

APPENDIX J. CALIBRATION CERTIFICATES

This appendix contains copies of the Calibration Documents for the following items of test equipment used for the measurements detailed in the test report
2015_SONY-CDTLE_S0007_04_SAR_0007_V1.0:

1	SYSTEM VALIDATION DIPOLE D2450V2 - SERIAL NUMBER 745	2
2	E-FIELD PROBE ES3DV3 - SERIAL NUMBER 3164	10
3	DIGITAL ACQUISITION ELECTRONICS DAE4 - SERIAL NUMBER 798	21

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**Calibration Laboratory of
Schmid & Partner
Engineering AG**
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Accreditation No.: SCS 108

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Multilateral Agreement for the recognition of calibration certificates

Client: **Tech Mahindra**

Certificate No: D2450V2-745_Jun14

CALIBRATION CERTIFICATE

Object: **D2450V2 - SN: 745**

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

Calibration date: **June 13, 2014**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$

Calibration Equipment used (M&E critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	09-Oct-13 (No. 217-01927)	Oct-14
Power sensor HP 8461A	US37282783	09-Oct-13 (No. 217-01927)	Oct-14
Power sensor HP 8461A	MY41092317	09-Oct-13 (No. 217-01928)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20K)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV9	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14
DAE4	SN: 601	30-Apr-14 (No. DAE4-601_Apr14)	Apr-15
Secondary Standards	ID #	Check Date (In house)	Scheduled Check
RF generator A&S SWT-406	100005	04-Aug-09 (In house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37380685 S4206	18-Oct-01 (In house check Oct-13)	In house check: Oct-14

Calibrated by:	Name: Lefi Kiyener	Function: Laboratory Technician	Signature:
Approved by:	Name: Katja Pekovic	Technical Manager	

Issued: June 16, 2014

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Certificate No: D2450V2-745_Jun14

Page 1 of 8

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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
- 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	$\Delta x, \Delta y, \Delta z = 5 \text{ mm}$	
Frequency	2450 MHz $\pm 1 \text{ MHz}$	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	$(22.0 \pm 0.2) \text{ °C}$	$38.4 \pm 6 \%$	$1.84 \text{ mho/m} \pm 6 \%$
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	12.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	$50.8 \text{ W/kg} \pm 17.0 \%$ (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW Input power	6.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	$24.2 \text{ W/kg} \pm 16.5 \%$ (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	$(22.0 \pm 0.2) \text{ °C}$	$51.1 \pm 6 \%$	$2.03 \text{ mho/m} \pm 6 \%$
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	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	$50.3 \text{ W/kg} \pm 17.0 \%$ (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.91 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	$23.3 \text{ W/kg} \pm 16.5 \%$ (k=2)

Appendix (Additional assessments outside the scope of SCS108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	$55.6 \Omega + 3.4 j\Omega$
Return Loss	-24.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$51.8 \Omega + 5.1 j\Omega$
Return Loss	-25.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.161 ns
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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	December 01, 2003

DASY5 Validation Report for Head TSL

Date: 13.06.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 745

Communication System: UTD 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.84$ S/m; $\epsilon_r = 38.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

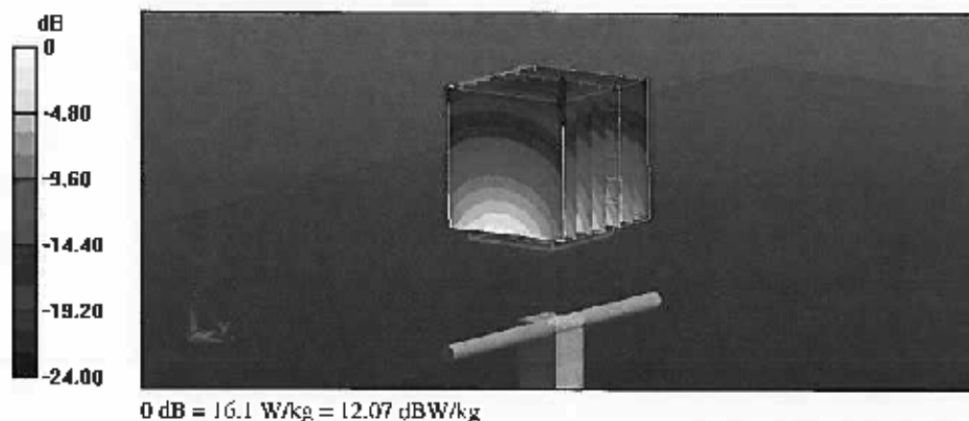
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm 2/Zuom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 95.60 V/m; Power Drift = 0.03 dB

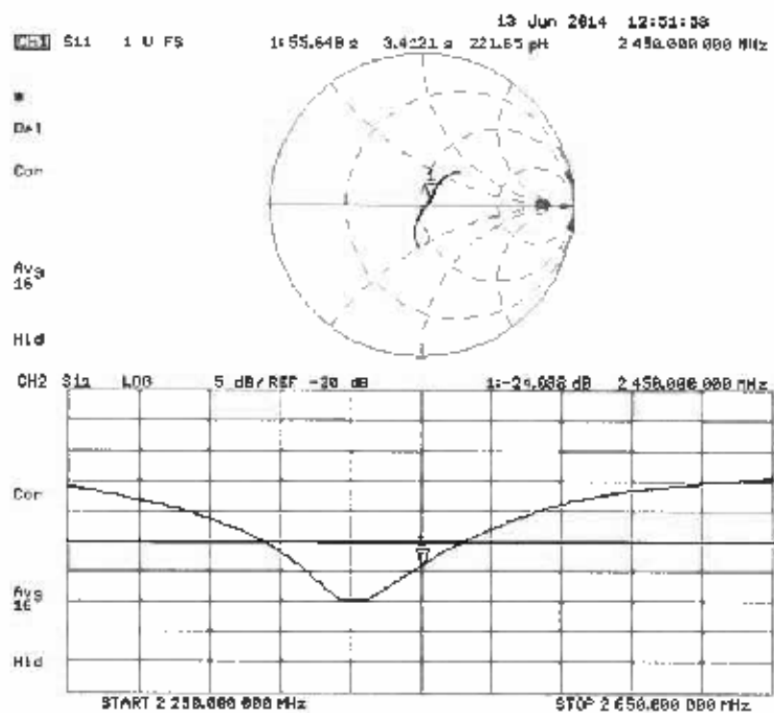
Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.1 W/kg

Maximum value of SAR (measured) = 16.1 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 13.06.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:745

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 51.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: BS3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAB4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

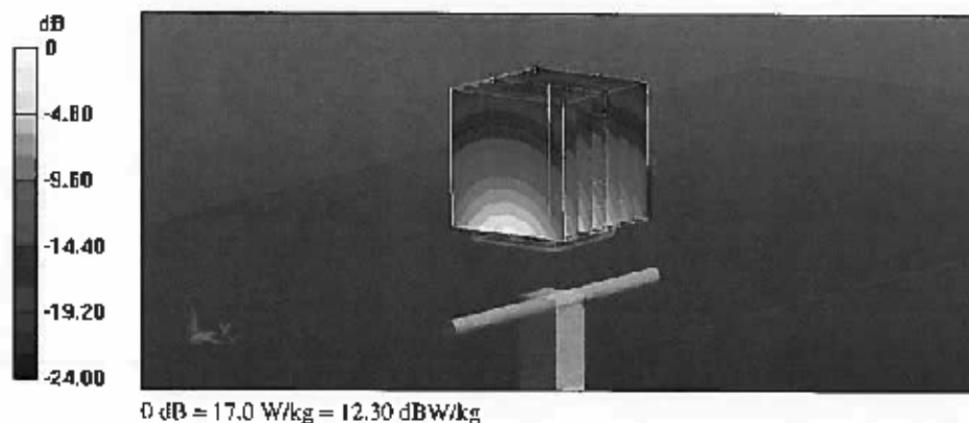
Dipole Calibration for Body Tissue/ $P_{in}=250$ mW, $d=10$ mm/Zoom Scan (7x7x7)/Cube 0:Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 94.73 V/m; Power Drift = -0.03 dB

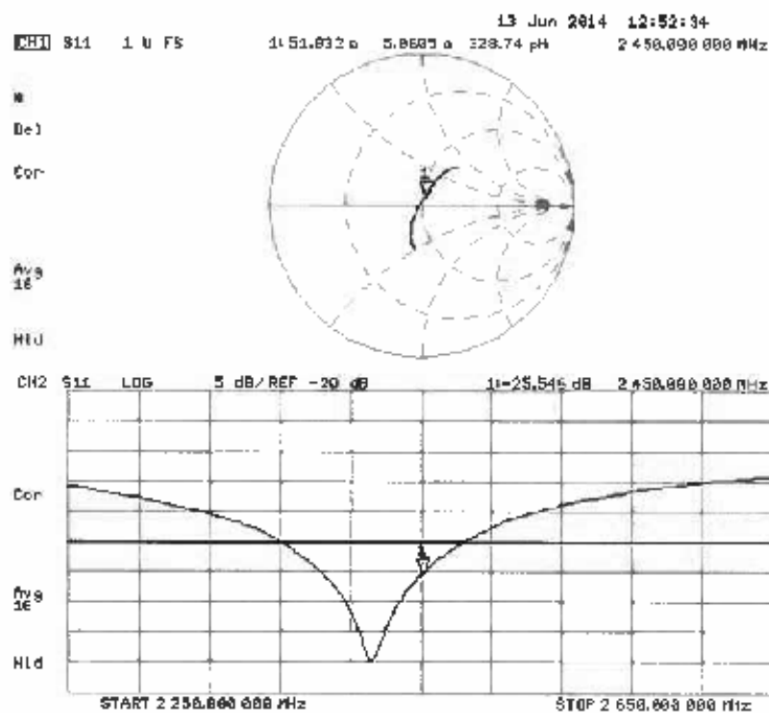
Peak SAR (extrapolated) = 27.2 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 5.91 W/kg

Maximum value of SAR (measured) = 17.0 W/kg



Impedance Measurement Plot for Body TSL



FINAL TEST REPORT – SAR TESTING

2015_SONY-CDTLE_S0007_04_SAR_0007_V1.0

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Accreditation No.: SCS 108

Client: Tech Mahindra

Certificate No: ES3-3164_Jun14

CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3164

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

Calibration date: June 17, 2014

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

All calibrations have been conducted in the closed laboratory facility; environment temperature $(22 \pm 3)^\circ\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4418B	GB41232874	03-Apr-14 (No. 217-01911)	Apr-15
Power sensor E4412A	MY41459087	03-Apr-14 (No. 217-01911)	Apr-15
Reference 3 dB Attenuator	SN. S5064 (3a)	03-Apr-14 (No. 217-01915)	Apr-15
Reference 20 dB Attenuator	SN. S5277 (20x)	03-Apr-14 (No. 217-01918)	Apr-15
Reference 30 dB Attenuator	SN. S5129 (30b)	03-Apr-14 (No. 217-01920)	Apr-15
Reference Probe ES3DV2	SN. 3D13	30-Dec-13 (No. ES3-3013, Dec13)	Dec-14
DAE4	SNr 660	13-Dec-13 (No. DAE4-000, Dec13)	Dec-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642J01700	4-Aug-98 (In house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8733E	US37390585	18-Oct-01 (In house check Oct-13)	In house check: Oct-14

	Name	Function	Signature
Calibrated by:	Jagan Kesava	Laboratory Technician	
Approved by:	Ketja Polovic	Technical Manager	
Issued: June 23, 2014			
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Certificate No: ES3-3164_Jun14

Page 1 of 11

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Accreditation No.: **SCS 108**

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., $\theta = 0$ 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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ 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 E²-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.
- DCPx,y,z**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- 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:3164

June 17, 2014

Probe ES3DV3

SN:3164

Manufactured: October 8, 2007
Calibrated: June 17, 2014

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

ES3DV3- SN:3164

June 17, 2014

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3164**Basic Calibration Parameters**

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm $(\mu V/m)$ ^{5A}	1.18	1.14	1.25	± 10.1 %
DCP (mV) ^{5B}	103.3	102.0	102.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc ^{5C} (k=2)
0	CW	X	0.0	0.0	1.0	0.00	200.0	±4.1 %
		Y	0.0	0.0	1.0		199.3	
		Z	0.0	0.0	1.0		207.9	

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%.

^{5A} The uncertainties of Norm(X,Y,Z) do not affect the E₂-field uncertainty inside TSL (see Pages 5 and 8).

^{5B} Numerical linearization parameter; uncertainty not required.

^{5C} 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:3164

June 17, 2014

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3164**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 ^a (mm)	Unc. (k=2)
750	41.9	0.89	6.42	6.42	6.42	0.32	1.83	± 12.0 %
835	41.5	0.90	6.22	6.22	6.22	0.23	2.31	± 12.0 %
900	41.5	0.97	6.07	6.07	6.07	0.22	2.48	± 12.0 %
1450	40.5	1.20	5.44	6.44	5.44	0.32	1.78	± 12.0 %
1750	40.1	1.37	5.23	5.23	5.23	0.42	1.66	± 12.0 %
1900	40.0	1.40	5.11	5.11	5.11	0.80	1.15	± 12.0 %
2300	39.5	1.67	4.74	4.74	4.74	0.54	1.44	± 12.0 %
2450	39.2	1.80	4.44	4.44	4.44	0.74	1.28	± 12.0 %
2500	39.0	1.96	4.31	4.31	4.31	0.80	1.25	± 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, 126, 150 and 220 MHz respectively. Above 6 GHz frequency validity can be extended to ±100 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:3164

June 17, 2014

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3164**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 ^H (mm)	Unc. (k=2)
750	55.5	0.98	6.05	6.05	6.05	0.30	1.57	± 12.0 %
835	55.2	0.97	6.06	6.06	6.06	0.41	1.68	± 12.0 %
900	55.0	1.05	5.93	5.93	5.93	0.80	1.19	± 12.0 %
1450	54.0	1.30	5.16	5.16	5.16	0.40	1.67	± 12.0 %
1750	53.4	1.49	4.85	4.85	4.85	0.39	1.90	± 12.0 %
1900	53.3	1.52	4.63	4.63	4.63	0.51	1.80	± 12.0 %
2300	52.9	1.81	4.39	4.39	4.39	0.80	1.23	± 12.0 %
2450	52.7	1.95	4.20	4.20	4.20	0.80	1.06	± 12.0 %
2600	52.5	2.18	4.07	4.07	4.07	0.80	1.00	± 12.0 %

^C Frequency validity above 200 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, 160 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

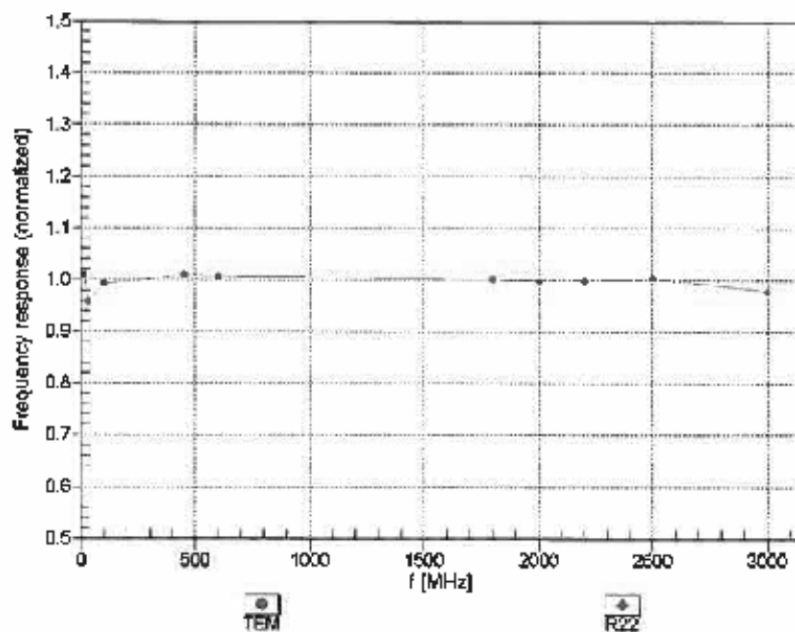
^F At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty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

^H 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 3-8 GHz at any distance larger than half the probe tip diameter from the boundary.

ES3DV3- SN:3164

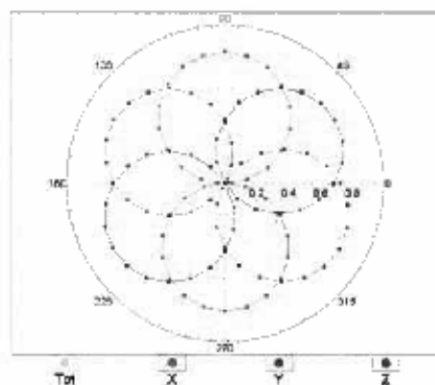
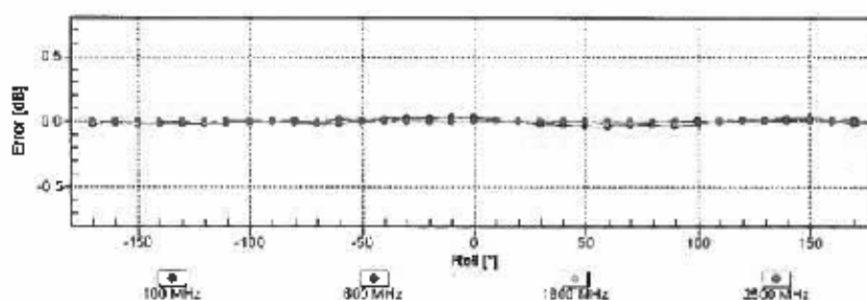
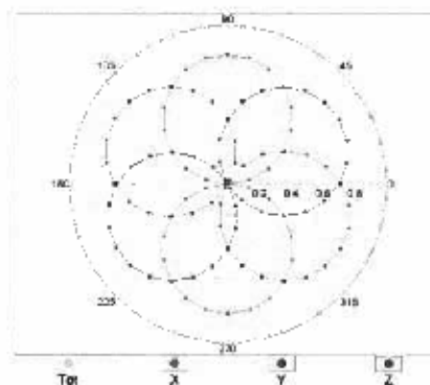
June 17, 2014

Frequency Response of E-Field (TEM-Cell: R110 EXX, Waveguide: R22)

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

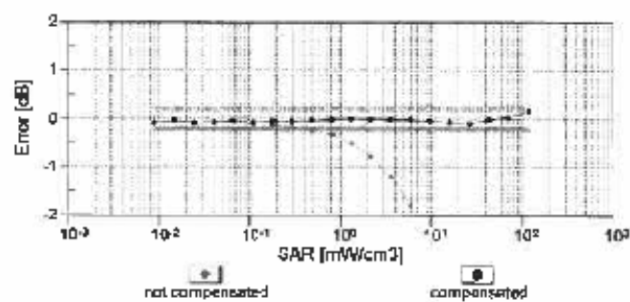
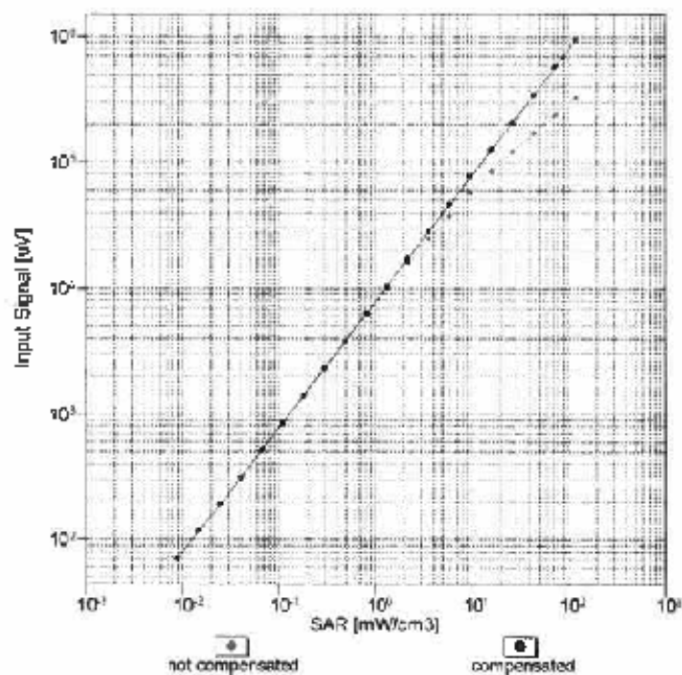
ESSDV3-SN:3164

June 17, 2014

Receiving Pattern (ϕ), $\theta = 0^\circ$ **f=600 MHz,TEM****f=1800 MHz,R22****Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)**

ES3DV3-SN3164

June 17, 2014

Dynamic Range $f(\text{SAR}_{\text{head}})$
(TEM cell, $f_{\text{avg}} = 1900 \text{ MHz}$)Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

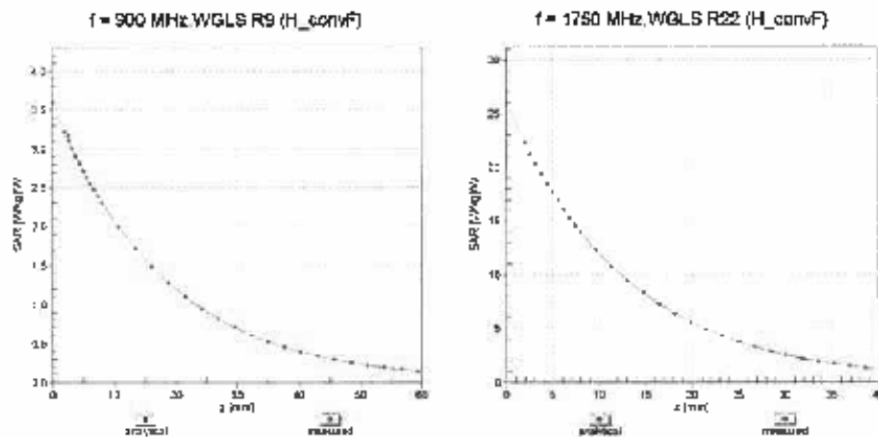
Certificate No: ES3-3164_Jun14

Page 9 of 11

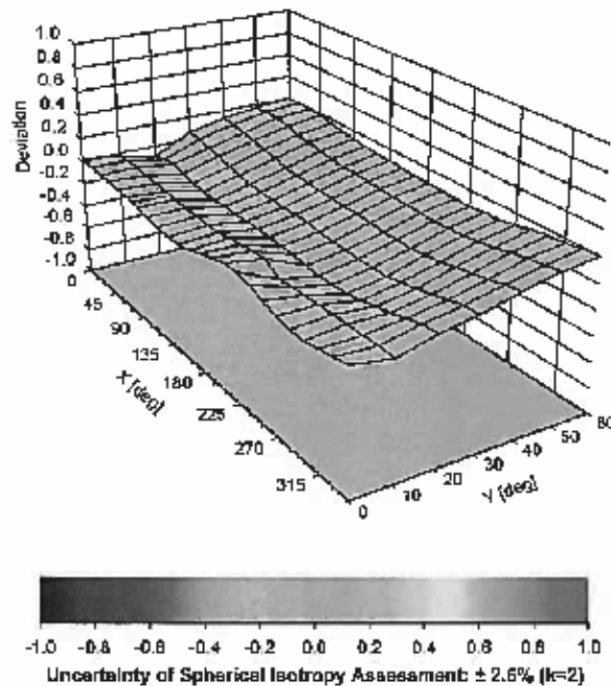
ES3DV3- SN:3164

June 17, 2014

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), $f = 900 \text{ MHz}$ 

ES3DV3– SN:3164

June 17, 2014

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3164**Other Probe Parameters**

Sensor Arrangement	Triangular
Connector Angle (°)	-110.4
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

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



S Schweizerischer Kalibrierdienst
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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 108**

Client: **Tech Mahindra**

Certificate No.: **DAE4-798_Jun14**

CALIBRATION CERTIFICATE

Object: **DAE4 - SD 000 D04 BJ - SN: 798**

Calibration procedure(s): **QA CAL-06.v28**
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **June 18, 2014**

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

All calibrations have been conducted in the closed laboratory facility; environment temperature ($22 \pm 3^\circ\text{C}$) and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration):

Primary Standards	ID #	Cal. Date (Certificate No.)	Scheduled Calibration
Kethley Multimeter Type 2001	SN: 0810278	01-Oct-13 (No:13878)	Oct-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UMS 053 AA 1001	07-Jan-14 (in house check)	In house check: Jan-15
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-14 (in house check)	In house check: Jan-15

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

Issued: June 18, 2014

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 108**

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	404.588 $\pm$ 0.02% (k=2)	404.151 $\pm$ 0.02% (k=2)	405.221 $\pm$ 0.02% (k=2)
Low Range	3.95364 $\pm$ 1.50% (k=2)	3.98226 $\pm$ 1.50% (k=2)	3.98483 $\pm$ 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	41.0 ° $\pm$ 1 °
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Appendix (Additional assessments outside the scope of SCS108)

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	200090.89	-8.85	-0.00
Channel X + Input	20004.09	-0.21	-0.00
Channel X - Input	-20002.09	3.84	+0.02
Channel Y + Input	200033.84	-3.15	-0.00
Channel Y + Input	20003.28	-0.80	-0.00
Channel Y - Input	-20001.40	4.69	-0.02
Channel Z + Input	200053.57	-3.48	-0.00
Channel Z + Input	19999.73	-4.40	-0.02
Channel Z - Input	-20005.97	-0.02	0.00

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2000.87	0.25	0.01
Channel X + Input	200.90	0.16	0.08
Channel X - Input	-199.20	0.02	-0.01
Channel Y + Input	2000.59	0.03	0.00
Channel Y + Input	200.35	-0.31	-0.15
Channel Y - Input	-199.01	0.36	-0.18
Channel Z + Input	2000.86	0.16	0.01
Channel Z + Input	200.30	-0.33	-0.17
Channel Z - Input	-200.60	-1.23	0.62

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	2.61	1.21
	-200	-0.30	-1.71
Channel Y	200	-13.15	-13.26
	-200	13.13	12.69
Channel Z	200	15.46	15.16
	-200	-17.67	-18.01

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	-	0.94	-5.95
Channel Y	200	8.67	-	0.59
Channel Z	200	10.64	7.09	-

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	16120	14109
Channel Y	16439	13703
Channel Z	15517	15011

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	0.92	-0.62	2.07	0.54
Channel Y	0.77	-0.36	2.06	0.50
Channel Z	-0.51	-2.50	1.22	0.57

6. Input Offset Current

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

7. Input Resistance (Typical values for information)

	Zeroing (k Ω m)	Measuring (M Ω m)
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