ELEMENT Washington DC LLC
18855 Adams CT, Morgan Hill, CA 95307 USA
Tel. +1.410.290.6652 / Fax +1.410.290.6654
http://www.element.com

WIFI 6 GHZ RF EXPOSURE EVALUATION

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

Date of Testing
07/15/2022 – 08/26/2022
Test Site/Location
Element Washington DC LLC
Morgan Hill, CA, USA
Document Serial No:
1C2205090027-16.BCG

FCC ID:	**BCGA2436**
APPLICANT:	**APPLE, INC.**

DUT Type: Tablet Device
Application Type: Certification
FCC Rule Part(s): CFR §2.1093
Model: A2436

Band & Mode	Tx Frequency	SAR	APD	PD
	MHz	1g Body - Tablet (W/kg)	Body - Tablet (W/m^2)	psPD (W/m^2)
WIFI 6 GHz	5955-7115	0.81	5.71	7.10

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.

TABLE OF CONTENTS

1 DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Tx Frequency
U-NII-5	5955 - 6415 MHz
U-NII-6	6435 - 6515 MHz
U-NII-7	6535 - 6875 MHz
U-NII-8	6895 - 7115 MHz

1.2 Nominal and Maximum Output Power Specifications

The 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 D01.

Note: Targets for 802.11ax RU operations can be found in 802.11ax RU SAR Exclusion Appendix of Measurement Report SN 1C2205090027-15.BCG.

1.2.1 Maximum WLAN Output Power

Mode	Channel	IEEE 802.11 (Maximum in dBm) - Ant 5T (Tolerance +0/-3.00dB)			
		SISO		MIMO	
		a	ax (SU)	ax (SU) CDD	ax (SU) SDM
6 GHz WIFI (20MHz BW)	1	4.25	4.25	-1.00	2.00
	5	4.25	4.25	-1.00	2.00
	9-29	4.25	4.25	-1.00	2.00
	33-61	3.50	3.50	-0.75	2.00
	65-85	3.00	3.00	-1.25	1.50
	89	3.00	3.00	-1.25	1.50
	93	3.00	3.00	-1.25	1.50
	97-113	3.00	3.00	-1.25	1.50
	117-181	3.00	3.00	-1.25	1.50
	185	3.00	3.00	-1.25	1.50
	189-225	6.50	6.50	1.75	4.50
	229	6.50	6.50	1.75	4.50
	233	6.50	6.50	1.75	4.50
6 GHz WIFI (40MHz BW)	3	[redacted]	7.25	2.00	5.00
	11	[redacted]	7.25	2.00	5.00
	19-27	[redacted]	7.25	2.00	5.00
	35-59	[redacted]	6.50	2.25	5.00
	67-75	[redacted]	6.00	1.75	4.50
	83	[redacted]	6.00	1.75	4.50
	91	[redacted]	6.00	1.75	4.50
	99-107	[redacted]	6.00	1.75	4.50
	115	[redacted]	6.00	1.75	4.50
	123-179	[redacted]	6.00	1.75	4.50
	187	[redacted]	6.00	1.75	4.50
	195-219	[redacted]	9.50	4.75	7.50
	227	[redacted]	9.50	4.75	7.50
6 GHz WIFI (80MHz BW)	7	[redacted]	10.25	5.00	8.00
	23	[redacted]	10.25	5.00	8.00
	39-55	[redacted]	9.50	5.25	8.00
	71	[redacted]	9.00	4.75	7.50
	87	[redacted]	9.00	4.75	7.50
	103	[redacted]	9.00	4.75	7.50
	119	[redacted]	9.00	4.75	7.50
	135-167	[redacted]	9.00	4.75	7.50
	183	[redacted]	9.00	4.75	7.50
	199	[redacted]	12.50	7.75	10.50
	215	[redacted]	12.50	7.75	10.50
6 GHz WIFI (160MHz BW)	15	[redacted]	13.75	8.50	11.50
	47	[redacted]	12.75	8.75	11.50
	79	[redacted]	12.50	8.25	11.00
	111	[redacted]	11.50	8.25	11.00
	143	[redacted]	11.50	8.25	11.00
	175	[redacted]	12.50	8.25	11.00
	207	[redacted]	15.75	11.25	14.00

Note: In MIMO operations, each antenna transmits at maximum allowed powers as indicated above.

Mode	Channel	IEEE 802.11 (Maximum in dBm) - Ant 5B (Tolerance +0/-3.00dB)			
		SISO		MIMO	
		a	ax (SU)	ax (SU) CDD	ax (SU) SDM
6 GHz WIFI (20MHz BW)	1	4.25	4.25	-1.00	2.00
	5	4.25	4.25	-1.00	2.00
	9-29	4.25	4.25	-1.00	2.00
	33-61	3.50	3.50	-0.75	2.00
	65-85	3.00	3.00	-1.25	1.50
	89	3.00	3.00	-1.25	1.50
	93	3.00	3.00	-1.25	1.50
	97-113	3.00	3.00	-1.25	1.50
	117-181	3.00	3.00	-1.25	1.50
	185	3.00	3.00	-1.25	1.50
	189-225	6.50	6.50	1.75	4.50
	229	6.50	6.50	1.75	4.50
	233	6.50	6.50	1.75	4.50
6 GHz WIFI (40MHz BW)	3		7.25	2.00	5.00
	11		7.25	2.00	5.00
	19-27		7.25	2.00	5.00
	35-59		6.50	2.25	5.00
	67-75		6.00	1.75	4.50
	83		6.00	1.75	4.50
	91		6.00	1.75	4.50
	99-107		6.00	1.75	4.50
	115		6.00	1.75	4.50
	123-179		6.00	1.75	4.50
	187		6.00	1.75	4.50
	195-219		9.50	4.75	7.50
	227		9.50	4.75	7.50
6 GHz WIFI (80MHz BW)	7		10.25	5.00	8.00
	23		10.25	5.00	8.00
	39-55		9.50	5.25	8.00
	71		9.00	4.75	7.50
	87		9.00	4.75	7.50
	103		9.00	4.75	7.50
	119		9.00	4.75	7.50
	135-167		9.00	4.75	7.50
	183		9.00	4.75	7.50
	199		12.50	7.75	10.50
	215		12.50	7.75	10.50
6 GHz WIFI (160MHz BW)	15		12.75	8.50	11.50
	47		12.25	8.75	11.50
	79		12.25	8.25	11.00
	111		11.50	8.25	11.00
	143		11.50	8.25	11.00
	175		12.25	8.25	11.00
	207		16.00	11.25	14.00

Note: In MIMO operations, each antenna transmits at maximum allowed powers as indicated above.

1.3 DUT Antenna Locations

The overall diagonal dimension of the device is > 200 mm. A diagram showing the location of the device antennas can be found in SAR Part 1 Report, DUT Antenna Diagram & SAR Test Setup Photographs Appendix. Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC filing.

Table 1-1
Device Surfaces - Tablet

Device Sides/Edges for Testing						
Mode	Back	Front	Top	Bottom	Right	Left
6 GHz WLAN Ant 5T	Yes	No	No	No	Yes	No
6 GHz WLAN Ant 5B	Yes	No	No	No	Yes	No

Note: Per FCC KDB Publication 616217 D04v01r01, particular edges were not required to be evaluated for SAR based on the SAR exclusion threshold in KDB 447498 D01. Additional edges may have been evaluated for simultaneous transmission analysis.

1.4 Miscellaneous Testing Considerations

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

6 GHz WIFI SAR results are used for simultaneous transmission analysis with the other WWAN/BT/WIFI transmitters. Analysis can be found in SAR report. During the transitions, when utilization is over 50%, please refer to Part 1 SAR Report S/N 1C2205090027-15.BCG Section 10.3 and 10.4 for antennas that are considered spatially separated.

To make the most efficient use of the additional available subcarriers (data tones), IEEE 802.11ax can utilize Orthogonal Frequency-Division Multiple Access (OFDMA) which divides the existing 802.11 channels into smaller subchannels called Resource Units (RUs). Possible RU sizes are: 26T, 52T, 106T, 242T, 484T, and 996T.

Per FCC Guidance, 802.11ax RU was considered a higher order 802.11 mode when compared to a/b/g/n/ac to apply KDB Publication 248227 D01v02r02 for OFDM mode selection. Therefore, SAR tests were not required for 802.11ax RU based on the maximum allowed output powers of OFDM modes and the reported SAR values. Per FCC Guidance, maximum conducted powers were performed for each RU size to demonstrate that the output powers would not be higher than the other OFDM 802.11 modes. Please see Measurement Report SN 1C2205090027-15.BCG for 802.11ax RU output powers.

The WLAN/Bluetooth chipset in this device is produced by two different suppliers. The electrically identical modules are manufactured with identical mechanical structures to meet the same specifications and functions. Two device variants are referenced as Variant 1 and Variant 2 in this report. WLAN SAR/APD worst case configuration was tested for Variant 1 and Variant 2.

1.5 Guidance Applied

- November 2017, October 2018, April 2019, November 2019, October 2020 TCBC Workshop Notes
- SPEAG DASY6 System Handbook
- SPEAG DASY6 Application Note (Interim Procedures for Devices Operating at 6-10 GHz) (Nov 2021)
- IEEE 1528-2013
- IEC TR 63170:2018
- IEC 62479:2010
- FCC KDB 865664 D02 v01r02
- FCC KDB 648474 D04 v01r03
- FCC KDB 248227 D01 v02r02
- FCC KDB 447498 D01
- FCC KDB 865664 D01 v01r04
- April 2019 TCB Workshop Notes (IEEE 802.11ax)
- FCC KDB Publication 616217 D04v01r02

1.6 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.

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. [15]

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 [44] and Health Canada RF Exposure Guidelines Safety Code 6 [35]. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave [17] 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.[20]

3 DOSIMETRIC ASSESSMENT

3.1 Measurement Procedure

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE1528-2013:

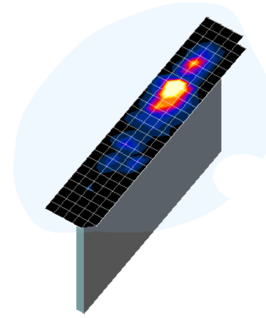

Figure 3-1
Sample SAR Area Scan

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 IEEE1528-2013.
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 IEEE1528-2013. 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.

4.2 SAR Testing for Tablet per KDB Publication 616217 D04v01r02

Per FCC KDB Publication 616217 D04v01r02, the back surface and edges of the tablet should be tested for SAR compliance with the tablet touching the phantom. The SAR Exclusion Threshold in KDB 447498 D01 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent tablet edge is used to determine if SAR testing is required for the adjacent edges, with the adjacent edge positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

5 RF EXPOSURE LIMITS

5.1 Uncontrolled Environment

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

5.2 Controlled Environment

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

5.3 RF Exposure Limits for Frequencies Below 6 GHz

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

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

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

5.4 RF Exposure Limits for Frequencies Above 6 GHz

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

Peak Spatially Averaged Power Density was evaluated over a circular area of 4 cm2 per interim FCC Guidance for near-field power density evaluations per October 2018 TCB Workshop notes.

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

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

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

6 MEASUREMENT PROCEDURES

6.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01, 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 OFDM Transmission Mode and SAR Test Channel Selection

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

6.2.3 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 6.2.2). When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

6.2.4 Subsequent Test Configuration Procedures

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

6.2.5 MIMO SAR Considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provisions in KDB Publication 447498 D01 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is <1.6 W/kg, no additional SAR measurements for MIMO are required. Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation. When 10g SAR measurement is considered, a factor of 2.5 is applied to the thresholds above.

7 RF CONDUCTED POWERS

Table 7-1
6 GHz WLAN Maximum Average RF Power – 802.11ax 160 MHz BW, Antenna 5T, Variant 1

6GHz (160MHz) Conducted Power [dBm]		
Freq [MHz]	Channel	IEEE Transmission Mode
		802.11ax
		Average
6025	15	11.76
6185	47	10.87
6505	111	10.38
6825	175	10.52
6985	207	14.16

Table 7-2
6 GHz WLAN Maximum Average RF Power – 802.11ax 160 MHz BW, Antenna 5T, Variant 2

6GHz (160MHz) Conducted Power [dBm]		
Freq [MHz]	Channel	IEEE Transmission Mode
		802.11ax
		Average
6025	15	11.76
6185	47	10.96
6505	111	10.41
6825	175	10.51
6985	207	14.42

Table 7-3
6 GHz WLAN Maximum Average RF Power – 802.11ax 160 MHz BW, Antenna 5B, Variant 1

6GHz (160MHz) Conducted Power [dBm]		
Freq [MHz]	Channel	IEEE Transmission Mode
		802.11ax
		Average
6025	15	11.72
6185	47	10.81
6505	111	10.45
6825	175	10.36
6985	207	14.03

Table 7-4
6 GHz WLAN Maximum Average RF Power – 802.11ax 160 MHz BW, Antenna 5B, Variant 2

6GHz (160MHz) Conducted Power [dBm]		
Freq [MHz]	Channel	IEEE Transmission Mode
		802.11ax
		Average
6025	15	11.60
6185	47	11.01
6505	111	10.45
6825	175	10.38
6985	207	14.95

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 identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- The WLAN chipset in this device is produced by two different suppliers. The electrically identical modules are manufactured with identical mechanical structures to meet the same specifications and functions.
- Two device variants are referenced as Variant 1 and Variant 2 in this report.
- WLAN SAR worst case configuration was spot checked on Variant 1 and Variant 2. The Variant with the highest reported SAR value was evaluated for the remaining WLAN configurations.

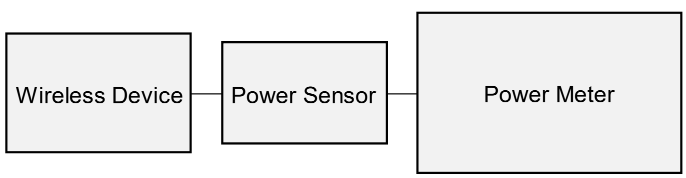

Figure 7-1
Power Measurement Setup

8 SYSTEM VERIFICATION

8.1 SAR Test System Verification

Table 8-1
Measured 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
07/15/2022	6500 Head	20.3	5935	5.201	34.972	5.411	35.143	-3.88%	-0.49%
			5970	5.245	34.888	5.448	35.120	-3.73%	-0.66%
			5985	5.262	34.870	5.464	35.110	-3.70%	-0.68%
			6000	5.277	34.844	5.480	35.100	-3.70%	-0.73%
			6025	5.313	34.806	5.510	35.070	-3.58%	-0.75%
			6065	5.356	34.726	5.557	35.022	-3.62%	-0.85%
			6075	5.368	34.705	5.569	35.010	-3.61%	-0.87%
			6085	5.382	34.686	5.580	34.998	-3.55%	-0.89%
			6275	5.611	34.360	5.805	34.770	-3.34%	-1.18%
			6285	5.625	34.338	5.816	34.758	-3.28%	-1.21%
			6305	5.644	34.306	5.840	34.734	-3.36%	-1.23%
			6345	5.706	34.259	5.887	34.686	-3.07%	-1.23%
			6475	5.844	34.029	6.041	34.530	-3.26%	-1.45%
			6485	5.855	34.008	6.052	34.518	-3.26%	-1.48%
			6500	5.870	33.981	6.070	34.500	-3.29%	-1.50%
			6505	5.875	33.969	6.076	34.494	-3.31%	-1.52%
			6545	5.941	33.900	6.122	34.446	-2.96%	-1.59%
			6675	6.098	33.704	6.273	34.290	-2.79%	-1.71%
			6685	6.098	33.680	6.285	34.278	-2.98%	-1.74%
			6715	6.132	33.578	6.319	34.242	-2.96%	-1.94%
			6785	6.215	33.549	6.400	34.158	-2.89%	-1.78%
			6825	6.262	33.398	6.447	34.110	-2.87%	-2.09%
			6985	6.447	33.189	6.633	33.918	-2.80%	-2.15%
			6995	6.450	33.179	6.644	33.906	-2.92%	-2.14%
			7000	6.450	33.177	6.650	33.900	-3.01%	-2.13%
			7005	6.454	33.174	6.656	33.894	-3.03%	-2.12%
			7025	6.479	33.112	6.680	33.870	-3.01%	-2.24%

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.

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 SAR System Validation Appendix.

Table 8-2
System Verification Results

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	Measured SAR_{1g} (W/kg)	1 W Target SAR_{1g} (W/kg)	1 W Normalized SAR_{1g} (W/kg)	$Deviation_{1g}$ (%)	Measured SAR_{10g} (W/kg)	1 W Target SAR_{10g} (W/kg)	1 W Normalized SAR_{10g} (W/kg)	$Deviation_{10g}$ (%)	Measured $4cm^2$ APD (W/m^2)	1W Target $4cm^2$ APD (W/m^2)	1 W Normalized $4cm^2$ APD (W/m^2)	Deviation $4cm^2$ APD (%)
AM2	6500	Head	07/15/2022	21.9	20.6	0.025	1019	7421	7.270	285.000	290.800	2.04%	1.330	52.600	53.200	1.14%	32.4000	1300.0000	1296.000	-0.31%

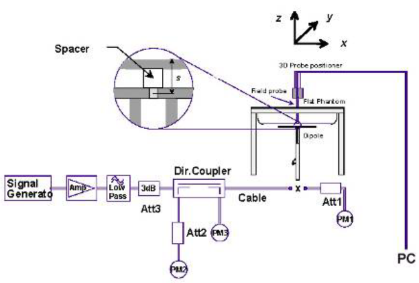

Figure 8-1
System Verification Setup Diagram

Figure 8-2
System Verification Setup Photo

8.2 Power Density Test System Verification

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

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

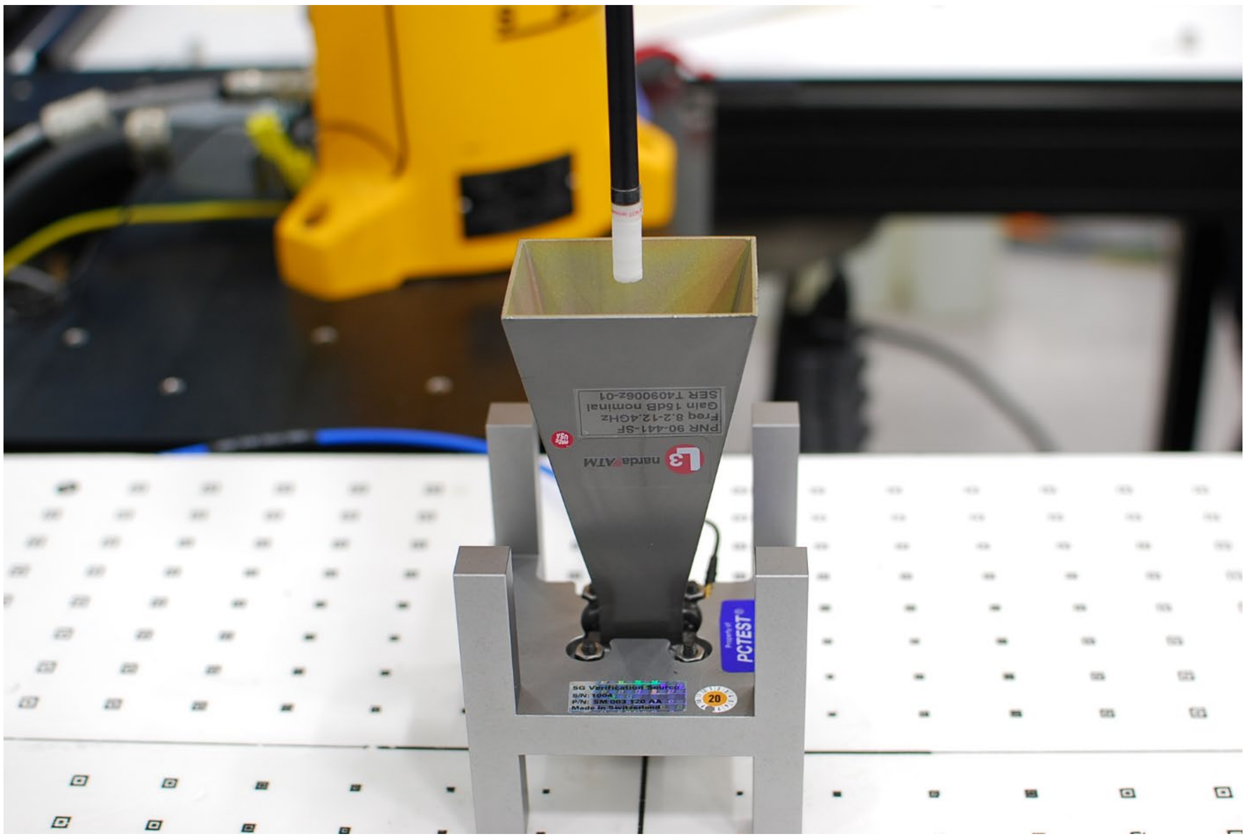

Figure 8-3
System Verification Setup Photo

Table 8-3
10 GHz Verifications

System Verification											
System	Frequency (GHz)	Date	Source S/N	Probe S/N	Prad (mW)	Normal psPD (W/m² over 4 cm²)		Deviation (dB)	Total psPD (W/m² over 4 cm²)		Deviation (dB)
						Measured	Target		Measured	Target	
AM5	10	07/19/2022	1006	9364	86.1	49.30	50.80	-0.13	49.80	50.80	-0.09
AM5	10	08/26/2022	1006	9364	86.1	49.60	50.80	-0.10	49.90	50.80	-0.08

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

element

9 DATA SUMMARY

9.1 SAR and Absorbed Power Density Results

Table 9-1
6 GHz WLAN Body SISO SAR – Tablet

MEASUREMENT RESULTS																				
FREQUENCY		Mode	Service	Bandwidth [MHz]	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Spacing (mm)	Antenna Config.	Variant	Device Serial Number	Data Rate (Mbps)	Side	Duty Cycle (%)	SAR (1g)	SAR (10g)	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported SAR (1g)	Reported SAR (10g)	Plot #
MHz	Ch.														(W/kg)	(W/kg)			(W/kg)	(W/kg)	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.20	0	5T	V2	2070TW	68.1	Back	97.95	0.055	0.020	1.358	1.021	0.076	0.028	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	0.00	0	5T	V2	2070TW	68.1	Top	97.95	0.003	0.000	1.358	1.021	0.004	0.000	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.06	0	5T	V2	2070TW	68.1	Bottom	97.95	0.005	0.002	1.358	1.021	0.007	0.003	
6025.00	15	802.11ax	OFDM	160	13.75	11.76	0.08	0	5T	V2	2070TW	68.1	Right	97.95	0.232	0.078	1.581	1.021	0.374	0.126	
6185.00	47	802.11ax	OFDM	160	12.75	10.96	-0.09	0	5T	V2	2070TW	68.1	Right	97.95	0.186	0.059	1.510	1.021	0.287	0.091	
6505.00	111	802.11ax	OFDM	160	11.50	10.41	0.05	0	5T	V2	2070TW	68.1	Right	97.95	0.238	0.069	1.285	1.021	0.312	0.091	
6825.00	175	802.11ax	OFDM	160	12.50	10.51	-0.02	0	5T	V2	2070TW	68.1	Right	97.95	0.205	0.061	1.581	1.021	0.331	0.098	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.20	0	5T	V2	2070TW	68.1	Right	97.95	0.579	0.161	1.358	1.021	0.803	0.223	A1
6985.00	207	802.11ax	OFDM	160	15.75	14.16	0.01	0	5T	V1	90V2PG	68.1	Right	97.95	0.549	0.153	1.442	1.021	0.808	0.225	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	0.08	0	5T	V2	2070TW	68.1	Left	97.95	0.003	0.001	1.358	1.021	0.004	0.001	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.06	0	5B	V2	2070TW	68.1	Back	97.95	0.066	0.025	1.274	1.021	0.086	0.033	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	0	5B	V2	2070TW	68.1	Top	97.95	0.001	0.000	1.274	1.021	0.001	0.000	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.02	0	5B	V2	2070TW	68.1	Bottom	97.95	0.052	0.019	1.274	1.021	0.068	0.025	
6025.00	15	802.11ax	OFDM	160	12.75	11.60	-0.14	0	5B	V2	2070TW	68.1	Right	97.95	0.233	0.079	1.303	1.021	0.310	0.105	
6185.00	47	802.11ax	OFDM	160	12.25	11.01	0.06	0	5B	V2	2070TW	68.1	Right	97.95	0.191	0.063	1.330	1.021	0.259	0.086	
6505.00	111	802.11ax	OFDM	160	11.50	10.45	-0.07	0	5B	V2	2070TW	68.1	Right	97.95	0.203	0.067	1.274	1.021	0.264	0.087	
6825.00	175	802.11ax	OFDM	160	12.25	10.38	0.03	0	5B	V2	2070TW	68.1	Right	97.95	0.193	0.070	1.538	1.021	0.303	0.110	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	0	5B	V2	2070TW	68.1	Right	97.95	0.522	0.177	1.274	1.021	0.679	0.230	
6985.00	207	802.11ax	OFDM	160	16.00	14.03	-0.17	0	5B	V1	90V2PG	68.1	Right	97.95	0.445	0.157	1.574	1.021	0.715	0.252	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.00	0	5B	V2	2070TW	68.1	Left	97.95	0.012	0.004	1.274	1.021	0.016	0.005	
ANSI / IEEE C95.1 1992 - SAFETY LIMIT Spatial Peak Uncontrolled Exposure/General Population								Body 1.6 W/kg (mW/g) averaged over 1 gram													

element

Table 9-2
6 GHz WLAN Body SISO Absorbed Power Density - Tablet

MEASUREMENT RESULTS																			
FREQUENCY		Mode	Service	Bandwidth [MHz]	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Spacing (mm)	Antenna Config.	Variant	Device Serial Number	Data Rate (Mbps)	Side	Duty Cycle (%)	Measured APD	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Reported APD	Plot #
MHz	Ch.														W/m^2 (4cm^2)			W/m^2 (4cm^2)	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.20	0.0	5T	V2	2070TW	68.1	Back	97.95	0.446	1.358	1.021	0.618	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	0.00	0.0	5T	V2	2070TW	68.1	Top	97.95	0.007	1.358	1.021	0.010	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.06	0.0	5T	V2	2070TW	68.1	Bottom	97.95	0.040	1.358	1.021	0.055	
6025.00	15	802.11ax	OFDM	160	13.75	11.76	0.08	0.0	5T	V2	2070TW	68.1	Right	97.95	1.770	1.581	1.021	2.857	
6185.00	47	802.11ax	OFDM	160	12.75	10.96	-0.09	0.0	5T	V2	2070TW	68.1	Right	97.95	1.350	1.510	1.021	2.081	
6505.00	111	802.11ax	OFDM	160	11.50	10.41	0.05	0.0	5T	V2	2070TW	68.1	Right	97.95	1.600	1.285	1.021	2.099	
6825.00	175	802.11ax	OFDM	160	12.50	10.51	-0.02	0.0	5T	V2	2070TW	68.1	Right	97.95	1.420	1.581	1.021	2.292	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.20	0.0	5T	V2	2070TW	68.1	Right	97.95	3.740	1.358	1.021	5.186	A1
6985.00	207	802.11ax	OFDM	160	15.75	14.16	0.01	0.0	5T	V1	90V2PG	68.1	Right	97.95	3.550	1.442	1.021	5.227	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	0.08	0.0	5T	V2	2070TW	68.1	Left	97.95	0.025	1.358	1.021	0.035	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.06	0.0	5B	V2	2070TW	68.1	Back	97.95	0.563	1.274	1.021	0.732	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	0.0	5B	V2	2070TW	68.1	Top	97.95	0.013	1.274	1.021	0.017	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.02	0.0	5B	V2	2070TW	68.1	Bottom	97.95	0.413	1.274	1.021	0.537	
6025.00	15	802.11ax	OFDM	160	12.75	11.60	-0.14	0.0	5B	V2	2070TW	68.1	Right	97.95	1.790	1.303	1.021	2.381	
6185.00	47	802.11ax	OFDM	160	12.25	11.01	0.06	0.0	5B	V2	2070TW	68.1	Right	97.95	1.440	1.330	1.021	1.955	
6505.00	111	802.11ax	OFDM	160	11.50	10.45	-0.07	0.0	5B	V2	2070TW	68.1	Right	97.95	1.530	1.274	1.021	1.990	
6825.00	175	802.11ax	OFDM	160	12.25	10.38	0.03	0.0	5B	V2	2070TW	68.1	Right	97.95	1.580	1.538	1.021	2.481	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	0.0	5B	V2	2070TW	68.1	Right	97.95	4.010	1.274	1.021	5.216	
6985.00	207	802.11ax	OFDM	160	16.00	14.03	-0.17	0.0	5B	V1	90V2PG	68.1	Right	97.95	3.550	1.574	1.021	5.705	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.00	0.0	5B	V2	2070TW	68.1	Left	97.95	0.097	1.274	1.021	0.126	

SAR and Absorbed Power Density General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01.
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 and APD results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01.
6. Per FCC guidance, SAR was performed using 6.5 GHz SAR probe calibration factors. Per October 2020 TCB Workshop notes, 5 channels were tested. Absorbed power density (APD) using a 4cm^2 averaging area is reported based on SAR measurements.

WLAN Notes:

1. 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.
2. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools. The reported SAR was scaled to the 100% transmission duty factor to determine compliance. Procedures used to measure the duty factor are identical to that in the associated EMC test reports.
3. For WIFI 6 GHz, the RF Exposure was evaluated at the maximum output power, therefore no evaluations for time-averaging were required.

9.2 Power Density Results

Table 9-3
6 GHz WLAN SISO Power Density - Tablet

MEASUREMENT RESULTS																								
Frequency (MHz)	Channel	Mode	Service	Bandwidth [MHz]	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift (dB)	Spacing (mm)	Antenna Config.	Variant	DUT Serial Number	Data Rate (Mbps)	Side	Duty Cycle (%)	Grid Step (λ)	iPD (W/m^2)	Scaling Factor for Measurement Uncertainty per IEC 62479	Scaling Factor (Power)	Scaling Factor (Duty Cycle)	Normal psPD (W/m^2)	Scaled Normal psPD (W/m^2)	Total psPD (W/m^2)	Scaled Total psPD (W/m^2)	Plot #
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.19	2	5T	V2	2070TW	68.1	Back	97.95	0.25	-	1.554	1.358	1.021	2.700	5.818	2.730	5.882	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.07	2	5T	V2	2070TW	68.1	Top	97.95	0.25	-	1.554	1.358	1.021	0.241	0.519	0.253	0.545	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	0.02	2	5T	V2	2070TW	68.1	Bottom	97.95	0.25	-	1.554	1.358	1.021	0.278	0.599	0.294	0.633	
6025.00	15	802.11ax	OFDM	160	13.75	11.76	0.20	2	5T	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.581	1.021	1.950	4.892	2.100	5.268	
6185.00	47	802.11ax	OFDM	160	12.75	10.96	0.05	2	5T	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.510	1.021	2.360	5.654	2.960	7.092	
6505.00	111	802.11ax	OFDM	160	11.50	10.41	0.20	2	5T	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.285	1.021	3.240	6.606	3.400	6.932	
6825.00	175	802.11ax	OFDM	160	12.50	10.51	0.03	2	5T	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.581	1.021	1.920	4.816	2.610	6.547	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.03	2	5T	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.358	1.021	2.990	6.442	3.290	7.089	
6985.00	207	802.11ax	OFDM	160	15.75	14.42	-0.01	2	5T	V2	2070TW	68.1	Left	97.95	0.25	-	1.554	1.358	1.021	0.980	2.112	1.150	2.478	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	2	5B	V2	2070TW	68.1	Back	97.95	0.25	-	1.554	1.274	1.021	2.930	5.923	2.930	5.923	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.20	2	5B	V2	2070TW	68.1	Top	97.95	0.25	-	1.554	1.274	1.021	0.246	0.497	0.395	0.798	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.07	2	5B	V2	2070TW	68.1	Bottom	97.95	0.25	-	1.554	1.274	1.021	1.010	2.042	1.040	2.102	
6025.00	15	802.11ax	OFDM	160	12.75	11.6	0.06	2	5B	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.303	1.021	3.310	6.843	3.410	7.050	
6185.00	47	802.11ax	OFDM	160	12.25	11.01	-0.06	2	5B	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.330	1.021	3.250	6.858	3.330	7.027	
6505.00	111	802.11ax	OFDM	160	11.50	10.45	-0.10	2	5B	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.274	1.021	3.130	6.327	3.510	7.095	A2
6825.00	175	802.11ax	OFDM	160	12.25	10.38	-0.11	2	5B	V2	2070TW	68.1	Right	97.95	0.25	-	1.554	1.538	1.021	2.600	6.345	2.870	7.003	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	-0.04	2	5B	V2	2070TW	68.1	Right	97.95	0.25	4.550	1.554	1.274	1.021	3.090	6.246	3.310	6.691	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.04	8.58	5B	V2	2070TW	68.1	Right	97.95	0.25	4.660	1.554	1.274	1.021	1.750	3.537	1.870	3.780	
6985.00	207	802.11ax	OFDM	160	16.00	14.95	0.20	2	5B	V2	2070TW	68.1	Left	97.95	0.25	-	1.554	1.274	1.021	0.683	1.381	0.774	1.565	
47 CFR §1.1310 - SAFETY LIMIT Spatial Average Uncontrolled Exposure / General Population											Power Density 10 W/m^2 averaged over 4 cm^2													

Power Density General Notes

1. The manufacturer has confirmed that the devices tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
2. Batteries are fully charged at the beginning of the measurements. The DUT was connected to a wall charger for some measurements due to the test duration. It was confirmed that the charger plugged into this DUT did not impact the near-field PD test results.
3. Power density was calculated by repeated E-field measurements on two measurement planes separated by λ/4.
4. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools.
5. Per FCC guidance and equipment manufacturer guidance, power density results were scaled according to IEC 62479:2010 for the portion of the measurement uncertainty > 30%. Total expanded uncertainty of 2.68 dB (85.4%) was used to determine the psPD measurement scaling factor.
6. Per equipment manufacturer guidance, power density was measured at d=2mm and d=λ/5mm using the same grid size and grid step size for some frequencies and surfaces. The integrated Power Density (iPD) was calculated based on these measurements. Since iPD ratio between the two distances is ≥ -1dB, the grid step was sufficient for determining compliance at d=2mm.
7. PD results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01.
8. PTP-PR algorithm was used during psPD measurement and calculations.

10 EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
-	WL25-1	Conducted Cable Set (25GHz)	12/19/2021	Annual	12/19/2022	WL25-1
Agilent	N9038A	MXE EMI Receiver	N/A	N/A	N/A	MY51210133
Rohde & Schwarz	FSW67	Signal / Spectrum Analyzer	N/A	N/A	N/A	103200
Sunol	JB5	Bi-Log Antenna (30M - 5GHz)	N/A	N/A	N/A	A051107
Emco	3115	Horn Antenna (1-18GHz)	N/A	N/A	N/A	9704-5182
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433975
Keysight Technologies	N9030A	3Hz-44GHz PXA Signal Analyzer	8/18/2022	Annual	8/18/2023	MY49430494
SPEAG	EUmmWV3	EUmmWV3 Probe	6/16/2022	Annual	6/16/2023	9364
SPEAG	SM 003 100 AA	10 GHz System Verification Antenna	10/27/2021	Annual	10/27/2022	1006
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/20/2021	Annual	10/20/2022	1333
SPEAG	EX3DV4	SAR Probe	3/22/2022	Annual	3/22/2023	7421
SPEAG	DAE4	Dasy Data Acquisition Electronics	3/22/2022	Annual	3/22/2023	604
SPEAG	D6.5GHzV2	6.5GHz SAR Dipole	1/14/2022	Annual	1/14/2023	1019
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Control Company	4040	Therm./Clock/Humidity Monitor	3/12/2021	Biennial	3/12/2023	210202100
Agilent	SMF100A	Signal Generator	3/28/2022	Biennial	3/28/2024	101590
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/9/2021	Annual	11/9/2022	1277
Mitutoyo	500-196-30	CD-6"ASX 6Inch Digital Caliper	2/16/2022	Triennial	2/16/2025	A20238413
Anritsu	MS2038C	20 GHz Vector Network Analyzer	2/18/2022	Annual	2/18/2023	1214109
MCL	BW-N6W5+	6dB Attenuator	CBT	N/A	CBT	1139
Narda	BW-S3W2	Attenuator (3dB)	CBT	N/A	CBT	120
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
MiniCircuits	ZUDC10-83-S+	Directional Coupler	9/15/2021	Annual	9/15/2022	2111
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Anritsu	MA2411B	Pulse Power Sensor	9/21/2021	Annual	9/21/2022	1315051
Anritsu	MA2411B	Pulse Power Sensor	9/21/2021	Annual	9/21/2022	1339008
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1520

Note:

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

11 MEASUREMENT UNCERTAINTIES

Applicable for SAR measurements:

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	E2.1	9.3	N	1	1	1	9.3	9.3	∞
Axial Isotropy	E2.2	0.25	N	1	0.7	0.7	0.2	0.2	∞
Hemishperical Isotropy	E2.2	1.3	N	1	0.7	0.7	0.9	0.9	∞
Boundary Effect	E2.3	2	R	1.732	1	1	1.2	1.2	∞
Linearity	E2.4	0.3	N	1	1	1	0.3	0.3	∞
System Detection Limits	E2.4	0.25	R	1.732	1	1	0.1	0.1	∞
Modulation Response	E2.5	4.8	R	1.732	1	1	2.8	2.8	∞
Readout Electronics	E2.6	0.3	N	1	1	1	0.3	0.3	∞
Response Time	E2.7	0.8	R	1.732	1	1	0.5	0.5	∞
Integration Time	E2.8	2.6	R	1.732	1	1	1.5	1.5	∞
RF Ambient Conditions - Noise	E6.1	3	R	1.732	1	1	1.7	1.7	∞
RF Ambient Conditions - Reflections	E6.1	3	R	1.732	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	0.8	R	1.732	1	1	0.5	0.5	∞
Probe Positioning w/ respect to Phantom	E6.3	6.7	R	1.732	1	1	3.9	3.9	∞
Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation	E5	4	R	1.732	1	1	2.3	2.3	∞
Test Sample Related									
Test Sample Positioning	E4.2	3.12	N	1	1	1	3.1	3.1	35
Device Holder Uncertainty	E4.1	1.67	N	1	1	1	1.7	1.7	5
Output Power Variation - SAR drift measurement	E2.9	5	R	1.732	1	1	2.9	2.9	∞
SAR Scaling	E6.5	0	R	1.732	1	1	0.0	0.0	∞
Phantom & Tissue Parameters									
Phantom Uncertainty (Shape & Thickness tolerances)	E3.1	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
Liquid Conductivity - measurement uncertainty	E3.3	4.3	N	1	0.78	0.71	3.3	3.0	76
Liquid Permittivity - measurement uncertainty	E3.3	4.2	N	1	0.23	0.26	1.0	1.1	75
Liquid Conductivity - Temperature Uncertainty	E3.4	3.4	R	1.732	0.78	0.71	1.5	1.4	∞
Liquid Permittivity - Temperature Unceritainty	E3.4	0.6	R	1.732	0.23	0.26	0.1	0.1	∞
Liquid Conductivity - deviation from target values	E3.2	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
Liquid Permittivity - deviation from target values	E3.2	5.0	R	1.73	0.60	0.49	1.7	1.4	∞
Combined Standard Uncertainty (k=1)			RSS				13.8	13.6	191
Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				27.6	27.1	

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

Applicable for Power Density Measurements:

a	b	c	d	e	f = c x f/e	g
Uncertainty Component	Unc. (± dB)	Prob. Dist.	Div.	c_i	u_i (± dB)	v_i
Measurement System						
Calibration	0.49	N	1	1	0.49	∞
Probe Correction	0.00	R	1.73	1	0.00	∞
Frequency Response	0.20	R	1.73	1	0.12	∞
Sensor Cross Coupling	0.00	R	1.73	1	0.00	∞
Isotropy	0.50	R	1.73	1	0.29	∞
Linearity	0.20	R	1.73	1	0.12	∞
Probe Scattering	0.00	R	1.73	1	0.00	∞
Probe Positioning offset	0.30	R	1.73	1	0.17	∞
Probe Positioning Repeatability	0.04	R	1.73	1	0.02	∞
Sensor Mechanical Offset	0.00	R	1.73	1	0.00	∞
Probe Spatial Resolution	0.00	R	1.73	1	0.00	∞
Field Impedence Dependance	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Drift	0.00	R	1.73	1	0.00	∞
Amplitude and Phase Noise	0.04	R	1.73	1	0.02	∞
Measurement Area Truncation	0.00	R	1.73	1	0.00	∞
Data Acquisition	0.03	N	1	1	0.03	∞
Sampling	0.00	R	1.73	1	0.00	∞
Field Reconstruction	2.00	R	1.73	1	1.15	∞
Forward Transformation	0.00	R	1.73	1	0.00	∞
Power Density Scaling	0.00	R	1.73	1	0.00	∞
Spatial Averaging	0.10	R	1.73	1	0.06	∞
System Detection Limit	0.04	R	1.73	1	0.02	∞
Test Sample Related						
Probe Coupling with DUT	0.00	R	1.73	1	0.00	∞
Modulation Response	0.40	R	1.73	1	0.23	∞
Integration Time	0.00	R	1.73	1	0.00	∞
Response Time	0.00	R	1.73	1	0.00	∞
Device Holder Influence	0.10	R	1.73	1	0.06	∞
DUT alignment	0.00	R	1.73	1	0.00	∞
RF Ambient Conditions	0.04	R	1.73	1	0.02	∞
Ambient Reflections	0.04	R	1.73	1	0.02	∞
Immunity/Secondary Reception	0.00	R	1.73	1	0.00	∞
Drift of DUT	0.21	R	1.73	1	0.12	∞
Combined Standard Uncertainty (k=1)		RSS			1.34	∞
Expanded Uncertainty (95% CONFIDENCE LEVEL)		k=2			2.68	

13 CONCLUSION

13.1 Measurement Conclusion

The SAR and power density measurements indicate that the DUT complies with the RF radiation exposure limits of the FCC, 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 RF Exposure 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.

14 REFERENCES

[1] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.

[2] IEC TR 63170:2018, Measurement Procedure for the Evaluation of Power Density Related to Human Exposure to Radiofrequency Fields from Wireless Communication Devices Operating between 6 GHz and 100 GHz

[3] IEC TR 62630: 2010, Guidance for Evaluating Exposure from Multiple Electromagnetic Sources

[4] K. Pokovic, T. Schmid, J. Frohlich, and N. Kuster. Novel Probes and Evaluation Procedures to Assess Field Magnitude and Polarization. IEEE Transactions on Electromagnetic Compatibility 42(2): 240 -244, 2000

[5] R. W. Gerchberg and W. O. Saxton. A Practical Algorithm for the Determination of Phase from Image and Diffraction Plane Pictures. Optik 35(2): 237 – 246, 1972

[6] A. P. Anderson and S. Sali. New Possibilities for Phaseless Microwave Diagnostics. Part 1: Error Reduction Techniques. IEE Proceedings H – Microwaves, Antennas and Propagation 132(5): 290 – 298, 1985

[7] FCC KDB 865664 D02 v01r04: SAR Measurement Requirements for 100 MHz to 6 GHz. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[8] FCC KDB 447498 D01 v02r01: RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices. Federal Communications Commission – Office of Engineering and Technology, Laboratory Division.

[9] November 2017 Telecommunications Certification Body Council (TCBC) Workshop Notes

[10] October 2018 Telecommunications Certification Body Council (TCBC) Workshop Notes

[11] April 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes

[12] November 2019 Telecommunications Certification Body Council (TCBC) Workshop Notes

[13] SPEAG DASY6 System Handbook (September 2019)

[14] SPEAG DASY6 Application Note (Interim Procedures for Devices Operating at 6-10 GHz)

[15] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.

[16] ANSI/IEEE C95.1-2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.

[17] ANSI/IEEE C95.3-2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave, New York: IEEE, December 2002.

[18] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528-2013, IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.

[19] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.

[20] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.

[21] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 1 -124.

[22] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.

[23] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.

[24] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.

[25] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.

[26] G. Hartsgrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.

[27] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.

[28] W. Gander, Computermathematick, Birkhaeuser, Basel, 1992.

[29] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.

[30] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.

[31] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields High-frequency: 10kHz-300GHz, Jan. 1995.

[32] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hoschschule Zürich, Dosimetric Evaluation of the Cellular Phone.

[33] IEC 62209-1, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz), July 2016.

[34] Innovation, Science, Economic Development Canada RSS-102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) Issue 5, March 2015.

[35] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2015

[36] FCC SAR Test Procedures for 2G-3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225, D01-D07

[37] SAR Measurement Guidance for IEEE 802.11 Transmitters, KDB Publication 248227 D01

[38] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474 D03-D04

[39] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04

[40] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01-D02

[41] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01-D02

[42] Anexo à Resolução No. 533, de 10 de Septembro de 2009.

[43] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), Mar. 2010.

[44] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.