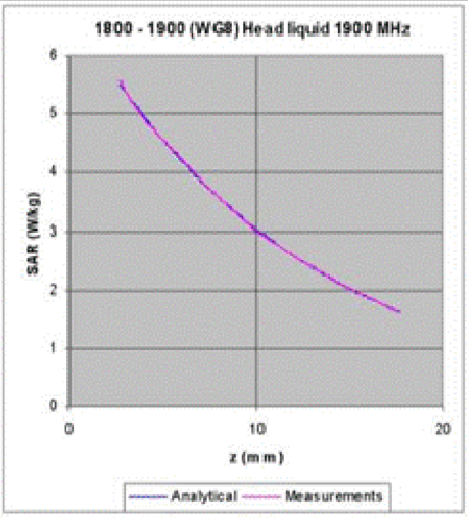


Figure 5 The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

Product Service





Product Service

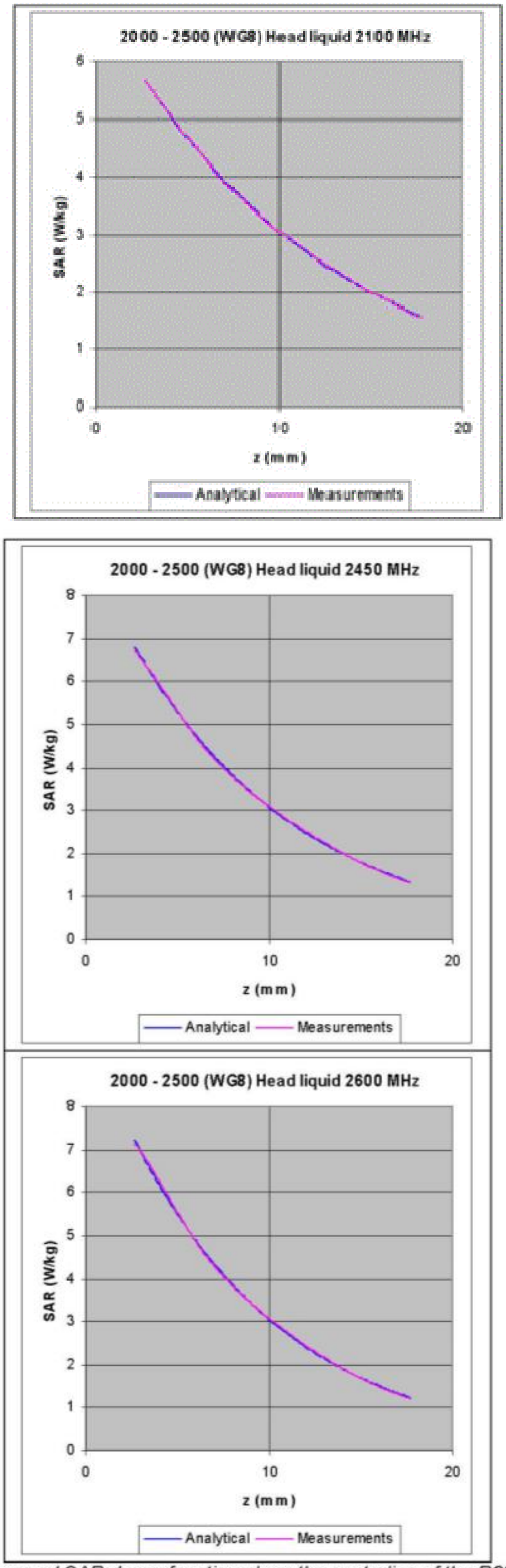
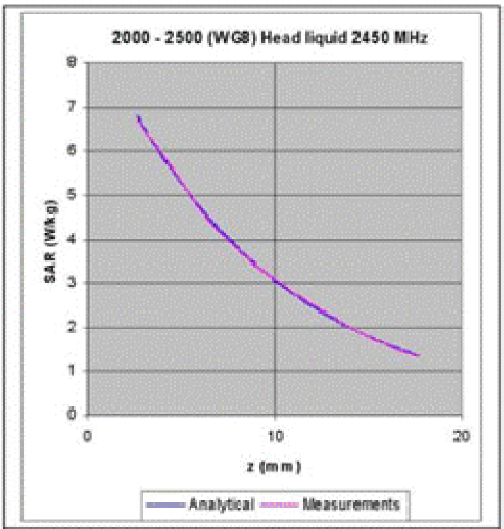


Figure 6. The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.



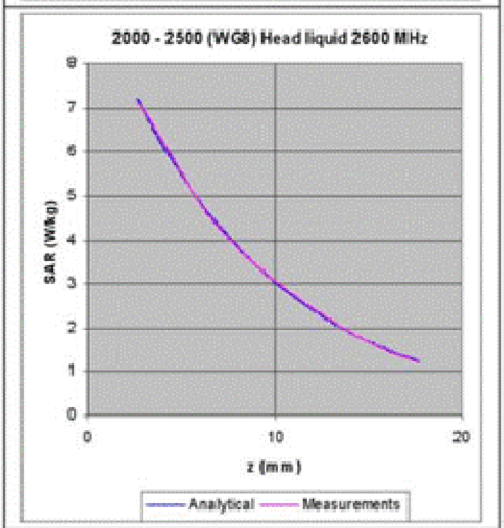
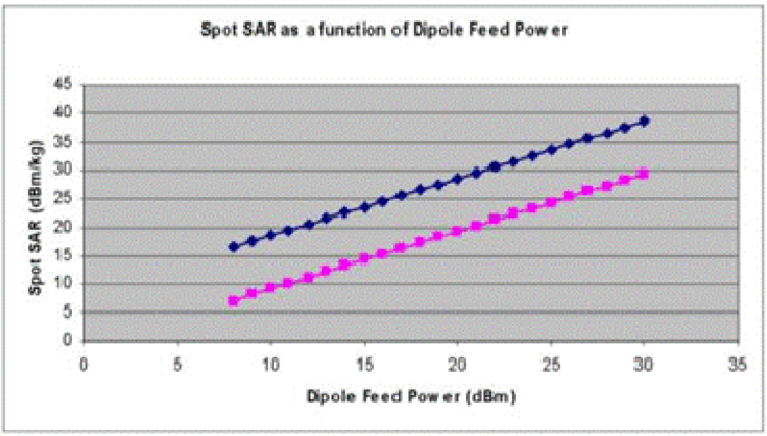


Figure 6. The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.

Product Service



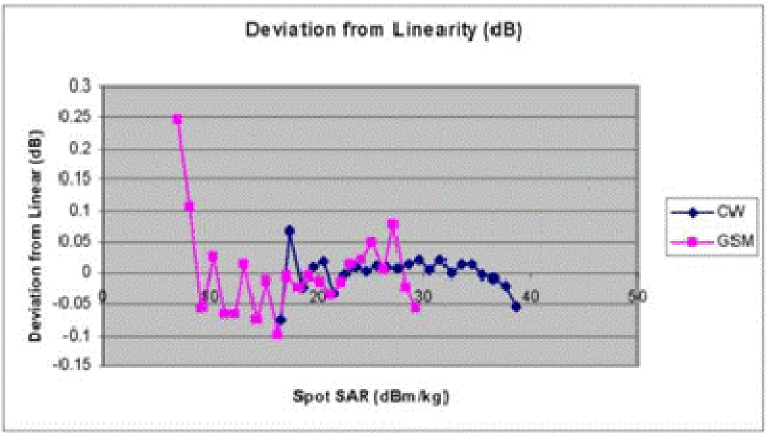


Figure 7: The typical linearity response of 5mm probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of of 8 (ie 9dB) lower than CW. The lower diagram shows the departure from linearity of the same two datasets.

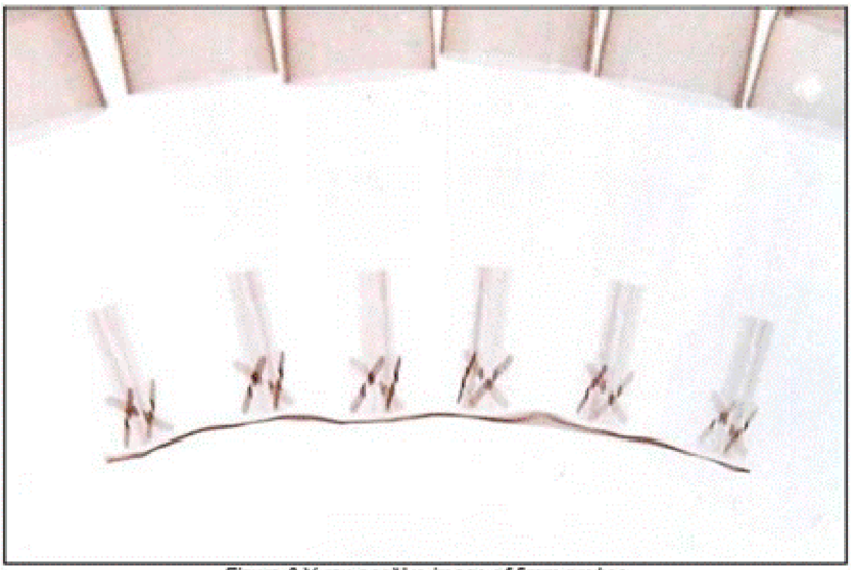


Figure 8 X-ray positive image of 5mm probes

Product Service

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

Frequency (MHz)	Fluid Type	Measured		Target		% Deviation		Verdict	
		Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity (S/m)	Relative Permittivity	Conductivity	Relative Permittivity	Conductivity
450	Head	44.09	0.84	43.5	0.87	1.4	-3.3	Pass	Pass
835		42.14	0.90	41.5	0.90	1.5	0.1	Pass	Pass
900		41.13	0.96	41.5	0.97	-0.9	-0.9	Pass	Pass
1800		39.72	1.43	40.0	1.40	-0.7	2.0	Pass	Pass
1900		39.71	1.41	40.0	1.40	-0.7	0.6	Pass	Pass
2100		40.50	1.48	39.8	1.49	1.8	-0.6	Pass	Pass
2450		39.17	1.85	39.2	1.80	-0.1	2.8	Pass	Pass
2600		38.60	2.01	39.0	1.96	-1.0	2.7	Pass	Pass

Table of test equipment calibration status

Instrument description	Supplier / Manufacturer	Model	Serial No.	Last calibration date	Cal certificate number	See Annex	Calibration due date
Power sensor	Rohde & Schwarz	NRP-Z23	100063	14/08/2013	10-300287035	1	14/08/2015
Power sensor	Rohde & Schwarz	NRP-Z23	100169	06/08/2014	1400-48811	2	06/08/2016
Dielectric property measurement	Indexsar	DiLine (sensor lengths: 160mm, 80mm and 60mm)	N/A	(absolute) – checked against NPL values using reference liquids.	N/A		N/A
Vector network analyser	Anritsu	MS6423B	003102	17/02/2015	RMA20027002	3	17/02/2016
SMA autocalibration module	Anritsu	36581KKF/1	001902	22/01/2015	RMA20021769	4	22/01/2016

Annex 1

Calibration Certificate of NRP-Z23 power sensor, S/N 100063

ROHDE & SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number 10-300287035
Zertifikatsnummer

Unit Data

Item / Gegenstand	Average power sensor
Manufacturer / Hersteller	ROHDE & SCHWARZ
Type / Typ	NRP-Z23
Material Number / Materialnummer	1137.8002.02
Serial Number / Seriennummer	100063
Asset Number / Inventarnummer	

Order Data

Customer / Auftraggeber	IndexSAR Ltd Oakfield House, RH5 5BG Newdigate GB
Order Number / Bestellnummer	-
Date of Receipt / Eingangsdatum	2013-08-08

Performance

Place and Date of Calibration / Ort und Datum der Kalibrierung	Memmingen, 2013-08-14
Scope of Calibration / Umfang der Kalibrierung	Standard Calibration
Statement of Compliance (Incoming) / Konformitätsaussage (Anlieferung)	Measurement results within specifications
Statement of Compliance (Outgoing) / Konformitätsaussage (Auslieferung)	Measurement results within specifications
Extent of Calibration Documents / Umfang des Kalibrierdokuments	2 Pages Calibration Certificate 17 Pages Outgoing Results 17 Pages Incoming Results

This calibration certificate documents, that the named item is tested and measured against defined specifications.
Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2).
Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national / international standards, which realize the physical units of measurement according to the International System of Units (SI).
In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories.
Principles and methods of calibration correspond with EN ISO/IEC 17025. The applied quality system is certified to EN ISO 9001.
This calibration certificate may not be reproduced other than in full.
Calibration certificates without signatures are not valid.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte lagen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI).
Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien.
Grundsätze und Verfahren der Kalibrierung entsprechen EN ISO/IEC 17025.
Das angewandte Qualitätsmanagement-System ist zertifiziert nach EN ISO 9001.
Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden.
Kalibrierscheine ohne Signifizierungen sind ungültig.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Rohde & Schwarz GmbH & Co. KG; Service Operations West

Date of Issue / Ausstellungsdatum	Head of Laboratory / Laborleitung	Person Responsible / Bearbeiter
2013-08-14	Courage	Ruprecht Schmid

Page 1/2

ROHDE & SCHWARZ GmbH & Co KG · Mühldorfstraße 15 · D-81671 München, Federal Republic of Germany · Telefon (089) 41 29-0 · Telefax (089) 41 29-132 75
Geschäftsführung: Manfred Fleischmann (Vorsitzender), Christian Leicher, Gerhard Geier
Sitz München · Registereintrag: HRA 16 270 · Persönlich haftender Gesellschafter: RUSEG Verwaltungs-GmbH · Sitz München · Registereintrag: AG München HRB 7 534

TÜV SÜD
Product Service

Material Number 1157.8003.02 Serial Number 100043

Certificate Number 10-300287035

Calibration Method
Kalibrieranweisung
NRVC-1109.0930.32

Relative Humidity
Relative Luftfeuchte
20%-60%

Ambient Temperature
Umgebungstemperatur
$(23\ ^{+1}_{-1})$ °C

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	Type Typ	Serial Number Seriennummer	Calibration Certificate Number Kalibrierscheinnummer	Cal. Due Kalibr. bis
Dual Channel Powermeter	NRVD	100862	0114 D-K-15195-01-00 2013-08	2014-11-30
Dual Channel Power Meter	NRVD	826583/0023	0113 D-K-15195-01-00 2013-08	2014-11-30
Vector Network Analyzer	ZVM	835228/0020	0102-DKD-K-16101-2011-08	2013-10-31
Acess. Set for Lin. Measurement	NRVC-B2	840917/0028	0085 D-K-15195-01-00 2013-01	2014-04-30
Calibration Kit Type-N ;50 Ohm	85054B	.2705A00160	217-01723 [METAS]	2015-03-31
Power Standard	NRVC	836497/0005	0082 D-K-15195-01-00 2013-01	2014-04-30

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Notes
Anmerkungen

Installed options are included in calibration. Depending on installed options, numbers of pages of the record are not consecutive.

TÜV SÜD Product Service

Annex 2

Calibration Certificate of NRP-Z23 power sensor, S/N 100169

ROHDE&SCHWARZ

Calibration Certificate
Kalibrierschein

Certificate Number Zertifikatsnummer: **1400-48811**

Unit data

Item / Gegenstand	AVERAGE POWER SENSOR
Manufacturer / Hersteller	Rohde & Schwarz
Type / Typ	NRP-Z23
Material number / Materialnummer	1137.8002.02
Serial number / Seriennummer	ID: 1137.8002.02-100169-aj Ser.: 100169
Asset number / Anlagennummer	
Recommended Calibration Interval	24 Months

Order data

Customer / Auftraggeber	IndexSAR Ltd Oakfield House, Newdigate RH5 5BG Great Britain
On behalf of (where applicable) / In namen von (Wenn gewunscht)	
Order number / Bestellungnummer	1024R&S
Date of receipt / Eingangsdatum	2014-08-06 (YYYY-MM-DD)

Performance

Place and date of calibration / Ort u. Datum d. Kalibrierung	Fleet; 2014-08-06 (YYYY-MM-DD)
Scope of calibration / Umfang der Kalibrierung	Factory Standard Calibration
Statement of Compliance (Incoming) / Konformitätsaussage (Anlieferung)	All measured values are within the data sheet specifications.
Statement of Compliance (Outgoing) / Konformitätsaussage (Auslieferung)	All measured values are within the data sheet specifications.
Extent of calibration documents / Umfang der Kalibrierdokumentation	2 Pages Calibration Certificate 40 Pages Calibration Results 2 Pages Incoming Report

This calibration certificate documents, that the named item is tested and measured against defined specifications.
Measurement results are located usually in the corresponding interval with a probability of approx. 95% (coverage factor k = 2).
Calibration is performed with test equipment and standards directly or indirectly traceable by means of approved calibration techniques to the PTB/DKD or other national / international standards, which realize the physical units of measurement according to the International System of Units (SI). In all cases where no standards are available, measurements are referenced to standards of the R&S laboratories.
Principles and methods of calibration correspond essentially with the technical requirements of EN ISO/IEC 17025. The applied quality system is certified to EN ISO 9001.
This calibration certificate may not be reproduced other than in full. Calibration certificates without signatures are not valid.
The user is obliged to have the object recalibrated at appropriate intervals.

Dieser Kalibrierschein dokumentiert, dass der genannte Gegenstand nach festgelegten Vorgaben geprüft und gemessen wurde. Die Messwerte liegen im Regelfall mit einer Wahrscheinlichkeit von annähernd 95% im zugeordneten Werteintervall (Erweiterte Messunsicherheit mit k = 2).
Die Kalibrierung erfolgte mit Messmitteln und Normalen, die direkt oder indirekt durch Ableitung mittels anerkannter Kalibriertechniken rückgeführt sind auf Normale der PTB/DKD oder anderer nationaler/internationaler Standards zur Darstellung der physikalischen Einheiten in Übereinstimmung mit dem Internationalen Einheitensystem (SI). Wenn keine Normale existieren, erfolgt die Rückführung auf Bezugsnormale der R&S-Laboratorien.
Grundsätze und Verfahren der Kalibrierung entsprechen im Wesentlichen den technischen Anforderungen der EN ISO/IEC 17025.
Das angewandte Qualitätsmanagement-System ist zertifiziert nach EN ISO 9001.
Dieser Kalibrierschein darf nur vollständig und unverändert weiterverbreitet werden. Kalibrierscheine ohne Unterschriften sind ungültig.
Für die Einhaltung einer angemessenen Frist zur Wiederholung der Kalibrierung ist der Benutzer verantwortlich.

Rohde & Schwarz UK

Date of issue / Ausstellungsdatum	Head of laboratory / Laborleitung	Person responsible / Bearbeiter
2014-08-06 (YYYY-MM-DD)	Carol Mckenzie	Martin Gill

Page (Seite) 1 of 2

ROHDE & SCHWARZ UK Ltd. Ancells Business Park, Fleet Hampshire, GU51 2UZ, United Kingdom
Registered in England No. 539607

Product Service

Material number Materialnummer	1137.8002.02	**Certificate Number** Zertifikatsnummer	**1400-48811**
Serial number Seriennummer	ID: 1137.8002.02-100169-aj Ser.: 100169		

Calibration instruction Kalibrieranweisung	See first page of calibration results	**Date of receipt** Eingangsdatum	**2014-08-06** (YYYY-MM-DD)
Ambient temperature Umgebungstemperatur	(23 ± 2) °C	**Relative humidity** Relative Luftfeuchte	**20 % - 60 %**

This calibration fulfils the requirements of the standard / guideline
Diese Kalibrierung entspricht den Forderungen der Norm / Richtlinie

Working standards used (having a significant effect on the accuracy)
Verwendete Gebrauchsnormale (mit signifikantem Einfluss auf die Genauigkeit)

Item Gegenstand	**Type** Typ	**Serial number** Seriennummer	**Calibration certificate number** Kalibrierschein Nummer	**Cal. due** Kalibr.bis
See page 2 of calibration results				

UGB (Uncertainty guard Band): Measurement uncertainty violates the datasheet limit

UGB1 A compliance statement may be possible where a confidence level of less than 95 % is acceptable.
Die Bestätigung der Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

UGB2 A non-compliance statement may be possible where a confidence level of less than 95 % is acceptable.
Die Bestätigung der Nicht-Konformität ist möglich, sofern ein Grad des Vertrauens von weniger als 95% akzeptabel ist.

Conformity statements take the measurement uncertainties into account.
Die Konformitätsaussagen berücksichtigen die Messunsicherheiten.

Ref.: ILAC-G8 1996 'Guidelines on Assessment and Reporting of Compliance with Specification (based on measurements and tests in a laboratory)'

Notes
Anmerkungen

TÜV SÜD Product Service

Annex 3

Calibration certificate of Anritsu MS4623B VNA

Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 456675
Email: service.esc@eu.anritsu.com

Date of Issue:	17/02/2015	**Certificate N°:**	RMA20027002
Customer:	INDEXSAR LTD	**Order No:**	Contract
Manufacturer:	Anritsu Company		

Model	Serial Number	Description
MS4623B	003102	VNA,10 MHZ-6 GHZ,ACTIVE

Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.

Repair required before calibration	(yes)
Electrical Safety	(yes)
Laser safety class	( )

Authorised Signature

Murray Coleman
Head of Customer Services (EMEA)

Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited.
The attached results relate only to the instrument under calibration.
Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353178)
This Certificate comprises of:
Certificate of Calibration
Call Report
25 Page(s) of test results

Annex 3

Calibration certificate of Anritsu MS4623B VNA

Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax:+44 (0) 1582 455875
Email: service.eso@eu.anritsu.com

Date of Issue:	17/02/2015	**Certificate N°:**	RMA20027002
Customer:	INDEXSAR LTD	**Order No:**	Contract
Manufacturer:	Anritsu Company		

Model	Serial Number	Description
MS4623B	003102	VNA,10 MHZ-6 GHZ,ACTIVE

Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.

Repair required before calibration	(yes)
Electrical Safety	(yes)
Laser safety class	( )

Authorised Signature

Murray Coleman
Head of Customer Services (EMEA)

Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited.
The attached results relate only to the instrument under calibration.
Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353178)
This Certificate comprises of:
Certificate of Calibration
Call Report
25 Page(s) of test results

Product Service

Annex 4

Calibration certificate of Anritsu 36581KKF/1 auto-cal kit

Certificate of Calibration

Anritsu
Discover What's Possible™

Customer:
INDEXSAR LTD
INDEXSAR LTD_

OAKFIELD HOUSE
NEWDIGATE
SURREY RH5 5BG
UNITED KINGDOM

ANRITSU EMEA LIMITED
200 CAPABILITY GREEN
LUTON LU1 3LU
UNITED KINGDOM
Tel: +44 (0) 1582 433285
Fax: +44 (0) 1582 455575
Email: service.esc@eu.anritsu.com

Date of Issue:	22/01/2015	**Certificate N°:**	**RMA20026648**
Customer:	**INDEXSAR LTD**	**Order No:**	**1045ANR**
Manufacturer:	Anritsu Company		

Model	Serial Number	Description
MS4623B	**003102**	VNA,10 MHZ-6 GHZ,ACTIVE
36581KKF/1	**001902**	TESTED & CHARACTERIZED TO 6 GHZ

Anritsu EMEA Limited does hereby certify the above listed equipment complies to published or stated specifications at the measured parameters, and has been calibrated to the general requirements of ISO 17025 against instruments whose accuracies are traceable to National or International Standards, where such standards are applicable.

Within specification before calibration	(yes)
Repair required before calibration	(no)
Electrical Safety	(yes)
Laser safety class	( )

Authorised Signature

Murray Coleman
Head of Customer Services (EMEA)

Note: Original calibration results are attached and copies held on file at Anritsu EMEA Limited.
The attached results relate only to the instrument under calibration.
Anritsu EMEA Limited Quality system is certified to ISO9001:2000 (Cert. No. FQA 0353176)
This Certificate comprises of:
Certificate of Calibration
Cal Report
13 Page(s) of test results

Product Service

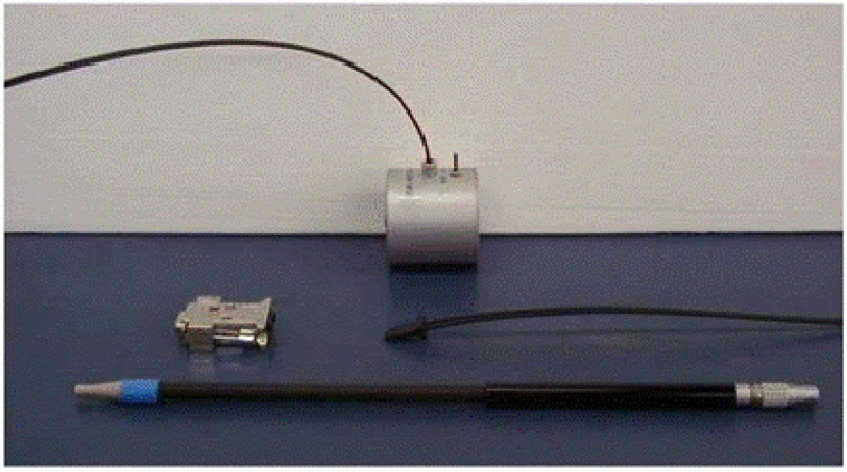
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP – 050

S/N 0204

March 2015



Indexsar Limited
Oakfield House
Cudworth Lane
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Surrey RH5 5BG
Tel: +44 (0) 1306 632 870
Fax: +44 (0) 1306 631 834
e-mail: enquiries@indexsar.com

Product Service

Indexsar Limited
Oakfield House
Cudworth Lane
Newdigate
Surrey RH5 5BG
Tel: +44 (0) 1306 632 870
Fax: +44 (0) 1306 631 834
e-mail: enquiries@indexsar.com

Calibration Certificate 1503/0204
Date of Issue: 31 March 2015
Immersible SAR Probe

Type:	IXP-050
Manufacturer:	IndexSAR, UK
Serial Number:	0204
Place of Calibration:	IndexSAR, UK
Date of Receipt of Probe:	10 February 2015
Calibration Dates:	25 February– 13 March 2015
Customer:	TUV Sud

IndexSAR Ltd hereby declares that the IXP-050 Probe named above has been calibrated for conformity to the current versions of IEEE 1528, IEC 62209-1, IEC 62209-2, and FCC SAR 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:	[signature]	**Engineer**
Approved by:	[signature]	**Director**

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

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INTRODUCTION

Straight probes work on either SARA-C (to measure SAR values in flat phantoms containing Body tissue simulant fluid), or on SARA2 (where they, too, can measure in a flat phantom with Body fluid, or in a SAM phantom containing Head fluid).

This Report presents measured calibration data for a particular Indexsar SAR probe (S/N 0204) for use on SARA-C only. **The calibration factors do not apply to, and will not give correct readings on, the IndexSAR SARA2 system.**

Indexsar probes are characterised using procedures that, where applicable, follow the recommendations of IEC 62209-1 [Ref 1], IEEE 1528 [Ref 2], IEC 62209-2 [Ref 3] and FCC [Ref 4] 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 the following stages

1) Determination of the channel sensitivity factors which optimise the probe's overall axial isotropy

2) Channel sensitivity factors are largely frequency independent. Consequently, they can be combined to model the exponential decay of SAR in a waveguide fluid cell at each frequency of interest, 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] - [4]. 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.

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For this value of DCP, the typical linearity response of IXP-050 probes to CW and to GSM modulation is shown in Figure 4, along with departures of this same dataset from linearity.

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

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

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

3. Selecting channel sensitivity factors to optimise isotropic response

Within SARA-C, an L-probe's predominant mode of operation is with the tip pointing directly towards the source of radiation. Consequently, optimising the probe's response to boresight signals ("axial isotropy") is far more important than optimising its spherical isotropy (where the direction, as well as the polarisation angle, of the incoming radiation must be taken into account).

The setup for measuring the probe's axial isotropy is shown in Figure 1. Since isotropy is frequency-independent, measurements are normally made at a frequency of 900MHz as lower frequencies are more tolerant of positional inaccuracies.

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

The waveguide stands in an upright position and the liquid cell section is filled with 900MHz brain fluid to within 10 mm of the open end. The depth of liquid ensures there is negligible radiation from the waveguide open top and that the probe calibration is not influenced by reflections from nearby objects.

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

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

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

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

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

Figure 2 represents the output from each diode sensor as a function of probe rotation angle.

4. Determination of Conversion ("Liquid") Factors at each frequency of interest

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

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

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

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

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).

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

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

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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 ± 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.

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

Different waveguides are used for 700MHz, 835/900MHz, 1450MHz, 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.

According to [1], this calibration technique provides excellent accuracy, with standard uncertainty of less than 3.6% depending on the frequency and medium. The calibration itself is reduced to power measurements traceable to a standard calibration procedure. The practical limitation to the frequency band of 800 to 5800 MHz because of the waveguide size is not severe in the context of compliance testing.

During calibration, the probe is lowered carefully until it is just touching the cross-sectional centre of the dielectric window. 240 samples are then taken and written to an Excel template file before moving the probe vertically upwards. This cycle is repeated 150 times. The vertical separation between readings is determined from practical considerations of the expected SAR decay rate, and range from 0.35mm steps below 3GHz, 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.

For calibrations at 450MHz, where waveguide calibrations become unfeasible, a full 3D SAR scan over a tuned dipole is performed, and the conversion factor adjusted to make the measured 1g and 10g volume-averaged SAR values agree with published targets.

CALIBRATION FACTORS MEASURED FOR PROBE S/N 0204

The probe was calibrated at 700, 835, 900, 1800, 1900, 2100, 2450 and 2600 MHz in liquid samples representing brain and body liquid at these frequencies.