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# Report On

Specific Absorption Rate Testing of the
Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS

COMMERCIAL-IN-CONFIDENCE

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| | |
|---|---|
| **REPORT ON** | Specific Absorption Rate Testing of the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS<br><br>Document 75928148 Report 07 Issue 2<br><br>January 2015 |
| **PREPARED FOR** | Sharp Communication Compliance Ltd<br>Inspired<br>Easthampstead Road<br>Bracknell<br>Berkshire<br>RG12 1NS |
| **PREPARED BY** | **Nigel Grigsby**<br>Senior Engineer |
| **APPROVED BY** | **Mark Jenkins**<br>Authorised Signatory |
| **DATED** | 13 January 2015 |

**This report has been up-issued to Issue 2 to removed references to the model number.**

**CONTENTS**

# SECTION 1

# REPORT SUMMARY

Specific Absorption Rate Testing of the
Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS

## 1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Specific Absorption Rate Testing of the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS to the requirements of KDB 447498 – D01 v05 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 | Tablet |
| Serial/IMEI Number(s) | 004401115303337 (SAR Test: WLAN 2.4/5GHz Head)<br>004401115303238 (SAR Test: WLAN 2.4/5GHz Body)<br>004401115303360 (Conducted: WLAN – 2.4GHz/5GHz) |
| Number of Samples Tested | 2 |
| Hardware Version | PP1 |
| Software Version | AB070 |
| Battery Cell Manufacturer | Sharp Corporation |
| Battery Model Number | Integral Battery; Non Removable |
| Test Specification/Issue/Date | KDB 447498 – D01 v05r02 General RF Exposure Guidance |
| Start of Test | 01 December 2014 |
| Finish of Test | 04 December 2014 |
| Related Document(s) | FCC 47CFR 2.1093: 2013<br>KDB 248227 - v01r02 (Rev 1.2)<br>KDB 865664 – D01 v01r03<br>KDB 865664 – D02 v01r01<br>KDB 648474 – D04 v01r02<br>IEEE 1528-2013 |
| Name of Engineer(s) | Nigel Grigsby<br>Simon Hau |

## 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) Body | 0.58 (Measured) | 0.70 (Scaled) |
| Max 10g SAR (W/kg) Extremity | 0.16 (Measured) | 0.19 (Scaled) |
| Max 1g SAR (W/kg) Head | 0.03 (Measured) | 0.03 (Scaled) |
| The maximum 1g / 10g 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

| Band | Test Configuration | Max Reported Scaled SAR (W/kg) |
|---|---|---|
| WLAN 2.4GHz | Head 1g | 0.03 |
| | Body 1g | 0.33 |
| | Extremity 10g | 0.16 |
| WLAN 5.18GHz | Head 1g | -** |
| | Body 1g | 0.70 |
| | Extremity 10g | 0.19 |
| WLAN 5.32GHz | Head 1g | -** |
| | Body 1g | 0.61 |
| | Extremity 10g | 0.15 |
| WLAN 5.54GHz | Head 1g | -** |
| | Body 1g | 0.43 |
| | Extremity 10g | 0.10 |
| The maximum 1g / 10g 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.<br>** Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area | | |

## 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 | Max 10g SAR (W/kg)* | Percentage Drift on Reference |
|---|---|---|---|---|---|---|
| 03/12/2014 | 2450 | 2450 | 52.49 | -7.40% | 25.00 | -6.19% |
| 02/12/2014 | 2450 | 2450 | 54.21 | 0.56% | 25.61 | 0.81% |
| 02/12/2014 | 5200 | 5200 | 70.24 | -8.99% | 20.27 | -6.95% |
| 03/12/2014 | 5200 | 5200 | 70.18 | -8.27% | 20.20 | -6.48% |
| 02/12/2014 | 5500 | 5500 | 73.19 | -8.85% | 19.83 | -8.39% |
| 03/12/2014 | 5500 | 5500 | 76.74 | -7.88% | 21.44 | -8.39% |

*Normalised to a forward power of 1W

### 1.3.2 Results Summary Tables

WLAN 2450MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC 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 | 11 | 2462.0 | 13.84 | 14.0 | 0.03 | **0.03** | Figure 06 |
| Left 15° | 11 | 2462.0 | 13.84 | 14.0 | 0.01 | 0.01 | Figure 07 |
| Right Cheek | 11 | 2462.0 | 13.84 | 14.0 | 0.03 | **0.03** | Figure 08 |
| Right 15° | 11 | 2462.0 | 13.84 | 14.0 | 0.02 | 0.02 | Figure 09 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)<br>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:<br>≤ 0.8W/kg when the transmission band is ≤ 100MHz<br>≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz<br>≤ 0.4W/kg when the transmission band is ≥ 200MHz | | | | | | | |

WLAN 2450MHz Body Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC 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 | | | | | | | |
| 0mm | Front Facing | 11 | 2462.0 | 13.84 | 14.0 | 0.28 | 0.29 | Figure 10 |
| 0mm | Rear Facing | 11 | 2462.0 | 13.84 | 14.0 | 0.32 | 0.33 | Figure 11 |
| 0mm | Right Edge | 11 | 2462.0 | 13.84 | 14.0 | 0.10 | 0.10 | Figure 12 |
| 0mm | Bottom Edge | 11 | 2462.0 | 13.84 | 14.0 | 0.25 | 0.26 | Figure 13 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)<br>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:<br>≤ 0.8W/kg when the transmission band is ≤ 100MHz<br>≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz<br>≤ 0.4W/kg when the transmission band is ≥ 200MHz<br>Testing was carried out with a 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02 | | | | | | | | |

WLAN 2450MHz Extremity Configuration Specific Absorption Rate (Maximum SAR) 10g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS.

| Position | | Channel Number | Frequency (MHz) | Measured Conducted Power (dBm) | Tune Up limit (dBm) | Measured 10g SAR (W/kg) | Scaled 10g SAR (W/kg) | Area scan (Figure number) |
|---|---|---|---|---|---|---|---|---|
| Spacing | Position | | | | | | | |
| 0mm | Front Facing | 11 | 2462.0 | 13.84 | 14.0 | 0.14 | 0.15 | Figure 14 |
| 0mm | Rear Facing | 11 | 2462.0 | 13.84 | 14.0 | 0.15 | 0.16 | Figure 15 |
| 0mm | Right Edge | 11 | 2462.0 | 13.84 | 14.0 | 0.05 | 0.05 | Figure 16 |
| 0mm | Bottom Edge | 11 | 2462.0 | 13.84 | 14.0 | 0.11 | 0.11 | Figure 17 |
| Limit for General Population (Uncontrolled Exposure) 1.6 W/kg (1g)<br>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:<br>≤ 0.8W/kg when the transmission band is ≤ 100MHz<br>≤ 0.6W/kg when the transmission band is between 100MHz and 200MHz<br>≤ 0.4W/kg when the transmission band is ≥ 200MHz<br>Testing was carried out with a 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02 | | | | | | | | |

WLAN 5180MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | 36 | 5180.0 | 11.7 | 12.5 | - | -** | Figure 18 |
| Left 15° | 36 | 5180.0 | 11.7 | 12.5 | - | -** | Figure 19 |
| Right Cheek | 36 | 5180.0 | 11.7 | 12.5 | - | -** | Figure 20 |
| Right 15° | 36 | 5180.0 | 11.7 | 12.5 | - | -** | Figure 21 |

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 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 36 as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

** Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area.

WLAN 5180MHz Body Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | | | | | | | |
| 0mm | Front Facing | 36 | 5180.0 | 11.7 | 12.5 | 0.58 | **0.70** | Figure 22 |
| 0mm | Rear Facing | 36 | 5180.0 | 11.7 | 12.5 | 0.18 | 0.22 | Figure 23 |
| 0mm | Right Edge | 36 | 5180.0 | 11.7 | 12.5 | 0.05 | 0.06 | Figure 24 |
| 0mm | Bottom Edge | 36 | 5180.0 | 11.7 | 12.5 | 0.29 | 0.35 | Figure 25 |

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 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 36 as this was the channel with the maximum output power.

Testing was carried out with a 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

*(NUA) Not UKAS Accredited

WLAN 5180MHz Extremity Configuration Specific Absorption Rate (Maximum SAR) 10g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| Position | | Channel Number | Frequency (MHz) | Measured Conducted Power (dBm) | Tune Up limit (dBm) | Measured 10g SAR (W/kg) | Scaled 10g SAR (W/kg) | Area scan (Figure number) |
|---|---|---|---|---|---|---|---|---|
| Spacing | Position | | | | | | | |
| 0mm | Front Facing | 36 | 5180.0 | 11.7 | 12.5 | 0.16 | **0.19** | Figure 26 |
| 0mm | Rear Facing | 36 | 5180.0 | 11.7 | 12.5 | 0.05 | 0.06 | Figure 27 |
| 0mm | Right Edge | 36 | 5180.0 | 11.7 | 12.5 | 0.01 | 0.01 | Figure 28 |
| 0mm | Bottom Edge | 36 | 5180.0 | 11.7 | 12.5 | 0.10 | 0.12 | Figure 29 |

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 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

KDB 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 36 as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

WLAN 5320MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | 64 | 5320.0 | 11.79 | 12.5 | - | -** | Figure 30 |
| Left 15° | 64 | 5320.0 | 11.79 | 12.5 | - | -** | Figure 31 |
| Right Cheek | 64 | 5320.0 | 11.79 | 12.5 | - | -** | Figure 32 |
| Right 15° | 64 | 5320.0 | 11.79 | 12.5 | - | -** | Figure 33 |

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 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 64 as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

** Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area.

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WLAN 5320MHz Body Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | | | | | | | |
| 0mm | Front Facing | 64 | 5320.0 | 11.79 | 12.5 | 0.52 | 0.61* | Figure 34 |
| 0mm | Rear Facing | 64 | 5320.0 | 11.79 | 12.5 | 0.15 | 0.18* | Figure 35 |
| 0mm | Right Edge | 64 | 5320.0 | 11.79 | 12.5 | 0.03 | 0.04* | Figure 36 |
| 0mm | Bottom Edge | 64 | 5320.0 | 11.79 | 12.5 | 0.29 | 0.34* | Figure 37 |

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 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

KDB 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 64 as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

WLAN 5320MHz Extremity Configuration Specific Absorption Rate (Maximum SAR) 10g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| Position | | Channel Number | Frequency (MHz) | Measured Conducted Power (dBm) | Tune Up limit (dBm) | Measured 10g SAR (W/kg) | Scaled 10g SAR (W/kg) | Area scan (Figure number) |
|---|---|---|---|---|---|---|---|---|
| Spacing | Position | | | | | | | |
| 0mm | Front Facing | 64 | 5320.0 | 11.79 | 12.5 | 0.13 | 0.15* | Figure 38 |
| 0mm | Rear Facing | 64 | 5320.0 | 11.79 | 12.5 | 0.04 | 0.05* | Figure 39 |
| 0mm | Right Edge | 64 | 5320.0 | 11.79 | 12.5 | 0.02 | 0.02* | Figure 40 |
| 0mm | Bottom Edge | 64 | 5320.0 | 11.79 | 12.5 | 0.10 | 0.12* | Figure 41 |

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 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

KDB 248227 - v01r02 (Rev 1.2) – Testing was carried out on the default Channel 64 as this was the channel with the maximum output power.

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WLAN 5540MHz Head Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | 108 | 5540 | 11.58 | 12.5 | - | -** | Figure 42 |
| Left 15° | 108 | 5540 | 11.58 | 12.5 | - | -** | Figure 43 |
| Right Cheek | 108 | 5540 | 11.58 | 12.5 | - | -** | Figure 44 |
| Right 15° | 108 | 5540 | 11.58 | 12.5 | - | -** | Figure 45 |

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 248227 - v01r02 (Rev 1.2) – Testing was carried out on Channel 108 instead of the default test channel as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

** Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area.

WLAN 5540MHz Body Configuration Specific Absorption Rate (Maximum SAR) 1g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| 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 | | | | | | | |
| 0mm | Front Facing | 108 | 5540.0 | 11.58 | 12.5 | 0.35 | 0.43* | Figure 46 |
| 0mm | Rear Facing | 108 | 5540.0 | 11.58 | 12.5 | 0.17 | 0.21* | Figure 47 |
| 0mm | Right Edge | 108 | 5540.0 | 11.58 | 12.5 | 0.05 | 0.06* | Figure 48 |
| 0mm | Bottom Edge | 108 | 5540.0 | 11.58 | 12.5 | 0.19 | 0.23* | Figure 49 |

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 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

KDB 248227 - v01r02 (Rev 1.2) – Testing was carried out on Channel 108 instead of the default test channel as this was the channel with the maximum output power.

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WLAN 5540MHz Extremity Configuration Specific Absorption Rate (Maximum SAR) 10g Results for the Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS. (NUA)*

| Position | | Channel Number | Frequency (MHz) | Measured Conducted Power (dBm) | Tune Up limit (dBm) | Measured 10g SAR (W/kg) | Scaled 10g SAR (W/kg) | Area scan (Figure number) |
|---|---|---|---|---|---|---|---|---|
| Spacing | Position | | | | | | | |
| 0mm | Front Facing | 108 | 5540.0. | 11.58 | 12.5 | 0.08 | 0.10* | Figure 50 |
| 0mm | Rear Facing | 108 | 5540.0 | 11.58 | 12.5 | 0.05 | 0.06* | Figure 51 |
| 0mm | Right Edge | 108 | 5540.0 | 11.58 | 12.5 | 0.02 | 0.02* | Figure 52 |
| 0mm | Bottom Edge | 108 | 5540.0 | 11.58 | 12.5 | 0.06 | 0.07* | Figure 53 |

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 0mm separation distance to meet the requirements of KDB 648474 – D04 v01r02

KDB 248227 - v01r02 (Rev 1.2) – Testing was carried out on Channel 108 instead of the default test channel as this was the channel with the maximum output power.

*(NUA) Not UKAS Accredited

### 1.3.3 Simultaneous Transmission

The device was only tested on WLAN bands therefore simultaneous transmissions caluulations were not required.

### 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)]·[√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) |
|---|---|---|---|
| 2441 | 5.01 | 5 | 0.21 |

Bluetooth Body SAR Estimation

| Frequency (MHz) | Maximum Power (mW) | Distance (mm) | Estimated SAR (W/kg) |
|---|---|---|---|
| 2441 | 5.01 | 10 | 0.10 |

## 1.4 PRODUCT INFORMATION

### 1.4.1 Technical Description

The equipment under test (EUT) was a Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC 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 an integral battery supplied and manufactured by Sharp Corporation. The battery was fully charged before each measurement and there were no external connections.

For head SAR assessment, testing was performed with the device in the declared normal position of operation for WLAN 2.4GHz and WLAN 5GHz 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 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 WLAN 2.4GHz and WLAN 5GHz frequency bands at maximum power. The device was placed at a distance of 0mm 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.

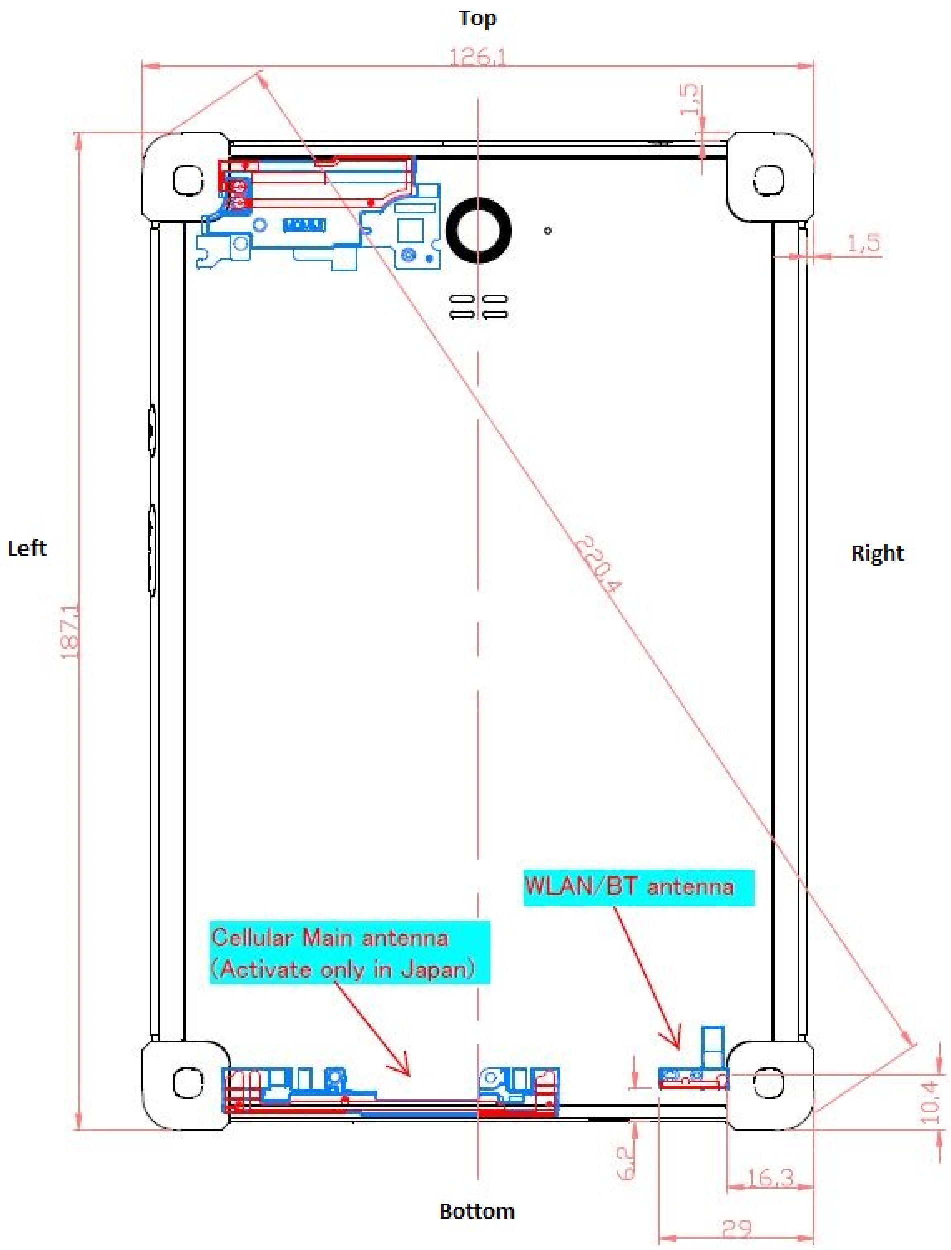
Testing was performed in each position at the frequency that gave the highest output power for each band. For all bands the scaled SAR levels were found to be <0.80 W/kg (KDB 447498 D01) therefore no additional testing was required at the relevant frequencies / channels of the bands. WLAN testing was achieved using the devices internal software, customer supplied software and settings supplied by the customer. The worst case data rate for WLAN testing was obtained from data provided by TUV. The worst case was deemed as the data rate which produced the highest level of conducted average power. For 2.4GHz WLAN this was 9Mbps for 802.11g. For 5GHz WLAN this was MCS1, 20MHz for 802.11ac.

Product Service

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.

As the device was capable of next to the ear operations the device was tested in accordance with KDB 648474 – D04 v01r02 Phablet SAR considerations. For body the device was tested at 0mm separation distance for 1g body and 10g extremity SAR for all surfaces and edges with an antenna located ≤ 25mm from that edge or surface.

### 1.4.3 Device Dimensions and Antenna Locations



Product Service

## 1.5 FCC POWER MEASUREMENTS

### 1.5.1 Method

Conducted power measurements were made using a power meter.

### 1.5.2 Conducted Power Measurements

**WLAN**

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11(b) - 2.4 GHz – 11Mbps | 2412 | 16.82 | 13.26 |
| | 2437 | 16.46 | 12.98 |
| | 2462 | 17.17 | 13.81 |
| 802.11(g) - 2.4 GHz - 12Mbps | 2412 | 22.35 | 12.73 |
| | 2437 | 22.46 | 12.72 |
| | 2462 | 22.74 | **13.84** |
| 802.11 (n) - 2.4 GHz – MCS2 | 2412 | 22.86 | 12.97 |
| | 2437 | 22.83 | 12.86 |
| | 2462 | 22.88 | 13.28 |
| 802.11a - 5GHz - 9Mbps | 5180 | 22.23 | 11.56 |
| | 5200 | 22.11 | 11.44 |
| | 5220 | 23.06 | 11.54 |
| | 5240 | 22.1 | 11.18 |
| | 5260 | 22.34 | 11.21 |
| | 5280 | 22.02 | 11.54 |
| | 5300 | 22.31 | 11.6 |
| | 5320 | 22.73 | 11.73 |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11a - 5GHz - 9Mbps | 5500 | 21.98 | 11.25 |
| | 5520 | 21.97 | 11.24 |
| | 5540 | 22.12 | 11.77 |
| | 5560 | 22.31 | 11.39 |
| | 5580 | 22.09 | 11.18 |
| | 5600 | 22.37 | 11.35 |
| | 5620 | 21.89 | 11.29 |
| | 5640 | 22.15 | 11.33 |
| | 5660 | 22.26 | 11.55 |
| | 5680 | 22.86 | 11.26 |
| | 5700 | 21.82 | 11.29 |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11n20 - 5GHz – MCS1 | 5180 | 22.41 | 11.69 |
| | 5200 | 22.76 | 11.63 |
| | 5220 | 22.64 | 11.61 |
| | 5240 | 22.46 | 11.57 |
| | 5260 | 22.43 | 11.37 |
| | 5280 | 22.24 | 11.68 |
| | 5300 | 22.35 | 11.39 |
| | 5320 | 22.41 | 11.59 |
| | 5500 | 21.95 | 11.15 |
| | 5520 | 21.98 | 11.63 |
| | 5540 | 22.33 | 11.74 |
| | 5560 | 21.85 | 11.27 |
| | 5580 | 22.26 | 11.14 |
| | 5600 | 22.23 | 11.41 |
| | 5620 | 22.24 | 11.36 |
| | 5640 | 22.34 | 11.6 |
| | 5660 | 21.89 | 11.24 |
| | 5680 | 22.01 | 10.99 |
| | 5700 | 21.7 | 11.01 |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11n40 - 5GHz – MCS0 | 5190 | 22.97 | 11.46 |
| | 5230 | 22.48 | 11.06 |
| | 5270 | 22.41 | 11.24 |
| | 5310 | 22.96 | 11.07 |
| | 5510 | 22.88 | 11.36 |
| | 5550 | 22.6 | 11.41 |
| | 5590 | 22.45 | 11.19 |
| | 5630 | 22.73 | 11.33 |
| | 5670 | 23.42 | 11.71 |
| * Channel not available | | | |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11ac20 - 5GHz – MCS1 | 5180 | 22.19 | **11.70** |
| | 5200 | 21.98 | 11.34 |
| | 5220 | 22.14 | 11.61 |
| | 5240 | 22.07 | 11.49 |
| | 5260 | 21.75 | 11.26 |
| | 5280 | 22.05 | 11.60 |
| | 5300 | 22.27 | 11.65 |
| | 5320 | 22.11 | **11.79** |
| | 5500 | 21.87 | 11.36 |
| | 5520 | 21.84 | 11.33 |
| | 5540 | 22.02 | **11.58** |
| | 5560 | 21.69 | 11.32 |
| | 5580 | 21.42 | 11.05 |
| | 5600 | 21.61 | 11.03 |
| | 5620 | 21.47 | 11.16 |
| | 5640 | 21.95 | 11.52 |
| | 5660 | 21.82 | 11.42 |
| | 5680 | 21.68 | 11.13 |
| | 5700 | 21.57 | 11.14 |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11ac40 - 5GHz – MCS1 | 5190 | 22.07 | 11.18 |
| | 5230 | 22.04 | 10.95 |
| | 5270 | 22.27 | 11.39 |
| | 5310 | 22.31 | 11.38 |
| | 5510 | 22.36 | 11.70 |
| | 5550 | 22.41 | 11.78 |
| | 5590 | 21.95 | 11.17 |
| | 5630 | 22.02 | 11.18 |
| | 5670 | 22.17 | 11.50 |

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| 802.11ac80 – 5GHz – MCS1 | 5210 | 22.03 | 10.47 |
| | 5290 | 21.95 | 10.45 |
| | 5530 | 22.15 | 10.86 |
| | 5610 | 22.10 | 10.63 |

### Bluetooth

| Modulation | Frequency (MHz) | Conducted Carrier Power (dBm) | |
|---|---|---|---|
| | | Peak | Average |
| DH1 | 2402 | 4.21 | 2.02 |
| | 2441 | 4.15 | 1.94 |
| | 2480 | 4.48 | 2.17 |

Product Service

### 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) | | | | |
| WLAN 2.4 GHz | 2462.0 | 14.0 | 50.12 | Head | < 5 | 7.9 | No |
| | | | | Body | < 5 | 7.9 | No |
| WLAN 5GHz | 5180.0 | 12.5 | 28.18 | Head | < 5 | 11.4 | No |
| | | | | Body | < 5 | 11.4 | No |
| WLAN 5GHz | 5320.0 | 12.5 | 28.18 | Head | < 5 | 11.6 | No |
| | | | | Body | < 5 | 11.6 | No |
| WLAN 5GHz | 5540.0 | 12.5 | 28.18 | Head | < 5 | 11.8 | No |
| | | | | Body | < 5 | 11.8 | No |
| Bluetooth | 2441.0 | 7.0 | 5.01 | Head | < 5 | 1.6 | Yes |
| | | | | Body | < 5 | 0.8 | Yes |

# SECTION 2

# TEST DETAILS

Specific Absorption Rate Testing of the
Sharp Quad-band LTE(B1 /B3/ B19/ B21), and Tri-band WCDMA(FDD I/ VI /XIX) Dual mode hand held Mini Phablet with Bluetooth, ANT+, W-LAN, NFC and GPS

## 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.

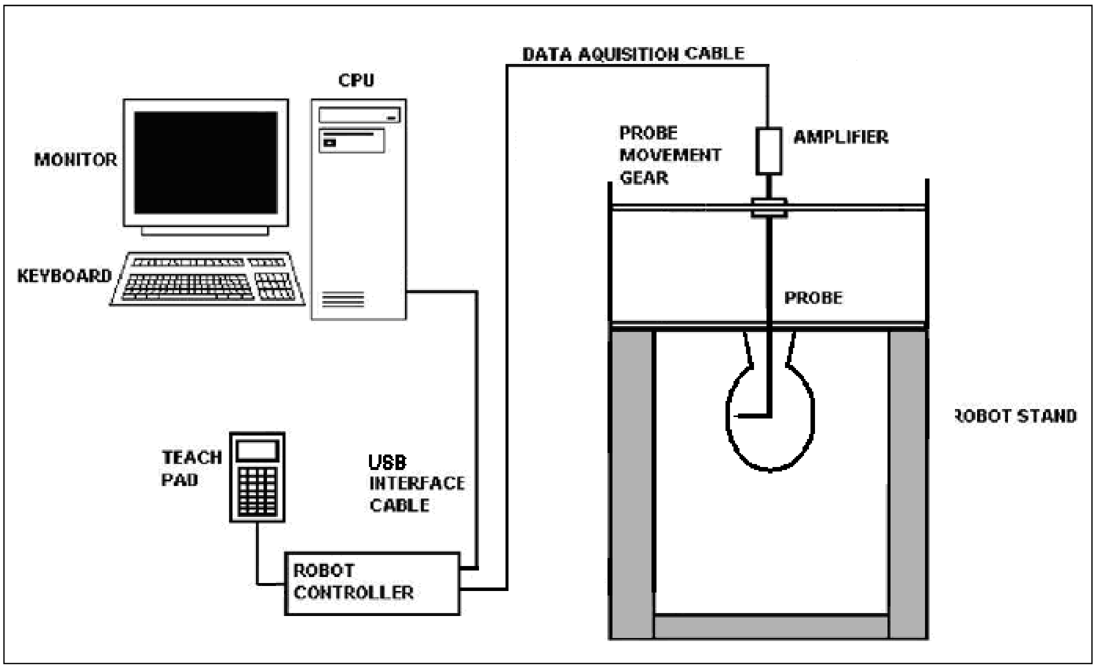



**Figure 1 Schematic diagram of the SARA-C measurement system showing the L-probe and upside-down SAM phantom**

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.

IFA-020 Fast Amplifier

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

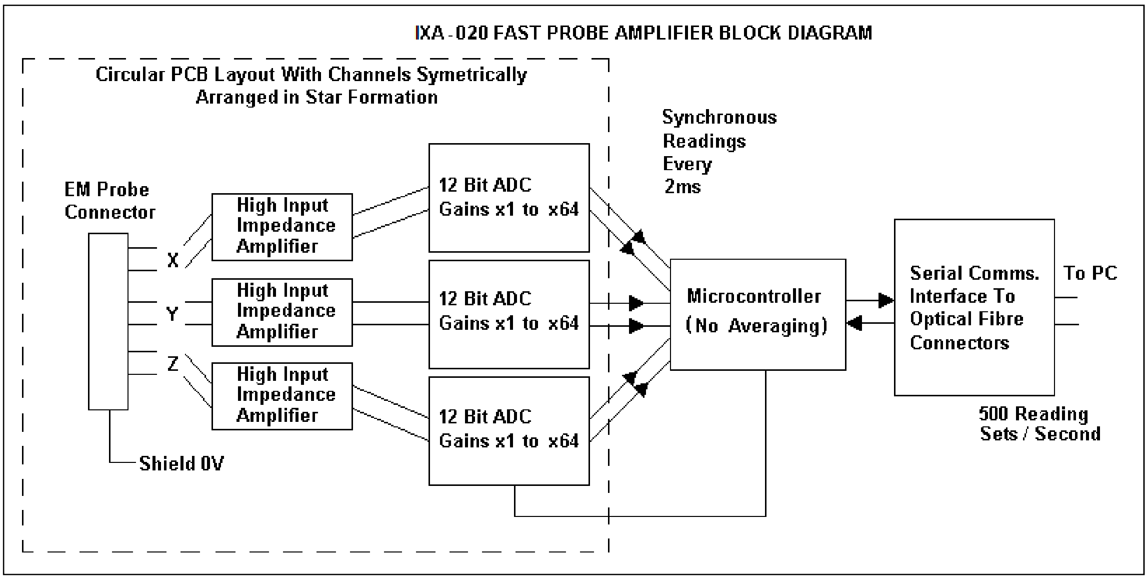



**Figure 2 Schematic diagram of the fast amplifier**

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.

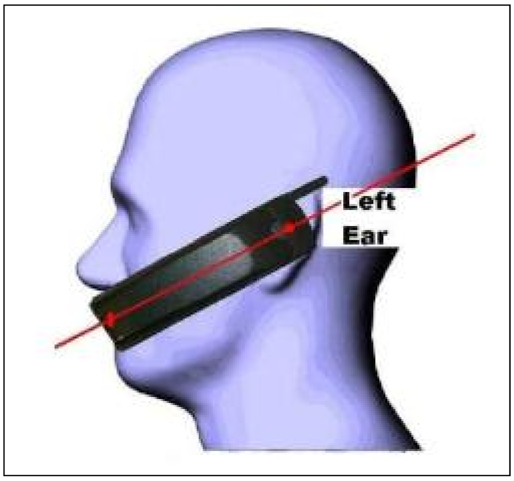



**Figure 3 Side view of mobile next to head showing alignment**

<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°.

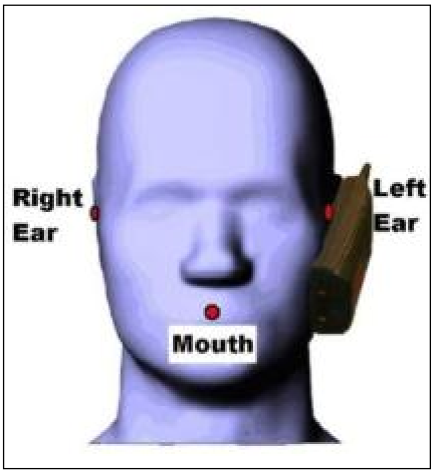



**Figure 4 Cheek position**

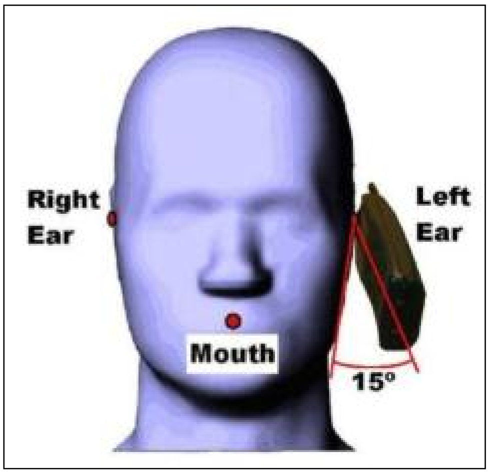



**Figure 5 15º Tilt Position**

Product Service

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

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-11:09:39 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.50°C | LIQUID SIMULANT: | 2450 Head |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 37.97 |
| RELATIVE HUMIDITY: | 25.70% | CONDUCTIVITY: | 1.791 |
| PHANTOM S/NO: | IXB-040 | LIQUID TEMPERATURE: | 23.00°C |
| PHANTOM ROTATION: | N/A | MAX SAR Y-AXIS LOCATION: | 53.90mm |
| DUT POSITION: | Left-Cheek | MAX SAR Z-AXIS LOCATION: | -83.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 3.05 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.028 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.026 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.025 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | -5.100 % |

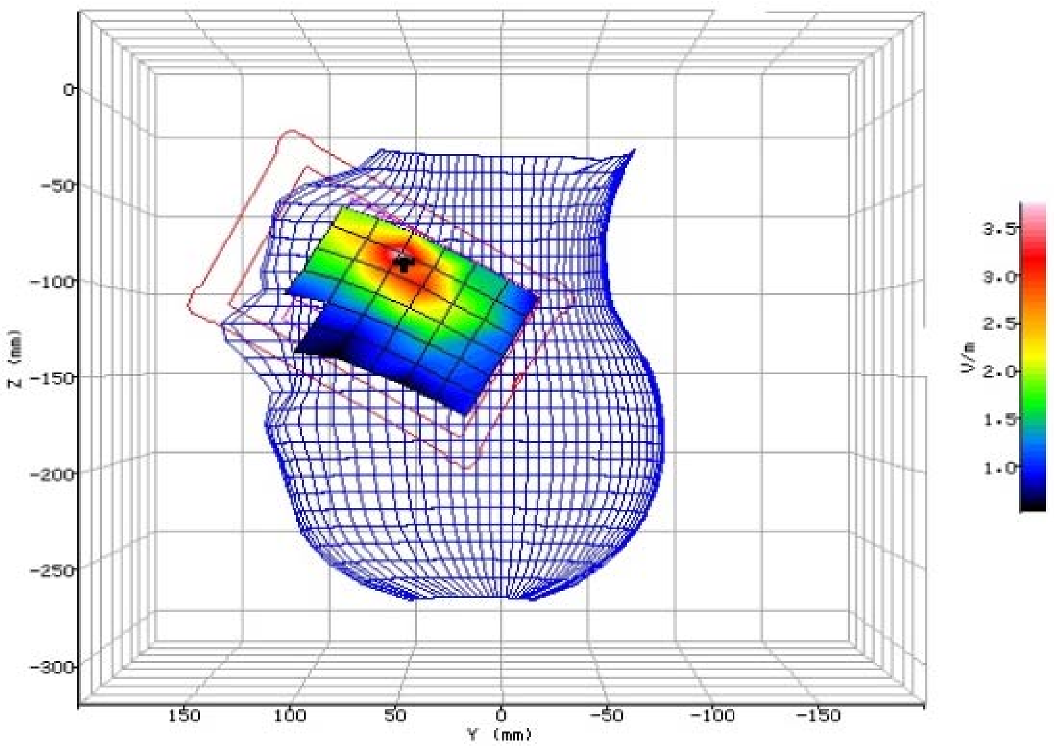



Figure 6: SAR Head Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-11:42:55 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.50°C | LIQUID SIMULANT: | 2450 Head |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 37.97 |
| RELATIVE HUMIDITY: | 25.70% | CONDUCTIVITY: | 1.791 |
| PHANTOM S/NO: | IXB-040 | LIQUID TEMPERATURE: | 23.00°C |
| PHANTOM ROTATION: | N/A | MAX SAR Y-AXIS LOCATION: | 10.70mm |
| DUT POSITION: | Left-15° | MAX SAR Z-AXIS LOCATION: | -118.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 1.94 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.012 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.010 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.010 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | -0.800 % |

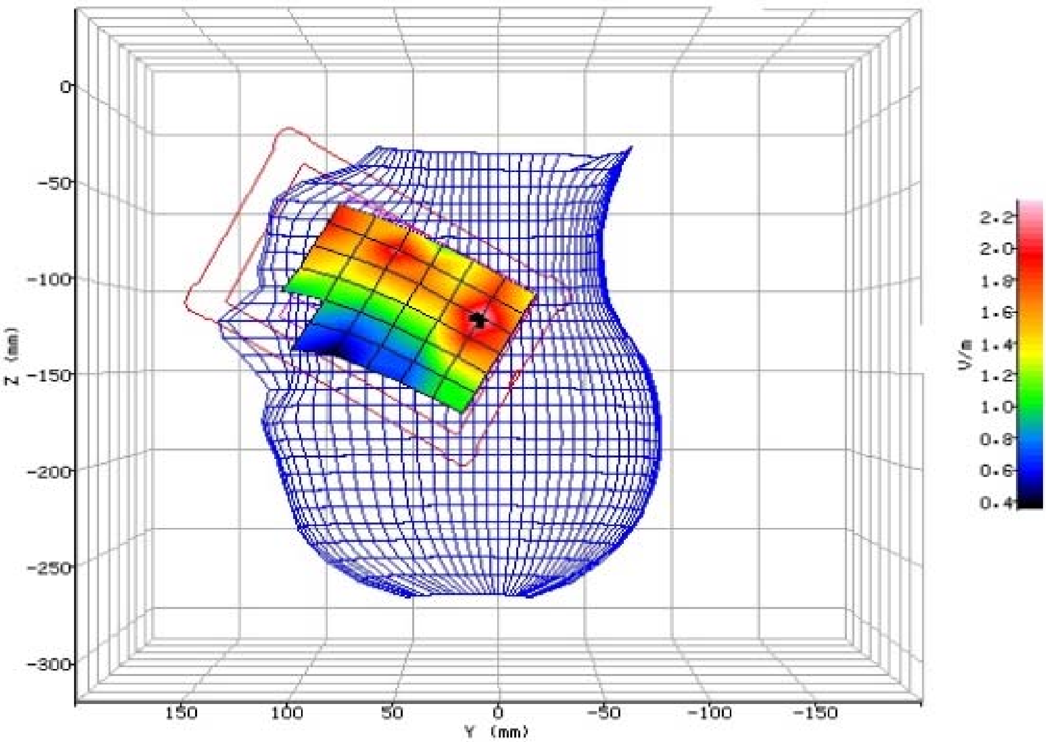



Figure 7: SAR Head Testing Results for the Sharp Phablet at 2462.0MHz.

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:20:05 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.50°C | LIQUID SIMULANT: | 2450 Head |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 37.97 |
| RELATIVE HUMIDITY: | 25.70% | CONDUCTIVITY: | 1.791 |
| PHANTOM S/NO: | IXB-040 | LIQUID TEMPERATURE: | 23.00°C |
| PHANTOM ROTATION: | N/A | MAX SAR Y-AXIS LOCATION: | 45.00mm |
| DUT POSITION: | Right-Cheek | MAX SAR Z-AXIS LOCATION: | -167.40mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 3.98 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.029 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.034 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.036 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 5.000 % |

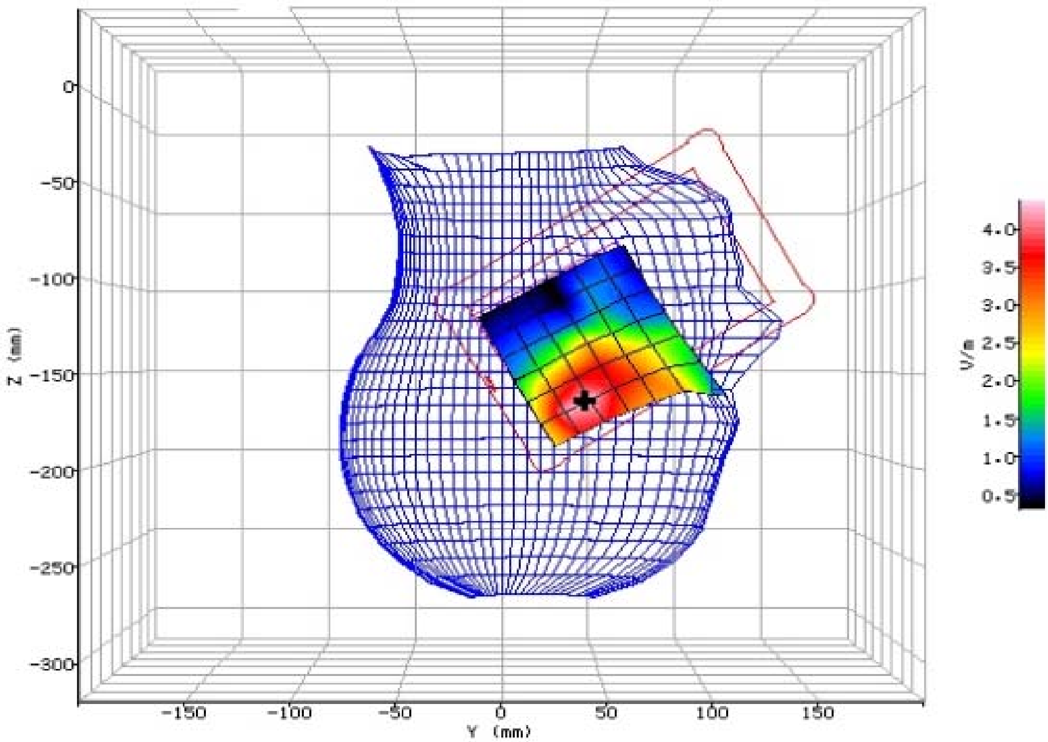



Figure 8: SAR Head Testing Results for the Sharp Phablet at 2462.0MHz.

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:52:01 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.50°C | LIQUID SIMULANT: | 2450 Head |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 37.97 |
| RELATIVE HUMIDITY: | 25.70% | CONDUCTIVITY: | 1.791 |
| PHANTOM S/NO: | IXB-040 | LIQUID TEMPERATURE: | 23.00°C |
| PHANTOM ROTATION: | N/A | MAX SAR Y-AXIS LOCATION: | 39.90mm |
| DUT POSITION: | Right-15° | MAX SAR Z-AXIS LOCATION: | -173.70mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 3.59 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.022 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.030 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.027 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | -9.800 % |

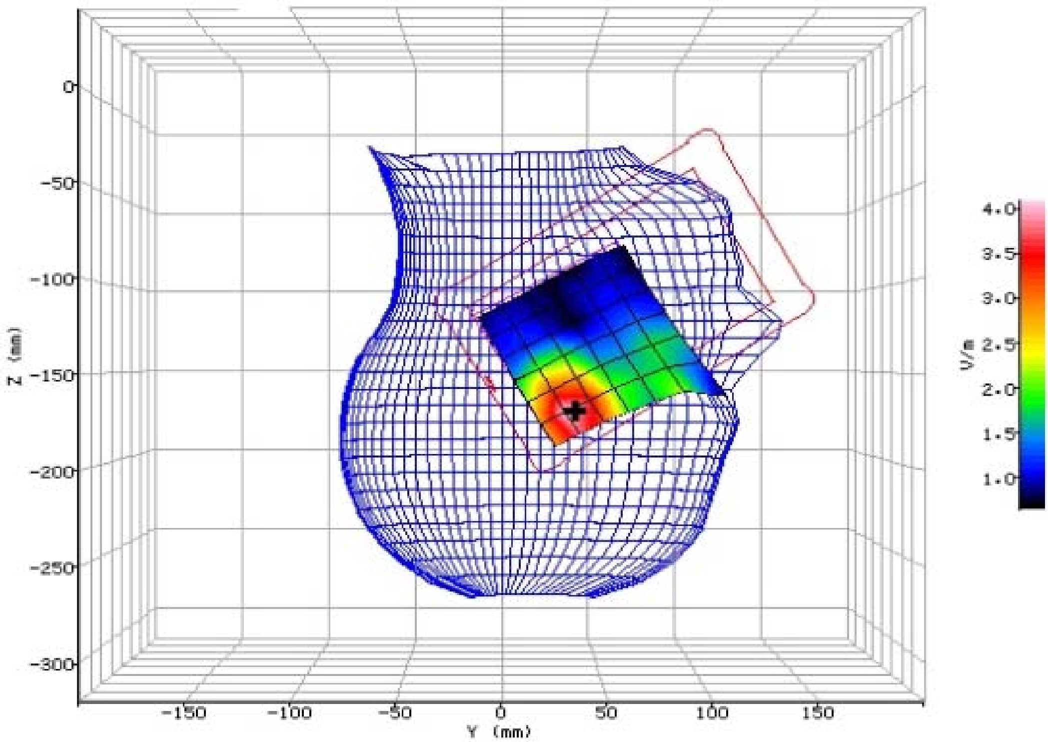



Figure 9: SAR Head Testing Results for the Sharp Phablet at 2462.0MHz.

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

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-12:01:24 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 80.10mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -47.00mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 10.98 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.279 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.291 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.290 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | -0.400 % |

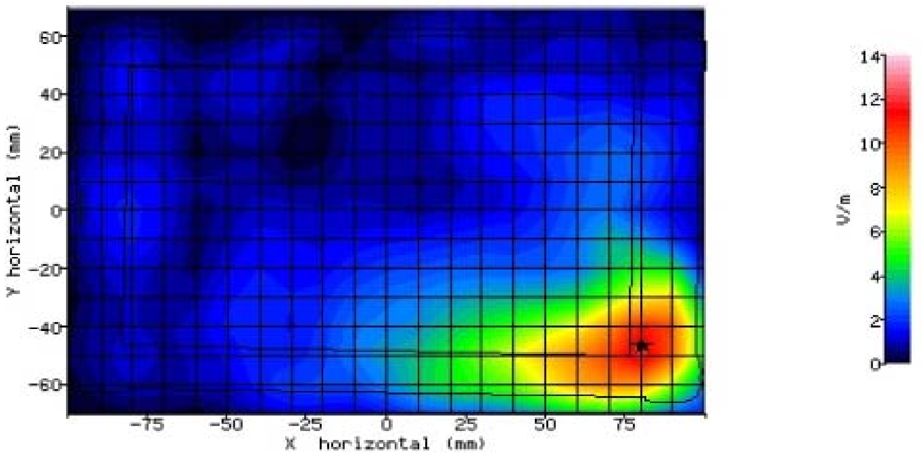



Figure 10: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-12:26:41 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 74.60mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 42.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 11.34 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.315 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.328 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.331 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 0.900 % |

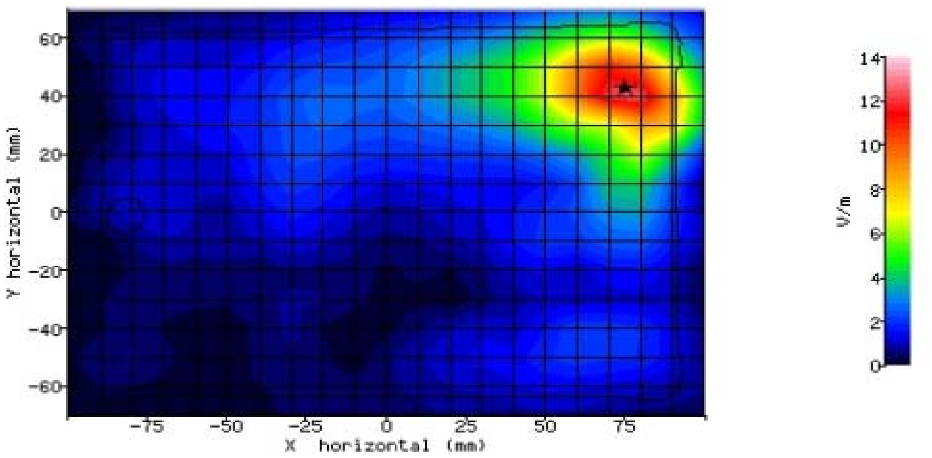



Figure 11: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-13:37:28 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 77.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | 0.20mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 6.70 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.103 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.109 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.110 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 1.000 % |

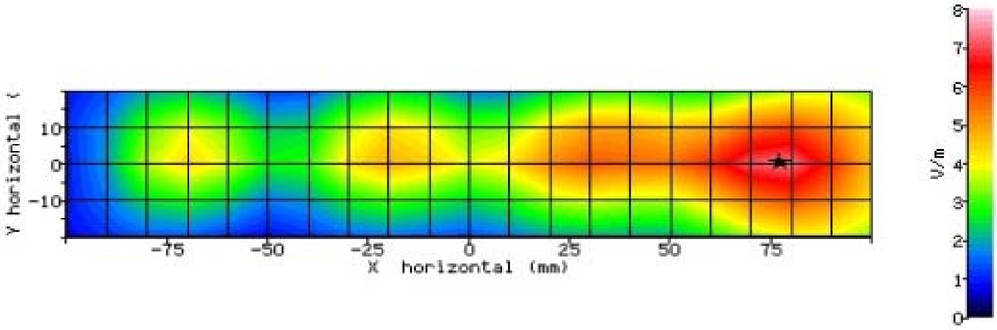



Figure 12: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-13:56:28 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -41.90mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 4.00mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 9.63 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | 0.250 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.275 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.283 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 2.900 % |

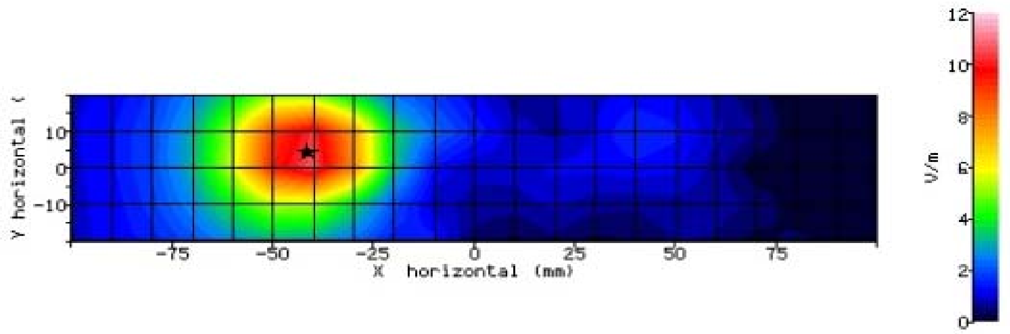



Figure 13: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

Product Service

## 2.4 WLAN 2450MHz EXTREMITY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-12:01:24 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 80.10mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -47.00mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 10.98 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.141 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.291 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.290 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | -0.400 % |

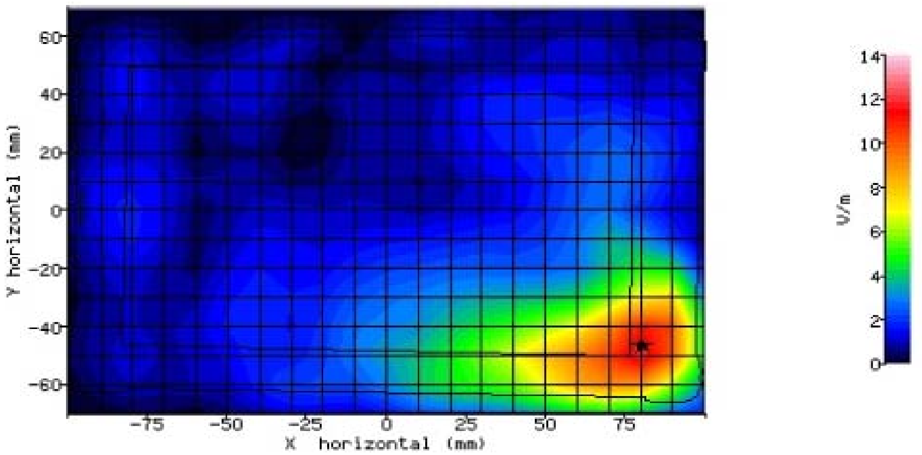



Figure 14: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-12:26:41 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 74.60mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 42.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 11.34 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.152 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.328 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.331 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 0.900 % |

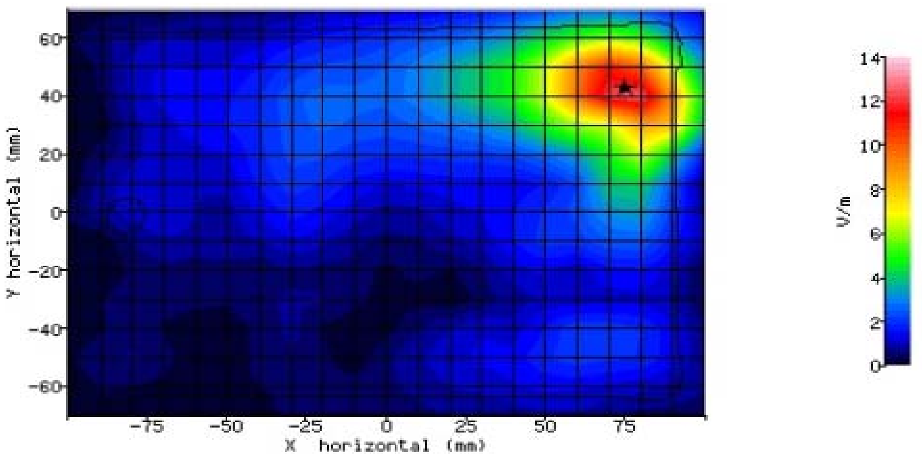



Figure 15: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-13:37:28 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 77.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | 0.20mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 6.70 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.053 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.109 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.110 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 1.000 % |

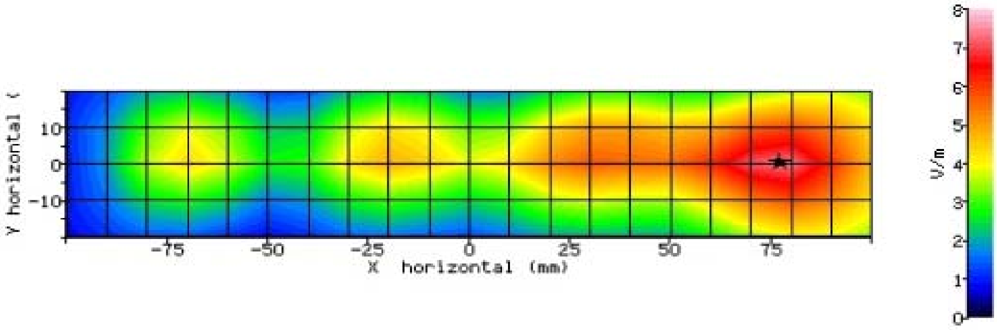



Figure 16: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 02/12/2014-13:56:28 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 2450 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 50.53 |
| RELATIVE HUMIDITY: | 32.00% | CONDUCTIVITY: | 2.000 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.80°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -41.90mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 4.00mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 9.63 |
| TEST FREQUENCY: | 2462.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.109 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.275 W/kg |
| INPUT POWER LEVEL: | 14dBm | SAR END: | 0.283 W/kg |
| PROBE BATTERY LAST CHANGED: | 02/12/2014 | SAR DRIFT DURING SCAN: | 2.900 % |

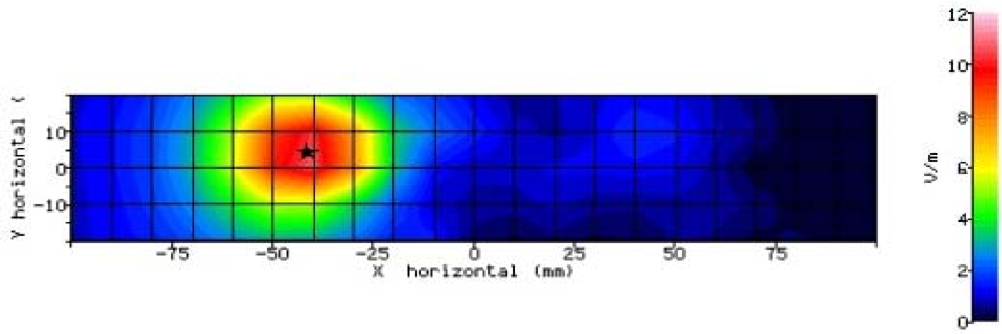



Figure 17: SAR Body Testing Results for the Sharp Phablet at 2462.0MHz.

## 2.5 WLAN 5180MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

Figure 18*
Figure 19*
Figure 20*
Figure 21*

*Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area

## 2.6 WLAN 5180MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-15:43:37 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.90mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -39.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 10.257 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | 0.581 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 1.086 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 1.105 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.700 % |

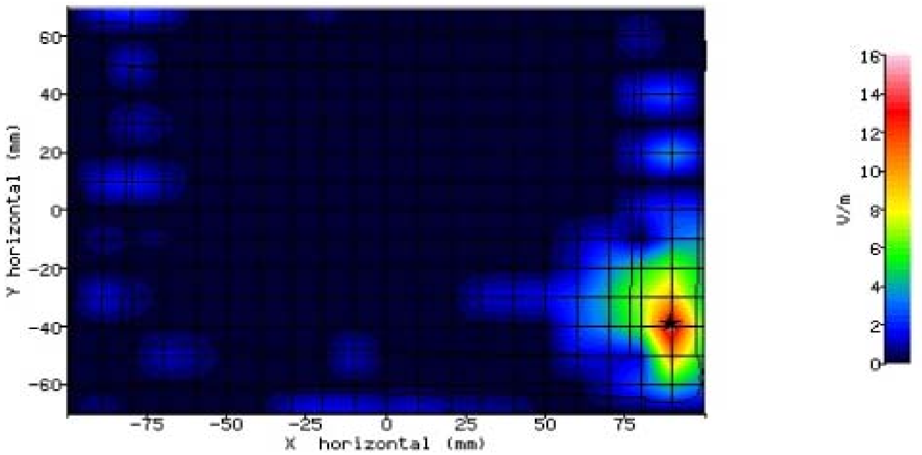



Figure 22: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-16:05:29 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 78.90mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 43.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.817 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | 0.178 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.329 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.338 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 2.600 % |

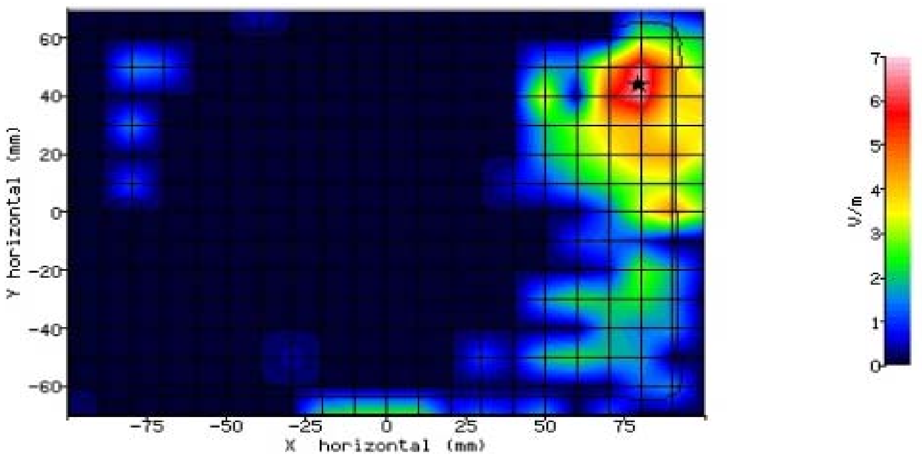



Figure 23: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-14:44:01 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 77.60mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -17.60mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 2.228 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | 0.048 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.028 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.030 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 7.400 % |

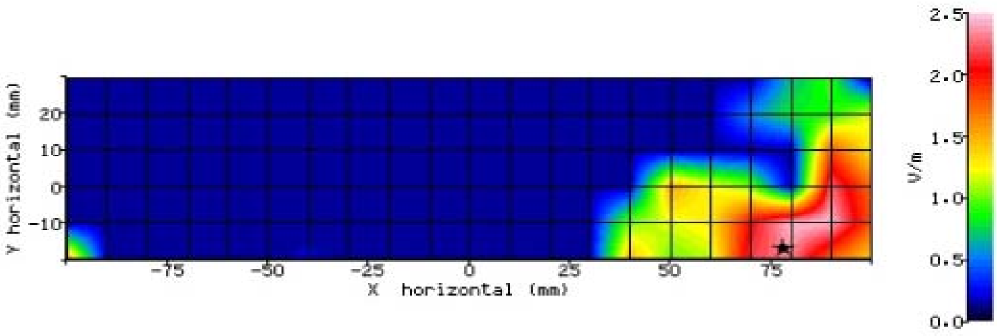



Figure 24: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-14:12:38 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -24.60mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 2.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 8.130 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | 0.289 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.484 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.467 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -3.500 % |

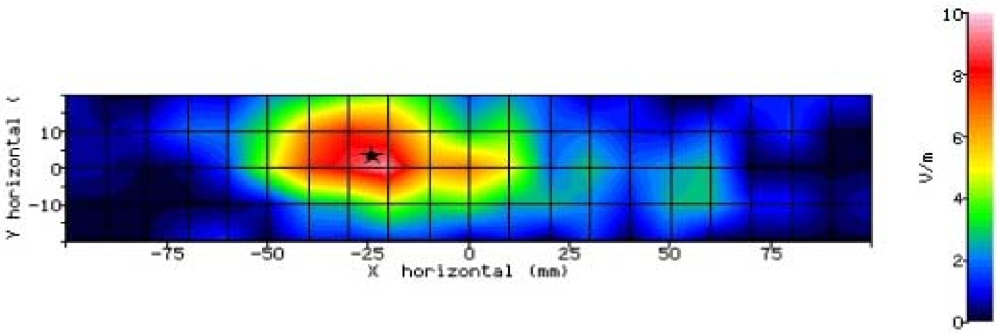



Figure 25: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

## 2.7 WLAN 5180MHz EXTREMITY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-15:43:37 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.90mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -39.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 10.257 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.155 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 1.086 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 1.105 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.700 % |

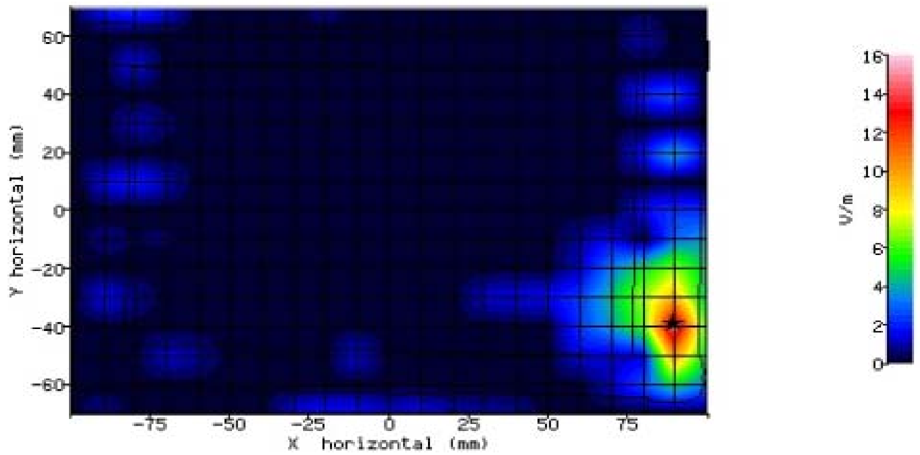



Figure 26: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-16:05:29 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 78.90mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 43.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.817 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.048 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.329 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.338 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 2.600 % |

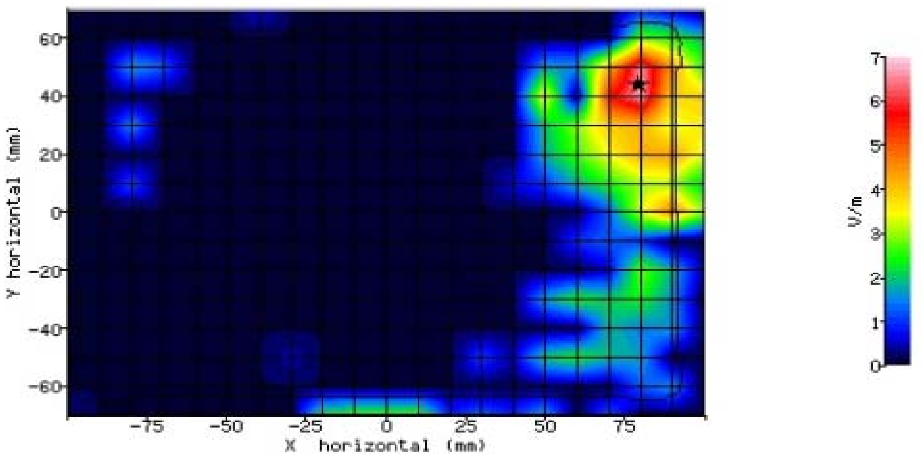



Figure 27: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-14:44:01 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 77.60mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -17.60mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 2.228 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.013 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.028 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.030 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 7.400 % |

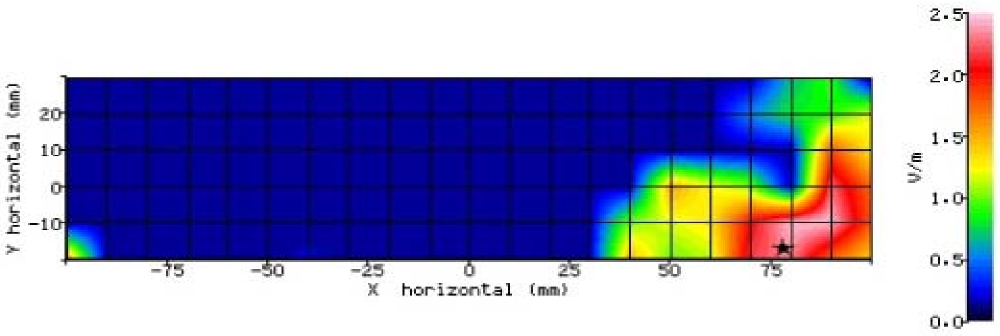



Figure 28: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-14:12:38 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -24.60mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 2.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 8.130 |
| TEST FREQUENCY: | 5180.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.102 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.484 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.467 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -3.500 % |

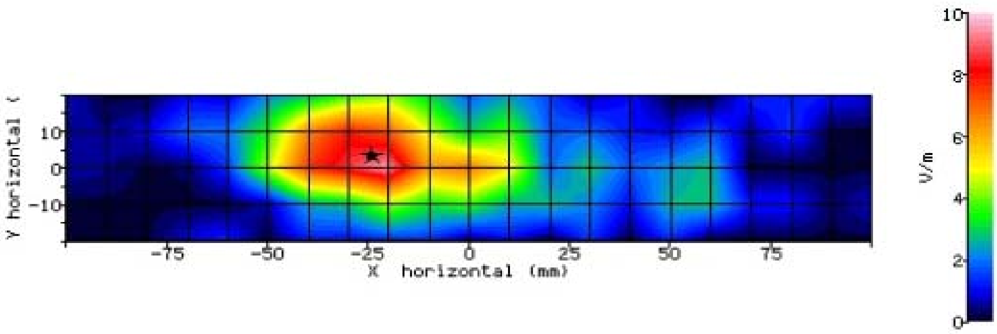



Figure 29: SAR Body Testing Results for the Sharp Phablet at 5180.0MHz. (NUA)

## 2.8 WLAN 5320MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

Figure 30*
Figure 31*
Figure 32*
Figure 33*

*Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area

Product Service

## 2.9 WLAN 5320MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-17:03:56 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.70mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -41.70mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 9.156 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | 0.523 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 1.072 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 1.059 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -1.300 % |

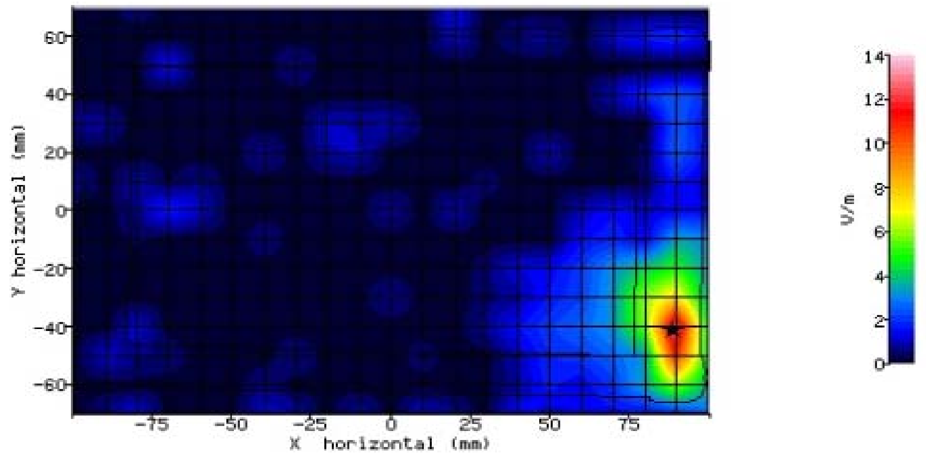



Figure 34: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-17:26:13 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 83.60mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 44.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.249 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | 0.146 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.250 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.273 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 9.300 % |

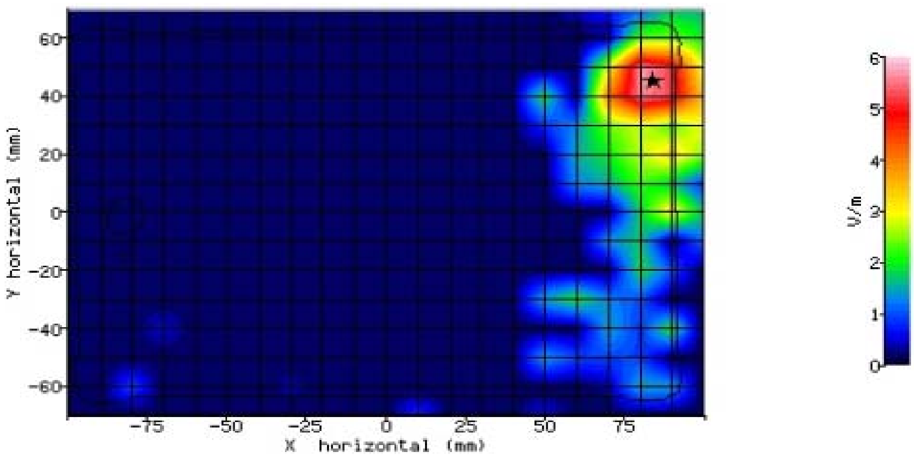



Figure 35: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 04/12/2014-08:37:31 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -1.10mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 2.548 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | 0.034 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.056 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.058 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 4.200 % |

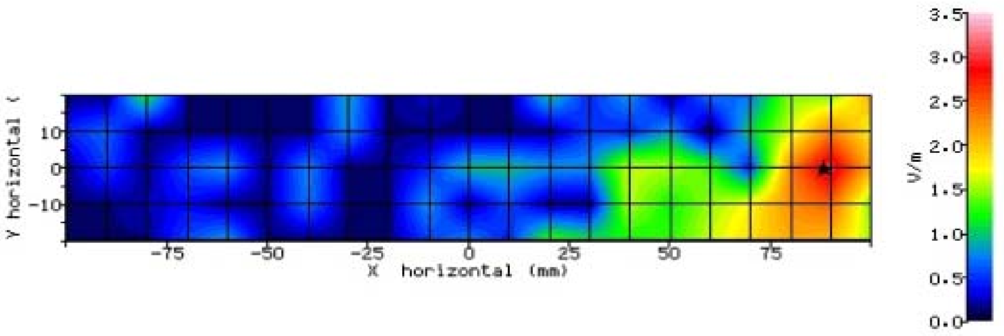



Figure 36: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 04/12/2014-08:55:09 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -41.80mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 3.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 7.546 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | 0.294 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.517 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.511 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -1.100 % |

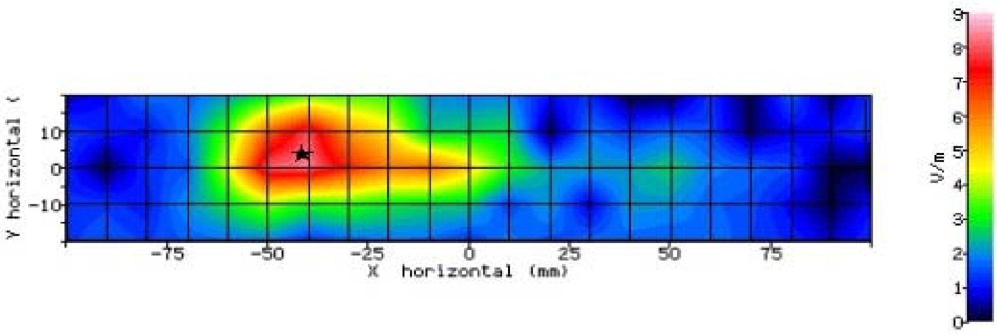



Figure 37: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

## 2.10 WLAN 5320MHz EXTREMITY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-17:03:56 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.70mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -41.70mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 9.156 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.130 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 1.072 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 1.059 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -1.300 % |

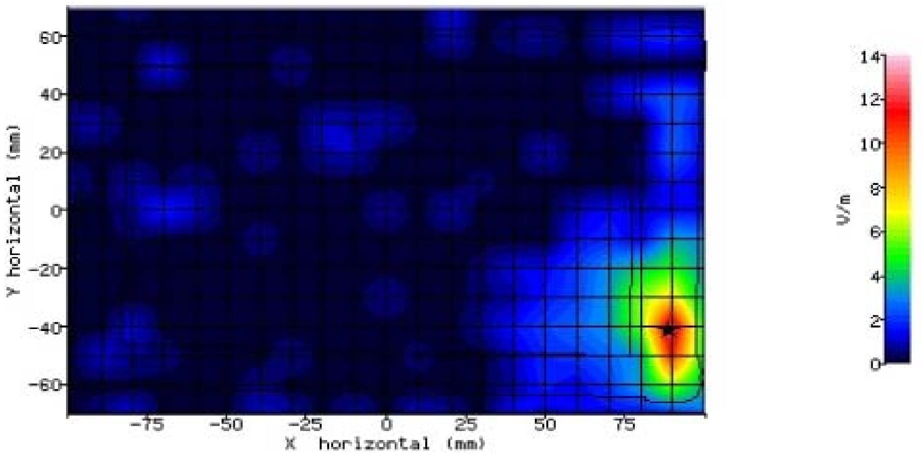



Figure 38: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-17:26:13 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 83.60mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 44.90mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.249 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.044 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.250 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.273 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 9.300 % |

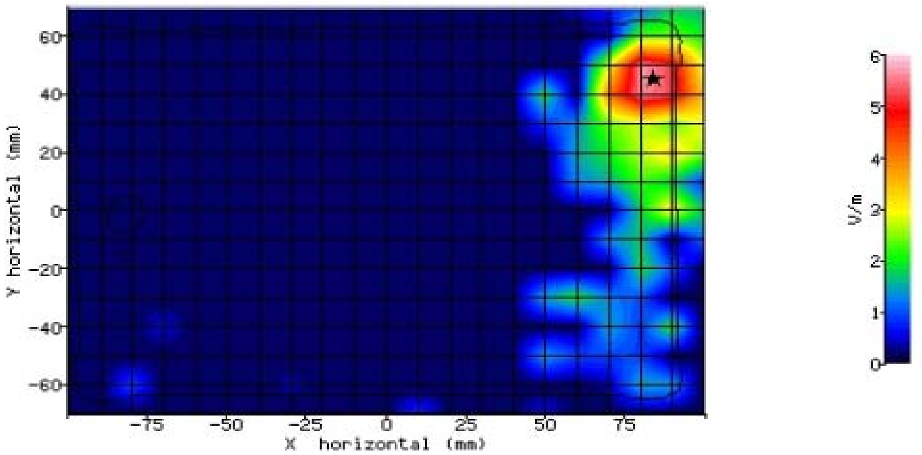



Figure 39: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C /  v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 04/12/2014-08:37:31 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -1.10mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 2.548 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.015 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.056 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.058 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 4.200 % |

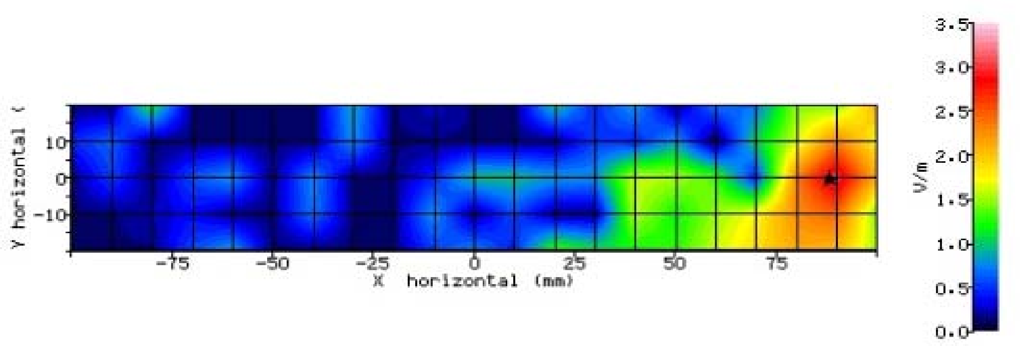



Figure 40: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 04/12/2014-08:55:09 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.80°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 48.61 |
| RELATIVE HUMIDITY: | 34.30% | CONDUCTIVITY: | 5.060 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | -41.80mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 3.50mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 7.546 |
| TEST FREQUENCY: | 5320.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.097 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.517 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.511 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -1.100 % |

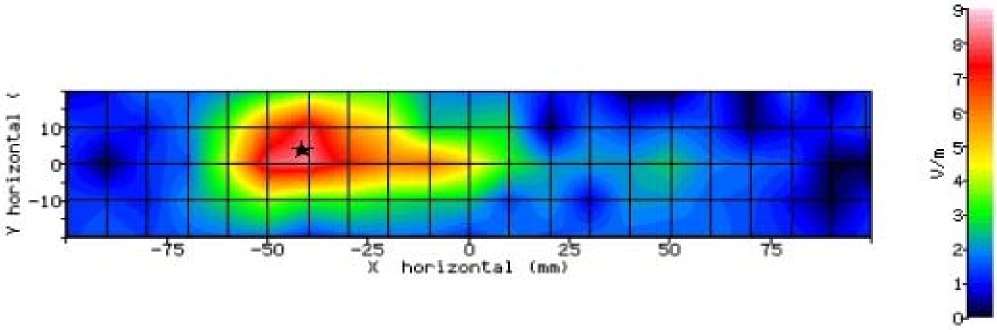



Figure 41: SAR Body Testing Results for the Sharp Phablet at 5320.0MHz. (NUA)

## 2.11 WLAN 5540MHz HEAD SAR TEST RESULTS AND COURSE AREA SCANS – 2D

Figure 42*
Figure 43*
Figure 44*
Figure 45*

*Due to the size of the device under test no measured SAR was found within the SAR system allowable scan area

## 2.12 WLAN 5540MHz BODY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-12:13:32 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.80mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -42.70mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 7.10 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | 0.349 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.778 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.809 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 3.900 % |

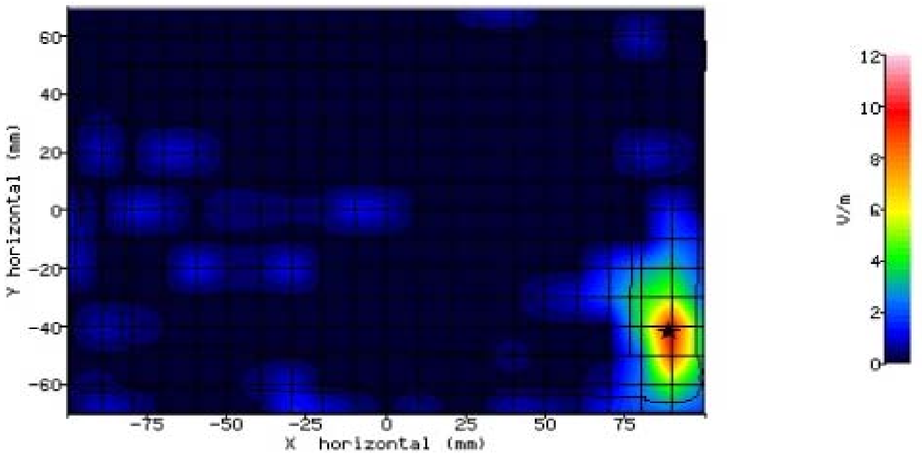



Figure 46: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-11:44:38 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 82.10mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 47.60mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.49 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | 0.167 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.320 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.320 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.100 % |

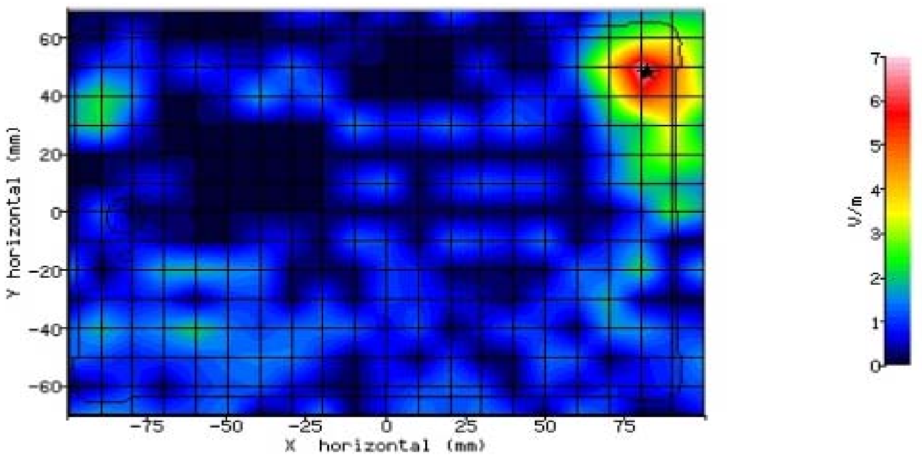



Figure 47: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:04:59 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 89.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -3.80mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 3.16 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | 0.052 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.086 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.084 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -2.100 % |

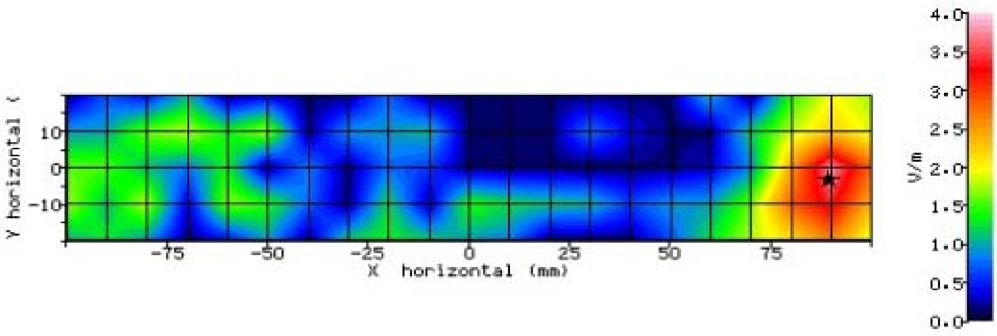



Figure 48: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:22:59 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 56.80mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 5.10mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.54 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | 0.190 W/kg |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | N/A |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.357 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.362 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.300 % |

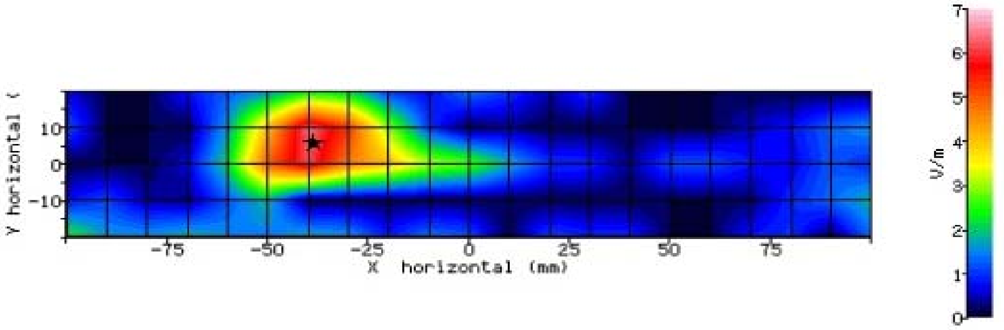



Figure 49: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

Product Service

## 2.13 WLAN 5540MHz EXTREMITY SAR TEST RESULTS AND COURSE AREA SCANS – 2D

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-12:13:32 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 88.80mm |
| DUT POSITION: | 0mm-Front Facing | MAX SAR Y-AXIS LOCATION: | -42.70mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 7.10 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.082 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.778 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.809 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 3.900 % |

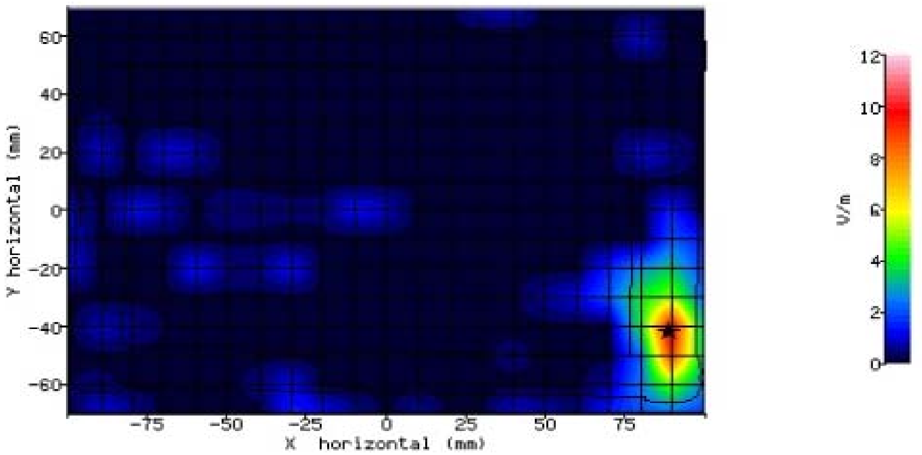



Figure 50: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-11:44:38 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 82.10mm |
| DUT POSITION: | 0mm-Rear Facing | MAX SAR Y-AXIS LOCATION: | 47.60mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.49 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.052 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.320 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.320 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.100 % |

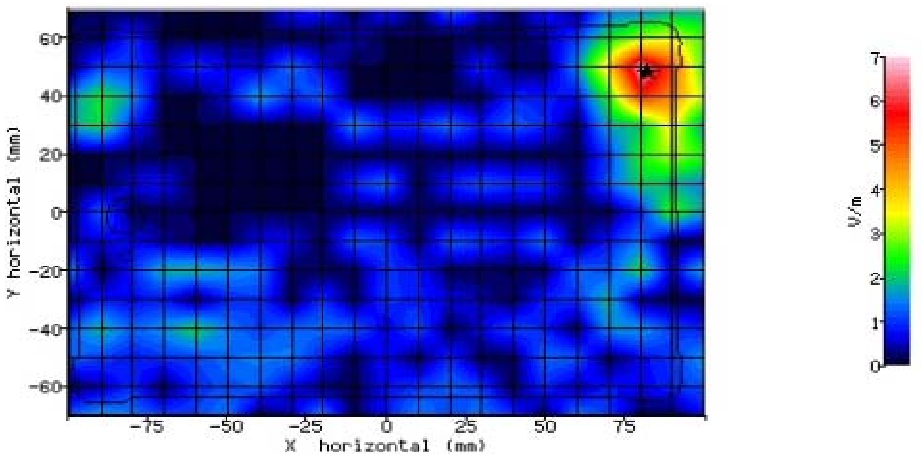



Figure 51: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

Product Service

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:04:59 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 89.00mm |
| DUT POSITION: | 0mm-Right Edge | MAX SAR Y-AXIS LOCATION: | -3.80mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 3.16 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.020 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.086 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.084 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | -2.100 % |

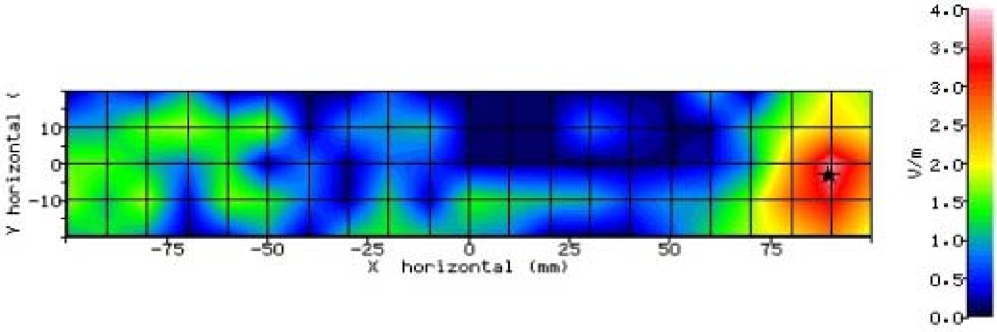



Figure 52: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

| | | | |
|---|---|---|---|
| SYSTEM / SOFTWARE: | SARA-C / v6.09.08 | INPUT POWER DRIFT: | 0 dB |
| DATE / TIME: | 03/12/2014-13:22:59 | DUT BATTERY MODEL/NO: | Integral |
| AMBIENT TEMPERATURE: | 22.90°C | LIQUID SIMULANT: | 5000 Body |
| DEVICE UNDER TEST: | Sharp Phablet | RELATIVE PERMITTIVITY: | 47.60 |
| RELATIVE HUMIDITY: | 35.30% | CONDUCTIVITY: | 5.536 |
| PHANTOM S/NO: | IXB-2HF | LIQUID TEMPERATURE: | 22.70°C |
| PHANTOM ROTATION: | N/A | MAX SAR X-AXIS LOCATION: | 56.80mm |
| DUT POSITION: | 0mm-Bottom Edge | MAX SAR Y-AXIS LOCATION: | 5.10mm |
| ANTENNA CONFIGURATION: | N/A | MAX E FIELD: | 5.54 |
| TEST FREQUENCY: | 5540.0MHz | SAR 1g: | N/A |
| TYPE OF MODULATION: | WLAN (OFDM) | SAR 10g: | 0.058 W/kg |
| MODN. DUTY CYCLE: | 100% | SAR START: | 0.357 W/kg |
| INPUT POWER LEVEL: | 12.5dBm | SAR END: | 0.362 W/kg |
| PROBE BATTERY LAST CHANGED: | 03/12/2014 | SAR DRIFT DURING SCAN: | 1.300 % |

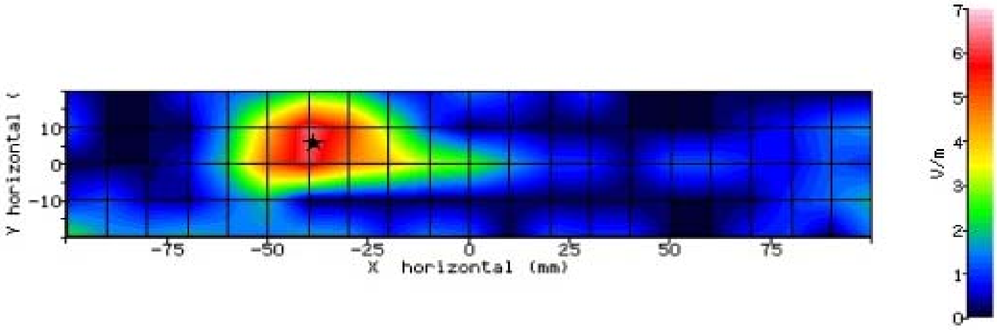



Figure 53: SAR Body Testing Results for the Sharp Phablet at 5540.0MHz. (NUA)

**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 | 21-May-2015 |
| 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 |
| Amplifier (5GHz) | IndexSar Ltd | 5GHz | 157 | - | TU |
| Power Sensor | Rohde & Schwarz | NRV-Z1 | 178 | 12 | 20-May-2015 |
| Directional Coupler | Hewlett Packard | 11692D | 452 | - | TU |
| Attenuator (20dB, 10W) | Weinschel | 37-20-34 | 482 | 12 | 22-Oct-2015 |
| Attenuator (20dB, 20W) | Narda | 766F-20 | 483 | 12 | 4-Jun-2015 |
| Spectrum Analyser | Hewlett Packard | 8562A | 2044 | 12 | 14-Feb-2015 |
| Validation Amplifier (10MHz - 2.5GHz) | IndexSar Ltd | VBM2500-3 | 2415 | - | TU |
| Multimeter | Iso-tech | IDM101 | 2418 | 12 | 26-Sep-2015 |
| Hygromer | Rotronic | I-1000 | 2784 | 12 | 10-Apr-2015 |
| Power Sensor | Rohde & Schwarz | NRV- Z5 | 2878 | 12 | 11-Jun-2015 |
| Power Meter | Rohde & Schwarz | NRVD | 2979 | 12 | 20-May-2015 |
| Hygrometer | Rotronic | I-1000 | 3068 | 12 | 10-Apr-2015 |
| Signal Generator (10MHz to 40GHz) | Rohde & Schwarz | SMR40 | 3171 | 12 | 18-Sep-2015 |
| Dual Channel Power Meter | Rohde & Schwarz | NRVD | 3259 | 12 | 12-Jun-2015 |
| Power Sensor | Rohde & Schwarz | NRV-Z1 | 3563 | 12 | 20-May-2015 |
| SAR 2450 MHz dipole | Speag | D2450V2 | 3875 | 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 |
| Part of SARAC System | IndexSar Ltd | White Benchtop | 4080 | - | TU |
| Part of SARAC System | IndexSar Ltd | Wooden Bench | 4081 | - | TU |
| Flat Phantom | IndexSar Ltd | IXB-2HF 800-6000MHz | 4255 | - | 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 | 4259 | - | 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 |
| SAR 5GHz Di-pole | Speag | D5GHzV2 | 4309 | - | 31-Dec-2014 |
| Immersible SAR Probe | IndexSar Ltd | IXP-021 | 4311 | 24 | 21-Mar-2016 |
| Immersible SAR Probe | IndexSar Ltd | IPX-050 | 4313 | 24 | 7-Mar-2015 |
| Flat Phantom | IndexSar Ltd | IXB-2HF 700-6000MHz | 4399 | - | TU |
| Immersible SAR Probe | IndexSar Ltd | IPX-020 | 4443 | 24 | 23-Apr-2015 |

| Instrument Description | Manufacturer | Model Type | TE Number | Cal Period (months) | Calibration Due Date |
|---|---|---|---|---|---|
| Immersible SAR Probe | IndexSar Ltd | IPX-025 | 4444 | 24 | 21-Mar-2016 |
| 2450MHz Head Fluid | IndexSar Ltd | Batch 11 | N/A | 1 | 06-Dec-2014 |
| 2450MHz Body Fluid | IndexSar Ltd | Batch 7 | N/A | 1 | 06-Dec-2014 |
| 5000MHz Head Fluid | IndexSar Ltd | Batch 4 | N/A | 1 | 06-Dec-2014 |
| 5000MHz Body Fluid | IndexSar Ltd | Batch 3 | N/A | 1 | 06-Dec-2014 |

TU – Traceability Unscheduled

## 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 | - |

## 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 | | | | | | | | | | | | | | | | | | | | | |
| $\varepsilon_r'$ | 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) | | | | | | | | | | | | | | | | | | | | | |
| $\varepsilon_r'$ | 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 |
|---|---|---|---|---|
| 2450 MHz Head | 39.2 | 37.97 | 1.80 | 1.79 |
| 2450MHz Body | 52.7 | 50.53 | 1.95 | 2.00 |
| 5200MHz Head | 36.0 | 35.63 | 4.66 | 4.55 |
| 5200MHz Body | 49.0 | 48.61 | 5.30 | 5.06 |
| 5500MHz Head | 35.6 | 34.76 | 4.96 | 4.91 |
| 5500MHz Body | 48.6 | 47.60 | 5.65 | 5.54 |

## 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 22.5°C to 24.2°C.
The actual humidity during the testing ranged from 25.7% to 35.3% RH.

### 3.4.2 Test Fluid Temperature Range

| Frequency | Body / Head Fluid | Min Temperature °C | Max Temperature °C |
|---|---|---|---|
| 2450MHz | Head | 23.0 | 23.0 |
| 2450MHz | Body | 22.8 | 22.8 |
| 5200MHz | Head | 22.8 | 22.8 |
| 5200MHz | Body | 22.7 | 22.7 |
| 5500MHz | Head | 22.8 | 22.8 |
| 5500MHz | Body | 22.7 | 22.7 |

### 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 9.8% (1.109 dB) for head and 9.3% (0.915 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 | 9.8 | R | 1.73 | 1 | 5.66 | ∞ |
| *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 | | | 12.13 | |
| Expanded uncertainty (95% confidence interval) | | | K=2 | | | 24.26 | |

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 | 9.3 | R | 1.73 | 1 | 5.37 | ∞ |
| *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 | | | 13.96 | |
| Expanded uncertainty (95% confidence interval) | | | K=2 | | | 27.92 | |

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).

Product Service

# ANNEX A

# PROBE CALIBRATION REPORT

TÜV SÜD Product Service

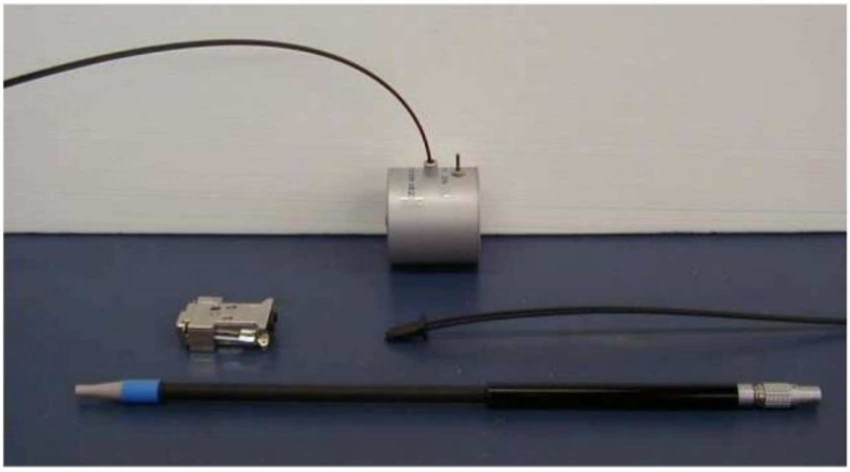
**IMMERSIBLE SAR PROBE**

**CALIBRATION REPORT**

**Part Number: IXP – 050**

# S/N 0204

**April 2013**



**Indexsar Limited**
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Fax: +44 (0) 1306 631 834
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Product Service

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*Fax: +44 (0) 1306 631 834*
*e-mail: enquiries@indexsar.com*

**Calibration Certificate 1304/0204**
**Date of Issue: 23rd April 2013**
**Immersible SAR Probe**

| | |
|---|---|
| **Type:** | IXP-050 |
| **Manufacturer:** | IndexSAR, UK |
| **Serial Number:** | 0204 |
| **Place of Calibration:** | IndexSAR, UK |
| **Date of Receipt of Probe:** | N/A |
| **Calibration Dates:** | 14th January – 7th March 2013 |
| **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 OET65 standards using the methods described in this calibration document. Where applicable, the standards used in the calibration process are traceable to the UK's National Physical Laboratory.**

| | | |
|---|---|---|
| **Calibrated by:** | A. Brinklow | **Technical Manager** |
| **Approved by:** | [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 can work on either SARA-C (to measure SAR values in flat phantoms containing Body tissue simulant fluid) or on SARA2 (where they can measure either 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 OET65 [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 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:

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

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 **Error! Reference source not found.**. 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.

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. Measurement of Spherical Isotropy

As mentioned earlier, in SARA-C a straight probe is always positioned so as to be end-on to the incoming signal source. The probe's axial isotropy response is therefore far more important than its spherical isotropy, which is included here for completeness only.

The setup for assessing the probe's spherical isotropy is shown in Figure 1.

A box phantom containing 900MHz head fluid is irradiated by a tuned dipole, mounted to the side of the phantom on the SARA2 robot's seventh axis. During calibration, the spherical response is generated by rotating the probe about its axis in 15 degree steps and changing the dipole polarisation in 10 degree steps.

The relative channel sensitivities are fixed by the earlier measurement of, and optimisation for, axial isotropy. The effect on spherical isotropy is shown in Figure 3.

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

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

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

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

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

Here, the density $\rho$ 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 $\delta$ (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 $\sigma$ is the conductivity of the tissue-simulant liquid in S/m, $\varepsilon_r$ is its relative permittivity, and $\omega$ is the radial frequency (rad/s). Values for $\sigma$ and $\varepsilon_r$ are obtained prior to each waveguide test using an Indexsar DiLine measurement kit, which uses the TEM method as recommended in [2]. $\sigma$ and $\varepsilon_r$ 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 $\sigma$ and $\varepsilon_r$ 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. 200 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 0.2mm 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.

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 450, 835, 900, 1800, 2100, 2450 and 2600MHz in liquid samples representing brain and body liquid at these frequencies.

The calibration was for CW signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The axial isotropy of the probe was measured by rotating the probe about its axis in 10 degree steps through 360 degrees in this orientation.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 2.7 mm from the probe tip in the direction of the probe amplifier. A value of 2.7 mm should be used for the tip to sensor offset distance in the software. The distance of 2.7mm for assembled probes has been confirmed by taking X-ray images of the probe tips (see Figure 8).

It is important that the diode compression point and air factors used in the software are the same as those quoted in the results tables, as these are used to convert the diode output voltages to a SAR value.

## CALIBRATION EQUIPMENT

The table on page 20 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 [6]. 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%

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## SUMMARY OF CAL FACTORS FOR PROBE IXP-020 S/N 0204

| Relative Channel Sensitivities (to optimise Axial Isotropy) | | | | |
|---|---|---|---|---|
| | X | Y | Z | |
| **Air Factors** | 91.78 | 66.90 | 81.32 | $(V/m)^2/mV$ |
| **DCPs** | 100 | 100 | 100 | mV |

| Measured Isotropy | (+/-) dB |
|---|---|
| Axial Isotropy | 0.02 |
| Spherical Isotropy | 0.66 |

| Additional Information | |
|---|---|
| Sensor offset (mm) | 2.7 |
| Elbow – Tip dimension (mm) | 0.0 |

| SAR Conversion Factors/ Boundary Corrections | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Head Fluid | | | Body Fluid | | | |
| Frequency* (MHz) | SAR Conv Factor | Boundary Correction f(0) | Boundary Correction d(mm) | SAR Conv Factor | Boundary Correction f(0) | Boundary Correction d(mm) | Notes |
| **450** | 0.317 | 0 | 1 | 0.317 | 0 | 1 | 3 |
| **700** | - | - | - | - | - | - | - |
| **835** | 0.310 | 1.69 | 1.08 | 0.327 | 0.59 | 1.91 | 1,2 |
| **900** | 0.313 | 0.80 | 1.52 | 0.327 | 1.17 | 1.31 | 1,2 |
| **1450** | - | - | - | - | - | - | - |
| **1800** | 0.357 | 0.77 | 1.68 | 0.381 | 0.64 | 2.07 | 1,2 |
| **1900** | 0.366 | 0.71 | 1.83 | 0.388 | 0.64 | 2.12 | 1,2 |
| **2100** | 0.397 | 0.70 | 1.96 | 0.413 | 0.78 | 1.86 | 1,2 |
| **2450** | 0.397 | 1.09 | 1.44 | 0.440 | 1.09 | 1.51 | 1,2 |
| **2600** | 0.394 | 1.26 | 1.35 | 0.449 | 1.17 | 1.46 | 1,2 |
| Notes | | | | | | | |
| 1) | Calibrations done at 22°C +/-2°C | | | | | | |
| 2) | Waveguide calibration | | | | | | |
| 3) | By validation | | | | | | |

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

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## PROBE SPECIFICATIONS

Indexsar probe 0204, 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 0204 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Overall length (mm) | 350 | | |
| Tip length (mm) | 10 | | |
| Body diameter (mm) | 12 | | |
| Tip diameter (mm) | 5.2 | 8 | 8 |
| Distance from probe tip to dipole centers (mm) | 2.7 | | |

| Typical Dynamic range | S/N 0204 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Minimum (W/kg) | 0.01 | <0.02 | 0.01 |
| Maximum (W/kg)<br>N.B. only measured to > 100 W/kg on representative probes | >100 | >100 | 100 |

| Isotropy (measured at 900MHz) | S/N 0204 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Axial rotation with probe normal to source (+/- dB) | 0.02 | 0.5 | 0.25 |
| Spherical isotropy covering all orientations to source (+/- dB) | 0.66 | N/A | N/A |

NB Isotropy is frequency independent

| | |
|---|---|
| **Construction** | Each probe contains three orthogonal dipole sensors arranged on a triangular prism core, protected against static charges by built-in shielding, and covered at the tip by PEEK cylindrical enclosure material. No adhesives are used in the immersed section. Outer case materials are PEEK and heat-shrink sleeving. |
| **Chemical resistance** | Tested to be resistant to TWEEN20 and sugar/salt-based simulant liquids but probes should be removed, cleaned and dried when not in use.<br><br>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 OET65
Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

[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.

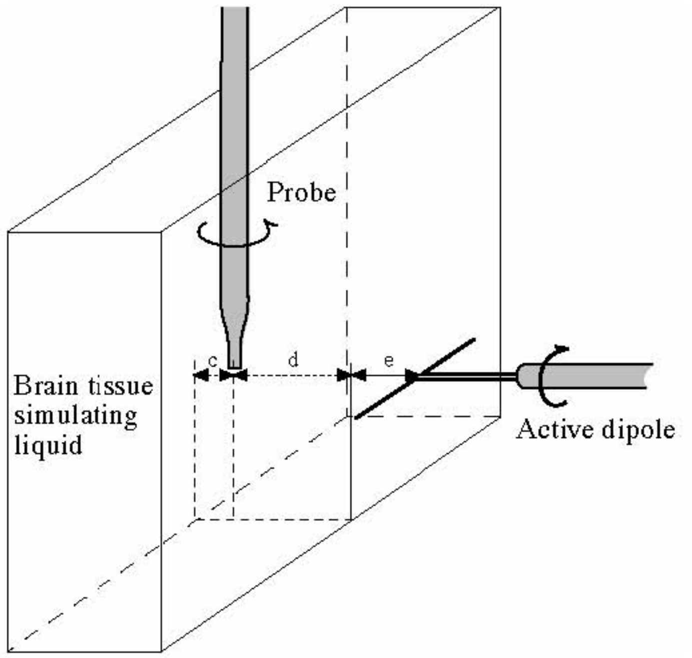


*Figure 1. Spherical isotropy jig showing probe, dipole and box filled with simulated brain liquid (see Ref [2], Section A.5.2.1)*

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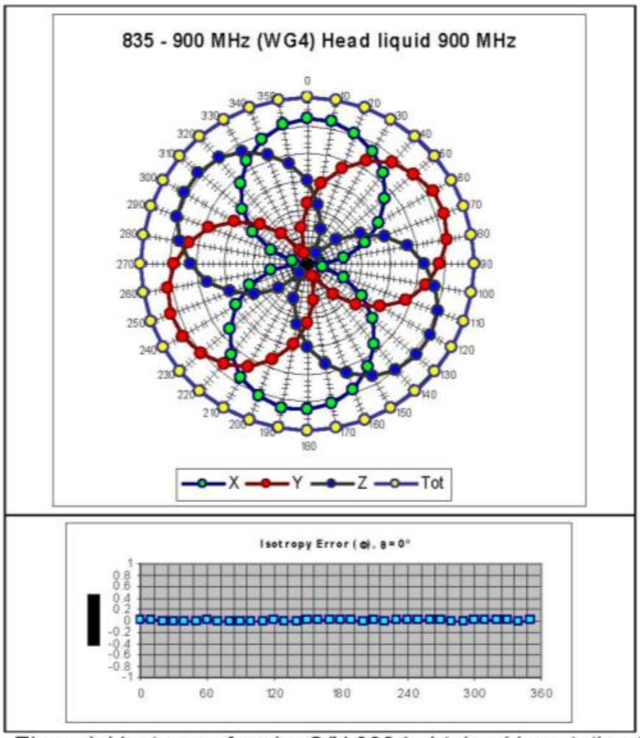


*Figure 2. The axial isotropy of probe S/N 0204 obtained by rotating the probe in a liquid-filled waveguide at 900 MHz. (NB Axial Isotropy is frequency independent)*

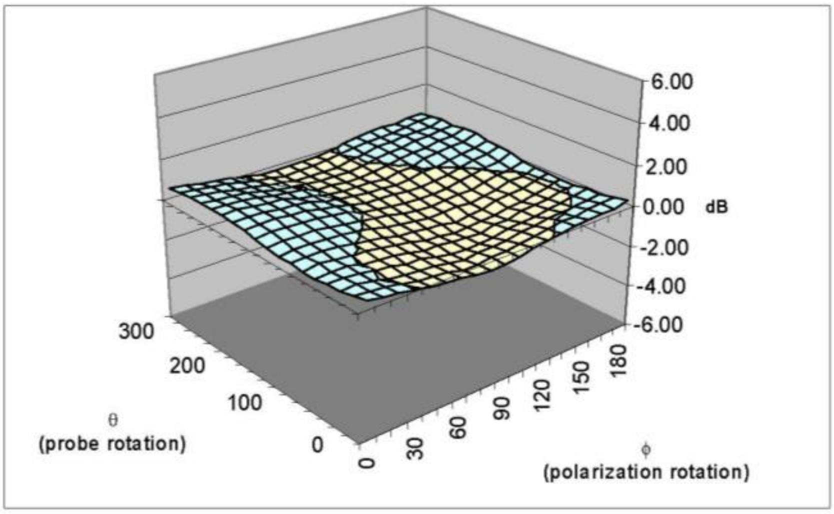


*Figure 3 Spherical isotropy diagram after optimisation of relative channel sensitivities for axial isotropy*

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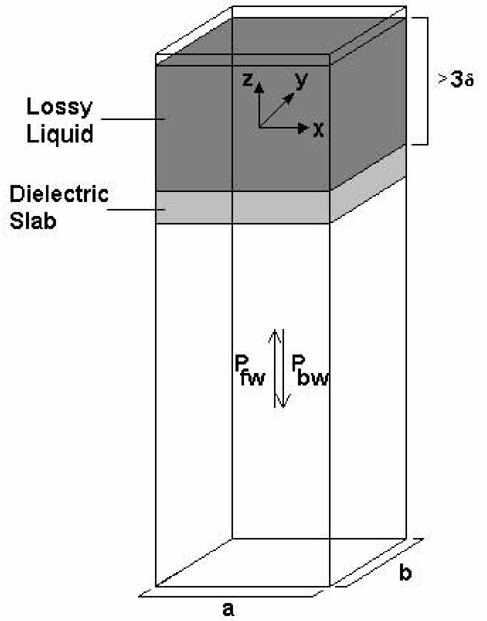


*Figure 4. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)*

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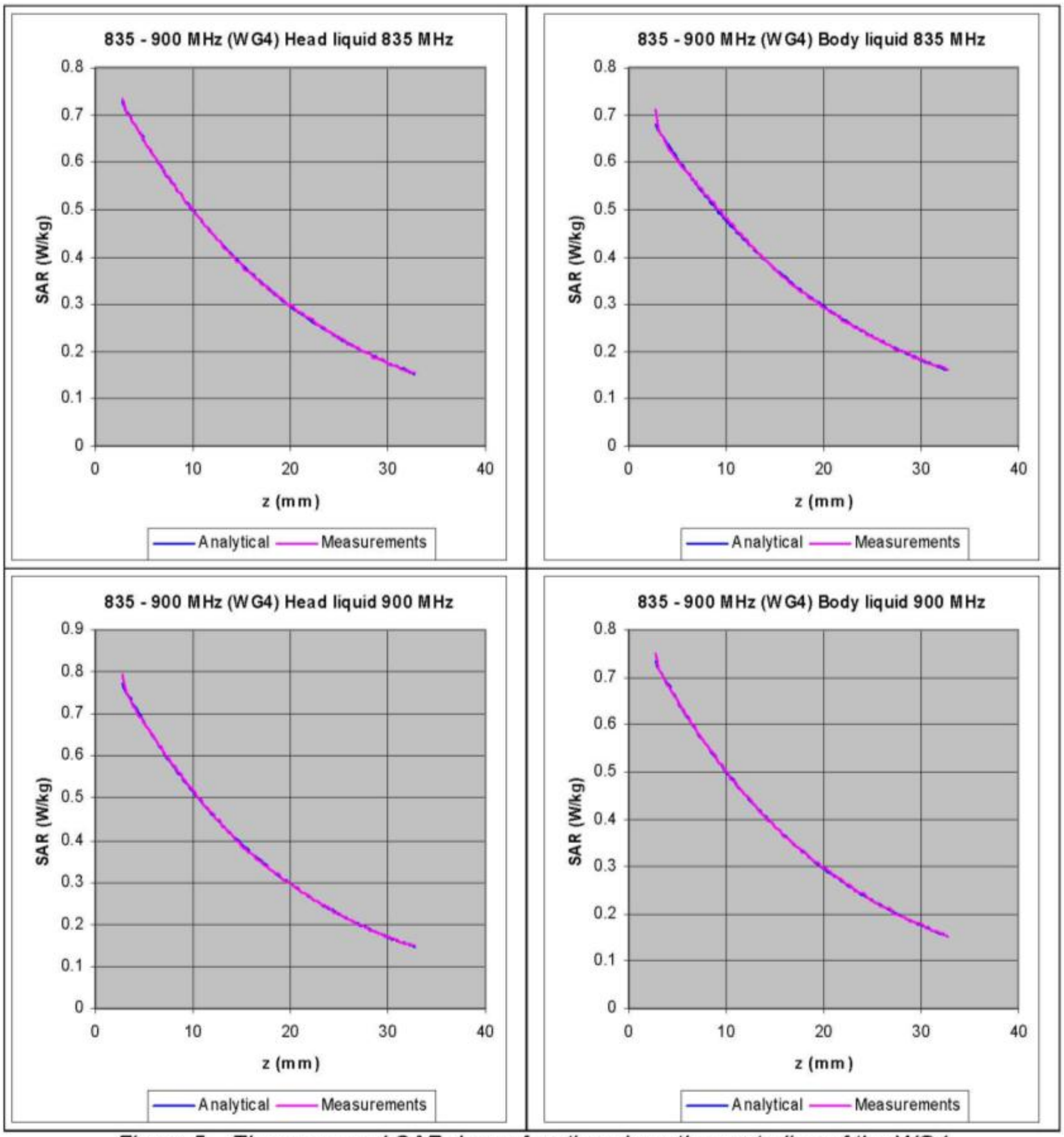


*Figure 5 . The measured SAR decay function along the centreline of the WG4 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.*

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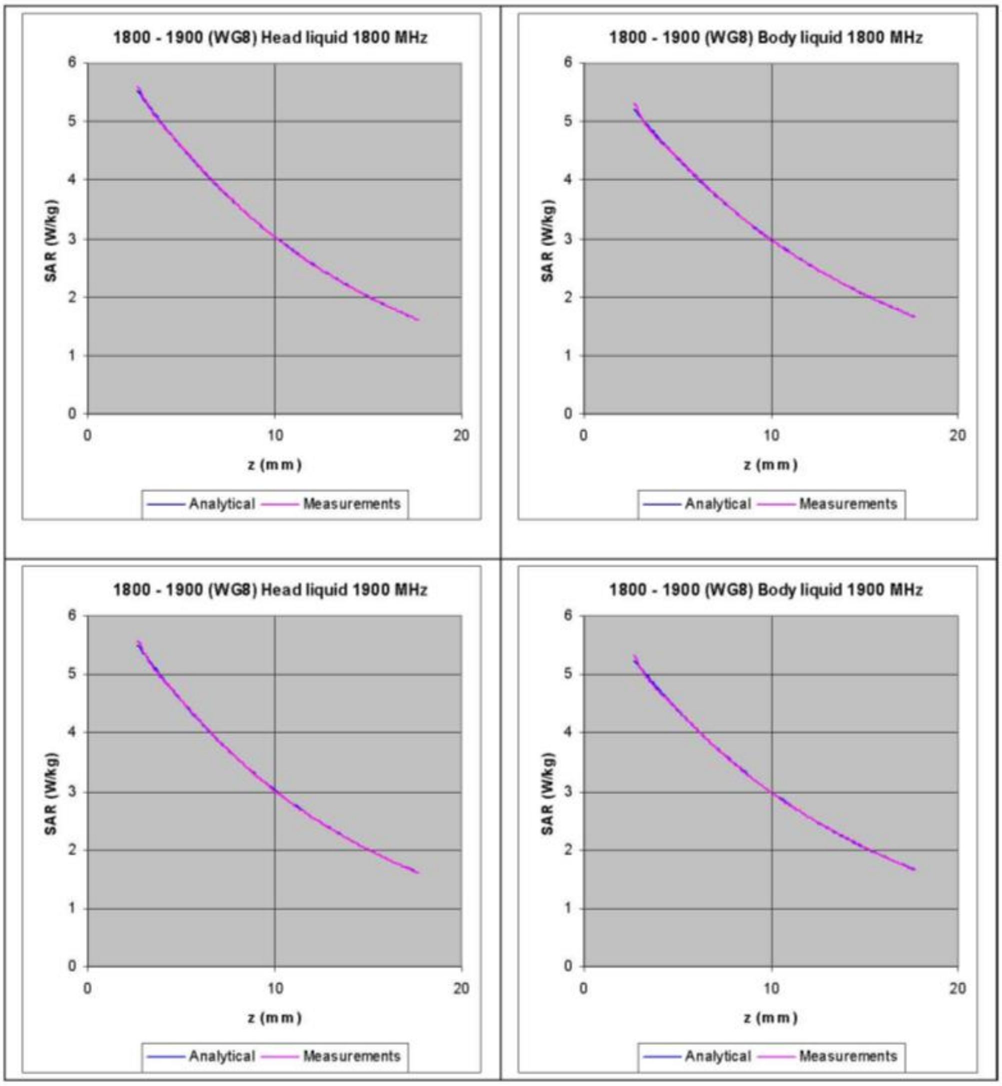

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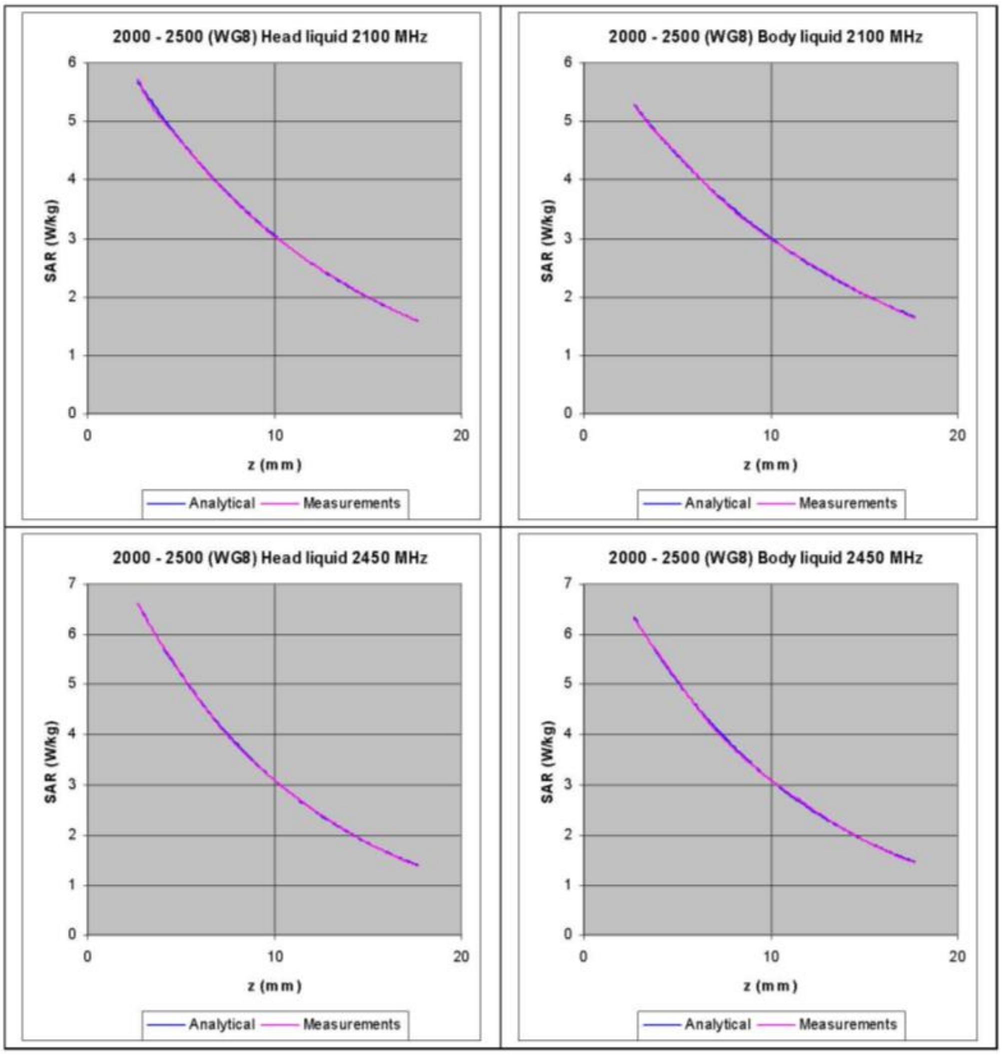

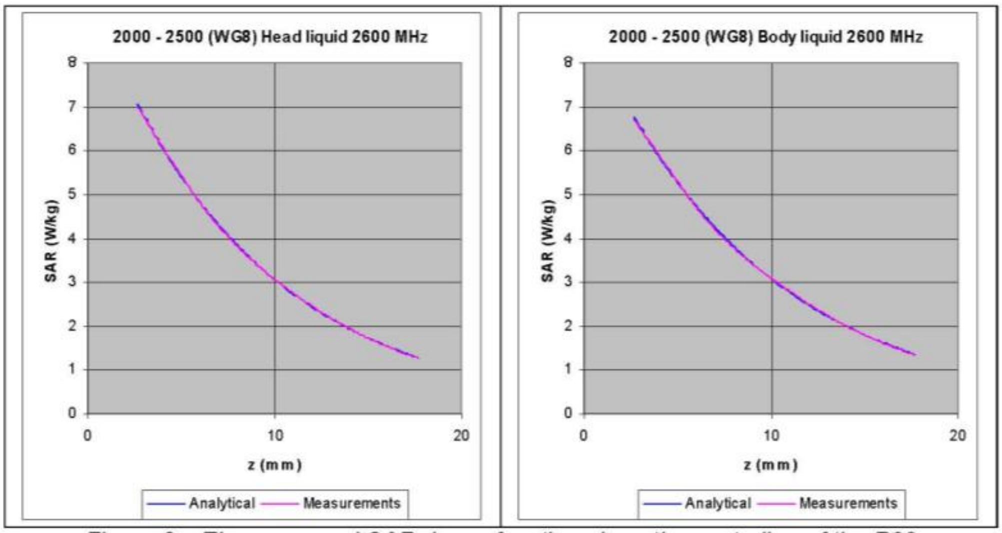


*Figure 6 . The measured SAR decay function along the centreline of the R22 waveguide with conversion factors adjusted to fit to the theoretical function for the particular dimension, frequency, power and liquid properties employed.*

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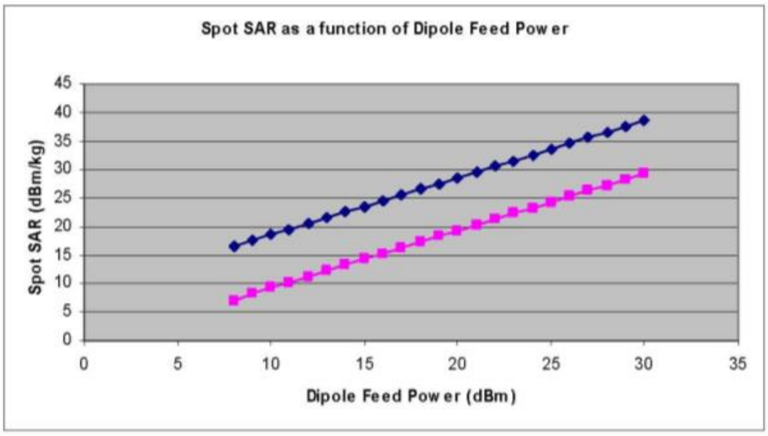


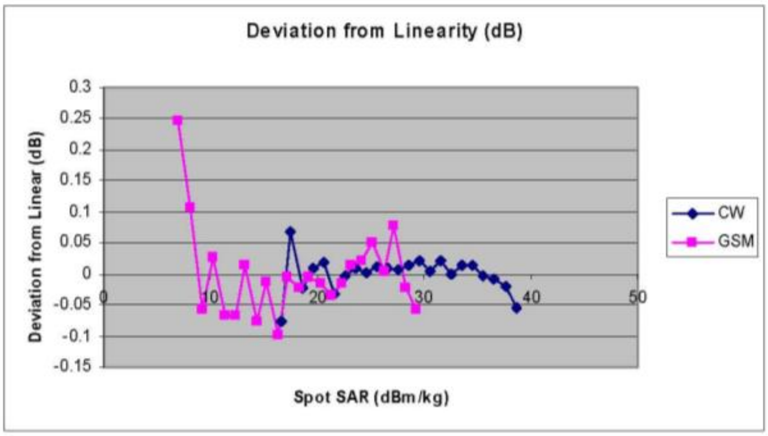


*Figure 7 : The typical linearity response of IXP-050 probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of 8 (ie 9dB) lower than CW. The lower diagram shows the departure from linearity of the same two datasets.*

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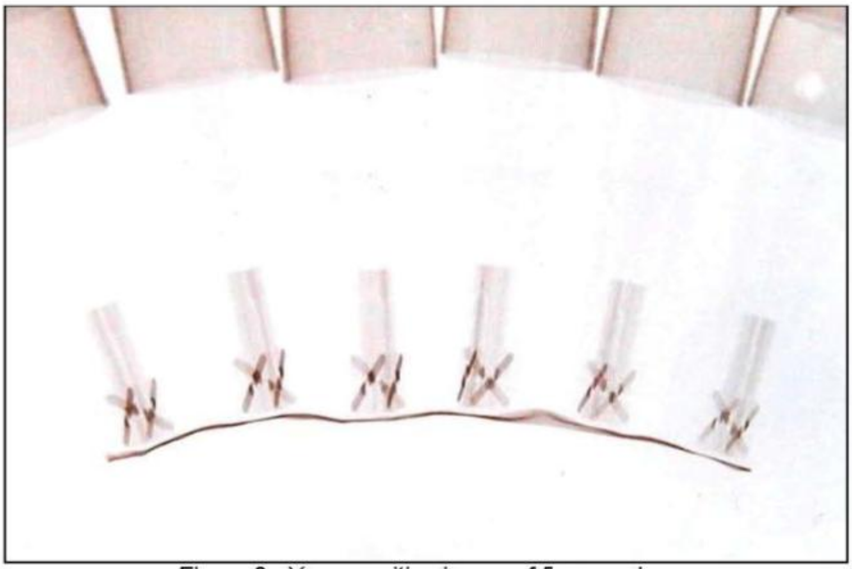

*Figure 8 : X-ray positive image of 5mm probes*

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

| Frequency (MHz) | Fluid Type | Relative Permittivity | Conductivity (S/m) | Relative Permittivity | Conductivity (S/m) | Relative Permittivity | Conductivity | Relative Permittivity | Conductivity |
|---|---|---|---|---|---|---|---|---|---|
| 450 | Head | 44.33 | 0.835 | 43.5 | 0.87 | 1.9 | -4.0 | Pass | Pass |
| 835 | | 42.25 | 0.900 | 41.5 | 0.90 | 1.8 | 0.0 | Pass | Pass |
| 900 | | 41.45 | 0.962 | 41.5 | 0.97 | -0.1 | -0.8 | Pass | Pass |
| 1800 | | 39.92 | 1.395 | 40.0 | 1.40 | -0.2 | -0.4 | Pass | Pass |
| 1900 | | 39.67 | 1.400 | 40.0 | 1.40 | -0.8 | 0.0 | Pass | Pass |
| 2100 | | 40.96 | 1.500 | 39.8 | 1.49 | 2.9 | 0.7 | Pass | Pass |
| 2450 | | 39.81 | 1.821 | 39.2 | 1.80 | 1.6 | 1.2 | Pass | Pass |
| 2600 | | 39.30 | 1.971 | 39.0 | 1.96 | 0.8 | 0.6 | Pass | Pass |
| 450 | Body | 57.53 | 0.902 | 56.7 | 0.94 | 1.5 | -3.7 | Pass | Pass |
| 835 | | 55.14 | 0.958 | 55.2 | 0.97 | -0.1 | -1.2 | Pass | Pass |
| 900 | | 54.53 | 1.023 | 55 | 1.05 | -0.9 | -2.6 | Pass | Pass |
| 1800 | | 53.07 | 1.521 | 53.3 | 1.52 | -0.4 | 0.1 | Pass | Pass |
| 1900 | | 52.85 | 1.533 | 53.3 | 1.52 | -0.8 | 0.9 | Pass | Pass |
| 2100 | | 53.92 | 1.568 | 53.2 | 1.62 | 1.4 | -3.2 | Pass | Pass |
| 2450 | | 52.90 | 1.957 | 52.7 | 1.95 | 0.4 | 0.4 | Pass | Pass |
| 2600 | | 52.47 | 2.132 | 52.5 | 2.16 | -0.1 | -1.3 | Pass | Pass |

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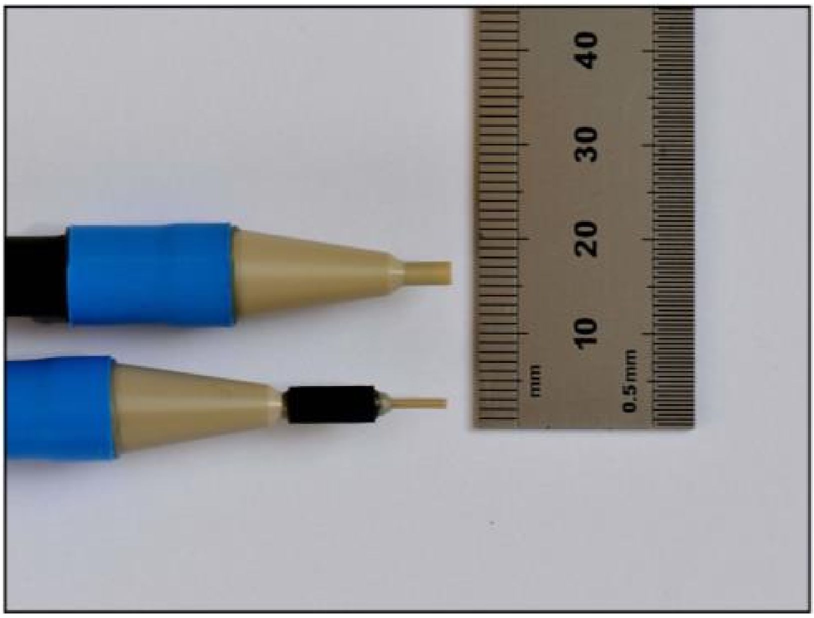
**IMMERSIBLE SAR PROBE**

**CALIBRATION REPORT**

**Part Number: IXP – 025**

# S/N G0011

**August 2014**

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TÜV SÜD Product Service

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**Calibration Certificate 1408/G0011**
**Date of Issue: 26 August 2014**
**Immersible SAR Probe**

| | |
|---|---|
| **Type:** | IXP-025 |
| **Manufacturer:** | IndexSAR, UK |
| **Serial Number:** | G0011 |
| **Place of Calibration:** | IndexSAR, UK |
| **Date of Receipt of Probe:** | N/A |
| **Calibration Dates:** | 11-21 March 2014 |
| **Customer:** | TUV Sud |

**IndexSAR Ltd hereby declares that the IXP-025 Probe named above has been calibrated for conformity to the current versions of IEEE 1528, IEC 62209-1, IEC 62209-2, and FCC OET65 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:** | A. Brinklow | **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

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 G0011) 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 OET65 [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) Use of these channel sensitivity factors to compare the SAR decay curve in a waveguide fluid cell with an analytical curve 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-025 probes to CW and to GSM modulation is shown in Figure 3, 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, a 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).

A 5-6GHz 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 5-6GHz brain fluid to within 1 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 5mm above the centre of the dielectric window. This particular separation ensures that the probe is operating in a part of the waveguide where boundary corrections are not necessary.

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

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

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

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

Figure 1 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:

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

Here, the density $\rho$ 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 $\delta$ (which is the reciprocal of the waveguide-mode attenuation coefficient) is a property of the lossy liquid and is given by Equation (5).

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

where $\sigma$ is the conductivity of the tissue-simulant liquid in S/m, $\varepsilon_r$ is its relative permittivity, and $\omega$ is the radial frequency (rad/s). Values for $\sigma$ and $\varepsilon_r$ are obtained prior to each waveguide test using an Indexsar DiLine measurement kit, which uses the TEM method as recommended in [2]. $\sigma$ and $\varepsilon_r$ 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 $\sigma$ and $\varepsilon_r$ 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. 200 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 0.2mm 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.

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 G0011

The probe was calibrated at 5.2, 5.5 and 5.8GHz in liquid samples representing brain and body liquid at these frequencies.

The calibration was for CW signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The axial isotropy of the probe was measured by rotating the probe about its axis in 10 degree steps through 360 degrees in this orientation.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 1.39 mm from the probe tip in the direction of the probe amplifier. A value of 1.39 mm should be used for the tip to sensor offset distance in the software. The distance of 1.39mm for assembled probes has been confirmed by taking X-ray images of the probe tips (see Figure 4).

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 20 indicates the calibration status of all test equipment used during probe calibration.

### MEASUREMENT UNCERTAINTIES

A complete measurement uncertainty analysis for the SARA-C measurement system has been published in Reference [6]. 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 homogeneity | 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%

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# SUMMARY OF CAL FACTORS FOR PROBE IXP-025 S/N G0011

| | Relative Channel Sensitivities (to optimise Axial Isotropy) | | | |
|---|---|---|---|---|
| | X | Y | Z | |
| **Air Factors*** | 302.94 | 335.24 | 321.81 | $(V/m)^2/mV$ |
| **DCPs** | 100 | 100 | 100 | mV |

| Measured Isotropy | (+/-) dB |
|---|---|
| Axial Isotropy* | 0.07 |

| Physical Information | |
|---|---|
| Sensor offset (mm) | 1.39 |
| Elbow – Tip dimension (mm) | 0.0 |

**SAR Conversion Factors/ Boundary Corrections**

| | Head Fluid | | | Body Fluid | | | |
|---|---|---|---|---|---|---|---|
| **Frequency* (MHz)** | **SAR Conv Factor** | **Boundary Correction f(0)** | **Boundary Correction d(mm)** | **SAR Conv Factor** | **Boundary Correction f(0)** | **Boundary Correction d(mm)** | **Notes** |
| **5200** | 0.94 | 0.32 | 2.1 | 1.04 | 0.27 | 3.6 | 1,2 |
| **5500** | 0.89 | 0.34 | 1.7 | 1.20 | 0.36 | 4.7 | 1,2 |
| **5800** | 0.93 | 0.31 | 1.8 | 1.37 | 0.37 | 5.9 | 1,2 |

| Notes | |
|---|---|
| 1) | Calibrations done at 22°C +/-2°C |
| 2) | Waveguide calibration |
| 3) | By interpolation |

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

## PROBE SPECIFICATIONS

Indexsar probe G0011, 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 G0011 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Overall length (mm) | 350 | | |
| Tip length (mm) | 10 | | |
| Body diameter (mm) | 12 | | |
| Tip diameter (mm) | 2.55 | 8 | 8 |
| Distance from probe tip to dipole centers (mm) | 1.39 | | |

| **Typical Dynamic range** | S/N G0011 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Minimum (W/kg) | 0.01 | <0.02 | 0.01 |
| Maximum (W/kg)<br>N.B. only measured to > 100 W/kg on representative probes | >100 | >100 | 100 |

| **Isotropy (measured at 5200MHz)** | S/N G0011 | BSEN [1] | IEEE [2] |
|---|---|---|---|
| Axial rotation with probe normal to source (+/- dB) | <0.07 | 0.5 | 0.25 |

| | |
|---|---|
| **Construction** | Each probe contains three orthogonal dipole sensors arranged on a triangular prism core, protected against static charges by built-in shielding, and covered at the tip by PEEK cylindrical enclosure material. No adhesives are used in the immersed section. Outer case materials are PEEK and heat-shrink sleeving. |
| **Chemical resistance** | Tested to be resistant to TWEEN20 and sugar/salt-based simulant liquids but probes should be removed, cleaned and dried when not in use.<br><br>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 OET65
Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

[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.

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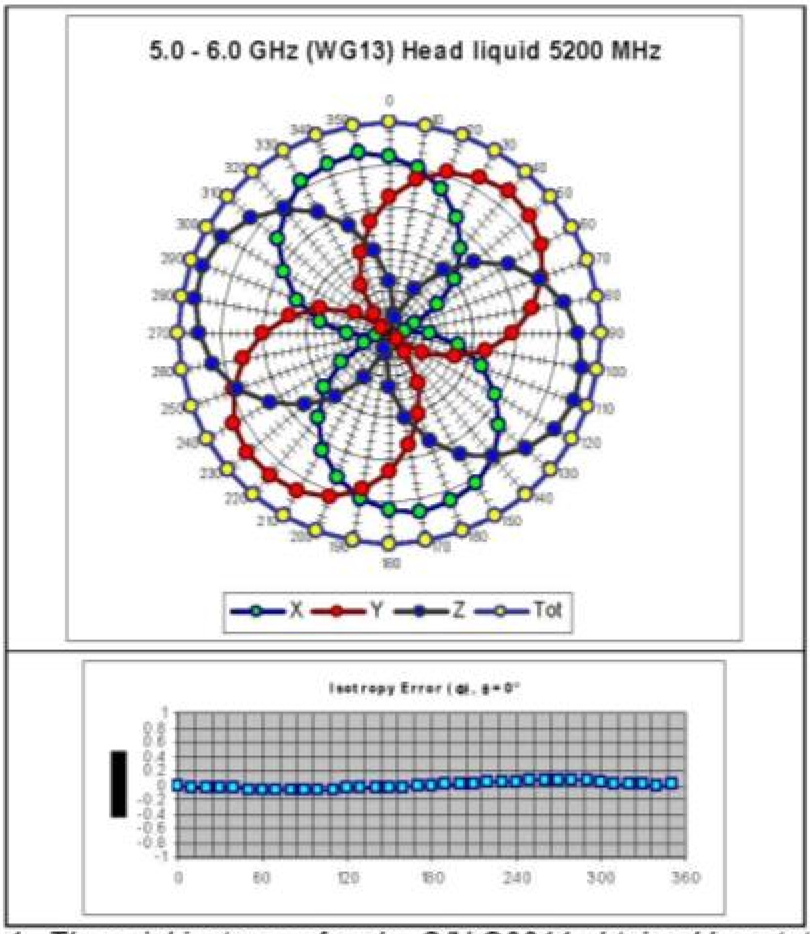



*Figure 1. The axial isotropy of probe S/N G0011 obtained by rotating the probe in a liquid-filled waveguide at 5200 MHz. (NB Axial Isotropy is largely independent of frequency)*

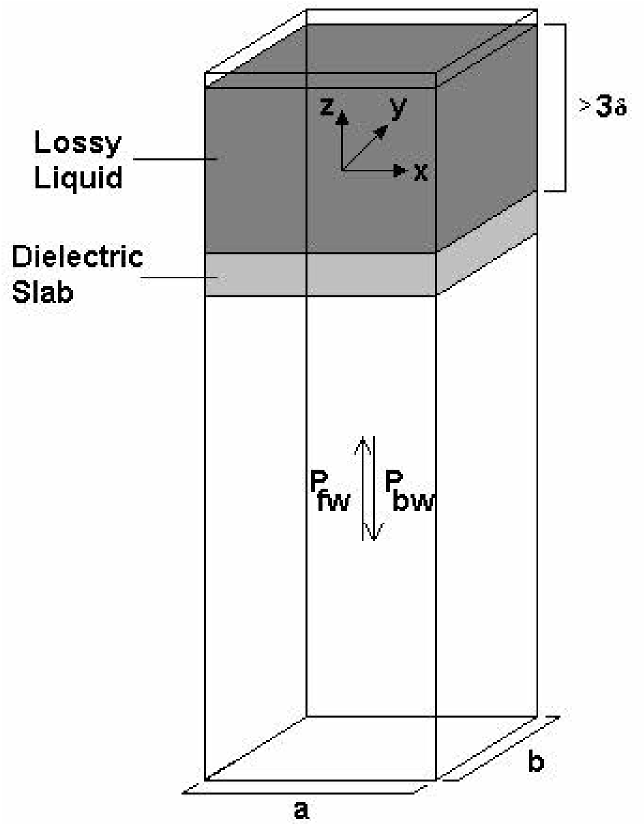
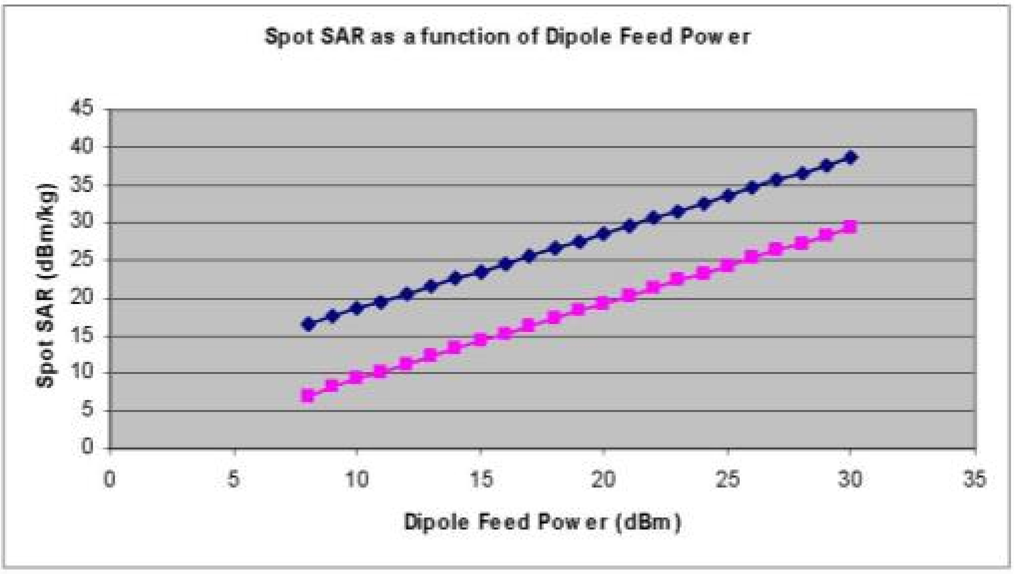



*Figure 2. Geometry used for waveguide calibration (after Ref [2]. Section A.3.2.2)*



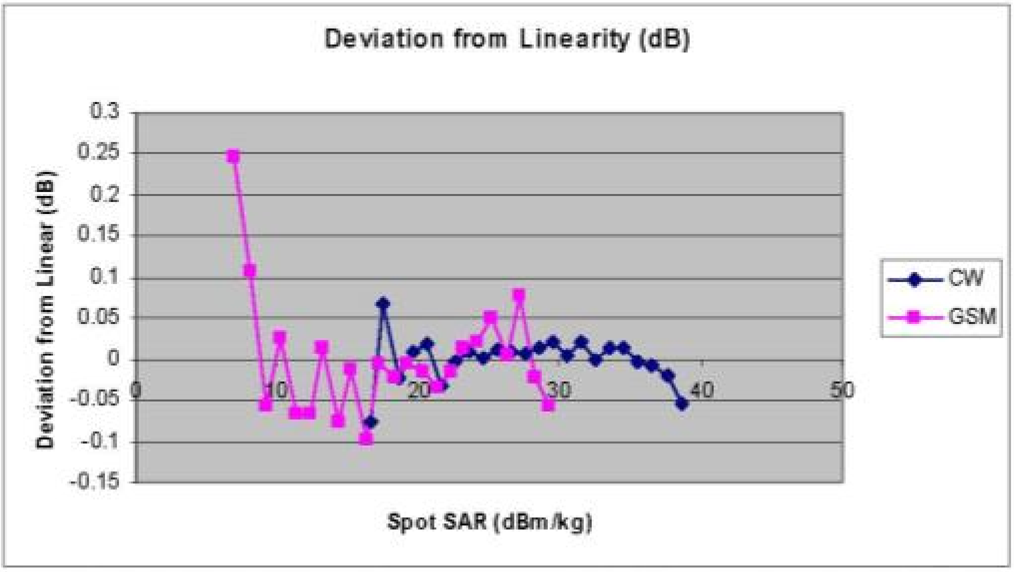




*Figure 3 : The typical linearity response of IXP-025 probes to both CW (blue) and GSM (pink) modulation in close proximity to a source dipole. The top diagram shows the SAR reading as a function of dipole feed power, with GSM modulation being approx a factor of 8 (ie 9dB) lower than CW. The lower diagram shows the departure from linearity of the same two datasets.*

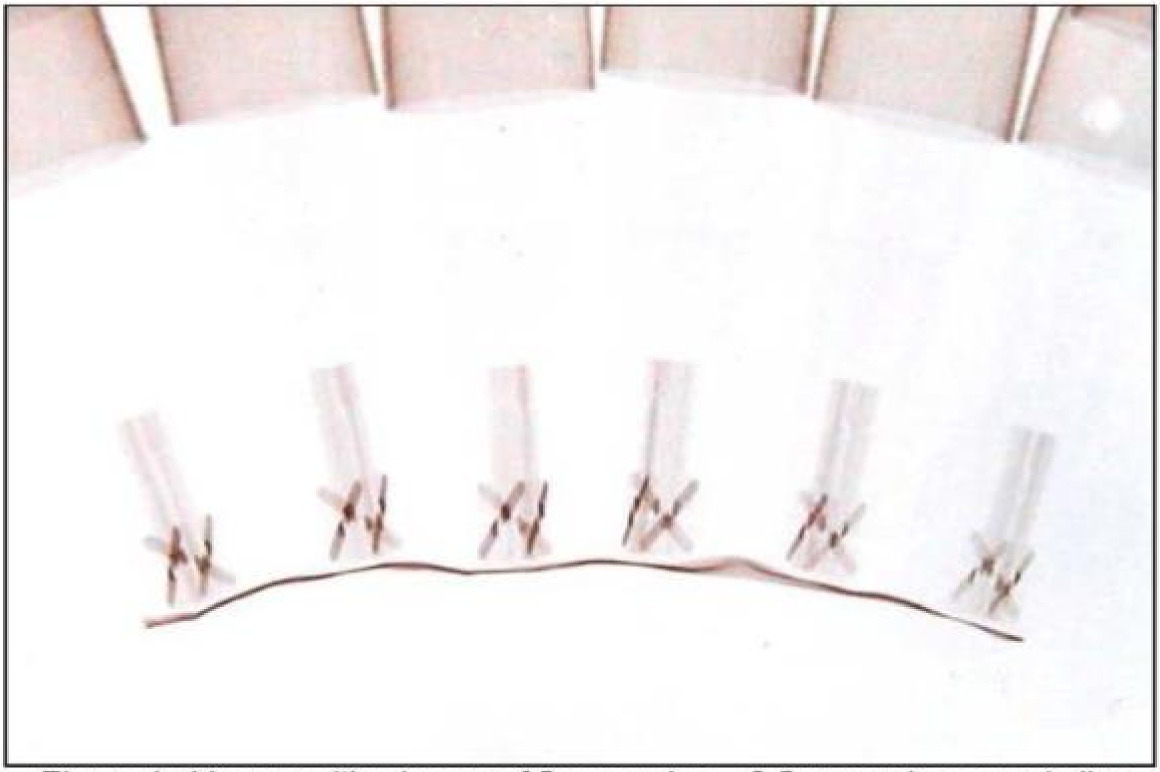


Figure 4 : X-ray positive image of 5mm probes. 2.5mm probes are similar

**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 |
| 5200 | Head | 37.01 | 4.82 | 36.0 | 4.66 | 2.8 | 3.3 | Pass | Pass |
| 5500 | | 36.34 | 5.12 | 35.7 | 4.97 | 1.9 | 3.0 | Pass | Pass |
| 5800 | | 35.61 | 5.47 | 35.3 | 5.27 | 0.9 | 3.7 | Pass | Pass |
| 5200 | Body | 49.19 | 5.30 | 49.0 | 5.30 | 0.4 | -0.1 | Pass | Pass |
| 5500 | | 48.38 | 5.62 | 48.6 | 5.65 | -0.5 | -0.5 | Pass | Pass |
| 5800 | | 47.41 | 6.06 | 48.2 | 6.00 | -1.6 | 1.1 | Pass | Pass |

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### Table of test equipment calibration status

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Last calibration date | Calibration due date |
|---|---|---|---|---|---|
| Power sensor | Rohde & Schwarz | NRP-Z23 | 100063 | 09/08/2012 | 09/08/2014 |
| Dielectric property measurement | Indexsar | DiLine (sensor lengths: 160mm, 80mm and 60mm) | N/A | (absolute) – checked against NPL values using reference liquids | N/A |
| Vector network analyser | Anritsu | MS6423B | 003102 | 21/01/2014 | 21/01/2015 |
| SMA autocalibration module | Anritsu | 36581KKF/1 | 001902 | 21/01/2014 | 21/01/2015 |

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**IMMERSIBLE SAR PROBE**

**CALIBRATION REPORT**

**Part Number: IXP–020**

# S/N L0020

**August 2014**

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**Calibration Certificate 1408/L0020**
**Date of Issue: 26 August 2014**
**Immersible SAR Probe**

| | |
|---|---|
| **Type:** | IXP-020 |
| **Manufacturer:** | IndexSAR, UK |
| **Serial Number:** | L0020 |
| **Place of Calibration:** | IndexSAR, UK |
| **Date of Receipt of Probe:** | N/A |
| **Calibration Dates:** | 15 March – 23 April 2013 |
| **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 OET65 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:** | A. Brinklow | **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 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 OET65 [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