

SAR TEST REPORT

**FCC 47 CFR § 2.1093
IEEE Std 1528-2013**

for

802.11a/b/g/n/ac RTL8822CE Combo module

Model Name.: RTL8822CE

Prepared for:

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

Prepared by

**Compliance Certification Services Inc.
Wugu Lab.
No.11, Wugong 6th Rd., Wugu Dist.,
New Taipei City, Taiwan
Issue Date: June 20, 2023**

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Revision History

Rev.	Issue Date	Revisions	Effect Page	Revised By
00	November 29, 2022	Initial Issue	ALL	Allison Chen
01	June 20, 2023	See the following Note Rev.(01)	P.20	Allison Chen

Note:

Rev.(01)



1. Modify test data in section 7.1.

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Report No.: TMWK2207003035KS

1 Attestation of Test Results

Applicant Name	Realtek Semiconductor Corp.		
Model Name	RTL8822CE		
Applicable Standards	FCC 47 CFR § 2.1093 Published RF exposure KDB procedures IEEE Std 1528-2013		
Exposure Category	SAR Limits (W/Kg)		
	Peak spatial-average (1g of tissue)		
General population	1.6		
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)		
	DTS	NII	DSS
Body	0.764	1.188	0.084
Simultaneous TX	1.594		
Receive EUT Date:	August 11, 2022		
Date Tested	August 26, 2022 to September 23, 2022		
Test Results	Pass		
<p>Compliance Certification Services Inc. , tested the above equipment in accordance with the requirements set forth in the above standards. Determination of compliance is based on the results of the compliance measurement,not taking into account measurement instrumentation uncertainty.All indications of Pass/Fail in this report are opinions expressed by Compliance Certification Services Inc, based on interpretations and/or observations of test results. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.</p>			
Approved & Released By:		Tested by:	
			
Sky Zhou Asst. Section Manager Compliance Certification Services Inc.		Jack Yang Engineer Compliance Certification Services Inc.	

2 Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE STD 1528- 2013, the following FCC Published RF exposure [KDB](#) procedures:

- 248227 D01 802.11 Wi-Fi SAR v02r02
- 447498 D01 General RF Exposure Guidance v06
- 616217 D04 SAR for laptop and tablets v01r02
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02

In addition to the above, the following information was used:

- [TCB workshop](#) October, 2016; Page 7, RF Exposure Procedures (Bluetooth Duty Factor)

Report No.: TMWK2207003035KS

3 Device Under Test (DUT) Information

3.1 DUT Description

Applicant Name	Realtek Semiconductor Corp.
Applicant Address	No. 2, Innovation Road II, Hsinchu Science Park, Hsinchu 300, Taiwan
Manufacturer Name	Realtek Semiconductor Corp.
Manufacturer Address	No. 2, Innovation Road II, Hsinchu Science Park, Hsinchu 300, Taiwan
Product	802.11a/b/g/n/ac RTL8822CE Combo module
Trade Name	Realtek
Model No.	RTL8822CE
Model Discrepancy	N/A
Device Dimension	Overall (Length x Width): 299 mm x 197 mm Overall Diagonal: 358 mm Display Diagonal: 305 mm
Back Cover	<input checked="" type="checkbox"/> Normal Battery Cover <input type="checkbox"/> Normal Battery Cover with NFC <input type="checkbox"/> Wireless Charger Battery Cover <input type="checkbox"/> Wireless Charger Battery Cover with NFC <input type="checkbox"/> The Back Cover is not removable.
Battery Options	<input checked="" type="checkbox"/> Standard – Lithium-ion battery, Rating 11.1Vdc, 2860mAH <input type="checkbox"/> Extended (large capacity) <input type="checkbox"/> The rechargeable battery is not user accessible.
Hardware Version	DMA-BA25 A102-2
Software Version	Microsoft Windows 10 2019 LTSC
Host Model Name	MIT-W102
Sample Stage	PVT

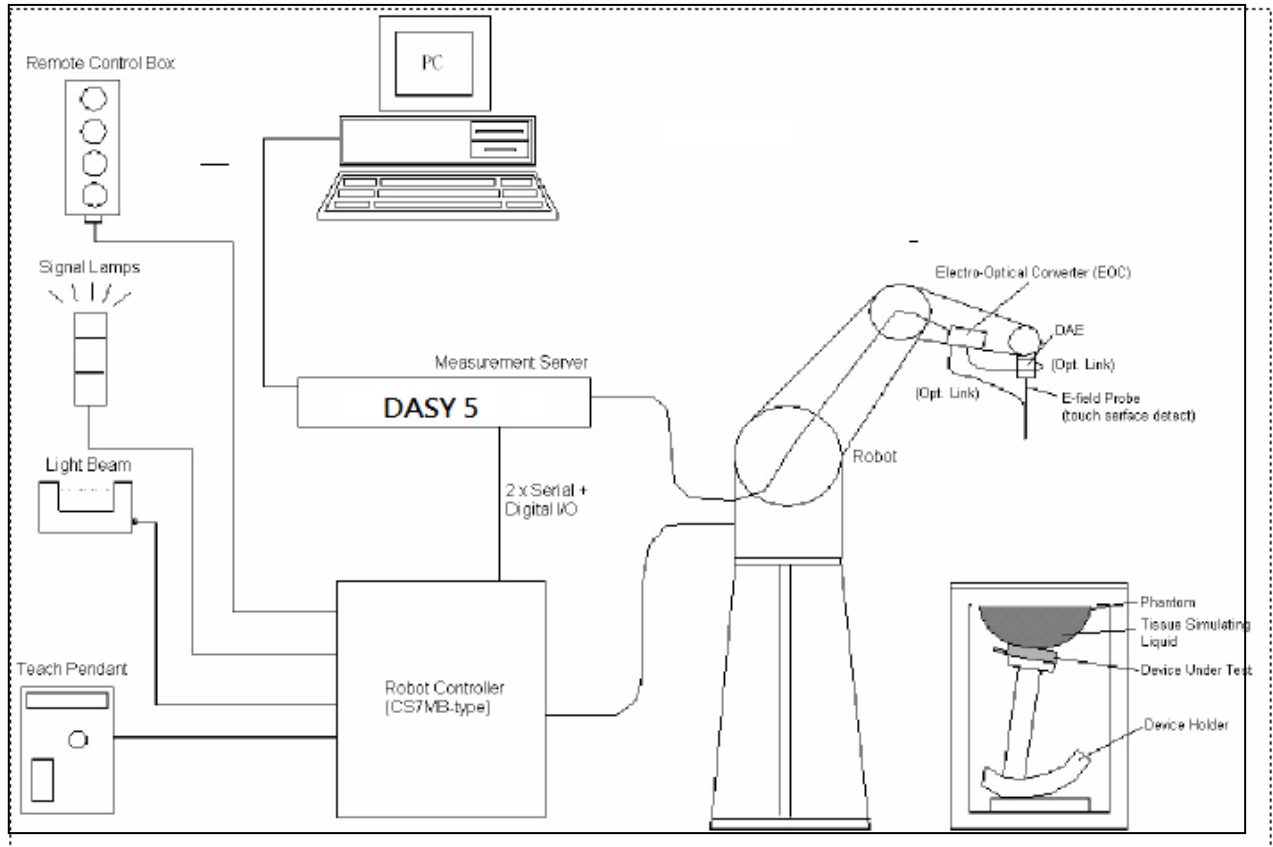
3.2 Wireless Technologies

Wireless technologies	Frequency bands	Peak Antenna Gain (dBi)	Operating mode	Duty Cycle used for SAR testing
Wi-Fi (Main)	2.4 GHz	2.94	802.11b 802.11g 802.11n (HT20) 802.11n (HT40)	94.3% (802.11b) 73.0% (802.11g) 71.7% (802.11n 20MHz BW) 55.7% (802.11n 40MHz BW)
	5.2 GHz 5.3 GHz 5.5 GHz 5.8 GHz	2.96 2.93 2.69 2.88	802.11a 802.11n (HT20) 802.11n (HT40) 802.11ac (VHT20) 802.11ac (VHT40) 802.11ac (VHT80)	73.0% (802.11a) 71.7% (802.11n/ac 20MHz BW) 55.7% (802.11n/ac 40MHz BW) 38.6% (802.11ac 80MHz BW)
Antenna Specification	Brand Name	JOINSOON ELECTRONICS MFG. CO., LTD		
	Type	PIFA Antenna		
	Parts Number	1510-0137-0022		
Wi-Fi (Aux)	2.4 GHz	2.91	802.11b 802.11g 802.11n (HT20) 802.11n (HT40)	94.3% (802.11b) 73.0% (802.11g) 71.7% (802.11n 20MHz BW) 55.7% (802.11n 40MHz BW)
	5.2 GHz 5.3 GHz 5.5 GHz 5.8 GHz	2.82 2.82 2.25 2.84	802.11a 802.11n (HT20) 802.11n (HT40) 802.11ac (VHT20) 802.11ac (VHT40) 802.11ac (VHT80)	73.0% (802.11a) 71.7% (802.11n/ac 20MHz BW) 55.7% (802.11n/ac 40MHz BW) 38.6% (802.11ac 80MHz BW)
Bluetooth	2.4 GHz	2.91	BR,EDR,LE	77.42%
Antenna Specification	Brand Name	JOINSOON ELECTRONICS MFG. CO., LTD		
	Type	PIFA Antenna		
	Parts Number	1510-0137-0023		
NFC	13.56MHz			N/A ¹

Notes:

1. The sample selected for test was prototype that representative to production product and was provided by manufacturer
2. Variant information between/among model numbers / trademarks is provided by the applicant, test results of this report are applicable to the sample EUT received of main test model name.
3. Antenna information is provided by the applicant, test results of this report are applicable to the sample EUT received

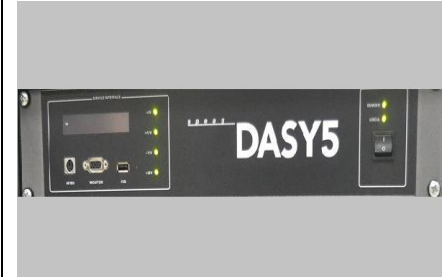


4 SAR Measurement System



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

- A standard high precision 6-axis robot (Stäubli 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 7 or Windows XP.
- DASY software version: NEO52 D10.3 S14.6.13.
- 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.

4.1 System Components

DASY5 Measurement Server	
	<p>The 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 DAE4 electronic box as well as the 16-bit AD-converter system for optical detection and digital I/O interface are contained on the DASY5 I/O-board, which is directly connected to the PC/104 bus of the CPU board.</p> <p>The measurement server performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation.</p>
	<p>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.</p> <p>Calibration: No calibration required.</p>
Data Acquisition Electronics (DAE)	
	<p>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 200MΩ; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.</p>

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 μ W/g to > 100 mW/g; Linearity: ± 0.2 dB
 (noise: typically < 1 μ W/g)

Dimensions: Overall length: 330 mm (Tip: 20 mm)
 Tip diameter: 2.5 mm (Body: 12 mm)
 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



Construction: The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE1528: 2013. 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

ELI Phantom


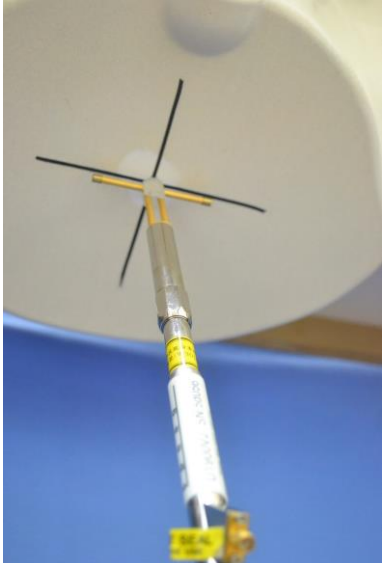
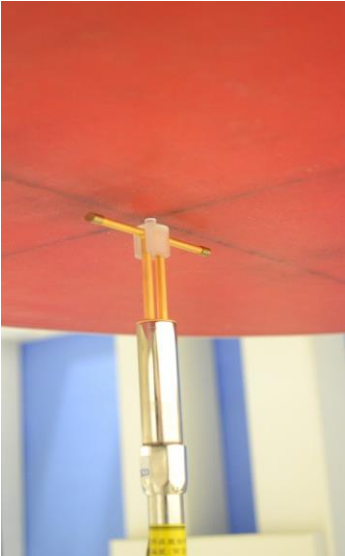


Construction: Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEEE1528: 2013 and all known tissue simulating liquids. ELI4 has been optimized regarding its performance 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 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	
	<p>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).</p>
System Validation Kits for SAM Phantom	
	<p>Construction: Symmetrical dipole with 1/4 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.</p> <p>Frequency: 2450, 5300, 5600, 5800 MHz</p> <p>Return loss: > 20 dB at specified validation position</p> <p>Power capability: > 100 W (f < 1GHz); > 40 W (f > 1GHz)</p> <p>Dimensions: D2450V2: dipole length: 51.5 mm; overall height: 290 mm D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm</p>
System Validation Kits for ELI phantom	
	<p>Construction: Symmetrical dipole with 1/4 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.</p> <p>Frequency: 2450, 5300, 5600, 5800 MHz</p> <p>Return loss: > 20 dB at specified validation position</p> <p>Power capability: > 100 W (f < 1GHz); > 40 W (f > 1GHz)</p> <p>Dimensions: D2450V2: dipole length: 51.5 mm; overall height: 290 mm D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm</p>

4.2 SAR Scan Procedures

Step 1: 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.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE1528 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 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.	

Step 3: Zoom Scan

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

- Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm	3 – 4 GHz: ≤ 5 mm 4 – 6 GHz: ≤ 4 mm
Maximum zoom scan spatial resolution, normal to phantom surface	Uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	≤ 1.5 · $\Delta z_{\text{Zoom}}(n-1)$	
Maximum zoom scan volume	x, y, z	≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm	

Step 4: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1

Step 5: Z-Scan (FCC only)

The Z Scan measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. In order to get a reasonable extrapolation the extrapolated distance should not be larger than the step size in Z-direction

5 Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg and the measured 10-g SAR within a frequency band is < 3.75 W/kg. The expanded SAR measurement uncertainty must be $\leq 30\%$, for a confidence interval of $k = 2$. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE1528: 2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.

6 RF Exposure Conditions (Test Configurations)

Refer to Appendixes 1 for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.

6.1 Standalone SAR Test Exclusion Considerations

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

- When the separation distance from the antenna to an adjacent edge is ≤ 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.
- 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.

SAR Test Exclusion Calculations for WLAN

Antennas < 50mm to adjacent edges

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)					Calculated Threshold Value				
		dBm	mW	Rear	Edge 1	Edge 2	Edge 3	Edge 4	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Main Antenna													
Wi-Fi 2.4 GHz	2462	18.00	63	5.6	157.24	257.99	13.24	25.99	16.5	> 50 mm	> 50 mm	7.6	3.8
Wi-Fi 5.2 GHz	5240	14.00	25	5.6	157.24	257.99	13.24	25.99	9.5	> 50 mm	> 50 mm	4.4	2.2
Wi-Fi 5.3 GHz	5320	14.00	25	5.6	157.24	257.99	13.24	25.99	9.6	> 50 mm	> 50 mm	4.4	2.2
Wi-Fi 5.5 GHz	5700	14.25	27	5.6	157.24	257.99	13.24	25.99	10.7	> 50 mm	> 50 mm	5	2.5
Wi-Fi 5.8 GHz	5825	13.00	20	5.6	157.24	257.99	13.24	25.99	8	> 50 mm	> 50 mm	3.7	1.9
Aux Antenna													
Wi-Fi 2.4 GHz	2462	17.50	56	16.7	10.69	282.67	164.29	6.62	5.2	8	> 50 mm	> 50 mm	12.6
Wi-Fi 5.2 GHz	5240	18.00	63	16.7	10.69	282.67	164.29	6.62	8.5	13.1	> 50 mm	> 50 mm	20.6
Wi-Fi 5.3 GHz	5320	18.00	63	16.7	10.69	282.67	164.29	6.62	8.5	13.2	> 50 mm	> 50 mm	20.8
Wi-Fi 5.5 GHz	5700	14.50	28	16.7	10.69	282.67	164.29	6.62	3.9	6.1	> 50 mm	> 50 mm	9.5
Wi-Fi 5.8 GHz	5825	15.50	35	16.7	10.69	282.67	164.29	6.62	5	7.7	> 50 mm	> 50 mm	12.1
Bluetooth	2480	6.00	4	16.7	10.69	282.67	164.29	6.62	0.4	0.6	> 50 mm	> 50 mm	0.9

Note(s):

According to KDB 447498, if the calculated threshold value is >3 then SAR testing is required.

**SAR Test Exclusion Calculations for WLAN
Antennas > 50mm to adjacent edges**

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)					Calculated Threshold Value				
		dBm	mW	Rear	Edge 1	Edge 2	Edge 3	Edge 4	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Main Antenna													
Wi-Fi 2.4 GHz	2462	18.00	63	5.6	157.24	257.99	13.24	25.99	< 50 mm	1168 mW -EXEMPT-	2175.5 mW -EXEMPT-	< 50 mm	< 50 mm
Wi-Fi 5.2 GHz	5240	14.00	25	5.6	157.24	257.99	13.24	25.99	< 50 mm	1137.9 mW -EXEMPT-	2145.4 mW -EXEMPT-	< 50 mm	< 50 mm
Wi-Fi 5.3 GHz	5320	14.00	25	5.6	157.24	257.99	13.24	25.99	< 50 mm	1137.4 mW -EXEMPT-	2144.9 mW -EXEMPT-	< 50 mm	< 50 mm
Wi-Fi 5.5 GHz	5700	14.25	27	5.6	157.24	257.99	13.24	25.99	< 50 mm	1135.2 mW -EXEMPT-	2142.7 mW -EXEMPT-	< 50 mm	< 50 mm
Wi-Fi 5.8 GHz	5825	13.00	20	5.6	157.24	257.99	13.24	25.99	< 50 mm	1134.6 mW -EXEMPT-	2142.1 mW -EXEMPT-	< 50 mm	< 50 mm
Aux Antenna													
Wi-Fi 2.4 GHz	2462	17.50	56	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2422.3 mW -EXEMPT-	1238.5 mW -EXEMPT-	< 50 mm
Wi-Fi 5.2 GHz	5240	18.00	63	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2392.2 mW -EXEMPT-	1208.4 mW -EXEMPT-	< 50 mm
Wi-Fi 5.3 GHz	5320	18.00	63	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2391.7 mW -EXEMPT-	1207.9 mW -EXEMPT-	< 50 mm
Wi-Fi 5.5 GHz	5700	14.50	28	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2389.5 mW -EXEMPT-	1205.7 mW -EXEMPT-	< 50 mm
Wi-Fi 5.8 GHz	5825	15.50	35	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2388.9 mW -EXEMPT-	1205.1 mW -EXEMPT-	< 50 mm
Bluetooth	2480	6.00	4	16.7	10.69	282.67	164.29	6.62	< 50 mm	< 50 mm	2422 mW -EXEMPT-	1238.2 mW -EXEMPT-	< 50 mm

Note(s):

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

6.2 Required Test Configurations

The table below identifies the standalone test configurations required for this device according to the findings in Section 6.1:

Test Configurations	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Main Antenna					
Wi-Fi 2.4 GHz	Yes	No	No	Yes	Yes
Wi-Fi 5.2 GHz	Yes	No	No	Yes	No
Wi-Fi 5.3 GHz	Yes	No	No	Yes	No
Wi-Fi 5.5 GHz	Yes	No	No	Yes	No
Wi-Fi 5.8 GHz	Yes	No	No	Yes	No

Test Configurations	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Aux Antenna					
Wi-Fi 2.4 GHz	Yes	Yes	No	No	Yes
Wi-Fi 5.2 GHz	Yes	Yes	No	No	Yes
Wi-Fi 5.3 GHz	Yes	Yes	No	No	Yes
Wi-Fi 5.5 GHz	Yes	Yes	No	No	Yes
Wi-Fi 5.8 GHz	Yes	Yes	No	No	Yes
Bluetooth	No	No	No	No	No

Note(s):

Yes = Testing is required.

No = Testing is not required.

7 Dielectric Property Measurements & System Check

7.1 Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within $\pm 2^\circ\text{C}$ of the temperature when the tissue parameters are characterized.

The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

The dielectric constant (ϵ_r) and conductivity (σ) of typical tissue-equivalent media recipes are expected to be within $\pm 5\%$ of the required target values; but for SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEEE Std 1528-2013, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for ϵ_r and σ may be relaxed to $\pm 10\%$. This is limited to frequencies ≤ 3 GHz.

Tissue Dielectric Parameters

FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

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

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

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 MΩ+ 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

Dielectric Property Measurements Results:

Date	Tissue Type	Frequency (MHz)	Relative Permittivity (ϵ_r)			Conductivity (σ)		
			Measured	Target	Delta (%)	Measured	Target	Delta (%)
2022/9/19	Head	2400	39.94	39.30	1.63	1.79	1.76	1.82
		2450	39.86	39.20	1.68	1.83	1.80	1.44
		2480	39.83	39.16	1.71	1.85	1.83	1.04
2022/9/21	Head	2400	38.14	39.30	-2.95	1.83	1.76	4.10
		2450	37.97	39.20	-3.14	1.89	1.80	4.94
		2480	37.90	39.16	-3.22	1.92	1.83	4.91
2022/9/22	Head	5250	34.95	35.95	-2.78	4.66	4.71	-1.17
		5300	34.82	35.90	-3.01	4.69	4.76	-1.51
		5350	34.80	35.85	-2.93	4.81	4.81	0.06
2022/9/22	Head	5500	34.72	35.65	-2.61	4.94	4.97	-0.54
		5600	34.44	35.50	-2.99	5.02	5.07	-1.01
		5720	34.14	35.38	-3.50	5.24	5.19	0.92
2022/9/23	Head	5500	35.12	35.65	-1.49	4.99	4.97	0.56
		5600	34.84	35.50	-1.86	5.08	5.07	0.10
		5720	34.54	35.38	-2.37	5.30	5.19	2.02
2022/9/23	Head	5720	34.54	35.38	-2.37	5.30	5.19	2.02
		5750	34.51	35.35	-2.38	5.23	5.22	0.19
		5850	34.19	35.25	-3.01	5.26	5.32	-1.20

7.2 System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ± 0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm for measurements > 3 GHz.
- The DASY system with an E-Field Probe 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 15 mm was aligned with the dipole.
For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube
- Distance between probe sensors and phantom surface was set to 2 mm.
- The dipole input power (forward power) was 250 mW (below 2GHz) and 100 mW
- The results are normalized to 1 W input power.

System Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within $\pm 10\%$ of the manufacturer calibrated dipole SAR target. Refer to Appendix 2 for the SAR System Check Plots.

Date	Tissue Type	Dipole S/N	Input Power (mW)	Measured 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Delta 1g ± 10 (%)	Measured 10g SAR (W/kg)	Targeted 10g SAR (W/kg)	Normalized 10g SAR (W/kg)	Delta 10g ± 10 (%)	Plot No.
2022/9/19	Head	D2450V2-727	250	13.80	52.80	55.2	4.55	6.43	25.00	25.72	2.88	1
2022/9/21	Head	D2450V2-727	250	13.70	52.80	54.8	3.79	6.36	25.00	25.44	1.76	2
2022/9/22	Head	D5GHzV2-1023-5250	100	8.81	81.00	88.1	8.77	2.52	23.10	25.2	9.09	3
2022/9/22	Head	D5GHzV2-1023-5600	100	8.32	84.40	83.2	-1.42	2.33	23.80	23.3	-2.10	4
2022/9/23	Head	D5GHzV2-1023-5600	100	8.72	84.40	87.2	3.32	2.45	23.80	24.5	2.94	5
2022/9/23	Head	D6GHzV2-1023-5750	100	8.11	81.00	81.1	0.12	2.30	22.90	23	0.44	6

8 Conducted Output Power Measurements

8.1 Wi-Fi 2.4GHz (DTS Band)

The maximum output power specified for production units are determined for all applicable 802.11 transmission modes in each standalone and aggregated frequency band. Maximum output power is measured for the highest maximum output power configuration(s) in each frequency band according to the default power measurement procedures.

SAR Test reduction was applied from KDB 248227 guidance, Sec. 2.1, b), 1) 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 802.11g/n/ac/ax mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band. Additional output power measurements were not deemed necessary.

SAR testing is not required for OFDM mode(s) when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

Measured Results

Band	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)		Tune-up Limit (dBm)		SAR Test (Yes/No)	
					Chain A	Chain B	Chain A	Chain B	Chain A	Chain B
2.4GHz (DTS)	802.11b	1 Mbps	1	2412	17.43	17.08	18.0	17.5	Yes	Yes
			6	2437	17.24	16.72	18.0	17.5		
			11	2462	16.91	16.53	18.0	17.5		
	802.11g	6 Mbps	1	2412	Not Required		17.0	17.0	No	No
			6	2437						
			11	2462						
	802.11n (HT20)	MCS0	1	2412	Not Required		16.0	16.0	No	No
			6	2437						
			11	2462						
	802.11n (HT40)	MCS0	3	2422	Not Required		16.0	16.0	No	No
			6	2437						
			9	2452						

8.2 Wi-Fi 5GHz (U-NII Bands)

The maximum output power specified for production units are determined for all applicable 802.11 transmission modes in each standalone and aggregated frequency band. Maximum output power is measured for the highest maximum output power configuration(s) in each frequency band according to the default power measurement procedures.

When the same transmission mode configurations have the same maximum output power on the same channel for the 802.11 a/g/n/ac modes, the channel in the lower order/sequence 802.11 mode (i.e. a, g, n then ac) is selected.

SAR Test reduction was applied from KDB 248227 guidance, Sec. 2.1, b), 1) 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 in the initial test configuration, for each frequency band. Additional output power measurements were not deemed necessary.

Measured Results

Band	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)		Tune-up Limit (dBm)		SAR Test (Yes/No)	
					Chain A	Chain B	Chain A	Chain B	Chain A	Chain B
5.2GHz (U-NII 1)	802.11a	6 Mbps	36	5180	13.26	17.33	14.0	18.0	No	No
			40	5200	13.32	17.31	14.0	18.0		
			44	5220	13.35	17.39	14.0	18.0		
			48	5240	13.47	17.42	14.0	18.0		
	802.11n (HT20)	MCS0	36	5180	Not Required		13.0	17.0	No	No
			40	5200						
			44	5220						
			48	5240						
	802.11ac (VHT20)	MCS0	36	5180	Not Required		13.0	17.0	No	No
			40	5200						
			44	5220						
			48	5240						
	802.11n (HT40)	MCS0	38	5190	Not Required		13.0	17.0	No	No
			46	5230						
802.11ac (VHT40)	MCS0	38	5190	Not Required		13.0	17.0	No	No	
		46	5230							
802.11ac (VHT80)	MCS0	42	5210	Not Required		13.0	16.0	No	No	
5.3GHz (U-NII 2A)	802.11a	6 Mbps	52	5260	13.56	17.21	14.0	18.0	Yes	Yes
			56	5280	13.61	17.15	14.0	18.0		
			60	5300	13.54	17.23	14.0	18.0		
			64	5320	13.43	17.12	14.0	18.0		
	802.11n (HT20)	MCS0	52	5260	Not Required		13.0	17.0	No	No
			56	5280						
			60	5300						
			64	5320						
	802.11ac (VHT20)	MCS0	52	5260	Not Required		13.0	17.0	No	No
			56	5280						
			60	5300						
			64	5320						
	802.11n (HT40)	MCS0	54	5270	Not Required		13.0	17.0	No	No
			62	5310						
802.11ac (VHT40)	MCS0	54	5270	Not Required		13.0	17.0	No	No	
		62	5310							
802.11ac (VHT80)	MCS0	58	5290	Not Required		13.0	16.0	No	No	

Measured Results (continued)

Band	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)		Tune-up Limit (dBm)		SAR Test (Yes/No)	
					Chain A	Chain B	Chain A	Chain B	Chain A	Chain B
5.5GHz (U-NII 2C)	802.11a	6 Mbps	100	5500	13.59	13.92	14.25	14.5	Yes	Yes
			116	5580	13.94	14.20	14.25	14.5		
			124	5620	14.11	14.37	14.25	14.5		
			132	5660	14.19	14.43	14.25	14.5		
			140	5700	13.91	14.23	14.25	14.5		
			144	5720	13.83	14.08	14.25	14.5		
	802.11n (HT20)	MCS0	100	5500	Not Required		13.5	13.5	No	No
			116	5580						
			124	5620						
			132	5660						
			140	5700						
			144	5720						
	802.11ac (VHT20)	MCS0	100	5500	Not Required		13.5	13.5	No	No
			116	5580						
			124	5620						
			132	5660						
			140	5700						
			144	5720						
	802.11n (HT40)	MCS0	102	5510	Not Required		13.5	13.5	No	No
			110	5550						
			118	5590						
			126	5630						
			134	5670						
			142	5710						
	802.11ac (VHT40)	MCS0	102	5510	Not Required		13.5	13.5	No	No
			110	5550						
			118	5590						
			126	5630						
			134	5670						
			142	5710						
802.11ac (VHT80)	MCS0	106	5530	Not Required		13.0	13.0	No	No	
		122	5610							
		138	5690							
5.8GHz (U-NII 3)	802.11a	6 Mbps	149	5745	12.52	14.78	13.0	15.5	Yes	Yes
			157	5785	12.61	14.83	13.0	15.5		
			165	5825	12.63	14.85	13.0	15.5		
	802.11n (HT20)	MCS0	149	5745	Not Required		12.0	14.5	No	No
			157	5785						
			165	5825						
	802.11ac (VHT20)	MCS0	149	5745	Not Required		12.0	14.5	No	No
			157	5785						
			165	5825						
	802.11n (HT40)	MCS0	151	5755	Not Required		12.0	14.5	No	No
			159	5795						
	802.11ac (VHT40)	MCS0	151	5755	Not Required		12.0	14.5	No	No
			159	5795						
	802.11ac (VHT80)	MCS0	155	5775	Not Required		12.0	12.0	No	No

8.3 Bluetooth.

Average Power Measured Results

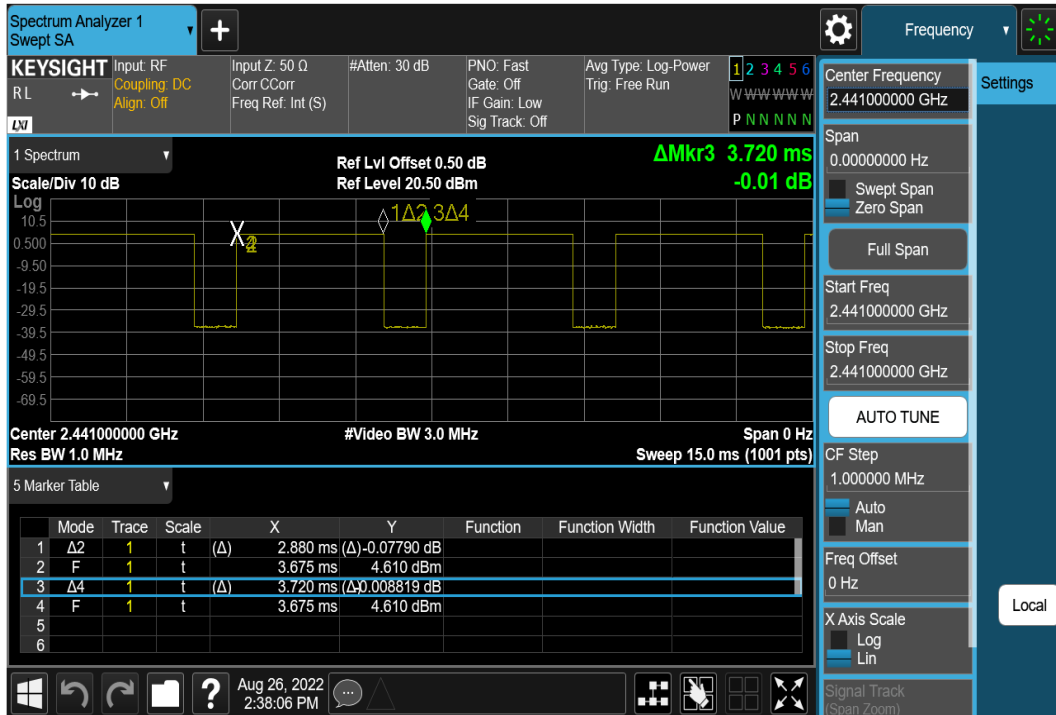
Band (GHz)	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)	Meas. Avg Pwr (mW)	Tune-up Limit (dBm)	SAR Test (Yes/No)
2.4	GFSK	1 Mbps	0	2402	5.56	3.60	6.0	Yes
			39	2441	5.19	3.30		
			78	2480	4.73	2.97		
	EDR, $\pi/4$ DQPSK	2 Mbps	0	2402	5.43	3.49	6.0	No
			39	2441	5.16	3.28		
			78	2480	4.53	2.84		
	EDR, 8-DPSK	3 Mbps	0	2402	5.29	3.38	6.0	No
			39	2441	5.13	3.26		
			78	2480	4.56	2.86		
	LE, GFSK	1 Mbps	0	2402	4.63	2.90	5.0	No
			19	2440	4.33	2.71		
			39	2480	3.71	2.35		

Duty Factor Measured Results

Mode	Type	T on (ms)	Period (ms)	Duty Cycle	Crest Factor (1/duty cycle)
GFSK	DH5	2.88	3.72	77.42%	1.11

Duty Cycle plots

GFSK



9 Measured and Reported (Scaled) SAR Results

9.1 Wi-Fi (DTS Band)

RF Exposure Conditions	Mode	Antenna	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Body	802.11b	SISO Main(A) 0	0	Rear	1	2412	94.3%	18.0	17.43	0.632	0.764	1
				Edge 3	1	2412	94.3%	18.0	17.43	0.115	0.139	
				Edge 4	1	2412	94.3%	18.0	17.43	0.138	0.167	
Body	802.11b	SISO Aux(B) 1	0	Rear	1	2412	94.3%	17.5	17.08	0.203	0.237	
				Edge 1	1	2412	94.3%	17.5	17.08	0.077	0.090	
				Edge 4	1	2412	94.3%	17.5	17.08	0.583	0.681	2

9.2 Wi-Fi (U-NII Band)

RF Exposure Conditions	Frequency Band	Mode	Antenna	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
									Tune-up Limit	Meas.	Meas.	Scaled	
Body	5.3 (U-NII 2A)	802.11a	SISO Main(A) 0	0	Rear	56	5280	73.0%	14.0	13.61	0.421	0.631	3
					Edge 3	56	5280	73.0%	14.0	13.61	0.232	0.348	
Body	5.3 (U-NII 2A)	802.11a	SISO Aux(B) 1	0	Rear	60	5300	73.0%	18.0	17.23	0.180	0.294	
					Edge 1	60	5300	73.0%	18.0	17.23	0.386	0.631	4
					Edge 4	60	5300	73.0%	18.0	17.23	0.197	0.322	
Body	5.5 (U-NII 2C)	802.11a	SISO Main(A) 0	0	Rear	100	5500	73.0%	14.25	13.59	0.734	1.171	5
					Rear	116	5580	73.0%	14.25	13.94	0.728	1.071	
					Rear	124	5620	73.0%	14.25	14.11	0.722	1.021	
					Rear	132	5660	73.0%	14.25	14.19	0.661	0.918	
					Rear	140	5700	73.0%	14.25	13.91	0.621	0.920	
					Rear	144	5720	73.0%	14.25	13.83	0.716	1.080	
					Edge 3	132	5660	73.0%	14.25	14.19	0.364	0.506	
Body	5.5 (U-NII 2C)	802.11a	SISO Aux(B) 1	0	Rear	132	5660	73.0%	14.5	14.43	0.205	0.285	
					Edge 1	100	5500	73.0%	14.5	13.92	0.397	0.622	
					Edge 1	116	5580	73.0%	14.5	14.20	0.749	1.099	
					Edge 1	124	5620	73.0%	14.5	14.37	0.842	1.188	6
					Edge 1	132	5660	73.0%	14.5	14.43	0.832	1.158	
					Edge 1	140	5700	73.0%	14.5	14.23	0.624	0.910	
					Edge 1	144	5720	73.0%	14.5	14.08	0.545	0.822	
Body	5.8 (U-NII 3)	802.11a	SISO Main(A) 0	0	Rear	149	5745	73.0%	13.0	12.52	0.588	0.900	
					Rear	157	5785	73.0%	13.0	12.61	0.751	1.125	
					Rear	165	5825	73.0%	13.0	12.63	0.780	1.164	7
					Edge 3	165	5825	73.0%	13.0	12.63	0.347	0.518	
Body	5.8 (U-NII 3)	802.11a	SISO Aux(B) 1	0	Rear	165	5825	73.0%	15.5	14.85	0.044	0.070	
					Edge 1	165	5825	73.0%	15.5	14.85	0.431	0.686	8
					Edge 4	165	5825	73.0%	15.5	14.85	0.164	0.261	

9.3 Bluetooth

RF Exposure Conditions	Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
							Tune-up Limit	Meas.	Meas.	Scaled	
Body	GFSK_1M	0	Edge 1	0	2402	77.42%	6.0	5.56	0.004	0.006	
			Edge 4	0	2402	77.42%	6.0	5.56	0.059	0.084	9

10 SAR Measurement Variability

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

- 1) Repeated measurement is not required when the original highest measured SAR is <math>< 0.8</math> or 2 W/kg (1-g or 10-g respectively); steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.8 or 2 W/kg (1-g or 10-g respectively), repeat that measurement once.
- 3) Perform a second repeated measurement only if the **ratio of largest to smallest SAR** for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 or 3.6 W/kg (~ 10% from the 1-g or 10-g respective SAR limit).
- 4) Perform a third repeated measurement only if the original, first, or second repeated measurement is ≥ 1.5 or 3.75 W/kg (1-g or 10-g respectively) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20 .

Wi-Fi (U-NII Band)

RF Exposure Conditions	RF Exposure Conditions	Mode	Antenna	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Meas. SAR (W/kg)		Largest to Smallest SAR Ratio	Delta Target $\leq 5\%$
									Original	Repeated		
Body	5.5 (U-NII 2C)	802.11a	SISO Aux(B) 1	0	Edge 1	124	5620	73.0%	0.842	0.848	1.01	1%

11 Simultaneous Transmission SAR Analysis

KDB 447498 D01 General RF Exposure Guidance provides two procedures for determining simultaneous transmission SAR test exclusion: Sum of SAR and SAR to Peak Location Ratio (SPLSR)

Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based upon Sum of SAR the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met.

SAR to Peak Location Ratio (SPLSR)

KDB 447498 D01 General RF Exposure Guidance explains how to calculate the SAR to Peak Location Ratio (SPLSR) between pairs of simultaneously transmitting antennas:

$$\text{SPLSR} = (\text{SAR}_1 + \text{SAR}_2)^{1.5} / R_i$$

Where:

SAR₁ is the highest measured or estimated SAR for the first of a pair of simultaneous transmitting antennas, in a specific test operating mode and exposure condition

SAR₂ is the highest measured 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 $[(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2]$

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:

$$(\text{SAR}_1 + \text{SAR}_2)^{1.5} / R_i \leq 0.04$$

When an individual antenna transmits at on two bands simultaneously, the sum of the highest reported SAR for the frequency bands should be used to determine SAR₁.or SAR₂. When SPLSR is necessary, the smallest distance between the peak SAR locations for the antenna pair with respect to the peaks from each antenna should be used.

The antennas in all antenna pairs that do not qualify for simultaneous transmission SAR test exclusion must be tested for SAR compliance, according to the enlarged zoom scan and volume scan post-processing procedures in KDB Publication 865664 D01

Simultaneous Transmission Condition

RF Exposure Condition	Item	Capable Transmit Configurations				
Standalone	1	DTS (Main)	+	DTS (Aux)	+	BT
	2	U-NII (Main)	+	U-NII (Aux)	+	BT

Notes:

1. Wi-Fi 2.4GHz & Wi-Fi 5GHz cannot transmit simultaneously.
2. Wi-Fi SISO mode SAR result can also represent for MIMO mode SAR and is used for MIMO mode simultaneous transmission analysis because antennas are not overlapping and the MIMO mode maximum power is equal or less than SISO mode.

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:
 - o 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.
 - o 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.
 - o When the minimum test separation distance is > 50 mm, the estimated SAR value is 0.4 W/kg
3. Please refer to Estimated SAR Tables to see which test positions are inherently compliant as they consist of only estimated SAR values for all applicable transmitters and consequently will always have sum of SAR values < 1.2 W/kg. Simultaneous transmission SAR analysis was therefore not performed for these test positions.

Estimated SAR for WLAN

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)					Estimated 1-g SAR Value (W/kg)				
		dBm	mW	Rear	Edge 1	Edge 2	Edge 3	Edge 4	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Main Antenna													
Wi-Fi 2.4 GHz	2462	18.00	63	5.6	157.24	257.99	13.24	25.99	-MEASURE-	0.400	0.400	-MEASURE-	-MEASURE-
Wi-Fi 5.2 GHz	5240	14.00	25	5.6	157.24	257.99	13.24	25.99	-MEASURE-	0.400	0.400	-MEASURE-	0.293
Wi-Fi 5.3 GHz	5320	14.00	25	5.6	157.24	257.99	13.24	25.99	-MEASURE-	0.400	0.400	-MEASURE-	0.296
Wi-Fi 5.5 GHz	5700	14.25	27	5.6	157.24	257.99	13.24	25.99	-MEASURE-	0.400	0.400	-MEASURE-	0.331
Wi-Fi 5.8 GHz	5825	13.00	20	5.6	157.24	257.99	13.24	25.99	-MEASURE-	0.400	0.400	-MEASURE-	0.248
Aux Antenna													
Wi-Fi 2.4 GHz	2462	17.50	56	16.7	10.69	282.67	164.29	6.62	-MEASURE-	-MEASURE-	0.400	0.400	-MEASURE-
Wi-Fi 5.2 GHz	5240	18.00	63	16.7	10.69	282.67	164.29	6.62	-MEASURE-	-MEASURE-	0.400	0.400	-MEASURE-
Wi-Fi 5.3 GHz	5320	18.00	63	16.7	10.69	282.67	164.29	6.62	-MEASURE-	-MEASURE-	0.400	0.400	-MEASURE-
Wi-Fi 5.5 GHz	5700	14.50	28	16.7	10.69	282.67	164.29	6.62	-MEASURE-	-MEASURE-	0.400	0.400	-MEASURE-
Wi-Fi 5.8 GHz	5825	15.50	35	16.7	10.69	282.67	164.29	6.62	-MEASURE-	-MEASURE-	0.400	0.400	-MEASURE-
Bluetooth	2480	6.00	4	16.7	10.69	282.67	164.29	6.62	0.049	0.076	0.400	0.400	0.120

11.1 Sum of the SAR for Wi-Fi & BT

Test Position	DTS					U-NII		BT	DTS + BT	U-NII + BT
	Chain 0	Chain 1	Chain 0	Chain 1	⑤	① + ② + ⑤	③ + ④ + ⑤			
	①	②	③	④	⑤					
Rear	0.764	0.237	1.171	0.294	0.049		1.050		1.514	
Edge 1	0.400	0.090	0.400	1.188	0.006		0.496		1.594	
Edge 3	0.139	0.400	0.518	0.400	0.400		0.939		1.318	
Edge 4	0.167	0.681	0.331	0.483	0.084		0.932		0.898	

Conclusion:

Simultaneous transmission SAR measurement (Volume Scan) is not required because either the sum of the 1-g SAR is < 1.6 W/kg or the SPLSR is < 0.04 for all circumstances that require SPLSR calculation.

12 Equipment List & Calibration Status

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Network Analyzer	SPEAG	DAKS_VNA R140	0140417	2023/1/24
Dielectric Assessment Kit	SPEAG	DAKS-3.5	1001	2023/1/26
Thermometer	TES	TES-1306	210801061	2022/10/21

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Agilent	N5181A	MY50141235	2023/7/22
Power Meter	Anritsu	ML2496A	2136002	2022/12/5
Power Sensor	Anritsu	MA2411B	1911386	2022/10/24
Power Meter	Agilent	E4417A	MY52240003	2022/10/25
Power Sensor	Agilent	E9301H	MY52200004	2022/10/23
Dual Directional Coupler	Agilent	772D	MY46151242	2023/8/29
Amplifier	EMCI	ZVE-8G	S1900977	N/A
Data Acquisition Electronic	SPEAG	DAE4	877	2023/4/27
Dosimetric E-Field Probe	SPEAG	EX3DV4	3665	2023/8/27
System Validation Dipole	SPEAG	D2450V2	727	2023/4/24
System Validation Dipole	SPEAG	D5GHzV2	1023	2023/1/26
Humidity/Temp meter	TECPEL	DTM-303A	TP130075	2023/1/13
Thermometer	TES	TES-1306	210801061	2022/10/21

Software Version

DASY NEO52 D10.3 S14.6.13

SEMCAD-X-PostPro

Report No.: TMWK2207003035KS

13 Facilities

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

No.11, Wugong 6th Rd., Wugu Dist., New Taipei City, Taiwan.

No. 12, Ln. 116, Wugong 3rd Rd., Wugu Dist., New Taipei City, Taiwan.

14 Appendixes

Exhibit	Content
1	SAR Setup Photos
2	SAR System Check Plots
3	Highest SAR Test Plots
4	SAR DAE and Probe Calibration Certificates
5	SAR Dipole Calibration Certificates

END OF REPORT