

CALIBRATION REPORT

F.1 E-Field Probe



中国认可 国际互认 CALIBRATION **CNAS L0570**

Client

Auden

Certificate No: Z20-60233

CALIBRATION CERTIFICATE

Object EX3DV4 - SN: 3578

Calibration Procedure(s)

FF-Z11-004-01

Calibration Procedures for Dosimetric E-field Probes

Calibration date: July 06, 2020

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	16-Jun-20(CTTL, No.J2	0X04344)	Jun-21
Power sensor NRP-Z91		101547	16-Jun-20(CTTL, No.J2	0X04344)	Jun-21
Power sensor NRP-Z91		101548	16-Jun-20(CTTL, No.J2	0X04344)	Jun-21
Reference 10dBAttenua	tor	18N50W-10dB	10-Feb-20(CTTL, No.J2	20X00525)	Feb-22
Reference 20dBAttenua	tor	18N50W-20dB	10-Feb-20(CTTL, No.J2	20X00526)	Feb-22
Reference Probe EX3D	V 4	SN 3617	30-Jan-20(SPEAG, No.	EX3-3617_Jan20	(2) Jan-21
DAE4		SN 1556	4-Feb-20(SPEAG, No.D	AE4-1556_Feb20) Feb-21
Secondary Standards		ID#	Cal Date(Calibrated by, Cer	tificate No.)	Scheduled Calibration
SignalGenerator MG370	00A	6201052605	23-Jun-20(CTTL, No.J2	0X04343)	Jun-21
Network Analyzer E507	1C	MY46110673	10-Feb-20(CTTL, No.J2	20X00515)	Feb-21
	Nar	ne	Function		Signature
Calibrated by:	Yu	Zongying	SAR Test Engineer		and the
Reviewed by:	Lin	Нао	SAR Test Engineer		科北
Approved by:	Qi	Dianyuan	SAR Project Leader	-	2
				Issued: July 08,	
This calibration certificate s	hall	not be reproduced	d except in full without wri	tten approval of the	ne laboratory.

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Glossary:

TSL tissue simulating liquid
NORMx,y,z sensitivity in free space
ConvF sensitivity in TSL / NORMx,y,z
DCP diode compression point

CF crest factor (1/duty_cycle) of the RF signal A,B,C,D modulation dependent linearization parameters

Polarization Φ rotation around probe axis

Polarization θ θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i

θ=0 is normal to probe axis

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

- NORMx,y,z: Assessed for E-field polarization θ=0 (f≤900MHz in TEM-cell; f>1800MHz: waveguide).
 NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect 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 (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; VRx,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≤800MHz) and inside waveguide using analytical field distributions based on power measurements for f >800MHz. 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 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±50MHz to±100MHz.
- Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat
 phantom exposed by a patch antenna.
- Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the
 probe tip (on probe axis). No tolerance required.
- Connector Angle: The angle is assessed using the information gained by determining the NORMx (no uncertainty required).

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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3578

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
$Norm(\mu V/(V/m)^2)^A$	0.42	0.38	0.45	±10.0%
DCP(mV) ^B	104.5	107.6	107.2	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dBõV	С	D dB	VR mV	Unc ^E (<i>k</i> =2)
0 CW	Х	0.0	0.0	1.0	0.00	183.1	±2.1%	
		Υ	0.0	0.0	1.0		164.5	
		Z	0.0	0.0	1.0		183.3	

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 4).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainly 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:3578

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)
750	41.9	0.89	9.94	9.94	9.94	0.40	0.75	±12.1%
835	41.5	0.90	9.54	9.54	9.54	0.17	1.25	±12.1%
900	41.5	0.97	9.52	9.52	9.52	0.18	1.23	±12.1%
1450	40.5	1.20	8.57	8.57	8.57	0.15	1.21	±12.19
1750	40.1	1.37	8.29	8.29	8.29	0.23	1.07	±12.19
1900	40.0	1.40	8.00	8.00	8.00	0.22	1.12	±12.19
2000	40.0	1.40	8.08	8.08	8.08	0.23	1.14	±12.19
2300	39.5	1.67	7.74	7.74	7.74	0.54	0.72	±12.19
2450	39.2	1.80	7.55	7.55	7.55	0.57	0.73	±12.19
2600	39.0	1.96	7.34	7.34	7.34	0.63	0.69	±12.19
3300	38.2	2.71	7.00	7.00	7.00	0.51	0.93	±13.39
3500	37.9	2.91	6.95	6.95	6.95	0.47	0.99	±13.39
3700	37.7	3.12	6.75	6.75	6.75	0.50	0.95	±13.39
3900	37.5	3.32	6.65	6.65	6.65	0.40	1.20	±13.39
4100	37.2	3.53	6.63	6.63	6.63	0.40	1.20	±13.39
4200	37.1	3.63	6.56	6.56	6.56	0.40	1.15	±13.39
4400	36.9	3.84	6.40	6.40	6.40	0.40	1.15	±13.39
4600	36.7	4.04	6.35	6.35	6.35	0.45	1.20	±13.39
4800	36.4	4.25	6.27	6.27	6.27	0.45	1.30	±13.39
4950	36.3	4.40	6.13	6.13	6.13	0.45	1.25	±13.39
5250	35.9	4.71	5.43	5.43	5.43	0.45	1.25	±13.39
5600	35.5	5.07	4.80	4.80	4.80	0.55	1.25	±13.39
5750	35.4	5.22	4.83	4.83	4.83	0.50	1.45	±13.39

^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 $\pm 10\%$ 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 $\pm 5\%$. 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.



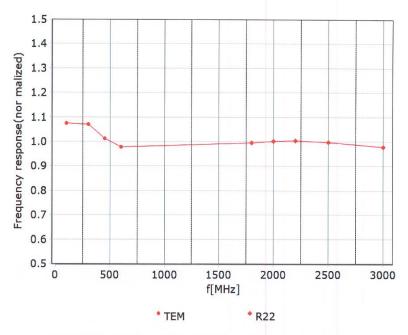


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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ±7.4% (k=2)



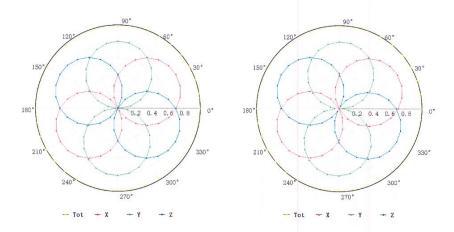


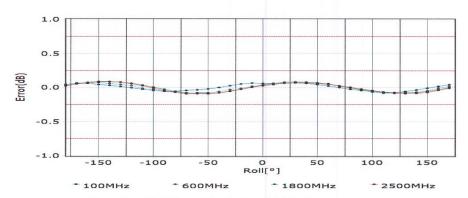
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Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM

f=1800 MHz, R22



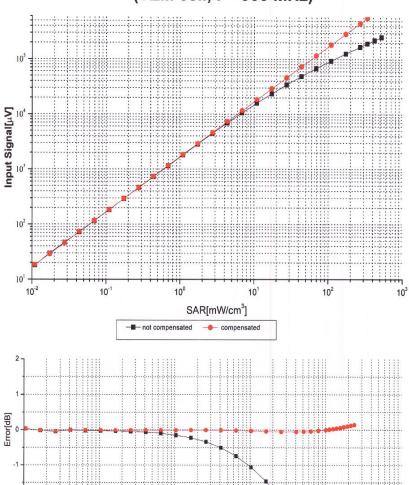


Uncertainty of Axial Isotropy Assessment: ±1.2% (k=2)





Dynamic Range f(SAR_{head}) (TEM cell, f = 900 MHz)



Uncertainty of Linearity Assessment: ±0.9% (k=2)

compensated

SAR[mW/cm3]

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10-1

-2 -



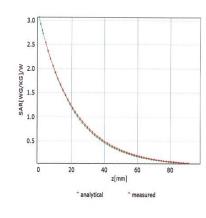


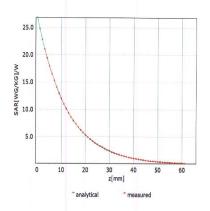
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Conversion Factor Assessment

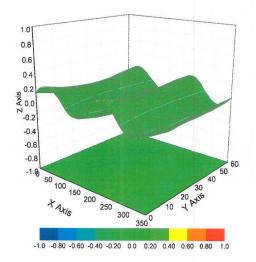
f=750 MHz,WGLS R9(H_convF)

f=1750 MHz,WGLS R22(H_convF)





Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±3.2% (k=2)





DASY/EASY - Parameters of Probe: EX3DV4 - SN:3578

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	170.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	10mm
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



Data Acquisition Electronics



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Certificate No: Z19-60362

Client: **CALIBRATION CERTIFICATE** Object DAE3 - SN: 360 Calibration Procedure(s) FF-Z11-002-01 Calibration Procedure for the Data Acquisition Electronics (DAEx) Calibration date: October 16, 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 Process Calibrator 753 1971018 24-Jun-19 (CTTL, No.J19X05126) Jun-20 Name Function Signature Calibrated by: Yu Zongying SAR Test Engineer Reviewed by: Lin Hao SAR Test Engineer Approved by: Qi Dianyuan SAR Project Leader Issued: October 18, 2019

Certificate No: Z19-60362

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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 provide 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 = 6.1μV , full range = -100...+300 mV

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

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

Calibration Factors	X	Υ	z
High Range	404.185 ± 0.15% (k=2)	404.020 ± 0.15% (k=2)	404.034 ± 0.15% (k=2)
Low Range	3.93488 ± 0.7% (k=2)	3.93589 ± 0.7% (k=2)	3.97175 ± 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	37° ± 1 °
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CALIBRATION CERTIFICATE

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Object

D2450V2 - SN: 952

Calibration Procedure(s)

Client

FF-Z11-003-01

Calibration Procedures for dipole validation kits

Calibration date:

June 10, 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) $^{\circ}$ $^{\circ}$ 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	106277	20-Aug-18 (CTTL, No.J18X06862)	Aug-19
Power sensor NRP8S	104291	20-Aug-18 (CTTL, No.J18X06862)	Aug-19
Reference Probe EX3DV4	SN 7514	27-Aug-18(SPEAG,No.EX3-7514_Aug18)	Aug-19
DAE4	SN 1556	20-Aug-18(SPEAG,No.DAE4-1556_Aug18)	Aug-19
Secondary Standards	ID#	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	23-Jan-19 (CTTL, No.J19X00336)	Jan-20
NetworkAnalyzer E5071C	MY46110673	24-Jan-19 (CTTL, No.J19X00547)	Jan-20

and the second	Name	Function	Signature
Calibrated by:	Zhao Jing	SAR Test Engineer	松光
Reviewed by:	Lin Hao	SAR Test Engineer	11/26
Approved by:	Qi Dianyuan	SAR Project Leader	20

Issued: June 14, 2019

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p e a CALIBRATION LABORATORY

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Glossary:

TSL ConvF N/A

tissue simulating liquid sensitivity in TSL / NORMx,y,z not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "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
- c) 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
- d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

e) 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	52.10.2.1495
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

	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	39.8 ± 6 %	1.83 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	2000	

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.6 W/kg ± 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	6.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.4 W/kg ± 18.7 % (k=2)

Body TSL parameters
The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.1 ± 6 %	1.96 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	mana -	

SAR result with Body TSL

Condition	
250 mW input power	12.8 W/kg
normalized to 1W	50.9 W/kg ± 18.8 % (k=2)
Condition	
250 mW input power	5.94 W/kg
normalized to 1W	23.7 W/kg ± 18.7 % (k=2)
	250 mW input power normalized to 1W Condition 250 mW input power

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.1Ω+ 2.51 JΩ
Return Loss	- 26.8dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.3Ω+ 3.40 jΩ	
Return Loss	- 27.9dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.020 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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Date: 06.10.2019

DASY5 Validation Report for Head TSL Test Laboratory: CTTL, Beijing, China DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 952

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1 Medium parameters used: f = 2450 MHz; $\sigma = 1.825$ S/m; $\epsilon_t = 39.75$; $\rho = 1000$ kg/m3 Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 SN7514; ConvF(6.95, 6.95, 6.95) @ 2450 MHz; Calibrated: 8/27/2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1556; Calibrated: 8/20/2018
- Phantom: MFP_V5.1C; Type: QD 000 P51CA; Serial: 1062
 Measurement SW: DASY52, Version 52.10 (2); SEMCAD X Version 14.6.12 (7450)

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

Reference Value = 97.66 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 27.4 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.11 W/kgMaximum value of SAR (measured) = 22.3 W/kg

dB 4.37 8.74 -13.12

0 dB = 22.3 W/kg = 13.48 dBW/kg

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-17.49

-21.86

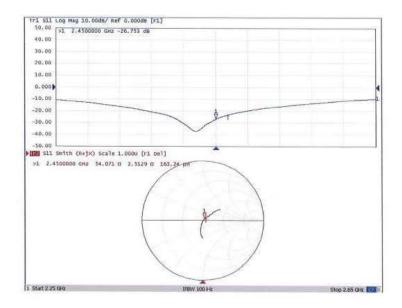
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Impedance Measurement Plot for Head TSL







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Date: 06,10,2019

DASY5 Validation Report for Body TSL Test Laboratory: CTTL, Beijing, China DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 952

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1 Medium parameters used: f = 2450 MHz; $\sigma = 1.962$ S/m; $\varepsilon_r = 52.06$; $\rho = 1000$ kg/m3

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 SN7514; ConvF(7.13, 7.13, 7.13) @ 2450 MHz; Calibrated: 8/27/2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- · Electronics: DAE4 Sn1556; Calibrated: 8/20/2018
- Phantom: MFP_V5.1C; Type: QD 000 P51CA; Serial: 1062
 Measurement SW: DASY52, Version 52.10 (2); SEMCAD X Version 14.6.12 (7450)

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

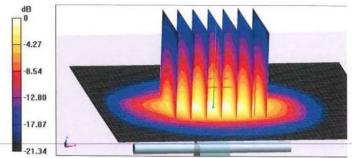
dy=5mm, dz=5mm

Reference Value = 89.63 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 26.4 W/kg

SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.94 W/kg

Maximum value of SAR (measured) = 21.3 W/kg



0 dB = 21.3 W/kg = 13.28 dBW/kg

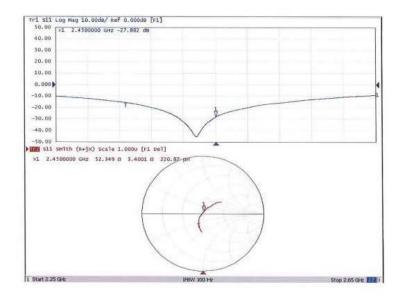
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Impedance Measurement Plot for Body TSL



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