Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-15:29:01	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	71.00mm
DUT POSITION:	10mm-Rear Facing	**MAX SAR Y-AXIS LOCATION:**	-19.60mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	3.081
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.027 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.025 W/kg
INPUT POWER LEVEL:	24.7dBm	**SAR END:**	0.025 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-0.400 %

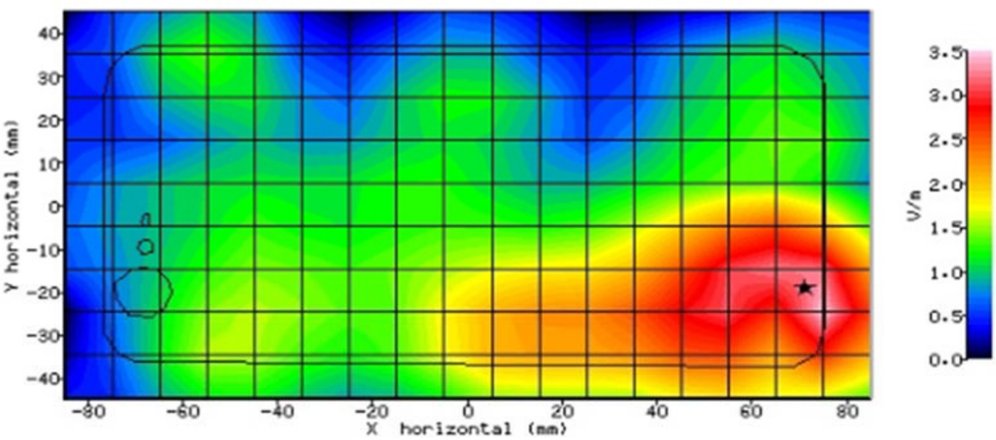

Figure 91: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-15:51:45	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	57.30mm
DUT POSITION:	10mm-Left Edge	**MAX SAR Y-AXIS LOCATION:**	-1.00mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	3.045
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.023 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.024 W/kg
INPUT POWER LEVEL:	24.7dBm	**SAR END:**	0.025 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	2.600 %

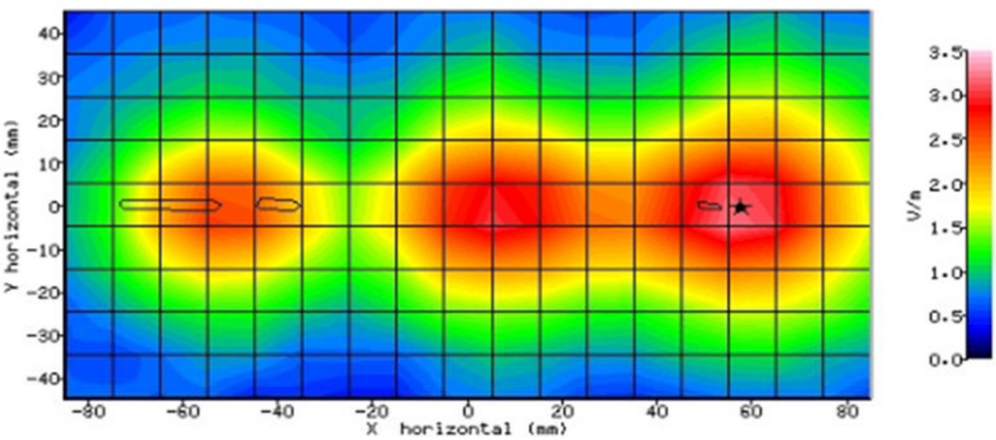

Figure 92: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-16:10:27	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-22.60mm
DUT POSITION:	10mm-Bottom Edge	**MAX SAR Y-AXIS LOCATION:**	0.20mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	2.547
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.019 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.020 W/kg
INPUT POWER LEVEL:	24.7dBm	**SAR END:**	0.020 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-2.600 %

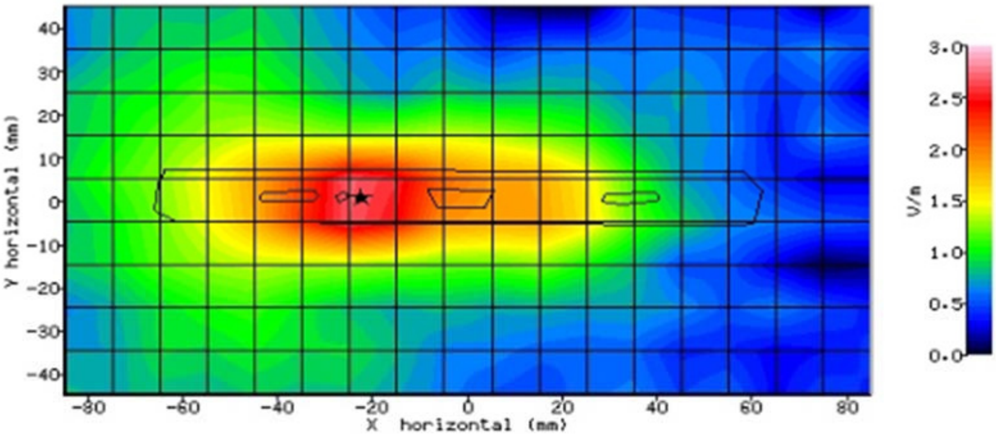

Figure 93: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

2.24 LTE BAND 38 HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	13/04/2016-08:24:37	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.80°C	**LIQUID SIMULANT:**	2600 Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	38.26
RELATIVE HUMIDITY:	38.90%	**CONDUCTIVITY:**	1.996
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	22.50°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	68.10mm
DUT POSITION:	Left-Cheek	**MAX SAR Z-AXIS LOCATION:**	-142.00mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	7.855
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.154 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.158 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.156 W/kg
PROBE BATTERY LAST CHANGED:	12/04/2016	**SAR DRIFT DURING SCAN:**	-0.800 %

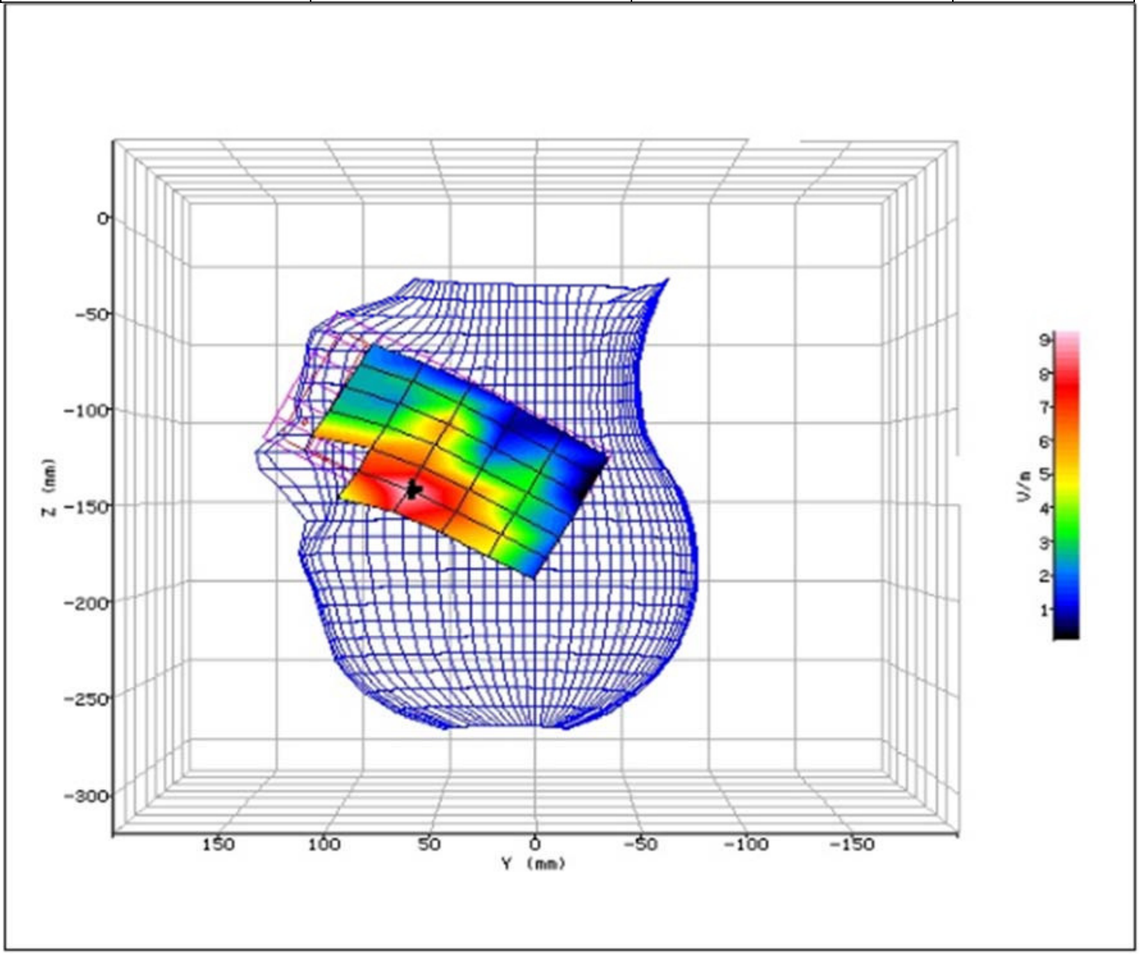

Figure 94: SAR Head Testing Results for the Sharp Smart phone at 2595.0MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	13/04/2016-08:53:47	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.80°C	**LIQUID SIMULANT:**	2600 Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	38.26
RELATIVE HUMIDITY:	38.90%	**CONDUCTIVITY:**	1.996
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	22.50°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	29.00mm
DUT POSITION:	Left-15°	**MAX SAR Z-AXIS LOCATION:**	-166.00mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	6.429
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.146 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.120 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.119 W/kg
PROBE BATTERY LAST CHANGED:	12/04/2016	**SAR DRIFT DURING SCAN:**	-0.600 %

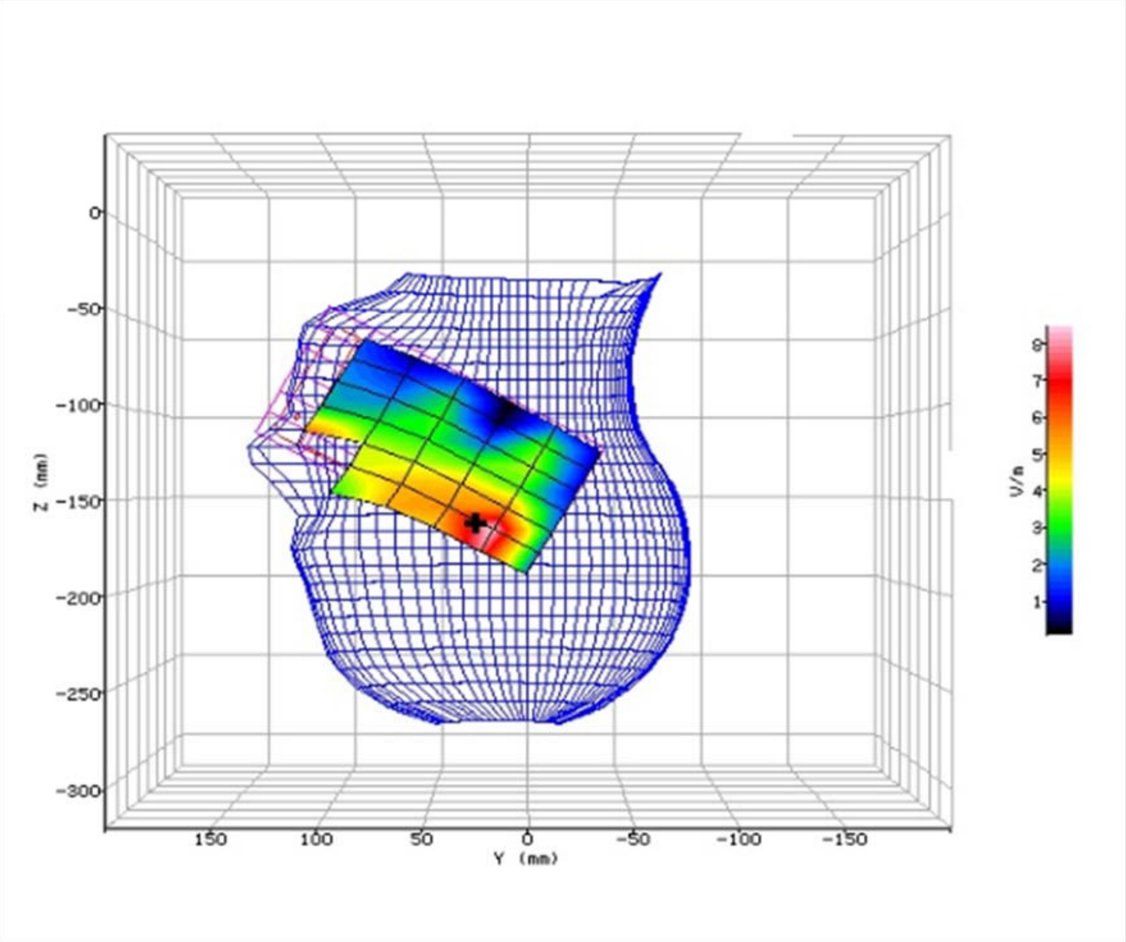

Figure 95: SAR Head Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	12/04/2016-16:25:28	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.80°C	**LIQUID SIMULANT:**	2600 Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	38.26
RELATIVE HUMIDITY:	38.90%	**CONDUCTIVITY:**	1.996
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	22.50°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	58.20mm
DUT POSITION:	Right-Cheek	**MAX SAR Z-AXIS LOCATION:**	-93.80mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	12.155
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.566 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.474 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.452 W/kg
PROBE BATTERY LAST CHANGED:	12/04/2016	**SAR DRIFT DURING SCAN:**	-4.700 %

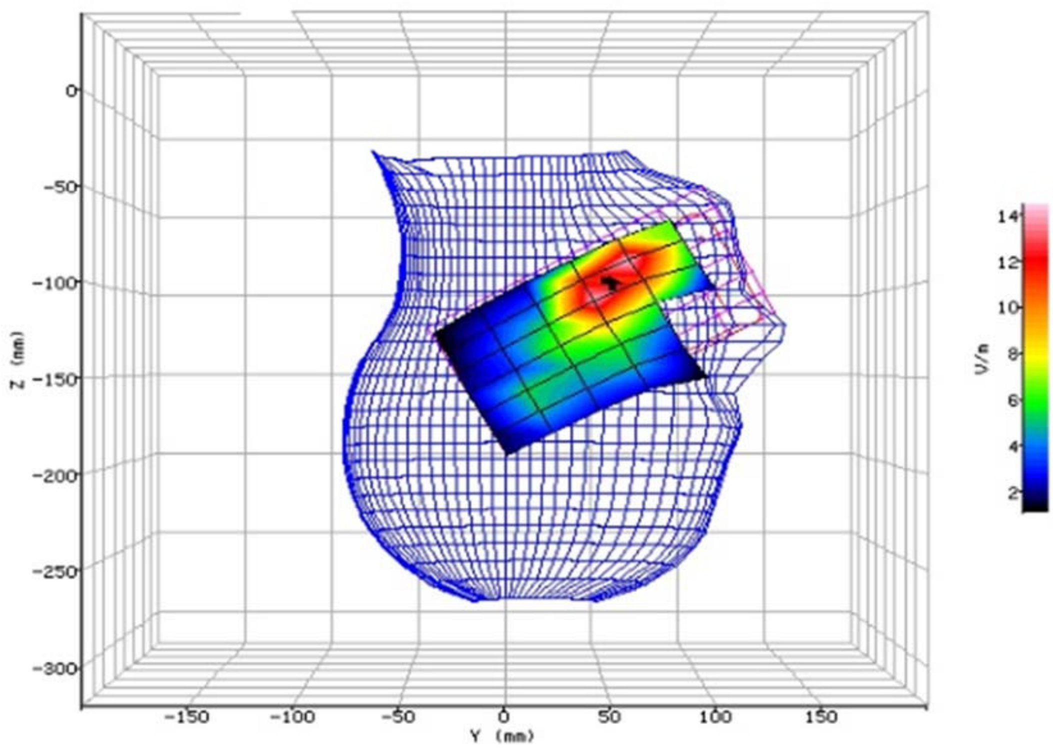

Figure 96: SAR Head Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	INPUT POWER DRIFT:	0 dB
DATE / TIME:	12/04/2016-16:49:51	DUT BATTERY MODEL/NO:	Integral
AMBIENT TEMPERATURE:	22.80°C	LIQUID SIMULANT:	2600 Head
DEVICE UNDER TEST:	-	RELATIVE PERMITTIVITY:	38.26
RELATIVE HUMIDITY:	38.90%	CONDUCTIVITY:	1.996
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	22.50°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	55.50mm
DUT POSITION:	Right-15°	MAX SAR Z-AXIS LOCATION:	-91.90mm
ANTENNA CONFIGURATION:	N/A	MAX E FIELD:	5.503
TEST FREQUENCY:	2595.0MHz	SAR 1g:	0.099 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	SAR 10g:	-
MODN. DUTY CYCLE:	100%	SAR START:	0.078 W/kg
INPUT POWER LEVEL:	23.7dBm	SAR END:	0.077 W/kg
PROBE BATTERY LAST CHANGED:	12/04/2016	SAR DRIFT DURING SCAN:	-1.400 %

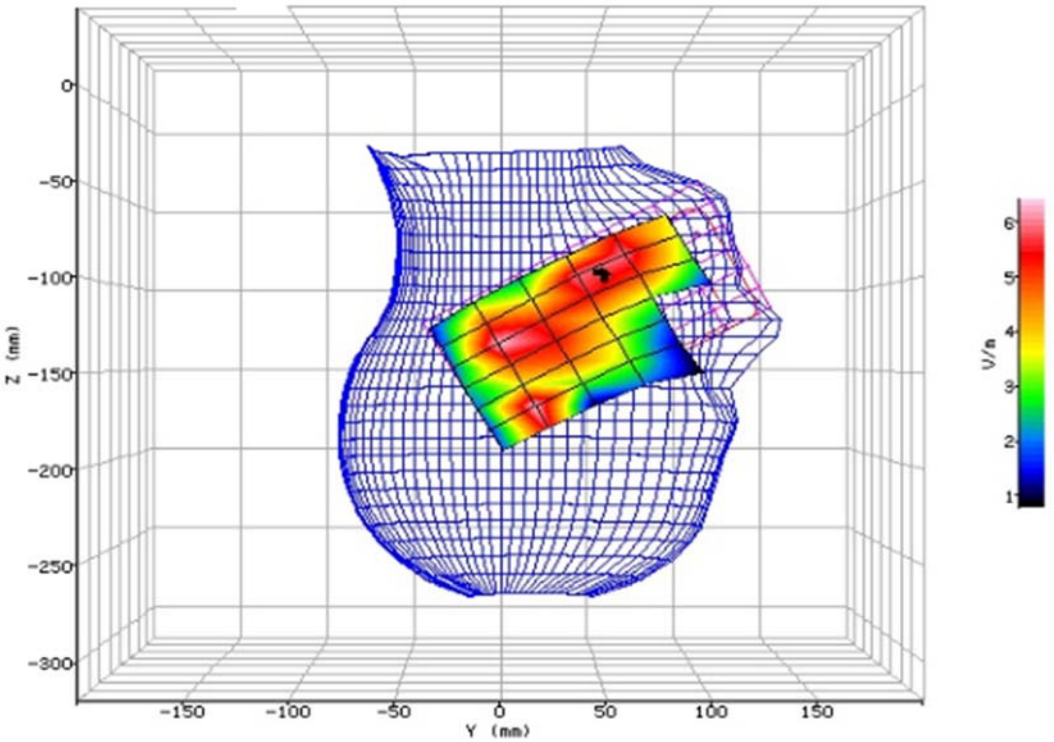

Figure 97: SAR Head Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

2.25 LTE BAND 38 BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-17:25:19	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	53.90mm
DUT POSITION:	10mm-Front Facing	**MAX SAR Y-AXIS LOCATION:**	21.20mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	13.560
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.451 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.466 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.448 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-3.900 %

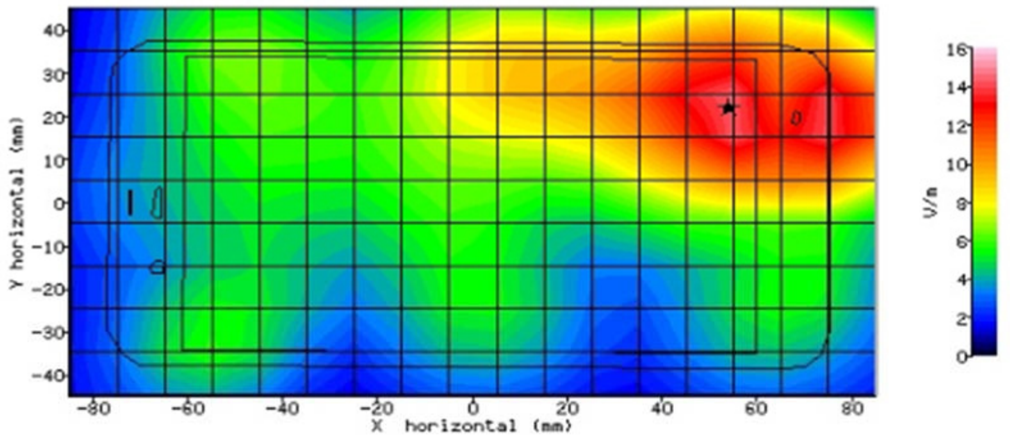

Figure 98: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-17:44:04	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	71.30mm
DUT POSITION:	10mm-Rear Facing	**MAX SAR Y-AXIS LOCATION:**	-20.00mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	13.143
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.461 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.430 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.425 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-0.200 %

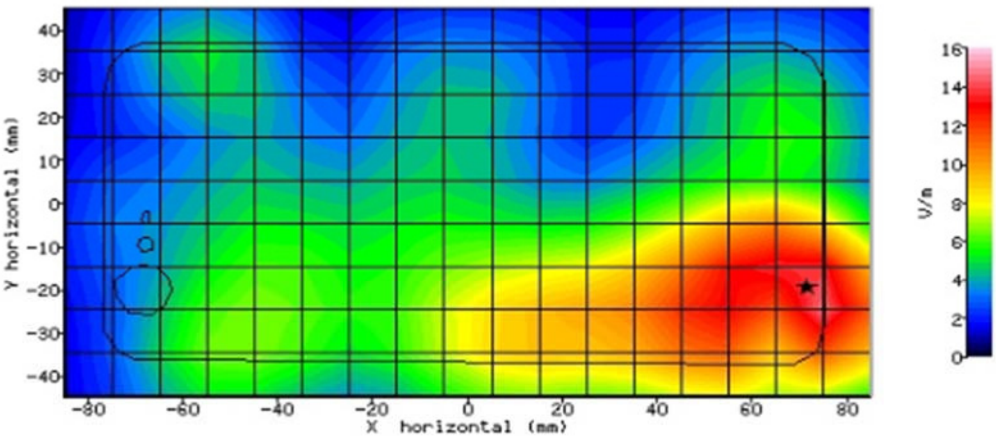

Figure 99: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-17:04:53	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	55.60mm
DUT POSITION:	10mm-Left Edge	**MAX SAR Y-AXIS LOCATION:**	-0.80mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	13.314
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.453 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.476 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.433 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-2.100 %

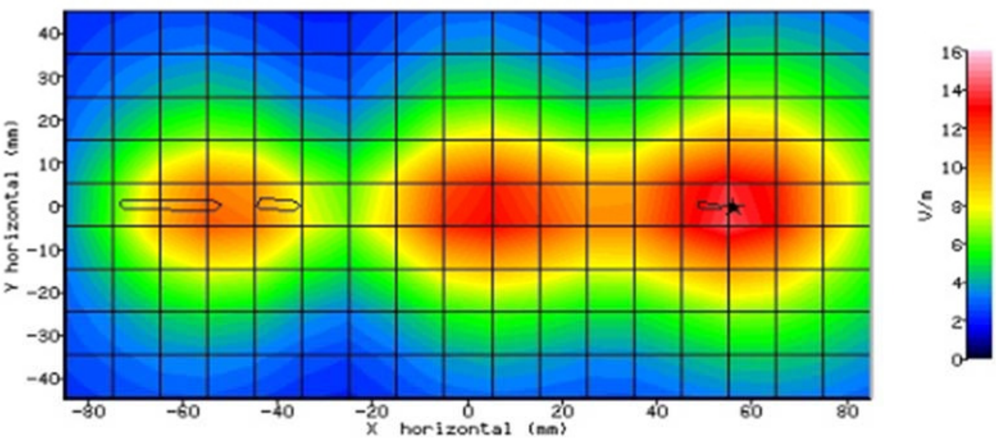

Figure 100: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	15/04/2016-16:46:18	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	2600 Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	51.73
RELATIVE HUMIDITY:	26.20%	**CONDUCTIVITY:**	2.413
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-21.70mm
DUT POSITION:	10mm-Bottom Edge	**MAX SAR Y-AXIS LOCATION:**	-0.80mm
ANTENNA CONFIGURATION:	N/A	**MAX E FIELD:**	10.940
TEST FREQUENCY:	2595.0MHz	**SAR 1g:**	0.351 W/kg
TYPE OF MODULATION:	QPSK (RMC Mode)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.374 W/kg
INPUT POWER LEVEL:	23.7dBm	**SAR END:**	0.366 W/kg
PROBE BATTERY LAST CHANGED:	15/04/2016	**SAR DRIFT DURING SCAN:**	-2.200 %

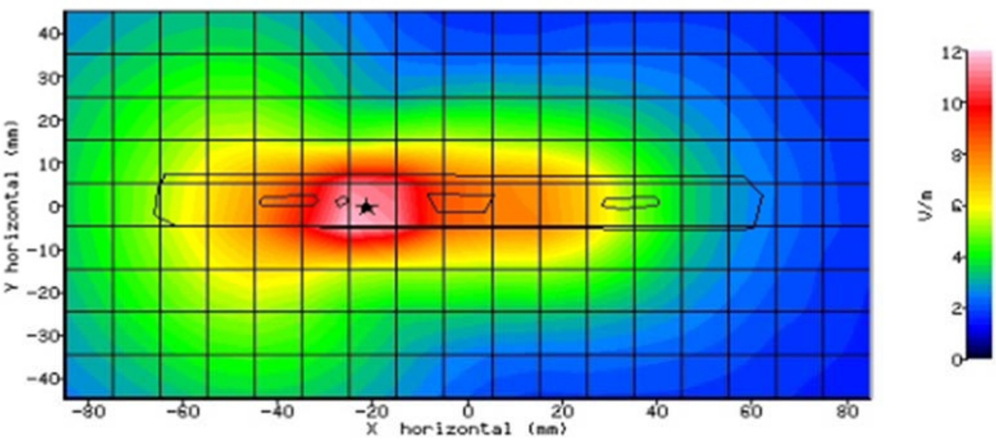

Figure 101: SAR Body Testing Results for the Sharp Smart phone at 2595.0MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	19/04/2016-16:37:21	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.00°C	**LIQUID SIMULANT:**	2450Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	38.81
RELATIVE HUMIDITY:	35.30%	**CONDUCTIVITY:**	1.836
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	18.60mm
DUT POSITION:	Left-Cheek	**MAX SAR Z-AXIS LOCATION:**	-168.40mm
ANTENNA CONFIGURATION:	0	**MAX E FIELD:**	6.308
TEST FREQUENCY:	2412.0MHz	**SAR 1g:**	0.210 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.200 W/kg
INPUT POWER LEVEL:	11dBm	**SAR END:**	0.206 W/kg
PROBE BATTERY LAST CHANGED:	19/04/2016	**SAR DRIFT DURING SCAN:**	3.100 %

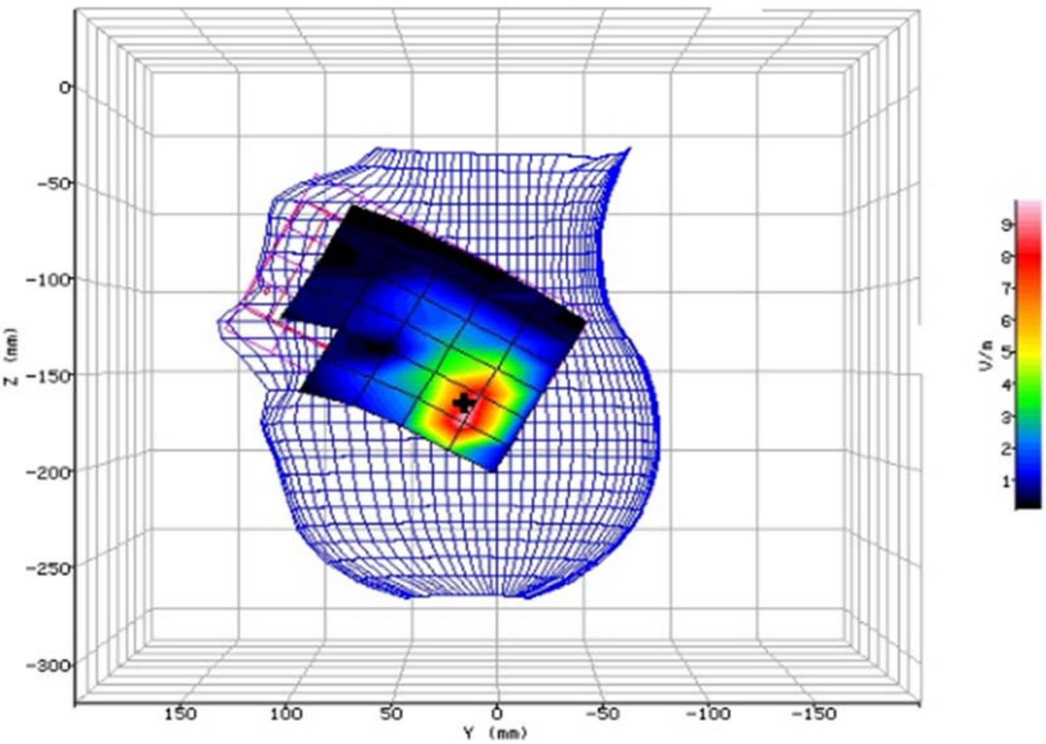

Figure 102: SAR Head Testing Results for the Sharp Smart phone at 2412.0MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	19/04/2016-11:10:43	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.10°C	**LIQUID SIMULANT:**	2450Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	52.13
RELATIVE HUMIDITY:	37.80%	**CONDUCTIVITY:**	1.975
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-5.90mm
DUT POSITION:	10mm-Top Edge	**MAX SAR Y-AXIS LOCATION:**	1.50mm
ANTENNA CONFIGURATION:	0	**MAX E FIELD:**	5.115
TEST FREQUENCY:	2412.0MHz	**SAR 1g:**	0.074 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.076 W/kg
INPUT POWER LEVEL:	11dBm	**SAR END:**	0.075 W/kg
PROBE BATTERY LAST CHANGED:	19/04/2016	**SAR DRIFT DURING SCAN:**	-0.700 %

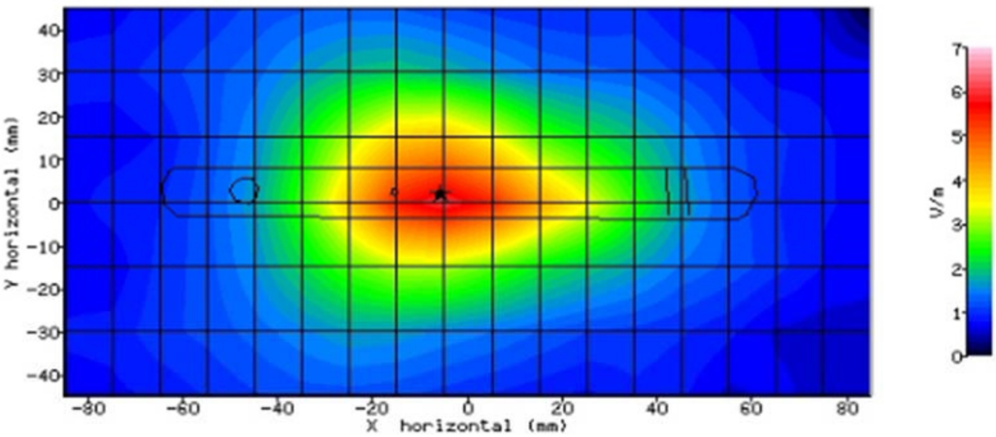

Figure 103: SAR Body Testing Results for the Sharp Smart phone at 2412.0MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	19/04/2016-15:54:20	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.00°C	**LIQUID SIMULANT:**	2450Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	38.81
RELATIVE HUMIDITY:	35.30%	**CONDUCTIVITY:**	1.836
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	38.00mm
DUT POSITION:	Right-Cheek	**MAX SAR Z-AXIS LOCATION:**	-162.00mm
ANTENNA CONFIGURATION:	1	**MAX E FIELD:**	4.629
TEST FREQUENCY:	2437.0MHz	**SAR 1g:**	0.083 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.088 W/kg
INPUT POWER LEVEL:	11dBm	**SAR END:**	0.087 W/kg
PROBE BATTERY LAST CHANGED:	19/04/2016	**SAR DRIFT DURING SCAN:**	-0.900 %

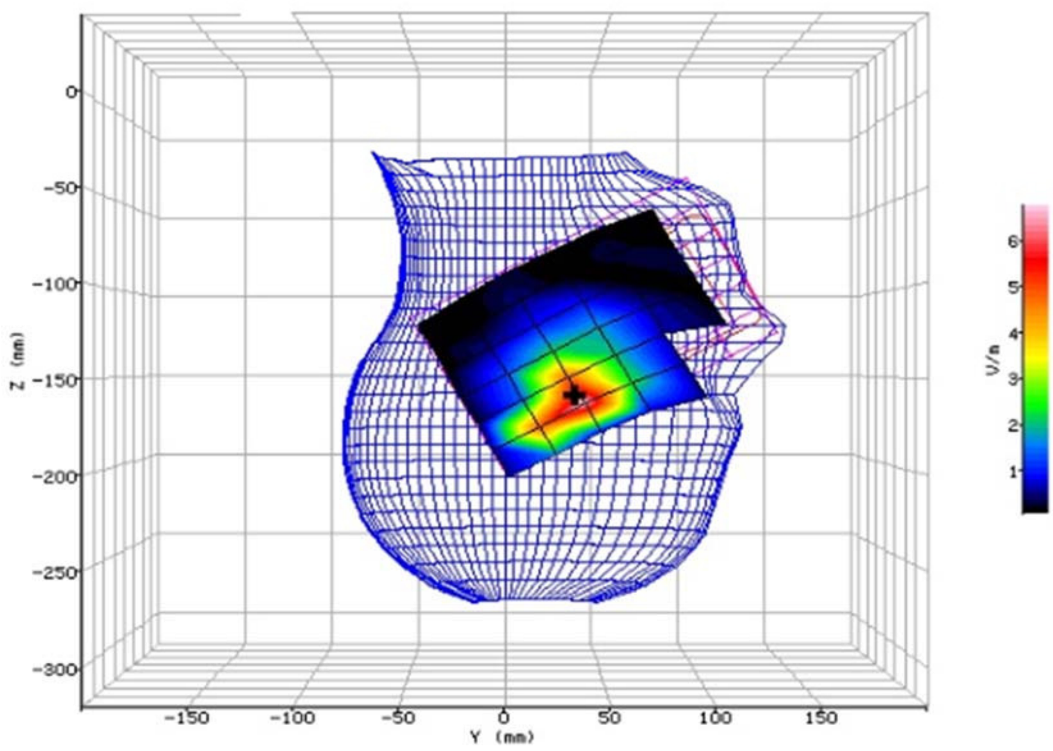

Figure 104: SAR Head Testing Results for the Sharp Smart phone at 2437.0MHz.

Product Service

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

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	19/04/2016-12:17:21	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.10°C	**LIQUID SIMULANT:**	2450Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	52.13
RELATIVE HUMIDITY:	37.80%	**CONDUCTIVITY:**	1.975
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-48.50mm
DUT POSITION:	10mm-Front Facing	**MAX SAR Y-AXIS LOCATION:**	-21.60mm
ANTENNA CONFIGURATION:	1	**MAX E FIELD:**	1.897
TEST FREQUENCY:	2437.0MHz	**SAR 1g:**	0.009 W/kg
TYPE OF MODULATION:	WLAN (DSSS)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.008 W/kg
INPUT POWER LEVEL:	11dBm	**SAR END:**	0.009 W/kg
PROBE BATTERY LAST CHANGED:	19/04/2016	**SAR DRIFT DURING SCAN:**	7.500 %

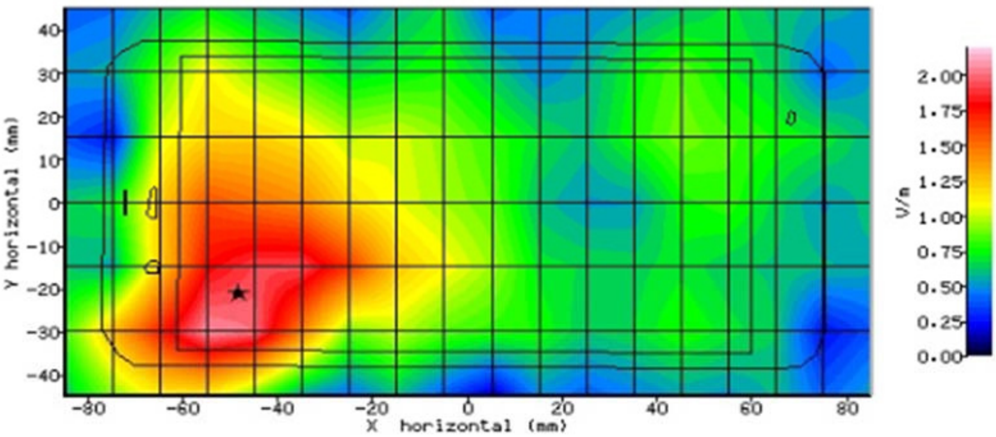

Figure 105: SAR Body Testing Results for the Sharp Smart phone at 2437.0MHz.

Product Service

2.30 WLAN - U-NII-2 HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	20/04/2016-15:17:45	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	22.90°C	**LIQUID SIMULANT:**	5000Head
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	34.44
RELATIVE HUMIDITY:	32.60%	**CONDUCTIVITY:**	4.466
PHANTOM S/NO:	IXB-040	**LIQUID TEMPERATURE:**	23.20°C
PHANTOM ROTATION:	N/A	**MAX SAR Y-AXIS LOCATION:**	5.40mm
DUT POSITION:	Left-15°	**MAX SAR Z-AXIS LOCATION:**	-177.90mm
ANTENNA CONFIGURATION:	0	**MAX E FIELD:**	1.281
TEST FREQUENCY:	5260.0MHz	**SAR 1g:**	0.047 W/kg
TYPE OF MODULATION:	WLAN (OFDM)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.025 W/kg
INPUT POWER LEVEL:	12dBm	**SAR END:**	0.025 W/kg
PROBE BATTERY LAST CHANGED:	20/04/2016	**SAR DRIFT DURING SCAN:**	0.000 %

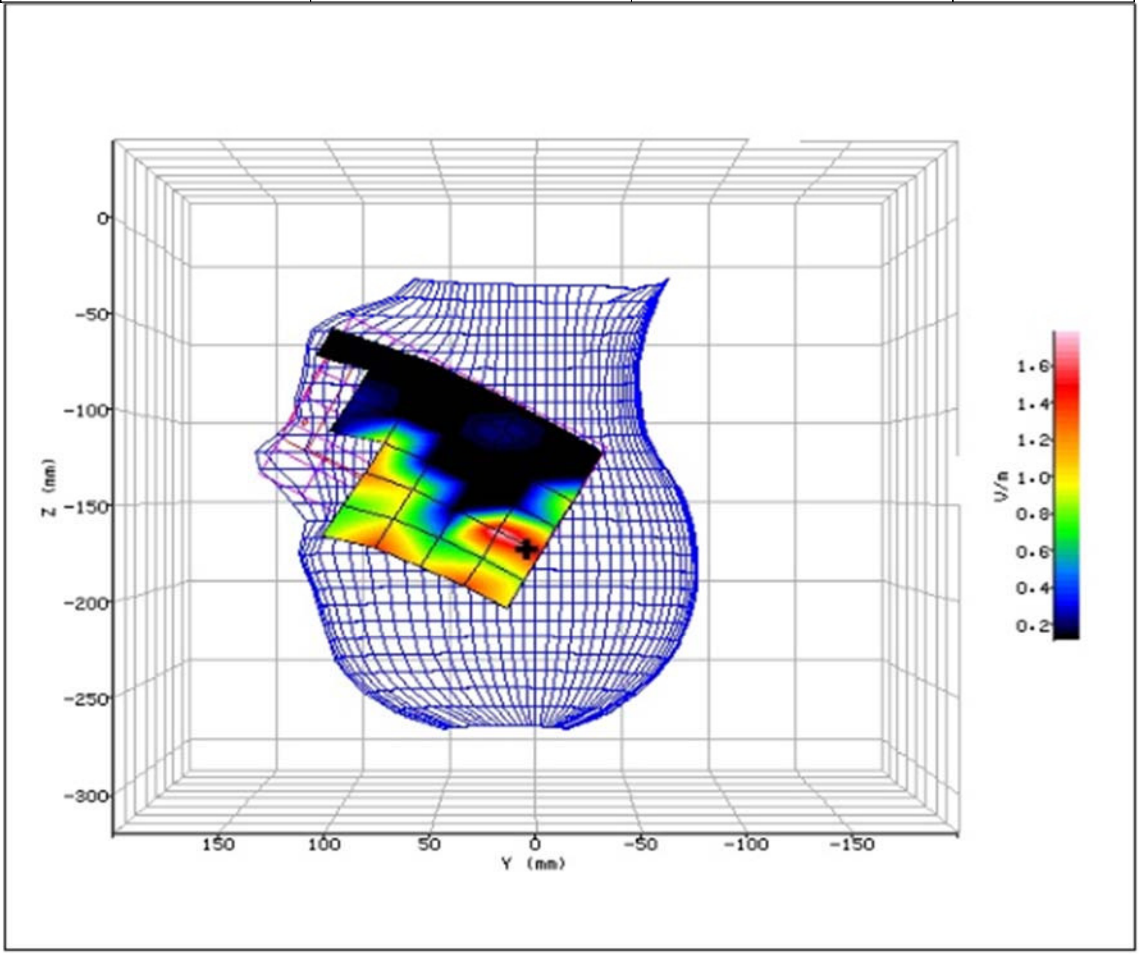

Figure 106: SAR Head Testing Results for the Sharp Smart phone at 5260.0MHz.

Product Service

2.31 WLAN - U-NII-2 BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	20/04/2016-17:26:15	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.10°C	**LIQUID SIMULANT:**	5000Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	47.60
RELATIVE HUMIDITY:	38.50%	**CONDUCTIVITY:**	5.035
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-40.80mm
DUT POSITION:	10mm-Rear Facing	**MAX SAR Y-AXIS LOCATION:**	-33.70mm
ANTENNA CONFIGURATION:	0	**MAX E FIELD:**	3.112
TEST FREQUENCY:	5260.0MHz	**SAR 1g:**	0.063 W/kg
TYPE OF MODULATION:	WLAN (OFDM)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.096 W/kg
INPUT POWER LEVEL:	12dBm	**SAR END:**	0.104 W/kg
PROBE BATTERY LAST CHANGED:	20/04/2016	**SAR DRIFT DURING SCAN:**	9.100 %

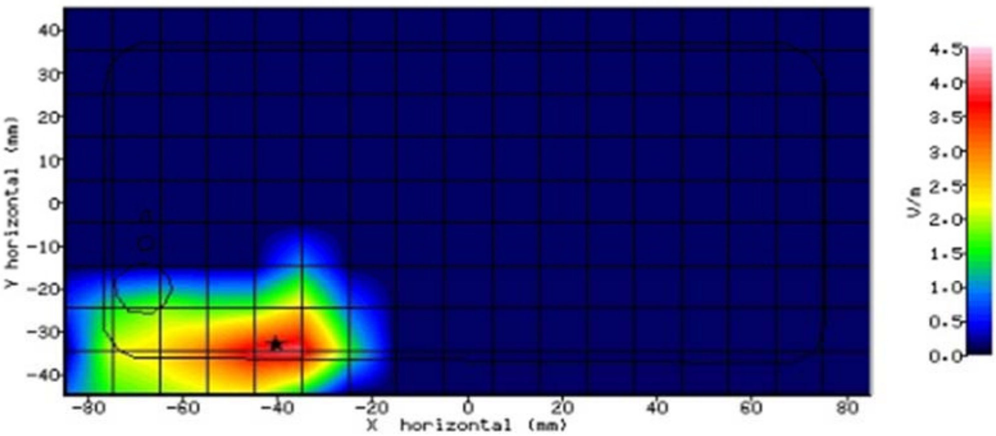

Figure 107: SAR Body Testing Results for the Sharp Smart phone at 5260.0MHz.

Product Service

2.32 WLAN - U-NII-2 HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	INPUT POWER DRIFT:	0 dB
DATE / TIME:	20/04/2016-14:44:59	DUT BATTERY MODEL/NO:	Integral
AMBIENT TEMPERATURE:	22.90°C	LIQUID SIMULANT:	5000Head
DEVICE UNDER TEST:	-	RELATIVE PERMITTIVITY:	34.44
RELATIVE HUMIDITY:	32.60%	CONDUCTIVITY:	4.466
PHANTOM S/NO:	IXB-040	LIQUID TEMPERATURE:	23.20°C
PHANTOM ROTATION:	N/A	MAX SAR Y-AXIS LOCATION:	26.00mm
DUT POSITION:	Right-Cheek	MAX SAR Z-AXIS LOCATION:	-176.70mm
ANTENNA CONFIGURATION:	1	MAX E FIELD:	1.670
TEST FREQUENCY:	5280.0MHz	SAR 1g:	0.091 W/kg
TYPE OF MODULATION:	WLAN (OFDM)	SAR 10g:	-
MODN. DUTY CYCLE:	100%	SAR START:	0.103 W/kg
INPUT POWER LEVEL:	12dBm	SAR END:	0.106 W/kg
PROBE BATTERY LAST CHANGED:	20/04/2016	SAR DRIFT DURING SCAN:	2.600 %

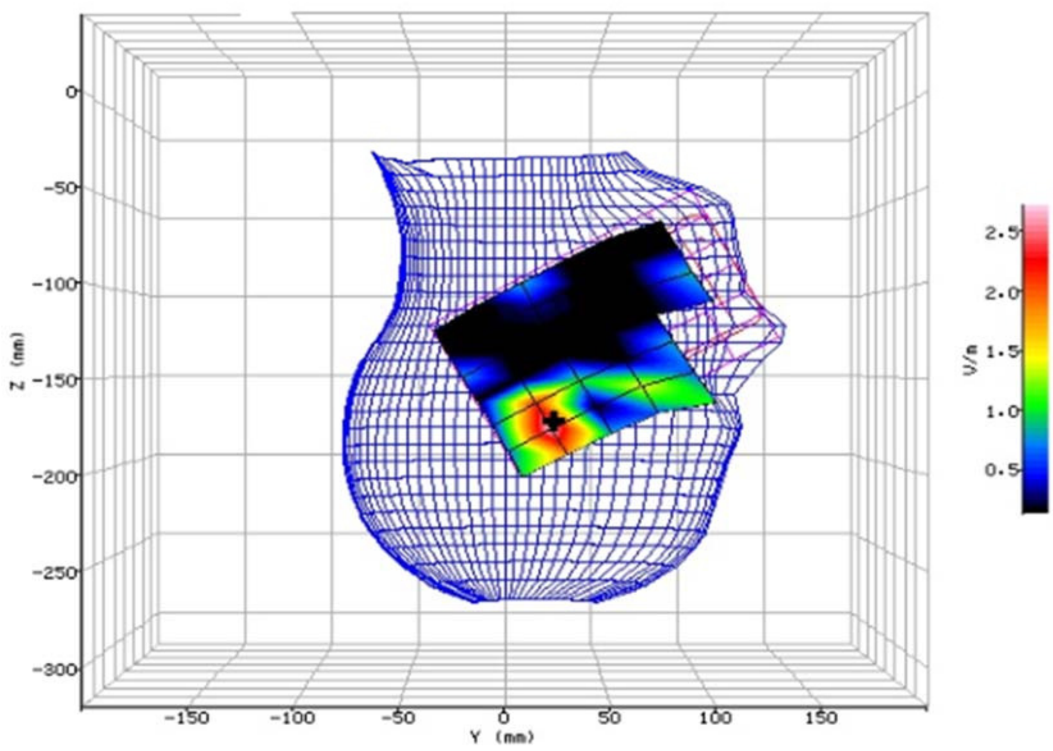

Figure 108: SAR Head Testing Results for the Sharp Smart phone at 5280.0MHz.

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Product Service

2.33 WLAN - U-NII-2 BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

SYSTEM / SOFTWARE:	SARA-C / v6.09.22	**INPUT POWER DRIFT:**	0 dB
DATE / TIME:	21/04/2016-08:20:21	**DUT BATTERY MODEL/NO:**	Integral
AMBIENT TEMPERATURE:	23.10°C	**LIQUID SIMULANT:**	5000Body
DEVICE UNDER TEST:	-	**RELATIVE PERMITTIVITY:**	47.60
RELATIVE HUMIDITY:	38.50%	**CONDUCTIVITY:**	5.035
PHANTOM S/NO:	IXB-2HF	**LIQUID TEMPERATURE:**	23.00°C
PHANTOM ROTATION:	N/A	**MAX SAR X-AXIS LOCATION:**	-58.80mm
DUT POSITION:	10mm-Rear Facing	**MAX SAR Y-AXIS LOCATION:**	30.40mm
ANTENNA CONFIGURATION:	1	**MAX E FIELD:**	1.447
TEST FREQUENCY:	5280.0MHz	**SAR 1g:**	0.012 W/kg
TYPE OF MODULATION:	WLAN (OFDM)	**SAR 10g:**	-
MODN. DUTY CYCLE:	100%	**SAR START:**	0.025 W/kg
INPUT POWER LEVEL:	12dBm	**SAR END:**	0.027 W/kg
PROBE BATTERY LAST CHANGED:	21/04/2016	**SAR DRIFT DURING SCAN:**	9.000 %

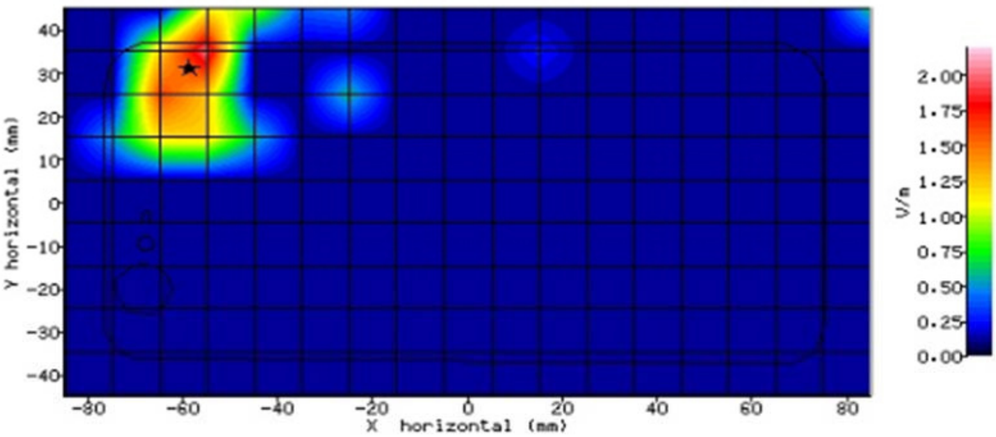

Figure 109: SAR Body Testing Results for the Sharp Smart phone at 5280.0MHz.

Product Service

SECTION 3

TEST EQUIPMENT USED

Product Service

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
Communications Tester	Rohde & Schwarz	CMU 200	442	-	TU
Attenuator (20dB, 20W)	Narda	766F-20	483	12	3-Jun-2016
Dipole Positioner/Support (plastic)	IndexSar Ltd	IXH-020	1585	-	TU
Bi-directional Coupler	IndexSar Ltd	7401 (VDC0830-20)	2414	-	TU
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	16-Nov-2016
Hygrometer	Rotronic	I-1000	3068	12	20-May-2016
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	06-Oct-2016
SAR 1800 MHz dipole	Speag	D1800V2	3855	36	19-Feb-2017
SAR 900 MHz dipole	Speag	D900V2	3856	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
SAR 5GHz dipole	Speag	D5GHzV2	4309	-	TU
Head Phantom	IndexSar Ltd	IXB-040 Inverted SAM phantom	4075	-	TU
Part of SARAC System	IndexSar Ltd	Robot Controller	4076	-	TU
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	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	4313	24	13-Mar-2017
Flat Phantom	IndexSar Ltd	IXB-2HF 700-6000MHz	4399	-	TU
Flat Phantom	IndexSar Ltd	IXB-2HF 700-6000MHz	4400	-	TU

Instrument Description	Manufacturer	Model Type	TE Number	Cal Period (months)	Calibration Due Date
SAR Probe	IndexSar Ltd	IPX-020	4317	24	20-Mar-2017
SAR Probe	IndexSar Ltd	IXP-021	4311	24	20-May-2016
SAR Probe	IndexSar Ltd	IXP-025	4562	24	21-Mar-2017
700MHz Head Fluid	IndexSar Ltd	Batch 1	N/A	1	15-May-2016
700MHz Body Fluid	IndexSar Ltd	Batch 1	N/A	1	15-May-2016
835MHz Head Fluid	IndexSar Ltd	Batch 21	N/A	1	15-May-2016
835MHz Body Fluid	IndexSar Ltd	Batch 13	N/A	1	15-May-2016
1900MHz Head Fluid	IndexSar Ltd	Batch 9	N/A	1	15-May-2016
1900MHz Body Fluid	IndexSar Ltd	Batch 5	N/A	1	15-May-2016
2450MHz Head Fluid	IndexSar Ltd	Batch 12	N/A	1	15-May-2016
2450MHz Body Fluid	IndexSar Ltd	Batch 8	N/A	1	15-May-2016
2600MHz Head Fluid	IndexSar Ltd	Batch 12	N/A	1	15-May-2015
2600MHz Body Fluid	IndexSar Ltd	Batch 8	N/A	1	15-May-2016
5000MHz Head Fluid	IndexSar Ltd	Batch 6	N/A	1	15-May-2016
5000MHz Body Fluid	IndexSar Ltd	Batch 3	N/A	1	15-May-2016

TU – TraceabTU - Traceability Unscheduled

Product Service

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.6.09.22	23 Aug 2015
GLP2 Probe amplifier	Version 2	-

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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.

<u>IEEE 1528 Recipes</u>

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

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

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

Fluid Type and Frequency	Relative Permittivity εR (ε') Target	Relative Permittivity εR (ε') Measured	Conductivity σ Target	Conductivity σ Measured
700MHz Head	42.2	42.8	0.89	0.90
700MHz Body	55.7	55.2	0.96	0.99
835MHz Head	41.5	40.5	0.90	0.88
835MHz Body	55.2	54.2	0.97	0.98
1900MHz Head	40.0	39.9	1.40	1.44
1900MHz Body	53.3	54.4	1.52	1.58
2450 MHz Head	39.2	38.8	1.80	1.83
2450MHz Body	52.7	52.1	1.95	1.97
2600MHz Head	39.0	38.3	1.96	1.99
2600MHz Body	52.2	51.7	2.16	2.14
5200MHz Head	36.0	34.4	4.66	4.45
5200MHz Body	49.0	47.6	5.30	5.04

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 22.2°C to 23.3°C.
The actual humidity during the testing ranged from 25.8% to 46.2% RH.

3.4.2 Test Fluid Temperature Range

Frequency	Body / Head Fluid	Min Temperature °C	Max Temperature °C
700MHz	Head	22.8	23.0
700MHz	Body	22.9	23.0
835MHz	Head	22.4	23.1
835MHz	Body	23.1	23.1
1900MHz	Head	22.8	22.9
1900MHz	Body	23.1	23.1
2450MHz	Head	23.0	23.2
2450MHz	Body	23.0	23.0
2600MHz	Head	22.5	22.5
2600MHz	Body	23.0	23.0
5000MHz	Head	23.2	23.2
5000MHz	Body	23.0	23.0

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 -9.0% (1.098 dB) for head and 9.0% (0.918 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	7.0	R	1.73	1	5.20	∞
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	9.0	R	1.73	1	5.43	∞
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			11.92	
Expanded uncertainty (95% confidence interval)			K=2			23.84	

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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	9.0	R	1.73	1	5.20	∞
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			11.71	
Expanded uncertainty (95% confidence interval)			K=2			23.42	

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

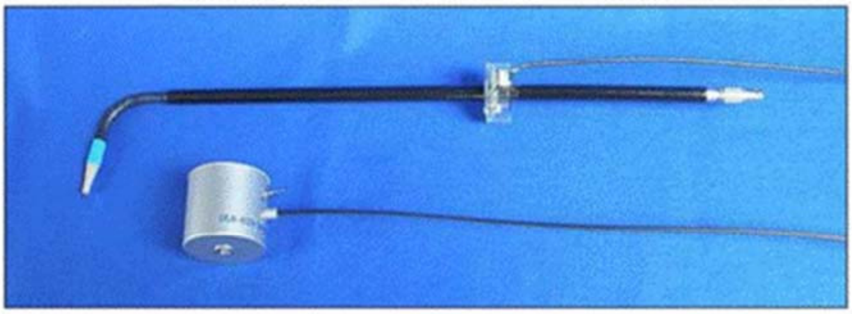
IMMERSIBLE SAR PROBE

CALIBRATION REPORT

Part Number: IXP–020

S/N L0020

March 2015



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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:	[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.

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.

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:

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

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:

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

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

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

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

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

Dedicated waveguides have been designed to accommodate the geometry of an L-shaped probe as it traces out the decay profile. Traditional straight probes measure the decay rate of a vertical-travelling signal above a horizontal dielectric window; for the L-shaped probes, the geometry has had to be changed, and the waveguide now lies horizontally and instead of being open at the end, is capped with a metal plate (see Figure 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 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.

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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 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

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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.

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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.

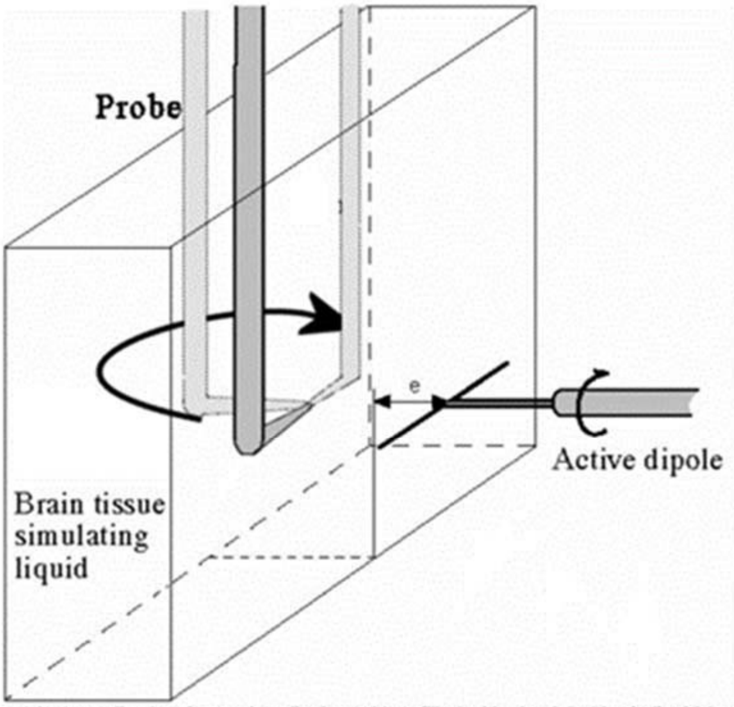

Figure 1 Isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)

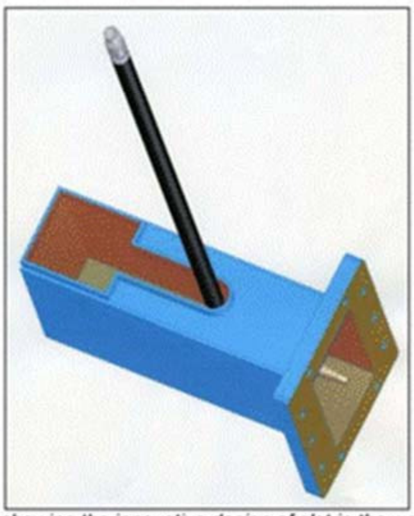

Figure 2 Schematic showing the innovative design of slot in the waveguide termination

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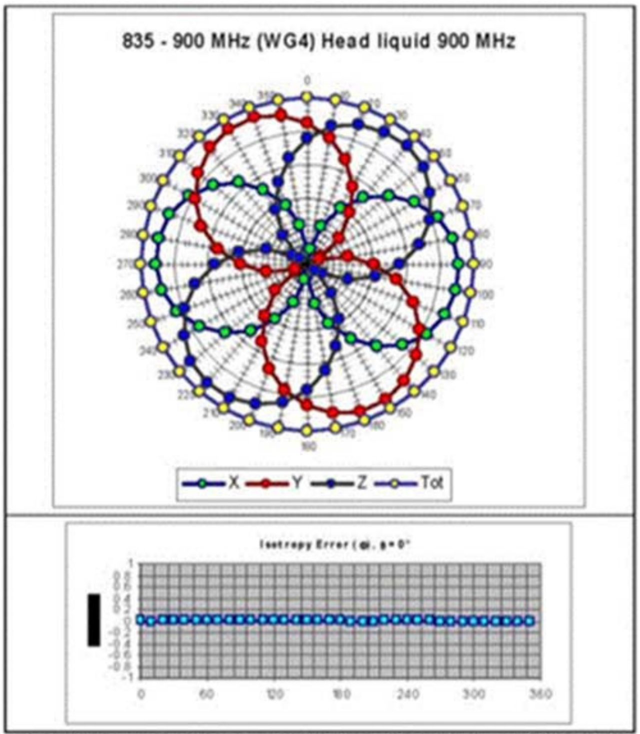

Figure 3 The axial isotropy of probe S/N L0020 obtained by rotating a 900MHz dipole with probe tip aligned with dipole boresight (NB Axial Isotropy is frequency independent)

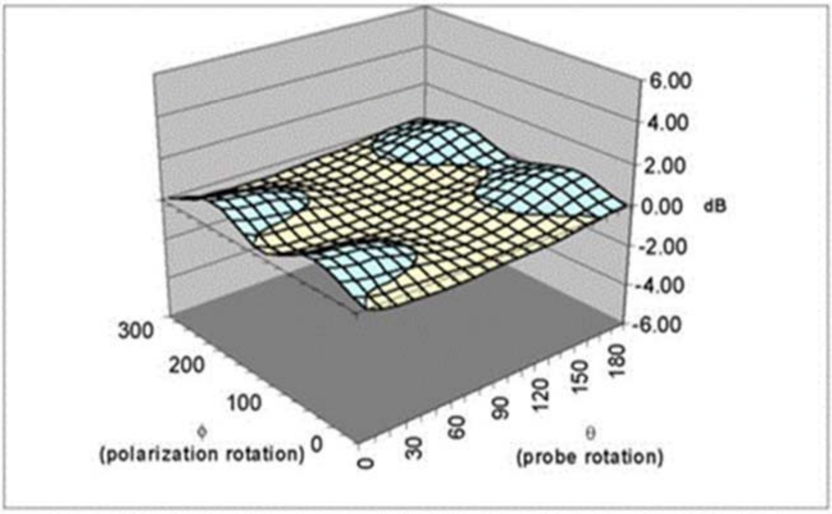

Figure 4 Residual Surface Isotropy at 900 MHz after optimisation for axial isotropy

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