Appendix C: System Calibration Certificate

Calibration information for E-field probes





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Client

JYT

Certificate No: Z23-60001

CALIBRATION CERTIFICATE

Object

EX3DV4 - SN: 3924

Calibration Procedure(s)

FF-Z11-004-02

Calibration Procedures for Dosimetric E-field Probes

Calibration date:

January 03, 2023

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	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.J21X00485)	Jan-23
Reference Probe EX3DV4	SN 3846	20-May-22(SPEAG, No.EX3-3846_May	22) May-23
DAE4	SN 771	20-Jan-22(SPEAG, No.DAE4-771_Jan2	22) Jan-23
Secondary Standards	ID#	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGenerator MG3700A	6201052605	14-Jun-22(CTTL, No.J22X04182)	Jun-23
Network Analyzer E5071C	MY46110673	14-Jan-22(CTTL, No.J22X00406)	Jan-23
	lame	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	Que 1
Reviewed by:	Lin Hao	SAR Test Engineer	林光
Approved by:	Qi Dianyuan	SAR Project Leader	dra

Issued: January 10, 2023

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Certificate No: Z23-60001

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Glossary:

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

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

Φ rotation around probe axis Polarization Φ

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

0=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

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).

Certificate No: Z23-60001

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3924

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(µV/(V/m)²)^	0.51	0.41	0.67	±10.0%
DCP(mV) ^B	101.3	100.4	99.2	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dBõV	С	D dB	VR mV	Unc ^E (<i>k</i> =2)
0	0 CW	х	0.0	0.0	1.0	0.00	171.4	±2.0%
		Y	0.0	0.0	1.0		151.5	
		Z	0.0	0.0	1.0		199.7	

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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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.





DASY/EASY - Parameters of Probe: EX3DV4 - SN:3924

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	10.20	10.20	10.20	0.12	1.31	±12.7%
835	41.5	0.90	9.80	9.80	9.80	0.17	1.11	±12.7%
900	41.5	0.97	9.71	9.71	9.71	0.12	1.44	±12.7%
1750	40.1	1.37	8.38	8.38	8.38	0.20	1.12	±12.7%
1900	40.0	1.40	8.05	8.05	8.05	0.21	1.08	±12.7%
2100	39.8	1.49	8.10	8.10	8.10	0.18	1.17	±12.7%
2300	39.5	1.67	7.85	7.85	7.85	0.38	0.76	±12.7%
2450	39.2	1.80	7.60	7.60	7.60	0.41	0.76	±12.7%
2600	39.0	1.96	7.35	7.35	7.35	0.38	0.83	±12.7%
3300	38.2	2.71	7.20	7.20	7.20	0.34	1.02	±13.9%
3500	37.9	2.91	7.02	7.02	7.02	0.36	0.93	±13.9%
3700	37.7	3.12	6.75	6.75	6.75	0.35	1.05	±13.9%
3900	37.5	3.32	6.62	6.62	6.62	0.30	1.45	±13.9%
4100	37.2	3.53	6.53	6.53	6.53	0.30	1.40	±13.9%
4400	36.9	3.84	6.32	6.32	6.32	0.30	1.50	±13.9%
4600	36.7	4.04	6.24	6.24	6.24	0.40	1.35	±13.9%
4800	36.4	4.25	6.17	6.17	6.17	0.35	1.50	±13.9%
4950	36.3	4.40	5.95	5.95	5.95	0.40	1.35	±13.9%
5250	35.9	4.71	5.41	5.41	5.41	0.45	1.30	±13.9%
5600	35.5	5.07	4.80	4.80	4.80	0.40	1.53	±13.9%
5750	35.4	5.22	4.90	4.90	4.90	0.40	1.55	±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.

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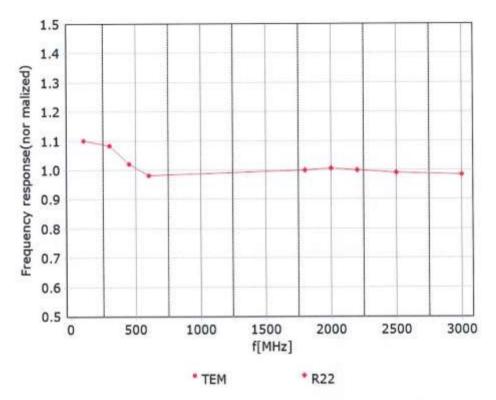
FAt frequency up to 6 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to $\pm 10\%$ if liquid compensation formula is applied to measured SAR values. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

GAIpha/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.





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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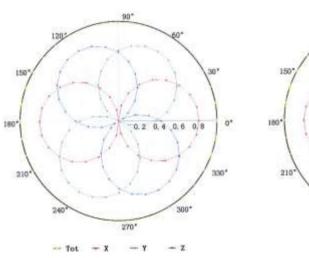


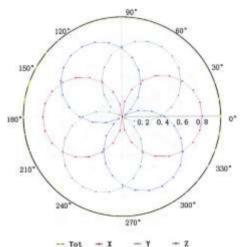
E-mail: emf@caict.ac.en

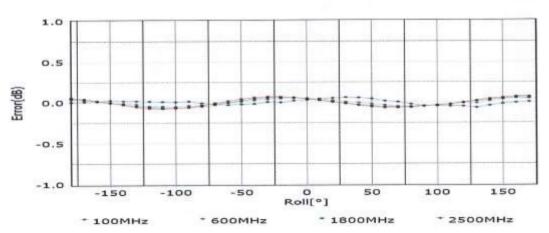
Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM

f=1800 MHz, R22







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

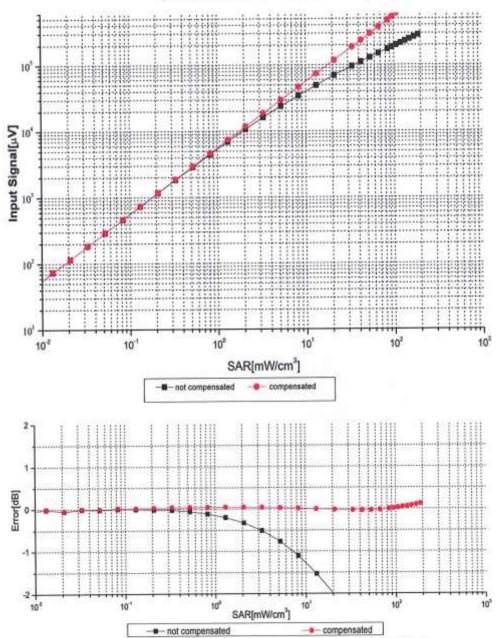
Certificate No: Z23-60001

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



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

Certificate No: Z23-60001

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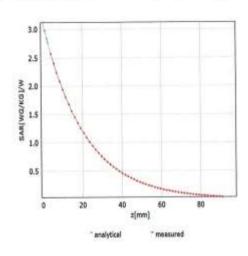


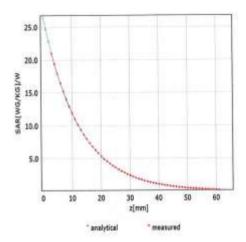


Conversion Factor Assessment

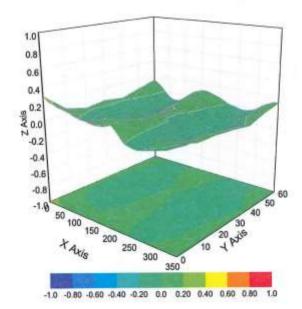
f=750 MHz,WGLS R9(H_convF)

f=1750 MHz,WGLS R22(H_convF)





Deviation from Isotropy in Liquid



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

Certificate No: Z23-60001

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3924

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	161.7
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

Certificate No: Z23-60001

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Calibration information for Dipole

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





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Client JYT (Auden) Accreditation No.: SCS 0108

Certificate No: D1750V2-1177 Feb21

CALIBRATION CERTIFICATE

Object

D1750V2 - SN:1177

Calibration procedure(s)

QA CAL-05.v11

Calibration Procedure for SAR Validation Sources between 0.7-3 GHz

Calibration date:

February 10, 2021

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (St). 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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Reference 20 dB Attenuator	SN: BH9394 (20k)	31-Mar-20 (No. 217-03106)	Apr-21
Type-N mismatch combination	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	Apr-21
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21
Secondary Standards	ID#	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21
	Name	Function	Signature
Calibrated by:	Jeffrey Katzman	Laboratory Technician	1.40
Approved by:	Katja Pokovic	Technical Manager	BAL

Issued: February 11, 2021

Certificate No: D1750V2-1177_Feb21

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





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

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

Glossary:

TSL

tissue simulating liquid

ConvF

sensitivity in TSL / NORM x.v.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 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"

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%.

Certificate No: D1750V2-1177_Feb21

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Measurement Conditions

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

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1,37 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.4 ± 6 %	1.34 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	erene.	****

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.00 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4,73 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.0 W/kg ± 16.5 % (k=2)

Certificate No: D1750V2-1177_Feb21

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.5 Ω - 1.2 jΩ	
Return Loss	- 37.5 dB	

General Antenna Parameters and Design

Electrical Delay (one direction) 1.218 ns	Electrical Delay (one direction)	1.218 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

Certificate No: D1750V2-1177_Feb21

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DASY5 Validation Report for Head TSL

Date: 10.02.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1177

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used: f = 1750 MHz; $\sigma = 1.34 \text{ S/m}$; $\varepsilon_r = 39.4$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.67, 8.67, 8.67) @ 1750 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.3 V/m; Power Drift = 0.02 dB

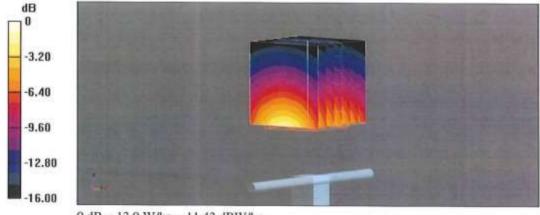
Peak SAR (extrapolated) = 16.7 W/kg

SAR(1 g) = 9 W/kg; SAR(10 g) = 4.73 W/kg

Smallest distance from peaks to all points 3 dB below = 10 mm

Ratio of SAR at M2 to SAR at M1 = 54.2%

Maximum value of SAR (measured) = 13.9 W/kg

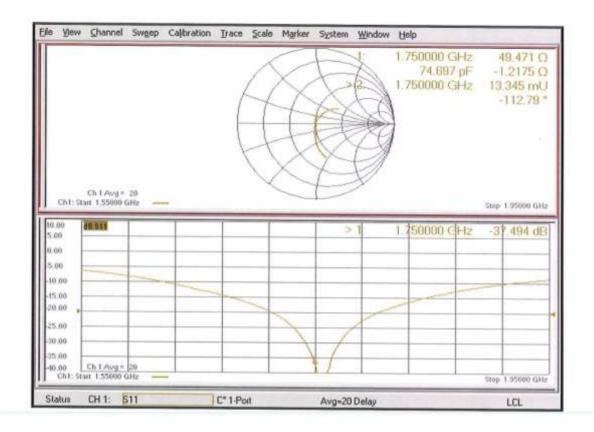


0 dB = 13.9 W/kg = 11.43 dBW/kg

Certificate No: D1750V2-1177_Feb21

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Impedance Measurement Plot for Head TSL



Certificate No: D1750V2-1177_Feb21

Dipole Impedance and Return Loss calibration Report

Object: D1750V2 - SN: 1177

Calibration Date: February 01, 2023

IEC/IEEE 62209-1528, IEC 62209-1:2016, FCC KDB 865664 Calibration reference:

Janet Wei (Janet Wei, SAR project engineer)
Winner thang Calibrated By:

Reviewed By:

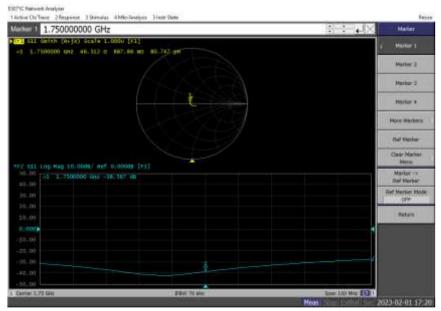
(Winner Zhang, Technical manager)

Environment of Test Site

Temperature:	21 ~ 23°C
Humidity:	50~60% RH
Atmospheric Pressure:	1011 mbar

Test Data

Measurement Plot for Head TSL In 2023



Comparison with Original report

Items	Calibrated By JYT In 2022	Calibrated By JYT In 2023	Deviation	Limit
Impendence for Head TSL	49.62Ω +2.47jΩ	46.51Ω +0.89jΩ	0.12Ω –3.67jΩ	±5Ω
Return Loss for Head TSL	-40.42	-38.57	-4.58%	±20%(No less than 20 dB)

Result

Compliance

Calibration information for DAE



Add: No.52 HunYuanBei Road, Haidian District, Beijing, 100191, China Fax: +86-10-62304633-2504 Tel: +86-10-62304633-2512 E-mail: cttl@chinattl.com Http://www.chinattl.cn



Certificate No: Z22-60209

Client :

CALIBRATION CERTIFICATE

Object DAE4 - SN: 1373

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Scheduled Calibration Cal Date(Calibrated by, Certificate No.) Primary Standards ID# Jun-22 15-Jun-21 (CTTL, No.J21X04465) Process Calibrator 753 1971018

Calibrated by:

Name

Function

Signature

Yu Zongying

Qi Dianyuan

SAR Test Engineer

Reviewed by:

Approved by:

Lin Hao

SAR Test Engineer SAR Project Leader

Issued: June 09, 2022

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Certificate No: Z22-60209

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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.

Certificate No: Z22-60209

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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	403.940 ± 0.15% (k=2)	403.903 ± 0.15% (k=2)	404.196 ± 0.15% (k=2)
Low Range	3.98687 ± 0.7% (k=2)	4.00795 ± 0.7% (k=2)	4.01128 ± 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system		347° ± 1 °	
Connector Angle to be used	III DAST system	347 1.1	

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-----End of Report-----