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# SAR EVALUATION REPORT

**Applicant Name:**
LG Electronics MobileComm U.S.A., Inc.
1000 Sylvan Avenue
Englewood Cliffs, NJ 07632
United States

**Date of Testing:**
05/16/16 - 05/17/16
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Document Serial No.:**
0Y1605160917.ZNF

**FCC ID:** **ZNFUS610**

**APPLICANT:** **LG ELECTRONICS MOBILECOMM U.S.A., INC.**

**DUT Type:** Portable Handset
**Application Type:** Certification
**FCC Rule Part(s):** CFR §2.1093
**Model(s):** LG-US610, LGUS610, US610, LG-K212, LGK212, K212

| Equipment Class | Band & Mode | Tx Frequency | SAR | | |
|---|---|---|---|---|---|
| | | | 1 gm Head (W/kg) | 1 gm Body-Worn (W/kg) | 1 gm Hotspot (W/kg) |
| PCE | Cell. CDMA/EVDO | 824.70 - 848.31 MHz | 0.38 | 0.42 | 0.41 |
| PCE | PCS CDMA/EVDO | 1851.25 - 1908.75 MHz | 0.52 | 0.69 | 0.66 |
| PCE | GSM/GPRS/EDGE 850 | 824.20 - 848.80 MHz | 0.29 | 0.32 | 0.32 |
| PCE | GSM/GPRS/EDGE 1900 | 1850.20 - 1909.80 MHz | 0.39 | 0.45 | 0.45 |
| PCE | UMTS 850 | 826.40 - 846.60 MHz | 0.34 | 0.38 | 0.38 |
| PCE | UMTS 1750 | 1712.4 - 1752.6 MHz | 0.38 | 0.74 | 0.74 |
| PCE | UMTS 1900 | 1852.4 - 1907.6 MHz | 0.53 | 0.61 | 0.61 |
| PCE | LTE Band 12 | 699.7 - 715.3 MHz | 0.18 | 0.35 | 0.35 |
| PCE | LTE Band 17 | 706.5 - 713.5 MHz | N/A | N/A | N/A |
| PCE | LTE Band 13 | 779.5 - 784.5 MHz | 0.30 | 0.53 | 0.53 |
| PCE | LTE Band 5 (Cell) | 824.7 - 848.3 MHz | 0.33 | 0.40 | 0.40 |
| PCE | LTE Band 4 (AWS) | 1710.7 - 1754.3 MHz | 0.43 | 0.76 | 0.76 |
| PCE | LTE Band 25 (PCS) | 1850.7 - 1914.3 MHz | 0.60 | 0.75 | 0.88 |
| PCE | LTE Band 2 (PCS) | 1850.7 - 1909.3 MHz | N/A | N/A | N/A |
| DTS | 2.4 GHz WLAN | 2412 - 2462 MHz | 1.01 | 0.25 | 0.25 |
| DSS/DTS | Bluetooth | 2402 - 2480 MHz | N/A | | |
| **Simultaneous SAR per KDB 690783 D01v01r03:** | | | 1.54 | 1.01 | 1.13 |

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE C95.1-1992 and has been tested in accordance with the measurement procedures specified in Section 1.7 of this report; for North American frequency bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.

Randy Ortanez
President

The SAR Tick is an initiative of the Mobile Manufacturers Forum (MMF). While a product may be considered eligible, use of the SAR Tick logo requires an agreement with the MMF. Further details can be obtained by emailing: sartick@mmfai.info.

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# 1 DEVICE UNDER TEST

## 1.1 Device Overview

| Band & Mode | Operating Modes | Tx Frequency |
|---|---|---|
| Cell. CDMA/EVDO | Voice/Data | 824.70 - 848.31 MHz |
| PCS CDMA/EVDO | Voice/Data | 1851.25 - 1908.75 MHz |
| GSM/GPRS/EDGE 850 | Voice/Data | 824.20 - 848.80 MHz |
| GSM/GPRS/EDGE 1900 | Voice/Data | 1850.20 - 1909.80 MHz |
| UMTS 850 | Voice/Data | 826.40 - 846.60 MHz |
| UMTS 1750 | Voice/Data | 1712.4 - 1752.6 MHz |
| UMTS 1900 | Voice/Data | 1852.4 - 1907.6 MHz |
| LTE Band 12 | Data | 699.7 - 715.3 MHz |
| LTE Band 17 | Data | 706.5 - 713.5 MHz |
| LTE Band 13 | Data | 779.5 - 784.5 MHz |
| LTE Band 5 (Cell) | Data | 824.7 - 848.3 MHz |
| LTE Band 4 (AWS) | Data | 1710.7 - 1754.3 MHz |
| LTE Band 25 (PCS) | Data | 1850.7 - 1914.3 MHz |
| LTE Band 2 (PCS) | Data | 1850.7 - 1909.3 MHz |
| 2.4 GHz WLAN | Data | 2412 - 2462 MHz |
| Bluetooth | Data | 2402 - 2480 MHz |

## 1.2 Power Reduction for SAR

There is no power reduction used for any band/mode implemented in this device for SAR purposes.

## 1.3 Nominal and Maximum Output Power Specifications

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v06.

| Mode / Band | | Voice (dBm) | Burst Average GMSK (dBm) | | Burst Average 8-PSK (dBm) | |
|---|---|---|---|---|---|---|
| | | 1 TX Slot | *1 TX Slots* | *2 TX Slots* | *1 TX Slots* | *2 TX Slots* |
| GSM/GPRS/EDGE 850 | Maximum | **33.2** | **33.2** | **31.7** | **27.7** | **26.7** |
| | Nominal | **32.7** | **32.7** | **31.2** | **27.2** | **26.2** |
| GSM/GPRS/EDGE 1900 | Maximum | **29.7** | **29.7** | **28.7** | **26.7** | **25.7** |
| | Nominal | **29.2** | **29.2** | **28.2** | **26.2** | **25.2** |

| Mode / Band | | Modulated Average (dBm) | | |
|---|---|---|---|---|
| | | *3GPP WCDMA* | *3GPP HSDPA* | *3GPP HSUPA* |
| UMTS Band 5 (850 MHz) | Maximum | **24.7** | **24.7** | **24.7** |
| | Nominal | **24.2** | **24.2** | **24.2** |
| UMTS Band 4 (1750 MHz) | Maximum | **23.2** | **23.2** | **23.2** |
| | Nominal | **22.7** | **22.7** | **22.7** |
| UMTS Band 2 (1900 MHz) | Maximum | **23.2** | **23.2** | **23.2** |
| | Nominal | **22.7** | **22.7** | **22.7** |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| Cell. CDMA/EVDO | Maximum | **24.7** |
| | Nominal | **24.2** |
| PCS CDMA/EVDO | Maximum | **24.7** |
| | Nominal | **24.2** |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| LTE Band 12 | Maximum | **24.7** |
| | Nominal | **24.2** |
| LTE Band 17 | Maximum | **24.7** |
| | Nominal | **24.2** |
| LTE Band 13 | Maximum | **24.7** |
| | Nominal | **24.2** |
| LTE Band 5 (Cell) | Maximum | **24.7** |
| | Nominal | **24.2** |
| LTE Band 4 (AWS) | Maximum | **24.2** |
| | Nominal | **23.7** |
| LTE Band 25 (PCS) | Maximum | **23.7** |
| | Nominal | **23.2** |
| LTE Band 2 (PCS) | Maximum | **23.7** |
| | Nominal | **23.2** |

| Mode / Band | | Modulated Average (dBm) | | |
|---|---|---|---|---|
| | | Ch.1-11 | | |
| IEEE 802.11b (2.4 GHz) | Maximum | **17.5** | | |
| | Nominal | **16.5** | | |
| | | **Ch.1** | **Ch.2-10** | **Ch.11** |
| IEEE 802.11g (2.4 GHz) | Maximum | **13.5** | **16.5** | **13.5** |
| | Nominal | **12.5** | **15.5** | **12.5** |
| IEEE 802.11n (2.4 GHz) | Maximum | **13.5** | **16.5** | **13.5** |
| | Nominal | **12.5** | **15.5** | **12.5** |
| Mode / Band | | Modulated Average (dBm) | | |
| Bluetooth | Maximum | **8.5** | | |
| | Nominal | **7.5** | | |
| Bluetooth LE | Maximum | **-1.0** | | |
| | Nominal | **-2.0** | | |

## 1.4 DUT Antenna Locations

The overall dimensions of this device are > 9 x 5 cm. Since the diagonal dimension of this device is > 160 mm and <200 mm, it is considered a "phablet." A diagram showing the location of the device antennas can be found in Appendix F.

**Table 1-1**
**Device Edges/Sides for SAR Testing**

| Mode | Back | Front | Top | Bottom | Right | Left |
|---|---|---|---|---|---|---|
| Cell. EVDO | Yes | Yes | No | Yes | Yes | Yes |
| PCS EVDO | Yes | Yes | No | Yes | No | Yes |
| GPRS 850 | Yes | Yes | No | Yes | Yes | Yes |
| GPRS 1900 | Yes | Yes | No | Yes | No | Yes |
| UMTS 850 | Yes | Yes | No | Yes | Yes | Yes |
| UMTS 1750 | Yes | Yes | No | Yes | No | Yes |
| UMTS 1900 | Yes | Yes | No | Yes | No | Yes |
| LTE Band 12 | Yes | Yes | No | Yes | Yes | Yes |
| LTE Band 13 | Yes | Yes | No | Yes | Yes | Yes |
| LTE Band 5 (Cell) | Yes | Yes | No | Yes | Yes | Yes |
| LTE Band 4 (AWS) | Yes | Yes | No | Yes | No | Yes |
| LTE Band 25 (PCS) | Yes | Yes | No | Yes | No | Yes |
| 2.4 GHz WLAN | Yes | Yes | Yes | No | Yes | No |

Note: Particular DUT edges were not required to be evaluated for wireless router SAR if the edges were greater than 2.5 cm from the transmitting antenna according to FCC KDB Publication 941225 D06v02r01 Section III. The distances between the transmit antennas and the edges of the device are included in the filing.

## 1.5 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, transmitters are considered to be transmitting simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds. Possible transmission paths for the DUT are shown in Figure 1-1 and are color-coded to indicate communication modes which share the same path. Modes which share the same transmission path cannot transmit simultaneously with one another.

**Path 1**

GSM GPRS/EDGE    UMTS    CDMA/EVDO    LTE

**Path 2**

BT/WIFI

**Figure 1-1**
**Simultaneous Transmission Paths**

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v06 4.3.2 procedures.

**Table 1-2**
**Simultaneous Transmission Scenarios**

| No. | Capable Transmit Configuration | Head | Body-Worn Accessory | Wireless Router | Phablet | Notes |
|---|---|---|---|---|---|---|
| 1 | 1x CDMA voice + 2.4 GHz WI-FI | Yes | Yes | N/A | Yes | |
| 2 | 1x CDMA voice + 2.4 GHz Bluetooth | N/A | Yes | N/A | Yes | |
| 3 | GSM voice + 2.4 GHz WI-FI | Yes | Yes | N/A | Yes | |
| 4 | GSM voice + 2.4 GHz Bluetooth | N/A | Yes | N/A | Yes | |
| 5 | UMTS + 2.4 GHz WI-FI | Yes | Yes | Yes | Yes | |
| 6 | UMTS + 2.4 GHz Bluetooth | N/A | Yes | N/A | Yes | |
| 7 | LTE + 2.4 GHz WI-FI | Yes* | Yes* | Yes | Yes | *-Pre-installed VOIP applications are considered. |
| 8 | LTE + 2.4 GHz Bluetooth | N/A | Yes* | N/A | Yes | *-Pre-installed VOIP applications are considered. |
| 9 | CDMA/EVDO data + 2.4 GHz WI-FI | Yes* | Yes* | Yes | Yes | *-Pre-installed VOIP applications are considered. |
| 10 | CDMA/EVDO data + 2.4 GHz Bluetooth | N/A | Yes* | N/A | Yes | *-Pre-installed VOIP applications are considered. |
| 11 | GPRS/EDGE + 2.4 GHz WI-FI | Yes* | Yes* | Yes | Yes | *-Pre-installed VOIP applications are considered. |
| 12 | GPRS/EDGE + 2.4 GHz Bluetooth | N/A | Yes* | N/A | Yes | *-Pre-installed VOIP applications are considered. |

1. 2.4 GHz WLAN, and 2.4 GHz Bluetooth share the same antenna path and cannot transmit simultaneously.
2. All licensed modes share the same antenna path and cannot transmit simultaneously.
3. When the user utilizes multiple services in UMTS 3G mode it uses multi-Radio Access Bearer or multi-RAB. The power control is based on a physical control channel (Dedicated Physical Control Channel [DPCCH]) and power control will be adjusted to meet the needs of both services. Therefore, the UMTS+WLAN scenario also represents the UMTS Voice/DATA + WLAN Hotspot scenario.
4. Per the manufacturer, WIFI Direct is expected to be used in conjunction with a held-to-ear or body-worn accessory voice call. Therefore, there are no simultaneous transmission scenarios involving WIFI direct beyond that listed in the above table.

## 1.6 Miscellaneous SAR Test Considerations

### (A) WIFI/BT

Per FCC KDB 447498 D01v06, the 1g SAR exclusion threshold for distances <50mm is defined by the following equation:

$$\frac{Max\ Power\ of\ Channel\ (mW)}{Test\ Separation\ Dist\ (mm)} * \sqrt{Frequency(GHz)} \leq 3.0$$

Based on the maximum conducted power of Bluetooth (rounded to the nearest mW) and the antenna to user separation distance, body-worn Bluetooth SAR was not required; [(7/10)* √2.480] = 1.1< 3.0. Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

Per FCC KDB 447498 D01v06, the 10g SAR exclusion threshold for distances <50mm is defined by the following equation:

$$\frac{Max\ Power\ of\ Channel\ (mW)}{Test\ Separation\ Dist\ (mm)} * \sqrt{Frequency(GHz)} \leq 7.5$$

Based on the maximum conducted power of Bluetooth (rounded to the nearest mW) and the antenna to user separation distance, phablet Bluetooth SAR was not required; [(7/5)* √2.480] = 2.2 < 7.5. Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

Per FCC KDB Publication 648474 D04v01r03, this device is considered a "phablet" since the diagonal dimension is greater than 160mm and less than 200mm. Phablet SAR tests are required when wireless router mode does not apply or if wireless router 1g SAR > 1.2 W/kg. Phablet SAR was not evaluated for 2.4 GHz operations since wireless router 1g SAR was < 1.2 W/kg.

### (B) Licensed Transmitter(s)

GSM/GPRS/EDGE DTM is not supported for US bands. Therefore, the GSM Voice modes in this report do not transmit simultaneously with GPRS/EDGE Data.

This device is only capable of QPSK HSUPA in the uplink. Therefore, no additional SAR tests are required beyond that described for devices with HSUPA in KDB 941225 D01v03r01.

LTE SAR for the higher modulations and lower bandwidths were not tested since the maximum average output power of all required channels and configurations was not more than 0.5 dB higher than the highest bandwidth; and the reported LTE SAR for the highest bandwidth was less than 1.45 W/kg for all configurations according to FCC KDB 941225 D05v02r04.

This device supports both LTE Band 17 and LTE Band 12. Since the supported frequency span for LTE Band 17 falls completely within the supported frequency span for LTE Band 12, LTE B17 has the same target power as LTE B12, and both LTE bands share the same transmission path, SAR was only assessed for LTE Band 12.

This device supports both LTE Band 2 and LTE Band 25. Since the supported frequency span for LTE Band 2 falls completely within the supported frequency span for LTE Band 25, LTE B2 has the same target power as LTE B25, and both LTE bands share the same transmission path, SAR was only assessed for LTE Band 25.

Per FCC KDB Publication 648474 D04v01r03, this device is considered a "phablet" since the diagonal dimension is greater than 160mm and less than 200mm. Therefore, phablet SAR tests are required when wireless router mode does not apply or if wireless router 1g SAR > 1.2 W/kg. Phablet SAR was not evaluated for licensed technologies since wireless router 1g SAR was < 1.2 W/kg for these modes.

## 1.7 Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 941225 D01v03r01, D05v02r04, D06v02r01 (2G/3G/4G and Hotspot)
- FCC KDB Publication 248227 D01v02r02 (SAR Considerations for 802.11 Devices)
- FCC KDB Publication 447498 D01v06 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)
- FCC KDB Publication 648474 D04v01r03 (Phablet Procedures)
- October 2013 TCB Workshop Notes (GPRS Testing Considerations)

## 1.8 Device Serial Numbers

Several samples with identical hardware were used to support SAR testing. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.

| | Head Serial Number | Body-Worn Serial Number | Hotspot Serial Number |
|---|---|---|---|
| Cell. CDMA/EVDO | 00483 | 00475 | 00475 |
| PCS CDMA/EVDO | 00483 | 00475 | 00475 |
| GSM/GPRS/EDGE 850 | 00483 | 00491 | 00491 |
| GSM/GPRS/EDGE 1900 | 00483 | 00475 | 00475 |
| UMTS 850 | 00483 | 00491 | 00491 |
| UMTS 1750 | 00491 | 00475 | 00475 |
| UMTS 1900 | 00483 | 00475 | 00475 |
| LTE Band 12 | 00483 | 00483 | 00483 |
| LTE Band 13 | 00483 | 00483 | 00483 |
| LTE Band 5 (Cell) | 00483 | 00475 | 00475 |
| LTE Band 4 (AWS) | 00491 | 00475 | 00475 |
| LTE Band 25 (PCS) | 00483 | 00475 | 00475 |
| 2.4 GHz WLAN | 00541 | 00541 | 00541 |

# 2 LTE INFORMATION

| LTE Information | | | |
|---|---|---|---|
| **FCC ID** | **ZNFUS610** | | |
| Form Factor | Portable Handset | | |
| Frequency Range of each LTE transmission band | LTE Band 12 (699.7 - 715.3 MHz) | | |
| | LTE Band 17 (706.5 - 713.5 MHz) | | |
| | LTE Band 13 (779.5 - 784.5 MHz) | | |
| | LTE Band 5 (Cell) (824.7 - 848.3 MHz) | | |
| | LTE Band 4 (AWS) (1710.7 - 1754.3 MHz) | | |
| | LTE Band 25 (PCS) (1850.7 - 1914.3 MHz) | | |
| | LTE Band 2 (PCS) (1850.7 - 1909.3 MHz) | | |
| Channel Bandwidths | LTE Band 12: 1.4 MHz, 3 MHz, 5 MHz, 10 MHz | | |
| | LTE Band 17: 5 MHz, 10 MHz | | |
| | LTE Band 13: 5 MHz, 10 MHz | | |
| | LTE Band 5 (Cell): 1.4 MHz, 3 MHz, 5 MHz, 10 MHz | | |
| | LTE Band 4 (AWS): 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz | | |
| | LTE Band 25 (PCS): 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz | | |
| | LTE Band 2 (PCS): 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz | | |
| Channel Numbers and Frequencies (MHz) | Low | Mid | High |
| LTE Band 12: 1.4 MHz | 699.7 (23017) | 707.5 (23095) | 715.3 (23173) |
| LTE Band 12: 3 MHz | 700.5 (23025) | 707.5 (23095) | 714.5 (23165) |
| LTE Band 12: 5 MHz | 701.5 (23035) | 707.5 (23095) | 713.5 (23155) |
| LTE Band 12: 10 MHz | 704 (23060) | 707.5 (23095) | 711 (23130) |
| LTE Band 17: 5 MHz | 706.5 (23755) | 710 (23790) | 713.5 (23825) |
| LTE Band 17: 10 MHz | 709 (23780) | 710 (23790) | 711 (23800) |
| LTE Band 13: 5 MHz | 779.5 (23205) | 782 (23230) | 784.5 (23255) |
| LTE Band 13: 10 MHz | N/A | 782 (23230) | N/A |
| LTE Band 5 (Cell): 1.4 MHz | 824.7 (20407) | 836.5 (20525) | 848.3 (20643) |
| LTE Band 5 (Cell): 3 MHz | 825.5 (20415) | 836.5 (20525) | 847.5 (20635) |
| LTE Band 5 (Cell): 5 MHz | 826.5 (20425) | 836.5 (20525) | 846.5 (20625) |
| LTE Band 5 (Cell): 10 MHz | 829 (20450) | 836.5 (20525) | 844 (20600) |
| LTE Band 4 (AWS): 1.4 MHz | 1710.7 (19957) | 1732.5 (20175) | 1754.3 (20393) |
| LTE Band 4 (AWS): 3 MHz | 1711.5 (19965) | 1732.5 (20175) | 1753.5 (20385) |
| LTE Band 4 (AWS): 5 MHz | 1712.5 (19975) | 1732.5 (20175) | 1752.5 (20375) |
| LTE Band 4 (AWS): 10 MHz | 1715 (20000) | 1732.5 (20175) | 1750 (20350) |
| LTE Band 4 (AWS): 15 MHz | 1717.5 (20025) | 1732.5 (20175) | 1747.5 (20325) |
| LTE Band 4 (AWS): 20 MHz | 1720 (20050) | 1732.5 (20175) | 1745 (20300) |
| LTE Band 25 (PCS): 1.4 MHz | 1850.7 (26047) | 1882.5 (26365) | 1914.3 (26683) |
| LTE Band 25 (PCS): 3 MHz | 1851.5 (26055) | 1882.5 (26365) | 1913.5 (26675) |
| LTE Band 25 (PCS): 5 MHz | 1852.5 (26065) | 1882.5 (26365) | 1912.5 (26665) |
| LTE Band 25 (PCS): 10 MHz | 1855 (26090) | 1882.5 (26365) | 1910 (26640) |
| LTE Band 25 (PCS): 15 MHz | 1857.5 (26115) | 1882.5 (26365) | 1907.5 (26615) |
| LTE Band 25 (PCS): 20 MHz | 1860 (26140) | 1882.5 (26365) | 1905 (26590) |
| LTE Band 2 (PCS): 1.4 MHz | 1850.7 (18607) | 1880 (18900) | 1909.3 (19193) |
| LTE Band 2 (PCS): 3 MHz | 1851.5 (18615) | 1880 (18900) | 1908.5 (19185) |
| LTE Band 2 (PCS): 5 MHz | 1852.5 (18625) | 1880 (18900) | 1907.5 (19175) |
| LTE Band 2 (PCS): 10 MHz | 1855 (18650) | 1880 (18900) | 1905 (19150) |
| LTE Band 2 (PCS): 15 MHz | 1857.5 (18675) | 1880 (18900) | 1902.5 (19125) |
| LTE Band 2 (PCS): 20 MHz | 1860 (18700) | 1880 (18900) | 1900 (19100) |
| UE Category | 4 | | |
| Modulations Supported in UL | QPSK, 16QAM | | |
| LTE MPR Permanently implemented per 3GPP TS 36.101 section 6.2.3~6.2.5? (manufacturer attestation to be provided) | YES | | |
| A-MPR (Additional MPR) disabled for SAR Testing? | YES | | |
| LTE Release 10 Additional Information | This device does not support full CA features on 3GPP Release 10. The following LTE Release 10 Features are not supported: LTE CA, Relay, HetNet, Enhanced MIMO, eICIC, WIFI Offloading, MDH, eMBMS, Cross-Carrier Scheduling, Enhanced SC-FDMA. | | |

# 3 INTRODUCTION

The FCC and Innovation, Science, and Economic Development Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices. [1]

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [3] and Health Canada RF Exposure Guidelines Safety Code 6 [22]. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave [4] is used for guidance in measuring the Specific Absorption Rate (SAR) due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the International Committee for Non-Ionizing Radiation Protection (ICNIRP) in Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," Report No. Vol 74. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

## 3.1 SAR Definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density ($\rho$). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Equation 3-1).

**Equation 3-1**
**SAR Mathematical Equation**

$$SAR = \frac{d}{dt}\left(\frac{dU}{dm}\right) = \frac{d}{dt}\left(\frac{dU}{\rho dv}\right)$$

**SAR is expressed in units of Watts per Kilogram (W/kg).**

$$SAR = \frac{\sigma \cdot E^2}{\rho}$$

where:

$\sigma$ = conductivity of the tissue-simulating material (S/m)
$\rho$ = mass density of the tissue-simulating material (kg/m$^3$)
E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relation to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.[6]

# 4 DOSIMETRIC ASSESSMENT

## 4.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

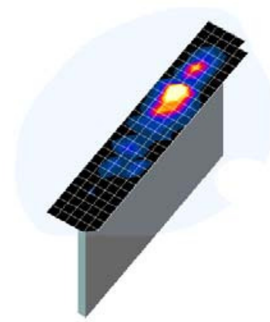


**Figure 4-1**
**Sample SAR Area Scan**

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 4-1) and IEEE 1528-2013.
2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.
3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 4-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):
   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 4-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).
   b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the "Not a knot" condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.
   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

**Table 4-1**
**Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04***

| Frequency | Maximum Area Scan Resolution (mm) ($\Delta x_{area}$, $\Delta y_{area}$) | Maximum Zoom Scan Resolution (mm) ($\Delta x_{zoom}$, $\Delta y_{zoom}$) | Maximum Zoom Scan Spatial Resolution (mm) | | | Minimum Zoom Scan Volume (mm) (x,y,z) |
|---|---|---|---|---|---|---|
| | | | Uniform Grid | Graded Grid | | |
| | | | $\Delta z_{zoom}(n)$ | $\Delta z_{zoom}(1)$* | $\Delta z_{zoom}(n>1)$* | |
| ≤ 2 GHz | ≤ 15 | ≤ 8 | ≤ 5 | ≤ 4 | ≤ 1.5*$\Delta z_{zoom}(n-1)$ | ≥ 30 |
| 2-3 GHz | ≤ 12 | ≤ 5 | ≤ 5 | ≤ 4 | ≤ 1.5*$\Delta z_{zoom}(n-1)$ | ≥ 30 |
| 3-4 GHz | ≤ 12 | ≤ 5 | ≤ 4 | ≤ 3 | ≤ 1.5*$\Delta z_{zoom}(n-1)$ | ≥ 28 |
| 4-5 GHz | ≤ 10 | ≤ 4 | ≤ 3 | ≤ 2.5 | ≤ 1.5*$\Delta z_{zoom}(n-1)$ | ≥ 25 |
| 5-6 GHz | ≤ 10 | ≤ 4 | ≤ 2 | ≤ 2 | ≤ 1.5*$\Delta z_{zoom}(n-1)$ | ≥ 22 |

*Also compliant to IEEE 1528-2013 Table 6

# 5 DEFINITION OF REFERENCE POINTS

## 5.1 EAR REFERENCE POINT

Figure 5-2 shows the front, back and side views of the SAM Twin Phantom. The point "M" is the reference point for the center of the mouth, "LE" is the left ear reference point (ERP), and "RE" is the right ERP. The ERP is 15mm posterior to the entrance to the ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 5-1. The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front), also called the Reference Pivoting Line, is not perpendicular to the reference plane (see Figure 5-1). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5].

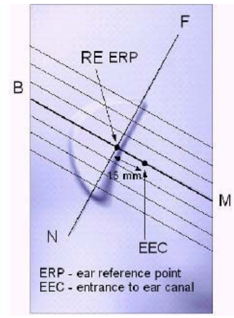



**Figure 5-1**
**Close-Up Side view of ERP**

## 5.2 HANDSET REFERENCE POINTS

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the acoustic output located along the "vertical centerline" on the front of the device aligned to the "ear reference point" (See Figure 5-3). The acoustic output was than located at the same level as the center of the ear reference point. The test device was positioned so that the "vertical centerline" was bisecting the front surface of the handset at its top and bottom edges, positioning the "ear reference point" on the outer surface of the both the left and right head phantoms on the ear reference point.

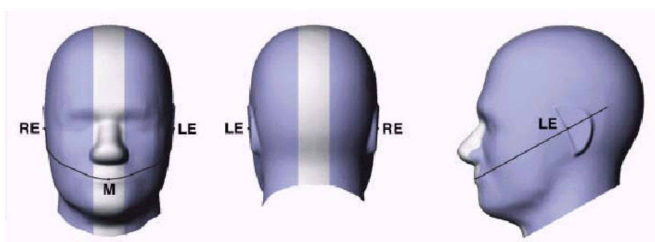



**Figure 5-2**
**Front, back and side view of SAM Twin Phantom**

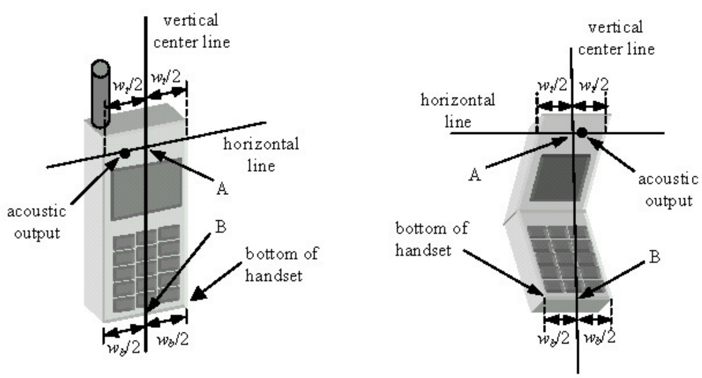



**Figure 5-3**
**Handset Vertical Center & Horizontal Line Reference Points**

# 6 TEST CONFIGURATION POSITIONS

## 6.1 Device Holder

The device holder is made out of low-loss POM material having the following dielectric parameters: relative permittivity ε = 3 and loss tangent δ = 0.02.

## 6.2 Positioning for Cheek

1. The test device was positioned with the device close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 6-1), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

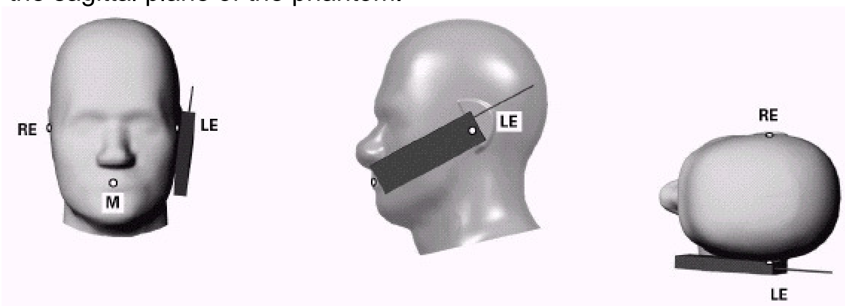



**Figure 6-1 Front, Side and Top View of Cheek Position**

2. The handset was translated towards the phantom along the line passing through RE & LE until the handset touches the pinna.
3. While maintaining the handset in this plane, the handset was rotated around the LE-RE line until the vertical centerline was in the reference plane.
4. The phone was then rotated around the vertical centerline until the phone (horizontal line) was symmetrical was respect to the line NF.
5. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the device contact with the ear, the device was rotated about the NF line until any point on the handset made contact with a phantom point below the ear (cheek) (See Figure 6-2).

## 6.3 Positioning for Ear / 15º Tilt

With the test device aligned in the "Cheek Position":

1. While maintaining the orientation of the phone, the phone was retracted parallel to the reference plane far enough to enable a rotation of the phone by 15degrees.
2. The phone was then rotated around the horizontal line by 15 degrees.
3. While maintaining the orientation of the phone, the phone was moved parallel to the reference plane until any part of the handset touched the head. (In this position, point A was located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact was at any location other than the pinna, the angle of the phone would then be reduced. In this situation, the tilted position was obtained when any part of the phone was in contact of the ear as well as a second part of the phone was in contact with the head (see Figure 6-2).

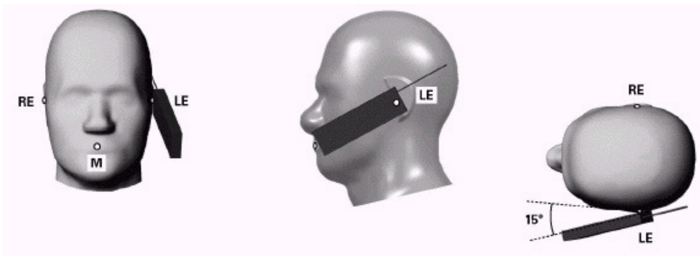



**Figure 6-2 Front, Side and Top View of Ear/15º Tilt Position**

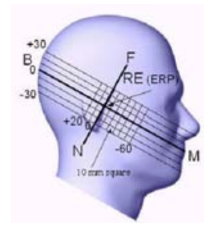



**Figure 6-3**
**Side view w/ relevant markings**

## 6.4 SAR Evaluations near the Mouth/Jaw Regions of the SAM Phantom

Antennas located near the bottom of a phone may require SAR measurements around the mouth and jaw regions of the SAM head phantom. This typically applies to clam-shell style phones that are generally longer in the unfolded normal use positions or to certain older style long rectangular phones. Per IEEE 1528-2013, a rotated SAM phantom is necessary to allow probe access to such regions. Both SAM heads of the TwinSAM-Chin20 are rotated 20 degrees around the NF line. Each head can be removed from the table for emptying and cleaning.

Under these circumstances, the following procedures apply, adopted from the FCC guidance on SAR handsets document FCC KDB Publication 648474 D04v01r03. The SAR required in these regions of SAM should be measured using a flat phantom. The phone should be positioned with a separation distance of 4 mm between the ear reference point (ERP) and the outer surface of the flat phantom shell. While maintaining this distance at the ERP location, the low (bottom) edge of the phone should be lowered from the phantom to establish the same separation distance between the peak SAR location identified by the truncated partial SAR distribution measured with the SAM phantom. The distance from the peak SAR location to the phone is determined by the straight line passing perpendicularly through the phantom surface. When it is not feasible to maintain 4 mm separation at the ERP while also establishing the required separation at the peak SAR location, the top edge of the phone will be allowed to touch the phantom with a separation < 4 mm at the ERP. The phone should not be tilted to the left or right while placed in this inclined position to the flat phantom.

## 6.5 Body-Worn Accessory Configurations

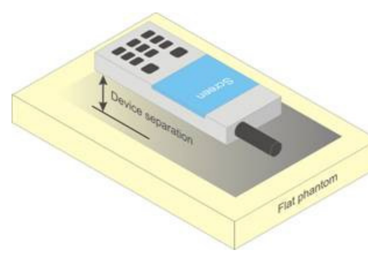



**Figure 6-4**
**Sample Body-Worn Diagram**

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 6-4). Per FCC KDB Publication 648474 D04v01r03, Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in FCC KDB Publication 447498 D01v06 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are tested with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration with a separation distance between the back of the device and the flat phantom is used. Test position spacing was documented.
Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom in head fluid. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessories, including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

## 6.6 Extremity Exposure Configurations

Devices that are designed or intended for use on extremities or mainly operated in extremity only exposure conditions; i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity SAR Exclusion Thresholds found in KDB Publication 447498 D01v06 should be applied to determine SAR test requirements.

Per KDB Publication 447498 D01v06, Cell phones (handsets) are not normally designed to be used on extremities or operated in extremity only exposure conditions. The maximum output power levels of handsets generally do not require extremity SAR testing to show compliance. Therefore, extremity SAR was not evaluated for this device.

## 6.7 Wireless Router Configurations

Some battery-operated handsets have the capability to transmit and receive user data through simultaneous transmission of WIFI simultaneously with a separate licensed transmitter. The FCC has provided guidance in FCC KDB Publication 941225 D06v02r01 where SAR test considerations for handsets (L x W ≥ 9 cm x 5 cm) are based on a composite test separation distance of 10 mm from the front, back and edges of the device containing transmitting antennas within 2.5 cm of their edges, determined from general mixed use conditions for this type of devices. Since the hotspot SAR results may overlap with the body-worn accessory SAR requirements, the more conservative configurations can be considered, thus excluding some body-worn accessory SAR tests.

When the user enables the personal wireless router functions for the handset, actual operations include simultaneous transmission of both the WIFI transmitter and another licensed transmitter. Both transmitters often do not transmit at the same transmitting frequency and thus cannot be evaluated for SAR under actual use conditions due to the limitations of the SAR assessment probes. Therefore, SAR must be evaluated for each frequency transmission and mode separately and spatially summed with the WIFI transmitter according to FCC KDB Publication 447498 D01v06 procedures. The "Portable Hotspot" feature on the handset was NOT activated during SAR assessments, to ensure the SAR measurements were evaluated for a single transmission frequency RF signal at a time.

## 6.8 Phablet Configurations

For smart phones with a display diagonal dimension > 150 mm or an overall diagonal dimension > 160 mm that provide similar mobile web access and multimedia support found in mini-tablets or UMPC mini-tablets that support voice calls next to the ear, the phablets procedures outlined in KDB Publication 648474 D04v01r03 should be applied to evaluate SAR compliance. A device marketed as phablets, regardless of form factors and operating characteristics must be tested as a phablet to determine SAR compliance. In addition to the normally required head and body-worn accessory SAR test procedures required for handsets, the UMPC mini-tablet procedures must also be applied to test the SAR of all surfaces and edges with an antenna <=25 mm from that surface or edge, in direct contact with the phantom, for 10-g SAR. The UMPC mini-tablet 1-g SAR at 5 mm is not required. When hotspot mode applies, 10-g SAR is required only for the surfaces and edges with hotspot mode 1-g SAR > 1.2 W/kg.

# 7 RF EXPOSURE LIMITS

## 7.1 Uncontrolled Environment

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

## 7.2 Controlled Environment

CONTROLLED ENVIRONMENTS are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Table 7-1**
**SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6**

| HUMAN EXPOSURE LIMITS | | |
|---|---|---|
| | UNCONTROLLED ENVIRONMENT *General Population* (W/kg) or (mW/g) | CONTROLLED ENVIRONMENT *Occupational* (W/kg) or (mW/g) |
| **Peak Spatial Average SAR** Head | 1.6 | 8.0 |
| **Whole Body SAR** | 0.08 | 0.4 |
| **Peak Spatial Average SAR** Hands, Feet, Ankle, Wrists, etc. | 4.0 | 20 |

1. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

# 8 FCC MEASUREMENT PROCEDURES

Power measurements for licensed transmitters are performed using a base station simulator under digital average power.

## 8.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, when SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as *reported* SAR. The highest *reported* SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

## 8.2 3G SAR Test Reduction Procedure

In FCC KDB Publication 941225 D01v03r01, certain transmission modes within a frequency band and wireless mode evaluated for SAR are defined as primary modes. The equivalent modes considered for SAR test reduction are denoted as secondary modes. When the maximum output power including tune-up tolerance specified for production units in a secondary mode is ≤ 0.25 dB higher than the primary mode or when the highest reported SAR of the primary mode, scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode, is ≤ 1.2 W/kg, SAR measurements are not required for the secondary mode. These criteria are referred to as the 3G SAR test reduction procedure. When the 3G SAR test reduction procedure is not satisfied, SAR measurements are additionally required for the secondary mode.

## 8.3 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01v03r01 “3G SAR Measurement Procedures.”

The device is placed into a simulated call using a base station simulator in a RF shielded chamber. Establishing connections in this manner ensure a consistent means for testing SAR and are recommended for evaluating SAR [4]. Devices under test are evaluated prior to testing, with a fully charged battery and were configured to operate at maximum output power. In order to verify that the device is tested throughout the SAR test at maximum output power, the SAR measurement system measures a “point SAR” at an arbitrary reference point at the start and end of the 1 gram SAR evaluation, to assess for any power drifts during the evaluation. If the power drift deviates by more than 5%, the SAR test and drift measurements are repeated.

## 8.4 SAR Measurement Conditions for CDMA2000

The following procedures were performed according to FCC KDB Publication 941225 D01v03r01 “3G SAR Measurement Procedures.”

### 8.4.1 Output Power Verification

See 3GPP2 C.S0011/TIA-98-E as recommended by FCC KDB Publication 941225 D01v03r01 “3G SAR Measurement Procedures.” Maximum output power is verified on the High, Middle and Low channels according to procedures in section 4.4.5.2 of 3GPP2 C.S0011/TIA-98-E. SO55 tests were measured with power control bits in the “All Up” condition.

1. If the mobile station (MS) supports Reverse TCH RC 1 and Forward TCH RC 1, set up a call using Fundamental Channel Test Mode 1 (RC=1/1) with 9600 bps data rate only.
2. Under RC1, C.S0011 Table 4.4.5.2-1, Table 8-1 parameters were applied.
3. If the MS supports the RC 3 Reverse FCH, RC3 Reverse $SCH_0$ and demodulation of RC 3,4, or 5, set up a call using Supplemental Channel Test Mode 3 (RC 3/3) with 9600 bps Fundamental Channel and 9600 bps SCH0 data rate.
4. Under RC3, C.S0011 Table 4.4.5.2-2, Table 8-2 was applied.

**Table 8-1**
**Parameters for Max. Power for RC1**

| Parameter | Units | Value |
|---|---|---|
| $\hat{I}_{or}$ | dBm/1.23 MHz | -104 |
| $\frac{\text{Pilot } E_c}{I_{or}}$ | dB | -7 |
| $\frac{\text{Traffic } E_c}{I_{or}}$ | dB | -7.4 |

**Table 8-2**
**Parameters for Max. Power for RC3**

| Parameter | Units | Value |
|---|---|---|
| $\hat{I}_{or}$ | dBm/1.23 MHz | -86 |
| $\frac{\text{Pilot } E_c}{I_{or}}$ | dB | -7 |
| $\frac{\text{Traffic } E_c}{I_{or}}$ | dB | -7.4 |

5. FCHs were configured at full rate for maximum SAR with “All Up” power control bits.

### 8.4.2 Head SAR Measurements

SAR for next to the ear head exposure is measured in RC3 with the handset configured to transmit at fullrate in SO55. The 3G SAR test reduction procedure is applied to RC1 with RC3 as the primary mode; otherwise, SAR is required for the channel with maximum measured output in RC1 using the head exposure configuration that results in the highest reported SAR in RC3.

Head SAR is additionally evaluated using EVDO Rev. A to support compliance for VoIP operations. See Section 8.4.5 for EVDO Rev. A configuration parameters.

### 8.4.3 Body-worn SAR Measurements

SAR for body-worn exposure configurations is measured in RC3 with the DUT configured to transmit at full rate on FCH with all other code channels disabled using TDSO / SO32. The 3G SAR test reduction procedure is applied to the multiple code channel configuration (FCH+SCHn), with FCH only as the primary mode. Otherwise, SAR is required for multiple code channel configuration (FCH + SCHn), with FCH at full rate and SCH0 enabled at 9600 bps, using the highest reported SAR configuration for FCH only. When multiple code channels are enabled, the transmitter output can shift by more than 0.5 dB and may lead to higher SAR drifts and SCH dropouts.

The 3G SAR test reduction procedure is applied to body-worn accessory SAR in RC1 with RC3 as the primary mode. Otherwise, SAR is required for RC1, with SO55 and full rate, using the highest reported SAR configuration for body-worn accessory exposure in RC3.

### 8.4.4 Body-worn SAR Measurements for EVDO Devices

For handsets with Ev-Do capabilities, the 3G SAR test reduction procedure is applied to Ev-Do Rev. 0 with 1x RTT RC3 as the primary mode to determine body-worn accessory test requirements. Otherwise, body-worn accessory SAR is required for Rev. 0, at 153.6 kbps, using the highest reported SAR configuration for body-worn accessory exposure in RC3.

The 3G SAR test reduction procedure is applied to Rev. A, with Rev. 0 as the primary mode to determine body-worn accessory SAR test requirements. When SAR is not required for Rev. 0, the 3G SAR test reduction is applied with 1x RTT RC3 as the primary mode.

When SAR is required for EVDO Rev. A, SAR is measured with a Reverse Data Channel payload size of 4096 bits and a Termination Target of 16 slots defined for Subtype 2 Physical Layer configurations, using the highest reported SAR configuration for body-worn accessory exposure in Rev. 0 or 1x RTT RC3, as appropriate.

#### 8.4.5 Body SAR Measurements for EVDO Hotspot

Hotspot Body SAR is measured using Subtype 0/1 Physical Layer configurations for Rev. 0. The 3G SAR test reduction procedure is applied to Rev. A, Subtype 2 Physical layer configuration, with Rev. 0 as the primary mode; otherwise, SAR is measured for Rev. A using the highest reported SAR configuration for body-worn accessory exposure in Rev. 0. The AT is tested with a Reverse Data Channel rate of 153.6 kbps in Subtype 0/1 Physical Layer configurations; and a Reverse Data Channel payload size of 4096 bits and Termination Target of 16 slots in Subtype 2 Physical Layer configurations.

For Ev-Do data devices that also support 1x RTT voice and/or data operations, the 3G SAR test reduction procedure is applied to 1x RTT RC3 and RC1 with Ev-Do Rev. 0 and Rev. A as the respective primary modes. Otherwise, the 'Body-Worn Accessory SAR' procedures in the '3GPP2 CDMA 2000 1x Handsets' section are applied.

### 8.5 SAR Measurement Conditions for UMTS

#### 8.5.1 Output Power Verification

Maximum output power is verified on the High, Middle and Low channels according to the general descriptions in section 5.2 of 3GPP TS 34.121, using the appropriate RMC with TPC (transmit power control) set to all "1s" or applying the required inner loop power control procedures to maintain maximum output power while HSUPA is active. Results for all applicable physical channel configurations (DPCCH, DPDCHn and spreading codes, HS-DPCCH etc) are tabulated in this test report. All configurations that are not supported by the DUT or cannot be measured due to technical or equipment limitations are identified.

#### 8.5.2 Head SAR Measurements

SAR for next to the ear head exposure is measured using a 12.2 kbps RMC with TPC bits configured to all "1's". The 3G SAR test reduction procedure is applied to AMR configurations with 12.2 kbps RMC as the primary mode. Otherwise, SAR is measured for 12.2 kbps AMR in 3.4 kbps SRB (signaling radio bearer) using the highest reported SAR configuration in 12.2 kbps RMC for head exposure.

#### 8.5.3 Body SAR Measurements

SAR for body exposure configurations is measured using the 12.2 kbps RMC with the TPC bits all "1s". The 3G SAR test reduction procedure is applied to other spreading codes and multiple $DPDCH_n$ configurations supported by the handset with 12.2 kbps RMC as the primary mode. Otherwise, SAR is measured using an applicable RMC configuration with the corresponding spreading code or $DPDCH_n$, for the highest reported SAR configuration in 12.2 kbps RMC.

#### 8.5.4 SAR Measurements with Rel 5 HSDPA

The 3G SAR test reduction procedure is applied to HSDPA body configurations with 12.2 kbps RMC as the primary mode. Otherwise, Body SAR for HSDPA is measured using an FRC with H-Set 1 in Sub-test 1 and a 12.2 kbps RMC configured in Test Loop Mode 1, for the highest reported SAR configuration in

12.2 kbps RMC without HSDPA. Handsets with both HSDPA and HSUPA are tested according to Release 6 HSPA test procedures.

### 8.5.5 SAR Measurements with Rel 6 HSUPA

The 3G SAR test reduction procedure is applied to HSPA (HSUPA/HSDPA with RMC) body configurations with 12.2 kbps RMC as the primary mode. Otherwise, Body SAR for HSPA is measured with E-DCH Sub-test 5, using H-Set 1 and QPSK for FRC and a 12.2 kbps RMC configured in Test Loop Mode 1 and power control algorithm 2, according to the highest reported body SAR configuration in 12.2 kbps RMC without HSPA.

When VOIP applies to head exposure, the 3G SAR test reduction procedure is applied with 12.2 kbps RMC as the primary mode; otherwise, the same HSPA configuration used for body SAR measurements are applied to head exposure testing.

## 8.6 SAR Measurement Conditions for LTE

LTE modes are tested according to FCC KDB 941225 D05v02r04 publication. Establishing connections with base station simulators ensure a consistent means for testing SAR and are recommended for evaluating SAR [4]. The R&S CMW500 or Anritsu MT8820C simulators are used for LTE output power measurements and SAR testing. Closed loop power control was used so the UE transmits with maximum output power during SAR testing. SAR tests were performed with the same number of RB and RB offsets transmitting on all TTI frames (maximum TTI).

### 8.6.1 Spectrum Plots for RB Configurations

A properly configured base station simulator was used for SAR tests and power measurements. Therefore, spectrum plots for RB configurations were not required to be included in this report.

### 8.6.2 MPR

MPR is permanently implemented for this device by the manufacturer. The specific manufacturer target MPR is indicated alongside the SAR results. MPR is enabled for this device, according to 3GPP TS36.101 Section 6.2.3 – 6.2.5 under Table 6.2.3-1.

### 8.6.3 A-MPR

A-MPR (Additional MPR) has been disabled for all SAR tests by setting NS=01 on the base station simulator.

### 8.6.4 Required RB Size and RB Offsets for SAR Testing

According to FCC KDB 941225 D05v02r04:

a. Per Section 5.2.1, SAR is required for QPSK 1 RB Allocation for the largest bandwidth
   i. The required channel and offset combination with the highest maximum output power is required for SAR.
   ii. When the reported SAR is ≤ 0.8 W/kg, testing of the remaining RB offset configurations and required test channels is not required. Otherwise, SAR is required for the remaining required test channels using the RB offset configuration with highest output power for that channel.
   iii. When the reported SAR for a required test channel is > 1.45 W/kg, SAR is required for all RB offset configurations for that channel.

b. Per Section 5.2.2, SAR is required for 50% RB allocation using the largest bandwidth following the same procedures outlined in Section 5.2.1.
c. Per Section 5.2.3, QPSK SAR is not required for the 100% allocation when the highest maximum output power for the 100% allocation is less than the highest maximum output power of the 1 RB and 50% RB allocations and the reported SAR for the 1 RB and 50% RB allocations is < 0.8 W/kg.
d. Per Section 5.2.4 and 5.3, SAR tests for higher order modulations and lower bandwidths configurations are not required when the conducted power of the required test configurations determined by Sections 5.2.1 through 5.2.3 is less than or equal to ½ dB higher than the equivalent configuration using QPSK modulation and when the QPSK SAR for those configurations is <1.45 W/kg.

## 8.7 SAR Testing with 802.11 Transmitters

The normal network operating configurations of 802.11 transmitters are not suitable for SAR measurements. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227 D01v02r02 for more details.

### 8.7.1 General Device Setup

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters.

A periodic duty factor is required for current generation SAR systems to measure SAR. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

### 8.7.2 Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all positions in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.

### 8.7.3 2.4 GHz SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either the fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.

2) When the reported SAR is > 0.8 W/kg, SAR is required for that position using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power, is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

### 8.7.4 OFDM Transmission Mode and SAR Test Channel Selection

When the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11g then 802.11n, is used for SAR measurement. When the maximum output power are the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

### 8.7.5 Initial Test Configuration Procedure

For OFDM, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order IEEE 802.11 mode. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required. Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured. When there are multiple untested channels having the same subsequent highest average RF output power, the channel with higher frequency from the lowest 802.11 mode is considered for SAR measurements (See Section 8.7.4).

### 8.7.6 Subsequent Test Configuration Procedures

For OFDM configurations in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure. When the highest reported SAR (for the initial test configuration), adjusted by the ratio of the specified maximum output power of the subsequent test configuration to initial test configuration, is ≤ 1.2 W/kg, no additional SAR tests for the subsequent test configurations are required.

# 9 RF CONDUCTED POWERS

## 9.1 CDMA Conducted Powers

| Band | Channel | Frequency | SO55 [dBm] | SO55 [dBm] | TDSO SO32 [dBm] | TDSO SO32 [dBm] | 1x EvDO Rev. 0 [dBm] | 1x EvDO Rev. A [dBm] |
|---|---|---|---|---|---|---|---|---|
| | F-RC | MHz | RC1 | RC3 | FCH+SCH | FCH | (RTAP) | (RETAP) |
| Cellular | 1013 | 824.7 | 24.42 | 24.43 | 24.42 | 24.41 | 24.43 | 24.45 |
| | 384 | 836.52 | 24.41 | 24.42 | 24.42 | 24.42 | 24.39 | 24.43 |
| | 777 | 848.31 | 24.35 | 24.31 | 24.45 | 24.43 | 24.41 | 24.40 |
| PCS | 25 | 1851.25 | 24.65 | 24.62 | 24.62 | 24.60 | 24.67 | 24.57 |
| | 600 | 1880 | 24.68 | 24.65 | 24.65 | 24.65 | 24.53 | 24.53 |
| | 1175 | 1908.75 | 24.66 | 24.65 | 24.63 | 24.60 | 24.55 | 24.55 |

Note: RC1 is only applicable for IS-95 compatibility.

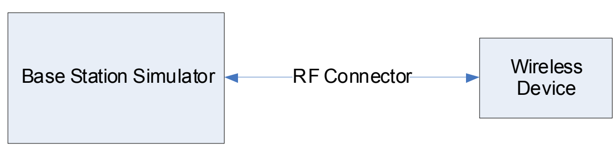



**Figure 9-1**
**Power Measurement Setup**

## 9.2 GSM Conducted Powers

| Maximum Burst-Averaged Output Power | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS/EDGE Data (GMSK)* | | *EDGE Data (8-PSK)* | |
| **Band** | **Channel** | **GSM [dBm] CS (1 Slot)** | **GPRS [dBm] 1 Tx Slot** | **GPRS [dBm] 2 Tx Slot** | **EDGE [dBm] 1 Tx Slot** | **EDGE [dBm] 2 Tx Slot** |
| **GSM 850** | 128 | 33.12 | 33.15 | **31.65** | 27.62 | 26.62 |
| | 190 | 33.13 | 33.11 | **31.69** | 27.70 | 26.58 |
| | 251 | 33.16 | 33.13 | **31.62** | 27.68 | 26.60 |
| **GSM 1900** | 512 | 29.57 | 29.61 | **28.48** | 26.64 | 25.63 |
| | 661 | 29.64 | 29.62 | **28.55** | 26.58 | 25.62 |
| | 810 | 29.63 | 29.61 | **28.57** | 26.62 | 25.59 |

| Calculated Maximum Frame-Averaged Output Power | | | | | | |
|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS/EDGE Data (GMSK)* | | *EDGE Data (8-PSK)* | |
| **Band** | **Channel** | **GSM [dBm] CS (1 Slot)** | **GPRS [dBm] 1 Tx Slot** | **GPRS [dBm] 2 Tx Slot** | **EDGE [dBm] 1 Tx Slot** | **EDGE [dBm] 2 Tx Slot** |
| **GSM 850** | 128 | 24.09 | 24.12 | **25.63** | 18.59 | 20.60 |
| | 190 | 24.10 | 24.08 | **25.67** | 18.67 | 20.56 |
| | 251 | 24.13 | 24.10 | **25.60** | 18.65 | 20.58 |
| **GSM 1900** | 512 | 20.54 | 20.58 | **22.46** | 17.61 | 19.61 |
| | 661 | 20.61 | 20.59 | **22.53** | 17.55 | 19.60 |
| | 810 | 20.60 | 20.58 | **22.55** | 17.59 | 19.57 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **GSM 850** | **Frame Avg.Targets:** | 23.67 | 23.67 | **25.18** | 18.17 | 20.18 |
| **GSM 1900** | | 20.17 | 20.17 | **22.18** | 17.17 | 19.18 |

Note:

1. Both burst-averaged and calculated frame-averaged powers are included. Frame-averaged power was calculated from the measured burst-averaged power by converting the slot powers into linear units and calculating the energy over 8 timeslots.
2. GPRS/EDGE (GMSK) output powers were measured with coding scheme setting of 1 (CS1) on the base station simulator. CS1 was configured to measure GPRS output power measurements and SAR to ensure GMSK modulation in the signal. Our Investigation has shown that CS1 - CS4 settings do not have any impact on the output levels or modulation in the GPRS modes.
3. EDGE (8-PSK) output powers were measured with MCS7 on the base station simulator. MCS7 coding scheme was used to measure the output powers for EDGE since investigation has shown that choosing MCS7 coding scheme will ensure 8-PSK modulation. It has been shown that MCS levels that produce 8PSK modulation do not have an impact on output power.

**GSM Class:** B
**GPRS Multislot class:** 10 (Max 2 Tx uplink slots)
**EDGE Multislot class:** 10 (Max 2 Tx uplink slots)
**DTM Multislot Class:** N/A

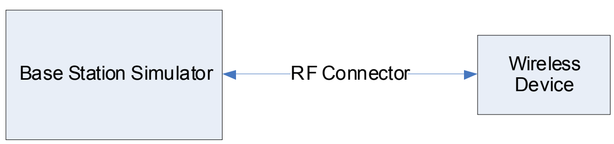



**Figure 9-2**
**Power Measurement Setup**

## 9.3 UMTS Conducted Powers

| 3GPP Release Version | Mode | 3GPP 34.121 Subtest | Cellular Band [dBm] | | | AWS Band [dBm] | | | PCS Band [dBm] | | | 3GPP MPR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4132 | 4183 | 4233 | 1312 | 1412 | 1513 | 9262 | 9400 | 9538 | |
| 99 | WCDMA | 12.2 kbps RMC | 24.58 | 24.59 | 24.43 | 23.18 | 23.20 | 23.00 | 23.08 | 23.10 | 23.10 | - |
| 99 | | 12.2 kbps AMR | 24.54 | 24.51 | 24.37 | 23.16 | 23.03 | 23.18 | 23.00 | 23.01 | 23.03 | - |
| 6 | HSDPA | Subtest 1 | 24.60 | 24.64 | 24.60 | 23.01 | 23.07 | 23.00 | 23.15 | 23.16 | 23.20 | 0 |
| 6 | | Subtest 2 | 24.59 | 24.61 | 24.58 | 22.99 | 23.02 | 22.98 | 23.12 | 23.15 | 23.10 | 0 |
| 6 | | Subtest 3 | 24.14 | 24.19 | 24.16 | 22.38 | 22.45 | 22.41 | 22.60 | 22.50 | 22.55 | 0.5 |
| 6 | | Subtest 4 | 24.13 | 24.14 | 24.19 | 22.40 | 22.42 | 22.39 | 22.57 | 22.61 | 22.57 | 0.5 |
| 6 | HSUPA | Subtest 1 | 24.21 | 24.34 | 24.31 | 22.90 | 22.79 | 22.71 | 23.00 | 23.03 | 22.90 | 0 |
| 6 | | Subtest 2 | 22.59 | 22.58 | 22.63 | 21.24 | 21.25 | 21.13 | 21.61 | 21.68 | 21.54 | 2 |
| 6 | | Subtest 3 | 23.30 | 23.40 | 23.37 | 21.80 | 21.84 | 21.70 | 22.20 | 22.18 | 21.84 | 1 |
| 6 | | Subtest 4 | 22.69 | 22.70 | 22.68 | 21.30 | 21.44 | 21.33 | 21.59 | 21.66 | 21.50 | 2 |
| 6 | | Subtest 5 | 24.34 | 24.44 | 24.39 | 22.80 | 22.90 | 23.00 | 22.57 | 23.02 | 22.85 | 0 |

This device does not support DC-HSDPA.

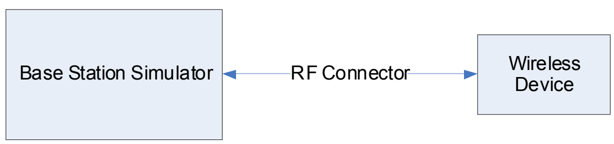



**Figure 9-3**
**Power Measurement Setup**

## 9.4 LTE Conducted Powers

### 9.4.1 LTE Band 12

**Table 9-1**
**LTE Band 12 Conducted Powers - 10 MHz Bandwidth**

| LTE Band 12 10 MHz Bandwidth | | | | | |
|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Mid Channel 23095 (707.5 MHz) Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | **24.59** | 0 | 0 |
| | 1 | 25 | 24.55 | | 0 |
| | 1 | 49 | 24.58 | | 0 |
| | 25 | 0 | 23.49 | 0-1 | 1 |
| | 25 | 12 | **23.51** | | 1 |
| | 25 | 25 | 23.41 | | 1 |
| | 50 | 0 | 23.39 | | 1 |
| 16QAM | 1 | 0 | 23.18 | 0-1 | 1 |
| | 1 | 25 | 23.34 | | 1 |
| | 1 | 49 | 23.33 | | 1 |
| | 25 | 0 | 22.05 | 0-2 | 2 |
| | 25 | 12 | 22.14 | | 2 |
| | 25 | 25 | 21.96 | | 2 |
| | 50 | 0 | 22.12 | | 2 |

Note: LTE Band 12 at 10 MHz bandwidth does not support three non-overlapping channels. Per KDB Publication 941225 D05v02, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

## Table 9-2
## LTE Band 12 Conducted Powers - 5 MHz Bandwidth

| LTE Band 12 5 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 23035 (701.5 MHz) Conducted Power [dBm] | Mid Channel 23095 (707.5 MHz) Conducted Power [dBm] | High Channel 23155 (713.5 MHz) Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | 24.55 | 24.55 | 24.56 | 0 | 0 |
| | 1 | 12 | 24.56 | 24.57 | 24.56 | | 0 |
| | 1 | 24 | 24.62 | 24.57 | 24.65 | | 0 |
| | 12 | 0 | 23.30 | 23.48 | 23.50 | 0-1 | 1 |
| | 12 | 6 | 23.34 | 23.38 | 23.44 | | 1 |
| | 12 | 13 | 23.30 | 23.50 | 23.34 | | 1 |
| | 25 | 0 | 23.27 | 23.55 | 23.41 | | 1 |
| 16QAM | 1 | 0 | 23.09 | 23.07 | 23.43 | 0-1 | 1 |
| | 1 | 12 | 23.07 | 23.18 | 23.32 | | 1 |
| | 1 | 24 | 23.05 | 23.11 | 23.10 | | 1 |
| | 12 | 0 | 21.76 | 22.18 | 22.20 | 0-2 | 2 |
| | 12 | 6 | 21.73 | 22.08 | 22.05 | | 2 |
| | 12 | 13 | 21.93 | 22.22 | 21.98 | | 2 |
| | 25 | 0 | 21.84 | 22.21 | 22.15 | | 2 |

## Table 9-3
## LTE Band 12 Conducted Powers - 3 MHz Bandwidth

| LTE Band 12 3 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 23025 (700.5 MHz) | Mid Channel 23095 (707.5 MHz) | High Channel 23165 (714.5 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.70 | 24.61 | 24.69 | 0 | 0 |
| | 1 | 7 | 24.66 | 24.67 | 24.70 | | 0 |
| | 1 | 14 | 24.57 | 24.66 | 24.62 | | 0 |
| | 8 | 0 | 23.39 | 23.44 | 23.46 | 0-1 | 1 |
| | 8 | 4 | 23.23 | 23.37 | 23.31 | | 1 |
| | 8 | 7 | 23.30 | 23.40 | 23.36 | | 1 |
| | 15 | 0 | 23.39 | 23.39 | 23.36 | | 1 |
| 16QAM | 1 | 0 | 23.39 | 23.37 | 23.01 | 0-1 | 1 |
| | 1 | 7 | 23.02 | 23.41 | 23.18 | | 1 |
| | 1 | 14 | 22.99 | 23.35 | 23.03 | | 1 |
| | 8 | 0 | 21.79 | 22.35 | 21.91 | 0-2 | 2 |
| | 8 | 4 | 21.72 | 21.92 | 21.87 | | 2 |
| | 8 | 7 | 21.79 | 22.04 | 21.84 | | 2 |
| | 15 | 0 | 21.98 | 21.82 | 21.86 | | 2 |

## Table 9-4
## LTE Band 12 Conducted Powers -1.4 MHz Bandwidth

| LTE Band 12 1.4 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 23017 (699.7 MHz) | 23095 (707.5 MHz) | 23173 (715.3 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.57 | 24.56 | 24.55 | 0 | 0 |
| | 1 | 2 | 24.56 | 24.55 | 24.58 | | 0 |
| | 1 | 5 | 24.67 | 24.62 | 24.63 | | 0 |
| | 3 | 0 | 24.65 | 24.62 | 24.36 | | 0 |
| | 3 | 2 | 24.70 | 24.65 | 24.70 | | 0 |
| | 3 | 3 | 24.56 | 24.60 | 24.66 | | 0 |
| | 6 | 0 | 23.32 | 23.47 | 23.20 | 0-1 | 1 |
| 16QAM | 1 | 0 | 23.21 | 22.73 | 23.62 | 0-1 | 1 |
| | 1 | 2 | 23.45 | 23.03 | 23.44 | | 1 |
| | 1 | 5 | 23.46 | 23.10 | 23.49 | | 1 |
| | 3 | 0 | 23.04 | 23.16 | 23.23 | | 1 |
| | 3 | 2 | 23.09 | 23.28 | 23.08 | | 1 |
| | 3 | 3 | 23.15 | 23.33 | 23.22 | | 1 |
| | 6 | 0 | 22.11 | 22.19 | 21.92 | 0-2 | 2 |

### 9.4.2 LTE Band 13

**Table 9-5**
**LTE Band 13 Conducted Powers - 10 MHz Bandwidth**

| LTE Band 13<br>10 MHzBandwidth | | | | | |
|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Mid Channel<br>23230<br>(782.0 MHz)<br>Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | 24.57 | 0 | 0 |
| | 1 | 25 | 24.65 | | 0 |
| | 1 | 49 | **24.70** | | 0 |
| | 25 | 0 | 23.34 | 0-1 | 1 |
| | 25 | 12 | 23.24 | | 1 |
| | 25 | 25 | **23.36** | | 1 |
| | 50 | 0 | 23.29 | | 1 |
| 16QAM | 1 | 0 | 22.92 | 0-1 | 1 |
| | 1 | 25 | 23.05 | | 1 |
| | 1 | 49 | 22.98 | | 1 |
| | 25 | 0 | 22.03 | 0-2 | 2 |
| | 25 | 12 | 21.98 | | 2 |
| | 25 | 25 | 22.10 | | 2 |
| | 50 | 0 | 21.86 | | 2 |

**Table 9-6**
**LTE Band 13 Conducted Powers - 5 MHz Bandwidth**

| LTE Band 13 5 MHzBandwidth | | | | | |
|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Mid Channel 23230 (782.0 MHz) Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | 24.55 | 0 | 0 |
| | 1 | 12 | 24.58 | | 0 |
| | 1 | 24 | 24.62 | | 0 |
| | 12 | 0 | 23.24 | 0-1 | 1 |
| | 12 | 6 | 23.30 | | 1 |
| | 12 | 13 | 23.26 | | 1 |
| | 25 | 0 | 23.26 | | 1 |
| 16QAM | 1 | 0 | 22.84 | 0-1 | 1 |
| | 1 | 12 | 23.02 | | 1 |
| | 1 | 24 | 22.80 | | 1 |
| | 12 | 0 | 21.76 | 0-2 | 2 |
| | 12 | 6 | 21.89 | | 2 |
| | 12 | 13 | 22.15 | | 2 |
| | 25 | 0 | 22.07 | | 2 |

Note: LTE Band 13 at 5 MHz bandwidth does not support three non-overlapping channels. Per KDB Publication 941225 D05v02, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

### 9.4.3 LTE Band 5 (Cell)

**Table 9-7**
**LTE Band 5 (Cell) Conducted Powers - 10 MHz Bandwidth**

| LTE Band 5 (Cell) 10 MHz Bandwidth | | | | | |
|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Mid Channel 20525 (836.5 MHz) Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | 24.66 | 0 | 0 |
| | 1 | 25 | **24.70** | | 0 |
| | 1 | 49 | 24.68 | | 0 |
| | 25 | 0 | 23.40 | 0-1 | 1 |
| | 25 | 12 | **23.41** | | 1 |
| | 25 | 25 | 23.38 | | 1 |
| | 50 | 0 | 23.40 | | 1 |
| 16QAM | 1 | 0 | 23.12 | 0-1 | 1 |
| | 1 | 25 | 23.10 | | 1 |
| | 1 | 49 | 23.23 | | 1 |
| | 25 | 0 | 22.14 | 0-2 | 2 |
| | 25 | 12 | 22.15 | | 2 |
| | 25 | 25 | 22.11 | | 2 |
| | 50 | 0 | 22.12 | | 2 |

Note: LTE Band 5 (Cell) at 10 MHz bandwidth does not support three non-overlapping channels. Per KDB Publication 941225 D05v02, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

**Table 9-8**
**LTE Band 5 (Cell) Conducted Powers - 5 MHz Bandwidth**

| LTE Band 5 (Cell) 5 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 20425 (826.5 MHz) | Mid Channel 20525 (836.5 MHz) | High Channel 20625 (846.5 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.57 | 24.56 | 24.56 | 0 | 0 |
| | 1 | 12 | 24.70 | 24.69 | 24.67 | | 0 |
| | 1 | 24 | 24.65 | 24.55 | 24.56 | | 0 |
| | 12 | 0 | 23.53 | 23.49 | 23.57 | 0-1 | 1 |
| | 12 | 6 | 23.47 | 23.34 | 23.45 | | 1 |
| | 12 | 13 | 23.48 | 23.33 | 23.37 | | 1 |
| | 25 | 0 | 23.46 | 23.28 | 23.53 | | 1 |
| 16QAM | 1 | 0 | 23.24 | 23.04 | 23.20 | 0-1 | 1 |
| | 1 | 12 | 23.26 | 22.81 | 23.33 | | 1 |
| | 1 | 24 | 23.26 | 23.02 | 23.28 | | 1 |
| | 12 | 0 | 22.24 | 22.04 | 22.25 | 0-2 | 2 |
| | 12 | 6 | 22.19 | 21.98 | 22.23 | | 2 |
| | 12 | 13 | 22.22 | 21.98 | 22.03 | | 2 |
| | 25 | 0 | 22.12 | 22.03 | 22.23 | | 2 |

## Table 9-9
## LTE Band 5 (Cell) Conducted Powers - 3 MHz Bandwidth

| LTE Band 5 (Cell) 3 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 20415 (825.5 MHz) | 20525 (836.5 MHz) | 20635 (847.5 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.68 | 24.70 | 24.70 | 0 | 0 |
| | 1 | 7 | 24.63 | 24.67 | 24.68 | | 0 |
| | 1 | 14 | 24.69 | 24.68 | 24.55 | | 0 |
| | 8 | 0 | 23.57 | 23.36 | 23.55 | 0-1 | 1 |
| | 8 | 4 | 23.42 | 23.37 | 23.41 | | 1 |
| | 8 | 7 | 23.44 | 23.36 | 23.43 | | 1 |
| | 15 | 0 | 23.45 | 23.32 | 23.55 | | 1 |
| 16QAM | 1 | 0 | 23.19 | 23.30 | 23.47 | 0-1 | 1 |
| | 1 | 7 | 23.22 | 23.22 | 23.05 | | 1 |
| | 1 | 14 | 23.16 | 23.20 | 22.89 | | 1 |
| | 8 | 0 | 22.26 | 22.24 | 22.20 | 0-2 | 2 |
| | 8 | 4 | 22.05 | 21.88 | 22.01 | | 2 |
| | 8 | 7 | 22.07 | 21.94 | 22.06 | | 2 |
| | 15 | 0 | 22.22 | 21.81 | 22.28 | | 2 |

## Table 9-10
## LTE Band 5 (Cell) Conducted Powers -1.4 MHz Bandwidth

| LTE Band 5 (Cell) 1.4 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 20407 (824.7 MHz) | 20525 (836.5 MHz) | 20643 (848.3 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.69 | 24.61 | 24.61 | 0 | 0 |
| | 1 | 2 | 24.66 | 24.62 | 24.63 | | 0 |
| | 1 | 5 | 24.57 | 24.66 | 24.55 | | 0 |
| | 3 | 0 | 24.68 | 24.61 | 24.64 | | 0 |
| | 3 | 2 | 24.70 | 24.63 | 24.63 | | 0 |
| | 3 | 3 | 24.70 | 24.57 | 24.60 | | 0 |
| | 6 | 0 | 23.46 | 23.34 | 23.40 | 0-1 | 1 |
| 16QAM | 1 | 0 | 23.70 | 22.75 | 23.70 | 0-1 | 1 |
| | 1 | 2 | 23.61 | 22.82 | 23.59 | | 1 |
| | 1 | 5 | 23.31 | 22.81 | 23.40 | | 1 |
| | 3 | 0 | 23.10 | 23.06 | 23.16 | | 1 |
| | 3 | 2 | 23.09 | 23.23 | 23.00 | | 1 |
| | 3 | 3 | 22.93 | 23.25 | 22.99 | | 1 |
| | 6 | 0 | 22.17 | 22.18 | 22.31 | 0-2 | 2 |

### 9.4.4 LTE Band 4 (AWS)

**Table 9-11**
**LTE Band 4 (AWS) Conducted Powers - 20 MHz Bandwidth**

| LTE Band 4 (AWS) 20 MHzBandwidth | | | | | |
|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Mid Channel 20175 (1732.5 MHz) Conducted Power [dBm] | MPR Allowed per 3GPP [dB] | MPR [dB] |
| QPSK | 1 | 0 | 24.05 | 0 | 0 |
| | 1 | 50 | 24.16 | | 0 |
| | 1 | 99 | **24.20** | | 0 |
| | 50 | 0 | 22.94 | 0-1 | 1 |
| | 50 | 25 | **22.95** | | 1 |
| | 50 | 50 | 22.93 | | 1 |
| | 100 | 0 | 22.89 | | 1 |
| 16QAM | 1 | 0 | 22.39 | 0-1 | 1 |
| | 1 | 50 | 22.55 | | 1 |
| | 1 | 99 | 23.04 | | 1 |
| | 50 | 0 | 21.63 | 0-2 | 2 |
| | 50 | 25 | 21.61 | | 2 |
| | 50 | 50 | 21.75 | | 2 |
| | 100 | 0 | 21.71 | | 2 |

Note: LTE Band 4 (AWS) at 20 MHz bandwidth does not support three non-overlapping channels. Per KDB Publication 941225 D05v02, when a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing.

## Table 9-12
## LTE Band 4 (AWS) Conducted Powers - 15 MHz Bandwidth

| LTE Band 4 (AWS) 15 MHzBandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 20025 (1717.5 MHz) | 20175 (1732.5 MHz) | 20325 (1747.5 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.12 | 24.20 | 24.20 | 0 | 0 |
| | 1 | 36 | 24.09 | 24.08 | 24.17 | | 0 |
| | 1 | 74 | 24.07 | 24.19 | 24.07 | | 0 |
| | 36 | 0 | 22.90 | 22.93 | 23.03 | 0-1 | 1 |
| | 36 | 18 | 22.82 | 22.93 | 22.79 | | 1 |
| | 36 | 37 | 22.84 | 22.79 | 22.83 | | 1 |
| | 75 | 0 | 22.80 | 22.76 | 22.80 | | 1 |
| 16QAM | 1 | 0 | 22.66 | 22.67 | 22.62 | 0-1 | 1 |
| | 1 | 36 | 22.66 | 22.52 | 22.49 | | 1 |
| | 1 | 74 | 22.72 | 22.77 | 22.73 | | 1 |
| | 36 | 0 | 21.52 | 21.52 | 21.69 | 0-2 | 2 |
| | 36 | 18 | 21.57 | 21.54 | 21.56 | | 2 |
| | 36 | 37 | 21.29 | 21.62 | 21.61 | | 2 |
| | 75 | 0 | 21.48 | 21.67 | 21.64 | | 2 |

## Table 9-13
## LTE Band 4 (AWS) Conducted Powers - 10 MHz Bandwidth

| LTE Band 4 (AWS) 10 MHzBandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 20000 (1715.0 MHz) | 20175 (1732.5 MHz) | 20350 (1750.0 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.09 | 24.05 | 24.18 | 0 | 0 |
| | 1 | 25 | 24.10 | 24.18 | 24.18 | | 0 |
| | 1 | 49 | 24.05 | 24.09 | 24.09 | | 0 |
| | 25 | 0 | 22.95 | 22.98 | 22.81 | 0-1 | 1 |
| | 25 | 12 | 22.86 | 22.97 | 22.80 | | 1 |
| | 25 | 25 | 22.73 | 22.93 | 22.86 | | 1 |
| | 50 | 0 | 22.88 | 23.00 | 22.78 | | 1 |
| 16QAM | 1 | 0 | 22.81 | 22.60 | 22.58 | 0-1 | 1 |
| | 1 | 25 | 22.98 | 22.62 | 22.54 | | 1 |
| | 1 | 49 | 22.75 | 22.55 | 22.67 | | 1 |
| | 25 | 0 | 21.78 | 21.75 | 21.53 | 0-2 | 2 |
| | 25 | 12 | 21.61 | 21.74 | 21.54 | | 2 |
| | 25 | 25 | 21.57 | 21.68 | 21.55 | | 2 |
| | 50 | 0 | 21.48 | 21.59 | 21.52 | | 2 |

## Table 9-14
## LTE Band 4 (AWS) Conducted Powers - 5 MHz Bandwidth

| LTE Band 4 (AWS) 5 MHzBandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 19975 (1712.5 MHz) | 20175 (1732.5 MHz) | 20375 (1752.5 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.11 | 24.13 | 24.12 | 0 | 0 |
| | 1 | 12 | 24.08 | 24.05 | 24.16 | | 0 |
| | 1 | 24 | 24.08 | 24.07 | 24.10 | | 0 |
| | 12 | 0 | 22.79 | 22.88 | 22.86 | 0-1 | 1 |
| | 12 | 6 | 22.86 | 23.02 | 22.82 | | 1 |
| | 12 | 13 | 22.81 | 22.85 | 22.97 | | 1 |
| | 25 | 0 | 22.91 | 22.85 | 22.86 | | 1 |
| 16QAM | 1 | 0 | 22.39 | 22.47 | 22.36 | 0-1 | 1 |
| | 1 | 12 | 22.47 | 22.71 | 22.25 | | 1 |
| | 1 | 24 | 22.44 | 22.81 | 23.20 | | 1 |
| | 12 | 0 | 21.38 | 21.39 | 21.70 | 0-2 | 2 |
| | 12 | 6 | 21.41 | 21.52 | 21.63 | | 2 |
| | 12 | 13 | 21.36 | 21.57 | 21.66 | | 2 |
| | 25 | 0 | 21.41 | 21.63 | 21.58 | | 2 |

## Table 9-15
## LTE Band 4 (AWS) Conducted Powers - 3 MHz Bandwidth

| LTE Band 4 (AWS) 3 MHzBandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 19965 (1711.5 MHz) | 20175 (1732.5 MHz) | 20385 (1753.5 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.16 | 24.20 | 24.13 | 0 | 0 |
| | 1 | 7 | 24.07 | 24.18 | 24.15 | | 0 |
| | 1 | 14 | 24.15 | 24.09 | 24.16 | | 0 |
| | 8 | 0 | 22.78 | 22.98 | 23.01 | 0-1 | 1 |
| | 8 | 4 | 22.79 | 22.97 | 23.02 | | 1 |
| | 8 | 7 | 22.79 | 22.90 | 22.96 | | 1 |
| | 15 | 0 | 22.81 | 23.09 | 22.99 | | 1 |
| 16QAM | 1 | 0 | 22.53 | 22.66 | 22.36 | 0-1 | 1 |
| | 1 | 7 | 22.52 | 22.84 | 22.69 | | 1 |
| | 1 | 14 | 22.47 | 22.61 | 22.38 | | 1 |
| | 8 | 0 | 21.33 | 21.80 | 21.73 | 0-2 | 2 |
| | 8 | 4 | 21.25 | 21.51 | 21.66 | | 2 |
| | 8 | 7 | 21.25 | 21.41 | 21.61 | | 2 |
| | 15 | 0 | 21.52 | 21.34 | 21.69 | | 2 |

## Table 9-16
## LTE Band 4 (AWS) Conducted Powers -1.4 MHz Bandwidth

| LTE Band 4 (AWS) 1.4 MHzBandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 19957 (1710.7 MHz) | 20175 (1732.5 MHz) | 20393 (1754.3 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 24.14 | 24.11 | 24.16 | 0 | 0 |
| | 1 | 2 | 24.19 | 24.12 | 24.18 | | 0 |
| | 1 | 5 | 24.07 | 24.05 | 24.18 | | 0 |
| | 3 | 0 | 24.02 | 24.01 | 24.15 | | 0 |
| | 3 | 2 | 24.16 | 24.03 | 24.20 | | 0 |
| | 3 | 3 | 24.03 | 23.91 | 24.17 | | 0 |
| | 6 | 0 | 22.69 | 22.71 | 22.98 | 0-1 | 1 |
| 16QAM | 1 | 0 | 22.97 | 22.53 | 22.36 | 0-1 | 1 |
| | 1 | 2 | 23.15 | 22.60 | 22.36 | | 1 |
| | 1 | 5 | 23.11 | 22.79 | 22.67 | | 1 |
| | 3 | 0 | 22.66 | 22.57 | 22.73 | | 1 |
| | 3 | 2 | 22.68 | 22.58 | 22.81 | | 1 |
| | 3 | 3 | 22.37 | 22.47 | 22.91 | | 1 |
| | 6 | 0 | 21.48 | 21.79 | 21.87 | 0-2 | 2 |

## 9.4.5 LTE Band 25 (PCS)

### Table 9-17
### LTE Band 25 (PCS) Conducted Powers - 20 MHz Bandwidth

| LTE Band 25 (PCS) 20 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 26140 (1860.0 MHz) | 26365 (1882.5 MHz) | 26590 (1905.0 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.60 | 23.59 | 23.59 | 0 | 0 |
| | 1 | 50 | 23.66 | 23.62 | **23.70** | | 0 |
| | 1 | 99 | 23.58 | 23.58 | 23.59 | | 0 |
| | 50 | 0 | 22.33 | 22.37 | 22.23 | 0-1 | 1 |
| | 50 | 25 | 22.30 | **22.42** | 22.27 | | 1 |
| | 50 | 50 | 22.33 | 22.32 | 22.23 | | 1 |
| | 100 | 0 | 22.26 | 22.34 | 22.30 | | 1 |
| 16QAM | 1 | 0 | 22.15 | 22.32 | 22.58 | 0-1 | 1 |
| | 1 | 50 | 21.83 | 22.70 | 22.50 | | 1 |
| | 1 | 99 | 21.75 | 22.14 | 21.94 | | 1 |
| | 50 | 0 | 21.16 | 21.21 | 21.08 | 0-2 | 2 |
| | 50 | 25 | 21.01 | 21.17 | 21.11 | | 2 |
| | 50 | 50 | 21.06 | 21.07 | 20.93 | | 2 |
| | 100 | 0 | 20.98 | 21.00 | 21.08 | | 2 |

### Table 9-18
### LTE Band 25 (PCS) Conducted Powers - 15 MHz Bandwidth

| LTE Band 25 (PCS) 15 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel | Mid Channel | High Channel | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | 26115 (1857.5 MHz) | 26365 (1882.5 MHz) | 26615 (1907.5 MHz) | | |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.69 | 23.59 | 23.59 | 0 | 0 |
| | 1 | 36 | 23.66 | 23.57 | 23.57 | | 0 |
| | 1 | 74 | 23.63 | 23.55 | 23.55 | | 0 |
| | 36 | 0 | 22.39 | 22.29 | 22.35 | 0-1 | 1 |
| | 36 | 18 | 22.32 | 22.37 | 22.23 | | 1 |
| | 36 | 37 | 22.29 | 22.27 | 22.22 | | 1 |
| | 75 | 0 | 22.28 | 22.28 | 22.37 | | 1 |
| 16QAM | 1 | 0 | 22.00 | 22.34 | 21.98 | 0-1 | 1 |
| | 1 | 36 | 21.94 | 22.17 | 21.96 | | 1 |
| | 1 | 74 | 22.00 | 22.17 | 21.86 | | 1 |
| | 36 | 0 | 20.89 | 21.08 | 21.15 | 0-2 | 2 |
| | 36 | 18 | 20.86 | 21.07 | 21.05 | | 2 |
| | 36 | 37 | 20.82 | 20.98 | 20.99 | | 2 |
| | 75 | 0 | 20.98 | 21.10 | 21.05 | | 2 |

## Table 9-19
## LTE Band 25 (PCS) Conducted Powers - 10 MHz Bandwidth

| LTE Band 25 (PCS) 10 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 26090 (1855.0 MHz) | Mid Channel 26365 (1882.5 MHz) | High Channel 26640 (1910.0 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.63 | 23.68 | 23.62 | 0 | 0 |
| | 1 | 25 | 23.63 | 23.69 | 23.55 | | 0 |
| | 1 | 49 | 23.58 | 23.55 | 23.56 | | 0 |
| | 25 | 0 | 22.35 | 22.39 | 22.45 | 0-1 | 1 |
| | 25 | 12 | 22.31 | 22.41 | 22.31 | | 1 |
| | 25 | 25 | 22.38 | 22.31 | 22.26 | | 1 |
| | 50 | 0 | 22.33 | 22.39 | 22.35 | | 1 |
| 16QAM | 1 | 0 | 22.01 | 22.38 | 21.93 | 0-1 | 1 |
| | 1 | 25 | 22.11 | 22.50 | 21.82 | | 1 |
| | 1 | 49 | 21.98 | 22.27 | 21.73 | | 1 |
| | 25 | 0 | 20.91 | 21.00 | 21.17 | 0-2 | 2 |
| | 25 | 12 | 21.07 | 21.13 | 21.05 | | 2 |
| | 25 | 25 | 21.03 | 21.03 | 21.02 | | 2 |
| | 50 | 0 | 20.99 | 21.13 | 21.12 | | 2 |

## Table 9-20
## LTE Band 25 (PCS) Conducted Powers - 5 MHz Bandwidth

| LTE Band 25 (PCS) 5 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 26065 (1852.5 MHz) | Mid Channel 26365 (1882.5 MHz) | High Channel 26665 (1912.5 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.62 | 23.62 | 23.58 | 0 | 0 |
| | 1 | 12 | 23.58 | 23.60 | 23.57 | | 0 |
| | 1 | 24 | 23.58 | 23.57 | 23.53 | | 0 |
| | 12 | 0 | 22.25 | 22.20 | 22.20 | 0-1 | 1 |
| | 12 | 6 | 22.22 | 22.23 | 22.27 | | 1 |
| | 12 | 13 | 22.31 | 22.21 | 22.30 | | 1 |
| | 25 | 0 | 22.18 | 22.20 | 22.23 | | 1 |
| 16QAM | 1 | 0 | 21.75 | 21.91 | 21.91 | 0-1 | 1 |
| | 1 | 12 | 21.89 | 21.96 | 22.13 | | 1 |
| | 1 | 24 | 21.83 | 22.25 | 21.88 | | 1 |
| | 12 | 0 | 20.80 | 20.98 | 20.77 | 0-2 | 2 |
| | 12 | 6 | 20.87 | 21.00 | 20.76 | | 2 |
| | 12 | 13 | 20.97 | 20.95 | 20.90 | | 2 |
| | 25 | 0 | 20.86 | 21.12 | 20.96 | | 2 |

## Table 9-21
## LTE Band 25 (PCS) Conducted Powers - 3 MHz Bandwidth

| LTE Band 25 (PCS) 3 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 26055 (1851.5 MHz) | Mid Channel 26365 (1882.5 MHz) | High Channel 26675 (1913.5 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.65 | 23.69 | 23.61 | 0 | 0 |
| | 1 | 7 | 23.67 | 23.60 | 23.70 | | 0 |
| | 1 | 14 | 23.57 | 23.65 | 23.70 | | 0 |
| | 8 | 0 | 22.15 | 22.22 | 22.29 | 0-1 | 1 |
| | 8 | 4 | 22.18 | 22.20 | 22.41 | | 1 |
| | 8 | 7 | 22.22 | 22.21 | 22.37 | | 1 |
| | 15 | 0 | 22.21 | 22.21 | 22.29 | | 1 |
| 16QAM | 1 | 0 | 21.89 | 22.11 | 21.76 | 0-1 | 1 |
| | 1 | 7 | 22.12 | 22.05 | 21.83 | | 1 |
| | 1 | 14 | 21.93 | 21.99 | 21.73 | | 1 |
| | 8 | 0 | 20.88 | 21.20 | 20.80 | 0-2 | 2 |
| | 8 | 4 | 20.82 | 20.76 | 20.94 | | 2 |
| | 8 | 7 | 21.16 | 20.90 | 21.00 | | 2 |
| | 15 | 0 | 21.20 | 21.02 | 20.98 | | 2 |

## Table 9-22
## LTE Band 25 (PCS) Conducted Powers -1.4 MHz Bandwidth

| LTE Band 25 (PCS) 1.4 MHz Bandwidth | | | | | | | |
|---|---|---|---|---|---|---|---|
| Modulation | RB Size | RB Offset | Low Channel 26047 (1850.7 MHz) | Mid Channel 26365 (1882.5 MHz) | High Channel 26683 (1914.3 MHz) | MPR Allowed per 3GPP [dB] | MPR [dB] |
| | | | Conducted Power [dBm] | | | | |
| QPSK | 1 | 0 | 23.61 | 23.62 | 23.63 | 0 | 0 |
| | 1 | 2 | 23.59 | 23.60 | 23.57 | | 0 |
| | 1 | 5 | 23.57 | 23.56 | 23.60 | | 0 |
| | 3 | 0 | 23.38 | 23.57 | 23.60 | | 0 |
| | 3 | 2 | 23.54 | 23.59 | 23.56 | | 0 |
| | 3 | 3 | 23.42 | 23.45 | 23.48 | | 0 |
| | 6 | 0 | 22.09 | 22.25 | 22.33 | 0-1 | 1 |
| 16QAM | 1 | 0 | 22.68 | 21.77 | 22.00 | 0-1 | 1 |
| | 1 | 2 | 22.43 | 21.84 | 22.15 | | 1 |
| | 1 | 5 | 22.29 | 21.70 | 22.13 | | 1 |
| | 3 | 0 | 21.99 | 22.00 | 22.03 | | 1 |
| | 3 | 2 | 21.82 | 22.15 | 22.10 | | 1 |
| | 3 | 3 | 21.78 | 22.20 | 22.04 | | 1 |
| | 6 | 0 | 20.86 | 21.22 | 21.28 | 0-2 | 2 |

## 9.5 WLAN Conducted Powers

**Table 9-23**
**IEEE 802.11b/g/n Average RF Power**

| Freq [MHz] | Channel | 2.4GHz Conducted Power [dBm] | | |
|---|---|---|---|---|
| | | IEEE Transmission Mode | | |
| | | 802.11b | 802.11g | 802.11n |
| 2412 | 1 | **17.12** | 13.14 | 13.47 |
| 2437 | 6 | 16.95 | 16.03 | 16.29 |
| 2462 | 11 | 16.78 | 12.74 | 13.09 |

Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, due to an even number of channels, both channels were measured.
- The bolded data rate and channel above were tested for SAR.

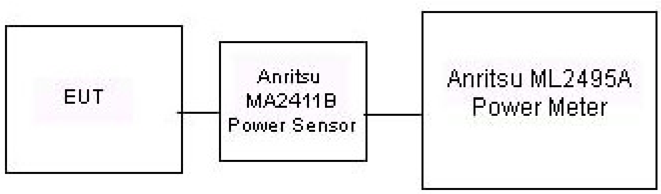



**Figure 9-4**
**Power Measurement Setup for Bandwidths < 50 MHz**

# 10 SYSTEM VERIFICATION

## 10.1 Tissue Verification

**Table 10-1**
**Measured Tissue Properties**

| Calibrated for Tests Performed on: | Tissue Type | Tissue Temp During Calibration (˚C) | Measured Frequency (MHz) | Measured Conductivity, σ (S/m) | Measured Dielectric Constant, ε | TARGET Conductivity, σ (S/m) | TARGET Dielectric Constant, ε | % dev σ | % dev ε |
|---|---|---|---|---|---|---|---|---|---|
| 5/17/2016 | 750H | 22.3 | 700 | 0.860 | 41.322 | 0.889 | 42.201 | -3.26% | -2.08% |
| | | | 710 | 0.870 | 41.181 | 0.890 | 42.149 | -2.25% | -2.30% |
| | | | 740 | 0.897 | 40.756 | 0.893 | 41.994 | 0.45% | -2.95% |
| | | | 755 | 0.911 | 40.525 | 0.894 | 41.916 | 1.90% | -3.32% |
| | | | 770 | 0.924 | 40.379 | 0.895 | 41.838 | 3.24% | -3.49% |
| | | | 785 | 0.940 | 40.109 | 0.896 | 41.760 | 4.91% | -3.95% |
| 5/16/2016 | 835H | 23.5 | 820 | 0.909 | 40.771 | 0.899 | 41.578 | 1.11% | -1.94% |
| | | | 835 | 0.924 | 40.569 | 0.900 | 41.500 | 2.67% | -2.24% |
| | | | 850 | 0.940 | 40.378 | 0.916 | 41.500 | 2.62% | -2.70% |
| 5/17/2016 | 1750H | 22.3 | 1710 | 1.337 | 39.587 | 1.348 | 40.142 | -0.82% | -1.38% |
| | | | 1750 | 1.374 | 39.385 | 1.371 | 40.079 | 0.22% | -1.73% |
| | | | 1790 | 1.421 | 39.201 | 1.394 | 40.016 | 1.94% | -2.04% |
| 5/16/2016 | 1900H | 21.3 | 1850 | 1.389 | 39.249 | 1.400 | 40.000 | -0.79% | -1.88% |
| | | | 1880 | 1.425 | 39.118 | 1.400 | 40.000 | 1.79% | -2.20% |
| | | | 1910 | 1.457 | 38.991 | 1.400 | 40.000 | 4.07% | -2.52% |
| 5/16/2016 | 2450H | 24.5 | 2400 | 1.816 | 39.800 | 1.756 | 39.289 | 3.42% | 1.30% |
| | | | 2450 | 1.875 | 39.613 | 1.800 | 39.200 | 4.17% | 1.05% |
| | | | 2500 | 1.939 | 39.425 | 1.855 | 39.136 | 4.53% | 0.74% |
| 5/17/2016 | 750B | 22.5 | 700 | 0.921 | 56.156 | 0.959 | 55.726 | -3.96% | 0.77% |
| | | | 710 | 0.931 | 56.018 | 0.960 | 55.687 | -3.02% | 0.59% |
| | | | 740 | 0.961 | 55.823 | 0.963 | 55.570 | -0.21% | 0.46% |
| | | | 755 | 0.974 | 55.585 | 0.964 | 55.512 | 1.04% | 0.13% |
| | | | 770 | 0.991 | 55.452 | 0.965 | 55.453 | 2.69% | 0.00% |
| | | | 785 | 1.005 | 55.328 | 0.966 | 55.395 | 4.04% | -0.12% |
| 5/17/2016 | 835B | 21.6 | 820 | 0.994 | 53.561 | 0.969 | 55.258 | 2.58% | -3.07% |
| | | | 835 | 1.010 | 53.394 | 0.970 | 55.200 | 4.12% | -3.27% |
| | | | 850 | 1.026 | 53.191 | 0.988 | 55.154 | 3.85% | -3.56% |
| 5/17/2016 | 1750B | 21.1 | 1710 | 1.454 | 53.285 | 1.463 | 53.537 | -0.62% | -0.47% |
| | | | 1750 | 1.502 | 53.094 | 1.488 | 53.432 | 0.94% | -0.63% |
| | | | 1790 | 1.543 | 52.934 | 1.514 | 53.326 | 1.92% | -0.74% |
| 5/16/2016 | 1900B | 22.4 | 1850 | 1.527 | 53.353 | 1.520 | 53.300 | 0.46% | 0.10% |
| | | | 1880 | 1.558 | 53.255 | 1.520 | 53.300 | 2.50% | -0.08% |
| | | | 1910 | 1.592 | 53.165 | 1.520 | 53.300 | 4.74% | -0.25% |
| 5/16/2016 | 2450B | 24.1 | 2400 | 1.887 | 51.929 | 1.902 | 52.767 | -0.79% | -1.59% |
| | | | 2450 | 1.947 | 51.717 | 1.950 | 52.700 | -0.15% | -1.87% |
| | | | 2500 | 2.021 | 51.537 | 2.021 | 52.636 | 0.00% | -2.09% |

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB Publication 865664 D01v01r04 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

## 10.2 Test System Verification

Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in Appendix E.

**Table 10-2**
**System Verification Results**

| System Verification TARGET & MEASURED | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAR System # | Tissue Frequency (MHz) | Tissue Type | Date: | Amb. Temp (°C) | Liquid Temp (°C) | Input Power (W) | Dipole SN | Probe SN | Measured $SAR_{1g}$ (W/kg) | 1 W Target $SAR_{1g}$ (W/kg) | 1 W Normalized $SAR_{1g}$ (W/kg) | $Deviation_{1g}$ (%) |
| C | 750 | HEAD | 05/17/2016 | 24.2 | 22.3 | 0.200 | 1003 | 3288 | 1.630 | 8.350 | 8.150 | -2.40% |
| A | 835 | HEAD | 05/16/2016 | 22.4 | 23.5 | 0.200 | 4d132 | 3332 | 2.010 | 9.470 | 10.050 | 6.12% |
| K | 1750 | HEAD | 05/17/2016 | 23.5 | 22.3 | 0.100 | 1148 | 3022 | 3.550 | 36.200 | 35.500 | -1.93% |
| K | 1900 | HEAD | 05/16/2016 | 22.2 | 21.3 | 0.100 | 5d149 | 3022 | 4.190 | 40.700 | 41.900 | 2.95% |
| C | 2450 | HEAD | 05/16/2016 | 23.5 | 23.5 | 0.100 | 797 | 3288 | 5.180 | 52.700 | 51.800 | -1.71% |
| G | 750 | BODY | 05/17/2016 | 21.2 | 22.5 | 0.200 | 1046 | 3334 | 1.750 | 8.770 | 8.750 | -0.23% |
| J | 835 | BODY | 05/17/2016 | 21.6 | 21.6 | 0.200 | 4d119 | 3318 | 1.950 | 9.140 | 9.750 | 6.67% |
| E | 1750 | BODY | 05/17/2016 | 22.3 | 21.1 | 0.100 | 1051 | 7406 | 3.830 | 36.500 | 38.300 | 4.93% |
| H | 1900 | BODY | 05/16/2016 | 23.5 | 22.4 | 0.100 | 5d149 | 3319 | 4.060 | 40.400 | 40.600 | 0.50% |
| G | 2450 | BODY | 05/16/2016 | 20.8 | 23.0 | 0.100 | 882 | 3334 | 5.130 | 49.400 | 51.300 | 3.85% |

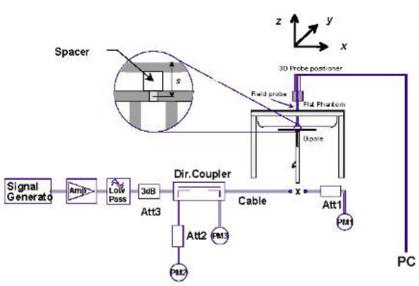



**Figure 10-1**
**System Verification Setup Diagram**

**Figure 10-2**
**System Verification Setup Photo**

## 11.1 Standalone Head SAR Data

**Table 11-1**
**Cell. CDMA Head SAR**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 24.7 | 24.42 | 0.09 | Right | Cheek | 00483 | 1:1 | 0.351 | 1.067 | 0.375 | A1 |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 24.7 | 24.42 | -0.05 | Right | Tilt | 00483 | 1:1 | 0.196 | 1.067 | 0.209 | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 24.7 | 24.42 | -0.04 | Left | Cheek | 00483 | 1:1 | 0.281 | 1.067 | 0.300 | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 24.7 | 24.42 | 0.06 | Left | Tilt | 00483 | 1:1 | 0.171 | 1.067 | 0.182 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. A | 24.7 | 24.43 | -0.13 | Right | Cheek | 00483 | 1:1 | 0.319 | 1.064 | 0.339 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. A | 24.7 | 24.43 | 0.01 | Right | Tilt | 00483 | 1:1 | 0.165 | 1.064 | 0.176 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. A | 24.7 | 24.43 | 0.06 | Left | Cheek | 00483 | 1:1 | 0.275 | 1.064 | 0.293 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. A | 24.7 | 24.43 | 0.01 | Left | Tilt | 00483 | 1:1 | 0.149 | 1.064 | 0.159 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

**Table 11-2**
**PCS CDMA Head SAR**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 24.7 | 24.65 | 0.02 | Right | Cheek | 00483 | 1:1 | 0.335 | 1.012 | 0.339 | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 24.7 | 24.65 | -0.01 | Right | Tilt | 00483 | 1:1 | 0.218 | 1.012 | 0.221 | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 24.7 | 24.65 | 0.12 | Left | Cheek | 00483 | 1:1 | 0.478 | 1.012 | 0.484 | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 24.7 | 24.65 | 0.15 | Left | Tilt | 00483 | 1:1 | 0.345 | 1.012 | 0.349 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. A | 24.7 | 24.53 | -0.10 | Right | Cheek | 00483 | 1:1 | 0.346 | 1.040 | 0.360 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. A | 24.7 | 24.53 | 0.08 | Right | Tilt | 00483 | 1:1 | 0.227 | 1.040 | 0.236 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. A | 24.7 | 24.53 | -0.11 | Left | Cheek | 00483 | 1:1 | 0.495 | 1.040 | 0.515 | A2 |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. A | 24.7 | 24.53 | -0.04 | Left | Tilt | 00483 | 1:1 | 0.339 | 1.040 | 0.353 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## Table 11-3
## GSM 850 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | # of Time Slots | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 33.13 | 0.03 | Right | Cheek | 00483 | 1 | 1:8.3 | 0.229 | 1.016 | 0.233 | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 33.13 | 0.15 | Right | Tilt | 00483 | 1 | 1:8.3 | 0.117 | 1.016 | 0.119 | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 33.13 | 0.03 | Left | Cheek | 00483 | 1 | 1:8.3 | 0.187 | 1.016 | 0.190 | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 33.13 | -0.01 | Left | Tilt | 00483 | 1 | 1:8.3 | 0.106 | 1.016 | 0.108 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | -0.06 | Right | Cheek | 00483 | 2 | 1:4.15 | 0.293 | 1.002 | 0.294 | A3 |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.08 | Right | Tilt | 00483 | 2 | 1:4.15 | 0.146 | 1.002 | 0.146 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.07 | Left | Cheek | 00483 | 2 | 1:4.15 | 0.249 | 1.002 | 0.249 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.02 | Left | Tilt | 00483 | 2 | 1:4.15 | 0.138 | 1.002 | 0.138 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | |

## Table 11-4
## GSM 1900 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | # of Time Slots | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.64 | 0.07 | Right | Cheek | 00483 | 1 | 1:8.3 | 0.158 | 1.014 | 0.160 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.64 | -0.07 | Right | Tilt | 00483 | 1 | 1:8.3 | 0.098 | 1.014 | 0.099 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.64 | 0.07 | Left | Cheek | 00483 | 1 | 1:8.3 | 0.217 | 1.014 | 0.220 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.64 | 0.11 | Left | Tilt | 00483 | 1 | 1:8.3 | 0.137 | 1.014 | 0.139 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.02 | Right | Cheek | 00483 | 2 | 1:4.15 | 0.294 | 1.035 | 0.304 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | 0.09 | Right | Tilt | 00483 | 2 | 1:4.15 | 0.169 | 1.035 | 0.175 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | 0.11 | Left | Cheek | 00483 | 2 | 1:4.15 | 0.378 | 1.035 | 0.391 | A4 |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | 0.08 | Left | Tilt | 00483 | 2 | 1:4.15 | 0.248 | 1.035 | 0.257 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | |

## Table 11-5
## UMTS 850 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.00 | Right | Cheek | 00483 | 1:1 | 0.332 | 1.026 | 0.341 | A5 |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.02 | Right | Tilt | 00483 | 1:1 | 0.181 | 1.026 | 0.186 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.04 | Left | Cheek | 00483 | 1:1 | 0.259 | 1.026 | 0.266 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.01 | Left | Tilt | 00483 | 1:1 | 0.158 | 1.026 | 0.162 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## Table 11-6
## UMTS 1750 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.07 | Right | Cheek | 00491 | 1:1 | 0.266 | 1.000 | 0.266 | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.04 | Right | Tilt | 00491 | 1:1 | 0.177 | 1.000 | 0.177 | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.03 | Left | Cheek | 00491 | 1:1 | 0.379 | 1.000 | 0.379 | A6 |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.14 | Left | Tilt | 00491 | 1:1 | 0.246 | 1.000 | 0.246 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## Table 11-7
## UMTS 1900 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | 0.00 | Right | Cheek | 00483 | 1:1 | 0.306 | 1.023 | 0.313 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | -0.12 | Right | Tilt | 00483 | 1:1 | 0.237 | 1.023 | 0.242 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | 0.07 | Left | Cheek | 00483 | 1:1 | 0.522 | 1.023 | 0.534 | A7 |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | 0.02 | Left | Tilt | 00483 | 1:1 | 0.324 | 1.023 | 0.331 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## Table 11-8
## LTE Band 12 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Side | Test Position | Modulation | RB Size | RB Offset | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.02 | 0 | Right | Cheek | QPSK | 1 | 0 | 00483 | 1:1 | 0.178 | 1.026 | 0.183 | A8 |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | 0.08 | 1 | Right | Cheek | QPSK | 25 | 12 | 00483 | 1:1 | 0.139 | 1.045 | 0.145 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.02 | 0 | Right | Tilt | QPSK | 1 | 0 | 00483 | 1:1 | 0.097 | 1.026 | 0.100 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.05 | 1 | Right | Tilt | QPSK | 25 | 12 | 00483 | 1:1 | 0.069 | 1.045 | 0.072 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.14 | 0 | Left | Cheek | QPSK | 1 | 0 | 00483 | 1:1 | 0.153 | 1.026 | 0.157 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | 0.06 | 1 | Left | Cheek | QPSK | 25 | 12 | 00483 | 1:1 | 0.118 | 1.045 | 0.123 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.05 | 0 | Left | Tilt | QPSK | 1 | 0 | 00483 | 1:1 | 0.086 | 1.026 | 0.088 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | 0.09 | 1 | Left | Tilt | QPSK | 25 | 12 | 00483 | 1:1 | 0.069 | 1.045 | 0.072 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-9
## LTE Band 13 Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Side | Test Position | Modulation | RB Size | RB Offset | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.02 | 0 | Right | Cheek | QPSK | 1 | 49 | 00483 | 1:1 | 0.299 | 1.000 | 0.299 | A9 |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.08 | 1 | Right | Cheek | QPSK | 25 | 25 | 00483 | 1:1 | 0.221 | 1.081 | 0.239 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.03 | 0 | Right | Tilt | QPSK | 1 | 49 | 00483 | 1:1 | 0.161 | 1.000 | 0.161 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.01 | 1 | Right | Tilt | QPSK | 25 | 25 | 00483 | 1:1 | 0.120 | 1.081 | 0.130 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | -0.15 | 0 | Left | Cheek | QPSK | 1 | 49 | 00483 | 1:1 | 0.241 | 1.000 | 0.241 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.03 | 1 | Left | Cheek | QPSK | 25 | 25 | 00483 | 1:1 | 0.167 | 1.081 | 0.181 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | -0.10 | 0 | Left | Tilt | QPSK | 1 | 49 | 00483 | 1:1 | 0.149 | 1.000 | 0.149 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.07 | 1 | Left | Tilt | QPSK | 25 | 25 | 00483 | 1:1 | 0.103 | 1.081 | 0.111 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-10
## LTE Band 5 (Cell) Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Side | Test Position | Modulation | RB Size | RB Offset | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | 0.03 | 0 | Right | Cheek | QPSK | 1 | 25 | 00483 | 1:1 | 0.332 | 1.000 | 0.332 | A10 |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.03 | 1 | Right | Cheek | QPSK | 25 | 12 | 00483 | 1:1 | 0.250 | 1.069 | 0.267 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.04 | 0 | Right | Tilt | QPSK | 1 | 25 | 00483 | 1:1 | 0.183 | 1.000 | 0.183 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.04 | 1 | Right | Tilt | QPSK | 25 | 12 | 00483 | 1:1 | 0.130 | 1.069 | 0.139 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.06 | 0 | Left | Cheek | QPSK | 1 | 25 | 00483 | 1:1 | 0.289 | 1.000 | 0.289 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | -0.01 | 1 | Left | Cheek | QPSK | 25 | 12 | 00483 | 1:1 | 0.209 | 1.069 | 0.223 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.03 | 0 | Left | Tilt | QPSK | 1 | 25 | 00483 | 1:1 | 0.161 | 1.000 | 0.161 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.10 | 1 | Left | Tilt | QPSK | 25 | 12 | 00483 | 1:1 | 0.118 | 1.069 | 0.126 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-11
## LTE Band 4 (AWS) Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Side | Test Position | Modulation | RB Size | RB Offset | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.13 | 0 | Right | Cheek | QPSK | 1 | 99 | 00491 | 1:1 | 0.342 | 1.000 | 0.342 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.05 | 1 | Right | Cheek | QPSK | 50 | 25 | 00491 | 1:1 | 0.286 | 1.059 | 0.303 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | -0.10 | 0 | Right | Tilt | QPSK | 1 | 99 | 00491 | 1:1 | 0.208 | 1.000 | 0.208 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | 0.03 | 1 | Right | Tilt | QPSK | 50 | 25 | 00491 | 1:1 | 0.185 | 1.059 | 0.196 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.15 | 0 | Left | Cheek | QPSK | 1 | 99 | 00491 | 1:1 | 0.429 | 1.000 | 0.429 | A11 |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | 0.06 | 1 | Left | Cheek | QPSK | 50 | 25 | 00491 | 1:1 | 0.401 | 1.059 | 0.425 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.02 | 0 | Left | Tilt | QPSK | 1 | 99 | 00491 | 1:1 | 0.313 | 1.000 | 0.313 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.02 | 1 | Left | Tilt | QPSK | 50 | 25 | 00491 | 1:1 | 0.264 | 1.059 | 0.280 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-12
## LTE Band 25 (PCS) Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Side | Test Position | Modulation | RB Size | RB Offset | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | 0.00 | 0 | Right | Cheek | QPSK | 1 | 50 | 00483 | 1:1 | 0.387 | 1.000 | 0.387 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | -0.02 | 1 | Right | Cheek | QPSK | 50 | 25 | 00483 | 1:1 | 0.351 | 1.067 | 0.375 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | -0.08 | 0 | Right | Tilt | QPSK | 1 | 50 | 00483 | 1:1 | 0.254 | 1.000 | 0.254 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | 0.05 | 1 | Right | Tilt | QPSK | 50 | 25 | 00483 | 1:1 | 0.214 | 1.067 | 0.228 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | 0.11 | 0 | Left | Cheek | QPSK | 1 | 50 | 00483 | 1:1 | 0.597 | 1.000 | 0.597 | A12 |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | 0.09 | 1 | Left | Cheek | QPSK | 50 | 25 | 00483 | 1:1 | 0.535 | 1.067 | 0.571 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | 0.03 | 0 | Left | Tilt | QPSK | 1 | 50 | 00483 | 1:1 | 0.430 | 1.000 | 0.430 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | 0.04 | 1 | Left | Tilt | QPSK | 50 | 25 | 00483 | 1:1 | 0.378 | 1.067 | 0.403 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | |

## Table 11-13
## DTS Head SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Data Rate (Mbps) | Duty Cycle (%) | Peak SAR of Area Scan | SAR (1g) | Scaling Factor (Power) | Scaling Factor (Duty Cycle) | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | W/kg | (W/kg) | | | (W/kg) | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | 0.00 | Right | Cheek | 00541 | 1 | 99.5 | 0.503 | - | 1.091 | 1.005 | - | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.02 | Right | Tilt | 00541 | 1 | 99.5 | 0.338 | - | 1.091 | 1.005 | - | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.10 | Left | Cheek | 00541 | 1 | 99.5 | 1.177 | 0.905 | 1.091 | 1.005 | 0.992 | |
| 2437 | 6 | 802.11b | DSSS | 22 | 17.5 | 16.95 | -0.02 | Left | Cheek | 00541 | 1 | 99.5 | 1.022 | 0.781 | 1.135 | 1.005 | 0.891 | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.04 | Left | Tilt | 00541 | 1 | 99.5 | 0.695 | 0.597 | 1.091 | 1.005 | 0.655 | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.10 | Left | Cheek | 00541 | 1 | 99.5 | 1.210 | 0.921 | 1.091 | 1.005 | 1.010 | A13 |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

**Blue Entry Represents Variability Measurement**

## 11.2 Standalone Body-Worn SAR Data

### Table 11-14
### CDMA/GSM/GPRS/UMTS Body-Worn SAR Data

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | # of Time Slots | Duty Cycle | Side | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.52 | 384 | Cell. CDMA | TDSO / SO32 | 24.7 | 24.42 | 0.01 | 10 mm | 00475 | N/A | 1:1 | back | 0.391 | 1.067 | 0.417 | A14 |
| 1880.00 | 600 | PCS CDMA | TDSO / SO32 | 24.7 | 24.65 | -0.06 | 10 mm | 00475 | N/A | 1:1 | back | 0.685 | 1.012 | 0.693 | A16 |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 33.13 | 0.00 | 10 mm | 00491 | 1 | 1:8.3 | back | 0.231 | 1.016 | 0.235 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | -0.06 | 10 mm | 00491 | 2 | 1:4.15 | back | 0.314 | 1.002 | 0.315 | A18 |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.64 | -0.01 | 10 mm | 00475 | 1 | 1:8.3 | back | 0.251 | 1.014 | 0.255 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.01 | 10 mm | 00475 | 2 | 1:4.15 | back | 0.436 | 1.035 | 0.451 | A19 |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.03 | 10 mm | 00491 | N/A | 1:1 | back | 0.373 | 1.026 | 0.383 | A20 |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.03 | 10 mm | 00475 | N/A | 1:1 | back | 0.736 | 1.000 | 0.736 | A21 |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | -0.01 | 10 mm | 00475 | N/A | 1:1 | back | 0.591 | 1.023 | 0.605 | A22 |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | |

### Table 11-15
### LTE Body-Worn SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.07 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | back | 1:1 | 0.344 | 1.026 | 0.353 | A23 |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.09 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | back | 1:1 | 0.238 | 1.045 | 0.249 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.07 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | back | 1:1 | 0.525 | 1.000 | 0.525 | A24 |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.06 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | back | 1:1 | 0.391 | 1.081 | 0.423 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | 0.07 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | back | 1:1 | 0.396 | 1.000 | 0.396 | A25 |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.00 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | back | 1:1 | 0.296 | 1.069 | 0.316 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.17 | 0 | 00475 | QPSK | 1 | 99 | 10 mm | back | 1:1 | 0.757 | 1.000 | 0.757 | A26 |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | back | 1:1 | 0.664 | 1.059 | 0.703 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | -0.02 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | back | 1:1 | 0.747 | 1.000 | 0.747 | A27 |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | -0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | back | 1:1 | 0.666 | 1.067 | 0.711 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

### Table 11-16
### DTS Body-Worn SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | Data Rate (Mbps) | Side | Duty Cycle (%) | Peak SAR of Area Scan | SAR (1g) | Scaling Factor (Power) | Scaling Factor (Duty Cycle) | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | W/kg | (W/kg) | | | (W/kg) | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.10 | 10 mm | 00541 | 1 | back | 99.5 | 0.265 | 0.227 | 1.091 | 1.005 | 0.249 | A29 |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## 11.3 Standalone Hotspot SAR Data

### Table 11-17
### CDMA/GPRS/UMTS Hotspot SAR Data

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | # of GPRS Slots | Duty Cycle | Side | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. 0 | 24.7 | 24.39 | 0.02 | 10 mm | 00475 | N/A | 1:1 | back | 0.381 | 1.074 | 0.409 | A15 |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. 0 | 24.7 | 24.39 | 0.05 | 10 mm | 00475 | N/A | 1:1 | front | 0.312 | 1.074 | 0.335 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. 0 | 24.7 | 24.39 | -0.03 | 10 mm | 00475 | N/A | 1:1 | bottom | 0.245 | 1.074 | 0.263 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. 0 | 24.7 | 24.39 | -0.05 | 10 mm | 00475 | N/A | 1:1 | right | 0.321 | 1.074 | 0.345 | |
| 836.52 | 384 | Cell. CDMA | EVDO Rev. 0 | 24.7 | 24.39 | -0.10 | 10 mm | 00475 | N/A | 1:1 | left | 0.218 | 1.074 | 0.234 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. 0 | 24.7 | 24.53 | 0.00 | 10 mm | 00475 | N/A | 1:1 | back | 0.619 | 1.040 | 0.644 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. 0 | 24.7 | 24.53 | 0.12 | 10 mm | 00475 | N/A | 1:1 | front | 0.635 | 1.040 | 0.660 | A17 |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. 0 | 24.7 | 24.53 | -0.08 | 10 mm | 00475 | N/A | 1:1 | bottom | 0.377 | 1.040 | 0.392 | |
| 1880.00 | 600 | PCS CDMA | EVDO Rev. 0 | 24.7 | 24.53 | 0.11 | 10 mm | 00475 | N/A | 1:1 | left | 0.537 | 1.040 | 0.558 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | -0.06 | 10 mm | 00491 | 2 | 1:4.15 | back | 0.314 | 1.002 | 0.315 | A18 |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | -0.05 | 10 mm | 00491 | 2 | 1:4.15 | front | 0.236 | 1.002 | 0.236 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.14 | 10 mm | 00491 | 2 | 1:4.15 | bottom | 0.154 | 1.002 | 0.154 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.08 | 10 mm | 00491 | 2 | 1:4.15 | right | 0.163 | 1.002 | 0.163 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.69 | 0.01 | 10 mm | 00491 | 2 | 1:4.15 | left | 0.162 | 1.002 | 0.162 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.01 | 10 mm | 00475 | 2 | 1:4.15 | back | 0.436 | 1.035 | 0.451 | A19 |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.11 | 10 mm | 00475 | 2 | 1:4.15 | front | 0.423 | 1.035 | 0.438 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.01 | 10 mm | 00475 | 2 | 1:4.15 | bottom | 0.265 | 1.035 | 0.274 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.55 | -0.01 | 10 mm | 00475 | 2 | 1:4.15 | left | 0.365 | 1.035 | 0.378 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.03 | 10 mm | 00491 | N/A | 1:1 | back | 0.373 | 1.026 | 0.383 | A20 |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | -0.01 | 10 mm | 00491 | N/A | 1:1 | front | 0.300 | 1.026 | 0.308 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | -0.11 | 10 mm | 00491 | N/A | 1:1 | bottom | 0.244 | 1.026 | 0.250 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.00 | 10 mm | 00491 | N/A | 1:1 | right | 0.343 | 1.026 | 0.352 | |
| 836.60 | 4183 | UMTS 850 | RMC | 24.7 | 24.59 | 0.03 | 10 mm | 00491 | N/A | 1:1 | left | 0.208 | 1.026 | 0.213 | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.03 | 10 mm | 00475 | N/A | 1:1 | back | 0.736 | 1.000 | 0.736 | A21 |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.02 | 10 mm | 00475 | N/A | 1:1 | front | 0.591 | 1.000 | 0.591 | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.05 | 10 mm | 00475 | N/A | 1:1 | bottom | 0.261 | 1.000 | 0.261 | |
| 1732.40 | 1412 | UMTS 1750 | RMC | 23.2 | 23.20 | 0.00 | 10 mm | 00475 | N/A | 1:1 | left | 0.285 | 1.000 | 0.285 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | -0.01 | 10 mm | 00475 | N/A | 1:1 | back | 0.591 | 1.023 | 0.605 | A22 |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | -0.04 | 10 mm | 00475 | N/A | 1:1 | front | 0.558 | 1.023 | 0.571 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | -0.03 | 10 mm | 00475 | N/A | 1:1 | bottom | 0.351 | 1.023 | 0.359 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 23.10 | 0.01 | 10 mm | 00475 | N/A | 1:1 | left | 0.520 | 1.023 | 0.532 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## Table 11-18
## LTE Band 12 Hotspot SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.07 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | back | 1:1 | 0.344 | 1.026 | 0.353 | A23 |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.09 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | back | 1:1 | 0.238 | 1.045 | 0.249 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.07 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | front | 1:1 | 0.217 | 1.026 | 0.223 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.03 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | front | 1:1 | 0.159 | 1.045 | 0.166 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | -0.02 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | bottom | 1:1 | 0.117 | 1.026 | 0.120 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.04 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | bottom | 1:1 | 0.090 | 1.045 | 0.094 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | -0.14 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | right | 1:1 | 0.306 | 1.026 | 0.314 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | -0.10 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | right | 1:1 | 0.210 | 1.045 | 0.219 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 24.7 | 24.59 | 0.03 | 0 | 00483 | QPSK | 1 | 0 | 10 mm | left | 1:1 | 0.155 | 1.026 | 0.159 | |
| 707.50 | 23095 | Mid | LTE Band 12 | 10 | 23.7 | 23.51 | 0.01 | 1 | 00483 | QPSK | 25 | 12 | 10 mm | left | 1:1 | 0.110 | 1.045 | 0.115 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-19
## LTE Band 13 Hotspot SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.07 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | back | 1:1 | 0.525 | 1.000 | 0.525 | A24 |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.06 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | back | 1:1 | 0.391 | 1.081 | 0.423 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.19 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | front | 1:1 | 0.380 | 1.000 | 0.380 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.04 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | front | 1:1 | 0.284 | 1.081 | 0.307 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | -0.18 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | bottom | 1:1 | 0.225 | 1.000 | 0.225 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.06 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | bottom | 1:1 | 0.154 | 1.081 | 0.166 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.14 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | right | 1:1 | 0.410 | 1.000 | 0.410 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | 0.02 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | right | 1:1 | 0.276 | 1.081 | 0.298 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 24.7 | 24.70 | 0.02 | 0 | 00483 | QPSK | 1 | 49 | 10 mm | left | 1:1 | 0.296 | 1.000 | 0.296 | |
| 782.00 | 23230 | Mid | LTE Band 13 | 10 | 23.7 | 23.36 | -0.07 | 1 | 00483 | QPSK | 25 | 25 | 10 mm | left | 1:1 | 0.215 | 1.081 | 0.232 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-20
## LTE Band 5 (Cell) Hotspot SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) | Scaling Factor | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | 0.07 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | back | 1:1 | 0.396 | 1.000 | 0.396 | A25 |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.00 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | back | 1:1 | 0.296 | 1.069 | 0.316 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.15 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | front | 1:1 | 0.327 | 1.000 | 0.327 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | -0.04 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | front | 1:1 | 0.244 | 1.069 | 0.261 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.04 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | bottom | 1:1 | 0.229 | 1.000 | 0.229 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | -0.01 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | bottom | 1:1 | 0.171 | 1.069 | 0.183 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | -0.13 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | right | 1:1 | 0.381 | 1.000 | 0.381 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | -0.14 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | right | 1:1 | 0.267 | 1.069 | 0.285 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 24.7 | 24.70 | 0.04 | 0 | 00475 | QPSK | 1 | 25 | 10 mm | left | 1:1 | 0.227 | 1.000 | 0.227 | |
| 836.50 | 20525 | Mid | LTE Band 5 (Cell) | 10 | 23.7 | 23.41 | 0.05 | 1 | 00475 | QPSK | 25 | 12 | 10 mm | left | 1:1 | 0.165 | 1.069 | 0.176 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## Table 11-21
## LTE Band 4 (AWS) Hotspot SAR

MEASUREMENT RESULTS

| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) (W/kg) | Scaling Factor | Reported SAR (1g) (W/kg) | Plot # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | | | | | | | | | | | | | | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.17 | 0 | 00475 | QPSK | 1 | 99 | 10 mm | back | 1:1 | 0.757 | 1.000 | 0.757 | A26 |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | back | 1:1 | 0.664 | 1.059 | 0.703 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | 0.03 | 0 | 00475 | QPSK | 1 | 99 | 10 mm | front | 1:1 | 0.693 | 1.000 | 0.693 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | 0.04 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | front | 1:1 | 0.628 | 1.059 | 0.665 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | -0.10 | 0 | 00475 | QPSK | 1 | 99 | 10 mm | bottom | 1:1 | 0.295 | 1.000 | 0.295 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.06 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | bottom | 1:1 | 0.277 | 1.059 | 0.293 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 24.2 | 24.20 | -0.10 | 0 | 00475 | QPSK | 1 | 99 | 10 mm | left | 1:1 | 0.384 | 1.000 | 0.384 | |
| 1732.50 | 20175 | Mid | LTE Band 4 (AWS) | 20 | 23.2 | 22.95 | -0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | left | 1:1 | 0.325 | 1.059 | 0.344 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | | |

## Table 11-22
## LTE Band 25 (PCS) Hotspot SAR

MEASUREMENT RESULTS

| FREQUENCY | | | Mode | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | MPR [dB] | Device Serial Number | Modulation | RB Size | RB Offset | Spacing | Side | Duty Cycle | SAR (1g) (W/kg) | Scaling Factor | Reported SAR (1g) (W/kg) | Plot # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | | | | | | | | | | | | | | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | -0.02 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | back | 1:1 | 0.747 | 1.000 | 0.747 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | -0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | back | 1:1 | 0.666 | 1.067 | 0.711 | |
| 1860.00 | 26140 | Low | LTE Band 25 (PCS) | 20 | 23.7 | 23.66 | 0.16 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | front | 1:1 | 0.870 | 1.009 | 0.878 | A28 |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 23.7 | 23.62 | -0.14 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | front | 1:1 | 0.863 | 1.019 | 0.879 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | 0.08 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | front | 1:1 | 0.837 | 1.000 | 0.837 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | -0.08 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | front | 1:1 | 0.750 | 1.067 | 0.800 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.34 | -0.04 | 1 | 00475 | QPSK | 100 | 0 | 10 mm | front | 1:1 | 0.761 | 1.086 | 0.826 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | -0.08 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | bottom | 1:1 | 0.423 | 1.000 | 0.423 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | 0.02 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | bottom | 1:1 | 0.400 | 1.067 | 0.427 | |
| 1905.00 | 26590 | High | LTE Band 25 (PCS) | 20 | 23.7 | 23.70 | -0.01 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | left | 1:1 | 0.635 | 1.000 | 0.635 | |
| 1882.50 | 26365 | Mid | LTE Band 25 (PCS) | 20 | 22.7 | 22.42 | -0.09 | 1 | 00475 | QPSK | 50 | 25 | 10 mm | left | 1:1 | 0.614 | 1.067 | 0.655 | |
| 1860.00 | 26140 | Low | LTE Band 25 (PCS) | 20 | 23.7 | 23.66 | 0.16 | 0 | 00475 | QPSK | 1 | 50 | 10 mm | front | 1:1 | 0.748 | 1.009 | 0.755 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | | |

**Blue Entry Represents Variability Measurement**

## Table 11-23
## WLAN Hotspot SAR

MEASUREMENT RESULTS

| FREQUENCY | | Mode | Service | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | Data Rate (Mbps) | Side | Duty Cycle (%) | Peak SAR of Area Scan W/kg | SAR (1g) (W/kg) | Scaling Factor (Power) | Scaling Factor (Duty Cycle) | Reported SAR (1g) (W/kg) | Plot # |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MHz | Ch. | | | | | | | | | | | | | | | | | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | -0.10 | 10 mm | 00541 | 1 | back | 99.5 | 0.265 | 0.227 | 1.091 | 1.005 | 0.249 | A29 |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | 0.03 | 10 mm | 00541 | 1 | front | 99.5 | 0.168 | - | 1.091 | 1.005 | - | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | 0.12 | 10 mm | 00541 | 1 | top | 99.5 | 0.133 | - | 1.091 | 1.005 | - | |
| 2412 | 1 | 802.11b | DSSS | 22 | 17.5 | 17.12 | 0.13 | 10 mm | 00541 | 1 | right | 99.5 | 0.125 | - | 1.091 | 1.005 | - | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | |

## 11.4 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. Device was tested using a fixed spacing for body-worn accessory testing. A separation distance of 10 mm was considered because the manufacturer has determined that there will be body-worn accessories available in the marketplace for users to support this separation distance.
7. Per FCC KDB Publication 648474 D04v01r03, body-worn SAR was evaluated without a headset connected to the device. Since the standalone reported body-worn SAR was ≤ 1.2 W/kg, no additional body-worn SAR evaluations using a headset cable were required.
8. Per FCC KDB 865664 D01v01r04, variability SAR tests were performed when the measured SAR results for a frequency band were greater than or equal to 0.8 W/kg. Repeated SAR measurements are highlighted in the tables above for clarity. Please see Section 13 for variability analysis.
9. During SAR Testing for the Wireless Router conditions per FCC KDB Publication 941225 D06v02r01, the actual Portable Hotspot operation (with actual simultaneous transmission of a transmitter with WIFI) was not activated (See Section 6.7 for more details).
10. Per FCC KDB Publication 648474 D04v01r03, this device is considered a "phablet" since the diagonal dimension is > 160 mm and < 200 mm. Therefore, phablet SAR tests are required when wireless router mode does not apply or if wireless router 1g SAR > 1.2 W/kg.

GSM Test Notes:

1. Body-Worn accessory testing is typically associated with voice operations. Therefore, GSM voice was evaluated for body-worn SAR.
2. Justification for reduced test configurations per KDB Publication 941225 D01v03r01 and October 2013 TCB Workshop Notes: The source-based frame-averaged output power was evaluated for all GPRS/EDGE slot configurations. The configuration with the highest target frame averaged output power was evaluated for hotspot SAR. When the maximum frame-averaged powers are equivalent across two or more slots (within 0.25 dB), the configuration with the most number of time slots was tested.
3. Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is ≤ 0.8 W/kg then testing at the other channels is not required for such test configuration(s). When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel was used.
4. GPRS was additionally evaluated for head and body-worn exposure conditions to address possible VoIP scenarios.

CDMA Notes:

1. Head SAR for CDMA2000 mode was tested under RC3/SO55 per FCC KDB Publication 941225 D01v03r01.
2. Body-Worn SAR was tested with 1x RTT with TDSO / SO32 FCH Only. EVDO Rev0 and RevA and TDSO / SO32 FCH+SCH SAR tests were not required per the 3G SAR Test Reduction Procedure in FCC KDB Publication 941225 D01v03r01.
3. CDMA Wireless Router SAR is measured using Subtype 0/1 Physical Layer configurations for Rev. 0 according to KDB 941225 D01v03r01 procedures for data devices. Wireless Router SAR tests for

Subtype 2 of Rev.A and 1x RTT configurations were not required per the 3G SAR Test Reduction Policy in KDB Publication 941225 D01v03r01.
4. Head SAR was additionally evaluated using EVDO Rev. A to determine compliance for VoIP operations.
5. Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is ≤ 0.8 W/kg then testing at the other channels is not required for such test configuration(s). When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel was used.

UMTS Notes:
1. UMTS mode in was tested under RMC 12.2 kbps with HSPA Inactive per KDB Publication 941225 D01v03r01. AMR and HSPA SAR was not required per the 3G Test Reduction Procedure in KDB Publication 941225 D01v03r01.
2. Per FCC KDB Publication 447498 D01v06, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is ≤ 0.8 W/kg then testing at the other channels is not required for such test configuration(s). When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel was used.

LTE Notes:
1. LTE Considerations: LTE test configurations are determined according to SAR Evaluation Considerations for LTE Devices in FCC KDB Publication 941225 D05v02r04. The general test procedures used for testing can be found in Section 8.6.4.
2. MPR is permanently implemented for this device by the manufacturer. The specific manufacturer target MPR is indicated alongside the SAR results. MPR is enabled for this device, according to 3GPP TS36.101 Section 6.2.3 – 6.2.5 under Table 6.2.3-1.
3. A-MPR was disabled for all SAR tests by setting NS=01 on the base station simulator. SAR tests were performed with the same number of RB and RB offsets transmitting on all TTI frames (maximum TTI).

WLAN Notes:
1. For held-to-ear and hotspot operations, the initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 8.7.3 for more information. When the maximum reported 1g averaged SAR is ≤0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg or all test channels were measured.
3. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools. The reported SAR was scaled to the 100% transmission duty factor to determine compliance. Procedures used to measure the duty factor are identical to that in the associated EMC test reports.

# 12 FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

## 12.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

## 12.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 4.3.2 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1-g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1-g or 10-g SAR.

When standalone SAR is not required to be measured, per FCC KDB 447498 D01v06 4.3.2 b), the following equation must be used to estimate the standalone 1g SAR for simultaneous transmission assessment involving that transmitter.

$$\text{Estimated SAR} = \frac{\sqrt{f(GHz)}}{7.5} * \frac{(\text{Max Power of channel, mW})}{\text{Min. Separation Distance, mm}}$$

**Table 12-1**
**Estimated SAR**

| Mode | Frequency | Maximum Allowed Power | Separation Distance (Body) | Estimated SAR (Body) |
|---|---|---|---|---|
| | [MHz] | [dBm] | [mm] | [W/kg] |
| Bluetooth | 2480 | 8.50 | 10 | 0.147 |

Note: Held-to ear configurations are not applicable to Bluetooth operations and therefore were not considered for simultaneous transmission. Per KDB Publication 447498 D01v06, the maximum power of the channel was rounded to the nearest mW before calculation.

SAR testing was not required for phablet exposure conditions per FCC KDB 648474 D04v01r03. Therefore, no further analysis was required to determine that possible simultaneous scenarios would not exceed the SAR limit.

## 12.3 Head SAR Simultaneous Transmission Analysis

**Table 12-2**
**Simultaneous Transmission Scenario with 2.4 GHz WLAN (Held to Ear)**

| Exposure Condition | Mode | 2G/3G/4G SAR (W/kg) | 2.4 GHz WLAN SAR (W/kg) | Σ SAR (W/kg) | SPLSR |
|---|---|---|---|---|---|
| Head SAR | Cell. CDMA/EVDO | 0.375 | 1.010 | 1.385 | N/A |
| | PCS CDMA/EVDO | 0.515 | 1.010 | 1.525 | N/A |
| | GSM/GPRS 850 | 0.294 | 1.010 | 1.304 | N/A |
| | GSM/GPRS 1900 | 0.391 | 1.010 | 1.401 | N/A |
| | UMTS 850 | 0.341 | 1.010 | 1.351 | N/A |
| | UMTS 1750 | 0.379 | 1.010 | 1.389 | N/A |
| | UMTS 1900 | 0.534 | 1.010 | **1.544** | N/A |
| | LTE Band 12 | 0.183 | 1.010 | 1.193 | N/A |
| | LTE Band 13 | 0.299 | 1.010 | 1.309 | N/A |
| | LTE Band 5 (Cell) | 0.332 | 1.010 | 1.342 | N/A |
| | LTE Band 4 (AWS) | 0.429 | 1.010 | 1.439 | N/A |
| | LTE Band 25 (PCS) | 0.597 | 1.010 | See Note 1 | 0.03 |

Note 1: No evaluation was performed to determine the aggregate 1g SAR for these configurations as the SPLS ratio between the antenna pairs was not greater than 0.04 per FCC KDB 447498 D01v05. See Section 12.6 for detailed SPLS ratio analysis.

## 12.4 Body-Worn Simultaneous Transmission Analysis

**Table 12-3**
**Simultaneous Transmission Scenario with 2.4 GHz WLAN (Body-Worn at 1.0 cm)**

| Exposure Condition | Mode | 2G/3G/4G SAR (W/kg) | 2.4 GHz WLAN SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|---|
| Body-Worn | Cell. CDMA | 0.417 | 0.249 | 0.666 |
| | PCS CDMA | 0.693 | 0.249 | 0.942 |
| | GSM/GPRS 850 | 0.315 | 0.249 | 0.564 |
| | GSM/GPRS 1900 | 0.451 | 0.249 | 0.700 |
| | UMTS 850 | 0.383 | 0.249 | 0.632 |
| | UMTS 1750 | 0.736 | 0.249 | 0.985 |
| | UMTS 1900 | 0.605 | 0.249 | 0.854 |
| | LTE Band 12 | 0.353 | 0.249 | 0.602 |
| | LTE Band 13 | 0.525 | 0.249 | 0.774 |
| | LTE Band 5 (Cell) | 0.396 | 0.249 | 0.645 |
| | LTE Band 4 (AWS) | 0.757 | 0.249 | **1.006** |
| | LTE Band 25 (PCS) | 0.747 | 0.249 | 0.996 |

**Table 12-4**
**Simultaneous Transmission Scenario with Bluetooth (Body-Worn at 1.0 cm)**

| Exposure Condition | Mode | 2G/3G/4G SAR (W/kg) | Bluetooth SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|---|
| Body-Worn | Cell. CDMA | 0.417 | 0.147 | 0.564 |
| | PCS CDMA | 0.693 | 0.147 | 0.840 |
| | GSM/GPRS 850 | 0.315 | 0.147 | 0.462 |
| | GSM/GPRS 1900 | 0.451 | 0.147 | 0.598 |
| | UMTS 850 | 0.383 | 0.147 | 0.530 |
| | UMTS 1750 | 0.736 | 0.147 | 0.883 |
| | UMTS 1900 | 0.605 | 0.147 | 0.752 |
| | LTE Band 12 | 0.353 | 0.147 | 0.500 |
| | LTE Band 13 | 0.525 | 0.147 | 0.672 |
| | LTE Band 5 (Cell) | 0.396 | 0.147 | 0.543 |
| | LTE Band 4 (AWS) | 0.757 | 0.147 | **0.904** |
| | LTE Band 25 (PCS) | 0.747 | 0.147 | 0.894 |

Note: Bluetooth SAR was not required to be measured per FCC KDB 447498. Estimated SAR results were used in the above table to determine simultaneous transmission SAR test exclusion.

## 12.5 Hotspot SAR Simultaneous Transmission Analysis

**Table 12-5**
**Simultaneous Transmission Scenario (2.4 GHz Hotspot at 1.0 cm)**

| Exposure Condition | Mode | 2G/3G/4G SAR (W/kg) | 2.4 GHz WLAN SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|---|
| Hotspot SAR | Cell. EVDO | 0.409 | 0.249 | 0.658 |
| | PCS EVDO | 0.660 | 0.249 | 0.909 |
| | GPRS 850 | 0.315 | 0.249 | 0.564 |
| | GPRS 1900 | 0.451 | 0.249 | 0.700 |
| | UMTS 850 | 0.383 | 0.249 | 0.632 |
| | UMTS 1750 | 0.736 | 0.249 | 0.985 |
| | UMTS 1900 | 0.605 | 0.249 | 0.854 |
| | LTE Band 12 | 0.353 | 0.249 | 0.602 |
| | LTE Band 13 | 0.525 | 0.249 | 0.774 |
| | LTE Band 5 (Cell) | 0.396 | 0.249 | 0.645 |
| | LTE Band 4 (AWS) | 0.757 | 0.249 | 1.006 |
| | LTE Band 25 (PCS) | 0.879 | 0.249 | **1.128** |

## 12.6 SPLSR Evaluation and Analysis

Per FCC KDB Publication 447498 D01v05r02, when the sum of the standalone transmitters is more than 1.6 W/kg for 1g and 4 W/kg for 10g, the SAR sum to peak locations can be analyzed to determine SAR distribution overlaps. When the SAR peak to location ratio (shown below) for each pair of antennas is ≤ 0.04 for 1g and ≤0.10 for 10g, simultaneous SAR evaluation is not required. The distance between the transmitters was calculated using the following formula.

$$\text{Distance}_{Tx1-Tx2} = R_i = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

$$\text{SPLS Ratio} = \frac{(SAR_1 + SAR_2)^{1.5}}{R_i}$$

### 12.6.1 Left Cheek SPLSR Evaluation and Analysis

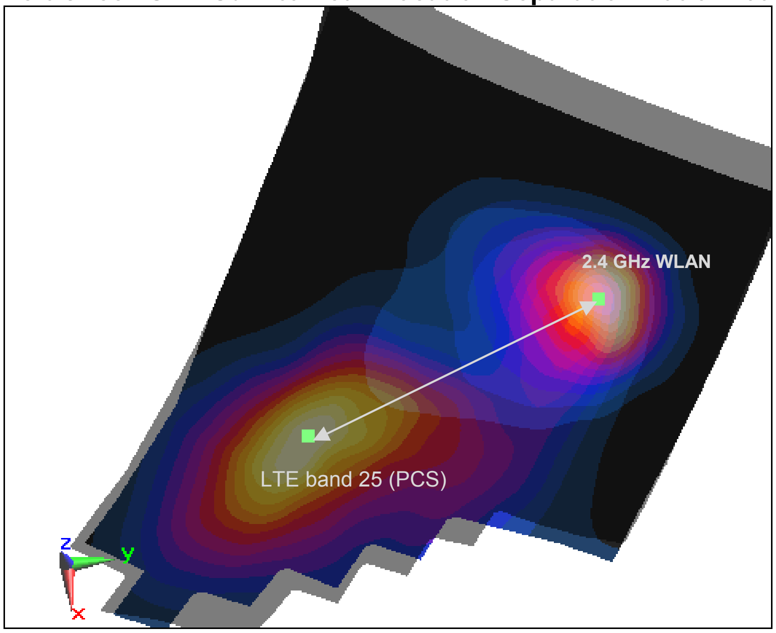
**Table 12-6**
**Peak SAR Locations for Left Cheek**

| Mode/Band | x (mm) | y (mm) | z (mm) | Reported SAR (W/kg) |
|---|---|---|---|---|
| 2.4 GHz WLAN | 19.30 | 326.00 | -171.00 | 1.01 |
| LTE Band 25 (PCS) | 46.00 | 251.00 | -170.00 | 0.597 |

**Table 12-7**
**Left Cheek SAR Sum to Peak Location Separation Ratio Calculations**

| Antenna Pair | | Standalone 1g SAR (W/kg) | | Standalone SAR Sum (W/kg) | Peak SAR Separation Distance (mm) | SPLS Ratio |
|---|---|---|---|---|---|---|
| Ant "a" | Ant "b" | a | b | a+b | $D_{a-b}$ | $(a+b)^{1.5}/D_{a-b}$ |
| 2.4 GHz WLAN | LTE Band 25 (PCS) | 1.01 | 0.597 | 1.607 | 79.62 | 0.03 |

**Table 12-8**
**Left Cheek SAR Sum to Peak Location Separation Ratio Plot**




## 12.7 Simultaneous Transmission Conclusion

The above numerical summed SAR results and SPLSR analysis are sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2.

# 13 SAR MEASUREMENT VARIABILITY

## 13.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r04, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement Variability was assessed using the following procedures for each frequency band:

1) When the original highest measured SAR is ≥ 0.80 W/kg, the measurement was repeated once.
2) A second repeated measurement was preformed only if the ratio of largest to smallest SAR for the original and first repeated measurements was > 1.20 or when the original or repeated measurement was ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
3) A third repeated measurement was performed only if the original, first or second repeated measurement was ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.
4) Repeated measurements are not required when the original highest measured SAR is < 0.80 W/kg

**Table 13-1**
**Head SAR Measurement Variability Results**

| HEAD VARIABILITY RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Band | FREQUENCY | | Mode/Band | Service | Side | Test Position | Data Rate (Mbps) | Measured SAR (1g) | 1st Repeated SAR (1g) | Ratio | 2nd Repeated SAR (1g) | Ratio | 3rd Repeated SAR (1g) | Ratio |
| | MHz | Ch. | | | | | | (W/kg) | (W/kg) | | (W/kg) | | (W/kg) | |
| 2450 | 2412.00 | 1 | 802.11b, 22 MHz Bandwidth | DSSS | Left | Cheek | 1 | 0.905 | 0.921 | 1.02 | N/A | N/A | N/A | N/A |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | Head<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | |

**Table 13-2**
**Body SAR Measurement Variability Results**

| BODY VARIABILITY RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Band | FREQUENCY | | Mode | Service | Side | Spacing | Measured SAR (1g) | 1st Repeated SAR (1g) | Ratio | 2nd Repeated SAR (1g) | Ratio | 3rd Repeated SAR (1g) | Ratio |
| | MHz | Ch. | | | | | (W/kg) | (W/kg) | | (W/kg) | | (W/kg) | |
| 1900 | 1860.00 | 26140 | LTE Band 25 (PCS), 20 MHz Bandwidth | QPSK, 1 RB, 50 RB Offset | front | 10 mm | 0.870 | 0.748 | 1.16 | N/A | N/A | N/A | N/A |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | |

## 13.2 Measurement Uncertainty

The measured SAR was <1.5 W/kg for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

# 14 EQUIPMENT LIST

| Manufacturer | Model | Description | Cal Date | Cal Interval | Cal Due | Serial Number |
|---|---|---|---|---|---|---|
| Agilent | 8594A | (9kHz-2.9GHz) Spectrum Analyzer | N/A | N/A | N/A | 3051A00187 |
| Agilent | 8753ES | S-Parameter Network Analyzer | 3/3/2016 | Annual | 3/3/2017 | US39170122 |
| Agilent | E4432B | ESG-D Series Signal Generator | 3/5/2016 | Annual | 3/5/2017 | US40053896 |
| Agilent | E4438C | ESG Vector Signal Generator | 3/13/2015 | Biennial | 3/13/2017 | MY42082385 |
| Agilent | E8257D | (250kHz-20GHz) Signal Generator | 3/2/2016 | Annual | 3/2/2017 | MY45470194 |
| Agilent | N5182A | MXG Vector Signal Generator | 3/5/2016 | Annual | 3/5/2017 | MY47420800 |
| Agilent | N9020A | MXA Signal Analyzer | 11/5/2015 | Annual | 11/5/2016 | US46470561 |
| Amplifier Research | 15S1G6 | Amplifier | N/A | CBT | N/A | 433971 |
| Amplifier Research | 15S1G6 | Amplifier | N/A | CBT | N/A | 433972 |
| Anritsu | MA24106A | USB Power Sensor | 3/28/2016 | Annual | 3/28/2017 | 1344554 |
| Anritsu | MA24106A | USB Power Sensor | 3/4/2016 | Annual | 3/4/2017 | 1349514 |
| Anritsu | MA2411B | Pulse Power Sensor | 2/28/2016 | Annual | 2/28/2017 | 1207470 |
| Anritsu | MA2481A | Power Sensor | 3/3/2016 | Annual | 3/3/2017 | 5318 |
| Anritsu | ML2438A | Power Meter | 3/3/2016 | Annual | 3/3/2017 | 1070030 |
| Anritsu | ML2495A | Power Meter | 10/16/2015 | Biennial | 10/16/2017 | 941001 |
| Anritsu | MT8820C | Radio Communication Analyzer | 12/4/2015 | Annual | 12/4/2016 | 6201300731 |
| Anritsu | MT8820C | Radio Communication Analyzer | 11/12/2015 | Annual | 11/12/2016 | 6201144418 |
| COMTech | AR85729-5 | Solid State Amplifier | N/A | CBT | N/A | M1S5A00-009 |
| Control Company | 4040 | Digital Thermometer | 3/18/2015 | Biennial | 3/18/2017 | 150194987 |
| Control Company | 4353 | Long Stem Thermometer | 3/5/2015 | Biennial | 3/5/2017 | 150149534 |
| Keysight | 772D | Dual Directional Coupler | N/A | CBT | N/A | MY52180215 |
| MCL | BW-N6W5+ | 6dB Attenuator | N/A | CBT | N/A | 1139 |
| MiniCircuits | SLP-2400+ | Low Pass Filter | N/A | CBT | N/A | R8979500903 |
| Mini-Circuits | BW-N20W5 | Power Attenuator | N/A | CBT | N/A | 1226 |
| Mini-Circuits | BW-N20W5+ | DC to 18 GHz Precision Fixed 20 dB Attenuator | N/A | CBT | N/A | N/A |
| Mini-Circuits | NLP-1200+ | Low Pass Filter DC to 1000 MHz | N/A | CBT | N/A | N/A |
| Mini-Circuits | NLP-2950+ | Low Pass Filter DC to 2700 MHz | N/A | CBT | N/A | N/A |
| Mitutoyo | CD-6"CSX | Digital Caliper | 3/2/2016 | Biennial | 3/2/2018 | 13264162 |
| Narda | 4014C-6 | 4 - 8 GHz SMA 6 dB Directional Coupler | N/A | CBT | N/A | N/A |
| Narda | 4772-3 | Attenuator (3dB) | N/A | CBT | N/A | 9406 |
| Pasternack | NC-100 | Torque Wrench | 11/6/2015 | Biennial | 11/6/2017 | N/A |
| Pasternack | NC-100 | Torque Wrench | 11/6/2015 | Biennial | 11/6/2017 | N/A |
| Pasternack | PE2208-6 | Bidirectional Coupler | CBT | CBT | CBT | N/A |
| Rohde & Schwarz | CMW500 | Radio Communication Tester | 8/19/2015 | Biennial | 8/19/2017 | 101767 |
| Seekonk | NC-100 | Torque Wrench 5/16", 8" lbs | 3/2/2016 | Biennial | 3/2/2018 | N/A |
| Seekonk | NC-100 | Torque Wrench | 11/6/2015 | Biennial | 11/6/2017 | N/A |
| SPEAG | DAK-3.5 | Dielectric Assessment Kit | 10/20/2015 | Annual | 10/20/2016 | 1091 |
| SPEAG | DAKS-3.5 | Portable Dielectric Assessment Kit | 7/14/2015 | Annual | 7/14/2016 | 1039 |
| SPEAG | DAKS-3.5 | Portable Dielectric Assessment Kit | 8/19/2015 | Annual | 8/19/2016 | 1041 |
| SPEAG | D750V3 | 750 MHz SAR Dipole | 1/15/2016 | Annual | 1/15/2017 | 1003 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 1/20/2016 | Annual | 1/20/2017 | 4d132 |
| SPEAG | D1750V2 | 1750 MHz SAR Dipole | 5/9/2016 | Annual | 5/9/2017 | 1148 |
| SPEAG | D1900V2 | 1900 MHz SAR Dipole | 7/14/2015 | Annual | 7/14/2016 | 5d149 |
| SPEAG | D2450V2 | 2450 MHz SAR Dipole | 2/18/2016 | Annual | 2/18/2017 | 882 |
| SPEAG | D2450V2 | 2450 MHz SAR Dipole | 10/21/2015 | Annual | 10/21/2016 | 797 |
| SPEAG | D750V3 | 750 MHz SAR Dipole | 2/16/2016 | Annual | 2/16/2017 | 1046 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 4/14/2016 | Annual | 4/14/2017 | 4d119 |
| SPEAG | D1750V2 | 1750 MHz SAR Dipole | 4/13/2016 | Annual | 4/13/2017 | 1051 |
| SPEAG | ES3DV3 | SAR Probe | 9/18/2015 | Annual | 9/18/2016 | 3288 |
| SPEAG | ES3DV3 | SAR Probe | 9/18/2015 | Annual | 9/18/2016 | 3332 |
| SPEAG | ES3DV2 | SAR Probe | 8/26/2015 | Annual | 8/26/2016 | 3022 |
| SPEAG | ES3DV3 | SAR Probe | 11/17/2015 | Annual | 11/17/2016 | 3334 |
| SPEAG | ES3DV3 | SAR Probe | 2/19/2016 | Annual | 2/19/2017 | 3318 |
| SPEAG | EX3DV4 | SAR Probe | 4/19/2016 | Annual | 4/19/2017 | 7406 |
| SPEAG | ES3DV3 | SAR Probe | 3/18/2016 | Annual | 3/18/2017 | 3319 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 9/18/2015 | Annual | 9/18/2016 | 1364 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 1/15/2016 | Annual | 1/15/2017 | 1466 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 9/16/2015 | Annual | 9/16/2016 | 1323 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 11/11/2015 | Annual | 11/11/2016 | 1415 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 2/19/2016 | Annual | 2/19/2017 | 665 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 4/14/2016 | Annual | 4/14/2017 | 1407 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 3/14/2016 | Annual | 3/14/2017 | 1368 |

Note: CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.

# 15 MEASUREMENT UNCERTAINTIES

| a | c | d | e= f(d,k) | f | g | h = c x f/e | i = c x g/e | k |
|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Tol. (± %) | Prob. Dist. | Div. | $c_i$ 1gm | $c_i$ 10 gms | 1gm $u_i$ (± %) | 10gms $u_i$ (± %) | $v_i$ |
| **Measurement System** | | | | | | | | |
| Probe Calibration | 6.55 | N | 1 | 1.0 | 1.0 | 6.6 | 6.6 | ∞ |
| Axial Isotropy | 0.25 | N | 1 | 0.7 | 0.7 | 0.2 | 0.2 | ∞ |
| Hemishperical Isotropy | 1.3 | N | 1 | 0.7 | 0.7 | 0.9 | 0.9 | ∞ |
| Boundary Effect | 2.0 | R | 1.73 | 1.0 | 1.0 | 1.2 | 1.2 | ∞ |
| Linearity | 0.3 | N | 1 | 1.0 | 1.0 | 0.3 | 0.3 | ∞ |
| System Detection Limits | 0.25 | R | 1.73 | 1.0 | 1.0 | 0.1 | 0.1 | ∞ |
| Readout Electronics | 0.3 | N | 1 | 1.0 | 1.0 | 0.3 | 0.3 | ∞ |
| Response Time | 0.8 | R | 1.73 | 1.0 | 1.0 | 0.5 | 0.5 | ∞ |
| Integration Time | 2.6 | R | 1.73 | 1.0 | 1.0 | 1.5 | 1.5 | ∞ |
| RF Ambient Conditions - Noise | 3.0 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| RF Ambient Conditions - Reflections | 3.0 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | 0.4 | R | 1.73 | 1.0 | 1.0 | 0.2 | 0.2 | ∞ |
| Probe Positioning w/ respect to Phantom | 6.7 | R | 1.73 | 1.0 | 1.0 | 3.9 | 3.9 | ∞ |
| Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation | 4.0 | R | 1.73 | 1.0 | 1.0 | 2.3 | 2.3 | ∞ |
| **Test Sample Related** | | | | | | | | |
| Test Sample Positioning | 2.7 | N | 1 | 1.0 | 1.0 | 2.7 | 2.7 | 35 |
| Device Holder Uncertainty | 1.67 | N | 1 | 1.0 | 1.0 | 1.7 | 1.7 | 5 |
| Output Power Variation - SAR drift measurement | 5.0 | R | 1.73 | 1.0 | 1.0 | 2.9 | 2.9 | ∞ |
| SAR Scaling | 0.0 | R | 1.73 | 1.0 | 1.0 | 0.0 | 0.0 | ∞ |
| **Phantom & Tissue Parameters** | | | | | | | | |
| Phantom Uncertainty (Shape & Thickness tolerances) | 7.6 | R | 1.73 | 1.0 | 1.0 | 4.4 | 4.4 | ∞ |
| Liquid Conductivity - measurement uncertainty | 4.2 | N | 1 | 0.78 | 0.71 | 3.3 | 3.0 | 10 |
| Liquid Permittivity - measurement uncertainty | 4.1 | N | 1 | 0.23 | 0.26 | 1.0 | 1.1 | 10 |
| Liquid Conductivity - Temperature Uncertainty | 3.4 | R | 1.73 | 0.78 | 0.71 | 1.5 | 1.4 | ∞ |
| Liquid Permittivity - Temperature Unceritainty | 0.6 | R | 1.73 | 0.23 | 0.26 | 0.1 | 0.1 | ∞ |
| Liquid Conductivity - deviation from target values | 5.0 | R | 1.73 | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| Liquid Permittivity - deviation from target values | 5.0 | R | 1.73 | 0.60 | 0.49 | 1.7 | 1.4 | ∞ |
| **Combined Standard Uncertainty (k=1)** | | RSS | | | | 11.5 | 11.3 | 60 |
| **Expanded Uncertainty** (95% CONFIDENCE LEVEL) | | k=2 | | | | 23.0 | 22.6 | |

# 16 CONCLUSION

## 16.1 Measurement Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of the FCC and Innovation, Science, and Economic Development Canada, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables. [3]

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# APPENDIX A: SAR TEST DATA

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

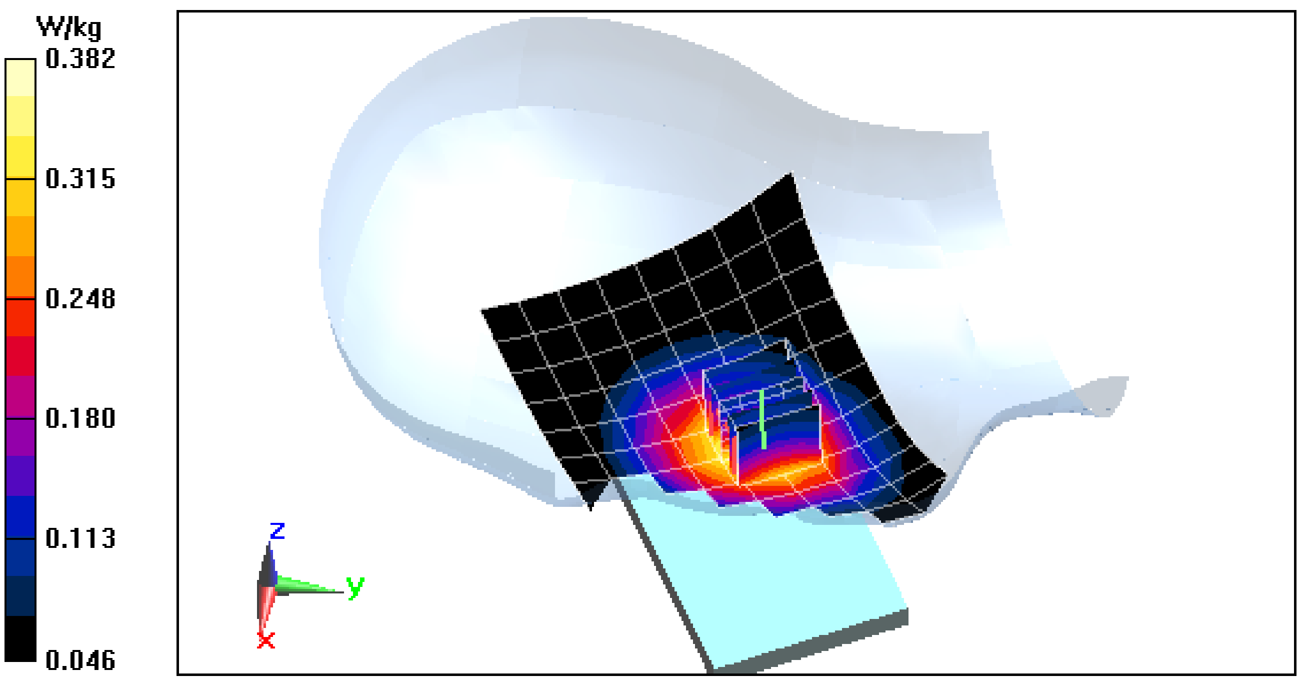
Communication System: UID 0, CDMA; Frequency: 836.52 MHz; Duty Cycle: 1:1
Medium: 835 Head Medium parameters used (interpolated):
f = 836.52 MHz; σ = 0.926 S/m; $\varepsilon_r$ = 40.55; ρ = 1000 kg/m$^3$
Phantom section: Right Section

Test Date: 05-16-2016; Ambient Temp: 22.4°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3332; ConvF(6.23, 6.23, 6.23); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1466; Calibrated: 1/15/2016
Phantom: SAM Main; Type: QD000P40CC; Serial: TP 1114
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: Cell. CDMA, Right Head, Cheek, Mid.ch

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.96 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 0.443 W/kg
**SAR(1 g) = 0.351 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

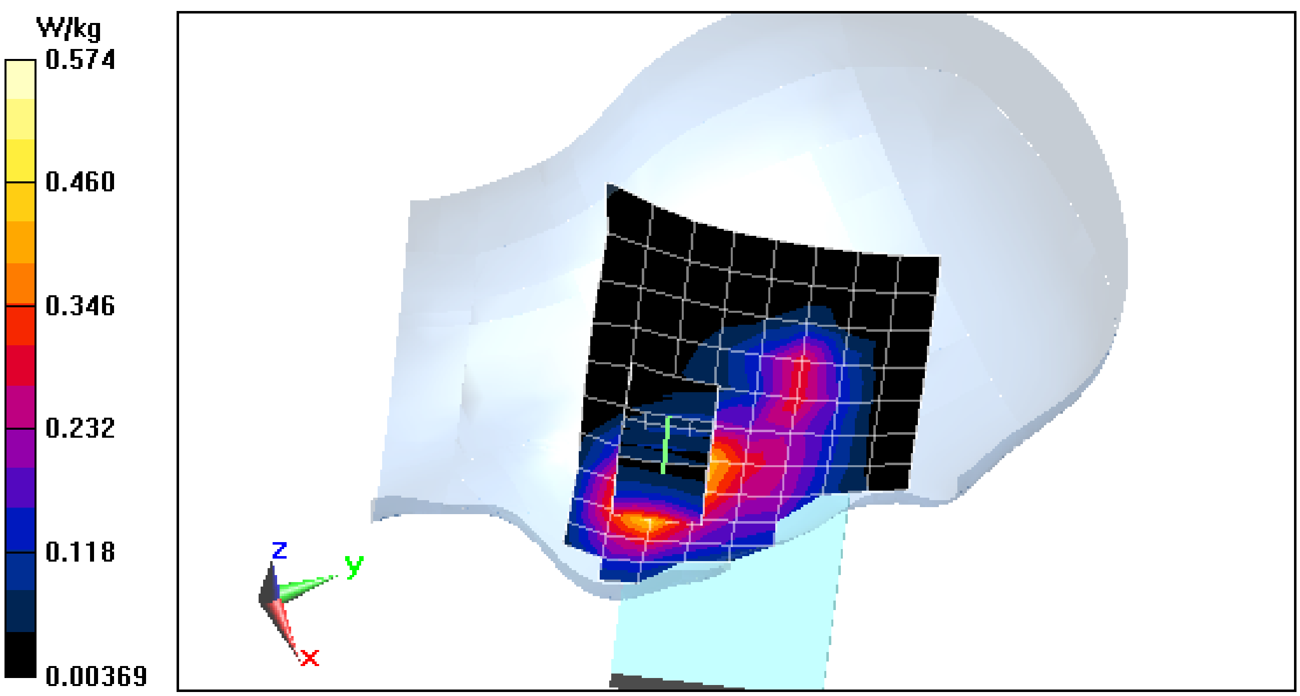
Communication System: UID 0, PCS CDMA; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.425 S/m; $\varepsilon_r$ = 39.118; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-16-2016; Ambient Temp: 22.2°C; Tissue Temp: 21.3°C

Probe: ES3DV2 - SN3022; ConvF(4.93, 4.93, 4.93); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Right; Type: QD000P40CD; Serial: TP:7535
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: PCS EVDO Rev A, Left Head, Cheek, Mid.ch

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.53 V/m; Power Drift = -0.11 dB
Peak SAR (extrapolated) = 0.759 W/kg
**SAR(1 g) = 0.495 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

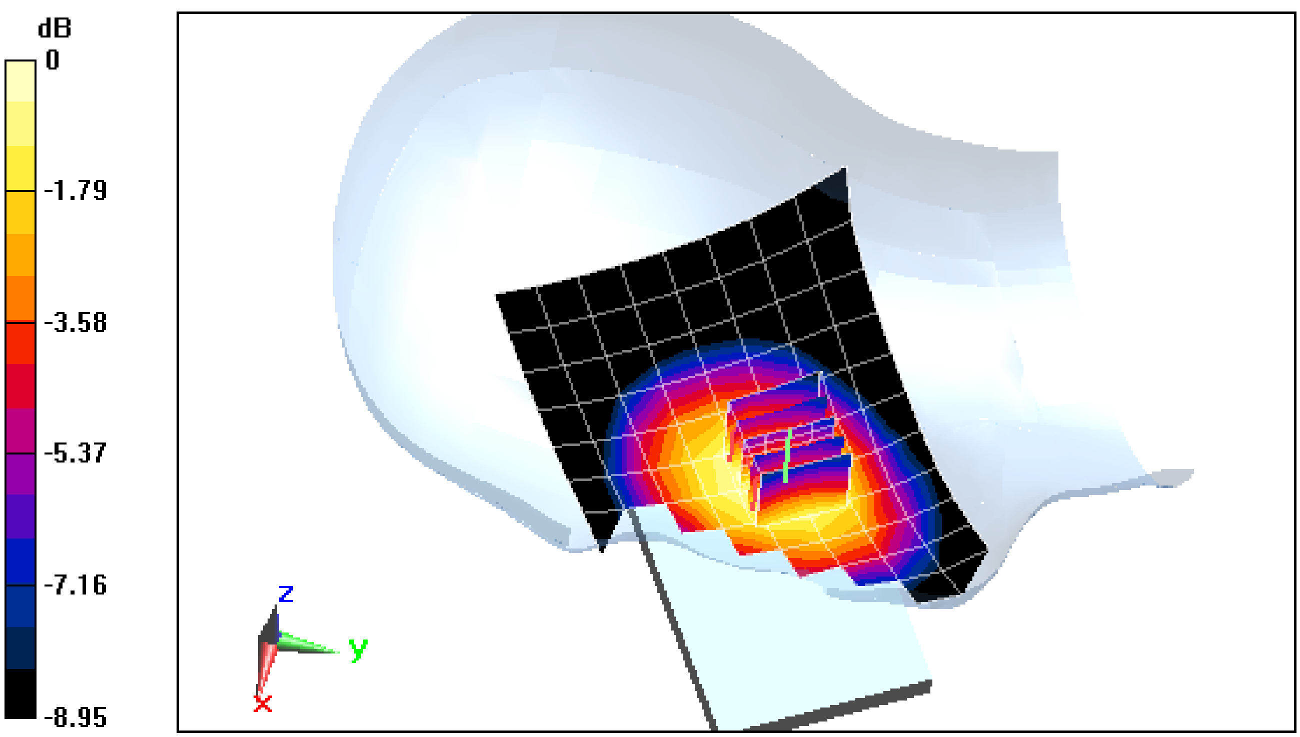
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 836.6 MHz; Duty Cycle: 1:4.15
Medium: 835 Head Medium parameters used (interpolated):
f = 836.6 MHz; σ = 0.926 S/m; $\varepsilon_r$ = 40.549; ρ = 1000 kg/$m^3$
Phantom section: Right Section

Test Date: 05-16-2016; Ambient Temp: 22.4°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3332; ConvF(6.23, 6.23, 6.23); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1466; Calibrated: 1/15/2016
Phantom: SAM Main; Type: QD000P40CC; Serial: TP 1114
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: GPRS 850, Right Head, Cheek, Mid.ch, 2 Tx slots**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 18.58 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 0.370 W/kg
**SAR(1 g) = 0.293 W/kg**




0 dB = 0.323 W/kg = -4.91 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

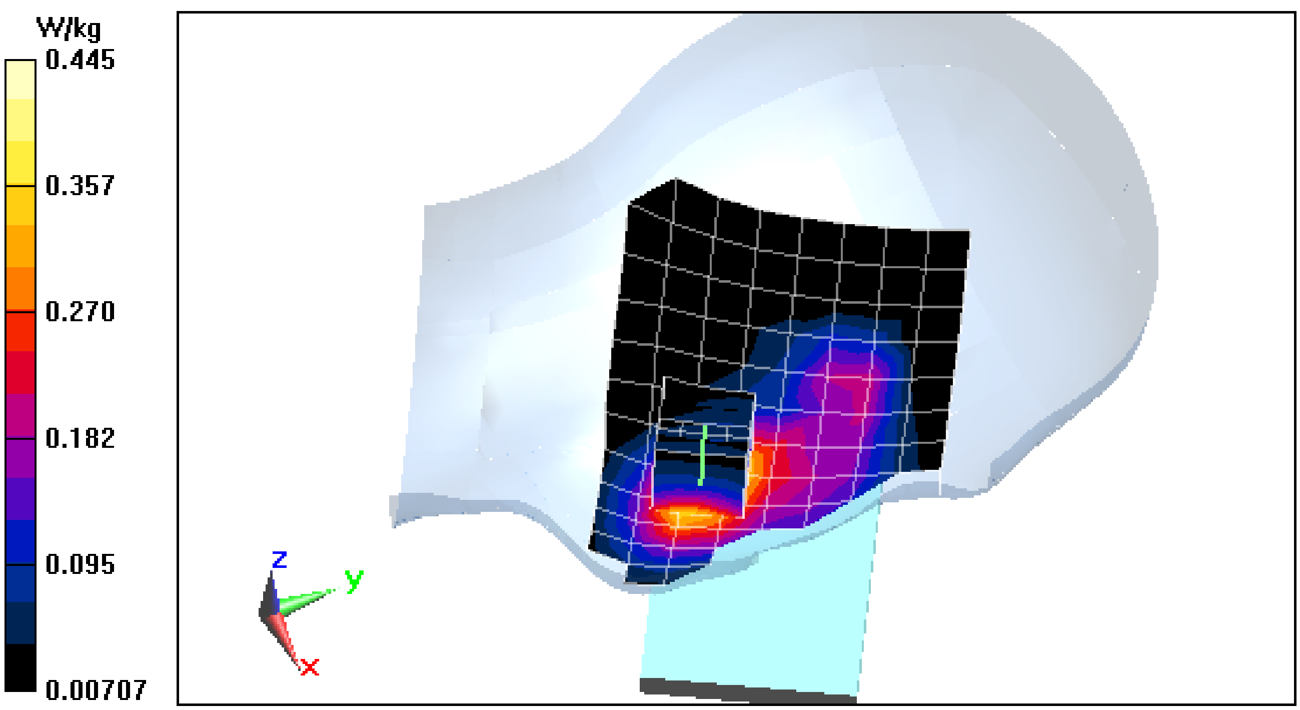
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 1880 MHz; Duty Cycle: 1:4.15
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.425 S/m; $\varepsilon_r$ = 39.118; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-16-2016; Ambient Temp: 22.2°C; Tissue Temp: 21.3°C

Probe: ES3DV2 - SN3022; ConvF(4.93, 4.93, 4.93); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Right; Type: QD000P40CD; Serial: TP:7535
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: GPRS 1900, Left Head, Cheek, Mid.ch, 2 Tx slots**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 17.19 V/m; Power Drift = 0.11 dB
Peak SAR (extrapolated) = 0.588 W/kg
**SAR(1 g) = 0.378 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

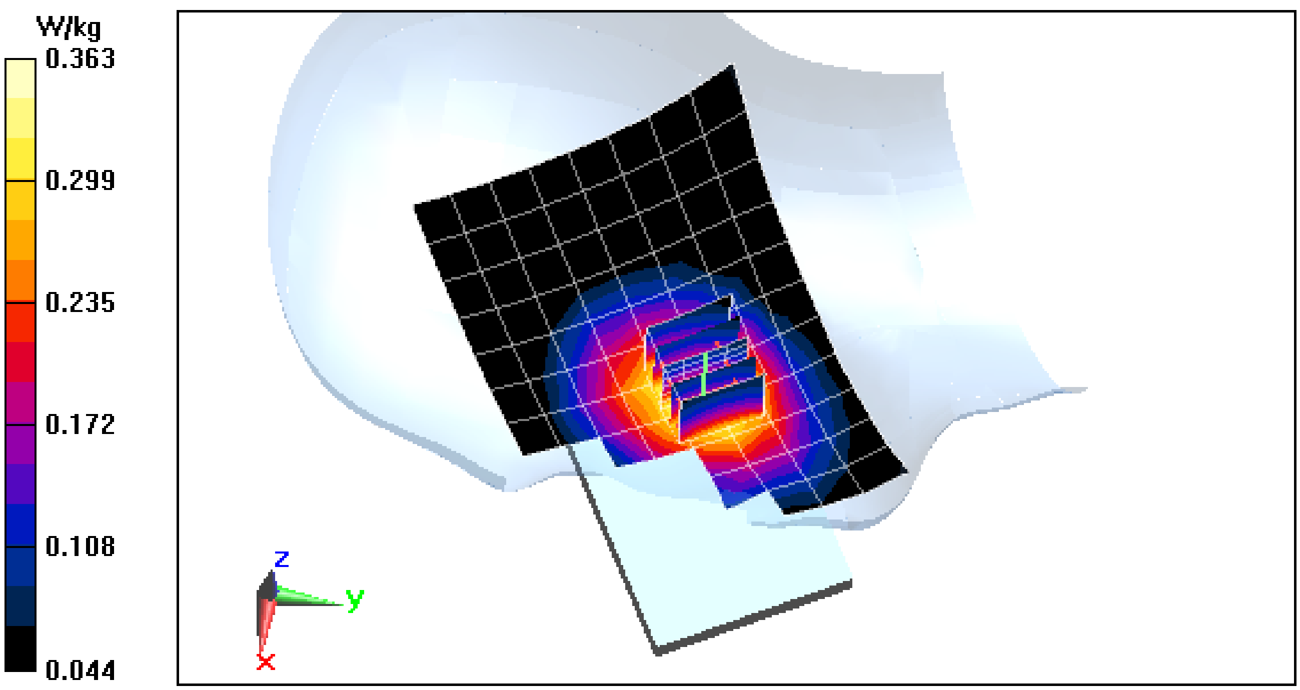
Communication System: UID 0, UMTS; Frequency: 836.6 MHz; Duty Cycle: 1:1
Medium: 835 Head Medium parameters used (interpolated):
f = 836.6 MHz; $\sigma$ = 0.926 S/m; $\varepsilon_r$ = 40.549; $\rho$ = 1000 kg/m$^3$
Phantom section: Right Section

Test Date: 05-16-2016; Ambient Temp: 22.4°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3332; ConvF(6.23, 6.23, 6.23); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1466; Calibrated: 1/15/2016
Phantom: SAM Main; Type: QD000P40CC; Serial: TP 1114
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: UMTS 850, Right Head, Cheek, Mid.ch

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.64 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 0.418 W/kg
**SAR(1 g) = 0.332 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00491**

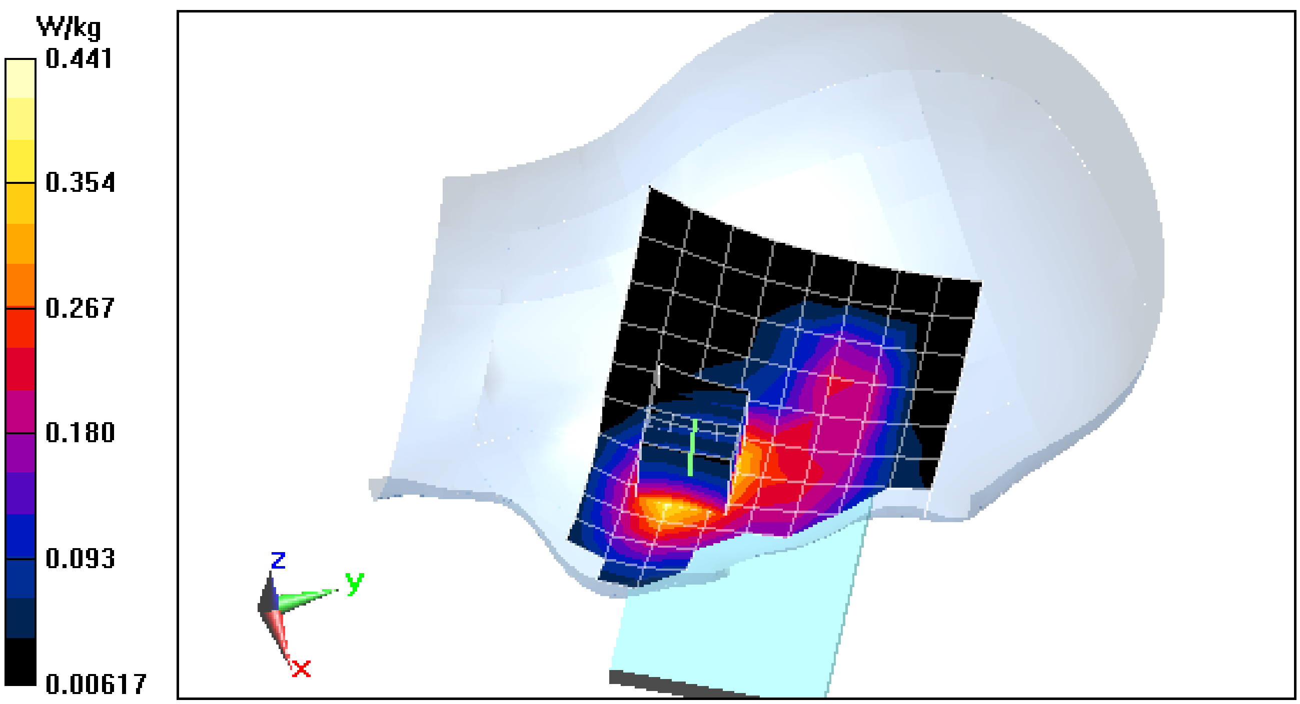
Communication System: UID 0, UMTS; Frequency: 1732.4 MHz; Duty Cycle: 1:1
Medium: 1750 Head Medium parameters used (interpolated):
f = 1732.4 MHz; $\sigma$ = 1.358 S/m; $\varepsilon_r$ = 39.474; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-17-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.3°C

Probe: ES3DV2 - SN3022; ConvF(5.08, 5.08, 5.08); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Left; Type: QD000P40CC; Serial: TP: 1375
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: UMTS 1750, Left Head, Cheek, Mid.ch

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 17.73 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 0.565 W/kg
**SAR(1 g) = 0.379 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

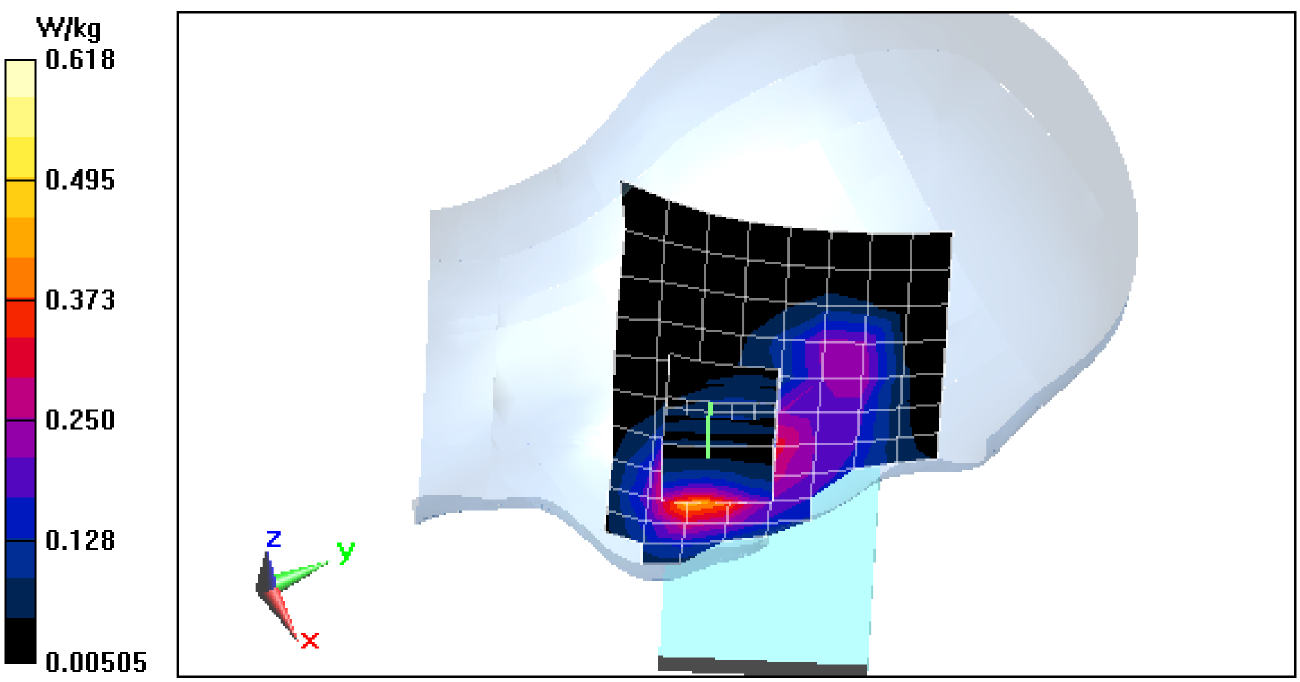
Communication System: UID 0, UMTS; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.425 S/m; $\varepsilon_r$ = 39.118; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-16-2016; Ambient Temp: 22.2°C; Tissue Temp: 21.3°C

Probe: ES3DV2 - SN3022; ConvF(4.93, 4.93, 4.93); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Right; Type: QD000P40CD; Serial: TP:7535
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: UMTS 1900, Left Head, Cheek, Mid.ch

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.75 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.820 W/kg
**SAR(1 g) = 0.522 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

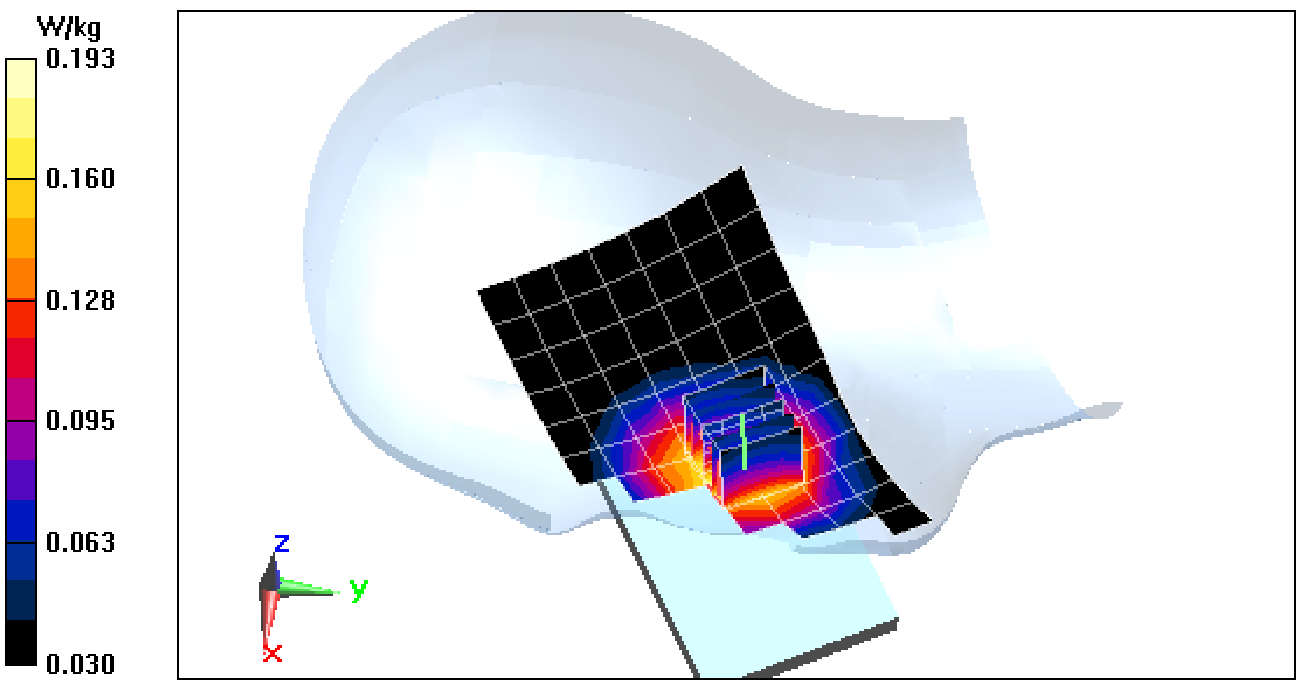
Communication System: UID 0, LTE Band 12; Frequency: 707.5 MHz; Duty Cycle: 1:1
Medium: 750 Head Medium parameters used (interpolated):
f = 707.5 MHz; $\sigma$ = 0.868 S/m; $\varepsilon_r$ = 41.216; $\rho$ = 1000 kg/$m^3$
Phantom section: Right Section

Test Date: 05-17-2016; Ambient Temp: 24.2°C; Tissue Temp: 22.3°C

Probe: ES3DV3 - SN3288; ConvF(6.69, 6.69, 6.69); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2015
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 12, Right Head, Cheek, Mid.ch,**
**10 MHz Bandwidth, QPSK, 1 RB, 0 RB Offset**

**Area Scan (8x13x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 15.37 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.220 W/kg
**SAR(1 g) = 0.178 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

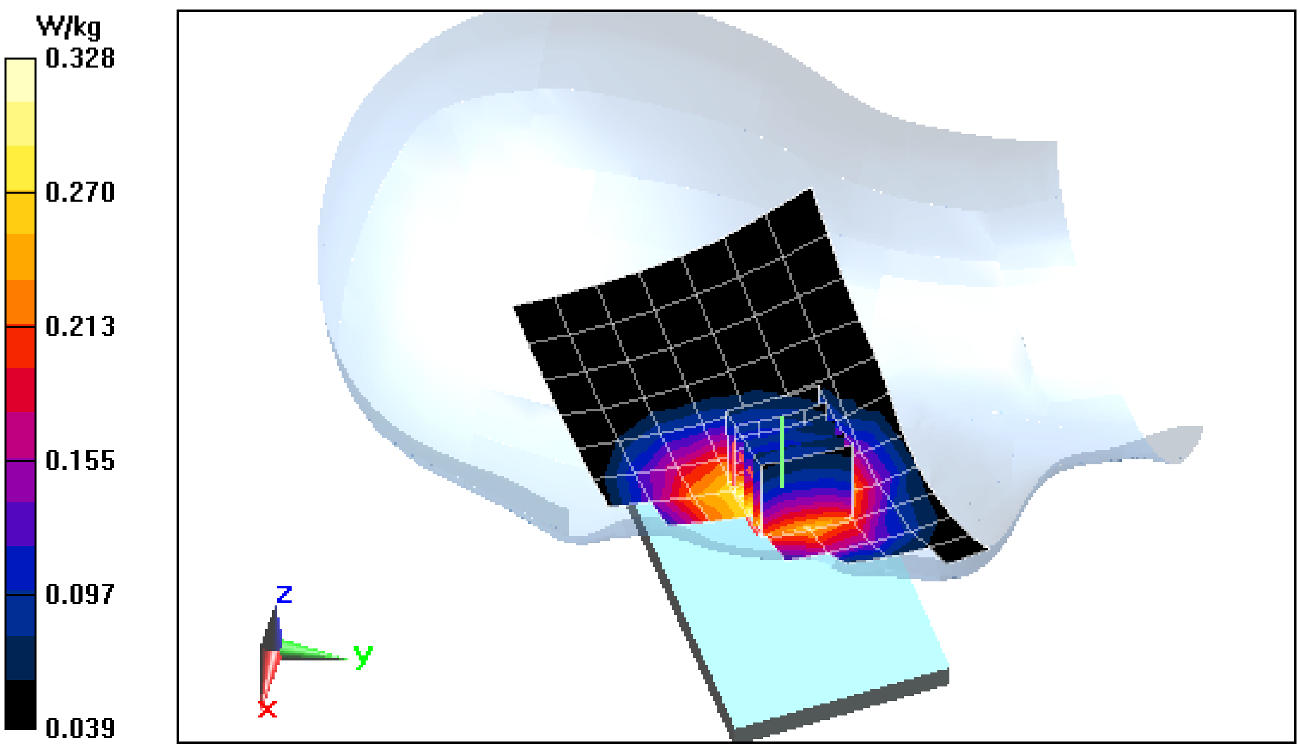
Communication System: UID 0, LTE Band 13; Frequency: 782 MHz; Duty Cycle: 1:1
Medium: 750 Head Medium parameters used (interpolated):
f = 782 MHz; $\sigma$ = 0.937 S/m; $\varepsilon_r$ = 40.163; $\rho$ = 1000 kg/m$^3$
Phantom section: Right Section

Test Date: 05-17-2016; Ambient Temp: 24.2°C; Tissue Temp: 22.3°C

Probe: ES3DV3 - SN3288; ConvF(6.69, 6.69, 6.69); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2015
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 13, Right Head, Cheek, Mid.ch,**
**10 MHz Bandwidth, QPSK, 1 RB, 49 RB Offset**

**Area Scan (8x13x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.19 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.380 W/kg
**SAR(1 g) = 0.299 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

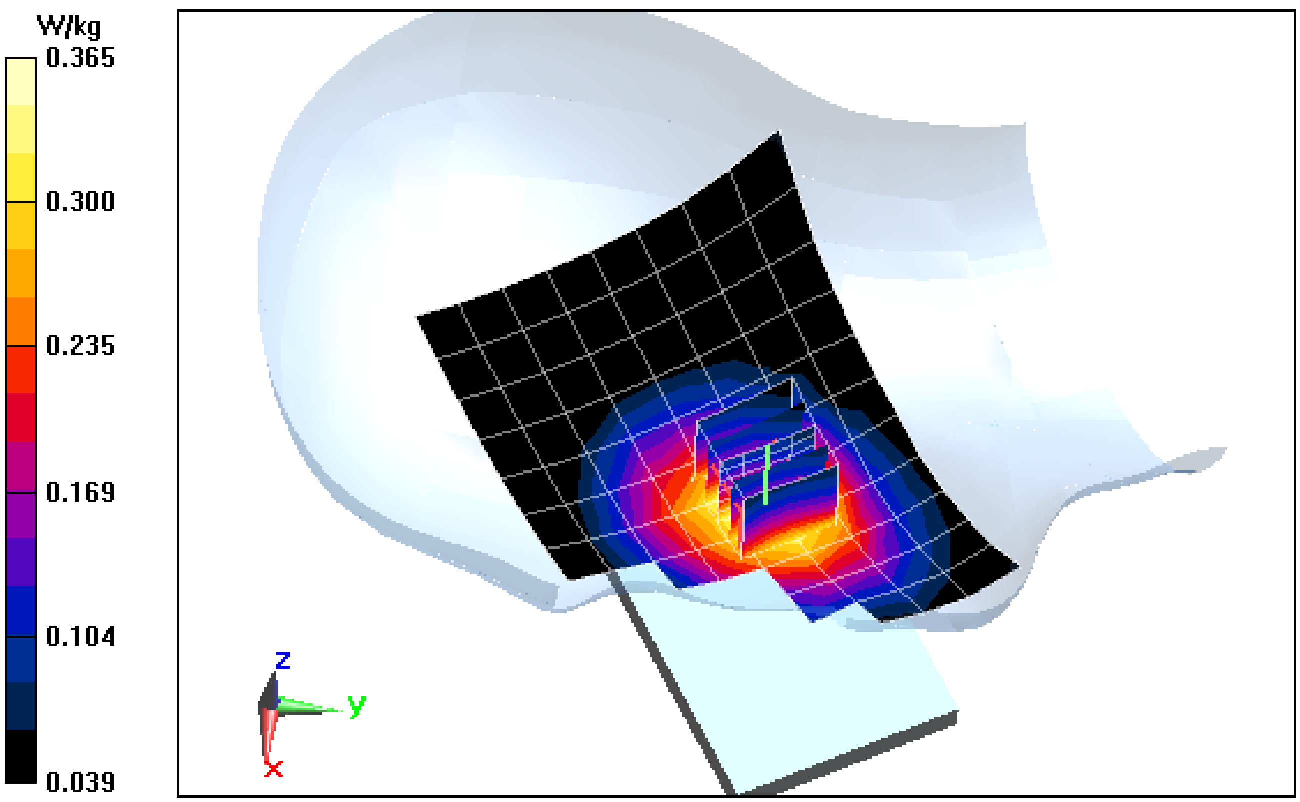
Communication System: UID 0, LTE Band 5 (Cell.); Frequency: 836.5 MHz; Duty Cycle: 1:1
Medium: 835 Head Medium parameters used (interpolated):
f = 836.5 MHz; $\sigma$ = 0.926 S/m; $\varepsilon_r$ = 40.55; $\rho$ = 1000 kg/$m^3$
Phantom section: Right Section

Test Date: 05-16-2016; Ambient Temp: 22.4°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3332; ConvF(6.23, 6.23, 6.23); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1466; Calibrated: 1/15/2016
Phantom: SAM Main; Type: QD000P40CC; Serial: TP 1114
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 5 (Cell.), Right Head, Cheek, Mid.ch,**
**10 MHz Bandwidth, QPSK, 1 RB, 25 RB Offset**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.56 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 0.416 W/kg
**SAR(1 g) = 0.332 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00491**

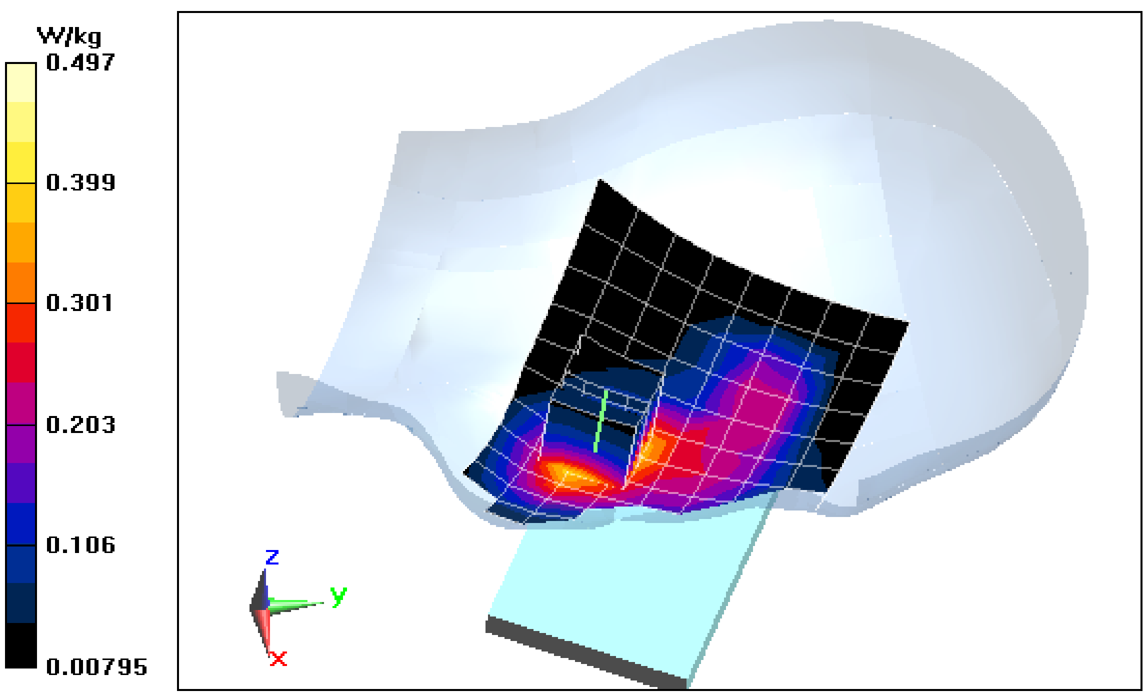
Communication System: UID 0, LTE Band 4 (AWS); Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium: 1750 Head Medium parameters used (interpolated):
f = 1732.5 MHz; σ = 1.358 S/m; $\varepsilon_r$ = 39.473; ρ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-17-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.3°C

Probe: ES3DV2 - SN3022; ConvF(5.08, 5.08, 5.08); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Left; Type: QD000P40CC; Serial: TP: 1375
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 4 (AWS), Left Head, Cheek, Mid.ch,**
**20 MHz Bandwidth, QPSK, 1 RB, 99 RB Offset**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.56 V/m; Power Drift = 0.15 dB
Peak SAR (extrapolated) = 0.632 W/kg
**SAR(1 g) = 0.429 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

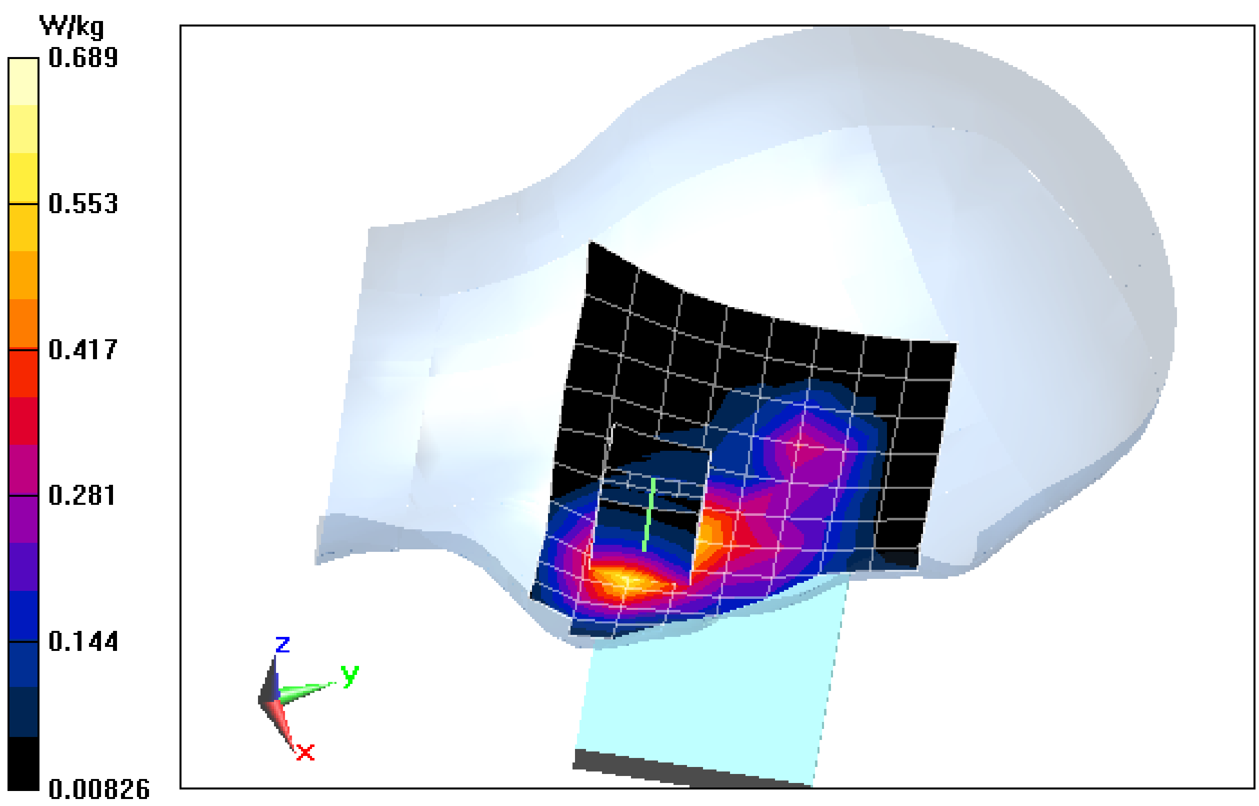
Communication System: UID 0, LTE Band 25 (PCS); Frequency: 1905 MHz; Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used (interpolated):
f = 1905 MHz; $\sigma$ = 1.452 S/m; $\varepsilon_r$ = 39.012; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-16-2016; Ambient Temp: 22.2°C; Tissue Temp: 21.3°C

Probe: ES3DV2 - SN3022; ConvF(4.93, 4.93, 4.93); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Right; Type: QD000P40CD; Serial: TP:7535
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 25 (PCS), Left Head, Cheek, High.ch,**
**20 MHz Bandwidth, QPSK, 1 RB, 50 RB Offset**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 22.24 V/m; Power Drift = 0.11 dB
Peak SAR (extrapolated) = 0.920 W/kg
**SAR(1 g) = 0.597 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00541**

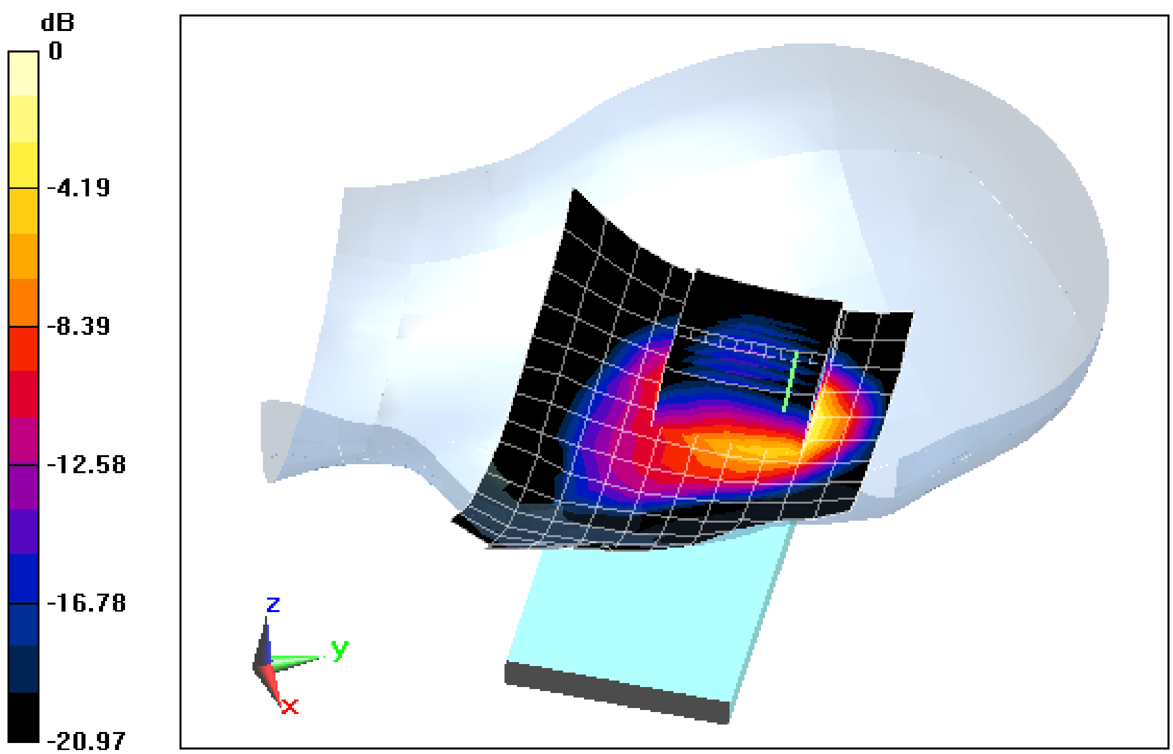
Communication System: UID 0, IEEE 802.11b; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium: 2450 Head Medium parameters used (interpolated):
f = 2412 MHz; $\sigma$ = 1.83 S/m; $\varepsilon_r$ = 39.755; $\rho$ = 1000 kg/$m^3$
Phantom section: Left Section

Test Date: 5-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3288; ConvF(4.57, 4.57, 4.57); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2015
Phantom: Sub TWIN SAM; Type: QD000P40CC; Serial: TP-1357
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: IEEE 802.11b, 22 MHz Bandwidth, Left Head, Cheek, Ch 1, 1 Mbps**

**Area Scan (11x18x1):** Measurement grid: dx=12mm, dy=12mm
**Zoom Scan (11x10x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 11.14 V/m; Power Drift = -0.10 dB
Peak SAR (extrapolated) = 1.88 W/kg
**SAR(1 g) = 0.921 W/kg**




0 dB = 1.22 W/kg = 0.86 dBW/kg

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

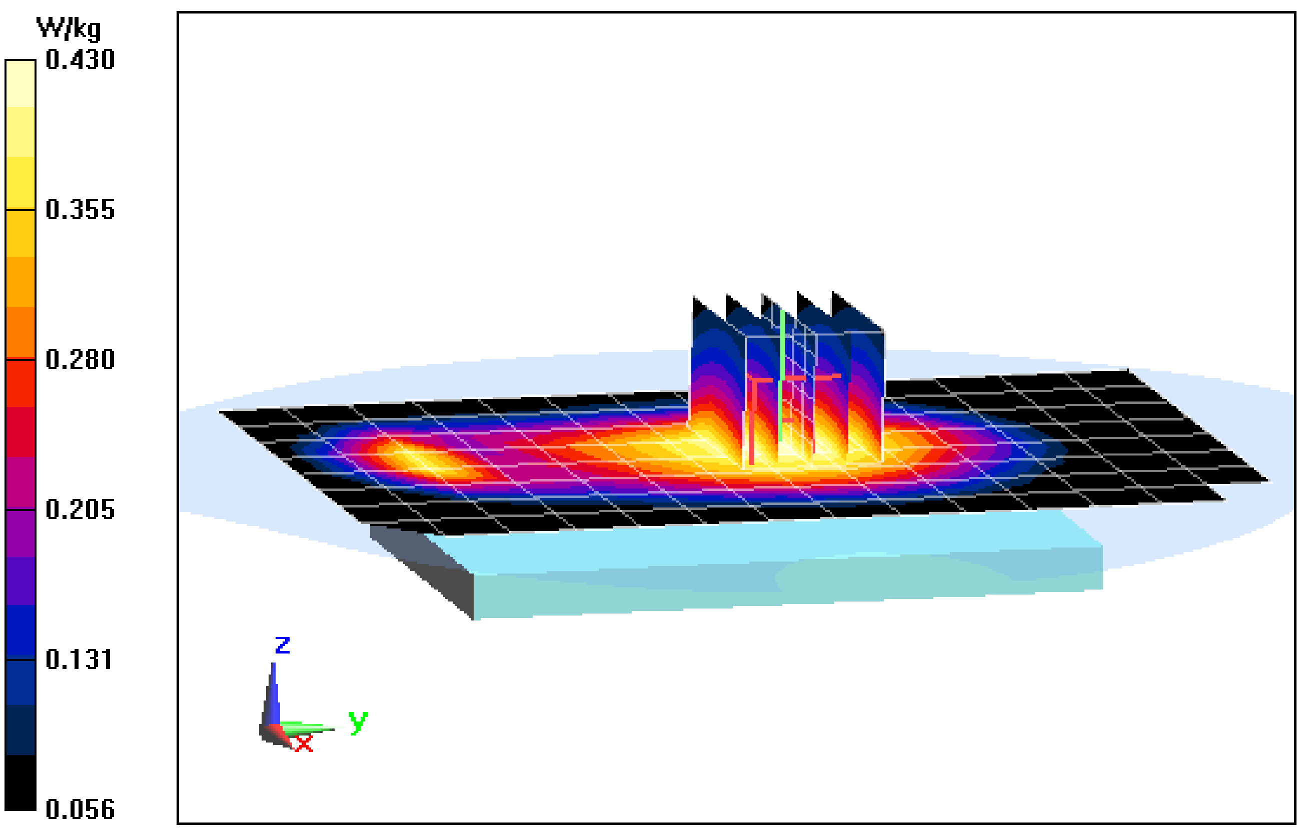
Communication System: UID 0, CDMA; Frequency: 836.52 MHz; Duty Cycle: 1:1
Medium: 835 Body Medium parameters used (interpolated):
f = 836.52 MHz; σ = 1.012 S/m; $\varepsilon_r$ = 53.373; ρ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: Cell. CDMA, Body SAR, Back side, Mid.ch**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.35 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 0.497 W/kg
**SAR(1 g) = 0.391 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

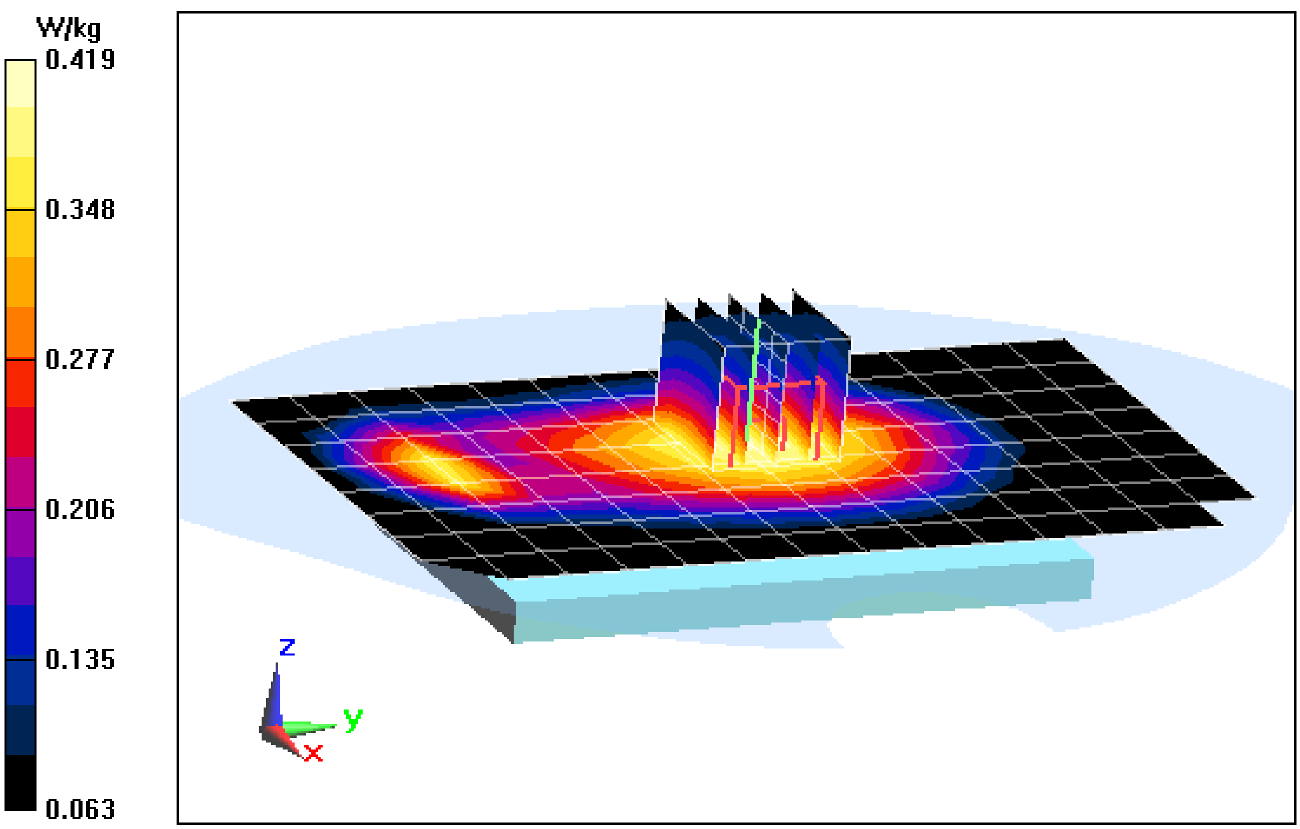
Communication System: UID 0, CDMA; Frequency: 836.52 MHz; Duty Cycle: 1:1
Medium: 835 Body Medium parameters used (interpolated):
f = 836.52 MHz; $\sigma$ = 1.012 S/m; $\varepsilon_r$ = 53.373; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: Cell. EVDO, Body SAR, Back side, Mid.ch**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.08 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.485 W/kg
**SAR(1 g) = 0.381 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

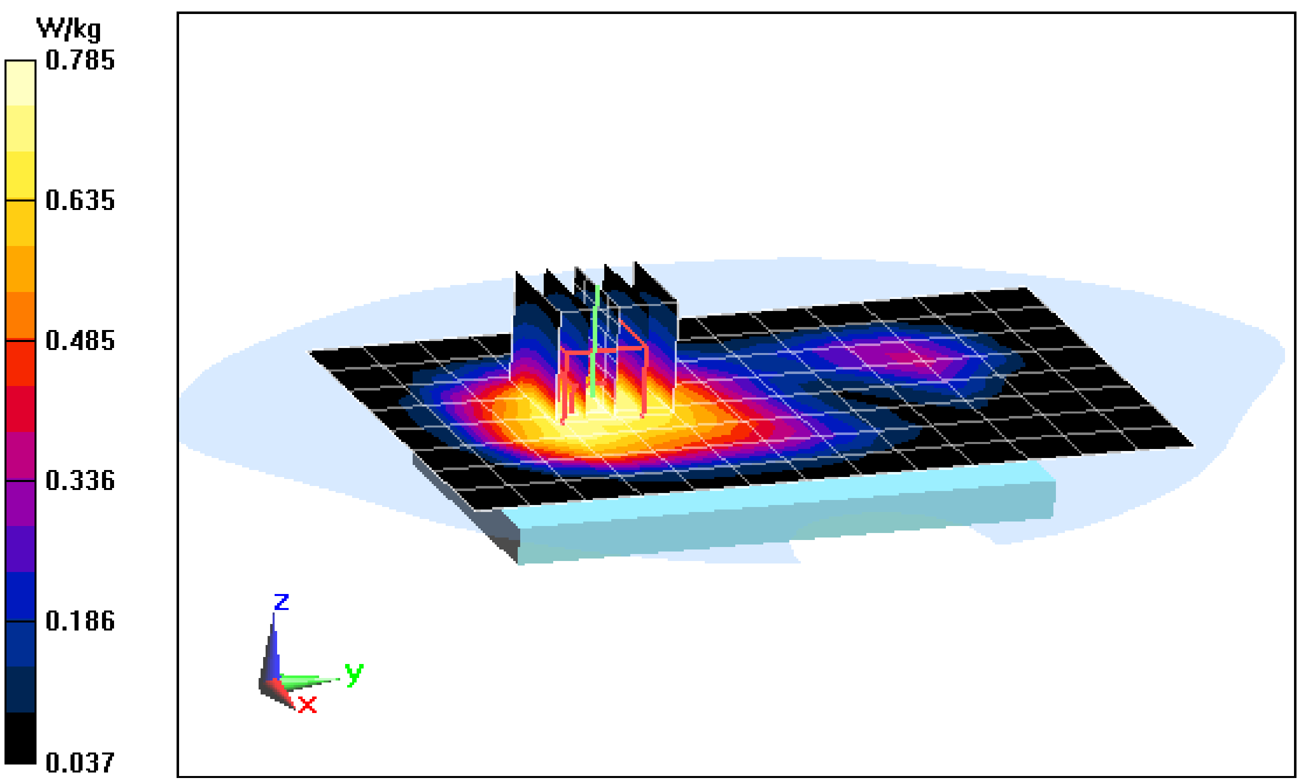
Communication System: UID 0, CDMA; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.558 S/m; $\varepsilon_r$ = 53.255; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: PCS CDMA, Body SAR, Back side, Mid.ch**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 22.04 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 1.01 W/kg
**SAR(1 g) = 0.685 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

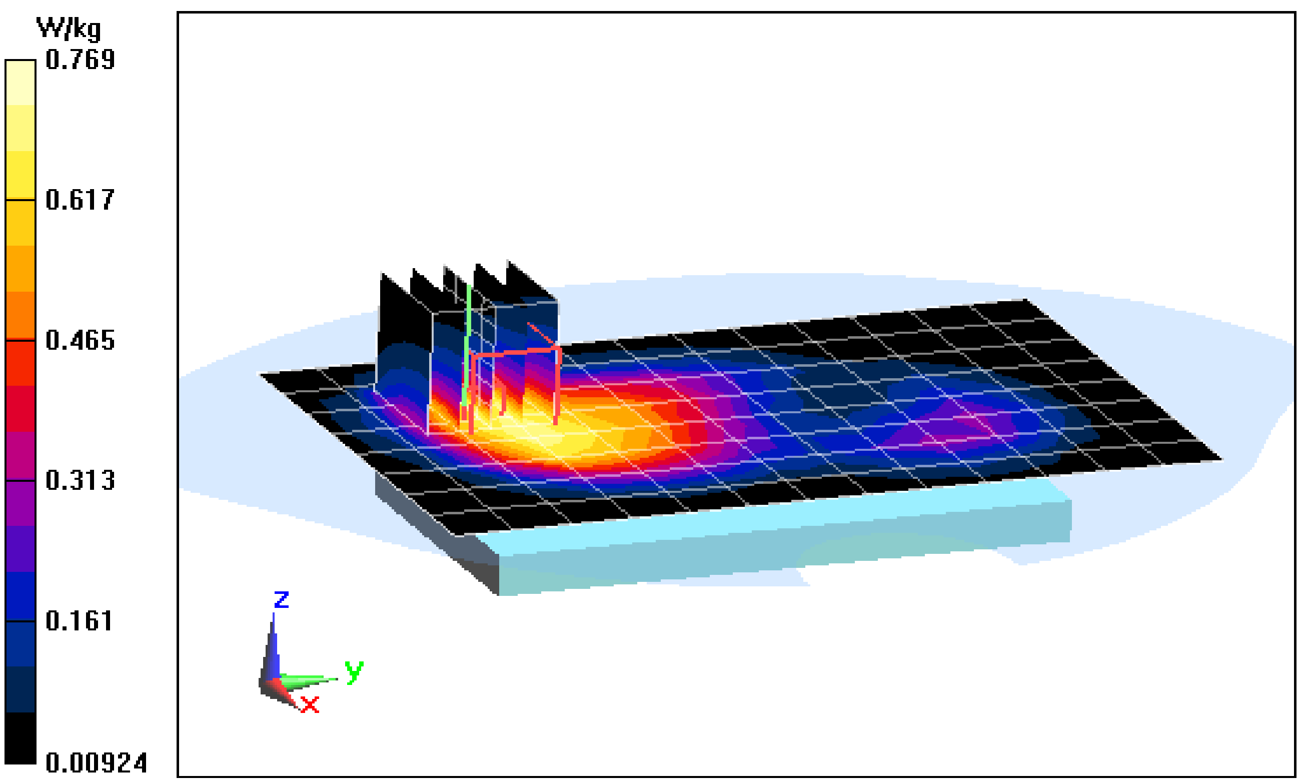
Communication System: UID 0, CDMA; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.558 S/m; $\varepsilon_r$ = 53.255; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: PCS EVDO, Body SAR, Front side, Mid.ch**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 21.10 V/m; Power Drift = 0.12 dB
Peak SAR (extrapolated) = 1.08 W/kg
**SAR(1 g) = 0.635 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00491**

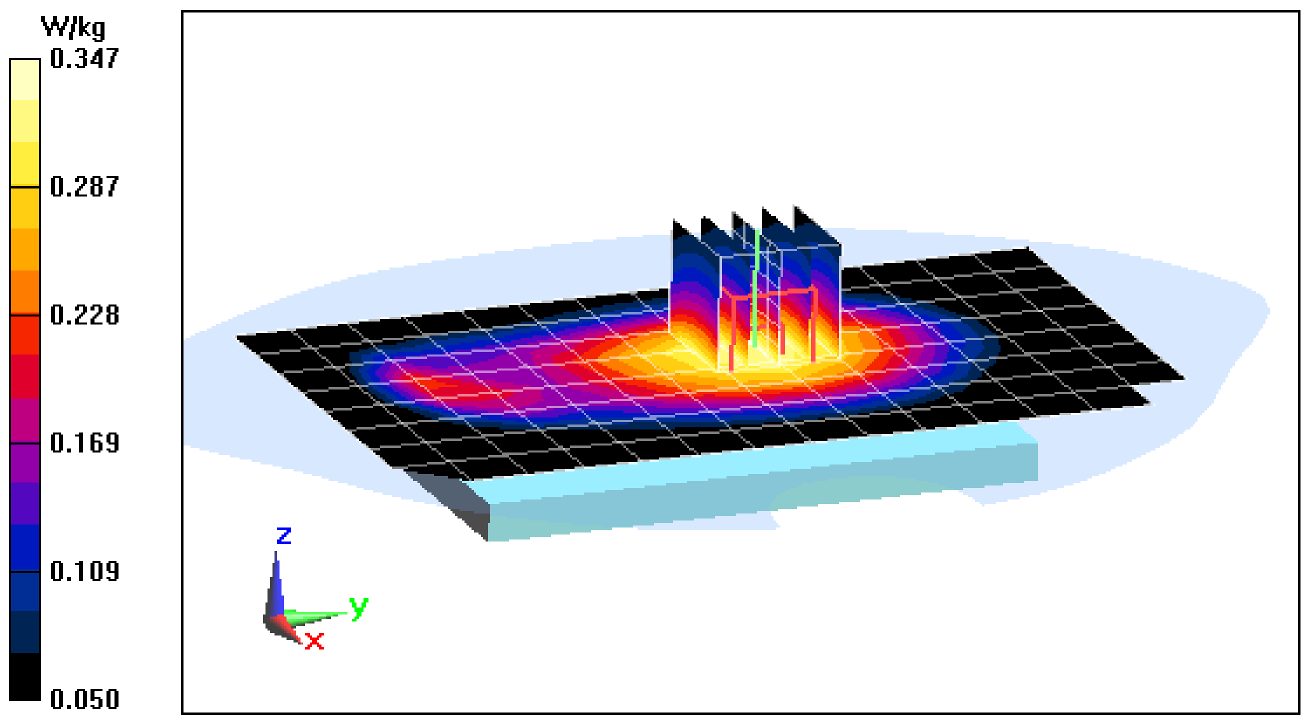
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 836.6 MHz; Duty Cycle: 1:4.15
Medium: 835 Body Medium parameters used (interpolated):
f = 836.6 MHz; $\sigma$ = 1.012 S/m; $\varepsilon_r$ = 53.372; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: GPRS 850, Body SAR, Back side, Mid.ch, 2 Tx Slots

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 18.43 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 0.399 W/kg
**SAR(1 g) = 0.314 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

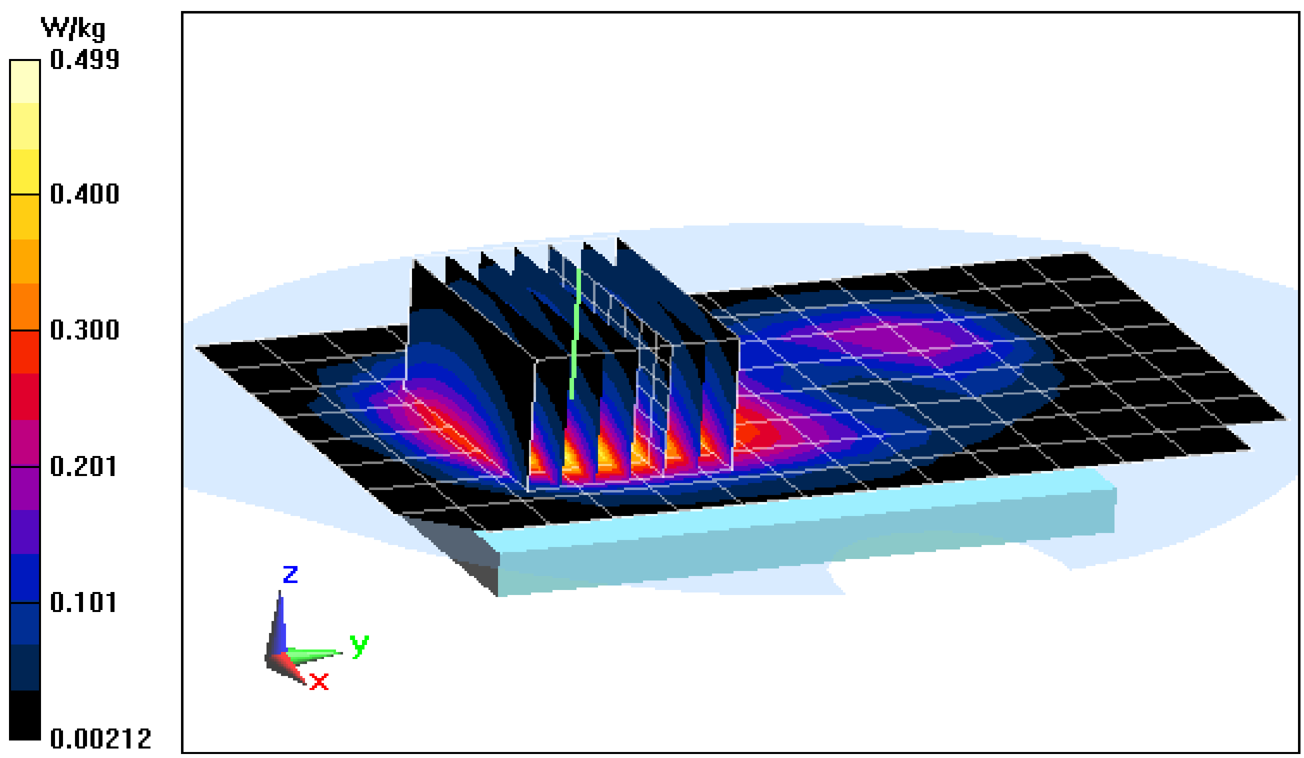
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 1880 MHz; Duty Cycle: 1:4.15
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.558 S/m; $\varepsilon_r$ = 53.255; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: GPRS 1900, Body SAR, Back side, Mid.ch, 2 Tx Slots

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (9x7x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 16.48 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 0.668 W/kg
**SAR(1 g) = 0.436 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00491**

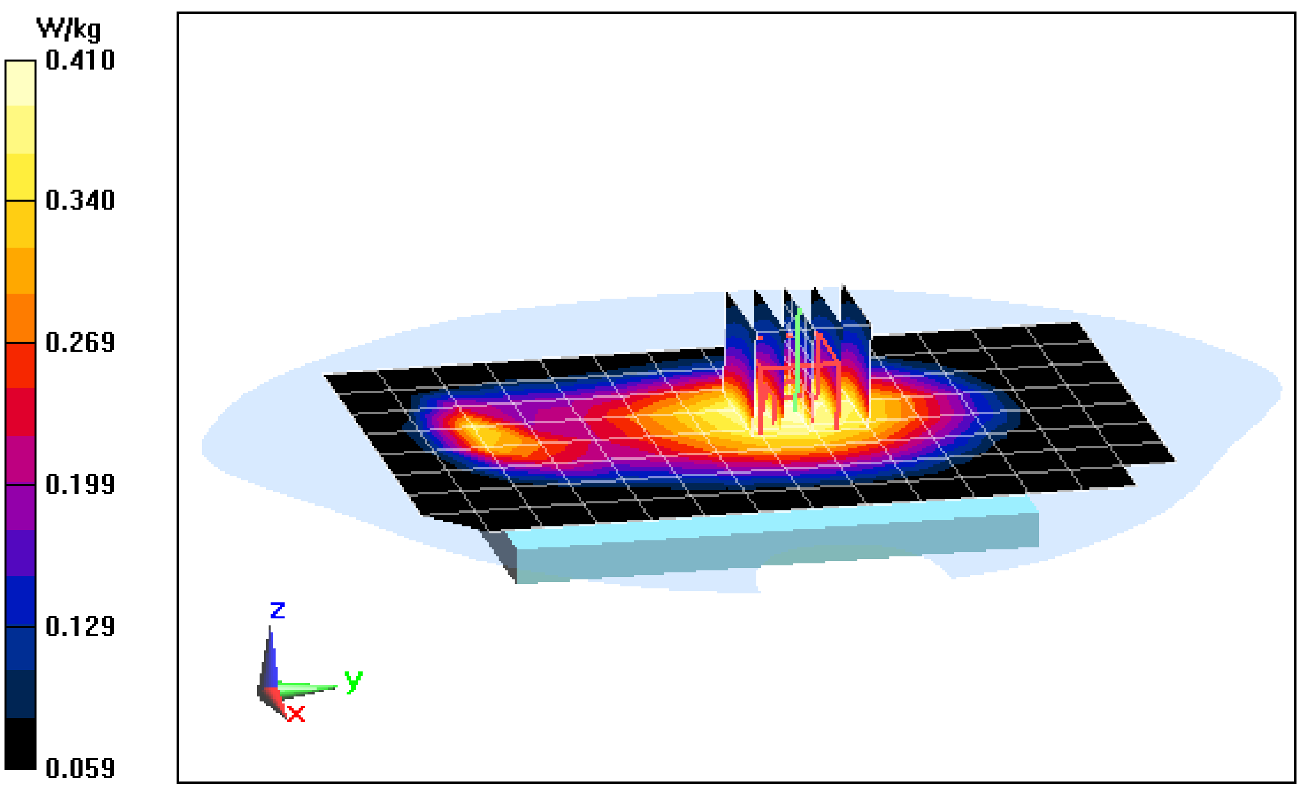
Communication System: UID 0, UMTS; Frequency: 836.6 MHz; Duty Cycle: 1:1
Medium: 835 Body Medium parameters used (interpolated):
f = 836.6 MHz; $\sigma$ = 1.012 S/m; $\varepsilon_r$ = 53.372; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: UMTS 850, Body SAR, Back side, Mid.ch**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.72 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 0.470 W/kg
**SAR(1 g) = 0.373 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

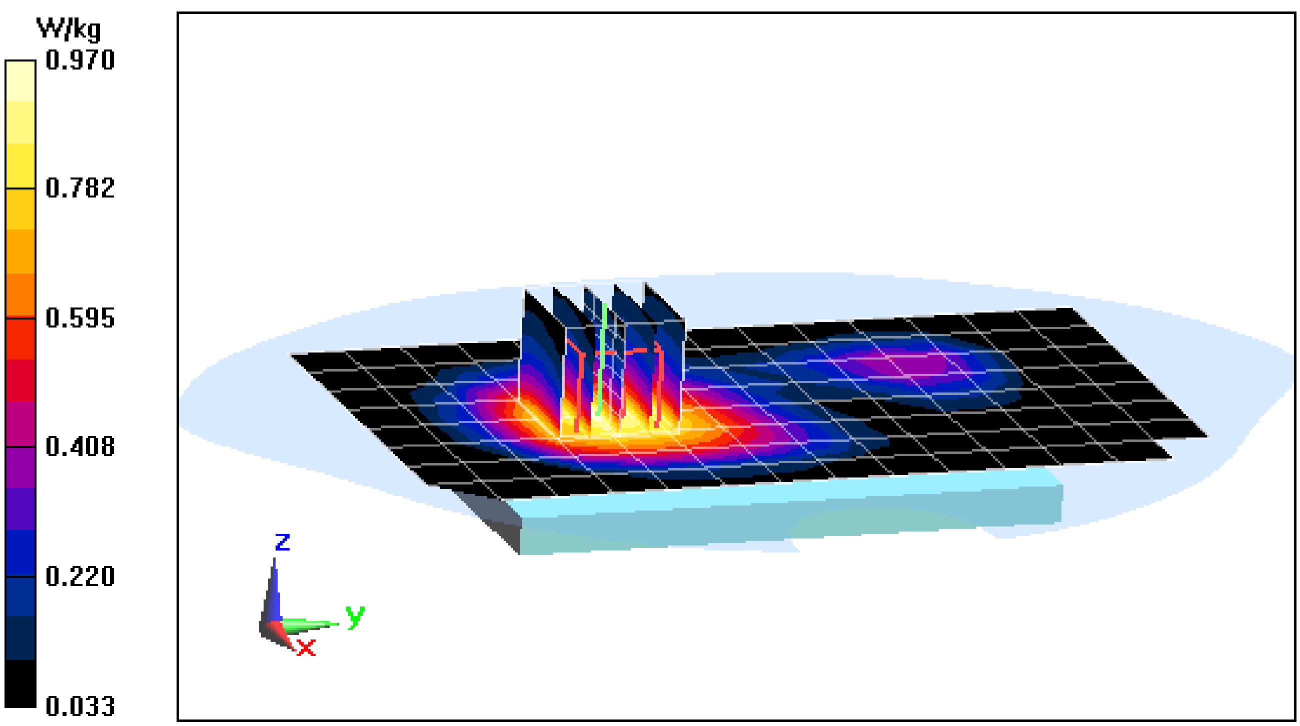
Communication System: UID 0, UMTS; Frequency: 1732.4 MHz; Duty Cycle: 1:1
Medium: 1750 Body Medium parameters used (interpolated):
f = 1732.4 MHz; $\sigma$ = 1.481 S/m; $\varepsilon_r$ = 53.178; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 22.3°C; Tissue Temp: 21.1°C

Probe: EX3DV4 - SN7406; ConvF(7.78, 7.78, 7.78); Calibrated: 4/19/2016;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 4/14/2016
Phantom: SAM 5.0 front; Type: QD000P40CD; Serial: TP:-1648
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: UMTS 1750, Body SAR, Back side, Mid.ch**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 26.45 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 1.11 W/kg
**SAR(1 g) = 0.736 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

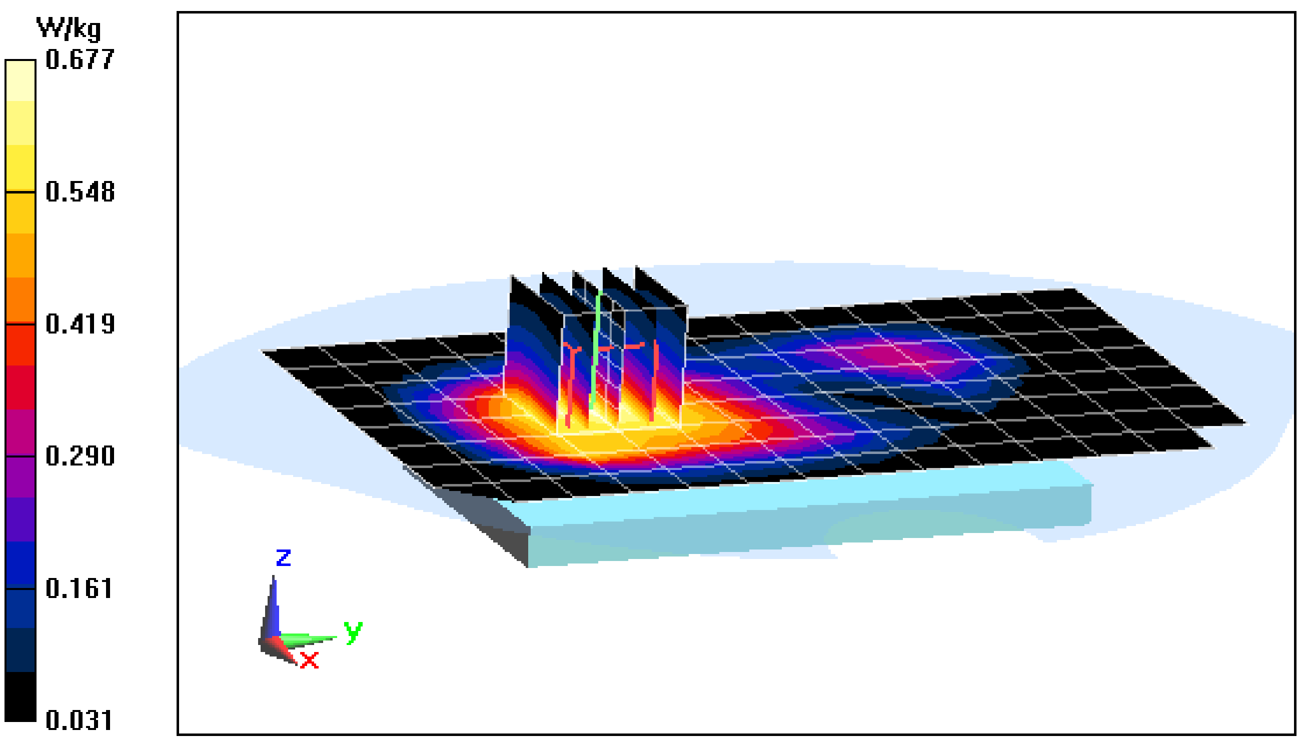
Communication System: UID 0, UMTS; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; σ = 1.558 S/m; $\varepsilon_r$ = 53.255; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: UMTS 1900, Body SAR, Back side, Mid.ch**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.48 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 0.877 W/kg
**SAR(1 g) = 0.591 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

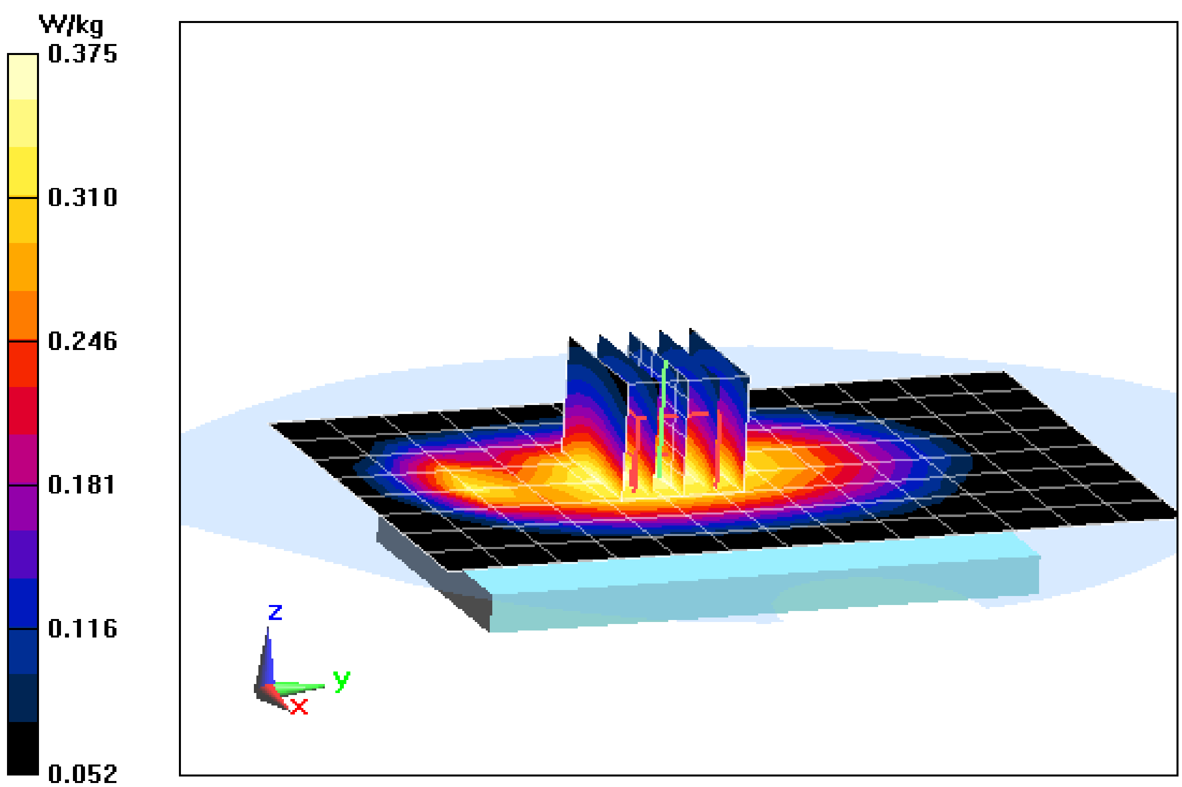
Communication System: UID 0, LTE Band 12; Frequency: 707.5 MHz; Duty Cycle: 1:1
Medium: 750 Body Medium parameters used (interpolated):
f = 707.5 MHz; $\sigma$ = 0.928 S/m; $\varepsilon_r$ = 56.052; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.2°C; Tissue Temp: 22.5°C

Probe: ES3DV3 - SN3334; ConvF(6.37, 6.37, 6.37); Calibrated: 11/17/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1415; Calibrated: 11/11/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 12, Body SAR, Back side, Mid.ch,**
**10 MHz Bandwidth, QPSK, 1 RB, 0 RB Offset**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 19.31 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.425 W/kg
**SAR(1 g) = 0.344 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00483**

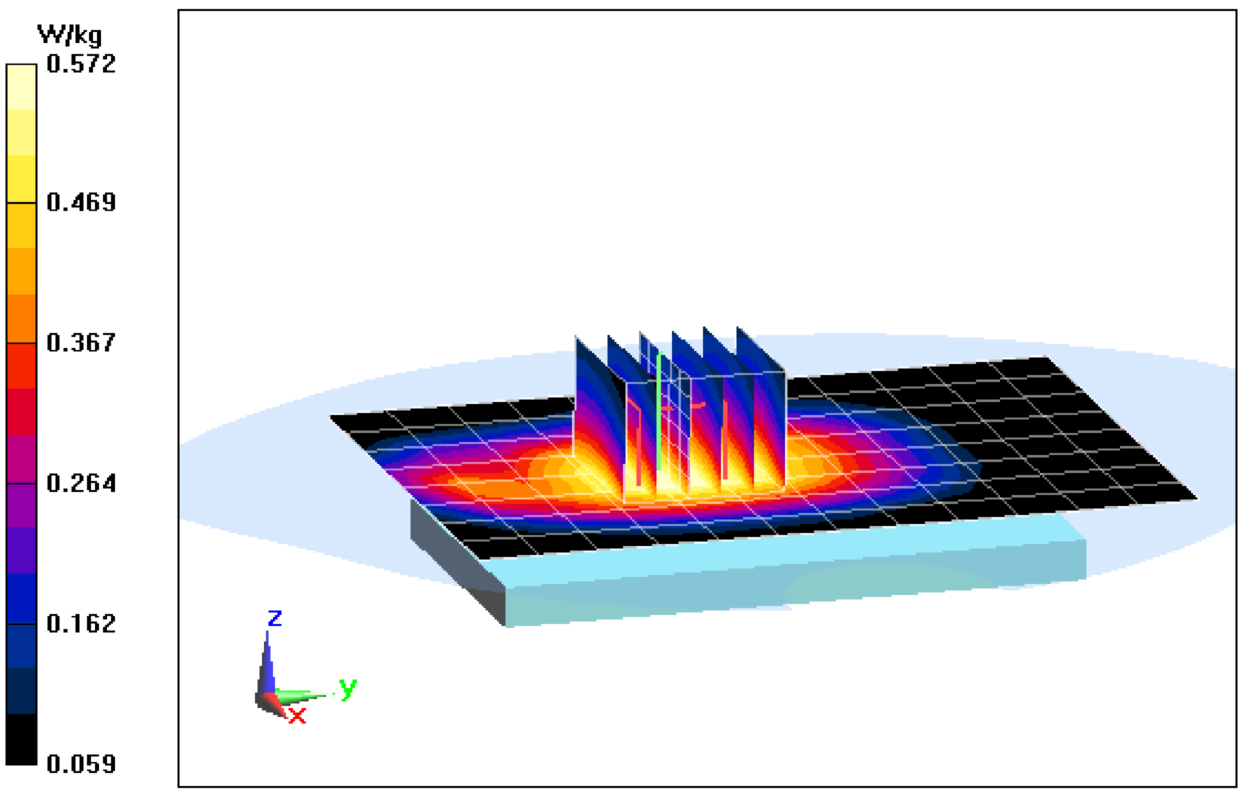
Communication System: UID 0, LTE Band 13; Frequency: 782 MHz; Duty Cycle: 1:1
Medium: 750 Body Medium parameters used (interpolated):
f = 782 MHz; $\sigma$ = 1.002 S/m; $\varepsilon_r$ = 55.353; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.2°C; Tissue Temp: 22.5°C

Probe: ES3DV3 - SN3334; ConvF(6.37, 6.37, 6.37); Calibrated: 11/17/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1415; Calibrated: 11/11/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 13, Body SAR, Back side, Mid.ch,**
**10 MHz Bandwidth, QPSK, 1 RB, 49 RB Offset**

**Area Scan (9x13x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 22.94 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.655 W/kg
**SAR(1 g) = 0.525 W/kg**



**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

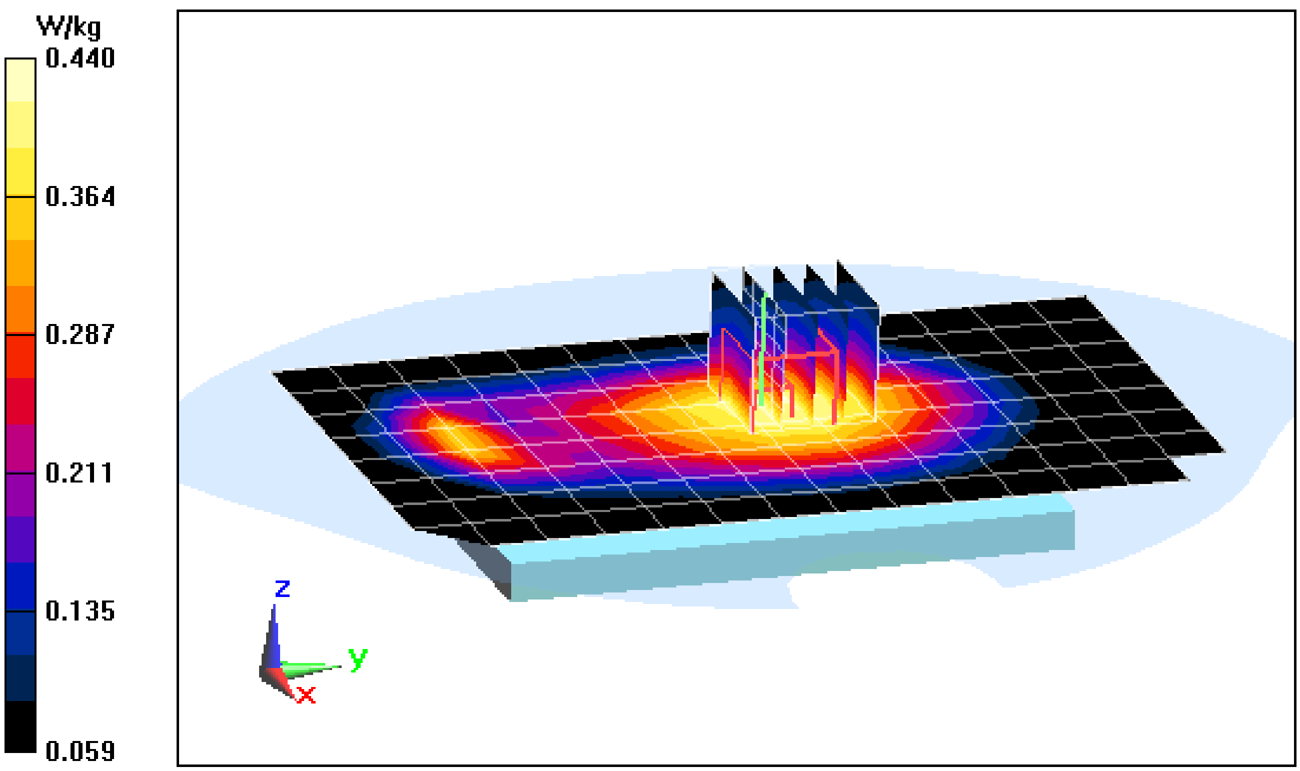
Communication System: UID 0, LTE Band 5; Frequency: 836.5 MHz; Duty Cycle: 1:1
Medium: 835 Body Medium parameters used (interpolated):
f = 836.5 MHz; $\sigma$ = 1.012 S/m; $\varepsilon_r$ = 53.374; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 5 (Cell.), Body SAR, Back side,**
**Mid.ch, 10 MHz Bandwidth, QPSK, 1 RB, 25 RB Offset**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.38 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.503 W/kg
**SAR(1 g) = 0.396 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

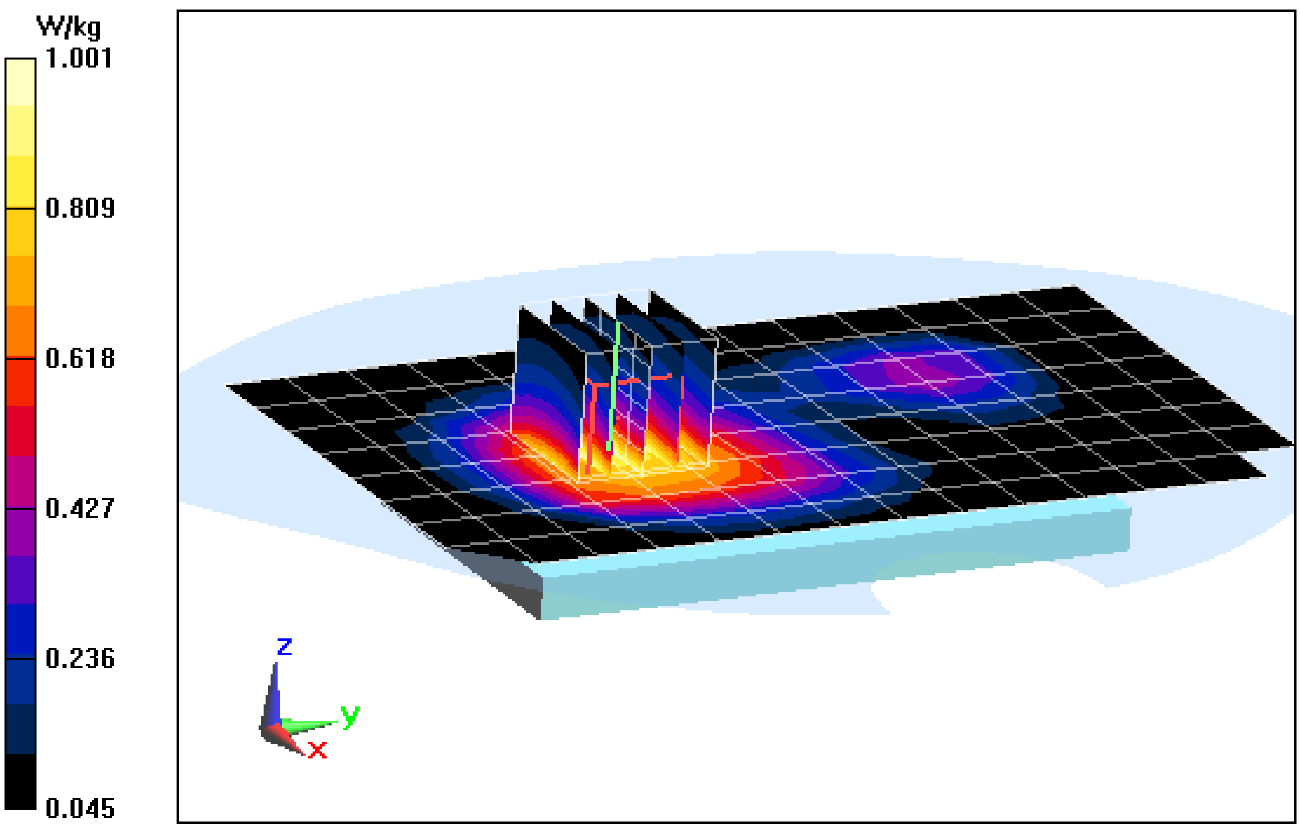
Communication System: UID 0, LTE Band 4 (AWS); Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium: 1750 Body Medium parameters used (interpolated):
f = 1732.5 MHz; σ = 1.481 S/m; $\varepsilon_r$ = 53.178; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 22.3°C; Tissue Temp: 21.1°C

Probe: EX3DV4 - SN7406; ConvF(7.78, 7.78, 7.78); Calibrated: 4/19/2016;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 4/14/2016
Phantom: SAM 5.0 front; Type: QD000P40CD; Serial: TP:-1648
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 4 (AWS), Body SAR, Back side, Mid.ch,**
**20 MHz Bandwidth, QPSK, 1 RB, 99 RB Offset**

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 26.26 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 1.14 W/kg
**SAR(1 g) = 0.757 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

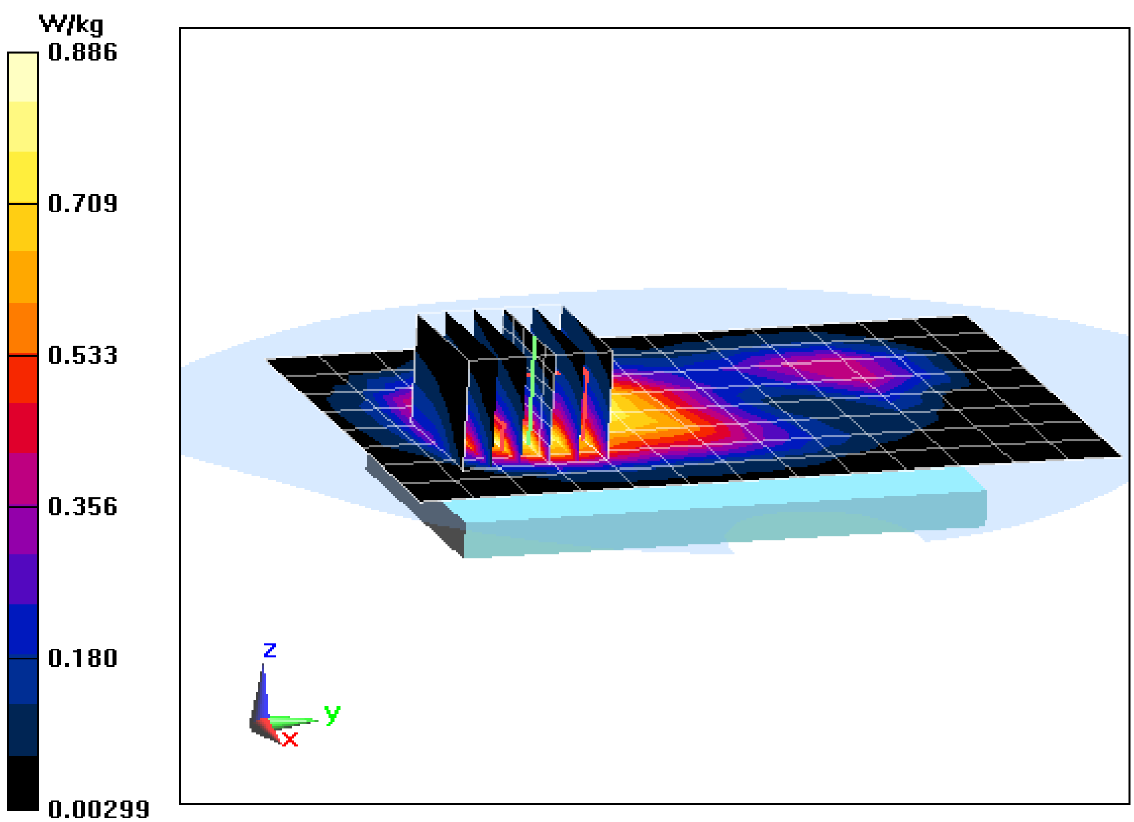
Communication System: UID 0, LTE Band 25 (PCS); Frequency: 1905 MHz; Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used (interpolated):
$f = 1905$ MHz; $\sigma = 1.586$ S/m; $\varepsilon_r = 53.18$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 25 (PCS), Body SAR, Back side, High.ch,
20 MHz Bandwidth, QPSK, 1 RB, 50 RB Offset**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x6x7)/Cube 1:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 22.97 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 1.36 W/kg
**SAR(1 g) = 0.747 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00475**

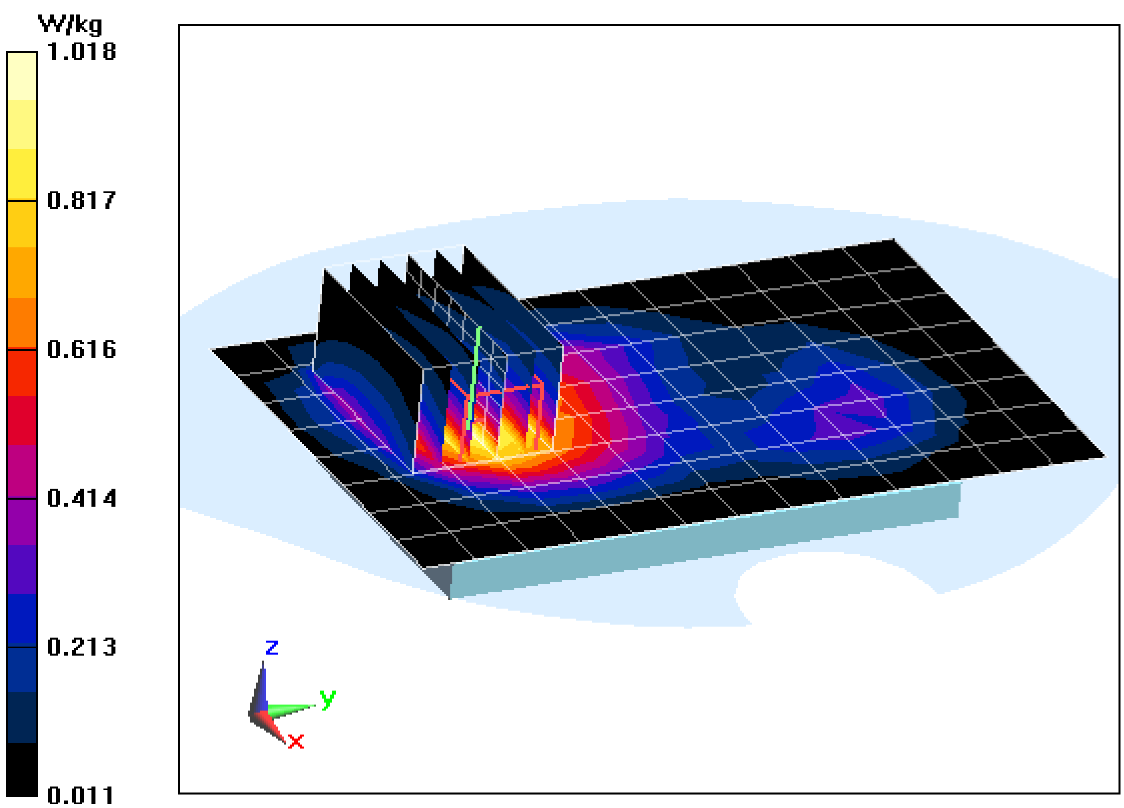
Communication System: UID 0, LTE Band 25 (PCS); Frequency: 1860 MHz; Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used (interpolated):
f = 1860 MHz; $\sigma$ = 1.537 S/m; $\varepsilon_r$ = 53.32; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

**Mode: LTE Band 25 (PCS), Body SAR, Front side, Low.ch,
20 MHz Bandwidth, QPSK, 1 RB, 50 RB Offset**

**Area Scan (9x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (8x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 24.08 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 1.32 W/kg
**SAR(1 g) = 0.870 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFUS610; Type: Portable Handset; Serial: 00541**

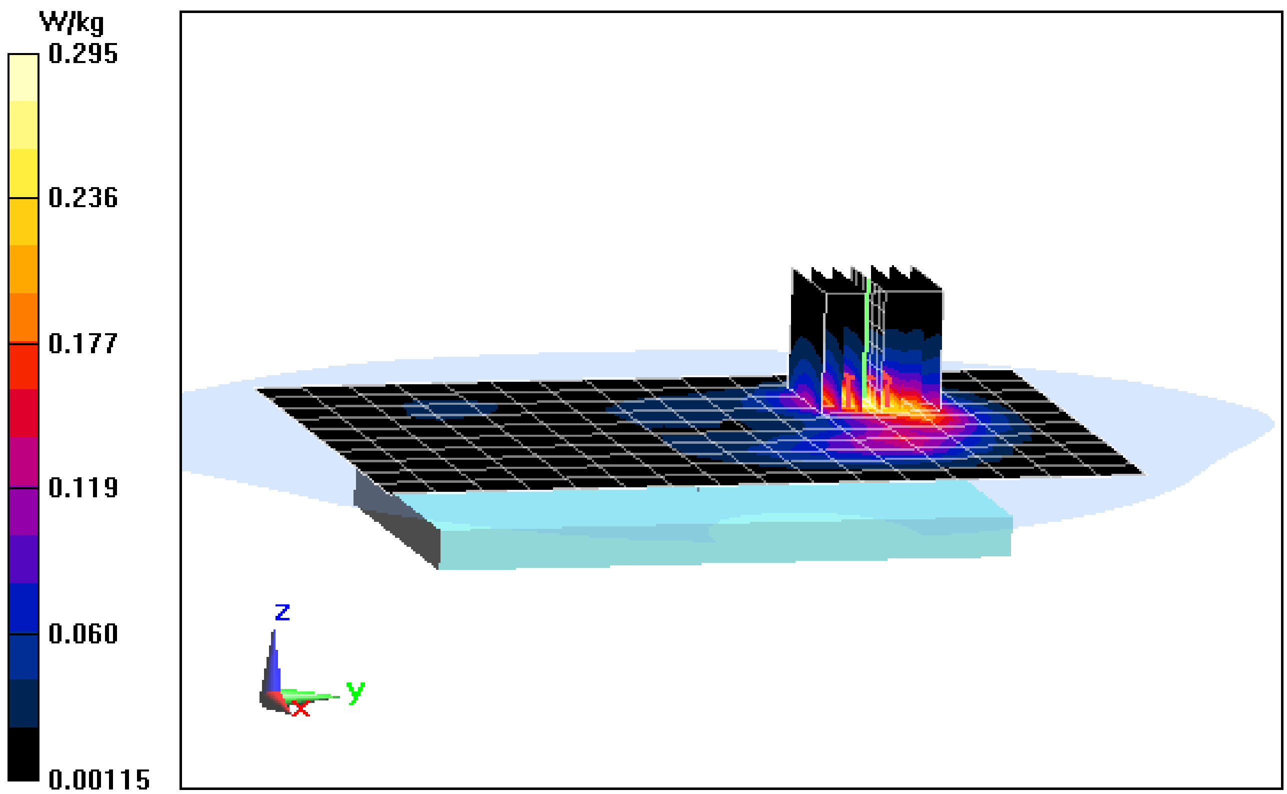
Communication System: UID 0, IEEE 802.11b; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium: 2450 Body Medium parameters used (interpolated):
f = 2412 MHz; $\sigma$ = 1.901 S/m; $\varepsilon_r$ = 51.878; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 20.8°C; Tissue Temp: 23.0°C

Probe: ES3DV3 - SN3334; ConvF(4.45, 4.45, 4.45); Calibrated: 11/17/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1415; Calibrated: 11/11/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## Mode: IEEE 802.11b, 22 MHz Bandwidth, Body SAR, Ch 01, 1 Mbps, Back Side

**Area Scan (11x17x1):** Measurement grid: dx=12mm, dy=12mm
**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 11.73 V/m; Power Drift = -0.10 dB
Peak SAR (extrapolated) = 0.505 W/kg
**SAR(1 g) = 0.227 W/kg**



# APPENDIX B: SYSTEM VERIFICATION

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 750 MHz; Type: D750V3; Serial: 1003**

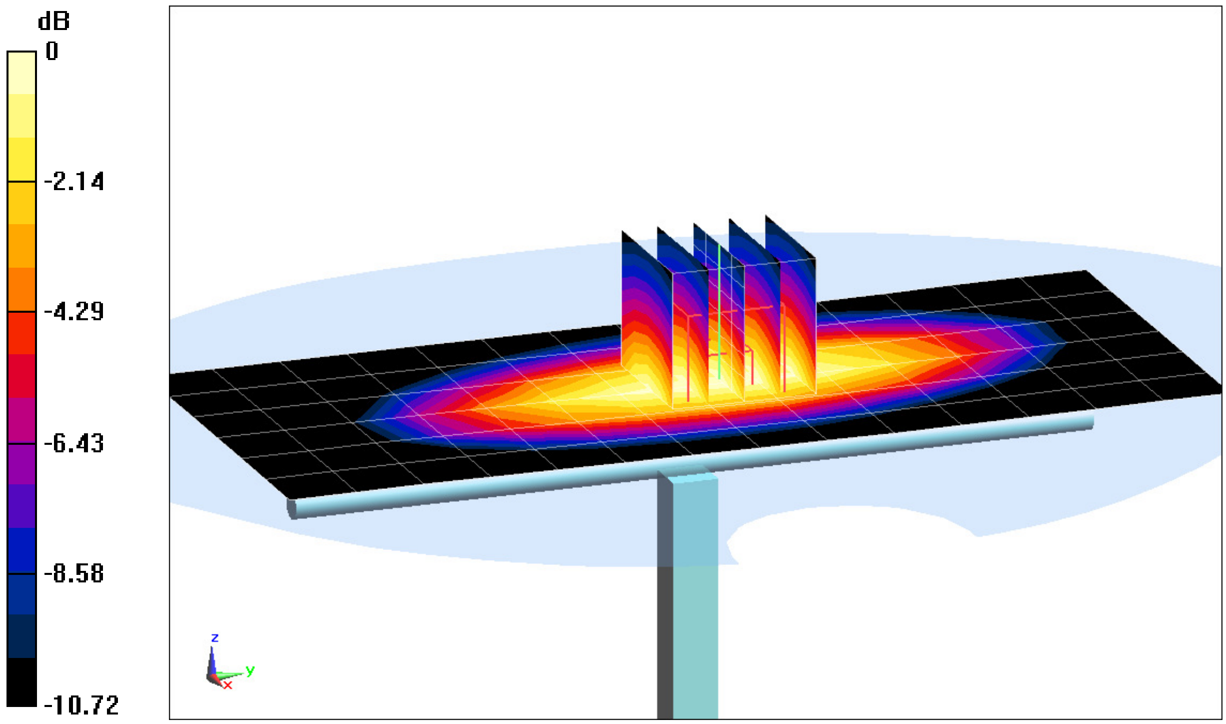
Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1
Medium: 750 Head Medium parameters used (interpolated):
f = 750 MHz; $\sigma$ = 0.906 S/m; $\varepsilon_r$ = 40.602; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-17-2016; Ambient Temp: 24.2°C; Tissue Temp: 22.3°C

Probe: ES3DV3 - SN3288; ConvF(6.69, 6.69, 6.69); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2015
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 750 MHz System Verification at 23.0 dBm (200 mW)

**Area Scan (7x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 2.44 W/kg
**SAR(1 g) = 1.63 W/kg**
Deviation(1 g) = -2.40%




0 dB = 1.91 W/kg = 2.81 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d132**

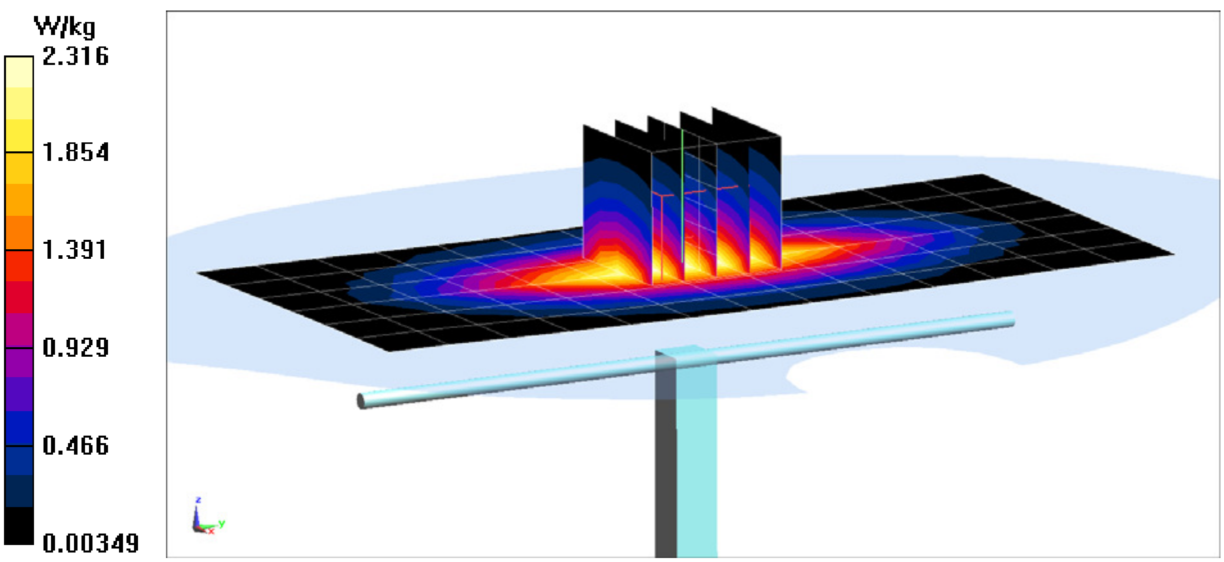
Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1
Medium: 835 Head Medium parameters used:
f = 835 MHz; σ = 0.924 S/m; $\varepsilon_r$ = 40.569; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-16-2016; Ambient Temp: 22.4°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3332; ConvF(6.23, 6.23, 6.23); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1466; Calibrated: 1/15/2016
Phantom: SAM Main; Type: QD000P40CC; Serial: TP 1114
Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

## 835 MHz System Verification at 23.0 dBm (200 mW)

**Area Scan (7x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 3.00 W/kg
**SAR(1 g) = 2.01 W/kg**
Deviation(1 g) = 6.12%



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: 1148**

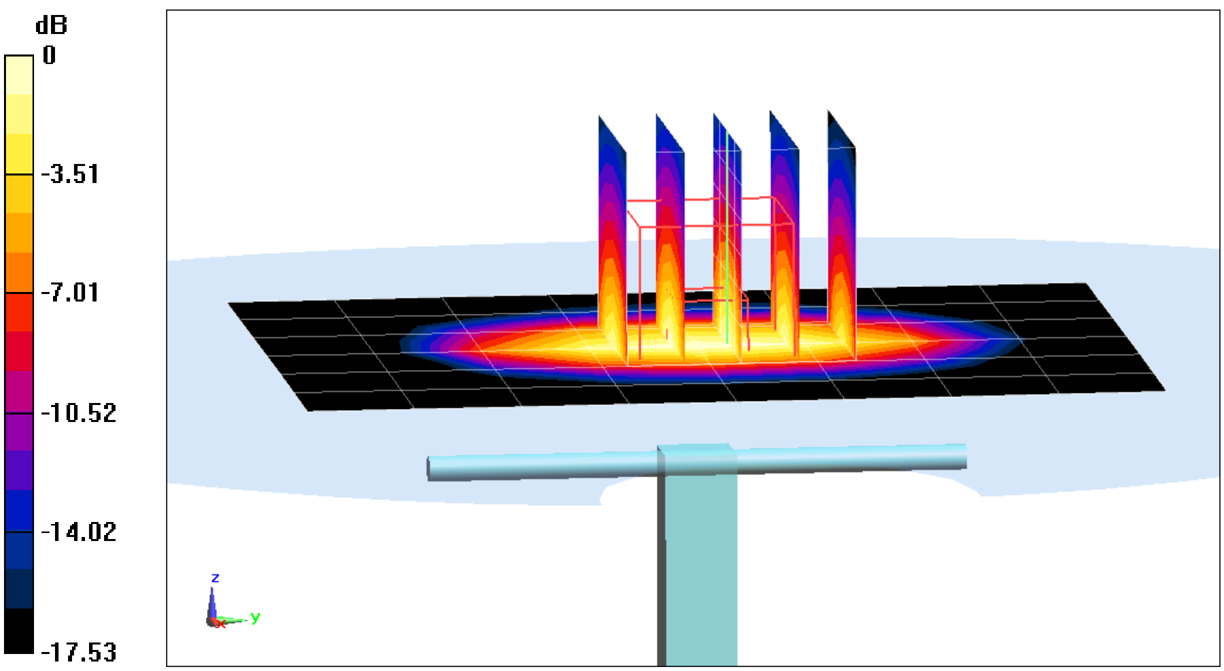
Communication System: UID 0, CW; Frequency: 1750 MHz; Duty Cycle: 1:1
Medium: 1750 Head Medium parameters used:
f = 1750 MHz; $\sigma$ = 1.374 S/m; $\varepsilon_r$ = 39.385; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section ; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.3°C

Probe: ES3DV2 - SN3022; ConvF(5.08, 5.08, 5.08); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Left; Type: QD000P40CC; Serial: TP: 1375
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 1750 MHz System Verification at 20.0 dBm (100 mW)

**Area Scan (7x9x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 6.38 W/kg
**SAR(1 g) = 3.55 W/kg**
Deviation(1 g) = -1.93%




0 dB = 4.44 W/kg = 6.47 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: 5d149**

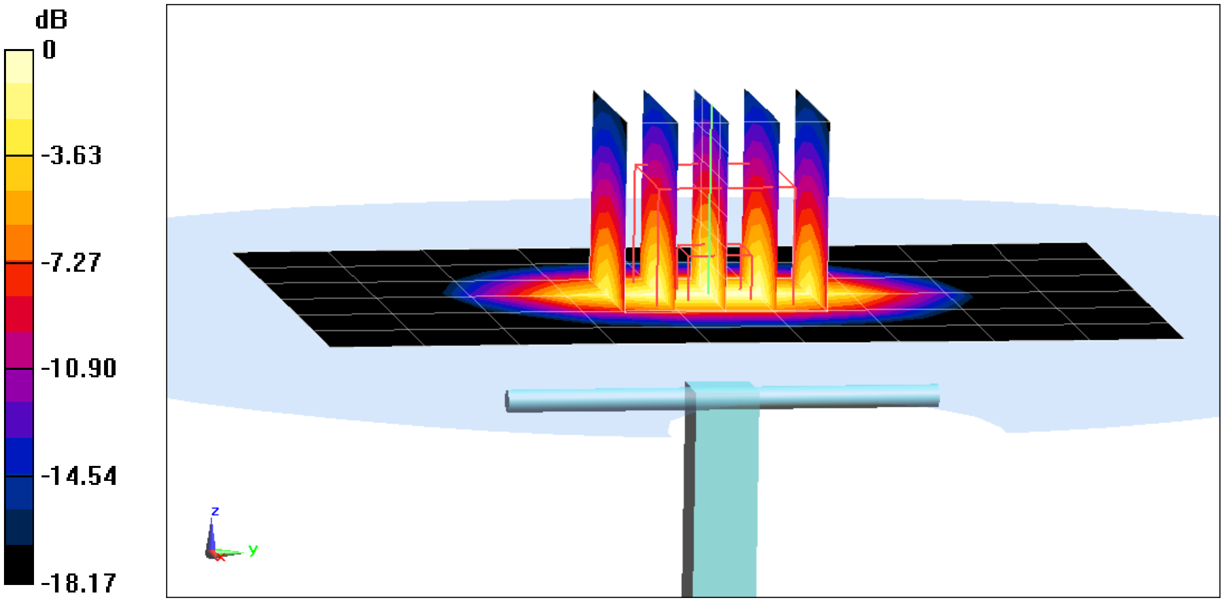
Communication System: UID 0, CW; Frequency: 1900 MHz; Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used (interpolated):
f = 1900 MHz; $\sigma$ = 1.446 S/m; $\varepsilon_r$ = 39.033; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section ; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 22.2°C; Tissue Temp: 21.3°C

Probe: ES3DV2 - SN3022; ConvF(4.93, 4.93, 4.93); Calibrated: 8/26/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/16/2015
Phantom: SAM Right; Type: QD000P40CD; Serial: TP:7535
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**1900 MHz System Verification at 20.0 dBm (100 mW)**

**Area Scan (7x10x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 7.79 W/kg
**SAR(1 g) = 4.19 W/kg**
Deviation(1 g) = 2.95%




0 dB = 5.35 W/kg = 7.28 dBW/kg

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 797**

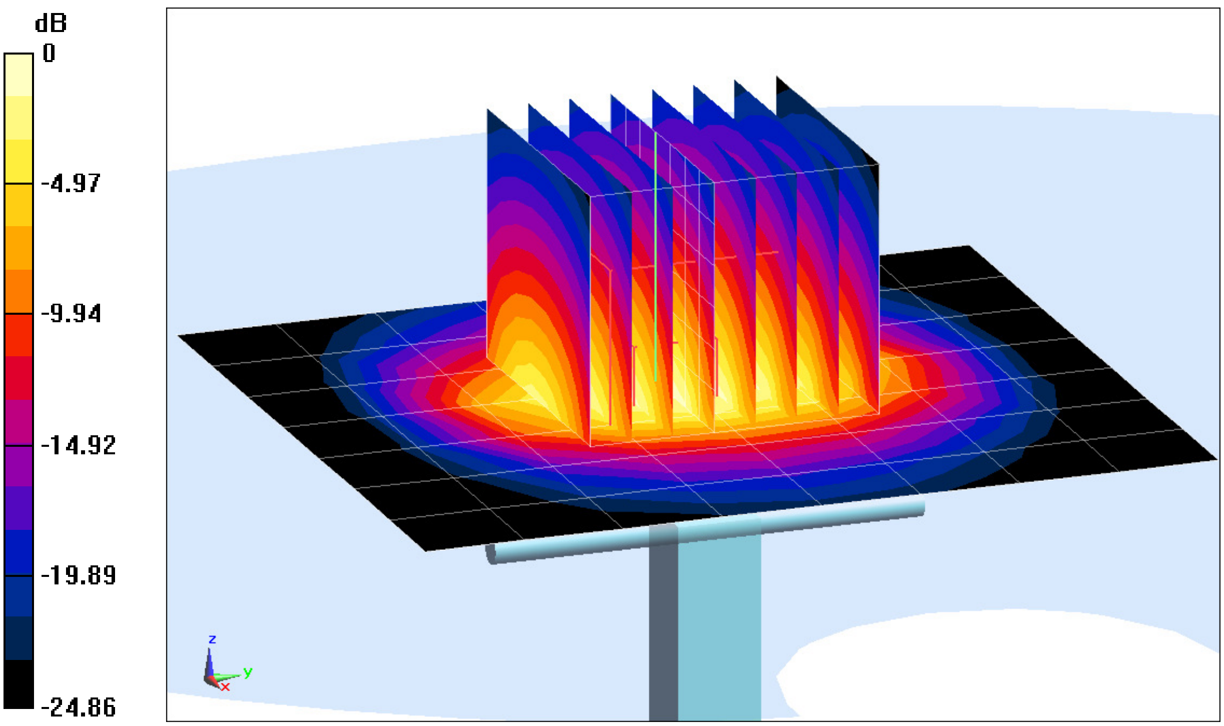
Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: 2450 Head Medium parameters used:
f = 2450 MHz; $\sigma$ = 1.875 S/m; $\varepsilon_r$ = 39.613; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 23.5°C

Probe: ES3DV3 - SN3288; ConvF(4.57, 4.57, 4.57); Calibrated: 9/18/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2015
Phantom: Sub TWIN SAM; Type: QD000P40CC; Serial: TP-1357
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 2450 MHz System Verification at 20.0 dBm (100 mW)

**Area Scan (8x9x1):** Measurement grid: dx=12mm, dy=12mm
**Zoom Scan (8x8x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Peak SAR (extrapolated) = 10.5 W/kg
**SAR(1 g) = 5.18 W/kg**
Deviation(1 g) = -1.71%




0 dB = 6.58 W/kg = 8.18 dBW/kg

**DUT: Dipole 750 MHz; Type: D750V3; Serial: 1046**

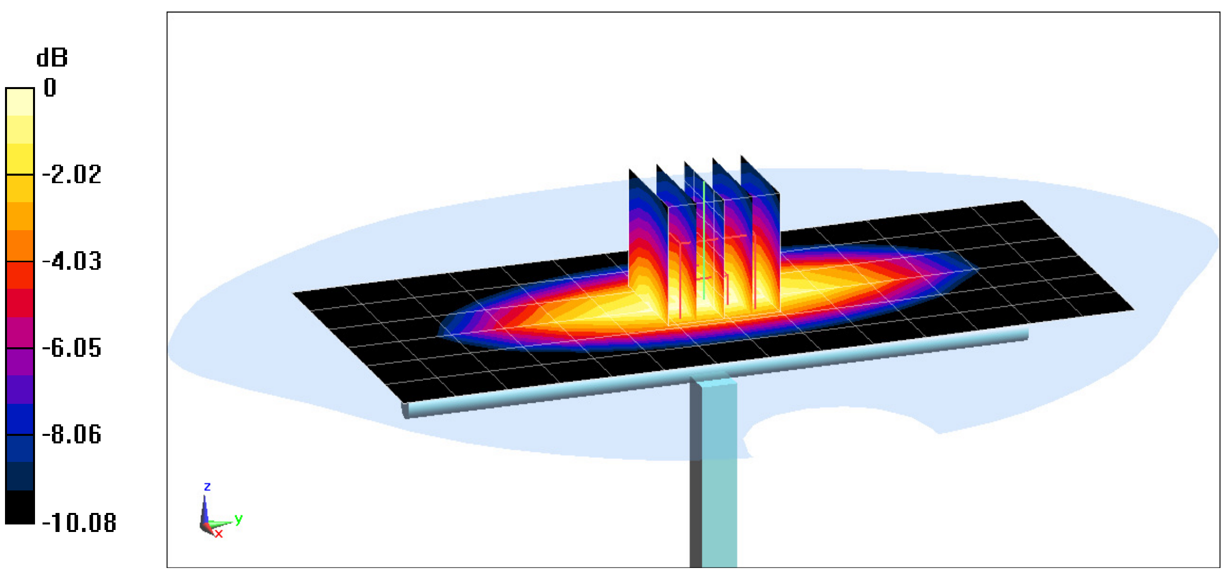
Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1
Medium: 750 Body Medium parameters used (interpolated):
f = 750 MHz; $\sigma$ = 0.97 S/m; $\varepsilon_r$ = 55.664; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-17-2016; Ambient Temp: 21.2°C; Tissue Temp: 22.5°C

Probe: ES3DV3 - SN3334; ConvF(6.37, 6.37, 6.37); Calibrated: 11/17/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1415; Calibrated: 11/11/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**750 MHz System Verification at 23.0 dBm (200 mW)**

**Area Scan (7x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 2.55 W/kg
**SAR(1 g) = 1.75 W/kg**
Deviation(1 g) = -0.23%




0 dB = 2.04 W/kg = 3.10 dBW/kg

**DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d119**

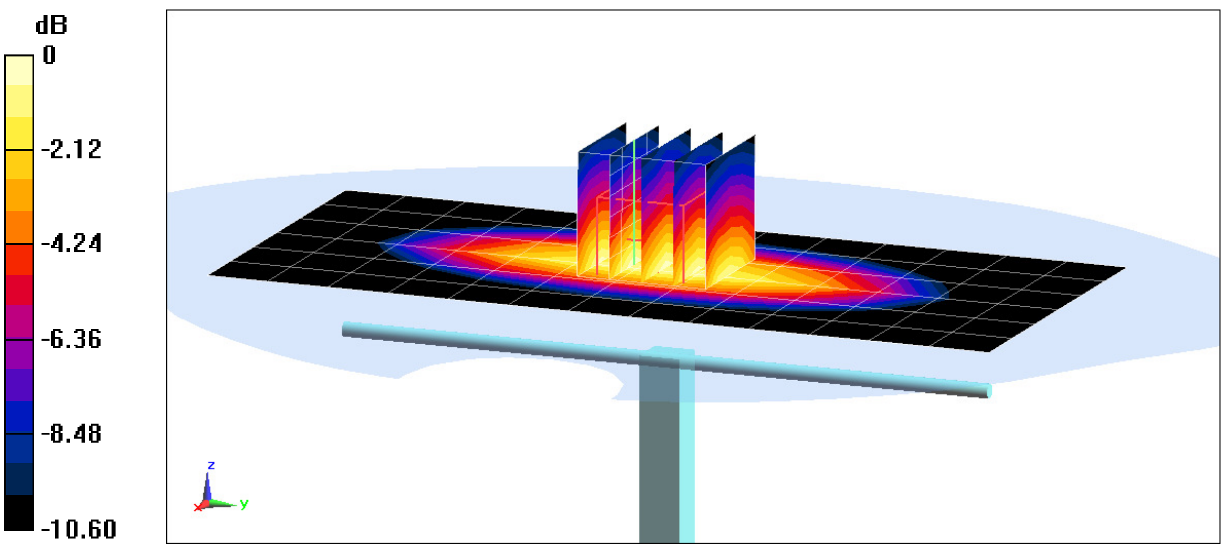
Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1
Medium: 835 Body Medium parameters used:
f = 835 MHz; $\sigma$ = 1.01 S/m; $\varepsilon_r$ = 53.394; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-17-2016; Ambient Temp: 21.6°C; Tissue Temp: 21.6°C

Probe: ES3DV3 - SN3318; ConvF(6.11, 6.11, 6.11); Calibrated: 2/19/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/19/2016
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**835 MHz System Verification at 23.0 dBm (200 mW)**

**Area Scan (7x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 2.89 W/kg
**SAR(1 g) = 1.95 W/kg**
Deviation(1 g) = 6.67%




0 dB = 2.33 W/kg = 3.67 dBW/kg

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: 1051**

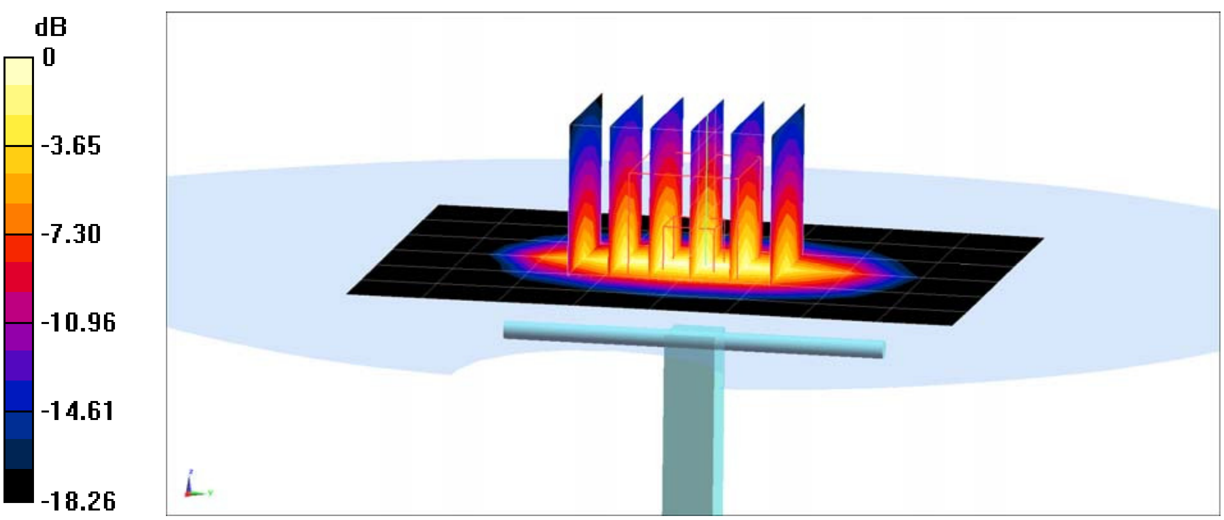
Communication System: UID 0, CW; Frequency: 1750 MHz; Duty Cycle: 1:1
Medium: 1750 Body Medium parameters used:
f = 1750 MHz; σ = 1.502 S/m; $\varepsilon_r$ = 53.094; ρ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-17-2016; Ambient Temp: 22.3°C; Tissue Temp: 21.1°C

Probe: EX3DV4 - SN7406; ConvF(7.78, 7.78, 7.78); Calibrated: 4/19/2016;
Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 4/14/2016
Phantom: SAM 5.0 front; Type: QD000P40CD; Serial: TP:-1648
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 1750 MHz System Verification at 20.0 dBm (100 mW)

**Area Scan (7x9x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 6.85 W/kg
**SAR(1 g) = 3.83 W/kg**
Deviation(1 g) = 4.93%




0 dB = 5.80 W/kg = 7.63 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: 5d149**

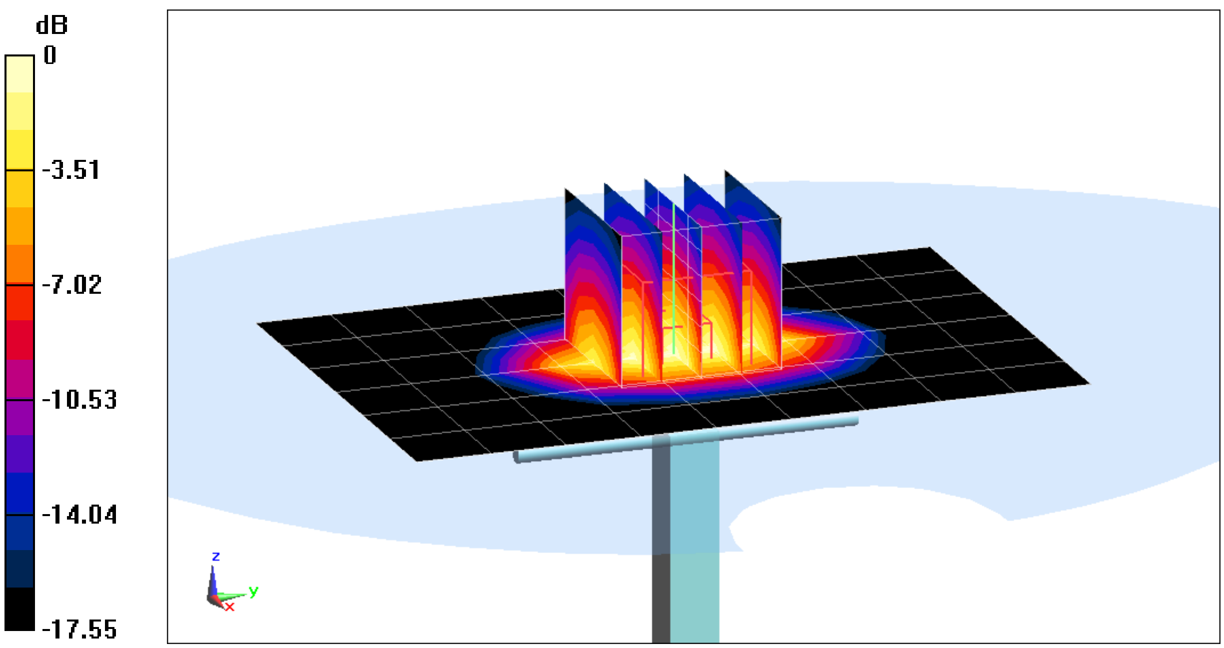
Communication System: UID 0, CW; Frequency: 1900 MHz; Duty Cycle: 1:1
Medium: 1900 Body; Medium parameters used (interpolated):
f = 1900 MHz; $\sigma$ = 1.581 S/m; $\varepsilon_r$ = 53.195; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 23.5°C; Tissue Temp: 22.4°C

Probe: ES3DV3 - SN3319; ConvF(4.7, 4.7, 4.7); Calibrated: 3/18/2016;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1368; Calibrated: 3/14/2016
Phantom: SAM with CRP (Left); Type: SAM; Serial: 1715
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 1900 MHz System Verification at 20.0 dBm (100 mW)

**Area Scan (7x10x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 7.26 W/kg
**SAR(1 g) = 4.06 W/kg**
Deviation(1 g) = 0.50%




0 dB = 5.16 W/kg = 7.13 dBW/kg

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 882**

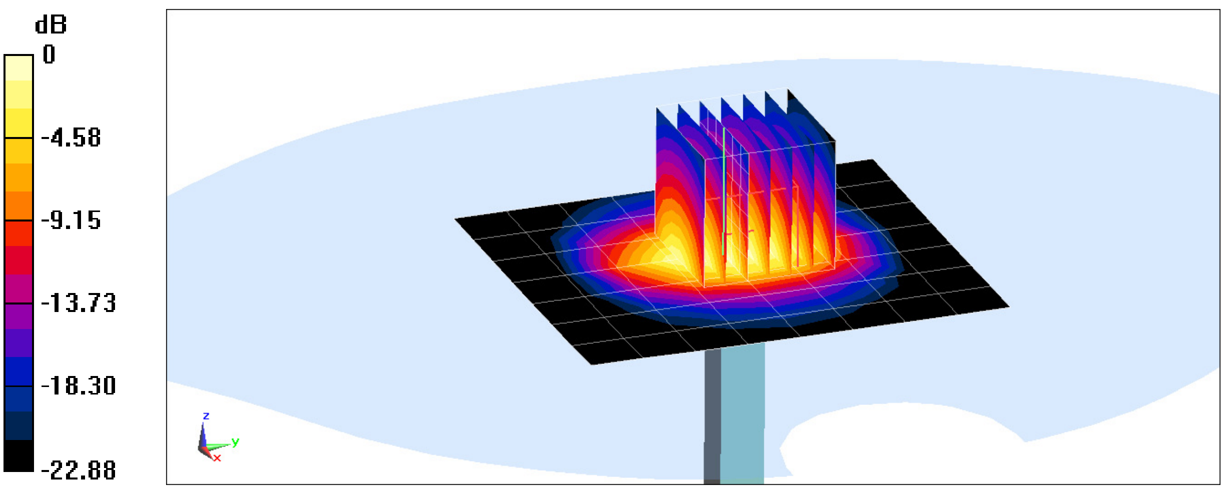
Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: 2450 Body Medium parameters used:
f = 2450 MHz; $\sigma$ = 1.947 S/m; $\varepsilon_r$ = 51.717; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-16-2016; Ambient Temp: 20.8°C; Tissue Temp: 23.0°C

Probe: ES3DV3 - SN3334; ConvF(4.45, 4.45, 4.45); Calibrated: 11/17/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1415; Calibrated: 11/11/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 2450 MHz System Verification at 20.0 dBm (100 mW)

**Area Scan (8x9x1):** Measurement grid: dx=12mm, dy=12mm
**Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Peak SAR (extrapolated) = 10.8 W/kg
**SAR(1 g) = 5.13 W/kg**
Deviation(1 g) = 3.85%




0 dB = 7.03 W/kg = 8.47 dBW/kg

# APPENDIX C: PROBE CALIBRATION

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**Client** PC Test

**Certificate No: D750V3-1003_Jan16**

# CALIBRATION CERTIFICATE

Object: D750V3 - SN:1003

Calibration procedure(s): QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

BN ✓
1/28/2016

Calibration date: January 15, 2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 15, 2016

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Swiss Calibration Service

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The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 750 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.9 | 0.89 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 42.2 ± 6 % | 0.91 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.12 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **8.35 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.39 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **5.49 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.5 | 0.96 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 55.4 ± 6 % | 0.98 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.20 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **8.66 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.45 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **5.73 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 53.7 Ω - 2.3 jΩ |
| Return Loss | - 27.6 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 49.3 Ω - 4.3 jΩ |
| Return Loss | - 27.3 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.043 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

## Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | January 21, 2009 |

Date: 15.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

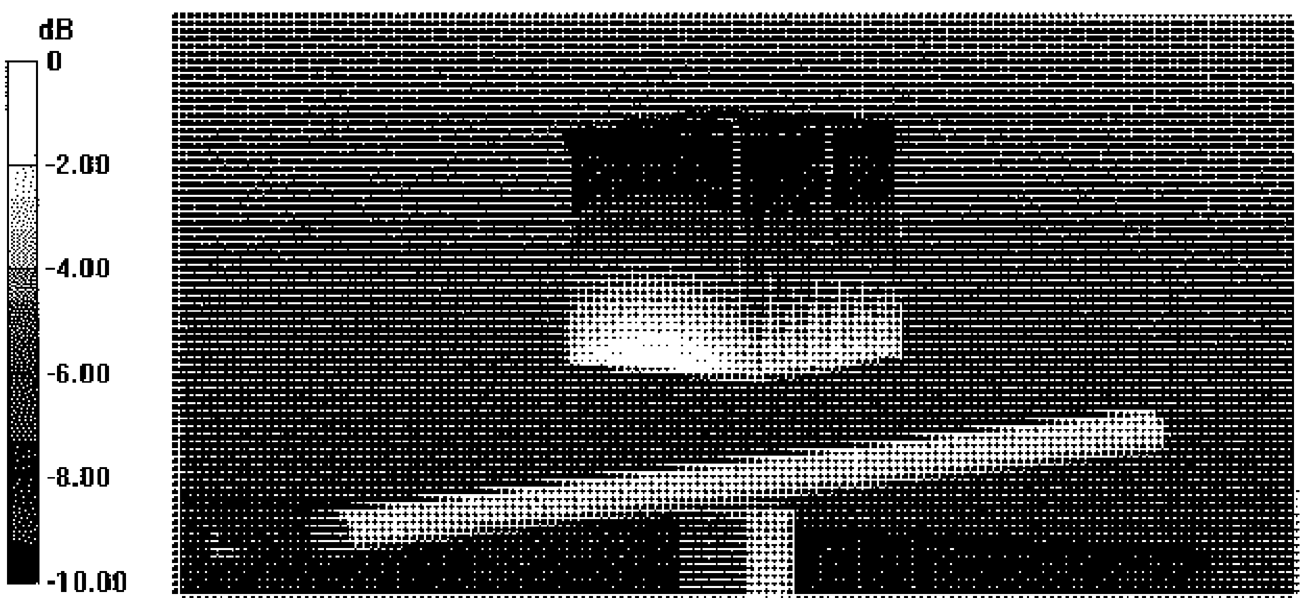
**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1003**

Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma$ = 0.91 S/m; $\varepsilon_r$ = 42.2; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

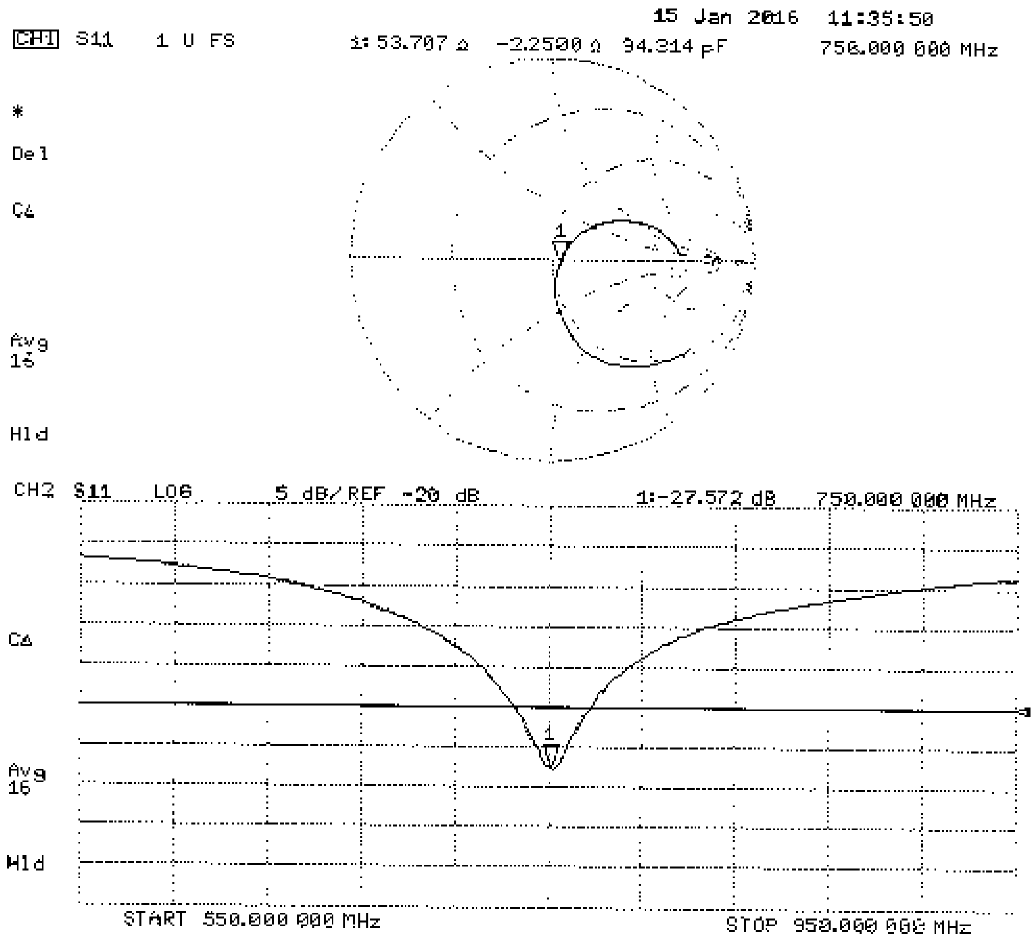
- Probe: EX3DV4 - SN7349; ConvF(10.28, 10.28, 10.28); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 58.50 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.18 W/kg
**SAR(1 g) = 2.12 W/kg; SAR(10 g) = 1.39 W/kg**
Maximum value of SAR (measured) = 2.83 W/kg




0 dB = 2.83 W/kg = 4.52 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 15.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

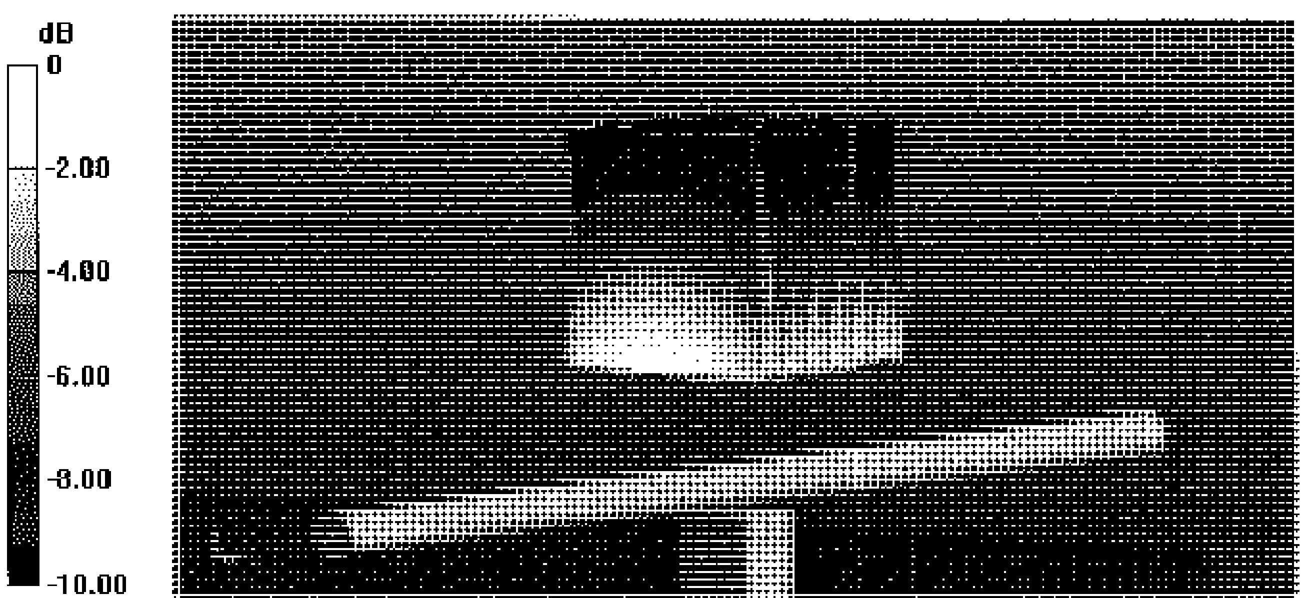
**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1003**

Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma = 0.98$ S/m; $\varepsilon_r = 55.4$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

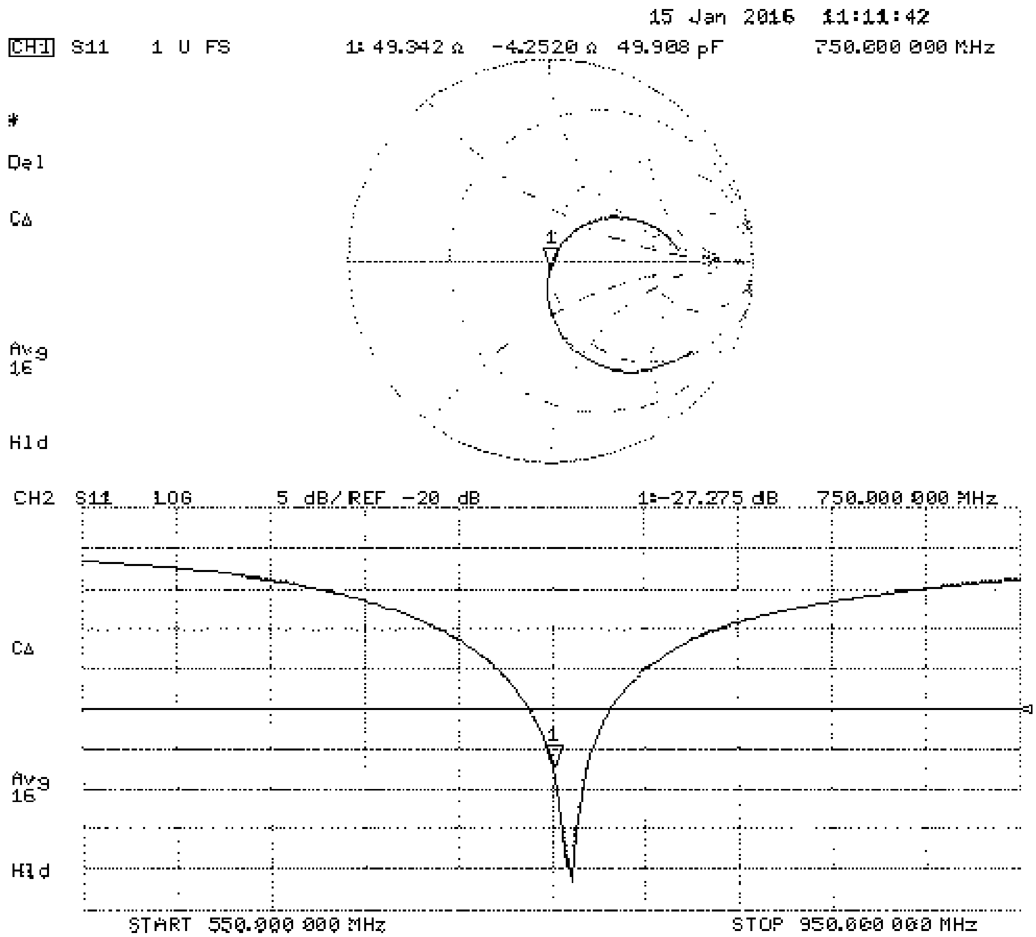
- Probe: EX3DV4 - SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.97 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.27 W/kg
**SAR(1 g) = 2.2 W/kg; SAR(10 g) = 1.45 W/kg**
Maximum value of SAR (measured) = 2.91 W/kg




0 dB = 2.91 W/kg = 4.64 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
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**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D835V2-4d132_Jan16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D835V2 - SN: 4d132 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | January 20, 2016 |

BNV
1/28/2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 20, 2016

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 835 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.5 | 0.90 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 42.0 ± 6 % | 0.93 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.47 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.57 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.17 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.2 | 0.97 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 55.2 ± 6 % | 1.01 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.49 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.66 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.63 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.37 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.2 Ω - 2.7 jΩ |
| Return Loss | - 30.8 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 47.8 Ω - 4.9 jΩ |
| Return Loss | - 25.3 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.388 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | July 22, 2011 |

## DASY5 Validation Report for Head TSL

Date: 20.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

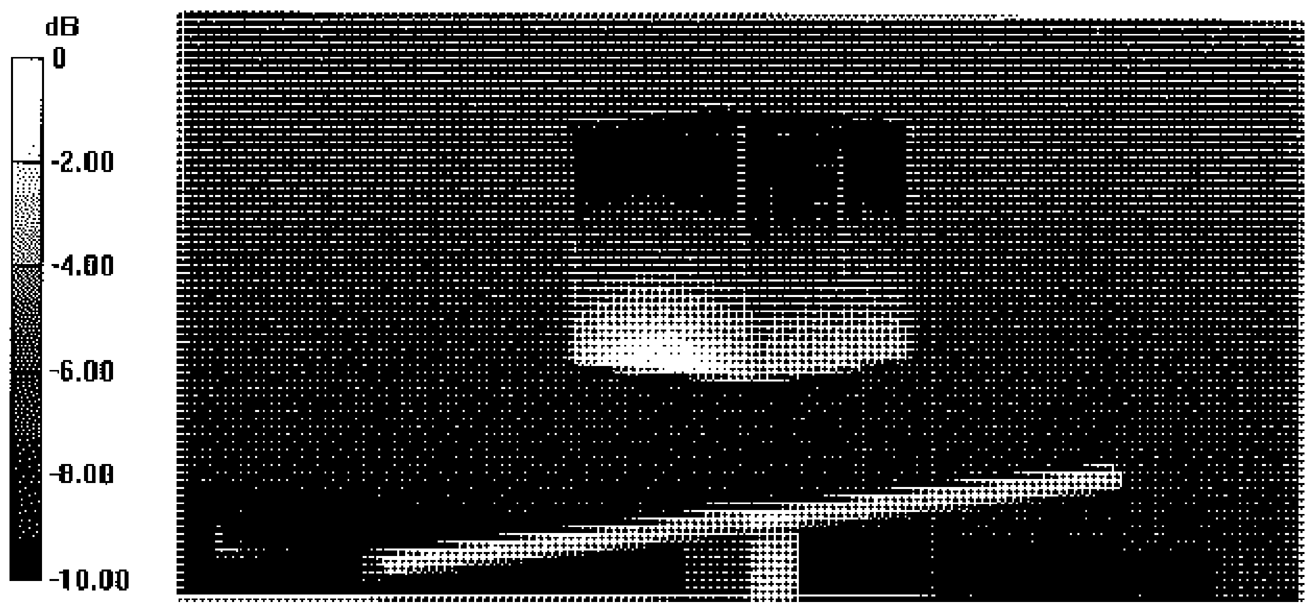
**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d132**

Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 42$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

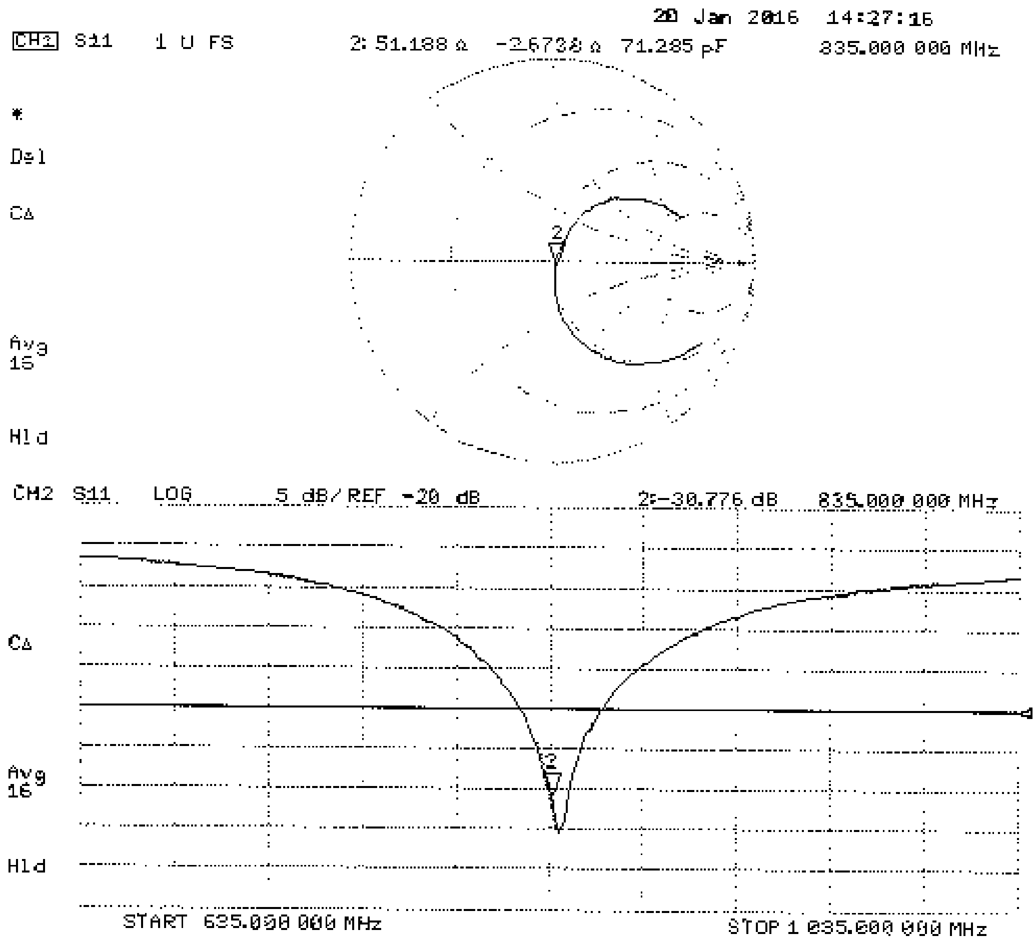
- Probe: EX3DV4 - SN7349; ConvF(9.83, 9.83, 9.83); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 61.94 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.67 W/kg
**SAR(1 g) = 2.42 W/kg; SAR(10 g) = 1.57 W/kg**
Maximum value of SAR (measured) = 3.24 W/kg




0 dB = 3.24 W/kg = 5.11 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 20.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

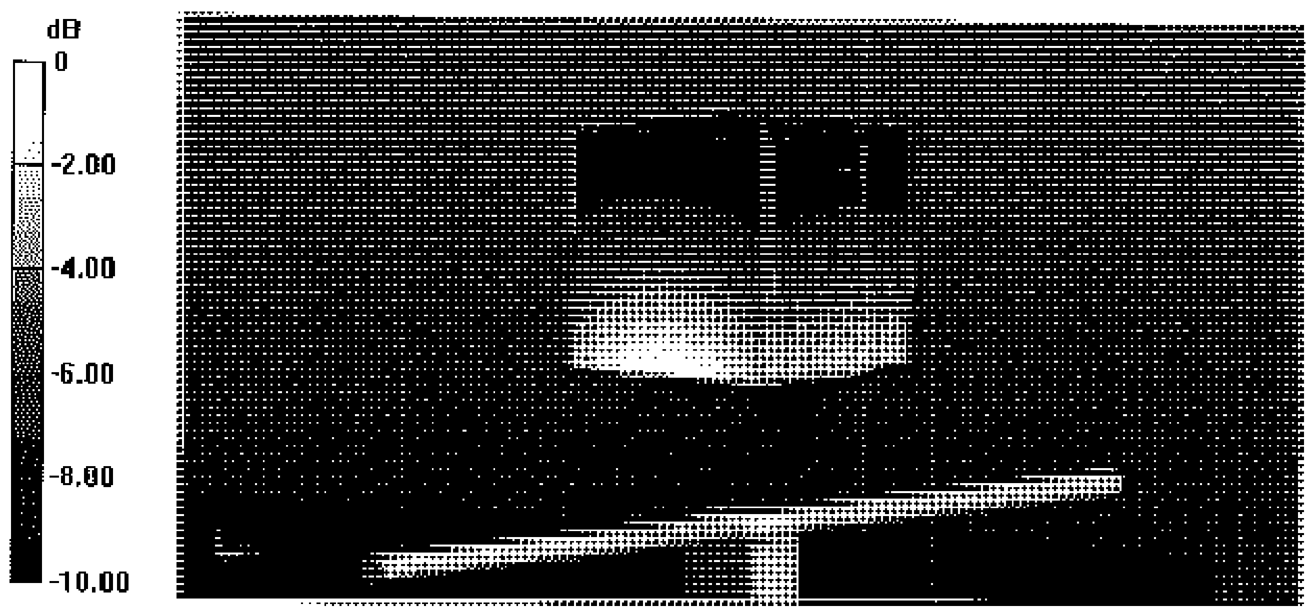
**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d132**

Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma = 1.01$ S/m; $\varepsilon_r = 55.2$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

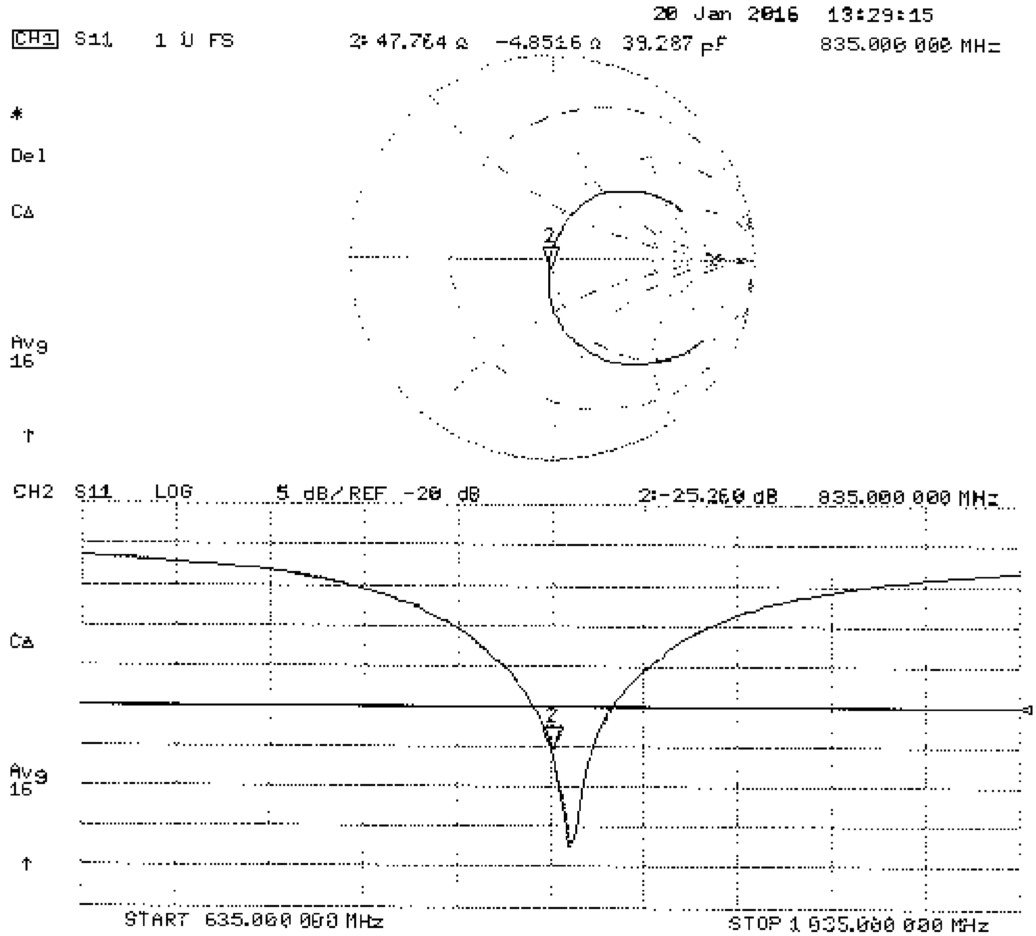
- Probe: EX3DV4 - SN7349; ConvF(9.73, 9.73, 9.73); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue EX-Probe/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.29 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.66 W/kg
**SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.63 W/kg**
Maximum value of SAR (measured) = 3.29 W/kg




0 dB = 3.29 W/kg = 5.17 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1750V2-1148_May16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D1750V2 - SN: 1148 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | May 09, 2016 |

BN✓ 5/17/2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (No. 217-02223) | In house check: Oct-16 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Oct-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: May 11, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 1750 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.1 | 1.37 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 39.7 ± 6 % | 1.36 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.03 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **36.2 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.78 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **19.1 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 53.4 | 1.49 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 53.8 ± 6 % | 1.50 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.30 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **37.1 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.93 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **19.7 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 49.9 Ω - 0.7 jΩ |
| Return Loss | - 43.3 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 46.2 Ω - 1.4 jΩ |
| Return Loss | - 27.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.221 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | September 30, 2014 |

## DASY5 Validation Report for Head TSL

Date: 09.05.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN: 1148**

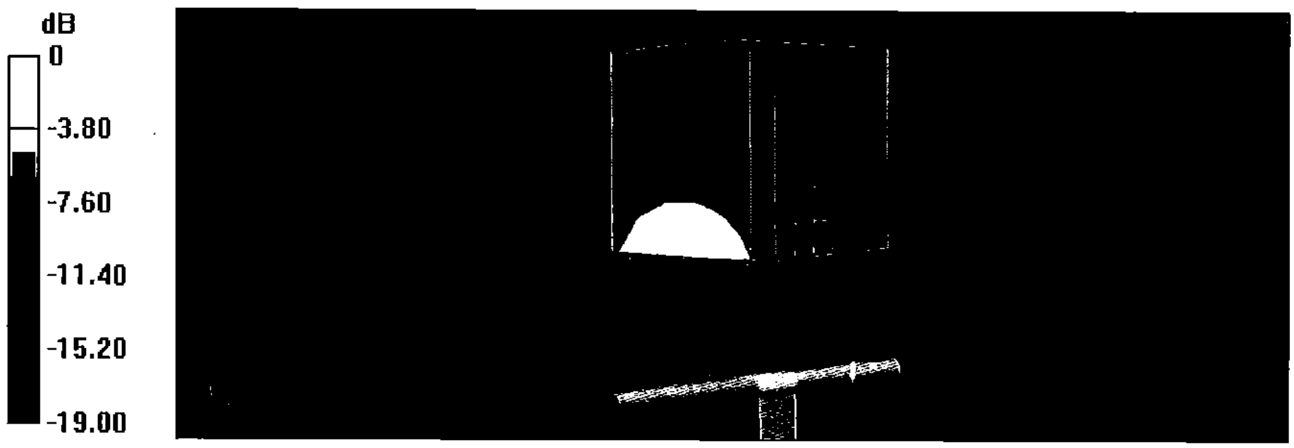
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; $\sigma$ = 1.36 S/m; $\varepsilon_r$ = 39.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.54, 8.54, 8.54); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

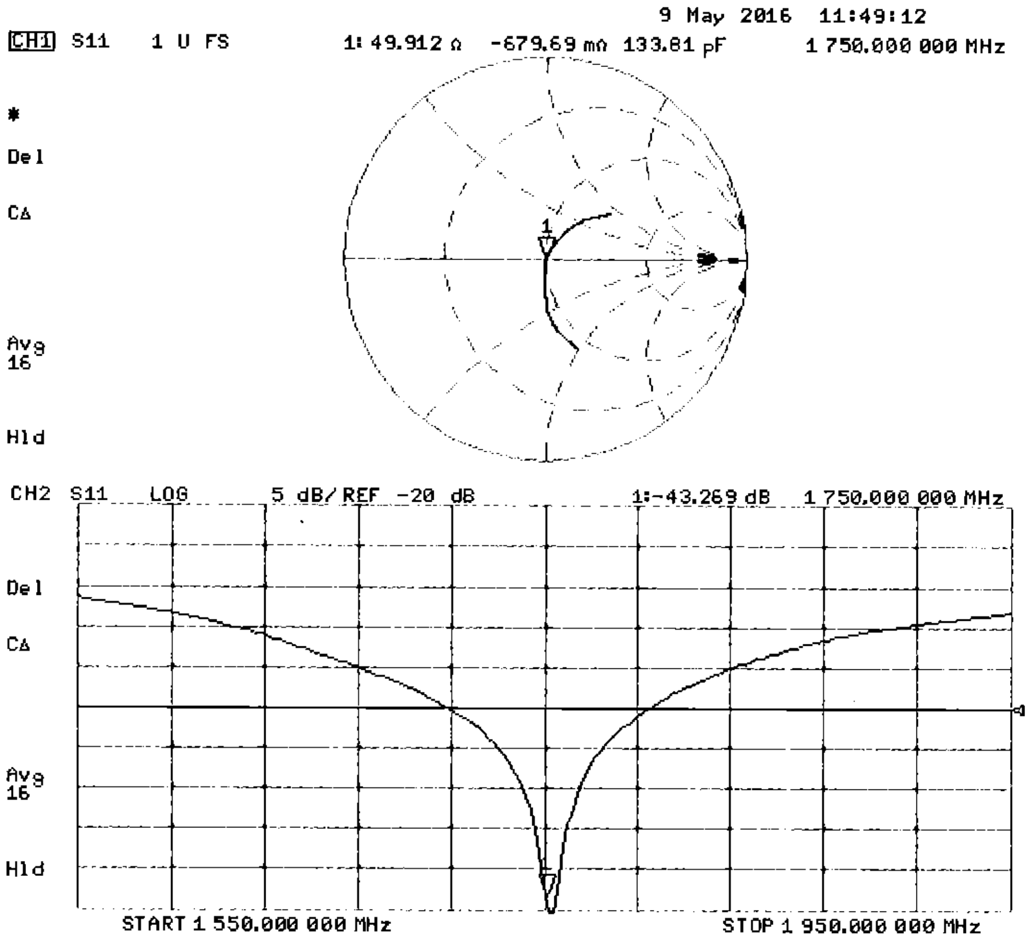
## Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 103.5 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 16.7 W/kg
**SAR(1 g) = 9.03 W/kg; SAR(10 g) = 4.78 W/kg**
Maximum value of SAR (measured) = 13.6 W/kg




0 dB = 13.6 W/kg = 11.34 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 09.05.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN: 1148**

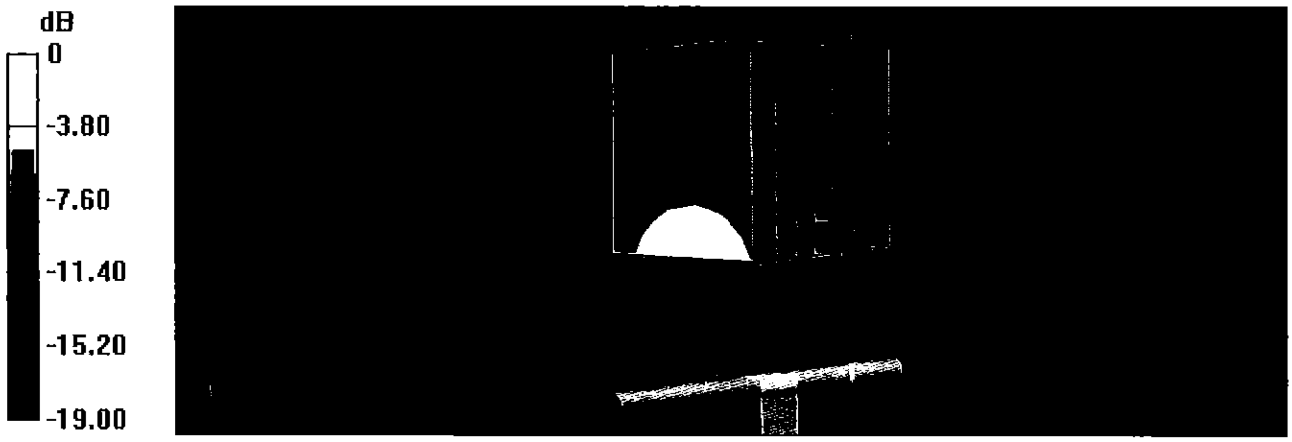
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; $\sigma$ = 1.5 S/m; $\varepsilon_r$ = 53.8; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.25, 8.25, 8.25); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

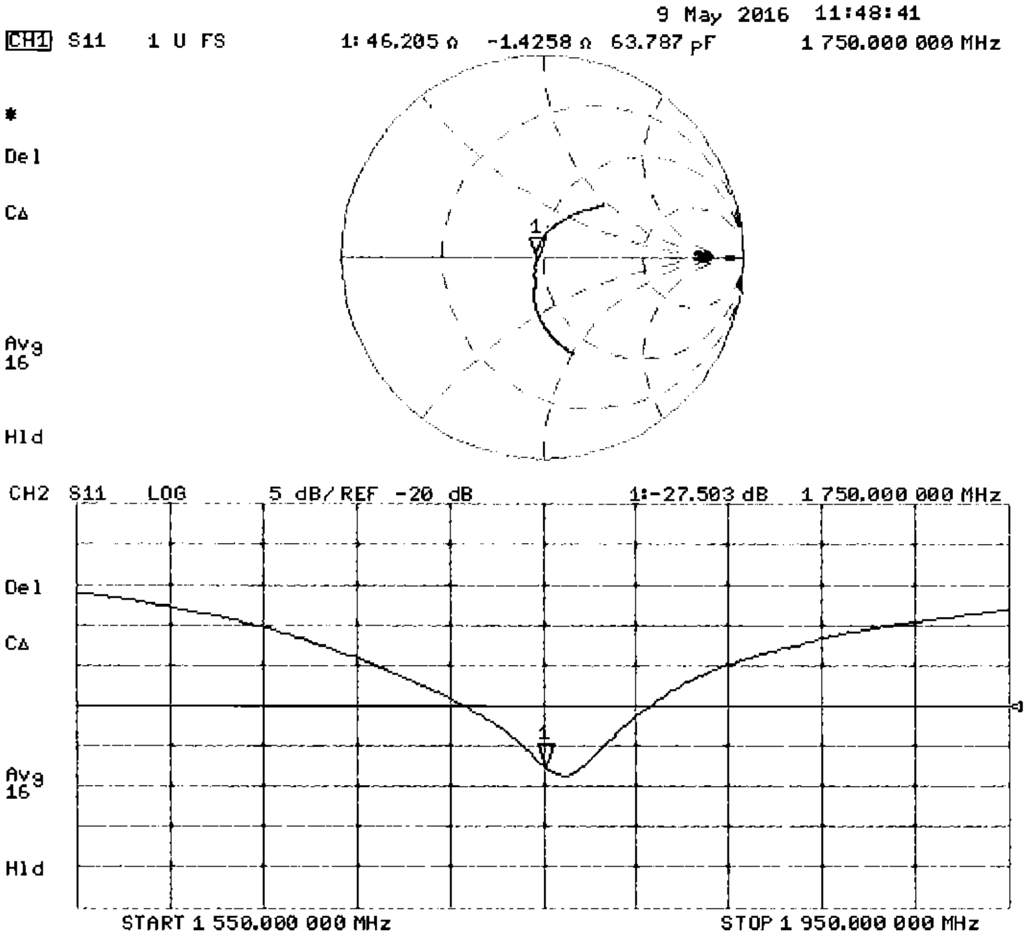
### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 102.0 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 16.6 W/kg
**SAR(1 g) = 9.3 W/kg; SAR(10 g) = 4.93 W/kg**
Maximum value of SAR (measured) = 14.1 W/kg




0 dB = 14.1 W/kg = 11.49 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1900V2-5d149_Jul15**

# CALIBRATION CERTIFICATE

Object D1900V2 - SN:5d149

Calibration procedure(s) QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

CC✓
8/4/15

Calibration date: July 14, 2015

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-14 (No. 217-02020) | Oct-15 |
| Power sensor HP 8481A | US37292783 | 07-Oct-14 (No. 217-02020) | Oct-15 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-14 (No. 217-02021) | Oct-15 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe ES3DV3 | SN: 3205 | 30-Dec-14 (No. ES3-3205_Dec14) | Dec-15 |
| DAE4 | SN: 601 | 18-Aug-14 (No. DAE4-601_Aug14) | Aug-15 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator R&S SMT-06 | 100005 | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | [signature] |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: July 14, 2015

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 1900 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.0 | 1.40 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 39.7 ± 6 % | 1.38 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 10.1 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **40.7 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.34 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **21.5 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 53.3 | 1.52 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.7 ± 6 % | 1.54 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 10.2 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **40.4 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.49 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **21.8 W/kg ± 16.5 % (k=2)** |

( (

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.4 Ω + 5.6 jΩ |
| Return Loss | - 24.9 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 47.7 Ω + 6.1 jΩ |
| Return Loss | - 23.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.197 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | March 11, 2011 |

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## DASY5 Validation Report for Head TSL

Date: 14.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149**

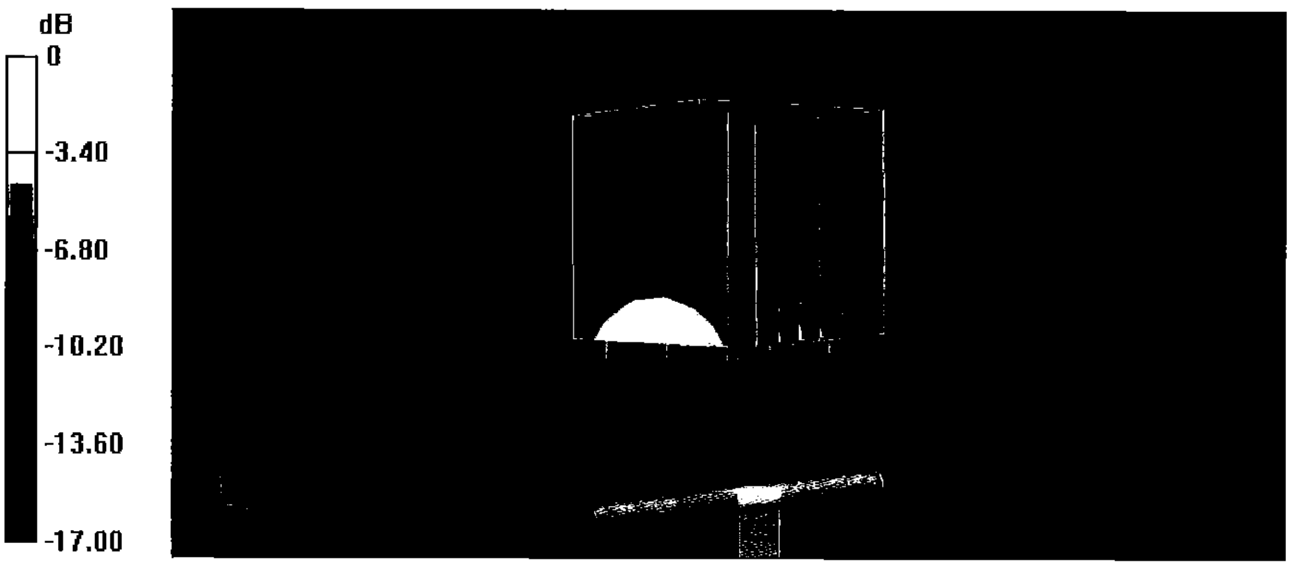
Communication System: UID 0 - CW; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.38 S/m; $\varepsilon_r$ = 39.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5, 5, 5); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.22 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 18.3 W/kg
**SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.34 W/kg**
Maximum value of SAR (measured) = 12.9 W/kg




0 dB = 12.9 W/kg = 11.11 dBW/kg

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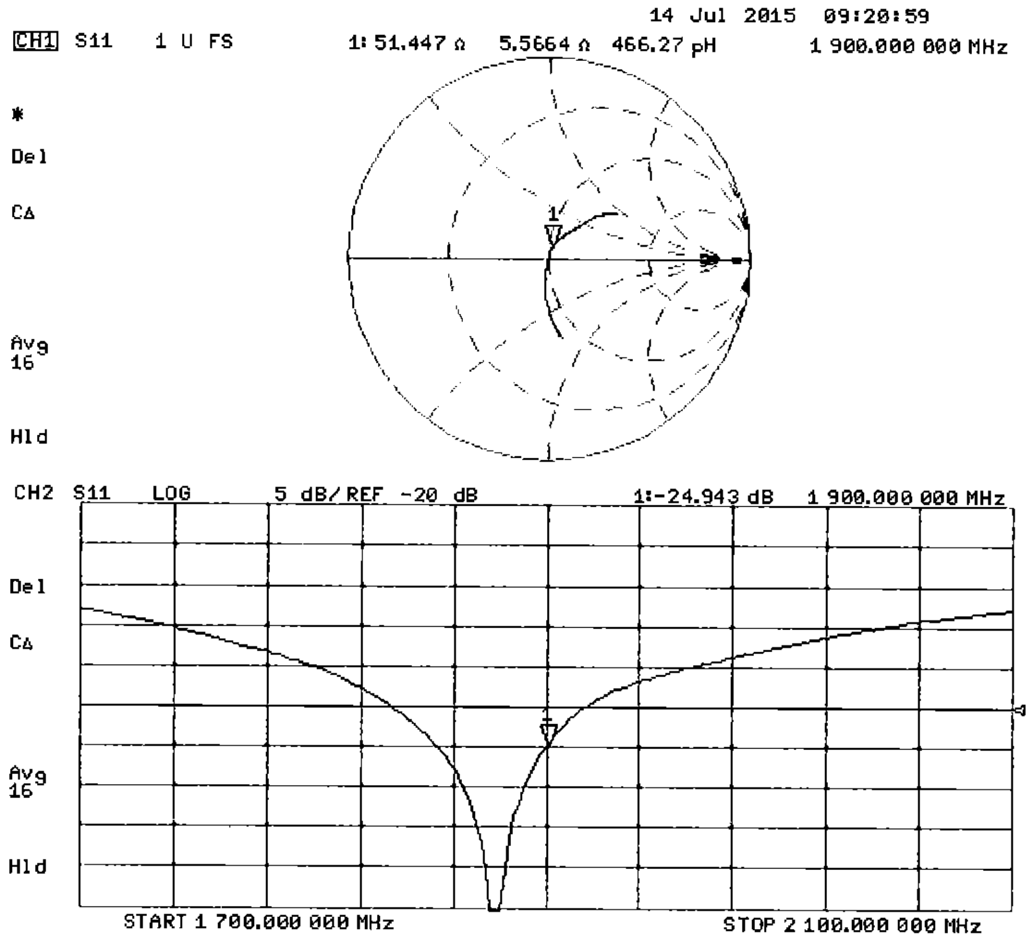
## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 14.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149**

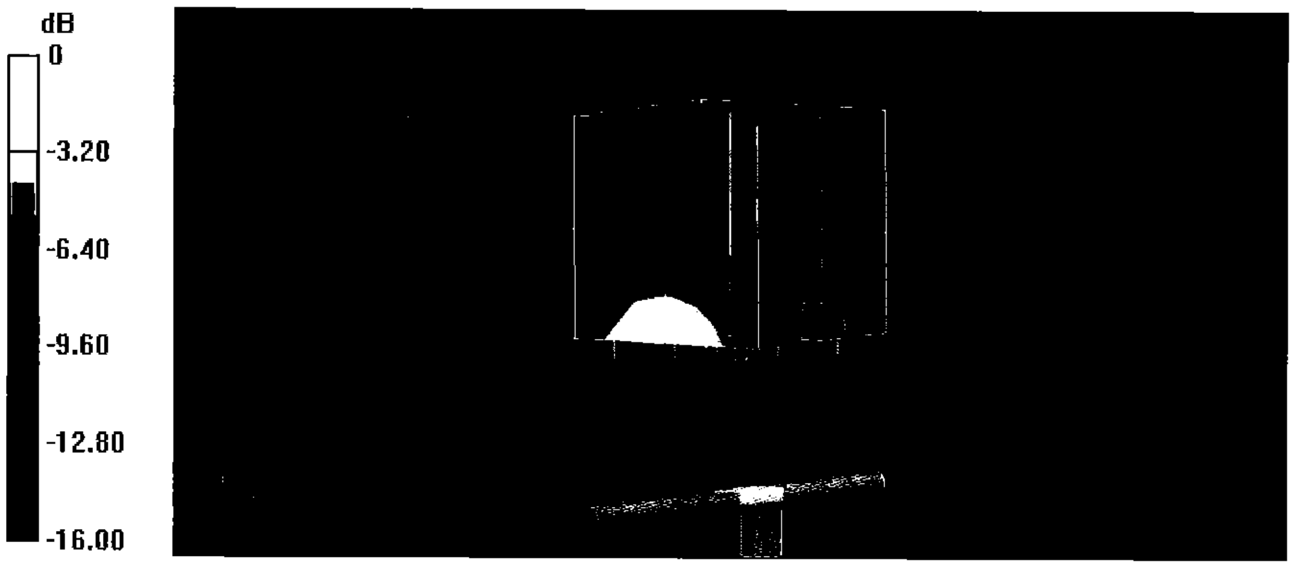
Communication System: UID 0 - CW; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma = 1.54$ S/m; $\varepsilon_r = 52.7$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.65, 4.65, 4.65); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

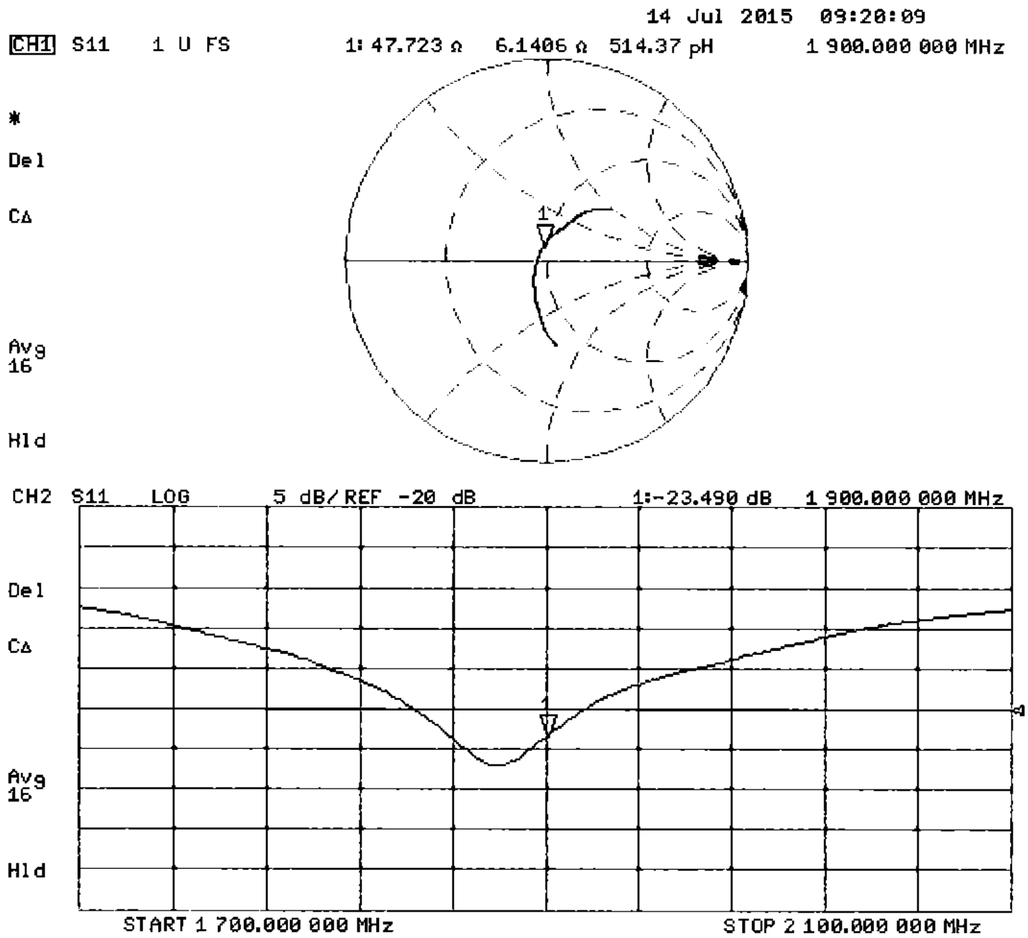
### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 95.96 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 17.2 W/kg
**SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.49 W/kg**
Maximum value of SAR (measured) = 12.9 W/kg




0 dB = 12.9 W/kg = 11.11 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2450V2-797_Oct15**

# CALIBRATION CERTIFICATE

Object D2450V2 - SN: 797

Calibration procedure(s) QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

BN ✓ 11/03/15

Calibration date: October 21, 2015

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 30-Dec-14 (No. EX3-7349_Dec14) | Dec-15 |
| DAE4 | SN: 601 | 17-Aug-15 (No. DAE4-601_Aug15) | Aug-16 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | *[signature]* |
| Approved by: | Katja Pokovic | Technical Manager | *[signature]* |

Issued: October 22, 2015

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 2450 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 39.2 | 1.80 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 38.0 ± 6 % | 1.84 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.4 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **52.7 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.17 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.4 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 52.7 | 1.95 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.8 ± 6 % | 1.99 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 13.0 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **51.5 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 6.08 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **24.2 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 54.1 Ω + 8.0 jΩ |
| Return Loss | - 21.3 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 49.8 Ω + 9.3 jΩ |
| Return Loss | - 20.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.152 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | January 24, 2006 |

## DASY5 Validation Report for Head TSL

Date: 21.10.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 797**

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.84 S/m; $\varepsilon_r$ = 38; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

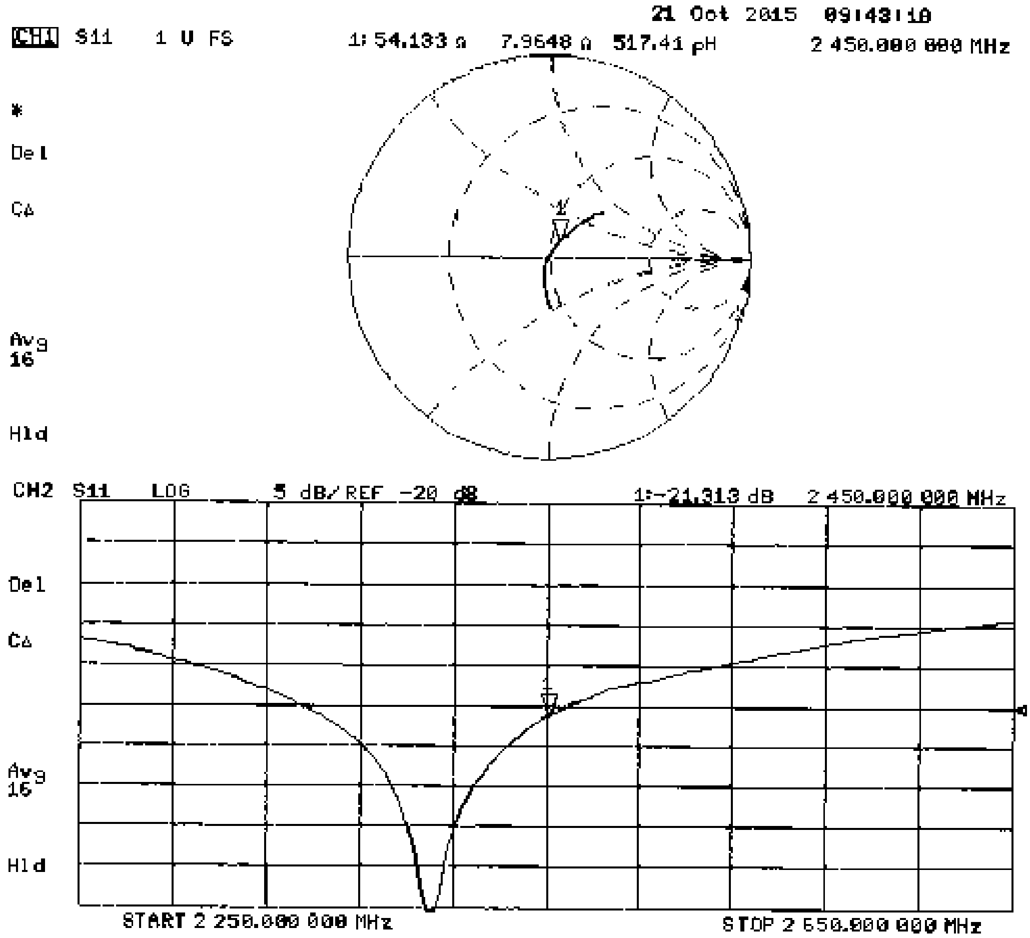
- Probe: EX3DV4 - SN7349; ConvF(7.67, 7.67, 7.67); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 114.6 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 27.8 W/kg
**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.17 W/kg**
Maximum value of SAR (measured) = 22.3 W/kg


0 dB = 22.3 W/kg = 13.48 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 21.10.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz ; Type: D2450V2; Serial: D2450V2 - SN: 797**

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma = 1.99$ S/m; $\varepsilon_r = 52.8$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

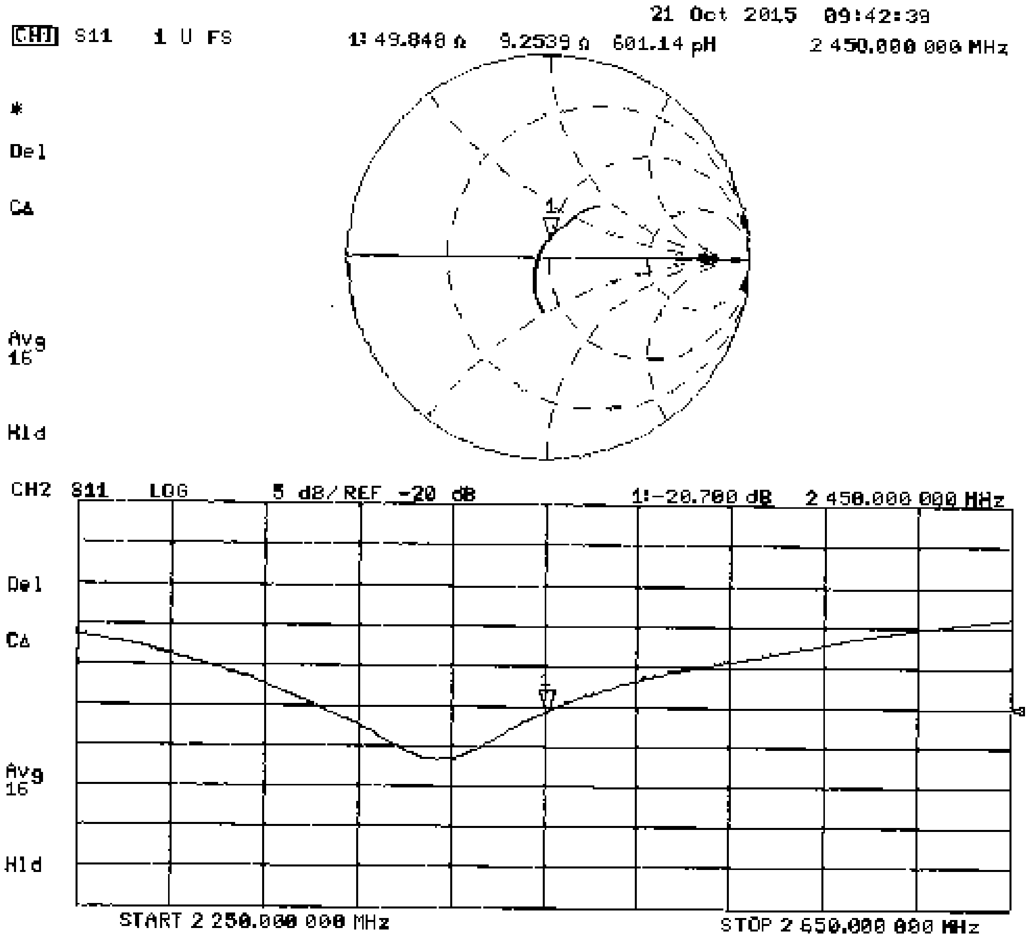
DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.53, 7.53, 7.53); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 108.1 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 25.8 W/kg
**SAR(1 g) = 13 W/kg; SAR(10 g) = 6.08 W/kg**
Maximum value of SAR (measured) = 21.2 W/kg


0 dB = 21.2 W/kg = 13.26 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**Client PC Test**

**Certificate No: D750V3-1046_Feb16**

# CALIBRATION CERTIFICATE

Object: D750V3 - SN:1046

Calibration procedure(s): QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: February 16, 2016

BN ✓ 3/1/2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: February 17, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 750 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.9 | 0.89 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 41.8 ± 6 % | 0.90 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.07 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **8.20 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.35 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **5.36 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.5 | 0.96 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 55.1 ± 6 % | 0.98 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.23 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **8.77 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.47 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **5.80 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 56.7 Ω + 2.3 jΩ |
| Return Loss | - 23.6 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.7 Ω - 0.8 jΩ |
| Return Loss | - 34.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.037 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | September 02, 2011 |

## DASY5 Validation Report for Head TSL

Date: 16.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1046**

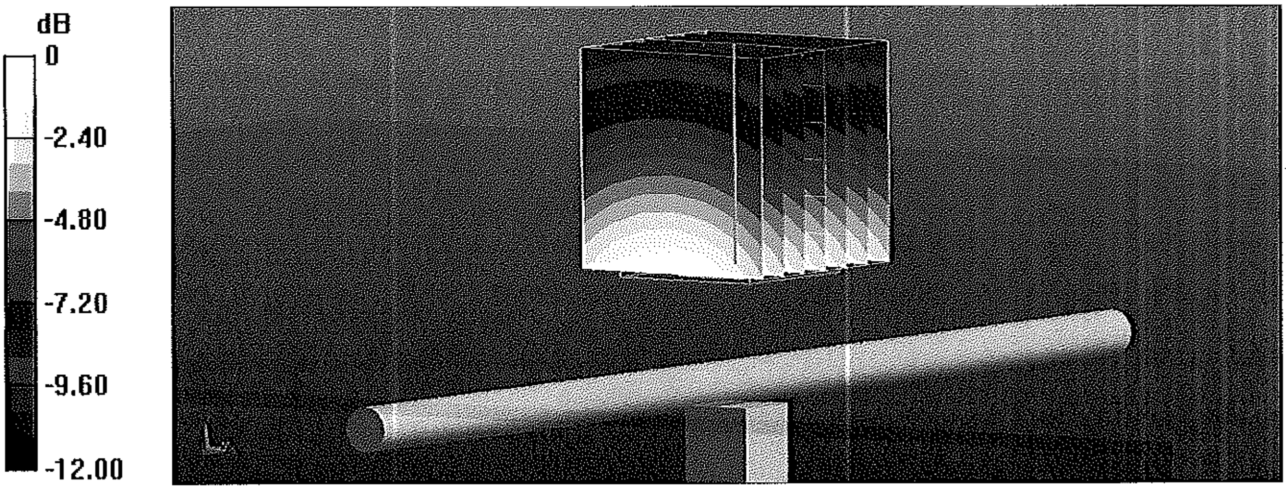
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma$ = 0.9 S/m; $\varepsilon_r$ = 41.8; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.28, 10.28, 10.28); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

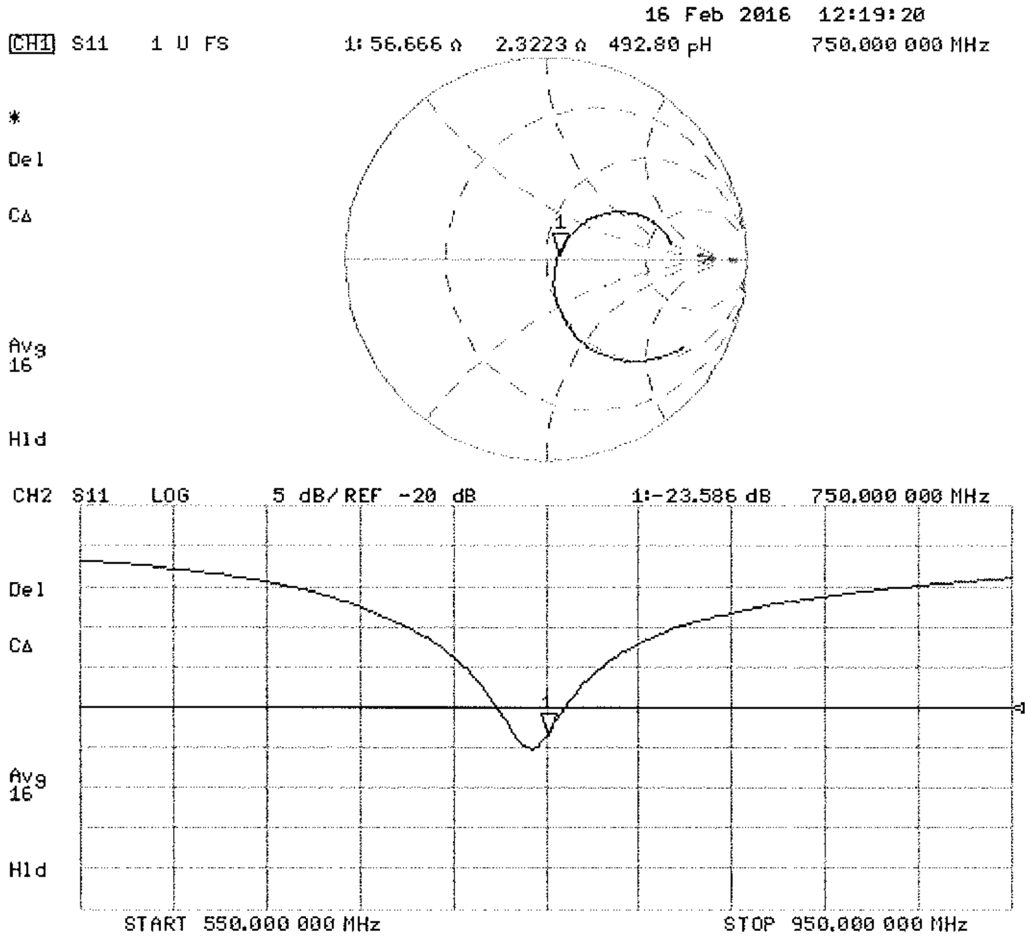
### Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 58.40 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 3.11 W/kg
**SAR(1 g) = 2.07 W/kg; SAR(10 g) = 1.35 W/kg**
Maximum value of SAR (measured) = 2.75 W/kg




0 dB = 2.75 W/kg = 4.39 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 16.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1046**

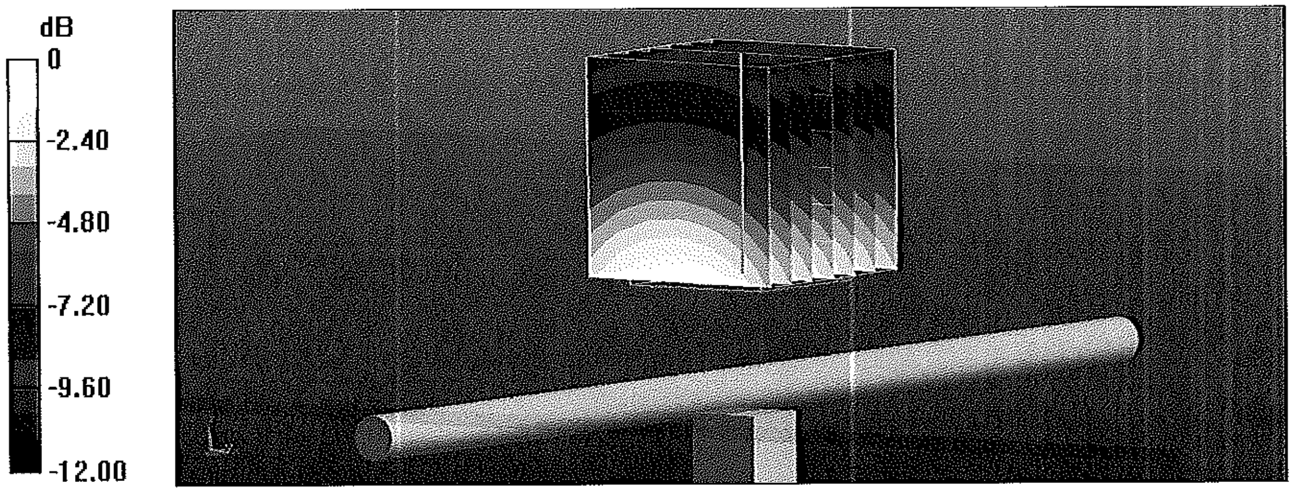
Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma$ = 0.98 S/m; $\varepsilon_r$ = 55.1; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

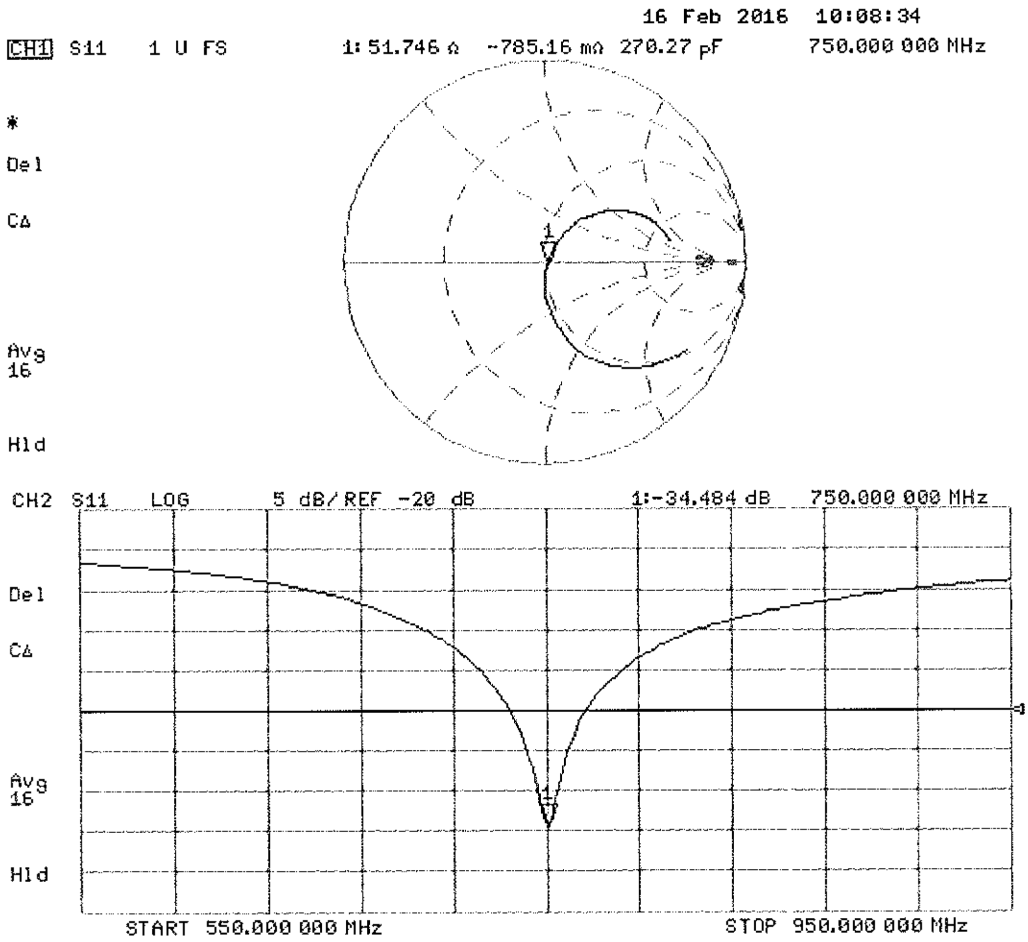
### Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.48 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 3.31 W/kg
**SAR(1 g) = 2.23 W/kg; SAR(10 g) = 1.47 W/kg**
Maximum value of SAR (measured) = 2.94 W/kg




0 dB = 2.94 W/kg = 4.68 dBW/kg

## Impedance Measurement Plot for Body TSL



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**Accreditation No.: SCS 0108**

Client **PC Test**

**Certificate No: D835V2-4d119_Apr16**

# CALIBRATION CERTIFICATE

Object D835V2 - SN: 4d119

PM ✓ 4/25/16

Calibration procedure(s) QA CAL-05.v9
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: April 14, 2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (No. 217-02223) | In house check: Oct-16 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Oct-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: April 15, 2016

**Calibration Laboratory of**
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Accreditation No.: **SCS 0108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 835 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.5 | 0.90 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 41.7 ± 6 % | 0.93 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.34 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.14 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.52 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **5.97 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.2 | 0.97 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 54.4 ± 6 % | 1.02 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.38 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.14 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.56 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.04 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.8 Ω - 4.1 jΩ |
| Return Loss | - 27.8 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 46.9 Ω - 6.1 jΩ |
| Return Loss | - 23.0 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.385 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

## Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | June 29, 2010 |

## DASY5 Validation Report for Head TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d119**

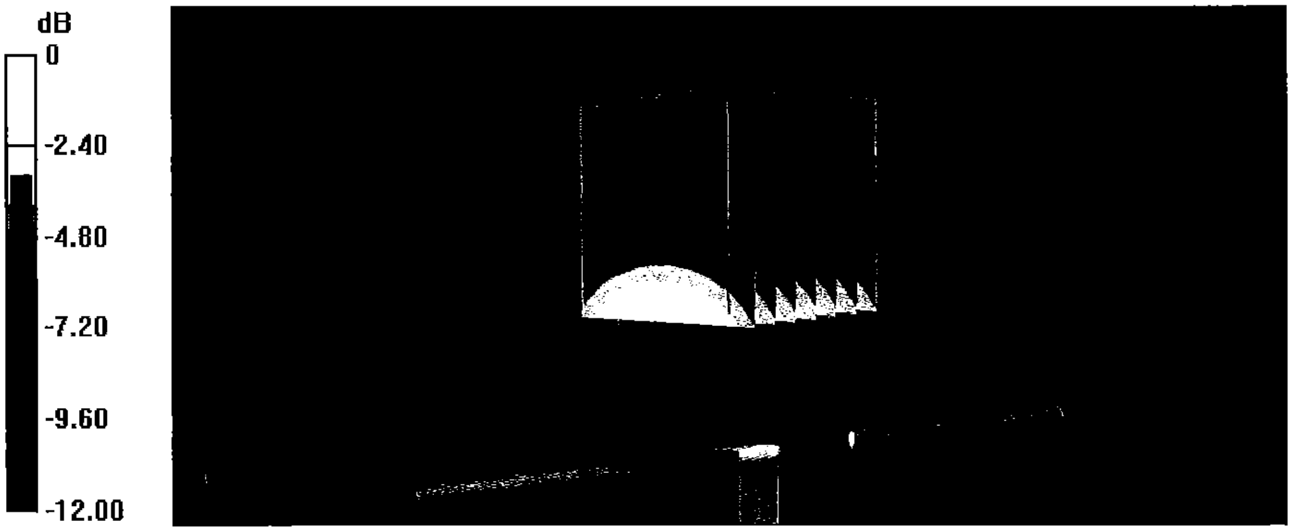
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 0.93 S/m; $\varepsilon_r$ = 41.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.83, 9.83, 9.83); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

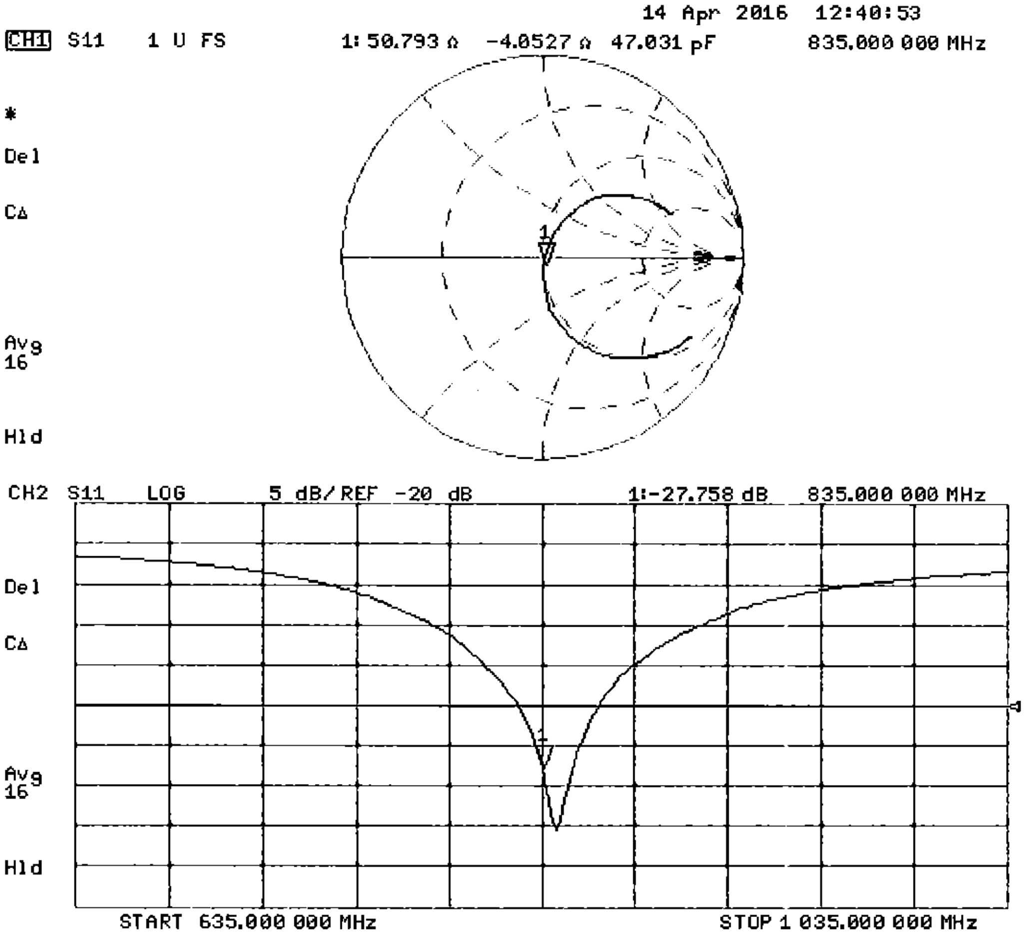
## Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 60.95 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 3.48 W/kg
**SAR(1 g) = 2.34 W/kg; SAR(10 g) = 1.52 W/kg**
Maximum value of SAR (measured) = 3.11 W/kg




0 dB = 3.11 W/kg = 4.93 dBW/kg

# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d119**

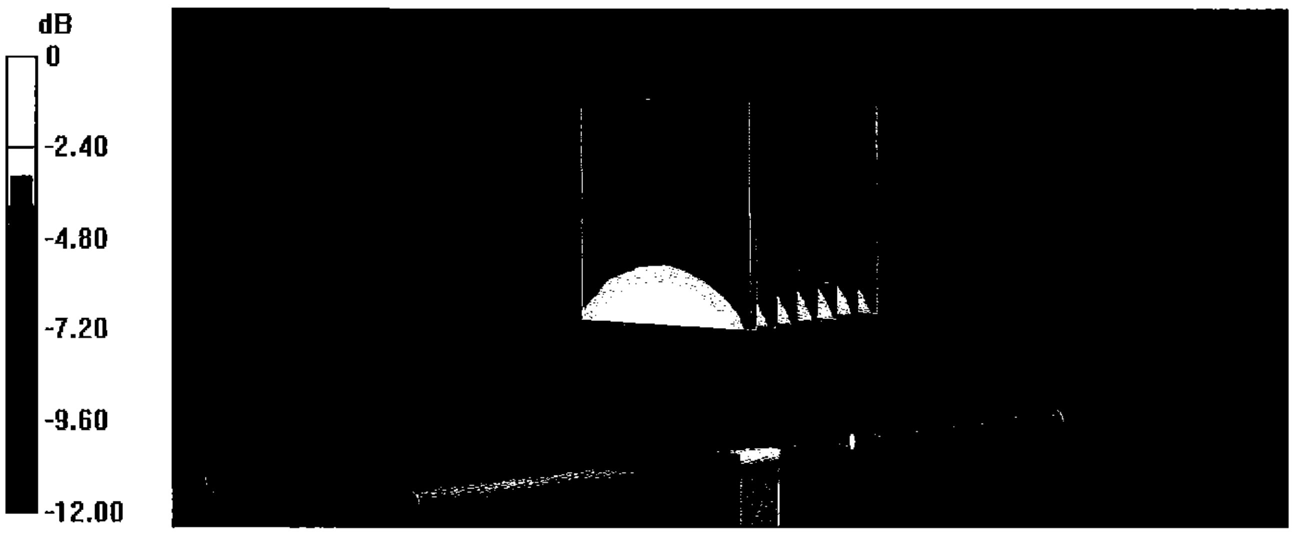
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 1.02 S/m; $\varepsilon_r$ = 54.4; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.73, 9.73, 9.73); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

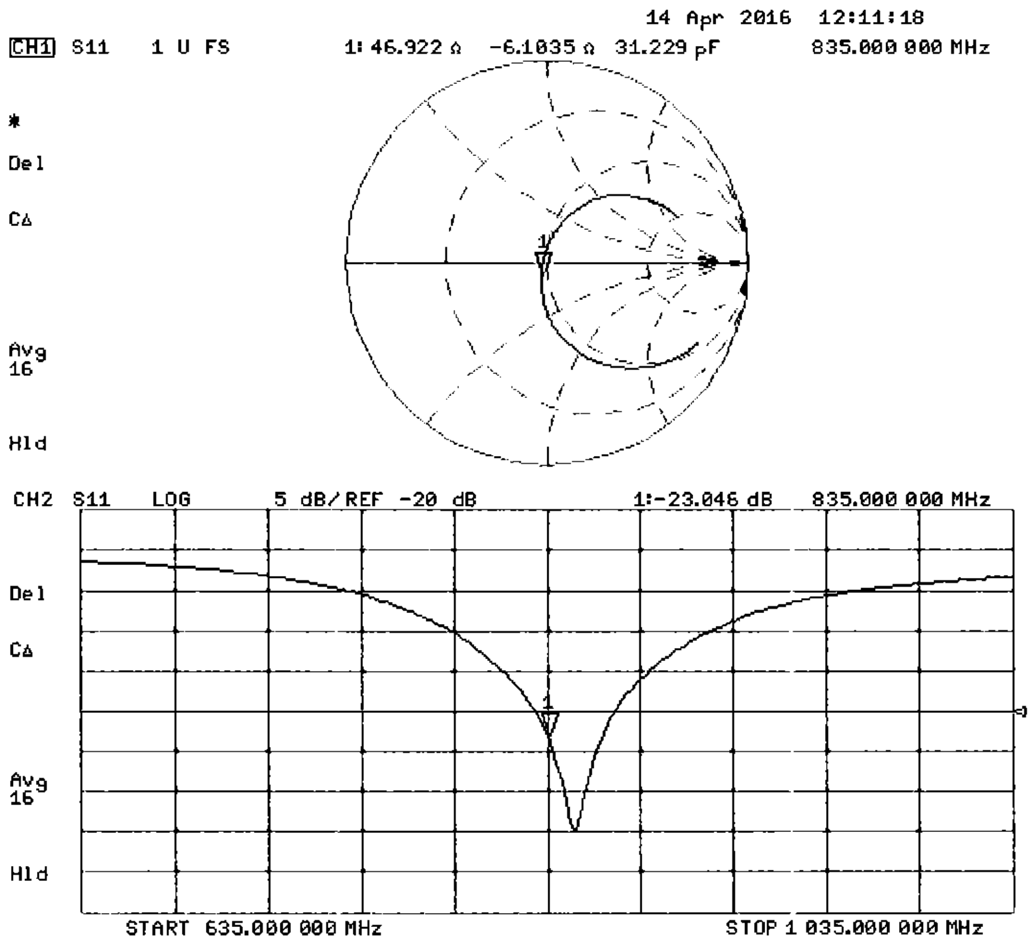
## Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 58.35 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 3.46 W/kg
**SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.56 W/kg**
Maximum value of SAR (measured) = 3.11 W/kg




0 dB = 3.11 W/kg = 4.93 dBW/kg

## Impedance Measurement Plot for Body TSL



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**Accreditation No.: SCS 0108**

Client **PC Test**

Certificate No: **D1750V2-1051_Apr16**

# CALIBRATION CERTIFICATE

PM ✓
4/25/16

| | |
|---|---|
| Object | D1750V2 - SN: 1051 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | April 13, 2016 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (No. 217-02222) | In house check: Oct-16 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (No. 217-02223) | In house check: Oct-16 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Oct-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: April 15, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 1750 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.1 | 1.37 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 39.9 ± 6 % | 1.35 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 8.94 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **36.1 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.75 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **19.1 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 53.4 | 1.49 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.8 ± 6 % | 1.48 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.12 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **36.5 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.87 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **19.5 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.6 Ω + 0.9 jΩ |
| Return Loss | - 35.0 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 47.9 Ω + 1.0 jΩ |
| Return Loss | - 32.6 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.221 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

## Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | February 19, 2010 |

## DASY5 Validation Report for Head TSL

Date: 13.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN: 1051**

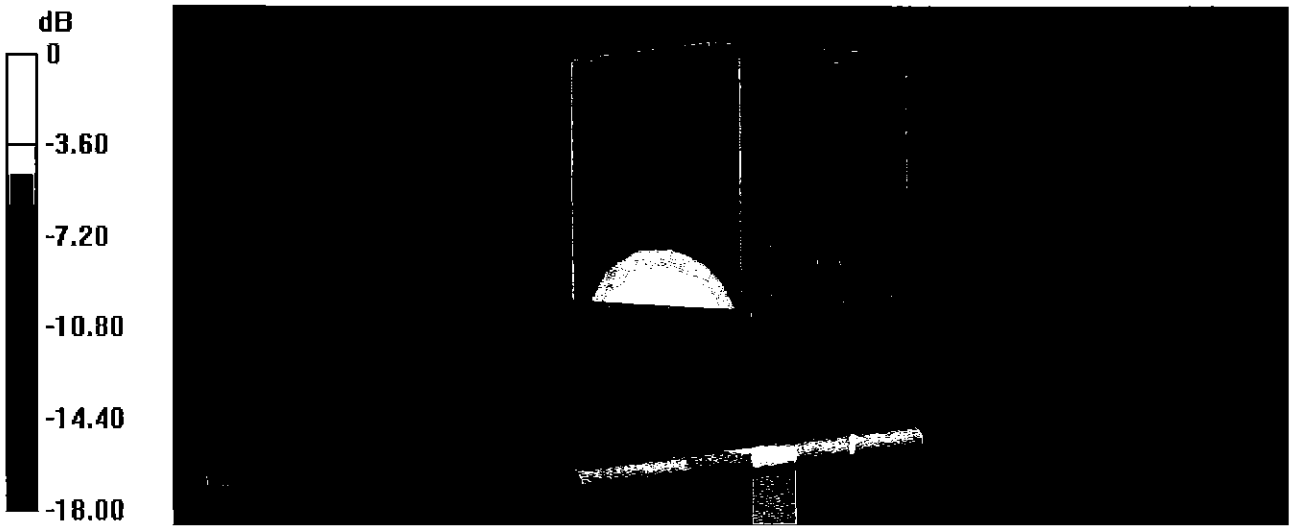
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; $\sigma$ = 1.35 S/m; $\varepsilon_r$ = 39.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.54, 8.54, 8.54); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

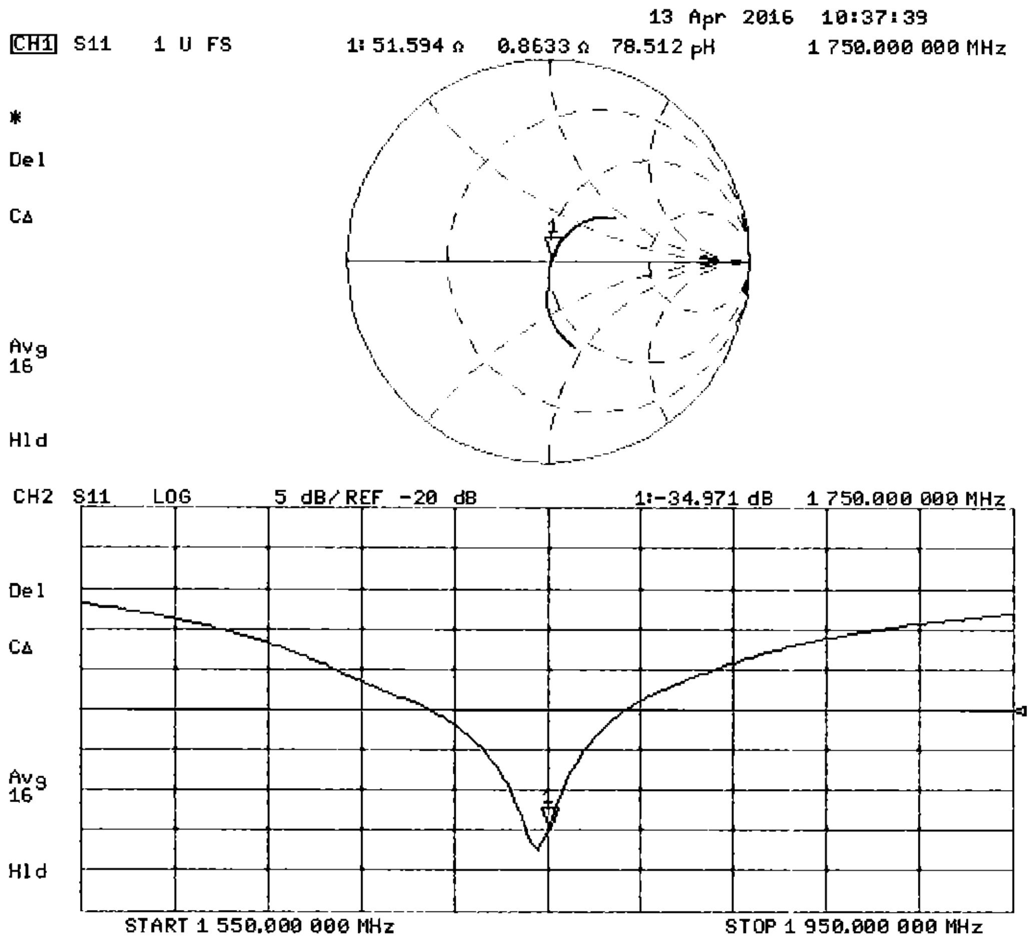
### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 104.0 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 16.2 W/kg
**SAR(1 g) = 8.94 W/kg; SAR(10 g) = 4.75 W/kg**
Maximum value of SAR (measured) = 13.5 W/kg




0 dB = 13.5 W/kg = 11.30 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 13.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN: 1051**

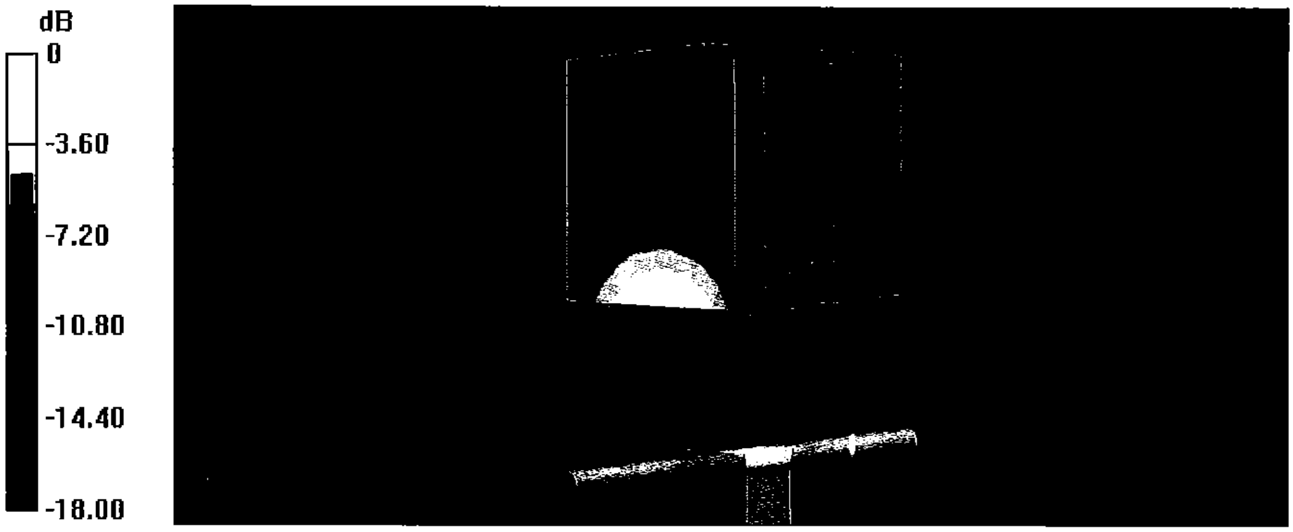
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; $\sigma$ = 1.48 S/m; $\varepsilon_r$ = 52.8; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.25, 8.25, 8.25); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

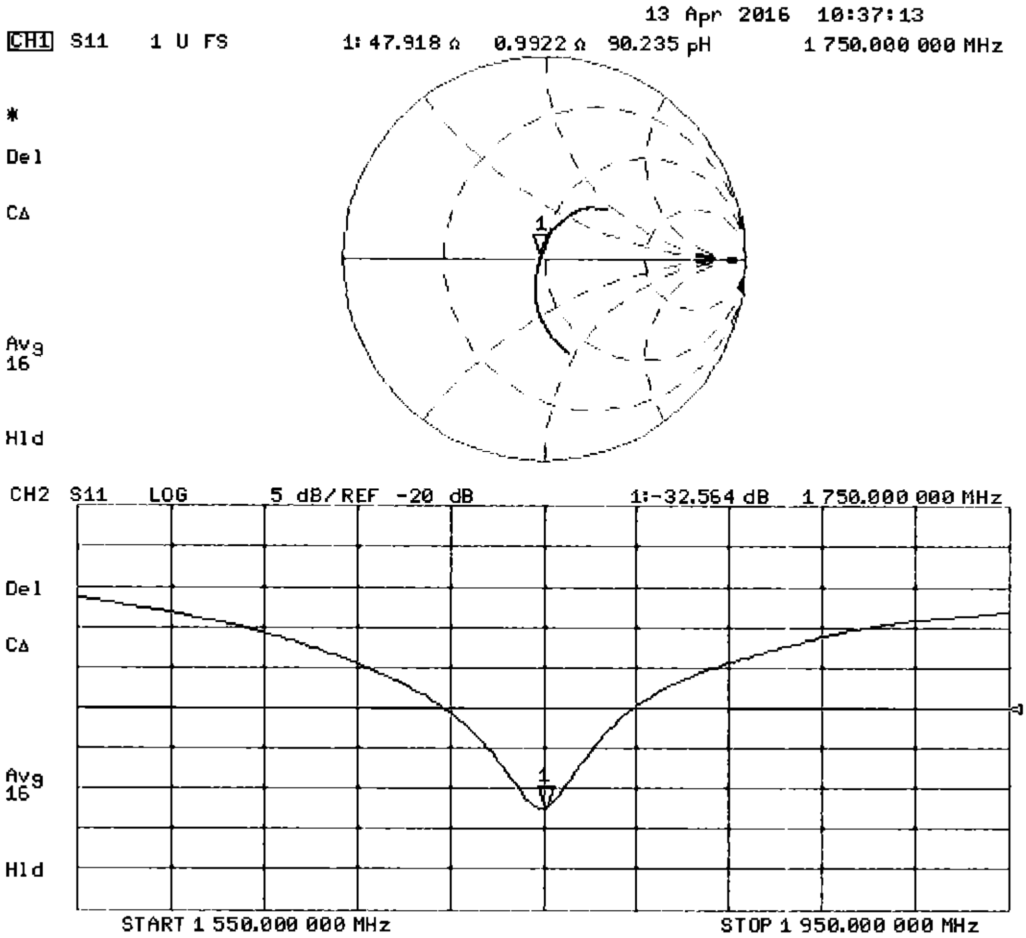
## Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 100.6 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 16.0 W/kg
**SAR(1 g) = 9.12 W/kg; SAR(10 g) = 4.87 W/kg**
Maximum value of SAR (measured) = 13.8 W/kg




0 dB = 13.8 W/kg = 11.40 dBW/kg

## Impedance Measurement Plot for Body TSL



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**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
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**S** Swiss Calibration Service

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**Accreditation No.: SCS 0108**

**Client** **PC Test**

**Certificate No: D2450V2-882_Feb16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D2450V2 - SN: 882 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | February 18, 2016 |

BN ✓ 03/01/2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter EPM-442A | GB37480704 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | US37292783 | 07-Oct-15 (No. 217-02222) | Oct-16 |
| Power sensor HP 8481A | MY41092317 | 07-Oct-15 (No. 217-02223) | Oct-16 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 01-Apr-15 (No. 217-02131) | Mar-16 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134) | Mar-16 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-15 (No. EX3-7349_Dec15) | Dec-16 |
| DAE4 | SN: 601 | 30-Dec-15 (No. DAE4-601_Dec15) | Dec-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| RF generator R&S SMT-06 | 100972 | 15-Jun-15 (in house check Jun-15) | In house check: Jun-18 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Claudio Leubler | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: February 19, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A | not applicable or not measured |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

e) DASY4/5 System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 2450 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 39.2 | 1.80 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 38.7 ± 6 % | 1.84 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 12.8 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **50.5 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.92 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.5 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 52.7 | 1.95 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.9 ± 6 % | 2.00 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 12.5 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **49.4 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.81 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **23.1 W/kg ± 16.5 % (k=2)** |

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.5 Ω + 1.0 jΩ |
| Return Loss | - 31.5 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 48.7 Ω + 3.5 jΩ |
| Return Loss | - 28.6 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.157 ns |

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | October 06, 2011 |

## DASY5 Validation Report for Head TSL

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 882**

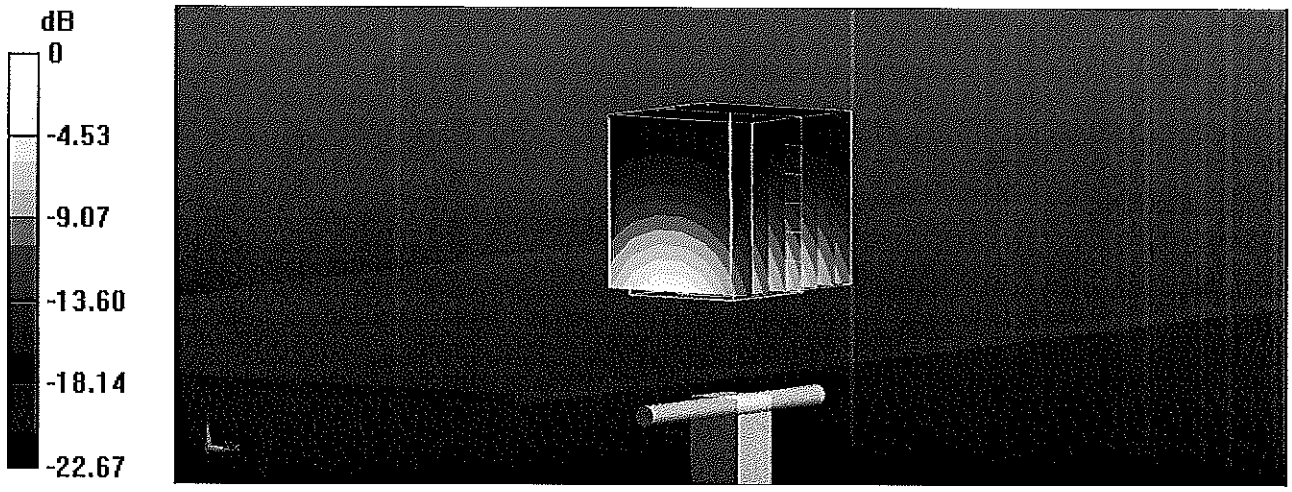
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.84 S/m; $\varepsilon_r$ = 38.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.76, 7.76, 7.76); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

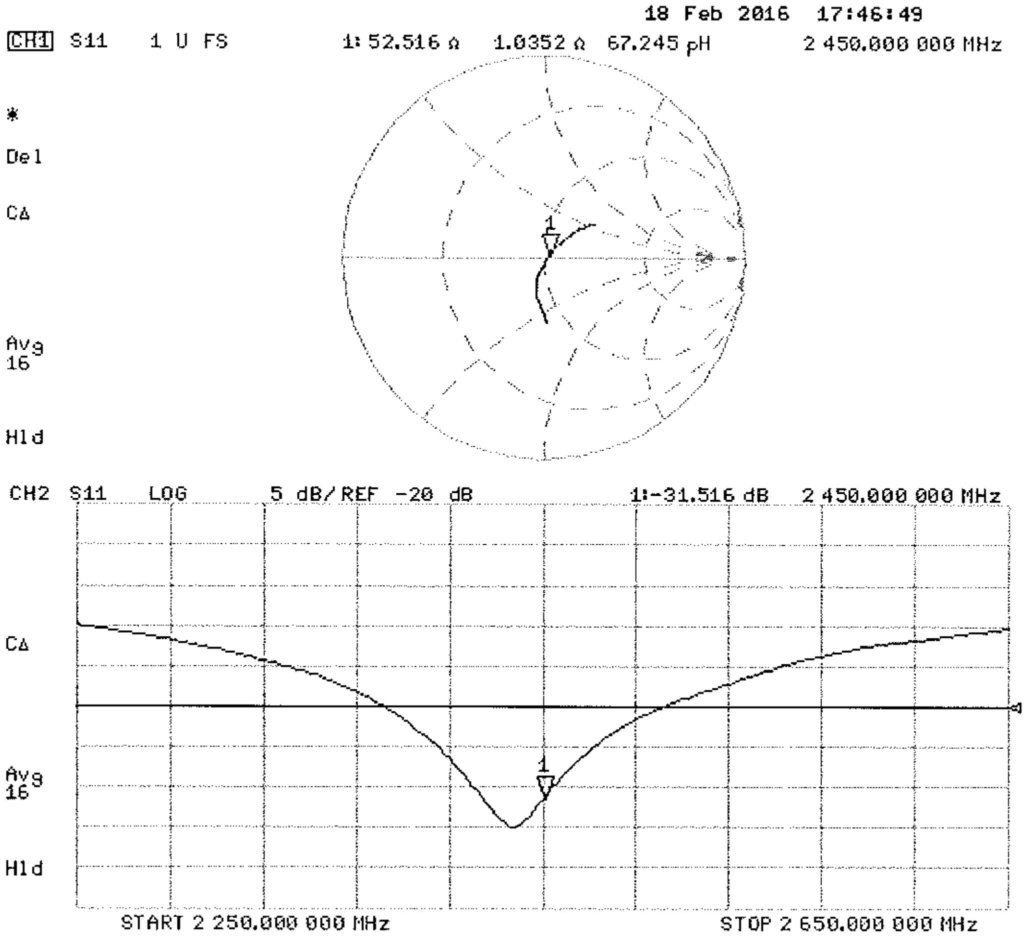
## Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 109.8 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 25.7 W/kg
**SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.92 W/kg**
Maximum value of SAR (measured) = 20.1 W/kg




0 dB = 20.1 W/kg = 13.03 dBW/kg

## Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 882**

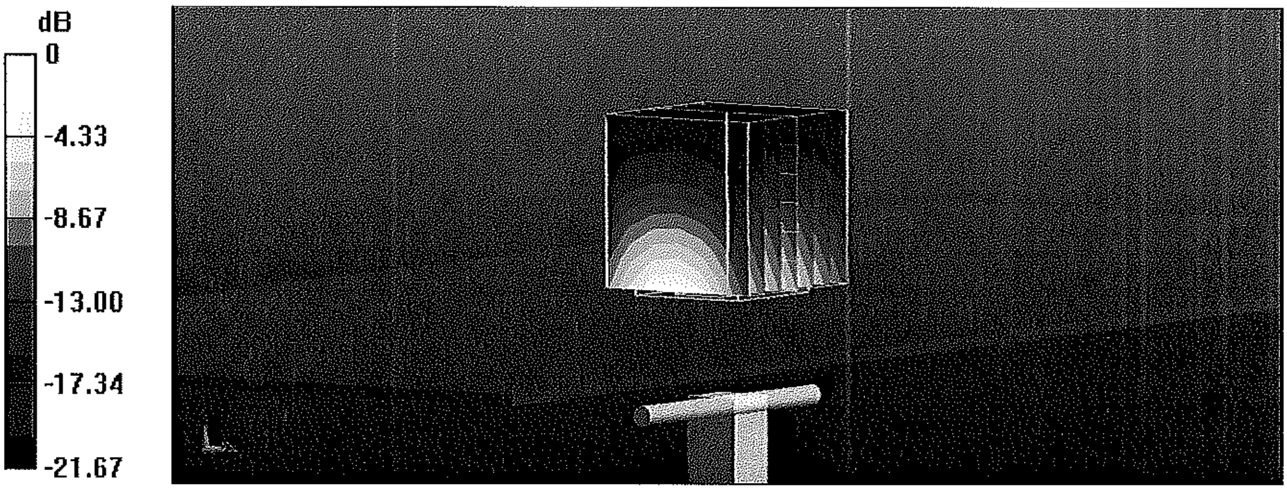
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma = 2$ S/m; $\varepsilon_r = 52.9$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

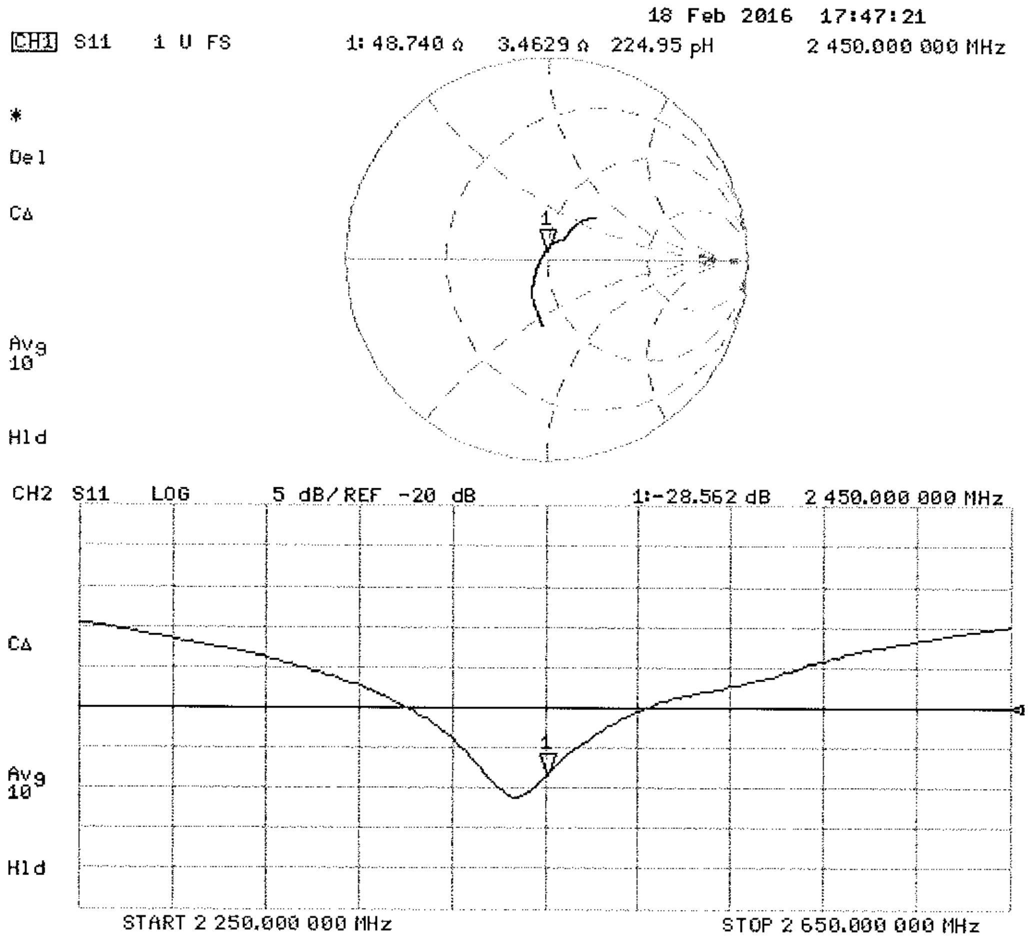
## Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 104.8 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 24.8 W/kg
**SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.81 W/kg**
Maximum value of SAR (measured) = 20.0 W/kg




0 dB = 20.0 W/kg = 13.01 dBW/kg

## Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **ES3-3288_Sep15**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3288

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

BN ✓ 10/02/15

Calibration date: September 18, 2015

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: September 19, 2015

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Accreditation No.: **SCS 0108**

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

# SN:3288

Manufactured: July 6, 2010
Calibrated: September 18, 2015

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)²)[A] | 1.05 | 1.16 | 0.92 | ± 10.1 % |
| DCP (mV)[B] | 106.9 | 106.9 | 107.4 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 190.7 | ±3.0 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 181.4 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 179.1 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.55 | 61.8 | 10.9 | 10.00 | 38.0 | ±1.2 % |
| | | Y | 99.34 | 97.0 | 21.5 | | 36.6 | |
| | | Z | 6.26 | 70.5 | 13.9 | | 35.2 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.28 | 67.4 | 18.7 | 2.91 | 129.4 | ±0.5 % |
| | | Y | 3.60 | 69.3 | 19.8 | | 143.8 | |
| | | Z | 3.38 | 67.9 | 18.8 | | 143.0 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.07 | 70.1 | 19.4 | 1.87 | 131.0 | ±0.7 % |
| | | Y | 3.79 | 74.2 | 21.4 | | 145.4 | |
| | | Z | 3.15 | 70.5 | 19.4 | | 144.5 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.64 | 69.8 | 22.8 | 9.46 | 122.7 | ±2.7 % |
| | | Y | 10.89 | 70.2 | 22.9 | | 140.0 | |
| | | Z | 10.70 | 70.2 | 23.0 | | 136.7 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 10.49 | 86.3 | 22.8 | 9.39 | 138.5 | ±2.2 % |
| | | Y | 13.76 | 90.7 | 24.6 | | 145.7 | |
| | | Z | 7.99 | 82.4 | 21.3 | | 141.8 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 9.73 | 85.3 | 22.7 | 9.57 | 149.4 | ±2.7 % |
| | | Y | 9.12 | 84.3 | 22.7 | | 131.8 | |
| | | Z | 8.21 | 83.4 | 22.1 | | 134.8 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 34.75 | 99.7 | 24.5 | 6.56 | 135.8 | ±2.5 % |
| | | Y | 22.21 | 94.5 | 23.5 | | 146.5 | |
| | | Z | 8.93 | 81.8 | 18.8 | | 148.3 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 51.22 | 100.0 | 22.6 | 4.80 | 132.9 | ±1.9 % |
| | | Y | 45.95 | 99.6 | 23.0 | | 139.7 | |
| | | Z | 14.90 | 87.0 | 19.2 | | 138.0 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 66.25 | 99.8 | 21.6 | 3.55 | 141.8 | ±1.9 % |
| | | Y | 61.05 | 99.6 | 21.6 | | 149.8 | |
| | | Z | 70.48 | 99.7 | 20.8 | | 126.6 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 98.24 | 98.4 | 18.0 | 1.16 | 135.4 | ±1.9 % |
| | | Y | 71.59 | 99.7 | 19.3 | | 144.2 | |
| | | Z | 98.96 | 91.6 | 15.1 | | 146.2 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.44 | 67.9 | 19.9 | 5.67 | 148.9 | ±1.4 % |
| | | Y | 6.27 | 67.2 | 19.6 | | 131.4 | |
| | | Z | 6.28 | 67.3 | 19.5 | | 137.9 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.52 | 74.2 | 25.3 | 9.29 | 134.3 | ±2.5 % |
| | | Y | 9.97 | 75.1 | 25.7 | | 146.8 | |
| | | Z | 9.47 | 74.4 | 25.4 | | 147.4 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.31 | 67.5 | 19.8 | 5.80 | 147.4 | ±1.4 % |
| | | Y | 6.21 | 67.1 | 19.6 | | 131.0 | |
| | | Z | 6.16 | 67.0 | 19.5 | | 136.4 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.11 | 68.9 | 21.2 | 8.07 | 137.9 | ±2.2 % |
| | | Y | 10.26 | 69.3 | 21.5 | | 147.7 | |
| | | Z | 9.85 | 68.3 | 20.9 | | 126.0 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 8.90 | 73.2 | 25.0 | 9.28 | 129.8 | ±3.3 % |
| | | Y | 9.32 | 74.0 | 25.2 | | 142.5 | |
| | | Z | 8.86 | 73.4 | 25.1 | | 142.1 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.98 | 66.9 | 19.6 | 5.75 | 143.7 | ±1.2 % |
| | | Y | 5.91 | 66.6 | 19.4 | | 128.0 | |
| | | Z | 5.84 | 66.5 | 19.3 | | 133.4 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.43 | 67.5 | 19.8 | 5.82 | 148.9 | ±1.4 % |
| | | Y | 6.31 | 67.0 | 19.6 | | 132.2 | |
| | | Z | 6.30 | 67.1 | 19.5 | | 138.0 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.93 | 67.3 | 20.0 | 5.73 | 145.7 | ±1.2 % |
| | | Y | 4.89 | 66.9 | 19.8 | | 131.7 | |
| | | Z | 4.82 | 66.9 | 19.7 | | 134.9 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 7.96 | 77.5 | 27.4 | 9.21 | 143.6 | ±2.7 % |
| | | Y | 7.61 | 75.5 | 26.3 | | 129.2 | |
| | | Z | 7.10 | 74.5 | 25.9 | | 129.7 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.89 | 67.1 | 19.9 | 5.72 | 138.9 | ±1.2 % |
| | | Y | 5.02 | 67.5 | 20.1 | | 148.1 | |
| | | Z | 4.77 | 66.7 | 19.6 | | 129.3 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.93 | 67.3 | 20.0 | 5.72 | 143.8 | ±1.2 % |
| | | Y | 5.08 | 67.8 | 20.3 | | 149.0 | |
| | | Z | 4.73 | 66.5 | 19.5 | | 129.4 | |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.73 | 68.7 | 21.3 | 8.10 | 130.0 | ±1.9 % |
| | | Y | 9.74 | 68.6 | 21.2 | | 132.7 | |
| | | Z | 9.78 | 69.0 | 21.4 | | 136.2 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.83 | 66.9 | 19.4 | 5.97 | 134.3 | ±1.4 % |
| | | Y | 6.98 | 67.3 | 19.6 | | 139.3 | |
| | | Z | 6.92 | 67.4 | 19.6 | | 142.7 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 7.94 | 77.5 | 27.4 | 9.21 | 143.5 | ±2.7 % |
| | | Y | 7.44 | 74.8 | 25.9 | | 125.0 | |
| | | Z | 7.14 | 74.7 | 26.0 | | 131.4 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 8.95 | 74.9 | 26.1 | 9.24 | 140.8 | ±2.7 % |
| | | Y | 8.53 | 72.8 | 24.7 | | 127.2 | |
| | | Z | 8.14 | 72.3 | 24.6 | | 127.1 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.66 | 75.7 | 26.4 | 9.30 | 149.7 | ±3.0 % |
| | | Y | 9.20 | 73.6 | 25.1 | | 135.1 | |
| | | Z | 8.81 | 73.3 | 25.1 | | 134.3 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.39 | 67.0 | 18.8 | 3.96 | 138.0 | ±0.7 % |
| | | Y | 4.51 | 67.5 | 19.2 | | 141.4 | |
| | | Z | 4.46 | 67.3 | 18.9 | | 146.2 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.59 | 67.1 | 18.7 | 3.46 | 128.3 | ±0.5 % |
| | | Y | 3.80 | 68.2 | 19.5 | | 130.9 | |
| | | Z | 3.74 | 68.1 | 19.2 | | 135.6 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.55 | 67.3 | 18.9 | 3.39 | 129.6 | ±0.5 % |
| | | Y | 3.73 | 68.2 | 19.4 | | 132.7 | |
| | | Z | 3.63 | 67.8 | 19.0 | | 137.7 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.30 | 67.4 | 19.6 | 5.81 | 145.6 | ±1.4 % |
| | | Y | 6.38 | 67.7 | 19.9 | | 148.2 | |
| | | Z | 6.12 | 66.8 | 19.4 | | 129.8 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.56 | 66.9 | 19.5 | 6.06 | 126.9 | ±1.2 % |
| | | Y | 6.71 | 67.4 | 19.8 | | 129.7 | |
| | | Z | 6.71 | 67.5 | 19.8 | | 136.5 | |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle) | X | 9.96 | 68.8 | 21.5 | 8.37 | 132.0 | ±2.2 % |
| | | Y | 10.06 | 69.0 | 21.6 | | 137.4 | |
| | | Z | 10.06 | 69.3 | 21.7 | | 140.2 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.89 | 69.6 | 19.3 | 3.76 | 139.4 | ±0.5 % |
| | | Y | 5.05 | 70.0 | 19.6 | | 143.9 | |
| | | Z | 4.98 | 70.0 | 19.5 | | 146.8 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.81 | 69.6 | 19.4 | 3.77 | 136.6 | ±0.7 % |
| | | Y | 5.07 | 70.4 | 19.9 | | 146.8 | |
| | | Z | 4.90 | 70.2 | 19.6 | | 144.5 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.82 | 69.8 | 19.4 | 1.54 | 136.4 | ±0.7 % |
| | | Y | 3.19 | 72.3 | 20.7 | | 145.1 | |
| | | Z | 2.84 | 69.7 | 19.1 | | 145.5 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.77 | 68.6 | 21.3 | 8.23 | 130.4 | ±2.2 % |
| | | Y | 9.95 | 69.0 | 21.5 | | 140.4 | |
| | | Z | 9.88 | 69.0 | 21.5 | | 138.1 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.69 | 6.69 | 6.69 | 0.80 | 1.17 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.41 | 6.41 | 6.41 | 0.68 | 1.22 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.40 | 5.40 | 5.40 | 0.57 | 1.39 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.17 | 5.17 | 5.17 | 0.76 | 1.14 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.85 | 4.85 | 4.85 | 0.64 | 1.32 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.57 | 4.57 | 4.57 | 0.75 | 1.34 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.44 | 4.44 | 4.44 | 0.68 | 1.38 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

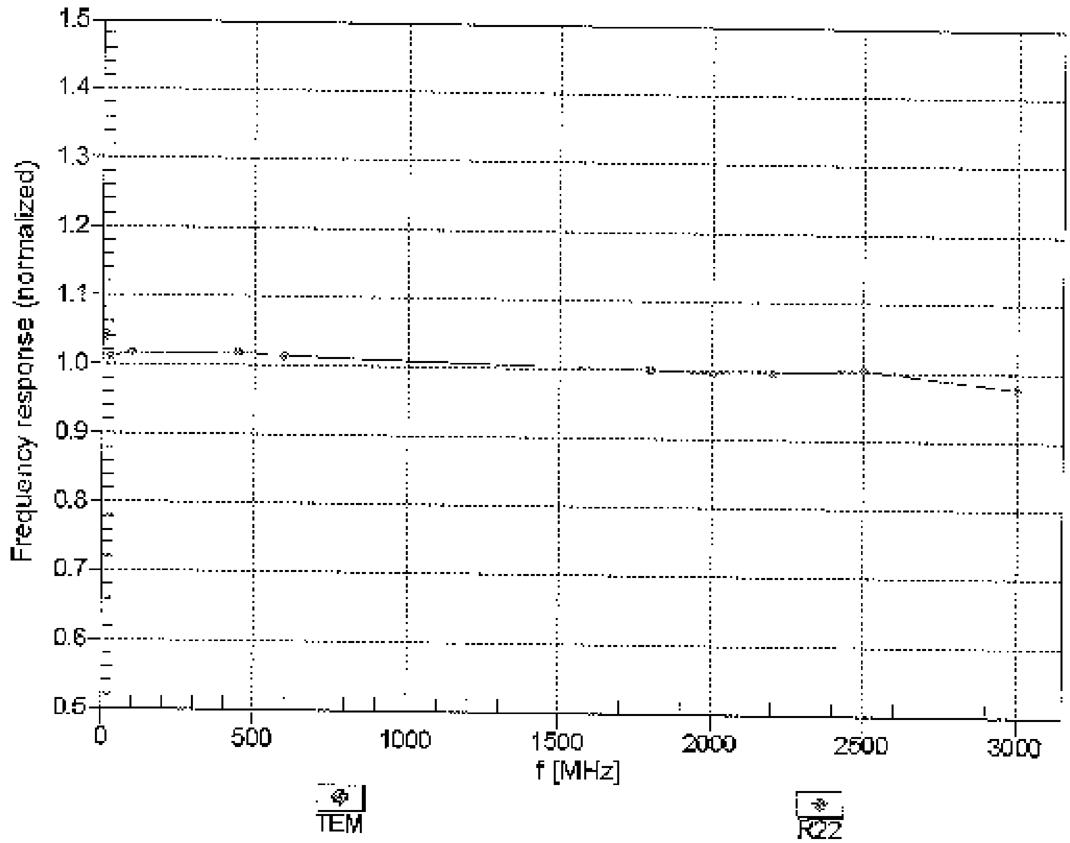
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.57 | 6.57 | 6.57 | 0.80 | 1.13 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.40 | 6.40 | 6.40 | 0.53 | 1.45 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.99 | 4.99 | 4.99 | 0.37 | 1.82 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.81 | 4.81 | 4.81 | 0.42 | 1.72 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.54 | 4.54 | 4.54 | 0.80 | 1.24 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.37 | 4.37 | 4.37 | 0.80 | 1.20 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.23 | 4.23 | 4.23 | 0.80 | 1.18 | ± 12.0 % |

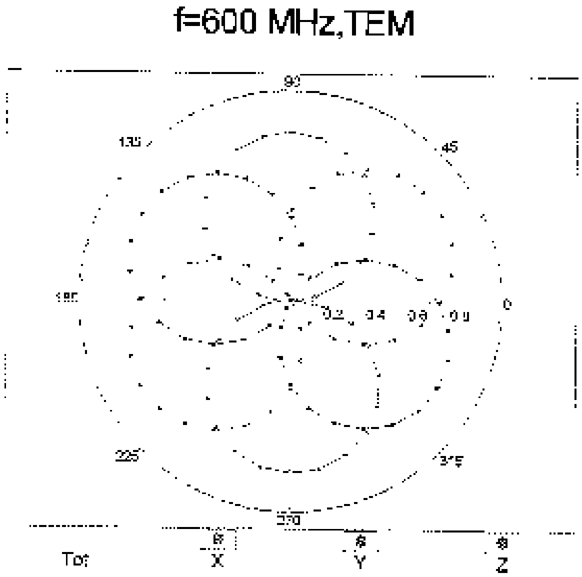
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

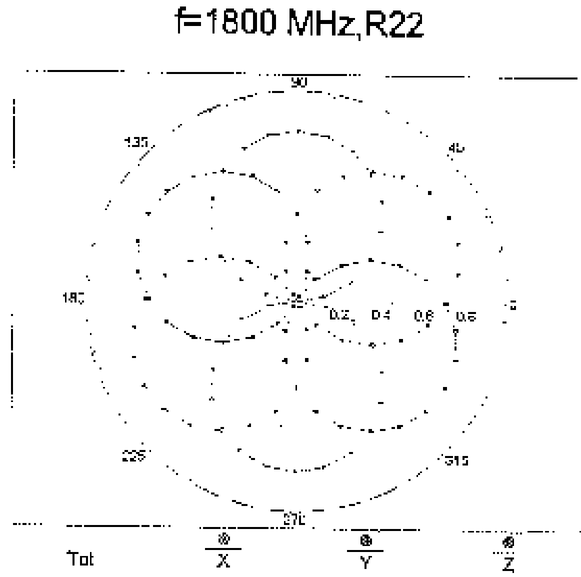
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)

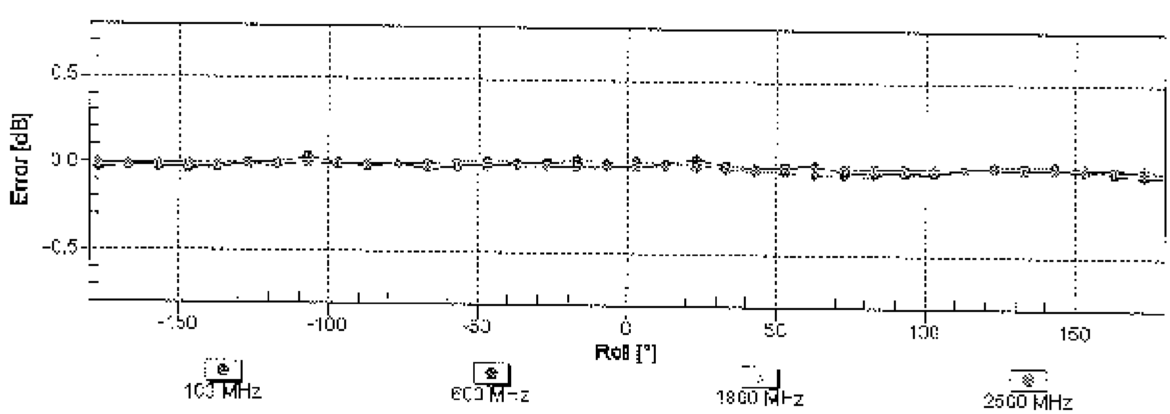



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern (ϕ), $\vartheta = 0°$

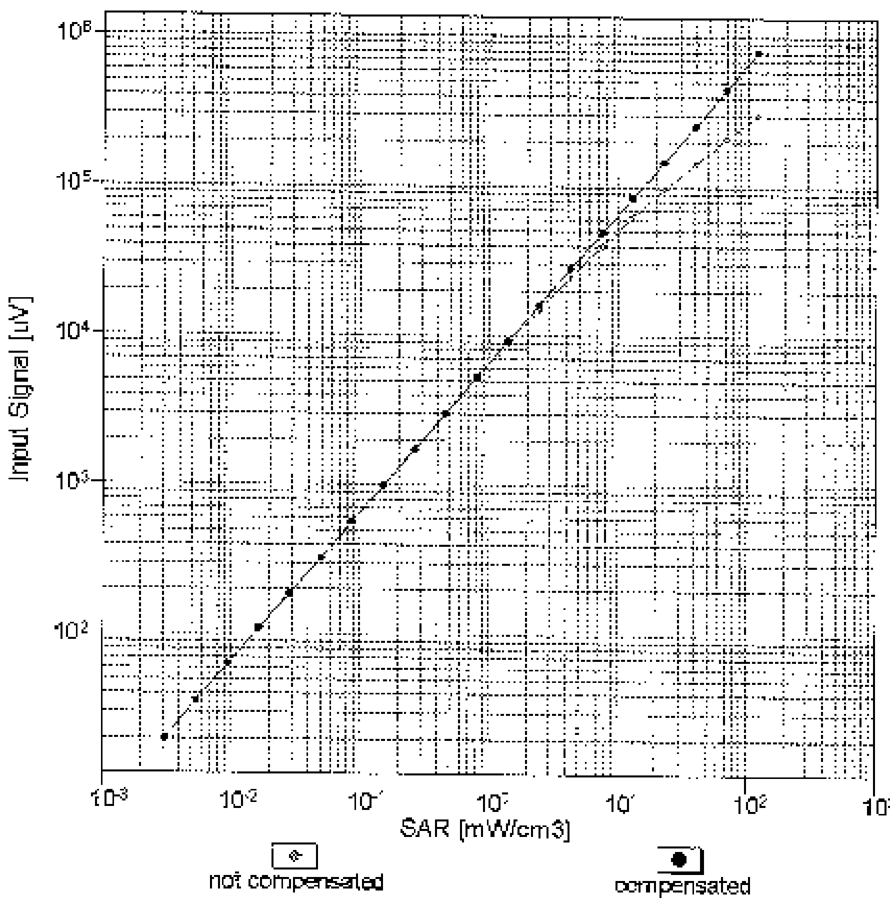


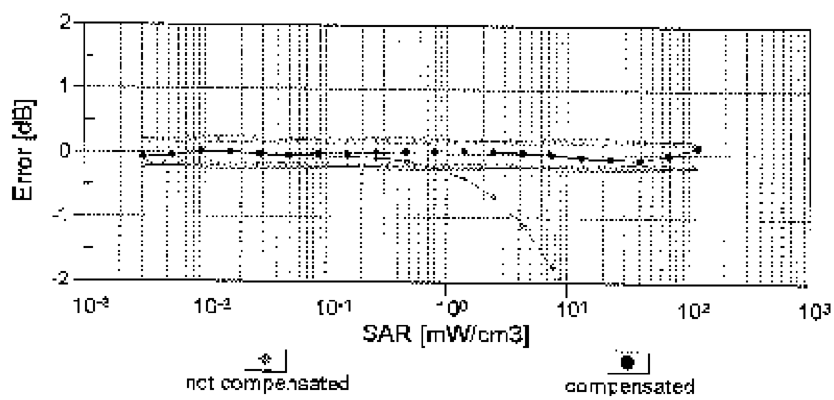




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

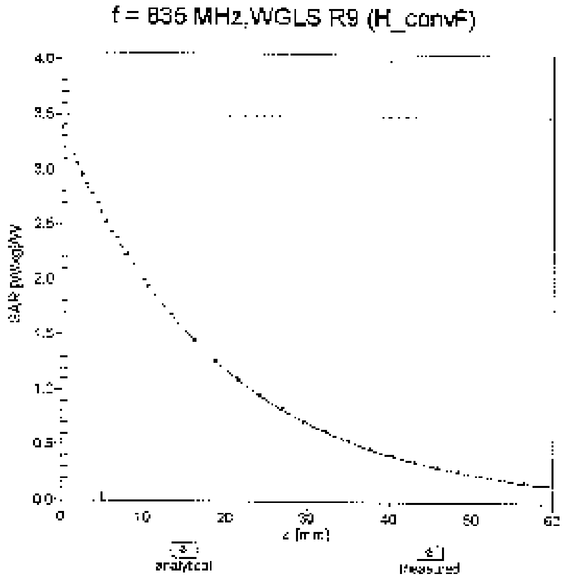
# Dynamic Range f($SAR_{head}$)
### (TEM cell , $f_{eval}$= 1900 MHz)

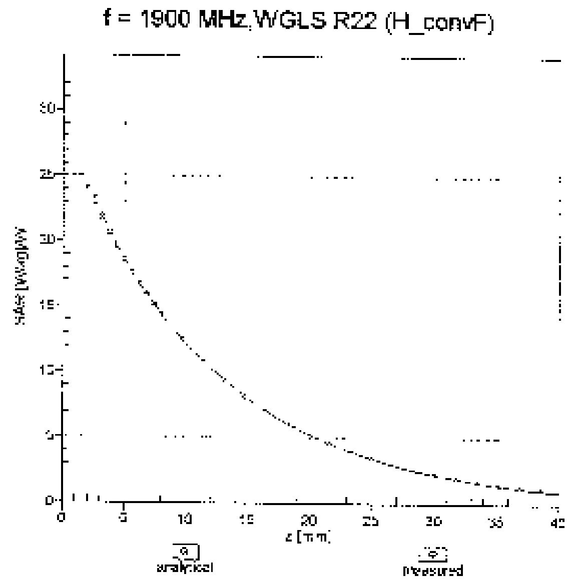



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

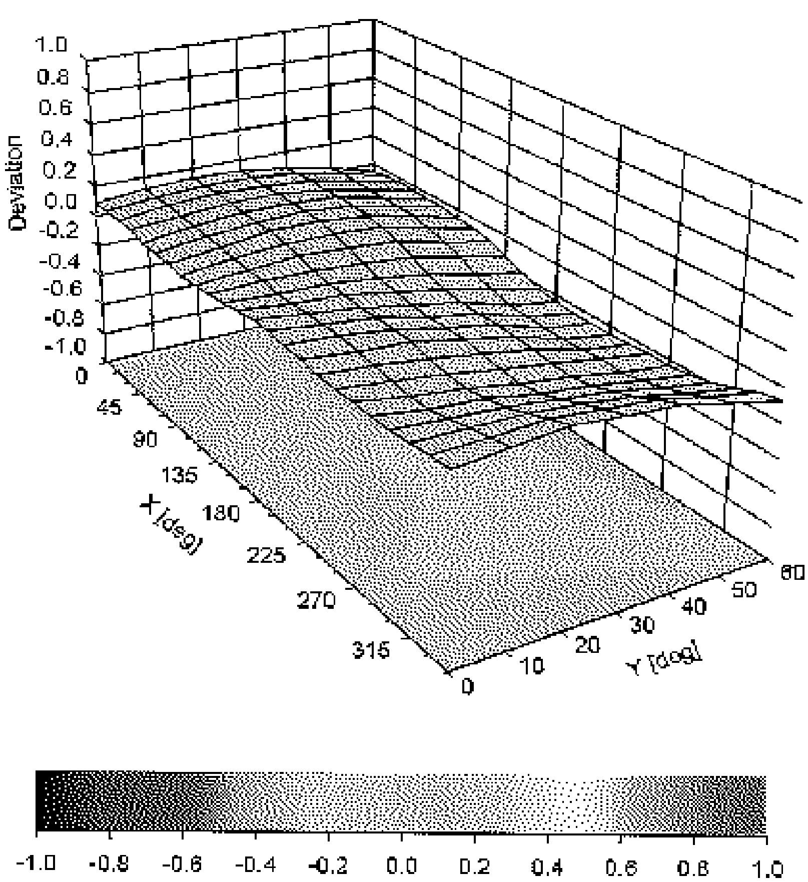
# Conversion Factor Assessment




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 73.1 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **ES3-3332_Sep15**

# CALIBRATION CERTIFICATE

Object ES3DV3 - SN:3332

BN ✓ 10/02/15

Calibration procedure(s) QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: September 18, 2015

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: September 19, 2015

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

# SN:3332

Manufactured: January 24, 2012
Calibrated: September 18, 2015

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.93 | 1.15 | 0.99 | ± 10.1 % |
| DCP (mV)[B] | 108.2 | 105.6 | 111.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB$\sqrt{\mu V}$ | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 180.2 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 198.1 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 187.7 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.96 | 64.5 | 11.8 | 10.00 | 35.0 | ±1.2 % |
| | | Y | 2.25 | 60.5 | 10.6 | | 40.1 | |
| | | Z | 2.62 | 65.4 | 12.1 | | 36.6 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.44 | 68.4 | 19.2 | 2.91 | 147.3 | ±0.5 % |
| | | Y | 3.37 | 67.7 | 18.7 | | 139.1 | |
| | | Z | 3.45 | 69.0 | 19.4 | | 149.1 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.28 | 71.7 | 20.1 | 1.87 | 148.2 | ±0.9 % |
| | | Y | 3.30 | 71.1 | 19.7 | | 137.5 | |
| | | Z | 4.01 | 76.3 | 22.2 | | 149.5 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.53 | 69.8 | 22.7 | 9.46 | 139.2 | ±2.5 % |
| | | Y | 10.78 | 69.9 | 22.7 | | 131.2 | |
| | | Z | 10.35 | 69.9 | 22.9 | | 138.0 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 5.49 | 76.7 | 19.0 | 9.39 | 136.0 | ±1.7 % |
| | | Y | 10.71 | 86.8 | 23.3 | | 136.5 | |
| | | Z | 4.51 | 77.8 | 20.5 | | 131.7 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 6.10 | 78.4 | 19.8 | 9.57 | 129.5 | ±2.5 % |
| | | Y | 10.58 | 86.6 | 23.3 | | 129.0 | |
| | | Z | 4.53 | 77.3 | 20.2 | | 146.7 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 6.33 | 78.5 | 17.8 | 6.56 | 140.5 | ±1.9 % |
| | | Y | 37.44 | 99.7 | 24.4 | | 145.2 | |
| | | Z | 24.95 | 99.6 | 24.7 | | 141.3 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 54.77 | 99.9 | 21.9 | 4.80 | 140.5 | ±2.5 % |
| | | Y | 45.73 | 99.6 | 22.9 | | 135.1 | |
| | | Z | 16.63 | 92.9 | 21.5 | | 136.4 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 93.62 | 99.9 | 20.2 | 3.55 | 127.4 | ±1.9 % |
| | | Y | 67.21 | 100.0 | 21.5 | | 144.3 | |
| | | Z | 46.91 | 99.9 | 21.3 | | 149.2 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 97.19 | 90.7 | 14.6 | 1.16 | 145.1 | ±1.9 % |
| | | Y | 96.34 | 95.4 | 17.0 | | 135.4 | |
| | | Z | 96.75 | 90.9 | 14.5 | | 146.6 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.19 | 67.1 | 19.4 | 5.67 | 135.5 | ±1.4 % |
| | | Y | 6.42 | 67.7 | 19.7 | | 146.7 | |
| | | Z | 6.28 | 67.8 | 19.9 | | 135.8 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 8.89 | 72.8 | 24.6 | 9.29 | 142.1 | ±2.7 % |
| | | Y | 9.60 | 73.9 | 24.9 | | 135.4 | |
| | | Z | 8.51 | 72.3 | 24.5 | | 136.8 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.05 | 66.7 | 19.3 | 5.80 | 134.0 | ±1.4 % |
| | | Y | 6.32 | 67.4 | 19.7 | | 145.7 | |
| | | Z | 6.03 | 67.1 | 19.6 | | 133.7 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 9.80 | 68.3 | 20.9 | 8.07 | 123.8 | ±2.2 % |
| | | Y | 10.05 | 68.7 | 21.1 | | 136.1 | |
| | | Z | 9.72 | 68.4 | 21.0 | | 123.8 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 8.37 | 72.1 | 24.4 | 9.28 | 136.9 | ±2.7 % |
| | | Y | 9.10 | 73.2 | 24.8 | | 131.4 | |
| | | Z | 7.92 | 71.3 | 24.2 | | 133.2 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.75 | 66.3 | 19.1 | 5.75 | 130.7 | ±1.4 % |
| | | Y | 6.00 | 66.8 | 19.4 | | 142.7 | |
| | | Z | 5.71 | 66.6 | 19.4 | | 131.5 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.17 | 66.7 | 19.3 | 5.82 | 136.2 | ±1.4 % |
| | | Y | 6.44 | 67.3 | 19.6 | | 147.2 | |
| | | Z | 6.16 | 67.2 | 19.7 | | 135.7 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.74 | 66.7 | 19.6 | 5.73 | 133.7 | ±1.2 % |
| | | Y | 5.01 | 67.4 | 19.9 | | 145.0 | |
| | | Z | 4.65 | 67.0 | 19.9 | | 133.6 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 6.67 | 73.1 | 25.1 | 9.21 | 126.3 | ±2.5 % |
| | | Y | 8.06 | 76.9 | 26.9 | | 144.3 | |
| | | Z | 6.29 | 72.8 | 25.4 | | 129.2 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.87 | 67.3 | 19.9 | 5.72 | 149.0 | ±1.2 % |
| | | Y | 4.98 | 67.2 | 19.8 | | 144.1 | |
| | | Z | 4.63 | 66.9 | 19.9 | | 131.7 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.66 | 66.4 | 19.4 | 5.72 | 127.1 | ±1.2 % |
| | | Y | 4.98 | 67.2 | 19.8 | | 144.1 | |
| | | Z | 4.63 | 66.9 | 19.9 | | 131.9 | |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.73 | 68.9 | 21.4 | 8.10 | 141.6 | ±2.2 % |
| | | Y | 9.66 | 68.3 | 21.0 | | 128.4 | |
| | | Z | 9.56 | 69.0 | 21.4 | | 139.9 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.84 | 67.3 | 19.5 | 5.97 | 145.4 | ±1.4 % |
| | | Y | 6.90 | 66.9 | 19.3 | | 134.3 | |
| | | Z | 6.82 | 68.0 | 20.1 | | 144.5 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 6.71 | 73.3 | 25.2 | 9.21 | 127.4 | ±2.5 % |
| | | Y | 8.21 | 77.5 | 27.2 | | 147.1 | |
| | | Z | 6.58 | 74.2 | 26.2 | | 146.3 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 8.26 | 73.2 | 25.2 | 9.24 | 147.4 | ±2.5 % |
| | | Y | 9.17 | 74.7 | 25.7 | | 148.9 | |
| | | Z | 7.77 | 72.2 | 24.9 | | 149.4 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.34 | 72.0 | 24.4 | 9.30 | 130.4 | ±2.2 % |
| | | Y | 9.09 | 73.2 | 24.8 | | 130.6 | |
| | | Z | 8.00 | 71.6 | 24.4 | | 132.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.39 | 67.2 | 18.8 | 3.96 | 143.6 | ±0.7 % |
| | | Y | 4.42 | 66.9 | 18.7 | | 137.9 | |
| | | Z | 4.44 | 68.0 | 19.3 | | 149.9 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.61 | 67.5 | 18.9 | 3.46 | 134.1 | ±0.7 % |
| | | Y | 3.62 | 68.1 | 19.3 | | 149.7 | |
| | | Z | 3.86 | 69.8 | 20.3 | | 136.7 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.55 | 67.5 | 18.8 | 3.39 | 135.0 | ±0.7 % |
| | | Y | 3.64 | 67.5 | 18.9 | | 128.2 | |
| | | Z | 3.70 | 69.2 | 19.9 | | 140.6 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.00 | 66.5 | 19.2 | 5.81 | 127.3 | ±1.7 % |
| | | Y | 6.31 | 67.3 | 19.7 | | 143.5 | |
| | | Z | 6.10 | 67.3 | 19.8 | | 133.1 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.58 | 67.1 | 19.6 | 6.06 | 132.3 | ±1.7 % |
| | | Y | 6.89 | 67.9 | 20.0 | | 150.0 | |
| | | Z | 6.66 | 67.9 | 20.1 | | 139.0 | |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle) | X | 9.89 | 68.9 | 21.5 | 8.37 | 137.7 | ±2.5 % |
| | | Y | 9.99 | 68.7 | 21.4 | | 131.9 | |
| | | Z | 9.84 | 69.3 | 21.8 | | 142.0 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.79 | 69.6 | 19.3 | 3.76 | 144.7 | ±0.5 % |
| | | Y | 4.91 | 69.1 | 19.1 | | 139.1 | |
| | | Z | 5.14 | 72.5 | 20.9 | | 148.7 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 5.05 | 70.9 | 19.9 | 3.77 | 143.6 | ±0.9 % |
| | | Y | 4.92 | 69.5 | 19.3 | | 137.0 | |
| | | Z | 5.15 | 72.8 | 21.0 | | 146.1 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.75 | 69.3 | 19.0 | 1.54 | 143.9 | ±0.7 % |
| | | Y | 2.86 | 69.9 | 19.3 | | 134.9 | |
| | | Z | 3.83 | 76.3 | 22.3 | | 149.9 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.83 | 69.0 | 21.5 | 8.23 | 142.4 | ±2.2 % |
| | | Y | 9.78 | 68.4 | 21.1 | | 130.2 | |
| | | Z | 9.68 | 69.0 | 21.6 | | 141.2 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.44 | 6.44 | 6.44 | 0.46 | 1.55 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.23 | 6.23 | 6.23 | 0.25 | 2.20 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.25 | 5.25 | 5.25 | 0.46 | 1.48 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.06 | 5.06 | 5.06 | 0.61 | 1.30 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.78 | 4.78 | 4.78 | 0.61 | 1.43 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.44 | 4.44 | 4.44 | 0.80 | 1.26 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.31 | 4.31 | 4.31 | 0.80 | 1.27 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

## Calibration Parameter Determined in Body Tissue Simulating Media

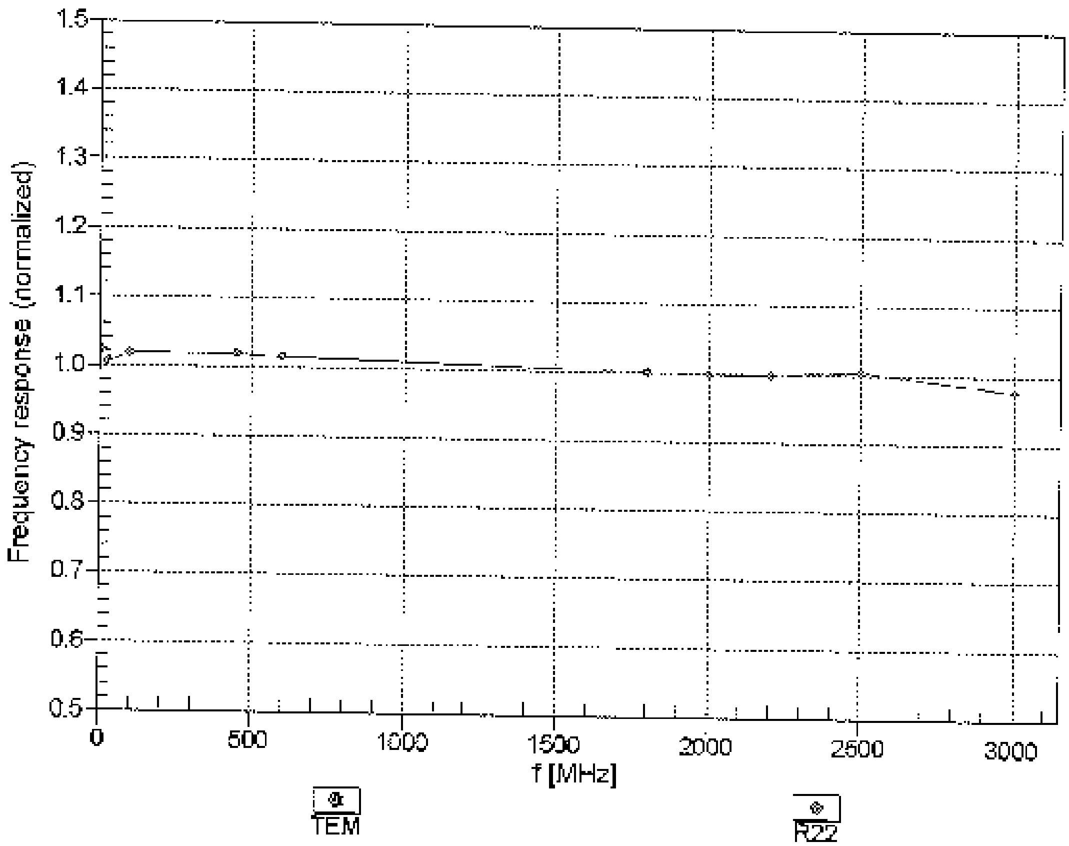
| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.36 | 6.36 | 6.36 | 0.80 | 1.16 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.21 | 6.21 | 6.21 | 0.53 | 1.43 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.85 | 4.85 | 4.85 | 0.40 | 1.67 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.70 | 4.70 | 4.70 | 0.55 | 1.55 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.46 | 4.46 | 4.46 | 0.80 | 1.25 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.30 | 4.30 | 4.30 | 0.80 | 1.25 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.06 | 4.06 | 4.06 | 0.80 | 1.20 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

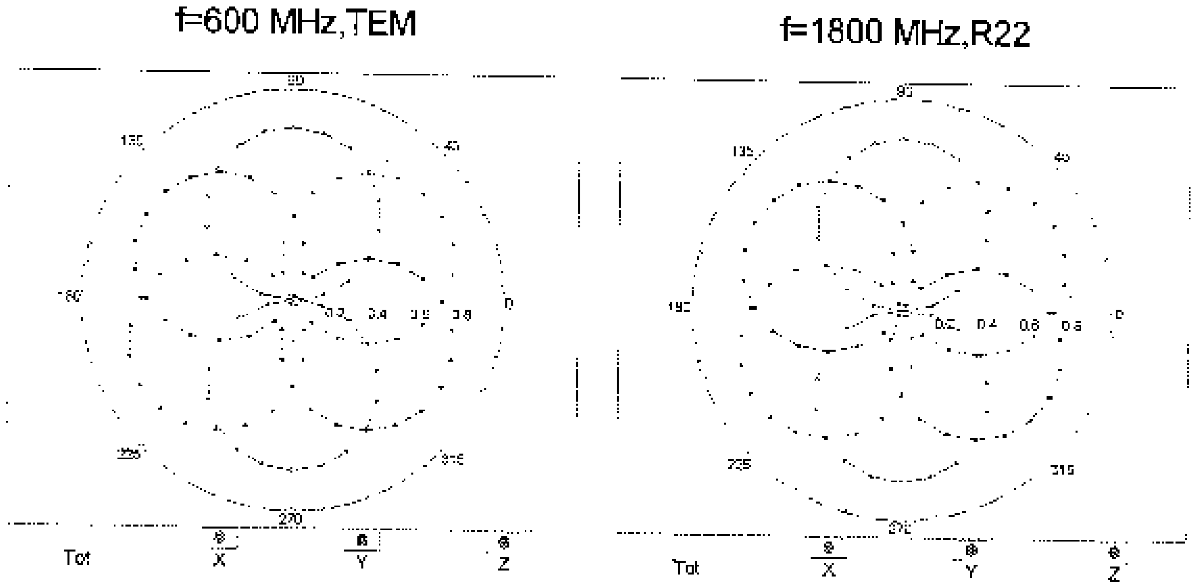
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

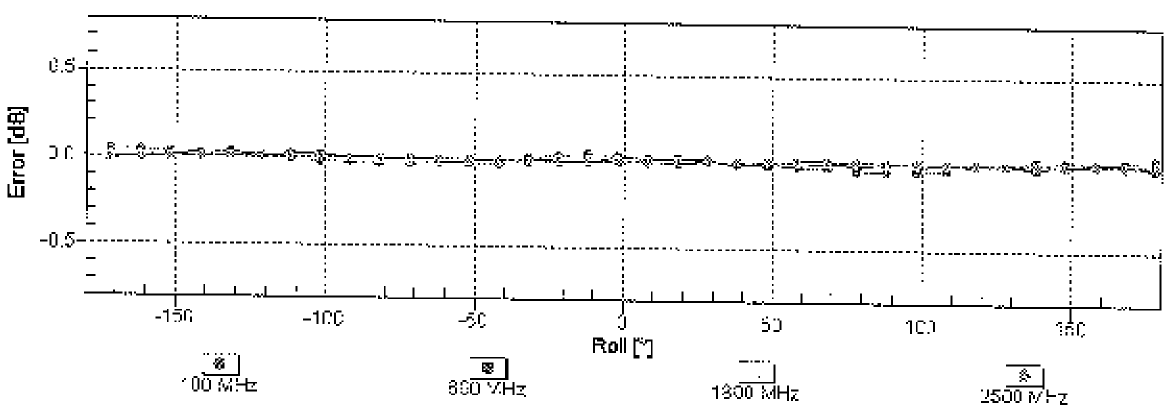
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)




**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern (ϕ), ϑ = 0°

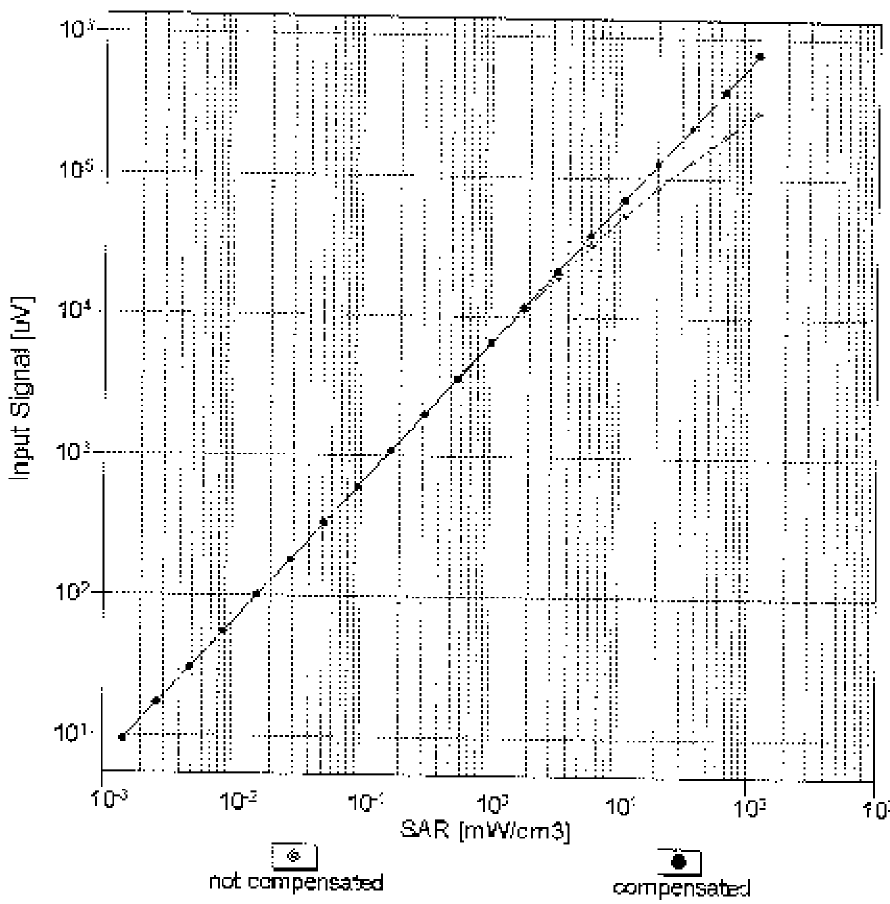


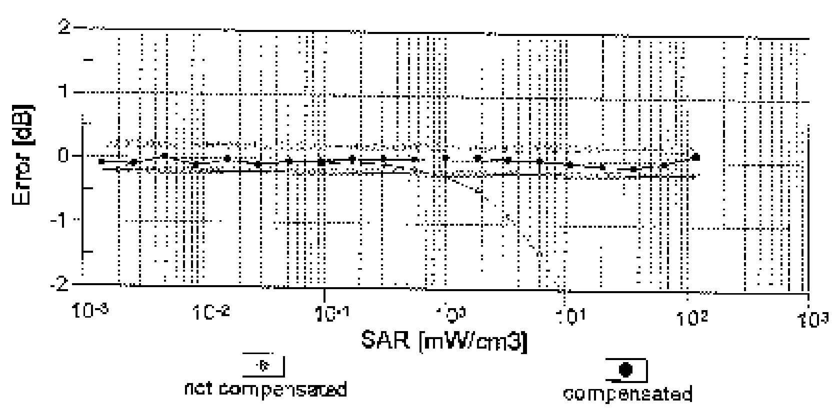




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)

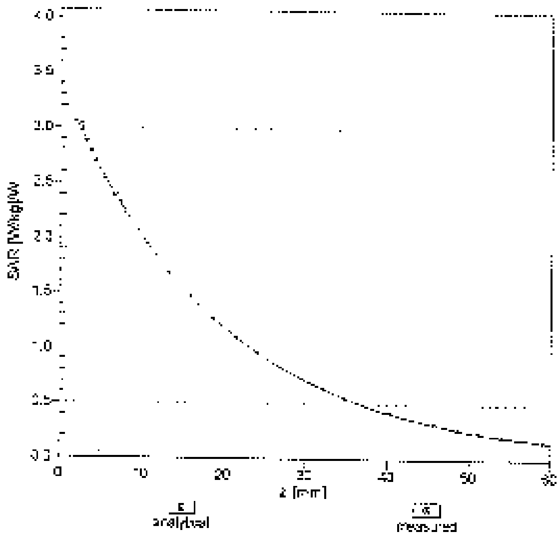
**(TEM cell , $f_{eval}$= 1900 MHz)**

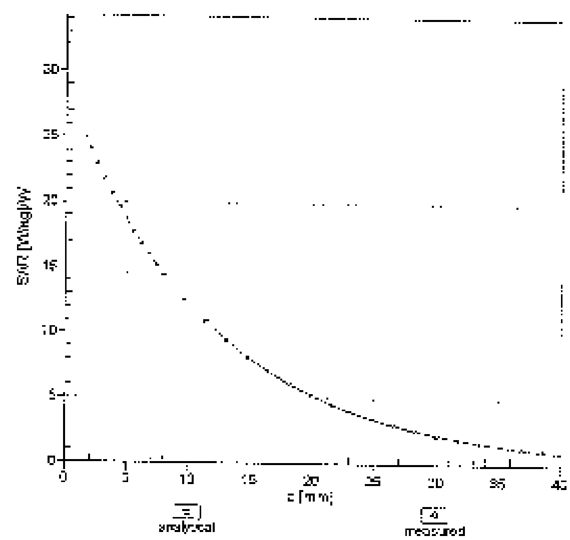



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

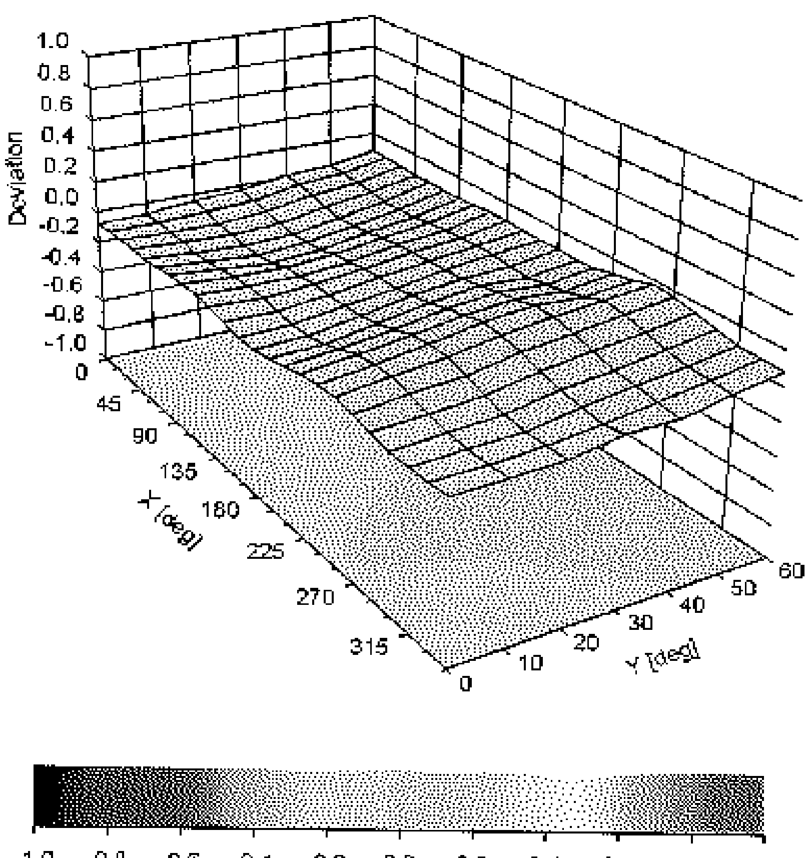
# Conversion Factor Assessment




# Deviation from Isotropy in Liquid

**Error (φ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -1.9 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **ES3-3022_Aug15**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ES3DV2 - SN:3022 |
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | August 26, 2015 |

BN √ 9/3/2015

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: August 27, 2015

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV2

## SN:3022

Manufactured: April 15, 2003
Calibrated: August 26, 2015

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 1.00 | 1.03 | 0.95 | ± 10.1 % |
| DCP (mV)[B] | 99.9 | 99.7 | 100.9 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 179.6 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 183.9 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 179.0 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 3.60 | 65.9 | 14.2 | 10.00 | 43.5 | ±2.2 % |
| | | Y | 2.84 | 63.5 | 13.0 | | 43.3 | |
| | | Z | 2.76 | 63.7 | 12.7 | | 41.7 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.32 | 67.0 | 18.7 | 2.91 | 144.4 | ±0.7 % |
| | | Y | 3.24 | 66.3 | 18.0 | | 147.3 | |
| | | Z | 3.19 | 66.3 | 18.0 | | 143.5 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.15 | 69.9 | 19.5 | 1.87 | 146.1 | ±0.7 % |
| | | Y | 2.88 | 67.7 | 18.0 | | 147.9 | |
| | | Z | 2.78 | 67.4 | 17.8 | | 145.6 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.40 | 71.3 | 23.8 | 9.46 | 144.9 | ±3.3 % |
| | | Y | 11.15 | 70.5 | 23.1 | | 146.9 | |
| | | Z | 10.95 | 70.5 | 23.3 | | 140.3 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 20.66 | 99.8 | 29.2 | 9.39 | 132.6 | ±2.2 % |
| | | Y | 14.36 | 93.3 | 26.6 | | 145.3 | |
| | | Z | 17.17 | 97.2 | 27.8 | | 145.4 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 17.22 | 96.5 | 28.2 | 9.57 | 125.4 | ±1.9 % |
| | | Y | 11.06 | 88.6 | 25.0 | | 136.0 | |
| | | Z | 8.71 | 84.6 | 23.4 | | 130.7 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 31.05 | 99.5 | 25.9 | 6.56 | 135.2 | ±2.2 % |
| | | Y | 25.28 | 97.4 | 25.0 | | 132.5 | |
| | | Z | 21.58 | 95.7 | 24.5 | | 144.4 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 42.88 | 99.9 | 24.0 | 4.80 | 129.5 | ±1.9 % |
| | | Y | 40.80 | 99.6 | 23.7 | | 124.9 | |
| | | Z | 38.42 | 99.7 | 23.7 | | 137.8 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 44.48 | 100.0 | 23.2 | 3.55 | 138.2 | ±1.9 % |
| | | Y | 44.03 | 99.7 | 22.8 | | 133.0 | |
| | | Z | 41.36 | 99.8 | 22.8 | | 147.5 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 16.08 | 99.5 | 23.3 | 1.16 | 127.5 | ±1.4 % |
| | | Y | 79.69 | 99.6 | 19.3 | | 146.2 | |
| | | Z | 45.81 | 99.9 | 20.4 | | 138.2 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.43 | 67.4 | 19.8 | 5.67 | 138.7 | ±1.4 % |
| | | Y | 6.27 | 66.8 | 19.2 | | 134.9 | |
| | | Z | 6.16 | 66.6 | 19.2 | | 127.6 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.13 | 75.0 | 25.9 | 9.29 | 129.4 | ±3.3 % |
| | | Y | 9.46 | 73.0 | 24.5 | | 131.8 | |
| | | Z | 9.52 | 74.0 | 25.4 | | 137.0 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.27 | 66.9 | 19.7 | 5.80 | 137.0 | ±1.7 % |
| | | Y | 6.24 | 66.7 | 19.3 | | 140.0 | |
| | | Z | 6.06 | 66.3 | 19.2 | | 127.1 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.16 | 68.7 | 21.3 | 8.07 | 127.7 | ±2.2 % |
| | | Y | 9.99 | 68.2 | 20.9 | | 131.5 | |
| | | Z | 10.22 | 69.1 | 21.4 | | 141.6 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.34 | 73.4 | 25.2 | 9.28 | 125.0 | ±3.3 % |
| | | Y | 8.92 | 72.2 | 24.3 | | 127.2 | |
| | | Z | 8.95 | 73.1 | 25.1 | | 131.9 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.95 | 66.4 | 19.4 | 5.75 | 134.4 | ±1.4 % |
| | | Y | 5.92 | 66.2 | 19.1 | | 137.0 | |
| | | Z | 5.98 | 66.7 | 19.5 | | 146.8 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.39 | 66.9 | 19.6 | 5.82 | 139.9 | ±1.7 % |
| | | Y | 6.35 | 66.7 | 19.3 | | 141.9 | |
| | | Z | 6.15 | 66.2 | 19.2 | | 128.4 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.96 | 66.6 | 19.8 | 5.73 | 137.3 | ±1.4 % |
| | | Y | 4.85 | 66.1 | 19.3 | | 139.8 | |
| | | Z | 4.85 | 66.6 | 19.7 | | 146.7 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.75 | 78.7 | 28.3 | 9.21 | 138.9 | ±3.0 % |
| | | Y | 7.69 | 75.1 | 26.1 | | 140.1 | |
| | | Z | 7.80 | 76.6 | 27.2 | | 144.0 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.88 | 66.2 | 19.6 | 5.72 | 132.0 | ±1.4 % |
| | | Y | 4.77 | 65.8 | 19.1 | | 132.6 | |
| | | Z | 4.83 | 66.5 | 19.6 | | 146.0 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.91 | 66.3 | 19.7 | 5.72 | 131.7 | ±1.4 % |
| | | Y | 4.82 | 66.0 | 19.2 | | 138.4 | |
| | | Z | 4.86 | 66.7 | 19.7 | | 145.7 | |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 10.04 | 69.1 | 21.7 | 8.10 | 140.9 | ±2.2 % |
| | | Y | 9.62 | 67.9 | 20.8 | | 125.2 | |
| | | Z | 9.74 | 68.6 | 21.3 | | 133.3 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 7.01 | 67.1 | 19.6 | 5.97 | 143.7 | ±1.4 % |
| | | Y | 6.78 | 66.2 | 19.0 | | 129.3 | |
| | | Z | 6.80 | 66.7 | 19.3 | | 136.5 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 8.55 | 78.0 | 27.9 | 9.21 | 134.6 | ±3.0 % |
| | | Y | 7.79 | 75.6 | 26.3 | | 141.6 | |
| | | Z | 7.89 | 76.9 | 27.4 | | 145.2 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 9.30 | 74.8 | 26.1 | 9.24 | 134.8 | ±3.3 % |
| | | Y | 8.65 | 72.5 | 24.5 | | 136.4 | |
| | | Z | 8.33 | 72.3 | 24.8 | | 126.6 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 10.20 | 76.2 | 26.8 | 9.30 | 144.8 | ±3.3 % |
| | | Y | 9.41 | 73.7 | 25.1 | | 145.9 | |
| | | Z | 9.18 | 73.9 | 25.6 | | 138.6 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.45 | 66.7 | 18.9 | 3.96 | 147.0 | ±0.9 % |
| | | Y | 4.21 | 65.5 | 17.9 | | 126.5 | |
| | | Z | 4.36 | 66.5 | 18.5 | | 148.0 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.57 | 66.3 | 18.5 | 3.46 | 134.3 | ±0.7 % |
| | | Y | 3.48 | 65.6 | 17.8 | | 136.8 | |
| | | Z | 3.51 | 66.2 | 18.3 | | 136.4 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.53 | 66.4 | 18.6 | 3.39 | 135.8 | ±0.7 % |
| | | Y | 3.45 | 65.8 | 17.9 | | 140.4 | |
| | | Z | 3.50 | 66.5 | 18.5 | | 137.0 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.18 | 66.5 | 19.5 | 5.81 | 129.4 | ±1.4 % |
| | | Y | 6.15 | 66.3 | 19.1 | | 133.6 | |
| | | Z | 6.13 | 66.5 | 19.3 | | 131.2 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.77 | 67.2 | 19.9 | 6.06 | 134.8 | ±1.7 % |
| | | Y | 6.81 | 67.3 | 19.7 | | 144.8 | |
| | | Z | 6.68 | 67.1 | 19.7 | | 136.7 | |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle) | X | 10.30 | 69.4 | 22.0 | 8.37 | 142.0 | ±2.5 % |
| | | Y | 9.90 | 68.2 | 21.1 | | 126.8 | |
| | | Z | 10.15 | 69.3 | 21.9 | | 142.6 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.72 | 68.1 | 18.9 | 3.76 | 147.8 | ±0.7 % |
| | | Y | 4.56 | 67.5 | 18.2 | | 133.6 | |
| | | Z | 4.61 | 68.2 | 18.7 | | 147.4 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.57 | 67.8 | 18.8 | 3.77 | 144.3 | ±0.7 % |
| | | Y | 4.43 | 67.3 | 18.1 | | 131.3 | |
| | | Z | 4.57 | 68.3 | 18.8 | | 145.0 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.64 | 67.9 | 18.7 | 1.54 | 142.1 | ±0.5 % |
| | | Y | 2.36 | 65.4 | 16.8 | | 130.3 | |
| | | Z | 2.50 | 66.7 | 17.7 | | 145.0 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.04 | 69.0 | 21.7 | 8.23 | 138.8 | ±2.2 % |
| | | Y | 9.71 | 68.0 | 20.9 | | 125.6 | |
| | | Z | 9.94 | 69.0 | 21.6 | | 140.4 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.33 | 6.33 | 6.33 | 0.46 | 1.43 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.11 | 6.11 | 6.11 | 0.24 | 2.08 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.08 | 5.08 | 5.08 | 0.45 | 1.47 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 4.93 | 4.93 | 4.93 | 0.59 | 1.25 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.63 | 4.63 | 4.63 | 0.55 | 1.39 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.30 | 4.30 | 4.30 | 0.51 | 1.47 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.12 | 4.12 | 4.12 | 0.57 | 1.46 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

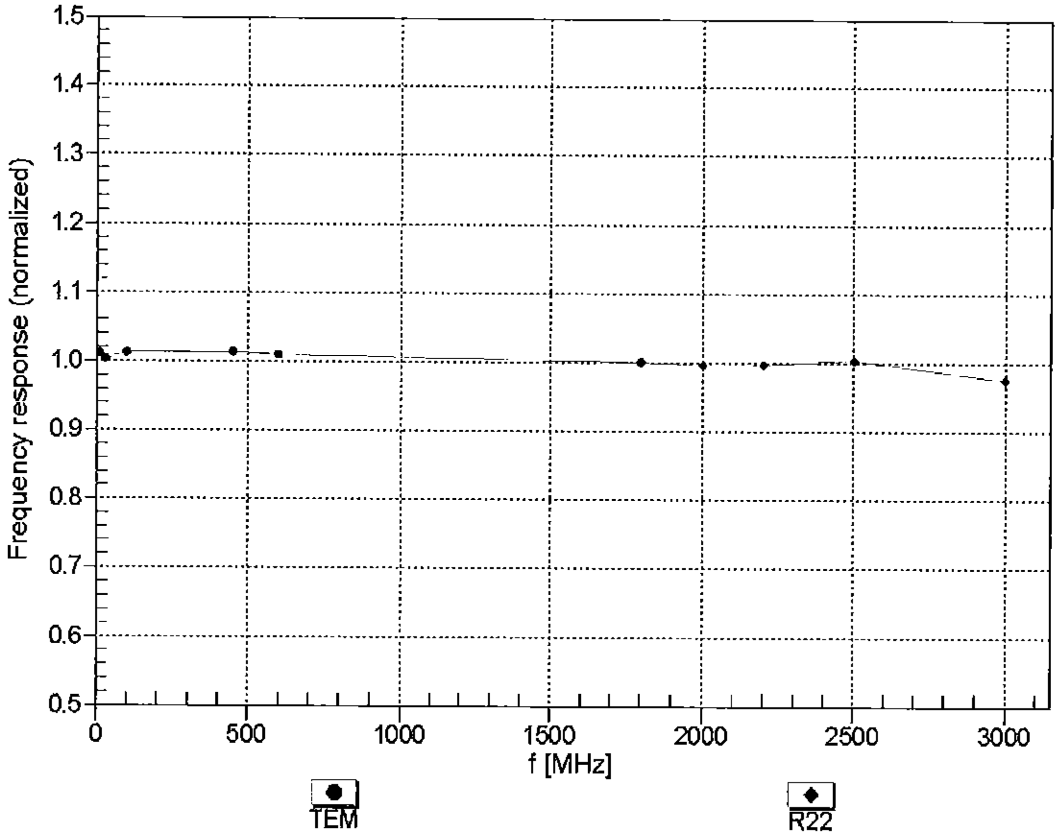
# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.16 | 6.16 | 6.16 | 0.50 | 1.34 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.13 | 6.13 | 6.13 | 0.25 | 2.16 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.79 | 4.79 | 4.79 | 0.61 | 1.33 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.56 | 4.56 | 4.56 | 0.31 | 2.02 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.32 | 4.32 | 4.32 | 0.79 | 1.19 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.08 | 4.08 | 4.08 | 0.80 | 1.12 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 3.96 | 3.96 | 3.96 | 0.80 | 1.10 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

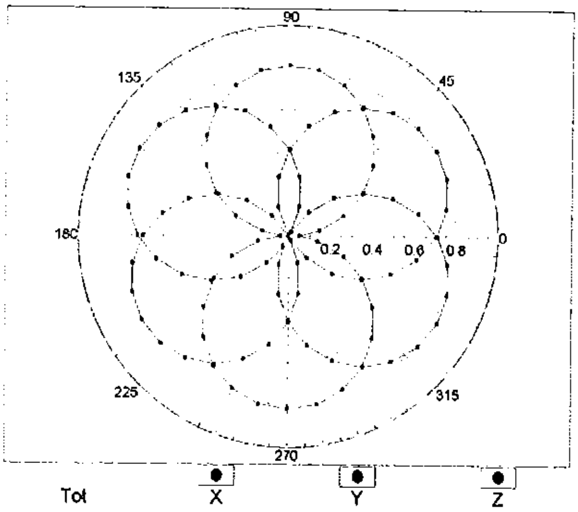
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



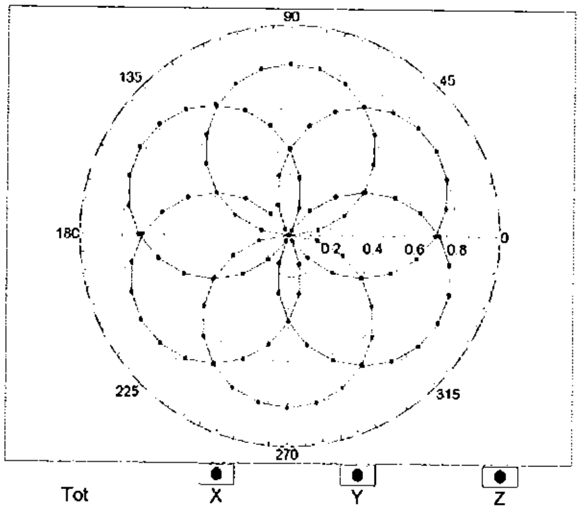

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

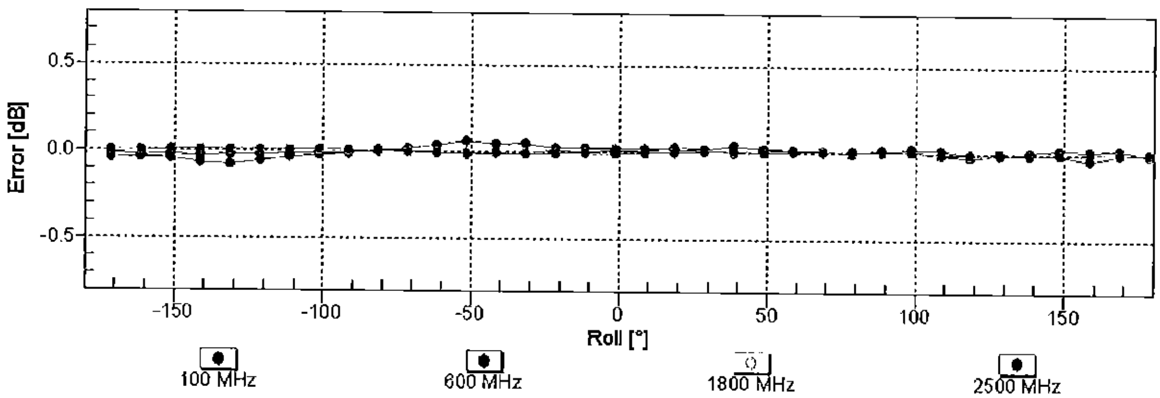
# Receiving Pattern (ϕ), $\vartheta$ = 0°

f=600 MHz,TEM



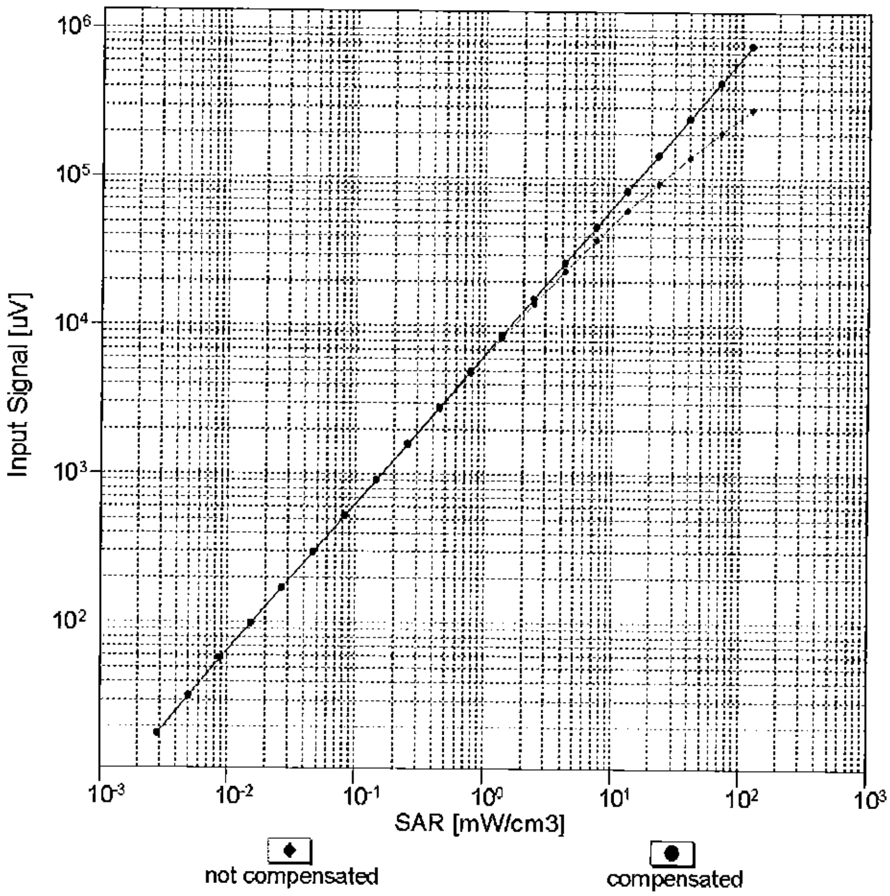

f=1800 MHz,R22

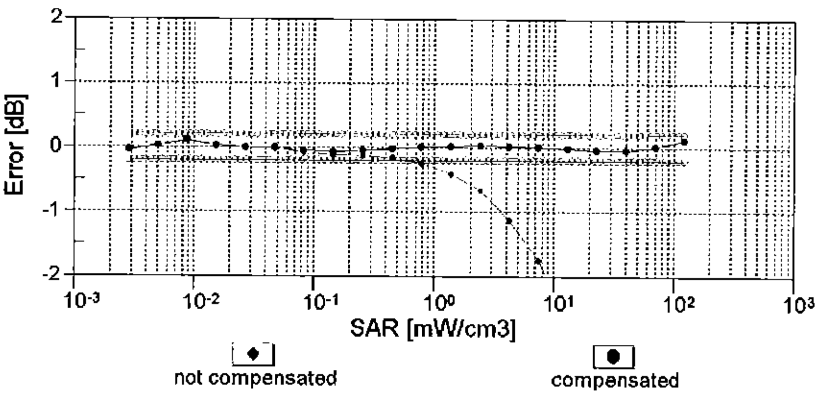



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

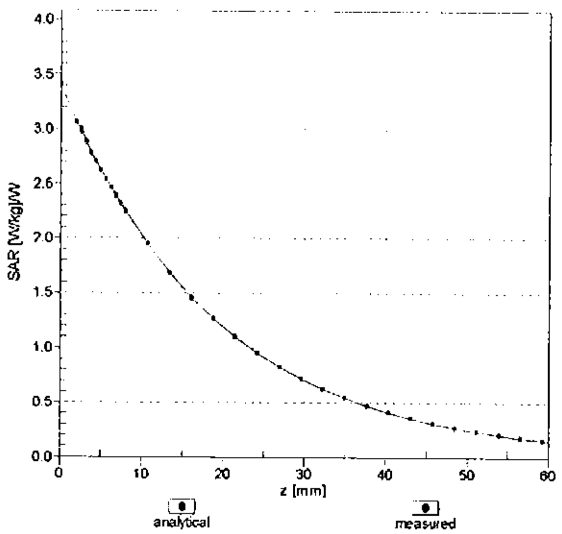
# Dynamic Range f($SAR_{head}$)
**(TEM cell , $f_{eval}$= 1900 MHz)**

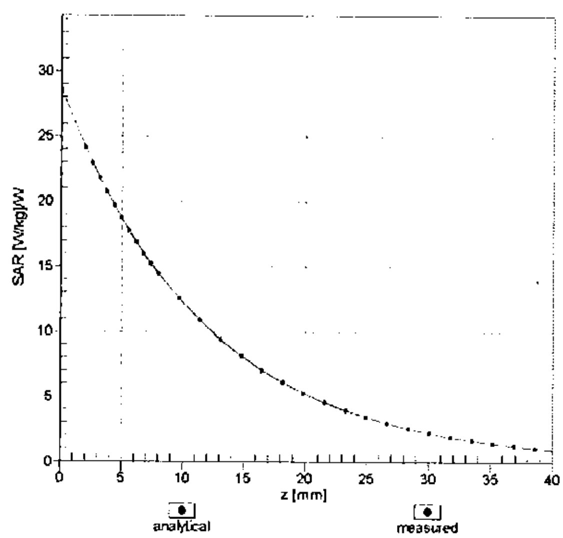



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

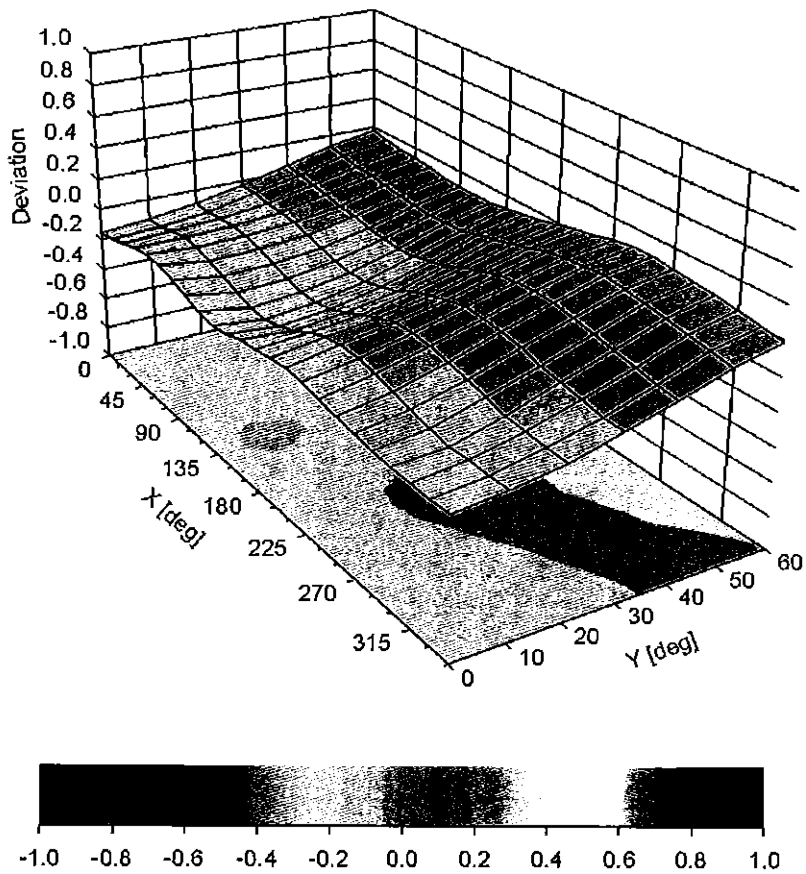
# Conversion Factor Assessment




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 98.5 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
**S** Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

**Accreditation No.: SCS 0108**

Client **PC Test**

Certificate No: **ES3-3334_Nov15**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ES3DV3 - SN:3334 |
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | November 17, 2015 |

BN 11/24/15

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 17, 2015

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization paramaters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

# SN:3334

Manufactured: January 24, 2012
Calibrated: November 17, 2015

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)$^A$ | 1.03 | 1.03 | 0.99 | ± 10.1 % |
| DCP (mV)$^B$ | 107.6 | 105.3 | 107.9 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc$^E$ (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 192.1 | ±2.7 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 183.6 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 183.3 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.27 | 60.1 | 10.2 | 10.00 | 38.6 | ±1.4 % |
| | | Y | 1.99 | 59.3 | 10.2 | | 38.4 | |
| | | Z | 5.38 | 67.8 | 12.9 | | 37.2 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.40 | 68.0 | 18.9 | 2.91 | 131.7 | ±0.5 % |
| | | Y | 3.27 | 67.0 | 18.2 | | 130.2 | |
| | | Z | 3.41 | 68.3 | 19.1 | | 148.5 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 2.93 | 68.9 | 18.7 | 1.87 | 132.9 | ±0.7 % |
| | | Y | 3.12 | 69.6 | 18.8 | | 130.2 | |
| | | Z | 3.24 | 71.1 | 19.7 | | 128.2 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.90 | 70.3 | 23.0 | 9.46 | 133.5 | ±3.3 % |
| | | Y | 10.53 | 69.0 | 22.1 | | 124.6 | |
| | | Z | 11.14 | 71.2 | 23.6 | | 147.1 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 15.05 | 91.0 | 24.4 | 9.39 | 139.5 | ±1.9 % |
| | | Y | 10.11 | 85.5 | 23.3 | | 131.9 | |
| | | Z | 11.84 | 87.6 | 23.4 | | 130.0 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 10.42 | 84.9 | 22.6 | 9.57 | 131.5 | ±3.0 % |
| | | Y | 13.29 | 89.7 | 24.6 | | 141.1 | |
| | | Z | 14.17 | 90.2 | 24.2 | | 148.7 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 11.26 | 83.1 | 19.4 | 6.56 | 140.7 | ±1.9 % |
| | | Y | 26.29 | 95.5 | 23.8 | | 134.7 | |
| | | Z | 16.82 | 88.9 | 21.3 | | 131.6 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 64.74 | 99.9 | 22.2 | 4.80 | 131.5 | ±2.2 % |
| | | Y | 56.71 | 99.8 | 22.7 | | 124.7 | |
| | | Z | 63.10 | 99.9 | 22.2 | | 124.1 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 62.11 | 99.6 | 21.6 | 3.55 | 146.1 | ±1.9 % |
| | | Y | 77.61 | 99.8 | 21.2 | | 132.0 | |
| | | Z | 72.33 | 99.7 | 21.2 | | 133.3 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 96.24 | 92.7 | 15.9 | 1.16 | 137.2 | ±1.7 % |
| | | Y | 95.69 | 93.1 | 16.2 | | 129.5 | |
| | | Z | 98.67 | 94.1 | 16.4 | | 149.7 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.14 | 66.8 | 19.2 | 5.67 | 126.2 | ±1.7 % |
| | | Y | 6.21 | 66.8 | 19.1 | | 139.9 | |
| | | Z | 6.41 | 67.9 | 19.9 | | 145.9 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.07 | 75.4 | 25.8 | 9.29 | 138.2 | ±2.5 % |
| | | Y | 9.54 | 73.3 | 24.5 | | 130.5 | |
| | | Z | 9.84 | 75.1 | 25.8 | | 130.6 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.34 | 67.6 | 19.8 | 5.80 | 149.5 | ±1.4 % |
| | | Y | 6.13 | 66.6 | 19.1 | | 132.1 | |
| | | Z | 6.19 | 67.2 | 19.7 | | 137.8 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.13 | 68.9 | 21.2 | 8.07 | 138.8 | ±2.7 % |
| | | Y | 10.16 | 68.9 | 21.1 | | 149.6 | |
| | | Z | 9.96 | 68.7 | 21.1 | | 127.1 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.42 | 74.4 | 25.5 | 9.28 | 132.9 | ±3.0 % |
| | | Y | 9.50 | 74.0 | 25.0 | | 143.7 | |
| | | Z | 9.01 | 73.4 | 25.0 | | 126.5 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.03 | 67.1 | 19.6 | 5.75 | 145.5 | ±1.4 % |
| | | Y | 5.81 | 66.0 | 18.9 | | 128.9 | |
| | | Z | 5.91 | 66.8 | 19.5 | | 135.1 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.19 | 66.5 | 19.2 | 5.82 | 126.7 | ±1.4 % |
| | | Y | 6.20 | 66.4 | 19.0 | | 132.8 | |
| | | Z | 6.39 | 67.5 | 19.8 | | 141.1 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.05 | 67.6 | 20.0 | 5.73 | 146.8 | ±1.4 % |
| | | Y | 4.82 | 66.2 | 19.2 | | 132.2 | |
| | | Z | 4.96 | 67.4 | 20.0 | | 143.8 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.88 | 79.7 | 28.3 | 9.21 | 147.9 | ±3.0 % |
| | | Y | 8.00 | 76.1 | 26.2 | | 138.9 | |
| | | Z | 8.39 | 78.5 | 27.8 | | 141.5 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.99 | 67.3 | 19.9 | 5.72 | 140.7 | ±1.2 % |
| | | Y | 4.80 | 66.2 | 19.1 | | 131.3 | |
| | | Z | 4.90 | 67.1 | 19.8 | | 136.1 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.99 | 67.3 | 19.9 | 5.72 | 145.4 | ±1.4 % |
| | | Y | 4.81 | 66.2 | 19.2 | | 130.9 | |
| | | Z | 4.89 | 67.1 | 19.8 | | 136.0 | |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.78 | 68.8 | 21.3 | 8.10 | 131.0 | ±2.5 % |
| | | Y | 9.73 | 68.4 | 21.0 | | 140.7 | |
| | | Z | 9.94 | 69.4 | 21.6 | | 146.6 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.88 | 66.9 | 19.3 | 5.97 | 133.9 | ±1.7 % |
| | | Y | 6.96 | 67.1 | 19.3 | | 144.8 | |
| | | Z | 6.71 | 66.6 | 19.2 | | 125.7 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 9.00 | 80.2 | 28.5 | 9.21 | 148.2 | ±3.0 % |
| | | Y | 7.73 | 75.1 | 25.7 | | 131.6 | |
| | | Z | 8.27 | 78.2 | 27.7 | | 136.1 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 9.59 | 76.3 | 26.7 | 9.24 | 144.1 | ±2.7 % |
| | | Y | 8.74 | 72.9 | 24.5 | | 133.4 | |
| | | Z | 9.14 | 75.2 | 26.1 | | 136.9 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.25 | 73.9 | 25.3 | 9.30 | 124.8 | ±3.0 % |
| | | Y | 9.40 | 73.7 | 24.9 | | 142.1 | |
| | | Z | 9.86 | 76.1 | 26.5 | | 145.3 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.38 | 66.9 | 18.7 | 3.96 | 133.3 | ±0.9 % |
| | | Y | 4.44 | 66.9 | 18.6 | | 148.2 | |
| | | Z | 4.30 | 66.7 | 18.6 | | 128.9 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.68 | 67.3 | 18.7 | 3.46 | 145.8 | ±0.7 % |
| | | Y | 3.58 | 66.6 | 18.2 | | 136.3 | |
| | | Z | 3.62 | 67.3 | 18.8 | | 139.4 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.73 | 68.0 | 19.1 | 3.39 | 147.5 | ±0.7 % |
| | | Y | 3.55 | 66.7 | 18.3 | | 138.6 | |
| | | Z | 3.60 | 67.6 | 18.9 | | 143.0 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.30 | 67.4 | 19.7 | 5.81 | 141.4 | ±1.2 % |
| | | Y | 6.11 | 66.5 | 19.1 | | 130.3 | |
| | | Z | 6.17 | 67.0 | 19.5 | | 136.8 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.86 | 68.0 | 20.1 | 6.06 | 147.0 | ±1.7 % |
| | | Y | 6.68 | 67.1 | 19.5 | | 136.0 | |
| | | Z | 6.75 | 67.7 | 20.0 | | 141.6 | |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle) | X | 9.97 | 68.8 | 21.4 | 8.37 | 126.9 | ±2.7 % |
| | | Y | 10.07 | 68.9 | 21.4 | | 143.6 | |
| | | Z | 10.21 | 69.7 | 22.0 | | 147.4 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.77 | 68.5 | 18.8 | 3.76 | 134.9 | ±0.5 % |
| | | Y | 4.69 | 68.1 | 18.5 | | 126.7 | |
| | | Z | 4.74 | 68.8 | 18.9 | | 129.4 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.72 | 68.7 | 18.8 | 3.77 | 132.9 | ±0.7 % |
| | | Y | 4.78 | 68.9 | 18.9 | | 147.4 | |
| | | Z | 4.63 | 68.7 | 18.9 | | 127.1 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.72 | 68.9 | 18.8 | 1.54 | 131.9 | ±0.5 % |
| | | Y | 2.65 | 68.0 | 18.1 | | 145.9 | |
| | | Z | 2.72 | 69.3 | 19.0 | | 127.3 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.81 | 68.6 | 21.2 | 8.23 | 131.6 | ±2.7 % |
| | | Y | 9.90 | 68.7 | 21.2 | | 144.1 | |
| | | Z | 9.97 | 69.3 | 21.7 | | 146.0 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 6 | 55.5 | 0.75 | 6.13 | 6.13 | 6.13 | 0.00 | 1.00 | ± 13.3 % |
| 13 | 55.5 | 0.75 | 5.76 | 5.76 | 5.76 | 0.00 | 1.00 | ± 13.3 % |
| 750 | 41.9 | 0.89 | 6.56 | 6.56 | 6.56 | 0.24 | 2.36 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.37 | 6.37 | 6.37 | 0.37 | 1.70 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.39 | 5.39 | 5.39 | 0.58 | 1.32 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.18 | 5.18 | 5.18 | 0.77 | 1.20 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.85 | 4.85 | 4.85 | 0.71 | 1.28 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.58 | 4.58 | 4.58 | 0.79 | 1.17 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.46 | 4.46 | 4.46 | 0.80 | 1.26 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

## Calibration Parameter Determined in Body Tissue Simulating Media

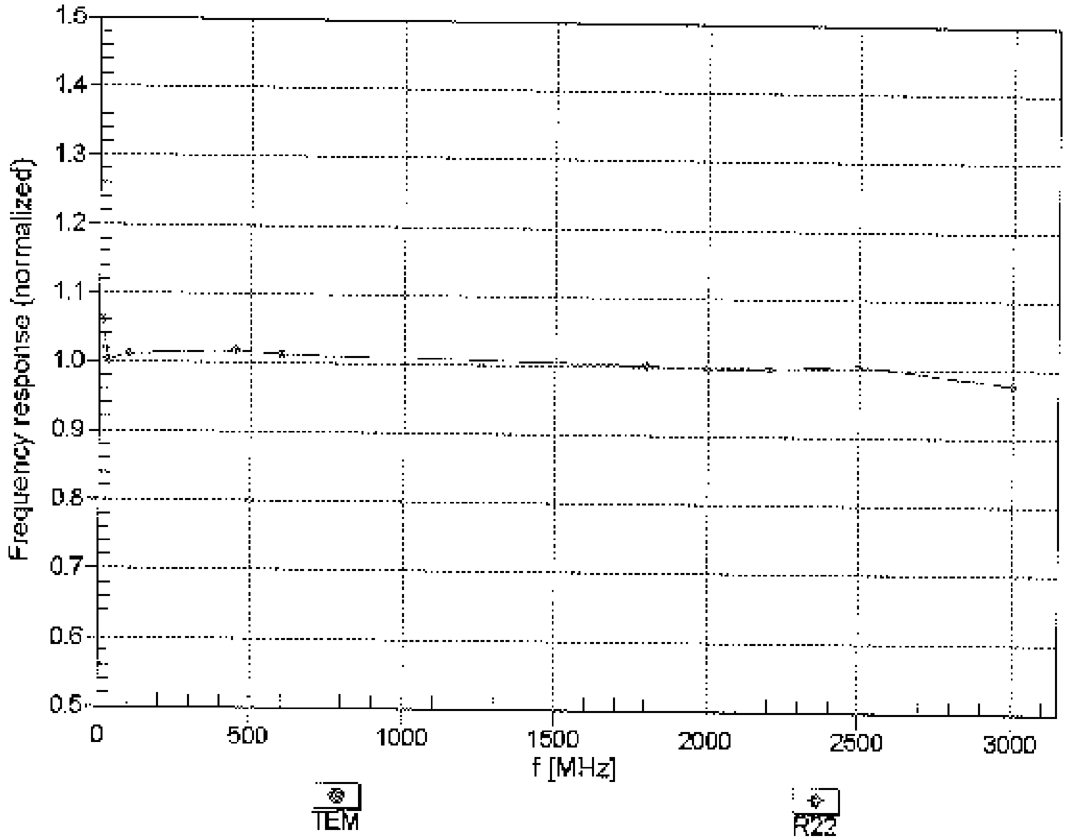
| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.37 | 6.37 | 6.37 | 0.74 | 1.22 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.24 | 6.24 | 6.24 | 0.31 | 1.94 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.03 | 5.03 | 5.03 | 0.50 | 1.57 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.84 | 4.84 | 4.84 | 0.50 | 1.58 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.61 | 4.61 | 4.61 | 0.74 | 1.23 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.45 | 4.45 | 4.45 | 0.74 | 1.20 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.29 | 4.29 | 4.29 | 0.80 | 1.20 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

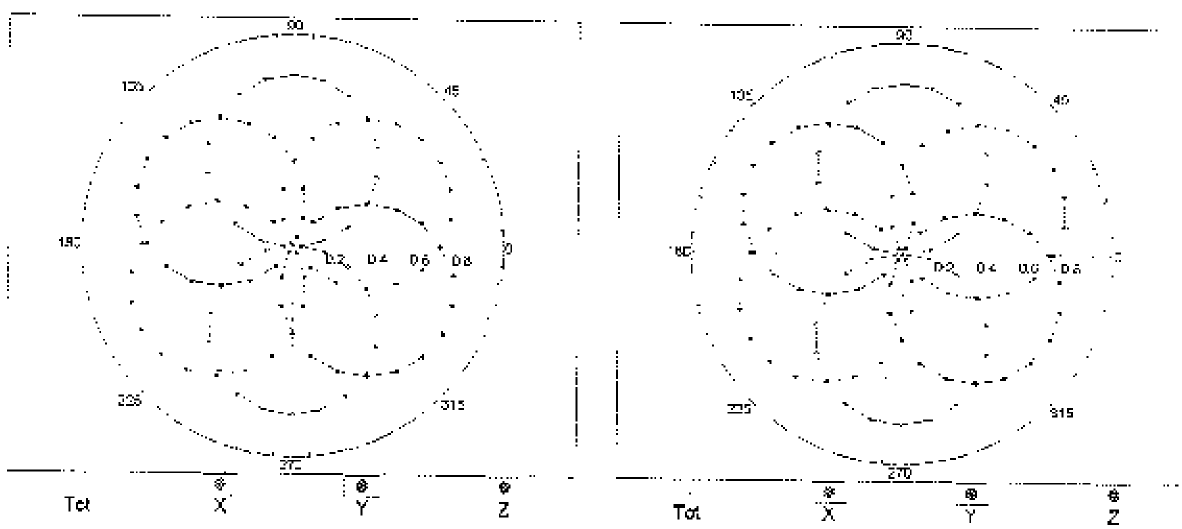
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**

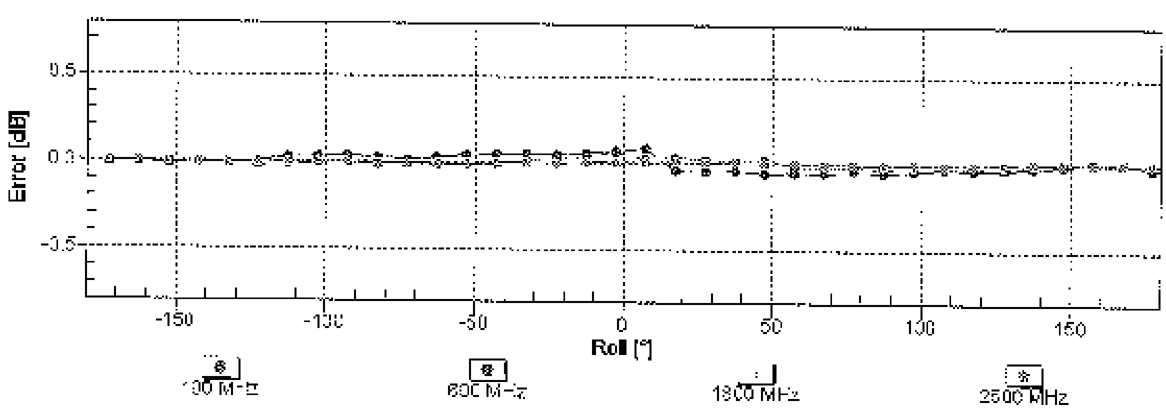



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM  f=1800 MHz,R22

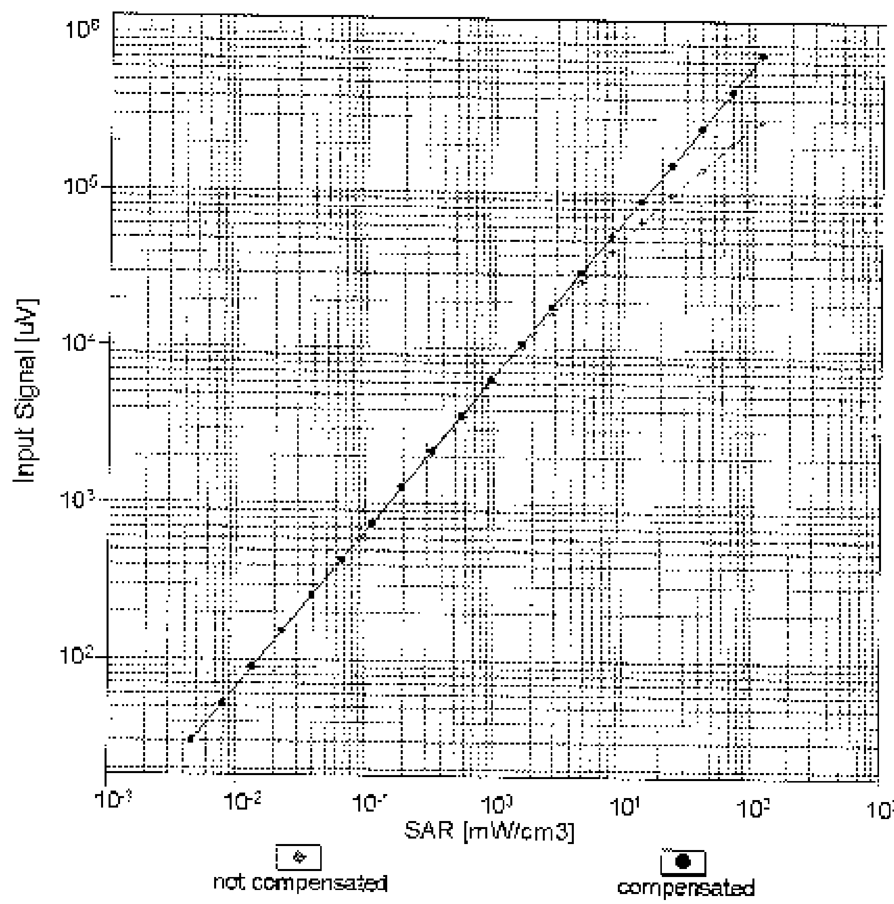


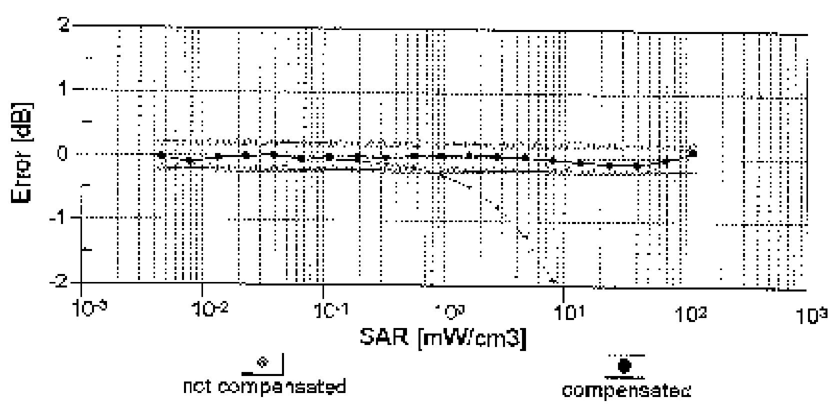




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)

**(TEM cell , $f_{eval}$= 1900 MHz)**

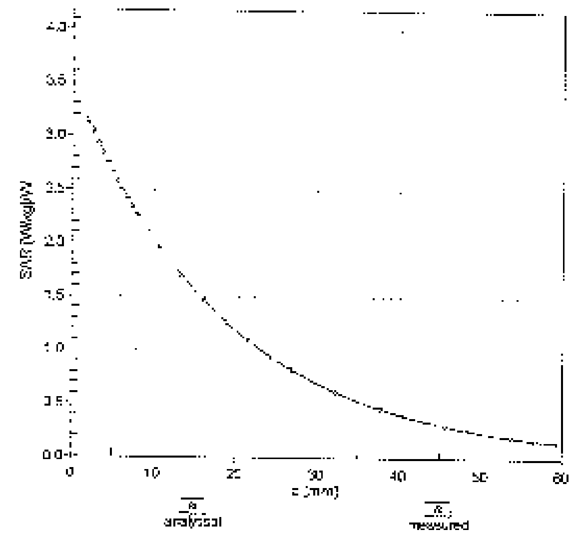


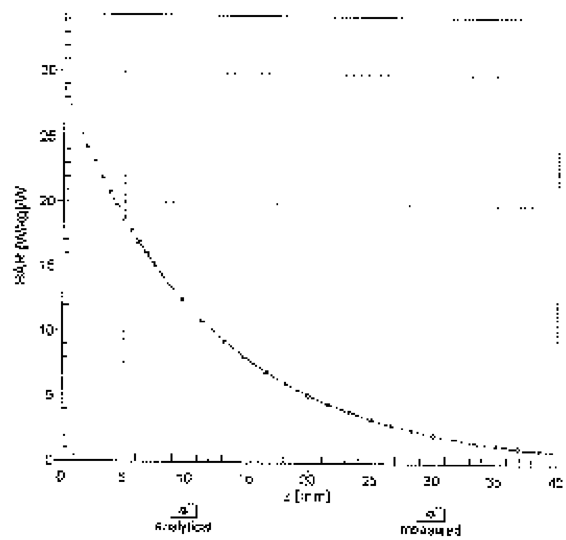

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

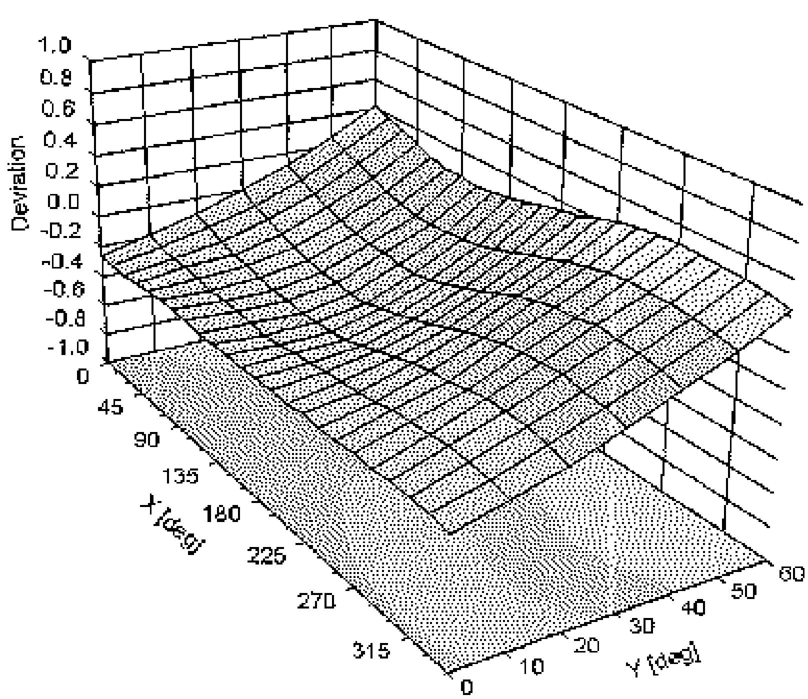


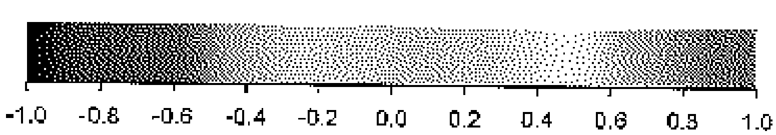

f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 17.4 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**Client** **PC Test**

**Certificate No: ES3-3318_Feb16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ES3DV3 - SN:3318 |
| Calibration procedure(s) | QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | February 19, 2016 |

BN ✓ 03/01/2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: February 20, 2016

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

## SN:3318

Manufactured: January 10, 2012
Calibrated: February 19, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 1.16 | 0.93 | 1.29 | ± 10.1 % |
| DCP (mV)[B] | 102.2 | 104.2 | 103.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 199.2 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 176.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 194.6 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 3.19 | 63.2 | 12.6 | 10.00 | 42.3 | ±1.4 % |
| | | Y | 19.74 | 82.9 | 18.6 | | 35.5 | |
| | | Z | 4.87 | 67.6 | 14.6 | | 43.3 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 2.99 | 68.6 | 18.5 | 1.87 | 141.3 | ±0.9 % |
| | | Y | 3.46 | 71.1 | 19.6 | | 145.1 | |
| | | Z | 3.19 | 70.2 | 19.5 | | 144.7 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.30 | 67.0 | 19.4 | 5.67 | 128.2 | ±1.4 % |
| | | Y | 6.32 | 67.0 | 19.2 | | 129.9 | |
| | | Z | 6.36 | 67.5 | 19.8 | | 131.3 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 11.31 | 78.0 | 27.3 | 9.29 | 146.7 | ±3.5 % |
| | | Y | 9.35 | 72.8 | 24.3 | | 141.3 | |
| | | Z | 11.02 | 76.9 | 26.7 | | 131.7 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.22 | 66.7 | 19.4 | 5.80 | 126.2 | ±1.4 % |
| | | Y | 6.20 | 66.5 | 19.1 | | 128.1 | |
| | | Z | 6.27 | 67.1 | 19.7 | | 131.1 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 10.46 | 76.6 | 26.8 | 9.28 | 138.8 | ±3.3 % |
| | | Y | 8.80 | 72.0 | 24.0 | | 134.3 | |
| | | Z | 10.01 | 75.0 | 25.9 | | 122.1 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.12 | 67.0 | 19.6 | 5.75 | 146.0 | ±1.7 % |
| | | Y | 6.15 | 67.1 | 19.5 | | 148.7 | |
| | | Z | 5.95 | 66.5 | 19.4 | | 127.4 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.33 | 66.7 | 19.4 | 5.82 | 127.2 | ±1.4 % |
| | | Y | 6.33 | 66.6 | 19.2 | | 128.2 | |
| | | Z | 6.38 | 67.1 | 19.7 | | 133.6 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.10 | 67.2 | 20.0 | 5.73 | 147.9 | ±1.2 % |
| | | Y | 4.85 | 66.3 | 19.3 | | 127.1 | |
| | | Z | 4.97 | 66.7 | 19.8 | | 133.9 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.71 | 78.3 | 27.8 | 9.21 | 127.5 | ±3.0 % |
| | | Y | 7.52 | 74.8 | 25.7 | | 144.7 | |
| | | Z | 10.09 | 81.9 | 29.5 | | 136.4 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.09 | 67.2 | 20.0 | 5.72 | 146.9 | ±1.2 % |
| | | Y | 4.97 | 66.9 | 19.6 | | 140.9 | |
| | | Z | 4.95 | 66.6 | 19.7 | | 133.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 5.11 | 67.3 | 20.0 | 5.72 | 146.8 | ±1.2 % |
| | | Y | 5.03 | 67.2 | 19.8 | | 147.0 | |
| | | Z | 5.00 | 66.8 | 19.8 | | 135.0 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 8.73 | 78.3 | 27.8 | 9.21 | 126.7 | ±3.0 % |
| | | Y | 7.60 | 75.1 | 25.9 | | 146.1 | |
| | | Z | 10.76 | 83.8 | 30.4 | | 143.4 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 9.61 | 75.3 | 26.2 | 9.24 | 129.4 | ±3.3 % |
| | | Y | 8.55 | 72.3 | 24.3 | | 143.1 | |
| | | Z | 11.05 | 79.1 | 28.1 | | 146.1 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 10.44 | 76.5 | 26.8 | 9.30 | 137.7 | ±3.3 % |
| | | Y | 8.62 | 71.3 | 23.6 | | 125.8 | |
| | | Z | 10.24 | 75.6 | 26.2 | | 125.3 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.51 | 67.8 | 20.0 | 5.81 | 148.5 | ±1.7 % |
| | | Y | 6.42 | 67.3 | 19.6 | | 144.3 | |
| | | Z | 6.31 | 67.3 | 19.8 | | 134.7 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.80 | 67.4 | 19.9 | 6.06 | 128.6 | ±1.4 % |
| | | Y | 6.69 | 66.9 | 19.4 | | 125.3 | |
| | | Z | 6.91 | 68.0 | 20.3 | | 140.1 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.48 | 6.48 | 6.48 | 0.54 | 1.35 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.23 | 6.23 | 6.23 | 0.70 | 1.21 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.34 | 5.34 | 5.34 | 0.72 | 1.27 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.13 | 5.13 | 5.13 | 0.80 | 1.18 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.78 | 4.78 | 4.78 | 0.76 | 1.29 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.57 | 4.57 | 4.57 | 0.59 | 1.49 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.40 | 4.40 | 4.40 | 0.80 | 1.31 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

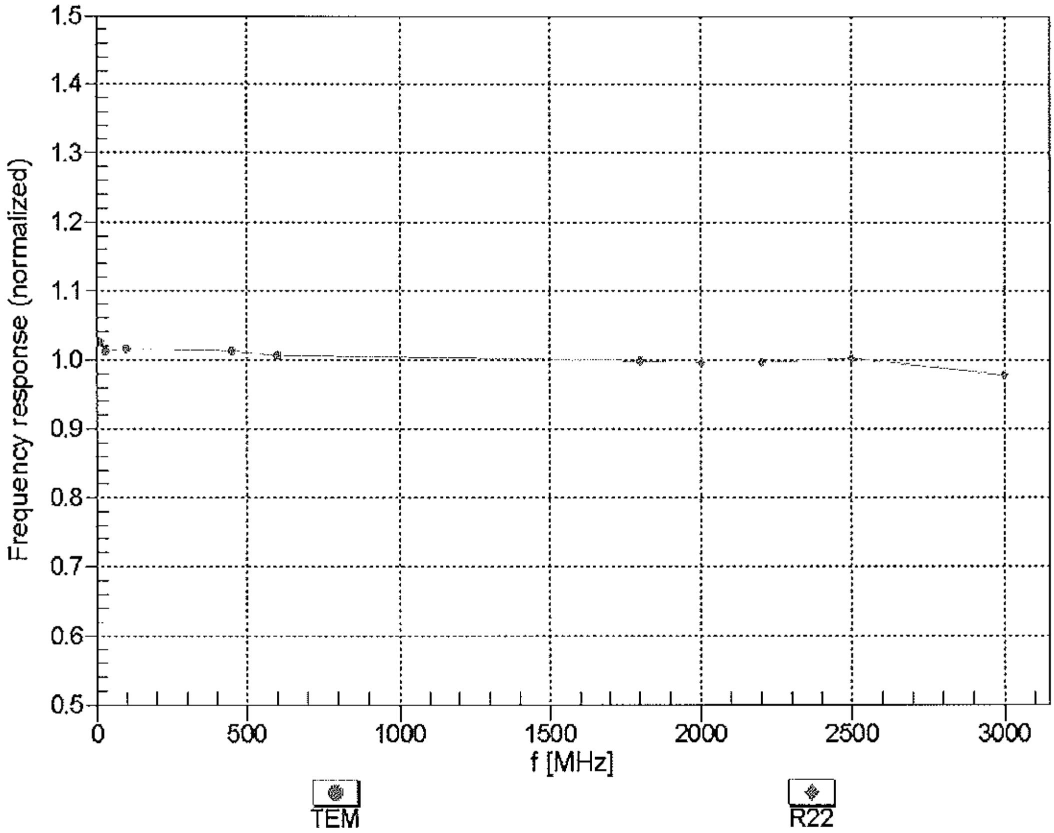
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.19 | 6.19 | 6.19 | 0.50 | 1.51 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.11 | 6.11 | 6.11 | 0.47 | 1.56 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.02 | 5.02 | 5.02 | 0.49 | 1.55 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.81 | 4.81 | 4.81 | 0.80 | 1.24 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.55 | 4.55 | 4.55 | 0.80 | 1.27 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.45 | 4.45 | 4.45 | 0.80 | 1.16 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.18 | 4.18 | 4.18 | 0.80 | 1.13 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

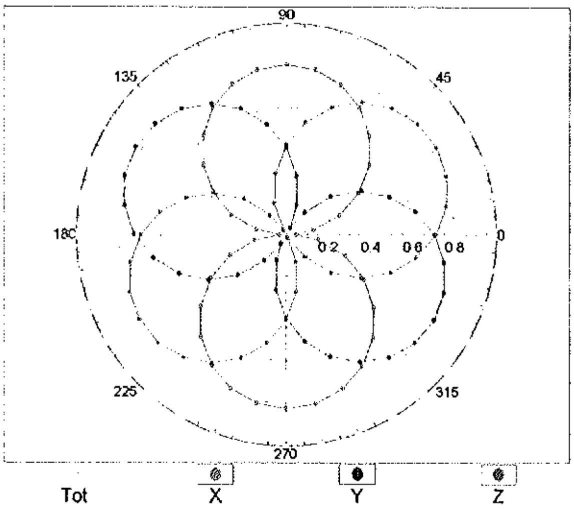
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



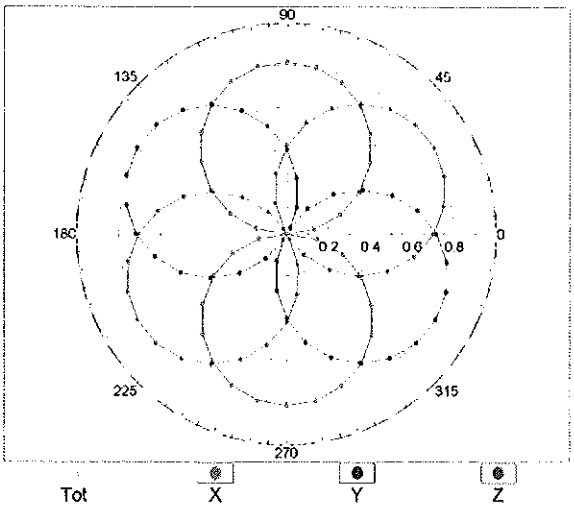

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

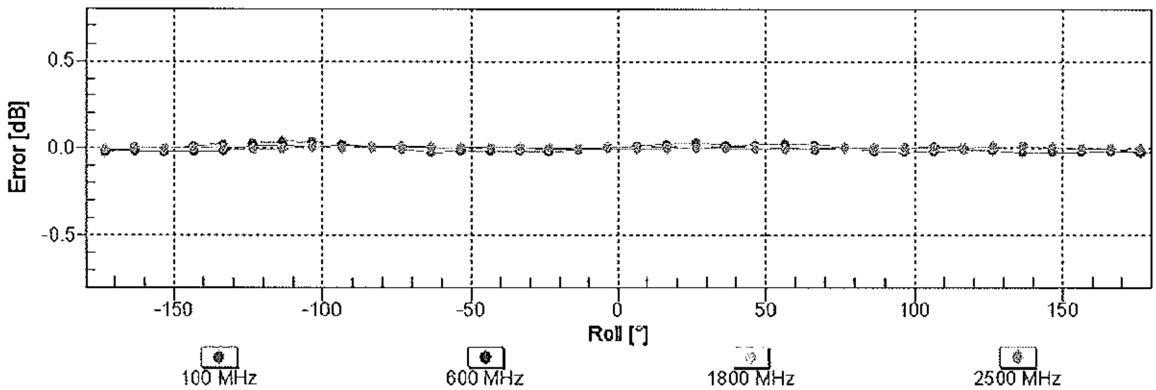
# Receiving Pattern (ϕ), $\vartheta$ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

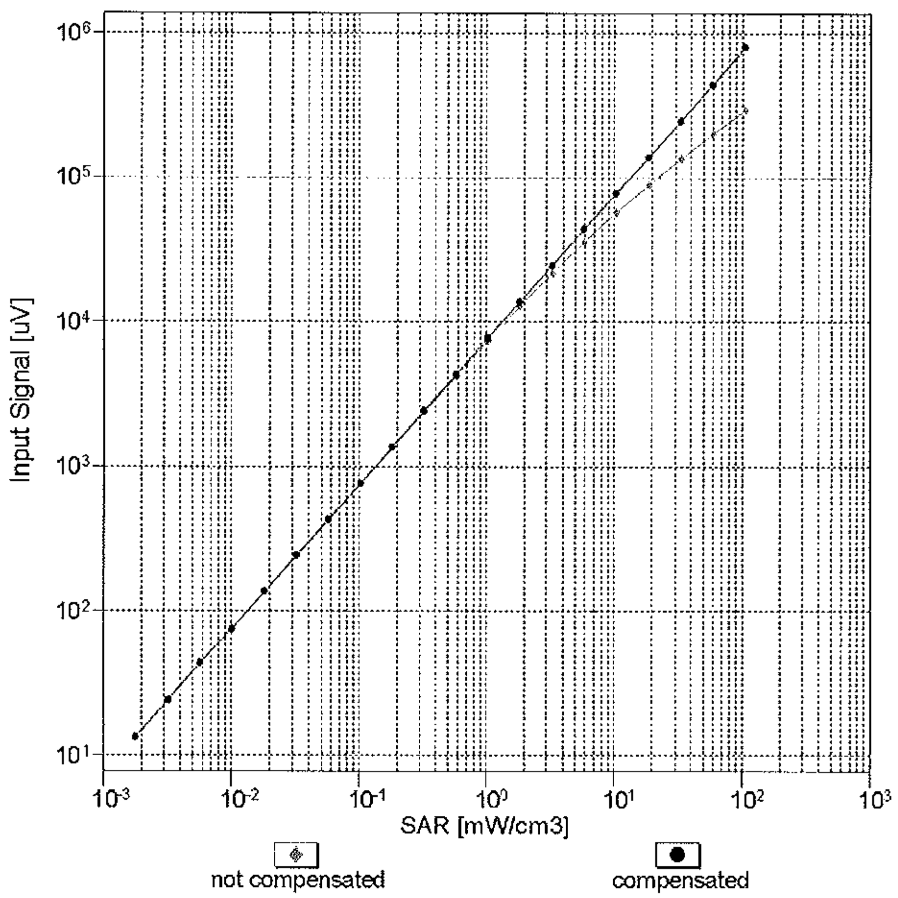


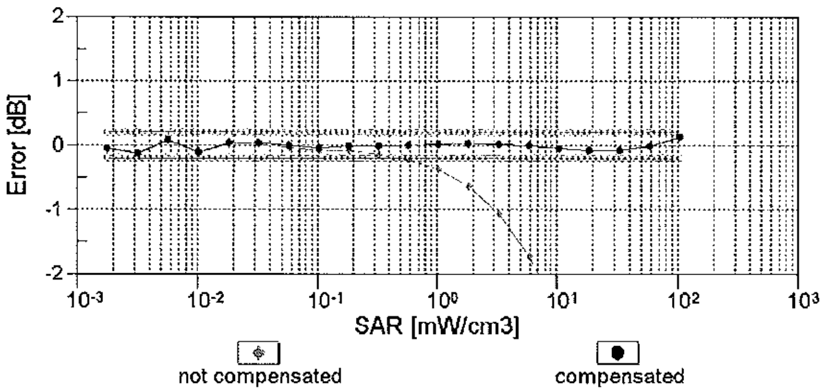




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f(SAR$_{head}$)

**(TEM cell , $f_{eval}$= 1900 MHz)**

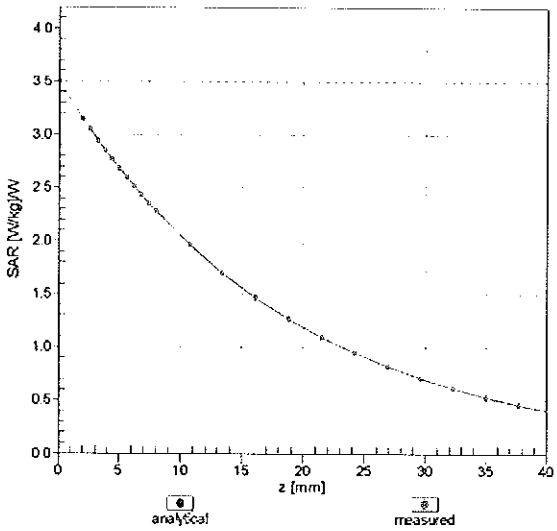


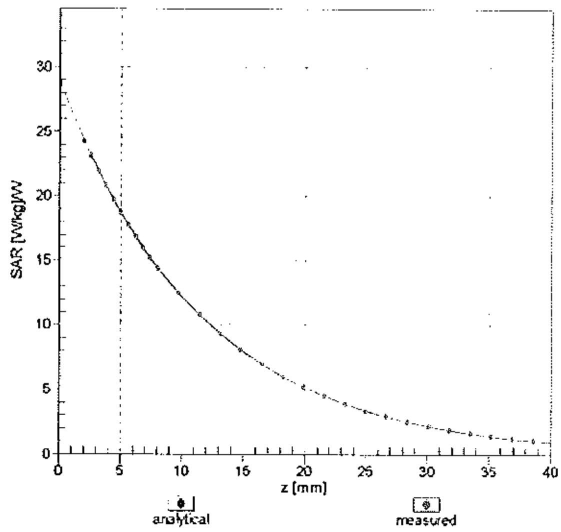

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

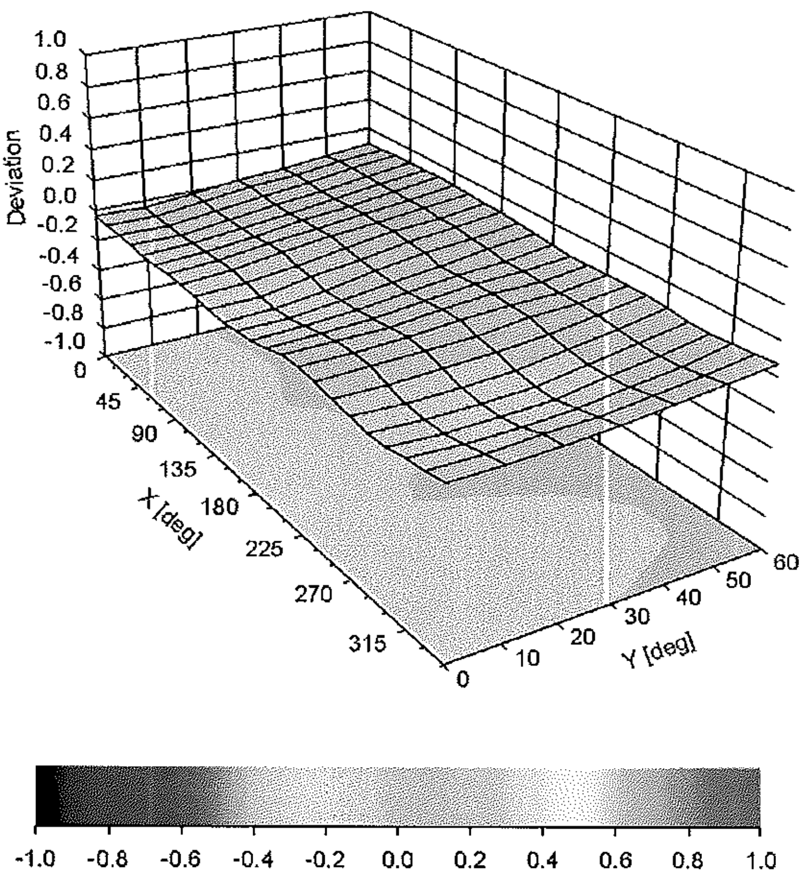



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 76.5 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
**S** Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

Client **PC Test**

Certificate No: **EX3-7406_Apr16**

# CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7406

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

BN 04/26/2016

Calibration date: April 19, 2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (No. 217-02285/02284) | In house check: Jun-16 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (No. 217-02285) | In house check: Jun-16 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (No. 217-02284) | In house check: Jun-16 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Apr-13) | In house check: Jun-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: April 20, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
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## Methods Applied and Interpretation of Parameters:

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- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe EX3DV4

## SN:7406

Manufactured: November 24, 2015
Calibrated: April 19, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:7406

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)$^A$ | 0.48 | 0.44 | 0.47 | ± 10.1 % |
| DCP (mV)$^B$ | 100.7 | 97.9 | 98.6 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc$^E$ (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 120.4 | ±3.3 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 148.3 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 146.7 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 0.81 | 54.6 | 7.4 | 10.00 | 50.3 | ±2.2 % |
| | | Y | 0.68 | 55.1 | 7.9 | | 47.9 | |
| | | Z | 1.34 | 61.0 | 11.0 | | 46.8 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 2.83 | 68.0 | 18.3 | 1.87 | 127.8 | ±0.5 % |
| | | Y | 2.82 | 68.4 | 18.4 | | 117.8 | |
| | | Z | 3.00 | 69.2 | 19.0 | | 115.9 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.54 | 67.4 | 19.5 | 5.67 | 142.1 | ±1.2 % |
| | | Y | 6.19 | 66.7 | 19.3 | | 127.6 | |
| | | Z | 6.37 | 66.7 | 19.2 | | 125.7 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 7.58 | 67.9 | 21.8 | 9.29 | 114.4 | ±1.7 % |
| | | Y | 7.34 | 68.3 | 22.5 | | 144.3 | |
| | | Z | 7.53 | 67.7 | 21.8 | | 139.5 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.34 | 66.9 | 19.4 | 5.80 | 137.5 | ±1.2 % |
| | | Y | 5.90 | 65.9 | 19.0 | | 123.8 | |
| | | Z | 6.24 | 66.4 | 19.2 | | 123.7 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 7.17 | 67.2 | 21.5 | 9.28 | 109.5 | ±1.7 % |
| | | Y | 6.83 | 67.6 | 22.3 | | 137.0 | |
| | | Z | 7.23 | 67.4 | 21.7 | | 135.1 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.99 | 66.4 | 19.2 | 5.75 | 132.4 | ±0.9 % |
| | | Y | 5.61 | 65.8 | 19.1 | | 119.4 | |
| | | Z | 5.91 | 65.9 | 19.0 | | 120.1 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.47 | 67.0 | 19.5 | 5.82 | 137.0 | ±1.2 % |
| | | Y | 5.96 | 66.0 | 19.1 | | 123.9 | |
| | | Z | 6.33 | 66.3 | 19.1 | | 124.2 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.71 | 65.5 | 18.9 | 5.73 | 113.2 | ±1.2 % |
| | | Y | 4.60 | 66.2 | 19.6 | | 144.2 | |
| | | Z | 4.93 | 66.5 | 19.5 | | 143.2 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.68 | 68.2 | 22.4 | 9.21 | 117.6 | ±1.7 % |
| | | Y | 5.56 | 70.1 | 24.1 | | 146.1 | |
| | | Z | 5.87 | 69.4 | 23.2 | | 143.7 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.75 | 65.7 | 19.1 | 5.72 | 112.3 | ±0.9 % |
| | | Y | 4.58 | 66.1 | 19.5 | | 143.2 | |
| | | Z | 4.95 | 66.7 | 19.6 | | 142.0 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.71 | 65.5 | 18.9 | 5.72 | 110.2 | ±0.9 % |
| | | Y | 4.53 | 65.8 | 19.4 | | 141.4 | |
| | | Z | 4.90 | 66.5 | 19.5 | | 138.1 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.69 | 68.3 | 22.5 | 9.21 | 117.3 | ±1.7 % |
| | | Y | 5.47 | 69.5 | 23.8 | | 145.1 | |
| | | Z | 5.85 | 69.3 | 23.1 | | 142.0 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 7.04 | 68.1 | 22.2 | 9.24 | 141.2 | ±1.9 % |
| | | Y | 6.35 | 67.2 | 22.2 | | 125.4 | |
| | | Z | 6.82 | 67.1 | 21.7 | | 127.5 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 7.45 | 68.3 | 22.2 | 9.30 | 148.0 | ±1.9 % |
| | | Y | 6.84 | 67.5 | 22.3 | | 132.0 | |
| | | Z | 7.24 | 67.4 | 21.8 | | 134.6 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.35 | 66.9 | 19.4 | 5.81 | 135.3 | ±1.2 % |
| | | Y | 5.92 | 65.9 | 19.0 | | 122.9 | |
| | | Z | 6.26 | 66.4 | 19.2 | | 122.1 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.92 | 67.4 | 19.7 | 6.06 | 139.3 | ±1.2 % |
| | | Y | 6.52 | 66.6 | 19.5 | | 127.9 | |
| | | Z | 6.82 | 66.9 | 19.5 | | 126.8 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:7406

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 10.52 | 10.52 | 10.52 | 0.52 | 0.89 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 9.83 | 9.83 | 9.83 | 0.54 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.85 | 8.85 | 8.85 | 0.49 | 0.85 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.22 | 8.22 | 8.22 | 0.40 | 0.88 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.67 | 7.67 | 7.67 | 0.36 | 0.89 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.29 | 7.29 | 7.29 | 0.40 | 0.80 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.08 | 7.08 | 7.08 | 0.37 | 0.95 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

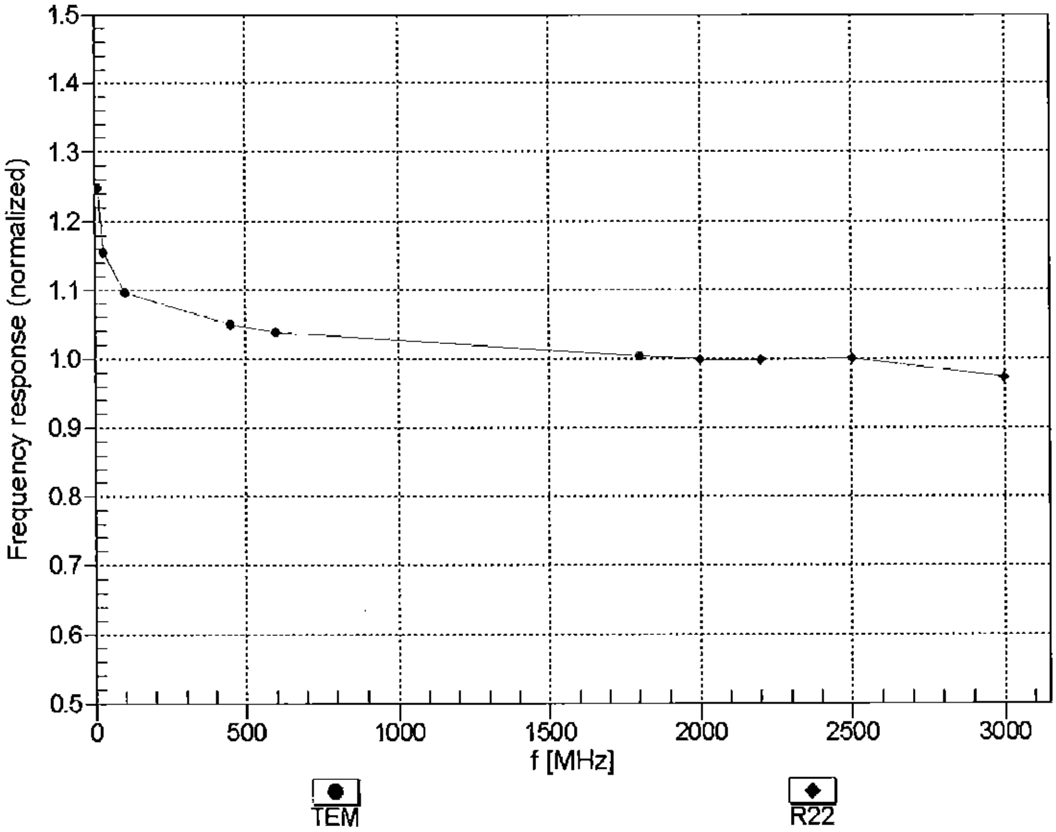
# DASY/EASY - Parameters of Probe: EX3DV4 - SN:7406

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 9.54 | 9.54 | 9.54 | 0.46 | 0.80 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.35 | 9.35 | 9.35 | 0.45 | 0.84 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 7.78 | 7.78 | 7.78 | 0.37 | 0.85 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.49 | 7.49 | 7.49 | 0.33 | 0.91 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.37 | 7.37 | 7.37 | 0.42 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.24 | 7.24 | 7.24 | 0.37 | 0.88 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 6.94 | 6.94 | 6.94 | 0.27 | 0.99 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

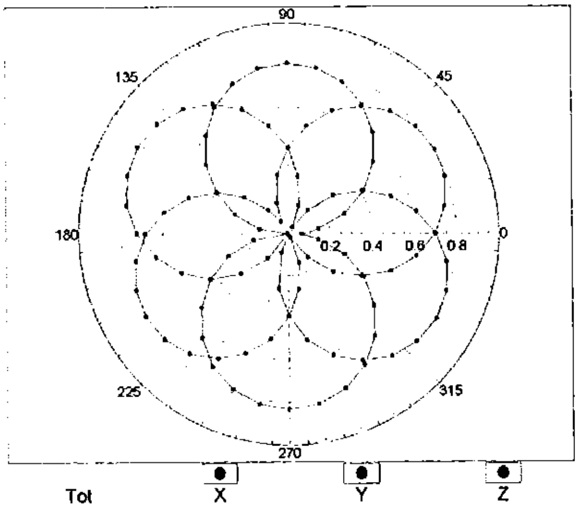
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)



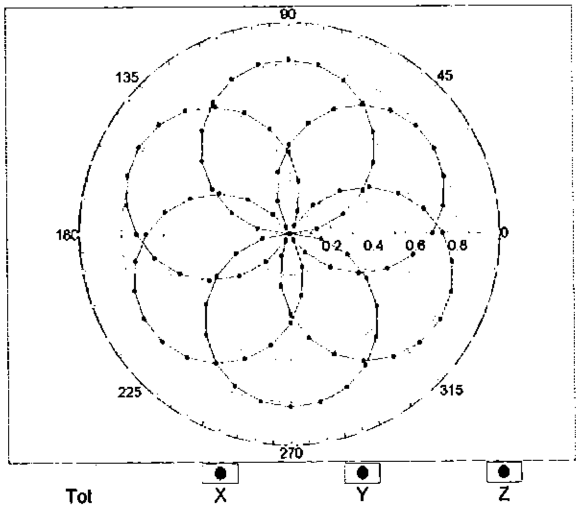

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

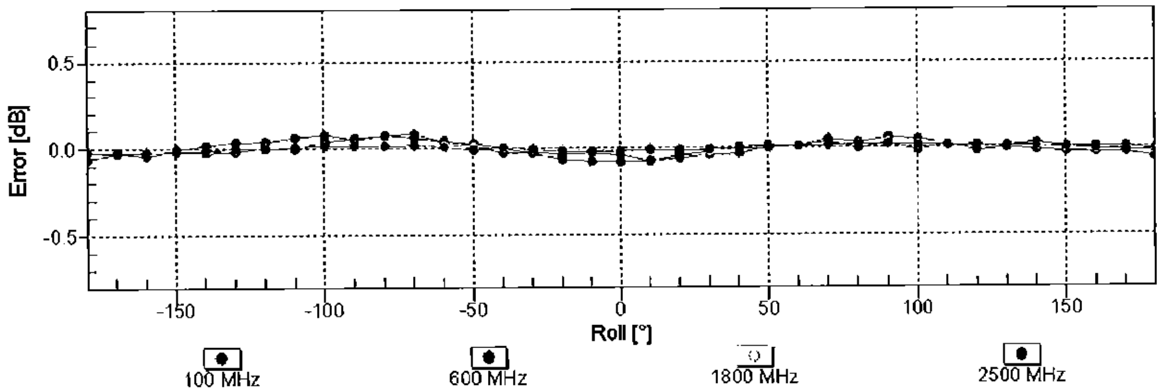
# Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



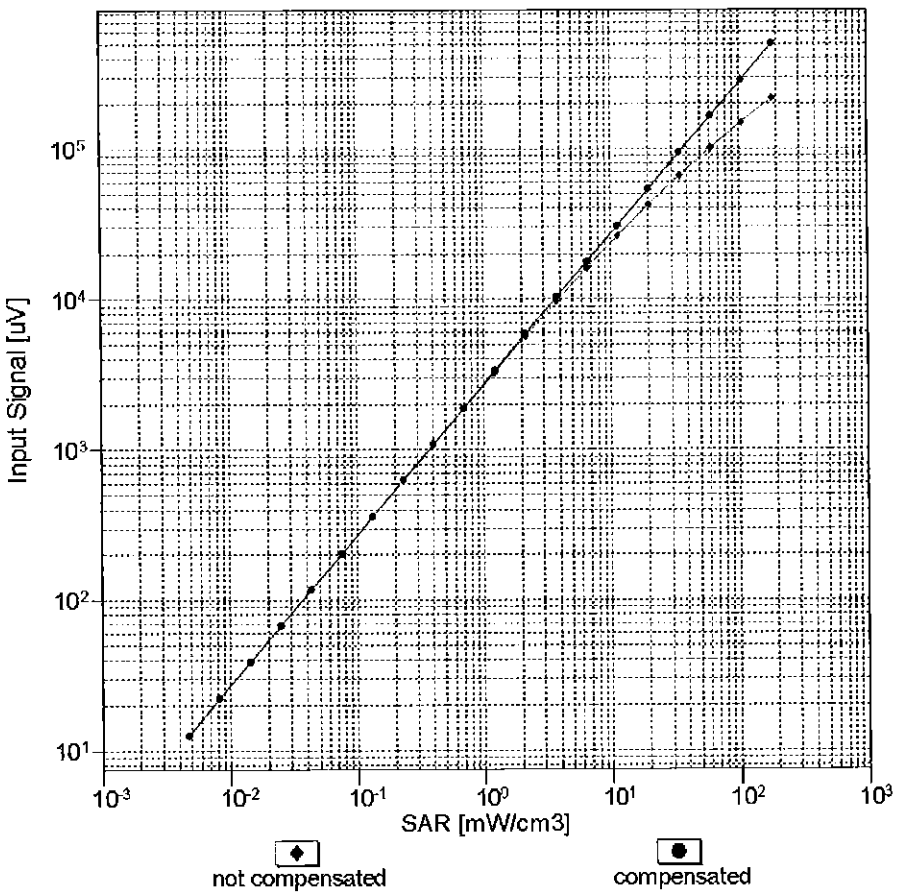

f=1800 MHz,R22

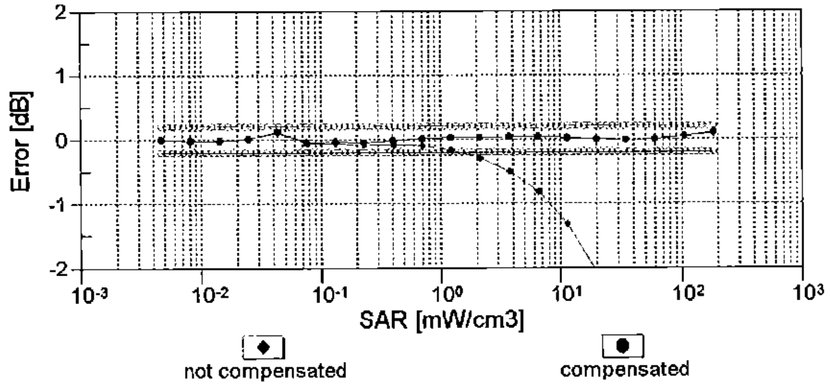



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)
**(TEM cell , $f_{eval}$= 1900 MHz)**

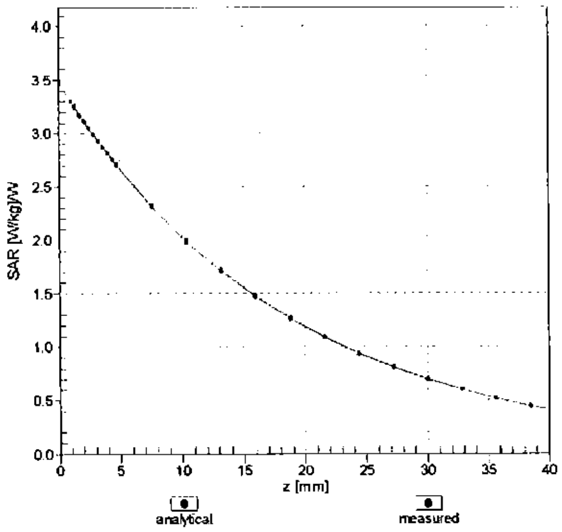


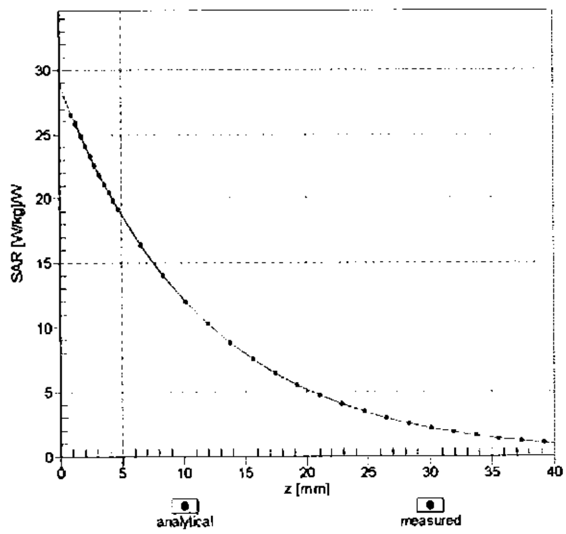

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

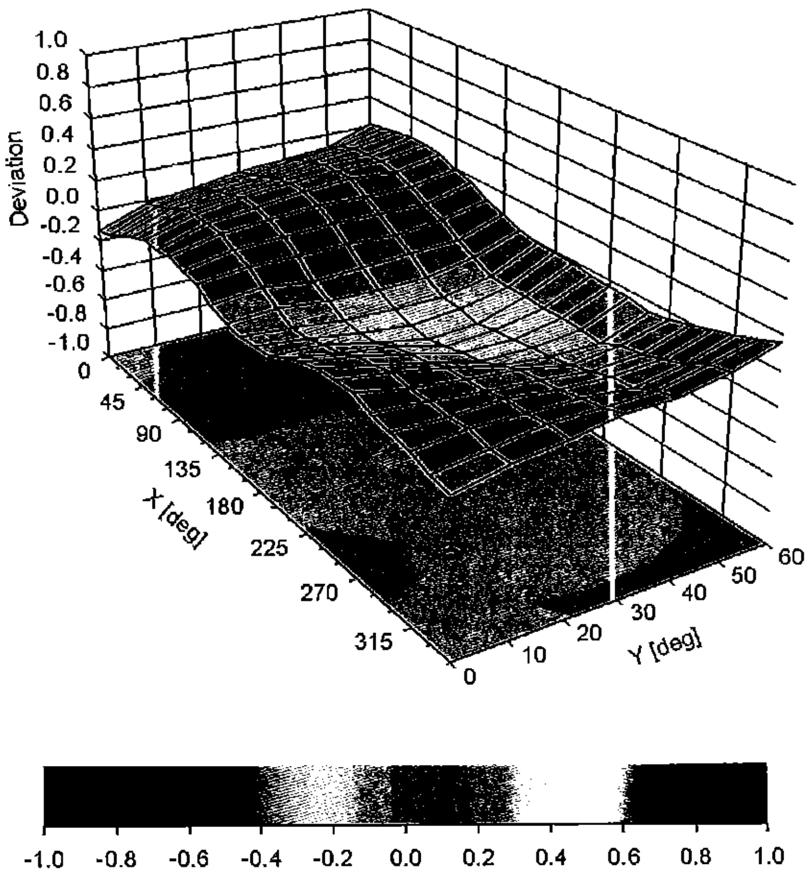



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:7406

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 0.4 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 9 mm |
| Tip Diameter | 2.5 mm |
| Probe Tip to Sensor X Calibration Point | 1 mm |
| Probe Tip to Sensor Y Calibration Point | 1 mm |
| Probe Tip to Sensor Z Calibration Point | 1 mm |
| Recommended Measurement Distance from Surface | 1.4 mm |

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
**S** Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**Client** PC Test

**Certificate No: ES3-3319_Mar16**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3319

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

BN 03/30/2016

Calibration date: March 18, 2016

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 21, 2016

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "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)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

# SN:3319

Manufactured: January 10, 2012
Calibrated: March 18, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)²)[A] | 1.12 | 1.08 | 1.16 | ± 10.1 % |
| DCP (mV)[B] | 104.1 | 104.5 | 103.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 203.1 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 203.8 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 200.4 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.29 | 60.1 | 11.2 | 10.00 | 42.0 | ±1.2 % |
| | | Y | 1.95 | 58.7 | 10.4 | | 42.0 | |
| | | Z | 3.15 | 62.5 | 12.1 | | 42.9 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.45 | 71.5 | 19.9 | 1.87 | 122.0 | ±0.5 % |
| | | Y | 2.88 | 68.4 | 18.6 | | 122.8 | |
| | | Z | 3.35 | 70.8 | 19.5 | | 120.5 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.39 | 67.3 | 19.5 | 5.67 | 132.3 | ±1.2 % |
| | | Y | 6.54 | 68.2 | 20.1 | | 134.5 | |
| | | Z | 6.40 | 67.4 | 19.6 | | 130.2 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.41 | 75.3 | 25.6 | 9.29 | 124.2 | ±2.2 % |
| | | Y | 10.45 | 76.3 | 26.6 | | 122.6 | |
| | | Z | 10.82 | 75.9 | 25.8 | | 124.8 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.30 | 67.1 | 19.5 | 5.80 | 130.7 | ±1.2 % |
| | | Y | 6.35 | 67.5 | 19.9 | | 131.5 | |
| | | Z | 6.33 | 67.1 | 19.6 | | 128.5 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.70 | 74.1 | 25.2 | 9.28 | 118.8 | ±2.2 % |
| | | Y | 9.65 | 74.9 | 26.0 | | 117.1 | |
| | | Z | 10.15 | 75.0 | 25.5 | | 119.2 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.00 | 66.6 | 19.3 | 5.75 | 127.4 | ±1.2 % |
| | | Y | 6.01 | 66.9 | 19.6 | | 128.9 | |
| | | Z | 6.02 | 66.6 | 19.3 | | 125.6 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.45 | 67.2 | 19.6 | 5.82 | 132.2 | ±1.2 % |
| | | Y | 6.47 | 67.5 | 19.9 | | 133.5 | |
| | | Z | 6.45 | 67.1 | 19.5 | | 130.0 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.76 | 65.7 | 19.0 | 5.73 | 110.8 | ±0.9 % |
| | | Y | 4.80 | 66.3 | 19.5 | | 112.0 | |
| | | Z | 4.84 | 65.9 | 19.1 | | 109.2 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.98 | 78.7 | 27.7 | 9.21 | 132.0 | ±2.5 % |
| | | Y | 9.71 | 82.4 | 30.0 | | 132.2 | |
| | | Z | 9.79 | 80.4 | 28.4 | | 133.4 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.76 | 65.6 | 19.0 | 5.72 | 109.8 | ±0.9 % |
| | | Y | 4.76 | 66.1 | 19.4 | | 111.4 | |
| | | Z | 4.83 | 65.8 | 19.1 | | 108.9 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.77 | 65.7 | 19.1 | 5.72 | 109.2 | ±0.9 % |
| | | Y | 4.78 | 66.2 | 19.4 | | 111.9 | |
| | | Z | 5.24 | 67.7 | 20.2 | | 149.0 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 8.93 | 78.5 | 27.6 | 9.21 | 131.4 | ±2.5 % |
| | | Y | 9.48 | 81.7 | 29.7 | | 131.7 | |
| | | Z | 9.69 | 80.3 | 28.3 | | 131.6 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 8.94 | 73.0 | 24.7 | 9.24 | 111.2 | ±2.2 % |
| | | Y | 9.05 | 74.3 | 25.9 | | 111.8 | |
| | | Z | 9.29 | 73.6 | 24.9 | | 111.3 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.62 | 73.9 | 25.1 | 9.30 | 117.4 | ±2.2 % |
| | | Y | 9.73 | 75.1 | 26.1 | | 118.2 | |
| | | Z | 10.08 | 74.8 | 25.5 | | 118.2 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.31 | 67.1 | 19.6 | 5.81 | 128.6 | ±1.2 % |
| | | Y | 6.39 | 67.6 | 20.0 | | 132.2 | |
| | | Z | 6.33 | 67.1 | 19.6 | | 127.2 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.87 | 67.6 | 19.9 | 6.06 | 132.8 | ±1.4 % |
| | | Y | 6.96 | 68.2 | 20.3 | | 137.0 | |
| | | Z | 6.88 | 67.6 | 19.9 | | 131.3 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.44 | 6.44 | 6.44 | 0.49 | 1.80 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.16 | 6.16 | 6.16 | 0.46 | 1.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.20 | 5.20 | 5.20 | 0.51 | 1.45 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.03 | 5.03 | 5.03 | 0.58 | 1.40 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.69 | 4.69 | 4.69 | 0.80 | 1.21 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.47 | 4.47 | 4.47 | 0.75 | 1.32 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.33 | 4.33 | 4.33 | 0.80 | 1.31 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

## Calibration Parameter Determined in Body Tissue Simulating Media

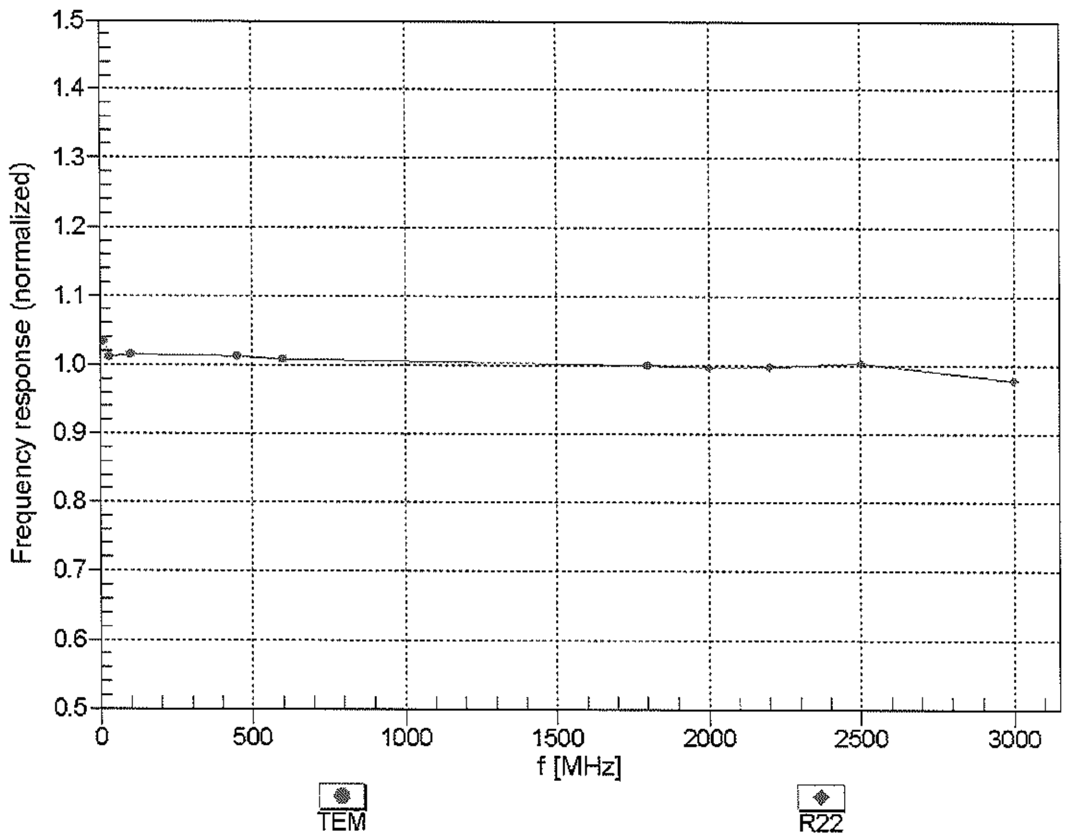
| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.06 | 6.06 | 6.06 | 0.47 | 1.45 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.04 | 6.04 | 6.04 | 0.63 | 1.27 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.91 | 4.91 | 4.91 | 0.46 | 1.66 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.70 | 4.70 | 4.70 | 0.80 | 1.24 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.36 | 4.36 | 4.36 | 0.74 | 1.33 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.20 | 4.20 | 4.20 | 0.80 | 1.25 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 3.99 | 3.99 | 3.99 | 0.80 | 1.20 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

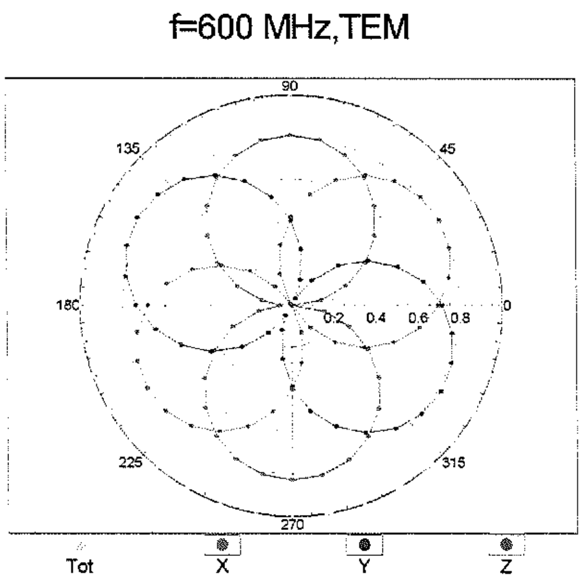
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

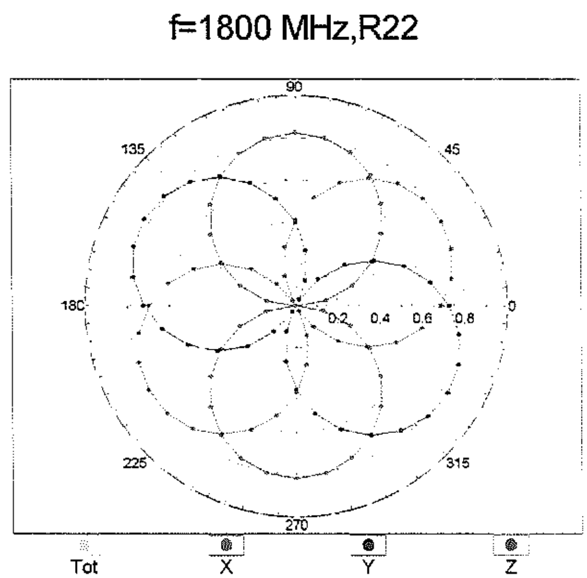
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)

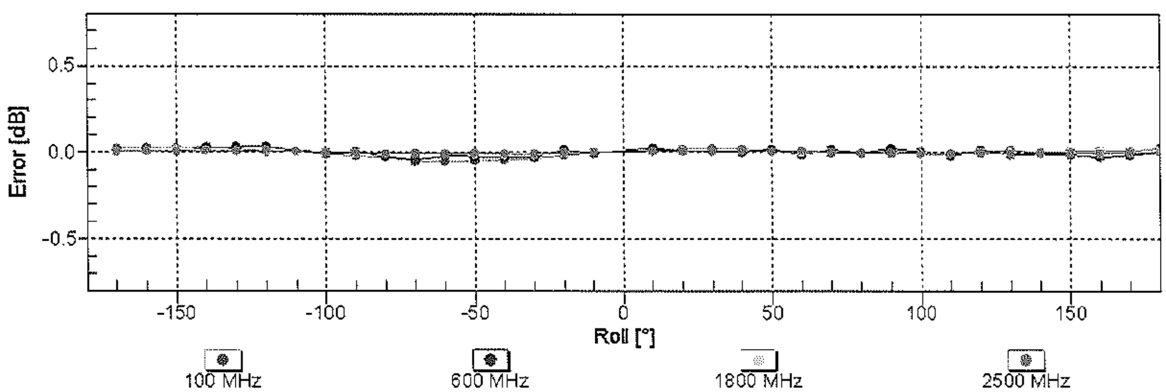



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern (ϕ), $\vartheta = 0°$

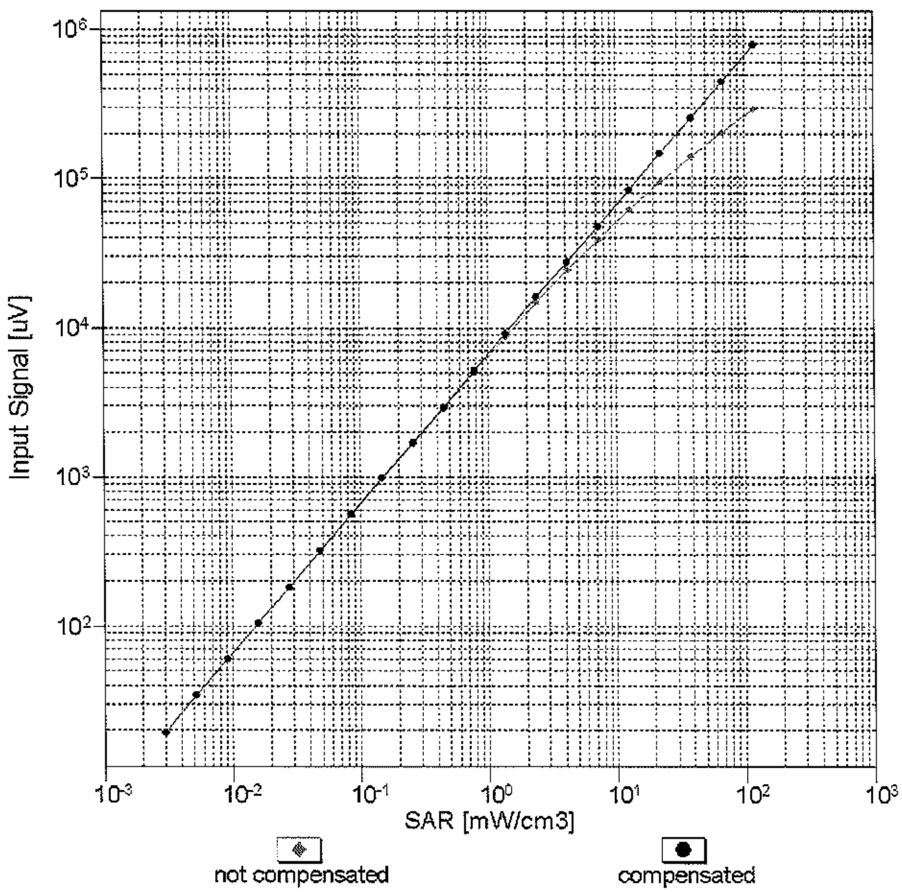


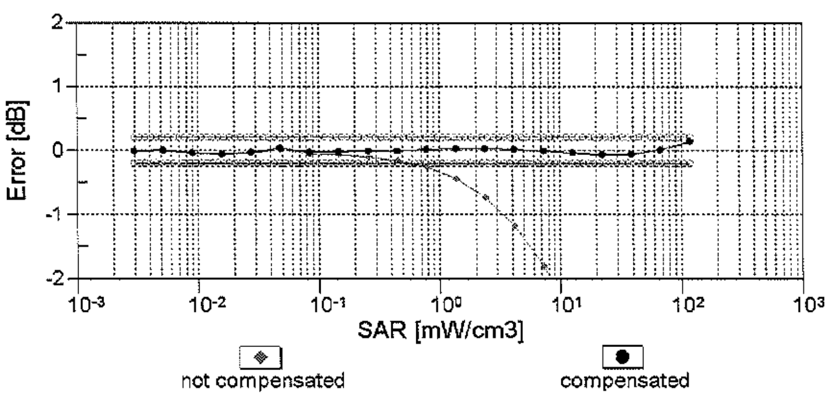




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)
## (TEM cell , $f_{eval}$= 1900 MHz)

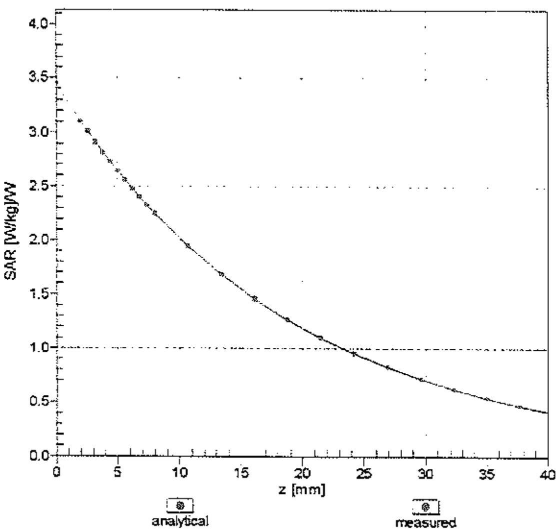


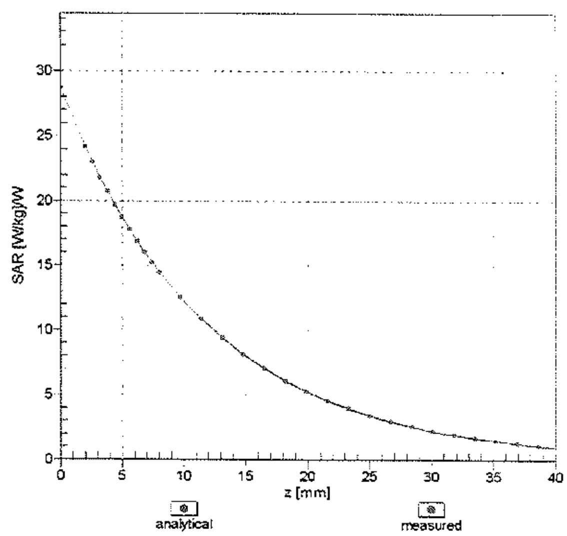

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

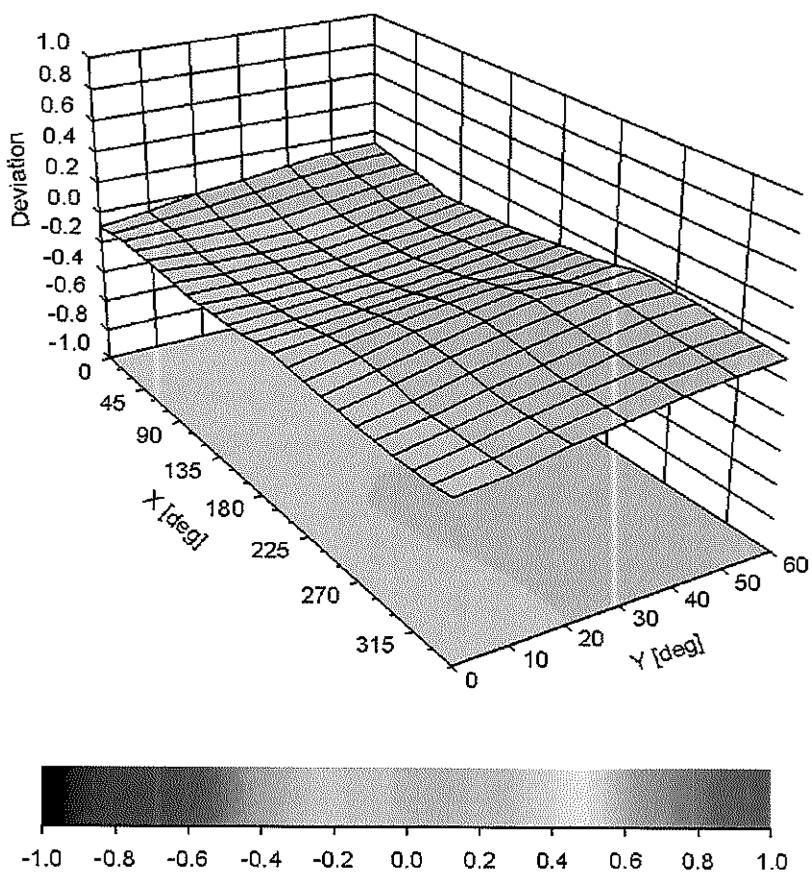



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 60 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

# APPENDIX D: SAR TISSUE SPECIFICATIONS

Measurement Procedure for Tissue verification:

1) The network analyzer and probe system was configured and calibrated.
2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
3) The complex admittance with respect to the probe aperture was measured
4) The complex relative permittivity $\varepsilon'$ can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\varepsilon_r\varepsilon_0}{[\ln(b/a)]^2}\int_a^b\int_a^b\int_0^\pi \cos\phi' \frac{\exp\left[-j\omega r(\mu_0\varepsilon_r'\varepsilon_0)^{1/2}\right]}{r}\, d\phi' d\rho' d\rho$$

where $Y$ is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, $\omega$ is the angular frequency, and $j = \sqrt{-1}$.

**Table D-I**
**Composition of the Tissue Equivalent Matter**

| Frequency (MHz) | 750 | 750 | 835 | 835 | 1750 | 1750 | 1900 | 1900 | 2450 | 2450 |
|---|---|---|---|---|---|---|---|---|---|---|
| Tissue | Head | Body | Head | Body | Head | Body | Head | Body | Head | Body |
| Ingredients (% by weight) | | | | | | | | | | |
| Bactericide | See page 2-3 | See page 2 | 0.1 | 0.1 | | | | | See page 4 | |
| DGBE | | | | | 47 | 31 | 44.92 | 29.44 | | 26.7 |
| HEC | | | 1 | 1 | | | | | | |
| NaCl | | | 1.45 | 0.94 | 0.4 | 0.2 | 0.18 | 0.39 | | 0.1 |
| Sucrose | | | 57 | 44.9 | | | | | | |
| Water | | | 40.45 | 53.06 | 52.6 | 68.8 | 54.9 | 70.17 | | 73.2 |

## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

| | |
|---|---|
| $H_2O$ | Water, 35 – 58% |
| Sucrose | Sugar, white, refined, 40 – 60% |
| NaCl | Sodium Chloride, 0 – 6% |
| Hydroxyethyl-cellulose | Medium Viscosity (CAS# 9004-62-0), <0.3% |
| Preventol-D7 | Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyyl-3(2H)-isothiazolone, 0.1 – 0.7% |
| | Relevant for safety; Refer to the respective Safety Data Sheet*. |

**Figure D-1**
**Composition of 750 MHz Head and Body Tissue Equivalent Matter**

**Note:** 750MHz liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

### Measurement Certificate / Material Test

| | |
|---|---|
| Item Name | **Body Tissue Simulating Liquid (MSL750V2)** |
| Product No. | SL AAM 075 AA (Charge: 150223-3) |
| Manufacturer | SPEAG |

**Measurement Method**

TSL dielectric parameters measured using calibrated OCP probe.

**Setup Validation**

Validation results were within ± 2.5% towards the target values of Methanol.

**Target Parameters**

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

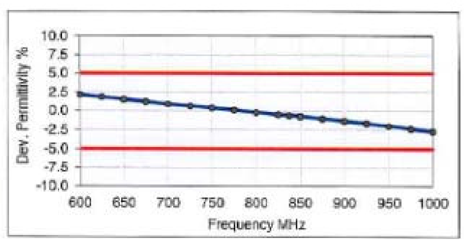
**Test Condition**

| | |
|---|---|
| Ambient | Environment temperatur (22 ± 3)°C and humidity < 70%. |
| TSL Temperature | 22°C |
| Test Date | 25-Feb-15 |
| Operator | IEN |

**Additional Information**

| | |
|---|---|
| TSL Density | 1.212 g/cm$^3$ |
| TSL Heat-capacity | 3.006 kJ/(kg*K) |

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | HP-e' | HP-e'' | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 600 | 57.3 | 24.76 | 0.83 | 56.1 | 0.95 | 2.2 | -13.2 |
| 625 | 57.1 | 24.43 | 0.85 | 56.0 | 0.95 | 1.8 | -11.0 |
| 650 | 56.8 | 24.09 | 0.87 | 55.9 | 0.96 | 1.5 | -8.8 |
| 675 | 56.5 | 23.80 | 0.89 | 55.8 | 0.96 | 1.2 | -6.7 |
| 700 | 56.2 | 23.51 | 0.92 | 55.7 | 0.96 | 0.9 | -4.6 |
| 725 | 56.0 | 23.28 | 0.94 | 55.6 | 0.96 | 0.6 | -2.4 |
| 750 | 55.7 | 23.06 | 0.96 | 55.5 | 0.96 | 0.4 | -0.1 |
| 775 | 55.5 | 22.87 | 0.99 | 55.4 | 0.97 | 0.1 | 2.1 |
| 800 | 55.2 | 22.68 | 1.01 | 55.3 | 0.97 | -0.2 | 4.4 |
| 825 | 55.0 | 22.52 | 1.03 | 55.2 | 0.98 | -0.5 | 5.7 |
| 838 | 54.9 | 22.44 | 1.05 | 55.2 | 0.98 | -0.6 | 6.3 |
| 850 | 54.8 | 22.36 | 1.06 | 55.2 | 0.99 | -0.7 | 7.0 |
| 875 | 54.5 | 22.24 | 1.08 | 55.1 | 1.02 | -1.0 | 6.2 |
| 900 | 54.3 | 22.12 | 1.11 | 55.0 | 1.05 | -1.3 | 5.5 |
| 925 | 54.1 | 22.01 | 1.13 | 55.0 | 1.06 | -1.6 | 6.5 |
| 950 | 53.9 | 21.89 | 1.16 | 54.9 | 1.08 | -2.0 | 7.6 |
| 975 | 53.6 | 21.81 | 1.18 | 54.9 | 1.09 | -2.3 | 8.8 |
| 1000 | 53.4 | 21.73 | 1.21 | 54.8 | 1.10 | -2.7 | 10.1 |



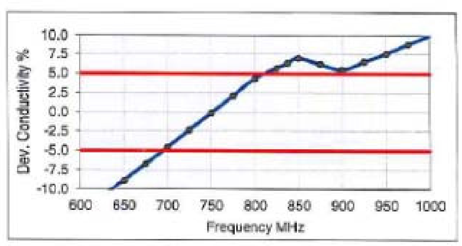




**Figure D-2**
**750MHz Body Tissue Equivalent Matter**

## Measurement Certificate / Material Test

| | |
|---|---|
| Item Name | **Head Tissue Simulating Liquid (HSL750V2)** |
| Product No. | SL AAH 075 AA (Charge: 150213-1) |
| Manufacturer | SPEAG |

### Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

### Setup Validation

Validation results were within ± 2.5% towards the target values of Methanol.

### Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

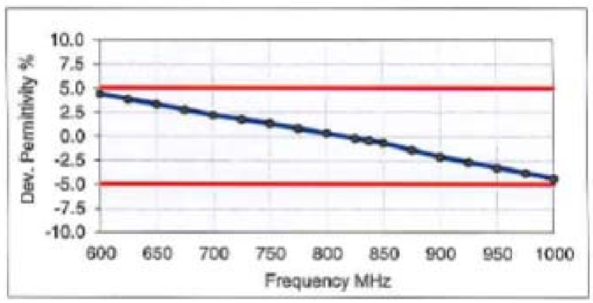
### Test Condition

| | |
|---|---|
| Ambient | Environment temperatur (22 ± 3)°C and humidity < 70%. |
| TSL Temperature | 22°C |
| Test Date | 18-Feb-15 |
| Operator | IEN |

### Additional Information

| | |
|---|---|
| TSL Density | 1.284 g/cm$^3$ |
| TSL Heat-capacity | 2.701 kJ/(kg*K) |

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | HP-e' | HP-e" | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 600 | 44.6 | 22.42 | 0.75 | 42.7 | 0.88 | 4.5 | -15.1 |
| 625 | 44.3 | 22.20 | 0.77 | 42.6 | 0.88 | 3.9 | -12.7 |
| 650 | 43.9 | 21.98 | 0.79 | 42.5 | 0.89 | 3.3 | -10.3 |
| 675 | 43.5 | 21.75 | 0.82 | 42.3 | 0.89 | 2.8 | -8.0 |
| 700 | 43.1 | 21.53 | 0.84 | 42.2 | 0.89 | 2.2 | -5.7 |
| 725 | 42.8 | 21.36 | 0.86 | 42.1 | 0.89 | 1.8 | -3.3 |
| 750 | 42.5 | 21.22 | 0.89 | 41.9 | 0.89 | 1.3 | -0.9 |
| 775 | 42.2 | 21.06 | 0.91 | 41.8 | 0.90 | 0.8 | 1.4 |
| 800 | 41.8 | 20.90 | 0.93 | 41.7 | 0.90 | 0.3 | 3.7 |
| 825 | 41.5 | 20.77 | 0.95 | 41.6 | 0.91 | -0.2 | 5.1 |
| 838 | 41.4 | 20.71 | 0.96 | 41.5 | 0.91 | -0.4 | 5.8 |
| 850 | 41.2 | 20.65 | 0.98 | 41.5 | 0.92 | -0.7 | 6.6 |
| 875 | 40.9 | 20.53 | 1.00 | 41.5 | 0.94 | -1.4 | 6.0 |
| 900 | 40.6 | 20.42 | 1.02 | 41.5 | 0.97 | -2.1 | 5.4 |
| 925 | 40.4 | 20.32 | 1.05 | 41.5 | 0.98 | -2.6 | 6.5 |
| 950 | 40.1 | 20.22 | 1.07 | 41.4 | 0.99 | -3.2 | 7.5 |
| 975 | 39.8 | 20.14 | 1.09 | 41.4 | 1.00 | -3.8 | 8.7 |
| 1000 | 39.5 | 20.05 | 1.12 | 41.3 | 1.01 | -4.3 | 9.9 |



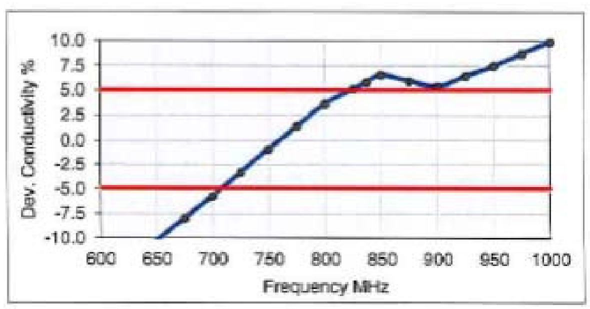




**Figure D-3**
**750MHz Head Tissue Equivalent Matter**

## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

| | |
|---|---|
| $H_2O$ | Water, 52 – 75% |
| $C_8H_{18}O_3$ | Diethylene glycol monobutyl ether (DGBE), 25 – 48%<br>(CAS-No. 112-34-5, EC-No. 203-961-6, EC-index-No. 603-096-00-8)<br>Relevant for safety; Refer to the respective Safety Data Sheet*. |
| NaCl | Sodium Chloride, <1.0% |

**Figure D-4**
**Composition of 2.4 GHz Head Tissue Equivalent Matter**

**Note:** 2.4 GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

### Measurement Certificate / Material Test

| | |
|---|---|
| Item Name | **Head Tissue Simulating Liquid (HSL2450V2)** |
| Product No. | SL AAH 245 BA (Charge: 150206-3) |
| Manufacturer | SPEAG |

**Measurement Method**

TSL dielectric parameters measured using calibrated OCP probe.

**Setup Validation**

Validation results were within ± 2.5% towards the target values of Methanol.

**Target Parameters**

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

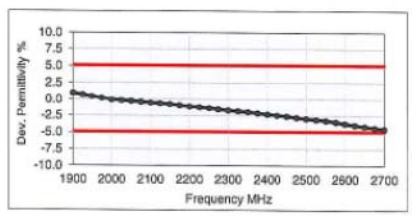
**Test Condition**

| | |
|---|---|
| Ambient | Environment temperatur (22 ± 3)°C and humidity < 70%. |
| TSL Temperature | 23°C |
| Test Date | 11-Feb-15 |
| Operator | IEN |

**Additional Information**

| | |
|---|---|
| TSL Density | 0.988 g/cm$^3$ |
| TSL Heat-capacity | 3.680 kJ/(kg*K) |

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | HP-e' | HP-e" | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 1900 | 40.4 | 11.89 | 1.26 | 40.0 | 1.40 | 1.0 | -10.2 |
| 1925 | 40.3 | 11.98 | 1.28 | 40.0 | 1.40 | 0.7 | -8.3 |
| 1950 | 40.2 | 12.07 | 1.31 | 40.0 | 1.40 | 0.4 | -6.4 |
| 1975 | 40.1 | 12.15 | 1.34 | 40.0 | 1.40 | 0.2 | -4.6 |
| 2000 | 40.0 | 12.23 | 1.36 | 40.0 | 1.40 | -0.1 | -2.8 |
| 2025 | 39.9 | 12.32 | 1.39 | 40.0 | 1.42 | -0.2 | -2.4 |
| 2050 | 39.8 | 12.41 | 1.42 | 39.9 | 1.44 | -0.3 | -2.0 |
| 2075 | 39.7 | 12.50 | 1.44 | 39.9 | 1.47 | -0.4 | -1.6 |
| 2100 | 39.6 | 12.59 | 1.47 | 39.8 | 1.49 | -0.5 | -1.2 |
| 2125 | 39.5 | 12.66 | 1.50 | 39.8 | 1.51 | -0.7 | -0.9 |
| 2150 | 39.4 | 12.73 | 1.52 | 39.7 | 1.53 | -0.8 | -0.7 |
| 2175 | 39.3 | 12.83 | 1.55 | 39.7 | 1.56 | -0.9 | -0.2 |
| 2200 | 39.2 | 12.92 | 1.58 | 39.6 | 1.58 | -1.1 | 0.2 |
| 2225 | 39.1 | 13.00 | 1.61 | 39.6 | 1.60 | -1.2 | 0.6 |
| 2250 | 39.0 | 13.08 | 1.64 | 39.6 | 1.62 | -1.3 | 0.9 |
| 2275 | 38.9 | 13.17 | 1.67 | 39.5 | 1.64 | -1.5 | 1.4 |
| 2300 | 38.8 | 13.26 | 1.70 | 39.5 | 1.67 | -1.7 | 1.8 |
| 2325 | 38.7 | 13.34 | 1.73 | 39.4 | 1.69 | -1.8 | 2.2 |
| 2350 | 38.6 | 13.42 | 1.75 | 39.4 | 1.71 | -2.0 | 2.5 |
| 2375 | 38.5 | 13.50 | 1.78 | 39.3 | 1.73 | -2.1 | 2.9 |
| 2400 | 38.4 | 13.58 | 1.81 | 39.3 | 1.76 | -2.3 | 3.3 |
| 2425 | 38.3 | 13.65 | 1.84 | 39.2 | 1.78 | -2.4 | 3.6 |
| 2450 | 38.2 | 13.73 | 1.87 | 39.2 | 1.80 | -2.6 | 3.9 |
| 2475 | 38.1 | 13.80 | 1.90 | 39.2 | 1.83 | -2.8 | 4.0 |
| 2500 | 38.0 | 13.87 | 1.93 | 39.1 | 1.85 | -3.0 | 4.0 |
| 2525 | 37.9 | 13.90 | 1.95 | 39.1 | 1.88 | -3.1 | 3.8 |
| 2550 | 37.8 | 13.93 | 1.98 | 39.1 | 1.91 | -3.2 | 3.5 |
| 2575 | 37.7 | 14.05 | 2.01 | 39.0 | 1.94 | -3.5 | 4.0 |
| 2600 | 37.6 | 14.17 | 2.05 | 39.0 | 1.96 | -3.7 | 4.4 |
| 2625 | 37.4 | 14.23 | 2.08 | 39.0 | 1.99 | -3.9 | 4.4 |
| 2650 | 37.3 | 14.29 | 2.11 | 38.9 | 2.02 | -4.1 | 4.4 |
| 2675 | 37.2 | 14.37 | 2.14 | 38.9 | 2.05 | -4.3 | 4.6 |
| 2700 | 37.1 | 14.45 | 2.17 | 38.9 | 2.07 | -4.5 | 4.7 |



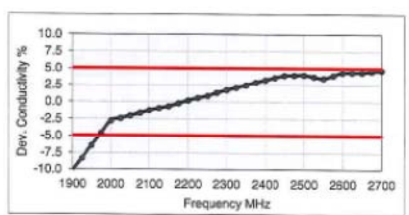




**Figure D-5**
**2.4 GHz Head Tissue Equivalent Matter**

# APPENDIX E: SAR SYSTEM VALIDATION

Per FCC KDB Publication 865664 D02v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

**Table E-I**
**SAR System Validation Summary**

| SAR SYSTEM # | FREQ. [MHz] | DATE | PROBE SN | PROBE TYPE | PROBE CAL. POINT | | COND. | PERM. | CW VALIDATION | | | MOD. VALIDATION | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | (σ) | (εr) | SENSITIVITY | PROBE LINEARITY | PROBE ISOTROPY | MOD. TYPE | DUTY FACTOR | PAR |
| C | 750 | 10/5/2015 | 3288 | ES3DV3 | 750 | Head | 0.898 | 41.055 | PASS | PASS | PASS | N/A | N/A | N/A |
| A | 835 | 2/16/2016 | 3332 | ES3DV3 | 835 | Head | 0.924 | 41.825 | PASS | PASS | PASS | GMSK | PASS | N/A |
| K | 1750 | 2/9/2016 | 3022 | ES3DV2 | 1750 | Head | 1.385 | 38.918 | PASS | PASS | PASS | N/A | N/A | N/A |
| K | 1900 | 2/11/2016 | 3022 | ES3DV2 | 1900 | Head | 1.429 | 38.354 | PASS | PASS | PASS | GMSK | PASS | N/A |
| C | 2450 | 10/7/2015 | 3288 | ES3DV3 | 2450 | Head | 1.878 | 39.821 | PASS | PASS | PASS | OFDM/TDD | PASS | PASS |
| G | 750 | 12/3/2015 | 3334 | ES3DV3 | 750 | Body | 0.994 | 55.948 | PASS | PASS | PASS | N/A | N/A | N/A |
| J | 835 | 3/9/2016 | 3318 | ES3DV3 | 835 | Body | 0.989 | 52.941 | PASS | PASS | PASS | GMSK | PASS | N/A |
| E | 1750 | 4/25/2016 | 7406 | EX3DV4 | 1750 | Body | 1.490 | 53.432 | PASS | PASS | PASS | N/A | N/A | N/A |
| H | 1900 | 4/6/2016 | 3319 | ES3DV3 | 1900 | Body | 1.584 | 53.356 | PASS | PASS | PASS | GMSK | PASS | N/A |
| G | 2450 | 12/4/2015 | 3334 | ES3DV3 | 2450 | Body | 1.997 | 51.699 | PASS | PASS | PASS | OFDM/TDD | PASS | PASS |

NOTE: While the probes have been calibrated for both CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to FCC KDB Publication 865664 D01v01r04.