SAR TEST REPORT

for

MODEL NO. 1657

FCC ID: C3K1657

Test Report No. S-TR13-FCCSAR-2
Issue Date: 5-11-2015

FCC CFR 47 PART 2.1093

FCC KDB's 865664 D01, 447498 D01, 616217 D04,
248227 D01 v01r02

Prepared by

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ACCREDITED
TESTING CERT #3472.01

Report V2.0

1 Record of Revisions

Revision	Date	Section	Page(s)	Summary of Changes	Author/Revised By:
1.0	05/06/2015	All	All	First Version	Z. Gray
2.0	05/11/2015	Cover, 7	1, 6	Removed references to IEEE 1528-2013	Z. Gray
		8	16, 17, 18, 19, 21	Removed conducted values for MIMO in 802.11 a/b/g modes. Corrected 5.2, 5.3 GHz max power.	
		11.5	31	Added justification for testing 5GHz WLAN MIMO in HT40 mode.	
		14.1	46	Adjusted 3/8/15 5.8 GHz verification result to match the SAR value from corrected plot. Added	
		15.2	49	Fixed incorrect conductivity value to match that in plot 10.	

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Test Report Attestation

Microsoft Corporation
Model: 1657

Applicable Standards

Specification	Test Result
FCC CFR 47 PART 2.1093 FCC KDB's 865664 D01, 447498 D01, 616217 D04, 248227 D01 v01r02	Pass

Note: This report contains SAR evaluation data for 2.4GHz BT, 2.4GHz WLAN and 5GHz WLAN modes only. It is to be used in conjunction with Document #0Y1502160488.C3K issued by PCTEST Lab Columbia, MD, USA, which contains WWAN SAR measurements and Simultaneous Transmission Evaluation, to prove full compliance to the above mentioned standards.

This test report replaces the report #S-TR13-ICSAR-1 issued by Microsoft EMC labs on 05/06/2015.

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

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 Product Description

Company Name:	Microsoft Corporation		
Address:	One Microsoft Way		
City, State, Zip:	Redmond, WA 98052		
Customer Contact:	Jennifer Liu		
Functional Description of EUT:	Handheld Computing Device		
RF Exposure Conditions:	Body Exposure (General Population / Uncontrolled)		
Model:	1657		
Equipment Design State:	DV/Productions		
Equipment Condition:	Good		
Radio Information:	WLAN 2.4 GHz: 802.11b, 802.11g, 802.11n WLAN 5 GHz: 802.11a, 802.11n, 802.11ac Bluetooth™ (Basic and Enhanced Data Rates) UMTS WCDMA Bands 1 and 8 LTE Bands 1, 3, 7, 8, 20		
Frequency Range of Operation:	WLAN:		2412 MHz – 2472 MHz 5180 MHz – 5825 MHz
	Bluetooth		2402 – 2480 MHz
	UMTS	Band 2	1852.4 MHz – 1907.6 MHz
		Band 5	826.4 MHz – 846.6 MHz
	LTE	Band 2	1850.7 MHz – 1909.3 MHz
		Band 4	1710.7 MHz – 1754.3 MHz
		Band 5	824.7 MHz – 848.3 MHz
		Band 13	779.5 MHz – 784.5 MHz
		Band 17	706.5 MHz – 713.5 MHz
Modulations supported:	WLAN: CCK, BPSK, QPSK, 16-QAM, 64-QAM Bluetooth: GFSK, $\frac{\pi}{4}$ DQPSK, and 8 DPSK UMTS: QPSK, 16-QAM LTE: QPSK, 16-QAM		
Peak Antenna Gains:	706.5 MHz – 713.5 MHz: 0 dBi 779.5 MHz – 784.5 MHz: 0.58 dBi 824.7 MHz – 848.3 MHz: 0.57 dBi 1710.7 MHz – 1754.3 MHz: 2.28 dBi 1850.7 MHz – 1909.3 MHz: 1.65 dBi 2.4 GHz: 3.6 dBi 5 GHz: 4.2 dBi		
Dates of Testing:	2/24/2015 – 3/17/2015		

4.1 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.

4.2 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.

4.3 EQUIPMENT MODIFICATIONS

No modifications were made during testing.

4.4 EQUIPMENT UNDER TEST

Model Number	Serial Number	SW Version	FW Version
1657	000100645252	Windows 8.1	1.41222.851
1657	000085145252	Windows 8.1	1.41222.851

4.5 Supported Air Interfaces and Transmission Configurations

The EUT has three transmit antennas which support the following air interfaces and transmission configurations. The antennas are labeled as Main Antenna (Path B) for WLAN, Auxiliary Antenna (Path A) for WLAN, and Cellular Antenna.

4.5.1 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		
Band 2	UMTS	5		
	LTE	1.4, 3, 5, 10, 15, 20		
Band 4	LTE	1.4, 3, 5, 10, 15, 20		
Band 5	UMTS	5		
	LTE	1.4, 3, 5, 10		
Band 13	LTE	5, 10		
Band 17	LTE	5, 10		

4.5.2 Transmission Configurations

Main Antenna (Path B)	Auxiliary Antenna (Path A)	Cellular Antenna
		LTE, UMTS
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	
	WLAN 2.4 GHz	LTE, UMTS
	WLAN 5 GHz	LTE, UMTS
Bluetooth		LTE, UMTS
Bluetooth	WLAN 2.4 GHz	LTE, UMTS
Bluetooth	WLAN 5 GHz	LTE, UMTS

5 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	1.09
	NII	802.11n HT40	Top 0mm	1.22

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)

5.1 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)

6 Test Equipment List

Manufacturer	Description	Model #	Serial /#	Cal. Due	Cal. Cycle
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	MY50901710	12/17/2015	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	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	SAR Validation Dipole, 5 GHz	D5GHzV2	1159	08/06/2015	1 yr Cal. Ext.
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

7 Test Methodology

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 v01r02

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	2.43	-0.6	-0.6	4
39	2440	3.64	0.55	0.55	
78	2480	2.25	-0.84	-0.83	

8.2 Bluetooth LE Conducted Output Power Measurements

Channel	Frequency (MHz)	Conducted Average Output Power (dBm)	
		Measured	Maximum Target Power
0	2402	1.9	4
19	2440	3.12	
39	2480	1.75	

8.3 WLAN 2.4 GHz Conducted Output Power Measurements

Mode	Channel	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	10.25	11.5	10.55	11.5				
	6	2437	10.33	11.5	10.45	11.5				
	11	2462	10.68	11.5	10.49	11.5				
802.11g 6Mbps	1	2412	9.54	11.5	9.48	11.5				
	6	2437	9.55	11.5	9.59	11.5				
	11	2462	10.16	11.5	9.98	11.5				
802.11n HT20 MCS0	1	2412	10.61	11.5	10.81	11.5	10.38	11.5	10.87	11.5
	6	2437	10.9	11.5	10.77	11.5	10.77	11.5	10.63	11.5
	11	2462	10.94	11.5	10.63	11.5	10.66	11.5	10.73	11.5

8.4 WLAN 5 GHz Conducted Output Power Measurements

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

Mode	Channel	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	6.59	7.8	6.35	7.8				
	40	5200	6.47	7.8	6.32	7.8				
	44	5220	6.3	7.8	6.12	7.8				
	48	5240	6.41	7.8	6.44	7.8				
802.11n HT20 MCS0	36	5180	6.55	7.8	6.09	7.8	6.43	7.8	6.24	7.8
	40	5200	6.51	7.8	6.19	7.8	6.45	7.8	6.15	7.8
	44	5220	6.56	7.8	6.4	7.8	6.5	7.8	6.17	7.8
	48	5240	6.42	7.8	6.13	7.8	6.36	7.8	6.41	7.8
802.11n HT40 MCS0	38	5190	6.37	7.8	6.24	7.8	6.29	7.8	6.08	7.8
	46	5230	6.57	7.8	6.25	7.8	6.26	7.8	6.26	7.8
802.11ac VHT20 MCS0	36	5180	6.46	7.8	6.18	7.8	6.57	7.8	6.19	7.8
	40	5200	6.55	7.8	6.27	7.8	6.55	7.8	6.3	7.8
	44	5220	6.52	7.8	6.27	7.8	6.44	7.8	6.31	7.8
	48	5240	6.38	7.8	6.25	7.8	6.46	7.8	6.31	7.8
802.11ac VHT40 MCS0	38	5190	6.52	7.8	6.09	7.8	5.77	7.8	6.37	7.8
	46	5230	6.5	7.8	6.1	7.8	5.96	7.8	6	7.8
802.11ac VHT80 MCS0	42	5210	6.42	6.8	6.34	6.8	5.8	6.8	6.12	6.8

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

Mode	Channel	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	6.5	7.8	6.53	7.8				
	56	5280	6.48	7.8	6.47	7.8				
	60	5300	6.38	7.8	6.46	7.8				
	64	5320	6.2	7.8	6.42	7.8				
802.11n HT20 MCS0	52	5260	6.47	7.8	6.28	7.8	6.28	7.8	6.32	7.8
	56	5280	6.37	7.8	6.42	7.8	6.37	7.8	6.26	7.8
	60	5300	6.12	7.8	6.49	7.8	6.2	7.8	6.5	7.8
	64	5320	6.14	7.8	6.43	7.8	6.2	7.8	6.3	7.8
802.11n HT40 MCS0	54	5270	6.46	7.8	6.38	7.8	6.15	7.8	6	7.8
	62	5310	6.24	7.8	6.45	7.8	5.9	7.8	5.96	7.8
802.11ac VHT20 MCS0	52	5260	6.49	7.8	6.5	7.8	6.18	7.8	6.23	7.8
	56	5280	6.38	7.8	6.47	7.8	6.42	7.8	6.22	7.8
	60	5300	6.18	7.8	6.42	7.8	6.35	7.8	6.22	7.8
	64	5320	6.02	7.8	6.45	7.8	6.23	7.8	6.45	7.8
802.11ac VHT40 MCS0	54	5270	6.09	7.8	6.27	7.8	6.08	7.8	5.8	7.8
	62	5310	6.01	7.8	6.44	7.8	5.38	7.8	5.95	7.8
802.11ac VHT80 MCS0	56	5290	6.47	6.8	6.2	6.8	5.8	6.8	5.77	6.8

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

Mode	Channel	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	6.45	7.8	6.8	7.8				
	104	5520	6.65	7.8	6.9	7.8				
	108	5540	6.7	7.8	6.85	7.8				
	112	5560	6.62	7.8	6.83	7.8				
	116	5580	6.75	7.8	6.65	7.8				
	120	5600	6.65	7.8	6.85	7.8				
	124	5620	6.4	7.8	6.6	7.8				
	128	5640	6.35	7.8	6.2	7.8				
	132	5660	6.1	7.8	6.4	7.8				
	136	5680	6.23	7.8	6.33	7.8				
	140	5700	6.05	7.8	6.1	7.8				
802.11n HT20 MCS0	100	5500	6.55	7.8	6.75	7.8	6.4	7.8	6.6	7.8
	104	5520	6.6	7.8	6.75	7.8	6.55	7.8	6.65	7.8
	108	5540	6.5	7.8	6.9	7.8	6.35	7.8	6.7	7.8
	112	5560	6.5	7.8	6.85	7.8	6.4	7.8	6.9	7.8
	116	5580	6.35	7.8	6.95	7.8	6.45	7.8	6.9	7.8
	120	5600	6.7	7.8	6.8	7.8	6.45	7.8	6.65	7.8
	124	5620	6.45	7.8	6.6	7.8	6.65	7.8	6.6	7.8
	128	5640	6.25	7.8	6.65	7.8	6.35	7.8	6.35	7.8
	132	5660	6.3	7.8	6.4	7.8	6.25	7.8	6.55	7.8
	136	5680	6.25	7.8	6.35	7.8	6.25	7.8	6.3	7.8
	140	5700	6	7.8	6.1	7.8	5.85	7.8	6.35	7.8
802.11n HT40 MCS0	102	5510	6.1	7.8	6.75	7.8	5.8	7.8	6	7.8
	110	5550	6.15	7.8	6.75	7.8	5.65	7.8	6.35	7.8
	118	5590	6.4	7.8	6.5	7.8	6.05	7.8	6.35	7.8
	126	5630	6.45	7.8	6.4	7.8	5.9	7.8	6	7.8
	134	5670	6.15	7.8	6.05	7.8	5.8	7.8	5.8	7.8

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

Mode	Channel	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	6.5	7.8	6.6	7.8	6.2	7.8	6.6	7.8
	104	5520	6.6	7.8	6.75	7.8	6.4	7.8	6.85	7.8
	108	5540	6.6	7.8	6.67	7.8	6.55	7.8	6.65	7.8
	112	5560	6.45	7.8	6.65	7.8	6.3	7.8	6.75	7.8
	116	5580	6.7	7.8	6.85	7.8	6.5	7.8	6.9	7.8
	120	5600	6.8	7.8	6.6	7.8	6.45	7.8	6.65	7.8
	124	5620	6.7	7.8	6.6	7.8	6.5	7.8	6.6	7.8
	128	5640	6.3	7.8	6.35	7.8	6.2	7.8	6.4	7.8
	132	5660	6.5	7.8	6.45	7.8	6.2	7.8	6.5	7.8
	136	5680	6.25	7.8	6.3	7.8	6.15	7.8	6.15	7.8
	140	5700	6.02	7.8	6.15	7.8	5.7	7.8	6.3	7.8
802.11ac VHT40 MCS0	102	5510	6.3	7.8	6.7	7.8	5.4	7.8	6.1	7.8
	110	5550	6.4	7.8	6.7	7.8	6	7.8	6.3	7.8
	118	5590	6.65	7.8	6.4	7.8	5.95	7.8	6.25	7.8
	126	5630	6.2	7.8	6.5	7.8	5.7	7.8	6.1	7.8
	134	5670	6.1	7.8	6.15	7.8	5.4	7.8	5.95	7.8
802.11ac VHT80 MCS0	106	5530	5.7	6.8	5.6	6.8	5	6.8	5	6.8
	122	5610	5.8	6.8	5.9	6.8	4.8	6.8	4.9	6.8

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

Mode	Channel	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	6.25	7.8	6.8	7.8				
	153	5765	6.2	7.8	6.65	7.8				
	157	5785	6	7.8	6.45	7.8				
	161	5805	6.4	7.8	6.65	7.8				
	165	5825	6.25	7.8	6.65	7.8				
802.11n HT20 MCS0	149	5745	6.3	7.8	6.4	7.8	6	7.8	6.25	7.8
	153	5765	6.05	7.8	6.6	7.8	6.15	7.8	6.5	7.8
	157	5785	6.1	7.8	6.55	7.8	6.35	7.8	6.5	7.8
	161	5805	6.3	7.8	6.6	7.8	6.25	7.8	6.6	7.8
	165	5825	6.05	7.8	6.65	7.8	6.25	7.8	6.45	7.8
802.11n HT40 MCS0	151	5755	5.9	7.8	6.75	7.8	5.8	7.8	6.3	7.8
	159	5795	6.3	7.8	6.65	7.8	5.9	7.8	6.1	7.8
802.11ac VHT20 MCS0	149	5745	6	7.8	6.5	7.8	6.2	7.8	6.45	7.8
	153	5765	6.05	7.8	6.4	7.8	6.2	7.8	6.5	7.8
	157	5785	5.95	7.8	6.55	7.8	6.2	7.8	6.6	7.8
	161	5805	6.05	7.8	6.65	7.8	6.15	7.8	6.65	7.8
	165	5825	6.1	7.8	6.65	7.8	6.05	7.8	6.5	7.8
802.11ac VHT40 MCS0	151	5755	6.2	7.8	6.23	7.8	5.65	7.8	5.85	7.8
	159	5795	6.2	7.8	6.25	7.8	5.75	7.8	6.15	7.8
802.11ac VHT80 MCS0	155	5775	5.1	6.8	5.3	6.8	4.5	6.8	4.9	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. 11 2462 MHz
1	DBPSK	10.68
2	DQPSK	10.44
5.5	CCK	9.73
11	CCK	9.73

802.11n HT20		
Data Rate (Mbps)	**Modulation**	**Maximum Conducted Avg. Output Power (dBm)**
		Ch. 11 2462 MHz
6.5 (MCS0)	BPSK	10.94
13 (MCS1)	QPSK	10.85
19.5 (MCS2)	QPSK	10.78
26 (MCS3)	16-QAM	10.71
39 (MCS4)	16-QAM	10.52
52 (MCS5)	64-QAM	10.48
58.5 (MCS6)	64-QAM	10.41
65 (MCS7)	64-QAM	10.35

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. 36 5180 MHz	Ch. 52 5260 MHz	Ch. 104 5520 MHz	Ch. 161 5805 MHz
6	BPSK	6.59	6.65	7	6.9
9	BPSK	6.31	6.42	6.9	6.8
12	QPSK	6.58	6.48	6.9	6.8
18	QPSK	6.55	6.27	6.65	6.7
24	16-QAM	6.03	6.08	6.65	6.7
36	16-QAM	6.12	5.83	6.5	6.6
48	64-QAM	6.17	6.17	6.5	6.4
54	64-QAM	6.09	5.75	6.3	6.2

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. 151 5755 MHz
13.5 (MCS0)	BPSK	6.57	6.46	6.75	6.75
27 (MCS1)	QPSK	6.12	6.06	6.55	6.5
40.5 (MCS2)	QPSK	6.01	5.9	6.1	6.35
54 (MCS3)	16-QAM	5.94	5.83	6.05	6.3
81 (MCS4)	16-QAM	5.71	5.65	5.85	6.15
108 (MCS5)	64-QAM	5.59	5.55	5.75	6.05
121.5 (MCS6)	64-QAM	5.5	5.44	5.7	5.95
135 (MCS7)	64-QAM	5.47	5.34	5.7	5.85

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)	2.51 (4 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

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 ≤ 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

- All WLAN measurements were made with the device transmitting at 100% duty cycle.
- Each WLAN MIMO configuration was measured with an area scan covering all transmitting WLAN antennas. The resultant MIMO sar for each zoom scan is reported in the section for the transmitting antenna nearest that zoom scan. (Zoom scans are measured and reported for each transmitting antenna per MIMO configuration.)
- 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	10.33	11.5	0.052	**0.07**
	20	B	Top Tilt	6	2437	10.33	11.5	0.025	**0.03**
	20	B	Back	1	2412	10.25	11.5	0.733	**0.98**
	20	B	Back	6	2437	10.33	11.5	0.789	**1.03**
	20	B	Back	11	2462	10.68	11.5	0.838	**1.01**
802.11n MCS0 **1TX**	20	B	Back	1	2412	10.61	11.5	0.757	**0.93**
	20	B	Back	6	2437	10.9	11.5	0.854	**0.98**
	20	B	Back	11	2462	10.94	11.5	0.854	**0.97**
802.11n MCS0 **2TX**	20	B	Top	6	2437	10.77	11.5	0.068	**0.08**
	20	B	Top Tilt	6	2437	10.77	11.5	0.07	**0.08**
	20	B	Back	1	2412	10.38	11.5	0.778	**1.01**
	20	B	Back	6	2437	10.77	11.5	0.813	**0.96**
	20	B	Back	11	2462	10.66	11.5	0.827	**1.00**

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	10.45	11.5	0.132	**0.17**
	20	A	Top Tilt	6	2437	10.45	11.5	0.164	**0.21**
	20	A	Back	1	2412	10.55	11.5	0.777	**0.97**
	20	A	Back	6	2437	10.45	11.5	0.792	**1.01**
	20	A	Back	11	2462	10.49	11.5	0.802	**1.01**
802.11n MCS0 **1TX**	20	A	Back	1	2412	10.81	11.5	0.834	**0.98**
	20	A	Back	6	2437	10.77	11.5	0.806	**0.95**
	20	A	Back	11	2462	10.73	11.5	0.905	**1.08**
	20	A	Back	11	2462	10.73	11.5	0.917	**1.09 (Repeat) (Plot 1)**
802.11n MCS0 **2TX**	20	A	Top	6	2437	10.63	11.5	0.188	**0.23**
	20	A	Top Tilt	6	2437	10.63	11.5	0.242	**0.30**
	20	A	Back	1	2412	10.87	11.5	0.893	**1.03**
	20	A	Back	6	2437	10.63	11.5	0.861	**1.05**
	20	A	Back	11	2462	10.73	11.5	0.862	**1.03**

11.5 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 802.11n HT40 mode since HT40 showed the highest scaled SAR values in SISO testing.
- 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	§15.247 802.11g	UNII	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		√			

11.6 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	6.59	7.8	0.265	**0.35**
	20	B	Top	36	5180	6.59	7.8	0.723	**0.96**
	20	B	Top	48	5240	6.41	7.8	0.743	**1.02**
	20	B	Top Tilt	36	5180	6.59	7.8	0.638	**0.84**
	20	B	Top Tilt	48	5240	6.41	7.8	0.701	**0.97**
802.11n MCS0 **1TX**	40	B	Top	38	5190	6.37	7.8	0.801	**1.11**
	40	B	Top	38	5190	6.37	7.8	0.823	**1.14 (Repeat) (Plot 2)**
	40	B	Top	46	5230	6.57	7.8	0.811	**1.08**
802.11ac MCS0 **1TX**	80	B	Top	42	5210	6.42	6.8	0.772	**0.79**
802.11n MCS0 **2TX**	40	B	Back	38	5190	6.29	7.8	0.245	**0.35**
	40	B	Top	38	5190	6.29	7.8	0.688	**0.97**
	40	B	Top	46	5230	6.26	7.8	0.748	**1.07**
	40	B	Top Tilt	38	5190	6.29	7.8	0.574	**1.00**
	40	B	Top Tilt	46	5230	6.26	7.8	0.539	**0.95**

11.7 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	36	5180	6.35	7.8	0.321	**0.45**
	20	A	Top	36	5180	6.35	7.8	0.586	**0.82**
	20	A	Top Tilt	48	5240	6.44	7.8	0.574	**0.79**
802.11n MCS0 **1TX**	40	A	Top	46	5230	6.25	7.8	0.487	**0.70**
802.11n MCS0 **2TX**	40	A	Back	46	5230	6.26	7.8	0.307	**0.44**
	40	A	Top	46	5230	6.26	7.8	0.523	**0.75**
	40	A	Top Tilt	46	5230	6.26	7.8	0.431	**0.61**

11.8 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	52	5260	6.5	7.8	0.239	**0.32**
	20	B	Top	52	5260	6.5	7.8	0.799	**1.08**
	20	B	Top	60	5300	6.38	7.8	0.821	**1.14**
	20	B	Top Tilt	52	5260	6.5	7.8	0.752	**1.01**
	20	B	Top Tilt	60	5300	6.38	7.8	0.669	**0.93**
802.11n MCS0 **1TX**	40	B	Top	54	5290	6.46	7.8	0.844	**1.15 (Plot 3)**
	40	B	Top	54	5290	6.46	7.8	0.826	**1.12 (Repeat)**
	40	B	Top	62	5310	6.24	7.8	0.799	**1.14**
802.11ac MCS0 **1TX**	80	B	Top	58	5290	6.47	6.8	0.914	**0.99**
802.11n MCS0 **2TX**	40	B	Back	54	5270	6.15	7.8	0.229	**0.33**
	40	B	Top	54	5270	6.15	7.8	0.709	**1.04**
	40	B	Top	62	5290	5.9	7.8	0.729	**1.13**
	40	B	Top Tilt	54	5270	6.15	7.8	0.683	**1.00**
	40	B	Top Tilt	62	5290	5.9	7.8	0.633	**0.98**

11.9 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	52	5260	6.53	7.8	0.332	**0.44**
	20	A	Top	52	5260	6.53	7.8	0.505	**0.68**
	20	A	Top Tilt	52	5260	6.53	7.8	0.593	**0.79**
802.11n MCS0 **1TX**	40	A	Top Tilt	62	5310	6.45	7.8	0.546	**0.75**
802.11n MCS0 **2TX**	40	A	Back	54	5270	6	7.8	0.339	**0.51**
	40	A	Top	54	5270	6	7.8	0.437	**0.69**
	40	A	Top Tilt	54	5270	6	7.8	0.496	**0.79**

11.10 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	6.4	7.8	0.214	**0.3**
	20	B	Top	104	5520	6.65	7.8	0.726	**0.95**
	20	B	Top	116	5580	6.75	7.8	0.824	**1.05**
	20	B	Top	124	5620	6.4	7.8	0.812	**1.12**
	20	B	Top	136	5680	6.23	7.8	0.826	**1.19**
	20	B	Top Tilt	104	5520	6.65	7.8	0.585	**0.76**
	20	B	Top Tilt	116	5580	6.75	7.8	0.636	**0.81**
	20	B	Top Tilt	124	5620	6.4	7.8	0.661	**0.91**
	20	B	Top Tilt	136	5680	6.23	7.8	0.683	**0.98**
802.11n MCS0 **1TX**	40	B	Top	102	5510	6.1	7.8	0.725	**1.07**
	40	B	Top	118	5590	6.4	7.8	0.79	**1.09**
	40	B	Top	126	5630	6.45	7.8	0.88	**1.2**
	40	B	Top	134	5670	6.15	7.8	0.83	**1.21**
	40	B	Top	134	5670	6.15	7.8	0.834	**1.22 (Repeat) (Plot 4)**
802.11ac MCS0 **1TX**	80	B	Top	122	5610	5.8	6.8	0.644	**0.81**
802.11n MCS0 **2TX**	40	B	Back	134	5670	5.8	7.8	0.173	**0.27**
	40	B	Top	102	5510	5.8	7.8	0.578	**0.92**
	40	B	Top	118	5590	6.05	7.8	0.688	**1.03**
	40	B	Top	126	5630	5.9	7.8	0.771	**1.19**
	40	B	Top	134	5670	5.8	7.8	0.746	**1.18**
	40	B	Top Tilt	102	5510	5.8	7.8	0.587	**0.93**
	40	B	Top Tilt	118	5590	6.05	7.8	0.662	**0.99**
	40	B	Top Tilt	126	5630	5.9	7.8	0.637	**0.99**
	40	B	Top Tilt	134	5670	5.8	7.8	0.654	**1.04**

11.11 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	6.9	7.8	0.267	**0.33**
	20	A	Top	104	5520	6.9	7.8	0.428	**0.53**
	20	A	Top Tilt	104	5520	6.9	7.8	0.494	**0.61**
802.11n MCS0 **1TX**	40	A	Top Tilt	102	5510	6.75	7.8	0.459	**0.58**
802.11n MCS0 **2TX**	40	A	Back	134	5670	5.8	7.8	0.256	**0.41**
	40	A	Top	134	5670	5.8	7.8	0.411	**0.65**
	40	A	Top Tilt	134	5670	5.8	7.8	0.472	**0.75**

11.12 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	161	5805	6.4	7.8	0.211	**0.29**
	20	B	Top	149	5745	6.25	7.8	0.714	**1.02**
	20	B	Top	161	5805	6.4	7.8	0.676	**0.93**
	20	B	Top	165	5825	6.25	7.8	0.664	**0.95**
	20	B	Top Tilt	149	5745	6.25	7.8	0.622	**0.89**
	20	B	Top Tilt	161	5805	6.4	7.8	0.632	**0.87**
	20	B	Top Tilt	165	5825	6.25	7.8	0.629	**0.9**
802.11n MCS0 **1TX**	40	B	Top	151	5755	5.9	7.8	0.684	**1.06 (Plot 5)**
	40	B	Top	151	5755	5.9	7.8	0.673	**1.06 (Repeat)**
	40	B	Top	159	5795	6.3	7.8	0.679	**0.96**
802.11ac MCS0 **1TX**	80	B	Top	155	1775	5.1	6.8	0.533	**0.79**
802.11n MCS0 **2TX**	40	B	Back	151	5755	5.8	7.8	0.204	**0.32**
	40	B	Top	151	5755	5.8	7.8	0.663	**1.05**
	40	B	Top	159	5795	5.9	7.8	0.587	**0.91**
	40	B	Top Tilt	151	5755	5.8	7.8	0.644	**1.02**
	40	B	Top Tilt	159	5795	5.9	7.8	0.539	**0.83**

11.13 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	149	5745	6.8	7.8	0.268	**0.34**
	20	A	Top	149	5745	6.8	7.8	0.368	**0.46**
	20	A	Top Tilt	149	5745	6.8	7.8	0.407	**0.51**
802.11n MCS0 **1TX**	40	A	Top Tilt	151	5755	6.75	7.8	0.392	**0.5**
802.11n MCS0 **2TX**	40	A	Back	151	5755	6.3	7.8	0.223	**0.31**
	40	A	Top	151	5755	6.3	7.8	0.306	**0.43**
	40	A	Top Tilt	151	5755	6.3	7.8	0.357	**0.5**

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. The repeated measurement results below and their reported SAR values are also shown in the previous section, but are again shown here to demonstrate compliance with the requirement.

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)	Largest / Smallest Ratio
2.4	802.11n 1TX	20	A	Back	11	2462	0.905	0.917	**1.01**
5.2	802.11n 1TX	40	B	Top	38	5190	0.801	0.823	**1.03**
5.3	802.11n 1TX	40	B	Top	54	5270	0.844	0.826	**1.02**
5.6	802.11n 1TX	40	B	Top	134	5670	0.83	0.834	**1.00**
5.8	802.11n 1TX	40	B	Top	151	5755	0.684	0.673	**1.02**

13 Simultaneous Transmission Evaluation

Simultaneous transmission analysis is performed in report C3K1657 FCC SAR Report. The following data from this test report is used in the simultaneous transmission analysis in conjunction with the cellular SAR data from the report cited. Plots showing relevant peak locations are shown in the following pages.

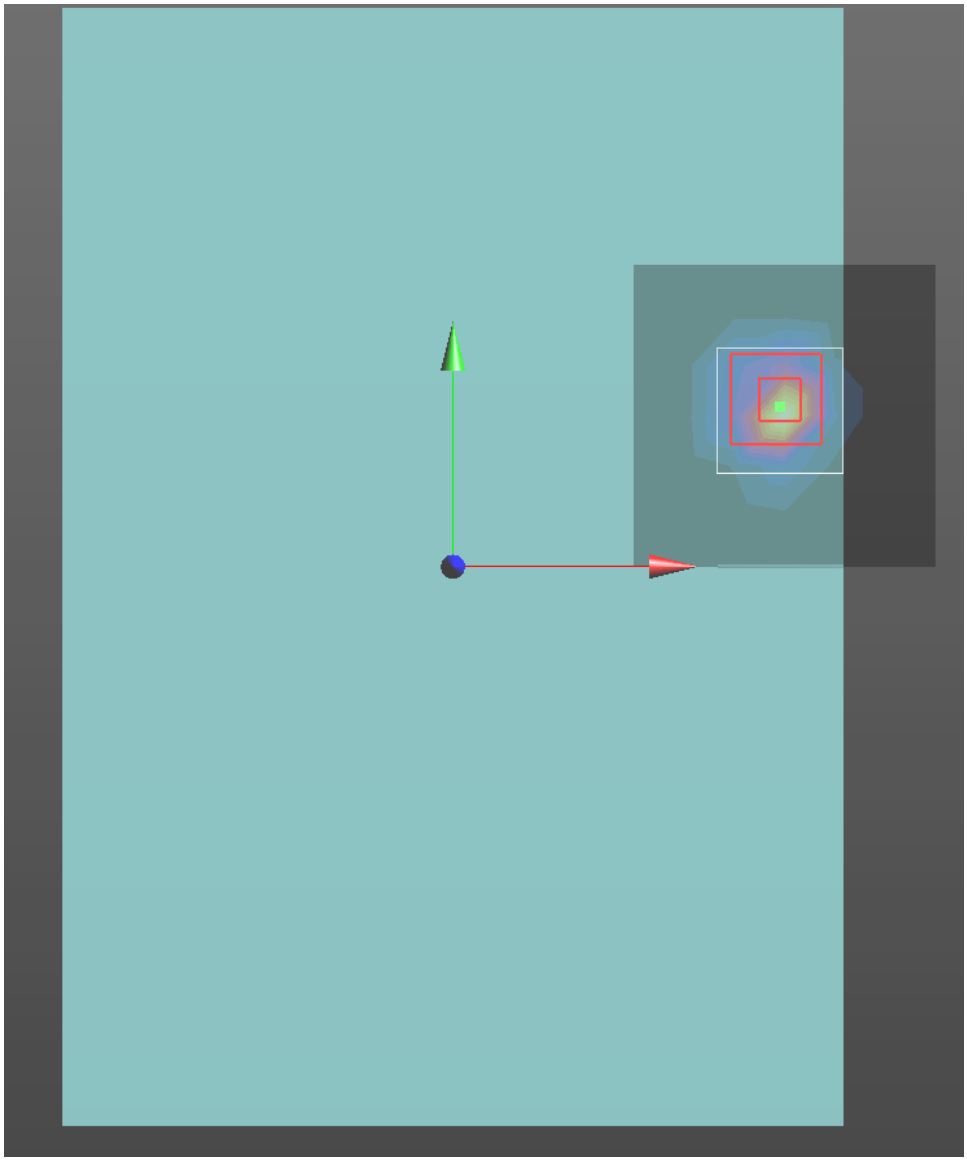
13.1 Important Standalone SAR values for Simultaneous Transmission Evaluation

Band	Test Position	Air Interface	Ch.	Freq. (MHz)	Antenna	Peak SAR Location Coordinates (mm from Phantom origin)			Reported SAR (W/kg)
						X	Y	Z	
WLAN 2.4 GHz	Back	802.11n	11	2462	A	88.4	35.8	-2.4	1.09
	Top Tilt	802.11b	6	2437	A	-1.6	20.6	-4.7	0.21
	Top	802.11b	6	2437	A	-8.6	-22.6	-4.2	0.17
U-NII-1	Back	802.11a	36	5180	A	88.4	35.8	-2.5	0.45
	Top Tilt	802.11a	36	5180	A	9.2	37.4	-3.9	0.79
	Top	802.11a	36	5180	A	2.8	36.2	-3.6	0.82
U-NII-2A	Back	802.11a	52	5260	A	88.4	34.8	-2.6	0.44
	Top Tilt	802.11a	52	5260	A	9.2	37.4	03.8	0.79
	Top	802.11a	52	5260	A	1.8	38.2	-3.1	0.68
U-NII-2C	Back	802.11a	104	5520	A	92.5	41.5	-4.7	0.33
	Top Tilt	802.11a	104	5520	A	2.5	41.5	-6.2	0.61
	Top	802.11a	104	5520	A	1.4	38.2	-6	0.53
U-NII-3	Back	802.11a	149	5745	A	90.5	43.5	-4.8	0.34
	Top Tilt	802.11a	149	5745	A	3.2	38.4	-6.2	0.51
	Top	802.11a	149	5745	A	2.5	38.5	-6.2	0.46

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

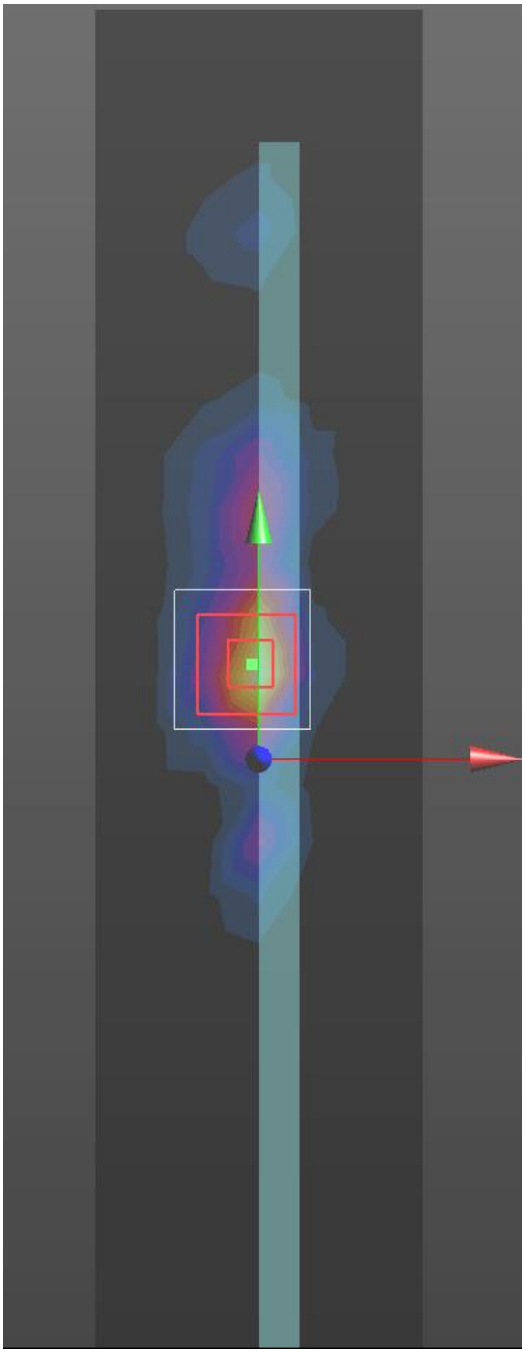
13.2 SAR Peak Location Illustrations

13.2.1 Antenna A – Back 0mm – 802.11n HT20 – Channel 11 – 2462 MHz



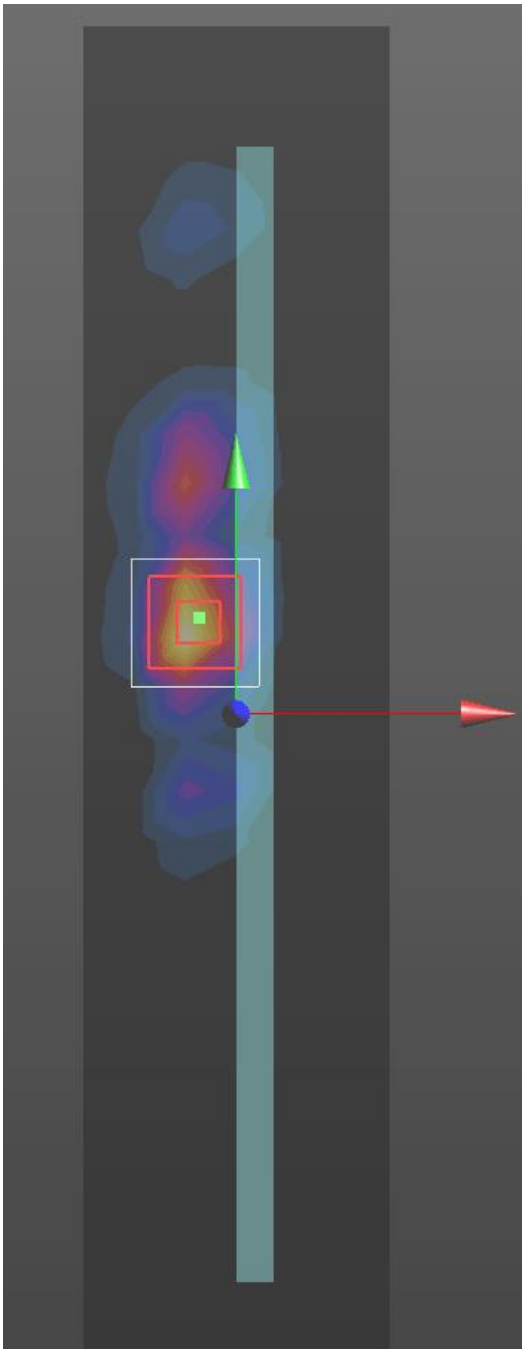
Peak location: 88.4, 35.8, -2.5

13.2.1 Antenna A – Top Tilt 0mm– 802.11b – Channel 6 – 2437 MHz



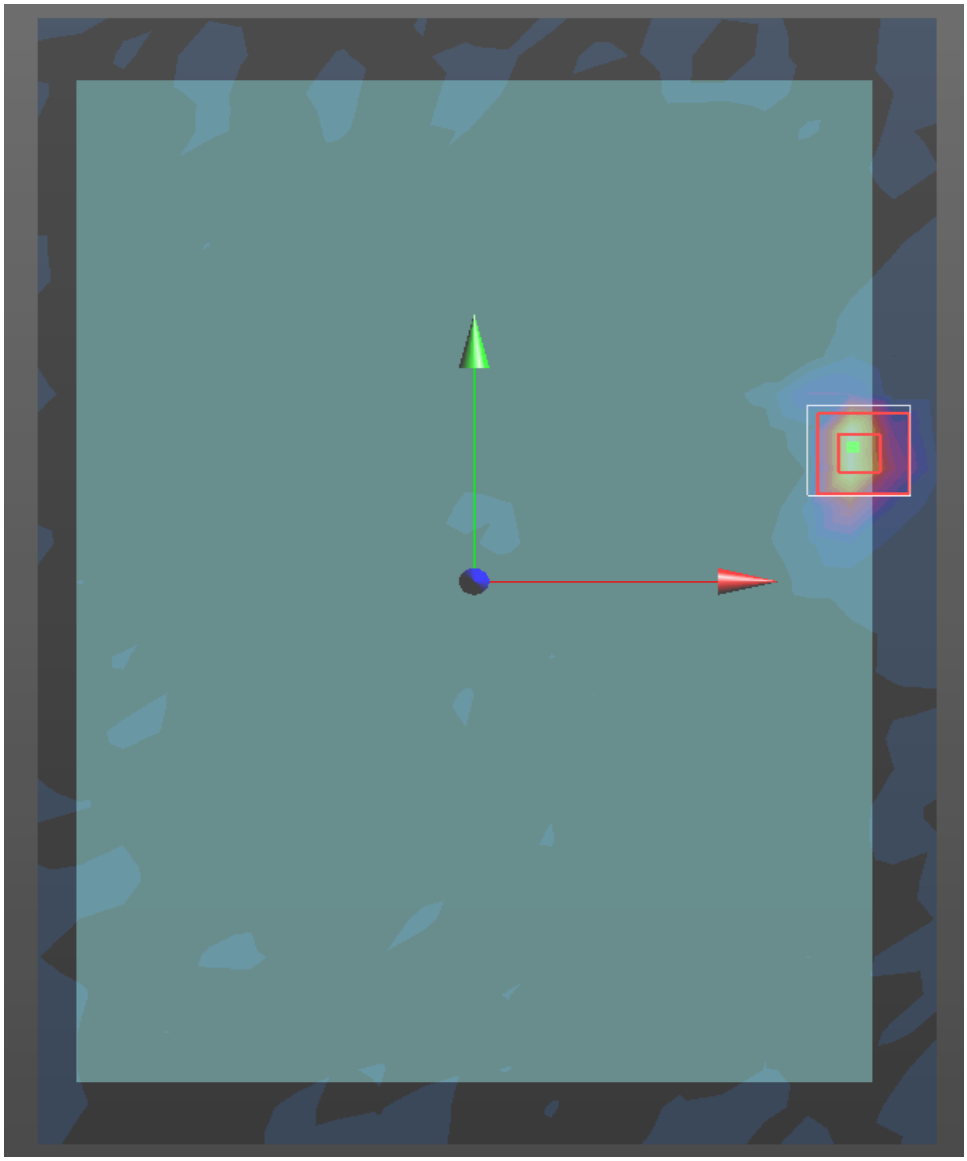
Peak location: -1.6, 20.6, -4.7

13.2.2 Antenna A – Top 0mm – 802.11b – Channel 6 – 2437 MHz



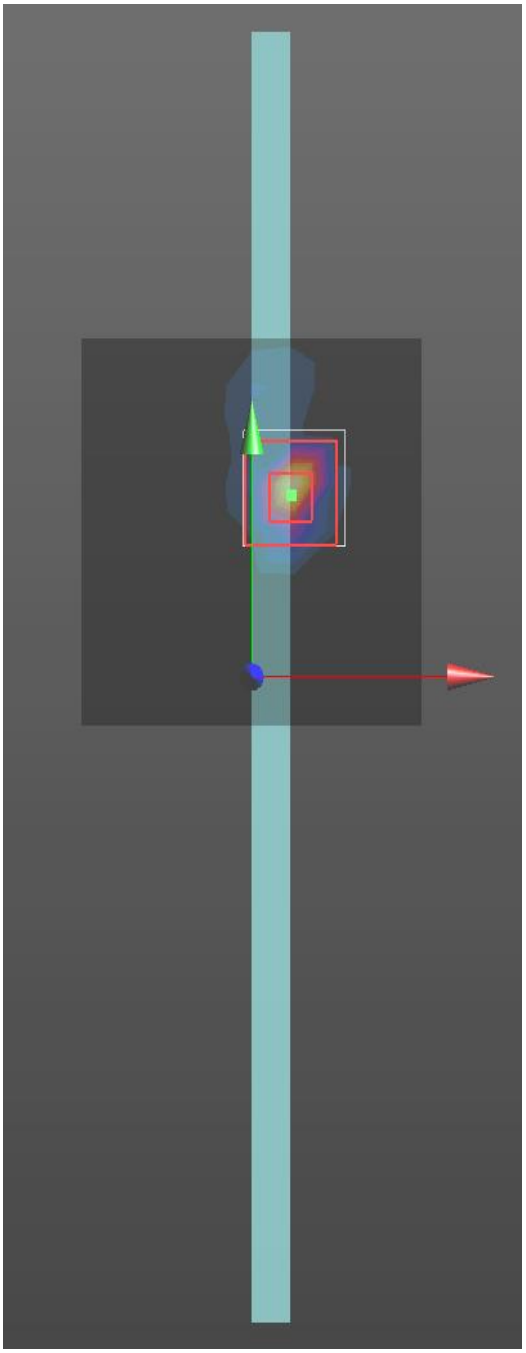
Peak location: -8.6, 22.6, -4.2

13.2.3 Antenna A – Back 0mm – 802.11a – Channel 36 – 5180 MHz



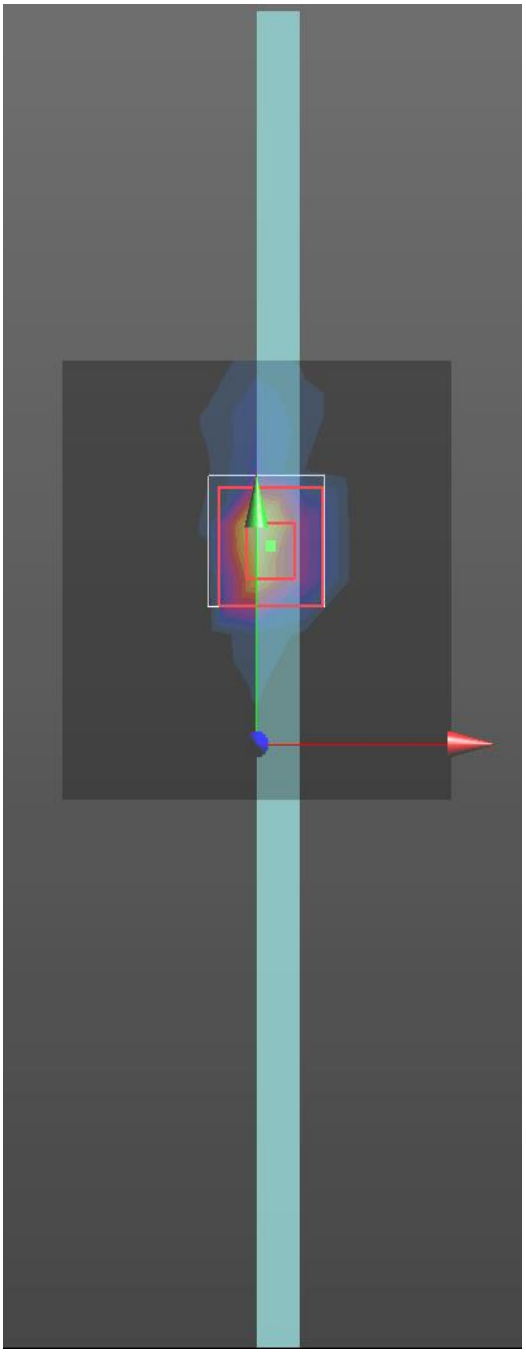
Peak location: 88.4, 35.8, -2.5

13.2.4 Antenna A – Top Tilt 0mm – 802.11a – Channel 36 – 5180 MHz



Peak location: 9.2, 37.4, -3.9

13.2.5 Antenna A – Top 0mm – 802.11a – Channel 36 – 5180 MHz

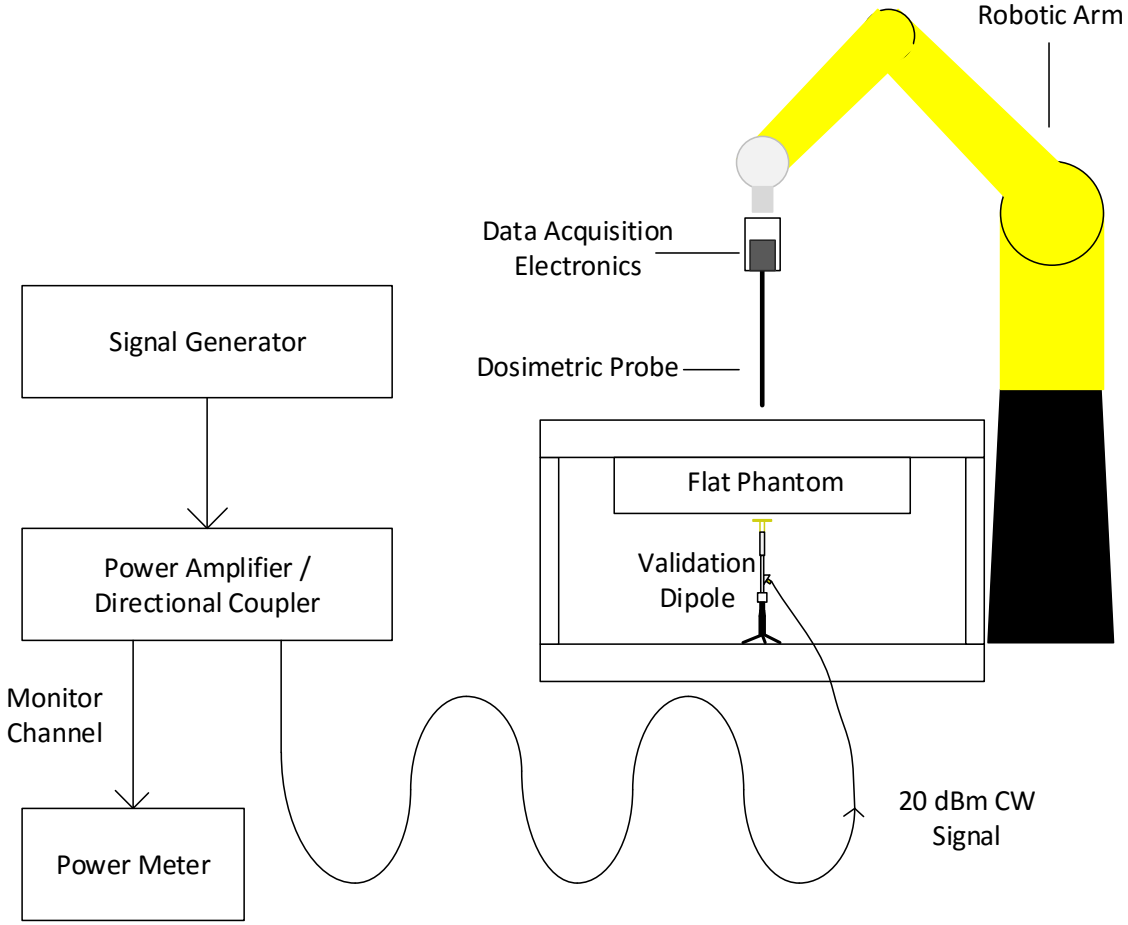


Peak location: 2.8, 36.2, -3.6

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 value.

Date	Tissue-Sim. Liquid	Probe SN	Dipole	Freq. (MHz)	Meas. 1-g SAR (W/kg)	Norm. 1-g SAR (W/kg)	Dipole Target 1-g SAR (W/kg)	Dev. from Target 1-g SAR (%)
2/24/2015	MSL	3939	D2450V2_916	2450	5.02	50.2	51.7	**-2.90 (Plot 6)**
2/27/2015	MSL	3939	D2450V2_916	2450	5.1	51	51.7	**-1.35**
3/2/2015	MSL	3939	D2450V2_916	2450	5.15	51.5	51.7	**-0.39**
3/3/2015	MBBL	3939	D5GHzV2_1158	5200	7.72	77.2	76.7	**0.65**
3/6/2015	MBBL	3939	D5GHzV2_1158	5200	7.78	77.8	76.7	**1.43**
3/11/2015	MBBL	3939	D5GHzV2_1158	5200	7.76	77.6	76.7	**1.17**
3/17/2015	MBBL	3939	D5GHzV2_1158	5200	7.2	72	76.7	**-6.13 (Plot 7)**
3/3/2015	MBBL	3939	D5GHzV2_1159	5300	8.16	81.6	75	**5.99 (Plot 8)**
3/6/2015	MBBL	3939	D5GHzV2_1159	5300	7.83	78.3	75	**1.38**
3/11/2015	MBBL	3939	D5GHzV2_1159	5300	7.92	79.2	75	**2.76**
3/17/2015	MBBL	3939	D5GHzV2_1159	5300	7.65	76.5	75	**2.0**
3/4/2015	MBBL	3940	D5GHzV2_1159	5500	8.13	83.1	78.1	**6.40 (Plot 9)**
3/4/2015	MBBL	3940	D5GHzV2_1158	5600	8.16	81.6	83.1	**-1.81 (Plot 10)**
3/8/2015	MBBL	3940	D5GHzV2_1158	5800	7.76	77.6	76.3	**1.70 (Plot 11)**

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)	ε_r	σ (S/m)	ε_r	σ (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

(ε_r = relative permittivity, σ = conductivity and ρ = 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

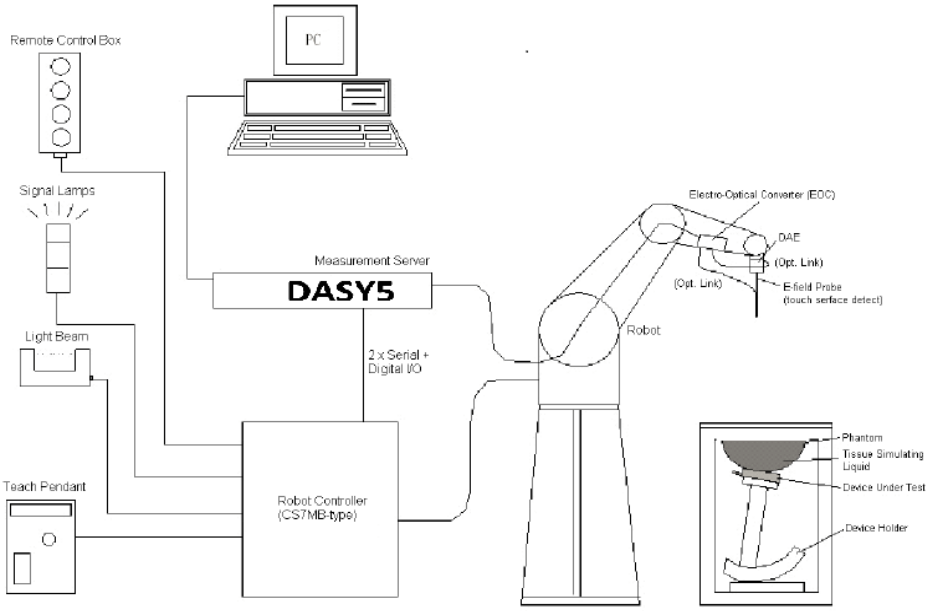
Date	Tissue-Simulating Liquid	Freq. (MHz)	Rel. Perm. ε'_r	Target ε'_r	ε'_r Dev. %	Cond. σ (S/m)	Target σ (S/m)	σ Dev. %
2/24/2015	MSL 2450 130710-1 23.1 °C	2412	52.51	52.75	**-0.45**	1.935	1.91	**1.31**
		2437	52.46	52.72	**-0.49**	1.972	1.94	**1.65**
		2450	52.42	52.70	**-0.53**	1.988	1.95	**1.95**
		2462	52.39	52.68	**-0.55**	2.004	1.97	**1.73**
2/27/2015	MSL 2450 130710-1 23.3 °C	2412	51.18	52.75	**-2.98**	1.909	1.91	**-0.05**
		2437	51.1	52.72	**-3.07**	1.943	1.94	**0.15**
		2450	51.08	52.70	**-3.07**	1.96	1.95	**0.51**
		2462	51.05	52.68	**-3.09**	1.974	1.97	**0.20**
3/2/2015	MSL 2450 130710-1 23 °C	2412	52.08	52.75	**-1.27**	1.938	1.91	**1.47**
		2437	51.95	52.72	**-1.46**	1.97	1.94	**1.55**
		2450	51.92	52.70	**-1.48**	1.987	1.95	**1.90**
		2462	51.89	52.68	**-1.50**	2.003	1.97	**1.68**
3/3/2015	MBBL 3500-5800 130705-2 22.7 °C	5180	48.05	49.04	**-2.02**	5.366	5.28	**1.63**
		5200	47.96	49.01	**-2.14**	5.384	5.30	**1.58**
		5260	47.89	48.93	**-2.13**	5.489	5.37	**2.22**
		5320	47.68	48.85	**-2.40**	5.537	5.44	**1.78**
3/6/2015	MBBL 3500-5800 130705-2 22.4 °C	5180	47.74	49.04	**-2.65**	5.39	5.28	**2.08**
		5200	47.71	49.01	**-2.65**	5.42	5.30	**2.26**
		5260	47.58	48.93	**-2.76**	5.489	5.37	**2.22**
		5320	47.44	48.85	**-2.89**	5.57	5.44	**2.39**
3/11/2015	MBBL 3500-5800 130705-2 22.6 °C	5180	48.1	49.04	**-1.92**	5.352	5.28	**1.36**
		5200	48.09	49.01	**-1.88**	5.386	5.30	**1.62**
		5260	47.97	48.93	**-1.96**	5.457	5.37	**1.62**
		5320	47.88	48.85	**-1.99**	5.55	5.44	**2.02**
3/17/2015	MBBL 3500-5800 130705-2 2 °C	5180	48.65	49.04	**-0.80**	5.437	5.28	**2.97**
		5200	48.63	49.01	**-0.78**	5.468	5.30	**3.17**
		5260	48.55	48.93	**-0.78**	5.558	5.37	**3.50**
		5320	48.41	48.85	**-0.90**	5.644	5.44	**3.75**
3/4/2015	MBBL 3500-5800 130705-1 21.8 °C	5500	46.57	48.61	**-4.20**	5.651	5.65	**0.02**
		5600	46.44	48.47	**-4.19**	5.791	5.77	**0.36**
		5700	46.32	48.34	**-4.18**	5.962	5.88	**1.39**
		5800	46.21	48.20	**-4.13**	6.057	6.00	**0.95**
		5825	46.18	48.17	**-4.13**	6.09	6.03	**1.00**
3/8/2015	MBBL 3500-5800 130705-1 20.4 °C	5500	48.37	48.61	**-0.49**	**5.773**	5.65	**2.18**
		5600	48.22	48.47	**-0.52**	5.919	5.77	**2.58**
		5700	48.06	48.34	**-0.58**	6.064	5.88	**3.13**
		5800	47.9	48.20	**-0.62**	6.212	6.00	**3.53**
		5825	47.86	48.17	**-0.64**	6.249	6.03	**3.63**

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 System Validation Summary

System validations were performed in accordance with **KDB 865664 D01 Section 3.3**. The results are tabulated here in accordance with the requirements of that section. System validations were performed using head tissue-simulating liquid.

Although system validation was also performed using a modulated input with the modulated probe calibration, those results are not included here since the modulated probe calibrations were not used in the testing of this report. Only CW probe calibrations were used.

System Validation – Probe EX3DV4 – SN 3939								
Freq. (MHz)	HBBL Properties		CW Input / CW Probe Calibration			OFDM Input / CW Probe Calibration		
	ε'r	**σ (S/m)**	4.0 W/kg Target SAR	Probe Linearity	Probe Isotropy	4.0 W/kg Target SAR	Probe Linearity	Probe Isotropy
2450	37.58	1.871	Pass 8/14/2014	Pass 8/14/2014	Pass 8/14/2014			
	38.31	1.858				Pass 2/5/2015	Pass 2/5/2015	Pass 2/5/2015
5200	34.82	4.679	Pass 8/20/2014	Pass 8/20/2014	Pass 8/20/2014			
	36.58	4.522				Pass 2/5/2015	Pass 2/5/2015	Pass 2/5/2015
5300	36.42	4.631	Pass 2/6/2015	Pass 2/6/2015	Pass 2/6/2015	Pass 2/6/2015	Pass 2/6/2015	Pass 2/6/2015

System Validation – Probe EX3DV4 – SN 3940								
Freq. (MHz)	HBBL Properties		CW Input / CW Probe Calibration			OFDM Input / CW Probe Calibration		
	ε'r	**σ (S/m)**	4.0 W/kg Target SAR	Probe Linearity	Probe Isotropy	4.0 W/kg Target SAR	Probe Linearity	Probe Isotropy
5500	34.85	5	Pass 2/11/2015	Pass 2/11/2015	Pass 2/11/2015	Pass 2/11/2015	Pass 2/11/2015	Pass 2/11/2015
5600	34.1	5.124	Pass 8/25/2014	Pass 8/25/2014	Pass 8/25/2014			
	34.68	5.115				Pass 2/11/2015	Pass 2/11/2015	Pass 2/11/2015
5800	33.75	5.46	Pass 8/26/2014	Pass 8/26/2014	Pass 8/26/2014			
	34.34	5.343				Pass 2/11/2014	Pass 2/11/2014	Pass 2/11/2014

18 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 0.917 W/kg. Therefore, SAR measurement uncertainty analysis is not required for this report.

19 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
  - Dipole D5GHzV2-1159 Calibration Extension
  - Validation Dipole D5GHzV2-1159_Aug13
  - Dosimetric Probe EX3-DV4-3939_Jul14
  - Dosimetric Probe EX3-DV4-3940_Jul14

End of Test Report