# Tissue Parameters

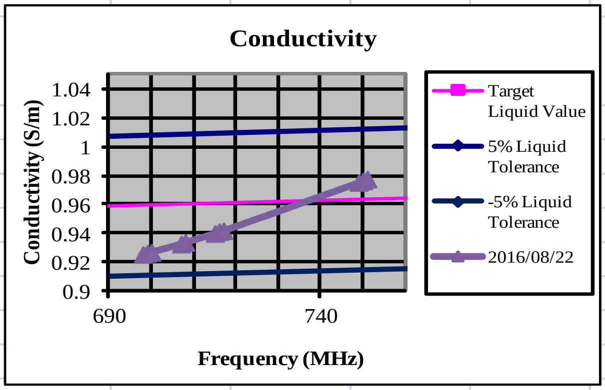
Recipe for liquids below 1 GHz:
Water 35-58%
Sugar 40-60%
Salt 0-6%
Hydroxyethyl-cellulose <0.3%
Preventol-D7 0.1-0.7%

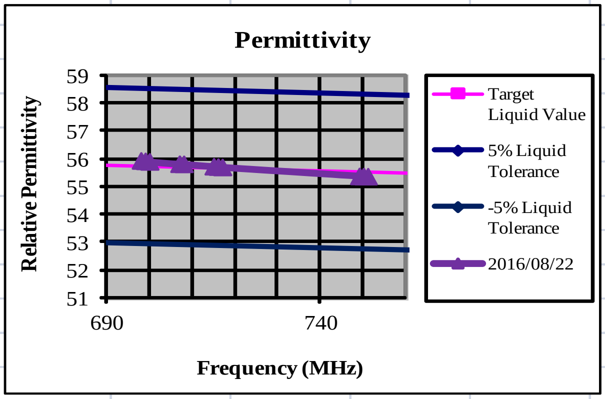
Recipe for liquids above 1-3 GHz:
Water 52-75%
DGBE 25-48%
Salt <1.0%

SAR measurements were made within 24 hours of the measurement of liquid parameters. Relative permittivity and conductivity are within ±5% of the target.

## 750 MHz Body Liquid

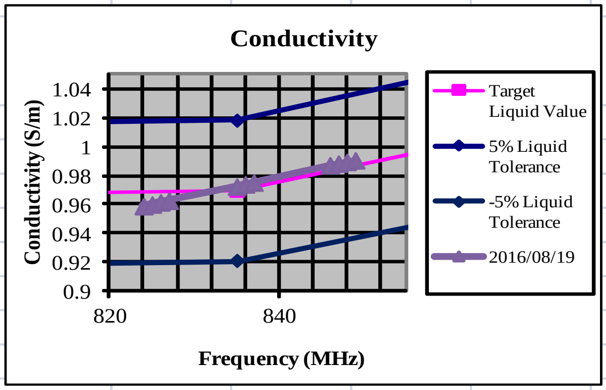
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/22 | 23.2 | 698 | 55.9481 | 0.9256 |
| | | 699 | 55.9302 | 0.9265 |
| | | 700 | 55.9125 | 0.9272 |
| | | 707 | 55.8279 | 0.9328 |
| | | 708 | 55.8248 | 0.9339 |
| | | 715 | 55.7398 | 0.9401 |
| | | 716 | 55.7267 | 0.9414 |
| | | 717 | 55.712 | 0.942 |
| | | 749 | 55.3914 | 0.9753 |
| | | 750 | 55.3863 | 0.9764 |
| | | 751 | 55.3814 | 0.9777 |

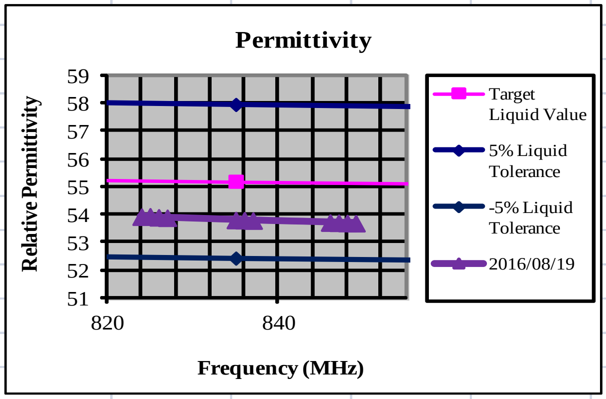


**850 MHz Body Liquid**

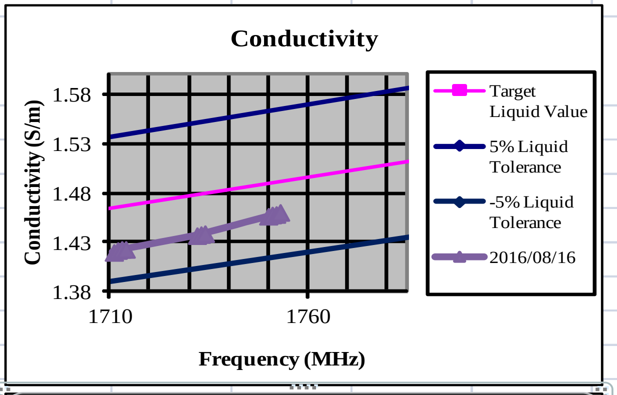
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/19 | 23.7 | 824 | 53.9281 | 0.959 |
| | | 825 | 53.9398 | 0.9601 |
| | | 826 | 53.902 | 0.9616 |
| | | 827 | 53.8872 | 0.9628 |
| | | 835 | 53.8086 | 0.9725 |
| | | 836 | 53.7988 | 0.9741 |
| | | 837 | 53.7868 | 0.9753 |
| | | 846 | 53.7155 | 0.9873 |
| | | 847 | 53.7076 | 0.9884 |
| | | 848 | 53.6995 | 0.9896 |
| | | 849 | 53.6926 | 0.9907 |

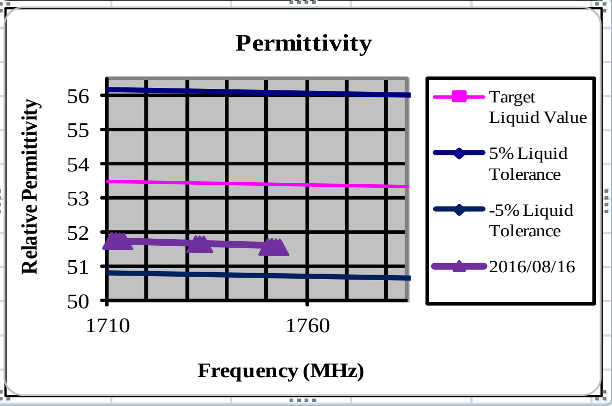


## 1750 MHz Body Liquid

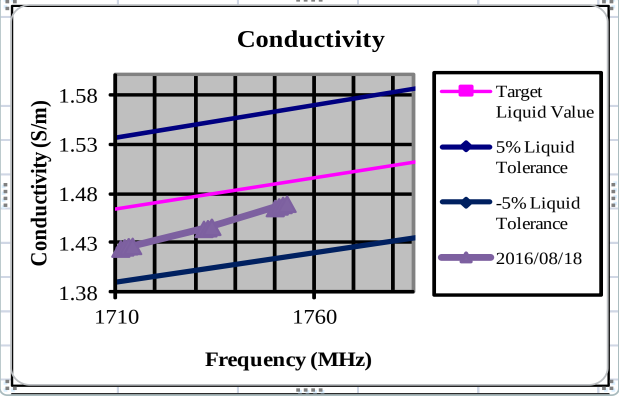
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/16 | 23.6 | 1711 | 51.7701 | 1.4199 |
| | | 1712 | 51.7598 | 1.4219 |
| | | 1713 | 51.7564 | 1.423 |
| | | 1714 | 51.7516 | 1.423 |
| | | 1732 | 51.6718 | 1.437 |
| | | 1733 | 51.6678 | 1.438 |
| | | 1734 | 51.6644 | 1.439 |
| | | 1750 | 51.5915 | 1.4566 |
| | | 1751 | 51.5937 | 1.4579 |
| | | 1752 | 51.5815 | 1.4584 |
| | | 1753 | 51.5787 | 1.4605 |

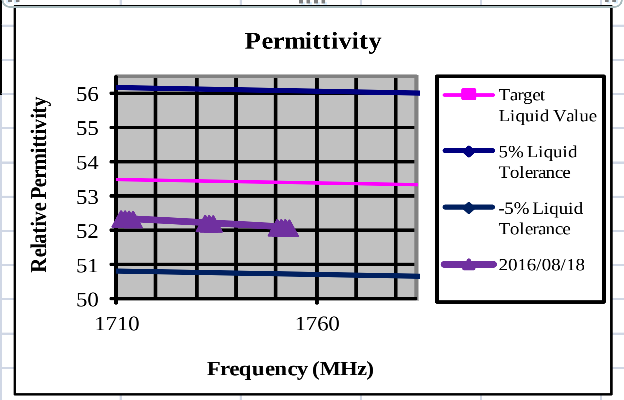


**1750 MHz Body Liquid**

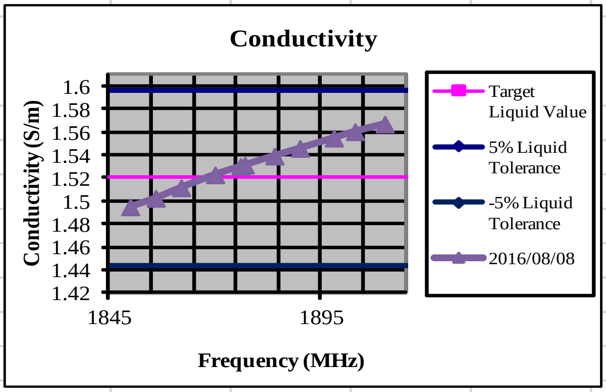
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/18 | 23.5 | 1711 | 52.3479 | 1.4245 |
| | | 1712 | 52.3462 | 1.4257 |
| | | 1713 | 52.3397 | 1.4268 |
| | | 1714 | 52.3319 | 1.4272 |
| | | 1732 | 52.2173 | 1.4444 |
| | | 1733 | 52.2095 | 1.4451 |
| | | 1734 | 52.2027 | 1.4465 |
| | | 1750 | 52.0937 | 1.4656 |
| | | 1751 | 52.091 | 1.4672 |
| | | 1752 | 52.0905 | 1.4687 |
| | | 1753 | 52.0812 | 1.4699 |

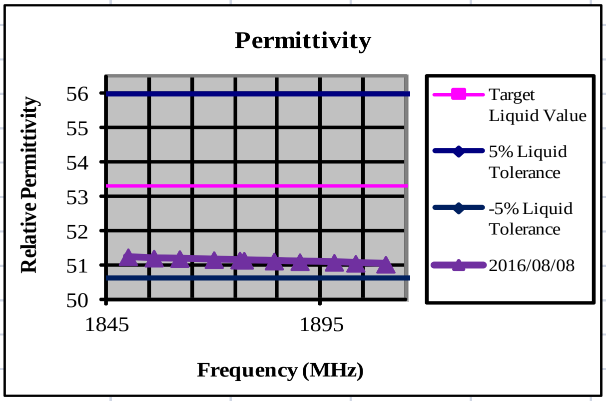


**1900 MHz Body Liquid**

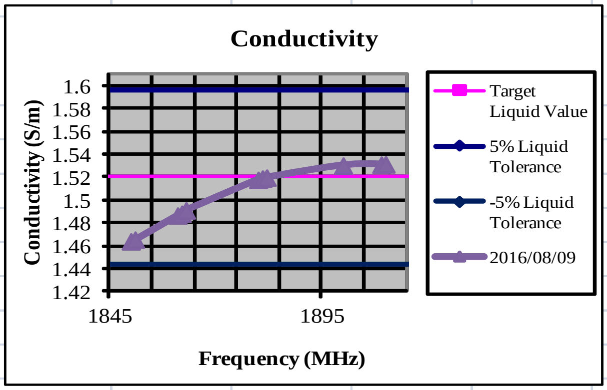
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/08 | 23.2 | 1850 | 51.2502 | 1.495 |
| | | 1856 | 51.2118 | 1.5025 |
| | | 1862 | 51.1968 | 1.5117 |
| | | 1870 | 51.1681 | 1.5229 |
| | | 1876 | 51.1543 | 1.5302 |
| | | 1877 | 51.1478 | 1.5314 |
| | | 1884 | 51.1259 | 1.5393 |
| | | 1890 | 51.1068 | 1.5459 |
| | | 1898 | 51.088 | 1.5549 |
| | | 1903 | 51.0603 | 1.5605 |
| | | 1910 | 51.0315 | 1.5671 |

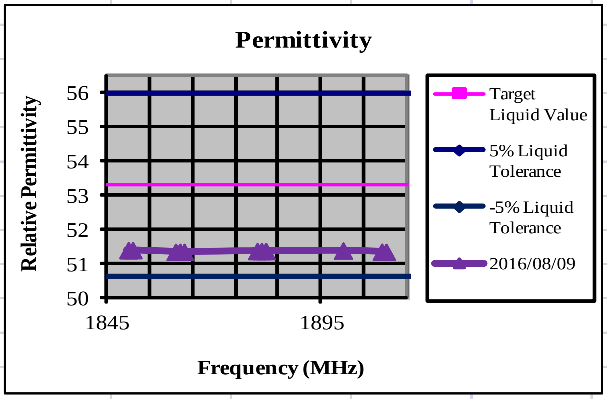


**1900 MHz Body Liquid**

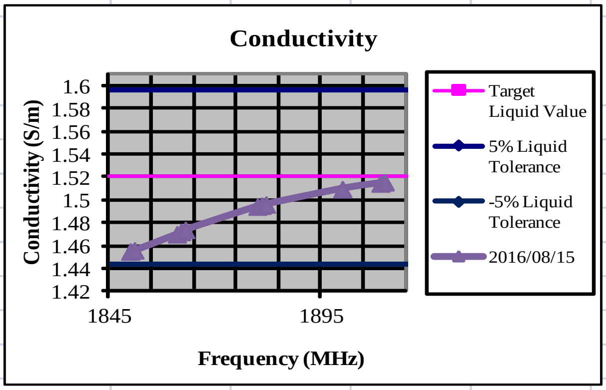
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/09 | 23.1 | 1850 | 51.3955 | 1.464 |
| | | 1851 | 51.3967 | 1.4655 |
| | | 1861 | 51.3486 | 1.4866 |
| | | 1862 | 51.3481 | 1.4882 |
| | | 1863 | 51.3474 | 1.4912 |
| | | 1880 | 51.3684 | 1.5179 |
| | | 1881 | 51.369 | 1.519 |
| | | 1882 | 51.3705 | 1.5198 |
| | | 1900 | 51.3849 | 1.5304 |
| | | 1909 | 51.3504 | 1.5312 |
| | | 1910 | 51.3444 | 1.5315 |

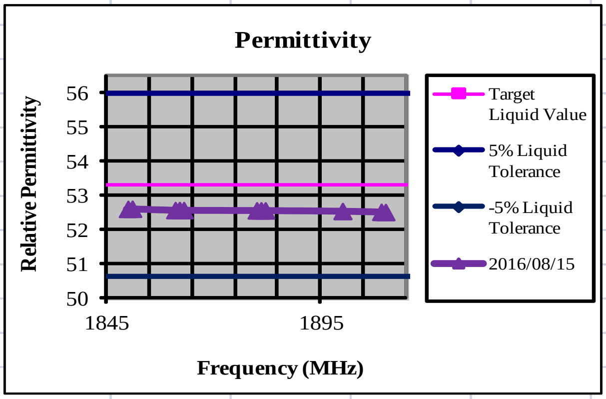


## 1900 MHz Body Liquid

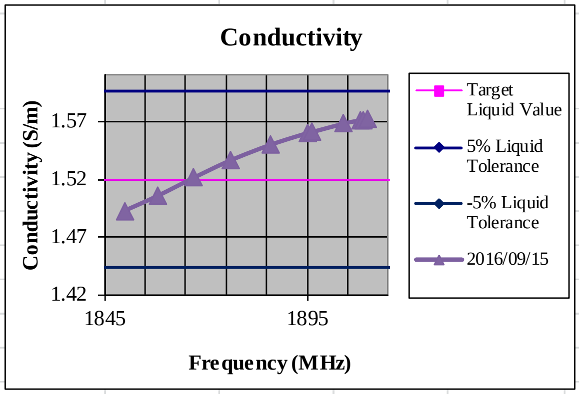
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/08/15 | 23.2 | 1850 | 52.6046 | 1.455 |
| | | 1851 | 52.6096 | 1.456 |
| | | 1861 | 52.5707 | 1.4701 |
| | | 1862 | 52.572 | 1.4722 |
| | | 1863 | 52.5698 | 1.474 |
| | | 1880 | 52.563 | 1.4944 |
| | | 1881 | 52.5624 | 1.4952 |
| | | 1882 | 52.5603 | 1.4962 |
| | | 1900 | 52.5433 | 1.5096 |
| | | 1909 | 52.519 | 1.5146 |
| | | 1910 | 52.5137 | 1.5157 |

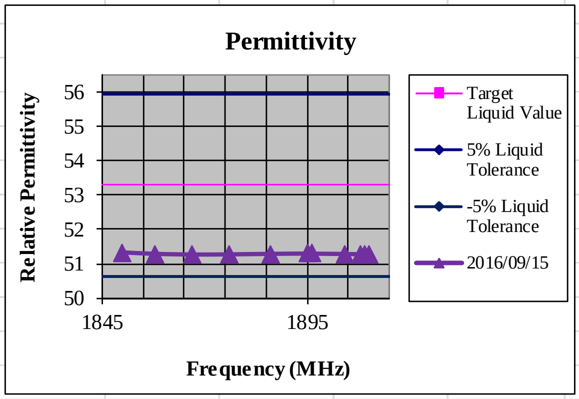


**1900 MHz Body Liquid**

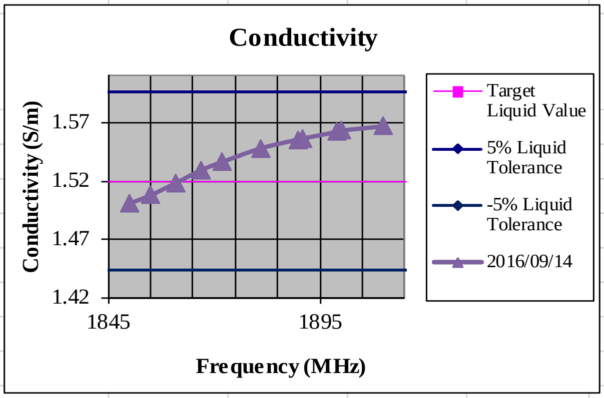
| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/09/15 | 21.5 | 1850 | 51.3303 | 1.493 |
| | | 1858 | 51.2876 | 1.5056 |
| | | 1867 | 51.2684 | 1.5214 |
| | | 1876 | 51.2727 | 1.5363 |
| | | 1886 | 51.288 | 1.5499 |
| | | 1895 | 51.2959 | 1.5599 |
| | | 1896 | 51.2935 | 1.5606 |
| | | 1904 | 51.2841 | 1.5681 |
| | | 1908 | 51.2737 | 1.5709 |
| | | 1909 | 51.269 | 1.5711 |
| | | 1910 | 51.2688 | 1.572 |

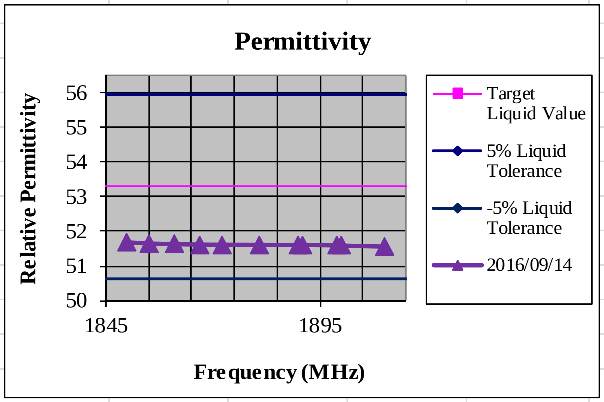


## 1900 MHz Body Liquid

| Date | Temp (°C) | Frequency (MHz) | Relative Permativity | Conductivity (S/m) |
|---|---|---|---|---|
| 2016/09/14 | 22.6 | 1850 | 51.6831 | 1.5007 |
| | | 1855 | 51.6491 | 1.5078 |
| | | 1861 | 51.63 | 1.5184 |
| | | 1867 | 51.6171 | 1.5294 |
| | | 1872 | 51.6138 | 1.5364 |
| | | 1881 | 51.6095 | 1.5479 |
| | | 1890 | 51.6064 | 1.5556 |
| | | 1891 | 51.6068 | 1.5564 |
| | | 1899 | 51.5937 | 1.562 |
| | | 1900 | 51.5878 | 1.5631 |
| | | 1910 | 51.5596 | 1.5668 |



## Test Equipment

### SAR1 Lab

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| Robot | Staubli | TX90 | F10/5D3NA1/ A/01 | N/A | N/A |
| SAM Twin Phantom | SPEAG | SM 000 T01 DA | 1592 | N/A | N/A |
| Elliptical Phantom | SPEAG | QD OVA 001 BB | 1092 | N/A | N/A |
| Software | SPEAG | Dasy52.6.2.482 | N/A | N/A | N/A |
| Device Holder | SPEAG | SD 000H01 | N/A | N/A | N/A |
| Data Acquisition Electronics | SPEAG | DAE4 | 1265 | 2016/05/11 | 2018/05/11 |
| SAR Probe | SPEAG | ES3DV3 | 3244 | 2016/04/28 | 2017/04/28 |

Shared Equipment

| Instrument description | Supplier / Manufacturer | Model | Serial No. | Calibration (date) | Calibration Due (date) |
|---|---|---|---|---|---|
| 835 MHz Dipole | SPEAG | D835V2 | 4d113 | 2016/04/15 | 2018/04/15 |
| 1900 MHz Dipole | SPEAG | D1900V2 | 5d135 | 2016/04/24 | 2018/04/25 |
| 750 MHz Dipole | SPEAG | D750V3 | 1032 | 2016/04/16 | 2018/04/16 |
| 1750 MHz Dipole | SPEAG | D1750V2 | 1045 | 2016/05/11 | 2018/05/11 |
| Network Analyzer | Agilent | N9923A | MY51491621 | 2015/10/05 | 2016/10/05 |
| Directional coupler | Werlatone | C6529 | 11249 | N/A | N/A |
| RF Amplifier | Vectawave | VTL5400 | N/A | N/A | N/A |
| Dielectric Measurement Kit | SPEAG | DAK-3.5 | 1023 | 2015/10/05 | 2016/10/05 |
| Synthesized CW Generator | Agilent | 8371213 | US37101255 | N/A | N/A |
| Power Sensor | Agilent | EPM | MY41400484 | 2015/10/17 | 2016/10/17 |
| Power Sensor | Agilent | EPM | MY41400492 | 2015/10/17 | 2016/10/17 |
| 20 dB Attenuator | Huber & Suhner | N/A | N/A | N/A | N/A |
| 3 dB Attenuator | Huber & Suhner | N/A | N/A | N/A | N/A |
| 3 dB Attenuator | Huber & Suhner | N/A | N/A | N/A | N/A |
| Radio Communications Tester | Rohde & Schwarz | CMW 500 | 127068 | 2015/3/12 | 2018/3/12 |
| Radio Communications Tester | Rohde & Schwarz | CMU 200 | 110759 | 2015/07 | 2017/07 |
| 900 MHz Body Tissue Simulant | SPEAG | MSL 900 | 100818-1 | 2016/08/19 | N/A |
| 1900 MHz Body Tissue Simulant | SPEAG | MSL 1900 | 110615-4 | 2016/08/16, 2016/09/14 | N/A |
| 900 MHz Body Tissue Simulant | SPEAG | MSL 750 | MSL750 | 2016/08/22 | N/A |
| 1750 MHz Body Tissue Simulant | SPEAG | MSL 1900 | 100824-2 | 2016/08/18 | N/A |

## Equipment Calibration/Performance Documents:

*Attached:*
*SAR Probe ES3DV3 Calibration Reports*
*750 MHz Dipole Calibration Report*
*835 MHz Dipole Calibration Report*
*1750 MHz Dipole Calibration Report*
*1900 MHz Dipole Calibration Report*

**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** Cetecom USA

**Certificate No: ES3-3244_Apr16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ES3DV3 - SN:3244 |
| 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: | April 28, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (No. 217-02285/02284) | In house check: Jun-16 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (No. 217-02285) | In house check: Jun-16 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (No. 217-02284) | In house check: Jun-16 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Apr-13) | In house check: Jun-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

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

Issued: April 28, 2016

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

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

Accredited by the Swiss Accreditation Service (SAS) Accreditation No.: **SCS 0108**
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

## Glossary:

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

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

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

# Probe ES3DV3

## SN:3244

| | |
|---|---|
| Manufactured: | May 5, 2009 |
| Repaired: | April 20, 2016 |
| Calibrated: | April 28, 2016 |

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3244

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)$^A$ | 0.83 | 1.07 | 1.01 | ± 10.1 % |
| DCP (mV)$^B$ | 108.8 | 105.1 | 101.5 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc$^E$ (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 193.4 | ±3.0 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 191.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 188.4 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.52 | 68.5 | 19.0 | 2.91 | 129.0 | ±0.7 % |
| | | Y | 3.43 | 68.0 | 19.0 | | 131.5 | |
| | | Z | 3.25 | 65.8 | 17.3 | | 129.9 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 5.30 | 74.0 | 17.3 | 9.39 | 135.3 | ±2.5 % |
| | | Y | 28.15 | 99.5 | 28.4 | | 122.5 | |
| | | Z | 17.41 | 90.7 | 25.3 | | 137.8 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 5.51 | 74.3 | 15.6 | 6.56 | 130.2 | ±1.9 % |
| | | Y | 42.73 | 100.0 | 25.7 | | 146.1 | |
| | | Z | 14.84 | 84.4 | 20.7 | | 134.2 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 6.53 | 76.3 | 15.3 | 4.80 | 147.5 | ±1.7 % |
| | | Y | 53.91 | 99.7 | 24.0 | | 127.0 | |
| | | Z | 16.66 | 83.7 | 18.7 | | 122.5 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 3.99 | 71.3 | 12.6 | 3.55 | 132.2 | ±1.9 % |
| | | Y | 71.74 | 99.6 | 22.4 | | 134.3 | |
| | | Z | 10.08 | 77.9 | 16.1 | | 127.9 | |
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 4.05 | 67.2 | 18.8 | 3.97 | 141.9 | ±0.9 % |
| | | Y | 4.03 | 66.6 | 18.7 | | 129.9 | |
| | | Z | 4.10 | 66.1 | 18.0 | | 148.7 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.37 | 67.4 | 19.4 | 5.67 | 136.7 | ±1.7 % |
| | | Y | 6.70 | 68.6 | 20.3 | | 147.5 | |
| | | Z | 6.54 | 67.4 | 19.3 | | 143.4 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.19 | 72.8 | 24.1 | 9.29 | 147.0 | ±3.0 % |
| | | Y | 11.65 | 77.3 | 26.5 | | 124.4 | |
| | | Z | 10.68 | 74.4 | 24.7 | | 119.8 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.25 | 67.1 | 19.4 | 5.80 | 136.0 | ±1.7 % |
| | | Y | 6.36 | 67.3 | 19.7 | | 127.5 | |
| | | Z | 6.50 | 67.2 | 19.4 | | 143.5 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 8.74 | 72.3 | 24.0 | 9.28 | 142.7 | ±3.3 % |
| | | Y | 11.45 | 77.6 | 26.8 | | 126.3 | |
| | | Z | 11.36 | 76.8 | 26.0 | | 144.9 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.97 | 66.7 | 19.2 | 5.75 | 134.9 | ±1.7 % |
| | | Y | 6.08 | 66.8 | 19.5 | | 125.8 | |
| | | Z | 6.19 | 66.7 | 19.1 | | 140.7 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.00 | 67.3 | 19.8 | 5.73 | 138.4 | ±1.4 % |
| | | Y | 5.16 | 66.9 | 19.7 | | 131.3 | |
| | | Z | 5.24 | 66.8 | 19.3 | | 146.0 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 7.14 | 73.7 | 24.9 | 9.21 | 132.7 | ±2.7 % |
| | | Y | 12.83 | 86.7 | 31.2 | | 147.3 | |
| | | Z | 9.65 | 78.2 | 26.8 | | 133.2 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.99 | 67.2 | 19.7 | 5.72 | 137.3 | ±1.4 % |
| | | Y | 5.14 | 66.9 | 19.7 | | 127.8 | |
| | | Z | 5.19 | 66.6 | 19.2 | | 140.0 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.27 | 67.1 | 19.4 | 5.81 | 135.4 | ±1.7 % |
| | | Y | 6.65 | 68.3 | 20.3 | | 148.8 | |
| | | Z | 6.42 | 66.9 | 19.2 | | 138.4 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 5.20 | 70.2 | 19.4 | 3.76 | 130.0 | ±0.7 % |
| | | Y | 4.80 | 67.5 | 18.5 | | 147.3 | |
| | | Z | 4.69 | 66.5 | 17.6 | | 134.4 | |

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

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3244

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.46 | 6.46 | 6.46 | 0.80 | 1.21 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.27 | 6.27 | 6.27 | 0.73 | 1.26 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.11 | 6.11 | 6.11 | 0.46 | 1.59 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.42 | 5.42 | 5.42 | 0.57 | 1.47 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.17 | 5.17 | 5.17 | 0.58 | 1.45 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 5.14 | 5.14 | 5.14 | 0.80 | 1.22 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 5.00 | 5.00 | 5.00 | 0.72 | 1.36 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.63 | 4.63 | 4.63 | 0.80 | 1.31 | ± 12.0 % |
| 2550 | 39.1 | 1.91 | 4.44 | 4.44 | 4.44 | 0.80 | 1.29 | ± 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:3244

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.32 | 6.32 | 6.32 | 0.65 | 1.31 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.24 | 6.24 | 6.24 | 0.80 | 1.12 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.06 | 6.06 | 6.06 | 0.79 | 1.21 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.06 | 5.06 | 5.06 | 0.53 | 1.57 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.81 | 4.81 | 4.81 | 0.44 | 1.80 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 4.94 | 4.94 | 4.94 | 0.55 | 1.54 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.56 | 4.56 | 4.56 | 0.73 | 1.21 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.38 | 4.38 | 4.38 | 0.79 | 1.20 | ± 12.0 % |
| 2550 | 52.6 | 2.09 | 4.26 | 4.26 | 4.26 | 0.80 | 1.07 | ± 12.0 % |

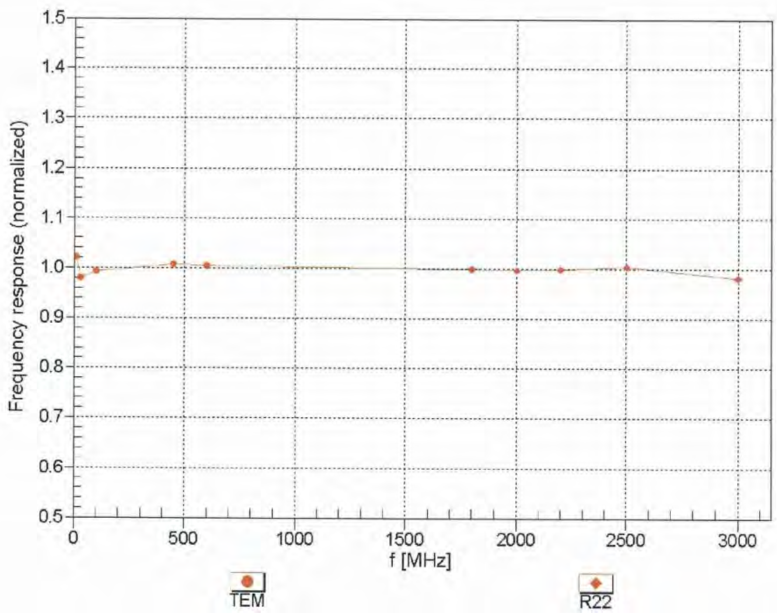
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz 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.

ES3DV3– SN:3244 April 28, 2016

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

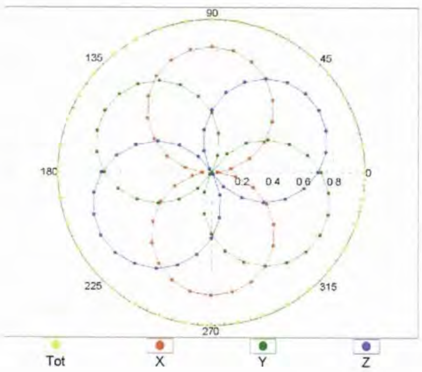



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

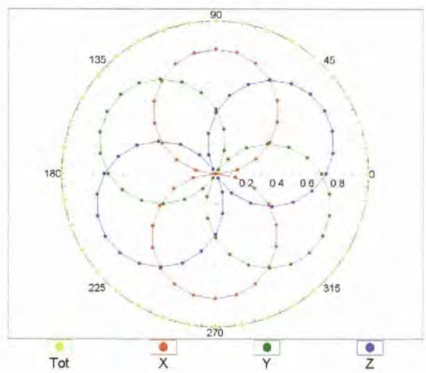
ES3DV3– SN:3244 April 28, 2016

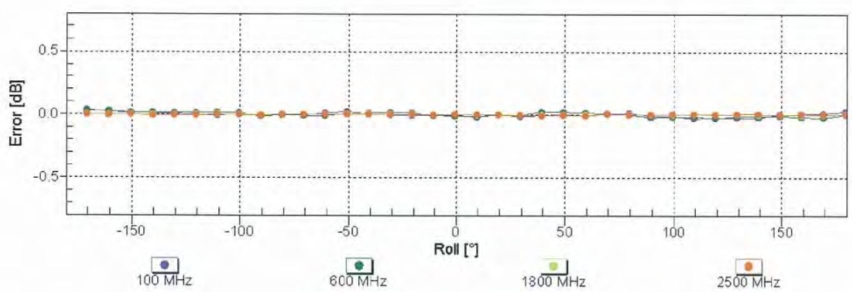
## Receiving Pattern ($\phi$), $\vartheta$ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

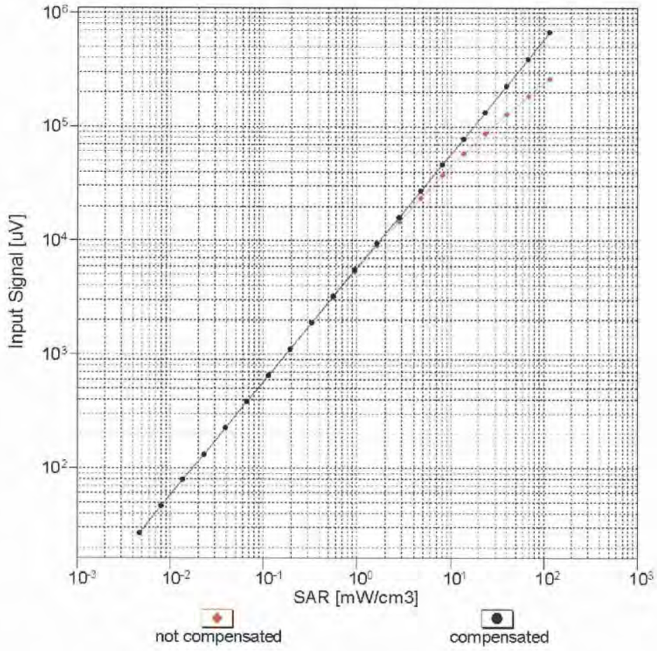


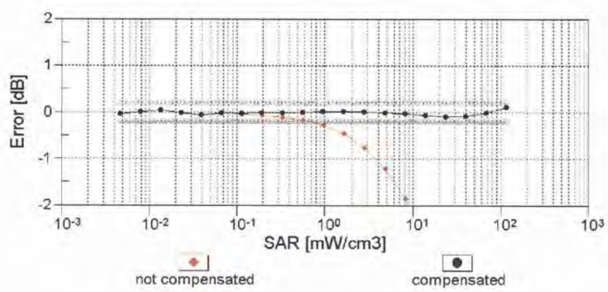




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

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

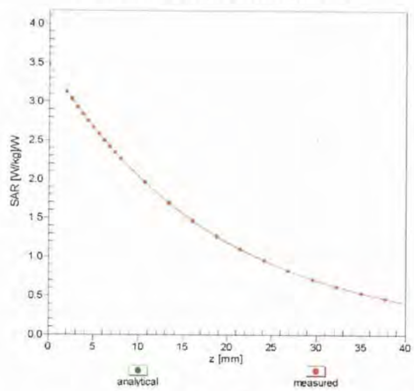
**(TEM cell , $f_{eval}$= 1900 MHz)**

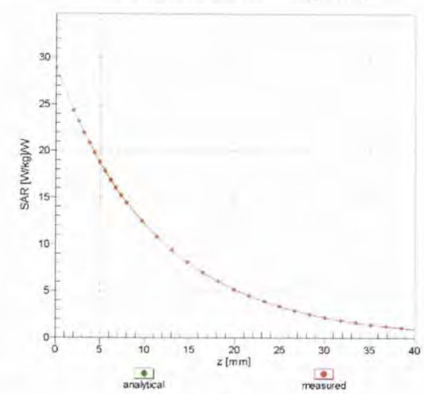



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

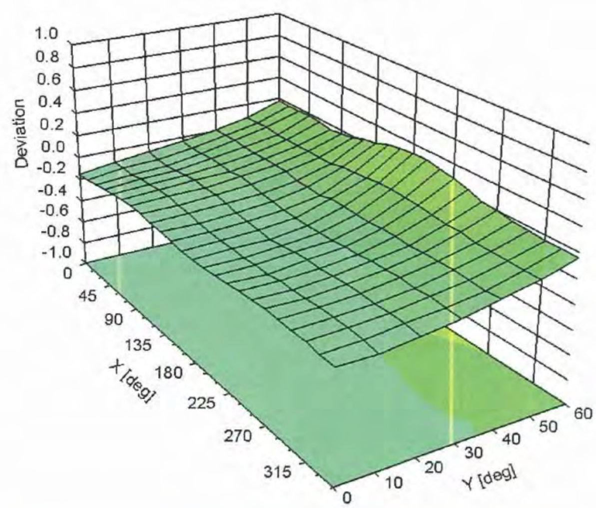
# Conversion Factor Assessment

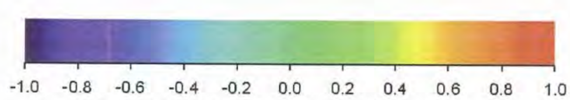



# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3244

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 69.3 |
| 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 |

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**Accreditation No.: SCS 0108**

**Client** **Cetecom USA**

**Certificate No: DAE4-1265_May16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 1265 |
| Calibration procedure(s) | QA CAL-06.v29<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | May 11, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 09-Sep-15 (No:17153) | Sep-16 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 05-Jan-16 (in house check) | In house check: Jan-17 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 05-Jan-16 (in house check) | In house check: Jan-17 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dominique Steffen | Technician | |
| Approved by: | Fin Bomholt | Deputy Technical Manager | i.V. |

Issued: May 11, 2016

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**Accreditation No.: SCS 0108**

## Glossary

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV , full range = -100...+300 mV

Low Range: 1LSB = 61nV , full range = -1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| **High Range** | 405.895 ± 0.02% (k=2) | 404.913 ± 0.02% (k=2) | 404.189 ± 0.02% (k=2) |
| **Low Range** | 4.00300 ± 1.50% (k=2) | 3.99777 ± 1.50% (k=2) | 3.99268 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 186.5 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 199996.57 | 2.25 | 0.00 |
| Channel X | + Input | 20001.53 | 0.14 | 0.00 |
| Channel X | - Input | -19998.65 | 1.83 | -0.01 |
| Channel Y | + Input | 199999.96 | 5.88 | 0.00 |
| Channel Y | + Input | 19998.73 | -2.57 | -0.01 |
| Channel Y | - Input | -20000.63 | -0.18 | 0.00 |
| Channel Z | + Input | 199996.32 | 1.58 | 0.00 |
| Channel Z | + Input | 19998.73 | -2.58 | -0.01 |
| Channel Z | - Input | -20002.02 | -1.50 | 0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2001.76 | 0.48 | 0.02 |
| Channel X | + Input | 202.56 | 0.86 | 0.43 |
| Channel X | - Input | -196.82 | 1.38 | -0.70 |
| Channel Y | + Input | 2000.80 | -0.29 | -0.01 |
| Channel Y | + Input | 200.62 | -0.92 | -0.46 |
| Channel Y | - Input | -198.82 | -0.51 | 0.26 |
| Channel Z | + Input | 2000.63 | -0.50 | -0.02 |
| Channel Z | + Input | 201.07 | -0.54 | -0.27 |
| Channel Z | - Input | -199.54 | -1.24 | 0.63 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | 13.25 | 11.04 |
| | - 200 | -10.12 | -11.61 |
| Channel Y | 200 | 5.42 | 5.34 |
| | - 200 | -7.31 | -7.71 |
| Channel Z | 200 | -5.72 | -5.60 |
| | - 200 | 4.97 | 4.71 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | 1.22 | -3.61 |
| Channel Y | 200 | 7.54 | - | 2.57 |
| Channel Z | 200 | 10.32 | 4.88 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| Channel X | 16042 | 15738 |
| Channel Y | 16342 | 15898 |
| Channel Z | 15927 | 15633 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| Channel X | 1.48 | -0.22 | 3.38 | 0.67 |
| Channel Y | 0.25 | -1.44 | 2.14 | 0.67 |
| Channel Z | 0.55 | -1.31 | 1.91 | 0.65 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| Channel X | 200 | 200 |
| Channel Y | 200 | 200 |
| Channel Z | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|---|---|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

## 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| Supply (+ Vcc) | +0.01 | +6 | +14 |
| Supply (- Vcc) | –0.01 | -8 | -9 |

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Accreditation No.: **SCS 0108**

Client **Cetecom USA** Certificate No: **D750V3-1032_Apr16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D750V3 - SN: 1032 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | April 14, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

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

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

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

Issued: April 15, 2016

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Accreditation No.: **SCS 0108**

**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.9 | 0.89 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 42.0 ± 6 % | 0.90 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.07 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **8.21 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.36 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **5.40 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.5 | 0.96 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 54.6 ± 6 % | 0.99 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.20 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **8.57 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.45 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **5.68 W/kg ± 16.5 % (k=2)** |

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

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 54.2 Ω - 0.2 jΩ |
| Return Loss | - 27.9 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 50.1 Ω - 2.1 jΩ |
| Return Loss | - 33.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.030 ns |

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

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

### Additional EUT Data

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

## DASY5 Validation Report for Head TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

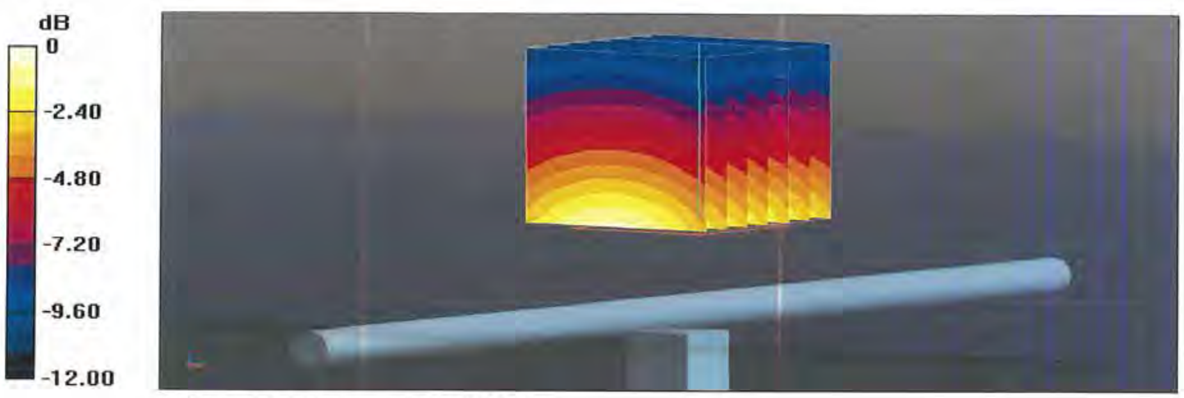
**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1032**

Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma$ = 0.9 S/m; $\varepsilon_r$ = 42; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

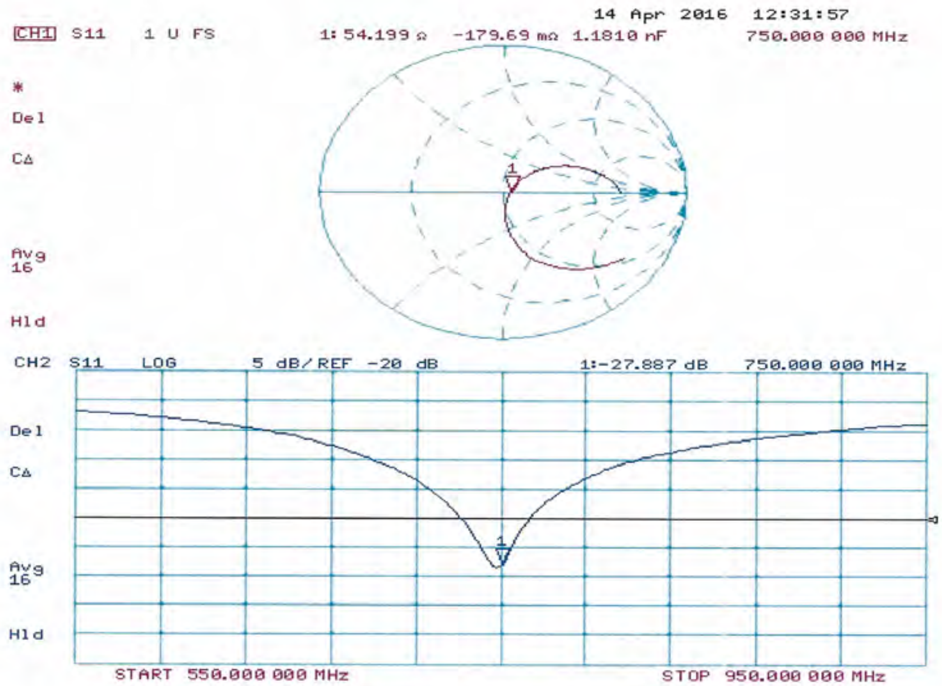
- Probe: EX3DV4 - SN7349; ConvF(10.28, 10.28, 10.28); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.99 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 3.08 W/kg
**SAR(1 g) = 2.07 W/kg; SAR(10 g) = 1.36 W/kg**
Maximum value of SAR (measured) = 2.75 W/kg




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

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

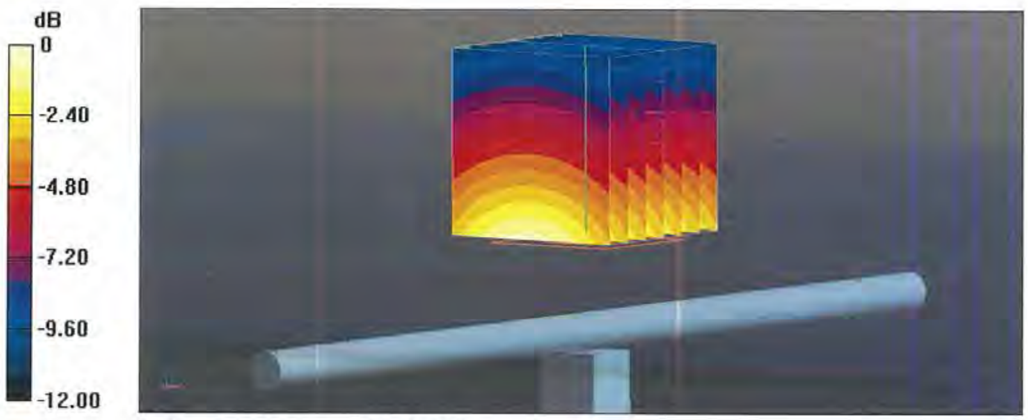
**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1032**

Communication System: UID 0 - CW; Frequency: 750 MHz
Medium parameters used: f = 750 MHz; $\sigma = 0.99$ S/m; $\varepsilon_r = 54.6$; $\rho = 1000$ kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

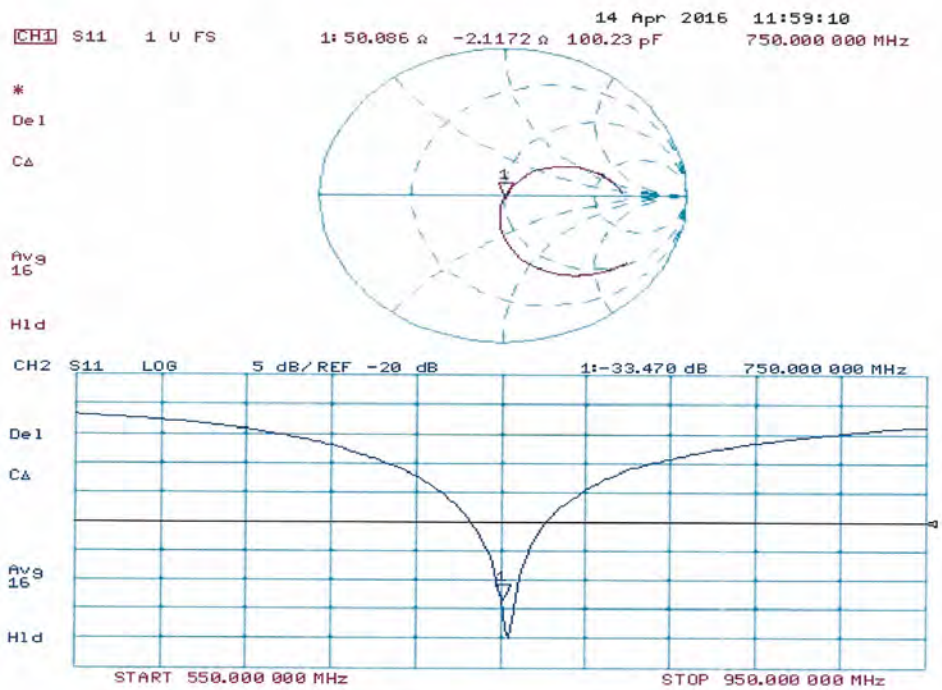
- Probe: EX3DV4 - SN7349; ConvF(9.99, 9.99, 9.99); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.78 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 3.24 W/kg
**SAR(1 g) = 2.2 W/kg; SAR(10 g) = 1.45 W/kg**
Maximum value of SAR (measured) = 2.91 W/kg




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

**Impedance Measurement Plot for Body TSL**



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Accreditation No.: **SCS 0108**

Client **Cetecom USA**

Certificate No: **D835V2-4d113_Apr16**

# CALIBRATION CERTIFICATE

Object: D835V2 - SN: 4d113

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

Calibration date: April 14, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

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

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

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

Issued: April 15, 2016

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Accreditation No.: **SCS 0108**

**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.37 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **9.26 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.54 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.05 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Body TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.46 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **9.45 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.62 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **6.28 W/kg ± 16.5 % (k=2)** |

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

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.7 Ω - 3.1 jΩ |
| Return Loss | - 29.1 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 48.1 Ω - 5.1 jΩ |
| Return Loss | - 25.1 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.393 ns |

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

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

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | May 26, 2010 |

## DASY5 Validation Report for Head TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d113**

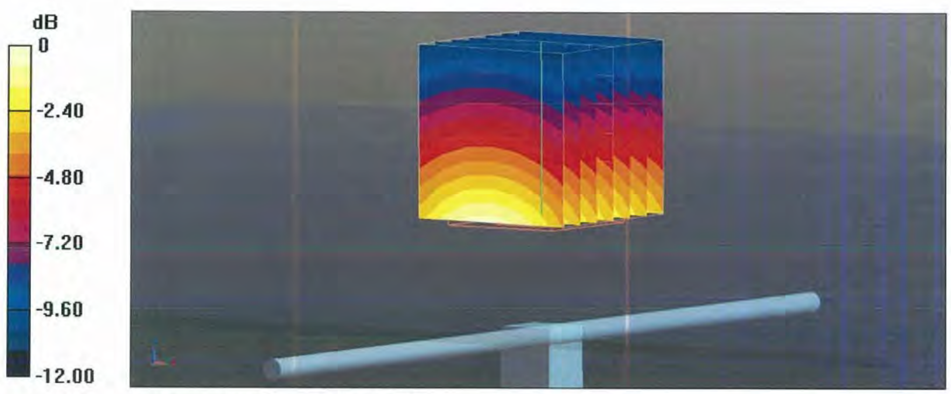
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 0.93 S/m; $\varepsilon_r$ = 41.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

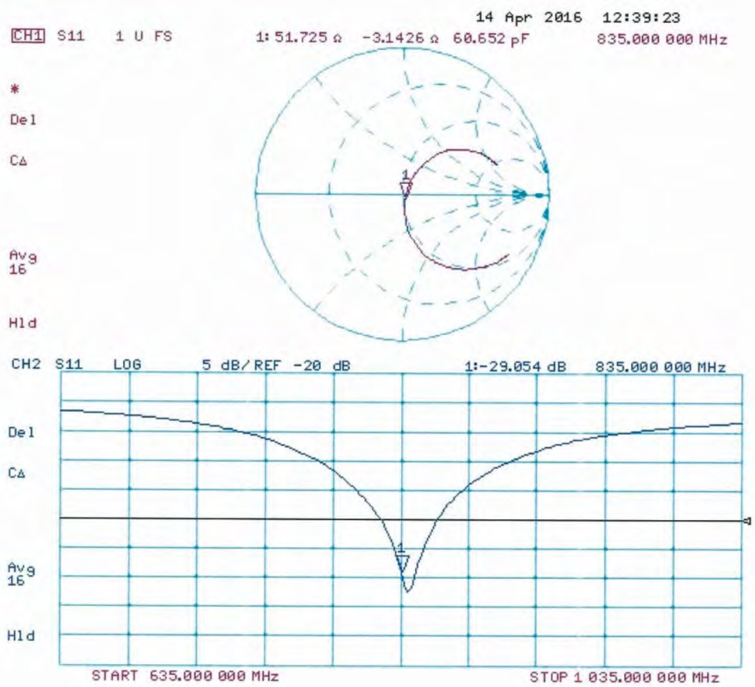
### Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 61.30 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.53 W/kg
**SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.54 W/kg**
Maximum value of SAR (measured) = 3.16 W/kg




0 dB = 3.16 W/kg = 5.00 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 14.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d113**

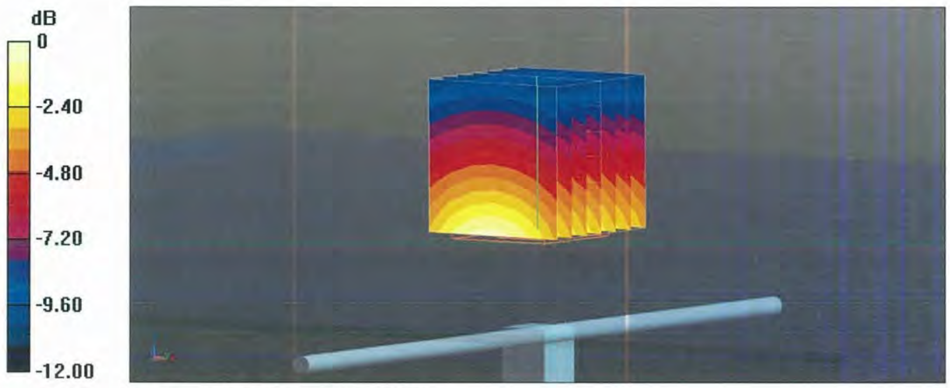
Communication System: UID 0 - CW; Frequency: 835 MHz
Medium parameters used: f = 835 MHz; $\sigma$ = 1.02 S/m; $\varepsilon_r$ = 54.4; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

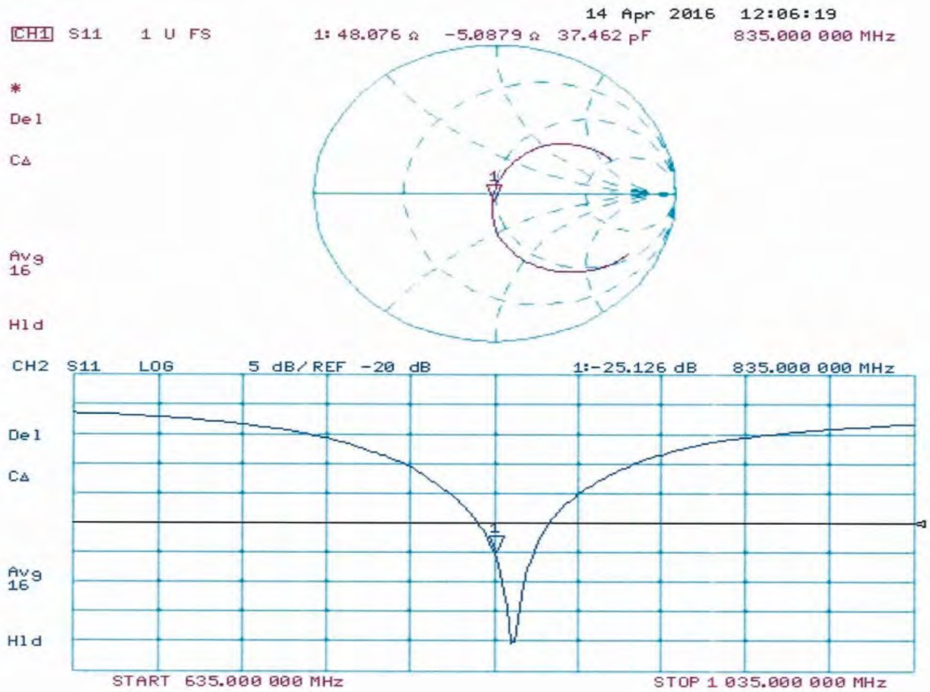
### Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 59.55 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 3.56 W/kg
**SAR(1 g) = 2.46 W/kg; SAR(10 g) = 1.62 W/kg**
Maximum value of SAR (measured) = 3.22 W/kg




0 dB = 3.22 W/kg = 5.08 dBW/kg

## Impedance Measurement Plot for Body TSL



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**Accreditation No.: SCS 0108**

**Client** Cetecom USA

**Certificate No: D1750V2-1045_May16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D1750V2 - SN:1045 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | May 11, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

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

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

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

Issued: May 18, 2016

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Accreditation No.: **SCS 0108**

**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.1 | 1.37 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 39.8 ± 6 % | 1.36 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.00 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **36.1 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.78 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **19.2 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

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

## SAR result with Body TSL

| **SAR averaged over 1 cm³ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.19 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **36.7 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.90 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **19.6 W/kg ± 16.5 % (k=2)** |

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

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 49.3 Ω - 0.4 jΩ |
| Return Loss | - 41.6 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 45.5 Ω - 1.0 jΩ |
| Return Loss | - 26.4 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.219 ns |

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

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

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | February 19, 2010 |

## DASY5 Validation Report for Head TSL

Date: 11.05.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1045**

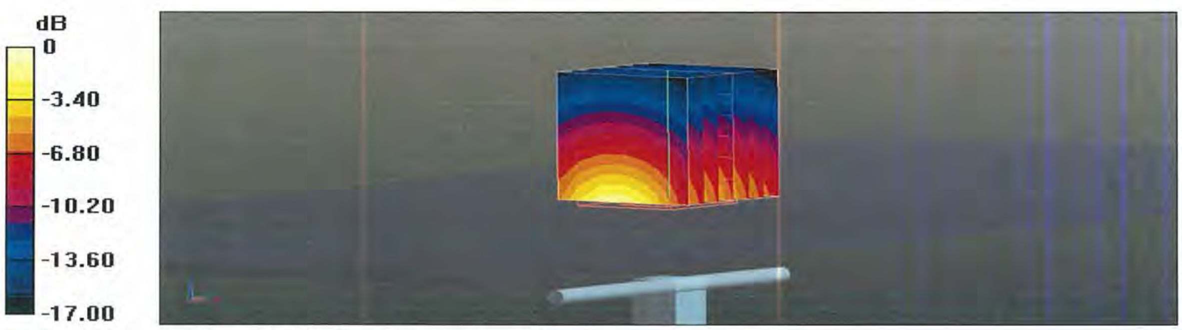
Communication System: UID 0 - CW; Frequency: 1750 MHz
Medium parameters used: f = 1750 MHz; $\sigma$ = 1.36 S/m; $\varepsilon_r$ = 39.8; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

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

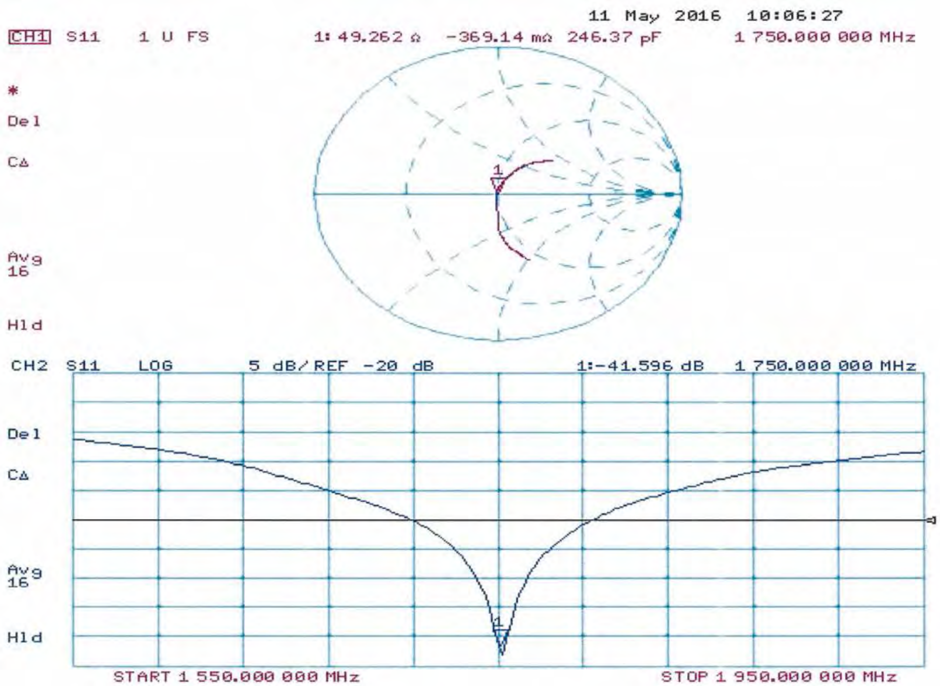
### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 103.8 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 16.5 W/kg
**SAR(1 g) = 9 W/kg; SAR(10 g) = 4.78 W/kg**
Maximum value of SAR (measured) = 13.6 W/kg




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

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 11.05.2016

Test Laboratory: SPEAG, Zurich, Switzerland

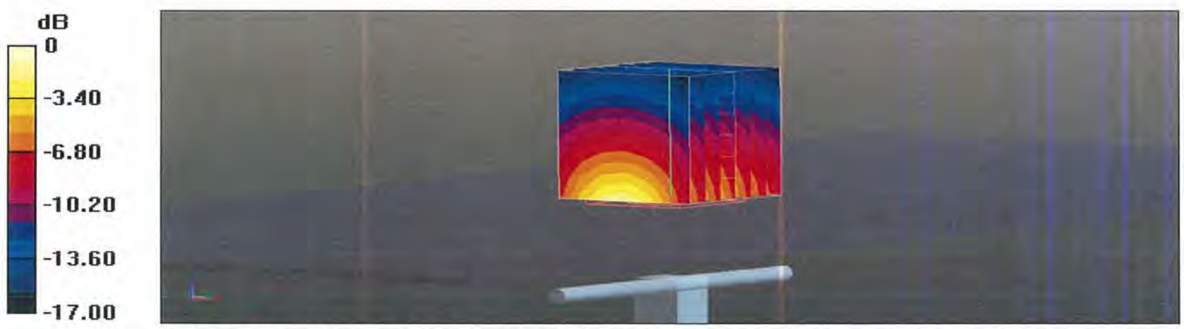
**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1045**

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

DASY52 Configuration:

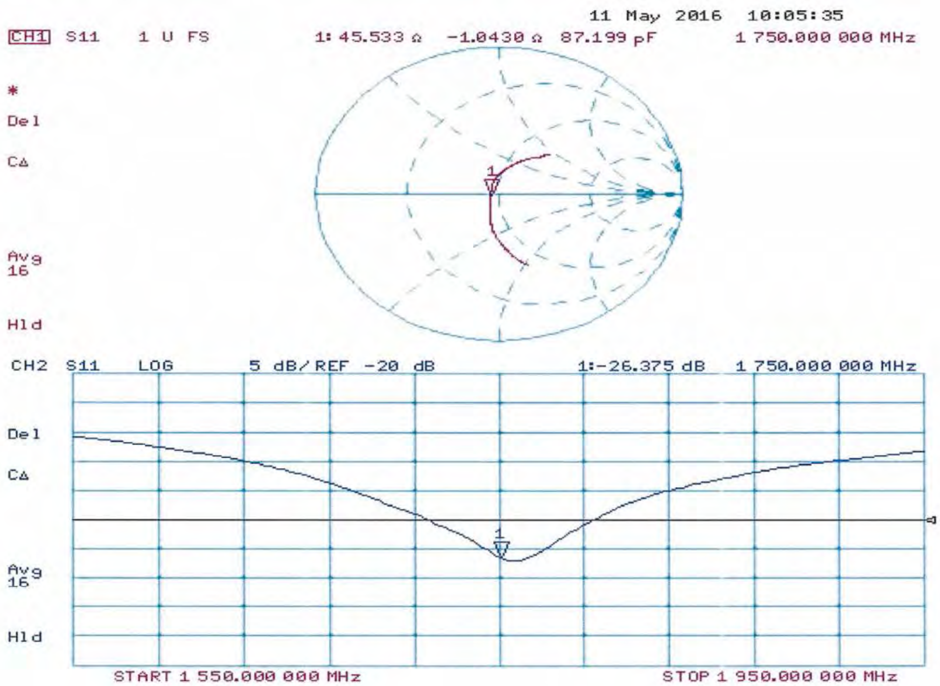
- Probe: EX3DV4 - SN7349; ConvF(8.25, 8.25, 8.25); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.89 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 16.1 W/kg
**SAR(1 g) = 9.19 W/kg; SAR(10 g) = 4.9 W/kg**
Maximum value of SAR (measured) = 13.7 W/kg




0 dB = 13.7 W/kg = 11.37 dBW/kg

**Impedance Measurement Plot for Body TSL**



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**Accreditation No.: SCS 0108**

**Client** Cetecom USA

**Certificate No: D1900V2-5d135_Apr16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D1900V2 - SN: 5d135 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | April 25, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

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

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

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

Issued: April 26, 2016

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Accreditation No.: **SCS 0108**

**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

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

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 40.0 | 1.40 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 40.0 ± 6 % | 1.37 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.29 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **37.6 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 4.90 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **19.8 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 53.3 | 1.52 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 52.9 ± 6 % | 1.49 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 cm³ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 9.60 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **38.8 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 5.09 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **20.5 W/kg ± 16.5 % (k=2)** |

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

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 52.8 Ω + 9.9 jΩ |
| Return Loss | - 20.0 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 48.2 Ω + 9.7 jΩ |
| Return Loss | - 20.0 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.203 ns |

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

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

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |
| Manufactured on | April 14, 2010 |

## DASY5 Validation Report for Head TSL

Date: 25.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d135**

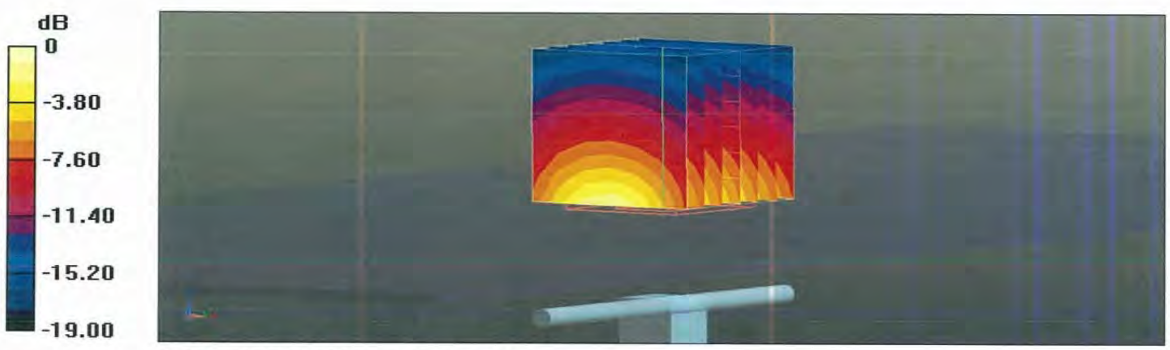
Communication System: UID 0 - CW; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.37 S/m; $\varepsilon_r$ = 40; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.2, 8.2, 8.2); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

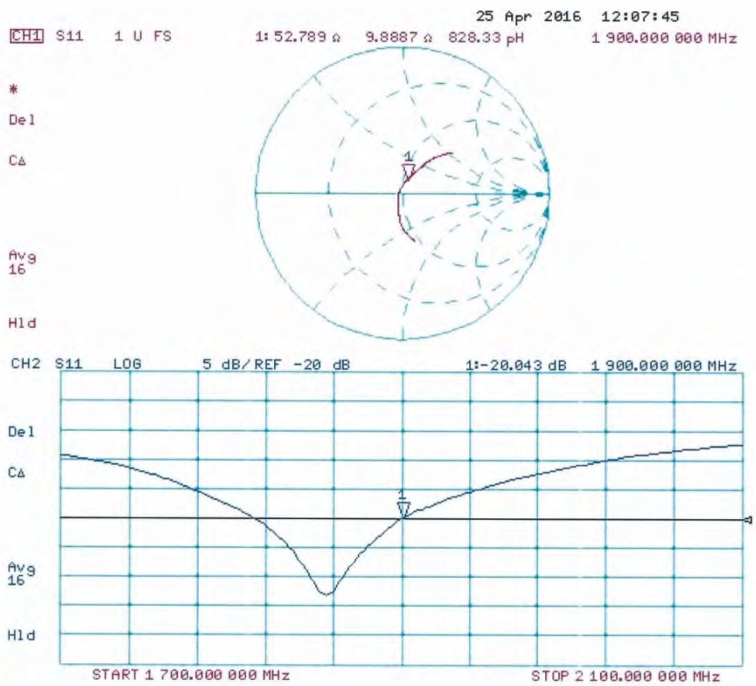
### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 106.8 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 16.8 W/kg
**SAR(1 g) = 9.29 W/kg; SAR(10 g) = 4.9 W/kg**
Maximum value of SAR (measured) = 14.2 W/kg




0 dB = 14.2 W/kg = 11.52 dBW/kg

## Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 25.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

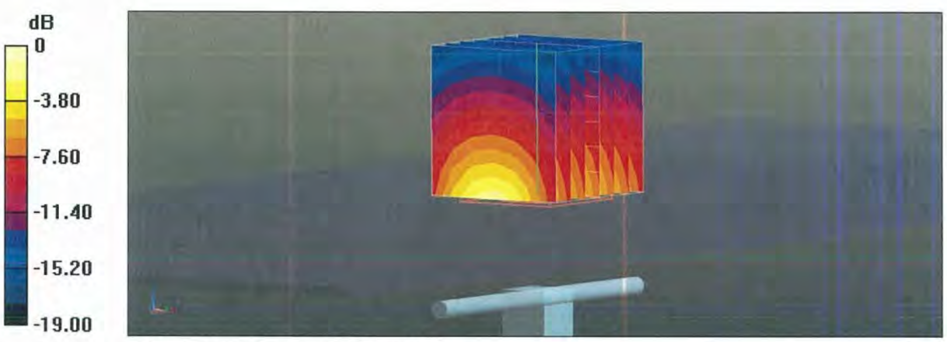
**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d135**

Communication System: UID 0 - CW; Frequency: 1900 MHz
Medium parameters used: f = 1900 MHz; $\sigma$ = 1.49 S/m; $\varepsilon_r$ = 52.9; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

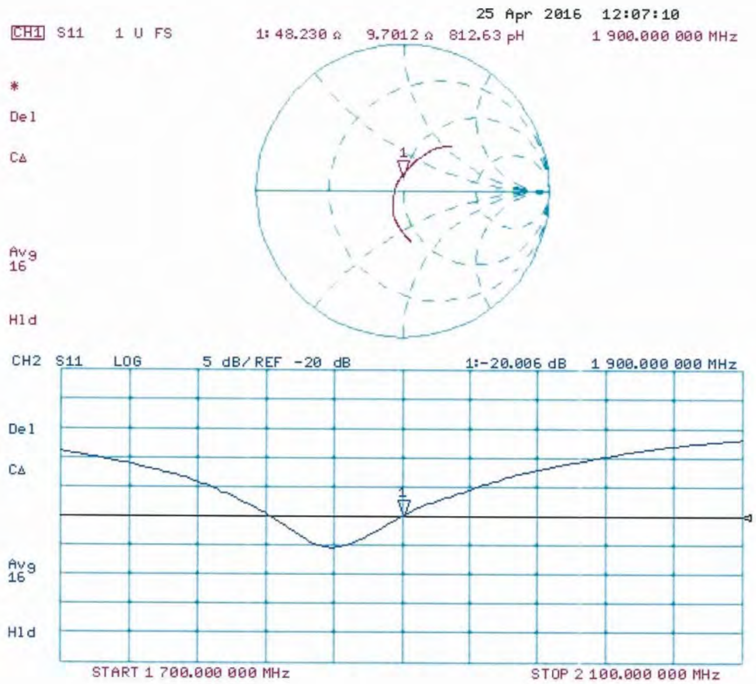
- Probe: EX3DV4 - SN7349; ConvF(8.03, 8.03, 8.03); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 102.9 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 16.8 W/kg
**SAR(1 g) = 9.6 W/kg; SAR(10 g) = 5.09 W/kg**
Maximum value of SAR (measured) = 14.5 W/kg




0 dB = 14.5 W/kg = 11.61 dBW/kg

**Impedance Measurement Plot for Body TSL**



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**Accreditation No.: SCS 0108**

**Client** Cetecom USA

**Certificate No: ES3-3244_Apr16**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3244

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

Calibration date: April 28, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-15 (No. ES3-3013_Dec15) | Dec-16 |
| DAE4 | SN: 660 | 23-Dec-15 (No. DAE4-660_Dec15) | Dec-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (No. 217-02285/02284) | In house check: Jun-16 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (No. 217-02285) | In house check: Jun-16 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (No. 217-02284) | In house check: Jun-16 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Apr-13) | In house check: Jun-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

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

Issued: April 28, 2016

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Accreditation No.: **SCS 0108**

## Glossary:

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

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

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

# Probe ES3DV3

## SN:3244

Manufactured: May 5, 2009
Repaired: April 20, 2016
Calibrated: April 28, 2016

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3244

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$)[A] | 0.83 | 1.07 | 1.01 | ± 10.1 % |
| DCP (mV)[B] | 108.8 | 105.1 | 101.5 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 193.4 | ±3.0 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 191.2 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 188.4 | |
| 10011-CAB | UMTS-FDD (WCDMA) | X | 3.52 | 68.5 | 19.0 | 2.91 | 129.0 | ±0.7 % |
| | | Y | 3.43 | 68.0 | 19.0 | | 131.5 | |
| | | Z | 3.25 | 65.8 | 17.3 | | 129.9 | |
| 10021-DAB | GSM-FDD (TDMA, GMSK) | X | 5.30 | 74.0 | 17.3 | 9.39 | 135.3 | ±2.5 % |
| | | Y | 28.15 | 99.5 | 28.4 | | 122.5 | |
| | | Z | 17.41 | 90.7 | 25.3 | | 137.8 | |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1) | X | 5.51 | 74.3 | 15.6 | 6.56 | 130.2 | ±1.9 % |
| | | Y | 42.73 | 100.0 | 25.7 | | 146.1 | |
| | | Z | 14.84 | 84.4 | 20.7 | | 134.2 | |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2) | X | 6.53 | 76.3 | 15.3 | 4.80 | 147.5 | ±1.7 % |
| | | Y | 53.91 | 99.7 | 24.0 | | 127.0 | |
| | | Z | 16.66 | 83.7 | 18.7 | | 122.5 | |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3) | X | 3.99 | 71.3 | 12.6 | 3.55 | 132.2 | ±1.9 % |
| | | Y | 71.74 | 99.6 | 22.4 | | 134.3 | |
| | | Z | 10.08 | 77.9 | 16.1 | | 127.9 | |
| 10081-CAB | CDMA2000 (1xRTT, RC3) | X | 4.05 | 67.2 | 18.8 | 3.97 | 141.9 | ±0.9 % |
| | | Y | 4.03 | 66.6 | 18.7 | | 129.9 | |
| | | Z | 4.10 | 66.1 | 18.0 | | 148.7 | |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.37 | 67.4 | 19.4 | 5.67 | 136.7 | ±1.7 % |
| | | Y | 6.70 | 68.6 | 20.3 | | 147.5 | |
| | | Z | 6.54 | 67.4 | 19.3 | | 143.4 | |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.19 | 72.8 | 24.1 | 9.29 | 147.0 | ±3.0 % |
| | | Y | 11.65 | 77.3 | 26.5 | | 124.4 | |
| | | Z | 10.68 | 74.4 | 24.7 | | 119.8 | |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.25 | 67.1 | 19.4 | 5.80 | 136.0 | ±1.7 % |
| | | Y | 6.36 | 67.3 | 19.7 | | 127.5 | |
| | | Z | 6.50 | 67.2 | 19.4 | | 143.5 | |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 8.74 | 72.3 | 24.0 | 9.28 | 142.7 | ±3.3 % |
| | | Y | 11.45 | 77.6 | 26.8 | | 126.3 | |
| | | Z | 11.36 | 76.8 | 26.0 | | 144.9 | |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK) | X | 5.97 | 66.7 | 19.2 | 5.75 | 134.9 | ±1.7 % |
| | | Y | 6.08 | 66.8 | 19.5 | | 125.8 | |
| | | Z | 6.19 | 66.7 | 19.1 | | 140.7 | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 5.00 | 67.3 | 19.8 | 5.73 | 138.4 | ±1.4 % |
| | | Y | 5.16 | 66.9 | 19.7 | | 131.3 | |
| | | Z | 5.24 | 66.8 | 19.3 | | 146.0 | |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK) | X | 7.14 | 73.7 | 24.9 | 9.21 | 132.7 | ±2.7 % |
| | | Y | 12.83 | 86.7 | 31.2 | | 147.3 | |
| | | Z | 9.65 | 78.2 | 26.8 | | 133.2 | |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK) | X | 4.99 | 67.2 | 19.7 | 5.72 | 137.3 | ±1.4 % |
| | | Y | 5.14 | 66.9 | 19.7 | | 127.8 | |
| | | Z | 5.19 | 66.6 | 19.2 | | 140.0 | |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | X | 6.27 | 67.1 | 19.4 | 5.81 | 135.4 | ±1.7 % |
| | | Y | 6.65 | 68.3 | 20.3 | | 148.8 | |
| | | Z | 6.42 | 66.9 | 19.2 | | 138.4 | |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0) | X | 5.20 | 70.2 | 19.4 | 3.76 | 130.0 | ±0.7 % |
| | | Y | 4.80 | 67.5 | 18.5 | | 147.3 | |
| | | Z | 4.69 | 66.5 | 17.6 | | 134.4 | |

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

[A] The uncertainties of Norm X,Y,Z do not affect the $E^2$-field uncertainty inside TSL (see Pages 6 and 7).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3244

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) C | Relative Permittivity F | Conductivity (S/m) F | ConvF X | ConvF Y | ConvF Z | Alpha G | Depth G (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.46 | 6.46 | 6.46 | 0.80 | 1.21 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.27 | 6.27 | 6.27 | 0.73 | 1.26 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.11 | 6.11 | 6.11 | 0.46 | 1.59 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.42 | 5.42 | 5.42 | 0.57 | 1.47 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.17 | 5.17 | 5.17 | 0.58 | 1.45 | ± 12.0 % |
| 1950 | 40.0 | 1.40 | 5.14 | 5.14 | 5.14 | 0.80 | 1.22 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 5.00 | 5.00 | 5.00 | 0.72 | 1.36 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 4.63 | 4.63 | 4.63 | 0.80 | 1.31 | ± 12.0 % |
| 2550 | 39.1 | 1.91 | 4.44 | 4.44 | 4.44 | 0.80 | 1.29 | ± 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:3244

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 55.5 | 0.96 | 6.32 | 6.32 | 6.32 | 0.65 | 1.31 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.24 | 6.24 | 6.24 | 0.80 | 1.12 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.06 | 6.06 | 6.06 | 0.79 | 1.21 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 5.06 | 5.06 | 5.06 | 0.53 | 1.57 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.81 | 4.81 | 4.81 | 0.44 | 1.80 | ± 12.0 % |
| 1950 | 53.3 | 1.52 | 4.94 | 4.94 | 4.94 | 0.55 | 1.54 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 4.56 | 4.56 | 4.56 | 0.73 | 1.21 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 4.38 | 4.38 | 4.38 | 0.79 | 1.20 | ± 12.0 % |
| 2550 | 52.6 | 2.09 | 4.26 | 4.26 | 4.26 | 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 (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.

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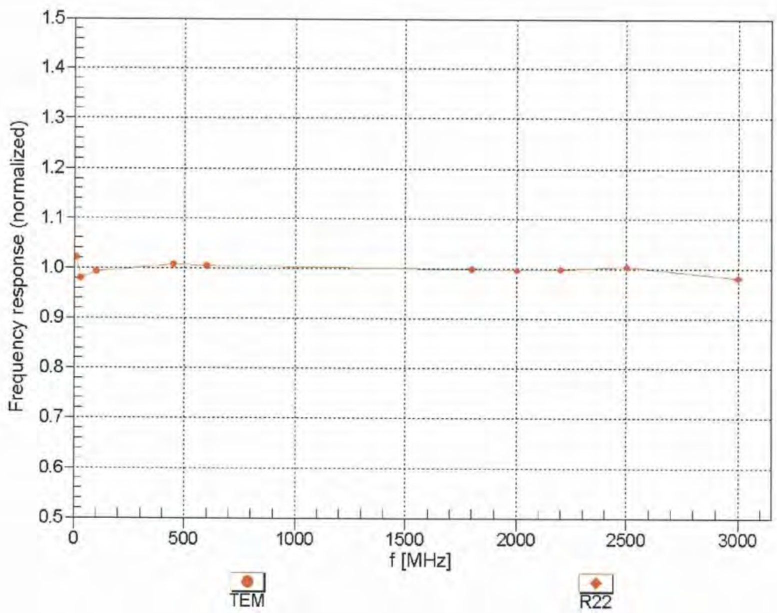
# Frequency Response of E-Field
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**




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

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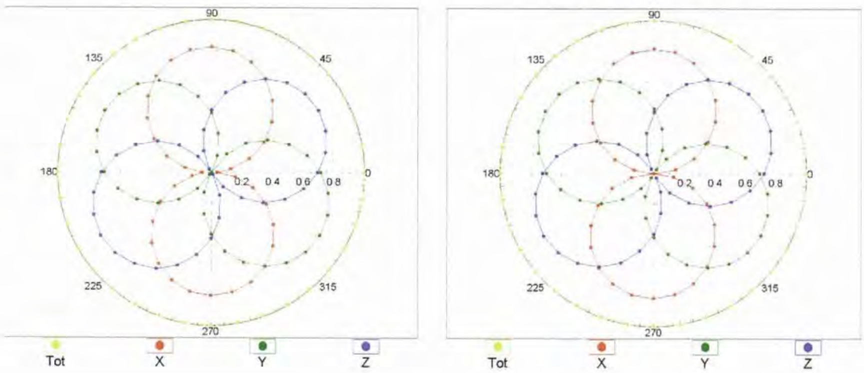
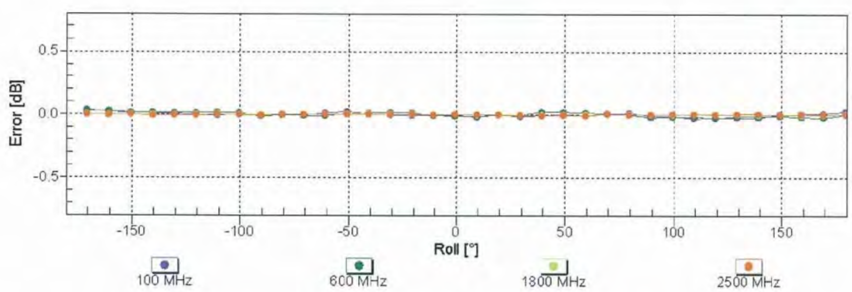
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM f=1800 MHz,R22




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

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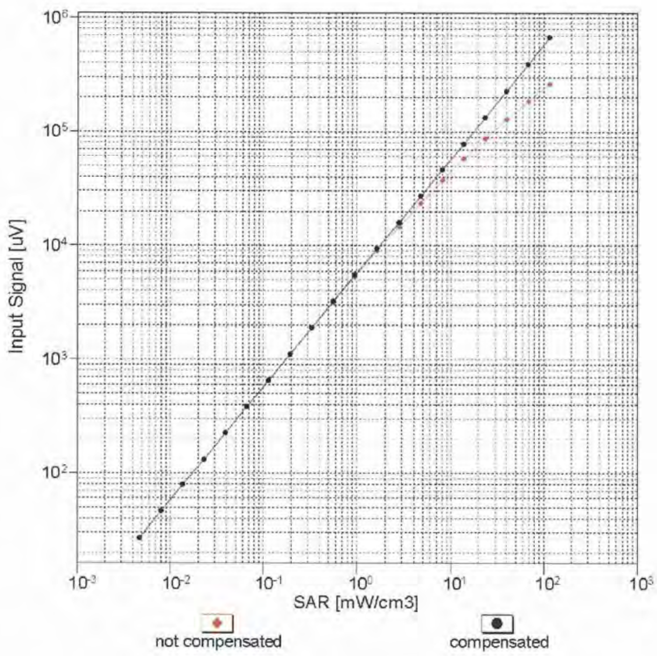
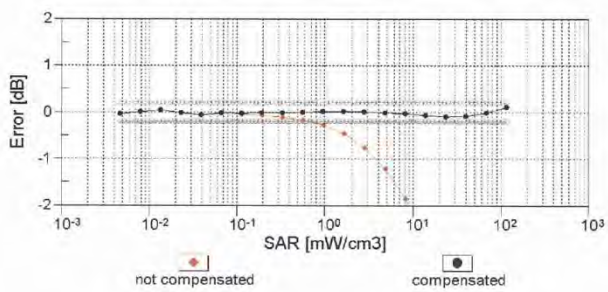
## Dynamic Range f($SAR_{head}$)
**(TEM cell , $f_{eval}$= 1900 MHz)**




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

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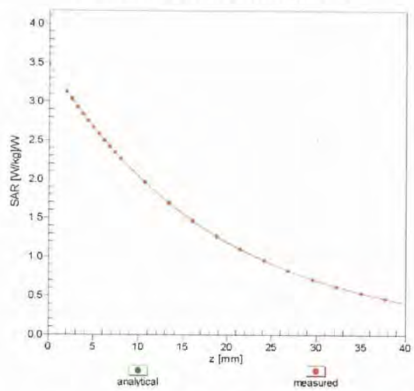
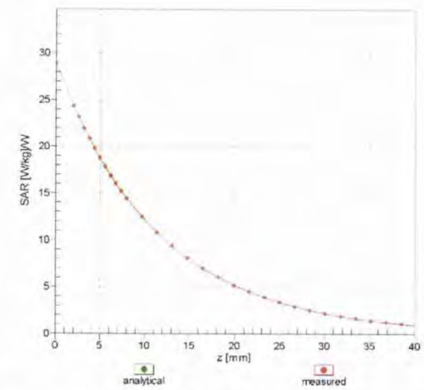
# Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

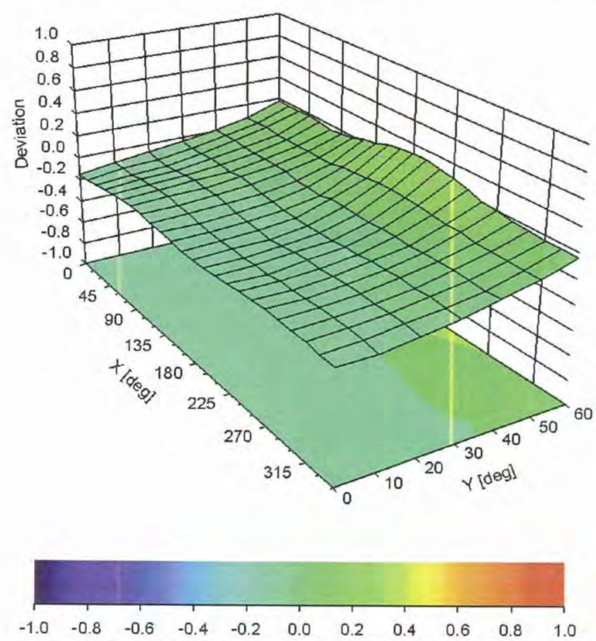



f = 1900 MHz,WGLS R22 (H_convF)




# 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:3244

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 69.3 |
| 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**
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**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
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Accreditation No.: **SCS 0108**

Client **Cetecom USA**

Certificate No: **DAE4-1265_May16**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 1265 |
| Calibration procedure(s) | QA CAL-06.v29<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | May 11, 2016 |

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 09-Sep-15 (No:17153) | Sep-16 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 05-Jan-16 (in house check) | In house check: Jan-17 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 05-Jan-16 (in house check) | In house check: Jan-17 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dominique Steffen | Technician | |
| Approved by: | Fin Bomholt | Deputy Technical Manager | i.V. |

Issued: May 11, 2016

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

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Accreditation No.: **SCS 0108**

**Glossary**

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

**Methods Applied and Interpretation of Parameters**

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1µV , full range = -100...+300 mV

Low Range: 1LSB = 61nV , full range = -1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| High Range | 405.895 ± 0.02% (k=2) | 404.913 ± 0.02% (k=2) | 404.189 ± 0.02% (k=2) |
| Low Range | 4.00300 ± 1.50% (k=2) | 3.99777 ± 1.50% (k=2) | 3.99268 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 186.5 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 199996.57 | 2.25 | 0.00 |
| Channel X | + Input | 20001.53 | 0.14 | 0.00 |
| Channel X | - Input | -19998.65 | 1.83 | -0.01 |
| Channel Y | + Input | 199999.96 | 5.88 | 0.00 |
| Channel Y | + Input | 19998.73 | -2.57 | -0.01 |
| Channel Y | - Input | -20000.63 | -0.18 | 0.00 |
| Channel Z | + Input | 199996.32 | 1.58 | 0.00 |
| Channel Z | + Input | 19998.73 | -2.58 | -0.01 |
| Channel Z | - Input | -20002.02 | -1.50 | 0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2001.76 | 0.48 | 0.02 |
| Channel X | + Input | 202.56 | 0.86 | 0.43 |
| Channel X | - Input | -196.82 | 1.38 | -0.70 |
| Channel Y | + Input | 2000.80 | -0.29 | -0.01 |
| Channel Y | + Input | 200.62 | -0.92 | -0.46 |
| Channel Y | - Input | -198.82 | -0.51 | 0.26 |
| Channel Z | + Input | 2000.63 | -0.50 | -0.02 |
| Channel Z | + Input | 201.07 | -0.54 | -0.27 |
| Channel Z | - Input | -199.54 | -1.24 | 0.63 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | 13.25 | 11.04 |
| | - 200 | -10.12 | -11.61 |
| Channel Y | 200 | 5.42 | 5.34 |
| | - 200 | -7.31 | -7.71 |
| Channel Z | 200 | -5.72 | -5.60 |
| | - 200 | 4.97 | 4.71 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | 1.22 | -3.61 |
| Channel Y | 200 | 7.54 | - | 2.57 |
| Channel Z | 200 | 10.32 | 4.88 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| Channel X | 16042 | 15738 |
| Channel Y | 16342 | 15898 |
| Channel Z | 15927 | 15633 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| Channel X | 1.48 | -0.22 | 3.38 | 0.67 |
| Channel Y | 0.25 | -1.44 | 2.14 | 0.67 |
| Channel Z | 0.55 | -1.31 | 1.91 | 0.65 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| Channel X | 200 | 200 |
| Channel Y | 200 | 200 |
| Channel Z | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|---|---|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

## 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| Supply (+ Vcc) | +0.01 | +6 | +14 |
| Supply (- Vcc) | −0.01 | -8 | -9 |