ANSI/IEEE Std. C95.1-2005

in accordance with the requirements of
FCC Report and Order: ET Docket 93-62

FCC TEST REPORT

For

802.11a/b/g/n/ac RTL8821AE Combo module
(Tested inside of Notebook Computer, model lenovo Flex 3-1580)

Trade Name: REALTEK

Model: RTL8821AE

Issued to

Realtek Semiconductor Corp
No. 2, Innovation Road II, Hsinchu Science Park, Hsinchu 300, Taiwan

Issued by

Compliance Certification Services Inc.
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Testing Laboratory
1309

Issued Date: 2015/07/30

Revision History

Rev.	Issue Date	Revisions	Effect Page	Revised By
00	2015/07/30	Initial Issue	ALL	Peter Chen
01	2015/08/31	Revise simultaneous transmission notes Revise output power table Add simultaneous transmission SAR analysis	21, 34, 37, 41, 42, 43	Peter Chen

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1 Certificate of Compliance (SAR Evaluation)

Applicant Realtek Semiconductor Corp
No. 2, Innovation Road II, Hsinchu Science Park, Hsinchu 300, Taiwan

Equipment Under Test: 802.11a/b/g/n/ac RTL8821AE Combo module
(Tested inside of Notebook Computer, model lenovo Flex 3-1580)

Trade Name: REALTEK

Model Number: RTL8821AE

Date of Test: July 27~28, 2015

Device Category: PORTABLE DEVICES

Exposure Category: GENERAL POPULATION/UNCONTROLLED EXPOSURE

Applicable Standards	
FCC	● IEEE 1528 2013 ● KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r03 ● KDB 447498 D01 General RF Exposure Guidance v05r02 ● KDB 616217 D04 SAR for laptop and tablets v01r01 ● KDB 248227 D01 SAR Measurement Guidance for 802.11 Transmitters v02
Limit	
1.6 W/kg	
Test Result	
Pass	

The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Approved by:

Alex Wu
Section Manager
Compliance Certification Services Inc.

Tested by:

Peter Chen
SAR Engineer
Compliance Certification Services Inc.

2 Description of Equipment Under Test

Product	802.11a/b/g/n/ac RTL8821AE Combo module (Tested inside of Notebook Computer, model lenovo Flex 3-1580)		
Trade Name	REALTEK		
Model Number	RTL8821AE		
Host Manufacturer	lenovo	Host Model Name	Flex 3-1570; Flex 3-1535; Flex 3-1580
Host Model discrepancy	Market segmentation		
RF Module	REALTEK	Model:	RTL8821AE
Transmitters	Wi-Fi & Bluetooth		
Modulation Technique	Bluetooth:GFSK for 1Mbps;π/4-DQPSK for 2Mbps;8DPSK for 3Mbps		
	802.11a: Orthogonal Frequency Division Multiplexing (OFDM)		
	802.11b: Direct Sequence Spread Spectrum(DSSS)		
	802.11g: Orthogonal Frequency Division Multiplexing (OFDM)		
	802.11n: Orthogonal Frequency Division Multiplexing (OFDM)		
	802.11ac: Orthogonal Frequency Division Multiplexing (OFDM)		
Antenna Specification	Ant 1	Brand name	Wistron Neweb Corporation
		Parts Number	Main: 025.900CR.0011
			Aux: 025.900CS.0011
		Type	PIFA
	Ant 2	Brand name	High-Tek Electronics Co.,Ltd
		Parts Number	Main: 025.900CP.0001
			Aux: 025.900CQ.0001
		Type	PIFA
Rechargeable Li-polymer Battery–alternate	1.Brand: LG Model: L14L3P21 Rating: 11.1 Vdc / 4050mAh, 45Wh 2.Brand: SIMPLO Model: L14M3P21 Rating: 11.1 Vdc / 4050mAh, 45Wh 3.Brand: LG Model: L14L2P21 Rating: 7.4 Vdc / 4050mAh, 30Wh 4.Brand: SIMPLO Model: L14M2P21 Rating: 7.4 Vdc / 4050mAh, 30Wh Test is using battery No.1 There are difference rating of battery, we chooses No.1 to perform the SAR testing of maximum rating.		

Remark:

1. The sample selected for test was prototype that representative to production product and was provided by manufacturer

2.1 Summary of Highest SAR Values

Results for highest reported SAR values for each frequency band and mode.

Technology/Band	Test configuration	Mode	Highest Reported 1g-SAR (W/kg)
Wi-Fi 2.4 GHz	Tablet@Edge 1	802.11B	0.162
Wi-Fi 5.2 GHz(U-NII 1)	Tablet@Edge 1	802.11a	0.465
Wi-Fi 5.5 GHz(U-NII 2C)	Tablet@Edge 1	802.11a	0.458
Wi-Fi 5.8 GHz(U-NII 3)	Tablet@Edge 1	802.11a	0.690

3 Requirements for Compliance Testing Defined

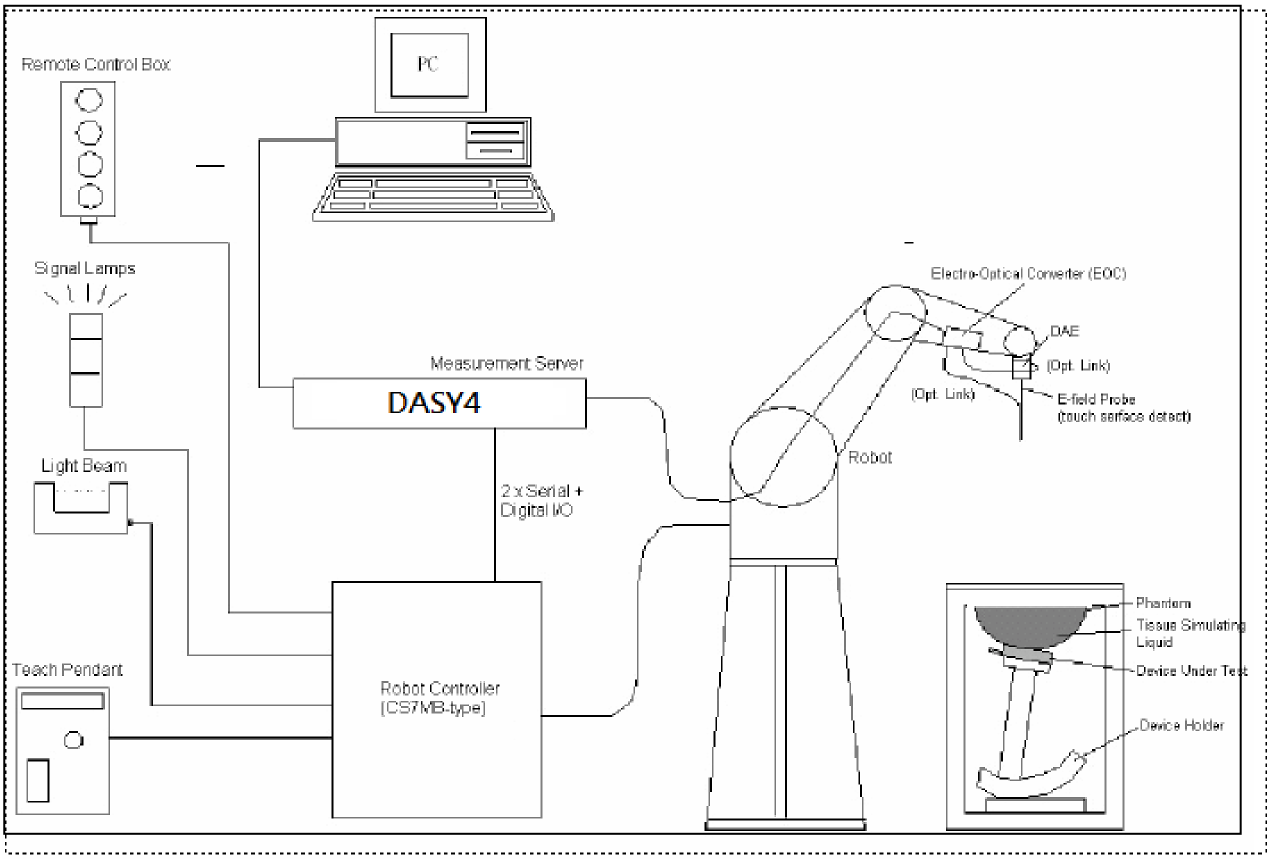
3.1 Requirements for Compliance Testing Defined by the FCC

The US Federal Communications Commission has released the report and order “Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996 [1]. The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 W/kg for an uncontrolled environment and 8.0 mW/g for an occupational/controlled environment as recommended by the ANSI/IEEE standard C95.1-1992 [6].

4 Dosimetric Assessment System

These measurements were performed with the automated near-field scanning system DASY4/DASY5 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9 m) which positions the probes with a positional repeatability of better than ± 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The SAR measurements were conducted with the dosimetric probe EX3DV4-SN: 3554 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure with accuracy of better than ±10%. The spherical isotropy was evaluated with the procedure and found to be better than ±0.25 dB. The phantom used was the SAM Twin Phantom as described in FCC supplement C, IEEE 1528 2013.

4.1 Measurement System Diagram



The DASY4 system for performing compliance tests consists of the following items:

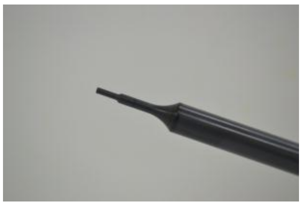
- A standard high precision 6-axis robot (St¨aubli RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- 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 between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected 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.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 2000 or Windows XP.
- DASY4/DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing validating the proper functioning of the system.

4.2 System Components

DASY4/DASY5 Measurement Server	
	The DASY4/DASY5 measurement server is based on a PC/104 CPU board with a 166MHz low-power Pentium, 32MB chip disk and 64MB RAM. The necessary circuits for communication with either the DAE3 electronic box as well as the 16-bit AD-converter system for optical detection and digital I/O interface are contained on the DASY4/DASY5 I/O-board, which is directly connected to the PC/104 bus of the CPU board. The measurement server performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation.
	The PC-operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with two expansion slots which are reserved for future applications. Please note that the expansion slots do not have a standardized pinout and therefore only the expansion cards provided by SPEAG can be inserted. Expansion cards from any other supplier could seriously damage the measurement server. Calibration: No calibration required.

Data Acquisition Electronics (DAE)	
	The data acquisition electronics (DAE4) consists of a highly sensitive electrometer grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock. The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE4 box is 200MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

EX3DV4 Isotropic E-Field Probe for Dosimetric Measurements



Construction:	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration:	Basic Broad Band Calibration in air: 10-3000 MHz. Conversion Factors (CF) for HSL 900 and HSL 1800 CF-Calibration for other liquids and frequencies upon request.
Frequency:	10 MHz to > 6 GHz; Linearity: ± 0.2 dB (30 MHz to 3 GHz)
Directivity:	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in HSL (rotation normal to probe axis)
Dynamic Range:	10 μW/g to > 100 mW/g; Linearity: ± 0.2 dB (noise: typically < 1 μW/g)
Dimensions:	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1 mm
Application:	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.

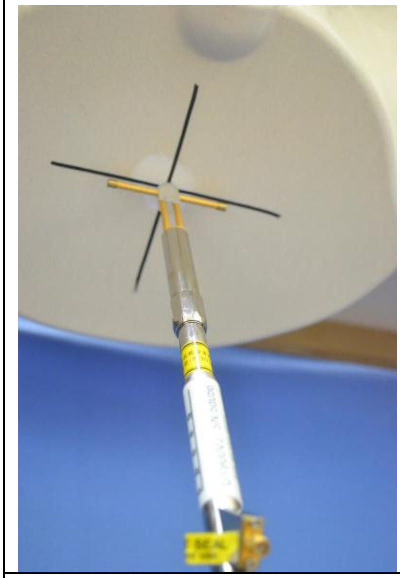
SAM Phantom (V4.0)

Construction:	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 2013, CENELEC 50361 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.
Shell Thickness:	2 ±0.2 mm
Filling Volume:	Approx. 25 liters
Dimensions:	Height: 810mm; Length: 1000mm; Width: 500mm

SAM Phantom (ELI4)

Construction:	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209 Part II and all known tissue simulating liquids. ELI4 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 supported by software version DASY4/DASY5 and higher and is compatible with all SPEAG dosimetric probes and dipoles
Shell Thickness:	2.0 ± 0.2 mm (sagging: <1%)
Filling Volume:	Approx. 25 liters
Dimensions:	Major ellipse axis: 600 mm
Minor axis:	400 mm 500mm

Device Holder for SAM Twin Phantom		
	**Construction:**	In combination with the Twin SAM Phantom V4.0 or Twin SAM, the Mounting Device (made from POM) enables the rotation of the mounted transmitter in spherical coordinates, whereby the rotation point is the ear opening. The devices can be easily and accurately positioned according to IEC, IEEE, CENELEC, FCC or other specifications. The device holder can be locked at different phantom locations (left head, right head, and flat phantom).

System Validation Kits for SAM Phantom (V4.0)		
	**Construction:**	Symmetrical dipole with l/4 balun Enables measurement of feedpoint impedance with NWA Matched for use near flat phantoms filled with brain simulating solutions Includes distance holder and tripod adaptor.
	Frequency:	2450, 5200, 5300, 5600, 5800 MHz
	Return loss:	> 20 dB at specified validation position
	Power capability:	> 100 W (f < 1GHz); > 40 W (f > 1GHz)
	Dimensions:	D2450V2: dipole length: 51.5 mm; overall height: 290 mm D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm

System Validation Kits for ELI4 phantom		
	**Construction:**	Symmetrical dipole with l/4 balun Enables measurement of feedpoint impedance with NWA Matched for use near flat phantoms filled with brain simulating solutions Includes distance holder and tripod adaptor.
	Frequency:	2450, 5200, 5300, 5600, 5800 MHz
	Return loss:	> 20 dB at specified validation position
	Power capability:	> 100 W (f < 1GHz); > 40 W (f > 1GHz)
	Dimensions:	D2450V2: dipole length: 51.5 mm; overall height: 290 mm D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm

5 Evaluation Procedures

Data Evaluation

The DASY4/DASY5 post processing software (SEMCAD) automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe parameters:	- Sensitivity	$Norm_i$, a_{i0}, a_{i1}, a_{i2}
	- Conversion factor	$ConvF_i$
	- Diode compression point	dcp_i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

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

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

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

with V_i	= Compensated signal of channel i	(i = x, y, z)
U_i	= Input signal of channel i	(i = x, y, z)
cf	= Crest factor of exciting field	(DASY parameter)
dcp_i	= Diode compression point	(DASY parameter)

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

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \bullet ConvF}}$$

H-field probes:

$$H_i = \sqrt{Vi} \cdot \frac{a_{i10} + a_{i11} f + a_{i12} f^2}{f}$$

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

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

$\mu V/(V/m)^2$ for E0field Probes

$ConvF$ = Sensitivity enhancement in solution

aij = Sensor sensitivity factors for H-field probes

f = Carrier frequency (GHz)

Ei = Electric field strength of channel i in V/m

Hi = Magnetic field strength of channel i in A/m

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

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

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

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

with *SAR* = local specific absorption rate in W/kg

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

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

ρ = equivalent tissue density in g/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 as a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{377} \quad \text{or} \quad P_{pwe} = H_{tot}^2 \cdot 37.7$$

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

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

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

6 SAR Measurement Procedures

6.1 Normal SAR Test Procedure

- **Power Reference Measurement**

The reference and drift jobs are useful jobs for monitoring the power drift of the device under test in the batch process. Both jobs measure the field at a specified reference position, at a selectable distance from the phantom surface. The reference position can be either the selected section's grid reference point or a user point in this section. The reference job projects the selected point onto the phantom surface, orients the probe perpendicularly to the surface, and approaches the surface using the selected detection method.

- **Area Scan**

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hot spot. The sophisticated interpolation routines implemented in DASY4/DASY5 software can find the maximum locations even in relatively coarse grids. The scan area is defined by an editable grid. This grid is anchored at the grid reference point of the selected section in the phantom. When the area scan's property sheet is brought-up, the grid resolution has to less than 15 mm by 15 mm at frequency ≤2GHz; the grid resolution has to less than 12mm by 12 mm at frequency between 2GHz to 4GHz; grid resolution has to less than 10 mm by 10 mm at frequency between 4GHz to 6GHz.

According to KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe abgle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

- **Zoom Scan**

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The default zoom scan measures points in accordance with the frequency can be divided into three parts. (1)The zoom scan volume was set to 5x5x7 points at frequency ≤ 2GHz. (2) The zoom scan volume was set to 7x7x7 points at frequency between 2GHz to 4GHz (3) The zoom scan volume was set to 7x7x12 points at frequency between 4GHz to 6GHz. The measures points within a cube whose base faces are centered around the maximum found in a preceding area scan job within the same procedure. If the preceding Area Scan job indicates more then one maximum, the number of Zoom Scans has to be enlarged accordingly.

According to KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01

<table>
<tr><td colspan="3"></td><td>≤ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>≤ 2 GHz: ≤ 8 mm
2 – 3 GHz: ≤ 5 mm</td><td>3 – 4 GHz: ≤ 5 mm
4 – 6 GHz: ≤ 4 mm</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">Uniform grid: $\Delta z_{Zoom}(n)$</td><td>≤ 5 mm</td><td>3 – 4 GHz: ≤ 4 mm
4 – 5 GHz: ≤ 3 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$:between 1^{st} two points losest to phantom surface</td><td>≤ 4 mm</td><td>3 – 4 GHz: ≤ 3 mm
4 – 5 GHz: ≤ 2.5 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">≤ 1.5·$\Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Maximum zoom scan volume</td><td>x, y, z</td><td>≥ 30 mm</td><td colspan="2">3 – 4 GHz: ≥ 28 mm
4 – 5 GHz: ≥ 25 mm
5 – 6 GHz: ≥ 22 mm</td></tr>
</table>

- **Power Drift Measurement**

The drift job measures the field at the same location as the most recent reference job within the same procedure, and with the same settings. The drift measurement gives the field difference in dB from the reading conducted within the last reference measurement. Several drift measurements are possible for one reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. In the properties of the Drift job, the user can specify a limit for the drift and have DASY4/DASY5 software stop the measurements if this limit is exceeded.

- **Z-Scan**

The Z Scan job measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. A user can anchor the grid to the current probe location. As with any other grids, the local Z-axis of the anchor location establishes the Z-axis of the grid.

7 Measurement Uncertainty

According to KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz section 2.8.2, SAR measurement uncertainty analysis is required in SAR reports only when the highest measured SAR in a frequency band is ≥ 1.5 W/kg for 1-g SAR, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approva

8 Device Under Test

8.1 Wireless Technologies

Wireless technologies	Tx Frequency Bands	Operating mode	Duty Cycle used for testing
Wi-Fi	2.4GHz Band	802.11b 802.11g 802.11n(HT20) 802.11n(HT40)	100%
	5GHz Band	802.11a 802.11n(HT20) 802.11n(HT40) 802.11ac(VHT20) 802.11ac(VHT40) 802.11ac(VHT80)	100%
Bluetooth	2.4GHz	2.1 4.0 LE	N/A

8.2 Maximum Tune-up Power

Tolerance (dB): ± 1.0		RF Output Power (dBm)	
Band	Mode	Target	Max. tune-up power
2.4GHz	802.11b	16.0	17.0
	802.11g	16.0	17.0
	802.11n HT20	16.0	17.0
	802.11n HT40	16.0	17.0
Tolerance (dB): ± 1.0		RF Output Power (dBm)	
5.2GHz Band	802.11a	16.0	17.0
	802.11n HT20	16.0	17.0
	802.11n HT40	13.0	14.0
	802.11ac VHT20	16.0	17.0
	802.11ac VHT40	13.0	14.0
	802.11ac VHT80	10.0	11.0
5.3GHz Band	802.11a	13.5	14.5
	802.11n HT20	13.5	14.5
	802.11n HT40	13.0	14.0
	802.11ac VHT20	13.5	14.5
	802.11ac VHT40	13.0	14.0
	802.11ac VHT80	10.0	11.0
5.5GHz Band	802.11a	13.5	14.5
	802.11n HT20	13.5	14.5
	802.11n HT40	13.0	14.0
	802.11ac VHT20	13.5	14.5
	802.11ac VHT40	13.0	14.0
	802.11ac VHT80	10.0	11.0
5.8GHz Band	802.11a	13.5	14.5
	802.11n HT20	13.5	14.5
	802.11n HT40	13.0	14.0
	802.11ac VHT20	13.5	14.5
	802.11ac VHT40	13.0	14.0
	802.11ac VHT80	11.0	12.0
Tolerance (dB): ± 1.0		RF Output Power (dBm)	
Bluetooth	DH5	5.0	6.0
	3DH5	4.0	5.0
	BLE	5.0	6.0

8.3 Simultaneous Transmission

RF Exposure Condition	Transmit Configurations
Wi-Fi	2.4GHz(Chain 0) 2.4GHz(Chain 1) 2.4GHz(Chain 0) + Bluetooth (Chain 1) 2.4GHz(Chain 1) + Bluetooth (Chain 0) 5GHz(Chain 0) 5GHz(Chain 1) 5GHz(Chain 0) + Bluetooth (Chain 1) 5GHz(Chain 1) + Bluetooth (Chain 0) Bluetooth (Chain 0) Bluetooth (Chain 1)

Note(s):

1. The EUT supports the antenna with TX/RX diversity function for 2.4GHz WLAN and Bluetooth, but only one of them will be used at the same time. Base on WLAN’s operation mode to select the other antenna to work.
2. The EUT supports the antenna with TX/RX diversity function for 5GHz WLAN and Bluetooth, and both them can transmit and receive signal simultaneously.

9 Summary of SAR Test Exclusion Configurations

9.1 Standalone SAR Test Exclusion Calculations

Since the Dedicated Host Approach is applied, the standalone SAR test exclusion procedure in KDB 447498 section4.3.1 is applied in conjunction with KDB 616217 section 4.3 to determine the minimum test separation distance:

1. According to KDB 447498 Section 4.1 5) if the antenna is at close proximity to user then the outer surface of the DUT should be treated as the radiating surface. The test separation distance is then determined by the smallest distance between the outer surface of the device and the user. For the purposes of this report close proximity has been defined as closer than 50 mm. For antennas <50 mm from the rear or edge the separation distance used for the estimated SAR calculations is 0 mm.
2. When the minimum test separation distance is < 5mm, a distance of 5mm is applied to determine SAR test exclusion.
3. When the separation distance from the antenna to an adjacent edge is > 5 mm, the actual antenna-to-edge separation distance is applied to determine SAR test exclusion.
4. If the antenna to DUT adjacent edge or bottom separation distance >50mm the actual antenna to user separation distance is used to determine SAR exclusion and estimated SAR value.

Refer to Appendix for the specific details on the antenna-to-antenna and antenna-to-edge distances used for test exclusion calculations.

9.1.1 SAR Exclusion Calculations for Wi-Fi Antenna < 50mm from the User

According to KDB 447498 v05 r02 in section 4.3.1, if the calculated **threshold value is > 3** then SAR testing is required.

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Calculated Threshold Value				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Main	2.4GHz	2437	17.0	50	18.8	4.0	256.0	240.0	90.0	4.2	19.5	>200mm	>200mm	>50mm
	5.2GHz	5240	17.0	50	18.8	4.0	256.0	240.0	90.0	6.1	28.6	>200mm	>200mm	>50mm
	5.3GHz	5260	14.5	28	18.8	4.0	256.0	240.0	90.0	3.4	16.1	>200mm	>200mm	>50mm
	5.5GHz	5580	14.5	28	18.8	4.0	256.0	240.0	90.0	3.5	16.5	>200mm	>200mm	>50mm
	5.8GHz	5785	14.5	28	18.8	4.0	256.0	240.0	90.0	3.6	16.8	>200mm	>200mm	>50mm

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Calculated Threshold Value				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Aux	2.4GHz	2437	17.0	50	18.8	4.0	80.0	240.0	266.0	4.2	19.5	>50mm	>200mm	>200mm
	5.2GHz	5240	17.0	50	18.8	4.0	80.0	240.0	266.0	6.1	28.6	>50mm	>200mm	>200mm
	5.3GHz	5260	14.5	28	18.8	4.0	80.0	240.0	266.0	3.4	16.1	>50mm	>200mm	>200mm
	5.5GHz	5580	14.5	28	18.8	4.0	80.0	240.0	266.0	3.5	16.5	>50mm	>200mm	>200mm
	5.8GHz	5785	14.5	28	18.8	4.0	80.0	240.0	266.0	3.6	16.8	>50mm	>200mm	>200mm
Bluetooth	DH5	2402	6.0	4	18.8	4.0	80.0	240.0	266.0	0.3	1.5	>50mm	>200mm	>200mm

9.1.2 SAR Exclusion Calculations for Wi-Fi Antenna > 50mm from the User

According to KDB 447498 v05 r02, if the calculated Power threshold is less than the output power then SAR testing is required.

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Calculated Threshold Value				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Main	2.4GHz	2437	17.0	50	18.8	4.0	256.0	240.0	90.0	<50mm	<50mm	>200mm	>200mm	496.1
	5.2GHz	5240	17.0	50	18.8	4.0	256.0	240.0	90.0	<50mm	<50mm	>200mm	>200mm	465.5
	5.3GHz	5260	14.5	28	18.8	4.0	256.0	240.0	90.0	<50mm	<50mm	>200mm	>200mm	465.4
	5.5GHz	5580	14.5	28	18.8	4.0	256.0	240.0	90.0	<50mm	<50mm	>200mm	>200mm	463.5
	5.8GHz	5785	14.5	28	18.8	4.0	256.0	240.0	90.0	<50mm	<50mm	>200mm	>200mm	462.4

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Calculated Threshold Value				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Aux	2.4GHz	2437	17.0	50	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	1450.4	>200mm	>200mm
	5.2GHz	5240	17.0	50	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	1450.4	>200mm	>200mm
	5.3GHz	5260	14.5	28	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	1545.7	>200mm	>200mm
	5.5GHz	5580	14.5	28	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	1545.7	>200mm	>200mm
	5.8GHz	5785	14.5	28	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	1545.7	>200mm	>200mm
Bluetooth	DH5	2402	6.0	4	18.8	4.0	80.0	240.0	266.0	<50mm	<50mm	2236.5	>200mm	>200mm

9.1.3 SAR Required Test Configuration

For Wi-Fi and Bluetooth

Test Configurations	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Main 2.4GHz	YES	YES	YES	No	No
Wi-Fi Main 5.2GHz	YES	YES	YES	No	No
Wi-Fi Main 5.3GHz	YES	YES	YES	No	No
Wi-Fi Main 5.5GHz	YES	YES	YES	No	No
Wi-Fi Main 5.8GHz	YES	YES	YES	No	No
Bluetooth	No	No	No	No	No
Wi-Fi Aux 2.4GHz	YES	YES	YES	No	No
Wi-Fi Aux 5.2GHz	YES	YES	YES	No	No
Wi-Fi Aux 5.3GHz	YES	YES	YES	No	No
Wi-Fi Aux 5.5GHz	YES	YES	YES	No	No
Wi-Fi Aux 5.8GHz	YES	YES	YES	No	No

Note(s):

1. Yes = SAR is required.
2. No = SAR is not required.

10 Exposure Limit

(A). Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.4	8.0	2.0

(B). Limits for General Population/Uncontrolled Exposure (W/kg)

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

NOTE: **Whole-Body SAR** is averaged over the entire body, **partial-body SAR** is averaged over any 1 gram 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.

Population/Uncontrolled Environments:

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

Occupational/Controlled Environments:

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

NOTE GENERAL POPULATION/UNCONTROLLED EXPOSURE PARTIAL BODY LIMIT 1.6 W/kg

11 Tissue Dielectric Properties

11.1 Test Liquid Confirmation

Simulating Liquids Parameter Check

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine of the dielectric parameters are within the tolerances of the specified target values

The relative permittivity and conductivity of the tissue material should be within ± 5% of the values given in the table below 5% may not be easily achieved at certain frequencies.

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in IEEE 1528 2013 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in IEEE 1528 2013 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in IEEE 1528 2013

Target Frequency (MHz)	Head		Body	
	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5800	35.3	5.27	48.2	6.00

11.2 Typical Composition of Ingredients for Liquid Tissue Phantoms

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.

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

alt: 99^{+}% Pure Sodium Chloride   Sugar: 98^{+}% Pure Sucrose
Water: De-ionized, 16 $M\Omega^{+}$ resistivity   HEC: Hydroxy thyl 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

Simulating Liquids for 5 GHz, Manufactured by SPEAG

Ingredients	(% by weight)
Water	78
Mineral oil	11
Emulsifiers	9
Additives and Salt	2

11.3 Simulating Liquids Parameter Check Results

Date	Band	Freq(MHz)	Measured			Standard		Δ		Limit(%)
			e' (εr)	e''	σ	e' (εr)	σ	e' (εr)	σ	±5
2015/7/27	Body 2450	2412	52.36	13.62	1.82	52.75	1.91	-0.75%	-4.64%	±5
		2437	52.29	13.73	1.86	52.72	1.94	-0.80%	-4.09%	±5
		2442	52.28	13.73	1.86	52.71	1.94	-0.83%	-4.08%	±5
		2450	52.26	13.77	1.87	52.70	1.95	-0.84%	-3.87%	±5
		2462	52.19	13.81	1.89	52.68	1.97	-0.95%	-3.94%	±5
		2472	52.15	13.87	1.90	52.67	1.98	-0.99%	-3.88%	±5
2015/7/28	Body 5000	5180	48.97	18.06	5.20	49.02	5.28	-0.09%	-1.49%	±5
		5200	48.94	18.16	5.25	49.00	5.30	-0.13%	-0.99%	±5
		5220	48.93	18.24	5.29	48.98	5.32	-0.11%	-0.65%	±5
		5240	48.99	18.26	5.32	48.96	5.35	0.05%	-0.62%	±5
		5260	48.96	18.23	5.33	48.94	5.37	0.03%	-0.82%	±5
		5280	48.83	18.17	5.33	48.92	5.40	-0.18%	-1.25%	±5
		5300	48.73	18.21	5.36	48.90	5.42	-0.34%	-1.05%	±5
		5320	48.71	18.30	5.41	48.86	5.44	-0.31%	-0.62%	±5
		5500	48.42	18.41	5.62	48.60	5.65	-0.36%	-0.46%	±5
		5520	48.34	18.45	5.66	48.58	5.67	-0.49%	-0.26%	±5
		5540	48.33	18.52	5.70	48.56	5.70	-0.48%	0.03%	±5
		5560	48.33	18.57	5.74	48.54	5.72	-0.43%	0.26%	±5
		5580	48.34	18.55	5.75	48.52	5.75	-0.38%	0.05%	±5
		5600	48.25	18.50	5.76	48.50	5.77	-0.51%	-0.24%	±5
		5620	48.19	18.52	5.78	48.46	5.79	-0.55%	-0.17%	±5
		5640	48.11	18.56	5.81	48.42	5.81	-0.63%	0.01%	±5
		5660	48.14	18.63	5.86	48.38	5.84	-0.50%	0.39%	±5
		5680	48.16	18.63	5.88	48.34	5.86	-0.38%	0.35%	±5
		5700	48.10	18.60	5.89	48.30	5.88	-0.42%	0.15%	±5
		5745	47.93	18.67	5.96	48.26	5.93	-0.67%	0.42%	±5
		5765	47.94	18.73	6.00	48.24	5.96	-0.62%	0.71%	±5
		5785	47.94	18.75	6.03	48.22	5.98	-0.56%	0.73%	±5
		5805	47.94	18.69	6.03	48.19	6.01	-0.51%	0.38%	±5
		5825	47.88	18.72	6.06	48.15	6.03	-0.56%	0.44%	±5

12 System Performance Check

The system performance check is performed prior to any usage of the system in order to guarantee reproducible results. The system performance check verifies that the system operates within its specifications. The system performance check results are tabulated below. And also the corresponding SAR plot is attached as well in the SAR plots files.

System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the SAM twin phantom filled with Body simulating liquid of the following parameters.
- The DASY4/DASY5 system with an E-fileld probe EX3DV4 SN: 3554 was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15 mm (below 1 GHz) and 10 mm (above 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 10mm was aligned with the dipole.
- Special 7x7x7 fine cube was chosen for cube integration (dx=dy= 5 mm, dz= 5 mm).
- Distance between probe sensors and phantom surface was set to 3.0 mm.
- The dipole input power (forward power) was 100 mW±3%.
- The results are normalized to 1 W input power.

Reference SAR Values for System Performance Check

The reference SAR values can be obtained from the calibration certificate of system validation dipoles

System Dipole	Serial No.	Cal. Date	Freq. (MHz)	Target SAR Values (W/kg)		
				1g/10g	Head	Body
D2450V2	728	2015/5/28	2450	1g	53.0	51.0
				10g	24.8	23.8
D5GHzV2	1004	2014/11/20	5200	1g	80.5	74.7
				10g	22.9	20.7
D5GHzV2	1004	2014/11/20	5300	1g	85.7	77.7
				10g	24.4	21.6
D5GHzV2	1004	2014/11/20	5600	1g	84.1	81.2
				10g	23.9	22.4
D5GHzV2	1004	2014/11/20	5800	1g	80.3	74.2
				10g	22.8	20.3

12.1 System Performance Check Results

Date	System Dipole			Parameters	Target	Measured	Deviation[%]	Limited[%]
	Type	Serial No.	Liquid					
2015/7/27	D2450V2	728	Body	1g SAR:	51.0	48.6	-4.71	± 5
				10g SAR:	23.8	22.8	-4.20	± 5
2015/7/28	D5GHzV2 (5.2GHz)	1004	Body	1g SAR:	74.7	73.5	-1.61	± 5
				10g SAR:	20.7	20.5	-0.97	± 5
2015/7/28	D5GHzV2 (5.3GHz)	1004	Body	1g SAR:	77.7	75.6	-2.70	± 5
				10g SAR:	21.6	21.2	-1.85	± 5
2015/7/28	D5GHzV2 (5.6GHz)	1004	Body	1g SAR:	81.2	80.8	-0.49	± 5
				10g SAR:	22.4	22.7	1.34	± 5
2015/7/28	D5GHzV2 (5.8GHz)	1004	Body	1g SAR:	74.2	73.6	-0.81	± 5
				10g SAR:	20.3	21.2	4.43	± 5

13 RF Output Power Measurement

According to KDB248227D01 802.11 Wi-Fi SAR V02 section 4, the default power measurement procedures are:

1) Power must be measured at each transmit antenna port according to the DSSS and OFDM transmission configurations in each standalone and aggregated frequency band.

2) Power measurement is required for the transmission mode configuration with the highest maximum output power specified for production units.

a) When the same highest maximum output power specification applies to multiple transmission modes, the largest channel bandwidth configuration with the lowest order modulation and lowest data rate is measured.

b) When the same highest maximum output power is specified for multiple largest channel bandwidth configurations with the same lowest order modulation or lowest order modulation and lowest data rate, power measurement is required for all equivalent 802.11 configurations with the same maximum output power.

3) For each transmission mode configuration, power must be measured for the highest and lowest channels; and at the mid-band channel(s) when there are at least 3 channels. For configurations with multiple mid-band channels, due to an even number of channels, both channels should be measured.

13.1 Wi-Fi (2.4GHz Band) Output power table

Band (GHz)	Mode	Data rate (Mbps)	Ch #	Freq. (MHz)	Avg. Pwr (dBm)			Maximum Tune-up Pwr (dBm)			SAR Test (Yes/No)	Note
					Main	Aux	Total	Main	Aux	Total		
2.4	802.11b	1	1	2412	15.8			17.0			Yes	
			6	2437	16.0			17.0				
			11	2462	15.7			17.0				
	802.11b	1	1	2412		16.0			17.0		Yes	
			6	2437		15.9			17.0			
			11	2462		15.6			17.0			
	802.11g	6	1	2412	No Required			16.0			No	1
			6	2437				17.0				
			11	2462				16.0				
	802.11g	6	1	2412					16.0		No	1
			6	2437					17.0			
			11	2462					16.0			
	802.11n HT20	MCS0	1	2412				14.0			No	1
			6	2437				17.0				
			11	2462				14.0				
	802.11n HT20	MCS0	1	2412					14.0		No	1
			6	2437					17.0			
			11	2462					14.0			
	802.11n HT40	MCS0	3	2422	12.9			14.0			Yes	
			6	2437	15.6			17.0				
			9	2452	12.8			14.0				
	802.11n HT40	MCS0	3	2422		12.7			14.0		Yes	
			6	2437		15.8			17.0			
			9	2452		12.8			14.0			

Note(s):

1. Output Power and SAR is not required for 802.11n HT20 channels when the lalrge bandwidth with the same maxmum power in 802.11n HT40 and the highest reported SAR <0.8 W/Kg.

13.2 Wi-Fi (5GHz Band)

Output power table

Band (GHz)	Mode	Data rate (Mbps)	Ch #	Freq. (MHz)	Avg. Pwr (dBm)			Maximum Tune-up			SAR Test (Yes/No)	Note
					Main	Aux	Total	Main	Aux	Total		
5.2 (U-NII 1)	802.11a	6	36	5180	16.3			17.0			Yes	
			40	5200	16.2			17.0			Yes	
			44	5220	16.2			17.0			Yes	
			48	5240	16.5			17.0			Yes	
			36	5180		16.2			17.0		Yes	
			40	5200		16.1			17.0		Yes	
			44	5220		16.1			17.0		Yes	
			48	5240		16.4			17.0		Yes	
	802.11n (HT20)	MCS0	36-48	5180-5240	No Required			17.0			No	1
	802.11n (HT40)	MCS0	38-46	5190-5230				14.0			No	1
	802.11ac VHT20	VHT0	36-48	5180-5240				17.0			No	1
	802.11ac VHT40	VHT0	38-46	5190-5230				14.0			No	1
	802.11ac VHT80	VHT0	42-155	5210-5775				11.0			No	1
	802.11n (HT20)	MCS0	36-48	5180-5240					17.0		No	1
	802.11n (HT40)	MCS0	38-46	5190-5230					14.0		No	1
	802.11ac VHT20	VHT0	36-48	5180-5240					17.0		No	1
	802.11ac VHT40	VHT0	38-46	5190-5230					14.0		No	1
	802.11ac VHT80	VHT0	42-155	5210-5775					11.0		No	1
5.3 (U-NII 2A)	802.11a	6	52	5260	13.7			14.5			Yes	
			56	5280	13.3			14.5			Yes	
			60	5300	13.5			14.5			Yes	
			64	5320	13.5			14.5			Yes	
			52	5260		13.8			14.5		Yes	
			56	5280		13.4			14.5		Yes	
			60	5300		13.6			14.5		Yes	
			64	5320		13.4			14.5		Yes	

Note(s):

1. Output Power and SAR measurement is not required for 802.11 a/n/ac channels when the specified maximum tune-up powers are less then 802.11a/n/HT20 and the measured SAR is ≤ 1.2 W/Kg.
2. When the specified maximum output power is the same for both UNII band I and UNII band 2A, begin SAR measurement in UNII band 2A; and if the highest reported SAR for UNII band 2A is
   2.1. ≤ 1.2 W/kg, SAR is not required for UNII band I.
   2.2. > 1.2 W/kg, both bands should be tested independently for SAR.

Band (GHz)	Mode	Data rate (Mbps)	Ch #	Freq. (MHz)	Avg. Pwr (dBm)			Maximum Tune-up			SAR Test (Yes/No)	Note
					Main	Aux	Total	Main	Aux	Total		
	802.11n (HT20)	MCS0	52-64	5260-5320				14.5			Yes	
	802.11n (HT40)	MCS0	54-62	5270-5310				14.0			No	1
	802.11ac VHT20	VHT0	36-48	5180-5240				14.5			No	1
	802.11ac VHT40	VHT0	38-46	5190-5230				14.0			No	1
5.3 (U-NII 2A)	802.11ac VHT80	VHT0	42-155	5210-5775	No Required			11.0			No	1
	802.11n (HT20)	MCS0	52-64	5260-5320					14.5		Yes	
	802.11n (HT40)	MCS0	54-62	5270-5310					14.0		No	1
	802.11ac VHT20	VHT0	36-48	5180-5240					14.5		No	1
	802.11ac VHT40	VHT0	38-46	5190-5230					14.0		No	1
	802.11ac VHT80	VHT0	42-155	5210-5775					11.0		No	1
			100	5500	13.6			14.5			Yes	
			104	5520	13.5			14.5			Yes	
			108	5540	13.6			14.5			Yes	
			112	5560	13.7			14.5			Yes	
			116	5580	13.8			14.5			Yes	
			132	5660	13.7			14.5			Yes	
			136	5680	13.7			14.5			Yes	
5.5 (U-NII-2C)	802.11a	6	140	5700	13.6			14.5			Yes	
			100	5500		13.5			14.5		Yes	
			104	5520		13.4			14.5		Yes	
			108	5540		13.4			14.5		Yes	
			112	5560		13.5			14.5		Yes	
			116	5580		13.7			14.5		Yes	
			132	5660		13.5			14.5		Yes	
			136	5680		13.3			14.5		Yes	
			140	5700		13.4			14.5		Yes	

Note(s):

1. Output Power and SAR measurement is not required for 802.11 a/n/ac channels when the specified maximum tune-up powers are less then 802.11a/n/HT20 and the measured SAR is ≤ 1.2 W/Kg.
2. When the specified maximum output power is the same for both UNII band I and UNII band 2A, begin SAR measurement in UNII band 2A; and if the highest reported SAR for UNII band 2A is
   - 2.1. ≤ 1.2 W/kg, SAR is not required for UNII band I.
   - 2.2. > 1.2 W/kg, both bands should be tested independently for SAR.

Band (GHz)	Mode	Data rate (Mbps)	Ch #	Freq. (MHz)	Avg. Pwr (dBm)			Maximum Tune-up			SAR Test (Yes/No)	Note
					Main	Aux	Total	Main	Aux	Total		
5.5 (U-NII-2C)	802.11n (HT20)	MCS0	100-140	5500-5700	No Required			14.5			No	1
	802.11n (HT40)	MCS0	102-134	5510-5680				14.0			No	1
	802.11ac VHT20	VHT0	100-140	5500-5700				14.5			No	1
	802.11ac VHT40	VHT0	102-134	5510-5680				14.0			No	1
	802.11ac VHT80	VHT0	106	5530				11.0			No	1
	802.11n (HT20)	MCS0	100-140	5500-5700					14.5		No	1
	802.11n (HT40)	MCS0	102-134	5510-5680					14.0		No	1
	802.11ac VHT20	VHT0	100-140	5500-5700					14.5		No	1
	802.11ac VHT40	VHT0	102-134	5510-5680					14.0		No	1
	802.11ac VHT80	VHT0	106	5530					11.0		No	1
5.8 (U-NII-3)	802.11a	6	149	5745	13.5			14.5			Yes	
			153	5765	13.4			14.5			Yes	
			157	5785	13.7			14.5			Yes	
			161	5805	13.6			14.5			Yes	
			165	5825	13.4			14.5			Yes	
			149	5745		13.6			14.5		Yes	
			153	5765		13.6			14.5		Yes	
			157	5785		13.8			14.5		Yes	
			161	5805		13.7			14.5		Yes	
			165	5825		13.6			14.5		Yes	

Note(s):

1. Output Power and SAR measurement is not required for 802.11 a/n/ac channels when the specified maximum tune-up powers are less then 802.11a/n/HT20 and the measured SAR is ≤ 1.2 W/Kg.

Band (GHz)	Mode	Data rate (Mbps)	Ch #	Freq. (MHz)	Avg. Pwr (dBm)			Maximum Tune-up			SAR Test (Yes/No)	Note
					Main	Aux	Total	Main	Aux	Total		
5.8 (U-NII-3)	802.11n (HT20)	MCS0	149-165	5745-5825	No Required			14.5			NO	1
	802.11n (HT40)	MCS0	151-159	5755-5795	No Required			14.0			NO	1
	802.11ac VHT20	VHT0	149-165	5745-5825	No Required			14.5			NO	1
	802.11ac VHT40	VHT0	151-159	5755-5795	No Required			14.0			NO	1
	802.11ac VHT80	VHT0	155	5775	No Required			12.0			NO	1
	802.11n (HT20)	MCS0	149-165	5745-5825	No Required				14.5		NO	1
	802.11n (HT40)	MCS0	151-159	5755-5795	No Required				14.0		NO	1
	802.11ac VHT20	VHT0	149-165	5745-5825	No Required				14.5		NO	1
	802.11ac VHT40	VHT0	151-159	5755-5795	No Required				14.0		NO	1
	802.11ac VHT80	VHT0	155	5775	No Required				12.0		NO	1

Note(s):

1. Output Power and SAR measurement is not required for 802.11 a/n/ac channels when the specified maximum tune-up powers are less then 802.11a/n/HT20 and the measured SAR is ≤ 1.2 W/Kg.

13.3 Bluetooth

Refer section 9, the Bluetooth maximum tune-up power is 6 dBm .This power level qualifies not required for SAR testing.

14 SAR Measurements Results

Wi-Fi (2.4GHz Band):

Test Mode	Band	Mode	Dist. (mm)	Test Position	Ch#	Freq. (MHz)	Chain	Power (dBm)		Maxima SAR	Meas. 1g SAR (W/kg)	Reported SAR (W/kg)	Note	Plot No.
								Tune up limit	Meas.					
Tablet	2.4G	802.11b	0	Rear	6	2437	0	17.0	16.0	0.137	0.097	0.122		
			0	Edge1	6	2437	0	17.0	16.0	0.197	0.129	0.162		1
			0	Rear	6	2437	1	17.0	15.9	0.102	0.073	0.094		
			0	Edge1	6	2437	1	17.0	15.9	0.162	0.112	0.144		
		802.11n HT40	0	Rear	6	2437	0	17.0	15.6	0.073				
			0	Edge1	6	2437	0	17.0	15.6	0.126	0.080	0.111		
			0	Rear	6	2437	1	17.0	15.8	0.075				
			0	Edge1	6	2437	1	17.0	15.8	0.095	0.064	0.084		
		802.11b	0	Edge1	6	2437	0	17.0	16.0	0.202	0.129	0.162	2	
			0	Edge1	6	2437	1	17.0	16.0	0.177	0.122	0.154	2	

Note(s):

1. Highest reported SAR is ≤ 0.4 W/kg. Therefore, SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band.
2. Ant 1 was performed the SAR testing. Ant 2 was performed the spot check of SAR only.

Wi-Fi (5 GHz Band):

Test Mode	Band (GHz)	Mode	Dist. (mm)	Test Position	Ch#	Freq. (MHz)	Chain	Power (dBm)		Maxima SAR	Meas. 1g SAR (W/kg)	Reported SAR (W/kg)	Note	Plot No.
								Tune up limit	Meas.					
Tablet	5.2 (U-NII 1)	802.11a	0	Rear	48	5240	0	17.0	16.5	0.032				
			0	Rear	48	5240	1	17.0	16.4	0.076				
			0	Edge 1	48	5240	0	17.0	16.5	0.550	0.197	0.221		
			0	Edge 1	48	5240	1	17.0	16.4	1.090	0.405	0.465		2
	5.5 (U-NII-2C)	802.11a	0	Rear	116	5580	0	14.5	13.8	0.126				
			0	Rear	116	5580	1	14.5	13.7	0.209				
			0	Edge 1	116	5580	0	14.5	13.8	0.990	0.390	0.458		3
			0	Edge 1	116	5580	1	14.5	13.7	0.497	0.139	0.167		
	5.8 (U-NII-3)	802.11a	0	Rear	157	5785	0	14.5	13.7	0.062				
			0	Rear	157	5785	1	14.5	13.8	0.124				
			0	Edge 1	157	5785	0	14.5	13.7	1.290	0.574	0.690		4
			0	Edge 1	157	5785	1	14.5	13.8	0.685	0.181	0.213		
	5.8 (U-NII-3)	802.11a	0	Edge 1	157	5785	0	14.5	13.7	1.19	0.562	0.676	2	
	5.2 (U-NII 1)	802.11a	0	Edge 1	48	5240	1	17.0	16.4	0.85	0.358	0.411	2	

Note(s):

1. Highest reported SAR is > 0.4 W/kg. Due to the highest reported SAR for this test position, other test positions in this exposure condition were evaluated until a SAR ≤ 0.8 W/kg was reported.
2. Ant 1 was performed the SAR testing. Ant 2 was performed the spot check of SAR only.

15 Simultaneous Transmission SAR Analysis

KDB 447498 D01 General RF Exposure Guidance v05, introduces a new formula for calculating the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$SPLSR = (SAR_1 + SAR_2)^{1.5} / R_i$

Where:

SAR_1 is the highest Reported or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR_2 is the highest Reported or estimated SAR for the second of a pair of simultaneous transmitting antennas, in the same test operating mode and exposure condition as the first

R_i is the separation distance between the pair of simultaneous transmitting antennas. When the SAR is measured, for both antennas in the pair, it is determined by the actual x, y and z coordinates in the 1-g SAR for each SAR peak location, based on the extrapolated and interpolated result in the zoom scan measurement, using the formula of $[(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]$

A new threshold of 0.04 is also introduced in the draft KDB. Thus, in order for a pair of simultaneous transmitting antennas with the sum of 1-g SAR > 1.6 W/kg to qualify for exemption from Simultaneous Transmission SAR measurements, it has to satisfy the condition of:

$(SAR_1 + SAR_2)^{1.5} / R_i < 0.04$

15.1 Estimated SAR for Simultaneous Transmission SAR Analysis

Considerations for SAR estimation

1. When standalone SAR test exclusion applies, standalone SAR must also be estimated to determine simultaneous transmission SAR test exclusion.
2. Dedicated Host Approach criteria for SAR test exclusion is likewise applied to SAR estimation, with certain distinctions between test exclusion and SAR estimation:
   - When the separation distance from the antenna to an adjacent edge is ≤ 5 mm, a distance of 5 mm is applied for SAR estimation; this is the same between test exclusion and SAR estimation calculations.
   - When the separation distance from the antenna to an adjacent edge is > 5 mm but ≤ 50 mm, the actual antenna-to-edge separation distance is applied for SAR estimation.
   - When the minimum test separation distance is > 50 mm, the estimated SAR value is 0.4 W/kg

15.1.1 Estimated SAR for Bluetooth

According to section 9, the Bluetooth 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)]·[$\sqrt{f_{(GHz)}}$/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.
- 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distances is > 50 mm.

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Estimated 1-g SAR (W/Kg)				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Main	2.4GHz	2437	17.0	50	18.8	4.0	256.0	240.0	90.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Main	5.2GHz	5210	17.0	50	18.8	4.0	256.0	240.0	90.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Main	5.3GHz	5290	14.5	28	18.8	4.0	256.0	240.0	90.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Main	5.5GHz	5690	14.5	28	18.8	4.0	256.0	240.0	90.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Main	5.8GHz	5755	14.5	28	18.8	4.0	256.0	240.0	90.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Main	Bluetooth	2402	6.00	4	18.8	4.0	256.0	240.0	90.0	0.044	0.165	0.400	0.400	0.400

Antenna	Band	Frequency (MHz)	Output Power		Separation Distances(mm)					Estimated 1-g SAR (W/Kg)				
			dBm	mW	Rear	Edge1	Edge2	Edge3	Edge4	Rear	Edge1	Edge2	Edge3	Edge4
Wi-Fi Aux	2.4GHz	2437	17.0	50	18.8	4.0	80.0	240.0	266.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Aux	5.2GHz	5210	17.0	50	18.8	4.0	80.0	240.0	266.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Aux	5.3GHz	5290	14.5	28	18.8	4.0	80.0	240.0	266.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Aux	5.5GHz	5690	14.5	28	18.8	4.0	80.0	240.0	266.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Aux	5.8GHz	5755	14.5	28	18.8	4.0	80.0	240.0	266.0	Measure	Measure	0.400	0.400	0.400
Wi-Fi Aux	Bluetooth	2402	6.00	4	18.8	4.0	80.0	240.0	266.0	0.044	0.165	0.400	0.400	0.400

15.2 Sum of the SAR for Simultaneous Transmission Analysis

15.2.1 Sum of the SAR for Wi-Fi & Bluetooth

Band	Simulataneous Transmission Scenario			∑ 1-g SAR (W/kg)	SPLSR (Yes/No)
	Wi-Fi Main	Wi-Fi Aux	Bluetooth		
2.4 GHz	0.162		0.165	0.327	No
		0.154	0.165	0.319	No

Note(s):
As the Sum of the SAR is not greater than 1.6W/Kg, so SPLSR is not required

Band	Simulataneous Transmission Scenario			∑ 1-g SAR (W/kg)	SPLSR (Yes/No)
	Wi-Fi Main	Wi-Fi Aux	Bluetooth		
5GHz	0.676		0.165	0.841	No
		0.465	0.165	0.630	No

Note(s):
As the Sum of the SAR is not greater than 1.6W/Kg, so SPLSR is required

16 Equipment List & Calibration Status

Name of Equipment	Manufacturer	Type/Model	Serial Number	Calibration Cycle(year)	Calibration Due
S-Parameter Network Analyzer	Agilent	E5071C	MY46213916	1	2016/6/25
Electronic Probe kit	Hewlett Packard	85070D	N/A	N/A	N/A
Power Meter	Agilent	4416	GB41291611	1	2015/9/4
Power Sensor	Agilent	8481H	MY41091956	1	2015/9/4
Data Acquisition Electronics (DAE)	SPEAG	DAE4	917	1	2015/12/28
Dosimetric E-Field Probe	SPEAG	EX3DV4	3554	1	2015/9/23
2450 MHz System Validation Dipole	SPEAG	D2450V2	728	1	2016/5/27
5GHz System Validation Dipole	SPEAG	D5GHzV2	1004	1	2015/11/19
Robot	Staubli	RX90L	F02/5T69A1/A/01	N/A	N/A
Amplifier	Mini-Circuit	ZVE-8G	665500309	N/A	N/A
Amplifier	Mini-Circuit	ZHL-1724HLN	D072602#2	N/A	N/A

17 Facilities

All measurement facilities used to collect the measurement data are located at

☐ No. 81-1, Lane 210, Bade Rd. 2, Luchu Hsiang, Taoyuan Hsien, Taiwan, R.O.C.

☒ No.11, Wugong 6th Rd., Wugu Dist., New Taipei City 24891, Taiwan. (R.O.C.)

☐ No. 199, Chunghsen Road, Hsintien City, Taipei Hsien, Taiwan, R.O.C.

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19 Attachments

Exhibit	Content
1	System Performance Check Plots
2	SAR Test Data Plots
3	Calibration Data Report
4	T150722W03-SF PHOTOs

END OF REPORT