# SAR TEST REPORT

for

MODEL NO. 1645

Test Report No. S-TR12-FCCSAR-1
Issue Date: 3-16-2015

FCC CFR 47 PART 2.1093

IC RSS-102 Issue 4

IEEE 1528-2013

*Prepared by*
Microsoft EMC Laboratory
17760 NE 67th Ct,
Redmond WA, 98052, U.S.A.
425-421-9799
sajose@microsoft.com


TESTING CERT #3472.01

Report V2.0

# 1 Record of Revisions

| Revision | Date | Section | Page(s) | Summary of Changes | Author/Revised By: |
|---|---|---|---|---|---|
| 1.0 | 03/16/2015 | All | All | First Version | Z. Gray |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

# Test Report Attestation

**Microsoft Corporation**
**Model: 1645**

**Applicable Standards**

| Specification | Test Result |
|---|---|
| FCC CFR 47 PART 2.1093<br>IC RSS-102 Issue 4<br>IEEE 1528-2013 | Pass |

Microsoft EMC Laboratory attests that the product model identified in this report has been tested to and meets the requirements identified in the above standards. The test results in this report solely pertains to the specific sample tested, under the conditions and operating modes as provided by the customer. All indications of Pass/Fail in this report are opinions expressed by the Microsoft EMC Laboratory based on interpretations and/or observations of test result on the tested sample only.

This report shall not be used to claim product certification, approval, or endorsement by A2LA or any agency of any Government. Reproduction, duplication or publication of extracts from this test report is prohibited and requires prior written approval of Microsoft EMC Laboratory.

Written By: Zack Gray
SAR Test Lead

Reviewed/ Issued By: Sajay Jose
EMC/RF Compliance Lab Manager

# Table of Contents

# 2 Deviations from Standard

None.

# 3 Facilities and Accreditation

## 3.1 TEST FACILITY

All test facilities used to collect the test data are located at Microsoft EMC Laboratory: 17760 NE 67th Ct, Redmond, WA, 98052, USA.

## 3.2 ACCREDITATIONS

The lab is established and follows procedures as outlined in IEC/ISO 17025 and A2LA accreditation requirements.

A2LA Accredited Testing Certificate Number: 3472.01
Expiration Date: Aug 31, 2015

## 3.3 Test Equipment

The site and related equipment are constructed in conformance with the requirements of IEEE 1528-2013 and other equivalent applicable standards. The calibrations of the measuring instruments, including any accessories that may affect such calibration, are checked frequently to assure their accuracy. Adjustments are made and correction factors applied in accordance with instructions contained in the user manual for the measuring equipment.

# 4 Highest Reported SAR Values

| Exposure Condition | Equipment Class | Mode of Operation | Test Position | 1-g Reported SAR (W/kg) |
|---|---|---|---|---|
| Body Exposure | DTS | 802.11n HT20 | Back 0mm | 1.04 |
| | NII | 802.11n HT40 | Top 0mm | 1.54 |
| | Bluetooth | 1-DH5 | Back 0mm | 0.22 |
| | Simultaneous Transmission | Bluetooth + 802.11b | Back 0mm | 1.26 |

Reported SAR Values are obtained by scaling the measured SAR values up to the maximum allowable output power for each configuration using the following equation:

$$SAR = MEASURED * 10^{\frac{(PMAX-P)}{10}}$$

where

SAR = Reported SAR (W/kg)
MEASURED = Measured SAR (W/kg)
PMAX = Maximum Conducted Average Output Power (dBm)
P = Measured Conducted Average Output Power (dBm)

## 4.1 SAR Limits

The following are the relevant SAR limits for FCC and IC based on the recommendations of ANSI C95.1-1999:

| Exposure Condition | Limit (W/kg) |
|---|---|
| Localized Body SAR | 1.6 (1-g cube) |

# 5 Test Equipment List

| Manufacturer | Description | Model # | Serial /# | Cal. Due | Cal. Cycle |
|---|---|---|---|---|---|
| Agilent | Signal Generator | N5181A | MY50144778 | 02/11/2015 | 1 yr |
| Agilent | Signal Generator | N5181A | MY50144791 | 12/18/2015 | 1 yr |
| PRANA | Power Amplifier + Directional Coupler | TU16 | 1305-1353 | N/A | N/A |
| PRANA | Power Amplifier + Directional Coupler | TU16 | 1305-1352 | N/A | N/A |
| PRANA | Power Amplifier + Directional Coupler | UX15 | 1305-1354 | N/A | N/A |
| PRANA | Power Amplifier + Directional Coupler | UX15 | 1305-1355 | N/A | N/A |
| Agilent | Power Meter | 1914A | MY50801712 | 02/28/2015 | 1 yr |
| Agilent | Power Meter | 1914A | MY50901710 | 12/17/2015 | 1 yr |
| Agilent | Power Sensor | 9304A | MY53040017 | 02/24/2015 | 1 yr |
| Agilent | Power Sensor | 9304A | MY53040025 | 02/24/2015 | 1 yr |
| Agilent | Power Sensor | 9304A | MY53040024 | 12/24/2015 | 1 yr |
| Agilent | Power Sensor | 9304A | MY53040018 | 12/24/2015 | 1 yr |
| Agilent | Network Analyzer | E5071C | MY46316957 | 02/10/2015 | 1 yr |
| Agilent | Network Analyzer | E5071C | MY46316847 | 12/18/2015 | 1 yr |
| Agilent | Dielectric Probe Kit | 85070E | MY44300740 | N/A | N/A |
| Agilent | Dielectric Probe Kit | 85070E | MY44300736 | N/A | N/A |
| SPEAG | DASY Data Acquisition Electronics | DAE4 | 1383 | 7/11/2015 | 1 yr |
| SPEAG | DASY Data Acquisition Electronics | DAE4 | 1384 | 7/11/2015 | 1 yr |
| SPEAG | Dosimetric E-Field Probe | EX3DV4 | 3939 | 7/17/2015 | 1 yr |
| SPEAG | Dosimetric E-Field Probe | EX3DV4 | 3940 | 7/17/2015 | 1 yr |
| SPEAG | SAR Validation Dipole, 2450 MHz | D2450V2 | 916 | 07/16/2015 | 1 yr |
| SPEAG | SAR Validation Dipole, 5 GHz | D5GHzV2 | 1158 | 07/15/2015 | 1 yr |
| SPEAG | Elliptical Phantom | ELI V5.0 | 1217 | N/A | N/A |
| SPEAG | Elliptical Phantom | ELI V5.0 | 1218 | N/A | N/A |
| Thomas Scientific | Mini Thermometer | 9327K19 | 130477954 | 09/08/2015 | 1 yr |
| Thomas Scientific | Mini Thermometer | 9327K19 | 130477975 | 09/08/2015 | 1 yr |
| Thomas Scientific | Mini Thermometer | 9327K19 | 130477955 | 09/08/2015 | 1 yr |

# 6 Product Description

| | |
|---|---|
| Company Name: | Microsoft Corporation |
| Address: | One Microsoft Way |
| City, State, Zip: | Redmond, WA 98052 |
| Customer Contact: | Sahithi Kandula |
| Functional Description of EUT: | Handheld computing device with 802.11 2x2 a/b/g/n/ac WLAN and Bluetooth radios |
| RF Exposure Conditions: | Body Exposure |
| Model: | 1645 |
| Equipment Design State: | DV/Productions |
| Equipment Condition: | Good |
| Radio Information: | WLAN 2.4 GHz: 802.11b, 802.11g, 802.11n<br>WLAN 5 GHz: 802.11a, 802.11n, 802.11ac<br>Bluetooth™ (Basic and Enhanced Data Rates) |
| Frequency of Operation: | WLAN: 2412 MHz – 2462 MHz<br>5180 MHz – 5825 MHz<br>Bluetooth: 2402-2480 MHz |
| Modulations supported: | WLAN: CCK, BPSK, QPSK, 16-QAM, 64-QAM<br>Bluetooth: GFSK, $\frac{\pi}{4}$ DQPSK, and 8 DPSK |
| Antenna Information: | 2.4 GHz: 3.6 dBi<br>5 GHz: 4.2 dBi |
| Dates of Testing: | 1/14/2015 – 1/30/2015 |

## 6.1 TEST CONFIGURATIONS

Radiated and Conducted measurements were performed with customer-provided test software “WiFi Tool” (V2.6), which utilizes “DUT Labtool” (V2.0.0.57) provided by the module manufacturer, to program the EUT in continuous transmit mode.

## 6.2 ENVIRONMENTAL CONDITIONS

Ambient air temperature of the test site was within the range of 18 ºC to 25 ºC. Testing conditions were within tolerance and any deviations required from the EUT are reported.

## 6.3 EQUIPMENT MODIFICATIONS

No modifications were made during testing.

## 6.4 EQUIPMENT UNDER TEST

| Model Number | Serial Number | SW Version | FW Version |
|---|---|---|---|
| 1645 | 00576345952 | Windows 8.1 | 1.41214.851 |
| 1645 | 00567345952 | Windows 8.1 | 1.41214.851 |
| 1645 | 00200544952 | Windows 8.1 | 1.41214.851 |

### 6.4.1 Accessory Test Equipment

| Description | Model Number | Serial Number |
|---|---|---|
| Type Cover | 1654 | 048763733954 |

## 6.5 Supported Air Interfaces and Transmission Configurations

The EUT has two antennas which support the following air interfaces and transmission configurations. The antennas are labeled as Main Antenna (Path B) and Auxiliary Antenna (Path A).

### 6.5.1 Supported Air Interfaces

| Band | Air Interface | BW (MHz) | | |
|---|---|---|---|---|
| | | 20 | 40 | 80 |
| WLAN 2.4 GHz | 802.11b | X | | |
| | 802.11g | X | | |
| | 802.11n | X | | |
| WLAN 5 GHz | 802.11a | X | | |
| | 802.11n | X | X | |
| | 802.11ac | X | X | X |
| 2.4 GHz | Bluetooth | NA | | |
| | BTLE | NA | | |

### 6.5.2 Transmission Configurations

| Main Antenna (Path B) | Auxiliary Antenna (Path A) |
|---|---|
| WLAN 2.4 GHz | |
| | WLAN 2.4 GHz |
| WLAN 5 GHz | |
| | WLAN 5 GHz |
| WLAN 2.4 GHz | WLAN 2.4 GHz |
| WLAN 5 GHz | WLAN 5 GHz |
| Bluetooth | |
| Bluetooth | WLAN 2.4 GHz |
| Bluetooth | WLAN 5 GHz |

# 7 Test Methodology

Test setup and procedure are performed according to **IEEE 1528-2013 Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques.**

In addition, the following publications were used as guidance.

For FCC SAR testing and reporting according to FCC standards the following KDBs were adhered to:

447498 D01 General RF Exposure Guidance v05r02
865664 D01 SAR Measurements Requirements for 100 MHz to 6 GHz v01r03
865664 D02 RF Exposure Reporting v01r01
616217 D04 SAR for laptops and tablets v01r01
248227 D01 SAR Measurement Procedures for 802.11 a/b/g Transmitters DR02

For Industrie Canada, RSS-102 – RF (Radio Frequency) Exposure Compliance of Radiocommunication Apparatus, Issue 4 March 2010 was adhered to. The above FCC KDB's were applied for Industrie Canada testing as well except for instances where IC rules specifically cite different required test methods.

# 8 Conducted RF Average Output Power Measurements

Bluetooth and WLAN output power measurements are made with the DUT connected to the power sensor of a broadband power meter.

## 8.1 Bluetooth Conducted Output Power Measurements

| Channel | Frequency (MHz) | Conducted Average Output Power (dBm) | | | |
|---|---|---|---|---|---|
| | | Modulation | | | Maximum Target Power |
| | | GFSK | π/4-DPSK | 8DPSK | |
| 0 | 2402 | 3.9 | 0.6 | 0.6 | 4 |
| 39 | 2440 | 3.65 | 0.35 | 0.38 | |
| 78 | 2480 | 3.35 | 0.05 | 0.05 | |

## 8.2 Bluetooth LE Conducted Output Power Measurements

| Channel | Frequency (MHz) | Conducted Average Output Power (dBm) | |
|---|---|---|---|
| | | Measured | Maximum Target Power |
| 0 | 2402 | 3.4 | 4 |
| 19 | 2440 | 3.2 | |
| 39 | 2480 | 2.9 | |

## 8.3 WLAN 2.4 GHz Conducted Output Power Measurements

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11b 1Mbps | 1 | 2412 | 10.15 | 11.5 | 9.56 | 11.5 | 10.24 | 11.5 | 9.5 | 11.5 |
| | 6 | 2437 | 10.52 | 11.5 | 9.68 | 11.5 | 10.5 | 11.5 | 9.5 | 11.5 |
| | 11 | 2462 | 10.42 | 11.5 | 9.53 | 11.5 | 10.45 | 11.5 | 9.66 | 11.5 |
| 802.11g 6Mbps | 1 | 2412 | 9.48 | 11.5 | 9.26 | 11.5 | 9.28 | 11.5 | 9.39 | 11.5 |
| | 6 | 2437 | 9.63 | 11.5 | 9.28 | 11.5 | 9.43 | 11.5 | 9.4 | 11.5 |
| | 11 | 2462 | 9.88 | 11.5 | 9.26 | 11.5 | 9.6 | 11.5 | 9.2 | 11.5 |
| 802.11n HT20 MCS0 | 1 | 2412 | 10.38 | 11.5 | 10.22 | 11.5 | 10.35 | 11.5 | 10.24 | 11.5 |
| | 6 | 2437 | 10.34 | 11.5 | 10.27 | 11.5 | 10.8 | 11.5 | 10.26 | 11.5 |
| | 11 | 2462 | 10.68 | 11.5 | 10.4 | 11.5 | 10.62 | 11.5 | 10.32 | 11.5 |

## 8.4 WLAN 5 GHz Conducted Output Power Measurements

### 8.4.1 5.2 GHz Conducted Measurements (U-NII-1)

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11a 6Mbps | 36 | 5180 | 7.7 | 7.8 | 7.68 | 7.8 | 7.7 | 7.8 | 7.6 | 7.8 |
| | 40 | 5200 | 7.5 | 7.8 | 7.51 | 7.8 | 7.7 | 7.8 | 7.48 | 7.8 |
| | 44 | 5220 | 7.55 | 7.8 | 7.7 | 7.8 | 7.7 | 7.8 | 7.6 | 7.8 |
| | 48 | 5240 | 7.7 | 7.8 | 7.7 | 7.8 | 7.7 | 7.8 | 7.55 | 7.8 |
| 802.11n HT20 MCS0 | 36 | 5180 | 7.7 | 7.8 | 7.58 | 7.8 | 7.55 | 7.8 | 7.31 | 7.8 |
| | 40 | 5200 | 7.7 | 7.8 | 7.47 | 7.8 | 7.53 | 7.8 | 7.52 | 7.8 |
| | 44 | 5220 | 7.57 | 7.8 | 7.67 | 7.8 | 7.64 | 7.8 | 7.61 | 7.8 |
| | 48 | 5240 | 7.7 | 7.8 | 7.45 | 7.8 | 7.62 | 7.8 | 7.55 | 7.8 |
| 802.11n HT40 MCS0 | 38 | 5190 | 7.54 | 7.8 | 7.54 | 7.8 | 7.29 | 7.8 | 7 | 7.8 |
| | 46 | 5230 | 7.42 | 7.8 | 7.7 | 7.8 | 7.28 | 7.8 | 7.08 | 7.8 |
| 802.11ac VHT20 MCS0 | 36 | 5180 | 7.54 | 7.8 | 7.6 | 7.8 | 7.33 | 7.8 | 7.31 | 7.8 |
| | 40 | 5200 | 7.7 | 7.8 | 7.67 | 7.8 | 7.53 | 7.8 | 7.44 | 7.8 |
| | 44 | 5220 | 7.6 | 7.8 | 7.58 | 7.8 | 7.53 | 7.8 | 7.33 | 7.8 |
| | 48 | 5240 | 7.7 | 7.8 | 7.7 | 7.8 | 7.56 | 7.8 | 7.55 | 7.8 |
| 802.11ac VHT40 MCS0 | 38 | 5190 | 7.6 | 7.8 | 7.58 | 7.8 | 6.89 | 7.8 | 7.2 | 7.8 |
| | 46 | 5230 | 7.65 | 7.8 | 7.44 | 7.8 | 7.31 | 7.8 | 6.91 | 7.8 |
| 802.11ac VHT80 MCS0 | 42 | 5210 | 6.47 | 6.8 | 6.09 | 6.8 | 6.02 | 6.8 | 5.45 | 6.8 |

### 8.4.2 5.3 GHz Conducted Measurements (U-NII-2A)

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11a 6Mbps | 52 | 5260 | 7.63 | 7.8 | 7.6 | 7.8 | 7.45 | 7.8 | 7.55 | 7.8 |
| | 56 | 5280 | 7.7 | 7.8 | 7.61 | 7.8 | 7.45 | 7.8 | 7.27 | 7.8 |
| | 60 | 5300 | 7.62 | 7.8 | 7.54 | 7.8 | 7.43 | 7.8 | 7.55 | 7.8 |
| | 64 | 5320 | 7.43 | 7.8 | 7.48 | 7.8 | 7.41 | 7.8 | 7.41 | 7.8 |
| 802.11n HT20 MCS0 | 52 | 5260 | 7.46 | 7.8 | 7.46 | 7.8 | 7.23 | 7.8 | 7.55 | 7.8 |
| | 56 | 5280 | 7.6 | 7.8 | 7.6 | 7.8 | 7.35 | 7.8 | 7.34 | 7.8 |
| | 60 | 5300 | 7.21 | 7.8 | 7.21 | 7.8 | 7.31 | 7.8 | 7.23 | 7.8 |
| | 64 | 5320 | 7.42 | 7.8 | 7.42 | 7.8 | 7.34 | 7.8 | 7.35 | 7.8 |
| 802.11n HT40 MCS0 | 54 | 5270 | 7.31 | 7.8 | 7.47 | 7.8 | 7.1 | 7.8 | 7.23 | 7.8 |
| | 62 | 5310 | 7.3 | 7.8 | 7.25 | 7.8 | 7.07 | 7.8 | 7.02 | 7.8 |
| 802.11ac VHT20 MCS0 | 52 | 5260 | 7.38 | 7.8 | 7.56 | 7.8 | 7.37 | 7.8 | 7.35 | 7.8 |
| | 56 | 5280 | 7.2 | 7.8 | 7.34 | 7.8 | 7.29 | 7.8 | 7.48 | 7.8 |
| | 60 | 5300 | 7.5 | 7.8 | 7.6 | 7.8 | 7.31 | 7.8 | 7.46 | 7.8 |
| | 64 | 5320 | 7.17 | 7.8 | 7.39 | 7.8 | 7.06 | 7.8 | 7.54 | 7.8 |
| 802.11ac VHT40 MCS0 | 54 | 5270 | 7.54 | 7.8 | 7.29 | 7.8 | 6.82 | 7.8 | 7.05 | 7.8 |
| | 62 | 5310 | 7.2 | 7.8 | 7.29 | 7.8 | 7.13 | 7.8 | 7.2 | 7.8 |
| 802.11ac VHT80 MCS0 | 56 | 5290 | 5.57 | 6.8 | 6.04 | 6.8 | 5.6 | 6.8 | 5.99 | 6.8 |

### 8.4.3 5.6 GHz Conducted Measurements (U-NII-2C)

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11a 6Mbps | 100 | 5500 | 6.6 | 7.8 | 7.2 | 7.8 | 6.5 | 7.8 | 7.2 | 7.8 |
| | 104 | 5520 | 6.7 | 7.8 | 7.3 | 7.8 | 6.4 | 7.8 | 7.45 | 7.8 |
| | 108 | 5540 | 6.4 | 7.8 | 7.15 | 7.8 | 6.5 | 7.8 | 7.25 | 7.8 |
| | 112 | 5560 | 6.7 | 7.8 | 7.1 | 7.8 | 6.6 | 7.8 | 7.2 | 7.8 |
| | 116 | 5580 | 6.75 | 7.8 | 7.25 | 7.8 | 6.55 | 7.8 | 7.1 | 7.8 |
| | 120 | 5600 | 6.7 | 7.8 | 7.05 | 7.8 | 6.8 | 7.8 | 7.15 | 7.8 |
| | 124 | 5620 | 6.85 | 7.8 | 7.05 | 7.8 | 6.75 | 7.8 | 6.9 | 7.8 |
| | 128 | 5640 | 6.65 | 7.8 | 6.7 | 7.8 | 6.8 | 7.8 | 6.8 | 7.8 |
| | 132 | 5660 | 6.7 | 7.8 | 6.7 | 7.8 | 6.7 | 7.8 | 6.4 | 7.8 |
| | 136 | 5680 | 6.65 | 7.8 | 6.4 | 7.8 | 6.8 | 7.8 | 6.5 | 7.8 |
| | 140 | 5700 | 6.5 | 7.8 | 6.45 | 7.8 | 6.65 | 7.8 | 6.35 | 7.8 |
| 802.11n HT20 MCS0 | 100 | 5500 | 6.6 | 7.8 | 7.35 | 7.8 | 6.4 | 7.8 | 7.35 | 7.8 |
| | 104 | 5520 | 6.5 | 7.8 | 7.4 | 7.8 | 6.4 | 7.8 | 7.4 | 7.8 |
| | 108 | 5540 | 6.65 | 7.8 | 7.35 | 7.8 | 6.6 | 7.8 | 7.3 | 7.8 |
| | 112 | 5560 | 6.6 | 7.8 | 7.2 | 7.8 | 6.4 | 7.8 | 7.2 | 7.8 |
| | 116 | 5580 | 6.85 | 7.8 | 7.1 | 7.8 | 6.8 | 7.8 | 7.25 | 7.8 |
| | 120 | 5600 | 6.75 | 7.8 | 7.2 | 7.8 | 6.7 | 7.8 | 7.15 | 7.8 |
| | 124 | 5620 | 6.9 | 7.8 | 6.9 | 7.8 | 6.8 | 7.8 | 7 | 7.8 |
| | 128 | 5640 | 6.8 | 7.8 | 6.8 | 7.8 | 6.7 | 7.8 | 6.65 | 7.8 |
| | 132 | 5660 | 6.9 | 7.8 | 6.5 | 7.8 | 6.8 | 7.8 | 6.65 | 7.8 |
| | 136 | 5680 | 6.8 | 7.8 | 6.55 | 7.8 | 6.5 | 7.8 | 6.3 | 7.8 |
| | 140 | 5700 | 6.85 | 7.8 | 6.45 | 7.8 | 6.7 | 7.8 | 6.4 | 7.8 |
| 802.11n HT40 MCS0 | 102 | 5510 | 6.4 | 7.8 | 7.25 | 7.8 | 6.3 | 7.8 | 6.55 | 7.8 |
| | 110 | 5550 | 6.65 | 7.8 | 7.15 | 7.8 | 6.1 | 7.8 | 7 | 7.8 |
| | 118 | 5590 | 6.85 | 7.8 | 7.1 | 7.8 | 6.3 | 7.8 | 6.5 | 7.8 |
| | 126 | 5630 | 6.85 | 7.8 | 6.75 | 7.8 | 6.5 | 7.8 | 6.55 | 7.8 |
| | 134 | 5670 | 6.75 | 7.8 | 6.4 | 7.8 | 6.2 | 7.8 | 6.15 | 7.8 |

## 5.6 GHz Conducted Measurements (U-NII-2C) Continued

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11ac VHT20 MCS0 | 100 | 5500 | 6.65 | 7.8 | 7.3 | 7.8 | 6.35 | 7.8 | 7.15 | 7.8 |
| | 104 | 5520 | 6.5 | 7.8 | 7.3 | 7.8 | 6.45 | 7.8 | 7.1 | 7.8 |
| | 108 | 5540 | 6.65 | 7.8 | 7.25 | 7.8 | 6.25 | 7.8 | 7.2 | 7.8 |
| | 112 | 5560 | 6.5 | 7.8 | 7 | 7.8 | 6.6 | 7.8 | 7.1 | 7.8 |
| | 116 | 5580 | 6.7 | 7.8 | 7.1 | 7.8 | 6.35 | 7.8 | 7 | 7.8 |
| | 120 | 5600 | 6.9 | 7.8 | 7.05 | 7.8 | 6.65 | 7.8 | 6.95 | 7.8 |
| | 124 | 5620 | 6.85 | 7.8 | 6.7 | 7.8 | 6.4 | 7.8 | 6.55 | 7.8 |
| | 128 | 5640 | 6.75 | 7.8 | 6.65 | 7.8 | 6.7 | 7.8 | 6.35 | 7.8 |
| | 132 | 5660 | 6.95 | 7.8 | 6.15 | 7.8 | 6.5 | 7.8 | 6.3 | 7.8 |
| | 136 | 5680 | 6.7 | 7.8 | 6.15 | 7.8 | 6.55 | 7.8 | 6 | 7.8 |
| | 140 | 5700 | 6.8 | 7.8 | 6.05 | 7.8 | 6.6 | 7.8 | 6 | 7.8 |
| 802.11ac VHT40 MCS0 | 102 | 5510 | 6.4 | 7.8 | 7.25 | 7.8 | 6 | 7.8 | 6.7 | 7.8 |
| | 110 | 5550 | 6.4 | 7.8 | 7.15 | 7.8 | 6 | 7.8 | 6.35 | 7.8 |
| | 118 | 5590 | 6.6 | 7.8 | 6.85 | 7.8 | 6.2 | 7.8 | 6.7 | 7.8 |
| | 126 | 5630 | 6.65 | 7.8 | 6.65 | 7.8 | 5.9 | 7.8 | 6.2 | 7.8 |
| | 134 | 5670 | 6.75 | 7.8 | 6.15 | 7.8 | 5.95 | 7.8 | 5.9 | 7.8 |
| 802.11ac VHT80 MCS0 | 106 | 5530 | 6.4 | 6.8 | 6.8 | 6.8 | 5.4 | 6.8 | 6.35 | 6.8 |
| | 122 | 5610 | 6.75 | 6.8 | 6.65 | 6.8 | 5.6 | 6.8 | 6.1 | 6.8 |

### 8.4.4 5.8 GHz Conducted Measurements (U-NII-3)

| Mode | Chann. | Freq. (MHz) | Maximum Conducted Average Output Power (dBm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SISO (1 TX) | | | | MIMO (2 TX) | | | |
| | | | Main Ant | | Aux Ant | | Main Ant | | Aux Ant | |
| | | | Meas. | Max | Meas. | Max | Meas. | Max | Meas. | Max |
| 802.11a 6Mbps | 149 | 5745 | 6.85 | 7.8 | 6.5 | 7.8 | 6.9 | 7.8 | 6.6 | 7.8 |
| | 153 | 5765 | 6.8 | 7.8 | 6.7 | 7.8 | 6.8 | 7.8 | 6.75 | 7.8 |
| | 157 | 5785 | 6.6 | 7.8 | 6.8 | 7.8 | 6.7 | 7.8 | 6.9 | 7.8 |
| | 161 | 5805 | 7 | 7.8 | 7 | 7.8 | 6.9 | 7.8 | 6.8 | 7.8 |
| | 165 | 5825 | 7.05 | 7.8 | 7.1 | 7.8 | 7.05 | 7.8 | 7.2 | 7.8 |
| 802.11n HT20 MCS0 | 149 | 5745 | 6.85 | 7.8 | 6.6 | 7.8 | 6.65 | 7.8 | 6.5 | 7.8 |
| | 153 | 5765 | 6.55 | 7.8 | 6.7 | 7.8 | 6.75 | 7.8 | 6.75 | 7.8 |
| | 157 | 5785 | 6.7 | 7.8 | 6.9 | 7.8 | 6.65 | 7.8 | 6.9 | 7.8 |
| | 161 | 5805 | 7 | 7.8 | 7.1 | 7.8 | 6.6 | 7.8 | 7.1 | 7.8 |
| | 165 | 5825 | 7.1 | 7.8 | 7.2 | 7.8 | 7 | 7.8 | 7.2 | 7.8 |
| 802.11n HT40 MCS0 | 151 | 5755 | 6.7 | 7.8 | 6.5 | 7.8 | 6.05 | 7.8 | 6.6 | 7.8 |
| | 159 | 5795 | 6.8 | 7.8 | 6.95 | 7.8 | 6.35 | 7.8 | 6.95 | 7.8 |
| 802.11ac VHT20 MCS0 | 149 | 5745 | 6.75 | 7.8 | 6.55 | 7.8 | 6.65 | 7.8 | 6.5 | 7.8 |
| | 153 | 5765 | 6.5 | 7.8 | 6.8 | 7.8 | 6.6 | 7.8 | 6.75 | 7.8 |
| | 157 | 5785 | 6.65 | 7.8 | 6.95 | 7.8 | 6.55 | 7.8 | 6.9 | 7.8 |
| | 161 | 5805 | 6.8 | 7.8 | 7.1 | 7.8 | 6.6 | 7.8 | 7.1 | 7.8 |
| | 165 | 5825 | 7.1 | 7.8 | 7.25 | 7.8 | 6.75 | 7.8 | 7.15 | 7.8 |
| 802.11ac VHT40 MCS0 | 151 | 5755 | 6.6 | 7.8 | 6.55 | 7.8 | 6.3 | 7.8 | 6.5 | 7.8 |
| | 159 | 5795 | 6.6 | 7.8 | 6.9 | 7.8 | 5.75 | 7.8 | 6.9 | 7.8 |
| 802.11ac VHT80 MCS0 | 155 | 5775 | 6.6 | 6.8 | 6.6 | 6.8 | 5.75 | 6.8 | 6.65 | 6.8 |

## 8.5 Power Measurements at Higher Data Rates

Based on the conducted output power measurements at the lowest data rates, conducted power measurements at higher data rates were performed on the highest power channels in each band. These measurements are used to confirm that higher data rates do not give higher output power than the lowest data rates. From **KDB 248227 SAR Measurement Procedures for 802.11 a/b/g Transmitters v01r02**:

When maximum SAR for the lowest data rate conditions are sufficiently below the SAR limit and the maximum average output power of the other data rates and modulations are lower, extensive SAR measurements at higher data rates are typically unnecessary.

### 8.5.1 WLAN 2.4 GHz Conducted Power Measurements at Higher Data Rates

| 802.11b | | |
|---|---|---|
| Data Rate (Mbps) | Modulation | Maximum Conducted Avg. Output Power (dBm) |
| | | Ch. 6<br>2437 MHz |
| 1 | DBPSK | 10.52 |
| 2 | DQPSK | 10.45 |
| 5.5 | CCK | 9.9 |
| 11 | CCK | 9.85 |

| 802.11n HT20 | | |
|---|---|---|
| Data Rate (Mbps) | Modulation | Maximum Conducted Avg. Output Power (dBm) |
| | | Ch. 11<br>2462 MHz |
| 6.5 (MCS0) | BPSK | 10.68 |
| 13 (MCS1) | QPSK | 10.6 |
| 19.5 (MCS2) | QPSK | 10.6 |
| 26 (MCS3) | 16-QAM | 10.5 |
| 39 (MCS4) | 16-QAM | 10.4 |
| 52 (MCS5) | 64-QAM | 10.25 |
| 58.5 (MCS6) | 64-QAM | 10.2 |
| 65 (MCS7) | 64-QAM | 10.2 |

### 8.5.2 WlAN 5 GHz Conducted Power Measurements at Higher Data Rates

| 802.11a | | | | | |
|---|---|---|---|---|---|
| Data Rate (Mbps) | Modulation | Maximum Conducted Avg. Output Power (dBm) | | | |
| | | Ch. 48 5240 MHz | Ch. 56 5280 MHz | Ch. 104 5520 MHz | Ch. 165 5825 MHz |
| 6 | BPSK | 7.7 | 7.7 | 7.45 | 7.2 |
| 9 | BPSK | 7.57 | 7.61 | 7.4 | 7.05 |
| 12 | QPSK | 7.57 | 7.43 | 7.4 | 7 |
| 18 | QPSK | 7.48 | 7.4 | 7.35 | 6.9 |
| 24 | 16-QAM | 7.47 | 7.2 | 7.3 | 6.85 |
| 36 | 16-QAM | 7.24 | 7.01 | 7 | 6.6 |
| 48 | 64-QAM | 7.18 | 7.04 | 6.8 | 6.6 |
| 54 | 64-QAM | 6.91 | 7 | 6.75 | 6.45 |

| 802.11n HT40 | | | | | |
|---|---|---|---|---|---|
| Data Rate (Mbps) | Modulation | Maximum Conducted Avg. Output Power (dBm) | | | |
| | | Ch. 46 5230 MHz | Ch. 54 5270 MHz | Ch. 102 5510 MHz | Ch. 159 5795 MHz |
| 13.5 (MCS0) | BPSK | 7.7 | 7.47 | 7.25 | 6.95 |
| 27 (MCS1) | QPSK | 7.33 | 7.4 | 7.15 | 6.7 |
| 40.5 (MCS2) | QPSK | 7.24 | 7.32 | 7.05 | 6.6 |
| 54 (MCS3) | 16-QAM | 7.04 | 7.23 | 6.9 | 6.4 |
| 81 (MCS4) | 16-QAM | 6.93 | 7 | 6.55 | 6.25 |
| 108 (MCS5) | 64-QAM | 6.78 | 6.84 | 6.45 | 6.1 |
| 121.5 (MCS6) | 64-QAM | 6.58 | 6.76 | 6.35 | 6.05 |
| 135 (MCS7) | 64-QAM | 6.62 | 6.52 | 6.25 | 6 |

# 9 Test Configurations

The standalone SAR test exclusion equations (KDB 447498 D01 4.3.1) are used to determine which device edges and faces require testing for a given antenna and air interface technology. From **KDB 616217 D04 v01r01** (SAR for laptop and tablets) section 4.3, the SAR test exclusion threshold from KDB 447498 can be applied to determine SAR test exclusion for adjacent edge configurations. The closest distance from the antenna to an adjacent edge is used to determine if SAR testing is required for the adjacent edges. SAR evaluation for the front surface of tablet display screens is not necessary since it is not expected to exceed the extremity SAR limit.

1) For antenna to edge separation distances ≤ 50mm, the 1-g SAR test exclusion threshold can be determined by evaluating whether the following is true:

$$\frac{Pmax}{d} * \sqrt{f} \leq 3.0$$

- $P_{max}$ = maximum possible average conducted power of transmitter, including tolerances (mW)
- d = closest intended separation distance between transmitting antenna and edge / face of device (mm) (5mm at the least)
- *f = frequency of the transmitter for that* power level in GHz

2) For antenna to edge separation distances > 50mm, the SAR test exclusion threshold is determined according to the following:

   a) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)·( $f_{(MHz)}$/150)] mW, at 100 MHz to 1500 MHz
   b) b) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm)·10] mW at > 1500 MHz and ≤ 6 GHz

## 9.1 Evaluation of Required Test Configurations

The following table shows the most conservative parameters used for SAR Test Exclusion Evaluation for each air interface technology:

| Parameters used to Evaluate SAR Test Exclusion | Air Interface | | |
|---|---|---|---|
| | WLAN 2.4 GHz | WLAN 5 GHz | BT |
| Max Freq. (GHz) | 2.462 | 5.825 | 2.48 |
| Max Power including Tune-up tolerances (mW) | 14.13 (11.5 dBm) | 6.03 (7.8 dBm) | 3.55 (5.5 dBm) |

The following table shows the SAR test exclusion thresholds for the given edge / face and air interface combinations, and whether SAR testing is required for each combination. Testing is required for a given configuration when the Max Power from the table above is greater than the exclusion threshold in the table below.

| **Standalone SAR Test Exclusion** | WLAN Antenna A (Aux) | | | | WLAN Antenna B (Main) | | | |
|---|---|---|---|---|---|---|---|---|
| Device Side | Separation Distance (mm) | Exclusion Threshold (mW) | | | Separation Distance (mm) | Exclusion Threshold (mW) | | |
| | | WLAN 2.4 GHz | WLAN 5 GHz | BT | | WLAN 2.4 GHz | WLAN 5 GHz | BT |
| Top Edge | 5 | **9.56** | **6.22** | **9.53** | **5** | **9.56** | **6.22** | **9.53** |
| Bottom Edge | 183 | **349.89** | **227.47** | **348.62** | **183** | **349.89** | **227.47** | **348.62** |
| Left Edge | 165.4 | **316.24** | **205.59** | **315.09** | **76.83** | **146.90** | **95.50** | **146.36** |
| Right Edge | 72.4 | **138.43** | **89.99** | **137.92** | **137.84** | **263.54** | **171.34** | **262.59** |
| Back | 5 | **9.56** | **6.22** | **9.53** | **5** | **9.56** | **6.22** | **9.53** |

See attachments for antenna locations diagram.

**SAR Testing Required and Performed**

**SAR Testing Not Required**

**SAR Testing Performed though Not Required**

## 9.2 Test Positions

This device features beveled edges which a user could have flat against their body. For any device edge which required traditional testing (the device edge perpendicular to the phantom), tests were also performed on that edge with the bevel parallel to the phantom surface. This requires the device itself to be tilted as shown in the test setup photos.

| Exposure Condition | Phantom Used | DUT Test Position | Test Setup Photo (See Appendix) |
|---|---|---|---|
| Body | Flat Section (SAM, ELI, or Triple-Flat) | Back 0mm | Photo 1 |
| | | Top Edge 0mm | Photo 2 |
| | | Top Tilt 0mm | Photo 3 |

## 9.3 Additional Test Positions with Accessory Attached

This device supports use with an optional keyboard / cover accessory. The following test configurations were also performed with this accessory attached to the device and folded back as it would be in typical use exposure conditions.

| Exposure Condition | Phantom Used | DUT Test Position | Test Setup Photo (See Appendix) |
|---|---|---|---|
| Body | Flat Section (SAM, ELI, or Triple-Flat) | Back 0mm with Type Cover | Photo 4 |
| | | Top Edge 0mm with Type Cover | Photo 5 |
| | | Top Tilt 0mm with Type Cover | Photo 6 |

# 10 SAR Test Procedures

The SAR Evaluation was performed in the following steps:

- **Power Reference Measurement.**
  The Power Measurement and Power Drift Measurements are for monitoring the power drift of the device under test. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is set to 2mm for the EX3DV4 probe as recommended by SPEAG. The Power Reference Measurement is taken at a point close to the antenna whose output is being measured in order to maximize SNR, thus minimizing drift error.

- **Area Scan**
  The Area Scan is used as a fast scan in two dimensions to find the areas of high field values (or hot spots), before doing a fine measurement around the hotspot. The sophisticated interpolation routines implemented in DASY5 software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maxima found and lists all maxima found in the scan area within a certain range of the global maximum. A 2 dB range is required by IEEE STD 1528. Zoom scans need only be performed on all secondary maxima within this range when the absolute maximum found is under 2 dB less than the SAR limit in question (i.e., less than 1 W/kg for the 1.6 W/kg SAR limit). Otherwise, the zoom scan is only performed at the highest maxima found in the area scan. The exception to this is in MIMO configurations where at least one zoom scan should be measured per transmit antenna.

  The following x-y grid spacings for the given transmitter frequency ranges are used for area scans in accordance with FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz:

  700 MHz – 2 GHz: ≤ 15 mm
  2 GHz – 4 GHz: ≤ 12 mm
  4 GHz – 6 GHz: ≤ 10 mm

- **Zoom Scan**
  Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1g or 10g of simulated tissue. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1g and 10g and displays these values next to the job's label. The sides of the zoom scan cube should be parallel to the edges of the EUT when possible. The dimensions of a Zoom Scan and spacing between measurement points vary by frequency according to FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, shown in Table 2 below:

### Table 2: Zoom Scan Dimensions

| Transmitter Frequency Range | Cube Dimensions | x-y coordinate spatial resolution | z coordinate spatial resolution |
|---|---|---|---|
| 700 MHz – 2 GHz | ≥ 30 mm | ≤ 8 mm | ≤ 5 mm |
| 2 GHz – 3 GHz | ≥ 28 mm | ≤ 5 mm, *≤ 8 mm | ≤ 4 mm |
| 3 – 4 GHz | ≥ 25 mm | ≤ 5 mm, *≤ 7 mm | ≤ 3 mm |
| 4 – 6 GHz | ≥ 22 mm | ≤ 4 mm, *≤ 5 mm | ≤ 2 mm |

*optional x-y coordinate spatial resolution when Area Scan SAR ≤ 87.5% of applicable SAR limit

- **Power Drift Measurement**
  The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. The absolute value of this difference must be $\leq$ 0.21 dB; if it is not, the entire test is repeated or the difference accounted for.

# 11 SAR Test Results

## 11.1 General SAR Testing Notes

- From **KDB 447498 D01 General RF Exposure Guidance v05r02**, the following test channel reduction was be applied to each test position of an exposure condition in each wireless mode and configuration. Initial testing for each test position for each band was performed on the middle required test channel (or required test channel with the highest power for 5 GHz modes). Testing of other required channels within the operating mode of a frequency band is not required when the *reported* 1-g or 10-g SAR for the mid-band or highest output power channel is:
  - ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
  - ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- Initial testing in all modes was performed without the optional accessory type cover. Testing with the type cover attached to the device and folded back was performed on the worst case test position and mode for all bands for each transmit antenna.
- All WLAN measurements were made with the device transmitting at 100% duty cycle.
- Tissue-simulating liquid temperature was maintained within +/- 2°C of that which was measured during liquid verification.

## 11.2 WLAN 2.4 GHz SAR Testing Notes

(Guidance from KDB 248227 v01r02)

- Initial testing was performed in 802.11b mode
- Testing was not performed in 802.11g mode since the measured average output power for 802.11g is less than 0.25 greater than that measured for 802.11b.
- Testing in 802.11n mode was performed in the worst-case configuration found in 802.11b SAR testing. It was performed at the highest bandwidth that uses the maximum supported tune-up power of 802.11n. (HT40 is not supported for 2.4 GHz so HT20 was tested.)
- MIMO (simultaneous transmission of Path A and Path B) was tested in 802.11n mode.

## 11.3 WLAN 2.4 GHz Main Antenna (Path B) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11b** 1 Mbps **1TX** | 20 | B | Top | 6 | 2437 | 10.52 | 11.5 | 0.101 | **0.13** |
| | 20 | B | Top Tilt | 6 | 2437 | 10.52 | 11.5 | 0.109 | **0.14** |
| | 20 | B | Back | 1 | 2412 | 10.15 | 11.5 | 0.632 | **0.86** |
| | 20 | B | Back | 6 | 2437 | 10.52 | 11.5 | 0.675 | **0.85** |
| | 20 | B | Back | 11 | 2462 | 10.42 | 11.5 | 0.708 | **0.91** |
| **802.11n** MCS0 **1TX** | 20 | B | Back | 1 | 2412 | 10.38 | 11.5 | 0.624 | **0.81** |
| | 20 | B | Back | 6 | 2437 | 10.34 | 11.5 | 0.723 | **0.94** |
| | 20 | B | Back | 11 | 2462 | 10.68 | 11.5 | 0.709 | **0.86** |
| **802.11n** MCS0 **2TX** | 20 | B | Top | 6 | 2437 | 10.8 | 11.5 | 0.1 | **0.12** |
| | 20 | B | Top Tilt | 6 | 2437 | 10.8 | 11.5 | 0.122 | **0.14** |
| | 20 | B | Back | 1 | 2412 | 10.35 | 11.5 | 0.592 | **0.77** |
| | 20 | B | Back | 6 | 2437 | 10.8 | 11.5 | 0.695 | **0.82** |
| | 20 | B | Back | 11 | 2462 | 10.62 | 11.5 | 0.668 | **0.82** |

## 11.4 WLAN 2.4 GHz Aux. Antenna (Path A) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11b** 1 Mbps **1TX** | 20 | A | Top | 6 | 2437 | 9.68 | 11.5 | 0.0993 | **0.15** |
| | 20 | A | Top Tilt | 6 | 2437 | 9.68 | 11.5 | 0.135 | **0.21** |
| | 20 | A | Back | 1 | 2412 | 9.56 | 11.5 | 0.623 | **0.97** |
| | 20 | A | Back | 6 | 2437 | 9.68 | 11.5 | 0.601 | **0.91** |
| | 20 | A | Back | 11 | 2462 | 9.53 | 11.5 | 0.601 | **0.95** |
| **802.11n** MCS0 **1TX** | 20 | A | Back | 1 | 2412 | 10.22 | 11.5 | 0.774 | **1.04 (Plot 1)** |
| | 20 | A | Back | 6 | 2437 | 10.27 | 11.5 | 0.782 | **1.04** |
| | 20 | A | Back | 11 | 2462 | 10.4 | 11.5 | 0.719 | **0.93** |
| **802.11n** MCS0 **2TX** | 20 | A | Top | 6 | 2437 | 10.26 | 11.5 | 0.113 | **0.15** |
| | 20 | A | Top Tilt | 6 | 2437 | 10.26 | 11.5 | 0.146 | **0.19** |
| | 20 | A | Back | 1 | 2412 | 10.24 | 11.5 | 0.72 | **0.96** |
| | 20 | A | Back | 6 | 2437 | 10.26 | 11.5 | 0.761 | **1.01 (Plot 2)** |
| | 20 | A | Back | 11 | 2462 | 10.32 | 11.5 | 0.686 | **0.90** |

## 11.5 WLAN 2.4 GHz SAR Test Results with Type Cover Accessory

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11n** MCS0 **1TX** | 20 | A | Back w/Type Cover | 1 | 2412 | 10.22 | 11.5 | 0.195 | **0.26** |
| **802.11n** MCS0 **1TX** | 20 | B | Back w/Type Cover | 6 | 2437 | 10.34 | 11.5 | 0.162 | **0.21** |

## 11.6 WLAN 5 GHz SAR Testing Notes

- Guidance from **KDB 248227 v01r02** was followed in choosing required test channels.
  - For each antenna, the channel with the highest output power in each sub-band was chosen as the initial test channel. If this highest-power channel was not a default test channel, it replaced an adjacent "default test channel" as a "required test channel" (Blue checks in the table below note the "default test channels." A channel noted by a red asterisk is only tested if it is has the highest power in a sub-band.)
  - The remaining default test channels were only tested according the test channel reduction already noted previously in the General SAR Testing Notes section.
- Testing in 802.11n mode was performed in the worst-case configuration found in 802.11a SAR testing. It was performed at the highest bandwidth that uses the maximum supported tune-up power of 802.11n.
- MIMO (simultaneous transmission of Path A and Path B) was tested in 802.11a mode.
- 802.11ac SAR is tested according to the note from the **April 2013 TCB Workshop RF Exposure Procedures Update** which says to *"include 802.11ac SAR for the highest 802.11a configuration in each 5 GHz band and exposure condition."*

| Mode | | GHz | Channel | Turbo Channel | "Default Test Channels" §15.247 802.11b | "Default Test Channels" §15.247 802.11g | "Default Test Channels" UNII | |
|---|---|---|---|---|---|---|---|---|
| 802.11 b/g | | 2.412 | 1* | | √ | ∇ | | |
| | | 2.437 | 6 | 6 | √ | ∇ | | |
| | | 2.462 | 11* | | √ | ∇ | | |
| 802.11a | UNII | 5.18 | 36 | | | | √ | |
| | | 5.20 | 40 | 42 (5.21 GHz) | | | | * |
| | | 5.22 | 44 | | | | | * |
| | | 5.24 | 48 | 50 (5.25 GHz) | | | √ | |
| | | 5.26 | 52 | | | | √ | |
| | | 5.28 | 56 | 58 (5.29 GHz) | | | | * |
| | | 5.30 | 60 | | | | | * |
| | | 5.32 | 64 | | | | √ | |
| | | 5.500 | 100 | Unknown | | | | * |
| | | 5.520 | 104 | | | | √ | |
| | | 5.540 | 108 | | | | | * |
| | | 5.560 | 112 | | | | | * |
| | | 5.580 | 116 | | | | √ | |
| | | 5.600 | 120 | | | | | * |
| | | 5.620 | 124 | | | | √ | |
| | | 5.640 | 128 | | | | | * |
| | | 5.660 | 132 | | | | | * |
| | | 5.680 | 136 | | | | √ | |
| | | 5.700 | 140 | | | | | * |
| | UNII or §15.247 | 5.745 | 149 | | √ | | √ | |
| | | 5.765 | 153 | 152 (5.76 GHz) | | * | | * |
| | | 5.785 | 157 | | √ | | | * |
| | | 5.805 | 161 | 160 (5.80 GHz) | | * | √ | |
| | §15.247 | 5.825 | 165 | | √ | | | |

## 11.7 WLAN 5.2 GHz Main Antenna (Path B) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | B | Back | 36 | 5180 | 7.7 | 7.8 | 0.403 | **0.41** |
| | 20 | B | Top | 36 | 5180 | 7.7 | 7.8 | 1.28 | **1.31** |
| | 20 | B | Top | 48 | 5240 | 7.7 | 7.8 | 1.32 | **1.35 (Repeat)** |
| | 20 | B | Top Tilt | 36 | 5180 | 7.7 | 7.8 | 1.03 | **1.05** |
| | 20 | B | Top Tilt | 48 | 5240 | 7.7 | 7.8 | 1.00 | **1.02** |
| **802.11n** MCS0 **1TX** | 40 | B | Top | 38 | 5190 | 7.54 | 7.8 | 1.12 | **1.19** |
| | 40 | B | Top | 46 | 5230 | 7.42 | 7.8 | 1.22 | **1.33** |
| **802.11ac** MCS0 **1TX** | 80 | B | Top | 42 | 5210 | 6.47 | 6.8 | 0.915 | **0.99** |
| **802.11a** 6 Mbps **2TX** | 20 | B | Back | 36 | 5180 | 7.6 | 7.8 | 0.409 | **0.43** |
| | 20 | B | Top | 36 | 5180 | 7.7 | 7.8 | 1.24 | **1.27** |
| | 20 | B | Top | 48 | 5240 | 7.7 | 7.8 | 1.17 | **1.20** |
| | 20 | B | Top Tilt | 36 | 5180 | 7.7 | 7.8 | 1.05 | **1.07** |
| | 20 | B | Top Tilt | 48 | 5240 | 7.7 | 7.8 | 1.05 | **1.07** |

## 11.8 WLAN 5.2 GHz Aux. Antenna (Path A) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Back | 48 | 5240 | 7.7 | 7.8 | 0.42 | **0.43** |
| | 20 | A | Top | 48 | 5240 | 7.7 | 7.8 | 0.55 | **0.56** |
| | 20 | A | Top Tilt | 48 | 5240 | 7.7 | 7.8 | 0.64 | **0.65** |
| **802.11n** MCS0 **1TX** | 40 | A | Top Tilt | 46 | 5230 | 7.7 | 7.8 | 0.60 | **0.61** |
| **802.11a** 6 Mbps **2TX** | 20 | A | Back | 36 | 5180 | 7.6 | 7.8 | 0.393 | **0.41** |
| | 20 | A | Top | 48 | 5240 | 7.55 | 7.8 | 0.488 | **0.52** |
| | 20 | A | Top Tilt | 48 | 5240 | 7.55 | 7.8 | 0.6 | **0.64** |

## 11.9 WLAN 5.2 GHz SAR Test Results with Type Cover Accessory

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Top Tilt w/Type Cover | 48 | 5240 | 7.7 | 7.8 | 0.646 | **0.66** |
| **802.11n** MCS0 **1TX** | 40 | B | Top w/Type Cover | 48 | 5240 | 7.7 | 7.8 | 1.32 | **1.35** |

## 11.10 WLAN 5.3 GHz Main Antenna (Path B) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | B | Back | 56 | 5280 | 7.7 | 7.8 | 0.46 | **0.47** |
| | 20 | B | Top | 56 | 5280 | 7.7 | 7.8 | 1.22 | **1.25** |
| | 20 | B | Top | 64 | 5320 | 7.43 | 7.8 | 1.17 | **1.27** |
| | 20 | B | Top Tilt | 56 | 5280 | 7.7 | 7.8 | 1.12 | **1.15** |
| | 20 | B | Top Tilt | 64 | 5320 | 7.43 | 7.8 | 1.16 | **1.26** |
| **802.11n** MCS0 **1TX** | 40 | B | Top | 54 | 5290 | 7.31 | 7.8 | 1.19 | **1.33** |
| | 40 | B | Top | 62 | 5310 | 7.3 | 7.8 | 1.13 | **1.27** |
| **802.11ac** MCS0 **1TX** | 80 | B | Top | 58 | 5290 | 5.6 | 6.8 | 0.803 | **1.06** |
| **802.11a** 6 Mbps **2TX** | 20 | B | Back | 52 | 5260 | 7.45 | 7.8 | 0.47 | **0.51** |
| | 20 | B | Top | 52 | 5260 | 7.45 | 7.8 | 1.24 | **1.34** |
| | 20 | B | Top | 60 | 5300 | 7.43 | 7.8 | 1.29 | **1.40 (Plot 4)** |
| | 20 | B | Top Tilt | 52 | 5260 | 7.45 | 7.8 | 1.09 | **1.18** |
| | 20 | B | Top Tilt | 60 | 5300 | 7.43 | 7.8 | 0.997 | **1.09** |

## 11.11 WLAN 5.3 GHz Aux. Antenna (Path A) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Back | 56 | 5280 | 7.61 | 7.8 | 0.454 | **0.47** |
| | 20 | A | Top | 56 | 5280 | 7.61 | 7.8 | 0.583 | **0.61** |
| | 20 | A | Top Tilt | 56 | 5280 | 7.61 | 7.8 | 0.619 | **0.65** |
| **802.11n** MCS0 **1TX** | 40 | A | Top Tilt | 54 | 5270 | 7.47 | 7.8 | 0.62 | **0.67** |
| **802.11a** 6 Mbps **2TX** | 20 | A | Back | 52 | 5260 | 7.55 | 7.8 | 0.432 | **0.46** |
| | 20 | A | Top | 52 | 5260 | 7.55 | 7.8 | 0.575 | **0.61** |
| | 20 | A | Top Tilt | 52 | 5260 | 7.55 | 7.8 | 0.631 | **0.67** |

## 11.12 WLAN 5.3 GHz SAR Test Results with Type Cover Accessory

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Top Tilt w/Type Cover | 56 | 5280 | 7.61 | 7.8 | 0.573 | **0.60** |
| **802.11a** 6 Mbps **2TX** | 20 | B | Top w/Type Cover | 60 | 5300 | 7.43 | 7.8 | 1.22 | **1.33** |

## 11.13 WLAN 5.6 GHz Main Antenna (Path B) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | B | Back | 124 | 5620 | 6.85 | 7.8 | 0.366 | **0.46** |
| | 20 | B | Top | 104 | 5520 | 6.7 | 7.8 | 0.997 | **1.28** |
| | 20 | B | Top | 116 | 5580 | 6.75 | 7.8 | 1.07 | **1.36** |
| | 20 | B | Top | 124 | 5620 | 6.85 | 7.8 | 1.09 | **1.36** |
| | 20 | B | Top | 136 | 5680 | 6.65 | 7.8 | 1.15 | **1.50** |
| | 20 | B | Top Tilt | 104 | 5520 | 6.7 | 7.8 | 0.814 | **1.05** |
| | 20 | B | Top Tilt | 116 | 5580 | 6.75 | 7.8 | 0.858 | **1.09** |
| | 20 | B | Top Tilt | 124 | 5620 | 6.85 | 7.8 | 0.885 | **1.10** |
| | 20 | B | Top Tilt | 136 | 5680 | 6.65 | 7.8 | 0.917 | **1.20** |
| **802.11n** MCS0 **1TX** | 40 | B | Top | 102 | 5510 | 6.4 | 7.8 | 1.02 | **1.41** |
| | 40 | B | Top | 118 | 5590 | 6.85 | 7.8 | 1.09 | **1.36** |
| | 40 | B | Top | 126 | 5630 | 6.85 | 7.8 | 1.12 | **1.39** |
| | 40 | B | Top | 134 | 5670 | 6.75 | 7.8 | 1.21 | **1.54 (Plot 5)** |
| **802.11ac** MCS0 **1TX** | 80 | B | Top | 122 | 5610 | 6.75 | 6.8 | 1.06 | **1.07** |
| **802.11a** 6 Mbps **2TX** | 20 | B | Back | 104 | 5520 | 6.4 | 7.8 | 0.291 | **0.40** |
| | 20 | B | Top | 104 | 5520 | 6.4 | 7.8 | 0.966 | **1.33** |
| | 20 | B | Top | 116 | 5580 | 6.55 | 7.8 | 1.06 | **1.41** |
| | 20 | B | Top | 124 | 5620 | 6.8 | 7.8 | 1.12 | **1.41** |
| | 20 | B | Top | 136 | 5680 | 6.75 | 7.8 | 1.1 | **1.40** |
| | 20 | B | Top Tilt | 104 | 5520 | 6.4 | 7.8 | 0.866 | **1.20** |
| | 20 | B | Top Tilt | 116 | 5580 | 6.55 | 7.8 | 0.986 | **1.31** |
| | 20 | B | Top Tilt | 124 | 5620 | 6.8 | 7.8 | 0.992 | **1.25** |
| | 20 | B | Top Tilt | 136 | 5680 | 6.75 | 7.8 | 0.994 | **1.27** |

## 11.14 WLAN 5.6 GHz Aux. Antenna (Path A) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Back | 104 | 5520 | 7.3 | 7.8 | 0.249 | **0.28** |
| | 20 | A | Top | 104 | 5520 | 7.3 | 7.8 | 0.51 | **0.57** |
| | 20 | A | Top Tilt | 104 | 5520 | 7.3 | 7.8 | 0.545 | **0.61** |
| **802.11n** MCS0 **1TX** | 40 | A | Top Tilt | 102 | 5510 | 7.25 | 7.8 | 0.494 | **0.56** |
| **802.11a** 6 Mbps **2TX** | 20 | A | Back | 104 | 5520 | 7.45 | 7.8 | 0.247 | **0.27** |
| | 20 | A | Top | 136 | 5680 | 6.5 | 7.8 | 0.552 | **0.74** |
| | 20 | A | Top Tilt | 104 | 5520 | 7.45 | 7.8 | 0.523 | **0.57** |

## 11.15 WLAN 5.6 GHz SAR Test Results with Type Cover Accessory

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Top Tilt w/Type Cover | 104 | 5520 | 7.3 | 7.8 | 0.534 | **0.60** |
| **802.11n** MCS0 **1TX** | 40 | B | Top w/Type Cover | 134 | 5670 | 6.75 | 7.8 | 1.19 | **1.52** |

## 11.16 WLAN 5.8 GHz Main Antenna (Path B) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | B | Back | 165 | 6825 | 7.05 | 7.8 | 0.327 | **0.39** |
| | 20 | B | Top | 149 | 5745 | 6.85 | 7.8 | 0.963 | **1.20** |
| | 20 | B | Top | 161 | 5805 | 7 | 7.8 | 0.97 | **1.17** |
| | 20 | B | Top | 165 | 5825 | 7.05 | 7.8 | 0.993 | **1.18** |
| | 20 | B | Top Tilt | 149 | 5745 | 6.85 | 7.8 | 0.872 | **1.09** |
| | 20 | B | Top Tilt | 161 | 5805 | 7 | 7.8 | 0.823 | **0.99** |
| | 20 | B | Top Tilt | 165 | 5825 | 7.05 | 7.8 | 0.826 | **0.98** |
| **802.11n** MCS0 **1TX** | 40 | B | Top | 151 | 5755 | 6.7 | 7.8 | 0.933 | **1.20** |
| | 40 | B | Top | 159 | 5795 | 6.8 | 7.8 | 0.913 | **1.15** |
| **802.11ac** MCS0 **1TX** | 80 | B | Top | 155 | 1775 | 6.6 | 6.8 | 0.956 | **1.00** |
| **802.11a** 6 Mbps **2TX** | 20 | B | Back | 149 | 5745 | 6.9 | 7.8 | 0.349 | **0.43** |
| | 20 | B | Top | 149 | 5745 | 6.9 | 7.8 | 0.961 | **1.18** |
| | 20 | B | Top | 161 | 5805 | 6.9 | 7.8 | 0.934 | **1.15** |
| | 20 | B | Top | 165 | 5825 | 7.05 | 7.8 | 0.938 | **1.11** |
| | 20 | B | Top Tilt | 149 | 5745 | 6.9 | 7.8 | 0.901 | **1.11** |
| | 20 | B | Top Tilt | 161 | 5805 | 6.9 | 7.8 | 0.894 | **1.10** |
| | 20 | B | Top Tilt | 165 | 5825 | 7.05 | 7.8 | 0.83 | **0.99** |

## 11.17 WLAN 5.8 GHz Aux. Antenna (Path A) SAR Test Results

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Back | 165 | 5825 | 7.1 | 7.8 | 0.195 | **0.23** |
| | 20 | A | Top | 165 | 5825 | 7.1 | 7.8 | 0.353 | **0.41** |
| | 20 | A | Top Tilt | 165 | 5825 | 7.1 | 7.8 | 0.388 | **0.46** |
| **802.11n** MCS0 **1TX** | 40 | A | Top Tilt | 159 | 5795 | 6.95 | 7.8 | 0.448 | **0.54** |
| **802.11a** 6 Mbps **2TX** | 20 | A | Back | 149 | 5745 | 6.6 | 7.8 | 0.186 | **0.25** |
| | 20 | A | Top | 149 | 5745 | 6.6 | 7.8 | 0.448 | **0.59** |
| | 20 | A | Top Tilt | 165 | 5825 | 7.2 | 7.8 | 0.38 | **0.44** |

## 11.18 WLAN 5.8 GHz SAR Test Results with Type Cover Accessory

| Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| **802.11a** 6 Mbps **1TX** | 20 | A | Top Tilt w/Type Cover | 165 | 5825 | 7.1 | 7.8 | 0.389 | **0.46** |
| **802.11n** MCS0 **1TX** | 40 | B | Top w/Type Cover | 151 | 5755 | 6.7 | 7.8 | 0.949 | **1.22 (Repeat)** |

## 11.19 Bluetooth SAR Test Results

Bluetooth SAR tests were performed to simplify simultaneous transmission SAR evaluation.

| Mode | Ant. | Position | Ch. | Freq. (MHz) | Avg. Pwr. (dBM) | Max. Pwr. (dBm) | Meas. 1g SAR (W/kg) | Reported 1g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|
| **BT 1-DH5** | B | Top | 39 | 2440 | 3.65 | 4 | 0.0187 | **0.02** |
| | B | Top Tilt | 39 | 2440 | 3.65 | 4 | 0.0206 | **0.02** |
| | B | Back | 39 | 2440 | 3.65 | 4 | 0.176 | **0.19** |
| **BTLE** | B | Top | 19 | 2440 | 3.2 | 4 | 0.026 | **0.03** |
| | B | Top Tilt | 19 | 2440 | 3.2 | 4 | 0.0262 | **0.03** |
| | B | Back | 19 | 2440 | 3.2 | 4 | 0.179 | **0.22** |

# 12 Repeated SAR Measurements

SAR measurements are repeated according to the rules of **KDB 865664 D01 v01r03 Section 2.8.1 SAR measurement variability**. SAR measurement variability must be assessed for each frequency band.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

## 12.1 SAR Variability Repeat Measurements

| Band (GHz) | Mode | BW (MHz) | Ant. | Position | Ch. | Freq. (MHz) | Orig. 1-g SAR Meas. (W/kg | Repeat 1-g SAR Meas. (W/kg) | Repeat Reported 1-g SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|---|
| 2.4 | 802.11n 1TX | 20 | A | Back | 1 | 2412 | 0.774 | 0.758 | **1.02** |
| 5.2 | 802.11a 1TX | 20 | B | Top | 48 | 5240 | 1.32 | 1.33 | **1.36 (Plot 3)** |
| 5.3 | 802.11a 2TX | 20 | B | Top | 60 | 5300 | 1.29 | 1.18 | **1.29** |
| 5.6 | 802.11n 1TX | 40 | B | Top | 134 | 5670 | 1.21 | 1.19 | **1.52** |
| 5.8 | 802.11n 1TX | 40 | B | Top w/Type Cover | 151 | 5755 | 0.949 | 0.974 | **1.25 (Plot 6)** |

# 13 Simultaneous Transmission Evaluation

(KDB 447498 D01 v05r02) Simultaneous transmission SAR must be considered for all operating configurations and exposure conditions in which separate antennas can transmit signals at the same time. All such simultaneous transmission configurations must be shown to be compliant, which can be done in any of the following three ways:

1. The sum of the highest standalone *Reported* SAR values from each antenna in the configuration is less than the SAR limit.
2. The SAR to peak location separation ratio is ≤ 0.04. This ratio is calculated as:

$$\frac{(Reported\ SAR^{Antenna1} + Reported\ SAR^{Antenna2})^{1.5}}{Distance\ Beetween\ Antenna\ 1\ and\ Antenna\ 2\ peak\ SAR\ locations\ in\ mm}$$

3. When neither 1 nor 2 suffice, simultaneous transmission must be measured either by volume scans or multiple zoom scans so that each applicable air interface is tested at all antenna locations in question. The separate scans from the simultaneously transmitting antennas are then summed together point by point to obtain the simultaneous transmission measured SAR value. The reported simultaneous transmission SAR value must be less than the limit.

## 13.1 Important Standalone SAR values for Simultaneous Transmission Evaluation

| Exposure Condition | Test Position | Air Interface | Ch. | Freq. (MHz) | Antenna | Peak SAR Location Coordinates | | Reported SAR (W/kg) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | X | Y | |
| Body | Back | 802.11b | 1 | 2412 | A | NA | NA | 1.04 |
| | Top Tilt | 802.11n | 54 | 5270 | A | NA | NA | 0.67 |
| | Back | BTLE | 39 | 2440 | B | NA | NA | 0.22 |
| | Top Tilt | BTLE | 19 | 2440 | B | NA | NA | 0.03 |

*Main Antenna (Chain B) WLAN measurements are not noted since it cannot transmit WLAN at the same time as Bluetooth.

## 13.2 Simultaneous Transmission Evaluation Results

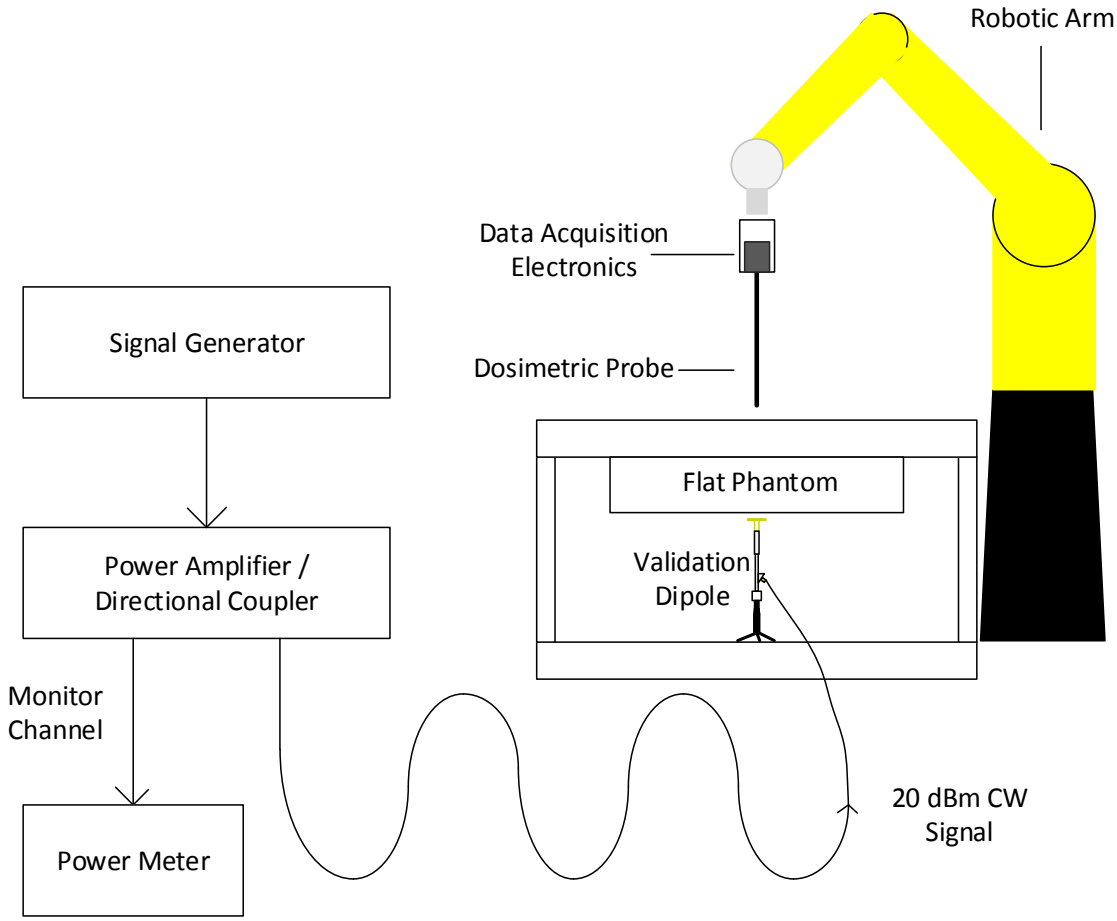
### 13.2.1 Bluetooth (Antenna B) + WLAN (Antenna A) Simultaneous Transmission Analysis

| Exposure Condition | Test Position | Antennas + Air Interfaces Used | | Peak Location Sep. Distance (mm) | Simultaneous Transmission Evaluation Method Used | Result |
|---|---|---|---|---|---|---|
| | | Main Antenna (Chain B) | Aux. Antenna (Chain A) | | | |
| Body | Back | Bluetooth | 802.11b | N/A | Standalone Sum | 1.26 |
| | Top Tilt | Bluetooth | 802.11a | N/A | Standalone Sum | 0.7 |

## 14 SAR System Verification

System Verifications were performed in accordance with **IEEE 1528-2013** and **KDB 865664 D01 v01r03.** Verifications were performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent liquid combinations used with each SAR system for system verification were used for device testing. Verifications were performed before each series of SAR measurements using the same calibration point and tissue-equivalent medium and every three days thereafter when necessary.

The test setup diagram is shown below. A CW signal is created by a signal generator and fed through a power amplifier with directional coupler outputs. The forward output power is adjusted to 20 dBm while the coupled output power is normalized to 0dB for easy monitoring. When the forward power is attached to the dipole, the power is then adjusted if necessary so that the coupled channel again reads 0 dB on the power meter. Tissue-simulating liquid depth in the phantom is maintained to be at least 15 cm for frequencies below 3 GHz and 10 cm for frequencies above 5 GHz.




System Verification Setup

## 14.1 SAR System Verification Results

All verifications are performed with a 100 mW (20 dBm) input to the dipole. The resultant measured SAR is normalized to 1 W (30 dBm) for comparison to calibrated dipole targets. All normalized SAR system verification results were within 10% of the respective dipole target values.

| Date | Tissue-Sim. Liquid | Dipole | Freq. (MHz) | Meas. 1-g SAR (W/kg) | Norm. 1-g SAR (W/kg) | Dipole Target 1-g SAR (W/kg) | Deviation from Target 1-g SAR (%) |
|---|---|---|---|---|---|---|---|
| 1/21/2015 | MSL | D2450V2_916 | 2450 | 5.06 | 50.6 | 51.7 | **-2.13** |
| 1/29/2015 | MSL | D2450V2_916 | 2450 | 5.29 | 52.9 | 51.7 | **2.32 (Plot 7)** |
| 1/14/2015 | MBBL | D5GHzV2_1158 | 5200 | 7.75 | 77.5 | 76.7 | **1.04** |
| 1/18/2015 | MBBL | D5GHzV2_1158 | 5200 | 7.77 | 77.7 | 76.7 | **1.30** |
| 1/30/2015 | MBBL | D5GHzV2_1158 | 5200 | 7.85 | 78.5 | 76.7 | **2.35 (Plot 8)** |
| 1/14/2015 | MBBL | D5GHzV2_1158 | 5600 | 8.06 | 80.6 | 83.1 | **-3.01 (Plot 9)** |
| 1/18/2015 | MBBL | D5GHzV2_1158 | 5600 | 8.42 | 84.2 | 83.1 | **1.32** |
| 1/14/2015 | MBBL | D5GHzV2_1158 | 5800 | 7.25 | 72.5 | 76.3 | **-4.98 (Plot 10)** |
| 1/18/2015 | MBBL | D5GHzV2_1158 | 5800 | 7.34 | 73.4 | 76.3 | **-3.80** |

# 15 Tissue-Simulating Liquid Verification

**(KDB 854664 D01 v01r03 Section 2.4)** The tissue dielectric parameters of tissue-equivalent media used for SAR measurements must be characterized within a temperature range of 18°C to 25°C, measured with calibrated instruments and apparatuses, such as network analyzers and temperature probes. The temperature of the tissue-equivalent medium during SAR measurement must also be within 18°C to 25°C and within ± 2°C of the temperature when the tissue parameters are characterized. The tissue dielectric measurement system must be calibrated before use. The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

The target parameters for the tissue-simulating liquids are obtained from the following table from KDB 865664 D01:

| Target Frequency | Head | | Body | |
|---|---|---|---|---|
| (MHz) | $\varepsilon_r$ | $\sigma$ (S/m) | $\varepsilon_r$ | $\sigma$ (S/m) |
| 150 | 52.3 | 0.76 | 61.9 | 0.80 |
| 300 | 45.3 | 0.87 | 58.2 | 0.92 |
| 450 | 43.5 | 0.87 | 56.7 | 0.94 |
| 835 | 41.5 | 0.90 | 55.2 | 0.97 |
| 900 | 41.5 | 0.97 | 55.0 | 1.05 |
| 915 | 41.5 | 0.98 | 55.0 | 1.06 |
| 1450 | 40.5 | 1.20 | 54.0 | 1.30 |
| 1610 | 40.3 | 1.29 | 53.8 | 1.40 |
| 1800 – 2000 | 40.0 | 1.40 | 53.3 | 1.52 |
| 2450 | 39.2 | 1.80 | 52.7 | 1.95 |
| 3000 | 38.5 | 2.40 | 52.0 | 2.73 |
| 5800 | 35.3 | 5.27 | 48.2 | 6.00 |

($\varepsilon_r$ = relative permittivity, $\sigma$ = conductivity and $\rho$ = 1000 kg/m$^3$)

## 15.1 Tissue-Simulating Liquid Ingredients and Maintenance

The Tissue-simulating liquids were manufactured by SPEAG. The following information on the maintenance of

MSL 2450 Ingredients: Water, DGBE

MBBL 3500 – 5800 Ingredients: Water, Mineral Oil, Emulsifiers, Sodium Chloride

**DGBE BASED LIQUIDS**

DGBE is easily dissolved in water. Given a DGBE-water mixture, mainly water will evaporate, however DGBE will evaporate to a smaller percentage. For the frequency liquids around 2.5 GHz, no NaCl is contained and should therefore not be added for any corrections.
Evaporated water can be replaced and will mainly increase the permittivity, and to a small extent the conductivity, typically as follows:

HSLxxxxV2: permittivity 0.8 to 1.0 per % of water, conductivity 0 to 0.1 per % of water

MSLxxxxV2: permittivity 0.8 per % of water, conductivity 0 to 0.01 per % of water

**OIL BASED LIQUIDS**

Oil based liquids are an emulsion of a complex mixture of ingredients. Their appearance is yellow or brown transparent or slightly opaque / milky in most cases. Some older liquids may show a non-transparent upper zone with a creamy appearance after some time without stirring. Before using or handling the liquid, it must therefore be stirred to become entirely homogeneous. An opaque appearance is possible but will not influence the dielectric parameters if it is homogeneous during the measurement at the probe surface.
Evaporated water can be replaced and will increase the permittivity, and to a smaller extent the conductivity.

The **sensitivities to water addition** (% parameter increase per weight% water added) of oil based SPEAG broadband tissue simulating liquids at the frequencies of interest are typically in the following range:

| | | |
|---|---|---|
| HBBL3500-5800V5 | at 3.5 GHz: | permittivity 0.79, conductivity 0.14 |
| | at 5.5 GHz: | permittivity 0.83, conductivity 0.41 |
| MBBL3500-5800V5 | at 3.5 GHz: | permittivity 0.44, conductivity 0.00 |
| | at 5.5 GHz: | permittivity 0.48, conductivity 0.18 |

The **temperature gradients** shall be observed especially during conductivity measurement:

| | | |
|---|---|---|
| HBBL3500-5800V5 | at 3.5 GHz: | permittivity -0.07, conductivity -0.43 %/°C |
| | at 5.5 GHz: | permittivity -0.23, conductivity -0.96 %/°C |
| MBBL3500-5800V5 | at 3.5 GHz: | permittivity -0.35, conductivity -1.14 %/°C |
| | at 5.5 GHz: | permittivity -0.08, conductivity -1.52 %/°C |

## 15.2 Tissue-Simulating Liquid Measurements

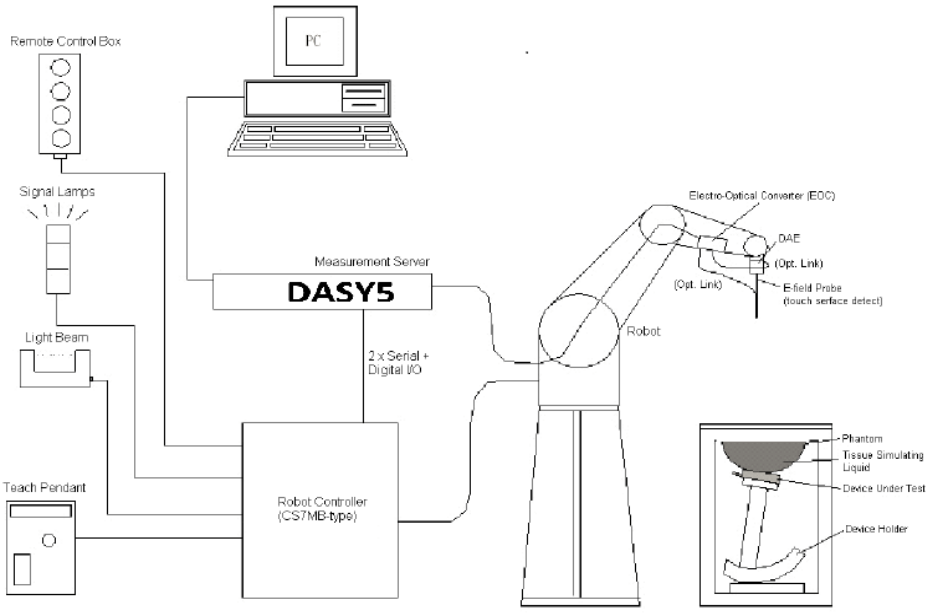
| Date | Tissue-Simulating Liquid | Freq. (MHz) | Rel. Perm. $\varepsilon'_r$ | Target $\varepsilon'_r$ | $\varepsilon'_r$ Dev. % | Cond. σ (S/m) | Target σ (S/m) | σ Dev. % |
|---|---|---|---|---|---|---|---|---|
| 1/21/2015 | MSL 2450 130710-1 22.6 °C | 2412 | 50.34 | 52.75 | **-4.57** | 1.907 | 1.91 | **-0.35** |
| | | 2437 | 50.23 | 52.72 | **-4.72** | 1.94 | 1.94 | **0.13** |
| | | 2450 | 50.2 | 52.70 | **-4.74** | 1.957 | 1.95 | **0.36** |
| | | 2462 | 50.15 | 52.68 | **-4.81** | 1.971 | 1.97 | **0.20** |
| 1/29/2015 | MSL 2450 130710-1 23 °C | 2412 | 51.01 | 52.75 | **-3.30** | 1.861 | 1.91 | **-2.75** |
| | | 2437 | 50.9 | 52.72 | **-3.45** | 1.896 | 1.94 | **-2.15** |
| | | 2450 | 50.87 | 52.70 | **-3.47** | 1.914 | 1.95 | **-1.85** |
| | | 2462 | 50.82 | 52.68 | **-3.54** | 1.931 | 1.97 | **-1.83** |
| 1/14/2015 | MBBL 3500-5800 130705-2 22.3 °C | 5180 | 46.78 | 49.04 | **-4.61** | 5.397 | 5.28 | **2.29** |
| | | 5200 | 46.73 | 49.01 | **-4.66** | 5.428 | 5.30 | **2.43** |
| | | 5260 | 46.62 | 48.93 | **-4.73** | 5.508 | 5.37 | **2.58** |
| | | 5320 | 46.49 | 48.85 | **-4.83** | 5.595 | 5.44 | **2.86** |
| 1/14/2015 | MBBL 3500-5800 130705-1 22.3 °C | 5500 | 46.91 | 48.61 | **-3.49** | 5.634 | 5.65 | **-0.28** |
| | | 5600 | 46.75 | 48.47 | **-3.55** | 5.761 | 5.77 | **-0.09** |
| | | 5700 | 46.59 | 48.34 | **-3.61** | 5.887 | 5.88 | **0.06** |
| | | 5800 | 46.43 | 48.20 | **-3.67** | 6.015 | 6.00 | **0.25** |
| 1/18/2015 | MBBL 3500-5800 130705-2 22.5 °C | 5180 | 47.1 | 49.04 | **-3.96** | 5.341 | 5.28 | **1.23** |
| | | 5200 | 47.12 | 49.01 | **-3.86** | 5.375 | 5.30 | **1.43** |
| | | 5260 | 46.94 | 48.93 | **-4.07** | 5.448 | 5.37 | **1.46** |
| | | 5320 | 46.8 | 48.85 | **-4.20** | 5.529 | 5.44 | **1.65** |
| 1/18/2015 | MBBL 3500-5800 130705-1 21.8 °C | 5500 | 47.22 | 48.61 | **-2.85** | 5.659 | 5.65 | **0.17** |
| | | 5600 | 47.03 | 48.47 | **-2.97** | 5.798 | 5.77 | **0.55** |
| | | 5700 | 46.85 | 48.34 | **-3.07** | 5.94 | 5.88 | **0.97** |
| | | 5800 | 46.67 | 48.20 | **-3.17** | 6.084 | 6.00 | **1.40** |
| | | 5825 | 46.62 | 48.17 | **-3.21** | 6.15 | 6.03 | **2.00** |
| 1/30/2015 | MBBL 3500-5800 130705-1 21.4 °C | 5180 | 49.49 | 49.04 | **0.91** | 5.303 | 5.28 | **0.51** |
| | | 5200 | 49.45 | 49.01 | **0.89** | 5.329 | 5.30 | **0.54** |
| | | 5260 | 49.33 | 48.93 | **0.81** | 5.419 | 5.37 | **0.92** |
| | | 5320 | 49.20 | 48.85 | **0.71** | 5.49 | 5.44 | **0.93** |

# 16 System Specification

## 16.1 SPEAG DASY5 SYSTEM

DASY 5 system performing SAR testing contains the following items, which are illustrated in the figure below.

- 6-axis robot (model: TX90XL) with controller and teach pendant.
- Dosimetric E-field probe.
- Light beam unit which allows automatic “tooling” of the probe.
- The electro-optical convertor (EOC) which is mounted on the robot arm.
- The data acquisition electronics (DAE).
- Elliptical Phantom
- Device holder.
- Remote control.
- PC.
- DASY5 software.
- Validation dipole.




**DASY5 System Setup**

## 17 Measurement Uncertainty

**KDB 865664 D01 v01r03 section 2.8.2** says:

SAR measurement uncertainty analysis is required in SAR reports only when the highest measured SAR in a frequency band is ≥ 1.5 W/kg for 1-g SAR.

The highest **measured** 1-g SAR in this report is 1.33 W/kg. Therefore, SAR measurement uncertainty analysis is not required for this report.

## 18 Appendices

The following are contained in the attached appendices:

- Highest SAR Test and SAR System Verification Plots
- SAR Test Setup Photos
- Calibration Report Documents for:
    - Validation Dipole D2450V2-916_Jul14
    - Validation Dipole D5GHzV2-1158_Jul14
    - Dosimetric Probe EX3-DV4-3939_Jul14
    - Dosimetric Probe EX3-DV4-3940_Jul14

# End of Test Report