Low Channel 3.6634MHz BW20MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 9:56:07 AM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3663.4 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3664.0 MHz; σ = 3.22 mho/m; ε_r = 50.64; ρ = 1000 kg/m^3
Phantom section: Flat Section

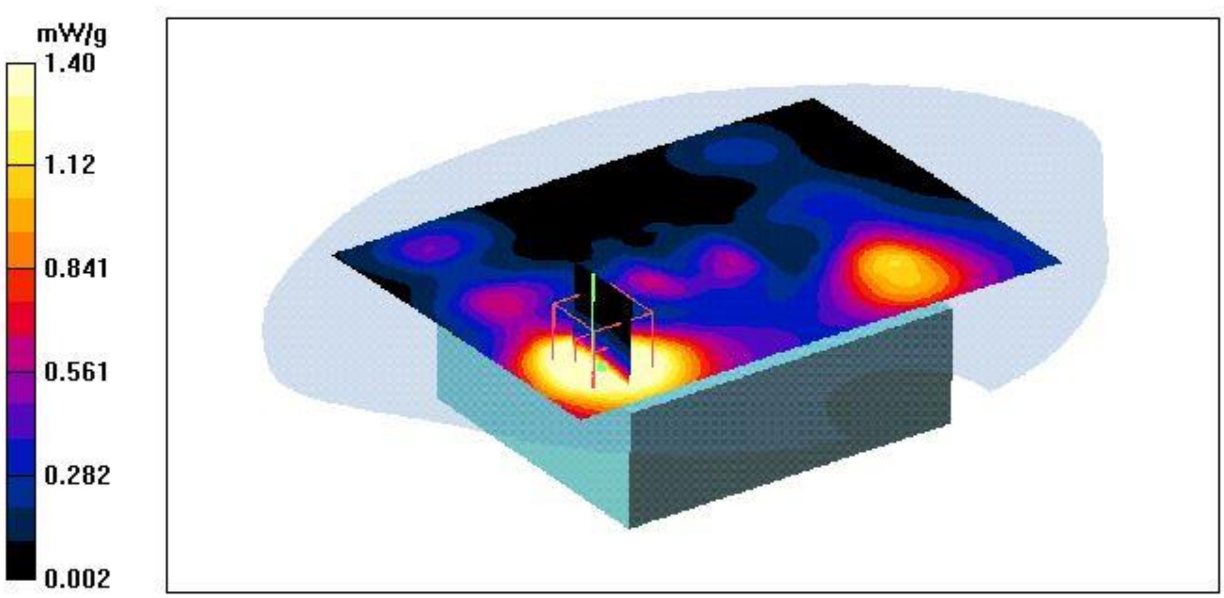
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 1.99 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 14.8 V/m; Power Drift = -2.58 dB
Peak SAR (extrapolated) = 1.99 W/kg
SAR(1g) = 0.865 mW/g
Maximum value of SAR (measured) = 1.40 mW/g



Mid Channel 3.6784MHz BW20MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 10:39:50 AM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3678.4 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3676.8 MHz; σ = 3.24 mho/m; ε_r = 50.62; ρ = 1000 kg/m^3
Phantom section: Flat Section

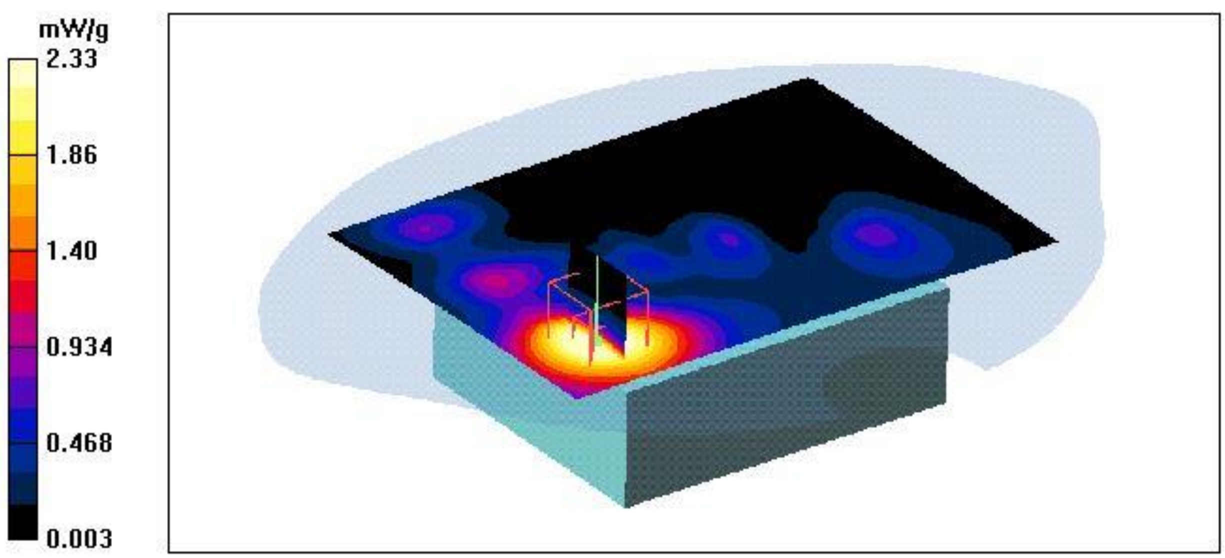
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 2.55 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 14.1 V/m; Power Drift = -0.902 dB
Peak SAR (extrapolated) = 3.31 W/kg
SAR(1g) = 1.34 mW/g
Maximum value of SAR (measured) = 2.33 mW/g



High Channel 3.6884MHz BW20MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 1:19:46 PM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3688.4 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3689.6 MHz; σ = 3.25 mho/m; ε_r = 50.58; ρ = 1000 kg/m^3
Phantom section: Flat Section

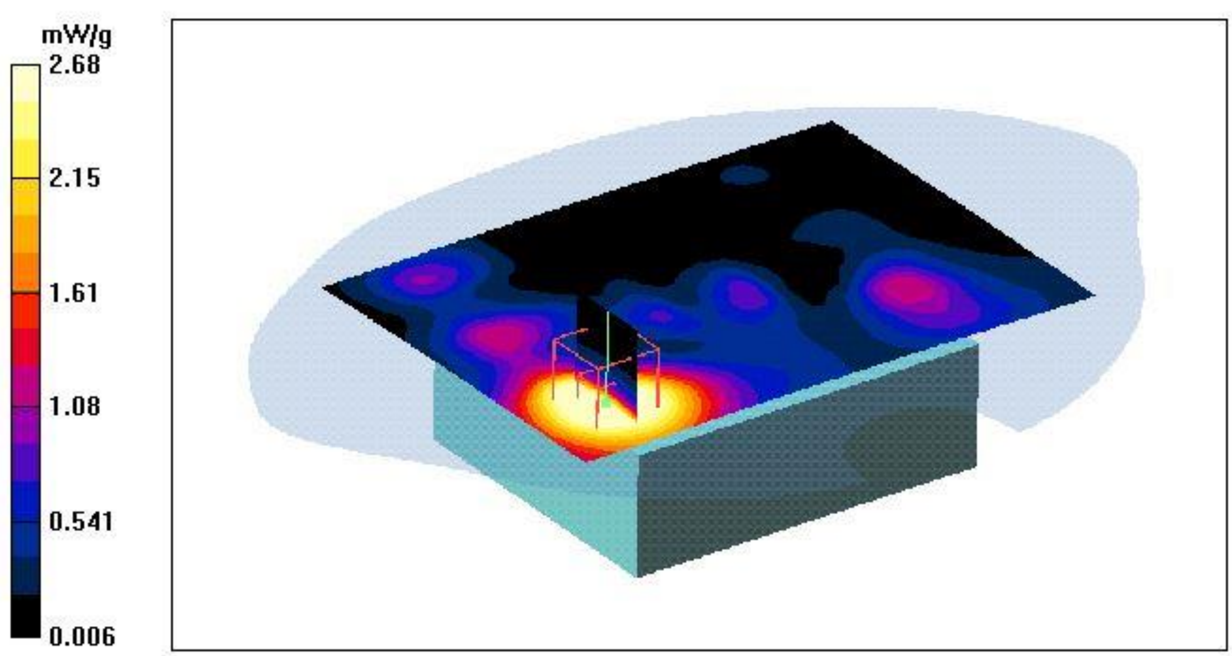
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 3.45 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 18.1 V/m; Power Drift = -2.34 dB
Peak SAR (extrapolated) = 3.83 W/kg
SAR(1g) = 1.41 mW/g
Maximum value of SAR (measured) = 2.68 mW/g



Low Channel 3.6559MHz BW10MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 2:00:05 PM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3655.9 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3654.4 MHz; σ = 3.21 mho/m; ε_r = 50.6; ρ = 1000 kg/m^3
Phantom section: Flat Section

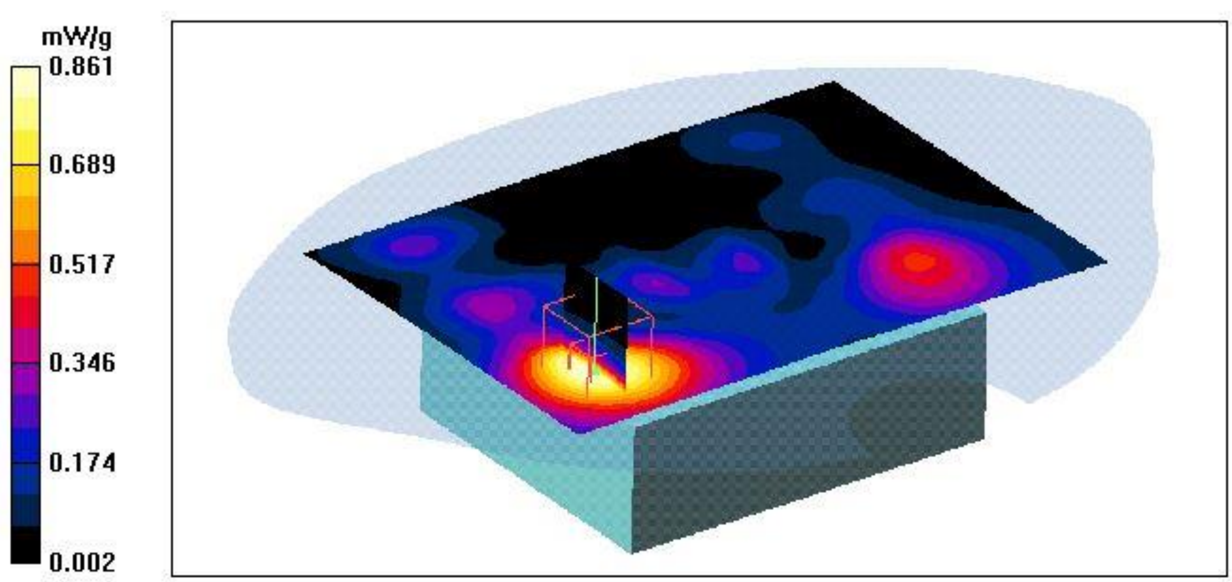
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 0.876 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.84 V/m; Power Drift = -0.740 dB
Peak SAR (extrapolated) = 1.22 W/kg
SAR(1) = 0.528 mW/g
Maximum value of SAR (measured) = 0.861 mW/g



Mid Channel 3.6734MHz BW10MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 2:46:38 PM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3673.4 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3673.6 MHz; σ = 3.23 mho/m; ε_r = 50.6; ρ = 1000 kg/m^3
Phantom section: Flat Section

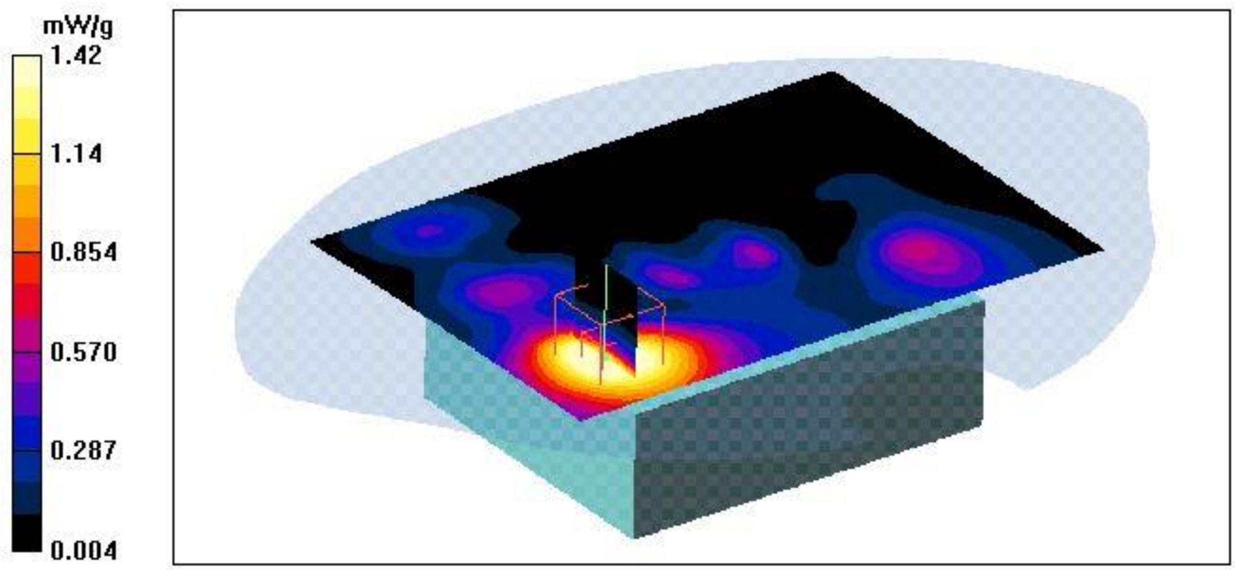
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 1.61 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 11.7 V/m; Power Drift = -1.40 dB
Peak SAR (extrapolated) = 2.01 W/kg
SAR(1g) = 0.877 mW/g
Maximum value of SAR (measured) = 1.42 mW/g



High Channel 3.6934MHz BW10MHz (Body) (Belt Clip)

Date/Time: 7/8/2016 3:29:07 PM

DUT: Rajant CX1; Type: Wireless Mesh

Communication System: OFDM; ; Frequency: 3693.4 MHz;Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3700 MHz; σ = 3.31 mho/m; ε_r = 50.58; ρ = 1000 kg/m^3
Phantom section: Flat Section

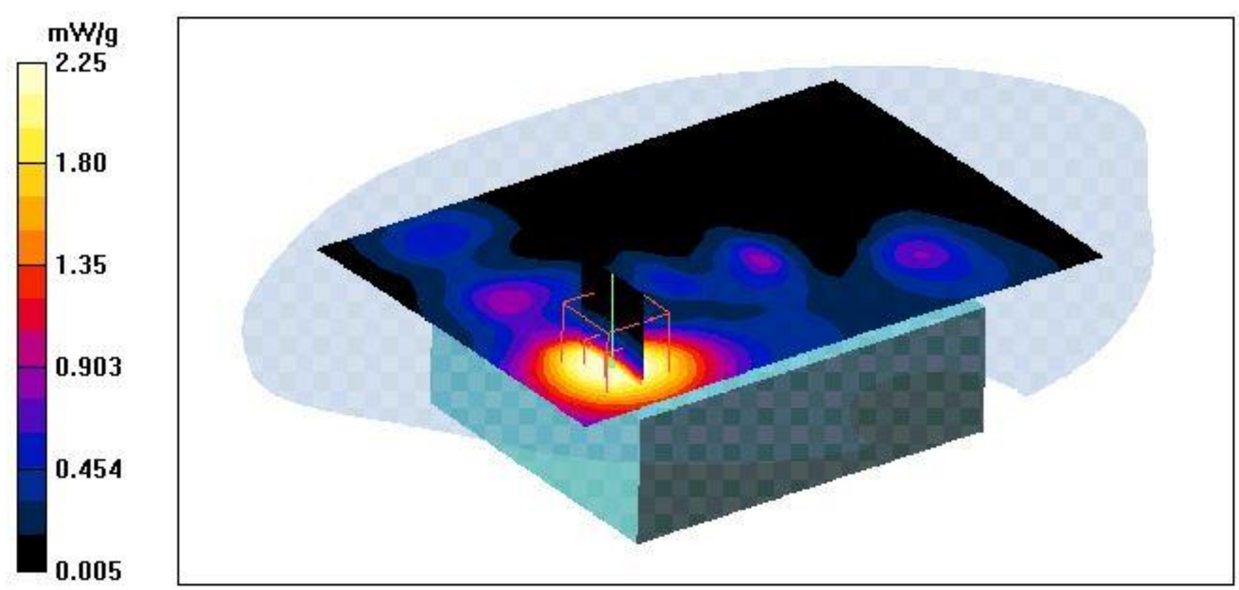
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

SAR Body/Area Scan (131x181x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 2.43 mW/g

SAR Body/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 13.1 V/m; Power Drift = -0.867 dB
Peak SAR (extrapolated) = 3.17 W/kg
SAR(1g) = 1.38 mW/g
Maximum value of SAR (measured) = 2.25 mW/g



APPENDIX B

3700 MHz SYSTEM PERFORMANCE CHECK - FCC

3700MHz Validation (Body)

Date/Time: 7/5/2016 4:46:48 PM

DUT: D3700V2; Serial: 1014

Communication System: CW; ; Frequency: 3700 MHz; Duty Cycle: 1:1
Medium: BSL3700 Medium parameters used: f = 3700 MHz; σ = 3.31 mho/m; ε_r = 50.58; ρ = 1000 kg/m^3
Phantom section: Flat Section

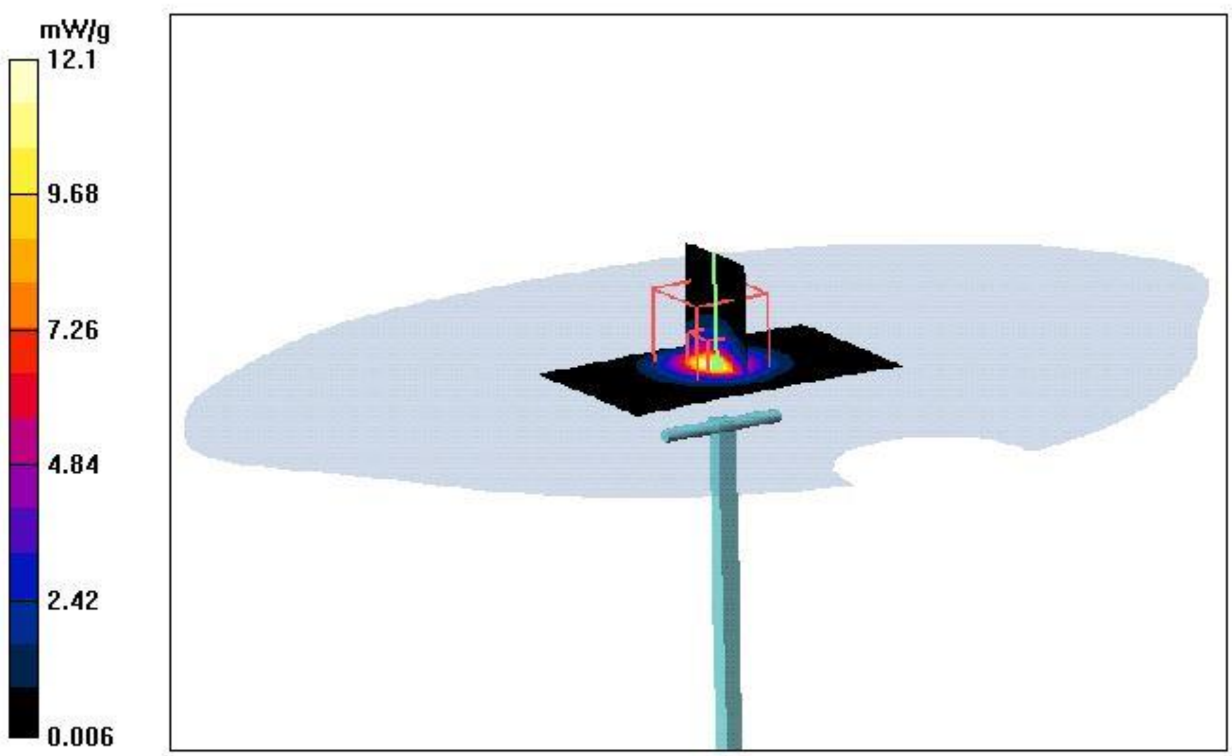
- Probe: EX3DV4 - SN7395; ConvF(6.54, 6.54, 6.54); Calibrated: 3/31/2016
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn584; Calibrated: 10/20/2015
- Phantom: SAM with CRP; Type: SAM; Serial: TP 1310
- Measurement SW: DASY4, V4.7 Build 71; Postprocessing SW: SEMCAD, V1.8 Build 184

d=10mm, Pin=100mW/Area Scan (51x81x1):

Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (interpolated) = 12.1 mW/g

d=10mm, Pin=100mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.8 V/m; Power Drift = -0.010 dB
Peak SAR (extrapolated) = 17.8 W/kg
SAR(1g) = 6.32 mW/g
Maximum value of SAR (measured) = 12.1 mW/g



APPENDIX C

3700 MHz DIPOLE CALIBRATION CERTIFICATE

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

ilac-MRA

SWISS ACCREDITATION sas.admin.ch SCS 0108

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

Client **MET Laboratories** **Certificate No: D3700V2-1014_Mar16**

CALIBRATION CERTIFICATE

Object	D3700V2 - SN:1014
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	March 30, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 3503	31-Dec-15 (No. EX3-3503_Dec15)	Dec-16
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: March 30, 2016

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

Certificate No: D3700V2-1014_Mar16 Page 1 of 8

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

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Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-2, "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
c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

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%.

Certificate No: D3700V2-1014_Mar16 Page 2 of 8

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.8 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3700 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	37.7	3.12 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.7 ± 6 %	3.10 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	100 mW input power	6.60 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**65.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.0 W/kg ± 19.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	51.0	3.55 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.8 ± 6 %	3.47 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	100 mW input power	6.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**60.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.7 W/kg ± 19.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.7 Ω - 9.2 jΩ
Return Loss	- 20.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.2 Ω - 7.4 jΩ
Return Loss	- 22.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.140 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	December 18, 2015

DASY5 Validation Report for Head TSL

Date: 30.03.2016

Test Laboratory: SPEAG, Zurich, Switzerland

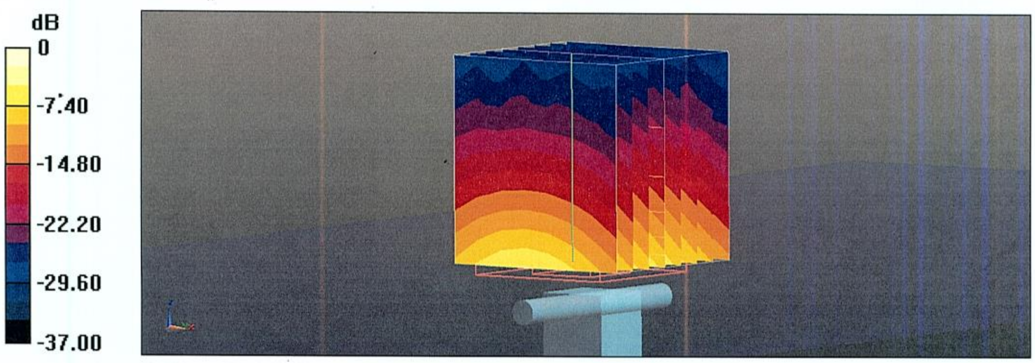
DUT: Dipole 3700 MHz D3700V2; Type: D3700V2; Serial: D3700V2 - SN: 1014

Communication System: UID 0 - CW; Frequency: 3700 MHz
Medium parameters used: f = 3700 MHz; σ = 3.1 S/m; ε_r = 36.7; ρ = 1000 kg/m^3
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

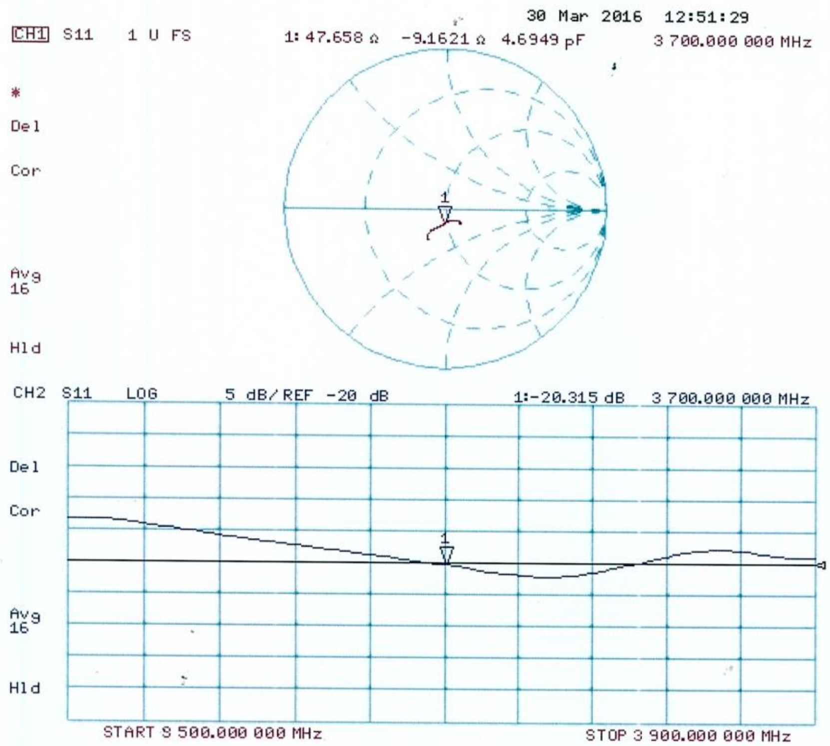
- Probe: EX3DV4 - SN3503; ConvF(7.23, 7.23, 7.23); Calibrated: 31.12.2015;
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom Type: QD000P50AA
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm/Zoom Scan (4x4x3mm), dist=1.8mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.8mm
Reference Value = 63.46 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 18.8 W/kg
SAR(1 g) = 6.6 W/kg; SAR(10 g) = 2.41 W/kg
Maximum value of SAR (measured) = 12.2 W/kg



0 dB = 12.2 W/kg = 10.86 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 30.03.2016

Test Laboratory: SPEAG, Zurich, Switzerland

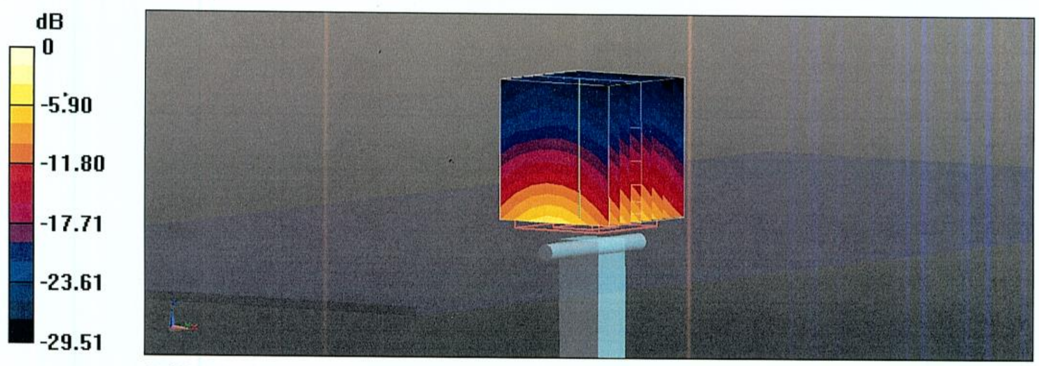
DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN: 1014

Communication System: UID 0 - CW; Frequency: 3700 MHz
Medium parameters used: f = 3700 MHz; σ = 3.47 S/m; ε_r = 49.8; ρ = 1000 kg/m^3
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

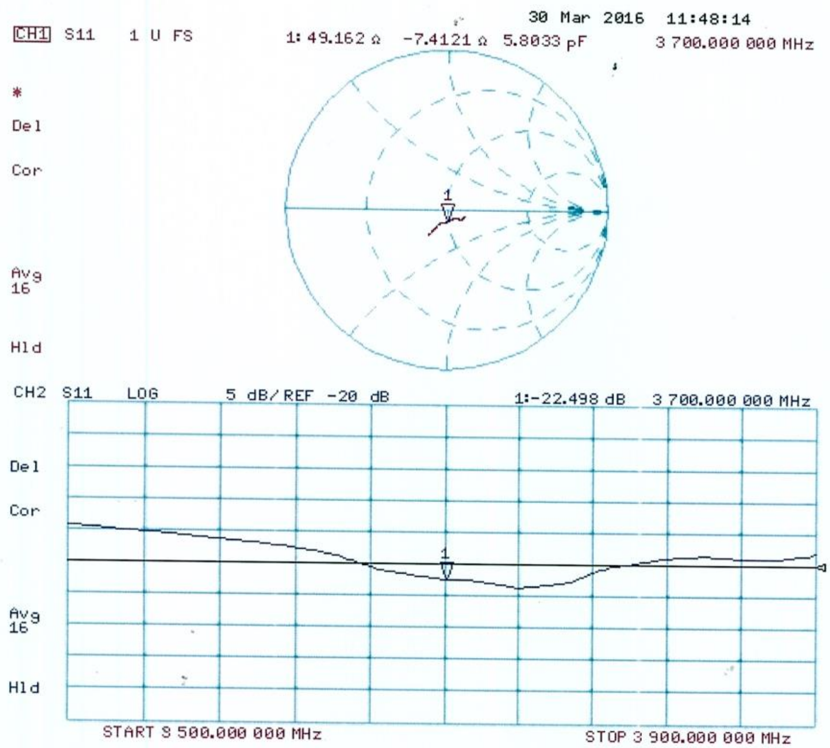
- Probe: EX3DV4 - SN3503; ConvF(7.18, 7.18, 7.18); Calibrated: 31.12.2015;
- Sensor-Surface: 1.8mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom Type: QD000P50AA
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm 2/Zoom Scan (4x4x3mm), dist=1.8mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.8mm
Reference Value = 58.12 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 16.6 W/kg
SAR(1 g) = 6.03 W/kg; SAR(10 g) = 2.18 W/kg
Maximum value of SAR (measured) = 11.0 W/kg



0 dB = 11.0 W/kg = 10.41 dBW/kg

Impedance Measurement Plot for Body TSL



Certificate No: D3700V2-1014_Mar16 Page 8 of 8

APPENDIX D

PROBE CALIBRATION CERTIFICATE

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

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Accreditation No.: SCS 0108

Client **MET Laboratories**

Certificate No: EX3-7395_Mar16

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7395
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:	March 31, 2016

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter 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	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
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-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 1, 2016

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

S Schweizerischer Kalibrierdienst
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Swiss Calibration Service

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

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

Probe EX3DV4

SN:7395

Manufactured: July 2, 2015
Calibrated: March 31, 2016

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7395

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.42	0.42	0.44	± 10.1 %
DCP (mV)[B]	100.3	96.7	97.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	126.9	±3.5 %
		Y	0.0	0.0	1.0		125.4	
		Z	0.0	0.0	1.0		121.1	

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.

EX3DV4– SN:7395 March 31, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7395

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)
3700	37.7	3.12	6.46	6.46	6.46	0.46	0.98	± 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:7395

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)
3700	51.0	3.55	6.54	6.54	6.54	0.40	1.11	± 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.

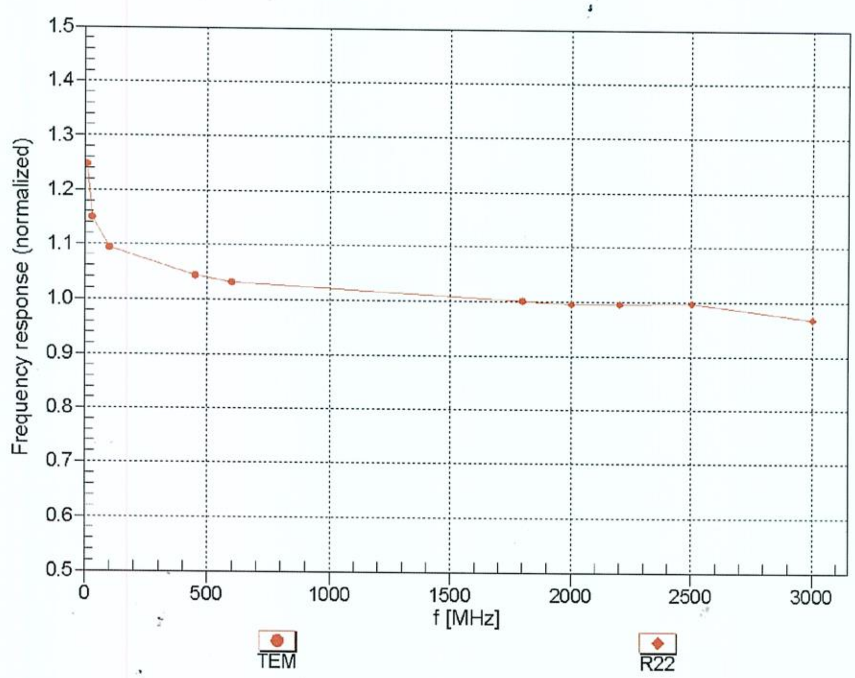
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF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

EX3DV4– SN:7395 March 31, 2016

Frequency Response of E-Field

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



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

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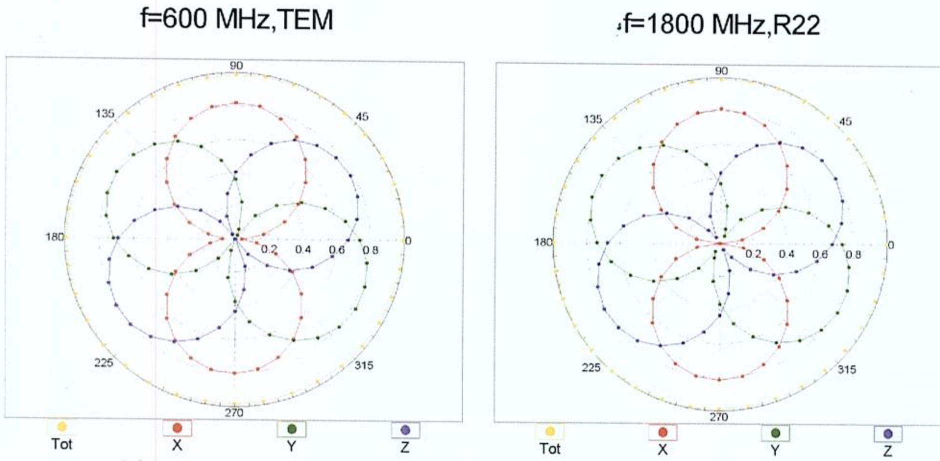
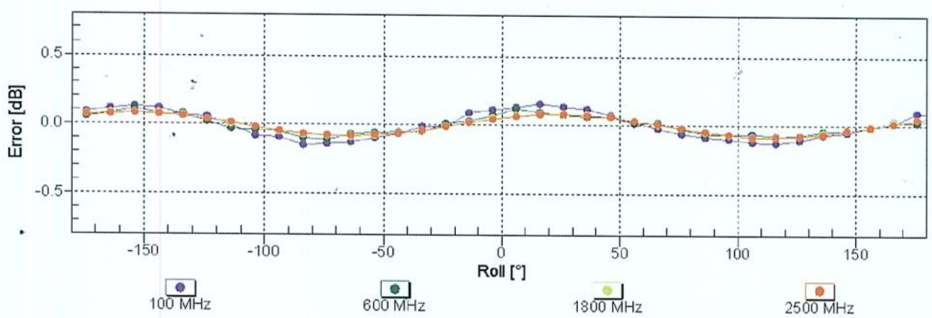
Receiving Pattern (ϕ), ϑ = 0°

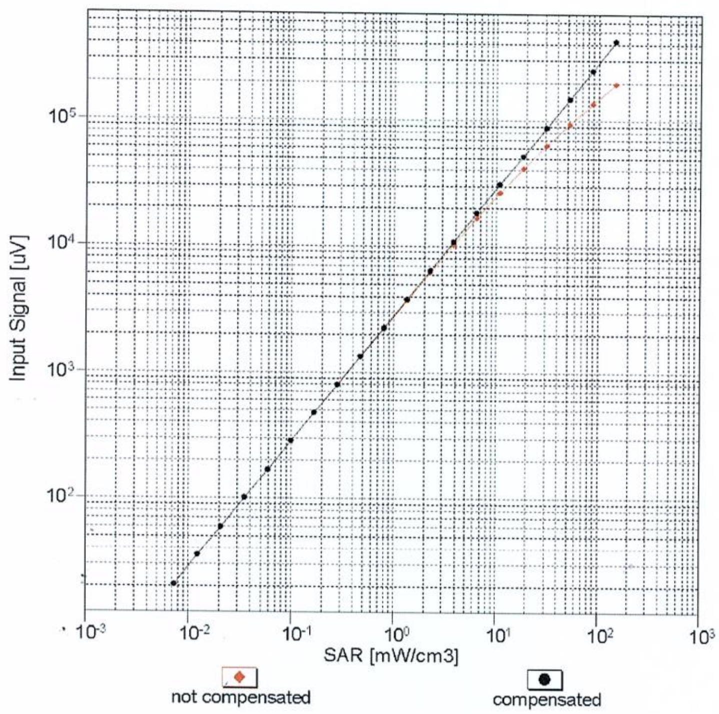


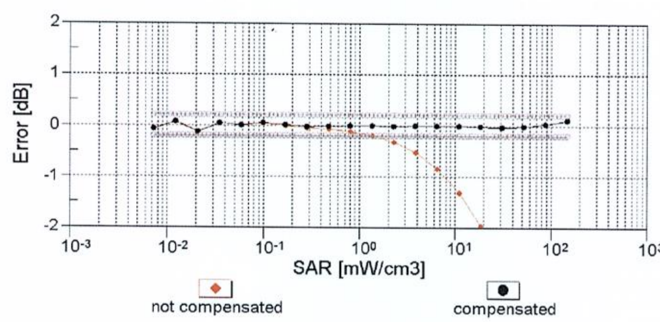


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

EX3DV4– SN:7395 March 31, 2016

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





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

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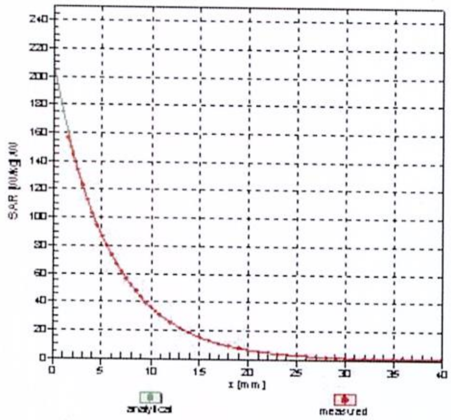
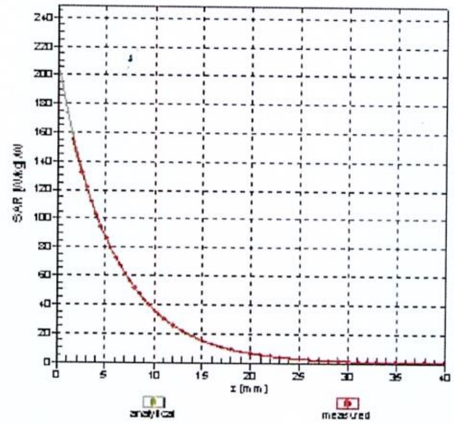
EX3DV4– SN:7395 March 31, 2016

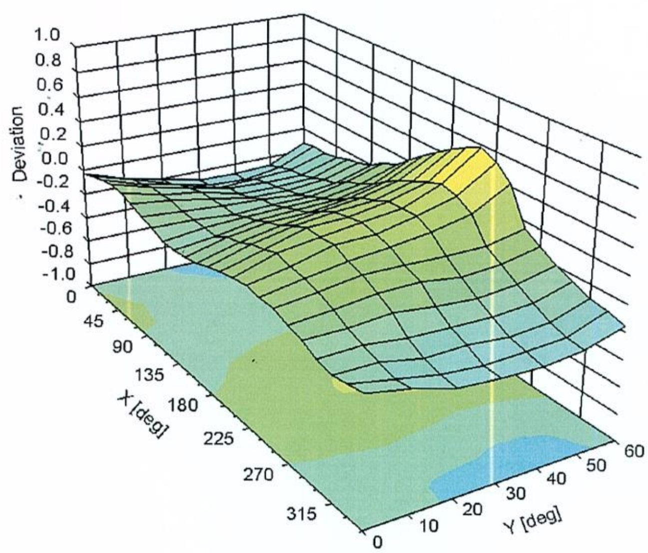
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

Certificate No: EX3-7395_Mar16 Page 10 of 11

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7395

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-13.9
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

APPENDIX E

DAE CALIBRATION CERTIFICATE

Calibration Laboratory of
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Accreditation No.: SCS 0108

Client **MET Laboratories**

Certificate No: DAE3-584_Oct15

CALIBRATION CERTIFICATE

Object	DAE3 - SD 000 D03 AA - SN: 584
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	October 20, 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	09-Sep-15 (No:17153)	Sep-16
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	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:	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	i.V.

Issued: October 20, 2015

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

Calibration Laboratory of
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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.

Certificate No: DAE3-584_Oct15 Page 2 of 5

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	404.501 ± 0.02% (k=2)	404.686 ± 0.02% (k=2)	404.127 ± 0.02% (k=2)
Low Range	3.92829 ± 1.50% (k=2)	3.91783 ± 1.50% (k=2)	3.94494 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	142.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200028.79	-4.71	-0.00
Channel X	+ Input	20005.07	0.77	0.00
Channel X	- Input	-20003.62	1.35	-0.01
Channel Y	+ Input	200023.38	-9.99	-0.00
Channel Y	+ Input	20006.53	2.31	0.01
Channel Y	- Input	-19996.90	8.28	-0.04
Channel Z	+ Input	200032.09	-1.56	-0.00
Channel Z	+ Input	20002.03	-2.16	-0.01
Channel Z	- Input	-20003.24	2.01	-0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.67	-0.02	-0.00
Channel X	+ Input	200.96	0.12	0.06
Channel X	- Input	-199.04	0.27	-0.14
Channel Y	+ Input	2000.80	0.16	0.01
Channel Y	+ Input	200.79	-0.05	-0.03
Channel Y	- Input	-199.95	-0.58	0.29
Channel Z	+ Input	2000.55	-0.05	-0.00
Channel Z	+ Input	199.27	-1.51	-0.75
Channel Z	- Input	-200.40	-1.02	0.51

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	3.90	2.11
	- 200	-0.39	-2.20
Channel Y	200	3.57	2.79
	- 200	-3.98	-4.33
Channel Z	200	-6.27	-6.52
	- 200	4.66	4.58

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	-	-0.83	-4.11
Channel Y	200	6.63	-	0.02
Channel Z	200	7.33	4.80	-

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	16109	15828
Channel Y	16204	15609
Channel Z	16291	16815

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	1.37	-0.77	2.33	0.50
Channel Y	0.32	-0.70	1.98	0.44
Channel Z	-0.34	-1.59	0.65	0.45

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

APPENDIX F

3700 MHz MEASURED FLUID DIELECTRIC PARAMETERS

Rajant CX1-3600

Body Simulating Liquid Parameters for 3600MHz and 3750MHz

July 5, 2016 9:25 AM

Frequency	e'	e"
3.60000 GHz	50.759	15.838
3.60320 GHz	50.764	15.834
3.60640 GHz	50.778	15.844
3.60960 GHz	50.760	15.840
3.61280 GHz	50.751	15.835
3.61600 GHz	50.757	15.847
3.61920 GHz	50.756	15.845
3.62240 GHz	50.762	15.844
3.62560 GHz	50.755	15.854
3.62880 GHz	50.731	15.849
3.63200 GHz	50.731	15.855
3.63520 GHz	50.727	15.851
3.63840 GHz	50.726	15.851
3.64160 GHz	50.724	15.851
3.64480 GHz	50.710	15.854
3.64800 GHz	50.693	15.863
3.65120 GHz	50.685	15.859
3.65440 GHz	50.666	15.854
3.65760 GHz	50.661	15.856
3.66080 GHz	50.644	15.847
3.66400 GHz	50.644	15.860
3.66720 GHz	50.636	15.882
3.67040 GHz	50.632	15.884
3.67360 GHz	50.631	15.861
3.67680 GHz	50.623	15.883
3.68000 GHz	50.615	15.879
3.68320 GHz	50.602	15.890
3.68640 GHz	50.587	15.896
3.68960 GHz	50.584	15.900
3.69280 GHz	50.595	15.903

3.69600 GHz	50.589	15.906
3.69920 GHz	50.582	15.920
3.70240 GHz	50.585	15.919
3.70560 GHz	50.585	15.917
3.70880 GHz	50.561	15.927
3.71200 GHz	50.573	15.937
3.71520 GHz	50.564	15.939
3.71840 GHz	50.563	15.947
3.72160 GHz	50.565	15.932
3.72480 GHz	50.558	15.930
3.72800 GHz	50.562	15.959
3.73120 GHz	50.545	15.946
3.73440 GHz	50.541	15.953
3.73760 GHz	50.545	15.957
3.74080 GHz	50.540	15.958
3.74400 GHz	50.533	15.959
3.74720 GHz	50.519	15.960
3.75040 GHz	50.527	15.948

APPENDIX G

PHANTOM CERTIFICATE OF CONFORMITY

Schmid & Partner Engineering AG

s p e a g

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

Certificate of conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 C
Series No	TP-1150 and higher
Manufacturer / Origin	Untersee Composites Hauptstr. 69 CH-8559 Fruthwilen Switzerland

Tests

The series production process used allows the limitation to test of first articles.
Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series units (called samples).

Test	Requirement	Details	Units tested
Shape	Compliance with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness	Compliant with the requirements according to the standards	2mm +/- 0.2mm in specific areas; 6mm +/- 0.2mm at ERP	First article, Samples
Material parameters	Dielectric parameters for required frequencies	200 MHz – 3 GHz Relative permittivity < 5 Loss tangent < 0.05.	Material sample TP 104-5
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions	DEGMBE based simulating liquids	Pre-series, First article, Samples

Standards

[1] CENELEC EN 50361
[2] IEEE Std 1528-200x Draft CD 1.1 (Dec 02)
[3] IEC 62209/CD (Nov 02)
(*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of [1] and [3].

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standard [1] and draft standards [2] and [3].

Date 7.8.2003

Signature / Stamp

s p e a g
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