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SAR EVALUATION REPORT

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

Date of Testing:
06/14/2023 – 07/18/2023
Test Report Issue Date:
08/10/2023
Test Site/Location:
Element Morgan Hill, CA, USA
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FCC ID: **BCG-A2980**

APPLICANT: **APPLE, INC.**

DUT Type: Watch
Application Type: Certification
FCC Rule Part(s): CFR §2.1093
Model: A2980

Equipment Class	Band & Mode	Tx Frequency	SAR	
			1g Head (W/kg)	10g Extremity (W/kg)
DTS	2.4 GHz WLAN	2412 - 2472 MHz	0.45	0.12
NII	U-NII-1	5180 - 5240 MHz	N/A	N/A
NII	U-NII-2A	5260 - 5320 MHz	0.14	< 0.1
NII	U-NII-2C	5500 - 5720 MHz	0.16	< 0.1
NII	U-NII-3	5745 - 5825 MHz	0.19	< 0.1
DSS/DTS	Bluetooth	2402 - 2480 MHz	0.28	0.10
NII	802.15.4 ab-NB	5728.75 - 5846.25 MHz	<0.1	<0.1
Simultaneous SAR per KDB 690783 D01v01r03:			0.47	0.12

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 watch 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 1.8 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

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.

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

1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
2.4 GHz WLAN	Voice/Data	2412 - 2472 MHz
U-NII-1	Voice/Data	5180 - 5240 MHz
U-NII-2A	Voice/Data	5260 - 5320 MHz
U-NII-2C	Voice/Data	5500 - 5720 MHz
U-NII-3	Voice/Data	5745 - 5825 MHz
Bluetooth	Data	2402 - 2480 MHz
802.15.4 ab-NB	Data	5728.75 - 5846.25 MHz
NFC	Data	13.56 MHz
UWB	Data	6489.6 - 7987.2 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 – 2.4 GHz WiFi Mode

Mode/ Band			IEEE 802.11b (2.4 GHz)		IEEE 802.11g (2.4 GHz)		IEEE 802.11n (2.4 GHz)	
		Channel	Maximum	Nominal	Maximum	Nominal	Maximum	Nominal
Modulated Average - Single Tx Chain (dBm)	20 MHz Bandwidth	1	20.00	19.00	17.00	16.00	17.00	16.00
		2	20.00	19.00	19.00	18.00	19.00	18.00
		3	20.00	19.00	19.00	18.00	19.00	18.00
		4	20.00	19.00	19.00	18.00	19.00	18.00
		5	20.00	19.00	19.00	18.00	19.00	18.00
		6	20.00	19.00	19.00	18.00	19.00	18.00
		7	20.00	19.00	19.00	18.00	19.00	18.00
		8	20.00	19.00	19.00	18.00	19.00	18.00
		9	20.00	19.00	19.00	18.00	19.00	18.00
		10	20.00	19.00	19.00	18.00	19.00	18.00
		11	20.00	19.00	17.00	16.00	17.00	16.00
		12	20.00	19.00	14.50	13.50	14.50	13.50
		13	18.00	17.00	2.50	1.50	2.50	1.50

1.3.2 Maximum Output Power – 5 GHz WiFi Mode

Mode/ Band		Channel	IEEE 802.11a (5 GHz) Maximum	IEEE 802.11a (5 GHz) Nominal	IEEE 802.11n (5 GHz) Maximum	IEEE 802.11n (5 GHz) Nominal
Modulated Average - Single Tx Chain (dBm)	20 MHz Bandwidth	36	17.00	16.00	17.00	16.00
		40	17.00	16.00	17.00	16.00
		44	17.00	16.00	17.00	16.00
		48	17.00	16.00	17.00	16.00
		52	17.00	16.00	17.00	16.00
		56	17.00	16.00	17.00	16.00
		60	17.00	16.00	17.00	16.00
		64	17.00	16.00	17.00	16.00
		100	17.00	16.00	17.00	16.00
		104	17.00	16.00	17.00	16.00
		108	17.00	16.00	17.00	16.00
		112	17.00	16.00	17.00	16.00
		116	17.00	16.00	17.00	16.00
		120	17.00	16.00	17.00	16.00
		124	17.00	16.00	17.00	16.00
		128	17.00	16.00	17.00	16.00
		132	17.00	16.00	17.00	16.00
		136	15.00	14.00	15.00	14.00
		140	12.50	11.50	12.50	11.50
		144	17.00	16.00	17.00	16.00
		149	17.00	16.00	17.00	16.00
		153	17.00	16.00	17.00	16.00
		157	17.00	16.00	17.00	16.00
		161	17.00	16.00	17.00	16.00
		165	17.00	16.00	17.00	16.00

1.3.3 Maximum Output Power – Bluetooth Mode

Mode / Band		Modulated Average - Single Tx Chain (dBm)
Bluetooth BDR	Maximum	**19.00**
	Nominal	**18.00**
Bluetooth EDR	Maximum	**14.50**
	Nominal	**13.50**
Bluetooth HDR	Maximum	**14.50**
	Nominal	**13.50**
Bluetooth LE	Maximum	**19.00**
	Nominal	**18.00**

1.3.4 Maximum Output Power – 802.15.4 ab-NB Mode

Mode / Band		Modulated Average - Single Tx Chain (dBm)
802.15.4 ab-NB	Maximum	**16.00**
	Nominal	**14.00**

1.4 DUT Antenna Locations

A diagram showing the location of the device antennas can be found in the DUT Antenna Diagram & SAR Test Setup Photographs Appendix**.**

1.5 Near Field Communications (NFC) Antenna

This DUT has NFC operations. The NFC antenna is integrated into the device for this model. Therefore, all SAR tests were performed with the device which already incorporates the NFC antenna. A diagram showing the location of the NFC antenna can be found in the DUT Antenna Diagram & SAR Test Setup Photographs Appendix**.**

1.6 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	Head	Extremity
1	2.4 GHz Bluetooth + 5 GHz WI-FI	Yes	Yes
2	2.4 GHz Bluetooth + 802.15.4 ab-NB	Yes	Yes
3	802.15.4 ab-NB + 2.4 GHz WI-FI	Yes	Yes

1. 2.4 GHz WLAN, and 2.4 GHz Bluetooth share the same antenna path and cannot transmit simultaneously.
2. 2.4 GHz WLAN, and 5 GHz WLAN share the same antenna path and cannot transmit simultaneously.
3. 802.15.4 ab-NB, and 5 GHz WLAN share the same antenna path and cannot transmit simultaneously.
4. This device supports VOWIFI.

1.7 Miscellaneous SAR Test Considerations

(A) WIFI/BT

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 KDB 248227 D01v02r02.

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.

1.8 Guidance Applied

- FCC KDB Publication 248227 D01v02r02 (SAR Considerations for 802.11 Devices)
- FCC KDB Publication 447498 D01v06 (General SAR Guidance, Wrist-worn Device Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)
- IEEE 1528-2013

1.9 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.

1.10 Device Housing Types and Wrist Band Types

This device has one housing type that was evaluated independently for SAR: Aluminum. The device can also be used with different wristband accessories. The non-metallic wrist accessory, sport band, was evaluated for all exposure conditions. The available metallic wrist accessories, metal links band and metal loop band, were additionally evaluated.

2 INTRODUCTION

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

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

2.1 SAR Definition

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

Equation 2-1
SAR Mathematical Equation

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

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

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

where:

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

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

3 DOSIMETRIC ASSESSMENT

3.1 Measurement Procedure

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

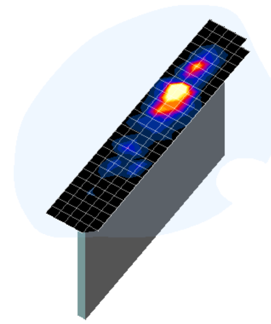


Figure 3-1
Sample SAR Area Scan

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface, and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 3-1) and IEEE 1528-2013.
2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.
3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 3-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):
    a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).
    b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.
    c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

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

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

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. Additionally, a manufacturer provided low-loss foam was used to position the device for head SAR evaluations.

4.2 Positioning for Head

Devices that are designed to be worn on the wrist may operate in speaker mode for voice communication, with the device worn on the wrist and positioned next to the mouth. When next-to-mouth SAR evaluation is required, the device is positioned at 10 mm from a flat phantom filled with head tissue-equivalent medium. The device is evaluated with wrist bands strapped together to represent normal use conditions.

4.3 Extremity Exposure Configurations

Devices that are 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. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. When extremity SAR evaluation is required, the device is evaluated with the back of the device touching the flat phantom, which is filled with head tissue-equivalent medium. The device was evaluated with Sport wristband unstrapped and touching the phantom. For Metal Loop and Metal Links wristbands, the device was evaluated with wristbands strapped and the distance between wristbands and the phantom was minimized to represent the spacing created by actual use conditions.

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 SAR Testing with 802.11 Transmitters

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

6.2.1 General Device Setup

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

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

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

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

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

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

6.2.4 2.4 GHz SAR Test Requirements

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

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

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

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

6.2.5 OFDM Transmission Mode and SAR Test Channel Selection

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

6.2.6 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 6.2.5). When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.2.7 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.

7 RF CONDUCTED POWERS

7.1 WLAN Conducted Powers

Table 7-1
2.4 GHz WLAN Maximum Average RF Power

2.4GHz Conducted Power [dBm]				
Freq [MHz]	Channel	IEEE Transmission Mode		
		802.11b	802.11g	802.11n
		Average	Average	Average
2412	1	18.72	16.02	16.01
2417	2	[redacted]	18.05	18.04
2437	6	18.80	18.16	18.09
2457	10	[redacted]	17.95	17.94
2462	11	18.78	16.04	16.02

Table 7-2
5 GHz WLAN Maximum Average RF Power

5GHz (20MHz) Conducted Power [dBm]			
Freq [MHz]	Channel	IEEE Transmission Mode	
		802.11a	802.11n
		Average	Average
5180	36	16.15	16.00
5200	40	16.17	16.28
5220	44	16.18	16.27
5240	48	16.11	16.15
5260	52	16.06	16.06
5280	56	16.02	15.97
5300	60	16.19	16.17
5320	64	16.00	16.13
5500	100	16.37	16.32
5600	120	16.15	16.17
5620	124	16.34	16.01
5720	144	15.95	15.86
5745	149	16.16	15.93
5785	157	16.08	15.99
5825	165	16.00	16.09

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

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.

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

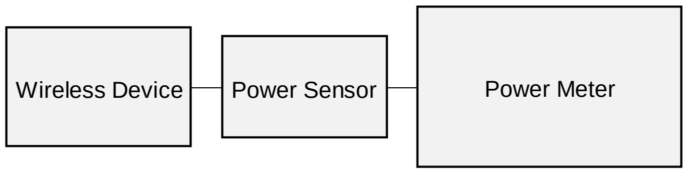


Figure 7-1
Power Measurement Setup

7.2 Bluetooth Conducted Powers

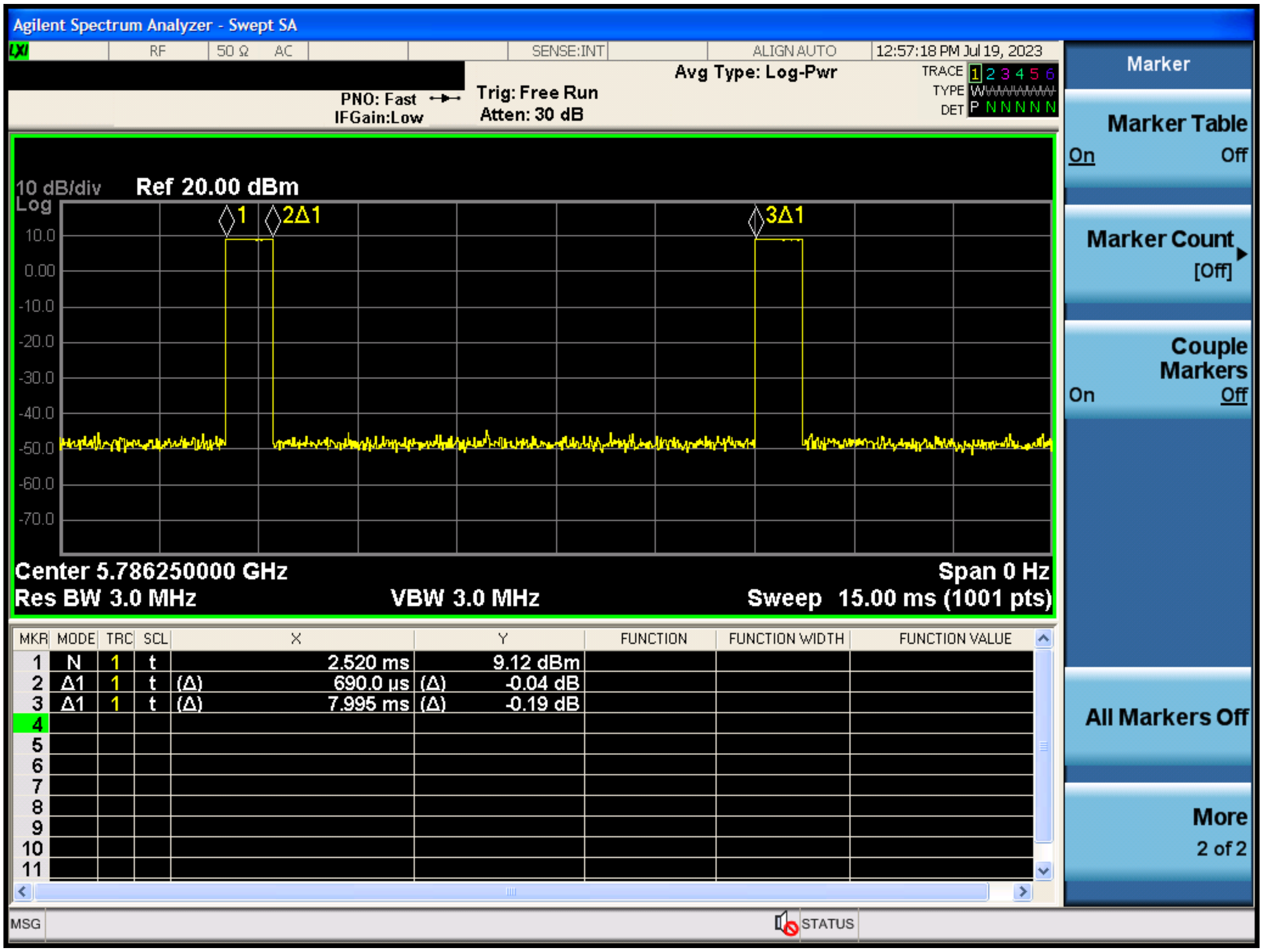
Table 7-3
Bluetooth Average RF Power

Frequency [MHz]	Modulation	Data Rate [Mbps]	Channel No.	Avg Conducted Power	
				[dBm]	[mW]
2402	GFSK	1.0	0	18.57	71.945
2441	GFSK	1.0	39	18.43	69.663
2480	GFSK	1.0	78	18.17	65.615

Note 1: Bluetooth was evaluated with a test mode with 100% transmission duty factor.

Table 7-4
802.15.4 ab-NB Average RF Power

Band	Channel	Frequency	Average
802.15.4 ab-NB	Low	5728.75	15.85
	Mid	5786.25	15.79
	High	5846.25	15.83



$$Duty\ Cycle = \frac{Pulse\ Width}{Period} * 100\% = \frac{0.690}{7.995} * 100\% = 8.6\%$$

Figure 7-2
802.15.4 ab-NB Duty Cycle Plot & Calculation

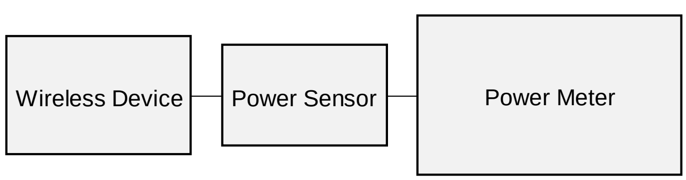


Figure 7-3
Power Measurement Setup

8 SYSTEM VERIFICATION

8.1

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
06/14/2023	2450 Head	22.2	2400	1.839	39.756	1.756	39.289	4.73%	1.19%
			2450	1.875	39.666	1.800	39.200	4.17%	1.19%
			2480	1.900	39.618	1.833	39.162	3.66%	1.16%
			2500	1.915	39.590	1.855	39.136	3.23%	1.16%
			2510	1.922	39.575	1.866	39.123	3.00%	1.16%
			2535	1.941	39.522	1.893	39.092	2.54%	1.10%
			2550	1.955	39.493	1.909	39.073	2.41%	1.07%
			2560	1.964	39.481	1.920	39.060	2.29%	1.08%
			2600	1.998	39.440	1.964	39.009	1.73%	1.10%
			2650	2.038	39.361	2.018	38.945	0.99%	1.07%
			2680	2.061	39.319	2.051	38.907	0.49%	1.06%
			2700	2.076	39.292	2.073	38.882	0.14%	1.05%
06/19/2023	5200-5800 Head	20.5	5180	4.639	35.340	4.635	36.009	0.09%	-1.86%
			5190	4.653	35.334	4.645	35.998	0.17%	-1.84%
			5200	4.668	35.314	4.655	35.986	0.28%	-1.87%
			5210	4.682	35.285	4.666	35.975	0.34%	-1.92%
			5220	4.692	35.258	4.676	35.963	0.34%	-1.96%
			5240	4.715	35.227	4.696	35.940	0.40%	-1.98%
			5250	4.729	35.203	4.706	35.929	0.49%	-2.02%
			5260	4.741	35.184	4.717	35.917	0.51%	-2.04%
			5270	4.750	35.164	4.727	35.906	0.49%	-2.07%
			5280	4.758	35.150	4.737	35.894	0.44%	-2.07%
			5290	4.773	35.130	4.748	35.883	0.53%	-2.10%
			5300	4.788	35.103	4.758	35.871	0.63%	-2.14%
			5310	4.800	35.091	4.768	35.860	0.67%	-2.14%
			5320	4.810	35.084	4.778	35.849	0.67%	-2.13%
			5500	5.004	34.733	4.963	35.643	0.83%	-2.55%
			5510	5.019	34.712	4.973	35.632	0.92%	-2.58%
			5520	5.030	34.691	4.983	35.620	0.94%	-2.61%
			5530	5.038	34.671	4.994	35.609	0.88%	-2.63%
			5540	5.048	34.649	5.004	35.597	0.88%	-2.66%
			5550	5.061	34.628	5.014	35.586	0.94%	-2.69%
			5560	5.075	34.606	5.024	35.574	1.02%	-2.72%
			5580	5.098	34.583	5.045	35.551	1.05%	-2.72%
			5600	5.123	34.526	5.065	35.529	1.15%	-2.82%
			5610	5.136	34.501	5.076	35.518	1.18%	-2.86%
			5620	5.148	34.487	5.086	35.506	1.22%	-2.87%
			5640	5.175	34.450	5.106	35.483	1.35%	-2.91%
			5660	5.195	34.404	5.127	35.460	1.33%	-2.98%
			5670	5.208	34.389	5.137	35.449	1.38%	-2.99%
			5680	5.224	34.366	5.147	35.437	1.50%	-3.02%
			5690	5.238	34.342	5.158	35.426	1.55%	-3.06%
			5700	5.249	34.333	5.168	35.414	1.57%	-3.05%
			5710	5.262	34.325	5.178	35.403	1.62%	-3.04%
			5720	5.278	34.302	5.188	35.391	1.73%	-3.08%
			5745	5.306	34.246	5.214	35.363	1.76%	-3.16%
			5750	5.309	34.243	5.219	35.357	1.72%	-3.15%
			5755	5.315	34.241	5.224	35.351	1.74%	-3.14%
			5765	5.330	34.227	5.234	35.340	1.83%	-3.15%
			5775	5.342	34.202	5.245	35.329	1.85%	-3.19%
			5785	5.353	34.177	5.255	35.317	1.86%	-3.23%
			5795	5.369	34.161	5.265	35.305	1.98%	-3.24%
			5800	5.376	34.159	5.270	35.300	2.01%	-3.23%
			5800	5.376	34.159	5.270	35.300	2.01%	-3.23%
			5805	5.385	34.157	5.275	35.294	2.09%	-3.22%
			5825	5.401	34.115	5.296	35.271	1.98%	-3.28%
			5835	5.405	34.097	5.305	35.230	1.89%	-3.22%
			5845	5.419	34.081	5.315	35.210	1.96%	-3.21%
			5855	5.433	34.056	5.325	35.197	2.03%	-3.24%
			5865	5.444	34.038	5.336	35.190	2.02%	-3.27%
			5865	5.444	34.038	5.336	35.190	2.02%	-3.27%
			5865	5.444	34.038	5.336	35.190	2.02%	-3.27%
			5865	5.444	34.038	5.336	35.190	2.02%	-3.27%
			5875	5.452	34.030	5.347	35.183	1.96%	-3.28%
			5885	5.463	34.026	5.357	35.177	1.98%	-3.27%
			5905	5.496	33.990	5.379	35.163	2.18%	-3.34%
07/18/2023	5200-5800 Head	21.0	5180	4.412	35.749	4.635	36.009	-4.81%	-0.72%
			5190	4.425	35.728	4.645	35.998	-4.74%	-0.75%
			5200	4.434	35.714	4.655	35.986	-4.75%	-0.76%
			5210	4.443	35.706	4.666	35.975	-4.78%	-0.75%
			5220	4.455	35.688	4.676	35.963	-4.73%	-0.76%
			5240	4.478	35.642	4.696	35.940	-4.64%	-0.83%
			5250	4.487	35.622	4.706	35.929	-4.65%	-0.85%
			5260	4.499	35.606	4.717	35.917	-4.62%	-0.87%
			5270	4.512	35.585	4.727	35.906	-4.55%	-0.89%
			5280	4.524	35.577	4.737	35.894	-4.50%	-0.88%
			5290	4.534	35.563	4.748	35.883	-4.51%	-0.89%
			5300	4.545	35.543	4.758	35.871	-4.48%	-0.91%
			5310	4.554	35.528	4.768	35.860	-4.49%	-0.93%
			5320	4.567	35.510	4.778	35.849	-4.42%	-0.95%
			5500	4.759	35.201	4.963	35.643	-4.11%	-1.24%
			5510	4.770	35.180	4.973	35.632	-4.08%	-1.27%
			5520	4.783	35.165	4.983	35.620	-4.01%	-1.28%
			5530	4.795	35.151	4.994	35.609	-3.98%	-1.29%
			5540	4.808	35.131	5.004	35.597	-3.92%	-1.31%
			5550	4.821	35.103	5.014	35.586	-3.85%	-1.36%
			5560	4.833	35.082	5.024	35.574	-3.80%	-1.38%
			5580	4.854	35.051	5.045	35.551	-3.79%	-1.41%
			5600	4.874	35.021	5.065	35.529	-3.77%	-1.43%
			5610	4.886	35.001	5.076	35.518	-3.74%	-1.46%
			5620	4.898	34.976	5.086	35.506	-3.70%	-1.49%
			5640	4.923	34.930	5.106	35.483	-3.58%	-1.56%
			5660	4.947	34.919	5.127	35.460	-3.51%	-1.53%
			5670	4.957	34.905	5.137	35.449	-3.50%	-1.53%
			5680	4.967	34.885	5.147	35.437	-3.50%	-1.56%
			5690	4.977	34.868	5.158	35.426	-3.51%	-1.58%
			5700	4.989	34.848	5.168	35.414	-3.46%	-1.60%
			5710	5.003	34.824	5.178	35.403	-3.38%	-1.64%
			5720	5.015	34.805	5.188	35.391	-3.33%	-1.66%
			5745	5.042	34.767	5.214	35.363	-3.30%	-1.69%
			5750	5.048	34.758	5.219	35.357	-3.28%	-1.69%
			5755	5.056	34.750	5.224	35.351	-3.22%	-1.70%
			5765	5.067	34.731	5.234	35.340	-3.19%	-1.72%
			5775	5.076	34.718	5.245	35.329	-3.22%	-1.73%
			5785	5.090	34.706	5.255	35.317	-3.14%	-1.73%
			5795	5.101	34.697	5.265	35.305	-3.11%	-1.72%
			5800	5.107	34.691	5.270	35.300	-3.09%	-1.73%
			5800	5.107	34.691	5.270	35.300	-3.09%	-1.73%
			5805	5.112	34.683	5.275	35.294	-3.09%	-1.73%
			5825	5.132	34.641	5.296	35.271	-3.10%	-1.79%
			5835	5.144	34.629	5.305	35.230	-3.03%	-1.71%
			5845	5.154	34.610	5.315	35.210	-3.03%	-1.70%
			5855	5.162	34.590	5.325	35.197	-3.06%	-1.72%
			5865	5.172	34.576	5.336	35.190	-3.07%	-1.74%
			5865	5.172	34.576	5.336	35.190	-3.07%	-1.74%
			5865	5.172	34.576	5.336	35.190	-3.07%	-1.74%
			5865	5.172	34.576	5.336	35.190	-3.07%	-1.74%
			5875	5.185	34.566	5.347	35.183	-3.03%	-1.75%
			5885	5.198	34.551	5.357	35.177	-2.97%	-1.78%
			5905	5.222	34.504	5.379	35.163	-2.92%	-1.87%

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

Per April 2019 TCB Workshop Notes, single head-tissue simulating liquid specified in IEC 62209-1 is permitted to use for all SAR tests.

8.2 Test System Verification

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

Table 8-2
System Verification Results – 1g

SAR System	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp. (C)	Liquid Temp. (C)	Input Power (W)	Source SN	Probe SN	Measured SAR1g (W/kg)	1W Target SAR1g (W/kg)	1W Normalized SAR 1g (W/kg)	Deviation 1g (%)
AM2	2450	HEAD	06/14/2023	21.1	21.2	0.10	921	7308	5.200	54.200	52.000	-4.06%
AM1	5250	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	4.040	80.500	80.800	0.37%
AM1	5250	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	3.850	80.500	77.000	-4.35%
AM1	5600	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	4.280	83.700	85.600	2.27%
AM1	5600	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	4.260	83.700	85.200	1.79%
AM1	5750	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	3.830	80.500	76.600	-4.84%
AM1	5750	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	3.810	80.500	76.200	-5.34%

Table 8-3
System Verification Results – 10g

SAR System	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp. (C)	Liquid Temp. (C)	Input Power (W)	Source SN	Probe SN	Measured SAR10g (W/kg)	1W Target SAR10g (W/kg)	1W Normalized SAR 10g (W/kg)	Deviation 10g (%)
AM2	2450	HEAD	06/14/2023	21.1	21.2	0.10	921	7308	2.420	25.500	24.200	-5.10%
AM1	5250	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	1.140	22.900	22.800	-0.44%
AM1	5250	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	1.100	22.900	22.000	-3.93%
AM1	5600	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	1.200	23.700	24.000	1.27%
AM1	5600	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	1.210	23.700	24.200	2.11%
AM1	5750	HEAD	06/19/2023	22.0	20.5	0.05	1123	7420	1.080	22.700	21.600	-4.85%
AM1	5750	HEAD	07/18/2023	22.5	20.7	0.05	1123	7420	1.080	22.700	21.600	-4.85%

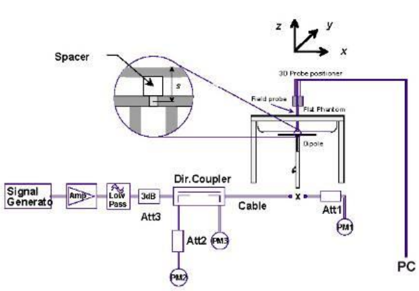


Figure 8-1
System Verification Setup Diagram

Figure 8-2
System Verification Setup Photo

9 SAR DATA SUMMARY

9.1 Standalone Head SAR Data

Table 9-1
2.4 GHz WLAN Head SAR

MEASUREMENT RESULTS																			
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Bandwidth [MHz]	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.														(W/kg)			(W/kg)	
2437	6	front	10 mm	802.11b	DSSS	Aluminum	Sport	FQ21R9LF2Q	22	1	20.0	18.80	0.03	99.6	0.336	1.318	1.004	0.445	A1
2437	6	front	10 mm	802.11b	DSSS	Aluminum	Metal Loop	FQ21R9LF2Q	22	1	20.0	18.80	-0.02	99.6	0.271	1.318	1.004	0.359	
2437	6	front	10 mm	802.11b	DSSS	Aluminum	Metal Links	FQ21R9LF2Q	22	1	20.0	18.80	0.01	99.6	0.235	1.318	1.004	0.311	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Head 1.6 W/kg (mW/g) averaged over 1 gram							

Table 9-2
5 GHz WLAN Head SAR

MEASUREMENT RESULTS																			
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Bandwidth [MHz]	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.														(W/kg)			(W/kg)	
5300	60	front	10 mm	802.11a	OFDM	Aluminum	Sport	R7016HW6R0	20	6	17.0	16.19	0.08	98.6	0.113	1.205	1.014	0.138	
5300	60	front	10 mm	802.11a	OFDM	Aluminum	Metal Loop	R7016HW6R0	20	6	17.0	16.19	0.09	98.6	0.088	1.205	1.014	0.108	
5300	60	front	10 mm	802.11a	OFDM	Aluminum	Metal Links	R7016HW6R0	20	6	17.0	16.19	-0.05	98.6	0.111	1.205	1.014	0.136	
5500	100	front	10 mm	802.11a	OFDM	Aluminum	Sport	R7016HW6R0	20	6	17.0	16.37	0.07	98.6	0.132	1.156	1.014	0.155	
5500	100	front	10 mm	802.11a	OFDM	Aluminum	Metal Loop	R7016HW6R0	20	6	17.0	16.37	0.18	98.6	0.118	1.156	1.014	0.138	
5500	100	front	10 mm	802.11a	OFDM	Aluminum	Metal Links	R7016HW6R0	20	6	17.0	16.37	0.04	98.6	0.129	1.156	1.014	0.151	
5745	149	front	10 mm	802.11a	OFDM	Aluminum	Sport	R7016HW6R0	20	6	17.0	16.16	0.04	98.6	0.158	1.213	1.014	0.194	A2
5745	149	front	10 mm	802.11a	OFDM	Aluminum	Metal Loop	R7016HW6R0	20	6	17.0	16.16	-0.09	98.6	0.137	1.213	1.014	0.169	
5745	149	front	10 mm	802.11a	OFDM	Aluminum	Metal Links	R7016HW6R0	20	6	17.0	16.16	0.03	98.6	0.136	1.213	1.014	0.167	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Head 1.6 W/kg (mW/g) averaged over 1 gram							

Table 9-3
Bluetooth Head SAR

MEASUREMENT RESULTS																		
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	SAR (1g)	Scaling Factor (Cond Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.													(W/kg)			(W/kg)	
2402	0	front	10 mm	Bluetooth	FHSS	Aluminum	Sport	D02WJ26VQF	1	19.0	18.57	-0.08	100.0	0.248	1.104	1.000	0.274	A3
2402	0	front	10 mm	Bluetooth	FHSS	Aluminum	Metal Loop	D02WJ26VQF	1	19.0	18.57	0.00	100.0	0.215	1.104	1.000	0.237	
2402	0	front	10 mm	Bluetooth	FHSS	Aluminum	Metal Links	D02WJ26VQF	1	19.0	18.57	-0.01	100.0	0.192	1.104	1.000	0.275	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population											Head 1.6 W/kg (mW/g) averaged over 1 gram							

Table 9-4
802.15.4 ab-NB Head SAR

MEASUREMENT RESULTS																	
FREQUENCY		Side	Spacing	Mode	Housing Type	Wristband Type	Device Serial Number	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	SAR (1g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Plot #
MHz	Ch.												(W/kg)			(W/kg)	
5728.75	Low	front	10 mm	802.15.4 ab-NB	Aluminum	Metal Links	LL2NXY3F4T	1	16.00	15.85	0.21	8.6	0.005	1.035	1.035	0.005	
5728.75	Low	front	10 mm	802.15.4 ab-NB	Aluminum	Metal Loop	LL2NXY3F4T	1	16.00	15.85	-0.21	8.6	0.007	1.035	1.035	0.007	A4
5728.75	Low	front	10 mm	802.15.4 ab-NB	Aluminum	Sport	LL2NXY3F4T	1	16.00	15.85	-0.21	8.6	0.004	1.035	1.035	0.004	
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 8.9% transmission duty factor to determine compliance since the duty factor of the device is permanently limited to 8.9% per the manufacturer.

9.2 Standalone Extremity SAR Data

Table 9-5
2.4 GHz WLAN Extremity SAR

MEASUREMENT RESULTS																			
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Bandwidth [MHz]	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	SAR (10g)	Reported SAR (10g)	Plot #
MHz	Ch.																(W/kg)	(W/kg)	
2437	6	back	0 mm	802.11b	DSSS	Aluminum	Sport	D02WJ26VQF	22	1	20.0	18.80	0.00	99.6	1.318	1.004	0.078	0.103	
2437	6	back	0 mm	802.11b	DSSS	Aluminum	Metal Loop	D02WJ26VQF	22	1	20.0	18.80	-0.02	99.6	1.318	1.004	0.092	0.122	A5
2437	6	back	0 mm	802.11b	DSSS	Aluminum	Metal Links	D02WJ26VQF	22	1	20.0	18.80	-0.04	99.6	1.318	1.004	0.068	0.090	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Extremity 4.0 W/kg (mW/g) averaged over 1 gram							

Table 9-6
5 GHz WLAN Extremity SAR

MEASUREMENT RESULTS																			
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Bandwidth [MHz]	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	SAR (10g)	Reported SAR (10g)	Plot #
MHz	Ch.																(W/kg)	(W/kg)	
5300	60	back	0 mm	802.11a	OFDM	Aluminum	Sport	D9PYGNVJYK	20	6	17.0	16.19	0.07	98.6	1.205	1.014	0.008	0.010	
5300	60	back	0 mm	802.11a	OFDM	Aluminum	Metal Loop	D9PYGNVJYK	20	6	17.0	16.19	0.05	98.6	1.205	1.014	0.012	0.015	
5300	60	back	0 mm	802.11a	OFDM	Aluminum	Metal Links	D9PYGNVJYK	20	6	17.0	16.19	0.01	98.6	1.205	1.014	0.013	0.016	A6
5500	100	back	0 mm	802.11a	OFDM	Aluminum	Sport	D9PYGNVJYK	20	6	17.0	16.37	0.07	98.6	1.156	1.014	0.006	0.007	
5500	100	back	0 mm	802.11a	OFDM	Aluminum	Metal Loop	D9PYGNVJYK	20	6	17.0	16.37	0.08	98.6	1.156	1.014	0.009	0.011	
5500	100	back	0 mm	802.11a	OFDM	Aluminum	Metal Links	D9PYGNVJYK	20	6	17.0	16.37	0.04	98.6	1.156	1.014	0.010	0.012	
5745	149	back	0 mm	802.11a	OFDM	Aluminum	Sport	D9PYGNVJYK	20	6	17.0	16.16	0.01	98.6	1.213	1.014	0.010	0.012	
5745	149	back	0 mm	802.11a	OFDM	Aluminum	Metal Loop	D9PYGNVJYK	20	6	17.0	16.16	0.04	98.6	1.213	1.014	0.006	0.007	
5745	149	back	0 mm	802.11a	OFDM	Aluminum	Metal Links	D9PYGNVJYK	20	6	17.0	16.16	0.05	98.6	1.213	1.014	0.004	0.005	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population												Body 4.0 W/kg (mW/g) averaged over 1 gram							

Table 9-7
Bluetooth Extremity SAR

MEASUREMENT RESULTS																			
FREQUENCY		Side	Spacing	Mode	Service	Housing Type	Wristband Type	Device Serial Number	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Maximum Duty Cycle (%)	Duty Cycle (%)	Scaling Factor (Cond Power)	Scaling Factor (Duty Cycle)	SAR (10g)	Reported SAR (10g)	Plot #
MHz	Ch.																(W/kg)	(W/kg)	
2402	0	back	0 mm	Bluetooth	FHSS	Aluminum	Sport	D02WJ26VQF	1	19.0	18.57	-0.02	100.0	100.0	1.104	1.000	0.069	0.076	
2402	0	back	0 mm	Bluetooth	FHSS	Aluminum	Metal Loop	D02WJ26VQF	1	19.0	18.57	0.01	100.0	100.0	1.104	1.000	0.078	0.086	A7
2402	0	back	0 mm	Bluetooth	FHSS	Aluminum	Metal Links	D02WJ26VQF	1	19.0	18.57	-0.02	100.0	100.0	1.104	1.000	0.070	0.100	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population										Extremity 4.0 W/kg (mW/g) averaged over 1 gram									

Table 9-8
802.15.4 ab-NB Extremity SAR

MEASUREMENT RESULTS																	
FREQUENCY		Side	Spacing	Mode	Housing Type	Wristband Type	Device Serial Number	Data Rate (Mbps)	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle (%)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	SAR (10g)	Reported SAR (10g)	Plot #
MHz	Ch.														(W/kg)	(W/kg)	
5728.75	Low	back	0 mm	802.15.4 ab-NB	Aluminum	Metal Links	LL2NXY3F4T	1	16.0	15.85	-0.21	8.6	1.035	1.035	0.000	0.000	
5728.75	Low	back	0 mm	802.15.4 ab-NB	Aluminum	Metal Loop	LL2NXY3F4T	1	16.0	15.85	0.21	8.6	1.035	1.035	0.000	0.000	
5728.75	Low	back	0 mm	802.15.4 ab-NB	Aluminum	Sport	LL2NXY3F4T	1	16.0	15.85	0.21	8.6	1.035	1.035	0.000	0.000	A8
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population					Extremity 4.0 W/kg (mW/g) averaged over 10 gram												

Note: The reported SAR was scaled to the 8.9% transmission duty factor to determine compliance since the duty factor of the device is permanently limited to 8.9% per the manufacturer.

9.3 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical, and thermal characteristics and are within operational tolerances expected for production units.
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. Per FCC KDB Publication 865664 D01v01r04, variability SAR tests were not required since measured SAR results for all frequency bands were less than 0.8 W/kg and 2.0 W/kg for 10g SAR.
7. This device has one housing type: Aluminum. The non-metallic wrist accessory, sport band, was evaluated for all exposure conditions. The available metallic wrist accessories, metal links band and metal loop band, were additionally evaluated.
8. This device is a portable wrist-worn device and does not support any other use conditions. Therefore, the procedures in FCC KDB Publication 447498 D01v06 Section 6.2 have been applied for extremity and next to mouth (head) conditions.
9. Unless otherwise noted, when 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds below.
10. The orange highlights throughout the report represent the highest scaled SAR per Equipment Class

WLAN Notes:

1. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 6.2.4 for more information.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg for 1g evaluations. See Section 6.2.5 for more information.
3. When the maximum reported 1g averaged SAR is ≤0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg for 1g evaluations or all test channels were measured. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.
4. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools. The reported SAR was scaled to the 100% transmission duty factor to determine compliance.

Bluetooth Notes

1. To determine compliance, Bluetooth SAR was measured with the maximum power condition. Bluetooth was evaluated with a test mode with 100% transmission duty factor.

802.15.4 ab-NB Notes

1. To determine compliance, the reported SAR was scaled to the 8.9% transmission duty factor to determine compliance since the duty factor of the device is permanently limited to 8.9% per the

manufacturer. See Section 7.2 for the time domain and plot and calculation for the duty factor of the device.

10 FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

10.1 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 together.

10.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore, simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 4.3.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤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.

10.3 Head SAR Simultaneous Transmission Analysis

For SAR summation, the highest reported SAR across all housing and wristband types was used as a conservative evaluation for the simultaneous transmission analysis.

Table 10-1
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WLAN (Head at 1.0 cm)

Exposure Condition	2.4 GHz Bluetooth SAR (W/kg)	5 GHz WLAN SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Head SAR	0.275	0.194	**0.469**

Table 10-2
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 802.15.4 ab-NB (Head at 1.0 cm)

Exposure Condition	2.4 GHz Bluetooth SAR (W/kg)	802.15.4 ab-NB SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Head SAR	0.275	0.007	**0.282**

Table 10-3
Simultaneous Transmission Scenario with 2.4 GHz WLAN and 802.15.4 ab-NB (Head at 1.0 cm)

Exposure Condition	2.4 GHz WLAN SAR (W/kg)	802.15.4 ab-NB SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Head SAR	0.445	0.007	**0.452**

10.4 Extremity SAR Simultaneous Transmission Analysis

For SAR summation, the highest reported SAR across all housing and wristband types was used as a conservative evaluation for the simultaneous transmission analysis.

Table 10-4
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 5 GHz WLAN (Extremity at 0.0 cm)

Exposure Condition	2.4 GHz Bluetooth SAR (W/kg)	5 GHz WLAN SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Extremity SAR	0.100	0.016	**0.116**

Table 10-5
Simultaneous Transmission Scenario with 2.4 GHz Bluetooth and 802.15.4 ab-NB (Extremity at 0.0 cm)

Exposure Condition	2.4 GHz Bluetooth SAR (W/kg)	802.15.4 ab-NB SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Extremity SAR	0.100	0.000	**0.100**

Table 10-6
Simultaneous Transmission Scenario with 2.4 GHz WLAN and 802.15.4 ab-NB (Extremity at 0.0 cm)

Exposure Condition	2.4 GHz WLAN SAR (W/kg)	802.15.4 ab-NB SAR (W/kg)	Σ SAR (W/kg)
	1	2	1+2
Extremity SAR	0.122	0.000	**0.122**

10.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06.

11 SAR MEASUREMENT VARIABILITY

11.1 Measurement Variability

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

11.2 Measurement Uncertainty

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

12 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	E4404B	Spectrum Analyzer	N/A	N/A	N/A	MY45113242
Agilent	E4438C	ESG Vector Signal Generator	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
Agilent	N4010A	Wireless Connectivity Test Set	N/A	N/A	N/A	GB46170464
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343972
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MN8110B	I/O Adaptor	CBT	N/A	CBT	6261747881
Anritsu	ML2496A	Power Meter	6/15/2023	Annual	6/15/2024	1138001
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	6/15/2023	Annual	6/15/2024	1827526
Anritsu	MA24106A	USB Power Sensor	6/15/2023	Annual	6/15/2024	1827527
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
Pasternack	NC-100	Torque Wrench	11/28/2022	Biennial	11/28/2024	81962
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	5 GHz SAR Dipole	3/22/2022	Biennial	3/22/2024	1123
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/15/2023	Annual	2/15/2024	467
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/13/2022	Annual	10/13/2023	1333
SPEAG	EX3DV4	SAR Probe	2/13/2023	Annual	2/13/2024	7308
SPEAG	EX3DV4	SAR Probe	10/20/2022	Annual	10/20/2023	7420

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. Each equipment item was used solely within its respective calibration period.

13 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

14 CONCLUSION

14.1 Measurement Conclusion

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

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

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