FCC SAR Test Report

Report No.	:	**KES-SR-19T0010**
FCC ID	:	**PFRWLE900VXVW**
Applicant	:	**Vieworks Co., Ltd.**
Manufacturer	:	**Vieworks Co., Ltd.**
Address	:	**41-3, Burim-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14055, South Korea**
DUT Type	:	**X-ray Detector**
Model No.	:	**WLE900VX 7AA000S-VW**
FCC Rule Part(s)	:	**CFR §2.1093**
Date of Testing	:	**2019.08.19 ~ 2019.08.21**
Issued Date	:	**2019.10.21**

CERTIFICATION: The above equipment have been tested by **KES Co., Ltd. Laboratory**, and found compliance with the requirement of the above standards. I attest to the accuracy of data. All measurements reported herein were performed by me of 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. It should not be reproduced except in full, without the written approval of our laboratory. The client should not use it to claim product certification, approval, or endorsement by any government agency.

Tested By : Wihan Jeong / Engineer

Approved By : Gyucheol Shin / Technical Manager

This test report is not related to KS Q ISO/IEC 17025 and KOLAS

Revision history

Report No.	Reason for Change	Date Issued
KES-SR-19T0010	Initial release	2019.10.21

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1. General Information

1.1. Host model Information

Applicant Information

Host model No.	:	**FXRD-3643VAW**
Derived model(s)	:	**FXRD-3643VAW PLUS**
Applicant	:	**Vieworks Co., Ltd.**
Address	:	**41-3, Burim-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14055, South Korea**
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Manufacturer Information

Manufacturer	:	**Vieworks Co., Ltd.**
Address	:	**41-3, Burim-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do, 14055, South Korea**

1.2. Highest SAR Summary

EUT Type	X-ray Detector			
Brand Name(Applicant)	Vieworks Co., Ltd.			
Model Name	WLE900VX 7AA000S-VW			
Antenna Type	PCB Antenna			
EUT Stage	Identical Prototype			
TX Frequency Range	**Band**	**Mode**	**Bandwidth**	**Frequency**
	DTS	802.11n	20 MHz	2412 ~ 2462 MHz
		802.11n	40 MHz	2422 ~ 2452 MHz
	U-NII-1	802.11n/ac	20 MHz	5180 ~ 5240 MHz
		802.11n/ac	40 MHz	5190 ~ 5230 MHz
		802.11ac	80 MHz	5210 MHz
	U-NII-3	802.11n/ac	20 MHz	5745 ~ 5825 MHz
		802.11n/ac	40 MHz	5755 ~ 5795 MHz
		802.11ac	80 MHz	5775 MHz
RX Frequency Range	**Band**	**Mode**	**Bandwidth**	**Frequency**
	DTS	802.11n	20 MHz	2412 ~ 2462 MHz
		802.11n	40 MHz	2422 ~ 2452 MHz
	U-NII-1	802.11n/ac	20 MHz	5180 ~ 5240 MHz
		802.11n/ac	40 MHz	5190 ~ 5230 MHz
		802.11ac	80 MHz	5210 MHz
	U-NII-3	802.11n/ac	20 MHz	5745 ~ 5825 MHz
		802.11n/ac	40 MHz	5755 ~ 5795 MHz
		802.11ac	80 MHz	5775 MHz

Band	**Mode**	**Reported SAR Body 1g SAR (W/Kg)**		
		SISO(Ant.0)	**SISO(Ant.1)**	**SISO(Ant.2)**
DTS	2.4 GHz WLAN	0.232	0.037	0.198
U-NII-1	5.2 GHz WLAN	0.149	0.098	0.155
U-NII-3	5.8 GHz WLAN	0.244	0.304	0.263

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE C95.1-1992.

1.3. Device Overview

Band	Operating Modes	Tx Frequency
DTS	2.4 GHz WLAN	2412 ~ 2462 MHz
U-NII-1	5.2 GHz WLAN	5180 ~ 5240 MHz
U-NII-3	5.8 GHz WLAN	5745 ~ 5825 MHz

1.4. Power Reduction for SAR

This DUT does not support power reduction function.

1.5. 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.

Maximum WLAN Output Power

Mode / Band		Modulation Average (dBm)
2.4 GHz Band WLAN	Maximum	19.0
	Nominal	18.0
5.2 GHz Band WLAN	Maximum	18.0
	Nominal	17.0
5.8 GHz Band WLAN	Maximum	19.0
	Nominal	18.0

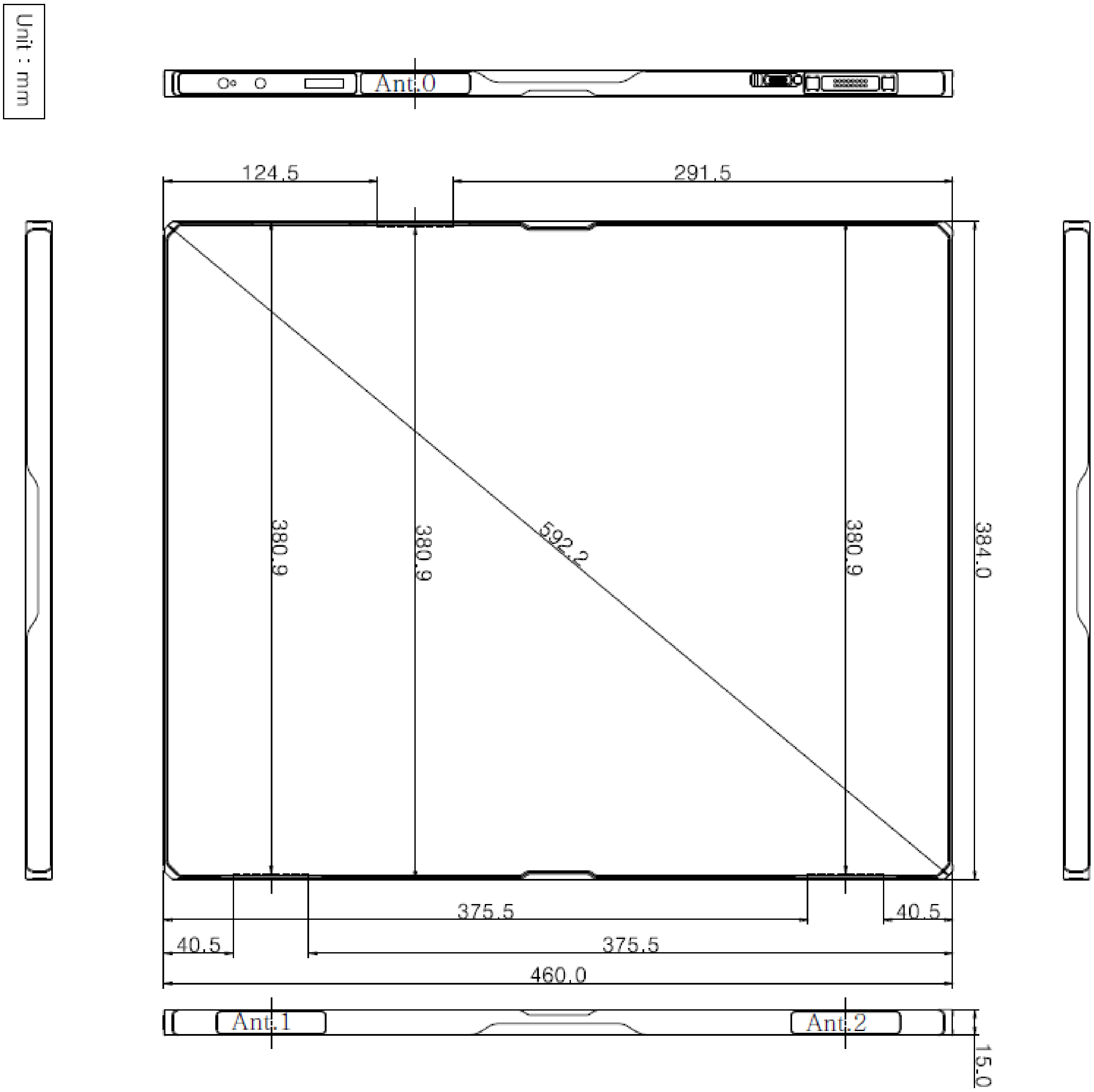
Note:

- Tune up tolerance is maintained to ±2 dBm at the nominal tune up power.
- The modulation power is changed because excluded mode 802.11a/b/g from the original grant.

1.6. Simultaneous Transmission Capabilities

2.4GHz and 5GHz of WLAN cannot be used simultaneously from the module.

1.7. DUT Antenna Locations



Note: Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC Filing.

1.8. Near Field Communications (NFC) Antenna

This DUT does not support NFC function.

1.9. SAR Test Configurations and Exclusions

(A) WLAN

Per FCC KDB 447498 D01v06, the 1g SAR exclusion threshold for distances < 50 mm is defined by the following equation:

$$\frac{Max\ Power\ of\ Channel\ (mW)}{Test\ Separation\ Dist\ (mm)} * \sqrt{Frequency(GHz)} \leq 3.0$$

Band	Mode	Equation	Result	SAR Exclusion Threshold	Required SAR
DTS	2.4 GHz WLAN Ant.0	[(73/5)*√2.437]	22.93	3.0	O
	2.4 GHz WLAN Ant.1	[(73/5)*√2.437]	22.93	3.0	O
	2.4 GHz WLAN Ant.2	[(76/5)*√2.437]	23.85	3.0	O
U-NII-2A	5.2 GHz WLAN Ant.0	[(54/5)*√5.180]	24.67	3.0	O
	5.2 GHz WLAN Ant.1	[(52/5)*√5.180]	23.83	3.0	O
	5.2 GHz WLAN Ant.2	[(52/5)*√5.240]	23.75	3.0	O
U-NII-3	5.8 GHz WLAN Ant.0	[(54/5)*√5.795]	26.09	3.0	O
	5.8 GHz WLAN Ant.1	[(52/5)*√5.785]	25.19	3.0	O
	5.8 GHz WLAN Ant.2	[(52/5)*√5.795]	24.98	3.0	O

1.10. Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- FCC KDB Publication 690783 D01 SAR Listings on Grants v01r03
- FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB Publication 865664 D02 RF Exposure Reporting v01r02

1.11. 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.
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, 3KHz to 300 GHz and Health Canada RF Exposure Guidelines Safety Code 6. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave 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

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

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

SAR is expressed in units of Watts per kilogram (W/kg)
SAR measurement can be related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

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.

2.2. SPEAG DASY System

DASY system consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY software defined. The DASY software can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (ECO). The ECO performs the conversion form the optical into digital electric signal of the DAE and transfers data to the PC.

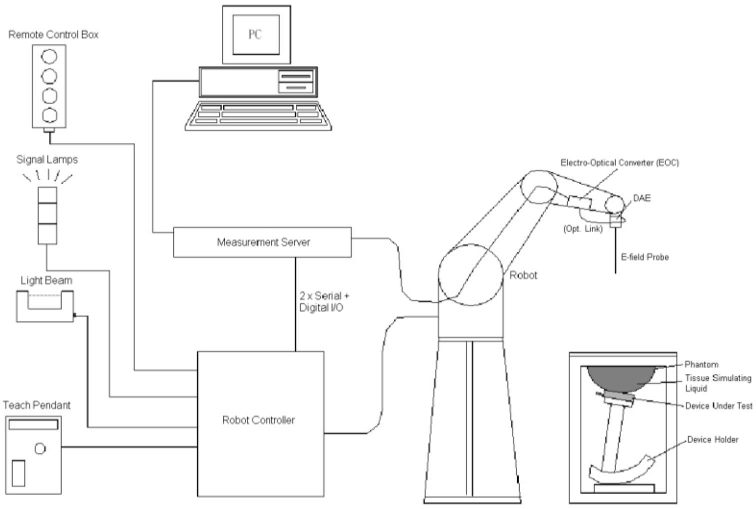


Figure 2. SPEAG DASY system configuration

2.3. Robot

The DASY system uses the high precision robots from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

Figure 3. SPEAG DASY System

2.4. Probe

The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.

Model	EX3DV4	 **Figure 4. Probe**
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Frequency	10 ㎒ to > 6 ㎓ Linearity: ± 0.2 ㏈ (30 ㎒ to 6 ㎓)	
Directivity	± 0.3 dB in TSL (rotation around probe axis) ± 0.5 dB in TSL (rotation normal to probe axis)	
Dynamic Range	10 µW/g to > 100 ㎽/g Linearity: ± 0.2 ㏈ (noise: typically < 1 µW/g)	
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

2.5. Data Acquisition Electronics (DAE)

Model	DAE4	 **Figure 5. DAE**
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4 mV, 40 0mV)	
Input Offset Voltage	± 0.2 ㏈ in HSL (rotation around probe axis) ± 0.3 ㏈ in tissue material (rotation normal to probe axis)	
Input Bias Current	< 50 fA	
Dimensions	60 x 60 x 68 mm	

2.6. Phantoms

Model	Twin SAM
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 liters

Figure 6. Twin SAM

Model	ELI
Construction	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.
Material	Vinylester, glass fiber reinforced (VE-GF)
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters

Figure 7. ELI

2.7. Device holder

Model	Mounting device
Construction	In combination with the Twin SAM Phantom or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).
Material	POM

Figure 8. Mounting device

Model	Laptop extensions kit
Construction	Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner.
Material	POM, Acrylic glass, Foam

Figure 9. Laptop extensions kit

2.8. System Validation Dipoles

Model	D-Serial
Construction	Symmetrical dipole with l/4 balun. Enables measurement of feed point impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions.
Frequency	750 MHz to 5800 MHz
Return Loss	> 20 dB
Power Capability	> 100 W (f < 1 GHz), > 40 W (f > 1 GHz)

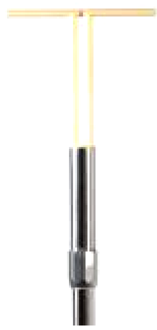


Figure 10. Dipole Antenna

3. Dosimetric Assessment

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

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 4-1) 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.

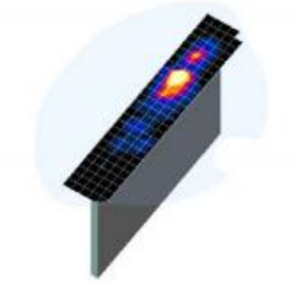


Figure 4-1 Sample SAR Area Scan

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 4-1) 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 4-1. 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 4-1 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. RF Exposure Limits

4.1. 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.

4.2. 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 7-1 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. FCC Measurement Procedures

5.1. 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.

5.2. SAR Testing with 802.11 Transmitters

Normal network operating configurations are not suitable for measuring the SAR of 802.11 b/g/n transmitters. 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 248227D01v02r02 for more details.

5.3. 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. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

5.4. U-NII-1 and U-NII-2A

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following, with respect to the highest reported SAR and maximum output power specified for production units. The procedures are applied independently to each exposure configuration; for example, head, body, hotspot mode etc.

1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, each band is tested independently for SAR.

2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, each band is tested independently for SAR.

5.5. 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 Rader (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. When band gap channels are disabled, each band is tested independently according to the normally required OFDM SAR measurements and probe calibration frequency points requirements.

5.6. Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position.
When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test position are measured.

5.7. 2.4 GHz SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a 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 exposure configuration 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.

5.8. OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 GHz and 5 GHz bands, 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 80211n and 802.11ac or 802.11g then 802.11n is used for SAR measurement. When the maximum output power ware 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.

5.9. Initial Test Configuration Procedure

For OFDM, in both 2.4 and 5 GHz bands, 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 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, and lowest data rate. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.
When the reported SAR ≤ 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.

5.10. 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 applicable. When the highest reported SAR for the initial test configuration, adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power is ≤ 1.2 W/kg, no additional SAR testing for the subsequent test configurations is required.

5.11. MIMO SAR considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provision in KDB Publication 447498 D01v06 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is < 1.6 W/kg, no additional SAR measurements for MIMO are required.
Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

6. RF Conducted Powers

6.1. W-LAN Conducted Powers

The measuring conducted power (Unit: dBm) are shown as below.

6.1.1. 2.4 GHz WLAN

Ant.0 (SISO)

Mode	Data rate	Conducted Power (dBm)		
		Low	Mid	High
802.11n HT20	MCS 0	14.75	18.66	14.74
802.11n HT40	MCS 0	13.09	16.33	13.21

Ant.1 (SISO)

Mode	Data rate	Conducted Power (dBm)		
		Low	Mid	High
802.11n HT20	MCS 0	15.00	18.66	15.42
802.11n HT40	MCS 0	12.87	16.40	12.91

Ant.2 (SISO)

Mode	Data rate	Conducted Power (dBm)		
		Low	Mid	High
802.11n HT20	MCS 0	15.21	18.83	14.72
802.11n HT40	MCS 0	13.20	16.09	13.18

Ant.0 + Ant.1 (MIMO)

Mode	Data rate	Conducted Power (dBm)		
		Low	Mid	High
802.11n HT20	MCS 8	15.69	18.37	15.61
802.11n HT40	MCS 8	13.47	16.04	13.50

Ant.0 + Ant.1 + Ant.2 (MIMO)

Mode	Data rate	Conducted Power (dBm)		
		Low	Mid	High
802.11n HT20	MCS 8	16.33	18.84	16.22
802.11n HT40	MCS 8	14.11	16.22	14.17

Note: 802.11b and 802.11g mode of 2.4 GHz WLAN are not supported on this device.

5GHz WLAN

Ant.0 (SISO)

Mode	Data rate	Conducted Power (dBm)					
		5.2 GHz WLAN			5.8 GHz WLAN		
		Low	Mid	High	Low	Mid	High
802.11n HT20	MCS 0	17.34	17.25	17.26	18.93	18.92	18.77
802.11n HT40	MCS 0	13.63	-	14.18	18.68	-	18.98
802.11ac VHT20	MCS 0	17.24	17.29	17.26	18.87	18.83	18.85
802.11ac VHT40	MCS 0	13.63	-	14.13	18.76	-	18.72
802.11ac VHT80	MCS 0	12.05	-	-	18.92	-	-

Ant.1 (SISO)

Mode	Data rate	Conducted Power (dBm)					
		5.2 GHz WLAN			5.8 GHz WLAN		
		Low	Mid	High	Low	Mid	High
802.11n HT20	MCS 0	17.14	15.75	16.65	18.86	18.88	18.75
802.11n HT40	MCS 0	13.28	-	13.60	18.88	-	18.96
802.11ac VHT20	MCS 0	17.19	15.71	16.20	18.83	18.97	18.93
802.11ac VHT40	MCS 0	13.23	-	13.55	18.63	-	18.88
802.11ac VHT80	MCS 0	12.02	-	-	18.85	-	-

Ant.2 (SISO)

Mode	Data rate	Conducted Power (dBm)					
		5.2 GHz WLAN			5.8 GHz WLAN		
		Low	Mid	High	Low	Mid	High
802.11n HT20	MCS 0	16.51	17.04	17.15	18.73	18.78	18.60
802.11n HT40	MCS 0	13.45	-	13.82	18.80	-	18.96
802.11ac VHT20	MCS 0	16.43	16.82	16.92	18.73	18.83	18.74
802.11ac VHT40	MCS 0	13.44	-	13.84	18.78	-	18.94
802.11ac VHT80	MCS 0	12.09	-	-	18.97	-	-

Ant.0 + Ant.1 (MIMO)

Mode	Data rate	Conducted Power (dBm)					
		5.2 GHz WLAN			5.8 GHz WLAN		
		Low	Mid	High	Low	Mid	High
802.11n HT20	MCS 8	16.15	16.65	16.73	18.51	18.52	18.59
802.11n HT40	MCS 8	13.42	-	18.56	18.56	-	18.56
802.11ac VHT20	MCS 0	16.41	16.89	16.96	18.53	18.55	18.53
802.11ac VHT40	MCS 0	13.49	-	13.88	18.72	-	18.67
802.11ac VHT80	MCS 0	11.92	-	-	18.60	-	-

Ant.0 + Ant.1 + Ant.2 (MIMO)

Mode	Data rate	Conducted Power (dBm)					
		5.2 GHz WLAN			5.8 GHz WLAN		
		Low	Mid	High	Low	Mid	High
802.11n HT20	MCS 8	16.15	16.79	16.69	18.55	18.65	18.61
802.11n HT40	MCS 8	13.45	-	14.03	18.92	-	18.74
802.11ac VHT20	MCS 0	16.04	16.45	16.66	18.53	18.57	18.52
802.11ac VHT40	MCS 0	13.74	-	13.92	18.82	-	18.62
802.11ac VHT80	MCS 0	12.03	-	-	18.67	-	-

Note: 802.11a mode of 5 GHz WLAN is not supported on this device.

Note:

Justification for reduced test configurations for WIFI channels 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, duo to an even number of channels, both channels were measured.

● Output Power and SAR is not required for 802.11 g/n HT20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjust SAR is ≤ 1.2 W/kg.

● The underlined data rate and channel above were tested for SAR.

● DUTY cycle of this device is 100 %.

-DUTY Cycle[%] = (Pulse / Period) X 100 = (1/1)X100 = 100 %

7. System Verification

Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

Table 8-1 Measured Tissue Properties - Body

Tissue Type	Measured Frequency (MHz)	Tissue Temp (℃)	Measured Conductivity (σ)	Measured Permittivity (ε_r)	Target Conductivity (σ)	Target Permittivity (ε_r)	Conductivity Deviation (%)	Permittivity Deviation (%)	Tests Performed On:
HSL 2450	2450	21.9	1.825	40.027	1.80	39.2	1.39	2.11	2019.08.19
	2437		1.810	40.068	1.81	39.3	0.18	2.06	
HSL 5GHz	5200	21.7	4.491	35.477	4.66	36.0	-3.63	-1.45	2019.08.20
	5180		4.453	35.536	4.63	36.0	-3.92	-1.31	
	5240		4.525	35.440	4.70	35.9	-3.64	-1.39	
HSL 5GHz	5800	21.8	5.129	35.749	5.27	35.3	-2.68	1.27	2019.08.21
	5785		5.141	35.709	5.25	35.3	-2.16	1.11	
	5795		5.125	35.694	5.26	35.3	-2.66	1.10	

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.

System Verification

The measuring results for system check are shown as below. Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in Appendix A.

Table 8-3 System Verification Results

SAR System #	Test Date	Tissue Frequency (MHz)	Amb. Temp (℃)	Liquid Temp (℃)	Input Power (mW)	Dipole SN	Probe SN	1W Target SAR-1 g (W/kg)	Measured SAR-1 g (W/kg)	Normalized to 1W SAR-1 g (W/kg)	Deviation (%)
#1	2019.08.19	2450	22.7	21.9	250	896	7359	51.40	13.10	52.40	1.95
#1	2019.08.20	5200	22.5	21.7	100	1170	7359	77.30	7.43	74.30	-3.88
#1	2019.08.21	5800	22.6	21.8	100	1170	7359	79.40	8.22	82.20	3.53

Note: Body SAR used head tissue simulating liquid since the TCB Workshop in April 2019.

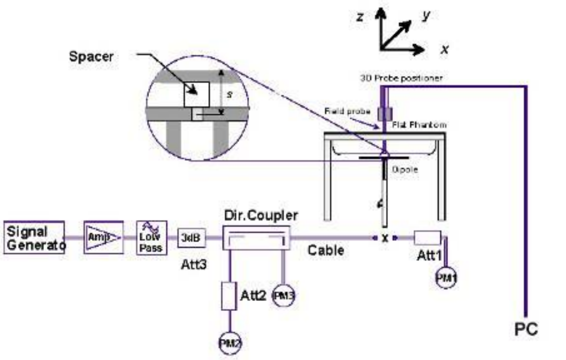


Figure 8-1 System Verification Setup Diagram

Figure 8-2 System Verification Setup Photo

8. SAR Data Summary

8.1. Standalone Body SAR Data

Table 9-1 WLAN Body SAR

Measurement Results														
Frequency		Mode	Antenna Status	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Spacing [cm]	Test Position	Duty Cycle	SAR (1g) W/kg	Scaling Factor (Duty Cycle)	Scaling Factor (Power)	Reported SAR(1g) W/kg	Plot #
MHz	Ch.													
2437	6	802.11n HT20	Ant.0	19.0	18.66	-0.160	0	Front Side	0.982	0.211	1.018	1.081	0.232	1
2437	6	802.11n HT20	Ant.1	19.0	18.66	0.030	0	Front Side	0.982	0.034	1.018	1.081	0.037	2
2437	6	802.11n HT20	Ant.2	19.0	18.83	0.110	0	Front Side	0.982	0.187	1.018	1.040	0.198	3
5180	36	802.11n HT20	Ant..0	18.0	17.34	0.030	0	Front Side	0.982	0.126	1.018	1.164	0.149	4
5180	36	802.11ac VHT20	Ant.1	18.0	17.19	-0.150	0	Front Side	0.982	0.080	1.018	1.205	0.098	5
5240	48	802.11n HT20	Ant.2	18.0	17.15	-0.080	0	Front Side	0.982	0.125	1.018	1.216	0.155	6
5795	159	802.11n HT40	Ant..0	19.0	18.98	-0.090	0	Front Side	0.966	0.235	1.035	1.005	0.244	7
5785	**157**	**802.11ac VHT20**	**Ant.1**	**19.0**	**18.97**	**0.050**	**0**	**Front Side**	**0.979**	**0.296**	**1.021**	**1.007**	**0.304**	**8**
5795	159	802.11n HT40	Ant.2	19.0	18.96	0.030	0	Front Side	0.966	0.252	1.035	1.009	0.263	9
ANSI / IEEE C95.1 1992 – SAFETY LIMIT Spatial Peak Uncontrolled Exposure / General Population							Body SARW/kg (mW/g) averaged over 1 gram							

8.2. SAR Test Notes

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 Publication447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all 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. The front with touch configuration was only tested since only the front is touched to human body in normal operation condition of this device.
7. FCC has permitted the use of single head-tissue simulating liquid specified February 19, 2019 TCBC Workshop.
8. When antennas are spatially separated to the extent that SAR distributions do not overlap and can be treated independently, SAR compliance for simultaneous transmission is determined separately for each individual antenna. In general, when the aggregate SAR from multiple antennas at any location in the combined SAR distribution is either ≤ 1.2 W/kg where at least 90% of the SAR is attributed to a single SAR distribution or ≤ 0.4 W/kg where no more than one SAR distribution is contributing > 0.1 W/kg, the antennas may be considered spatially separated. The conditions can be established either by inspection or quantitative comparison using interpolated results from area scans to determine that the antennas are spatially separated. Under such circumstances, each transmitting antenna is tested independently, one at a time, according to procedures in this document. Per KDB Publication 447498 D01v06.

WLAN Notes:

1. The initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for W-LAN 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 duo to the maximum allowed powers and the highest reported DSSS SAR when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output and the adjust SAR is ≤ 1.2 W/kg.
3. 5.2GHz band WLAN is exempted. Because of adjusted SAR is ≤ 1.2 W/kg and the band is lower maximum output power specified for production units.For WLAN 2.4 GHz, the highest measured maximum output power channel for DSSS was selected Per KDB 248227 D01 v02r02 for SAR measurement. When the reported SAR is ≤ 0.4 W/kg, no further SAR testing is required per KDB Publication 248227 D01v02r02.
4. Justification for test configurations for W-LAN 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.
5. When the maximum reported 1g averaged SAR ≤ 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 or all test channels were measured.
6. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor to determine compliance.

7. SAR Measurement Uncertainty

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

8. Equipment List

Equipment	Manufacturer	Model	Serial No.	Cal. Date	Next Cal. Date	Cal. Interval
SAR Chamber	Dymstec	N/A	N/A	N/A	N/A	N/A
Thermo-Hygrostat	㈜한국문터스	HK-030-AU1	1506231	N/A	N/A	N/A
Staubli Robot Unit	Staubli	TX60L	F15/5Y7QA1/A/01	N/A	N/A	N/A
Electro Optical Converter	SPEAG	EOC60	1096	N/A	N/A	N/A
2mm Oval Phantom V4.0C	SPEAG	QD OVA 002 AA	1190	N/A	N/A	N/A
Device Holder	SPEAG	Laptop Holder	SM LH1 001 CD	N/A	N/A	N/A
Data Acquisition Electronics	SPEAG	DAE4	1344	2018-11-15	2019-11-15	1 Year
E-Field Probe	SPEAG	EX3DV4	7359	2019-01-31	2020-01-31	1 Year
Dipole Antenna	SPEAG	D2450V2	896	2018-05-30	2020-05-30	2 Years
Dipole Antenna	SPEAG	D5GHzV2	1170	2018-01-25	2020-01-25	2 Years
Vector Signal Generator	R&S	SMBV100A	256397	2019-06-25	2020-06-25	1 Year
RF POWER AMPLIFIER	NONE	RFSPA24	001	2019-06-24	2020-06-24	1 Year
BROADBAND AMPLIFIER	EMPOWER	1138	1030	2019-06-24	2020-06-24	1 Year
DUAL DIRECTIONAL COUPLER	HP	11692D	1212A03523	2019-06-25	2020-06-25	1 Year
EPM Series Power Meter	HP	E4419B	GB40202055	2019-01-16	2020-01-16	1 Year
E-Series AVG Power Sensor	Agilent	E9300H	MY41495967	2019-01-15	2020-01-15	1 Year
E-Series AVG Power Sensor	Agilent	E9300H	US39215405	2019-01-15	2020-01-15	1 Year
POWER METER	ANRITSU	ML2495A	1438001	2019-01-15	2020-01-15	1 Year
Pulse Power Sensor	ANRITSU	MA2411B	1339205	2019-01-15	2020-01-15	1 Year
Attenuator	HP	8491B	22234	2019-01-15	2020-01-15	1 Year
Attenuator	MINI-CIRCUITS	UNAT-10+	VUU38501715	2019-01-15	2020-01-15	1 Year
Low Pass Filter	FILTRON	F-LPCA-KOO1410	1408004S	2019-01-16	2020-01-16	1 Year
Low Pass Filter	FILTRON	F-LPCA-KOO1420	1408008S	2019-01-16	2020-01-16	1 Year
DIELECTRIC ASSESSMENT KIT	SPEAG	DAK3.5	1092	N/A	N/A	N/A
S-Parameter Network Analyzer	Agilent	8753ES	MY40000210	2019-06-24	2020-06-24	1 Year
HYGRO-THERMOMETER	DAEKWANG	811CE	NONE	2019-06-27	2020-06-27	1 Year
Spectrum Analyzer	Agilent	N9010A	MY51440103	2019-01-16	2020-01-16	1 Year

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.

9. 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.

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