

F.4 5GHz Dipole

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CALIBRATION LABORATORY

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CNAS L0570

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Client **baluntek** Certificate No: **Z21-60173**

CALIBRATION CERTIFICATE			
Object	D5GHzV2 - SN: 1200		
Calibration Procedure(s)	FF-Z11-003-01 Calibration Procedures for dipole validation kits		
Calibration date:	May 18, 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	106277	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
Power sensor NRP8S	104291	23-Sep-20 (CTTL, No.J20X08336)	Sep-21
ReferenceProbe EX3DV4	SN 3846	26-Apr-21(CTTL-SPEAG,No.Z21-60084)	Apr-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	25-Feb-20 (CTTL, No.J20X00516)	Feb-21
NetworkAnalyzerE5071C	MY46110673	10-Feb-20 (CTTL, No.J20X00515)	Feb-21
Calibrated by:	Name Zhao Jing	Function SAR Test Engineer	Signature
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	
Issued: May 24, 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 / NORM _{x,y,z}
N/A	not applicable or not measured

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 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
- 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
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

Additional Documentation:

- 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	35.5 ± 6 %	4.67 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	7.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	77.8 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.1 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	34.9 ± 6 %	5.05 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	8.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.2 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 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	34.7 ± 6 %	5.21 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	7.75 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	77.2 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	Condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.7 W/kg ± 24.2 % (k=2)



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Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.36 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.1 ± 6 %	5.34 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.33 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.4 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.5 W/kg ± 24.2 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	5.82 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.72 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.2 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.6 W/kg ± 24.2 % (k=2)



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Body TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.3	5.94 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.1 ± 6 %	6.05 mho/m ± 6 %
Body TSL temperature change during test	<1.0 °C	----	----

SAR result with Body TSL at 5750 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.34 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.4 W/kg ± 24.4 % (k=2)
SAR averaged over 10 cm^3 (10 g) of Body TSL	Condition	
SAR measured	100 mW input power	2.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.3 W/kg ± 24.2 % (k=2)



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Appendix (Additional assessments outside the scope of CNAS L0570)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	45.1 Ω + 1.25j Ω
Return Loss	- 25.5dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	49.7 Ω + 7.81j Ω
Return Loss	- 22.1dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	45.9 Ω + 4.85j Ω
Return Loss	- 23.5dB

Antenna Parameters with Body TSL at 5250 MHz

Impedance, transformed to feed point	43.9 Ω + 2.08j Ω
Return Loss	- 23.3dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	50.3 Ω + 8.89j Ω
Return Loss	- 21.1dB

Antenna Parameters with Body TSL at 5750 MHz

Impedance, transformed to feed point	46.6 Ω + 5.63j Ω
Return Loss	- 23.3dB



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General Antenna Parameters and Design

Electrical Delay (one direction)	1.096 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: 05.18.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1200

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

Medium parameters used: $f = 5250$ MHz; $\sigma = 4.668$ S/m; $\epsilon_r = 35.48$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5600$ MHz; $\sigma = 5.045$ S/m; $\epsilon_r = 34.88$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5750$ MHz; $\sigma = 5.208$ S/m; $\epsilon_r = 34.67$; $\rho = 1000$ kg/m³,

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3846; ConvF(5.43, 5.43, 5.43) @ 5250 MHz; ConvF(4.69, 4.69, 4.69) @ 5600 MHz; ConvF(4.9, 4.9, 4.9) @ 5750 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)

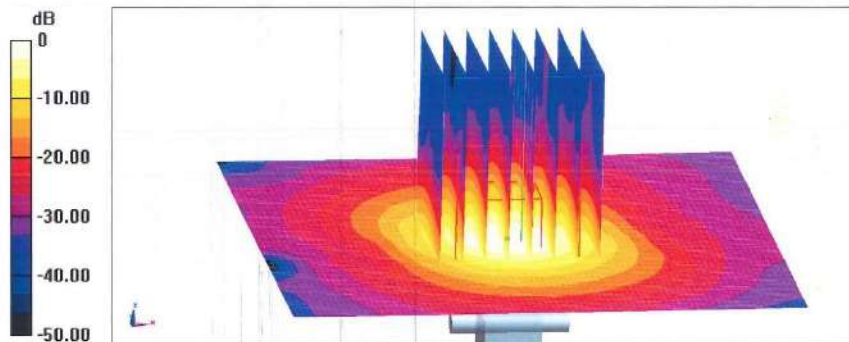
Dipole Calibration /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 69.22 V/m; Power Drift = -0.08 dB
 Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 7.8 W/kg; SAR(10 g) = 2.22 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 63.3%
 Maximum value of SAR (measured) = 18.9 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 = 70.18 V/m; Power Drift = -0.07 dB
 Peak SAR (extrapolated) = 35.5 W/kg
SAR(1 g) = 8.15 W/kg; SAR(10 g) = 2.32 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.4 mm
 Ratio of SAR at M2 to SAR at M1 = 62.9%
 Maximum value of SAR (measured) = 19.8 W/kg



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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 = 68.06 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 34.6 W/kg
SAR(1 g) = 7.75 W/kg; SAR(10 g) = 2.18 W/kg
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 62.1%
Maximum value of SAR (measured) = 19.0 W/kg

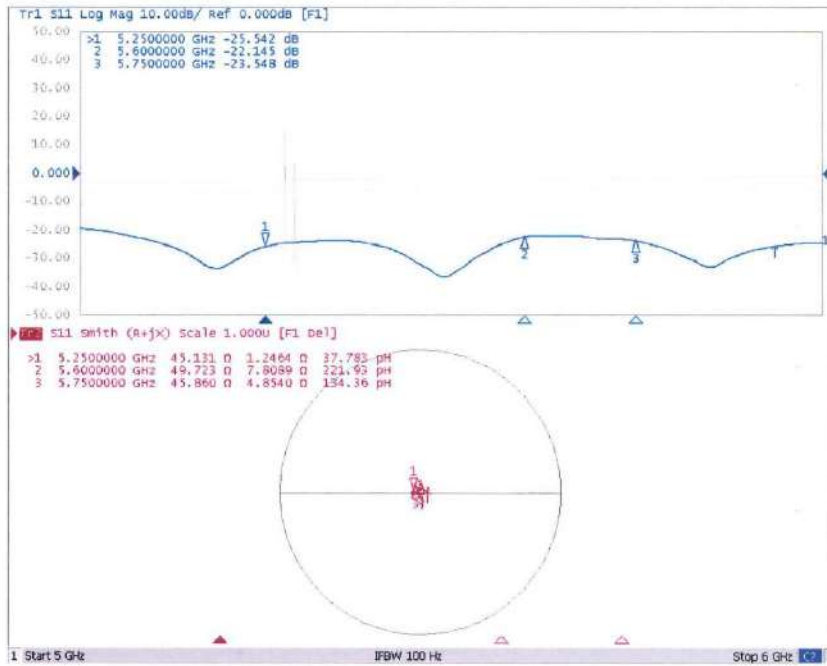


0 dB = 19.0 W/kg = 12.79 dBW/kg



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Impedance Measurement Plot for Head TSL





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DASY5 Validation Report for Body TSL

Date: 05.18.2021

Test Laboratory: CTTL, Beijing, China

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1200

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

Medium parameters used: $f = 5250$ MHz; $\sigma = 5.34$ S/m; $\epsilon_r = 49.12$; $\rho = 1000$ kg/m³,
 Medium parameters used: $f = 5600$ MHz; $\sigma = 5.815$ S/m; $\epsilon_r = 48.44$; $\rho = 1000$
 kg/m³, Medium parameters used: $f = 5750$ MHz; $\sigma = 6.045$ S/m; $\epsilon_r = 48.11$; $\rho =$
 1000 kg/m³,

Phantom section: Right Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3846; ConvF(4.95, 4.95, 4.95) @ 5250 MHz; ConvF(4.32, 4.32, 4.32) @ 5600 MHz; ConvF(4.38, 4.38, 4.38) @ 5750 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)

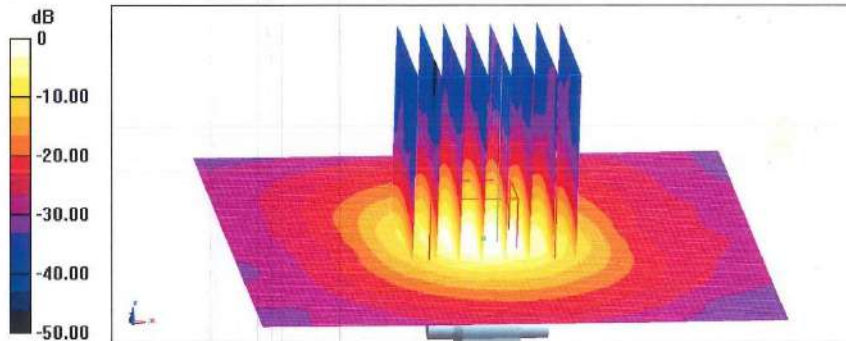
Dipole Calibration /Pin=100mW, d=10mm, f=5250 MHz/Zoom Scan,
 dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 65.86 V/m; Power Drift = 0.00 dB
 Peak SAR (extrapolated) = 29.6 W/kg
SAR(1 g) = 7.33 W/kg; SAR(10 g) = 2.05 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 65.3%
 Maximum value of SAR (measured) = 17.2 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 = 66.06 V/m; Power Drift = 0.02 dB
 Peak SAR (extrapolated) = 33.1 W/kg
SAR(1 g) = 7.72 W/kg; SAR(10 g) = 2.16 W/kg
 Smallest distance from peaks to all points 3 dB below = 7.2 mm
 Ratio of SAR at M2 to SAR at M1 = 63.1%
 Maximum value of SAR (measured) = 18.8 W/kg



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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 = 64.58 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 32.8 W/kg
SAR(1 g) = 7.34 W/kg; SAR(10 g) = 2.03 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 62%
Maximum value of SAR (measured) = 18.1 W/kg



0 dB = 18.1 W/kg = 12.58 dBW/kg



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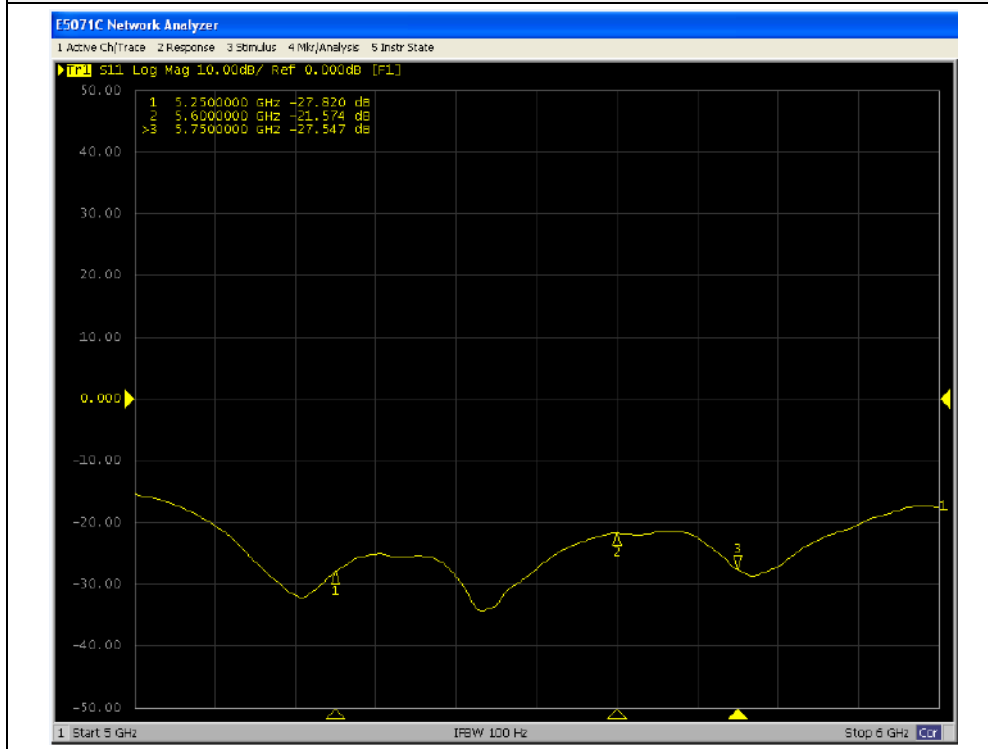
Impedance Measurement Plot for Body TSL

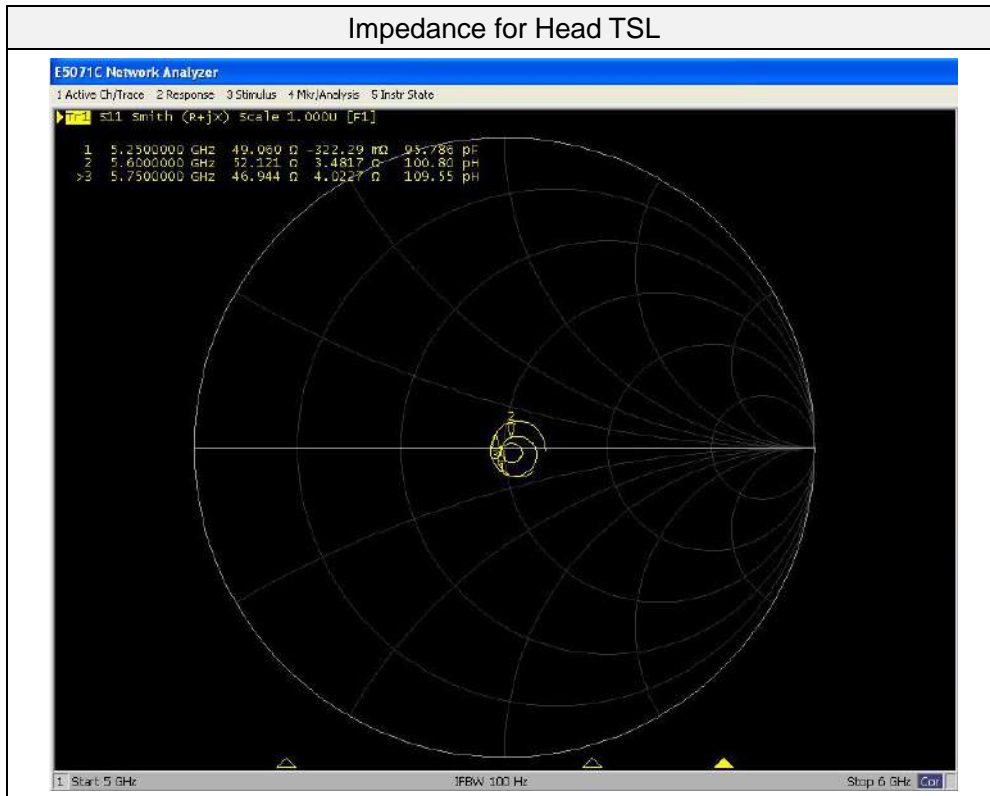


D5GHzV2 Dipole impedance and return loss Validation

Meas. Results	Current Meas.	Previous Meas.	Max. Deviation
Meas. Data	2023.05.16	2022.05.17	/
5.25GHz Return Loss(dB)	-27.820	-29.961	-7.15%
5.25GHz Impedance	49.06 Ω -0.322 j Ω	48.925 Ω +1.802 j Ω	-2.124 Ω (Imaginary part)
5.6GHz Return Loss(dB)	-21.574	-25.244	-14.54%
5.6GHz Impedance	52.121 Ω +3.482 j Ω	47.163 Ω +3.417 j Ω	4.958 Ω (Real part)
5.75GHz Return Loss(dB)	-27.547	-27.284	0.96%
5.75GHz Impedance	46.944 Ω +4.023 j Ω	50.693 Ω +8.724 j Ω	-4.701 Ω (Imaginary part)

Return Loss for Head TSL





--END OF REPORT--