FCC TEST REPORT

APPLICANT	:	Qingdao THUNDEROBOT Technology Co.,Ltd.
PRODUCT NAME	:	Notebook
MODEL NAME	:	ZERO 18 Pro, ZERO 18
BRAND NAME	:	THUNDEROBOT
FCC ID	:	2BFDF-ZERO18PRO
STANDARD(S)	:	FCC 47 CFR Part 2(2.1093) IEEE 1528-2013 IEC TR 63170:2018 IEC/IEEE 62209-1528:2020
RECEIPT DATE	:	2025-03-14
TEST DATE	:	2025-04-10 to 2025-04-30
ISSUE DATE	:	2025-06-18

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Change History		
Version	**Date**	**Reason for Change**
1.0	2025-06-18	First edition

1 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) and power density found during testing as bellows:

Frequency Band		Reported SAR	APD	Scaled PD
		Body 1g SAR (W/kg)	Body (mW/cm^2)	$4cm^2$ psPD (mW/cm^2)
WLAN	WLAN 2.4GHz	1.172	N/A	N/A
	WLAN 5GHz	1.468	N/A	N/A
	WLAN 6GHz	1.466	0.921	0.569

Note:

1. This device is compliance with Specific Absorption Rate (SAR) for general population or uncontrolled exposure limits (1.6 W/kg for 1g SAR and 1.0 mW/cm^2 for iPD) specified in FCC 47 CFR part 1 (1.1310) and IEEE C95.1-1991), and had been tested in accordance with the measurement methods and procedures specified in IEC/IEEE 62209-1528 and TCBC workshop notes and IEC TR 63170.
2. The declarations of EUT presented in the report are provided by applicant and/or manufacturer, and the test laboratory is not responsible for the accuracy of the information.

2 Technical Information

Note: Provide by applicant.

2.1 Applicant and Manufacturer Information

Applicant:	Qingdao THUNDEROBOT Technology Co.,Ltd.
Applicant Address:	No. 1, Haier Road, Laoshan District, Qingdao.
Manufacturer:	Qingdao THUNDEROBOT Technology Co.,Ltd.
Manufacturer Address:	No. 1, Haier Road, Laoshan District, Qingdao.

2.2 Equipment under Test (EUT) Description

Product Name:	Notebook
EUT No.:	1#, 3#
Hardware Version:	A55B1_MB, R55B2C_MB
Software Version:	Windows 11
Operation Frequency:	WLAN 2.4GHz: 2412 MHz ~ 2462 MHz WLAN 5.2GHz: 5180 MHz ~ 5240 MHz WLAN 5.3GHz: 5260 MHz ~ 5320 MHz WLAN 5.5GHz: 5500 MHz ~ 5720 MHz WLAN 5.8GHz: 5745 MHz ~ 5825 MHz WLAN 6.2GHz: 5925 MHz ~ 6425 MHz WLAN 6.5GHz: 6425 MHz ~ 6525 MHz WLAN 6.7GHz: 6525 MHz ~ 6875 MHz WLAN 7.0GHz: 6875 MHz ~ 7125 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Modulation technology:	802.11b: DSSS 802.11g/n-HT20/40: OFDM 802.11a/ac-VHT20/40/80/160: OFDM 802.11ax-HEW20/40/80/160: OFDMA Bluetooth BR+EDR: GFSK, π/4-DQPSK, 8-DPSK Bluetooth LE: GFSK
Antenna Type:	WLAN: Pifa Antenna Bluetooth: Pifa Antenna

Note:

1. This computer is available in two models differentiated primarily by their motherboards:
   a) ZERO 18 Pro: Features A55B1_MB motherboard and supports 330W/280W adapters
   b) ZERO 18: Equipped with R55B2C_MB motherboard and uses 230W adapters
   Both models share identical antenna and WiFi module configurations.
2. This device underwent a motherboard update. Accordingly, we conducted worst-case scenario validation using the ZERO 18 model, while the primary test model remained the ZERO 18 Pro.
3. For a more detailed description, please refer to specification or user manual supplied by the applicant and/or manufacturer.

2.3 Environment of Test Site

Temperature:	18°C ~25°C
Humidity:	35%~75% RH

During SAR test, EUT is in Traffic Mode (Channel Allocated) at Normal Voltage Condition. A communication link is set up with a System Simulator (SS) by air link, and a call is established.

The EUT shall use its internal transmitter. The antenna(s), battery and accessories shall be those specified by the Factory. The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output. If a wireless link is used, the antenna connected to the output of the base station simulator shall be placed at least 50 cm away from the handset.
The signal transmitted by the simulator to the antenna feeding point shall be lower than the output power level of the handset by at least 35 dB.

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3 Specific Absorption Rate (SAR)

3.1 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 or controlled and general population or uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational or controlled exposure limits are higher than the limits for general population or uncontrolled.

3.2 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:

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

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

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength. However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

4 RF Exposure Limits

4.1 Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Limits for General Population/Uncontrolled Exposure (W/kg)

Type Exposure	Uncontrolled Environment Limit
Spatial Peak SAR (1g cube tissue for head and trunk)	1.6 W/kg
Spatial Peak SAR (10g cube tissue for limbs)	4.0 W/kg
Spatial Peak SAR (1g cube tissue for whole body)	0.08 W/kg

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f2)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f2)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

Note:

1. Occupational/Uncontrolled Environments are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure (i.e. as a result of employment or occupation).
2. Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

4.2 Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

5 Applied Reference Documents

Leading reference documents for testing:

Identity	Document Title	Remark
FCC 47 CFR Part 2(2.1093)	Radio Frequency Radiation Exposure Evaluation: Portable Devices	/
IEEE 1528-2013	IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques	/
IEC/IEEE 62209-1528:2020	Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices –Part 1528: Human models, instrumentation, and procedures (Frequency range of 4 MHz to 10 GHz)	/
IEC TR 63170:2018	Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz	/
KDB 447498 D01v06	General RF Exposure Guidance	/
KDB 248227 D01v02r02	SAR Measurement Procedures for 802.11 Transmitters	/
KDB 616217 D04 v01r01	SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers	/
KDB 865664 D02v01r02	RF Exposure Reporting	/
KDB 941225 D06v02r01	SAR Evaluation Procedures For Portable Devices With Wireless Router Capabilities	/
Note: Any additions, deviation, or exclusions from the method shall be noted in the “Remark” .		

6 SAR Measurement System

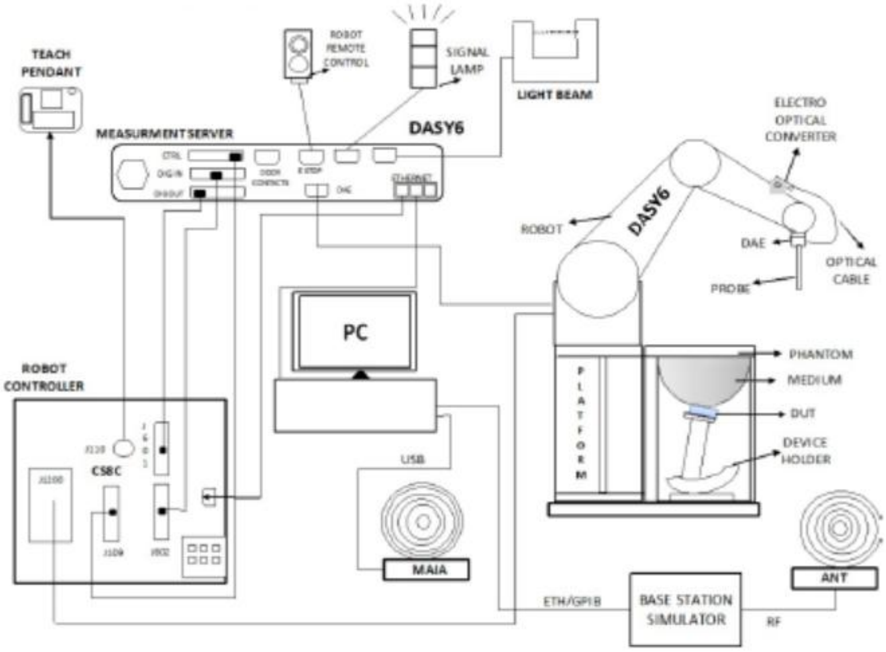


Fig.6.1 SPEAG DASY System Configurations

The DASY system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software.
- A data acquisition electronic (DAE) attached to the robot arm extension.
- A dosimetric probe equipped with an optical surface detector system.
- The electro-optical converter (EOC) performs the conversion between optical and electrical signals.
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning.
- A computer operating Windows XP.
- DASY software.
- Remove control with teach pendant and additional circuitry for robot safety such as warming lamps, etc.
- The SAM twin phantom.
- A device holder.
- Tissue simulating liquid.
- Dipole for evaluating the proper functioning of the system.

Component details are described in the following sub-sections.

6.1 E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG). 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. This probe has a built in optical surface detection system to prevent from collision with phantom.

➢ **E-Field Probe Specification**

<EX3DV4 Probe>

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 µW/g to 100 mW/g; Linearity: ± 0.2 dB	
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	**Fig 6.2 Photo of EX3DV4**

6.2 EUmmWave Probe

The probe designed allows measurement at distances as small as 2 mm from the sensor to the surface of EUT. The typical senor to the tip of probe is 1.5 mm.

Frequency	750 MHz ~110 GHz
Probe Overall Length	320 mm
Probe Body Diameter	8.0 mm
Tip Length	23.0 mm
Tip Diameter	8.0 mm
Two dipoles' Length of Probe	0.9 mm – Diode located
Dynamic Range	＜20 V/m – 10000 V/m with PRE-10 (min ＜ 50 V/m – 3000 V/m)
Linearity	＜0.2 dB
Position Precision	＜0.2 mm
Distance between Diode Sensors and Probe's tip	1.5 mm
Minimum Mechanical Separation between Probe Tip and a Surface	0.5 mm
Applications	E-field measurement of mm-Wave transmitters operating above 10 GHz in ＜ 2mm distance from device (free-space) power density H-field and far-field analysis using total field reconstruction.
Compatibility	cDASY 6 + 5G Module SW1.0 and higher

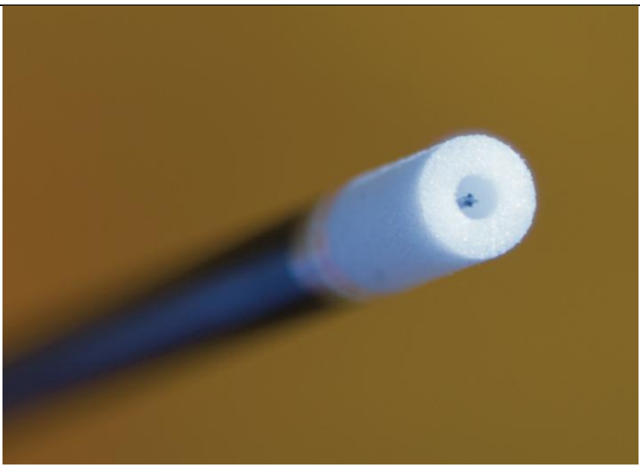
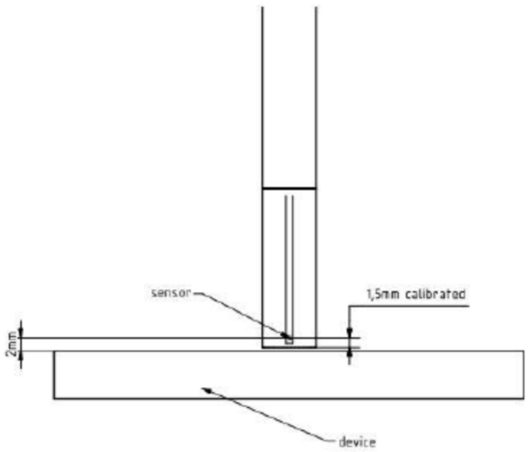


Fig 6.3 Photo of EUmmWave Probe



6.3 Data Acquisition Electronics (DAE)

The Data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bits AD-converter and a command decoder and 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 input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

Fig 6.4 Photo of DAE

6.4 Robot

The SPEAG DASY system uses the high precision robots (DASY6: TX60XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY6: CS8c) from Stäubliis used. The Stäublirobot series have many features that are important for our application:

- High precision (repeatability 0.02 mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; nobelt drives)
- Jerk-free straight movements
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)

Fig. 6.5 Photo of Robot

6.5 Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DAS 6: 400MHz, Intel Celeron), chip-disk (DASY6: 128 MB), RAM (DASY6: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bits 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 the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.

Fig. 6.6 Photo of Server for DASY6

6.6 Light Beam Unit

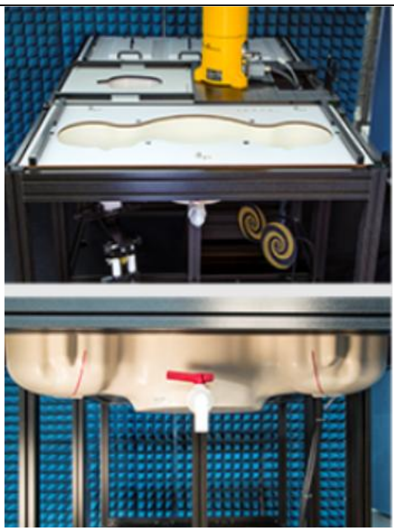
The light beam switch allows automatic "tooling" of the probe. During the process, the actual position of the probe tip with respect to the robot arm is measured, as well as the probe length and the horizontal probe offset. The software then corrects all movements, such that the robot coordinates are valid for the probe tip.

The repeatability of this process is better than 0.1 mm. If a position has been taught with an aligned probe, the same position will be reached with another aligned probe within 0.1 mm, even if the other probe has different dimensions. During probe rotations, the probe tip will keep its actual position.

Fig. 6.7 Photo of Light Beam

6.7 Phantom

<SAM Twin Phantom>

Shell Thickness	2 ± 0.2 mm (sagging: <1%) Center ear point: 6 ± 0.2 mm	 **Fig. 6.8 Photo of SAM Phantom**
Filling Volume Dimensions	Approx. 25 liters Length: 1000 mm; Width: 500 mm; Height: adjustable feet	
Measurement Areas	Left Head, Right Head, Flat phantom	

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections. A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters. On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

6.8 Data storage and Evaluation

- **Data Storage**

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files. The post-processing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verifications of the complete software setup even after the measurement and allows correction of erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type (e.g., [V/m], [mW/g]). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a non-lose media, will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

- **Data Evaluation**

The DASY post-processing software (SEMCAD) automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe Parameters:	- Sensitivity	$Norm_i$, a_{i0}, a_{i1}, a_{i2}
	- Conversion	$ConvF_i$
	- Diode compression point	dcp_i
Device Parameters:	- Frequency	f
	- Crest	cf
Media Parameters:	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY components. In the direct measuring mode of the multi-meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power.

The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

WithV_i = compensated signal of channel i, (i = x, y, z)
U_i= input signal of channel i, (i = x, y, z)
cf = crest factor of exciting field (DASY parameter)
dcp^i= diode compression point (DASY parameter)
From the compensated input signals, the primary field data for each channel can be evaluated:

E- Field Probes: $E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$

H-Field Probes: $H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$

WithV_i = compensated signal of channel i, (i = x, y, z)
$Norm_i$= senor sensitivity of channel i, (i = x, y, z), µV/ (V/m) ^{2}
ConvF = sensitivity enhancement in solution
a_{ij} = sensor sensitivity factors for H-field probes
f = carrier frequency (GHz)
E_i = electric field strength of channel i in V/m
Hi = magnetic field strength of channel i in A/m
The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

With SAR = local specific absorption rate in mW/g
Etot= total field strength in V/m
σ = conductivity in (mho/m) or (Siemens/m)
ρ= equipment tissue density in g/cm3
Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

6.9 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Num.	Calibration	
				Last Cal.	Due Date
SPEAG	2450MHz System Validation Kit	D2450V2	805	2024.10.22	2027.10.21
SPEAG	5000MHz System Validation Kit	D5GHzV2	1176	2024.10.22	2027.10.21
SPEAG	D6.5GHz System Validation Kit	D6.5GHzV2	1054	2021.11.01	2025.06.30
SPEAG	5G Verification Source	10GHz	1019	2023.12.03	2026.12.02
SPEAG	DOSIMETRIC ASSESSMENT SYSTEM Software	cDASY6	16.0.0.116	NCR	NCR
SPEAG	DOSIMETRIC ASSESSMENT SYSTEM Software	cDASY6 mmWave	V2.4.2.62	NCR	NCR
SPEAG	Dosimetric E-Field Probe	EX3DV4	3823	2024.11.11	2025.11.10
SPEAG	Dosimetric E-Field Probe	EX3DV4	7608	2025.03.20	2026.03.19
SPEAG	EUmmWave Probe	EUmmMV4	9602	2025.03.19	2026.03.18
SPEAG	Data Acquisition Electronics	DAE4	480	2024.11.11	2025.11.10
SPEAG	Data Acquisition Electronics	DAE4	1643	2025.03.21	2026.03.20
SPEAG	Dielectric Assessment KIT	DAK-3.5	1279	2025.03.18	2026.03.17
SPEAG	ELI V8.0 (20deg probe tilt)	QD OVA 004 Ax	N/A	NCR	NCR
SPEAG	ELI V8.0 (20deg probe tilt)	N/A	2181	NCR	NCR
SPEAG	mmWave	N/A	N/A	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR
R&S	Network Emulator	CMW500	165755	2025.01.06	2026.01.05
Agilent	Network Analyzer	E5071B	MY42404762	2025.01.06	2026.01.05
mini-circuits	Amplifier	ZHL-42W+	608501717	NCR	NCR
mini-circuits	Amplifier	ZVE-8G+	754401735	NA	NA
Agilent	Signal Generator	N5182B	MY53050509	2024.09.11	2025.09.10
Agilent	Power Senor	NRP8S	103215	2025.01.06	2026.01.05
Agilent	Power Meter	E4416A	MY45102093	2024.09.11	2025.09.10
Anritsu	Power Sensor	NRP8S	103240	2025.01.06	2026.01.05
Anritsu	Power Meter	E4418B	GB43318055	2025.01.06	2026.01.05
Agilent	Dual Directional Coupler	778D	50422	NA	NA
MCL	Attenuation	351-218-010	N/A	NA	NA
R&S	Spectrum Analyzer	N9030A	MY54170556	2024.09.18	2025.09.17
KTJ	Thermo meter	TA298	N/A	2024.11.20	2025.11.19

SPEAG	Tissue Simulating Liquids	HBBL600-10000V6	24H

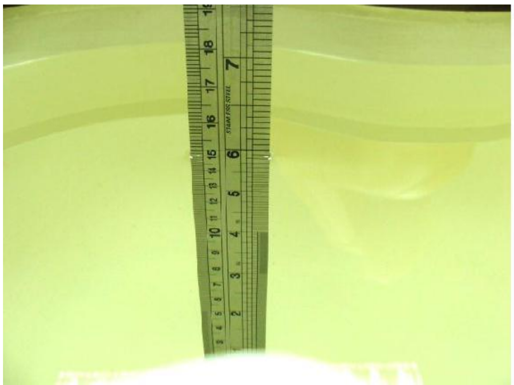
Note:

1. The calibration certificate of DASY can be referred to annex F of this report.
2. Referring to KDB 865664 D01v01r04, the dipole calibration interval can be extended to 3 years with justification. The dipoles are also not physically damaged, or repaired during the interval.
3. The Insertion Loss calibration of Dual Directional Coupler and Attenuator were characterized via the network analyzer and compensated during system check.
4. The dielectric probe kit was calibrated via the network analyzer, with the specified procedure (calibrated in pure water) and calibration kit (standard) short circuit, before the dielectric measurement. The specific procedure and calibration kit are provided by SPEAG.
5. In system check we need to monitor the level on the power meter, and adjust the power amplifier level to have precise power level to the dipole; the measured SAR will be normalized to 1 W input power according to the ratio of 1 W to the input power to the dipole. For system check, the calibration of the power amplifier is deemed not critically required for correct measurement; the power meter is critical and we do have calibration for it
6. Attenuator insertion loss is calibrated by the network Analyzer, which the calibration is valid, before system check.
7. N.C.R means No Calibration Requirement.

7 Tissue Simulating Liquids

➢ **Description of Tissue Simulation Liquids**

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. 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, which is shown in Fig. 7.1, for body SAR testing, the liquid height from the centre of the flat phantom to liquid top surface is larger than 15 cm, which is shown in Fig. 7.2.



. Fig 7.1 Photo of Liquid Height for Head SAR **Fig 7.2 Photo of Liquid Height for Body SAR**

➢ **Target Dielectric Properties of the Tissue-equivalent Liquid Material**

The relative permittivity and conductivity of the tissue material should be within ±5% of the values given in the table below recommended by the FCC OET 65 supplement C.

Frequency	Head Tissue Simulating Media	
(MHz)	ε_r (F/m)	σ (S/m)
6000	35.07	5.48
6500	34.46	6.07
7000	33.88	6.65

(ε r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3)

The dielectric parameters of liquids were verified prior to the SAR evaluation using a Speag Dielectric Probe Kit and an Agilent Network Analyzer.

The following table shows the measuring results for simulating liquid.

Table 1: Dielectric Performance of Tissue Simulating Liquid

Frequency (MHz)	Tissue Type	Liquid Temp. (℃)	Conductivity (σ)	Conductivity Target (σ)	Delta (σ) (%)	Limit (%)	Date
2450	HSL	22.3	1.815	1.80	0.83	±5	2025.4.26
5250	HSL	22.3	4.740	4.71	0.64	±5	2025.4.24
5600	HSL	22.4	5.041	5.07	-0.57	±5	2025.4.27
5750	HSL	22.2	5.180	5.22	-0.77	±5	2025.4.28
6500	HSL	22.1	6.110	6.07	0.66	±5	2025.4.30

Frequency (MHz)	Tissue Type	Liquid Temp. (℃)	Permittivity (εr)	Permittivity Target (εr)	Delta (εr) (%)	Limit (%)	Date
2450	HSL	22.3	38.774	39.20	-1.09	±5	2025.4.26
5250	HSL	22.3	35.135	35.95	-2.27	±5	2025.4.24
5600	HSL	22.4	34.550	35.50	-2.68	±5	2025.4.27
5750	HSL	22.2	34.920	35.35	-1.22	±5	2024.4.28
6500	HSL	22.1	34.500	34.46	0.12	±5	2025.4.30

Note:

According to April 2019 TCB Workshop that FCC has permitted the use of single head-tissue simulating liquid specified in IEC 62209-1 for all SAR tests.

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8 SAR System Verification

Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

8.1 SAR System Performance Check

➢ **System Validation**

According to FCC KDB 865664 D02, SAR system verification is required to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles are used with the required tissue-equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point must be validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media. A tabulated summary of the system validation status, measurement frequencies, SAR probes, calibrated signal type(s) and tissue dielectric parameters has been included.

➢ **Purpose of System Performance Check**

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

➢ **System Setup**

In the simplified setup for system evaluation, the EUT 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:

Fig 8.1 Photo of Dipole Setup

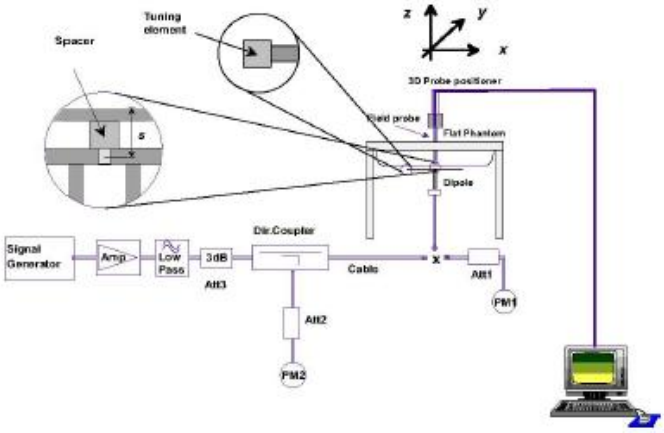

Fig 8.2 System Setup for System Evaluation

➢ System Verification Results

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10%. Below table shows the target SAR and measured SAR after normalized to 1 W input power. The table as below indicates the system performance check can meet the variation criterion and the plots can be referred to annex C of this report.

Frequency (MHz)	**Input Power (mW)**	**Dipole S/N**	**Probe S/N**	**DAE S/N**
2450	100	D2450V2-805	3823	480
5250	100	D5GHzV2-1176-5250	3823	480
5600	100	D5GHzV2-1176-5600	3823	480
5750	100	D5GHzV2-1176-5750	3823	480
6500	100	D6.5GHzV2-1054-6500	7608	1643

Frequency (MHz)	**Tissue Type**	**Conductivity (σ)**	**Permittivity (εr)**	**CW Signal Validation**		
				Sensitivity	**Probe Linearity**	**Probe Isotropy**
2450	HSL	1.863	38.85	PASS	PASS	PASS
5250	HSL	4.528	35.32	PASS	PASS	PASS
5600	HSL	4.905	34.89	PASS	PASS	PASS
5750	HSL	5.077	34.28	PASS	PASS	PASS
6500	HSL	6.07	34.46	PASS	PASS	PASS

Frequency (MHz)	Tissue Type	Conductivity (σ)	Permittivity (εr)	Modulation Signal Validation		
				Mod. Type	Duty Factor	PAR
2450	HSL	1.863	38.85	OFDM	PASS	PASS
5250	HSL	4.528	35.32	OFDM	N/A	PASS
5600	HSL	4.905	34.89	OFDM	N/A	PASS
5750	HSL	5.077	34.28	OFDM	N/A	PASS
6500	HSL	6.07	34.46	OFDM	N/A	PASS

<Validation Results>

Date	Freq. (MHz)	Tissue Type	Measured 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)
2025.4.26	2450	HSL	5.54	52.8	55.4	4.92
2025.4.24	5250	HSL	7.66	77.3	76.6	-0.91
2025.4.27	5600	HSL	8.27	82.4	82.7	0.36
2025.4.28	5750	HSL	8.3	77.2	83	7.51
2025.4.30	6500	HSL	31.4	288.	314	9.03

Date	Freq. (MHz)	Tissue Type	Measured 10g SAR (W/kg)	Targeted 10g SAR (W/kg)	Normalized 10g SAR (W/kg)	Deviation (%)
2025.4.26	2450	HSL	2.46	24.5	24.6	0.41
2025.4.24	5250	HSL	2.32	21.5	23.2	7.91
2025.4.27	5600	HSL	2.46	22.8	24.6	7.89
2025.4.28	5750	HSL	2.29	21.2	22.9	8.02
2025.4.30	6500	HSL	5.29	53.1	54.5	2.64

Note: System checks the specific test data please see annex C.

8.2 PD System Verification Source

➢ **General description**

The EUT is replaced by a calibrated source, the same spatial resolution, measurement region and test separation used in the calibration was applied to system check. Through visual inspection into the measured power density distribution, both the spatially (shape) and numerically (level) have no noticeable difference. The measurement results should be within ±10% of the calibrated targets.

Frequency [GHz]	Grid step	Grid extent X/Y [mm]	Measurement points
10	0.25 ($\frac{\lambda}{4}$)	120/120	16 × 16
30	0.25 ($\frac{\lambda}{4}$)	60/60	24 × 24
60	0.25 ($\frac{\lambda}{4}$)	32.5/32.5	26 × 26
90	0.25 ($\frac{\lambda}{4}$)	30/30	36 × 36

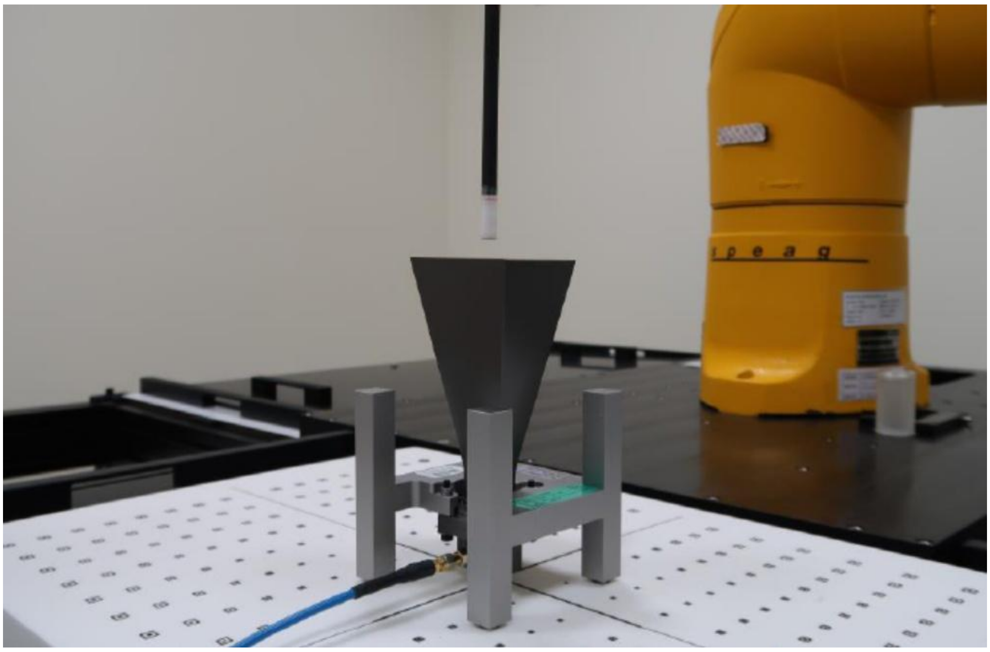

Fig 8.3 Photos of Verification Setup

➢ **Validation Results**

After system check testing, the results of power density will be compared with the reference value derived from the certificate report. The deviation of system check should be within ±10%.

<Validation Setup>

Frequency (GHz)	6.5G Verification Source	Probe S/N	DAE S/N
10	10GHz-SN 1019	9602	1643

<Validation Results>

Date	Frequency (GHz)	Test Distance (mm)	Measured 4cm (W/m^2)	Targeted 4cm (W/m^2)	Deviation (%)
2025.04.24	10	5.5	42.5	44.7	-4.9

Note: System checks the specific test data please see annex C.

9 EUT Test Position

➢ **Position defined of Laptop Computer**

Fig.9.1 shows an example of a laptop computer with antennas installed in the keyboard section. The location of each antenna is clearly shown. The required tests for each antenna for this configuration are:

- Antenna 1: Front edge and bottom side (1 g), Left edge and top side (10 g)
- Antenna 2: Front edge and bottom side (1 g), Right edge and top side (10 g)
- Antenna 3: Left edge (10 g), Bottom side (1 g)
- Antenna 4: Right edge (10 g), Bottom side (1 g)

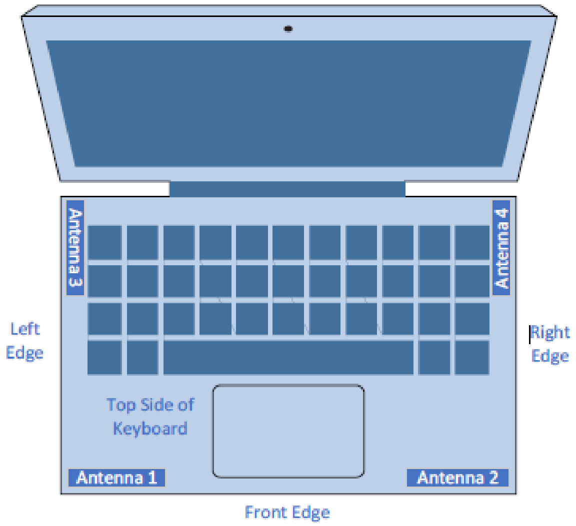

Fig.9.1 Example of a laptop computer showing locations of antennas in the keyboard section

It is recommended that all edges that may produce a higher SAR be evaluated along with the required bottom surface evaluation if the highest SAR exposure condition is unknown. Engineering judgement and best practices are to be employed to determine foreseeable use cases to determine which edges are to be evaluated along with the bottom surface.

- **Test Position**

According to KDB 616217 D04, SAR measurement is required for the bottom surface of the keyboard of the laptop PC and positioned 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.

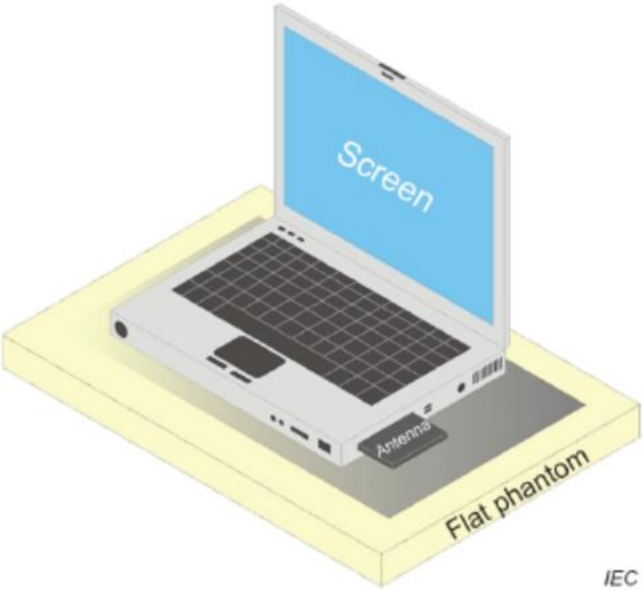

Fig.9.2 Illustration for Body Position

10 Measurement Procedures

The measurement procedures are as bellows:

<Conducted power measurement>

- For WWAN power measurement, use base station simulator to configure EUT WWAN transition in conducted connection with RF cable, at maximum power in each supported wireless interface and frequency band.
- Read the WWAN RF power level from the base station simulator.
- For WLAN/BT power measurement, use engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power in each supported wireless interface and frequency band.
- Connect EUT RF port through RF cable to the power meter or spectrum analyzer, and measure WLAN/BT output power.

<Conducted power measurement>

- Use base station simulator to configure EUT WWAN transmission in radiated connection, and engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power, in the highest power channel.
- Place the EUT in positions as annex B demonstrates.
- Set scan area, grid size and other setting on the DASY software.
- Measure SAR results for the highest power channel on each testing position.
- Find out the largest SAR result on these testing positions of each band.
- Measure SAR results for other channels in worst SAR testing position if the Reported SAR or highest power channel is larger than 0.8 W/kg.

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

- Power reference measurement.
- Area scan.
- Zoom scan.
- Power drift measurement.

10.1 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 10 g 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 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

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

10.2 Power Reference Measurement

The Power Reference Measurement and Power Drift Measurement are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

10.3 Area Scan Procedures

Area scans are defined prior to the measurement process being executed with a user defined variable spacing between each measurement point (integral) allowing low uncertainty measurements to be conducted. Scans defined for FCC applications utilize a $10mm^2$ step integral, with 1mm interpolation used to locate the peak SAR area used for zoom scan assessments.

When an Area Scan has measured all reachable points, it computes the field maxima found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing.

10.4 Zoom Scan Procedures

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. A density of 1000 kg/m^3 is used to represent the head and body tissue density and not the phantom liquid density, in order to be consistent with the definition of the liquid dielectric properties, i.e. the side length of the 1g cube is 10 mm, with the side length of the 10 g cube 21,5 mm. The zoom scan integer steps can be user defined so as to reduce uncertainty, but normal practice for typical test applications utilize a physical step of 5 x 5 x 7 (8 mm x 8 mm x 5 mm) providing a volume of 32 mm in the X & Y axis, and 30 mm in the Z axis.

10.5 SAR Averaged Methods

In DASY, the interpolation and extrapolation are both based on the modified Quadratic Sheppard'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 1g and 10g cubes, the extrapolation distance should not be larger than 5 mm.

10.6 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 drifts more than 5%, the SAR will be retested.

11 Power Density Measurement Procedure

➢ **Computation of the Electric Field Polarization Ellipse**

For the numerical description of an arbitrarily oriented ellipse in three-dimensional space, five parameters are needed: the semi-major axis (a), the semi-minor axis (b), two angles describing the orientation of the normal vector of the ellipse (ϕ ,θ), and one angle describing the tilt of the semi-major axis (Ψ). For the two extreme cases, i.e. circular and linear polarizations, three parameters only (a, ϕ and θ) are sufficient for the description of the incident field.

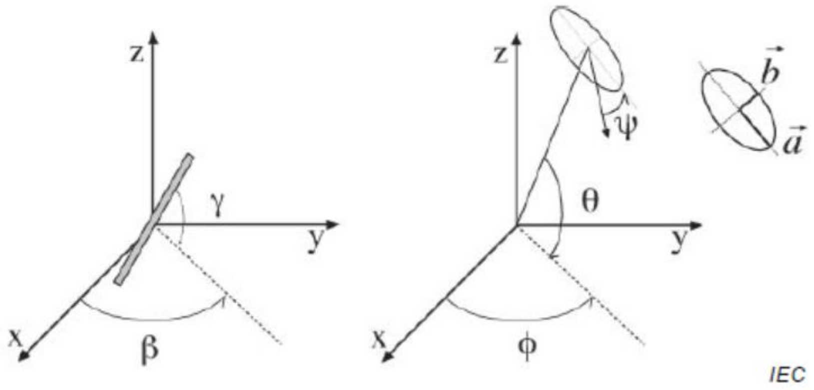

Fig 11.1 Illustration of the angles used for the numerical description of the sensor and the orientation of an ellipse in 3-D space

For the construction of the ellipse parameters from measured data, the problem can be reformulated as a nonlinear search problem. The semi-major and semi-minor axes of an elliptical field can be express as functions of the three angles (φ , θ and Ψ). The parameters can be uniquely determined towards minimizing the error based on least-squares for the given set of angles and the measured data. In this way, the numbers of three parameters is reduced from five to three, which means that least three sensors readings are necessary to gain sufficient information for the reconstruction of ellipse parameters. However, to suppress the noise and increase the reconstruction accuracy, it is desirable to have an over determined system of equations. The solution to use a probe consisting of two sensors angled byγ_1 and γ_2 toward the probe axis and to perform measurements at three angular positions of the probe, i.e. at
β_1, β_2 and β_3, results in over determination of two. If there is a need for more information or increased accuracy, more rotation angles can be added.

The reconstruction of ellipse parameters can be separated into linear and non-linear parts that are best solved by the givens algorithm combined with a downhill simplex algorithm. To minimize the mutual coupling, sensor angles are set with a 90° shift ($\gamma_1=\gamma_2+90°$), and, to simplify, the first rotation angle of the probe (β_1) can be set to 0°.

- **Total Field and Power Flux Density Reconstruction**

Computation of the power density in general requires knowledge of the electric and magnetic field amplitudes and phases in the plane of incidence. Reconstruction of these quantities from pseudo-vector E-field measurements is feasible, as they are constrained by Maxi well's equations. The SPEAG have developed a reconstruction approach based on the Gerchberg-Saxton algorithm, which benefits from the availability of the E-Field polarization ellipse information obtained with the EUmmWV2 probe. This reconstruction algorithm, together with the ability of the probe to measure extremely close to the source without perturbing the field, permits reconstruction of the E-field and H-field, as well as of the power density, on measurement planes located as near as λ /5 away.

- **Power Flux Density Averaging**

The average of the reconstructed power density is evaluated over a circular area in each measurement plane. The area of the circle is defined by the user; the default is 1cm2. The computed peak average value is displayed in the box at the top right. Note that the average is evaluated only for grid points where the averaging circle is completely filed with values; for points at the edge where the averaging circle is only partly filled with values, the average power density is set to zero. Two average power density values are computed.

12 Conducted Output Power

Remark: The conducted power of WLAN/Bluetooth was recorded in annex E.

13 Test Position Evaluation

➢ **Antenna Location**

The location of antenna was recorded in annex B	
Antenna	Support band
ANT1	TX & RX: WiFi 2.4GHz/5GHz/6GHz, Bluetooth
ANT2 (MAIN)	TX & RX: WiFi 2.4GHz/5GHz/6GHz

➢ **Body SAR Measurement Position**

Antenna	Bottom Surface	Front Edge	Bottom Edge	Left Edge	Right Edge
ANT1	Yes	Yes	No	No	No
ANT2 (MAIN)	Yes	Yes	No	No	No

14 RF Exposure Test Results

14.1 SAR Test Results

➢ **Test Guidance**

1. The reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
   a. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
   b. For SAR testing of WLAN signal with non-100% duty cycle, the measured SAR is scaled-up by the duty cycle scaling factor which is equal to "1 / (duty cycle)".
   c. For WLAN/Bluetooth: Reported SAR (W/kg) = Measured SAR (W/kg) * Duty Cycle scaling factor * Tune-up scaling factor.
2. Per KDB 447498 D01v06, for each exposure position, testing of other required channels within the operating mode of a frequency band is not required when the *reported* 1-g or 10-g SAR for the mid-band or highest output power channel is:
   a. ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
   b. ≤ 0.6 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
   c. ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz
3. Per KDB248227 D01v02r02, 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 required for operations in the U.S. 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. Unless it is permitted by specific KDB procedures or continuous transmission is specifically restricted by the device, the reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. When a device is not capable of sustaining continuous transmission or the output can become nonlinear, and it is limited by hardware design and unable to transmit at higher than 85% duty factor, a periodic duty factor within 15% of the maximum duty factor the device is capable of transmitting should be used. The reported SAR must be scaled to the maximum transmission duty factor to determine compliance. Descriptions of the procedures applied to establish the specific duty factor used for SAR testing are required in SAR reports to support the test results.

4. Evaluate SAR / APD with DASY6 Module SAR V16.0 or higher. The configurations to be tested are defined in the relevant Knowledge Database (KDB). The 4cm^2 psSAR and absorbed psPD are reported.

➢ **Body SAR Data**

Plot No.	Frequency Bands	Test Position	CH.	Ave. Power (dBm)	Tune-up Limit (dBm)	Tune-up Scaling Factor	Mea. SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)	Meas. APD (W/m^2)
ANT 1									
	WLAN 2.4GHz	Front Edge	1	16.15	17.00	1.216	0.870	1.058	N/A
	WLAN 2.4GHz	Bottom Surface	1	16.15	17.00	1.216	0.129	0.157	N/A
	WLAN 2.4GHz	Front Edge	6	15.83	16.50	1.167	0.803	0.937	N/A
	WLAN 2.4GHz	Front Edge	11	16.03	16.50	1.114	0.828	0.923	N/A
ANT 2									
	WLAN 2.4GHz	Front Edge	6	17.38	18.00	1.153	0.845	0.975	N/A
	WLAN 2.4GHz	Bottom Surface	6	17.38	18.00	1.153	0.170	0.196	N/A
	WLAN 2.4GHz	Front Edge	1	17.17	18.00	1.211	0.960	1.162	N/A
1#	WLAN 2.4GHz	Front Edge	11	17.31	18.00	1.172	1.000	1.172	N/A
ANT 1+2									
	WLAN 2.4GHz	Front Edge	3	16.09	16.50	1.099	0.463	0.509	N/A
	WLAN 2.4GHz	Bottom Surface	3	16.09	16.50	1.099	0.167	0.184	N/A
	WLAN 2.4GHz	Front Edge	6	15.96	16.50	1.132	0.421	0.477	N/A
	WLAN 2.4GHz	Front Edge	9	16.00	16.50	1.122	0.484	0.543	N/A
ANT 1									
	WLAN 5.2GHz	Front Edge	36	14.02	15.00	1.253	1.090	1.366	N/A
	WLAN 5.2GHz	Bottom Surface	36	14.02	15.00	1.253	0.289	0.362	N/A
	WLAN 5.2GHz	Front Edge	44	13.95	15.00	1.274	0.990	1.260	N/A
	WLAN 5.2GHz	Front Edge	48	13.92	15.00	1.282	1.030	1.321	N/A
ANT 2									
2#	WLAN 5.2GHz	Front Edge	42	9.94	10.50	1.138	1.290	1.468	N/A
	WLAN 5.2GHz	Bottom Surface	42	9.94	10.50	1.138	0.265	0.302	N/A
ANT 1+2									
	WLAN 5.2GHz	Front Edge	44	12.98	13.50	1.127	0.868	0.978	N/A
	WLAN 5.2GHz	Bottom Surface	44	12.98	13.50	1.127	0.163	0.184	N/A
	WLAN 5.2GHz	Front Edge	36	12.73	13.50	1.194	0.854	1.020	N/A
	WLAN 5.2GHz	Front Edge	48	12.33	13.50	1.309	1.030	1.348	N/A
ANT 1									
	WLAN 5.3GHz	Front Edge	64	15.23	15.50	1.064	1.261	1.342	N/A
	WLAN 5.3GHz	Bottom Surface	64	15.23	15.50	1.064	0.341	0.363	N/A

	WLAN 5.3GHz	Front Edge	52	14.91	15.00	1.021	1.256	1.282	N/A
3#	WLAN 5.3GHz	Front Edge	60	15.11	15.50	1.094	1.330	1.455	N/A
ANT 2									
	WLAN 5.3GHz	Front Edge	54	9.72	10.50	1.197	1.130	1.352	N/A
	WLAN 5.3GHz	Bottom Surface	54	9.72	10.50	1.197	0.202	0.242	N/A
	WLAN 5.3GHz	Front Edge	62	9.72	10.50	1.197	1.043	1.248	N/A
ANT 1+2									
	WLAN 5.3GHz	Front Edge	62	13.48	14.00	1.127	1.230	1.386	N/A
	WLAN 5.3GHz	Bottom Surface	62	13.48	14.00	1.127	0.201	0.227	N/A
	WLAN 5.3GHz	Front Edge	54	13.25	14.00	1.189	0.993	1.180	N/A
ANT 1									
	WLAN 5.5GHz	Front Edge	100	14.08	14.50	1.102	0.944	1.040	N/A
	WLAN 5.5GHz	Bottom Surface	100	14.08	14.50	1.102	0.139	0.153	N/A
	WLAN 5.5GHz	Front Edge	120	13.69	14.00	1.074	1.240	1.332	N/A
	WLAN 5.5GHz	Front Edge	140	13.81	14.00	1.045	1.141	1.192	N/A
ANT 2									
4#	WLAN 5.5GHz	Front Edge	114	11.65	12.00	1.084	1.270	1.377	N/A
	WLAN 5.5GHz	Bottom Surface	114	11.65	12.00	1.084	0.287	0.311	N/A
ANT 1+2									
	WLAN 5.5GHz	Front Edge	134	14.35	14.50	1.035	1.264	1.309	N/A
	WLAN 5.5GHz	Bottom Surface	134	14.35	14.50	1.035	0.325	0.336	N/A
	WLAN 5.5GHz	Front Edge	102	14.21	14.50	1.069	1.170	1.251	N/A
	WLAN 5.5GHz	Front Edge	118	14.26	14.50	1.057	1.277	1.349	N/A
ANT 1									
5#	WLAN 5.8GHz	Front Edge	159	13.90	14.50	1.148	1.270	1.458	N/A
	WLAN 5.8GHz	Bottom Surface	159	13.90	14.50	1.148	0.270	0.310	N/A
	WLAN 5.8GHz	Front Edge	151	13.56	14.50	1.242	1.155	1.434	N/A
ANT 2									
	WLAN 5.8GHz	Front Edge	159	11.12	11.50	1.091	1.320	1.441	N/A
	WLAN 5.8GHz	Bottom Surface	159	11.12	11.50	1.091	0.158	0.172	N/A
	WLAN 5.8GHz	Front Edge	151	10.96	11.00	1.009	0.843	0.851	N/A
ANT 1+2									
	WLAN 5.8GHz	Front Edge	151	13.90	14.50	1.148	1.240	1.424	N/A
	WLAN 5.8GHz	Bottom Surface	151	13.90	14.50	1.148	0.221	0.254	N/A
	WLAN 5.8GHz	Front Edge	159	13.84	14.00	1.038	1.064	1.104	N/A
ANT 1									
	WLAN 6.2GHz	Front Edge	15	10.27	11.00	1.183	0.237	0.280	1.3
	WLAN 6.2GHz	Bottom Surface	15	10.27	11.00	1.183	0.107	0.127	0.74

ANT 2									
6#	WLAN 6.2GHz	Front Edge	79	10.41	11.00	1.146	1.280	1.466	8.72
	WLAN 6.2GHz	Bottom Surface	79	10.41	11.00	1.146	0.276	0.316	1.25
	WLAN 6.2GHz	Front Edge	15	10.12	10.50	1.091	1.070	1.168	7.51
	WLAN 6.2GHz	Front Edge	47	10.26	11.00	1.186	1.150	1.364	7.82
ANT 1+2									
	WLAN 6.2GHz	Front Edge	79	17.94	18.50	1.138	1.230	1.399	8.17
	WLAN 6.2GHz	Bottom Surface	79	17.94	18.50	1.138	0.364	0.414	1.28
ANT 1									
	WLAN 6.5GHz	Front Edge	111	9.78	10.50	1.180	0.576	0.68	2.66
	WLAN 6.5GHz	Bottom Surface	111	9.78	10.50	1.180	0.192	0.227	1.12
ANT 2									
7#	WLAN 6.5GHz	Front Edge	111	10.69	11.00	1.074	1.350	1.45	9.21
	WLAN 6.5GHz	Bottom Surface	111	10.69	11.00	1.074	0.579	0.622	1.713
ANT 1+2									
	WLAN 6.5GHz	Front Edge	111	17.60	18.00	1.096	1.280	1.403	8.74
	WLAN 6.5GHz	Bottom Surface	111	17.60	18.00	1.096	0.457	0.501	1.83
ANT 1									
	WLAN 6.7GHz	Front Edge	143	9.72	10.50	1.197	0.396	0.474	1.95
	WLAN 6.7GHz	Bottom Surface	143	9.72	10.50	1.197	0.159	0.19	1.12
ANT 2									
	WLAN 6.7GHz	Front Edge	143	10.52	11.00	1.117	0.604	0.675	4.02
	WLAN 6.7GHz	Bottom Surface	143	10.52	11.00	1.117	0.183	0.204	1.01
ANT 1+2									
8#	WLAN 6.7GHz	Front Edge	143	18.01	18.50	1.119	0.630	0.705	4.25
	WLAN 6.7GHz	Bottom Surface	143	18.01	18.50	1.119	0.282	0.316	1.59
ANT 1									
	WLAN 7.0GHz	Front Edge	207	9.37	10.00	1.156	0.415	0.48	2.12
	WLAN 7.0GHz	Bottom Surface	207	9.37	10.00	1.156	0.180	0.208	0.651
ANT 2									
9#	WLAN 7.0GHz	Front Edge	207	10.56	11.00	1.107	1.200	1.328	8.87
	WLAN 7.0GHz	Bottom Surface	207	10.56	11.00	1.107	0.409	0.453	2.93
ANT 1+2									
	WLAN 7.0GHz	Front Edge	207	17.12	17.50	1.091	0.521	0.569	2.26
	WLAN 7.0GHz	Bottom Surface	207	17.12	17.50	1.091	0.146	0.159	0.92
ANT 1									
10#	Bluetooth/DH5	Front Edge	78	7.39	8.00	1.151	0.148	0.17	N/A
	Bluetooth/DH5	Bottom Surface	78	7.39	8.00	1.151	0.114	0.131	N/A

Note:

1. Per KDB 447498 D01v06, for each exposure position, if the highest output channel Reported SAR ≤ 0.8 W/kg, other channels SAR testing is not necessary.
2. Additional WLAN SAR testing was performed for simultaneous transmission analysis.
3. Per KDB 865664 D01v01r04, for each frequency band, repeated SAR measurement is required when the measured SAR is ≥0.8W/kg.
4. According to KDB 865664 D02v01r02, SAR plot is required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination.
5. The WLAN Reported 1g SAR (W/kg) has been calculated together with the duty cycle scaling factor 1.023.
6. There is a protrusion less than 5 mm on the bottom of this device, the 0 mm distance with its thickness was tested and maximum scaled SAR is less than 1.2 W/kg on 1-g.
7. The EUT was directly contact the phantom under SAR measurement.

14.2 Repeated SAR Assessment

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz. 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.

1. Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg;
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 (~ 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.

➢ **Repeated SAR Data**

Plot No.	Band/Mode	Test Position	CH.	Ave. Power (dBm)	Tune-up Limit (dBm)	Tune-up Scaling Factor	Mea. SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
ANT 2								
OR.	WLAN 2.4GHz	Front Edge	11	17.31	18.00	1.172	1.000	1.172
1st	WLAN 2.4GHz	Front Edge	11	17.31	18.00	1.172	0.981	1.150
ANT 1								
OR.	WLAN 5.2GHz	Front Edge	36	14.02	15.00	1.253	1.090	1.366
1st	WLAN 5.2GHz	Front Edge	36	14.02	15.00	1.253	0.985	1.234
ANT 2								
OR.	WLAN 5.2GHz	Front Edge	42	9.94	10.50	1.138	1.290	1.468
1st	WLAN 5.2GHz	Front Edge	42	9.94	10.50	1.138	1.120	1.274
ANT 1 + ANT 2								
OR.	WLAN 5.2GHz	Front Edge	48	12.33	13.50	1.309	1.030	1.348
1st	WLAN 5.2GHz	Front Edge	48	12.33	13.50	1.309	0.983	1.287
ANT 1								
OR.	WLAN 5.3GHz	Front Edge	60	15.11	15.50	1.094	1.330	1.455
1st	WLAN 5.3GHz	Front Edge	60	15.11	15.50	1.094	1.240	1.357
ANT 2								

OR.	WLAN 5.3GHz	Front Edge	54	9.72	10.50	1.197	1.130	1.352
1st	WLAN 5.3GHz	Front Edge	54	9.72	10.50	1.197	1.020	1.221
ANT 1 + ANT 2								
OR.	WLAN 5.3GHz	Front Edge	62	13.48	14.00	1.127	1.230	1.386
1st	WLAN 5.3GHz	Front Edge	62	13.48	14.00	1.127	1.085	1.223
ANT 1								
OR.	WLAN 5.5GHz	Front Edge	120	13.69	14.00	1.074	1.240	1.332
1st	WLAN 5.5GHz	Front Edge	120	13.69	14.00	1.074	1.130	1.214
ANT 2								
OR.	WLAN 5.5GHz	Front Edge	114	11.65	12.00	1.084	1.270	1.377
1st	WLAN 5.5GHz	Front Edge	114	11.65	12.00	1.084	1.120	1.214
ANT 1 + ANT 2								
OR.	WLAN 5.5GHz	Front Edge	118	14.26	14.50	1.057	1.277	1.349
1st	WLAN 5.5GHz	Front Edge	118	14.26	14.50	1.057	1.080	1.141
ANT 1								
OR.	WLAN 5.8GHz	Front Edge	159	13.90	14.50	1.148	1.270	1.458
1st	WLAN 5.8GHz	Front Edge	159	13.90	14.50	1.148	1.120	1.286
ANT 2								
OR.	WLAN 5.8GHz	Front Edge	159	11.12	11.50	1.091	1.320	1.441
1st	WLAN 5.8GHz	Front Edge	159	11.12	11.50	1.091	1.170	1.277
ANT 1 + ANT 2								
OR.	WLAN 5.8GHz	Front Edge	151	13.90	14.50	1.148	1.240	1.424
1st	WLAN 5.8GHz	Front Edge	151	13.90	14.50	1.148	1.090	1.251

14.3 PD Test Results

- **General Note**

1. The reported PD is the measured Total PD value adjusted for maximum tune-up tolerance.
   d. Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
   e. For PD testing of WLAN signal with non-100% duty cycle, the measured PD is scaled-up by the duty cycle scaling factor which is equal to "1 / (duty cycle)".
   f. For WLAN: Reported PD (W/m^2)= Measured Total PD (W/m^2)* Duty Cycle scaling factor * Tune-up scaling factor.
2. According to the equipment user manual that the most conservative test distance of 2 mm was applied to PD measurement and the REC (field reconstruction) component of the uncertainty budget for a given E-field is valid only for d ≥λ / 5mm.
3. According to TCBC workshop in April 2021 that in addition to tune-up tolerance scaling, adjust measured results per amount that measurement uncertainty exceeds 30% (e.g. per methods of IEC 62479:2010). Total expanded uncertainty of 1.51 dB which was converted to 41.6% was used to determining the psPD measurement scaling factor.
4. The duty cycle scaling factor of 1.023 should be calculated the final power density.
5. According to TCBC workshop in October 2018 that $4cm^2$ averaging area may now be considered.
6. RF exposure compliance with PD is demonstrated for various radio configurations using below equation:

   *Final PD = Mea. $psPD_{tot+}$ * tune-up factor * duty cycle factor * Uncertainty Factor*

   Where Uncertainty factor = 1 + (| 1- $10^{1.51/10}$ * 100% | – 30%)
7. The final psPD should be scaled to the uncertainty factor of 1.12.
8. The measurement procedure consists of measuring the PDinc at two different distances: d=2mm (compliance distance) and d=λ /5. The same grid extents and grid steps should be used for both measurements. The grid extents should be large enough to fully capture the transmitted energy. The grid step should be fine enough to demonstrate that the integrated Power Density iPDn varies by less than 1 dB between the d=2mm and d=λ /5 measurements. We recommend using as first approximation a grid step L_{grid} that is a function of the distance to the transmitting structure and not larger than:

$$l_{grid} = \begin{cases} 1.25d & for\, d < \lambda/5 \\ \lambda/4 & for\, d \geq \lambda/5 \end{cases}$$

PD Test Results

Plot No.	Frequency Bands	Exposure Position	Gap (mm)	Ch.	Grip Step (λ)	iPDn (W/m²)	iPDn Ratio (<1dB)	Total psPDtot+ (W/m²)
Antenna 1								
	WLAN 6.2GHz	Bottom Surface	2	15	0.0625	0.172	0.508	0.377
	WLAN 6.2GHz	Bottom Surface	10	15	0.0625	0.153		0.11
Antenna 2								
	WLAN 6.2GHz	Bottom Surface	2	79	0.0625	0.39	0.819	1.03
	WLAN 6.2GHz	Bottom Surface	10	79	0.0625	0.323		0.563

Plot No.	Frequency Bands	Exposure Position	Ch.	Ave. Power (dBm)	Tune-up Limit (dBm)	Tune-up Scaling Factor	psPDtot+ over 4cm² (W/m²)	
							Mea.	Scaled
Antenna 1								
	WLAN 6.2GHz	Front Edge	15	10.27	11.00	1.183	1.53	2.027
	WLAN 6.2GHz	Bottom Surface	15	10.27	11.00	1.183	0.377	0.5
Antenna 2								
	WLAN 6.2GHz	Front Edge	79	10.41	11.50	1.285	3.31	4.765
	WLAN 6.2GHz	Bottom Surface	79	10.41	11.50	1.285	1.03	1.483
Antenna 1+2								
11#	WLAN 6.2GHz	Front Edge	79	17.94	19.00	1.276	3.49	4.989
	WLAN 6.2GHz	Bottom Surface	79	17.94	19.00	1.276	1.07	1.53
Antenna 1								
	WLAN 6.5GHz	Front Edge	111	9.78	10.50	1.180	1.8	2.38
	WLAN 6.5GHz	Bottom Surface	111	9.78	10.50	1.180	0.351	0.464
Antenna 2								
	WLAN 6.5GHz	Front Edge	111	10.69	11.50	1.205	3.58	4.832
	WLAN 6.5GHz	Bottom Surface	111	10.69	11.50	1.205	1.37	1.849
Antenna 1+2								
12#	WLAN 6.5GHz	Front Edge	111	17.60	18.00	1.096	3.52	4.323
	WLAN 6.5GHz	Bottom Surface	111	17.60	18.00	1.096	1.65	2.026
Antenna 1								
	WLAN 6.7GHz	Front Edge	143	9.72	10.50	1.197	0.159	0.213
	WLAN 6.7GHz	Bottom Surface	143	9.72	10.50	1.197	0.185	0.248
Antenna 2								
13#	WLAN 6.7GHz	Front Edge	143	10.52	11.50	1.253	2.16	3.032
	WLAN 6.7GHz	Bottom Surface	143	10.52	11.50	1.253	0.483	0.678

Antenna 1+2								
	WLAN 6.7GHz	Front Edge	143	18.01	19.00	1.256	1.72	2.42
	WLAN 6.7GHz	Bottom Surface	143	18.01	19.00	1.256	0.093	0.131
Antenna 1								
	WLAN 7.0GHz	Front Edge	10	9.37	10	1.156	1.93	2.499
	WLAN 7.0GHz	Bottom Surface	10	9.37	10	1.156	0.604	0.782
Antenna 2								
14#	WLAN 7.0GHz	Front Edge	10	10.56	11.50	1.242	4.09	5.688
	WLAN 7.0GHz	Bottom Surface	10	10.56	11.50	1.242	1.13	1.571
Antenna 1+2								
	WLAN 7.0GHz	Front Edge	10	17.12	18.00	1.225	3.320	4.554
	WLAN 7.0GHz	Bottom Surface	10	17.12	18.00	1.225	1.120	1.536

14.4 Validated Test Results

Plot No.	Frequency Bands	Test Position	CH.	Ave. Power (dBm)	Tune-up Limit (dBm)	Tune-up Scaling Factor	Mea. SAR_{1g} (W/kg)	Reported SAR_{1g} (W/kg)
ANT 2								
OR.	WLAN 5.2GHz	Front Edge	42	9.94	10.50	1.138	1.290	1.468
1st	WLAN 5.2GHz	Front Edge	42	9.94	10.50	1.138	0.832	0.947

15 Simultaneous Transmission Analysis

Remark: This product does not support simultaneous transmission, so the simultaneous transmission evaluation is not required.

16 Measurement Uncertainty

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A Type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in below Table.

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor	1/k(b)	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

Error Description	Uncertainty (±dB)	Probability Distribution	Divisor	*ci*	Standard Uncertainty (±dB)	ν_i or ν_{eff}
Uncertainty terms dependent on the measurement system						
Probe calibration	0.49	N	1	1	0.49	∞
Probe correction	0	R	1.732	1	0	∞
Frequency response	0.20	R	1.732	1	0.12	∞
Sensor cross coupling	0	R	1.732	1	0	∞
Isotropy	0.50	R	1.732	1	0.29	∞
Linearity	0.20	R	1.732	1	0.12	∞
Probe scattering	0	R	1.732	1	0	∞
Probe positioning offset	0.30	R	1.732	1	0.17	∞
Probe positioning repeatability	0.04	R	1.732	1	0.02	∞
Sensor mechanical offset	0	R	1.732	1	0	∞
Probe spatial resolution	0	R	1.732	1	0	∞
Field impedance dependance	0	R	1.732	1	0	∞
Amplitude and phase drift	0	R	1.732	1	0	∞
Amplitude and phase noise	0.04	R	1.732	1	0.02	∞
Measurement area truncation	0	R	1.732	1	0	∞
Data acquisition	0.03	R	1.732	1	0.03	∞
Sampling	0	R	1.732	1	0	∞
Field reconstruction	2.0	R	1.732	1	1.15	∞
Forward transformation	0	R	1.732	1	0	∞
Power density scaling	-	R	1.732	1	-	∞
Spatial averaging	0.10	R	1.732	1	0.06	∞
System Detection Limits	0.04	R	1.732	1	0.02	∞
Uncertainty terms dependent on the DUT and environmental factors						
Probe coupling with DUT	0	R	1.732	1	0	∞
Modulation response	0.40	R	1.732	1	0.23	∞
Integration time	0	R	1.732	1	0	∞
Response time	0	R	1.732	1	0	∞
Device holder influence	0.10	R	1.732	1	0.06	∞
DUT alignment	0	R	1.732	1	0	∞
RF ambient	0.04	R	1.732	1	0.02	∞
Ambient reflections	0.04	R	1.732	1	0.02	∞
Immunity / secondary reception	0	R	1.732	1	0	∞
Drift of the DUT	-	R	1.732	1	-	∞
Combined standard uncertainty					0.75 dB	∞
Coverage Factor for 95%					K=2	N/A
Expanded standard uncertainty					1.51 dB	

PD Uncertainty Budget for Frequency Range 6 – 10GHz

17 Measurement Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of FCC, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested. Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

Annex A General Information

1. Identification of the Responsible Testing Laboratory

Laboratory Name:	Shenzhen Morlab Communications Technology Co., Ltd.
Laboratory Address:	FL.1-3, Building A, FeiYang Science Park, No.8 LongChang Road, Block 67, BaoAn District, ShenZhen, GuangDong Province, P. R. China
Telephone:	+86 755 36698555
Facsimile:	+86 755 36698525

2. Identification of the Responsible Testing Location

Name:	Shenzhen Morlab Communications Technology Co., Ltd.
Address:	FL.1-3, Building A, FeiYang Science Park, No.8 LongChang Road, Block 67, BaoAn District, ShenZhen, GuangDong Province, P. R. China

3. Facilities and Accreditations

The FCC designation number is CN1192, the test firm registration number is 226174.

Note：

The main report is end here and the other annex (B,C,D,E,F) will be submitted separately.

****** END OF MAIN REPORT ******