

Annex D

Appendix to Test Report No.: 1-6965/13-16-02



Testing Laboratory

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Accredited Test Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2005) by the Deutsche Akkreditierungsstelle GmbH (DAkkS) The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate with the registration number: D-PL-12076-01-01

Appendix with Calibration data, Phantom certificate and system check information



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2 Calibration report "Probe ES3DV3"

Schmid & I Engineer	ring AG	ory of	HACMBA (PRATO S	Schweizerlecher Kalibrierdie Service suisse d'étaionnage Servizio svizzero di taratura Swiss Calibration Service
The Swiss Acc	reditation Servi	itation Service (SAS) ice is one of the signatoric recognition of calibration	is to the EA	No.: SCS 108
Client Ce	etecom	Sector Strands	Certificate No	ES3-3320_Jun13
CALIBR	RATION	CERTIFICAT	E	
Object		ES3DV3 - SN:33	320	
Calibration proc	ceduro(s)		DA CAI -23.v4, QA CAL-25.v4 idure for dosimetric E-field probes	
Calibration date This calibration The measureme	certificate docur	June 1, 2013 ments the traceability to natio	onal standards, which realize the physical units robability are given on the following pages and	a of measurements (SI). are part of the certificate.
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Calibration Laboratory of Schmid & Parlner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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Schweizerischer Kalibrierdienst Service suisse d'étalonnage

Servizio svizzero di taratura

Swiss Calibration Service

Accreditation No.: SCS 108

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

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
ĊF	crest factor (1/duly_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization ϕ	o rotation around probe axis
Polarization 9	B rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., B = 0 is normal to probe axis

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

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization 9 = 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 E²-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 Yemperature 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 canter from the probe tip (on probe axis). No tolerance required.

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ES3DV3 - SN:3320

June 4, 2013

Probe ES3DV3

SN:3320

Manufactured: Calibrated:

January 10, 2012 June 4, 2013

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

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June 4, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3320

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor 2	Unc (k=2)
Norm (µV/(V/m) ²) ^A	0.98	1.15	0.95	± 10.1 %
DCP (mV) ⁸	104.4	102.5	103.1	

Modulation Calibration Parameters

	Communication System Name		A dB	B dBõV	c	D dB	VR mV	Unc [≞] (k≂2)
		X	0.0	D.0	1.0	0.00	137.2	±2.2 %
		Y	0.0	0.0	1.0		149.9	
<u>.</u>	<u> </u>	Z	0.0	0.0	1.Q		176.5	

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%.

 The uncertainties of NormX,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6)
 Numerical linearization parameter: uncertainty not required.
 Uncertainty is dotermined using the max, deviation from linear response applying rectangular distribution and is expressed for the square of the field using. field value.

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ES3DV3- \$N:3320

June 4, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3320

f (MHz) ^c	Relative Permittivity ^F	Conductivity (S/m)	ConvF X	ConvF Y	ConvF Z	Aípha	Depth (mm)	Unct (k=2)
750	41,9	0.89	6.54	6.54	6.54	0.80	1.13	± 12.0 %
835	41.5	0.90	6.32	6.32	6.32	0.80	1.1 5	± 12.0 %
900	41.5	0.97	6.21	6.21	6.21	0.80	1.06	± 12.0 %
<u>1750</u>	40. <u>1</u>	1.37	5.23	5.23	5.23	0.80	1.19	± 12.0 %
1900	40.0	1.40	5.06	5.06	5.06	0.61	1.39	± 12.0 %
2450	39.2	1.80	4.49	4.49	4.49	0.80	1.30	± 12.0 %

Calibration Parameter Determined in Head Tissue Simulating Media

⁶ Frequency valid/ly of \pm 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to \pm 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. ¹ At frequencies below 3 GHz, the validity of tissue parameters (s and d) can be relaxed to \pm 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (s and d) can be relaxed to \pm 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target fissue parameters.

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ES3DV3- SN:3320

June 4, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3320

f (MHz) ^c	Relative Permittivity ^F	Conductivity {S/m} ^F	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	6.36	6.36	6.36	0.80	1.14	± 12.0 %
835	55.2	0.97	6.29	6.29	6.29	0.79	1.16	: ±12.0 %
900	55.0	1.05	6.25	6.25	6.25	0.73	1.03	± 12.0 %
1750	53.4	1.49	5.04	5.04	5.04	0.74	1.29	± 12.0 %
1900	53.3	1.52	4.78	4.78	4.78	0.56	1.52	± 12.0 %
2450	52.7	1.95	4.36	4.36	4.36	0.74	1.11	± 12.0 %

Calibration Parameter Determined in Body Tissue Simulating Media

⁶ Frequency validity 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.
⁶ 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 farget tissue parameters.

Certificate No: ES3-3320_Jun13

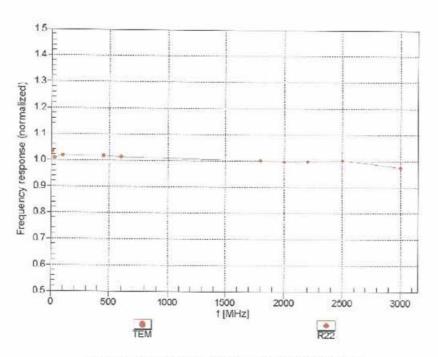
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ES3DV3- SN:3320

June 4, 2013

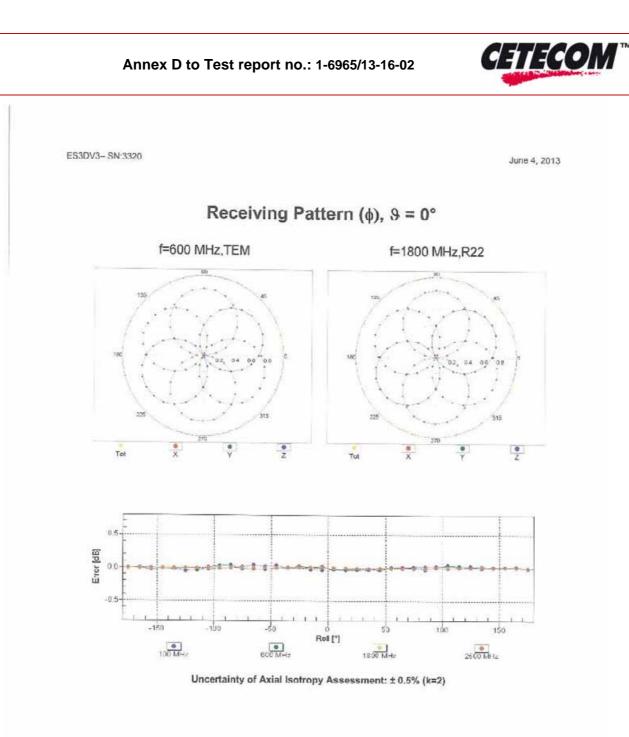
Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)





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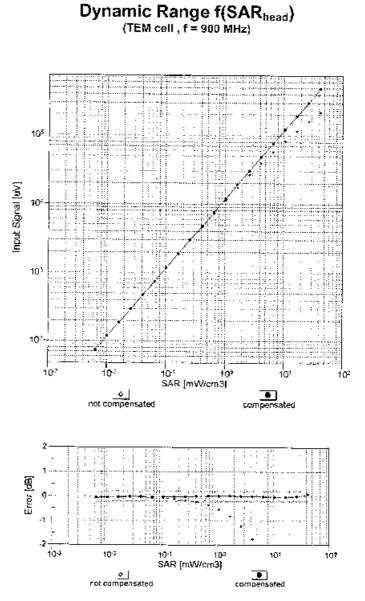
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E\$3DV3- SN:3320

June 4, 2013



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

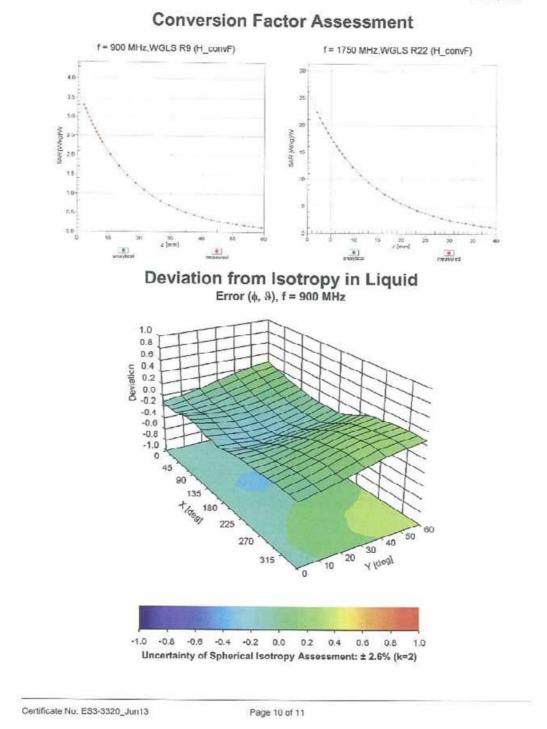
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ES3DV3-SN:3320

June 4, 2013





ES3DV3- \$N:3320

June 4, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3320

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	94.8
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disəbled
Probe Overall Length	337 mm
Probe Body Diameter	
Tip Leng(h	10 mm
Tip Diameter	
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Celibration Point	2.mm
Recommended Measurement Distance from Surface	3 mm

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Calibration Labor Schmid & Partner Engineering AG Zeughausstrasse 43, 8004	and a strengt	SHISS C BARATO S	Schweizerischer Kalibriordi Service suisse d'étalonnage Servizio svizzero di taratura Swisa Calibration Service
	reditation Service (SAS) ervice is one of the signatoric the recognition of calibration	os to the EA	No.: SCS 108
Client Cetecom	San 189 199 299 29	Certificate No	: ES3-3326_Sep13
CALIBRATIO	CERTIFICAT	E	
Object	ES3DV3 - SN:33	326	al Restrictions M
Calibration procedure(s)		QA CAL-23.v5, QA CAL 25.v6 dure for dosimetric E-field probes	
The measurements and the	uncertainties with confidence p	unal standards, which realize the physical unit robability are given on the following pages and	are part of the certificate.
This calibration certificate do The measurements and the All calibrations have been co	cuments the traceability to nati uncertainties with confidence p	onal standards, which realize the physical unit	are part of the certificate.
This calibration certificate do The measurements and the All calibrations have been co	cuments the traceability to nati uncertainties with confidence p inducted in the closed laborato	unal standards, which realize the physical unit robability are given on the following pages and	are part of the certificate.
This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419B	cuments the traceability to nati uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration)	onal standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)°C	are part of the contificate. and humidity < 70%.
This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419B Power sensor E4412A	Currents the traceability to nation uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration) ID QB41293874 MY41498087	onal standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)*C Cal Date (Certificate No.) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733)	and humidity < 70%. Scheduled Calibration Apr-14 Apr-14
This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419B Power sensor E4412A Reference 3 dB Attenuator	Currents the traceability to nation uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration) ID QB41293874 MY41498087 SN: S6064 (3e)	onal standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)*C Cal Date (Certificate No.) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733)	and humidity < 70%. Scheduled Calibration Apr-14 Apr-14 Apr-14
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This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419B Power sensor E4412A Reference 3 dB Attenuator	cuments the traceability to nati uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration) ID GB41293874 MY41498087 SN: S6064 (3e) SN: S5277 (20x) SN: S5129 (30b)	Cal Date (Certificate No.) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01735) 04-Apr-13 (No. 217-01738)	and humidity < 70%. and humidity < 70%. Scheduled Calibration Apr-14 Apr-14 Apr-14 Apr-14 Apr-14 Apr-14
This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419D Power sensor E4412A Rafarance 3 dB Attenuator Reference 20 dB Attenuator	Currents the traceability to nation uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration) ID GB41293874 MY41498087 SN: S6054 (3e) SN: S55277 (20X)	orial standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)*C Cal Date (Certificate No.) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01737) 04-Apr-13 (No. 217-01735)	and humidity < 70%. and humidity < 70%. Scheduled Calibration Apr-14 Apr-14 Apr-14 Apr-14
This calibration certificate do The measurements and the All calibrations have been co Calibration Equipment used Primary Standards Power meter E4419D Power sensor E4412A Reference 3 dB Attenuator Reference 20 dB Attenuator Reference Probe ES3DV2 DAE4	currents the traceability to nati uncertainties with confidence p inducted in the closed laborato (M&TE critical for calibration) ID GB41293874 MY41498087 SN: S60277 (20x) SN: S6129 (30b) SN: S6129 (30b) SN: 560	onal standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)°C Cal Date (Cortificate No.) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01733) 04-Apr-13 (No. 217-01737) 04-Apr-13 (No. 217-01737) 04-Apr-13 (No. 217-01738) 28-Dec-12 (No. 253-3013 Duc12) 31-Jan-13 (No. DAE4-660_Jan13)	and humidity < 70%. Scheduled Calibration Apr-14 Apr-14 Apr-14 Apr-14 Dec-13 Jan-14
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Certificate No: ES3-3326_Sep13

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



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Schweizerischer Kalibrierdienst Service suisse d'étalonnage Servizio svizzero di teratura

Swiss Calibration Service

Accreditation No.: SCS 108

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

Glossary:

tissue simulating liquid
sensitivity in free space
sensitivity in TSL / NORMx.v.z
diode compression paint
crest factor (1/duty_cycle) of the RF signal
modulation dependent linearization parameters
o rotation around probe axis
9 rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis

Calibration is Performed According to the Following Standards:

- 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
- Techniques", December 2003
 IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization 9 = 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 E²-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.

Certificate No: E\$3-3326_Sep13

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ES3DV3 - SN:3326

September 2, 2013

Probe ES3DV3

SN:3326

Manufactured: Calibrated:

January 10, 2012 September 2, 2013

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

Certificate No: ES3-3326_Sep13

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ES3DV3- SN:3326

September 2, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3326

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Une (k=2)
Norm (µV/(V/m) ²)*	1.18	0.93	0.92	± 10.1 %
DCP (mV) ^u	99.9	105.6	96.2	

Modulation Calibration Parameters

DID	Communication System Name	1	A	в	c	D	VR	Uno ^t
	<u> </u>		d₿	dBõV		dB	mν	(k=2)
0		X	Ð.Q	0.0	1.0	0.00	149.2	±2.5 %
<u> </u>	·	ΙΥ	0.0	0.0	1.0		132.5	·
	<u> </u>	ļZ	0.0	<u>0.a</u>	1.0	-	174.1	

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%.

* The uncertainties of NormX,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6). ⁿ Numerical linearization parameter: uncertainty not required. ^E Uncertainty is determined using the max-doviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Certificate No: ES3-3326_Sep13

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ES3DV3- \$N:3326

September 2, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3326

f (MHz) ^c	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF 2	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	6.48	6,48	6.48	0.33	1.77	± 12.0 %
835	41.5	0.90	6.25	6.25	6.25	0.32	1.77	± 12.0 %
900	<u>4</u> 1.5	0.97	6.08	6.08	6.08	0.37	1.68	± 12.0 %
1750	40.1	1.37	5.40	5.40	5.40	0.56	1.38	± 12.0 %
1900	40 <u>.</u> 0	1.40	5,05	5.05	<u>5.05</u>	0.59	1.35	± 12.0 %
2450	39.2	1.80	4.47	4.47	4.47	0.75	1.35	± 12.0 %

Calibration Parameter Determined in Head Tissue Simulating Media

^G Frequency validity of ± 100 MHz only applies for DASY v6.4 and higher (see Page 2), olse it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvE uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
⁷ At frequencies below 3 GHz, the validity of tissue parameters (*c* and *σ*) can be relaxed to ± 10% if figuid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (*c* and *σ*) is restricted to ± 5%. The uncertainty is the RSS of the ConvE uncertainty for indicated target tissue parameters.

Certificale No: E\$3-3326_Sep13

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ES3DV3-- SN:3326

September 2, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3326

f (MHz) ^c	Relative Permittivity ^F	Conductivity (\$/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	6.12	6.12	<u>6.1</u> 2	0.80	1.19	<u>± 12.0 %</u>
835	55.2	0.97	6,04	6.04	6.04	0.59	1.39	± 12.0 %
900	55.0	1.05	5.9 6	5.96	5.96	<u>0.6</u> 4 j	1.34	± 12.0 %
1750	53,4	1,49	4.85	4.85	4.85	0.60	1.41	± 12.0 %
1900	53.3	1.52	4.65	4.65	4.65	0.46	1.75	± 12.0 %
2450	52.7	1,95	4.18	4.18	4.18	0.67	1,19	± 12.0 %

Calibration Parameter Determined in Body Tissue Simulating Media

⁶ Frequency validity 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.
⁷ At frequencies below 3 GHz, the validity of issue 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 frequency band.

Certificate No: ES3-3325_Sep13

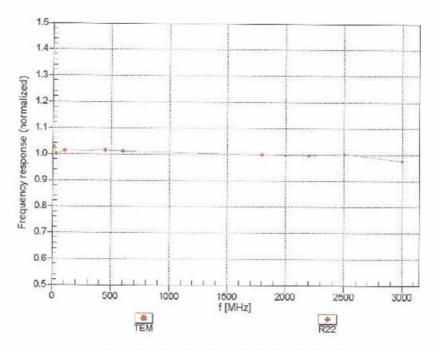
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ES3DV3-SN:3326

September 2, 2013

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





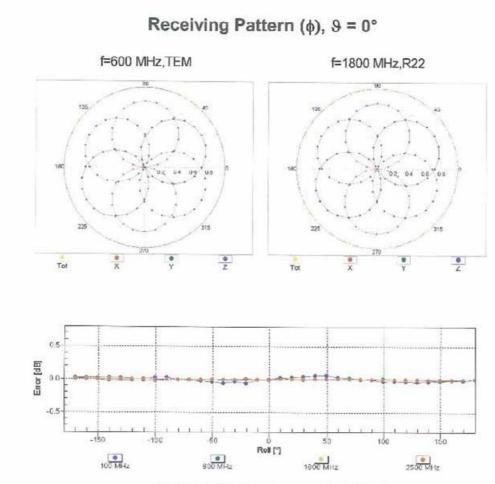
Certificate No: ES3-3326_Sep13

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ES3DV3-- SN:3326

September 2, 2013



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

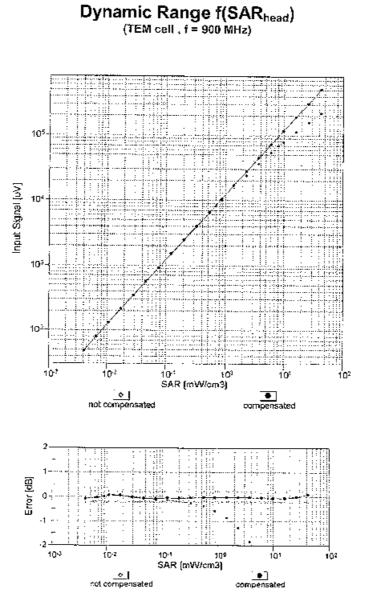
Certificate No: ES3-3326_Sep13

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E53DV3-- SN:3326

September 2, 2013

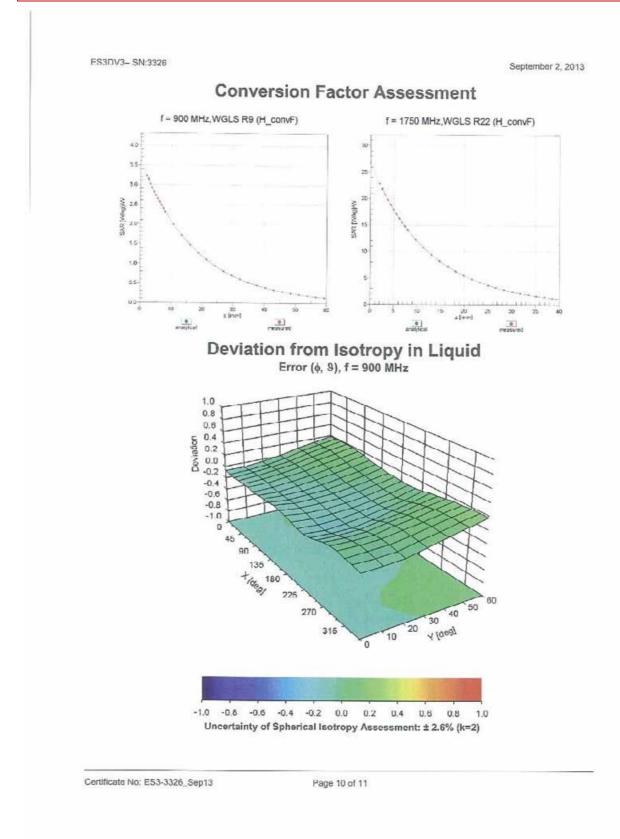


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Certificate No: ES3-3326_Sep13

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ES3DV3-- SN:3326

September 2, 2013

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3326

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (*)	-50.6
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	
Probe Body Diameter	
Tip Length	
Tip Diameter	
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	j 3 mm

Certificate No: ES3-3326_Sep13

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4 Calibration report "Probe EX3DV4"

Engineering AG	ory of		Schweizerischer Kalibrierdier Service suisse d'étalonnage Servizio svizzero di taratura
Zeughausstrasse 43, 8004 Zur	rich, Switzerland	Mandalahahaha CORAT	Swiss Calibration Service
Accredited by the Swiss Accred The Swiss Accreditation Servi Multilateral Agreement for the	Ice is one of the signatorie	es to the EA	No.: SCS 108
Client Cetecom			EX3-3944_Aug13
CALIBRATION	CERTIFICAT	E	
Object	EX3DV4 - SN:39	344	teo di menere la
Calibration procedure(s)		QA CAL-14.v3, QA CAL-23.v4, QA edure for dosimetric E-field probes	CAL-25.v4
Colibration date:	August 2, 2013	Stern IN BOAR MARGARIA	1 - 0 11
The measurements and the und All calibrations have been cond	certainties with confidence p ucted in the closed laborato	ional standards, which realize the physical units robability are given on the following pages and ry facility: environment temperature $(22 \pm 3)^{\circ}$ C i	are part of the certificato.
The measurements and the uno	certainties with confidence p ucted in the closed laborato	robability are given on the following pages and	are part of the certificato.
The measurements and the und All calibrations have been cond	certainties with confidence p ucted in the closed laborato	robability are given on the following pages and	are part of the certificato.
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The measurements and the und All calibrations have been cond Calibration Equipment used (Ma Primary Standards	entainties with confidence p ucted in the closed laborato &TE critical for calibration)	robability are given on the following pages and ry facility: environment temperature (22 ± 3)°C i Cal Date (Certificate No.)	are part of the certificato. and humidity < 70%. Scheduled Calibration
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Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



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Schweizerischer Kalibrlerdienst s Service suisse d'étalonnage С Servizio svizzero di taratora s Swiss Calibration Service

Accreditation No.: SCS 108

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

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMX, v.z
DCP	diade compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization ϕ	or rotation around probe axis
Polarization 9	9 rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., 9 = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2003, TEEE 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

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization 9 = 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^z-field uncertainty inside TSL (see below ConvF).
- NORM(f)x,y,z = NORMx,y,z * Irequency_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,

Certificate No: EX3-3944, Aug13

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EX3DV4 - SN:3944

August 2, 2013

Probe EX3DV4

SN:3944

Manufactured: Calibrated:

May 2, 2013 August 2, 2013

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

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EX3DV4- SN;3944

August 2, 2013

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3944

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm_(µV/(Wm) ²) ^A	0.56	0.63	0.43	± 10.1 %
DCP (mV) ^e	99.5	98.2	99.3	

Modulation Calibration Parameters

GIU	Communication System Name		A dB	B dBõV	°.	l D dB	VR mV	Unc [⊭] (k≕2)
0	CW	X	0.0	0.0	1.0	0.00	132.3	±2.7 %
		Y.	0.0	0.0	10		134.7	
1		2	0.0	0.0	1.0		154.8	

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%.

⁴ The uncertainties of NormX,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6). ⁶ Numerical linearization parameter, uncertainty not required. ⁶ Uncertainty is determined using the max, deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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EX3DV4- \$N:3944

August 2, 2013

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3944

f (MHz) ^c	Relative Permitlivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (ភាពា)	Unct. (k=2)
2600	39.0	1.96	7.43	7.43	7.43	0.52	<u>0,</u> 71	± 12.0 %
3500	37.9	2.91	7.35	7.35	7.35	1.00	0.46	± 13.1 %
5200	36.0	4.66	5.37	5.37	5.37	0.30	1.80	± 13.1 %
5 <u>3</u> 00	35.9	4.76	5.22	5.22	5.22	0.28	1.80	± 13.1 %
5500 j	35.6	4.96	5.00	5.00	5,00	0.31	1.80	±13.1%
5600	35.5	5.07	4.88	4.98	4.88	0.26	1.80	± 13.1 %
5800	35.3	5.27	4.75	4.75	4.75	0.36	1.80	± 13.1 %

Calibration Parameter Determined in Head Tissue Simulating Media

⁶ Frequency validity of ± 100 MHz only applies for OASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvE uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
⁶ At frequencies below 3 GHz, the validity of tissue parameters (r, and e) 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 (r, and e) 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 (r, and e) can be relaxed to ± 5%. The uncertainty is the RSS of the ConvE uncertainty for indicated target tissue parameters.

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EX3DV4- SN:3944

August 2, 2013

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3944

f(MHz) ^c	Relative Permittivity ^F	Conductivity (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
2600	52.5	2.16	7.27	7.27	7.27	0.60	0.50	± 12.0 %
3500	51.3	3.31	6.94	6.94	6.94	1.00	0.51	± 13.1 %
5200	49.0	5.30	4.47	4.47	4.47	0.42 j	1.90	<u>±1</u> 3.1 %
5300	48.9	5.42	4.30	4.30	4.30	0.43	1.90	± 13.1 %
5500	48.6	5.65	4.09	4.09	4.09	0.46	1.90	± 13.1%
5600	48.5	5.77	4,33	4.33	4.33	0.32	1.90	± 13.1 %
5 80 0	48.2	6.00	4.20	4.20	4.20	0.46	1.90	±13.1%

Calibration Parameter Determined in Body Tissue Simulating Media

⁶ Frequency validity 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 ConvE uncertainty at calibration frequency and the uncertainty for the indicated frequency bond.
⁶ At frequencies below 3 GHz, the validity of tissue parameters (c and c) can be relaxed to ± 10% if fliquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (c and c) is restricted to ± 5%. The uncertainty is the RSS of the ConvE uncertainty for indicated target tissue parameters.

Certificate No: EX3-3944_Aug13

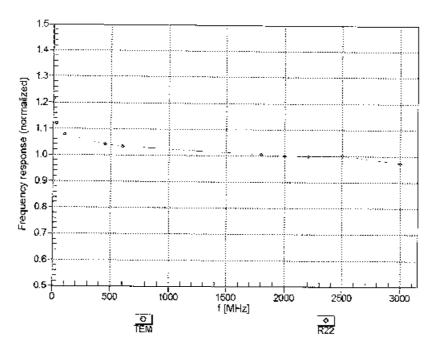
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EX3DV4- SN:3944

August 2, 2013

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



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

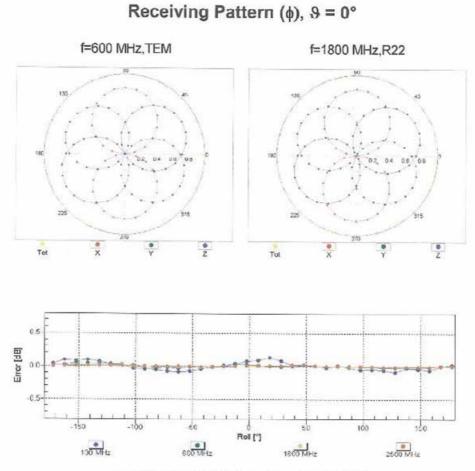
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EX3DV4- SN:3944

August 2, 2013



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

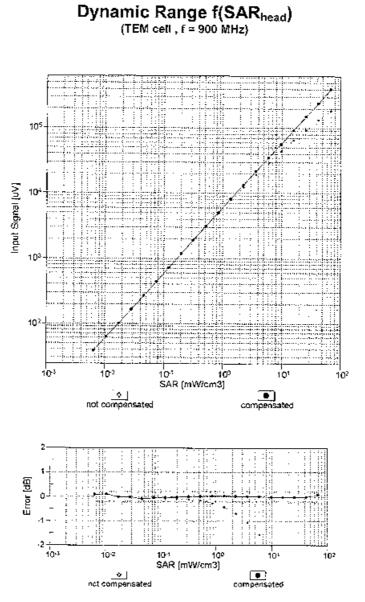
Certificate No: EX3-3944_Aug13

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EX3DV4- \$N:3944

August 2, 2013



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

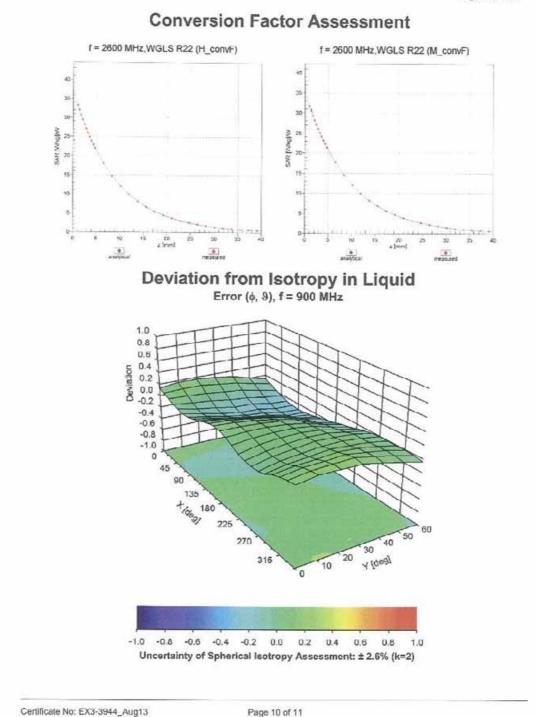
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EX3DV4_ SN:3944

August 2, 2013





EX3DV4-- SN:3944

August 2, 2013

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3944

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-2.3
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 ოო
Probe Tip to Sensor Y Calibration Point	
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	2 mm

Certificate No: EX3-3944_Aug13

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5 Calibration report "750 MHz System validation dipole"

Engineering AG Zeughausstracse 43, 8004 Zurid	ry of ch, Switzerland	HACEMEA CONSTRACTOR	S Schweizerischer Kalibrierdiene: Service suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service
Accredited by the Swiss Accredit The Swiss Accreditation Servic Multilateral Agreement for the r	e is one of the algnatori	es to the EA	ion No.: SCS 108
Client Cetecom		PERSONAL PER	No: D750V3-1041_Aug13
CALIBRATION O	ERTIFICATI	ENCONTRACT	
Object	D750V3 - SN: 10	041	
Calibration procodure(s)	QA CAL-05.v9 Calibration proce	edure for dipolo validation kits a	bove 700 MHz
Calibration date:	August 15, 2013		
The measurements and the unce	rtaintics with confidence p	ional standards, which realize the physical robability are given on the following pages ry facility, environment temperature (22 ± 3	and are part of the centificate.
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M&1	ntaintics with confidence p sted in the closed laborato TE critical for calibration)	robability are given on the following pages ry facility, environment temperature (22 ± 3	and are part of the centificate. I)*C and humidity < 70%,
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M&T Primary Standards	rtaintics with confidence p sted in the closed laborato FE critical for calibration)	robability are given on the following pages ry facility, environment temperature (22 ± 3 Cal Date (Certificate No.)	and are part of the centificate. I)*C and humidity < 70%. Scheduled Calibration
he measurements and the unce all calibrations have been conduct alibration Equipment used (M&1 himary Standards lower meter EPM-142A	ntaintics with confidence p sted in the closed laborato TE critical for calibration)	robability are given on the following pages ry facility, unvironment temperature (22 ± 3 Cal Date (Certificate No.) 01-Nov-12 (No. 217-01640)	and are part of the centificate. 0°C and humidity < 70%. Scheduled Calibration Oct-13
he measurements and the unce all calibrations have been conduct alibration Equipment used (M&1 trimary Standards ower meter EPM-142A ower sensor HP 8481A	rtaintics with confidence p sted in the closed laborato TE critical for calibration) ID # GB37480704	robability are given on the following pages ry facility, environment temperature (22 ± 3 Cal Date (Certificate No.)	and are part of the certificate. 0°C and humidity < 70%. Scheduled Calibration Oct-13 Oct-13
he measurements and the unce alibration Equipment used (M&1 trimary Standards tower meter EPM-142A dower sensor HP 8481A toforence 20 dB Attenuator ype-N mismatch combination	rtaintics with confidence p cted in the closed laborato TE critical for calibration) ID # GB37480704 US37292783	robability are given on the following pages ry facility, environment temperature (22 ± 3 Cal Date (Certificate No.) D1-Nov-12 (No. 217-01640) 01-Nov-12 (No. 217-01640)	and are part of the certificate. 0°C and humidity < 70% Scheduled Calibration Oct-13
The measurements and the unce Calibration Equipment used (M&T Primary Standards Power meter EPM-442A Power sensor HP 8481A Reference 20 dB Attenuator yoe-N mismatch combination Reference Probe ES3DV3	ID * GB3/480/04 US3/292783 SN: 5058 (20k) SN: 5047.3 / 05327 SN: 3205	Cal Date (Certificate No.) 01-Nov-12 (No. 217-01640) 04-Apr-13 (No. 217-01736)	and are part of the certificate. 0°C and humidity < 70% Scheduled Calibration Oct-13 Oct-13 Apr-14
The measurements and the unce Calibration Equipment used (M&T Primary Standards Power meter EPM-H42A Vower sensor HP 8481A Reference 20 dB Attenuator ype-N mismatch combination Reference Probe ES3DV3	ID # GB3/480704 US3/292783 SN: 5058 (20k) SN: 5054 (20 06327	Cal Date (Certificate No.) D1-Nov-12 (No. 217-01640) 04-Apr-13 (No. 217-01736) 04-Apr-13 (No. 217-01739)	and are part of the certificate. 0°C and humidity < 70%. Scheduled Calibration Oct-13 Oct-13 Oct-13 Apr-14 Apr-14
The measurements and the unce All calibrations have been conduct Calibration Equipment used (M&1 Primary Standards Power meter EPM-442A Power sensor HP 8481A Reference 20 dB Attenuator ype-N mismatch combination teterence Probe ES3DV3 IAE4	ID * GB3/480/04 US3/292783 SN: 5058 (20k) SN: 5047.3 / 05327 SN: 3205	Cal Date (Certificate No.) 01-Nov-12 (No. 217-01640) 04-Apr-13 (No. 217-01736)	and are part of the certificate. ()*C and humidity < 70%, Scheduled Calibration Oct-13 Oct-13 Apr-14 Apr-14 Dec-13
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Certificate No: D750V3 1041_Aug13

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Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 43, 6004 Zurich, Switzerland



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Schweizerischer Kalibrierdienst Scrvice suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service

Accreditation No.: SCS 108

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

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) 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%.

Certilicate No: D750V3-1041_Aug13

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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	15 mm	with Spacer
Zoom Scan Resolution	dx, dy , $dz = 5 mm$	
Frequency	750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.7±6%	0.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.52 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ² (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 250 mW input power	1.40 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.5 ± 6 %	0.98 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.75 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition 250 mW input power	1.47 W/kg

Certificate No: D750V3-1041_Aug13



Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.9 Ω - 2.6 jΩ
Return Loss	- 26.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.8 Ω - 4.2 jΩ
Return Loss	- 27.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.007 ==
Electrical Berry (one direction)	1.007 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 antanna 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 toaded 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	July 28, 2011

Certificate No: D750V3-1041_Aug13

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DASY5 Validation Report for Head TSL

Date: 15.08.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1041

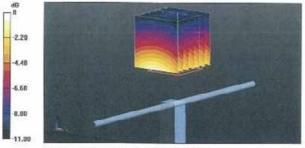
Communication System: UID 0 - CW ; Frequency: 750 MHz Medium parameters used; f = 750 MHz; σ = 0.9 S/m; ϵ_r = 41.7; p = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(6.28, 6.28, 6.28); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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

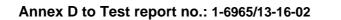
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 53.053 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 3.27 W/kg SAR(1 g) = 2.15 W/kg; SAR(10 g) = 1.4 W/kg Maximum value of SAR (measured) = 2.50 W/kg



0 dB = 2.50 W/kg = 3.98 dBW/kg

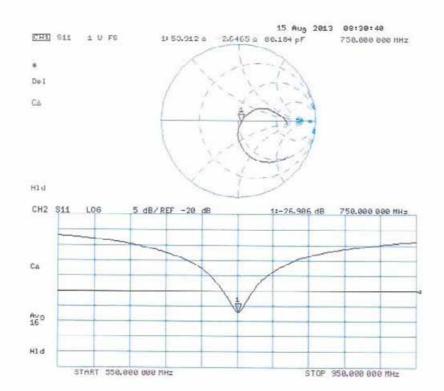
Certificate No: D750V3-1041_Aug13

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Impedance Measurement Plot for Head TSL



Certificate No: D750V3-1041_Aug13

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DASY5 Validation Report for Body TSL

Date: 14.08.2013

Test Laboratory: SPEAG, Zurich, Switzerland

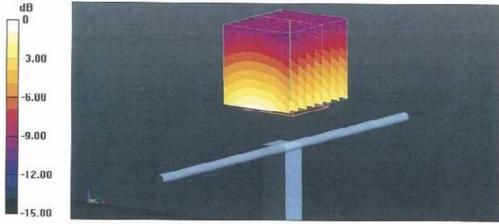
DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1041

Communication System: UID 0 - CW ; Frequency: 750 MHz Medium parameters used: f = 750 MHz; σ = 0.98 S/m; ϵ_r = 54.5; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(6.11, 6.11, 6.11); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 53.053 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 3.25 W/kg SAR(1 g) = 2.23 W/kg; SAR(10 g) = 1.47 W/kg Maximum value of SAR (measured) = 2.59 W/kg



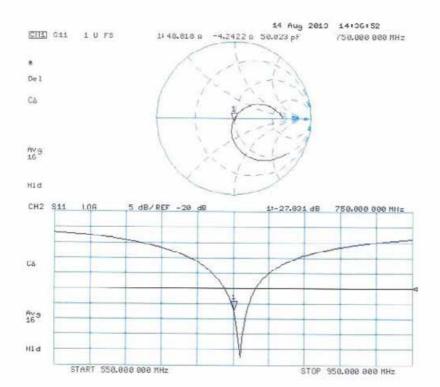
0 dB = 2.59 W/kg = 4.13 dBW/kg

Certificate No: D750V3-1041 Aug13

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Impedance Measurement Plot for Body TSL



Certificate No: D750V3-1041_Aug13

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6 Calibration report "835 MHz System validation dipole"

Engineering AG Zeughausstrasse 43, 8004 Zuric	h, Switzerland	HAC MRA (C U Z)	Schweizerischer Kalibrierdien Service suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service
Accredited by the Swiss Accredit The Swiss Accreditation Sarvic Multilateral Agreement for the r	e is one of the signatorie	es to the EA	on No.: SCS 108
Client Cetecom		Certificate	No: D835V2-4d153_Jun13
CALIBRATION C	CERTIFICATE		
Object	D835V2 - SN: 4d	1153	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits at	oove 700 MHz
Calibration date:	June 06, 2013		
The measurements and the unce	rtainties with confidence p	innal standards, which realize the physical σ robability are given on the following pages in ry facility; environment temperature (22 \pm 3)	and are part of the certificate.
The measurements and the unco All calibrations have been conduc Calibration Equipment used (M&7	rtainties with confidence p sted in the closed laborator TE critical for calibration)	robability are given on the following pages : ny facility: environment temperature (22 ± 3)	and are part of the certificate. °C and humidity < 70%,
The measurements and the unco All calibrations have been conduc Calibration Equipment used (M&T Primary Standards	rtainties with confidence p sted in the closed laborator TE critical for calibration)	robability are given on the following pages in ny facility: environment temperature (22 ± 3) Cal Date (Certificate No.)	and are part of the certificate. *C and humidity < 70%, Scheduled Calibration
The measurements and the unco All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter EPM-442A	International Statement (International Statement Stateme	Cal Data (Certificate No.) 01-Nov-12 (No. 217-01640)	and are part of the certificate. "C and humidity < 70%, Scheduled Calibration Oct-13
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Certificate No: D835V2-4d153_Jun13

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



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Schweizerischer Kallbrierdienst Service suisse d'étalonnage Servizio suizzero di taratura Swiss Calibration Service

Accreditation No.: SCS 108

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

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%.

Certificate No: D835V2-4d153, Jun13



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	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dix, dy, oʻz = 5 mm	· · · · -
Frequency	835 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.4 ± 6 %	0.94 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.58 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 250 mW input power	1.60 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.5 ± 6 %	1.00 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.41 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.40 W/kg ± 17.0 % (k=2)
······		• • • • • • •
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ² (10 g) of Body TSL SAR measured	condition 250 mW input power	1.56 W/kg

Certificate No: D835V2-4d153_Jun13



Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.0 Ω - 2.7 jΩ
Return Loss	- 29.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.5 Ω - 4.3 ϳΩ
Return Loss	- 25.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.432 ns
,	1.102.03

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 and caps are added to the dipole arms in order to improve matching when toaded 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 28, 2012

Certificate No: D835V2-4d153 Jun13

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DASY5 Validation Report for Head TSL

Date: 06.06.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d153

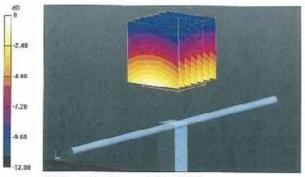
Communication System: UID 0 - CW ; Frequency: 835 MHz Medium parameters used: f = 835 MHz; $\sigma = 0.94$ S/m; $\epsilon_r = 40.4$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(6.05, 6.05, 6.05); Calibrated: 28.12.2012;
- Sensor Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.262 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 3.78 W/kg SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.6 W/kg Maximum value of SAR (measured) = 2.92 W/kg



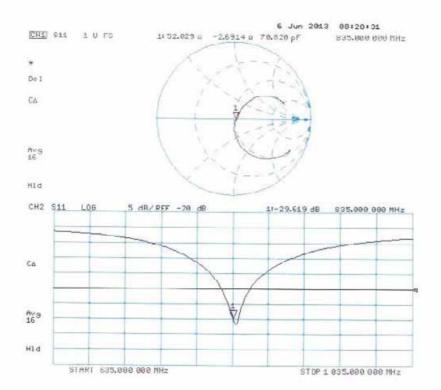
0 dB = 2.92 W/kg = 4.65 dBW/kg

Certificate No: D835V2-4d153_Jun13

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Impedance Measurement Plot for Head TSL



Certificate No: D835V2-4d153_Jun13

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DASY5 Validation Report for Body TSL

Date: 05.06.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d153

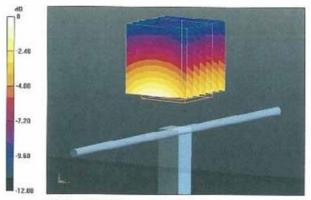
Communication System: UID 0 - CW ; Frequency: 835 MHz Medium parameters used: f = 835 MHz, $\sigma = 1$ S/m; $\epsilon_r = 54.5$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(6.04, 6.04, 6.04); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.6(1115); SEMCAD X 14.6.9(7117)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 54.892 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 3.59 W/kg SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.56 W/kg Maximum value of SAR (measured) = 2.81 W/kg



0 dB = 2.81 W/kg = 4.49 dBW/kg

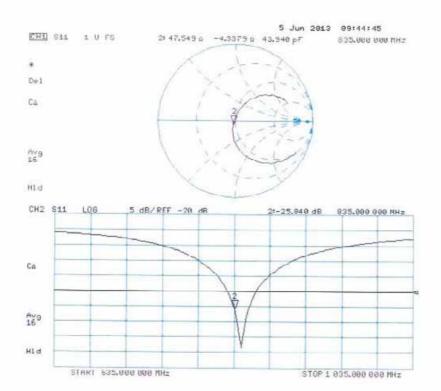
Certificate No: D835V2-4d153_Jun13

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Impedance Measurement Plot for Body TSL



Certificate No: D835V2-4d153_Jun13

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7 Calibration report "1900 MHz System validation dipole"

	12	Welahahaha ORA	Servizio svizzero di teratura Swiss Calibration Service
Accredited by the Swiss Accredit The Swiss Accreditation Servic Multilateral Agreement for the r	e is one of the signatorie	es to the EA	n No.: SCS 108
Client Cetecom	an Chingle and	Certificate N	u: D1900V2-5d009_May
CALIBRATION O	CERTIFICATE		
Object	D1900V2 - SN: 5	6009	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits ab	ove 700 MHz
Calibration date:	May 15, 2013		
The measurements and the unce All calibrations have been conduc	artainties with confidence p	ional standards, which realize the physical un robability are given on the following pages an ry facility: environment temperature (22 ± 3) ⁴	nd are part of the certificate.
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The measurements and the unce All calibrations have been conduc	Initialinties with contidence p cted in the closed laborato TE critical for calibration) ID # GB37480704 US37282703 SN: 5058 (20k) SN:	robability are given on the following pages ar ty facility: environment temperature (22 ± 3)* Cal Date (Certificate No.) 01-Nov-12 (No. 217-01640) 04-Apr-13 (No. 217-01736) 04-Apr-13 (No. 217-01736) 04-Apr-13 (No. 217-01739) 28-Dec-12 (No. ES3-3205_Dec12) 25-Apr-13 (No. DAE4-601_Apr13) Check Date (in house) 18-Oct-02 (in house check Oct-11) 04-Aug-99 (in house check Oct-11) 18-Oct-01 (in house check Oct-12) Function	nd are part of the certificate. C and humidity < 70%. <u>Scheduled Calibration</u> Oct-13 Oct-13 Apr-14 Apr-14 Dec-13 Apr-14 <u>Scheduled Check</u> In house check: Oct-13 In house check: Oct-13 In house check: Oct-13



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



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Schweizerischer Kallbrierdienst Service suisse d'étatonnage

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Swiss Calibration Service

Accreditation No.: SCS 108

Accredited by the Swiss Accreditation Service (SAS)

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

Glossary:

TŞL	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%.

Certificate No: D1900V2-5d009_May13

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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	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy. dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	•••• •••••••••••••••••••••••••••••••••

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.3 ± 6 %	1.35 mbo/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	9.85 W/kg
SAR for nominal Read TSL parameters	normalized to 1W	40.1 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition 250 mW input power	5.18 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.6 ± 6 %	1.49 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	10.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.9 W/kg ± 17.0 % (k=2)
	·	
SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition 250 mW input power	5.38 W/kg

Certificate No: D1900V2-5d009_May13



Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.2 Ω + 2.1 jΩ
Return Loss	- 32.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.8 Ω + 3.2 jΩ
Return Loss	- 26.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction) 1,188 ns			
	1, 1 88 ns		Electrical Delay (one direction)

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

Manulactured by	SPEAG
Manufactured on	February 22, 2002

Certificate No: D1900V2-5d009_May13

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DASY5 Validation Report for Head TSL

Date: 15.05.2013

Test Laboratory: SPEAG, Zurich, Switzerland

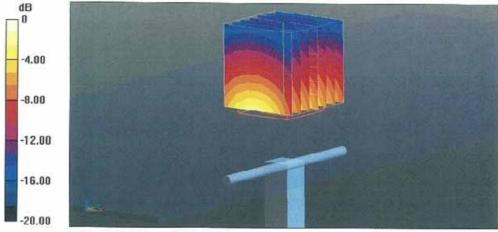
DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d009

Communication System: UID 0 - CW ; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.35$ S/m; $\varepsilon_r = 39.3$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(4.98, 4.98, 4.98); 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 52.8.6(1115); SEMCAD X 14.6.9(7117)

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 = 96.587 V/m; Power Drift = 0.06 dB Peak SAR (extrapolated) = 17.9 W/kg SAR(1 g) = 9.85 W/kg; SAR(10 g) = 5.18 W/kg Maximum value of SAR (measured) = 12.2 W/kg



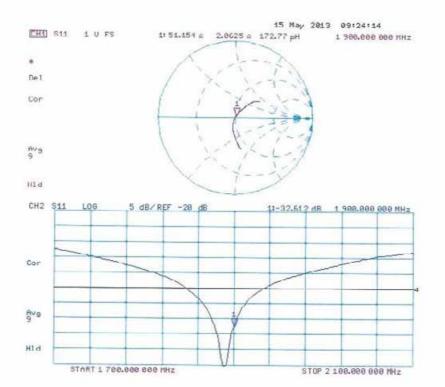
0 dB = 12.2 W/kg = 10.86 dBW/kg

Certificate No: D1900V2-5d009_May13

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Impedance Measurement Plot for Head TSL



Certificate No: D1900V2-5d009_May13

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Date: 15.05.2013

DASY5 Validation Report for Body TSL

Test Laboratory: SPEAG, Zurich, Switzerland

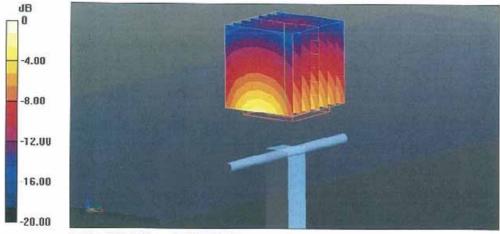
DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d009

Communication System: UID 0 - CW ; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.49$ S/m; $\varepsilon_r = 53.6$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(4.6, 4.6, 4.6); 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 52.8.6(1115); SEMCAD X 14.6.9(7117)

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 = 96.587 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 17.2 W/kg SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.38 W/kg Maximum value of SAR (measured) = 12.7 W/kg



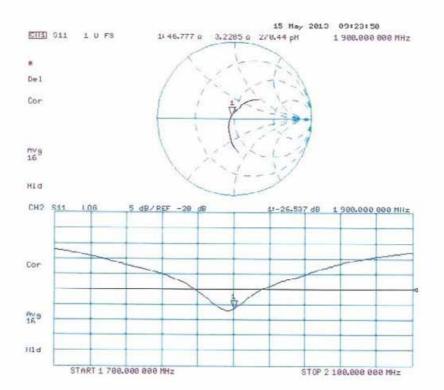
0 dB = 12.7 W/kg = 11.04 dBW/kg

Certificate No: D1900V2-5d009_May13

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Impedance Measurement Plot for Body TSL



Certificate No: D1900V2-5d009_May13

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Calibration Laborator Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zuric	-20.004	Hac MRA	Service suisse d'étalonnag Servizio avizzoro di torotur
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Client Cetecom			o: D2450V2-710_Aug
CALIBRATION C	ERTIFICATE		
Object	D2450V2 - SN: 7	10	
Calibration procedure(s)	QA CAL-05.v8 Calibration proce	dure for dipole validation kits ab	ove 700 MHz
Calibration date:	August 13, 2012		
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Calibration Laboratory of Schmid & Partner Engineering AG Zeughausstrasse 49, 8004 Zurich, Switzorland



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Accreditation No.: SCS 108

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

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%.

Certificate No: D2450V2-710_Aug12

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Measurement Conditions

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

DASY Version	DASY5	V52.8.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, olz ≃ 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	39.2 ± 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	12.9 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	51.5 mW /g ± 17.0 % (k=2)
	1	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.01 mW / g
	1	

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	51.3 ± 6 %	1.99 mbo/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	13.0 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	$51.2 \text{ mW} / \text{g} \pm 17.0 \% (\text{k}=2)$
· · · · · · · · · · · · · · · · · · ·		
	· · · · · · · · · · · · · · · · · · ·	
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ² (10 g) of Body TSL SAR measured	condition 250 mW input power	6.03 mW / g

Certificato No: D2450V2-710_Aug12



Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.4 Ω + 0.5 jΩ
Return Loss	- 32.3 d8

Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 Ω + 2.7 jΩ
Return Loss	- 31.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the leeding 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 tength 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	July 05, 2002

Certificate No: D2450V2-710_Aug12

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Antenna Parameters with Head TSL

	From cal. data		Measured	2013-08-13
Impedance; transformed to feed point	52.4 Ω	+0.5 jΩ	51.1 Ω	+4.0 jΩ
Return Loss	-32.3	dB	-28.1	dB

Antenna Parameters with Body TSL

	From c	From cal. data		2013-08-13
Impedance; transformed to feed point	49.6 Ω	+2.7 jΩ	53.7 Ω	+4.4 jΩ
Return Loss	-31.4	dB	-24.2	dB



DASY5 Validation Report for Head TSL

Date: 13.08.2012

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 710

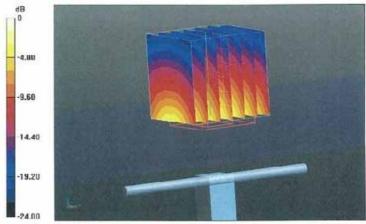
Communication System: CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; σ = 1.81 mho/m; e_r = 39.2; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(4.45, 4.45, 4.45); Calibrated: 30.12.2011;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- · Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.2(969); SEMCAD X 14.6.6(6824)

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 = 99.363 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 26.515 mW/g SAR(1 g) = 12.9 mW/g; SAR(10 g) = 6.01 mW/g Maximum value of SAR (measured) = 16.6 W/kg



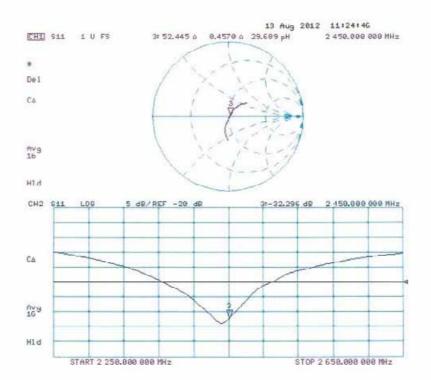
0 dB = 16.6 W/kg = 24.40 dB W/kg

Certificate No: D2450V2-710_Aug12

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Impedance Measurement Plot for Head TSL



Certificate No: D2450V2-710_Aug12

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DASY5 Validation Report for Body TSL

Date: 13.08.2012

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 710

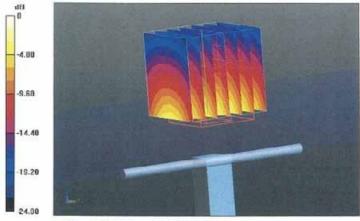
Communication System: CW; Frequency: 2450 MHz Mcdium parameters used: f = 2450 MHz; $\sigma = 1.99$ mho/m; $\epsilon_r = 51.3$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 SN3205; ConvF(4.26, 4.26, 4.26); Calibrated: 30.12.2011;
- Sensor Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.06.2012
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.2(969); SEMCAD X 14.6.6(6824)

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 = 95.331 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 26.640 mW/g SAR(1 g) = 13 mW/g; SAR(10 g) = 6.03 mW/g Maximum value of SAR (measured) = 16.9 W/kg



0 dB = 16.9 W/kg = 24.56 dB W/kg

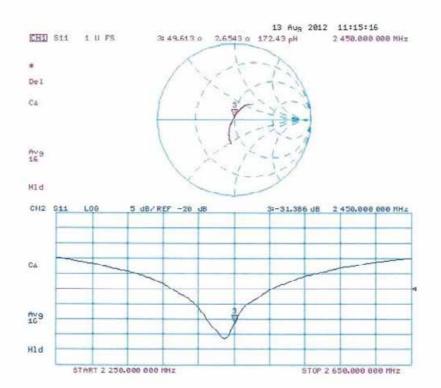
Certificate No: D2450V2-710_Aug12

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Impedance Measurement Plot for Body TSL



Certificate No: D2450V2-710_Aug12

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CALIBRATION	CERTIFICATI		
Object	D5GHzV2 - SN:	1055	
Calibration procedure(s)	QA CAL-22.v2		
	Calibration proce	edure for dipole validation kits t	between 3-6 GHz
	August 19, 2013		
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Calibration Laboratory of Schmid & Partner Engineering AG Zoughausstrasse 43, 8004 Zurich, Switzerland



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Swiss Calibration Service

Accreditation No.: SCS 108

Accreduted by the Swiss Accreditation Service (SAS)

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

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

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%.

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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 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 5500 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	35.0 ± 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	8.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 100 mW input power	2.32 W/kg

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	4.98 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.6 ± 6 %	4.80 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	8.55 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.9 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg ± 19.5 % (k=2)

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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	34.2 ± 6 %	5.11 mbo/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	8.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.1 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)

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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	48.5 ± 6 %	5.43 mbo/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	7.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.2 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition	2.08 W/kg

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 mbo/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.0 ± 6 %	5.83 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	7.80 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.7 W/kg ± 19.5 % (k∞2)

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Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

<u> </u>	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	47.5±6%	6.25 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	7.34 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.3 W/kg ± 19.9 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition 100 mW input power	2.03 W/kg

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Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.8 Ω ~ 7.0 jΩ
Return Loss	- 23.1 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	54,4 Ω - 3.8 jΩ
Return Loss	- 25.0 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	57.1 Ω - 3.9 ϳΩ
Return Loss	- 22.4 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51,3 Ω - 5.4 jΩ
Return Loss	- 25.3 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to leed point	55.2 Ω - 1.3 jΩ
Return Loss	~ 25.9 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	59.6 Ω - 3.2 jΩ
Return Loss	- 20.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.204 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	June 09, 2006

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DASY5 Validation Report for Head TSL

Date: 16.08.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1055

Communication System: UID 0 - CW ; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz

Medium parameters used: f = 5200 MHz; $\sigma = 4.5 \text{ S/m}$; $\varepsilon_r = 35$; $\rho = 1000 \text{ kg/m}^3$, Medium parameters used: f = 5500 MHz; $\sigma = 4.8 \text{ S/m}$; $\varepsilon_r = 34.6$; $\rho = 1000 \text{ kg/m}^3$. Medium parameters used: f = 5800 MHz; $\sigma = 5.11 \text{ S/m}$; $\varepsilon_r = 34.2$; $\rho = 1000 \text{ kg/m}^3$ 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(4.91, 4.91, 4.91); 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 52.8.7(1137); SEMCAD X 14.6.10(7164)

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=1.4mmReference Value = 64.445 V/m; Power Drift = 0.06 dB Peak SAR (extrapolated) = 29.5 W/kg SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.32 W/kg Maximum value of SAR (measured) = 18.7 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 = 64.617 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 32.9 W/kg SAR(1 g) = 8.55 W/kg; SAR(10 g) = 2.45 W/kg Maximum value of SAR (measured) = 20.2 W/kg

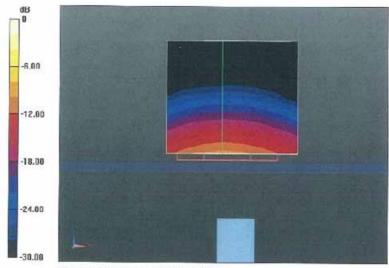
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 61.447 V/m; Power Drift = 0.08 dBPeak SAR (extrapolated) = 33.1 W/kgSAR(1 g) = 8.07 W/kg; SAR(10 g) = 2.29 W/kgMaximum value of SAR (measured) = 19.7 W/kg

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0 dB = 19.7 W/kg = 12.94 dBW/kg

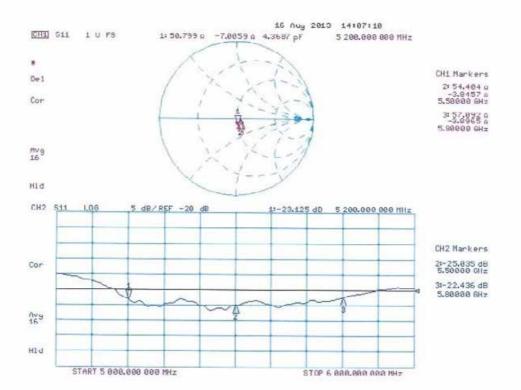
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Annex D to Test report no.: 1-6965/13-16-02



Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 19.08.2013

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1055

Communication System: UID 0 - CW ; Frequency: 5200 MHz, Frequency: 5500 MHz, Frequency: 5800 MHz

Medium parameters used: f = 5200 MHz; $\sigma = 5.43$ S/m; $\varepsilon_r = 48.5$; $\rho = 1000$ kg/m³, Medium parameters used: f = 5500 MHz; σ = 5.83 S/m; ϵ_r = 48; ρ = 1000 kg/m³. Medium parameters used: f = 5800 MHz; σ = 6.25 S/m; $\varepsilon_r = 47.5$; $\rho = 1000 \text{ kg/m}^3$ 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(4.43, 4.43, 4.43); 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 52.8.7(1137); SEMCAD X 14.6.10(7164).

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,

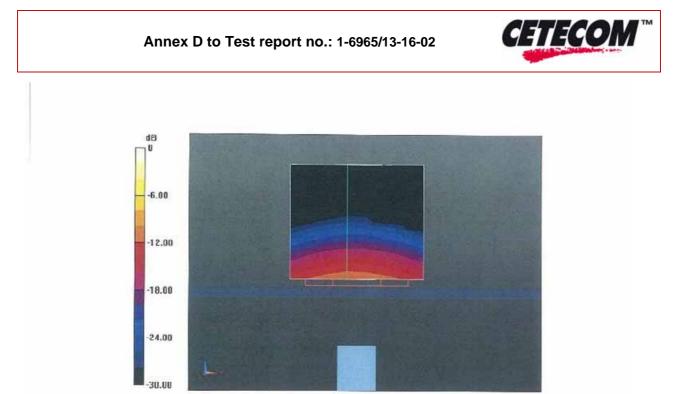
dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 58.885 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.08 W/kgMaximum value of SAR (measured) = 17.2 W/kg

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 = 58.418 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 33.1 W/kg SAR(1 g) = 7.8 W/kg; SAR(10 g) = 2.17 W/kgMaximum value of SAR (measured) = 18.7 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 = 54.883 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 33.7 W/kgSAR(1 g) = 7.34 W/kg; SAR(10 g) = 2.03 W/kgMaximum value of SAR (measured) = 17.9 W/kg

Certificate No: D5GHzV2-1055_Aug13

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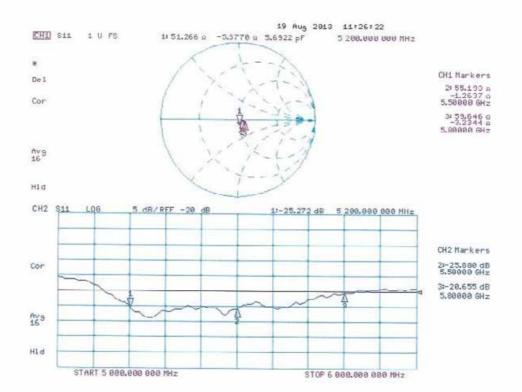


0 dB = 17.9 W/kg = 12.53 dBW/kg

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Impedance Measurement Plot for Body TSL



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10 Calibration certificate of Data Acquisition Unit (DAE)

	h, Switzerland	RORATO S	Servizio svizzero di taratura Swiss Calibration Service
Accredited by the Swiss Accredita fhe Swiss Accreditation Servic Multilateral Agreement for the n	e is one of the signatories	to the EA	on No.: SCS 108
Client Cetecom		Certificate I	No: DAE3-413_Jan14
CALIBRATION O	CERTIFICATE		
Object	DAE3 - SD 000 D	03 AA - SN: 413	
Calibration procedure(s)	QA CAL-06.v26 Calibration proces	dure for the data acquisition ele	actronics (DAE)
Calibration date:	January 16, 2014		and a second second
The measurements and the unce	rtainties with confidence pro	anal standards, which realize the physical u obability are given on the following pages i i facility: environment temperature (22 ± 3)	and are part of the certificate.
The measurements and the unce All calibrations have been conduc Calibration Equipment used (M&1	rtainties with confidence pro	obability are given on the following pages	and are part of the certificate.
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11 Calibration certificate of Data Acquisition Unit (DAE)

The Swiss Accreditation Service Multilateral Agreement for the	tation Service (SAS)		No.: SCS 108
55			
Client Cetecom		Certificate No:	DAE4-1387_Aug13
CALIBRATION	CERTIFICATE		
Object	DAE4 - SD 000 D	04 BM - SN: 1387	
Calibration procedure(s)	QA CAL-06.v26 Calibration proces	durc for the data acquisition elect	ronics (DAE)
Calibration date:	August 28, 2013		
This calibration certificate docum The measurements and the unc All calibrations have been condu	ertainties with confidence pro	onal standards, which realize the physical unit obability are given on the following pages and / facility: environment temperature (22 ± 3)°C	are part of the certificate.
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12 Certificate of "SAM Twin Phantom V4.0/V4.0C"

Schmid & Partner Engineering AG

Zeugheusstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

Certificate of conformity / First Article Inspection

ltem	SAM Twin Phantom V4.0
Type No	QD 000 P40 BA
Series No	TP-1002 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	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 llquids defined in the standards	Liquid type HSL 1800 and others according to the standard.	Pre-series, First article

Standards

- [1] CENELEC EN 50361
- [2] IEEE P1528-200x draft 6.5
- (3) IEC PT 62209 draft 0.9
- (*) The ITIS 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 18.11.2001 Schmid & Partner Fin Brudielt Signature / Stamp Engineering AG Zeughausstrasse 43, CH-B004 Zurich Tel. +41 1 245 97 00, Fax +41 1 243 97 79

Doc No 861 - QD 000 P40 BA - B

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13 Application Note System Performance Check

13.1 Purpose of system performance check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check is performed prior to any usage of the system in order to guarantee reproducible results.

The measurement of the Specific Absorption Rate (SAR) is a complicated task and the result depends on the proper functioning of many components and the correct settings of many parameters. Faulty results due to drift, failures or incorrect parameters might not be recognized, since they often look similar in distribution to the correct ones. The Dosimetric Assessment System DASY4 incorporates a system performance check procedure to test the proper functioning of the system. The system performance check uses normal SAR measurements in a simplified setup (the flat section of the SAM Twin Phantom) with a well characterized source (a matched dipole at a specified distance). This setup was selected to give a high sensitivity to all parameters that might fail or vary over time (e.g., probe, liquid parameters, and software settings) and a low sensitivity to external effects inherent in the system (e.g., positioning uncertainty of the device holder). The system performance check does not replace the calibration of the components. The accuracy of the system performance check is not sufficient for calibration purposes. It is possible to calculate the field quite accurately in this simple setup; however, due to the open field situation some factors (e.g., laboratory reflections) cannot be accounted for. Calibrations in the flat phantom are possible with transfer calibration methods, using either temperature probes or calibrated E-field probes. The system performance check also does not test the system performance for arbitrary field situations encountered during real measurements of mobile phones. These checks are performed at SPEAG by testing the components under various conditions (e.g., spherical isotropy measurements in liquid, linearity measurements, temperature variations, etc.), the results of which are used for an error estimation of the system. The system performance check will indicate situations where the system uncertainty is exceeded due to drift or failure.

13.2 System Performance check procedure

Preparation

The conductivity should be measured before the validation and the measured liquid parameters must be entered in the software. If the measured values differ from targeted values in the dipole document, the liquid composition should be adjusted. If the validation is performed with slightly different (measured) liquid parameters, the expected SAR will also be different. See the application note about SAR sensitivities for an estimate of possible SAR deviations. Note that the liquid parameters are temperature dependent with approximately - 0.5% decrease in permittivity and + 1% increase in conductivity for a temperature decrease of 1° C. The dipole must be placed beneath the flat phantom section of the Generic Twin Phantom with the correct distance holder in place. The distance holder should touch the phantom surface with a light pressure at the reference marking (little hole) and be oriented parallel to the long side of the phantom. Accurate positioning is not necessary, since the system will search for the peak SAR location, except that the dipole arms should be parallel to the surface. The device holder for mobile phones can be left in place but should be rotated away from the dipole. The forward power into the dipole at the dipole SMA connector should be determined as accurately as possible. See section 4 for a description of the recommended setup to measure the dipole input power. The actual dipole input power level can be between 20mW and several watts. The result can later be normalized to any power level. It is strongly recommended to note the actually used power level in the "comment"-window of the measurement file; otherwise you loose this crucial information for later reference.

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System Performance Check

The DASY4 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks, so you must save the finished validation under a different name. The validation document requires the Generic Twin Phantom, so this phantom must be properly installed in your system. (You can create your own measurement procedures by opening a new document or editing an existing document file). Before you start the validation, you just have to tell the system with which components (probe, medium, and device) you are performing the validation; the system will take care of all parameters. After the validation, which will take about 20 minutes, the results of each task are displayed in the document window. Selecting all measured tasks and opening the predefined "validation" graphic format displays all necessary information for validation. A description of the different measurement tasks in the predefined document is given below, together with the information that can be deduced from their results:

- The "reference" and "drift" measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the amplifier output power. If it is too high (above ± 0.1dB) the validation should be repeated; some amplifiers have very high drift during warm-up. A stable amplifier gives drift results in the DASY4 system below ± 0.02 dB.
- The "surface check" measurement tests the optical surface detection system of the DASY4 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). In that case it is better to abort the validation and stir the liquid. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.) However, varying breaking indices of different liquid compositions might also influence the distance. If the indicated difference varies from the actual setting, the probe parameter "optical surface distance" should be changed in the probe settings (see manual). For more information see the application note about SAR evaluation.
- The "area scan" measures the SAR above the dipole on a parallel plane to the surface. It is used to
 locate the approximate location of the peak SAR with 2D spline interpolation. The proposed scan uses
 large grid spacing for faster measurement; due to the symmetric field the peak detection is reliable. If a
 finer graphic is desired, the grid spacing can be reduced. Grid spacing and orientation have no influence
 on the SAR result.
- The zoom scan job measures the field in a volume around the peak SAR value assessed in the previous "area" scan (for more information see the application note on SAR evaluation).

If the validation measurements give reasonable results, the peak 1g and 10g spatial SAR values averaged between the two cubes and normalized to 1W dipole input power give the reference data for comparisons. The next section analyzes the expected uncertainties of these values. Section 6 describes some additional checks for further information or troubleshooting.

13.3 Uncertainty Budget

Please note that in the following Tables, the tolerance of the following uncertainty components depends on the actual equipment and setup at the user location and need to be either assessed or verified on-site by the end user of the DASY4 system:

- RF ambient conditions
- Dipole Axis to Liquid Distance
- Input power and SAR drift measurement
- Liquid permittivity measurement uncertainty
- · Liquid conductivity measurement uncertainty

Note: All errors are given in percent of SAR, so 0.1 dB corresponds to 2.3%. The field error would be half of that. The liquid parameter assessment give the targeted values from the dipole document. All errors are given in percent of SAR, so 0.1dB corresponds to 2.3%. The field error would be half of that.



System validation

In the table below, the system validation uncertainty with respect to the analytically assessed SAR value of a dipole source as given in the P1528 standard is given. This uncertainty is smaller than the expected uncertainty for mobile phone measurements due to the simplified setup and the symmetric field distribution.

Error Sources	Uncertainty Value	Probability Distribution	Divi- sor	c _i 1g	c _i 10g	Standard Uncertainty 1g	Standard Uncertainty 10g	V _i ² Or V _{eff}
Measurement System								
Probe calibration	± 4.8%	Normal	1	1	1	± 4.8%	± 4.8%	8
Axial isotropy	± 4.7%	Rectangular	√3	0.7	0.7	± 1.9%	± 1.9%	8
Hemispherical isotropy	± 0.0%	Rectangular	√3	0.7	0.7	± 0.0%	± 3.9%	8
Boundary effects	± 1.0%	Rectangular	√3	1	1	± 0.6%	± 0.6%	8
Probe linearity	± 4.7%	Rectangular	√3	1	1	± 2.7%	± 2.7%	8
System detection limits	± 1.0%	Rectangular	√3	1	1	± 0.6%	± 0.6%	8
Readout electronics	± 1.0%	Normal	1	1	1	± 1.0%	± 1.0%	8
Response time	± 0.0%	Rectangular	√3	1	1	± 0.0%	± 0.0%	8
Integration time	± 0.0%	Rectangular	√3	1	1	± 0.0%	± 0.0%	8
RF ambient conditions	± 3.0%	Rectangular	√3	1	1	± 1.7%	± 1.7%	8
Probe positioner	± 0.4%	Rectangular	√3	1	1	± 0.2%	± 0.2%	8
Probe positioning	± 2.9%	Rectangular	√3	1	1	± 1.7%	± 1.7%	8
Max. SAR evaluation	± 1.0%	Rectangular	√3	1	1	± 0.6%	± 0.6%	8
Test Sample Related								
Dipole axis to liquid distance	± 2.0%	Normal	1	1	1	± 1.2%	± 1.2%	8
Power drift	± 4.7%	Rectangular	√3	1	1	± 2.7%	± 2.7%	8
Phantom and Set-up								
Phantom uncertainty	± 4.0%	Rectangular	√3	1	1	± 2.3%	± 2.3%	8
Liquid conductivity (target)	± 5.0%	Rectangular	√3	0.64	0.43	± 1.8%	± 1.2%	8
Liquid conductivity (meas.)	± 2.5%	Normal	1	0.64	0.43	± 1.6%	± 1.1%	8
Liquid permittivity (target)	± 5.0%	Rectangular	√3	0.6	0.49	± 1.7%	± 1.4%	8
Liquid permittivity (meas.)	± 2.5%	Normal	1	0.6	0.49	± 1.5%	± 1.2%	8
Combined Uncertainty						± 8.4%	± 8.1%	
Expanded Std. Uncertainty						± 16.8%	± 16.2%	



Performance check repeatability

The repeatability check of the validation is insensitive to external effects and gives an indication of the variations in the DASY4 measurement system, provided that the same power reading setup is used for all validations. The repeatability estimate is given in the following table:

Error Sources	Uncertainty Value	Probability Distribution	Divi- sor	c _i 1g	c _i 10g	Standard Uncertainty 1g	Standard Uncertainty 10g	V _i ² Or V _{eff}
Measurement System								
Probe calibration	± 4.8%	Normal	1	1	1	0	0	∞
Axial isotropy	± 4.7%	Rectangular	√3	0.7	0.7	0	0	∞
Hemispherical isotropy	± 0.0%	Rectangular	√3	0.7	0.7	0	0	∞
Boundary effects	± 1.0%	Rectangular	√3	1	1	0	0	∞
Probe linearity	± 4.7%	Rectangular	√3	1	1	0	0	∞
System detection limits	± 1.0%	Rectangular	√3	1	1	0	0	8
Readout electronics	± 1.0%	Normal	1	1	1	0	0	8
Response time	± 0.0%	Rectangular	√3	1	1	0	0	8
Integration time	± 0.0%	Rectangular	√3	1	1	0	0	8
RF ambient conditions	± 3.0%	Rectangular	√3	1	1	0	0	8
Probe positioner	± 0.4%	Rectangular	√3	1	1	0	0	8
Probe positioning	± 2.9%	Rectangular	√3	1	1	0	0	8
Max. SAR evaluation	± 1.0%	Rectangular	√3	1	1	0	0	8
Test Sample Related								
Dipole axis to liquid distance	± 2.0%	Normal	1	1	1	± 1.2%	± 1.2%	8
Power drift	± 4.7%	Rectangular	√3	1	1	± 2.7%	± 2.7%	8
Phantom and Set-up								
Phantom uncertainty	± 4.0%	Rectangular	√3	1	1	± 2.3%	± 2.3%	8
Liquid conductivity (target)	± 5.0%	Rectangular	√3	0.64	0.43	± 1.8%	± 1.2%	8
Liquid conductivity (meas.)	± 2.5%	Normal	1	0.64	0.43	± 1.6%	± 1.1%	∞
Liquid permittivity (target)	± 5.0%	Rectangular	√3	0.6	0.49	± 1.7%	± 1.4%	∞
Liquid permittivity (meas.)	± 2.5%	Normal	1	0.6	0.49	± 1.5%	± 1.2%	∞
Combined Uncertainty						± 5.3%	± 4.9%	
Expanded Std. Uncertainty						± 10.6%	± 9.7%	

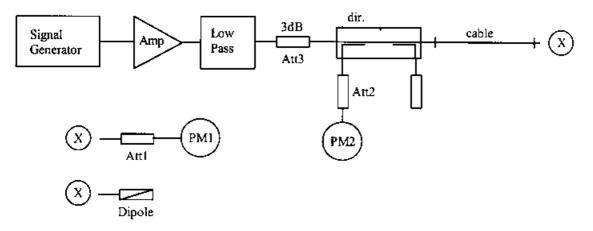
The expected repeatability deviation is low. Excessive drift (e.g., drift in liquid parameters), partial system failures or incorrect parameter settings (e.g., wrong probe or device settings) will lead to unexpectedly high repeatability deviations. The repeatability gives an indication that the system operates within its initial specifications. Excessive drift, system failure and operator errors are easily detected.

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13.4 Power set-up for validation

The uncertainty of the dipole input power is a significant contribution to the absolute uncertainty and the expected deviation in interlaboratory comparisons. The values in Section 2 for a typical and a sophisticated setup are just average values. Refer to the manual of the power meter and the detector head for the evaluation of the uncertainty in your system. The uncertainty also depends on the source matching and the general setup. Below follows the description of a recommended setup and procedures to increase the accuracy of the power reading:



The figure shows the recommended setup. The PM1 (incl. Att1) measures the forward power at the location of the validation dipole connector. The signal generator is adjusted for the desired forward power at the dipole connector and the power meter PM2 is read at that level. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter PM2. If the signal generator does not allow a setting in 0.01dB steps, the remaining difference at PM2 must be noted and considered in the normalization of the validation results. The requirements for the components are:

- The signal generator and amplifier should be stable (after warm-up). The forward power to the dipole should be above 10mW to avoid the influence of measurement noise. If the signal generator can deliver 15dBm or more, an amplifier is not necessary. Some high power amplifiers should not be operated at a level far below their maximum output power level (e.g. a 100W power amplifier operated at 250mW output can be quite noisy). An attenuator between the signal generator and amplifier is recommended to protect the amplifier input.
- The low pass filter after the amplifier reduces the effect of harmonics and noise from the amplifier. For most amplifiers in normal operation the filter is not necessary.
- The attenuator after the amplifier improves the source matching and the accuracy of the power head. (See power meter manual.) It can also be used also to make the amplifier operate at its optimal output level for noise and stability. In a setup without directional coupler, this attenuator should be at least 10dB.
- The directional coupler (recommended ³ 20dB) is used to monitor the forward power and adjust the signal generator output for constant forward power. A medium quality coupler is sufficient because the loads (dipole and power head) are well matched. (If the setup is used for reflective loads, a high quality coupler with respect to directivity and output matching is necessary to avoid additional errors.)
- The power meter PM2 should have a low drift and a resolution of 0.01dBm, but otherwise its accuracy has no impact on the power setting. Calibration is not required.
- The cable between the coupler and dipole must be of high quality, without large attenuation and phase changes when it is moved. Otherwise, the power meter head PM1 should be brought to the location of the dipole for measuring.
- The power meter PM1 and attenuator Att1 must be high quality components. They should be calibrated, preferably together. The attenuator (³10dB) improves the accuracy of the power reading. (Some higher power heads come with a built-in calibrated attenuator.) The exact attenuation of the attenuator at the frequency used must be known; many attenuators are up to 0.2dB off from the specified value.
- Use the same power level for the power setup with power meter PM1 as for the actual measurement to avoid linearity and range switching errors in the power meter PM2. If the validation is performed at various power levels, do the power setting procedure at each level.



- The dipole must be connected directly to the cable at location "X". If the power meter has a different connector system, use high quality couplers. Preferably, use the couplers at the attenuator Att1 and calibrate the attenuator with the coupler.
- Always remember: We are measuring power, so 1% is equivalent to 0.04dB.

13.5 Laboratory reflection

In near-field situations, the absorption is predominantly caused by induction effects from the magnetic nearfield. The absorption from reflected fields in the laboratory is negligible. On the other hand, the magnetic field around the dipole depends on the currents and therefore on the feed point impedance. The feed point impedance of the dipole is mainly determined from the proximity of the absorbing phantom, but reflections in the laboratory can change the impedance slightly. A 1% increase in the real part of the feed point impedance will produce approximately a 1% decrease in the SAR for the same forward power. The possible influence of laboratory reflections should be investigated during installation. The validation setup is suitable for this check, since the validation is sensitive to laboratory reflections. The same tests can be performed with a mobile phone, but most phones are less sensitive to reflections due to the shorter distance to the phantom. The fastest way to check for reflection effects is to position the probe in the phantom above the feed point and start a continuous field measurement in the DASY4 multi-meter window. Placing absorbers in front of possible reflectors (e.g. on the ground near the dipole or in front of a metallic robot socket) will reveal their influence immediately. A 10dB absorber (e.g. ferrite tiles or flat absorber mats) is probably sufficient, as the influence of the reflections is small anyway. If you place the absorber too near the dipole, the absorber itself will interact with the reactive near-field. Instead of measuring the SAR, it is also possible to monitor the dipole impedance with a network analyzer for reflection effects. The network analyzer must be calibrated at the SMA connector and the electrical delay (two times the forward delay in the dipole document) must be set in the NWA for comparisons with the reflection data in the dipole document. If the absorber has a significant influence on the results, the absorber should be left in place for validation or measurements. The reference data in the dipole document are produced in a low reflection environment.

13.6 Additional system checks

While the validation gives a good check of the DASY4 system components, it does not include all parameters necessary for real phone measurements (e.g. device modulation or device positioning). For system validation (repeatability) or comparisons between laboratories a reference device can be useful. This can be any mobile phone with a stable output power (preferably a device whose output power can be set through the keyboard). For comparisons, the same device should be sent around, since the SAR variations between samples can be large. Several measurement possibilities in the DASY software allow additional tests of the performance of the DASY system and components. These tests can be useful to localize component failures:

- The validation can be performed at different power levels to check the noise level or the correct compensation of the diode compression in the probe.
- If a pulsed signal with high peak power levels is fed to the dipole, the performance of the diode compression compensation can be tested. The correct crest factor parameter in the DASY software must be set (see manual). The system should give the same SAR output for the same averaged input power.
- The probe isotropy can be checked with a 1D-probe rotation scan above the feed point. The automatic probe alignment procedure must be passed through for accurate probe rotation movements (optional DASY4 feature with a robot-mounted light beam unit). Otherwise the probe tip might move on a small circle during rotation, producing some additional isotropy errors in gradient fields.