FCC SAR TEST REPORT

The following samples were submitted and identified on behalf of the client as:

EUT Description	GSM/WCDMA/LTE Phone with BT, DTS/UNII a/b/g/n/ac, GPS and NFC
Company Name	Sony Mobile Communications, Inc.
Company Address	4-12-3 Higashi-shinagawa, Shinagawa-ku, Tokyo, 140-0002, Japan
Standards	IEEE/ANSI C95.1-1992, IEEE 1528-2013, KDB 248227D01v02r02, KDB 865664 D01v01r04, KDB 865664 D02v01r02, KDB 941225 D01v03r01, KDB 941225 D06v02r01, KDB 447498 D01v06, KDB 941225 D05v02r05, KDB 648474 D04 v01r03
FCC ID	PY7-10933K
Date of Receipt:	2020-11-19
Date of Test:	2020-11-20 to 2021-01-29
Date of Issue:	2021-02-02
Test Result:	**PASS ***

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this tes do not relate to other samples of the same product. The manufacturer should ensure that all proc series production are in conformity with the product sample detailed in this report.

Signed on behalf of SGS

Sr. Engineer	**Supervisor**
Jackson Li	**Simon Ling**
Date: Feb. 02, 2021	**Date: Feb. 02, 2021**

Authorized Signature:

Derek Yang

Wireless Laboratory Manager

The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS International Electrical Approvals or testing done by SGS International Electrical Approvals in connection with, distribution or use of the product described in this report must be approved by SGS International Electrical Approvals in writing.

REVISION HISTORY

Report Number	Revision	Description	Issue Date
ZR/2020/B003007	00	Original	2021-01-22
ZR/2020/B003007	01	1st revised	2021-01-29
ZR/2020/B003007	02	2st revised	2021-02-02

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1 General Information

1.1 Testing Laboratory

Company:	SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch E&E Lab
Address:	No. 1 Workshop, M-10, Middle section, Science & Technology Park, Shenzhen, Guangdong, China
Post code:	518057
Telephone:	+86 (0) 755 2601 2053
Fax:	+86 (0) 755 2671 0594
E-mail:	ee.shenzhen@sgs.com

1.2 Details of Applicant

Applicant:	Sony Mobile Communications, Inc.
Address:	4-12-3 Higashi-shinagawa, Shinagawa-ku, Tokyo, 140-0002, Japan
Manufacturer:	Sony Mobile Communications, Inc.
Address:	4-12-3 Higashi-shinagawa, Shinagawa-ku, Tokyo, 140-0002, Japan
Factory:	Dong Guan Huabel Electronic Technology Co.,Ltd
Address:	No.9 Industrial Northern Road,National High-Tech Industrial Development Zone,SongShan Lake,Dong Guan City

1.3 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

• CNAS (No. CNAS L2929)

CNAS has accredited SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab to ISO/IEC 17025:2017 General Requirements for the Competence of Testing and Calibration Laboratories (CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence in the field of testing.

• A2LA (Certificate No. 3816.01)

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation (A2LA). Certificate No. 3816.01.

• VCCI

The 10m Semi-anechoic chamber and Shielded Room of SGS-CSTC Standards Technical Services Co., Ltd. have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-823, R-4188, T-1153 and C-2383 respectively.

• FCC –Designation Number: CN1178

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized as an accredited testing laboratory.

Designation Number: CN1178. Test Firm Registration Number: 406779.

• Industry Canada (IC)

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized by ISED as an accredited testing laboratory.

CAB identifier: CN0006

IC#: 4620C.

1.4 Description of EUT

EUT Description	GSM/WCDMA/LTE Phone with BT, DTS/UNII a/b/g/n/ac, GPS and NFC			
FCC ID	PY7-10933K			
SN:	HQ60AT5799/HQ60AT5785			
Hardware Version:	A			
Software Version:	0.141			
Mode of Operation	☒GSM ☒GPRS ☒EGPRS ☒WCDMA ☒HSDPA ☒HSUPA ☐HSPA+ ☒LTE FDD ☐LTE TDD ☒WIFI 2.4G 802.11 b/g/n(20M) ☒WIFI 5G 802.11 a/ac(20M/40M/80M)/n(20M/40M) ☒Bluetooth			
Duty Cycle	GSM	1/8.3		
	GPRS (support multi class 12 max)	1/2.075 (1Dn4UP) 1/2.77 (1Dn3UP) 1/4.15 (1Dn2UP) 1/8.3 (1Dn1UP)		
	LTE FDD	1:1		
	WCDMA	1:1		
	WLAN802.11 b	99.49%		
	WLAN802.11 a	96.76%		
	Bluetooth	76.92%		
TX Frequency Range (MHz)	GSM850	824	–	849
	GSM1900	1850	–	1910
	WCDMA Band V	824	–	849
	LTE FDD Band 5	824	–	849
	LTE FDD Band 12	699	–	716
	WiFi 2.4GHz	2412	–	2462
	WiFi 5GHz	5150	–	5350
		5470	–	5850
	Bluetooth	2402	–	2480

Note: This project not supports WLAN 5GHz Hotspot(All band).

TEST SUMMARY

Frequency Band	Maximum Reported SAR(W/kg)		
	Head	**Body-worn**	**Hotspot**
GSM850	0.51	**0.50**	0.79
GSM1900	0.17	0.19	**0.94**
WCDMA Band V	0.30	0.28	0.40
LTE Band 5	0.26	0.22	0.34
LTE Band 12	0.13	0.14	0.16
WI-FI (2.4GHz)	**0.67**	0.39	0.19
WI-FI (5GHz)	0.66	0.21	/
BT	/	/	/
SAR Limited(W/kg)	1.6		
Maximum Simultaneous Transmission SAR (W/kg)			
Scenario	**Head**	**Body-worn**	**Hotspot**
Sum SAR	1.02	0.89	0.94
SPLSR	N/A	N/A	N/A
SPLSR Limited	0.04		

DUT Antenna Locations:

Please see the Appendix D for antenna locations.

The test device is a mobile phone. The overall diagonal dimension of this device is 142.0 mm.

According to the distance between LTE/WCDMA/GSM&WIFI&BT antennas and the sides of the EUT we can draw the conclusion that:

EUT Sides for SAR Testing						
Mode	Front	Back	Left	Right	Top	Bottom
Main Ant	Yes	Yes	Yes	Yes	No	Yes
WIFI&BT Ant	Yes	Yes	No	Yes	Yes	No

Table 1： EUT Sides for SAR Testing

Note:
1) When the antenna-to-edge distance is greater than 2.5cm, such position does not need to be tested.

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Power reduction by country code detection mechanism:

This device uses the mobile country code (MCC) to indicate whether the users in CE countries or FCC countries. The selection between CE countries and FCC countries power levels is based on the country code detection mechanism. It can determine the countries where users are and set the relevant power level for 2G antenna accordingly.

Antenna Power Level (dBm)	
Band	MCC OF FCC COUNTRY (FCC standard)
GSM1900	27.0
WiFi 2.4G 802.11b	14.5
WiFi 2.4G 802.11g	12.0
WiFi 2.4G 802.11n 20M	11.5

Based on the summery table of countries detection mechanism above, we plan to perform the SAR test as below:
For conducted power test, both the full power level and reduced power level will be tested by setting different MCC to validate that the country code detection mechanism works.

For FCC SAR test:
For FCC SAR test, SAR test should be evaluated at the power level of FCC mobile country code for each exposure conditions.

GSM - conducted power table:

GSM 850									
Burst Output Power(dBm)					Tune up	Division Factors	Frame-Average Output Power(dBm)			Tune up
Channel		128	190	251			128	190	251	
GSM(GMSK)	GSM	32.86	32.89	32.89	34.00	-9.19	23.67	23.70	23.70	24.81
GPRS/ EGPRS (GMSK)	1 TX Slot	32.86	32.84	32.77	34.00	-9.19	23.67	23.65	23.58	24.81
	2 TX Slots	32.14	32.02	31.93	32.50	-6.18	25.96	25.84	25.75	26.32
	3 TX Slots	30.24	30.01	29.90	31.00	-4.42	25.82	25.59	25.48	26.58
	4 TX Slots	29.19	**29.05**	28.85	30.00	-3.17	26.02	25.86	25.68	**26.83**
EGPRS (8PSK)	1 TX Slot	26.89	26.95	26.92	27.00	-9.19	17.70	17.76	17.73	17.81
	2 TX Slots	25.99	25.85	25.79	26.00	-6.18	19.81	19.67	19.61	19.82
	3 TX Slots	23.79	23.90	23.88	24.00	-4.42	19.37	19.48	19.46	19.58
	4 TX Slots	22.74	22.71	22.67	23.00	-3.17	19.57	19.54	19.50	19.83
GSM 1900										
Burst Output Power(dBm)					Tune up	Division Factors	Frame-Average Output Power(dBm)			Tune up
Channel		512	661	810			512	661	810	
GSM(GMSK)	GSM	26.12	26.08	26.10	27.00	-9.19	16.93	16.89	16.91	17.81
GPRS/ EGPRS (GMSK)	1 TX Slot	26.13	26.11	26.09	27.00	-9.19	16.94	16.92	16.90	17.81
	2 TX Slots	24.95	24.91	24.94	25.00	-6.18	18.77	18.73	18.76	18.82
	3 TX Slots	22.94	22.89	22.96	23.00	-4.42	18.52	18.47	18.54	18.58
	4 TX Slots	**21.93**	**21.86**	**21.90**	22.00	-3.17	18.76	18.69	18.73	**18.83**
EGPRS (8PSK)	1 TX Slot	22.75	22.86	22.70	23.00	-9.19	13.56	13.67	13.51	13.81
	2 TX Slots	21.86	21.75	21.63	22.00	-6.18	15.68	15.57	15.45	15.82
	3 TX Slots	19.85	19.52	19.56	20.00	-4.42	15.43	15.10	15.14	15.58
	4 TX Slots	17.98	17.89	17.99	18.00	-3.17	14.81	14.72	14.82	14.83

Note:

1）. CMW500 measures GSM peak and average output power for active timeslots. For SAR the time based average power is relevant. The difference in between depends on the duty cycle of the TDMA signal:

No. of timeslots	1	**2**	3	**4**
Duty Cycle	1:8.3	1:4.15	1:2.77	1:2.075
Time based avg. power compared to slotted avg. power	-9.19	-6.18	-4.42	-3.17

2）. The frame-averaged power is linearly proportion to the slot number configured and it is linearly scaled the maximum burst-averaged power based on time slots. The calculated method is shown as below:

Frame-averaged power = 10 x log (Burst-averaged power mW x Slot used / 8

3）. When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel must be used

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WCDMA - conducted power table:

WCDMA Band V					
Average Conducted Power(dBm)					
Channel		4132	4182	4233	Tune up
WCDMA	12.2kbps RMC	22.68	**22.75**	22.70	24.00
	12.2kbps AMR	22.60	22.67	22.59	24.00
HSDPA	Subtest 1	21.98	22.05	22.09	23.00
	Subtest 2	21.96	22.02	22.07	23.00
	Subtest 3	21.50	21.56	21.62	22.50
	Subtest 4	21.46	21.58	21.63	22.50
HSUPA	Subtest 1	19.94	20.06	20.09	20.50
	Subtest 2	20.00	20.04	20.14	20.50
	Subtest 3	20.97	21.08	21.13	21.50
	Subtest 4	19.52	19.61	19.68	20.00
	Subtest 5	21.00	21.10	21.17	21.50

LTE - conducted power table:

LTE Band 5				Conducted Power(dBm)			
Bandwidth	Modulation	RB size	RB offset	Channel 20407	Channel 20525	Channel 20643	Tune up
1.4MHz	QPSK	1	0	22.32	22.33	22.37	24.00
		1	2	22.48	22.50	22.65	24.00
		1	5	22.36	22.34	22.54	24.00
		3	0	22.44	22.44	22.49	24.00
		3	2	22.43	22.50	22.56	24.00
		3	3	22.32	22.47	22.51	24.00
		6	0	21.45	21.52	21.48	23.00
	16QAM	1	0	21.52	21.84	21.32	23.00
		1	2	21.46	21.72	22.03	23.00
		1	5	21.68	21.47	21.52	23.00
		3	0	21.45	21.55	21.49	23.00
		3	2	21.53	21.45	21.48	23.00
		3	3	21.49	21.64	21.57	23.00
		6	0	20.51	20.47	20.50	22.00
Bandwidth	Modulation	RB size	RB offset	Channel 20415	Channel 20525	Channel 20635	Tune up
3MHz	QPSK	1	0	22.47	22.45	22.47	24.00
		1	7	22.55	22.51	22.52	24.00
		1	14	22.32	22.46	22.53	24.00
		8	0	21.43	21.42	21.50	23.00
		8	4	21.57	21.41	21.47	23.00
		8	7	21.35	21.40	21.44	23.00
		15	0	21.41	21.42	21.49	23.00
	16QAM	1	0	21.84	21.85	21.51	23.00
		1	7	21.97	22.14	21.69	23.00
		1	14	21.61	21.41	21.66	23.00
		8	0	20.46	20.56	20.64	22.00
		8	4	20.57	20.52	20.70	22.00
		8	7	20.35	20.30	20.68	22.00
		15	0	20.32	20.57	20.48	22.00

Bandwidth	Modulation	RB size	RB offset	Channel 20425	Channel 20525	Channel 20625	Tune up
5MHz	QPSK	1	0	22.28	22.37	22.42	24.00
		1	13	22.54	22.36	22.51	24.00
		1	24	22.32	22.32	22.43	24.00
		12	0	21.36	21.40	21.54	23.00
		12	6	21.49	21.46	21.46	23.00
		12	13	21.51	21.39	21.52	23.00
		25	0	21.34	21.45	21.56	23.00
	16QAM	1	0	21.81	21.48	21.51	23.00
		1	13	22.03	21.51	22.03	23.00
		1	24	21.26	21.47	21.82	23.00
		12	0	20.46	20.42	20.51	22.00
		12	6	20.50	20.40	20.48	22.00
		12	13	20.44	20.50	20.47	22.00
		25	0	20.48	20.41	20.37	22.00
Bandwidth	Modulation	RB size	RB offset	Channel 20450	Channel 20525	Channel 20600	Tune up
10MHz	QPSK	1	0	22.29	22.51	22.26	24.00
		1	25	22.47	**22.72**	22.52	24.00
		1	49	22.23	22.41	22.54	24.00
		25	0	21.48	21.55	21.45	23.00
		25	13	21.44	**21.58**	21.52	23.00
		25	25	21.49	21.50	21.43	23.00
		50	0	21.43	21.50	21.48	23.00
	16QAM	1	0	21.37	21.36	21.53	23.00
		1	25	22.09	21.70	21.65	23.00
		1	49	22.02	21.64	21.67	23.00
		25	0	20.51	20.54	20.51	22.00
		25	13	20.48	20.50	20.54	22.00
		25	25	20.39	20.57	20.39	22.00
		50	0	20.48	20.51	20.41	22.00

LTE Band 12				Conducted Power(dBm)			
Bandwidth	Modulation	RB size	RB offset	Channel 23017	Channel 23095	Channel 23173	Tune up
1.4MHz	QPSK	1	0	22.26	22.34	22.24	24.00
		1	2	22.50	22.36	22.47	24.00
		1	5	22.30	22.17	22.32	24.00
		3	0	22.39	22.33	22.43	24.00
		3	2	22.38	22.32	22.34	24.00
		3	3	22.45	22.38	22.47	24.00
		6	0	21.54	21.36	21.51	23.00
	16QAM	1	0	21.54	21.28	21.37	23.00
		1	2	22.01	21.99	22.03	23.00
		1	5	21.64	21.59	21.61	23.00
		3	0	21.55	21.30	21.43	23.00
		3	2	21.56	21.50	21.46	23.00
		3	3	21.51	21.34	21.39	23.00
		6	0	20.73	20.41	20.40	22.00
Bandwidth	Modulation	RB size	RB offset	Channel 23025	Channel 23095	Channel 23165	Tune up
3MHz	QPSK	1	0	22.35	22.35	22.23	24.00
		1	7	22.55	22.32	22.39	24.00
		1	14	22.35	22.40	22.32	24.00
		8	0	21.38	21.45	21.47	23.00
		8	4	21.40	21.48	21.43	23.00
		8	7	21.54	21.46	21.43	23.00
		15	0	21.49	21.48	21.45	23.00
	16QAM	1	0	21.99	21.60	21.94	23.00
		1	7	22.20	21.86	21.71	23.00
		1	14	21.35	21.96	21.63	23.00
		8	0	20.63	20.53	20.47	22.00
		8	4	20.56	20.43	20.46	22.00
		8	7	20.40	20.51	20.56	22.00
		15	0	20.53	20.45	20.54	22.00

Bandwidth	Modulation	RB size	RB offset	Channel 23035	Channel 23095	Channel 23155	Tune up
5MHz	QPSK	1	0	22.23	22.26	22.19	24.00
		1	13	22.21	22.34	22.42	24.00
		1	24	22.36	22.24	22.32	24.00
		12	0	21.44	21.46	21.46	23.00
		12	6	21.44	21.47	21.52	23.00
		12	13	21.42	21.45	21.35	23.00
		25	0	21.34	21.36	21.42	23.00
	16QAM	1	0	21.52	21.28	21.73	23.00
		1	13	21.45	21.42	21.33	23.00
		1	24	21.86	21.48	21.33	23.00
		12	0	20.32	20.50	20.49	22.00
		12	6	20.50	20.50	20.53	22.00
		12	13	20.45	20.40	20.34	22.00
		25	0	20.52	20.49	20.41	22.00
Bandwidth	Modulation	RB size	RB offset	Channel 23060	Channel 23095	Channel 23130	Tune up
10MHz	QPSK	1	0	22.35	22.29	22.26	24.00
		1	25	22.34	22.38	22.31	24.00
		1	49	22.35	**22.44**	22.35	24.00
		25	0	21.43	21.51	**21.56**	23.00
		25	13	21.46	21.46	21.54	23.00
		25	25	21.49	21.41	21.52	23.00
		50	0	21.54	21.52	21.50	23.00
	16QAM	1	0	21.87	21.59	21.91	23.00
		1	25	22.06	21.84	21.76	23.00
		1	49	21.97	21.93	21.34	23.00
		25	0	20.46	20.45	20.52	22.00
		25	13	20.48	20.39	20.50	22.00
		25	25	20.55	20.50	20.40	22.00
		50	0	20.49	20.56	20.50	22.00

WiFi 2.4G - conducted power table:

WiFi 2.4G						
Mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11b	1	2412	1	13.00	11.84	NO
	2	2417		14.50	13.55	NO
	6	2437		14.50	**14.12**	Yes
	11	2462		14.50	13.87	NO
802.11g	1	2412	6	11.00	10.37	NO
	2	2417		12.00	11.43	NO
	6	2437		12.00	11.94	NO
	11	2462		12.00	11.99	NO
802.11n 20M	1	2412	6.5	10.50	9.87	NO
	2	2417		11.50	10.57	NO
	6	2437		11.50	11.18	NO
	11	2462		11.50	11.04	NO

WiFi 5G - conducted power table:

5GHz	mode	Channel	Frequency (MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11a	U-NII-1	36	5180	6	15.00	13.91	NO
		40	5200		16.00	**15.22**	**Yes**
		44	5220		16.00	15.14	NO
		48	5240		16.00	15.19	NO
	U-NII-2A	52	5260		16.00	15.25	NO
		56	5280		16.00	15.27	NO
		60	5300		16.00	15.28	NO
		64	5320		16.00	**15.34**	**Yes**
	U-NII-2C	100	5500		16.00	15.25	NO
		104	5520		16.00	15.23	NO
		108	5540		16.00	15.22	NO
		112	5560		16.00	**15.41**	**Yes**
		116	5580		16.00	15.26	NO
		120	5600		16.00	15.04	NO
		124	5620		16.00	15.00	NO
		128	5640		16.00	15.05	NO
		132	5660		16.00	15.16	NO
		136	5680		16.00	15.07	NO
		140	5700		15.00	14.05	NO
		144	5720		15.00	14.08	NO
	U-NII-3	149	5745		16.00	15.59	NO
		153	5765		16.00	15.64	NO
		157	5785		16.00	**15.83**	**Yes**
		161	5805		16.00	15.81	NO
		165	5825		16.00	15.23	NO
5GHz	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11n-HT20	U-NII-1	36	5180	MCS0	14.50	13.96	NO
		40	5200		15.50	14.50	NO
		44	5220		15.50	14.44	NO
		48	5240		15.50	14.68	NO
	U-NII-2A	52	5260		15.50	14.62	NO
		56	5280		15.50	14.85	NO
		60	5300		15.50	14.70	NO
		64	5320		15.50	14.81	NO
	U-NII-2C	100	5500		15.50	14.82	NO
		104	5520		15.50	14.72	NO
		108	5540		15.50	14.87	NO
		112	5560		15.50	15.05	NO
		116	5580		15.50	14.87	NO

		120	5600		15.50	14.41	NO
		124	5620		15.50	14.43	NO
		128	5640		15.50	14.53	NO
		132	5660		15.50	14.38	NO
		136	5680		15.50	14.53	NO
		140	5700		14.50	14.07	NO
		144	5720		14.50	14.02	NO
	U-NII-3	149	5745		15.50	14.43	NO
		153	5765		15.50	14.51	NO
		157	5785		15.50	14.35	NO
		161	5805		15.50	14.38	NO
		165	5825		15.50	14.40	NO
5GHz	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11n-HT40	U-NII-1	38	5190	MCS0	15.50	14.55	NO
		46	5230		15.50	14.72	NO
	U-NII-2A	54	5270		15.50	14.75	NO
		62	5310		15.50	14.62	NO
	U-NII-2C	102	5510		15.50	14.71	NO
		110	5550		15.50	14.82	NO
		118	5590		15.50	14.78	NO
		126	5630		15.50	14.48	NO
		134	5670		15.50	14.50	NO
		142	5710		15.50	14.44	NO
	U-NII-3	151	5755		15.50	14.37	NO
		159	5795		15.50	14.49	NO
5GHz	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11ac 20M	U-NII-1	36	5180	MCS0	13.50	12.34	NO
		40	5200		14.50	13.38	NO
		44	5220		14.50	13.44	NO
		48	5240		14.50	13.52	NO
	U-NII-2A	52	5260		14.50	13.82	NO
		56	5280		14.50	13.87	NO
		60	5300		14.50	13.65	NO
		64	5320		14.50	13.56	NO
	U-NII-2C	100	5500		14.50	13.66	NO
		104	5520		14.50	13.83	NO
		108	5540		14.50	13.71	NO
		112	5560		14.50	13.64	NO
		116	5580		14.50	13.70	NO
		120	5600		14.50	13.83	NO
		124	5620		14.50	13.88	NO
		128	5640		14.50	13.93	NO
		132	5660		14.50	13.79	NO

		136	5680		14.50	13.90	NO
		140	5700		13.50	13.04	NO
		144	5720		13.50	13.02	NO
	U-NII-3	149	5745		14.50	13.54	NO
		153	5765		14.50	13.48	NO
		157	5785		14.50	13.53	NO
		161	5805		14.50	13.35	NO
		165	5825		14.50	13.45	NO
5GHz	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11ac 40M	U-NII-1	38	5190	MCS0.	14.50	13.56	NO
		46	5230		14.50	13.68	NO
	U-NII-2A	54	5270		14.50	13.86	NO
		62	5310		14.50	13.69	NO
	U-NII-2C	102	5510		14.50	13.84	NO
		110	5550		14.50	14.06	NO
		118	5590		14.50	13.82	NO
		126	5630		14.50	13.90	NO
		134	5670		14.50	13.83	NO
		142	5710		14.50	13.77	NO
	U-NII-3	151	5755		14.50	13.31	NO
		159	5795		14.50	13.48	NO
5GHz	mode	Channel	Frequency(MHz)	Data Rate(Mbps)	Tune up	Average Power (dBm)	SAR Test
802.11ac 80M	U-NII-1	42	5210	MCS0	14.50	13.50	NO
	U-NII-2A	58	5290		14.50	13.77	NO
	U-NII-2C	106	5530		14.50	13.87	NO
		122	5610		14.50	13.83	NO
		138	5690		14.50	13.75	NO
	U-NII-3	155	5775		14.50	13.20	NO

BT - conducted power table:

BT		Average Conducted Power(dBm)			
Band	Channel	0	39	78	Tune up
BT	GFSK	8.91	8.18	7.44	9.50
	π/4DQPSK	6.02	4.77	4.60	7.50
	8DPSK	5.93	4.72	4.54	7.50
Band	Channel	0	19	39	Tune up
BLE 1M	GFSK	-4.45	-2.64	-3.92	-1.00
BLE 2M	GFSK	-4.49	-2.66	-3.89	-1.00

1.5 Test Environment

Ambient Temperature: 22±2° C
Tissue Simulating Liquid: 22±2° C

1.6 Operation Description

1. The EUT is controlled by using a Radio Communication Tester (MT8821C & CMU200), and the communication between the EUT and the tester is established by air link.
2. Measurements are performed respectively on the lowest, middle and highest channels of the operating band(s). The EUT is set to maximum power level during all tests, and at the beginning of each test the battery is fully charged.
3. During the SAR testing, the DASY 5 system checks power drift by comparing the e-field strength of one specific location measured at the beginning with that measured at the end of the SAR testing.
4. SAR test reduction for GPRS mode is determined by the source-based time-averaged output power. The data mode with highest specified time-averaged output power should be tested for SAR compliance.
5. The 3G SAR test reduction procedure is applied to HSDPA with 12.2 kbps RMC as the primary mode. Since the maximum output power in a secondary mode (HSDPA) is ≤ ¼ dB higher than the primary mode (WCDMA), SAR measurement is not required for the secondary mode (HSDPA).
6. The 3G SAR test reduction procedure is applied to HSPA (HSUPA/HSDPA with RMC) with 12.2 kbps RMC as the primary mode. Since the maximum output power in a secondary mode (HSPA) is ≤ ¼ dB higher than the primary mode (WCDMA), SAR measurement is not required for the secondary mode (HSPA).

7. LTE modes test according to KDB 941225D05v02r05.

a. Per Section 5.2.1, the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation.

- Using the RB offset and required test channel combination with the highest maximum output power for RB offsets at the upper edge, middle and lower edge of each required test channel.
- When the reported SAR is ≤ 0.8 W/kg, testing of the remaining RB offset configurations and required test channels is not required for 1 RB allocation; otherwise, SAR is required for the remaining required test channels and only for the RB offset configuration with the highest output power for that channel.
- When the reported SAR of a required test channel is > 1.45 W/kg, SAR is required for all three RB offset configurations for that required test channel.

b. Per Section 5.2.2, the largest channel bandwidth and measure SAR for QPSK with 50% RB allocation

- The procedures required for 1 RB allocation in 5.2.1 are applied to measure the SAR for QPSK with 50% RB allocation.

c. Per Section 5.2.3, the largest channel bandwidth and measure SAR for QPSK with 100% RB allocation

- For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation in 5.2.1 and 5.2.2 are ≤ 0.8 W/kg.
- Otherwise, SAR is measured for the highest output power channel and if the reported SAR is > 1.45 W/kg, the remaining required test channels must also be tested.

d. Per Section 5.2.4, Higher order modulations

- For each modulation besides QPSK; e.g., 16-QAM, 64-QAM, apply the QPSK procedures in sections 5.2.1, 5.2.2 and 5.2.3 to determine the QAM configurations that may need SAR measurement. For each configuration identified as required for testing, SAR is required only when the highest maximum output power for the configuration in the higher order modulation is > ½ dB higher than the same configuration in QPSK or when the reported SAR for the QPSK configuration is > 1.45 W/kg.

e. Per Section 5.3, other channel bandwidth standalone SAR test requirements

- For the other channel bandwidths used by the device in a frequency band, apply all the procedures required for the largest channel bandwidth in section 5.2 to determine the channels and RB configurations that need SAR testing and only measure SAR when the highest maximum output power of a configuration requiring testing in the smaller channel bandwidth is > ½ dB higher than the equivalent channel configurations in the largest channel bandwidth configuration or the reported SAR of a configuration for the largest channel bandwidth is > 1.45 W/kg. The equivalent channel configuration for the RB allocation, RB offset and modulation etc. is determined for the smaller channel bandwidth according to the same number of RB allocated in the largest channel bandwidth.

8. WLAN

Initial Test Position SAR Test Reduction Procedure

DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures. The initial test position procedure is described in the following:

1）. When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combinations within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).

2）. When the reported SAR of the initial test position is > 0.4 W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position using subsequent highest extrapolated or estimated 1-g SAR conditions determined by area scans or next closest/smallest test separation distance and maximum RF coupling test positions based on manufacturer justification, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.

3）. 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. a) Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

Initial Test Configuration Procedures

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. SAR test reduction for subsequent highest output test channels is determined according to 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 subsequent next highest measured output power channel(s) in the initial test configuration until reported SAR is ≤ 1.2 W/kg or all required channels are tested.

Subsequent 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. The initial test position procedure is applied to next to the ear, UMPC mini-tablet and hotspot mode configurations. When the same maximum output power is specified for multiple transmission modes, additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. The subsequent test configuration and SAR measurement procedures are described in the following.

1）. When SAR test exclusion provisions of KDB Publication 447498 are applicable and SAR measurement is not required for the initial test configuration, SAR is also not required for the next highest maximum output power transmission mode subsequent test configuration(s) in that frequency band or aggregated band and exposure configuration.

2）. When the highest reported SAR for the initial test configuration (when applicable, include subsequent highest output channels), 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.

3）. The number of channels in the initial test configuration and subsequent test configuration can be different due to differences in channel bandwidth. When SAR measurement is required for a subsequent test configuration and the channel bandwidth is smaller than that in the initial test configuration, all channels in the subsequent test configuration that overlap with the larger bandwidth channel tested in the initial test configuration should be used to determine the highest maximum output power channel. This step requires additional power measurement to identify the highest maximum output power channel in the subsequent test configuration to determine SAR test reduction.

a) SAR should first be measured for the channel with highest measured output power in the subsequent test configuration.

b) SAR for subsequent highest measured maximum output power channels in the subsequent test configuration is required only when the reported SAR of the preceding higher maximum output power channel(s) in the subsequent test configuration is > 1.2 W/kg or until all required channels are tested. i) For channels with the same measured maximum output power, SAR should be measured using the channel closest to the center frequency of the larger channel bandwidth channel in the initial test configuration.

4）. SAR measurements for the remaining highest specified maximum output power OFDM transmission mode configurations that have not been tested in the initial test configuration (highest maximum output) or subsequent test configuration(s) (subsequent next highest maximum output power) is determined by recursively applying the subsequent test configuration procedures in this section to the remaining configurations according to the following:

a) replace “subsequent test configuration” with “next subsequent test configuration” (i.e., subsequent next highest specified maximum output power configuration)

b) replace “initial test configuration” with “all tested higher output power configurations”

2.4 GHz WiFi SAR Procedures:

Separate SAR procedures are applied to DSSS and OFDM configurations in the 2.4 GHz band to simplify DSSS test requirements. For 802.11b DSSS SAR measurements, DSSS SAR procedure applies to fixed exposure test position and initial test position procedure applies to multiple exposure test positions. When SAR measurement is required for an OFDM configuration, the initial test configuration, subsequent test configuration and initial test position procedures are applied. The SAR test exclusion requirements for 802.11g/n OFDM configurations are described in following.

802.11b DSSS SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

1）. When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.

2）. When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied (section 5.3, including sub-sections). SAR is not required for the following 2.4 GHz OFDM conditions.

1）. When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.

2）. 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.

SAR Test Requirements for OFDM configurations

When SAR measurement is required for 802.11 g/n OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

5 GHz WiFi SAR Procedures:

U-NII-1 and U-NII-2A Bands

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following：

1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, both bands are tested independently for SAR.

2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, both bands are tested independently for SAR.

3) The two U-NII bands may be aggregated to support a 160 MHz channel on channel number 50. Without additional testing, the maximum output power for this is limited to the lower of the maximum output power certified for the two bands. When SAR measurement is required for at least one of the bands and the highest reported SAR adjusted by the ratio of specified maximum output power of aggregated to standalone band is > 1.2 W/kg, SAR is required for the 160 MHz channel. This procedure does not apply to an aggregated band with maximum output higher than the standalone band(s); the aggregated band must be tested independently for SAR. SAR is not required when the 160 MHz channel is operating at a reduced maximum power and also qualifies for SAR test exclusion.

U-NII-2C and U-NII-3 Bands

The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. when Terminal Doppler Weather Radar (TDWR) restriction applies, all channels that operate at 5.60 – 5.65 GHz must be included to apply the SAR test reduction and measurement procedures.

When the same transmitter and antenna(s) are used for U-NII-2C band and U-NII-3 band or 5.8 GHz band of §15.247, the bands may be aggregated to enable additional channels with 20, 40 or 80 MHz bandwidth to span across the band gap, as illustrated in Appendix B. The maximum output power for the additional band gap channels is limited to the lower of those certified for the bands. Unless band gap channels are permanently disabled, they must be considered for SAR testing. The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. To maintain SAR measurement accuracy and to facilitate test reduction, the channels in U-NII-2C band above 5.65 GHz may be grouped with the 5.8 GHz channels in U-NII-3 or §15.247 band to enable two SAR probe calibration frequency points to cover the bands, including the band gap channels. When band gap channels are supported and the bands are not aggregated for SAR testing, band gap channels must be considered independently in each band according to the normally required OFDM SAR measurement and probe calibration frequency points requirements.

OFDM Transmission Mode SAR Test Configuration and Channel Selection Requirements

The initial test configuration for 5 GHz OFDM transmission modes is determined by the 802.11 configuration with the highest maximum output power specified for production units, including tune-up tolerance, in each standalone and aggregated frequency band. SAR for the initial test configuration is measured using the highest maximum output power channel determined by the default power measurement procedures. When multiple configurations in a frequency band have the same specified maximum output power, the initial test configuration is determined according to the following steps applied sequentially.

1) The largest channel bandwidth configuration is selected among the multiple configurations with the same specified maximum output power.

2) If multiple configurations have the same specified maximum output power and largest channel bandwidth, the lowest order modulation among the largest channel bandwidth configurations is selected.

3) If multiple configurations have the same specified maximum output power, largest channel bandwidth and lowest order modulation, the lowest data rate configuration among these configurations is selected.

4) When multiple transmission modes (802.11a/g/n/ac) have the same specified maximum output power, largest channel bandwidth, lowest order modulation and lowest data rate, the lowest order 802.11 mode is selected; i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over 802.11n. After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following. These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s), with respect to the default power measurement procedures or additional power measurements required for further SAR test reduction. The same procedures also apply to subsequent highest output power channel(s) selection.

a) The channel closest to mid-band frequency is selected for SAR measurement.

b) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

SAR Test Requirements for OFDM configurations:

When SAR measurement is required for 802.11 a/n/ac OFDM configurations, each standalone and frequency aggregated band is considered separately for SAR test reduction. When the same transmitter and antenna(s) are used for U-NII-1 and U-NII-2A bands, additional SAR test reduction applies. When band gap channels between U-NII-2C band and 5.8 GHz U-NII-3 or §15.247 band are supported, the highest maximum output power transmission mode configuration and maximum output power channel across the bands must be used to determine SAR test reduction, according to the initial test configuration and subsequent test configuration requirements. In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

WiFi CDD/MIMO SAR Considerations

Per KDB 248227D01v02r02, simultaneous transmission provisions in KDB Publication 447498 should be used to determine simultaneous transmission SAR test exclusion for WiFi MIMO. If the sum of 1-g SAR single transmission SAR measurement is <1.6W/kg, no additional SAR measurements for MIMO are required. Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

9. According to KDB447498D01v06, testing of other required channels is not required when the reported 1-g SAR for the highest output channel is ≤ 0.8 W/kg, when the transmission band is ≤ 100MHz.

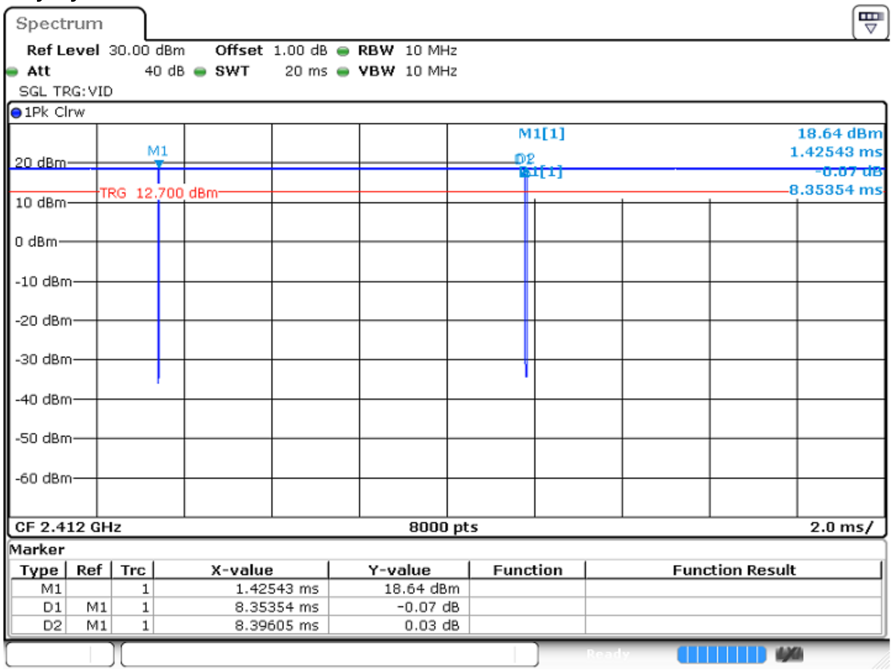
10. According to KDB865664D01v01r04, SAR measurement variability must be assessed for each frequency band. When the original highest measured SAR is ≥ 0.8 W/kg, repeated that measurement once. Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit)

11. According to KDB447498D01v06 – The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances≤ 50 mm are determined by: [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for product specific 10-g SAR.

Duty cycle:

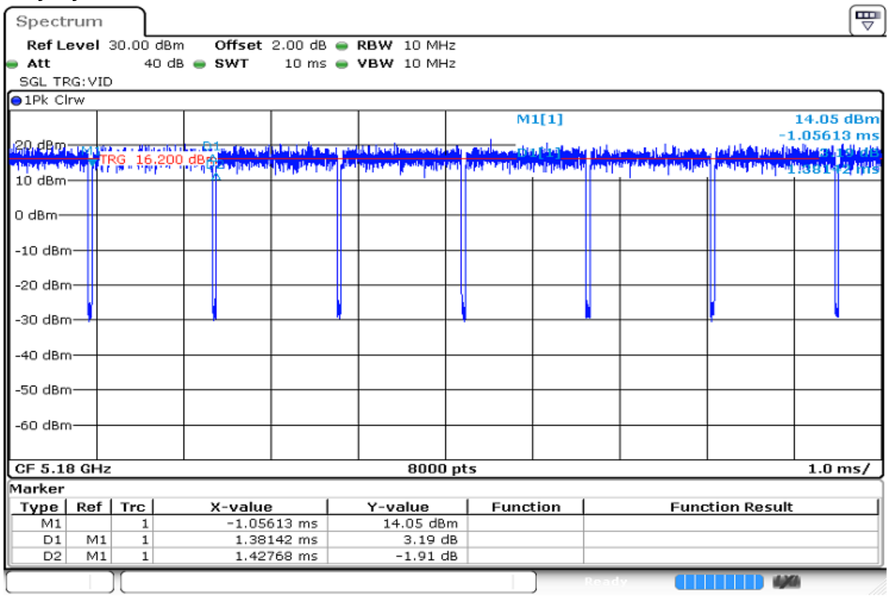
2.4GHz Wi-Fi 802.11b:

duty cycle=8.35354/8.39605=99.49%



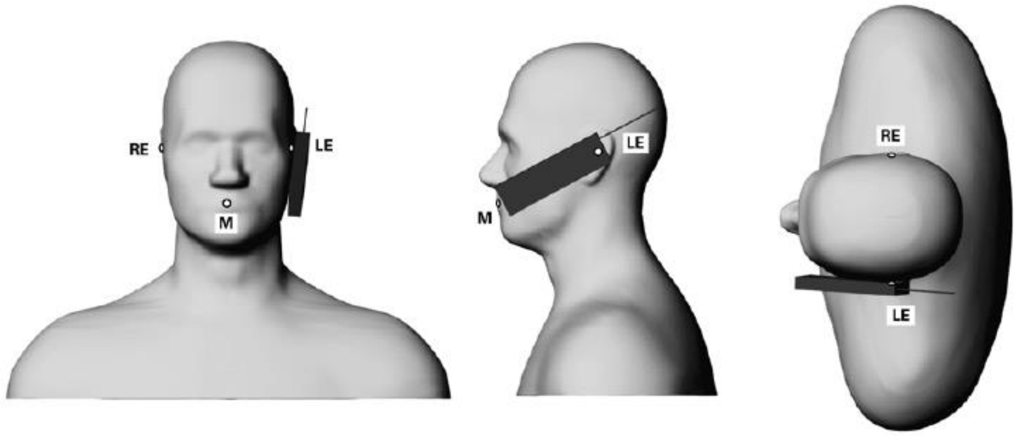
5GHz Wi-Fi 802.11b:

duty cycle=1.38142/1.42768=96.76%

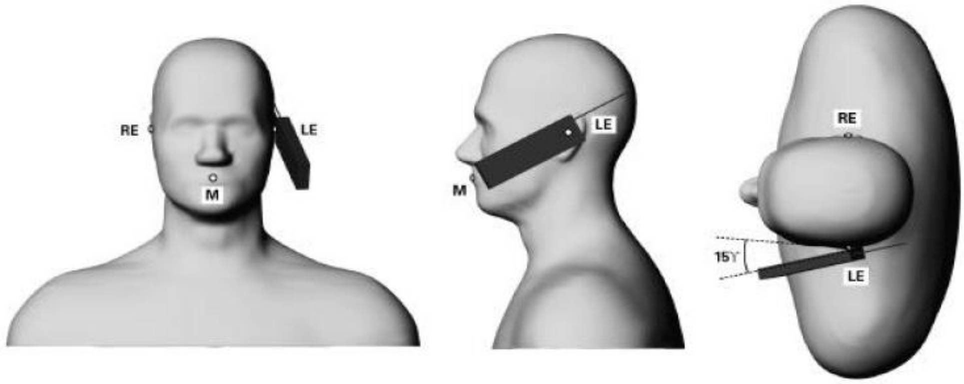


1.7 Positioning Procedure

Head SAR measurement statement



Phone position 1, “cheek” or “touch” position. The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning.



Phone position 2, “tilted position.” The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for phone positioning.

Cheek/Touch Position:
The handset was brought toward the mouth of the head phantom by pivoting against the ear reference point until any point of the mouthpiece or keypad touched the phantom.
Ear/Tilt Position:
With the phone aligned in the Cheek/Touch position, the handset was tilted away from the mouth with respect to the test device reference point by 15 degrees.

Body SAR measurement statement

1. Body-worn exposure: 15mm

Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in KDB Publication 447498 D01 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. When the same wireless transmission configuration is used for testing body-worn accessory and hotspot mode SAR, respectively, in voice and data mode, SAR results for the most conservative test separation distance configuration may be used to support both SAR conditions. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for the body-worn accessory with a headset attached to the handset.

2. Hotspot exposure: 10mm

A test separation distance of 10 mm is required between the phantom and all surfaces and edges with a transmitting antenna located within 25 mm from that surface or edge when the form factor of a handset is larger than 9 cm × 5 cm,

Test configurations of WWAN:

(1) Front side
(2) Back side
(3) Bottom side
(4) Right side
(5) Left side

Test configurations of WLAN:

(1) Front side
(2) Back side
(3) Top side
(4) Right side

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1.8 Evaluation Procedures

The entire evaluation of the spatial peak values is performed within the Post-processing engine (SEMCAD). The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1.The extraction of the measured data (grid and values) from the Zoom Scan.

2.The calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters).

3.The generation of a high-resolution mesh within the measured volume.

4.The interpolation of all measured values from the measurement grid to the high-resolution grid.

5.The extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface.

6.The calculation of the averaged SAR within masses of 1g and 10g.

The probe is calibrated at the center of the dipole sensors that is located 1 to 2.7mm away from the probe tip. During measurements, the probe stops shortly above the phantom surface, depending on the probe and the surface detecting system. Both distances are included as parameters in the probe configuration file. The software always knows exactly how far away the measured point is from the surface. As the probe cannot directly measure at the surface, the values between the deepest measured point and the surface must be extrapolated. The angle between the probe axis and the surface normal line is less than 30 degree.

In the Area Scan, the gradient of the interpolation function is evaluated to find all the extreme of the SAR distribution. The uncertainty on the locations of the extreme is less than 1/20 of the grid size. Only local maximum within –2 dB of the global maximum are searched and passed for the Cube Scan measurement. In the Cube Scan, the interpolation function is used to extrapolate the Peak SAR from the lowest measurement points to the inner phantom surface (the extrapolation distance). The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5mm.

The maximum search is automatically performed after each area scan measurement. It is based on splines in two or three dimensions. The procedure can find the maximum for most SAR distributions even with relatively large grid spacing. After the area scanning measurement, the probe is automatically moved to a position at the interpolated maximum. The following scan can directly use this position for reference, e.g., for a finer resolution grid or the cube evaluations. The 1g and 10g peak evaluations are only available for the predefined cube 7x7x7 scans.

The routines are verified and optimized for the grid dimensions used in these cube measurements. The measured volume of 30x30x30mm contains about 30g of tissue. The first procedure is an extrapolation (incl. Boundary correction) to get the points between the lowest measured plane and the surface. The next step uses 3D interpolation to get all points within the measured volume. In the last step, a 1g cube is placed numerically into the volume and its averaged SAR is calculated. This cube is the moved around until the highest averaged SAR is found.

If the highest SAR is found at the edge of the measured volume, the system will issue a warning: higher SAR values might be found outside of the measured volume. In that case the cube measurement can be repeated, using the new interpolated maximum as the center.

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1.9 Probe Calibration Procedures

For the calibration of E-field probes in lossy liquids, an electric field with an accurately known field strength must be produced within the measured liquid. For standardization purposes it would be desirable if all measurements which are necessary to assess the correct field strength would be traceable to standardized measurement procedures. In the following two different calibration techniques are summarized:

1.9.1 Transfer Calibration with Temperature Probes

In lossy liquids the specific absorption rate (SAR) is related both to the electric field (E) and the temperature gradient ($\delta T / \delta t$) in the liquid.

$$SAR = C\frac{\delta T}{\delta t},$$

Whereby σ is the conductivity, ρ the density and c the heat capacity of the liquid.

1. Hence, the electric field in lossy liquid can be measured indirectly by measuring the temperature gradient in the liquid. Non-disturbing temperature probes (optical probes or thermistor probes with resistive lines) with high spatial resolution (<1-2 mm) and fast reaction time (<1 s) are available and can be easily calibrated with high precision [1]. The setup and the exciting source have no influence on the calibration; only the relative positioning uncertainties of the standard temperature probe and the E-field probe to be calibrated must be considered. However, several problems limit the available accuracy of probe calibrations with temperature probes:
2.The temperature gradient is not directly measurable but must be evaluated from temperature measurements at different time steps. Special precaution is necessary to avoid measurement errors caused by temperature gradients due to energy equalizing effects or convection currents in the liquid. Such effects cannot be completely avoided, as the measured field itself destroys the thermal equilibrium in the liquid. With a careful setup these errors can be kept small.

3.The measured volume around the temperature probe is not well defined. It is difficult to calculate the energy transfer from a surrounding gradient temperature field into the probe. These effects must be considered, since temperature probes are calibrated in liquid with homogeneous temperatures. There is no traceable standard for temperature rise measurements.
The calibration depends on the assessment of the specific density, the heat capacity and the conductivity of the medium. While the specific density and heat capacity can be measured accurately with standardized procedures (~ 2% for c; much better for ρ), there is no standard for the measurement of the conductivity. Depending on the method and liquid, the error can well exceed ±5%.
4.Temperature rise measurements are not very sensitive and therefore are often performed at a higher power level than the E-field measurements. The nonlinearities in the system (e.g., power measurements, different components, etc.) must be considered.
Considering these problems, the possible accuracy of the calibration of E-field probes with temperature gradient measurements in a carefully designed setup is about ±10% (RSS) [2]. Recently, a setup which is a combination of the waveguide techniques and the thermal measurements was presented in [3]. The estimated uncertainty of the setup is ±5% (RSS) when the same liquid is used for the calibration and for actual measurements and ±7-9% (RSS) when not, which is in good agreement with the estimates given in [2].

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1.9.2 Calibration with Analytical Fields

In this method a technical setup is used in which the field can be calculated analytically from measurements of other physical magnitudes (e.g., input power). This corresponds to the standard field method for probe calibration in air; however, there is no standard defined for fields in lossy liquids.

When using calculated fields in lossy liquids for probe calibration, several points must be considered in the assessment of the uncertainty:

1.The setup must enable accurate determination of the incident power.

2.The accuracy of the calculated field strength will depend on the assessment of the dielectric parameters of the liquid.

3.Due to the small wavelength in liquids with high permittivity, even small setups might be above the resonant cutoff frequencies. The field distribution in the setup must be carefully checked for conformity with the theoretical field distribution.

References

1) N. Kuster, Q. Balzano, and J.C. Lin, Eds., Mobile Communications Safety, Chapman & Hall, London, 1997.

2) K. Meier, M. Burkhardt, T. Schmid, and N. Kuster, \Broadband calibration of E-field probes in lossy media", IEEE Transactions on Microwave Theory and Techniques, vol. 44, no. 10, pp. 1954{1962, Oct. 1996.

3) K. Jokela, P. Hyysalo, and L. Puranen, \Calibration of specific absorption rate (SAR) probes in waveguide at 900 MHz", IEEE Transactions on Instrumentation and Measurements, vol. 47, no. 2, pp. 432{438, Apr. 1998.

1.10 The SAR Measurement System

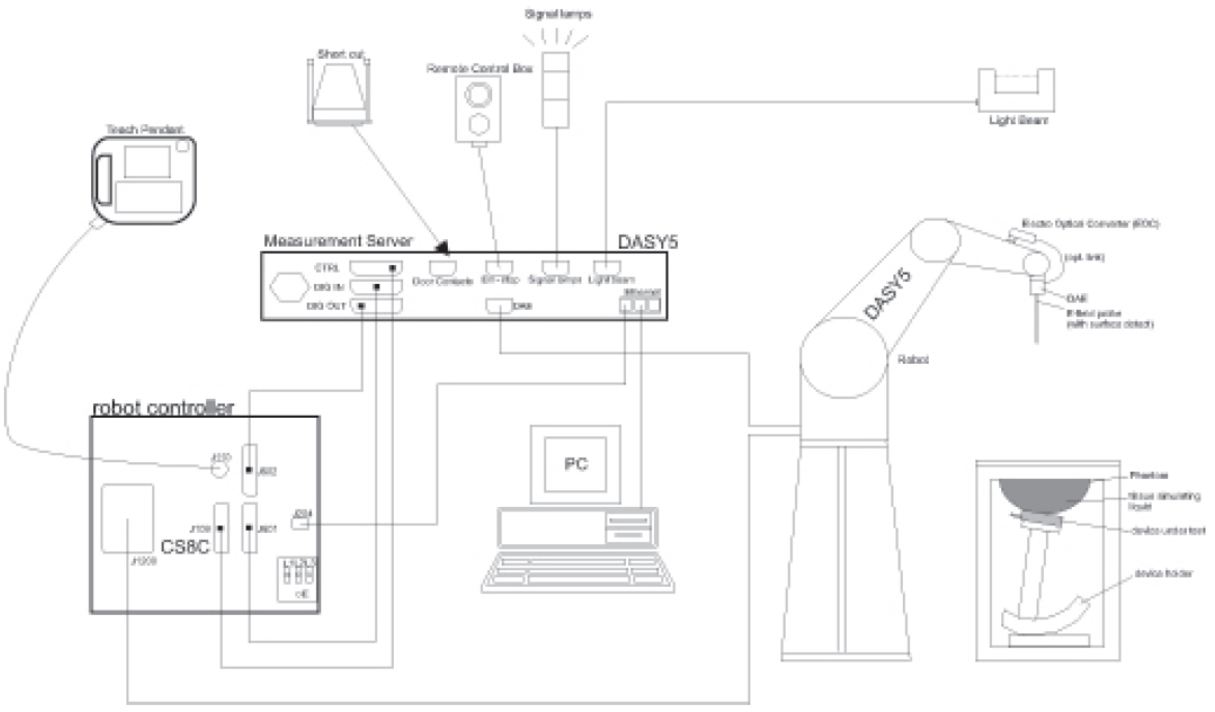
This SAR Measurement System uses a Computer-controlled 3-D stepper motor system (SPEAG DASY5 professional system). A E-field probe is used to determine the internal electric fields. The SAR can be obtained from the equation SAR= σ (|Ei|2)/ ρ where σ and ρ are the conductivity and mass density of the tissue-Simulate.

The DASY5 system for performing compliance tests consists of the following items:
A standard high precision 6-axis robot (Stabile RX family) with controller, teach pendant and software .An arm extension for accommodation the data acquisition electronics (DAE).

A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

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 between optical and electrical of the signals for the digital communication to DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.



F-1. SAR Measurement System Configuration

- 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.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand, right-hand and Body Worn usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing to validating the proper functioning of the system.

1.11 System Component

EX3DV4 E-Field Probe

	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available.
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	± 0.3 dB in TSL (rotation around probe axis) ± 0.5 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields); the only probe that enables compliance testing for frequencies up to 6 GHz with precision of better 30%.
Compatibility	DASY3, DASY4, DASY52 SAR and higher, EASY4/MRI

Data Acquisition Electronics (DAE)

Model	DAE4
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV,400mV)
Input Offset Voltage	< 5μV (with auto zero)
Input Bias Current	< 50 f A
Dimensions	60 x 60 x 68 mm

SAM Twin Phantom

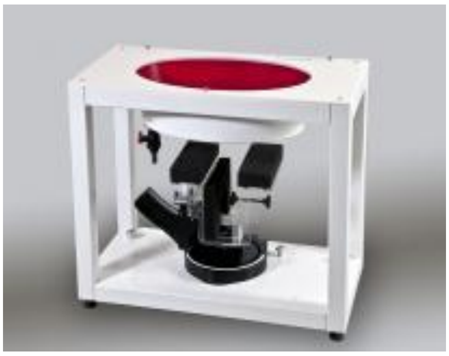
Material	Vinylester, glass fiber reinforced (VE-GF)
Liquid Compatibility	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)
Dimensions (incl. Wooden Support)	Length: 1000 mm Width: 500 mm Height: adjustable feet
Filling Volume	approx. 25 liters
Wooden Support	SPEAG standard phantom table

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.

Twin SAM V5.0 has the same shell geometry and is manufactured from the same material as Twin SAM V4.0, but has reinforced top structure.

ELI Phantom

Material	Vinylester, glass fiber reinforced (VE-GF)
Liquid Compatibility	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters
Wooden Support	SPEAG standard phantom table



Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.

ELI V5.0 has the same shell geometry and is manufactured from the same material as ELI4, but has reinforced top structure.

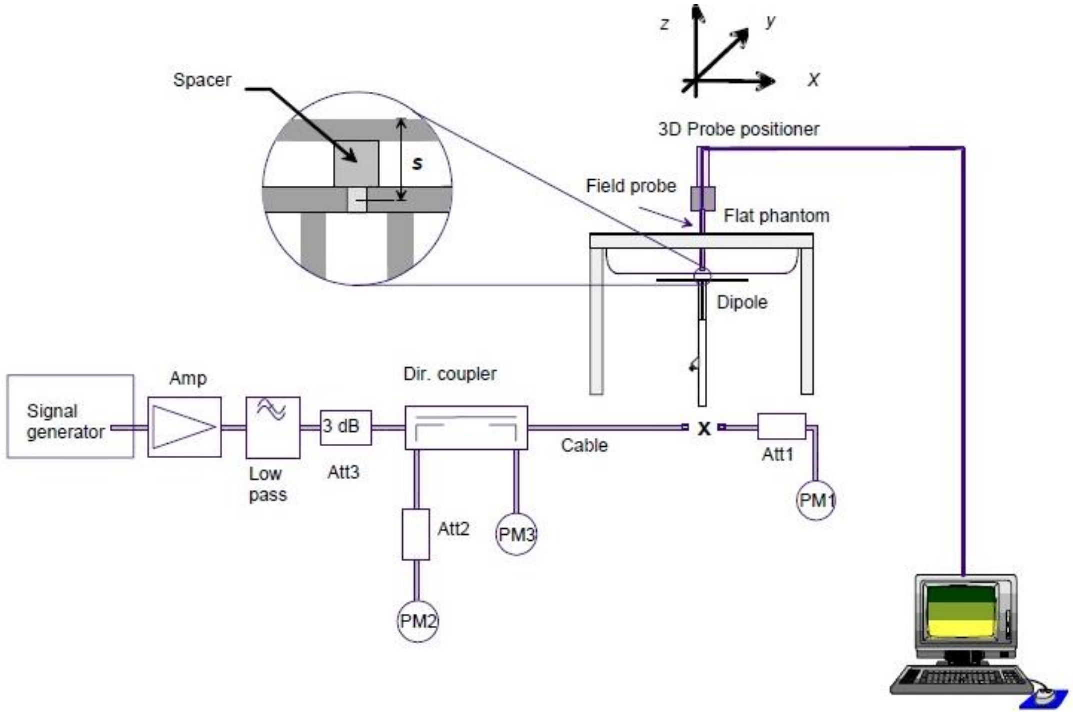
Device Holder for Transmitters

F-2. **Device Holder for Transmitters**

- The DASY device holder is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation centres for both scales are the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.
- The DASY device holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity ε=3 and loss tangent δ=0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

1.12 SAR System Check

The microwave circuit arrangement for system Check is sketched in F-12. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within +/- 10% from the target SAR values. The tests were conducted on the same days as the measurement of the EUT. The obtained results from the system accuracy verification are displayed in the following table (A power level of 250mW (below 3GHz) or 100mW (3-6GHz) was input to the dipole antenna). During the tests, the ambient temperature of the laboratory was in the range 22±2°C, the relative humidity was in the range 60% and the liquid depth above the ear reference points was above 15±0.5 cm in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.



F-12. The block diagram of system check

Validation Kit		Measured SAR 250mW	Measured SAR 250mW	Measured SAR (normalized to 1W)	Measured SAR (normalized to 1W)	Target SAR (normalized to 1W) (±10%)	Target SAR (normalized to 1W) (±10%)	Liquid Temp. (℃)	Measured Date
		1g (W/kg)	10g (W/kg)	1g (W/kg)	10g (W/kg)	1-g(W/kg)	10-g(W/kg)		
D750V3	Head	2.17	1.42	8.68	5.68	8.39 (7.55~9.23)	5.63 (5.07~6.19)	22.1	2020/11/23
D835V2	Head	2.44	1.62	9.76	6.48	9.64 (8.68~10.60)	6.29 (5.66~6.92)	22.1	2020/11/20
D835V2	Head	2.48	1.62	9.92	6.48	9.64 (8.68~10.60)	6.29 (5.66~6.92)	22.1	2021/1/29
D1900V2	Head	10.60	5.50	42.40	22.00	39.3 (35.37~43.23)	20.2 (18.18~22.22)	22.3	2020/12/23
D1900V2	Head	9.97	5.24	39.88	20.96	39.3 (35.37~43.23)	20.2 (18.18~22.22)	22.3	2021/1/29
D2450V2	Head	12.40	5.60	49.60	22.40	51.9 (46.71~57.09)	23.8 (21.42~26.18)	22.0	2020/12/24
Validation Kit		Measured SAR 100mW	Measured SAR 100mW	Measured SAR (normalized to 1W)	Measured SAR (normalized to 1W)	Target SAR (normalized to 1W) (±10%)	Target SAR (normalized to 1W) (±10%)	Liquid Temp. (℃)	Measured Date
		1g (W/kg)	10g (W/kg)	1g (W/kg)	10g (W/kg)	1-g(W/kg)	10-g(W/kg)		
D5GHzV2	Head (5.25GHz)	8.14	2.34	81.40	23.40	75.2 (67.68~82.72)	21.5 (19.35~23.65)	22.2	2020/12/25
	Head (5.6GHz)	8.57	2.44	85.70	24.40	80 (72~88)	22.7 (20.43~24.97)	22.2	2020/12/9
	Head (5.75GHz)	7.85	2.23	78.50	22.30	78.7 (70.83~86.57)	22.3 (20.07~24.53)	22.2	2021/1/10

Table 1. Results of system check

1.13 Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this Tissue Simulate Liquids were measured by using the Agilent Model 85070E Dielectric Probe in conjunction with Agilent E5071C Network Analyzer (300 KHz-8500 MHz). The Conductivity (σ) and Permittivity (ρ) are listed in bellow table. For the SAR measurement given in this report. The temperature variation of the Tissue Simulate Liquids was 22±2°C.

Tissue Type	Measured Frequency （MHz）	Target Tissue (±5%)		Measured Tissue		Liquid Temp.(℃)	Measured Date
		εr	σ(S/m)	εr	σ(S/m)		
750 Head	750	41.9 (39.81~44)	0.89 (0.85~0.94)	41.806	0.888	22.1	2020/11/23
835 Head	835	41.5 (39.43~43.58)	0.90 (0.86~0.95)	40.849	0.886	22.1	2020/11/20
835 Head	835	41.5 (39.43~43.58)	0.90 (0.86~0.95)	43.217	0.891	22.1	2021/1/29
1900 Head	1900	40.0 (38.00~42.00)	1.40 (1.33~1.47)	40.268	1.456	22.3	2020/12/23
1900 Head	1900	40.0 (38.00~42.00)	1.40 (1.33~1.47)	41.495	1.408	22.3	2021/1/29
2450 Head	2450	39.20 (37.24~41.16)	1.80 (1.71~1.89)	38.351	1.814	22.0	2020/12/24
5250Head	5250	35.9 (34.11~37.70)	4.71 (4.47~4.95)	36.548	4.821	22.2	2020/12/25
5600 Head	5600	35.5 (33.73~37.28)	5.07 (4.82~5.32)	35.243	5.159	22.2	2020/12/9
5750 Head	5750	35.4 (33.63~37.17)	5.22 (4.96~5.48)	35.605	5.286	22.2	2021/1/10

Table 2. Dielectric Parameters of Tissue Simulant Fluid

The composition of the tissue simulating liquid:

Ingredients (% by weight)	Frequency (MHz)				
	450	900	1800-2000	2300-2500	2500-2700
Water	38.56	40.30	55.24	55.00	54.92
Salt (NaCl)	3.95	1.38	0.31	0.2	0.23
Sucrose	56.32	57.90	0	0	0
HEC	0.98	0.24	0	0	0
Bactericide	0.19	0.18	0	0	0
Tween	0	0	44.45	44.80	44.85

Salt: 99^{+}% Pure Sodium Chloride

Sucrose: 98^{+}% Pure Sucrose

Water: De-ionized, 16 MΩ^{+} resistivity

HEC: Hydroxyethyl Cellulose

Tween: Polyoxyethylene (20) sorbitan monolaurate

HSL5GHz is composed of the following ingredients：

Water：50-65%

Mineral oil：10-30%

Emulsifiers：8-25%

Sodium salt：0-1.5%

Table 3. Recipes for tissue simulating liquid

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1.14 Test Standards and Limits

According to FCC 47CFR §2.1093(d) The limits to be used for evaluation are based generally on criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (''SAR'') in Section 4.2 of ''IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz,'' ANSI/IEEE C95.1, By the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017.

These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in ''Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields,'' NCRP Report No. 86, Section 17.4.5. Copyright NCRP, 1986, Bethesda, Maryland 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards. The criteria to be used are specified in paragraphs (d)(1) and (d)(2) of this section and shall apply for portable devices transmitting in the frequency range from 100 kHz to 6 GHz. Portable devices that transmit at frequencies above 6 GHz are to be evaluated in terms of the MPE limits specified in § 1.1310 of this chapter.

Measurements and calculations to demonstrate compliance with MPE field strength or power density limits for devices operating above 6 GHz should be made at a minimum distance of 5 cm from the radiating source.

1. Limits for Occupational/Controlled exposure: 0.4 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 8 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 20 W/kg, as averaged over a 10 grams of tissue (defined as a tissue volume in the shape of a cube).

Occupational/Controlled limits apply when persons are exposed as a consequence of their employment provided these persons are fully aware of and exercise control over their exposure. Awareness of exposure can be accomplished by use of warning labels or by specific training or education through appropriate means, such as an RF safety program in a work environment.

2. Limits for General Population/Uncontrolled exposure: 0.08 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 1.6 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube).

Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 4 W/kg, as averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube).

General Population/Uncontrolled limits apply when the general public may be exposed, or when persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or do not exercise control over their exposure.

Warning labels placed on consumer devices such as cellular telephones will not be sufficient reason to allow these devices to be evaluated subject to limits for occupational/controlled exposure in paragraph (d)(1) of this section(Table .4)

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
Spatial Peak SAR (Brain)	**1.60 W/kg**	8.00 W/kg
Spatial Average SAR (Whole Body)	0.08 W/kg	0.40 W/kg
Spatial Peak SAR (Hands/Feet/Ankle/Wrist)	4.00 W/kg	20.00 W/kg

Table 4. RF exposure limits

Notes:

1. Uncontrolled environments are defined as locations where there is potential exposure of individuals who have no knowledge or control of their potential exposure.

2. Controlled environments are defined as locations where there is potential exposure of individuals who have knowledge of their potential exposure and can exercise control over their exposure.

2 Summary of Results

<GSM 850>

Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data										
Left cheek	GSM	190/836.6	1:8.3	0.321	0.03	29.05	30.00	1.245	0.399	22.1
Left tilted	GSM	190/836.6	1:8.3	0.256	0.09	29.05	30.00	1.245	0.319	22.1
Right cheek	GSM	190/836.6	1:8.3	0.411	-0.04	29.05	30.00	1.245	**0.511**	22.1
Right tilted	GSM	190/836.6	1:8.3	0.261	-0.11	29.05	30.00	1.245	0.325	22.1
Body worn Test data(Separate 15mm)										
Front side	GSM	190/836.6	1:8.3	0.386	-0.11	29.05	30.00	1.245	0.480	22.1
Back side	GSM	190/836.6	1:8.3	0.402	-0.03	29.05	30.00	1.245	**0.500**	22.1
Hotspot Test data(Separate 10mm)										
Front side	GPRS 4TS	190/836.6	1:2.075	0.519	-0.18	29.05	30.00	1.245	0.646	22.1
Back side	GPRS 4TS	190/836.6	1:2.075	0.560	0.00	29.05	30.00	1.245	0.697	22.1
Left side	GPRS 4TS	190/836.6	1:2.075	0.334	0.19	29.05	30.00	1.245	0.416	22.1
Right side	GPRS 4TS	190/836.6	1:2.075	0.638	0.10	29.05	30.00	1.245	**0.794**	22.1
Bottom side	GPRS 4TS	190/836.6	1:2.075	0.563	-0.17	29.05	30.00	1.245	0.701	22.1

<GSM 1900>

Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data										
Left cheek	GSM	661/1880	1:8.3	0.160	0.02	21.86	22.00	1.033	**0.165**	22.3
Left tilted	GSM	661/1880	1:8.3	0.131	-0.13	21.86	22.00	1.033	0.135	22.3
Right cheek	GSM	661/1880	1:8.3	0.154	0.09	21.86	22.00	1.033	0.159	22.3
Right tilted	GSM	661/1880	1:8.3	0.122	-0.14	21.86	22.00	1.033	0.126	22.3
Body worn Test data(Separate 15mm)										
Front side	GSM	661/1880	1:8.3	0.162	0.04	21.86	22.00	1.033	0.167	22.3
Back side	GSM	661/1880	1:8.3	0.179	-0.06	21.86	22.00	1.033	**0.185**	22.3
Hotspot Test data(Separate 10mm)										
Front side	GPRS 4TS	661/1880	1:2.075	0.390	-0.08	21.86	22.00	1.033	0.403	22.3
Back side	GPRS 4TS	661/1880	1:2.075	0.403	0.06	21.86	22.00	1.033	0.416	22.3
Left side	GPRS 4TS	661/1880	1:2.075	0.095	-0.04	21.86	22.00	1.033	0.098	22.3
Right side	GPRS 4TS	661/1880	1:2.075	0.040	0.03	21.86	22.00	1.033	0.041	22.3
Bottom side	GPRS 4TS	661/1880	1:2.075	0.864	-0.13	21.86	22.00	1.033	0.892	22.3
Bottom side	GPRS 4TS	512/1850.2	1:2.075	0.929	-0.14	21.93	22.00	1.016	**0.944**	22.3
Bottom side- repeat	GPRS 4TS	512/1850.2	1:2.075	0.895	0.01	21.93	22.00	1.016	0.910	22.3
Bottom side	GPRS 4TS	810/1909.8	1:2.075	0.758	-0.13	21.90	22.00	1.023	0.776	22.3

Test Position	Channel/ Frequency (MHz)	Measured SAR (1g)	1st Repeated SAR (1g)	Ratio	2nd Repeated SAR (1g)	3rd Repeated SAR (1g)
Bottom side	512/1850.2	0.929	0.895	1.038	N/A	N/A
1) When the original highest measured SAR is ≥ 0.80 W/kg, the measurement was repeated once.						
2) A second repeated measurement was preformed only if the ratio of largest to smallest SAR for the original and first repeated measurements was > 1.20 or when the original or repeated measurement was ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).						
3) A third repeated measurement was performed only if the original, first or second repeated measurement was≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.						
4) Repeated measurements are not required when the original highest measured SAR is < 0.80 W/kg						

<WCDMA Band V>

Test position	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data										
Left cheek	RMC	4182/836.4	1:1	0.167	0.06	22.75	24.00	1.334	0.223	22.1
Left tilted	RMC	4182/836.4	1:1	0.117	-0.04	22.75	24.00	1.334	0.156	22.1
Right cheek	RMC	4182/836.4	1:1	0.224	-0.04	22.75	24.00	1.334	**0.299**	22.1
Right tilted	RMC	4182/836.4	1:1	0.094	-0.09	22.75	24.00	1.334	0.125	22.1
Body worn Test data(Separate 15mm)										
Front side	RMC	4182/836.4	1:1	0.208	0.05	22.75	24.00	1.334	**0.277**	22.1
Back side	RMC	4182/836.4	1:1	0.207	0.07	22.75	24.00	1.334	0.276	22.1
Hotspot Test data(Separate 10mm)										
Front side	RMC	4182/836.4	1:1	0.296	-0.04	22.75	24.00	1.334	**0.395**	22.1
Back side	RMC	4182/836.4	1:1	0.275	-0.17	22.75	24.00	1.334	0.367	22.1
Left side	RMC	4182/836.4	1:1	0.112	-0.12	22.75	24.00	1.334	0.149	22.1
Right side	RMC	4182/836.4	1:1	0.207	-0.02	22.75	24.00	1.334	0.276	22.1
Bottom side	RMC	4182/836.4	1:1	0.190	-0.18	22.75	24.00	1.334	0.253	22.1

<LTE Band 5>

Test position	BW.	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg)1-g	Power Drift(dB)	Conducted power(dBm)	Tune up Limit(dBm)	Scaled factor	Scaled SAR(W/kg)	Liquid Temp.
Head Test data(1RB)											
Left cheek	10	QPSK 1RB_25	20525/836.5	1:1	0.121	0.08	22.72	24.00	1.343	0.162	22.1
Left tilted	10	QPSK 1RB_25	20525/836.5	1:1	0.072	0.08	22.72	24.00	1.343	0.097	22.1
Right cheek	10	QPSK 1RB_25	20525/836.5	1:1	0.193	0.15	22.72	24.00	1.343	**0.259**	22.1
Right tilted	10	QPSK 1RB_25	20525/836.5	1:1	0.057	0.15	22.72	24.00	1.343	0.077	22.1
Head Test data(50%RB)											
Left cheek	10	QPSK 25RB_13	20525/836.5	1:1	0.093	0.01	21.58	23.00	1.387	0.129	22.1
Left tilted	10	QPSK 25RB_13	20525/836.5	1:1	0.056	0.01	21.58	23.00	1.387	0.078	22.1
Right cheek	10	QPSK 25RB_13	20525/836.5	1:1	0.153	0.04	21.58	23.00	1.387	0.212	22.1
Right tilted	10	QPSK 25RB_13	20525/836.5	1:1	0.0495	0.02	21.58	23.00	1.387	0.069	22.1
Body worn Test data(Separate 15mm 1RB)											
Front side	10	QPSK 1RB_25	20525/836.5	1:1	0.160	-0.10	22.72	24.00	1.343	**0.215**	22.1
Back side	10	QPSK 1RB_25	20525/836.5	1:1	0.144	-0.15	22.72	24.00	1.343	0.193	22.1
Body worn Test data (Separate 15mm 50%RB)											
Front side	10	QPSK 25RB_13	20450/829	1:1	0.114	-0.07	21.58	23.00	1.387	0.158	22.1
Back side	10	QPSK 25RB_13	20450/829	1:1	0.099	-0.05	21.58	23.00	1.387	0.138	22.1
Hotspot Test data(Separate 10mm 1RB)											
Front side	10	QPSK 1RB_25	20525/836.5	1:1	0.221	-0.06	22.72	24.00	1.343	0.297	22.1
Back side	10	QPSK 1RB_25	20525/836.5	1:1	0.250	-0.13	22.72	24.00	1.343	**0.336**	22.1
Left side	10	QPSK 1RB_25	20525/836.5	1:1	0.109	-0.12	22.72	24.00	1.343	0.146	22.1
Right side	10	QPSK 1RB_25	20525/836.5	1:1	0.201	-0.10	22.72	24.00	1.343	0.270	22.1
Bottom side	10	QPSK 1RB_25	20525/836.5	1:1	0.178	-0.05	22.72	24.00	1.343	0.239	22.1
Hotspot Test data (Separate 10mm 50%RB)											
Front side	10	QPSK 25RB_13	20450/829	1:1	0.165	-0.02	21.58	23.00	1.387	0.229	22.1
Back side	10	QPSK 25RB_13	20450/829	1:1	0.150	-0.08	21.58	23.00	1.387	0.208	22.1
Left side	10	QPSK 25RB_13	20450/829	1:1	0.087	-0.09	21.58	23.00	1.387	0.120	22.1
Right side	10	QPSK 25RB_13	20450/829	1:1	0.142	-0.10	21.58	23.00	1.387	0.197	22.1
Bottom side	10	QPSK 25RB_13	20450/829	1:1	0.123	-0.08	21.58	23.00	1.387	0.171	22.1

<LTE Band 12>

Test position	BW.	Test mode	Test Ch./Freq.	Duty Cycle	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data(1RB)											
Left cheek	10	QPSK 1RB_49	23095/707.5	1:1	0.057	0.06	22.44	24.00	1.432	0.081	22.1
Left tilted	10	QPSK 1RB_49	23095/707.5	1:1	0.036	0.01	22.44	24.00	1.432	0.052	22.1
Right cheek	10	QPSK 1RB_49	23095/707.5	1:1	0.091	-0.01	22.44	24.00	1.432	**0.131**	22.1
Right tilted	10	QPSK 1RB_49	23095/707.5	1:1	0.029	-0.03	22.44	24.00	1.432	0.041	22.1
Head Test data(50%RB)											
Left cheek	10	QPSK 25RB_0	23130/711	1:1	0.047	0.01	21.56	23.00	1.393	0.066	22.1
Left tilted	10	QPSK 25RB_0	23130/711	1:1	0.028	0.06	21.56	23.00	1.393	0.039	22.1
Right cheek	10	QPSK 25RB_0	23130/711	1:1	0.061	0.04	21.56	23.00	1.393	0.086	22.1
Right tilted	10	QPSK 25RB_0	23130/711	1:1	0.025	0.01	21.56	23.00	1.393	0.035	22.1
Body worn Test data(Separate 15mm 1RB)											
Front side	10	QPSK 1RB_49	23095/707.5	1:1	0.091	-0.08	22.44	24.00	1.432	0.130	22.1
Back side	10	QPSK 1RB_49	23095/707.5	1:1	0.097	-0.15	22.44	24.00	1.432	**0.139**	22.1
Body worn Test data (Separate 15mm 50%RB)											
Front side	10	QPSK 25RB_0	23130/711	1:1	0.081	-0.15	21.56	23.00	1.393	0.113	22.1
Back side	10	QPSK 25RB_0	23130/711	1:1	0.083	-0.05	21.56	23.00	1.393	0.115	22.1
Hotspot Test data(Separate 10mm 1RB)											
Front side	10	QPSK 1RB_49	23095/707.5	1:1	0.088	-0.06	22.44	24.00	1.432	0.126	22.1
Back side	10	QPSK 1RB_49	23095/707.5	1:1	0.113	-0.08	22.44	24.00	1.432	**0.162**	22.1
Left side	10	QPSK 1RB_49	23095/707.5	1:1	0.053	-0.13	22.44	24.00	1.432	0.076	22.1
Right side	10	QPSK 1RB_49	23095/707.5	1:1	0.078	-0.11	22.44	24.00	1.432	0.111	22.1
Bottom side	10	QPSK 1RB_49	23095/707.5	1:1	0.068	0.00	22.44	24.00	1.432	0.098	22.1
Hotspot Test data (Separate 10mm 50%RB)											
Front side	10	QPSK 25RB_0	23130/711	1:1	0.090	-0.02	21.56	23.00	1.393	0.125	22.1
Back side	10	QPSK 25RB_0	23130/711	1:1	0.096	-0.12	21.56	23.00	1.393	0.134	22.1
Left side	10	QPSK 25RB_0	23130/711	1:1	0.044	-0.05	21.56	23.00	1.393	0.061	22.1
Right side	10	QPSK 25RB_0	23130/711	1:1	0.066	0.01	21.56	23.00	1.393	0.092	22.1
Bottom side	10	QPSK 25RB_0	23130/711	1:1	0.059	-0.09	21.56	23.00	1.393	0.082	22.1

<WiFi 2.4G>

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data											
Left cheek	802.11b	6/2437	99.49%	1.005	0.520	0.08	14.12	14.50	1.091	0.570	22.0
Left tilted	802.11b	6/2437	99.49%	1.005	0.612	0.06	14.12	14.50	1.091	**0.671**	22.0
Right cheek	802.11b	6/2437	99.49%	1.005	0.185	0.04	14.12	14.50	1.091	0.203	22.0
Right tilted	802.11b	6/2437	99.49%	1.005	0.213	0.14	14.12	14.50	1.091	0.234	22.0
Hotspot Test data (Separate 10mm)											
Front side	802.11b	6/2437	99.49%	1.005	0.090	0.08	14.12	14.50	1.091	0.098	22.0
Back side	802.11b	6/2437	99.49%	1.005	0.122	-0.05	14.12	14.50	1.091	0.134	22.0
Right side	802.11b	6/2437	99.49%	1.005	0.051	0.05	14.12	14.50	1.091	0.055	22.0
Top side	802.11b	6/2437	99.49%	1.005	0.170	0.11	14.12	14.50	1.091	**0.186**	22.0

<WiFi 5G>

Test position	Test mode	Test Ch./Freq.	Duty Cycle	Duty Cycle Scaled factor	SAR (W/kg) 1-g	Power Drift (dB)	Conducted Power (dBm)	Tune up Limit (dBm)	Scaled factor	Scaled SAR (W/kg)	Liquid Temp
Head Test data of U-NII-2A											
Left cheek	802.11a	64/5320	96.76%	1.033	0.485	0.01	15.34	16.00	1.164	0.584	22.2
Left tilted	802.11a	64/5320	96.76%	1.033	0.548	0.13	15.34	16.00	1.164	**0.659**	22.2
Right cheek	802.11a	64/5320	96.76%	1.033	0.422	0.01	15.34	16.00	1.164	0.508	22.2
Right tilted	802.11a	64/5320	96.76%	1.033	0.450	0.01	15.34	16.00	1.164	0.541	22.2
Head Test data of U-NII-2C											
Left cheek	802.11a	112/5560	96.76%	1.033	0.271	0.04	15.41	16.00	1.146	0.321	22.2
Left tilted	802.11a	112/5560	96.76%	1.033	0.291	0.02	15.41	16.00	1.146	0.345	22.2
Right cheek	802.11a	112/5560	96.76%	1.033	0.162	0.02	15.41	16.00	1.146	0.192	22.2
Right tilted	802.11a	112/5560	96.76%	1.033	0.216	0.09	15.41	16.00	1.146	0.256	22.2
Head Test data of U-NII-3											
Left cheek	802.11a	157/5785	96.76%	1.033	0.356	0.03	15.83	16.00	1.040	0.383	22.2
Left tilted	802.11a	157/5785	96.76%	1.033	0.423	0.04	15.83	16.00	1.040	0.455	22.2
Right cheek	802.11a	157/5785	96.76%	1.033	0.228	0.09	15.83	16.00	1.040	0.245	22.2
Right tilted	802.11a	157/5785	96.76%	1.033	0.227	0.03	15.83	16.00	1.040	0.244	22.2
Body worn Test data of U-NII-2A (Separate 15mm)											
Front side	802.11a	64/5320	96.76%	1.033	0.042	-0.01	15.34	16.00	1.164	0.050	22.2
Back side	802.11a	64/5320	96.76%	1.033	0.141	-0.06	15.34	16.00	1.164	0.170	22.2
Body worn Test data of U-NII-2C(Separate 15mm)											
Front side	802.11a	112/5560	96.76%	1.033	0.013	0.00	15.41	16.00	1.146	0.016	22.2
Back side	802.11a	112/5560	96.76%	1.033	0.174	-0.02	15.41	16.00	1.146	**0.206**	22.2
Body worn Test data of U-NII-3(Separate 15mm)											
Front side	802.11a	157/5785	96.76%	1.033	0.037	0.06	15.83	16.00	1.040	0.040	22.2
Back side	802.11a	157/5785	96.76%	1.033	0.120	0.09	15.83	16.00	1.040	0.129	22.2

Note:

This project not supports WLAN 5GHz Hotspot(All band).

3 Simultaneous Transmission Analysis

3.1 Simultaneous Transmission Scenarios:

NO.	Simultaneous Transmission Configuration	Head	Body worn	Hotspot
1	GSM + WiFi	Yes	Yes	Yes
2	GSM + BT	Yes	Yes	Yes
3	WCDMA + WiFi	Yes	Yes	Yes
4	WCDMA + BT	Yes	Yes	Yes
5	LTE + WiFi	Yes	Yes	Yes
6	LTE + BT	Yes	Yes	Yes
7	BT+WIFI (They share the same antenna and cannot transmit at the same time by design.)	No	No	No

Note:

1) Wi-Fi and Bluetooth share the same Tx antenna and can't transmit simultaneously.

2) The device does not support DTM function.

3) * VoLTE or pre-installed VOIP applications are considered.

4) This project not supports WLAN 5GHz Hotspot(All band).

3.2 Estimated SAR calculation

Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and Product specific 10g SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Threshold condition is satisfied. These test exclusion conditions are based on source-based time-averaged maximum conducted output power of the RF channel requiring evaluation, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions.

Freq. Band	Frequency (GHz)	Position	Average Power		Test Separation(mm)	Calculate Value	Exclusion Threshold	Exclusion (Y/N)
			dBm	mW				
Wi-Fi	2.462	Head	14.5	28.18	0	8.8	3	N
		Body-worn	14.5	28.18	15	2.9	3	Y
		hotspot	14.5	28.18	10	4.4	3	N
Wi-Fi	5.85	Head	16.0	39.81	0	19.3	3	N
		Body-worn	16.0	39.81	15	6.4	3	N
Bluetooth	2.48	Head	9.5	8.91	0	2.8	3	Y
		Body-worn	9.5	8.91	15	0.9	3	Y
		hotspot	9.5	8.91	10	1.4	3	Y

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

When the standalone SAR test exclusion is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to the following to determine simultaneous transmission SAR test exclusion:

- (max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)]·[√f(GHz)/x] W/kg for test separation distances ≤ 50 mm;

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Where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR.
When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Estimated SAR Result

Freq. Band	Frequency (GHz)	Test Position	max. power(dBm)	Test Separation (mm)	Estimated 1g SAR (W/kg)
WiFi 2.4G	2.462	Body-worn	14.5	15	0.393
Bluetooth	2.48	Head	9.5	5	0.374
		Body-worn	9.5	15	0.125
		hotspot	9.5	10	0.187

3.3 SPLSR evaluation and analysis

Per KDB447498D01, when the sum of SAR is larger than the limit, SAR test exclusion is determined by the SAR sum to peak location separation ratio(SPLSR).

The simultaneous transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the SAR to peak location separation ratio to qualify for test exclusion.

The ratio is determined by (SAR1 + SAR2)^1.5/Ri, rounded to two decimal digits, and must be ≤ 0.04 for all antenna pairs in the configuration to qualify for 1-g SAR test exclusion.

SAR1 and SAR2 are the highest reported or estimated SAR for each antenna in the pair, and Ri is the separation distance between the peak SAR locations for the antenna pair in mm.

When standalone test exclusion applies, SAR is estimated; the peak location is assumed to be at the feed-point or geometric center of the antenna.

3.4 Simultaneous Transmission Combination Scenario

Test position		Main Antenna SARmax (W/kg)					WiFi/BT Antenna SARmax (W/kg)			Summed 1g SARmax (W/kg)	SPLSR
		GSM850	GSM1900	WCDMA Band V	LTE Band 5	LTE Band 12	WLAN 2.4G	WLAN 5G	BT		
Head	Left cheek	0.399	0.165	0.223	0.162	0.081	0.570	0.584	0.374	0.983	NA
	Left tilted	0.319	0.135	0.156	0.097	0.052	0.671	0.659	0.374	0.990	NA
	Right cheek	0.511	0.159	0.299	0.259	0.131	0.203	0.508	0.374	1.019	NA
	Right tilted	0.325	0.126	0.125	0.077	0.041	0.234	0.541	0.374	0.866	NA
Body worn	Front side	0.480	0.167	0.277	0.215	0.130	0.393	0.050	0.125	0.873	NA
	Back side	0.500	0.185	0.276	0.193	0.139	0.393	0.206	0.125	0.893	NA
Hotspot	Front side	0.646	0.403	0.395	0.297	0.126	0.098	/	0.187	0.744	NA
	Back side	0.697	0.416	0.367	0.336	0.162	0.134	/	0.187	0.831	NA
	Left side	0.416	0.098	0.149	0.146	0.076	/	/	/	0.416	NA
	Right side	0.794	0.041	0.276	0.270	0.111	0.055	/	0.187	0.849	NA
	Bottom side	0.701	0.944	0.253	0.239	0.098	/	/	/	0.944	NA
	Top side	/	/	/	/	/	0.186	/	0.187	0.186	NA

4 Instruments List

Test Platform	SPEAG DASY5 Professional					
Location	SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch					
Description	SAR Test System (Frequency range 300MHz-6GHz)					
Software Reference	DASY52; SEMCAD					
Hardware Reference						
	Equipment	Manufacturer	Model	Serial Number	Calibration Date	Due date of calibration
☒	Twin Phantom	SPEAG	SAM 2	1913	NCR	NCR
☒	Twin Phantom	SPEAG	SAM 3	1912	NCR	NCR
☒	Twin Phantom	SPEAG	SAM 10	1563	NCR	NCR
☒	DAE	SPEAG	DAE4	1428	2020-03-03	2021-03-02
☒	DAE	SPEAG	DAE4	1267	2020-06-12	2021-06-11
☒	E-Field Probe	SPEAG	EX3DV4	3962	2020-04-01	2021-03-31
☒	E-Field Probe	SPEAG	EX3DV4	3793	2020-05-09	2021-05-08
☒	Validation Kits	SPEAG	D750V3	1160	2019-05-22	2022-05-21
☒	Validation Kits	SPEAG	D835V2	4d105	2019-12-17	2022-12-16
☒	Validation Kits	SPEAG	D1900V2	5d028	2019-12-17	2022-12-16
☒	Validation Kits	SPEAG	D2450V2	733	2019-12-17	2022-12-16
☒	Validation Kits	SPEAG	D5GHzV2	1165	2019-12-20	2022-12-19
☒	Agilent Network Analyzer	Agilent	E5071C	MY46523590	2020-04-02	2021-04-01
☒	Dielectric Probe Kit	Agilent	85070E	US01440210	NCR	NCR
☒	Universal Radio Communication Tester	R&S	CMW500	124587	2020-04-02	2021-04-01
☒	Radio Communication Analyzer	Anritsu Corporation	MT8821C	6201502984	2020-06-11	2021-06-10
☒	RF Bi-Directional Coupler	Agilent	86205-60001	MY31400031	NCR	NCR
☒	Signal Generator	Agilent	N5171B	MY53050736	2020-04-15	2021-04-14
☒	Preamplifier	Mini-Circuits	ZHL-42W	15542	NCR	NCR
☒	Preamplifier	Compliance Directions Systems Inc.	AMP28-3W	073501433	NCR	NCR
☒	Power Meter	Agilent	E4416A	GB41292095	2020-04-15	2021-04-14
☒	Power Sensor	Agilent	8481H	MY41091234	2020-04-15	2021-04-14
☒	Power Sensor	R&S	NRP-Z92	100025	2020-04-16	2021-04-15
☒	Attenuator	SHX	TS2-3dB	30704	NCR	NCR
☒	Coaxial low pass filter	Mini-Circuits	VLF-2500(+)	NA	NCR	NCR

☒	Coaxial low pass filter	Microlab Fxr	LA-F13	NA	NCR	NCR
☒	DC POWER SUPPLY	SAKO	SK1730SL5A	NA	NCR	NCR
☒	Speed reading thermometer	MingGao	T809	NA	2020-04-15	2021-04-14
☒	Humidity and Temperature Indicator	KIMTOKA	KIMTOKA	NA	2020-04-21	2021-04-20

Note: All the equipments are within the valid period when the tests are performed.

5 Measurements

Please see the Appendix B

6 SAR System Performance Check

Please see the Appendix A

7 Photographs

Please see the Appendix D

8 DAE & Probe Calibration Certificate

Please see the Appendix C

9 SAR measurement variability and uncertainty

SAR measurement variability

Per KDB865664 D01 SAR measurement 100 MHz to 6 GHz v01r04, SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. The 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 < 0.80 W/kg; steps 2) through 4) do not apply.

2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.

3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).

4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

SAR measurement variability

Per KDB865664 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.

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