

APPENDIX D: SYSTEM VALIDATION

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table D.1: System Validation Part 1

System No.	Probe SN.	Liquid name	Validation date	Frequency point	Permittivity ϵ	Conductivity σ (S/m)
1	966	Head	2024-06-26	2450 MHz	1.882	38.250
2	1218	Head	2024-06-26	5200 MHz	4.564	34.807
3	1218	Head	2024-06-26	5300 MHz	4.649	34.738
4	1218	Head	2024-06-26	5600 MHz	4.920	34.278
5	1218	Head	2024-06-26	5800 MHz	5.124	33.938

Table D.2: System Validation Part 2

CW Validation	Sensitivity	PASS	PASS
	Probe linearity	PASS	PASS
	Probe Isotropy	PASS	PASS
Mod Validation	MOD.type	QPSK	QPSK
	Duty factor	PASS	PASS
	PAR	PASS	PASS

APPENDIX E: RELEVANT PAGES FROM PROBE CALIBRATION REPORT(S)



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Client	Intertek	Certificate No: 24J02Z000079																																																									
CALIBRATION CERTIFICATE																																																											
Object	EX3DV4 - SN : 7322																																																										
Calibration Procedure(s)	FF-Z11-004-02 Calibration Procedures for Dosimetric E-field Probes																																																										
Calibration date:	March 26, 2024																																																										
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.</p>																																																											
<p>Calibration Equipment used (M&TE critical for calibration)</p> <table border="1"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power Meter NRP2</td> <td>101919</td> <td>12-Jun-23(CTTL, No.J23X05435)</td> <td>Jun-24</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>101547</td> <td>12-Jun-23(CTTL, No.J23X05435)</td> <td>Jun-24</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>101548</td> <td>12-Jun-23(CTTL, No.J23X05435)</td> <td>Jun-24</td> </tr> <tr> <td>Reference 10dBAttenuator</td> <td>18N50W-10dB</td> <td>19-Jan-23(CTTL, No.J23X00212)</td> <td>Jan-25</td> </tr> <tr> <td>Reference 20dBAttenuator</td> <td>18N50W-20dB</td> <td>19-Jan-23(CTTL, No.J23X00211)</td> <td>Jan-25</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN 3846</td> <td>31-May-23(SPEAG, No.EX-3846_May23)</td> <td>May-24</td> </tr> <tr> <td>DAE4</td> <td>SN 1555</td> <td>24-Aug-23(SPEAG, No.DAE4-1555_Aug23)</td> <td>Aug-24</td> </tr> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Cal Date(Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> <tr> <td>Signal/Generator MG3700A</td> <td>6201052605</td> <td>12-Jun-23(CTTL, No.J23X05434)</td> <td>Jun-24</td> </tr> <tr> <td>Network Analyzer E5071C</td> <td>MY46110673</td> <td>25-Dec-23(CTTL, No.J23X13425)</td> <td>Dec-24</td> </tr> <tr> <td>Reference 10dBAttenuator</td> <td>BT0520</td> <td>11-May-23(CTTL, No.J23X04061)</td> <td>May-25</td> </tr> <tr> <td>Reference 20dBAttenuator</td> <td>BT0267</td> <td>11-May-23(CTTL, No.J23X04062)</td> <td>May-25</td> </tr> <tr> <td>OCP DAK-12</td> <td>SN 1174</td> <td>25-Oct-23(SPEAG, No.OCP-DAK12-1174_Oct23)</td> <td>Oct-24</td> </tr> </tbody> </table>				Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRP2	101919	12-Jun-23(CTTL, No.J23X05435)	Jun-24	Power sensor NRP-Z91	101547	12-Jun-23(CTTL, No.J23X05435)	Jun-24	Power sensor NRP-Z91	101548	12-Jun-23(CTTL, No.J23X05435)	Jun-24	Reference 10dBAttenuator	18N50W-10dB	19-Jan-23(CTTL, No.J23X00212)	Jan-25	Reference 20dBAttenuator	18N50W-20dB	19-Jan-23(CTTL, No.J23X00211)	Jan-25	Reference Probe EX3DV4	SN 3846	31-May-23(SPEAG, No.EX-3846_May23)	May-24	DAE4	SN 1555	24-Aug-23(SPEAG, No.DAE4-1555_Aug23)	Aug-24	Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Signal/Generator MG3700A	6201052605	12-Jun-23(CTTL, No.J23X05434)	Jun-24	Network Analyzer E5071C	MY46110673	25-Dec-23(CTTL, No.J23X13425)	Dec-24	Reference 10dBAttenuator	BT0520	11-May-23(CTTL, No.J23X04061)	May-25	Reference 20dBAttenuator	BT0267	11-May-23(CTTL, No.J23X04062)	May-25	OCP DAK-12	SN 1174	25-Oct-23(SPEAG, No.OCP-DAK12-1174_Oct23)	Oct-24
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Calibrated by:	Name	Function	Signature																																																								
	Yu Zongying	SAR Test Engineer																																																									
Reviewed by:	Lin Jun	SAR Test Engineer																																																									
Approved by:	Qi Dianyuan	SAR Project Leader																																																									
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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:

- 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:

- **NORM_{x,y,z}:** Assessed for E-field polarization $\theta=0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ 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.
- **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.
- **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 $f \leq 800$ 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 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 ± 50 MHz to ± 100 MHz.
- **Spherical isotropy (3D deviation from isotropy):** in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- **Sensor Offset:** The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- **Connector Angle:** The angle is assessed using the information gained by determining the NORM_{x,y,z} (no uncertainty required).



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7322

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μ V/(V/m) ²) ^A	0.46	0.57	0.54	$\pm 10.0\%$
DCP(mV) ^B	98.7	97.4	100.9	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB/ μ V	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	159.1	$\pm 2.2\%$
		Y	0.0	0.0	1.0		177.9	
		Z	0.0	0.0	1.0		176.2	

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 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:7322

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	10.03	10.03	10.03	0.14	1.31	± 12.7%
835	41.5	0.90	9.65	9.65	9.65	0.11	1.59	± 12.7%
1750	40.1	1.37	8.30	8.30	8.30	0.23	1.06	± 12.7%
1900	40.0	1.40	7.96	7.96	7.96	0.27	0.99	± 12.7%
2300	39.5	1.67	7.64	7.64	7.64	0.65	0.65	± 12.7%
2450	39.2	1.80	7.36	7.36	7.36	0.60	0.69	± 12.7%
2600	39.0	1.96	7.10	7.10	7.10	0.41	0.90	± 12.7%
5250	35.9	4.71	5.25	5.25	5.25	0.45	1.40	± 13.9%
5600	35.5	5.07	4.65	4.65	4.65	0.55	1.20	± 13.9%
5750	35.4	5.22	4.80	4.80	4.80	0.50	1.30	± 13.9%

^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 up to 6 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

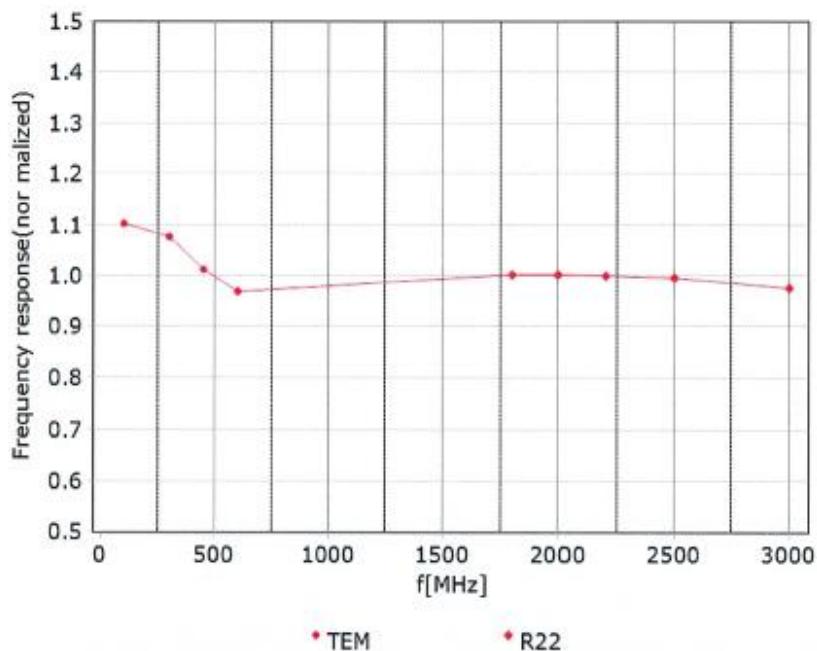
^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from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



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



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

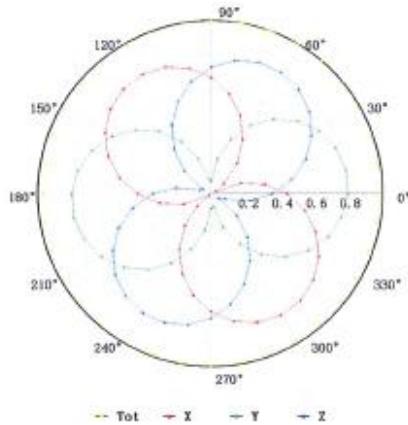


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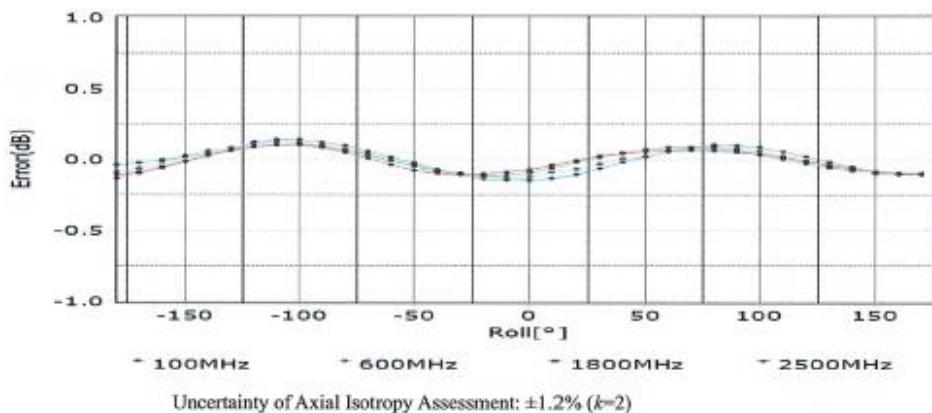
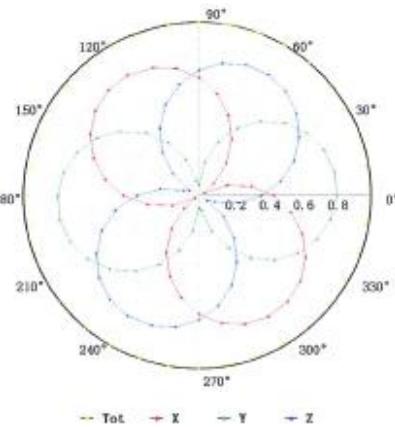


Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM

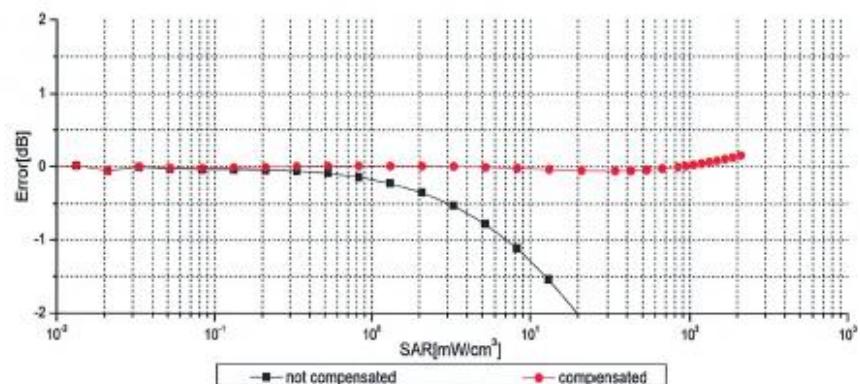
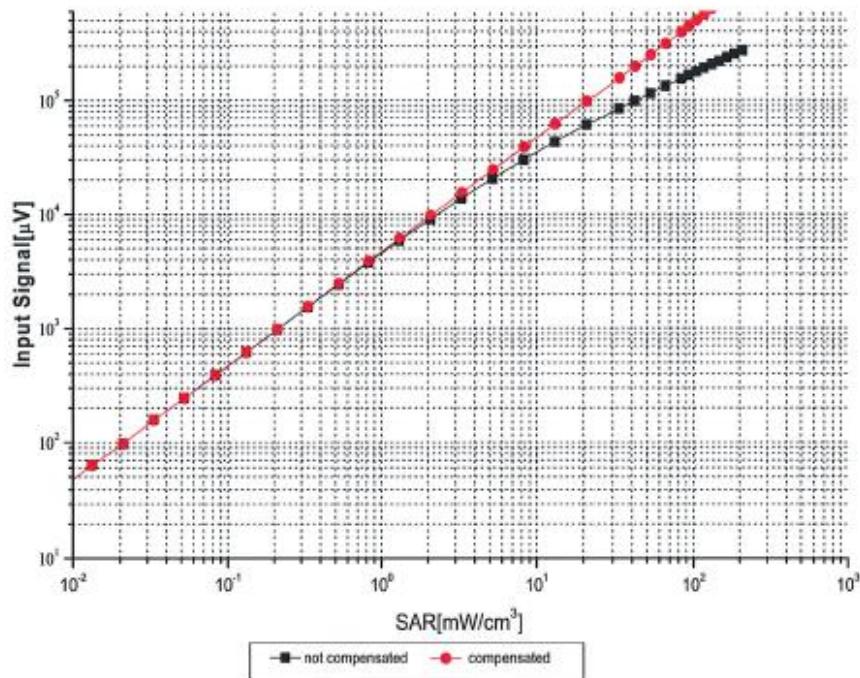


f=1800 MHz, R22



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



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



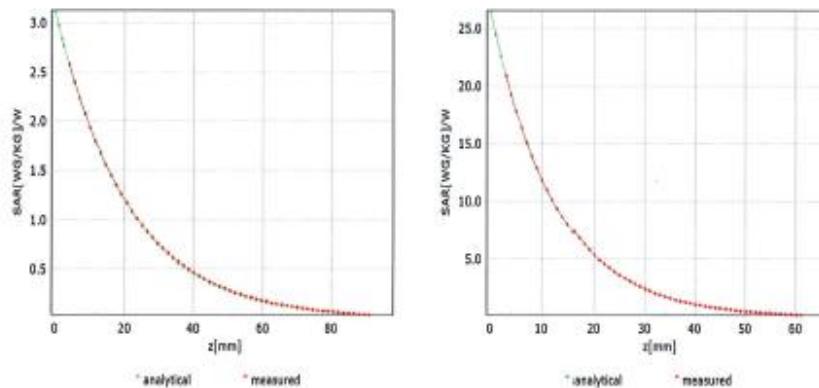
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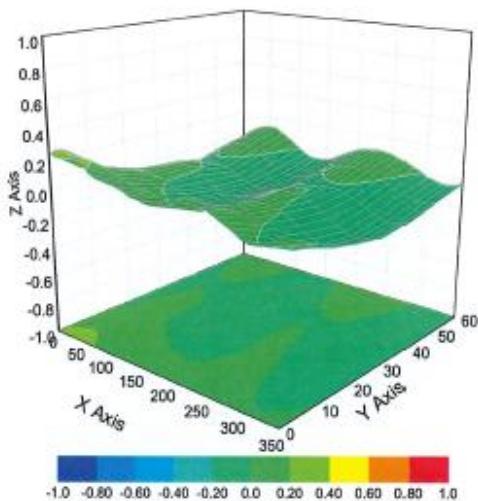
Conversion Factor Assessment

$f=750 \text{ MHz}, \text{WGLS R9(H_convF)}$

$f=1750 \text{ MHz}, \text{WGLS R22(H_convF)}$



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: $\pm 3.2\% (k=2)$



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7322

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	41.2
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

APPENDIX F: RELEVANT PAGES FROM DIPOLE VALIDATION KIT REPORT(S)



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Client

Intertek

Certificate No: Z21-60413

CALIBRATION CERTIFICATE

Object D2450V2 - SN: 966

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

Calibration date: October 21, 2021

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 NRP2	106277	24-Sep-21 (CTTL, No.J21X08326)	Sep-22
Power sensor NRP8S	104291	24-Sep-21 (CTTL, No.J21X08326)	Sep-22
Reference Probe EX3DV4	SN 7517	03-Feb-21(CTTL-SPEAG, No.Z21-60001)	Feb-22
DAE4	SN 1556	15-Jan-21(SPEAG, No.DAE4-1556_Jan21)	Jan-22
Secondary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	01-Feb-21 (CTTL, No.J21X00593)	Jan-22
Network Analyzer E5071C	MY48110673	14-Jan-21 (CTTL, No.J21X00232)	Jan-22

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

Issued: October 27, 2021

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Glossary:

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

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "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	V52.10.4
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	

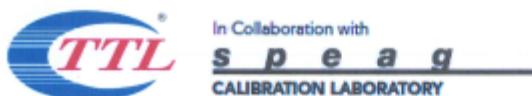
Head TSL parameters

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	39.5 ± 6 %	1.81 mho/m ± 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	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.4 W/kg ± 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.98 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.9 W/kg ± 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	54.2Ω + 3.04jΩ
Return Loss	- 26.0dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.064 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: 10.21.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 966

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.809$ S/m; $\epsilon_r = 39.51$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7517; ConvF(7.34, 7.34, 7.34) @ 2450 MHz; Calibrated: 2021-02-03
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1556; Calibrated: 2021-01-15
- Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

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

Reference Value = 107.2 V/m; Power Drift = 0.00 dB

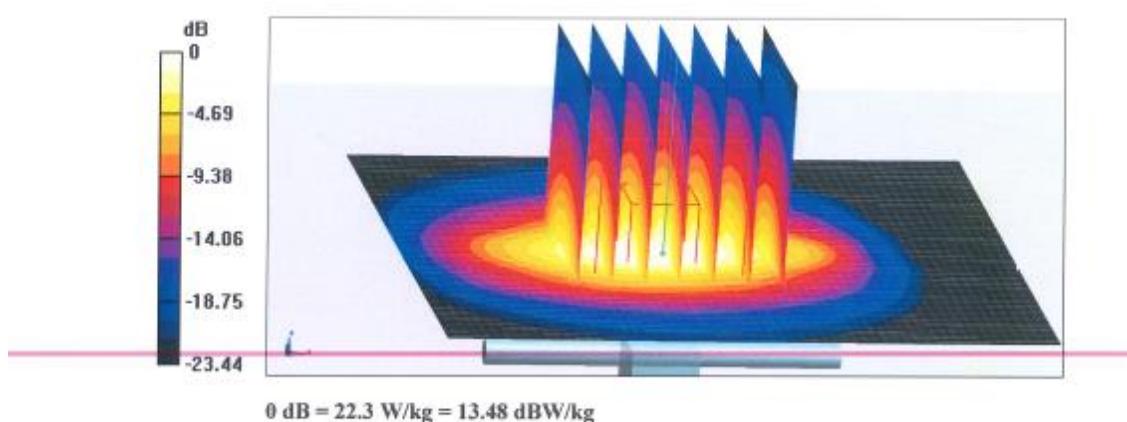
Peak SAR (extrapolated) = 27.7 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 5.98 W/kg

Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 46.9%

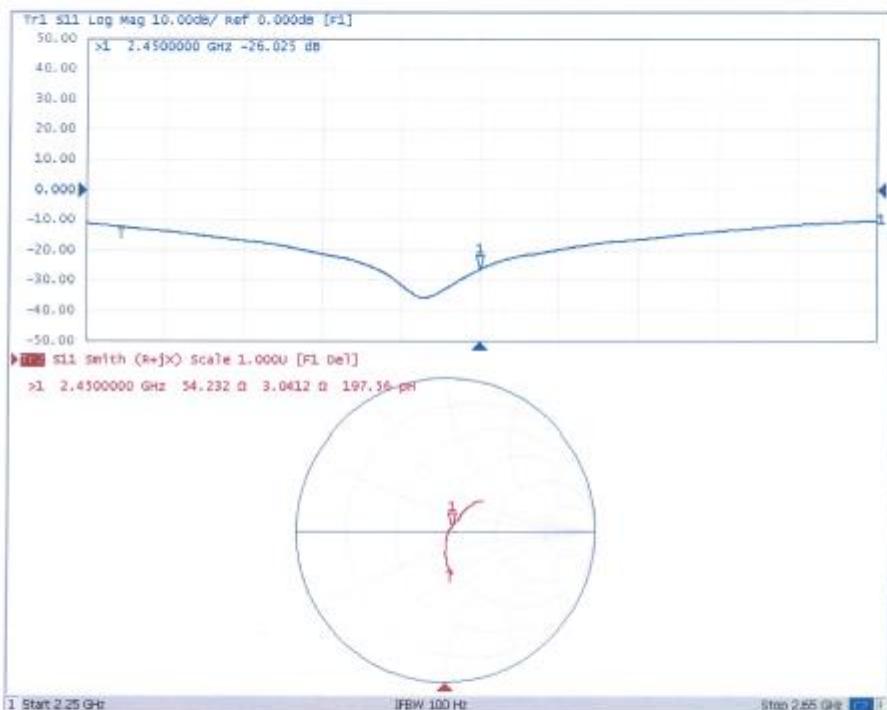
Maximum value of SAR (measured) = 22.3 W/kg





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Impedance Measurement Plot for Head TSL



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Client

Intertek

Certificate No: Z21-60415

CALIBRATION CERTIFICATE

Object D5GHzV2 - SN: 1218

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

Calibration date: October 15, 2021

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 NRP2	106277	24-Sep-21 (CTTL, No.J21X08326)	Sep-22
Power sensor NRP8S	104291	24-Sep-21 (CTTL, No.J21X08326)	Sep-22
ReferenceProbe EX3DV4	SN 3617	27-Jan-21(SPEAG, No. EX3-3617_Jan21)	Jan-22
DAE4	SN 1556	15-Jan-21(SPEAG, No. DAE4-1556_Jan21)	Jan-22
Secondary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	01-Feb-21 (CTTL, No.J21X00593)	Jan-22
NetworkAnalyzerE5071C	MY46110673	14-Jan-21 (CTTL, No.J21X00232)	Jan-22

Calibrated by: Name Zhao Jing Function SAR Test Engineer Signature

Reviewed by: Lin Hao SAR Test Engineer

Approved by: Qi Dianyuan SAR Project Leader

Issued: October 21, 2021

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 / NORMx,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "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	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	$dx, dy = 4 \text{ mm}, dz = 1.4 \text{ mm}$	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz $\pm 1 \text{ MHz}$ 5300 MHz $\pm 1 \text{ MHz}$ 5600 MHz $\pm 1 \text{ MHz}$ 5800 MHz $\pm 1 \text{ MHz}$	

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	35.5 ± 6 %	4.59 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	---	---

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.67 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	76.4 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.9 W/kg ± 24.2 % (k=2)



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Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.3 ± 6 %	4.71 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	---	---

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.82 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	77.9 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.4 W/kg ± 24.2 % (k=2)

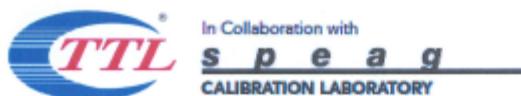
Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.8 ± 6 %	5.04 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	---	---

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.3 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.0 W/kg ± 24.2 % (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	34.5 ± 6 %	5.23 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	—	—

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.86 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.2 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.3 W/kg ± 24.2 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)**Antenna Parameters with Head TSL at 5200 MHz**

Impedance, transformed to feed point	52.5Ω - 5.98jΩ
Return Loss	- 24.0dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	49.2Ω - 0.41jΩ
Return Loss	- 40.8dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	52.9Ω - 2.25jΩ
Return Loss	- 28.9dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.3Ω + 5.56jΩ
Return Loss	- 22.1dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.093 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: 10.15.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1218

Communication System: CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz,
Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 4.589 \text{ S/m}$; $\epsilon_r = 35.48$; $\rho = 1000 \text{ kg/m}^3$, Medium parameters used: $f = 5300 \text{ MHz}$; $\sigma = 4.711 \text{ S/m}$; $\epsilon_r = 35.29$; $\rho = 1000 \text{ kg/m}^3$, Medium parameters used: $f = 5600 \text{ MHz}$; $\sigma = 5.041 \text{ S/m}$; $\epsilon_r = 34.82$; $\rho = 1000 \text{ kg/m}^3$, Medium parameters used: $f = 5800 \text{ MHz}$; $\sigma = 5.232 \text{ S/m}$; $\epsilon_r = 34.49$; $\rho = 1000 \text{ kg/m}^3$,

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3617; ConvF(5.5, 5.5, 5.5) @ 5200 MHz; ConvF(5.3, 5.3, 5.3) @ 5300 MHz; ConvF(5, 5, 5) @ 5600 MHz; ConvF(5.02, 5.02, 5.02) @ 5800 MHz; Calibrated: 2021-01-27
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1556; Calibrated: 2021-01-15
- Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Dipole Calibration /Pin=100mW, d=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.69 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 30.4 W/kg

SAR(1 g) = 7.67 W/kg; SAR(10 g) = 2.2 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 65.5%

Maximum value of SAR (measured) = 17.7 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 72.16 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 32.0 W/kg

SAR(1 g) = 7.82 W/kg; SAR(10 g) = 2.25 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 64.1%

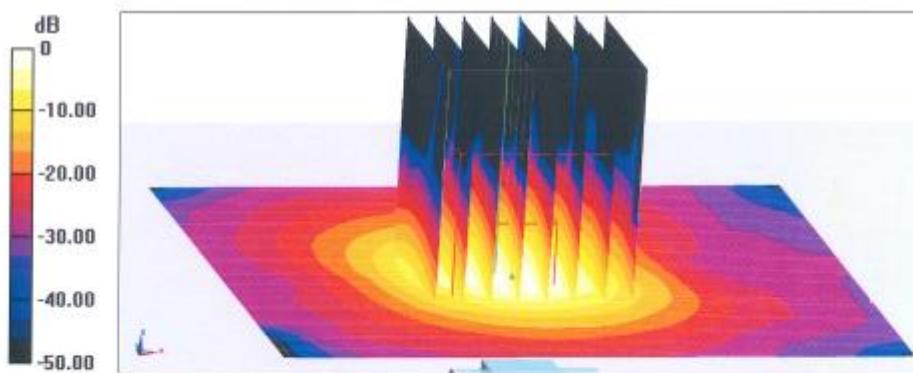
Maximum value of SAR (measured) = 18.1 W/kg



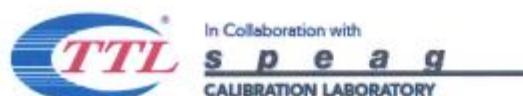
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Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.99 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 35.2 W/kg
SAR(1 g) = 8.06 W/kg; SAR(10 g) = 2.31 W/kg
Smallest distance from peaks to all points 3 dB below = 7.5 mm
Ratio of SAR at M2 to SAR at M1 = 62.5%
Maximum value of SAR (measured) = 19.6 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.43 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 35.7 W/kg
SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.24 W/kg
Smallest distance from peaks to all points 3 dB below = 7.5 mm
Ratio of SAR at M2 to SAR at M1 = 61.2%
Maximum value of SAR (measured) = 19.4 W/kg

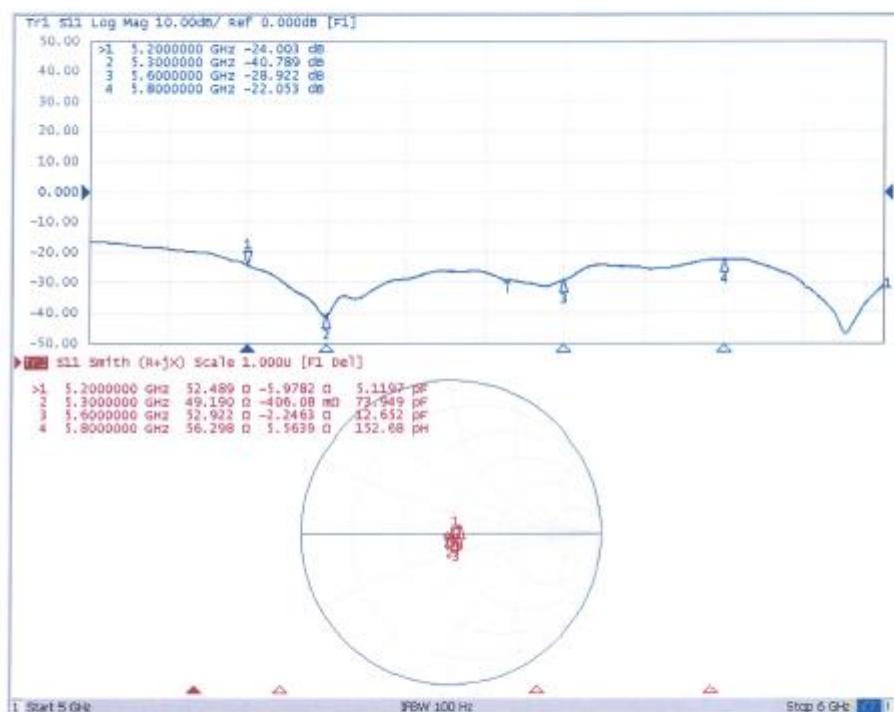


0 dB = 19.4 W/kg = 12.88 dBW/kg



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Impedance Measurement Plot for Head TSL



APPENDIX G: RELEVANT PAGES FROM DAE CALIBRATION REPORT(S)

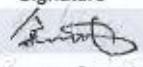
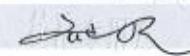
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CALIBRATION
CNAS L0570

Client : **Intertek** Certificate No: 24J02Z000078

CALIBRATION CERTIFICATE

Object	DAE4 - SN: 1473		
Calibration Procedure(s)	FF-Z11-002-01 Calibration Procedure for the Data Acquisition Electronics (DAEx)		
Calibration date:	March 18, 2024		
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
Process Calibrator 753	1971018	12-Jun-23 (CTTL, No.J23X05436)	Jun-24
Calibrated by:	Name	Function	Signature
	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Jun	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	
Issued: March 20, 2024			
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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 = $6.1\mu V$, full range = $-100\dots+300\text{ mV}$
Low Range: 1LSB = 61nV , full range = $-1\dots+3\text{mV}$

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

Calibration Factors	X	Y	Z
High Range	$404.013 \pm 0.15\% \text{ (k=2)}$	$404.606 \pm 0.15\% \text{ (k=2)}$	$404.459 \pm 0.15\% \text{ (k=2)}$
Low Range	$3.96391 \pm 0.7\% \text{ (k=2)}$	$3.99545 \pm 0.7\% \text{ (k=2)}$	$3.98870 \pm 0.7\% \text{ (k=2)}$

Connector Angle

Connector Angle to be used in DASY system	$346^\circ \pm 1^\circ$
---	-------------------------