



SAR EVALUATION REPORT

FCC 47 CFR § 2.1093

For
BLUETOOTH HEADSET

FCC ID: APITUNE220TWS
Model Name: TUNE220TWS

Report Number: 20191012-SAR-1
Issue Date: October 18, 2019

Prepared for
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Prepared by
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Revision History

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V1.0	October 18, 2019	Initial Issue	\

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1. Attestation of Test Results

Applicant Name	Harman International Industries, Inc.	
Address	8500 Balboa Boulevard, Northridge, CA 91329, UNITED STATES	
Manufacturer	Harman International Industries, Inc.	
Address	8500 Balboa Boulevard, Northridge, CA 91329, UNITED STATES	
EUT Name	BLUETOOTH HEADSET	
Model Name	TUNE220TWS	
Sample Status	Normal	
Brand	JBL	
Sample Received Date	October 12, 2019	
Date of Tested	October 17, 2019	
Applicable Standards	FCC 47 CFR § 2.1093 KDB publication	
SAR Limits (W/Kg)		
Exposure Category	Peak spatial-average(1g of tissue)	Extremities (hands, wrists, ankles, etc.) (10g of tissue)
General population / Uncontrolled exposure	1.6	4
The Highest Reported SAR (W/kg)		
RF Exposure Conditions	Equipment Class	
	DSS (BT)	
	Left ear	Right ear
Head (1-g)	0.166	0.022
Test Results	Pass	
Prepared By <i>Jacky Jiang</i> Jacky Jiang Engineer Project Associate	Reviewed By: <i>Shawn Wen</i> Shawn Wen Laboratory Leader	Approved By: <i>Stephen Guo</i> Stephen Guo Laboratory Manager

2. Test Specification, Methods and Procedures

The following FCC Published RF exposure KDB procedures:

- 447498 D01 General RF Exposure Guidance v06
- 690783 D01 SAR Listings on Grants v01r03
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02

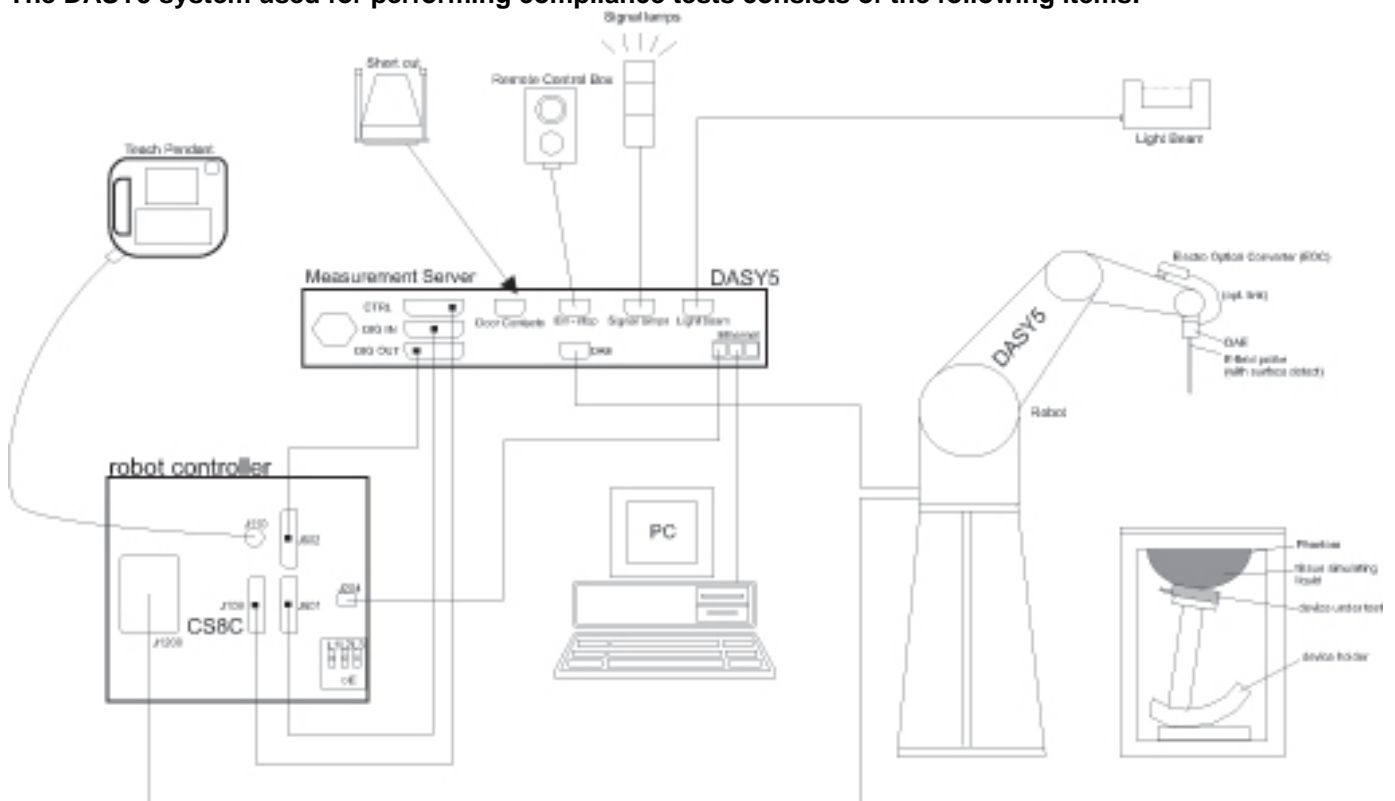
3. Facilities and Accreditation

Test Location	UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch.
Address	Building 10, Innovation Technology Park, Song Shan Lake Hi tech Development Zone, Dongguan, 523808, China
Accreditation Certificate	<p>A2LA (Certificate No.: 4102.01) UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been assessed and proved to be in compliance with A2LA.</p> <p>FCC (FCC Recognized No.: CN1187) UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been recognized to perform compliance testing on equipment subject to the Commission's Declaration of Conformity (DoC) and Certification rules</p> <p>IC(Company No.: 21320) UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been registered and fully described in a report filed with Industry Canada. The Company Number is 21320.</p> <p>VCCI (Registration No.: G-20019, R-20004, C-20012 and T-20011) UL Verification Services (Guangzhou) Co., Ltd. Song Shan Lake Branch has been assessed and proved to be in compliance with VCCI, the Membership No. is 3793.</p> <p>Facility Name: Chamber D, the VCCI registration No. is G-20019 and R-20004 Shielding Room B , the VCCI registration No. is C-20012 and T-20011</p>
Description	<p>All measurement facilities use to collect the measurement data are located at Building 10, Innovation Technology Park, Song Shan Lake Hi tech Development Zone, Dongguan, 523808, China</p> <p>This test report is only published to and used by the applicant, and it is not for evidence purpose in China.</p>

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 Win7 and the DASY52 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 v01r04 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	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ 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 v01r04 SAR Measurement 100 MHz to 6 GHz

		≤ 3 GHz	> 3 GHz	
Maximum zoom scan spatial resolution: $\Delta x_{Zoom}, \Delta y_{Zoom}$		≤ 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 1 st 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	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
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 <i>reported</i> SAR from the area scan based <i>1-g SAR estimation</i> 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.

Step 5: Z-Scan (FCC only)

The Z Scan measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. In order to get a reasonable extrapolation the extrapolated distance should not be greater than the step size in Z-direction.

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.

	Name of equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
<input checked="" type="checkbox"/>	ENA Network Analyzer	Keysight	E5080A	MY55100583	December 10, 2019
<input checked="" type="checkbox"/>	Dielectric Assessment Kit	SPEAG	SM DAK 040 SA	1155	NCR
<input checked="" type="checkbox"/>	DC power supply	Keysight	E36103A	MY55350020	December 10, 2019
<input checked="" type="checkbox"/>	Signal Generator	Rohde & Schwarz	SME06	837633\001	December 10, 2019
<input checked="" type="checkbox"/>	BI-Directional Coupler	WERLATONE	C8060-102	3423	December 10, 2019
<input checked="" type="checkbox"/>	Peak and Average Power Sensor	Keysight	E9323A	MY55440013	December 10, 2019
<input checked="" type="checkbox"/>	Peak and Average Power Sensor	Keysight	E9323A	MY55420006	December 10, 2019
<input checked="" type="checkbox"/>	Dual Channel PK Power Meter	Keysight	N1912A	MY55416024	December 10, 2019
<input checked="" type="checkbox"/>	Amplifier	CORAD TECHNOLOGY LTD	AMF-4D-00400600-50-30P	1983561	NCR
<input type="checkbox"/>	Base Station Simulator	Rohde & Schwarz	CMW500	155523	December 10, 2019
<input checked="" type="checkbox"/>	Dosimetric E-Field Probe	SPEAG	EX3DV4	7383	December 19, 2019
<input checked="" type="checkbox"/>	Data Acquisition Electronic	SPEAG	DAE3	427	December 11, 2019
<input type="checkbox"/>	Dipole Kit 750 MHz	SPEAG	D750V3	1153	December 6, 2021
<input type="checkbox"/>	Dipole Kit 835 MHz	SPEAG	D835V2	4d206	December 5, 2021
<input type="checkbox"/>	Dipole Kit 900 MHz	SPEAG	D900V2	1d190	December 5, 2021
<input type="checkbox"/>	Dipole Kit 1800 MHz	SPEAG	D1800V2	2d212	December 6, 2021
<input type="checkbox"/>	Dipole Kit 1900 MHz	SPEAG	D1900V2	5d212	December 7, 2021
<input type="checkbox"/>	Dipole Kit 2300 MHz	SPEAG	D2300V2	1065	December 4, 2021
<input checked="" type="checkbox"/>	Dipole Kit 2450 MHz	SPEAG	D2450V2	977	December 4, 2021
<input type="checkbox"/>	Dipole Kit 2600 MHz	SPEAG	D2600V2	1117	December 7, 2021
<input checked="" type="checkbox"/>	Dipole Kit 5 GHz	SPEAG	D5GHzV2	1231	December 14, 2021
<input checked="" type="checkbox"/>	Software	SPEAG	DASY52	N/A	NCR
<input checked="" type="checkbox"/>	Twin Phantom	SPEAG	SAM V5.0	1805	NCR
<input type="checkbox"/>	ELI Phantom	SPEAG	ELI V5.0	1235	NCR
<input checked="" type="checkbox"/>	Thermometer	Control Company	4242	150709653	December 6, 2019
<input checked="" type="checkbox"/>	Hygrometer	\	GX-138	\	September 5, 2019

Note:

- 1) As per KDB865664D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
 - a) There is no physical damage on the dipole;
 - b) System check with specific dipole is within 10% of calibrated value;
 - c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement.
 - d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.
- 2) Dielectric assessment kit is calibrated against air, distilled water and a shorting block performed before measuring liquid parameters.
- 3) NCR is short for "No Calibration Requirement".

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, the extensive SAR measurement uncertainty analysis described in IEEE Std. 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

6. Device Under Test (DUT) Information

6.1. DUT Description

The EUT is a portable wireless headset with BT radio.	
Device Dimension	Overall (Length x Width x Height): 43 mm x 20 mm x 24 mm
Accessory	None

6.2. Wireless Technology

Wireless technology	Frequency band
BT	2.4 GHz

7. SAR Test Configuration

The EUT is an in-ear headset, and it may extreme close to the human's head when used, so 1-g head SAR (0mm) evaluation is considered.

8. Conducted Output Power Measurement

8.1. BT (Average power)

	BT 2450	Average Conducted Power (dBm)			Duty cycle (%)
		0CH	39CH	78CH	
Left ear	DH5	9.84	9.48	8.78	58
	2DH5	9.78	9.49	8.81	\
	3DH5	9.82	9.52	8.80	\

	BT 2450	Average Conducted Power (dBm)			Duty cycle (%)
		0CH	39CH	78CH	
Right ear	DH5	10.14	9.66	8.82	58
	2DH5	10.23	9.72	8.82	\
	3DH5	10.23	9.68	8.83	\

	BT 2450	Average Conducted Power (dBm)			Duty cycle (%)
		0CH	39CH	78CH	
Left ear	BLE	4.01	4.04	3.27	\

	BT 2450	Average Conducted Power (dBm)			Duty cycle (%)
		0CH	39CH	78CH	
Right ear	BLE	4.78	5.35	4.74	\

Note:

- 1) The mode with the highest output power is selected to perform SAR evaluation as the primary mode. The other mode as the secondary mode are not required when their output power are ≤ 0.25 dB higher than the primary mode.

9. Dielectric Property Measurements & System Check

9.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within $\pm 2^\circ\text{C}$ 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.

Tissue Dielectric Parameters

FCC KDB 865664 D01 v01r04 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

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

Dielectric Property Measurements Results:

Liquid	Freq.	Liquid Parameters				Delta(%)		Limit (%)	Temp. (°C)	Test Date
		Measured		Target		ϵ_r	σ			
		ϵ_r	σ	ϵ_r	σ					
Head 2450	2360	39.88	1.68	39.36	1.72	1.32	-2.44	±5	22.2	October 17 2019
	2450	38.65	1.83	39.20	1.80	-1.40	1.44			
	2540	38.22	1.92	39.09	1.90	-2.23	1.00			

9.2. 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 10mm (above 1GHz) and 15mm (below 1GHz) from dipole center to the simulating liquid surface.
- For area scan, standard grid spacing for head measurements is 15 mm in x- and y- dimension (≤ 2 GHz), 12 mm in x- and y-dimension (2-4 GHz) and 10mm in x- and y- dimension (4-6GHz).
- For zoom scan, $\Delta x_{\text{zoom}}, \Delta y_{\text{zoom}} \leq 2$ GHz - ≤ 8 mm, 2-4GHz - ≤ 5 mm and 4-6 GHz- ≤ 4 mm; $\Delta z_{\text{zoom}} \leq 3$ GHz - ≤ 5 mm, 3-4 GHz- ≤ 4 mm and 4-6GHz- ≤ 2 mm.
- Distance between probe sensors and phantom surface was set to 3 mm except for 5 GHz band. For 5GHz band, Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was set to 100 mW or 250 mW depend on the certificate of the dipoles.
- 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.

System Dipole	T.S. Liquid		Measured Results		Target (Ref. value)	Delta (%)	Limit (%)	Temp. (°C)	Test Date
			Zoom Scan (W/Kg)	Normalize to 1W (W/Kg)					
977	Head 2450	1g	13.600	54.40	53.70	1.30	±10	22.2	October 17 2019
		10g	6.330	25.32	25.00	1.28			

10. Measured and Reported (Scaled) SAR Results

As per KDB 447498 sec.4.1.e), When SAR or MPE is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as reported.

Scaled SAR calculation formula:

Scaled SAR = Tune-up in mW / Conducted power in mW * Duty cycle (if available) * SAR value

SAR Test Reduction criteria are as follows:

KDB 447498 D01 General RF Exposure Guidance:

A) Per KDB447498 D01 v06, all SAR measurement results are scaled to the maximum tune-up tolerance limit to demonstrate SAR compliance.

B) 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.

Per KDB865664 D01 v01r04:

For each frequency band, repeated SAR measurement is required only when the measured SAR is ≥ 0.8 W/Kg; if the deviation among the repeated measurement is $\leq 20\%$, and the measured SAR < 1.45 W/Kg, only one repeated measurement is required.

10.1. SAR Test Results of BT

Test Positon (Body 0mm)	Test Mode	Channel/ Frequency	Power (dBm)		SAR Value 1g (Zoom Scan)	Power Drift	Duty Factor (%)	Scaled (W/Kg)
			Tune-up	Meas.				
Left ear								
Top surface	3DH5	39/2441	11.00	9.52	0.068	0.15	58.0	0.166
Left side	3DH5	39/2441	11.00	9.52	0.054	0.18	58.0	0.132
Right side	3DH5	39/2441	11.00	9.52	0.029	0.05	58.0	0.071
Top side	3DH5	39/2441	11.00	9.52	0.026	-0.14	58.0	0.062
Bottom side	3DH5	39/2441	11.00	9.52	0.020	0.06	58.0	0.048
Cochlea side	3DH5	39/2441	11.00	9.52	0.009	-0.16	58.0	0.022
Right ear								
Top surface	3DH5	39/2441	11.00	9.68	0.009	0.09	58.0	0.022
Left side	3DH5	39/2441	11.00	9.68	0.008	0.18	58.0	0.018
Right side	3DH5	39/2441	11.00	9.68	0.006	-0.16	58.0	0.015
Top side	3DH5	39/2441	11.00	9.68	0.006	0.09	58.0	0.015
Bottom side	3DH5	39/2441	11.00	9.68	0.006	0.10	58.0	0.015
Cochlea side	3DH5	39/2441	11.00	9.68	0.006	0.13	58.0	0.015

11. Simultaneous Transmission SAR Analysis

There is only one antenna assembled, so simultaneous transmission doesn't exist.

Appendixes

Refer to separated files for the following appendixes.

20191012-SAR-1_App A Photo

20191012-SAR-1_App B System Check Plot

20191012-SAR-1_App C Highest Test Plot

20191012-SAR-1_App D Cal. Certificates

-----End of Report-----