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# SAR EVALUATION REPORT

**Applicant Name:**
Logitech Far East Ltd.
No. 2, Creation Road IV Science-Based Industrial Park
Hsin-Chu,
Taiwan

**Date of Testing:**
07/17/17
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Document Serial No.:**
1M1707180224-01.JNZ

| | |
|---|---|
| **FCC ID:** | **JNZS00166** |
| **APPLICANT:** | **LOGITECH** |

**DUT Type:** Portable Speaker
**Application Type:** Certification
**FCC Rule Part(s):** CFR §2.1093
**Model:** S-00166
**Serial Number:** Pre-Production [S/N: 0561]

| Equipment Class | Band & Mode | Tx Frequency | SAR | |
|---|---|---|---|---|
| | | | 1 gm Body W/kg | 10 gm Extremity (W/kg) |
| DTS | 2.4 GHz WLAN | 2412 - 2462 MHz | 0.38 | 0.69 |
| NII | U-NII-1 | 5180 - 5240 MHz | 0.23 | 0.48 |
| NII | U-NII-2A | 5260 - 5320 MHz | N/A | N/A |
| NII | U-NII-2C | 5500 - 5720 MHz | 0.13 | 0.19 |
| NII | U-NII-3 | 5745 - 5825 MHz | < 0.1 | < 0.1 |
| DSS/DTS | Bluetooth | 2402 - 2480 MHz | < 0.1 | < 0.1 |
| **Simultaneous SAR per KDB 690783 D01v01r03:** | | | 0.40 | 0.71 |

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE C95.1-1992 and has been tested in accordance with the measurement procedures specified in Section 1.7 of this report; for North American frequency bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.

Randy Ortanez
President

The SAR Tick is an initiative of the Mobile Manufacturers Forum (MMF). While a product may be considered eligible, use of the SAR Tick logo requires an agreement with the MMF. Further details can be obtained by emailing: sartick@mmfai.info.

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# 1 DEVICE UNDER TEST

## 1.1 Device Overview

| Band & Mode | Operating Modes | Tx Frequency |
|---|---|---|
| 2.4 GHz WLAN | Data | 2412 - 2462 MHz |
| U-NII-1 | Data | 5180 - 5240 MHz |
| U-NII-2A | Data | 5260 - 5320 MHz |
| U-NII-2C | Data | 5500 - 5720 MHz |
| U-NII-3 | Data | 5745 - 5825 MHz |
| Bluetooth | Data | 2402 - 2480 MHz |

## 1.2 Power Reduction for SAR

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

## 1.3 Nominal and Maximum Output Power Specifications

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v06.

| Mode / Band | | Modulated Average - Single Tx Chain | | |
|---|---|---|---|---|
| | | Ch. 1-5 | Ch. 6 | Ch. 7-11 |
| IEEE 802.11b (2.4 GHz) | Maximum | **20.0** | **21.25** | **19.0** |
| | Nominal | **19.5** | **20.75** | **18.5** |
| IEEE 802.11g (2.4 GHz) | Maximum | **18.25** | **21.0** | **17.75** |
| | Nominal | **17.75** | **20.5** | **17.25** |
| IEEE 802.11n (2.4 GHz) | Maximum | **17.25** | **20.75** | **17.0** |
| | Nominal | **16.75** | **20.25** | **16.5** |

| Mode / Band | | Modulated Average (dBm) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 20 MHz Bandwidth | | | 40 MHz Bandwidth | | |
| IEEE 802.11a U-NII-1 (5 GHz) | Channels | 36 | 40 | 44-48 | | | |
| | Maximum | **18.75** | **21.25** | **18.5** | | | |
| | Nominal | **18.25** | **20.75** | **18.0** | | | |
| IEEE 802.11a U-NII-2A (5 GHz) | Channels | 52 | 56-64 | | | | |
| | Maximum | **19.0** | **18.75** | | | | |
| | Nominal | **18.5** | **18.25** | | | | |
| IEEE 802.11a U-NII-2C (5 GHz) | Channels | 100-112 | 116 | 120-144 | | | |
| | Maximum | **17.5** | **18.25** | **16.5** | | | |
| | Nominal | **17.0** | **17.75** | **16.0** | | | |
| IEEE 802.11a U-NII-3 (5 GHz) | Channels | 149-165 | | | | | |
| | Maximum | **16.75** | | | | | |
| | Nominal | **16.25** | | | | | |
| IEEE 802.11n U-NII-1 (5 GHz) | Channels | 36 | 40 | 44-48 | 38 | 46 | |
| | Maximum | **18.5** | **21.0** | **18.0** | **17.0** | **17.75** | |
| | Nominal | **18.0** | **20.5** | **17.5** | **16.5** | **17.25** | |
| IEEE 802.11n U-NII-2A (5 GHz) | Channels | 52 | 56-60 | 64 | 54 | 62 | |
| | Maximum | **18.5** | **18.25** | **18.0** | **17.75** | **16.0** | |
| | Nominal | **18.0** | **17.75** | **17.5** | **17.25** | **15.5** | |
| IEEE 802.11n U-NII-2C (5 GHz) | Channels | 100-112 | 116 | 120-144 | 102 | 110 | 118-142 |
| | Maximum | **16.75** | **17.5** | **15.5** | **15.0** | **17.5** | **16.75** |
| | Nominal | **16.25** | **17.0** | **15.0** | **14.5** | **17.0** | **16.25** |
| IEEE 802.11n U-NII-3 (5 GHz) | Channels | 149 | 153-161 | 165 | 151-159 | | |
| | Maximum | **17.0** | **16.25** | **17.0** | **18.5** | | |
| | Nominal | **16.5** | **15.75** | **16.5** | **18.0** | | |

| Mode / Band | | Modulated Average (dBm) |
|---|---|---|
| Bluetooth | Maximum | **4.5** |
| | Nominal | **4.0** |
| Bluetooth LE | Maximum | **9.5** |
| | Nominal | **9.0** |

## 1.4 DUT Antenna Locations

A diagram showing the location of the device antennas can be found in Appendix F.

**Table 1-1**
**Device Edges/Sides for SAR Testing**

| Mode | Top | Bottom | Side |
|---|---|---|---|
| 2.4 GHz WLAN | No | No | Yes |
| 5 GHz WLAN | No | No | Yes |
| Bluetooth | Yes | No | Yes |

Note:

1. Particular DUT edges were not required to be evaluated for SAR if the edges were greater than 2.5 cm from the transmitting antenna according to FCC KDB Publication 941225 D0701r02. The distances between the transmit antennas and the edges of the device are included in the filing.
2. This device is a cylinder with flat top and bottom faces. Please see section 4.3 for more details about SAR Test Setup

## 1.5 Simultaneous Transmission Capabilities

According to FCC KDB Publication 447498 D01v06, transmitters are considered to be transmitting simultaneously when there is overlapping transmission, with the exception of transmissions during network hand-offs with maximum hand-off duration less than 30 seconds.

This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis according to FCC KDB Publication 447498 D01v06 4.3.2 procedures.

**Table 1-2**
**Simultaneous Transmission Scenarios**

| No. | Capable Transmit Configuration | Body | Extremity | Notes |
|---|---|---|---|---|
| 1 | 2.4 GHz WI-FI Chain0 + 2.4 GHz Bluetooth | Yes | Yes | |
| 2 | 5 GHz WI-FI Chain0 + 2.4 GHz Bluetooth | Yes | Yes | |
| 3 | 2.4 GHz WI-FI Chain1 + 2.4 GHz Bluetooth | Yes | Yes | |
| 4 | 5 GHz WI-FI Chain1 + 2.4 GHz Bluetooth | Yes | Yes | |
| 5 | 2.4 GHz WI-FI Chain0 + 2.4 GHz WI-FI Chain1 | No | No | |
| 6 | 5 GHz WI-FI Chain0 + 2.4 GHz WI-FI Chain1 | No | No | |
| 7 | 2.4 GHz WI-FI Chain0 + 5 GHz WI-FI Chain1 | No | No | |
| 8 | 5 GHz WI-FI Chain0 + 5 GHz WI-FI Chain1 | No | No | |

1. 2.4 GHz WLAN and 5 GHz WLAN share the same antenna path and cannot transmit simultaneously.

## 1.6 Miscellaneous SAR Test Considerations

### (A) WIFI/BT

Since U-NII-1 band has a higher maximum output power than U-NII-2A band and the highest reported SAR for U-NII-1 is less than 1.2 W/kg, SAR is not required for U-NII-2A band according to FCC KDB Publication 248227 D01v02r02.

This device supports two WLAN antennas which share the same transmission path (Chain0 and Chain1). They are identical and share the same powers and targets and cannot transmit simultaneously.

## 1.7 Guidance Applied

- FCC KDB Publication 248227 D01v02r02 (SAR Considerations for 802.11 Devices)
- FCC KDB Publication 447498 D01v06 (General SAR Guidance)
- FCC KDB Publication 865664 D01v01r04, D02v01r02 (SAR Measurements up to 6 GHz)
- FCC KDB Publication 941225 D07v01r02 (UMPC Mini Tablet)

## 2 INTRODUCTION

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

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

### 2.1 SAR Definition

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

**Equation 2-1**
**SAR Mathematical Equation**

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

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

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

where:

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

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

## 3 DOSIMETRIC ASSESSMENT

### 3.1 Measurement Procedure

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

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 3-1) and IEEE 1528-2013.
2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.

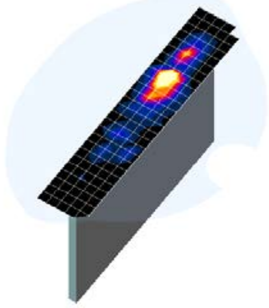

**Figure 3-1**
**Sample SAR Area Scan**

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 3-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):
   a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 3-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).
   b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.
   c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.
4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

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

| Frequency | Maximum Area Scan Resolution (mm) ($\Delta x_{area}$, $\Delta y_{area}$) | Maximum Zoom Scan Resolution (mm) ($\Delta x_{zoom}$, $\Delta y_{zoom}$) | 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 UMPC Mini-Tablet Devices per KDB Publication 941225 D07v01r02

Per FCC guidance, procedures from FCC KDB Publication 941225 D07v01r02 were followed when testing this device. Per FCC KDB Publication 941225 D07v01r02, the top surface (BT) and side of the device (BT & WLAN) should be tested for SAR compliance at 0mm for 10g-SAR (Extremity) and at 10mm for 1g-SAR (Body). The SAR Exclusion Threshold in KDB 941225 D07v01r02 of all surfaces and side edges with a transmitting antenna located at ≤ 25 mm from that surface or edge can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent device surface is used to determine if SAR testing is required for the adjacent surface, with the adjacent surface positioned against the phantom and the edge containing the antenna positioned perpendicular to the phantom.

## 4.3 SAR Test Positioning Based on Form Factor

This device is a cylinder with flat top and bottom faces. When testing the curved side of the device, the device was positioned under the phantom with the long side parallel to the bottom of the phantom. The worst case orientation of the device in this position for SAR testing was determined for each band, mode, and antenna. SAR test setup photos can be found in Appendix F.

# 5 RF EXPOSURE LIMITS

## 5.1 Uncontrolled Environment

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

## 5.2 Controlled Environment

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

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

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

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

# 6 FCC MEASUREMENT PROCEDURES

## 6.1 Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, when SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as *reported* SAR. The highest *reported* SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

## 6.2 SAR Testing with 802.11 Transmitters

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

### 6.2.1 General Device Setup

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

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

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

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

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

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

### 6.2.4 2.4 GHz SAR Test Requirements

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

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

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

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

### 6.2.5 OFDM Transmission Mode and SAR Test Channel Selection

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

### 6.2.6 Initial Test Configuration Procedure

For OFDM, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order IEEE 802.11 mode. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR is ≤ 0.8 W/kg, no additional measurements on other test channels are required. Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured. When there are multiple untested channels having the same subsequent highest average RF output power, the channel with higher frequency from the lowest 802.11 mode is considered for SAR measurements (See Section 6.2.5).

### 6.2.7 Subsequent Test Configuration Procedures

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

# 7 RF CONDUCTED POWERS

## 7.1 WLAN Conducted Powers

**Table 7-1**
**2.4 GHz Average RF Power**

| 2.4GHz Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11b | 802.11g | 802.11n |
| | | Average | Average | Average |
| 2412 | 1 | 19.56 | 17.77 | 16.74 |
| 2437 | 6 | **20.74** | 20.63 | 20.37 |
| 2462 | 11 | 18.55 | 17.31 | 16.62 |

**Table 7-2**
**5 GHz Average RF Power – 20 MHz Bandwidth**

| 5GHz (20MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11a |
| | | Average |
| 5180 | 36 | 18.34 |
| 5200 | 40 | **20.72** |
| 5240 | 48 | 17.92 |
| 5260 | 52 | 18.46 |
| 5280 | 56 | 18.39 |
| 5320 | 64 | 18.19 |
| 5500 | 100 | 17.18 |
| 5580 | 116 | **17.73** |
| 5700 | 140 | 15.94 |
| 5745 | 149 | 16.21 |
| 5785 | 157 | 16.34 |
| 5825 | 165 | 16.24 |

**Table 7-3**
**5 GHz Average RF Power – 40 MHz Bandwidth**

| 5GHz (40MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11n |
| | | Average |
| 5190 | 38 | 16.45 |
| 5230 | 46 | 17.34 |
| 5270 | 54 | 17.28 |
| 5310 | 62 | 15.52 |
| 5510 | 102 | 14.42 |
| 5550 | 110 | 16.95 |
| 5670 | 134 | 16.29 |
| 5755 | 151 | 17.99 |
| 5795 | 159 | **18.13** |

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

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported.
- The bolded data rate and channel above were tested for SAR.

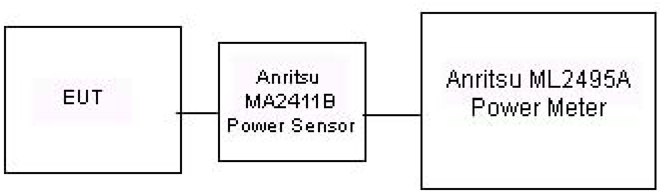


**Figure 7-1**
**Power Measurement Setup**

## 7.1 Bluetooth LE Conducted Powers

**Table 7-4**
**Bluetooth LE Average RF Power**

| Frequency [MHz] | Data Rate [Mbps] | Channel No. | Bluetooth Mode | Average Conducted Power | |
|---|---|---|---|---|---|
| | | | | [dBm] | [mW] |
| 2402 | 1.0 | 0 | LE | 7.70 | 5.888 |
| 2440 | 1.0 | 19 | LE | 8.50 | 7.079 |
| 2480 | 1.0 | 39 | LE | **9.23** | 8.375 |

Note: The bolded data rates and channel above were tested for SAR.

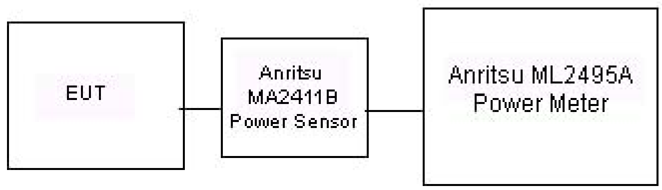


**Figure 7-2**
**Power Measurement Setup**

# 8 SYSTEM VERIFICATION

## 8.1 Tissue 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 |
|---|---|---|---|---|---|---|---|---|---|
| 07/17/2017 | 2450B | 23.5 | 2400 | 1.885 | 52.067 | 1.902 | 52.767 | -0.89% | -1.33% |
| | | | 2450 | 1.944 | 51.893 | 1.950 | 52.700 | -0.31% | -1.53% |
| | | | 2500 | 2.018 | 51.682 | 2.021 | 52.636 | -0.15% | -1.81% |
| 07/17/2017 | 5200B-5800B | 21.0 | 5180 | 5.361 | 47.846 | 5.276 | 49.041 | 1.61% | -2.44% |
| | | | 5200 | 5.393 | 47.833 | 5.299 | 49.014 | 1.77% | -2.41% |
| | | | 5220 | 5.432 | 47.797 | 5.323 | 48.987 | 2.05% | -2.43% |
| | | | 5240 | 5.457 | 47.730 | 5.346 | 48.960 | 2.08% | -2.51% |
| | | | 5260 | 5.477 | 47.704 | 5.369 | 48.933 | 2.01% | -2.51% |
| | | | 5280 | 5.509 | 47.663 | 5.393 | 48.906 | 2.15% | -2.54% |
| | | | 5320 | 5.553 | 47.604 | 5.439 | 48.851 | 2.10% | -2.55% |
| | | | 5500 | 5.803 | 47.304 | 5.650 | 48.607 | 2.71% | -2.68% |
| | | | 5540 | 5.854 | 47.232 | 5.696 | 48.553 | 2.77% | -2.72% |
| | | | 5560 | 5.876 | 47.146 | 5.720 | 48.526 | 2.73% | -2.84% |
| | | | 5580 | 5.915 | 47.137 | 5.743 | 48.499 | 2.99% | -2.81% |
| | | | 5600 | 5.955 | 47.069 | 5.766 | 48.471 | 3.28% | -2.89% |
| | | | 5620 | 5.969 | 47.042 | 5.790 | 48.444 | 3.09% | -2.89% |
| | | | 5640 | 6.012 | 47.027 | 5.813 | 48.417 | 3.42% | -2.87% |
| | | | 5660 | 6.026 | 47.017 | 5.837 | 48.390 | 3.24% | -2.84% |
| | | | 5680 | 6.048 | 46.965 | 5.860 | 48.363 | 3.21% | -2.89% |
| | | | 5700 | 6.088 | 46.880 | 5.883 | 48.336 | 3.48% | -3.01% |
| | | | 5745 | 6.154 | 46.831 | 5.936 | 48.275 | 3.67% | -2.99% |
| | | | 5785 | 6.215 | 46.803 | 5.982 | 48.220 | 3.90% | -2.94% |
| | | | 5800 | 6.230 | 46.770 | 6.000 | 48.200 | 3.83% | -2.97% |
| | | | 5805 | 6.234 | 46.763 | 6.006 | 48.193 | 3.80% | -2.97% |
| | | | 5825 | 6.266 | 46.692 | 6.029 | 48.166 | 3.93% | -3.06% |

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.

## 8.2 Test System Verification

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

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

| System Verification TARGET & MEASURED | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAR System # | Tissue Frequency (MHz) | Tissue Type | Date: | Amb. Temp (°C) | Liquid Temp (°C) | Input Power (W) | Source SN | Probe SN | Measured $SAR_{1g}$ (W/kg) | 1 W Target $SAR_{1g}$ (W/kg) | 1 W Normalized $SAR_{1g}$ (W/kg) | $Deviation_{1g}$ (%) |
| K | 2450 | BODY | 07/17/2017 | 20.8 | 22.0 | 0.100 | 797 | 7406 | 5.010 | 50.700 | 50.100 | -1.18% |
| D | 5250 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 3.790 | 75.900 | 75.800 | -0.13% |
| D | 5600 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 4.000 | 78.900 | 80.000 | 1.39% |
| D | 5750 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 3.640 | 76.300 | 72.800 | -4.59% |

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

| System Verification TARGET & MEASURED | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAR System # | Tissue Frequency (MHz) | Tissue Type | Date: | Amb. Temp (°C) | Liquid Temp (°C) | Input Power (W) | Source SN | Probe SN | Measured $SAR_{10g}$ (W/kg) | 1 W Target $SAR_{10g}$ (W/kg) | 1 W Normalized $SAR_{10g}$ (W/kg) | $Deviation_{10g}$ (%) |
| K | 2450 | BODY | 07/17/2017 | 20.8 | 22.0 | 0.100 | 797 | 7406 | 2.280 | 24.200 | 22.800 | -5.79% |
| D | 5250 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 1.050 | 21.300 | 21.000 | -1.41% |
| D | 5600 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 1.100 | 22.100 | 22.000 | -0.45% |
| D | 5750 | BODY | 07/17/2017 | 22.1 | 21.0 | 0.050 | 1123 | 3589 | 1.000 | 21.300 | 20.000 | -6.10% |

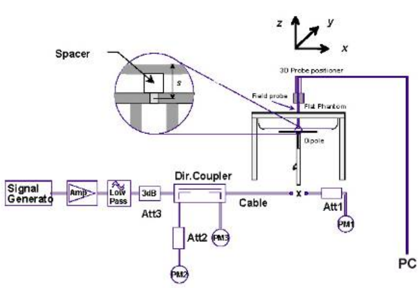


**Figure 8-1**
**System Verification Setup Diagram**

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

# 9 SAR DATA SUMMARY

## 9.1 Standalone Body SAR Data

### Table 9-1
### WLAN Body SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Antenna Config. | Device Serial Number | Data Rate (Mbps) | Position | Duty Cycle (%) | Peak SAR of Area Scan | SAR (1g) | Scaling Factor (Power) | Scaling Factor (Duty Cycle) | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | W/kg | (W/kg) | | | (W/kg) | |
| 2412 | 1 | 802.11b | DSSS | 22 | 20.00 | 19.56 | 0.14 | 10 mm | Chain0 | 0561 | 1 | side | 99.7 | 0.376 | 0.260 | 1.107 | 1.003 | 0.289 | |
| 2437 | 6 | 802.11b | DSSS | 22 | 21.25 | 20.74 | -0.14 | 10 mm | Chain0 | 0561 | 1 | side | 99.7 | 0.516 | 0.335 | 1.125 | 1.003 | 0.378 | A1 |
| 2462 | 11 | 802.11b | DSSS | 22 | 19.00 | 18.55 | 0.03 | 10 mm | Chain0 | 0561 | 1 | side | 99.7 | 0.283 | 0.192 | 1.109 | 1.003 | 0.214 | |
| 2437 | 6 | 802.11b | DSSS | 22 | 21.25 | 20.74 | 0.12 | 10 mm | Chain1 | 0561 | 1 | side | 99.7 | 0.484 | 0.329 | 1.125 | 1.003 | 0.371 | |
| 5200 | 40 | 802.11a | OFDM | 20 | 21.25 | 20.72 | -0.11 | 10 mm | Chain0 | 0561 | 6 | side | 98.3 | 0.371 | 0.159 | 1.130 | 1.017 | 0.183 | |
| 5200 | 40 | 802.11a | OFDM | 20 | 21.25 | 20.72 | -0.21 | 10 mm | Chain1 | 0561 | 6 | side | 98.3 | 0.473 | 0.202 | 1.130 | 1.017 | 0.232 | A2 |
| 5580 | 116 | 802.11a | OFDM | 20 | 18.25 | 17.73 | 0.18 | 10 mm | Chain0 | 0561 | 6 | side | 98.3 | 0.126 | 0.052 | 1.127 | 1.017 | 0.060 | |
| 5580 | 116 | 802.11a | OFDM | 20 | 18.25 | 17.73 | 0.02 | 10 mm | Chain1 | 0561 | 6 | side | 98.3 | 0.293 | 0.113 | 1.127 | 1.017 | 0.130 | |
| 5795 | 159 | 802.11n | OFDM | 40 | 18.50 | 18.13 | 0.17 | 10 mm | Chain0 | 0561 | 13.5 | side | 96.5 | 0.036 | 0.014 | 1.089 | 1.036 | 0.016 | |
| 5795 | 159 | 802.11n | OFDM | 40 | 18.50 | 18.13 | 0.12 | 10 mm | Chain1 | 0561 | 13.5 | side | 96.5 | 0.118 | 0.037 | 1.089 | 1.036 | 0.042 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | | | |

### Table 9-2
### Bluetooth Body SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | Data Rate (Mbps) | Position | Duty Cycle | SAR (1g) | Scaling Factor (Cond Power) | Scaling Factor (Duty Factor) | Reported SAR (1g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | | (W/kg) | |
| 2480 | 39 | Bluetooth LE | FHSS | 9.5 | 9.23 | 0.10 | 10 mm | 0561 | 1 | top | 61.2 | 0.005 | 1.064 | 1.634 | 0.009 | |
| 2480 | 39 | Bluetooth LE | FHSS | 9.5 | 9.23 | -0.18 | 10 mm | 0561 | 1 | side | 61.2 | 0.012 | 1.064 | 1.634 | 0.021 | A3 |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Body<br>1.6 W/kg (mW/g)<br>averaged over 1 gram | | | | | | | | | |

## 9.2 Standalone Extremity SAR Data

### Table 9-3
### WLAN Extremity SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Bandwidth [MHz] | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Antenna Config. | Device Serial Number | Data Rate (Mbps) | Position | Duty Cycle (%) | Peak SAR of Area Scan | SAR (10g) | Scaling Factor (Power) | Scaling Factor (Duty Cycle) | Reported SAR (10g) | Plot # |
| MHz | Ch. | | | | | | | | | | | | | W/kg | (W/kg) | | | (W/kg) | |
| 2412 | 1 | 802.11b | DSSS | 22 | 20.00 | 19.56 | 0.01 | 0 mm | Chain0 | 0561 | 1 | side | 99.7 | 1.662 | 0.450 | 1.107 | 1.003 | 0.500 | |
| 2437 | 6 | 802.11b | DSSS | 22 | 21.25 | 20.74 | 0.18 | 0 mm | Chain0 | 0561 | 1 | side | 99.7 | 2.204 | 0.608 | 1.125 | 1.003 | 0.686 | A4 |
| 2462 | 11 | 802.11b | DSSS | 22 | 19.00 | 18.55 | 0.07 | 0 mm | Chain0 | 0561 | 1 | side | 99.7 | 1.477 | 0.390 | 1.109 | 1.003 | 0.434 | |
| 2437 | 6 | 802.11b | DSSS | 22 | 21.25 | 20.74 | -0.21 | 0 mm | Chain1 | 0561 | 1 | side | 99.7 | 2.077 | 0.486 | 1.125 | 1.003 | 0.548 | |
| 5200 | 40 | 802.11a | OFDM | 20 | 21.25 | 20.72 | 0.01 | 0 mm | Chain0 | 0561 | 6 | side | 98.3 | 1.485 | 0.247 | 1.130 | 1.017 | 0.284 | |
| 5200 | 40 | 802.11a | OFDM | 20 | 21.25 | 20.72 | 0.02 | 0 mm | Chain1 | 0561 | 6 | side | 98.3 | 3.563 | 0.416 | 1.130 | 1.017 | 0.478 | A5 |
| 5580 | 116 | 802.11a | OFDM | 20 | 18.25 | 17.73 | 0.09 | 0 mm | Chain0 | 0561 | 6 | side | 98.3 | 0.548 | 0.088 | 1.127 | 1.017 | 0.101 | |
| 5580 | 116 | 802.11a | OFDM | 20 | 18.25 | 17.73 | -0.10 | 0 mm | Chain1 | 0561 | 6 | side | 98.3 | 1.398 | 0.165 | 1.127 | 1.017 | 0.189 | |
| 5795 | 159 | 802.11n | OFDM | 40 | 18.50 | 18.13 | 0.17 | 0 mm | Chain0 | 0561 | 13.5 | side | 96.5 | 0.189 | 0.022 | 1.089 | 1.036 | 0.025 | |
| 5795 | 159 | 802.11n | OFDM | 40 | 18.50 | 18.13 | 0.19 | 0 mm | Chain1 | 0561 | 13.5 | side | 96.5 | 0.643 | 0.066 | 1.089 | 1.036 | 0.074 | |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | | Extremity<br>4.0 W/kg (mW/g)<br>averaged over 10 grams | | | | | | | | | | | |

## Table 9-4
## Bluetooth Extremity SAR

| MEASUREMENT RESULTS | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FREQUENCY | | Mode | Service | Maximum Allowed Power [dBm] | Conducted Power [dBm] | Power Drift [dB] | Spacing | Device Serial Number | Data Rate (Mbps) | Position | Duty Cycle (%) | SAR (10g) | Scaling Factor (Cond Power) | Scaling Factor (Duty Factor) | Reported SAR (10g) | Plot # |
| MHz | Ch. | | | | | | | | | | | (W/kg) | | | (W/kg) | |
| 2480 | 39 | Bluetooth LE | FHSS | 9.5 | 9.23 | -0.17 | 0 mm | 0561 | 1 | top | 61.2 | 0.007 | 1.064 | 1.634 | 0.012 | |
| 2480 | 39 | Bluetooth LE | FHSS | 9.5 | 9.23 | 0.17 | 0 mm | 0561 | 1 | side | 61.2 | 0.016 | 1.064 | 1.634 | 0.028 | A6 |
| ANSI / IEEE C95.1 1992 - SAFETY LIMIT<br>Spatial Peak<br>Uncontrolled Exposure/General Population | | | | | | | Extremity<br>4.0 W/kg (mW/g)<br>averaged over 10 grams | | | | | | | | | |

## 9.3 SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in FCC KDB Publication 941225 D07v01r02 and FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units.
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. Per FCC KDB 865664 D01v01r04, variability SAR tests were not performed since the measured SAR results for a frequency band were less than 0.8 W/kg.
7. FCC KDB Publication 941225 D07v01r02, SAR tests are required for the top surface (BT) and side of the device (BT & WLAN) with the device touching the phantom. The SAR Exclusion Threshold in FCC KDB 941225 D07v01r02 was applied to determine SAR test exclusion for adjacent edge configurations.

WLAN Notes:

1. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR. See Section 6.2.4 for more information.
2. Justification for test configurations for WLAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI 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. See Section 6.2.5 for more information.
3. When the maximum reported 1g averaged SAR is ≤0.8 W/kg and 10g average SAR is ≤2.0 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported 1g SAR result was ≤ 1.20 W/kg and 10g SAR was ≤3.0 W/kg or all test channels were measured.
4. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools. The reported SAR was scaled to the 100% transmission duty factor to determine compliance. Procedures used to measure the duty factor are identical to that in the associated EMC test reports.

Bluetooth Note:

1. Per October 2016 TCB Workshop Notes, 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.

# 10 FCC MULTI-TX AND ANTENNA SAR CONSIDERATIONS

## 10.1 Introduction

The following procedures adopted from FCC KDB Publication 447498 D01v06 are applicable to devices with built-in unlicensed transmitters such as 802.11 and Bluetooth devices which may simultaneously transmit with the licensed transmitter.

## 10.2 Simultaneous Transmission Procedures

This device contains transmitters that may operate simultaneously. Therefore simultaneous transmission analysis is required. Per FCC KDB Publication 447498 D01v06 4.3.2 and IEEE 1528-2013 Section 6.3.4.1.2, simultaneous transmission SAR test exclusion may be applied when the sum of the 1-g SAR for all the simultaneous transmitting antennas in a specific a physical test configuration is ≤1.6 W/kg. The different test positions in an exposure condition may be considered collectively to determine SAR test exclusion according to the sum of 1-g or 10-g SAR.

## 10.3 Body SAR Simultaneous Transmission Analysis

**Table 10-1**
**Simultaneous Transmission Scenario (Bluetooth + 2.4 GHz WLAN Chain0 at 1.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 2.4 GHz WLAN Chain0 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 1g Body SAR | 0.021 | 0.378 | **0.399** |

**Table 10-2**
**Simultaneous Transmission Scenario (Bluetooth + 2.4 GHz WLAN Chain1 at 1.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 2.4 GHz WLAN Chain1 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 1g Body SAR | 0.021 | 0.371 | 0.392 |

**Table 10-3**
**Simultaneous Transmission Scenario (Bluetooth + 5 GHz WLAN Chain0 at 1.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 5 GHz WLAN Chain0 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 1g Body SAR | 0.021 | 0.183 | 0.204 |

**Table 10-4**
**Simultaneous Transmission Scenario (Bluetooth + 5 GHz WLAN Chain1 at 1.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 5 GHz WLAN Chain1 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 1g Body SAR | 0.021 | 0.232 | 0.253 |

## 10.4 Extremity SAR Simultaneous Transmission Analysis

**Table 10-5**
**Simultaneous Transmission Scenario (Bluetooth + 2.4 GHz WLAN Chain0 at 0.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 2.4 GHz WLAN Chain0 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 10g Extremity SAR | 0.028 | 0.686 | **0.714** |

**Table 10-6**
**Simultaneous Transmission Scenario (Bluetooth + 2.4 GHz WLAN Chain1 at 0.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 2.4 GHz WLAN Chain1 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 10g Extremity SAR | 0.028 | 0.548 | 0.576 |

**Table 10-7**
**Simultaneous Transmission Scenario (Bluetooth + 5 GHz WLAN Chain0 at 0.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 5 GHz WLAN Chain0 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 10g Extremity SAR | 0.028 | 0.284 | 0.312 |

**Table 10-8**
**Simultaneous Transmission Scenario (Bluetooth + 5 GHz WLAN Chain1 at 0.0 cm)**

| Exposure Condition | Bluetooth SAR (W/kg) | 5 GHz WLAN Chain1 SAR (W/kg) | Σ SAR (W/kg) |
|---|---|---|---|
| 10g Extremity SAR | 0.028 | 0.478 | 0.506 |

## 10.5 Simultaneous Transmission Conclusion

The above numerical summed SAR results for all the worst-case simultaneous transmission conditions were below the SAR limit. Therefore, the above analysis is sufficient to determine that simultaneous transmission cases will not exceed the SAR limit and therefore no measured volumetric simultaneous SAR summation is required per FCC KDB Publication 447498 D01v06 and IEEE 1528-2013 Section 6.3.4.1.2.

# 11 SAR MEASUREMENT VARIABILITY

## 11.1 Measurement Variability

Per FCC KDB Publication 865664 D01v01, SAR measurement variability was not assessed for each frequency band since all measured SAR values are < 0.80 W/kg or 2.0 W/kg for 1g and 10g SAR, respectively.

## 11.2 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.

# 12 EQUIPMENT LIST

| Manufacturer | Model | Description | Cal Date | Cal Interval | Cal Due | Serial Number |
|---|---|---|---|---|---|---|
| Agilent | E8257D | (250kHz-20GHz) Signal Generator | 3/22/2017 | Annual | 3/22/2018 | MY45470194 |
| Agilent | 8594A | (9kHz-2.9GHz) Spectrum Analyzer | N/A | N/A | N/A | 3051A00187 |
| Agilent | E4438C | ESG Vector Signal Generator | 3/24/2017 | Biennial | 3/24/2019 | MY42082385 |
| Agilent | N9020A | MXA Signal Analyzer | 10/28/2016 | Annual | 10/28/2017 | US46470561 |
| Agilent | N5182A | MXG Vector Signal Generator | 10/27/2016 | Annual | 10/27/2017 | MY47420603 |
| Agilent | 8753ES | S-Parameter Network Analyzer | 10/26/2016 | Annual | 10/26/2017 | US39170118 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433971 |
| Amplifier Research | 15S1G6 | Amplifier | CBT | N/A | CBT | 433972 |
| Anritsu | ML2495A | Power Meter | 10/16/2015 | Biennial | 10/16/2017 | 941001 |
| Anritsu | MA2411B | Pulse Power Sensor | 8/18/2016 | Annual | 8/18/2017 | 1126066 |
| Anritsu | MA2411B | Pulse Power Sensor | 2/10/2017 | Annual | 2/10/2018 | 1207364 |
| Anritsu | MA24106A | USB Power Sensor | 6/7/2017 | Annual | 6/7/2018 | 1231535 |
| Anritsu | MA24106A | USB Power Sensor | 6/7/2017 | Annual | 6/7/2018 | 1231538 |
| COMTech | AR85729-5 | Solid State Amplifier | CBT | N/A | CBT | M1S5A00-009 |
| Control Company | 4040 | Therm./Clock/Humidity Monitor | 3/31/2017 | Biennial | 3/31/2019 | 170232394 |
| Control Company | 4352 | Ultra Long Stem Thermometer | 3/8/2016 | Biennial | 3/8/2018 | 160261694 |
| Keysight | 772D | Dual Directional Coupler | CBT | N/A | CBT | MY52180215 |
| Keysight Technologies | 85033E | andard Mechanical Calibration Kit (DC to 9GHz, 3.5mr | 6/1/2017 | Annual | 6/1/2018 | MY53401181 |
| MCL | BW-N6W5+ | 6dB Attenuator | CBT | N/A | CBT | 1139 |
| MiniCircuits | VLF-6000+ | Low Pass Filter | CBT | N/A | CBT | N/A |
| MiniCircuits | SLP-2400+ | Low Pass Filter | CBT | N/A | CBT | R8979500903 |
| Mini-Circuits | BW-N20W5+ | DC to 18 GHz Precision Fixed 20 dB Attenuator | CBT | N/A | CBT | N/A |
| Mini-Circuits | NLP-2950+ | Low Pass Filter DC to 2700 MHz | CBT | N/A | CBT | N/A |
| Mini-Circuits | BW-N20W5 | Power Attenuator | CBT | N/A | CBT | 1226 |
| Mitutoyo | CD-6"CSX | Digital Caliper | 3/2/2016 | Biennial | 3/2/2018 | 13264162 |
| Narda | 4014C-6 | 4 - 8 GHz SMA 6 dB Directional Coupler | CBT | N/A | CBT | N/A |
| Narda | BW-S3W2 | Attenuator (3dB) | CBT | N/A | CBT | 120 |
| Pasternack | PE2209-10 | Bidirectional Coupler | CBT | N/A | CBT | N/A |
| Pasternack | NC-100 | Torque Wrench | 3/8/2017 | Annual | 3/8/2018 | N/A |
| SPEAG | D2450V2 | 2450 MHz SAR Dipole | 9/13/2016 | Annual | 9/13/2017 | 797 |
| SPEAG | D5GHzV2 | 5 GHz SAR Dipole | 3/9/2017 | Annual | 3/9/2018 | 1123 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 4/11/2017 | Annual | 4/11/2018 | 1407 |
| SPEAG | DAE4 | Dasy Data Acquisition Electronics | 1/16/2017 | Annual | 1/16/2018 | 1466 |
| SPEAG | DAK-3.5 | Dielectric Assessment Kit | 5/10/2017 | Annual | 5/10/2018 | 1070 |
| SPEAG | EX3DV4 | SAR Probe | 1/13/2017 | Annual | 1/13/2018 | 3589 |
| SPEAG | EX3DV4 | SAR Probe | 4/18/2017 | Annual | 4/18/2018 | 7406 |

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.

# 13 MEASUREMENT UNCERTAINTIES

| a | c | d | e= f(d,k) | f | g | h = c x f/e | i = c x g/e | k |
|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Tol. (± %) | Prob. Dist. | Div. | $c_i$ 1gm | $c_i$ 10 gms | 1gm $u_i$ (± %) | 10gms $u_i$ (± %) | $v_i$ |
| **Measurement System** | | | | | | | | |
| Probe Calibration | 6.55 | N | 1 | 1.0 | 1.0 | 6.6 | 6.6 | ∞ |
| Axial Isotropy | 0.25 | N | 1 | 0.7 | 0.7 | 0.2 | 0.2 | ∞ |
| Hemishperical Isotropy | 1.3 | N | 1 | 0.7 | 0.7 | 0.9 | 0.9 | ∞ |
| Boundary Effect | 2.0 | R | 1.73 | 1.0 | 1.0 | 1.2 | 1.2 | ∞ |
| Linearity | 0.3 | N | 1 | 1.0 | 1.0 | 0.3 | 0.3 | ∞ |
| System Detection Limits | 0.25 | R | 1.73 | 1.0 | 1.0 | 0.1 | 0.1 | ∞ |
| Readout Electronics | 0.3 | N | 1 | 1.0 | 1.0 | 0.3 | 0.3 | ∞ |
| Response Time | 0.8 | R | 1.73 | 1.0 | 1.0 | 0.5 | 0.5 | ∞ |
| Integration Time | 2.6 | R | 1.73 | 1.0 | 1.0 | 1.5 | 1.5 | ∞ |
| RF Ambient Conditions - Noise | 3.0 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| RF Ambient Conditions - Reflections | 3.0 | R | 1.73 | 1.0 | 1.0 | 1.7 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | 0.4 | R | 1.73 | 1.0 | 1.0 | 0.2 | 0.2 | ∞ |
| Probe Positioning w/ respect to Phantom | 6.7 | R | 1.73 | 1.0 | 1.0 | 3.9 | 3.9 | ∞ |
| Extrapolation, Interpolation & Integration algorithms for Max. SAR Evaluation | 4.0 | R | 1.73 | 1.0 | 1.0 | 2.3 | 2.3 | ∞ |
| **Test Sample Related** | | | | | | | | |
| Test Sample Positioning | 2.7 | N | 1 | 1.0 | 1.0 | 2.7 | 2.7 | 35 |
| Device Holder Uncertainty | 1.67 | N | 1 | 1.0 | 1.0 | 1.7 | 1.7 | 5 |
| Output Power Variation - SAR drift measurement | 5.0 | R | 1.73 | 1.0 | 1.0 | 2.9 | 2.9 | ∞ |
| SAR Scaling | 0.0 | R | 1.73 | 1.0 | 1.0 | 0.0 | 0.0 | ∞ |
| **Phantom & Tissue Parameters** | | | | | | | | |
| Phantom Uncertainty (Shape & Thickness tolerances) | 7.6 | R | 1.73 | 1.0 | 1.0 | 4.4 | 4.4 | ∞ |
| Liquid Conductivity - measurement uncertainty | 4.2 | N | 1 | 0.78 | 0.71 | 3.3 | 3.0 | 10 |
| Liquid Permittivity - measurement uncertainty | 4.1 | N | 1 | 0.23 | 0.26 | 1.0 | 1.1 | 10 |
| Liquid Conductivity - Temperature Uncertainty | 3.4 | R | 1.73 | 0.78 | 0.71 | 1.5 | 1.4 | ∞ |
| Liquid Permittivity - Temperature Unceritainty | 0.6 | R | 1.73 | 0.23 | 0.26 | 0.1 | 0.1 | ∞ |
| Liquid Conductivity - deviation from target values | 5.0 | R | 1.73 | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| Liquid Permittivity - deviation from target values | 5.0 | R | 1.73 | 0.60 | 0.49 | 1.7 | 1.4 | ∞ |
| **Combined Standard Uncertainty (k=1)** | | RSS | | | | 11.5 | 11.3 | 60 |
| **Expanded Uncertainty** (95% CONFIDENCE LEVEL) | | k=2 | | | | 23.0 | 22.6 | |

# 14 CONCLUSION

## 14.1 Measurement Conclusion

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

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

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