



SAR TEST REPORT

No. I22Z70452-SEM02

For

Samsung Electronics Co., Ltd.

Notebook PC

Model name: NP750XFH, NP754XFH, NP750XFS, NP754XFS

With

Hardware Version: REV1.0

Software Version: Windows11

FCC ID: ZCANP750XFH

Issued Date: 2022-12-8

Note:

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No.I22Z70452-SEM02

REPORT HISTORY

Report Number	Revision	Issue Date	Description
I22Z70452-SEM02	Rev.0	2022-12-8	Initial creation of test report

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1 Test Laboratory

1.1 Testing Location

Company Name:	CTTL
Address:	No. 52, Huayuan North Road, Haidian District, Beijing, P. R. China 100191.

1.2 Testing Environment

Temperature:	18°C~25°C,
Relative humidity:	30%~ 70%
Ground system resistance:	< 0.5 Ω
Ambient noise & Reflection:	< 0.012 W/kg

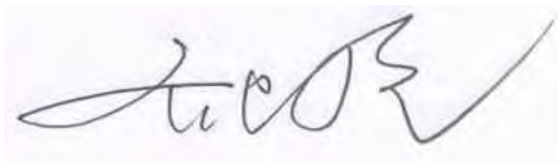
1.3 Project Data

Project Leader:	Qi Dianyuan
Test Engineer:	Yao Juming
Testing Start Date:	November 15, 2022
Testing End Date:	November 26, 2022

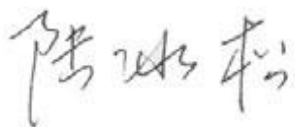
1.4 Signature



Yao Juming
(Prepared this test report)



Qi Dianyuan
(Reviewed this test report)



Lu Bingsong
Deputy Director of the laboratory
(Approved this test report)

2 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for Samsung Electronics Co., Ltd. Notebook PC NP750XFH, NP754XFH, NP750XFS, NP754XFS are as follows:

Table 2.1: Highest Reported SAR (1g)

Exposure Configuration	Technology Band	Highest Reported SAR 1g(W/kg)	Equipment Class
Body	WLAN 2.4 GHz Main. Antenna	0.83	DTS
	WLAN 2.4 GHz Aux Antenna	1.03	
	WLAN 2.4 GHz MIMO Antenna	0.56	
	WLAN 5 GHz Main. Antenna	1.14	NII
	WLAN 5 GHz Aux Antenna	1.16	
	WLAN 5 GHz MIMO Antenna	1.08	
	BT	0.10	DSS

The SAR values found for the Mobile Phone are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1g tissue according to the ANSI C95.1-1992.

For body operation, this device has been tested and meets FCC RF exposure guidelines when used with any accessory that contains no metal and which provides a minimum separation distance of 0mm between this device and the body of the user. Use of other accessories may not ensure compliance with FCC RF exposure guidelines.

The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output.

The measurement together with the test system set-up is described in annex C of this test report. A detailed description of the equipment under test can be found in chapter 4 of this test report. The highest reported SAR value is obtained at the case of **(Table 2.1)**, and the values is:

Body SAR 1.16 W/kg (1g).

Table 2.2: The sum of reported SAR values for WIFI5GHz (Main Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.14	0.10	1.24

Table 2.3: The sum of reported SAR values for WIFI5GHz (Aux Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.16	0.10	1.26

Table 2.4: The sum of reported SAR values for WIFI5GHz (MIMO Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.08	0.11	1.19

According to the above tables, the highest sum of reported SAR values is **1.26 W/kg (1g)**. The detail for simultaneous transmission consideration is described in chapter 13.

3 Client Information

3.1 Applicant Information

Company Name:	Samsung Electronics Co., Ltd.
Address/Post:	19 Chapin Rd.,Building D Pine Brook, NJ 07058
Contact Person:	Jenni Chun
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Telephone:	+1-201-937-4203

3.2 Manufacturer Information

Company Name:	Samsung Electronics Co., Ltd.
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Contact Person:	Sunghoon Cho
E-mail:	ggobi.cho@samsung.com
Telephone:	+82-10-2722-4159
Fax:	/

4 Equipment Under Test (EUT) and Ancillary Equipment (AE)

4.1 About EUT

Description:	Notebook PC
Model name:	NP750XFH, NP754XFH, NP750XFS, NP754XFS
Operating mode(s):	BT, Wi-Fi2.4G/5G
Tested Tx Frequency:	2412 – 2462 MHz (Wi-Fi 2.4G)
	2402 – 2480 MHz (Bluetooth)
	5150-5250 MHz (U-NII-1)
	5250-5350 MHz (U-NII-2A)
	5470-5725 MHz (U-NII-2C)
	5725-5825 MHz (U-NII-3)
Test device Production information:	Production unit
Device type:	Portable device
Antenna type:	Integrated antenna

4.2 Internal Identification of EUT used during the test

EUT ID*	IMEI	HW	SW Version
EUT1	I22Z70452UT21a	REV1.0	Windows11
EUT2	I22Z70452UT25a	REV1.0	Windows11
EUT3	I22Z70452UT17a	REV1.0	Windows11

*EUT ID: is used to identify the test sample in the lab internally.

Note: It is performed to test SAR with the EUT1~2 and conducted power with the EUT3.

4.3 Internal Identification of AE used during the test

AE ID*	Description	Model	SN	Manufacturer
AE1	Battery	AA-PBSN4AT	/	SAMSUNG SDI Co., LTD.

*AE ID: is used to identify the test sample in the lab internally.

5 TEST METHODOLOGY

5.1 Applicable Limit Regulations

ANSI C95.1–1992:IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

It specifies the maximum exposure limit of **1.6 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

5.2 Applicable Measurement Standards

IEEE 1528–2013: Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

KDB616217 D04 SAR for laptop and tablets v01r02 SAR Evaluation Considerations for Laptop, Notebook, Notebook and Tablet Computers.

KDB648474 D04 Handset SAR v01r03: SAR Evaluation Considerations for Wireless Handsets.

KDB248227 D01 802.11 Wi-Fi SAR v02r02: SAR GUIDANCE FOR IEEE 802.11 (Wi-Fi) TRANSMITTERS

KDB865664 D01 SAR measurement 100 MHz to 6 GHz v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz.

KDB865664 D02 RF Exposure Reporting v01r02: RF Exposure Compliance Reporting and Documentation Considerations

6 Specific Absorption Rate (SAR)

6.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

6.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dv} \right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = c \left(\frac{\delta T}{\delta t} \right)$$

Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of tissue and E is the RMS electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

7 Tissue Simulating Liquids

7.1 Targets for tissue simulating liquid

Table 7.1: Targets for tissue simulating liquid

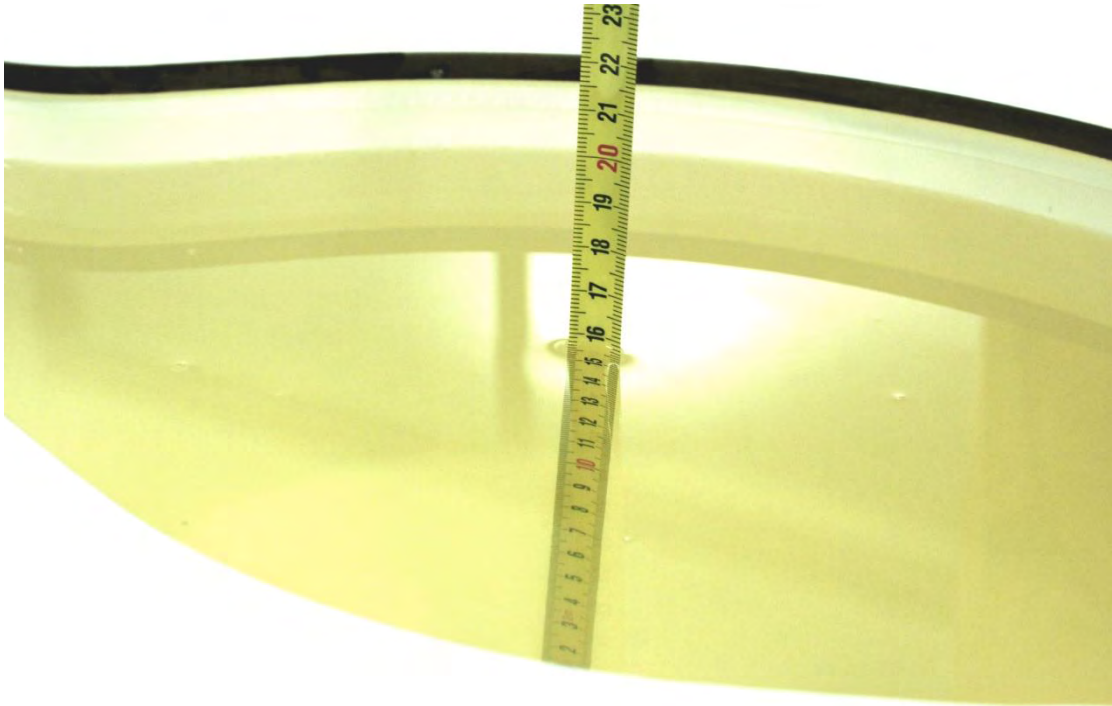
Frequency(MHz)	Liquid Type	Conductivity(σ)	$\pm 10\%$ Range	Permittivity(ϵ)	$\pm 10\%$ Range
2450	Head	1.80	1.62~1.98	39.2	35.28~43.12
5250	Head	4.71	4.47~4.95	35.93	34.13~37.73
5600	Head	5.07	4.82~5.32	35.53	33.8~37.3
5750	Head	5.22	4.96~5.48	35.36	33.59~37.13

7.2 Dielectric Performance

Table 7.3: Dielectric Performance of Tissue Simulating Liquid

Measurement Date yyyy/mm/dd	Frequency	Type	Permittivity ϵ	Drift (%)	Conductivity σ (S/m)	Drift (%)
2022/11/15	2450 MHz	Head	40.33	2.88	1.824	1.33
2022/11/22	5250 MHz	Head	35.8	-0.36	4.641	-1.46
2022/11/24	5600 MHz	Head	35.14	-1.10	4.923	-2.90
2022/11/26	5750 MHz	Head	35.87	1.44	5.079	-2.70

Note: The liquid temperature is 22.0°C



Picture 7-1 Liquid depth in the Flat Phantom (2450MHz)

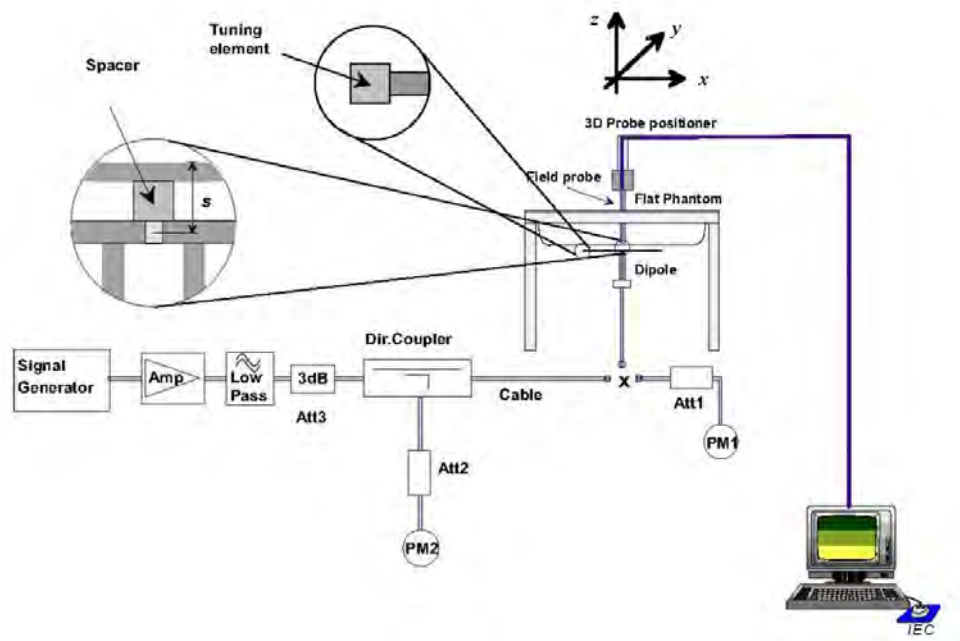


Picture 7-2 Liquid depth in the Flat Phantom (5GHz)

8 System verification

8.1 System Setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



Picture 8.1 System Setup for System Evaluation



Picture 8.2 Photo of Dipole Setup

8.2 System Verification

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device.

Table 8.1: System Verification of Head

Measurement Date (yyyy-mm-dd)	Frequency	Target value (W/kg)		Measured value (W/kg)		Deviation	
		10 g Average	1 g Average	10 g Average	1 g Average	10 g Average	1 g Average
2022/11/15	2450 MHz	24.9	52.7	24.6	53.4	-1.20%	1.33%
2022/11/22	5250 MHz	22.3	78.1	23.1	79.8	3.59%	2.18%
2022/11/24	5600 MHz	23.7	83.2	23.9	83.3	0.84%	0.12%
2022/11/26	5750 MHz	22.8	80.4	24.3	84.5	6.58%	5.10%

9 Measurement Procedures

9.1 Tests to be performed

In order to determine the highest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes shall be tested for each frequency band according to steps 1 to 3 below. A flowchart of the test process is shown in picture 9.1.

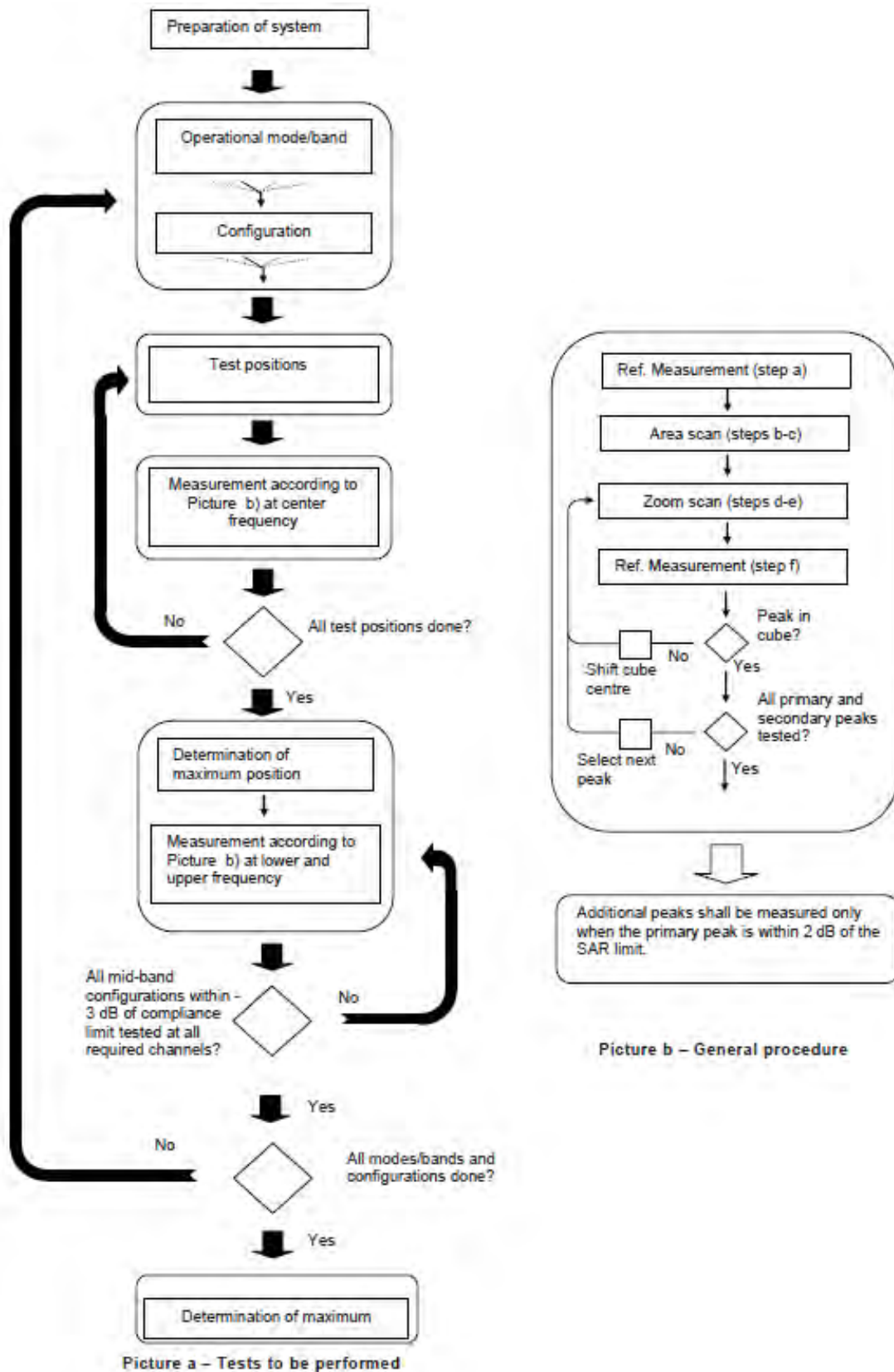
Step 1: The tests described in 9.2 shall be performed at the channel that is closest to the centre of the transmit frequency band (f_c) for:

- a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom, as described in annex D),
- b) all configurations for each device position in a), e.g., antenna extended and retracted, and
- c) all operational modes, e.g., analogue and digital, for each device position in a) and configuration in b) in each frequency band.

If more than three frequencies need to be tested according to 11.1 (i.e., $N_c > 3$), then all frequencies, configurations and modes shall be tested for all of the above test conditions.

Step 2: For the condition providing highest peak spatial-average SAR determined in Step 1, perform all tests described in 9.2 at all other test frequencies, i.e., lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the peak spatial-average SAR value determined in Step 1 is within 3 dB of the applicable SAR limit, it is recommended that all other test frequencies shall be tested as well.

Step 3: Examine all data to determine the highest value of the peak spatial-average SAR found in Steps 1 to 2.



Picture 9.1Block diagram of the tests to be performed

9.2 General Measurement Procedure

The area and zoom scan resolutions specified in the table below must be applied to the SAR measurements and fully documented in SAR reports to qualify for TCB approval. Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std 1528-2013. The results should be documented as part of the system validation records and may be requested to support test results when all the measurement parameters in the following table are not satisfied.

			≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location			$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}			≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

9.3 Bluetooth & Wi-Fi Measurement Procedures for SAR

Normal network operating configurations are not suitable for measuring the SAR of 802.11 transmitters in general. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure that the results are consistent and reliable.

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in a test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements.

9.4 Power Drift

To control the output power stability during the SAR test, DASY5 system calculates the power drift by measuring the E-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in section 14 labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

10 Conducted Output Power

10.1 Wi-Fi and BT Measurement result

The maximum output power of BT antenna is 10.46dBm.

The maximum tune up of BT antenna is 10.5dBm.

WIFI 2.4G conducted power- Main Antenna:

802.11b								
Channel\data rate	1Mbps	2Mbps	5.5Mbps	11Mbps				
11(2462MHz)	16.95	16.83	16.68	16.47				
6(2437(MHz)	16.83	/	/	/				
1(2412MHz)	16.73	/	/	/				
Tune up	17.00	17.00	17.00	17.00				
802.11g								
Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
11(2462MHz)	11.34	/	/	/	/	/	/	/
Tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	16.47	16.36	16.33	16.28	16.20	15.95	15.98	15.96
Tune up	17.00	17.00	17.00	17.00	17.00	16.00	16.00	16.00
1(2412MHz)	11.44	/	/	/	/	/	/	/
Tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11n-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	10.75	/	/	/	/	/	/	/
Tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	16.57	16.65	16.54	16.58	16.49	16.41	16.32	16.31
Tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	10.59	/	/	/	/	/	/	/
Tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11n-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	8.64	/	/	/	/	/	/	/
Tune up	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
6(2437MHz)	16.75	16.88	16.79	16.72	16.66	16.59	16.50	16.44
Tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	5.66	/	/	/	/	/	/	/
Tune up	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

802.11ax-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	9.57	/	/	/	/	/	/	/
Tune up	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
6(2437(MHz)	16.49	16.56	16.54	16.48	16.44	16.36	16.30	16.22
Tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	10.64	/	/	/	/	/	/	/
Tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11ax-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	9.61	/	/	/	/	/	/	/
Tune up	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
6(2437MHz)	16.43	16.35	16.22	16.17	16.12	16.08	16.03	15.98
Tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	6.39	/	/	/	/	/	/	/
Tune up	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

WIFI 2.4G conducted power- Aux. Antenna:

802.11b								
Channel\data rate	1Mbps	2Mbps	5.5Mbps	11Mbps				
11(2462MHz)	16.16	/	/	/				
6(2437(MHz)	16.18	16.06	15.88	15.67				
1(2412MHz)	16.05	/	/	/				
tune up	17.00	17.00	17.00	17.00				
802.11g								
Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
11(2462MHz)	10.81	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	15.70	15.65	15.59	15.53	15.47	15.40	15.29	15.22
tune up	17.00	17.00	17.00	17.00	17.00	16.00	16.00	16.00
1(2412MHz)	10.79	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11n-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	10.78	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	15.84	15.88	15.78	15.72	15.66	15.59	15.50	15.43
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	10.64	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00

802.11n-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	8.74	/	/	/	/	/	/	/
tune up	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
6(2437MHz)	15.84	15.86	15.79	15.67	15.53	15.48	15.39	15.33
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	5.63	/	/	/	/	/	/	/
tune up	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
802.11ax-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	9.80	/	/	/	/	/	/	/
tune up	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00
6(2437(MHz)	15.70	15.67	15.59	15.48	15.43	15.36	15.29	15.18
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	10.66	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11ax-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	8.62	/	/	/	/	/	/	/
tune up	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
6(2437MHz)	15.66	15.67	15.55	15.51	15.47	15.39	15.28	15.20
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	5.74	/	/	/	/	/	/	/
tune up	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00

WIFI2.4G - MIMO conducted power:

802.11g								
Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
11(2462MHz)	11.64	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	16.72	16.68	16.93	16.91	16.79	16.60	16.46	16.48
tune up	17.00	17.00	17.00	17.00	17.00	16.00	16.00	16.00
1(2412MHz)	11.44	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
802.11n-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	11.78	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437(MHz)	16.64	16.89	17.00	16.94	16.87	16.87	16.91	16.91
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	11.63	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00

802.11n-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	11.95	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437MHz)	16.89	16.82	16.81	16.83	16.79	16.79	16.83	16.82
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	9.98	/	/	/	/	/	/	/
tune up	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
802.11ax-20MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
11(2462MHz)	12.65	/	/	/	/	/	/	/
tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
6(2437(MHz)	16.60	16.87	16.93	16.95	16.90	16.93	16.99	16.94
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
1(2412MHz)	13.43	/	/	/	/	/	/	/
tune up	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
802.11ax-40MHz								
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
9(2452MHz)	11.76	/	/	/	/	/	/	/
tune up	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
6(2437MHz)	16.65	16.69	16.72	16.79	16.81	16.80	16.87	16.84
tune up	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
3(2422MHz)	10.62	/	/	/	/	/	/	/
tune up	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Tune up power for WIFI 5G- SISO:

802.11a	Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11n (20M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11n (40M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
Tune up	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac (20M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac (40M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ac (80M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	42 (5210MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	58 (5290MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	106 (5530MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	138 (5690MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	155 (5775MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ac (160M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	50 (5250MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	114 (5570MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ax (20M)	Channel/data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ax (40M)	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Channel/data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Tune up	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Channel/data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
	42 (5210MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ax (80M)	58 (5290MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	106 (5530MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	138 (5690MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	155 (5775MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	Channel/data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
802.11ax (160M)	50 (5250MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	114 (5570MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

Tune up power for WIFI 5G- MIMO:

802.11n (20M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11n (40M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
Tune up	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac (20M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac (40M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ac (80M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	42 (5210MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	58 (5290MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	106 (5530MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	138 (5690MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	155 (5775MHz)	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00
802.11ac (160M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
Tune up	50 (5250MHz)	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
	114 (5570MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ax (20M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
Tune up	36 (5180MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	52 (5260MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	64 (5320MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	100 (5500MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	132 (5660MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	165 (5825MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ax (40M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
Tune up	38 (5190MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	54 (5270MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	62 (5310MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	102 (5510MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	134 (5670MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	159 (5795MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ax (80M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
Tune up	42 (5210MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	58 (5290MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	106 (5530MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	138 (5690MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
	155 (5775MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
802.11ax (160M)	Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9	MCS10	MCS11
Tune up	50 (5250MHz)	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
	114 (5570MHz)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

WIFI 5G conducted power - Main Antenna:

802.11ac(dBm)-80MHz										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
42(5210 MHz)	12.41	12.43	12.41	12.28	12.27	12.23	12.22	12.27	12.07	12.05
155(5775 MHz)	12.19	12.15	12.14	11.96	11.94	12.00	12.01	12.02	11.79	11.73
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac(dBm)-160MHz										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
50(5250 MHz)	12.46	12.28	12.14	11.98	11.93	11.91	11.82	11.77	11.66	11.57
114(5570 MHz)	12.97	12.88	12.71	12.66	12.58	12.51	12.48	12.43	12.32	12.24
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

WIFI 5G conducted power - Aux. Antenna:

802.11ac(dBm)-80MHz										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
42(5210 MHz)	11.98	12.03	11.96	11.84	11.88	11.82	11.89	11.88	11.64	11.63
155(5775 MHz)	12.29	11.96	11.91	11.86	11.88	11.89	11.88	11.81	11.64	11.56
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac(dBm)-160MHz										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
50(5250 MHz)	12.39	11.93	11.85	11.64	11.58	11.49	11.47	11.44	11.33	11.32
114(5570 MHz)	12.93	12.92	12.83	12.82	12.69	12.59	12.60	12.55	12.49	12.33
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

WIFI5G-MIMO conducted power:

802.11ac(dBm)-160MHz MIMO										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
50(5250 MHz)	13.30	13.28	13.25	13.08	13.11	13.15	12.14	13.25	13.05	13.02
Tune up	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
114(5570 MHz)	12.26	12.04	12.03	11.88	11.89	11.84	11.83	11.79	11.65	11.61
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

802.11ac(dBm)-80MHz MIMO										
Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7	MCS8	MCS9
42(5210 MHz)	12.97	12.85	12.94	12.83	12.92	12.86	12.79	12.75	12.68	12.59
Tune up	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
155(5775 MHz)	13.82	13.59	13.49	13.43	13.37	13.30	13.27	13.23	13.17	13.10
Tune up	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00

11 Simultaneous TX SAR Considerations

11.1 Transmit Antenna Separation Distances

Please refer to the picture of antenna locations in the document: “The Photos of SAR test-I22Z70452”

11.2 SAR Measurement Positions

According to the KDB616217 D04, the edges with less than 2.5 cm distance to the antennas need to be tested for SAR.

SAR measurement positions						
Mode	Front	Rear	Left edge	Right edge	Top edge	Bottom edge
WLAN	Yes	Yes	No	No	No	No

12 Evaluation of Simultaneous

Table 12.1: The sum of reported SAR values for WIFI5GHz (Main Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.14	0.10	1.24

Table 12.2: The sum of reported SAR values for WIFI5GHz (Aux Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.16	0.10	1.26

Table 12.3: The sum of reported SAR values for WIFI5GHz (MIMO Antenna) and BT

	Position	WIFI5GHz	BT	Sum
Maximum reported SAR value for Body	Rear 0mm	1.08	0.11	1.19

Conclusion:

According to the above tables, the sum of reported SAR values is $<1.6\text{W/kg}$. So the simultaneous transmission SAR with volume scans is not required.

13 SAR Test Result

It is determined by user manual for the distance between the EUT and the phantom bottom.
The distance are 0mm, and just applied to the condition of body worn accessory.

The calculated SAR is obtained by the following formula:

$$\text{Reported SAR} = \text{Measured SAR} \times 10^{(P_{\text{Target}} - P_{\text{Measured}})/10}$$

Where P_{Target} is the power of manufacturing upper limit;

P_{Measured} is the measured power in chapter 11.

13.1 WLAN Evaluation for 2.4G

Main Antenna:

Table 13.1-1: SAR Values (WiFi 802.11b – Body)

Frequency		Test Position	Figure No./ Note	Ambient Temperature: 23.1 °C		Liquid Temperature: 22.2°C				
Ch.	MHz			Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g)(W/kg)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Power Drift (dB)
11	2462	Front	Note1	16.95	17.00	0.249	0.25	0.103	0.10	0.07
11	2462	Rear	Note1	16.95	17.00	0.781	0.79	0.298	0.30	0.15
6	2437	Rear	Note1/Fig.1	16.83	17.00	0.788	0.82	0.31	0.31	0.15
1	2412	Rear	Note1	16.73	17.00	0.764	0.81	0.295	0.30	0.07
11	2462	Front	Note2	16.95	17.00	0.212	0.21	0.095	0.10	-0.13
11	2462	Rear	Note2	16.95	17.00	0.566	0.57	0.236	0.24	0.16
6	2437	Rear	Note2	16.83	17.00	0.601	0.62	0.246	0.25	0.17
1	2412	Rear	Note2	16.73	17.00	0.726	0.77	0.31	0.31	-0.13

Note: The distance between the EUT and the phantom bottom is 0mm.

Note1: The supplier of Antenna is SPEED.

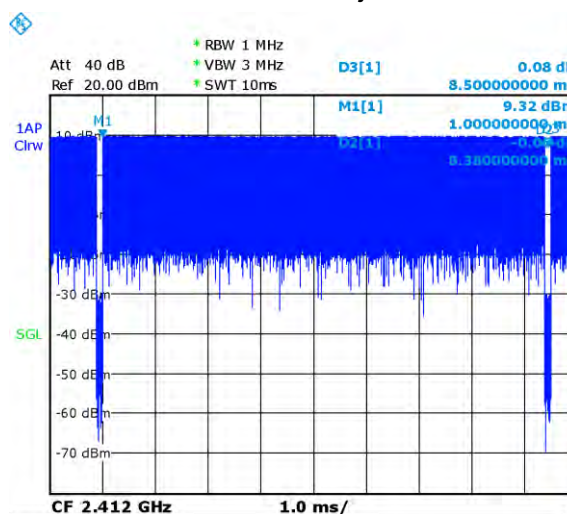
Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.1-2: SAR Values (WLAN - Body) – 802.11b (Scaled Reported SAR)

Frequency		Test Position	Ambient Temperature: 23.1 °C		Liquid Temperature: 22.2°C	
Ch.	MHz		Actual duty factor	maximum duty factor	Reported SAR (1g)(W/kg)	Scaled reported SAR (1g)(W/kg)
6	2437	Rear	98.9%	100%	0.82	0.83

SAR is not required for OFDM because the 802.11b adjusted SAR $\leq$ 1.2 W/kg.



Picture 13.1 Duty factor plot for 2.4G

Aux. antenna:

Table 13.1-3: SAR Values (WiFi 802.11b – Body)

Ambient Temperature: 23.1 °C				Liquid Temperature: 22.2 °C						
Frequency		Test Position	Figure No./ Note	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g)(W/kg)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Power Drift (dB)
Ch.	MHz									
6	2437	Front	Note1	16.18	17.00	0.415	0.50	0.186	0.19	-0.14
11	2462	Rear	Note1	16.16	17.00	0.68	0.83	0.308	0.32	-0.08
6	2437	Rear	Note1/Fig.2	16.18	17.00	0.841	1.02	0.344	0.36	0.09
1	2412	Rear	Note1	16.05	17.00	0.667	0.83	0.301	0.31	-0.11
6	2437	Front	Note2	16.18	17.00	0.447	0.54	0.188	0.19	-0.11
11	2462	Rear	Note2	16.16	17.00	0.667	0.81	0.28	0.29	0.17
6	2437	Rear	Note2	16.18	17.00	0.727	0.88	0.297	0.31	-0.05
1	2412	Rear	Note2	16.05	17.00	0.747	0.93	0.301	0.31	0.07

Note: The distance between the EUT and the phantom bottom is 0mm.

Note1: The supplier of Antenna is SPEED.

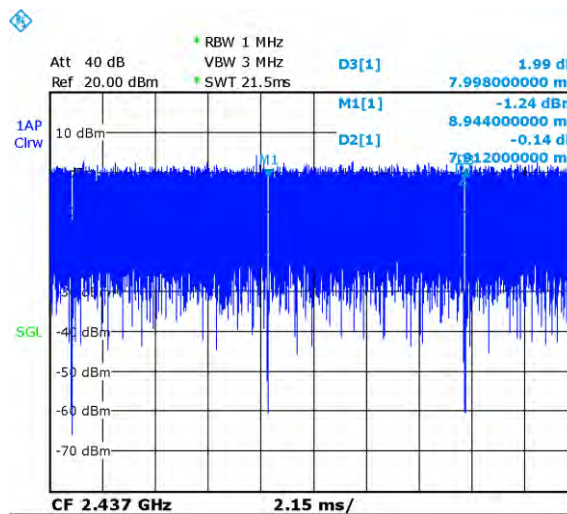
Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.1-4: SAR Values (WLAN - Body) – 802.11b (Scaled Reported SAR)

Ambient Temperature: 23.1 °C				Liquid Temperature: 22.2 °C		
Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g)(W/kg)	Scaled reported SAR (1g)(W/kg)
Ch.	MHz					
6	2437	Rear	98.9%	100%	1.02	1.03

SAR is not required for OFDM because the 802.11b adjusted SAR $\leq$ 1.2 W/kg.



Picture 13.2 Duty factor plot for 2.4G

MIMO:

Table 13.1-5: SAR Values (WiFi 802.11n-20M – Body)

Frequency		Test Position	Figure No./ Note	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
Ch.	MHz									
6	2437	Front	Note1	17.00	17.00	0.151	0.15	0.067	0.07	0.01
6	2437	Rear	Note1	17.00	17.00	0.457	0.46	0.197	0.20	-0.04
6	2437	Front	Note1	17.00	17.00	0.234	0.23	0.11	0.11	-0.13
6	2437	Rear	Note1/Fig.3	17.00	17.00	0.553	0.55	0.24	0.24	0.17

Note: The distance between the EUT and the phantom bottom is 0mm.

Note1: The supplier of Antenna is SPEED.

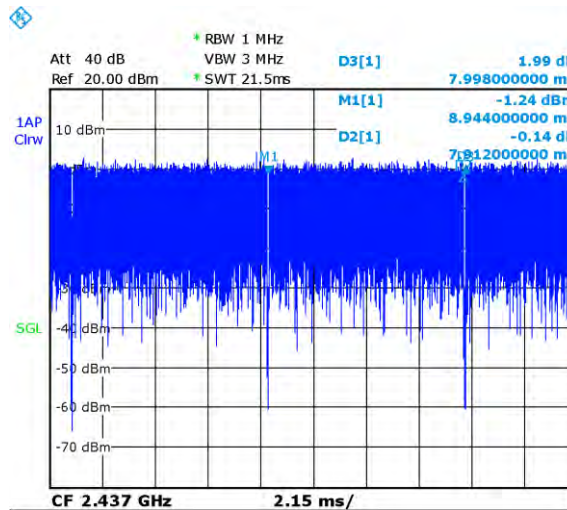
Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.1-6: SAR Values (WLAN - Body) – 802.11b (Scaled Reported SAR)

Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g)(W/kg)	Scaled reported SAR (1g)(W/kg)
Ch.	MHz					
6	2437	Rear	98.9%	100%	0.55	0.56

SAR is not required for OFDM because the 802.11b adjusted SAR ≤ 1.2 W/kg.



Picture 13.3 Duty factor plot for 2.4G

13.2 WLAN Evaluation For 5G

Table 13.2-11: SAR Values (WLAN - Body) – Main antenna

Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(1g) (W/kg)	Reported SAR(1g)(W/kg)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Power Drift (dB)
Ch.	MHz									
50	5250	Front	Note1	12.46	13.00	0.208	0.24	0.089	0.09	-0.08
50	5250	Rear	Note1	12.46	13.00	0.599	0.68	0.215	0.22	0.06
114	5570	Front	Note1	12.97	13.00	0.177	0.18	0.073	0.07	0.09
114	5570	Rear	Note1	12.97	13.00	0.555	0.56	0.188	0.19	0.02
155	5775	Front	Note1	12.19	13.00	0.291	0.35	0.114	0.12	-0.03
155	5775	Rear	Note1/Fig.4	12.19	13.00	0.945	1.14	0.313	0.33	0.05
50	5250	Front	Note2	12.46	13.00	0.189	0.21	0.061	0.06	-0.03
50	5250	Rear	Note2	12.46	13.00	0.419	0.47	0.136	0.14	-0.10
114	5570	Front	Note2	12.97	13.00	0.379	0.38	0.115	0.12	-0.15
114	5570	Rear	Note2	12.97	13.00	0.619	0.62	0.177	0.18	-0.18
155	5775	Front	Note2	12.19	13.00	0.305	0.37	0.11	0.11	0.06
155	5775	Rear	Note2	12.19	13.00	0.501	0.60	0.165	0.17	-0.05

Note: The distance between the EUT and the phantom bottom is 0mm.

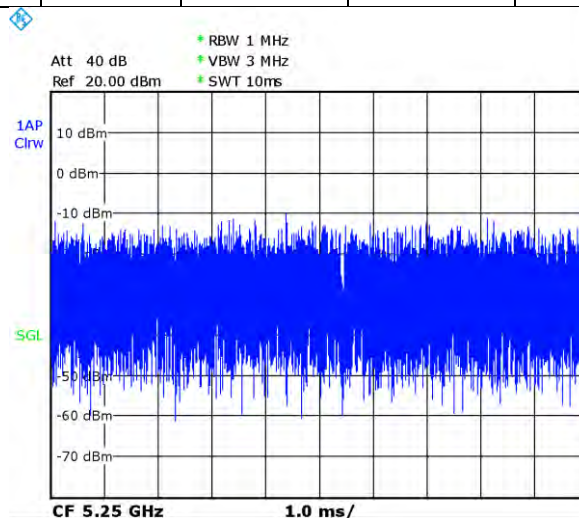
Note1: The supplier of Antenna is SPEED.

Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.2-12: SAR Values (WLAN - Body) – 802.11a (Scaled Reported SAR)

Frequency		Test Position	D (mm)	Actual duty factor	maximum duty factor	Reported SAR (1g) (W/kg)	Scaled reported SAR (1g) (W/kg)
Ch.	MHz						
155	5775	Rear	0	100%	100%	1.14	1.14



Picture 13.4 Duty factor plot for 5G

Table 13.2-13: SAR Values (WLAN - Body) – Aux antenna

Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
Ch.	MHz									
50	5250	Front	Note1	12.39	13.00	0.245	0.28	0.078	0.08	-0.14
50	5250	Rear	Note1	12.39	13.00	0.879	1.01	0.248	0.26	-0.15
114	5570	Front	Note1	12.93	13.00	0.281	0.29	0.097	0.10	-0.06
114	5570	Rear	Note1	12.93	13.00	1.01	1.03	0.282	0.28	-0.08
155	5775	Front	Note1	12.29	13.00	0.14	0.16	0.049	0.05	0.17
155	5775	Rear	Note1	12.29	13.00	0.701	0.83	0.197	0.20	-0.06
50	5250	Front	Note2	12.39	13.00	0.291	0.33	0.102	0.10	0.12
50	5250	Rear	Note2	12.39	13.00	0.818	0.94	0.228	0.23	0.04
114	5570	Front	Note2	12.93	13.00	0.472	0.48	0.161	0.16	0.06
114	5570	Rear	Note2	12.93	13.00	1.11	1.13	0.301	0.30	0.15
155	5775	Front	Note2	12.29	13.00	0.432	0.51	0.161	0.16	0.11
155	5775	Rear	Note2/Fig.5	12.29	13.00	0.984	1.16	0.299	0.31	0.04

Note: The distance between the EUT and the phantom bottom is 0mm.

Note1: The supplier of Antenna is SPEED.

Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.2-14: SAR Values (WLAN - Body) – 802.11a (Scaled Reported SAR)

Frequency		Test Position	D (mm)	Actual duty factor	maximum duty factor	Reported SAR (1g) (W/kg)	Scaled reported SAR (1g) (W/kg)
Ch.	MHz						
155	5775	Rear	0	100%	100%	1.16	1.16

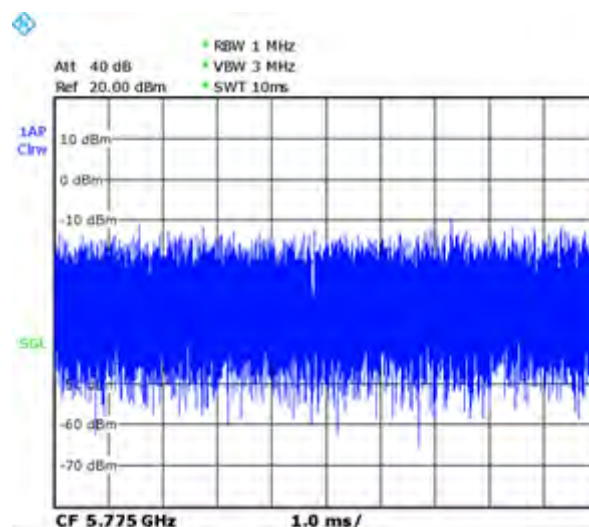

Picture 13.5 Duty factor plot for 5G

Table 13.2-15: SAR Values (WLAN - Body) – MIMO antenna

Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
Ch.	MHz									
50	5250	Front	Note1	13.30	13.50	0.282	0.30	0.106	0.11	-0.01
50	5250	Rear	Note1	13.30	13.50	0.825	0.86	0.276	0.28	0.18
114	5570	Front	Note1	12.26	13.00	0.296	0.35	0.106	0.11	0.03
114	5570	Rear	Note1/Fig.6	12.26	13.00	0.908	1.08	0.303	0.31	-0.13
155	5775	Front	Note1	13.82	14.00	0.116	0.12	0.04	0.04	-0.12
155	5775	Rear	Note1	13.82	14.00	0.602	0.63	0.162	0.16	0.12
50	5250	Front	Note2	13.30	13.50	0.166	0.17	0.061	0.06	0.16
50	5250	Rear	Note2	13.30	13.50	0.539	0.56	0.155	0.16	-0.12
114	5570	Front	Note2	12.26	13.00	0.263	0.31	0.092	0.09	-0.05
114	5570	Rear	Note2	12.26	13.00	0.624	0.74	0.168	0.17	0.01
155	5775	Front	Note2	13.82	14.00	0.395	0.41	0.132	0.13	-0.04
155	5775	Rear	Note2	13.82	14.00	0.615	0.64	0.178	0.18	-0.06

Note: The distance between the EUT and the phantom bottom is 0mm.

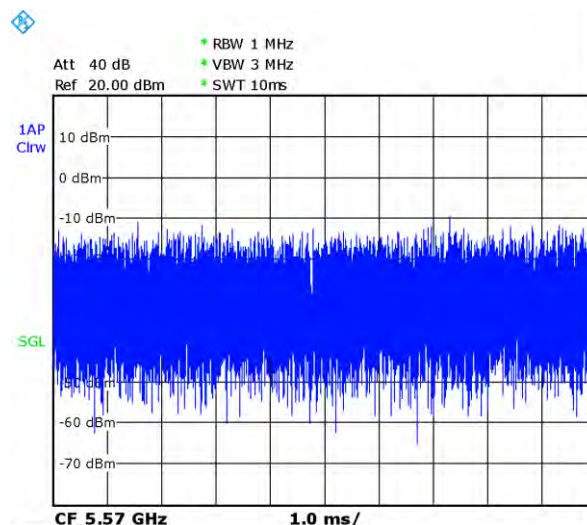
Note1: The supplier of Antenna is SPEED.

Note2: The supplier of Antenna is innowave.

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. The scaled reported SAR is presented as below.

Table 13.2-16: SAR Values (WLAN - Body) – 802.11a (Scaled Reported SAR)

Frequency		Test Position	D (mm)	Actual duty factor	maximum duty factor	Reported SAR (1g) (W/kg)	Scaled reported SAR (1g) (W/kg)
Ch.	MHz						
114	5570	Rear	0	100%	100%	1.08	1.08


Picture 13.6 Duty factor plot for 5G

13.3 SAR Results for BT

Table 13.3-1: SAR Values (Bluetooth - Body)

Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Ambient Temperature: 23.1 °C Liquid Temperature: 22.2°C				
Ch	MHz					Measured SAR(1g) (W/kg)	Reported SAR(1g)(W/kg)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Power Drift (dB)
39	2441	Front	Note1	10.46	10.50	0.03	0.03	0.015	0.02	0.14
39	2441	Rear	Note1	10.46	10.50	0.073	0.07	0.036	0.04	0.12
39	2441	Front	Note2	10.46	10.50	0.041	0.04	0.019	0.02	-0.16
39	2441	Rear	Note2/Fig.7	10.46	10.50	0.103	0.10	0.048	0.05	0.09

Note: The distance between the EUT and the phantom bottom is 0mm.

Note1: The supplier of Antenna is SPEED.

Note2: The supplier of Antenna is innowave.

14 SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg ($\sim 10\%$ from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

Table 14.1: SAR Measurement Variability for Body WIFI2.4G- Aux. Antenna (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
Ch.	MHz						
6	2437	Rear	0	0.841	0.833	1.01	/

Table 14.2: SAR Measurement Variability for Body WIFI5G-Main Antenna (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
Ch.	MHz						
155	5775	Rear	0	0.945	0.921	1.03	/

Table 14.3: SAR Measurement Variability for Body WIFI5G-Aux. Antenna (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
Ch.	MHz						
114	5570	Rear	0	1.11	1.07	1.04	/

Table 14.4: SAR Measurement Variability for Body WIFI5G-MIMO Antenna (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
Ch.	MHz						
114	5570	Rear	0	0.908	0.903	1.01	/

15 Measurement Uncertainty

15.1 Measurement Uncertainty for Normal SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6.0	N	1	1	1	6.0	6.0	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	N	1	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521

Combined standard uncertainty	$u_c' = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$					9.55	9.43	257
Expanded uncertainty (confidence interval of 95 %)	$u_e = 2u_c$					19.1	18.9	

15.2 Measurement Uncertainty for Normal SAR Tests (3~6GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6.55	N	1	1	1	6.55	6.55	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	2.0	R	$\sqrt{3}$	1	1	1.2	1.2	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RFambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
12	Probe positioning with respect to phantom shell	B	6.7	R	$\sqrt{3}$	1	1	3.9	3.9	∞
13	Post-processing	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞

21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c' = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$						10.7	10.6	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						21.4	21.1	

16 MAIN TEST INSTRUMENTS

Table 16.1: List of Main Instruments

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Network analyzer	E5071C	MY46110673	January 14, 2022	One year
02	Power sensor	NRP110T	101139	January 13, 2022	One year
03	Power sensor	NRP110T	101159		
04	Signal Generator	E4438C	MY49071430	January 13, 2022	One year
05	Amplifier	60S1G4	0331848	No Calibration Requested	
06	E-field Probe	SPEAG EX3DV4	7548	August 1, 2022	One year
07	DAE	SPEAG DAE4	1331	September 15, 2022	One year
08	Dipole Validation Kit	SPEAG D2450V2	853	July 20,2022	One year
09	Dipole Validation Kit	SPEAG D5GHzV2	1060	July 5,2022	One year

END OF REPORT BODY

ANNEX A Graph Results

WLAN2450-Main Antenna_CH6 Rear 0mm

Date: 11/15/2022

Electronics: DAE4 Sn1331

Medium: H2450

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 1.793$ S/m; $\epsilon_r = 40.407$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: WIFI 2450 Frequency: 2437 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.32,7.32,7.32)

Area Scan (91x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 1.33 W/kg

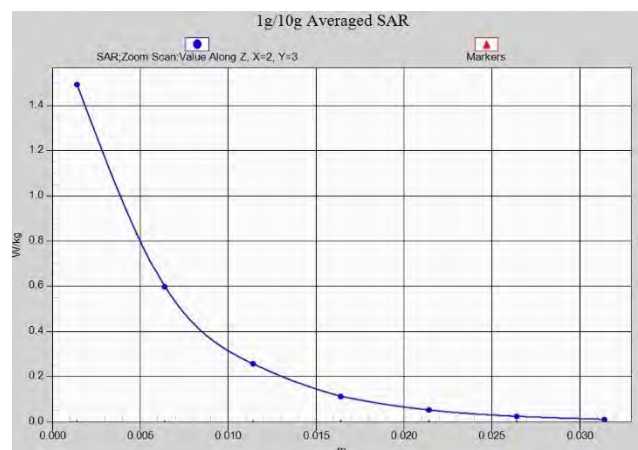
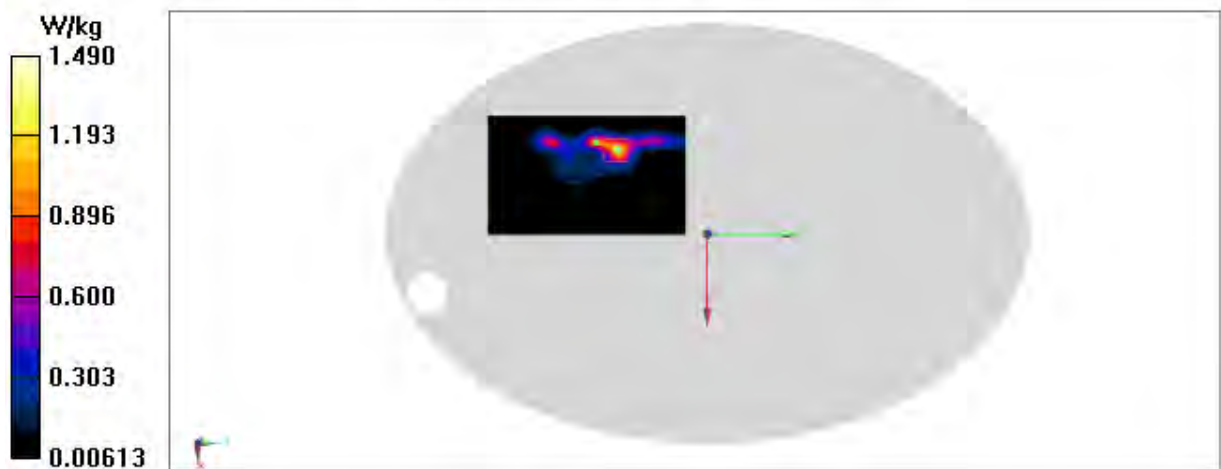
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0 V/m; Power Drift = 0.15 dB

Peak SAR (extrapolated) = 2.13 W/kg

SAR(1 g) = 0.788 W/kg; SAR(10 g) = 0.310 W/kg

Maximum value of SAR (measured) = 1.49 W/kg



WLAN2450-Aux Antenna_CH6 Rear 0mm

Date: 11/15/2022

Electronics: DAE4 Sn1331

Medium: H2450

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 1.793$ S/m; $\epsilon_r = 40.407$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: WIFI 2450 Frequency: 2412 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.32,7.32,7.32)

Area Scan (61x131x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 1.31 W/kg

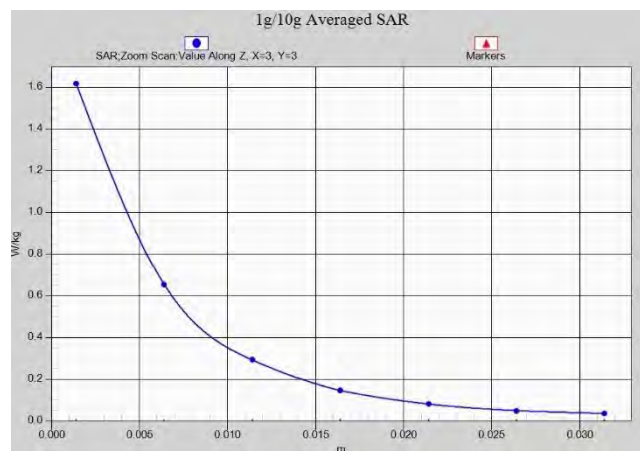
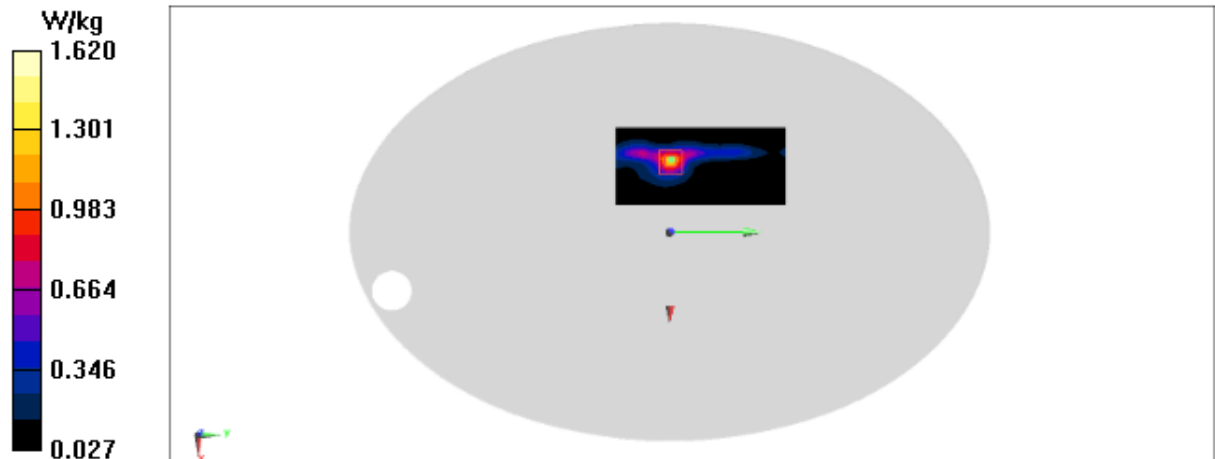
Zoom Scan (8x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 2.23 W/kg

SAR(1 g) = 0.841 W/kg; SAR(10 g) = 0.344 W/kg

Maximum value of SAR (measured) = 1.62 W/kg



WLAN2450-MIMO_CH6 Rear 0mm

Date: 11/15/2022

Electronics: DAE4 Sn1331

Medium: H2450

Medium parameters used (interpolated): $f = 2437$ MHz; $\sigma = 1.793$ S/m; $\epsilon_r = 40.407$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: WIFI 2450 Frequency: 2437 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.32,7.32,7.32)

Area Scan (61x191x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 0.986 W/kg

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

Reference Value = 0 V/m; Power Drift = 0.17 dB

Peak SAR (extrapolated) = 1.26 W/kg

SAR(1 g) = 0.553 W/kg; SAR(10 g) = 0.240 W/kg

Maximum value of SAR (measured) = 0.972 W/kg

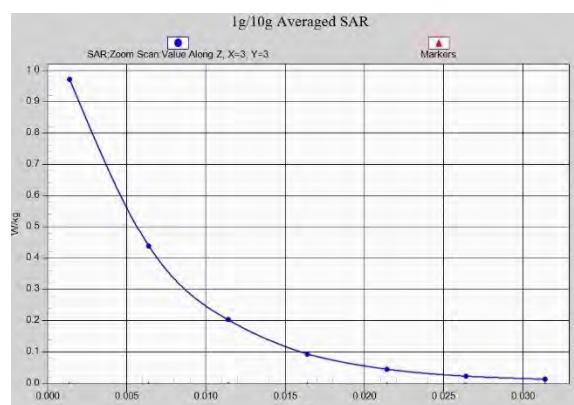
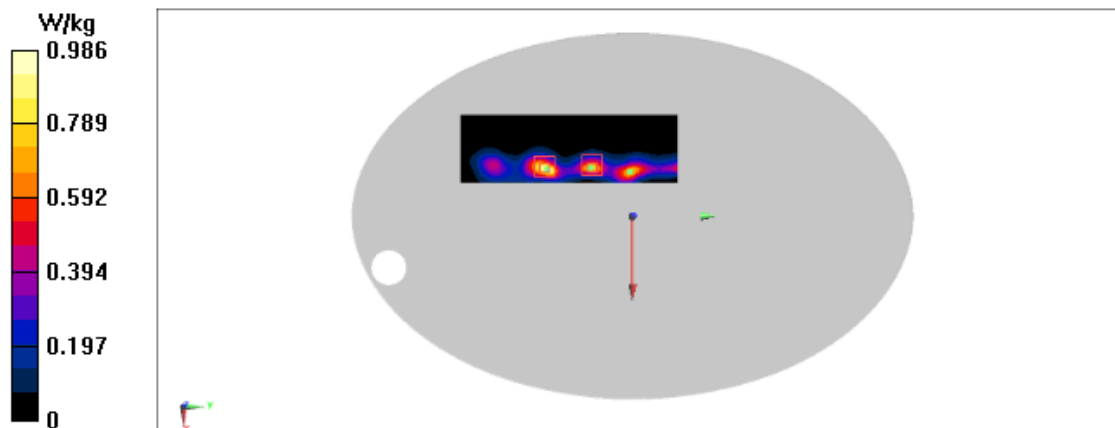
Zoom Scan (7x7x7)/Cube 1: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 1.02 W/kg

SAR(1 g) = 0.462 W/kg; SAR(10 g) = 0.193 W/kg

Maximum value of SAR (measured) = 0.798 W/kg



WLAN5G-Main Antenna_CH155 Rear

Date: 11/26/2022

Electronics: DAE4 Sn1331

Medium: head 5 GHz

Medium parameters used: $f = 5775$ MHz; $\sigma = 5.11$ S/m; $\epsilon_r = 35.851$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.5°C, Liquid Temperature: 22.3°C

Communication System: WLAN5G 5250 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(4.64, 4.64, 4.64)

Area Scan (101x201x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 2.20 W/kg

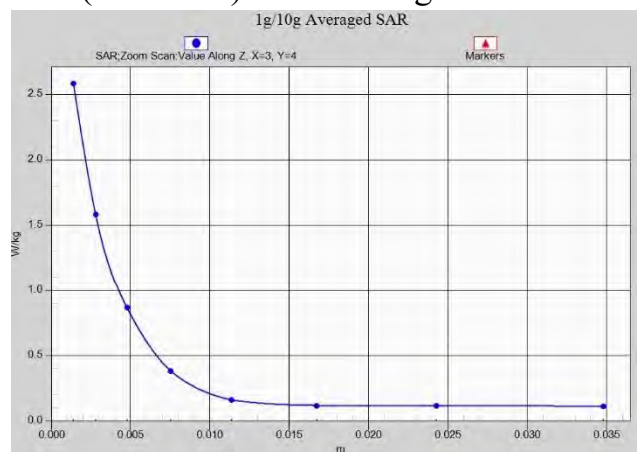
Zoom Scan (8x8x8)/Cube 0: Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 2.055 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 4.98 W/kg

SAR(1 g) = 0.945 W/kg; SAR(10 g) = 0.313 W/kg

Maximum value of SAR (measured) = 2.59 W/kg



WLAN5G-Aux. Antenna_CH155 Rear

Date: 11/26/2022

Electronics: DAE4 Sn1331

Medium: H5G

Medium parameters used: $f = 5775$ MHz; $\sigma = 5.11$ S/m; $\epsilon_r = 35.851$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: WLAN5G Frequency: 5775 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN7548 ConvF(4.64, 4.64, 4.64)

Area Scan (81x181x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 1.98 W/kg

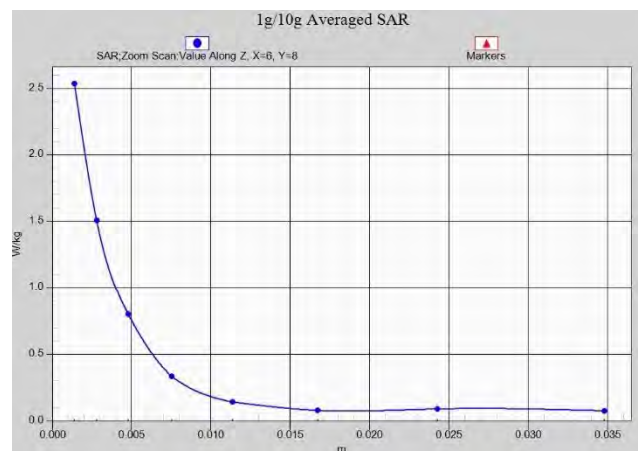
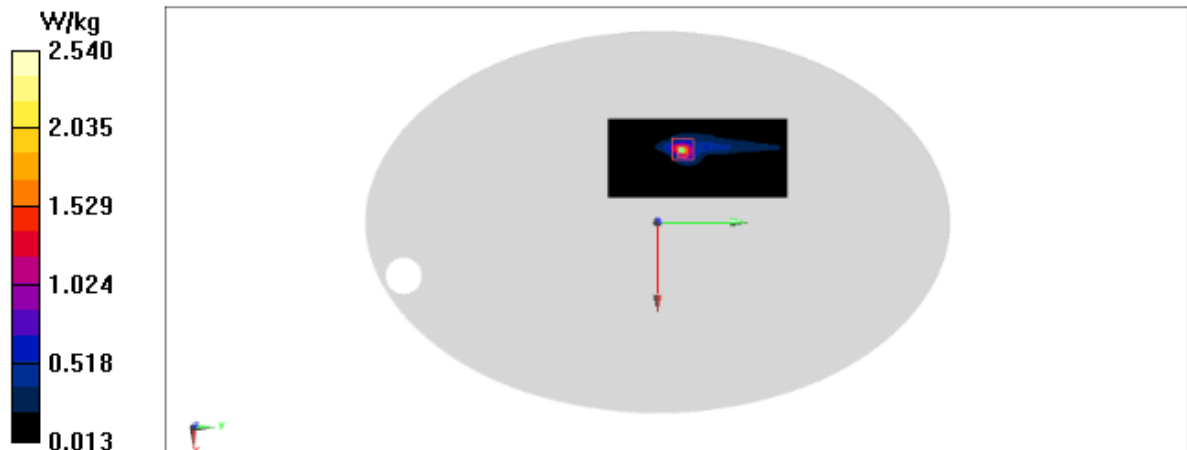
Zoom Scan (12x12x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 1.100 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 5.34 W/kg

SAR(1 g) = 0.984 W/kg; SAR(10 g) = 0.299 W/kg

Maximum value of SAR (measured) = 2.54 W/kg



WLAN5G-MIMO_CH114 Rear

Date: 11/24/2022

Electronics: DAE4 Sn1331

Medium: H5G

Medium parameters used: $f = 5570$ MHz; $\sigma = 4.977$ S/m; $\epsilon_r = 34.308$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: WLAN 11a Frequency: 5570 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN7548 ConvF(4.57, 4.57, 4.57)

Area Scan (121x261x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

Maximum value of SAR (interpolated) = 2.06 W/kg

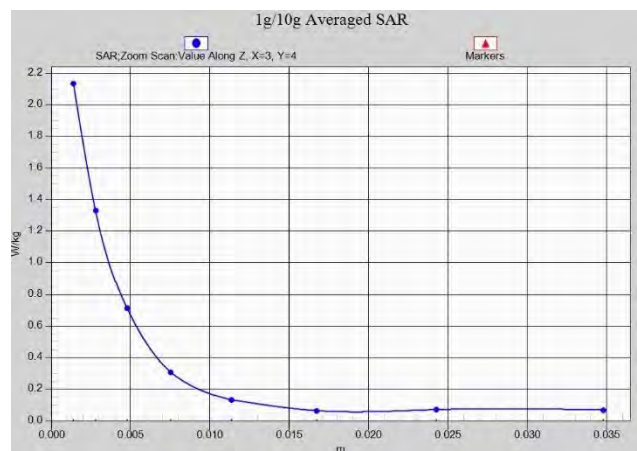
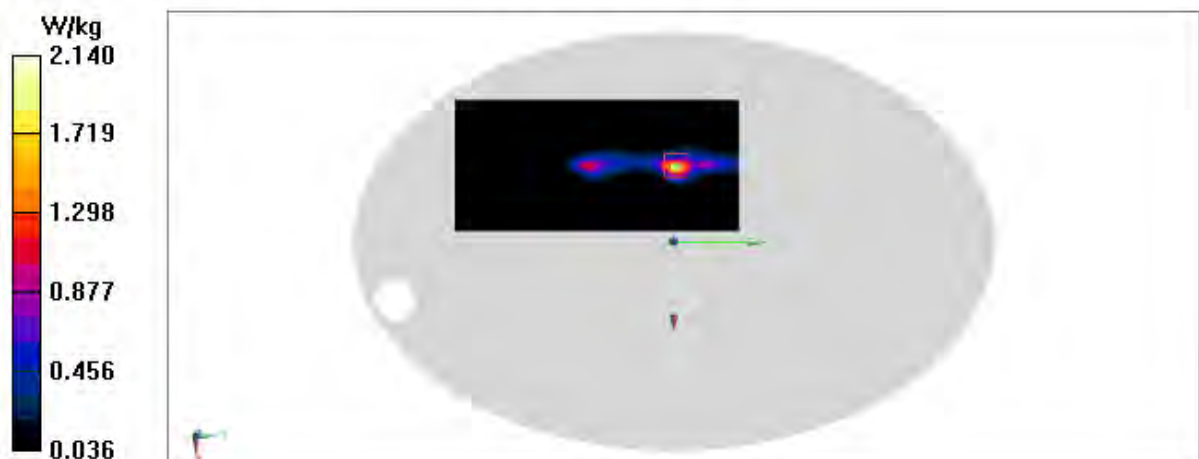
Zoom Scan (9x9x8)/Cube 0: Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 0 V/m; Power Drift = -0.13 dB

Peak SAR (extrapolated) = 4.21 W/kg

SAR(1 g) = 0.908 W/kg; SAR(10 g) = 0.303 W/kg

Maximum value of SAR (measured) = 2.14 W/kg



BT_CH39 Rear

Date: 11/15/2022

Electronics: DAE4 Sn1331

Medium: H2450

Medium parameters used (interpolated): $f = 2441$ MHz; $\sigma = 1.82$ S/m; $\epsilon_r = 40.335$; $\rho = 1000$ kg/m³

Ambient Temperature: 23.1°C Liquid Temperature: 22.2°C

Communication System: Bluetooth Frequency: 2441 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN7548 ConvF(7.32, 7.32, 7.32)

Area Scan (61x211x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 0.190 W/kg

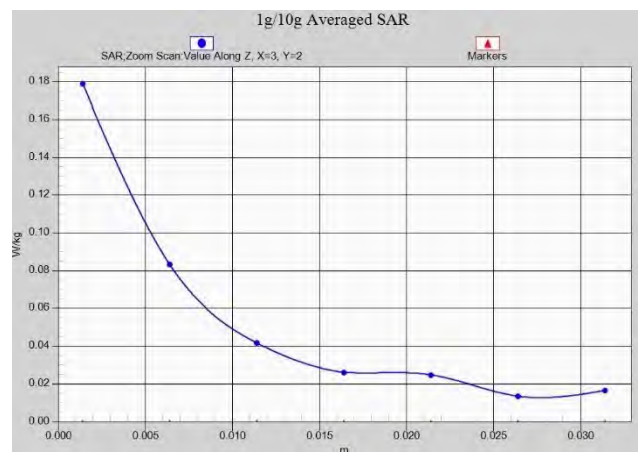
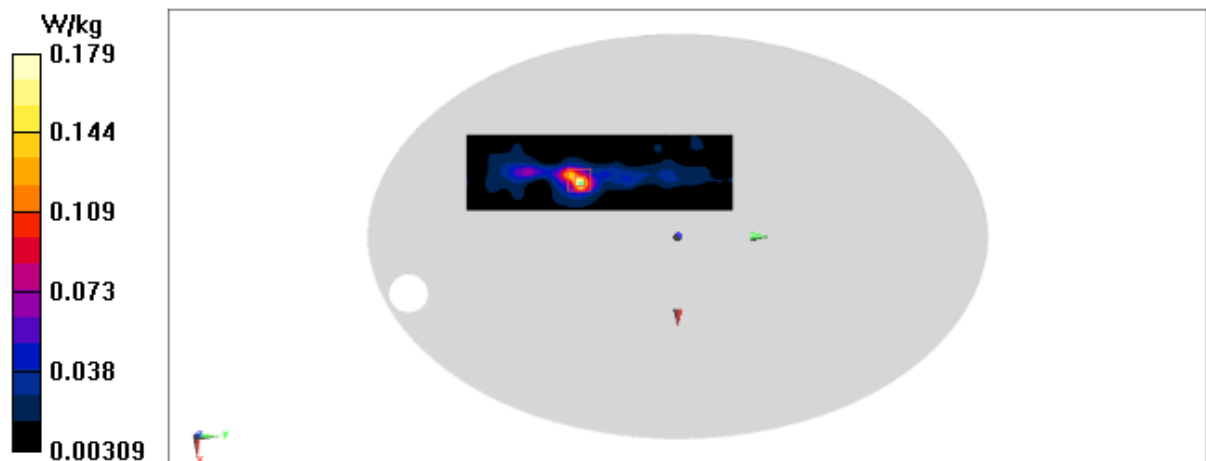
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0 V/m; Power Drift = 0.09dB

Peak SAR (extrapolated) = 0.261 W/kg

SAR(1 g) = 0.103 W/kg; SAR(10 g) = 0.048 W/kg

Maximum value of SAR (measured) = 0.179 W/kg



ANNEX B System Verification Results

2450MHz

Date: 11/15/2022

Electronics: DAE4 Sn1331

Medium: Head 2450MHz

Medium parameters used: $f = 2450\text{MHz}$; $\sigma = 1.824 \text{ mho/m}$; $\epsilon_r = 40.33$; $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature: 22.2°C Liquid Temperature: 22°C

Communication System: CW Frequency: 2450MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(7.32,7.32,7.32)

System Validation /Area Scan (81x191x1): Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$

Reference Value = 114.44 V/m ; Power Drift = -0.13

Fast SAR: SAR(1 g) = 13.38 W/kg ; SAR(10 g) = 6.18 W/kg

Maximum value of SAR (interpolated) = 22.14 W/kg

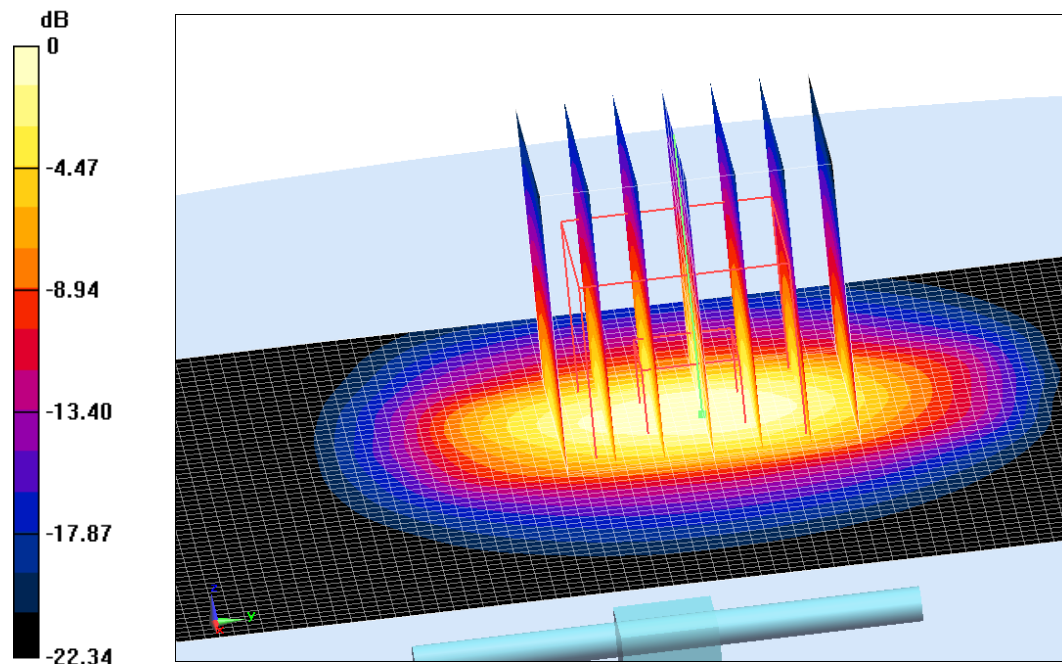
System Validation /Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 114.44 V/m ; Power Drift = -0.13

Peak SAR (extrapolated) = 25.85 W/kg

SAR(1 g) = 13.35 W/kg ; SAR(10 g) = 6.15 W/kg

Maximum value of SAR (measured) = 21.74 W/kg



$0 \text{ dB} = 21.74 \text{ W/kg} = 13.37 \text{ dB W/kg}$

Fig.B.1 validation 2450MHz 250mW

5250 MHz

Date: 11/22/2022

Electronics: DAE4 Sn1331

Medium: Head 5250 MHz

Medium parameters used: $f = 5250 \text{ MHz}$; $\sigma = 4.641 \text{ mho/m}$; $\epsilon_r = 35.8$; $\rho = 1000 \text{ kg/m}^3$

Ambient Temperature: 22.5°C Liquid Temperature: 22.3°C

Communication System: CW Frequency: 5250 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(4.98,4.98,4.98)

Area Scan (91x91x1): Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$

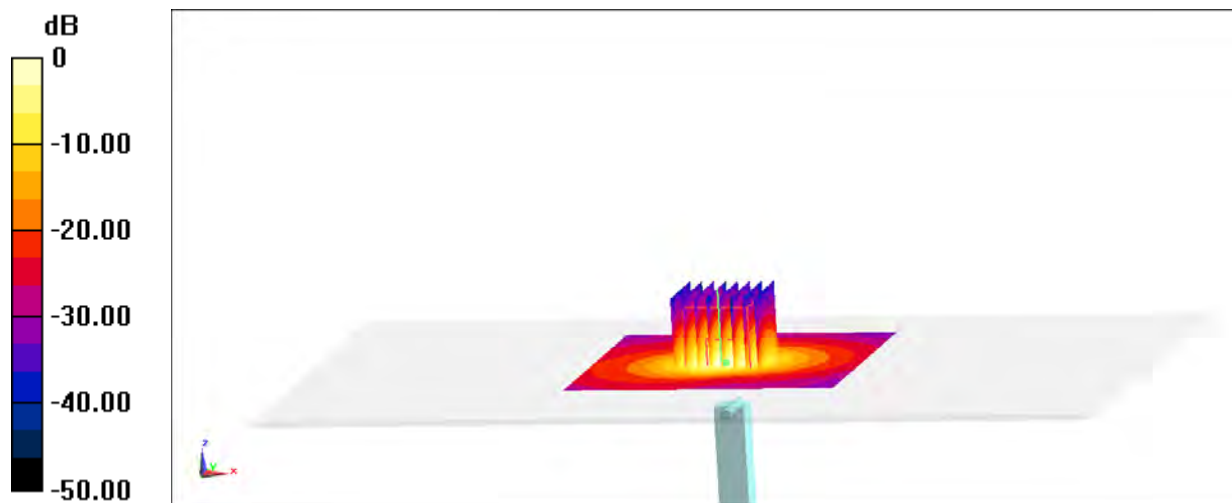
Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0: Measurement grid:
 $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 73.56V/m; Power Drift = -0.07

Peak SAR (extrapolated) = 34.5 W/kg

SAR(1 g) = 7.98W/kg; SAR(10 g) = 2.31 W/kg

Maximum value of SAR (measured) = 10.38 W/kg



0 dB = 10.56 W/kg = 10.16 dBW/kg

Fig.B.2 validation 5250 MHz 100mW

5600 MHz

Date: 11/24/2022

Electronics: DAE4 Sn1331

Medium: Head 5600 MHz

Medium parameters used: $f = 5600$ MHz; $\sigma = 4.923$ mho/m; $\epsilon_r = 35.14$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.5°C Liquid Temperature: 22.3°C

Communication System: CW Frequency: 5600 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(4.57,4.57,4.57)

Area Scan (91x91x1): Interpolated grid: $dx=1.000$ mm, $dy=1.000$ mm

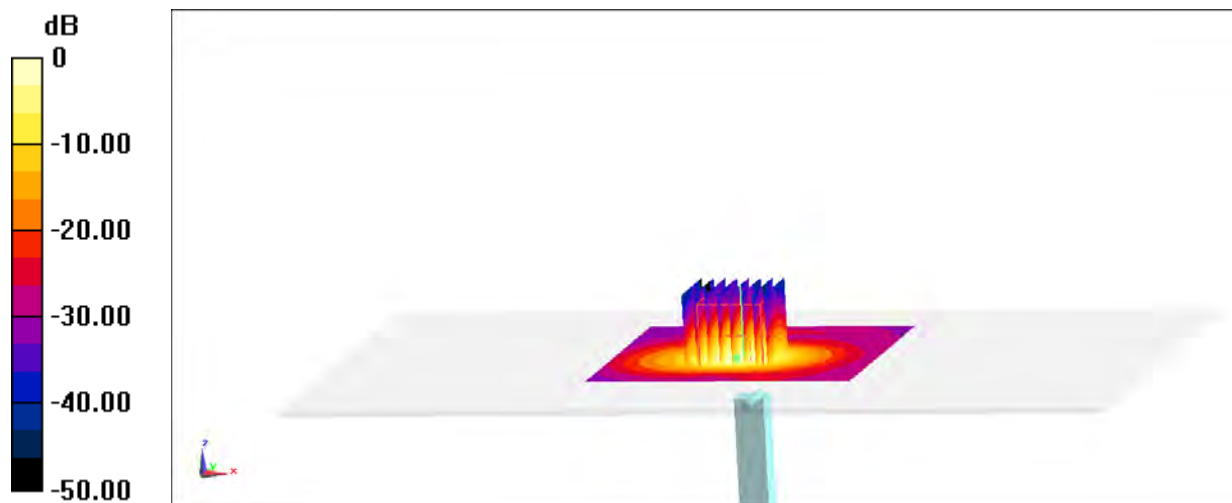
Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0: Measurement grid:
 $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 65.45 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 14.81 W/kg

SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.39 W/kg

Maximum value of SAR (measured) = 10.77 W/kg



0 dB = 10.77 W/kg = 10.32 dBW/kg

Fig.B.3 validation 5600 MHz 100mW

5750 MHz

Date: 11/26/2022

Electronics: DAE4 Sn1331

Medium: Head 5750 MHz

Medium parameters used: $f = 5750$ MHz; $\sigma = 5.079$ mho/m; $\epsilon_r = 35.87$; $\rho = 1000$ kg/m³

Ambient Temperature: 22.5°C Liquid Temperature: 22.3°C

Communication System: CW Frequency: 5750 MHz Duty Cycle: 1:1

Probe: EX3DV4 – SN7548 ConvF(4.64,4.64,4.64)

Area Scan (91x91x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

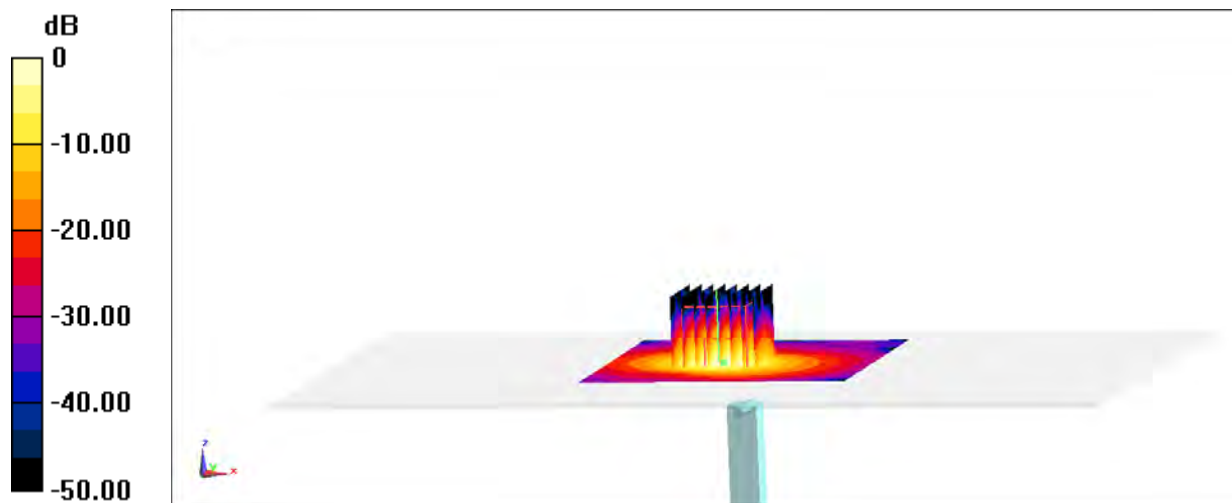
Zoom Scan (4x4x1.4mm, graded), dist=1.4mm (8x8x7)/Cube 0: Measurement grid:
dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 69.57 V/m; Power Drift = -0.12 dB

Peak SAR (extrapolated) = 19.25 W/kg

SAR(1 g) = 8.45 W/kg; SAR(10 g) = 2.43 W/kg

Maximum value of SAR (measured) = 11.54 W/kg



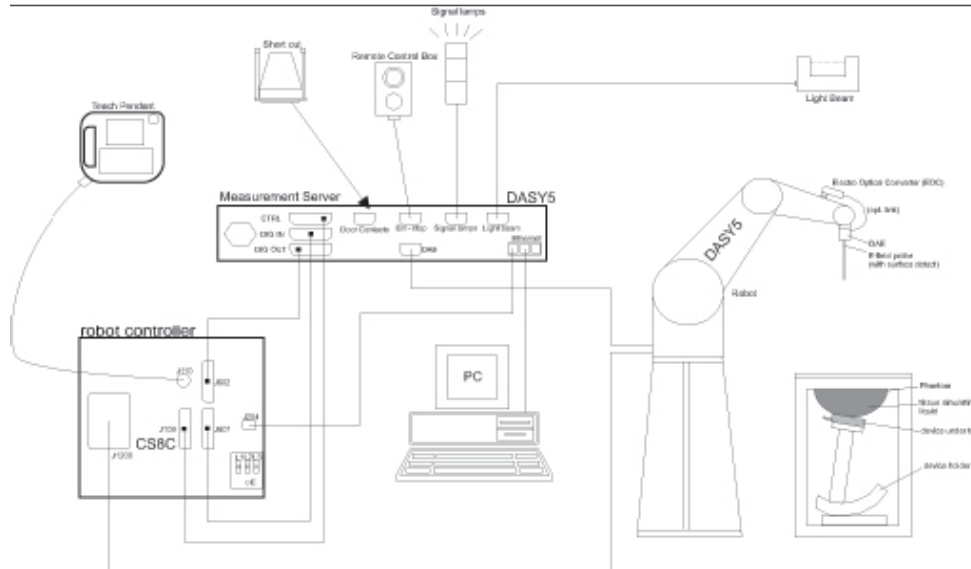
0 dB = 11.54 W/kg = 10.62 dBW/kg

Fig.B.4 validation 5750 MHz 100mW

ANNEX C SAR Measurement Setup

C.1 Measurement Set-up

The Dasy4 or DASY5 system for performing compliance tests is illustrated above graphically. This system consists of the following items:



Picture C.1 SAR Lab Test Measurement Set-up

- A standard high precision 6-axis robot (StäubliTX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY4 or DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

C.2 Dasy4 or DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multifiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY4 or DASY5 software reads the reflection during a software approach and looks for the maximum using 2nd order curve fitting. The approach is stopped at reaching the maximum.

Probe Specifications:

Model:	ES3DV3, EX3DV4
Frequency	10MHz — 6.0GHz(EX3DV4)
Range:	10MHz — 4GHz(ES3DV3)
Calibration:	In head and body simulating tissue at Frequencies from 835 up to 5800MHz
Linearity:	± 0.2 dB(30 MHz to 6 GHz) for EX3DV4 ± 0.2 dB(30 MHz to 4 GHz) for ES3DV3
DynamicRange:	10 mW/kg — 100W/kg
Probe Length:	330 mm
Probe Tip	
Length:	20 mm
Body Diameter:	12 mm
Tip Diameter:	2.5 mm (3.9 mm for ES3DV3)
Tip-Center:	1 mm (2.0mm for ES3DV3)
Application:	SAR Dosimetry Testing Compliance tests of mobile phones Dosimetry in strong gradient fields



Picture C.2Near-field Probe



Picture C.3E-field Probe

C.3 E-field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm²) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed

in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm².

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C \frac{\Delta T}{\Delta t}$$

Where:

Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

ΔT = Temperature increase due to RF exposure.

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m³).

C.4 Other Test Equipment

C.4.1 Data Acquisition Electronics(DAE)

The data acquisition electronics consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



PictureC.4: DAE

C.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90XL; DASY5: RX160L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)



Picture C.5DASY 4



Picture C.6DASY 5

C.4.3 Measurement Server

The Measurement server is based on a PC/104 CPU board with CPU (dasy4: 166 MHz, Intel Pentium; DASY5: 400 MHz, Intel Celeron), chipdisk (DASY4: 32 MB; DASY5: 128MB), RAM (DASY4: 64 MB, DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.



Picture C.7 Server for DASY 4



Picture C.8 Server for DASY 5

C.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of $\pm 0.5\text{mm}$ would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales are the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

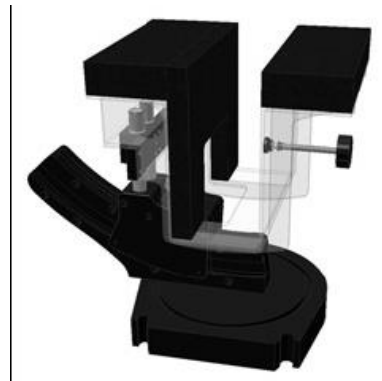
The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity $\epsilon = 3$ and loss tangent $\delta = 0.02$. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.



Picture C.9-1: Device Holder



Picture C.9-2: Laptop Extension Kit

C.4.5 Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to

Represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness: $2 \pm 0.2 \text{ mm}$

Filling Volume: Approx. 25 liters

Dimensions: 810 x 1000 x 500 mm (H x L x W)

Available: Special



Picture C.10: SAM Twin Phantom

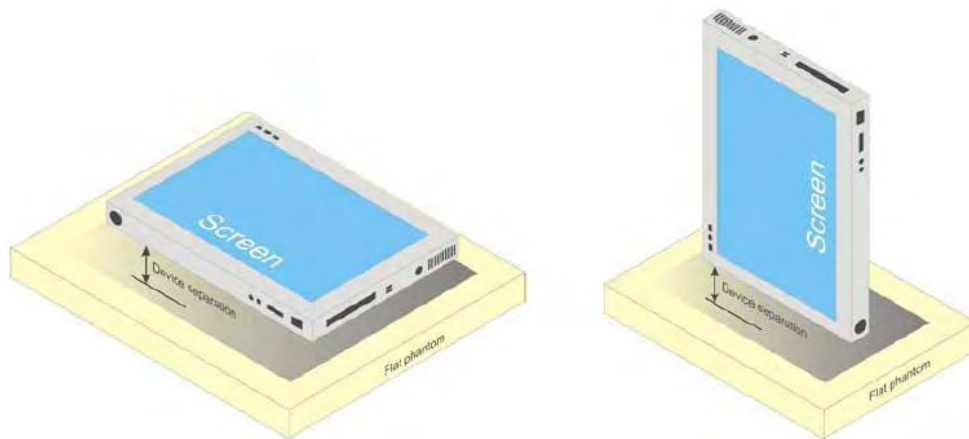
ANNEX D Position of the wireless device in relation to the phantom

D.1 Body-supported device

Other devices that fall into this category include tablet type portable computers and credit card transaction authorisation terminals, point-of-sale and/or inventory terminals. Where these devices may be torso or limb-supported, the same principles for body-supported devices are applied. The example in Picture D.1 shows a tablet form factor portable computer for which SAR should be separately assessed with

- a) each surface and
- b) the separation distances

positioned against the flat phantom that correspond to the intended use as specified by the manufacturer. If the intended use is not specified in the user instructions, the device shall be tested directly against the flat phantom in all usable orientations.



Picture D.1 Tablet form factor portable computer

D.2 DUT Setup Photos



Picture D.2

ANNEX E Equivalent Media Recipes

The liquid used for the frequency range of 800-3000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

TableE.1: Composition of the Tissue Equivalent Matter

Frequency (MHz)	835Head	835Body	1900 Head	1900 Body	2450 Head	2450 Body	5800 Head	5800 Body
Ingredients (% by weight)								
Water	41.45	52.5	55.242	69.91	58.79	72.60	65.53	65.53
Sugar	56.0	45.0	\	\	\	\	\	\
Salt	1.45	1.4	0.306	0.13	0.06	0.18	\	\
Preventol	0.1	0.1	\	\	\	\	\	\
Cellulose	1.0	1.0	\	\	\	\	\	\
Glycol Monobutyl	\	\	44.452	29.96	41.15	27.22	\	\
Diethyleneglycol monohexylether	\	\	\	\	\	\	17.24	17.24
Triton X-100	\	\	\	\	\	\	17.24	17.24
Dielectric Parameters Target Value	$\epsilon=41.5$ $\sigma=0.90$	$\epsilon=55.2$ $\sigma=0.97$	$\epsilon=40.0$ $\sigma=1.40$	$\epsilon=53.3$ $\sigma=1.52$	$\epsilon=39.2$ $\sigma=1.80$	$\epsilon=52.7$ $\sigma=1.95$	$\epsilon=35.3$ $\sigma=5.27$	$\epsilon=48.2$ $\sigma=6.00$

Note: There are a little adjustment respectively for 750, 1750, 2600, 5G based on the recipe of closest frequency in table E.1.

ANNEX F System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table F.1: System Validation for 7548

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
7548	Head 750MHz	August.2,2022	750 MHz	OK
7548	Head 900MHz	August.2,2022	900 MHz	OK
7548	Head 1450MHz	August.2,2022	1450 MHz	OK
7548	Head 1750MHz	August.2,2022	1750 MHz	OK
7548	Head 1900MHz	August.2,2022	1900 MHz	OK
7548	Head 2000MHz	August.3,2022	2000 MHz	OK
7548	Head 2300MHz	August.3,2022	2300 MHz	OK
7548	Head 2450MHz	August.3,2022	2450 MHz	OK
7548	Head 2600MHz	August.3,2022	2600 MHz	OK
7548	Head 3300MHz	August.3,2022	3300 MHz	OK
7548	Head 3500MHz	August.3,2022	3500 MHz	OK
7548	Head 3700MHz	August.3,2022	3700 MHz	OK
7548	Head 5250MHz	August.4,2022	5250 MHz	OK
7548	Head 5600MHz	August.4,2022	5600 MHz	OK
7548	Head 5750MHz	August.4,2022	5750 MHz	OK

ANNEX G Probe Calibration Certificate

Probe 7548 Calibration Certificate



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国际互认
校准
CALIBRATION
CNAS L0570

Client **CTTL**

Certificate No: **Z22-60260**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN : 7548**

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

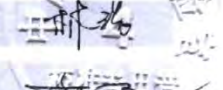
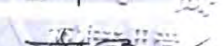
Calibration date: **August 01, 2022**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°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	14-Jun-22(CTTL, No.J22X04181)	Jun-23
Power sensor NRP-Z91	101547	14-Jun-22(CTTL, No.J22X04181)	Jun-23
Power sensor NRP-Z91	101548	14-Jun-22(CTTL, No.J22X04181)	Jun-23
Reference 10dBAttenuator	18N50W-10dB	20-Jan-21(CTTL, No.J21X00486)	Jan-23
Reference 20dBAttenuator	18N50W-20dB	20-Jan-21(CTTL, No.J21X00485)	Jan-23
Reference Probe EX3DV4	SN 3846	20-May-22(SPEAG, No.EX3-3846_May22)	May-23
DAE4	SN 771	20-Jan-22(SPEAG, No.DAE4-771_Jan22)	Jan-23
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGenerator MG3700A	6201052605	14-Jun-22(CTTL, No.J22X04182)	Jun-23
Network Analyzer E5071C	MY46110673	14-Jan-22(CTTL, No.J22X00406)	Jan-23

	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: August 08, 2022

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
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), i $\theta=0$ 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 $\theta=0$ ($f \leq 900\text{MHz}$ in TEM-cell; $f > 1800\text{MHz}$: 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.
- DCP_{x,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.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; VR_{x,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 $f \leq 800\text{MHz}$) and inside waveguide using analytical field distributions based on power measurements for $f > 800\text{MHz}$. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to 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 $\pm 50\text{MHz}$ to $\pm 100\text{MHz}$.
- 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).

DASY/EASY – Parameters of Probe: EX3DV4 – SN:7548

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k=2$)
Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.62	0.70	0.63	$\pm 10.0\%$
DCP(mV) ^B	101.7	102.0	102.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\cdot\mu\text{V}$	C	D dB	VR mV	Unc ^E ($k=2$)
0	CW	X	0.0	0.0	1.0	0.00	193.2	$\pm 2.2\%$
		Y	0.0	0.0	1.0		208.5	
		Z	0.0	0.0	1.0		192.2	

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 E^2 -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.

DASY/EASY – Parameters of Probe: EX3DV4 – SN:7548

Calibration Parameter Determined in Head Tissue Simulating Media

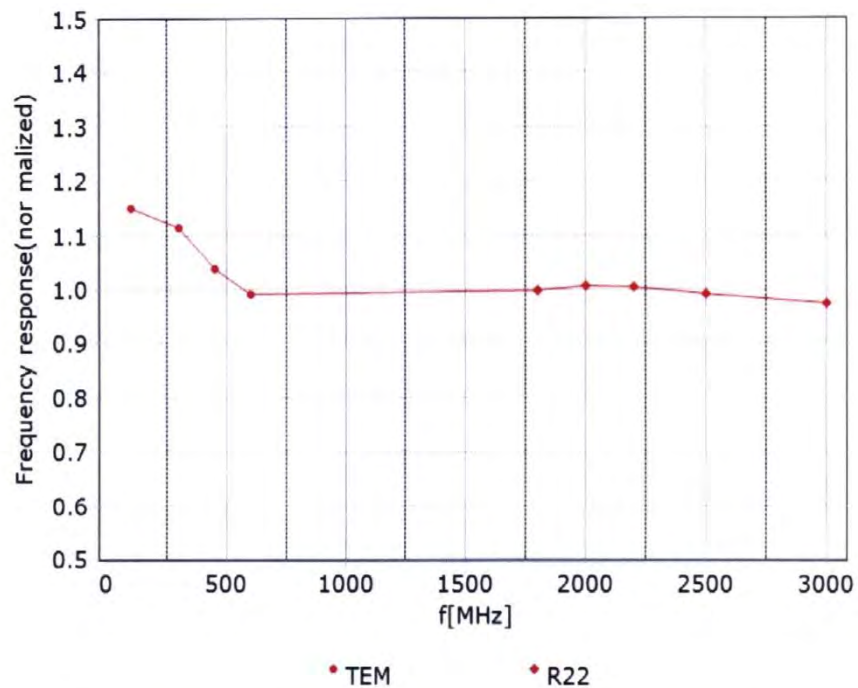
f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unct. (k=2)
750	41.9	0.89	10.30	10.30	10.30	0.16	1.29	± 12.1%
900	41.5	0.97	9.81	9.81	9.81	0.16	1.32	± 12.1%
1450	40.5	1.20	8.56	8.56	8.56	0.20	0.91	± 12.1%
1750	40.1	1.37	8.13	8.13	8.13	0.22	1.00	± 12.1%
1900	40.0	1.40	7.80	7.80	7.80	0.25	1.00	± 12.1%
2100	39.8	1.49	7.95	7.95	7.95	0.19	1.24	± 12.1%
2300	39.5	1.67	7.61	7.61	7.61	0.46	0.72	± 12.1%
2450	39.2	1.80	7.32	7.32	7.32	0.50	0.72	± 12.1%
2600	39.0	1.96	7.12	7.12	7.12	0.56	0.68	± 12.1%
3300	38.2	2.71	6.75	6.75	6.75	0.40	0.90	± 13.3%
3500	37.9	2.91	6.61	6.61	6.61	0.38	1.02	± 13.3%
3700	37.7	3.12	6.41	6.41	6.41	0.35	1.07	± 13.3%
3900	37.5	3.32	6.30	6.30	6.30	0.30	1.50	± 13.3%
4100	37.2	3.53	6.22	6.22	6.22	0.30	1.38	± 13.3%
4200	37.1	3.63	6.10	6.10	6.10	0.35	1.35	± 13.3%
4400	36.9	3.84	6.00	6.00	6.00	0.35	1.35	± 13.3%
4600	36.7	4.04	5.92	5.92	5.92	0.40	1.30	± 13.3%
4800	36.4	4.25	5.88	5.88	5.88	0.40	1.38	± 13.3%
4950	36.3	4.40	5.68	5.68	5.68	0.40	1.40	± 13.3%
5250	35.9	4.71	4.98	4.98	4.98	0.45	1.35	± 13.3%
5600	35.5	5.07	4.57	4.57	4.57	0.45	1.40	± 13.3%
5750	35.4	5.22	4.64	4.64	4.64	0.40	1.60	± 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.

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



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

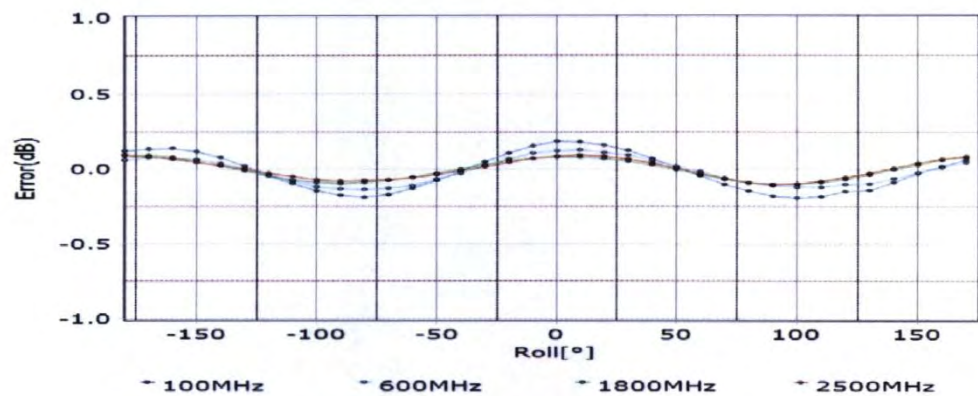
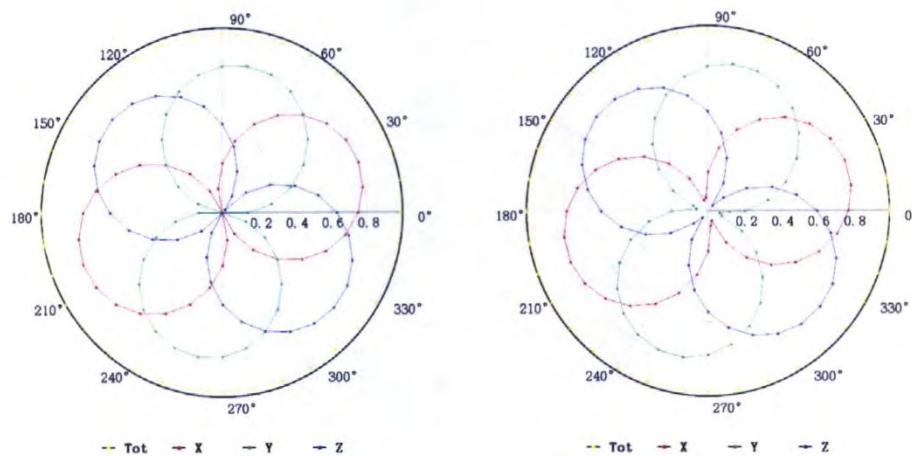


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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM

f=1800 MHz, R22

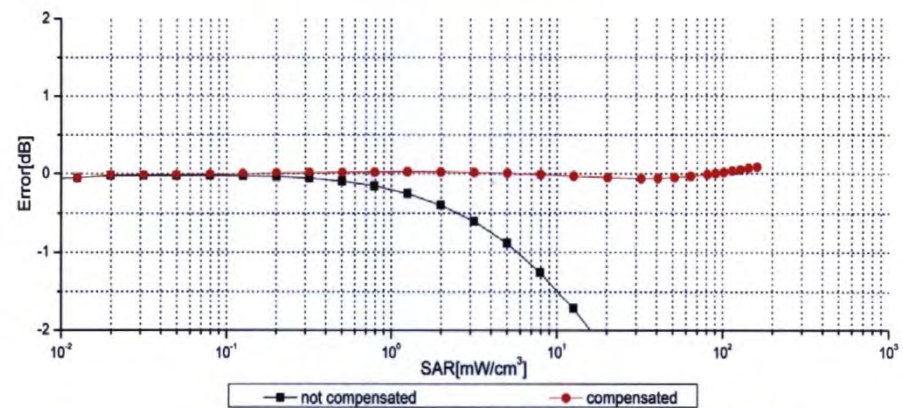
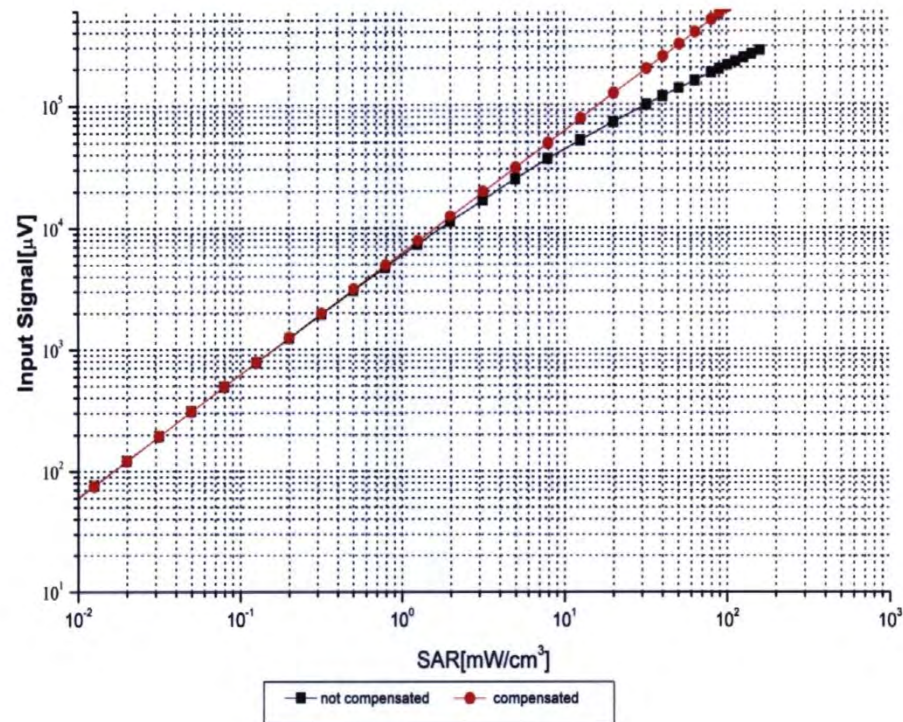


Uncertainty of Axial Isotropy Assessment: $\pm 1.2\%$ ($k=2$)



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Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f = 900 \text{ MHz}$)



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

Certificate No:Z22-60260

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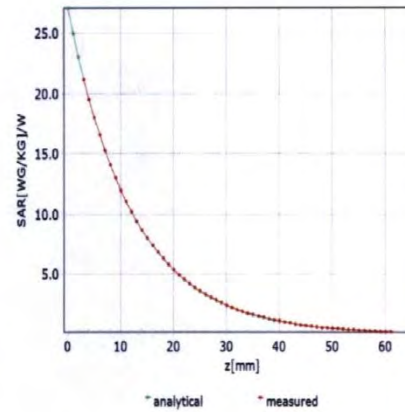
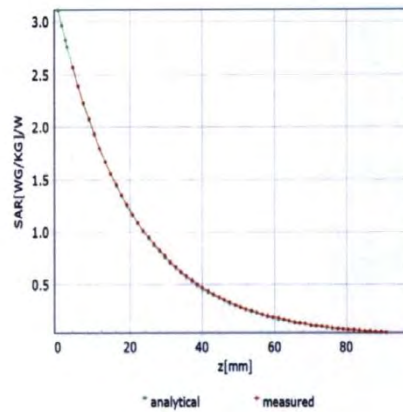


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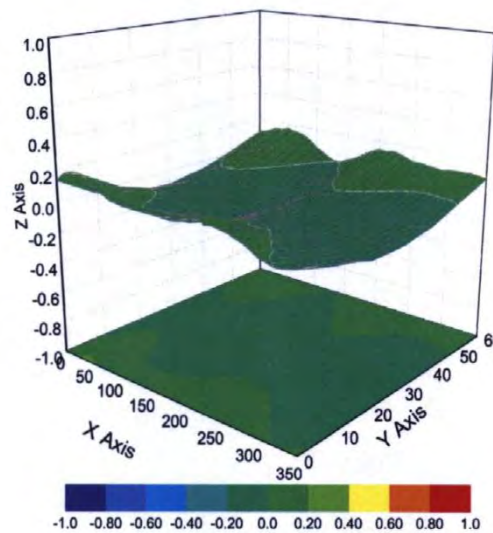
Conversion Factor Assessment

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

$f=1750\text{ MHz}$, 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:7548

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	146.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Probe Tip to Sensor X Calibration Point	1mm
Probe Tip to Sensor Y Calibration Point	1mm
Probe Tip to Sensor Z Calibration Point	1mm
Recommended Measurement Distance from Surface	1.4mm

ANNEX H Dipole Calibration Certificate

2450 MHz Dipole Calibration Certificate

Calibration Laboratory of
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Engineering AG
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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **CTTL (Auden)**

Certificate No: **D2450V2-853_Jul22**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:853**

Calibration procedure(s) **QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

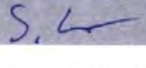
Calibration date: **July 20, 2022**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°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	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 7349	31-Dec-21 (No. EX3-7349_Dec21)	Dec-22
DAE4	SN: 601	02-May-22 (No. DAE4-601_May22)	May-23
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Aldonia Georgiadou	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: July 22, 2022

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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:

- 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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

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 source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss:** This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). 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 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	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	37.9 $\pm$ 6 %	1.85 mho/m $\pm$ 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	250 mW input power	13.5 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.7 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.9 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	$54.3 \Omega + 4.7 j\Omega$
Return Loss	- 24.3 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.162 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: 20.07.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:853

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.85$ S/m; $\epsilon_r = 37.9$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 116.2 V/m; Power Drift = 0.03 dB

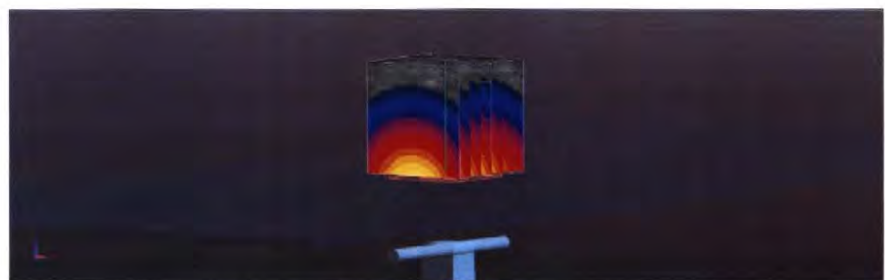
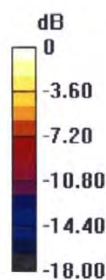
Peak SAR (extrapolated) = 26.6 W/kg

SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.29 W/kg

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

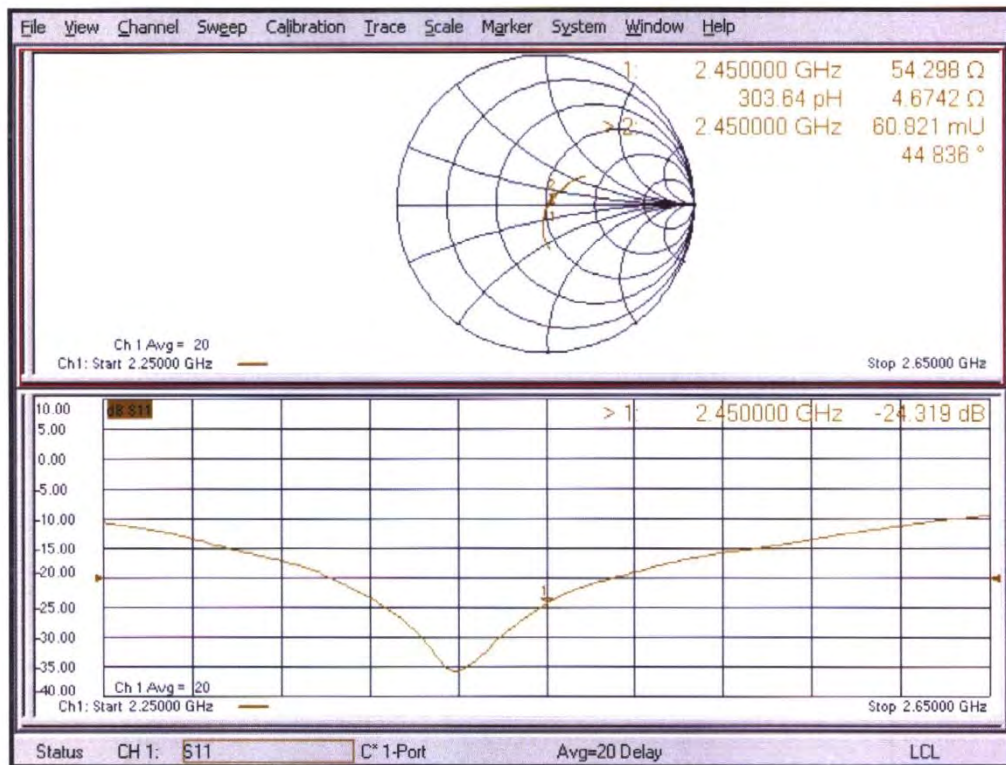
Ratio of SAR at M2 to SAR at M1 = 50.6%

Maximum value of SAR (measured) = 22.2 W/kg



0 dB = 22.2 W/kg = 13.47 dBW/kg

Impedance Measurement Plot for Head TSL



5 GHz Dipole Calibration Certificate

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Accreditation No.: **SCS 0108**

Client **CTTL (Auden)**

Certificate No: **D5GHzV2-1060_Jul22**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1060**

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

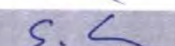
Calibration date: **July 05, 2022**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°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	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 3503	08-Mar-22 (No. EX3-3503_Mar22)	Mar-23
DAE4	SN: 601	02-May-22 (No. DAE4-601_May22)	May-23
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Aldonia Georgiadou	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: July 8, 2022

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Certificate No: D5GHzV2-1060_Jul22

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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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

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 source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss:** This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). 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 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	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz $\pm$ 1 MHz 5250 MHz $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5500 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5750 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	34.9 $\pm$ 6 %	4.50 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.84 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	77.8 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.3 W/kg $\pm$ 19.5 % (k=2)

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	34.8 ± 6 %	4.55 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °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	7.87 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.3 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.60 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.17 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.4 ± 6 %	4.80 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.60 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.44 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.1 W/kg ± 19.5 % (k=2)

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	34.3 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °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	8.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.7 W/kg ± 19.5 % (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	34.1 ± 6 %	5.05 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °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	8.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.8 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.0 ± 6 %	5.10 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL at 5200 MHz**

Impedance, transformed to feed point	49.4 Ω - 6.5 j Ω
Return Loss	- 23.7 dB

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	47.7 Ω - 5.5 j Ω
Return Loss	- 24.3 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	46.2 Ω - 3.2 j Ω
Return Loss	- 25.8 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	50.0 Ω - 3.1 j Ω
Return Loss	- 30.1 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.6 Ω + 0.5 j Ω
Return Loss	- 29.2 dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	51.9 Ω - 1.7 j Ω
Return Loss	- 32.1 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	51.2 Ω - 3.2 j Ω
Return Loss	- 29.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 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: 05.07.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1060

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5250 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.50$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5250$ MHz; $\sigma = 4.55$ S/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5300$ MHz; $\sigma = 4.60$ S/m; $\epsilon_r = 34.7$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5500$ MHz; $\sigma = 4.80$ S/m; $\epsilon_r = 34.4$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5600$ MHz; $\sigma = 4.90$ S/m; $\epsilon_r = 34.3$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5750$ MHz; $\sigma = 5.05$ S/m; $\epsilon_r = 34.1$; $\rho = 1000$ kg/m³,Medium parameters used: $f = 5800$ MHz; $\sigma = 5.10$ S/m; $\epsilon_r = 34.0$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.8, 5.8, 5.8) @ 5200 MHz, ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.49, 5.49, 5.49) @ 5300 MHz, ConvF(5.25, 5.25, 5.25) @ 5500 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 74.40 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 27.9 W/kg

SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.26 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 69.1%

Maximum value of SAR (measured) = 17.6 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan,**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.86 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 27.1 W/kg

SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.25 W/kg

Smallest distance from peaks to all points 3 dB below = 6.8 mm

Ratio of SAR at M2 to SAR at M1 = 69.8%

Maximum value of SAR (measured) = 17.4 W/kg

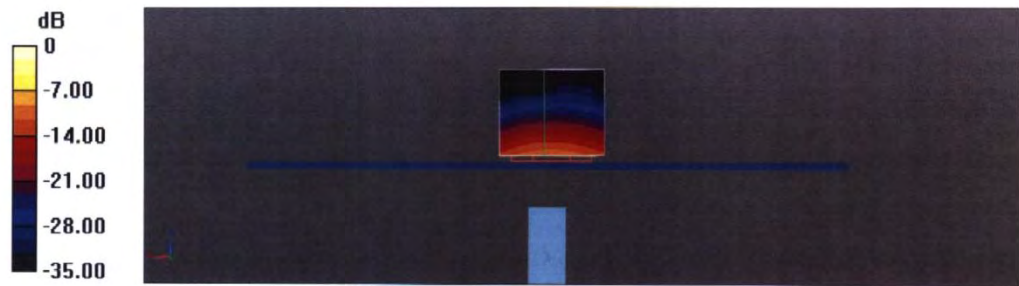
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 77.09 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 28.9 W/kg
SAR(1 g) = 8.17 W/kg; SAR(10 g) = 2.33 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 68.9%
Maximum value of SAR (measured) = 18.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 76.69 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 8.60 W/kg; SAR(10 g) = 2.44 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 66.4%
Maximum value of SAR (measured) = 19.8 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 76.44 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 31.2 W/kg
SAR(1 g) = 8.39 W/kg; SAR(10 g) = 2.40 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 67.3%
Maximum value of SAR (measured) = 19.3 W/kg

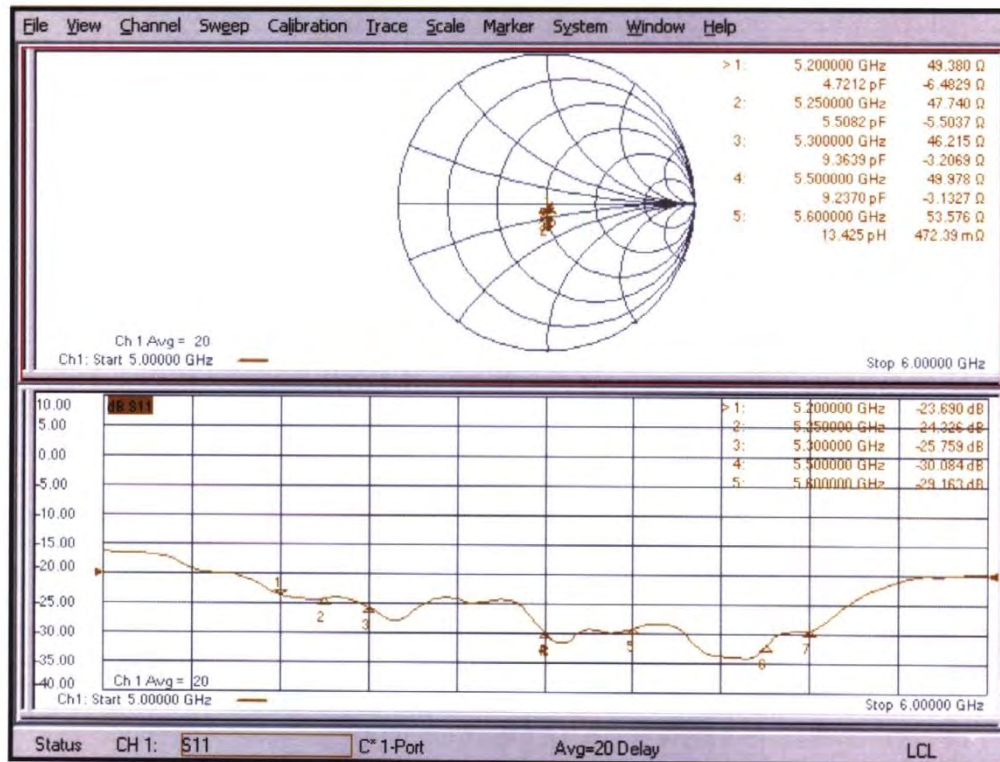
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.53 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 31.8 W/kg
SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.31 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.4%
Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.35 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 8.27 W/kg; SAR(10 g) = 2.34 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.2%
Maximum value of SAR (measured) = 19.4 W/kg

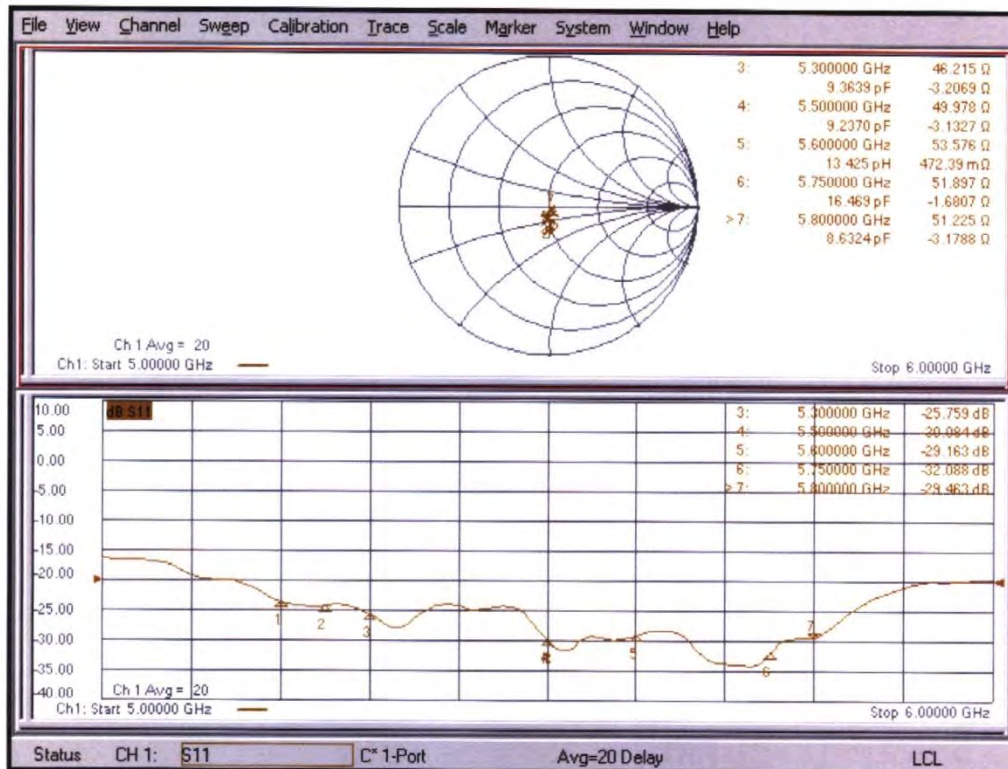


0 dB = 19.8 W/kg = 12.96 dBW/kg

Impedance Measurement Plot for Head TSL (5200, 5250, 5300, 5500, 5600 MHz)



Impedance Measurement Plot for Head TSL (5300, 5500, 5600, 5750, 5800 MHz)



ANNEX I Accreditation Certificate

United States Department of Commerce National Institute of Standards and Technology NVLAP[®]  Certificate of Accreditation to ISO/IEC 17025:2017 NVLAP LAB CODE: 600118-0 Telecommunication Technology Labs, CAICT Beijing China <i>is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:</i> Electromagnetic Compatibility & Telecommunications <i>This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).</i> <table><tr><td> 2022-10-01 through 2023-09-30 <i>Effective Dates</i> </td><td></td><td>  <i>For the National Voluntary Laboratory Accreditation Program</i> </td></tr></table>		2022-10-01 through 2023-09-30 <i>Effective Dates</i>		 <i>For the National Voluntary Laboratory Accreditation Program</i>
2022-10-01 through 2023-09-30 <i>Effective Dates</i>		 <i>For the National Voluntary Laboratory Accreditation Program</i>		