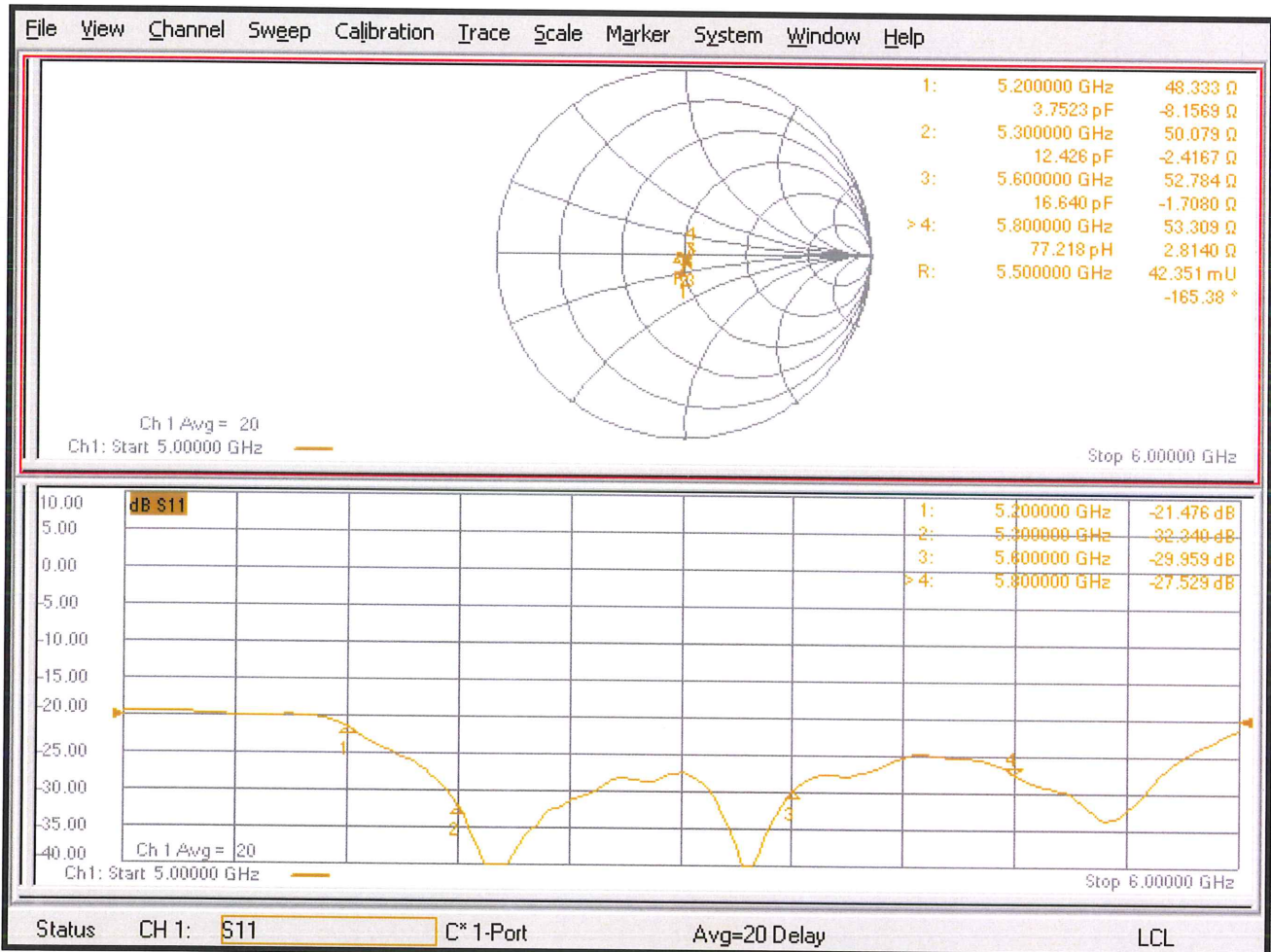


# Impedance Measurement Plot for Head TSL





## Dipole Internal Calibration Record

Asset No. :	E-436	Model No. :	D5GHzV2	Cal. Date :	February 9, 2021
Equipment :	ENA Network Analyzer	Serial No. :	1121	Next Cal. Date :	February 8, 2024
Environmental condition :		Temp :	23.5 °C	R.H. :	51%

### Standard List

1	IEEE Std 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate(SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, 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	EMCI	EMC053035	980869	N/A	December 7, 2021
Power Meter	Anritsu	MA2487A	6K00004714	N/A	August 15, 2021
Power Sensor	Anritsu	MA2491A	34138	N/A	August 15, 2021
Directional Coupler	Woken	TS-PCC0M-05	107090019	N/A	N/A
Signal Generator	R & S	SMB100A	113244	N/A	August 2, 2021
ENA Network Analyzer	Agilent	E5071C	MY46524658	N/A	March 22, 2021

### For Head Tissue

Frequency	Item	Original Cal. Result	Verified on 2022/1/24	Deviation	Result
5.2G	Impedance, transformed to feed point( $\Omega$ )	48.3 $\Omega$ -8.2j $\Omega$	44.3 $\Omega$ -5.3j $\Omega$	<5 $\Omega$	Pass
	Return Loss(dB)	-21.5	-21.65	-0.7%	Pass
	SAR Value for 1g(mW/g)	8.04	7.83	3%	Pass
	SAR Value for 10g(mW/g)	2.3	2.26	1.7%	Pass
5.3G	Impedance, transformed to feed point	50.1 $\Omega$ -2.4j $\Omega$	51.4 $\Omega$ +2.8j $\Omega$	<5 $\Omega$	Pass
	Return Loss(dB)	-32.3	-30.4	5.9%	Pass
	SAR Value for 1g(mW/g)	8.26	8.17	1.1%	Pass
	SAR Value for 10g(mW/g)	2.37	2.35	0.8%	Pass
5.6G	Impedance, transformed to feed point	52.8 $\Omega$ -1.7j $\Omega$	47.9 $\Omega$ -1.3j $\Omega$	<5 $\Omega$	Pass
	Return Loss(dB)	-30	-31.78	-5.9%	Pass
	SAR Value for 1g(mW/g)	8.53	8.27	3.0%	Pass
	SAR Value for 10g(mW/g)	2.43	2.37	2.5%	Pass
5.8G	Impedance, transformed to feed point	53.3 $\Omega$ +2.8j $\Omega$	49.2 $\Omega$ +3.5j $\Omega$	<5 $\Omega$	Pass
	Return Loss(dB)	-27.5	-28.83	-4.8%	Pass
	SAR Value for 1g(mW/g)	8.25	8.01	2.9%	Pass
	SAR Value for 10g(mW/g)	2.33	2.27	2.6%	Pass

Note : SAR System Uncertainty : % , ( 95% CONFIDENCE LEVEL , Expanded uncertainty K=2 )

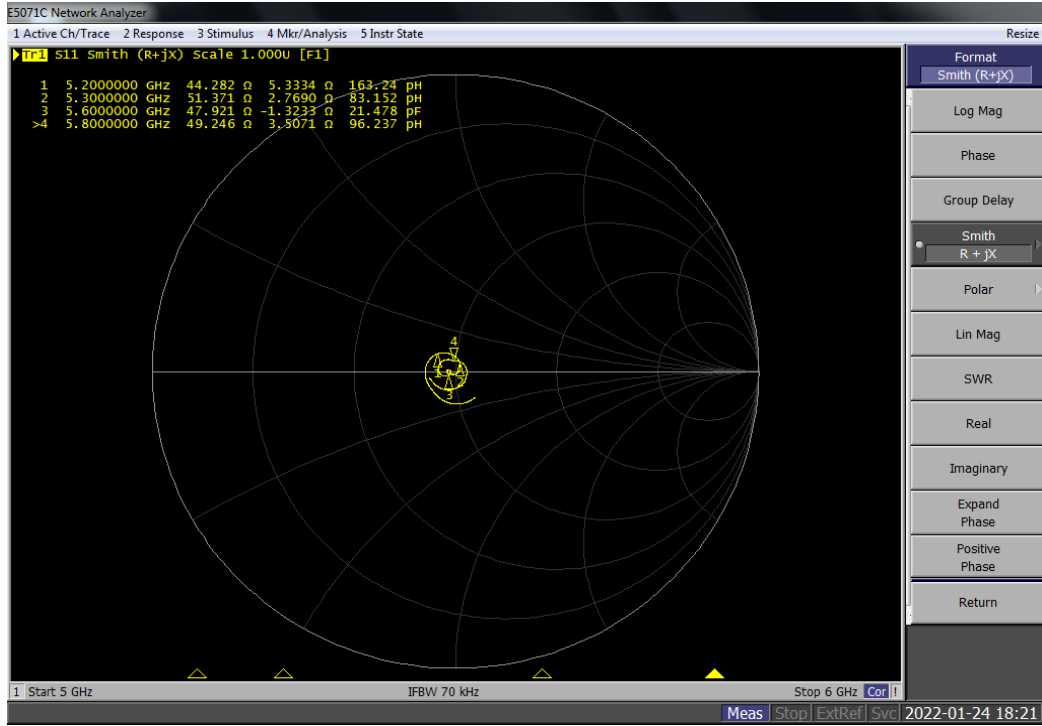
Tester :

*Jenny Chang*

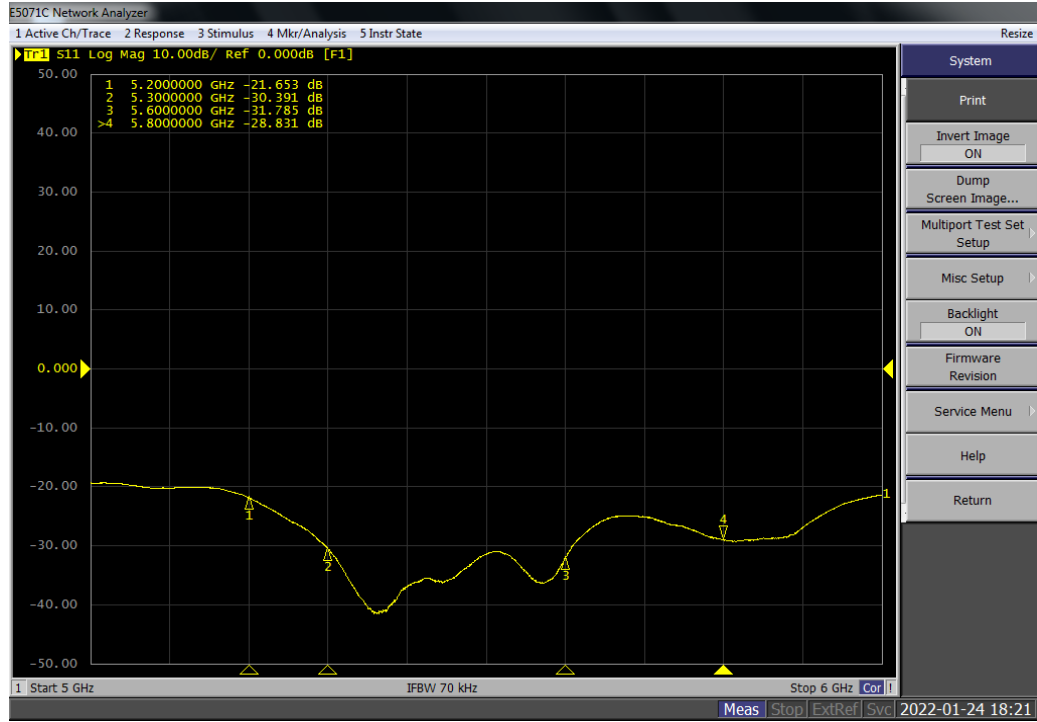
Technical Director :

*Peter Chen*

# Impedance Test-Head



# Return Loss-Head



## System Check\_H5G

Frequency: 5200 MHz; Duty Cycle: 1:1; Room Ambient Temperature: 23.0°C; Liquid Temperature: 22.0°C

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.777$  S/m;  $\epsilon_r = 35.51$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY5 Configuration:

- Area Scan Setting: Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Electronics: DAE4 Sn1486; Calibrated: 2021/6/1
- Probe: EX3DV4 - SN7369; ConvF(5.15, 5.15, 5.15) @ 5200 MHz; Calibrated: 2021/6/3
- Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Phantom: ELI V5.0 (20deg probe tilt); Type: QD OVA 002 AA; Serial: 1240

### Configuration/Pin=100mW/Area Scan (10x10x1): Measurement grid:

$dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 11.6 W/kg

### Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement

grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

Reference Value = 61.34 V/m; Power Drift = 0.00 dB

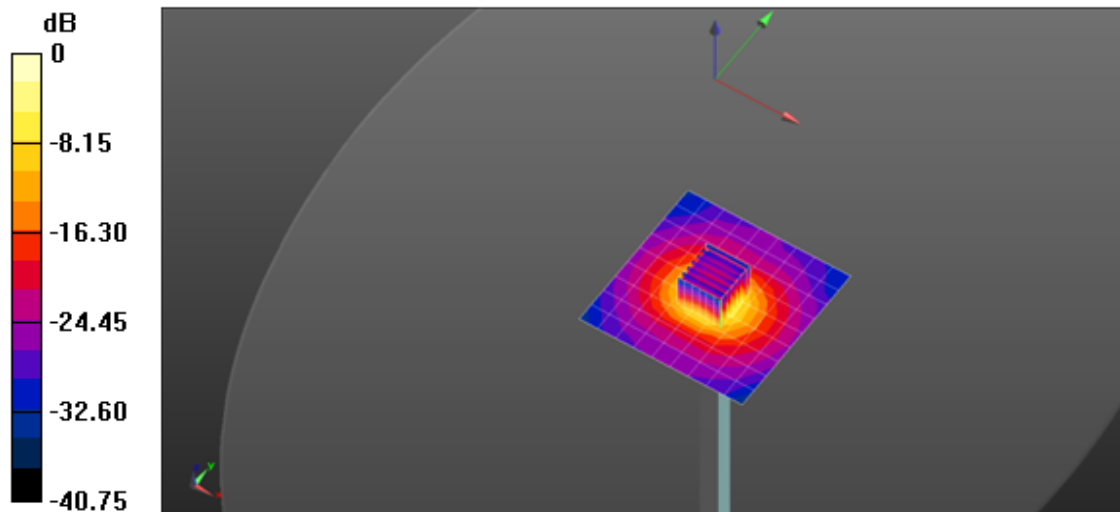
Peak SAR (extrapolated) = 29.9 W/kg

**SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.26 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.5 mm

Ratio of SAR at M2 to SAR at M1 = 56.3%

Maximum value of SAR (measured) = 19.2 W/kg



0 dB = 19.2 W/kg = 12.83 dBW/kg

## System Check\_H5G

Frequency: 5300 MHz; Duty Cycle: 1:1; Room Ambient Temperature: 23.0°C; Liquid Temperature: 22.0°C

Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.899$  S/m;  $\epsilon_r = 35.252$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY5 Configuration:

- Area Scan Setting: Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg

- Electronics: DAE4 Sn1486; Calibrated: 2021/6/1

- Probe: EX3DV4 - SN7369; ConvF(5, 5, 5) @ 5300 MHz; Calibrated: 2021/6/3

- Sensor-Surface: 1.4mm (Mechanical Surface Detection)

- Phantom: ELI V5.0 (20deg probe tilt); Type: QD OVA 002 AA; Serial: 1240

**Configuration/Pin=100mW/Area Scan (10x10x1):** Measurement grid:

$dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 12.3 W/kg

**Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0:** Measurement

grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

Reference Value = 62.00 V/m; Power Drift = 0.01 dB

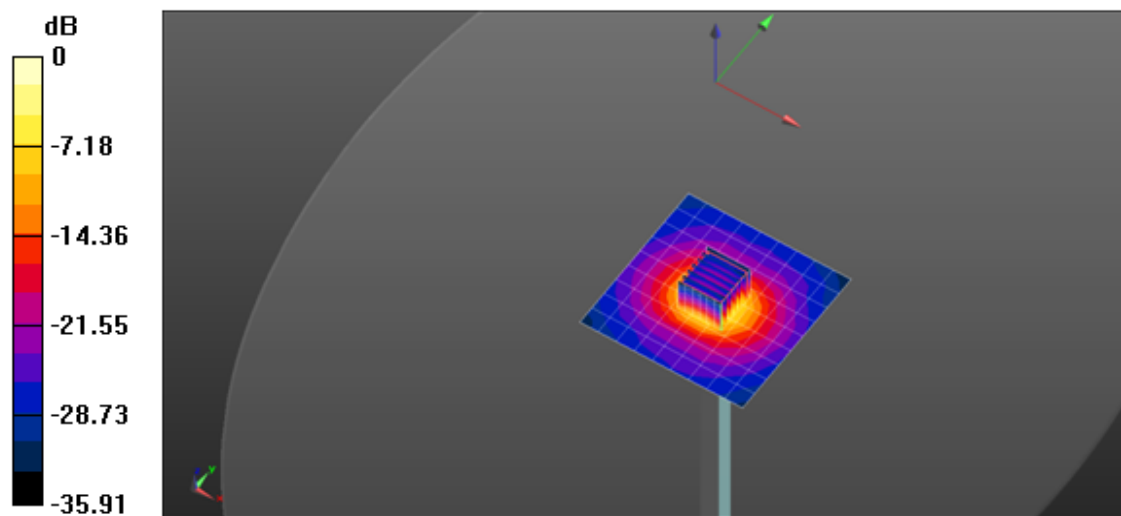
Peak SAR (extrapolated) = 32.2 W/kg

**SAR(1 g) = 8.17 W/kg; SAR(10 g) = 2.35 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.5 mm

Ratio of SAR at M2 to SAR at M1 = 55.3%

Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

## System Check\_H5G

Frequency: 5600 MHz; Duty Cycle: 1:1; Room Ambient Temperature: 23.0°C; Liquid Temperature: 22.0°C

Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.264$  S/m;  $\epsilon_r = 34.496$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY5 Configuration:

- Area Scan Setting: Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Electronics: DAE4 Sn1486; Calibrated: 2021/6/1
- Probe: EX3DV4 - SN7369; ConvF(4.66, 4.66, 4.66) @ 5600 MHz; Calibrated: 2021/6/3
- Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Phantom: ELI V5.0 (20deg probe tilt); Type: QD OVA 002 AA; Serial: 1240

### Configuration/Pin=100mW/Area Scan (10x10x1): Measurement grid:

$dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 13.0 W/kg

### Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement

grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

Reference Value = 60.64 V/m; Power Drift = -0.00 dB

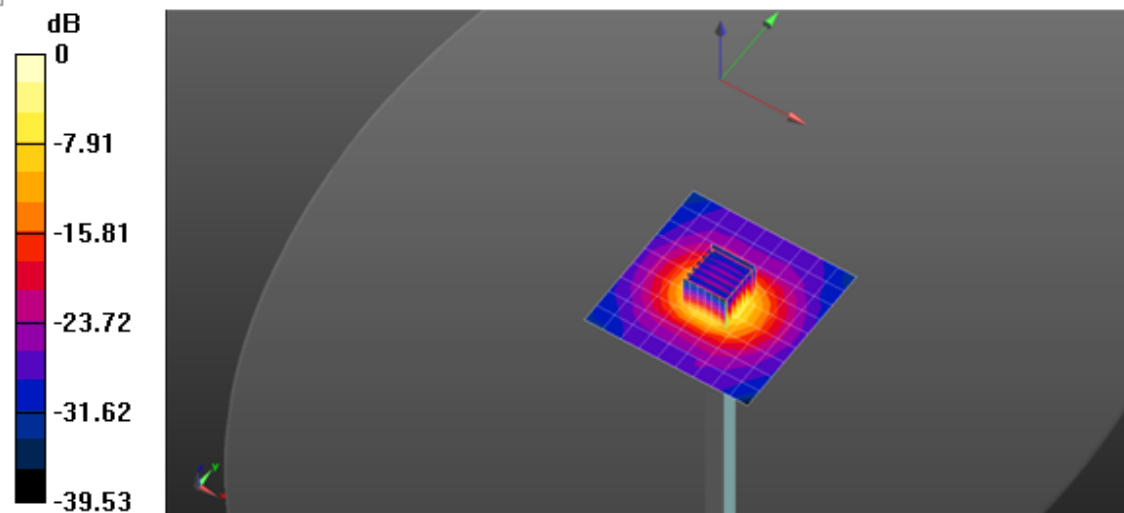
Peak SAR (extrapolated) = 34.9 W/kg

**SAR(1 g) = 8.27 W/kg; SAR(10 g) = 2.37 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.6 mm

Ratio of SAR at M2 to SAR at M1 = 52.8%

Maximum value of SAR (measured) = 21.0 W/kg



0 dB = 21.0 W/kg = 13.22 dBW/kg

## System Check\_H5G

Frequency: 5800 MHz; Duty Cycle: 1:1; Room Ambient Temperature: 23.0°C; Liquid Temperature: 22.0°C

Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.503$  S/m;  $\epsilon_r = 34.001$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY5 Configuration:

- Area Scan Setting: Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg

- Electronics: DAE4 Sn1486; Calibrated: 2021/6/1

- Probe: EX3DV4 - SN7369; ConvF(4.61, 4.61, 4.61) @ 5800 MHz; Calibrated: 2021/6/3

- Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)),

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

- Phantom: ELI V5.0 (20deg probe tilt); Type: QD OVA 002 AA; Serial: 1240

### Configuration/Pin=100mW/Area Scan (10x10x1): Measurement grid:

$dx=10$ mm,  $dy=10$ mm

Maximum value of SAR (measured) = 12.9 W/kg

### Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement

grid:  $dx=4$ mm,  $dy=4$ mm,  $dz=2$ mm

Reference Value = 58.58 V/m; Power Drift = -0.00 dB

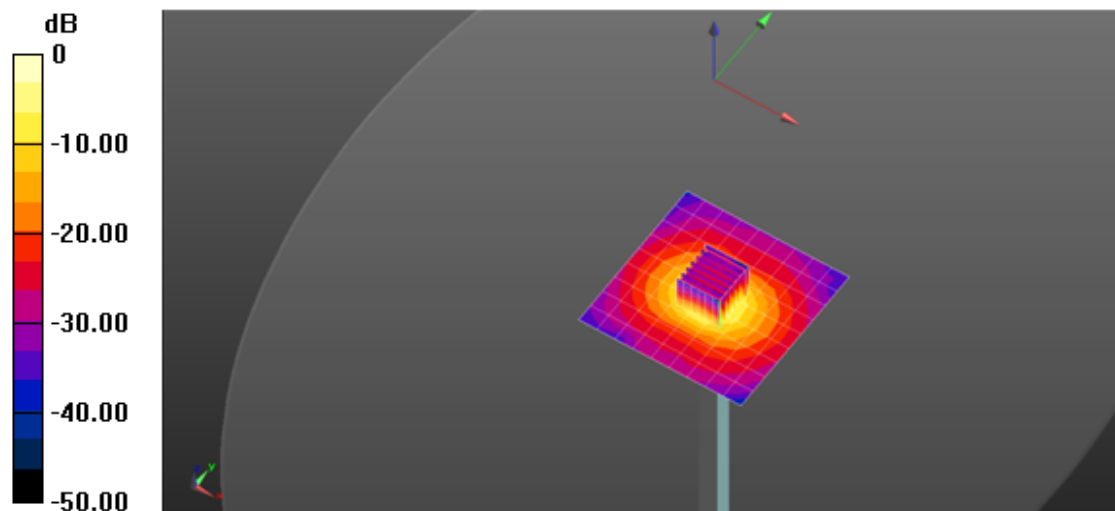
Peak SAR (extrapolated) = 36.1 W/kg

**SAR(1 g) = 8.01 W/kg; SAR(10 g) = 2.27 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.5 mm

Ratio of SAR at M2 to SAR at M1 = 50.6%

Maximum value of SAR (measured) = 21.0 W/kg



0 dB = 21.0 W/kg = 13.22 dBW/kg





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**

**Client** BTL-TW (Auden)

**Certificate No:** D6.5GHzV2-1041\_Sep21

## CALIBRATION CERTIFICATE

**Object** D6.5GHzV2 - SN:1041

**Calibration procedure(s)** QA CAL-22.v6  
Calibration Procedure for SAR Validation Sources between 3-10 GHz

**Calibration date:** September 02, 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 ( $22 \pm 3$ )°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 R&S ZVL13	SN: 101093	10-May-12 (in house check Dec-18)	In house check: Dec-21

**Calibrated by:** Name: Jeton Kastrati, Function: Laboratory Technician, Signature:

**Approved by:** Name: Niels Kuster, Function: Quality Manager, Signature:

Issued: September 7, 2021

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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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:

- 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:

- 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.

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

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	34.5	6.07 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	33.6 ± 6 %	6.12 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	100 mW input power	29.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>289 W/kg ± 24.7 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	100 mW input power	5.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>53.0 W/kg ± 24.4 % (k=2)</b>

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.6 $\Omega$ - 1.5 $j\Omega$
Return Loss	- 36.2 dB

### APD (Absorbed Power Density)

APD averaged over 1 cm <sup>2</sup>	Condition	
APD measured	100 mW input power	289 W/m <sup>2</sup>
APD measured	normalized to 1W	<b>2890 W/m<sup>2</sup> <math>\pm</math> 29.2 % (k=2)</b>

APD averaged over 4 cm <sup>2</sup>	condition	
APD measured	100 mW input power	129 W/m <sup>2</sup>
APD measured	normalized to 1W	<b>1290 W/m<sup>2</sup> <math>\pm</math> 28.9 % (k=2)</b>

### 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
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# DASY6 Validation Report for Head TSL

Measurement Report for D6.5GHz-1041, 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: 1041	-

## 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	6.12	33.6

## Hardware Setup

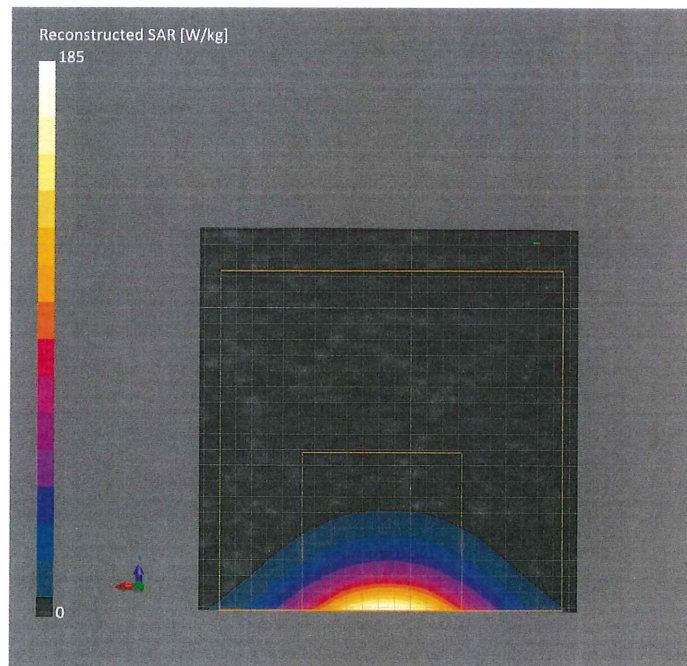
Phantom	TSL	Probe, Calibration Date	DAE, Calibration Date
MFP V8.0 Center - 1182	HBBL600-10000V6	EX3DV4 - SN7405, 2020-12-30	DAE4 Sn908, 2021-06-24

## 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	2021-09-02, 10:54
psSAR1g [W/Kg]	29.1
psSAR10g [W/Kg]	5.34
Power Drift [dB]	0.02
Power Scaling	Disabled
Scaling Factor [dB]	
TSL Correction	No correction
M2/M1 [%]	50.0
Dist 3dB Peak [mm]	4.6

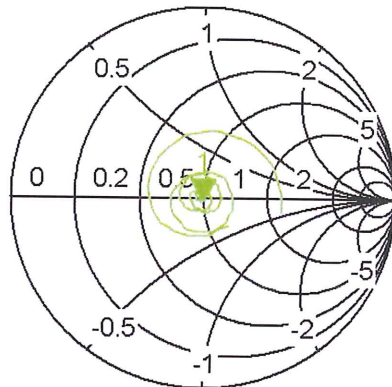


# Impedance Measurement Plot for Head TSL



Trc1 S11 Smith Ref 1 U Cal

S11



1 6.500000 GHz 49.642  $\Omega$   
 -j1.503  $\Omega$   
 16.294 pF

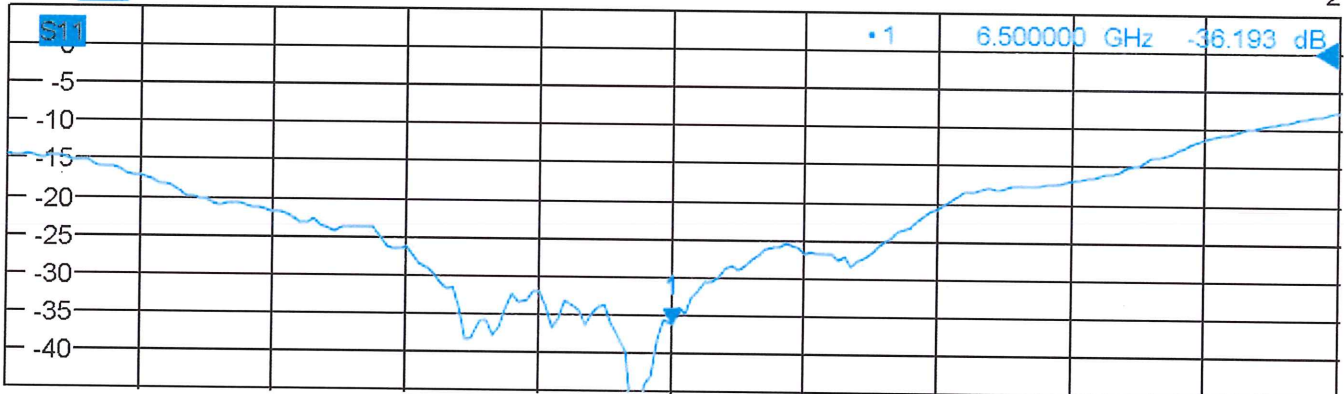
Ch1 Center 6.5 GHz

Pwr 0 dBm

Span 2 GHz

Trc2 S11 dB Mag 5 dB/ Ref 0 dB Cal

2



Ch1 Center 6.5 GHz

Pwr 0 dBm

Span 2 GHz



## Dipole Internal Calibration Record

Asset No. :	E-1082	Model No. :	D6.5GHzV2	Serial No. :	1041
Environmental	22.6°C, 55 %	Original Cal. Date :	September 2, 2021	Next Cal. Date :	September 1, 2024

### Standard List

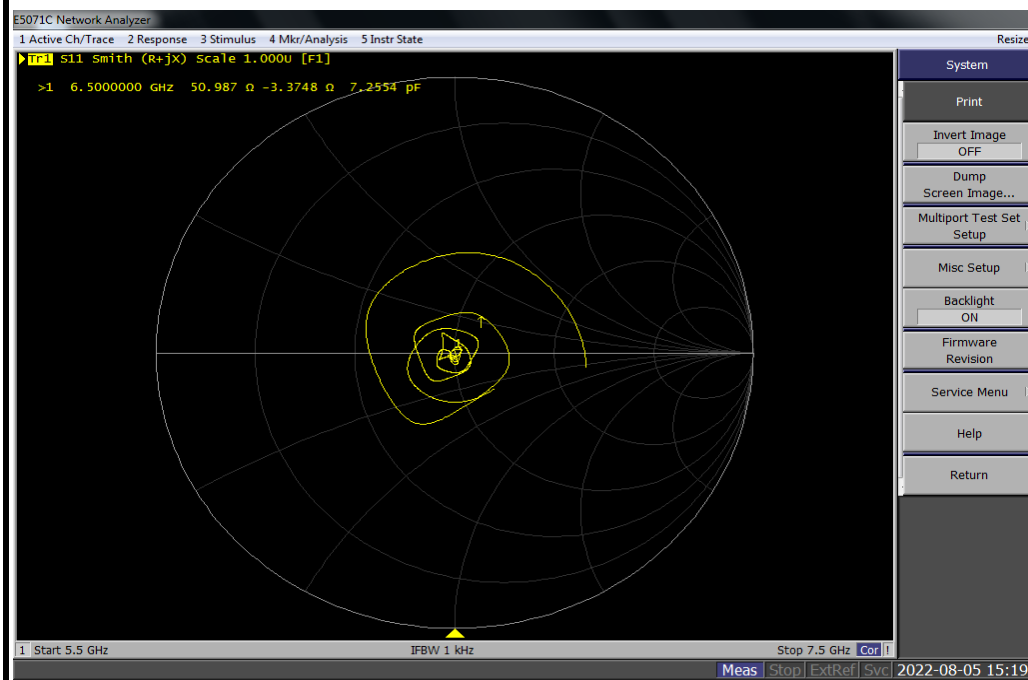
1	IEC 62209-1528:2020	Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1528: Human models, instrumentation, and procedures(Frequency range of 4 MHz to 10 GHz)
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### Equipment Information

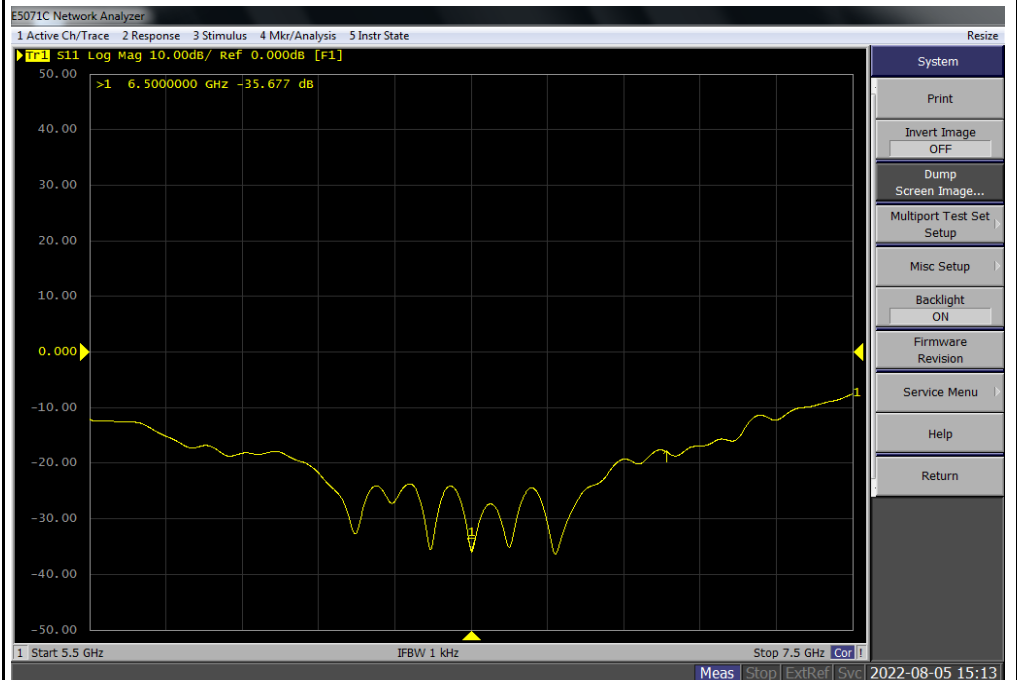
Equipment :	Manufacturer :	Model No. :	Serial No. :	Cal.Organization :	Cal. Date :
Power Amplifier	EMCI	EMC053035	980869	N/A	N/A
Power Meter	Anritsu	MA2495A	1128008	N/A	June 1, 2022
Power Sensor	Anritsu	MA2411B	1126001	N/A	June 1, 2022
Directional Coupler	Woken	TS-PCC0M-05	107090019	N/A	N/A
Signal Generator	R&S	SMR40	100502	N/A	January 10, 2022
ENA Network Analyzer	Agilent	E5071C	MY46524658	N/A	March 21, 2022

Model No	For Head Tissue				
	Item	Original Cal. Result	Verified on 2022/08/05	Deviation	Result
D6.5GHzV2	Impedance, transformed to feed point	49.6Ω-1.5jΩ	51.0Ω-3.4jΩ	<5Ω	Pass
	Return Loss(dB)	-36.2	-35.7	1.4%	Pass
	SAR Value for 1g(mW/g)	29.1	27.8	-4.5%	Pass
	SAR Value for 10g(mW/g)	5.34	5.21	-2.4%	Pass

#### Impedance Test-Head



#### Return Loss-Head



Validation Report for Head TSL

Measurement Report for Device, , , CW, Channel 0 (6500.0 MHz)

Device Under Test Properties

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

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, HSL	.	.	0--	6500.0, 0	5.4	5.99	33.6

Hardware Setup

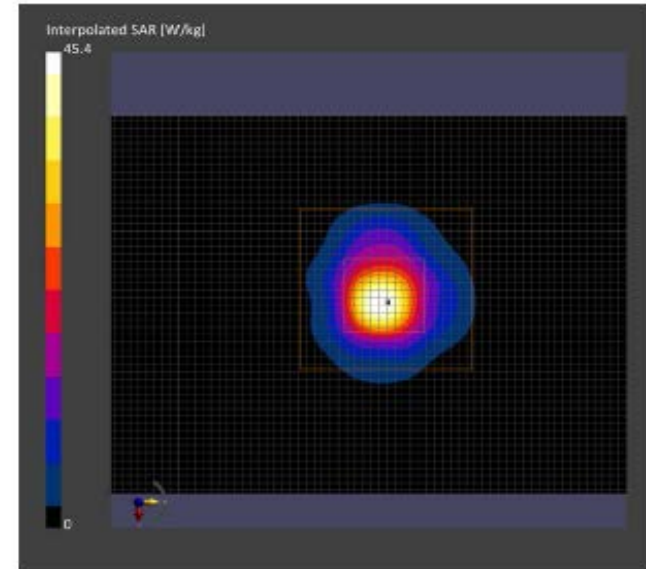
Phantom	TSL, Measured Date	Probe, Calibration Date	DAE, Calibration Date
ELI V5.0 (20deg probe tilt) - 1240	H6E- 2022-08-05 Charge:xxxx,	EX3DV4 - SN7369, 2022-05-28	DAE4 Sn1486, 2022-05-31

Scans 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	All points	All points
Scan Method	Measured	Measured

Measurement Results

	Area Scan	Zoom Scan
Date	2022-08-05	2022-08-05
psSAR1g [W/Kg]	23.8	27.8
psSAR10g [W/Kg]	4.74	5.21
Power Drift [dB]	-0.02	0.02
Power Scaling	Disabled	Disabled
Scaling Factor [dB]		
TSL Correction	Positive	Positive
M2/M1 [%]		52.9
Dist 3dB Peak [mm]		4.6



Calibrator:

*Jerry Chang*

Approver:

*Peter Chen*