

SAR Test Report

Report No. : SFBEDW-WTW-P22110161A
Applicant : Dell Inc.
Address : One Dell Way, Round Rock, Texas 78682, USA
Product : 5G Module
FCC ID : E2KFM350GL
Brand : DELL
Model No. : FM350-GL
FCC Rule Part : CFR §2.1093
Standards : IEEE Std 1528:2013
KDB 865664 D01 v01r04, KDB 865664 D02 v01r02,
KDB 248227 D01 v02r02, KDB 447498 D01 v06, KDB 616217 D04 v01r02,
KDB 941225 D01 v03r01, KDB 941225 D05 v02r05, KDB 941225 D05A v01r02
Sample Received Date : DEC. 20, 2022
Date of Testing : Jan. 07, 2023
Lab Address : No. 47-2, 14th Ling, Chia Pau Vil., Lin Kou Dist., New Taipei City, Taiwan
Test Location : No. 19, Hwa Ya 2nd Rd., Wen Hwa Vil., Kwei Shan Dist., Taoyuan City, Taiwan

CERTIFICATION: The above equipment have been tested by **Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch-Lin Kou Laboratories**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's SAR characteristics under the conditions specified in this report. It should not be reproduced except in full, without the written approval of our laboratory. The client should not use it to claim product certification, approval, or endorsement by TAF or any government agencies.

This report is issued as a supplementary report to BV CPS report no.: SFBEDW-WTW-P22110161. The differences compared with original report is adding band UNII-4 and there is no any HW change in this filling. Therefore, the evaluation results were kept and referred from original test report. Only WLAN 5.9G was performed with full testing in this report and evaluating the simultaneous transmission.

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FCC Accredited No.: TW0003

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Release Control Record

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1. Summary of Maximum SAR Value

Equipment Class	Mode	Highest SAR _{1g} Body (W/kg)
PCB	WCDMA II	0.40
	WCDMA IV	0.29
	WCDMA V	0.54
	LTE 2	0.60
	LTE 4	0.85
	LTE 5	0.52
	LTE 7	0.76
	LTE 12	0.73
	LTE 13	0.65
	LTE 14	0.60
	LTE 17	0.88
	LTE 25	0.72
	LTE 26	0.60
	LTE 30	0.67
	LTE 38	0.97
	LTE 41	0.87
	LTE 48	0.60
	LTE 66	1.02
	LTE 71	0.70
	5GNR-n2	0.56
	5GNR-n5	0.50
	5GNR-n7	0.83
	5GNR-n25	0.96
	5GNR-n30	0.58
	5GNR-n38	0.98
	5GNR-n41	0.54
	5GNR-n48	0.78
	5GNR-n66	0.86
	5GNR-n71	0.66
	5GNR-n77	0.86
	5GNR-n78	0.56
DTS	2.4G WLAN	0.53
NII	5.3G WLAN	0.97
	5.6G WLAN	1.08
	5.8G WLAN	0.89
	5.9G WLAN	0.78
6XD	6G WLAN	0.91
DSS	Bluetooth	0.08

Mode	Highest APD [W/m ²]	Highest PD (W/m ²)
WLAN 6G	5.32	2.88

Highest Simultaneous Transmission	Highest SAR _{1g} Body (W/kg)
	1.59
	Total Exposure Ratio (TER)
	0.98

Note:

1. The SAR criteria (**Head & Body: SAR-1g 1.6 W/kg, and Extremity: SAR-10g 4.0 W/kg**) for general population/uncontrolled exposure is specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992.

Test Reference Guidance: IEEE C95.1:1992

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2. Description of Equipment Under Test

EUT Type	5G Module
FCC ID	E2KFM350GL
Brand Name	DELL
Model Name	FM350-GL
EUT Configurations	Sample 1 : EUT with Speed antenna Sample 2 : EUT with WNC antenna
Tx Frequency Bands (Unit: MHz)	WCDMA Band II : 1852.4 ~ 1907.6 WCDMA Band IV : 1712.4 ~ 1752.6 WCDMA Band V : 826.4 ~ 846.6 LTE Band 2 : 1850.7 ~ 1909.3 (BW: 1.4M, 3M, 5M, 10M, 15M, 20M) LTE Band 4 : 1710.7 ~ 1754.3 (BW: 1.4M, 3M, 5M, 10M, 15M, 20M) LTE Band 5 : 824.7 ~ 848.3 (BW: 1.4M, 3M, 5M, 10M) LTE Band 7 : 2502.5 ~ 2567.5 (BW: 5M, 10M, 15M, 20M) LTE Band 12 : 699.7 ~ 715.3 (BW: 1.4M, 3M, 5M, 10M) LTE Band 13 : 779.5 ~ 784.5 (BW: 5M, 10M) LTE Band 14 : 790.5 ~ 795.5 (BW: 5M, 10M) LTE Band 17 : 706.5 ~ 713.5 (BW: 5M, 10M) LTE Band 25 : 1850.7 ~ 1914.3 (BW: 1.4M, 3M, 5M, 10M, 15M, 20M) LTE Band 26 : 814.7 ~ 848.3 (BW: 1.4M, 3M, 5M, 10M, 15M) LTE Band 30 : 2307.5 ~ 2312.5 (BW: 5M, 10M) LTE Band 38 : 2572.5 ~ 2617.5 (BW: 5M, 10M, 15M, 20M) LTE Band 41 : 2502.5 ~ 2687.5 (BW: 5M, 10M, 15M, 20M) LTE Band 48 : 3552.5 ~ 3697.5 (BW: 5M, 10M, 15M, 20M) LTE Band 66 : 1710.7 ~ 1779.3 (BW: 1.4M, 3M, 5M, 10M, 15M, 20M) LTE Band 71 : 665.5 ~ 695.5 (BW: 5M, 10M, 15M, 20M) 5GNR-n2 : 1850 ~ 1910 5GNR-n5 : 824 ~ 849 5GNR-n7 : 2500 ~ 2570 5GNR-n25 : 1850 ~ 1915 5GNR-n30 : 2305 ~ 2315 5GNR-n38 : 2570 ~ 2620 5GNR-n41 : 2496 ~ 2690 5GNR-n48 : 3550 ~ 3700 5GNR-n66 : 1710 ~ 1780 5GNR-n71 : 663 ~ 698 5GNR-n77 : 3300 ~ 4200 5GNR-n78 : 3300 ~ 3800 WLAN : 2412 ~ 2472, 5180 ~ 5240, 5260 ~ 5320, 5500 ~ 5720, 5745 ~ 5825, 5815 ~ 5885, 5955 ~ 6415, 6435 ~ 6545, 6555 ~ 6885, 6895 ~ 7115 Bluetooth : 2402 ~ 2480
Uplink Modulations	WCDMA : QPSK LTE : QPSK, 16QAM, 64QAM, 256QAM 5G NR: π/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM 802.11b : DSSS 802.11a/g/n/ac : OFDM 802.11ax : OFDMA Bluetooth : GFSK, π/4-DQPSK, 8DPSK
SCS	15/30 KHz

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EN-DC uplink Combinations	LTE 2 + 5GNR-n5 LTE 2 + 5GNR-n71 LTE 2 + 5GNR-n77 LTE 2 + 5GNR-n78 LTE 5 + 5GNR-n2 LTE 5 + 5GNR-n66 LTE 5 + 5GNR-n77 LTE 5 + 5GNR-n78 LTE 7 + 5GNR-n78 LTE 12 + 5GNR-n2 LTE 12 + 5GNR-n66 LTE 12 + 5GNR-n77 LTE 13 + 5GNR-n2 LTE 13 + 5GNR-n66 LTE 13 + 5GNR-n77 LTE 14 + 5GNR-n2 LTE 14 + 5GNR-n66 LTE 14 + 5GNR-n77 LTE 25 + 5GNR-n41 LTE 26 + 5GNR-n78 LTE 30 + 5GNR-n5 LTE 30 + 5GNR-n77 LTE 38 + 5GNR-n78 LTE 41 + 5GNR-n41 LTE 41 + 5GNR-n77 LTE 48 + 5GNR-n5 LTE 48 + 5GNR-n66 LTE 66 + 5GNR-n5 LTE 66 + 5GNR-n71 LTE 66 + 5GNR-n77
Maximum Tune-up Conducted Power (Unit: dBm)	Please refer to Appendix D.
Antenna Type	Refer to Note
EUT Stage	Mass Product

Note:

1. The EUT is authorized for use in specific End-product. Please refer to below for more details.

Product	Brand	Model
Portable Computer	DELL	P166G

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2. The antenna information is listed as below.

WWAN

Laptop Mode

Manufacturer	Type	P/N	Connector	Peak Gain (dBi)												
				617-698 MHz	698-821 MHz	824-960 MHz	1425-1515 MHz	1710-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz				
Speed	PIFA (Tx1/ Rx1)	F-0G-FH-6159-001-00 (DC33002R29L)	IPEX MHF4	1.57	2.15	2.44	0.41	2.85	2.67	0.44	1.93	1.55				
	Type	P/N		Peak Gain (dBi)												
	PIFA (Rx2)	F-0G-FH-6159-002-00 (DC33002R21L)	IPEX MHF4	1.00	2.41	0.05	-0.99	-0.89	3.43	3.76	1.49	3.78	1.33			
	Type	P/N	Connector	1452-1496 MHz		1710-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz				
	PIFA (Tx2/ Rx3)	F-0G-FH-6159-001-00 (DC33002R29L)		0.12		2.41		1.63		0.86		2.29				
	Type	P/N	Connector	1805-2200 MHz			2300-2690 MHz			3400-3800 MHz			4200-5000 MHz			
	PIFA (Rx4)	F-0G-FH-6157-003-00 (DC33002R25L)		2.82			2.58			5.00			3.94			
Manufacturer	Type	P/N	Connector	Peak Gain (dBi)												
WNC	PIFA (Tx1/ Rx1)	81ELA715.G77 (DC33002RJ5L)		617-698 MHz	698-821 MHz	824-960 MHz	1425-1515 MHz	1710-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz				
	Type	P/N	Connector	617-698 MHz	717-821 MHz	824-960 MHz	1425-1515 MHz	1557-1610 MHz	1805-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz			
	PIFA (Rx2)	81ELA715.G79 (DC33002RJ1L)	IPEX MHF4	0.96	2.28	-0.91	-1.14	-1.06	3.39	3.10	1.36	3.33	1.04			
	Type	P/N	Connector	1452-1496 MHz		1710-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz				
	PIFA (Tx2/ Rx3)	81ELA715.G77 (DC33002RJ5L)		0.16		2.20		1.70		0.73		2.01				
	Type	P/N	Connector	1805-2200 MHz			2300-2690 MHz			3400-3800 MHz			4200-5000 MHz			
	PIFA (Rx4)	81ELA715.G82 (DC33002RJ7L)	IPEX MHF4	1.22			1.09			2.62			1.67			

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Tablet Mode

Manufacturer	Type	P/N	Connector	Peak Gain (dBi)									
				617-698 MHz	698-821 MHz	824-960 MHz	1425-1515 MHz	1710-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz	
Speed	PIFA (Tx1/ Rx1)	F-0G-FH-6159-001-00 (DC33002R29L)	IPEX MHF4	-12.00	-6.64	-3.77	-5.64	-0.79	0.56	0.94	0.71	2.48	
	Type	P/N		Peak Gain (dBi)									
	PIFA (Rx2)	F-0G-FH-6159-002-00 (DC33002R21L)	IPEX MHF4	-2.09	-3.18	-4.12	-3.24	-3.19	1.01	2.10	2.25	3.09	3.24
	Type	P/N	Connector	1452-1496 MHz		1710-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz	
	PIFA (Tx2/ Rx3)	F-0G-FH-6159-001-00 (DC33002R29L)		-1.89		-0.47		0.28		0.88		0.85	
	Type	P/N	Connector	1805-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz			
	PIFA (Rx4)	F-0G-FH-6157-003-00 (DC33002R25L)		1.62		3.01		3.81		5.89			
Manufacturer	Type	P/N	Connector	Peak Gain (dBi)									
WNC	PIFA (Tx1/ Rx1)	81ELA715.G77 (DC33002RJ5L)		617-698 MHz	698-821 MHz	824-960 MHz	1425-1515 MHz	1710-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz	
	Type	P/N	Connector	617-698 MHz	717-821 MHz	824-960 MHz	1425-1515 MHz	1557-1610 MHz	1805-2200 MHz	2300-2690 MHz	3400-3800 MHz	4200-4700 MHz	5150-5925 MHz
	PIFA (Rx2)	81ELA715.G79 (DC33002RJ1L)	IPEX MHF4	-2.51	-3.65	-4.02	-4.23	-3.83	0.51	2.15	0.56	2.23	1.89
	Type	P/N	Connector	1452-1496 MHz		1710-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz	
	PIFA (Tx2/ Rx3)	81ELA715.G77 (DC33002RJ5L)		-2.39		-0.79		0.33		0.43		0.35	
	Type	P/N	Connector	1805-2200 MHz		2300-2690 MHz		3400-3800 MHz		4200-5000 MHz			
	PIFA (Rx4)	81ELA715.G82 (DC33002RJ7L)		0.52		1.93		3.35		5.87			

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WLAN

Laptop Mode

Manufacturer	Type	P/N	Connector	Peak Gain (dBi)											
				BT	2.4GHz	5.15-5.25 GHz	5.25-5.35 GHz	5.47-5.725 GHz	5.725-5.850 GHz	5.85-5.895 GHz	5.925-6.425 GHz	6.425-6.525 GHz	6.525-6.875 GHz	6.875-7.125 GHz	
Speed	PIFA (Main)	F-0G-FH-6158-001-00 (DC33002R23L)	IPEX	-	2.87	2.91	2.88	4.10	4.10	3.50	4.74	4.12	4.89	4.91	
	PIFA (Aux)	F-0G-FH-6158-001-00 (DC33002R23L)	IPEX	2.77	2.77	3.47	3.65	1.51	2.72	2.79	3.64	4.02	4.31	4.67	
Manufacturer	Type	P/N	Connector	Peak Gain (dBi)											
				BT	2.4GHz	5.15-5.25 GHz	5.25-5.35 GHz	5.47-5.725 GHz	5.725-5.850 GHz	5.85-5.895 GHz	5.925-6.425 GHz	6.425-6.525 GHz	6.525-6.875 GHz	6.875-7.125 GHz	
WNC	PIFA (Main)	81ELA715.G83 (DC33002RJ3L)	IPEX	-	2.76	2.51	2.68	3.71	3.35	3.23	4.13	4.03	3.99	3.98	
	PIFA (Aux)	81ELA715.G83 (DC33002RJ3L)	IPEX	2.43	2.43	2.43	1.92	0.94	2.02	2.23	2.77	2.99	4.32	3.76	

Tablet Mode

Manufacturer	Type	P/N	Connector	Peak Gain (dBi)											
				BT	2.4GHz	5.15-5.25 GHz	5.25-5.35 GHz	5.47-5.725 GHz	5.725-5.850 GHz	5.85-5.895 GHz	5.925-6.425 GHz	6.425-6.525 GHz	6.525-6.875 GHz	6.875-7.125 GHz	
Speed	PIFA (Main)	F-0G-FH-6158-001-00 (DC33002R23L)	IPEX	-	-0.50	2.79	3.15	3.28	3.28	2.66	1.93	1.57	0.84	0.37	
	PIFA (Aux)	F-0G-FH-6158-001-00 (DC33002R23L)	IPEX	-1.20	-1.20	2.29	2.74	2.00	1.38	1.64	2.24	1.18	3.38	2.74	
Manufacturer	Type	P/N	Connector	Peak Gain (dBi)											
				BT	2.4GHz	5.15-5.25 GHz	5.25-5.35 GHz	5.47-5.725 GHz	5.725-5.850 GHz	5.85-5.895 GHz	5.925-6.425 GHz	6.425-6.525 GHz	6.525-6.875 GHz	6.875-7.125 GHz	
WNC	PIFA (Main)	81ELA715.G83 (DC33002RJ3L)	IPEX	-	-1.07	2.14	2.61	1.36	1.07	0.50	1.20	0.24	0.71	0.12	
	PIFA (Aux)	81ELA715.G83 (DC33002RJ3L)	IPEX	-1.54	-1.54	0.75	0.00	0.09	0.41	1.35	1.32	1.54	1.54	1.02	

3. The above EUT information is declared by manufacturer and for more detailed features description please refers to the manufacturer's specifications or User's Manual.

List of End-product Accessory:

Battery	Brand Name	DELL
	Model Name	GT6TK
	Power Rating	11.55Vdc; 60 Wh; 5065 mAh
	Type	Li-ion
WLAN Module	Brand Name	Intel® Wi-Fi 6E AX211
	Model Name	AX211D2W
	FCC ID	PD9AX211D2

Report Issue History Record:

Issue No.	Description	Date Issued
SFBEDW-WTW-P22110161	Initial release	Feb. 23, 2023
SFBEDW-WTW-P22110161A	Add band UNII-4	May 03, 2023

3. SAR Measurement System

3.1 Definition of Specific Absorption Rate (SAR)

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.

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:

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

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

SAR measurement can be related to the electrical field in the tissue by

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

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

3.2 SPEAG DASY6 System

DASY6 system consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY6 software defined. The DASY6 software can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC.

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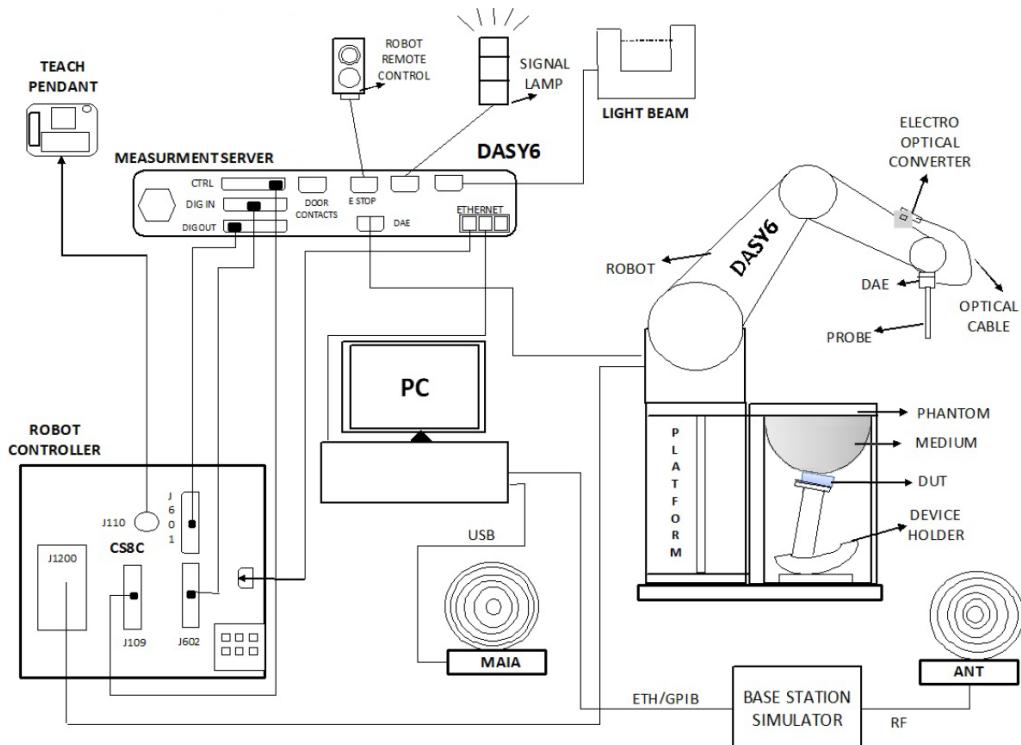


Fig-3.1 SPEAG DASY6 System Setup

3.2.1 Robot

The DASY6 system uses the high precision robots from Stäubli SA (France). For the 6-axis controller system, the robot controller version of CS8c from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)



Fig-3.2 SPEAG DASY6 System

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3.2.2 Probes

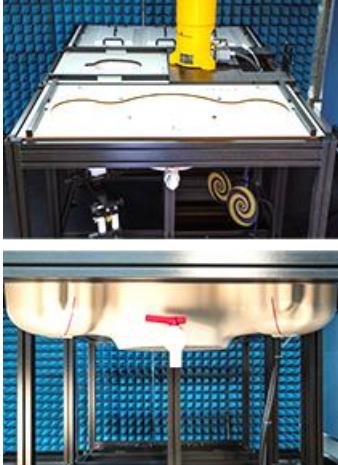
The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.

Model	EX3DV4	
Construction	Symmetrical design with triangular core. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE).	
Frequency	4 MHz to 10 GHz Linearity: ± 0.2 dB	
Directivity	± 0.1 dB in TSL (rotation around probe axis) ± 0.3 dB in TSL (rotation normal to probe axis)	
Dynamic Range	10 μ W/g to 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μ W/g)	
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

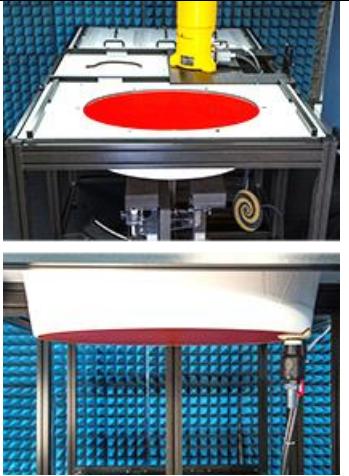
3.2.3 Data Acquisition Electronics (DAE)

Model	DAE3, DAE4	
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)	
Input Offset Voltage	$< 5\mu$ V (with auto zero)	
Input Bias Current	< 50 fA	
Dimensions	60 x 60 x 68 mm	

3.2.4 Phantoms

Model	SAM-Twin Phantom	
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE Std 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body-mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.	
Material	Vinylester, fiberglass reinforced (VE-GF)	
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)	
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet	
Filling Volume	approx. 25 liters	

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Model	ELI	
Construction	The ELI phantom is used for compliance testing of handheld and body-mounted wireless devices. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.	
Material	Vinylester, fiberglass reinforced (VE-GF)	
Shell Thickness	2.0 ± 0.2 mm (bottom plate)	
Dimensions	Major axis: 600 mm Minor axis: 400 mm	
Filling Volume	approx. 30 liters	

3.2.5 Device Holder

Model	MD4HHTV5 - Mounting Device for Hand-Held Transmitters	
Construction	In combination with the Twin SAM or ELI phantoms, the Mounting Device for Hand-Held Transmitters enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).	
Material	Polyoxymethylene (POM)	

Model	MDA4WTV5 - Mounting Device Adaptor for Ultra Wide Transmitters	
Construction	An upgrade kit to Mounting Device to enable easy mounting of wider devices like big smart-phones, e-books, small tablets, etc. It holds devices with width up to 140 mm.	
Material	Polyoxymethylene (POM)	

Model	MDA4SPV6 - Mounting Device Adaptor for Smart Phones	
Construction	The solid low-density MDA4SPV6 adaptor assuring no impact on the DUT radiation performance and is conform with any DUT design and shape.	
Material	ROHACELL	

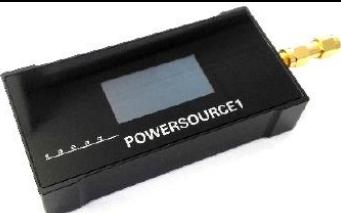
SAR Test Report

Model	MD4LAPV5 - Mounting Device for Laptops and other Body-Worn Transmitters	
Construction	In combination with the Twin SAM or ELI phantoms, the Mounting Device (Body-Worn) enables testing of transmitter devices according to IEC 62209-2 specifications. The device holder can be locked for positioning at a flat phantom section.	
Material	Polyoxymethylene (POM), PET-G, Foam	

3.2.6 System Validation Dipoles

Model	D-Serial	
Construction	Symmetrical dipole with 1/4 balun. Enables measurement of feed point impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions.	
Frequency	750 MHz to 5800 MHz	
Return Loss	> 20 dB	
Power Capability	> 100 W (f < 1GHz), > 40 W (f > 1GHz)	

3.2.7 Power Source

Model	Powersource1	
Signal Type	Continuous Wave	
Operating Frequencies	600 MHz to 5850 MHz	
Output Power	-5.0 dBm to +17.0 dBm	
Power Supply	5V DC, via USB jack	
Power Consumption	<3 W	
Applications	System performance check and validation with a CW signal.	

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3.2.8 Tissue Simulating Liquids

For SAR measurement of the field distribution inside the phantom, the phantom must be filled with homogeneous tissue simulating liquid to a depth of at least 15 cm. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 10 % are listed in Table-3.1.

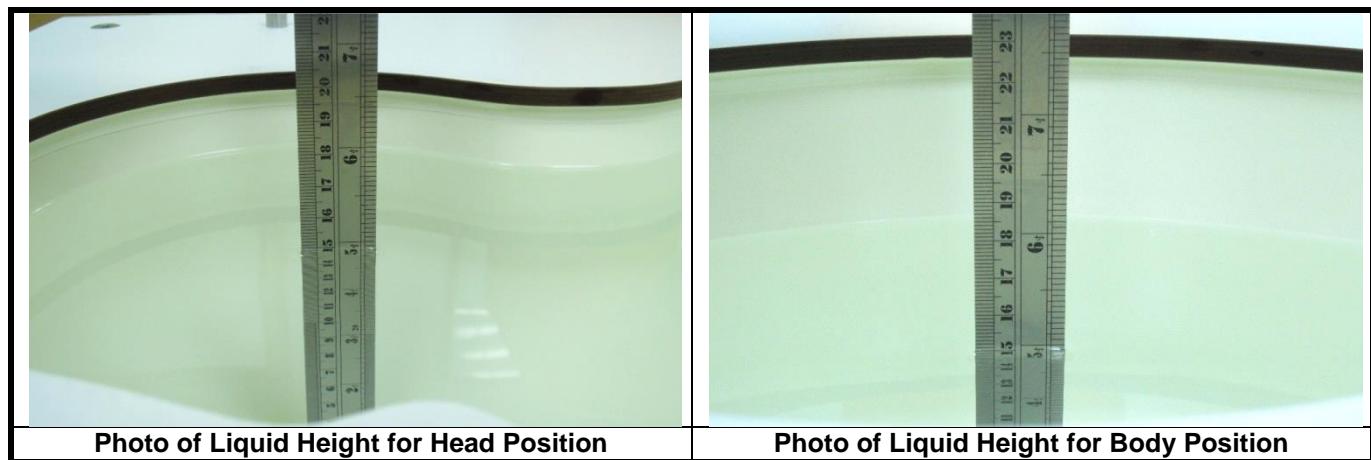


Table-3.1 Targets of Tissue Simulating Liquid

Frequency (MHz)	Target Permittivity	Range of ±10 %	Target Conductivity	Range of ±10 %
450	43.5	39.2 ~ 47.9	0.87	0.78 ~ 0.96
750	41.9	37.7 ~ 46.1	0.89	0.80 ~ 0.98
835	41.5	37.4 ~ 45.7	0.90	0.81 ~ 0.99
900	41.5	37.4 ~ 45.7	0.97	0.87 ~ 1.07
1450	40.5	36.5 ~ 44.6	1.20	1.08 ~ 1.32
1500	40.4	36.4 ~ 44.4	1.23	1.11 ~ 1.35
1640	40.2	36.2 ~ 44.2	1.31	1.18 ~ 1.44
1750	40.1	36.1 ~ 44.1	1.37	1.23 ~ 1.51
1800	40.0	36.0 ~ 44.0	1.40	1.26 ~ 1.54
1900	40.0	36.0 ~ 44.0	1.40	1.26 ~ 1.54
2000	40.0	36.0 ~ 44.0	1.40	1.26 ~ 1.54
2100	39.8	35.8 ~ 43.8	1.49	1.34 ~ 1.64
2300	39.5	35.6 ~ 43.5	1.67	1.50 ~ 1.84
2450	39.2	35.3 ~ 43.1	1.80	1.62 ~ 1.98
2600	39.0	35.1 ~ 42.9	1.96	1.76 ~ 2.16
3000	38.5	34.7 ~ 42.4	2.40	2.16 ~ 2.64
3500	37.9	34.1 ~ 41.7	2.91	2.62 ~ 3.20
4000	37.4	33.7 ~ 41.1	3.43	3.09 ~ 3.77
4500	36.8	33.1 ~ 40.5	3.94	3.55 ~ 4.33
5000	36.2	32.6 ~ 39.8	4.45	4.01 ~ 4.90
5200	36.0	32.4 ~ 39.6	4.66	4.19 ~ 5.13
5400	35.8	32.2 ~ 39.4	4.86	4.37 ~ 5.35
5600	35.5	32.0 ~ 39.1	5.07	4.56 ~ 5.58
5800	35.3	31.8 ~ 38.8	5.27	4.74 ~ 5.80
6000	35.1	31.6 ~ 38.6	5.48	4.93 ~ 6.03
6500	34.5	31.1 ~ 38.0	6.07	5.46 ~ 6.68

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The dielectric properties of the tissue simulating liquids are defined in IEC 62209-1 and IEC 62209-2. The dielectric properties of the tissue simulating liquids were verified prior to the SAR evaluation using a dielectric assessment kit and a network analyzer.

Since the range of $\pm 10\%$ of the required target values is used to measure relative permittivity and conductivity, the SAR correction procedure is applied to correct measured SAR for the deviations in permittivity and conductivity. Only positive correction has been used to scale up the measured SAR, and SAR result would not be corrected if the correction Δ SAR has a negative sign.

The following table gives the recipes for tissue simulating liquids.

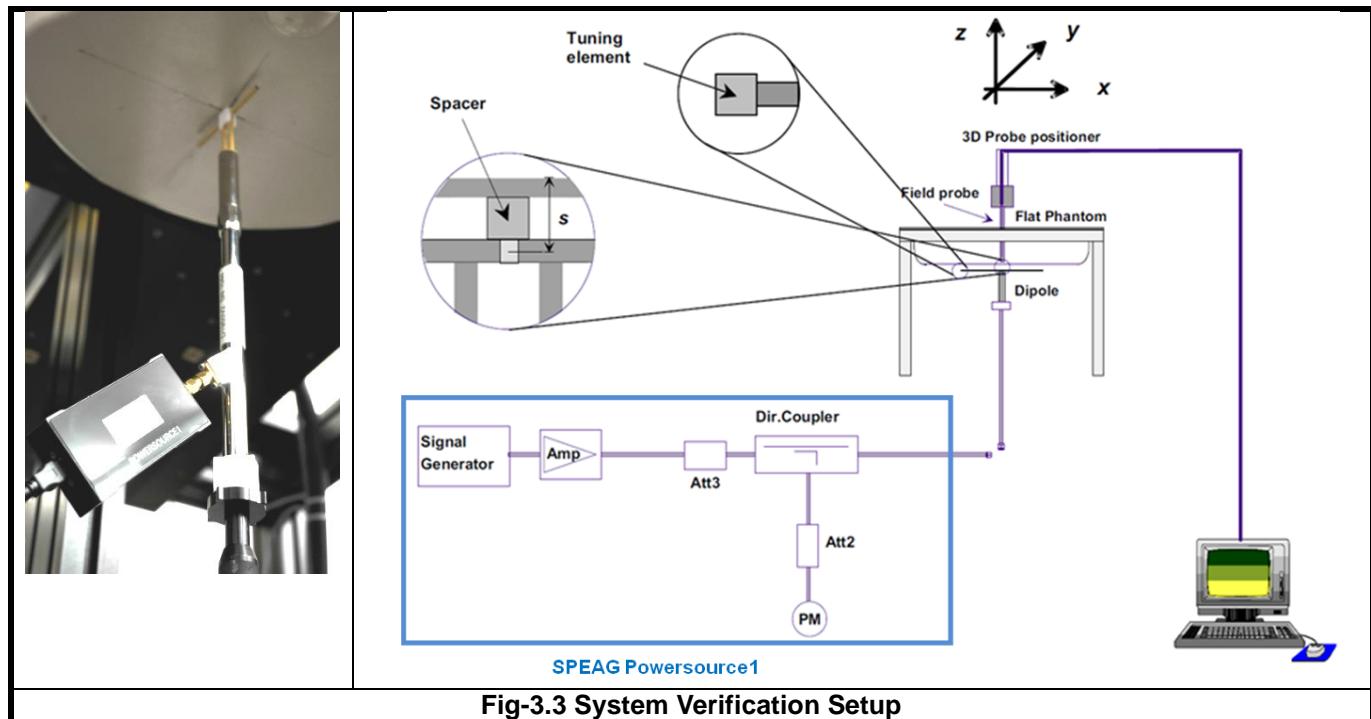
Table-3.2 Recipes of Tissue Simulating Liquid

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono-hexylether	Oxidized Mineral Oil
H750	0.2	-	0.2	1.5	56.0	-	42.1	-	-
H835	0.2	-	0.2	1.5	57.0	-	41.1	-	-
H900	0.2	-	0.2	1.4	58.0	-	40.2	-	-
H1450	-	43.3	-	0.6	-	-	56.1	-	-
H1640	-	45.8	-	0.5	-	-	53.7	-	-
H1750	-	47.0	-	0.4	-	-	52.6	-	-
H1800	-	44.5	-	0.3	-	-	55.2	-	-
H1900	-	44.5	-	0.2	-	-	55.3	-	-
H2000	-	44.5	-	0.1	-	-	55.4	-	-
H2300	-	44.9	-	0.1	-	-	55.0	-	-
H2450	-	45.0	-	0.1	-	-	54.9	-	-
H2600	-	45.1	-	0.1	-	-	54.8	-	-
H3500	-	8.0	-	0.2	-	20.0	71.8	-	-
H5G	-	-	-	-	-	17.2	65.5	17.3	-
H6G	-	-	-	-	-	-	56.0	-	44.0

SAR Test Report

3.3 SAR System Verification

The system check verifies that the system operates within its specifications. It is performed daily or before every SAR measurement. The system check uses normal SAR measurements in the flat section of the phantom with a matched dipole at a specified distance. The system verification setup is shown as below.



The SPEAG Powersource1 is a portable and very stable RF source providing a continuous wave (CW) signal. It is designed for conducting SAR system checks and SAR system validation of DASY and is compatible with IEC 62209-1, IEC 62209-2 and IEEE Std 1528 standards. The Powersource1 has been calibrated by SPEAG's ISO/IEC 17025-accredited calibration center. When using Powersource1, the setup can be simplified, as shown in Fig-3.3. The signal purity is warranted by design. Since the Powersource1 is calibrated, no additional equipment is needed and the Powersource1 can directly be connected to the SMA connector of the dipole without a cable as all separate components (signal generator, amplifier, coupler and power meter) are built into the unit.

The validation dipole is placed beneath the flat phantom with the specific spacer in place. The distance spacer is to touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The Powersource1 is adjusted for the desired forward power of 17 dBm at the dipole connector and the RF output power would be turned on. After system check testing, the SAR result will be normalized to 1W forward input power and compared with the reference SAR value derived from validation dipole certificate report. The deviation of system check should be within 10 %.

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3.4 SAR Measurement Procedure

According to the SAR test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

The SAR measurement procedures for each of test conditions are as follows:

- (a) Make EUT to transmit maximum output power
- (b) Measure conducted output power through RF cable
- (c) Place the EUT in the specific position of phantom
- (d) Perform SAR testing steps on the DASY system
- (e) Record the SAR value

3.4.1 Area Scan and Zoom Scan Procedure

First area scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an area scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, zoom scan is required. The zoom scan is performed around the highest E-field value to determine the averaged SAR-distribution.

Measure the local SAR at a test point at 1.4 mm of the inner surface of the phantom recommended by SEPAG. The area scan (two-dimensional SAR distribution) is performed cover at least an area larger than the projection of the EUT or antenna. The measurement resolution and spatial resolution for interpolation shall be chosen to allow identification of the local peak locations to within one-half of the linear dimension of the corresponding side of the zoom scan volume. Following table provides the measurement parameters required for the area scan.

Parameter	$f \leq 3 \text{ GHz}$	$3 \text{ GHz} < f \leq 6 \text{ GHz}$
Maximum distance from closest measurement point to phantom surface	5 ± 1	$\delta \ln(2)/2 \pm 0.5$
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: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$	$\leq 2 \text{ GHz}: \leq 15 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 12 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 12 \text{ mm}$ $4 - 6 \text{ GHz}: \leq 10 \text{ mm}$

From the scanned SAR distribution, identify the position of the maximum SAR value, in addition identify the positions of any local maxima with SAR values within 2 dB of the maximum value that will not be within the zoom scan of other peaks. Additional peaks shall be measured only when the primary peak is within 2 dB of the SAR compliance limit (e.g. 1 W/kg for 1.6 W/kg, 1 g limit; or 1.26 W/kg for 2 W/kg, 10 g limit).

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The zoom scan (three-dimensional SAR distribution) is performed at the local maxima locations identified in previous area scan procedure. The zoom scan volume must be larger than the required minimum dimensions. When graded grids are used, which only applies in the direction normal to the phantom surface, the initial grid separation closest to the phantom surface and subsequent graded grid increment ratios must satisfy the required protocols. The 1-g SAR averaging volume must be fully contained within the zoom scan measurement volume boundaries; otherwise, the measurement must be repeated by shifting or expanding the zoom scan volume. The similar requirements also apply to 10-g SAR measurements. Following table provides the measurement parameters required for the zoom scan.

Parameter	$f \leq 3 \text{ GHz}$	$3 \text{ GHz} < f \leq 6 \text{ GHz}$
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$	$\leq 2 \text{ GHz}: \leq 8 \text{ mm}$ $2 - 3 \text{ GHz}: \leq 5 \text{ mm}$	$3 - 4 \text{ GHz}: \leq 5 \text{ mm}$ $4 - 6 \text{ GHz}: \leq 4 \text{ mm}$
Maximum zoom scan spatial resolution, normal to phantom surface	<i>uniform grid: $\Delta z_{\text{Zoom}}(n)$</i>	$\leq 5 \text{ mm}$
	<i>graded grids: $\Delta z_{\text{Zoom}}(1)$</i>	$\leq 4 \text{ mm}$
	$\Delta z_{\text{Zoom}}(n>1)$	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1) \text{ mm}$
Minimum zoom scan volume (x, y, z)	$\geq 30 \text{ mm}$	$3 - 4 \text{ GHz}: \geq 28 \text{ mm}$ $4 - 5 \text{ GHz}: \geq 25 \text{ mm}$ $5 - 6 \text{ GHz}: \geq 22 \text{ mm}$

Per IEC 62209-2 AMD1, the successively higher resolution zoom scan is required if the zoom scan measured as defined above complies with both of the following criteria, or if the peak spatial-average SAR is below 0.1 W/kg, no additional measurements are needed:

- (1) The smallest horizontal distance from the local SAR peaks to all points 3 dB below the SAR peak shall be larger than the horizontal grid steps in both x and y directions ($\Delta x, \Delta y$). This shall be checked for the measured zoom scan plane conformal to the phantom at the distance zM1.
- (2) The ratio of the SAR at the second measured point (M2) to the SAR at the closest measured point (M1) at the x-y location of the measured maximum SAR value shall be at least 30 %.

If one or both of the above criteria are not met, the zoom scan measurement shall be repeated using a finer resolution. New horizontal and vertical grid steps shall be determined from the measured SAR distribution so that the above criteria are met. Compliance with the above two criteria shall be demonstrated for the new measured zoom scan.

3.4.2 Volume Scan Procedure

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

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3.4.3 Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of EUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drift more than 5%, the SAR will be retested.

3.4.4 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

- (a) Extraction of the measured data (grid and values) from the Zoom Scan
- (b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- (c) Generation of a high-resolution mesh within the measured volume
- (d) Interpolation of all measured values from the measurement grid to the high-resolution grid
- (e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- (f) Calculation of the averaged SAR within masses of 1g and 10g

3.4.5 SAR Averaged Methods

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

4. SAR Measurement Evaluation

4.1 EUT Configuration and Setting

<Considerations Related to WLAN for Setup and Testing>

In general, various vendor specific external test software and chipset based internal test modes are typically used for SAR measurement. These chipset based test mode utilities are generally hardware and manufacturer dependent, and often include substantial flexibility to reconfigure or reprogram a device. A Wi-Fi device must be configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools for SAR measurement. The test frequencies established using test mode must correspond to the actual channel frequencies. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. In addition, a periodic transmission duty factor is required for current generation SAR systems to measure SAR correctly. The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

According to KDB 248227 D01, this device has installed WLAN engineering testing software which can provide continuous transmitting RF signal. During WLAN SAR testing, this device was operated to transmit continuously at the maximum transmission duty with specified transmission mode, operating frequency, lowest data rate, and maximum output power.

Initial Test Configuration

An initial test configuration is determined for OFDM transmission modes in 2.4 GHz and 5 GHz bands according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band.

Subsequent Test Configuration

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. Additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. When the highest reported SAR for the initial test configuration according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.



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SAR Test Configuration and Channel Selection

When multiple channel bandwidth configurations in a frequency band have the same specified maximum output power, the initial test configuration is using largest channel bandwidth, lowest order modulation, lowest data rate, and lowest order 802.11 mode (i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n). After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following.

- 1) The channel closest to mid-band frequency is selected for SAR measurement.
- 2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

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4.2 EUT Testing Position

4.2.1 Body Exposure Conditions

For laptop PC, according to KDB 616217 D04, SAR evaluation is required for the bottom surface of the keyboard. This EUT was tested in the base of EUT directly against the flat phantom. The required minimum test separation distance for incorporating transmitters and antennas into laptop computer display is determined with the display screen opened at an angle of 90° to the keyboard compartment.

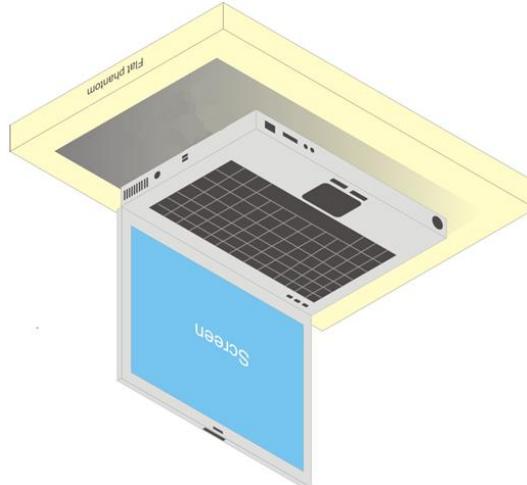


Fig-4.1 Illustration for Laptop Setup

For full-size tablet, according to KDB 616217 D04, SAR evaluation is required for back surface and edges of the devices. The back surface and edges of the tablet are tested with the tablet touching the phantom. Exposures from antennas through the front surface of the display section of a tablet are generally limited to the user's hands. Exposures to hands for typical consumer transmitters used in tablets are not expected to exceed the extremity SAR limit; therefore, SAR evaluation for the front surface of tablet display screens are generally not necessary. When voice mode is supported on a tablet and it is limited to speaker mode or headset operations only, additional SAR testing for this type of voice use is not required.

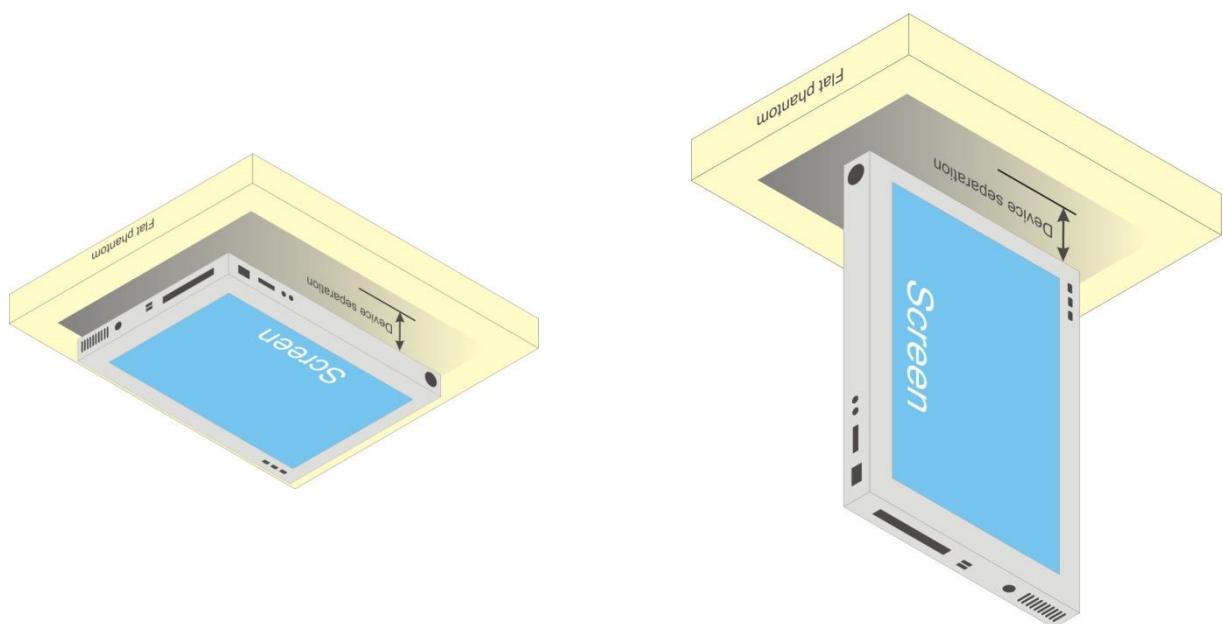


Fig-4.2 Illustration for Tablet Setup

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4.3 Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

Plot No.	Test Date	Frequency (MHz)	Liquid Temp. (°C)	Measured Conductivity (σ)	Measured Permittivity (ϵ_r)	Target Conductivity (σ)	Target Permittivity (ϵ_r)	Conductivity Deviation (%)	Permittivity Deviation (%)
S38	Jan. 07, 2023	5750	21.1	5.16	35	5.22	35.4	-1.15	-1.13
S38	Jan. 07, 2023	6500	21.1	5.67	34.7	6.07	34.5	-6.59	0.58

Note:

The dielectric properties of the tissue simulating liquid have been measured within 24 hours before the SAR testing and within $\pm 10\%$ of the target values. Liquid temperature during the SAR testing has kept within $\pm 2\text{ }^{\circ}\text{C}$.

4.4 System Validation

The SAR measurement system was validated according to procedures in KDB 865664 D01. The validation status in tabulated summary is as below.

Plot No.	Test Date	Probe S/N	Calibration Point	Measured Conductivity (σ)	Measured Permittivity (ϵ_r)	Validation for CW			Validation for Modulation		
						Sensitivity Range	Probe Linearity	Probe Isotropy	Modulation Type	Duty Factor	PAR
S38	Jan. 07, 2023	7736	5750	5.16	35	Pass	Pass	Pass	OFDM	N/A	Pass
S38	Jan. 07, 2023	7736	6500	5.67	34.7	Pass	Pass	Pass	OFDM	N/A	Pass

4.5 System Verification

The measuring result for system verification is tabulated as below.

Plot No.	Test Date	Frequency (MHz)	1W Target SAR-1g (W/kg)	Measured SAR-1g (W/kg)	Normalized to 1W SAR-1g (W/kg)	Deviation (%)	Dipole S/N	Probe S/N	DAE S/N
S38	Jan. 07, 2023	5750	79.40	3.87	77.22	-2.75	1019	7736	1698
S38	Jan. 07, 2023	6500	289.00	28.8	288.00	-0.35	1008	7736	1698

Note:

Comparing to the reference SAR value provided by SPEAG, the validation data should be within its specification of 10 %. The result indicates the system check can meet the variation criterion and the plots can be referred to Appendix A of this report.



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4.6 Maximum Output Power

4.6.1 Maximum Target Conducted Power

Refer to Appendix D.

4.6.2 Measured Conducted Power Result

Refer to Appendix E.

4.7 SAR Testing Results

4.7.1 SAR Test Reduction Considerations

<KDB 447498 D01, General RF Exposure Guidance>

Testing of other required channels within the operating mode of a frequency band is not required when the reported SAR for the mid-band or highest output power channel is:

- (1) $\leq 0.8 \text{ W/kg}$ or 2.0 W/kg , for 1-g or 10-g respectively, when the transmission band is $\leq 100 \text{ MHz}$
- (2) $\leq 0.6 \text{ W/kg}$ or 1.5 W/kg , for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- (3) $\leq 0.4 \text{ W/kg}$ or 1.0 W/kg , for 1-g or 10-g respectively, when the transmission band is $\geq 200 \text{ MHz}$

When SAR is not measured at the maximum power level allowed for production units, the measured SAR will be scaled to the maximum tune-up tolerance limit to determine compliance. The scaling factor for the tune-up power is defined as maximum tune-up limit (mW) / measured conducted power (mW). The reported SAR would be calculated by measured SAR x tune-up power scaling factor.

The SAR has been measured with highest transmission duty factor supported by the test mode tools for WLAN and/or Bluetooth. When the transmission duty factor could not achieve 100%, the reported SAR will be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up power. The scaling factor for the duty factor is defined as 100% / transmission duty cycle (%). The reported SAR would be calculated by measured SAR x tune-up power scaling factor x duty cycle scaling factor.

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<KDB 248227 D01, SAR Guidance for Wi-Fi Transmitters>

- (1) For handsets operating next to ear, hotspot mode or mini-tablet configurations, the initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When the reported SAR of initial test position is ≤ 0.4 W/kg, SAR testing for remaining test positions is not required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
- (2) For WLAN 2.4 GHz, the highest measured maximum output power channel for DSSS was selected for SAR measurement. When the reported SAR is ≤ 0.8 W/kg, no further SAR testing is required. Otherwise, SAR is evaluated at the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel. For OFDM modes (802.11g/n), SAR is not required when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and it is ≤ 1.2 W/kg.
- (3) For WLAN 5GHz, the initial test configuration was selected according to the transmission mode with the highest maximum output power. When the reported SAR of initial test configuration is > 0.8 W/kg, SAR is required for the subsequent highest measured output power channel until the reported SAR result is ≤ 1.2 W/kg or all required channels are measured. For other transmission modes, SAR is not required when the highest reported SAR for initial test configuration is adjusted by the ratio of subsequent test configuration to initial test configuration specified maximum output power and it is ≤ 1.2 W/kg.
- (4) For WLAN MIMO mode, the power-based standalone SAR test exclusion or the sum of SAR provision in KDB 447498 to determine simultaneous transmission SAR test exclusion should be applied. Otherwise, SAR for MIMO mode will be measured with all applicable antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

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4.7.2 SAR Test Results for Body Exposure Condition (Test Separation Distance is 0 mm)

Plot No.	Band	Mode	Test Position	Separation Distance (mm)	Ch.	Sample	Ant Status	Duty Cycle	Crest Factor	Max. Tune-up Power (dBm)	Measured Conducted Power (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR-1g (W/kg)	Scaled SAR-1g (W/kg)
	WLAN5.9G	802.11ac VHT160	Bottom for Laptop	0	163	1	Ant 0	97.00	1.03	12.50	12.47	1.01	-0.02	0.743	0.77
	WLAN5.9G	802.11ac VHT160	Rear Face	0	163	1	Ant 0	97.00	1.03	13.00	12.97	1.01	0.04	0.321	0.33
	WLAN5.9G	802.11ac VHT160	Left Side	0	163	1	Ant 0	97.00	1.03	13.00	12.97	1.01	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Right Side	0	163	1	Ant 0	97.00	1.03	13.00	12.97	1.01	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Top Side	0	163	1	Ant 0	97.00	1.03	13.00	12.97	1.01	-0.11	0.494	0.51
	WLAN5.9G	802.11ac VHT160	Bottom Side	0	163	1	Ant 0	97.00	1.03	13.00	12.97	1.01	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Bottom for Laptop	0	163	1	Ant 1	98.00	1.02	12.50	12.47	1.01	-0.04	0.714	0.74
	WLAN5.9G	802.11ac VHT160	Rear Face	0	163	1	Ant 1	98.00	1.02	13.00	12.98	1.00	0.05	0.365	0.37
	WLAN5.9G	802.11ac VHT160	Left Side	0	163	1	Ant 1	98.00	1.02	13.00	12.98	1.00	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Right Side	0	163	1	Ant 1	98.00	1.02	13.00	12.98	1.00	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Top Side	0	163	1	Ant 1	98.00	1.02	13.00	12.98	1.00	-0.11	0.554	0.57
	WLAN5.9G	802.11ac VHT160	Bottom Side	0	163	1	Ant 1	98.00	1.02	13.00	12.98	1.00	0	<0.001	0.00
38	WLAN5.9G	802.11ac VHT160	Bottom for Laptop	0	163	1	Ant 0+1	98.57	1.01	15.50	15.43	1.02	-0.02	0.76	0.78
	WLAN5.9G	802.11ac VHT160	Rear Face	0	163	1	Ant 0+1	98.57	1.01	16.00	15.98	1.00	0.05	0.298	0.30
	WLAN5.9G	802.11ac VHT160	Left Side	0	163	1	Ant 0+1	98.57	1.01	16.00	15.98	1.00	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Right Side	0	163	1	Ant 0+1	98.57	1.01	16.00	15.98	1.00	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Top Side	0	163	1	Ant 0+1	98.57	1.01	16.00	15.98	1.00	0.09	0.586	0.59
	WLAN5.9G	802.11ac VHT160	Bottom Side	0	163	1	Ant 0+1	98.57	1.01	16.00	15.98	1.00	0	<0.001	0.00
	WLAN5.9G	802.11ac VHT160	Bottom for Laptop	0	163	2	Ant 0+1	98.57	1.01	15.50	15.43	1.02	0.07	0.718	0.74

Note

1. SAR testing was performed on the maximum power mode.
2. The "< 0.001" means there is no SAR value or the SAR is too low to be measured.

SAR Test Report

4.7.3 SAR Measurement Variability

According to KDB 865664 D01, SAR measurement variability was 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. Alternatively, if the highest measured SAR for both head and body tissue-equivalent media are ≤ 1.45 W/kg and the ratio of these highest SAR values, i.e., largest divided by smallest value, is ≤ 1.10 , the highest SAR configuration for either head or body tissue-equivalent medium maybe used to perform the repeated measurement. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR repeated measurement procedure:

1. When the highest measured SAR is < 0.80 W/kg, repeated measurement is not required.
2. When the highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3. 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, perform a second repeated measurement.
4. If the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 , and the original, first or second repeated measurement is ≥ 1.5 W/kg, perform a third repeated measurement.

Since all the measured SAR1g are less than 0.8 W/kg, the repeated measurement is not required.

SAR Test Report

4.7.4 Simultaneous Multi-band Transmission Evaluation

<SAR Summation Analysis>

Simultaneous transmission SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneous transmitting antenna. When the sum of SAR_{1g} of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit (SAR_{1g} 1.6 W/kg), the simultaneous transmission SAR is not required. When the sum of SAR_{1g} is greater than the SAR limit (SAR_{1g} 1.6 W/kg), SAR test exclusion is determined by the SPLSR.

Refer to Appendix H for the Simultaneous transmission SAR analysis for this device.

<SAR to Peak Location Separation Ratio Analysis>

The simultaneous transmitting antennas in each operating mode and exposure condition combination are considered one pair at a time to determine the SPLSR. When SAR is measured for both antennas in the pair, the peak location separation distance is computed by the following formula.

$$\text{Peak Location Separation Distance} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

Where (x_1, y_1, z_1) and (x_2, y_2, z_2) are the coordinates of the extrapolated peak SAR locations in the area or zoom scans.

When standalone test exclusion applies, SAR is estimated; the peak location is assumed to be at the feed-point or geometric center of the antenna. Due to curvatures on the SAM phantom, when SAR is estimated for one of the antennas in an antenna pair, the measured peak SAR location will be translated onto the test device to determine the peak location separation for the antenna pair.

The SPLSR is determined by the following formula.

$$\text{SPLSR} = \frac{(SAR_1 + SAR_2)^{1.5}}{R_i}$$

Where SAR_1 and SAR_2 are the highest reported or estimated SAR for each antenna in the pair, and R_i is the separation distance between the peak SAR locations for the antenna pair in mm.

When the SPLSR is ≤ 0.04 , the simultaneous transmission SAR is not required. Otherwise, the enlarged zoom scan and volume scan post-processing procedures will be performed.

Refer to Appendix I for SAR to Peak Location Separation Ratio Analysis.

Test Engineer : Daniel Hou

SAR Test Report

5. Calibration of Test Equipment

Equipment	Manufacturer	Model	SN	Cal. Date	Cal. Interval
System Validation Dipole	SPEAG	D5GHzV2	1019	Mar. 18, 2022	1 Year
System Validation Dipole	SPEAG	D6.5GHzV2	1008	Aug. 29, 2022	1 Year
Dosimetric E-Field Probe	SPEAG	EX3DV4	7736	Nov. 15, 2022	1 Year
Data Acquisition Electronics	SPEAG	DAE4	1698	Nov. 17, 2022	1 Year
Analog Signal Generator	R&S	SMA100B	104417	Oct. 21, 2022	1 Year
Mini-Circuits Wideband Amplifier	Mini-Circuits	ZVA-183-S+	434502031A	Jul. 09, 2022	1 Year
Universal Wireless Test Set	Anritsu	MT8870A	6201699387	Sep. 22, 2022	1 Year
Thermometer	YFE	YF-160A	120702365	Aug. 09, 2022	1 Year
Dielectric Assessment Kit	SPEAG	DAKS-3.5	1092	May. 23, 2022	1 Year
Dielectric Assessment Kit	SPEAG	DAKS_VNA R140	0010917	May. 23, 2022	1 Year
Powersource1	SPEAG	SE_UMS_160 BA	4010	Jul. 25, 2022	1 Year

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6. Measurement Uncertainty

According to KDB 865664 D01, SAR measurement uncertainty analysis is required in SAR reports only when the highest measured SAR in a frequency band is ≥ 1.5 W/kg for 1-g SAR, and ≥ 3.75 W/kg for 10-g SAR. The procedures described in IEEE Std 1528-2013 should be applied. The expanded SAR measurement uncertainty must be $\leq 30\%$, for a confidence interval of $k = 2$. When the highest measured SAR within a frequency band is < 1.5 W/kg for 1-g and < 3.75 W/kg for 10-g, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval. Hence, the measurement uncertainty analysis for SAR is not required in this SAR report because the test result met the condition. The uncertainty analysis for power density tabulated as below.

Source of Uncertainty	Uncertainty (\pm dB)	Probability Distribution	Divisor	Ci	Standard Uncertainty (\pm dB)	Vi
Measurement System						
Probe Calibration	0.49	Normal	1	1	0.49	∞
Hemispherical Isotropy	0.50	Rectangular	$\sqrt{3}$	1	0.29	∞
Linearity	0.20	Rectangular	$\sqrt{3}$	1	0.12	∞
System Detection Limits	0.04	Rectangular	$\sqrt{3}$	1	0.02	∞
Modulation Response	0.40	Rectangular	$\sqrt{3}$	1	0.23	∞
Readout Electronics	0.03	Normal	1	1	0.03	∞
Response Time	0.00	Rectangular	$\sqrt{3}$	1	0.00	∞
Integration Time	0.00	Rectangular	$\sqrt{3}$	1	0.00	∞
RF Ambient Conditions – Noise	0.20	Rectangular	$\sqrt{3}$	1	0.12	∞
RF Ambient Conditions – Reflections	0.20	Rectangular	$\sqrt{3}$	1	0.12	∞
Probe Positioner Mechanical Tolerance	0.04	Rectangular	$\sqrt{3}$	1	0.02	∞
Probe Positioning with Respect to Phantom	0.30	Rectangular	$\sqrt{3}$	1	0.17	∞
S _{avg} Reconstruction	2.00	Rectangular	$\sqrt{3}$	1	1.15	∞
Test Sample Related						
Power Drift of Measurement	0.20	Rectangular	$\sqrt{3}$	1	0.12	∞
Input Power	0.00	Normal	1	1	0.00	∞
Combined Standard Uncertainty					± 1.34	
Expanded Uncertainty (K=2)					± 2.68	

Uncertainty Budget for Power Density Measurement for Frequency Range of 6 GHz to 10 GHz



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SAR Test Report

7. Information of the Testing Laboratories

We, Bureau Veritas Consumer Products Services (H.K.) Ltd., Taoyuan Branch, were founded in 1988 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are accredited and approved according to ISO/IEC 17025.

If you have any comments, please feel free to contact us at the following:

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Web Site: <https://ee.bureauveritas.com.tw/BVInternet/Default>

The road map of all our labs can be found in our web site also.

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