



FCC SAR Report

Report No. : SESF1810089
Client/Manufacturer : Benq Corporation
Address : 16 Jihu Road, Neihu, Taipei 114, Taiwan
Product : BenQ Wireless Dongle
Model : WDR02U
FCC ID : JVPWDR02U
Standards : FCC 47 CFR Part 2 (2.1093) / IEEE C95.1:2005 / IEEE 1528-2013 / KDB 865664 D01 v01r04 / KDB 248227 D01 v02r02 / KDB 447498 D01 v06 / KDB 447498 D02 v02r01
Test Date : Nov 11th, 2018 ~ Nov 15th, 2018

Statement of Compliance:

The SAR values measured for the test sample are below the maximum recommended level of 1.6W/kg averaged over any 1g tissue according to FCC Knowledge Data Base/ FCC 47CFR Part 2 (2.1093) / IEEE Std.1528-2013.

The test result only corresponds to the tested sample. It is not permitted to copy this report, in part or in full, without the permission of the test laboratory.

The testing described in this report has been carried out to the best of our knowledge and ability, and our responsibility is limited to the exercise of reasonable care. This certification is not intended to believe the sellers from their legal and/or contractual obligations.

Approved By: _____





Release Version

Report No.	Version	Issue Date	Description
SESF1810089	Rev 01	2018-11-16	Initial release



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1. Summary of Maximum SAR Value

Equipment Class	Highest Reported SAR _{1-g} (W/kg)
DTS	1.584
U-NII	1.525
Highest Simultaneous Transmission SAR	Body
	Highest Simultaneous SAR _{1-g} (W/kg)
N/A	N/A



2. Description of Equipment under Test

Product Name	BenQ Wireless Dongle
Model No.	WDR02U
Product Type	WLAN (2TX, 2RX)
Antenna Type	PCB
Antenna Peak Gain	2.4G: 2dBi, 5G: 2dBi
Device Category	Portable
RF Exposure Environment	Uncontrolled
Wi-Fi	
MODULATION TYPE	CCK, DQPSK, DBPSK for DSSS
	64QAM, 16QAM, QPSK, BPSK for OFDM
MODULATION TECHNOLOGY	DSSS, OFDM
TRANSFER RATE	802.11b: up to 11Mbps
	802.11a/g: up to 54Mbps
	802.11n : up to 150Mbps
	802.11ac: up to 433.3Mbps
OPERATING FREQUENCY	For 15.407 5.18 ~ 5.24GHz, 5.745 ~ 5.825GHz
	For 15.247 2.412 ~ 2.462GHz
NUMBER OF CHANNEL	For 15.407 25 for 802.11a, 802.11n (HT20), 802.11ac (VHT20) 12 for 802.11n (HT40), 802.11ac (VHT40) 6 for 802.11ac (VHT80)
	For 15.247 (2.4GHz) 11 for 802.11b/g, 802.11n (HT20), 7 for 802.11n (HT40)



Bluetooth	
MODULATION TYPE	GFSK, $\pi/4$ -DQPSK, 8DPSK for FHSS GFSK for DTS
MODULATION TECHNOLOGY	FHSS, DTS
DATA RATE	Up to 3Mbps for BT-EDR mode Up to 1Mbps for BT-LF mode
FREQUENCY RANGE	BT-EDR, BT-LF mode: 2402MHz ~ 2480MHz
NUMBER OF CHANNEL	BT-EDR mode: 79 BT-LF mode: 40

Additional Information

1. WLAN/BT coexistence mode:

◆ 2x2 WLAN + BT:

- 5GHz 802.11a/n (or 11ac) transmit concurrent with BT.
- 2.4GHz: timely shared coexistence.



3. General Information

Our Lab,

Test Site	Cerpass Technology (Suzhou) Co.,Ltd
Test Site Location	No.66,Tangzhuang Road, Suzhou Industrial Park, Jiangsu 215006, China



4. Basic restrictions and Standards

4.1. Test Standards

1. IEEE 1512-2013
2. FCC KDB Publication 447498 D01 General RF Exposure Guidance v06
3. FCC KDB Publication 447498 D02 SAR Procedures for Dongle Xmtr v02r01
4. FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
5. FCC KDB Publication 248227 D01 802.11 Wi-Fi SAR v02r02

4.2. Environment Condition

Item	Target	Measured
Ambient Temperature(°C)	18~25	21.5±2
Temperature of Simulant(°C)	20~22	21±2
Relative Humidity(%RH)	30~70	52

4.3. RF Exposure Limits

Human Exposure	Basic restrictions for electric, magnetic and electromagnetic fields. (Unit in mW/g or W/kg)
Spatial Peak SAR ¹ (Head and Body)	1.60
Spatial Average SAR ² (Whole Body)	0.08
Spatial Peak SAR ³ (Arms and Legs)	4.00

Notes:

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

5. DASY5 Measurement System

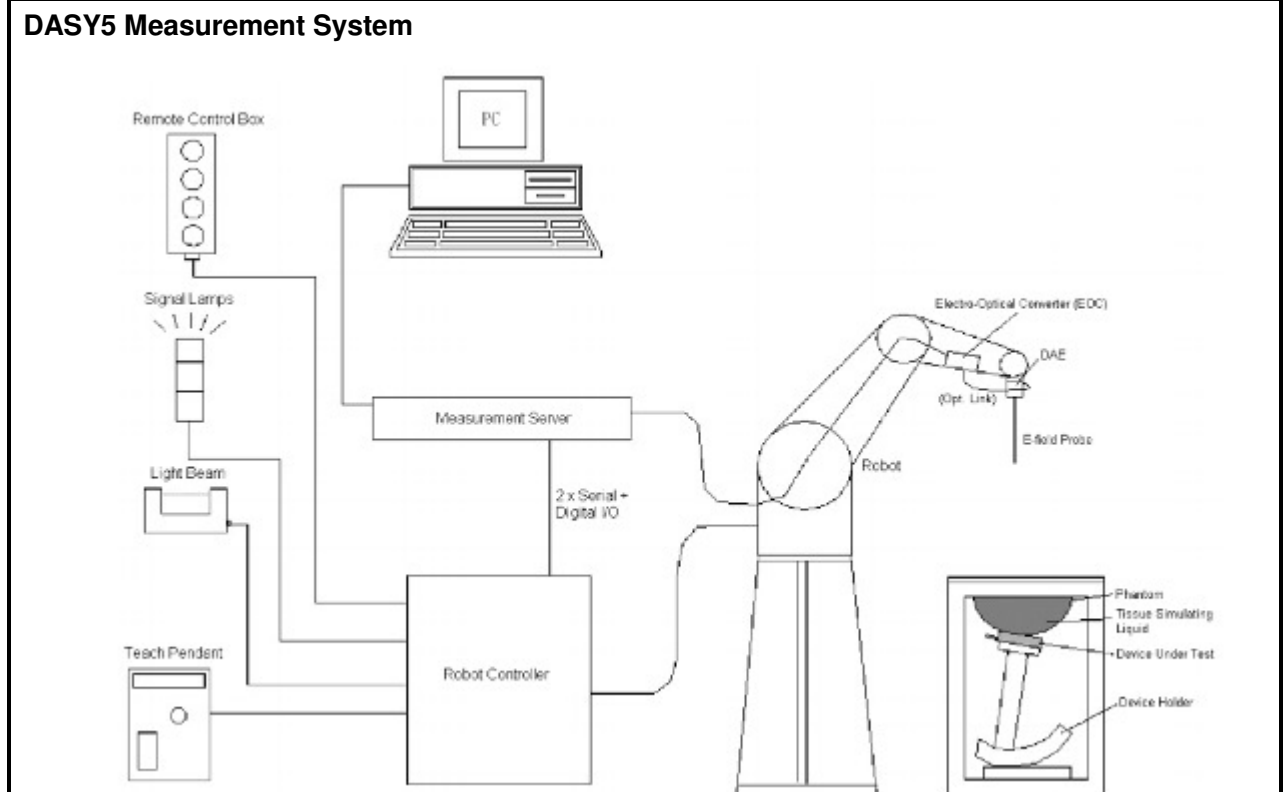


Figure 2.1 SPEAG DASY5 System Configurations

The DASY5 system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic(DAE)attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter(ECO)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 7
- DASY5 software
- Remove control with teach pendant 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



5.1. Uncertainty of Inter-/Extrapolation and Averaging

In order to evaluate the uncertainty of the interpolation, extrapolation and averaged SAR calculation algorithms of the Postprocessor, DASY5 allows the generation of measurement grids which are artificially predefined by analytically based test functions. Therefore, the grids of area scans and zoom scans can be filled with uncertainty test data, according to the SAR benchmark functions of IEEE 1512. The three analytical functions shown in equations as below are used to describe the possible range of the expected SAR distributions for the tested handsets. The field gradients are covered by the spatially flat distribution f1, the spatially steep distribution f3 and f2 accounts for H-field cancellation on the phantom/tissue surface.

$$f_1(x, y, z) = Ae^{-\frac{z}{2a}} \cos^2 \left(\frac{\pi}{2} \frac{\sqrt{x'^2 + y'^2}}{5a} \right)$$


$$f_2(x, y, z) = Ae^{-\frac{z}{a}} \frac{a^2}{a^2 + x'^2} \left(3 - e^{-\frac{2z}{a}} \right) \cos^2 \left(\frac{\pi}{2} \frac{y'}{3a} \right)$$

$$f_3(x, y, z) = A \frac{a^2}{\frac{a^2}{4} + x'^2 + y'^2} \left(e^{-\frac{2z}{a}} + \frac{a^2}{2(a + 2z)^2} \right)$$

5.2. DASY5 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.

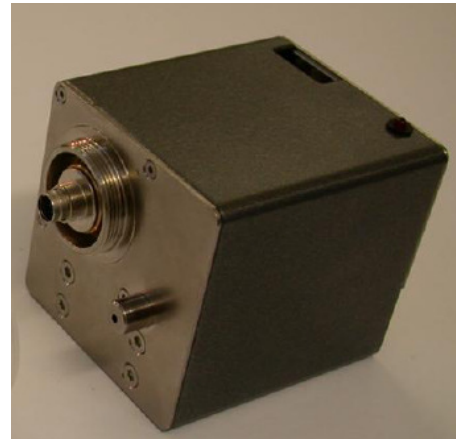
SPEAG conducts the probe calibration in compliance with international and national standards (e.g. IEEE 1512, EN 62209-1, IEC 62209, etc.) under ISO 17025. The calibration data are in Appendix D.

Model	EX3DV4	
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 (30 MHz to 6 GHz)	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 μ W/g to 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μ W/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	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	



5.3. Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 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 DAE4 is 200M Ohm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.



5.4. Robot

The DASY5 system uses the high precision robots TX90 XL type out of the newer series from Stäubli SA (France). For the 6-axis controller DASY5 system, the CS8C robot controller version from Stäubli is used. The XL robot series have many features that are important for our application:

- High precision (repeatability 0.02 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller



5.5. Light Beam Unit

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

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





5.6. Measurement Server

The DASY5 measurement server is based on a PC/104 CPU board with a 400MHz intel ULV Celeron, 112MB chipdisk and 112MB RAM. The necessary circuits for communication with the DAE electronics box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY5 I/O board, which is directly connected to the PC/104 bus of the CPU board.



5.7. SAM Phantom

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

- Left head
- Right head
- Flat phantom



The ELI4 Phantom also is a fiberglass shell phantom with 2mm shell thickness. It has 30 liters filling volume, and with a dimension of 600mm for major ellipse axis, 400mm for minor axis. It is intended for compliance testing of handheld and body-mounted wireless devices in frequency range of 30 MHz to 6GHz. ELI4 is fully compatible with standard and all known tissue simulating liquids.



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.

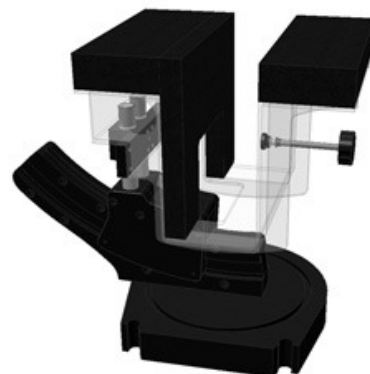


5.8. Device Holder

The DASY5 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 (EPR). Thus the device needs no repositioning when changing the angles. The DASY5 device holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity $\epsilon_r = 3$ 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.



The laptop extension is lightweight and made of POM, acrylic glass and foam. It fits easily on upper part of the mounting device in place of the phone positioned. The extension is fully compatible with the SAM Twin and ELI phantoms.





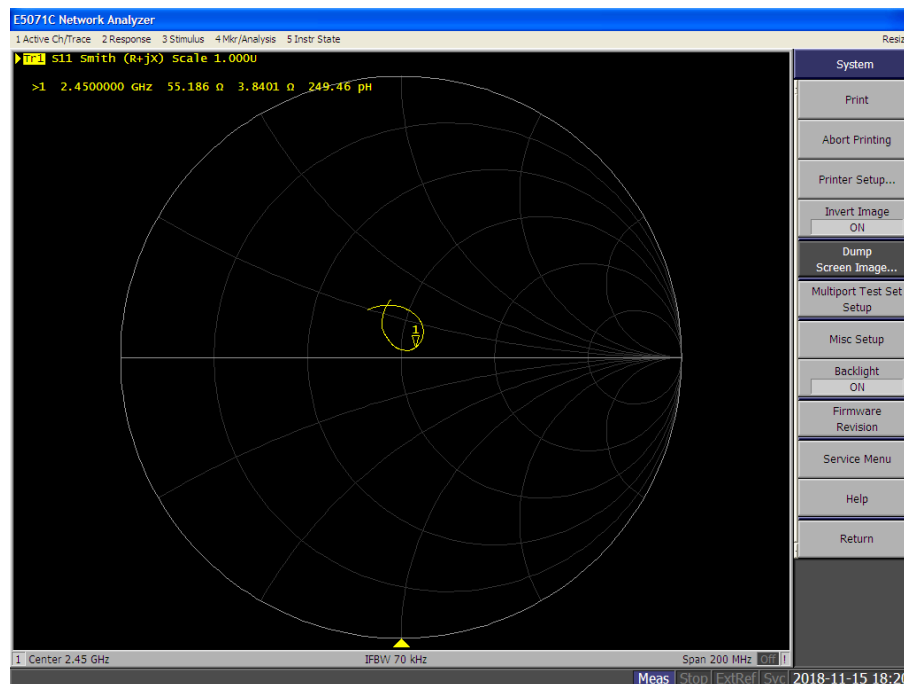
5.9. Test Equipment List

Instrument	Manufacturer	Model No.	Serial No.	Cali. Due Date
Stäubli Robot TX60L	Stäubli	TX60L	5P6VA1/A/01	only once
Robot Controller	Stäubli	CS8C	5P6VA1/C/01	only once
Dipole Validation Kits	Speag	D2450V2	914	2019.05.18
Dipole Validation Kits	Speag	D5GHzV2	1156	2019.05.21
SAM ELI Phantom	Speag	SAM	1211	N/A
Laptop Holder	Speag	SM LH1 0012D	N/A	N/A
Data Acquisition Electronic	Speag	DAE4	1379	2019.05.22
E-Field Probe	Speag	EX3DV4	3927	2019.05.24
SAR Software	Speag	DASY5	V5.2 Build 162	N/A
Power Amplifier	Mini-Circuit	ZVA-183W-S+	MN136701248	2019.09.02
Directional Coupler	Agilent	772D	MY52180104	2019.09.02
Spectrum Analyzer	R&S	FSP40	100324	2019.03.21
Vector Network	Agilent	E50712	MY4631693	2019.01.14
Signal Generator	R&S	SML	103127	2019.03.08
Power Meter	R&S	BLWA0830-160/100/40D	76659	2019.03.25
AUG Power Sensor	R&S	NRP-Z91	100384	2019.03.08

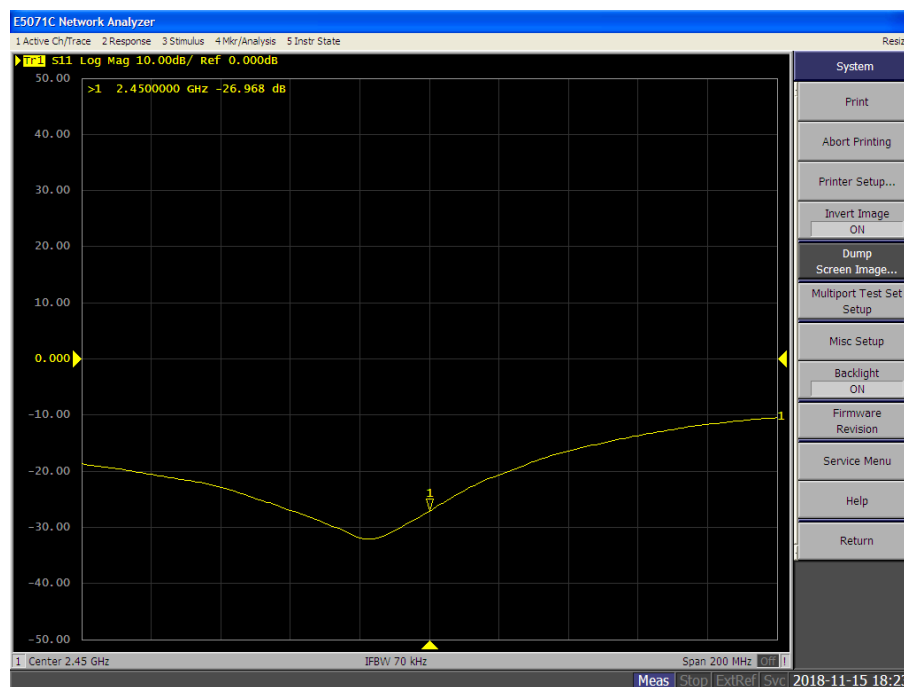


5.10. Annual Internal Check of Dipole

2450MHz Body calibrated impedance 51.758Ω; measured impedance: 55.186Ω (within 5Ω)



2450MHz Body calibrated return loss: -25.649 dB; Measured return loss: -26.968dB (within 20%)

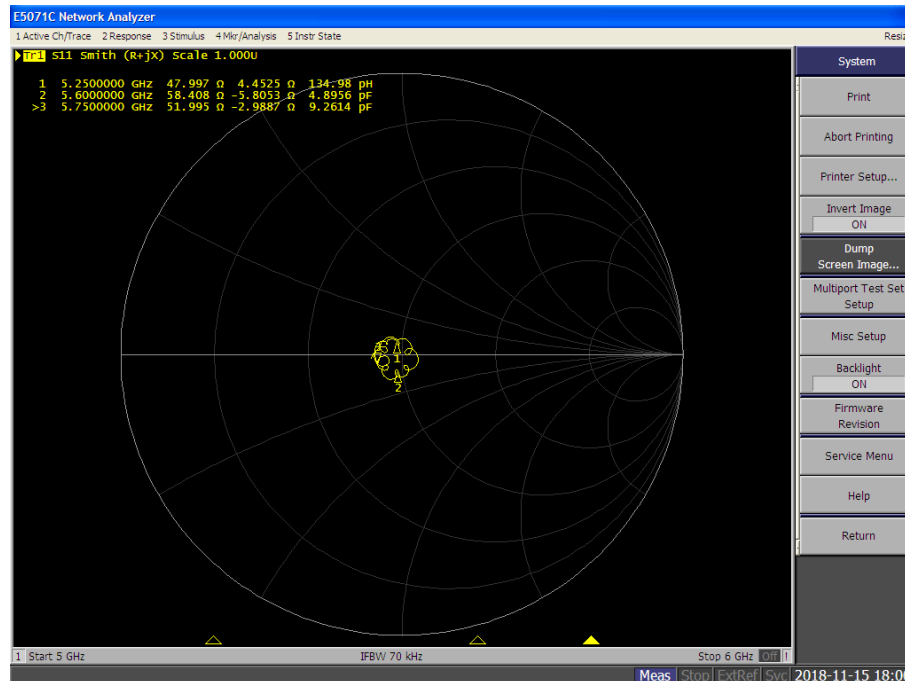




5250MHz Body calibrated impedance 50.123Ω; measured impedance: 47.997Ω (within 5Ω)

5600MHz Body calibrated impedance 57.351Ω; measured impedance: 58.408Ω (within 5Ω)

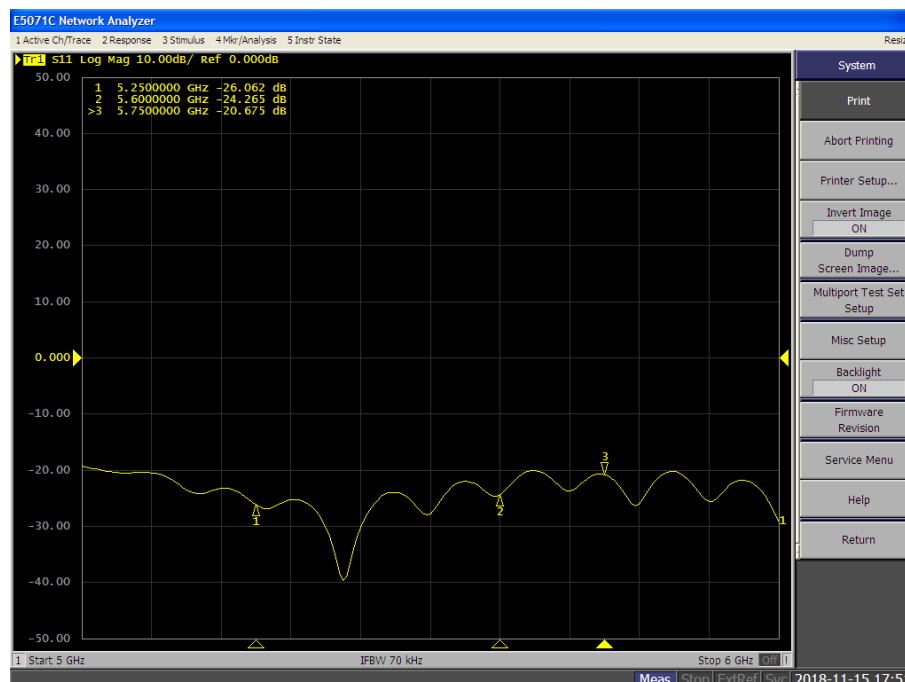
5750MHz Body calibrated impedance 55.798Ω; measured impedance: 51.995Ω (within 5Ω)



5250MHz Body calibrated return loss: -26.614 dB; Measured return loss: -26.602dB (within 20%)

5600MHz Body calibrated return loss: -22.306 dB; Measured return loss: -24.265dB (within 20%)

5750MHz Body calibrated return loss: -23.611 dB; Measured return loss: -20.675dB (within 20%)





6. The SAR Measurement Procedure

6.1. System Performance Check

6.1.1 Purpose

1. To verify the simulating liquids are valid for testing.
2. To verify the performance of testing system is valid for testing.

6.1.2 Tissue Dielectric Parameters for Head and Body Phantoms

Target Frequency	Head		Body	
(MHz)	ϵ_r	σ (S/m)	ϵ_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
850	41.5	0.92	55.2	0.99
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5200	36.0	4.66	49.0	5.30
5300	35.87	4.76	48.88	5.42
5600	35.5	5.07	48.5	5.77
5800	35.3	5.27	48.2	6.00

(ϵ_r = relative permittivity, σ = conductivity and $\rho = 1000 \text{ kg/m}^3$)



6.1.3 Tissue Calibration Result

■ The dielectric parameters of the liquids were verified prior to the SAR evaluation using DASY5 Dielectric Assessment Kit and Agilent Vector Network Analyzer E50712.

Tissue parameter for body							
Fre. <MHz>	Permittivity	Conductivity	Target Permittivity	Target Conductivity	Delta Permittivity%	Delta Conductivity %	Tissue Temperature°C
23-07-2016							
2450	52.47	1.96	52.70	1.95	0.00	0.01	21.0
2412	52.54	1.93	52.75	1.91	0.00	0.01	21.0
2437	52.51	1.95	52.73	1.93	0.00	0.01	21.0
2462	52.42	1.98	52.69	1.96	-0.01	0.01	21.0
23-07-2016							
5200	49.17	5.31	49.00	5.30	0.00	0.00	21.0
5260	49.12	5.35	48.85	5.42	0.01	-0.01	21.0
24-07-2016							
5600	48.52	5.77	48.50	5.77	0.00	0.00	21.0
5580	48.57	5.75	48.52	5.75	0.00	0.00	21.0
5660	48.35	5.82	48.39	5.82	0.00	0.00	21.0
5680	48.33	5.84	48.37	5.85	0.00	0.00	21.0
5720	48.24	5.89	48.33	5.89	0.00	0.00	21.0
24-07-2016							
5800	48.42	5.97	48.20	6.00	0.00	-0.01	21.0
5765	48.49	5.94	48.26	5.93	0.00	0.00	21.0
5785	48.45	5.96	48.24	5.97	0.00	0.00	21.0
5805	48.41	5.98	48.19	6.01	0.00	0.00	21.0

Note: 1. The Delta Permittivity% and Delta Conductivity% should be both within $\pm 5\%$ limit of target values.
2. Refer to KDB 865664 D01 v01r04, The depth of body tissue-equivalent liquid in a phantom must be ≥ 15.0 cm with $\leq \pm 0.5$ cm variation for SAR measurements ≤ 3 GHz and ≥ 10.0 cm with $\leq \pm 0.5$ cm variation for measurements > 3 GHz.



6.1.4 System Performance Check Procedure

The DASY5 installation includes predefined files with recommended procedures for measurements and the system performance check. They are read-only document files and destined as fully defined but unmeasured masks, so the finished system performance check must be saved under a different name. The system performance check document requires the SAM Twin Phantom or ELI4 Phantom, so the phantom must be properly installed in your system. (User defined measurement procedures can be created by opening a new document or editing an existing document file). Before you start the system performance check, you need only to tell the system with which components (probe, medium, and device) you are performing the system performance check; the system will take care of all parameters.

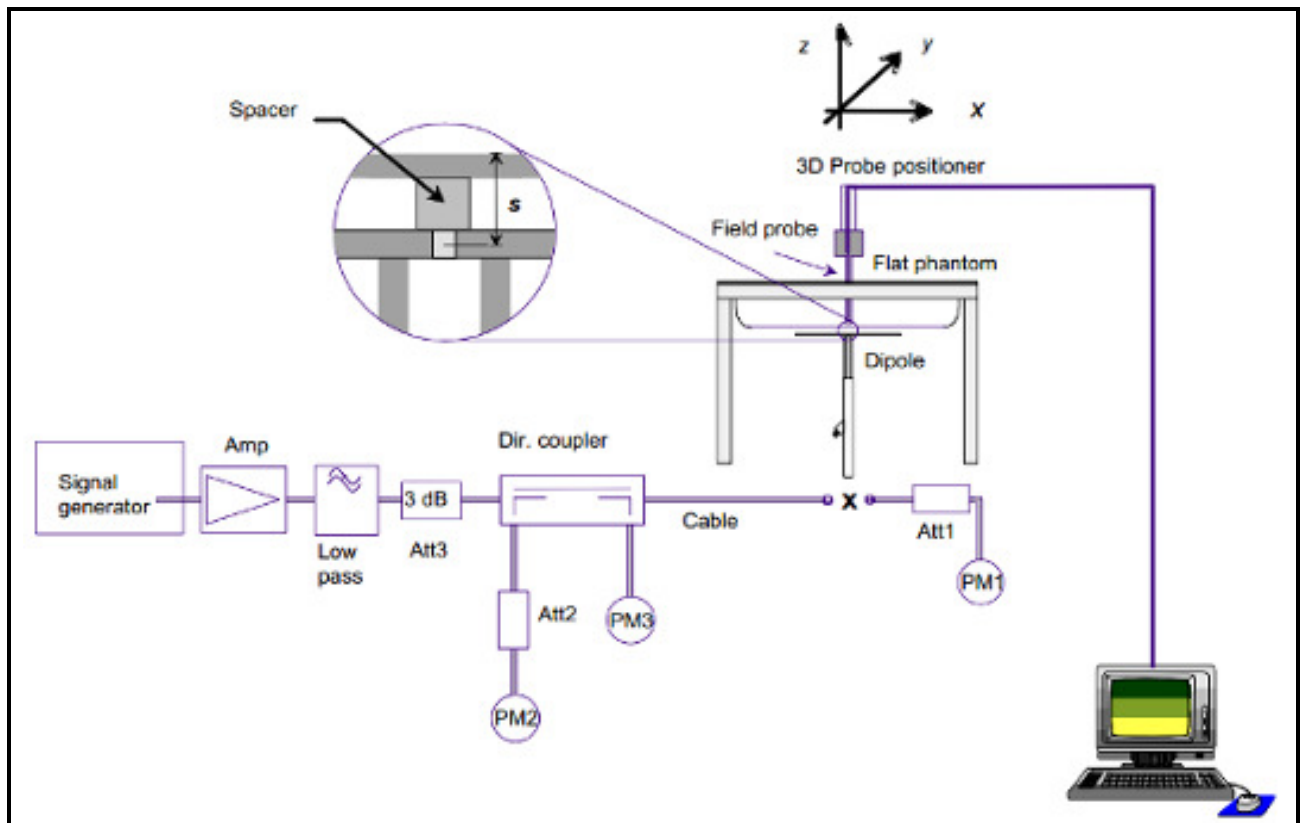
■ **The Power Reference Measurement and Power Drift Measurement** jobs are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the Dipole output power. If it is too high (above ± 0.2 dB), the system performance check should be repeated;

■ **The Surface Check** job tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1 mm). In that case it is better to abort the system performance check and stir the liquid;

■ **The Area Scan** job measures the SAR above the dipole on a plane parallel to the surface. It is used to locate the approximate location of the peak SAR. The proposed scan uses large grid spacing for faster measurement; due to the symmetric field, the peak detection is reliable;

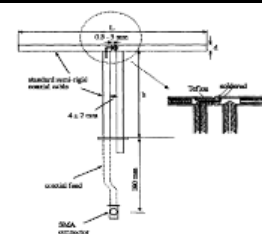
■ **The Zoom Scan** job measures the field in a volume around the peak SAR value assessed in the previous Area Scan job (for more information see the application note on SAR evaluation). If the system performance check gives reasonable results. The dipole input power (forward power) was 250 mW, 1 g and 10 g spatial average SAR values normalized to 1 W dipole input power give reference data for comparisons and it's equal to 10x(dipole forward power). The next sections analyze the expected uncertainties of these values, as well as additional checks for further information or troubleshooting.

6.1.5 System Performance Check Setup



6.1.6 Validation Dipoles

The dipoles use is based on the IEEE Std.1512-2013 and FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04 standard, and is complied with mechanical and electrical specifications in line with the requirements of both EN62209-1 and EN62209-2. The table below provides details for the mechanical and electrical specifications for the dipoles.



**6.1.7 Result of System Performance Check: Valid Result**

System Performance Check at 2450MHz, 5250MHz and 5750MHz for Body.				
Validation Dipole: D2450V2-SN 914				
Frequency [MHz]	Description	SAR [w/kg] 1g	SAR [w/kg] 10g	Tissue Temp. [°C]
2450 MHz	Reference result ± 10% window	52.5 47.25 to 57.75	24.6 22.14 to 27.06	21.0
	12-11-2018	53.7	25.2	
Validation Dipole: D5GHzV2-SN1156				
Frequency [MHz]	Description	SAR [w/kg] 1g	SAR [w/kg] 10g	Tissue Temp. [°C]
5250MHz	Reference result ± 10% window	75.0 67.5 to 82.5	21.0 18.9 to 23.1	21.0
	14-11-2018	75.4	21.7	
Frequency [MHz]	Description	SAR [w/kg] 1g	SAR [w/kg] 10g	Tissue Temp. [°C]
5750MHz	Reference result ± 10% window	76.6 68.94 to 84.26	21.1 18.99 to 23.21	21.0
	14-11-2018	73.4	20.6	
Note: All SAR values are normalized to 1W forward power.				



6.2. Test Requirements

6.2.1 Test Procedures

Step 1 Setup a Connection

First, engineer should record the conducted power before the test. Then establish a call in handset at the maximum power level with a base station simulator via air interface, or make the EUT estimate by itself in testing band. Place the EUT to the specific test location. After the testing, must export SAR test data by SEMCAD. Then writing down the conducted power of the EUT into the report, also the SAR values tested.

Step 2 Power Reference Measurements

To measure the local E-field value at a fixed location which value will be taken as a reference value for calculating a possible power drift.

Step 3 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 fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal 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 Standard 1512 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 KDB 865664 D01v01r04

	≤ 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.	

**Step 4 Zoom Scan**

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. 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 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 v01r04

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{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 <i>reported</i> 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				

Step 5 Power Drift Measurements

Repetition of the E-field measurement at the fixed location mentioned in Step 1 to make sure the two results differ by less than ± 0.2 dB.



6.2.2 Test Channel

Per KDB248227 D01 v02r02, channel selection procedures below apply to both the initial test configuration and subsequent test configuration(s):

- 1) 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n.
- 2) The largest channel bandwidth configuration is selected among the multiple configurations in a frequency band with the same specified maximum output power.
- 3) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.
- 4) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.
- 5) The same procedures also apply to subsequent highest output power channel(s) selection.
 - a> The channel closest to mid-band frequency is selected for SAR measurement.
 - b> For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.



7. Wi-Fi/Bluetooth SAR Exclusion and Results

7.1. Maximum Tune-up Conducted Average Power

1.5dBm for 2.4GHz and 2dBm for 5GHz manufacture tolerance is included for tune up power in 802.11 a/b/g/n/ac SAR evaluation (excluding Bluetooth).

< WIFI 2x2Tx_ Single Chain Max Power> (Unit: dBm)

Ch.	Freq(MHz)	11b	11g	HT20/VHT20	HT40/VHT40
1	2412	21	21	21	--
3	2422	--	--	--	21
6	2437	21	21	21	21
9	2452	--	--	--	21
11	2462	21	21	21	--

Ch.	Freq(MHz)	11a	HT20	VHT20
36	5180	12	12	12
38	5200	12	12	12
44	5220	12	12	12
48	5240	12	12	12
149	5745	12	12	12
153	5765	12	12	12
157	5785	12	12	12
161	5805	12	12	12
165	5825	12	12	12

Ch.	Freq(MHz)	HT40	VHT40
38	5190	12	12
46	5230	12	12
151	5755	12	12
159	5795	12	12

Ch.	Freq(MHz)	VHT80
42	5210	12
155	5775	12

< Bluetooth Max Power > (Unit: dBm)

Bluetooth Max. Tune-up power
7.0dBm

**7.2. Measured Conducted Average Power**

< WIFI 2x2Tx_ Single Chain Max Power > (Unit: dBm)

Configurations	Mode		
	Channel / Frequency (MHz)		
2.4GHz WLAN Average Power	802.11b		
	1/2412	6/2437	11/2462
	16.20	15.73	15.67
	802.11g		
	1/2412	6/2437	11/2462
	16.31	15.76	16.08
	802.11n(HT20)		
	1/2412	6/2437	11/2462
	15.34	15.17	14.77
	802.11n(HT40)		
	3/2422	6/2437	9/2452
	15.76	15.75	15.42
5.2GHz WLAN Average Power	802.11a		
	36/5180	44/5220	48/5240
	14.25	13.55	14.01
	802.11n(HT20)		
	36/5180	44/5220	48/5240
	11.56	11.58	11.31
	802.11ac(VHT20)		
	36/5180	44/5220	48/5240
	11.71	11.71	11.35
	802.11n(HT40)		
	38/5190	46/5230	
	12.61	11.47	
	802.11ac(VHT40)		
	38/5190	38/5230	
	12.66	11.47	
	802.11ac(VHT80)		
	42/5210		
	11.78		
5.8GHz WLAN Average Power	802.11a		
	149/5745	157/5785	165/5825
	13.02	12.01	12.50
	802.11n(HT20)		
	149/5745	157/5785	165/5825
	10.98	11.85	13.10
	802.11ac(VHT20)		
	149/5745	157/5785	165/5825



	11.01	11.88	13.11
	802.11n(HT40)		
	151/5755	159/5795	
	11.23	11.52	
	802.11ac(VHT40)		
	151/5755	159/5795	
	11.27	11.59	
	802.11ac(VHT80)		
	155/5775		
	12.01		

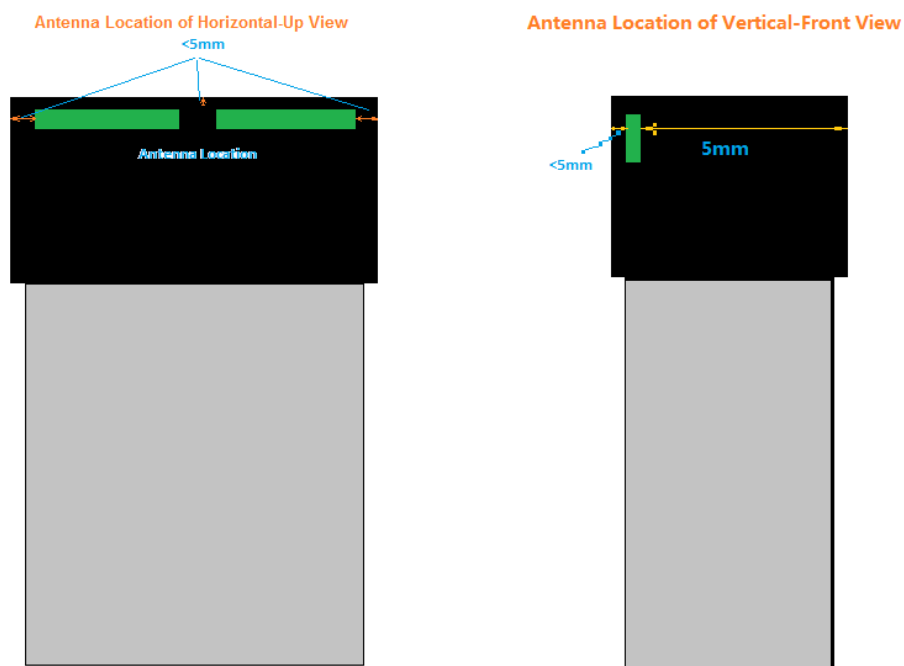
< Bluetooth Max Power > (Unit: dBm)

Configurations	Mode		
	Channel / Frequency (MHz)		
Bluetooth Average Power	DH5(GFSK)		
	0/2402	39/2441	78/2480
	9.25	8.92	9.46
	2DH5($\pi/4$ DQPSK)		
	0/2402	39/2441	78/2480
	8.11	7.95	8.44
	3DH5(8DPSK)		
	0/2402	39/2441	78/2480
	8.11	7.90	8.44
	LE(GFSK)		
	0/2402	19/2440	39/2480
	2.04	2.50	3.66

Note:Bluetooth power is less than P_{ref} , so SAR test is not required.



7.3. Antenna Location



Antenna	Distance to Edges(mm)			
	Horizontal-Up	Horizontal-Down	Vertical-Front	Vertical-Back
	5	<5	<5	<5



7.4. SAR exclusion

Per FCC KDB 447498 D01 v06 for 100MHz~6GHz:

1) The SAR exclusion threshold for distances<50mm is defined by the following equation:

$$\frac{\text{Max Power of Channel(mW)}}{\text{Test Separation Distance(mm)}} \times \sqrt{\text{Frequency(GHz)}} \leq 3.0, \text{ for 1-g SAR}$$

Based on the maximum conducted power and the antenna to use separation distance, Max. average output power Wi-Fi is Higher the P_{re} , therefore Wi-Fi SAR is required:

$$2.45\text{GHz WIFI: } [(125.89\text{mW}/5) * \sqrt{2.412}] = 39.10 > 3.0, \text{ for Body.}$$

$$5.2\text{GHz WIFI: } [(15.85\text{mW}/5) * \sqrt{5.180}] = 3.20 > 3.0, \text{ for Body.}$$

$$5.8\text{GHz WIFI: } [(15.85\text{mW}/5) * \sqrt{5.825}] = 7.65 > 3.0, \text{ for Body.}$$

Test Mode	Test Separation (mm)	Thresholds (mW)	Max. Tune-up power(dBm)	Max. Tune-up power(mW)	SAR Test (Y/N)
2.45GHz WIFI	5	10	21	125.89	Y
5.2GHz WIFI	5	7	12	15.85	Y
5.8GHz WIFI	5	6	12	15.85	Y

2) At test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following:

- [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50mm)·(f (MHz)/150)] mW, at 100 MHz to 1500 MHz
- [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

Note:

No test separation distances > 50 mm conditions.



7.5. Required Edges for SAR Testing

Test Mode	Horizontal-Up	Horizontal-Down	Vertical-Front	Vertical-Back
2.45GHz WIFI	Yes	Yes	Yes	Yes
5.2GHz WIFI	Yes	Yes	Yes	Yes
5.8GHz WIFI	Yes	Yes	Yes	Yes

7.6. Estimated SAR

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB 447498 D01v06, 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 a physical test configuration is $\leq 1.6\text{W/kg}$. When standalone SAR is not required to be measured, per FCC KDB 447498 D01v06 4.3.2 2, the following equation must be used to estimate the standalone 1g SAR for simultaneous transmission assessment involving that transmitter.

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

Where: Test separation distances $\leq 50\text{mm}$.



7.7. SAR Test Results Summary

■ DTS_WLAN 2.4GHz

Ant Port	Band	Test Position	Dist. mm	Ch.	Fre.	Max. Tune-up Power(dBm)	Measured Conducted Power (dBm)	Scaling Factor	Power Drift(dB)	Measured SAR-1g (W/kg)	Scaled SAR-1g (W/kg)
1	802.11g	Horizontal-Up	5	1	2412	21.0	16.31	1.29	-2.33	1.230	1.584
1	802.11g	Horizontal-Up	5	6	2437	21.0	15.76	1.33	0.14	0.932	1.242
1	802.11g	Horizontal-Up	5	11	2462	21.0	16.08	1.31	-0.03	1.180	1.541
1	802.11g	Horizontal-Down	5	1	2412	21.0	16.31	1.29	-0.16	0.829	1.067
1	802.11g	Vertical-Front	5	1	2412	21.0	16.31	1.29	0.29	0.356	0.458
1	802.11g	Vertical-Back	5	1	2412	21.0	16.31	1.29	-0.35	0.942	1.213
2	802.11g	Horizontal-Up	5	1	2412	21.0	15.38	1.37	-0.37	0.990	1.352
2	802.11g	Horizontal-Up	5	6	2437	21.0	14.72	1.43	-0.29	1.100	1.569
2	802.11g	Horizontal-Down	5	1	2412	21.0	15.38	1.37	-0.23	0.741	1.012
2	802.11g	Vertical-Front	5	1	2412	21.0	15.38	1.37	0.16	0.566	0.773
2	802.11g	Vertical-Back	5	1	2412	21.0	15.38	1.37	-0.08	0.156	0.213

Note:

1. Per KDB248227 D01 v02r02 section 5.2.1 2), when the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.
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, 802.11g/n OFDM SAR is not required, per KDB248227 D01 v02r01 section 5.2.2 2).



■ U-NII-1 _WLAN 5.2GHz

Ant Port	Band	Test Position	Dist. mm	Ch.	Fre.	Max. Tune-up Power(dBm)	Measured Conducted Power (dBm)	Scaling Factor	Power Drift(dB)	Measured SAR-1g (W/kg)	Scaled SAR-1g (W/kg)
1	802.11a	Horizontal-Up	5	36	5180	12.0	13.75	0.87	-0.42	1.520	1.327
1	802.11a	Horizontal-Up	5	48	5240	12.0	12.45	0.96	-0.09	1.210	1.166
1	802.11a	Horizontal-Down	5	36	5180	12.0	13.75	0.87	-0.01	0.831	0.725
1	802.11a	Vertical-Front	5	36	5180	12.0	13.75	0.87	-0.26	0.173	0.151
1	802.11a	Vertical-Back	5	36	5180	12.0	13.75	0.87	-0.32	0.581	0.507
2	802.11a	Horizontal-Up	5	36	5180	12.0	14.25	0.84	-0.20	1.010	0.851
2	802.11a	Horizontal-Up	5	48	5240	12.0	14.01	0.86	-0.48	1.070	0.916
2	802.11a	Horizontal-Down	5	36	5180	12.0	14.25	0.84	-0.20	0.497	0.419
2	802.11a	Vertical-Front	5	36	5180	12.0	14.25	0.84	-0.35	0.450	0.379
2	802.11a	Vertical-Back	5	36	5180	12.0	14.25	0.84	0.38	0.094	0.079

Note:

1. Per KDB248227 D01 v02r02 section 5.3.3 initial test configuration procedures, when the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until reported SAR is ≤ 1.2 W/kg.



■ U-NII-3_ WLAN 5.8GHz

Ant Port	Band	Test Position	Dist. mm	Ch.	Fre.	Max. Tune-up Power(dBm)	Measured Conducted Power (dBm)	Scaling Factor	Power Drift(dB)	Measured SAR-1g (W/kg)	Scaled SAR-1g (W/kg)
1	802.11ac (VHT20)	Horizontal-Down	5	149	5745	12.0	10.31	1.16	-0.16	1.180	1.373
1	802.11ac (VHT20)	Horizontal-Down	5	157	5785	12.0	10.47	1.15	-0.22	1.280	1.467
1	802.11ac (VHT20)	Horizontal-Down	5	165	5825	12.0	11.41	1.05	-0.53	1.450	1.525
1	802.11ac (VHT20)	Horizontal-Up	5	165	5825	12.0	11.41	1.05	-1.66	0.953	1.002
1	802.11ac (VHT20)	Vertical-Front	5	165	5825	12.0	11.41	1.05	-0.40	0.634	0.667
1	802.11ac (VHT20)	Vertical-Back	5	165	5825	12.0	11.41	1.05	-0.29	1.420	1.493
2	802.11ac (VHT20)	Vertical-Front	5	149	5745	12.0	11.01	1.09	0.01	1.240	1.351
2	802.11ac (VHT20)	Vertical-Front	5	157	5785	12.0	11.88	1.01	-0.05	1.050	1.061
2	802.11ac (VHT20)	Vertical-Front	5	165	5825	12.0	13.11	0.92	-0.19	1.280	1.172
2	802.11ac (VHT20)	Vertical-Back	5	165	5825	12.0	13.11	0.92	-0.20	0.717	0.656
2	802.11ac (VHT20)	Horizontal-Up	5	165	5825	12.0	13.11	0.92	-0.41	1.110	1.016
2	802.11ac (VHT20)	Horizontal-Down	5	165	5825	12.0	13.11	0.92	-0.32	0.964	0.882

Note:

1. Per KDB248227 D01 v02r02 section 5.3.3 initial test configuration procedures, when the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for subsequent next highest measured output power channel(s) in the initial test configuration until reported SAR is ≤ 1.2 W/kg.



8. Simultaneous Transmission Analysis

8.1. Max. Simultaneous SAR

N/A

8.2. Simultaneous Transmission Conclusion

N/A

**9. Measurement Uncertainty**

Error Description	Uncert. value	Prob. Dist.	Div.	(ci) 1g	(ci) 10g	Std.Unc. (1g)	Std. nc. (10g)	(vi) v _{eff}
Measurement System								
Probe Calibration	±6.0%	N	1	1	1	±6.0%	±6.0%	∞
Axial Isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%	∞
Boundary Effects	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Modulation Response	±2.4%	R	$\sqrt{3}$	1	1	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	$\sqrt{3}$	1	1	±1.5%	±1.5%	∞
RF Ambient Noise	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
RF Ambient Reflections	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Probe Positioner	±0.4%	R	$\sqrt{3}$	1	1	±0.2%	±0.2%	∞
Probe Positioning	±2.9%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Max.SAR Eval.	±2.0%	R	$\sqrt{3}$	1	1	±1.2%	±1.2%	∞
Test Sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%	∞
Power Scalingp	±0%	R	$\sqrt{3}$	0	0	±0%	±0%	∞
Phantom and Setup								
Phantom Uncertainty	±6.1%	R	$\sqrt{3}$	1	1	±3.5%	±3.5%	∞
SAR correction	±1.9%	R	$\sqrt{3}$	1	0.84	±1.1%	±0.9%	∞
Liquid Conductivity (mea.)DAK	±2.5%	R	$\sqrt{3}$	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity (mea.)DAK	±2.5%	R	$\sqrt{3}$	0.26	0.26	±0.3%	±0.4%	∞
Temp. unc. –ConductivityBB	±3.4%	R	$\sqrt{3}$	0.78	0.71	±1.5%	±1.4%	∞
Temp. unc. – PermittivityBB	±0.4%	R	$\sqrt{3}$	0.23	0.26	±0.1%	±0.1%	∞
Combined Std. Uncertainty						±11.2%	±11.1%	361
Expanded STD Uncertainty(k=2)						±22.3%	±22.2%	

DASY5 Uncertainty Budget, according to IEEE 1512/2011 and IEC 62209-1/2011(0.3-3GHz)



Error Description	Uncert. value	Prob. Dist.	Div.	(ci) 1g	(ci) 10g	Std.Unc. (1g)	Std. nc. (10g)	(vi) v _{eff}
Measurement System								
Probe Calibration	±6.55%	N	1	0	0			
Axial Isotropy	±4.7%	R	$\sqrt{3}$	0.7	0.7	±1.9%	±1.9%	∞
Hemispherical Isotropy	±9.6%	R	$\sqrt{3}$	0.7	0.7	±3.9%	±3.9%	∞
Boundary Effects	±2.0%	R	$\sqrt{3}$	1	1	±1.2%	±1.2%	∞
Linearity	±4.7%	R	$\sqrt{3}$	1	1	±2.7%	±2.7%	∞
System Detection Limits	±1.0%	R	$\sqrt{3}$	1	1	±0.6%	±0.6%	∞
Modulation Response ^m	±2.4%	R	$\sqrt{3}$	1	1	±1.4%	±1.4%	∞
Readout Electronics	±0.3%	N	1	1	1	±0.3%	±0.3%	∞
Response Time	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∞
Integration Time	±2.6%	R	$\sqrt{3}$	1	1	±1.5%	±1.5%	∞
RF Ambient Noise	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
RF Ambient Reflections	±3.0%	R	$\sqrt{3}$	1	1	±1.7%	±1.7%	∞
Probe Positioner	±0.8%	R	$\sqrt{3}$	1	1	±0.5%	±0.5%	∞
Probe Positioning	±6.7%	R	$\sqrt{3}$	1	1	±3.9%	±3.9%	∞
Max.SAR Eval.	±2.0%	R	$\sqrt{3}$	1	1	±1.2%	±1.2%	∞
Test Sample Related								
Device Positioning	±2.9%	N	1	1	1	±2.9%	±2.9%	145
Device Holder	±3.6%	N	1	1	1	±3.6%	±3.6%	5
Power Drift	±5.0%	R	$\sqrt{3}$	1	1	±2.9%	±2.9%	∞
Power Scaling ^p	±0%	R	$\sqrt{3}$	0	0	±0%	±0%	∞
Phantom and Setup								
Phantom Uncertainty	±6.6%	R	$\sqrt{3}$	1	1	±3.8%	±3.8%	∞
SAR correction	±1.9%	R	$\sqrt{3}$	1	0.84	±1.1%	±0.9%	∞
Liquid Conductivity (mea.) ^{DAK}	±2.5%	R	$\sqrt{3}$	0.78	0.71	±1.1%	±1.0%	∞
Liquid Permittivity (mea.) ^{DAK}	±2.5%	R	$\sqrt{3}$	0.26	0.26	±0.3%	±0.4%	∞
Temp. unc. – Conductivity ^{BB}	±3.4%	R	$\sqrt{3}$	0.78	0.71	±1.5%	±1.4%	∞
Temp. unc. – Permittivity ^{BB}	±0.4%	R	$\sqrt{3}$	0.23	0.26	±0.1%	±0.1%	∞
Combined Std. Uncertainty						±12.3%	±12.2%	748
Expanded STD Uncertainty(Coverage factor=2)						±24.6%	±24.5%	

DASY5 Uncertainty Budget, according to IEEE 1512/2011 and IEC 62209-1/2011(3-6GHz)

--END--