FCC SAR Test Report

FCC ID: M82-PWS872

Project No.	:	1706122
Equipment	:	Computer
Model Name	:	PWS-872
Applicant	:	Advantech Co., Ltd.
Address	:	No.1, Alley 20, Lane 26, Rueiguang Road, Neihu District, Taipei 11491, Taiwan, R.O.C.

Date of Receipt	:	Jul, 19. 2017
Date of Test	:	Aug, 16. 2017 ~ Aug, 24. 2017
Issued Date	:	Aug, 31. 2017
Tested by	:	BTL Inc.

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Testing Laboratory 0659

Declaration

BTL represents to the client that testing is done in accordance with standard procedures as applicable and that test instruments used has been calibrated with the standards traceable to National Measurement Laboratory (**NML**), or National Institute of Standards and Technology (**NIST**) .

BTL's reports apply only to the specific samples tested under conditions. It is manufacture's responsibility to ensure that additional production units of this model are manufactured with the identical electrical and mechanical components. **BTL** shall have no liability for any declarations, inferences or generalizations drawn by the client or others from **BTL** issued reports.

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BTL's laboratory quality assurance procedures are in compliance with the **ISO Guide17025** requirements, and accredited by the conformity assessment authorities listed in this test report.

Limitation

For the use of the authority's logo is limited unless the Test Standard(s)/Scope(s)/Item(s) mentioned in this test report is (are) included in the conformity assessment authorities acceptance respective.

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BTL

REPORT ISSUED HISTORY

Issued No.	Description	Issued Date
BTL-FCC-SAR-1-1706122	Original Issue.	Aug, 31. 2017

1. GENERAL SUMMARY

Equipment	Computer
Model Name	PWS-872
Brand Name	ADVANTECH
Manufacturer	Advantech Co., Ltd.
Address	No.1, Alley 20, Lane 26, Rueiguang Road, Neihu District, Taipei 11491, Taiwan, R.O.C.
Standard(s)	**FCC 47CFR §2.1093** Radio frequency Radiation Exposure Evaluation: Portable Devices **ANSI Std C95.1-1992** Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz – 300 GHz.(IEEE Std C95.1-1991) **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 **KDB447498 D01** General RF Exposure Guidance v06 **KDB616217 D04** SAR for laptop and tablets v01r02 **KDB248227 D01** 802. 11 Wi-Fi SAR v02r02 **KDB865664 D01** SAR measurement 100 MHz to 6 GHz v01r04 **KDB865664 D02** RF Exposure Reporting v01r02 **KDB690783 D01** SAR Listings on Grants v01r03

The above equipment has been tested and found compliance with the requirement of the relative standards by BTL Inc.
The test data, data evaluation, and equipment configuration contained in our test report (Ref No. BTL-FCC-SAR-1-1706122) were obtained utilizing the test procedures, test instruments, test sites that has been accredited by the Authority of TAF according to the ISO-17025 quality assessment standard and technical standard(s).

2. RF EMISSIONS MEASUREMENT

2.1. TEST FACILITY

The test facilities used to collect the test data in this report is **SAR room** at the location of No. 68-1, Ln. 169, Sec.2, Datong Rd., Xizhi Dist., New Taipei City 221, Taiwan.

2.2. MEASUREMENT UNCERTAINTY

Note: 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.

3. GENERAL INFORMATION

3.1.STATEMENT OF COMPLIANCE

The maximum results of Specific Absorption Rate (SAR).

Equipment Class	Mode	Highest Body (0mm) SAR-1g(W/kg)
DTS	2.4G WLAN	0.761
U-NII	5G WLAN	1.181
Highest Simultaneous Transmission SAR		Highest Body (0mm) SAR-1g(W/kg)
DTS+DSS		0.824
U-NII+DSS		1.244
DTS+DTS		0.803
U-NII+U-NII		1.306

Note:

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, and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528-2013.

3.1.1. GENERAL DESCRIPTION OF EUT

Equipment	Computer		
Model Name	PWS-872		
HW Version	V1.0.1		
SW Version	V1.0.1		
Modulation	WiFi(DSSS/OFDM),BT(GFSK/ π /4-DQPSK/8-DPSK)		
Operation Frequency Range(s)	Band	TX (MHz)	RX (MHz)
	Bluetooth	2400~2483.5	
	WIFI 2.4G	2412~2462	
	WIFI 5.2G	5150~5250	
	WIFI 5.3G	5250~5350	
	WIFI 5.5G	5475~5725	
	WIFI 5.8G	5725~5850	
Operation Channel List	Band	Modulation	Channel list
	WIFI 2.4G	802.11b/g/n HT20	1-6-11
		802.11n HT40	3-6-9
	WIFI 5.2G	802.11a/n HT20/ac VHT20	36-40-44-48
		802.11n HT40/ac VHT40	38-46
		802.11ac VHT80	42
	WIFI 5.3G	802.11a/n HT20/ac VHT20	52-56-60-64
		802.11n HT40/ac VHT40	54-62
		802.11ac VHT80	58
	WIFI 5.5G	802.11a/n HT20/ac VHT20	100-104-108-112 -116-132-136-140
		802.11n HT40/ac VHT40	102-110-118-134
		802.11ac VHT80	106-138
	WIFI 5.8G	802.11a/n HT20/ac VHT20	149-153-157-161 -165
		802.11n HT40/ac VHT40	151-159
		802.11ac VHT80	155
Antenna Gain	Band/Ant	Gain	
	2.4G Ant	3.56 dBi	
	5G Ant	3.44 dBi	
Other Information			
Battery	Brand	Advantech	
	Model	1760001918-01 (Advan4S1P027)	
	Capacitance	2730 mA	
	Rated Voltage	28.8 V	
	Manufacturer	Joules Miles Co., LTD.	

LABORATORY ENVIRONMENT

Temperature	Min. = 18ºC, Max. = 25ºC
Relative humidity	Min. = 30%, Max. = 70%
Ground system resistance	< 0.5Ω
Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards.	

3.2. MAIN TEST INSTRUMENTS

Item	Equipment	Manufacturer	Model	Serial No.	Cal. Date	Cal. Interval
1	E-field Probe	Speag	EX3DV4	3753	May. 05, 2017	1 Year
2	Data Acquisition Electronics	Speag	DAE4	1305	Apr. 25, 2017	1 Year
3	System Validation Dipole	Speag	D2450V2	973	Aug. 14, 2015	3 Year
4	System Validation Dipole	Speag	D5GHzV2	1221	Aug. 11, 2015	3 Year
5	Oval Flat Phantom	Speag	Oval Flat Phantom ELI 5.0	1240	N/A	N/A
6	Power Amplifier	Mini-Circuits	ZVE-2W-272+	N650001538	N/A	N/A
7	Power Amplifier	Mini-Circuits	ZVE-8G+	N628801631	N/A	N/A
8	ENA Network Analyzer	Keysight	E5071C	MY46524658	Dec. 06, 2016	1 Year
9	EXG Vector Signal Generator	Keysight	N5172B	MY53051229	Dec. 16, 2016	1 Year
10	Power Meter	Anritsu	ML2495A	1128008	Aug. 18, 2016	1 Year
11	Power Sensor	Anritsu	MA2411B	1126001	Aug. 18, 2016	1 Year
12	Power Meter	Anritsu	4232A	10179	Nov. 25, 2016	1 Year
13	Power Sensor	Anritsu	51011	34150	Nov. 25, 2016	1 Year
14	Spectrum Analyzer	Keysight	N9010A	MY54200483	Oct. 04, 2016	1 Year
15	Dielectric Assessment Kit	Speag	DAK-3.5	1226	Dec. 09, 2015	N/A
16	Low pass filter	Mini-Circuits	SLP-2950+	M108294	N/A	N/A
17	Attenuator	Worken	WFA0602-10	SA10-01	N/A	Note 2
18	Attenuator	Worken	WFA0602-10	SA10-02	N/A	Note 2
19	Attenuator	Worken	WFA0602-3	SA3-01	N/A	Note 2
20	Dual directional coupler	Woken	0110A05601O-10	DOM5CIW3E2	N/A	Note 2
21	Digital Thermometer	LKM electronic GmbH	DTM3000	1341359457	Jul. 20, 2016	1 Year
22	Thermo-hygrometer	Testo	608-H1	N/A	Oct. 19, 2016	1 Year

Note: 1.” N/A” denotes no model name, serial No. or calibration specified.

2. Prior to system verification and validation, the path loss from the signal generator to the system check source and the power meter, which includes the amplifier, cable, attenuator and directional coupler, was measured by the network analyzer. The reading of the power meter was offset by the path loss difference between the path to the power meter and the path to the system check source to monitor the actual power level fed to the system check source.

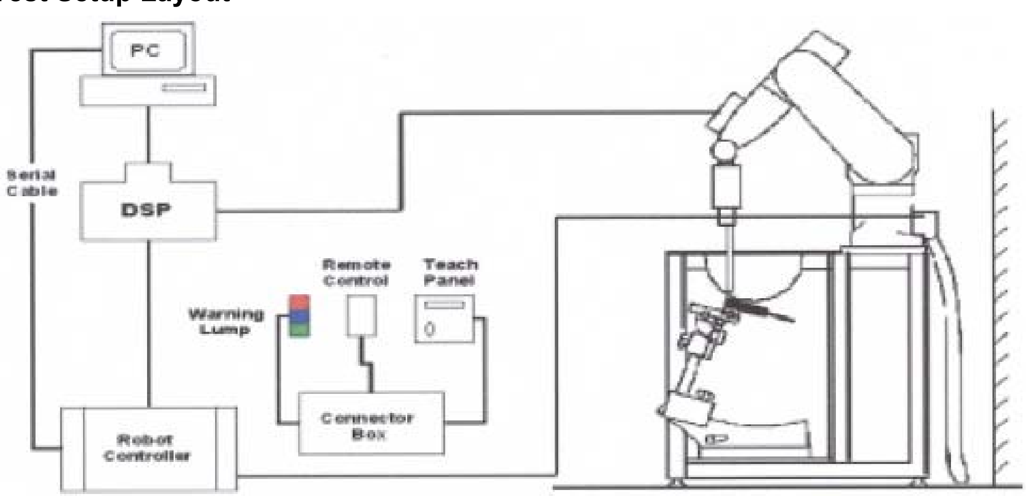
4. SAR MEASUREMENTS SYSTEM CONFIGURATION

4.1.SAR MEASUREMENT SET-UP

The DASY5 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
3. A data acquisition electronic (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.
4. A unit to operate the optical surface detector which is connected to the EOC.
5. The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
6. TheDASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows 7
7. DASY5 software and SEMCAD data evaluation software.
8. Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
9. The generic twin phantom enabling the testing of left-hand and right-hand usage.
10. The device holder for handheld mobile phones.
11. Tissue simulating liquid mixed according to the given recipes.
12. System validation dipoles allowing to validate the proper functioning of the system.

4.1.1.Test Setup Layout



4.2.DASY5E-FIELDPROBESYSTEM

The SAR measurements were conducted with the dosimetric probe EX3DV4(manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation.

4.2.1.EX3DV4 PROBE SPECIFICATION

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 (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 μW/g to > 100 mW/g Linearity:± 0.2dB
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1.0 mm


EX3DV4 E-field Probe

4.2.2.E-FIELD PROBE CALIBRATION

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than ±10%. The spherical isotropy was evaluated and found to be better than ± 0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, and in a wave guide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

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

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

Where: Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

ΔT = Temperature increase due to RF exposure.

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

Where: σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m3).

4.2.3.OTHER TEST EQUIPMENT

4.2.3.1. Device Holder for Transmitters

Construction: Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices (e.g., laptops, cameras, etc.) It is light weight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI4and SAM v6.0Phantoms.
Material: POM, Acrylic glass, Foam

4.2.3.2 Phantom

<table>
<tr><td>Model</td><td>ELI4 Phantom</td><td rowspan="6"></td></tr>
<tr><td>Construction</td><td>Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. 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. The phantom is compatible with all SPEAG dosimetric probes and dipoles.</td></tr>
<tr><td>Shell Thickness</td><td>2±0.1 mm</td></tr>
<tr><td>Filling Volume</td><td>Approx. 30 liters</td></tr>
<tr><td>Dimensions</td><td>Length: 600 mm ; Width: 190mm
Height: adjustable feet</td></tr>
<tr><td>Aailable</td><td>Special</td></tr>
</table>

4.2.4.SCANNING PROCEDURE

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. 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.

The “reference” and “drift” measurements 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 DUT’s output power and should vary max. ± 5 %.

The “surface check” measurement 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 ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

- Area Scan

The “area scan” measures the SAR above the DUT or verification dipole on a parallel plane to the surface. It is used to locate the approximate location of the peak SAR with 2D spline interpolation. The robot performs a stepped movement along one grid axis while the local electrical field strength is measured by the probe. The probe is touching the surface of the SAM during acquisition of measurement values. The standard scan uses large grid spacing for faster measurement.

Standard grid spacing for head measurements is 15 mm in x- and y- dimension(≤2GHz) , 12 mm in x- and y- dimension(2-4 GHz) and 10mm in x- and y- dimension(4-6GHz). If a finer resolution is needed, the grid spacing can be reduced. Grid spacing and orientation have no influence on the SAR result. For special applications where the standard scan method does not find the peak SAR within the grid, e.g. mobile phones with flip cover, the grid can be adapted in orientation.

- Zoom Scan

A “zoom scan” measures the field in a volume around the 2D peak SAR value acquired in the previous “coarse” scan. This is a fine grid with maximum scan spatial resolution: Δx_{zoom}, Δy_{zoom}≤ 2GHz -≤8mm, 2-4GHz -≤5 mm and 4-6 GHz-≤4mm; Δz_{zoom}≤3GHz -≤5 mm, 3-4 GHz-≤4mm and 4-6GHz-≤2mm where the robot additionally moves the probe along the z-axis away from the bottom of the Phantom. DASY is also able to perform repeated zoom scans if more than 1 peak is found during area scan. In this document, the evaluated peak 1g and 10g averaged SAR values are shown in the 2D-graphics in Appendix B. Test results relevant for the specified standard (see chapter 1.4.)are shown in table form form in chapter 7.2.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 2 mm steps. This measurement shows the continuity of the liquid and can - depending in the field strength – also show the liquid depth.

The following table summarizes the area scan and zoom scan resolutions per FCC KDB 865664D01:

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

4.2.5.SPATIAL PEAK SAR EVALUATION

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube measurements have been done. The basis of the evaluation are the SAR values measured 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 algorithm that finds the maximal averaged volume is separated into three different stages.

- The data between the dipole center of the probe and the surface of the phantom are extrapolated. This data cannot be measured since the center of the dipole is 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is about 1 mm (see probe calibration sheet). The extrapolated data from a cube measurement can be visualized by selecting "Graph Evaluated".
- The maximum interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.
- All neighboring volumes are evaluated until no neighboring volume with a higher average value is found.

Extrapolation

The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in the first 3 cm along the z-axis, polynomials of order four are calculated. These polynomials are then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from each other.

Interpolation

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computermathematik, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff].

Volume Averaging

At First the size of the cube is calculated. Then the volume is integrated with the trapezoidal algorithm. 8000 points (20x20x20) are interpolated to calculate the average.

Advanced Extrapolation

DASY5 uses the advanced extrapolation option which is able to compansate boundary effects on E-field probes.

4.2.6.DATA STORAGE AND EVALUATION

4.2.5.1Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DAE4". The 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 incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show 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.

4.4.2 Data Evaluation by SEMCAD

The SEMCAD software 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	Normi, 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	·
	Density	·

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 DASY5 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:

$$V_i = U_i + U_i^2 \cdot cf / dcp_i$$

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:

E-field probes: $E_i = (V_i \,/\, Norm_i \cdot ConvF)^{1/2}$

H-field probes: $H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1} f + a_{i2} f^2) / f$

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

$Norm_i$ = sensor sensitivity of channel i (i = x, y, z) [mV/(V/m)^2] for E-field Probes

ConvF = sensitivity enhancement in solution

aij = 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):

$$E_{tot} = (E_X^2 + E_Y^2 + E_Z^2)^{1/2}$$

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

$$SAR = (E_{tot})^2 \cdot \sigma / (\rho \cdot 1000)$$

With SAR = local specific absorption rate in mW/g

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

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

= equivalent tissue density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = E_{tot}^2 / 3770 \text{ or } P_{pwe} = H_{tot}^2 \cdot 37.7$$

With P_{pwe} = equivalent power density of a plane wave in mW/cm^2

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

H_{tot} = total magnetic field strength in A/m

5. SYSTEM VERIFICATION PROCEDURE

5.1. TISSUE VERIFICATION

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine of the dielectic parameter are within the tolerances of the specified target values. The measured conductivity and relative permittivity should be within ± 5% of the target values.

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

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono-hexylether
Body 2450	-	31.4	-	0.1	-	-	68.5	-
Body 5G	-	-	-	-	-	10.7	78.6	10.7

Salt: 99+% Pure Sodium Chloride; Sugar: 98+% Pure Sucrose; Water: De-ionized, 16M + 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 Verification									
Tissue Type	Frequency (MHz)	Liquid Temp. (℃)	Conductivity (σ)	Permittivity (εr)	Targeted Conductivity (σ)	Targeted Permittivity (εr)	Deviation Conductivity (σ) (%)	Deviation Permittivity (εr) (%)	Date
Body	2450	22.0	1.973	53.183	1.95	52.7	1.18	0.92	Aug. 21, 2017
Body	5300	22.6	5.495	47.444	5.42	48.9	1.38	-2.98	Aug. 24, 2017
Body	5600	22.0	5.900	46.819	5.77	48.5	2.25	-3.47	Aug. 16, 2017
Body	5800	22.0	6.240	46.303	6.00	48.2	4.00	-3.94	Aug. 21, 2017

Note:
1)The dielectric parameters of the tissue-equivalent liquid should be measured under similar ambient conditions and within 2 °C of the conditions expected during the SAR evaluation to satisfy protocol requirements.
2)KDB 865664 was ensured to be applied for probe calibration frequencies greater than or equal to 50MHz of the EUT frequencies.
3)The above measured tissue parameters were used in the DASY software to perform interpolation via the DASY software to determine actual dielectric parameters at the test frequencies. The SAR test plots may slightly differ from the table above since the DASY rounds to three significant digits.

5.2. SYSTEM CHECK

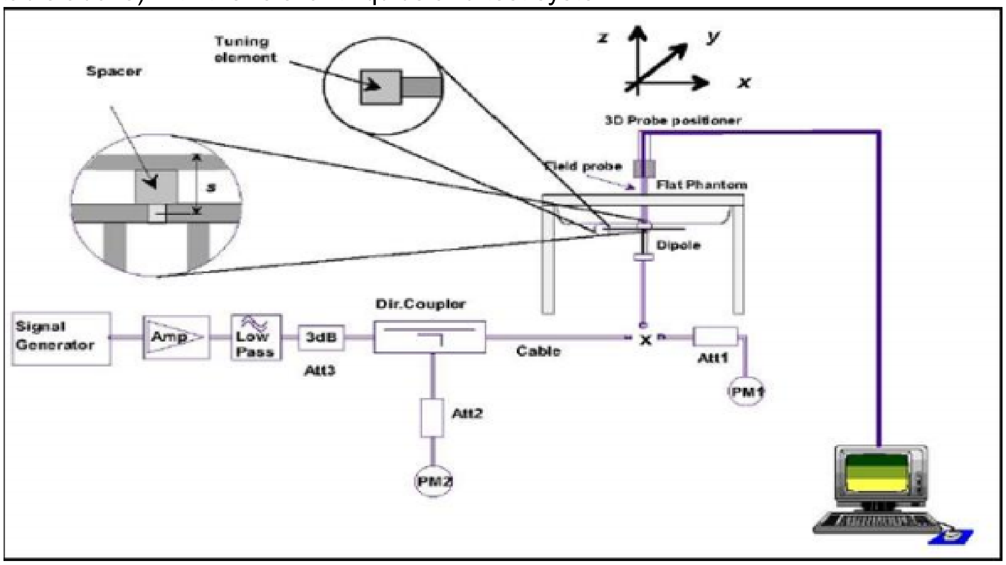
The system check is performed for verifying the accuracy of the complete measurement system and performance of the software. The system check is performed with tissue equivalent material according to IEEE P1528 (described above). The following table shows system check results for all frequency bands and tissue liquids used during the tests.

System Check	Date	Frequency (MHz)	Targeted SAR (W/kg)	Measured SAR (W/kg)	normalized SAR (W/kg)	Deviation (%)	Dipole S/N
Body	Aug. 21, 2017	2450	51.70	13.50	54.00	4.45	973
Body	Aug. 24, 2017	5300	75.80	7.35	73.50	-3.03	1221
Body	Aug. 24, 2017	5600	80.60	8.33	83.30	3.35	1221
Body	Aug. 16, 2017	5800	77.70	8.32	83.20	7.08	1221

5.3. 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 plexiglass 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 250 mW(below 5GHz) or 100mW(above 5GHz). 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 system check 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.

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.



6. SAR MEASUREMENT VARIABILITY AND UNCERTAINTY

6.1.SAR MEASUREMENT VARIABILITY

Per KDB865664 D01 SAR measurement 100 MHz to 6 GHz v01r04, SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. The 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.

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

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 is not required.

7. OPERATIONAL CONDITIONS DURING TEST

7.1 WIFI TEST CONFIGURATION

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal.

Mode	802.11b	802.11g	802.11n (HT20/ HT40)	802.11a	802.11n (HT20 /HT40	802.11ac (VHT80)
Duty cycle	100%					
Crest factor	1					

✧ **802.11b DSSS SAR Test Requirements**

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
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.

✧ **2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements**

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied. 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.

✧ **U-NII-1 and U-NII-2A Band**

For devices that operate in both U-NII-1 and U-NII-2A bands, When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, both bands are tested independently for SAR. When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, both bands are tested independently for SAR.

7.2 TEST POSITION OF PORTABLE DEVICES

7.2.1 Test Position Requirements

The SAR Exclusion Threshold in KDB 447498 D01can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent tablet edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned adjacent the phantom and the edge containing the antenna positioned perpendicular to the phantom.

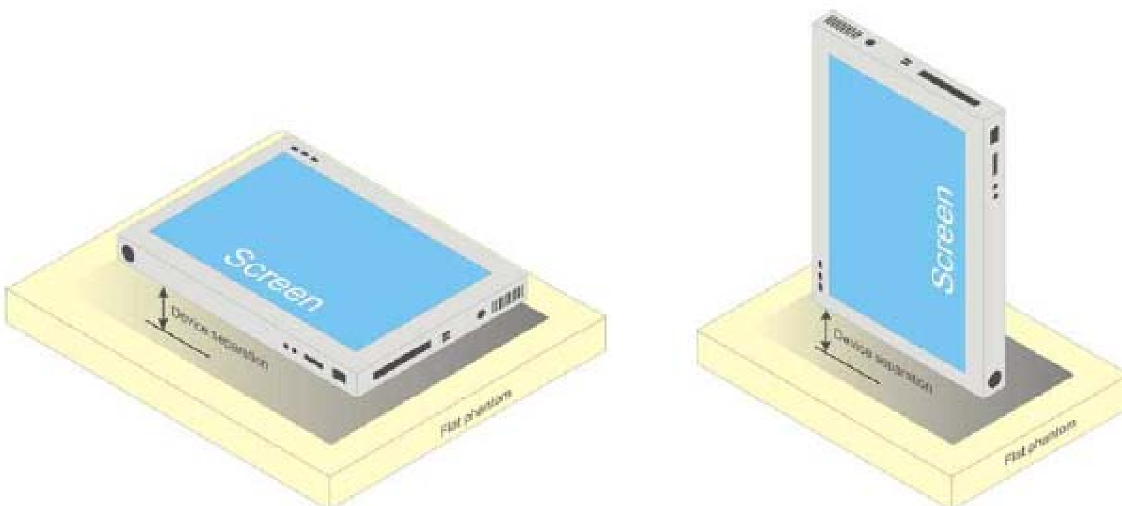


Fig 7.2.1: Test setup for PAD mode

7.2.2 SAR test reduction and exclusion guidance

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

$$\frac{\text{(max. power of channel, including tune-up tolerance, mW)}}{\text{(min. test separation distance, mm)}} \cdot \sqrt{\text{Frequency (GHz)}} \leq 3.0$$

The test exclusions are applicable only when the minimum test separation distance is ≤50mm and for transmission frequencies between 100MHz and 6GHz. When the minimum test separation distance is<5mm, a distance of 5mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

(2)The SAR exclusion threshold for distances>50mm is defined by the following equation, as illustrated in KDB 447498 D01 Appendix B:

a) at 100 MHz to1500 MHz

[Power allowed at numeric Threshold at 50 mm in step 1) + (test separation distance - 50 mm) · (f $_{(MHz)}$/150)] mW

b) at >1500MHz and ≤6GHz

[Power allowed at numeric Threshold at 50 mm in step 1) + (test separation distance - 50 mm) ·10] mW

The location of the antenna inside EUT is as below.

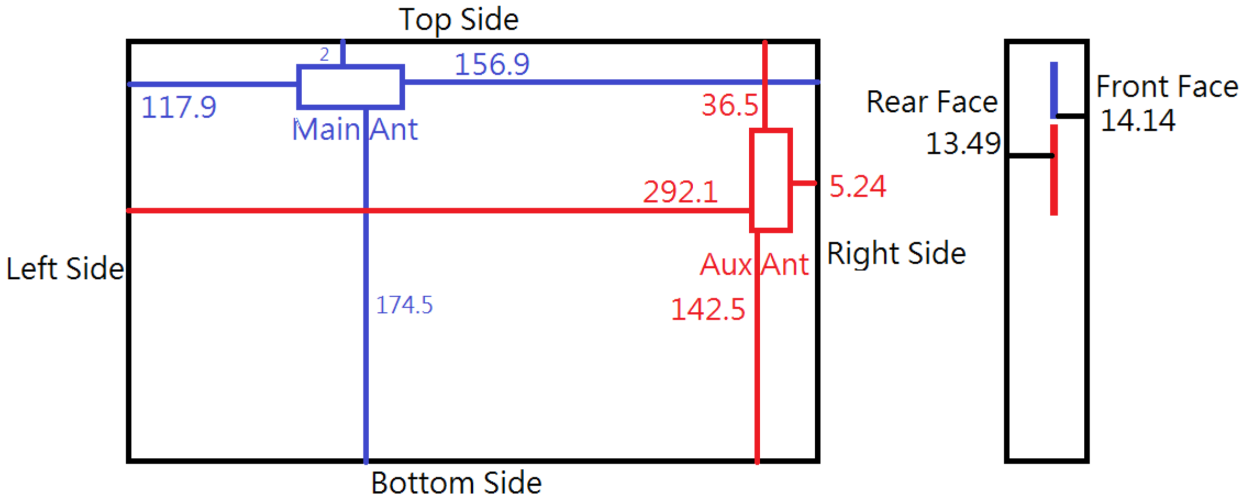


Fig 7.2.3: Antenna to the edge

Table 1 Antenna to edge distance (mm)

Tx Ant	Rear Face	Front Face	Right Side	Left Side	Top Side	Bottom Side
Main Ant	13.49	14.14	156.9	117.9	2	174.5
Aux Ant	13.49	14.14	5.24	292.1	36.5	142.5

Note: Body positions of the wireless device please refer to Appendix D.

The distance <50mm of the Main Ant

Band	Frequency	Turn-UP (dBm)	Turn-UP (mW)	Position	Rear Face	Top Side
				Antenna -to -edge distance(mm)	13.49	5
2.4G	2462	18	63.10	Calculated Threshold	26	10
				Test requirements(Yes/No)	Yes	Yes
BT	2441	2	1.58	Calculated Threshold	10	10
				Test requirements(Yes/No)	No	No
5.2G	5240	15	31.62	Calculated Threshold	18	7
				Test requirements(Yes/No)	Yes	Yes
5.3G	5320	15	31.62	Calculated Threshold	18	7
				Test requirements(Yes/No)	Yes	Yes
5.5G	5700	15	31.62	Calculated Threshold	17	6
				Test requirements(Yes/No)	Yes	Yes
5.8G	5825	17	50.12	Calculated Threshold	17	6
				Test requirements(Yes/No)	Yes	Yes

The distance >50mm for Main Ant

Band	Frequency	Turn-UP (dBm)	Turn-UP (mW)	Position	Right Side	Left Side	Bottom Side
				Antenna -to -edge distance(mm)	156.9	117.9	174.5
2.4G	2462	18	63.10	Exclusion considerations(mW)	1165	775	1341
				Test requirements(Yes/No)	No	No	No
BT	2441	2	1.58	Exclusion considerations(mW)	1165	775	1341
				Test requirements(Yes/No)	No	No	No
5.2G	5240	15	31.62	Exclusion considerations(mW)	1135	745	1311
				Test requirements(Yes/No)	No	No	No
5.3G	5320	15	31.62	Exclusion considerations(mW)	1134	744	1311
				Test requirements(Yes/No)	No	No	No
5.5G	5700	15	31.62	Exclusion considerations(mW)	1132	742	1308
				Test requirements(Yes/No)	No	No	No
5.8G	5825	17	50.12	Exclusion considerations(mW)	1131	741	1307
				Test requirements(Yes/No)	No	No	No

The distance <50mm of the Aux Ant

Band	Frequency	Turn-UP (dBm)	Turn-UP (mW)	Position	Rear Face	Right Side	Top Side
				Antenna -to -edge distance(mm)	13.49	5.24	36.5
2.4G	2462	18	63.10	Exclusion considerations	26	10	70
				Test requirements(Yes/No)	Yes	Yes	No
5.2G	5240	15	31.62	Exclusion considerations	18	7	48
				Test requirements(Yes/No)	Yes	Yes	No
5.3G	5320	15	31.62	Exclusion considerations	18	7	47
				Test requirements(Yes/No)	Yes	Yes	No
5.5G	5700	15	31.62	Exclusion considerations	17	7	46
				Test requirements(Yes/No)	Yes	Yes	No
5.8G	5825	17	50.12	Exclusion considerations	17	7	45
				Test requirements(Yes/No)	Yes	Yes	Yes

The distance >50mm for Aux Ant

Band	Frequency	Turn-UP (dBm)	Turn-UP (mW)	Position	Left Side	Bottom Side
				Antenna -to -edge distance(mm)	292.1	142.5
2.4G	2462	18	63.10	Exclusion considerations(mW)	2517	1021
				Test requirements(Yes/No)	No	No
5.2G	5240	15	31.62	Exclusion considerations(mW)	2487	991
				Test requirements(Yes/No)	No	No
5.3G	5320	15	31.62	Exclusion considerations(mW)	2486	990
				Test requirements(Yes/No)	No	No
5.5G	5700	15	31.62	Exclusion considerations(mW)	2484	988
				Test requirements(Yes/No)	No	No
5.8G	5825	17	50.12	Exclusion considerations(mW)	2483	987
				Test requirements(Yes/No)	No	No

8. POWER TEST RESULT

8.1 CONDUCTED POWER MEASUREMENTS OF BT

BT	Tune Up	Average Conducted Power (dBm)			SAR Test (Yes/No)
		CH0	CH39	CH78	
DH5	2	1.61	1.87	1.56	No

BT	Tune Up	Average Conducted Power (dBm)			SAR Test (Yes/No)
		CH0	CH19	CH39	
BLE	2	1.23	1.65	1.55	No

Note:
1) The conducted power of BT is measured with RMS detector.

8.2 CONDUCTED POWER MEASUREMENTS OF WIFI 2.4G

SISO_Ant 0

Mode	Channel	Frequency(MHz)	Data Rate (Mbps)	Tune up	Average Power (dBm)	SAR Test (Yes/No)
802.11b	1	2412	1	17	16.39	Yes
	6	2437		17	15.18	
	11	2462		14	13.49	
802.11g	1	2412	6	18	17.71	No
	6	2437		18	17.83	
	11	2462		18	17.9	
802.11n HT20	1	2412	6.5	18	17.81	No
	6	2437		18	17.82	
	11	2462		18	16.33	
802.11n HT40	3	2422	13.5	16	15.79	No
	6	2437		16	15.78	
	9	2452		16	15.74	

SISO_Ant 1

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power(dBm)	SAR Test (Yes/No)
802.11b	1	2412	1	17	16.02	Yes
	6	2437		17	15.07	
	11	2462		14	13.3	
802.11g	1	2412	6	18	17.69	No
	6	2437		18	17.78	
	11	2462		18	17.84	
802.11n HT20	1	2412	6.5	18	17.63	No
	6	2437		18	17.67	
	11	2462		18	16.27	
802.11n HT40	3	2422	13.5	16	15.7	No
	6	2437		16	15.69	
	9	2452		16	15.71	

MIMO_Ant 0+1

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Ant 0 Avg Power	Ant 1 Avg Power	Tune up	Average Power (dBm)	SAR Test (Yes/No)
802.11b	1	2412	MCS8	13.85	13.32	17	16.60	No
	6	2437		12.7	12.35	17	15.54	
	11	2462		10.84	10.27	14	13.57	
802.11g	1	2412	MCS8	15.08	14.81	18	17.96	No
	6	2437		14.87	14.75	18	17.82	
	11	2462		14.9	14.87	18	17.90	
802.11n HT20	1	2412	MCS8	14.84	14.66	18	17.76	No
	6	2437		14.96	14.9	18	17.94	
	11	2462		13.66	13.26	18	16.47	
802.11n HT40	3	2422	MCS8	12.95	12.86	16	15.92	No
	6	2437		12.89	12.8	16	15.86	
	9	2452		12.73	12.69	16	15.72	

Note:

The Average conducted power of WiFi is measured with RMS detector.

8.3 CONDUCTED POWER MEASUREMENTS OF WIFI 5AND I

SISO_Ant 0

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test (Yes/No)
802.11a	36	5180	6	15	14.33	Yes
	40	5200		15	14.25	
	44	5220		15	14.54	
	48	5240		15	14.35	
802.11n HT20	36	5180	6.5	15	14.14	No
	40	5200		15	14.11	
	44	5220		15	14.1	
	48	5240		15	14.06	
802.11n HT40	38	5190	13.5	15	14.11	No
	46	5230		15	14.02	
802.11ac VHT20	36	5180	6.5	15	14.02	No
	40	5200		15	14.33	
	44	5220		15	14.25	
	48	5240		15	14.54	
802.11ac VHT40	38	5190	13.5	15	14.35	No
	46	5230		15	14.14	
802.11ac VHT80	42	5210	29.3	15	14.11	No

SISO_Ant 1

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test (Yes/No)
802.11a	36	5180	6	15	14.33	Yes
	40	5200		15	14.25	
	44	5220		15	14.54	
	48	5240		15	14.35	
802.11n HT20	36	5180	6.5	15	14.14	No
	40	5200		15	14.11	
	44	5220		15	14.1	
	48	5240		15	14.06	
802.11n HT40	38	5190	13.5	15	14.29	No
	46	5230		15	14.16	
802.11ac VHT20	36	5180	6.5	15	14.18	No
	40	5200		15	14.33	
	44	5220		15	14.25	
	48	5240		15	14.54	
802.11ac VHT40	38	5190	13.5	15	14.35	No
	46	5230		15	14.14	
802.11ac VHT80	42	5210	29.3	15	14.11	No

MIMO_Ant 0+1

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Ant 0 Avg Power	Ant 1 Avg Power	Tune-up	Average Power (dBm)	SAR Test (Yes/No)
802.11a	36	5180	6.5	11.52	11.57	15	14.56	No
	40	5200		11.3	11.72	15	14.53	
	44	5220		11.63	11.87	15	14.76	
	48	5240		11.38	11.77	15	14.59	
802.11n HT20	36	5180	MCS8	11.19	11.46	15	14.34	No
	40	5200		11.17	11.54	15	14.37	
	44	5220		11.29	11.58	15	14.45	
	48	5240		11.17	11.65	15	14.43	
802.11n HT40	38	5190	MCS8	11.22	11.52	15	14.38	No
	46	5230		11.18	11.49	15	14.35	
802.11ac VHT20	36	5180	MCS8	10.89	11.58	15	14.26	No
	40	5200		11.52	11.57	15	14.56	
	44	5220		11.3	11.72	15	14.53	
	48	5240		11.63	11.87	15	14.76	
802.11ac VHT40	38	5190	MCS8	11.38	11.77	15	14.59	No
	46	5230		11.19	11.46	15	14.34	
802.11ac VHT80	42	5210	MCS8	11.17	11.54	15	14.37	No

Note:
1) The Average conducted power of WiFi is measured with RMS detector.

8.4 CONDUCTED POWER MEASUREMENTS OF WIFI 5G BAND II

SISO_Ant 0

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	52	5260	6	15	14.79	Yes
	56	5280		15	14.68	
	60	5300		15	14.43	
	64	5320		15	14.46	
802.11n HT20	52	5260	6.5	15	14.47	No
	56	5280		15	14.12	
	60	5300		15	14.18	
	64	5320		15	14.21	
802.11n HT40	54	5270	13.5	15	14.29	No
	62	5310		15	14.23	
802.11ac VHT20	52	5260	6.5	15	14.33	No
	56	5280		15	14.79	
	60	5300		15	14.68	
	64	5320		15	14.43	
802.11ac VHT40	54	5270	13.5	15	14.46	No
	62	5310		15	14.47	
802.11ac VHT80	58	5290	29.3	15	14.12	No

SISO_Ant 1

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	52	5260	6	15	14.84	Yes
	56	5280		15	14.71	
	60	5300		15	14.62	
	64	5320		15	14.81	
802.11n HT20	52	5260	6.5	15	14.8	No
	56	5280		15	14.24	
	60	5300		15	14.35	
	64	5320		15	14.63	
802.11n HT40	54	5270	13.5	15	14.52	No
	62	5310		15	14.48	
802.11ac VHT20	52	5260	6.5	15	14.46	No
	56	5280		15	14.84	
	60	5300		15	14.71	
	64	5320		15	14.62	
802.11ac VHT40	54	5270	13.5	15	14.81	No
	62	5310		15	14.8	
802.11ac VHT80	58	5290	29.3	15	14.24	No

MIMO_Ant 0+1

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Ant 0 Avg Power	Ant 1 Avg Power	Tune-up	Average Power (dBm)	SAR Test(Yes/ No)
802.11a	52	5260	MCS8	11.77	11.92	15	14.86	No
	56	5280		11.65	11.8	15	14.74	
	60	5300		11.51	11.78	15	14.66	
	64	5320		11.47	12.18	15	14.85	
802.11n HT20	52	5260	MCS8	11.76	11.9	15	14.84	No
	56	5280		11.26	11.63	15	14.46	
	60	5300		11.31	11.62	15	14.48	
	64	5320		11.35	12.03	15	14.71	
802.11n HT40	54	5270	MCS8	11.57	11.66	15	14.63	No
	62	5310		11.32	11.86	15	14.61	
802.11ac VHT20	52	5260	MCS8	11.53	11.91	15	14.73	No
	56	5280		11.77	11.92	15	14.86	
	60	5300		11.65	11.8	15	14.74	
	64	5320		11.51	11.78	15	14.66	
802.11ac VHT40	54	5270	MCS8	11.47	12.18	15	14.85	No
	62	5310		11.76	11.9	15	14.84	
802.11ac VHT80	58	5290	MCS8	11.26	11.63	15	14.46	No

Note:
1) The Average conducted power of WiFi is measured with RMS detector.

8.5 CONDUCTED POWER MEASUREMENTS OF WIFI 5G BAND III

SISO_Ant 0

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	100	5500	6	15	14.31	Yes
	104	5520		15	14.08	
	108	5540		15	14.15	
	112	5560		15	14.26	
	116	5580		15	14.49	
	132	5660		15	14.33	
	136	5680		15	14.35	
	140	5700		15	14.41	
802.11n HT20	100	5500	6.5	15	14.35	No
	104	5520		15	14.12	
	108	5540		15	14.17	
	112	5560		15	14.16	
	116	5580		15	14.41	
	132	5660		15	14.2	
	136	5680		15	14.17	
	140	5700		15	14.38	
802.11n HT40	102	5510	13.5	15	14.14	No
	118	5590		15	14.11	
	134	5670		15	14.34	
802.11ac VHT20	100	5500	6.5	15	14.42	No
	104	5520		15	14.27	
	108	5540		15	14.38	
	112	5560		15	14.31	
	116	5580		15	14.08	
	132	5660		15	14.15	
	136	5680		15	14.26	
	140	5700		15	14.49	
802.11ac VHT40	102	5510	13.5	15	14.33	No
	118	5590		15	14.35	
	134	5670		15	14.41	
802.11ac VHT80	106	5530	29.3	15	14.35	No
	122	5610		15	14.12	
	138	5690		15	14.17	

SISO_Ant 1

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	100	5500	6	15	14.13	Yes
	104	5520		15	14.02	
	108	5540		15	14.09	
	112	5560		15	14.2	
	116	5580		15	14.33	
	132	5660		15	14.29	
	136	5680		15	14.24	
	140	5700		15	14.26	
802.11n HT20	100	5500	6.5	15	14.1	No
	104	5520		15	14.08	
	108	5540		15	14.02	
	112	5560		15	14.04	
	116	5580		15	14.12	
	132	5660		15	14.06	
	136	5680		15	14.04	
	140	5700		15	14.11	
802.11n HT40	102	5510	13.5	15	14.01	No
	118	5590		15	14.07	
	134	5670		15	14.14	
802.11ac VHT20	100	5500	6.5	15	14.3	No
	104	5520		15	14.08	
	108	5540		15	14.19	
	112	5560		15	14.13	
	116	5580		15	14.02	
	132	5660		15	14.09	
	136	5680		15	14.2	
	140	5700		15	14.33	
802.11ac VHT40	102	5510	13.5	15	14.29	No
	118	5590		15	14.24	
	134	5670		15	14.26	
802.11ac VHT80	106	5530	29.3	15	14.1	No
	122	5610		15	14.08	
	138	5690		15	14.02	

MIMO_Ant 0+1

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Ant 0 Avg Power	Ant 1 Avg Power	Tune-up	Average Power (dBm)	SAR Test(Yes/No)
802.11a	100	5500	6.5	10.81	11.86	15	14.38	No
	104	5520		10.45	11.69	15	14.12	
	108	5540		10.52	11.77	15	14.20	
	112	5560		10.45	12.02	15	14.32	
	116	5580		10.67	12.24	15	14.54	
	132	5660		11.12	11.63	15	14.39	
	136	5680		11.29	11.45	15	14.38	
	140	5700		11.35	11.56	15	14.47	
802.11n HT20	100	5500	MCS8	10.74	11.9	15	14.37	No
	104	5520		10.71	11.62	15	14.20	
	108	5540		10.46	11.79	15	14.19	
	112	5560		10.51	11.83	15	14.23	
	116	5580		10.78	12.05	15	14.47	
	132	5660		11.05	11.49	15	14.29	
	136	5680		11.16	11.24	15	14.21	
	140	5700		11.25	11.53	15	14.40	
802.11n HT40	102	5510	MCS8	10.53	11.74	15	14.19	No
	118	5590		10.41	11.78	15	14.16	
	134	5670		11.24	11.46	15	14.36	
802.11ac VHT20	100	5500	MCS8	10.82	11.96	15	14.44	No
	104	5520		10.76	11.94	15	14.40	
	108	5540		11.26	11.49	15	14.39	
	112	5560		10.81	11.86	15	14.38	
	116	5580		10.45	11.69	15	14.12	
	132	5660		10.52	11.77	15	14.20	
	136	5680		10.45	12.02	15	14.32	
	140	5700		10.67	12.24	15	14.54	
802.11ac VHT40	102	5510	MCS8	11.12	11.63	15	14.39	No
	118	5590		11.29	11.45	15	14.38	
	134	5670		11.35	11.56	15	14.47	
802.11ac VHT80	106	5530	MCS8	10.74	11.9	15	14.37	No
	122	5610		10.71	11.62	15	14.20	
	138	5690		10.46	11.79	15	14.19	

8.6 CONDUCTED POWER MEASUREMENTS OF WIFI 5G BAND IV

SISO_Ant 0

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	149	5745	6	17	16.81	Yes
	153	5765		17	16.79	
	157	5785		17	16.84	
	161	5805		17	16.74	
	165	5825		17	16.89	
802.11n HT20	149	5745	6.5	17	16.80	No
	153	5765		17	16.77	
	157	5785		17	16.82	
	161	5805		17	16.73	
	165	5825		17	16.81	
802.11n HT40	151	5755	13.5	17	16.83	No
	159	5795		17	16.82	
802.11ac VHT20	149	5745	6.5	17	15.87	No
	153	5765		17	16.81	
	157	5785		17	16.79	
	161	5805		17	16.84	
	165	5825		17	16.74	
802.11ac VHT40	151	5755	13.5	17	16.89	No
	159	5795		17	16.80	
802.11ac VHT80	155	5775	29.3	17	16.77	No

SISO_Ant 1

Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune-up	Average Power(dBm)	SAR Test(Yes/No)
802.11a	149	5745	6	17	16.70	Yes
	153	5765		17	16.64	
	157	5785		17	16.73	
	161	5805		17	16.70	
	165	5825		17	16.62	
802.11n HT20	149	5745	6.5	17	16.77	No
	153	5765		17	16.70	
	157	5785		17	16.68	
	161	5805		17	16.65	
	165	5825		17	16.76	
802.11n HT40	151	5755	13.5	17	16.70	No
	159	5795		17	16.75	
802.11ac VHT20	149	5745	6.5	17	15.67	No
	153	5765		17	16.70	
	157	5785		17	16.64	
	161	5805		17	16.73	
	165	5825		17	16.70	
802.11ac VHT40	151	5755	13.5	17	16.62	No
	159	5795		17	16.77	
802.11ac VHT80	155	5775	29.3	17	16.70	

MIMO_Ant 0+1

Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Ant 0 Avg Power	Ant 1 Avg Power	Tune-up	Total Avg Power (dBm)	SAR Test (Yes/No)
802.11a	149	5745	6.5	14.23	13.44	17	16.86	Yes
	153	5765		14.25	13.38	17	16.85	
	157	5785		14.3	13.46	17	16.91	
	161	5805		14.33	13.09	17	16.76	
	165	5825		14.5	13.15	17	16.89	
802.11n HT20	149	5745	MCS8	14.29	13.49	17	16.92	
	153	5765		14.2	13.37	17	16.82	
	157	5785		14.36	13.51	17	16.97	
	161	5805		14.25	13.16	17	16.75	
	165	5825		14.5	13.11	17	16.87	
802.11n HT40	151	5755	MCS8	14.13	13.77	17	16.96	No
	159	5795		14.41	13.15	17	16.84	
802.11ac VHT20	149	5745	MCS8	12.98	12.9	17	15.95	No
	153	5765		14.23	13.44	17	16.86	
	157	5785		14.25	13.38	17	16.85	
	161	5805		14.3	13.46	17	16.91	
	165	5825		14.33	13.09	17	16.76	
802.11ac VHT40	151	5755	MCS8	14.5	13.15	17	16.89	No
	159	5795		14.29	13.49	17	16.92	
802.11ac VHT80	155	5775	MCS8	14.2	13.37	17	16.82	

Note:
1) The Average conducted power of WiFi is measured with RMS detector.

9. SAR TEST RESULTS

General Notes:

1) Per KDB447498 D01v06, all measurement SAR results are scaled to the maximum tune-up tolerance limit to demonstrate compliant.
2) 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 > ½ dB, instead of the middle channel, the highest output power channel must be used.
3) Per KDB865664 D01v01r04,for each frequency band, repeated SAR measurement is required only when the measured SAR is ≥0.8W/Kg; if the deviation among the repeated measurement is ≤20%,and the measured SAR <1.45W/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.

WLAN Notes:

1) For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode, 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 positions in an exposure condition. The test position with the highest extrapolated(peak)SAR is used as the initial test position. When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2) Justification for test configurations for WLAN per KDB Publication 248227 for 2.4GHZ WIFI single transmission chain operations, the highest measured maximum output power Channel for DSSS was selected for SAR measurement.SAR for OFDM modes(2.4GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 7.1 for more information.

9.1 SAR MEASUREMENT RESULT OF BODY

Body SAR Mode For WiFi 2.4G

Test No.	Band	CH	Test Position At 0 mm	Ant Status	Tune up (dBm)	Measured (dBm)	Drift (dB)	Area Scan Peak SAR	SAR Value (W/kg)1-g	Reported SAR
1	802.11b	1	Rear Face	0	17	16.5	0.14	0.225	0.076	0.085
2	802.11b	1	Top Side	0	17	16.5	-0.16	0.605	0.407	0.457
3	802.11b	1	Right Side	0	17	16.5	0.1	0.0247	0.00302	0.003
4	802.11b	1	Rear Face	1	17	16.02	0	0.0468	0.0111	0.014
5	802.11b	1	Top Side	1	17	16.02	0.13	0.0106	0.00423	0.005
6	802.11b	1	Right Side	1	17	16.02	-0.12	0.0329	0.0116	0.015
7	802.11g	11	Rear Face	0	18	17.9	0.18	0.415	0.345	0.353
8	802.11g	11	Top Side	0	18	17.9	-0.04	1.12	0.744	**0.761**
9	802.11g	11	Right Side	0	18	17.9	0.12	0.023	0.00787	0.008
10	802.11g	11	Rear Face	1	18	17.84	0.15	0.0607	0.0424	0.044
11	802.11g	11	Top Side	1	18	17.84	0.14	0.0665	0.0405	0.042
12	802.11g	11	Right Side	1	18	17.84	-0.09	0.149	0.103	0.107

Note:

Per KDB248227D01, the highest SAR measured for the initial test position or initial test configuration should be used to determine SAR test exclusion according to the sum of 1-g SAR and SAR peak to location ratio provisions in KDB 447498. In addition, a test lab may also choose to perform standalone SAR measurements for test positions and 802.11 configurations that are not required by the initial test position or initial test configuration procedures and apply the results to determine simultaneous transmission SAR test exclusion, according to sum of 1-g and SAR peak to location ratio requirements to reduce the number of simultaneous transmission SAR measurements.

Body SAR Mode For WiFi 5.3G

Test No.	Band	CH	Test Position At 0 mm	Ant Status	Tune up (dBm)	Measured (dBm)	Drift (dB)	Area Scan Peak SAR	SAR Value (W/kg)1-g	Reported SAR
31	802.11a	52	Rear Face	0	15	14.79	0.16	0.318	0.217	0.228
32	802.11a	52	Top Side	0	15	14.79	-0.04	1.15	0.689	0.723
33	802.11a	52	Right Side	0	15	14.79	0.12	0.0249	0.09	0.094
34	802.11a	52	Rear Face	1	15	14.84	0	0.454	0.332	0.344
35	802.11a	52	Top Side	1	15	14.84	0.15	0.66	0.212	0.220
36	802.11a	52	Right Side	1	15	14.84	0.12	1.64	1.13	**1.172**
105	802.11a	64	Right Side	1	15	14.81	0.13	1.16	0.821	0.858
205 Repeat test	802.11a	52	Right Side	1	15	14.84	-0.13	1.66	1.1	1.141

Note:

1) The adjusted Body SAR is 1.172 x (29.92 mW / 30.48 mW) = 1.15mW/g, the U-NII-1 is not required .
2) Per KDB248227D01, the highest SAR measured for the initial test position or initial test configuration should be used to determine SAR test exclusion according to the sum of 1-g SAR and SAR peak to location ratio provisions in KDB 447498. In addition, a test lab may also choose to perform standalone SAR measurements for test positions and 802.11 configurations that are not required by the initial test position or initial test configuration procedures and apply the results to determine simultaneous transmission SAR test exclusion, according to sum of 1-g and SAR peak to location ratio requirements to reduce the number of simultaneous transmission SAR measurements.

Body SAR Mode For WiFi 5.5G

Test No.	Band	CH	Test Position At 0 mm	Ant Status	Tune up (dBm)	Measured (dBm)	Drift (dB)	Area Scan Peak SAR	SAR Value (W/kg)1-g	Reported SAR
41	802.11a	116	Rear Face	0	15	14.49	0.1	0.283	0.182	0.205
42	802.11a	116	Top Side	0	15	14.49	-0.16	2.08	1.05	**1.181**
103	802.11a	140	Top Side	0	15	14.41	-0.17	1.47	0.744	0.852
43	802.11a	116	Right Side	0	15	14.49	0.1	0.013	0.00131	0.001
203 Repeat test	802.11a	116	Top Side	0	15	14.49	0.12	1.7	1.03	1.158
44	802.11a	116	Rear Face	1	15	14.33	0.19	0.489	0.316	0.369
45	802.11a	116	Top Side	1	15	14.33	0.17	0.163	0.107	0.125
46	802.11a	116	Right Side	1	15	14.33	0.01	1.36	0.739	0.862
104	802.11a	132	Right Side	1	15	14.29	0.16	1.28	0.712	0.838
204 Repeat test	802.11a	116	Right Side	1	15	14.33	0.18	1.21	0.719	0.839

Note:

1) Per KDB248227D01, the highest SAR measured for the initial test position or initial test configuration should be used to determine SAR test exclusion according to the sum of 1-g SAR and SAR peak to location ratio provisions in KDB 447498. In addition, a test lab may also choose to perform standalone SAR measurements for test positions and 802.11 configurations that are not required by the initial test position or initial test configuration procedures and apply the results to determine simultaneous transmission SAR test exclusion, according to sum of 1-g and SAR peak to location ratio requirements to reduce the number of simultaneous transmission SAR measurements.

Body SAR Mode For WiFi 5.8G

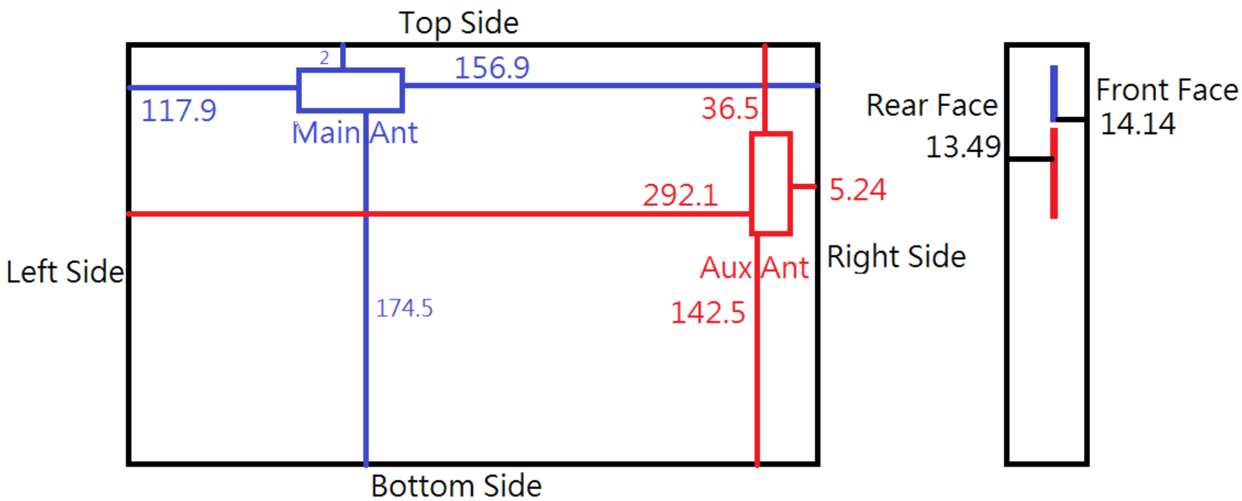
Test No.	Band	CH	Test Position At 0 mm	Ant Status	Tune up (dBm)	Measured (dBm)	Drift (dB)	Area Scan Peak SAR	SAR Value (W/kg)1-g	Reported SAR
51	802.11a	165	Rear Face	0	17	16.89	0.12	0.633	0.401	0.411
52	802.11a	165	Top Side	0	17	16.89	-0.17	2.34	1.1	**1.128**
201 Repeat test	802.11a	165	Top Side	0	17	16.89	-0.13	1.64	1.04	1.067
53	802.11a	165	Right Side	0	17	16.89	0.13	0.0297	0.0174	0.018
101	802.11a	149	Top Side	0	17	16.81	0.06	1.87	0.915	0.956
54	802.11a	157	Rear Face	1	17	16.73	0.18	0.809	0.54	0.575
55	802.11a	157	Top Side	1	17	16.73	0.13	0.31	0.139	0.148
56	802.11a	157	Right Side	1	17	16.73	-0.12	2.1	1.01	1.075
102	802.11a	161	Right Side	1	17	16.7	0.01	2.46	1.04	1.114
202 Repeat test	802.11a	161	Right Side	1	17	16.7	0.18	2.39	1	1.072

Note:

1) Per KDB248227D01, the highest SAR measured for the initial test position or initial test configuration should be used to determine SAR test exclusion according to the sum of 1-g SAR and SAR peak to location ratio provisions in KDB 447498. In addition, a test lab may also choose to perform standalone SAR measurements for test positions and 802.11 configurations that are not required by the initial test position or initial test configuration procedures and apply the results to determine simultaneous transmission SAR test exclusion, according to sum of 1-g and SAR peak to location ratio requirements to reduce the number of simultaneous transmission SAR measurements.

10. MULTIPLE TRANSMITTER INFORMATION

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



Per FCC KDB 447498D01v06, the 1-g SAR and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance,mm)][√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where:

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

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

Standalone SAR test exclusion for BT

Mode	Position	P_{max} (dBm)*	P_{max} (mW)	Distance (mm)	f (GHz)	Calculation Result	SAR Exclusion threshold	SAR test exclusion
BT	Body	2	1.58	5	2.441	0.493	3	Yes

Note:

1)* - maximum possible output power declared by manufacturer

2) Held to ear configurations are not applicable to Bluetooth for this device.

When standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] •

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

According to KDB 447498 D01,when standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standslone SAR was estimated according to following formula to result in substantially conservative SAR values of≤0.4W/Kg to determine simultaneous transmission SAR test exclusion.

$$\text{Estimated SAR} = \frac{\text{Max. Tune up Power}_{(mW)}}{\text{Min. Test Separation Distance}_{(mm)}} \times \frac{\sqrt{f_{(GHz)}}}{7.5}$$

BT Estimated SAR calculation

Mode	P_{max} (dBm) *	P_{max} (mW)	Distance (mm)	f (GHz)	X	Estimated SAR (W/Kg)*
BT	2	1.58	5	2.441	7.5	0.063

Note: * - maximum possible output power declared by manufacturer

11. SIMULTANEOUS TRANSMISSION CONDITIONS

WiFi 2.4G / WiFi 5G / BT transmit simultaneously

Co-Location	WiFi 2.4G	WiFi 5G	BT
WiFi 2.4G	Yes	No	Yes
WiFi 5G	No	Yes	Yes
BT	Yes	Yes	No

Note: 1). BT antenna only supports the aux antenna.
2). The module has support the MIMO Tx.

About The MIMO Tx for 2.4G

Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
Ant 0	0.353	0.761	0.008
Ant 1	0.044	0.042	0.107
MAX. $\sum SAR_{1g}$	0.397	0.803	0.115

MAX. $\sum SAR_{1g}$=0.803 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

About The MIMO Tx for 5.3G

Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
Ant 0	0.228	0.723	0.094
Ant 1	0.344	0.220	1.172
MAX. $\sum SAR_{1g}$	0.572	0.943	1.266

MAX. $\sum SAR_{1g}$=1.266 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

About The MIMO Tx for 5.5G

Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
Ant 0	0.205	1.181	0.001
Ant 1	0.369	0.125	0.862
MAX. $\sum SAR_{1g}$	0.574	1.306	0.863

MAX. $\sum SAR_{1g}$=1.306 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

About The MIMO Tx for 5.8G

Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
Ant 0	0.411	1.128	0.018
Ant 1	0.575	0.148	1.114
MAX. $\sum SAR_{1g}$	0.986	1.276	1.132

MAX. $\sum SAR_{1g}$=1.276 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

About The WiFi 2.4G and BT transmit simultaneously

Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
WiFi 2.4G Ant 0	0.353	0.761	0.008
BT	0.063	0.063	0.063
MAX. $\sum SAR_{1g}$	0.416	0.824	0.071

MAX. $\sum SAR_{1g}$=0.824 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

About The WiFi 5G and BT transmit simultaneously

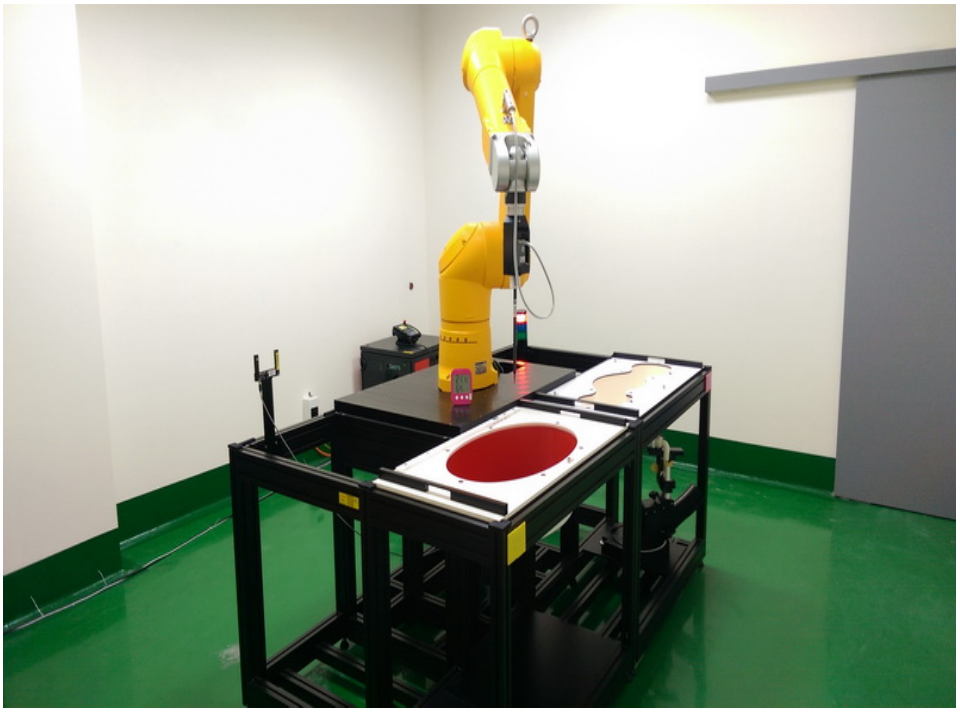
Test Position / SAR1g(W/Kg)	Rear Face	Top Side	Right Side
WiFi 5.3G Ant 0	0.228	0.723	0.094
WiFi 5.5G Ant 0	0.205	1.181	0.001
WiFi 5.8G Ant 0	0.411	1.128	0.018
BT	0.063	0.063	0.063
MAX. $\sum SAR_{1g}$	0.474	1.244	0.157

MAX. $\sum SAR_{1g}$=1.191 W/Kg < 1.6 W/Kg, so the SAR to peak location separation ratio should be not considered.

APPENDIX

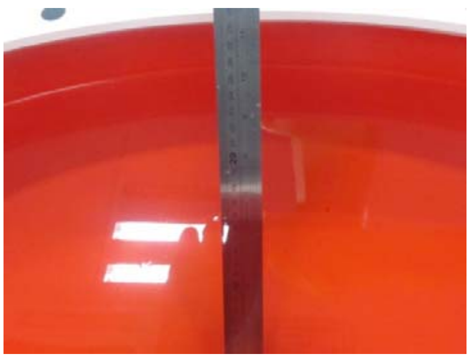
1. Test Layout

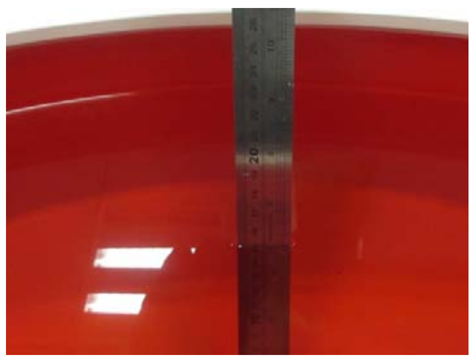
Specific Absorption Rate Test Layout



Liquid depth in the flat Phantom (≥15cm depth)

Body(2400MHz~2500MHz) Body(5GHz~6GHz)





Appendix A. SAR Plots of System Verification

Appendix B. SAR Plots of SAR Measurement

Appendix C. Calibration Certificate for Probe and Dipole

Appendix D. Photographs of the Test Set-Up