

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%

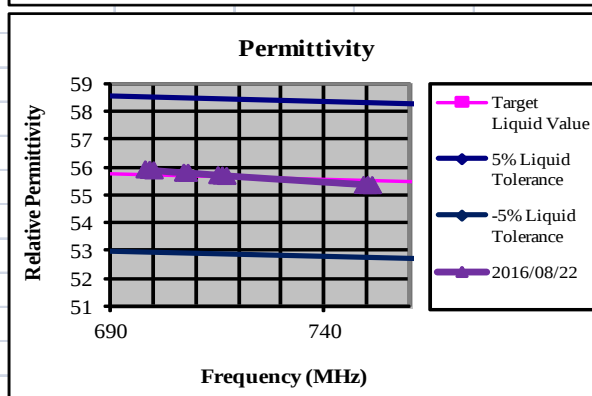
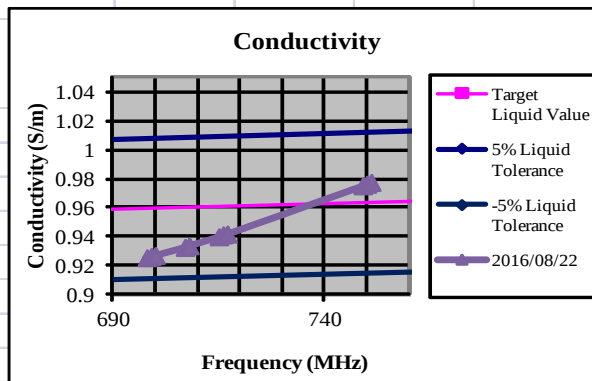
DGBE 25-48%

Salt <1.0%

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

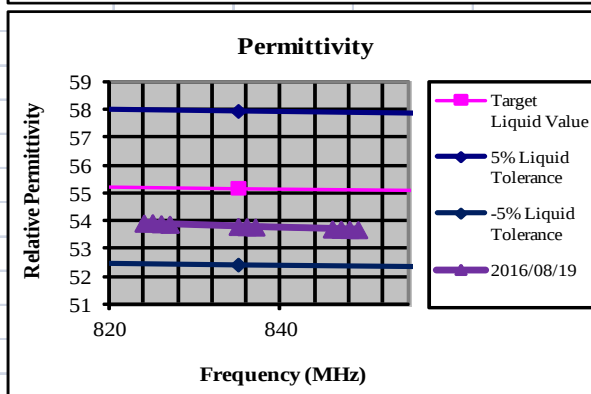
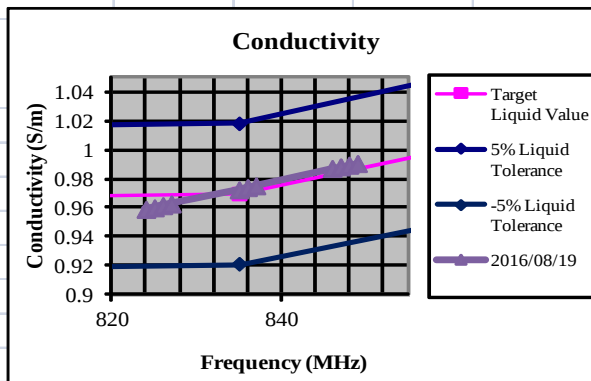
750 MHz Body Liquid

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



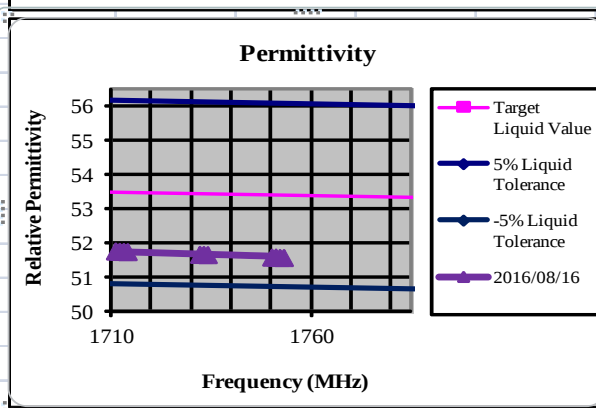
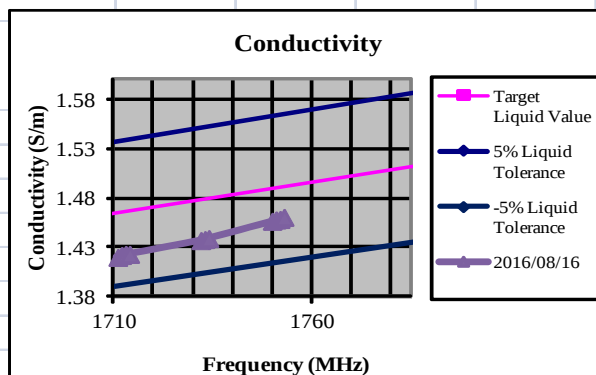
850 MHz Body Liquid

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



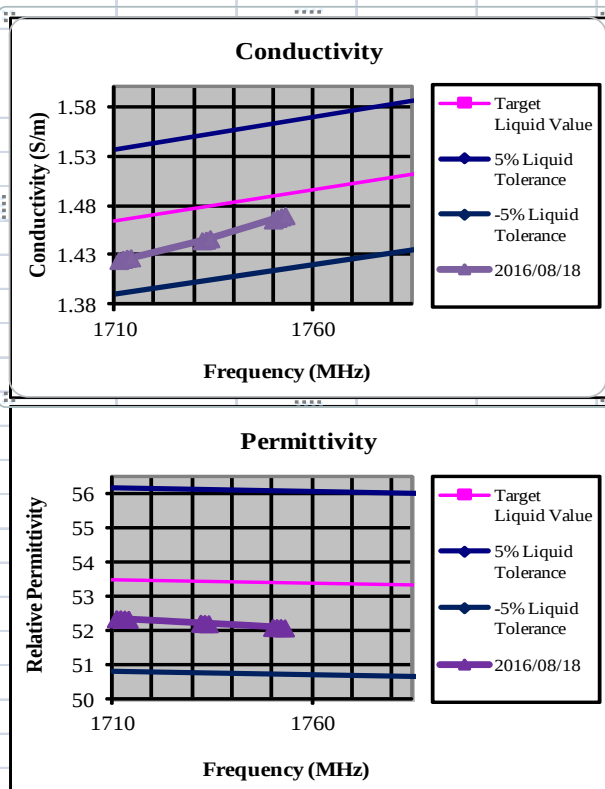
1750 MHz Body Liquid

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



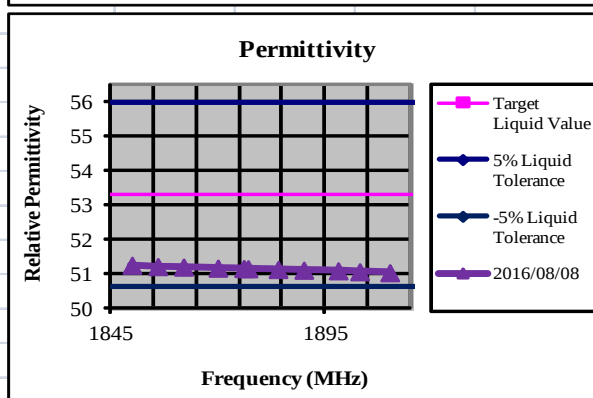
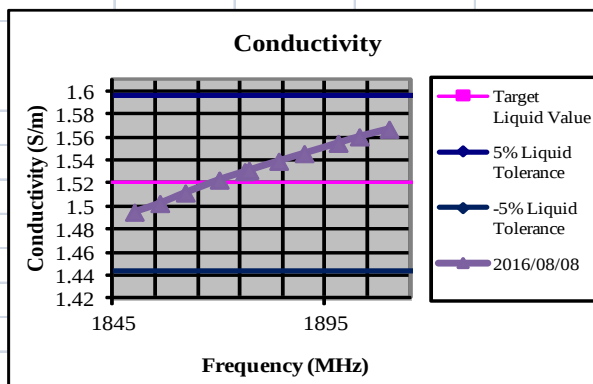
1750 MHz Body Liquid

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



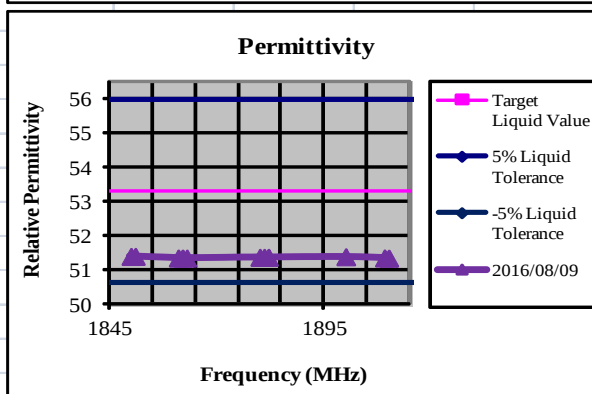
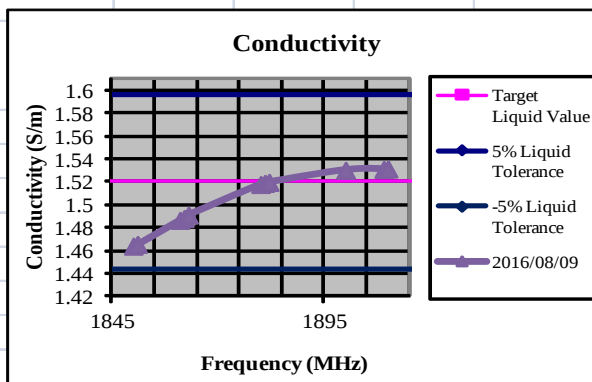
1900 MHz Body Liquid

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



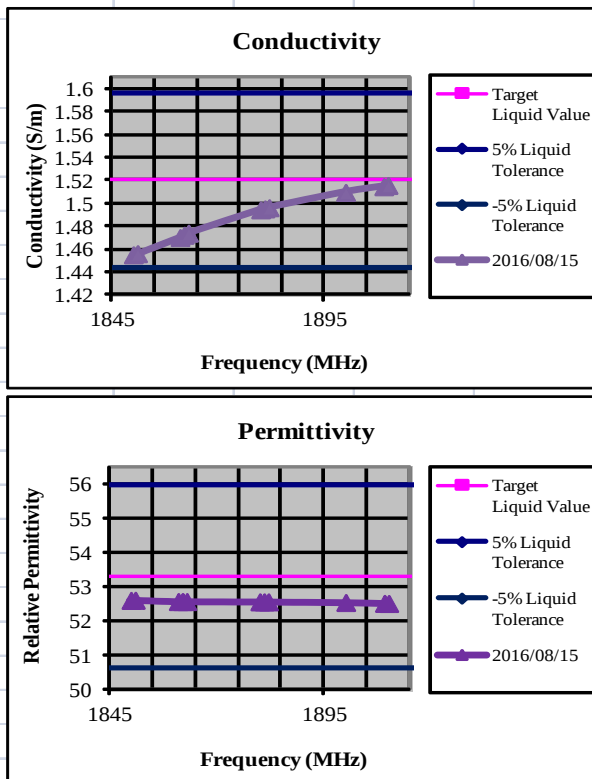
1900 MHz Body Liquid

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



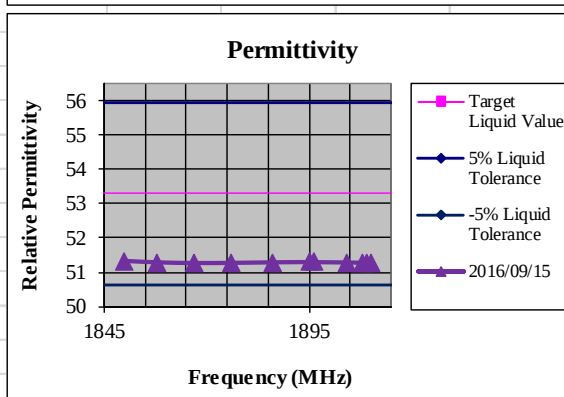
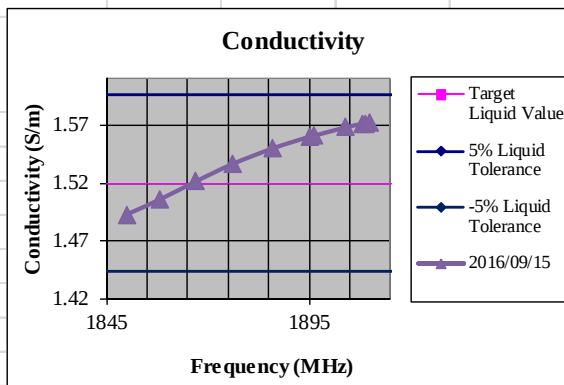
1900 MHz Body Liquid

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



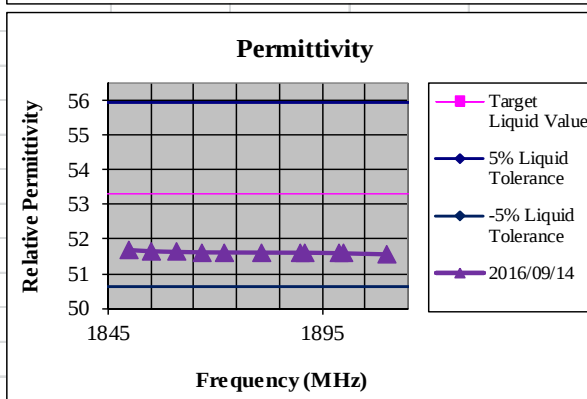
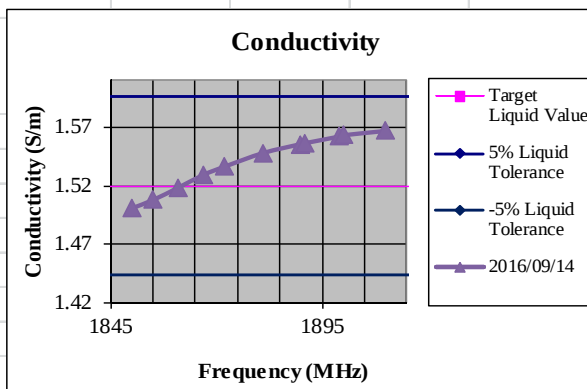
1900 MHz Body Liquid

Date	Temp (°C)	Frequency (MHz)	Relative Permittivity	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 Permittivity	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	VTLS400	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



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S Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

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

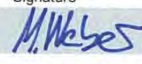
Calibration date: **April 28, 2016**

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	
Approved by:	Katja Pokovic	Technical Manager	
Issued: April 28, 2016			

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

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



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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\vartheta = 0$ 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:

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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,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.
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 $f \leq 800$ 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 NORM_{x,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 NORM_x (no uncertainty required).

ES3DV3 – SN:3244

April 28, 2016

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!)

ES3DV3- SN:3244

April 28, 2016

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

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.83	1.07	1.01	$\pm 10.1 \%$
DCP (mV) ^B	108.8	105.1	101.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	193.4	$\pm 3.0 \%$
		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	$\pm 0.7 \%$
		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	$\pm 2.5 \%$
		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	$\pm 1.9 \%$
		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	$\pm 1.7 \%$
		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	$\pm 1.9 \%$
		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	$\pm 0.9 \%$
		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	$\pm 1.7 \%$
		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	$\pm 3.0 \%$
		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	$\pm 1.7 \%$
		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	$\pm 3.3 \%$
		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	$\pm 1.7 \%$
		Y	6.08	66.8	19.5		125.8	
		Z	6.19	66.7	19.1		140.7	

ES3DV3-- SN:3244

April 28, 2016

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.

ES3DV3- SN:3244

April 28, 2016

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.

ES3DV3-- SN:3244

April 28, 2016

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.

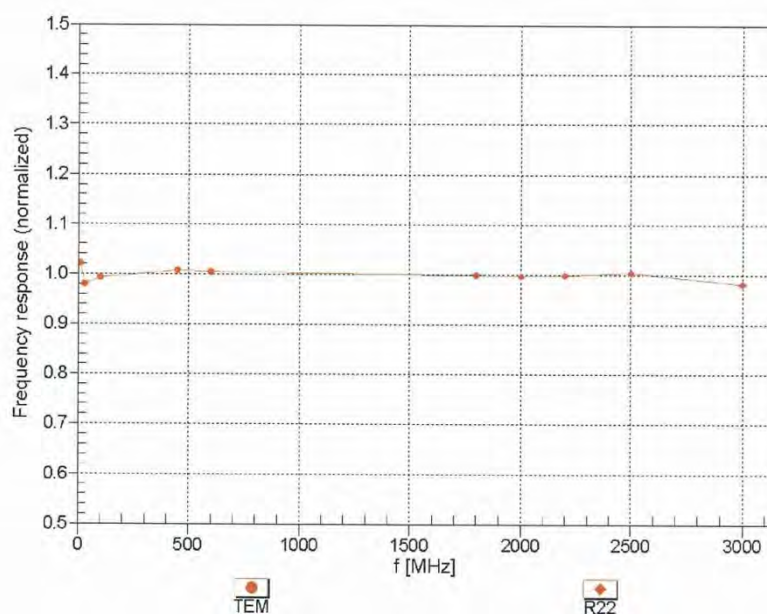
^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty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

ES3DV3- SN:3244

April 28, 2016

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

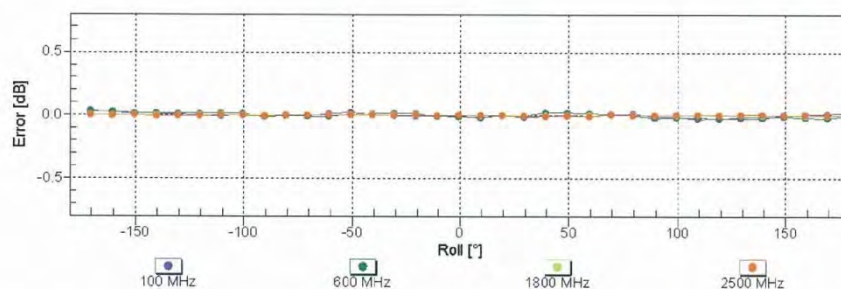
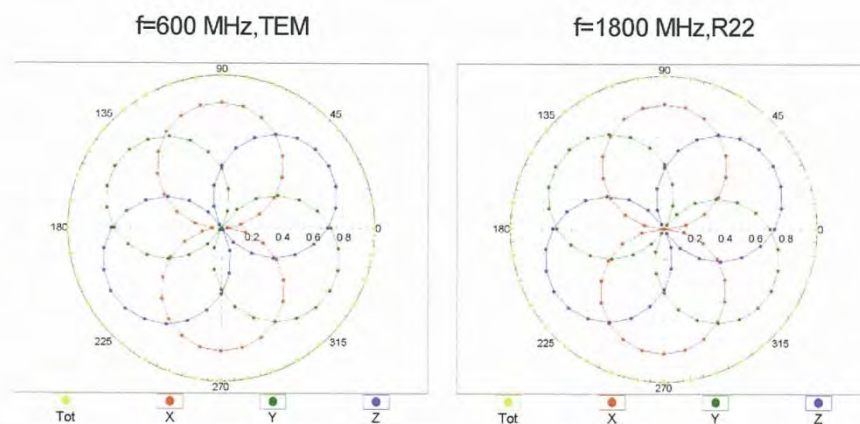


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

ES3DV3-- SN:3244

April 28, 2016

Receiving Pattern (ϕ), $\theta = 0^\circ$

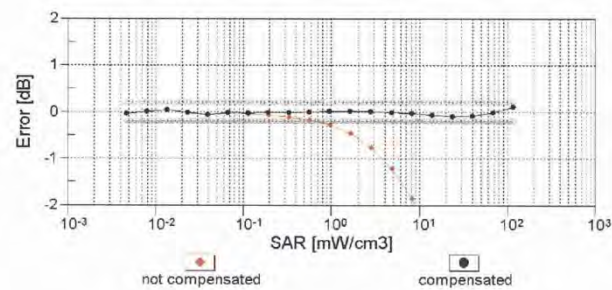
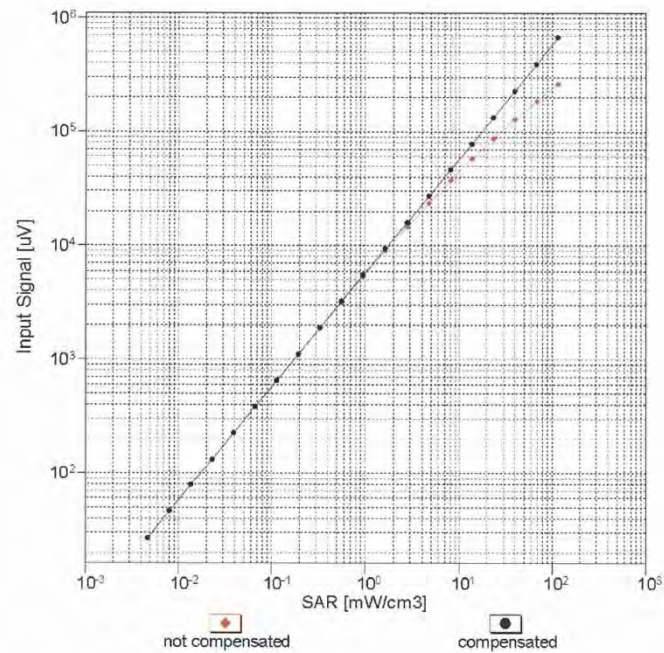


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

ES3DV3- SN:3244

April 28, 2016

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

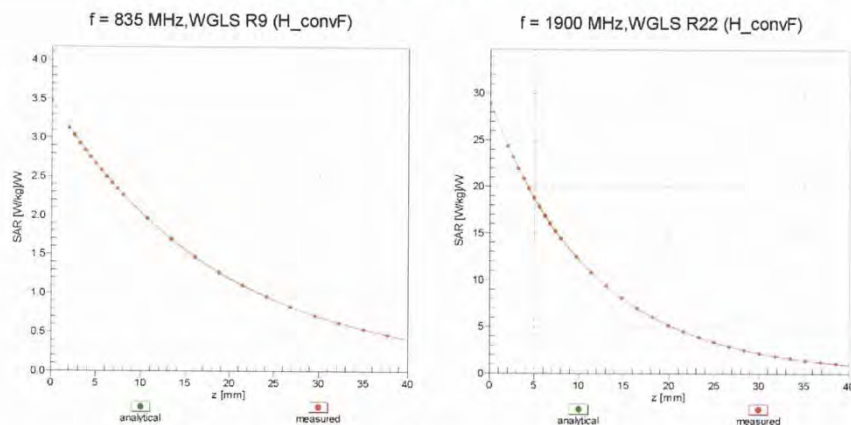


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

ES3DV3-- SN:3244

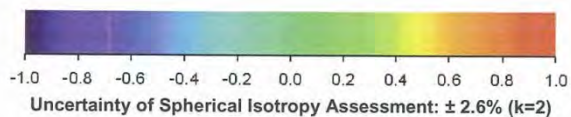
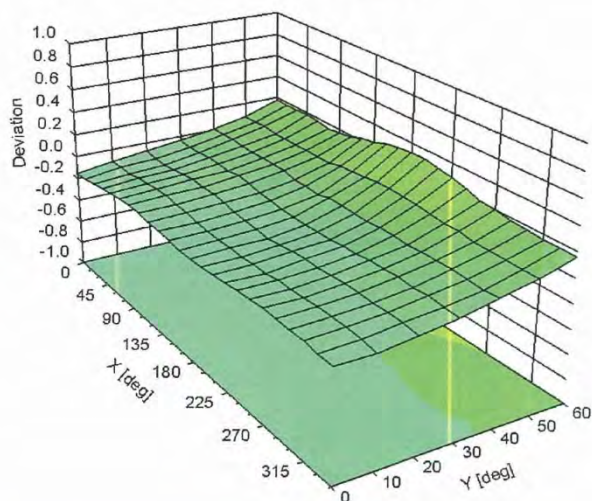
April 28, 2016

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ , θ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ (k=2)

ES3DV3-- SN:3244

April 28, 2016

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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Multilateral Agreement for the recognition of calibration certificates

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**
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 $(22 \pm 3)^{\circ}\text{C}$ 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	SI UMS 006 AA 1002	05-Jan-16 (in house check)	In house check: Jan 17

Calibrated by:	Name Dominique Steffen	Function Technician	Signature
Approved by:	Fin Bomholt	Deputy Technical Manager	

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 10M Ω

	Average (μ V)	min. Offset (μ V)	max. Offset (μ V)	Std. Deviation (μ V)
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**
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

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature

M. Weber

Approved by: **Name** Katja Pokovic **Function** Technical Manager

K. Pokovic

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:

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

Additional Documentation:

- 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 $\pm$ 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 $\pm$ 0.2) °C	42.0 $\pm$ 6 %	0.90 mho/m $\pm$ 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	2.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.21 W/kg $\pm$ 17.0 % (k=2)
SAR averaged over 10 cm³ (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 $\pm$ 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 $\pm$ 0.2) °C	54.6 $\pm$ 6 %	0.99 mho/m $\pm$ 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	2.20 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.57 W/kg $\pm$ 17.0 % (k=2)
SAR averaged over 10 cm³ (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 $\pm$ 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 j Ω
Return Loss	- 27.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.1 Ω - 2.1 j Ω
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: $f = 750 \text{ MHz}$; $\sigma = 0.9 \text{ S/m}$; $\epsilon_r = 42$; $\rho = 1000 \text{ kg/m}^3$

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:

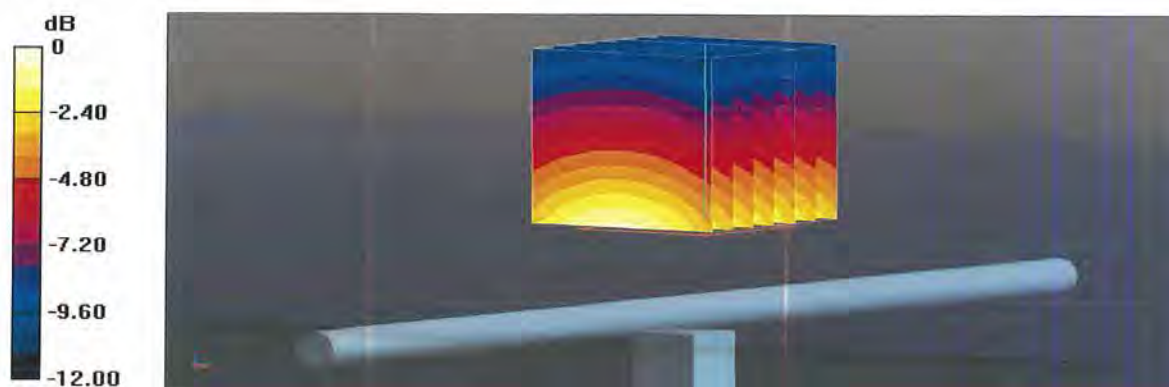
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 57.99 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.08 W/kg

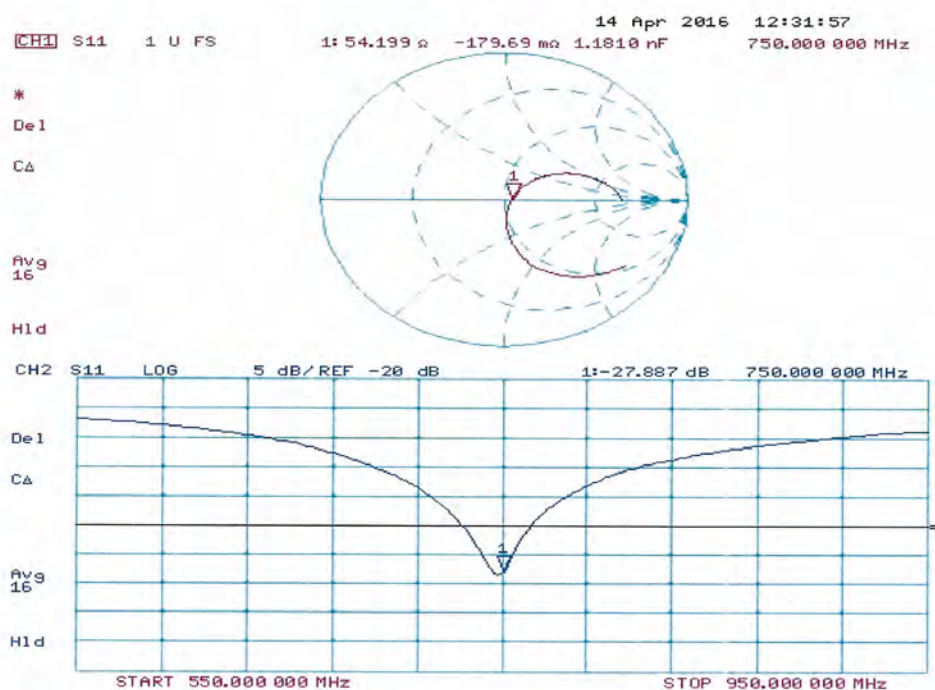
SAR(1 g) = 2.07 W/kg; SAR(10 g) = 1.36 W/kg

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: $f = 750 \text{ MHz}$; $\sigma = 0.99 \text{ S/m}$; $\epsilon_r = 54.6$; $\rho = 1000 \text{ kg/m}^3$

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:

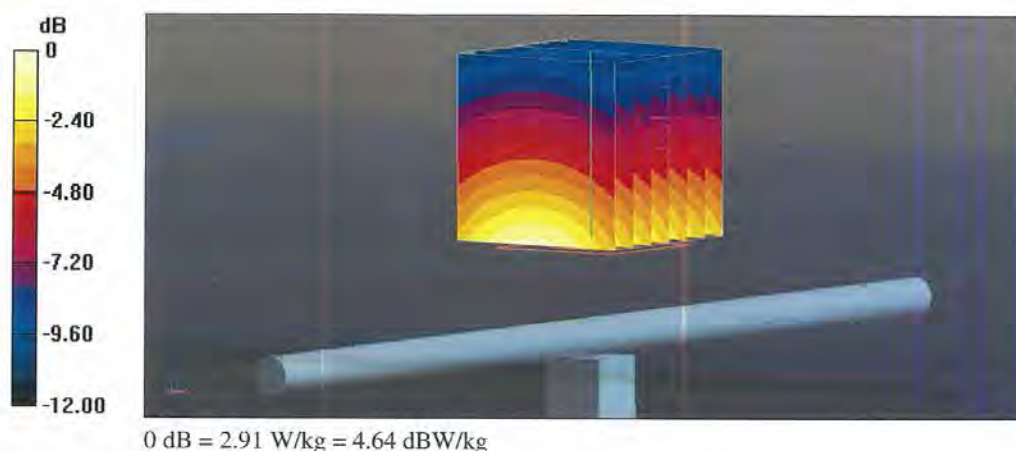
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 56.78 V/m; Power Drift = -0.02 dB

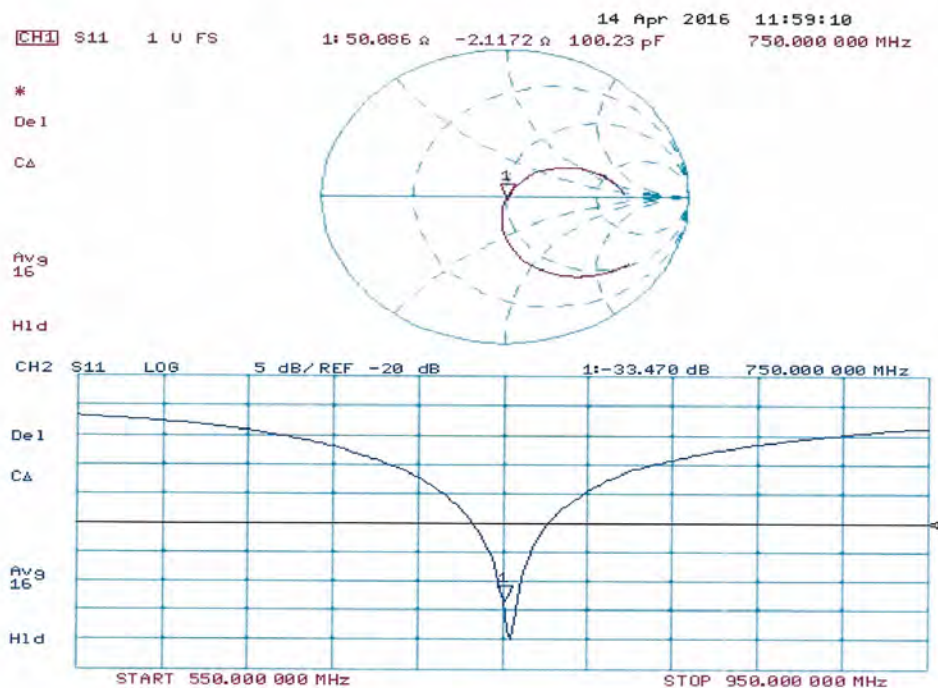
Peak SAR (extrapolated) = 3.24 W/kg

SAR(1 g) = 2.2 W/kg; SAR(10 g) = 1.45 W/kg

Maximum value of SAR (measured) = 2.91 W/kg



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 $(22 \pm 3)^{\circ}\text{C}$ 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

Calibrated by: **Michael Weber** **Laboratory Technician**

Signature



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:

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

Additional Documentation:

- 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 $\pm$ 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 $\pm$ 0.2) °C	41.7 $\pm$ 6 %	0.93 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 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 $\pm$ 0.2) °C	54.4 $\pm$ 6 %	1.02 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 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 j Ω
Return Loss	- 29.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.1 Ω - 5.1 j Ω
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: $f = 835 \text{ MHz}$; $\sigma = 0.93 \text{ S/m}$; $\epsilon_r = 41.7$; $\rho = 1000 \text{ kg/m}^3$

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, $d=15\text{mm}$ /Zoom Scan (7x7x7)/Cube 0:

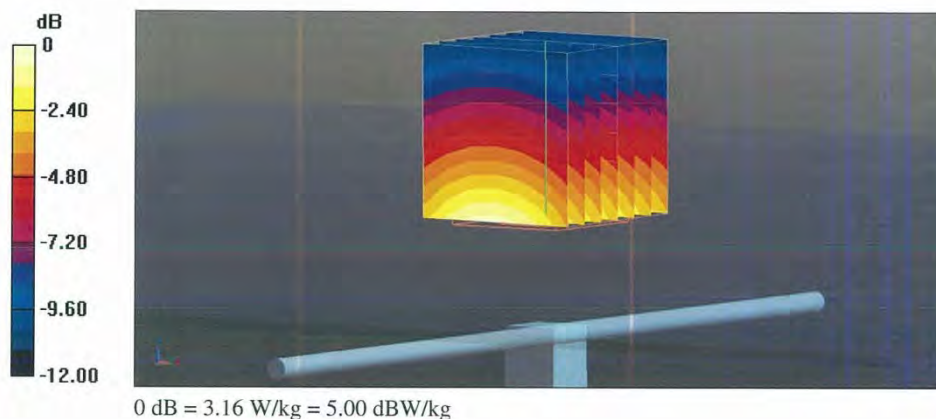
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 61.30 V/m; Power Drift = 0.01 dB

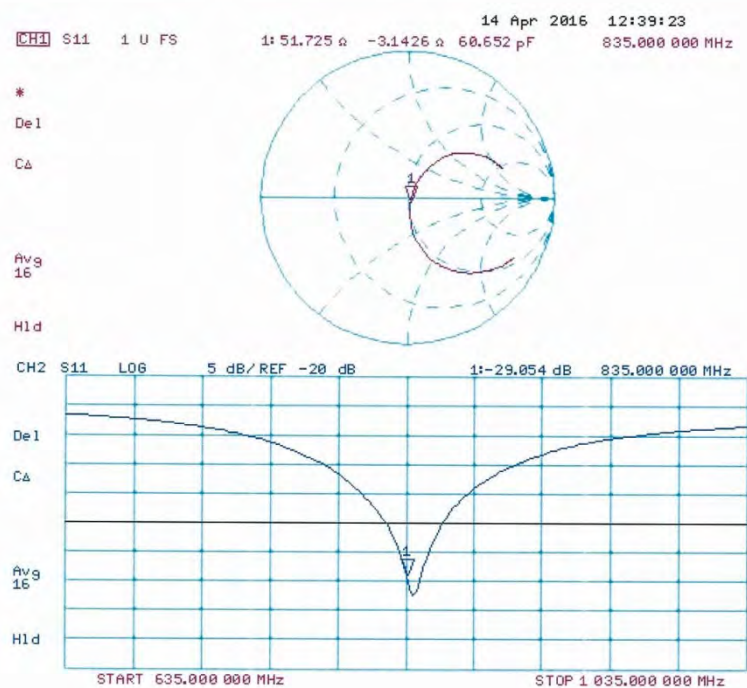
Peak SAR (extrapolated) = 3.53 W/kg

SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.54 W/kg

Maximum value of SAR (measured) = 3.16 W/kg



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: $f = 835 \text{ MHz}$; $\sigma = 1.02 \text{ S/m}$; $\epsilon_r = 54.4$; $\rho = 1000 \text{ kg/m}^3$

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, $d=15\text{mm}$ /Zoom Scan (7x7x7)/Cube 0:

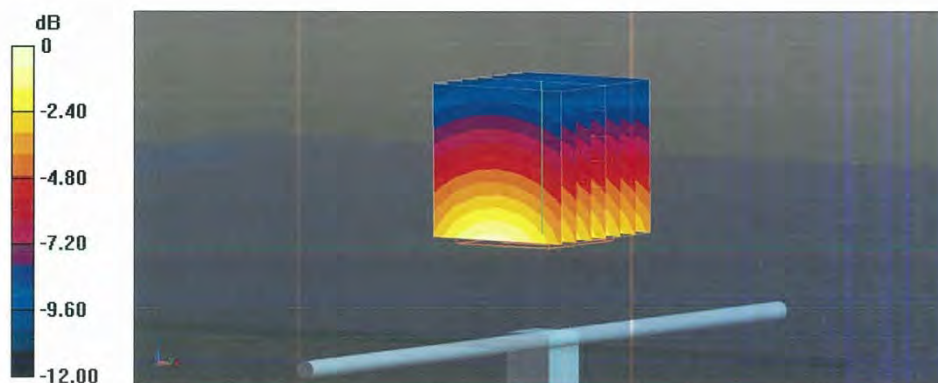
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 59.55 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 3.56 W/kg

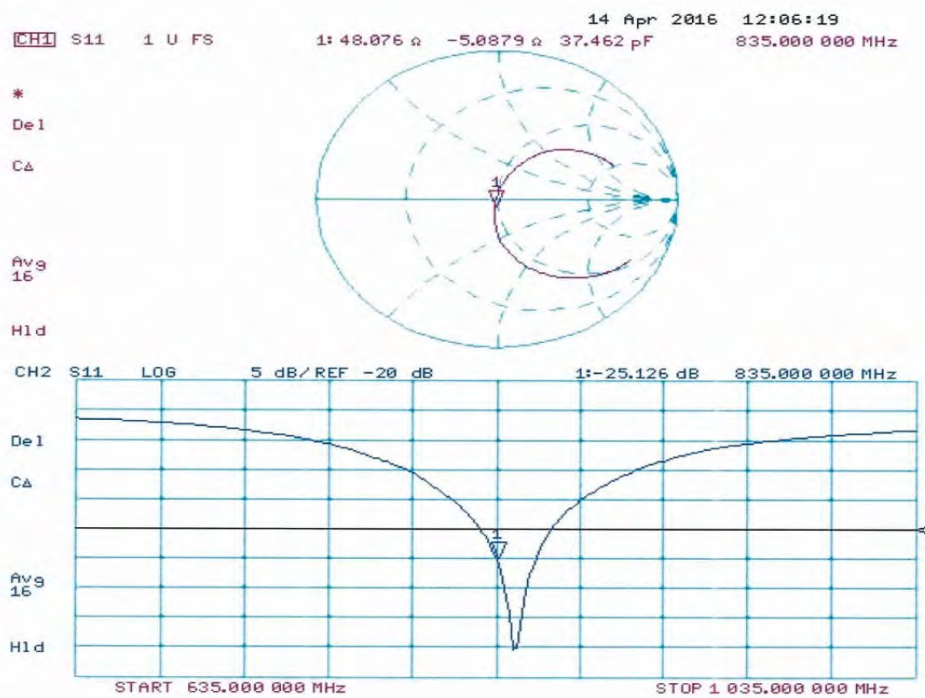
SAR(1 g) = 2.46 W/kg; SAR(10 g) = 1.62 W/kg

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
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

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature



Approved by: **Name** Katja Pokovic **Function** 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 $\pm$ 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 $\pm$ 0.2) °C	39.8 $\pm$ 6 %	1.36 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 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 $\pm$ 0.2) °C	53.8 $\pm$ 6 %	1.50 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 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 j Ω
Return Loss	- 41.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.5 Ω - 1.0 j Ω
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; $\epsilon_r = 39.8$; $\rho = 1000$ kg/m³

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:

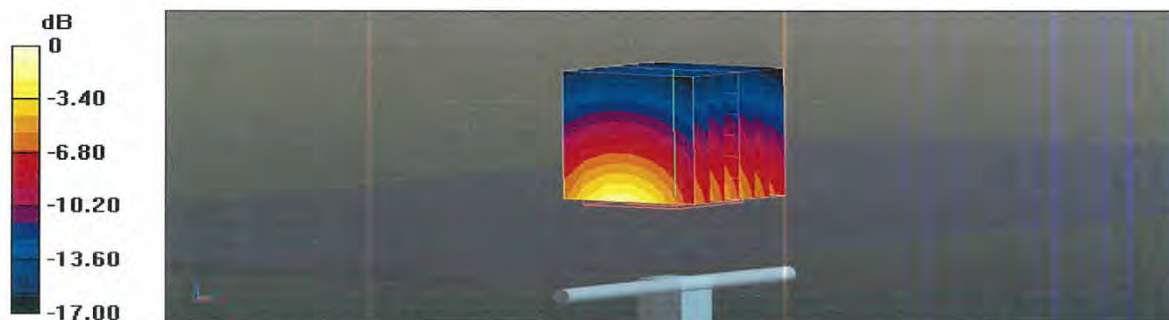
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.8 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 16.5 W/kg

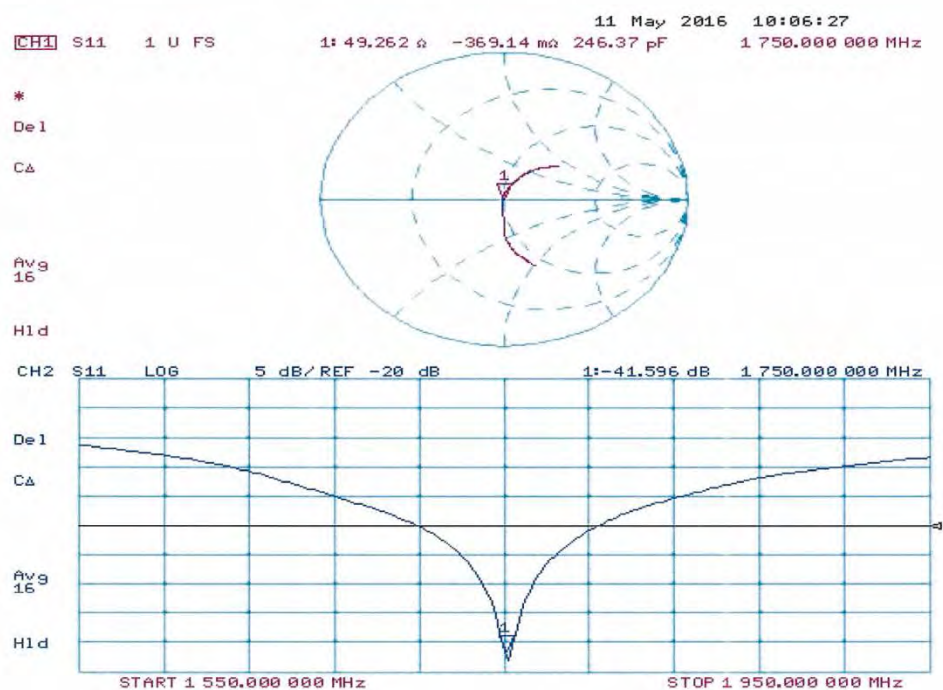
SAR(1 g) = 9 W/kg; SAR(10 g) = 4.78 W/kg

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; $\epsilon_r = 53.8$; $\rho = 1000$ kg/m³

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:

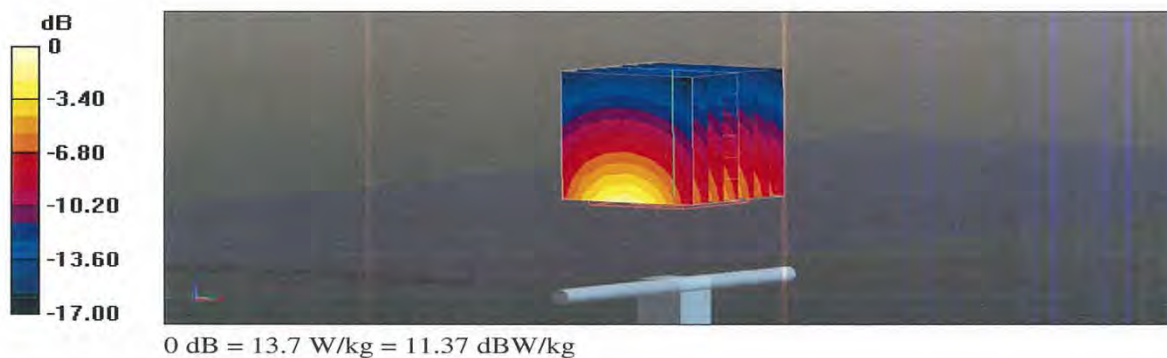
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.89 V/m; Power Drift = 0.02 dB

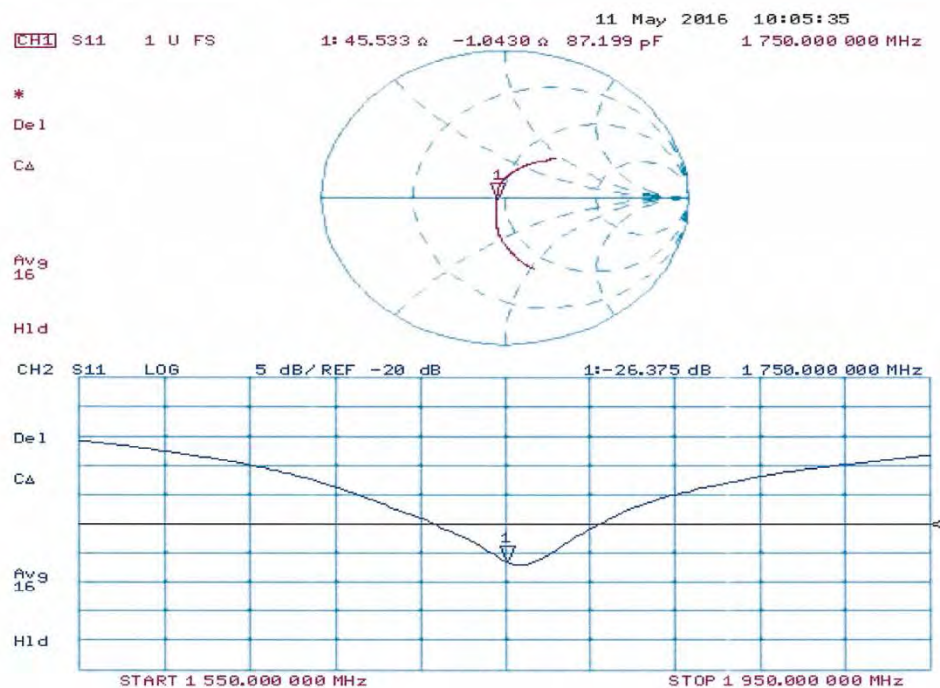
Peak SAR (extrapolated) = 16.1 W/kg

SAR(1 g) = 9.19 W/kg; SAR(10 g) = 4.9 W/kg

Maximum value of SAR (measured) = 13.7 W/kg



Impedance Measurement Plot for Body TSL



**Calibration Laboratory of
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Engineering AG**
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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**
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

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Approved by: **Name** Katja Pokovic **Function** Technical Manager

Signature




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:

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

Additional Documentation:

- 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 $\pm$ 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 $\pm$ 0.2) °C	40.0 $\pm$ 6 %	1.37 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 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 $\pm$ 0.2) °C	52.9 $\pm$ 6 %	1.49 mho/m $\pm$ 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 $\pm$ 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 $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	$52.8 \Omega + 9.9 j\Omega$
Return Loss	- 20.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$48.2 \Omega + 9.7 j\Omega$
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; $\epsilon_r = 40$; $\rho = 1000$ kg/m³

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:

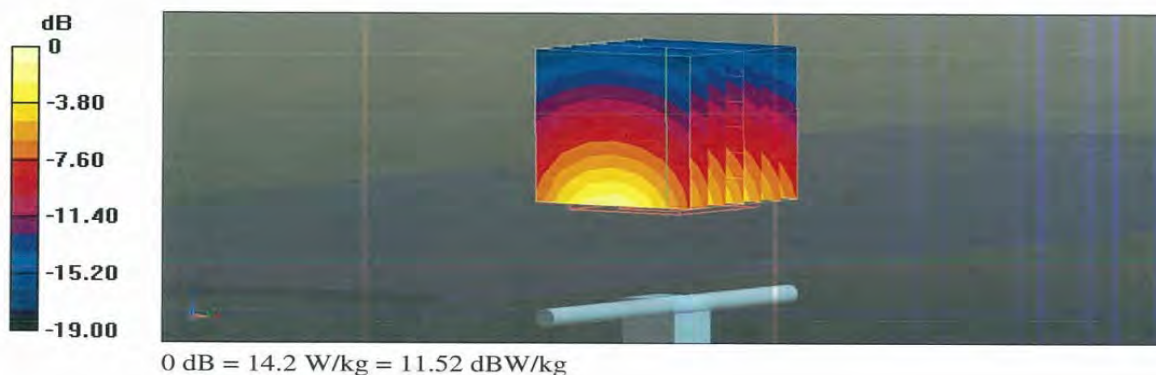
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.8 V/m; Power Drift = -0.00 dB

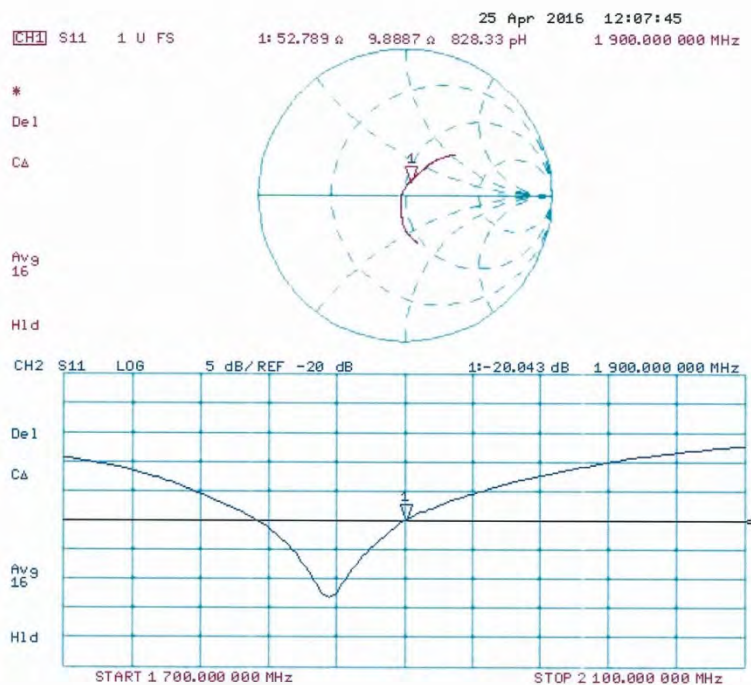
Peak SAR (extrapolated) = 16.8 W/kg

SAR(1 g) = 9.29 W/kg; SAR(10 g) = 4.9 W/kg

Maximum value of SAR (measured) = 14.2 W/kg



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; $\epsilon_r = 52.9$; $\rho = 1000$ kg/m³

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:

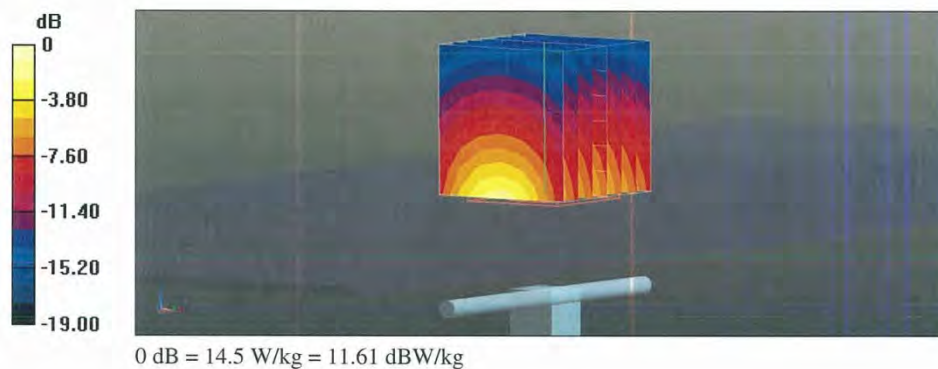
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 102.9 V/m; Power Drift = 0.00 dB

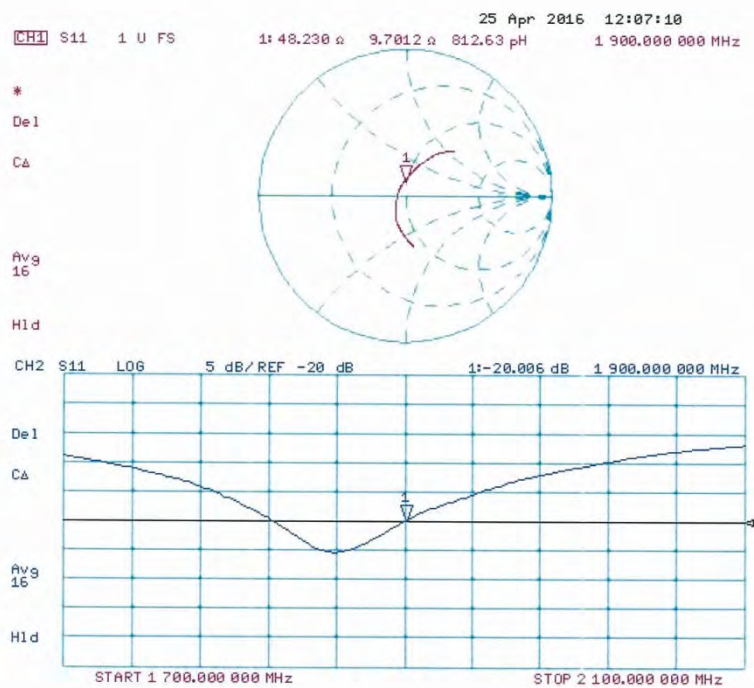
Peak SAR (extrapolated) = 16.8 W/kg

SAR(1 g) = 9.6 W/kg; SAR(10 g) = 5.09 W/kg

Maximum value of SAR (measured) = 14.5 W/kg



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

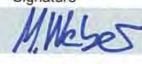
Calibration date: **April 28, 2016**

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	
Approved by:	Katja Pokovic	Technical Manager	
			Issued: April 28, 2016

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Accreditation No.: **SCS 0108**

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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\vartheta = 0$ 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:

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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,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.
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 $f \leq 800$ 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 NORM_{x,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 NORM_x (no uncertainty required).

ES3DV3 – SN:3244

April 28, 2016

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!)

ES3DV3- SN:3244

April 28, 2016

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

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.83	1.07	1.01	$\pm 10.1 \%$
DCP (mV) ^B	108.8	105.1	101.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	193.4	$\pm 3.0 \%$
		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	$\pm 0.7 \%$
		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	$\pm 2.5 \%$
		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	$\pm 1.9 \%$
		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	$\pm 1.7 \%$
		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	$\pm 1.9 \%$
		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	$\pm 0.9 \%$
		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	$\pm 1.7 \%$
		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	$\pm 3.0 \%$
		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	$\pm 1.7 \%$
		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	$\pm 3.3 \%$
		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	$\pm 1.7 \%$
		Y	6.08	66.8	19.5		125.8	
		Z	6.19	66.7	19.1		140.7	

ES3DV3-- SN:3244

April 28, 2016

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.

ES3DV3- SN:3244

April 28, 2016

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.

ES3DV3-- SN:3244

April 28, 2016

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.

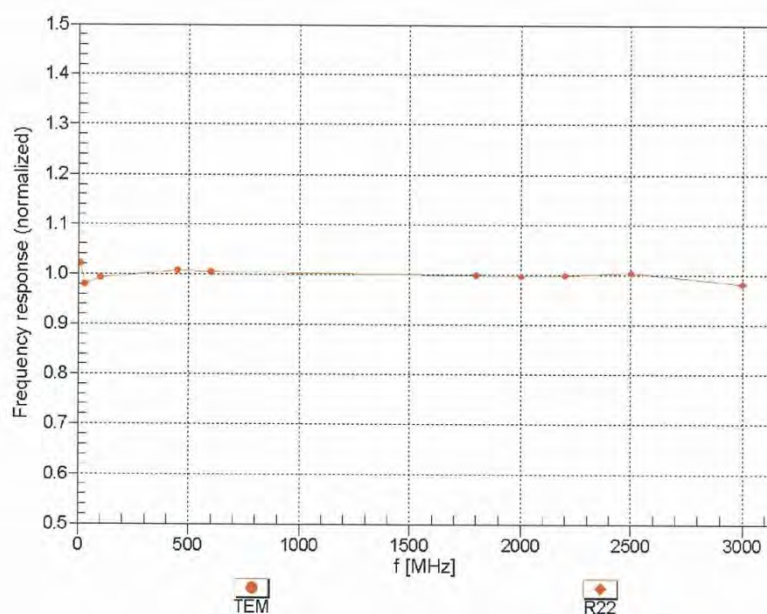
^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty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

ES3DV3- SN:3244

April 28, 2016

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

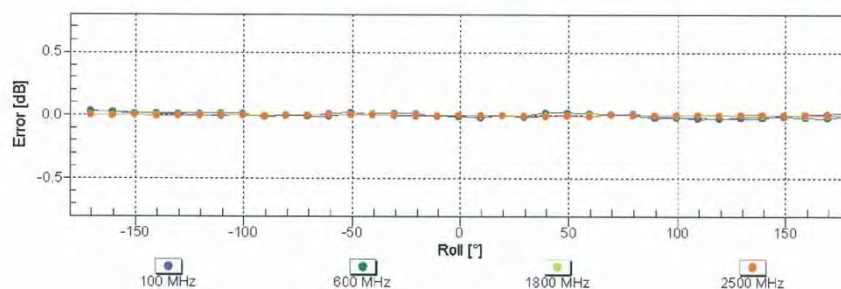
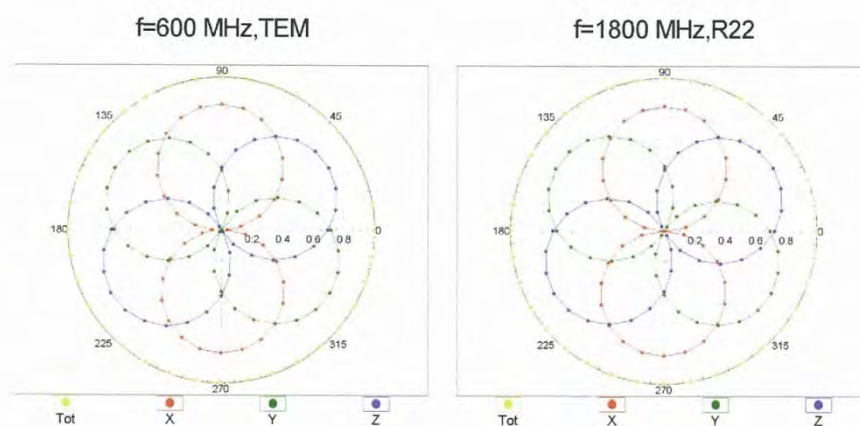


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

ES3DV3-- SN:3244

April 28, 2016

Receiving Pattern (ϕ), $\theta = 0^\circ$

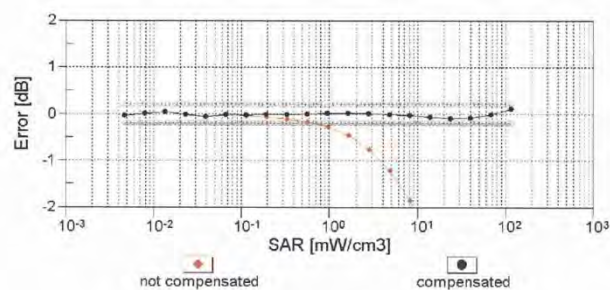
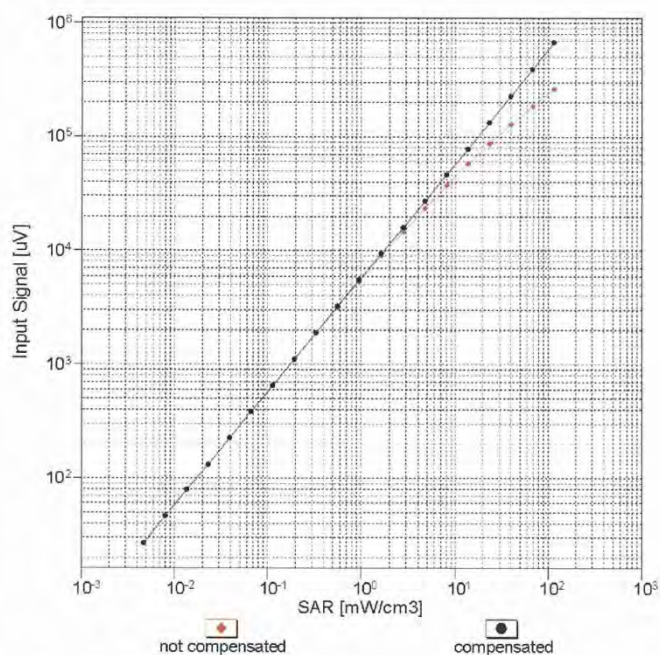


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

ES3DV3- SN:3244

April 28, 2016

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

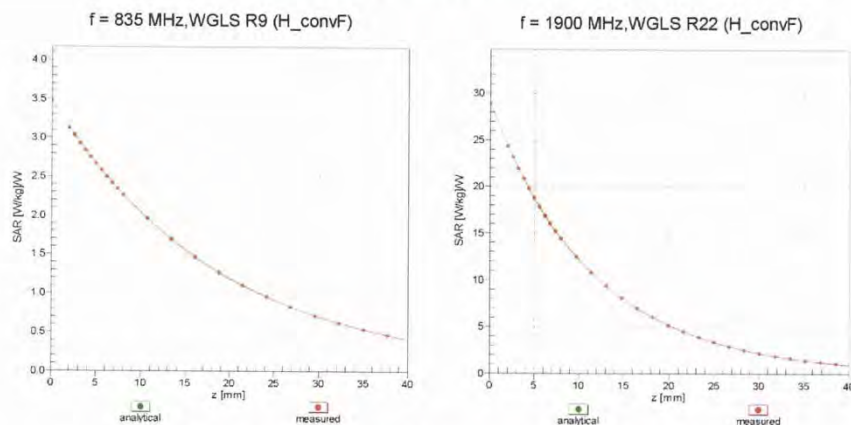


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

ES3DV3-- SN:3244

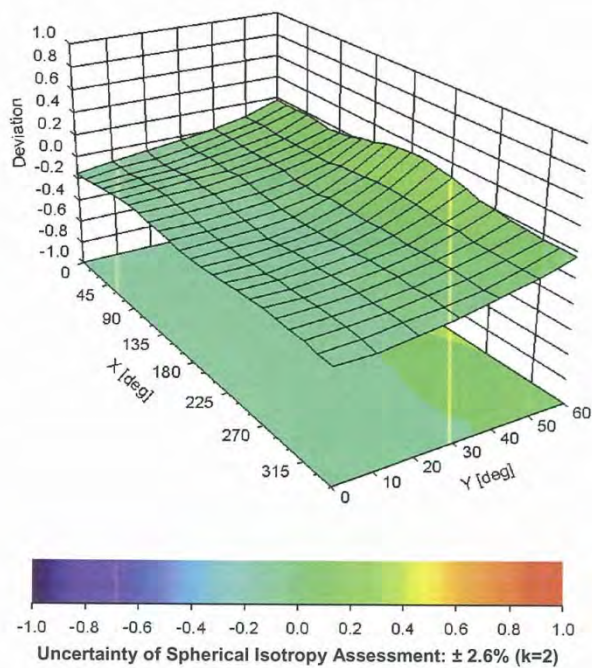
April 28, 2016

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ , θ), f = 900 MHz



ES3DV3-- SN:3244

April 28, 2016

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



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

Accreditation No.: **SCS 0108**

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
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	SI UMS 005 AA 1002	05-Jan-16 (in house check)	In house check: Jan 17

Calibrated by:	Name Dominique Steffen	Function Technician	Signature 
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: May 11, 2016

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

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



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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 = 6.1 μ V, full range = -100...+300 mV

Low Range: 1LSB = 61 nV, 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 $\pm$ 0.02% (k=2)	404.913 $\pm$ 0.02% (k=2)	404.189 $\pm$ 0.02% (k=2)
Low Range	4.00300 $\pm$ 1.50% (k=2)	3.99777 $\pm$ 1.50% (k=2)	3.99268 $\pm$ 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	186.5 $^{\circ}$ $\pm$ 1 $^{\circ}$
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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 10M Ω

	Average (μ V)	min. Offset (μ V)	max. Offset (μ V)	Std. Deviation (μ V)
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