SAR EVALUATION REPORT

IEEE Std 1528-2013

For
Body Worn Camera

FCC ID: X4GS01200
Model Name: AX1023

Report Number: 12910430-S1V2
Issue Date: 1/28/2020

Prepared for
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NVLAP LAB CODE 200065-0

Revision History

Rev.	Date	Revisions	Revised By
V1	7/15/2019	Initial Issue	--
V2	1/28/2020	Added U-NII 2-A and U-NII 2-C Bands Appendix C: Updated for new data	AJ Newcomer

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1. Attestation of Test Results

Applicant Name	Axon Enterprise, Inc.			
FCC ID	X4GS01200			
Model Name	AX1023			
Applicable Standards	Published RF exposure KDB procedures IEEE Std 1528-2013			
Exposure Category	SAR Limits (W/Kg)			
	Peak spatial-average (1g of tissue)		Extremities (hands, wrists, ankles, etc.) (10g of tissue)	
General population / Uncontrolled exposure	1.6		4	
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)			
	PCE	DTS	NII	DSS
Body-worn	0.765	0.043	0.091	<0.001
Extremity	2.112	0.248	0.448	0.019
*Simultaneous TX (Body-worn)	0.856	0.808	0.856	0.856
*Simultaneous TX (Extremity)	2.186	2.135	2.186	2.186
Date Tested	7/2/2019 to 7/10/2019			
Test Results	Pass			

***Note:** FCC ID: X4GS01200 and FCC ID: X4GAB7610 share the same host device. The data used for PCE Simultaneous TX has been leveraged from FCC ID: X4GAB7610.

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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Approved & Released By:	Prepared By:
	
Devin Chang Senior Test Engineer UL Verification Services Inc.	AJ Newcomer Laboratory Engineer UL Verification Services Inc.

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE STD 1528-2013, the following FCC Published RF exposure KDB procedures:

- 248227 D01 802.11 Wi-Fi SAR v02r02
- 447498 D01 General RF Exposure Guidance v06
- 447498 D03 Supplement C Cross-Reference v01
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02

In addition to the above, the following information was used:

- TCB workshop October 2016; RF Exposure Procedures (Bluetooth Duty Factor)
- TCB workshop October 2016; RF Exposure Procedures (DUT Holder Perturbations)
- TCB workshop May 2017; RF Exposure Procedures (Broadband Liquid Above 3 GHz)
- TCB workshop April 2019; RF Exposure Procedures (Tissue Simulating Liquids (TSL)

3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

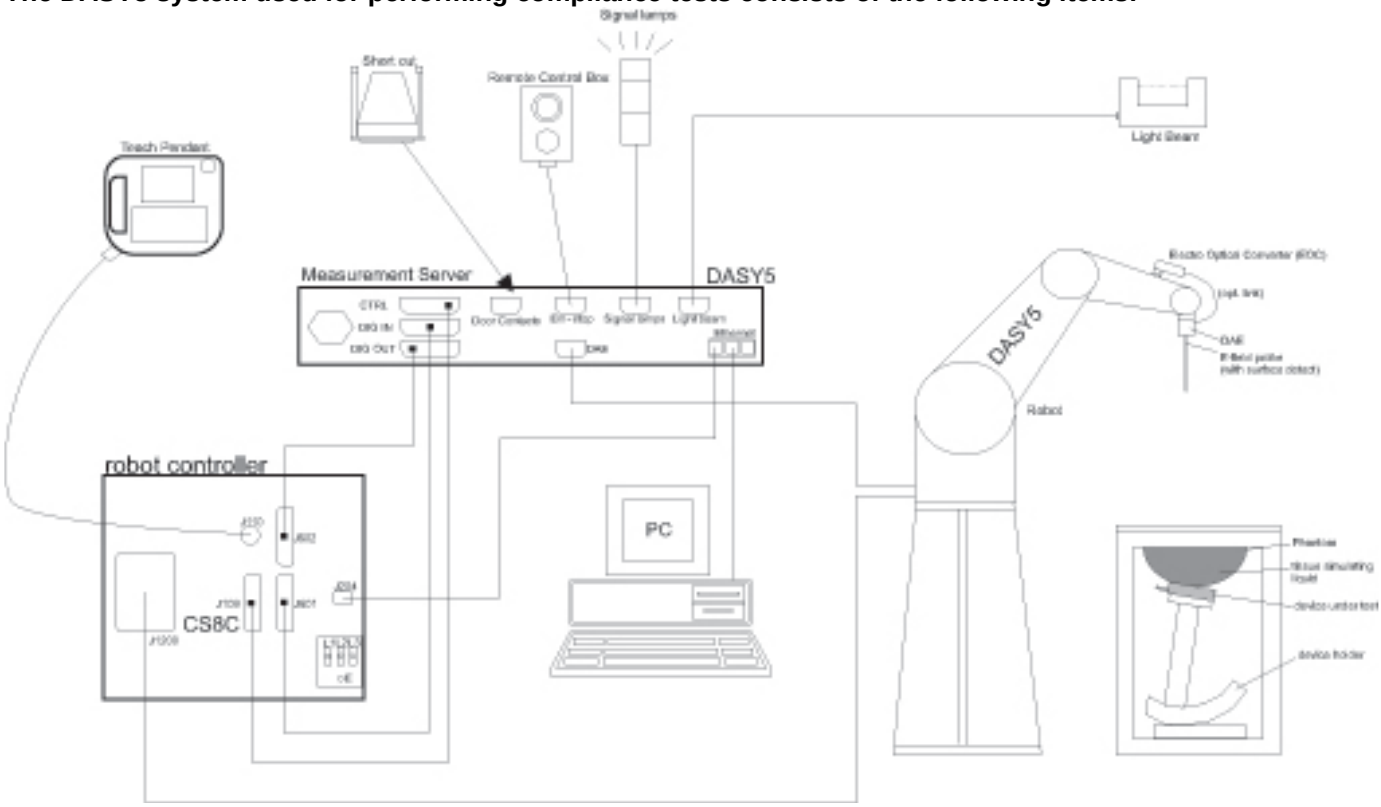
47173 Benicia Street	47266 Benicia Street
SAR Lab A	SAR Lab 1
SAR Lab B	SAR Lab 2
SAR Lab C	SAR Lab 3
SAR Lab D	SAR Lab 4
SAR Lab E	SAR Lab 5
SAR Lab F	SAR Lab 6
SAR Lab G	SAR Lab 7
SAR Lab H	SAR Lab 8

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY5 system used for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic Field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP or Win7 and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

4.2. SAR Scan Procedures

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. 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 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE Standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The Zoom Scan measures points (refer to table below) within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	≤ 1.5·$\Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm

Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.

* When zoom scan is required and the *reported* SAR from the *area scan based 1-g SAR estimation* procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.

Step 4: 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. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

4.3. Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Vector Network Analyzer	Rhode & Schwarz	ZNLE6	101273-va	4/24/2020
Dielectric Probe kit	SPEAG	DAK-3.5	1103	2/12/2020
Shorting Block	SPEAG	DAK-3.5 Short	SM DAK 200 DA	9/11/2019
Thermometer	Keysight	Traceable	170064398	5/21/2020

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Rhode & Schwarz	SMB100A	1890968-gX	2/14/2020
Power Sensor	Rhode & Schwarz	NRP18A	100995-hs	2/15/2020

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
E-Field Probe (SAR Lab 2)	SPEAG	EX3DV4	7483	11/14/2019
Data Acquisition Electronics (SAR Lab 2)	SPEAG	DAE4	1359	2/15/2020
System Validation Dipole	SPEAG	D2450V2	748	2/16/2020
System Validation Dipole	SPEAG	D2450V2	899	3/22/2020
System Validation Dipole	SPEAG	D5GHzV2	1138	8/21/2019

Other

Name of Equipment	Manufacturer	Type/Model	T Number	Serial No.	Cal. Due Date
Power Meter	Agilent	N1921A	T1270	MY55196015	1/26/2020
Power Sensor	Agilent	N1921A	T309	MY52270022	2/6/2020
Base Station Simulator	R & S	CMW500	T978	135385-Fp	2/15/2020

5. Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg and the measured 10-g SAR within a frequency band is < 3.75 W/kg. The expanded SAR measurement uncertainty must be ≤ 30%, for a confidence interval of k = 2. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.

6. Device Under Test (DUT) Information

6.1. DUT Description

Device Dimension	Overall (Length x Width): 97 mm x 83 mm Overall Diagonal: 105 mm This is a Body camera that can be used in handheld conditions and be mounted on the body with a metal clip.
Back Cover	The Back Cover is not removable
Battery Options	The rechargeable battery is not user accessible.
Test sample information	**S/N** **IMEI** **Notes** X6039501P N/A Wi-Fi/BT
Hardware Version	PVT
Software Version	0.7.57

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
Wi-Fi	2.4 GHz	802.11b 802.11g 802.11n (HT20) 802.11n (HT40)	100% (802.11b)
	5 GHz	802.11a 802.11n (HT20) 802.11n (HT40) 802.11ac (VHT20) 802.11ac (VHT40) 802.11ac (VHT80)	100% (802.11a) 100% (802.11n 20MHz BW)
	Does this device support bands 5.60 ~ 5.65 GHz? ☒ Yes ☐ No		
	Does this device support Band gap channel(s)? ☒ Yes ☐ No		
Bluetooth	2.4 GHz	BR, EDR, LE	100%

7. RF Exposure Conditions (Test Configurations)

Refer to Appendix A for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	SAR Required	Note
WLAN	Body	0 mm	Rear w/ clip	Yes	
	Extremity	0 mm	Rear	Yes	
			Edge 1 (Top)	Yes	
			Edge 2 (Right)	Yes	
			Edge 3 (Bottom)	Yes	
			Edge 4 (Left)	Yes	

8. Dielectric Property Measurements & System Check

8.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within ± 2°C of the temperature when the tissue parameters are characterized.
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.
Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.
The dielectric constant (εr) and conductivity (σ) of typical tissue-equivalent media recipes are expected to be within ± 5% of the required target values; but for SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEEE Std 1528-2013, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for εr and σ may be relaxed to ± 10%. This is limited to frequencies ≤ 3 GHz.

Tissue Dielectric Parameters
FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

Target Frequency (MHz)	Head		Body	
	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
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5800	35.3	5.27	48.2	6.00

IEC 62209-1
Refer to Table A.3 within the IEC 62209-1

Dielectric Property Measurements Results:

SAR Lab	Date	Band (MHz)	Tissue Type	Frequency (MHz)	Relative Permittivity (εr)			Conductivity (σ)		
					Measured	Target	Delta (%)	Measured	Target	Delta (%)
2	7/2/2019	2450	Head	2450	38.45	39.20	-1.91	1.86	1.80	3.28
				2400	38.52	39.30	-1.98	1.82	1.75	3.62
				2480	38.45	39.16	-1.82	1.87	1.83	2.10
2	7/2/2019	5600	Head	5600	36.30	35.53	2.16	4.85	5.06	-4.25
				5500	36.47	35.65	2.31	4.72	4.96	-4.72
				5725	36.11	35.39	2.03	5.00	5.19	-3.72
2	7/8/2019	2450	Head	2450	40.89	39.20	4.31	1.88	1.80	4.28
				2400	40.96	39.30	4.23	1.84	1.75	4.76
				2480	40.88	39.16	4.39	1.89	1.83	3.14
2	7/8/2019	5250	Head	5250	36.10	35.93	0.46	4.47	4.70	-4.85
				5150	36.23	36.05	0.51	4.38	4.60	-4.82
				5350	35.96	35.82	0.39	4.58	4.80	-4.78
2	7/8/2019	5750	Head	5750	35.24	35.36	-0.35	4.99	5.21	-4.21
				5700	35.32	35.42	-0.28	4.94	5.16	-4.27
				5850	35.05	35.30	-0.71	5.11	5.27	-3.00

8.2. System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be 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 media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

System Performance Check Measurement Conditions:

- The measurements were performed in the flat section of the TWIN SAM or ELI phantom, shell thickness: 2.0 ±0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm for measurements > 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
  For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube was chosen for the cube.
- Distance between probe sensors and phantom surface was set to 3 mm.
  For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was 100 mW.
- The results are normalized to 1 W input power.

System Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within ±10% of the manufacturer calibrated dipole SAR target. Refer to Appendix B for the SAR System Check Plots.

SAR Lab	Date	Tissue Type	Dipole Type _Serial #	Dipole Cal. Due Data	Measured Results for 1g SAR				Measured Results for 10g SAR				Plot No.
					Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	
2	7/2/2019	Head	D2450V2 SN:748	2/16/2020	4.970	49.70	52.00	**-4.42**	2.300	23.00	24.20	-4.96	1,2
2	7/2/2019	Head	D5GHzV2 SN:1138 (5.6 GHz)	8/21/2019	8.540	85.40	86.00	**-0.70**	2.430	24.30	24.60	-1.22	3,4
2	7/8/2019	Head	D2450V2 SN:899	3/22/2020	5.300	53.00	51.60	**2.71**	2.450	24.50	24.10	1.66	5,6
2	7/8/2019	Head	D5GHzV2 SN:1138 (5.25 GHz)	8/21/2019	7.910	79.10	82.60	**-4.24**	2.270	22.70	23.80	-4.62	7,8
2	7/8/2019	Head	D5GHzV2 SN:1138 (5.75 GHz)	8/21/2019	7.580	75.80	82.40	**-8.01**	2.160	21.60	23.60	-8.47	9,10

9. Conducted Output Power Measurements

9.1. Wi-Fi 2.4GHz (DTS Band)

Maximum Output Power (Tune-up Limit) for Wi-Fi 2.4 GHz

The maximum output power specified for production units are determined for all applicable 802.11 transmission modes in each standalone and aggregated frequency band. Maximum output power is measured for the highest maximum output power configuration(s) in each frequency band according to the default power measurement procedures.

For “Not required”, SAR Test reduction was applied from KDB 248227 guidance, Sec. 2.1, b), 1) when the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11b/g/n mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band. Additional output power measurements were not deemed necessary.

SAR testing is not required for OFDM mode(s) when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

Wi-Fi 2.4GHz Measured Results

Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
DSSS 2.4 GHz	802.11b	1	2412	18.70	19.37	Yes
		3	2422	21.20	21.61	
		6	2437	21.20	21.61	
		9	2452	21.00	21.61	
		11	2462	18.80	19.35	
OFDM 2.4 GHz	802.11g	1	2412		13.40	No
		3	2422		20.20	
		6	2437		20.16	
		8	2447		20.20	
		11	2462		13.10	
	802.11n (HT20)	1	2412		12.60	No
		3	2422		19.50	
		6	2437		19.52	
		8	2447		19.50	
		11	2462		12.15	
	802.11n (HT40)	3	2422		12.80	No
		5	2432		15.30	
		6	2437		15.15	
		7	2442		15.20	
		9	2452		11.22	

9.2. Wi-Fi 5GHz (U-NII Bands)

Maximum Output Power (Tune-up Limit) for Wi-Fi 5 GHz

When the same transmission mode configurations have the same maximum output power on the same channel for the 802.11 a/g/n/ac modes, the channel in the lower order/sequence 802.11 transmission mode is selected.

The maximum output power specified for production units are determined for all applicable 802.11 transmission modes in each standalone and aggregated frequency band. Maximum output power is measured for the highest maximum output power configuration(s) in each frequency band according to the default power measurement procedures.

For "Not required", SAR Test reduction was applied from KDB 248227 guidance, Sec. 2.1, b), 1) when the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band. Additional output power measurements were not deemed necessary.

Wi-Fi 5 GHz Measured Results

Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
UNII-1 5.2 GHz	802.11a	36	5180		17.12	No
		40	5200		17.00	
		44	5220		16.99	
		48	5240		16.93	
	802.11n (HT20)	36	5180	16.7	17.38	Yes
		40	5200	16.3	17.00	
		44	5220	16.3	17.01	
		48	5240	16.2	16.96	
	802.11ac (VHT20)	36	5180		17.12	No
		40	5200		17.00	
		44	5220		16.99	
		48	5240		16.93	
	802.11n (HT40)	38	5190		13.73	No
		46	5230		16.93	
	802.11ac (VHT40)	38	5190		13.73	No
		46	5230		16.93	
	802.11ac (VHT80)	42	5210		14.10	No
Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
UNII-2A 5.3 GHz	802.11a	52	5260		16.96	No
		56	5280		17.00	
		60	5300		16.80	
		64	5320		16.70	
	802.11n (HT20)	52	5260	16.3	17.04	No
		56	5280	16.5	17.00	
		60	5300	16.6	16.87	
		64	5320	16.7	16.70	
	802.11ac (VHT20)	52	5260		17.04	No
		56	5280		17.00	
		60	5300		16.87	
		64	5320		16.70	
	802.11n (HT40)	54	5270		16.99	No
		62	5310		13.20	
	802.11ac (VHT40)	54	5270		16.99	No
		62	5310		13.20	
	802.11ac (VHT80)	58	5290		13.60	No

Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
UNII-2C 5.5 GHz	802.11a	100	5500	16.9	17.94	Yes
		116	5580	17.6	19.10	
		140	5700	18.1	18.32	
		144	5720	18.2	19.25	
	802.11n (HT20)	100	5500		17.95	No
		116	5580		19.10	
		140	5700		18.34	
		144	5720		19.25	
	802.11ac (VHT20)	100	5500		17.95	No
		116	5580		19.10	
		124	5620		18.34	
		144	5720		19.25	
	802.11n (HT40)	102	5510		13.20	No
		110	5550		19.14	
		134	5670		18.10	
		142	5710		18.17	
	802.11ac (VHT40)	102	5510		13.20	No
		118	5590		19.14	
		126	5630		18.10	
		142	5710		18.17	
	802.11ac (VHT80)	106	5530		15.30	No
		122	5610		18.10	
		138	5690		18.10	
Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
UNII-3 5.8 GHz	802.11a	149	5745		17.22	No
		157	5785		16.65	
		165	5825		15.47	
	802.11n (HT20)	149	5745	16.0	17.26	Yes
		157	5785	15.2	16.68	
		165	5825	13.7	15.50	
	802.11ac (VHT20)	149	5745		17.26	No
		157	5785		16.68	
		165	5825		15.50	
	802.11n (HT40)	151	5755		17.25	No
		159	5795		16.60	
	802.11ac (VHT40)	151	5755		17.25	No
		159	5795		16.60	
	802.11ac (VHT80)	155	5775		15.99	No

9.3. Bluetooth

Maximum Output Power (Tune-up Limit) for Bluetooth

From October 2016 TCB workshop, Power and SAR measurements were performed with test software using DH5 modulation and a duty cycle of 100%.

SAR measurement is not required for the EDR and LE. When the secondary mode is ≤ ¼ dB higher than the primary mode.

Bluetooth Measured Results

Band	Mode	Ch #	Freq. (MHz)	Chain 0 Average Power (dBm)		
				Meas Pwr	Tune-up	SAR Test (Yes/No)
2.4	BR GFSK	0	2402	10.8	11.0	Yes
		39	2441	12.0	12.0	
		78	2480	10.4	11.0	
	EDR, π/4 DQPSK	0	2402	10.6	11.0	No
		39	2441	11.8	12.0	
		78	2480	10.2	11.0	
	EDR, 8-DPSK	0	2402	10.8	11.0	No
		39	2441	12.0	12.0	
		78	2480	10.4	11.0	
	LE, GFSK	0	2402	10.7	11.0	No
		19	2440	12.0	12.0	
		39	2480	10.5	11.0	

Duty Factor Measured Results

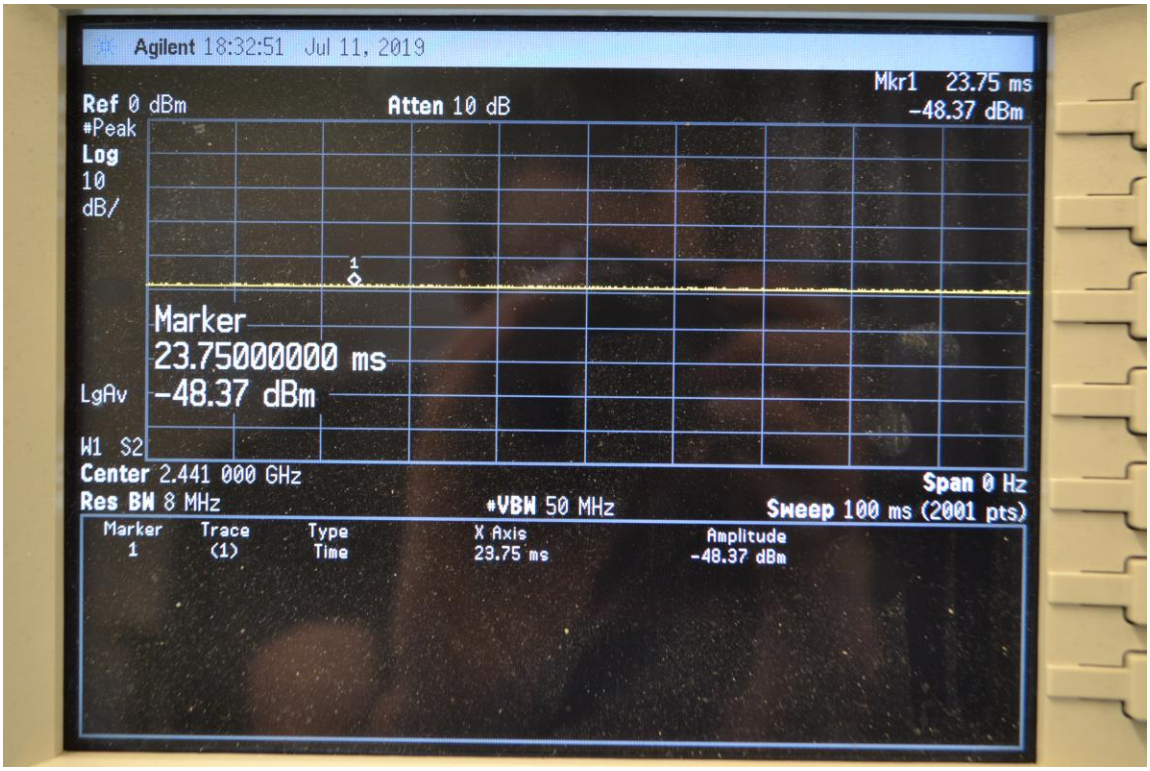
Mode	Type	T on (ms)	Period (ms)	Duty Cycle	Crest Factor (1/duty cycle)
GFSK	DH5	23.75	23.75	100.00%	1.00

Note(s):

Duty Cycle = (T on / period) * 100%

Duty Cycle plots

GFSK



10. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

- Reported SAR(W/kg) for WWAN and Bluetooth = Measured SAR *Tune-up Scaling Factor
- Reported SAR(W/kg) for Wi-Fi = Measured SAR * Tune-up scaling factor * Duty Cycle scaling factor
- Duty Cycle scaling factor = 1 / Duty cycle (%)

KDB 447498 D01 General RF Exposure Guidance:

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
- ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

KDB 248227 D01 SAR meas for 802.11:

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the *initial test position(s)* by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The *initial test position(s)* is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the *reported* SAR for the *initial test position* is:

- ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the *initial test position* to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the *reported* SAR is ≤ 0.8 W/kg or all required test positions are tested.
  - For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
  - When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the *initial test position* and subsequent test positions, when the *reported* SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the *reported* SAR is ≤ 1.2 W/kg or all required test channels are considered.
  - The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the *initial test position*, Area Scans were performed to determine the position with the *Maximum Value of SAR (measured)*. The position that produced the highest *Maximum Value of SAR* is considered the worst case position; thus used as the *initial test position*.

10.1. Wi-Fi (DTS Band)

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Body-worn	802.11b	Yes	0	Rear	6	2437	100.0%	21.6	21.2	0.039	**0.043**	1
RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		10-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Extremity	802.11b	No	0	Rear	6	2437	100.0%	21.6	21.2	0.096	0.105	
				Edge 1	6	2437	100.0%	21.6	21.2	0.070	0.077	
				Edge 2	6	2437	100.0%	21.6	21.2	0.226	**0.248**	2
				Edge 3	6	2437	100.0%	21.6	21.2	0.021	0.023	
				Edge 4	6	2437	100.0%	21.6	21.2	0.078	0.086	

10.2. Wi-Fi (U-NII Band)

UNII-1

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Body-worn	802.11n HT 20	Yes	0	Rear	36	5180	100.0%	17.38	16.70	0.078	**0.091**	3
RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		10-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Extremity	802.11n HT 20	No	0	Rear	36	5180	100.0%	17.38	16.70	0.043	0.050	
				Edge 1	36	5180	100.0%	17.38	16.70	0.014	0.016	
				Edge 2	36	5180	100.0%	17.38	16.70	0.383	**0.448**	4
				Edge 3	36	5180	100.0%	17.38	16.70	0.063	0.074	
				Edge 4	36	5180	100.0%	17.38	16.70	0.010	0.012	

UNII-2C

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Body-worn	802.11a	Yes	0	Rear	144	5720	100.0%	19.25	18.20	0.055	**0.070**	5
RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		10-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Extremity	802.11a	No	0	Rear	144	5720	100.0%	19.25	18.20	0.037	0.047	
				Edge 1	144	5720	100.0%	19.25	18.20	0.007	0.009	
				Edge 2	144	5720	100.0%	19.25	18.20	0.259	**0.330**	6
				Edge 3	144	5720	100.0%	19.25	18.20	0.031	0.039	
				Edge 4	144	5720	100.0%	19.25	18.20	0.011	0.014	

UNII-3

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Body-worn	802.11n HT 20	Yes	0	Rear	149	5745	100.0%	17.26	16.00	0.050	**0.067**	7
RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		10-g SAR (W/kg)		Plot No.
								Tune-up Limit	Meas.	Meas.	Scaled	
Extremity	802.11n HT 20	No	0	Rear	149	5745	100.0%	17.26	16.00	0.025	0.033	
				Edge 1	149	5745	100.0%	17.26	16.00	0.004	0.005	
				Edge 2	149	5745	100.0%	17.26	16.00	0.152	**0.203**	8
				Edge 3	149	5745	100.0%	17.26	16.00	0.017	0.023	
				Edge 4	149	5745	100.0%	17.26	16.00	0.005	0.007	

10.3. Bluetooth

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		Plot No.
							Tune-up Limit	Meas.	Meas.	Scaled	
Body-worn	GFSK	Yes	0	Rear	39	2441.0	12.0	12.0	<0.001	**<0.001**	9

RF Exposure Conditions	Mode	With Clip	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Power (dBm)		10-g SAR (W/kg)		Plot No.
							Tune-up Limit	Meas.	Meas.	Scaled	
Extremity	GFSK	No	0	Rear	39	2441.0	12.0	12.0	0.004	0.004	
				Edge 1	39	2441.0	12.0	12.0	0.004	0.004	
				Edge 2	39	2441.0	12.0	12.0	0.019	**0.019**	10
				Edge 3	39	2441.0	12.0	12.0	<0.001	<0.001	
				Edge 4	39	2441.0	12.0	12.0	0.008	0.008	

11. SAR Measurement Variability

In accordance with published RF Exposure KDB 865664 D01 SAR measurement 100 MHz to 6 GHz. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

1) Repeated measurement is not required when the original highest measured SAR is <0.8 or 2 W/kg (1-g or 10-g respectively); steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.8 or 2 W/kg (1-g or 10-g respectively), 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 or 3.6 W/kg (~ 10% from the 1-g or 10-g respective SAR limit).
4) Perform a third repeated measurement only if the original, first, or second repeated measurement is ≥ 1.5 or 3.75 W/kg (1-g or 10-g respectively) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

Note(s):

Repeated measurement is not required since the original highest measured SAR is <0.8 W/kg (1-g) or 2 W/kg (10-g) .

12. Simultaneous Transmission Conditions

RF Exposure Condition	Item	Capable Transmit Configurations				
Body-worn & Extremity	1	WWAN	+	Wi-Fi DTS		
	2	WWAN	+	Wi-Fi U-NII		
	3	WWAN	+	BT		
	4	WWAN	+	Wi-Fi DTS	+	BT
	5	WWAN	+	Wi-Fi U-NII	+	BT

12.1. Simultaneous transmission SAR test exclusion considerations

KDB 447498 D01 General RF Exposure Guidance provides two procedures for determining simultaneous transmission SAR test exclusion: Sum of SAR and SAR to Peak Location Ratio (SPLSR)

12.1.1. Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based upon Sum of SAR the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met.

12.2. Sum of the SAR for Body-worn WWAN & Wi-Fi & BT

RF Exposure conditions	Test Position	Standalone SAR (W/kg)				∑ 1-g SAR (W/kg)	
		1	2	3	4	1+2+4	1+3+4
		WWAN	Wi-Fi DTS	Wi-Fi U-NII	BT		
Body-worn	Rear	0.765	0.043	0.091	0.000	**0.808**	**0.856**

Conclusion:

Simultaneous transmission SAR measurement (Volume Scan) is not required because either the sum of the 1-g SAR is < 1.6 W/kg or the SPLSR is ≤ 0.04 for all circumstances that require SPLSR calculation.

12.3. Sum of the SAR for Extremity WWAN & Wi-Fi & BT

RF Exposure conditions	Test Position	Standalone SAR (W/kg)				∑ 10-g SAR (W/kg)	
		1	2	3	4	1+2+4	1+3+4
		WWAN	Wi-Fi DTS	Wi-Fi U-NII	BT		
Extremity	Rear	1.982	0.105	0.050	0.004	2.091	2.036
	Edge 1	0.182	0.077	0.016	0.004	0.263	0.202
	Edge 2	1.089	0.248	0.448	0.019	1.356	1.556
	Edge 3	2.112	0.023	0.074	0.000	**2.135**	**2.186**
	Edge 4	1.080	0.086	0.014	0.008	1.174	1.102

Conclusion:

Simultaneous transmission SAR measurement (Volume Scan) is not required because either the sum of the 10-g SAR is < 4.0 W/kg or the SPLSR is ≤ 0.10 for all circumstances that require SPLSR calculation.

Appendixes

Refer to separated files for the following appendixes.

Appendix A: SAR Setup Photos

Appendix B: SAR System Check Plots

Appendix C: SAR Highest Test Plots

Appendix D: SAR Tissue Ingredients

Appendix E: SAR Probe Certificates

Appendix F: SAR Dipole Certificates

END OF REPORT