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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:**
05/19/14 - 05/27/14
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Document Serial No.:**
0Y1405161011-R2.ZNF

**FCC ID:** ZNFB450

**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-B450, LGB450, B450, LG-MS450, LGMS450, MS450

| Equipment Class | Band & Mode | Tx Frequency | SAR | |
|---|---|---|---|---|
| | | | 1 gm Head (W/kg) | 1 gm Body-Worn (W/kg) |
| PCE | GSM/GPRS/EDGE Rx Only 850 | 824.20 - 848.80 MHz | 0.36 | 0.42 |
| PCE | GSM/GPRS/EDGE Rx Only 1900 | 1850.20 - 1909.80 MHz | 0.22 | 0.17 |
| PCE | UMTS 1900 | 1852.4 - 1907.6 MHz | 0.32 | 0.38 |
| DSS | Bluetooth | 2402 - 2480 MHz | N/A | |
| **Simultaneous SAR per KDB 690783 D01v01r02:** | | | N/A | 0.54 |

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.

Note: This revised Test Report (S/N: 0Y1405161011-R2.ZNF) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

Randy Ortanez
President

ACCREDITED
TESTING CERT#2041.01

# T A B L E   O F   C O N T E N T S

# 1 DEVICE UNDER TEST

## 1.1 Device Overview

| Band & Mode | Operating Modes | Tx Frequency |
|---|---|---|
| GSM/GPRS/EDGE Rx Only 850 | Voice/Data | 824.20 - 848.80 MHz |
| GSM/GPRS/EDGE Rx Only 1900 | Voice/Data | 1850.20 - 1909.80 MHz |
| UMTS 1900 | Voice/Data | 1852.4 - 1907.6 MHz |
| Bluetooth | Data | 2402 - 2480 MHz |

## 1.2 Nominal and Maximum Output Power Specifications

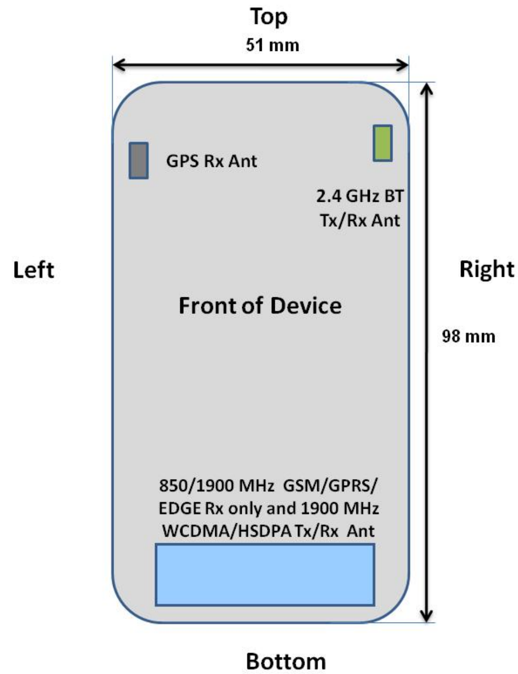
This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v05.

| Mode / Band | | Voice (dBm) | Burst Average GMSK (dBm) | | | |
|---|---|---|---|---|---|---|
| | | 1 TX Slot | *1 TX Slots* | *2 TX Slots* | *3 TX Slots* | *4 TX Slots* |
| GSM/GPRS 850 | Maximum | **33.2** | **33.2** | **31.2** | **29.7** | **28.7** |
| | Nominal | **32.7** | **32.7** | **30.7** | **29.2** | **28.2** |
| GSM/GPRS 1900 | Maximum | **29.7** | **29.7** | **28.2** | **26.7** | **25.7** |
| | Nominal | **29.2** | **29.2** | **27.7** | **26.2** | **25.2** |

| Mode / Band | | Modulated Average (dBm) | |
|---|---|---|---|
| | | *3GPP WCDMA* | *3GPP HSDPA* |
| UMTS Band 2 (1900 MHz) | Maximum | **23.2** | **23.2** |
| | Nominal | **22.7** | **22.7** |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| Bluetooth | Maximum | **9.5** |
| | Nominal | **8.0** |

## 1.3 DUT Antenna Locations




Note: Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC Filing.

**Figure 1-1**
**DUT Antenna Locations**

## 1.4 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D05v01, 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.
This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v05 3) procedures.

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

| No. | Capable Transmit Configuration | Head | Body-Worn Accessory |
|---|---|---|---|
| 1 | GSM voice + 2.4 GHz Bluetooth | N/A | Yes |
| 2 | UMTS + 2.4 GHz Bluetooth | N/A | Yes |

Note: VoIP is not supported in GSM/WCDMA.

## 1.5 SAR Test Exclusions Applied

**(A) BT**

Per FCC KDB 447498 D01v05, the 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, Bluetooth SAR was not required.
[(9/15)* √2.402] = 0.9 < 3.0
[(9/15)* √2.441] = 0.9 < 3.0
[(9/15)* √2.480] = 0.9 < 3.0
Per KDB Publication 447498 D01v05, the maximum power of the channel was rounded to the nearest mW before calculation.

**(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 Data.

## 1.6 Power Reduction for SAR

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

## 1.7 Guidance Applied

- IEEE 1528-2003
- FCC KDB Publication 941225 D01 v02 (3G)
- FCC KDB Publication 941225 D02 v02r02 (3G)
- FCC KDB Publication 941225 D03 v01(2G)
- FCC KDB Publication 447498 D01 v05r02 (General SAR Guidance)
- FCC KDB Publication 865664 D01 v01r03 (SAR Measurements up to 6 GHz)
- FCC KDB Publication 865664 D02 v01r01 (SAR Reporting up to 6 GHz)

## 1.8 Device Serial Numbers

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 |
|---|---|---|
| GSM/GPRS/EDGE 850 | 198 | 198 |
| GSM/GPRS/EDGE 1900 | 198 | 198 |
| UMTS 1900 | 198 | 198 |

# 2 INTRODUCTION

The FCC and Industry 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.

## 2.1 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 2-1).

**Equation 2-1**
**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]

# 3 DOSIMETRIC ASSESSMENT

## 3.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01 and IEEE 1528-2013:

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 D01v01 (See Table 3-1) 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.

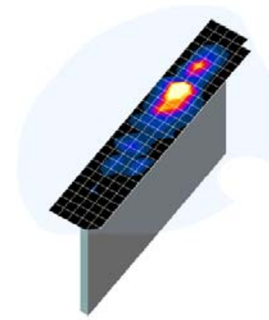


**Figure 3-1**
**Sample SAR Area Scan**

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 D01v01 (See Table 3-1) 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 3-1. 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 3-1**
**Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01***

| 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

# 4 DEFINITION OF REFERENCE POINTS

## 4.1 EAR REFERENCE POINT

Figure 4-2 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 4-1. 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 4-1). 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].

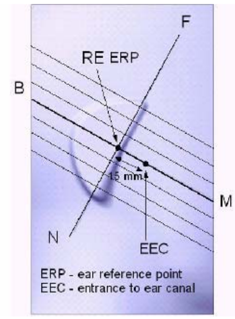



**Figure 4-1**
**Close-Up Side view of ERP**

## 4.2 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 4-3). 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 4-2**
**Front, back and side view of SAM Twin Phantom**

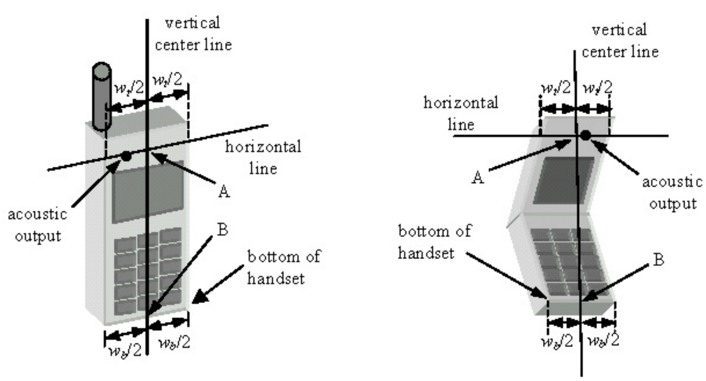



**Figure 4-3**
**Handset Vertical Center & Horizontal Line Reference Points**

# 5 TEST CONFIGURATION POSITIONS FOR HANDSETS

## 5.1 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.

## 5.2 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 5-1), 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 5-1 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 5-2).

## 5.3 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 5-2).

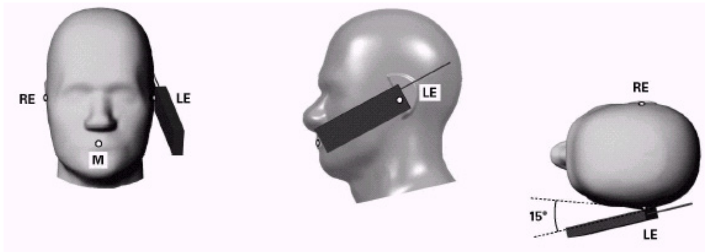



Figure 5-2 Front, Side and Top View of Ear/15º Tilt Position

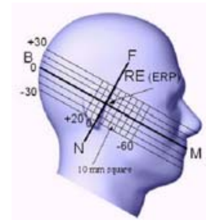



**Figure 5-3**
**Side view w/ relevant markings**

## 5.4 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 D04_v01. 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.

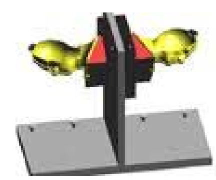


**Figure 5-4 Twin SAM Chin20**

## 5.5 Body-Worn Accessory Configurations

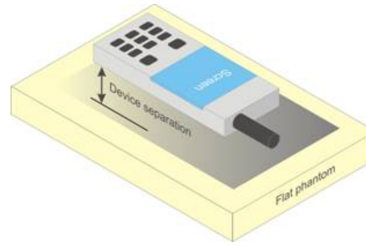



**Figure 5-5**
**Sample Body-Worn Diagram**

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 5-5). Per FCC KDB Publication 648474 D04v01, 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 D01v05 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.

## 5.6 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 44798 D01v05 should be applied to determine SAR test requirements.

Per KDB Publication 447498 D01v05, 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 RF EXPOSURE LIMITS

## 6.1 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.

## 6.2 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 6-1**
**SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6**

| HUMAN EXPOSURE LIMITS | | |
|---|---|---|
| | UNCONTROLLED ENVIRONMENT<br>*General Population*<br>(W/kg) or (mW/g) | CONTROLLED ENVIRONMENT<br>*Occupational*<br>(W/kg) or (mW/g) |
| **Peak Spatial Average SAR**<br>Head | 1.6 | 8.0 |
| **Whole Body SAR** | 0.08 | 0.4 |
| **Peak Spatial Average SAR**<br>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.

# 7 FCC MEASUREMENT PROCEDURES

Power measurements were performed using a base station simulator under digital average power.

## 7.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v05, 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 D01v01r02.

## 7.2 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01 “SAR Measurement Procedures for 3G Devices” v02, October 2007.

The device was 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 were 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 was 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 deviated by more than 5%, the SAR test and drift measurements were repeated.

## 7.3 SAR Measurement Conditions for UMTS

### 7.3.1 Output Power Verification

Maximum output power is measured on the High, Middle and Low channels for each applicable transmission band according to the general descriptions in section 5.2 of 3GPP TS 34.121, using the appropriate RMC or AMR with TPC (transmit power control) set to all “1s”.

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 (release 5), using the appropriate RMC with TPC (transmit power control) set to all “1s”. 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.

### 7.3.2 Head SAR Measurements for Handsets

SAR for head exposure configurations is measured using the 12.2 kbps RMC with TPC bits configured to all “1s”. SAR in AMR configurations is not required when the maximum average output of each RF channel for 12.2 kbps AMR is less than 0.25 dB higher than that measured in 12.2 kbps RMC. Otherwise, SAR is measured on the maximum output channel in 12.2 AMR with a

3.4 kbps SRB (signaling radio bearer) using the exposure configuration that resulted in the highest SAR for that RF channel in the 12.2 kbps RMC mode.

### 7.3.3 Body SAR Measurements

SAR for body exposure configurations is measured using the 12.2 kbps RMC with the TPC bits all "1s".

### 7.3.4 SAR Measurements for Handsets with Rel 5 HSDPA

Body SAR for HSDPA is not required for handsets with HSDPA capabilities when the maximum average output power of each RF channel with HSDPA active is less than 0.25 dB higher than that measured without HSDPA using 12.2 kbps RMC and the maximum SAR for 12.2 kbps RMC is ≤ 75% of the SAR limit. Otherwise, SAR is measured for HSDPA, using an FRC with H-Set 1 in Sub-test 1 and a 12.2 kbps RMC configured in Test Loop Mode 1, using the highest body SAR configuration measured in 12.2 kbps RMC without HSDPA, on the maximum output channel with the body exposure configuration that resulted in the highest SAR in 12.2 kbps RMC mode for that RF channel.

The H-set used in FRC for HSDPA should be configured according to the UE category of a test device. The number of HS-DSCH/HSPDSCHs, HARQ processes, minimum inter-TTI interval, transport block sizes and RV coding sequence are defined by the applicable H-set. To maintain a consistent test configuration and stable transmission conditions, QPSK is used in the FRC for SAR testing. HS-DPCCH should be configured with a CQI feedback cycle of 2 ms to maintain a constant rate of active CQI slots. DPCCH and DPDCH gain factors of βc=9 and βd=15, and power offset parameters of ΔACK= ΔNACK =5 and ΔCQI=2 is used. The CQI value is determined by the UE category, transport block size, number of HS-PDSCHs and modulation used in the FRC.

| Sub-Test | $\beta_c$ | $\beta_d$ | $\beta_d$ *(SF)* | $\beta_c/\beta_d$ | $\beta_{HS}$ *(Note1, Note 2)* | CM (dB) *(Note 3)* | MPR (dB) *(Note 3)* |
|---|---|---|---|---|---|---|---|
| 1 | 2/15 | 15/15 | 64 | 2/15 | 4/15 | 0.0 | 0.0 |
| 2 | 12/15 *(Note 4)* | 15/15 *(Note 4)* | 64 | 12/15 *(Note 4)* | 24/15 | 1.0 | 0.0 |
| 3 | 15/15 | 8/15 | 64 | 15/8 | 30/15 | 1.5 | 0.5 |
| 4 | 15/15 | 4/15 | 64 | 15/4 | 30/15 | 1.5 | 0.5 |

Note 1: $\Delta_{ACK}$, $\Delta_{NACK}$ and $\Delta_{CQI}$ = 8 ⇔ $A_{hs} = \beta_{hs}/\beta_c = 30/15$ ⇔ $\beta_{hs} = 30/15 * \beta_c$.

Note 2: For the HS-DPCCH power mask requirement test in clause 5.2C, 5.7A, and the Error Vector Magnitude (EVM) with HS-DPCCH test in clause 5.13.1A, and HSDPA EVM with phase discontinuity in clause 5.13.1AA, $\Delta_{ACK}$ and $\Delta_{NACK}$ = 8 ($A_{hs}$ = 30/15) with $\beta_{hs} = 30/15 * \beta_c$, and $\Delta_{CQI}$ = 7 ($A_{hs}$ = 24/15) with $\beta_{hs} = 24/15 * \beta_c$.

Note 3: CM = 1 for $\beta_c/\beta_d$ =12/15, $\beta_{hs}/\beta_c$=24/15. For all other combinations of DPDCH, DPCCH and HS-DPCCH the MPR is based on the relative CM difference. This is applicable for only UEs that support HSDPA in release 6 and later releases.

**Figure 7-1**
**Table C.10.1.4 of TS 234.121-1**

# 8 RF CONDUCTED POWERS

## 8.1 GSM Conducted Powers

| Maximum Burst-Averaged Output Power | | | | | | |
|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS Data (GMSK)* | | | |
| Band | Channel | GSM [dBm] CS (1 Slot) | GPRS [dBm] 1 Tx Slot | GPRS [dBm] 2 Tx Slot | GPRS [dBm] 3 Tx Slot | GPRS [dBm] 4 Tx Slot |
| GSM 850 | 128 | 32.77 | 32.75 | 30.50 | 29.04 | 27.90 |
| | 190 | 32.83 | 32.85 | 30.57 | 29.15 | 27.94 |
| | 251 | 32.81 | 32.79 | 30.55 | 29.11 | 27.93 |
| GSM 1900 | 512 | 28.75 | 28.77 | 27.48 | 25.45 | 24.43 |
| | 661 | 28.96 | 29.02 | 27.61 | 25.62 | 24.56 |
| | 810 | 29.20 | 29.26 | 27.86 | 25.88 | 24.83 |

| Calculated Maximum Frame-Averaged Output Power | | | | | | |
|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS Data (GMSK)* | | | |
| Band | Channel | GSM [dBm] CS (1 Slot) | GPRS [dBm] 1 Tx Slot | GPRS [dBm] 2 Tx Slot | GPRS [dBm] 3 Tx Slot | GPRS [dBm] 4 Tx Slot |
| GSM 850 | 128 | 23.74 | 23.72 | 24.48 | 24.78 | 24.89 |
| | 190 | 23.80 | 23.82 | 24.55 | 24.89 | 24.93 |
| | 251 | 23.78 | 23.76 | 24.53 | 24.85 | 24.92 |
| GSM 1900 | 512 | 19.72 | 19.74 | 21.46 | 21.19 | 21.42 |
| | 661 | 19.93 | 19.99 | 21.59 | 21.36 | 21.55 |
| | 810 | 20.17 | 20.23 | 21.84 | 21.62 | 21.82 |
| GSM 850 | Frame Avg. Targets: | 23.67 | 23.67 | 24.68 | 24.94 | 25.19 |
| GSM 1900 | | 20.17 | 20.17 | 21.68 | 21.94 | 22.19 |

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 (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.

**GSM Class:** B
**GPRS Multislot class:** 12 (Max 4 Tx uplink slots)
**EDGE Multislot class:** Rx Only
**DTM Multislot Class:** N/A

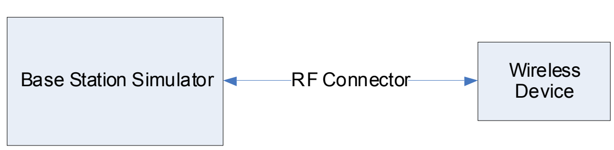



**Figure 8-1**
**Power Measurement Setup**

## 8.2 UMTS Conducted Powers

| 3GPP Release Version | Mode | 3GPP 34.121 Subtest | PCS Band [dBm] | | | 3GPP MPR [dB] |
|---|---|---|---|---|---|---|
| | | | 9262 | 9400 | 9538 | |
| 99 | WCDMA | 12.2 kbps RMC | 22.44 | 22.62 | 22.53 | - |
| 99 | | 12.2 kbps AMR | 22.52 | 22.58 | 22.47 | - |
| 5 | HSDPA | Subtest 1 | 22.45 | 22.57 | 22.75 | 0 |
| 5 | | Subtest 2 | 22.41 | 22.57 | 22.65 | 0 |
| 5 | | Subtest 3 | 21.54 | 21.59 | 21.54 | 0.5 |
| 5 | | Subtest 4 | 20.70 | 20.71 | 20.78 | 0.5 |

UMTS SAR was tested under RMC 12.2 kbps with HSDPA Inactive per KDB Publication 941225 D01v02. HSDPA SAR was not required since the average output power of the HSDPA subtests was not more than 0.25 dB higher than the RMC level and SAR was less than 1.2 W/kg.

This device does not support DC-HSDPA or HSUPA.

It is expected by the manufacturer that MPR for some HSDPA subtests may be up to 2 dB more than specified by 3GPP, but also as low as 0 dB according to the chipset implementation in this model.

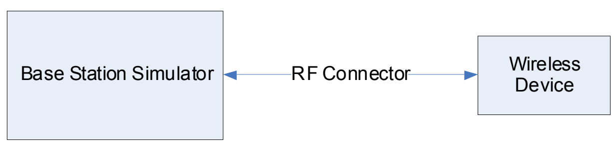



**Figure 8-2**
**Power Measurement Setup**

# 9 SYSTEM VERIFICATION

## 9.1 Tissue Verification

**Table 9-1**
**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 |
|---|---|---|---|---|---|---|---|---|---|
| 5/22/2014 | 835H | 22.1 | 820 | 0.915 | 42.772 | 0.899 | 41.578 | 1.78% | 2.87% |
| | | | 835 | 0.930 | 42.572 | 0.900 | 41.500 | 3.33% | 2.58% |
| | | | 850 | 0.942 | 42.370 | 0.916 | 41.500 | 2.84% | 2.10% |
| 5/27/2014 | 1900H | 22.9 | 1850 | 1.357 | 39.268 | 1.400 | 40.000 | -3.07% | -1.83% |
| | | | 1880 | 1.388 | 39.096 | 1.400 | 40.000 | -0.86% | -2.26% |
| | | | 1910 | 1.418 | 38.962 | 1.400 | 40.000 | 1.29% | -2.59% |
| 5/19/2014 | 835B | 21.0 | 820 | 0.937 | 53.570 | 0.969 | 55.258 | -3.30% | -3.05% |
| | | | 835 | 0.955 | 53.447 | 0.970 | 55.200 | -1.55% | -3.18% |
| | | | 850 | 0.970 | 53.230 | 0.988 | 55.154 | -1.82% | -3.49% |
| 5/21/2014 | 1900B | 21.8 | 1850 | 1.490 | 52.830 | 1.520 | 53.300 | -1.97% | -0.88% |
| | | | 1880 | 1.527 | 52.703 | 1.520 | 53.300 | 0.46% | -1.12% |
| | | | 1910 | 1.563 | 52.598 | 1.520 | 53.300 | 2.83% | -1.32% |

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 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.

## 9.2 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 9-2**
**System Verification Results**

| System Verification<br>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) | $Deviation_{1g}$ (%) |
| G | 835 | HEAD | 05/22/2014 | 21.1 | 22.0 | 0.100 | 4d119 | 3258 | 0.982 | 9.220 | 9.820 | 6.51% |
| I | 1900 | HEAD | 05/27/2014 | 24.1 | 23.4 | 0.100 | 5d149 | 3209 | 3.760 | 40.400 | 37.600 | -6.93% |
| B | 835 | BODY | 05/19/2014 | 22.1 | 21.0 | 0.100 | 4d133 | 3288 | 0.991 | 9.610 | 9.910 | 3.12% |
| J | 1900 | BODY | 05/21/2014 | 22.4 | 21.8 | 0.100 | 5d149 | 3332 | 4.310 | 40.500 | 43.100 | 6.42% |

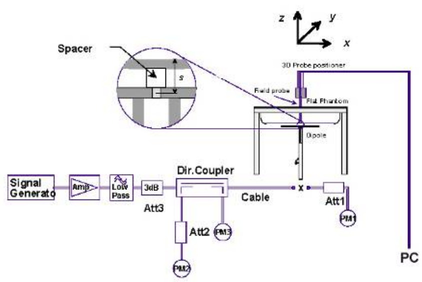



**Figure 9-1**
**System Verification Setup Diagram**

**Figure 9-2**
**System Verification Setup Photo**

# 10 SAR DATA SUMMARY

## 10.1 Standalone Head SAR Data

### Table 10-1
### 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 | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 32.83 | -0.06 | Right | Cheek | 198 | 1:8.3 | 0.301 | 1.089 | 0.328 | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 32.83 | 0.12 | Right | Tilt | 198 | 1:8.3 | 0.136 | 1.089 | 0.148 | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 32.83 | -0.01 | Left | Cheek | 198 | 1:8.3 | 0.329 | 1.089 | 0.358 | A1 |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 32.83 | 0.09 | Left | Tilt | 198 | 1:8.3 | 0.135 | 1.089 | 0.147 | |
| 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 10-2
### 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 | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 28.96 | -0.08 | Right | Cheek | 198 | 1:8.3 | 0.140 | 1.186 | 0.166 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 28.96 | 0.02 | Right | Tilt | 198 | 1:8.3 | 0.109 | 1.186 | 0.129 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 28.96 | 0.13 | Left | Cheek | 198 | 1:8.3 | 0.184 | 1.186 | 0.218 | A2 |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 28.96 | -0.04 | Left | Tilt | 198 | 1:8.3 | 0.110 | 1.186 | 0.130 | |
| 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 10-3
### 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 | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 22.62 | -0.09 | Right | Cheek | 198 | 1:1 | 0.248 | 1.143 | 0.283 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 22.62 | 0.06 | Right | Tilt | 198 | 1:1 | 0.234 | 1.143 | 0.267 | |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 22.62 | 0.00 | Left | Cheek | 198 | 1:1 | 0.280 | 1.143 | 0.320 | A3 |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 22.62 | 0.00 | Left | Tilt | 198 | 1:1 | 0.172 | 1.143 | 0.197 | |
| 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 | | | | | | | |

## 10.2 Standalone Body-Worn SAR Data

**Table 10-4**
**GSM/UMTS Body-Worn SAR Data**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | Duty Cycle | Side | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 190 | GSM 850 | GSM | 33.2 | 32.83 | -0.02 | 15 mm | 198 | 1:8.3 | back | 0.383 | 1.089 | 0.417 | A4 |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 28.96 | -0.03 | 15 mm | 198 | 1:8.3 | back | 0.143 | 1.186 | 0.170 | A5 |
| 1880.00 | 9400 | UMTS 1900 | RMC | 23.2 | 22.62 | 0.02 | 15 mm | 198 | 1:1 | back | 0.332 | 1.143 | 0.379 | A6 |
| 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 | | | | | | | |

## 10.3 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2003, and FCC KDB Publication 447498 D01v05.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all 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 D01v05.
6. Device was tested using a fixed spacing for body-worn accessory testing. A separation distance of 15 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 D04v01, SAR was evaluated without a headset connected to the device. Since the standalone reported SAR was ≤ 1.2 W/kg, no additional SAR evaluations using a headset cable were required.
8. Per FCC KDB 865664 D01 v01, variability SAR tests were not required since the measured SAR results for each frequency band were not greater than 0.8 W/kg. Please see Section 12 for variability analysis.

GSM Test Notes:

1. Body-Worn accessory testing is typically associated with voice operations. Therefore, GSM voice was evaluated for body-worn SAR.
2. Per FCC KDB Publication 447498 D01v05, 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 HSDPA Inactive per KDB Publication 941225 D01v02. HSDPA SAR was not required since the average output power of the HSDPA subtests was not more than 0.25 dB higher than the RMC level and SAR was less than 1.2 W/kg.
2. Per FCC KDB Publication 447498 D01v05, 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.

# 11 FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

## 11.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v05 are applicable to handsets with built-in unlicensed transmitters such as Bluetooth devices which may simultaneously transmit with the licensed transmitter.

## 11.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB 447498 D01v05 IV.C.1.iii 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. When standalone SAR is not required to be measured, per FCC KDB 447498 D01v05 4.3.2 2), 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 11-1**
**Estimated SAR**

| Mode | Frequency | Maximum Allowed Power | Separation Distance (Body) | Estimated SAR (Body) |
|---|---|---|---|---|
| | [MHz] | [dBm] | [mm] | [W/kg] |
| Bluetooth | 2441 | 9.50 | 15 | **0.125** |

Note: Held-to ear configurations are not applicable to Bluetooth operations and therefore were not considered for simultaneous transmission. Per KDB Publication 447498 D01v05, the maximum power of the channel was rounded to the nearest mW before calculation.

## 11.3 Body-Worn Simultaneous Transmission Analysis

**Table 11-2**
**Simultaneous Transmission Scenario with Bluetooth (Body-Worn at 1.5 cm)**

| Configuration | Mode | 2G/3G SAR (W/kg) | Bluetooth SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|---|
| Back Side | GSM 850 | 0.417 | 0.125 | **0.542** |
| Back Side | GSM 1900 | 0.170 | 0.125 | 0.295 |
| Back Side | UMTS 1900 | 0.379 | 0.125 | 0.504 |

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.

## 11.4 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is 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 D01v05 and IEEE 1528-2013 Section 6.3.4.1.2.

# 12 SAR MEASUREMENT VARIABILITY

## 12.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01, SAR measurement variability is assessed when the highest measured SAR is ≥ 0.8 W/kg. Since all measured SAR values are < 0.8 W/kg for this device, SAR measurement variability was not assessed.

## 12.2 Measurement Uncertainty

The measured SAR was <1.5 W/kg for all frequency bands. Therefore, per KDB Publication 865664 D01v01, the extended measurement uncertainty analysis per IEEE 1528-2003 was not required.

# 13 EQUIPMENT LIST

| Manufacturer | Model | Description | Cal Date | Cal Interval | Cal Due | Serial Number |
|---|---|---|---|---|---|---|
| Agilent | 8648D | (9kHz-4GHz) Signal Generator | 4/15/2014 | Annual | 4/15/2015 | 3629U00687 |
| Agilent | 8753E | (30kHz-6GHz) Network Analyzer | 7/23/2013 | Annual | 7/23/2014 | US37390350 |
| Agilent | 8753ES | S-Parameter Network Analyzer | 10/29/2013 | Annual | 10/29/2014 | US39170122 |
| Agilent | E4438C | ESG Vector Signal Generator | 4/25/2014 | Annual | 4/25/2015 | MY42082385 |
| Agilent | E8257D | (250kHz-20GHz) Signal Generator | 4/15/2014 | Annual | 4/15/2015 | MY45470194 |
| Agilent | N5182A | MXG Vector Signal Generator | 4/15/2014 | Annual | 4/15/2015 | MY47420651 |
| Agilent | N5182A | MXG Vector Signal Generator | 4/15/2014 | Annual | 4/15/2015 | MY47420800 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433971 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433972 |
| Anritsu | MA24106A | USB Power Sensor | 12/18/2013 | Annual | 12/18/2014 | 1344545 |
| Anritsu | MA24106A | USB Power Sensor | 1/3/2014 | Annual | 1/3/2015 | 1344554 |
| Anritsu | MA24106A | USB Power Sensor | 12/18/2013 | Annual | 12/18/2014 | 1344555 |
| Anritsu | MA24106A | USB Power Sensor | 12/18/2013 | Annual | 12/18/2014 | 1344556 |
| Anritsu | MA24106A | USB Power Sensor | 1/3/2014 | Annual | 1/3/2015 | 1344557 |
| Anritsu | MA24106A | USB Power Sensor | 12/18/2013 | Annual | 12/18/2014 | 1344559 |
| Anritsu | MT8820C | Radio Communication Analyzer | 12/12/2013 | Annual | 12/12/2014 | 6200901190 |
| COMTech | AR85729-5 | Solid State Amplifier | CBT | N/A | CBT | M1S5A00-009 |
| COMTECH | AR85729-5/5759B | Solid State Amplifier | CBT | N/A | CBT | M3W1A00-1002 |
| Control Company | 4052 | Long Stem Thermometer | 9/27/2013 | Biennial | 9/27/2015 | 130567447 |
| Control Company | 36934-158 | Wall-Mounted Thermometer | 4/29/2014 | Biennial | 4/29/2016 | 122014488 |
| Control Company | 61220-416 | Long-Stem Thermometer | 4/29/2014 | Biennial | 4/29/2016 | 111331323 |
| Fisher Scientific | 15-077-960 | Digital Thermometer | 11/6/2012 | Biennial | 11/6/2014 | 122640025 |
| Fisher Scientific | 15-078J | Long Stem Thermometer | 10/30/2012 | Biennial | 10/30/2014 | 122626059 |
| Gigatronics | 80701A | (0.05-18GHz) Power Sensor | 10/30/2013 | Annual | 10/30/2014 | 1833460 |
| Gigatronics | 8651A | Universal Power Meter | 10/30/2013 | Annual | 10/30/2014 | 8650319 |
| MCL | BW-N6W5+ | 6dB Attenuator | CBT | N/A | CBT | 1139 |
| MiniCircuits | SLP-2400+ | Low Pass Filter | CBT | N/A | CBT | R8979500903 |
| MiniCircuits | VLF-6000+ | Low Pass Filter | CBT | N/A | CBT | N/A |
| MiniCircuits | VLF-6000+ | Low Pass Filter | CBT | N/A | CBT | N/A |
| Mini-Circuits | BW-N20W5 | Power Attenuator | CBT | N/A | CBT | 1226 |
| Mini-Circuits | BW-N20W5+ | DC to 18 GHz Precision Fixed 20 dB Attenuator | CBT | N/A | CBT | N/A |
| Mini-Circuits | NLP-1200+ | Low Pass Filter DC to 1000 MHz | CBT | N/A | CBT | N/A |
| Mini-Circuits | NLP-2950+ | Low Pass Filter DC to 2700 MHz | CBT | N/A | CBT | N/A |
| Mitutoyo | CD-6"CSX | Digital Caliper | 5/8/2014 | Biennial | 5/8/2016 | 13264162 |
| Mitutoyo | CD-6"CSX | Digital Caliper | 5/8/2014 | Biennial | 5/8/2016 | 13264165 |
| Narda | 4014C-6 | 4 - 8 GHz SMA 6 dB Directional Coupler | CBT | N/A | CBT | N/A |
| Narda | 4772-3 | Attenuator (3dB) | CBT | N/A | CBT | 9406 |
| Narda | BW-S3W2 | Attenuator (3dB) | CBT | N/A | CBT | 120 |
| Pasternack | PE2208-6 | Bidirectional Coupler | CBT | N/A | CBT | N/A |
| Pasternack | PE2209-10 | Bidirectional Coupler | CBT | N/A | CBT | N/A |
| Rohde & Schwarz | CMU200 | Base Station Simulator | 9/23/2013 | Annual | 9/23/2014 | 109892 |
| Rohde & Schwarz | CMW500 | LTE Radio Communication Tester | 10/18/2013 | Annual | 10/18/2014 | 100976 |
| Rohde & Schwarz | CMW500 | LTE Radio Communication Tester | 2/20/2014 | Annual | 2/20/2015 | 128633 |
| Seekonk | NC-100 | Torque Wrench | 3/18/2014 | Biennial | 3/18/2016 | 22313 |
| Seekonk | NC-100 | Torque Wrench 5/16", 8" lbs | 3/18/2014 | Biennial | 3/18/2016 | N/A |
| Seekonk | NC-100 | Torque Wrench | 3/18/2014 | Biennial | 3/18/2016 | N/A |
| Seekonk | NC-100 | Torque Wrench | 3/18/2014 | Biennial | 3/18/2016 | N/A |
| SPEAG | D1900V2 | 1900 MHz SAR Dipole | 7/22/2013 | Annual | 7/22/2014 | 5d149 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 4/7/2014 | Annual | 4/7/2015 | 4d119 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 7/17/2013 | Annual | 7/17/2014 | 4d133 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 2/26/2014 | Annual | 2/26/2015 | 665 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 9/17/2013 | Annual | 9/17/2014 | 1323 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 3/17/2014 | Annual | 3/17/2015 | 1334 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 11/18/2013 | Annual | 11/18/2014 | 1407 |
| SPEAG | DAK-3.5 | Dielectric Assessment Kit | 11/13/2013 | Annual | 11/13/2014 | 1091 |
| SPEAG | DAKS-3.5 | Portable Dielectric Assessment Kit | 8/18/2013 | Annual | 8/18/2014 | 1008 |
| SPEAG | DAKS-3.5 | Portable Dielectric Assessment Kit | 8/18/2013 | Annual | 8/18/2014 | 1009 |
| SPEAG | ES3DV3 | SAR Probe | 3/19/2014 | Annual | 3/19/2015 | 3209 |
| SPEAG | ES3DV3 | SAR Probe | 2/25/2014 | Annual | 2/25/2015 | 3258 |
| SPEAG | ES3DV3 | SAR Probe | 9/23/2013 | Annual | 9/23/2014 | 3288 |
| SPEAG | ES3DV3 | SAR Probe | 11/25/2013 | Annual | 11/25/2014 | 3332 |
| VWR | 23226-658 | Long Stem Thermometer | 6/27/2012 | Biennial | 6/27/2014 | 122363923 |
| VWR | 36934-158 | Wall-Mounted Thermometer | 4/29/2014 | Biennial | 4/29/2016 | 111859323 |

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.

# 14 MEASUREMENT UNCERTAINTIES

Applicable for frequencies less than 3000 MHz.

| a | b | c | d | e= f(d,k) | f | g | h = c x f/e | i = c x g/e | k |
|---|---|---|---|---|---|---|---|---|---|
| **Uncertainty Component** | **IEEE 1528 Sec.** | **Tol. (± %)** | **Prob. Dist.** | **Div.** | **$c_i$ 1gm** | **$c_i$ 10 gms** | **1gm $u_i$ (± %)** | **10gms $u_i$ (± %)** | **$v_i$** |
| **Measurement System** | | | | | | | | | |
| Probe Calibration | E.2.1 | 6.0 | N | 1 | 1.0 | 1.0 | 6.0 | 6.0 | ∞ |
| Axial Isotropy | E.2.2 | 0.25 | N | 1 | 0.7 | 0.7 | 0.2 | 0.2 | ∞ |
| Hemishperical Isotropy | E.2.2 | 1.3 | N | 1 | 1.0 | 1.0 | 1.3 | 1.3 | ∞ |
| Boundary Effect | E.2.3 | 0.4 | N | 1 | 1.0 | 1.0 | 0.4 | 0.4 | ∞ |
| Linearity | E.2.4 | 0.3 | N | 1 | 1.0 | 1.0 | 0.3 | 0.3 | ∞ |
| System Detection Limits | E.2.5 | 5.1 | N | 1 | 1.0 | 1.0 | 5.1 | 5.1 | ∞ |
| Readout Electronics | E.2.6 | 1.0 | N | 1 | 1.0 | 1.0 | 1.0 | 1.0 | ∞ |
| Response Time | E.2.7 | 0.8 | R | 1.73 | 1.0 | 1.0 | 0.5 | 0.5 | ∞ |
| Integration Time | E.2.8 | 2.6 | R | 1.73 | 1.0 | 1.0 | 1.5 | 1.5 | ∞ |
| RF Ambient Conditions | E.6.1 | 3.0 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | E.6.2 | 0.4 | R | 1.73 | 1.0 | 1.0 | 0.2 | 0.2 | ∞ |
| Probe Positioning w/ respect to Phantom | E.6.3 | 2.9 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation | E.5 | 1.0 | R | 1.73 | 1.0 | 1.0 | 0.6 | 0.6 | ∞ |
| **Test Sample Related** | | | | | | | | | |
| Test Sample Positioning | E.4.2 | 6.0 | N | 1 | 1.0 | 1.0 | 6.0 | 6.0 | 287 |
| Device Holder Uncertainty | E.4.1 | 3.32 | R | 1.73 | 1.0 | 1.0 | 1.9 | 1.9 | ∞ |
| Output Power Variation - SAR drift measurement | 6.6.2 | 5.0 | R | 1.73 | 1.0 | 1.0 | 2.9 | 2.9 | ∞ |
| **Phantom & Tissue Parameters** | | | | | | | | | |
| Phantom Uncertainty (Shape & Thickness tolerances) | E.3.1 | 4.0 | R | 1.73 | 1.0 | 1.0 | 2.3 | 2.3 | ∞ |
| Liquid Conductivity - deviation from target values | E.3.2 | 5.0 | R | 1.73 | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| Liquid Conductivity - measurement uncertainty | E.3.3 | 3.8 | N | 1 | 0.64 | 0.43 | 2.4 | 1.6 | 6 |
| Liquid Permittivity - deviation from target values | E.3.2 | 5.0 | R | 1.73 | 0.60 | 0.49 | 1.7 | 1.4 | ∞ |
| Liquid Permittivity - measurement uncertainty | E.3.3 | 4.5 | N | 1 | 0.60 | 0.49 | 2.7 | 2.2 | 6 |
| **Combined Standard Uncertainty (k=1)** | | | RSS | | | | 12.1 | 11.7 | 299 |
| **Expanded Uncertainty** (95% CONFIDENCE LEVEL) | | | k=2 | | | | 24.2 | 23.5 | |

The above measurement uncertainties are according to IEEE Std. 1528-2003

# 15 CONCLUSION

## 15.1 Measurement Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of the FCC and Industry 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: ZNFB450; Type: Portable Handset; Serial: 198**

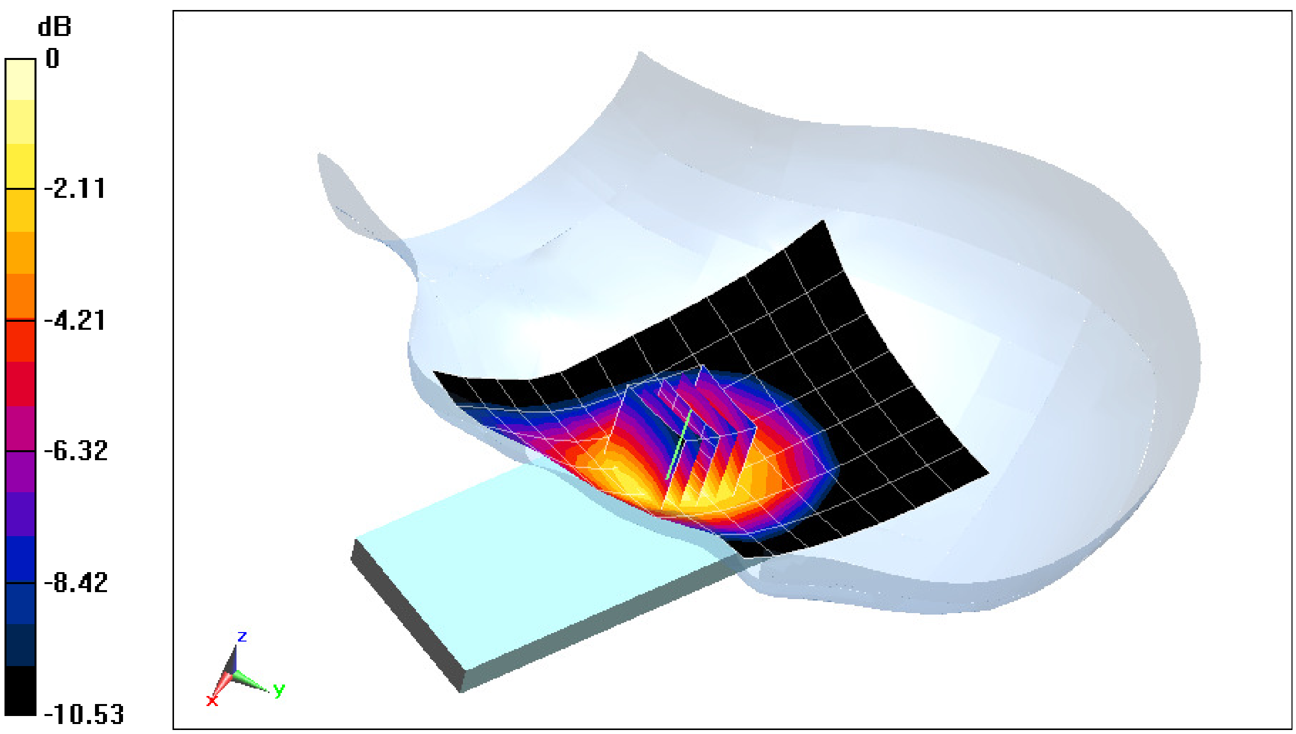
Communication System: UID 0, GSM (0); Frequency: 836.6 MHz;Duty Cycle: 1:8.3
Medium: 835 Head Medium parameters used (interpolated):
f = 836.6 MHz; $\sigma$ = 0.931 S/m; $\varepsilon_r$ = 42.55; $\rho$ = 1000 $kg/m^3$
Phantom section: Left Section

Test Date: 05-22-2014; Ambient Temp: 21.1°C; Tissue Temp: 22.0°C

Probe: ES3DV3 - SN3258; ConvF(6.27, 6.27, 6.27); Calibrated: 2/25/2014;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/26/2014
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## Mode: GSM 850, Left Head, Cheek, Mid.ch

**Area Scan (8x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 18.877 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 0.476 W/kg
**SAR(1 g) = 0.329 W/kg**




0 dB = 0.352 W/kg = -4.53 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFB450; Type: Portable Handset; Serial: 198**

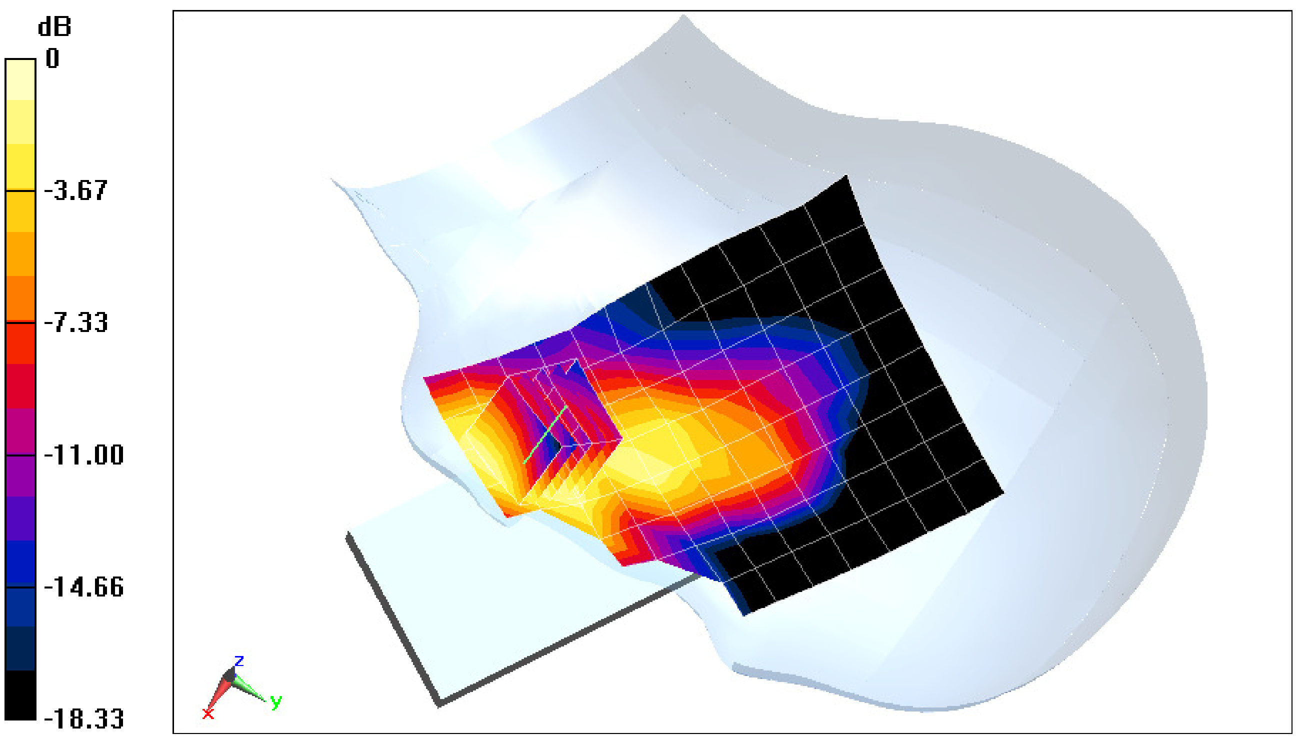
Communication System: UID 0, GSM1900; Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.388 S/m; $\varepsilon_r$ = 39.096; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-27-2014; Ambient Temp: 24.1°C; Tissue Temp: 23.4°C

Probe: ES3DV3 - SN3209; ConvF(5.13, 5.13, 5.13); Calibrated: 3/19/2014;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1334; Calibrated: 3/17/2014
Phantom: SAM left; Type: QD000P40CD; Serial: TP:1715
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## Mode: GSM 1900, Left 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 = 11.400 V/m; Power Drift = 0.13 dB
Peak SAR (extrapolated) = 0.290 W/kg
**SAR(1 g) = 0.184 W/kg**




0 dB = 0.198 W/kg = -7.03 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFB450; Type: Portable Handset; Serial: 198**

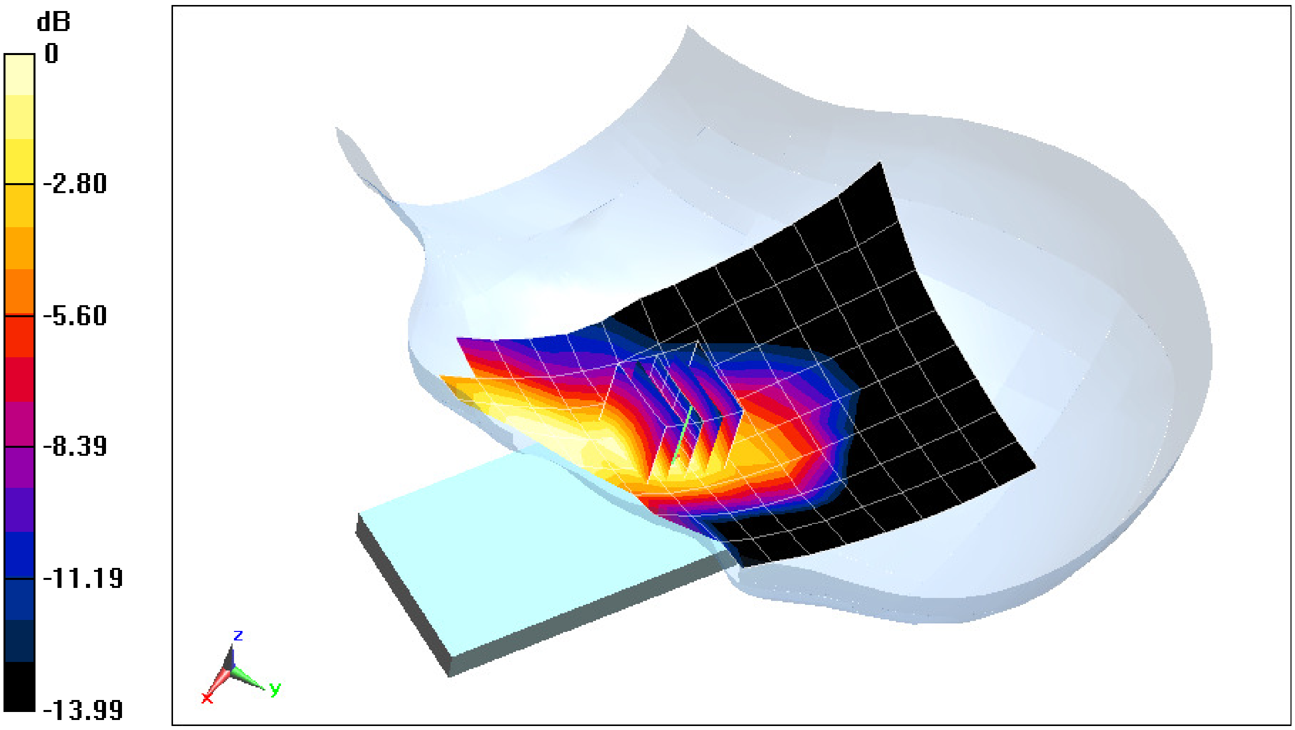
Communication System: UID 0, UMTS; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.388 S/m; $\varepsilon_r$ = 39.096; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 05-27-2014; Ambient Temp: 24.1°C; Tissue Temp: 23.4°C

Probe: ES3DV3 - SN3209; ConvF(5.13, 5.13, 5.13); Calibrated: 3/19/2014;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1334; Calibrated: 3/17/2014
Phantom: SAM left; Type: QD000P40CD; Serial: TP:1715
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## Mode: UMTS 1900, Left 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 = 15.236 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 0.475 W/kg
**SAR(1 g) = 0.280 W/kg**




0 dB = 0.300 W/kg = -5.23 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFB450; Type: Portable Handset; Serial: 198**

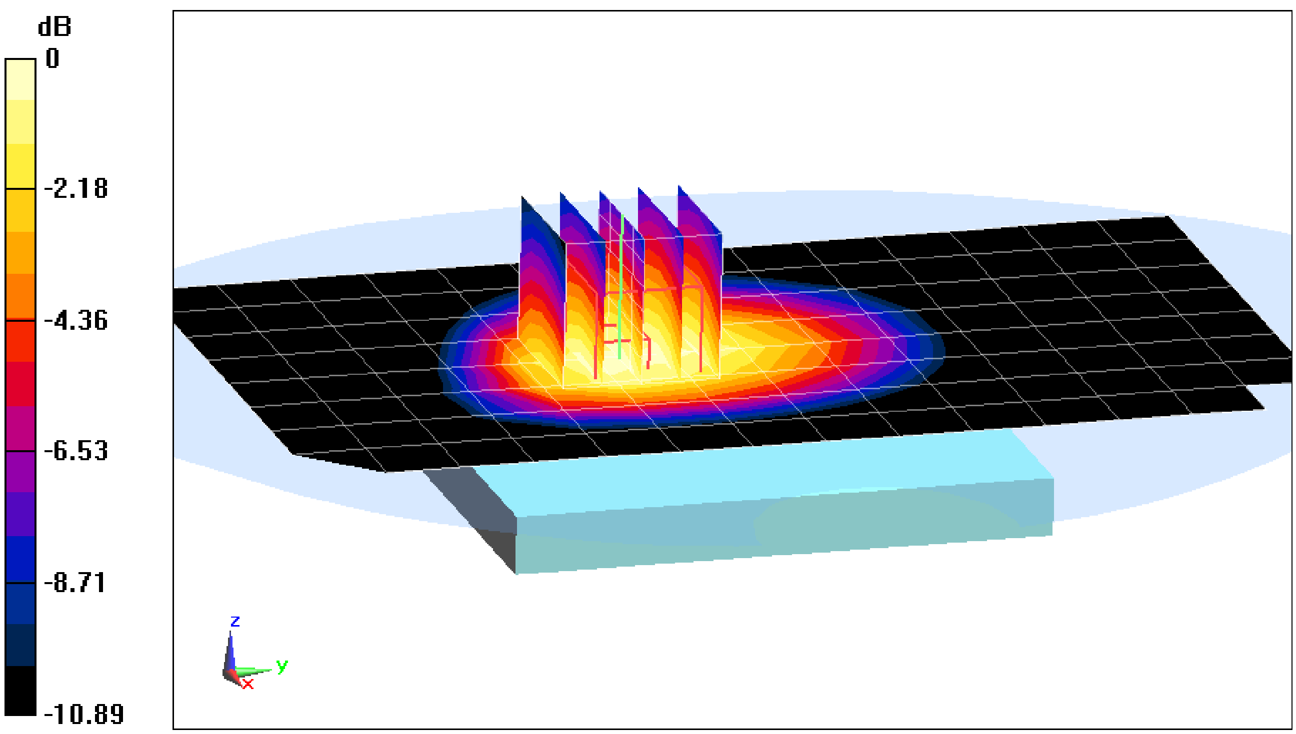
Communication System: UID 0, GSM850; Frequency: 836.6 MHz;Duty Cycle: 1:8.3
Medium: 835 Body Medium parameters used (interpolated):
f = 836.6 MHz; σ = 0.957 S/m; $\varepsilon_r$ = 53.424; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-19-2014; Ambient Temp: 22.1°C; Tissue Temp: 21.0°C

Probe: ES3DV3 - SN3288; ConvF(6.27, 6.27, 6.27); Calibrated: 9/23/2013;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/17/2013
Phantom: SAM with CRP; Type: SAM; Serial: TP1375
Measurement SW: DASY4, Version 4.7 (80); SEMCAD X Version 14.6.10 (7164)

## Mode: GSM 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 = 20.664 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 0.506 W/kg
**SAR(1 g) = 0.383 W/kg**




0 dB = 0.406 W/kg = -3.91 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFB450; Type: Portable Handset; Serial: 198**

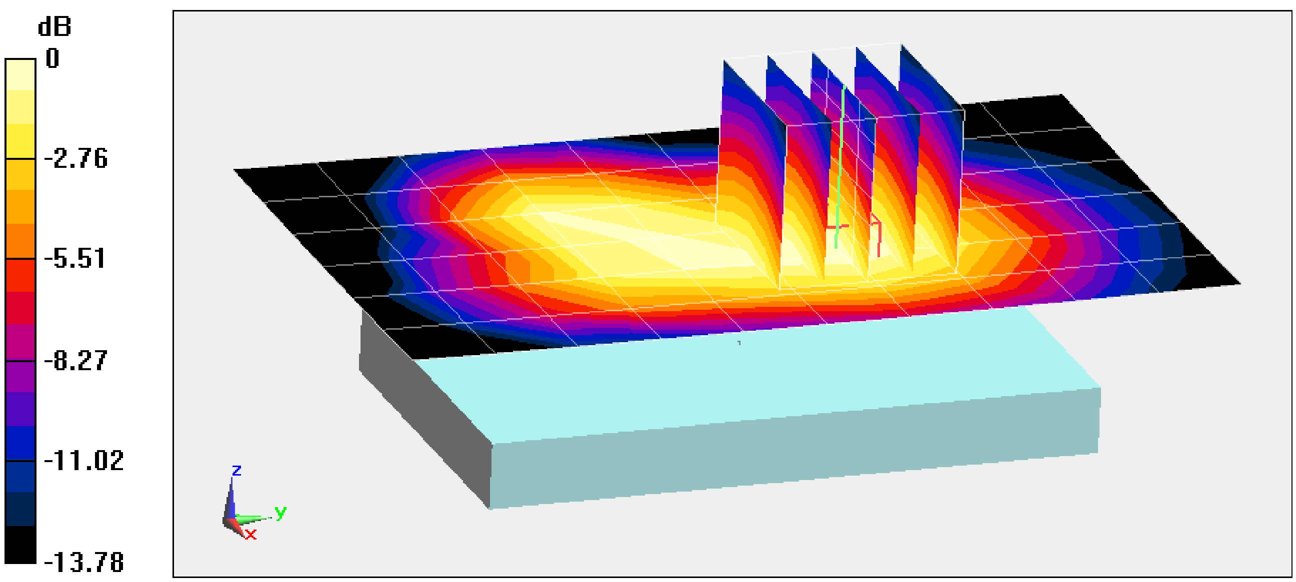
Communication System: UID 0, GSM; Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.527 S/m; $\varepsilon_r$ = 52.703; $\rho$ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-21-2014; Ambient Temp: 22.4°C; Tissue Temp: 21.8°C

Probe: ES3DV3 - SN3332; ConvF(4.7, 4.7, 4.7); Calibrated: 11/25/2013;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 11/18/2013
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1226
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## Mode: GSM 1900, Body SAR, Back side, Mid.ch

**Area Scan (7x11x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 10.126 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 0.210 W/kg
**SAR(1 g) = 0.143 W/kg**




0 dB = 0.156 W/kg = -8.07 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFB450; Type: Portable Handset; Serial: 198**

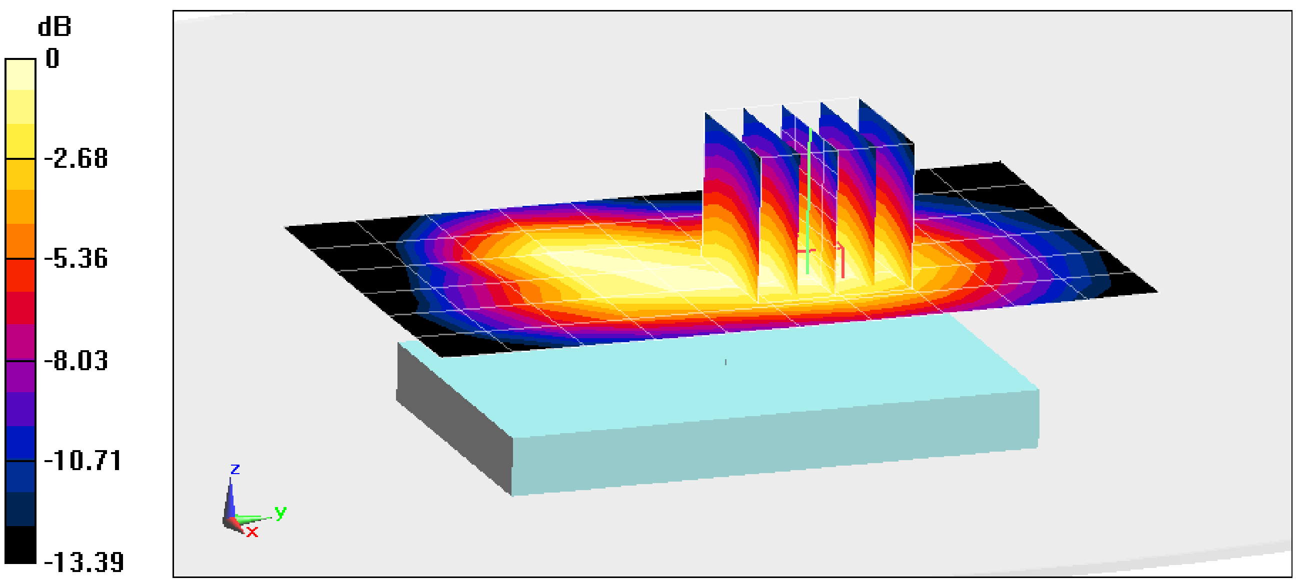
Communication System: UID 0, UMTS; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; σ = 1.527 S/m; $\varepsilon_r$ = 52.703; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-21-2014; Ambient Temp: 22.4°C; Tissue Temp: 21.8°C

Probe: ES3DV3 - SN3332; ConvF(4.7, 4.7, 4.7); Calibrated: 11/25/2013;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 11/18/2013
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1226
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

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

**Area Scan (7x11x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 15.450 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.492 W/kg
**SAR(1 g) = 0.332 W/kg**




0 dB = 0.358 W/kg = -4.46 dBW/kg

# APPENDIX B: SYSTEM VERIFICATION

# PCTEST ENGINEERING LABORATORY, INC.

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

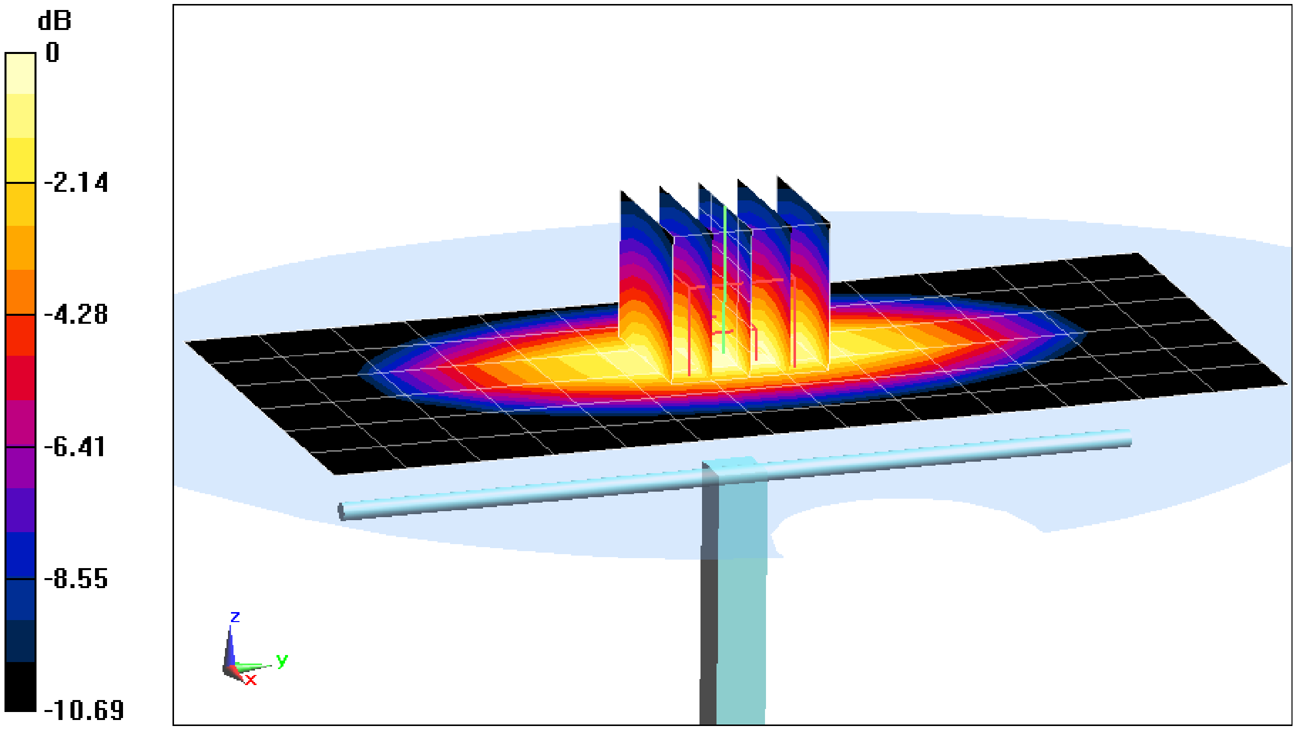
Communication System: UID 0, CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 835 Head Medium parameters used:
f = 835 MHz; $\sigma$ = 0.93 S/m; $\varepsilon_r$ = 42.572; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 05-22-2014; Ambient Temp: 21.1°C; Tissue Temp: 22.0°C

Probe: ES3DV3 - SN3258; ConvF(6.27, 6.27, 6.27); Calibrated: 2/25/2014;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn665; Calibrated: 2/26/2014
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## 835 MHz System Verification

**Area Scan (7x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Input Power = 20 dBm (100 mW)
Peak SAR (extrapolated) = 1.47 W/kg
**SAR(1 g) = 0.982 W/kg**
Deviation = 6.51 %




0 dB = 1.06 W/kg = 0.25 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

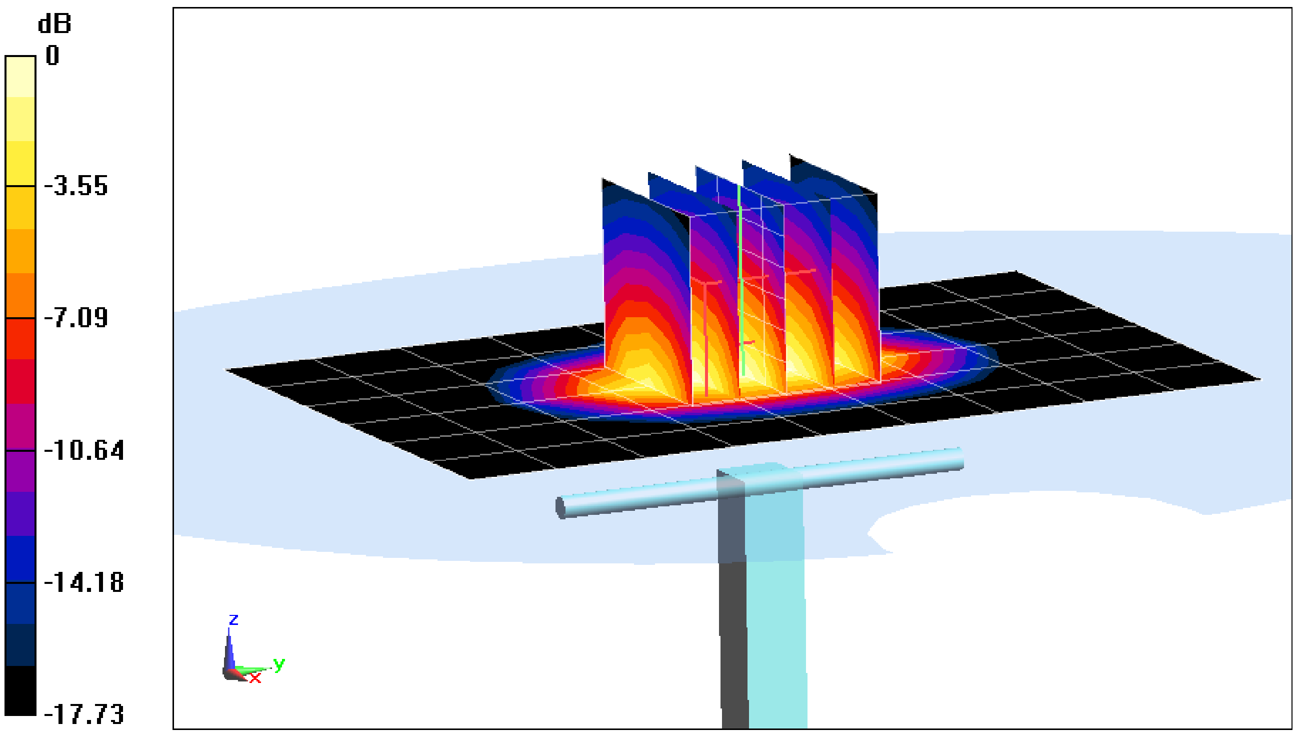
Communication System: UID 0, CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used (interpolated):
f = 1900 MHz; $\sigma$ = 1.408 S/m; $\varepsilon_r$ = 39.007; $\rho$ = 1000 $kg/m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-27-2014; Ambient Temp: 24.1°C; Tissue Temp: 23.4°C

Probe: ES3DV3 - SN3209; ConvF(5.13, 5.13, 5.13); Calibrated: 3/19/2014;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1334; Calibrated: 3/17/2014
Phantom: SAM left; Type: QD000P40CD; Serial: TP:1715
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## 1900 MHz System Verification

**Area Scan (7x10x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Input Power = 20 dBm (100 mW)
Peak SAR (extrapolated) = 6.98 W/kg
**SAR(1 g) = 3.76 W/kg**
Deviation = -6.93%




0 dB = 4.22 W/kg = 6.25 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d133**

Communication System: UID 0, CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 835 Body Medium parameters used:
f = 835 MHz; $\sigma = 0.955$ S/m; $\varepsilon_r = 53.447$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

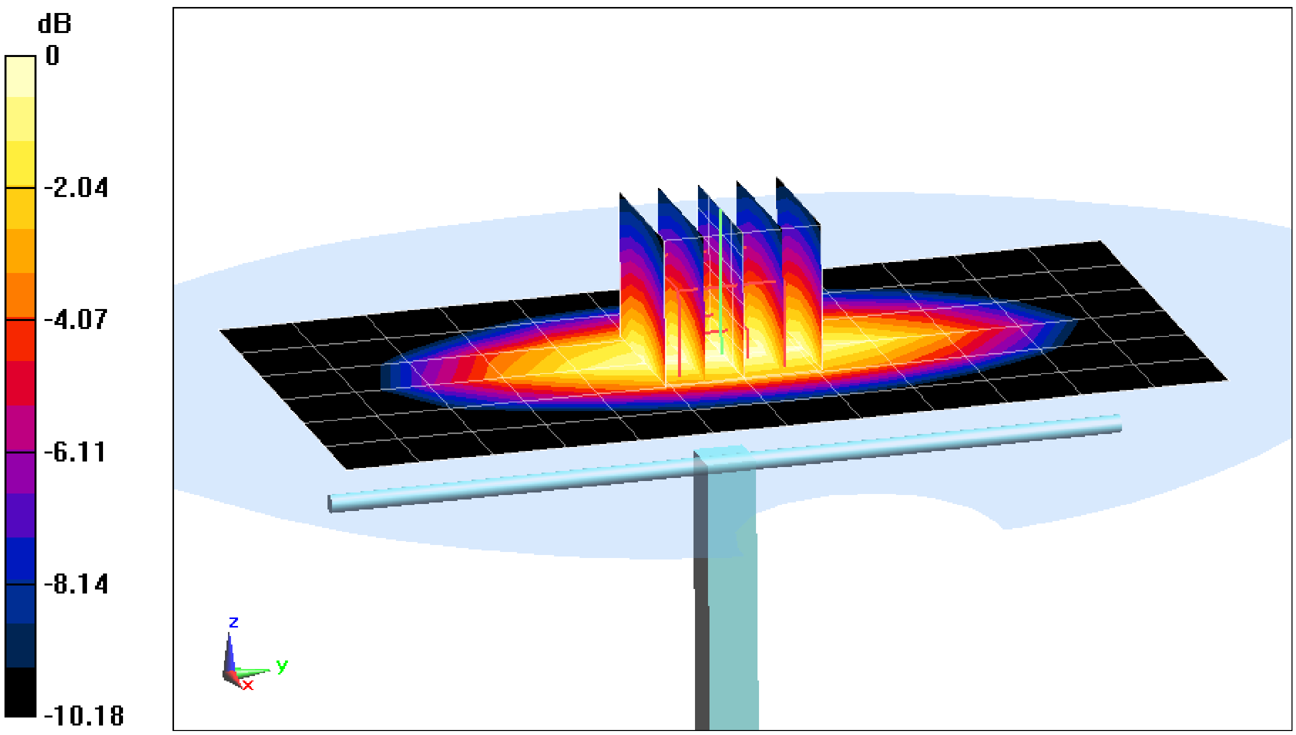
Test Date: 05-19-2014; Ambient Temp: 22.1°C; Tissue Temp: 21.0°C

Probe: ES3DV3 - SN3288; ConvF(6.27, 6.27, 6.27); Calibrated: 9/23/2013;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1323; Calibrated: 9/17/2013
Phantom: SAM with CRP; Type: SAM; Serial: TP1375
Measurement SW: DASY4, Version 4.7 (80); SEMCAD X Version 14.6.10 (7164)

## 835MHz System Verification

**Area Scan (7x13x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm

Input Power = 20 dBm (100 mW)
Peak SAR (extrapolated) = 1.44 W/kg
**SAR(1 g) = 0.991 W/kg**
Deviation = 3.12%




0 dB = 1.07 W/kg = 0.29 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

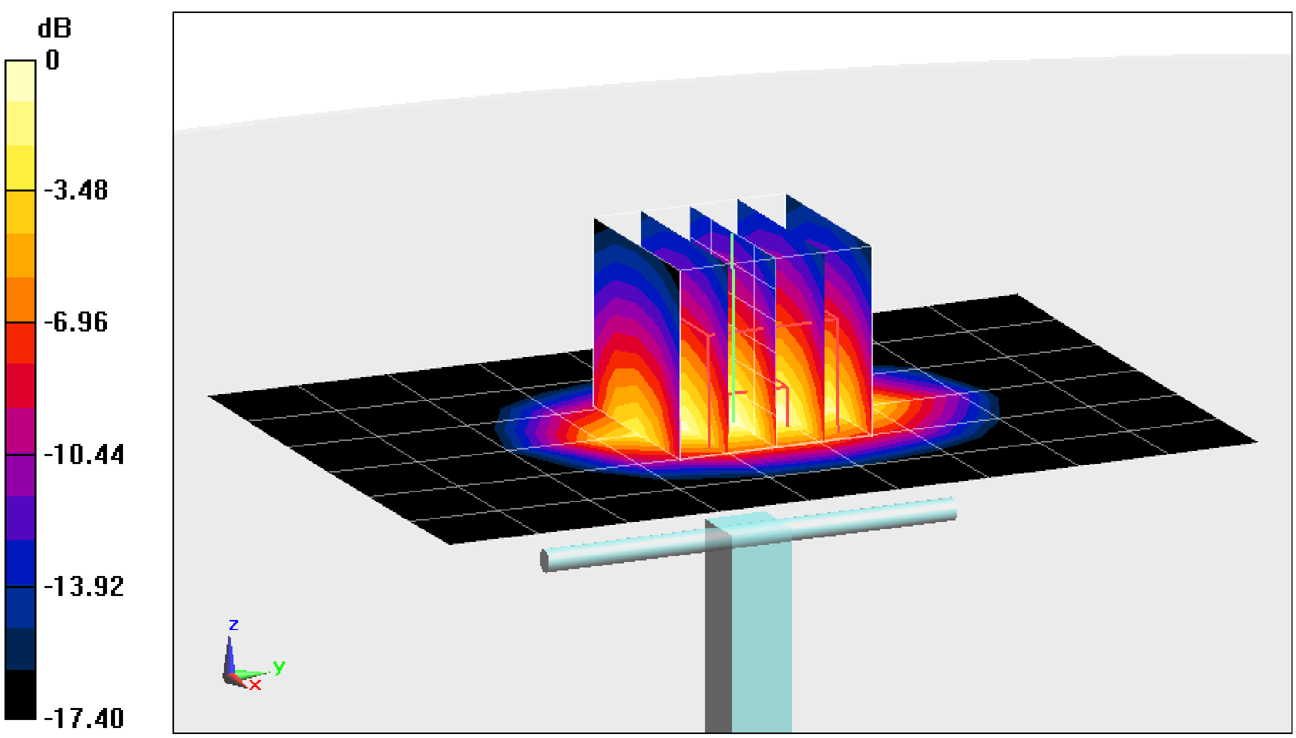
Communication System: UID 0, CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used (interpolated):
$f = 1900$ MHz; $\sigma = 1.551$ S/m; $\varepsilon_r = 52.633$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 05-21-2014; Ambient Temp: 22.4°C; Tissue Temp: 21.8°C

Probe: ES3DV3 - SN3332; ConvF(4.7, 4.7, 4.7); Calibrated: 11/25/2013;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1407; Calibrated: 11/18/2013
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1226
Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

## 1900 MHz System Verification

**Area Scan (7x10x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Input Power = 20 dBm (100 mW)
Peak SAR (extrapolated) = 7.77 W/kg
**SAR(1 g) = 4.31 W/kg**
Deviation = 6.42%




0 dB = 4.83 W/kg = 6.84 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**
**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 108**

**Client** **PC Test**

**Certificate No: ES3-3209_Mar14**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3209

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

CC✓ 3/27/14

Calibration date: March 19, 2014

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 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-13 (No. ES3-3013_Dec13) | Dec-14 |
| DAE4 | SN: 660 | 13-Dec-13 (No. DAE4-660_Dec13) | Dec-14 |
| | | | |
| 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-13) | In house check: Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Claudio Leubler | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 20, 2014





PCT #80244

## 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

## 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:3209

Manufactured: October 14, 2008
Calibrated: March 19, 2014

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3209

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 1.35 | 1.32 | 1.13 | ± 10.1 % |
| DCP (mV)[B] | 101.5 | 101.0 | 102.5 | |

## 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 | 188.4 | ±3.8 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 180.7 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 200.1 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.80 | 64.7 | 12.3 | 10.00 | 43.2 | ±1.4 % |
| | | Y | 3.12 | 65.6 | 13.1 | | 41.9 | |
| | | Z | 2.67 | 64.0 | 11.7 | | 39.4 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.39 | 67.7 | 19.0 | 2.91 | 149.2 | ±0.5 % |
| | | Y | 3.38 | 67.7 | 19.0 | | 146.1 | |
| | | Z | 3.35 | 67.6 | 18.7 | | 136.1 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.01 | 69.8 | 19.4 | 1.87 | 149.4 | ±0.7 % |
| | | Y | 3.06 | 70.1 | 19.6 | | 147.1 | |
| | | Z | 2.98 | 69.7 | 19.2 | | 136.4 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 5.47 | 79.6 | 20.4 | 9.39 | 146.9 | ±1.7 % |
| | | Y | 7.76 | 84.9 | 22.9 | | 134.2 | |
| | | Z | 4.34 | 75.3 | 18.5 | | 134.2 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 6.66 | 82.9 | 21.6 | 9.57 | 139.8 | ±2.5 % |
| | | Y | 9.36 | 88.2 | 24.2 | | 131.5 | |
| | | Z | 4.67 | 76.1 | 18.8 | | 144.8 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 5.89 | 79.1 | 17.9 | 6.56 | 141.2 | ±1.9 % |
| | | Y | 27.58 | 99.6 | 24.8 | | 145.8 | |
| | | Z | 5.42 | 77.8 | 17.4 | | 129.3 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 9.68 | 85.3 | 19.0 | 4.80 | 136.9 | ±2.2 % |
| | | Y | 36.47 | 100.0 | 23.3 | | 139.2 | |
| | | Z | 31.63 | 96.5 | 21.4 | | 149.2 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 40.09 | 99.7 | 21.7 | 3.55 | 125.9 | ±1.9 % |
| | | Y | 47.92 | 99.6 | 21.7 | | 127.6 | |
| | | Z | 61.98 | 99.9 | 20.8 | | 136.2 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 99.32 | 95.7 | 16.5 | 1.16 | 145.1 | ±1.7 % |
| | | Y | 55.30 | 99.5 | 19.3 | | 145.6 | |
| | | Z | 0.54 | 60.4 | 5.7 | | 132.7 | |
| 10039-CAB | CDMA2000 (1xRTT, RC1) | X | 4.77 | 67.1 | 19.2 | 4.57 | 145.6 | ±0.9 % |
| | | Y | 4.85 | 67.5 | 19.5 | | 147.8 | |
| | | Z | 4.67 | 66.7 | 18.9 | | 133.4 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 3.93 | 66.4 | 18.8 | 3.97 | 140.9 | ±0.7 % |
| | | Y | 4.02 | 66.9 | 19.1 | | 146.0 | |
| | | Z | 3.86 | 66.1 | 18.5 | | 129.1 | |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2) | X | 4.56 | 66.6 | 18.6 | 3.98 | 132.8 | ±0.7 % |
| | | Y | 4.58 | 66.7 | 18.7 | | 135.9 | |
| | | Z | 4.63 | 67.0 | 18.7 | | 143.0 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.42 | 67.5 | 19.8 | 5.67 | 139.3 | ±1.4 % |
| | | Y | 6.49 | 67.9 | 20.1 | | 143.0 | |
| | | Z | 6.18 | 66.7 | 19.3 | | 126.9 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.28 | 67.1 | 19.7 | 5.80 | 136.9 | ±1.4 % |
| | | Y | 6.35 | 67.5 | 20.0 | | 140.4 | |
| | | Z | 6.36 | 67.5 | 19.8 | | 147.1 | |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK) | X | 5.94 | 66.5 | 19.4 | 5.75 | 134.0 | ±1.4 % |
| | | Y | 6.01 | 66.9 | 19.8 | | 136.4 | |
| | | Z | 5.99 | 66.8 | 19.5 | | 143.6 | |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.02 | 68.5 | 21.1 | 8.10 | 127.2 | ±2.2 % |
| | | Y | 10.31 | 69.3 | 21.8 | | 130.2 | |
| | | Z | 10.12 | 68.8 | 21.2 | | 139.0 | |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.03 | 68.5 | 21.1 | 8.07 | 129.2 | ±2.2 % |
| | | Y | 10.31 | 69.3 | 21.7 | | 131.2 | |
| | | Z | 10.15 | 68.9 | 21.3 | | 141.0 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 8.54 | 72.4 | 24.8 | 9.28 | 139.6 | ±3.0 % |
| | | Y | 9.29 | 75.2 | 26.7 | | 144.1 | |
| | | Z | 8.55 | 72.5 | 24.7 | | 149.7 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.94 | 66.5 | 19.4 | 5.75 | 134.7 | ±1.4 % |
| | | Y | 6.00 | 66.9 | 19.7 | | 136.7 | |
| | | Z | 6.01 | 66.9 | 19.5 | | 143.3 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.40 | 67.1 | 19.7 | 5.82 | 139.9 | ±1.7 % |
| | | Y | 6.48 | 67.5 | 20.0 | | 142.9 | |
| | | Z | 6.43 | 67.3 | 19.7 | | 148.7 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.90 | 66.8 | 19.8 | 5.73 | 136.1 | ±1.4 % |
| | | Y | 5.03 | 67.2 | 20.2 | | 141.1 | |
| | | Z | 5.08 | 67.3 | 20.0 | | 148.1 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 6.56 | 72.5 | 25.2 | 9.21 | 125.7 | ±2.5 % |
| | | Y | 7.28 | 75.4 | 27.1 | | 128.8 | |
| | | Z | 6.78 | 73.0 | 25.2 | | 138.3 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.86 | 66.6 | 19.7 | 5.72 | 133.7 | ±1.4 % |
| | | Y | 4.97 | 66.9 | 20.0 | | 136.3 | |
| | | Z | 5.04 | 67.2 | 19.9 | | 145.7 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.88 | 66.7 | 19.7 | 5.72 | 133.3 | ±1.4 % |
| | | Y | 4.99 | 67.0 | 20.0 | | 136.5 | |
| | | Z | 5.06 | 67.3 | 19.9 | | 145.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK) | X | 10.05 | 69.2 | 21.7 | 8.09 | 146.7 | ±2.5 % |
| | | Y | 10.20 | 69.8 | 22.1 | | 146.9 | |
| | | Z | 9.76 | 68.5 | 21.1 | | 132.1 | |
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 10.05 | 69.2 | 21.7 | 8.10 | 148.5 | ±2.2 % |
| | | Y | 10.21 | 69.9 | 22.2 | | 148.0 | |
| | | Z | 9.75 | 68.5 | 21.2 | | 133.6 | |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK) | X | 9.96 | 69.2 | 21.6 | 8.03 | 148.9 | ±2.5 % |
| | | Y | 10.09 | 69.7 | 22.1 | | 147.4 | |
| | | Z | 9.67 | 68.5 | 21.1 | | 133.4 | |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK) | X | 10.00 | 68.5 | 21.1 | 8.06 | 127.8 | ±2.2 % |
| | | Y | 10.21 | 69.1 | 21.6 | | 127.3 | |
| | | Z | 10.11 | 68.9 | 21.2 | | 140.4 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.81 | 66.5 | 19.3 | 5.97 | 125.8 | ±1.4 % |
| | | Y | 7.07 | 67.5 | 19.9 | | 149.0 | |
| | | Z | 6.92 | 67.0 | 19.4 | | 136.8 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 6.62 | 72.8 | 25.3 | 9.21 | 128.5 | ±2.2 % |
| | | Y | 7.33 | 75.7 | 27.2 | | 129.5 | |
| | | Z | 6.87 | 73.4 | 25.5 | | 141.8 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 7.92 | 71.5 | 24.4 | 9.24 | 131.3 | ±3.0 % |
| | | Y | 8.35 | 73.3 | 25.7 | | 131.3 | |
| | | Z | 7.94 | 71.6 | 24.3 | | 140.2 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.52 | 72.3 | 24.8 | 9.30 | 138.8 | ±3.0 % |
| | | Y | 9.10 | 74.5 | 26.3 | | 139.5 | |
| | | Z | 8.53 | 72.3 | 24.6 | | 149.4 | |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10) | X | 5.98 | 67.1 | 19.1 | 4.87 | 144.4 | ±0.9 % |
| | | Y | 5.99 | 67.3 | 19.2 | | 144.0 | |
| | | Z | 5.80 | 66.6 | 18.7 | | 131.0 | |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.51 | 67.2 | 19.0 | 3.96 | 148.6 | ±0.7 % |
| | | Y | 4.30 | 66.3 | 18.6 | | 127.3 | |
| | | Z | 4.40 | 66.9 | 18.7 | | 135.9 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.61 | 66.9 | 18.8 | 3.46 | 138.3 | ±0.7 % |
| | | Y | 3.67 | 67.2 | 19.0 | | 140.5 | |
| | | Z | 3.62 | 67.0 | 18.7 | | 128.8 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.59 | 67.1 | 18.9 | 3.39 | 141.5 | ±0.7 % |
| | | Y | 3.59 | 67.1 | 18.9 | | 142.0 | |
| | | Z | 3.59 | 67.2 | 18.8 | | 130.8 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.27 | 67.0 | 19.7 | 5.81 | 135.3 | ±1.7 % |
| | | Y | 6.31 | 67.3 | 19.9 | | 136.0 | |
| | | Z | 6.36 | 67.4 | 19.8 | | 147.2 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.91 | 67.9 | 20.2 | 6.06 | 141.9 | ±1.7 % |
| | | Y | 6.94 | 68.1 | 20.4 | | 142.7 | |
| | | Z | 6.68 | 67.1 | 19.7 | | 130.3 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle) | X | 2.94 | 69.9 | 19.6 | 1.71 | 148.6 | ±0.5 % |
| | | Y | 2.81 | 68.8 | 19.0 | | 148.8 | |
| | | Z | 2.92 | 69.7 | 19.2 | | 138.1 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.76 | 68.7 | 19.1 | 3.76 | 128.0 | ±0.5 % |
| | | Y | 4.71 | 68.2 | 18.9 | | 129.2 | |
| | | Z | 4.85 | 68.8 | 19.0 | | 141.9 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.64 | 68.5 | 19.0 | 3.77 | 126.3 | ±0.7 % |
| | | Y | 4.60 | 68.2 | 18.9 | | 127.9 | |
| | | Z | 4.74 | 68.8 | 19.0 | | 140.6 | |

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 NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 8 and 9).
[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:3209

## 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) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.43 | 6.43 | 6.43 | 0.29 | 2.01 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.23 | 6.23 | 6.23 | 0.34 | 1.70 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.24 | 5.24 | 5.24 | 0.80 | 1.13 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.13 | 5.13 | 5.13 | 0.46 | 1.49 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.54 | 4.54 | 4.54 | 0.63 | 1.38 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.38 | 4.38 | 4.38 | 0.76 | 1.28 | ± 12.0 % |

[C] Frequency validity 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.
[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.

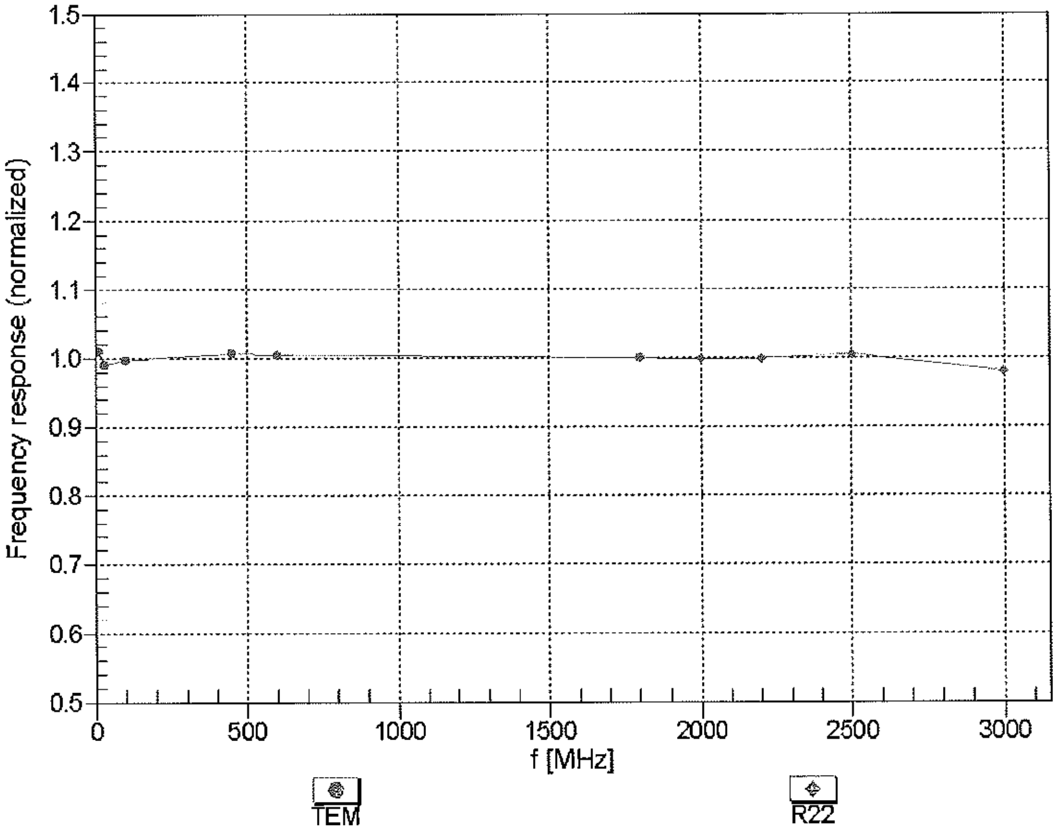
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3209

## 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) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.16 | 6.16 | 6.16 | 0.26 | 2.23 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.14 | 6.14 | 6.14 | 0.80 | 1.13 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.85 | 4.85 | 4.85 | 0.59 | 1.42 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.68 | 4.68 | 4.68 | 0.52 | 1.59 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.20 | 4.20 | 4.20 | 0.73 | 1.08 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.04 | 4.04 | 4.04 | 0.80 | 1.00 | ± 12.0 % |

[C] Frequency validity 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.
[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.

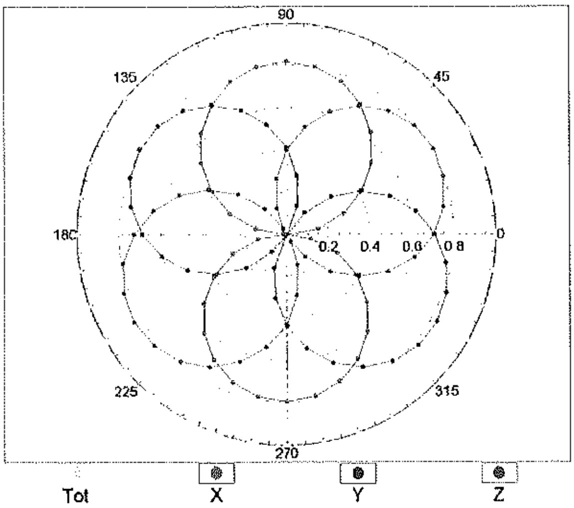
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



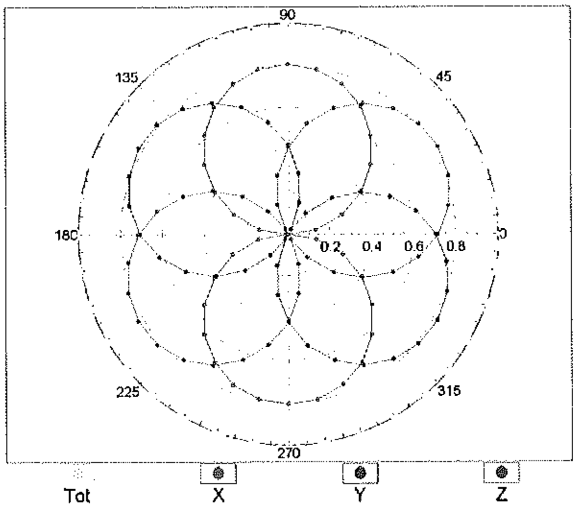

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

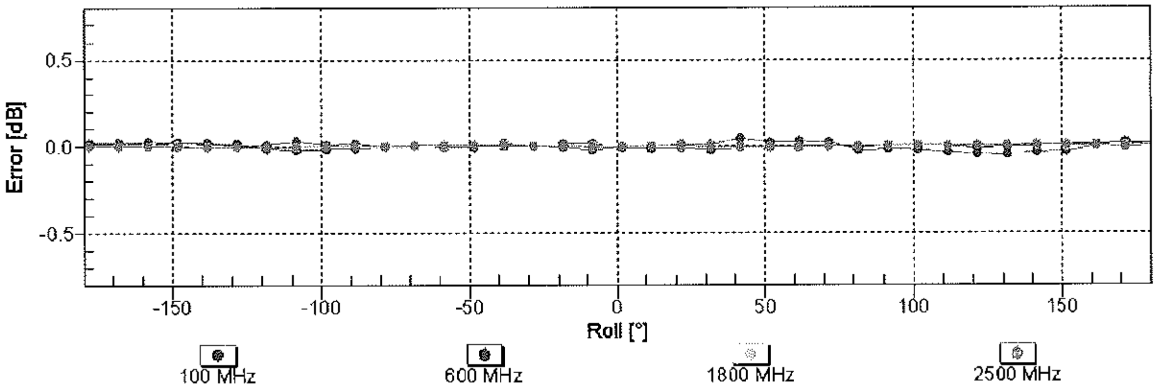
# Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM




f=1800 MHz,R22

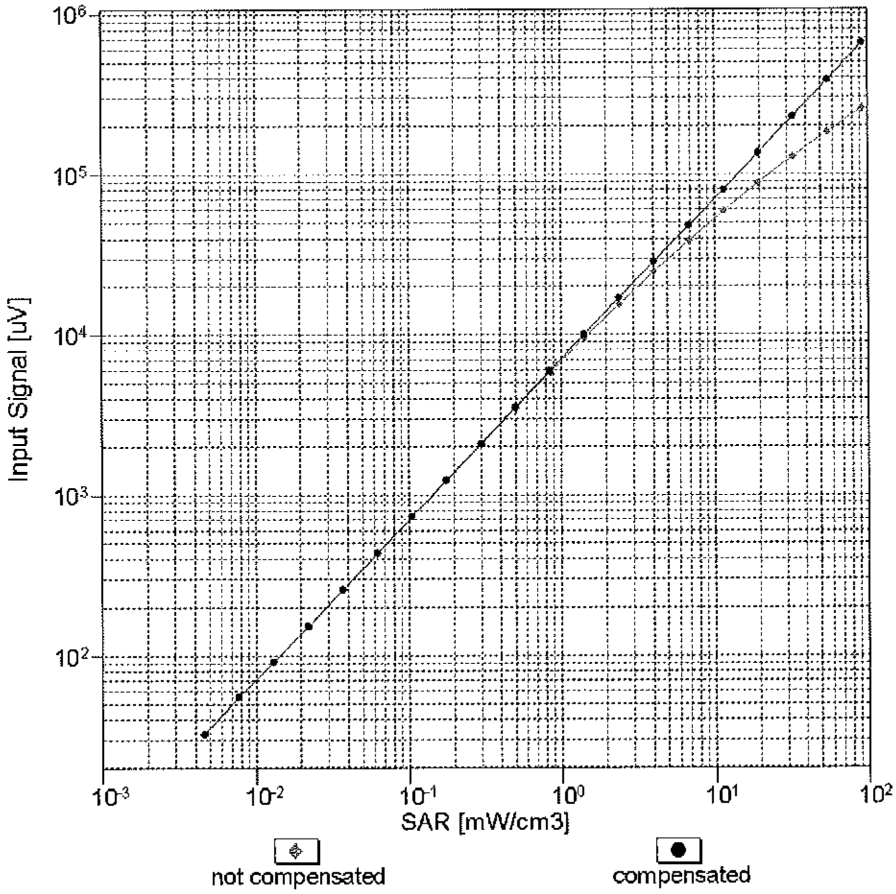


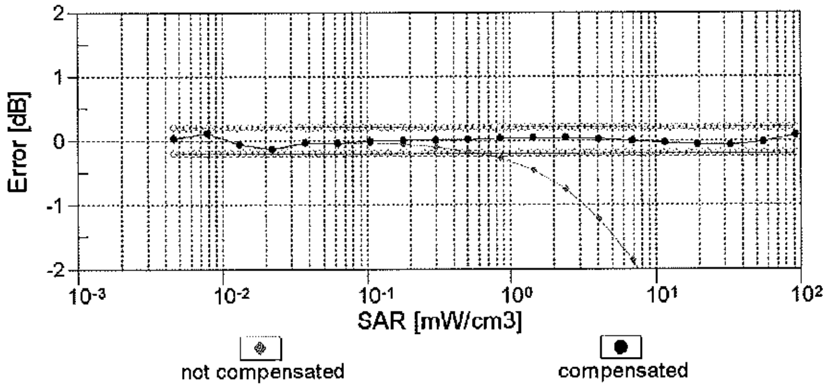




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)

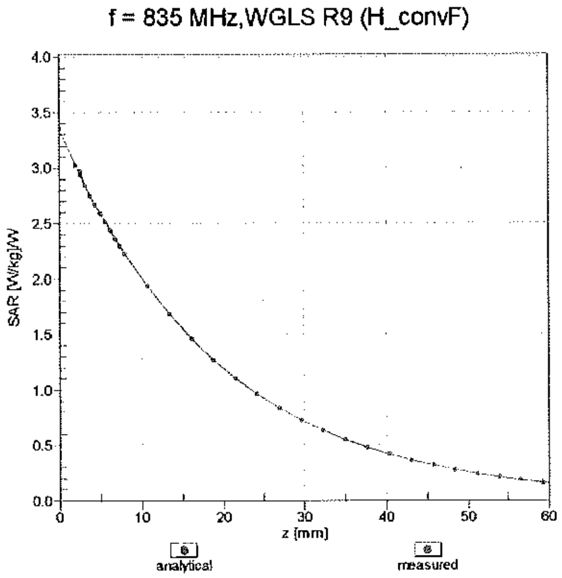
**(TEM cell , $f_{eval}$= 1900 MHz)**

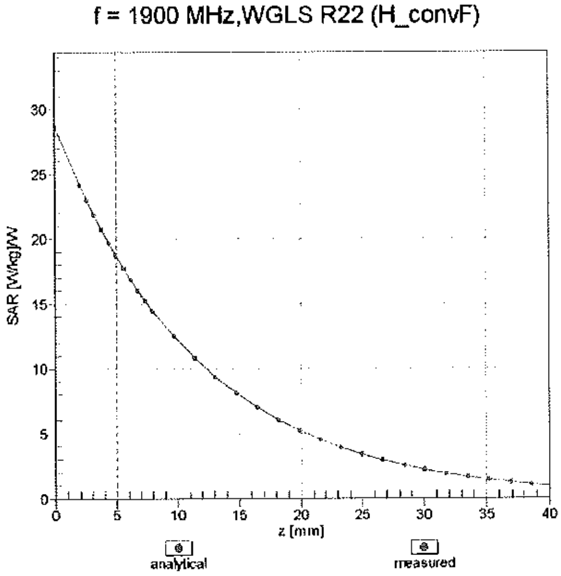



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

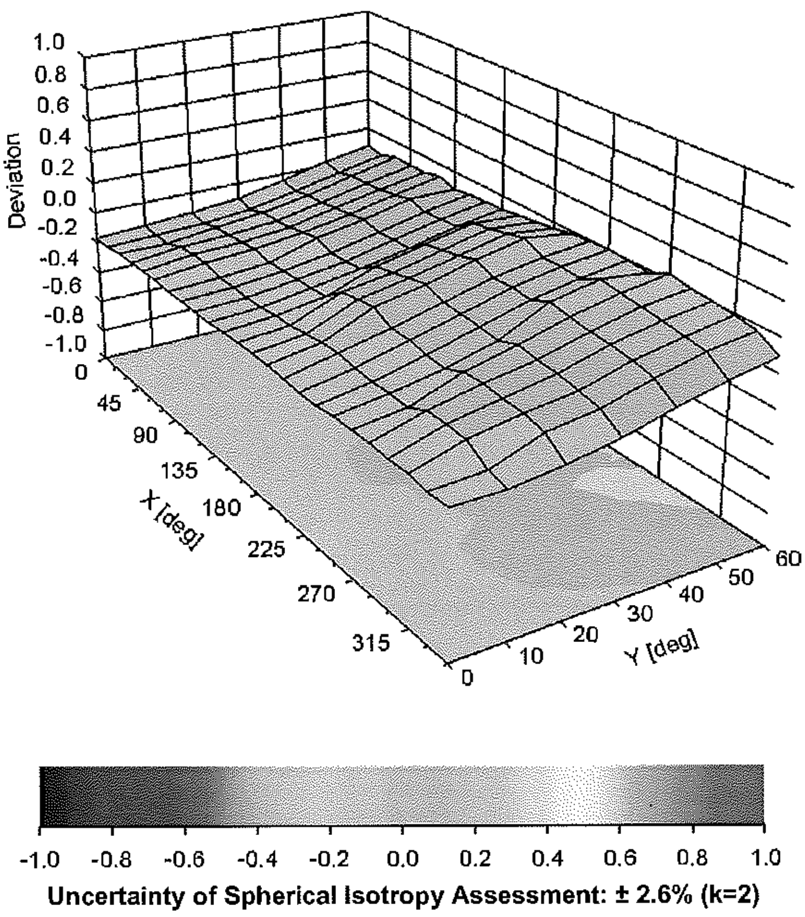
# Conversion Factor Assessment




# 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: ES3DV3 - SN:3209

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -38.3 |
| 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 108**

**Client** **PC Test**

**Certificate No: ES3-3258_Feb14**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ES3DV3 - SN:3258 |
| 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 25, 2014 |

CC✓ 3/6/14

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 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-13 (No. ES3-3013_Dec13) | Dec-14 |
| DAE4 | SN: 660 | 13-Dec-13 (No. DAE4-660_Dec13) | Dec-14 |
| | | | |
| 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-13) | In house check: Oct-14 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Israe El-Naouq | Laboratory Technician | [signature] |
| Approved by: | Katja Pokovic | Technical Manager | [signature] |

Issued: February 27, 2014





PCT# 80615

## 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

## 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:3258

Manufactured: January 25, 2010
Calibrated: February 25, 2014

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3258

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 1.29 | 1.19 | 1.23 | ± 10.1 % |
| DCP (mV)[B] | 104.5 | 107.0 | 103.0 | |

## 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 | 222.4 | ±3.8 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 202.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 207.1 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 5.09 | 65.6 | 14.1 | 10.00 | 44.8 | ±1.9 % |
| | | Y | 1.68 | 57.4 | 9.3 | | 40.7 | |
| | | Z | 4.01 | 62.4 | 13.0 | | 51.1 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.34 | 67.5 | 18.9 | 2.91 | 131.2 | ±0.5 % |
| | | Y | 3.43 | 67.9 | 18.7 | | 137.1 | |
| | | Z | 3.42 | 67.8 | 19.0 | | 146.0 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.40 | 70.9 | 19.8 | 1.87 | 134.2 | ±0.7 % |
| | | Y | 3.19 | 70.2 | 19.2 | | 137.9 | |
| | | Z | 3.46 | 70.8 | 19.6 | | 149.6 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 30.24 | 99.7 | 28.7 | 9.39 | 131.2 | ±1.4 % |
| | | Y | 12.91 | 88.5 | 23.9 | | 147.5 | |
| | | Z | 30.37 | 99.5 | 28.9 | | 128.0 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 29.88 | 100.0 | 29.0 | 9.57 | 123.0 | ±1.9 % |
| | | Y | 16.02 | 92.5 | 25.4 | | 140.7 | |
| | | Z | 30.01 | 100.0 | 29.4 | | 125.8 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 44.57 | 99.7 | 25.9 | 6.56 | 119.6 | ±1.7 % |
| | | Y | 28.97 | 95.3 | 23.2 | | 127.6 | |
| | | Z | 43.72 | 99.8 | 26.3 | | 120.1 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 53.52 | 99.7 | 24.4 | 4.80 | 129.4 | ±2.2 % |
| | | Y | 54.55 | 99.9 | 22.9 | | 143.3 | |
| | | Z | 51.63 | 99.7 | 24.8 | | 127.5 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 58.93 | 99.8 | 23.4 | 3.55 | 133.4 | ±2.2 % |
| | | Y | 77.54 | 99.7 | 21.3 | | 125.3 | |
| | | Z | 56.64 | 99.8 | 23.8 | | 130.8 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 47.03 | 99.5 | 21.3 | 1.16 | 136.3 | ±1.7 % |
| | | Y | 95.86 | 95.2 | 17.1 | | 138.2 | |
| | | Z | 39.68 | 100.0 | 22.2 | | 132.3 | |
| 10039-CAB | CDMA2000 (1xRTT, RC1) | X | 4.84 | 66.8 | 19.1 | 4.57 | 131.3 | ±0.9 % |
| | | Y | 4.75 | 67.0 | 18.9 | | 135.2 | |
| | | Z | 4.86 | 66.7 | 19.0 | | 127.2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 4.06 | 66.8 | 19.0 | 3.97 | 148.4 | ±0.7 % |
| | | Y | 3.96 | 66.6 | 18.6 | | 134.7 | |
| | | Z | 4.13 | 66.9 | 19.1 | | 143.4 | |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2) | X | 4.63 | 66.8 | 18.7 | 3.98 | 137.3 | ±0.7 % |
| | | Y | 4.75 | 67.5 | 18.8 | | 148.4 | |
| | | Z | 4.65 | 66.7 | 18.7 | | 133.2 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.66 | 68.5 | 20.3 | 5.67 | 144.0 | ±1.2 % |
| | | Y | 6.27 | 67.1 | 19.3 | | 130.6 | |
| | | Z | 6.62 | 68.2 | 20.1 | | 140.5 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.53 | 68.0 | 20.2 | 5.80 | 142.6 | ±1.4 % |
| | | Y | 6.17 | 66.8 | 19.3 | | 129.2 | |
| | | Z | 6.52 | 67.8 | 20.1 | | 139.0 | |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK) | X | 6.19 | 67.3 | 19.9 | 5.75 | 137.9 | ±1.4 % |
| | | Y | 6.12 | 67.3 | 19.6 | | 149.5 | |
| | | Z | 6.19 | 67.1 | 19.8 | | 136.1 | |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.49 | 69.5 | 21.7 | 8.10 | 132.4 | ±2.5 % |
| | | Y | 10.23 | 69.1 | 21.3 | | 144.3 | |
| | | Z | 10.45 | 69.3 | 21.6 | | 129.5 | |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.46 | 69.5 | 21.7 | 8.07 | 133.9 | ±2.5 % |
| | | Y | 10.26 | 69.2 | 21.3 | | 147.4 | |
| | | Z | 10.47 | 69.4 | 21.7 | | 130.5 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 11.61 | 77.4 | 26.8 | 9.28 | 118.8 | ±3.0 % |
| | | Y | 9.89 | 75.2 | 25.7 | | 144.9 | |
| | | Z | 12.01 | 77.8 | 26.9 | | 119.6 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.20 | 67.3 | 19.9 | 5.75 | 139.2 | ±1.2 % |
| | | Y | 5.86 | 66.2 | 19.0 | | 128.5 | |
| | | Z | 6.22 | 67.3 | 19.9 | | 136.3 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.63 | 67.8 | 20.1 | 5.82 | 144.1 | ±1.4 % |
| | | Y | 6.31 | 66.8 | 19.3 | | 133.1 | |
| | | Z | 6.66 | 67.7 | 20.0 | | 140.9 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.25 | 67.5 | 20.2 | 5.73 | 143.6 | ±1.2 % |
| | | Y | 4.92 | 66.7 | 19.5 | | 131.0 | |
| | | Z | 5.29 | 67.4 | 20.2 | | 140.7 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 13.49 | 87.5 | 31.6 | 9.21 | 139.0 | ±2.7 % |
| | | Y | 7.83 | 75.5 | 26.0 | | 124.9 | |
| | | Z | 13.47 | 86.5 | 31.1 | | 137.8 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.22 | 67.4 | 20.1 | 5.72 | 144.3 | ±1.4 % |
| | | Y | 5.08 | 67.5 | 19.9 | | 147.9 | |
| | | Z | 5.26 | 67.2 | 20.0 | | 139.6 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 5.24 | 67.5 | 20.1 | 5.72 | 144.5 | ±1.2 % |
| | | Y | 5.06 | 67.4 | 19.8 | | 147.0 | |
| | | Z | 5.29 | 67.3 | 20.1 | | 139.2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK) | X | 10.12 | 69.1 | 21.6 | 8.09 | 128.8 | ±2.2 % |
| | | Y | 9.76 | 68.4 | 21.0 | | 132.8 | |
| | | Z | 10.08 | 68.9 | 21.5 | | 123.4 | |
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 10.15 | 69.2 | 21.7 | 8.10 | 130.2 | ±2.2 % |
| | | Y | 9.77 | 68.5 | 21.0 | | 134.1 | |
| | | Z | 10.10 | 69.0 | 21.5 | | 124.0 | |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK) | X | 10.02 | 69.0 | 21.5 | 8.03 | 128.7 | ±2.2 % |
| | | Y | 9.67 | 68.5 | 21.0 | | 133.3 | |
| | | Z | 10.02 | 68.9 | 21.5 | | 123.9 | |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK) | X | 10.46 | 69.6 | 21.7 | 8.06 | 134.0 | ±2.2 % |
| | | Y | 10.09 | 68.8 | 21.1 | | 139.7 | |
| | | Z | 10.40 | 69.3 | 21.6 | | 128.7 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 7.09 | 67.1 | 19.6 | 5.97 | 131.2 | ±1.4 % |
| | | Y | 6.98 | 67.2 | 19.4 | | 138.0 | |
| | | Z | 7.06 | 66.8 | 19.4 | | 127.2 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 13.63 | 87.8 | 31.7 | 9.21 | 141.6 | ±3.0 % |
| | | Y | 7.85 | 75.5 | 26.0 | | 126.5 | |
| | | Z | 13.99 | 87.7 | 31.6 | | 141.4 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 12.86 | 81.4 | 28.9 | 9.24 | 142.1 | ±3.0 % |
| | | Y | 8.91 | 73.4 | 24.8 | | 129.9 | |
| | | Z | 13.15 | 81.4 | 28.8 | | 142.0 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 11.63 | 77.5 | 26.8 | 9.30 | 118.7 | ±3.0 % |
| | | Y | 9.62 | 74.3 | 25.2 | | 138.4 | |
| | | Z | 11.96 | 77.7 | 26.9 | | 119.3 | |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10) | X | 6.14 | 67.4 | 19.3 | 4.87 | 149.9 | ±0.9 % |
| | | Y | 5.90 | 66.9 | 18.7 | | 132.8 | |
| | | Z | 6.20 | 67.5 | 19.3 | | 146.6 | |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.45 | 66.9 | 18.9 | 3.96 | 130.1 | ±0.7 % |
| | | Y | 4.50 | 67.2 | 18.8 | | 137.9 | |
| | | Z | 4.64 | 67.6 | 19.3 | | 149.2 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.79 | 67.5 | 19.2 | 3.46 | 145.3 | ±0.7 % |
| | | Y | 3.74 | 67.5 | 18.9 | | 128.2 | |
| | | Z | 3.78 | 67.3 | 19.1 | | 139.1 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.77 | 67.8 | 19.3 | 3.39 | 147.0 | ±0.5 % |
| | | Y | 3.69 | 67.7 | 18.9 | | 130.1 | |
| | | Z | 3.73 | 67.3 | 19.0 | | 141.3 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.52 | 67.9 | 20.1 | 5.81 | 141.4 | ±1.4 % |
| | | Y | 6.41 | 67.6 | 19.7 | | 147.4 | |
| | | Z | 6.51 | 67.7 | 20.1 | | 135.4 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 7.17 | 68.7 | 20.7 | 6.06 | 147.7 | ±1.4 % |
| | | Y | 6.69 | 67.2 | 19.6 | | 128.6 | |
| | | Z | 7.12 | 68.4 | 20.5 | | 142.0 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle) | X | 3.04 | 70.0 | 19.6 | 1.71 | 129.8 | ±0.5 % |
| | | Y | 3.25 | 71.3 | 19.7 | | 136.9 | |
| | | Z | 3.09 | 69.9 | 19.5 | | 148.7 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.73 | 67.3 | 18.6 | 3.76 | 135.7 | ±0.5 % |
| | | Y | 4.93 | 69.1 | 19.0 | | 141.5 | |
| | | Z | 4.73 | 67.1 | 18.4 | | 132.7 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.67 | 67.5 | 18.6 | 3.77 | 134.0 | ±0.5 % |
| | | Y | 4.92 | 69.4 | 19.1 | | 139.8 | |
| | | Z | 4.65 | 67.1 | 18.5 | | 130.7 | |

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 NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 8 and 9).
[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:3258

## 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) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.53 | 6.53 | 6.53 | 0.40 | 1.60 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.27 | 6.27 | 6.27 | 0.80 | 1.17 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.19 | 5.19 | 5.19 | 0.80 | 1.10 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.04 | 5.04 | 5.04 | 0.68 | 1.27 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.52 | 4.52 | 4.52 | 0.78 | 1.23 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.34 | 4.34 | 4.34 | 0.76 | 1.33 | ± 12.0 % |

[C] Frequency validity 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.
[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:3258

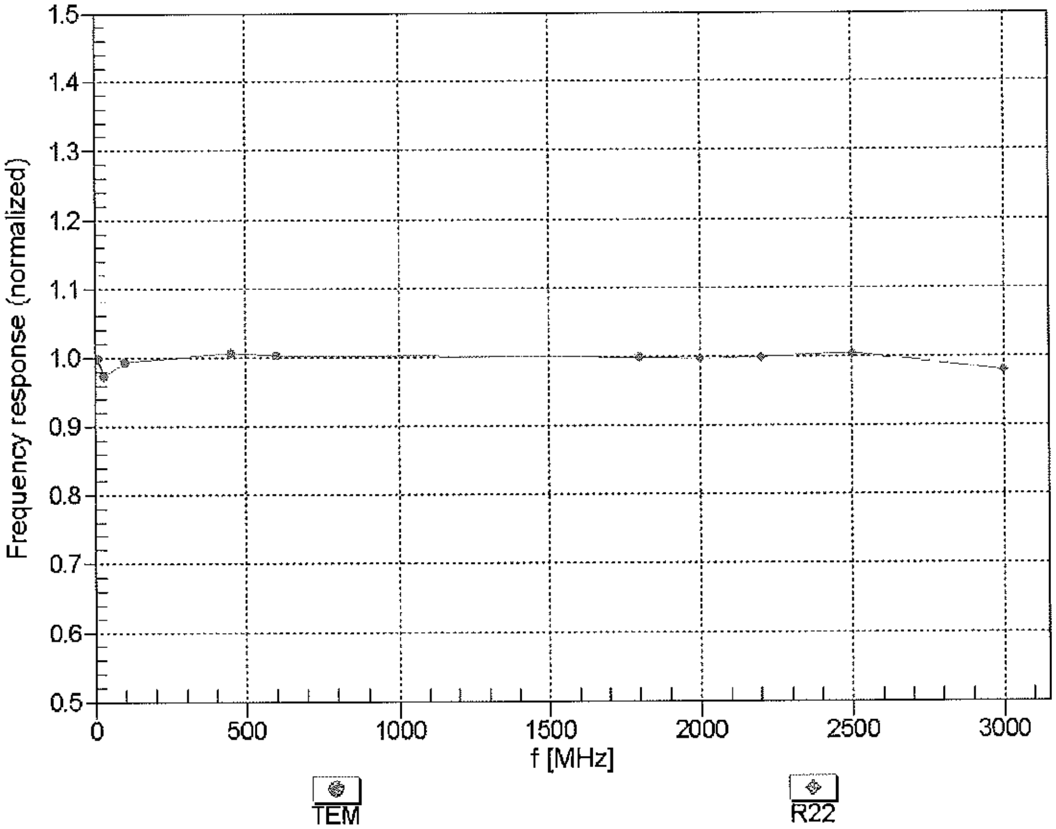
## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.15 | 6.15 | 6.15 | 0.61 | 1.32 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.11 | 6.11 | 6.11 | 0.80 | 1.15 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.83 | 4.83 | 4.83 | 0.47 | 1.74 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.61 | 4.61 | 4.61 | 0.55 | 1.59 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.14 | 4.14 | 4.14 | 0.80 | 1.11 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 3.91 | 3.91 | 3.91 | 0.80 | 1.00 | ± 12.0 % |

[C] Frequency validity 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.
[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

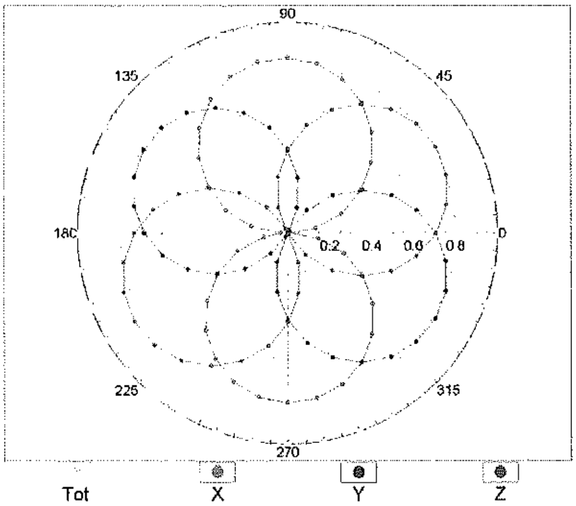
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



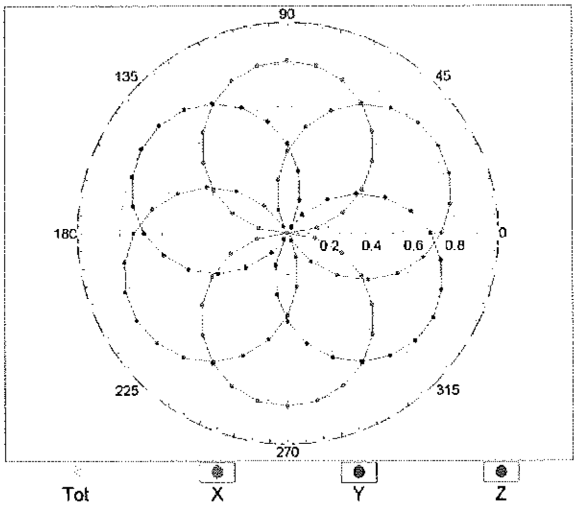

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

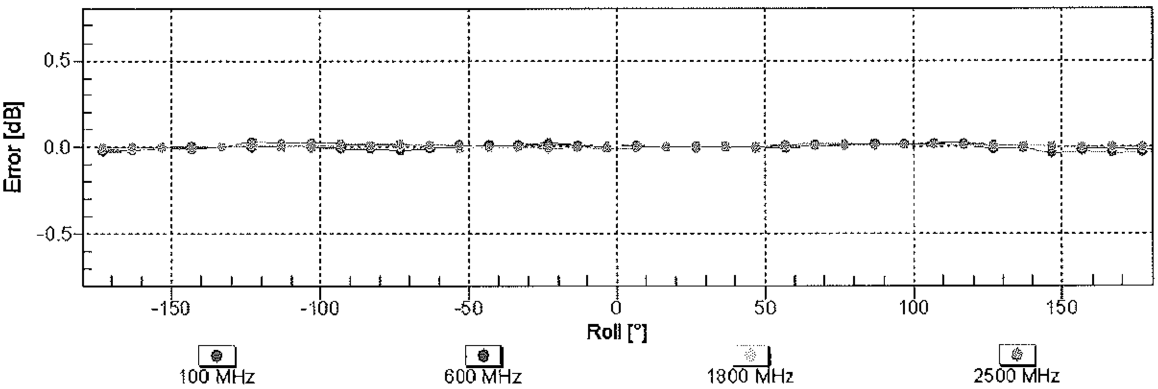
# Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



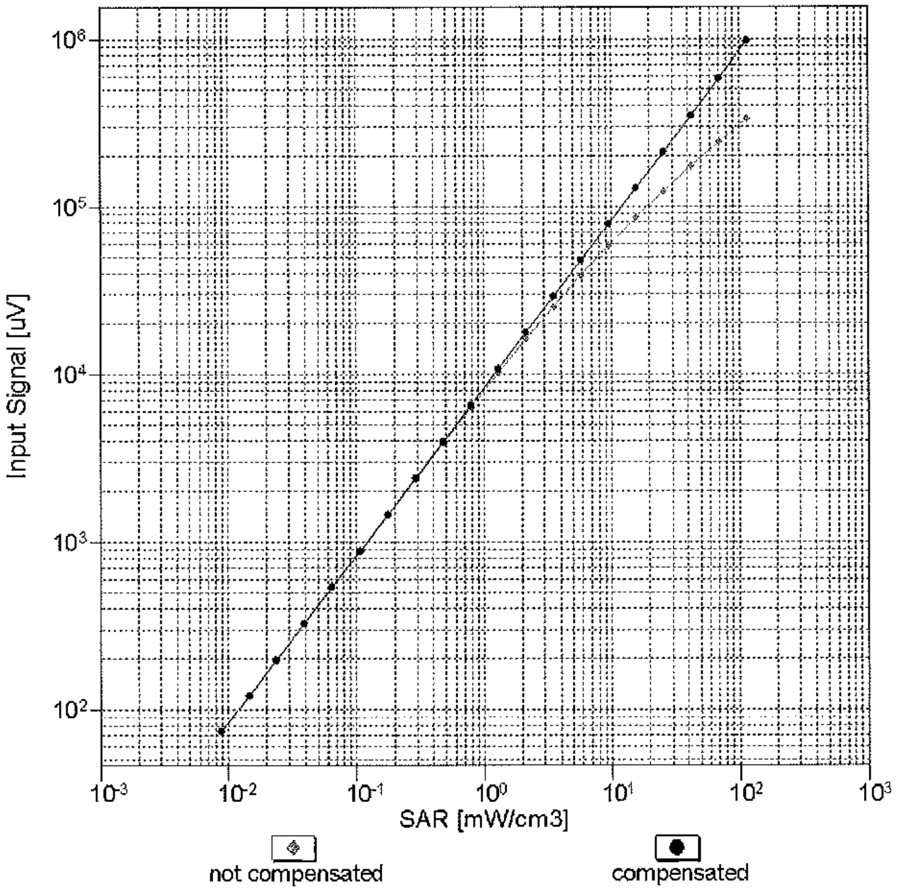

f=1800 MHz,R22

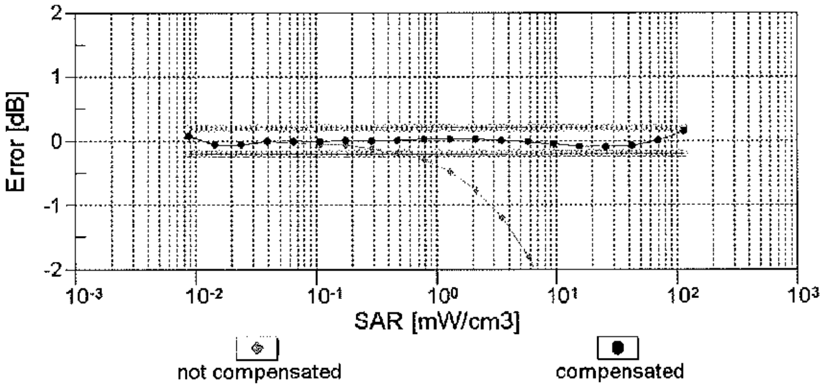



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

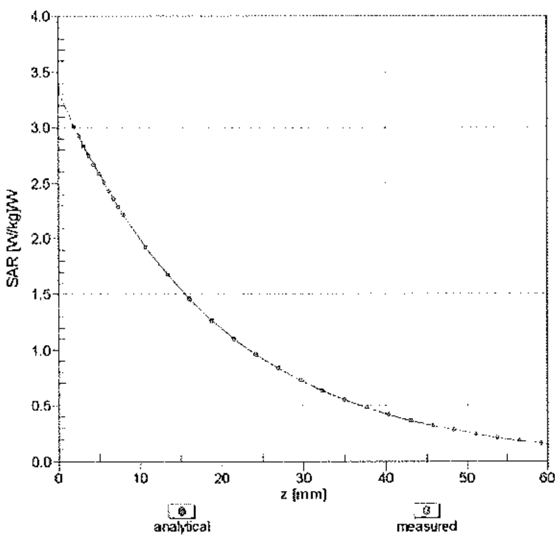
# Dynamic Range f($SAR_{head}$)
**(TEM cell , $f_{eval}$= 1900 MHz)**

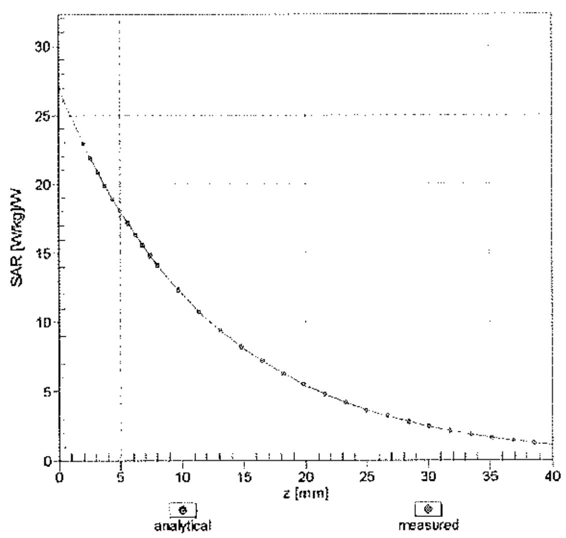



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

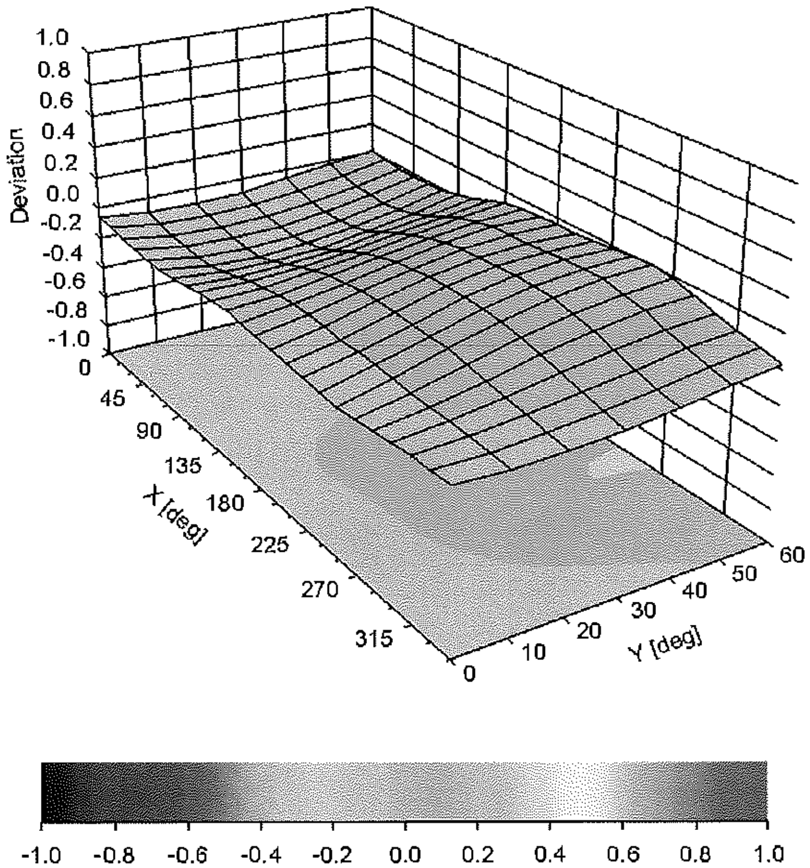
# Conversion Factor Assessment




# 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:3258

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -123.1 |
| 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 108**

Client **PC Test**

Certificate No: **ES3-3288_Sep13/2**

# CALIBRATION CERTIFICATE (Replacement of No: ES3-3288_Sep13)

Object: ES3DV3 - SN:3288

CC✓ 10/8/13

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 23, 2013

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 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 4-Sep-13 (No. DAE4-660_Sep13) | Apr-14 |
| | | | |
| 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-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

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

Issued: October 4, 2013





PCT# 80828

# Probe ES3DV3

## SN:3288

Manufactured: July 6, 2010
Calibrated: September 23, 2013

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

## 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 |

## 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

## 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.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.87 | 0.97 | 0.75 | ± 10.1 % |
| DCP (mV)[B] | 103.3 | 103.2 | 100.2 | |

## 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 | 171.1 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 135.0 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 154.3 | |

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 NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[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 | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.56 | 6.56 | 6.56 | 0.32 | 1.89 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.37 | 6.37 | 6.37 | 0.34 | 1.82 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.67 | 5.67 | 5.67 | 0.56 | 1.51 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.47 | 5.47 | 5.47 | 0.80 | 1.29 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.63 | 4.63 | 4.63 | 0.80 | 1.34 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.55 | 4.55 | 4.55 | 0.80 | 1.41 | ± 12.0 % |

[C] Frequency validity 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.
[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.

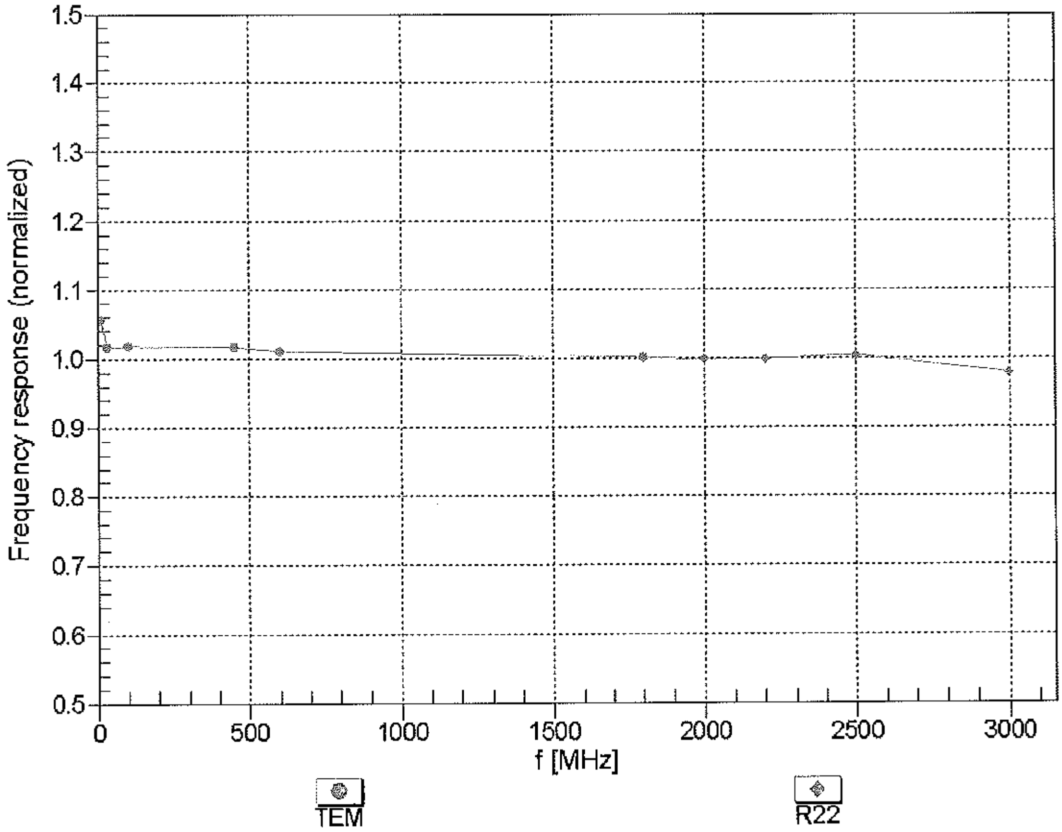
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## 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 | Depth (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.25 | 6.25 | 6.25 | 0.70 | 1.27 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.27 | 6.27 | 6.27 | 0.75 | 1.22 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.10 | 5.10 | 5.10 | 0.59 | 1.46 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.82 | 4.82 | 4.82 | 0.53 | 1.54 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.37 | 4.37 | 4.37 | 0.80 | 1.02 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.14 | 4.14 | 4.14 | 0.64 | 0.94 | ± 12.0 % |

[C] Frequency validity 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.
[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.

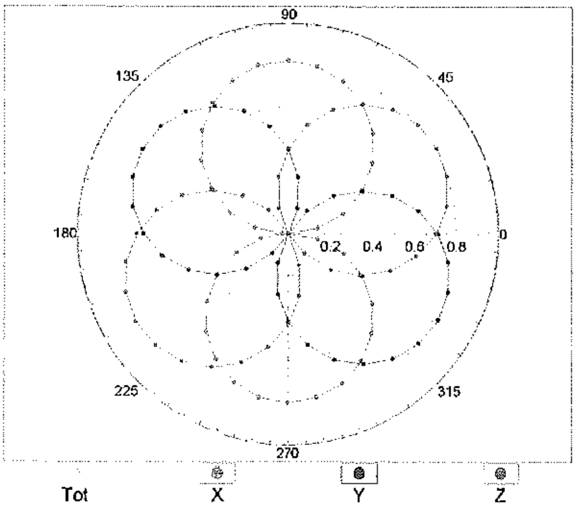
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



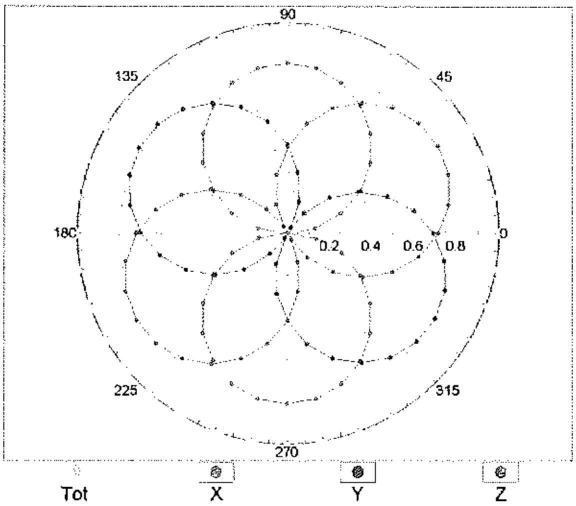

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

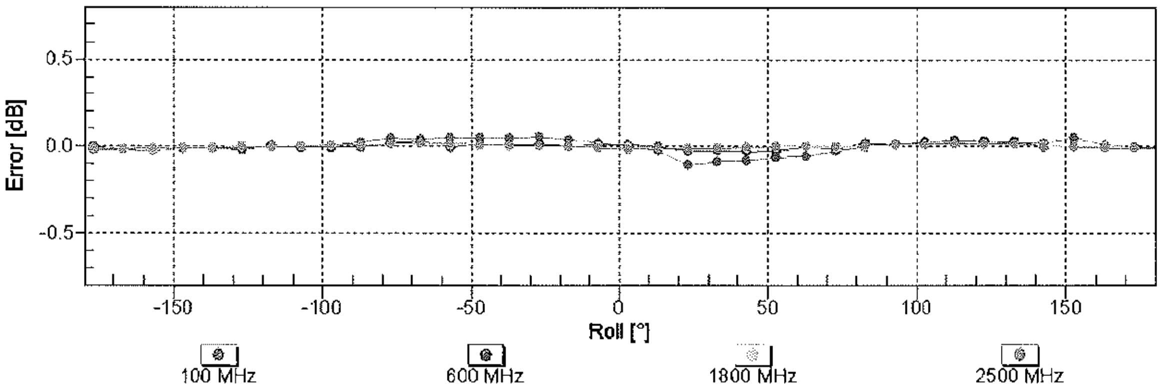
# Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



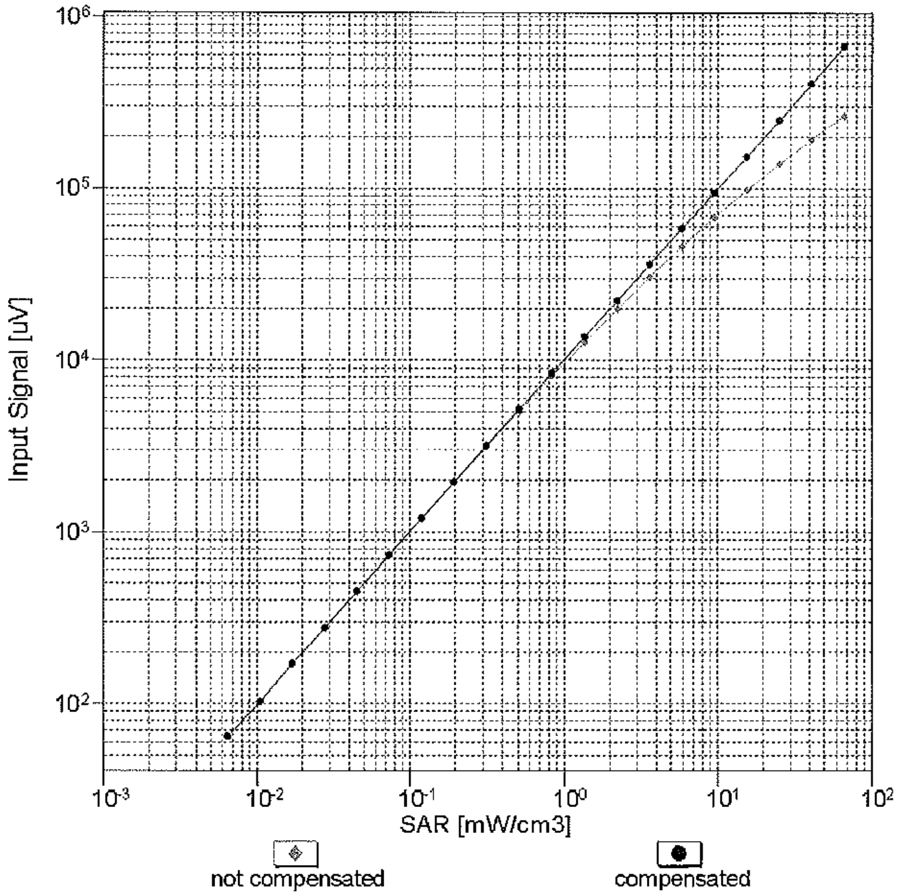

f=1800 MHz,R22

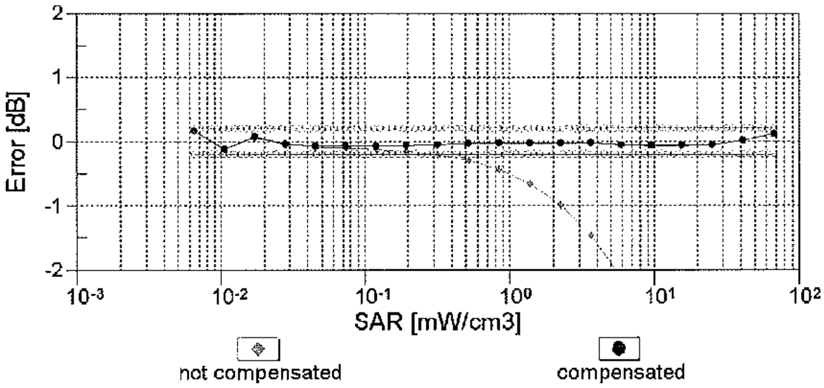



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

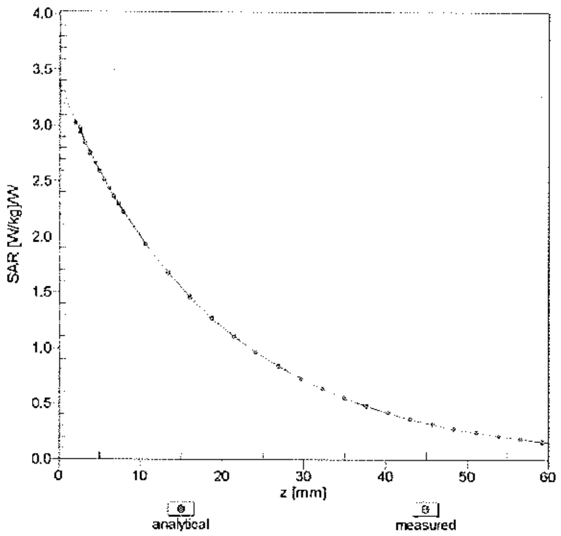
# Dynamic Range f($SAR_{head}$)
**(TEM cell , f = 900 MHz)**

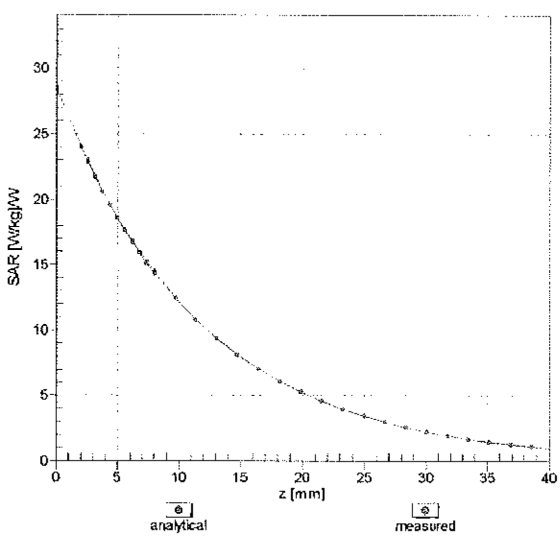



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

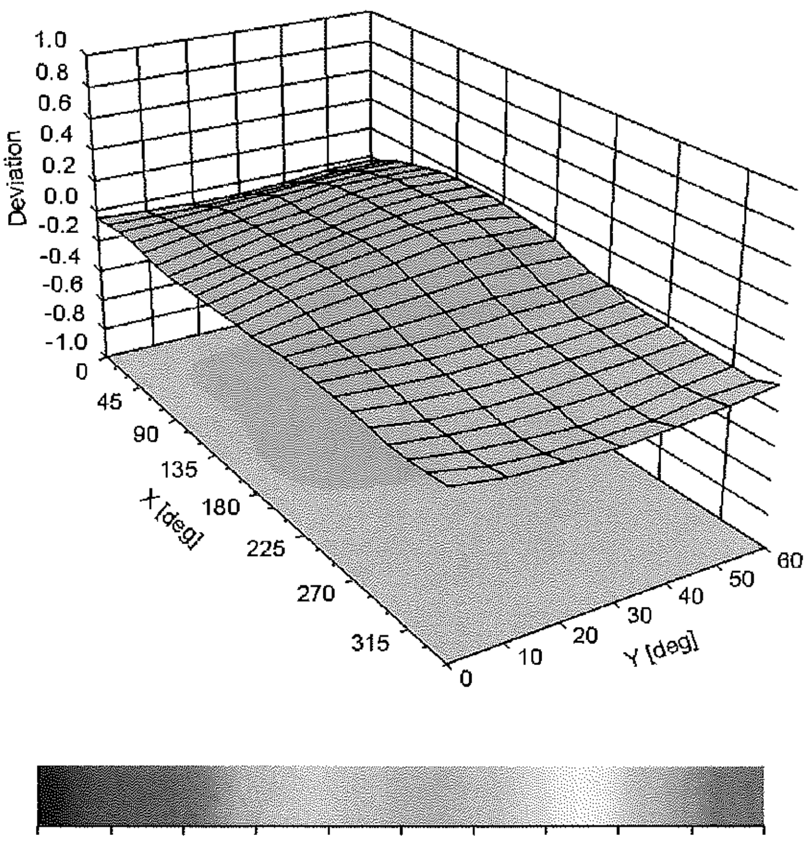
# Conversion Factor Assessment




# 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 (°) | -127.1 |
| 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 108**

**Client** **PC Test**

**Certificate No: ES3-3332_Nov13**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3332

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

JCC 1/12/14

Calibration date: November 25, 2013

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 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 4-Sep-13 (No. DAE4-660_Sep13) | Sep-14 |
| | | | |
| 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-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

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

Issued: November 25, 2013

## 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

## 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: November 25, 2013

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] | 0.94 | 1.16 | 0.97 | ± 10.1 % |
| DCP (mV)[B] | 103.5 | 101.0 | 111.0 | |

## 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 | 179.7 | ±2.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 147.3 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 188.8 | |

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 NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 5 and 6).
[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) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.46 | 6.46 | 6.46 | 0.52 | 1.42 | ± 12.0 % |
| 850 | 41.5 | 0.92 | 6.29 | 6.29 | 6.29 | 0.78 | 1.17 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.27 | 5.27 | 5.27 | 0.80 | 1.10 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.06 | 5.06 | 5.06 | 0.80 | 1.18 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.50 | 4.50 | 4.50 | 0.80 | 1.19 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.38 | 4.38 | 4.38 | 0.76 | 1.31 | ± 12.0 % |

[C] Frequency validity 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.
[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.

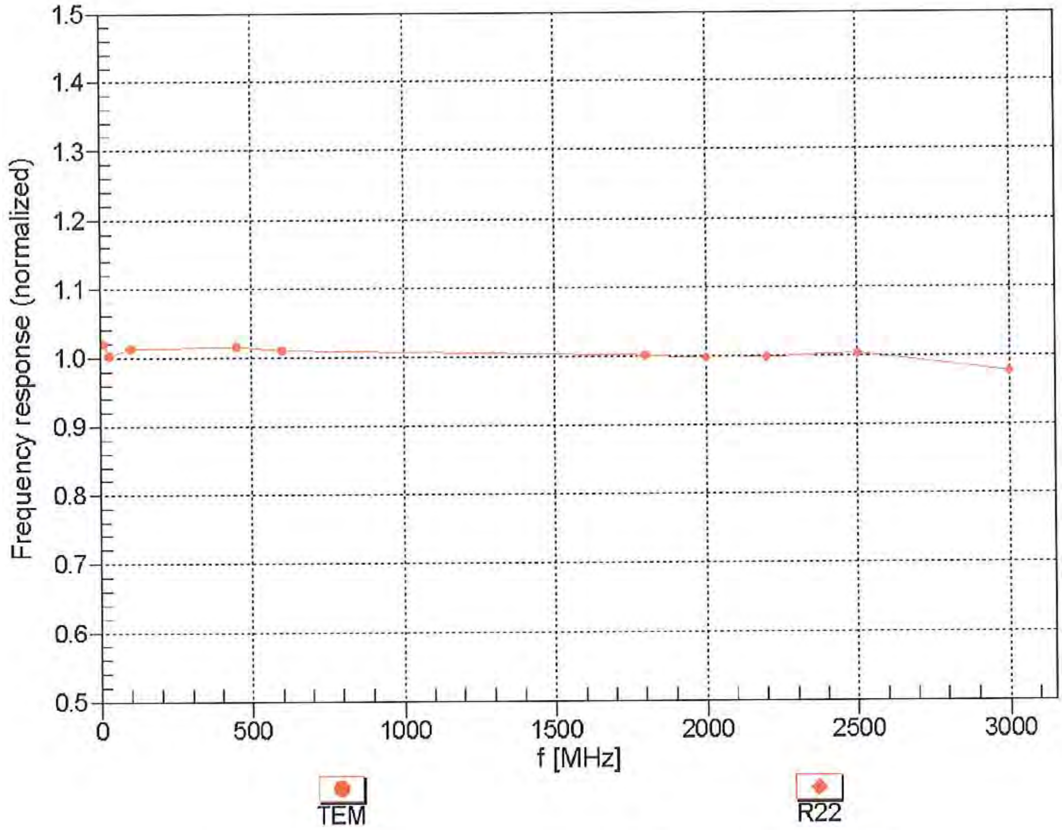
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

## 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) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.21 | 6.21 | 6.21 | 0.80 | 1.19 | ± 12.0 % |
| 850 | 55.2 | 0.99 | 6.08 | 6.08 | 6.08 | 0.51 | 1.48 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.93 | 4.93 | 4.93 | 0.42 | 1.72 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.70 | 4.70 | 4.70 | 0.48 | 1.59 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.24 | 4.24 | 4.24 | 0.80 | 1.01 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.07 | 4.07 | 4.07 | 0.80 | 0.50 | ± 12.0 % |

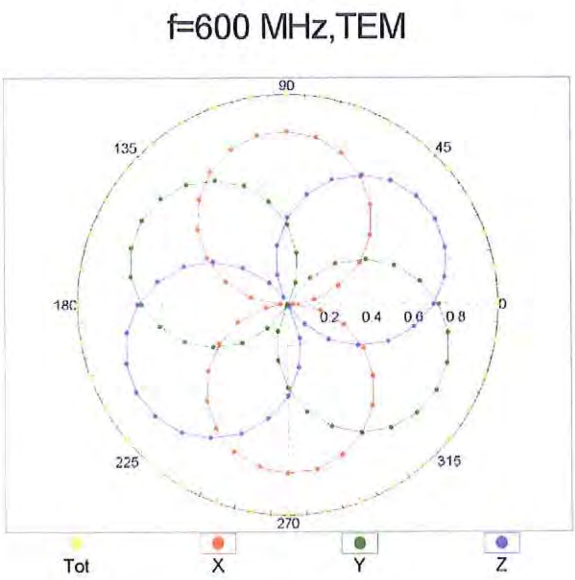
[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of 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.

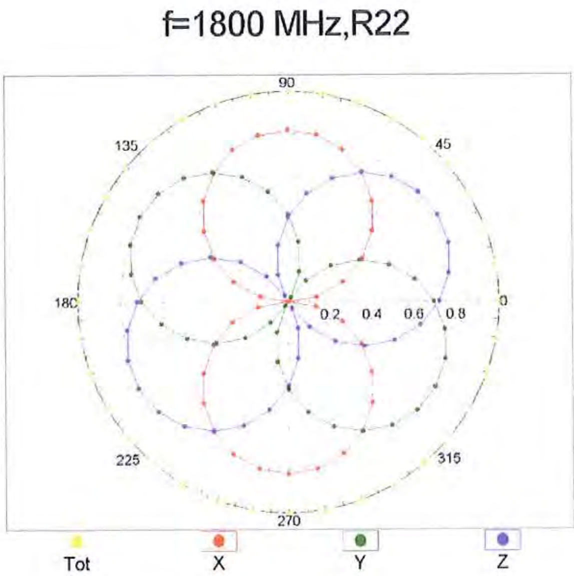
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**

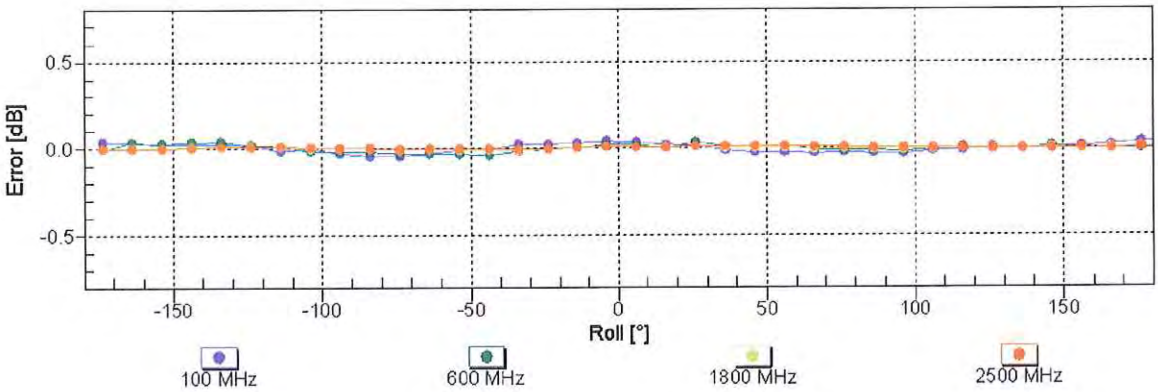



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

# Receiving Pattern (ϕ), $\vartheta = 0°$

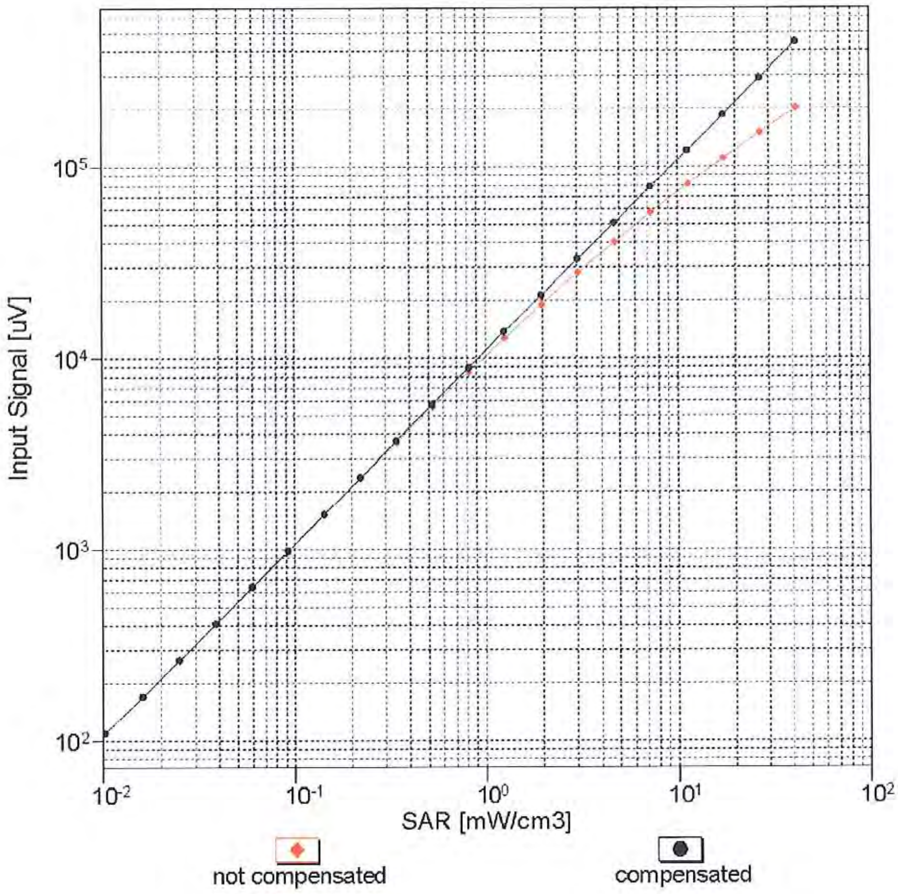


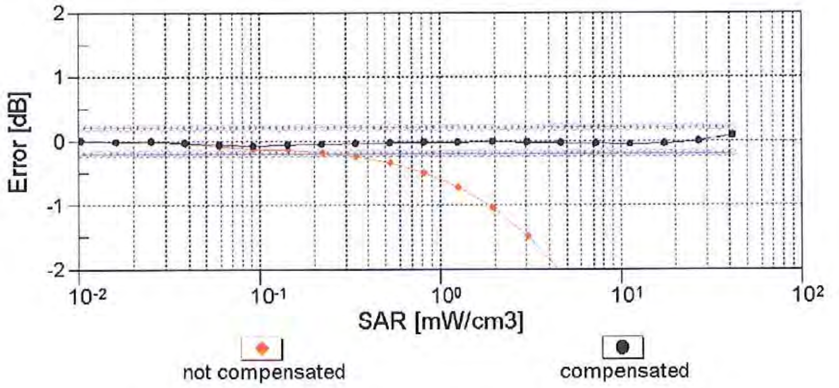




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)
**(TEM cell , f = 900 MHz)**

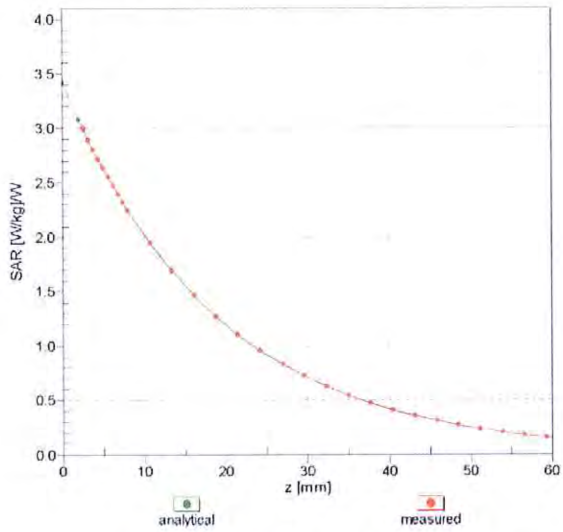


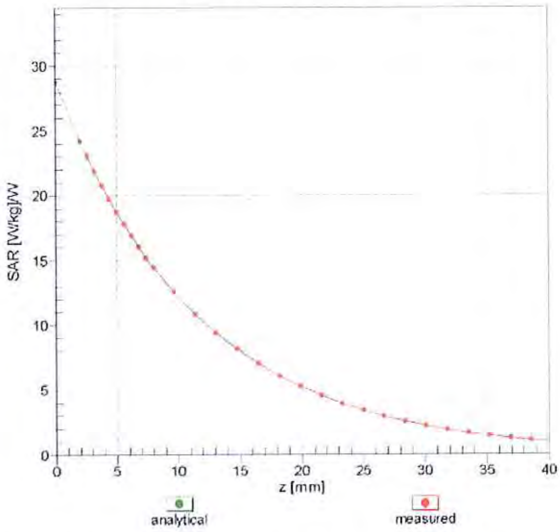

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 850 MHz,WGLS R9 (H_convF)

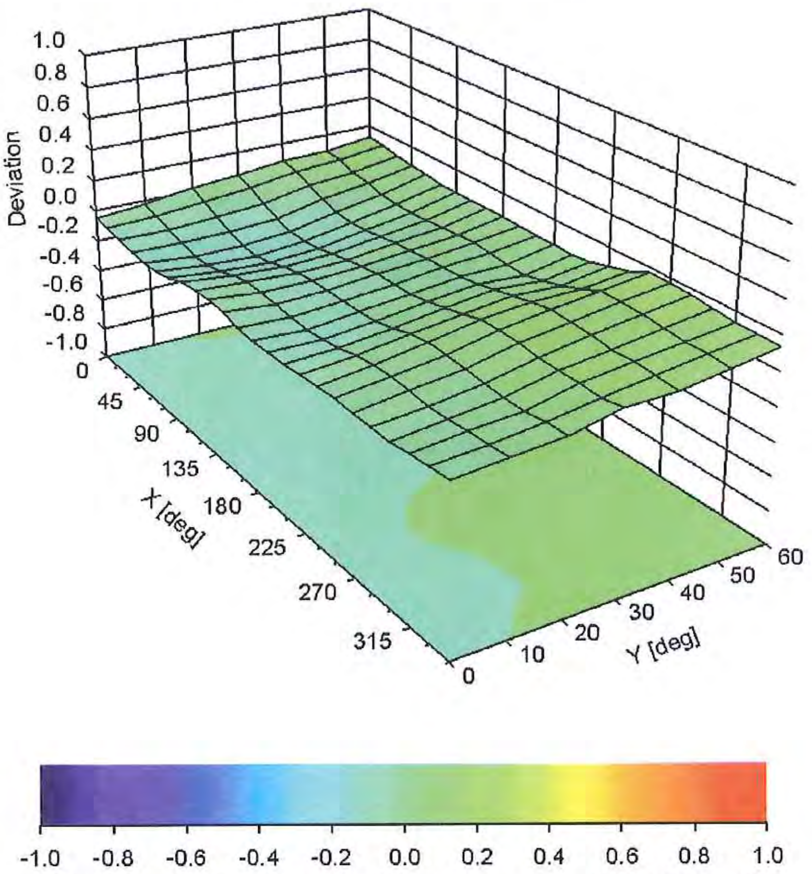



f = 1900 MHz,WGLS R22 (H_convF)




# 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:3332

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -3.9 |
| 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 108**

**Client** **PC Test**

**Certificate No: D835V2-4d119_Apr14**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D835V2 - SN: 4d119 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | April 07, 2014 |

QC✓ 4/25/14

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 | 09-Oct-13 (No. 217-01827) | Oct-14 |
| Power sensor HP 8481A | US37292783 | 09-Oct-13 (No. 217-01827) | Oct-14 |
| Power sensor HP 8481A | MY41092317 | 09-Oct-13 (No. 217-01828) | Oct-14 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 03-Apr-14 (No. 217-01918) | Apr-15 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921) | Apr-15 |
| Reference Probe ES3DV3 | SN: 3205 | 30-Dec-13 (No. ES3-3205_Dec13) | Dec-14 |
| DAE4 | SN: 601 | 25-Apr-13 (No. DAE4-601_Apr13) | Apr-14 |

| 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-13) | In house check: Oct-14 |

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

Issued: April 9, 2014

## 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) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

d) 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 | V52.8.7 |
| **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 | 41.6 ± 6 % | 0.94 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 | 2.38 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.22 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.53 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 | 53.6 ± 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 | 2.44 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.34 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.59 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.15 W/kg ± 16.5 % (k=2)** |

## Appendix

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.2 Ω - 1.6 jΩ |
| Return Loss | - 34.0 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 46.3 Ω - 4.5 jΩ |
| Return Loss | - 24.4 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.386 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: 07.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

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

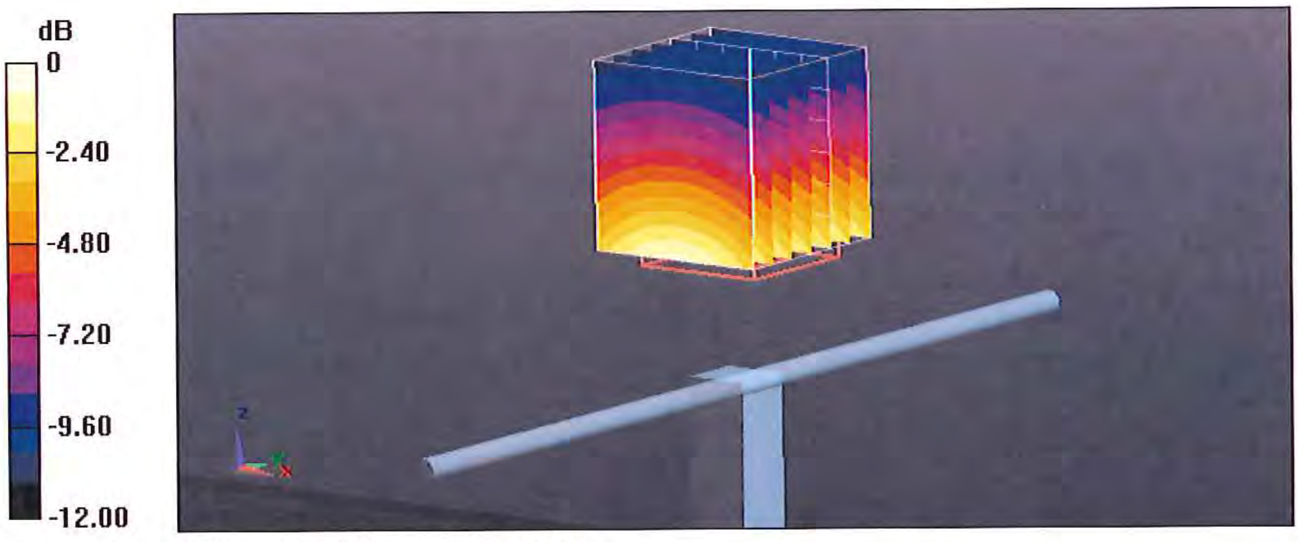
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 0.94 S/m; $\varepsilon_r$ = 41.6; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.22, 6.22, 6.22); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

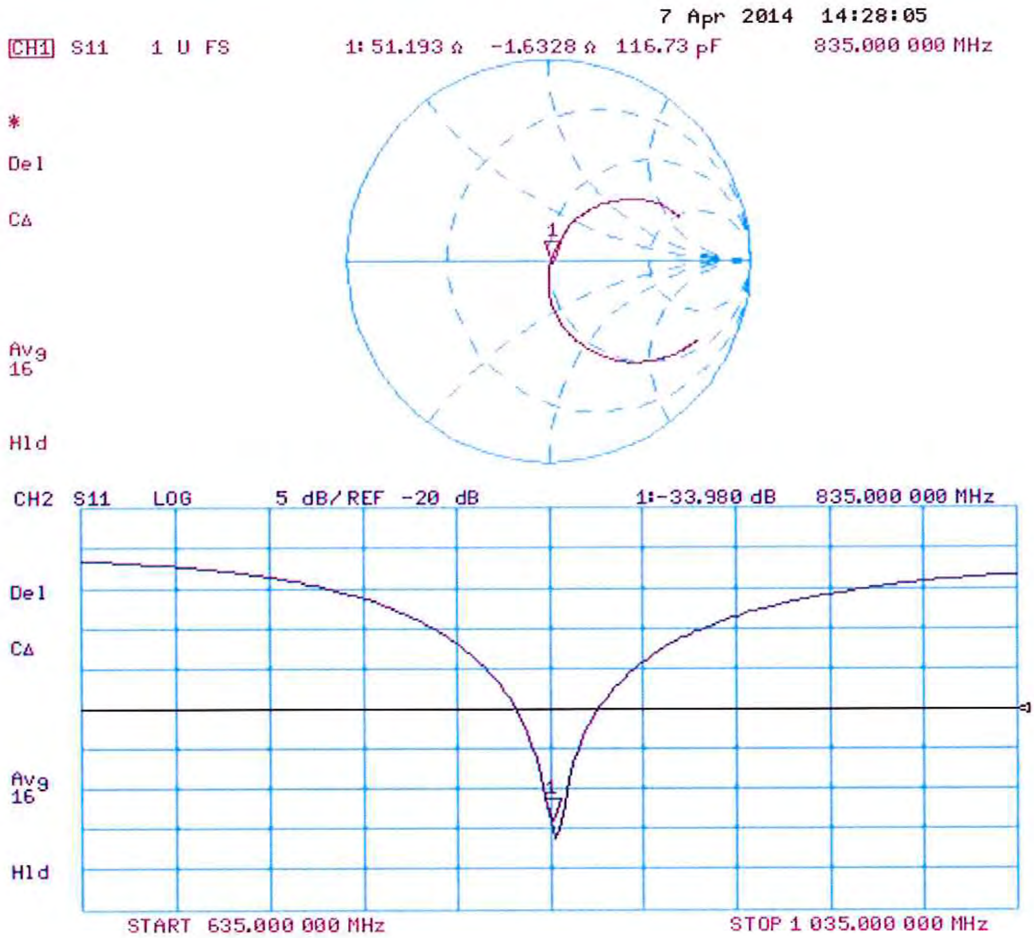
### Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.289 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.59 W/kg
**SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.53 W/kg**
Maximum value of SAR (measured) = 2.80 W/kg




0 dB = 2.80 W/kg = 4.47 dBW/kg

## Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 07.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

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

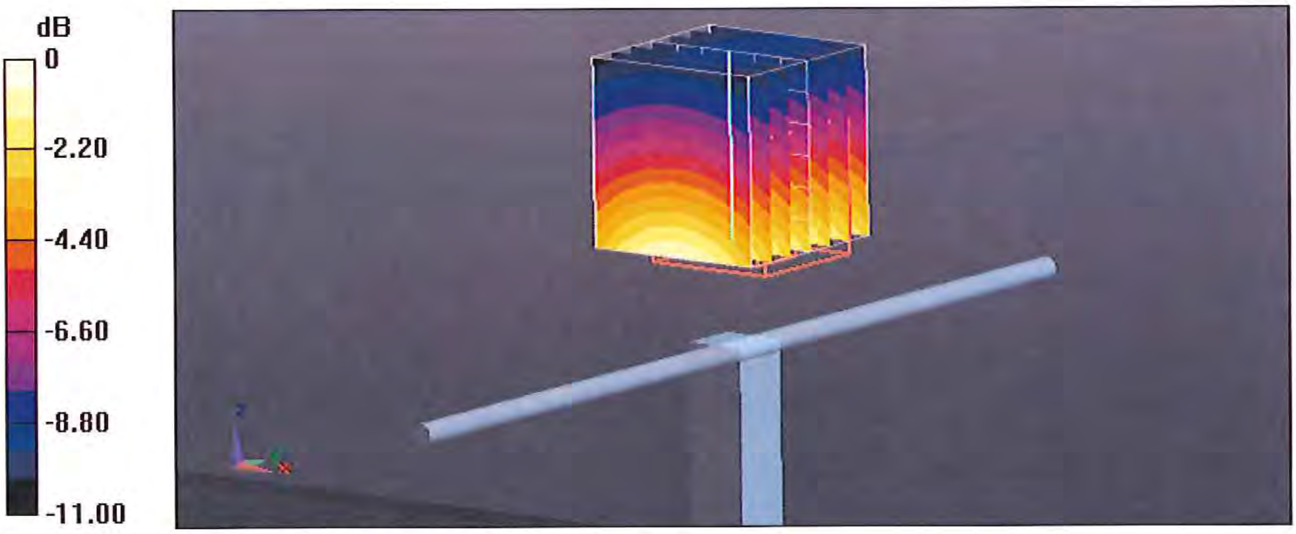
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 1.02 S/m; $\varepsilon_r$ = 53.6; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.09, 6.09, 6.09); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

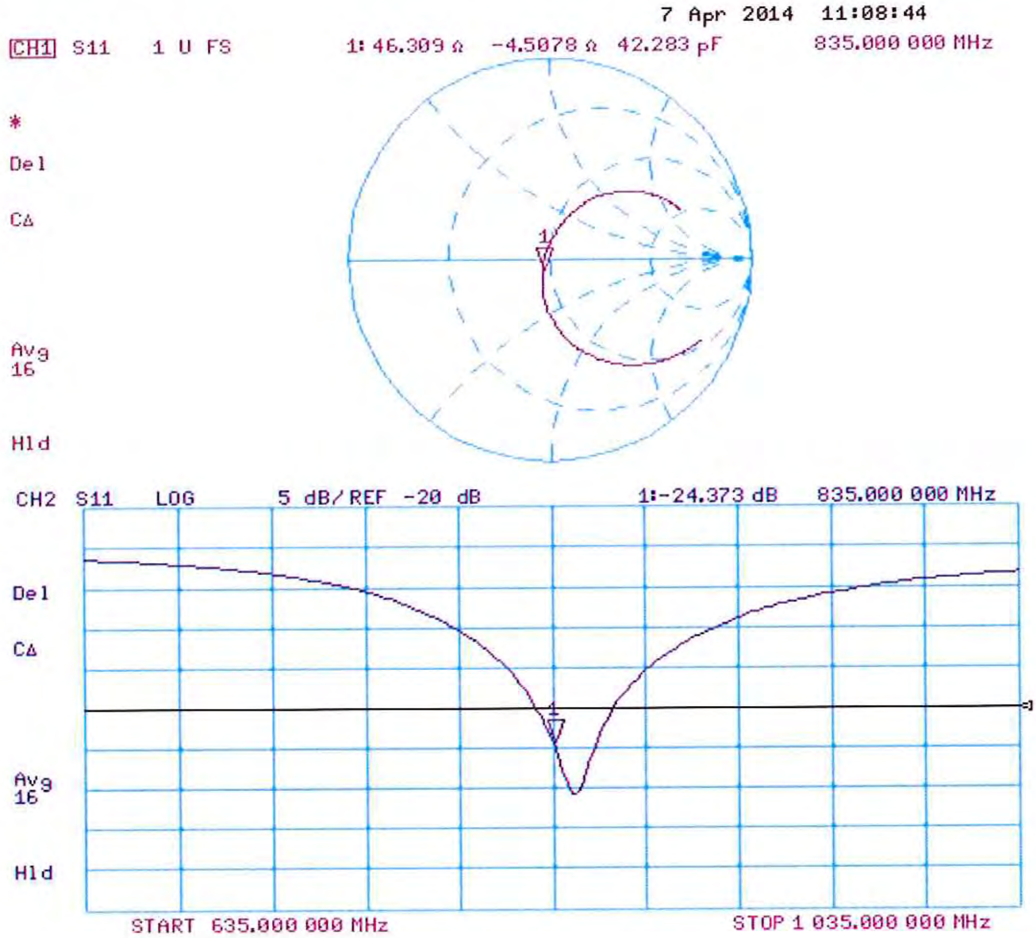
## Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 54.594 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 3.61 W/kg
**SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.59 W/kg**
Maximum value of SAR (measured) = 2.85 W/kg




0 dB = 2.85 W/kg = 4.55 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 108**

**Client** **PC Test**

**Certificate No: D835V2-4d133_Jul13**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D835V2 - SN: 4d133 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | July 17, 2013 |

✓ KOK 8/12/13

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 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Power sensor HP 8481A | US37292783 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 04-Apr-13 (No. 217-01736) | Apr-14 |
| Type-N mismatch combination | SN: 5047.3 / 06327 | 04-Apr-13 (No. 217-01739) | Apr-14 |
| Reference Probe ES3DV3 | SN: 3205 | 28-Dec-12 (No. ES3-3205_Dec12) | Dec-13 |
| DAE4 | SN: 601 | 25-Apr-13 (No. DAE4-601_Apr13) | Apr-14 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-11) | In house check: Oct-13 |
| RF generator R&S SMT-06 | 100005 | 04-Aug-99 (in house check Oct-11) | In house check: Oct-13 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

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

Issued: July 18, 2013

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



## 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

## Additional Documentation:

d) 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 | V52.8.7 |
| **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 | 41.8 ± 6 % | 0.92 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 | 2.44 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.62 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.59 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.28 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 | 54.9 ± 6 % | 1.00 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 | 2.46 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.61 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.62 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.36 W/kg ± 16.5 % (k=2)** |

## Appendix

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.0 Ω - 1.8 jΩ |
| Return Loss | - 31.8 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 48.2 Ω - 3.6 jΩ |
| Return Loss | - 27.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.395 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: 17.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d133**

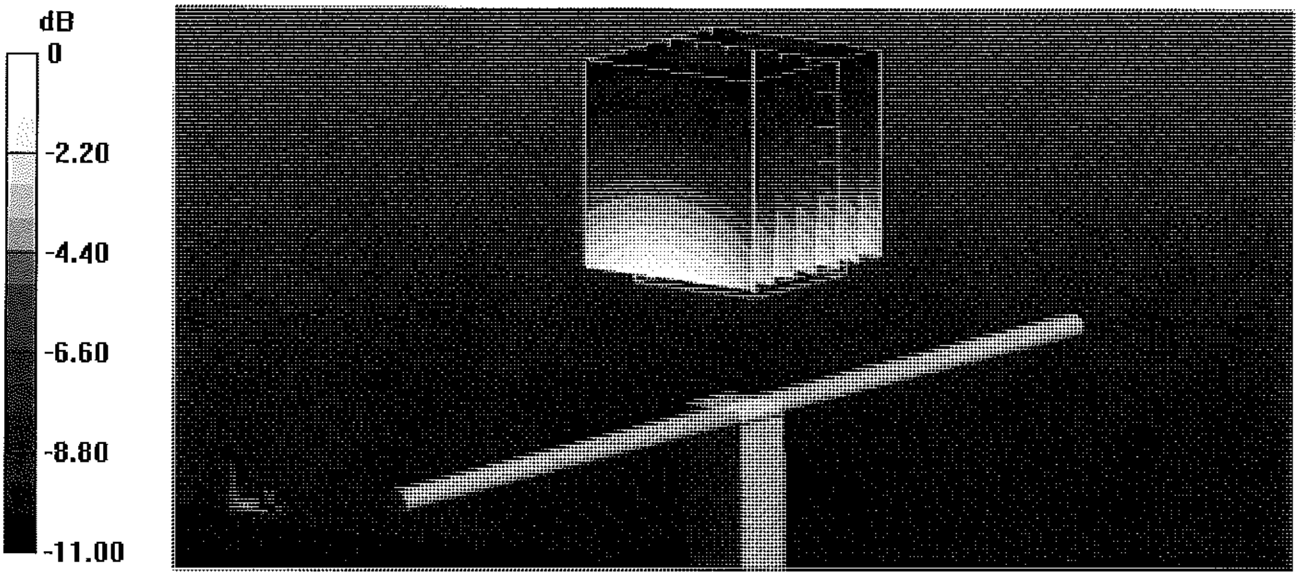
Communication System: UID 0 - CW ; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma = 0.92$ S/m; $\varepsilon_r = 41.8$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.05, 6.05, 6.05); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

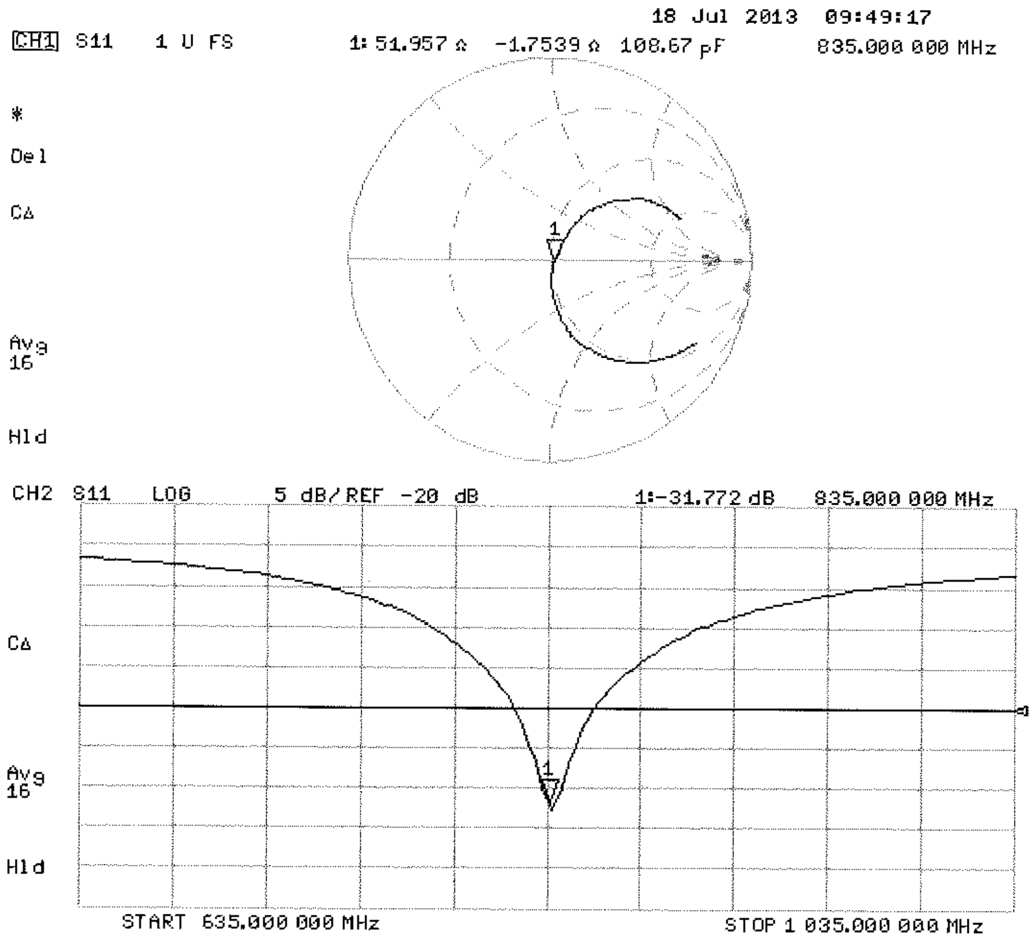
## Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.188 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 3.66 W/kg
**SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.59 W/kg**
Maximum value of SAR (measured) = 2.84 W/kg




0 dB = 2.84 W/kg = 4.53 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 17.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d133**

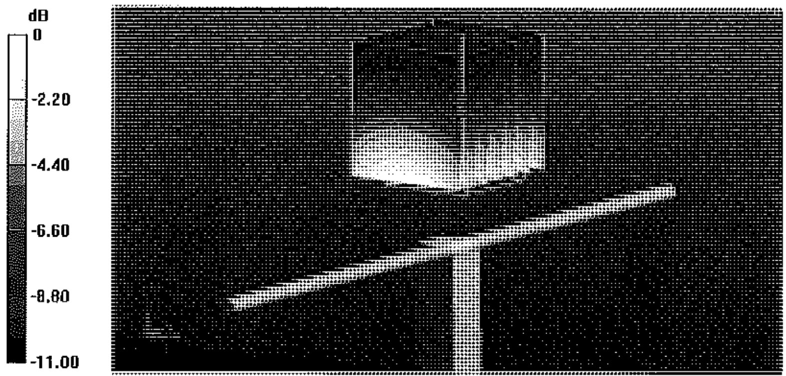
Communication System: UID 0 - CW ; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 1 S/m; $\varepsilon_r$ = 54.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.04, 6.04, 6.04); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

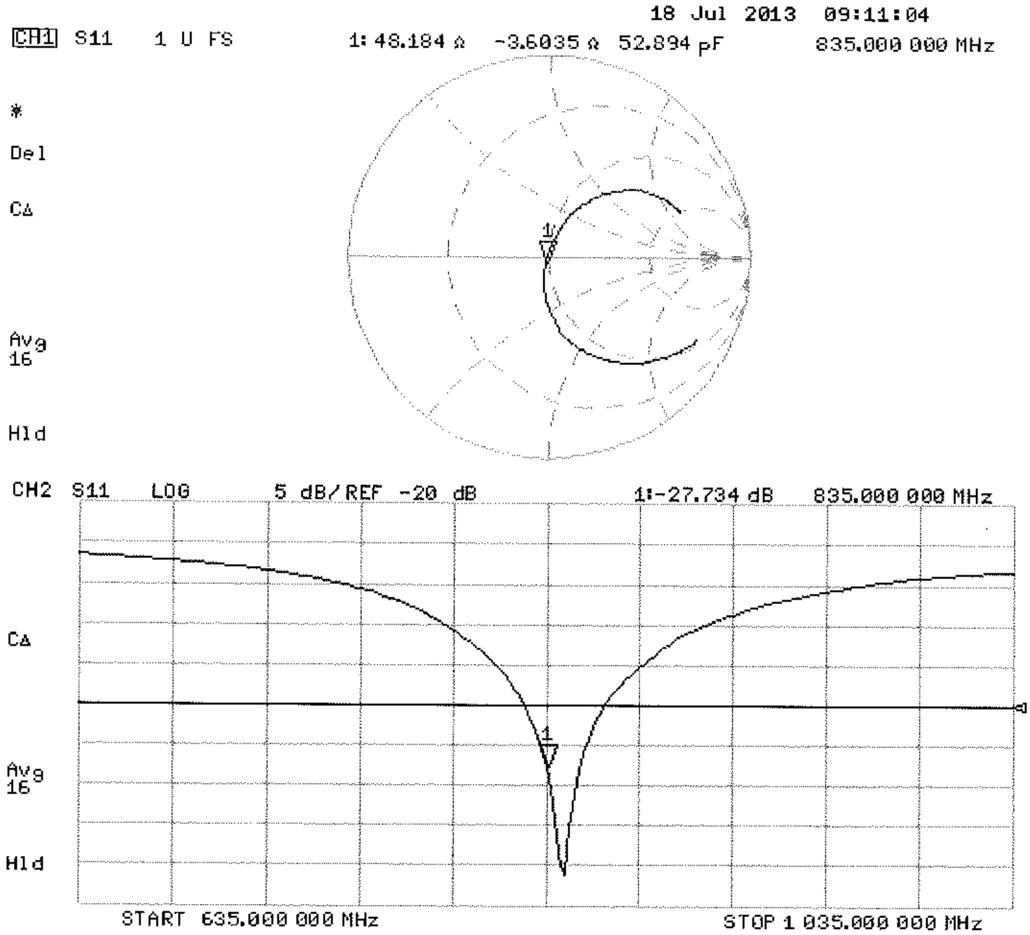
## Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 55.351 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 3.59 W/kg
**SAR(1 g) = 2.46 W/kg; SAR(10 g) = 1.62 W/kg**
Maximum value of SAR (measured) = 2.86 W/kg




0 dB = 2.86 W/kg = 4.56 dBW/kg

## Impedance Measurement Plot for Body TSL



**Calibration Laboratory of**
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**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 108**

**Client** PC Test

**Certificate No: D1900V2-5d149_Jul13**

# CALIBRATION CERTIFICATE

Object: D1900V2 - SN: 5d149

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

Calibration date: July 22, 2013

KJK 8/19/13

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 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Power sensor HP 8481A | US37292783 | 01-Nov-12 (No. 217-01640) | Oct-13 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 04-Apr-13 (No. 217-01736) | Apr-14 |
| Type-N mismatch combination | SN: 5047.3 / 06327 | 04-Apr-13 (No. 217-01739) | Apr-14 |
| Reference Probe ES3DV3 | SN: 3205 | 28-Dec-12 (No. ES3-3205_Dec12) | Dec-13 |
| DAE4 | SN: 601 | 25-Apr-13 (No. DAE4-601_Apr13) | Apr-14 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (in house check Oct-11) | In house check: Oct-13 |
| RF generator R&S SMT-06 | 100005 | 04-Aug-99 (in house check Oct-11) | In house check: Oct-13 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

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

Issued: July 22, 2013

**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 108**

## 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 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

## Additional Documentation:

d) 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 | V52.8.7 |
| **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 | 38.9 ± 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 | 9.99 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **40.4 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.28 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **21.3 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 | 53.4 ± 6 % | 1.49 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 | 10.0 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **40.5 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.36 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **21.6 W/kg ± 16.5 % (k=2)** |

## Appendix

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.9 Ω + 6.0 jΩ |
| Return Loss | - 23.8 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 48.5 Ω + 6.4 jΩ |
| Return Loss | - 23.5 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.196 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 |

## DASY5 Validation Report for Head TSL

Date: 22.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

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

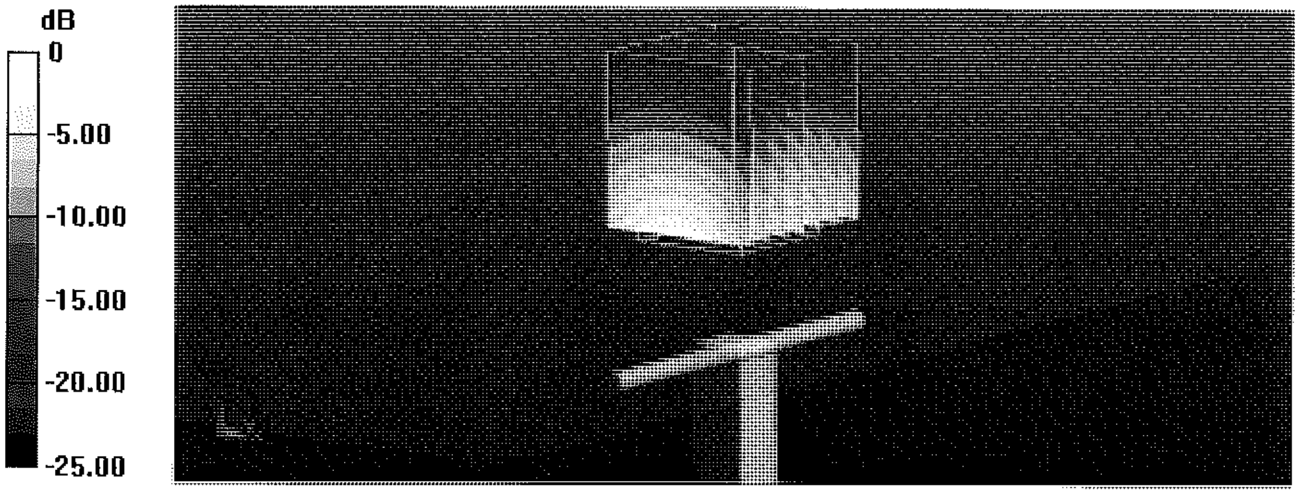
Communication System: UID 0 - CW ; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.36 S/m; $\varepsilon_r$ = 38.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.98, 4.98, 4.98); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

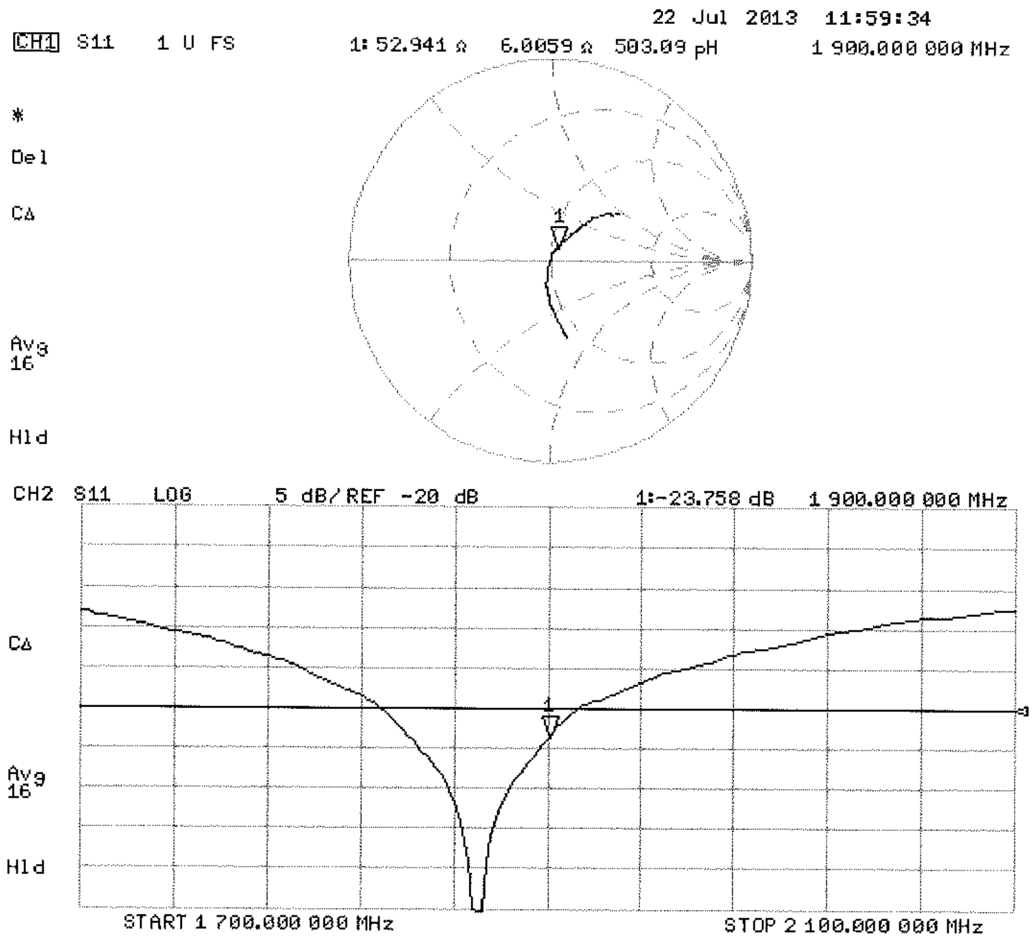
## Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 96.173 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 18.0 W/kg
**SAR(1 g) = 9.99 W/kg; SAR(10 g) = 5.28 W/kg**
Maximum value of SAR (measured) = 12.4 W/kg




0 dB = 12.4 W/kg = 10.93 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 22.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

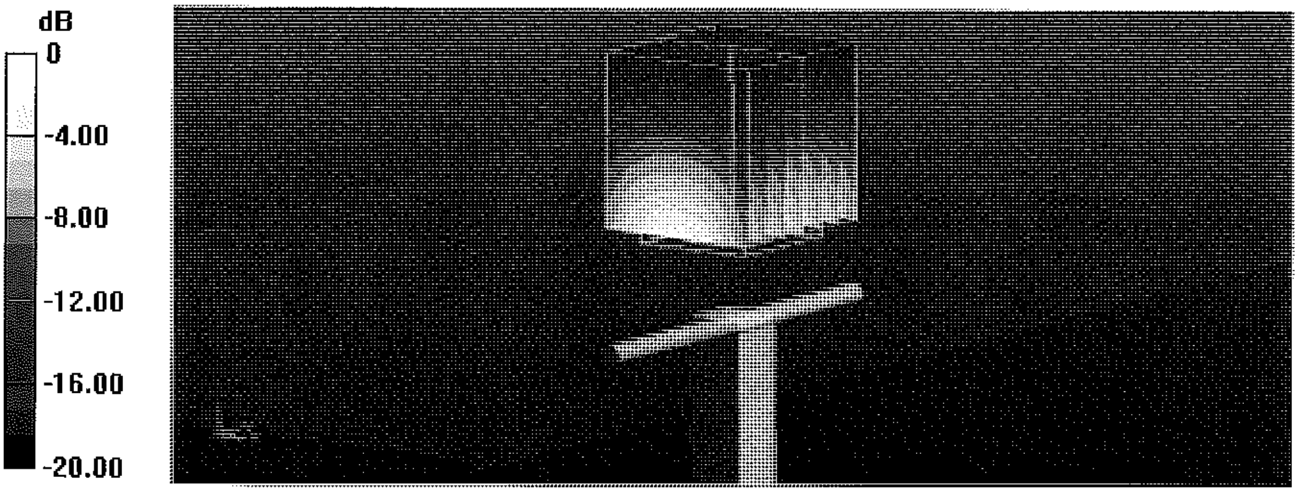
**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d149**

Communication System: UID 0 - CW ; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.49 S/m; $\varepsilon_r$ = 53.4; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

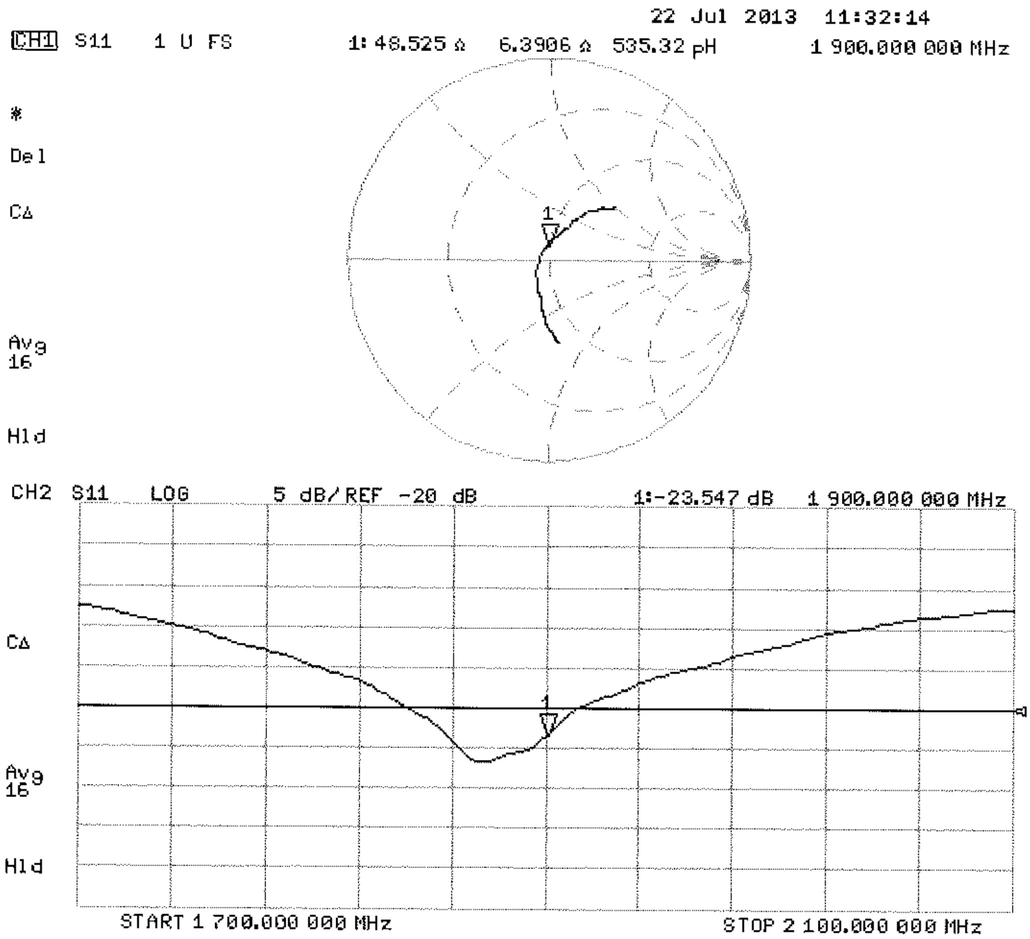
- Probe: ES3DV3 - SN3205; ConvF(4.6, 4.6, 4.6); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**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 = 96.173 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 17.0 W/kg
**SAR(1 g) = 10 W/kg; SAR(10 g) = 5.36 W/kg**
Maximum value of SAR (measured) = 12.6 W/kg




0 dB = 12.6 W/kg = 11.00 dBW/kg

## Impedance Measurement Plot for Body TSL



# 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) | 835 | 835 | 1900 | 1900 |
|---|---|---|---|---|
| Tissue | Head | Body | Head | Body |
| Ingredients (% by weight) | | | | |
| Bactericide | 0.1 | 0.1 | | |
| DGBE | | | 44.92 | 29.44 |
| HEC | 1 | 1 | | |
| NaCl | 1.45 | 0.94 | 0.18 | 0.39 |
| Sucrose | 57 | 44.9 | | |
| Water | 40.45 | 53.06 | 54.9 | 70.17 |

# APPENDIX E: SAR SYSTEM VALIDATION

Per FCC KDB 865664 D02v01, 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 865664 D01 v01 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) | ($\varepsilon_r$) | SENSI-TIVITY | PROBE LINEARITY | PROBE ISOTROPY | MOD. TYPE | DUTY FACTOR | PAR |
| G | 835 | 3/10/2014 | 3258 | ES3DV3 | 835 | Head | 0.914 | 41.20 | PASS | PASS | PASS | GMSK | PASS | N/A |
| I | 1900 | 4/18/2014 | 3209 | ES3DV3 | 1900 | Head | 1.429 | 38.29 | PASS | PASS | PASS | GMSK | PASS | N/A |
| B | 835 | 11/5/2013 | 3288 | ES3DV3 | 835 | Body | 0.952 | 53.32 | PASS | PASS | PASS | GMSK | PASS | N/A |
| J | 1900 | 1/14/2014 | 3332 | ES3DV3 | 1900 | Body | 1.576 | 51.59 | PASS | PASS | PASS | GMSK | PASS | N/A |

NOTE: While the probes have been calibrated for both a 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 D01v01 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 KDB 865664..