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CALIBRATION
CNAS L0570

Client BTL Inc . Certificate No: Z21-60224

CALIBRATION CERTIFICATE

Object D2450V2 - SN: 919

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

Calibration date: May 28, 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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106277	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
Power sensor NRP8S	104291	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
Reference Probe EX3DV4	SN 3846	6-Apr-21(CTTL-SPEAG,No.Z21-60084)	Apr-22
DAE4	SN 777	8-Jan-21(CTTL-SPEAG,No.Z21-60003)	Jan-22
Secondary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Signal Generator E4438C	MY49071430	01-Feb-21 (CTTL, No.J21X00593)	Jan-22
NetworkAnalyzer E5071C	MY46110673	14-Jan-21 (CTTL, No.J21X00232)	Jan-22

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

Issued: June 2, 2021

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Glossary:

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

Calibration is Performed According to the Following Standards:

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

b) IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016

c) IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010

d) KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

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

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Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Triple Flat Phantom 5.1C	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.8 ± 6 %	1.81 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.1 W/kg ± 18.8 % (*k*=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	250 mW input power	5.95 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.7 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	55.6Ω+ 2.17jΩ
Return Loss	- 24.8dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.070 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: 05.28.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 919

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

Medium parameters used: f = 2450 MHz; σ = 1.81 S/m; ε_r = 38.82; ρ = 1000 kg/m^3

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3846; ConvF(7.45, 7.45, 7.45) @ 2450 MHz; Calibrated: 2021-04-26
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 2021-01-08
- 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 = 98.10 V/m; Power Drift = -0.09 dB

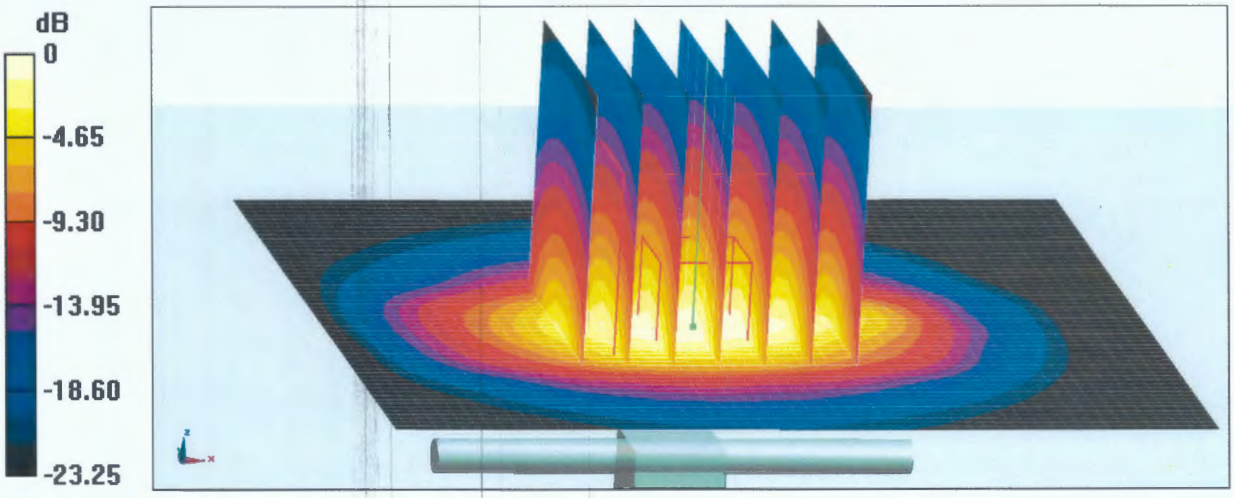
Peak SAR (extrapolated) = 28.3 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 5.95 W/kg

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

Ratio of SAR at M2 to SAR at M1 = 45.9%

Maximum value of SAR (measured) = 22.6 W/kg



0 dB = 22.6 W/kg = 13.54 dBW/kg

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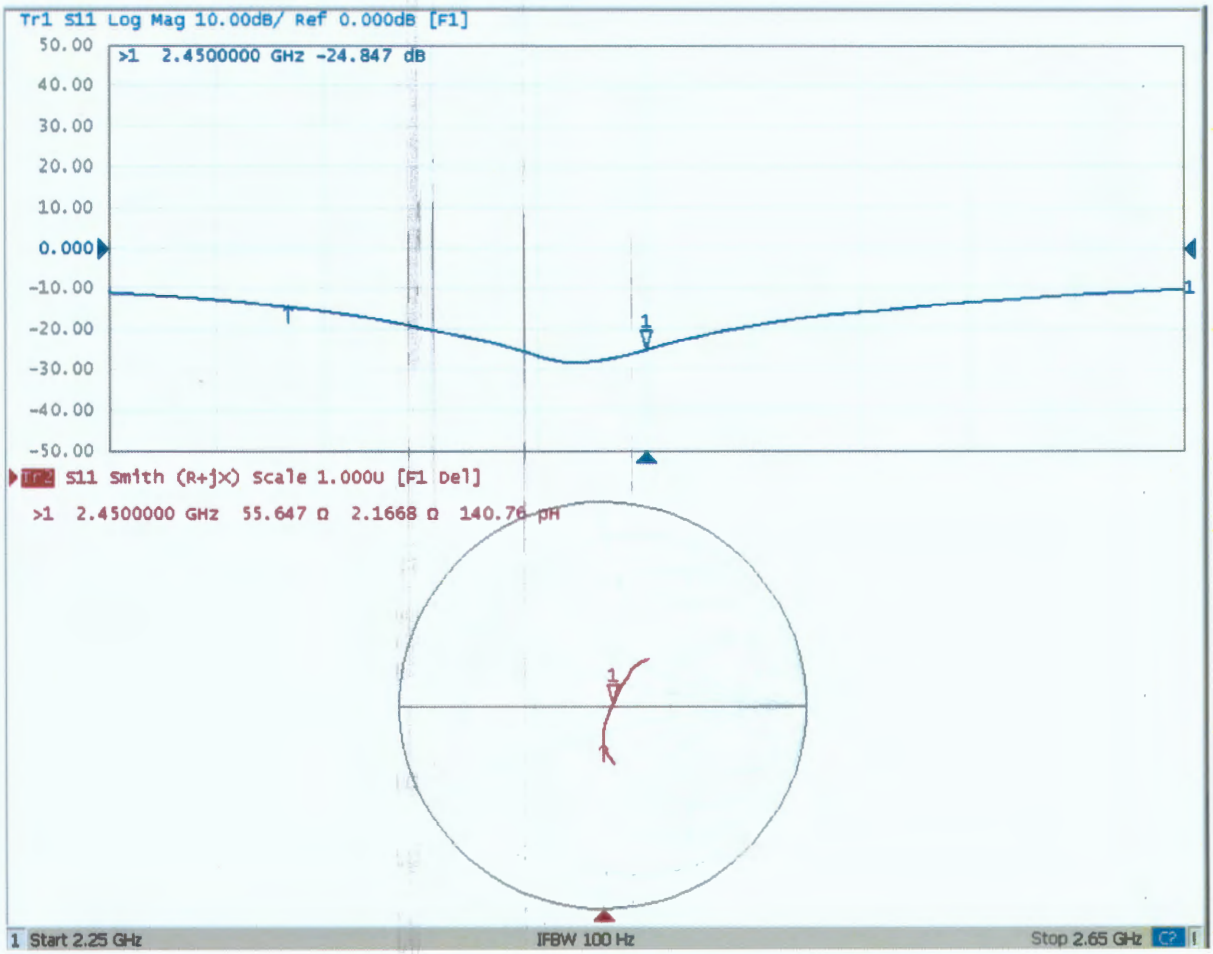
Impedance Measurement Plot for Head TSL



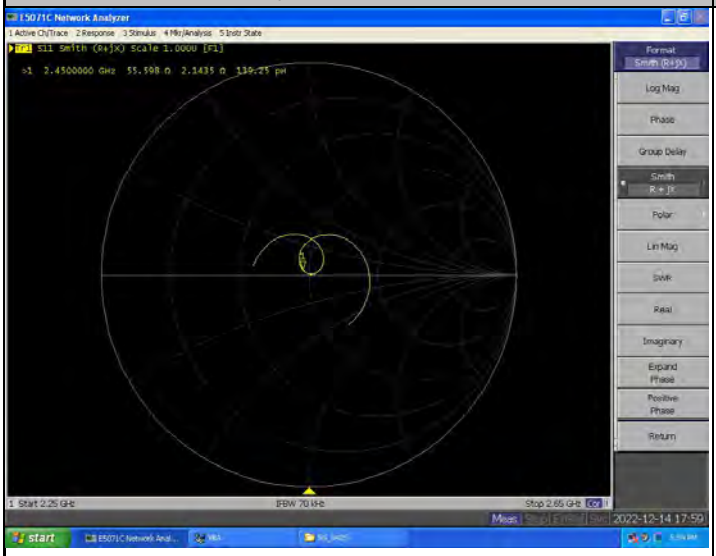
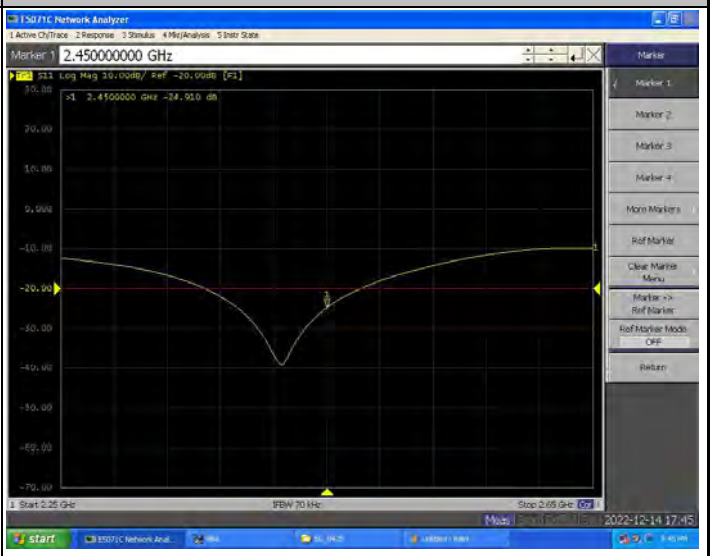
Dipole Internal Calibration Record

Asset No. :	E-434	Model No. :	D2450V2	Serial No. :	919
Environmental	23.4℃, 61 %	Original Cal. Date :	May 28, 2021	Next Cal. Date :	May 28, 2024

Standard List		
1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorpiton Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Texhniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

Equipment Information					
Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Cal. Date :
Power Amplifier	Mini-Circuits	ZHL-42W+	QA1333003	N/A	October 29, 2022
DC Source metter	Iteck	IT6154	006104126768201001	N/A	July 16, 2022
Vector Network Analyze	Agilent	E5071C	MY46102965	N/A	February 19, 2022
Signal Generator	Agilent	N5172B	MY53050758	N/A	February 19, 2022
Smart Power Sensor	R&S	NRP18S	726174	N/A	June 3, 2022
Dielectric Assessment	Speag	DAK-3.5	1226	N/A	January 24, 2022
Directional Coupler	Woken	TS-PCC0M-05	0107090019	N/A	February 19, 2022
Coupler	Woken	0110A05601O-10	COM5BNW1A2	N/A	February 19, 2022
Digital Themometer	TES	TES-1310	210706071	N/A	November 17, 2022

Model No	For Head Tissue				
	Item	Original Cal. Result	Verified on 2022/12/14	Deviation	Result
D2450V2	Impedance, transformed to feed	55.6Ω+2.17jΩ	55.59Ω+2.14jΩ	<5Ω	Pass
	Return Loss(dB)	-24.8	-24.91	0.4%	Pass
	SAR Value for 1g(mW/g)	13.1	13.6	3.8%	Pass
	SAR Value for 10g(mW/g)	5.95	6.22	4.5%	Pass

Impedance Test-Head	Return Loss-Head
	

Validation Report for Head TSL

Test Laboratory: BTL Inc. Date: 2022/12/14

System Check_H2450_1214

DUT: Dipole 2450 MHz D2450V2; SN:919;

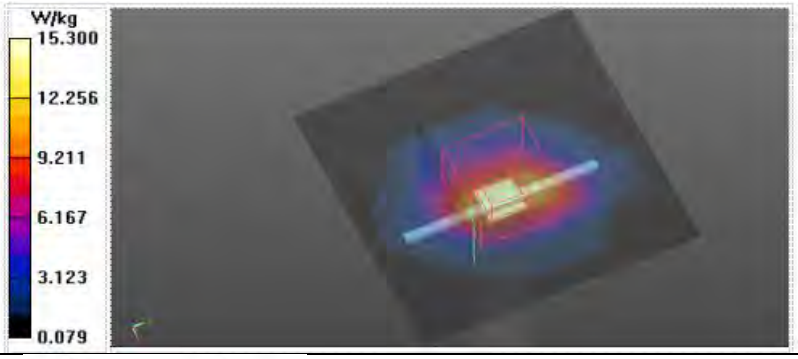
Communication System: UID 0, CW (0); Frequency: 2450 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 1.865 S/m; ε_r = 39.16; ρ = 1000 kg/m^3
Ambient Temperature: 23.2 ℃; Liquid Temperature: 22.5 ℃

DASY Configuration:

- Probe: EX3DV4 - SN3974; ConvF(5.68, 5.68, 5.68) @ 2450 MHz; Calibrated: 2022/1/24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 2021/12/29
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 1128
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Area Scan (6x6x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 12.7 W/kg

Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 83.15 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 29.3 W/kg
SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.22 W/kg
Maximum value of SAR (measured) = 15.3 W/kg



Calibrator: Justin Huang Approver: Herbert Liu

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CALIBRATION
CNAS L0570

Client BTL Inc . Certificate No: Z21-60226

CALIBRATION CERTIFICATE

Object D5GHzV2 - SN: 1160

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

Calibration date: May 27, 2021

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106277	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
Power sensor NRP8S	104291	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
ReferenceProbe EX3DV4	SN 3617	27-Jan-21(SPEAG,No.EX3-3617_Jan21)	Jan-22
DAE4	SN 777	08-Jan-21(CTTL-SPEAG,No.Z21-60003)	Jan-22
Secondary Standards	**ID #**	**Cal Date (Calibrated by, Certificate No.)**	**Scheduled Calibration**
Signal Generator E4438C	MY49071430	01-Feb-21 (CTTL, No.J21X00593)	Jan-22
NetworkAnalyzerE5071C	MY46110673	14-Jan-21 (CTTL, No.J21X00232)	Jan-22

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

Issued: June 2, 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 = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz	

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.3 ± 6 %	4.68 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.78 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.0 W/kg ± 24.4 % (*k*=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.4 W/kg ± 24.2 % (*k*=2)**

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Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	5.06 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.05 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**80.6 W/kg ± 24.4 % (*k*=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.0 W/kg ± 24.2 % (*k*=2)**

Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	5.22 mho/m ± 6 %
Head TSL temperature change during test	<1.0 °C	----	----

SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.65 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**76.5 W/kg ± 24.4 % (*k*=2)**
SAR averaged over 10 cm^3 (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**21.6 W/kg ± 24.2 % (*k*=2)**

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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	48.9Ω - 6.08jΩ
Return Loss	- 24.1dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.2Ω - 1.85jΩ
Return Loss	- 27.1dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	53.1Ω - 1.51jΩ
Return Loss	- 29.6dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.105 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: 05.27.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1160

Communication System: CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz,

Medium parameters used: f = 5250 MHz; σ = 4.683 S/m; ε_r = 36.33; ρ = 1000 kg/m^3, Medium parameters used: f = 5600 MHz; σ = 5.061 S/m; ε_r = 35.72; ρ = 1000 kg/m^3, Medium parameters used: f = 5750 MHz; σ = 5.224 S/m; ε_r = 35.5; ρ = 1000 kg/m^3,

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3617; ConvF(5.4, 5.4, 5.4) @ 5250 MHz; ConvF(5, 5, 5) @ 5600 MHz; ConvF(5.12, 5.12, 5.12) @ 5750 MHz; Calibrated: 2021-01-27
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 2021-01-08
- 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 /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.64 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 31.7 W/kg
SAR(1 g) = 7.78 W/kg; SAR(10 g) = 2.23 W/kg
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 64.8%
Maximum value of SAR (measured) = 18.3 W/kg

Dipole Calibration /Pin=100mW, d=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.46 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 35.6 W/kg
SAR(1 g) = 8.05 W/kg; SAR(10 g) = 2.3 W/kg
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 62.4%
Maximum value of SAR (measured) = 19.7 W/kg

In Collaboration with
s p e a g
CALIBRATION LABORATORY
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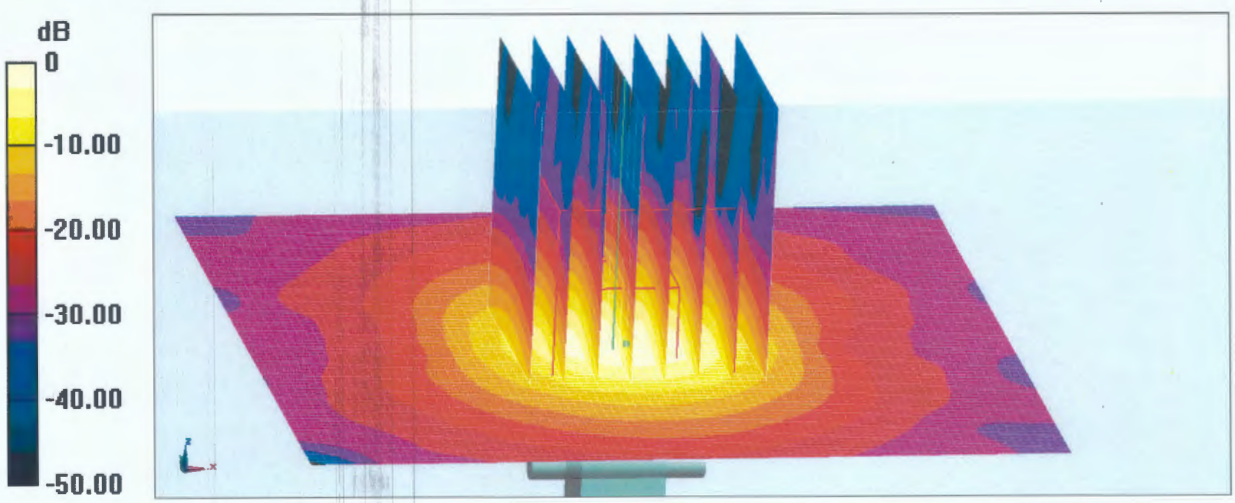
Tel: +86-10-62304633-2512 Fax: +86-10-62304633-2504
E-mail: cttl@chinattl.com http://www.chinattl.cn

Dipole Calibration /Pin=100mW, d=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.41 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 35.0 W/kg
SAR(1 g) = 7.65 W/kg; SAR(10 g) = 2.16 W/kg
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 61.4%
Maximum value of SAR (measured) = 18.6 W/kg



0 dB = 18.6 W/kg = 12.70 dBW/kg

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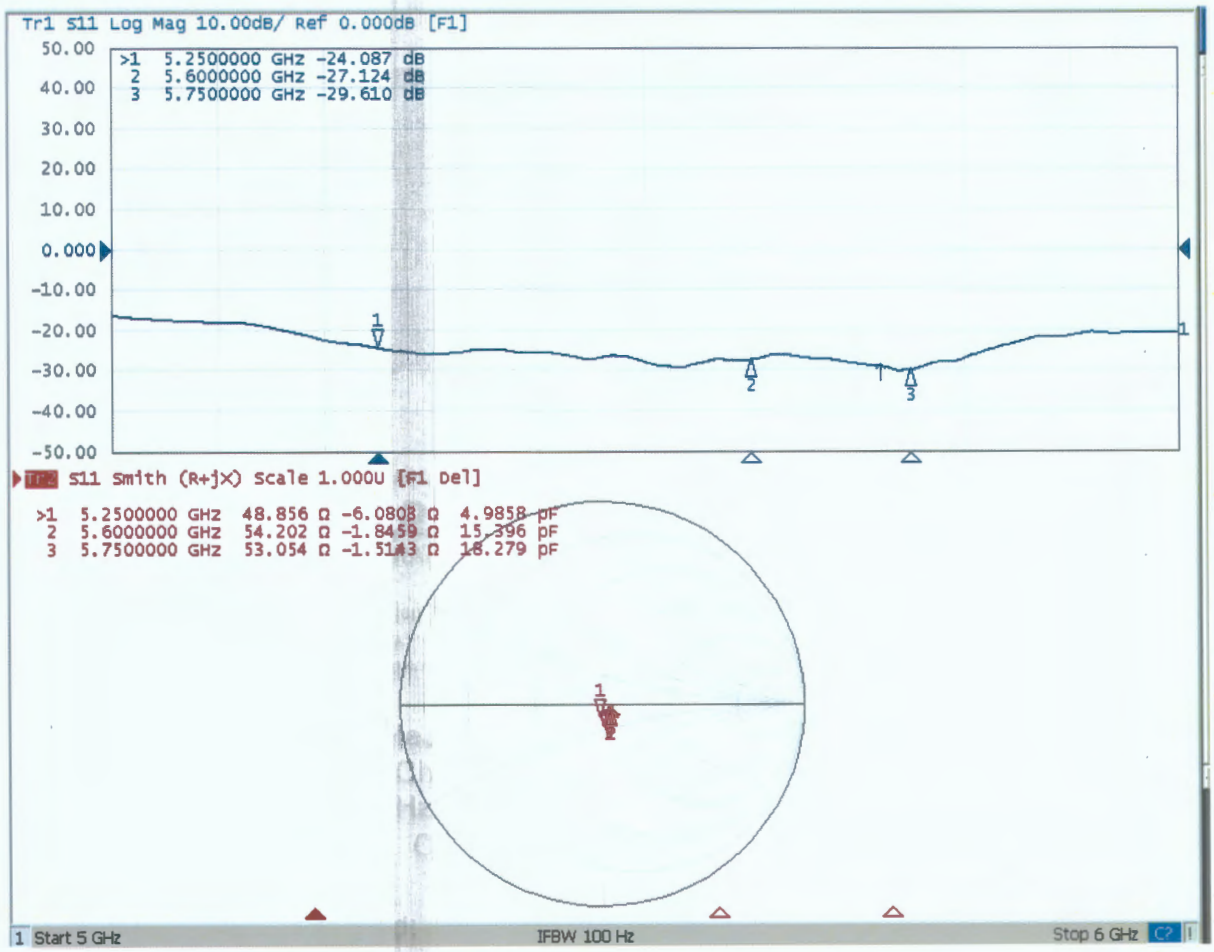
Impedance Measurement Plot for Head TSL



Dipole Internal Calibration Record

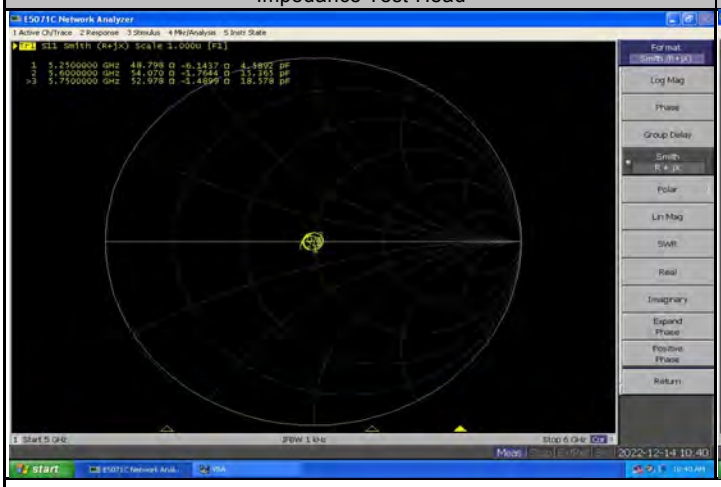
Asset No. :	E-436	Model No. :	D5GHzV2	Serial No. :	1160
Environmental	23.2℃, 52 %	Original Cal. Date :	May 27, 2021	Next Cal. Date :	May 27, 2024

Standard List		
1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorpiton Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Texhniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

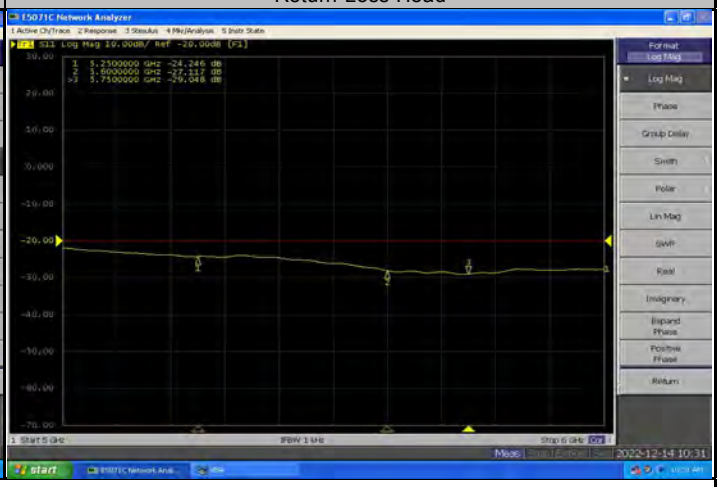
Equipment Information					
Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Cal. Date :
Power Amplifier	Talent Microwave	TLPA1G18G-40-33-HS	220330003	N/A	June 13, 2022
DC Source metter	Iteck	IT6154	006104126768201001	N/A	July 16, 2022
Vector Network Analyze	Agilent	E5071C	MY46102965	N/A	February 19, 2022
Signal Generator	Agilent	N5172B	MY53050758	N/A	February 19, 2022
Smart Power Sensor	R&S	NRP18S	726174	N/A	June 3, 2022
Dielectric Assessment	Speag	DAK-3.5	1226	N/A	January 24, 2022
Directional Coupler	Woken	TS-PCC0M-05	0107090019	N/A	February 19, 2022
Coupler	Woken	0110A05601O-10	COM5BNW1A2	N/A	February 19, 2022
Digital Themometer	TES	TES-1310	210706071	N/A	November 17, 2022

Model No	For Head Tissue				
	Item	Originak Cal. Result	Verified on 2022/12/14	Deviation	Result
D5GHzV2(5250MHz)	Impedance, transformed to feed	48.9Ω-6.08jΩ	48.8Ω-6.14jΩ	<5Ω	Pass
	Return Loss(dB)	-24.1	-24.246	0.6%	Pass
	SAR Value for	7.78	7.84	0.8%	Pass
	SAR Value for	2.23	2.22	-0.4%	Pass
D5GHzV2(5600MHz)	Impedance, transformed to feed	54.2Ω-1.85jΩ	54.1Ω-1.76jΩ	<5Ω	Pass
	Return Loss(dB)	-27.1	-27.117	0.1%	Pass
	SAR Value for	8.05	8.21	2.0%	Pass
	SAR Value for	2.3	2.33	1.3%	Pass
D5GHzV2(5750MHz)	Impedance, transformed to feed	53.1Ω-1.5jΩ	53.0Ω-1.49jΩ	<5Ω	Pass
	Return Loss(dB)	-29.6	-29.048	-1.9%	Pass
	SAR Value for	7.65	7.5	-2.0%	Pass
	SAR Value for	2.16	2.1	-2.8%	Pass

Impedance Test-Head



Return Loss-Head



Validation Report for Head TSL of 5.25GHz

Test Laboratory: BTL Inc. Date: 2022/12/14

System Check_H5250_1214

DUT: Dipole D5GHzV2;SN:1160;

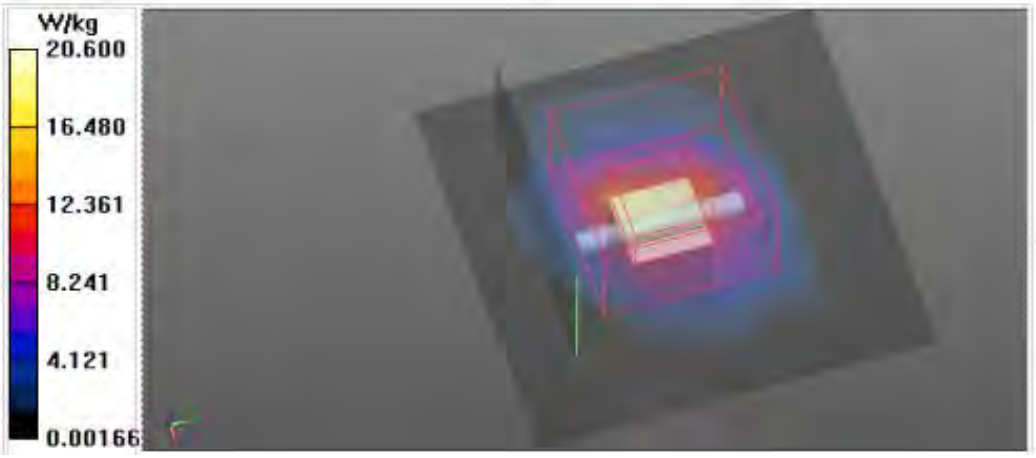
Communication System: UID 0, CW (0); Frequency: 5250 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): f = 5250 MHz; σ = 4.744 S/m; ε_r = 35.502; ρ = 1000 kg/m^3
Ambient Temperature: 23.1 ℃; Liquid Temperature: 22.5 ℃

DASY Configuration:

- Probe: EX3DV4 - SN3974; ConvF(5.68, 5.68, 5.68) @ 5250 MHz; Calibrated: 2022/1/24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 23.0
- Electronics: DAE4 Sn1390; Calibrated: 2021/12/29
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 1128
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Area Scan (6x6x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 15.0 W/kg

Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 70.21 V/m; Power Drift = 0.10 dB
Peak SAR (extrapolated) = 36.8 W/kg
SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 20.6 W/kg



Validation Report for Head TSL of 5.6GHz

Test Laboratory: BTL Inc. Date: 2022/12/14

System Check_H5600_1214

DUT: Dipole D5GHzV2;SN:1160;

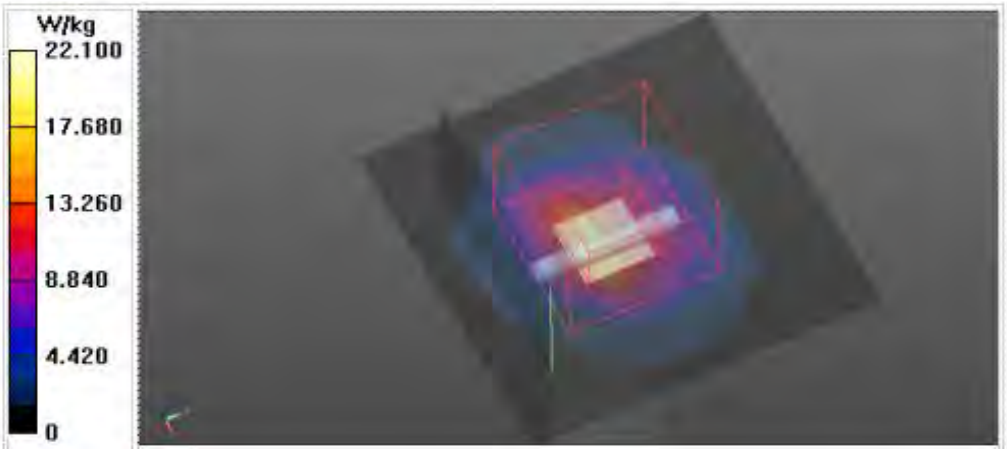
Communication System: UID 0, CW (0); Frequency: 5600 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5600 MHz; σ = 5.193 S/m; ε_r = 35.155; ρ = 1000 kg/m^3
Ambient Temperature: 23.1 ℃; Liquid Temperature: 22.5 ℃

DASY Configuration:

- Probe: EX3DV4 - SN3974; ConvF(5.01, 5.01, 5.01) @ 5600 MHz; Calibrated: 2022/1/24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 23.0
- Electronics: DAE4 Sn1390; Calibrated: 2021/12/29
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 1128
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Area Scan (6x6x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 14.9 W/kg

Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 69.38 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 39.3 W/kg
SAR(1 g) = 8.21 W/kg; SAR(10 g) = 2.33 W/kg
Maximum value of SAR (measured) = 22.1 W/kg



Validation Report for Head TSL of 5.75GHz

Test Laboratory: BTL Inc. Date: 2022/12/14

System Check_H5750_1214

DUT: Dipole D5GHzV2;SN:1160;

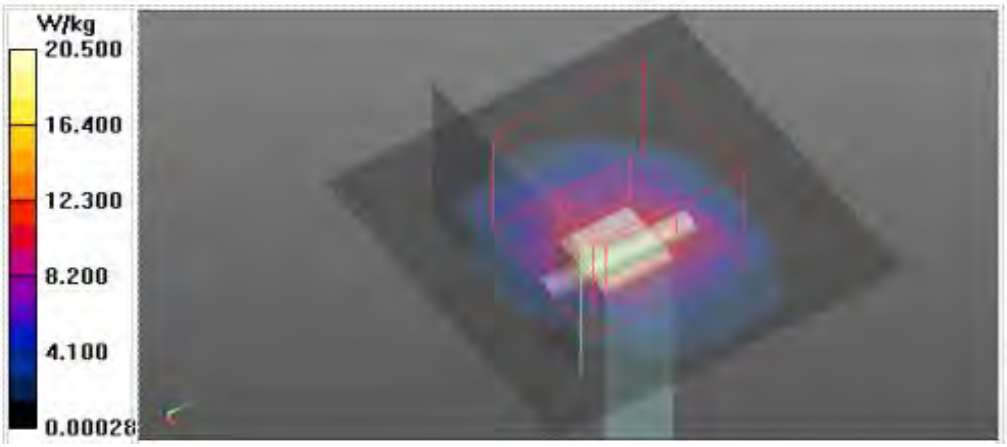
Communication System: UID 0, CW (0); Frequency: 5750 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5750 MHz; σ = 5.374 S/m; ε_r = 35.203; ρ = 1000 kg/m^3
Ambient Temperature: 23.1 ℃; Liquid Temperature: 22.5 ℃

DASY Configuration:

- Probe: EX3DV4 - SN3974; ConvF(5.04, 5.04, 5.04) @ 5750 MHz; Calibrated: 2022/1/24
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 1.0, 23.0
- Electronics: DAE4 Sn1390; Calibrated: 2021/12/29
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 1128
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

Area Scan (6x6x1): Measurement grid: dx=10mm, dy=10mm
Maximum value of SAR (measured) = 14.9 W/kg

Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 65.76 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 40.4 W/kg
SAR(1 g) = 7.5 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 20.5 W/kg



Calibrator: Juston Huang	Approver: Herbert Liu

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

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Accreditation No.: SCS 0108

Client **BTL-CN (Auden)**

Certificate No: D6.5GHzV2-1052_Nov21

CALIBRATION CERTIFICATE

Object	D6.5GHzV2 - SN:1052
Calibration procedure(s)	QA CAL-22.v6 Calibration Procedure for SAR Validation Sources between 3-10 GHz
Calibration date:	November 01, 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 (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Power sensor R&S NRP33T	SN: 100967	08-Apr-21 (No. 217-03293)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7405	30-Dec-20 (No. EX3-7405_Dec20)	Dec-21
DAE4	SN: 908	24-Jun-21 (No. DAE4-908_Jun21)	Jun-22

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator Anapico APSIN20G	SN: 669	28-Mar-17 (in house check Dec-18)	In house check: Dec-21
Network Analyzer Keysight E5063A	SN:MY54504221	31-Oct-19 (in house check Oct-19)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: November 2, 2021

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

S Schweizerischer Kalibrierdienst
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S Swiss Calibration Service

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.

Additional Documentation:

b) DASY 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.
- *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 absorbed power density (APD):* The absorbed power density is evaluated according to Samaras T, Christ A, Kuster N, "*Compliance assessment of the epithelial or absorbed power density above 6 GHz using SAR measurement systems*", Bioelectromagnetics, 2021 (submitted). The additional evaluation uncertainty of 0.55 dB (rectangular distribution) is considered.

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%.

Measurement Conditions

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

DASY Version	DASY6	V16.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	5 mm	with Spacer
Zoom Scan Resolution	dx, dy = 3.4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	6500 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	34.5	6.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	32.7 ± 6 %	6.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	29.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**290 W/kg ± 24.7 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	5.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**53.6 W/kg ± 24.4 % (k=2)**

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.8 Ω - 6.3 jΩ
Return Loss	- 24.0 dB

APD (Absorbed Power Density)

APD averaged over 1 cm²	Condition	
APD measured	100 mW input power	289 W/m²
APD measured	normalized to 1W	**2890 W/m² ± 29.2 % (k=2)**

APD averaged over 4 cm²	condition	
APD measured	100 mW input power	133 W/m²
APD measured	normalized to 1W	**1330 W/m² ± 28.9 % (k=2)**

General Antenna Parameters and Design

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

DASY6 Validation Report for Head TSL

Measurement Report for D6.5GHz-1052, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
D6.5GHz	16.0 x 6.0 x 300.0	SN: 1052	-

Exposure Conditions

Phantom Section, TSL	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz]	Conversion Factor	TSL Cond. [S/m]	TSL Permittivity
Flat, HSL	5.00	Band	CW,	6500	5.75	6.03	32.7

Hardware Setup

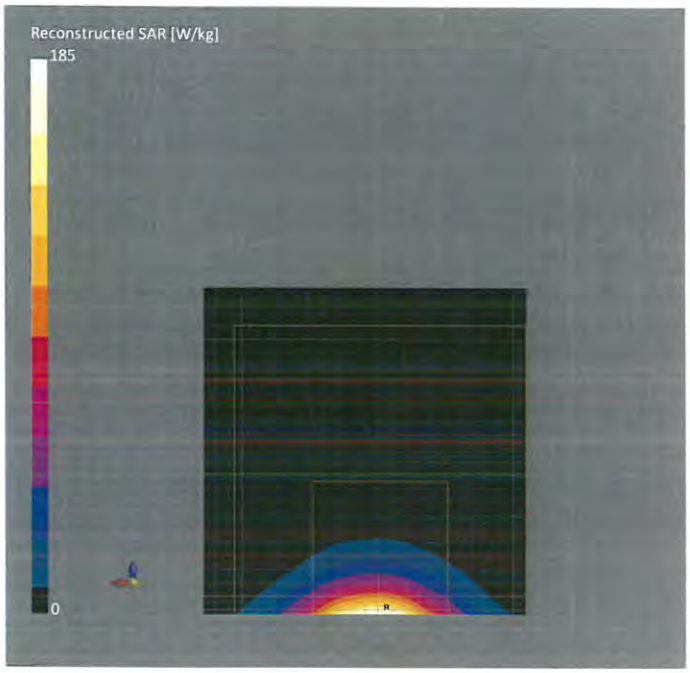
Phantom	TSL	Probe, Calibration Date	DAE, Calibration Date
MFP V8.0 Center - 1182	HBBL600-10000V6	EX3DV4 - SN7405, 2020-12-30	DAE4 Sn908, 2021-06-24

Scan Setup

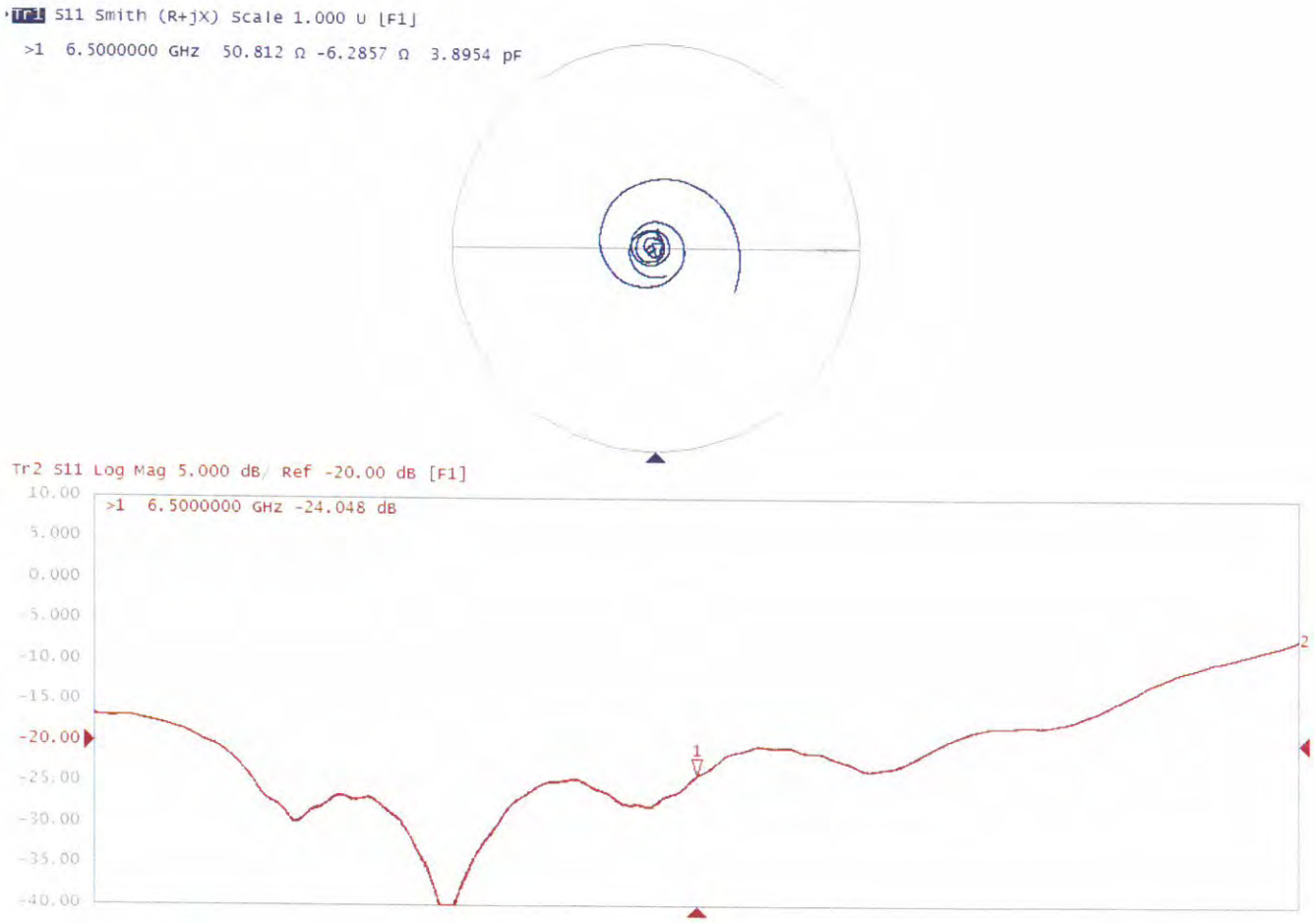
	Zoom Scan
Grid Extents [mm]	22.0 x 22.0 x 22.0
Grid Steps [mm]	3.4 x 3.4 x 1.4
Sensor Surface [mm]	1.4
Graded Grid	Yes
Grading Ratio	1.4
MAIA	N/A
Surface Detection	VMS + 6p
Scan Method	Measured

Measurement Results

	Zoom Scan
Date	2021-11-01, 12:59
psSAR1g [W/Kg]	29.3
psSAR10g [W/Kg]	5.43
Power Drift [dB]	0.02
Power Scaling	Disabled
Scaling Factor [dB]	
TSL Correction	No correction
M2/M1 [%]	51.5
Dist 3dB Peak [mm]	4.6



Impedance Measurement Plot for Head TSL



Dipole Internal Calibration Record

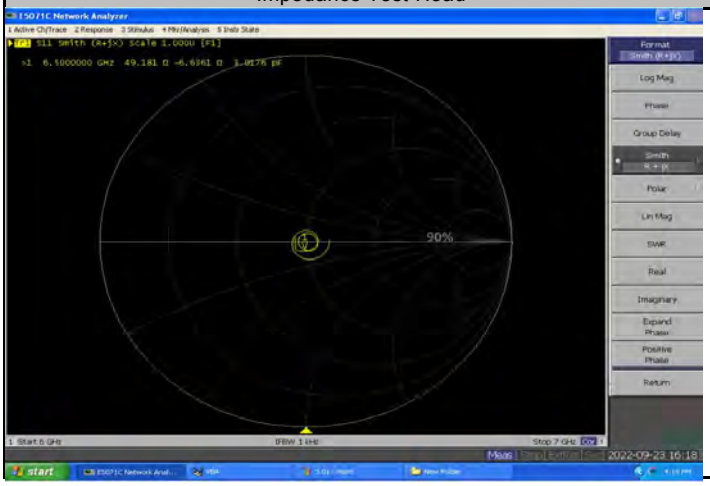
Asset No. :	E-1132	Model No. :	D6.5GHzV2	Serial No. :	1052
Environmental	22.8℃, 53 %	Original Cal. Date :	November 1, 2021	Next Cal. Date :	November 1, 2024

Standard List		
1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorpiton Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Texhniques, June 2013
2	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
3	KDB865664	SAR Measurement Requirements for 100 MHz to 6 GHz

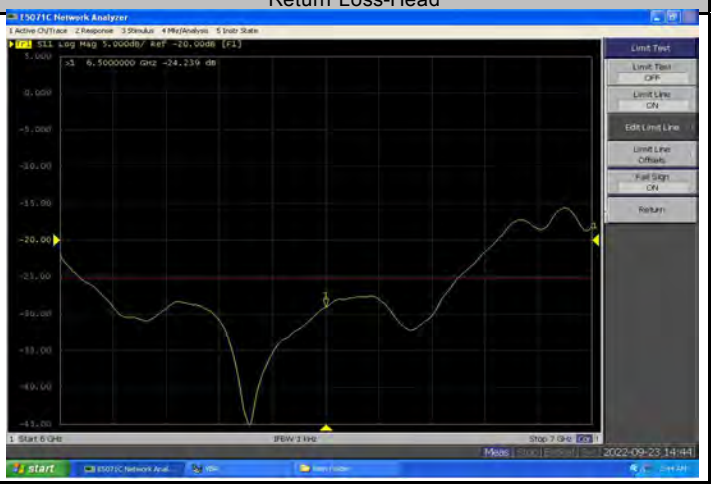
Equipment Information					
Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Cal. Date :
Power Amplifier	Mini-Circuits	ZVE-8G+	520701341	N/A	Apr. 14, 2022
DC Source metter	Iteck	IT6154	006104126768201001	N/A	Jul. 16, 2022
Signal Analyzer	R&S	FSV40	100948	N/A	October 29, 2022
Vector Network Analyze	Agilent	E5071C	MY46102965	N/A	Feb. 19, 2022
Signal Generator	Keysight	N5173B	MY59101420	N/A	Feb. 19, 2022
Smart Power Sensor	R&S	NRP-Z21	102209	N/A	Feb. 19, 2022
Dielectric Assessment	Speag	DAK-3.5	1226	N/A	Jan. 24, 2022
Directional Coupler	Woken	TS-PCC0M-05	0107090019	N/A	Feb. 19, 2022
Coupler	Woken	0110A05601O-10	COM5BNW1A2	N/A	Feb. 19, 2022
Digital Themometer	TES	TES-1310	210706071	N/A	Nov. 17, 2022

Model No	For Head Tissue				
	Item	Originak Cal. Result	Verified on 2022/9/23	Deviation	Result
D5GHzV2(5750MHz)	Impedance, transformed to feed	50.8Ω-6.3jΩ	49.2Ω-6.6jΩ	<5Ω	Pass
	Return Loss(dB)	-24	-24.239	1.0%	Pass
	SAR Value for	29.3	27.8	-5.1%	Pass
	SAR Value for	5.43	5.12	-5.7%	Pass

Impedance Test-Head



Return Loss-Head



Validation Report for Head TSL of 6.5GHz

Measurement Report for Device, , , UID 0 -, Channel 0 (6500.0MHz)Test Laboratory: BTL.Inc

Device under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	50.0 x 10.0 x 8.0		Phone

Exposure Conditions

Phantom Section, TSL	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor	TSL Conductivity [S/m]	TSL Permittivity
Flat ,	,		,	6500.0,	5.9	6.04	34.4

Hot, HSL			0--	6500.0, 0	5.9	6.04	34.4

Hardware Setup

Phantom	TSL, Measured Date	Probe, Calibration Date	DAE, Calibration Date
Twin-SAM V8.0 (30deg probe tilt) - 2081	HBBL-600-10000 Charge:xxxx, --	EX3DV4 - SN7351, 2022-02-04	DAE4 Sn1717, 2022-03-08

Scan Setup

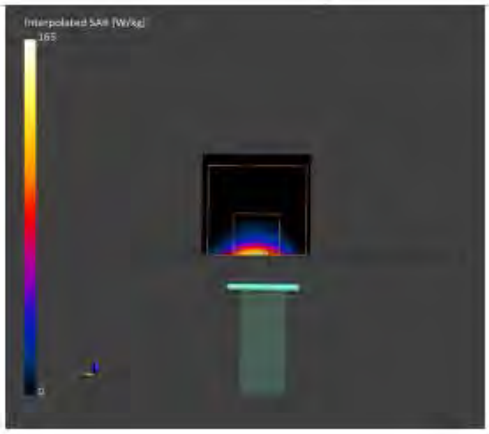
	Area Scan	Zoom Scan
Grid Extents [mm]	51.0 x 85.0	22.0 x 22.0 x 22.0
Grid Steps [mm]	8.5 x 8.5	3.4 x 3.4 x 1.4
Sensor Surface [mm]	3.0	1.4
Graded Grid	Yes	Yes
Grading Ratio	1.5	1.4
MAIA	N/A	N/A
Surface Detection	VMS + 6p	VMS + 6p
Scan Method	Measured	Measured

Measurement Results

	Area Scan	Zoom Scan
Date	2022-09-23	2022-09-23
psSAR1g [W/kg]	23.4	27.8
psSAR10g [W/kg]	4.87	5.12
Power Drift [dB]	-0.00	0.00
Power Scaling	Disabled	Disabled
Scaling Factor [dB]		
TSL Correction	No correction	No correction
M2/M1 [%]		50.3
Dist 3dB Peak [mm]		4.6

Warning(s) / Error(s)

Details	Area Scan	Zoom Scan
Warning(s)		Peak 10g averaged SAR on boundary.
Error(s)		



Calibrator:	Justin Huang	Approver:	Herbert Liu