



SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch

SZEMC-TRF-01 Rev. A/0 Aug01,2022

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Appendix C for SZCR2303000567AT

Calibration certificate

1. Dipole
D2450V2 - SN 955(2022/06/06)
2. DAE
DAE4 - SN 760(2022/06/06)
3. Probe
EX3DV4 - SN 3836(2022/06/27)



SGS-CSTC Standards Technical Services Co., Ltd.
Shenzhen Branch / 深圳 SGS-CSTC 实验室

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D2450V2 - SN 955

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Measurement Conditions

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

DASY Version	DASY52	52.10.4
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	40.0 ± 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	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.4 W/kg ± 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	6.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.9 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	52.80 ± 2.96jΩ
Return Loss	-28.1dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.071 ns
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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 arms, because they might bend or the soldered connections near the feed-point may be damaged.

Additional EUT Data

Manufactured by	SPEAG
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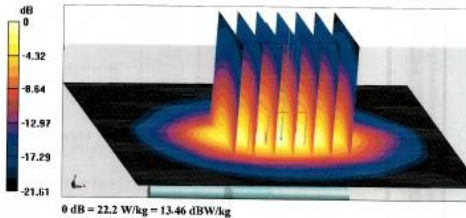
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DASY5 Validation Report for Head TSL
Test Laboratory: CTTL, Beijing, China
DU1: Dipole 2450 MHz; Type: D2450V2 - SN: 955
Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium parameters used: $f = 2450$ MHz; $\sigma = 1.806$ S/m; $\epsilon_r = 40.03$; $\rho = 1000$ kg/m³
Phantom section: Right Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)
DASY5 Configuration:

- Probe: EX3DV4 - SN7464; ConvF(7.77, 7.77, 7.77) @ 2450 MHz; Calibrated: 2022-01-26
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 S01556; Calibrated: 2022-01-12
- Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration/Zoom Scan (7x7x7) (7x7x7) Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.82 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 27.2 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.21 W/kg
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 49.5%
Maximum value of SAR (measured) = 22.2 W/kg



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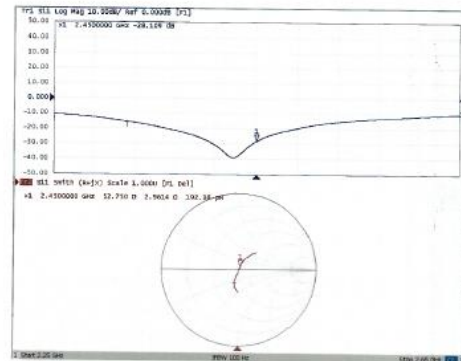
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Impedance Measurement Plot for Head TSL



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2. DAE4 - SN 760

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Client: CCS-SZ Certificate No: Z22-60169

CALIBRATION CERTIFICATE

Object: DAE4 - SN: 760

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

Calibration date: June 06, 2022

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	15-Jun-21 (CTTL No.J21X04485)	Jun-22

Calibrated by: Name: Yu Zongying Function: SAR Test Engineer Signature: [Signature]

Reviewed by: Name: Lin Hso Function: SAR Test Engineer Signature: [Signature]

Approved by: Name: Qi Dianyuan Function: SAR Project Leader Signature: [Signature]

Issued: June 09, 2022

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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	Y	Z
High Range	403.805 ± 0.15% (k=2)	405.067 ± 0.15% (k=2)	405.367 ± 0.15% (k=2)
Low Range	3.97876 ± 0.7% (k=2)	3.98240 ± 0.7% (k=2)	3.98267 ± 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	250° ± 1°
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3. EX3DV4 - SN 3836

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Client: CCS-SZ		Certificate No: Z22-60168																																													
CALIBRATION CERTIFICATE																																															
Object	EX3DV4 - SN: 3836																																														
Calibration Procedure(s)	FF-Z11-004-02 Calibration Procedures for Dosimetric E-field Probes																																														
Calibration date:	June 27, 2022																																														
<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&E 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>14-Jun-22(CTTL, No.J22X04181)</td> <td>Jun-23</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>101547</td> <td>14-Jun-22(CTTL, No.J22X04181)</td> <td>Jun-23</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>101548</td> <td>14-Jun-22(CTTL, No.J22X04181)</td> <td>Jun-23</td> </tr> <tr> <td>Reference 10dBAttenuator</td> <td>18N50W-10dB</td> <td>20-Jan-21(CTTL, No.J21X00486)</td> <td>Jan-23</td> </tr> <tr> <td>Reference 20dBAttenuator</td> <td>18N50W-20dB</td> <td>20-Jan-21(CTTL, No.J21X00486)</td> <td>Jan-23</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN 7464</td> <td>26-Jan-22(SPEAG, No EX3-7464, Jan22)</td> <td>Jan-23</td> </tr> <tr> <td>DAEA</td> <td>SN 1556</td> <td>20-Aug-21(SPEAG, No.DAE4-1555_Aug21/2)</td> <td>Aug-22</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Cal Date/Calibrated by, Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>SignalGenerator MG3700A</td> <td>6201062805</td> <td>14-Jun-22(CTTL, No.J22X04182)</td> <td>Jun-23</td> </tr> <tr> <td>Network Analyzer ES071C</td> <td>MY46110673</td> <td>14-Jan-22(CTTL, No.J22X00406)</td> <td>Jan-23</td> </tr> </tbody> </table> <p>Calibrated by: Yu Zongying SAR Test Engineer</p> <p>Reviewed by: Lin Hao SAR Test Engineer</p> <p>Approved by: Qi Dianyan SAR Project Leader</p> <p>Issued: July 06, 2022</p> <p>This calibration certificate shall not be reproduced except in full without written approval of the laboratory.</p>				Primary Standards	ID #	Cal Date/Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRP2	101919	14-Jun-22(CTTL, No.J22X04181)	Jun-23	Power sensor NRP-Z91	101547	14-Jun-22(CTTL, No.J22X04181)	Jun-23	Power sensor NRP-Z91	101548	14-Jun-22(CTTL, No.J22X04181)	Jun-23	Reference 10dBAttenuator	18N50W-10dB	20-Jan-21(CTTL, No.J21X00486)	Jan-23	Reference 20dBAttenuator	18N50W-20dB	20-Jan-21(CTTL, No.J21X00486)	Jan-23	Reference Probe EX3DV4	SN 7464	26-Jan-22(SPEAG, No EX3-7464, Jan22)	Jan-23	DAEA	SN 1556	20-Aug-21(SPEAG, No.DAE4-1555_Aug21/2)	Aug-22	Secondary Standards	ID #	Cal Date/Calibrated by, Certificate No.)	Scheduled Calibration	SignalGenerator MG3700A	6201062805	14-Jun-22(CTTL, No.J22X04182)	Jun-23	Network Analyzer ES071C	MY46110673	14-Jan-22(CTTL, No.J22X00406)	Jan-23
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<p>Glossary:</p> <p>TSL: tissue simulating liquid</p> <p>NORM_{x,y,z}: sensitivity in free space</p> <p>ConvF: sensitivity in TSL / NORM_{x,y,z}</p> <p>DCP: diode compression point</p> <p>CF: crest factor (RMS, cycle) of the RF signal</p> <p>A, B, C, D: modulation dependent linearization parameters</p> <p>Φ: rotation around probe axis</p> <p>Polarization 0: θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e. θ is normal to probe axis</p> <p>Connector Angle: information used in DASy4 system to align probe sensor X to the robot coordinate system</p> <p>Calibration is Performed According to the Following Standards:</p> <p>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</p> <p>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 2018</p> <p>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</p> <p>d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"</p> <p>Methods Applied and Interpretation of Parameters:</p> <ul style="list-style-type: none"> NORM_{x,y,z}: Assessed for E-field polarization θ=0 (f<900MHz in TEM-cell; f>1800MHz: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E-field uncertainty inside TSL (see below ConvF). NORM_{avg}: NORM_{avg} = 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}; V_{RF}; 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 values are given. These parameters are used in DASy4 software to improve probe accuracy close to the boundary. The sensitivity in TEL 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 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 NORM_x (no uncertainty required). 			
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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3836

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu V/(V/m)^2$) ^A	0.41	0.47	0.45	±10.0%
DCP(mV) ^B	92.8	102.2	100.3	

Modulation Calibration Parameters

UID	Communication System Name	A dB	B dB μV	C	D dB	VR mV	Unc ^C (k=2)
0	CW	X	0.0	0.0	1.0	0.00	138.2 ±2.7%
		Y	0.0	0.0	1.0		157.7
		Z	0.0	0.0	1.0		147.9

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.

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

Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc ^H (k=2)
750	41.9	0.85	9.28	9.28	9.28	0.16	1.34	±12.1%
835	41.6	0.90	8.99	8.99	8.99	0.22	1.19	±12.1%
1750	40.1	1.37	8.02	8.02	8.02	0.28	0.95	±12.1%
1900	40.0	1.40	7.65	7.65	7.65	0.30	0.92	±12.1%
2100	39.8	1.49	7.80	7.80	7.80	0.22	1.15	±12.1%
2300	39.6	1.67	7.57	7.57	7.57	0.85	0.88	±12.1%
2450	39.2	1.80	7.27	7.27	7.27	0.67	0.67	±12.1%
2600	39.0	1.96	6.99	6.99	6.99	0.58	0.75	±12.1%
3300	38.2	2.71	6.84	6.84	6.84	0.40	0.95	±13.3%
3500	37.9	2.91	6.80	6.80	6.80	0.43	0.94	±13.3%
3700	37.7	3.12	6.32	6.32	6.32	0.40	1.03	±13.3%
3900	37.5	3.32	6.36	6.36	6.36	0.35	1.35	±13.3%
4100	37.2	3.53	6.30	6.30	6.30	0.40	1.15	±13.3%
5250	35.9	4.71	5.28	5.28	5.28	0.45	1.30	±13.3%
5500	35.5	5.07	4.70	4.70	4.70	0.50	1.28	±13.3%
5750	35.4	5.22	4.78	4.78	4.78	0.45	1.40	±13.3%

^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ± 50 MHz. 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 $\pm 10, 25, 40, 50$ 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 (x and y) can be related to $\pm 10\%$ if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (x and y) 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 $\pm 1\%$ for frequencies below 3 GHz and below $\pm 2\%$ for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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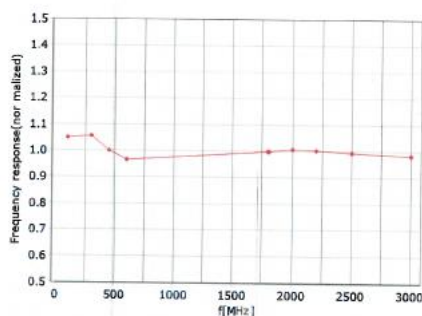
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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



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

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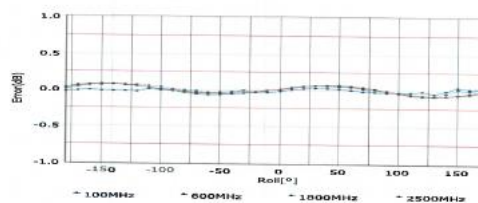
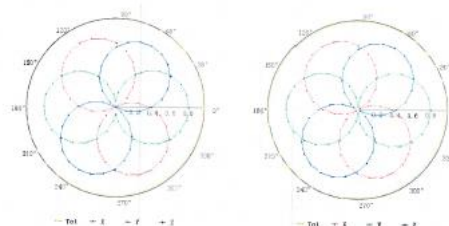
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM

f=1800 MHz, R22



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

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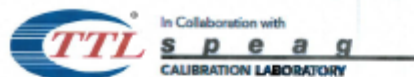


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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3836

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	46.5
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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