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

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Accreditation No.: SCS 108

Client **CCS-CN (Auden)**

Certificate No: **D2450V2-817_Jul13**

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 817
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	July 31, 2013

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe ES3DV3	SN: 3205	28-Dec-12 (No. ES3-3205_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14

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

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

Issued: July 31, 2013

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Accreditation No.: SCS 108

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.7
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 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 ± 0.2) °C	37.8 ± 6 %	1.81 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.5 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.5 ± 6 %	2.01 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.6 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**49.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.87 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.1 W/kg ± 16.5 % (k=2)**

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.5 Ω + 2.9 jΩ
Return Loss	- 27.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.7 Ω + 4.5 jΩ
Return Loss	- 27.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.159 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	October 23, 2007

DASY5 Validation Report for Head TSL

Date: 31.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

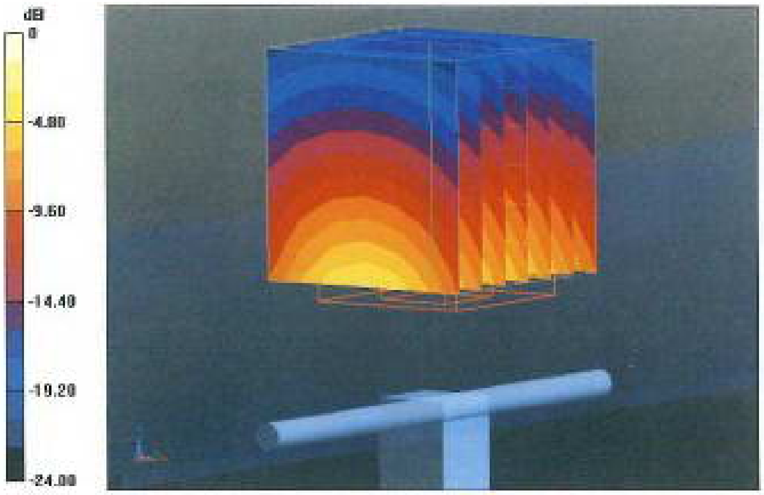
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 817

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.81 S/m; ε_r = 37.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.52, 4.52, 4.52); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.781 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 27.7 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.18 W/kg
Maximum value of SAR (measured) = 16.8 W/kg



0 dB = 16.8 W/kg = 12.25 dBW/kg

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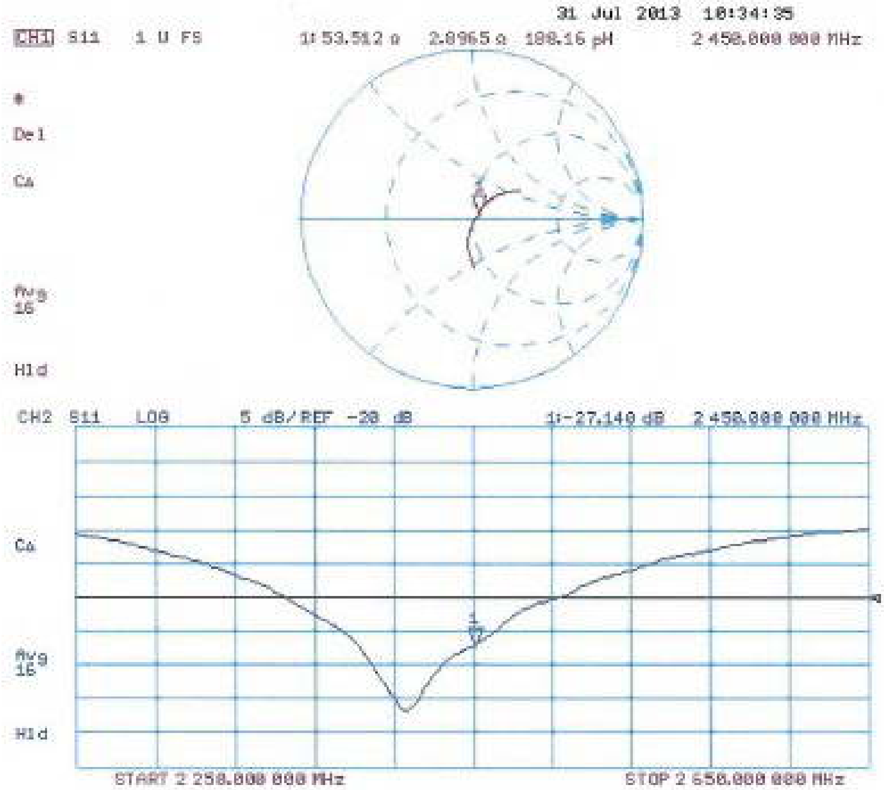
Impedance Measurement Plot for Head TSL



Certificate No: D2450V2-817_Jul13 Page 6 of 8

DASY5 Validation Report for Body TSL

Date: 31.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

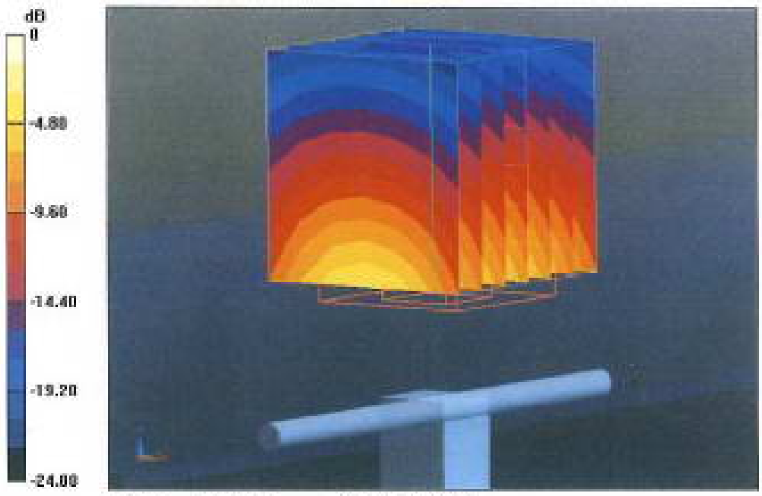
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 817

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.01 S/m; ε_r = 50.5; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

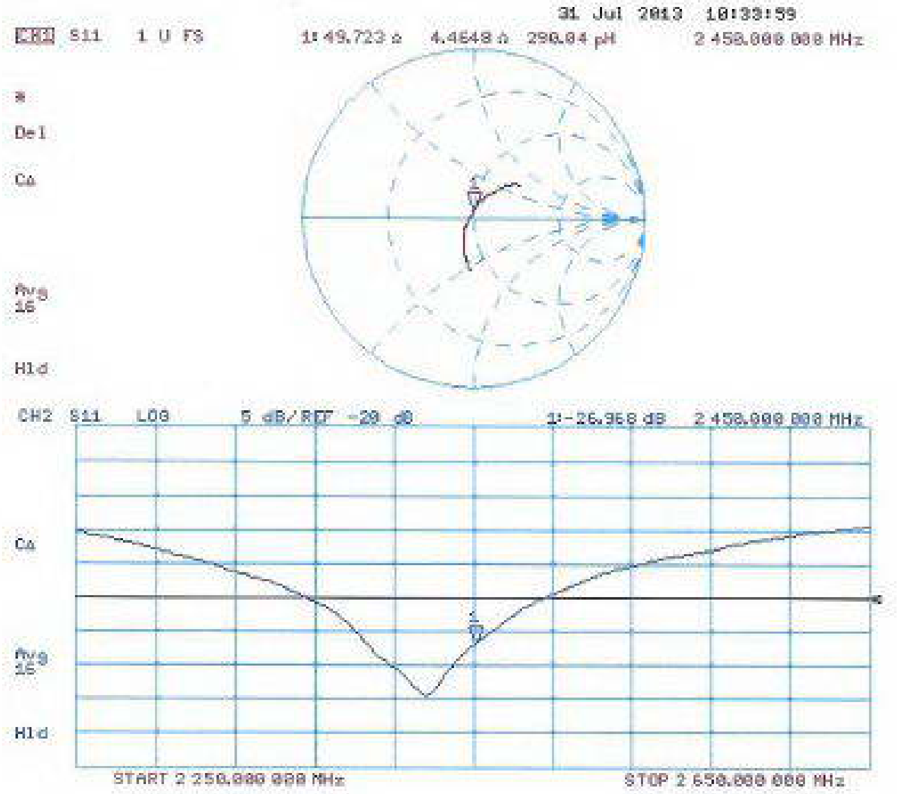
- Probe: ES3DV3 - SN3205; ConvF(4.42, 4.42, 4.42); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52.52.8.7(1137); SEMCAD X 14.6.10(7164)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 94.151 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 26.3 W/kg
SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.87 W/kg
Maximum value of SAR (measured) = 16.7 W/kg



0 dB = 16.7 W/kg = 12.23 dBW/kg

Impedance Measurement Plot for Body TSL



Certificate No: D2450V2-817_Jul13 Page 8 of 8

D2450V2, Serial No.817 Extended Dipole Calibrations

Per IEEE Std 1528-2003,the dipole should have a return loss better than -20dB at the test frequency to reduce uncertainty in the power measurement.
Per KDB 865664 D01,if dipoles are verified in return loss(<-20dB,within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration),the annual calibration is not necessary and the calibration interval can be extended.

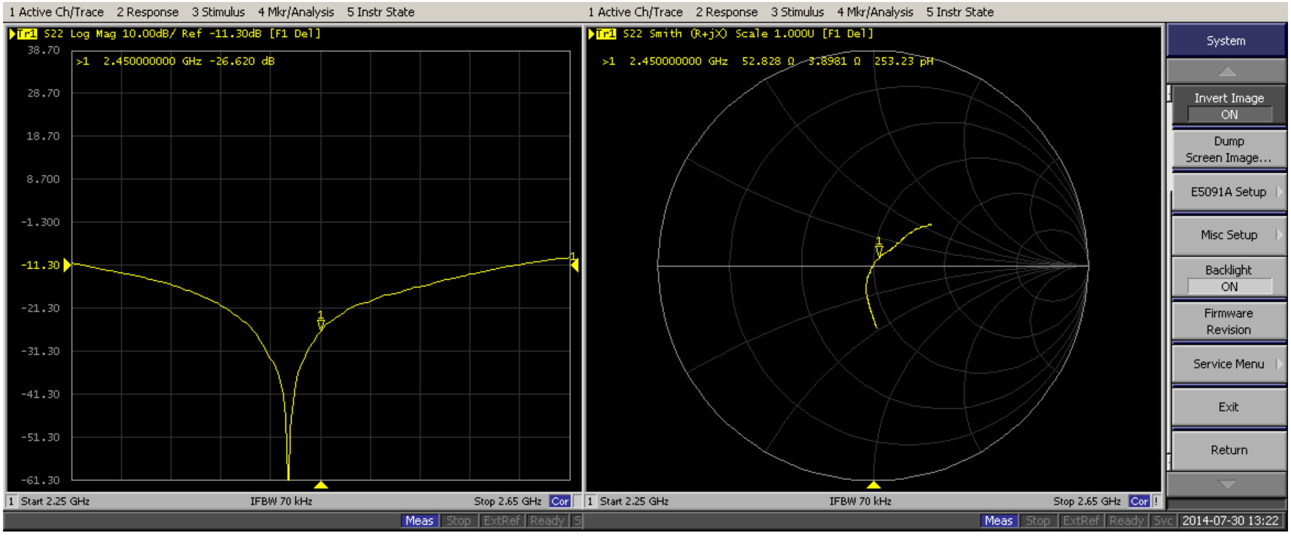
Justification of the extended calibration

D2450V2 Serial No.817						
2450 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
7.31.2013	-27.140	--	53.512	--	2.897	--
7.30.2014	-26.620	1.92	52.828	0.684	3.898	0.911

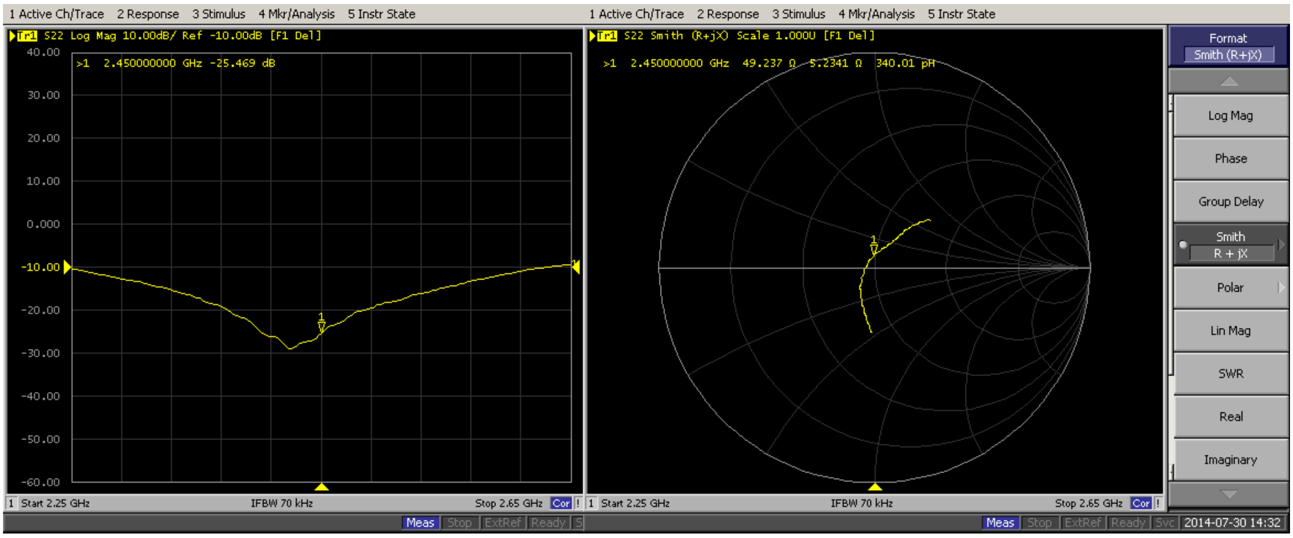
D2450V2 Serial No.817						
2450 Body						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
7.31.2013	-26.968	--	49.723	--	4.465	--
7.30.2014	-25.469	5.56	49.237	0.486	5.234	0.769

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data D2450V2 Serial No.817
2450 MHz-Head



2450 MHz-Body



Per IEEE Std 1528-2003,the dipole should have a return loss better than -20dB at the test frequency to reduce uncertainty in the power measurement.
Per KDB 865664 D01,if dipoles are verified in return loss(<-20dB,within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration),the annual calibration is not necessary and the calibration interval can be extended.

Justification of the extended calibration

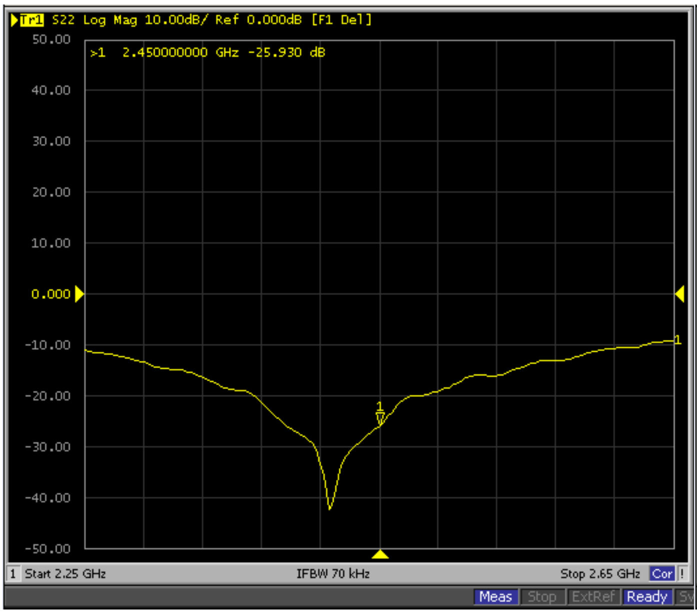
D2450V2 Serial No.817						
2450 Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
7.31.2013	-27.140	--	53.512	--	2.897	--
7.30.2014	-26.620	1.92	52.828	0.684	3.898	0.911
7.29.2015	-25.93	2.59	53.086	0.258	4.095	0.197

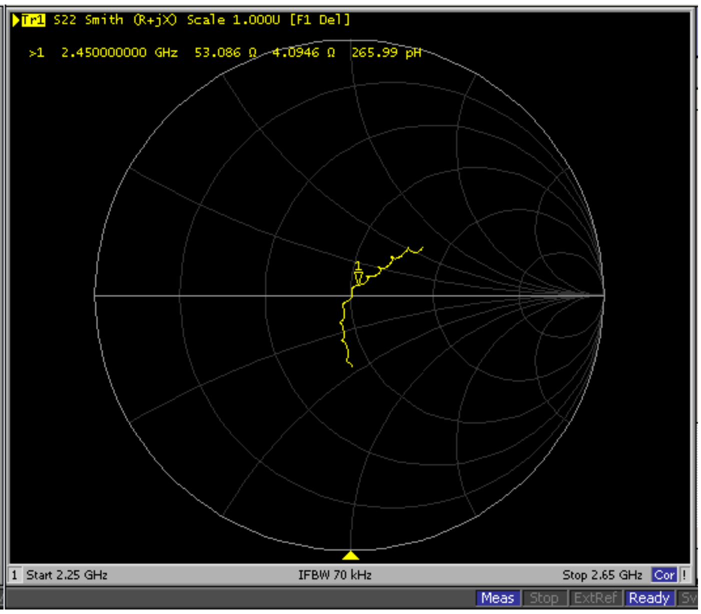
D2450V2 Serial No.817						
2450 Body						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
7.31.2013	-26.968	--	49.723	--	4.465	--
7.30.2014	-25.469	5.56	49.237	0.486	5.234	0.769
7.29.2015	-25.139	1.30	49.31	0.073	5.419	0.185

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

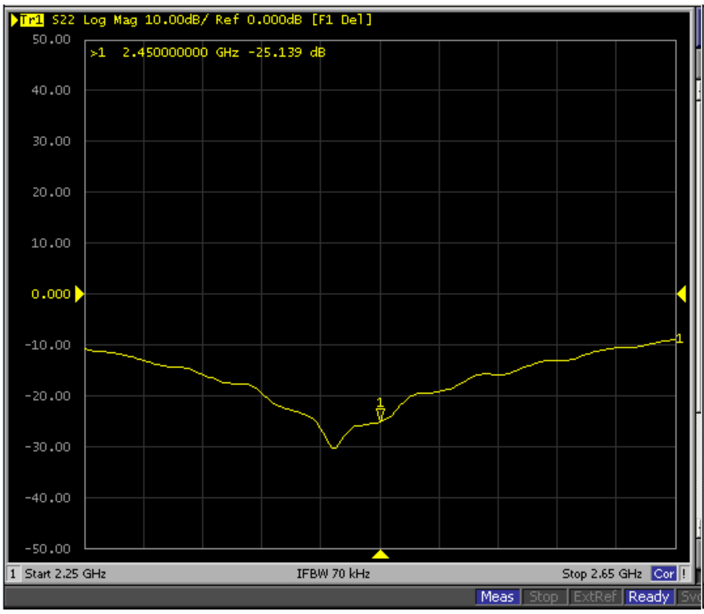
Dipole Verification Data D2450V2 Serial No.817

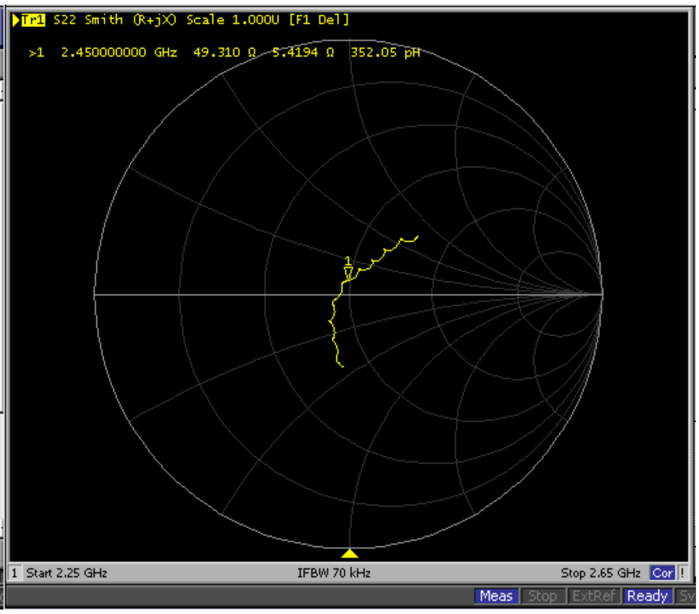
2450 MHz-Head





2450 MHz-Body





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Accreditation No.: SCS 108

Client CCS-CN (Auden)

Certificate No: D5GHzV2-1095_May13

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN: 1095
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	May 31, 2013

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe EX3DV4	SN: 3503	28-Dec-12 (No. EX3-3503_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14

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

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

Issued: May 31, 2013

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Certificate No: D5GHzV2-1095_May13 Page 1 of 16

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Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
b) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

c) 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	V52.8.6
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.5 ± 6 %	4.50 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.94 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**79.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.7 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.3 ± 6 %	4.60 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.1 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.7 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.1 ± 6 %	4.79 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**84.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.0 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.0 ± 6 %	4.89 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**82.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.4 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.86 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.3 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.6 ± 6 %	5.41 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.44 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.9 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.4 ± 6 %	5.53 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.58 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**76.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.12 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.3 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.1 ± 6 %	5.80 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.89 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**79.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.0 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.0 ± 6 %	5.80 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.76 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**77.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.6 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.6 ± 6 %	6.24 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.47 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.7 W/kg ± 19.5 % (k=2)**

Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.2 Ω - 6.4 jΩ
Return Loss	- 23.9 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	50.2 Ω - 3.3 jΩ
Return Loss	- 29.6 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	53.2 Ω - 2.2 jΩ
Return Loss	- 28.5 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.0 Ω - 1.1 jΩ
Return Loss	- 24.8 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	55.4 Ω - 2.8 jΩ
Return Loss	- 24.8 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	50.7 Ω - 5.3 jΩ
Return Loss	- 25.5 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	50.8 Ω - 1.5 jΩ
Return Loss	- 35.5 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	53.8 Ω - 1.2 jΩ
Return Loss	- 28.4 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.2 Ω + 1.1 jΩ
Return Loss	- 24.5 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	55.6 Ω + 0.3 jΩ
Return Loss	- 25.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.208 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	September 24, 2010

DASY5 Validation Report for Head TSL

Date: 30.05.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1095

Communication System: UID 0 - CW ; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.5 S/m; ε_r = 36.5; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 4.6 S/m; ε_r = 36.3; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 4.79 S/m; ε_r = 36.1; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 4.89 S/m; ε_r = 36; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 5.11 S/m; ε_r = 35.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.41, 5.41, 5.41); Calibrated: 28.12.2012, ConvF(5.1, 5.1, 5.1); Calibrated: 28.12.2012, ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.76, 4.76, 4.76); Calibrated: 28.12.2012, ConvF(4.81, 4.81, 4.81); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

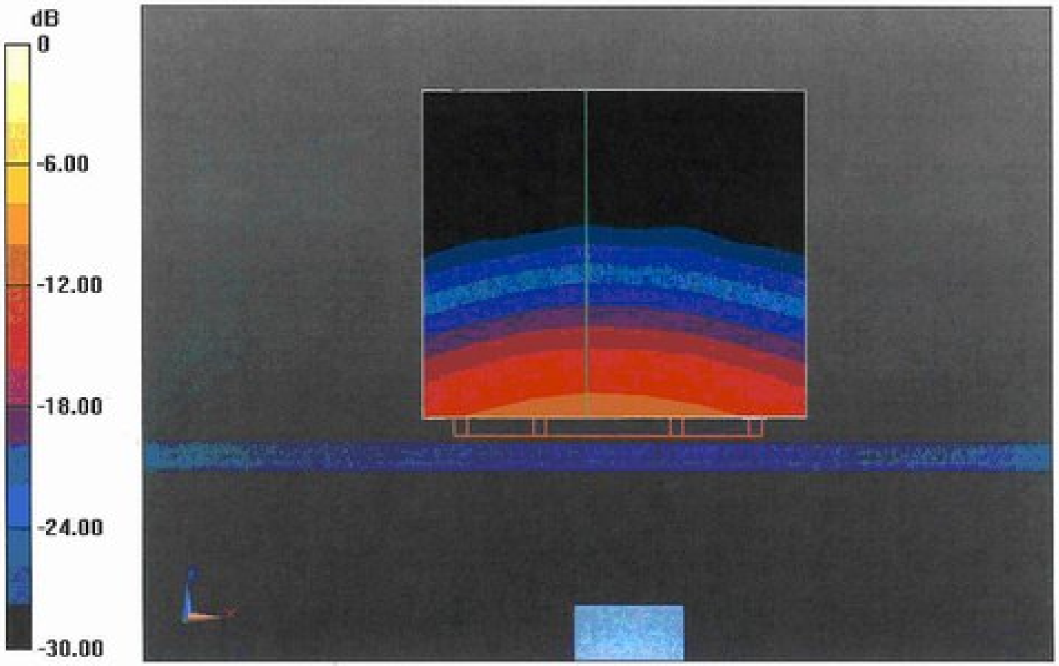
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.153 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 29.3 W/kg
SAR(1 g) = 7.94 W/kg; SAR(10 g) = 2.27 W/kg
Maximum value of SAR (measured) = 18.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.596 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 31.2 W/kg
SAR(1 g) = 8.3 W/kg; SAR(10 g) = 2.37 W/kg
Maximum value of SAR (measured) = 19.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.084 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 33.1 W/kg
SAR(1 g) = 8.42 W/kg; SAR(10 g) = 2.4 W/kg
Maximum value of SAR (measured) = 20.0 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.341 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 8.24 W/kg; SAR(10 g) = 2.34 W/kg
Maximum value of SAR (measured) = 19.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 61.473 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 32.8 W/kg
SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.23 W/kg
Maximum value of SAR (measured) = 19.2 W/kg



0 dB = 19.2 W/kg = 12.83 dBW/kg

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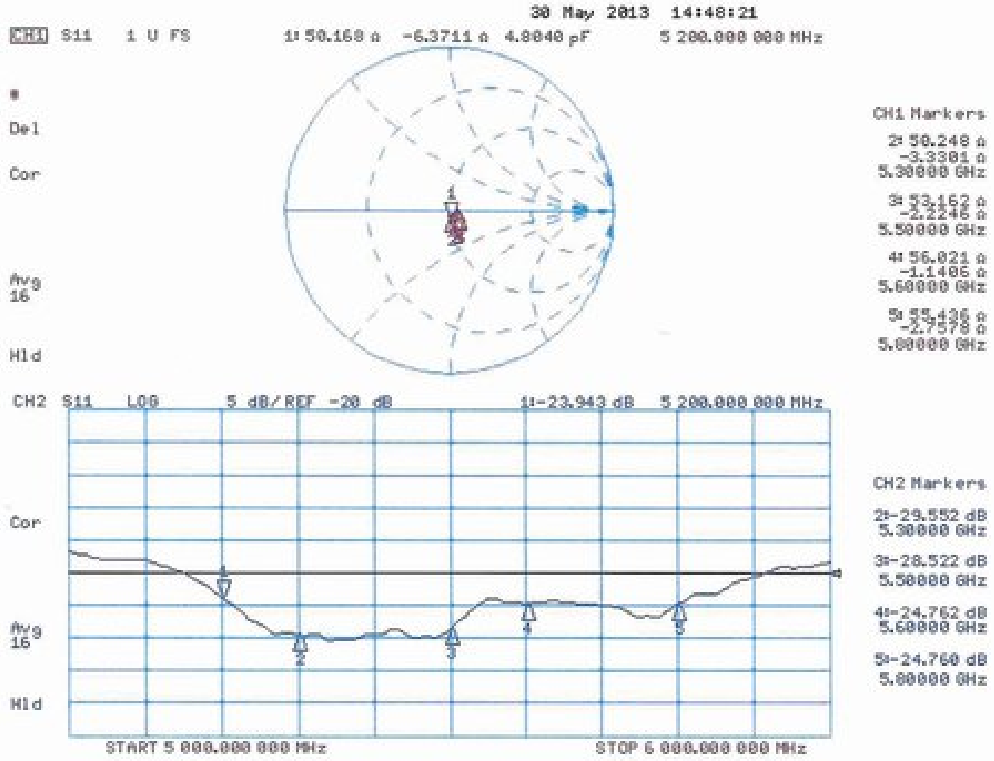
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 31.05.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1095

Communication System: UID 0 - CW ; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.41 S/m; ε_r = 49.6; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 5.53 S/m; ε_r = 49.4; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 5.8 S/m; ε_r = 49.1; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 5.8 S/m; ε_r = 49; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 6.24 S/m; ε_r = 48.6; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.91, 4.91, 4.91); Calibrated: 28.12.2012, ConvF(4.67, 4.67, 4.67); Calibrated: 28.12.2012, ConvF(4.43, 4.43, 4.43); Calibrated: 28.12.2012, ConvF(4.22, 4.22, 4.22); Calibrated: 28.12.2012, ConvF(4.38, 4.38, 4.38); Calibrated: 28.12.2012;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

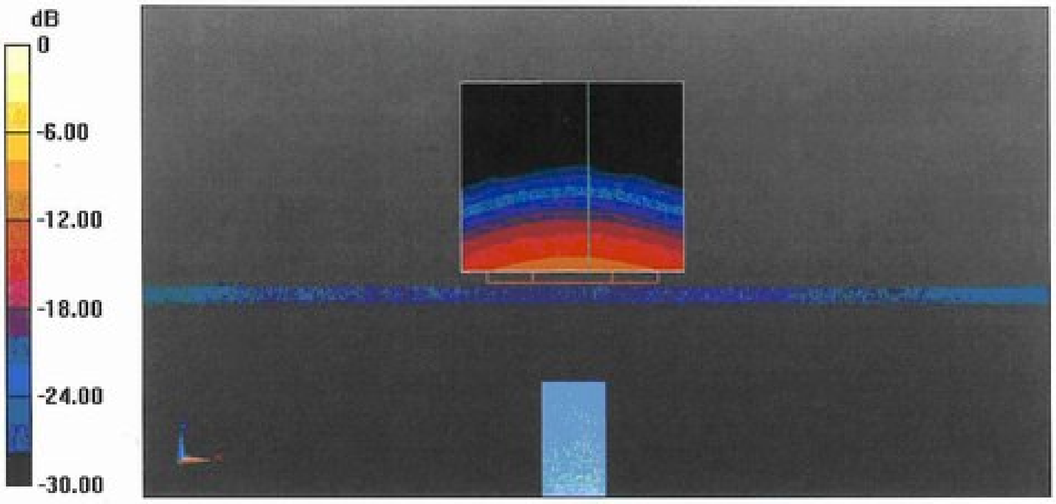
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.744 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 29.0 W/kg
SAR(1 g) = 7.44 W/kg; SAR(10 g) = 2.08 W/kg
Maximum value of SAR (measured) = 17.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.871 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 30.4 W/kg
SAR(1 g) = 7.58 W/kg; SAR(10 g) = 2.12 W/kg
Maximum value of SAR (measured) = 17.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.666 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 33.6 W/kg
SAR(1 g) = 7.89 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 18.7 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.108 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 34.2 W/kg
SAR(1 g) = 7.76 W/kg; SAR(10 g) = 2.15 W/kg
Maximum value of SAR (measured) = 18.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 55.451 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 34.6 W/kg
SAR(1 g) = 7.47 W/kg; SAR(10 g) = 2.06 W/kg
Maximum value of SAR (measured) = 18.2 W/kg



0 dB = 18.2 W/kg = 12.60 dBW/kg

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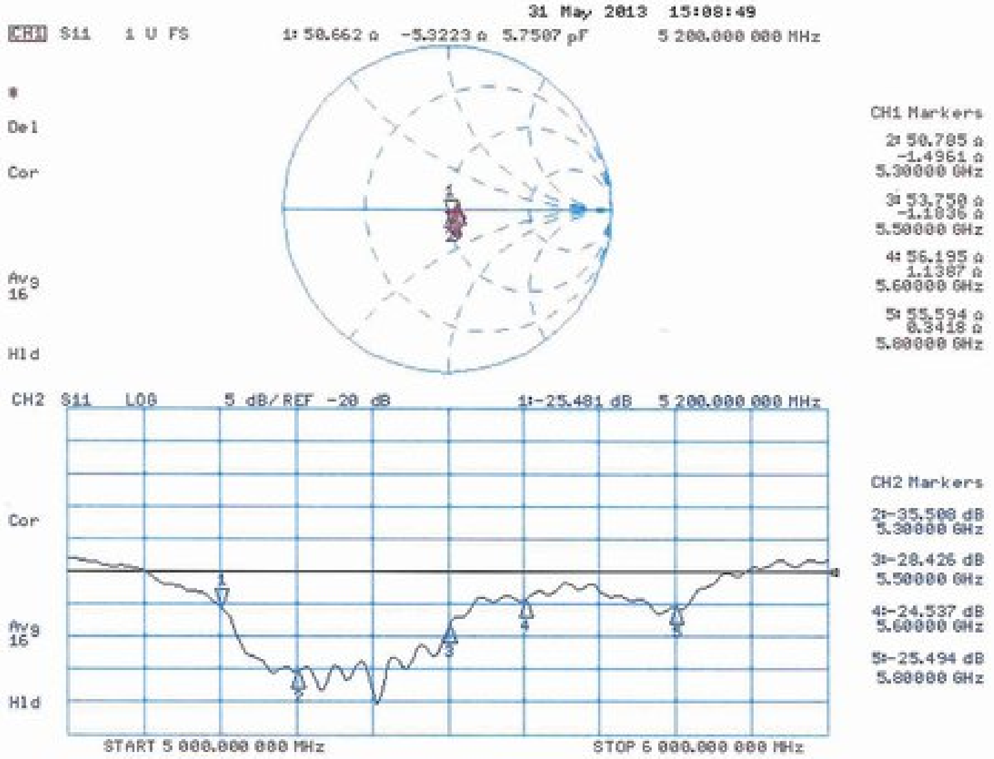
Impedance Measurement Plot for Body TSL



D5GHzV2,Serial No.1095 Extended Dipole Calibrations

Per IEEE Std 1528-2003,the dipole should have a return loss better than -20dB at the test frequency to reduce uncertainty in the power measurement
Per KDB 865664 D01,if dipoles are verified in return loss(<-20dB,within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration),the annual calibration is not necessary and the calibration interval can be extended.

Justification of the extended calibration

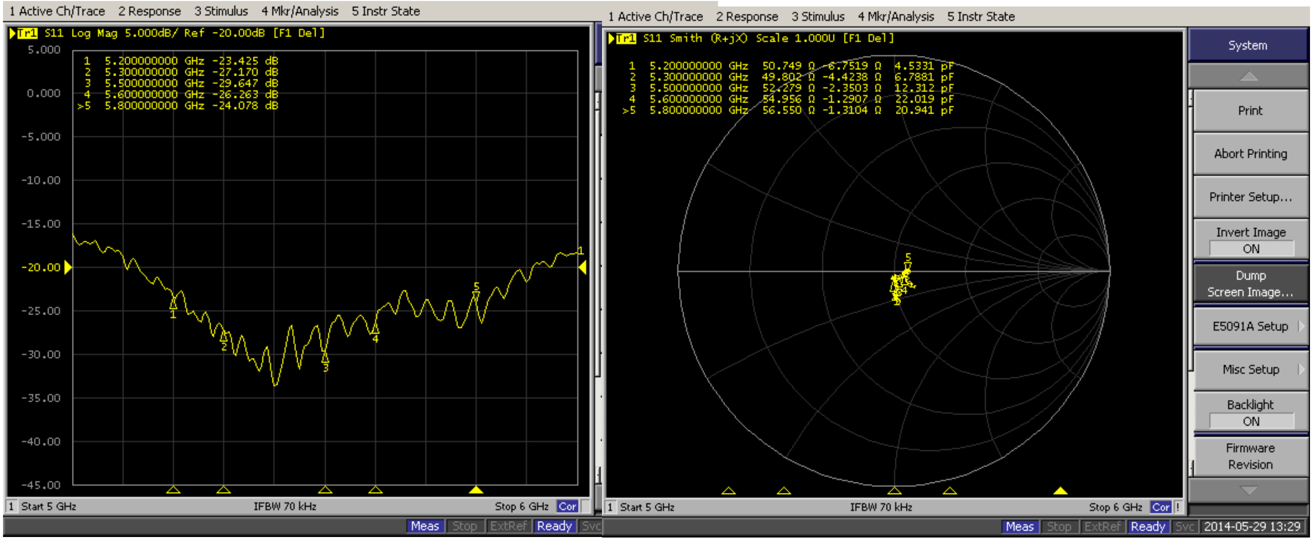
D5GHzV2 Serial No.1095							
Head							
Date of Measurement		Return Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
5200MHz	5.31.2013	-23.943	--	50.168	--	-6.371	--
	5.29.2014	-23.425	2.16	50.749	0.581	-6.752	0.381
5300MHz	5.31.2013	-29.552	--	50.248	--	-3.330	--
	5.29.2014	-27.170	8.06	49.802	0.446	-4.424	1.094
5500MHz	5.31.2013	-28.522	--	53.162	--	-2.225	--
	5.29.2014	-29.647	3.94	52.249	0.913	-2.350	0.125
5600MHz	5.31.2013	-24.762	--	56.021	--	-1.141	--
	5.29.2014	-26.263	6.06	54.956	1.065	-1.291	0.150
5800MHz	5.31.2013	-24.760	--	55.436	--	-2.758	--
	5.29.2014	-24.078	2.75	56.550	1.114	-1.310	1.448

D5GHzV2 Serial No.1095							
Body							
Date of Measurement		Return Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
5200MHz	5.31.2013	-25.481	--	50.662	--	-5.322	--
	5.29.2014	-23.945	6.03	50.975	0.313	-6.336	1.014
5300MHz	5.31.2013	-35.508	--	50.785	--	-1.496	--
	5.29.2014	-31.173	12.21	49.992	0.793	-2.732	1.236
5500MHz	5.31.2013	-28.426	--	53.750	--	-1.184	--
	5.29.2014	-28.353	0.26	52.867	0.883	-2.742	1.558
5600MHz	5.31.2013	-24.537	--	56.195	--	1.139	--
	5.29.2014	-24.330	0.84	56.344	0.149	0.347	0.792
5800MHz	5.31.2013	-25.494	--	55.594	--	0.342	--
	5.29.2014	-24.908	2.30	55.887	0.293	-1.203	1.545

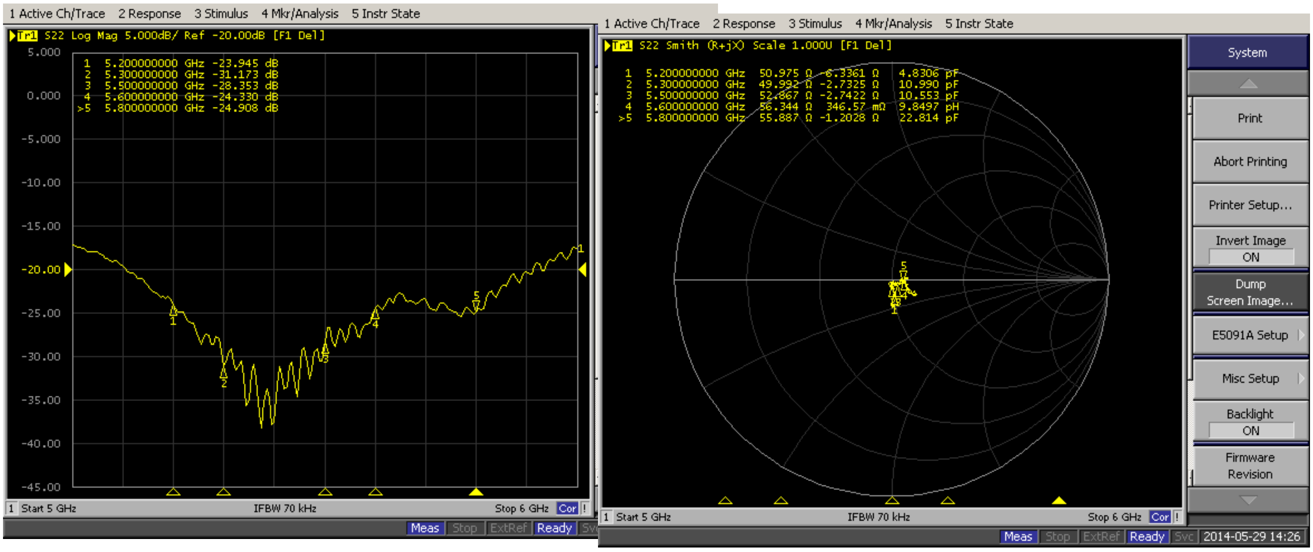
The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration.Therefore the verification result should support extended calibration.

Dipole Verification Data D5GHzV2 Serial No.1095

D5GHzV2-Head



D5GHzV2-Body



Per IEEE Std 1528-2003,the dipole should have a return loss better than -20dB at the test frequency to reduce uncertainty in the power measurement
Per KDB 865664 D01,if dipoles are verified in return loss(<-20dB,within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration),the annual calibration is not necessary and the calibration interval can be extended.

Justification of the extended calibration

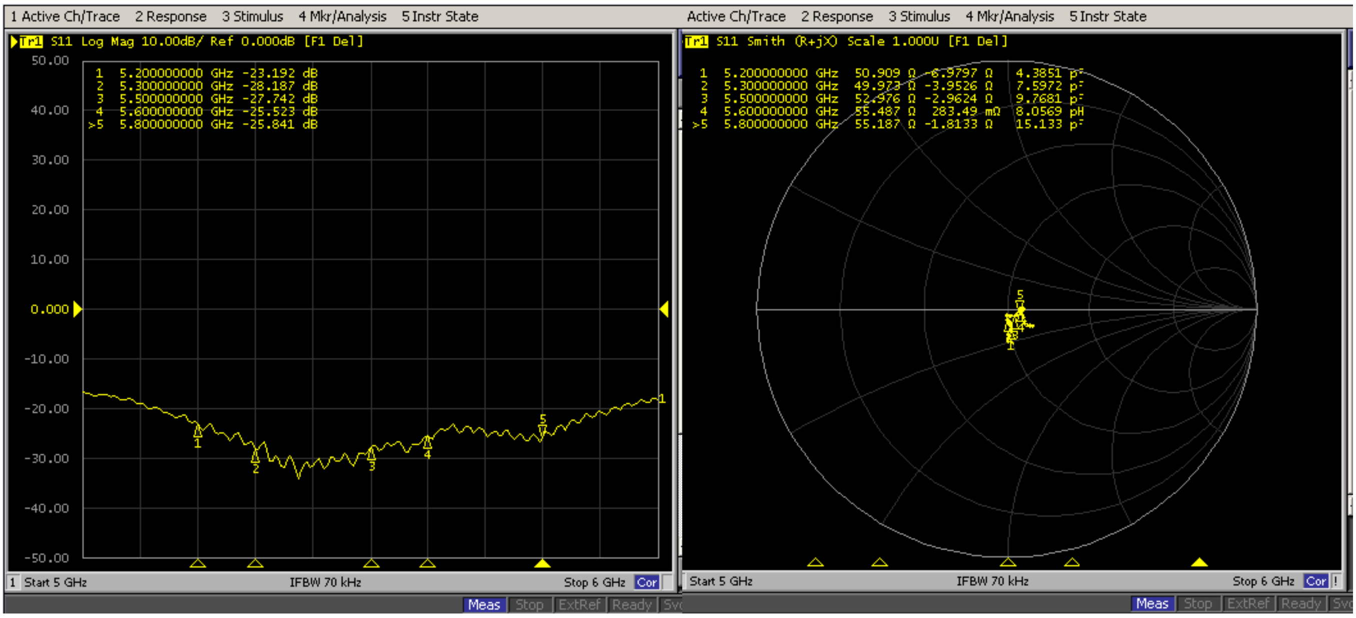
D5GHzV2 Serial No.1095							
Head							
Date of Measurement		Return Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
5200MHz	5.31.2013	-23.943	--	50.168	--	-6.371	--
	5.29.2014	-23.425	2.16	50.749	0.581	-6.752	0.381
	5.28.2015	-23.192	0.99	50.909	0.16	-6.980	0.228
5300MHz	5.31.2013	-29.552	--	50.248	--	-3.330	--
	5.29.2014	-27.170	8.06	49.802	0.446	-4.424	1.094
	5.28.2015	-28.187	3.74	49.973	0.171	-3.953	0.471
5500MHz	5.31.2013	-28.522	--	53.162	--	-2.225	--
	5.29.2014	-29.647	3.94	52.249	0.913	-2.350	0.125
	5.28.2015	-27.742	6.43	52.976	0.727	-2.962	0.612
5600MHz	5.31.2013	-24.762	--	56.021	--	-1.141	--
	5.29.2014	-26.263	6.06	54.956	1.065	-1.291	0.150
	5.28.2015	-25.523	2.82	55.487	0.531	0.283	1.008
5800MHz	5.31.2013	-24.760	--	55.436	--	-2.758	--
	5.29.2014	-24.078	2.75	56.550	1.114	-1.310	1.448
	5.28.2015	-25.841	7.32	55.187	1.363	-1.813	0.503

D5GHzV2 Serial No.1095								
Body								
Date of Measurement		Return Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
5200MHz	5.31.2013	-25.481	--	50.662	--	-5.322	--
	5.29.2014	-23.945	6.03	50.975	0.313	-6.336	1.014
	5.28.2015	-24.992	4.37	50.975	0	-5.587	0.749
5300MHz	5.31.2013	-35.508	--	50.785	--	-1.496	--
	5.29.2014	-31.173	12.21	49.992	0.793	-2.732	1.236
	5.28.2015	-32.699	4.90	49.852	0.14	-2.406	0.326
5500MHz	5.31.2013	-28.426	--	53.750	--	-1.184	--
	5.29.2014	-28.353	0.26	52.867	0.883	-2.742	1.558
	5.28.2015	-30.006	5.83	52.895	0.028	-1.424	1.318
5600MHz	5.31.2013	-24.537	--	56.195	--	1.139	--
	5.29.2014	-24.330	0.84	56.344	0.149	0.347	0.792
	5.28.2015	-25.266	3.85	55.666	0.678	0.746	0.399
5800MHz	5.31.2013	-25.494	--	55.594	--	0.342	--
	5.29.2014	-24.908	2.30	55.887	0.293	-1.203	1.545
	5.28.2015	-24.266	2.58	56.492	0.605	-0.292	0.911

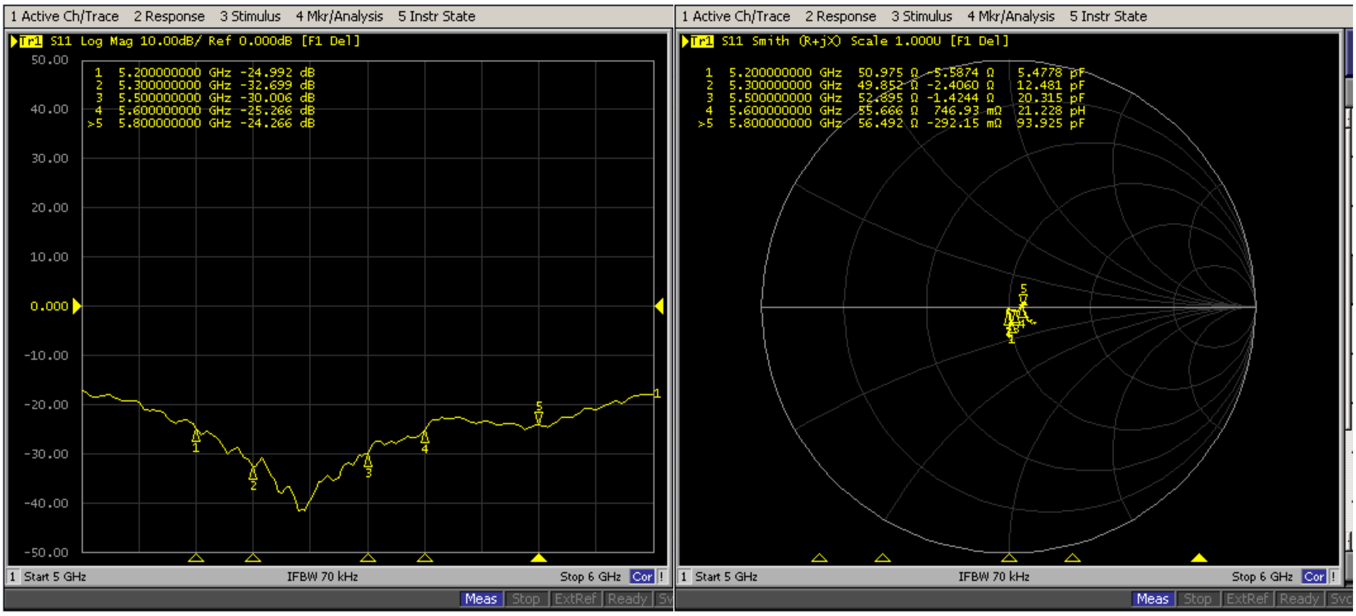
The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data D5GHzV2 Serial No.1095

D5GHzV2-Head



D5GHzV2-Body



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info@speag.com, http://www.speag.com

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IMPORTANT NOTICE

USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:
Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:
Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:
To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.

Schmid & Partner Engineering

TN_BR040315AD DAE4.doc 11.12.2009

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client CCS - CN (Auden)

Certificate No: DAE4-1245_Jul15

CALIBRATION CERTIFICATE

Object: DAE4 - SD 000 D04 BM - SN: 1245

Calibration procedure(s): QA CAL-06.v29
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: July 22, 2015

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Oct-14 (No:15573)	Oct-15
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (in house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (in house check)	In house check: Jan-16

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: July 22, 2015

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Certificate No: DAE4-1245_Jul15 Page 1 of 5

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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	405.968 ± 0.02% (k=2)	404.691 ± 0.02% (k=2)	405.828 ± 0.02% (k=2)
Low Range	4.00326 ± 1.50% (k=2)	3.98439 ± 1.50% (k=2)	4.02655 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	28.5 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200028.69	-6.39	-0.00
Channel X	+ Input	20006.54	1.92	0.01
Channel X	- Input	-20003.38	1.71	-0.01
Channel Y	+ Input	200030.86	-3.89	-0.00
Channel Y	+ Input	20003.32	-1.15	-0.01
Channel Y	- Input	-20004.69	0.56	-0.00
Channel Z	+ Input	200028.63	-11.14	-0.01
Channel Z	+ Input	20003.37	-0.96	-0.00
Channel Z	- Input	-20004.54	0.81	-0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.94	0.10	0.01
Channel X	+ Input	200.71	-0.31	-0.15
Channel X	- Input	-199.09	-0.05	0.03
Channel Y	+ Input	2000.77	-0.04	-0.00
Channel Y	+ Input	200.24	-0.79	-0.39
Channel Y	- Input	-199.48	-0.35	0.18
Channel Z	+ Input	2001.26	0.43	0.02
Channel Z	+ Input	199.86	-1.00	-0.50
Channel Z	- Input	-201.97	-2.76	1.38

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	-7.52	-8.59
	- 200	10.21	8.83
Channel Y	200	-7.45	-7.28
	- 200	6.40	6.24
Channel Z	200	-5.86	-6.35
	- 200	4.39	3.77

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	-	3.60	-3.27
Channel Y	200	9.38	-	3.62
Channel Z	200	9.93	6.83	-

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	15877	17010
Channel Y	16451	16190
Channel Z	15943	17349

5. Input Offset Measurement

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

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	1.17	-0.54	2.46	0.56
Channel Y	0.34	-0.62	1.45	0.44
Channel Z	-0.68	-1.73	0.92	0.51

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 CCS-CN (Auden)

Certificate No: EX3-3798_Jul15

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3798

Calibration procedure(s): QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: July 24, 2015

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
Reference Probe ES3DV2	SN: 3013	30-Dec-14 (No. ES3-3013_Dec14)	Dec-15
DAE4	SN: 660	14-Jan-15 (No. DAE4-660_Jan15)	Jan-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

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

Issued: July 24, 2015

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Certificate No: EX3-3798_Jul15 Page 1 of 11

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

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

Certificate No: EX3-3798_Jul15 Page 2 of 11

Probe EX3DV4

SN:3798

Manufactured: April 5, 2011
Calibrated: July 24, 2015

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3798

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.54	0.51	0.59	± 10.1 %
DCP (mV)[B]	101.3	100.9	102.8	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	140.4	±3.5 %
		Y	0.0	0.0	1.0		136.3	
		Z	0.0	0.0	1.0		128.7	

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

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3798

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)
835	41.5	0.90	9.13	9.13	9.13	0.38	0.97	± 12.0 %
900	41.5	0.97	8.88	8.88	8.88	0.23	1.50	± 12.0 %
1810	40.0	1.40	7.68	7.68	7.68	0.38	0.80	± 12.0 %
1900	40.0	1.40	7.63	7.63	7.63	0.42	0.81	± 12.0 %
2450	39.2	1.80	6.97	6.97	6.97	0.36	0.84	± 12.0 %
5200	36.0	4.66	5.08	5.08	5.08	0.35	1.80	± 13.1 %
5300	35.9	4.76	4.84	4.84	4.84	0.35	1.80	± 13.1 %
5500	35.6	4.96	4.81	4.81	4.81	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.59	4.59	4.59	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.67	4.67	4.67	0.40	1.80	± 13.1 %

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3798

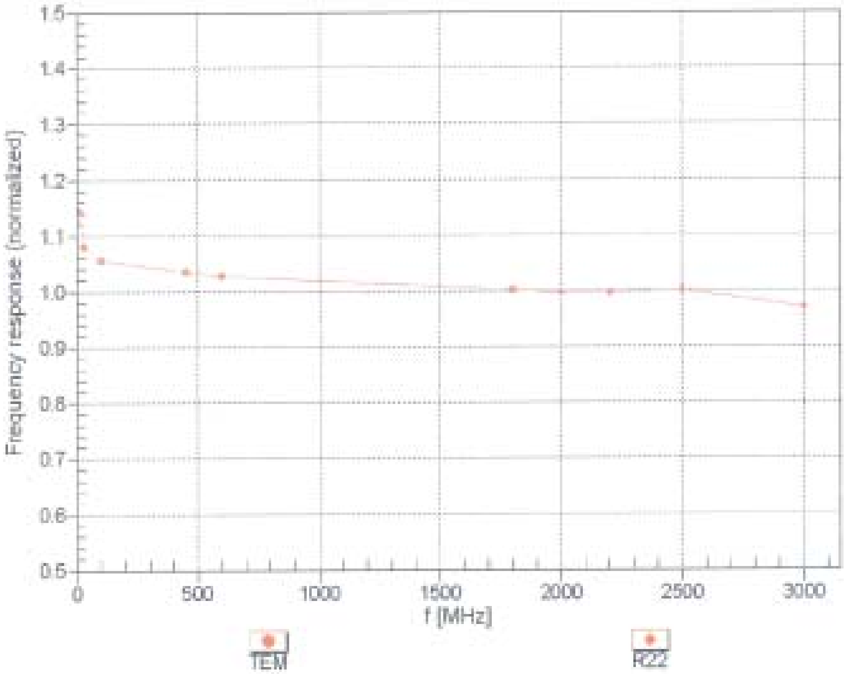
Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
835	55.2	0.97	8.87	8.87	8.87	0.30	1.10	± 12.0 %
900	55.0	1.05	8.59	8.59	8.59	0.29	1.11	± 12.0 %
1810	53.3	1.52	7.40	7.40	7.40	0.39	0.81	± 12.0 %
1900	53.3	1.52	7.29	7.29	7.29	0.30	0.96	± 12.0 %
2450	52.7	1.95	7.08	7.08	7.08	0.25	0.80	± 12.0 %
5200	49.0	5.30	4.64	4.64	4.64	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.42	4.42	4.42	0.40	1.90	± 13.1 %
5500	48.6	5.65	4.01	4.01	4.01	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.90	3.90	3.90	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.16	4.16	4.16	0.50	1.90	± 13.1 %

[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 assessements 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.

EX3DV4– SN:3798 July 24, 2015

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



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

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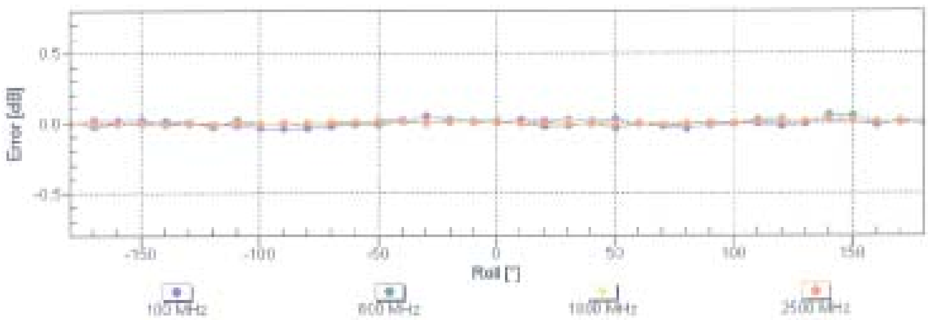
EX3DV4– SN:3798 July 24, 2015

Receiving Pattern (ϕ), ϑ = 0°

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



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

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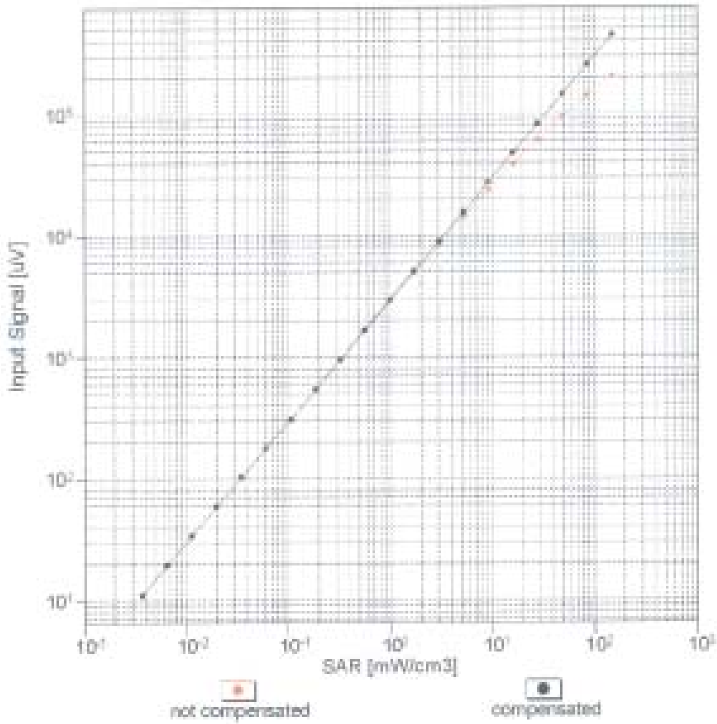
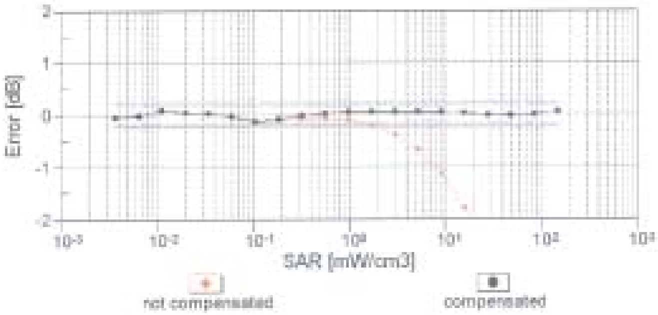
EX3DV4– SN:3798 July 24, 2015

Dynamic Range f(SAR$_{head}$)

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





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

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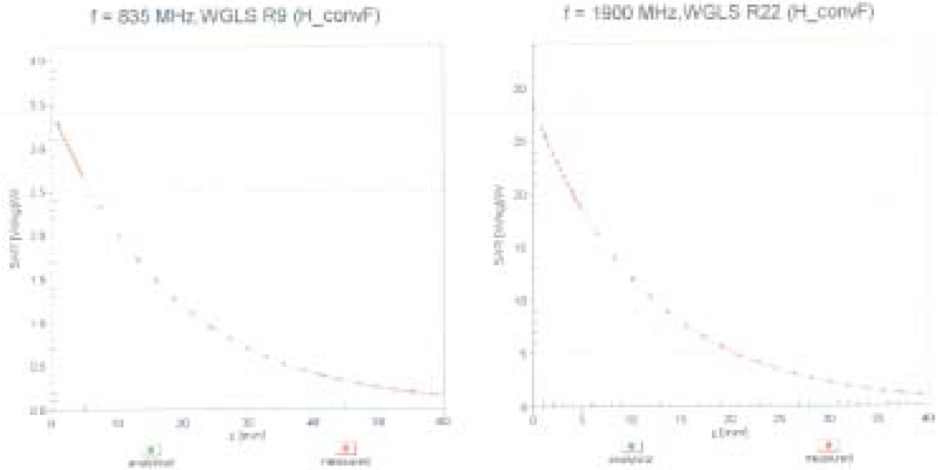
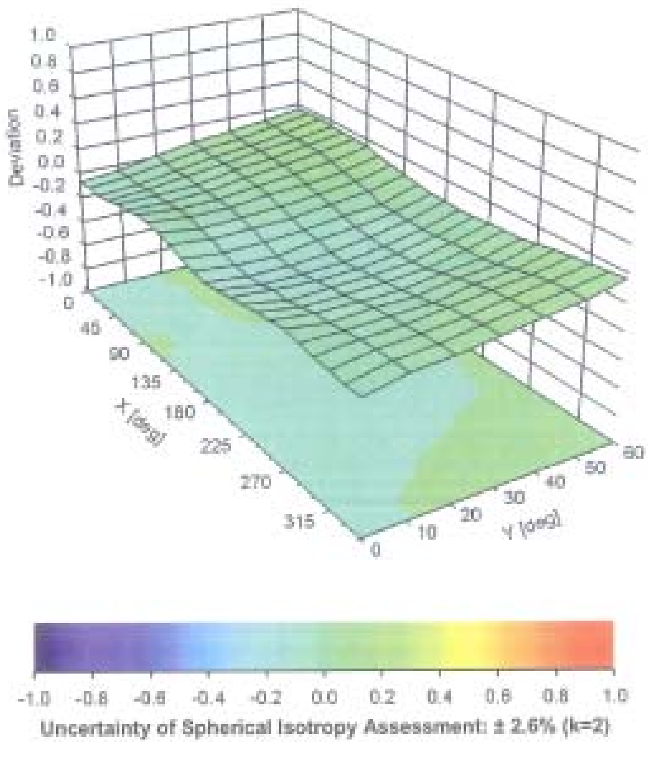
EX3DV4– SN:3798 July 24, 2015

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

Certificate No: EX3-3798_Jul15 Page 10 of 11

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3798

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	140.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm