

# TEST REPORT

Report No.: BCTC2412364163E

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Applicant: Imagineear Ltd

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Product Name: Media player

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Test Model: XP4

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Tested Date: 2024-10-16 to 2024-12-23

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Issued Date: 2024-12-23

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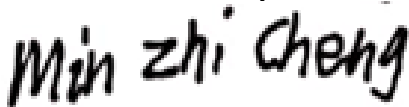
**Shenzhen BCTC Testing Co., Ltd.**



## FCC ID:2ASPC-XP4

Product Name: Media player  
Trademark: N/A  
Model/Type Ref.: XP4  
Applicant: Imagineear Ltd  
Address: The Blomfield Rooms, Fulham Palace, Bishop's Avenue, London SW6 6EA, United Kingdom  
Manufacturer: Chempros Limited  
Address: Unit 2312, Eastern Tower, Coastal Era Building, Nanshan, Shenzhen, CHINA, 518051  
Prepared By: Shenzhen BCTC Testing Co., Ltd.  
Address: 1-2/F., Building B, Pengzhou Industrial Park, No.158, Fuyuan 1st Road, Zhanche ng , Fuhai Subdistrict, Bao'an District, Shenzhen, Guangdong, China  
Sample Received Date: 2024-10-16  
Sample tested Date: 2024-10-16 to 2024-12-23  
Issue Date: 2024-12-23  
Test Standards: IEEE Std C95.1-2019  
IEEE Std 1528-2013  
FCC Part 2.1093  
Test Results: PASS  
Remark: This is SAR test report

Tested by:



Min Zhi Cheng/ Project Handler

Approved by:



Zero Zhou/Reviewer

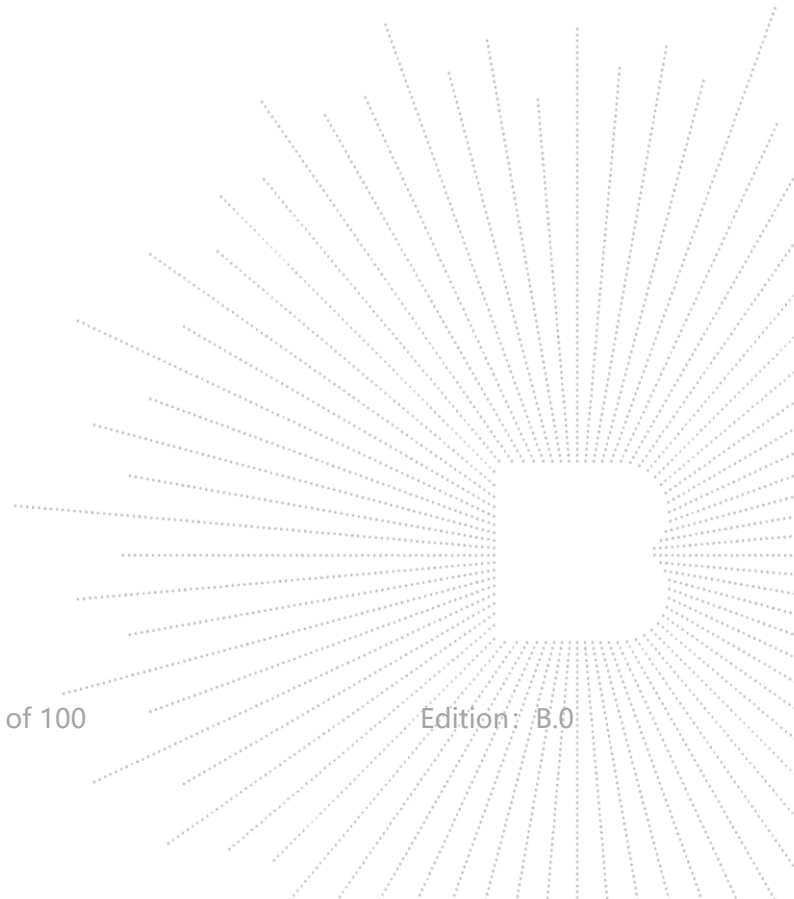
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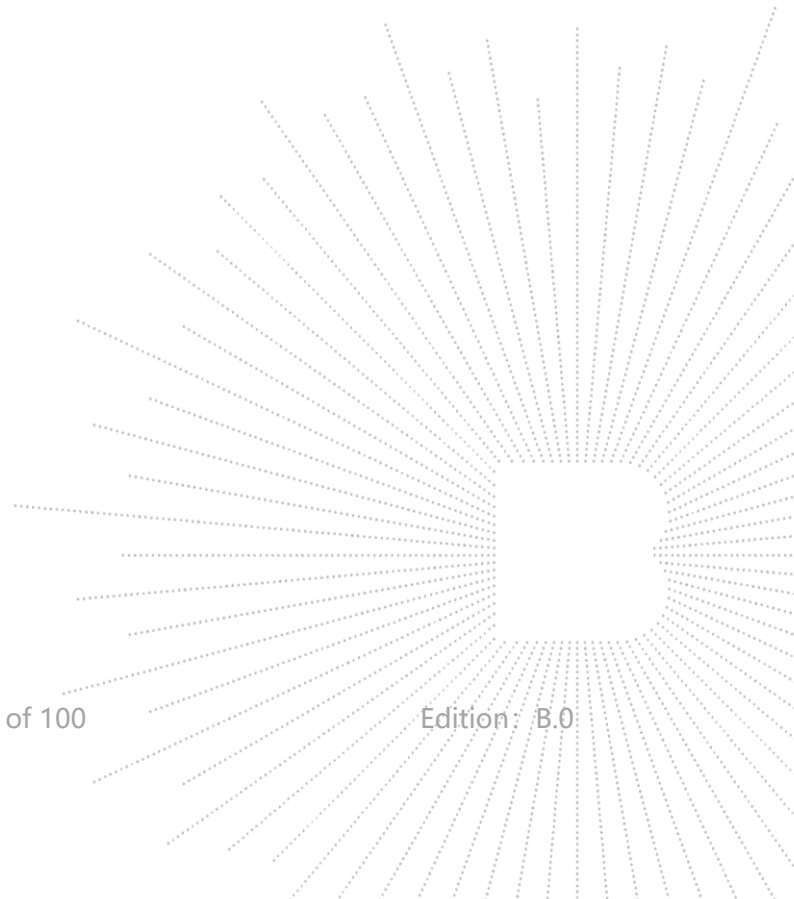
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(Note: N/A Means Not Applicable)



**1. Version**

Report No.	Issue Date	Description	Approved
BCTC2412364163E	2024-12-23	Original	Valid



## 2. Test Standards

IEEE Std C95.1-2019: IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz. It specifies the maximum exposure limit of 1.6 W/kg as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

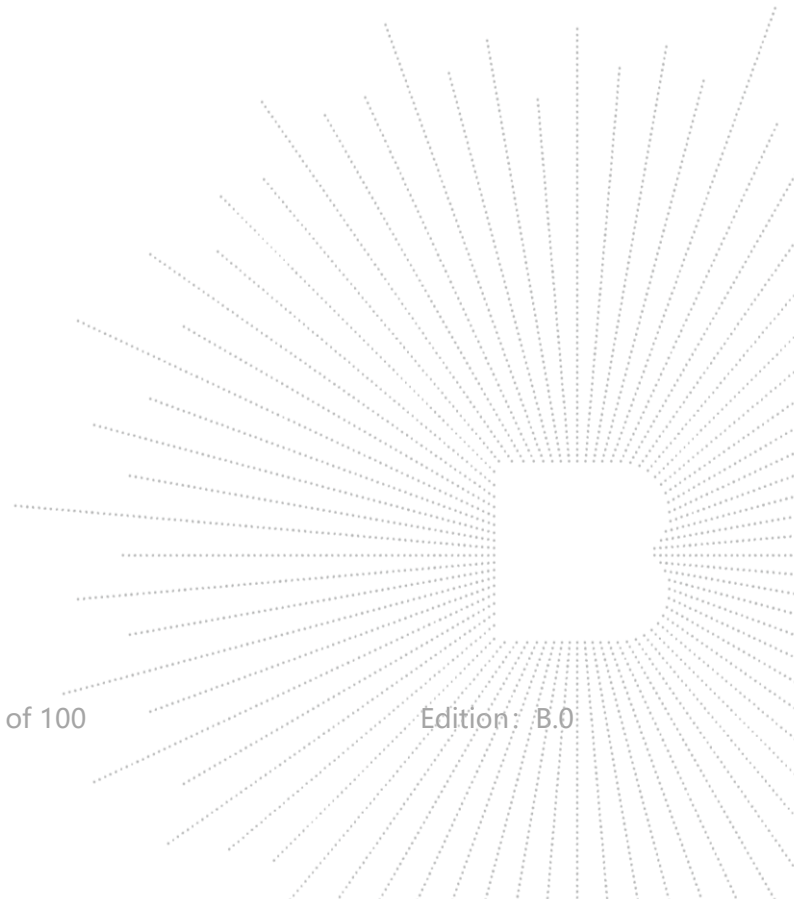
IEEE Std 1528-2013: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

FCC Part 2.1093 Radiofrequency Radiation Exposure Evaluation: Portable Devices

KDB 447498 D01 General RF Exposure Guidance v06: Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies

KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz

KDB 865664 D02 RF Exposure Reporting v01r02: RF Exposure Compliance Reporting and Documentation Considerations

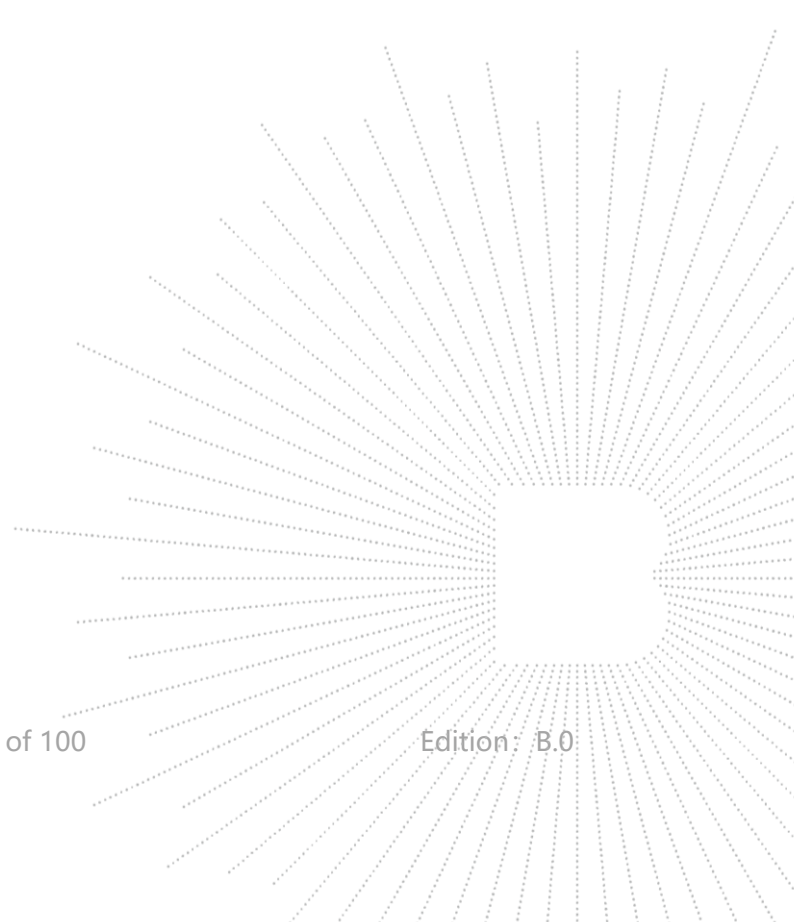


### 3. Test Summary

The maximum results of Specific Absorption Rate (SAR) have found during testing are as follows:

Frequency Band	Report SAR <sub>1g</sub> (W/kg)	SAR <sub>1g</sub> Limit (W/kg)
	Body (0mm Gap)	
FSK	0.001	1.6
Bluetooth	0.047	1.6
WIFI 2.4G	0.561	1.6
WIFI 5.2G	0.710	1.6
WIFI 5.3G	0.290	1.6
WIFI 5.6G	0.313	1.6
WIFI 5.8G	0.458	1.6
Simultaneous Transmission	0.711	1.6

The device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-2019, and had been tested in accordance with the measurement methods and procedure specified in IEEE 1528-2013.

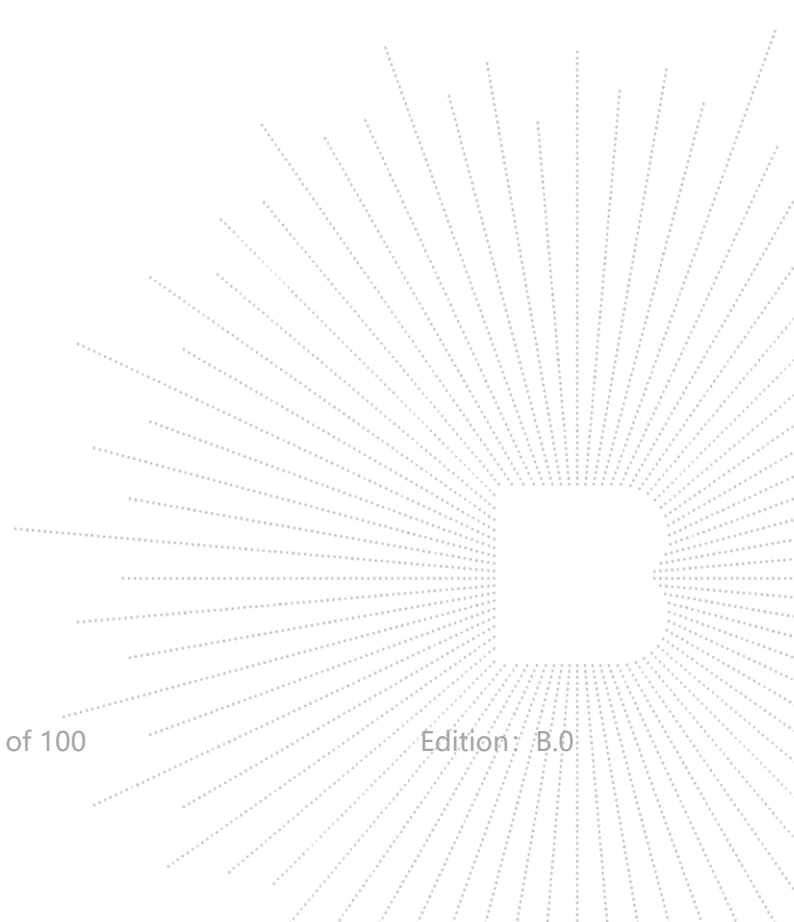


#### 4. SAR Limits

EXPOSURE LIMITS	FCC Limit (1g Tissue)	
	SAR (W/kg)	
	(General Population / Uncontrolled Exposure Environment)	(Occupational / Controlled Exposure Environment)
Spatial Average(averaged over the whole body)	0.08	0.4
Spatial Peak(averaged over any 1 g of tissue)	1.6	8.0
Spatial Peak(hands/wrists/ feet/anklesaveraged over 10 g)	4.0	20.0

Population/Uncontrolled Environments are defined as locations where there is the exposure of individual who have no knowledge or control of their exposure.

Occupational/Controlled 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).

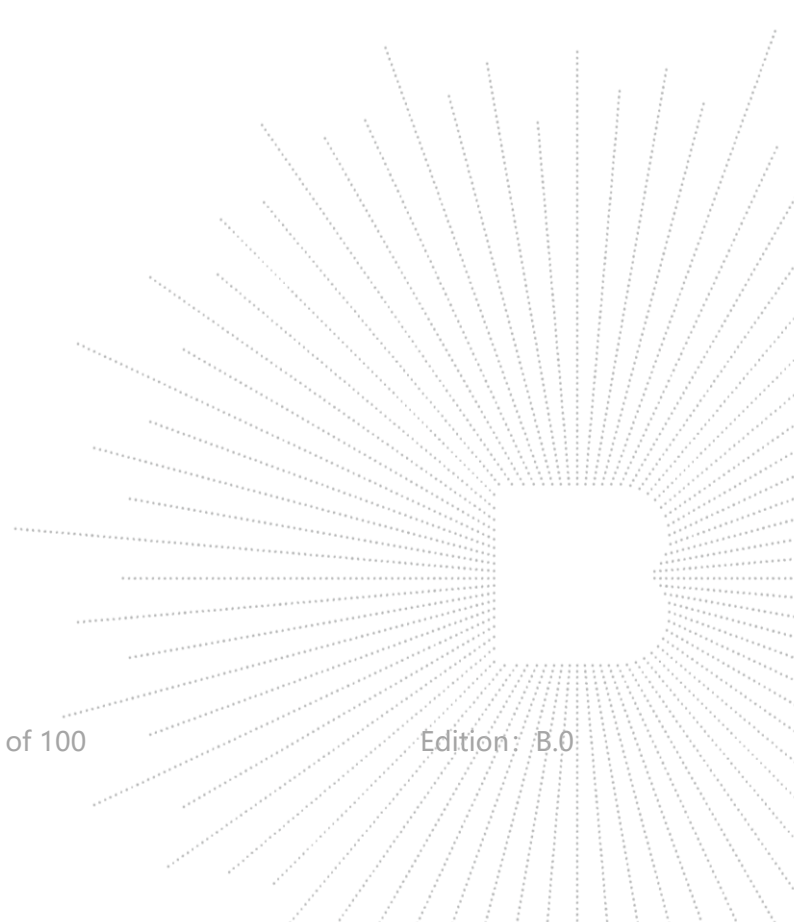




## 5. Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is  $< 1.5$  W/kg and the measured 10-g SAR within a frequency band is  $< 3.75$  W/kg. The expanded SAR measurement uncertainty must be  $\leq 30\%$ , for a confidence interval of  $k=2$ . If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.



## 6. Product Information and Test Setup

### 6.1 Product Information

Model/Type reference:	XP4
Model differences:	N/A
Hardware Version:	N/A
Software Version:	N/A
power supply:	DC 5V, 1.3A
Battery:	DC 3.7 V, 2200 mAh

#### Bluetooth

Operation Frequency:	Bluetooth: 2402-2480MHz
Type of Modulation:	Bluetooth: GFSK, $\pi/4$ DQPSK, 8DPSK
Number Of Channel	79CH
Antenna installation:	Internal antenna
Antenna Gain:	-0.51dBi
Remark:	The antenna gain of the product comes from the antenna report provided by the customer, and the test data is affected by the customer information.

#### BLE

<b>Operation Frequency:</b>	Bluetooth: 2402-2480MHz
<b>Type of Modulation:</b>	Bluetooth: GFSK, 1Mbps, 2Mbps
<b>Number Of Channel:</b>	40channel
<b>Antenna installation:</b>	Internal antenna
<b>Antenna Gain:</b>	-0.51dBi
<b>Remark:</b>	The antenna gain of the product comes from the antenna report provided by the customer, and the test data is affected by the customer information.

#### FSK

<b>Operation Frequency:</b>	2402-2480MHz
<b>Type of Modulation:</b>	GFSK
<b>Number Of Channel</b>	40channel
<b>Antenna installation:</b>	Internal antenna
<b>Antenna Gain:</b>	0.34dBi

## WIFI 2.4G

IEEE 802.11 WLAN Mode Supported	802.11b 802.11g 802.11n(20MHz channel bandwidth)
Operation Frequency:	802.11b/g/n 20MHz:2412~2462 MHz
Type of Modulation:	DSSS with DBPSK/DQPSK/CCK for 802.11b; OFDM with BPSK/QPSK/16QAM/64QAM for 802.11g/n
Number Of Channel:	11 channels for 802.11b/g/n(HT20);
Antenna installation:	Internal antenna
Antenna Gain:	-0.51dBi
Remark:	The antenna gain of the product comes from the antenna report provided by the customer, and the test data is affected by the customer information.

IEEE 802.11 WLAN Mode Supported:	802.11a/n/ac (20MHz channel bandwidth) 802.11n/ac (40MHz channel bandwidth) 802.11ac (80MHz channel bandwidth)
Operation Frequency:	5180-5240MHz for 802.11a/n/ac(HT20); 5190-5230MHz for 802.11n/ac(HT40); 5210MHz for 802.11 ac80; 5260-5320MHz for 802.11a/n/ac(HT20); 5270-5310MHz for 802.11n/ac(HT40); 5290MHz for 802.11 ac80; 5500-5700MHz for 802.11a/n/ac(HT20); 5510-5670MHz for 802.11n/ac(HT40); 5530MHz for 802.11 ac80; 5745-5825 MHz for 802.11a/n/ac(HT20); 5755-5795 MHz for 802.11n/ac(HT40); 5775MHz for 802.11 ac80
Data Rate:	802.11a: 6,9,12,18,24,36,48,54Mbps; 802.11n(HT20/HT40):MCS0-MCS15; 802.11ac(VHT20): NSS1, MCS0-MCS8 802.11ac(VHT40/VHT80):NSS1, MCS0-MCS9
Type of Modulation:	OFDM with BPSK/QPSK/16QAM/64QAM/256QAM for 802.11a/n/ac;
Antenna installation:	Internal antenna
Antenna Gain:	-8.29dBi
Remark:	The antenna gain of the product is provided by the customer, and the test data is affected by the customer information.

## 6.2 Test Setup Configuration

See test photographs attached in EUT TEST SETUP PHOTOGRAPHS for the actual connections between Product and support equipment.

## 6.3 Support Equipment

Cable of Product

No.	Cable Type	Quantity	Provider	Length (m)	Shielded	Note
1	--	--	Applicant	---	Yes/No	--
2	--	--	BCTC	--	Yes/No	--

No.	Device Type	Brand	Model	Series No.	Note
1.	---	---	---	---	---
2.	--	--	--	--	--

Notes:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

## 6.4 Test Environment

1. Normal Test Conditions:

Humidity(%):	35-75
Atmospheric Pressure(kPa):	95-105
Temperature(°C):	18-25

2. Extreme Test Conditions:

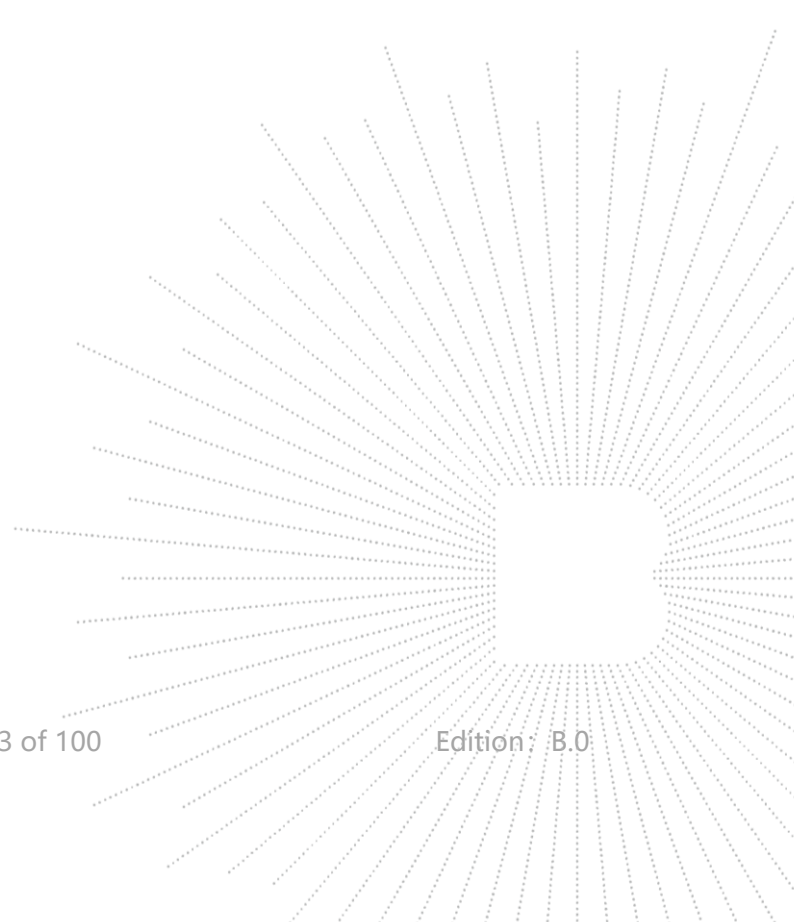
N/A

## 7. Test Facility and Test Instrument Used

### 7.1 Test Facility

All measurement facilities used to collect the measurement data are located at Shenzhen BCTC Testing Co., Ltd. Address: 1-2/F., Building B, Pengzhou Industrial Park, No.158, Fuyuan 1st Road, Zhancheng, Fuhai Subdistrict, Bao'an District, Shenzhen, Guangdong, China. The site and apparatus are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-1 other equivalent standards.

FCC Test Firm Registration Number: 712850  
A2LA certificate registration number is: CN1212  
ISED Registered No.: 23583  
ISED CAB identifier: CN0017



## 7.2 Test Instrument Used

Equipment	Manufacturer	Model#	Serial#	Last Cal.	Next Cal.
PC	DELL	\	\	N/A	N/A
SAR Measurement system	SATIMO	\	\	N/A	N/A
Signal Generator	Keysight	83711B	US37100131	Aug. 29, 2024	Aug. 28, 2025
Multimeter	Keithley	1160271	\	Nov. 10, 2024	Nov 09, 2025
S-parameter Network Analyzer	R&S	ZVB 8	101353	Dec. 07, 2024	Dec. 06, 2025
Wideband Radio Communication Tester	R&S	CMW500	\	Nov. 10, 2024	Nov 09, 2025
E SAR PROBE 6GHz	MVG	SSE2	2623-EPGO-420	July 18, 2024	July 17, 2025
DIPOLE 2450	SATIMO	SID 2450	SN 47/21 DIP 2G450-627	Nov. 25, 2024	Nov. 24, 2027
DIPOLE 5000	SATIMO	SID5000	SN 47/21 DIP 2G450-629	Nov. 25, 2024	Nov. 24, 2027
COMOSAR OPENCoaxial Probe	SATIMO	\	\	Nov. 18, 2024	Nov. 17, 2025
SAR Locator	SATIMO	\	\	Nov. 18, 2024	Nov. 17, 2025
Communication Antenna	SATIMO	\	\	Nov. 18, 2024	Nov. 17, 2025
FEATURE PHONEPOSITIONING DEVICE	SATIMO	\	\	N/A	N/A
DUMMY PROBE	SATIMO	\	\	N/A	N/A
SAM Phantom	MVG	\	SN 13/09 SAM68	N/A	N/A
Liquid measurement Kit	HP	85033D	3423A08186	N/A	N/A
Power meter	Keysight	E4419	A00065	May 16, 2024	May 15, 2025
Power sensor	Keysight	E9300A	US39211659	May 16, 2024	May 15, 2025
Power sensor	Keysight	E9300A	US39211305	May 16, 2024	May 15, 2025
Directional Coupler	Krytar 158020	131467	\	Nov. 10, 2024	Nov 09, 2025
Thermometer	BTE	\	\	Dec. 02, 2024	Dec. 01, 2025
Broad Band Tissue Simulation Liquid	Schmid	\	\	N/A	N/A

### Note:

Per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three year extended calibration interval. Each measured dipole is expected to evaluate with following criteria at least on annual interval.

1. There is no physical damage on the dipole;
2. System check with specific dipole is within 10% of calibrated values;
3. The most recent return-loss results, measured at least annually, deviates by no more than 20% from the previous measurement;
4. The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.

Network analyzer probe calibration against air, distilled water and a shorting block performed before measuring liquid parameters.

## 8. Specific Absorption Rate (SAR)

### 8.1 Introduction

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

### 8.2 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 ( $\rho$ ). 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 either related to the temperature elevation in tissue by

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

Where: C is the specific heat capacity,  $\delta T$  is the temperature rise and  $\delta t$  is the exposure duration, or related to the

electrical field in the tissue by

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

Where:  $\sigma$  is the conductivity of the tissue,  $\rho$  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.



## 9. SAR Measurement System

### 9.1 The Measurement System

Comosar is a system that is able to determine the SAR distribution inside a phantom of human being according to different standards. The Comosar system consists of the following items:

- Main computer to control all the system
- 6 axis robot
- Data acquisition system
- Miniature E-field probe
- Phone holder
- Head simulating tissue

The following figure shows the system.



The EUT under test operating at the maximum power level is placed in the phone holder, under the phantom, which is filled with head simulating liquid. The E-Field probe measures the electric field inside the phantom. The OpenSAR software computes the results to give a SAR value in a 1g or 10g mass.

### 9.2 Probe

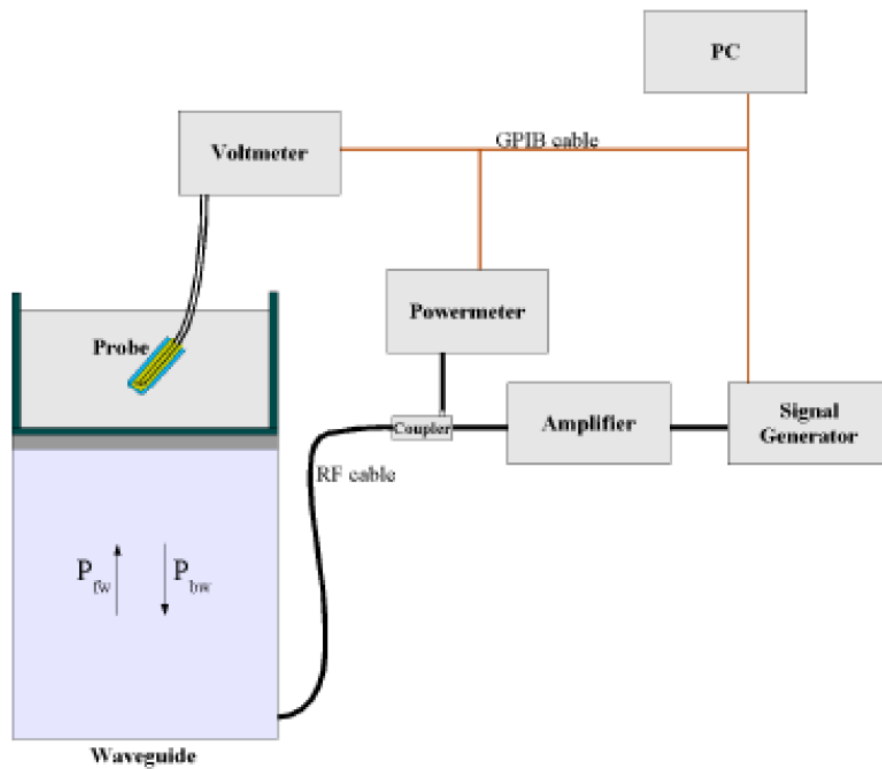
For the measurements the Specific Dosimetric E-Field Probe SN 46/21 EPGO362 with following specifications is used

- Dynamic range: 0.01-100 W/kg
- Tip Diameter : 5 mm
- Distance between probe tip and sensor center: 2.10mm
- Distance between sensor center and the inner phantom surface: 4 mm (repeatability better than +/- 1mm)
- Probe linearity: <0.25 dB
- Axial Isotropy: <0.25 dB
- Spherical Isotropy: <0.50 dB
- Calibration range: 835 to 2500MHz for head & body simulating liquid.

Angle between probe axis (evaluation axis) and surface normal line: less than 30°

Probe calibration is realized, in compliance with EN 62209-1 and IEEE 1528 STD, with CALISAR, Antennessa proprietary calibration system. The calibration is performed with the EN 62209-1 annex technique using reference guide at the five frequencies.





$$SAR = \frac{4(p_{fw} - p_{pbw})}{ab\delta} \cos^2 \left( \pi \frac{y}{a} \right) c^{(2\pi/\delta)}$$

Where :

Pfw = Forward Power

Pbw = Backward Power

a and b = Waveguide dimensions

l = Skin depth

Keithley configuration:

Rate = Medium; Filter = ON; RDGS = 10; Filter type = Moving Average; Range auto after each calibration, a SAR measurement is performed on a validation dipole and compared with a NPL calibrated probe, to verify it.

The calibration factors, CF(N), for the 3 sensors corresponding to dipole 1, dipole 2 and dipole 3 are:

$$CF(N) = SAR(N)/Vlin(N) \quad (N=1,2,3)$$

The linearised output voltage Vlin(N) is obtained from the displayed output voltage V(N) using

$$Vlin(N) = V(N) * (1 + V(N)/DCP(N)) \quad (N=1,2,3)$$

where DCP is the diode compression point in mV.

### 9.3 Probe Calibration Process

#### Dosimetric Assessment Procedure

Each E-Probe/Probe Amplifier combination has unique calibration parameters. SATIMO Probe calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm<sup>2</sup>) using an with CALISAR, Antenna proprietary calibration system.

#### Free Space Assessment Procedure

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and in a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1mW/cm<sup>2</sup>.

#### Temperature Assessment Procedure

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

Where:

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

$\Delta t$  = exposure time (30 seconds),

$C$  = heat capacity of tissue (brain or muscle),

$\Delta T$  = temperature increase due to RF exposure.

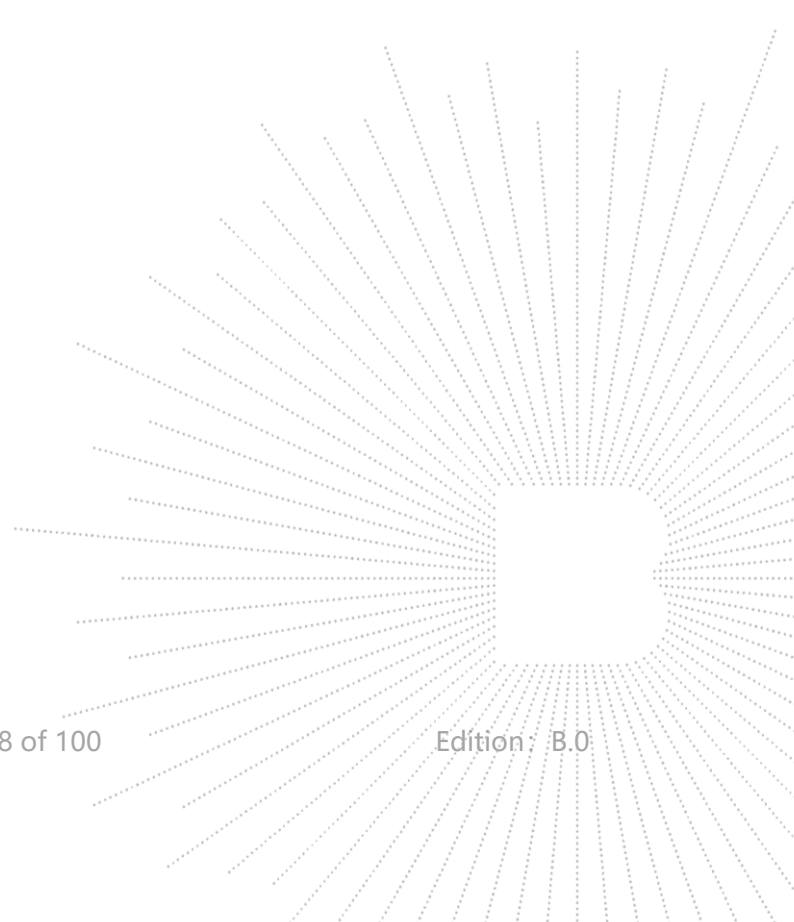
SAR is proportional to  $\Delta T/\Delta t$ , the initial rate of tissue heating, before thermal diffusion takes place. The electric field in the simulated tissue can be used to estimate SAR by equating the thermally derived SAR to that with the E- field component.

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

Where:

$\sigma$  = simulated tissue conductivity,

$\rho$  = Tissue density (1.25 g/cm<sup>3</sup> for brain tissue)

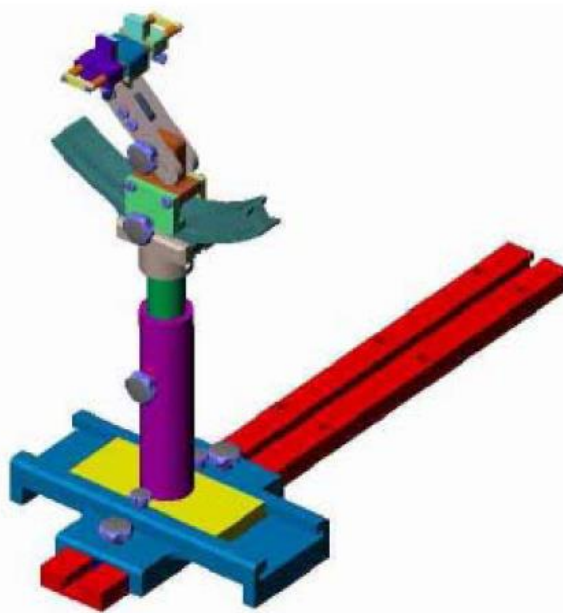


#### 9.4 Phantom

For the measurements the Specific Anthropomorphic Mannequin (SAM) defined by the IEEE SCC-34/SC2 group is used. The phantom is a polyurethane shell integrated in a wooden table. The thickness of the phantom amounts to 2mm +/- 0.2mm. It enables the dosimetric evaluation of left and right phone usage and includes an additional flat phantom part for the simplified performance check. The phantom set-up includes a cover, which prevents the evaporation of the liquid.

#### 9.5 Device Holder

The positioning system allows obtaining cheek and tilting position with a very good accuracy. In compliance with CENELEC, the tilt angle uncertainty is lower than 1°.



System Material	Permittivity	Loss Tangent
Delrin	3.7	0.005

## 10. Tissue Simulating Liquids

### 10.1 Composition of Tissue Simulating Liquid

For the measurement of the field distribution inside the SAM phantom with SMTIMO, 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. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm. Please see the following photos for the liquid height.



Liquid Height for Body SAR

The Composition of Tissue Simulating Liquid

Frequency (MHz)	Water (%)	Salt (%)	1,2-Propane diol (%)	HEC (%)	Preventol (%)	DGBE (%)
<b>Head/Body</b>						
835	40.3	1.4	57.9	0.2	0.2	0
900	40.3	1.4	57.9	0.2	0.2	0
1800-2000	55.2	0.3	0	0	0	44.5
2450	55.0	0.1	0	0	0	44.9
2600	54.9	0.1	0	0	0	45.0

Frequency (MHz)	Water (%)	Hexyl Carbitol (%)	Triton X-100 (%)
<b>Head/Body</b>			
5000-6000	65.52	17.24	17.24

## 10.2 Limit

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters

computed from the 4-Cole-Cole equations described in Reference [12] and extrapolated according to the head parameters specified in P1528.

Target Frequency (MHz)	Head	
	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )
150	0.76	52.3
300	0.87	45.3
450	0.87	43.5
750	0.89	41.9
835	0.90	41.5
900	0.97	41.5
915	0.98	41.5
1450	1.20	40.5
1610	1.29	40.3
1800-2000	1.40	40.0
2450	1.80	39.2
2600	1.96	39.0
3000	2.40	38.5
5200	4.66	36.0
5400	4.86	35.8
5600	5.07	35.5
5800	5.27	35.3

### 10.3 Tissue Calibration Result

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an R&S ZVB 8. Dielectric Probe Kit and an Agilent Network Analyzer.

Calibration Result for Dielectric Parameters of Tissue Simulating Liquid

Frequency (MHz)	Liquid	Target ( $\sigma$ )	Target ( $\epsilon_r$ )	Measured ( $\sigma$ )	Measured ( $\epsilon_r$ )	Delta ( $\sigma$ )%	Delta ( $\epsilon_r$ )%	Limit (%)	Temp. TSL (°C)	Date
2450	Head	1.80	39.20	1.838	40.722	2.11	3.88	±5	23.5	16/12/2024
5200	Head	4.66	36.00	4.509	35.133	-3.24	-2.41	±5	23.5	16/12/2024
5400	Head	4.86	35.80	4.944	34.664	1.73	-3.17	±5	23.5	16/12/2024
5600	Head	5.07	35.50	5.160	36.257	1.78	2.13	±5	23.5	16/12/2024
5800	Head	5.27	35.30	5.488	35.430	4.14	0.37	±5	23.5	16/12/2024

**Remark:**

1. The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within  $\pm 2^\circ\text{C}$  of the temperature when the tissue parameters are characterized.
2. The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

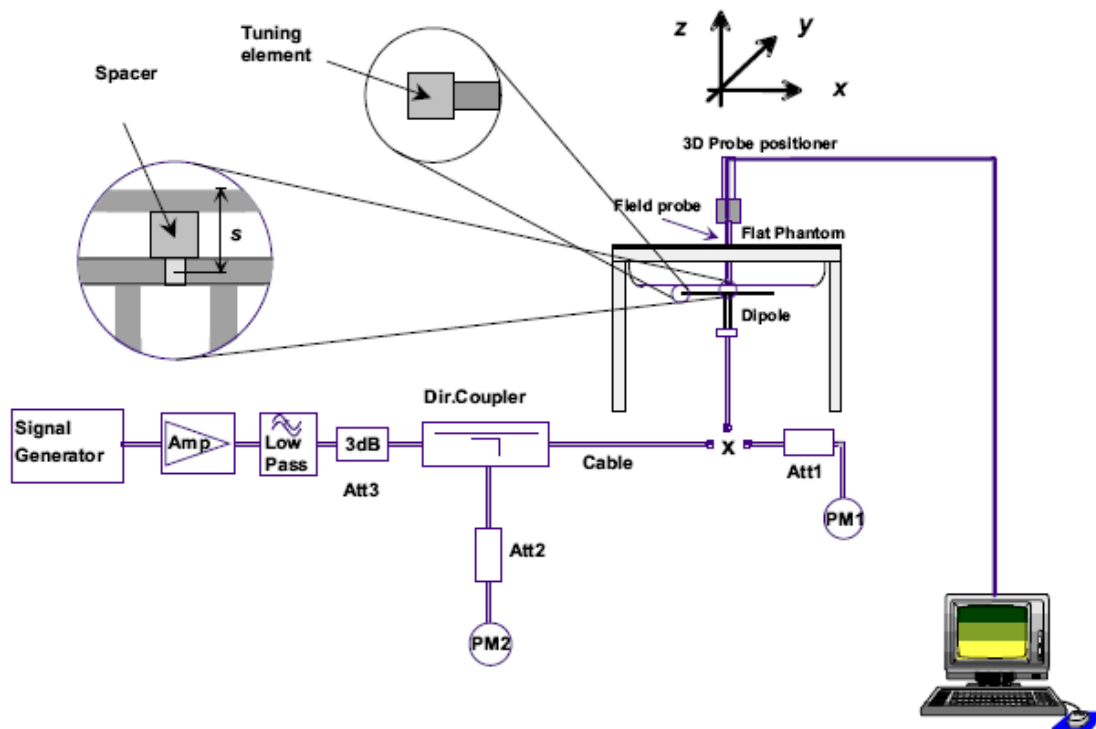
## 11. System Check

### 11.1 Purpose of System Performance Check

At the device test frequencies. System check verifies the measurement repeatability of a SAR system before compliance testing and is not a validation of all system specifications. The latter is not required for testing a device but is mandatory before the system is deployed. The system check detects possible short-term drift and unacceptable measurement errors or uncertainties in the system.

### 11.2 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 which comes from a signal generator at frequency 600MHz-6000MHz. 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 output power on dipole port must be calibrated to 20 dBm (100 mW) before dipole is connected.



System Verification Setup Block Diagram





Setup Photo of Dipole Antenna

### 11.3 Validation Results

Comparing to the original SAR value provided by SATIMO, the validation data should be within its specification of 10 %. The following table shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion.

Frequency (MHz)	Power	Measured SAR <sub>1g</sub> (W/Kg)	Normalize to 1 Watt	Drift (%)	1W Target SAR <sub>1g</sub> (W/Kg)	Difference Percentage (%)	Limit (%)	Liquid Temp	Date
2450	250 mW	13.749	54.995	-0.215	55.16	-0.299	±10	23.6	16/12/2024
5200	250 mW	18.881	75.523	0.015	76.41	-1.161	±10	23.6	16/12/2024
5400	250 mW	20.257	81.028	-3.673	80.52	0.631	±10	23.6	16/12/2024
5600	250 mW	19.699	78.794	0.513	79.08	-0.362	±10	23.6	16/12/2024
5800	250 mW	19.713	78.853	-2.452	76.49	3.089	±10	23.6	16/12/2024



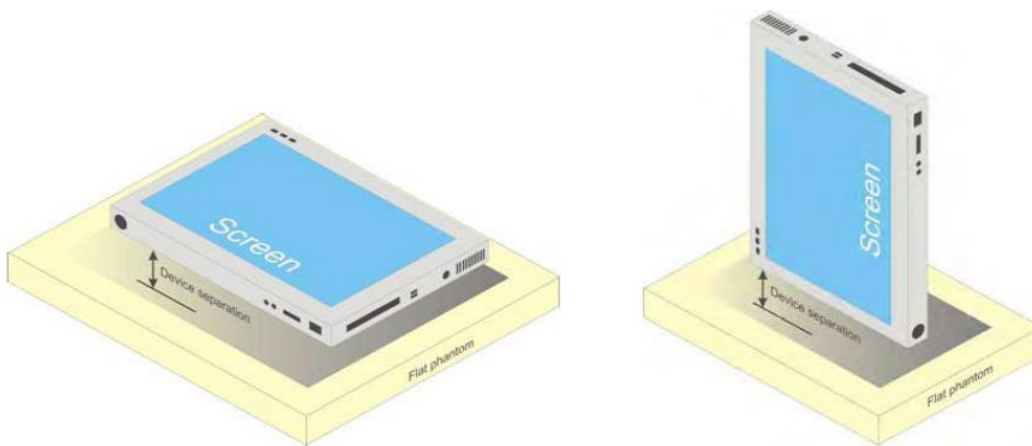
## 12. EUT Testing Position

### Body Position

A typical example of a body supported device is a wireless enabled laptop device that among other orientations may be supported on the thighs of a sitting user. To represent this orientation, the device shall be positioned with its base against the flat phantom. Other orientations may be specified by the manufacturer in the user instructions. If the intended use is not specified, the device shall be tested directly against the flat phantom in all usable orientations.

The example shows a tablet form factor portable computer for which SAR should be separately assessed with

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



Tablet form factor portable computer

## 13. SAR Measurement Procedures

### 13.1 Measurement Procedures

The measurement procedures are as follows:

- (a) Use base station simulator (if applicable) or engineering software to transmit RF power continuously (continuous Tx) in the highest power channel.
- (b) Keep EUT to radiate maximum output power or 100% factor (if applicable)
- (c) Measure output power through RF cable and power meter.
- (d) Place the EUT in the positions as Annex D demonstrates.
- (e) Set scan area, grid size and other setting on the SATIMO software.
- (f) Measure SAR results for the highest power channel on each testing position.
- (g) Find out the largest SAR result on these testing positions of each band
- (h) Measure SAR results for other channels in worst SAR testing position if the SAR of 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:

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

### 13.2 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 SATIMO 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. 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
- (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 3D 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

### 13.3 Area & Zoom Scan Procedures

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 measures 5x5x7 points with step size 8, 8 and 5 mm for 300 MHz to 3 GHz, and 8x8x8 points with step size 4, 4 and 2.5 mm for 3 GHz to 6 GHz. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g.

			$\leq 3$ GHz	$> 3$ GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface			5 mm $\pm$ 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2)$ mm $\pm$ 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location			30° $\pm$ 1°	20° $\pm$ 1°
Maximum area scan spatial resolution: $\Delta x_{Area}$ , $\Delta y_{Area}$			$\leq 2$ GHz: $\leq 15$ mm 2 – 3 GHz: $\leq 12$ mm	3 – 4 GHz: $\leq 12$ mm 4 – 6 GHz: $\leq 10$ mm
			When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	
Maximum zoom scan spatial resolution: $\Delta x_{Zoom}$ , $\Delta y_{Zoom}$			$\leq 2$ GHz: $\leq 8$ mm 2 – 3 GHz: $\leq 5$ mm*	3 – 4 GHz: $\leq 5$ mm* 4 – 6 GHz: $\leq 4$ mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		$\leq 5$ mm	3 – 4 GHz: $\leq 4$ mm 4 – 5 GHz: $\leq 3$ mm 5 – 6 GHz: $\leq 2$ mm
	graded grid	$\Delta z_{Zoom}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface	$\leq 4$ mm	3 – 4 GHz: $\leq 3$ mm 4 – 5 GHz: $\leq 2.5$ mm 5 – 6 GHz: $\leq 2$ mm
		$\Delta z_{Zoom}(n>1)$ : between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ mm	
Minimum zoom scan volume	x, y, z		$\geq 30$ mm	3 – 4 GHz: $\geq 28$ mm 4 – 5 GHz: $\geq 25$ mm 5 – 6 GHz: $\geq 22$ mm
Note: $\delta$ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the <u>area scan based 1-g SAR estimation</u> procedures of KDB Publication 447498 is $\leq 1.4$ W/kg, $\leq 8$ mm, $\leq 7$ mm and $\leq 5$ mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

### 13.4 Volume Scan Procedures

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 (step-size is 4, 4 and 2.5 mm). When all volume scan were completed, the software can combine and subsequently superpose these measurement data to calculating the multiband SAR.

### 13.5 SAR Averaged Methods

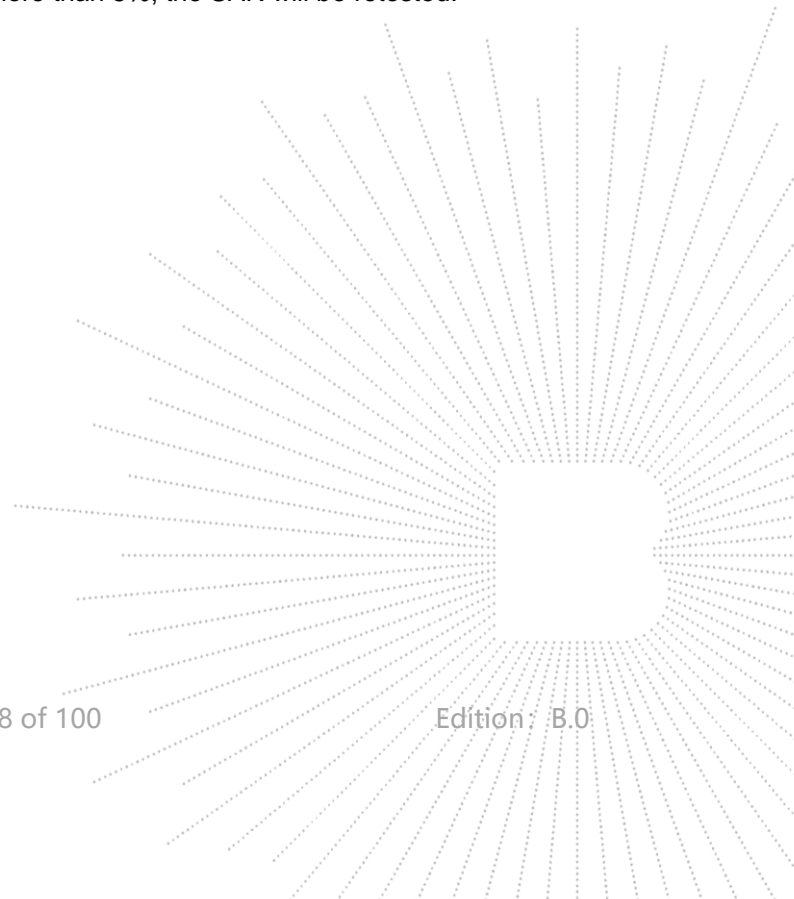
The local SAR inside the phantom is measured using small dipole sensing elements inside a probe body. The probe tip must not be in contact with the phantom surface in order to minimize measurements errors, but the highest local SAR will occur at the surface of the phantom.

An extrapolation is using to determinate this highest local SAR values. The extrapolation is based on a fourth-order least-square polynomial fit of measured data. The local SAR value is then extrapolated from the liquid surface with a 1mm step.

The measurements have to be performed over a limited time (due to the duration of the battery) so the step of measurement is high. It could vary between 5 and 8 mm. To obtain an accurate assessment of the maximum SAR averaged over 10g and 1 g requires a very fine resolution in the three dimensional scanned data array.

### 13.6 Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In SATIMO 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.



## 14. SAR Test Result

### 14.1 Conducted RF Output Power

BDR, EDR			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
1-DH5	2402	-1.78	-1.5
	2441	-2.22	
	2480	-3.55	
2-DH5	2402	-1.14	-1.0
	2441	-1.60	
	2480	-2.97	
3-DH5	2402	-0.83	-0.5
	2441	-1.32	
	2480	-2.66	

BLE			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
GFSK BLE 1M	2402	0.06	0.5
	2440	0.16	
	2480	-0.18	
GFSK BLE 2M	2402	0.01	0.5
	2440	0.13	
	2480	-0.24	

Note:

Per KDB 447498 D01v06, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances  $\leq 50$  mm are determined by:

$$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$$
 for 1-g SAR and  $\leq 7.5$  for 10-g extremity SAR

f(GHz) is the RF channel transmit frequency in GHz

Power and distance are rounded to the nearest mW and mm before calculation

The result is rounded to one decimal place for comparison

Turn up Power (dBm)	Turn up Power (mW)	Separation Distance (mm)	Frequency (MHz)	Result	Exclusion Thresholds
0.5	1.12	5	2480	0.35	3.0

Per KDB 447498 D01v06, when the minimum test separation distance is  $< 5$  mm, a distance of 5 mm is applied to determine SAR test exclusion.

According to the calculation results in the table above, Bluetooth SAR does not need to be tested.

WIFI 2.4G			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
802.11b	2412	16.45	16.5
802.11b	2437	16.23	
802.11b	2462	16.09	
802.11g	2412	15.29	15.5
802.11g	2437	15.34	
802.11g	2462	15.15	
802.11n20	2412	14.80	15.5
802.11n20	2437	15.07	
802.11n20	2462	14.70	

WIFI 5.2G			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
a	5180	15.82	16.0
a	5200	15.70	
a	5240	15.14	
n20	5180	12.46	15.0
n20	5200	14.25	
n20	5240	14.90	
n40	5190	10.22	13.5
n40	5230	13.34	
ac20	5180	14.71	15.0
ac20	5200	14.50	
ac20	5240	14.92	
ac40	5190	10.90	13.0
ac40	5230	12.89	
ac80	5210	9.09	9.5



WIFI 5.3G			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
a	5260	15.76	16.0
a	5280	15.67	
a	5320	13.35	
n20	5260	14.57	15.0
n20	5280	14.48	
n20	5320	12.99	
n40	5270	13.35	13.5
n40	5310	11.86	
ac20	5260	14.64	15.0
ac20	5280	14.65	
ac20	5320	15.03	
ac40	5270	13.20	13.5
ac40	5310	11.70	
ac80	5290	9.58	10.0

WIFI 5.6G			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
a	5500	13.55	14.0
a	5580	12.62	
a	5700	10.28	
n20	5500	12.16	12.5
n20	5580	11.17	
n20	5700	8.88	
n40	5510	10.09	10.5
n40	5550	10.33	
n40	5670	10.02	
ac20	5500	12.68	13.0
ac20	5580	12.60	
ac20	5700	10.20	
ac40	5510	10.80	11.0
ac40	5550	10.49	
ac40	5670	10.84	
ac80	5530	9.30	9.5

WIFI 5.8G			
Modulation	Frequency (MHz)	Output Power (dBm)	Tune-up power (dBm)
a	5745	12.58	13.0
a	5785	12.18	
a	5825	12.07	
n20	5745	11.26	12.0
n20	5785	11.88	
n20	5825	11.63	
n40	5755	10.00	10.5
n40	5795	9.93	
ac20	5745	11.32	11.5
ac20	5785	11.04	
ac20	5825	10.90	
ac40	5755	10.06	10.5
ac40	5795	9.96	
ac80	5775	8.82	9.0

FSK								
Modulation	Frequency (MHz)	Output Power (dBuV/m)	Output Power (dBm)	Max. Tune up Power (dBm)	Max. Tune up Power (mW)	Test distance (mm)	Result	exclusion thresholds for 1-g SAR
GFSK	2480	84.31	-15.59	-15.5	0.03	5	0.01	3.0

**Note:**

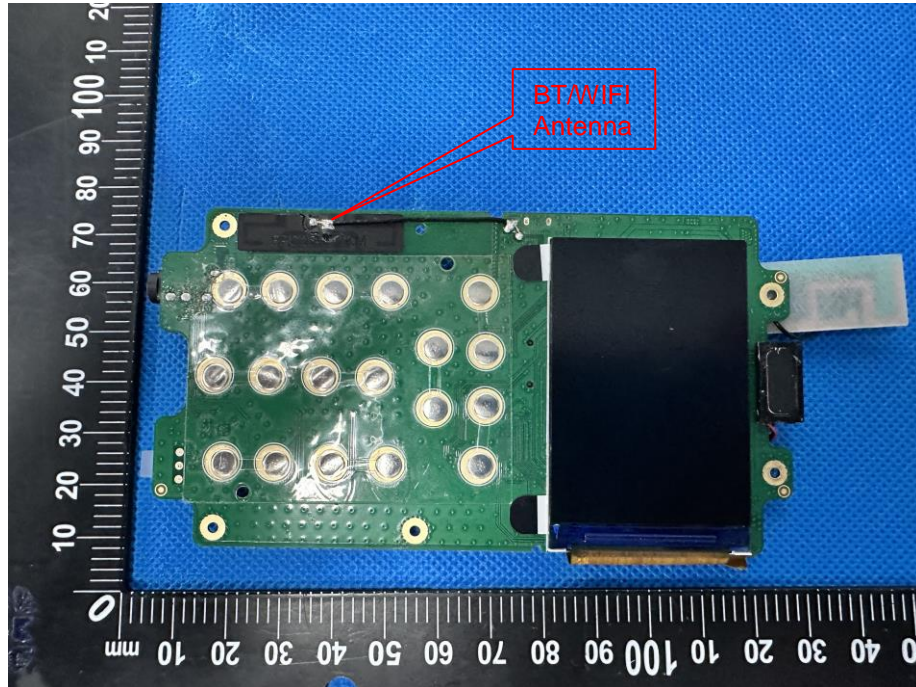
Per KDB 447498 D01v06, when the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

According to the calculation results in the table above, FSK SAR does not need to be tested.



## 14.2 Transmit Antennas and SAR Measurement Position

### EUT Antenna Location:



Distance of The Antenna to the EUT surface and edge (mm)						
Antennas	Front	Back	Top Side	Bottom Side	Left Side	Right Side
BT/WIFI	<25	<25	70	28	<25	55

Positions for SAR tests; Body mode						
Antennas	Front	Back	Top Side	Bottom Side	Left Side	Right Side
BT/WIFI	Yes	Yes	No	No	Yes	No

#### Note:

Referring to KDB 616217 D04 v01r02, KDB 248227 D01 v02r02 and KDB 447498 D01 v06, this device is overall diagonal dimension (>20cm) tablet, tested in direct contact (no gap) with flat phantom.

### 14.3 Measured and Reported (Scaled) SAR Results

The calculated SAR is obtained by the following formula:

1. Reported SAR for WWAN=Measured SAR \* Tune-up Scaling factor
2. Reported SAR for WLAN and Bluetooth=Measured SAR \* Tune-up Scaling factor \* Duty Cycle Scaling factor
3. Duty Cycle Scaling factor=1/ Duty Cycle (%)

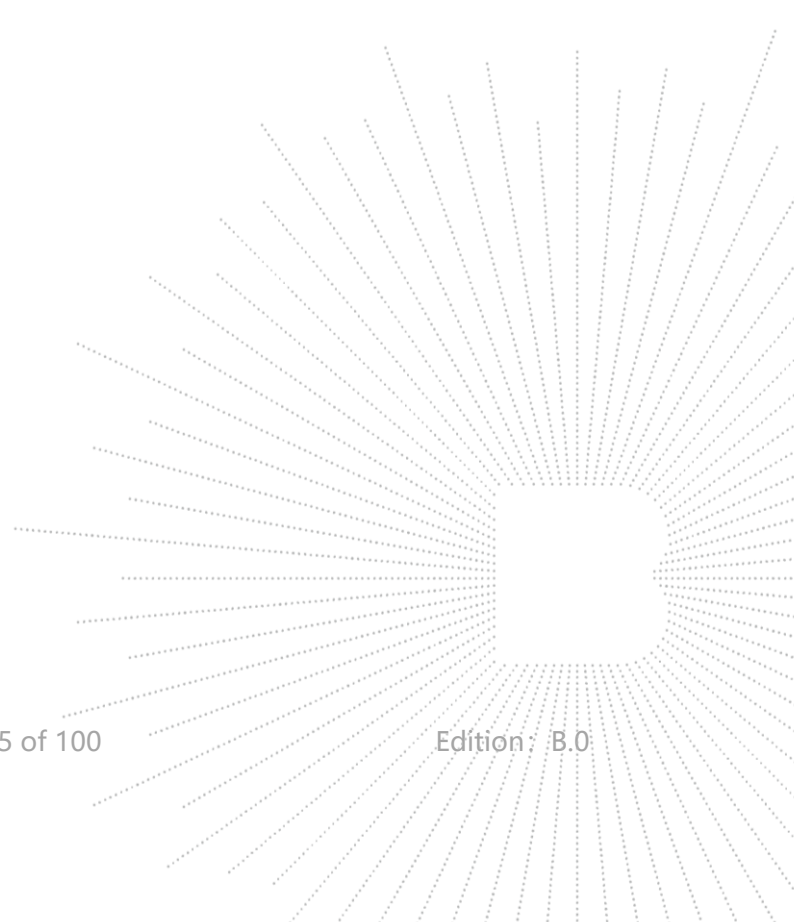
WIFI 2.4G									
RF Exposure Conditions	Mode	Test Position	Freq. (MHz)	Output Power (dBm)	Turn up (dBm)	Turn-up Scaling Factor	SAR1g (W/kg)		Plot No.
							Meas.	Scaled	
Body (0mm)	802.11b	Front	2412	16.45	16.5	1.012	0.174	0.176	1
	802.11b	Back	2412	16.45	16.5	1.012	0.555	<b>0.561</b>	
	802.11b	Left Side	2412	16.45	16.5	1.012	0.434	0.439	

WIFI 5.2G									
RF Exposure Conditions	Mode	Test Position	Freq. (MHz)	Output Power (dBm)	Turn up (dBm)	Turn-up Scaling Factor	SAR1g (W/kg)		Plot No.
							Meas.	Scaled	
Body (0mm)	802.11a	Front	5180	15.82	16.0	1.042	0.243	0.253	2
	802.11a	Back	5180	15.82	16.0	1.042	0.374	0.390	
	802.11a	Left Side	5180	15.82	16.0	1.042	0.681	<b>0.710</b>	

WIFI 5.3G									
RF Exposure Conditions	Mode	Test Position	Freq. (MHz)	Output Power (dBm)	Turn up (dBm)	Turn-up Scaling Factor	SAR1g (W/kg)		Plot No.
							Meas.	Scaled	
Body (0mm)	802.11a	Front	5260	15.76	16.0	1.057	0.239	0.253	3
	802.11a	Back	5260	15.76	16.0	1.057	0.274	<b>0.290</b>	
	802.11a	Left Side	5260	15.76	16.0	1.057	0.212	0.224	

WIFI 5.6G									
RF Exposure Conditions	Mode	Test Position	Freq. (MHz)	Output Power (dBm)	Turn up (dBm)	Turn-up Scaling Factor	SAR1g (W/kg)		Plot No.
							Meas.	Scaled	
Body (0mm)	802.11a	Front	5500	13.55	14.0	1.109	0.232	0.257	4
	802.11a	Back	5500	13.55	14.0	1.109	0.282	<b>0.313</b>	
	802.11a	Left Side	5500	13.55	14.0	1.109	0.247	0.274	

WIFI 5.8G									
RF Exposure Conditions	Mode	Test Position	Freq. (MHz)	Output Power (dBm)	Turn up (dBm)	Turn-up Scaling Factor	SAR1g (W/kg)		Plot No.
							Meas.	Scaled	
Body (0mm)	802.11a	Front	5745	12.58	13.0	1.102	0.287	0.316	
	802.11a	Back	5745	12.58	13.0	1.102	0.416	<b>0.458</b>	5
	802.11a	Left Side	5745	12.58	13.0	1.102	0.236	0.260	



## 14.4 SAR Measurement Variability

According to KDB865664, Repeated measurements are required only when the measured SAR is  $\geq 0.80$  W/kg. If the measured SAR value of the initial repeated measurement is  $< 1.45$  W/kg with  $\leq 20\%$  variation, only one repeated measurement is required to reaffirm that the results are not expected to have substantial variations, which may introduce significant compliance concerns. A second repeated measurement is required only if the measured result for the initial repeated measurement is within 10% of the SAR limit and vary by more than 20%, which are often related to device and measurement setup difficulties. The following procedures are applied to determine if repeated measurements are required. The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.<sup>19</sup> The repeated measurement results must be clearly identified in the SAR report. All measured SAR, including the repeated results, must be considered to determine compliance and for reporting according to KDB 690783. Repeated measurement is not required when the original highest measured SAR is  $< 0.80$  W/kg; steps 2) through 4) do not apply.

- 1) When the original highest measured SAR is  $\geq 0.80$  W/kg, repeat that measurement once.
- 2) 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  $\geq 1.45$  W/kg ( $\sim 10\%$  from the 1-g SAR limit).
- 3) Perform a third repeated measurement only if the original, first or second repeated measurement is  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is  $\geq 1.5$  W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is  $> 1.20$ .

Test Mode	Frequency Band (MHz)	RF Exposure Configuration	Test Position	Repeated SAR (yes/no)	Highest Measured SAR1-g (W/Kg)	First Repeated	
						Measured SAR1-g (W/Kg)	Largest to Smallest SAR Ratio
/	/	/	/	/	/	/	/

## 14.5 Simultaneous Transmission Evaluation

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.

Application Simultaneous Transmission information:

No.	Configurations	Body SAR
1	WWAN + WIFI	No
2	WWAN + Bluetooth	No
3	WIFI + Bluetooth	No

**Remark:**

1. WIFI and Bluetooth share the same antenna, and cannot transmit simultaneously.
2. The product does not support WWAN.
3. According to the KDB 447498 D01 v06, when standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:
  - $(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm}) \cdot [\sqrt{f(\text{GHz})} / x] \text{ W/kg}$  for test separation distances  $\leq 50 \text{ mm}$ ;  
where  $x = 7.5$  for 1-g SAR, and  $x = 18.75$  for 10-g SAR.
  - $0.4 \text{ W/kg}$  for 1-g SAR and  $1.0 \text{ W/kg}$  for 10-g SAR, when the test separation distances is  $> 50 \text{ mm}$

Estimated stand alone SAR						
Mode	Frequency (MHz)	Maximum Power (dBm)	Maximum Power (mW)	Separation Distance (mm)	X	Estimated SAR1-g (W/kg)
Bluetooth	2480	0.5	1.12	5	3.0	0.047
FSK	2480	-15.5	0.03	5	3.0	0.001

Note:

1. Maximum average power including tune-up tolerance;
2. When the minimum test separation distance is  $< 5 \text{ mm}$ , a distance of  $5 \text{ mm}$  is applied to determine SAR test exclusion

4. Per FCC KD B447498 D01, simultaneous transmission SAR test exclusion may be applied when the sum of the 1-g SAR for all the transmitting antenna in a specific a physical test configuration is  $\leq 1.6 \text{ W/Kg}$ . When the sum is greater than the SAR limit, SAR test exclusion is determined by the SAR to peak location separation ratio.

$$\text{Ratio} = \frac{(\text{SAR}_1 + \text{SAR}_2)^{1.5}}{(\text{peak location separation, mm})} < 0.04$$

5. Simultaneous transmission of maximum SAR sum calculation.

RF Exposure Conditions	Scaled SAR (W/kg)		Summed SAR (W/kg)	SAR1-g Limit (W/kg)
	BT/WIFI (ANT)	FSK (ANT)		
Body	0.710	0.001	0.711	1.6



## 15. Test Plots

### 15.1 System Performance Check

#### System check at 2450 MHz

Date of measurement: 16/12/2024

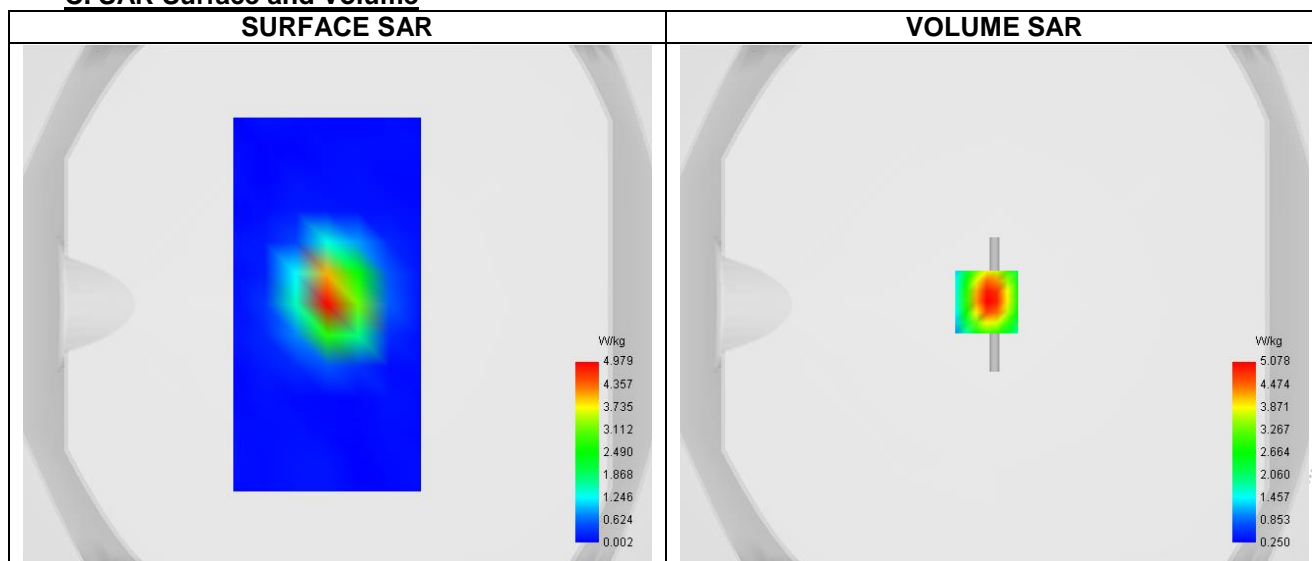
##### A. Experimental conditions.

Probe	SN 26/23 EPG0420
ConvF	1.32
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=8mm dy=8mm dz=5mm
Phantom	Validation plane
Device Position	Dipole
Band	CW2450
Signal	CW

##### B. Permittivity

Frequency (MHz)	2450.000
Relative permittivity (real part)	40.722
Relative permittivity (imaginary part)	14.330
Conductivity (S/m)	1.838

##### C. SAR Surface and Volume



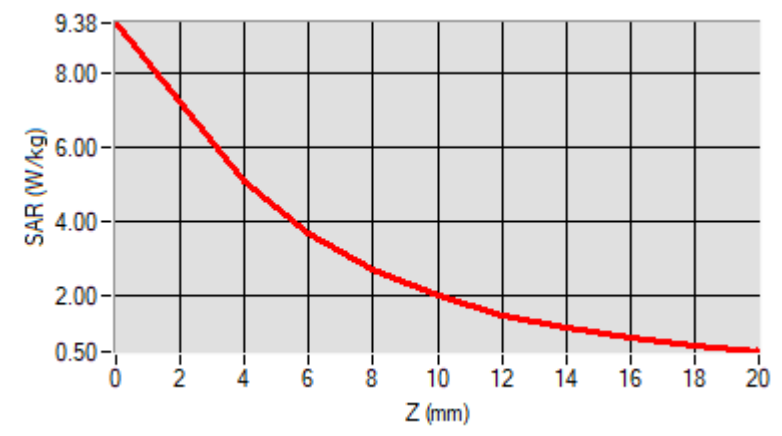
Maximum location: X=-3.00, Y=1.00 ; SAR Peak: 9.50 W/kg

##### D. SAR 1g & 10g

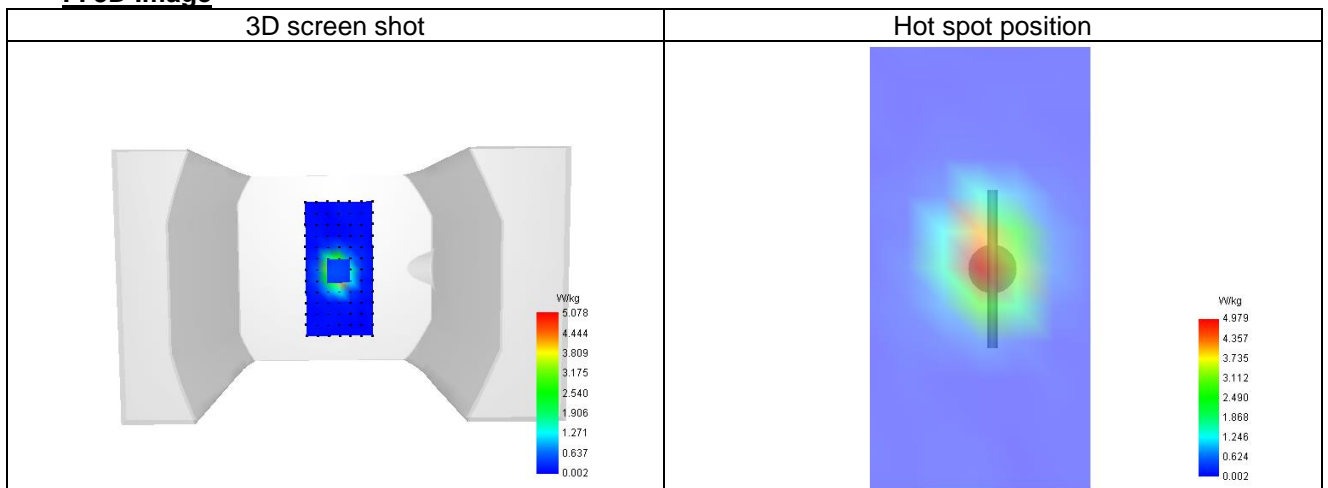
SAR 10g (W/Kg)	5.840
SAR 1g (W/Kg)	13.749
Variation (%)	-0.215
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

### E. Z Axis Scan

Z (mm)	0.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00
SAR (W/Kg)	9.380	5.078	3.712	2.709	2.001	1.499	1.138	0.871	0.667



### F. 3D Image



**System check at 5200 MHz**

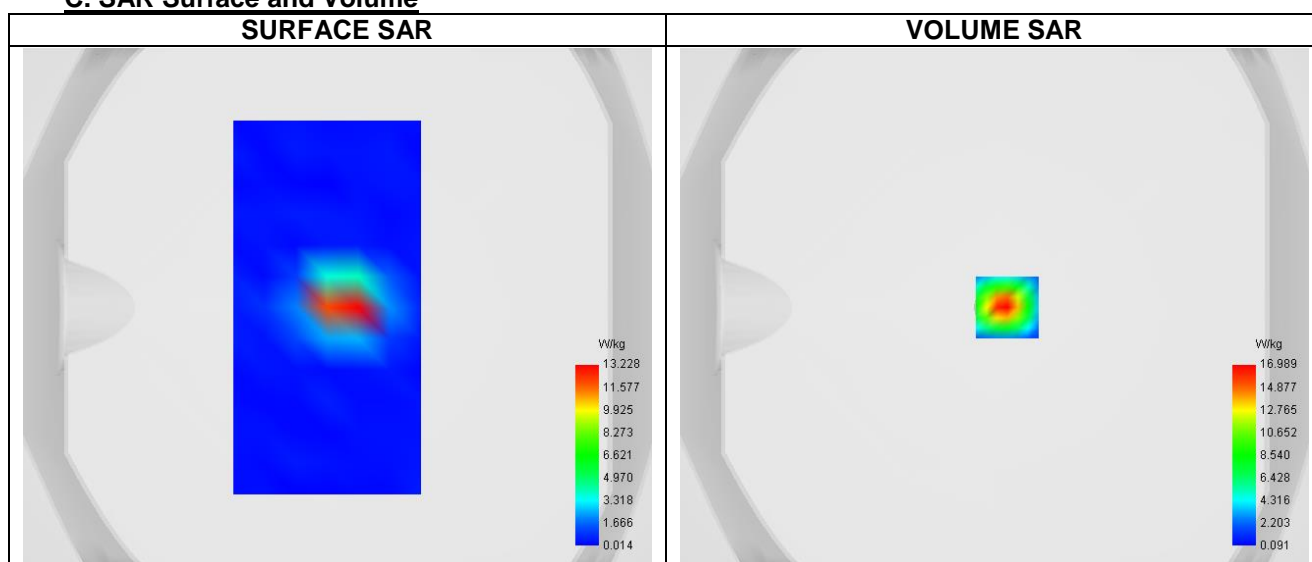
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPG0420
ConvF	0.97
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Dipole
Band	CW5200
Signal	CW

**B. Permittivity**

Frequency (MHz)	5200.000
Relative permittivity (real part)	35.133
Relative permittivity (imaginary part)	18.140
Conductivity (S/m)	4.509

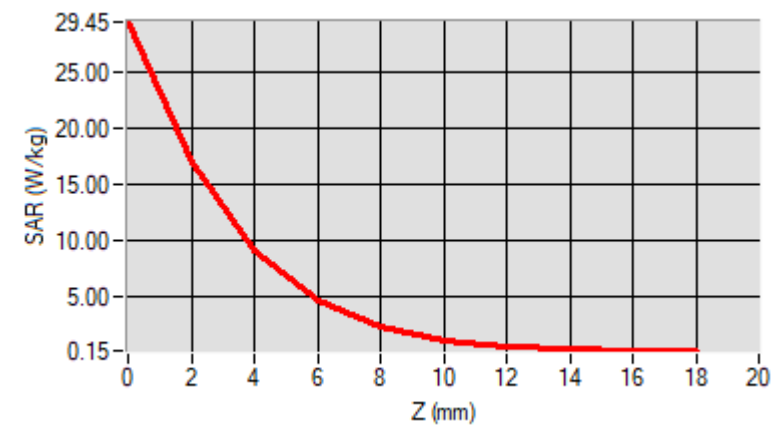
**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

SAR 10g (W/Kg)	5.579
SAR 1g (W/Kg)	18.881
Variation (%)	0.015
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

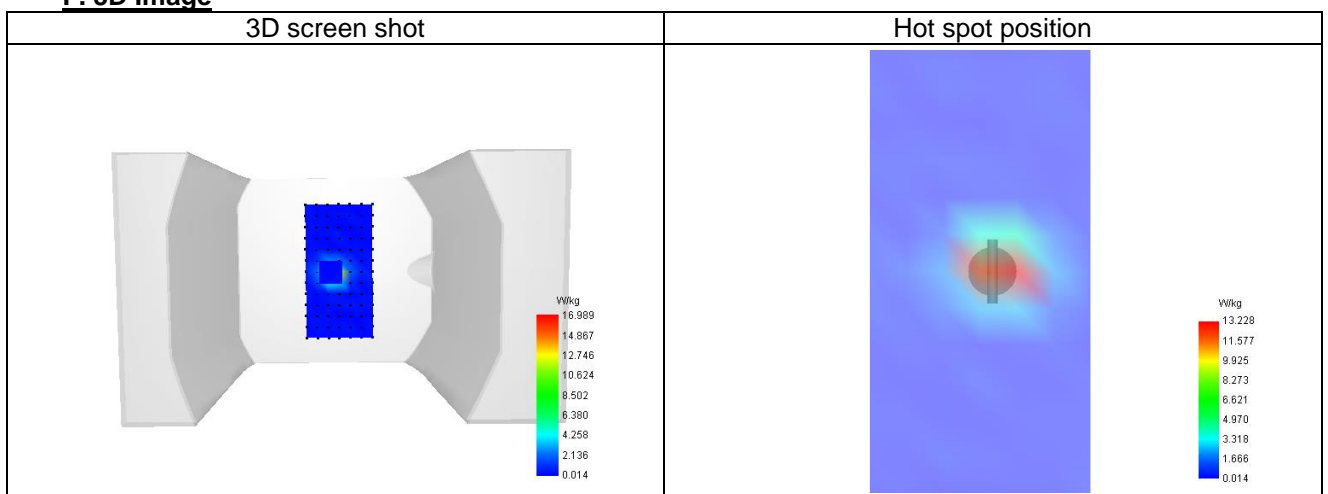
**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	29.452	16.989	9.130	4.585	2.232	1.083	0.552	0.315	0.209





### F. 3D Image



**System check at 5400 MHz**

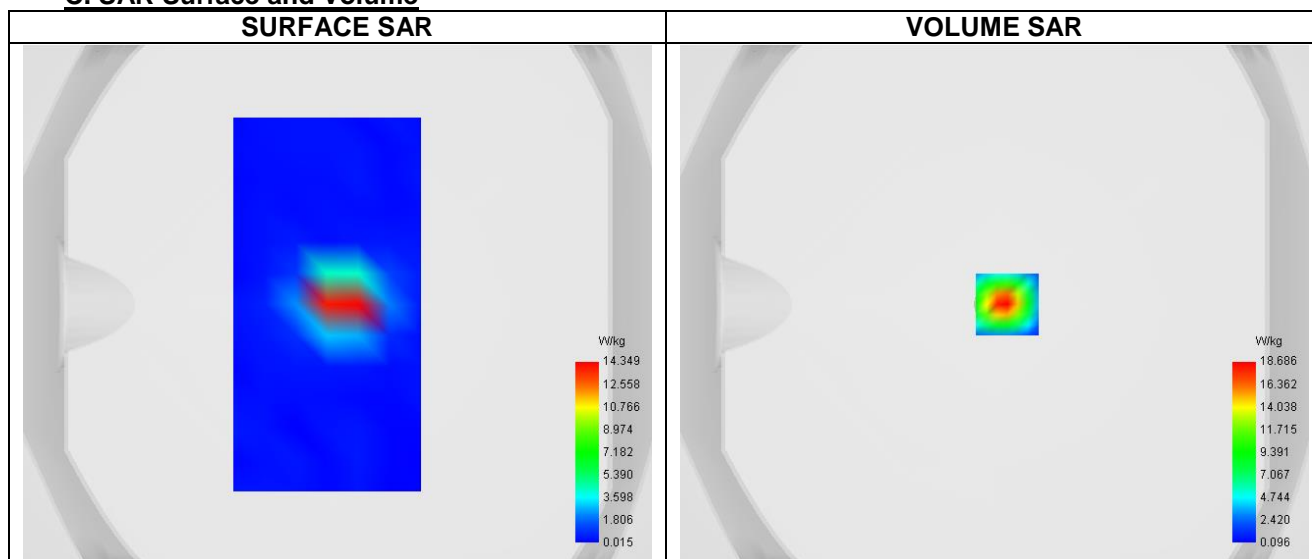
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPG0420
ConvF	1.00
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2mm
Phantom	Validation plane
Device Position	Dipole
Band	CW5400
Signal	CW

**B. Permittivity**

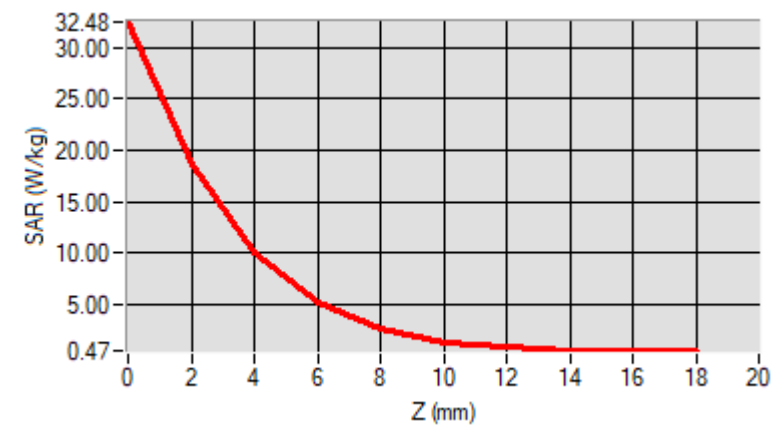
Frequency (MHz)	5400.000
Relative permittivity (real part)	34.664
Relative permittivity (imaginary part)	18.300
Conductivity (S/m)	4.944

**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

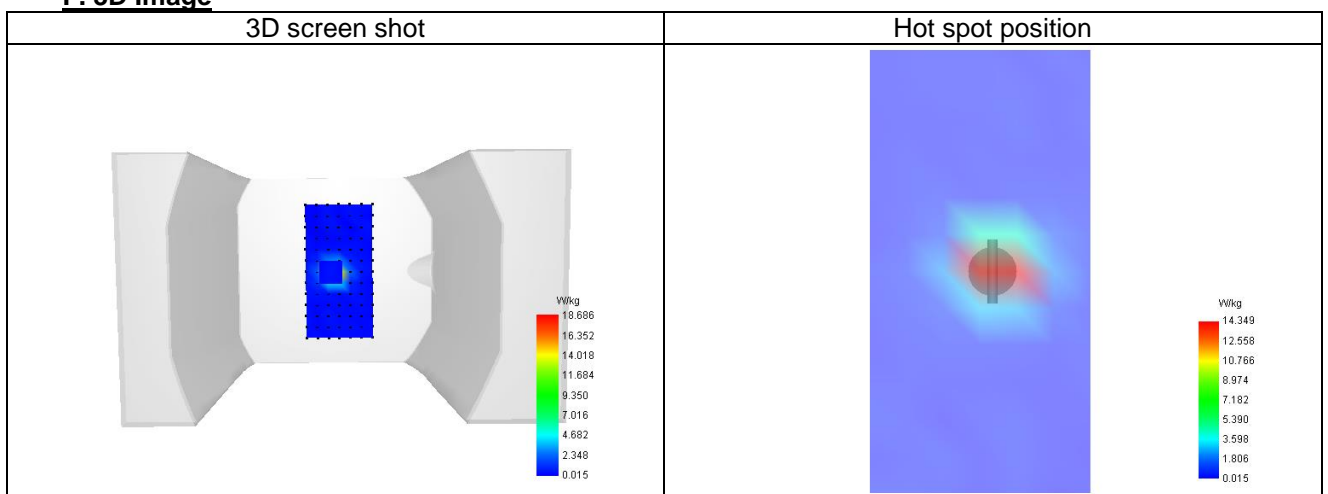
SAR 10g (W/Kg)	5.923
SAR 1g (W/Kg)	20.257
Variation (%)	-3.673
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	32.476	18.686	10.034	5.088	2.563	1.347	0.796	0.566	0.487



### F. 3D Image



**System check at 5600 MHz**

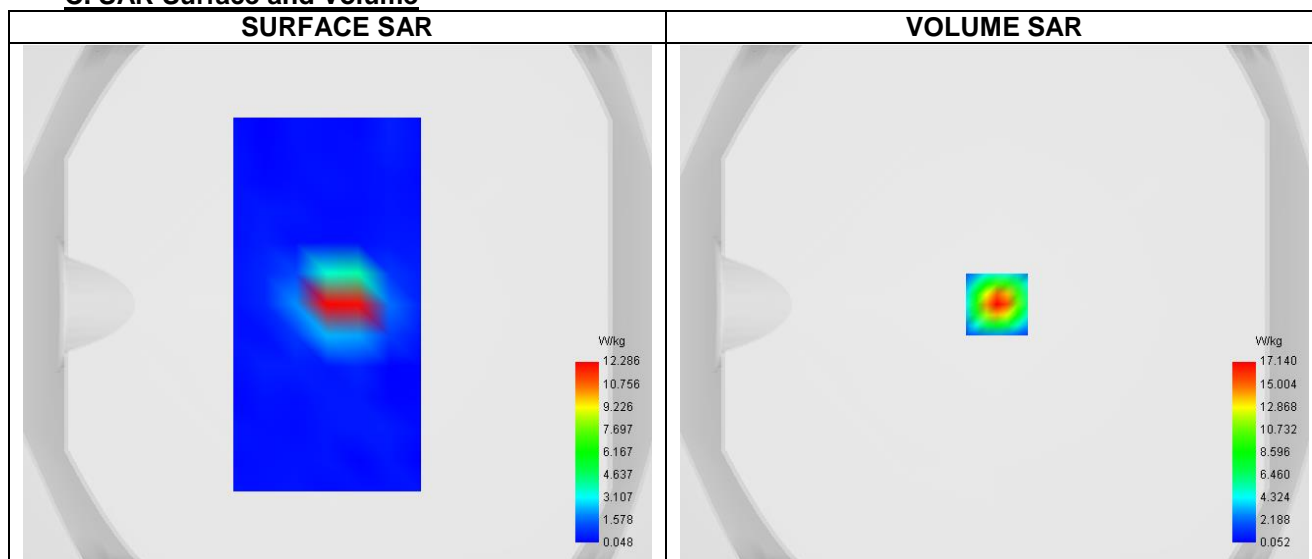
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPGO420
ConvF	0.95
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2mm
Phantom	Validation plane
Device Position	Dipole
Band	CW5600
Signal	CW

**B. Permittivity**

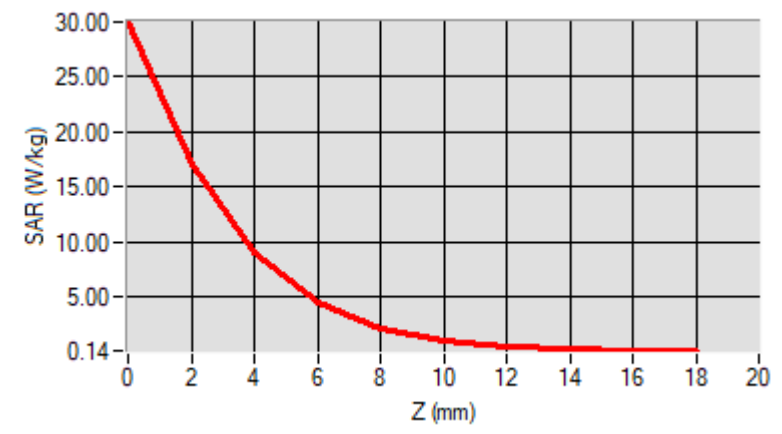
Frequency (MHz)	5600.000
Relative permittivity (real part)	36.257
Relative permittivity (imaginary part)	18.460
Conductivity (S/m)	5.160

**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

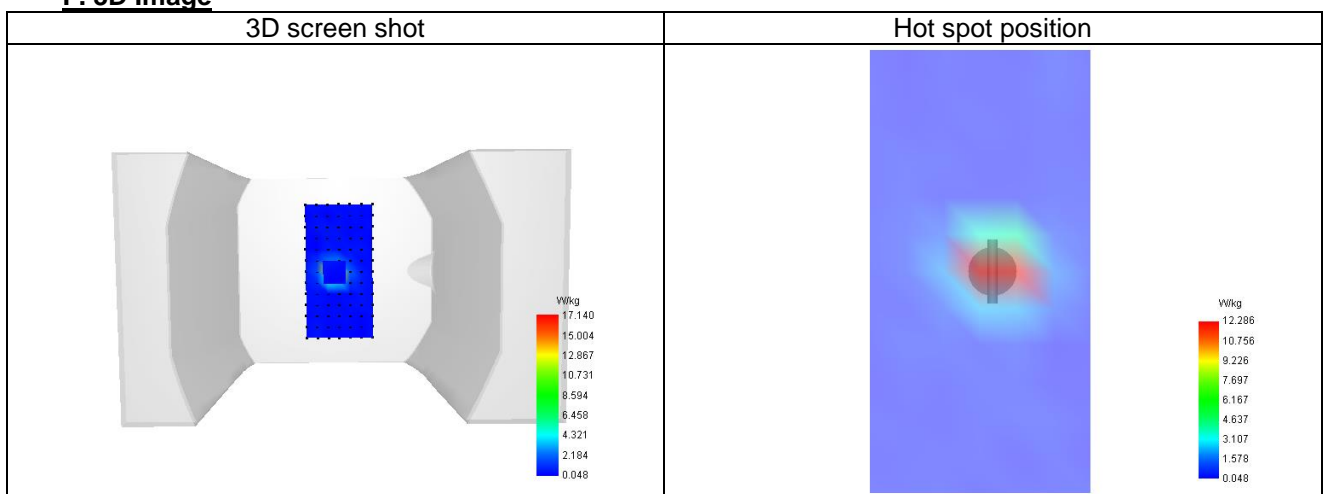
SAR 10g (W/Kg)	5.613
SAR 1g (W/Kg)	19.699
Variation (%)	0.513
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	30.005	17.140	9.077	4.467	2.119	0.999	0.495	0.280	0.189



### F. 3D Image



**System check at 5800 MHz**

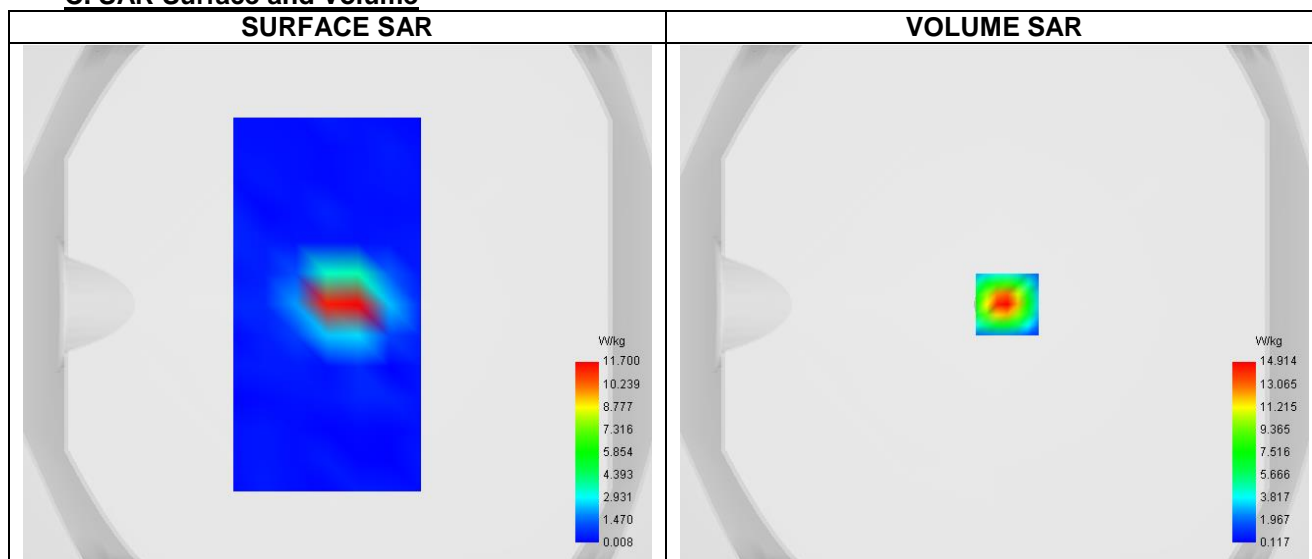
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPG0420
ConvF	1.05
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Dipole
Band	CW5800
Signal	CW

**B. Permittivity**

Frequency (MHz)	5800.000
Relative permittivity (real part)	35.430
Relative permittivity (imaginary part)	18.620
Conductivity (S/m)	5.488

**C. SAR Surface and Volume**


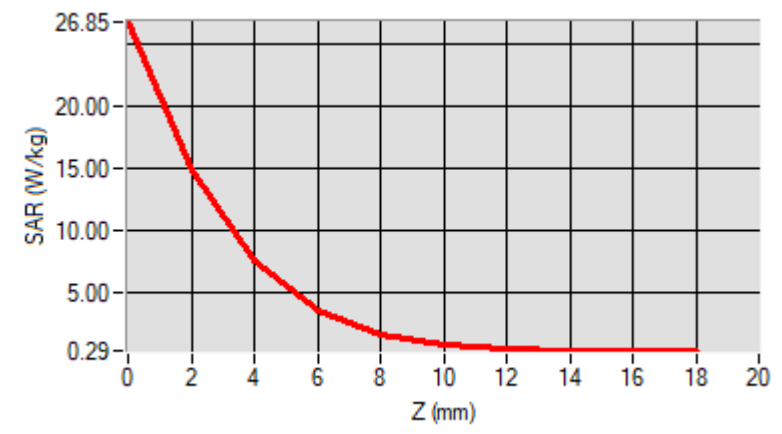
Maximum location: X=5.00, Y=0.00 ; SAR Peak: 28.22 W/kg

**D. SAR 1g & 10g**

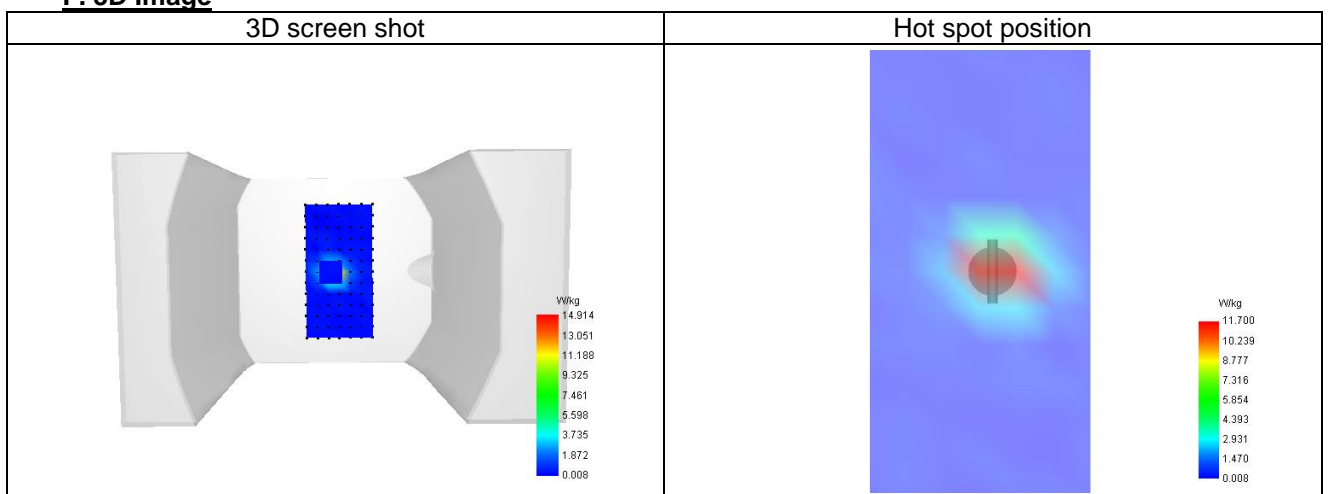
SAR 10g (W/Kg)	5.476
SAR 1g (W/Kg)	19.713
Variation (%)	-2.452
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	26.852	14.914	7.581	3.559	1.627	0.770	0.423	0.303	0.288



### F. 3D Image





## 15.2 SAR Test Graph Results

### Plot 1

Date of measurement: 16/12/2024

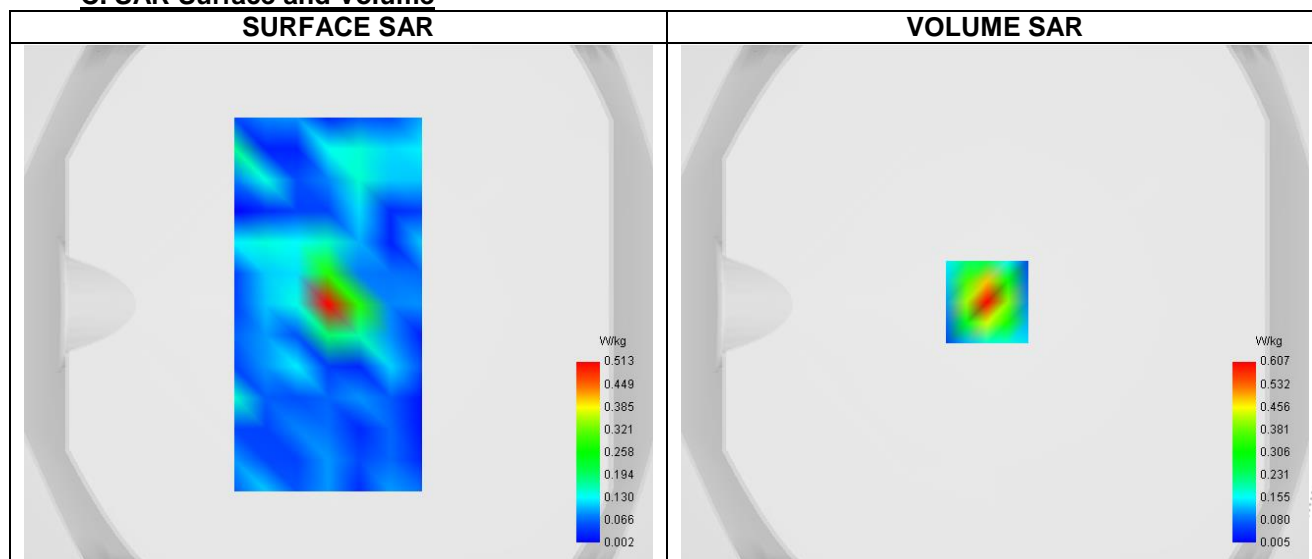
#### A. Experimental conditions.

Probe	SN 26/23 EPGO420
ConvF	1.11
Area Scan	surf_sam_plan.txt
Zoom Scan	5x5x7,dx=8mm dy=8mm dz=5.0mm
Phantom	Validation plane
Device Position	Body
Band	ISM
Signal	IEEE 802.11 b

#### B. Permittivity

Frequency (MHz)	2412.000
Relative permittivity (real part)	40.722
Relative permittivity (imaginary part)	13.207
Conductivity (S/m)	1.838

#### C. SAR Surface and Volume



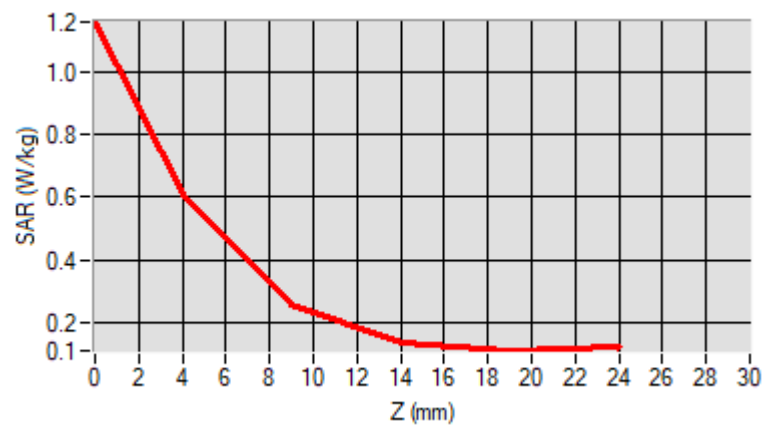
Maximum location: X=-3.00, Y=1.00 ; SAR Peak: 1.16 W/kg

#### D. SAR 1g & 10g

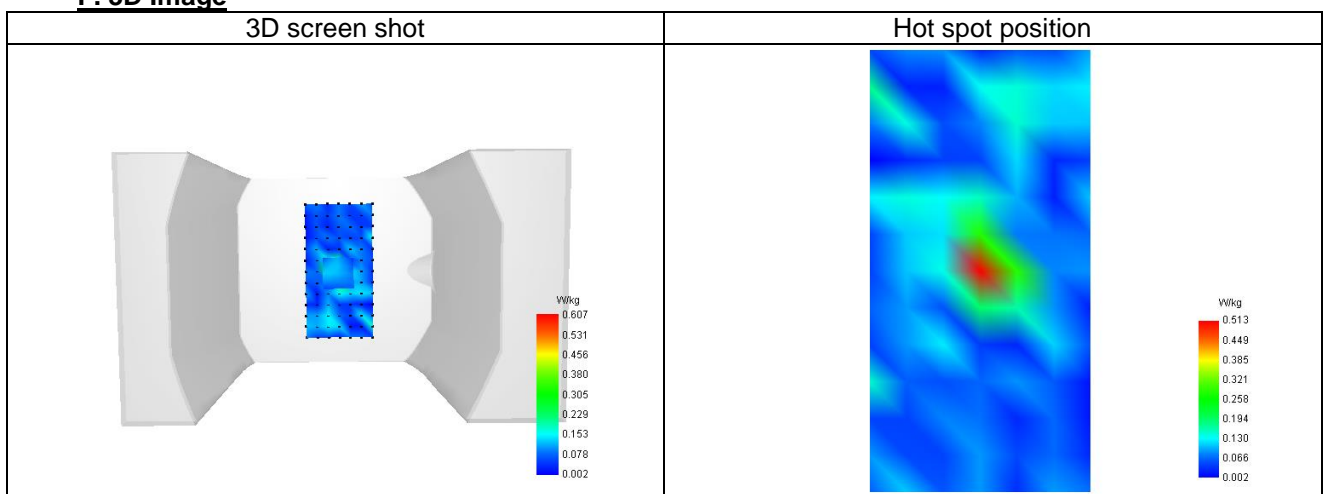
SAR 10g (W/Kg)	0.251
SAR 1g (W/Kg)	0.555
Variation (%)	2.030
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

#### E. Z Axis Scan

Z (mm)	0.00	4.00	9.00	14.00	19.00
SAR (W/Kg)	1.162	0.607	0.259	0.134	0.109



### F. 3D Image



**Plot 2**

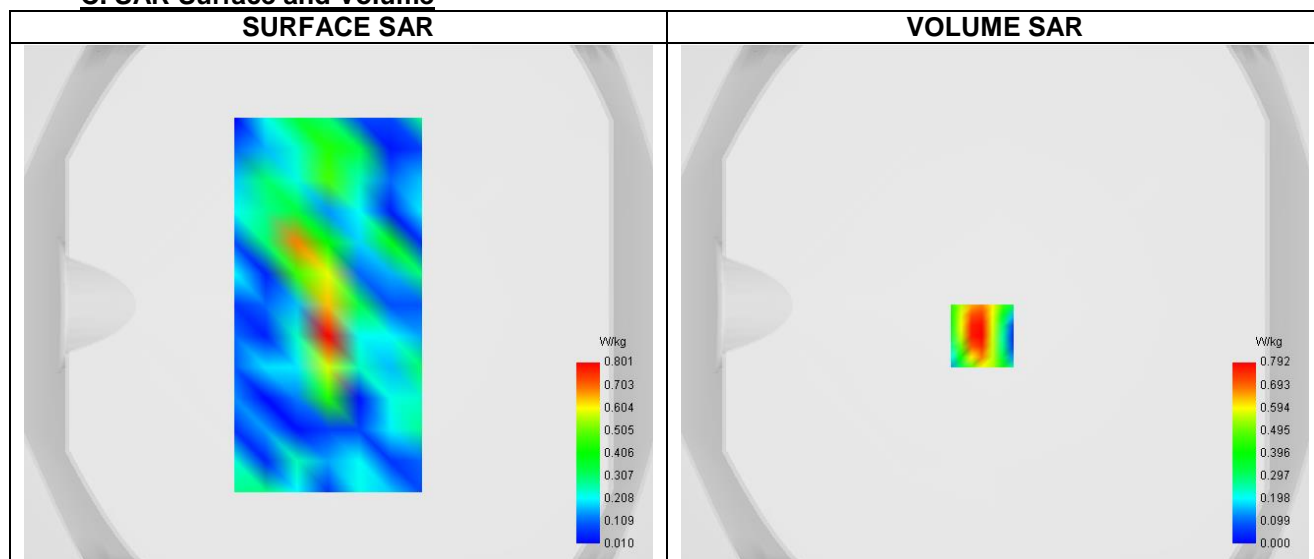
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPGO420
ConvF	1.18
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Body
Band	5200
Signal	--

**B. Permittivity**

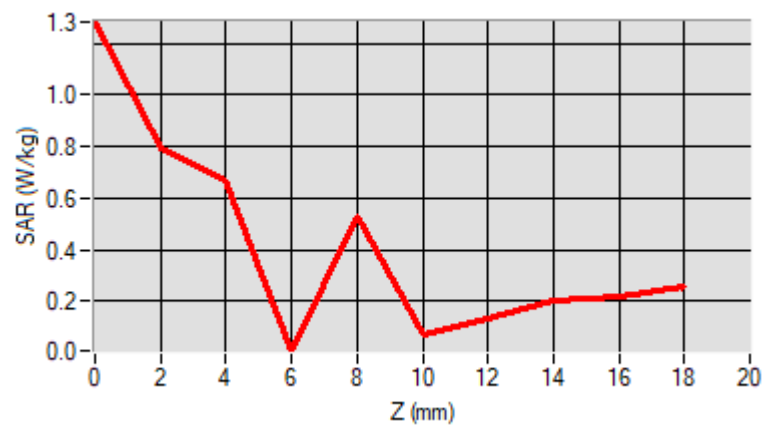
Frequency (MHz)	5180.000
Relative permittivity (real part)	35.133
Relative permittivity (imaginary part)	16.130
Conductivity (S/m)	4.509

**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

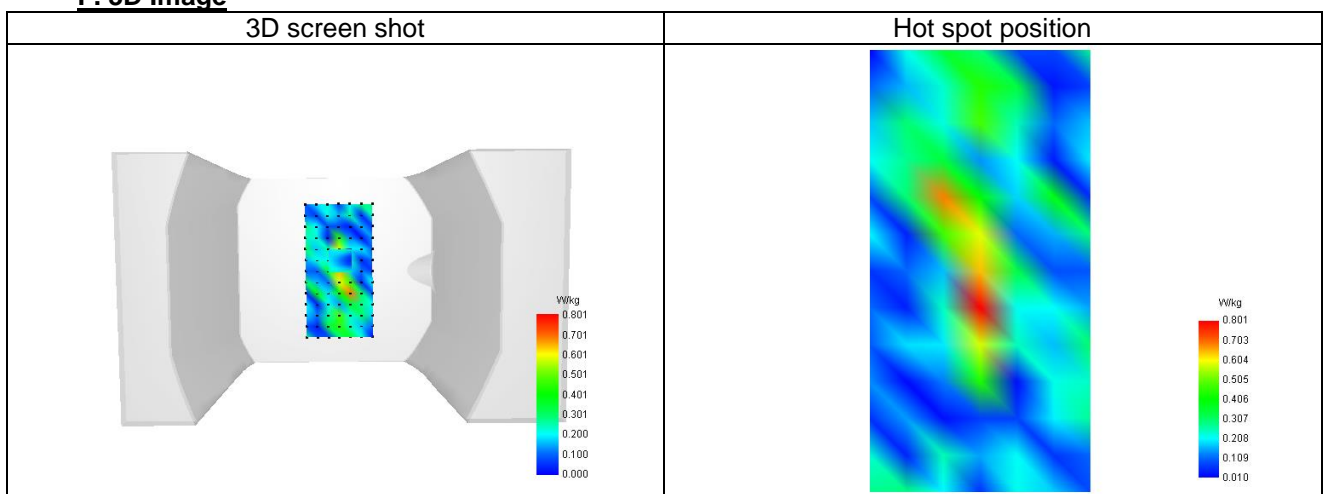
SAR 10g (W/Kg)	0.287
SAR 1g (W/Kg)	0.681
Variation (%)	1.380
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	1.283	0.792	0.668	0.008	0.526	0.070	0.132	0.202	0.220



### F. 3D Image



**Plot 3**

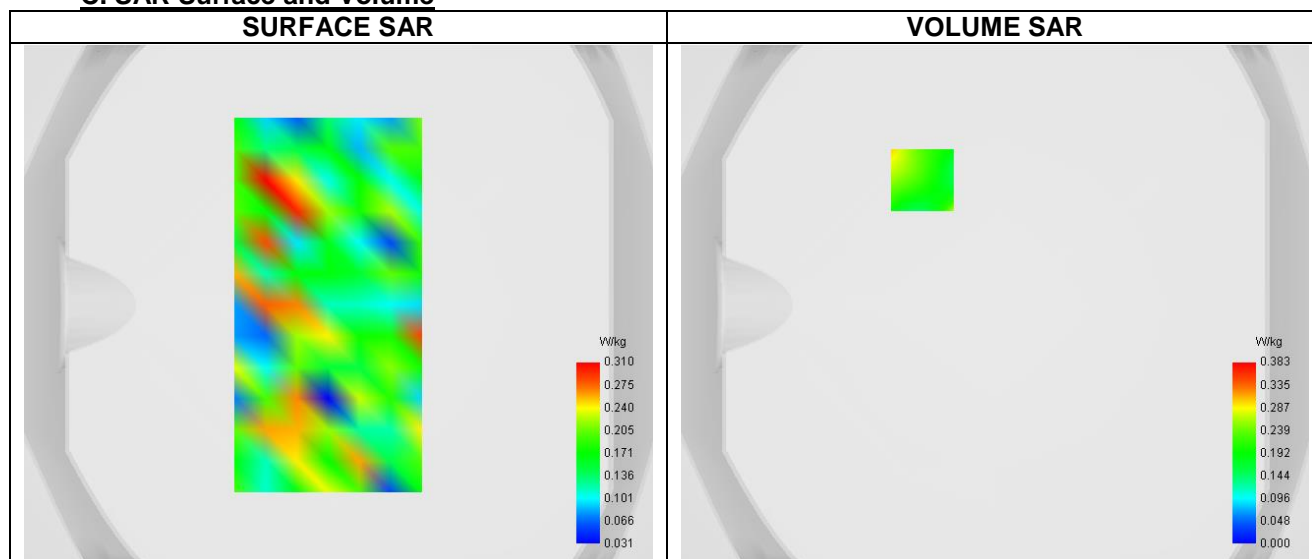
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPG0420
ConvF	1.18
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Body
Band	5400
Signal	--

**B. Permittivity**

Frequency (MHz)	5260.000
Relative permittivity (real part)	34.664
Relative permittivity (imaginary part)	16.158
Conductivity (S/m)	4.944

**C. SAR Surface and Volume**


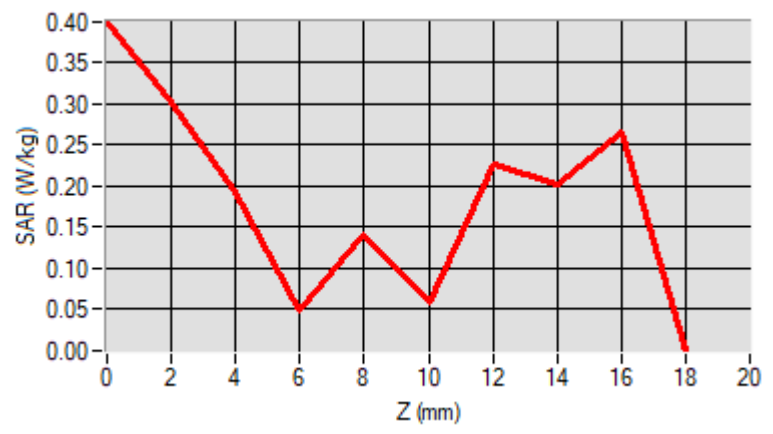
Maximum location: X=-28.00, Y=48.00 ; SAR Peak: 0.98 W/kg

**D. SAR 1g & 10g**

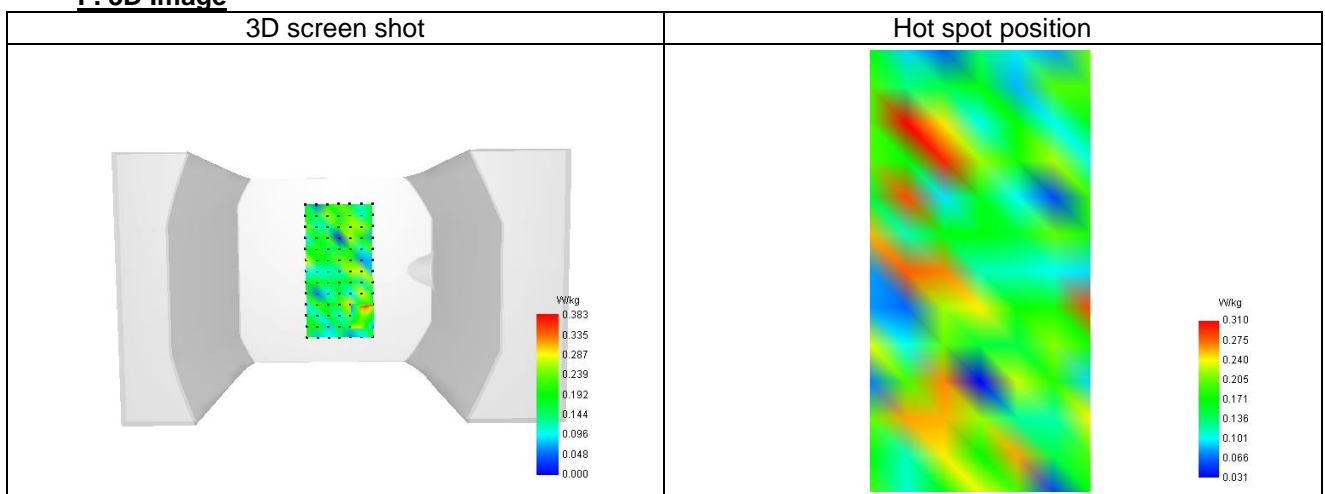
SAR 10g (W/Kg)	0.155
SAR 1g (W/Kg)	0.274
Variation (%)	-1.380
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	0.399	0.301	0.192	0.049	0.140	0.059	0.226	0.202	0.264



### F. 3D Image





**Plot 4**

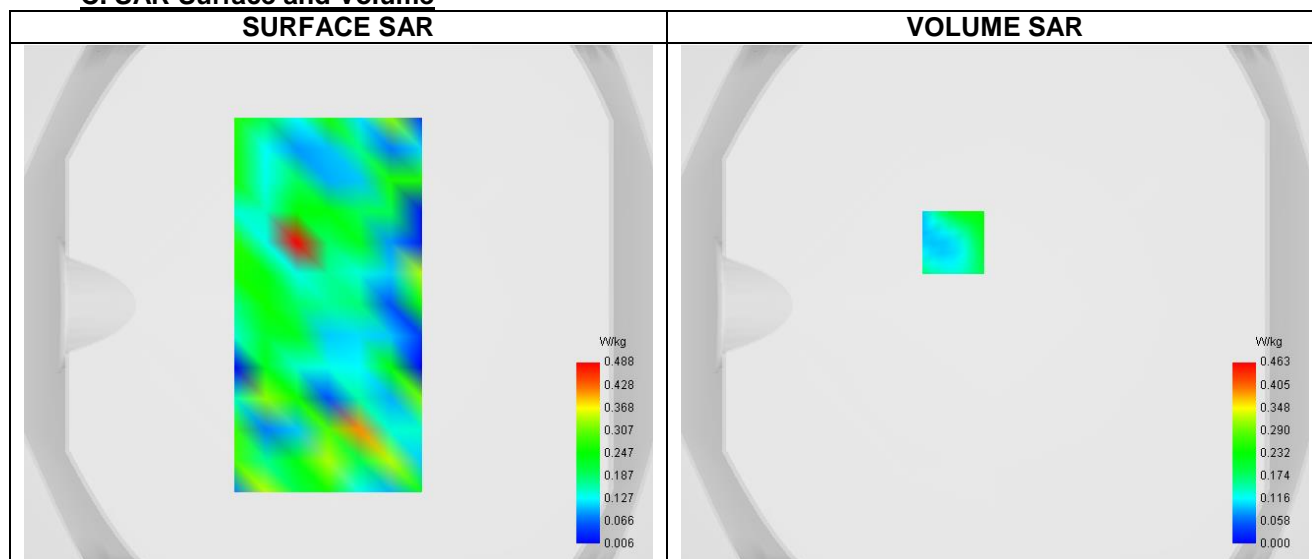
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPGO420
ConvF	1.20
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Body
Band	5600
Signal	--

**B. Permittivity**

Frequency (MHz)	5500.000
Relative permittivity (real part)	36.257
Relative permittivity (imaginary part)	16.300
Conductivity (S/m)	5.160

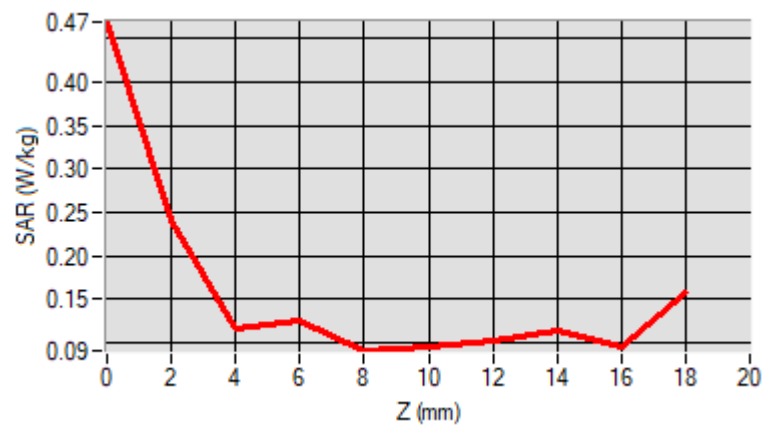
**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

SAR 10g (W/Kg)	0.149
SAR 1g (W/Kg)	0.282
Variation (%)	-3.330
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

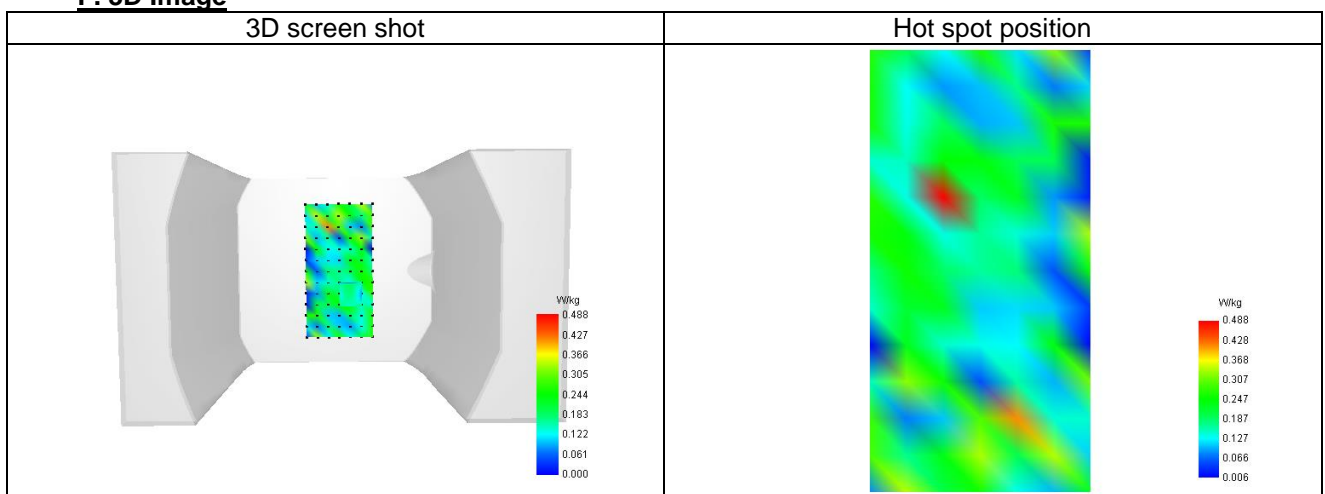
**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	0.469	0.241	0.116	0.125	0.091	0.097	0.102	0.113	0.095





### F. 3D Image



**Plot 5**

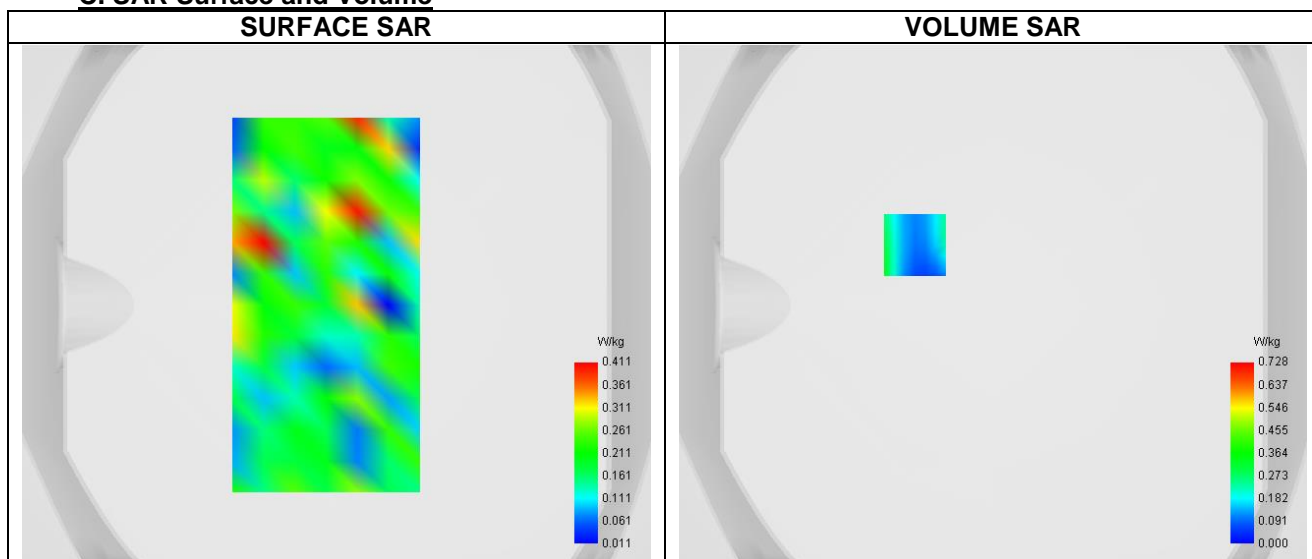
Date of measurement: 16/12/2024

**A. Experimental conditions.**

Probe	SN 26/23 EPGO420
ConvF	1.15
Area Scan	surf_sam_plan.txt
Zoom Scan	7x7x12,dx=4mm dy=4mm dz=2.0mm
Phantom	Validation plane
Device Position	Body
Band	5800
Signal	--

**B. Permittivity**

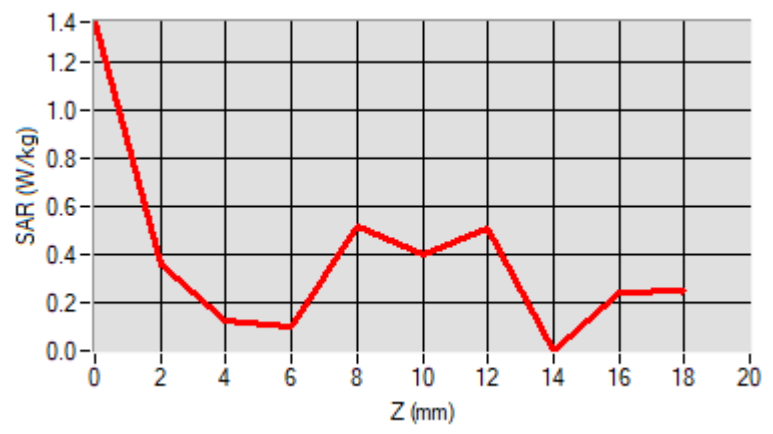
Frequency (MHz)	5745.000
Relative permittivity (real part)	35.430
Relative permittivity (imaginary part)	16.355
Conductivity (S/m)	5.488

**C. SAR Surface and Volume**

**D. SAR 1g & 10g**

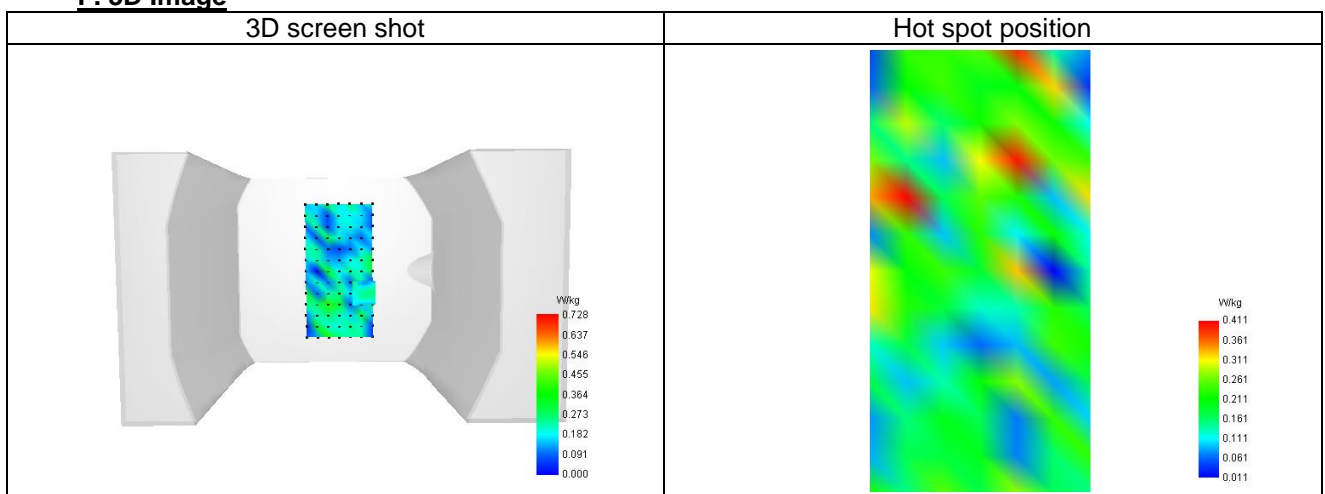
SAR 10g (W/Kg)	0.249
SAR 1g (W/Kg)	0.416
Variation (%)	3.640
Horizontal validation criteria: minimum distance (mm)	0.000000
Vertical validation criteria: SAR ratio M2/M1 (%)	0.000000

**E. Z Axis Scan**

Z (mm)	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00
SAR (W/Kg)	1.369	0.358	0.130	0.102	0.522	0.405	0.508	0.003	0.244

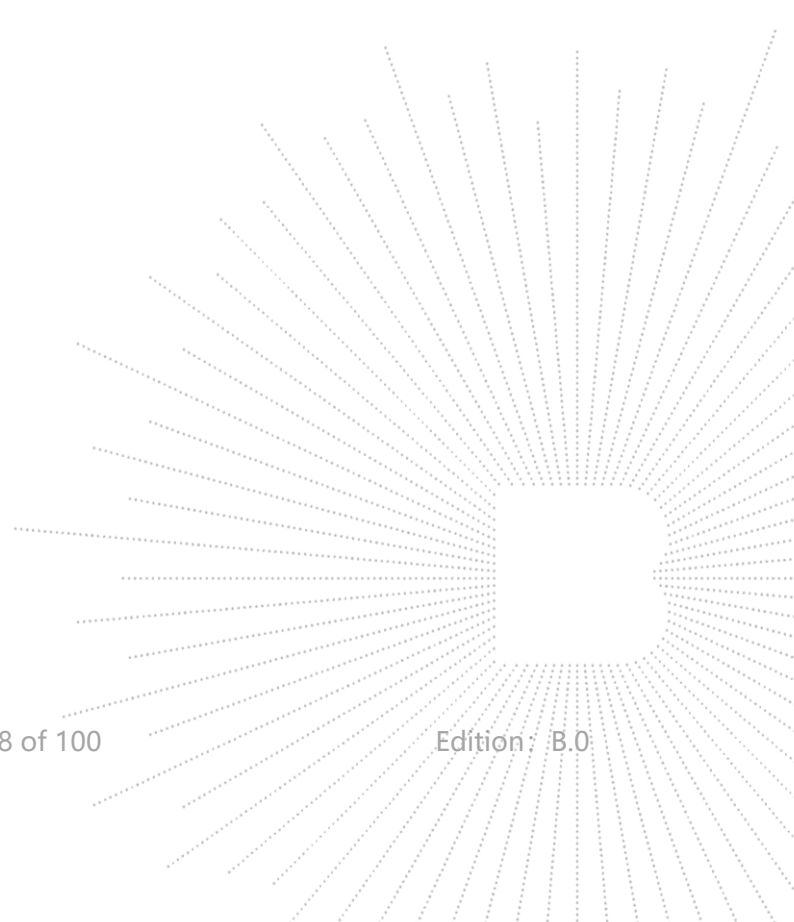


### F. 3D Image



**16 CALIBRATION CERTIFICATES**

**Probe-EPGO420 Calibration Certificate**  
**SID2450Dipole Calibration Certificate**  
**SID5000Dipole Calibration Certificate**





## COMOSAR E-Field Probe Calibration Report

Ref : ACR.199.1.23.BES.A

### SHENZHEN BCTC TECHNOLOGY CO., LTD.

1 ~2/ F, NO. B FACTORY BUILDING, PENGZHOU  
INDUSTRIAL PARK, FUYUAN 1ST ROAD,  
TANGWEI COMMUNITY, FUHAI STREET, BAO'AN  
DISTRICT, SHENZHEN, GUANGDONG, CHINA  
**MVG COMOSAR DOSIMETRIC E-FIELD PROBE**  
SERIAL NO.: 2623-EPGO-420

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 7/18/2024



Accreditations #2-6789  
Scope available on [www.cofrac.fr](http://www.cofrac.fr)

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#### Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric E-Field Probe calibration performed at MVG, using the CALIPROBE test bench, for use with a MVG COMOSAR system only. The test results covered by accreditation are traceable to the International System of Units (SI).

Page: 1/11


**COMOSAR E-FIELD PROBE CALIBRATION REPORT**

Ref: ACR.199.1.23 BES.A

	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Cyrille ONNEE	Measurement Responsible	7/18/2024	
<i>Checked &amp; approved by:</i>	Jérôme Luc	Technical Manager	7/18/2024	
<i>Authorized by:</i>	Yann Toutain	Laboratory Director	7/18/2024	

Yann  
Toutain ID

Signature numérique  
de Yann Toutain ID  
Date : 2024.07.18  
10:38:49 +02'00'

	<i>Customer Name</i>
<i>Distribution :</i>	Shenzhen BCTC Technology Co., Ltd.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Cyrille ONNEE	7/18/2024	Initial release

Page: 2/11

**Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vL**

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## 1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE2
Serial Number	2623-EPGO-420
Product Condition (new / used)	New
Frequency Range of Probe	0.15 GHz-7.5GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.228 MΩ Dipole 2: R2=0.238 MΩ Dipole 3: R3=0.230 MΩ

## 2 PRODUCT DESCRIPTION

### 2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards.



**Figure 1 – MVG COMOSAR Dosimetric E field Probe**

Probe Length	330 mm
Length of Individual Dipoles	24.5 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	2.55 mm
Distance between dipoles / probe extremity	12.7 mm

## 3 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their effect. All calibrations / measurements performed meet the fore-mentioned standards.

### 3.1 SENSITIVITY

The sensitivity factors of the three dipoles were determined using a two step calibration method (air and tissue simulating liquid) using waveguides as outlined in the standards for frequency range 600-7500MHz and using the calorimeter cell method (transfer method) as outlined in the standards for frequency 150-450 MHz.



### 3.2 LINEARITY

The evaluation of the linearity was done in free space using the waveguide, performing a power sweep to cover the SAR range 0.01W/kg to 100W/kg.

### 3.3 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole with the dipole mounted under the flat phantom in the test configuration suggested for system validations and checks. The probe was rotated along its main axis from 0 to 360 degrees in 15-degree steps. The hemispherical isotropy is determined by inserting the probe in a thin plastic box filled with tissue-equivalent liquid, with the plastic box illuminated with the fields from a half wave dipole. The dipole is rotated about its axis (0°–180°) in 15° increments. At each step the probe is rotated about its axis (0°–360°).

### 3.4 BOUNDARY EFFECT

The boundary effect is defined as the deviation between the SAR measured data and the expected exponential decay in the liquid when the probe is oriented normal to the interface. To evaluate this effect, the liquid filled flat phantom is exposed to fields from either a reference dipole or waveguide. With the probe normal to the phantom surface, the peak spatial average SAR is measured and compared to the analytical value at the surface.

The boundary effect uncertainty can be estimated according to the following uncertainty approximation formula based on linear and exponential extrapolations between the surface and  $d_{be} + d_{step}$  along lines that are approximately normal to the surface:

$$SAR_{uncertainty} [\%] = \delta SAR_{be} \frac{(d_{be} + d_{step})^2}{2d_{step}} \frac{(e^{-d_{be}/\delta} - e^{-d_{step}/\delta})}{\delta/2} \quad \text{for } (d_{be} + d_{step}) < 10 \text{ mm}$$

where

$SAR_{uncertainty}$	is the uncertainty in percent of the probe boundary effect
$d_{be}$	is the distance between the surface and the closest <i>zoom-scan</i> measurement point, in millimetre
$\Delta_{step}$	is the separation distance between the first and second measurement points that are closest to the phantom surface, in millimetre, assuming the boundary effect at the second location is negligible
$\delta$	is the minimum penetration depth in millimetres of the head tissue-equivalent liquids defined in this standard, i.e., $\delta \approx 14$ mm at 3 GHz;
$\Delta SAR_{be}$	in percent of SAR is the deviation between the measured SAR value, at the distance $d_{be}$ from the boundary, and the analytical SAR value.

The measured worst case boundary effect  $SAR_{uncertainty}[\%]$  for scanning distances larger than 4mm is 1.0% Limit, 2%).



#### 4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty associated with a SAR probe calibration using the waveguide or calorimetric cell technique depending on the frequency.

The estimated expanded uncertainty (k=2) in calibration for SAR (W/kg) is +/-11% for the frequency range 150-450MHz.

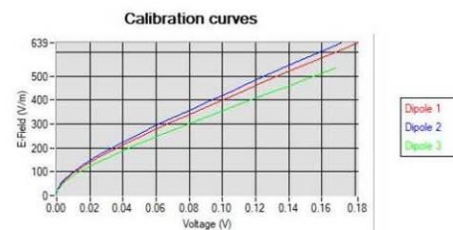
The estimated expanded uncertainty (k=2) in calibration for SAR (W/kg) is +/-14% for the frequency range 600-7500MHz.

#### 5 CALIBRATION RESULTS

Ambient condition	
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

##### 5.1 CALIBRATION IN AIR

The following curve represents the measurement in waveguide of the voltage picked up by the probe toward the E-field generated inside the waveguide.



From this curve, the sensitivity in air is calculated using the below formula.

$$E^2 = \sum_{i=1}^3 \frac{V_i (1 + V_i / DCP_i)}{Norm_i}$$

where

Vi=voltage readings on the 3 channels of the probe

DCPi=diode compression point given below for the 3 channels of the probe

Normi=dipole sensitivity given below for the 3 channels of the probe



Normx dipole 1 ( $\mu\text{V}/(\text{V}/\text{m})^2$ )	Normy dipole 2 ( $\mu\text{V}/(\text{V}/\text{m})^2$ )	Normz dipole 3 ( $\mu\text{V}/(\text{V}/\text{m})^2$ )
1.21	1.09	1.56

DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
106	109	103

## 5.2 CALIBRATION IN LIQUID

The calorimeter cell or the waveguide is used to determine the calibration in liquid using the formula below.

$$ConvF = \frac{E_{liquid}^2}{E_{air}^2}$$

The E-field in the liquid is determined from the SAR measurement according to the below formula.

$$E_{liquid}^2 = \frac{\rho SAR}{\sigma}$$

where

$\sigma$ =the conductivity of the liquid

$\rho$ =the volumetric density of the liquid

SAR=the SAR measured from the formula that depends on the setup used. The SAR formulas are given below

For the calorimeter cell (150-450 MHz), the formula is:

$$SAR = c \frac{dT}{dt}$$

where

$c$ =the specific heat for the liquid

$dT/dt$ =the temperature rises over the time

For the waveguide setup (600-75000 MHz), the formula is:

$$SAR = \frac{4P_W}{ab\delta} e^{-\frac{2z}{\delta}}$$

where

$a$ =the larger cross-sectional of the waveguide

$b$ =the smaller cross-sectional of the waveguide

$\delta$ =the skin depth for the liquid in the waveguide

$P_W$ =the power delivered to the liquid

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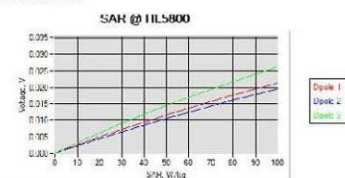
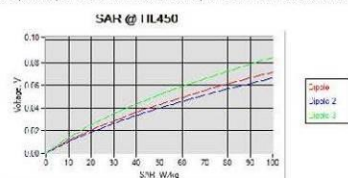

**COMOSAR E-FIELD PROBE CALIBRATION REPORT**

Ref: ACR.199.1.23.BES.A

The below table summarize the ConvF for the calibrated liquid. The curves give examples for the measured SAR depending on the voltage in some liquid.

Liquid	Frequency (MHz*)	ConvF
HL450	450	0.86
BL450	450	0.78
HL750	750	0.80
BL750	750	0.87
HL850	835	0.81
BL850	835	0.80
HL900	900	0.76
BL900	900	0.87
HL1800	1800	0.96
BL1800	1800	1.01
HL1900	1900	1.04
BL1900	1900	1.11
HL2100	2100	1.00
BL2100	2100	1.16
HL2300	2300	1.11
BL2300	2300	1.23
HL2450	2450	1.11
BL2450	2450	1.32
HL2600	2600	1.03
BL2600	2600	1.19
HL5200	5200	1.18
BL5200	5200	0.97
HL5400	5400	1.17
BL5400	5400	1.00
HL5600	5600	1.20
BL5600	5600	0.95
HL5800	5800	1.15
BL5800	5800	1.05

(\*) Frequency validity is  $\pm 50$ MHz below 600MHz,  $\pm 100$ MHz from 600MHz to 6GHz and  $\pm 700$ MHz above 6GHz



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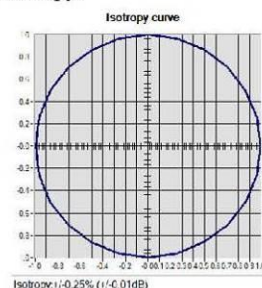
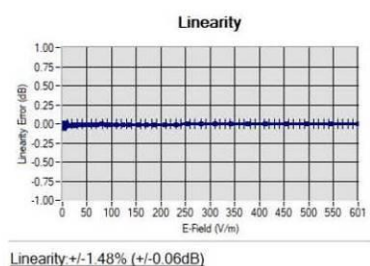
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## 6 VERIFICATION RESULTS

The figures below represent the measured linearity and axial isotropy for this probe. The probe specification is  $\pm 0.2$  dB for linearity and  $\pm 0.15$  dB for axial isotropy.





## 7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
CALIPROBE Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2024	08/2027
Network Analyzer	Agilent 8753ES	MY40003210	10/2023	10/2027
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2025
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2024	06/2027
Power Meter	Keysight U2000A	SN: MY62340002	10/2022	10/2025
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Fluoroptic Thermometer	LumaSense Luxtron 812	94264	09/2022	09/2025
Coaxial cell	MVG	SN 32/16 COAXCELL_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG2_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_0G600_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG4_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_0G900_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG6_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_1G500_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG8_1	Validated. No cal required.	Validated. No cal required.

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**COMOSAR E-FIELD PROBE CALIBRATION REPORT**

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Liquid transition	MVG	SN 32/16 WGLIQ_1G800B_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_1G800H_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG10_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_3G500_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG12_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_5G000_	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG14_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_7G000_1	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024

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## SAR Reference Dipole Calibration Report

Ref : ACR.329.15.21.BES.A

### **SHENZHEN BCTC TECHNOLOGY CO., LTD.**

**1 ~2/ F, NO. B FACTORY BUILDING, PENGZHOU  
INDUSTRIAL PARK, FUYUAN 1ST ROAD,  
TANGWEI COMMUNITY, FUHAI STREET, BAO'AN  
DISTRICT, SHENZHEN, GUANGDONG, CHINA  
MVG COMOSAR REFERENCE DIPOLE**

**FREQUENCY: 2450 MHZ**

**SERIAL NO.: SN 47/21 DIP 2G450-627**

**Calibrated at MVG**

**Z.I. de la pointe du diable**

**Technopôle Brest Iroise – 295 avenue Alexis de Rochon**

**29280 PLOUZANE - FRANCE**

**Calibration date: 11/25/2021**



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#### *Summary:*

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.