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:
06/15/2023 – 06/20/2023
Test Report Issue Date:
08/25/2023
Test Site/Location:
Element Materials Technology
Morgan Hill, CA, USA
Document Serial No.:
1C2305020011-01.BCG (Rev 1)

FCC ID: **BCG-A3048**

APPLICANT: **APPLE, INC.**

DUT Type: Wireless Earbuds
Application Type: Certification
FCC Rule Part(s): CFR §2.1093
Model: A3048

Equipment Class	Band & Mode	Tx Frequency	SAR	
			1g Head (W/kg)	1g Body-Worn (W/kg)
DSS/DTS	Bluetooth	2402 - 2480 MHz	0.43	1.17
NII	NB UNII-1	5157 - 5245 MHz	<0.1	1.00
NII	NB UNII-3	5731 - 5844 MHz	<0.1	0.93

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 1.6 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

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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T A B L E O F C O N T E N T S

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1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
Bluetooth	Data	2402 - 2480 MHz
NB UNII-1	Data	5157 - 5245 MHz
NB UNII-3	Data	5731 - 5844 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 D01v06.

1.3.1 Maximum Output Power

Mode / Band	Duty Cycle	Modulated Average (dBm)	
2.4 GHz Bluetooth BDR	34%	Maximum	**12.50**
		Nominal	**11.50**
2.4 GHz Bluetooth EDR	77%	Maximum	**9.50**
		Nominal	**8.50**
2.4 GHz Bluetooth HDR4/8 1-Slot	34%	Maximum	**9.50**
		Nominal	**8.50**
2.4 GHz Bluetooth HDR4/8 3/5-Slot	77%	Maximum	**9.50**
		Nominal	**8.50**
2.4 GHz Bluetooth HDRp4/8	100%	Maximum	**9.50**
		Nominal	**8.50**
2.4 Bluetooth LE1M	100%	Maximum	**9.00**
		Nominal	**8.00**

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Mode / Band	Duty Cycle	Modulated Average (dBm)	
NB UNII-1 BDR	34%	Maximum	**9.50**
		Nominal	**8.50**
NB UNII-1 HDR4/8 1-Slot	34%	Maximum	**9.00**
		Nominal	**8.00**
NB UNII-1 HDR4/8 3/5-Slot	77%	Maximum	**6.50**
		Nominal	**5.50**
NB UNII-1 HDRp4/8	100%	Maximum	**6.50**
		Nominal	**5.50**
NB UNII-1 LE2M	15%	Maximum	**10.00**
		Nominal	**9.00**

Mode / Band	Duty Cycle	Modulated Average (dBm)	
NB UNII-3 BDR	34%	Maximum	**10.50**
		Nominal	**9.50**
NB UNII-3 HDR4/8 1-Slot	34%	Maximum	**10.00**
		Nominal	**9.00**
NB UNII-3 HDR4/8 3/5-Slot	77%	Maximum	**7.50**
		Nominal	**6.50**
NB UNII-3 HDRp4/8	100%	Maximum	**7.50**
		Nominal	**6.50**
NB UNII-3 LE2M	15%	Maximum	**13.50**
		Nominal	**12.50**

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1.4 DUT Antenna Locations

Based on the expected use conditions, Head SAR was evaluated. Per manufacturer request, Body-Worn SAR was evaluated as an additional conservative SAR test condition. The antenna is located inside BCG-A3048 – which is a wireless earbud for the Left ear. A diagram showing the location of the device antenna can be found in DUT Antenna Diagram and SAR test Setup Photographs Appendix. More information about the configurations evaluated for SAR can be found in Section 4.2 and Section 4.3.

1.5 Simultaneous Transmission Capabilities

This Device does not support any Simultaneous transmission Scenarios.

1.6 Guidance Applied

- FCC KDB Publication 447498 D01v06 (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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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]

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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:

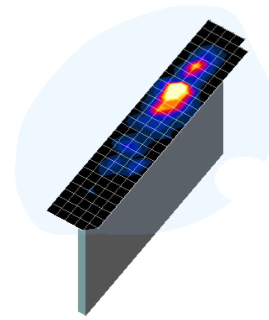

Figure 3-1
Sample SAR Area Scan

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 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 3-1. 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*$\Delta z_{zoom}(n-1)$	≥ 30
2-3 GHz	≤ 12	≤ 5	≤ 5	≤ 4	≤ 1.5*$\Delta z_{zoom}(n-1)$	≥ 30
3-4 GHz	≤ 12	≤ 5	≤ 4	≤ 3	≤ 1.5*$\Delta z_{zoom}(n-1)$	≥ 28
4-5 GHz	≤ 10	≤ 4	≤ 3	≤ 2.5	≤ 1.5*$\Delta z_{zoom}(n-1)$	≥ 25
5-6 GHz	≤ 10	≤ 4	≤ 2	≤ 2	≤ 1.5*$\Delta z_{zoom}(n-1)$	≥ 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 ε = 3 and loss tangent δ = 0.02.

4.2 Positioning for Head

This device is a wireless earbud for the left ear which is designed to be used in the ear canal. The antenna is located inside the earbud. SAR was evaluated with a separation distance of 0 mm between the earbud (the ear tip facing the phantom) and the flat phantom. The phantom is filled with head tissue equivalent medium.

4.3 Body-Worn Exposure Conditions

Per manufacturer request, Body-Worn SAR was evaluated as an additional conservative SAR test condition for the left earbud. The antenna touching position was additionally evaluated from normal use condition because it is more conservative in some cases. The DUT was evaluated with a separation distance of 0 mm between the back side of the earbud and the flat phantom. 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 *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.

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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.

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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	HDRp4	4.0	0	9.17	8.260
2441	HDRp4	4.0	39	9.04	8.017
2480	HDRp4	4.0	78	9.09	8.110

Table 7-2
NB UNII Average RF Power

rate	Band	Frequency	Channel	Average
HDRp4	UNII1	5157	Low	6.42
		5201	Middle	6.40
		5245	High	6.14
HDRp4	UNII3	5731	Low	7.44
		5788	Middle	7.19
		5844	High	7.37

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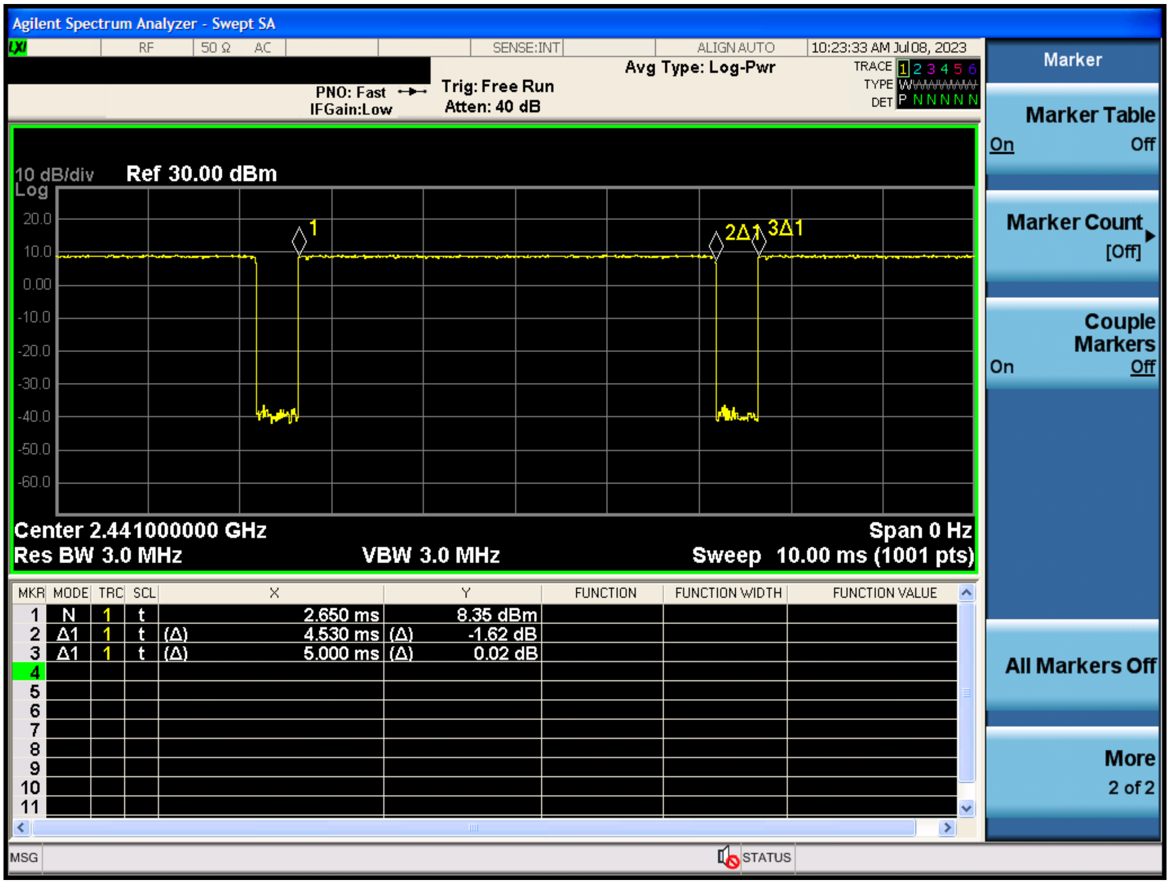
7.2 2.4 GHz Bluetooth Duty Cycle

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

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{4.530\ ms}{5.000\ ms} * 100\% = 90.6\%$$

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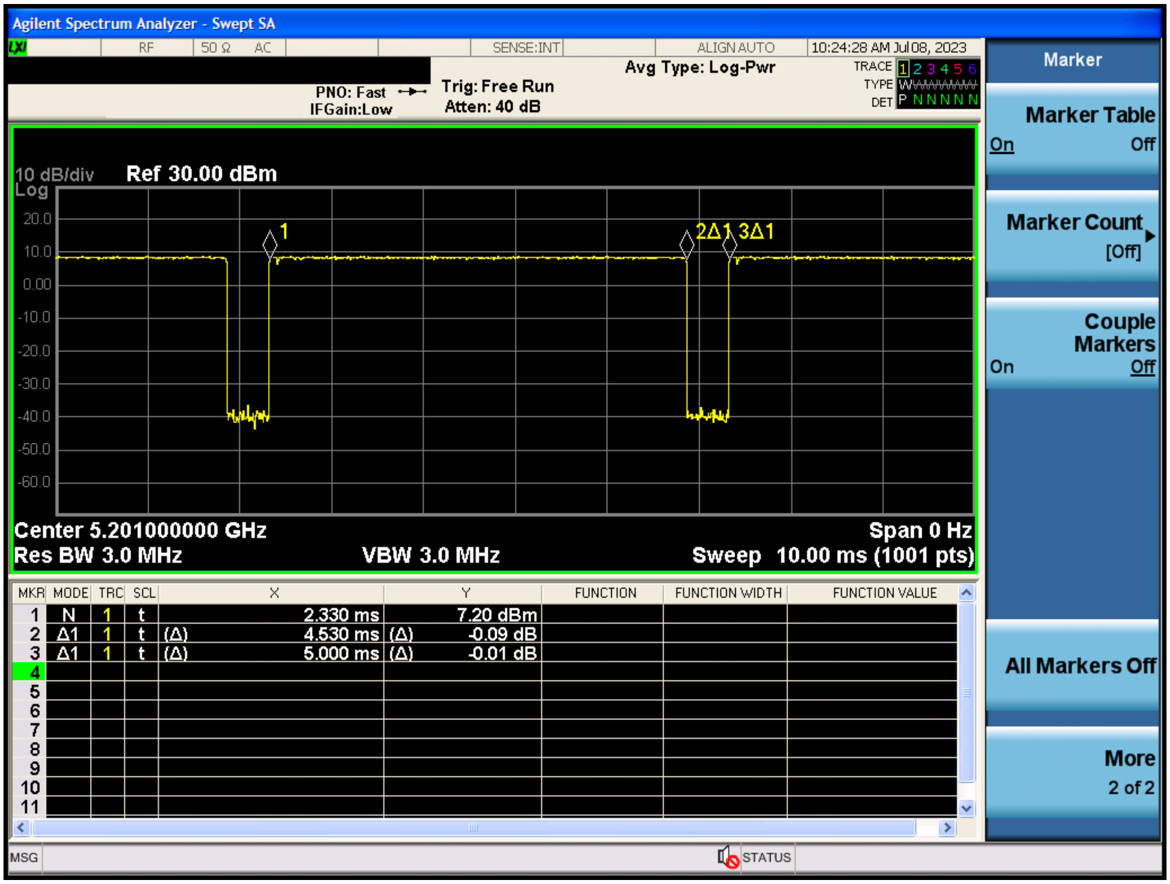
7.3 NB UNII Duty Cycle

7.3.1 Maximum NB UNII Transmission

Figure 7-2
NB UNII-1 Transmission Plot



Equation 7-2
NB UNII-1 Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{4.530\ ms}{5.000\ ms} * 100\% = 90.6\%$$

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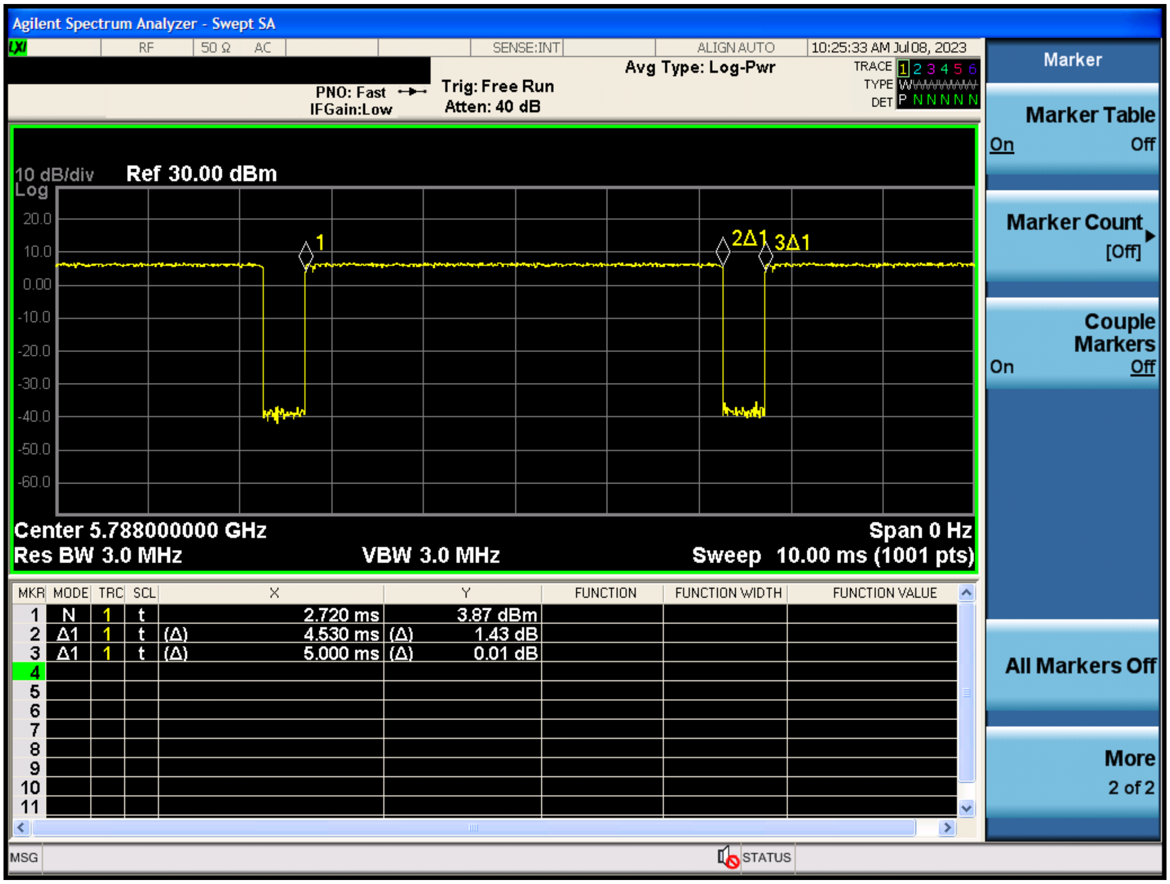
Figure 7-3
NB UNII-3 Transmission Plot



Equation 7-3
NB UNII-3 Duty Cycle Calculation

$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{4.530\ ms}{5.000\ ms} * 100\% = 90.6\%$$

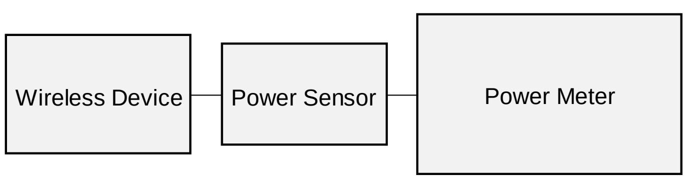


Figure 7-4
Power Measurement Setup

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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
06/15/2023	2450 Head	23.2	2300	1.672	38.589	1.670	39.500	0.12%	-2.31%
			2310	1.683	38.555	1.679	39.480	0.24%	-2.34%
			2320	1.695	38.520	1.687	39.460	0.47%	-2.38%
			2400	1.792	38.212	1.756	39.289	2.05%	-2.74%
			2450	1.850	38.005	1.800	39.200	2.78%	-3.05%
			2480	1.888	37.892	1.833	39.162	3.00%	-3.24%
			2500	1.911	37.827	1.855	39.136	3.02%	-3.34%
			2510	1.923	37.788	1.866	39.123	3.05%	-3.41%
			2535	1.952	37.675	1.893	39.092	3.12%	-3.62%
			2550	1.972	37.609	1.909	39.073	3.30%	-3.75%
			2560	1.985	37.571	1.920	39.060	3.39%	-3.81%
			2600	2.032	37.437	1.964	39.009	3.46%	-4.03%
			2650	2.094	37.212	2.018	38.945	3.77%	-4.45%
			2680	2.131	37.098	2.051	38.907	3.90%	-4.65%
			2700	2.154	37.022	2.073	38.882	3.91%	-4.78%
06/19/2023	2450 Head	24.6	2300	1.682	40.113	1.670	39.500	0.72%	1.55%
			2310	1.692	40.082	1.679	39.480	0.77%	1.52%
			2320	1.702	40.046	1.687	39.460	0.89%	1.49%
			2400	1.795	39.727	1.756	39.289	2.22%	1.11%
			2450	1.848	39.502	1.800	39.200	2.67%	0.77%
			2480	1.886	39.394	1.833	39.162	2.89%	0.59%
			2500	1.907	39.328	1.855	39.136	2.80%	0.49%
			2510	1.917	39.290	1.866	39.123	2.73%	0.43%
			2535	1.944	39.175	1.893	39.092	2.69%	0.21%
			2550	1.964	39.105	1.909	39.073	2.88%	0.08%
			2560	1.977	39.067	1.920	39.060	2.97%	0.02%
			2600	2.022	38.934	1.964	39.009	2.95%	-0.19%
			2650	2.079	38.709	2.018	38.945	3.02%	-0.61%
			2680	2.113	38.612	2.051	38.907	3.02%	-0.76%
			2700	2.134	38.541	2.073	38.882	2.94%	-0.88%

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Table 8-2
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
06/20/2023	5200-5800 Head	20.3	5180	4.536	34.995	4.635	36.009	-2.14%	-2.82%
			5190	4.546	34.979	4.645	35.998	-2.13%	-2.83%
			5200	4.559	34.971	4.655	35.986	-2.06%	-2.82%
			5210	4.570	34.956	4.666	35.975	-2.06%	-2.83%
			5220	4.579	34.937	4.676	35.963	-2.07%	-2.85%
			5240	4.596	34.905	4.696	35.940	-2.13%	-2.88%
			5250	4.609	34.888	4.706	35.929	-2.06%	-2.90%
			5260	4.622	34.873	4.717	35.917	-2.01%	-2.91%
			5270	4.630	34.853	4.727	35.906	-2.05%	-2.93%
			5280	4.638	34.847	4.737	35.894	-2.09%	-2.92%
			5290	4.648	34.838	4.748	35.883	-2.11%	-2.91%
			5300	4.658	34.828	4.758	35.871	-2.10%	-2.91%
			5310	4.669	34.808	4.768	35.860	-2.08%	-2.93%
			5320	4.679	34.788	4.778	35.849	-2.07%	-2.96%
			5500	4.852	34.552	4.963	35.643	-2.24%	-3.06%
			5510	4.865	34.530	4.973	35.632	-2.17%	-3.09%
			5520	4.878	34.512	4.983	35.620	-2.11%	-3.11%
			5530	4.886	34.496	4.994	35.609	-2.16%	-3.13%
			5540	4.893	34.482	5.004	35.597	-2.22%	-3.13%
			5550	4.903	34.469	5.014	35.586	-2.21%	-3.14%
			5560	4.915	34.456	5.024	35.574	-2.17%	-3.14%
			5580	4.939	34.434	5.045	35.551	-2.10%	-3.14%
			5600	4.965	34.415	5.065	35.529	-1.97%	-3.14%
			5610	4.975	34.399	5.076	35.518	-1.99%	-3.15%
			5620	4.982	34.379	5.086	35.506	-2.04%	-3.17%
			5640	5.003	34.340	5.106	35.483	-2.02%	-3.22%
			5660	5.029	34.319	5.127	35.460	-1.91%	-3.22%
			5670	5.036	34.318	5.137	35.449	-1.97%	-3.19%
			5680	5.046	34.308	5.147	35.437	-1.96%	-3.19%
			5690	5.056	34.292	5.158	35.426	-1.98%	-3.20%
			5700	5.071	34.266	5.168	35.414	-1.88%	-3.24%
			5710	5.083	34.243	5.178	35.403	-1.83%	-3.28%
			5720	5.090	34.230	5.188	35.391	-1.89%	-3.28%
			5745	5.117	34.201	5.214	35.363	-1.86%	-3.29%
			5750	5.123	34.196	5.219	35.357	-1.84%	-3.28%
			5755	5.128	34.190	5.224	35.351	-1.84%	-3.28%
			5765	5.140	34.180	5.234	35.340	-1.80%	-3.28%
			5775	5.152	34.175	5.245	35.329	-1.77%	-3.27%
			5785	5.161	34.159	5.255	35.317	-1.79%	-3.28%
			5795	5.171	34.142	5.265	35.305	-1.79%	-3.29%
			5800	5.176	34.133	5.270	35.300	-1.78%	-3.31%
			5800	5.176	34.133	5.270	35.300	-1.78%	-3.31%
			5805	5.181	34.128	5.275	35.294	-1.78%	-3.30%
			5825	5.203	34.108	5.296	35.271	-1.76%	-3.30%
			5835	5.209	34.084	5.305	35.230	-1.81%	-3.25%
			5845	5.216	34.069	5.315	35.210	-1.86%	-3.24%
			5855	5.228	34.059	5.325	35.197	-1.82%	-3.23%
			5865	5.242	34.055	5.336	35.190	-1.76%	-3.23%
			5865	5.242	34.055	5.336	35.190	-1.76%	-3.23%
			5865	5.242	34.055	5.336	35.190	-1.76%	-3.23%
			5865	5.242	34.055	5.336	35.190	-1.76%	-3.23%
			5875	5.253	34.038	5.347	35.183	-1.76%	-3.25%
			5885	5.261	34.026	5.357	35.177	-1.79%	-3.27%
			5905	5.284	34.004	5.379	35.163	-1.77%	-3.30%

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 ±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 Appendix D.

Table 8-3
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 (%)
AM9	2450	HEAD	06/15/2023	21.8	21.4	0.10	921	7427	1403	5.340	54.200	53.400	-1.48%
AM9	2450	HEAD	06/19/2023	21.1	22.6	0.10	921	7427	1403	5.400	54.200	54.000	-0.37%
AM9	5250	HEAD	06/20/2023	22.6	20.3	0.05	1066	7427	1403	3.990	80.300	79.800	-0.62%
AM9	5600	HEAD	06/20/2023	22.6	20.3	0.05	1066	7427	1403	4.190	83.900	83.800	-0.12%
AM9	5750	HEAD	06/20/2023	22.6	20.3	0.05	1066	7427	1403	3.950	79.500	79.000	-0.63%
AM9	5850	HEAD	06/20/2023	22.6	20.3	0.05	1066	7427	1403	3.890	82.200	77.800	-5.35%

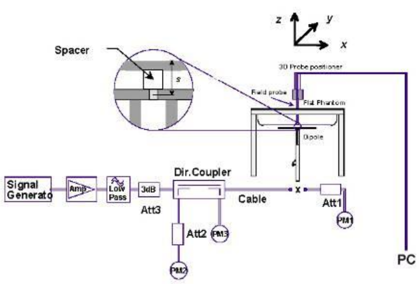

Figure 8-1
System Verification Setup Diagram

Figure 8-2
System Verification Setup Photo

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9 SAR DATA SUMMARY

9.1 Standalone Head SAR Data

Table 9-1
Bluetooth 2450 Head SAR

MEASUREMENT RESULTS																
FREQUENCY		Mode	Service	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Side	Spacing	Earbud	Device Serial Number	Data Rate (Mbps)	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.												(W/kg)			(W/kg)	
2402.00	0	Bluetooth	FHSS	9.50	9.17	-0.01	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.341	1.079	1.104	0.406	
2441.00	39	Bluetooth	FHSS	9.50	9.04	-0.02	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.348	1.112	1.104	0.427	A1
2480.00	78	Bluetooth	FHSS	9.50	9.09	-0.02	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.330	1.099	1.104	0.400	
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 100% transmission duty factor.

Table 9-2
NB UNII Head SAR

MEASUREMENT RESULTS																	
FREQUENCY		Mode	Service	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Side	Spacing	Earbud	Device Serial Number	Data Rate (Mbps)	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.												(W/kg)			(W/kg)	
5731.00	Low	NB UNII-3	FHSS	7.50	7.44	0	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.038	1.014	1.104	0.043	
5788.00	Mid	NB UNII-3	FHSS	7.50	7.19	0.01	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.029	1.074	1.104	0.034	
5844.00	High	NB UNII-3	FHSS	7.50	7.37	0.01	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.038	1.030	1.104	0.043	
5157.00	Low	NB UNII-1	FHSS	6.50	6.42	-0.04	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.039	1.019	1.104	0.044	
5201.00	Mid	NB UNII-1	FHSS	6.50	6.40	0.01	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.041	1.023	1.104	0.046	A2
5245.00	High	NB UNII-1	FHSS	6.50	6.14	0	front	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.038	1.086	1.104	0.046	
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 100% transmission duty factor.

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9.2 Standalone Body-Worn SAR Data

Table 9-3
Bluetooth 2450 Body-Worn SAR

MEASUREMENT RESULTS																	
FREQUENCY		Mode	Service	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Side	Spacing	Earbud	Device Serial Number	Data Rate (Mbps)	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.												(W/kg)			(W/kg)	
2402.00	0	Bluetooth	FHSS	9.50	9.17	0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.972	1.079	1.104	1.158	
2402.00	0	Bluetooth	FHSS	9.50	9.17	0.06	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.985	1.079	1.104	1.173	A3
2402.00	0	Bluetooth	FHSS	9.50	9.17	0.01	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.651	1.079	1.104	0.775	
2441.00	39	Bluetooth	FHSS	9.50	9.04	0	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.954	1.112	1.104	1.171	
2441.00	39	Bluetooth	FHSS	9.50	9.04	-0.02	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.669	1.112	1.104	0.821	
2480.00	78	Bluetooth	FHSS	9.50	9.09	-0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.955	1.099	1.104	1.159	
2480.00	78	Bluetooth	FHSS	9.50	9.09	0.02	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.733	1.099	1.104	0.889	
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: The reported SAR was scaled to 100% transmission duty factor.
Blue entries represent variability measurement.

Table 9-4
NB UNII Body-Worn SAR

MEASUREMENT RESULTS																	
FREQUENCY		Mode	Service	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Side	Spacing	Earbud	Device Serial Number	Data Rate (Mbps)	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.												(W/kg)			(W/kg)	
5731.00	Low	NB UNII-3	FHSS	7.50	7.44	-0.01	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.815	1.014	1.104	0.912	
5731.00	Low	NB UNII-3	FHSS	7.50	7.44	-0.01	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.827	1.014	1.104	0.926	
5731.00	Low	NB UNII-3	FHSS	7.50	7.44	0.02	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.359	1.014	1.104	0.402	
5788.00	Mid	NB UNII-3	FHSS	7.50	7.19	0.02	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.676	1.074	1.104	0.802	
5788.00	Mid	NB UNII-3	FHSS	7.50	7.19	0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.478	1.074	1.104	0.567	
5844.00	High	NB UNII-3	FHSS	7.50	7.37	-0.02	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.599	1.030	1.104	0.681	
5844.00	High	NB UNII-3	FHSS	7.50	7.37	-0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.300	1.030	1.104	0.341	
5157.00	Low	NB UNII-1	FHSS	6.50	6.42	-0.01	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.806	1.019	1.104	0.907	
5157.00	Low	NB UNII-1	FHSS	6.50	6.42	-0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.432	1.019	1.104	0.486	
5201.00	Mid	NB UNII-1	FHSS	6.50	6.40	0.01	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.819	1.023	1.104	0.925	
5201.00	Mid	NB UNII-1	FHSS	6.50	6.40	0	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.441	1.023	1.104	0.498	
5245.00	High	NB UNII-1	FHSS	6.50	6.14	-0.05	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.831	1.086	1.104	0.996	A4
5245.00	High	NB UNII-1	FHSS	6.50	6.14	0.02	back	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.816	1.086	1.104	0.978	
5245.00	High	NB UNII-1	FHSS	6.50	6.14	-0.01	antenna touching	0 mm	Left	GX1KJ3UR26JY	4	90.6	0.353	1.086	1.104	0.423	
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: The reported SAR was scaled to 100% transmission duty factor.
Blue entries represent variability measurement.

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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 D01v06.
5. To demonstrate compliance for Head, SAR testing was performed on a flat phantom filled with head tissue equivalent medium.
6. Per manufacturer request, Body-Worn SAR was additionally evaluated as a conservative SAR test condition for the right earbud (BCG-A3048). The antenna touching position was additionally evaluated from normal use condition because it is more conservative in some cases.
7. Per FCC KDB 865664 D01v01r04, variability SAR tests were performed when the measured SAR results for a frequency band were greater than or equal to 0.8 W/kg. Repeated SAR measurements are highlighted in the tables above for clarity. Please see Section 10 for variability analysis.
8. The orange highlights throughout the report represent the highest scaled SAR per Equipment Class.

Bluetooth Notes

1. Bluetooth SAR was evaluated with a test mode with hopping disabled with DH5 operation. The reported SAR was scaled to the 100% transmission duty factor to determine compliance. See section 7.2 for the time domain plot and calculation for the duty factor of the device.

NB UNII Notes

1. The repeated SAR was scaled to the 100% transmission duty factor to determine compliance. See section 7.3 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 D01v01r04, SAR measurement variability was assessed for each frequency band, which was determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media were required for SAR measurements in a frequency band, the variability measurement procedures were applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. These additional measurements were repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device was returned to ambient conditions (normal room temperature) with the battery fully charged before it was re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

SAR Measurement Variability was assessed using the following procedures for each frequency band:

1) When the original highest measured SAR is ≥ 0.80 W/kg, the measurement was repeated once.
2) A second repeated measurement was performed only if the ratio of largest to smallest SAR for the original and first repeated measurements was > 1.20 or when the original or repeated measurement was ≥ 1.45 W/kg (~ 10% from the 1g SAR limit).
3) A third repeated measurement was performed only if the original, first or second repeated measurement was ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.
4) Repeated measurements are not required when the original highest measured SAR is < 0.80 W/kg
5) When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

Table 10-1
Body SAR Measurement Variability Results

BODY VARIABILITY RESULTS															
Band	FREQUENCY		Mode	Service	Data Rate (Mbps)	Side	Earbud	Spacing	Measured SAR (1g)	1st Repeated SAR (1g)	Ratio	2nd Repeated SAR (1g)	Ratio	3rd Repeated SAR (1g)	Ratio
	MHz	Ch.							(W/kg)	(W/kg)		(W/kg)		(W/kg)	
2450	2402.00	0	Bluetooth	FHSS	4	Antenna touching	Left	0 mm	0.985	0.972	1.01	N/A	N/A	N/A	N/A
5250	5245.00	High	NB UNII 1	FHSS	4	Back	Left	0 mm	0.831	0.816	1.02	N/A	N/A	N/A	N/A
5750	5731.00	Low	NB UNII 3	FHSS	4	Back	Left	0 mm	0.827	0.815	1.01	N/A	N/A	N/A	N/A
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population								Body 1.6 W/kg (mW/g) averaged over 1 gram							

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
Rohde & Schwarz	FSP-7	Spectrum Analyzer	2/8/2023	Annual	2/8/2024	100990
Agilent	E4438C	ESG Vector Signal Generator	4/25/2023	Annual	4/25/2024	US41460739
Agilent	E4438C	ESG Vector Signal Generator	11/17/2022	Annual	11/17/2023	MY45093852
Agilent	N5182A	MXG Vector Signal Generator	4/1/2023	Annual	4/1/2024	MY47420837
Agilent	N5182A	MXG Vector Signal Generator	11/17/2022	Annual	11/17/2023	US46240505
Agilent	8753ES	S-Parameter Vector Network Analyzer	6/2/2023	Annual	6/2/2024	MY40003841
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Amplifier Research	150A100C	Amplifier	CBT	N/A	CBT	350132
Anritsu	ML2496A	Power Meter	8/16/2022	Annual	8/16/2023	1351001
Anritsu	MA2411B	Pulse Power Sensor	1/10/2023	Annual	1/10/2024	1315051
Anritsu	MA2411B	Pulse Power Sensor	10/21/2022	Annual	10/21/2023	1207364
Anritsu	MA24106A	USB Power Sensor	4/21/2023	Annual	4/21/2024	1244515
Anritsu	MA24106A	USB Power Sensor	3/10/2023	Annual	3/10/2024	2018527
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774685
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774675
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/17/2023	Annual	1/17/2024	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	3/15/2023	Annual	3/15/2024	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	TSF-100	Torque Wrench	7/11/2022	Annual	7/11/2023	47639-29
SPEAG	DAK-3.5	Dielectric Assessment Kit	10/17/2022	Annual	10/17/2023	1091
SPEAG	DAKS-3.5	Portable Dielectric Assessment Kit	9/19/2022	Annual	9/19/2023	1045
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1243
SPEAG	D2450V2	2450 MHz SAR Dipole	11/9/2021	Biennial	11/9/2023	921
SPEAG	D5GHzV2	5GHz SAR Dipole	11/17/2022	Annual	11/17/2023	1066
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/15/2023	Annual	2/15/2024	1403
SPEAG	EX3DV4	SAR Probe	2/13/2023	Annual	2/13/2024	7427

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_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

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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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