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SAR EVALUATION REPORT

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Date of Testing:
01/05/24
Test Site/Location:
Element, Columbia, MD, USA
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1M2312180128-01.A3L(R1)

FCC ID:	**A3LSMX910**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD.**
DUT Type:	Portable Computing Device
Application Type:	Class II Permissive Change
FCC Rule Part(s):	CFR §2.1093
Model(s):	SM-X910
Permissive Change(s):	See FCC Change Document
Date of Original Certification:	06/08/23

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.

Only operations relevant to this permissive change were evaluated for compliance. Please see the original compliance evaluation in RF Exposure Technical Report S/N 1M2303200036-01.A3L (Rev 1) for complete evaluation of all other operating modes. The operational description includes a description of all changed items.

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

ACCREDITED
CERT #2041.02

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 WLAN	Data	2412 - 2472 MHz
U-NII-1	Data	5180 - 5240 MHz
U-NII-2A	Data	5260 - 5320 MHz
U-NII-2C	Data	5500 - 5720 MHz
U-NII-3	Data	5745 - 5825 MHz
U-NII-4	Data	5845 - 5885 MHz
U-NII-5	Data	5935 - 6415 MHz
U-NII-6	Data	6435 - 6515 MHz
U-NII-7	Data	6535 - 6875 MHz
U-NII-8	Data	6895 - 7115 MHz
Bluetooth	Data	2402 - 2480 MHz

1.2 Power Reduction for SAR

This device uses a power reduction mechanism for SAR compliance. The power reduction mechanism is activated when the device is used in close proximity to the user's body. FCC KDB Publication 616217 D04v01r02 Section 6 was used as a guideline for selecting SAR test distances for this device. Detailed descriptions of the power reduction mechanism are included in the operational description. Due to equipment limitations, 802.11be could not be measured for power reduction verification. Please see A3LSMX910 FCC SAR Appendix F and A3LSMX910 6CD WIFI 6 GHz RF Exposure Appendix G for PRV measurements for all other modes.

1.3 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 D01v06.

Only operations relevant to this permissive change were evaluated for compliance. No other target changes have been made. Targets for all other bands/exposure conditions can be found in the original filing.

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

1.3.1 2.4 GHz Maximum SISO/MIMO WLAN Output Power

Mode	Band	IEEE 802.11 (in dBm)			
		SISO Antenna 2		MIMO	
		be (SU)		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.	Max	Nom.
2.4 GHz WIFI	2.45 GHz	18.0	17.0	21.0	20.0
		ch. 1: 17.0	16.0	ch. 1: 20.0	19.0
		ch. 11: 16.5	15.5	ch. 11: 19.5	18.5
		ch. 12: 9.0	8.0	ch. 12: 9.0	8.0
		ch. 13: 3.0	2.0	ch. 13: 3.0	2.0

1.3.2 2.4 GHz Reduced WLAN Output Powers

The below table is applicable in the following conditions:

- Grip sensor active

Mode	Band	IEEE 802.11 (in dBm)			
		SISO Antenna 2		MIMO	
		be (SU)		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.	Max	Nom.
2.4 GHz WIFI	2.45 GHz	13.0	12.0	16.0	15.0
		ch. 12: 9.0	8.0	ch. 12: 9.0	8.0
		ch. 13: 3.0	2.0	ch. 13: 3.0	2.0

1.3.3 5 GHz Maximum MIMO WLAN Output Power

Mode	Band	IEEE 802.11 (in dBm)	
		MIMO	
		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.
5 GHz WIFI (20MHz BW)	UNII-1	21.0 ch. 36: 20.5	20.0 19.5
	UNII-2A	21.0 ch. 64: 20.5	20.0 19.5
	UNII-2C	21.0 ch. 100: 20.5	20.0 19.5
	UNII-3	21.0	20.0
	UNII-4	21.0	20.0
5 GHz WIFI (40MHz BW)	UNII-1	20.0	19.0
	UNII-2A	20.0 ch. 62: 19.5	19.0 18.5
	UNII-2C	20.0 ch. 102: 19.5	19.0 18.5
	UNII-3	20.0	19.0
	UNII-4	20.0	19.0
5 GHz WIFI (80MHz BW)	UNII-1	19.0	18.0
	UNII-2A	19.0	18.0
	UNII-2C	19.0	18.0
	UNII-3	19.0	18.0
	UNII-4	19.0	18.0
5 GHz WIFI (160MHz BW)	UNII-1/2A	18.0	17.0
	UNII-2C	18.0	17.0
	UNII-3/4	18.0	17.0

1.3.4 5 GHz Reduced WLAN Output Powers

The below table is applicable in the following conditions:
- Grip sensor active

Mode	Band	IEEE 802.11 (in dBm)	
		MIMO	
		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.
5 GHz WIFI (20MHz BW)	UNII-1	12.0	11.0
	UNII-2A	12.0	11.0
	UNII-2C	12.0	11.0
	UNII-3	12.0	11.0
	UNII-4	12.0	11.0
5 GHz WIFI (40MHz BW)	UNII-1	12.0	11.0
	UNII-2A	12.0	11.0
	UNII-2C	12.0	11.0
	UNII-3	12.0	11.0
	UNII-4	12.0	11.0
5 GHz WIFI (80MHz BW)	UNII-1	12.0	11.0
	UNII-2A	12.0	11.0
	UNII-2C	12.0	11.0
	UNII-3	12.0	11.0
	UNII-4	12.0	11.0
5 GHz WIFI (160MHz BW)	UNII-1/2A	12.0	11.0
	UNII-2C	12.0	11.0
	UNII-3/4	12.0	11.0

1.3.1 6 GHz Maximum MIMO WLAN Output Power

Mode	Band	IEEE 802.11 (in dBm)	
		MIMO	
		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.
6GHz LPI WIFI (20 MHz BW)	U-NII-5	16.0 ch. 2: 7.0	15.0 6.0
	U-NII-6	16.0	15.0
	U-NII-7	16.0	15.0
	U-NII-8	16.0 ch. 233: 9.5	15.0 8.5
6GHz LPI WIFI (40 MHz BW)	U-NII-5	18.0	17.0
	U-NII-6	18.0	17.0
	U-NII-7	18.0	17.0
	U-NII-8	18.0	17.0
6GHz LPI WIFI (80 MHz BW)	U-NII-5	18.0	17.0
	U-NII-6	18.0	17.0
	U-NII-7	18.0	17.0
	U-NII-8	18.0	17.0
6GHz LPI WIFI (160 MHz BW)	U-NII-5	17.0	16.0
	U-NII-6	17.0	16.0
	U-NII-7	17.0	16.0
	U-NII-8	17.0	16.0
6GHz LPI WIFI (320 MHz BW)	U-NII-5	17.0	16.0
	U-NII-6	17.0	16.0
	U-NII-7	17.0	16.0
	U-NII-8	17.0	16.0
6GHz SP WIFI (20 MHz BW)	U-NII-5	16.0 ch. 2: 7.0	15.0 6.0
	U-NII-7	16.0	15.0
6GHz SP WIFI (40 MHz BW)	U-NII-5	18.0	17.0
	U-NII-7	18.0	17.0
6GHz SP WIFI (80 MHz BW)	U-NII-5	18.0	17.0
	U-NII-7	18.0	17.0
6GHz SP WIFI (160 MHz BW)	U-NII-5	17.0	16.0
	U-NII-7	17.0	16.0
6GHz SP WIFI (320 MHz BW)	U-NII-5	17.0	16.0

1.3.2 6 GHz Reduced WLAN Output Powers

The below table is applicable in the following conditions:
Grip sensor active

Mode	Band	IEEE 802.11 (in dBm)	
		MIMO	
		be (SU) (CDD+STBC, SDM)	
Maximum / Nominal Power		Max	Nom.
6GHz LPI WIFI (20 MHz BW)	U-NII-5	11.0 ch. 2: 7.0	10.0 6.0
	U-NII-6	11.0	10.0
	U-NII-7	11.0	10.0
	U-NII-8	11.0 ch. 233: 9.5	10.0 8.5
6GHz LPI WIFI (40 MHz BW)	U-NII-5	11.0	10.0
	U-NII-6	11.0	10.0
	U-NII-7	11.0	10.0
	U-NII-8	11.0	10.0
6GHz LPI WIFI (80 MHz BW)	U-NII-5	11.0	10.0
	U-NII-6	11.0	10.0
	U-NII-7	11.0	10.0
	U-NII-8	11.0	10.0
6GHz LPI WIFI (160 MHz BW)	U-NII-5	11.0	10.0
	U-NII-6	11.0	10.0
	U-NII-7	11.0	10.0
	U-NII-8	11.0	10.0
6GHz LPI WIFI (320 MHz BW)	U-NII-5	11.0	10.0
	U-NII-6	11.0	10.0
	U-NII-7	11.0	10.0
	U-NII-8	11.0	10.0
6GHz SP WIFI (20 MHz BW)	U-NII-5	11.0 ch. 2: 7.0	10.0 6.0
	U-NII-7	11.0	10.0
6GHz SP WIFI (40 MHz BW)	U-NII-5	11.0	10.0
	U-NII-7	11.0	10.0
6GHz SP WIFI (80 MHz BW)	U-NII-5	11.0	10.0
	U-NII-7	11.0	10.0
6GHz SP WIFI (160 MHz BW)	U-NII-5	11.0	10.0
	U-NII-7	11.0	10.0
6GHz SP WIFI (320 MHz BW)	U-NII-5	11.0	10.0

1.4 DUT Antenna Locations

The overall dimensions of this device are > 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 antenna dimensions and separation distances are shown in the technical description in the original FCC filing.

1.5 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, 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 D01v06 4.3.2 procedures.

Table 1-1
Simultaneous Transmission Scenarios

No.	Capable Transmit Configuration	Body
1	2.4 GHz WI-FI MIMO	Yes
2	2.4 GHz Bluetooth MIMO	Yes
3	5 GHz WI-FI MIMO	Yes
4	6 GHz WI-FI MIMO	Yes
5	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WI-FI Ant 2	Yes
6	2.4 GHz Bluetooth Ant 1+ 5 GHz WI-FI MIMO	Yes
7	2.4 GHz Bluetooth Ant 1+ 6 GHz WI-FI MIMO	Yes
8	2.4 GHz Bluetooth Ant 2+ 5 GHz WI-FI MIMO	Yes
9	2.4 GHz Bluetooth Ant 2+ 6 GHz WI-FI MIMO	Yes
10	2.4 GHz Bluetooth MIMO + 5 GHz WI-FI MIMO	Yes
11	2.4 GHz Bluetooth MIMO + 6 GHz WI-FI MIMO	Yes
12	2.4 GHz WI-FI MIMO + 5 GHz WI-FI MIMO	Yes
13	2.4 GHz WI-FI MIMO + 6 GHz WI-FI MIMO	Yes
14	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WI-FI Ant 2 + 5 GHz WI-FI MIMO	Yes
15	2.4 GHz Bluetooth Ant 1 + 2.4 GHz WI-FI Ant 2 + 6 GHz WI-FI MIMO	Yes

1. No other simultaneous scenarios besides described above is supported for this model.
2. 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. WLAN can transmit only when operating with MIMO.
3. Only Antenna 1 supports Bluetooth Tethering in SISO Mode.

1.6 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 802.11ax/be with the following features:

a) Up to 320 MHz Bandwidth only for 6 GHz
b) Up to 160 MHz Bandwidth only for 5 GHz
c) Up to 20 MHz Bandwidth only for 2.4 GHz
d) 2 Tx antenna output
e) Up to 4KQAM is supported
f) TDWR and Band gap channels are supported for 5/6 GHz
g) MU-MIMO UL Operations are not supported

Per April 2019 TCB Workshop Notes, SAR testing was not required for 802.11ax/be when applying the initial test configuration procedures of KDB 248227, with 802.11ax/be considered a higher order 802.11 mode.

This device supports 6 GHz WIFI Operations. RF Exposure assessment for these bands can be found in the WIFI6E RF Exposure Report and Simultaneous transmission analysis is addressed in the Multi-Tx and Antenna SAR Considerations Appendix of the original FCC filing.

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.

1.7 Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (SAR Considerations for 802.11 Devices)
- FCC KDB Publication 447498 D01v06 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)
- FCC KDB Publication 616217 D04v01r02 (Proximity Sensor)
- April 2019 TCB Workshop Notes (IEEE 802.11ax)

1.8 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.

1.9 Bibliography

Report Type	Report Serial Number
RF Exposure Part 1 Test Report	Original Filing
WIFI 6 GHz RF Exposure Report – Original Filing	1M2303200036-12.A3L

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:

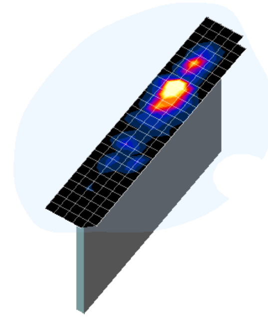

Figure 3-1
Sample SAR Area Scan

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	$\leq 1.5*\Delta z_{zoom}(n-1)$	≥ 30
2-3 GHz	≤ 12	≤ 5	≤ 5	≤ 4	$\leq 1.5*\Delta z_{zoom}(n-1)$	≥ 30
3-4 GHz	≤ 12	≤ 5	≤ 4	≤ 3	$\leq 1.5*\Delta z_{zoom}(n-1)$	≥ 28
4-5 GHz	≤ 10	≤ 4	≤ 3	≤ 2.5	$\leq 1.5*\Delta z_{zoom}(n-1)$	≥ 25
5-6 GHz	≤ 10	≤ 4	≤ 2	≤ 2	$\leq 1.5*\Delta z_{zoom}(n-1)$	≥ 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 Tablet per KDB Publication 616217 D04v01r02

Per FCC KDB Publication 616217 D04v01r02, the back surface and edges of the tablet should be tested for SAR compliance with the tablet touching the phantom. The SAR Exclusion Threshold in KDB 447498 D01v06 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent tablet edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

4.3 Proximity Sensor Considerations

This device uses a power reduction mechanism to reduce output powers in certain use conditions when the device is used close the user's body.

When the device's antenna is within a certain distance of the user, the sensor activates and reduces the maximum allowed output power. However, the sensor is not active when the device is moved beyond the sensor triggering distance and the maximum output power is no longer limited. Therefore, additional evaluation is needed in the vicinity of the triggering distance to ensure SAR is compliant when the device is allowed to operate at a non-reduced output power level. FCC KDB Publication 616217 D04v01r02 Section 6 was used as a guideline for selecting SAR test distances for this device at these additional test positions. Sensor triggering distance summary data is included in the Power Reduction Verification Appendix.

The sensor is designed to support sufficient detection range and sensitivity to cover regions of the sensors in all applicable directions since the sensor entirely covers the antennas.

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.

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.

6 FCC MEASUREMENT PROCEDURES

6.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, 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 Procedures Used to Establish RF Signal for SAR

The following procedures are according to FCC KDB Publication 941225 D01v03r01 “3G SAR Measurement Procedures.”

The device is placed into a simulated call using a base station simulator in an RF shielded chamber. Establishing connections in this manner ensure a consistent means for testing SAR and are recommended for evaluating SAR [4]. Devices under test are evaluated prior to testing, with a fully charged battery and were configured to operate at maximum output power. In order to verify that the device is tested throughout the SAR test at maximum output power, the SAR measurement system measures a “point SAR” at an arbitrary reference point at the start and end of the 1-gram SAR evaluation, to assess for any power drifts during the evaluation. If the power drift deviates by more than 5%, the SAR test and drift measurements are repeated.

6.3 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.

6.3.1 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.

6.3.2 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.

6.3.3 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.

6.3.4 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.

6.3.5 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.

6.3.6 Initial Test Configuration Procedure

For OFDM, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order IEEE 802.11 mode. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required. Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured. When there are multiple untested channels having the same subsequent highest average RF output power, the channel with higher frequency from the lowest 802.11 mode is considered for SAR measurements (See Section 6.3.5). When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.3.7 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.

6.3.8 MIMO SAR considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provisions in KDB Publication 447498 D01v06 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 – Ant 2

2.4GHz WIFI (20MHz 802.11be SISO ANT2)			
Freq. [MHz]	Channel	Detector	Conducted Power [dBm]
2412	1	Average	16.59
2417	2		17.55
2437	6		17.45
2457	10		17.47
2462	11		16.12

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

2.4GHz WIFI (20MHz 802.11be MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT1	ANT2	MIMO
2412	1	Average	16.61	16.59	19.61
2417	2		17.53	17.62	20.59
2437	6		17.68	17.31	20.51
2457	10		17.85	17.28	20.58
2462	11		16.21	15.98	19.11

Table 7-3
2.4 GHz WLAN Reduced Average RF Power with Grip sensor Active – Ant 2

2.4GHz WIFI (20MHz 802.11be SISO ANT2)			
Freq. [MHz]	Channel	Detector	Conducted Power [dBm]
2412	1	Average	12.76
2437	6		12.84
2462	11		12.93

Table 7-4
2.4 GHz WLAN Reduced Average RF Power with Grip Sensor Active - MIMO

2.4GHz WIFI (20MHz 802.11be MIMO)					
Freq [MHz]	Channel	Detector	Conducted Power [dBm]		
			ANT1	ANT2	MIMO
2412	1	Average	12.82	12.29	15.57
2437	6		12.58	12.22	15.41
2462	11		12.63	12.24	15.45

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

5GHz WIFI (20MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT1	ANT2	MIMO
UNII-1	5180	36	17.15	17.13	20.15
	5200	40	17.35	17.21	20.29
	5220	44	17.45	17.02	20.25
	5240	48	17.83	16.85	20.38
UNII-2A	5260	52	17.81	17.01	20.44
	5280	56	17.61	16.94	20.30
	5300	60	17.49	17.38	20.45
	5320	64	17.06	17.12	20.10
UNII-2C	5500	100	16.86	17.32	20.11
	5600	120	17.82	17.53	20.69
	5620	124	17.86	17.38	20.64
	5720	144	17.99	16.81	20.45
UNII-3	5745	149	17.91	17.08	20.53
	5785	157	17.56	17.48	20.53
	5825	165	17.73	17.38	20.57
UNII-4	5845	169	17.79	17.43	20.62
	5865	173	17.81	17.36	20.60
	5885	177	17.97	17.35	20.68

Table 7-6
5 GHz WLAN Reduced Average RF Power with Grip Sensor Active - MIMO

5GHz WIFI (80MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT1	ANT2	MIMO
UNII-1	5210	42	8.56	8.02	11.31
UNII-2A	5290	58	8.65	8.01	11.35
UNII-2C	5530	106	8.26	8.92	11.61
	5610	122	8.81	8.58	11.71
	5690	138	8.94	7.67	11.36
UNII-3	5775	155	8.96	8.61	11.80
UNII-4	5855	171	8.97	8.56	11.78

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

6GHz WIFI (80MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT1	ANT2	MIMO
UNII-5	5985	7	14.21	14.15	17.19
	6305	71	13.23	14.25	16.78
UNII-7	6545	119	13.94	14.45	17.21
	6785	167	13.68	13.56	16.63
UNII-8	7025	215	14.69	13.28	17.05

Table 7-8
6 GHz WLAN Reduced Average RF Power with Grip Sensor Active - MIMO

6GHz WIFI (80MHz 802.11be MIMO)					
Band	Freq [MHz]	Channel	Avg. Conducted Powers [dBm]		
			ANT1	ANT2	MIMO
UNII-5	5985	7	7.36	6.84	10.12
	6305	71	6.81	7.94	10.42
UNII-7	6545	119	7.11	7.98	10.58
	6785	167	7.21	7.49	10.36
UNII-8	7025	215	7.74	6.82	10.31

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.

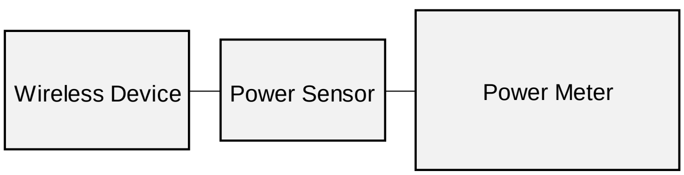

Figure 7-1
Power Measurement Setup

7.2 SAR and Absorbed Power Density Test Notes

General Notes:

1. Per April 2019 TCB Workshop Notes, SAR testing was not required for 802.11ax/be when applying the initial test configuration procedures of KDB 248227, with 802.11ax/be considered a higher order 802.11 mode. Please see the original filings for all SAR/APD test data. The test data reported in the original is the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01v06.
2. 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 6.3.4 for more information.
3. 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 6.3.5 for more information.
4. Per FCC guidance, SAR was performed using 6.5 GHz SAR probe calibration factors. Per October 2020 TCB Workshop notes, 5 channels were tested. Absorbed power density (APD) using a $4cm^2$ averaging area is reported based on SAR measurements.

7.3 PD Test Notes

1. Per April 2019 TCB Workshop Notes, testing was not required for 802.11be when applying the initial test configuration procedures of KDB 248227, with 802.11be considered a higher order 802.11 mode. Please see the original filing for all PD test data. PD results in the original filing were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D04.

8 MULTI-TX AND ANTENNA SAR CONSIDERATIONS

8.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

8.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1g SAR for all the simultaneous transmitting antennas in a specific physical test configuration is less than or equal to 1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1g or 10g SAR.

The standalone reported SAR in the original filing was used to determine simultaneous transmission compliance as it is more conservative. Please see the original filings for complete evaluation of simultaneous transmission.

8.3 Conclusion

The above numerical summed SAR results are sufficient to determine simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D04v01 and IEEE 1528- 2013 Section 6.3.4.1.

9 SAR MEASUREMENT VARIABILITY

9.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01r04, variability SAR tests were not required since measured SAR results in the original filing for all frequency bands were less than 0.8 W/kg for 1g SAR.

9.2 Measurement Uncertainty

The measured SAR in the original filing 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.

10 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N4010A	Wireless Connectivity Test Set	N/A	N/A	N/A	GB46170464
Anritsu	ML2496A	Power Meter	6/15/2023	Annual	6/15/2024	1138001
Anritsu	MA2411B	Pulse Power Sensor	6/15/2023	Annual	6/15/2024	1126066
Anritsu	MA2411B	Pulse Power Sensor	6/15/2023	Annual	6/15/2024	1339007
Anritsu	MA24106A	USB Power Sensor	4/21/2023	Annual	4/21/2024	1244515
Anritsu	MA24106A	USB Power Sensor	1/13/2023	Annual	1/13/2024	1344557
Seekonk	TSF-100	Torque Wrench	6/30/2023	Annual	6/30/2024	47639-29

Note: All equipment was used solely within its respective calibration period.

11 MEASUREMENT UNCERTAINTIES

a	b	c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Uncertainty Component	IEEE 1528 Sec.	Tol. (± %)	Prob. Dist.	Div.	c_i 1gm	c_i 10 gms	1gm u_i (± %)	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	1.732	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	1.732	1	1	0.1	0.1	∞
Modulation Response	E.2.5	4.8	R	1.732	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	1.732	1	1	0.5	0.5	∞
Integration Time	E.2.8	2.6	R	1.732	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E.6.1	3	R	1.732	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E.6.1	3	R	1.732	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.8	R	1.732	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E.6.3	6.7	R	1.732	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E.5	4	R	1.732	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	1.732	1	1	2.9	2.9	∞
SAR Scaling	E.6.5	0	R	1.732	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	1.732	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E.3.4	0.6	R	1.732	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

12 CONCLUSION

12.1 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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