SAR EVALUATION REPORT

CLASS II PERMISSIVE CHANGE

FCC 47 CFR § 2.1093
IEEE Std. 1528-2013

For
Notebook Computer

FCC ID: O57IPS540A13

Model Name: Lenovo IdeaPad S540-13ARE, Lenovo IdeaPad S540-13API

Report Number: 4789547060-SAR-2

Issue Date: June 30, 2020

Prepared for
Lenovo (Shanghai) Electronics Technology Co., Ltd
Section 304-305, Building No.4, #222, Meiyue Road, China (Shanghai) Pilot Free Trade Zone
Shanghai 200131 China

Prepared by
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Revision History

Rev.	Date	Revisions	Revised By
V1.0	June 30, 2020	Initial Issue	\
V2.0	Aug 12, 2020	1.Updated the App D, added the impedance and return loss data	Jacky Jiang

Note:

1. The Measurement result for the sample received is<Pass> according to < IEEE Std. 1528-2013> when <Accuracy Method> decision rule is applied.

2. This test report is only published to and used by the applicant, and it is not for evidence purpose in China.

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1. Attestation of Test Results

Applicant Name	Lenovo (Shanghai) Electronics Technology Co., Ltd		
Address	Section 304-305, Building No.4, #222, Meiyue Road, China (Shanghai) Pilot Free Trade Zone Shanghai 200131 China		
EUT Name	Notebook Computer		
Sample Status	Normal		
Brand	Lenovo		
Model	Lenovo IdeaPad S540-13ARE		
Series Model	Lenovo IdeaPad S540-13API		
Model Difference	Lenovo IdeaPad S540-13API have the same technical construction including circuit diagram, PCB Layout, components and component layout, all electrical construction and mechanical construction with Lenovo IdeaPad S540-13ARE. The difference lies only on the difference AMD platform's CPU and model name. all these changes do not degrade the RF performance of the certified product.		
Sample Received Date	June 16, 2020		
Date of Tested	June 17, 2020 June 28, 2020		
Applicable Standards	FCC 47 CFR § 2.1093 IEEE Std. 1528-2013 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**		
	DTS	**U-NII**	**DSS**
Body (1-g)	0.789	0.744	0.052
Simultaneous Transmission (1-g)	1.533		
Test Results	Pass		
Tested By:  Jacky Jiang Engineer Project Associate	Reviewed By:  Shawn Wen Laboratory Leader	Approved By:  Stephen Guo Laboratory Manager	

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with IEEE Std. 1528-2013, the following FCC Published RF exposure KDB procedures:

- 248227 D01 802.11 Wi-Fi SAR
- 447498 D01 General RF Exposure Guidance
- 690783 D01 SAR Listings on Grants
- 865664 D01 SAR measurement 100 MHz to 6 GHz
- 865664 D02 RF Exposure Reporting
- 616217 D04 SAR for laptop and tablets

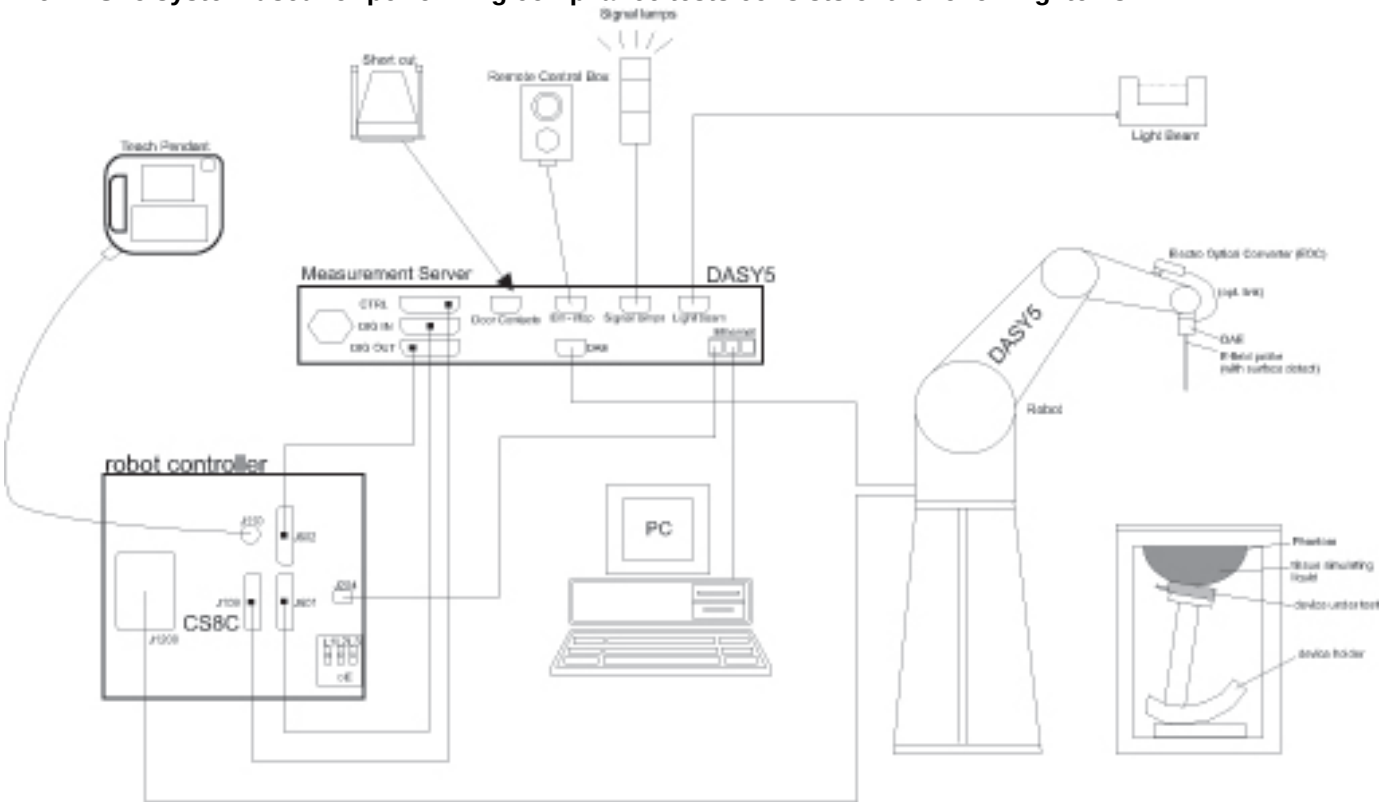
3. Facilities and Accreditation

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	**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. **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 **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. **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. 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
Description	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

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	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 v01r04 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.

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
ENA Network Analyzer	Keysight	E5080A	MY55100583	2020.12.05
Dielectric Assessment Kit	SPEAG	SM DAK 040 SA	1155	NCR
DC power supply	Keysight	E36103A	MY55350020	2020.12.04
Signal Generator	Rohde & Schwarz	SME06	837633\001	2020.12.04
BI-Directional Coupler	WERLATONE	C8060-102	3423	2020.12.04
Peak and Average Power Sensor	Keysight	E9323A	MY55440013	2020.12.05
Peak and Average Power Sensor	Keysight	E9323A	MY55420006	2020.12.05
Dual Channel PK Power Meter	Keysight	N1912A	MY55416024	2020.12.05
Amplifier	CORAD TECHNOLOGY LTD	AMF-4D-00400600-50-30P	1983561	NCR
Dosimetric E-Field Probe	SPEAG	EX3DV4	7383	2021.01.02
Data Acquisition Electronic	SPEAG	DAE3	427	2020.12.16
Dipole Kit 2450 MHz	SPEAG	D2450V2	977	2021.12.04
Dipole Kit 5 GHz	SPEAG	D5GHzV2	1231	2021.12.07
Software	SPEAG	DASY52	N/A	NCR
Twin Phantom	SPEAG	SAM V5.0	1805	NCR
ELI Phantom	SPEAG	ELI V5.0	1235	NCR
Thermometer	/	GX-138	150709653	2020.12.09
Hygrometer	VICTOR	ITHX-SD-5	18470005	2020.12.10

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 DUT is a wireless module with IEEE 802.11a/b/g/n/ac, and BT radio.	
DUT Dimension	Overall (Length x Width x Height): 30 mm x 22 mm x 3 mm
Host Dimension	Overall (Length x Width x Height): 296.9 mm x 208.5 mm x 15.95mm

The host antenna is designed for a lower peak gain in the intentional transmit frequency bands and therefore radiated performance in the intentional frequency bands and the spurious emissions out of bands are expected to be lower than that measured in the original modular approval.

6.2. Wireless Technology

Wireless technology	Frequency band
Wi-Fi	2.4 GHz
Wi-Fi	5 GHz
BT	2.4 GHz

6.3. Test signal, Output power and Test Frequencies

For 802.11 transmission modes the device was put into operation by using an own control software to program the test mode required to select the continuous transmission with 100% duty cycle.

The output power of the device was set to transmit at maximum power for all tests.

7. SAR Test Configuration

As per KDB 616217 D04, when antennas are incorporated in the keyboard section of a laptop computer, SAR is required for the bottom surface of the keyboard. Provided tablet use conditions are not supported by the laptop computer, SAR tests for bystander exposure from the edges of the keyboard and display screen of laptop computers are generally not required.

8. Conducted Output Power Measurement and tune-up tolerance

General note:

1) As per KDB 447498 sec.4.1.d) at the maximum rated output power and within the tune-up tolerance range specified for the product, but not more than 2 dB lower than the maximum tune-up tolerance limit.

8.1. Power measurement result of 2.4GHz Wi-Fi.

Mode	Channel	Frequency (MHz)	Data Rate	Chain A		Chain B		SAR Test	Duty Cycle (%)
				Average Power (dBm)	Tune-up Limit (dBm)	Average Power (dBm)	Tune-up Limit (dBm)		
802.11b	1	2412	1Mbps	19.45	19.50	19.95	20.00	Required	100
	6	2437		**20.90**	21.00	20.95	21.00		
	11	2462		19.90	20.00	**21.00**	21.00		
	12	2467		17.23	18.00	17.85	18.00	Excluded	\
	13	2472		14.82	15.00	14.64	15.00		
802.11g	1	2412	6Mbps	NMR	17.50	NMR	17.00	Excluded	
	6	2437			21.00		21.00		
	11	2462			17.00		16.50		
802.11n20	1	2412	HT0		13.50		13.50	Excluded	
	6	2437			17.00		17.00		
	11	2462			14.00		14.00		
802.11n40	3	2422			11.50		11.50	Excluded	
	6	2437			14.50		14.50		
	9	2452			12.50		12.00		

Note:
1) NMR is short for “No measurement requirement”.
2) For Channels 12,13, Per Kdb248227d01, in general these two channels require reduced output power to satisfy bandedge radiated field strength requirements at 2483.5MHz. Channels 1,6,11 are used to configure 22 MHz DSSS and 20 MHz OFDM channels for SAR measurement.

8.2. Power measurement result of 5GHz Wi-Fi.

Band	Mode	Channel	Frequency (MHz)	Data Rate	Chain A		Chain B		SAR Test
					Average power (dBm)	Tune-up Limit (dBm)	Average power (dBm)	Tune-up Limit (dBm)	
U-NII-1	802.11a	36	5180	6Mbps	NMR	16.00	NMR	17.00	Excluded
		40	5200			16.00		17.00	
		44	5220			16.00		17.00	
		48	5240			16.00		17.00	
	802.11n20	36	5180	HT0		13.00		13.00	
		40	5200			13.00		13.00	
		44	5220			13.00		13.00	
		48	5240			13.00		13.00	
	802.11n40	38	5190			15.00		15.00	
		46	5230			15.00		15.00	
	802.11ac80	42	5210	VHT0		15.00		15.00	
	802.11ac160	50	5250			15.00		15.00	
U-NII-2A	802.11a	52	5260	6Mbps	15.39	16.00	16.54	17.00	Required
		56	5280		15.45	16.00	16.57	17.00	
		60	5300		**15.99**	16.00	**16.91**	17.00	
		64	5320		15.54	16.00	16.87	17.00	
	802.11n20	52	5260	HT0	NMR	15.50	NMR	16.50	Excluded
		56	5280			15.50		16.50	
		60	5300			15.50		16.50	
		64	5320			15.50		16.50	
	802.11n40	54	5270			15.50		16.50	
		62	5310			15.50		16.50	
	802.11ac80	58	5290	VHT0		15.50		16.50	

Band	Mode	Channel	Frequency (MHz)	Data Rate	Chain A		Chain B		SAR Test
					Average power (dBm)	Tune-up Limit (dBm)	Average power (dBm)	Tune-up Limit (dBm)	
U-NII-2C	802.11a	100	5500	6Mbps	NMR	14.50	NMR	15.50	Excluded
		104	5520			14.50		15.50	
		108	5540			14.50		15.50	
		112	5560			14.50		15.50	
		116	5580			14.50		15.50	
		120	5600			14.50		15.50	
		124	5620			14.50		15.50	
		128	5640			14.50		15.50	
	802.11n20	100	5500	HT0		14.50		15.50	
		104	5520			14.50		15.50	
		108	5540			14.50		15.50	
		112	5560			14.50		15.50	
		116	5580			14.50		15.50	
		120	5600			14.50		15.50	
		124	5620			14.50		15.50	
		128	5640			14.50		15.50	
	802.11n40	102	5510		14.26	14.50	15.04	15.50	Required
		110	5550		14.10	14.50	14.98	15.50	
		118	5590		**14.38**	14.50	15.13	15.50	
		126	5630		14.23	14.50	**15.45**	15.50	
	802.11ac80	106	5530	VHT0	NMR	14.20	NMR	15.40	Excluded
		122	5610			14.20		15.40	
	802.11ac160	114	5570			14.40		15.20	

Band	Mode	Channel	Frequency (MHz)	Data Rate	Chain A		Chain B		SAR Test
					Average power (dBm)	Tune-up Limit (dBm)	Average power (dBm)	Tune-up Limit (dBm)	
U-NII-3	802.11a	132	5660	6Mbps	14.28	15.00	15.43	15.50	Required
		136	5680		14.31	15.00	15.36	15.50	
		140	5700		14.23	15.00	15.24	15.50	
		149	5745		**14.35**	15.00	15.25	15.50	
		153	5765		14.07	14.50	**15.45**	15.50	
		157	5785		14.21	14.50	15.23	15.50	
		161	5805		14.05	14.50	15.03	15.50	
		165	5825		14.33	15.00	15.40	15.50	
	802.11n20	132	5660	HT0	NMR	14.50	NMR	15.20	Excluded
		136	5680			14.50		15.20	
		140	5700			14.50		15.20	
		149	5745			14.50		15.20	
		153	5765			14.50		15.20	
		157	5785			14.50		15.20	
		161	5805			14.50		15.20	
		165	5825			14.50		15.20	
	802.11n40	134	5670			14.50		15.00	
		142	5710			14.50		15.00	
		151	5755			14.50		15.00	
		159	5795			14.50		15.00	
	802.11ac80	138	5690	VHT0		14.50		15.40	
		155	5775			14.50		15.40	

Note:
1) NMR is short for “No measurement requirement”.
2) When band gap channels between U-NII-2C and U-NII-3 band are supported channels in U-NII-2C band below 5.65 GHz are considered as one band and channels above 5.65 GHz, together with channels in 5.8 GHz U-NII-3 or § 15.247 band, are considered as a separate band.

8.3. Power measurement result BT

Band	Mode	Antenna	Average Conducted Power (dBm)			Tune-up	Duty Cycle (%)
			0CH	39CH	78CH		
2.4G	DH5	A	8.60	9.04	9.71	10	77%
	2DH5	A	NMR	NMR	NMR	9	NMR
	3DH5	A	NMR	NMR	NMR	9	NMR

Band	Mode	Antenna	Average Conducted Power (dBm)			Tune-up	Duty Cycle (%)
			0CH	19CH	39CH		
2.4G	BLE	A	NMR	NMR	NMR	9.00	62%

Note:
1) NMR is short for “No measurement requirement”.

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 ± 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.

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				Deviation(%)		Limit (%)	Temp. (℃)	Test Date
		Measured		Target						
		ϵ_r	σ	ϵ_r	σ	ϵ_r	σ			
Head 2450	2360	40.31	1.68	39.36	1.72	2.41	-2.09	±5	22.3	2020.6.17
	2450	40.21	1.80	39.20	1.80	2.58	-0.28			
	2540	39.75	1.90	39.09	1.90	1.69	-0.05			
Head 5250	5160	36.23	4.60	36.03	4.61	0.56	-0.28	±5	22.5	2020.6.27
	5250	36.09	4.73	35.93	4.71	0.45	0.42			
	5340	35.90	4.82	35.83	4.80	0.20	0.37			
Head 5600	5500	35.95	5.03	35.64	4.96	0.87	1.45	±5	21.8	2020.6.23
	5600	35.63	5.07	35.53	5.07	0.28	-0.04			
	5700	35.65	5.13	35.41	5.17	0.68	-0.83			
Head 5750	5660	36.05	5.14	35.46	5.13	1.66	0.21	±5	22.7	2020.6.26
	5750	35.68	5.32	35.36	5.22	0.90	1.84			
	5840	35.22	5.31	35.27	5.30	-0.14	0.17			

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(≤2GHz), 12 mm in x- and y-dimension(2-4 GHz) and 10mm in x- and y- dimension(4-6GHz).
- For zoom scan, Δx_{zoom}, Δy_{zoom}≤ 2GHz - ≤8mm, 2-4GHz - ≤5 mm and 4-6 GHz-≤4mm; Δz_{zoom} ≤3GHz - ≤5 mm, 3-4 GHz- ≤4mm and 4-6GHz-≤2mm.
- 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.

T.S. Liquid		Measured Results		Target (Ref. value)	Delta (%)	Limit (%)	Temp. (℃)	Test Date
		Zoom Scan (W/Kg)	Normalize to 1W (W/Kg)					
Head 2450	1-g	12.700	50.80	53.70	-5.40	±10	23.1	2020.6.17
	10-g	5.850	23.40	25.00	-6.40			
Head 5250	1-g	7.860	78.60	78.60	0.00	±10	22.1	2020.6.27
	10-g	2.270	22.70	22.50	0.89			
Head 5600	1-g	8.170	81.70	81.20	0.62	±10	22.5	2020.6.23
	10-g	2.320	23.20	23.40	-0.85			
Head 5750	1-g	8.270	82.70	80.00	3.37	±10	22.7	2020.6.26
	10-g	2.360	23.60	22.80	3.51			

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 ≥0.8W/Kg; if the deviation among the repeated measurement is ≤ 20%, and the measured SAR <1.45W/Kg, only one repeated measurement is required.

Per KDB 248227 D01 v02r02:

For Wi-Fi SAR testing, a communication link is set up with the testing software for Wi-Fi mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The RF signal utilized in SAR measurement has 100% duty cycle and its crest factor is 1. The test procedures in KDB 248227 D01 v02r02 are applied. (Refer to KDB 248227D01 v02r02 for more details)

Initial Test Position Procedure

For exposure condition with multiple test position, such as handsets operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When reported SAR for the initial test position is ≤ 0.4W/kg, no additional testing for the remaining test position is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8W/kg or all test position are measured. For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions /configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Initial Test Configuration Procedure

An initial test configuration is determined for OFDM transmission modes according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. SAR is measured using the highest measured maximum output power channel. For configurations with the same specified or measured maximum output power, additional transmission mode and test channel selection procedures are required (see section 5.3.2 of KDB 248227D01

v02r02). SAR test reduction of subsequent highest output test channels is based on the reported SAR of the initial test configuration.
For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode. For fixed exposure conditions that do not have multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration. When the reported SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for the subsequent next highest measured output power channel(s) in the initial test configuration until the reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Sub Test Configuration Procedure

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units.
When the highest reported SAR for the initial test configuration, according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.

Note:
1) The same procedure is applied to extremity SAR evaluation, and the corresponding limitation is 2.5 times of 1-g SAR.

10.1. SAR Test Results of 2.4G Wi-Fi

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
ANT A								
Bottom surface	802.11b	6/2437	21.00	20.90	0.771	-0.19	100.00	0.789
ANT B								
Bottom surface	802.11b	11/2462	21.00	21.00	0.365	-0.18	100.00	0.365
Worst case with ICT Antenna platform								
Bottom surface	802.11b	6/2437	21.00	20.90	0.600	0.06	100.00	0.614

OFDM mode SAR evaluation exclusion analysis for 1-g SAR for ANT

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11b	21	125.89	0.717	\	\
802.11g	21	125.89	\	0.717	Excluded
802.11n20	17	50.12	\	0.285	Excluded
802.11n 40	14.5	28.18	\	0.161	Excluded

Note:
1) The highest reported SAR for DSSS adjusted by the ratio of OFDM 802.11g/n to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, so SAR evaluation for 802.11g/n/ax is not required.

10.2. SAR Test Results of 5G Wi-Fi

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
ANT A								
U-NII-2A								
Bottom surface	802.11a	60/5300	16.0	15.99	0.735	-0.01	100.0	0.737
U-NII-2C								
Bottom surface	802.11n40	118/5590	14.5	14.38	0.676	0.02	100.0	0.695
U-NII-3								
Bottom surface	802.11a	149/5745	15.0	14.35	0.475	0.13	100.0	0.552
ANT B								
U-NII-2A								
Bottom surface	802.11a	60/5300	17.0	16.91	0.649	0.04	100.0	0.663
U-NII-2C								
Bottom surface	802.11n40	126/5630	15.5	15.45	0.735	0.15	100.0	0.744
U-NII-3								
Bottom surface	802.11a	153/5765	15.5	15.45	0.709	0.05	100.0	0.717
Worst case with ICT Antenna platform								
Bottom surface	802.11a	60/5300	16.0	15.99	0.602	-0.02	100.0	0.603

Subsequent test configuration SAR evaluation exclusion analysis for U-NII-2A band

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11a	17	50.12	0.737	\	\
802.11n20	16.5	44.67	\	0.657	Excluded
802.11n40	16.5	44.67	\	0.657	Excluded
802.11ac80	16.5	44.67	\	0.657	Excluded
802.11ac160	16.5	44.67	\	0.657	Excluded

Note:

1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for U-NII-2C band

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11 n40	15.5	35.48	0.744	\	\
802.11a	15.5	35.48	\	0.744	Excluded
802.11n20	15.5	35.48	\	0.744	Excluded
802.11ac80	15.4	28.18	\	0.727	Excluded
802.11ac160	15.2	28.18	\	0.694	Excluded

Note:

1) The 802.11n40 mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

Subsequent test configuration SAR evaluation exclusion analysis for U-NII-3 band

Mode	Tune-up (dBm)	Tune-up (mW)	Highest Reported SAR (W/Kg)	Adjusted SAR (W/Kg)	SAR Test
802.11 a	15.5	35.48	0.717	\	\
802.11n20	15.2	31.62	\	0.669	Excluded
802.11n40	15.0	31.62	\	0.639	Excluded
802.11ac80	15.4	31.62	\	0.701	Excluded

Note:

1) The 802.11a mode is selected as Initial Test Configuration for SAR test according to the specified maximum output power. As the highest reported SAR for the initial test configuration is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR test for the other 802.11 modes are not required.

10.3. SAR Test Results of 2.4GHz-DSS

Test Position	Test Mode	Channel/ Frequency	Power (dBm)		Measured SAR Value	Power Drift	Duty Cycle (%)	Scaled (W/Kg)
			Tune-up	Meas.	1-g (W/Kg)			
Result with SPD Antenna platform								
Bottom surface	Bluetooth/DH5	78/2480	11.50	11.10	0.037	0.13	77.0	0.052
Result with ICT Antenna platform								
Bottom surface	Bluetooth/DH5	78/2480	11.50	11.10	0.036	0.18	77.0	0.051

11. Simultaneous Transmission SAR Analysis

According to FCC OET KDB447498 D01, when the sum of 1g SAR for all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration.

Depend on the description of coexistence mode on the module certification report, the Wi-Fi and BT can transmit simultaneously, but 2.4G and 5G can't transmit an the same time.

11.1. Simultaneous Transmission calculation WLAN and BT antenna.

All the value stated in the table below are the worst case found for standalone measurement with disregard of the transmission mode or channel where the worst case was found.

Antenna	Position	Highest Reported SAR(1g)(W/kg)		
		WLAN 2.4GHz	WLAN 5GHz	Bluetooth
ANT A	Bottom Surface	0.789	0.737	0.052
ANT B	Bottom Surface	0.365	0.744	/

Position	Simultaneous Tx Antenna Combination		∑SAR 1g (W/kg)	Limit SAR (W/kg)
	ANT A	ANT B		
Bottom surface	WLAN 5GHz	WLAN 5GHz	1.481	1.6
	WLAN 5GHz+BT	WLAN 5GHz	1.533	
	BT	WLAN 5GHz	0.796	
	WLAN 2.4GHz	WLAN 2.4GHz	1.154	
	BT	WLAN 2.4GHz	0.417	

Note:
1) For 2.4G and 5G SAR was evaluated for SISO mode. The SAR distributions in MIMO mode were verified and the hot spots were sufficiently separated such that the two chains can be treated independently. So the highest SAR value across both chains in SISO mode represents the SAR value for MIMO mode.
2) Because the maximum SUM 1-g SAR ≤ 1.6 W/Kg, so the SPLSR analysis is not required.

Appendixes

Refer to separated files for the following appendixes.

4789547060-SAR-2_App A Photo

4789547060-SAR-2_App B System Check Plots

4789547060-SAR-2_App C Highest Test Plots

4789547060-SAR-2_App D Cal. Certificates

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