

1.2. Probe Calibration Certificate



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 CALIBRATION LABORATORY

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 CNAS L0570

Client

HTW

Certificate No: Z21-60064

CALIBRATION CERTIFICATE

Object EX3DV4 - SN : 7494

Calibration Procedure(s) FF-Z11-004-02
 Calibration Procedures for Dosimetric E-field Probes

Calibration date: April 09, 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	101919	16-Jun-20(CTTL, No.J20X04344)	Jun-21
Power sensor	NRP-Z91	101547	16-Jun-20(CTTL, No.J20X04344)	Jun-21
Power sensor	NRP-Z91	101548	16-Jun-20(CTTL, No.J20X04344)	Jun-21
Reference	10dBAttenuator	18N50W-10dB	10-Feb-20(CTTL, No.J20X00525)	Feb-22
Reference	20dBAttenuator	18N50W-20dB	10-Feb-20(CTTL, No.J20X00526)	Feb-22
Reference Probe	EX3DV4	SN 7307	29-May-20(SPEAG, No.EX3-7307_May20)	May-21
DAE4		SN 1555	25-Aug-20(SPEAG, No.DAE4-1555_Aug20)	Aug-21
Secondary Standards		ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGenerator	MG3700A	6201052605	23-Jun-20(CTTL, No.J20X04343)	Jun-21
Network Analyzer	E5071C	MY46110673	21-Jan-21(CTTL, No.J20X00515)	Jan-22

	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: April 11, 2021

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Glossary:

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

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

- $NORM_{x,y,z}$: Assessed for E-field polarization $\theta=0$ ($f \leq 900$ 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.
- $Ax,y,z; Bx,y,z; Cx,y,z; VRx,y,z; A,B,C$ 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 $f \leq 800$ 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 $NORM_x$ (no uncertainty required).



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7494

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μ V/(V/m) ²) ^A	0.41	0.47	0.41	\pm 10.0%
DCP(mV) ^B	98.9	100.2	99.0	

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	151.2	\pm 2.0%
		Y	0.0	0.0	1.0		164.8	
		Z	0.0	0.0	1.0		151.0	

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

^A The uncertainties of Norm X, Y, Z do not affect the E²-field uncertainty inside TSL (see Page 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:7494

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	10.70	10.70	10.70	0.40	0.75	±12.1%
835	41.5	0.90	10.41	10.41	10.41	0.13	1.39	±12.1%
1750	40.1	1.37	8.88	8.88	8.88	0.20	1.14	±12.1%
1900	40.0	1.40	8.55	8.55	8.55	0.22	1.08	±12.1%
2000	40.0	1.40	8.60	8.60	8.60	0.17	1.28	±12.1%
2300	39.5	1.67	8.30	8.30	8.30	0.62	0.62	±12.1%
2450	39.2	1.80	7.97	7.97	7.97	0.48	0.74	±12.1%
2600	39.0	1.96	7.68	7.68	7.68	0.40	0.85	±12.1%
5250	35.9	4.71	5.65	5.65	5.65	0.45	1.35	±13.3%
5600	35.5	5.07	4.95	4.95	4.95	0.55	1.35	±13.3%
5750	35.4	5.22	4.86	4.86	4.86	0.50	1.50	±13.3%

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

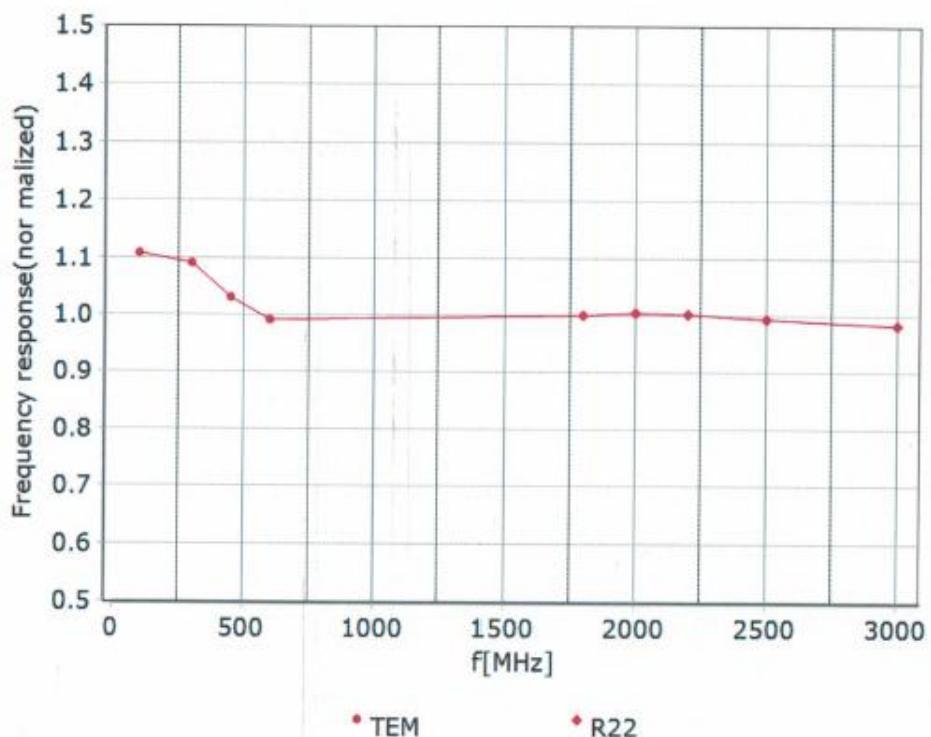
^F At frequency below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty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

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



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



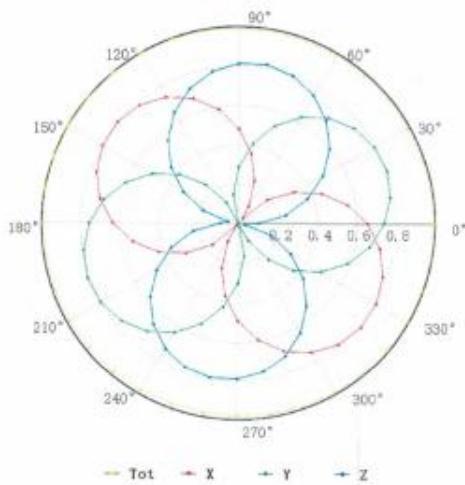
Uncertainty of Frequency Response of E-field: $\pm 7.4\% (k=2)$



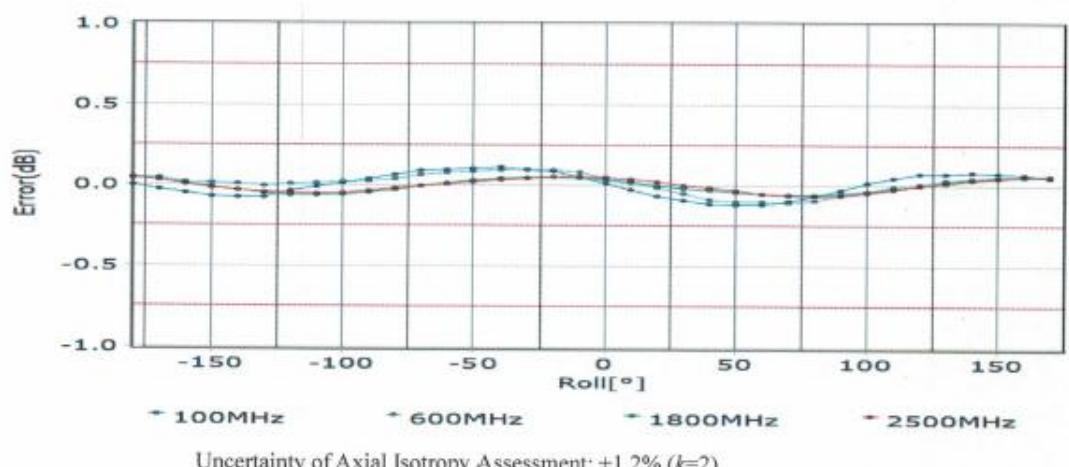
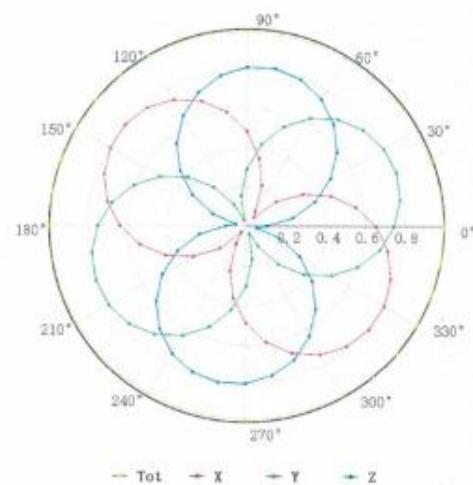
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM



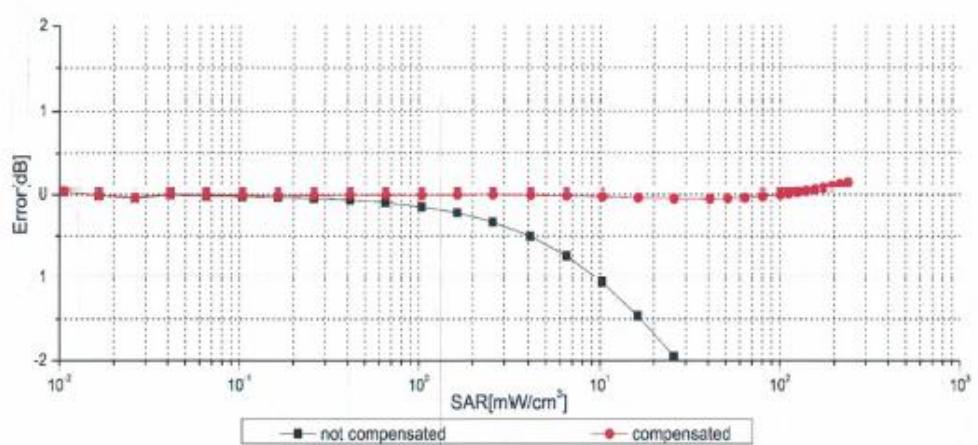
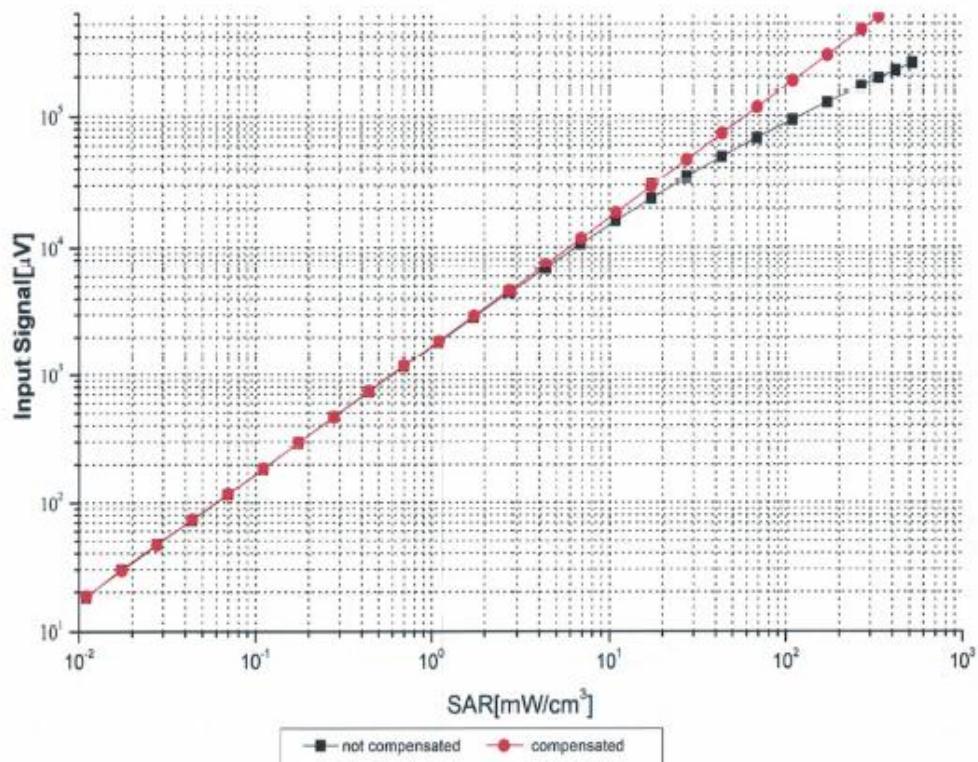
f=1800 MHz, R22





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



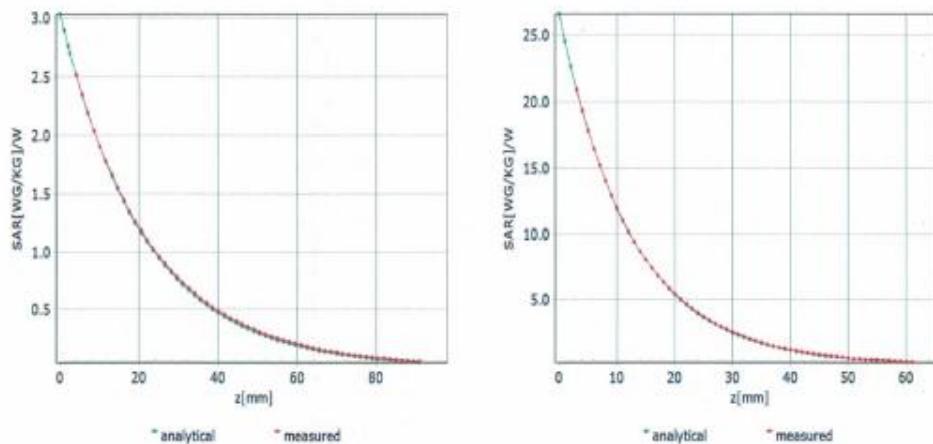
Uncertainty of Linearity Assessment: $\pm 0.9\% (k=2)$



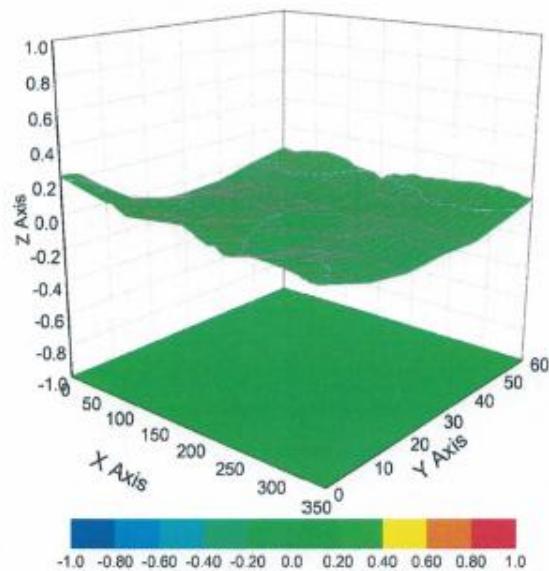
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Conversion Factor Assessment

$f=750 \text{ MHz}, \text{WGLS R9(H_convF)}$ $f=1750 \text{ MHz}, \text{WGLS R22(H_convF)}$



Deviation from Isotropy in Liquid



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



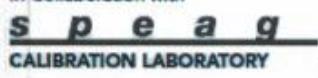
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DASY/EASY – Parameters of Probe: EX3DV4 – SN:7494

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	22.2
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

1.1. D835V2 Dipole Calibration Certificate

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Client	HTW	Certificate No: Z21-60017																																																						
<h3>CALIBRATION CERTIFICATE</h3> <table border="1"> <tr> <td>Object</td> <td>D835V2 - SN: 4d238</td> </tr> <tr> <td>Calibration Procedure(s)</td> <td>FF-Z11-003-01 Calibration Procedures for dipole validation kits</td> </tr> <tr> <td>Calibration date:</td> <td>January 22, 2021</td> </tr> <tr> <td colspan="2"> <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> </td> </tr> <tr> <td colspan="2"> <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>106276</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>Power sensor NRP6A</td> <td>101369</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>ReferenceProbe EX3DV4</td> <td>SN 7600</td> <td>30-Nov-20(CTTL-SPEAG, No.Z20-60421)</td> <td>Nov-21</td> </tr> <tr> <td>DAE4</td> <td>SN 771</td> <td>10-Feb-20(CTTL-SPEAG, No.Z20-60017)</td> <td>Feb-21</td> </tr> <tr> <td colspan="2">Secondary Standards</td> <td>ID #</td> <td>Cal Date(Calibrated by, Certificate No.)</td> </tr> <tr> <td colspan="2">Signal Generator E4438C</td> <td>MY49071430</td> <td>25-Feb-20 (CTTL, No.J20X00516)</td> </tr> <tr> <td colspan="2">NetworkAnalyzer E5071C</td> <td>MY46110673</td> <td>10-Feb-20 (CTTL, No.J20X00515)</td> </tr> </tbody> </table> </td> </tr> <tr> <td>Calibrated by:</td> <td>Name: Zhao Jing</td> <td>Function: SAR Test Engineer</td> <td>Signature: </td> </tr> <tr> <td>Reviewed by:</td> <td>Name: Lin Hao</td> <td>Function: SAR Test Engineer</td> <td>Signature: </td> </tr> <tr> <td>Approved by:</td> <td>Name: Qi Dianyuan</td> <td>Function: SAR Project Leader</td> <td>Signature: </td> </tr> </table>			Object	D835V2 - SN: 4d238	Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits	Calibration date:	January 22, 2021	<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>106276</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>Power sensor NRP6A</td> <td>101369</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>ReferenceProbe EX3DV4</td> <td>SN 7600</td> <td>30-Nov-20(CTTL-SPEAG, No.Z20-60421)</td> <td>Nov-21</td> </tr> <tr> <td>DAE4</td> <td>SN 771</td> <td>10-Feb-20(CTTL-SPEAG, No.Z20-60017)</td> <td>Feb-21</td> </tr> <tr> <td colspan="2">Secondary Standards</td> <td>ID #</td> <td>Cal Date(Calibrated by, Certificate No.)</td> </tr> <tr> <td colspan="2">Signal Generator E4438C</td> <td>MY49071430</td> <td>25-Feb-20 (CTTL, No.J20X00516)</td> </tr> <tr> <td colspan="2">NetworkAnalyzer E5071C</td> <td>MY46110673</td> <td>10-Feb-20 (CTTL, No.J20X00515)</td> </tr> </tbody> </table>		Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRP2	106276	12-May-20 (CTTL, No.J20X02965)	May-21	Power sensor NRP6A	101369	12-May-20 (CTTL, No.J20X02965)	May-21	ReferenceProbe EX3DV4	SN 7600	30-Nov-20(CTTL-SPEAG, No.Z20-60421)	Nov-21	DAE4	SN 771	10-Feb-20(CTTL-SPEAG, No.Z20-60017)	Feb-21	Secondary Standards		ID #	Cal Date(Calibrated by, Certificate No.)	Signal Generator E4438C		MY49071430	25-Feb-20 (CTTL, No.J20X00516)	NetworkAnalyzer E5071C		MY46110673	10-Feb-20 (CTTL, No.J20X00515)	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: 
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Glossary:

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

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- 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	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz \pm 1 MHz	

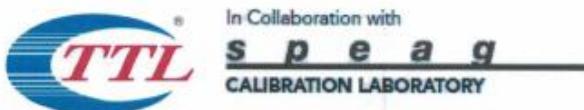
Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 \pm 0.2) °C	41.3 \pm 6 %	0.89 mho/m \pm 6 %
Head TSL temperature change during test	<1.0 °C	---	---

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.39 W/kg \pm 18.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.14 W/kg \pm 18.7 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.5Ω- 3.95jΩ
Return Loss	- 27.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.298 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: 01.22.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d238

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

Medium parameters used: $f = 835$ MHz; $\sigma = 0.885$ S/m; $\epsilon_r = 41.32$; $\rho = 1000$ kg/m³

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7600; ConvF(10.88, 10.88, 10.88) @ 835 MHz; Calibrated: 2020-11-30
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2020-02-10
- 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 (7483)

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

Reference Value = 58.12 V/m; Power Drift = -0.01 dB

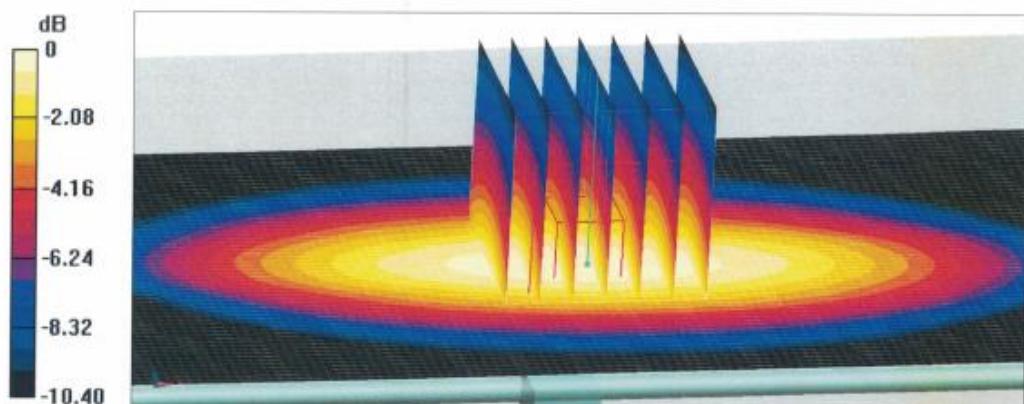
Peak SAR (extrapolated) = 3.58 W/kg

SAR(1 g) = 2.32 W/kg; SAR(10 g) = 1.52 W/kg

Smallest distance from peaks to all points 3 dB below = 19.8 mm

Ratio of SAR at M2 to SAR at M1 = 64.9%

Maximum value of SAR (measured) = 3.14 W/kg

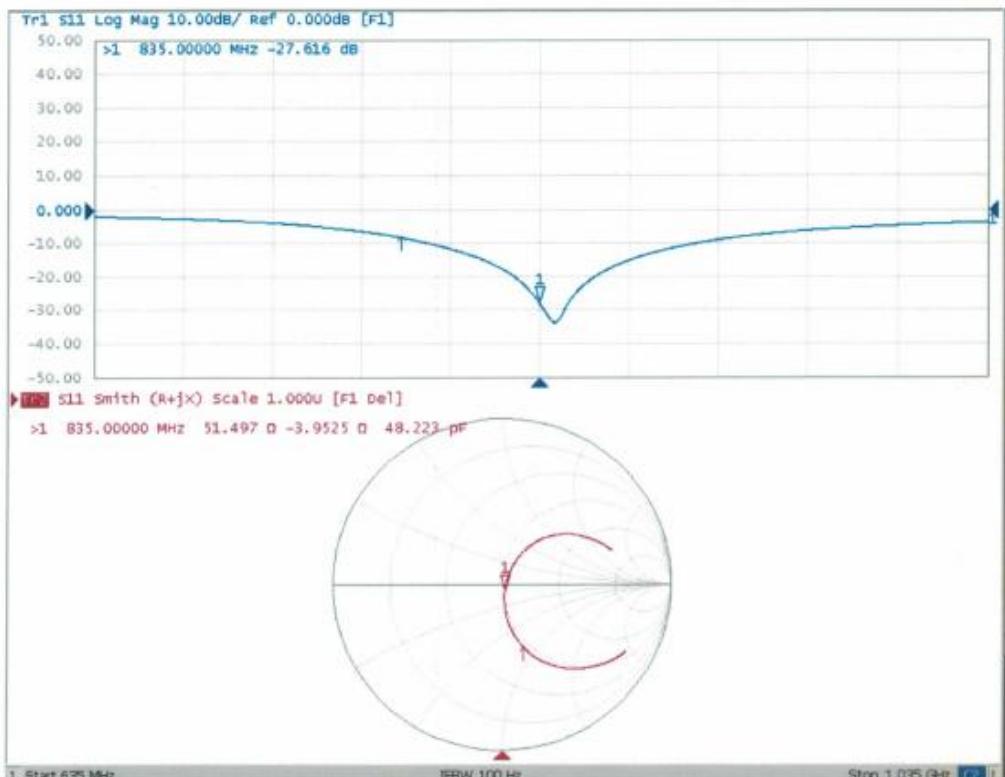


Appendix F: Dipole Calibration Certificate



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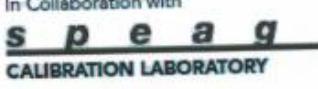
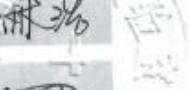
Impedance Measurement Plot for Head TSL



Certificate No: Z21-60017

Page 6 of 6

1.2. D1900V2 Dipole Calibration Certificate

 In Collaboration with 		  中国认可 国际互认 校准 CALIBRATION CNAS L0570	
Add: No.51 Xueyuan Road, Haidian District, Beijing, 100191, China Tel: +86-10-62304633-2079 Fax: +86-10-62304633-2504 E-mail: ctll@chinattl.com http://www.chinattl.cn		Certificate No: Z21-60019	
Client	HTW		
CALIBRATION CERTIFICATE			
Object	D1900V2 - SN: 5d226		
Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits		
Calibration date:	January 22, 2021		
<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>			
Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106276	12-May-20 (CTTL, No.J20X02965)	May-21
Power sensor NRP6A	101369	12-May-20 (CTTL, No.J20X02965)	May-21
ReferenceProbe EX3DV4	SN 7600	30-Nov-20(CTTL-SPEAG, No.Z20-60421)	Nov-21
DAE4	SN 771	10-Feb-20(CTTL-SPEAG, No.Z20-60017)	Feb-21
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	25-Feb-20 (CTTL, No.J20X00516)	Feb-21
NetworkAnalyzer E5071C	MY46110673	10-Feb-20 (CTTL, No.J20X00515)	Feb-21
Calibrated by:	Name	Function	Signature
	Zhao Jing	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	
Issued: January 29, 2021			
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.			



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lossary:

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	1900 MHz \pm 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 \pm 0.2) °C	40.1 \pm 6 %	1.38 mho/m \pm 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.85 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.8 W/kg \pm 18.8 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.05 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	20.3 W/kg \pm 18.7 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.5Ω+ 7.88jΩ
Return Loss	- 21.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.102 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: 01.22.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d226

Communication System: UID 0, CW; Frequency: 1900 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.38$ S/m; $\epsilon_r = 40.06$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7600; ConvF(8.7, 8.7, 8.7) @ 1900 MHz; Calibrated: 2020-11-30
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2020-02-10
- 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 (7483)

System Performance Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid:

dx=5mm, dy=5mm, dz=5mm

Reference Value = 97.77 V/m; Power Drift = -0.06 dB

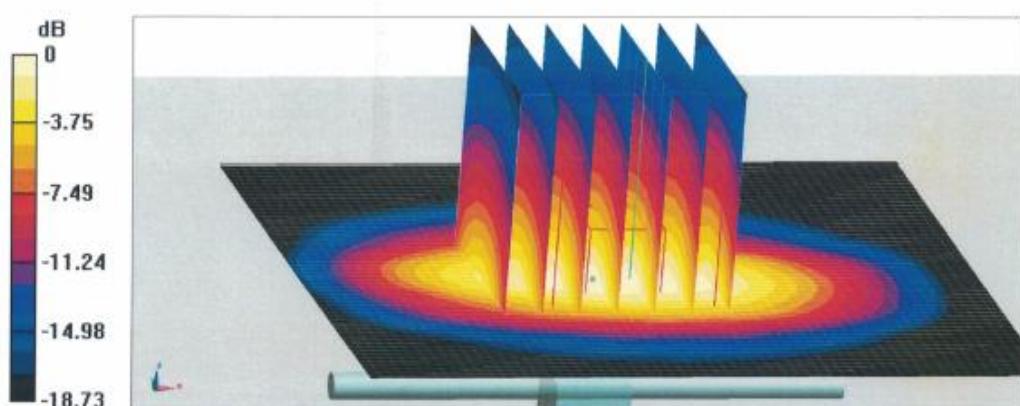
Peak SAR (extrapolated) = 19.0 W/kg

SAR(1 g) = 9.85 W/kg; SAR(10 g) = 5.05 W/kg

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

Ratio of SAR at M2 to SAR at M1 = 52.1%

Maximum value of SAR (measured) = 15.4 W/kg

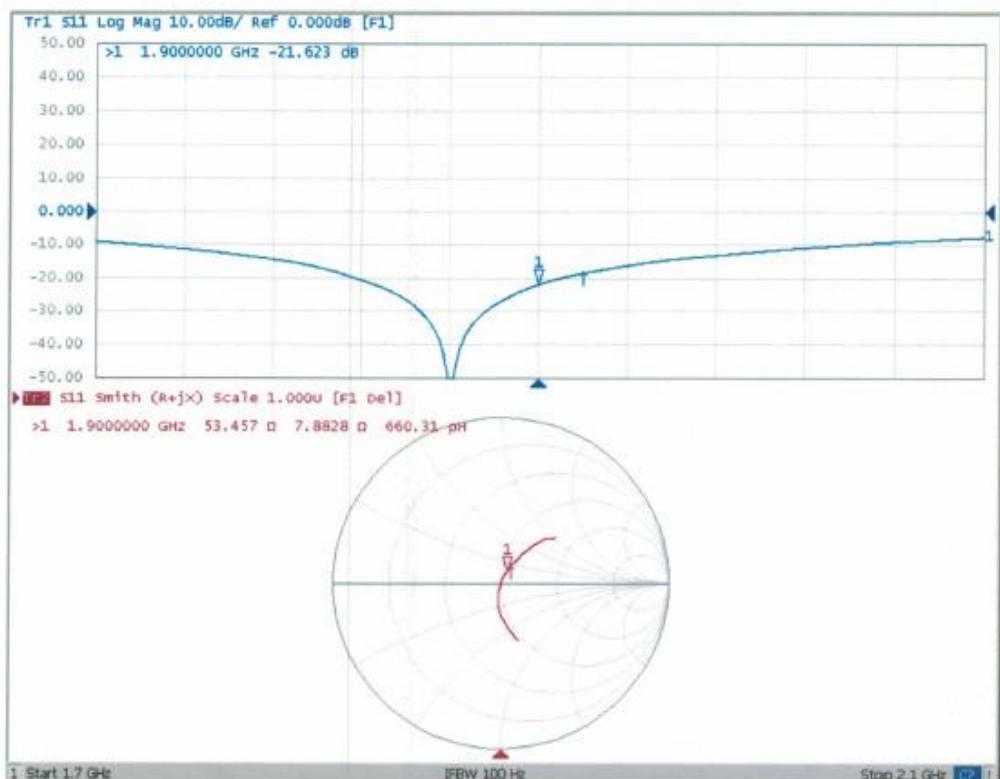


0 dB = 15.4 W/kg = 11.88 dBW/kg

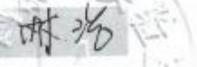
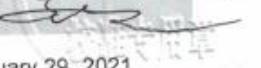


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Impedance Measurement Plot for Head TSL



1.3. D2450V2 Dipole Calibration Certificate

 In Collaboration with 		  中国认可 国际互认 校准 CALIBRATION CNAS L0570	
Client	HTW	Certificate No: Z21-60020	
CALIBRATION CERTIFICATE			
Object	D2450V2 - SN: 1009		
Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits		
Calibration date:	January 25, 2021		
<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>			
Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106276	12-May-20 (CTTL, No.J20X02965)	May-21
Power sensor NRP6A	101369	12-May-20 (CTTL, No.J20X02965)	May-21
ReferenceProbe EX3DV4	SN 7600	30-Nov-20(CTTL-SPEAG, No.Z20-60421)	Nov-21
DAE4	SN 771	10-Feb-20(CTTL-SPEAG, No.Z20-60017)	Feb-21
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	25-Feb-20 (CTTL, No.J20X00516)	Feb-21
Network Analyzer E5071C	MY46110673	10-Feb-20 (CTTL, No.J20X00515)	Feb-21
Calibrated by:	Name	Function	Signature
	Zhao Jing	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	
Issued: January 29, 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 \pm 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 \pm 0.2) °C	39.5 \pm 6 %	1.81 mho/m \pm 6 %
Head TSL temperature change during test	<1.0 °C	---	---

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.0 W/kg \pm 18.8 % (k=2)
SAR averaged over 10 cm³ (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.97 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.9 W/kg \pm 18.7 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.9Ω+ 2.04jΩ
Return Loss	- 27.4dB

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

Manufactured by	SPEAG
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DASY5 Validation Report for Head TSL

Date: 01.25.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 1009

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.81$ S/m; $\epsilon_r = 39.52$; $\rho = 1000$ kg/m³

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7600; ConvF(7.79, 7.79, 7.79) @ 2450 MHz; Calibrated: 2020-11-30
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2020-02-10
- 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 (7483)

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

Reference Value = 102.7 V/m; Power Drift = -0.06 dB

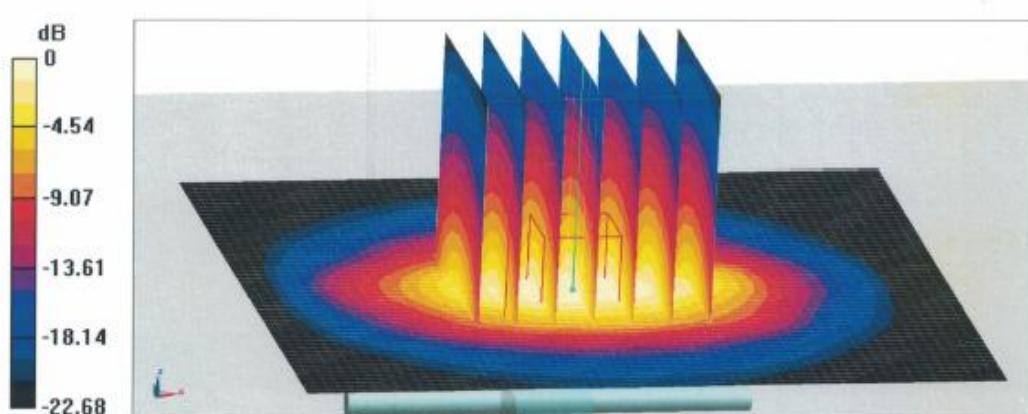
Peak SAR (extrapolated) = 27.2 W/kg

SAR(1 g) = 13 W/kg; SAR(10 g) = 5.97 W/kg

Smallest distance from peaks to all points 3 dB below = 9.5 mm

Ratio of SAR at M2 to SAR at M1 = 47.2%

Maximum value of SAR (measured) = 22.0 W/kg



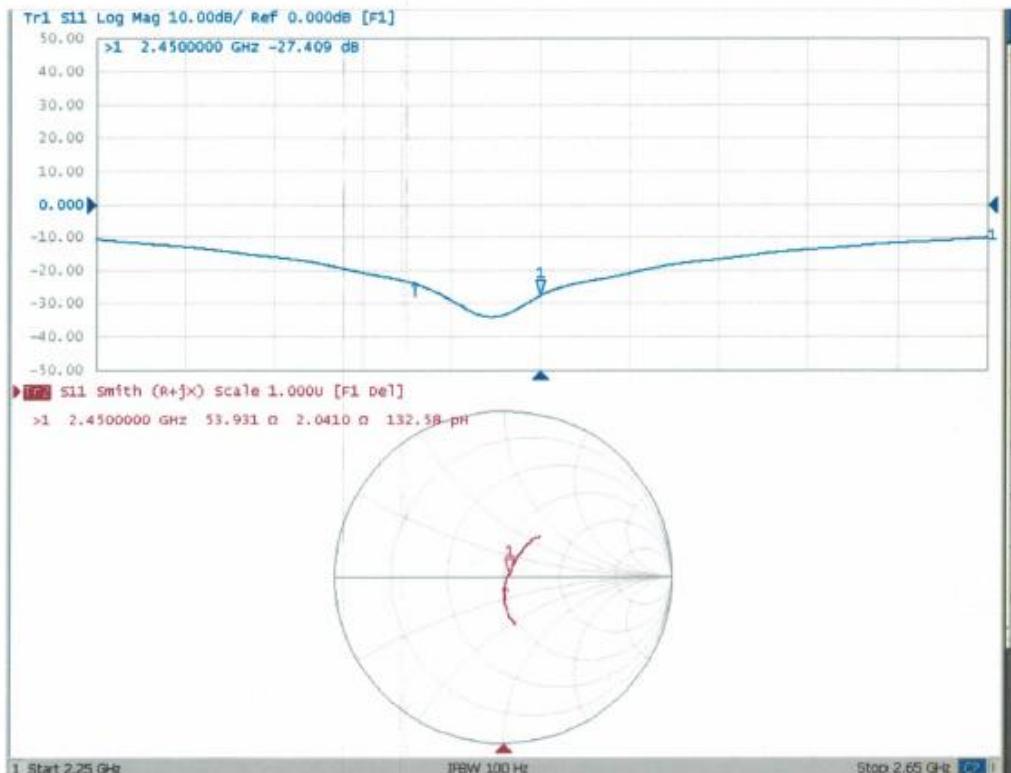
0 dB = 22.0 W/kg = 13.42 dBW/kg



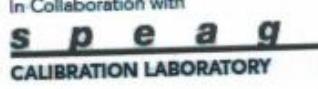
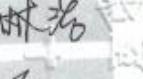
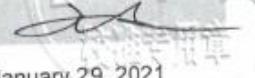
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Impedance Measurement Plot for Head TSL



1.4. D2600V2 Dipole Calibration Certificate

 TTL CALIBRATION LABORATORY In Collaboration with s p e a g 		 IEC MRA  CNAS 中国认可 国际互认 校准 CALIBRATION CNAS L0570																																	
Client	HTW	Certificate No: Z21-60021																																	
CALIBRATION CERTIFICATE																																			
Object	D2600V2 - SN: 1150																																		
Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits																																		
Calibration date:	January 25, 2021																																		
<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>																																			
Calibration Equipment used (M&TE critical for calibration)																																			
<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>106276</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>Power sensor NRP6A</td> <td>101369</td> <td>12-May-20 (CTTL, No.J20X02965)</td> <td>May-21</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN 7600</td> <td>30-Nov-20(CTTL-SPEAG, No.Z20-60421)</td> <td>Nov-21</td> </tr> <tr> <td>DAE4</td> <td>SN 771</td> <td>10-Feb-20(CTTL-SPEAG, No.Z20-60017)</td> <td>Feb-21</td> </tr> <tr> <td>Secondary Standards</td> <td>ID #</td> <td>Cal Date(Calibrated by, Certificate No.)</td> <td>Scheduled Calibration</td> </tr> <tr> <td>Signal Generator E4438C</td> <td>MY49071430</td> <td>25-Feb-20 (CTTL, No.J20X00516)</td> <td>Feb-21</td> </tr> <tr> <td>Network Analyzer E5071C</td> <td>MY46110673</td> <td>10-Feb-20 (CTTL, No.J20X00515)</td> <td>Feb-21</td> </tr> </tbody> </table>				Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Power Meter NRP2	106276	12-May-20 (CTTL, No.J20X02965)	May-21	Power sensor NRP6A	101369	12-May-20 (CTTL, No.J20X02965)	May-21	Reference Probe EX3DV4	SN 7600	30-Nov-20(CTTL-SPEAG, No.Z20-60421)	Nov-21	DAE4	SN 771	10-Feb-20(CTTL-SPEAG, No.Z20-60017)	Feb-21	Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration	Signal Generator E4438C	MY49071430	25-Feb-20 (CTTL, No.J20X00516)	Feb-21	Network Analyzer E5071C	MY46110673	10-Feb-20 (CTTL, No.J20X00515)	Feb-21
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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: January 29, 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, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.7 ± 6 %	1.97 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	14.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	56.5 W/kg ± 18.8 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	6.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.0 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	49.5Ω- 6.58jΩ
Return Loss	- 23.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.047 ns
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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: 01.25.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1150

Communication System: UID 0, CW; Frequency: 2600 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 2600$ MHz; $\sigma = 1.966$ S/m; $\epsilon_r = 39.65$; $\rho = 1000$ kg/m 3

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7600; ConvF(7.67, 7.67, 7.67) @ 2600 MHz; Calibrated: 2020-11-30
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn771; Calibrated: 2020-02-10
- 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 (7483)

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

Reference Value = 104.6 V/m; Power Drift = -0.03 dB

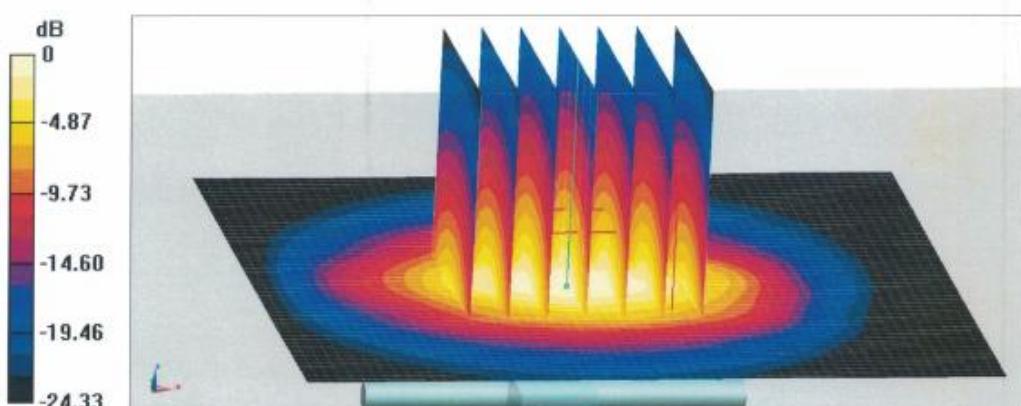
Peak SAR (extrapolated) = 31.1 W/kg

SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.24 W/kg

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

Ratio of SAR at M2 to SAR at M1 = 45.3%

Maximum value of SAR (measured) = 24.6 W/kg



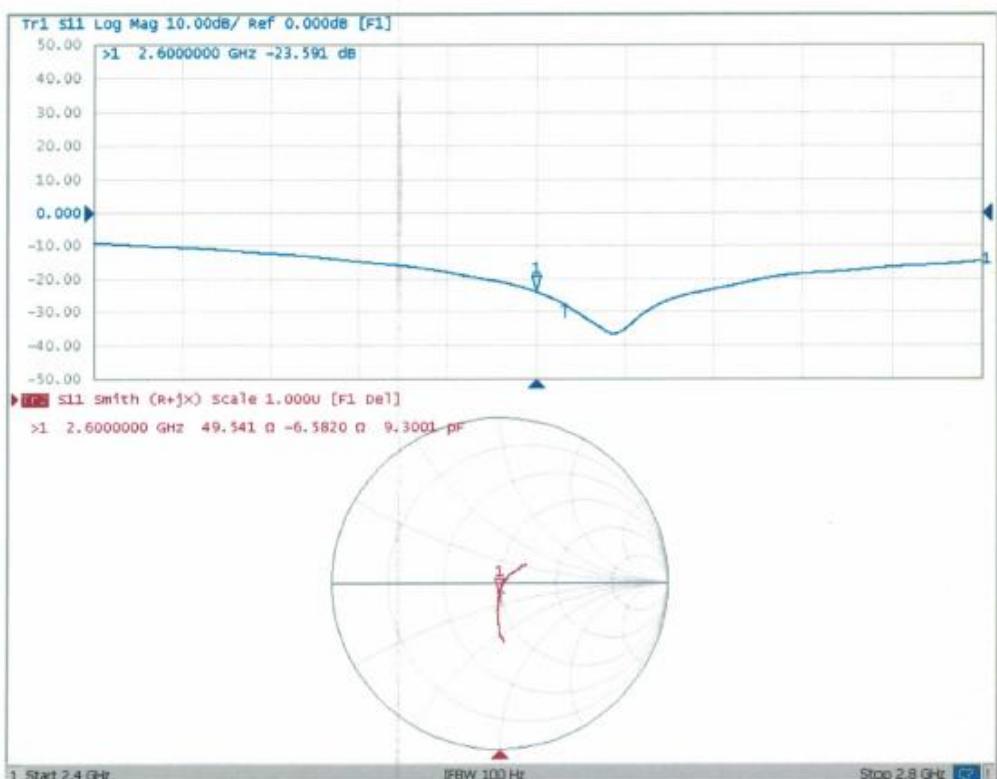
0 dB = 24.6 W/kg = 13.91 dBW/kg



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Impedance Measurement Plot for Head TSL



Certificate No: Z21-60021

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