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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:**
04/13/15 - 04/23/15
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Document Serial No.:**
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**FCC ID:** **ZNFVN210**

**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-VN210, LGVN210, VN210, LG-VN210PP, LGVN210PP, VN210PP

| Equipment Class | Band & Mode | Tx Frequency | SAR | |
|---|---|---|---|---|
| | | | 1 gm Head (W/kg) | 1 gm Body-Worn (W/kg) |
| PCE | GSM/GPRS/EDGE 850 | 824.20 - 848.80 MHz | 0.26 | 0.43 |
| PCE | GSM/GPRS/EDGE 1900 | 1850.20 - 1909.80 MHz | 0.57 | 0.50 |
| PCE | Cell. CDMA | 824.70 - 848.31 MHz | 0.36 | 0.57 |
| PCE | PCS CDMA | 1851.25 - 1908.75 MHz | 0.78 | 0.66 |
| DSS | Bluetooth | 2402 - 2480 MHz | N/A | |
| **Simultaneous SAR per KDB 690783 D01v01r03:** | | | N/A | 0.76 |

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

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

Randy Ortanez
President

ACCREDITED
TESTING CERT#2041.01

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

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# 1 DEVICE UNDER TEST

## 1.1 Device Overview

| Band & Mode | Operating Modes | Tx Frequency |
|---|---|---|
| GSM/GPRS/EDGE 850 | Voice/Data | 824.20 - 848.80 MHz |
| GSM/GPRS/EDGE 1900 | Voice/Data | 1850.20 - 1909.80 MHz |
| Cell. CDMA | Voice/Data | 824.70 - 848.31 MHz |
| PCS CDMA | Voice/Data | 1851.25 - 1908.75 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) | | Burst Average 8-PSK (dBm) | |
|---|---|---|---|---|---|---|
| | | 1 TX Slot | *1 TX Slots* | *2 TX Slots* | *1 TX Slots* | *2 TX Slots* |
| GSM/GPRS/EDGE 850 | Maximum | **32.7** | **32.7** | **31.7** | **26.7** | **25.7** |
| | Nominal | **32.2** | **32.2** | **31.2** | **26.2** | **25.2** |
| GSM/GPRS/EDGE 1900 | Maximum | **29.7** | **29.7** | **28.7** | **25.7** | **24.7** |
| | Nominal | **29.2** | **29.2** | **28.2** | **25.2** | **24.2** |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| Cell. CDMA | Maximum | **25.0** |
| | Nominal | **24.5** |
| PCS CDMA | Maximum | **25.0** |
| | Nominal | **24.5** |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| Bluetooth | Maximum | **8.5** |
| | Nominal | **7.5** |

## 1.3 DUT Antenna Locations

The overall dimensions of this device are > 9 x 5 cm. The overall diagonal dimension of the device is <160 mm and the diagonal display is <150 mm. A diagram showing the location of the device antennas can be found in Appendix F.

## 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 | Notes |
|---|---|---|---|---|
| 1 | 1x CDMA voice + 2.4 GHz Bluetooth | N/A | Yes | |
| 2 | GSM voice + 2.4 GHz Bluetooth | N/A | Yes | |
| 3 | GPRS/EDGE + 2.4 GHz Bluetooth | N/A | Yes* | *-Pre-installed VOIP applications are considered. |

Note: All licensed modes share the same antenna path and cannot transmit simultaneously.

## 1.5 Miscellaneous SAR Test Considerations

### (A) WIFI/BT

Per FCC KDB 447498 D01v05, the 1g SAR exclusion threshold for distances <50mm is defined by the following equation:

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

Based on the maximum conducted power of Bluetooth (rounded to the nearest mW) and the antenna to user separation distance, body-worn Bluetooth SAR was not required; [(7/15)* √2.480] = 0.7< 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/EDGE 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 D01v03, D06v02 (2G/3G)
- FCC KDB Publication 447498 D01v05r02 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r03, D02v01r01 (SAR Measurements up to 6 GHz)
- October 2013 TCB Workshop Notes (GPRS Testing Considerations)

## 1.8 Device Serial Numbers

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

| | Head Serial Number | Body-Worn Serial Number |
|---|---|---|
| GSM/GPRS/EDGE 850 | AE066E | 1WRM1 |
| GSM/GPRS/EDGE 1900 | 1WRM1 | 1WRM1 |
| Cell. CDMA | AE066E | 1WRM1 |
| PCS CDMA | 59C36 | 1WRM1 |

# 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:

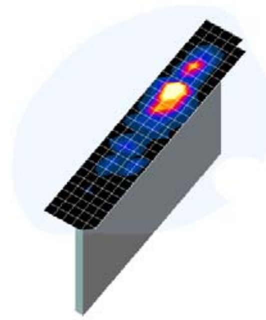

**Figure 3-1**
**Sample SAR Area Scan**

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 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.
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].

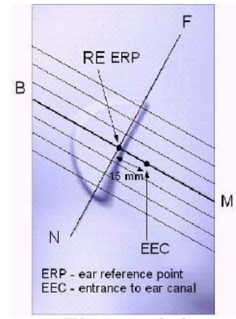


**Figure 4-1**
**Close-Up Side view of ERP**

## 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**

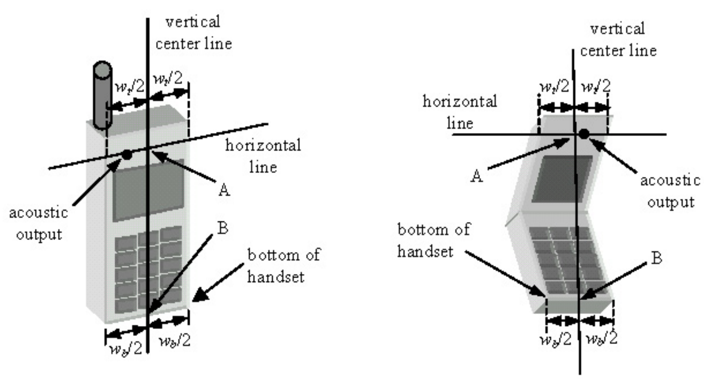


**Figure 4-3**
**Handset Vertical Center & Horizontal Line Reference Points**

# 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.

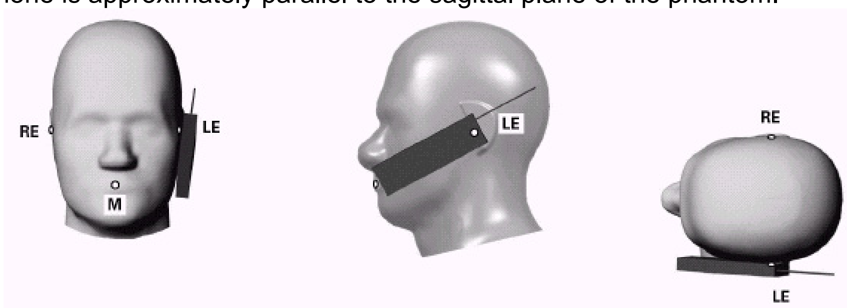


**Figure 5-1 Front, Side and Top View of Cheek Position**

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).

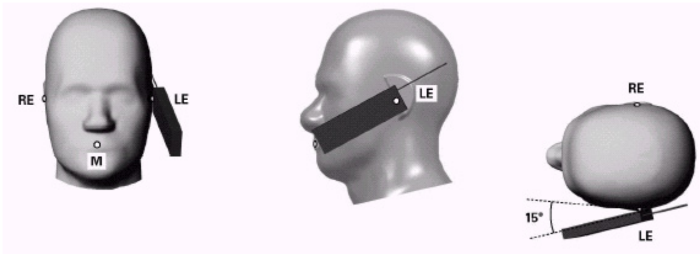


Figure 5-2 Front, Side and Top View of Ear/15º Tilt Position

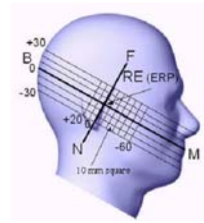


**Figure 5-3**
**Side view w/ relevant markings**

## 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.

## 5.5 Body-Worn Accessory Configurations

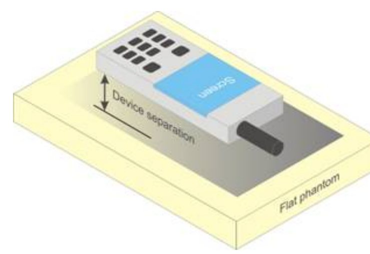


**Figure 5-4**
**Sample Body-Worn Diagram**

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration (see Figure 5-4). 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 for licensed transmitters are 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 3G SAR Test Reduction Procedure

In FCC KDB Publication 941225 D01v03, certain transmission modes within a frequency band and wireless mode evaluated for SAR are defined as primary modes. The equivalent modes considered for SAR test reduction are denoted as secondary modes. When the maximum output power including tune-up tolerance specified for production units in a secondary mode is ≤ 0.25 dB higher than the primary mode or when the highest reported SAR of the primary mode, scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode, is ≤ 1.2 W/kg, SAR measurements are not required for the secondary mode. These criteria are referred to as the 3G SAR test reduction procedure. When the 3G SAR test reduction procedure is not satisfied, SAR measurements are additionally required for the secondary mode.

## 7.3 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01v03 “3G SAR Measurement Procedures.”

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

## 7.4 SAR Measurement Conditions for CDMA2000

The following procedures were performed according to FCC KDB Publication 941225 D01v03 “3G SAR Measurement Procedures.”

### 7.4.1 Output Power Verification

See 3GPP2 C.S0011/TIA-98-E as recommended by FCC KDB Publication 941225 D01v03 “3G SAR Measurement Procedures.” Maximum output power is verified on the High, Middle and Low channels according to procedures in section 4.4.5.2 of 3GPP2 C.S0011/TIA-98-E. SO55 tests were measured with power control bits in the "All Up" condition.

1. If the mobile station (MS) supports Reverse TCH RC 1 and Forward TCH RC 1, set up a call using Fundamental Channel Test Mode 1 (RC=1/1) with 9600 bps data rate only.
2. Under RC1, C.S0011 Table 4.4.5.2-1, Table 7-1 parameters were applied.
3. If the MS supports the RC 3 Reverse FCH, RC3 Reverse $SCH_0$ and demodulation of RC 3,4, or 5, set up a call using Supplemental Channel Test Mode 3 (RC 3/3) with 9600 bps Fundamental Channel and 9600 bps SCH0 data rate.
4. Under RC3, C.S0011 Table 4.4.5.2-2, Table 7-2 was applied.

**Table 7-1**
**Parameters for Max. Power for RC1**

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

**Table 7-2**
**Parameters for Max. Power for RC3**

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

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

### 7.4.2 Head SAR Measurements

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

### 7.4.3 Body-worn SAR Measurements

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

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

# 8 RF CONDUCTED POWERS

## 8.1 CDMA Conducted Powers

| Band | Channel | Frequency | SO55 [dBm] | SO55 [dBm] | TDSO SO32 [dBm] | TDSO SO32 [dBm] |
|---|---|---|---|---|---|---|
| | F-RC | MHz | RC1 | RC3 | FCH+SCH | FCH |
| Cellular | 1013 | 824.7 | 24.96 | 25.00 | 24.99 | 25.00 |
| | 384 | 836.52 | 24.92 | 24.96 | 24.98 | 24.99 |
| | 777 | 848.31 | 24.97 | 24.99 | 25.00 | 25.00 |
| PCS | 25 | 1851.25 | 24.92 | 24.96 | 24.99 | 24.98 |
| | 600 | 1880 | 25.00 | 24.98 | 25.00 | 25.00 |
| | 1175 | 1908.75 | 24.88 | 24.93 | 24.97 | 24.99 |

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

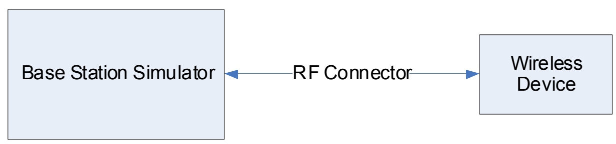


**Figure 8-1**
**Power Measurement Setup**

## 8.2 GSM Conducted Powers

| | | Maximum Burst-Averaged Output Power | | | | |
|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS/EDGE Data (GMSK)* | | *EDGE Data (8-PSK)* | |
| **Band** | **Channel** | **GSM [dBm] CS (1 Slot)** | **GPRS [dBm] 1 Tx Slot** | **GPRS [dBm] 2 Tx Slot** | **EDGE [dBm] 1 Tx Slot** | **EDGE [dBm] 2 Tx Slot** |
| **GSM 850** | 128 | 32.69 | 32.26 | **31.42** | 26.70 | 25.70 |
| | 190 | 32.41 | 32.36 | **31.70** | 26.68 | 25.69 |
| | 251 | 32.50 | 32.46 | **31.39** | 26.63 | 25.65 |
| **GSM 1900** | 512 | 29.36 | 29.51 | **28.22** | 25.70 | 24.51 |
| | 661 | 29.26 | 29.37 | **28.13** | 25.51 | 24.34 |
| | 810 | 29.19 | 29.33 | **28.16** | 25.58 | 24.29 |

| | | Calculated Maximum Frame-Averaged Output Power | | | | |
|---|---|---|---|---|---|---|
| | | *Voice* | *GPRS/EDGE Data (GMSK)* | | *EDGE Data (8-PSK)* | |
| **Band** | **Channel** | **GSM [dBm] CS (1 Slot)** | **GPRS [dBm] 1 Tx Slot** | **GPRS [dBm] 2 Tx Slot** | **EDGE [dBm] 1 Tx Slot** | **EDGE [dBm] 2 Tx Slot** |
| **GSM 850** | 128 | 23.66 | 23.23 | **25.40** | 17.67 | 19.68 |
| | 190 | 23.38 | 23.33 | **25.68** | 17.65 | 19.67 |
| | 251 | 23.47 | 23.43 | **25.37** | 17.60 | 19.63 |
| **GSM 1900** | 512 | 20.33 | 20.48 | **22.20** | 16.67 | 18.49 |
| | 661 | 20.23 | 20.34 | **22.11** | 16.48 | 18.32 |
| | 810 | 20.16 | 20.30 | **22.14** | 16.55 | 18.27 |
| **GSM 850** | **Frame Avg.Targets:** | 23.17 | 23.17 | **25.18** | 17.17 | 19.18 |
| **GSM 1900** | | 20.17 | 20.17 | **22.18** | 16.17 | 18.18 |

Notes:

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. The source-based frame-averaged output power was evaluated for all GPRS/EDGE slot configurations. The configuration with the highest target frame averaged output power was evaluated for VoIP SAR. When the maximum frame-averaged powers are equivalent across two or more slots (within 0.25 dB), the configuration with the most number of time slots was tested.
3. GPRS/EDGE (GMSK) output powers were measured with coding scheme setting of 1 (CS1) on the base station simulator. CS1 was configured to measure GPRS output power measurements and SAR to ensure GMSK modulation in the signal. Our Investigation has shown that CS1 - CS4 settings do not have any impact on the output levels or modulation in the GPRS modes.
4. EDGE (8-PSK) output powers were measured with MCS7 on the base station simulator. MCS7 coding scheme was used to measure the output powers for EDGE since investigation has shown that choosing MCS7 coding scheme will ensure 8-PSK modulation. It has been shown that MCS levels that produce 8PSK modulation do not have an impact on output power.

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

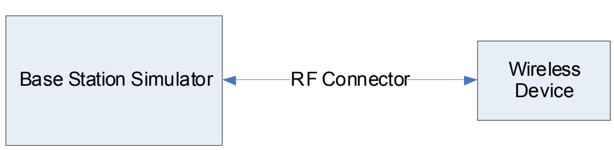


**Figure 8-2**
**Power Measurement Setup**

# 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 |
|---|---|---|---|---|---|---|---|---|---|
| 04/22/2015 | 835H | 21.8 | 820 | 0.874 | 41.096 | 0.899 | 41.578 | -2.78% | -1.16% |
| | | | 835 | 0.888 | 40.883 | 0.900 | 41.500 | -1.33% | -1.49% |
| | | | 850 | 0.904 | 40.713 | 0.916 | 41.500 | -1.31% | -1.90% |
| 04/13/2015 | 1900H | 21.8 | 1850 | 1.375 | 39.012 | 1.400 | 40.000 | -1.79% | -2.47% |
| | | | 1880 | 1.406 | 38.879 | 1.400 | 40.000 | 0.43% | -2.80% |
| | | | 1910 | 1.437 | 38.731 | 1.400 | 40.000 | 2.64% | -3.17% |
| 04/22/2015 | 1900H | 22.9 | 1850 | 1.348 | 39.515 | 1.400 | 40.000 | -3.71% | -1.21% |
| | | | 1880 | 1.373 | 39.490 | 1.400 | 40.000 | -1.93% | -1.28% |
| | | | 1910 | 1.409 | 39.334 | 1.400 | 40.000 | 0.64% | -1.66% |
| 04/22/2015 | 835B | 21.7 | 820 | 0.990 | 54.599 | 0.969 | 55.258 | 2.17% | -1.19% |
| | | | 835 | 1.003 | 54.467 | 0.970 | 55.200 | 3.40% | -1.33% |
| | | | 850 | 1.016 | 54.308 | 0.988 | 55.154 | 2.83% | -1.53% |
| 04/16/2015 | 1900B | 21.7 | 1850 | 1.478 | 52.963 | 1.520 | 53.300 | -2.76% | -0.63% |
| | | | 1880 | 1.510 | 52.856 | 1.520 | 53.300 | -0.66% | -0.83% |
| | | | 1910 | 1.548 | 52.755 | 1.520 | 53.300 | 1.84% | -1.02% |
| 04/23/2015 | 1900B | 21.0 | 1850 | 1.480 | 52.210 | 1.520 | 53.300 | -2.63% | -2.05% |
| | | | 1880 | 1.512 | 52.094 | 1.520 | 53.300 | -0.53% | -2.26% |
| | | | 1910 | 1.547 | 51.934 | 1.520 | 53.300 | 1.78% | -2.56% |

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)** | **$Deviation_{1g}$ (%)** |
| J | 835 | HEAD | 04/22/2015 | 21.3 | 21.8 | 0.100 | 4d133 | 3022 | 0.880 | 9.200 | 8.800 | -4.35% |
| J | 1900 | HEAD | 04/13/2015 | 21.9 | 21.8 | 0.100 | 5d149 | 3022 | 4.300 | 40.200 | 43.000 | 6.97% |
| G | 1900 | HEAD | 04/22/2015 | 23.2 | 22.3 | 0.100 | 5d149 | 3318 | 3.960 | 40.200 | 39.600 | -1.49% |
| C | 835 | BODY | 04/22/2015 | 21.8 | 21.7 | 0.100 | 4d132 | 3333 | 0.941 | 9.140 | 9.410 | 2.95% |
| K | 1900 | BODY | 04/16/2015 | 22.9 | 21.7 | 0.100 | 5d149 | 3288 | 4.010 | 40.400 | 40.100 | -0.74% |
| K | 1900 | BODY | 04/23/2015 | 22.1 | 21.0 | 0.100 | 5d149 | 3288 | 4.200 | 40.400 | 42.000 | 3.96% |

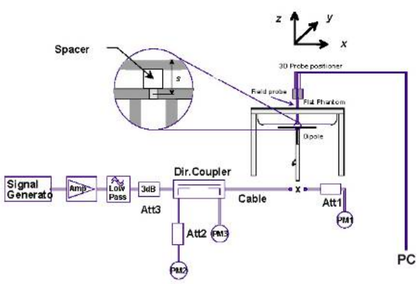


**Figure 9-1**
**System Verification Setup Diagram**

**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 | # of Time Slots | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 190 | GSM 850 | GSM | 32.7 | 32.41 | -0.18 | Right | Cheek | AE066E | 1 | 1:8.3 | 0.128 | 1.069 | 0.137 | |
| 836.60 | 190 | GSM 850 | GSM | 32.7 | 32.41 | -0.04 | Right | Tilt | AE066E | 1 | 1:8.3 | 0.096 | 1.069 | 0.103 | |
| 836.60 | 190 | GSM 850 | GSM | 32.7 | 32.41 | -0.12 | Left | Cheek | AE066E | 1 | 1:8.3 | 0.174 | 1.069 | 0.186 | |
| 836.60 | 190 | GSM 850 | GSM | 32.7 | 32.41 | 0.05 | Left | Tilt | AE066E | 1 | 1:8.3 | 0.100 | 1.069 | 0.107 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.70 | -0.09 | Right | Cheek | AE066E | 2 | 1:4.15 | 0.251 | 1.000 | 0.251 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.70 | -0.02 | Right | Tilt | AE066E | 2 | 1:4.15 | 0.156 | 1.000 | 0.156 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.70 | -0.07 | Left | Cheek | AE066E | 2 | 1:4.15 | 0.260 | 1.000 | 0.260 | A1 |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.70 | -0.05 | Left | Tilt | AE066E | 2 | 1:4.15 | 0.151 | 1.000 | 0.151 | |
| 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 | # of Time Slots | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.26 | 0.03 | Right | Cheek | 1WRM1 | 1 | 1:8.3 | 0.344 | 1.107 | 0.381 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.26 | 0.09 | Right | Tilt | 1WRM1 | 1 | 1:8.3 | 0.063 | 1.107 | 0.070 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.26 | 0.10 | Left | Cheek | 1WRM1 | 1 | 1:8.3 | 0.453 | 1.107 | 0.501 | |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.26 | -0.03 | Left | Tilt | 1WRM1 | 1 | 1:8.3 | 0.070 | 1.107 | 0.077 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.13 | 0.07 | Right | Cheek | 1WRM1 | 2 | 1:4.15 | 0.388 | 1.140 | 0.442 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.13 | 0.04 | Right | Tilt | 1WRM1 | 2 | 1:4.15 | 0.076 | 1.140 | 0.087 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.13 | -0.05 | Left | Cheek | 1WRM1 | 2 | 1:4.15 | 0.501 | 1.140 | 0.571 | A2 |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.13 | -0.18 | Left | Tilt | 1WRM1 | 2 | 1:4.15 | 0.035 | 1.140 | 0.040 | |
| 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**
**Cell. CDMA Head SAR**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 25.0 | 24.96 | -0.15 | Right | Cheek | AE066E | 1:1 | 0.327 | 1.009 | 0.330 | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 25.0 | 24.96 | 0.06 | Right | Tilt | AE066E | 1:1 | 0.216 | 1.009 | 0.218 | |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 25.0 | 24.96 | -0.13 | Left | Cheek | AE066E | 1:1 | 0.360 | 1.009 | 0.363 | A3 |
| 836.52 | 384 | Cell. CDMA | RC3 / SO55 | 25.0 | 24.96 | 0.00 | Left | Tilt | AE066E | 1:1 | 0.204 | 1.009 | 0.206 | |
| 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 10-4**
**PCS CDMA Head SAR**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode/Band | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Side | Test Position | Device Serial Number | Duty Cycle | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | (W/kg) | | (W/kg) | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 25.0 | 24.98 | -0.15 | Right | Cheek | 59C36 | 1:1 | 0.780 | 1.005 | 0.784 | A4 |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 25.0 | 24.98 | -0.03 | Right | Tilt | 59C36 | 1:1 | 0.138 | 1.005 | 0.139 | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 25.0 | 24.98 | -0.03 | Left | Mouth-Jaw | 59C36 | 1:1 | 0.718 | 1.005 | 0.722 | |
| 1880.00 | 600 | PCS CDMA | RC3 / SO55 | 25.0 | 24.98 | 0.02 | Left | Tilt | 59C36 | 1:1 | 0.190 | 1.005 | 0.191 | |
| 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 10-5**
**GSM/CDMA Body-Worn SAR Data**

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | # of Time Slots | Duty Cycle | Side | SAR (1g) | Scaling Factor | Scaled SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | (W/kg) | |
| 836.60 | 190 | GSM 850 | GSM | 32.7 | 32.41 | 0.00 | 15 mm | 1WRM1 | 1 | 1:8.3 | back | 0.371 | 1.069 | 0.397 | |
| 836.60 | 190 | GSM 850 | GPRS | 31.7 | 31.70 | 0.03 | 15 mm | 1WRM1 | 2 | 1:4.15 | back | 0.433 | 1.000 | 0.433 | A5 |
| 1880.00 | 661 | GSM 1900 | GSM | 29.7 | 29.26 | -0.13 | 15 mm | 1WRM1 | 1 | 1:8.3 | back | 0.302 | 1.107 | 0.334 | |
| 1880.00 | 661 | GSM 1900 | GPRS | 28.7 | 28.13 | -0.14 | 15 mm | 1WRM1 | 2 | 1:4.15 | back | 0.438 | 1.140 | 0.499 | A6 |
| 836.52 | 384 | Cell. CDMA | TDSO / SO32 | 25.0 | 24.99 | 0.01 | 15 mm | 1WRM1 | N/A | 1:1 | back | 0.565 | 1.002 | 0.566 | A7 |
| 1880.00 | 600 | PCS CDMA | TDSO / SO32 | 25.0 | 25.00 | -0.01 | 15 mm | 1WRM1 | N/A | 1:1 | back | 0.661 | 1.000 | 0.661 | A8 |
| 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.
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, body-worn SAR was evaluated without a headset connected to the device. Since the standalone reported body-worn SAR was ≤ 1.2 W/kg, no additional body-worn SAR evaluations using a headset cable were required.
8. Per FCC KDB 865664 D01 v01, variability SAR tests were not performed since the measured SAR results for all frequency bands was less than 0.8 W/kg. Please see Section 12 for more information.

GSM Test Notes:

1. Body-Worn accessory testing is typically associated with voice operations. Therefore, GSM voice was evaluated for body-worn SAR.
2. Justification for reduced test configurations per KDB Publication 941225 D01v01 and October 2013 TCB Workshop Notes: The source-based frame-averaged output power was evaluated for all GPRS/EDGE slot configurations. The configuration with the highest target frame averaged output power was evaluated for hotspot SAR. When the maximum frame-averaged powers are equivalent across two or more slots (within 0.25 dB), the configuration with the most number of time slots was tested.
3. Per FCC KDB Publication 447498 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.
4. GPRS Mode was additionally tested for VoIP.

CDMA Notes:

1. Head SAR for CDMA2000 mode was tested under RC3/SO55 per FCC KDB Publication 941225 D01v03.
2. Body-Worn SAR was tested with 1x RTT with TDSO / SO32 FCH Only. TDSO / SO32 FCH+SCH SAR tests were not required since the maximum output target power was not more than 0.25 dB higher than the TDSO / SO32 FCH only powers and SAR is less than 1.2 W/kg, per FCC KDB Publication 941225 D01.
3. 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 D01v05r02 are applicable to devices with built-in unlicensed transmitters such as 802.11 and 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. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1-g or 10-g SAR.

When standalone SAR is not required to be measured, per FCC KDB 447498 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 | 2480 | 8.50 | 15 | 0.098 |

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 | 0.397 | 0.098 | 0.495 |
| Back Side | GPRS 850 | 0.433 | 0.098 | 0.531 |
| Back Side | GSM 1900 | 0.334 | 0.098 | 0.432 |
| Back Side | GPRS 1900 | 0.499 | 0.098 | 0.597 |
| Back Side | Cell. CDMA | 0.566 | 0.098 | 0.664 |
| Back Side | PCS CDMA | 0.661 | 0.098 | **0.759** |

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 was not assessed for each frequency band since all measured SAR values are < 0.80 W/kg.

## 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 | 8594A | (9kHz-2.9GHz) Spectrum Analyzer | N/A | N/A | N/A | 3051A00187 |
| Agilent | 8648D | (9kHz-4GHz) Signal Generator | 3/15/2015 | Annual | 3/15/2016 | 3629U00687 |
| Agilent | 8753E | (30kHz-6GHz) Network Analyzer | 12/30/2014 | Annual | 12/30/2015 | JP38020182 |
| Agilent | 8753ES | S-Parameter Network Analyzer | 3/12/2015 | Annual | 3/12/2016 | MY40000670 |
| Agilent | 8753ES | Network Analyzer | 3/20/2015 | Annual | 3/20/2016 | MY40001472 |
| Agilent | 8753ES | S-Parameter Network Analyzer | 5/22/2014 | Annual | 5/22/2015 | US39170118 |
| Agilent | E4438C | ESG Vector Signal Generator | 3/13/2015 | Annual | 3/13/2016 | MY42082385 |
| Agilent | E4438C | ESG Vector Signal Generator | 3/12/2015 | Annual | 3/12/2016 | MY45090700 |
| Agilent | E5515C | Wireless Communications Test Set | 11/5/2013 | Biennial | 11/5/2015 | GB46310798 |
| Agilent | E8257D | (250kHz-20GHz) Signal Generator | 3/15/2015 | Annual | 3/15/2016 | MY45470194 |
| Agilent | N5182A | MXG Vector Signal Generator | 10/27/2014 | Annual | 10/27/2015 | MY47420603 |
| Agilent | N5182A | MXG Vector Signal Generator | 3/16/2015 | Annual | 3/16/2016 | MY47420651 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433971 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433972 |
| Anritsu | MA24106A | USB Power Sensor | 5/14/2014 | Annual | 5/14/2015 | 1231535 |
| Anritsu | MA24106A | USB Power Sensor | 5/14/2014 | Annual | 5/14/2015 | 1231538 |
| Anritsu | MA2411B | Pulse Power Sensor | 11/17/2014 | Annual | 11/17/2015 | 1126066 |
| Anritsu | MA2411B | Pulse Power Sensor | 11/17/2014 | Annual | 11/17/2015 | 1207364 |
| Anritsu | MA2411B | Pulse Power Sensor | 11/13/2014 | Annual | 11/13/2015 | 1339018 |
| 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 | 4040 | Digital Thermometer | 3/18/2015 | Biennial | 3/18/2017 | 150194895 |
| Control Company | 4040 | Digital Thermometer | 3/18/2015 | Biennial | 3/18/2017 | 150194896 |
| Control Company | 4040 | Digital Thermometer | 3/15/2015 | Biennial | 3/15/2017 | 150194897 |
| Control Company | 4040 | Digital Thermometer | 3/15/2015 | Biennial | 3/15/2017 | 150194898 |
| Control Company | 4052 | Long Stem Thermometer | 9/27/2013 | Biennial | 9/27/2015 | 130567447 |
| Control Company | 4353 | Long Stem Thermometer | 1/22/2015 | Biennial | 1/22/2017 | 150053169 |
| Control Company | 4353 | Long Stem Thermometer | 3/5/2015 | Biennial | 3/5/2017 | 150149534 |
| Control Company | 4353 | Long Stem Thermometer | 3/5/2015 | Biennial | 3/5/2017 | 150149565 |
| Gigatronics | 80701A | (0.05-18GHz) Power Sensor | 10/30/2014 | Annual | 10/30/2015 | 1833460 |
| Gigatronics | 8651A | Universal Power Meter | 10/30/2014 | Annual | 10/30/2015 | 8650319 |
| MCL | BW-N6W5+ | 6dB Attenuator | CBT | N/A | CBT | 1139 |
| MiniCircuits | SLP-2400+ | Low Pass Filter | CBT | N/A | CBT | R8979500903 |
| 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 |
| 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 | CMW500 | Radio Communication Tester | 3/18/2015 | Annual | 3/18/2016 | 128633 |
| Rohde & Schwarz | CMW500 | Radio Communication Tester | 4/8/2015 | Annual | 4/8/2016 | 140148 |
| Seekonk | NC-100 | Torque Wrench | 3/18/2014 | Biennial | 3/18/2016 | 22313 |
| 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 | 7/23/2014 | Annual | 7/23/2015 | 5d149 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 1/16/2015 | Annual | 1/16/2016 | 4d132 |
| SPEAG | D835V2 | 835 MHz SAR Dipole | 7/24/2014 | Annual | 7/24/2015 | 4d133 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 1/14/2015 | Annual | 1/14/2016 | 1272 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 8/12/2014 | Annual | 8/12/2015 | 1322 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 9/18/2014 | Annual | 9/18/2015 | 1364 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 10/23/2014 | Annual | 10/23/2015 | 1408 |
| SPEAG | DAK-3.5 | Dielectric Assessment Kit | 5/6/2014 | Annual | 5/6/2015 | 1070 |
| SPEAG | DAKS-3.5 | Portable Dielectric Assessment Kit | 8/12/2014 | Annual | 8/12/2015 | 1041 |
| SPEAG | ES3DV2 | SAR Probe | 8/19/2014 | Annual | 8/19/2015 | 3022 |
| SPEAG | ES3DV3 | SAR Probe | 9/24/2014 | Annual | 9/24/2015 | 3288 |
| SPEAG | ES3DV3 | SAR Probe | 1/23/2015 | Annual | 1/23/2016 | 3318 |
| SPEAG | ES3DV3 | SAR Probe | 10/24/2014 | Annual | 10/24/2015 | 3333 |
| VWR | 36934-158 | Wall-Mounted Thermometer | 4/29/2014 | Biennial | 4/29/2016 | 111859323 |
| VWR | 36934-158 | Wall-Mounted Thermometer | 8/8/2013 | Biennial | 8/8/2015 | 130477877 |

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

| 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: ZNFVN210; Type: Portable Handset; Serial: AE066E**

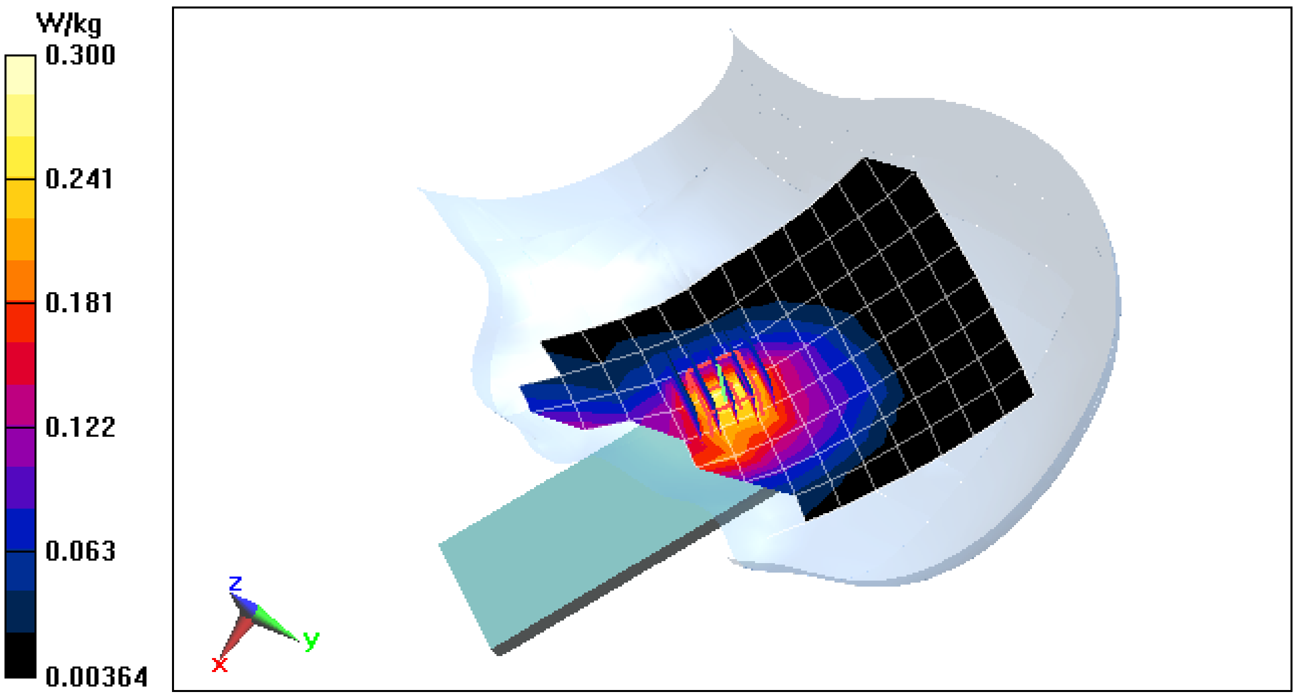
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 836.6 MHz;Duty Cycle: 1:4.15
Medium: 835 Head Medium parameters used (interpolated):
f = 836.6 MHz; σ = 0.89 S/m; $\varepsilon_r$ = 40.865; ρ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 04-22-2015; Ambient Temp: 21.3°C; Tissue Temp: 21.8°C

Probe: ES3DV2 - SN3022; ConvF(6.18, 6.18, 6.18); Calibrated: 8/19/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1322; Calibrated: 8/12/2014
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## Mode: GPRS 850, Left Head, Cheek, Mid.ch, 2 Tx slots

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 17.03 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 0.323 W/kg
**SAR(1 g) = 0.260 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 1WRM1**

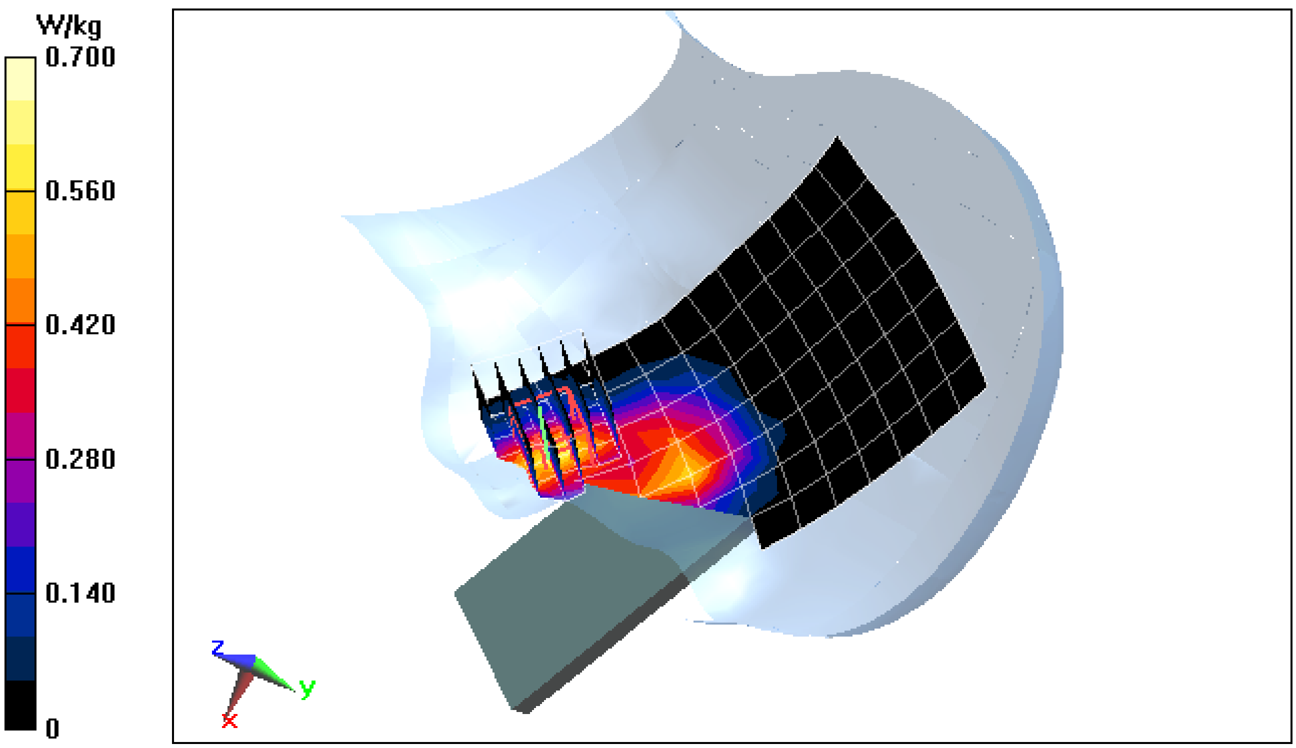
Communication System: UID 0, GSM GPRS; 2 Tx slots (0); Frequency: 1880 MHz;Duty Cycle: 1:4.15
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.373 S/m; $\varepsilon_r$ = 39.49; $\rho$ = 1000 kg/m$^3$
Phantom section: Left Section

Test Date: 04-22-2015; Ambient Temp: 23.2°C; Tissue Temp: 22.3°C

Probe: ES3DV3 - SN3318; ConvF(5.05, 5.05, 5.05); Calibrated: 1/23/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1272; Calibrated: 1/14/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (8x14x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.12 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 0.936 W/kg
**SAR(1 g) = 0.501 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: AE066E**

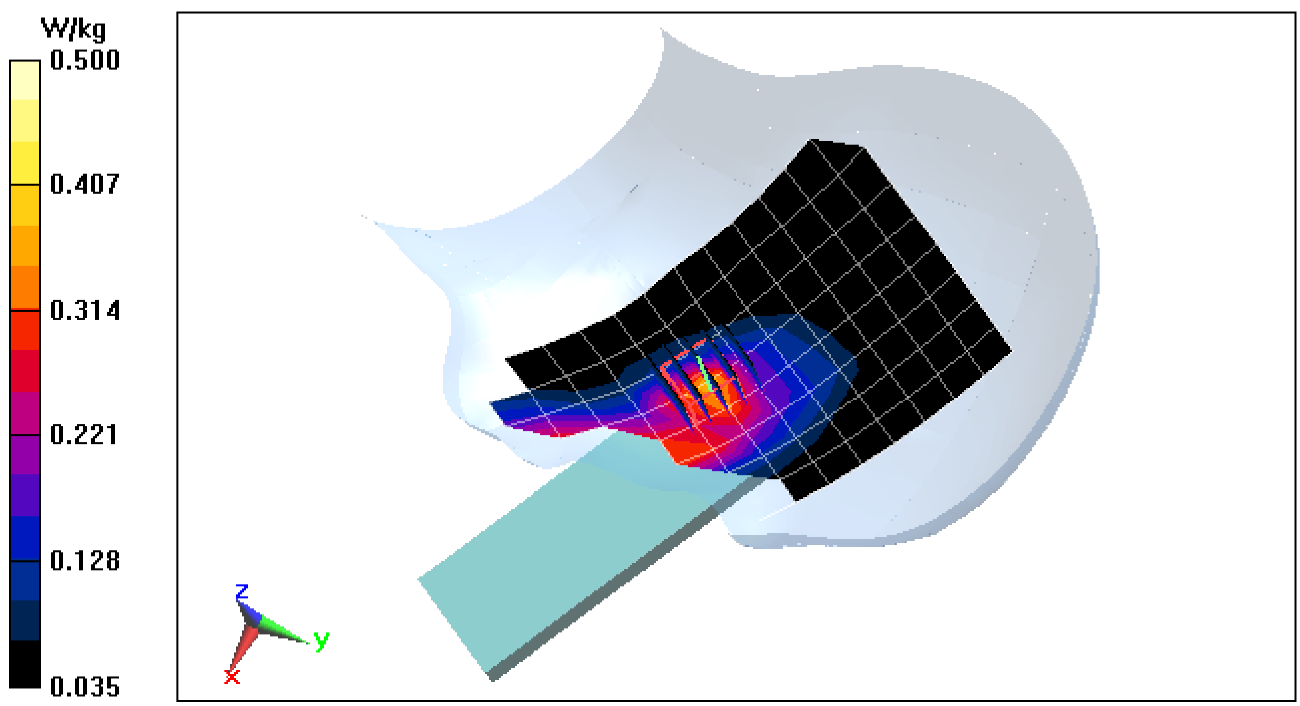
Communication System: UID 0, Cellular CDMA ; Frequency: 836.52 MHz;Duty Cycle: 1:1
Medium: 835 Head Medium parameters used (interpolated):
f = 836.52 MHz; $\sigma$ = 0.89 S/m; $\varepsilon_r$ = 40.866; $\rho$ = 1000 kg/$m^3$
Phantom section: Left Section

Test Date: 04-22-2015; Ambient Temp: 21.3°C; Tissue Temp: 21.8°C

Probe: ES3DV2 - SN3022; ConvF(6.18, 6.18, 6.18); Calibrated: 8/19/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1322; Calibrated: 8/12/2014
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

**Mode: Cell. CDMA, 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 = 20.20 V/m; Power Drift = -0.13 dB
Peak SAR (extrapolated) = 0.555 W/kg
**SAR(1 g) = 0.360 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 59C36**

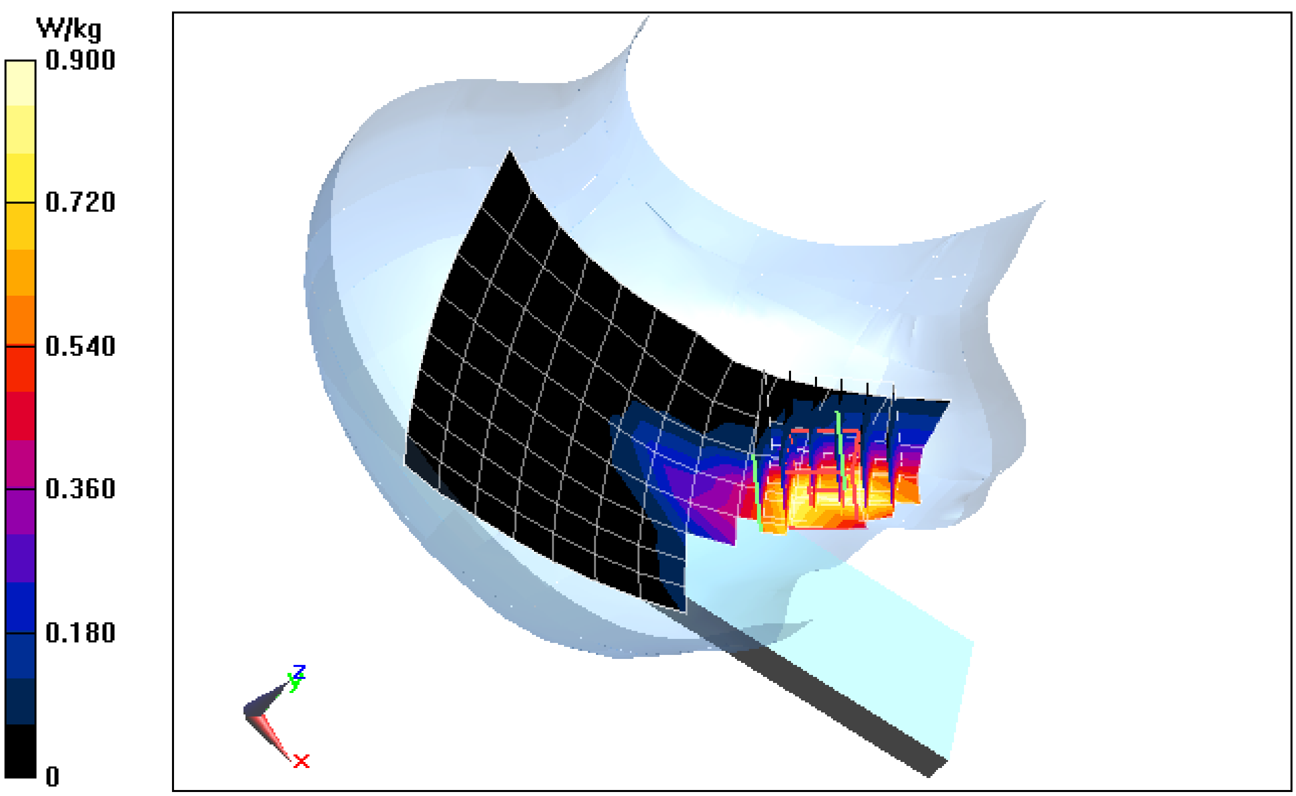
Communication System: UID 0, CDMA; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.406 S/m; $\varepsilon_r$ = 38.879; $\rho$ = 1000 kg/$m^3$
Phantom section: Right Section

Test Date: 04-13-2015; Ambient Temp: 21.9°C; Tissue Temp: 21.8°C

Probe: ES3DV2 - SN3022; ConvF(4.85, 4.85, 4.85); Calibrated: 8/19/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1322; Calibrated: 8/12/2014
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (6x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 23.69 V/m; Power Drift = -0.15 dB
Peak SAR (extrapolated) = 1.20 W/kg
**SAR(1 g) = 0.780 W/kg**



# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 1WRM1**

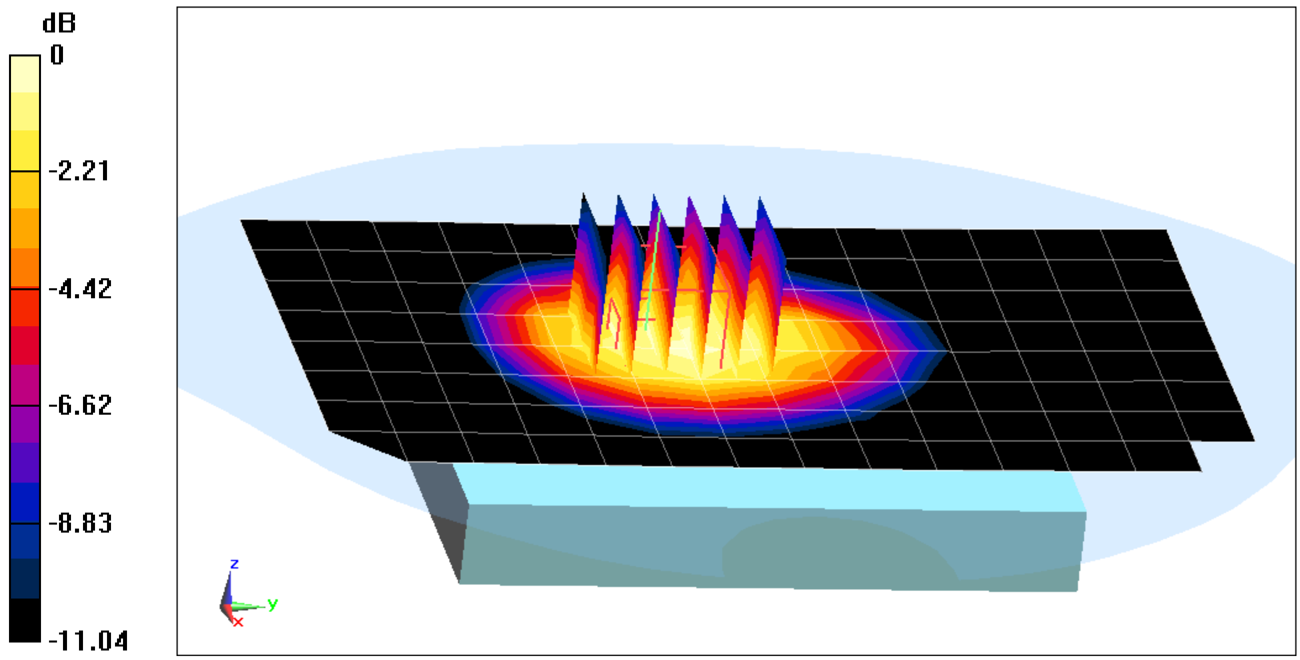
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 836.6 MHz;Duty Cycle: 1:4.15
Medium: 835 Body Medium parameters used (interpolated):
f = 836.6 MHz; σ = 1.004 S/m; $\varepsilon_r$ = 54.45; ρ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-22-2015; Ambient Temp: 21.8°C; Tissue Temp: 21.7°C

Probe: ES3DV3 - SN3333; ConvF(6.12, 6.12, 6.12); Calibrated: 10/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1408; Calibrated: 10/23/2014
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x6x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 20.87 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 0.593 W/kg
**SAR(1 g) = 0.433 W/kg**




0 dB = 0.483 W/kg = -3.16 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 1WRM1**

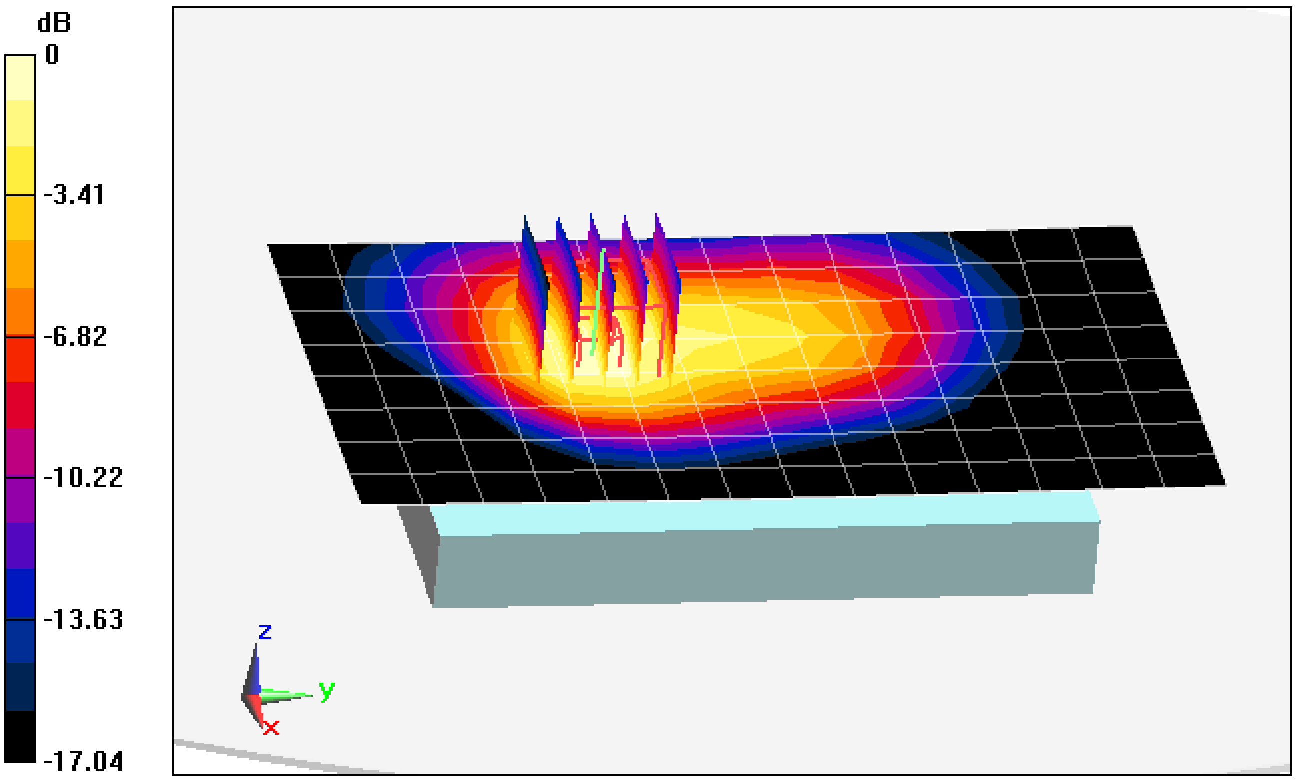
Communication System: UID 0, GSM GPRS; 2 Tx slots; Frequency: 1880 MHz;Duty Cycle: 1:4.15
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.512 S/m; $\varepsilon_r$ = 52.094; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-23-2015; Ambient Temp: 22.1°C; Tissue Temp: 21.0°C

Probe: ES3DV3 - SN3288; ConvF(4.82, 4.82, 4.82); Calibrated: 9/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2014
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1229
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 17.55 V/m; Power Drift = -0.14 dB
Peak SAR (extrapolated) = 0.690 W/kg
**SAR(1 g) = 0.438 W/kg**




0 dB = 0.520 W/kg = -2.84 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 1WRM1**

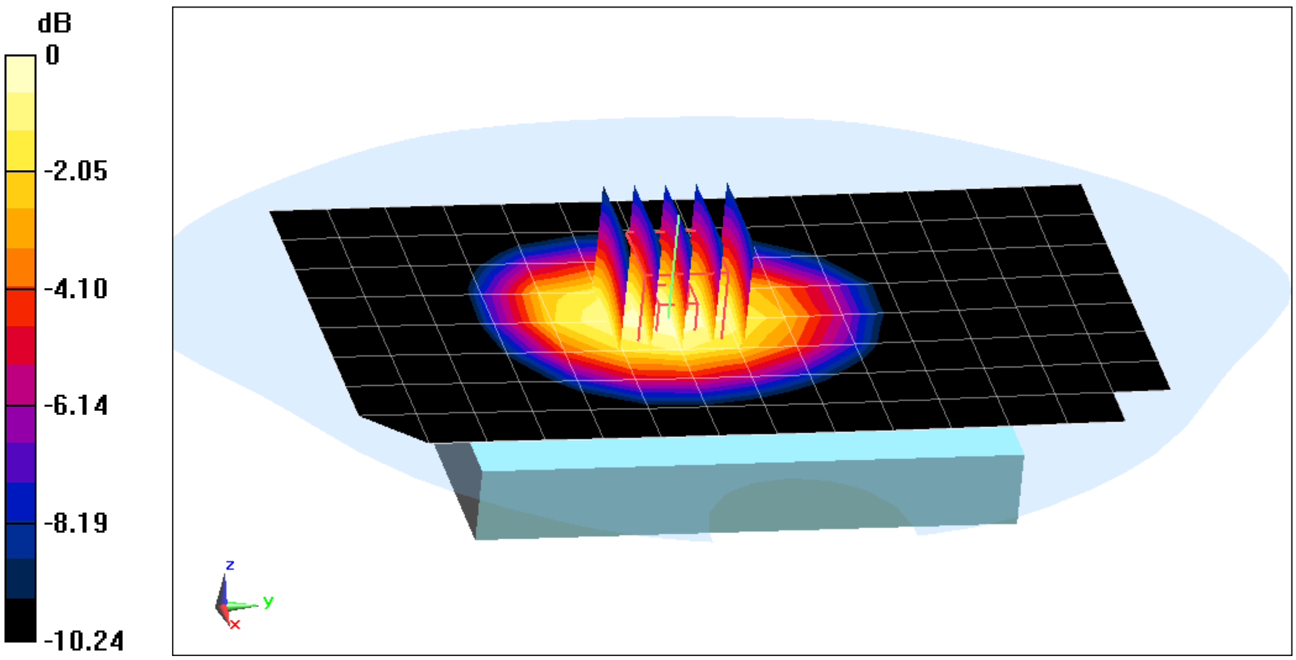
Communication System: UID 0, CDMA; Frequency: 836.52 MHz;Duty Cycle: 1:1
Medium: 835 Body Medium parameters used (interpolated):
f = 836.52 MHz; σ = 1.004 S/m; $\varepsilon_r$ = 54.451; ρ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-22-2015; Ambient Temp: 21.8°C; Tissue Temp: 21.7°C

Probe: ES3DV3 - SN3333; ConvF(6.12, 6.12, 6.12); Calibrated: 10/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1408; Calibrated: 10/23/2014
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 24.73 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 0.771 W/kg
**SAR(1 g) = 0.565 W/kg**




0 dB = 0.641 W/kg = -1.93 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

**DUT: ZNFVN210; Type: Portable Handset; Serial: 1WRM1**

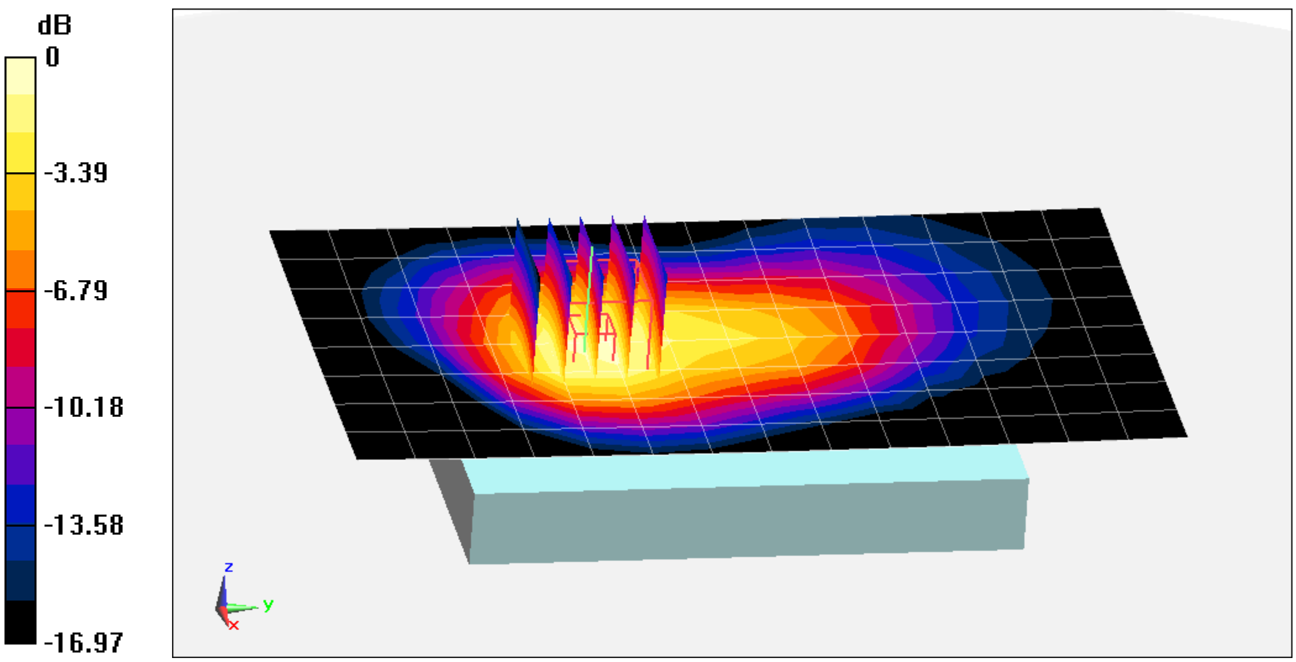
Communication System: UID 0, CDMA; Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used:
f = 1880 MHz; $\sigma$ = 1.51 S/m; $\varepsilon_r$ = 52.856; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-16-2015; Ambient Temp: 22.9°C; Tissue Temp: 21.7°C

Probe: ES3DV3 - SN3288; ConvF(4.82, 4.82, 4.82); Calibrated: 9/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2014
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1229
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

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

**Area Scan (9x15x1):** Measurement grid: dx=15mm, dy=15mm
**Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 21.17 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 1.06 W/kg
**SAR(1 g) = 0.661 W/kg**




0 dB = 0.796 W/kg = -0.99 dBW/kg

# APPENDIX B: SYSTEM VERIFICATION

# PCTEST ENGINEERING LABORATORY, INC.

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

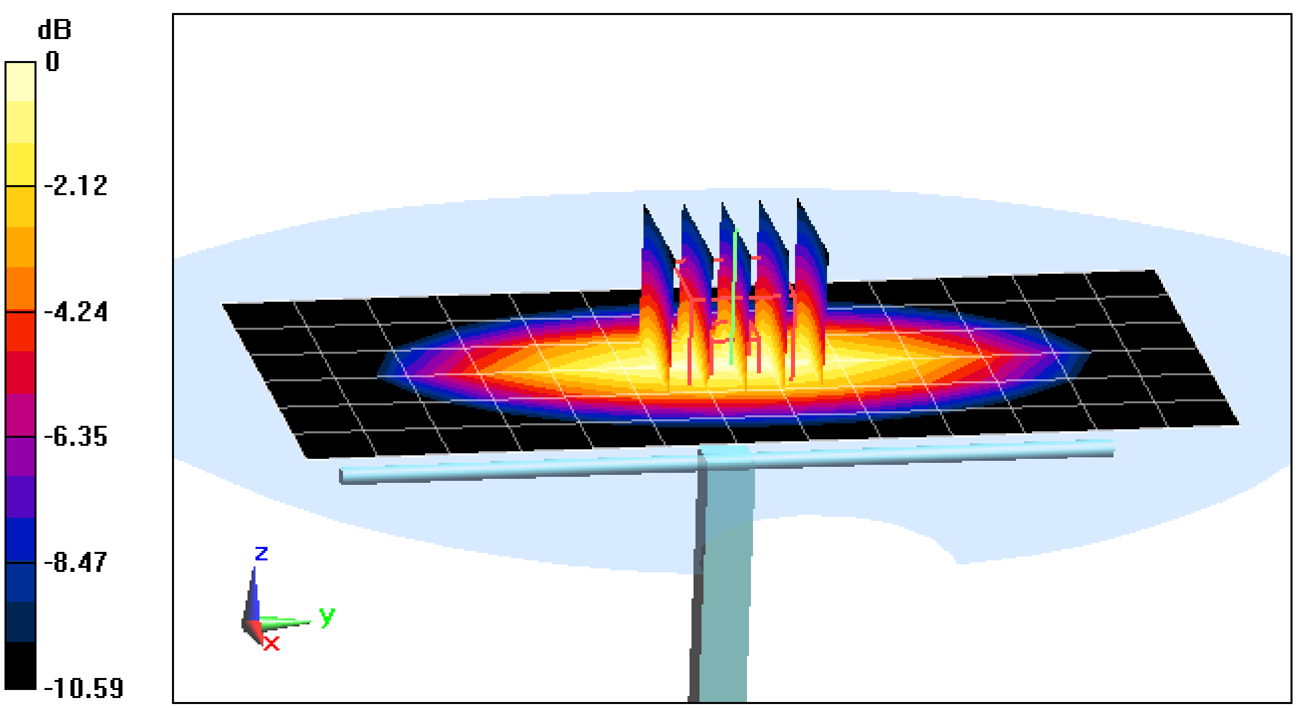
Communication System: UID 0, CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 835 Head Medium parameters used:
f = 835 MHz; $\sigma$ = 0.888 S/m; $\varepsilon_r$ = 40.883; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-22-2015; Ambient Temp: 21.3°C; Tissue Temp: 21.8°C

Probe: ES3DV2 - SN3022; ConvF(6.18, 6.18, 6.18); Calibrated: 8/19/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1322; Calibrated: 8/12/2014
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 835 MHz System Verification

**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) = 1.30 W/kg
**SAR(1 g) = 0.880 W/kg**
Deviation = -4.35 %




0 dB = 1.03 W/kg = 0.13 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

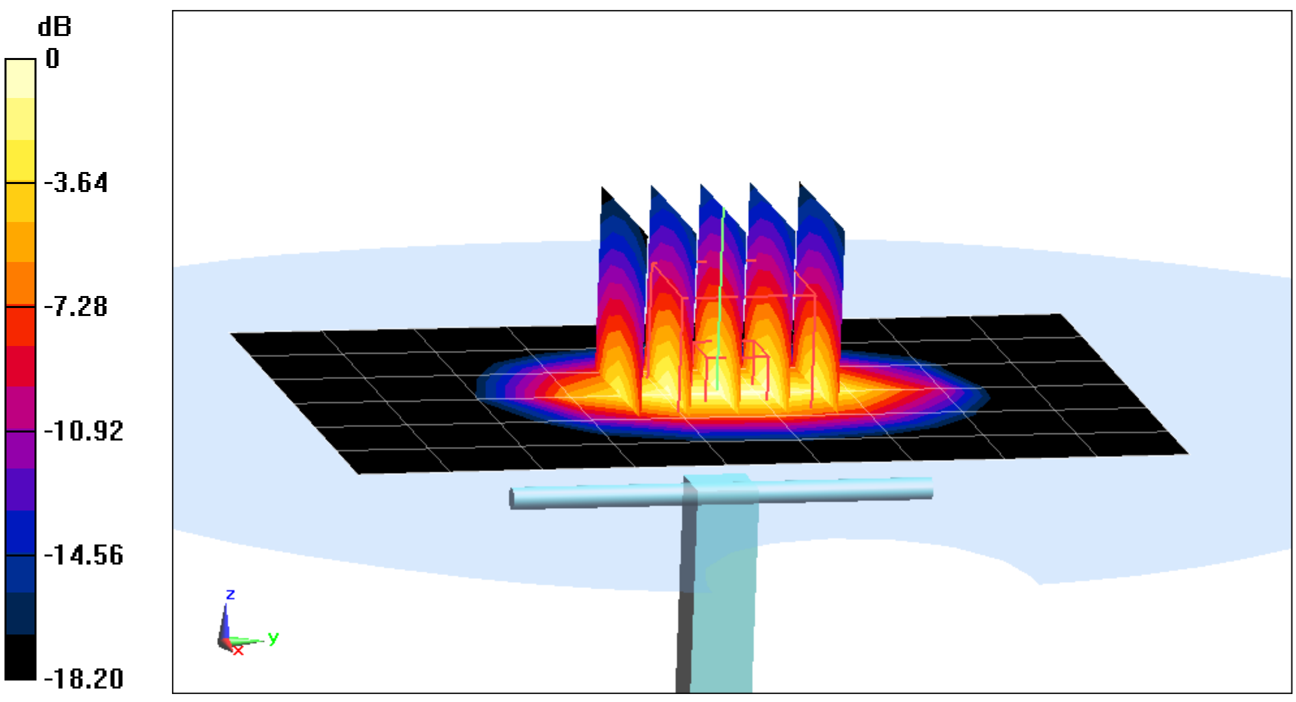
Communication System: UID 0, CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used (interpolated):
f = 1900 MHz; $\sigma$ = 1.427 S/m; $\varepsilon_r$ = 38.78; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 04-13-2015; Ambient Temp: 21.9°C; Tissue Temp: 21.8°C

Probe: ES3DV2 - SN3022; ConvF(4.85, 4.85, 4.85); Calibrated: 8/19/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1322; Calibrated: 8/12/2014
Phantom: SAM with CRP v4.0; Type: QD000P40CD; Serial: TP:1800
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 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) = 7.78 W/kg
**SAR(1 g) = 4.3 W/kg**
Deviation = 6.97 %




0 dB = 5.39 W/kg = 7.32 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

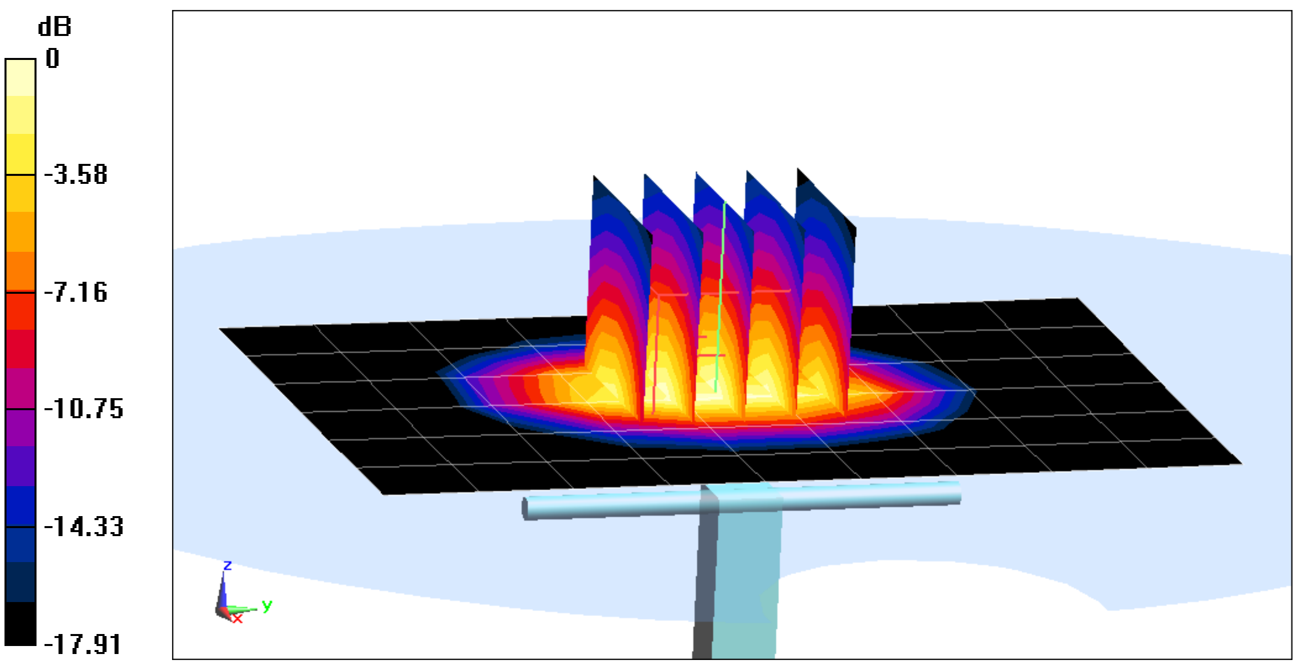
Communication System: UID 0, CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 Head Medium parameters used (interpolated):
f = 1900 MHz; σ = 1.397 S/m; $\varepsilon_r$ = 39.386; ρ = 1000 $kg/m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 04-22-2015; Ambient Temp: 23.2°C; Tissue Temp: 22.3°C

Probe: ES3DV3 - SN3318; ConvF(5.05, 5.05, 5.05); Calibrated: 1/23/2015;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1272; Calibrated: 1/14/2015
Phantom: SAM Front; Type: SAM; Serial: 1686
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 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) = 7.26 W/kg
**SAR(1 g) = 3.96 W/kg**
Deviation = -1.49 %




0 dB = 5.03 W/kg = 7.02 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

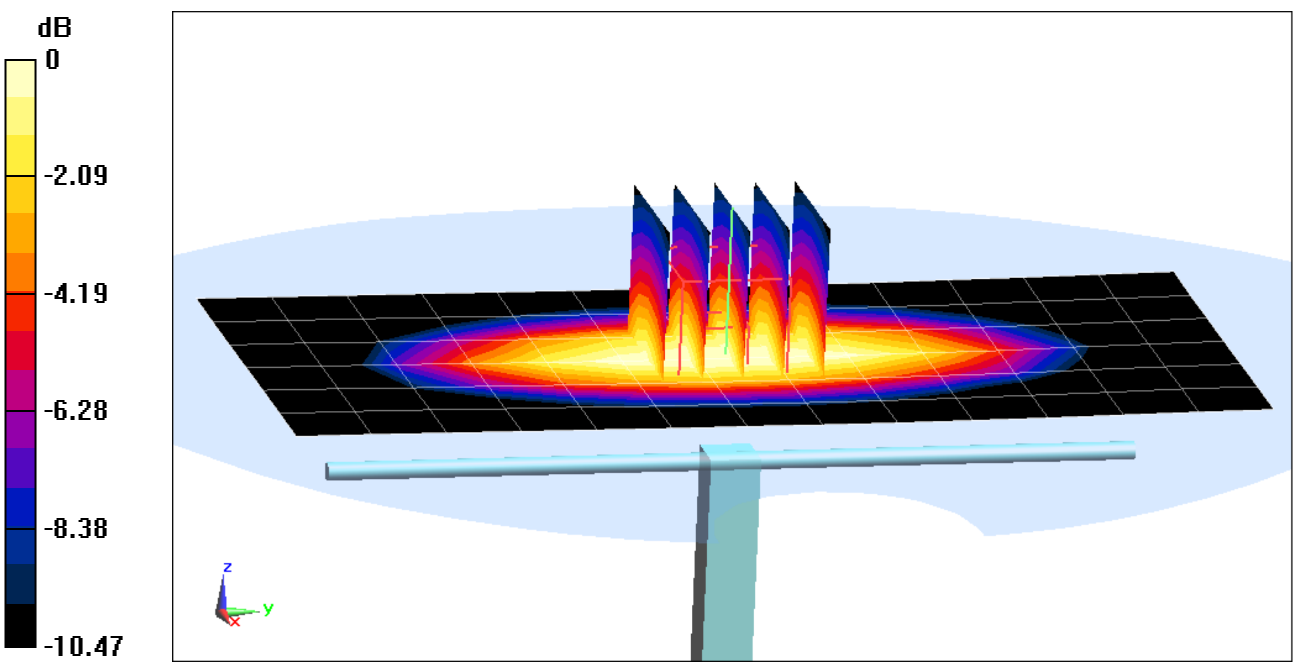
Communication System: UID 0, CW; Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 835 Body Medium parameters used:
f = 835 MHz; $\sigma$ = 1.003 S/m; $\varepsilon_r$ = 54.467; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section; Space: 1.5 cm

Test Date: 04-22-2015; Ambient Temp: 21.8°C; Tissue Temp: 21.7°C

Probe: ES3DV3 - SN3333; ConvF(6.12, 6.12, 6.12); Calibrated: 10/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1408; Calibrated: 10/23/2014
Phantom: Main TWIN SAM; Type: QD000P40CC; Serial: TP-1406
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 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) = 1.38 W/kg
**SAR(1 g) = 0.941 W/kg**
Deviation = 2.95 %




0 dB = 1.10 W/kg = 0.41 dBW/kg

# PCTEST ENGINEERING LABORATORY, INC.

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

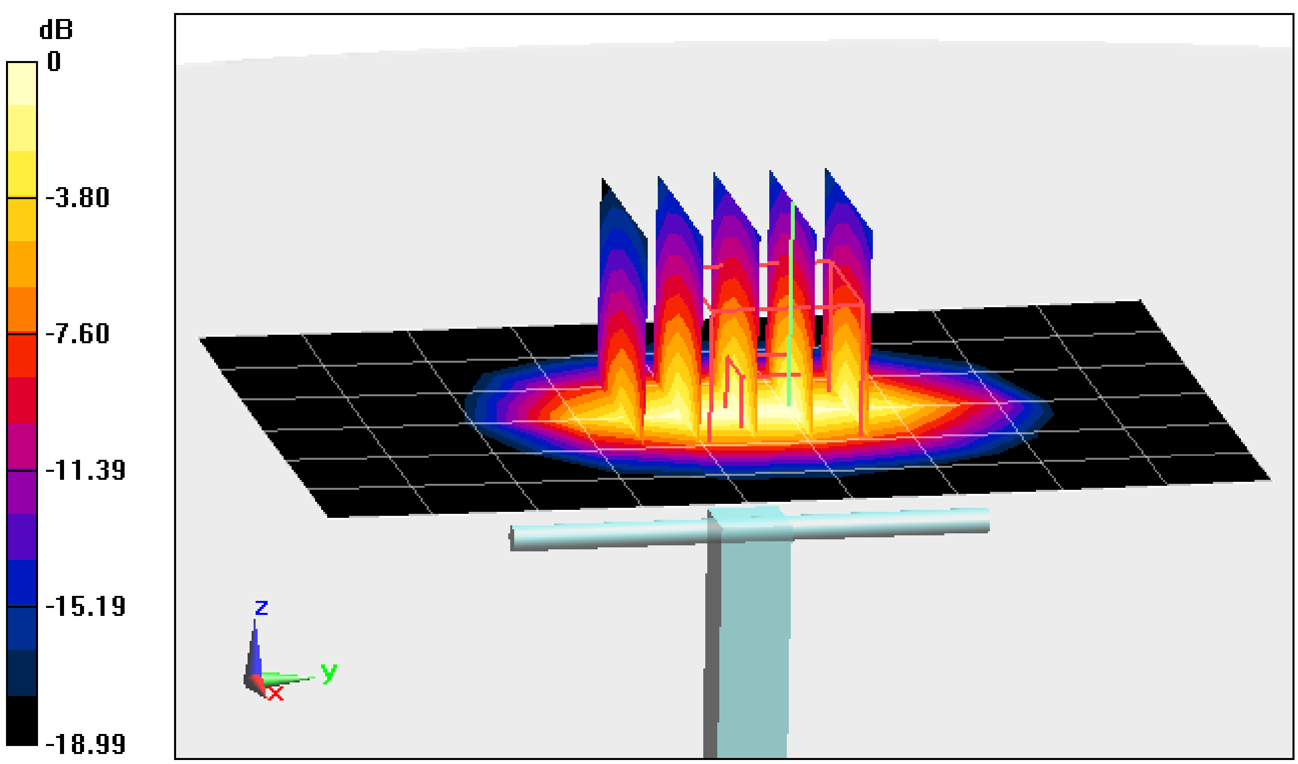
Communication System: UID 0, CW; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 Body Medium parameters used (interpolated):
f = 1900 MHz; σ = 1.535 S/m; $\varepsilon_r$ = 51.987; ρ = 1000 kg/$m^3$
Phantom section: Flat Section; Space: 1.0 cm

Test Date: 04-23-2015; Ambient Temp: 22.1°C; Tissue Temp: 21.0°C

Probe: ES3DV3 - SN3288; ConvF(4.82, 4.82, 4.82); Calibrated: 9/24/2014;
Sensor-Surface: 3mm (Mechanical Surface Detection)
Electronics: DAE4 Sn1364; Calibrated: 9/18/2014
Phantom: ELI v5.0; Type: QDOVA001BB; Serial: 1229
Measurement SW: DASY52, Version 52.8 (8);SEMCAD X Version 14.6.10 (7331)

## 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) = 7.54 W/kg
**SAR(1 g) = 4.2 W/kg**
Deviation = 3.96 %




0 dB = 4.95 W/kg = 6.95 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: **ES3-3022_Aug14/2**

# CALIBRATION CERTIFICATE (Replacement of No: ES3-3022_Aug14)

Object: ES3DV2 - SN:3022

Calibration procedure(s): QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

CC
12/12/14

Calibration date: August 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 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Power sensor E4412A | MY41498087 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 03-Apr-14 (No. 217-01915) | Apr-15 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919) | Apr-15 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920) | Apr-15 |
| 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: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 3, 2014

**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**

## 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 ES3DV2

## SN:3022

Manufactured: April 15, 2003
Calibrated: August 19, 2014

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

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (μV/(V/m)$^2$)[A] | 1.00 | 1.04 | 0.96 | ± 10.1 % |
| DCP (mV)[B] | 103.0 | 96.3 | 101.6 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 181.8 | ±2.7 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 183.0 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 192.3 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.51 | 63.1 | 12.7 | 10.00 | 42.6 | ±1.9 % |
| | | Y | 2.62 | 63.1 | 12.9 | | 42.7 | |
| | | Z | 3.12 | 65.7 | 13.6 | | 40.4 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.33 | 67.8 | 19.2 | 2.91 | 145.9 | ±0.9 % |
| | | Y | 3.13 | 64.9 | 16.9 | | 147.4 | |
| | | Z | 3.20 | 66.4 | 18.2 | | 139.6 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.05 | 70.1 | 19.8 | 1.87 | 147.2 | ±0.9 % |
| | | Y | 2.62 | 65.1 | 16.2 | | 147.4 | |
| | | Z | 2.85 | 68.2 | 18.4 | | 141.7 | |
| 10013-CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.10 | 70.9 | 23.6 | 9.46 | 143.9 | ±3.0 % |
| | | Y | 11.04 | 70.2 | 22.9 | | 144.2 | |
| | | Z | 10.77 | 70.2 | 23.1 | | 134.7 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 19.66 | 99.7 | 28.6 | 9.39 | 126.0 | ±1.9 % |
| | | Y | 11.04 | 89.6 | 25.5 | | 138.9 | |
| | | Z | 10.45 | 88.8 | 24.9 | | 137.5 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 20.19 | 99.6 | 28.5 | 9.57 | 142.0 | ±2.5 % |
| | | Y | 10.53 | 88.4 | 25.0 | | 145.5 | |
| | | Z | 15.52 | 96.5 | 27.8 | | 147.6 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 31.93 | 99.6 | 25.2 | 6.56 | 149.5 | ±1.9 % |
| | | Y | 12.70 | 87.9 | 22.2 | | 148.0 | |
| | | Z | 27.00 | 99.8 | 25.7 | | 135.3 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 38.32 | 99.8 | 23.8 | 4.80 | 148.1 | ±2.2 % |
| | | Y | 9.80 | 83.2 | 19.3 | | 138.8 | |
| | | Z | 31.96 | 99.9 | 24.2 | | 128.9 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 40.03 | 99.5 | 22.8 | 3.55 | 130.5 | ±2.2 % |
| | | Y | 40.27 | 99.6 | 23.0 | | 148.1 | |
| | | Z | 43.09 | 99.7 | 22.5 | | 140.1 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 38.93 | 99.4 | 20.4 | 1.16 | 146.7 | ±1.9 % |
| | | Y | 32.83 | 92.5 | 17.9 | | 139.2 | |
| | | Z | 31.94 | 99.5 | 20.8 | | 133.1 | |
| 10039-CAB | CDMA2000 (1xRTT, RC1) | X | 4.66 | 66.8 | 19.3 | 4.57 | 144.5 | ±1.2 % |
| | | Y | 4.56 | 65.3 | 17.9 | | 137.2 | |
| | | Z | 4.52 | 66.1 | 18.7 | | 131.7 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 3.82 | 66.0 | 18.7 | 3.97 | 140.3 | ±0.9 % |
| | | Y | 3.77 | 64.5 | 17.3 | | 133.6 | |
| | | Z | 3.79 | 65.7 | 18.4 | | 128.2 | |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2) | X | 4.40 | 66.2 | 18.5 | 3.98 | 130.9 | ±1.2 % |
| | | Y | 4.39 | 65.0 | 17.4 | | 131.1 | |
| | | Z | 4.47 | 66.3 | 18.4 | | 140.0 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.30 | 67.3 | 19.8 | 5.67 | 137.4 | ±1.7 % |
| | | Y | 6.25 | 66.3 | 18.9 | | 135.9 | |
| | | Z | 6.36 | 67.4 | 19.7 | | 147.5 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.14 | 66.8 | 19.6 | 5.80 | 134.6 | ±1.7 % |
| | | Y | 6.17 | 66.1 | 18.9 | | 133.9 | |
| | | Z | 6.24 | 67.0 | 19.7 | | 144.5 | |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK) | X | 5.82 | 66.3 | 19.4 | 5.75 | 131.2 | ±1.7 % |
| | | Y | 5.82 | 65.4 | 18.6 | | 130.3 | |
| | | Z | 5.91 | 66.5 | 19.4 | | 140.4 | |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.00 | 68.5 | 21.2 | 8.10 | 124.3 | ±2.5 % |
| | | Y | 9.89 | 67.9 | 20.6 | | 124.0 | |
| | | Z | 10.05 | 68.6 | 21.2 | | 133.2 | |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.01 | 68.6 | 21.2 | 8.07 | 125.8 | ±2.5 % |
| | | Y | 9.91 | 67.9 | 20.7 | | 125.8 | |
| | | Z | 10.09 | 68.8 | 21.3 | | 134.7 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.69 | 75.5 | 26.4 | 9.28 | 144.7 | ±3.3 % |
| | | Y | 9.09 | 72.7 | 24.6 | | 143.2 | |
| | | Z | 8.54 | 72.0 | 24.5 | | 124.8 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.82 | 66.2 | 19.4 | 5.75 | 131.3 | ±1.9 % |
| | | Y | 6.06 | 66.3 | 19.1 | | 149.2 | |
| | | Z | 5.91 | 66.5 | 19.4 | | 140.7 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.27 | 66.9 | 19.7 | 5.82 | 136.5 | ±1.4 % |
| | | Y | 6.19 | 65.8 | 18.7 | | 128.4 | |
| | | Z | 6.33 | 67.0 | 19.6 | | 145.4 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.81 | 66.4 | 19.7 | 5.73 | 134.8 | ±1.7 % |
| | | Y | 4.92 | 66.1 | 19.1 | | 149.9 | |
| | | Z | 4.78 | 66.4 | 19.6 | | 141.2 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 7.83 | 76.6 | 27.2 | 9.21 | 131.4 | ±3.5 % |
| | | Y | 7.54 | 74.5 | 25.8 | | 147.8 | |
| | | Z | 7.71 | 76.7 | 27.4 | | 145.3 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.90 | 66.9 | 20.0 | 5.72 | 147.6 | ±1.4 % |
| | | Y | 4.90 | 66.0 | 19.1 | | 148.0 | |
| | | Z | 4.78 | 66.4 | 19.6 | | 141.6 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 4.90 | 66.9 | 20.0 | 5.72 | 148.1 | ±1.4 % |
| | | Y | 4.89 | 65.9 | 19.0 | | 146.9 | |
| | | Z | 4.80 | 66.5 | 19.7 | | 142.1 | |
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK) | X | 9.80 | 68.7 | 21.4 | 8.09 | 135.1 | ±2.7 % |
| | | Y | 9.78 | 68.2 | 20.9 | | 135.5 | |
| | | Z | 9.70 | 68.5 | 21.2 | | 130.2 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.79 | 68.7 | 21.4 | 8.10 | 136.4 | ±2.7 % |
| | | Y | 9.81 | 68.3 | 20.9 | | 138.0 | |
| | | Z | 9.72 | 68.6 | 21.3 | | 132.8 | |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK) | X | 9.68 | 68.6 | 21.3 | 8.03 | 136.0 | ±2.7 % |
| | | Y | 9.74 | 68.3 | 21.0 | | 137.4 | |
| | | Z | 9.62 | 68.5 | 21.2 | | 132.6 | |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK) | X | 10.20 | 69.1 | 21.5 | 8.06 | 143.4 | ±2.5 % |
| | | Y | 9.91 | 68.0 | 20.7 | | 125.8 | |
| | | Z | 10.27 | 69.4 | 21.6 | | 148.4 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.87 | 66.9 | 19.6 | 5.97 | 139.5 | ±1.9 % |
| | | Y | 7.04 | 66.9 | 19.3 | | 149.3 | |
| | | Z | 6.89 | 67.0 | 19.5 | | 143.5 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 7.66 | 75.9 | 26.9 | 9.21 | 126.1 | ±3.0 % |
| | | Y | 7.17 | 73.1 | 25.1 | | 132.1 | |
| | | Z | 7.18 | 74.6 | 26.3 | | 128.0 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 8.58 | 73.1 | 25.3 | 9.24 | 127.6 | ±3.3 % |
| | | Y | 8.22 | 71.0 | 23.7 | | 126.9 | |
| | | Z | 8.83 | 74.3 | 26.0 | | 149.8 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.69 | 75.5 | 26.5 | 9.30 | 143.8 | ±3.3 % |
| | | Y | 8.88 | 72.0 | 24.2 | | 135.2 | |
| | | Z | 8.83 | 72.9 | 25.1 | | 131.3 | |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10) | X | 5.87 | 67.0 | 19.2 | 4.87 | 141.2 | ±1.4 % |
| | | Y | 5.77 | 65.8 | 18.1 | | 136.0 | |
| | | Z | 5.71 | 66.3 | 18.6 | | 132.7 | |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.44 | 67.2 | 19.2 | 3.96 | 147.3 | ±0.9 % |
| | | Y | 4.29 | 65.3 | 17.6 | | 139.2 | |
| | | Z | 4.31 | 66.3 | 18.5 | | 139.6 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.60 | 67.1 | 19.1 | 3.46 | 137.8 | ±0.7 % |
| | | Y | 3.44 | 64.8 | 17.2 | | 129.6 | |
| | | Z | 3.48 | 66.2 | 18.4 | | 130.5 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.50 | 66.9 | 18.9 | 3.39 | 139.5 | ±0.7 % |
| | | Y | 3.38 | 64.8 | 17.2 | | 132.0 | |
| | | Z | 3.48 | 66.5 | 18.5 | | 133.1 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.12 | 66.7 | 19.6 | 5.81 | 133.3 | ±1.9 % |
| | | Y | 6.35 | 66.7 | 19.3 | | 149.3 | |
| | | Z | 6.17 | 66.8 | 19.5 | | 132.7 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.72 | 67.4 | 20.0 | 6.06 | 138.7 | ±1.7 % |
| | | Y | 6.63 | 66.3 | 19.1 | | 131.4 | |
| | | Z | 6.72 | 67.3 | 19.9 | | 138.7 | |
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle) | X | 2.90 | 69.9 | 19.8 | 1.71 | 146.4 | ±0.5 % |
| | | Y | 2.54 | 65.2 | 16.5 | | 139.3 | |
| | | Z | 2.75 | 68.1 | 18.5 | | 146.4 | |
| 10316-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle) | X | 10.12 | 69.3 | 21.9 | 8.36 | 142.9 | ±3.0 % |
| | | Y | 10.01 | 68.5 | 21.3 | | 135.2 | |
| | | Z | 10.11 | 69.3 | 21.9 | | 141.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.59 | 68.2 | 19.0 | 3.76 | 126.7 | ±0.7 % |
| | | Y | 4.59 | 67.2 | 18.0 | | 142.4 | |
| | | Z | 4.64 | 68.5 | 19.0 | | 143.0 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.64 | 68.8 | 19.3 | 3.77 | 147.1 | ±0.9 % |
| | | Y | 4.47 | 67.1 | 17.9 | | 139.6 | |
| | | Z | 4.54 | 68.4 | 18.9 | | 147.2 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.66 | 69.0 | 19.4 | 1.54 | 145.8 | ±0.5 % |
| | | Y | 2.40 | 64.8 | 16.2 | | 140.0 | |
| | | Z | 2.62 | 67.8 | 18.4 | | 147.2 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.97 | 69.1 | 21.7 | 8.23 | 142.0 | ±3.0 % |
| | | Y | 10.08 | 68.9 | 21.4 | | 145.8 | |
| | | Z | 10.01 | 69.2 | 21.8 | | 143.3 | |

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 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: ES3DV2 - SN:3022

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.39 | 6.39 | 6.39 | 0.20 | 2.24 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.18 | 6.18 | 6.18 | 0.23 | 1.98 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.04 | 5.04 | 5.04 | 0.51 | 1.35 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 4.85 | 4.85 | 4.85 | 0.38 | 1.66 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.31 | 4.31 | 4.31 | 0.66 | 1.28 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.13 | 4.13 | 4.13 | 0.76 | 1.28 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

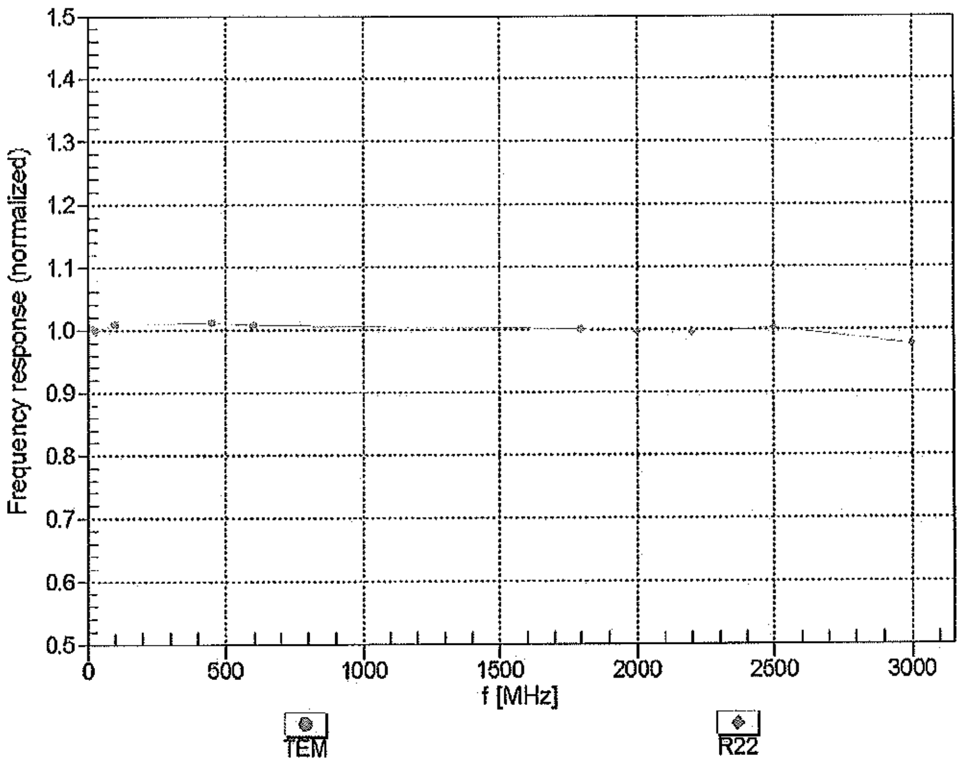
# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 450 | 56.7 | 0.94 | 6.78 | 6.78 | 6.78 | 0.12 | 1.30 | ± 13.3 % |
| 600 | 56.1 | 0.95 | 6.72 | 6.72 | 6.72 | 0.05 | 1.20 | ± 13.3 % |
| 750 | 55.5 | 0.96 | 6.02 | 6.02 | 6.02 | 0.23 | 2.05 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 5.98 | 5.98 | 5.98 | 0.29 | 1.85 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.70 | 4.70 | 4.70 | 0.66 | 1.25 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.49 | 4.49 | 4.49 | 0.33 | 2.02 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.05 | 4.05 | 4.05 | 0.80 | 1.01 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 3.94 | 3.94 | 3.94 | 0.68 | 1.03 | ± 12.0 % |

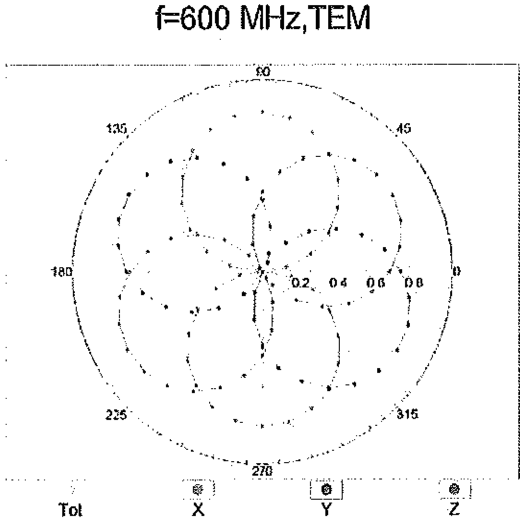
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

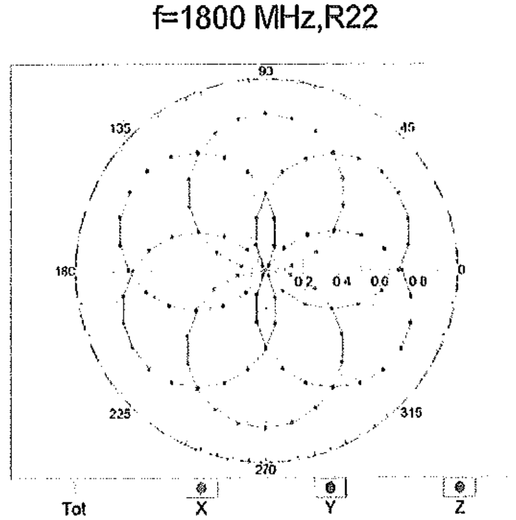
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)

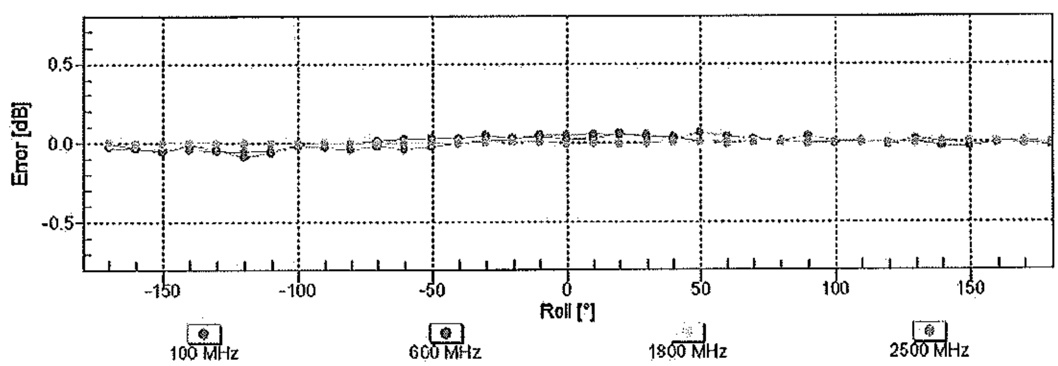



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

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



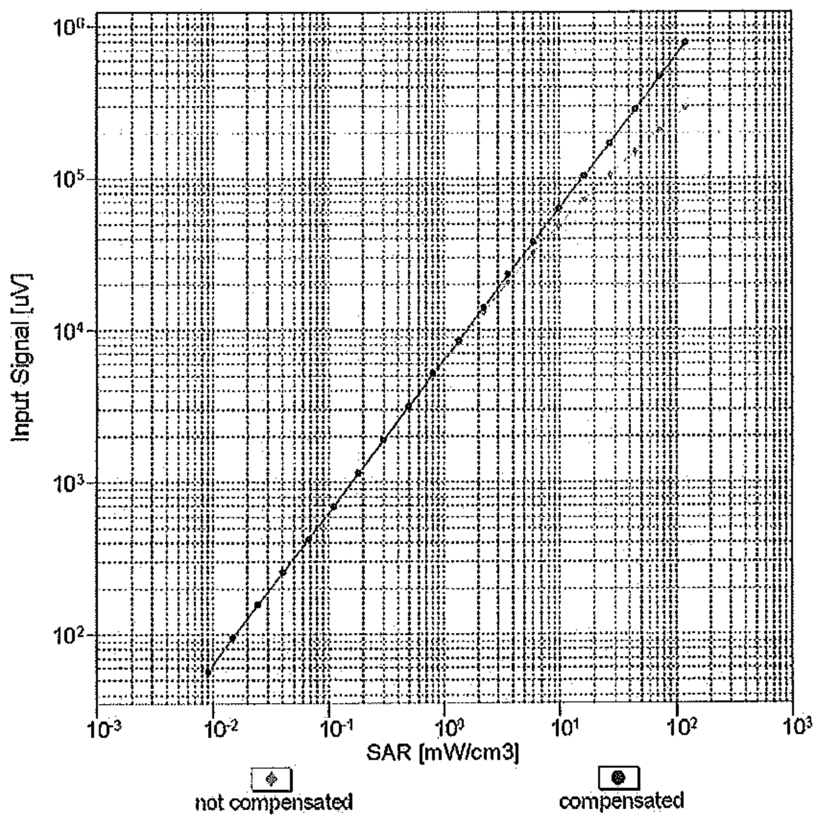



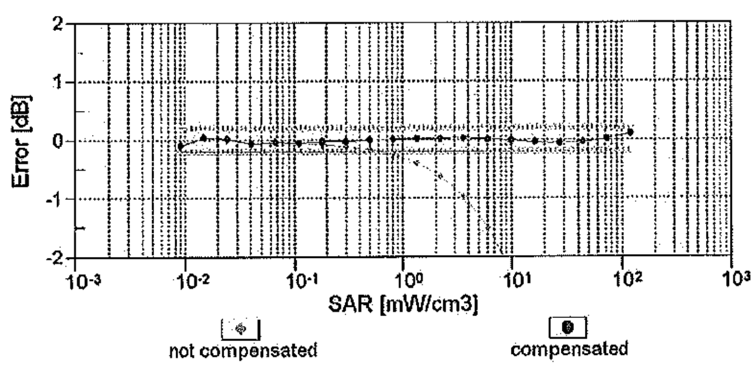




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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

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

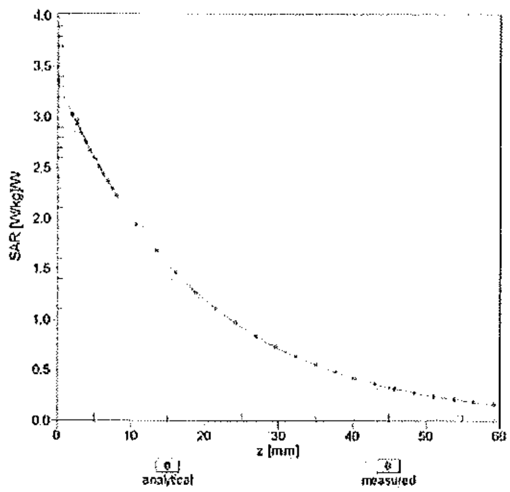


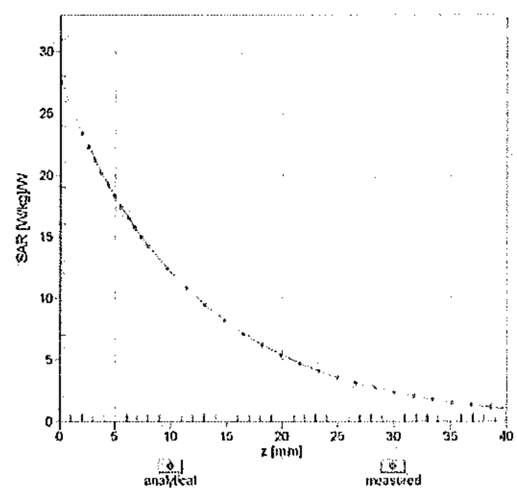

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

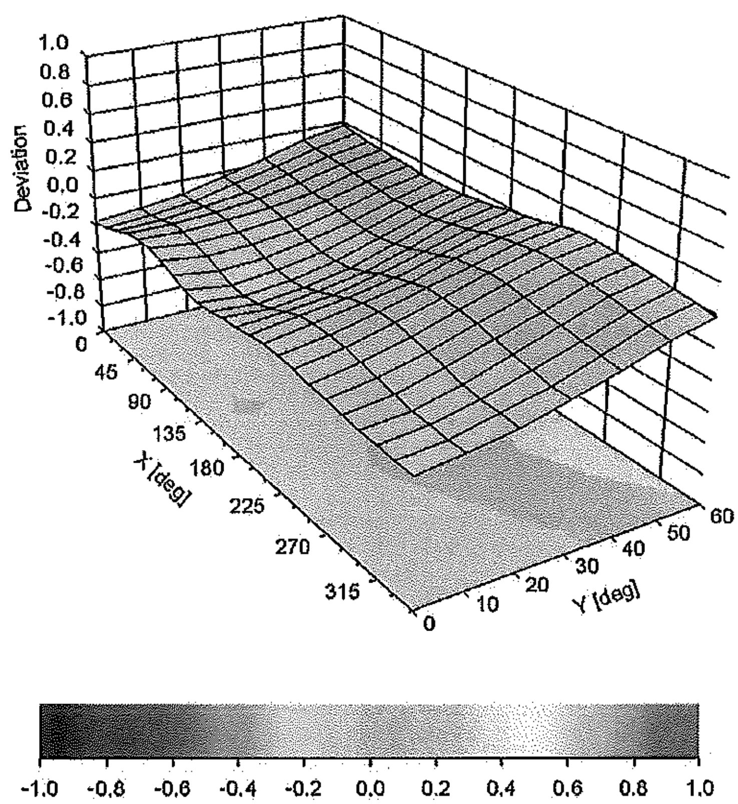



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -80.3 |
| 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
**S** Servizio svizzero di taratura
Swiss Calibration Service

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

**Accreditation No.: SCS 0108**

**Client** **PC Test**

**Certificate No: ES3-3318_Jan15**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3318

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

CC
1/30/15

Calibration date: January 23, 2015

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Power sensor E4412A | MY41498087 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 03-Apr-14 (No. 217-01915) | Apr-15 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919) | Apr-15 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920) | Apr-15 |
| Reference Probe ES3DV2 | SN: 3013 | 30-Dec-14 (No. ES3-3013_Dec14) | Dec-15 |
| DAE4 | SN: 660 | 14-Jan-15 (No. DAE4-660_Jan15) | Jan-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Israe Elnaouq | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 26, 2015

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

## Glossary:

| | |
|---|---|
| TSL | tissue simulating liquid |
| NORMx,y,z | sensitivity in free space |
| ConvF | sensitivity in TSL / NORMx,y,z |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

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

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the $E^2$-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ES3DV3

## SN:3318

| | |
|---|---|
| Manufactured: | January 10, 2012 |
| Calibrated: | January 23, 2015 |

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (μV/(V/m)$^2$)[A] | 1.15 | 0.92 | 1.28 | ± 10.1 % |
| DCP (mV)[B] | 106.4 | 109.2 | 103.4 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 200.6 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 185.3 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 207.7 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 3.26 | 66.4 | 14.0 | 10.00 | 41.4 | ±1.2 % |
| | | Y | 1.76 | 59.6 | 9.8 | | 36.1 | |
| | | Z | 1.82 | 57.7 | 9.6 | | 43.6 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.48 | 68.9 | 19.9 | 2.91 | 120.2 | ±0.5 % |
| | | Y | 3.76 | 70.1 | 19.9 | | 146.0 | |
| | | Z | 3.11 | 66.0 | 17.9 | | 124.4 | |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.71 | 74.2 | 21.7 | 1.87 | 121.7 | ±0.7 % |
| | | Y | 3.65 | 73.3 | 20.7 | | 147.5 | |
| | | Z | 2.77 | 67.4 | 17.8 | | 126.6 | |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.68 | 69.5 | 22.7 | 9.46 | 114.7 | ±2.5 % |
| | | Y | 10.82 | 70.4 | 23.0 | | 139.8 | |
| | | Z | 11.22 | 71.1 | 23.7 | | 122.2 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 16.13 | 95.0 | 26.6 | 9.39 | 122.7 | ±2.2 % |
| | | Y | 4.61 | 73.1 | 17.2 | | 130.8 | |
| | | Z | 15.10 | 92.0 | 25.4 | | 135.9 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 17.03 | 96.8 | 27.5 | 9.57 | 113.0 | ±1.9 % |
| | | Y | 4.15 | 71.7 | 16.8 | | 119.9 | |
| | | Z | 21.50 | 98.0 | 27.5 | | 130.9 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 35.51 | 99.5 | 24.5 | 6.56 | 147.6 | ±2.7 % |
| | | Y | 6.12 | 77.2 | 17.1 | | 118.1 | |
| | | Z | 38.50 | 99.7 | 24.7 | | 114.0 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 45.57 | 99.9 | 23.2 | 4.80 | 113.3 | ±1.7 % |
| | | Y | 2.73 | 68.4 | 12.6 | | 133.3 | |
| | | Z | 54.59 | 99.9 | 22.9 | | 131.0 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 53.68 | 99.5 | 21.9 | 3.55 | 123.0 | ±3.0 % |
| | | Y | 60.05 | 99.8 | 21.1 | | 144.9 | |
| | | Z | 66.60 | 99.6 | 21.6 | | 140.7 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 20.92 | 99.4 | 21.8 | 1.16 | 136.6 | ±2.2 % |
| | | Y | 95.40 | 88.3 | 13.8 | | 117.6 | |
| | | Z | 100.00 | 99.5 | 18.7 | | 110.1 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.50 | 68.1 | 20.2 | 5.67 | 130.5 | ±1.2 % |
| | | Y | 6.11 | 66.7 | 19.2 | | 107.2 | |
| | | Z | 6.55 | 68.2 | 20.1 | | 142.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.76 | 74.8 | 25.9 | 9.29 | 116.0 | ±2.5 % |
| | | Y | 8.85 | 72.2 | 24.1 | | 134.9 | |
| | | Z | 10.83 | 77.4 | 27.2 | | 131.5 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.36 | 67.7 | 20.1 | 5.80 | 128.7 | ±1.2 % |
| | | Y | 5.92 | 66.1 | 19.0 | | 106.6 | |
| | | Z | 6.42 | 67.7 | 20.0 | | 140.4 | |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.20 | 69.1 | 21.6 | 8.07 | 118.1 | ±2.5 % |
| | | Y | 10.27 | 69.3 | 21.4 | | 143.9 | |
| | | Z | 10.43 | 69.7 | 21.8 | | 131.0 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.09 | 73.7 | 25.5 | 9.28 | 112.0 | ±2.7 % |
| | | Y | 8.35 | 71.5 | 23.9 | | 131.1 | |
| | | Z | 9.58 | 74.4 | 25.6 | | 126.8 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.01 | 67.0 | 19.8 | 5.75 | 126.4 | ±1.2 % |
| | | Y | 6.17 | 67.7 | 19.9 | | 148.9 | |
| | | Z | 6.07 | 67.1 | 19.7 | | 137.2 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.41 | 67.4 | 19.9 | 5.82 | 130.9 | ±0.9 % |
| | | Y | 6.06 | 66.2 | 19.0 | | 109.1 | |
| | | Z | 6.54 | 67.7 | 20.0 | | 142.6 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 4.79 | 66.5 | 19.8 | 5.73 | 109.4 | ±0.9 % |
| | | Y | 4.82 | 67.1 | 19.8 | | 128.8 | |
| | | Z | 4.85 | 66.4 | 19.5 | | 119.0 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.44 | 79.3 | 28.7 | 9.21 | 125.1 | ±2.5 % |
| | | Y | 7.15 | 75.0 | 26.0 | | 144.0 | |
| | | Z | 10.13 | 83.8 | 30.8 | | 141.9 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.13 | 68.2 | 20.8 | 5.72 | 146.5 | ±0.9 % |
| | | Y | 4.77 | 66.8 | 19.6 | | 125.2 | |
| | | Z | 4.81 | 66.2 | 19.4 | | 118.5 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 5.11 | 68.1 | 20.7 | 5.72 | 146.4 | ±0.9 % |
| | | Y | 4.79 | 67.0 | 19.7 | | 126.0 | |
| | | Z | 4.88 | 66.6 | 19.7 | | 118.9 | |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.63 | 68.3 | 21.2 | 8.10 | 108.2 | ±2.5 % |
| | | Y | 9.84 | 68.9 | 21.3 | | 135.5 | |
| | | Z | 9.99 | 69.2 | 21.7 | | 124.0 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.99 | 67.3 | 19.7 | 5.97 | 134.8 | ±0.9 % |
| | | Y | 6.73 | 66.8 | 19.2 | | 115.9 | |
| | | Z | 6.71 | 66.2 | 19.0 | | 106.3 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 7.79 | 76.4 | 27.0 | 9.21 | 126.4 | ±2.5 % |
| | | Y | 7.19 | 75.1 | 26.1 | | 144.7 | |
| | | Z | 10.12 | 83.9 | 30.9 | | 142.0 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 8.19 | 71.9 | 24.7 | 9.24 | 103.3 | ±2.2 % |
| | | Y | 7.76 | 70.8 | 23.6 | | 122.0 | |
| | | Z | 9.31 | 75.2 | 26.4 | | 119.1 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.90 | 73.0 | 25.1 | 9.30 | 108.7 | ±2.2 % |
| | | Y | 8.38 | 71.6 | 24.0 | | 129.7 | |
| | | Z | 10.15 | 76.5 | 26.9 | | 126.1 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.42 | 67.2 | 19.2 | 3.96 | 119.1 | ±0.7 % |
| | | Y | 4.71 | 68.5 | 19.5 | | 143.8 | |
| | | Z | 4.39 | 66.7 | 18.6 | | 131.7 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.65 | 67.5 | 19.3 | 3.46 | 111.3 | ±0.5 % |
| | | Y | 3.89 | 69.0 | 19.6 | | 130.9 | |
| | | Z | 3.49 | 66.1 | 18.2 | | 122.4 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.60 | 67.6 | 19.3 | 3.39 | 114.4 | ±0.5 % |
| | | Y | 3.85 | 69.1 | 19.7 | | 133.4 | |
| | | Z | 3.45 | 66.2 | 18.2 | | 123.7 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.36 | 67.6 | 20.1 | 5.81 | 128.7 | ±1.2 % |
| | | Y | 5.95 | 66.1 | 19.0 | | 106.5 | |
| | | Z | 6.39 | 67.6 | 19.9 | | 140.7 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.98 | 68.4 | 20.6 | 6.06 | 134.9 | ±1.2 % |
| | | Y | 6.52 | 66.7 | 19.3 | | 111.3 | |
| | | Z | 7.06 | 68.6 | 20.5 | | 146.2 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.97 | 69.7 | 19.7 | 3.76 | 122.2 | ±0.5 % |
| | | Y | 5.31 | 71.6 | 20.2 | | 143.6 | |
| | | Z | 4.54 | 67.3 | 18.2 | | 133.0 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.77 | 69.4 | 19.6 | 3.77 | 120.8 | ±0.5 % |
| | | Y | 5.40 | 72.4 | 20.6 | | 141.3 | |
| | | Z | 4.71 | 68.5 | 18.9 | | 131.5 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 3.07 | 71.7 | 20.7 | 1.54 | 120.5 | ±0.7 % |
| | | Y | 3.52 | 73.8 | 21.0 | | 142.0 | |
| | | Z | 2.38 | 66.1 | 17.4 | | 129.6 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.73 | 68.3 | 21.2 | 8.23 | 114.7 | ±2.5 % |
| | | Y | 9.99 | 69.2 | 21.5 | | 138.0 | |
| | | Z | 10.10 | 69.4 | 21.9 | | 125.3 | |

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 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.58 | 6.58 | 6.58 | 0.36 | 1.73 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.39 | 6.39 | 6.39 | 0.80 | 1.14 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.27 | 5.27 | 5.27 | 0.76 | 1.19 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.05 | 5.05 | 5.05 | 0.44 | 1.55 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 4.78 | 4.78 | 4.78 | 0.80 | 1.23 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.50 | 4.50 | 4.50 | 0.55 | 1.49 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.34 | 4.34 | 4.34 | 0.76 | 1.32 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

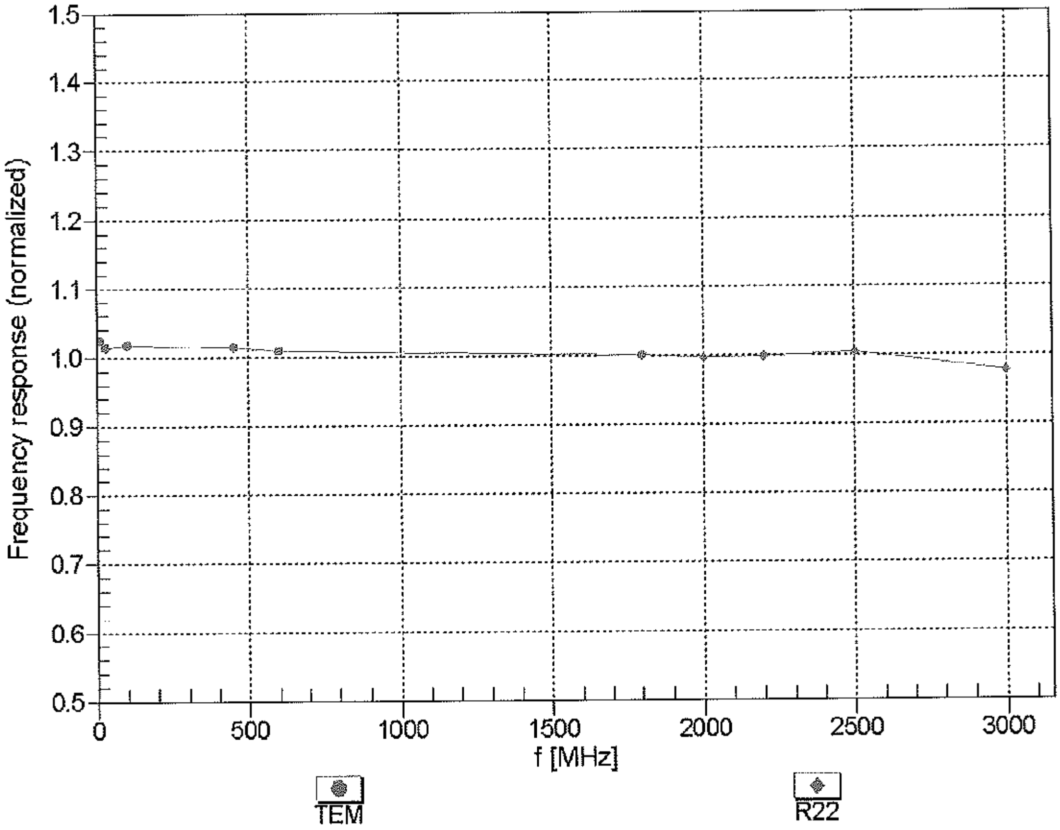
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.22 | 6.22 | 6.22 | 0.67 | 1.28 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.23 | 6.23 | 6.23 | 0.80 | 1.19 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.95 | 4.95 | 4.95 | 0.40 | 1.77 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.76 | 4.76 | 4.76 | 0.60 | 1.48 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.52 | 4.52 | 4.52 | 0.80 | 1.19 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.37 | 4.37 | 4.37 | 0.72 | 1.23 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.17 | 4.17 | 4.17 | 0.80 | 1.00 | ± 12.0 % |

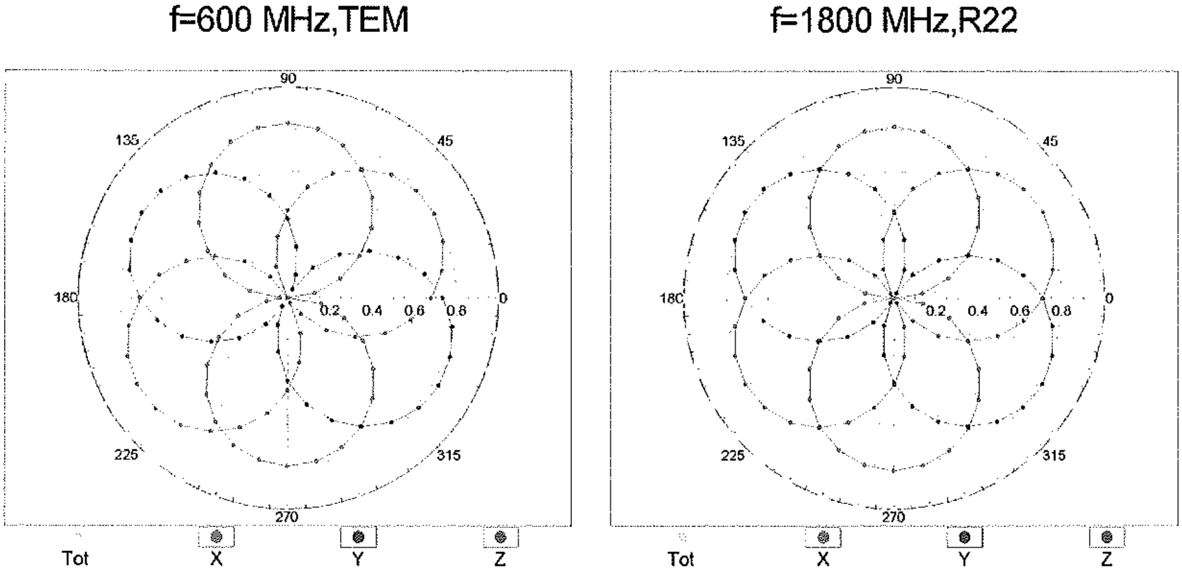
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

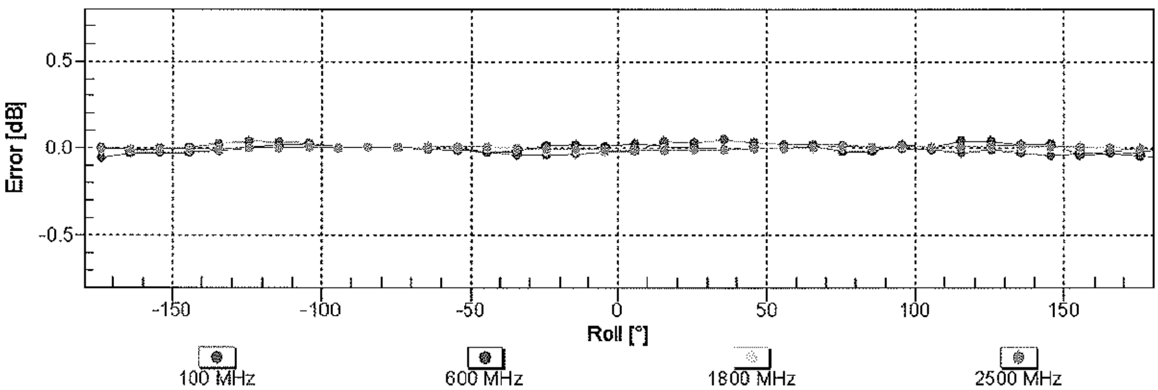
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)




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

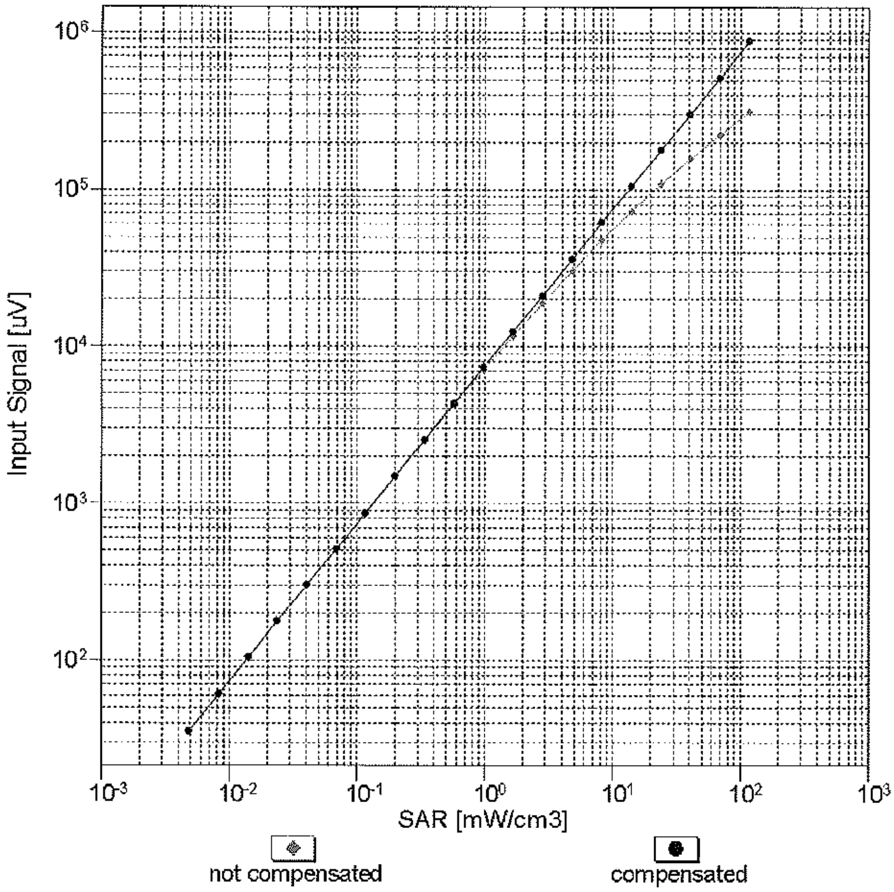
# Receiving Pattern (ϕ), $\vartheta = 0°$

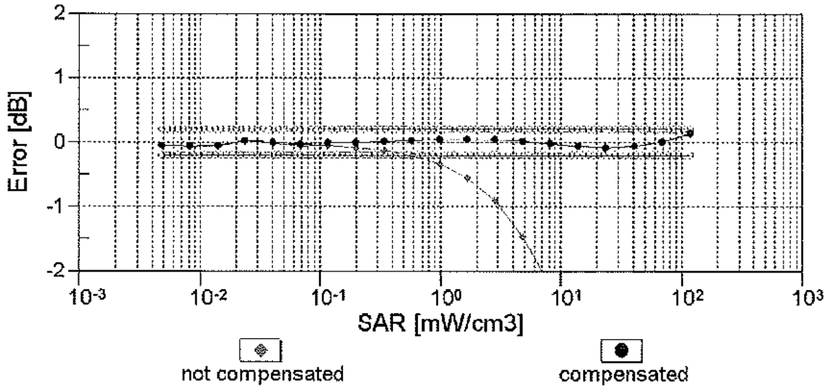



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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

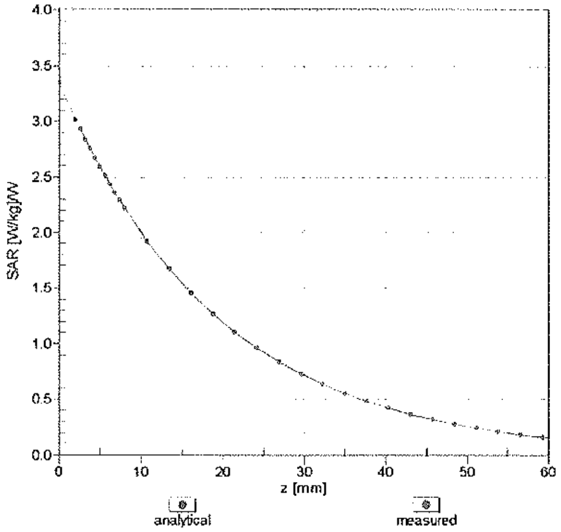


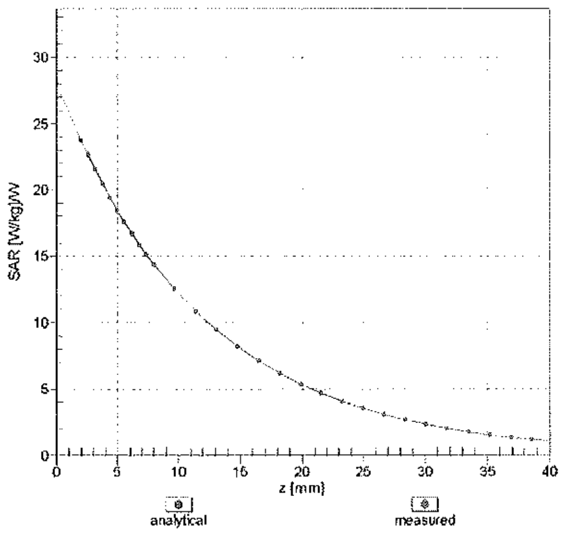

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

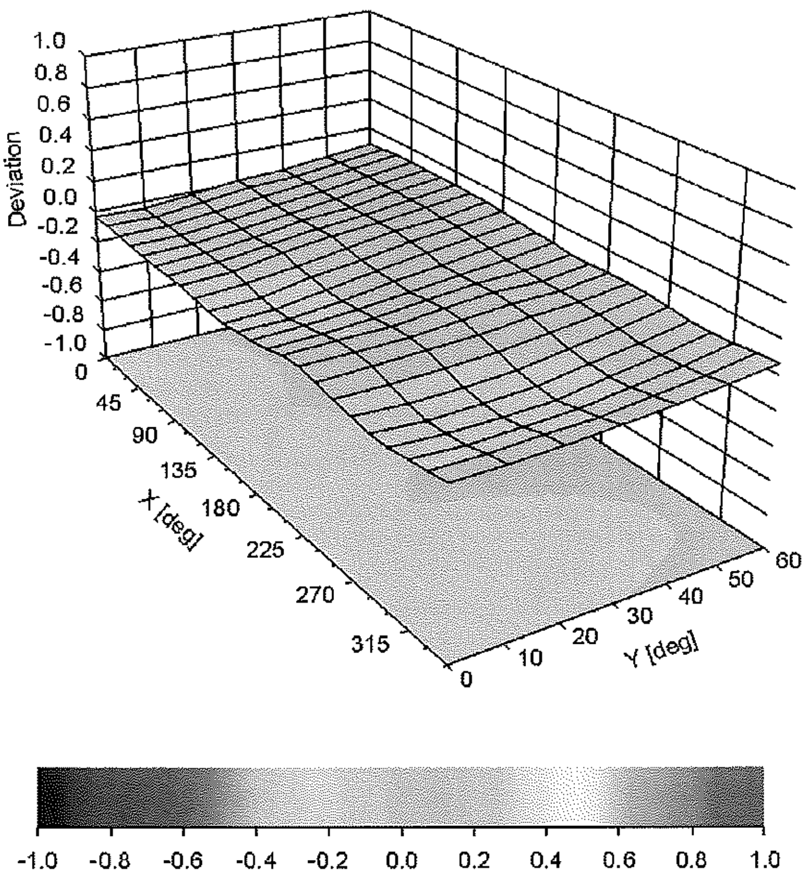



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -104.4 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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: **ES3-3333_Oct14**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3333

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

CC
10/31/14

Calibration date: October 24, 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 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Power sensor E4412A | MY41498087 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 03-Apr-14 (No. 217-01915) | Apr-15 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919) | Apr-15 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920) | Apr-15 |
| 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-14) | In house check: Oct-15 |

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

Issued: October 24, 2014

## 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:3333

Manufactured: January 24, 2012
Calibrated: October 24, 2014

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 1.08 | 0.90 | 0.88 | ± 10.1 % |
| DCP (mV)[B] | 102.7 | 107.7 | 106.3 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 190.7 | ±2.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 183.3 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 197.9 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 3.17 | 61.7 | 12.2 | 10.00 | 42.4 | ±1.9 % |
| | | Y | 3.16 | 63.7 | 12.4 | | 38.0 | |
| | | Z | 1.84 | 59.2 | 10.5 | | 39.9 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.22 | 65.9 | 17.6 | 2.91 | 128.5 | ±0.5 % |
| | | Y | 3.60 | 69.3 | 19.8 | | 146.7 | |
| | | Z | 3.51 | 68.1 | 18.8 | | 133.7 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 3.14 | 68.6 | 18.2 | 1.87 | 132.6 | ±0.7 % |
| | | Y | 3.64 | 73.3 | 21.1 | | 127.5 | |
| | | Z | 3.50 | 71.4 | 19.6 | | 136.4 | |
| 10013-CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.56 | 70.8 | 23.0 | 9.46 | 135.8 | ±3.5 % |
| | | Y | 10.93 | 70.2 | 23.0 | | 122.3 | |
| | | Z | 10.93 | 70.0 | 22.6 | | 132.8 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 24.60 | 96.9 | 27.6 | 9.39 | 147.6 | ±1.9 % |
| | | Y | 19.44 | 94.3 | 26.1 | | 148.6 | |
| | | Z | 9.58 | 82.7 | 21.9 | | 138.2 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 20.09 | 93.0 | 26.4 | 9.57 | 141.7 | ±2.7 % |
| | | Y | 24.86 | 99.0 | 27.9 | | 143.5 | |
| | | Z | 11.74 | 86.4 | 23.4 | | 134.4 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 23.76 | 91.2 | 23.1 | 6.56 | 147.8 | ±2.5 % |
| | | Y | 37.10 | 99.8 | 25.3 | | 149.9 | |
| | | Z | 16.01 | 88.1 | 21.6 | | 128.0 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 36.24 | 94.5 | 22.6 | 4.80 | 128.6 | ±2.5 % |
| | | Y | 47.57 | 99.9 | 23.7 | | 133.5 | |
| | | Z | 44.37 | 99.7 | 23.6 | | 140.1 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 65.86 | 99.7 | 22.7 | 3.55 | 133.1 | ±2.7 % |
| | | Y | 55.92 | 100.0 | 22.6 | | 142.0 | |
| | | Z | 59.41 | 100.0 | 22.2 | | 125.1 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 85.87 | 100.0 | 20.1 | 1.16 | 138.3 | ±2.2 % |
| | | Y | 14.41 | 99.2 | 23.3 | | 130.5 | |
| | | Z | 85.82 | 99.8 | 19.3 | | 135.9 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.49 | 67.4 | 19.4 | 5.67 | 144.6 | ±1.7 % |
| | | Y | 6.49 | 68.0 | 20.1 | | 139.9 | |
| | | Z | 6.54 | 67.9 | 19.7 | | 147.3 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.81 | 74.7 | 24.9 | 9.29 | 122.0 | ±3.0 % |
| | | Y | 10.50 | 75.9 | 26.1 | | 131.6 | |
| | | Z | 9.76 | 73.5 | 24.5 | | 138.6 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.43 | 67.2 | 19.4 | 5.80 | 143.3 | ±1.7 % |
| | | Y | 6.37 | 67.7 | 20.0 | | 138.0 | |
| | | Z | 6.43 | 67.5 | 19.7 | | 146.7 | |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.19 | 68.6 | 20.9 | 8.07 | 136.2 | ±2.5 % |
| | | Y | 10.15 | 68.9 | 21.4 | | 128.3 | |
| | | Z | 10.12 | 68.7 | 21.0 | | 137.9 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 11.48 | 77.0 | 26.1 | 9.28 | 147.5 | ±3.3 % |
| | | Y | 9.81 | 74.9 | 25.8 | | 125.7 | |
| | | Z | 9.22 | 72.8 | 24.3 | | 133.2 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.10 | 66.5 | 19.1 | 5.75 | 140.0 | ±1.7 % |
| | | Y | 6.04 | 67.1 | 19.8 | | 134.8 | |
| | | Z | 6.12 | 67.1 | 19.5 | | 143.2 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.57 | 67.2 | 19.4 | 5.82 | 146.3 | ±1.7 % |
| | | Y | 6.47 | 67.6 | 20.0 | | 139.6 | |
| | | Z | 6.56 | 67.6 | 19.7 | | 148.5 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.16 | 66.7 | 19.4 | 5.73 | 145.8 | ±1.4 % |
| | | Y | 5.02 | 67.5 | 20.2 | | 137.5 | |
| | | Z | 5.07 | 67.2 | 19.7 | | 147.1 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 10.07 | 79.2 | 27.3 | 9.21 | 136.5 | ±3.0 % |
| | | Y | 9.70 | 81.5 | 29.3 | | 142.5 | |
| | | Z | 7.63 | 74.3 | 25.3 | | 125.0 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.13 | 66.6 | 19.3 | 5.72 | 145.9 | ±1.4 % |
| | | Y | 5.01 | 67.4 | 20.1 | | 137.5 | |
| | | Z | 5.04 | 67.1 | 19.7 | | 146.3 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 5.14 | 66.6 | 19.3 | 5.72 | 145.7 | ±1.4 % |
| | | Y | 5.03 | 67.5 | 20.3 | | 137.4 | |
| | | Z | 5.06 | 67.2 | 19.7 | | 146.6 | |
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.88 | 68.3 | 20.8 | 8.10 | 130.9 | ±2.5 % |
| | | Y | 10.13 | 69.6 | 21.8 | | 149.0 | |
| | | Z | 9.77 | 68.4 | 20.9 | | 131.6 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.98 | 66.5 | 19.0 | 5.97 | 132.9 | ±1.7 % |
| | | Y | 7.14 | 67.8 | 20.0 | | 149.7 | |
| | | Z | 7.02 | 67.2 | 19.4 | | 134.3 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 10.13 | 79.4 | 27.4 | 9.21 | 137.5 | ±3.0 % |
| | | Y | 9.73 | 81.6 | 29.3 | | 143.3 | |
| | | Z | 7.59 | 74.1 | 25.1 | | 125.6 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 10.80 | 76.4 | 25.9 | 9.24 | 140.0 | ±3.3 % |
| | | Y | 10.19 | 77.2 | 27.1 | | 147.2 | |
| | | Z | 8.55 | 71.8 | 23.9 | | 124.9 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 11.59 | 77.3 | 26.3 | 9.30 | 148.4 | ±3.5 % |
| | | Y | 9.87 | 75.1 | 25.9 | | 126.0 | |
| | | Z | 9.21 | 72.7 | 24.2 | | 133.6 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.40 | 66.1 | 18.1 | 3.96 | 134.1 | ±0.7 % |
| | | Y | 4.48 | 67.4 | 19.2 | | 129.7 | |
| | | Z | 4.54 | 67.2 | 18.7 | | 137.4 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.59 | 65.7 | 17.7 | 3.46 | 127.5 | ±0.7 % |
| | | Y | 3.85 | 68.4 | 19.7 | | 143.4 | |
| | | Z | 3.78 | 67.6 | 18.8 | | 129.7 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.56 | 65.9 | 17.8 | 3.39 | 127.9 | ±0.7 % |
| | | Y | 3.81 | 68.6 | 19.8 | | 144.2 | |
| | | Z | 3.71 | 67.5 | 18.8 | | 130.7 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.44 | 67.1 | 19.4 | 5.81 | 143.0 | ±1.7 % |
| | | Y | 6.37 | 67.6 | 20.0 | | 137.9 | |
| | | Z | 6.43 | 67.5 | 19.7 | | 146.5 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 7.02 | 67.8 | 19.8 | 6.06 | 148.7 | ±1.9 % |
| | | Y | 6.96 | 68.2 | 20.4 | | 143.6 | |
| | | Z | 6.72 | 67.1 | 19.5 | | 126.9 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.73 | 67.0 | 17.9 | 3.76 | 140.2 | ±0.7 % |
| | | Y | 4.96 | 69.4 | 19.5 | | 130.7 | |
| | | Z | 5.05 | 69.3 | 19.1 | | 140.9 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.70 | 67.2 | 18.1 | 3.77 | 138.1 | ±0.7 % |
| | | Y | 4.85 | 69.5 | 19.6 | | 129.6 | |
| | | Z | 5.14 | 70.1 | 19.5 | | 139.3 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.47 | 66.1 | 17.1 | 1.54 | 133.2 | ±0.7 % |
| | | Y | 3.15 | 72.2 | 20.9 | | 127.9 | |
| | | Z | 3.32 | 72.0 | 20.1 | | 137.2 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.99 | 68.4 | 21.0 | 8.23 | 131.6 | ±2.5 % |
| | | Y | 9.84 | 68.6 | 21.4 | | 123.3 | |
| | | Z | 9.89 | 68.6 | 21.1 | | 133.4 | |

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

[A] The uncertainties of NormX,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 7 and 8).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

## 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 | 6.55 | 6.55 | 6.55 | 0.34 | 1.74 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.33 | 6.33 | 6.33 | 0.44 | 1.48 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.26 | 5.26 | 5.26 | 0.73 | 1.21 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.11 | 5.11 | 5.11 | 0.66 | 1.32 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.53 | 4.53 | 4.53 | 0.62 | 1.40 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.40 | 4.40 | 4.40 | 0.68 | 1.38 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

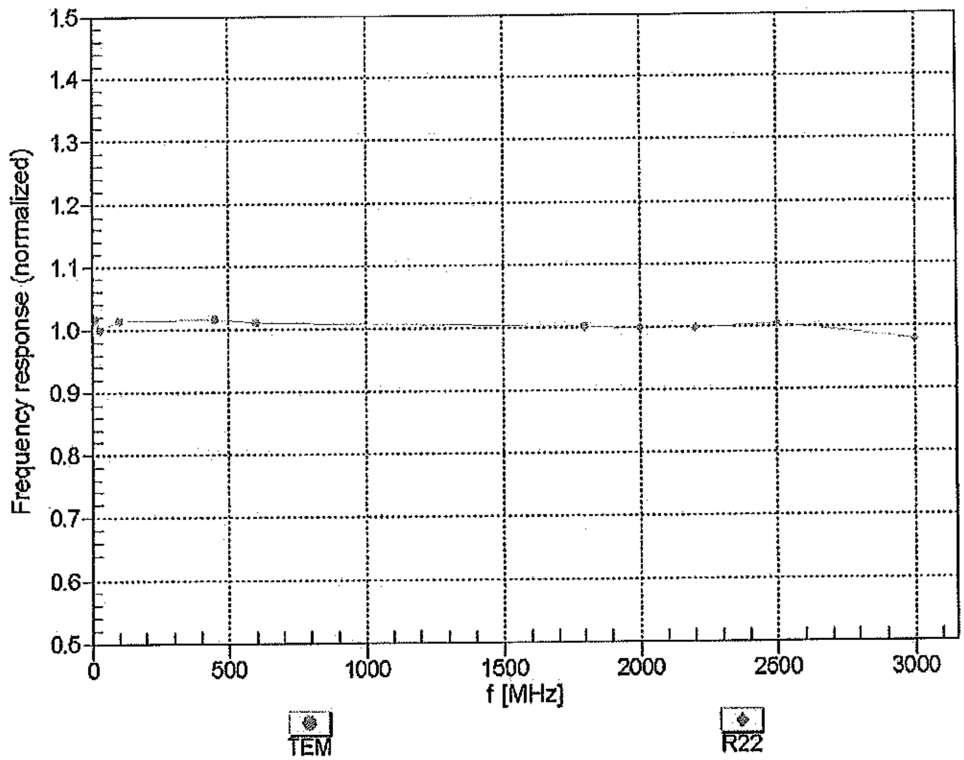
## Calibration Parameter Determined in Body Tissue Simulating Media

| 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 | 6.14 | 6.14 | 6.14 | 0.35 | 1.76 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.12 | 6.12 | 6.12 | 0.57 | 1.37 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.89 | 4.89 | 4.89 | 0.80 | 1.24 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.67 | 4.67 | 4.67 | 0.75 | 1.29 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.26 | 4.26 | 4.26 | 0.80 | 1.01 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.13 | 4.13 | 4.13 | 0.80 | 0.99 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

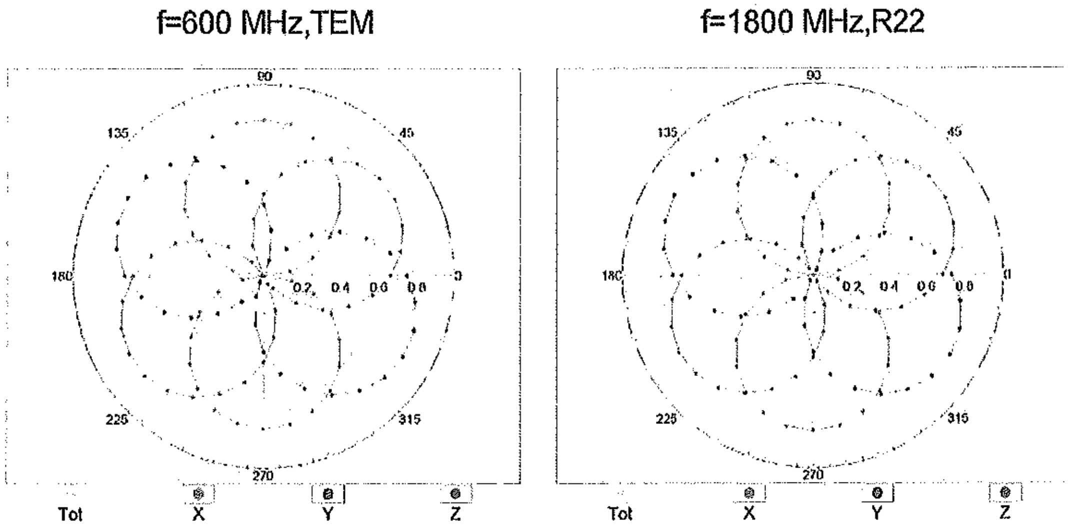
# Frequency Response of E-Field

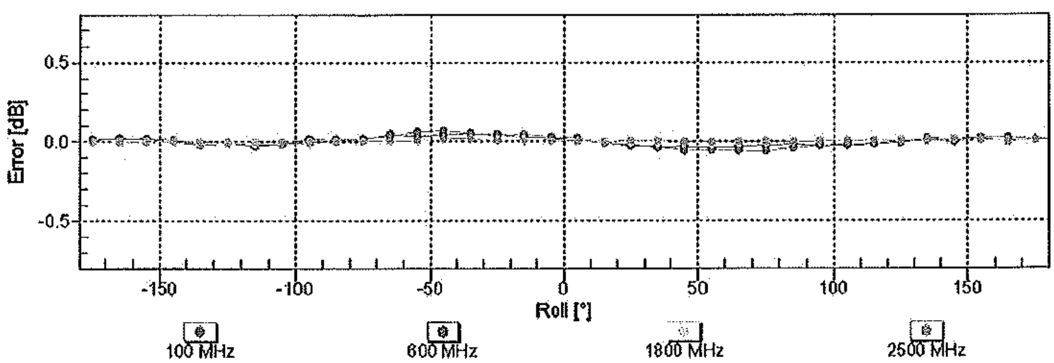
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**




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

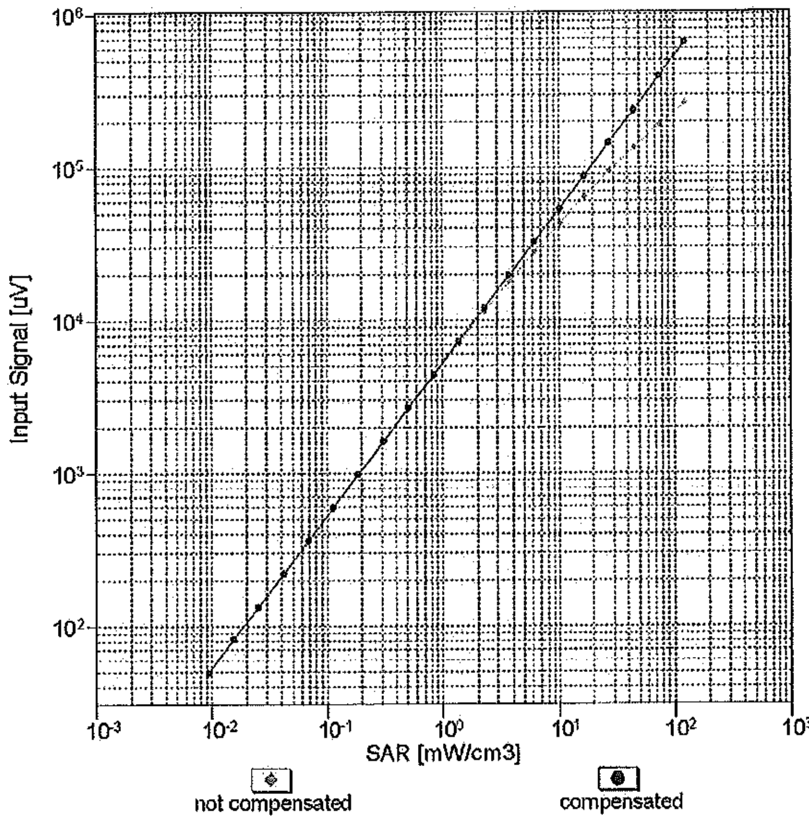
# Receiving Pattern (ϕ), $\vartheta = 0°$

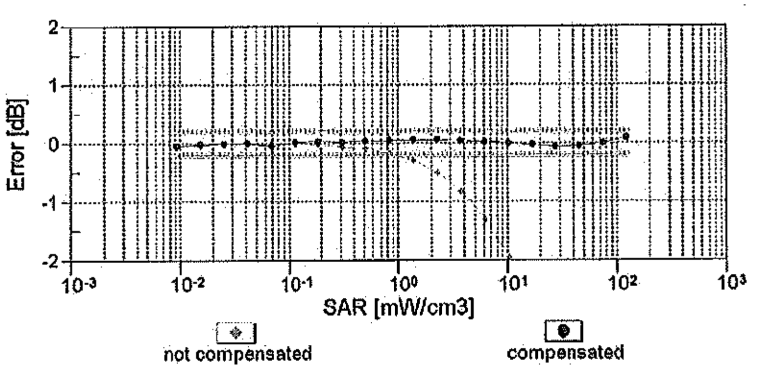



**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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

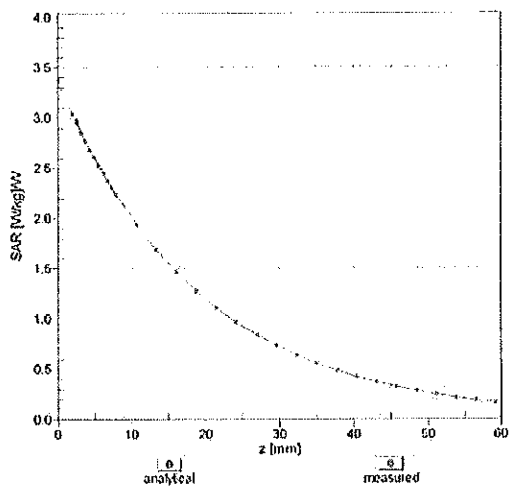


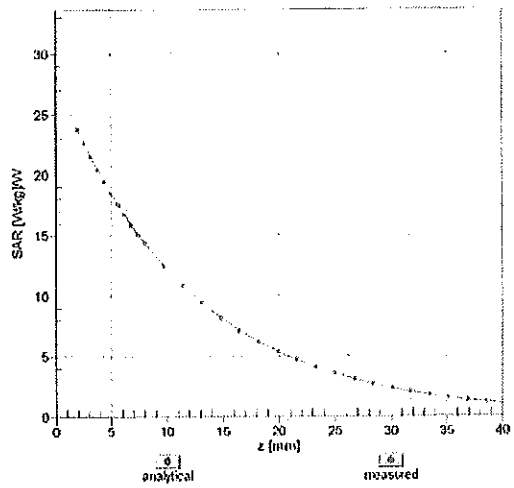

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

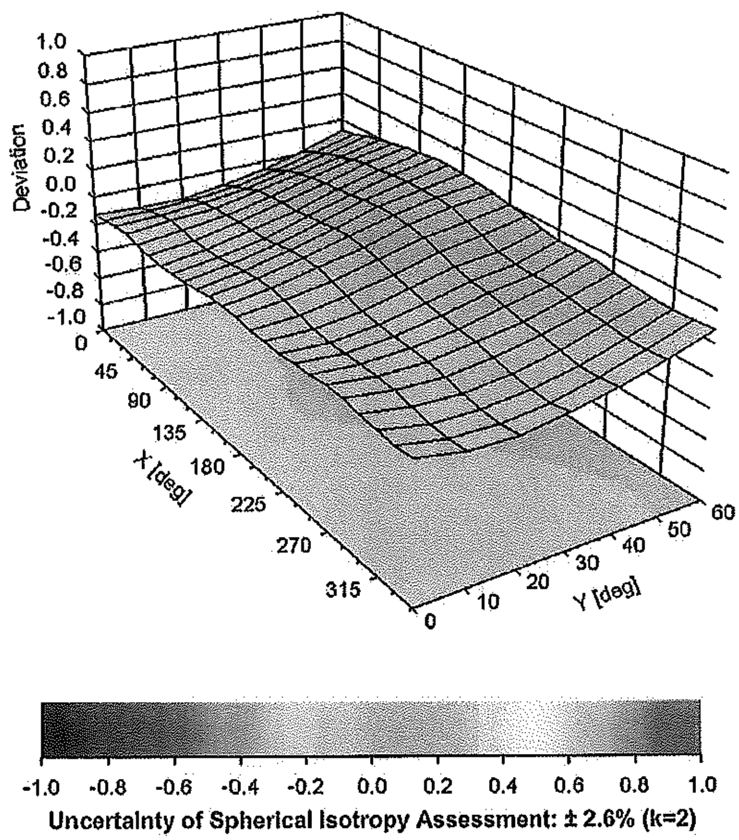



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -34.9 |
| 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
**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_Sep14/2**

# CALIBRATION CERTIFICATE (Replacement of No:ES3-3288_Sep14)

| | |
|---|---|
| Object | ES3DV3 - SN:3288 |
| 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: | September 24, 2014 |

CC 12/12/14

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 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Power sensor E4412A | MY41498087 | 03-Apr-14 (No. 217-01911) | Apr-15 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 03-Apr-14 (No. 217-01915) | Apr-15 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919) | Apr-15 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920) | Apr-15 |
| 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: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 3, 2014

## 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:3288

| | |
|---|---|
| Manufactured: | July 6, 2010 |
| Repaired: | September 18, 2014 |
| Calibrated: | September 24, 2014 |

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

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

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 1.05 | 1.16 | 0.92 | ± 10.1 % |
| DCP (mV)[B] | 105.1 | 104.6 | 106.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A<br>dB | B<br>dB√µV | C | D<br>dB | VR<br>mV | Unc[E]<br>(k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 195.8 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 175.9 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 177.1 | |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms) | X | 2.71 | 61.9 | 11.4 | 10.00 | 40.3 | ±2.2 % |
| | | Y | 2.37 | 60.2 | 11.2 | | 42.6 | |
| | | Z | 1.54 | 56.6 | 8.9 | | 41.2 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.29 | 67.1 | 18.4 | 2.91 | 133.8 | ±0.5 % |
| | | Y | 3.43 | 67.9 | 18.9 | | 139.5 | |
| | | Z | 3.45 | 68.1 | 18.9 | | 141.3 | |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) | X | 2.99 | 68.9 | 18.6 | 1.87 | 135.1 | ±0.7 % |
| | | Y | 3.59 | 72.4 | 20.4 | | 140.7 | |
| | | Z | 3.54 | 72.4 | 20.3 | | 143.0 | |
| 10013-CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.15 | 70.8 | 23.3 | 9.46 | 132.3 | ±3.5 % |
| | | Y | 11.29 | 70.8 | 23.2 | | 141.1 | |
| | | Z | 11.07 | 70.7 | 23.2 | | 139.2 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 14.71 | 90.5 | 24.5 | 9.39 | 149.0 | ±1.9 % |
| | | Y | 16.40 | 92.8 | 26.0 | | 131.3 | |
| | | Z | 11.34 | 87.2 | 23.6 | | 126.1 | |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0) | X | 15.91 | 92.2 | 25.3 | 9.57 | 138.9 | ±2.5 % |
| | | Y | 21.25 | 96.9 | 27.2 | | 142.0 | |
| | | Z | 11.68 | 87.2 | 23.5 | | 145.9 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 38.62 | 99.8 | 24.7 | 6.56 | 123.8 | ±2.2 % |
| | | Y | 36.71 | 99.7 | 25.2 | | 128.1 | |
| | | Z | 36.56 | 99.4 | 24.5 | | 129.5 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 56.60 | 99.6 | 22.6 | 4.80 | 138.8 | ±1.9 % |
| | | Y | 46.94 | 99.9 | 23.7 | | 149.9 | |
| | | Z | 51.17 | 99.8 | 22.9 | | 144.9 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 70.88 | 100.0 | 21.6 | 3.55 | 147.5 | ±1.9 % |
| | | Y | 52.58 | 99.8 | 22.6 | | 129.4 | |
| | | Z | 76.98 | 99.8 | 21.2 | | 128.7 | |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5) | X | 98.89 | 99.5 | 18.9 | 1.16 | 135.8 | ±1.4 % |
| | | Y | 78.39 | 99.6 | 19.5 | | 141.7 | |
| | | Z | 95.21 | 95.5 | 17.1 | | 143.4 | |
| 10039-CAB | CDMA2000 (1xRTT, RC1) | X | 4.72 | 66.7 | 18.9 | 4.57 | 133.7 | ±0.9 % |
| | | Y | 4.85 | 67.1 | 19.1 | | 137.7 | |
| | | Z | 4.81 | 67.4 | 19.2 | | 141.9 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 3.91 | 66.3 | 18.6 | 3.97 | 129.5 | ±0.7 % |
| | | Y | 4.00 | 66.6 | 18.7 | | 133.7 | |
| | | Z | 3.99 | 66.8 | 18.8 | | 137.5 | |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2) | X | 4.63 | 66.9 | 18.7 | 3.98 | 141.4 | ±0.7 % |
| | | Y | 4.78 | 67.5 | 19.0 | | 147.7 | |
| | | Z | 4.57 | 66.8 | 18.6 | | 127.8 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.59 | 68.2 | 20.1 | 5.67 | 149.2 | ±1.4 % |
| | | Y | 6.36 | 67.3 | 19.6 | | 130.7 | |
| | | Z | 6.36 | 67.5 | 19.6 | | 133.6 | |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.44 | 67.8 | 20.0 | 5.80 | 146.6 | ±1.4 % |
| | | Y | 6.23 | 66.8 | 19.4 | | 128.8 | |
| | | Z | 6.24 | 67.1 | 19.6 | | 131.4 | |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK) | X | 6.08 | 67.1 | 19.6 | 5.75 | 143.2 | ±1.4 % |
| | | Y | 6.20 | 67.4 | 19.8 | | 148.0 | |
| | | Z | 5.92 | 66.6 | 19.3 | | 128.5 | |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.32 | 69.3 | 21.5 | 8.10 | 137.0 | ±2.2 % |
| | | Y | 10.31 | 69.1 | 21.4 | | 143.5 | |
| | | Z | 10.37 | 69.5 | 21.6 | | 146.1 | |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.35 | 69.4 | 21.6 | 8.07 | 138.3 | ±2.2 % |
| | | Y | 10.36 | 69.3 | 21.4 | | 146.4 | |
| | | Z | 10.42 | 69.6 | 21.6 | | 149.0 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 9.95 | 75.7 | 26.2 | 9.28 | 134.9 | ±3.3 % |
| | | Y | 10.37 | 76.0 | 26.1 | | 146.6 | |
| | | Z | 9.77 | 75.4 | 26.0 | | 142.5 | |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 6.12 | 67.2 | 19.7 | 5.75 | 144.9 | ±1.4 % |
| | | Y | 6.21 | 67.4 | 19.8 | | 148.8 | |
| | | Z | 5.91 | 66.5 | 19.3 | | 128.7 | |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK) | X | 6.28 | 66.7 | 19.4 | 5.82 | 125.5 | ±1.2 % |
| | | Y | 6.37 | 66.8 | 19.4 | | 129.7 | |
| | | Z | 6.36 | 67.1 | 19.6 | | 132.9 | |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.08 | 67.6 | 20.2 | 5.73 | 147.0 | ±1.2 % |
| | | Y | 4.95 | 66.6 | 19.6 | | 128.6 | |
| | | Z | 4.91 | 66.9 | 19.8 | | 131.2 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 8.18 | 77.2 | 27.2 | 9.21 | 123.4 | ±2.7 % |
| | | Y | 8.37 | 76.6 | 26.6 | | 129.5 | |
| | | Z | 7.97 | 76.7 | 26.9 | | 128.7 | |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 5.05 | 67.4 | 20.1 | 5.72 | 146.2 | ±1.4 % |
| | | Y | 5.10 | 67.3 | 20.0 | | 142.8 | |
| | | Z | 4.87 | 66.7 | 19.6 | | 129.6 | |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK) | X | 5.04 | 67.4 | 20.0 | 5.72 | 145.5 | ±1.2 % |
| | | Y | 5.12 | 67.4 | 20.0 | | 143.4 | |
| | | Z | 4.87 | 66.7 | 19.6 | | 129.9 | |
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK) | X | 9.92 | 68.9 | 21.4 | 8.09 | 131.0 | ±2.2 % |
| | | Y | 9.84 | 68.5 | 21.1 | | 130.0 | |
| | | Z | 9.94 | 69.0 | 21.4 | | 138.6 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK) | X | 9.90 | 68.9 | 21.4 | 8.10 | 130.8 | ±2.2 % |
| | | Y | 9.81 | 68.4 | 21.0 | | 131.4 | |
| | | Z | 9.95 | 69.1 | 21.5 | | 140.5 | |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK) | X | 9.81 | 68.8 | 21.3 | 8.03 | 130.0 | ±2.2 % |
| | | Y | 9.89 | 68.9 | 21.3 | | 138.1 | |
| | | Z | 9.89 | 69.1 | 21.5 | | 140.5 | |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK) | X | 10.25 | 69.2 | 21.4 | 8.06 | 137.1 | ±2.2 % |
| | | Y | 10.30 | 69.2 | 21.4 | | 144.4 | |
| | | Z | 10.38 | 69.6 | 21.6 | | 148.4 | |
| 10225-CAB | UMTS-FDD (HSPA+) | X | 6.90 | 66.8 | 19.3 | 5.97 | 132.8 | ±1.4 % |
| | | Y | 7.09 | 67.3 | 19.6 | | 142.0 | |
| | | Z | 7.04 | 67.4 | 19.6 | | 143.5 | |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 9.61 | 81.9 | 29.6 | 9.21 | 149.3 | ±2.7 % |
| | | Y | 8.66 | 77.6 | 27.1 | | 133.7 | |
| | | Z | 8.20 | 77.5 | 27.3 | | 132.2 | |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 9.16 | 74.5 | 25.8 | 9.24 | 126.3 | ±3.0 % |
| | | Y | 9.62 | 75.0 | 25.8 | | 137.4 | |
| | | Z | 9.16 | 74.8 | 25.9 | | 135.2 | |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.97 | 75.7 | 26.3 | 9.30 | 133.7 | ±3.3 % |
| | | Y | 10.38 | 75.9 | 26.1 | | 146.1 | |
| | | Z | 9.91 | 75.7 | 26.3 | | 143.8 | |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10) | X | 5.86 | 66.6 | 18.7 | 4.87 | 129.9 | ±0.9 % |
| | | Y | 6.01 | 67.1 | 19.0 | | 135.7 | |
| | | Z | 5.95 | 67.1 | 19.0 | | 139.4 | |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4) | X | 4.40 | 66.7 | 18.6 | 3.96 | 136.4 | ±0.7 % |
| | | Y | 4.55 | 67.3 | 19.0 | | 138.3 | |
| | | Z | 4.56 | 67.6 | 19.1 | | 144.3 | |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate | X | 3.64 | 66.9 | 18.7 | 3.46 | 127.4 | ±0.5 % |
| | | Y | 3.77 | 67.6 | 19.1 | | 130.2 | |
| | | Z | 3.72 | 67.5 | 19.0 | | 134.4 | |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate | X | 3.58 | 67.0 | 18.7 | 3.39 | 128.4 | ±0.5 % |
| | | Y | 3.73 | 67.7 | 19.1 | | 132.7 | |
| | | Z | 3.69 | 67.8 | 19.1 | | 136.1 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.43 | 67.7 | 19.9 | 5.81 | 145.5 | ±1.4 % |
| | | Y | 6.49 | 67.7 | 19.9 | | 149.5 | |
| | | Z | 6.23 | 67.0 | 19.6 | | 129.5 | |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK) | X | 6.74 | 67.3 | 19.8 | 6.06 | 126.7 | ±1.4 % |
| | | Y | 6.83 | 67.5 | 19.8 | | 132.9 | |
| | | Z | 6.81 | 67.6 | 19.9 | | 135.8 | |
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle) | X | 3.00 | 69.9 | 19.4 | 1.71 | 133.9 | ±0.5 % |
| | | Y | 3.30 | 71.5 | 20.1 | | 141.0 | |
| | | Z | 3.22 | 71.4 | 20.0 | | 142.9 | |
| 10316-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle) | X | 10.17 | 69.2 | 21.8 | 8.36 | 130.5 | ±2.5 % |
| | | Y | 10.20 | 69.1 | 21.6 | | 138.4 | |
| | | Z | 10.20 | 69.4 | 21.8 | | 140.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 4.75 | 68.3 | 18.8 | 3.76 | 138.5 | ±0.7 % |
| | | Y | 5.00 | 69.1 | 19.2 | | 146.7 | |
| | | Z | 4.92 | 69.2 | 19.1 | | 148.5 | |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A) | X | 4.73 | 68.6 | 18.9 | 3.77 | 136.3 | ±0.7 % |
| | | Y | 4.97 | 69.4 | 19.4 | | 143.7 | |
| | | Z | 4.91 | 69.6 | 19.3 | | 146.0 | |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle) | X | 2.65 | 68.1 | 18.5 | 1.54 | 135.2 | ±0.5 % |
| | | Y | 3.05 | 70.8 | 19.9 | | 140.7 | |
| | | Z | 2.87 | 69.8 | 19.3 | | 144.8 | |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.00 | 69.0 | 21.5 | 8.23 | 130.8 | ±2.2 % |
| | | Y | 10.06 | 68.9 | 21.4 | | 138.6 | |
| | | Z | 10.08 | 69.3 | 21.7 | | 141.6 | |

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:3288

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.81 | 6.81 | 6.81 | 0.37 | 1.70 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.51 | 6.51 | 6.51 | 0.45 | 1.52 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.38 | 5.38 | 5.38 | 0.44 | 1.58 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.17 | 5.17 | 5.17 | 0.80 | 1.18 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.56 | 4.56 | 4.56 | 0.80 | 1.21 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 4.44 | 4.44 | 4.44 | 0.80 | 1.22 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

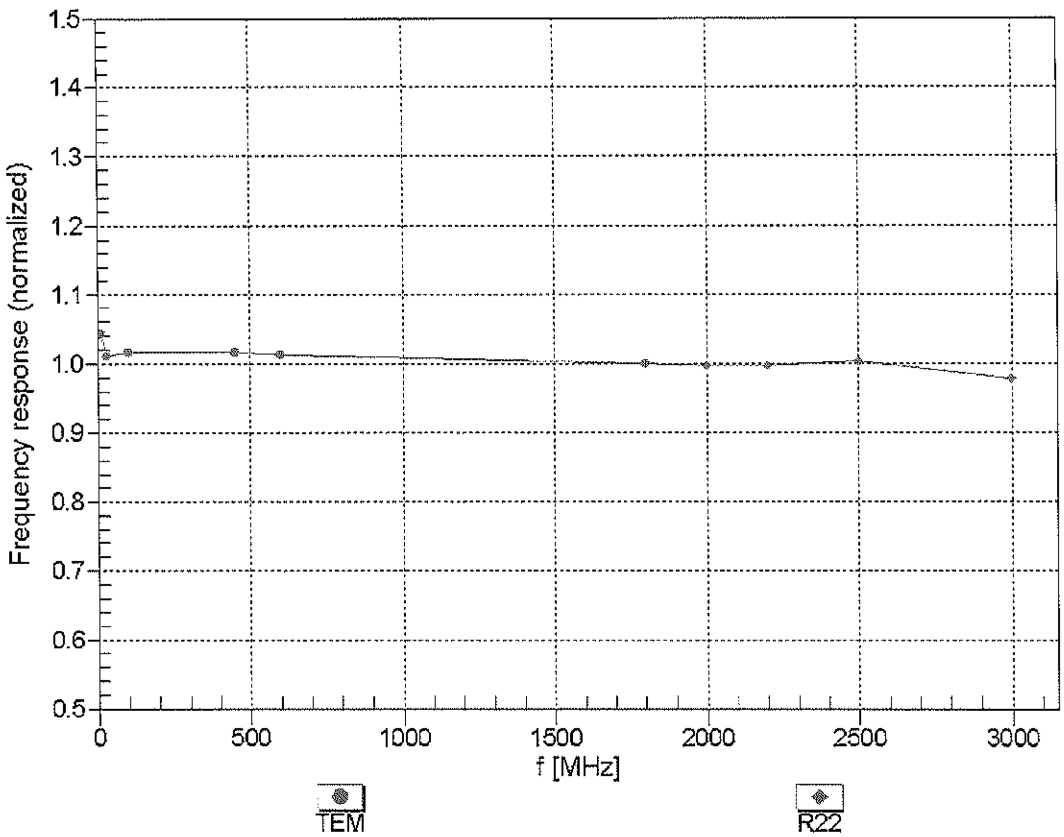
# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unct. (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.38 | 6.38 | 6.38 | 0.31 | 1.89 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.32 | 6.32 | 6.32 | 0.55 | 1.39 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.03 | 5.03 | 5.03 | 0.57 | 1.44 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.82 | 4.82 | 4.82 | 0.51 | 1.54 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.36 | 4.36 | 4.36 | 0.71 | 1.07 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 4.22 | 4.22 | 4.22 | 0.80 | 1.07 | ± 12.0 % |

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ($\varepsilon$ and $\sigma$) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

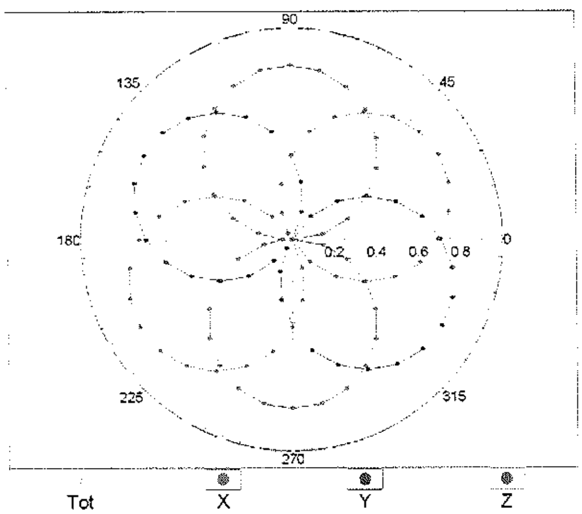
# Frequency Response of E-Field
## (TEM-Cell:ifi110 EXX, Waveguide: R22)



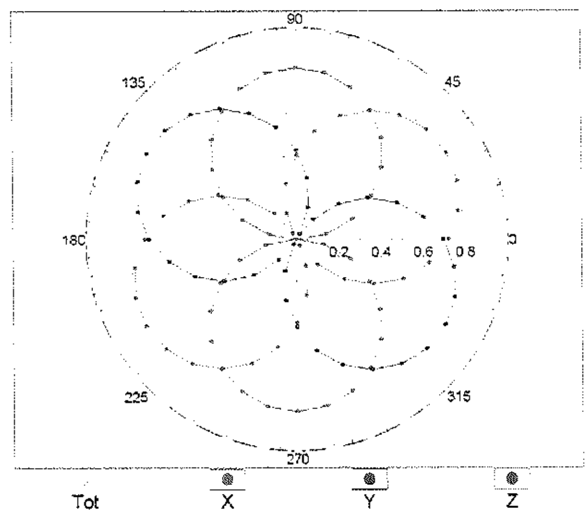

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

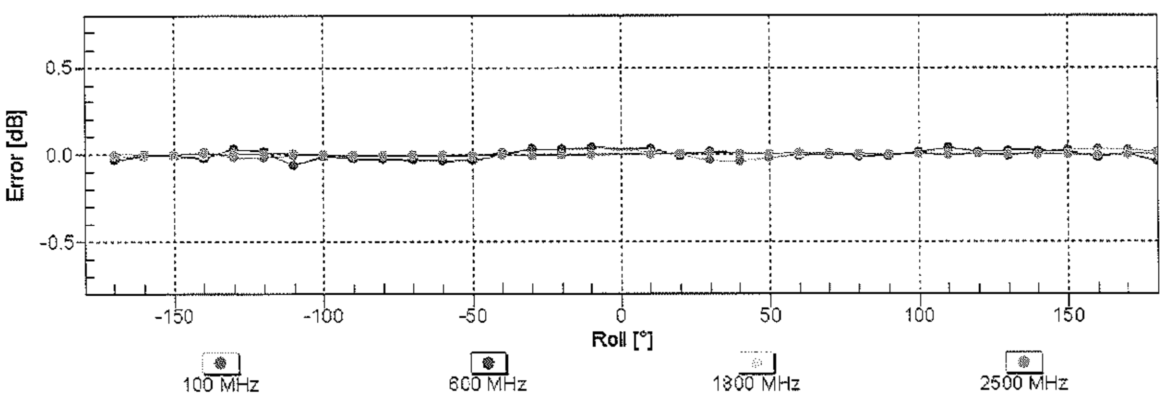
# Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM




f=1800 MHz,R22

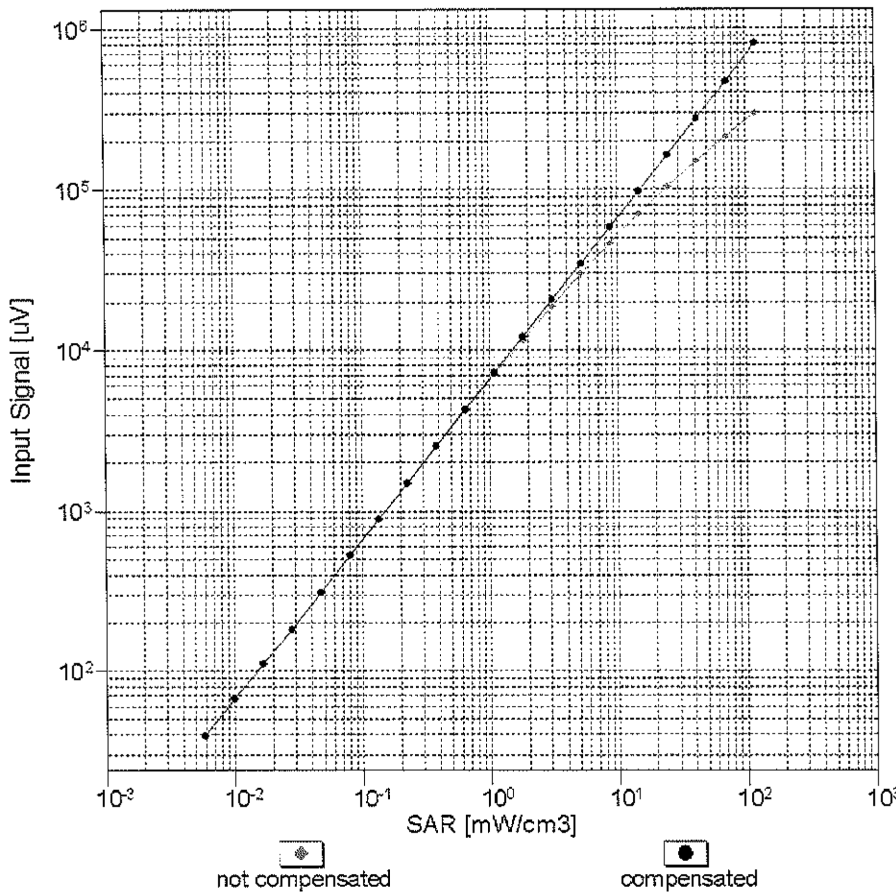


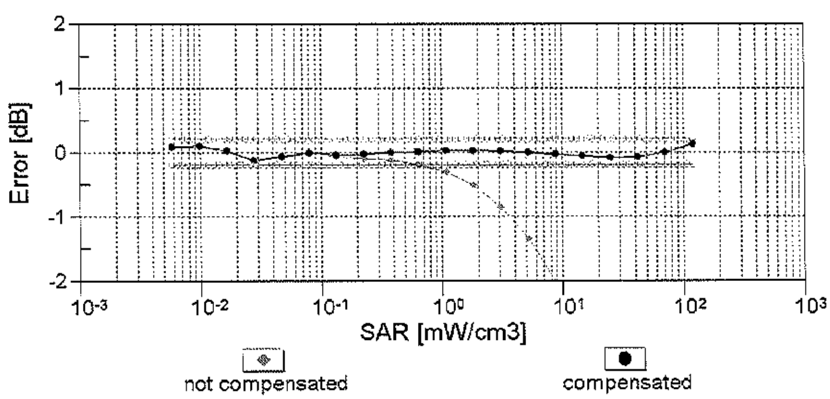




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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

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

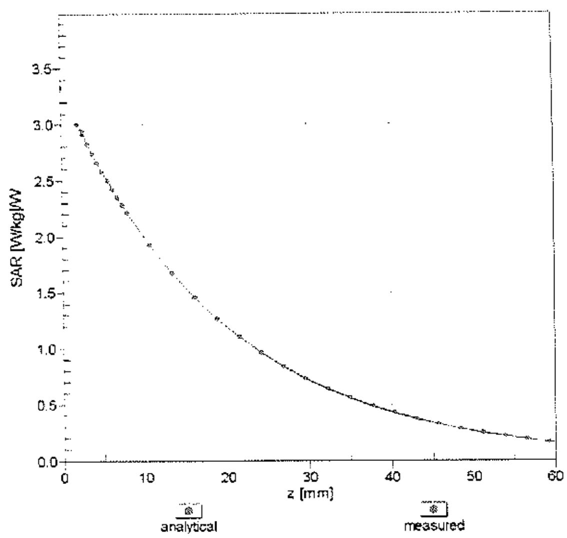


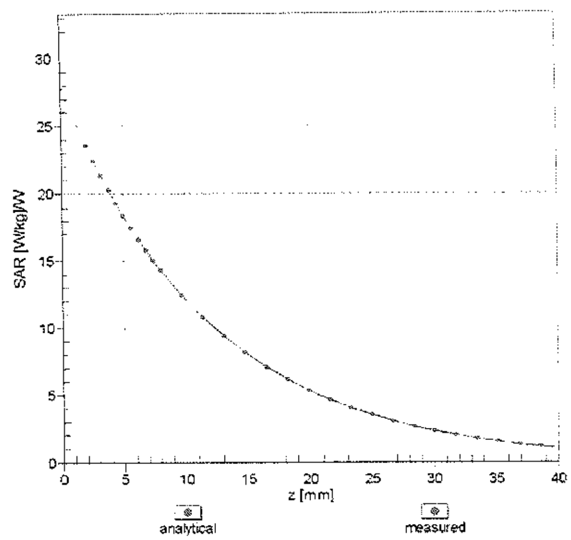

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

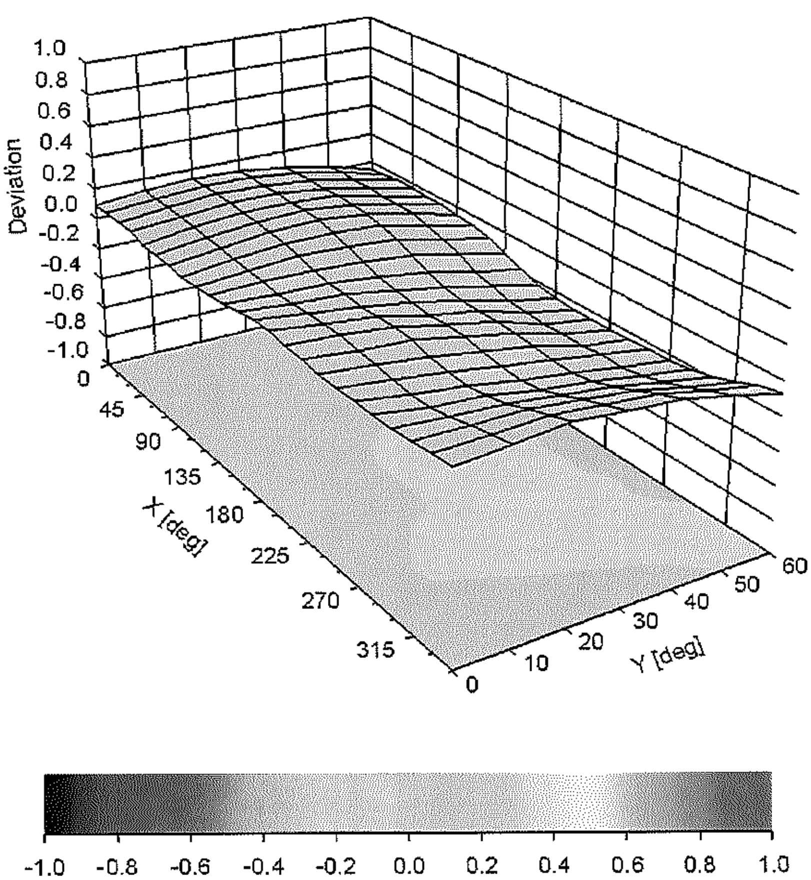



f = 1900 MHz,WGLS R22 (H_convF)




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

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

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -110 |
| 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 |