

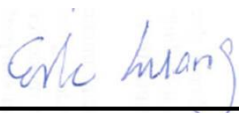
# FCC SAR Test Report

APPLICANT : Qualcomm Atheros, Inc.  
EQUIPMENT : 802.11 a/b/g/n/ac+ BT 4.1 M.2 Type Card  
BRAND NAME : Qualcomm Atheros  
MODEL NAME : QCNFA34AC  
FCC ID : PPD-QCNFA34AC  
STANDARD : FCC 47 CFR Part 2 (2.1093)  
ANSI/IEEE C95.1-1992  
IEEE 1528-2003


The product was installed into Notebook (Brand Name lenovo, Model Name: TP00067C) during test.

We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and had been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.



Reviewed by: Eric Huang / Deputy Manager



Approved by: Jones Tsai / Manager



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## Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FA572411-01	Rev. 01	Initial issue of report	Sep. 02, 2015

## 1. Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for Qualcomm Atheros, Inc., 802.11 a/b/g/n/ac+ BT 4.1 M.2 Type Card, QCNFA34AC, are as follows.

Equipment Class	Frequency Band	Highest SAR Summary	
		Body 1g SAR (W/kg)	Simultaneous Transmission 1g SAR (W/kg)
DTS	2.4GHz WLAN	1.15	1.15
NII	5.3GHz WLAN		0.83
	5.3GHz WLAN	0.73	
	5.5GHz WLAN	0.83	
	5.8GHz WLAN	0.53	
Date of Testing:		2015/08/13 ~ 2015/08/14	

This device is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits (1.6 W/kg) specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992, and had been tested in accordance with the measurement methods and procedures specified in IEEE 1528-2013 and FCC KDB publications.

## 2. Administration Data

Testing Laboratory	
Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No.52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978

Applicant	
Company Name	Qualcomm Atheros, Inc.
Address	1700 Technology Drive, San Jose, CA95110

Manufacturer	
Company Name	Qualcomm Atheros, Inc.
Address	1700 Technology Drive, San Jose, CA95110

### 3. Guidance Standard

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

- FCC 47 CFR Part 2 (2.1093)
- ANSI/IEEE C95.1-1992
- IEEE 1528-2013
- FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB 865664 D02 SAR Reporting v01r01
- FCC KDB 447498 D01 General RF Exposure Guidance v05r02
- FCC KDB 248227 D01 802.11 Wi-Fi SAR v02r01
- FCC KDB 616217 D04 SAR for laptop and tablets v01r01

### 4. Equipment Under Test (EUT)

#### 4.1 General Information

Product Feature & Specification	
Equipment Name	802.11 a/b/g/n/ac+ BT 4.1 M.2 Type Card
Brand Name	Qualcomm Atheros
Model Name	QCNFA34AC
FCC ID	PPD-QCNFA34AC
Wireless Technology and Frequency Range	WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5700 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	• 802.11a/b/g/n/ac HT20/HT40/VHT20/VHT40/VHT80 • Bluetooth v4.1 with LE
EUT Stage	Production Unit
<b>Remark:</b>	
1. Two kinds antenna will integrated into this host, the RF exposure evaluation just first selected the antenna vendor of YAGEO as the main test and SPEEDWIRE will verify worse case found in YAGEO tested results.	

Host Feature & Antenna Information			
Host		Notebook	
Brand Name		lenovo	
Model Name		TP00067C	
Antenna 1	Manufacturer	SPEEDWIRE	
	Antenna Type	Main: PIFA Antenna	Aux: PIFA Antenna
	Antenna P/N	DC330018300	DC330018310
	Peak gain	Main Antenna :	Aux Antenna :
		WLAN(2.4GHz): 0.94dBi	WLAN(2.4GHz): -1.92dBi
		WLAN(5150~5350 MHz): -0.51dBi	WLAN(5150~5350 MHz): -2.19dBi
		WLAN(5470~5725 MHz): -0.34dBi	WLAN(5470~5725 MHz): -2.77dBi
		WLAN(5725~5850 MHz): -1.05dBi	WLAN(5725~5850 MHz): -2.77dBi
Antenna 2	Manufacturer	YAGEO	
	Antenna Type	Main: PIFA Antenna	Aux: PIFA Antenna
	Antenna P/N	DC330018100	DC330018110
	Peak gain	Main Antenna :	Aux Antenna :
		WLAN(2.4GHz): 1.92dBi	WLAN(2.4GHz): -2.84dBi
		WLAN(5150~5350 MHz): -0.11dBi	WLAN(5150~5350 MHz): -0.73dBi
		WLAN(5470~5725 MHz): 0.58dBi	WLAN(5470~5725 MHz): -1.05dBi
		WLAN(5725~5850 MHz): 1.26dBi	WLAN(5725~5850 MHz): -1.51dBi
		Bluetooth: -2.84dBi	

## **5. RF Exposure Limits**

### **5.1 Uncontrolled Environment**

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

### **5.2 Controlled Environment**

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. The exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

**Limits for Occupational/Controlled Exposure (W/kg)**

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

**Limits for General Population/Uncontrolled Exposure (W/kg)**

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

1. Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

## **6. Specific Absorption Rate (SAR)**

### **6.1 Introduction**

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

### **6.2 SAR Definition**

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

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

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

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

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

## **7. System Description and Setup**

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



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP or Win7 and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.



## **8. Measurement Procedures**

The measurement procedures are as follows:

### <Conducted power measurement>

- (a) For WWAN power measurement, use base station simulator to configure EUT WWAN transmission in conducted connection with RF cable, at maximum power in each supported wireless interface and frequency band.
- (b) Read the WWAN RF power level from the base station simulator.
- (c) For WLAN/BT power measurement, use engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power in each supported wireless interface and frequency band
- (d) Connect EUT RF port through RF cable to the power meter, and measure WLAN/BT output power

### <SAR measurement>

- (a) Use base station simulator to configure EUT WWAN transmission in radiated connection, and engineering software to configure EUT WLAN/BT continuously transmission, at maximum RF power, in the highest power channel.
- (b) Place the EUT in the positions as Appendix D demonstrates.
- (c) Set scan area, grid size and other setting on the DASY software.
- (d) Measure SAR results for the highest power channel on each testing position.
- (e) Find out the largest SAR result on these testing positions of each band
- (f) Measure SAR results for other channels in worst SAR testing position if the reported SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- (a) Power reference measurement
- (b) Area scan
- (c) Zoom scan
- (d) Power drift measurement

### **8.1 Spatial Peak SAR Evaluation**

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

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

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

- (a) Extraction of the measured data (grid and values) from the Zoom Scan
- (b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- (c) Generation of a high-resolution mesh within the measured volume
- (d) Interpolation of all measured values from the measurement grid to the high-resolution grid
- (e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- (f) Calculation of the averaged SAR within masses of 1g and 10g

## **8.2 Power Reference Measurement**

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

## **8.3 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 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 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan), if only one zoom scan follows the area scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of zoom scans has to be increased accordingly.

Area scan parameters extracted from FCC KDB 865664 D01v01r04 SAR measurement 100 MHz to 6 GHz.

	$\leq 3$ GHz	$> 3$ GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	$5 \pm 1$ 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: $\Delta x_{\text{Area}}, \Delta y_{\text{Area}}$	$\leq 2$ GHz: $\leq 15$ mm $2 - 3$ GHz: $\leq 12$ mm	$3 - 4$ GHz: $\leq 12$ mm $4 - 6$ GHz: $\leq 10$ 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.	

### 8.4 Zoom Scan

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

Zoom scan parameters extracted from FCC KDB 865664 D01v01r04 SAR measurement 100 MHz to 6 GHz.

			$\leq 3$ GHz	$> 3$ GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			$\leq 2$ GHz: $\leq 8$ mm 2 – 3 GHz: $\leq 5$ mm*	3 – 4 GHz: $\leq 5$ mm* 4 – 6 GHz: $\leq 4$ mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{\text{Zoom}}(n)$		$\leq 5$ mm	3 – 4 GHz: $\leq 4$ mm 4 – 5 GHz: $\leq 3$ mm 5 – 6 GHz: $\leq 2$ mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$ : between 1 <sup>st</sup> two points closest to phantom surface	$\leq 4$ mm	3 – 4 GHz: $\leq 3$ mm 4 – 5 GHz: $\leq 2.5$ mm 5 – 6 GHz: $\leq 2$ 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		$\geq 30$ mm	3 – 4 GHz: $\geq 28$ mm 4 – 5 GHz: $\geq 25$ mm 5 – 6 GHz: $\geq 22$ mm
Note: $\delta$ 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 $\leq 1.4$ W/kg, $\leq 8$ mm, $\leq 7$ mm and $\leq 5$ 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.				

### 8.5 Volume Scan Procedures

The volume scan is used to assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

### 8.6 Power Drift Monitoring

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

## 9. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	2450MHz System Validation Kit	D2450V2	736	Aug. 21, 2014	Aug. 20, 2015
SPEAG	5GHz System Validation Kit	D5GHzV2	1006	Sep. 25, 2014	Sep. 24, 2015
SPEAG	Data Acquisition Electronics	DAE4	1279	Jul. 21, 2015	Jul. 20, 2016
SPEAG	Dosimetric E-Field Probe	EX3DV4	3954	Nov. 21, 2014	Nov. 20, 2015
Wisewind	Thermometer	ETP-101	TM560	Oct. 21, 2014	Oct. 20, 2015
SPEAG	Device Holder	N/A	N/A	N/A	N/A
R&S	Signal Generator	MG3710A	6201502524	May. 25, 2015	May. 24, 2016
Agilent	ENA Network Analyzer	E5071C	MY46316648	Feb. 11, 2015	Feb. 10, 2016
SPEAG	Dielectric Probe Kit	DAK-3.5	1138	Nov. 18, 2014	Nov. 17, 2015
LINE SEIKI	Digital Thermometer	LKMelectronic	DTM3000SPEZIAL	Jul. 17, 2015	Jul. 16, 2016
Anritsu	Power Meter	ML2495A	1419002	May. 13, 2015	May. 12, 2016
Anritsu	Power Sensor	MA2411B	1339124	May. 13, 2015	May. 12, 2016
Anritsu	Spectrum Analyzer	MS2830A	6201396378	Jun. 17, 2015	Jun. 16, 2016
Agilent	Dual Directional Coupler	778D	50422	Note 1	
Woken	Attenuator 1	WK0602-XX	N/A	Note 1	
PE	Attenuator 2	PE7005-10	N/A	Note 1	
PE	Attenuator 3	PE7005- 3	N/A	Note 1	
AR	Power Amplifier	5S1G4M2	0328767	Note 1	
Mini-Circuits	Power Amplifier	ZVE-3W	162601250	Note 1	

**General Note:**

1. 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.

## 10. System Verification

### 10.1 Tissue Verification

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Frequency (MHz)	Water (%)	Sugar (%)	Cellulose (%)	Salt (%)	Preventol (%)	DGBE (%)	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )
For Head								
750	41.1	57.0	0.2	1.4	0.2	0	0.89	41.9
835	40.3	57.9	0.2	1.4	0.2	0	0.90	41.5
900	40.3	57.9	0.2	1.4	0.2	0	0.97	41.5
1800, 1900, 2000	55.2	0	0	0.3	0	44.5	1.40	40.0
2450	55.0	0	0	0	0	45.0	1.80	39.2
2600	54.8	0	0	0.1	0	45.1	1.96	39.0
For Body								
750	51.7	47.2	0	0.9	0.1	0	0.96	55.5
835	50.8	48.2	0	0.9	0.1	0	0.97	55.2
900	50.8	48.2	0	0.9	0.1	0	1.05	55.0
1800, 1900, 2000	70.2	0	0	0.4	0	29.4	1.52	53.3
2450	68.6	0	0	0	0	31.4	1.95	52.7
2600	68.1	0	0	0.1	0	31.8	2.16	52.5

Simulating Liquid for 5GHz, Manufactured by SPEAG

Ingredients	(% by weight)
Water	64~78%
Mineral oil	11~18%
Emulsifiers	9~15%
Additives and Salt	2~3%

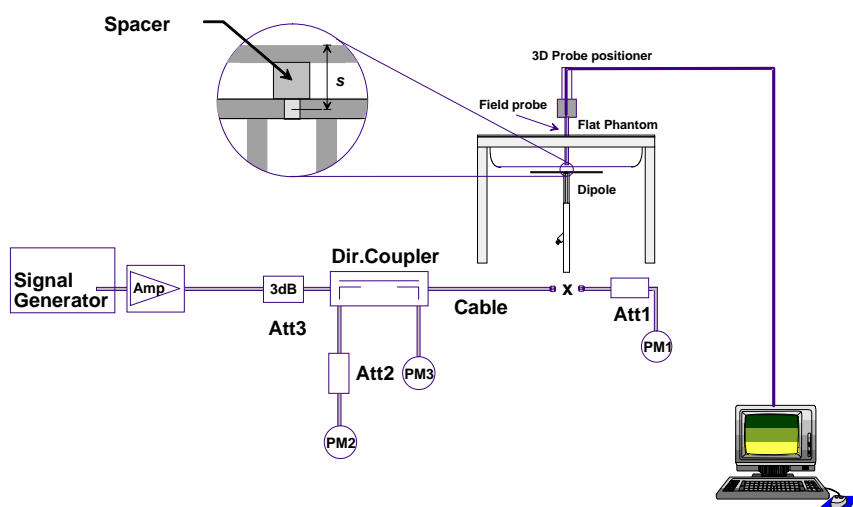
### <Tissue Dielectric Parameter Check Results>

Frequency (MHz)	Tissue Type	Liquid Temp. (°C)	Conductivity ( $\sigma$ )	Permittivity ( $\epsilon_r$ )	Conductivity Target ( $\sigma$ )	Permittivity Target ( $\epsilon_r$ )	Delta ( $\sigma$ ) (%)	Delta ( $\epsilon_r$ ) (%)	Limit (%)	Date
2450	MSL	22.6	1.931	53.584	1.95	52.70	-0.97	1.68	±5	2015/8/13
5300	MSL	22.4	5.563	47.029	5.42	48.90	2.64	-3.83	±5	2015/8/14
5600	MSL	22.4	5.946	46.449	5.77	48.50	3.05	-4.23	±5	2015/8/14
5800	MSL	22.4	6.183	46.178	6.00	48.20	3.05	-4.20	±5	2015/8/14

## 10.2 System Performance Check Results

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

Date	Frequency (MHz)	Tissue Type	Input Power (mW)	Dipole S/N	Probe S/N	DAE S/N	Measured 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)
2015/8/13	2450	MSL	250	D2450V2-736	EX3DV4 - SN3954	DAE4 Sn1279	11.90	50.60	47.60	-5.93
2015/8/14	5300	MSL	100	D5GHzV2-1006-5300	EX3DV4 - SN3954	DAE4 Sn1279	8.27	80.00	82.70	3.37
2015/8/14	5600	MSL	100	D5GHzV2-1006-5600	EX3DV4 - SN3954	DAE4 Sn1279	8.21	85.20	82.10	-3.64
2015/8/14	5800	MSL	100	D5GHzV2-1006-5800	EX3DV4 - SN3954	DAE4 Sn1279	8.02	78.40	80.20	2.30



**Fig 8.3.1 System Performance Check Setup**



**Fig 8.3.2 Setup Photo**

## 11. RF Exposure Positions

### 11.1 SAR Testing for Tablet

This device can be used also in full sized tablet exposure conditions, due to its size. Per FCC KDB 616217, the back surface and edges of the tablet should be tested for SAR compliance with the tablet touching the phantom. The SAR exclusion threshold in KDB 447498 D01v05r02 can 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 against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

## **12. Conducted RF Output Power (Unit: dBm)**

### **<WLAN Conducted Power>**

#### **General Note:**

1. Per KDB 248227 D01v02r01, SAR test reduction is determined according to 802.11 transmission mode configurations and certain exposure conditions with multiple test positions. In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration must be determined for each standalone and aggregated frequency band, according to the transmission mode configuration with the highest maximum output power specified for production units to perform SAR measurements. If the same highest maximum output power applies to different combinations of channel bandwidths, modulations and data rates, additional procedures are applied to determine which test configurations require SAR measurement. When applicable, an initial test position may be applied to reduce the number of SAR measurements required for next to the ear, UMPC mini-tablet or hotspot mode configurations with multiple test positions.
2. For 2.4 GHz 802.11b DSSS, either the initial test position procedure for multiple exposure test positions or the DSSS procedure for fixed exposure position is applied; these are mutually exclusive. For 2.4 GHz and 5 GHz OFDM configurations, the initial test configuration is applied to measure SAR using either the initial test position procedure for multiple exposure test position configurations or the initial test configuration procedures for fixed exposure test conditions. Based on the reported SAR of the measured configurations and maximum output power of the transmission mode configurations that are not included in the initial test configuration, the subsequent test configuration and initial test position procedures are applied to determine if SAR measurements are required for the remaining OFDM transmission configurations. In general, the number of test channels that require SAR measurement is minimized based on maximum output power measured for the test sample(s).
3. For OFDM transmission configurations in the 2.4 GHz and 5 GHz bands, When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel for each frequency band.
4. DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.<sup>18</sup> The initial test position procedure is described in the following:
  - a. When the reported SAR of the initial test position is  $\leq 0.4$  W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band.
  - b. When the reported SAR of the test position is  $> 0.4$  W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is  $\leq 0.8$  W/kg or all required test position are tested.
  - c. For all positions/configurations, when the reported SAR is  $> 0.8$  W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required channels are tested.



**<2.4GHz WLAN>**

	Mode	Channel	Frequency (MHz)	Data Rate	Ant A Average Power dBm		Ant B Average Power dBm		Ant A + Ant B Average Power dBm		Duty Cycle %
					Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	
2.4GHz WLAN	802.11b	CH 1	2412	1Mbps	18.70	20.50	19.41	20.50	22.08	23.50	99.04
		CH 6	2437		18.75	20.50	19.38	20.50	22.09	23.50	
		CH 11	2462		18.63	20.50	19.35	20.50	22.02	23.50	
	802.11g	CH 1	2412	6Mbps	14.44	16.00	14.90	16.00	17.69	19.00	95.37
		CH 6	2437		17.95	19.50	18.08	19.50	21.03	22.50	
		CH 11	2462		13.52	15.50	14.10	15.50	16.83	18.50	
	802.11n-HT20	CH 1	2412	MCS0	12.48	14.00	12.66	14.00	15.58	17.00	90.74
		CH 6	2437		17.94	19.50	18.11	19.50	21.04	22.50	
		CH 11	2462		12.30	14.00	12.91	14.00	15.63	17.00	
	802.11ac-VHT20	CH 1	2412	MCS0	12.45	14.00	12.56	14.00	15.52	17.00	95.10
		CH 6	2437		17.97	19.50	18.03	19.50	21.01	22.50	
		CH 11	2462		12.31	14.00	12.90	14.00	15.63	17.00	
	802.11n-HT40	CH 3	2422	MCS0	10.95	12.50	10.58	12.50	13.78	15.50	83.89
		CH 6	2437		15.53	17.50	16.48	17.50	19.04	20.50	
		CH 9	2452		9.56	11.50	9.80	11.50	12.69	14.50	
	802.11ac-VHT40	CH 3	2422	MCS0	10.57	12.50	10.59	12.50	13.59	15.50	88.68
		CH 6	2437		16.93	17.50	17.49	17.50	20.23	20.50	
		CH 9	2452		9.63	11.50	9.86	11.50	12.76	14.50	

**<5GHz WLAN>**

	Mode	Channel	Frequency (MHz)	Data Rate	Ant A Average Power dBm		Ant B Average Power dBm		Ant A + Ant B Average Power dBm		Duty Cycle %
					Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	
5.2GHz WLAN	802.11a	CH 36	5180	6Mbps	10.52	12.50	11.87	12.50	14.26	15.50	95.37
		CH 40	5200		14.21	15.00	14.76	15.00	17.50	18.00	
		CH 44	5220		14.14	15.00	14.98	15.00	17.59	18.00	
		CH 48	5240		14.26	15.00	14.99	15.00	17.65	18.00	
	802.11n-HT20	CH 36	5180	MCS0	10.64	12.50	10.52	12.50	13.59	15.50	90.74
		CH 40	5200		14.12	15.00	13.21	15.00	16.70	18.00	
		CH 44	5220		14.09	15.00	13.16	15.00	16.66	18.00	
		CH 48	5240		14.12	15.00	13.27	15.00	16.73	18.00	
	802.11n-HT40	CH 38	5190	MCS0	10.53	12.00	10.38	12.00	13.47	15.00	85.03
		CH 46	5230		13.52	15.00	13.31	15.00	16.43	18.00	
	802.11ac-VHT20	CH 36	5180	MCS0	10.80	12.50	10.66	12.50	13.74	15.50	96.04
		CH 40	5200		13.14	15.00	13.00	15.00	16.08	18.00	
		CH 44	5220		13.16	15.00	13.06	15.00	16.12	18.00	
		CH 48	5240		13.20	15.00	13.00	15.00	16.11	18.00	
	802.11ac-VHT40	CH 38	5190	MCS0	10.38	12.00	10.21	12.00	13.31	15.00	90.57
		CH 46	5230		13.35	15.00	13.10	15.00	16.24	18.00	
	802.11ac-VHT80	CH 42	5210	MCS0	9.71	11.00	9.36	11.00	12.55	14.00	85.12





	Mode	Channel	Frequency (MHz)	Data Rate	Ant A Average Power dBm		Ant B Average Power dBm		Ant A + Ant B Average Power dBm		Duty Cycle %
					Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	
5.3GHz WLAN	802.11a	CH 52	5260	6Mbps	14.52	16.50	15.37	16.50	17.98	19.50	95.37
		CH 56	5280		10.83	12.00	11.67	12.00	14.28	15.00	
		CH 60	5300		11.02	12.00	11.69	12.00	14.38	15.00	
		CH 64	5320		8.50	10.00	9.93	10.00	12.28	13.00	
	802.11n-HT20	CH 52	5260	MCS0	15.19	16.50	14.73	16.50	17.98	19.50	90.74
		CH 56	5280		12.16	12.50	11.27	12.50	14.75	15.50	
		CH 60	5300		12.36	12.50	11.39	12.50	14.91	15.50	
		CH 64	5320		8.70	9.00	8.65	9.00	11.69	12.00	
	802.11n-HT40	CH 54	5270	MCS0	14.32	16.00	14.22	16.00	17.28	19.00	85.03
		CH 62	5310		11.21	12.00	10.10	12.00	13.70	15.00	
	802.11ac-VHT20	CH 52	5260	MCS0	14.56	16.50	14.51	16.50	17.55	19.50	96.04
		CH 56	5280		11.76	12.50	10.59	12.50	14.22	15.50	
		CH 60	5300		11.78	12.50	10.89	12.50	14.37	15.50	
		CH 64	5320		7.58	9.00	7.45	9.00	10.53	12.00	
	802.11ac-VHT40	CH 54	5270	MCS0	14.14	16.00	14.00	16.00	17.08	19.00	90.57
		CH 62	5310		10.06	11.50	9.55	11.50	12.82	14.50	
	802.11ac-VHT80	CH 58	5290	MCS0	10.41	11.50	9.98	11.50	13.21	14.50	85.12

	Mode	Channel	Frequency (MHz)	Data Rate	Ant A Average Power dBm		Ant B Average Power dBm		Ant A + Ant B Average Power dBm		Duty Cycle %
					Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	
5.5GHz WLAN	802.11a	CH 100	5500	6Mbps	8.00	10.00	8.25	10.00	11.14	13.00	95.37
		CH 116	5580		14.53	16.50	14.93	16.50	17.74	19.50	
		CH 132	5660		14.69	16.50	15.00	16.50	17.86	19.50	
		CH 140	5700		7.34	9.00	7.78	9.00	10.58	12.00	
		CH 144	5720		14.62	16.50	14.81	16.50	17.73	19.50	
	802.11n-HT20	CH 100	5500	MCS0	7.16	9.00	7.21	9.00	10.20	12.00	90.74
		CH 116	5580		14.72	16.50	14.55	16.50	17.65	19.50	
		CH 132	5660		14.68	16.50	14.53	16.50	17.62	19.50	
		CH 140	5700		7.16	9.00	7.03	9.00	10.11	12.00	
		CH 144	5720		14.92	16.50	14.71	16.50	17.83	19.50	
	802.11n-HT40	CH 102	5510	MCS0	8.40	9.50	8.12	9.50	11.27	12.50	85.03
		CH 110	5550		15.03	16.00	14.83	16.00	17.94	19.00	
		CH 134	5670		13.20	15.00	13.00	15.00	16.11	18.00	
		CH 142	5710		15.01	16.00	14.80	16.00	17.92	19.00	
	802.11ac-VHT20	CH 100	5500	MCS0	7.19	9.00	7.12	9.00	10.17	12.00	96.04
		CH 116	5580		14.73	16.50	14.59	16.50	17.67	19.50	
		CH 132	5660		14.75	16.50	14.62	16.50	17.70	19.50	
		CH 140	5700		7.29	9.00	7.00	9.00	10.16	12.00	
		CH 144	5720		14.77	16.50	14.62	16.50	17.71	19.50	
	802.11ac-VHT40	CH 102	5510	MCS0	7.50	9.50	7.72	9.50	10.62	12.50	90.57
		CH 110	5550		14.66	16.00	14.21	16.00	17.45	19.00	
		CH 134	5670		13.40	15.00	13.00	15.00	16.21	18.00	
		CH 142	5710		14.63	16.00	14.22	16.00	17.44	19.00	
	802.11ac-VHT80	CH 106	5530	MCS0	10.59	12.50	10.61	12.50	13.61	15.50	85.12
		CH 138	5690		14.52	16.50	14.58	16.50	17.56	19.50	

	Mode	Channel	Frequency (MHz)	Data Rate	Ant A Average Power dBm		Ant B Average Power dBm		Ant A + Ant B Average Power dBm		Duty Cycle %
					Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	Average power (dBm)	Tune-Up Limit	
5.8GHz WLAN	802.11a	CH 149	5745	MCS0	14.83	16.50	14.52	16.50	17.69	19.50	95.37
		CH 157	5785		14.89	16.50	14.56	16.50	17.74	19.50	
		CH 165	5825		14.77	16.50	14.52	16.50	17.66	19.50	
	802.11n-HT20	CH 149	5745	MCS0	14.67	16.50	14.53	16.50	17.61	19.50	90.74
		CH 157	5785		14.56	16.50	14.63	16.50	17.61	19.50	
		CH 165	5825		14.59	16.50	14.61	16.50	17.61	19.50	
	802.11n-HT40	CH 151	5755	MCS0	14.08	16.00	14.06	16.00	17.08	19.00	85.03
		CH 159	5795		14.36	16.00	14.12	16.00	17.25	19.00	
	802.11ac-VHT20	CH 149	5745	MCS0	14.61	16.50	14.67	16.50	17.65	19.50	96.04
		CH 157	5785		14.88	16.50	14.53	16.50	17.72	19.50	
		CH 165	5825		14.78	16.50	14.52	16.50	17.66	19.50	
	802.11ac-VHT40	CH 151	5755	MCS0	14.30	16.00	14.33	16.00	17.33	19.00	90.57
		CH 159	5795		14.37	16.00	14.27	16.00	17.33	19.00	
	802.11ac-VHT80	CH 155	5775	MCS0	14.89	16.50	14.53	16.50	17.72	19.50	85.12

### 13. Bluetooth Exclusions Applied

Mode Band	Bluetooth Average power(dBm)		
	BR	EDR	LE
v4.1 with LE	6	6	1.5

**Note:**

1. Per KDB 447498 D01v05r02, the 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at *test separation distances* ≤ 50 mm are determined by:

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

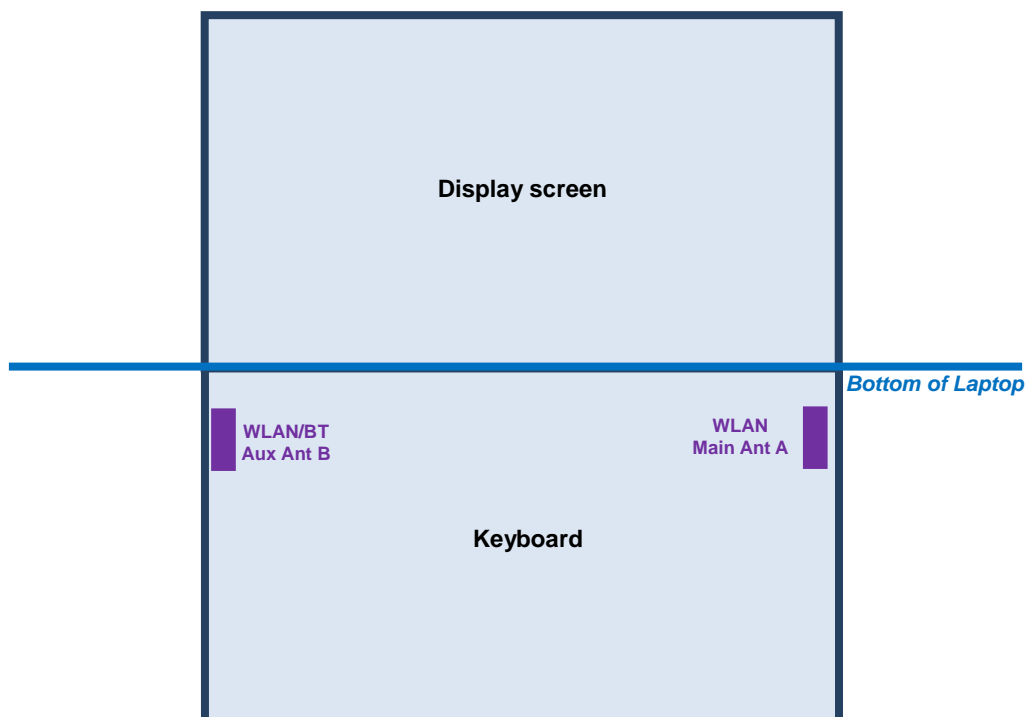
- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

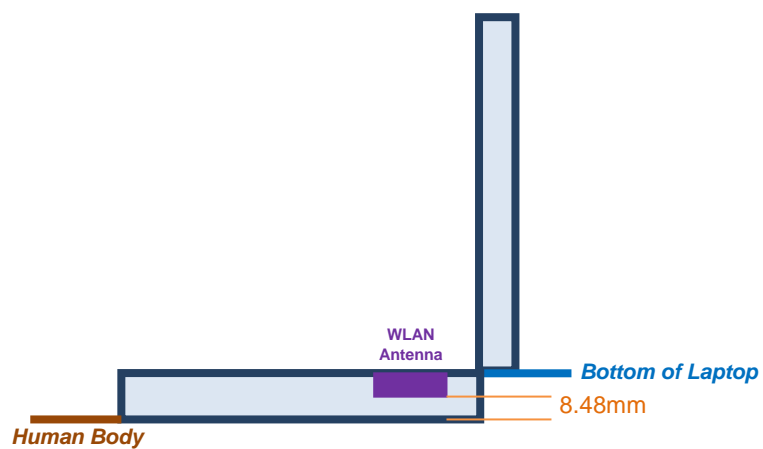
Bluetooth Max Power (dBm)	Separation Distance (mm)	Frequency (GHz)	exclusion thresholds
6.0	< 5	2.48	1.26

**Note:**

Per KDB 447498 D01v05r02, when the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion. The test exclusion threshold is 1.26 which is ≤ 3, SAR testing is not required.

## 14. Antenna Location





<Side view>

## 15. SAR Test Results

### General Note:

- Per KDB 447498 D01v05r02, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
  - Tune-up scaling Factor = tune-up limit power (mW) / EUT RF power (mW), where tune-up limit is the maximum rated power among all production units.
  - For SAR testing of WLAN signal with non-100% duty cycle, the measured SAR is scaled-up by the duty cycle scaling factor which is equal to "1/(duty cycle)"
  - For WWAN: Reported SAR(W/kg)= Measured SAR(W/kg)\*Tune-up Scaling Factor
  - For WLAN: Reported SAR(W/kg)= Measured SAR(W/kg)\* Duty Cycle scaling factor \* Tune-up scaling factor
- Per KDB 865664 D01v01r04, for each frequency band, repeated SAR measurement is required only when the measured SAR is  $\geq 0.8$  W/kg.
- Per KDB 248227 D01v02r01, for 2.4GHz 802.11g/n SAR testing is not required 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  $\leq 1.2$  W/kg.
- Per KDB 248227 D01v02r01, for U-NII-1 SAR testing is not required when the U-NII-2A band highest reported SAR for a test configuration is  $\leq 1.2$  W/kg, SAR is not required for U-NII-1 band.
- When the reported SAR of the test position is  $> 0.4$  W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position on the highest maximum output power channel, until the report SAR is  $\leq 0.8$  W/kg or all required test position are tested.
- For all positions / configurations, when the reported SAR is  $> 0.8$  W/kg, SAR is measured for these test positions / configurations on the subsequent next highest measured output power channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required channels are tested.
- Since the antennas are spatially separated and SAR distributions do not overlap, MIMO SAR was measured with both antennas transmitting simultaneously at the specified maximum output power in MIMO mode. The SAR value associated with antenna A and antenna B was scaled based on the difference between measured and maximum power for antenna A and antenna B respectively.
- During SAR testing the WLAN transmission was verified using a spectrum analyzer.

### 15.1 Body SAR

#### <WLAN SAR>

Plot No.	Band	Mode	Test Position	Gap (mm)	Antenna Vendor	Ch.	Freq. (MHz)	Tx Antenna	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Yageo	6	2437	A+B	Ant A 18.75	20.50	Ant A 1.496	99.04	1.010	-0.14	Ant A 0.720	Ant A 1.088
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Yageo	1	2412	A+B	Ant A 18.70	20.50	Ant A 1.514	99.04	1.010	-0.04	Ant A 0.525	Ant A 0.803
01	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Yageo	11	2462	A+B	Ant A 18.63	20.50	Ant A 1.538	99.04	1.010	-0.05	Ant A 0.741	Ant A 1.151
	WLAN2.4GHz	802.11b 1Mbps	Bottom of Laptop	0mm	Speedwire	11	2462	A+B	Ant B 19.35	20.50	Ant B 1.303	99.04	1.010	-0.15	Ant B 0.648	Ant B 0.853
02	WLAN5GHz	802.11a 6Mbps	Bottom of Laptop	0mm	Yageo	52	5260	A+B	Ant B 15.37	16.50	Ant B 1.297	95.37	1.049	-0.14	Ant B 0.533	Ant B 0.725
	WLAN5GHz	802.11a 6Mbps	Bottom of Laptop	0mm	Yageo	60	5300	A+B	Ant B 11.69	12.00	Ant B 1.074	95.37	1.049	-0.1	Ant B 0.204	Ant B 0.230
	WLAN5GHz	802.11a 6Mbps	Bottom of Laptop	0mm	Speedwire	52	5260	A+B	Ant A 14.52	16.50	Ant A 1.578	95.37	1.049	-0.1	Ant A 0.190	Ant A 0.314
03	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Yageo	138	5690	A+B	Ant B 14.58	16.50	Ant B 1.556	85.12	1.175	-0.19	Ant B 0.454	Ant B 0.830
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Yageo	106	5530	A+B	Ant B 10.61	12.50	Ant B 1.545	85.12	1.175	-0.15	Ant B 0.258	Ant B 0.468
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Speedwire	138	5690	A+B	Ant A 14.52	16.50	Ant A 1.578	85.12	1.175	-0.05	Ant A 0.198	Ant A 0.367
	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Yageo	155	5775	A+B	Ant B 14.53	16.50	Ant B 1.574	85.12	1.175	-0.13	Ant B 0.278	Ant B 0.514
04	WLAN5GHz	802.11ac-VHT80 MCS0	Bottom of Laptop	0mm	Speedwire	155	5775	A+B	Ant A 14.89	16.50	Ant A 1.449	85.12	1.175	-0.18	Ant A 0.309	Ant A 0.526

## 16. Simultaneous Transmission Analysis

NO.	Simultaneous Transmission Configurations	Body
1.	WLAN + Bluetooth	Yes

**General Note:**

- The worst case WLAN reported SAR for each configuration was used for SAR summation. Therefore, the following summations represent the absolute worst cases for simultaneous transmission with WLAN.
- EUT will choose either WLAN 2.4GHz or WLAN 5GHz according to the network signal condition; therefore, 2.4GHz WLAN and 5GHz WLAN will not operate simultaneously at any moment.
- The Scaled SAR summation is calculated based on the same configuration and test position.
- Per KDB 447498 D01v05r02, simultaneous transmission SAR is compliant if,
  - Scalar SAR summation  $< 1.6\text{W/kg}$ .
  - $\text{SPLSR} = (\text{SAR1} + \text{SAR2})^{1.5} / (\text{min. separation distance, mm})$ , and the peak separation distance is determined from the square root of  $[(x1-x2)^2 + (y1-y2)^2 + (z1-z2)^2]$ , where  $(x1, y1, z1)$  and  $(x2, y2, z2)$  are the coordinates of the extrapolated peak SAR locations in the zoom scan.
  - If  $\text{SPLSR} \leq 0.04$ , simultaneously transmission SAR measurement is not necessary.
  - Simultaneously transmission SAR measurement, and the reported multi-band SAR  $< 1.6\text{W/kg}$ .
- For simultaneous transmission analysis, Bluetooth SAR is estimated per KDB 447498 D01v05r02 based on the formula below.
  - $(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm}) \cdot [\sqrt{f(\text{GHz})} / x] \text{ W/kg}$  for test separation distances  $\leq 50 \text{ mm}$ ; where  $x = 7.5$  for 1-g SAR, and  $x = 18.75$  for 10-g SAR.
  - When the minimum separation distance is  $< 5 \text{ mm}$ , the distance is used 5mm to determine SAR test exclusion.
  - 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distances is  $> 50 \text{ mm}$ .

Bluetooth Max Power	Exposure Position	Bottom of Laptop
6.0 dBm	Estimated SAR (W/kg)	0.168 W/kg

### 16.1 Body Exposure Conditions

Band	Exposure Position	1	2	1+2 Summed 1g SAR (W/kg)
		WLAN	Bluetooth	
		1g SAR (W/kg)	Estimated 1g SAR (W/kg)	
2.4GHz WLAN	Bottom of Laptop at 0 mm	1.151	0.168	<b>1.32</b>
5GHz WLAN	Bottom of Laptop at 0 mm	0.830	0.168	<b>1.00</b>

**Test Engineer :** Frank Wu, and Domo Hsiao

## **17. Uncertainty Assessment**

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in table below.

<b>Uncertainty Distributions</b>	<b>Normal</b>	<b>Rectangular</b>	<b>Triangular</b>	<b>U-Shape</b>
Multi-plying Factor <sup>(a)</sup>	$1/k^{(b)}$	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b)  $k$  is the coverage factor

**Table 16.1. Standard Uncertainty for Assumed Distribution**

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.



Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) 1g	(Ci) 10g	Standard Uncertainty (1g) (±%)	Standard Uncertainty (10g) (±%)
<b>Measurement System</b>							
Probe Calibration	6.0	N	1	1	1	6.0	6.0
Axial Isotropy	4.7	R	1.732	0.7	0.7	1.9	1.9
Hemispherical Isotropy	9.6	R	1.732	0.7	0.7	3.9	3.9
Boundary Effects	1.0	R	1.732	1	1	0.6	0.6
Linearity	4.7	R	1.732	1	1	2.7	2.7
System Detection Limits	1.0	R	1.732	1	1	0.6	0.6
Modulation Response	3.2	R	1.732	1	1	1.8	1.8
Readout Electronics	0.3	N	1	1	1	0.3	0.3
Response Time	0.0	R	1.732	1	1	0.0	0.0
Integration Time	2.6	R	1.732	1	1	1.5	1.5
RF Ambient Noise	3.0	R	1.732	1	1	1.7	1.7
RF Ambient Reflections	3.0	R	1.732	1	1	1.7	1.7
Probe Positioner	0.4	R	1.732	1	1	0.2	0.2
Probe Positioning	2.9	R	1.732	1	1	1.7	1.7
Max. SAR Eval.	2.0	R	1.732	1	1	1.2	1.2
<b>Test Sample Related</b>							
Device Positioning	3.0	N	1	1	1	3.0	3.0
Device Holder	3.6	N	1	1	1	3.6	3.6
Power Drift	5.0	R	1.732	1	1	2.9	2.9
Power Scaling	0.0	R	1.732	1	1	0.0	0.0
<b>Phantom and Setup</b>							
Phantom Uncertainty	6.1	R	1.732	1	1	3.5	3.5
SAR correction	0.0	R	1.732	1	0.84	0.0	0.0
Liquid Conductivity Repeatability	0.2	N	1	0.78	0.71	0.1	0.1
Liquid Conductivity (target)	5.0	R	1.732	0.78	0.71	2.3	2.0
Liquid Conductivity (mea.)	2.5	R	1.732	0.78	0.71	1.1	1.0
Temp. unc. - Conductivity	3.4	R	1.732	0.78	0.71	1.5	1.4
Liquid Permittivity Repeatability	0.15	N	1	0.23	0.26	0.0	0.0
Liquid Permittivity (target)	5.0	R	1.732	0.23	0.26	0.7	0.8
Liquid Permittivity (mea.)	2.5	R	1.732	0.23	0.26	0.3	0.4
Temp. unc. - Permittivity	0.83	R	1.732	0.23	0.26	0.1	0.1
<b>Combined Std. Uncertainty</b>						11.4%	11.4%
<b>Coverage Factor for 95 %</b>						K=2	K=2
<b>Expanded STD Uncertainty</b>						22.9%	22.7%

**Table 16.2. Uncertainty Budget for frequency range 300 MHz to 3 GHz**

Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) 1g	(Ci) 10g	Standard Uncertainty (1g) (±%)	Standard Uncertainty (10g) (±%)
<b>Measurement System</b>							
Probe Calibration	6.55	N	1	1	1	6.6	6.6
Axial Isotropy	4.7	R	1.732	0.7	0.7	1.9	1.9
Hemispherical Isotropy	9.6	R	1.732	0.7	0.7	3.9	3.9
Boundary Effects	2.0	R	1.732	1	1	1.2	1.2
Linearity	4.7	R	1.732	1	1	2.7	2.7
System Detection Limits	1.0	R	1.732	1	1	0.6	0.6
Modulation Response	3.2	R	1.732	1	1	1.8	1.8
Readout Electronics	0.3	N	1	1	1	0.3	0.3
Response Time	0.0	R	1.732	1	1	0.0	0.0
Integration Time	2.6	R	1.732	1	1	1.5	1.5
RF Ambient Noise	3.0	R	1.732	1	1	1.7	1.7
RF Ambient Reflections	3.0	R	1.732	1	1	1.7	1.7
Probe Positioner	0.4	R	1.732	1	1	0.2	0.2
Probe Positioning	6.7	R	1.732	1	1	3.9	3.9
Max. SAR Eval.	4.0	R	1.732	1	1	2.3	2.3
<b>Test Sample Related</b>							
Device Positioning	3.0	N	1	1	1	3.0	3.0
Device Holder	3.6	N	1	1	1	3.6	3.6
Power Drift	5.0	R	1.732	1	1	2.9	2.9
Power Scaling	0.0	R	1.732	1	1	0.0	0.0
<b>Phantom and Setup</b>							
Phantom Uncertainty	6.6	R	1.732	1	1	3.8	3.8
SAR correction	0.0	R	1.732	1	0.84	0.0	0.0
Liquid Conductivity Repeatability	0.2	N	1	0.78	0.71	0.1	0.1
Liquid Conductivity (target)	5.0	R	1.732	0.78	0.71	2.3	2.0
Liquid Conductivity (mea.)	2.5	R	1.732	0.78	0.71	1.1	1.0
Temp. unc. - Conductivity	3.4	R	1.732	0.78	0.71	1.5	1.4
Liquid Permittivity Repeatability	0.15	N	1	0.23	0.26	0.0	0.0
Liquid Permittivity (target)	5.0	R	1.732	0.23	0.26	0.7	0.8
Liquid Permittivity (mea.)	2.5	R	1.732	0.23	0.26	0.3	0.4
Temp. unc. - Permittivity	0.83	R	1.732	0.23	0.26	0.1	0.1
<b>Combined Std. Uncertainty</b>						12.5%	12.5%
<b>Coverage Factor for 95 %</b>						K=2	K=2
<b>Expanded STD Uncertainty</b>						25.0%	24.9%

**Table 16.3. Uncertainty Budget for frequency range 3 GHz to 6 GHz**

## **18. References**

- [1] FCC 47 CFR Part 2 "Frequency Allocations and Radio Treaty Matters; General Rules and Regulations"
- [2] ANSI/IEEE Std. C95.1-1992, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz", September 1992
- [1] IEEE Std. 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", Sep 2013
- [2] SPEAG DASY System Handbook
- [3] FCC KDB 248227 D01 v02r01, "SAR Guidance for IEEE 802.11 (WiFi) Transmitters", Jun 2015.
- [4] FCC KDB 447498 D01 v05r02, "Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies", Feb 2014
- [5] FCC KDB 616217 D04 v01r01, "SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers", May 2013
- [6] FCC KDB 865664 D01 v01r04, "SAR Measurement Requirements for 100 MHz to 6 GHz", Aug 2015.
- [7] FCC KDB 865664 D02 v01r01, "RF Exposure Compliance Reporting and Documentation Considerations" May 2013.