



REPORT No.: XM19080032W08

Annex E DASY Calibration Certificate



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Client **Xiamen KEHU-Morlab**

Certificate No. **Z19-60377**

CALIBRATION CERTIFICATE

Object **DAE4 - SN: 1516**

Calibration Procedure(s) **FF-Z11-002-01**
Calibration Procedure for the Data Acquisition Electronics (DAEx)

Calibration date **November 11, 2019**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No)	Scheduled Calibration
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Process Calibrator 753	1971018	24-Jun-19 (CTTL, No J19X05126)	Jun-20
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	Name	Function
Calibrated by	Yu Zongying	SAR Test Engineer
Reviewed by	Lin Hao	SAR Test Engineer
Approved by	Qi Dianyuan	SAR Project Leader

Signature

Issued November 13, 2019

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Glossary:

DAE

data acquisition electronics

Connector angle

information used in DASY system to align probe sensor X to the robot coordinate system

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provides only calibration results for DAE, it does not contain other performance test results.



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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range 1LSB = 6.1 μ V, full range = -100 +300 mV

Low Range 1LSB = 61nV, full range = -1 +3mV

DASY measurement parameters Auto Zero Time 3 sec, Measuring time 3 sec

Calibration Factors	X	Y	Z
High Range	404 245 $\pm$ 0.15% (k=2)	404 709 $\pm$ 0.15% (k=2)	404 504 $\pm$ 0.15% (k=2)
Low Range	3 97857 $\pm$ 0.7% (k=2)	3 93710 $\pm$ 0.7% (k=2)	4 00091 $\pm$ 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	203.5° $\pm$ 1°
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Client

Xiamen KEHU-Morlab

Certificate No Z19-60378

CALIBRATION CERTIFICATE

Object EX3DV4 - SN 7445

Calibration Procedure(s) FF-Z11-004-01
Calibration Procedures for Dosimetric E-field Probes

Calibration date November 06, 2019

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No)	Scheduled Calibration
Power Meter NRP2	101919	18-Jun-19 (CTTL, No J19X05125)	Jun-20
Power sensor NRP-Z91	101547	18-Jun-19 (CTTL, No J19X05125)	Jun-20
Power sensor NRP-Z91	101548	18-Jun-19 (CTTL, No J19X05125)	Jun-20
Reference10dBA attenuator	18N50W-10dB	09-Feb-18(CTTL, No J18X01133)	Feb-20
Reference20dBA attenuator	18N50W-20dB	09-Feb-18(CTTL, No J18X01132)	Feb-20
Reference Probe EX3DV4	SN 7307	24-May-19(SPEAG No EX3-7307_May19/2)	May-20
DAE4	SN 1525	26-Aug-19(SPEAG, No DAE4-1525_Aug19)	Aug -20
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	18-Jun-19 (CTTL, No J19X05127)	Jun-20
Network Analyzer E5071C	MY46110673	24-Jan-19 (CTTL, No J19X00547)	Jan -20

	Name	Function
Calibrated by	Yu Zongying	SAR Test Engineer
Reviewed by	Lin Hao	SAR Test Engineer
Approved by	Qi Dianyuan	SAR Project Leader

Signature

Issued November 08, 2019

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Glossary

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A,B,C,D	modulation dependent linearization parameters
Polarization Φ	Φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), $\theta=0$ is normal to probe axis

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters

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



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Probe EX3DV4

SN: 7445

Calibrated November 06, 2019

Calibrated for DASY/EASY Systems

(Note non-compatible with DASY2 system!)



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DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7445

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu V/(V/m)^2$) ^A	0 38	0 53	0 38	±10 0%
DCP(mV) ^B	99 8	103 2	102 4	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu V}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0 0	0 0	1 0	0 00	151 8	±3 2%
		Y	0 0	0 0	1 0		187 1	
		Z	0 0	0 0	1 0		147 0	

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

^A The uncertainties of Norm X, Y, Z do not affect the E²-field uncertainty inside TSL (see Page 5 and Page 6)

^B Numerical linearization parameter uncertainty not required

^E Uncertainty is determined using the max deviation from linear response applying rectangular distribution and is expressed for the square of the field value



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DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7445

Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unct (k=2)
835	41.5	0.90	9.69	9.69	9.69	0.12	1.40	±12.1%
1750	40.1	1.37	8.38	8.38	8.38	0.19	1.39	±12.1%
1900	40.0	1.40	8.03	8.03	8.03	0.21	1.04	±12.1%
2450	39.2	1.80	7.50	7.50	7.50	0.43	0.79	±12.1%
2600	39.0	1.96	7.24	7.24	7.24	0.43	0.90	±12.1%
5750	35.4	5.22	4.64	4.64	4.64	0.40	1.65	±13.3%

^C Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ±110 MHz.

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

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7445

Calibration Parameter Determined in Body Tissue Simulating Media

f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unct (k=2)
835	55.2	0.97	9.74	9.74	9.74	0.13	1.53	±12.1%
1750	53.4	1.49	8.03	8.03	8.03	0.16	1.28	±12.1%
1900	53.3	1.52	7.70	7.70	7.70	0.16	1.27	±12.1%
2450	52.7	1.95	7.39	7.39	7.39	0.43	0.96	±12.1%
2600	52.5	2.16	7.14	7.14	7.14	0.58	0.73	±12.1%
5750	48.3	5.94	4.06	4.06	4.06	0.50	1.50	±13.3%

^C Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ±110 MHz.

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

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



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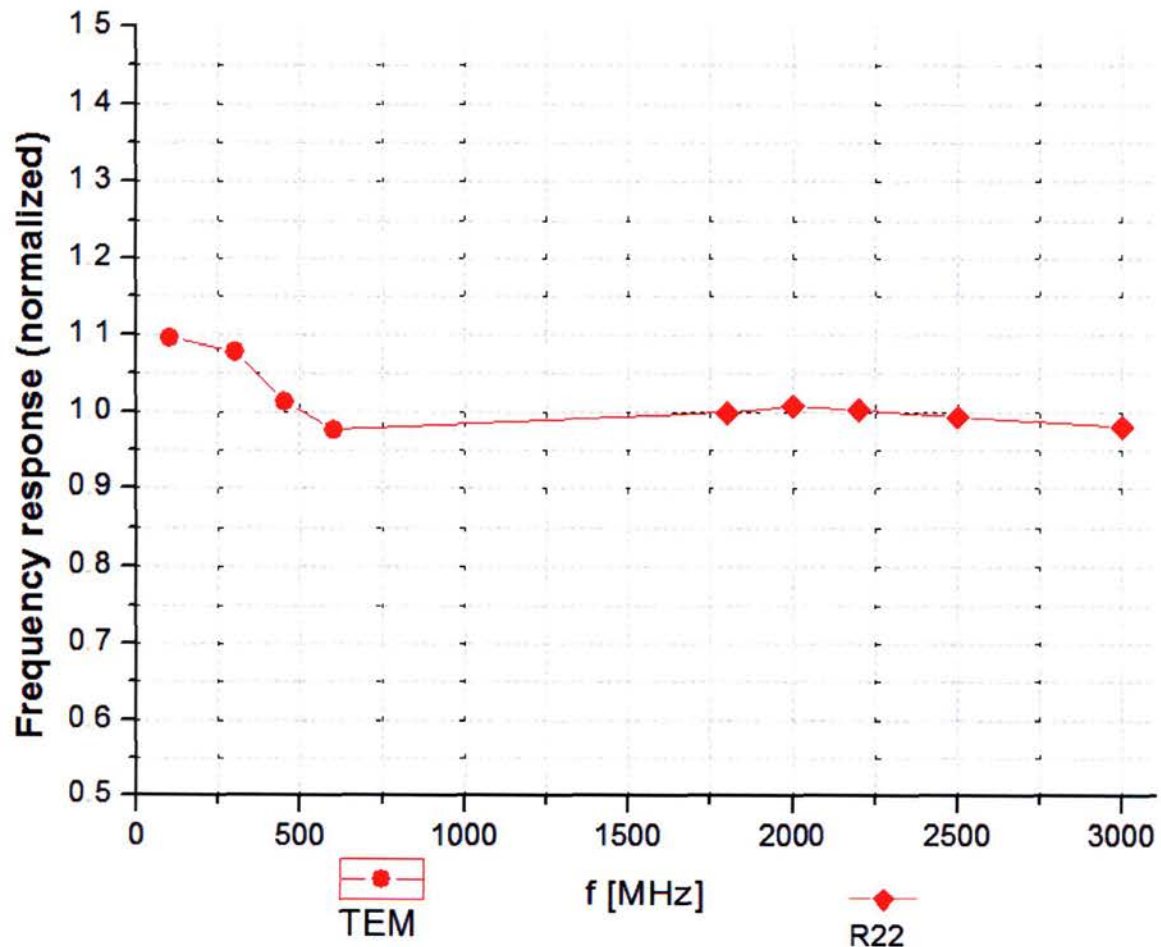
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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field $\pm 7.4\%$ ($k=2$)

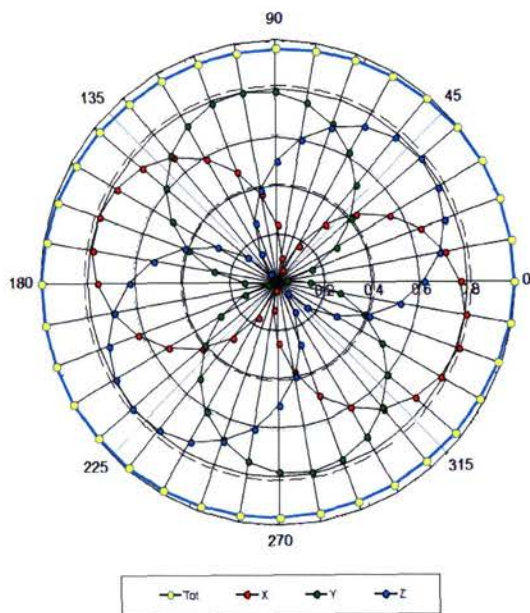


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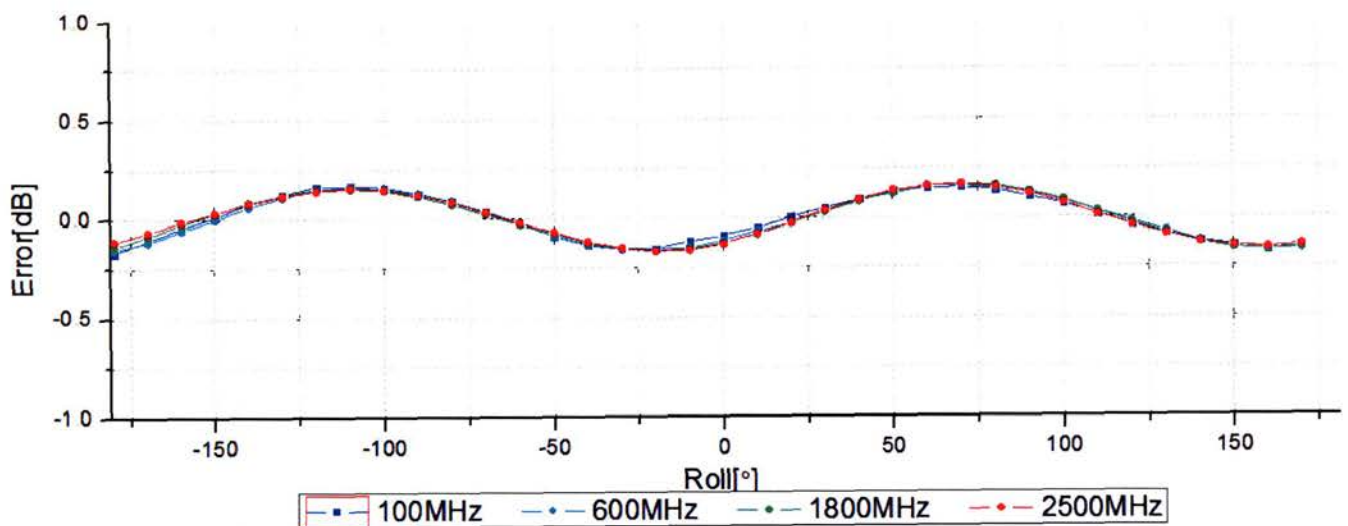
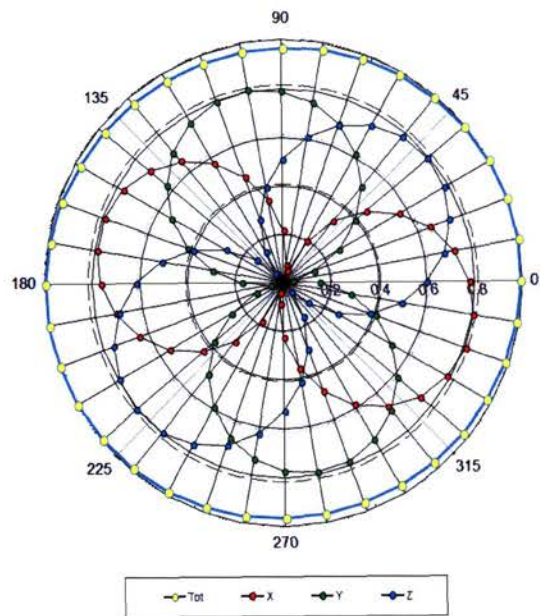
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM



f=1800 MHz, R22



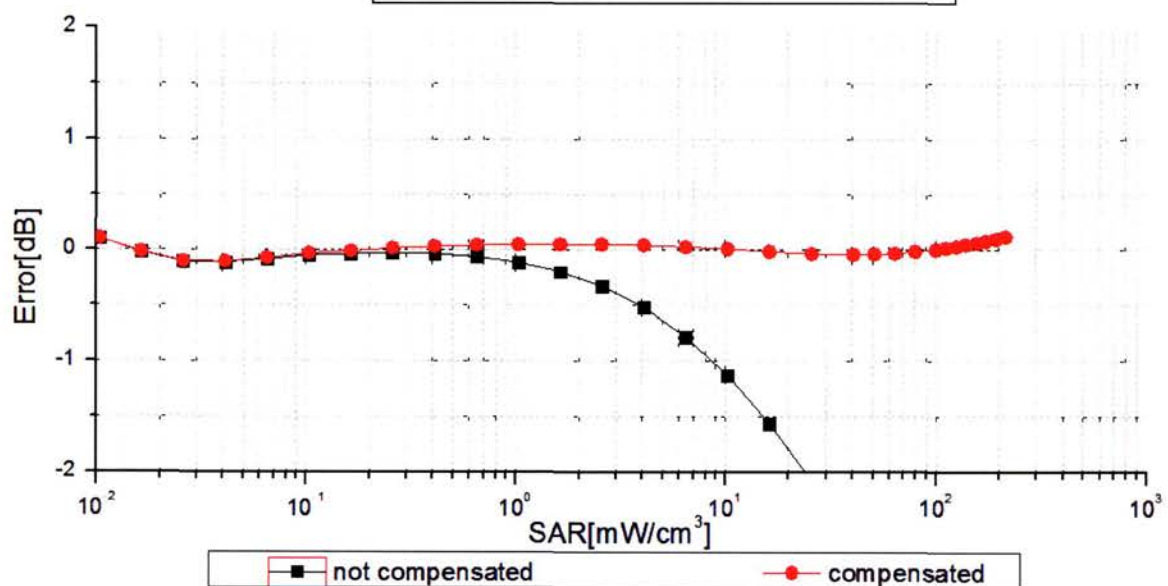
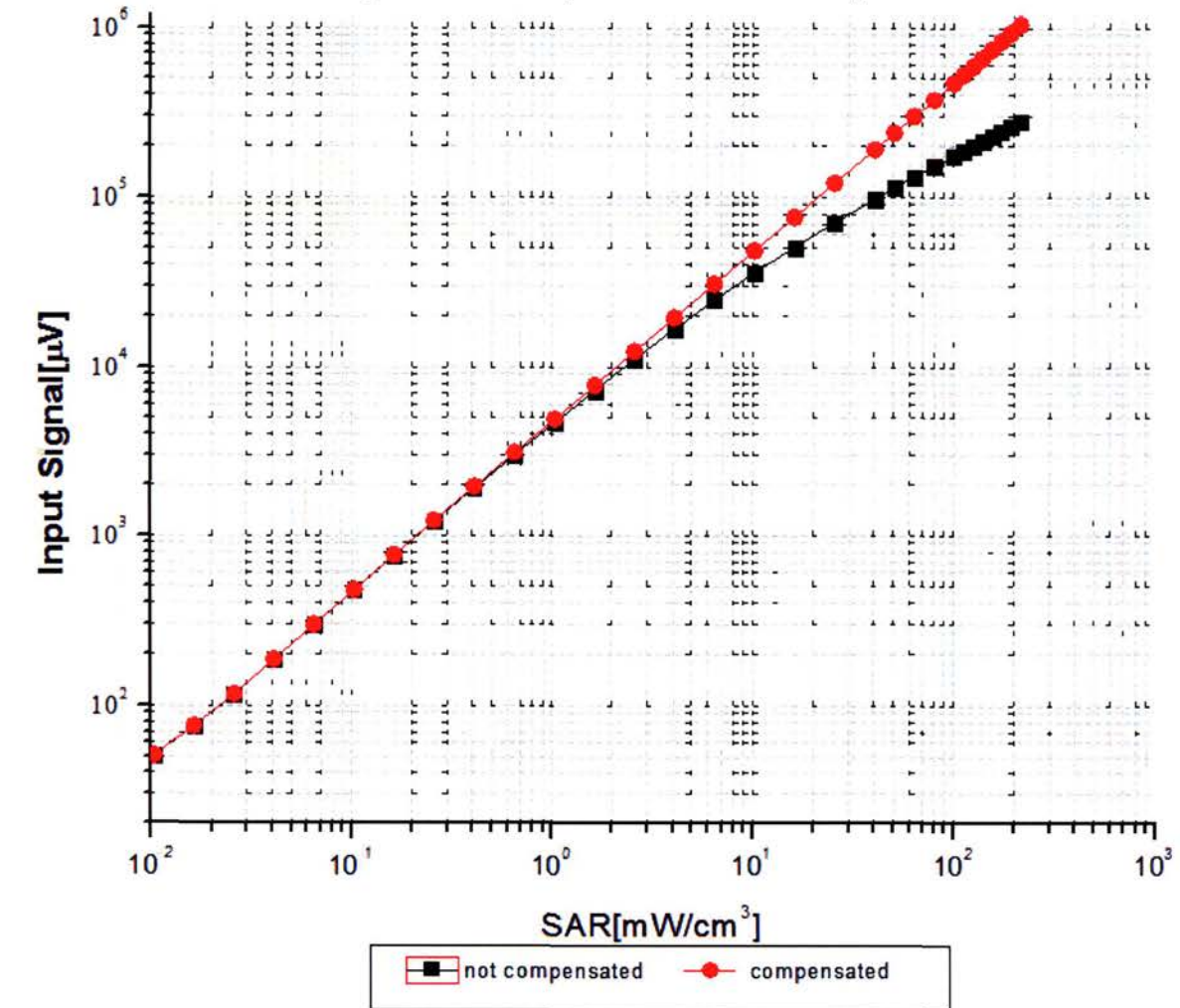
Uncertainty of Axial Isotropy Assessment $\pm 1.2\%$ ($k=2$)



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Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f = 900 \text{ MHz}$)



Uncertainty of Linearity Assessment: $\pm 0.9\%$ ($k=2$)



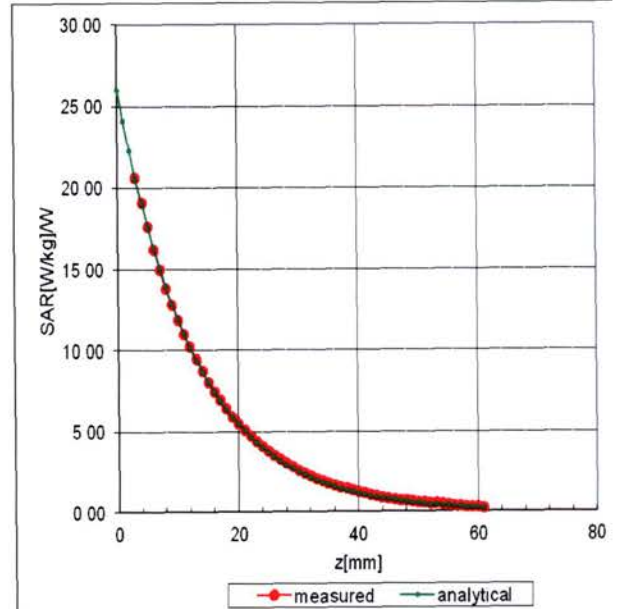
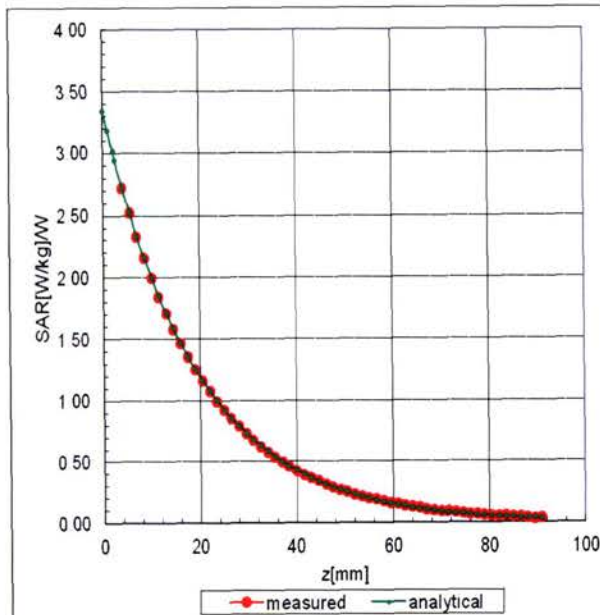
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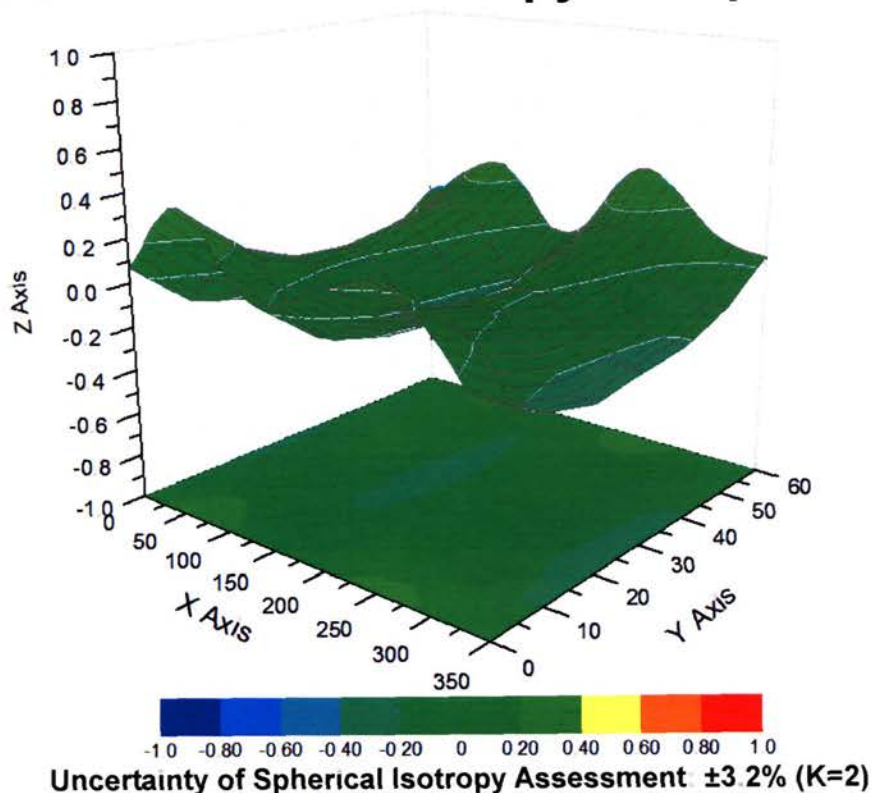
Conversion Factor Assessment

f=835 MHz, WGLS R9(H_convF)

f=1750 MHz, WGLS R22(H_convF)



Deviation from Isotropy in Liquid





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DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7445

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	110
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Probe Tip to Sensor X Calibration Point	1mm
Probe Tip to Sensor Y Calibration Point	1mm
Probe Tip to Sensor Z Calibration Point	1mm
Recommended Measurement Distance from Surface	1.4mm



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Client

KEHU

Certificate No: **Z18-60194**

CALIBRATION CERTIFICATE

Object **D750V3 - SN: 1173**

Calibration Procedure(s) **FF-Z11-003-01**
Calibration Procedures for dipole validation kits

Calibration date: **June 21, 2018**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRVD	102083	01-Nov-17 (CTTL, No.J17X08756)	Oct-18
Power sensor NRV-Z5	100542	01-Nov-17 (CTTL, No.J17X08756)	Oct-18
Reference Probe EX3DV4	SN 7464	12-Sep-17(SPEAG,No.EX3-7464_Sep17)	Sep-18
DAE4	SN 1525	02-Oct-17(SPEAG,No.DAE4-1525_Oct17)	Oct-18

Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	23-Jan-18 (CTTL, No.J18X00560)	Jan-19
NetworkAnalyzer E5071C	MY46110673	24-Jan-18 (CTTL, No.J18X00561)	Jan-19

	Name	Function
Calibrated by:	Zhao Jing	SAR Test Engineer
Reviewed by:	Lin Hao	SAR Test Engineer
Approved by:	Qi Dianyuan	SAR Project Leader

Signature

Issued: June 26, 2018

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Glossary:

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

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



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Measurement Conditions

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

DASY Version	DASY52	52.10.1.1476
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	750 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.9	0.89 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	42.6 $\pm$ 6 %	0.87 mho/m $\pm$ 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.02 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	8.26 mW / g $\pm$ 18.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.34 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	5.45 mW / g $\pm$ 18.7 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.96 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	54.6 $\pm$ 6 %	0.94 mho/m $\pm$ 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.13 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	8.65 mW / g $\pm$ 18.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.41 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	5.71 mW / g $\pm$ 18.7 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.2Ω- 3.01jΩ
Return Loss	- 24.9dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.3Ω- 4.51jΩ
Return Loss	- 26.1dB

General Antenna Parameters and Design

Electrical Delay (one direction)	0.900 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
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DASY5 Validation Report for Head TSL

Date: 06.21.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1173

Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 750$ MHz; $\sigma = 0.869$ S/m; $\epsilon_r = 42.6$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.57, 10.57, 10.57) @ 750 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

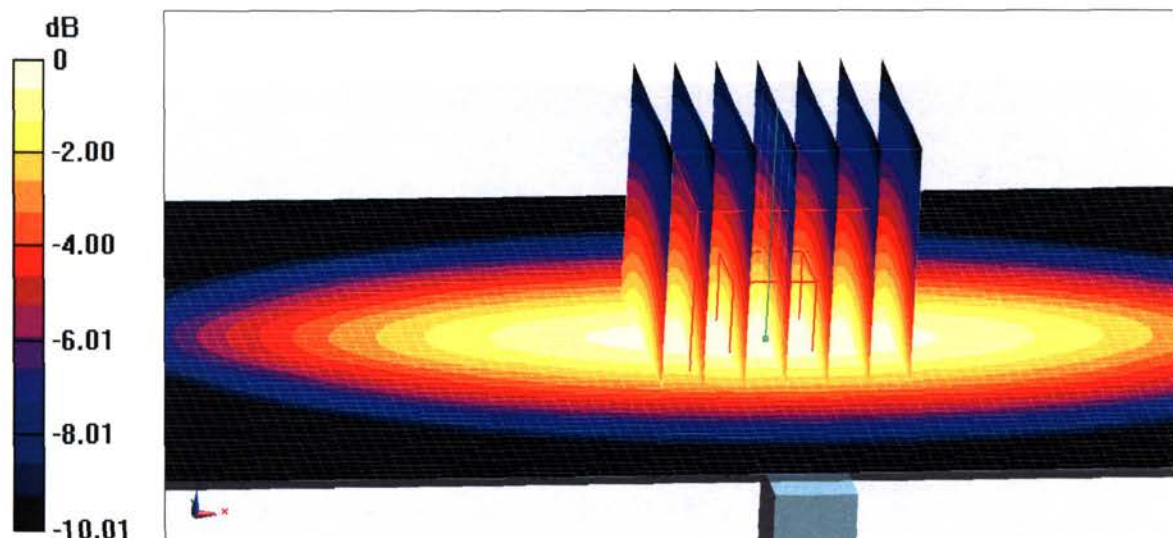
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.00 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 3.05 W/kg

SAR(1 g) = 2.02 W/kg; SAR(10 g) = 1.34 W/kg

Maximum value of SAR (measured) = 2.70 W/kg



0 dB = 2.70 W/kg = 4.31 dBW/kg



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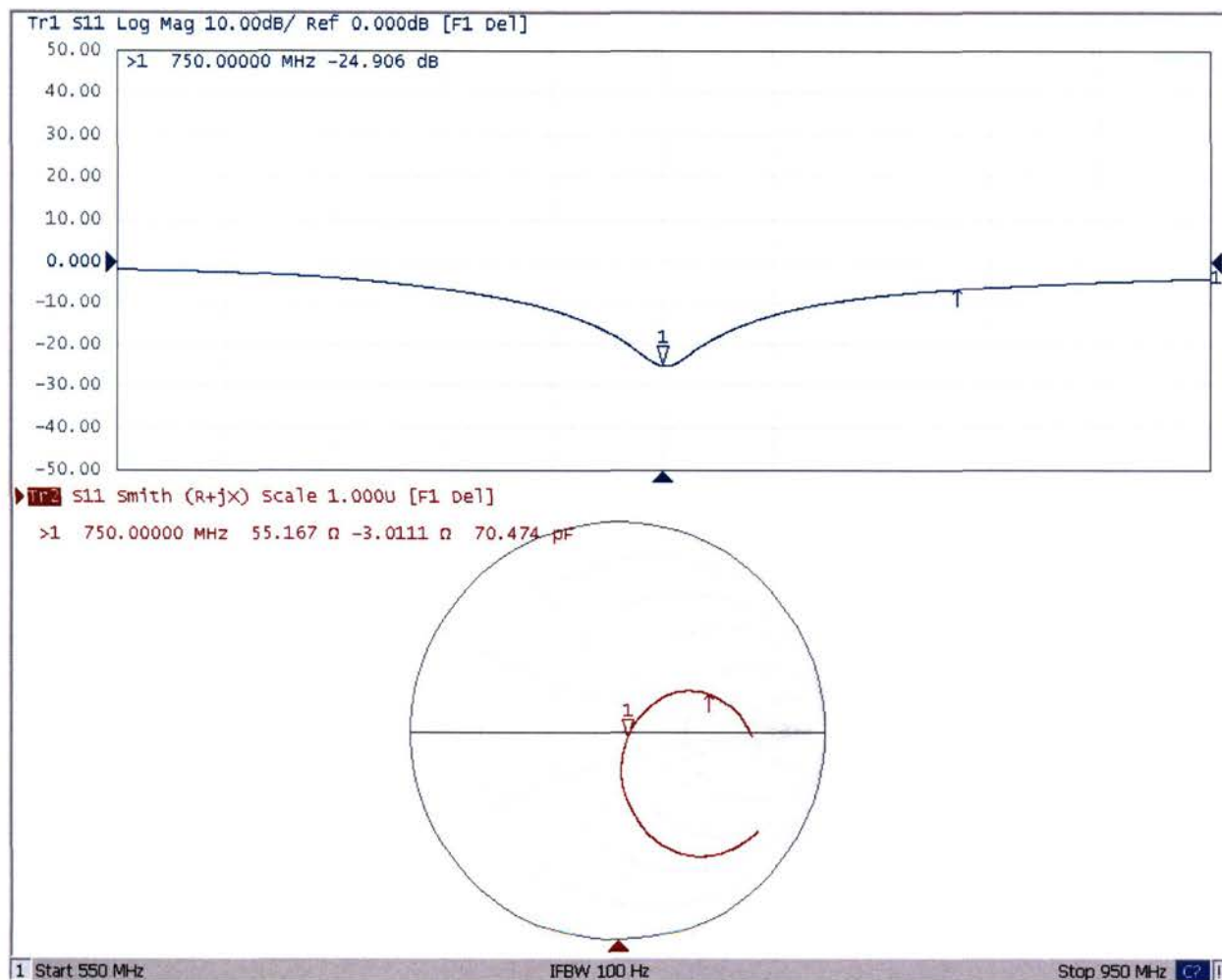
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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 06.21.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1173

Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 750$ MHz; $\sigma = 0.936$ S/m; $\epsilon_r = 54.56$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.63, 10.63, 10.63) @ 750 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

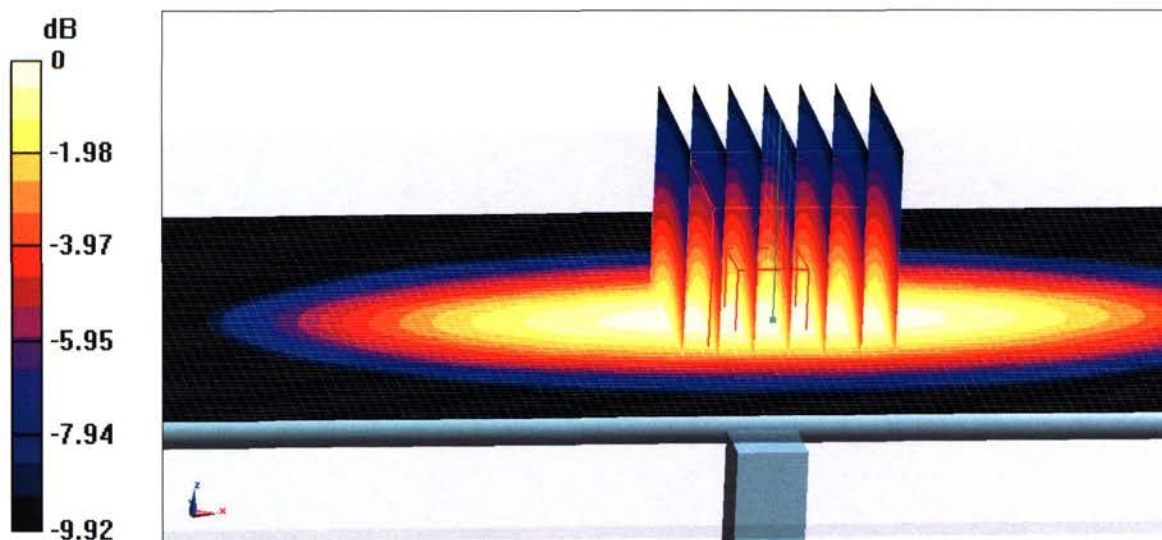
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 53.99 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.14 W/kg

SAR(1 g) = 2.13 W/kg; SAR(10 g) = 1.41 W/kg

Maximum value of SAR (measured) = 2.80 W/kg



0 dB = 2.80 W/kg = 4.47 dBW/kg

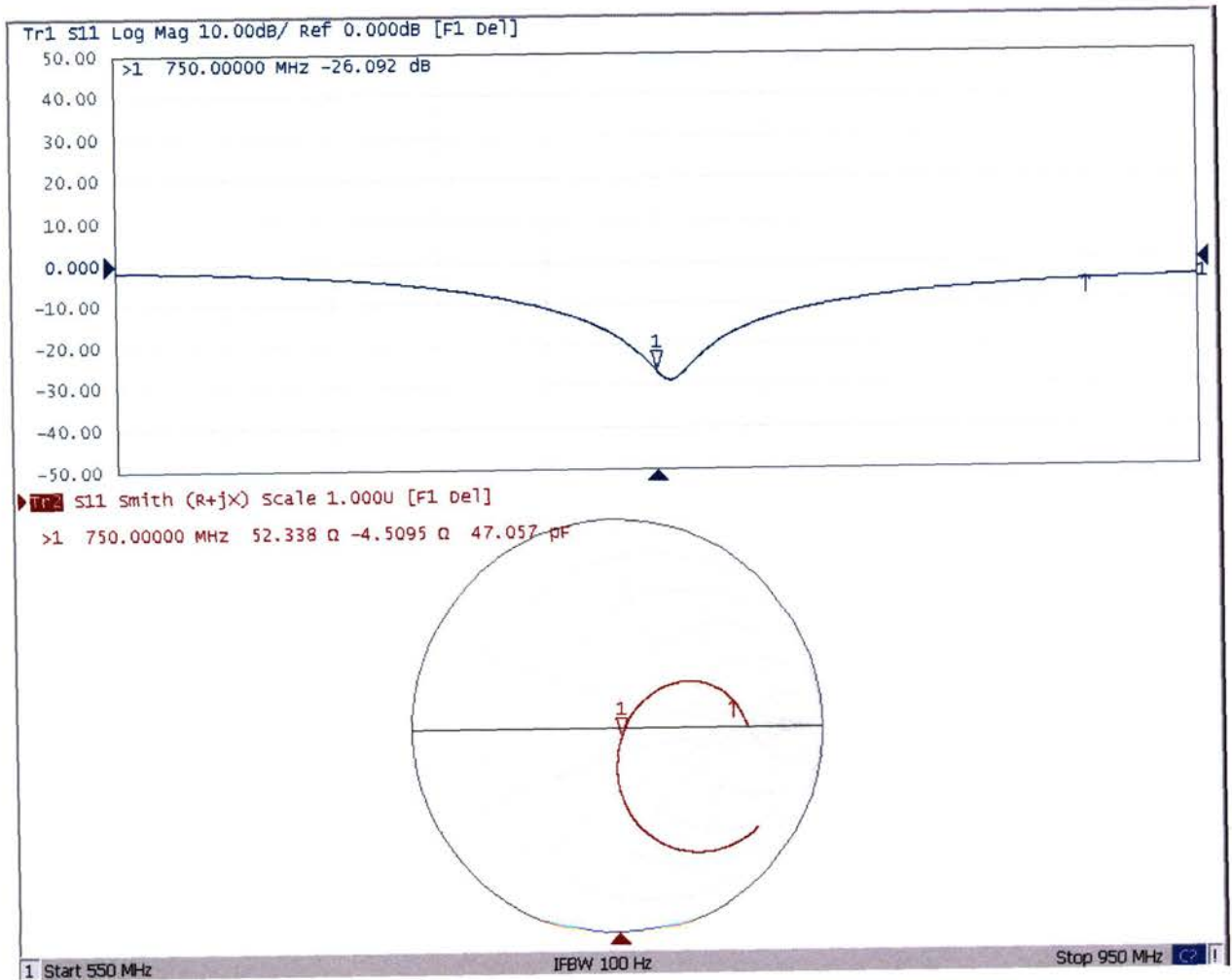


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Impedance Measurement Plot for Body TSL





Appendix Annual validation for Test Lab.

General calibration information

Date	2019.10.15
Test Laboratory	ShenZhen Morlab Communications Technology Co., Ltd.
Antenna serial No.	D750V3-SN:1173

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$57.84 \Omega - 1.53j \Omega$
Return Loss	-22.61dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.276 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feed point 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 arm, because they might bend or the soldered connections near the feed point may be damaged.

System Check_Head_750MHz

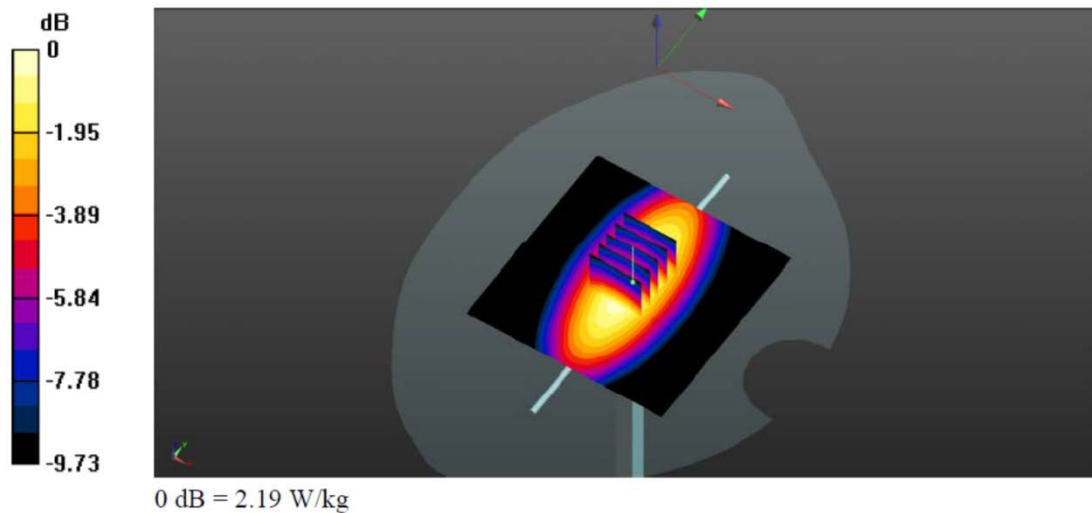
Communication System: UID 0, CW (0); Frequency: 750 MHz; Duty Cycle: 1:1
Medium: HSL_750 Medium parameters used: $f = 750 \text{ MHz}$; $\sigma = 0.929 \text{ S/m}$; $\epsilon_r = 42.139$; $\rho = 1000 \text{ kg/m}^3$
Ambient Temperature : 23.2°C ; Liquid Temperature : 22.1°C

DASY5 Configuration:

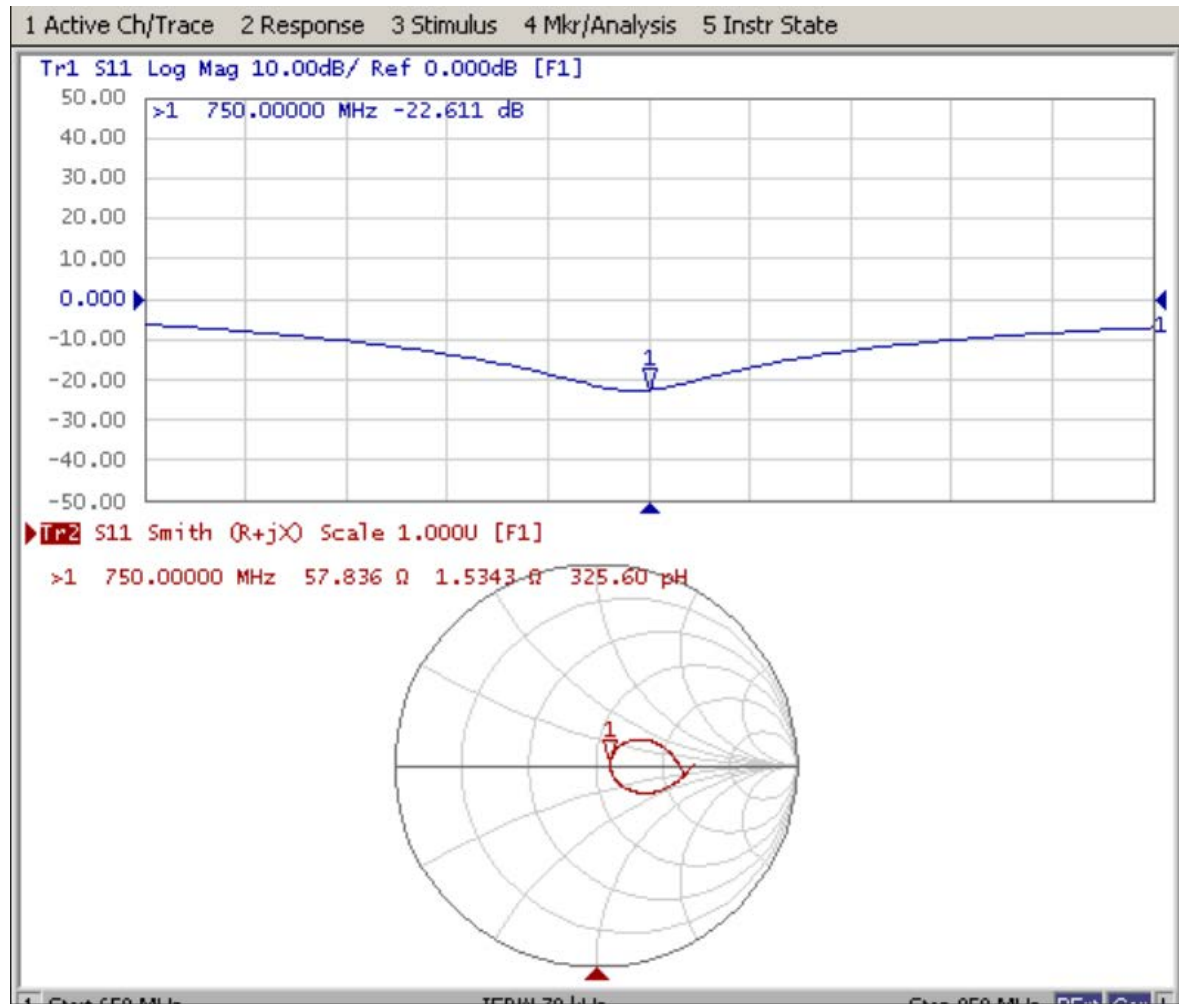
- Probe: ES3DV3 - SN3154; ConvF(6.34, 6.34, 6.34); Calibrated: 2019.07.16;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn480; Calibrated: 2019.04.11
- Phantom: SAM 1; Type: QD000P40CC; Serial: TP:1471
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

CW 750/Area Scan (81x81x1): Interpolated grid: $dx=1.500 \text{ mm}$, $dy=1.500 \text{ mm}$
Maximum value of SAR (interpolated) = 2.19 W/kg

CW 750/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8\text{mm}$, $dy=8\text{mm}$, $dz=5\text{mm}$
Reference Value = 49.15 V/m ; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 2.98 W/kg
SAR(1 g) = 2.04 W/kg ; SAR(10 g) = 1.37 W/kg
Maximum value of SAR (measured) = 2.20 W/kg



Appendix Impedance Measurement Plot for Head TSL





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Client **KEHU**

Certificate No: **Z18-60195**

CALIBRATION CERTIFICATE

Object **D835V2 - SN: 4d227**

Calibration Procedure(s) **FF-Z11-003-01**
Calibration Procedures for dipole validation kits

Calibration date: **June 22, 2018**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRVD	102083	01-Nov-17 (CTTL, No.J17X08756)	Oct-18
Power sensor NRV-Z5	100542	01-Nov-17 (CTTL, No.J17X08756)	Oct-18
Reference Probe EX3DV4	SN 7464	12-Sep-17(SPEAG,No.EX3-7464_Sep17)	Sep-18
DAE4	SN 1525	02-Oct-17(SPEAG,No.DAE4-1525_Oct17)	Oct-18
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	23-Jan-18 (CTTL, No.J18X00560)	Jan-19
NetworkAnalyzer E5071C	MY46110673	24-Jan-18 (CTTL, No.J18X00561)	Jan-19

	Name	Function
Calibrated by:	Zhao Jing	SAR Test Engineer
Reviewed by:	Lin Hao	SAR Test Engineer
Approved by:	Qi Dianyuan	SAR Project Leader

Signature

Issued: June 26, 2018

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



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Glossary:

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

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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



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Measurement Conditions

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

DASY Version	DASY52	52.10.1.1476
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	41.3 $\pm$ 6 %	0.92 mho/m $\pm$ 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.38 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	9.34 mW / g $\pm$ 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.54 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	6.07 mW / g $\pm$ 18.7 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.2	0.97 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	53.7 $\pm$ 6 %	1.00 mho/m $\pm$ 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.47 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	9.61 mW / g $\pm$ 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.61 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	6.31 mW / g $\pm$ 18.7 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.0Ω- 1.13jΩ
Return Loss	- 28.0dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.6Ω- 3.91jΩ
Return Loss	- 27.5dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.255 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

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DASY5 Validation Report for Head TSL

Date: 06.21.2018

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d227

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 835$ MHz; $\sigma = 0.922$ S/m; $\epsilon_r = 41.29$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.28, 10.28, 10.28) @ 835 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

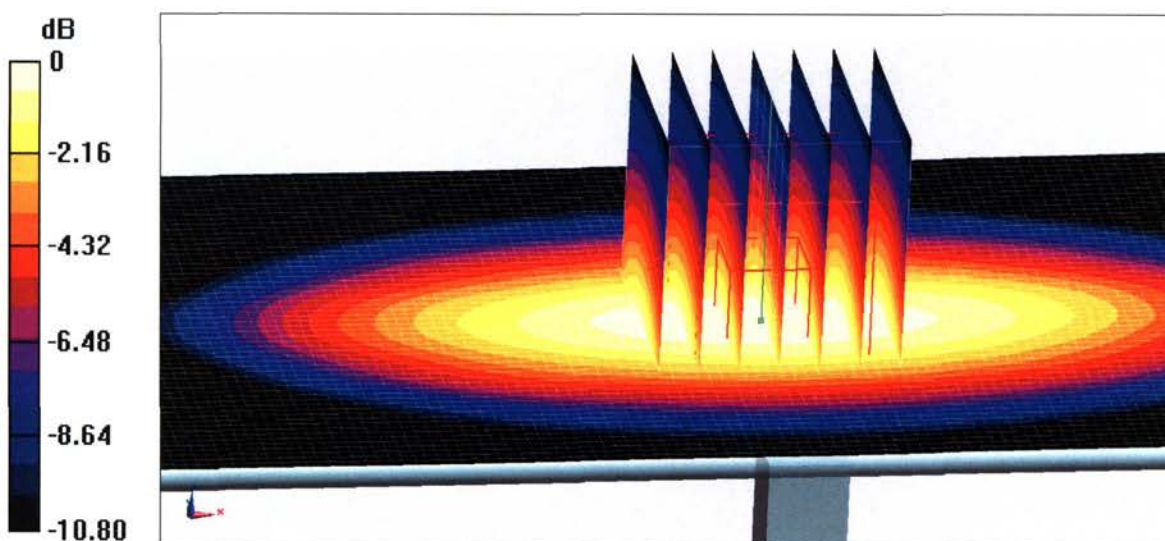
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 56.84 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 3.69 W/kg

SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.54 W/kg

Maximum value of SAR (measured) = 3.24 W/kg



0 dB = 3.24 W/kg = 5.11 dBW/kg

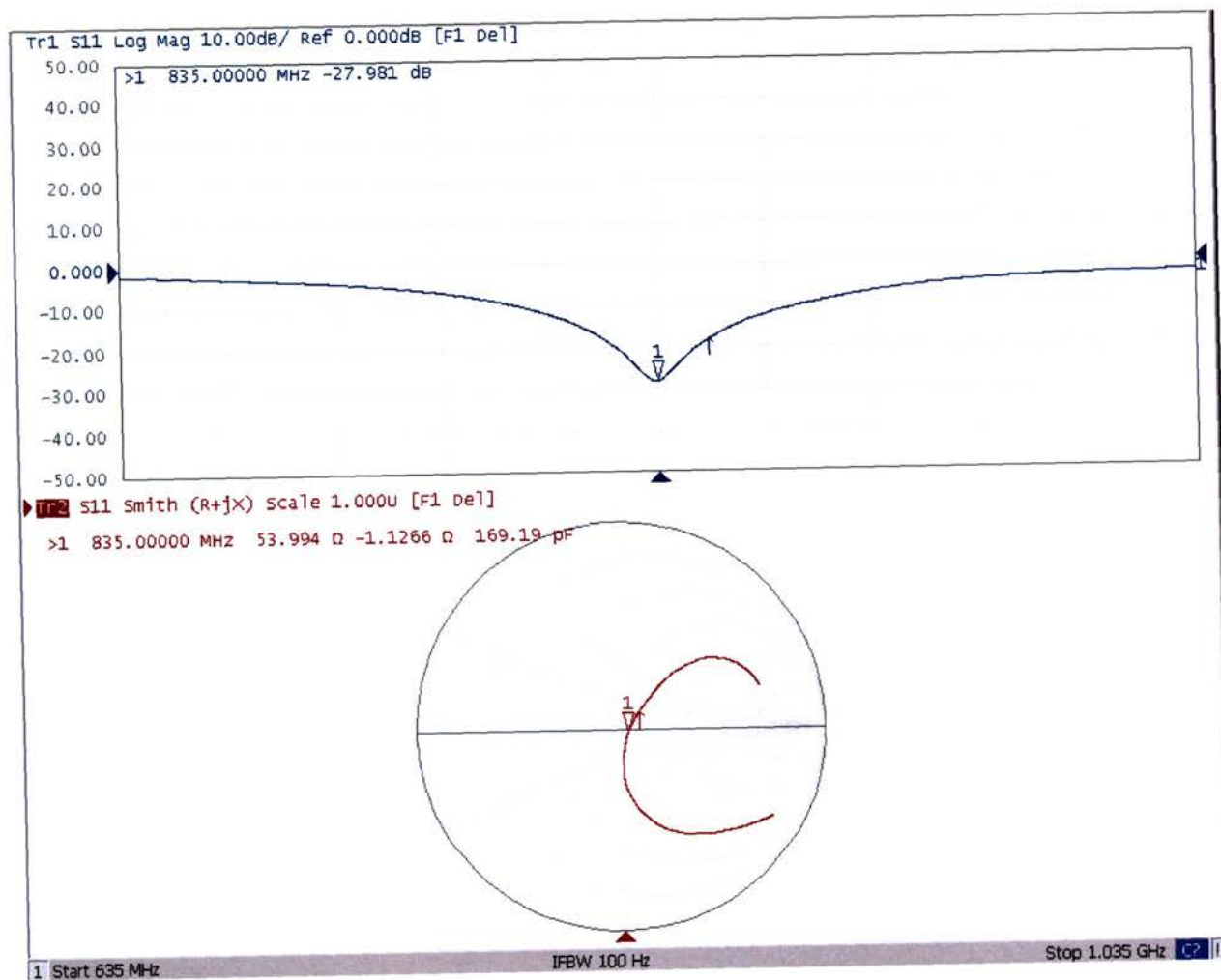


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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 06.22.2018

Test Laboratory: CCTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d227

Communication System: UID 0, CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.998 \text{ S/m}$; $\epsilon_r = 53.71$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(10.21, 10.21, 10.21) @ 835 MHz; Calibrated: 9/12/2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1525; Calibrated: 10/2/2017
- Phantom: MFP_V5.1C ; Type: QD 000 P51CA; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (1); SEMCAD X Version 14.6.11 (7439)

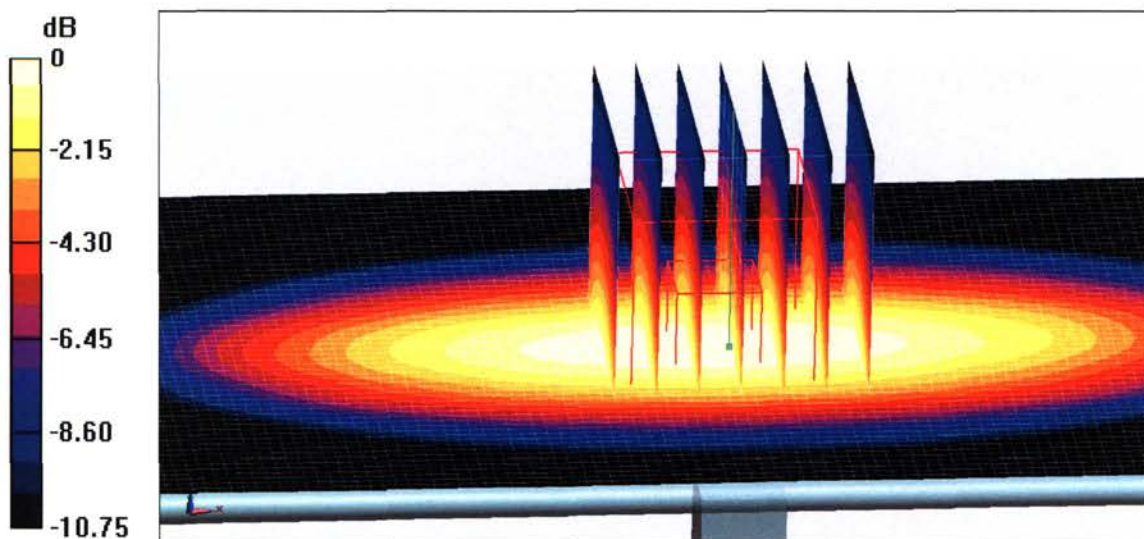
Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 55.85 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.81 W/kg

SAR(1 g) = 2.47 W/kg; SAR(10 g) = 1.61 W/kg

Maximum value of SAR (measured) = 3.35 W/kg



0 dB = 3.35 W/kg = 5.25 dBW/kg



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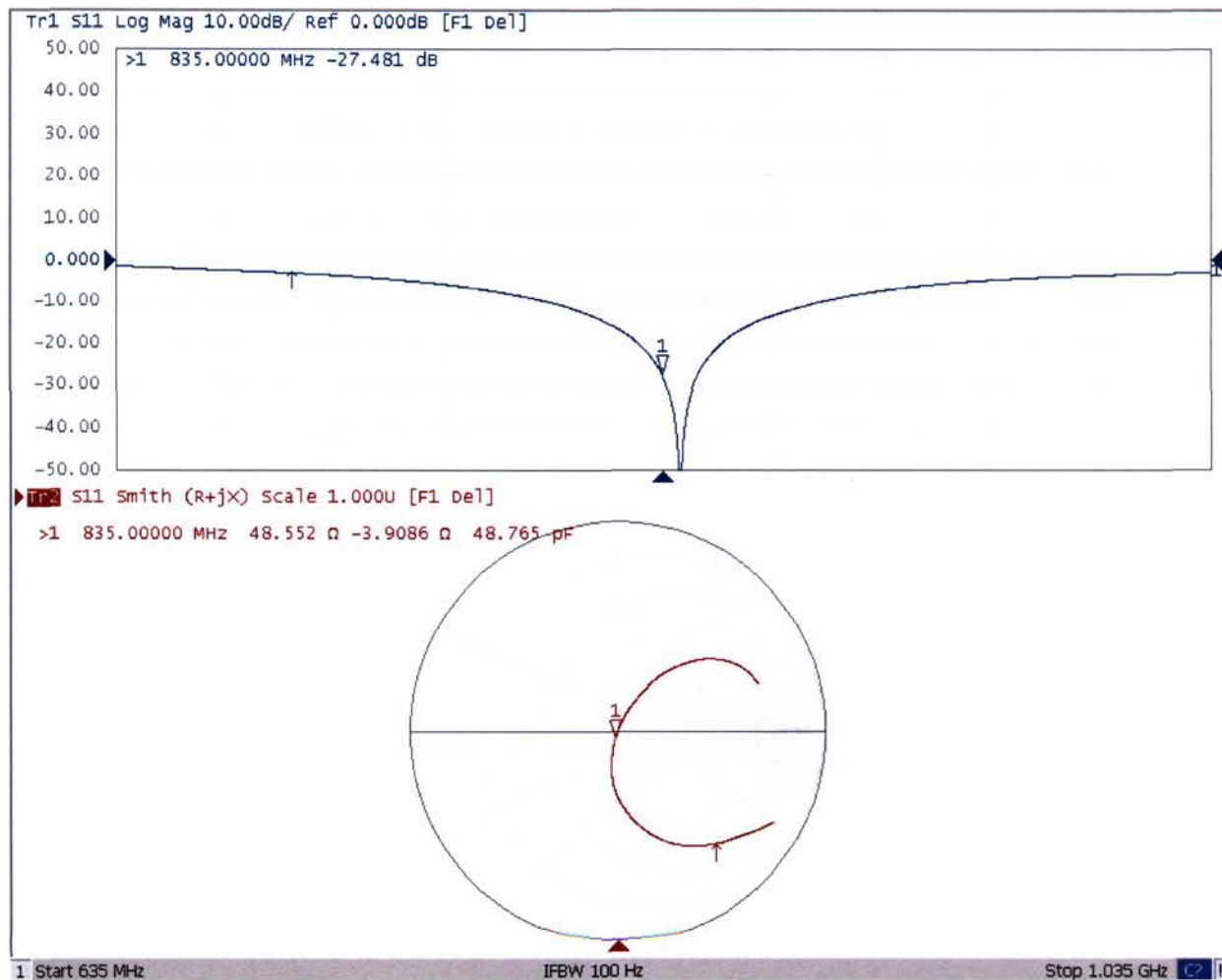
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Impedance Measurement Plot for Body TSL





Appendix Annual validation for Test Lab.

General calibration information

Date	2019.10.19
Test Laboratory	ShenZhen Morlab Communications Technology Co., Ltd.
Antenna serial No.	D1900V2-SN:5d221

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$55.77 \Omega + 0.768j \Omega$
Return Loss	-25.19dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.276 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feed point 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 arm, because they might bend or the soldered connections near the feed point may be damaged.

System Check_835MHz_Head

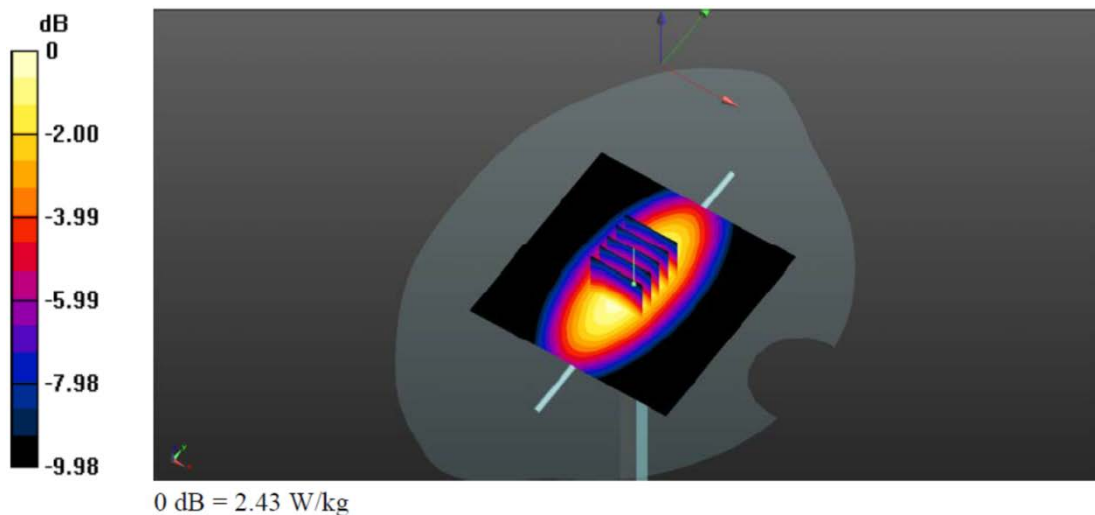
Communication System: UID 0, CW (0); Frequency: 835 MHz; Duty Cycle: 1:1
Medium: HSL_835 Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.913 \text{ S/m}$; $\epsilon_r = 42.266$; $\rho = 1000 \text{ kg/m}^3$
Ambient Temperature : 23.2°C ; Liquid Temperature : 22.7°C

DASY5 Configuration:

- Probe: EX3DV4 - SN3823; ConvF(9.32, 9.32, 9.32); Calibrated: 2018.11.12;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn480; Calibrated: 2019.04.11
- Phantom: SAM 1; Type: QD000P40CC; Serial: TP:1471
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

CW835/Area Scan (81x81x1): Interpolated grid: $dx=1.500 \text{ mm}$, $dy=1.500 \text{ mm}$
Maximum value of SAR (interpolated) = 2.45 W/kg

CW835/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8\text{mm}$, $dy=8\text{mm}$, $dz=5\text{mm}$
Reference Value = 53.72 V/m ; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 3.28 W/kg
SAR(1 g) = 2.34 W/kg ; SAR(10 g) = 1.51 W/kg
Maximum value of SAR (measured) = 2.43 W/kg



Appendix Impedance Measurement Plot for Head TSL

