SAR TEST REPORT

Report No.:STS2204026H01

Issued for

FrSky Electronic Co., Ltd.

F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi, 214125, Jiangsu, China

Product Name:	Tandem digital radio system
Brand Name:	FRSKY
Model Name:	TANDEM X18
Series Model:	TANDEM X18S, TANDEM X18SE, TANDEM X18PRO
FCC ID:	XYFTDX18HDSP
Test Standard:	ANSI/IEEE Std. C95.1
	FCC 47 CFR Part 2 (2.1093)
	IEEE STD 1528-2013
Max. Report SAR (1g):	Body: 0.715W/kg

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Test Report Certification

Applicant's name ..... :	FrSky Electronic Co., Ltd.
Address..... :	F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi, 214125, Jiangsu, China
Manufacturer's Name..... :	FrSky Electronic Co., Ltd.
Address..... :	F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi, 214125, Jiangsu, China

Product description

Product name..... :	Tandem digital radio system
Brand name ..... :	FRSKY
Model name ..... :	TANDEM X18
Series Model..... :	TANDEM X18S, TANDEM X18SE, TANDEM X18PRO
Standards ..... :	ANSI/IEEE Std. C95.1-1992 FCC 47 CFR Part 2 (2.1093) IEEE STD 1528-2013

The device was tested by Shenzhen STS Test Services Co., Ltd. in accordance with the measurement methods and procedures specified in KDB 865664 The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Date of Test

Date (s) of performance of tests.....:	05 May 2022
Date of Issue .....:	13 May 2022
Test Result .....:	**Pass**

Testing Engineer : Shi fan. long

(Shi fan. Long)

Technical Manager : Sean She

(Sean She)

Authorized Signatory : Bovey Yang

(Bovey Yang)

Table of Contents

Revision History

Rev.	Issue Date	Report No.	Effect Page	Contents
00	13 May 2022	STS2204026H01	ALL	Initial Issue

1. General Information

Environmental evaluation measurements of specific absorption rate (SAR) distributions in emulated human head and body tissues exposed to radio frequency (RF) radiation from wireless portable devices for compliance with the rules and regulations of the U.S. Federal Communications Commission (FCC).

1.1 EUT Description

Product Name	Tandem digital radio system		
Brand Name	FRSKY		
Model Name	TANDEM X18		
Series Model	TANDEM X18S, TANDEM X18SE, TANDEM X18PRO		
Model difference	Different product models only represent different appearance and color of products		
Device Category	Portable		
Product stage	Production unit		
RF Exposure Environment	General Population / Uncontrolled		
Hardware Version	1.0.0		
Software Version	ETHOS 1.1.1		
Frequency Range	Lora: 904 MHz ~ 925 MHz 2.4G: 2403.985 MHz ~2472.985 MHz BLE: 2402~2480MHz		
Max. Reported SAR(1g): (Limit:1.6W/kg)	Band	Mode	Body(W/kg)
	DTS	Lora	0.307
	DTS	2.4G ANT 1	0.715
	DTS	2.4G ANT 2	0.407
	DTS	BLE[Note]	0.642
FCC Equipment Class	Digital Transmission System(DTS)		
Operating Mode:	BLE: GFSK Lora: FSK 2.4G: FSK		
Battery	Rated Voltage: 7.4v 29.6Wh Charge Limit Voltage: 8.4v Capacity: 4000mAh		
Antenna Specification:	Lora: PIFA Antenna 2.4G: PIFA Antenna BLE: PCB Antenna		
Hotspot Mode	Not Support		
DTM Mode	Not Support		
Note: 1. Bluetooth SAR was estimated			

1.2 Test Environment

Ambient conditions in the SAR laboratory:

Items	Required
Temperature (℃)	18-25
Humidity (%RH)	30-70

1.3 Test Factory

ShenZhen STS Test Services Co.,Ltd.

A 1/F, Building B, Zhuoke Science Park, No.190 Chongqing Road, HepingShequ, Fuyong Sub-District, Bao'an District, Shenzhen, Guang Dong, China

FCC test Firm Registration No.: 625569

IC Registration No.: 12108A

A2LA Certificate No.: 4338.01

2. Test Standards and Limits

No.	Identity	Document Title
1	47 CFR Part 2	Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
2	ANSI/IEEE Std. C95.1-1992	IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
3	IEEE Std. 1528-2013	Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques
4	FCC KDB 447498 D04 v01	RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices
5	FCC KDB 865664 D01 v01r04	SAR Measurement 100 MHz to 6 GHz
6	FCC KDB 865664 D02 v01r02	RF Exposure Reporting

(A). Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.4	8.0	20.0

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

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

NOTE: Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1 gram 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.

Population/Uncontrolled Environments:

Are defined as locations where there is the exposure of individuals 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).

NOTE

GENERAL POPULATION/UNCONTROLLED EXPOSURE

PARTIAL BODY LIMIT

1.6 W/kg

3. SAR Measurement System

3.1 Definition of Specific Absorption Rate (SAR)

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.
The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

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

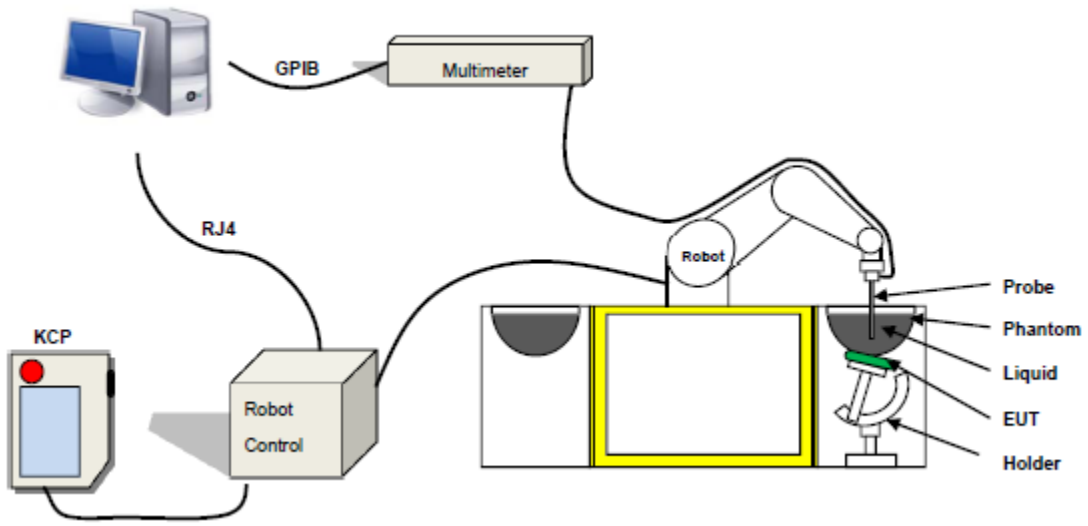
SAR is expressed in units of Watts per kilogram (W/kg) SAR measurement can be related to the electrical field in the tissue by

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

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

3.2 SAR System

MVG SAR System Diagram:



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 Open SAR software computes the results to give a SAR value in a 1g or 10g mass.

3.2.1 Probe

For the measurements the Specific Dosimetric E-Field Probe SN 07/21 EPGO352 with following specifications is used

- Probe Length: 330 mm
- Length of Individual Dipoles: 2 mm
- Maximum external diameter: 8 mm
- Probe Tip External Diameter: 2.5 mm
- Distance between dipole/probe extremity: 1 mm
- Dynamic range: 0.01-100 W/kg
- Probe linearity: 3%
- Axial Isotropy: ＜0.10 dB
- Spherical Isotropy: ＜0.10 dB
- Calibration range: 150 MHz to 6 GHz for head & body simulating liquid.
- Angle between probe axis (evaluation axis) and surface normal line: less than 30°

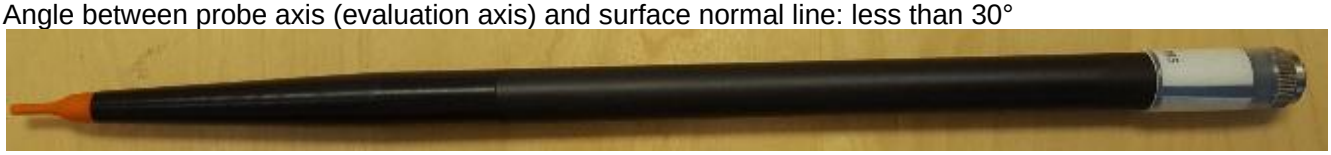


Figure 1-MVG COMOSAR Dosimetric E field Dipole

3.2.2 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.

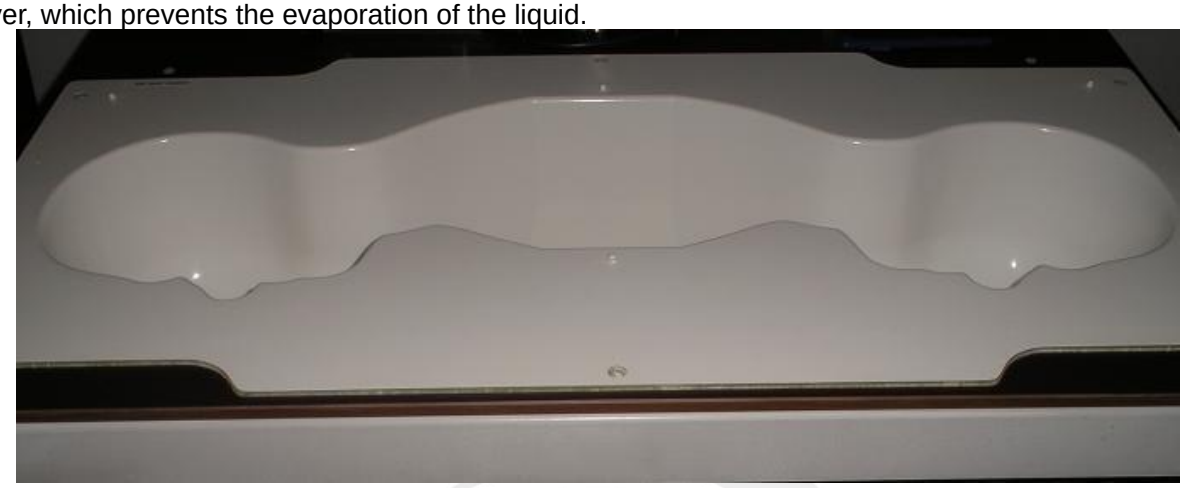
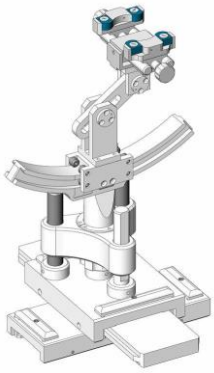


Figure-SN 32/14 SAM115

Figure-SN 32/14 SAM116

3.2.3 Device Holder



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

4. Tissue Simulating Liquids

4.1 Simulating Liquids Parameter Check

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.

Head Tissue

Frequency (MHz)	cellulose	DGBE	HEC	NaCl	Preventol	Sugar	X100	Water	Conductivity	Permittivity
	%	%	%	%	%	%	%	%	σ	εr
750	0.2	/	/	1.4	0.2	57.0	/	41.1	0.89	41.9
835	0.2	/	/	1.4	0.2	57.9	/	40.3	0.90	41.5
900	0.2	/	/	1.4	0.2	57.9	/	40.3	0.97	41.5
1800	/	44.5	/	0.3	/	/	30.45	55.2	1.4	40.0
1900	/	44.5	/	0.3	/	/	30.45	55.2	1.4	40.0
2000	/	44.5	/	0.3	/	/	/	55.2	1.4	40.0
2450	/	44.9	/	0.1	/	/	/	55.0	1.80	39.2
2600	/	45.0	/	0.1	/	/	/	54.9	1.96	39.0

Body Tissue

Frequency (MHz)	cellulose	DGBE	HEC	NaCl	Preventol	Sugar	X100	Water	Conductivity	Permittivity
	%	%	%	%	%	%	%	%	σ	εr
750	0.2	/	/	0.9	0.1	47.2	/	51.7	0.96	55.5
835	0.2	/	/	0.9	0.1	48.2	/	50.8	0.97	55.2
900	0.2	/	/	0.9	0.1	48.2	/	50.8	1.05	55.0
1800	/	29.4	/	0.4	/	/	30.45	70.2	1.52	53.3
1900	/	29.4	/	0.4	/	/	30.45	70.2	1.52	53.3
2000	/	29.4	/	0.4	/	/	/	70.2	1.52	53.3
2450	/	31.3	/	0.1	/	/	/	68.6	1.95	52.7
2600	/	31.7	/	0.1	/	/	/	68.2	2.16	52.3

Tissue dielectric parameters for head and body phantoms				
Frequency	εr		σ S/m	
	Head	Body	Head	Body
300	45.3	58.2	0.87	0.92
450	43.5	56.7	0.87	0.94
900	41.5	55.0	0.97	1.05
1450	40.5	54.0	1.20	1.30
1800	40.0	53.3	1.40	1.52
2450	39.2	52.7	1.80	1.95
3000	38.5	52.0	2.40	2.73
5800	35.3	48.2	5.27	6.00

LIQUID MEASUREMENT RESULTS

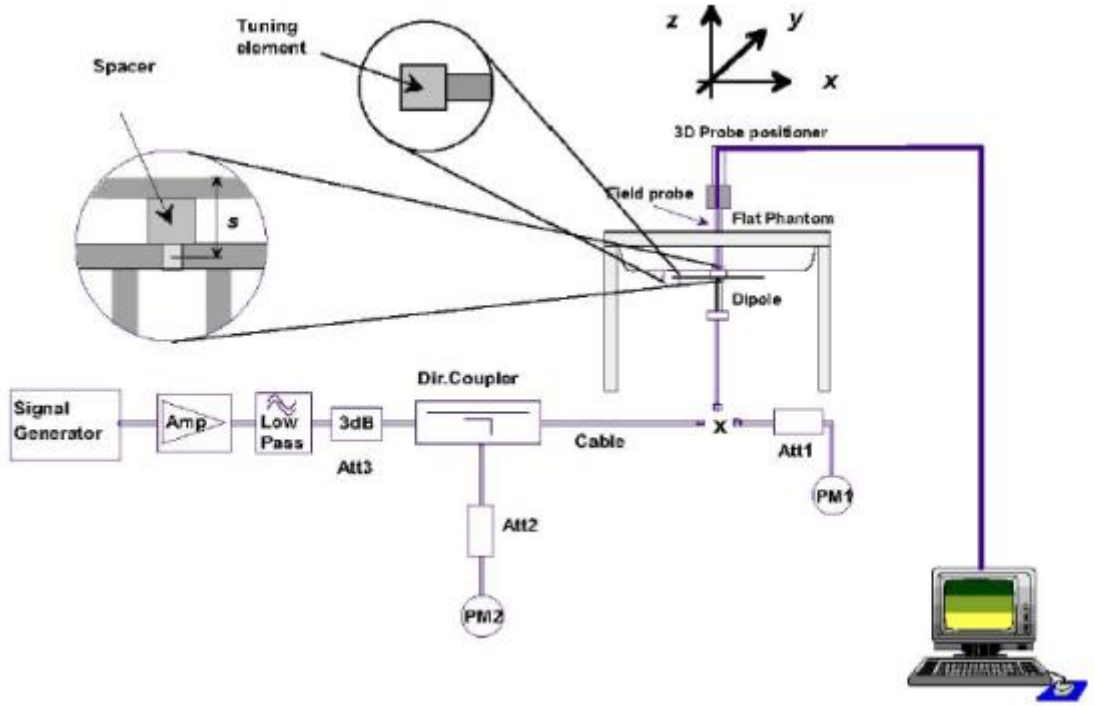
Date	Ambient		Simulating Liquid		Parameters	Target	Measured	Deviation %	Limited %
	Temp. [°C]	Humidity %	Frequency	Temp. [°C]					
2022-05-05	21.9	41	900 MHz	21.5	Permittivity	41.50	40.52	-2.36	±5
					Conductivity	0.97	0.96	-1.03	±5
2022-05-05	21.8	56	904 MHz	21.5	Permittivity	41.49	41.71	0.53	±5
					Conductivity	0.97	0.99	2.06	±5
2022-05-05	23.6	59	2403.985 MHz	23.3	Permittivity	39.27	40.29	2.60	±5
					Conductivity	1.77	1.78	0.56	±5
2022-05-05	20.1	55	2438.485MHz	19.8	Permittivity	39.22	39.32	0.25	±5
					Conductivity	1.79	1.76	-1.68	±5
2022-05-05	23.3	43	2450 MHz	23.0	Permittivity	39.20	38.55	-1.66	±5
					Conductivity	1.80	1.73	-3.89	±5
2022-05-05	21.8	57	2472.985 MHz	21.5	Permittivity	39.17	38.09	-2.76	±5
					Conductivity	1.82	1.82	0.00	±5

5. SAR System Validation

5.1 Validation System

Each MVG system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the MVG software, enable the user to conduct the system performance check and system validation. System kit includes a dipole, and dipole device holder.

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



5.2 Validation Result

Comparing to the original SAR value provided by MVG, the validation data should be within its specification of 10 %.

Date	Freq.	Power	Tested Value	Normalized SAR	Target SAR	Tolerance	Limit
	(MHz)	(mW)	(W/Kg)	(W/kg)	1g(W/kg)	(%)	(%)
2022-05-05	900	100	1.113	11.13	11.10	0.27	10
2022-05-05	2450	100	5.105	51.05	54.70	-6.67	10

Note:

1. The tolerance limit of System validation ±10%.
2. The dipole input power (forward power) was 100 mW.
3. The results are normalized to 1 W input power.

6. SAR Evaluation Procedures

The procedure for assessing the average SAR value consists of the following steps:
The following steps are used for each test position
- Establish a call with the maximum output power with a base station simulator. The connection between the mobile and the base station simulator is established via air interface
- Measurement of the local E-field value at a fixed location. This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid of 8 to 16mm * 8 to16 mm and a constant distance to the inner surface of the phantom. Since the sensors cannot directly measure at the inner phantom surface, the values between the sensors and the inner phantom surface are extrapolated. With these values the area of the maximum SAR is calculated by an interpolation scheme.
- Around this point, a cube of 30 * 30 * 30 mm or 32 * 32 * 32 mm is assessed by measuring 5 or 8 * 5 or 8*4 or 5 mm. With these data, the peak spatial-average SAR value can be calculated.

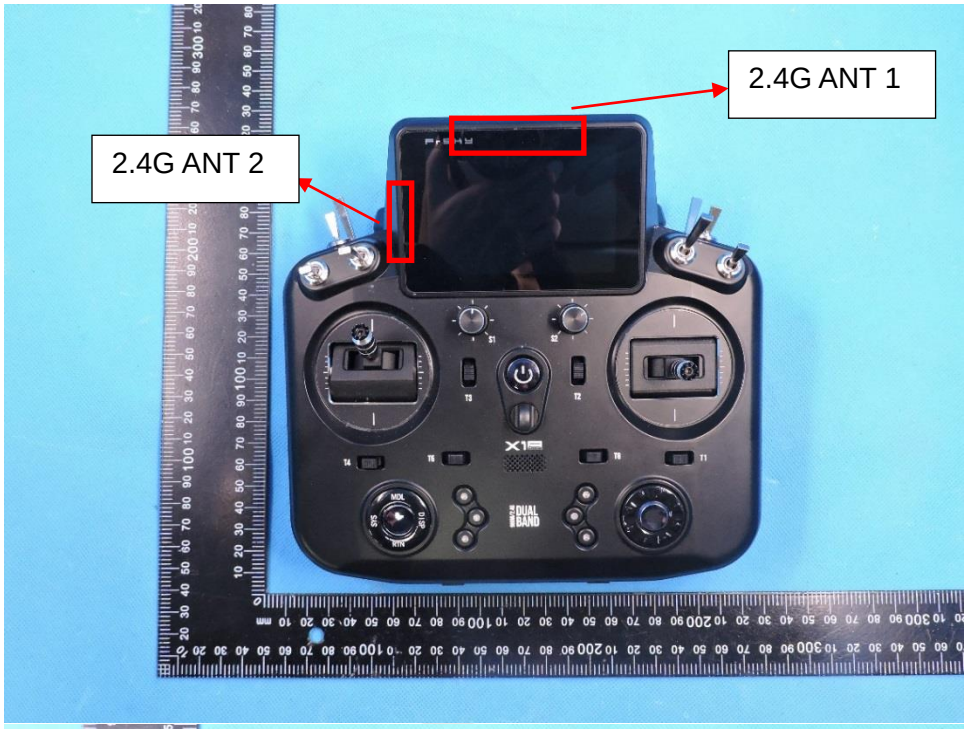
Area Scan& Zoom Scan:

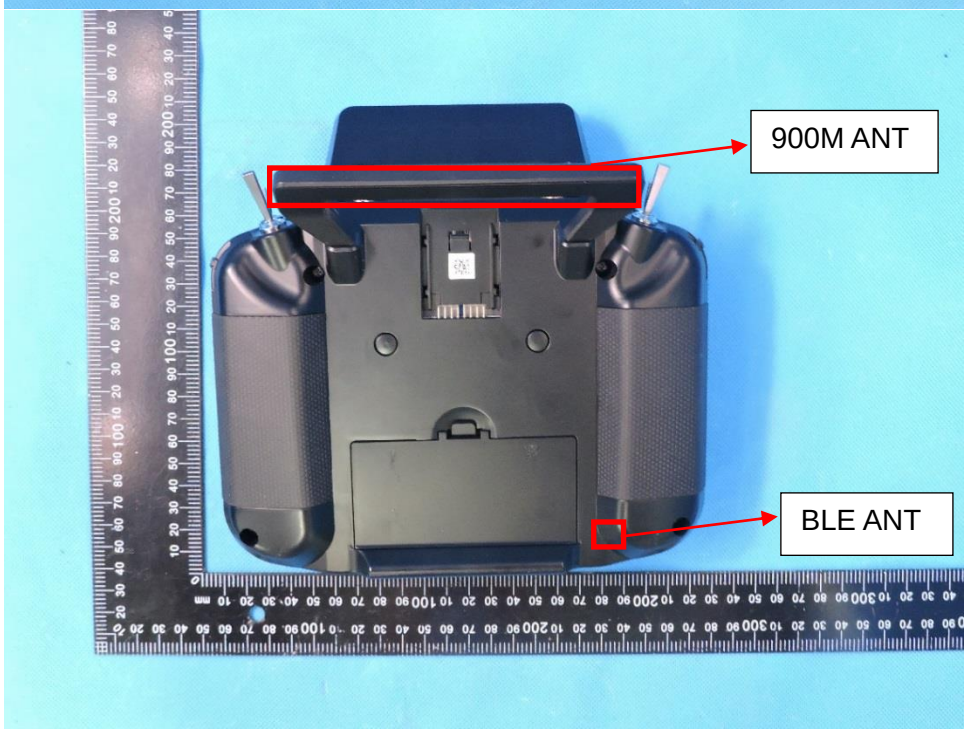
First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR -distribution over 10 g. Area scan and zoom scan resolution setting follows KDB 865664 D01v01r01 quoted below.
When the 1-g SAR of the highest peak is within 2 dB of the SAR limit, additional zoom scans are required for other peaks within 2 dB of the highest peak that have not been included in any zoom scan to ensure there is no increase in SAR.

7. EUT Antenna Location Sketch

It is a Tandem digital radio system, support Lora 2.4G BT mode.

Antenna Location





Antenna Separation Distance(cm)						
ANT	Back Side	Front Side	Left Side	Right Side	Top Side	Bottom Side
BLE	≤0.5	1	3.4	16.3	19	0.8
2.4G ANT 1	≤0.5	≤0.5	8	8	≤0.5	17.7
2.4G ANT 2	≤0.5	≤0.5	4.2	15.2	2	16.5
Lora	≤0.5	3.5	3.4	3.4	≤0.5	15.4

Note 1: The antenna information refer the manufacturer provide report, applicable only to the tested sample identified in the report.

7.1 SAR test exclusion consider table

The Lora /2.4G / BLE SAR evaluation of Maximum power (dBm) summing tolerance.

Exposure Position	Wireless Interface	BLE	2.4G ANT1	2.4G ANT2	Lora
	Calculated Frequency(GHz)	2.402	2.472985	2.472985	0.904
	Maximum Turn-up power (dBm)	0.5	15.5	14	21.5
	Maximum rated power(mW)	1.12	35.48	25.12	141.25
Back Side	Separation distance (cm)	0.5	0.5	0.5	0.5
	exclusion threshold(mW)	2.79	2.72	2.72	8.27
	Testing required?	NO	YES	YES	YES
Front Side	Separation distance (cm)	1	0.5	0.5	3.5
	exclusion threshold(mW)	10.39	2.72	2.72	143.32
	Testing required?	NO	YES	YES	NO
Left Side	Separation distance (cm)	3.4	8	4.2	3.4
	exclusion threshold(mW)	105.98	534.53	156.71	137.35
	Testing required?	NO	NO	NO	YES
Right Side	Separation distance (cm)	16.3	8	15.2	3.4
	exclusion threshold(mW)	2075.45	534.53	1814.55	137.35
	Testing required?	NO	NO	NO	YES
Top Side	Separation distance (cm)	19	0.5	2	0.5
	exclusion threshold(mW)	2776.16	2.72	38.15	8.27
	Testing required?	NO	YES	NO	YES
Bottom Side	Separation distance (cm)	0.8	17.7	16.5	15.4
	exclusion threshold(mW)	6.80	2424.89	2121.46	1257.26
	Testing required?	NO	NO	NO	NO

Note：

1. Maximum power is the source-based time-average power and represents the maximum RF output power among production units.
2. Per KDB 447498 D04, for larger devices, the test separation distance of adjacent edge configuration is determined by the closest separation between the antenna and the user.
3. Per KDB 447498 D04, if the maximum time-averaged power available does not exceed 1 mW. This stand-alone SAR exemption test.
4. Per KDB 447498 D04, the available maximum time-averaged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold Pth (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). Pth is given by:

$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^{x} & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$

Where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$

d = the separation distance (cm);

5. Per KDB 447498 D04, An alternative to the SAR-based exemption is using below table and the minimum separation distance (R in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in below table to apply, R must be at least λ/2π, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of λ/4 or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

RF Source frequency (MHz)	Threshold ERP(watts)
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.

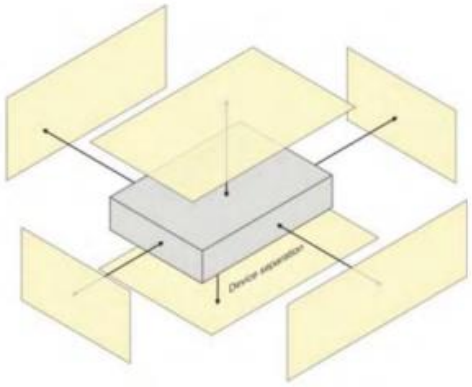
6. Per KDB 248227 D01, choose the highest output power channel to test SAR and determine further SAR exclusion 8.for each frequency band, testing at higher data rates and higher order modulations is not required when the maximum average output power for each of each of these configurations is less than 1/4db higher than those measured at the lower data rate than 11b mode, thus the SAR can be excluded.
7. Per KDB 616217 D04, SAR evaluation for the front surface of tablet display screens are generally not necessary.

8. EUT Test Position

EUT was tested on front and rear left and right top.

8.1 Body-worn Position Conditions

Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in KDB Publication 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. When the same wireless transmission configuration is used for testing body-worn accessory and hotspot mode SAR, respectively, in voice and data mode, SAR results for the most conservative *test separation distance* configuration may be used to support both SAR conditions. When the *reported* SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest *reported* SAR configuration for that wireless mode and frequency band should be repeated for the body-worn accessory with a headset attached to the handset.



9. Measurement Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in IEEE 1528: 2013.This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Uncertainty Component	Tol (+- %)	Prob. Dist.	Div.	Ci (1g)	Ci (10g)	1g Ui (+-%)	10g Ui (+-%)	vi
Measurement System								
Probe calibration	5.86	N	1	1	1	5.86	5.86	∞
Axial Isotropy	0.16	R	$\sqrt{3}$	√0.5	√0.5	0.07	0.07	∞
Hemispherical Isotropy	1.06	R	$\sqrt{3}$	√0.5	√0.5	0.43	0.43	∞
Boundary effect	1	R	$\sqrt{3}$	1	1	0.58	0.58	∞
Linearity	1.27	R	$\sqrt{3}$	1	1	0.73	0.73	∞
System detection limits	1.23	R	$\sqrt{3}$	1	1	0.71	0.71	∞
Modulation response	3.6	R	$\sqrt{3}$	1	1	3.60	3.60	∞
Readout Electronics	0.28	N	1	1	1	0.28	0.28	∞
Response Time	0.19	R	$\sqrt{3}$	1	1	0.11	0.11	∞
Integration Time	1.47	R	$\sqrt{3}$	1	1	0.85	0.85	∞
RF ambient conditions-Noise	3.5	R	$\sqrt{3}$	1	1	2.02	2.02	∞
RF ambient conditions-reflections	3.2	R	$\sqrt{3}$	1	1	1.85	1.85	∞
Probe positioner mechanical tolerance	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Probe positioning with respect to phantom shell	1.4	R	$\sqrt{3}$	1	1	0.81	0.81	∞
Post-processing	2.3	R	$\sqrt{3}$	1	1	1.33	1.33	∞
Test sample Related								
Test sample positioning	3.1	N	1	1	1	3.10	3.10	∞
Device holder uncertainty	3.8	N	1	1	1	3.80	3.80	∞
SAR drift measurement	4.8	R	$\sqrt{3}$	1	1	2.77	2.77	∞
SAR scaling	2	R	$\sqrt{3}$	1	1	1.15	1.15	∞
Phantom and tissue parameters								
Phantom uncertainty (shape and thickness uncertainty)	4	R	$\sqrt{3}$	1	1	2.31	2.31	∞
Uncertainty in SAR correction for deviations in permittivity and conductivity	2	N	1	1	0.84	2.00	1.68	∞
Liquid conductivity (temperature uncertainty)	2.5	R	$\sqrt{3}$	0.78	0.71	1.95	1.78	∞
Liquid conductivity (measured)	4	N	1	0.78	0.71	0.92	1.04	M
Liquid permittivity (temperature uncertainty)	2.5	R	$\sqrt{3}$	0.23	0.26	1.95	1.78	∞
Liquid permittivity (measured)	5	N	1	0.23	0.26	1.15	1.30	M
Combined Standard Uncertainty		RSS				10.60	10.51	
Expanded Uncertainty (95% Confidence interval)		K=2				21.21	21.03	

10. Output Power Measurement

10.1 Maximum test Result

BLE

BLE		
Channel Number	Frequency (MHz)	Average Power (dBm)
0	2402	0.38
19	2440	0.25
39	2480	0.16

Lora

Lora		
Channel Number	Frequency (MHz)	Average Power (dBm)
Low	904 MHz	21.13
Middle	914.5 MHz	20.61
High	925 MHz	20.53

2.4G

2.4G			
Channel Number	Frequency (MHz)	ANT 1 Average Power (dBm)	ANT 2 Average Power (dBm)
Low	2403.985 MHz	14.66	13.39
Middle	2438.485 MHz	14.34	13.71
High	2472.985 MHz	15.16	13.74

11. EUT And Test Setup Photo

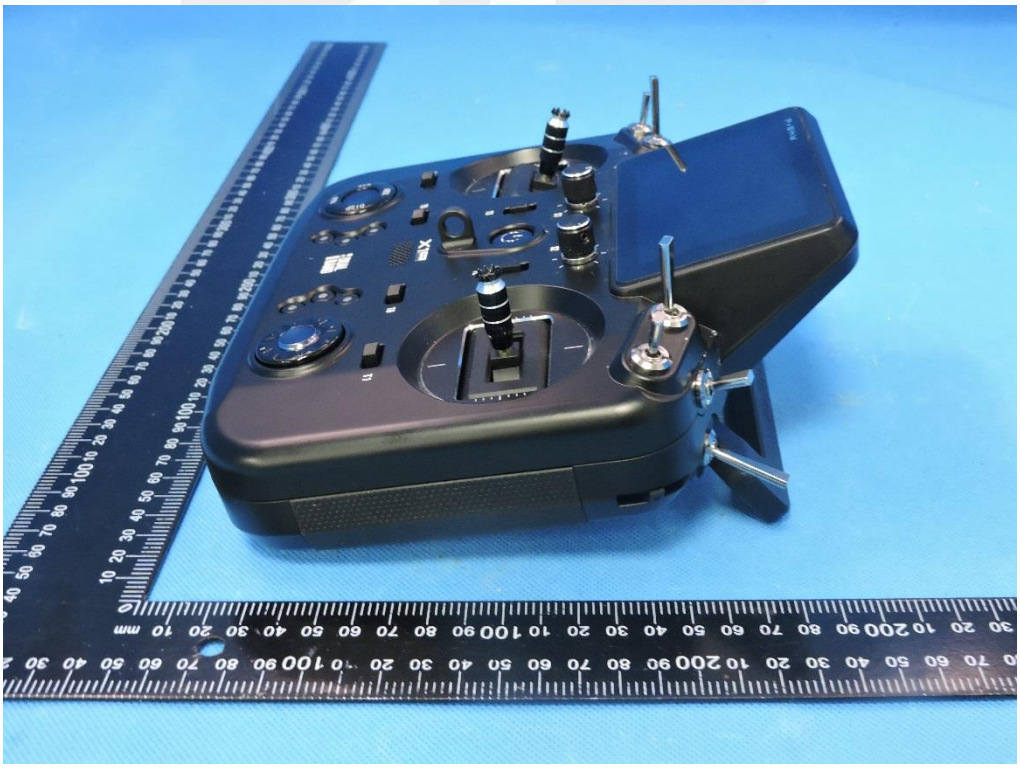
11.1 EUT Photos

Front side

Back side

Left Side

Right Side



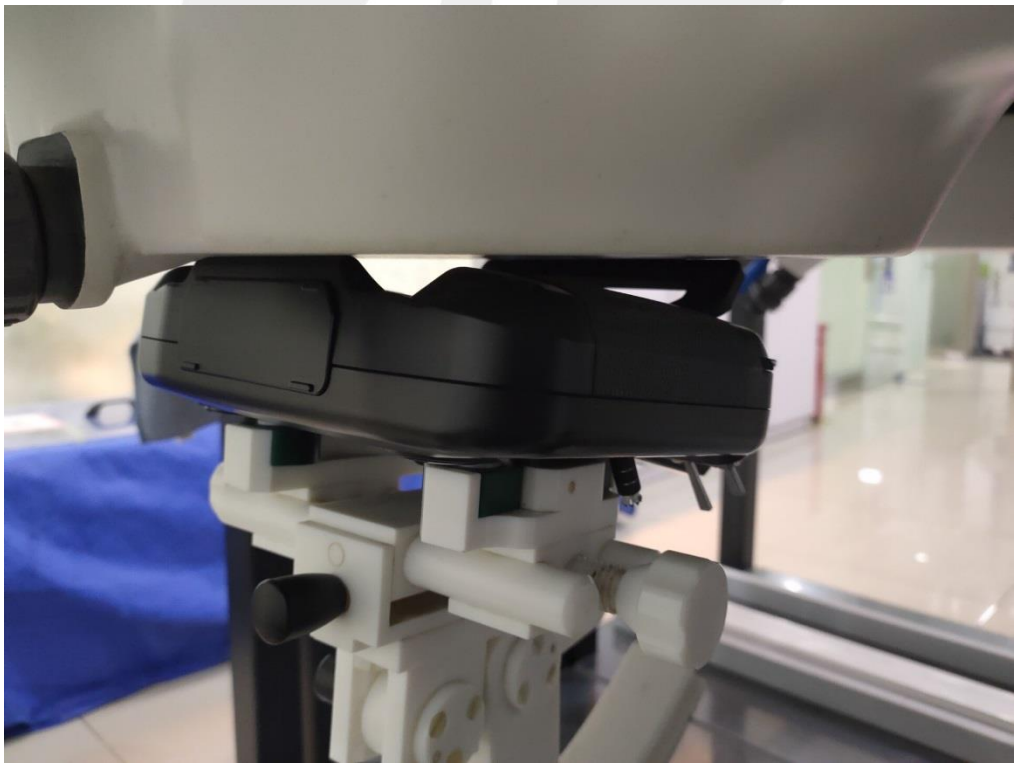
Top Side

Bottom Side

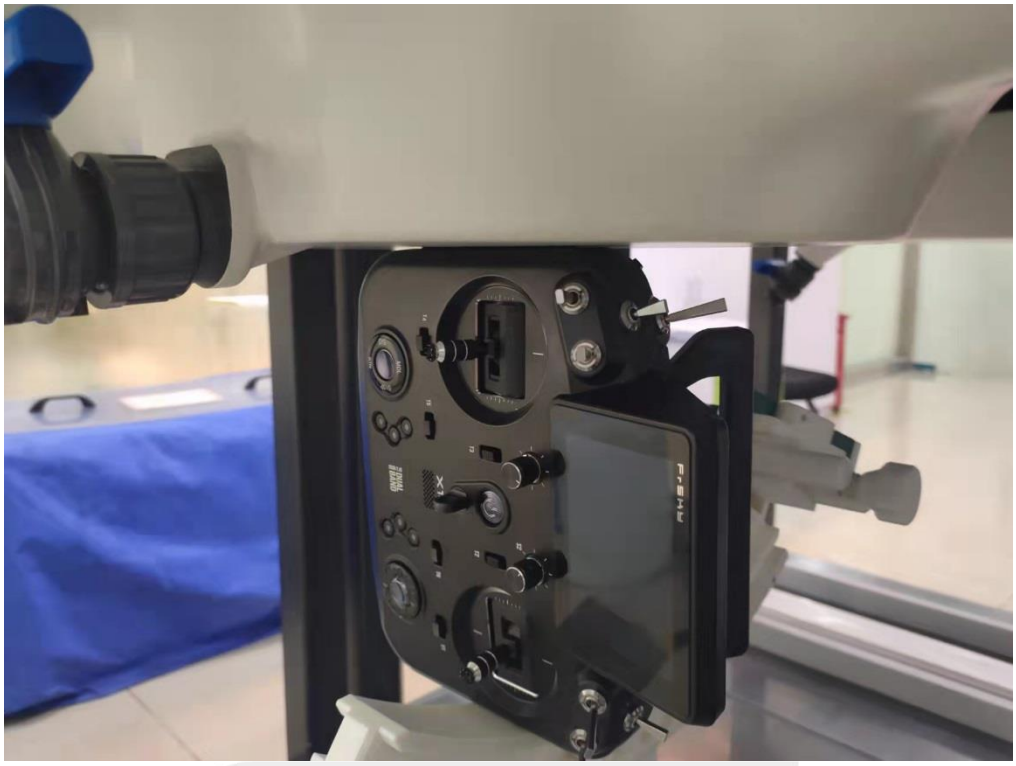
11.2 Setup Photos

Front side

Back side



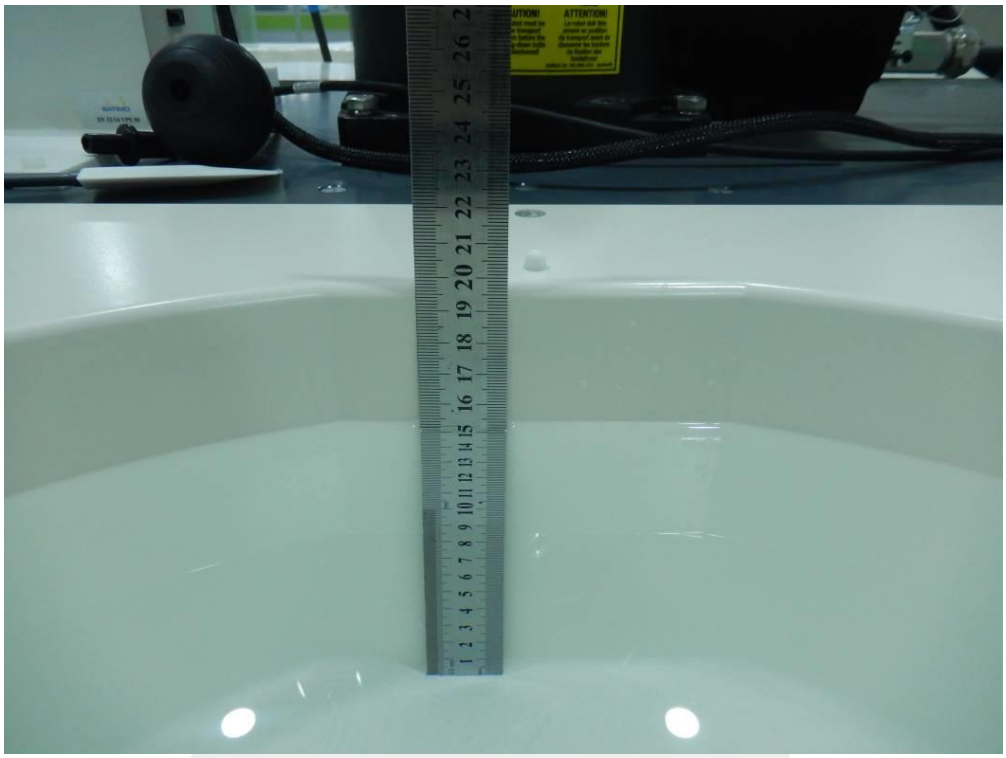
Left Side



Right Side

Top Side

Liquid depth (15 cm)



12. SAR Result Summary

12.1 Body-worn SAR

Band	Model	Test Position	Freq.	SAR (1g) (W/kg)	Power Drift(%)	Max.Turn-up Power(dBm)	Meas.Output Power(dBm)	Scaled SAR (W/Kg)	Meas.No.
Lora	FSK	Back Side	904	0.282	-3.59	21.50	21.13	**0.307**	**1**
		Left Side	904	0.011	3.11	21.50	21.13	0.012	/
		Right Side	904	0.01	-1.69	21.50	21.13	0.011	/
		Top Side	904	0.015	-2.81	21.50	21.13	0.016	/
2.4G ANT1	FSK	Front Side	2472.985	0.072	-1.86	15.50	15.16	0.078	/
		Back Side	2472.985	0.023	-1.29	15.50	15.16	0.025	/
		Top Side	2403.985	0.565	-2.94	15.50	14.66	0.686	**/**
		Top Side	2438.485	0.533	0.06	15.50	14.34	0.696	**/**
		Top Side	2472.985	0.661	-2.62	15.50	15.16	**0.715**	**2**
2.4G ANT2	FSK	Front Side	2472.985	0.046	2.12	14.00	13.74	0.049	/
		Back Side	2472.985	0.383	-2.88	14.00	13.74	**0.407**	3

Note:

1. The test separation of all above table is 0mm.
2. Per KDB 447498 D04, 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. Scaled SAR (W/kg) = Measured SAR(W/kg)*Tune-up Scaling Factor
3. Per KDB 447498 D04, The test reduction process provides for the use of test data for one specific channel, the transmission band span is ≤100 MHz, SAR ≤ 0.8 W/kg for 1-g, testing for other channel is optional.

Simultaneous Multi-band Transmission Evaluation:

Application Simultaneous Transmission information:

Position	Simultaneous State
Body	Lora+2.4G ANT 1
	Lora+2.4G ANT 2
	Lora+BLE
	2.4G ANT 1+BLE
	2.4G ANT 2+BLE

NOTE:

1. 2.4G does not support MIMO mode.
2. If the test separation distance is <5mm, 5mm is used for excluded SAR calculation.
3. KDB 447498 Appendix E, 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:

$$SARest = 1.6 \cdot Pant / Pth \ [W/kg].$$

Pant is maximum time-averaged power or effective radiated power (ERP), whichever is greater, and Pth is defined in Formula KDB 447498 (B.2).

Estimated SAR		Antenna to user(cm)	Pant	Pth	Stand Alone SAR(1g) [W/kg]
BLE	Body	≤0.5	1.12	2.79	0.642

Simultaneous Mode	Position	Mode	Max. 1-g SAR (W/kg)	1-g Sum SAR (W/kg)
Lora+2.4G ANT 1	Body	Lora	0.307	1.022
		2.4G ANT 1	0.715	
Lora+2.4G ANT 2	Body	Lora	0.307	0.714
		2.4G ANT 2	0.407	
Lora+BLE	Body	Lora	0.307	0.949
		BLE	0.642	
2.4G ANT 1+BLE	Body	2.4G ANT 1	0.715	1.357
		BLE	0.642	
2.4G ANT 2+BLE	Body	2.4G ANT 2	0.407	1.049
		BLE	0.642	

Simultaneous transmission SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneous transmitting antenna.

When the sum of SAR 1g of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit (SAR-1g 1.6 W/kg), the simultaneous transmission SAR is not required. When the sum of SAR 1g is greater than the SAR limit (SAR-1g 1.6 W/kg), SAR test exclusion is determined by the SPLSR.

13. Equipment List

Kind of Equipment	Manufacturer	Type No.	Serial No.	Last Calibration	Calibrated Until
900MHz Dipole	MVG	SID900	SN 30/14 DIP0G900-328	2020.07.14	2023.07.13
2450MHz Dipole	MVG	SID2450	SN 30/14 DIP2G450-335	2020.07.14	2023.07.13
E-Field Probe	MVG	SSE2	SN 07/21 EPGO352	2022.02.28	2023.02.27
Dielectric Probe Kit	MVG	SCLMP	SN 32/14 OCPG67	2021.11.23	2022.11.22
Antenna	MVG	ANTA3	SN 07/13 ZNTA52	N/A	N/A
Phantom1	MVG	SAM	SN 32/14 SAM115	N/A	N/A
Phantom2	MVG	SAM	SN 32/14 SAM116	N/A	N/A
Phone holder	MVG	N/A	SN 32/14 MSH97	N/A	N/A
Laptop holder	MVG	N/A	SN 32/14 LSH29	N/A	N/A
Attenuator	Agilent	99899	DC-18GHz	N/A	N/A
Directional coupler	Narda	4226-20	3305	N/A	N/A
Network Analyzer	Agilent	8753ES	US38432810	2021.09.29	2022.09.28
Multi Meter	Keithley	Multi Meter 2000	4050073	2021.10.08	2022.10.07
Signal Generator	Agilent	N5182A	MY50140530	2021.09.30	2022.09.29
Wireless Communication Test Set	Agilent	8960-E5515C	MY48360751	2021.09.30	2022.09.29
Wireless Communication Test Set	R&S	CMW500	117239	2021.09.30	2022.09.29
Power Amplifier	DESAY	ZHL-42W	9638	2021.10.09	2022.10.08
Power Meter	R&S	NRP	100510	2021.09.29	2022.09.28
Power Sensor	R&S	NRP-Z11	101919	2021.09.29	2022.09.28
Temperature hygrometer	SuWei	SW-108	N/A	2021.10.09	2022.10.08
Thermograph	Elitech	RC-4	S/N EF7176501537	2021.10.09	2022.10.08

Note:
Per KDB 865664 D01, Dipole SAR Validation Verification, STS LAB has adopted 3 years calibration intervals. On annual basis, every measurement dipole has been evaluated and is in compliance with the following criteria:
1. There is no physical damage on the dipole
2. System validation with specific dipole is within 10% of calibrated value
Return-loss in within 20% of calibrated measurement

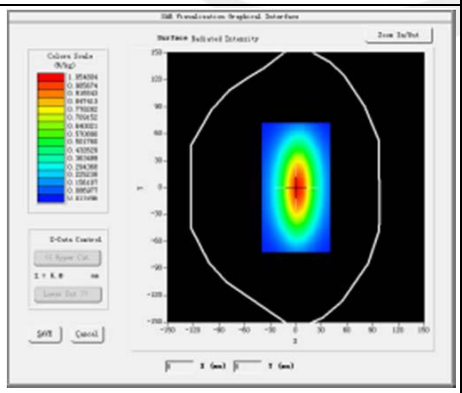
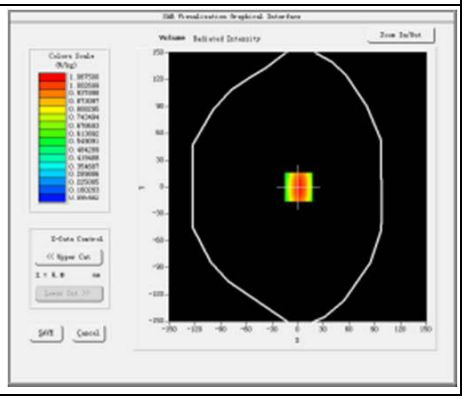
Appendix A. System Validation Plots

System Performance Check Data (900MHz)

Type: Phone measurement (Complete)
Area scan resolution: dx=8mm,dy=8mm
Zoom scan resolution: dx=8mm, dy=8mm, dz=5mm
Date of measurement: 2022-05-05

Experimental conditions.

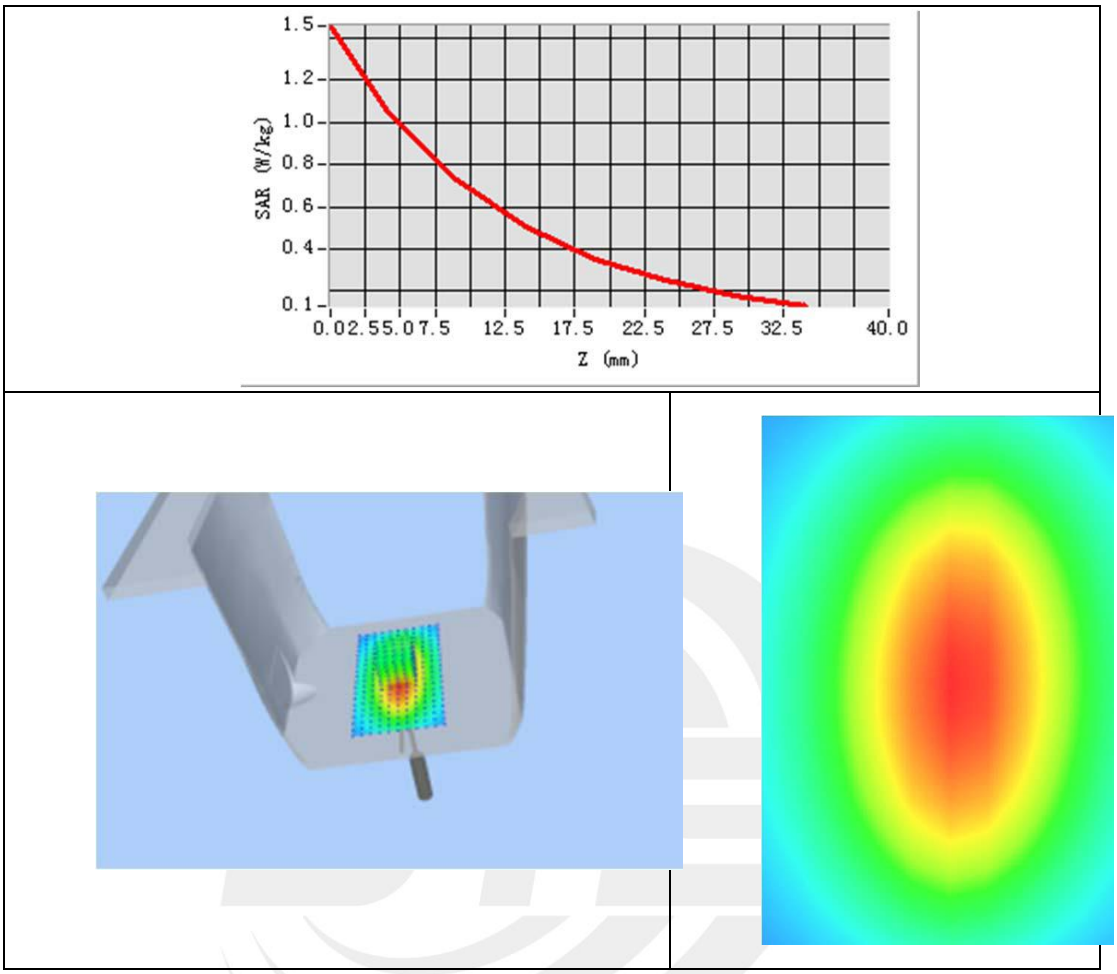
Phantom	Validation plane
Device Position	-
Band	900MHz
Channels	-
Signal	CW
Frequency (MHz)	900MHz
Relative permittivity	40.52
Conductivity (S/m)	0.96
Probe	SN 07/21 EPGO352
ConvF	1.51
Crest factor:	1:1

SURFACE SAR	VOLUME SAR
	

Maximum location: X=7.00, Y=-1.00

SAR 10g (W/Kg)	0.659615
SAR 1g (W/Kg)	1.112722

Z Axis Scan

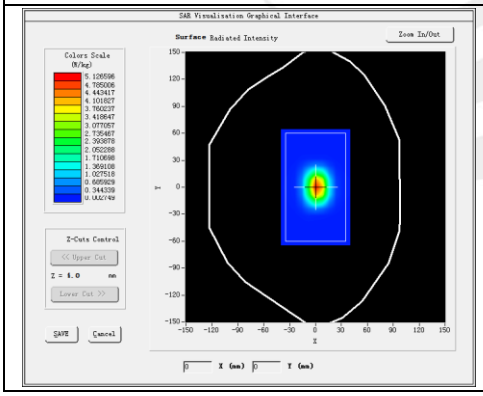
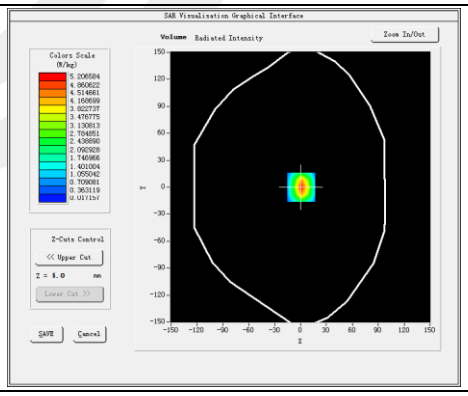


System Performance Check Data (2450MHz)

Type: Phone measurement (Complete)
Area scan resolution: dx=8mm, dy=8mm
Zoom scan resolution: dx=8mm, dy=8mm, dz=5mm
Date of measurement: 2022-05-05

Experimental conditions.

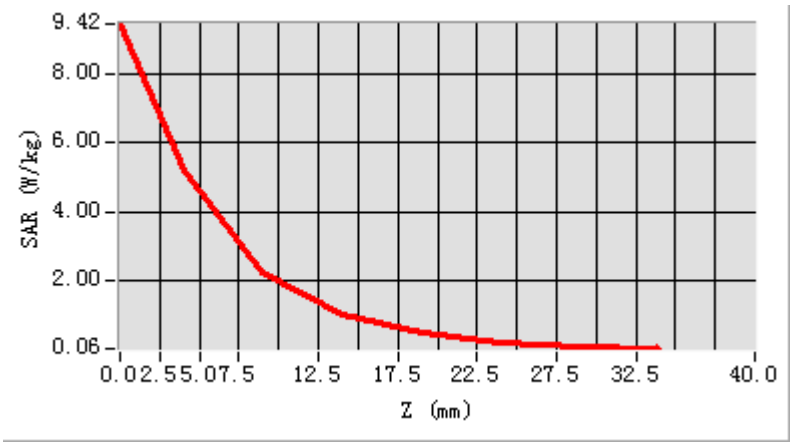
Device Position	Validation plane
Band	2450 MHz
Channels	-
Signal	CW
Frequency (MHz)	2450
Relative permittivity	38.55
Conductivity (S/m)	1.73
Probe	SN 07/21 EPGO352
ConvF	1.75
Crest factor:	1:1

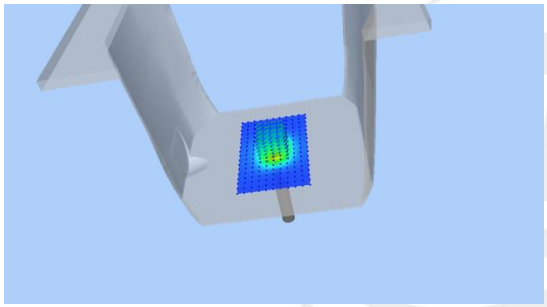
SURFACE SAR	VOLUME SAR
	

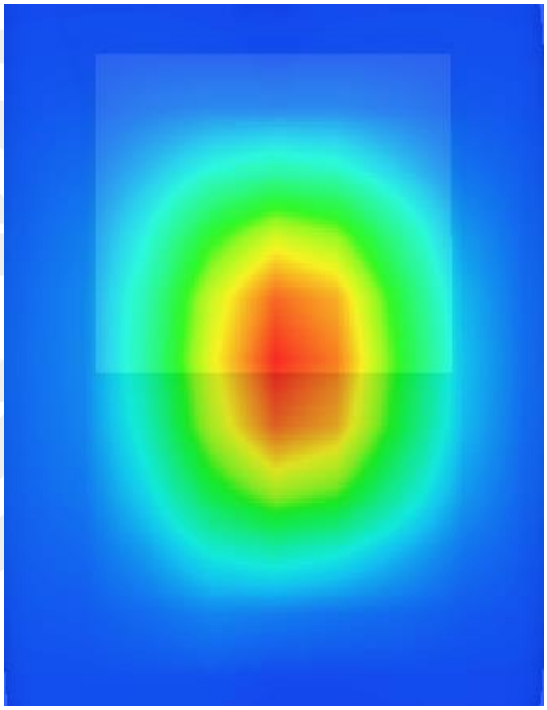
Maximum location: X=1.00, Y=0.00

SAR 10g (W/Kg)	2.395899
SAR 1g (W/Kg)	5.105083

Z Axis Scan


9.42
8.00
6.00
4.00
2.00
0.06
SAR (W/kg)
0.0 2.5 5.0 7.5 12.5 17.5 22.5 27.5 32.5 40.0
Z (mm)





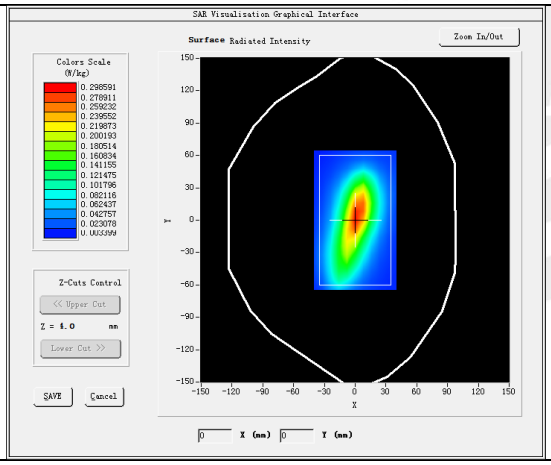
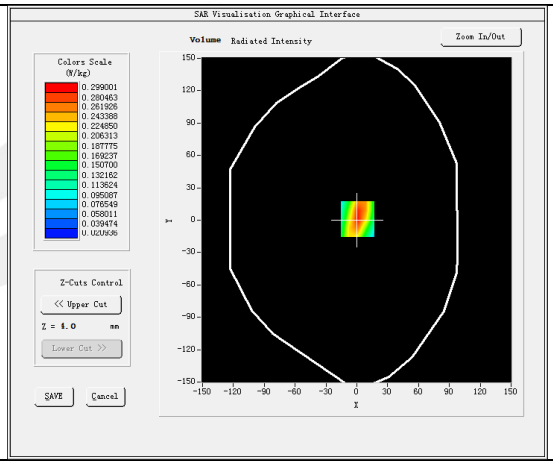
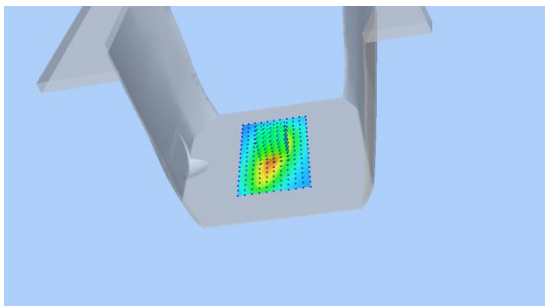
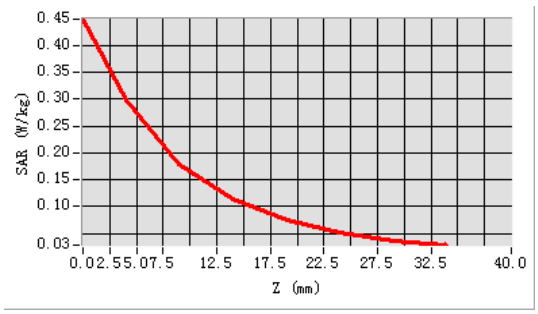
Appendix B. SAR Test Plots

Plot 1: DUT: Tandem digital radio system; EUT Model: TANDEM X18

Test Date	2022-05-05
Probe	SN 07/21 EPGO352
Area Scan	dx=8mm, dy=8mm, h= 5.00 mm
Zoom Scan	5x5x7,dx=8mm, dy=8mm, dz=5mm, Complete/ndx=8mm, dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Back Side
Band	Lora
Signal	Duty Cycle: 1.00 (Crest factor: 1.0)
Frequency (MHz)	904
Relative permittivity (real part)	40.10
Conductivity (S/m)	0.72

Maximum location: X=1.00, Y=1.00
SAR Peak: 0.45 W/kg

SAR 10g (W/Kg)	0.162710
SAR 1g (W/Kg)	0.282258

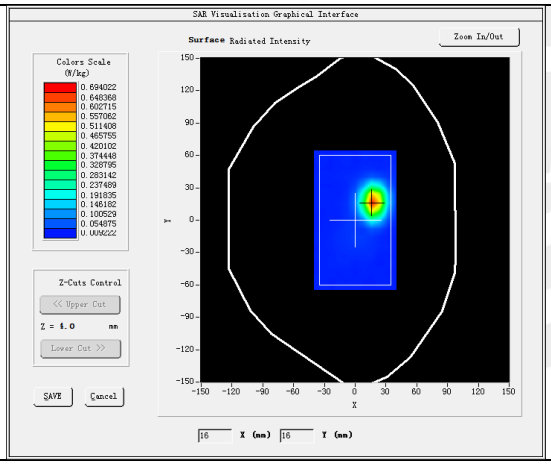
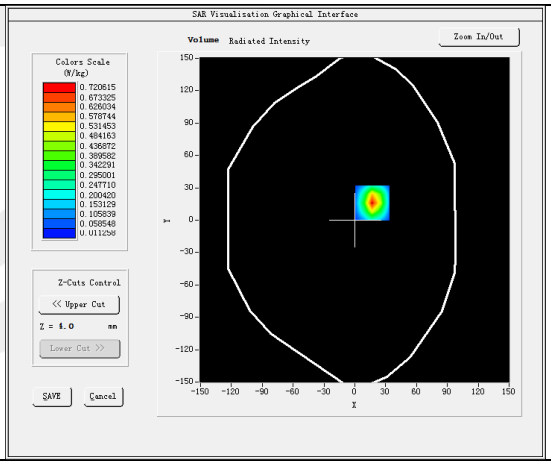
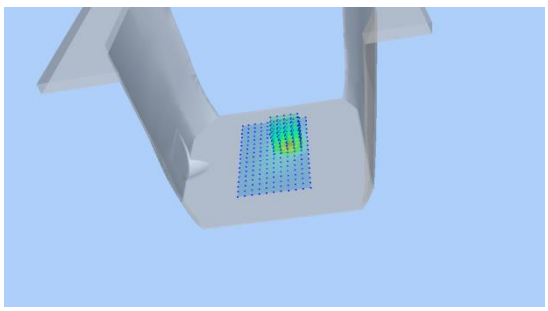
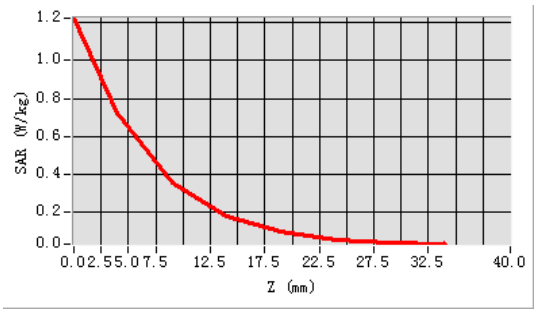
SURFACE SAR	VOLUME SAR
	
3D	**Z Axis Scan**
	

Plot 2: DUT: Tandem digital radio system; EUT Model: TANDEM X18

Test Date	2022-05-05
Probe	SN 07/21 EPGO352
Area Scan	dx=8mm, dy=8mm, h= 5.00 mm
Zoom Scan	5x5x7,dx=8mm, dy=8mm, dz=5mm, Complete/ndx=8mm, dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Top Side
Band	2.4G ANT 1
Signal	Duty Cycle: 1.00 (Crest factor: 1.0)
Frequency (MHz)	2472.985
Relative permittivity (real part)	40.13
Conductivity (S/m)	1.89

Maximum location: X=17.00, Y=16.00
SAR Peak: 1.22 W/kg

SAR 10g (W/Kg)	0.273689
SAR 1g (W/Kg)	0.660513

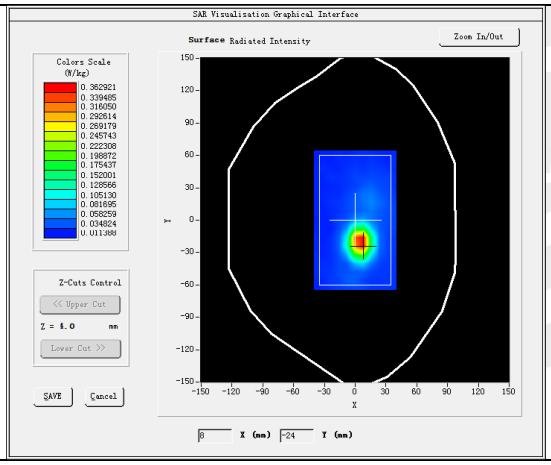
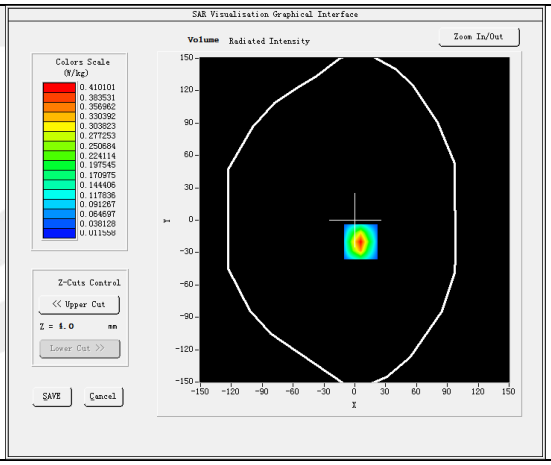
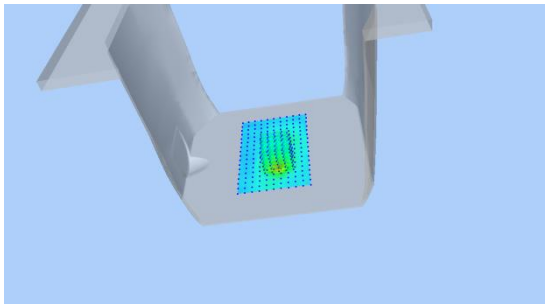
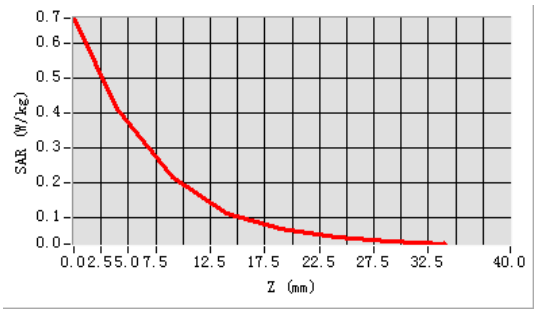
SURFACE SAR	VOLUME SAR
	
3D	**Z Axis Scan**
	

Plot 3: DUT: Tandem digital radio system; EUT Model: TANDEM X18

Test Date	2022-05-05
Probe	SN 07/21 EPGO352
Area Scan	dx=8mm, dy=8mm, h= 5.00 mm
Zoom Scan	5x5x7,dx=8mm, dy=8mm, dz=5mm, Complete/ndx=8mm, dy=8mm, h= 5.00 mm
Phantom	Validation plane
Device Position	Back Side
Band	2.4G ANT 2
Signal	Duty Cycle: 1.00 (Crest factor: 1.0)
Frequency (MHz)	2472.985
Relative permittivity (real part)	40.10
Conductivity (S/m)	1.91

Maximum location: X=6.00, Y=-20.00
SAR Peak: 0.67 W/kg

SAR 10g (W/Kg)	0.166251
SAR 1g (W/Kg)	0.383163

SURFACE SAR	VOLUME SAR
	
3D	**Z Axis Scan**
	

Appendix C. Probe Calibration And Dipole Calibration Report

Refer the appendix Calibration Report.

※※※※※END OF THE REPORT※※※※※