

FCC SAR Test Report

Client Name : Shenzhen Alldocube Science And Technology Co., Ltd.
Address : 1 Floor, A building, 3rd factory, Yujianfeng Industry park, 289#
Huafan Road, Tongsheng community, Dalang, Longhua
District, Shenzhen, China
Product Name : Pad
Date : Nov. 16, 2021

Shenzhen Anbotech Compliance Laboratory Limited



Shenzhen Anbotech Compliance Laboratory Limited

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TEST REPORT

Applicant : Shenzhen Alldocube Science And Technology Co., Ltd.
Manufacturer : Shenzhen Alldocube Science And Technology Co., Ltd.
Product Name : Pad
Model No. : T1021T
Trade Mark : ALLDOCUBE
Rating(s) : DC 3.8V from battery or DC 5V from adapter

**Test Standard(s) : IEEE 1528-2013;
ANSI/IEEE C95.1:2005; FCC 47 CFR Part 2 (2.1093);**

The device described above is tested by Shenzhen Anbotek Compliance Laboratory Limited to determine the maximum emission levels emanating from the device and the severe levels of the device can endure and its performance criterion. The measurement results are contained in this test report and Shenzhen Anbotek Compliance Laboratory Limited is assumed full of responsibility for the accuracy and completeness of these measurements. Also, this report shows that the EUT (Equipment Under Test) is technically compliant with the IEEE 1528-2013, FCC 47 CFR Part 2 (2.1093), ANSI/IEEE C95.1:2005 requirements.

This report applies to above tested sample only and shall not be reproduced in part without written approval of Shenzhen Anbotek Compliance Laboratory Limited.

Date of Test Nov. 03, 2021~ Nov. 16, 2021

Prepared By

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Approved & Authorized Signer

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Version

Version No.	Date	Description
01	Nov. 16, 2021	Original

1. Statement of Compliance

<Highest SAR Summary>

This 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 C95.1-2005, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013

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

<Highest SAR Summary>

Highest SAR Summary			
FrequencyBand	Highest Reported 1g-SAR(W/Kg)		SAR Test Limit (W/Kg)
	Body-worn (0mm)	Hotspot (0mm)	
WCDMA Band II	0.660	0.660	1.6
WCDMA Band V	0.726	0.726	
LTE Band 2	0.635	0.635	
LTE Band 4	0.550	0.550	
WLAN2.4G	0.238	0.238	
WLAN5.1G	0.143	0.143	
WLAN5.8G	0.120	0.120	
BT	0.209	0.209	
Simultaneous Reported SAR (W/Kg)	0.964	0.964	
Test Result	PASS		

This 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 C95.1-2005, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013

2. General Information

2.1. Client Information

Applicant	:	Shenzhen Alldocube Science And Technology Co., Ltd.
Address	:	1 Floor,A building,3rd factory,Yujianfeng Indusrty park,289# Huafan Road,Tongsheng community,Dalang,Longhua District,Shenzhen,China
Manufacturer	:	Shenzhen Alldocube Science And Technology Co., Ltd.
Address	:	1 Floor,A building,3rd factory,Yujianfeng Indusrty park,289# Huafan Road,Tongsheng community,Dalang,Longhua District,Shenzhen,China

2.2. Testing Laboratory Information

Test Site:	:	Shenzhen Anbotek Compliance Laboratory Limited
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2.3. Description of Equipment Under Test (EUT)

Product Name	:	Pad
Model No.	:	T1021T
Trade Mark	:	ALLDOCUBE
Test Power Supply	:	DC 3.8V from Battery or DC 5V from Adapter
Test Sample No.	:	1-2-1(Normal Sample), 1-2-2(Engineering Sample)
Tx Frequency	:	Bluetooth: 2402-2480MHz 2.4G WIFI: 2412-2462MHz 5.1G WIFI: 5180MHz~5240MHz 5.8G WIFI: 5745MHz~5825MHz UMTS Band 2: TX:1852.4~1907.6 MHz UMTS Band 5: TX: 826.4 ~ 846.6 MHz: LTE-FDD Band 2: TX: 1850.7 ~ 1909.3 MHz LTE-FDD Band 4: TX:1710.7 ~ 1754.3 MHz
Type of Modulation	:	WCDMA:QPSK,16QAM LTE: QPSK,16QAM Bluetooth: GFSK, $\pi/4$ DQPSK, 8DPSK WIFI:BPSK,QPSK,16QAM,64QAM 5.2G WIFI:OFDM with BPSK/QPSK/16QAM/64QAM/256QAM 5.8G WIFI:OFDM with BPSK/QPSK/16QAM/64QAM/256QAM
Category of device	:	Portable device
Remark: The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.		

2.4. Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

2.5. Applied Standard

The Specific Absorption Rate (SAR) testing specification, method, and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093:2013)
- ANSI/IEEE C95.1:2005
- IEEE Std 1528:2013
- KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- KDB 865664 D02 RF Exposure Reporting v01r02
- KDB 447498 D01 General RF Exposure Guidance v06
- KDB248227 D01 802.11 Wi-Fi SAR v02r02
- KDB941225 D01 3G SAR Procedures v03r01
- KDB 941225 D05 SAR for LTE Devices v02r05
- KDB 941225 D06 Hotspot SAR v02r01
- KDB648474 D04 Handset SAR v01r03

2.6. Environment of Test Site

Items	Required	Actual
Temperature (°C)	18-25	22~23
Humidity (%RH)	30-70	55~65

2.7. Test Configuration

The device was controlled by using a base station emulator. Communication between the device and the emulator was established by air link. The distance between the EUT and the antenna of the emulator is larger than 50 cm and the output power radiated from the emulator antenna is at least 30 dB smaller than the output power of EUT. The EUT was set from the emulator to radiate maximum output power during all tests. For WLAN SAR testing, WLAN engineering testing software installed on the EUT can provide continuous transmitting RF signal.

3. Specific Absorption Rate (SAR)

3.1. Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/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.

3.2. SAR Definition

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

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

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

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

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

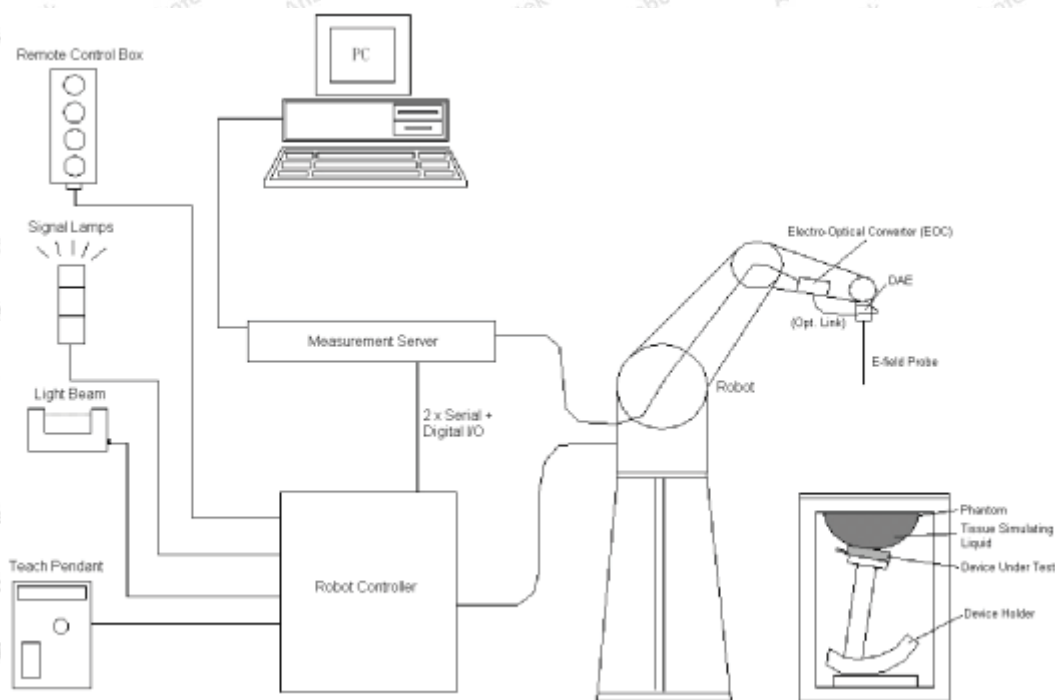
Where: C is the specific heat capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

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

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

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

4. SAR Measurement System



DASY System Configurations

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

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

components are described in details in the following sub-sections.

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4.1. E-Field Probe

The SAR measurement is conducted with the dosimetric probe (manufactured by SPEAG).The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

➤ E-Field Probe Specification
<EX3DV4 Probe>

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



Photo of EX3DV4

➤ E-Field Probe Calibration

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than ± 10%. The spherical isotropy shall be evaluated and within ± 0.25dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data can be referred to appendix C of this report.

4.2. Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock. The input impedance of the DAE is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

**Photo of DAE**

4.3. Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX60XL) type from Stäubli SA (France). For the 6-axis controllersystem, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäublirobot series have many features that are important for our application:

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

**Photo of DASY5**

4.4. Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chipdisk (DASY5: 128 MB), RAM (DASY5: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface

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are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.



Photo of Server for DASY5

4.5. Phantom

<SAM Twin Phantom>

Shell Thickness	2 ± 0.2 mm; Center ear point: 6 ± 0.2 mm
Filling Volume	Approx. 25 liters
Dimensions	Length: 1000 mm; Width: 500 mm; Height: adjustable feet
Measurement Areas	Left Hand, Right Hand, Flat Phantom



Photo of SAM Phantom

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

<ELI4 Phantom>

Shell Thickness	2 ± 0.2 mm (sagging: <1%)
Filling Volume	Approx. 30 liters
Dimensions	Major ellipse axis: 600 mm Minor axis: 400 mm



Photo of ELI4 Phantom

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The ELI4 phantom is intended for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.

4.6. 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 $\pm 0.5\text{mm}$ would produce a SAR uncertainty of $\pm 20\%$. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

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

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



Device Holder

4.7. Data Storage and Evaluation

➤ Data Storage

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

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

➤ Data Evaluation

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

Probe parameters:	- Sensitivity	Norm _i , a _{i0} , a _{i1} , a _{i2}
	- Conversion factor	ConvF _i
	- Diode compression point	dcp _i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

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

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

The formula for each channel can be given as:

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

with V_i = compensated signal of channel i, (i = x, y, z)

U_i = input signal of channel i, (i = x, y, z)

cf = crest factor of exciting field (DASY parameter)

dcp_i = diode compression point (DASY parameter)

From the compensated input signals, the primary field data for each channel can be evaluated:

$$\text{E-field Probes: } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

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

with V_i = compensated signal of channel i, (i = x, y, z)

Norm_i = sensor sensitivity of channel i, (i = x, y, z), $\mu\text{V}/(\text{V}/\text{m})^2$ for E-field Probes

ConvF = sensitivity enhancement in solution

a_{ij} = sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

E_i = electric field strength of channel i in V/m

H_i = magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

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

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

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

with SAR = local specific absorption rate in W/kg

E_{tot} = total field strength in V/m

σ = conductivity in [mho/m] or [Siemens/m]

ρ = equivalent tissue density in g/cm³

Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

5. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	750MHz System Validation Kit	D750V3	1163	Sep. 03,2019	Sep. 02,2022
SPEAG	835MHz System Validation Kit	D835V2	4d154	Jun 16,2021	Jun 15,2024
SPEAG	1750MHz System Validation Kit	D1750V2	1021	Jul. 1,2021	Jul. 02,2024
SPEAG	1900MHz System Validation Kit	D1900V2	5d175	Jun 15,2019	Jun 14,2022
SPEAG	2450MHz System Validation Kit	D2450V2	910	Jun 15,2021	Jun 14,2024
SPEAG	2600MHz System Validation Kit	D2600V2	1058	Jun. 19, 2021	Jun. 18,2024
SPEAG	5GHz System Validation Kit	D5GHzV2	1160	Oct. 02, 2021	Oct. 01, 2024
Rohde & Schwarz	UNIVERSAL RADIO COMMUNICATION TESTER	CMU 200	117888	Oct.22, 2021	Oct.21, 2022
Rohde & Schwarz	UNIVERSAL RADIO COMMUNICATION TESTER	CMW500	1201.0002K50-104 209-JC	Oct.22, 2021	Oct.21, 2022
SPEAG	Data Acquisition Electronics	DAE4	387	Sept.06,2021	Sept.05,2022
SPEAG	Dosimetric E-Field Probe	EX3DV4	7396	May 06,2021	May 05,2022
Agilent	ENA Series Network Analyzer	E5071C	MY46317418	Oct.22, 2021	Oct.21, 2022
SPEAG	DAK	DAK-3.5	1226	NCR	NCR
SPEAG	SAM Twin Phantom	QD000P40CD	1802	NCR	NCR
SPEAG	ELI Phantom	QDOVA004AA	2058	NCR	NCR
AR	Amplifier	ZHL-42W	QA1118004	NCR	NCR
Agilent	Power Meter	N1914A	MY50001102	Oct.22, 2021	Oct.21, 2022
Agilent	Power Sensor	N8481H	MY51240001	Oct.22, 2021	Oct.21, 2022
R&S	Spectrum Analyzer	N9020A	MY51170037	Oct.22, 2021	Oct.21, 2022
Agilent	Signal Generation	N5182A	MY48180656	Oct.22, 2021	Oct.21, 2022
Worken	Directional Coupler	0110A05601O-10	COM5BNW1A2	Oct.22, 2021	Oct.21, 2022

Note:

1. The calibration certificate of DASY can be referred to appendix C of this report.
2. The dipole calibration interval can be extended to 3 years with justification. The dipoles are also not physically damaged, or repaired during the interval.
3. The Insertion Loss calibration of Dual Directional Coupler and Attenuator were characterized via the network analyzer and compensated during system check.
4. The dielectric probe kit was calibrated via the network analyzer, with the specified procedure (calibrated in pure water) and calibration kit (standard) short circuit, before the dielectric measurement. The specific procedure and calibration kit are provided by Agilent.
5. In system check we need to monitor the level on the power meter, and adjust the power amplifier level to have precise power level to the dipole; the measured SAR will be normalized to 1W input power according to the ratio of

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1W to the input power to the dipole. For system check, the calibration of the power amplifier is deemed not critically required for correct measurement; the power meter is critical and we do have calibration for it

6. Tissue Simulating Liquids

For the measurement of the field distribution inside the SAM phantom with DASY, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm, which is shown in Fig. 6.1. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm, which is shown as followed:



Photo of Liquid Height for Head SAR



Photo of Liquid Height for Body SAR

The following table gives the recipes for tissue simulating liquid.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity (σ)	Permittivity (εr)
For Head								
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1750	55.2	0	0	0.3	0	44.5	1.37	40.1
1800,1900,2000	55.2	0	0	0.3	0	44.5	1.40	40.0
2450	55.0	0	0	0	0	45.0	1.80	39.2
2600	54.8	0	0	0.1	0	45.1	1.96	39.0
For Body								
900	50.8	48.2	0	0.9	0.1	0	0.97	55.2

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1750	70.2	0	0	0.4	0	29.4	1.49	53.4
1800,1900,2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7
2600	65.5	0	0	0	0	31.5	2.16	52.5

The following table shows the measuring results for simulating liquid.

Measured Frequency (MHz)	Target Tissue		Measured Tissue				Liquid Temp.	Test Data
	ϵ_r	σ	ϵ_r	Dev. (%)	σ	Dev. (%)		
850	55.2	0.97	55.95	1.36	0.99	2.06	22.3℃	11/08/2021
1750	53.4	1.49	53.87	0.88	1.46	-2.01	22.0℃	11/09/2021
1900	53.3	1.52	54.21	1.71	1.50	-1.32	22.1℃	11/10/2021
2450	52.7	1.95	53.65	1.80	1.93	-1.03	22.2℃	11/11/2021
2600	52.2	2.16	52.82	1.19	2.25	4.17	22.0℃	11/12/2021
5200	48.20	6.00	47.52	-1.41	6.16	2.67	22.0℃	11/05/2021

7. System Verification Procedures

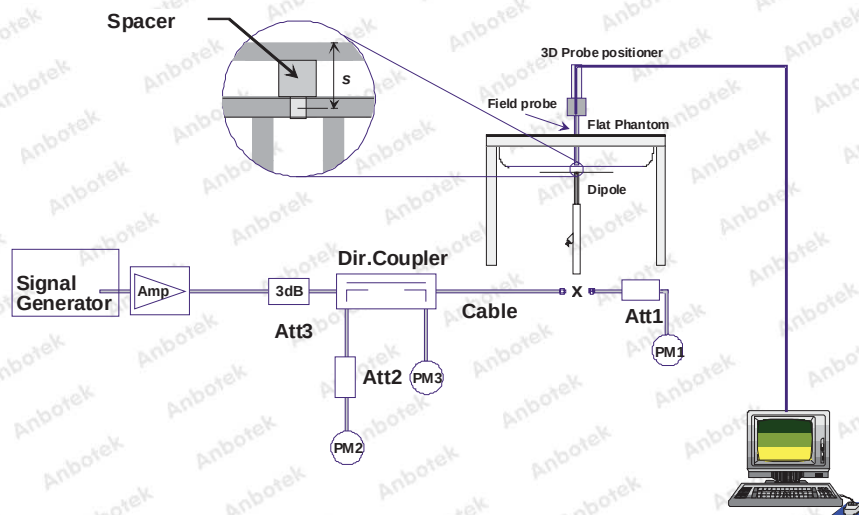
Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix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

➤ Purpose of System Performance check

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

➤ System Setup

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



System Setup for System Evaluation



Photo of Dipole Setup

➤ Validation Results

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

Date	Frequency (MHz)	Power fed onto reference dipole (mW)	Targeted SAR (W/kg)	Measured SAR (W/kg)	Normalized SAR (W/kg)	Deviation (%)
11/08/2021	850	250	9.57	2.49	9.96	4.08
11/09/2021	1750	250	36.7	9.28	37.12	1.14
11/10/2021	1900	250	40.1	10.01	40.04	-0.15
11/11/2021	2450	250	51.8	13.23	52.92	2.16
11/12/2021	2600	250	55.3	13.87	55.48	0.33
11/05/2021	5200	100	77.8	7.92	79.20	1.80

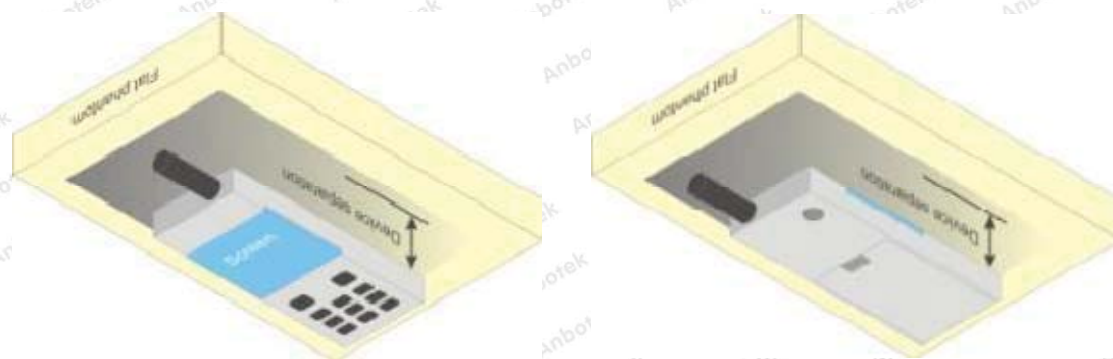
Target and Measurement SAR after Normalized

8. EUT Testing Position

8.1. Body Worn Position

Body-worn operating configurations are tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in a normal use configuration. Per KDB 648474 D04, 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 FCC KDB 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body-worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for body-worn accessory, measured without a headset connected to the handset is $< 1.2 \text{ W/kg}$, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a handset attached to the handset.

Accessories for body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then multiple accessories that contain metallic components are tested with the device with each accessory. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.



Body Worn Position

9. 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 middle channel.
- (b) Keep EUT to radiate maximum output power or 100% duty factor (if applicable)
- (c) Measure output power through RF cable and power meter.
- (d) Place the EUT in the positions as setup photos demonstrates.
- (e) Set scan area, grid size and other setting on the DASY software.
- (f) Measure SAR transmitting at the middle channel for all applicable exposure positions.
- (g) Identify the exposure position and device configuration resulting the highest SAR
- (h) Measure SAR at the lowest and highest channels at the worst exposure position and device configuration if applicable.

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

9.1. Spatial Peak SAR Evaluation

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

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

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

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

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- (f) Calculation of the averaged SAR within masses of 1g and 10g

9.2. Power Reference Measurement

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

9.3. Area Scan Procedures

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum found in the scanned area, within a range of the global maximum. The range (in dB0 is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}	≤ 2 GHz: ≤ 15 mm $2 - 3$ GHz: ≤ 12 mm	$3 - 4$ GHz: ≤ 12 mm $4 - 6$ GHz: ≤ 10 mm

When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.

9.4. Zoom Scan Procedures

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 grams of simulated tissue. The zoom scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the zoom scan evaluates the averaged SAR for 1 gram and 10 grams and displays these values next to the job's label.

Zoom scan parameters extracted from FCC KDB 865664 D01 SAR measurement 100 MHz to 6 GHz.

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.				
* When zoom scan is required and the <u>reported</u> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

9.5. 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. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

9.6. Power Drift Monitoring

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

10. Conducted Power

<WCDMA Conducted Power>

The following tests were conducted according to the test requirements outlines in 3GPP TS 34.121 specification. A summary of these settings are illustrated below:

HSDPA Setup Configuration:

- a. The EUT was connected to Base Station Agilent E5515C referred to the Setup Configuration.
- b. The RF path losses were compensated into the measurements.
- c. A call was established between EUT and Base Station with following setting:
 - i. Set Gain Factors (β_c and β_d) and parameters were set according to each
 - ii. Specific sub-test in the following table, C10.1.4, quoted from the TS 34.121
 - iii. Set RMC 12.2Kbps + HSDPA mode.
 - iv. Set Cell Power = -86 dBm
 - v. Set HS-DSCH Configuration Type to FRC (H-set 1, QPSK)
 - vi. Select HSDPA Uplink Parameters
 - vii. Set Delta ACK, Delta NACK and Delta CQI = 8
 - viii. Set Ack-Nack Repetition Factor to 3
 - ix. Set CQI Feedback Cycle (k) to 4 ms
 - x. Set CQI Repetition Factor to 2
 - xi. Power Ctrl Mode = All Up bits
- d. The transmitted maximum output power was recorded.

Table C.10.1.4: β values for transmitter characteristics tests with HS-DPCCH

Sub-test	β_c	β_d	β_d (SF)	β_c/β_d	β_{hs} (Note 1, Note 2)	CM (dB) (Note 3)	MPR (dB) (Note 3)
1	2/15	15/15	64	2/15	4/15	0.0	0.0
2	12/15 (Note 4)	15/15 (Note 4)	64	12/15 (Note 4)	24/15	1.0	0.0
3	15/15	8/15	64	15/8	30/15	1.5	0.5
4	15/15	4/15	64	15/4	30/15	1.5	0.5
Note 1: Δ_{ACK}, Δ_{NACK} and $\Delta_{CQI} = 30/15$ with $\beta_{hs} = 30/15 * \beta_c$. Note 2: For the HS-DPCCH power mask requirement test in clause 5.2C, 5.7A, and the Error Vector Magnitude (EVM) with HS-DPCCH test in clause 5.13.1A, and HSDPA EVM with phase discontinuity in clause 5.13.1AA, Δ_{ACK} and $\Delta_{NACK} = 30/15$ with $\beta_{hs} = 30/15 * \beta_c$, and $\Delta_{CQI} = 24/15$ with $\beta_{hs} = 24/15 * \beta_c$. Note 3: CM = 1 for $\beta_c/\beta_d = 12/15$, $\beta_{hs}/\beta_c = 24/15$. For all other combinations of DPCCH, DPCCH and HS-DPCCH the MPR is based on the relative CM difference. This is applicable for only UEs that support HSDPA in release 6 and later releases. Note 4: For subtest 2 the β_c/β_d ratio of 12/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to $\beta_c = 11/15$ and $\beta_d = 15/15$.							

Setup Configuration

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HSUPA Setup Configuration:

- The EUT was connected to Base Station Agilent E5515C referred to the Setup Configuration.
- The RF path losses were compensated into the measurements.
- A call was established between EUT and Base Station with following setting * :
 - Call Configs = 5.2B, 5.9B, 5.10B, and 5.13.2B with QPSK
 - Set the Gain Factors (β_c and β_d) and parameters (AG Index) were set according to each specific sub-test in the following table, C11.1.3, quoted from the TS 34.121
 - Set Cell Power = -86 dBm
 - Set Channel Type = 12.2k + HSPA
 - Set UE Target Power
 - Power Ctrl Mode= Alternating bits
 - Set and observe the E-TFCI
 - Confirm that E-TFCI is equal to the target E-TFCI of 75 for sub-test 1, and other subtest's E-TFCI
- The transmitted maximum output power was recorded.

Table C.11.1.3: β values for transmitter characteristics tests with HS-DPCCH and E-DCH

Sub-test	β_c	β_d	β_d (SF)	β_c/β_d	β_{HS} (Note 1)	β_{ec}	β_{ed} (Note 5) (Note 6)	β_{ed} (SF)	β_{ed} (Codes)	CM (dB) (Note 2)	MPR (dB) (Note 2)	AG Index (Note 6)	E-TFCI
1	11/15 (Note 3)	15/15 (Note 3)	64	11/15 (Note 3)	22/15	209/25	1309/225	4	1	1.0	0.0	20	75
2	6/15	15/15	64	6/15	12/15	12/15	94/75	4	1	3.0	2.0	12	67
3	15/15	9/15	64	15/9	30/15	30/15	β_{ed1} : 47/15 β_{ed2} : 47/15	4	2	2.0	1.0	15	92
4	2/15	15/15	64	2/15	4/15	2/15	56/75	4	1	3.0	2.0	17	71
5	15/15 (Note 4)	15/15 (Note 4)	64	15/15 (Note 4)	30/15	24/15	134/15	4	1	1.0	0.0	21	81
Note 1: Δ_{ACK} , Δ_{NACK} and $\Delta_{CQI} = 30/15$ with $\beta_{hs} = 30/15 * \beta_c$. Note 2: CM = 1 for $\beta_c/\beta_d = 12/15$, $\beta_{hs}/\beta_c = 24/15$. For all other combinations of DPDCH, DPCCH, HS-DPCCH, E-DPDCH and E-DPCCH the MPR is based on the relative CM difference. Note 3: For subtest 1 the β_c/β_d ratio of 11/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to $\beta_c = 10/15$ and $\beta_d = 15/15$. Note 4: For subtest 5 the β_c/β_d ratio of 15/15 for the TFC during the measurement period (TF1, TF0) is achieved by setting the signalled gain factors for the reference TFC (TF1, TF1) to $\beta_c = 14/15$ and $\beta_d = 15/15$. Note 5: In case of testing by UE using E-DPDCH Physical Layer category 1, Sub-test 3 is omitted according to TS25.306 Table 5.1g. Note 6: β_{ed} can not be set directly, it is set by Absolute Grant Value.													

Setup Configuration

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<WCDMA Conducted Power>

WCDMA	Band II (dBm)				Band V (dBm)			
TX Channel	Tune-up	9262	9400	9538	Tune-up	4132	4183	4233
Frequency (MHz)	power	1852.4	1880.0	1907.6	power	826.4	836.6	846.6
RMC 12.2Kbps	22	22.77	22.93	22.82	22.1	22.76	23.06	22.79
HSDPA Subtest-1	22.1	22.75	23.02	22.73	22	22.83	22.76	22.60
HSDPA Subtest-2	22	22.91	22.68	22.69	22	22.89	22.60	22.80
HSDPA Subtest-3	22	22.76	22.66	22.82	22	22.56	22.73	22.64
HSDPA Subtest-4	22	22.64	22.90	22.81	22	22.56	22.95	22.80
HSUPA Subtest-1	21	21.86	20.68	20.73	22.1	21.88	23.06	22.56
HSUPA Subtest-2	21	21.66	21.96	21.06	22	21.82	22.79	22.76
HSUPA Subtest-3	21.3	21.59	21.87	22.22	22	21.63	22.83	22.60
HSUPA Subtest-4	21	21.66	21.88	21.17	22	21.82	22.89	22.73
HSUPA Subtest-5	21.3	22.19	20.81	22.25	22	22.76	22.56	22.95

General Note

1. Per KDB 941225 D01 v02, RMC 12.2kbps setting is used to evaluate SAR. If AMR 12.2kbps power is < 0.25dB higher than RMC 12.2kbps, SAR tests with AMR 12.2kbps can be excluded.
2. By design, AMR and HSDPA/HSUPA RF power will not be larger than RMC 12.2kbps, detailed information is included in Tune-up Procure exhibit.
3. It is expected by the manufacturer that MPR for some HSDPA/HSUPA subtests may differ from the specification of 3GPP, according to the chipset implementation in this model. The implementation and expected deviation are detailed in tune-up procedure exhibit.

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LTE Mode:

LTE FDD Band 2				
TX Channel Bandwidth	Frequency (MHz)	RB Size/Offset	Burst Average Power [dBm]	
			QPSK	16QAM
1.4 MHz	1850.7	1 RB low	23.92	22.68
		1 RB high	23.87	22.70
		50% RB mid	23.93	22.79
		100% RB	22.89	21.97
	1880.0	1 RB low	23.22	23.25
		1 RB high	23.26	23.28
		50% RB mid	23.26	23.26
		100% RB	23.38	22.42
	1909.3	1 RB low	23.42	23.17
		1 RB high	23.41	23.16
		50% RB mid	23.42	23.16
		100% RB	23.55	22.21
3 MHz	1851.5	1 RB low	22.78	22.02
		1 RB high	22.78	22.04
		50% RB mid	22.68	22.05
		100% RB	22.80	21.96
	1880.0	1 RB low	23.10	21.88
		1 RB high	23.14	22.29
		50% RB mid	23.08	22.26
		100% RB	22.23	21.61
	1908.5	1 RB low	23.38	22.29
		1 RB high	23.29	22.35
		50% RB mid	23.15	22.30
		100% RB	22.78	21.62
5 MHz	1852.5	1 RB low	22.79	21.97
		1 RB high	22.80	21.96
		50% RB mid	22.92	21.96
		100% RB	22.62	21.87
	1880.0	1 RB low	23.36	22.14
		1 RB high	23.33	22.12
		50% RB mid	23.37	22.16
		100% RB	22.37	21.44
	1907.5	1 RB low	23.40	22.03

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10 MHz	1855.0	1 RB high	23.42	22.09
		50% RB mid	23.18	22.09
		100% RB	22.42	21.56
		1 RB low	22.72	21.80
	1880.0	1 RB high	22.49	21.81
		50% RB mid	22.72	21.82
		100% RB	22.71	21.85
		1 RB low	23.33	22.24
	1905.0	1 RB high	23.32	22.25
		50% RB mid	23.28	22.16
		100% RB	22.40	21.55
		1 RB low	23.28	22.45
15 MHz	1857.5	1 RB high	22.59	21.79
		50% RB mid	22.53	21.79
		100% RB	22.58	21.70
		1 RB low	23.17	22.89
	1880.0	1 RB high	23.21	22.87
		50% RB mid	23.10	22.77
		100% RB	22.19	21.45
		1 RB low	23.30	22.42
	1902.5	1 RB high	23.31	22.43
		50% RB mid	22.39	22.30
		100% RB	22.44	21.48
		1 RB low	22.60	21.93
20 MHz	1860.0	1 RB high	22.78	21.97
		50% RB mid	22.70	21.95
		100% RB	22.69	21.65
		1 RB low	23.59	22.97
	1880.0	1 RB high	23.99	22.75
		50% RB mid	22.85	22.88
		100% RB	22.40	21.56
		1 RB low	22.83	22.36
	1900.0	1 RB high	23.00	22.19
		50% RB mid	21.52	21.33
		100% RB	22.36	21.68

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LTE FDD Band 4				
TX Channel Bandwidth	Frequency (MHz)	RB Size/Offset	Average Power [dBm]	
			QPSK	16QAM
1.4 MHz	1710.7	1 RB low	23.14	21.92
		1 RB high	23.05	21.93
		50% RB mid	23.05	21.69
		100% RB	21.96	21.25
	1732.5	1 RB low	23.02	22.79
		1 RB high	23.04	22.85
		50% RB mid	22.95	22.86
		100% RB	23.15	21.78
	1754.3	1 RB low	23.00	22.15
		1 RB high	22.92	22.15
		50% RB mid	22.94	22.14
		100% RB	22.90	21.74
3 MHz	1711.5	1 RB low	22.18	21.23
		1 RB high	22.05	21.31
		50% RB mid	22.08	21.38
		100% RB	22.26	21.30
	1732.5	1 RB low	23.15	21.97
		1 RB high	23.07	21.99
		50% RB mid	23.12	22.02
		100% RB	22.19	21.47
	1753.5	1 RB low	23.08	21.70
		1 RB high	23.03	21.64
		50% RB mid	23.01	21.70
		100% RB	21.98	21.27
5 MHz	1712.	1 RB low	22.19	21.41
		1 RB high	22.14	21.03
		50% RB mid	22.03	21.46
		100% RB	22.19	21.33
	1732.5	1 RB low	23.13	21.74
		1 RB high	23.17	21.68
		50% RB mid	23.18	21.79
		100% RB	22.13	21.28
	1752.5	1 RB low	22.88	22.14

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10 MHz	1715.0	1 RB high	22.83	22.15
		50% RB mid	22.80	22.13
		100% RB	21.96	20.96
		1 RB low	22.17	21.19
	1732.5	1 RB high	22.12	21.25
		50% RB mid	21.93	21.05
		100% RB	22.29	21.32
		1 RB low	23.10	22.17
	1750.0	1 RB high	23.09	22.19
		50% RB mid	23.13	22.25
		100% RB	22.02	21.26
		1 RB low	23.21	21.84
15 MHz	1717.5	1 RB high	23.21	21.46
		50% RB mid	22.98	21.49
		100% RB	22.20	21.15
		1 RB low	22.18	21.36
	1732.5	1 RB high	22.19	21.28
		50% RB mid	22.22	21.23
		100% RB	22.20	21.34
		1 RB low	23.71	22.73
	1747.5	1 RB high	23.62	22.68
		50% RB mid	23.47	22.66
		100% RB	22.17	21.29
		1 RB low	23.33	22.71
20 MHz	1720.0	1 RB high	23.24	22.54
		50% RB mid	23.13	22.54
		100% RB	21.85	21.05
		1 RB low	22.16	21.58
	1732.5	1 RB high	22.06	21.48
		50% RB mid	22.29	21.49
		100% RB	22.33	21.46
		1 RB low	23.77	22.65
	1745.0	1 RB high	23.78	22.62
		50% RB mid	23.87	22.56
		100% RB	22.06	21.38
		1 RB low	23.79	23.11
		1 RB high	23.68	22.89
		50% RB mid	23.66	22.85
		100% RB	22.05	21.37

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<WLAN 2.4GHz Conducted Power>

Mode	Channel	Frequency (MHz)	Conducted Output Power(Average, dBm)
802.11b	1	2412	13.57
	6	2437	12.72
	11	2462	13.67
802.11g	1	2412	12.65
	6	2437	12.62
	11	2462	13.22
802.11n(20MHz)	1	2412	12.94
	6	2437	12.89
	11	2462	13.28
802.11n(40MHz)	3	2422	12.68
	6	2437	12.94
	9	2452	13.75

Mode	Channel Frequency (MHz)	Average Power output (dBm)
802.11a	5180	8.71
	5200	9.22
	5240	9.44
802.11n20	5180	7.19
	5200	7.55
	5240	8.09
802.11ac20	5180	7.33
	5200	7.66
	5240	7.79
802.11n40	5190	7.30
	5230	7.64
802.11ac40	5190	7.79
	5230	7.89
802.11ac80	5210	7.95

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Mode	Channel Frequency (MHz)	Average Power output (dBm)
802.11a	5745	7.38
	5785	6.45
	5825	7.49
802.11n20	5745	7.56
	5785	6.74
	5825	7.86
802.11ac20	5745	7.62
	5785	6.75
	5825	7.75
802.11n40	5755	7.82
	5795	7.69
802.11ac40	5755	7.51
	5795	7.28
802.11ac80	5775	6.96

Note:

1. Per KDB 447498 D01, the 1-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 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, where

$f(\text{GHz})$ 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

Mode	Frequency (GHz)	Tune-up Power (dBm)	Max. Power (mW)	Test distance (mm)	Result	exclusion thresholds for 1-g SAR
802.11b	2462	14	25.12	5	7.883	3.0
802.11a	5240	9.5	8.91	5	4.079	3.0
802.11a	5825	8	6.31	5	3.046	3.0

2. Base on the result of note1, RF exposure evaluation of 2.4G/5.2G/5.8G WIFI mode is required.

3. Per KDB 248227 D01, choose the highest output power channel to test SAR and determine further SAR exclusion.

4. Per KDB 248227 D01, In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. SAR is not required for the following 2.4 GHz OFDM conditions:

1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.

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2) When the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

DSSS SAR value * (OFDM power/DSSS power) = $0.238 \text{ W/kg} * (23.71 \text{ mW}/23.28 \text{ mW}) = 0.242 \text{ W/kg} \leq 1.2 \text{ W/kg}$, so the ratio of OFDM is not required RF exposure evaluation

<Bluetooth Conducted Power>

Mode	Frequency (MHz)	Conducted Power (dBm)	Tune-up power (dBm)
BLE-GFSK	2402	5.94	5
	2440	6.79	6
	2480	6.71	6
GFSK	2440	2.25	2.5
$\pi/4$ DQPSK	2440	4.06	3.5
8DPSK	2440	4.44	3.5

Note:

Per KDB 447498 D01v05r02, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 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 ≤ 7.5 for 10-g extremity SAR

$f(\text{GHz})$ is the RF channel transmit frequency in GHz

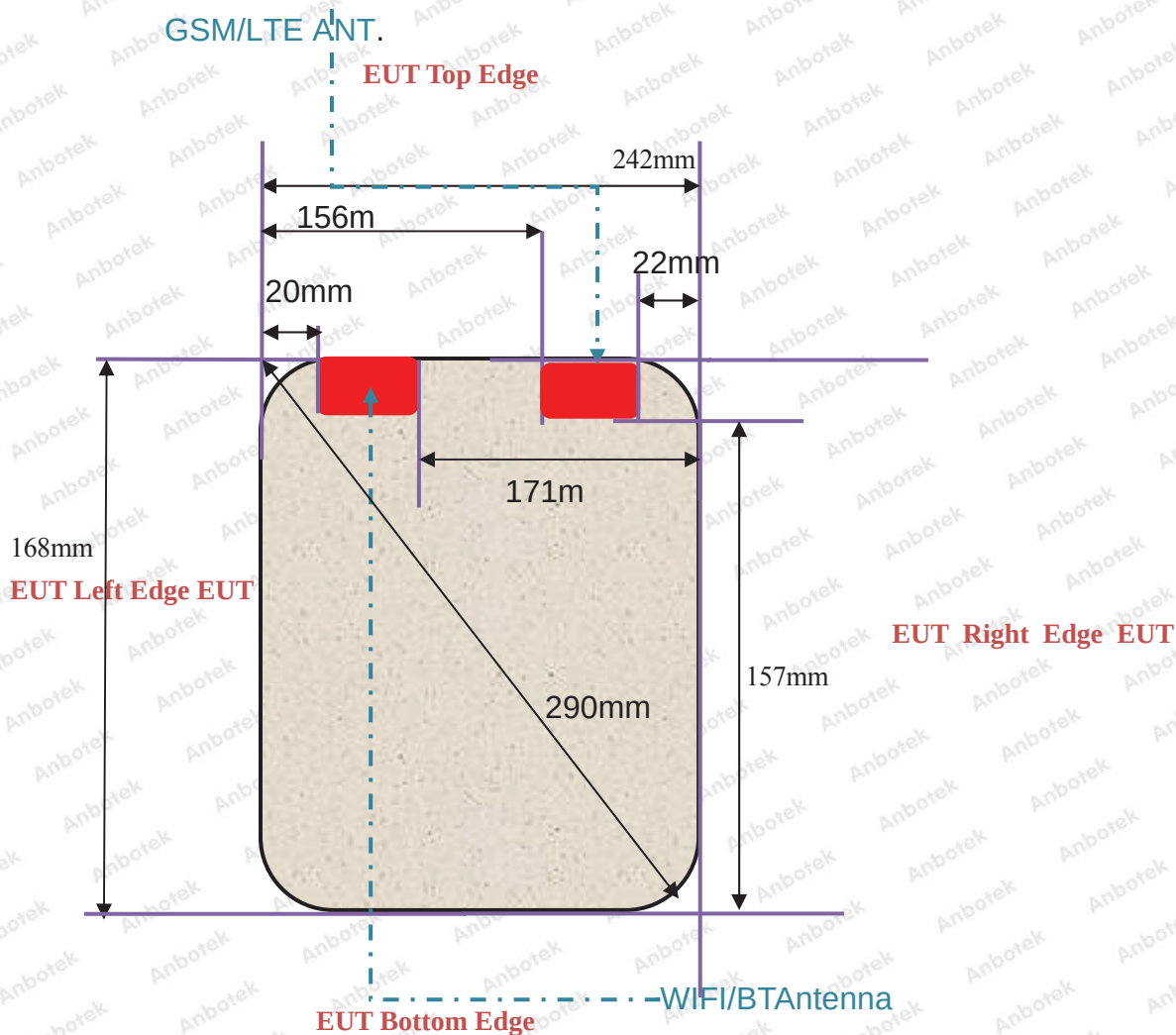
Power and distance are rounded to the nearest mW and mm before calculation

The result is rounded to one decimal place for comparison

Bluetooth Max Power (dBm)	Separation Distance (mm)	Frequency (GHz)	exclusion thresholds
7	5	2.48	1.578

Per KDB 447498 D01, when the minimum test separation distance is < 10 mm, a distance of 5 mm is applied to determine SAR test exclusion. The test exclusion threshold is 1.578 which is ≤ 3 , SAR testing is not required.

11. Antenna Location



EUT BACK VIEW

Distance of The Antenna to the EUT surface and edge						
Antennas	Front	Back	Top Side	Bottom Side	Left Side	Right Side
BT&WLAN	<25mm	<25mm	<25mm	157mm	<25mm	171mm
WWAN	<25mm	<25mm	<25mm	157mm	150mm	<25mm

Positions for SAR tests; Hotspot mode						
Antennas	Front	Back	Top Side	Bottom Side	Left Side	Right Side
BT&WLAN	Yes	Yes	Yes	No	Yes	No
WWAN	Yes	Yes	Yes	No	No	Yes

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General Note: According with FCC KDB 447498 D01, appendix A, <SAR test exclusion thresholds for 100MHz~6GHz and $\leq 50\text{mm}$ > table, this device SAR test configurations considerations are shown in the table above.

Per KDB 447498 D01, for larger devices, the test separation distance of adjacent edge configuration is determined by the closest separation between the antenna and the user.

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12.SAR Test Results Summary

General Note:

1.Per KDB 447498 D01v05r01, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.

Scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.

Reported SAR(W/kg)= Measured SAR(W/kg) Scaling Factor*

2.Per KDB 447498 D01v05r01, for each exposure position, if the highest output channel reported SAR $\leq$ 0.8W/kg, other channels SAR testing are not necessary

3.Per KDB 941225 D05, start with the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation, using the RB offset and required test channel combination with the highest maximum output power for RB offsets at the upper edge, middle and lower edge of each required test channel.

4.Per KDB 941225 D05, 50% RB allocation for QPSK SAR testing follows 1RB QPSK allocation procedure.

5.Per KDB 941225 D05, For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation are $\leq$ 0.8 W/kg. Otherwise, SAR is measured for the highest output power channel; and if the reported SAR is $>$ 1.45 W/kg, the remaining required test channels must also be tested.

6.Per KDB 941225 D05, 16QAM output power for each RB allocation configuration is $>$ not $\frac{1}{2}$ dB higher than the same configuration in QPSK and the reported SAR for the QPSK configuration is $\leq$ 1.45 W/kg; Per KDB 941225 D05, 16QAM SAR testing is not required.

7.Per KDB 941225 D05, Smaller bandwidth output power for each RB allocation configuration is $>$ not $\frac{1}{2}$ dB higher than the same configuration in the largest supported bandwidth, and the reported SAR for the largest supported bandwidth is $\leq$ 1.45 W/kg; Per KDB 941225 D05, smaller bandwidth SAR testing is not required.

8.Per KDB865664 D01, for each frequency band, repeated SAR measurement is required only when the measured SAR is $\geq$ 0.8W/Kg; if the deviation among the repeated measurement is $\leq$ 20%,and the measured SAR $<$ 1.45W/Kg, only one repeated measurement is required.

9.When the user enables the personal Wireless router functions for the handsets, actual operationsinclude simultaneous transmission of both the Wi-Fi transmitting frequency and thus cannot beevaluated for SAR under actual use conditions. The “Portable Hotspot” feature on the handset was

NOT activated, to ensure the SAR measurements were evaluated for a single transmissionfrequency RF signal.

12.1. Body-worn and Hotspot SAR Results

<WCDMA>

Plot No.	Band	Mode	Test Position	Gap (mm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR _{1g} (W/kg)	Reported SAR _{1g} (W/kg)
#1	WCDMA Band II	RMC 12.2K	Front	0	9400	1880.0	22.93	23	1.013	0.05	0.412	0.413
	WCDMA Band II	RMC 12.2K	Back	0	9400	1880.0	22.93	23	1.013	0.08	0.658	0.660
	WCDMA Band II	RMC 12.2K	Left Side	0	9400	1880.0	N/A	N/A	N/A	N/A	N/A	N/A
	WCDMA Band II	RMC 12.2K	Right Side	0	9400	1880.0	22.93	23	1.013	0.05	0.225	0.226
	WCDMA Band II	RMC 12.2K	Top Side	0	9400	1880.0	22.93	23	1.013	0.10	0.234	0.235
	WCDMA Band II	RMC 12.2K	Bottom Side	0	9400	1880.0	N/A	N/A	N/A	N/A	N/A	N/A
#2	WCDMA Band V	RMC 12.2K	Front	0	4183	836.6	23.06	23.1	1.009	0.03	0.389	0.390
	WCDMA Band V	RMC 12.2K	Back	0	4183	836.6	23.06	23.1	1.009	0.05	0.725	0.726
	WCDMA Band V	RMC 12.2K	Left Side	0	4183	836.6	N/A	N/A	N/A	N/A	N/A	N/A
	WCDMA Band V	RMC 12.2K	Right Side	0	4183	836.6	23.06	23.1	1.009	0.07	0.231	0.231
	WCDMA Band V	RMC 12.2K	Top Side	0	4183	836.6	23.06	23.1	1.009	0.12	0.324	0.325
	WCDMA Band V	RMC 12.2K	Bottom Side	0	4183	836.6	N/A	N/A	N/A	N/A	N/A	N/A

<LTE>

Plot No.	Band	Mode	Test Position	Gap (mm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR _{1g} (W/kg)	Reported SAR _{1g} (W/kg)
	LTE Band 2	20MHz/1RB	Front	0	18900	1880	23.99	24	1.000	0.08	0.375	0.375
	LTE Band 2	20MHz/50RB	Front	0	18900	1880	23.99	24	1.000	0.07	0.338	0.338
#3	LTE Band 2	20MHz/1RB	Back	0	18900	1880	23.99	24	1.000	0.12	0.635	0.635
	LTE Band 2	20MHz/50RB	Back	0	18900	1880	23.99	24	1.000	0.03	0.617	0.617
	LTE Band 2	20MHz/1RB	Left Side	0	18900	1880	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 2	20MHz/50RB	Left Side	0	18900	1880	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 2	20MHz/1RB	Right Side	0	18900	1880	23.99	24	1.000	0.06	0.267	0.267
	LTE Band 2	20MHz/50RB	Right Side	0	18900	1880	23.99	24	1.000	0.09	0.282	0.282
	LTE Band 2	20MHz/1RB	Top Side	0	18900	1880	23.99	24	1.000	0.08	0.310	0.310
	LTE Band 2	20MHz/50RB	Top Side	0	18900	1880	23.99	24	1.000	0.13	0.306	0.306
	LTE Band 2	20MHz/1RB	Bottom	0	18900	1880	N/A	N/A	N/A	N/A	N/A	N/A

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			Side									
	LTE Band 2	20MHz/50RB	Bottom Side	0	18900	1880	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 4	20MHz/1RB	Front	0	20175	1732.5	23.87	24	1.005	0.11	0.332	0.334
	LTE Band 4	20MHz/50RB	Front	0	20175	1732.5	23.87	24	1.005	0.11	0.313	0.315
#4	LTE Band 4	20MHz/1RB	Back	0	20175	1732.5	23.87	24	1.005	-0.08	0.547	0.550
	LTE Band 4	20MHz/50RB	Back	0	20175	1732.5	23.87	24	1.005	0.12	0.531	0.534
	LTE Band 4	20MHz/1RB	Left Side	0	20175	1732.5	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 4	20MHz/50RB	Left Side	0	20175	1732.5	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 4	20MHz/1RB	Right Side	0	20175	1732.5	23.87	24	1.005	0.08	0.226	0.227
	LTE Band 4	20MHz/50RB	Right Side	0	20175	1732.5	23.87	24	1.005	0.15	0.218	0.219
	LTE Band 4	20MHz/1RB	Top Side	0	20175	1732.5	23.87	24	1.005	0.13	0.210	0.211
	LTE Band 4	20MHz/50RB	Top Side	0	20175	1732.5	23.87	24	1.005	0.09	0.199	0.200
	LTE Band 4	20MHz/1RB	Bottom Side	0	20175	1732.5	N/A	N/A	N/A	N/A	N/A	N/A
	LTE Band 4	20MHz/50RB	Bottom Side	0	20175	1732.5	N/A	N/A	N/A	N/A	N/A	N/A

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<WIFI 2.4GHz>

Plot No.	Band	Mode	Test Position	Gap (mm)	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Scaling Factor	Power Drift (dB)	Measured SAR _{1g} (W/kg)	Reported SAR _{1g} (W/kg)
#5	WIFI2.4GHz	802.11b	Front	0	11	2462	14.83	15	1.011	0.05	0.157	0.159
	WIFI2.4GHz	802.11b	Back	0	11	2462	14.83	15	1.011	0.12	0.235	0.238
	WIFI2.4GHz	802.11b	Left Side	0	11	2462	14.83	15	1.011	0.05	0.093	0.094
	WIFI2.4GHz	802.11b	Right Side	0	11	2462	N/A	N/A	N/A	N/A	N/A	N/A
	WIFI2.4GHz	802.11b	Top Side	0	11	2462	14.83	15	1.011	0.11	0.096	0.097
#6	WIFI2.4GHz	802.11b	Bottom Side	0	11	2462	N/A	N/A	N/A	N/A	N/A	N/A
	WIFI5.2GHz	802.11a	Front	0	48	5240	9.14	9.5	1.039	0.06	0.100	0.104
	WIFI5.2GHz	802.11a	Back	0	48	5240	9.14	9.5	1.039	-0.10	0.138	0.143
	WIFI5.2GHz	802.11a	Left Side	0	48	5240	9.14	9.5	1.039	0.07	0.085	0.088
	WIFI5.2GHz	802.11a	Right Side	0	48	5240	N/A	N/A	N/A	N/A	N/A	N/A
#7	WIFI5.2GHz	802.11a	Top Side	0	48	5240	9.14	9.5	1.039	0.09	0.091	0.095
	WIFI5.2GHz	802.11a	Bottom Side	0	48	5240	N/A	N/A	N/A	N/A	N/A	N/A
	WIFI5.8GHz	802.11a	Front	0	165	5825	7.86	8	1.018	0.12	0.096	0.098
	WIFI5.8GHz	802.11a	Back	0	165	5825	7.86	8	1.018	0.07	0.118	0.120
	WIFI5.8GHz	802.11a	Left Side	0	165	5825	7.86	8	1.018	0.10	0.081	0.082
#7	WIFI5.8GHz	802.11a	Right Side	0	165	5825	N/A	N/A	N/A	N/A	N/A	N/A
	WIFI5.8GHz	802.11a	Top Side	0	165	5825	7.86	8	1.018	0.15	0.101	0.103
#7	WIFI5.8GHz	802.11a	Bottom Side	0	165	5825	N/A	N/A	N/A	N/A	N/A	N/A

Note:

1. Per KDB 865664 D01V01,for each frequency band ,repeated SAR measurement is required only when the measured SAR is $\geq 0.8\text{W/Kg}$.
2. Per KDB 865664 D01V01,if the ratio of largest to smallest SAR for the original and first repeated measurement is ≤ 1.2 and the measured SAR $< 1.45\text{W/Kg}$, only one repeated measurement is required.
3. Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is $\geq 1.45\text{W/Kg}$
- 4.The ratio is the difference in percentage between original and repeated measured SAR.

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13. Simultaneous Transmission Analysis

Simultaneous TX SAR Considerations

No.	Applicable Simultaneous Transmission
1.	WCDMA+WIFI 2.4G
2.	LTE+WIFI 2.4G
3.	WCDMA+ BT
4.	LTE+BT
5.	WCDMA+ WIFI 5.2G
6.	LTE+WIFI 5.2G
7.	WCDMA+ WIFI 5.8G
8.	LTE+WIFI 5.8G

Note:

1. WIFI 2.4GHz, WIFI 5GHz and Bluetooth share the same antenna, and can not transmit simultaneously.
2. EUT will choose either WCDMA/ LTE according to the network signal condition; therefore, WCDMA / LTE cannot transmit simultaneously.

Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB 447498 D01v05r02, simultaneous transmission SAR test exclusion may be applied when the sum of the 1-g SAR for all the simultaneous transmitting antennas in a specific physical test configuration is ≤ 1.6 W/kg. When standalone SAR is not required to be measured, per FCC KDB 447498 D01v05r02 4.3.2.2), the following equation must be used to estimate the standalone 1g SAR and 10g extremity SAR for simultaneous transmission assessment involving that transmitter.

$$\text{Estimated SAR} = \frac{\sqrt{f(\text{GHz})}}{7.5(18.75)} \cdot \frac{\text{Max. power of channel, mW}}{\text{Min. Separation Distance, mm}}$$

Mode	Max. tune-up Power (dBm)	Exposure Position	Body -worn
		Test Distance (mm)	5
BT	7	Estimated SAR (W/kg)	0.209

Note:

1. When the minimum *test separation distance* is < 5 mm, a distance of 5 mm according is applied to determine estimated SAR.
2. $(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm}) \cdot [\sqrt{f(\text{GHz})} / x]$ W/kg for test separation distances ≤ 50 mm; where $x = 7.5$ for 1-g SAR, and $x = 18.75$ for 10-g SAR.

Next to the mouth exposure requires 1-g SAR, and the wrist-worn condition requires 10-g extremity SAR.

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Evaluation of Simultaneous SAR

<WCDMA>

Test Position	WiFi SAR _{1-g} (W/Kg)	WCDMA Band 2 1-g (W/Kg)	WCDMA Band 5 1-g (W/Kg)	BT SAR _{1-g} (W/Kg)	MAX. ΣSAR _{1-g} (W/Kg)	SAR _{1-g} Limit (W/Kg)	Simut. Meas. Required
Front	0.159	0.413	0.390	0.209	0.622	1.6	N/A
Back	0.238	0.660	0.726	0.209	0.964	1.6	N/A
Left Side	0.094	N/A	N/A	0.209	N/A	1.6	N/A
Right Side	N/A	0.226	0.231	0.209	0.440	1.6	N/A
Top side	0.103	0.235	0.325	0.209	0.534	1.6	N/A
Bottom Side	N/A	N/A	N/A	0.209	N/A	1.6	N/A

<LTE>

Test Position	WiFi SAR _{1-g} (W/Kg)	LTE BAND 2 _{1-g} (W/Kg)	LTE BAND 4 _{1-g} (W/Kg)	BT SAR _{1-g} (W/Kg)	MAX. ΣSAR _{1-g} (W/Kg)	SAR _{1-g} Limit (W/Kg)	Simut. Meas. Required
Front	0.159	0.375	0.334	0.209	0.584	1.6	N/A
Back	0.238	0.635	0.550	0.209	0.873	1.6	N/A
Left Side	0.094	N/A	N/A	0.209	N/A	1.6	N/A
Right Side	N/A	0.282	0.227	0.209	0.491	1.6	N/A
Top side	0.103	0.310	0.211	0.209	0.519	1.6	N/A
Bottom Side	N/A	N/A	N/A	0.209	N/A	1.6	N/A

14. 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, the extensive SAR measurement uncertainty analysis is not required in SAR reports submitted for equipment approval.

Appendix A. EUT Photos and Test Setup Photos



Front with Phantom 0 mm



Back with Phantom 0 mm



Bottom with Phantom (0mm)



Top with Phantom (0mm)



Left with Phantom (0mm)



Right with Phantom (0mm)

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Appendix B. Plots of SAR System Check

System Performance Check at 835 MHz Body

DUT: Dipole 835 MHz; Type: D835V2; Serial: 4d154

Date: 11/08/2021

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 835$ MHz; $\sigma = 0.99$ S/m; $\epsilon_r = 55.95$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7396; ConvF(9.88, 9.88, 9.88); Calibrated: May, 06, 2021;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep. 06, 2021
- Phantom: SAM 1; Type: SAM;
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

Area Scan (61x91x1): Measurement grid: dx=15.00 mm, dy=15.00 mm

Maximum value of SAR (interpolated) = 2.858 W/kg

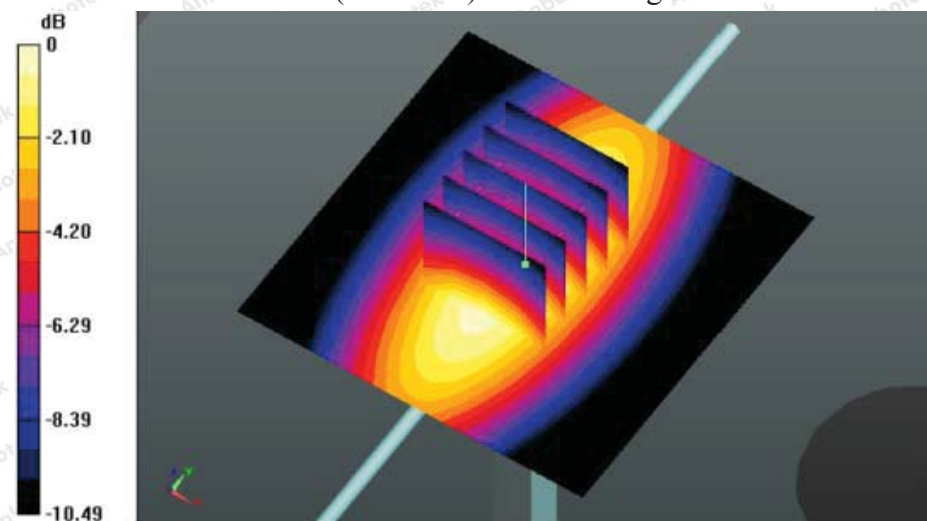
Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 50.394 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.251 W/kg

SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.45 W/kg

Maximum value of SAR (measured) = 2.753 W/kg



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1750MHz Head System Check

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2

Date: 11/09/2021

Communication System: CW; Frequency: 1750 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 1750$ MHz; $\sigma = 1.46$ S/m; $\epsilon_r = 53.87$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASYS (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: EX3DV4 - SN7396; ConvF(8.24, 8.24, 8.24); Calibrated: May, 06, 2021;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep. 06, 2021
- Phantom: SAM 1 ; Type: QD 000 P40 CD; Serial: TP - 1802
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Configuration/Pin=250mW/Area Scan (71x71x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

Maximum value of SAR (interpolated) = 12.35 W/kg

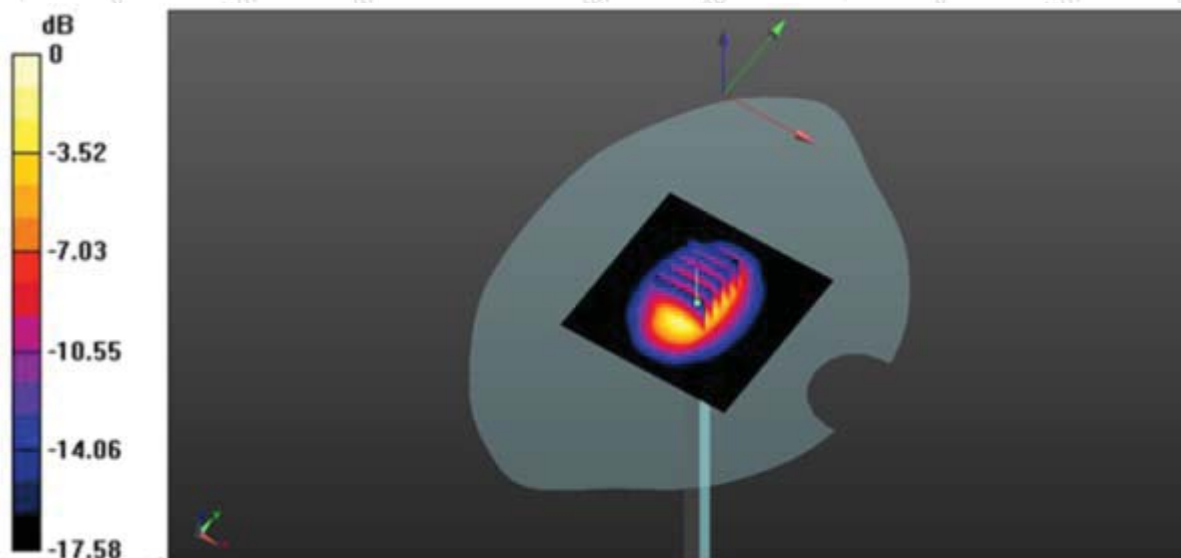
Configuration/Pin=250mW/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 92.233 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 16.241 W/kg

SAR(1 g) = 9.28 W/kg; SAR(10 g) = 5.03 W/kg

Maximum value of SAR (measured) = 12.24 W/kg



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System Performance Check at 1900 MHz Body

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: 5d175

Date: 11/10/2021

Communication System: CW; Frequency: 1900 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 1900$ MHz; $\sigma = 1.50$ S/m; $\epsilon_r = 54.21$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

Probe: EX3DV4 - SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: May, 06, 2021;

Sensor-Surface: 3mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: Sep. 06, 2021

Phantom: SAM 1; Type: SAM;

Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: $dx=15.00$ mm, $dy=15.00$ mm

Maximum value of SAR (interpolated) = 16.752 W/kg

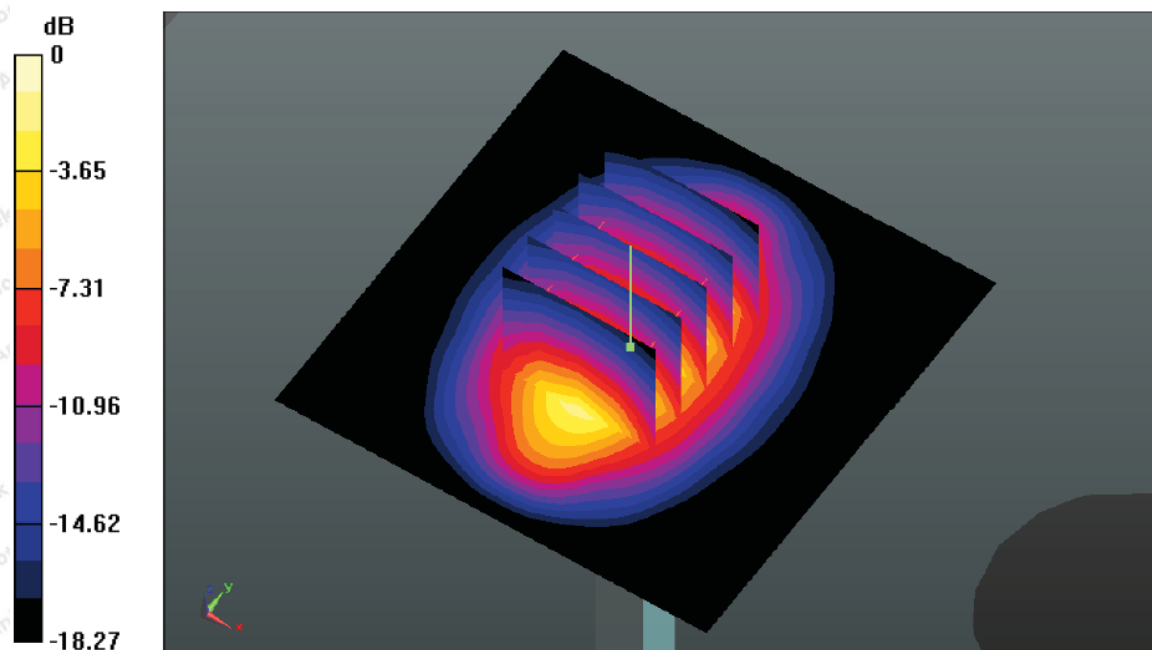
Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 87.841 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 19.84 W/kg

SAR(1 g) = 10.01 W/kg; SAR(10 g) = 5.28 W/kg

Maximum value of SAR (measured) = 15.10 W/kg

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System Performance Check at 2450 MHz Body

Date: 11/11/2021

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: 910

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

Medium parameters used (interpolated): $f = 2450$ MHz; $\sigma = 1.93$ S/m; $\epsilon_r = 53.65$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

Probe: EX3DV4 - SN7396; ConvF(7.53, 7.53, 7.53); Calibrated: May.06.2021;

Sensor-Surface: 3mm (Mechanical Surface Detection)

Electronics: DAE4 Sn387; Calibrated: Sep.06.2021

Phantom: SAM 1; Type: SAM;

Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.6.5 (6469)

Area Scan (61x91x1): Measurement grid: $dx=10.00$ mm, $dy=10.00$ mm

Maximum value of SAR (interpolated) = 19.925 W/kg

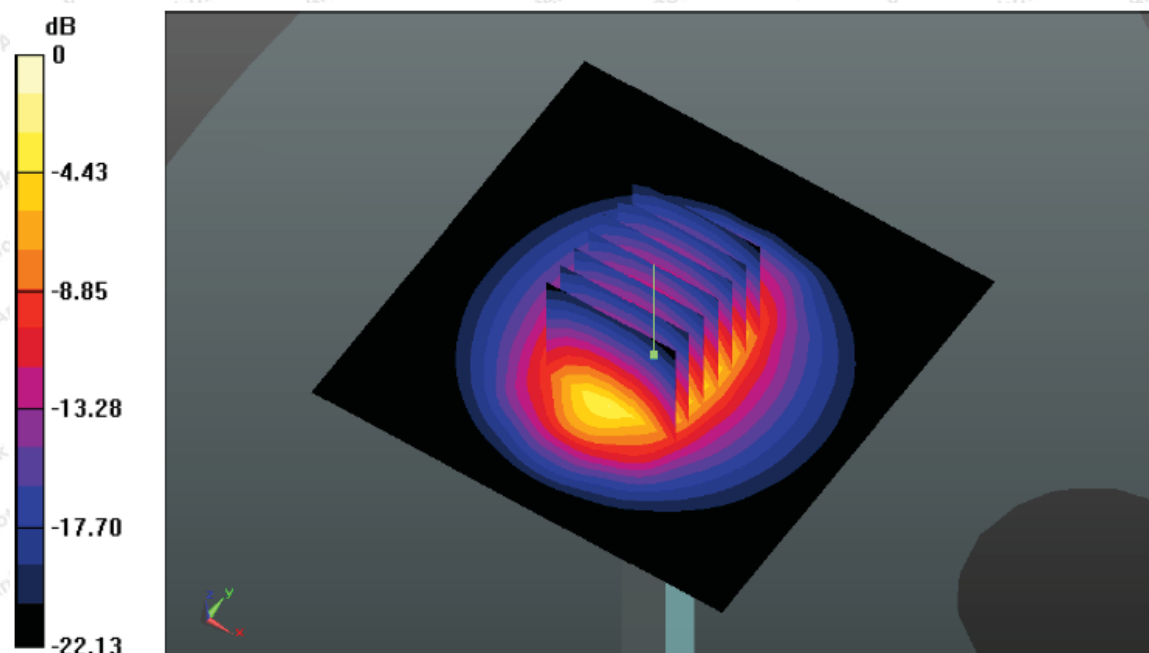
Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 84.545 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 26.140 W/kg

SAR(1 g) = 13.23 W/kg; SAR(10 g) = 5.94 W/kg

Maximum value of SAR (measured) = 19.96 W/kg



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2600MHz Head System Check at Body

DUT: Dipole 2600 MHz; Type: D2600V2;

Date: 11/12/2021

Communication System: CW; Frequency: 2600 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 2600$ MHz; $\sigma = 2.25$ S/m; $\epsilon_r = 52.82$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(7.38, 7.38, 7.38); Calibrated: May, 06, 2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep. 06, 2021
- Phantom: SAM; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

Configuration/Pin=250mW/Area Scan (81x81x1): Interpolated grid: $dx=1.200$ mm, $dy=1.200$ mm

Maximum value of SAR (interpolated) = 24.47 W/kg

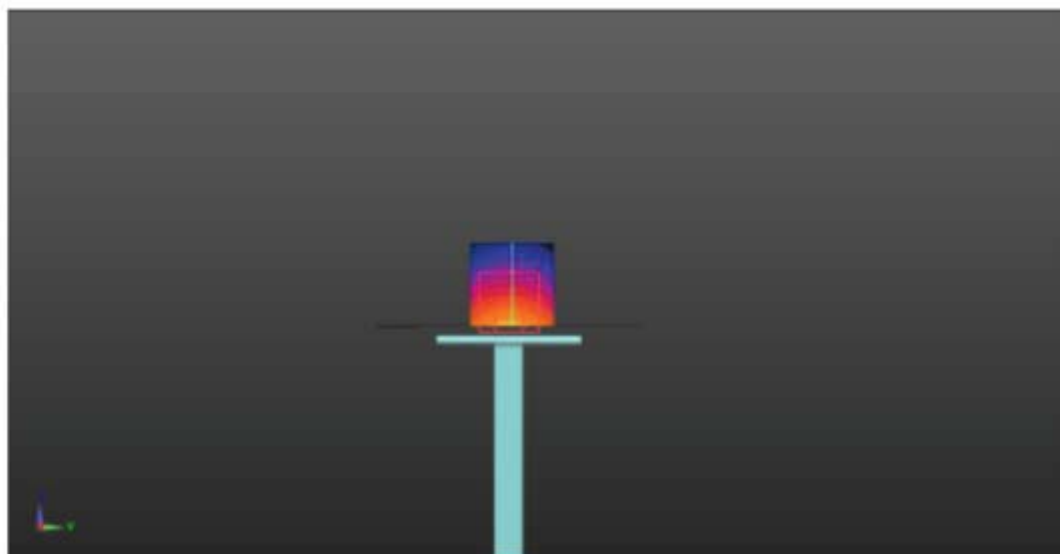
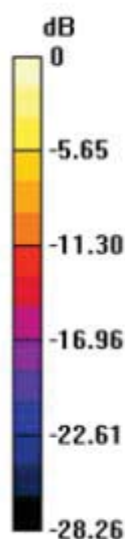
Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5$ mm, $dy=5$ mm, $dz=5$ mm

Reference Value = 110.210 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 33.63 W/kg

SAR(1 g) = 13.87 W/kg; SAR(10 g) = 6.34 W/kg

Maximum value of SAR (measured) = 25.32 W/kg



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5200MHz System Check

DUT: Dipole 5 GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1160

Date: 11/05/2021

Communication System: UID 0, CW; Frequency: 5200 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 6.16 \text{ S/m}$; $\epsilon_r = 47.52$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(4.93, 4.93, 4.93); Calibrated: May,06.2021;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM2; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Configuration/Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 49,357 V/m; Power Drift = 0.08 dB

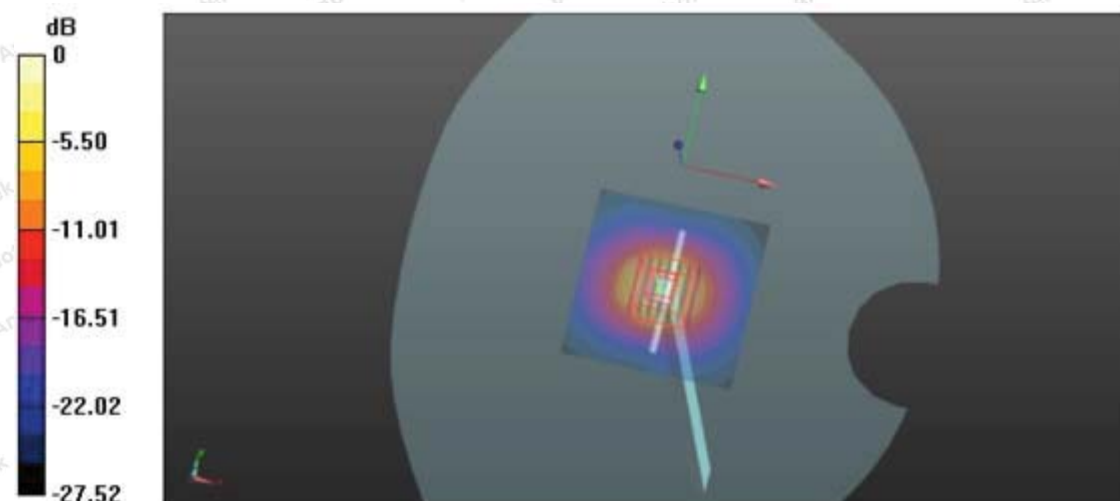
Peak SAR (extrapolated) = 31.68W/kg

SAR(1 g) = 7.92 W/kg; SAR(10 g) = 2.21W/kg

Maximum value of SAR (measured) = 19.25 W/kg

Configuration/Pin=100mW/Area Scan (71x71x1): Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$

Maximum value of SAR (interpolated) = 18.93 W/kg



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Appendix C. Plots of SAR Test Data

#1

Date: 11/10/2021

WCDMA 1900_RMC 12.2K_Body Back_Ch9400

Communication System: UID 0, Generic WCDMA (0); Frequency: 1880 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 1880$ MHz; $\sigma = 1.50$ S/m; $\epsilon_r = 54.21$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: May,06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

BODY/EARPHONE-H/Area Scan (8x13x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.674 W/kg

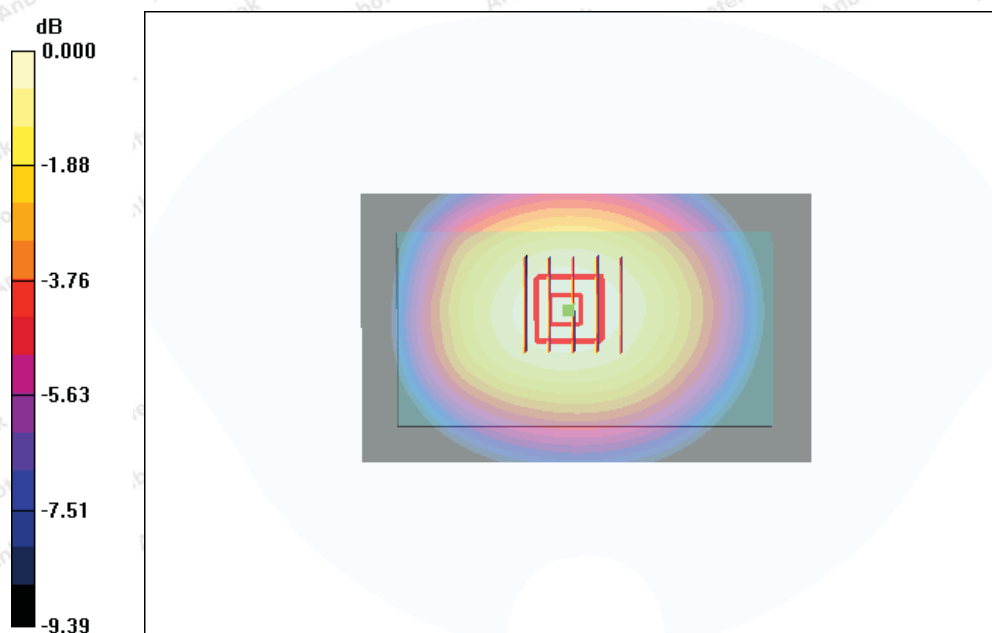
BODY/BACK/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 16.85V/m; Power Drift = 0.08dB

Peak SAR (extrapolated) = 0.687 W/kg

SAR(1 g) = 0.658 W/kg; SAR(10 g) = 0.421 W/kg

Maximum value of SAR (measured) = 0.692 W/kg



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#2

Date: 11/08/2021

WCDMA 850_RMC 12.2K_Body Back_Ch4183

Communication System: UID 0, Generic WCDMA (0); Frequency: 836.6 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 836.6$ MHz; $\sigma = 0.99$ S/m; $\epsilon_r = 55.95$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(9.88, 9.88, 9.88); Calibrated: May,06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

BODY/EARPHONE-H/Area Scan (8x13x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.768 W/kg

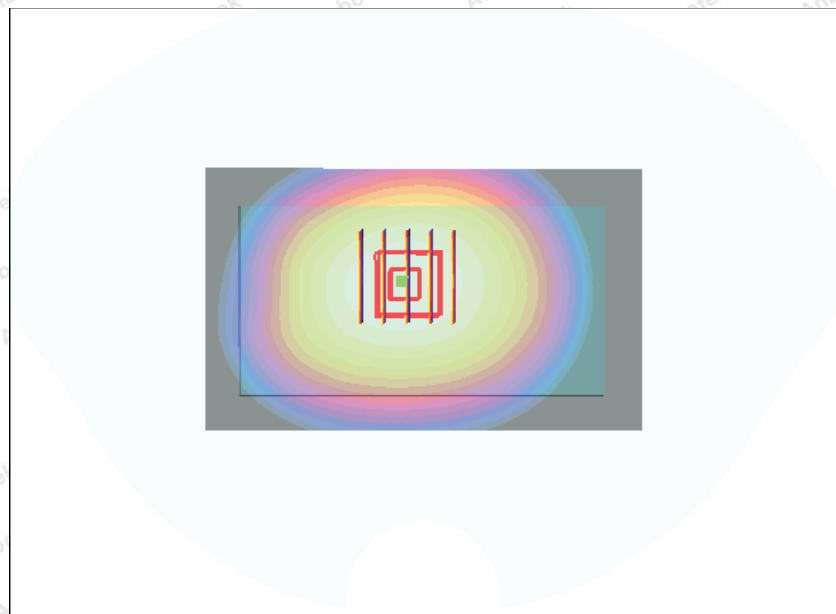
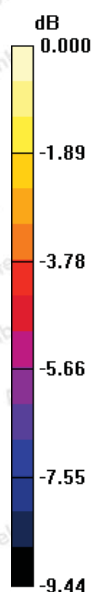
BODY/BACK/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 18.32 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 0.755 W/kg

SAR(1 g) = 0.725 W/kg; SAR(10 g) = 0.412 W/kg

Maximum value of SAR (measured) = 0.774 W/kg

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#3

Date: 11/10/2021

LTE Band 2_Body Back_1RB_Ch18900

Communication System: UID 0, Generic LTE (0); Frequency: 1880.0 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 1880.0$ MHz; $\sigma = 1.50$ S/m; $\epsilon_r = 54.21$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(7.97, 7.97, 7.97); Calibrated: May,06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM; Type: QD000P40CD; Serial: TP.1670
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

BODY/BACK-L/Area Scan (8x13x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (interpolated) = 0.686 W/kg

BODY/BACK-L/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 22.65 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 0.657 W/kg

SAR(1 g) = 0.635 W/kg; SAR(10 g) = 0.389 W/kg

Maximum value of SAR (measured) = 0.678 W/kg

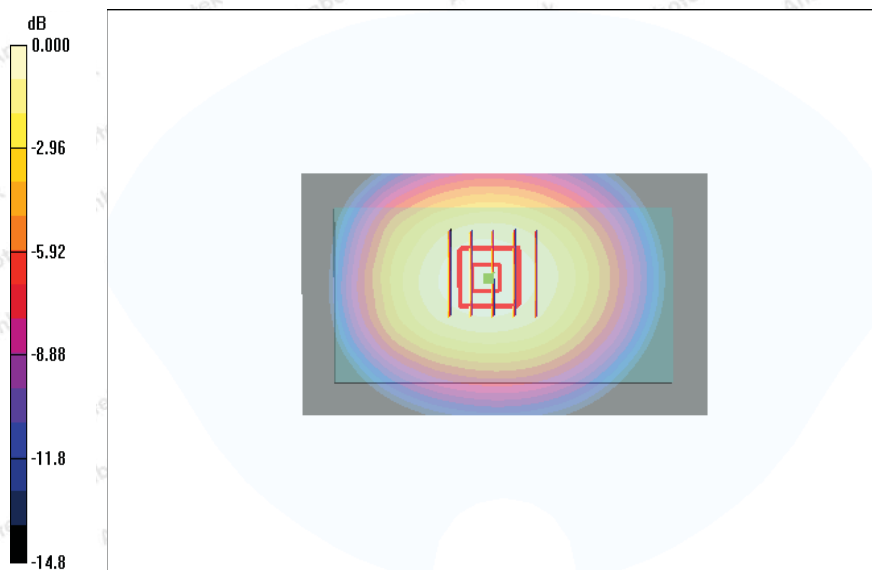
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#4

Date: 11/09/2021

LTE Band 4_Body Back_1RB_Ch20175

Communication System: UID 0, Generic LTE (0); Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): $f = 1732.5 \text{ MHz}$; $\sigma = 1.46 \text{ S/m}$; $\epsilon_r = 53.87$; $\rho = 1000 \text{ kg/m}^3$
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(8.24, 8.24, 8.24); Calibrated: May, 06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep. 06.2021
- Phantom: SAM; Type: QD000P40CD; Serial: TP.1670
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

BODY/BACK-L/Area Scan (8x13x1): Measurement grid: $dx=15\text{mm}$, $dy=15\text{mm}$

Maximum value of SAR (interpolated) = 0.604 W/kg

BODY/BACK-L/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8\text{mm}$, $dy=8\text{mm}$, $dz=5\text{mm}$

Reference Value = 13.58 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 0.587 W/kg

SAR(1 g) = 0.547 W/kg; SAR(10 g) = 0.325 W/kg

Maximum value of SAR (measured) = 0.596 W/kg

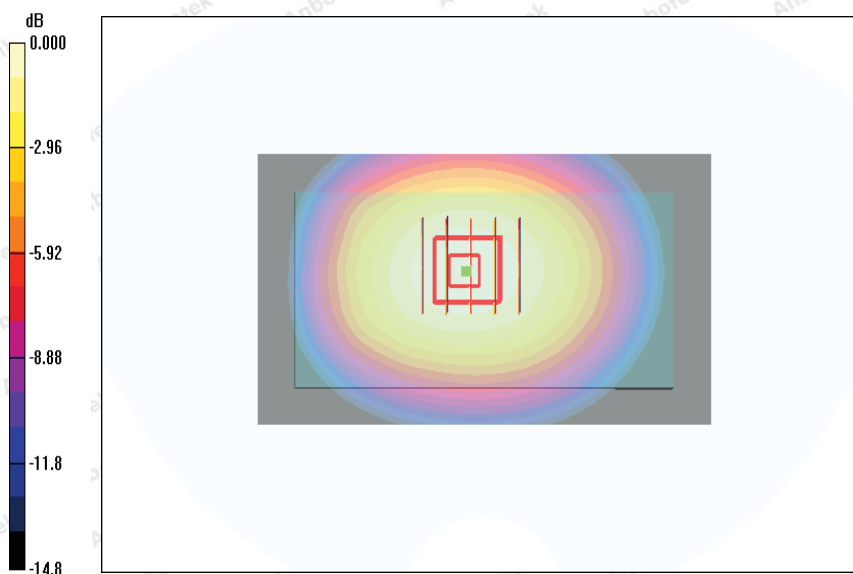
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#5

Date: 11/11/2021

WIFI 2.4G_802.11b_Body Back _Ch11

Communication System: UID 0, wifi (fcc) (0); Frequency: 2462 MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 2462$ MHz; $\sigma = 1.93$ S/m; $\epsilon_r = 53.65$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN7396; ConvF(7.53, 7.53, 7.53); Calibrated: May,06.2021;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM 1; Type: SAM;
- Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.10 (7164)

Configuration/BACK/Area Scan (33x17x1): Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.283 W/kg

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

Reference Value = 23.47 V/m; Power Drift = 0.12 dB

Peak SAR (extrapolated) = 0.298 W/kg

SAR(1 g) = 0.235 W/kg; SAR(10 g) = 0.136 W/kg

Maximum value of SAR (measured) = 0.285 W/kg

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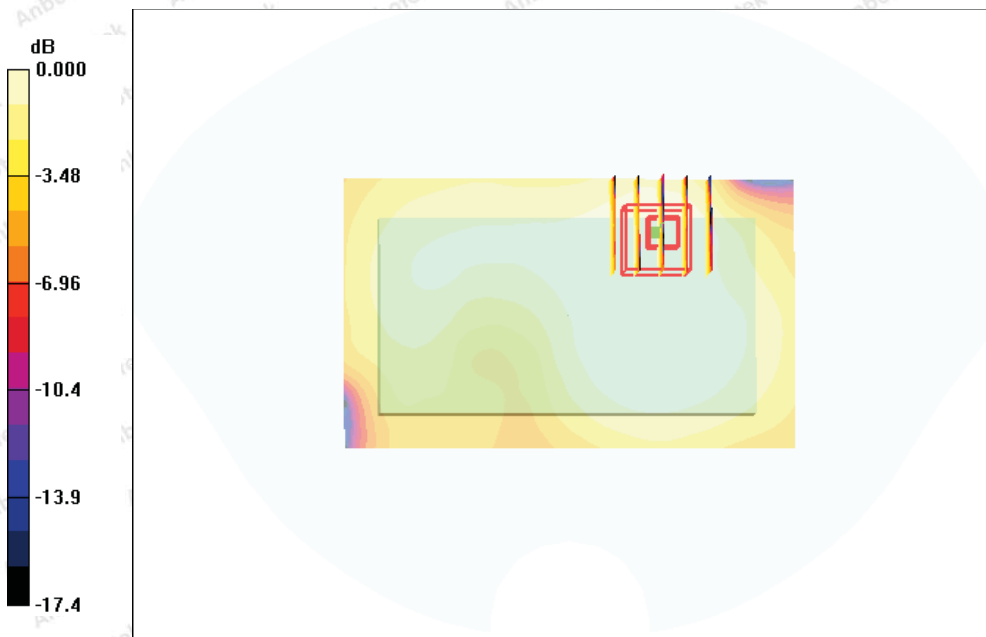
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#6

Date: 11/05/2021

WIFI 5.2G_Body back_Ch48

Communication System: UID 0, 802.11a (0); Frequency: 5240MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 5240 \text{ MHz}$; $\sigma = 6.16 \text{ S/m}$; $\epsilon_r = 47.52$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(4.93, 4.93, 4.93); Calibrated: May,06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM2; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

BODY back /Area Scan (9x13x1): Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.167W/kg

BODY back /Zoom Scan (8x8x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm

Reference Value = 13.54 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 0.154 W/kg

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SAR(1 g) = 0.138 W/kg; SAR(10 g) = 0.098 W/kg

Maximum value of SAR (measured) = 0.168 W/kg



#7

Date: 11/05/2021

WIFI 5.8G_Body back _Ch165

Communication System: UID 0, 802.11a (0); Frequency: 5825MHz; Duty Cycle: 1:1

Medium parameters used (interpolated): $f = 5825 \text{ MHz}$; $\sigma = 6.16 \text{ S/m}$; $\epsilon_r = 47.52$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 – SN7396; ConvF(4.93, 4.93, 4.93); Calibrated: May,06.2021;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn387; Calibrated: Sep.06.2021
- Phantom: SAM2; Type: QD000P40CD; Serial: TP:1670
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

BODY back /Area Scan (9x13x1): Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.154 W/kg

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BODY back /Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 18.52 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 0.136 W/kg

SAR(1 g) = 0.118 W/kg; SAR(10 g) = 0.092 W/kg

Maximum value of SAR (measured) = 0.134 W/kg



Appendix D. DASY System Calibration Certificate

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Client

Anbotek (Auden)

Certificate No: Z21-98671

CALIBRATION CERTIFICATE

Object EX3DV4 - SN:7396

Calibration Procedure(s) FF-Z12-006-08
Calibration Procedures for Dosimetric E-field Probes

Calibration date: May06, 2021

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

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	20-Jun-20 (CTTL, No.J20X07447)	Jun-21
Power sensor NRP-Z91	101547	20-Jun-20 (CTTL, No.J20X07447)	Jun-21
Power sensor NRP-Z91	101548	20-Jun-20 (CTTL, No.J20X07447)	Jun-21
Reference10dBAttenuator	18N50W-10dB	13-Mar-21(CTTL,No.J21X01547)	Mar-22
Reference20dBAttenuator	18N50W-20dB	13-Mar-21(CTTL, No.J21X01548)	Mar-22
Reference Probe EX3DV4	SN 7433	26-Sep-20(SPEAG,No.EX3-7433_Sep20)	Sep-21
DAE4	SN 549	13-Dec-20(SPEAG, No.DAE4-549_Dec20)	Dec -21
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	27-Jun-20 (CTTL, No.J20X04776)	Jun-21
Network Analyzer E5071C	MY46110673	13-Jan-21 (CTTL, No.J21X00285)	Jan -22

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: May06, 2021

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: Z21-98671

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[Http://www.chinattl.cn](http://www.chinattl.cn)**Glossary:**

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A,B,C,D	modulation dependent linearization parameters
Polarization Φ	Φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i $\theta=0$ is normal to probe axis

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta=0$ ($f \leq 900\text{MHz}$ in TEM-cell; $f > 1800\text{MHz}$: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; VR_{x,y,z}; A,B,C** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800\text{MHz}$) and inside waveguide using analytical field distributions based on power measurements for $f > 800\text{MHz}$. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from $\pm 50\text{MHz}$ to $\pm 100\text{MHz}$.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

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Probe EX3DV4

SN: 7396

Calibrated: May 06, 2021

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)





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DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.54	0.53	0.50	±10.0%
DCP(mV) ^B	97.8	104.5	102.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	199.9	±2.4%
		Y	0.0	0.0	1.0		203.3	
		Z	0.0	0.0	1.0		195.0	

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor k=2, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X, Y, Z do not affect the E²-field uncertainty inside TSL (see Page 5 and Page 6).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.





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DASY/EASY – Parameters of Probe: EX3DV4 – SN: 7396

Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unct. (k=2)
750	41.9	0.89	9.82	9.82	9.82	0.30	0.85	± 12.1%
835	41.5	0.90	9.71	9.71	9.71	0.15	1.36	± 12.1%
900	41.5	0.97	9.87	9.87	9.87	0.16	1.37	± 12.1%
1750	40.1	1.37	8.61	8.61	8.61	0.25	1.04	± 12.1%
1900	40.0	1.40	8.13	8.13	8.13	0.24	1.01	± 12.1%
2100	39.8	1.49	8.14	8.14	8.14	0.24	1.04	± 12.1%
2300	39.5	1.67	7.85	7.85	7.85	0.40	0.75	± 12.1%
2450	39.2	1.80	7.57	7.57	7.57	0.50	0.75	± 12.1%
2600	39.0	1.96	7.38	7.38	7.38	0.64	0.68	± 12.1%
5250	35.9	4.71	5.33	5.33	5.33	0.45	1.30	± 13.3%
5600	35.5	5.07	4.89	4.89	4.89	0.45	1.35	± 13.3%
5750	35.4	5.22	4.92	4.92	4.92	0.45	1.45	± 13.3%

^C Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^F At frequency below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

