

FCC SAR Test Report

Product : Testo Control Unit
Trade mark : 
Model/Type reference : 0480 0069
Serial Number : PH81SA1BK00159
Report Number : EED32K00112105
FCC ID : WAF-04800069
Date of Issue : Aug. 13, 2018
Test Standards : Refer to Section 1.5
Test result : PASS

Prepared for:

Testo SE & Co. KGaA

Testo-Strasse 1, Lenzkirch 79853, Germany

Prepared by:

Centre Testing International Group Co., Ltd.

Hongwei Industrial Zone, Bao'an 70 District,

Shenzhen, Guangdong, China

TEL: +86-755-3368 3668

FAX: +86-755-3368 3385

Tested by:

Huang xiao le

Huang xiaole (Test Project)

Reviewed by:

Kevin Yang

Kevin yang (Reviewer)

Date:

Aug. 13, 2018

Compiled by:

Max liang

Max liang (Project Engineer)

Approved by:

Sheek Luo

Sheek Luo (Lab supervisor)



Check No.:3096309230

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Modified History

REV.	Modification Description	Issued Date	Remark
REV.1.0	Initial Test Report Release	Aug. 13, 2018	

1 General information

1.1 Notes

The test results of this test report relate exclusively to the test item specified in this test report.

Centre Testing International Group Co., Ltd. does not assume responsibility for any conclusions and generalisations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report is not to be reproduced or published in full without the prior written permission.

1.2 Application details

Date of receipt of test item:	2018-05-11
Start of test:	2018-05-22
End of test:	2018-08-13

1.3 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for Testo SE & Co. KGaA.

Model Name: 0480 0069 are as below:

Band	MAX Reported SAR (W/kg)	
	1-g Head	1-g Body-worn Accessory(15mm)
WiFi 2.4G	0.137	0.046

Note:

For body operation, this device has been tested and meets FCC/IC RF exposure guidelines when used with any accessory that contains no metal and that positions a minimum of 15mm from the body. Use of other accessories may not ensure compliance with FCC/IC RF exposure guidelines.

The device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits according to the FCC rule §2.1093, the ANSI/IEEE C95.1:1992, the NCRP Report Number 86 for uncontrolled environment, according to the Industry Canada Radio Standards Specification RSS-102 for General Population/Uncontrolled exposure, and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528-2013

1.4 EUT Information

Device Information:			
Product Type:	Testo Control Unit		
Model:	0480 0069		
FCC ID:	WAF-04800069		
SN:	PH81SA1BK00159		
Device Type:	Portable device		
Exposure Category:	uncontrolled environment / general population		
Firmware version:	3.18.19(manufacturer declare)		
Hardware version:	V1.2(manufacturer declare)		
Antenna Type :	MONOPOLE Antenna		
Antenna Gain:	2.3dBi		
Device Operating Configurations:			
Supporting Mode(s) :	WiFi 2.4G(tested),BT		
Modulation:	DSSS ,OFDM;GFSK, π/4DQPSK, 8DPSK		
Operating Frequency Range(s):	Band	TX(MHz)	RX(MHz)
	WIFI 2.4G	2412~2462	
	BT	2402~2480	
Test Channels (low-mid-high):	1-6-11 (WiFi 2.4G)		
Power Source:	Battery: Rechargeable Li-ion Battery 3.8V, 2150mAh, 8.17Wh		

Remark: The tested sample(s) and the sample information are provided by the client.

1.5 Test standard/s

ANSI Std C95.1-1992	Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.
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
FCC 47 CFR Part 2 (§ 2.1093)	Radiofrequency radiation exposure evaluation: portable devices.
RSS-102	Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands (Issue 5 of March 2015)
KDB 447498 D01	General RF Exposure Guidance v06
KDB 248227 D01	SAR guidance for IEEE 802.11(Wi-Fi) transmitters v02r02
KDB 865664 D01	SAR Measurement 100 MHz to 6 GHz v01r04
KDB 865664 D02	RF Exposure Reporting v01r02
KDB 690783 D01	SAR Listings on Grants v01r03

1.6 RF exposure limits

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
Spatial Peak SAR* (Brain/Body/Arms/Legs)	1.60 mW/g	8.00 mW/g
Spatial Average SAR** (Whole Body)	0.08 mW/g	0.40 mW/g
Spatial Peak SAR*** (Hands/Feet/Ankle/Wrist)	4.00 mW/g	20.00 mW/g

The limit applied in this test report is shown in bold letters

Notes:

* The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

** The Spatial Average value of the SAR averaged over the whole body.

*** The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

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

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation).

1.7 SAR Definition

Specific Absorption Rate is defined as 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).

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

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

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

where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m³)

E = rms electric field strength (V/m)

1.8 Testing laboratory

Test Site	Centre Testing International Group Co., Ltd.
Test Location	Hongwei Industrial Zone, Bao'an 70 District, Shenzhen, Guangdong, China
Telephone	+86 (0) 755 3368 3668
Fax	+86 (0) 755 3368 3385

1.9 Test Environment

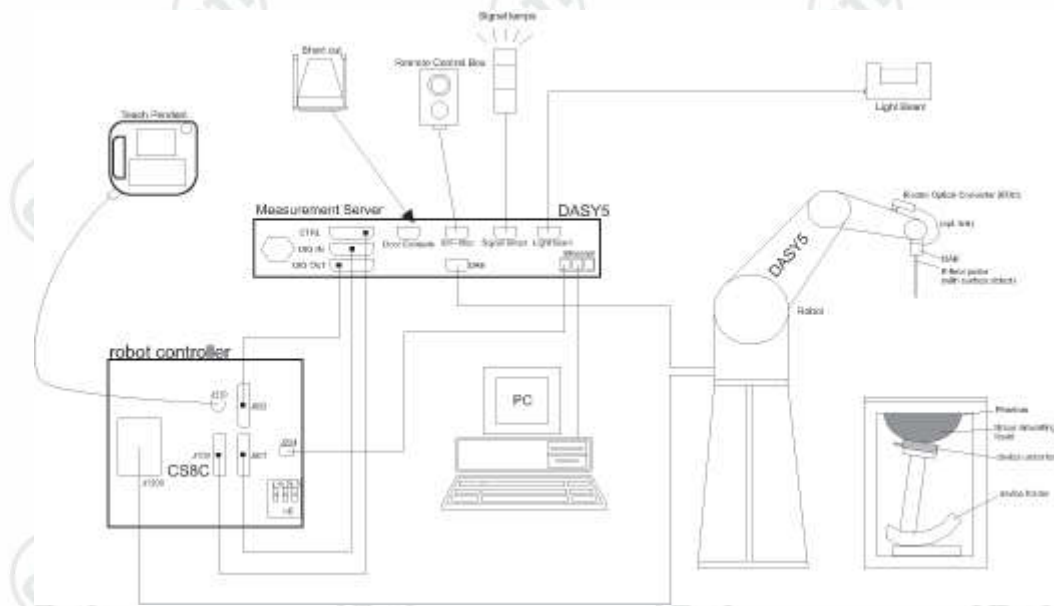
	Required	Actual
Ambient temperature:	18 – 25 °C	21.5 ± 2 °C
Tissue Simulating liquid:	18 – 25 °C	21.5 ± 2 °C
Relative humidity content:	30 – 70 %	30 – 70 %

1.10 Applicant and Manufacturer

Applicant/Client Name:	Testo SE & Co. KGaA
Applicant Address:	Testo-Strasse 1, Lenzkirch 79853, Germany
Manufacturer Name:	Shenzhen Phonemax Technology Co., Ltd.
Manufacturer Address:	5F, East block, LaoBing Building, Xingye Road, Xixiang, Bao'an District, Shenzhen
Factory:	Shenzhen Newsun Technology Co., Ltd
Address of Factory:	5F, Block A1, Zhongtai Information Industrial Park, No. 2 Dezheng Road, Shilong Community, Shiyan Street, Bao'an District, Shenzhen

2 SAR Measurement System Description and Setup

2.1 The Measurement System Description



The DASYS system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli TX/RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Win7 profesional operating system and the DASYS software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

2.2 Probe description

Dosimetric Probes: These probes are specially designed and calibrated for use in liquids with high permittivities. They should not be used in air, since the spherical isotropy in air is poor (± 2 dB). The dosimetric probes have special calibrations in various liquids at different frequencies.

Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available.
Frequency	10 MHz to 6 GHz; Linearity: ± 0.2 dB
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Dynamic range	5 μ W/g to 100 mW/g; Linearity: ± 0.2 dB



2.3 Data Acquisition Electronics description

The data acquisition electronics (DAE4) consist 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 with a 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 mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE4 box is 200M Ω ; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

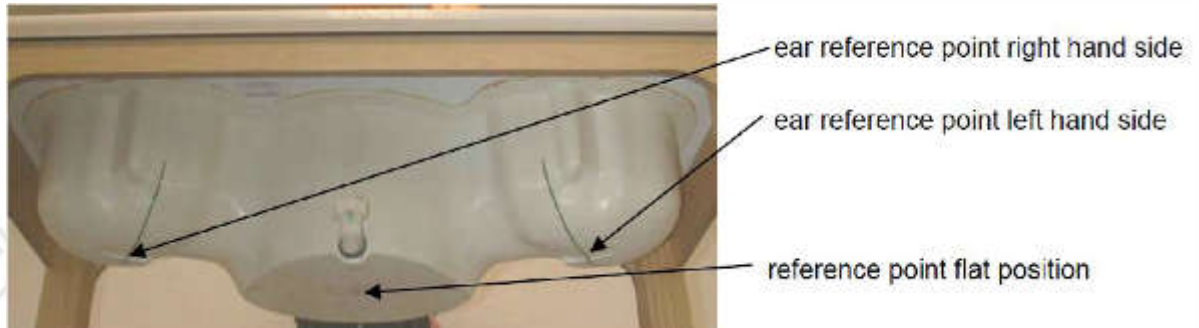
Batteries: The DAE works with either two standard 9V batteries or two 9V (actually 8.4V or 9.6 V) rechargeable batteries. Because the electronics automatically power-down unused components during braking or between measurements, the battery lifetime depends on system usage. Typical lifetimes are >20 hours for batteries and >10 hours for accus. Remove the batteries if you do not plan to use the DAE for a long period of time.



2.4 SAM Twin Phantom description

The SAM twin phantom is a fiberglass shell phantom with 2mm shell thickness (except the ear region, where shell thickness increases to 6 mm). The phantom has three measurement areas:

- ◆ Left hand
- ◆ Right hand
- ◆ Flat phantom



The phantom table for the DASY systems have the size of 100 x 50 x 85 cm (L xWx H). these tables are reinforced for mounting of the robot onto the table. For easy dislocation these tables have fork lift cut outs at the bottom.

The bottom plate contains three pairs 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 cover the phantom during off-periods to prevent water evaporation and changes in the liquid parameters.

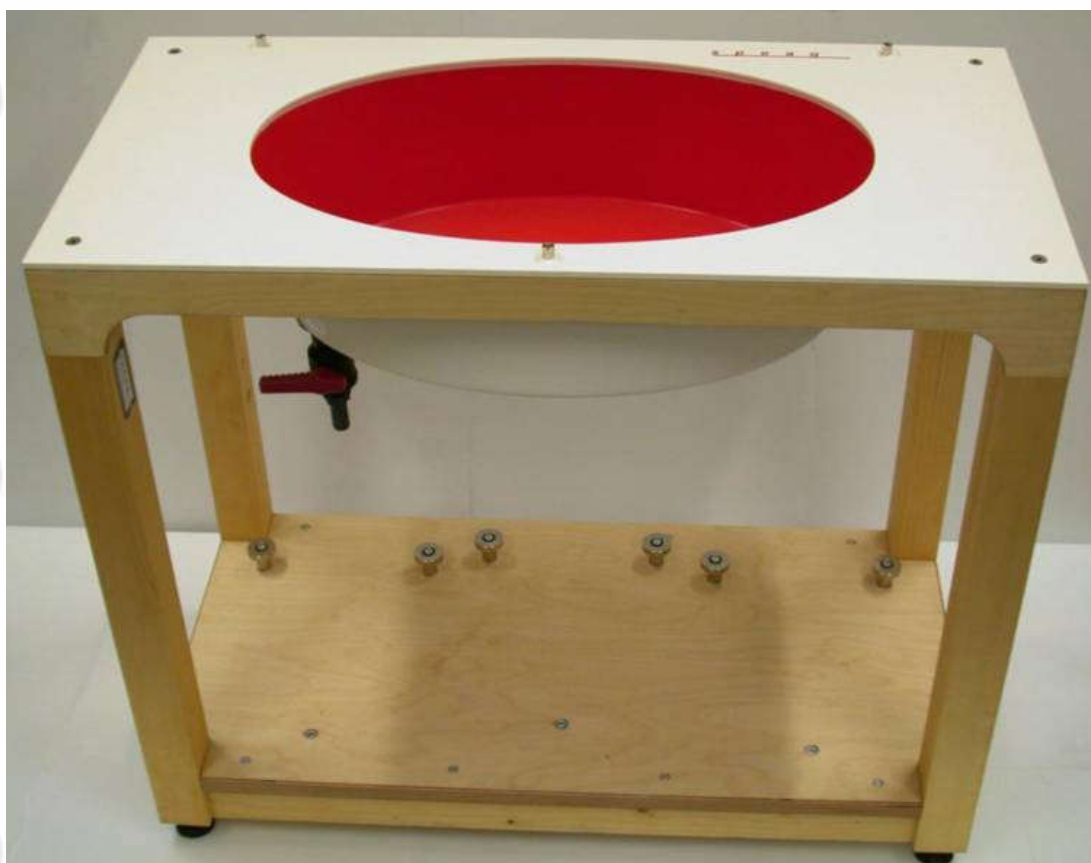
Three reference marks are provided on the phantom counter. These reference marks are used to teach the absolute phantom position relative to the robot.



2.5 ELI4 Phantom description

The ELI4 phantom is intended for compliance testing of handheld and body mounted wireless devices in the frequency range of 30MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209-2 and all known tissue simulating liquids.

ELI4 has been optimized regarding its performance and can be integrated into a SPEAG standard phantom table. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points



2.6 Device Holder description

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 5mm 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 the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers 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.



3 SAR Test Equipment List

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

	Manufacturer	Device Type	Type(Model)	Serial number	Date of last calibration	Valid period
☒	SPEAG	E-Field Probe	EX3DV4	7328	2018-02-23	One year
☐	SPEAG	835 MHz Dipole	D835V2	4d193	2018-02-19	Three years
☐	SPEAG	1750 MHz Dipole	D1750V2	1134	2018-02-22	Three years
☐	SPEAG	1900 MHz Dipole	D1900V2	5d198	2018-02-22	Three years
☐	SPEAG	2000 MHz Dipole	D2000V2	1078	2018-02-22	Three years
☐	SPEAG	2300 MHz Dipole	D2300V2	1082	2017-01-25	Three years
☒	SPEAG	2450 MHz Dipole	D2450V2	959	2018-02-16	Three years
☐	SPEAG	2600 MHz Dipole	D2600V2	1101	2018-02-16	Three years
☐	SPEAG	5 GHz Dipole	D5GHzV2	1208	2018-02-21	Three years
☒	SPEAG	DAKS probe	DAKS-3.5	1052	2018-02-20	Three years
☒	SPEAG	Planar R140 Vector Reflectometer	DAKS-VNA R140	0200514	2018-02-20	Three years
☒	SPEAG	Data acquisition electronics	DAE4	914	2017-12-19	One year
☐	R & S	Universal Radio Communication Tester	CMU200	101553	2018-03-16	One year
☒	BALUN	Power Amplifier and directional coupler	SU319W	BLSZ1550140	2018-02-05	One year
☒	Agilent	Signal Generator	E4438C	MY45095744	2018-03-13	One year
☒	KEITHLEY	RF Power Meter	3500	1128079	2017-08-21	One year
☒	Agilent	Power Meter	PM2002	312901	2017-11-16	One year
☒	Agilent	Power Meter Sensor	51011A-EMC	36251	2017-11-16	One year

Note:

- 1) Per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
 - a) There is no physical damage on the dipole;
 - b) System check with specific dipole is within 10% of calibrated value;
 - c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
 - d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.

4 SAR Measurement Procedures

4.1 Spatial Peak SAR Evaluation

The DASY5 software includes all numerical procedures necessary to evaluate the spatial peak SAR values. The base for the evaluation is a "cube" measurement in a volume of 30mm^3 ($7 \times 7 \times 7$ points). The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan. If the 10g cube or both cubes are not entirely inside the measured volumes, the system issues a warning regarding the evaluated spatial peak values within the Postprocessing engine (SEMCAD X). This means that if the measured volume is shifted, higher values might be possible. To get the correct values you can use a finer measurement grid for the area scan. In complicated field distributions, a large grid spacing for the area scan might miss some details and give an incorrectly interpolated peak location. The entire evaluation of the spatial peak values is performed within the Postprocessing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes.

The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. extraction of the measured data (grid and values) from the Zoom Scan
2. calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. generation of a high-resolution mesh within the measured volume
4. interpolation of all measured values from the measurement grid to the high-resolution grid
5. extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. calculation of the averaged SAR within masses of 1 g and 10 g

4.2 Data Storage and Evaluation

Data Storage

The DASY5 software stores the measured voltage acquired by the Data Acquisition Electronics (DAE) as raw data together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and communication system parameters) in measurement files with the extension .da5x. The postprocessing software evaluates the data every time the data is visualized or exported. This allows the verification and modification of the setup after completion of the measurement. For example, if a measurement has been performed with an incorrect crest factor, the parameter can be corrected afterwards and the data can be reevaluated.

To avoid unintentional parameter changes or data manipulations, the parameters in measured files are locked. In the administrator access mode of the software, the parameters can be unlocked. After changing the parameters, the measured scans can be reevaluated in the postprocessing engine.

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

Data Evaluation

The fields and SAR are calculated from the measured voltage (probe voltage acquired by the DAE) and the following parameters:

Probe parameters:

- Sensitivity

norm_i, a_{i0}, a_{i1}, a_{i2}

- Conversion Factor

convF_i

- Diode Compression Point

dcp_i

- Probe Modulation Response Factors

a_i, b_i, c_i, d

Device parameters:

- Frequency

f

- Crest factor

cf

Media parameters:

- Conductivity

σ

- Relative Permittivity

ρ

This parameters are stored in the DASY5 V52 measurement file.

These parameters must be correctly set in the DASY5 V52 software setup. They are available as configuration file and can be imported into the measurement file. The values displayed in the multimeter window are assessed using the parameters of the actual system setup. In the scan visualization and export modes, the parameters stored in the measurement file are used.

The measured voltage is not proportional to the exciting. It must be first linearized.

Approximated Probe Response Linearization using Crest Factor.

This linearization method is enabled when a custom defined communication system is measured. The compensation applied is a function of the measured voltage, the detector diode compression point and the crest factor of the measured signal.

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

with V_i = linearized voltage of channel i (uV) (i = x,y,z)
 U_i = measured voltage of channel i (uV) (i = x,y,z)
 cf = crest factor of exciting field (DASY parameter)
 dcp_i = diode compression point of channel i (uV) (Probe parameter, i = x,y,z)

Field and SAR Calculation

The primary field data for each channel are calculated using the linearized voltage:

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

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

with V_i = linearized voltage of channel i (i = x,y,z)

Norm_i = sensor sensitivity of channel i (i = x,y,z)

$\mu\text{V}/(\text{V/m})^2$ 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 RMS value of the field components gives the total field strength (Hermitian magnitude):

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

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

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

with SAR = local specific absorption rate in mW/g

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

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

ρ = equivalent tissue density in g/cm^3

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

Spatial Peak SAR for 1 g and 10 g

The DASY5 software includes all numerical procedures necessary to evaluate the spatial peak SAR values. The base for the evaluation is a "cube" measurement at the points of the fine cube grid consisting of 5 x 5 x 7 points (with 8mm horizontal resolution) or 7 x 7 x 7 points (with 5mm horizontal resolution) or 8 x 8 x 7 points (with 4mm horizontal resolution). The entire evaluation of the spatial peak values is performed within the Postprocessing engine (SEMCAD X). The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. extraction of the measured data (grid and values) from the Zoom Scan.
2. calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters).
3. generation of a high-resolution mesh within the measured volume.
4. interpolation of all measured values from the measurement grid to the high-resolution grid
5. extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface.
6. calculation of the averaged SAR within masses of 1 g and 10 g.

4.3 Data Storage and Evaluation

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

Step 1: Power reference measurement

The Power Reference Measurement and Power Drift Measurement are for monitoring the power drift of the device under test in the batch process. The Minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. By default, the Minimum distance of probe sensors to surface is 4 mm. This distance can be modified by the user, but cannot be smaller than the Distance of sensor calibration points to probe tip as defined in the probe properties. The SAR measurement was taken at a selected spatial reference point to monitor power variations during testing. This fixed location point was measured and used as a reference value.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hotspot. The sophisticated interpolation routines implemented in DASY5 software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maxima found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE 1528-2003 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.

Step 3: Zoom Scan

The Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 gram and 10 gram of simulated tissue. The default Zoom Scan is defined in the following table. DASY5 is also able to perform repeated zoom scans if more than 1 peak is found during area scan. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 gram and 10 gram and displays these values next to the job's label.

Area scan and Zoom scan resolutions per FCC KDB Publication 865664 D01:

Frequency	Maximun Area Scan resolution ($\Delta x_{Area}, \Delta y_{Area}$)	Maximun Zoom Scan spatial resolution ($\Delta x_{Zoom}, \Delta y_{Zoom}$)	Maximun Zoom Scan spatial resolution			Minimum zoom scan volume (x,y,z)
			Uniform Grid	Graded Grad		
			$\Delta z_{Zoom}(n)$	$\Delta z_{Zoom}(1)^*$	$\Delta z_{Zoom}(n>1)^*$	
$\leq 2\text{GHz}$	$\leq 15\text{mm}$	$\leq 8\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 1.5 * \Delta z_{Zoom}(n-1)$	$\geq 30\text{mm}$
2-3GHz	$\leq 12\text{mm}$	$\leq 5\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 1.5 * \Delta z_{Zoom}(n-1)$	$\geq 30\text{mm}$
3-4GHz	$\leq 12\text{mm}$	$\leq 5\text{mm}$	$\leq 4\text{mm}$	$\leq 3\text{mm}$	$\leq 1.5 * \Delta z_{Zoom}(n-1)$	$\geq 28\text{mm}$
4-5GHz	$\leq 10\text{mm}$	$\leq 4\text{mm}$	$\leq 3\text{mm}$	$\leq 2.5\text{mm}$	$\leq 1.5 * \Delta z_{Zoom}(n-1)$	$\geq 25\text{mm}$
5-6GHz	$\leq 10\text{mm}$	$\leq 4\text{mm}$	$\leq 2\text{mm}$	$\leq 2\text{mm}$	$\leq 1.5 * \Delta z_{Zoom}(n-1)$	$\geq 22\text{mm}$

Step 4: Power Drift Monitoring

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement job within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. If the value changed by more than 5%, the evaluation should be retested.

5 SAR Verification Procedure

5.1 Tissue Verification

The following materials are used for producing the tissue-equivalent materials.

(Liquids used for tests are marked with ☒):

Ingredients (% of weight)	Frequency (MHz)						
frequency band	☐ 835	☐ 900	☐ 1800	☐ 2000	☐ 2300	☒ 2450	☐ 2600
Tissue Type	Head	Head	Head	Head	Head	Head	Head
Water	41.45	40.92	52.64	54.9	62.82	62.7	55.242
Salt (NaCl)	1.45	1.48	0.36	0.18	0.51	0.5	0.306
Sugar	56.0	56.5	0.0	0.0	0.0	0.0	0.0
HEC	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Bactericide	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	47.0	44.92	36.67	0.0	44.452

Salt: 99+% Pure Sodium Chloride

Sugar: 98+% Pure Sucrose

Water: De-ionized, 16MΩ+ resistivity

HEC: Hydroxyethyl Cellulose

DGBE: 99+% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]

Triton X-100(ultra pure): Polyethylene glycol mono [4-(1,1,3,3-tetramethylbutyl)phenyl]ether

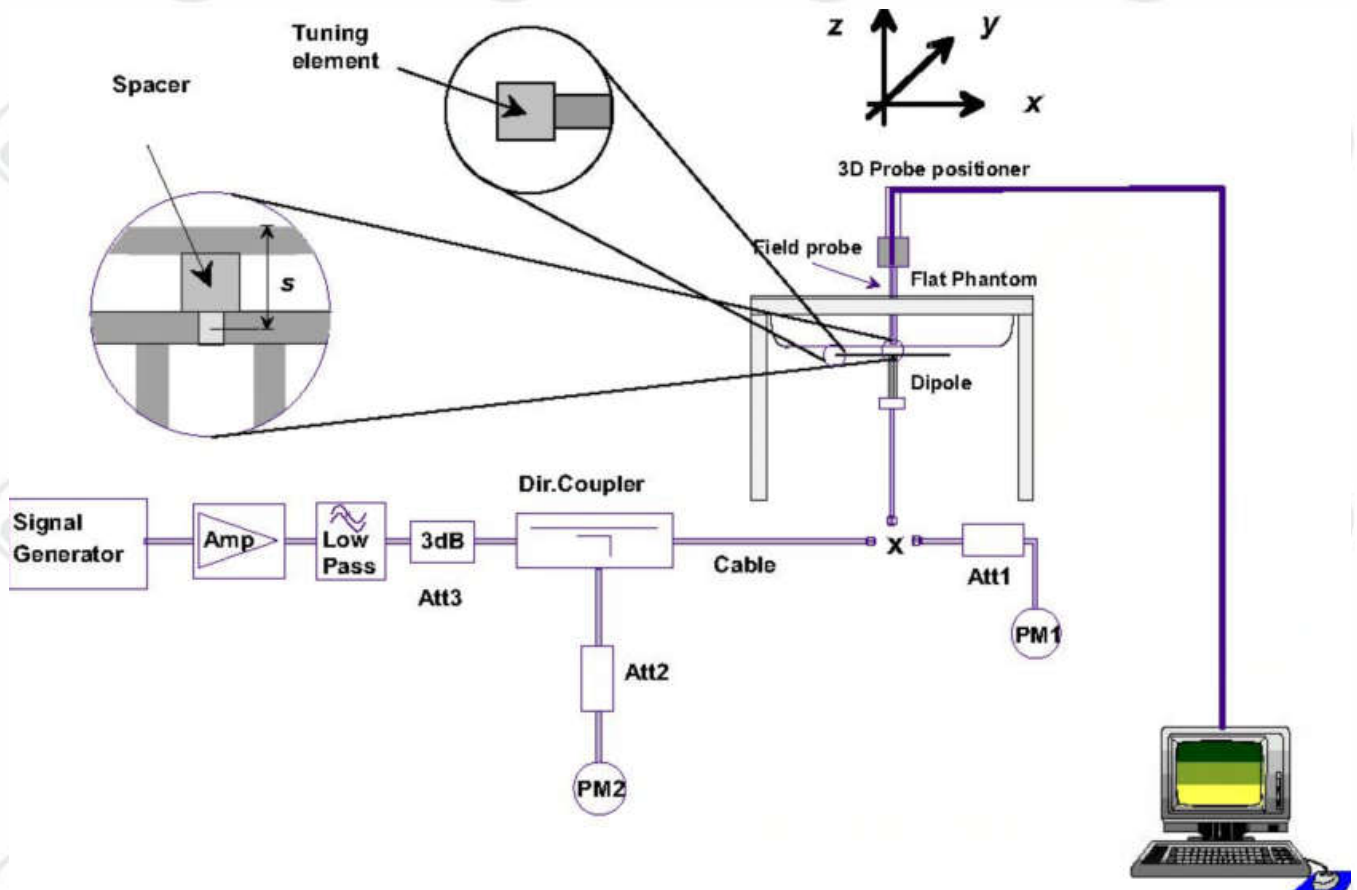
Tissue simulating liquids: parameters:

Tissue Type	Measured Frequency (MHz)	Target Tissue		Measured Tissue		Liquid Temp.	Test Date
		ϵ_r (+/-5%)	σ (S/m) (+/-5%)	ϵ_r	σ (S/m)		
2450 Head	2410	39.30 (37.34~41.26)	1.76 (1.67~1.85)	39.31	1.796	21.51°C	2018-5-22
	2435	39.20 (37.24~41.16)	1.79 (1.70~1.88)	39.28	1.833	21.51°C	2018-5-22
	2450	39.20 (37.24~41.16)	1.80 (1.71~1.89)	39.26	1.849	21.51°C	2018-5-22
	2460	39.20 (37.24~41.16)	1.81 (1.72~1.90)	39.24	1.858	21.51°C	2018-5-22
2450 Body	2410	52.80 (50.16~55.44)	1.91 (1.81~2.00)	53.70	1.878	21.49°C	2018-5-23
	2435	52.70 (50.07~55.34)	1.94 (1.84~2.04)	53.69	1.904	21.49°C	2018-5-23
	2450	52.70 (50.07~55.34)	1.95 (1.85~2.05)	53.72	1.928	21.49°C	2018-5-23
	2460	52.70 (50.07~55.34)	1.96 (1.86~2.06)	53.71	1.937	21.49°C	2018-5-23
ϵ_r = Relative permittivity, σ = Conductivity							

5.2 System check procedure

The System check is performed by using a System check dipole which is positioned parallel to the planar part of the SAM phantom at the reference point. The distance of the dipole to the SAM phantom is determined by a spacer. The dipole is connected to the signal source consisting of signal generator and amplifier via a directional coupler, N-connector cable and adaption to SMA. It is fed with a power of 250mW. To adjust this power a power meter is used. The power sensor is connected to the cable before the System check to measure the power at this point and do adjustments at the signal generator. At the outputs of the directional coupler both return loss as well as forward power are controlled during the validation to make sure that emitted power at the dipole is kept constant. This can also be checked by the power drift measurement after the test (result on plot).

System check results have to be equal or near the values determined during dipole calibration (target SAR in table above) with the relevant liquids and test system.



5.3 System check results

The system Check is performed for verifying the accuracy of the complete measurement system and performance of the software. The following table shows System check results for all frequency bands and tissue liquids used during the tests (plot(s) see annex A).

System Check (MHz)	Target SAR (1W) (+/-10%)		Measured SAR (Normalized to 1W)		Liquid Temp.	Test Date
	1-g (mW/g)	10-g (mW/g)	1-g (mW/g)	10-g (mW/g)		
D2450V2 Head	51.50 (46.35~56.65)	24.10 (21.69~26.51)	52.80	24.56	21.51°C	2018-5-22
D2450V2 Body	50.60 (45.54~55.66)	23.70 (21.33~26.07)	49.60	23.28	21.49°C	2018-5-22
Note: All SAR values are normalized to 1W forward power.						

6 SAR Measurement uncertainty evaluation

6.1 SAR measurement variability

In accordance with published RF Exposure KDB procedure 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

- 1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
- 4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

6.2 SAR measurement uncertainty

Per KDB865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

7 SAR Test Configuration

For WiFi SAR testing, a communication link is set up with the testing software for WiFi mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The test procedures in KDB 248227D01 v02r02 are applied.

Initial Test Position Procedure

For exposure condition with multiple test position, such as handsets operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is $\leq 0.4 \text{ W/kg}$, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is $\leq 0.8 \text{ W/kg}$ or all test position are measured. For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is $> 0.8 \text{ W/kg}$, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is $\leq 1.2 \text{ W/kg}$ or all required channels are tested.

Initial Test Configuration Procedure

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required (see section 5.3.2 of KDB 248227D01v02). SAR test reduction of subsequent highest output test channels is based on the reported SAR of the initial test configuration.

For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For

fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration.

When the reported SAR of the initial test configuration is $> 0.8 \text{ W/kg}$, SAR measurement is required for the subsequent next highest measured output power channel(s) in the initial test configuration until the reported SAR is $\leq 1.2 \text{ W/kg}$ or all required channels are tested.

Sub Test Configuration Procedure

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units.

When the highest reported SAR for the initial test configuration, according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is $\leq 1.2 \text{ W/kg}$, SAR is not required for that subsequent test configuration.

7.1 WIFI 2.4G Test Configurations

Per KDB 248227 D01 802.11 Wi-Fi SAR v02r02, SAR Test Reduction criteria are as follows:

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the initial test position(s) by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The relative SAR levels of multiple exposure test positions can be established by area scan measurements on the highest measured output power channel to determine the initial test position. The area scans must be measured using the same SAR measurement configurations, including test channel, maximum output power, probe tip to phantom distance, scan resolution etc.

When the reported SAR for the initial test position is:

- 1) ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- 2) > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
- 3) For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required test channels are considered.

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.
- 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.

8 SAR Test Results

8.1 Conducted Power Measurements

8.1.1 Conducted Power of WiFi 2.4G

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Tune-up	Average Power(dBm)	SAR Test (Yes/No)
802.11b	1	2412	1	17.0	16.22	Yes
	6	2437		17.0	16.40	Yes
	11	2462		17.0	16.35	Yes
802.11g	1	2412	6	16.0	Not Required	No
	6	2437		16.0	Not Required	No
	11	2462		16.0	Not Required	No
802.11n (HT20)	1	2412	6.5	16.0	Not Required	No
	6	2437		16.0	Not Required	No
	11	2462		16.0	Not Required	No
802.11n (HT40)	3	2422	13.5	15.0	Not Required	No
	6	2437		15.0	Not Required	No
	9	2452		15.0	Not Required	No

Note: 1) An entry of "Not Required" means power measurement is not required according to the default power measurement procedures in KDB248227D01.

8.1.2 Conducted Power of Bluetooth

For BT 3.0

Average Conducted Power(dBm)			
Channel	0CH	39CH	78CH
GFSK	5.44	4.99	4.72
$\pi/4$ DQPSK	5.33	4.87	4.56
8DPSK	5.23	4.84	4.54

Note: 1) channel /Frequency: 0/2402, 39/2441, 78/2480

For BT 4.0:

Average Conducted Power(dBm)			
Channel	0CH	19CH	39CH
BT	-6.92	-7.08	-7.50

Note: 1) channel /Frequency: 0/2402, 19/2440, 39/2480.

8.2 SAR test results

Notes:

1) Per KDB447498 D01v06, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is: ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz. When the maximum output power variation across the required test channels is $> \frac{1}{2}$ dB, instead of the middle channel, the highest output power channel must be used.

2) Per KDB447498 D01v06, All measurement SAR result is scaled-up to account for tune-up tolerance is compliant.

3) Per KDB865664 D01v01r04, for each frequency band, repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/Kg; if the deviation among the repeated measurement is $\leq 20\%$, and the measured SAR < 1.45 W/Kg, only one repeated measurement is required.

4) Per KDB865664 D02v01r02, SAR plot is only required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination; Plots are also required when the measured SAR is > 1.5 W/kg, or > 7.0 W/kg for occupational exposure. The published RF exposure KDB procedures may require additional plots; for example, to support SAR to peak location separation ratio test exclusion and/or volume scan post-processing (Refer to appendix B for details).

8.2.1 Results overview of WiFi 2.4G

Test Position of Head	Test channel /Frequency	Test Mode	SAR Value (W/kg)		Power Drift (dB)	Conducted Power (dBm)	Tune-up power (dBm)	Scaled SAR _{1-g} (W/kg)	Actual duty factor	Reported SAR 1-g(W/kg)
			1-g	10-g						
Left Hand Touched	6/2437	802.11b	0.118	0.052	0.050	16.40	17.00	0.135	99.58%	0.136
Left Hand Tilted 15°	6/2437	802.11b	0.055	0.021	0.040	16.40	17.00	0.063	99.58%	0.063
Right Hand Touched	6/2437	802.11b	0.045	0.018	0.070	16.40	17.00	0.052	99.58%	0.052
Right Hand Tilted 15°	6/2437	802.11b	0.050	0.018	0.010	16.40	17.00	0.057	99.58%	0.058
Left Hand Touched	11/2462	802.11b	0.116	0.050	0.030	16.35	17.00	0.135	99.58%	0.135
Left Hand Touched	1/2412	802.11b	0.114	0.049	0.170	16.22	17.00	0.136	99.61%	0.137

Note: Per KDB248227D01:

- 1) SAR is measured for 2.4 GHz 802.11b DSSS using initial test position procedure.
- 2) As the highest reported SAR for DSSS is adjusted by the ratio of OFDM 802.11g to DSSS specified maximum output power and the adjusted SAR is < 1.2 W/kg, so SAR for OFDM 802.11g is required
- 3) As the highest reported SAR for DSSS is adjusted by the ratio of OFDM 802.11n(20MHz&40MHz) to DSSS specified maximum output power and the adjusted SAR is < 1.2 W/kg, so SAR for OFDM 802.11n(20MHz&40MHz)is required

Test position of Body-Worn with 15mm	Test channel /Frequency	Test Mode	SAR Value (W/kg)		Power Drift (dB)	Conducted Power (dBm)	Tune-up power (dBm)	Scaled SAR _{1-g} (W/kg)	Actual duty factor	Reported SAR 1-g(W/kg)
			1-g	10-g						
Front Side	6/2437	802.11b	0.021	0.008	-0.010	16.40	17.00	0.024	99.58%	0.024
Back Side	6/2437	802.11b	0.040	0.017	-0.020	16.40	17.00	0.046	99.58%	0.046
Back Side	11/2462	802.11b	0.039	0.014	0.070	16.35	17.00	0.045	99.58%	0.045
Back Side	1/2412	802.11b	0.038	0.014	0.010	16.22	17.00	0.045	99.61%	0.046

Note: Per KDB248227D01:

- 1) SAR is measured for 2.4 GHz 802.11b DSSS using initial test position procedure.
- 2) As the highest reported SAR for DSSS is adjusted by the ratio of OFDM 802.11g to DSSS specified maximum output power and the adjusted SAR is < 1.2 W/kg, so SAR for OFDM 802.11g is required
- 3) As the highest reported SAR for DSSS is adjusted by the ratio of OFDM 802.11n(20MHz&40MHz) to DSSS specified maximum output power and the adjusted SAR is < 1.2 W/kg, so SAR for OFDM 802.11n(20MHz&40MHz)is required

8.3 Multiple Transmitter Information

The location of the antennas inside 0480 0069 is shown as below picture:



The SAR measurement positions of each side are as below:

Test mode	Front Side	Rear Side	Left Side	Right Side	Top Side	Bottom Side
Body-worn	Yes	Yes	No	No	No	No

8.4 Stand-alone SAR

Per FCC KDB 447498D01:

- 1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances $\leq$ 50 mm are determined by:

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

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Mode	Position	P_{max} (dBm)	P_{max} (mW)	Distance (mm)	F (GHz)	Calculation Result	SAR test exclusion Threshold	SAR test exclusion
BT	Head	5.50	3.55	5.00	2.450	1.11	3.00	Yes
BT	Body-worn	5.50	3.55	15.00	2.450	0.37	3.00	Yes

8.5 Simultaneous Transmission Possibilities and Conclusion

There is not simultaneous transmission possibility, because the BT and WiFi 2.4G share the same antenna and can't transmit simultaneously, and the reported SAR results is not exceed the SAR limit, so the tested result is comply with the IC&FCC limit.

Annex A: Appendix A: SAR System performance Check Plots

(Please See Appendix A)

Annex B: Appendix B: SAR Measurement results Plots

(Please See Appendix B)

Annex C: Appendix C: Calibration reports

(Please See Appendix C)

Annex D: Appendix D: Photo documentation

(Please See Appendix D)

——END OF REPORT——

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