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SAR EVALUATION REPORT

Applicant Name:
Samsung Electronics Co., Ltd.
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Yeongtong-gu, Suwon-si
Gyeonggi-do, 16677, Korea

Date of Testing:
04/01/2024-04/18/2024
Test Site/Location:
Element Washington DC LLC,
Columbia, MD, USA
Document Serial No.:
1M2403190019-01.A3L(R1)

FCC ID: **A3LNP940XMA**

APPLICANT: **SAMSUNG ELECTRONICS CO., LTD.**

DUT Type:	Portable Laptop
Application Type:	Certification
FCC Rule Part(s):	CFR §2.1093
Model(s):	NP940XMA
Additional Model(s):	NP944XMA

Equipment Class	Band & Mode	Tx Frequency	SAR 1g Body (W/kg)
DTS	2.4 GHz WIFI	2412 - 2472 MHz	**0.52**
NII	5 GHz WIFI	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz U-NII-4: 5845 - 5885 MHz	**0.56***
6CD	6 GHz WIFI	U-NII-5: 5935 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz	**0.59***
DSS	2.4 GHz Bluetooth	2402 - 2480 MHz	**0.47**
Simultaneous SAR per KDB 690783 D01v01r03:			**1.53**

Equipment Class	Band & Mode	Tx Frequency	APD (W/m^2) Body	Reported PD (W/m^2) Body
6CD	6 GHz WIFI	U-NII-5: 5935 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz	3.64*	5.51*

Note: * SAR/APD/PD values represent RF exposure during MIMO operations.

Note: This revised test report supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE C95.1-1992 and has been tested in accordance with the measurement procedures specified in Section 1.9 of this report; for North American frequency bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.

RJ Ortanez
Executive Vice President

The SAR Tick is an initiative of the Mobile & Wireless Forum (MWF). While a product may be considered eligible, use of the SAR Tick logo requires an agreement with the MWF. Further details can be obtained by emailing: sartick@mwfai.info.

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1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
2.4 GHz WIFI	Data	2412 - 2472 MHz
5 GHz WIFI	Data	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz U-NII-4: 5845 - 5885 MHz
6 GHz WIFI	Data	U-NII-5: 5935 - 6415 MHz U-NII-6: 6435 - 6515 MHz U-NII-7: 6535 - 6875 MHz U-NII-8: 6895 - 7115 MHz
2.4 GHz Bluetooth	Data	2402 - 2480 MHz

1.2 Nominal and Maximum Output Power Specifications

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D04v01.

Note: Targets for 802.11ax/be RU operations can be found in 802.11ax/be RU SAR Exclusion Appendix.

1.2.1 2.4 GHz SISO/MIMO WLAN Output Power

Band	IEEE 802.11 Modulated Output Power (in dBm)																					
	SISO										MIMO											
	Antenna 1										MIMO											
	b		g		n		ax (SU)		be (SU)		b (CDD + STBC)		g (CDD + STBC)		n (CDD + STBC, SDM)		ax (SU) (CDD + STBC, SDM)		be (SU) (CDD + STBC, SDM)	
Maximum / Nominal Power	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.
2.4 GHz WLAN	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	18.0	17.0	18.0	17.0	18.0	17.0	18.0	17.0	18.0	17.0
			ch. 10: 14.0	13.0	ch. 10: 14.0	13.0							ch. 10: 17.0	16.0	ch. 10: 17.0	16.0				
	ch. 12: 4.0	3.0	ch. 12: 4.0	3.0	ch. 12: 4.0	3.0	ch. 12: 4.0	3.0	ch. 12: 4.0	3.0	ch. 12: 7.0	6.0	ch. 12: 7.0	6.0	ch. 12: 7.0	6.0	ch. 12: 7.0	6.0	ch. 12: 7.0	6.0
	ch. 13: 0.0	-1.0	ch. 13: 0.0	-1.0	ch. 13: 0.0	-1.0	ch. 13: 0.0	-1.0	ch. 13: 0.0	-1.0	ch. 13: 3.0	2.0	ch. 13: 3.0	2.0	ch. 13: 3.0	2.0	ch. 13: 3.0	2.0	ch. 13: 3.0	2.0

1.2.2 5 GHz MIMO WLAN Output Power

Mode	Band	IEEE 802.11 Modulated Output Power (in dBm)									
		MIMO									
		a (CDD + STBC)		n (CDD + STBC, SDM)		ac (CDD + STBC, SDM)		ax (SU) (CDD + STBC, SDM)		be (SU) (CDD + STBC, SDM)	
Maximum / Nominal Power		Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.
5 GHz WIFI (20MHz BW)	UNII-1	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2A	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2C	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-3	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-4	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
5 GHz WIFI (40MHz BW)	UNII-1			15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2A			15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2C			15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-3			15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
	UNII-4			15.0	14.0	15.0	14.0	15.0	14.0	15.0	14.0
5 GHz WIFI (80MHz BW)	UNII-1					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2A					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2C					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-3					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-4					15.0	14.0	15.0	14.0	15.0	14.0
5 GHz WIFI (160MHz BW)	UNII-1/2A					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-2C					15.0	14.0	15.0	14.0	15.0	14.0
	UNII-3/4					15.0	14.0	15.0	14.0	15.0	14.0

1.2.3 6 GHz MIMO WLAN Output Power

Mode	Band	IEEE 802.11 Modulated Output Power (in dBm)					
		MIMO					
		a (CDD + STBC)		ax (SU) (CDD + STBC, SDM)		be (SU) (CDD + STBC, SDM)	
Maximum / Nominal Power		Max	Nom.	Max	Nom.	Max	Nom.
6 GHz WIFI (20MHz BW) - SP	UNII-5/7	12.0 ch. 2: 5.5	11.0 4.5	12.0 ch. 2: 5.5	11.0 4.5	12.0 ch. 2: 5.5	11.0 4.5
6 GHz WIFI (40MHz BW) - SP	UNII-5/7			12.0	11.0	12.0	11.0
6 GHz WIFI (80MHz BW) - SP	UNII-5/7			12.0	11.0	12.0	11.0
6 GHz WIFI (160MHz BW) - SP	UNII-5/7			12.0	11.0	12.0	11.0
6 GHz WIFI (320MHz BW) - SP	UNII-5					12.0	11.0

Mode	Band	IEEE 802.11 Modulated Output Power (in dBm)					
		MIMO					
		a (CDD + STBC)		ax (SU) (CDD + STBC, SDM)		be (SU) (CDD + STBC, SDM)	
Maximum / Nominal Power		Max	Nom.	Max	Nom.	Max	Nom.
6 GHz WIFI (20MHz BW) - LPI	UNII-5/6/7/8	7.0 ch. 2: 5.5	6.0 4.5	7.5 ch. 2: 5.5	6.5 4.5	7.5 ch. 2: 5.5	6.5 4.5
6 GHz WIFI (40MHz BW) - LPI	UNII-5/6/7/8			10.0	9.0	10.0	9.0
6 GHz WIFI (80MHz BW) - LPI	UNII-5/6/7/8			12.0	11.0	12.0	11.0
6 GHz WIFI (160MHz BW) - LPI	UNII-5/6/7/8			12.0	11.0	12.0	11.0
6 GHz WIFI (320MHz BW) - LPI	UNII-5/6/7/8					12.0	11.0

1.2.4 2.4 GHz Bluetooth Output Power

Mode	Data Rate	Modulated Output Power (in dBm)							
		Single Antenna				Each Chain in Dual Mode			
		Antenna 0		Antenna 1		Antenna 0 in Dual Mode		Antenna 1 in Dual Mode	
Maximum / Nominal Power		Max	Nom.	Max	Nom.	Max	Nom.	Max	Nom.
Bluetooth	1Mbps	17.5	16.5	17.5	16.5	10.5	9.5	14.0	13.0
Bluetooth EDR	2Mbps	15.0	14.0	15.0	14.0	9.5	8.5	10.5	9.5
Bluetooth EDR	3Mbps	15.0	14.0	15.0	14.0	9.5	8.5	10.5	9.5
Bluetooth LE	1Mbps	13.0	12.0	13.0	12.0	7.5	6.5	10.5	9.5
Bluetooth LE	2Mbps	13.0	12.0	13.0	12.0	7.5	6.5	10.5	9.5
Bluetooth LE	125kbps	7.5	6.5	N/A	N/A	N/A	N/A	N/A	N/A
Bluetooth LE	500kbps	7.5	6.5	N/A	N/A	N/A	N/A	N/A	N/A

1.3 DUT Antenna Locations

The overall dimensions of this device is > 200 mm. A diagram showing the location of the device antennas can be found in the DUT Antenna Diagram and SAR Test Setup Photographs Appendix. Exact dimensions and separation distances are shown in the Technical Descriptions in the FCC filings.

Table 1-1
Device Edges/Sides for SAR Testing Laptop Mode

Antenna	Back	Front	Top	Bottom	Right	Left
1	No	No	No	Yes	No	No
2	No	No	No	Yes	No	No

Note: Per FCC KDB Publication 616217 D04v01r01, particular edges were not required to be evaluated for SAR based on the SAR exclusion threshold in KDB 447498 D04v01. Additional edges may have been evaluated for simultaneous transmission analysis.

1.4 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D04v01, transmitters are considered to be operating simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D04v01 4.3.2 procedures.

Table 1-2
Simultaneous Transmission Scenarios

No.	Capable Transmit Configuration
1	2.4 GHz Bluetooth Ant 0
2	2.4 GHz Bluetooth Ant 1
3	2.4 GHz Bluetooth Dual
4	2.4 GHz WLAN Ant 1
5	2.4 GHz WLAN MIMO
6	5 GHz WLAN MIMO
7	6 GHz WLAN MIMO
8	2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO
9	2.4 GHz WLAN Ant 1 + 6 GHz WLAN MIMO
10	2.4 GHz WLAN MIMO + 5 GHz WLAN MIMO
11	2.4 GHz WLAN MIMO + 6 GHz WLAN MIMO
12	2.4 GHz Bluetooth Ant 0 + 2.4 GHz WLAN Ant 1
13	2.4 GHz Bluetooth Ant 0 + 5 GHz WLAN MIMO
14	2.4 GHz Bluetooth Ant 0 + 6 GHz WLAN MIMO
15	2.4 GHz Bluetooth Ant 1 + 5 GHz WLAN MIMO
16	2.4 GHz Bluetooth Ant 1 + 6 GHz WLAN MIMO
17	2.4 GHz Bluetooth Dual + 5 GHz WLAN MIMO
18	2.4 GHz Bluetooth Dual + 6 GHz WLAN MIMO
19	2.4 GHz Bluetooth Ant 0 + 2.4 GHz WLAN Ant 1 + 5 GHz WLAN MIMO
20	2.4 GHz Bluetooth Ant 0 + 2.4 GHz WLAN Ant 1 + 6 GHz WLAN MIMO

1. This device supports 2x2 MIMO Tx for WLAN 802.11b/a/g/n/ac/ax/be. 802.11b/a/g/n/ac/ax/be supports CDD and STBC and 802.11n/ac/ax/be additionally supports SDM.
2. This device supports Bluetooth Tethering.
3. 2.4 GHz WLAN Antenna 1 and 2.4 GHz Bluetooth Antenna 1 share the same antenna path and cannot transmit simultaneously.
4. 5 GHz WLAN and 6 GHz WLAN share the same antenna path and cannot transmit simultaneously.

1.5 Miscellaneous SAR Test Considerations

(A) WIFI/BT

Since U-NII-1 and U-NII-2A bands have the same maximum output power and the highest reported SAR for U-NII-2A is less than 1.2 W/kg, SAR is not required for U-NII-1 band according to FCC KDB Publication 248227 D01v02r02.

This device supports IEEE 802.11ac with the following features:

a) Up to 160 MHz Bandwidth only
b) No aggregate channel configurations
c) 2 Tx antenna output
d) 256 QAM is supported
e) TDWR and Band gap channels are supported

This device supports IEEE 802.11ax/be with the following features:

a) Up to 320 MHz Bandwidth only for 5/6 GHz
b) 2 Tx antenna output
c) Up to 1024 QAM is supported
d) TDWR and Band gap channels are supported for 5/6 GHz
e) MU-MIMO UL Operations are not supported

Per FCC Guidance, 802.11ax/be RU/MRU was considered a higher order 802.11 mode when compared to a/b/g/n/ac/be to apply KDB Publication 248227 D01v02r02 for OFDM mode selection. Therefore, SAR tests were not required for 802.11ax/be RU/MRU based on the maximum allowed output powers of OFDM modes and the reported SAR values. Per FCC Guidance, maximum conducted powers were performed for each RU/MRU size to demonstrate that the output powers would not be higher than the other OFDM 802.11 modes. Please see Measurement Reports SNs: 1M2403190019-06.A3L, 1M2403190019-08.A3L, 1M2403190019-10.A3L for 802.11ax/be RU/MRU output powers.

This device supports channel 1-13 for 2.4 GHz WLAN. However, because channel 12/13 targets are not higher than that of channels 1-11, channels 1, 6, and 11 were considered for SAR testing per FCC KDB 248227 D01V02r02.

Per FCC guidance, SAR was performed using 6.5 GHz SAR probe calibration factors. FCC KDB 648474 and FCC KDB 248227 were followed for test positions, distances, and modes. Per TCB workshop October 2020 notes, 5 channels were tested. Absorbed power density (APD) using a 4cm2 averaging area is reported based on SAR measurements. Incident power density is evaluated at 2mm ensuring that the resolution is sufficient such that integrated power density (iPD) between d=2mm and d=λ/5mm is ≥ -1dB per equipment manufacturer guidance. Power density results are scaled up for uncertainty above 30%.

1.6 Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (SAR Considerations for 802.11 Devices)
- FCC KDB Publication 447498 D04v01 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)
- April 2019 TCB Workshop Notes (IEEE 802.11ax/be)
- FCC KDB 648474 D04 (Accessories)
- FCC KDB Publication 616217 D04v01r02 (Laptop)
- IEC 62479:2010
- SPEAG DASY6 System Handbook
- IEC/IEEE 63195-1:2022
- SPEAG DASY6 Application Note (Interim Procedures for Devices Operating at 6-10 GHz) (Nov 2021)
- November 2017, October 2018, April 2019, November 2019, October 2020 TCBC Workshop Notes

1.7 Device Serial Numbers

Several samples with identical hardware were used to support SAR testing. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units. The serial numbers used for each test are indicated alongside the results in Section 9 and Section 10.

2 INTRODUCTION

The FCC and Innovation, Science, and Economic Development Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices. [1]

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [3] and Health Canada RF Exposure Guidelines Safety Code 6 [22]. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave [4] is used for guidance in measuring the Specific Absorption Rate (SAR) due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the International Committee for Non-Ionizing Radiation Protection (ICNIRP) in Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," Report No. Vol 74. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

2.1 SAR Definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dU) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ). It is also defined as the rate of RF energy absorption per unit mass at a point in an absorbing body (see Equation 2-1).

Equation 2-1
SAR Mathematical Equation

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

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

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

where:

σ = conductivity of the tissue-simulating material (S/m)
ρ = mass density of the tissue-simulating material (kg/m^3)
E = Total RMS electric field strength (V/m)

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relation to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.[6]

3 DOSIMETRIC ASSESSMENT

3.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

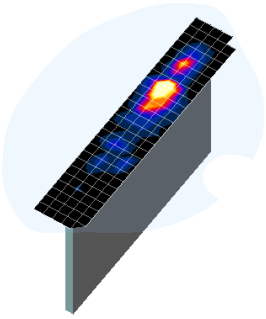

Figure 3-1
Sample SAR Area Scan

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 3-1) and IEEE 1528-2013.
2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.
3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 3-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):

   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).

   b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.

   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

Table 3-1
Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04*

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

*Also compliant to IEEE 1528-2013 Table 6

4 TEST CONFIGURATION POSITIONS

4.1 Device Holder

The device holder is made out of low-loss POM material having the following dielectric parameters: relative permittivity ε = 3 and loss tangent δ = 0.02.

4.2 SAR Testing for Laptop per KDB Publication 616217 D04v01r02

Per FCC KDB Publication 616217 D04v01r02, When antennas are incorporated in the keyboard section of a laptop computer, SAR is required for the bottom surface of the keyboard. The SAR Exclusion Threshold in KDB 447498 D04v01 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent laptop edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

5 RF EXPOSURE LIMITS

5.1 Uncontrolled Environment

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

5.2 Controlled Environment

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

5.3 RF Exposure Limits for Frequencies Below 6 GHz

Table 5-1
SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6

HUMAN EXPOSURE LIMITS		
	UNCONTROLLED ENVIRONMENT *General Population* (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT *Occupational* (W/kg) or (mW/g)
Peak Spatial Average SAR Head	1.6	8.0
Whole Body SAR	0.08	0.4
Peak Spatial Average SAR Hands, Feet, Ankle, Wrists, etc.	4.0	20

1. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The Spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

5.4 RF Exposure Limits for Frequencies Above 6 GHz

Per §1.1310 (d)(3), the MPE limits are applied for frequencies above 6 GHz. Power Density is expressed in units of W/m^2 or mW/cm^2.

Peak Spatially Averaged Power Density was evaluated over a circular area of 4 cm^2 per interim FCC Guidance for near-field power density evaluations per October 2018 TCB Workshop notes.

Table 5-2
Human Exposure Limits Specified in FCC 47 CFR §1.1310

Human Exposure to Radiofrequency (RF) Radiation Limits		
Frequency Range [MHz]	**Power Density** [mW/cm^2]	**Average Time** [Minutes]
(A) Limits For Occupational / Controlled Environments		
1,500 – 100,000	5.0	6
(B) Limits For General Population / Uncontrolled Environments		
1,500 – 100,000	1.0	30

Note: 1.0 mW/cm^2 is 10 W/m^2

6 FCC MEASUREMENT PROCEDURES

Power measurements for licensed transmitters are performed using a base station simulator under digital average power.

6.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D04v01, when SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as *reported* SAR. The highest *reported* SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

6.2 SAR Testing with 802.11 Transmitters

The normal network operating configurations of 802.11 transmitters are not suitable for SAR measurements. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227 D01v02r02 for more details.

6.2.1 General Device Setup

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters.

A periodic duty factor is required for current generation SAR systems to measure SAR. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

6.2.2 U-NII-1 and U-NII-2A

For devices that operate in both U-NII-1 and U-NII-2A bands, when the same maximum output power is specified for both bands, SAR measurement using OFDM SAR test procedures is not required for U-NII-1 unless the highest reported SAR for U-NII-2A is > 1.2 W/kg. When different maximum output powers are specified for the bands, SAR measurement for the U-NII band with the lower maximum output power is not required unless the highest reported SAR for the U-NII band with the higher maximum output power, adjusted by the ratio of lower to higher specified maximum output power for the two bands, is > 1.2 W/kg. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.2.3 U-NII-2C and U-NII-3

The frequency range covered by U-NII-2C and U-NII-3 is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. When Terminal Doppler Weather Radar (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification. Unless band gap channels are permanently disabled, SAR must be considered for these channels. Each band is tested independently according to the normally required OFDM SAR measurement and probe calibration frequency points requirements.

6.2.4 2.4 GHz SAR Test Requirements

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

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

2) When the reported SAR is > 0.8 W/kg, SAR is required for that position using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11 g/n/ax OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power, is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.2.5 OFDM Transmission Mode and SAR Test Channel Selection

When the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11a, 802.11n and 802.11ac or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 802.11n and 802.11ac or 802.11g then 802.11n, is used for SAR measurement. Per April 2019 TCB Workshop guidance, 802.11ax was considered the highest order 802.11 mode. When the maximum output power are the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

6.2.6 Subsequent Test Configuration Procedures

For OFDM configurations in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure. When the highest reported SAR (for the initial test configuration), adjusted by the ratio of the specified maximum output power of the subsequent test configuration to initial test configuration, is ≤ 1.2 W/kg, no additional SAR tests for the subsequent test configurations are required. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.2.7 MIMO SAR considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provisions in KDB Publication 447498 D04v01 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is <1.6 W/kg, no additional SAR measurements for MIMO are required. Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

7 RF CONDUCTED POWERS

7.1 WLAN Conducted Powers

Table 7-1
2.4 GHz WLAN Maximum Average RF Power – Antenna 1

2.4GHz WIFI (20MHz 802.11b SISO ANT 1)			
Freq. [MHz]	**Channel**	**Detector**	**Conducted Power [dBm]**
2412	1	Average	14.35
2437	6		14.23
2462	11		14.12
2.4GHz WIFI (20MHz 802.11g SISO ANT 1)			
Freq. [MHz]	**Channel**	**Detector**	**Conducted Power [dBm]**
2412	1	Average	14.36
2437	6		14.01
2462	11		14.17
2.4GHz WIFI (20MHz 802.11n SISO ANT 1)			
Freq. [MHz]	**Channel**	**Detector**	**Conducted Power [dBm]**
2412	1	Average	14.44
2437	6		14.13
2462	11		14.13
2.4GHz WIFI (20MHz 802.11ax SISO ANT 1)			
Freq. [MHz]	**Channel**	**Detector**	**Conducted Power [dBm]**
2412	1	Average	14.39
2437	6		14.48
2462	11		14.04
2.4GHz WIFI (20MHz 802.11be SISO ANT 1)			
Freq. [MHz]	**Channel**	**Detector**	**Conducted Power [dBm]**
2412	1	Average	14.49
2437	6		14.11
2462	11		14.15

Table 7-2
2.4 GHz WLAN Maximum Average RF Power – MIMO

2.4GHz WIFI (20MHz 802.11b MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT0	ANT1	MIMO
2412	1	Average	14.64	14.17	17.42
2437	6		14.06	14.09	17.09
2462	11		14.05	14.03	17.05
2.4GHz WIFI (20MHz 802.11g MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT0	ANT1	MIMO
2412	1	Average	14.70	14.36	17.54
2437	6		14.75	14.53	17.65
2462	11		14.13	14.08	17.12
2.4GHz WIFI (20MHz 802.11n MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT0	ANT1	MIMO
2412	1	Average	14.76	14.51	17.65
2437	6		14.21	14.02	17.13
2462	11		14.18	14.13	17.17
2.4GHz WIFI (20MHz 802.11ax MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT0	ANT1	MIMO
2412	1	Average	14.77	14.42	17.61
2437	6		14.15	14.01	17.09
2462	11		14.15	14.12	17.15
2.4GHz WIFI (20MHz 802.11be MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT0	ANT1	MIMO
2412	1	Average	14.68	14.49	17.60
2437	6		14.22	14.04	17.14
2462	11		14.27	14.20	17.25

Table 7-3
5 GHz WLAN Maximum Average RF Power – MIMO

5GHz WIFI (80MHz 802.11ac MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT0	ANT1	MIMO
UNII-1	5210	42	11.15	10.88	14.03
UNII-2A	5290	58	11.49	11.16	14.34
UNII-2C	5530	106	11.54	10.64	14.12
	5610	122	11.53	10.75	14.17
	5690	138	11.75	10.64	14.24
UNII-3	5775	155	11.55	11.01	14.30
UNII-4	5885	171	11.57	11.34	14.47
5GHz WIFI (80MHz 802.11ax MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT0	ANT1	MIMO
UNII-1	5210	42	11.16	11.20	14.19
UNII-2A	5290	58	11.03	11.01	14.03
UNII-2C	5530	106	11.74	11.01	14.40
	5610	122	11.67	11.01	14.36
	5690	138	11.99	11.02	14.54
UNII-3	5775	155	11.81	11.15	14.50
UNII-4	5885	171	11.31	11.01	14.17
5GHz WIFI (80MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT0	ANT1	MIMO
UNII-1	5210	42	11.29	11.19	14.25
UNII-2A	5290	58	11.05	11.05	14.06
UNII-2C	5530	106	11.78	11.01	14.42
	5610	122	11.73	11.03	14.40
	5690	138	11.46	11.04	14.27
UNII-3	5775	155	11.84	11.18	14.53
UNII-4	5885	171	11.34	11.01	14.19

Table 7-4
6 GHz WLAN Maximum Average RF Power - MIMO

6GHz WIFI (80MHz 802.11ax MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT0	ANT1	MIMO
UNII-5	5985	7	8.19	8.91	11.58
	6305	71	7.65	8.58	11.15
UNII-6	6465	103	8.46	8.61	11.55
UNII-7	6705	151	8.17	8.52	11.36
UNII-8	7025	215	7.75	8.31	11.05
6GHz WIFI (80MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT0	ANT1	MIMO
UNII-5	5985	7	8.41	8.98	11.71
	6305	71	7.70	8.64	11.21
UNII-6	6465	103	8.59	8.69	11.65
UNII-7	6705	151	8.20	8.55	11.39
UNII-8	7025	215	8.06	8.99	11.56

Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, due to an even number of channels, both channels were measured.

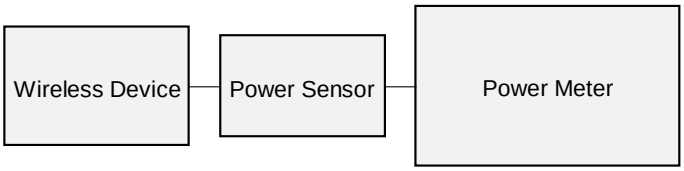

Figure 7-1
Power Measurement Setup

7.2 Bluetooth Conducted Powers

Table 7-5
Bluetooth Maximum Average RF Power – Antenna 0

Frequency [MHz]	Data Rate [Mbps]	Mod.	Power Scheme	Channel No.	Avg Conducted Power	
					[dBm]	[mW]
2402	1.0	GFSK	ePA	0	16.12	40.926
2441	1.0	GFSK	ePA	39	16.57	45.394
2480	1.0	GFSK	ePA	78	17.10	51.286
2402	2.0	π/4-DQPSK	ePA	0	13.30	21.380
2441	2.0	π/4-DQPSK	ePA	39	13.79	23.933
2480	2.0	π/4-DQPSK	ePA	78	14.13	25.882
2402	3.0	8DPSK	ePA	0	13.23	21.038
2441	3.0	8DPSK	ePA	39	13.81	24.044
2480	3.0	8DPSK	ePA	78	14.15	26.002

Table 7-6
Bluetooth Maximum Average RF Power – Antenna 1

Frequency [MHz]	Data Rate [Mbps]	Mod.	Power Scheme	Channel No.	Avg Conducted Power	
					[dBm]	[mW]
2402	1.0	GFSK	ePA	0	16.26	42.267
2441	1.0	GFSK	ePA	39	17.00	50.119
2480	1.0	GFSK	ePA	78	17.00	50.119
2402	2.0	π/4-DQPSK	ePA	0	13.44	22.080
2441	2.0	π/4-DQPSK	ePA	39	14.21	26.363
2480	2.0	π/4-DQPSK	ePA	78	14.26	26.669
2402	3.0	8DPSK	ePA	0	13.49	22.336
2441	3.0	8DPSK	ePA	39	14.19	26.242
2480	3.0	8DPSK	ePA	78	14.29	26.853

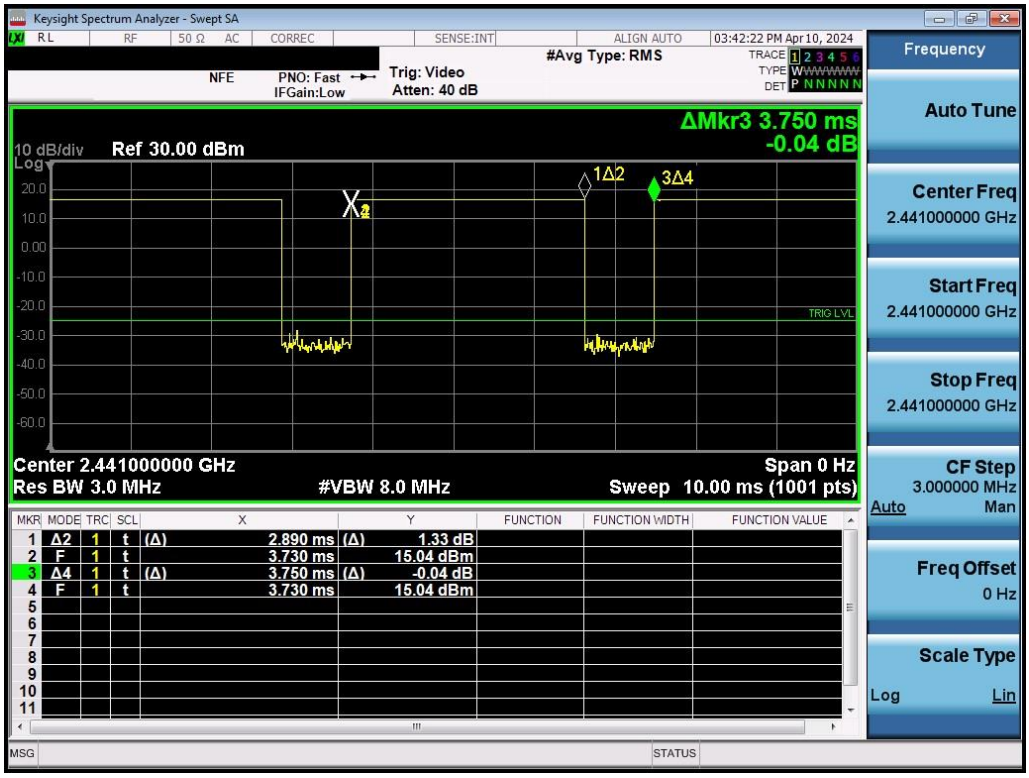

Figure 7-2
Bluetooth Transmission Plot – Antenna 0

Equation 7-1
Bluetooth Antenna 0 Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{2.89ms}{3.75ms} * 100\% = 77.07\%$$

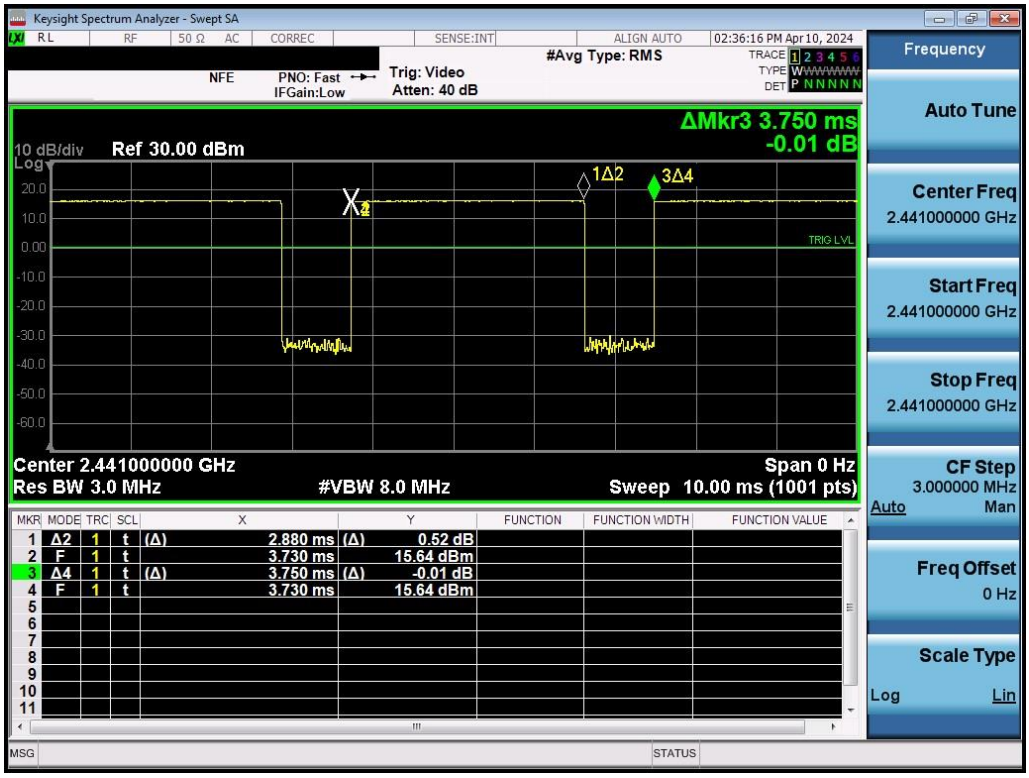

Figure 7-3
Bluetooth Transmission Plot – Antenna 1

Equation 7-2
Bluetooth Antenna 1 Duty Cycle Calculation

$$\boldsymbol{Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{2.88ms}{3.75ms} * 100\% = 76.80\%}$$

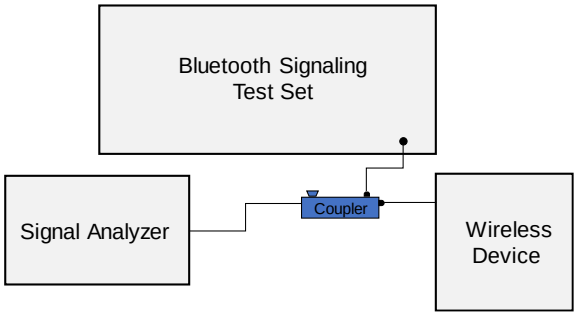

Figure 7-4
Power Measurement Setup

8 SYSTEM VERIFICATION

8.1 Tissue Verification

Table 8-1
Measured Head Tissue Properties

Calibrated for Tests Performed on:	Tissue Type	Tissue Temp During Calibration (°C)	Measured Frequency (MHz)	Measured Conductivity, σ (S/m)	Measured Dielectric Constant, ε	TARGET Conductivity, σ (S/m)	TARGET Dielectric Constant, ε	% dev σ	% dev ε
04/11/2024	2450 Head	21.1	2300	1.695	40.288	1.670	39.500	1.50%	1.99%
			2310	1.703	40.271	1.679	39.480	1.43%	2.00%
			2320	1.711	40.251	1.687	39.460	1.42%	2.00%
			2400	1.771	40.112	1.756	39.289	0.85%	2.09%
			2450	1.807	40.025	1.800	39.200	0.39%	2.10%
			2480	1.827	39.980	1.833	39.162	-0.33%	2.09%
			2500	1.842	39.945	1.855	39.136	-0.70%	2.07%
			2510	1.850	39.931	1.866	39.123	-0.86%	2.07%
			2535	1.870	39.896	1.893	39.092	-1.22%	2.06%
			2550	1.881	39.879	1.909	39.073	-1.47%	2.06%
			2560	1.889	39.868	1.920	39.060	-1.61%	2.07%
			2600	1.922	39.813	1.964	39.009	-2.14%	2.06%
			2650	1.966	39.736	2.018	38.945	-2.58%	2.03%
			2680	1.991	39.683	2.051	38.907	-2.93%	1.99%
			2700	2.008	39.645	2.073	38.882	-3.14%	1.96%
04/18/2024	2450 Head	19.7	2300	1.701	40.074	1.670	39.500	1.86%	1.45%
			2310	1.710	40.058	1.679	39.480	1.85%	1.46%
			2320	1.718	40.049	1.687	39.460	1.84%	1.49%
			2400	1.779	39.932	1.756	39.289	1.31%	1.64%
			2450	1.822	39.855	1.800	39.200	1.22%	1.67%
			2480	1.845	39.822	1.833	39.162	0.65%	1.69%
			2500	1.860	39.778	1.855	39.136	0.27%	1.64%
			2510	1.867	39.752	1.866	39.123	0.05%	1.61%
			2535	1.888	39.689	1.893	39.092	-0.26%	1.53%
			2550	1.902	39.666	1.909	39.073	-0.37%	1.52%
			2560	1.911	39.653	1.920	39.060	-0.47%	1.52%
			2600	1.943	39.599	1.964	39.009	-1.07%	1.51%
			2650	1.982	39.478	2.018	38.945	-1.78%	1.37%
			2680	2.010	39.439	2.051	38.907	-2.00%	1.37%
			2700	2.027	39.425	2.073	38.882	-2.22%	1.40%
04/01/2024	5200-5800 Head	20.9	5180	4.480	35.224	4.635	36.009	-3.34%	-2.18%
			5190	4.492	35.207	4.645	35.998	-3.29%	-2.20%
			5200	4.506	35.186	4.655	35.986	-3.20%	-2.22%
			5210	4.518	35.164	4.666	35.975	-3.17%	-2.25%
			5220	4.529	35.140	4.676	35.963	-3.14%	-2.29%
			5240	4.551	35.118	4.696	35.940	-3.09%	-2.29%
			5250	4.562	35.114	4.706	35.929	-3.06%	-2.27%
			5260	4.570	35.099	4.717	35.917	-3.12%	-2.28%
			5270	4.577	35.071	4.727	35.906	-3.17%	-2.33%
			5280	4.587	35.034	4.737	35.894	-3.17%	-2.40%
			5290	4.599	35.007	4.748	35.883	-3.14%	-2.44%
			5300	4.615	34.987	4.758	35.871	-3.01%	-2.46%
			5310	4.631	34.979	4.768	35.860	-2.87%	-2.46%
			5320	4.642	34.974	4.778	35.849	-2.85%	-2.44%
			5500	4.844	34.662	4.963	35.643	-2.40%	-2.75%
			5510	4.854	34.653	4.973	35.632	-2.39%	-2.75%
			5520	4.859	34.641	4.983	35.620	-2.49%	-2.75%
			5530	4.866	34.622	4.994	35.609	-2.56%	-2.77%
			5540	4.876	34.593	5.004	35.597	-2.56%	-2.82%
			5550	4.891	34.559	5.014	35.586	-2.45%	-2.89%
			5560	4.906	34.531	5.024	35.574	-2.35%	-2.93%
			5580	4.933	34.508	5.045	35.551	-2.22%	-2.93%
			5600	4.952	34.491	5.065	35.529	-2.23%	-2.92%
			5610	4.961	34.474	5.076	35.518	-2.27%	-2.94%
			5620	4.971	34.444	5.086	35.506	-2.26%	-2.99%
			5640	4.995	34.391	5.106	35.483	-2.17%	-3.08%
			5660	5.023	34.367	5.127	35.460	-2.03%	-3.08%
			5670	5.034	34.353	5.137	35.449	-2.01%	-3.09%
			5680	5.042	34.339	5.147	35.437	-2.04%	-3.10%
			5690	5.050	34.323	5.158	35.426	-2.09%	-3.11%
			5700	5.059	34.304	5.168	35.414	-2.11%	-3.13%
			5710	5.073	34.289	5.178	35.403	-2.03%	-3.15%
			5720	5.085	34.264	5.188	35.391	-1.99%	-3.18%
			5745	5.113	34.210	5.214	35.363	-1.94%	-3.26%
			5750	5.121	34.204	5.219	35.357	-1.88%	-3.26%
			5755	5.129	34.203	5.224	35.351	-1.82%	-3.25%
			5765	5.143	34.198	5.234	35.340	-1.74%	-3.23%
			5775	5.150	34.184	5.245	35.329	-1.81%	-3.24%
			5785	5.157	34.162	5.255	35.317	-1.86%	-3.27%
			5795	5.168	34.140	5.265	35.305	-1.84%	-3.30%
			5800	5.174	34.124	5.270	35.300	-1.82%	-3.33%
			5800	5.174	34.124	5.270	35.300	-1.82%	-3.33%
			5805	5.180	34.110	5.275	35.294	-1.80%	-3.35%
			5825	5.205	34.076	5.296	35.271	-1.72%	-3.39%
			5835	5.218	34.059	5.305	35.230	-1.64%	-3.32%
			5845	5.228	34.048	5.315	35.210	-1.64%	-3.30%
			5850	5.233	34.044	5.320	35.200	-1.64%	-3.28%
			5855	5.237	34.039	5.325	35.197	-1.65%	-3.29%
			5865	5.246	34.025	5.336	35.190	-1.69%	-3.31%
			5865	5.246	34.025	5.336	35.190	-1.69%	-3.31%
			5865	5.246	34.025	5.336	35.190	-1.69%	-3.31%
			5865	5.246	34.025	5.336	35.190	-1.69%	-3.31%
			5875	5.259	34.000	5.347	35.183	-1.65%	-3.36%
			5885	5.273	33.974	5.357	35.177	-1.57%	-3.42%
			5905	5.292	33.948	5.379	35.163	-1.62%	-3.46%
04/08/2024	6000 Head	20.1	5935	5.470	34.241	5.411	35.143	1.09%	-2.57%
			5970	5.512	34.170	5.448	35.120	1.17%	-2.71%
			5985	5.522	34.147	5.464	35.110	1.06%	-2.74%
			6000	5.554	34.127	5.480	35.100	1.35%	-2.77%
			6025	5.602	34.162	5.510	35.070	2.21%	-2.59%
			6065	5.660	34.087	5.557	35.022	1.85%	-2.67%
			6075	5.654	34.020	5.569	35.010	1.53%	-2.83%
			6085	5.666	33.990	5.580	34.998	1.54%	-2.88%
			6185	5.795	33.842	5.698	34.878	1.70%	-2.97%
			6275	5.927	33.633	5.805	34.770	2.10%	-3.27%
			6285	5.922	33.640	5.816	34.758	1.82%	-3.22%
			6305	5.949	33.590	5.840	34.734	1.87%	-3.29%
			6345	6.021	33.480	5.887	34.686	2.28%	-3.48%
			6475	6.179	33.252	6.041	34.530	1.89%	-4.93%
			6485	6.206	33.267	6.052	34.518	2.54%	-3.62%
			6500	6.208	33.245	6.070	34.500	2.27%	-3.64%
			6505	6.202	33.247	6.076	34.494	2.07%	-3.62%
			6545	6.248	33.051	6.122	34.446	2.06%	-4.05%
			6665	6.379	32.887	6.265	34.302	1.82%	-4.13%
			6675	6.404	32.844	6.273	34.290	2.09%	-4.22%
			6685	6.423	32.811	6.285	34.278	2.20%	-4.28%
			6715	6.455	32.865	6.319	34.242	2.15%	-4.02%
			6785	6.533	32.633	6.400	34.158	2.08%	-4.46%
			6825	6.591	32.626	6.447	34.110	2.23%	-4.35%
			6985	6.748	32.409	6.633	33.918	1.73%	-4.45%
			6995	6.747	32.367	6.644	33.906	1.55%	-4.54%
			7000	6.751	32.330	6.650	33.900	1.52%	-4.63%
			7005	6.760	32.299	6.656	33.894	1.56%	-4.71%
			7025	6.806	32.200	6.680	33.870	1.89%	-4.93%

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB Publication 865664 D01v01r04 and IEEE 1528-2013 6.6.1.2. The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

8.2 Test System Verification

Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in the SAR System Validation Appendix.

Table 8-2
System Verification Results

SAR System	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp. (C)	Liquid Temp. (C)	Input Power (W)	Source SN	Probe SN	DAE	Measured SAR 1g (W/kg)	1W Target SAR 1g (W/kg)	1W Normalized SAR 1g (W/kg)	Deviation 1g (%)	Measured SAR 10g (W/kg)	1W Target SAR 10g (W/kg)	1W Normalized SAR 10g (W/kg)	Deviation 10g (%)	Measured APD 4 cm² (W/m²)	1W Target APD 4 cm² (W/m²)	1W Normalized APD 4 cm²	Deviation APD 4 cm² (%)
K2	2450	HEAD	04/11/2024	20.7	21.1	0.10	882	7547	1322	5.200	53.000	52.000	-1.89%	2.430	24.900	24.300	-2.41%	N/A	N/A	N/A	N/A
O	2450	HEAD	04/18/2024	21.3	19.7	0.10	719	7803	1533	5.250	55.000	52.500	-4.55%	2.450	25.700	24.500	-4.67%	N/A	N/A	N/A	N/A
O	5250	HEAD	04/01/2024	22.3	20.9	0.05	1057	7803	1533	3.820	79.400	76.400	-3.78%	1.100	22.700	22.000	-3.08%	N/A	N/A	N/A	N/A
O	5600	HEAD	04/01/2024	22.3	20.9	0.05	1057	7803	1533	4.050	82.800	81.000	-2.17%	1.160	23.600	23.200	-1.69%	N/A	N/A	N/A	N/A
O	5750	HEAD	04/01/2024	22.3	20.9	0.05	1057	7803	1533	3.670	79.800	73.400	-8.02%	1.050	22.700	21.000	-7.49%	N/A	N/A	N/A	N/A
O	5850	HEAD	04/01/2024	22.3	20.9	0.05	1057	7803	1533	3.820	81.500	76.400	-6.62%	1.070	23.000	21.400	-6.96%	N/A	N/A	N/A	N/A
R	6500	HEAD	04/08/2024	20.5	19.7	0.03	1018	7410	1638	7.670	293.000	306.800	4.71%	1.420	53.900	56.800	5.38%	34.5	1310	1380	5.37%

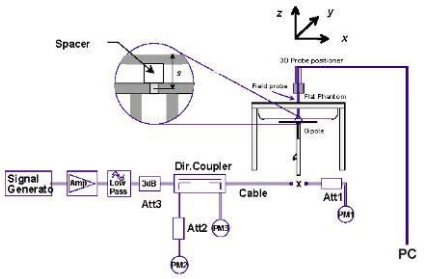

Figure 8-1
System Verification Setup Diagram

Figure 8-2
System Verification Setup Photo

8.3 Power Density Test System Verification

The system was verified to be within ±0.66 dB of the power density targets on the calibration certificate according to the test system specification in the user's manual and calibration facility recommendation. The 0.66 dB deviation threshold represents the expanded uncertainty for system performance checks using SPEAG's mmWave verification sources. The same spatial resolution and measurement region used in the source calibration was applied during the system check.

The measured power density distribution of verification source was also confirmed through visual inspection to have no noticeable differences, both spatially (shape) and numerically (level) from the distribution provided by the manufacturer, per November 2017 TCBC Workshop Notes.

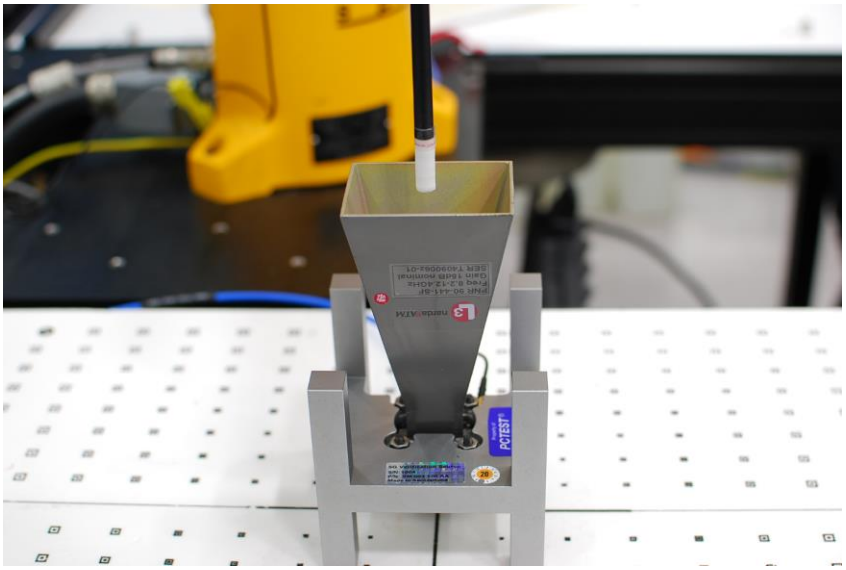

Figure 8-3
System Verification Setup Photo

Table 8-3
10 GHz Verifications

System Verification											
System	Frequency (GHz)	Date	Source S/N	Probe S/N	Prad (mW)	Normal psPD (W/m² over 4 cm²)		Deviation (dB)	Total psPD (W/m² over 4 cm²)		Deviation (dB)
						Measured	Target		Measured	Target	
Q	10	04/08/2024	1002	9622	93.3	52.20	54.60	-0.20	52.50	54.90	-0.19

Note: A **10 mm distance spacing** was used from the reference horn antenna aperture to the probe element.

9 SAR DATA SUMMARY

9.1 2.4 GHz WLAN SISO Standalone SAR

Table 9-1
2.4 GHz WLAN Antenna 1 Body

Exposure	Band / Mode	Bandwidth [MHz]	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate [Mbps]	Max Allowed Power [dBm]	Conducted Power [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	2.4 GHz WIFI/ IEEE 802.11b	22	DSSS	1	0041K	99.85	-0.06	2412.00	1	1	15.0	14.35	Bottom	0	0.445	1.161	1.002	0.518	A1
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population													Body 1.6 W/kg (mW/g) averaged over 1 gram						

Table 9-2
2.4 GHz WLAN MIMO Body

Exposure	Band / Mode	Bandwidth [MHz]	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate [Mbps]	Max Allowed Power [dBm]	Conducted Power [dBm]	Max Allowed Power (2nd ant) [dBm]	Conducted Power (2nd ant) [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	2.4 GHz WIFI/ IEEE 802.11b	22	DSSS	MIMO	00041K	99.85	0.01	2412.00	1	1	15.0	14.64	15.0	14.17	Bottom	0	0.362	1.211	1.002	0.439	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population															Body 1.6 W/kg (mW/g) averaged over 1 gram						

Note: To achieve the 18 dBm maximum allowed MIMO power shown in the documentation, each antenna transmits at a maximum allowed power of 15 dBm.

9.2 5 GHz WLAN Standalone SAR

Table 9-3
5 GHz WLAN MIMO Body

Exposure	Band / Mode	Bandwidth [MHz]	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	U-NII band	Data Rate [Mbps]	Max Allowed Power [dBm]	Conducted Power [dBm]	Max Allowed Power (2nd ant) [dBm]	Conducted Power (2nd ant) [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	5 GHz WIFI/ IEEE 802.11ac	80	OFDM	MIMO	0015V	99.67	0.03	5290.00	58	U-NII-2A	58.5	12.0	11.49	12.0	11.16	Bottom	0	0.375	1.213	1.003	0.456	
Body	5 GHz WIFI/ IEEE 802.11ac	80	OFDM	MIMO	0015V	99.67	-0.12	5690.00	138	U-NII-2C	58.5	12.0	11.75	12.0	10.64	Bottom	0	0.406	1.368	1.003	0.557	
Body	5 GHz WIFI/ IEEE 802.11ac	80	OFDM	MIMO	0015V	99.67	-0.17	5775.00	155	U-NII-3	58.5	12.0	11.55	12.0	11.01	Bottom	0	0.408	1.256	1.003	0.514	
Body	5 GHz WIFI/ IEEE 802.11ac	80	OFDM	MIMO	0015V	99.67	-0.11	5855.00	171	U-NII-4	58.5	12.0	11.57	12.0	11.34	Bottom	0	0.480	1.164	1.003	0.560	A2
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population																Body 1.6 W/kg (mW/g) averaged over 1 gram						

Note: To achieve the 15 dBm maximum allowed MIMO power shown in the documentation, each antenna transmits at a maximum allowed power of 12 dBm.

9.3 6 GHz Standalone SAR and APD

Table 9-4
6 GHz WLAN MIMO Body

Exposure	Band / Mode	Bandwidth [MHz]	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate	Max Allowed Power [dBm]	Conducted Power [dBm]	Max Allowed Power (2nd ant) [dBm]	Conducted Power (2nd ant) [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.11	5985.00	7	MCS0	9.0	8.19	9.0	8.91	Bottom	0	0.361	1.205	1.003	0.436	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.03	6305.00	71	MCS0	9.0	7.65	9.0	8.58	Bottom	0	0.430	1.365	1.003	0.589	A3
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.06	6465.00	103	MCS0	9.0	8.46	9.0	8.61	Bottom	0	0.327	1.132	1.003	0.371	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	-0.18	6705.00	151	MCS0	9.0	8.17	9.0	8.52	Bottom	0	0.365	1.211	1.003	0.443	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.07	7025.00	215	MCS0	9.0	7.75	9.0	8.31	Bottom	0	0.291	1.334	1.003	0.389	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population															Body 1.6 W/kg (mW/g) averaged over 1 gram						

Note: To achieve the 12 dBm maximum allowed MIMO power shown in the documentation, each antenna transmits at a maximum allowed power of 9 dBm.

Exposure	Band/ Mode	Bandwidth [MHz]	Service/ Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate	Max Allowed Power [dBm]	Conducted Power [dBm]	Max Allowed Power (2nd ant) [dBm]	Conducted Power (2nd ant) [dBm]	Test Position	Spacing [mm]	Measured APD [W/m² (4cm²)]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported APD [W/m² (4cm²)]	Plot #
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.11	5985.00	7	MCS0	9.0	8.19	9.0	8.91	Bottom	0	2.100	1.205	1.003	2.538	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.03	6305.00	71	MCS0	9.0	7.65	9.0	8.58	Bottom	0	2.660	1.365	1.003	3.642	A3
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.06	6465.00	103	MCS0	9.0	8.46	9.0	8.61	Bottom	0	1.900	1.132	1.003	2.157	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	-0.18	6705.00	151	MCS0	9.0	8.17	9.0	8.52	Bottom	0	2.290	1.211	1.003	2.782	
Body	6 GHz WIFI/ IEEE 802.11ax	80	OFDM	MIMO	0407A	99.69	0.07	7025.00	215	MCS0	9.0	7.75	9.0	8.31	Bottom	0	1.890	1.334	1.003	2.529	

9.4 Bluetooth SISO Standalone SAR

Table 9-5
Bluetooth Antenna 0 Body

Exposure	Band / Mode	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate [Mbps]	Max Allowed Power [dBm]	Conducted Power [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	2.4 GHz Bluetooth	FHSS	0	0032M	77.07	0.01	2480.00	78	1	17.5	17.10	Bottom	0	0.380	1.096	1.025	0.427	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Body 1.6 W/kg (mW/g) averaged over 1 gram						

Table 9-6
Bluetooth Antenna 1 Body

Exposure	Band / Mode	Service / Modulation	Ant.	Serial Number	Duty Cycle [%]	Power Drift [dB]	Frequency [MHz]	Channel #	Data Rate [Mbps]	Max Allowed Power [dBm]	Conducted Power [dBm]	Test Position	Spacing [mm]	Measured 1g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 1g SAR [W/kg]	Plot #
Body	2.4 GHz Bluetooth	FHSS	1	0032M	76.80	-0.01	2441.00	39	1	17.5	17.00	Bottom	0	0.411	1.122	1.016	0.469	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Body 1.6 W/kg (mW/g) averaged over 1 gram						

9.5 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, FCC KDB Publication 447498 D04v01, and FCC KDB Publication 616217 D04v01r02.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D04v01.
6. Per FCC KDB Publication 865664 D01v01r04, variability SAR tests were not required since measured SAR results for all frequency bands were less than 0.8 W/kg. Please see Section 11 for variability analysis.
7. FCC KDB Publication 616217 D04v01r02 Section 4.2, When antennas are incorporated in the keyboard section of a laptop computer, SAR is required for the bottom surface of the keyboard. Provided tablet use conditions are not supported by the laptop computer, SAR tests for bystander exposure from the edges of the keyboard and display screen of laptop computers are generally not required. The SAR Exclusion Threshold in FCC KDB 447498 D04v01 was applied to determine SAR test exclusion for adjacent edge configurations.
8. The orange highlights throughout the report represent the highest scaled SAR per Equipment Class.

WLAN Notes:

1. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n/ax/be) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 6.2.4 for more information.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg for 1g evaluations. See Section 6.2.5 for more information.

3. Per KDB Publication 248227 D01v02r02, SAR for MIMO was evaluated by following the simultaneous SAR provisions from KDB Publication 447498 D04v01 by either evaluating the sum of the 1g SAR values of each antenna transmitting independently or making a SAR measurement with both antennas transmitting simultaneously. Please see the Multi-Tx and Antenna SAR Considerations Appendix for complete analysis.
4. When the maximum reported 1g averaged SAR is ≤0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg for 1g evaluations or all test channels were measured.
5. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools. The reported SAR was scaled to the 100% transmission duty factor to determine compliance. Procedures used to measure the duty factor are identical to that in the associated EMC test reports.
6. Per FCC guidance, SAR was performed using 6.5 GHz SAR probe calibration factors. Per October 2020 TCB Workshop notes, 5 channels were tested.

Bluetooth Notes

1. Bluetooth SAR was measured with the device connected to a call box with hopping disabled with DH5 operation and Tx Tests test mode type. Per October 2016 TCB Workshop Notes, the reported SAR was scaled to the 79% transmission duty factor for Bluetooth Antenna 0 and 78% transmission duty factor for Bluetooth Antenna 1 to determine compliance. See RF Conducted Power Section for the time domain plot and calculation for the duty factor of the device.

10 POWER DENSITY DATA SUMMARY

10.1 6 GHz WIFI Power Density Results

Table 10-1
6 GHz WLAN Laptop

MEASUREMENT RESULTS																										
Frequency (MHz)	Channel	Mode	Service	Bandwidth [MHz]	Maximum Allowed Power (Ant 1) [dBm]	Conducted Power (Ant 1) [dBm]	Maximum Allowed Power (Ant 2) [dBm]	Conducted Power (Ant 2) [dBm]	Power Drift (dB)	Spacing (mm)	Antenna Config.	DUT Serial Number	Data Rate (Mbps)	Side	Duty Cycle (%)	Grid Step (λ)	iPD (W/m²)	Scaling Factor for Measurement Uncertainty per IEC 62479	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Normal psPD (W/m²)	Scaled Normal psPD (W/m²)	Total psPD (W/m²)	Scaled Total psPD (W/m²)	Plot #
5985.00	7	802.11ax	OFDM	80	9.00	8.19	9.00	8.91	0.20	2	MIMO	0716P	MCS0	Bottom	99.69	0.125	2.030	1.554	1.205	1.003	2.390	4.489	2.680	5.034	A5
5985.00	7	802.11ax	OFDM	80	9.00	8.19	9.00	8.91	0.16	10.02	MIMO	0716P	MCS0	Bottom	99.69	0.125	0.886	1.554	1.205	1.003	0.632	1.187	0.687	1.290	
6305.00	71	802.11ax	OFDM	80	9.00	7.65	9.00	8.58	-0.14	2	MIMO	0716P	MCS0	Bottom	99.69	0.125	-	1.554	1.365	1.003	2.380	5.064	2.590	5.510	
6465.00	103	802.11ax	OFDM	80	9.00	8.46	9.00	8.61	0.03	2	MIMO	0716P	MCS0	Bottom	99.69	0.125	-	1.554	1.132	1.003	1.570	2.770	1.860	3.282	
6705.00	151	802.11ax	OFDM	80	9.00	8.17	9.00	8.52	-0.10	2	MIMO	0716P	MCS0	Bottom	99.69	0.125	-	1.554	1.211	1.003	1.970	3.718	2.320	4.379	
7025.00	215	802.11ax	OFDM	80	9.00	7.75	9.00	8.31	-0.12	2	MIMO	0716P	MCS0	Bottom	99.69	0.125	-	1.554	1.334	1.003	1.120	2.329	1.280	2.661	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population																		Power Density 10 W/m² averaged over 4 cm²							

Power Density General Notes

1. The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
2. Batteries are fully charged at the beginning of the measurements. The DUT was connected to a wall charger for some measurements due to the test duration. It was confirmed that the charger plugged into this DUT did not impact the near-field PD test results.
3. Power density was calculated by repeated E-field measurements on two measurement planes separated by λ/4.
4. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools.
5. Per FCC guidance and equipment manufacturer guidance, power density results were scaled according to IEC 62479:2010 for the portion of the measurement uncertainty > 30%. Total expanded uncertainty of 2.68 dB (85.4%) was used to determine the psPD measurement scaling factor.
6. Per equipment manufacturer guidance, power density was measured at d=2mm and d=λ/5mm using the same grid size and grid step size for some frequencies and surfaces. The integrated Power Density (iPD) was calculated based on these measurements. Since iPD ratio between the two distances is ≥ -1dB, the grid step was sufficient for determining compliance at d=2mm.
7. PTP-PR algorithm was used during psPD measurement and calculations.
8. PD results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D04.
9. Per October 2020 TCB Workshop notes, 5 channels were tested.

11 SAR MEASUREMENT VARIABILITY

11.1 Measurement Variability

FCC KDB Publication 865664 D01v01, SAR measurement variability was not assessed for each frequency band since all measured SAR values are < 0.80 W/kg for 1g SAR and < 2.0 W/kg for 10g SAR.

11.2 Measurement Uncertainty

The measured SAR was <1.5 W/kg for 1g for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

12 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	E4404B	Spectrum Analyzer	N/A	N/A	N/A	MY45113242
Agilent	E4438C	ESG Vector Signal Generator	10/10/2023	Annual	10/10/2024	MY42082659
Agilent	E4438C	ESG Vector Signal Generator	11/15/2023	Annual	11/15/2024	MY45092078
Agilent	N5182A	MXG Vector Signal Generator	11/14/2023	Annual	11/14/2024	US46240505
Agilent	N5182A	MXG Vector Signal Generator	7/4/2023	Annual	7/4/2024	MY48180366
Agilent	8753ES	S-Parameter Vector Network Analyzer	7/21/2023	Annual	7/21/2024	US39170118
Agilent	8753ES	S-Parameter Vector Network Analyzer	1/10/2024	Annual	1/10/2025	MY40001472
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433971
Amplifier Research	150A100C	Amplifier	CBT	N/A	CBT	350132
Anritsu	MN8110B	I/O Adaptor	CBT	N/A	CBT	6261747881
Anritsu	ML2496A	Power Meter	6/15/2023	Annual	6/15/2024	1138001
Anritsu	MA2411B	Pulse Power Sensor	6/14/2023	Annual	6/14/2024	1911105
Anritsu	MA2411B	Pulse Power Sensor	6/15/2023	Annual	6/15/2024	1126066
Anritsu	MA24106A	USB Power Sensor	4/21/2023	Annual	4/21/2024	1349503
Anritsu	MA24106A	USB Power Sensor	10/31/2023	Annual	10/31/2024	1248508
Anritsu	MA24106A	USB Power Sensor	7/4/2023	Annual	7/4/2024	1244512
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/15/2024	Annual	1/15/2025	160574418
Mitutoyo	500-196-30	CD-6"ASX 6Inch Digital Caliper	2/16/2022	Triennial	2/16/2025	A20238413
Keysight Technologies	N6705B	DC Power Analyzer	5/5/2021	Triennial	5/5/2024	MY53004059
Keysight Technologies	N9020A	MXA Signal Analyzer	10/17/2023	Annual	10/17/2024	MY51240479
Keysight Technologies	N9020A	MXA Signal Analyzer	4/6/2023	Annual	4/6/2024	MY48010233
Agilent	N9020A	MXA Signal Analyzer	10/17/2023	Annual	10/17/2024	MY51240479
Mini-Circuits	VLF-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	VLF-6000+	Low Pass Filter DC to 6000 MHz	CBT	N/A	CBT	31634
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	CBT	N/A	CBT	2050
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	7/5/2023	Annual	7/5/2024	2111
Seekonk	TSF-100	Torque Wrench	6/30/2023	Annual	6/30/2024	47639-29
Seekonk	TSF-100	Torque Wrench	6/30/2023	Annual	6/30/2024	47639-1256
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/13/2023	Annual	11/13/2024	1277
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/9/2023	Annual	5/9/2024	1070
SPEAG	DAKS-3.5	Portable Dielectric Assessment Kit	8/14/2023	Annual	8/14/2024	1041
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1379
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1243
SPEAG	5G Verification Source 10GHz	10GHz System Verification Antenna	3/5/2024	Annual	3/5/2025	1002
SPEAG	D2450V2	2450 MHz SAR Dipole	8/18/2021	Triennial	8/18/2024	719
SPEAG	D2450V2	2450 MHz SAR Dipole	2/8/2024	Triennial	2/8/2025	882
SPEAG	D5GHzV2	5 GHz SAR Dipole	2/21/2024	Annual	2/21/2025	1057
SPEAG	D6.5GHzV2	6.5 GHz SAR Dipole	1/10/2024	Annual	1/10/2025	1018
SPEAG	DAE4ip	Dasy Data Acquisition Electronics	10/18/2023	Annual	10/18/2024	1638
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/9/2024	Annual	1/9/2025	1533
SPEAG	DAE4ip	Dasy Data Acquisition Electronics	11/15/2023	Annual	11/15/2024	1639
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/18/2023	Annual	10/18/2024	1322
SPEAG	EX3DV4	SAR Probe	1/11/2024	Annual	1/11/2025	7803
SPEAG	EX3DV4	SAR Probe	7/7/2023	Annual	7/7/2024	7410
SPEAG	EUmmWV4	EUmmWV4 Probe	2/2/2024	Annual	2/2/2025	9622
SPEAG	EX3DV4	SAR Probe	10/23/2023	Annual	10/23/2024	7547

Note: 1) All equipment was used solely within its respective calibration period. 2) CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.

13 MEASUREMENT UNCERTAINTIES

Applicable for SAR Measurements < 6 GHz:

Uncertainty Component	IEEE 1528 Sec.	Tol. (± %)	Prob. Dist.	f(d,k) Div.	c_i 1gm	c_i 10 gms	c x f/e 1gm u_i (± %)	c x g/e 10gms u_i (± %)	v_i
Measurement System									
Probe Calibration	E.2.1	7	N	1	1	1	7.0	7.0	∞
Axial Isotropy	E.2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E.2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E.2.3	2	R	1.73	1	1	1.2	1.2	∞
Linearity	E.2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E.2.4	0.25	R	1.73	1	1	0.1	0.1	∞
Modulation Response	E.2.5	4.8	R	1.73	1	1	2.8	2.8	∞
Readout Electronics	E.2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E.2.7	0.8	R	1.73	1	1	0.5	0.5	∞
Integration Time	E.2.8	2.6	R	1.73	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.8	R	1.73	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E.6.3	6.7	R	1.73	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E.5	4	R	1.73	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E.4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E.4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E.2.9	5	R	1.73	1	1	2.9	2.9	∞
SAR Scaling	E.6.5	0	R	1.73	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E.3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E.3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E.3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E.3.4	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E.3.4	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E.3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E.3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				12.2	12.0	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				24.4	24.0	

The above measurement uncertainties are according to IEEE Std. 1528-2013

Applicable for SAR Measurements > 6 GHz:

Uncertainty Component	IEEE 1528 Sec.	Tol. (± %)	Prob. Dist.	f(d,k) Div.	c_i 1gm	c_i 10 gms	c x f/e 1gm u_i (± %)	c x g/e 10gms u_i (± %)	v_i
Measurement System									
Probe Calibration	E.2.1	9.3	N	1	1	1	9.3	9.3	∞
Axial Isotropy	E.2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E.2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E.2.3	2	R	1.73	1	1	1.2	1.2	∞
Linearity	E.2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E.2.4	0.25	R	1.73	1	1	0.1	0.1	∞
Modulation Response	E.2.5	4.8	R	1.73	1	1	2.8	2.8	∞
Readout Electronics	E.2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E.2.7	0.8	R	1.73	1	1	0.5	0.5	∞
Integration Time	E.2.8	2.6	R	1.73	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	3	R	1.73	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.8	R	1.73	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E.6.3	6.7	R	1.73	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E.5	4	R	1.73	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E.4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E.4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E.2.9	5	R	1.73	1	1	2.9	2.9	∞
SAR Scaling	E.6.5	0	R	1.73	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E.3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E.3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E.3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E.3.4	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E.3.4	0.6	R	1.73	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E.3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E.3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				13.8	13.6	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				27.6	27.1	

The above measurement uncertainties are according to IEEE Std. 1528-2013

Applicable for Power Density Measurements:

a	b	c	d	e	f = c x f/e	g
Uncertainty Component	Unc. (± dB)	Prob. Dist.	Div.	c_i	u_i (± dB)	v_i
Measurement System						
Calibration	0.49	N	1	1	0.49	∞
Probe Correction	0.00	R	1.73	1	0.00	∞
Frequency Response	0.20	R	1.73	1	0.12	∞
Sensor Cross Coupling	0.00	R	1.73	1	0.00	∞
Isotropy	0.50	R	1.73	1	0.29	∞
Linearity	0.20	R	1.73	1	0.12	∞
Probe Scattering	0.00	R	1.73	1	0.00	∞
Probe Positioning offset	0.30	R	1.73	1	0.17	∞
Probe Positioning Repeatability	0.04	R	1.73	1	0.02	∞
Sensor MechanicalOffset	0.00	R	1.73	1	0.00	∞
Probe Spatial Resolution	0.00	R	1.73	1	0.00	∞
Field Impedence Dependance	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Drift	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Noise	0.04	R	1.73	1	0.02	∞
Measurement Area Truncation	0.00	R	1.73	1	0.00	∞
Data Acquisition	0.03	N	1	1	0.03	∞
Sampling	0.00	R	1.73	1	0.00	∞
Field Reconstruction	2.00	R	1.73	1	1.15	∞
Forward Transformation	0.00	R	1.73	1	0.00	∞
Power Density Scaling	0.00	R	1.73	1	0.00	∞
Spatial Averaging	0.10	R	1.73	1	0.06	∞
System Detection Limit	0.04	R	1.73	1	0.02	∞
Test Sample Related						
Probe Coupling with DUT	0.00	R	1.73	1	0.00	∞
Modulation Response	0.40	R	1.73	1	0.23	∞
Integration Time	0.00	R	1.73	1	0.00	∞
Response Time	0.00	R	1.73	1	0.00	∞
Device Holder Influence	0.10	R	1.73	1	0.06	∞
DUT alignment	0.00	R	1.73	1	0.00	∞
RF Ambient Conditions	0.04	R	1.73	1	0.02	∞
Ambient Reflections	0.04	R	1.73	1	0.02	∞
Immunity/Secondary Reception	0.00	R	1.73	1	0.00	∞
Drift of DUT	0.21	R	1.73	1	0.12	∞
Combined Standard Uncertainty (k=1)		RSS			1.34	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2				

14 CONCLUSION

14.1 Measurement Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of the FCC and Innovation, Science, and Economic Development Canada, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables. [3]

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