



# ELEMENT MATERIALS TECHNOLOGY

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## SAR EVALUATION REPORT

**Applicant Name:**  
Apple Inc.  
One Apple Park Way  
Cupertino, CA 95014 USA

**Date of Testing:**  
07/08/2024  
**Test Report Issue Date:**  
09/03/2024  
**Test Site/Location:**  
Element Morgan Hill, CA, USA  
**Document Serial No.:**  
1C2405230029-01.BCG-R1

**FCC ID:** BCG-A3184

**APPLICANT:** APPLE, INC.

**DUT Type:** Wireless Headphones  
**Application Type:** Certification  
**FCC Rule Part(s):** CFR §2.1093  
**Model:** A3184

Equipment Class	Band & Mode	Tx Frequency	SAR	
			1g Head (W/kg)	10g Extremity (W/kg)
DSS/DTS	Bluetooth	2402 - 2480 MHz	<0.1	0.16

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 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 1.6 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



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# 1 DEVICE UNDER TEST

## 1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
Bluetooth	Data	2402 - 2480 MHz

## 1.2 Power Reduction for SAR

There is no power reduction used for any band/mode implemented in this device for SAR purposes.

## 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 D04v01.

### 1.3.1 Maximum Output Power

Mode / Band	Modulated Average (dBm)	
2.4 GHz Bluetooth BDR	Maximum	<b>12.50</b>
	Nominal	<b>11.50</b>
2.4 GHz Bluetooth EDR	Maximum	<b>9.50</b>
	Nominal	<b>8.50</b>
2.4 GHz Bluetooth BLE	Maximum	<b>8.50</b>
	Nominal	<b>7.50</b>

## 1.4 DUT Antenna Locations

Based on the expected use conditions, Head SAR and Extremity SAR was evaluated. The antenna is located inside the left cushion on the DUT. A diagram showing the location of the antenna can be found in DUT ANTENNA DIAGRAM & SAR TEST SETUP PHOTOGRAPHS appendix. More information about the configuration evaluated for SAR can be found in Section 4.2 and Section 4.3.

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## 1.5 Simultaneous Transmission Capabilities

This Device does not support any Simultaneous transmission Scenarios.

## 1.6 Guidance Applied

- FCC KDB Publication 447498 D04v01 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)

## 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.

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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 ( $\rho$ ). 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:

- $\sigma$  = conductivity of the tissue-simulating material (S/m)
- $\rho$  = mass density of the tissue-simulating material (kg/m<sup>3</sup>)
- 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]

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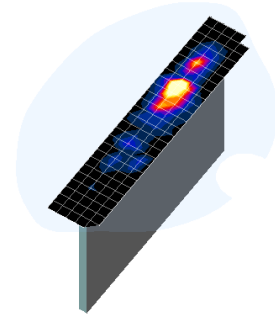
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## 3 DOSIMETRIC ASSESSMENT

### 3.1 Measurement Procedure

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

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 3-3-1) 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 3-3-1) 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 cDASY6 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 3-3-1. 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.



**Figure 3-1**  
Sample SAR Area Scan

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

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

\*Also compliant to IEEE 1528-2013 Table 6

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## 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  $\epsilon = 3$  and loss tangent  $\delta = 0.02$ .

### 4.2 Positioning for Head

Wireless Headphones are head mounted devices that are designed to be used at the ear but does not protrude into the pinna or the auditory canal. The device is evaluated with the audio-output (cushion side) of the device aligned to the ERP reference point. The device was oriented against the phantom in such a way that mimics expected use conditions. The phantom is filled with head tissue-equivalent medium. Since the device can be used with the radiating element located on the right and left sides of the head, SAR testing was performed for both sides to simulate all potential head use-case conditions.

### 4.3 Extremity Exposure Conditions

Devices that designed or intended for use on extremities or mainly operated in extremity only exposure conditions: i.e., hands, wrists, feet and ankles, may require extremity SAR evaluation, Based on the expected use conditions. Extremity SAR was evaluated with the outside (Logo) of the device touching the flat phantom, and the bottom edge touching the flat phantom. The antenna touching at 45° was additionally evaluated from normal condition because it is more conservative. The phantom is filled with head tissue-equivalent medium.

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# 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 <i>General Population (W/kg) or (mW/g)</i>	CONTROLLED ENVIRONMENT <i>Occupational (W/kg) or (mW/g)</i>
<b>Peak Spatial Average SAR</b> Head	1.6	8.0
<b>Whole Body SAR</b>	0.08	0.4
<b>Peak Spatial Average SAR</b> 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.

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### 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.

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# 7 RF CONDUCTED POWERS

## 7.1 Bluetooth Conducted Powers

Table 7-1  
Bluetooth Average RF Power

Frequency [MHz]	Modulation	Data Rate [Mbps]	Channel No.	Avg Conducted Power	
				[dBm]	[mW]
2402	GFSK	1.0	0	10.80	12.023
2441	GFSK	1.0	39	10.79	11.995
2480	GFSK	1.0	78	11.04	12.706

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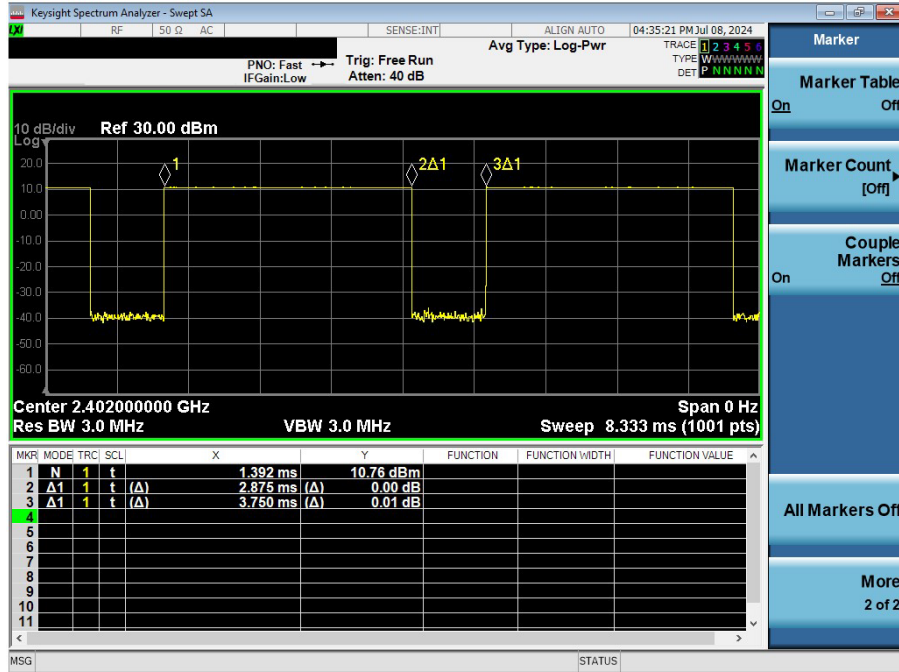
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## 7.2 Bluetooth Duty Cycle

### 7.2.1

### Maximum Bluetooth Transmission

Figure 7-1  
2.4 GHz Bluetooth Transmission Plot



Equation 7-1  
2.4 GHz Bluetooth Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{2.875\ ms}{3.750\ ms} * 100\% = 76.67\%$$

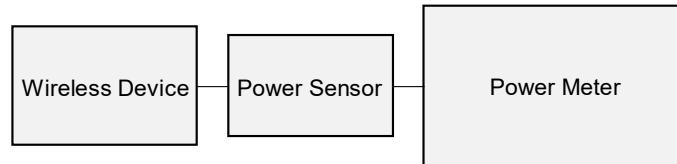


Figure 7-2  
Power Measurement Setup

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## 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, $\sigma$ (S/m)	Measured Dielectric Constant, $\epsilon$	TARGET Conductivity, $\sigma$ (S/m)	TARGET Dielectric Constant, $\epsilon$	% dev $\sigma$	% dev $\epsilon$
07/08/2024	2450 Head	24.6	2300	1.690	39.923	1.670	39.500	1.20%	1.07%
			2310	1.701	39.887	1.679	39.480	1.31%	1.03%
			2320	1.710	39.855	1.687	39.460	1.36%	1.00%
			2400	1.798	39.586	1.756	39.289	2.39%	0.76%
			2450	1.850	39.448	1.800	39.200	2.78%	0.63%
			2480	1.883	39.335	1.833	39.162	2.73%	0.44%
			2500	1.906	39.244	1.855	39.136	2.75%	0.28%
			2510	1.916	39.206	1.866	39.123	2.68%	0.21%
			2535	1.943	39.132	1.893	39.092	2.64%	0.10%
			2550	1.958	39.087	1.909	39.073	2.57%	0.04%
			2560	1.969	39.056	1.920	39.060	2.55%	-0.01%
			2600	2.015	38.887	1.964	39.009	2.60%	-0.31%
			2650	2.068	38.719	2.018	38.945	2.48%	-0.58%
			2680	2.103	38.612	2.051	38.907	2.54%	-0.76%
2700	2.122	38.529	2.073	38.882	2.36%	-0.91%			

Note: Per April 2019 TCB Workshop Notes, single head-tissue simulating liquid specified in IEC 62209-1 is permitted to use for all SAR tests. The above measured tissue parameters were used in the cDASY6 software. The cDASY6 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.

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## 8.2 Test System Verification

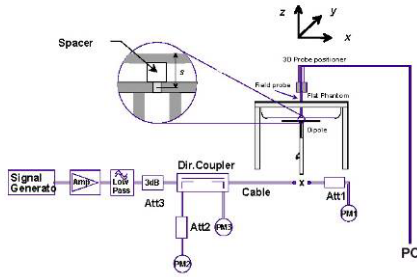
Prior to SAR assessment, the system is verified to  $\pm 10\%$  of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in SAR System Validation Appendix.

**Table 8-2  
System Verification Results – 1g**

System Verification TARGET & MEASURED													
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 (%)
AM16	2450	Head	07/08/2024	22.5	22.7	0.10	855	7552	1676	5.320	52.400	53.200	1.53%

**Table 8-3  
System Verification Results – 10g**

System Verification TARGET & MEASURED													
SAR System	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp. (C)	Liquid Temp. (C)	Input Power (W)	Source SN	Probe SN	DAE	Measured SAR 10g (W/kg)	1W Target SAR 10g (W/kg)	1W Normalized SAR 10g (W/kg)	Deviation 10g (%)
AM16	2450	Head	07/08/2024	22.5	22.7	0.10	855	7552	1676	2.410	24.600	24.100	-2.03%



**Figure 8-1  
System Verification Setup Diagram**



**Figure 8-2  
System Verification Setup Photo**

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# 9

# SAR DATA SUMMARY

## 9.1 2.4 GHz Bluetooth SISO Standalone Head SAR

Table 9-1

Exposure	Band / Mode	Service / Modulation	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 #
Head	2.4 GHz Bluetooth	FHSS	03D9X	76.67	-0.01	2402	0	1	12.50	10.80	Right Cheek	0	0.026	1.479	1.011	0.039	
Head	2.4 GHz Bluetooth	FHSS	03D9X	76.67	0.04	2441	39	1	12.50	10.79	Right Cheek	0	0.030	1.483	1.011	0.045	
Head	2.4 GHz Bluetooth	FHSS	03D9X	76.67	0.08	2480	78	1	12.50	11.04	Right Cheek	0	0.037	1.400	1.011	0.052	A1
Head	2.4 GHz Bluetooth	FHSS	03D9X	76.67	0.10	2480	78	1	12.50	11.04	Left Cheek	0	0.026	1.400	1.011	0.037	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Head 1.6 W/kg (mW/g) averaged over 1 gram					

Note: The reported SAR was scaled to the 77.5% transmission duty factor to determine compliance since the duty factor of the device is permanently limited to 77.5% per the manufacturer.

## 9.2 2.4 GHz Bluetooth SISO Standalone Extremity SAR

Table 9-2

Exposure	Band / Mode	Service / Modulation	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 10g SAR [W/kg]	Power Scaling Factor	Duty Cycle Scaling Factor	Reported 10g SAR [W/kg]	Plot #
Extremity	2.4 GHz Bluetooth	FHSS	005E98	76.67	0.03	2480	78	1	12.50	11.04	Bottom	0	0.053	1.400	1.011	0.075	
Extremity	2.4 GHz Bluetooth	FHSS	005E98	76.67	0.01	2402	0	1	12.50	10.80	Antenna Touching	0	0.106	1.479	1.011	0.158	A2
Extremity	2.4 GHz Bluetooth	FHSS	005E98	76.67	0.04	2441	39	1	12.50	10.79	Antenna Touching	0	0.103	1.483	1.011	0.154	
Extremity	2.4 GHz Bluetooth	FHSS	005E98	76.67	0.06	2480	78	1	12.50	11.04	Antenna Touching	0	0.092	1.400	1.011	0.130	
Extremity	2.4 GHz Bluetooth	FHSS	005E98	76.67	-0.10	2480	78	1	12.50	11.04	Logo	0	0.035	1.400	1.011	0.050	
ANSI/IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Extremity 4.0 W/kg (mW/g) averaged over 10 grams					

Note: The reported SAR was scaled to the 77.5% transmission duty factor to determine compliance since the duty factor of the device is permanently limited to 77.5% per the manufacturer.

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### 9.3 SAR Test Notes

#### General Notes:

1. Batteries are fully charged at the beginning of the SAR measurements.
2. Liquid tissue depth was at least 15.0 cm for all frequencies.
3. 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.
4. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D04v01.
5. Per FCC KDB 865664 D01v01r04, variability SAR tests were not required since measured SAR results for all frequency bands were less than 0.8 W/kg for 1g and 2.0 W/kg for 10g. Please see section 10 for variability analysis.
6. The orange highlights throughout the report represents the highest scaled SAR per Equipment Class.
7. For Head SAR evaluation, the DUT's audio-output (cushion side) was aligned to the ERP reference point.
8. For Extremity SAR evaluation, the DUT's outer edge (Logo) was positioned at 0 mm from the phantom.
9. Extremity SAR evaluation, was additionally tested with the bottom edge touching the phantom at 0 mm. Additional test setup and positioning information can be found in Section 4.2 and Section 4.3.
10. The antenna touching at 45° was additionally evaluated from normal condition because it is more conservative.

#### Bluetooth Notes

1. The reported Bluetooth SAR was evaluated with a test mode with hopping disabled with DH5 operation. The reported SAR was scaled to the 77.5% transmission duty factor to determine compliance since the duty factor of the device is limited to 77.5% per the manufacturer. See Section 7.2 for the time domain plot and calculation for the duty factor of the device.

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## 10 SAR MEASUREMENT VARIABILITY

### 10.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01, SAR measurement variability was not assessed for each frequency band since all measured SAR measured values are <0.8 W/Kg for 1g SAR and <2.0 W/kg for 10g SAR.

### 10.2 Measurement Uncertainty

The measured SAR was <1.5 W/kg for 1g and <3.75 W/kg for 10g for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

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# 11 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	11/14/2023	Annual	11/14/2024	MY45093852
Agilent	N5182A	MXG Vector Signal Generator	11/14/2023	Annual	11/14/2024	US46240505
Agilent	8753ES	S-Parameter Vector Network Analyzer	1/10/2024	Annual	1/10/2025	MY40001472
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	ML2496A	Power Meter	6/24/2024	Annual	6/24/2025	1840005
Anritsu	MA2411B	Pulse Power Sensor	8/22/2023	Annual	8/22/2024	1726262
Anritsu	MA2411B	Pulse Power Sensor	4/17/2024	Annual	4/17/2025	1726261
Anritsu	MA24106A	USB Power Sensor	12/4/2023	Annual	12/4/2024	1520503
Control Company	4352	Ultra Long Stem Thermometer	1/15/2024	Annual	1/15/2025	160508097
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	N9020A	MXA Signal Analyzer	3/22/2024	Annual	3/22/2025	US46470561
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Mini-Circuits	VLF-6000+	Low Pass Filter DC to 6000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	CBT	N/A	CBT	2050
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Narda	BW-S3W2	Attenuator (3dB)	CBT	N/A	CBT	120
Seekonk	NC-100	Torque Wrench	10/17/2023	Biennial	10/17/2025	22847
SPEAG	DAK-3.5	Dielectric Assessment Kit	10/25/2023	Annual	10/25/2024	1091
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1237
SPEAG	D2450V2	2450 MHz SAR Dipole	11/15/2022	Biennial	11/15/2024	855
SPEAG	DAE4	Dasy Data Acquisition Electronics	5/8/2024	Annual	5/8/2025	1676
SPEAG	EX3DV4	SAR Probe	5/13/2024	Annual	5/13/2025	7552

Note: 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.

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# 12 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 <sub>i</sub> 1gm	c <sub>i</sub> 10 gms	1gm u <sub>i</sub> (± %)	10gms u <sub>i</sub> (± %)	v <sub>i</sub>
<b>Measurement System</b>									
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	∞
<b>Test Sample Related</b>									
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	∞
<b>Phantom &amp; Tissue Parameters</b>									
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 Uncertainty	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	∞
<b>Combined Standard Uncertainty (k=1)</b>	RSS						12.2	12.0	191
<b>Expanded Uncertainty</b> (95% CONFIDENCE LEVEL)	k=2						24.4	24.0	

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

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## 13 CONCLUSION

### 13.1 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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