SAR TEST REPORT

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

Product Name	Notebook PC
Brand Name	HP
Model No.	HSN-W01C
Prepared for	HP Inc.
	1501 Page Mill Road Palo Alto, CA 94304
Standards	IEEE/ANSI C95.1-1992, IEEE 1528-2013, KDB248227D01v02r02,KDB865664D01v01r04, KDB865664D02v01r02,KDB447498D01v06, KDB616217D04v01r02,
FCC ID	TX2-RTL8822BE
Date of Receipt	Feb. 12, 2018
Date of Test(s)	Mar. 08, 2018 ~ Mar. 12, 2018
Date of Issue	Jun. 08, 2018

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 test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. 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 Taiwan Electronic & Communication Laboratory or testing done by SGS Taiwan Electronic & Communication Laboratory in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Electronic & Communication Laboratory in writing.

Signed on behalf of SGS

Clerk / Ruby Ou	Engineer / Bond Tsai	Asst. Manager / John Yeh
Ruby Ou	Bond Tsai	John Yeh

Date: Jun. 08, 2018

Revision History

Report Number	Revision	Description	Issue Date
E5/2018/20016	Rev.00	Initial creation of document	Apr. 03, 2018
E5/2018/20016	Rev.01	1st modification	Apr. 20, 2018
E5/2018/20016	Rev.02	2nd modification	Jun. 08, 2018

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Contents

1. General Information

1.1 Testing Laboratory

SGS Taiwan Ltd. Electronics & Communication Laboratory	
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Fax	+886-2-2298-0488
Internet	http://www.tw.sgs.com/

1.2 Details of Applicant

Company Name	HP Inc.
Company Address	1501 Page Mill Road Palo Alto, CA 94304

1.3 Description of EUT

General Information of Host:

Equipment Under Test	Notebook PC	
Brand Name	HP	
Model No.	HSN-W01C	
Integrated Module	Brand Name : Realtek Model Name : RTL8822BE	
FCC ID	TX2-RTL8822BE	
Mode of Operation	☒WLAN802.11 a/b/g/n(20M/40M)/ac(20M/40M/80M) ☒Bluetooth	
Duty Cycle	WLAN802.11 a/b/g/n(20M/40M)/ ac(20M/40M/80M)	1
	Bluetooth	1
TX Frequency Range (MHz)	WLAN802.11 b/g/n(20M)	2412 – 2472
	WLAN802.11 n(40M)	2422 – 2462
	WLAN802.11 a/n(20M)/ac(20M) 5.2G	5180 – 5240
	WLAN802.11 n(40M)/ac(40M) 5.2G	5190 – 5230
	WLAN802.11 ac(80M) 5.2G	5210
	WLAN802.11 a/n(20M)/ac(20M) 5.3G	5260 – 5320
	WLAN802.11 n(40M)/ac(40M) 5.3G	5270 – 5310
	WLAN802.11 ac(80M) 5.3G	5290
	WLAN802.11 a/n/ac(20M) 5.6G	5500 – 5720
	WLAN802.11 n/ac(40M) 5.6G	5510 – 5710
	WLAN802.11 ac(80M) 5.6G	5530 – 5690
	WLAN802.11 a/n(20M)/ac(20M) 5.8G	5745 – 5825
	WLAN802.11 n(40M)/ac(40M) 5.8G	5710 – 5795
	WLAN802.11 ac(80M) 5.8G	5775
	Bluetooth	2402 – 2480
Channel Number	WLAN802.11 b/g/n(20M)	1 – 13

(ARFCN)	WLAN802.11 n(40M)	3	–	11
	WLAN802.11 a/n(20M)/ac(20M) 5.2G	36	–	48
Channel Number (ARFCN)	WLAN802.11 n(40M)/ac(40M) 5.2G	38	–	46
	WLAN802.11 ac(80M) 5.2G		42	
	WLAN802.11 a/n(20M)/ac(20M) 5.3G	52	–	64
	WLAN802.11 n(40M)/ac(40M) 5.3G	54	–	62
	WLAN802.11 ac(80M) 5.3G		58	
	WLAN802.11 a/n/ac(20M) 5.6G	100	–	144
	WLAN802.11 n/ac(40M) 5.6G	102	–	142
	WLAN802.11 ac(80M) 5.6G	106	–	138
	WLAN802.11 a/n(20M)/ac(20M) 5.8G	149	–	165
	WLAN802.11 n(40M)/ac(40M) 5.8G	151	–	159
	WLAN802.11 ac(80M) 5.8G		155	
	Bluetooth	0	–	78

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Max. SAR (1g) (Unit: W/Kg)					
Antenna	Band	Measured	Reported	Channel	Position
Main	WLAN802.11b	0.49	0.49	1	Top side
	WLAN802.11g	0.61	0.61	2	Top side
	WLAN802.11 a 5.2G	0.52	0.52	48	Top side
	WLAN802.11 a 5.3G	0.57	0.58	56	Top side
	WLAN802.11 a 5.6G	0.65	0.66	116	Top side
	WLAN802.11 a 5.8G	0.59	0.60	157	Top side
Aux	WLAN802.11b	0.22	0.22	1	Top side
	WLAN802.11g	0.41	0.42	10	Top side
	Bluetooth(GFSK)	0.02	0.02	39	Top side
	WLAN802.11 a 5.2G	0.41	0.41	44	Top side
	WLAN802.11 a 5.3G	0.38	0.38	56	Top side
	WLAN802.11 a 5.6G	0.46	0.46	136	Top side
	WLAN802.11 a 5.8G	0.95	0.96	149	Top side

Antenna Information

Tablet mode								
Vendor	Wistron				Wistron			
Antenna	Main (PIFA)				Aux (PIFA)			
Part Number	025.901B9.0001(WA-P-LB-02-512)				025.901BA.0001 (WA-P-LB-02-513)			
Frequency	2.4G	5.2G	5.5G	5.8G	2.4G	5.2G	5.5G	5.8G
Gain (dBi)	-1.56	2.61	0.42	-1.43	-0.78	-1.01	0.16	-2.15
NB mode								
Antenna	Main (PIFA)				Aux (PIFA)			
Part Number	025.901B9.0001(WA-P-LB-02-512)				025.901BA.0001 (WA-P-LB-02-513)			
Frequency	2.4G	5.2G	5.5G	5.8G	2.4G	5.2G	5.5G	5.8G
Gain (dBi)	-4.92	-1.53	-1.70	-0.12	-0.9	0.35	-0.16	-3.39

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WLAN802.11 a/b/g/n(20M/40M)/ac(20M/40M/80M) conducted power table:

Band \ Antenna	SISO		MIMO
	Chain 0	Chain 1	Chain0+1
WLAN802.11b	V	V	-
WLAN802.11g	V	V	-
WLAN802.11n(20M)	V	V	V
WLAN802.11n(40M)	V	V	V
WLAN802.11ac	V	V	V
WLAN802.11a	V	V	-
WLAN802.11n(20M) 5G	V	V	V
WLAN802.11n(40M) 5G	V	V	V
WLAN802.11ac(20M) 5G	V	V	V
WLAN802.11ac(40M) 5G	V	V	V
WLAN802.11ac(80M) 5G	V	V	V

Main (Chain 0)

Main Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
2450 MHz	802.11b	1	2412	1Mbps	17.00	16.98
		6	2437		17.00	16.86
		11	2462		17.00	16.91
		12	2467		14.00	13.98
		13	2472		11.00	10.89
	802.11g	1	2412	6Mbps	14.00	13.84
		2	2417		18.00	17.98
		6	2437		18.00	17.89
		10	2457		18.00	17.97
		11	2462		15.00	14.91
		12	2467		12.00	11.94
		13	2472		8.00	7.95
	802.11n20-HT0	1	2412	MCS0	14.00	13.90
		6	2437		18.00	17.96
		11	2462		14.00	13.91
		12	2467		11.00	10.91
		13	2472		8.00	7.92
	802.11n40-HT0	3	2422	MCS0	14.00	13.92
		6	2437		17.00	16.85
		9	2452		14.00	13.94

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Main Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5.15-5.25 GHz	802.11a	36	5180	6Mbps	16.50	16.44
		40	5200		17.50	17.47
		44	5220		17.50	17.40
		48	5240		17.50	17.49
	802.11n20-HT0	36	5180	MCS0	16.50	16.47
		40	5200		17.50	17.38
		44	5220		17.50	17.41
		48	5240		17.50	17.43
	802.11ac20-VHT0	36	5180	MCS0	16.50	16.46
		40	5200		17.50	17.47
		44	5220		17.50	17.41
		48	5240		17.50	17.40
	802.11n40-HT0	38	5190	MCS0	12.50	12.39
		46	5230		16.50	16.41
	802.11ac40-VHT0	38	5190	MCS0	12.50	12.44
		46	5230		16.50	16.42
	802.11ac80-VHT0	42	5210	MCS0	11.50	11.38

Main Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5.25-5.35 GHz	802.11a	52	5260	6Mbps	17.50	17.39
		56	5280		17.50	17.43
		60	5300		17.50	17.42
		64	5320		15.50	15.44
	802.11n20-HT0	52	5260	MCS0	17.50	17.45
		56	5280		17.50	17.47
		60	5300		17.50	17.42
		64	5320		15.50	15.44
	802.11ac20-VHT0	52	5260	MCS0	17.50	17.43
		56	5280		17.50	17.46
		60	5300		17.50	17.40
		64	5320		15.50	15.39
	802.11n40-HT0	54	5270	MCS0	16.50	16.34
		62	5310		13.50	13.37
	802.11ac40-VHT0	54	5270	MCS0	16.50	16.41
		62	5310		13.50	13.39
	802.11ac80-VHT0	58	5290	MCS0	11.50	11.42

Main Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5600 MHz	802.11a	100	5500	6Mbps	14.50	14.45
		104	5520		17.50	17.45
		116	5580		17.50	17.49
		120	5600		17.50	17.37
		124	5620		17.50	17.35
		128	5640		17.50	17.39
		136	5680		17.50	17.48
		140	5700		14.50	14.40
	802.11n20-HT0	100	5500	MCS0	14.50	14.34
		104	5520		17.50	17.43
		116	5580		17.50	17.41
		120	5600		17.50	17.45
		124	5620		17.50	17.37
		128	5640		17.50	17.40
		136	5680		17.50	17.41
		140	5700		14.50	14.37
	802.11ac20-VHT0	100	5500	MCS0	14.50	14.42
		104	5520		17.50	17.42
		116	5580		17.50	17.40
		120	5600		17.50	17.35
		124	5620		17.50	17.38
		128	5640		17.50	17.39
		136	5680		17.50	17.45
		140	5700		14.50	14.34
		144	5720		14.50	14.41
	802.11n40-HT0	102	5510	MCS0	13.50	13.37
		110	5550		16.50	16.40
		118	5590		16.50	16.48
		126	5630		16.50	16.46
		134	5670		16.50	16.41
	802.11ac40-VHT0	102	5510	MCS0	13.50	13.34
		110	5550		16.50	16.39
		118	5590		16.50	16.43
		126	5630		16.50	16.47
		134	5670		16.50	16.41
		142	5710		16.50	16.37
	802.11ac80-VHT0	106	5530	MCS0	11.50	11.47
		122	5610		16.50	16.44
		138	5690		16.50	16.40

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Main Antenna						
Mode	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5800 MHz	802.11a	149	5745	6Mbps	17.50	17.40
		157	5785		17.50	17.44
		165	5825		17.50	17.42
	802.11n20-HT0	149	5745	MCS0	17.50	17.37
		157	5785		17.50	17.39
		165	5825		17.50	17.42
	802.11ac20-VHT0	149	5745	MCS0	17.50	17.47
		157	5785		17.50	17.44
		165	5825		17.50	17.42
	802.11n40-HT0	151	5755	MCS0	16.50	16.43
		159	5795		16.50	16.40
	802.11ac40-VHT0	151	5755	MCS0	16.50	16.39
		159	5795		16.50	16.45
	802.11ac80-VHT0	155	5775	MCS0	16.50	16.41

Aux (Chain 1)

Aux Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
2450 MHz	802.11b	1	2412	1Mbps	17.00	16.91
		6	2437		17.00	16.84
		11	2462		17.00	16.88
		12	2467		14.00	13.95
		13	2472		11.00	10.91
	802.11g	1	2412	6Mbps	14.00	13.91
		2	2417		18.00	17.96
		6	2437		18.00	17.99
		10	2457		18.00	17.97
		11	2462		15.00	14.95
		12	2467		12.00	11.96
		13	2472		8.00	7.93
	802.11n20-HT0	1	2412	MCS0	14.00	13.93
		6	2437		18.00	17.91
		11	2462		14.00	13.90
		12	2467		11.00	10.89
		13	2472		8.00	7.86
	802.11n40-HT0	3	2422	MCS0	14.00	13.94
		6	2437		17.00	16.87
		9	2452		14.00	13.94

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Aux Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5.15-5.25 GHz	802.11a	36	5180	6Mbps	16.50	16.43
		40	5200		17.50	17.46
		44	5220		17.50	17.49
		48	5240		17.50	17.40
	802.11n20-HT0	36	5180	MCS0	16.50	16.45
		40	5200		17.50	17.44
		44	5220		17.50	17.47
		48	5240		17.50	17.42
	802.11ac20-VHT0	36	5180	MCS0	16.50	16.36
		40	5200		17.50	17.42
		44	5220		17.50	17.45
		48	5240		17.50	17.40
	802.11n40-HT0	38	5190	MCS0	12.50	12.43
		46	5230		16.50	16.45
	802.11ac40-VHT0	38	5190	MCS0	12.50	12.40
		46	5230		16.50	16.46
	802.11ac80-VHT0	42	5210	MCS0	11.50	11.43

Aux Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5.25-5.35 GHz	802.11a	52	5260	6Mbps	17.50	17.40
		56	5280		17.50	17.45
		60	5300		17.50	17.41
		64	5320		15.50	15.45
	802.11n20-HT0	52	5260	MCS0	17.50	17.41
		56	5280		17.50	17.45
		60	5300		17.50	17.44
		64	5320		15.50	15.42
	802.11ac20-VHT0	52	5260	MCS0	17.50	17.45
		56	5280		17.50	17.47
		60	5300		17.50	17.42
		64	5320		15.50	15.36
	802.11n40-HT0	54	5270	MCS0	16.50	16.37
		62	5310		13.50	13.39
	802.11ac40-VHT0	54	5270	MCS0	16.50	16.40
		62	5310		13.50	13.41
	802.11ac80-VHT0	58	5290	MCS0	11.50	11.46

Aux Antenna						
Band	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5600 MHz	802.11a	100	5500	6Mbps	14.50	14.47
		104	5520		17.50	17.40
		116	5580		17.50	17.48
		120	5600		17.50	17.45
		124	5620		17.50	17.42
		128	5640		17.50	17.46
		136	5680		17.50	17.49
		140	5700		14.50	14.41
	802.11n20-HT0	100	5500	MCS0	14.50	14.34
		104	5520		17.50	17.45
		116	5580		17.50	17.40
		120	5600		17.50	17.42
		124	5620		17.50	17.33
		128	5640		17.50	17.44
		136	5680		17.50	17.45
		140	5700		14.50	14.47
	802.11ac20-VHT0	100	5500	MCS0	14.50	14.49
		104	5520		17.50	17.35
		116	5580		17.50	17.43
		120	5600		17.50	17.31
		124	5620		17.50	17.42
		128	5640		17.50	17.34
		136	5680		17.50	17.38
		140	5700		14.50	14.35
		144	5720		14.50	14.41
	802.11n40-HT0	102	5510	MCS0	13.50	13.47
		110	5550		16.50	16.40
		118	5590		16.50	16.35
		126	5630		16.50	16.42
		134	5670		16.50	16.43
	802.11ac40-VHT0	102	5510	MCS0	13.50	13.34
		110	5550		16.50	16.47
		118	5590		16.50	16.49
		126	5630		16.50	16.41
		134	5670		16.50	16.42
		142	5710		16.50	16.37
	802.11ac80-VHT0	106	5530	MCS0	11.50	11.48
		122	5610		16.50	16.44
		138	5690		16.50	16.38

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Aux Antenna						
Mode	Mode	Channel	Frequency (MHz)	Data Rate	Max. Rated Avg. Power + Max. Tolerance (dBm)	Average power (dBm)
5800 MHz	802.11a	149	5745	6Mbps	17.50	17.47
		157	5785		17.50	17.42
		165	5825		17.50	17.43
	802.11n20-HT0	149	5745	MCS0	17.50	17.45
		157	5785		17.50	17.42
		165	5825		17.50	17.36
	802.11ac20-VHT0	149	5745	MCS0	17.50	17.40
		157	5785		17.50	17.43
		165	5825		17.50	17.47
	802.11n40-HT0	151	5755	MCS0	16.50	16.46
		159	5795		16.50	16.44
	802.11ac40-VHT0	151	5755	MCS0	16.50	16.38
		159	5795		16.50	16.43
	802.11ac80-VHT0	155	5775	MCS0	16.50	16.47

Bluetooth conducted power table:

Mode	Channel	Frequency (MHz)	Average Output Power (dBm)			Max. Rated Avg. Power + Max. Tolerance (dBm)
			1Mbps	2Mbps	3Mbps	
BR/EDR	CH 00	2402	5.22	4.35	4.19	5.5
	CH 39	2441	5.34	4.18	4.14	
	CH 78	2480	5.10	4.09	4.17	

Mode	Channel	Frequency (MHz)	Average Output Power (dBm)	Max. Rated Avg. Power + Max. Tolerance (dBm)
			GFSK	
LE	CH 00	2402	5.12	5.5
	CH 20	2442	5.19	
	CH 39	2480	4.77	

1.4 Test Environment

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

1.5 Operation Description

Use chipset specific software to control the EUT, and makes it transmit in maximum power. 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.

EUT was tested as below,

Tablet mode

Main antenna :Back/top/left sides_0mm.

Aux antenna :Back/top sides_0mm.

Laptop mode

Laptop SAR is not required since the distance between antenna and user > 20cm.

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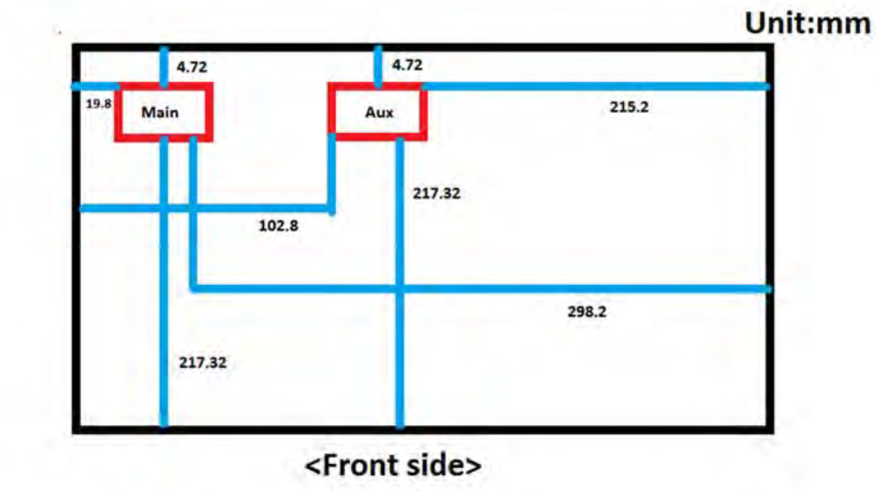

Antenna location (front side)

Note:

802.11b DSSS SAR Test Requirements:

1. SAR is measured for 2.4 GHz 802.11b DSSS mode using the highest measured maximum output power channel, 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.

802.11g/n OFDM SAR Test Exclusion Requirements:

3. SAR is not required for 802.11g/n since 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.

Initial Test Configuration:

4. 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.

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5. SAR is measured using the highest measured maximum output power channel. 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.

6. Since 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 is not required for subsequent test configuration.

7. For WLAN Main/Aux antennas, 5.2a / 5.3a / 5.6a / 5.8a is chosen to be the initial test configurations.

8. BT and WLAN Aux use the same antenna path, but they can't transmit at the same time.
9. According to KDB447498 D01, 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 ≤ 100 MHz.
10. According to KDB865664 D01, 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. Based on KDB447498D01,

    (1) SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances≤ 50 mm are determined by:

    $$\frac{\text{Max. tune up power(mW)}}{\text{Min. test separation distance(mm)}} \times \sqrt{\text{f(GHz)}} \leq 3$$

    When the minimum test separation distance is < 5mm, 5mm is applied to determine SAR test exclusion.

    (2) For test separation distances > 50 mm, and the frequency at 100 MHz to 1500MHz, the SAR test exclusion threshold is determined according to the following, and as illustrated in Appendix B of KDB447498 D01.

    [(Threshold at 50mm in step1) + (test separation distance-50mm)x($\frac{\text{f(MHz)}}{150}$)](mW),

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(3) For test separation distances > 50 mm, and the frequency at >1500MHz to 6GHz, the SAR test exclusion threshold is determined according to the following, and as illustrated in Appendix B of KDB447498 D01.

[(Threshold at 50mm in step1) + (test separation distance-50mm)x10](mW),

Mode		WLAN Main 2.45GHz	WLAN Main 5GHz
Max. tune-up power(dBm)		18	17.5
Max. tune-up power(mW)		63.096	56.234
Top side	Test separation distance	less than 5	less than 5
	Calculation value	19.800	27.144
	Require SAR testing?	**YES**	**YES**
Right side	Test separation distance	298.2	298.2
	>20cm	YES	YES
	Require SAR testing?	**NO**	**NO**
Left side	Test separation distance	19.8	19.8
	Calculation value	5.000	6.855
	Require SAR testing?	**YES**	**YES**
Bottom side	Test separation distance	217.32	217.32
	>20cm	YES	YES
	Require SAR testing?	**NO**	**NO**
Back side	Test separation distance	less than 5	less than 5
	Calculation value	19.800	27.144
	Require SAR testing?	**YES**	**YES**

Mode		WLAN Aux 2.45GHz	WLAN Aux 5GHz	BT
Max. tune-up power(dBm)		18	17.5	5.5
Max. tune-up power(mW)		63.096	56.234	3.548
Top side	Test separation distance	less than 5	less than 5	less than 5
	Calculation value	19.800	27.144	1.118
	Require SAR testing?	**YES**	**YES**	**YES**
Right side	Test separation distance	215.2	215.2	215.2
	>20cm	YES	YES	YES
	Require SAR testing?	**NO**	**NO**	**NO**
Left side	Test separation distance	102.8	102.8	102.8
	Calculation value	623.598	590.150	623.250
	Require SAR testing?	**NO**	**NO**	**NO**
Bottom side	Test separation distance	217.32	217.32	217.32
	>20cm	YES	YES	YES
	Require SAR testing?	**NO**	**NO**	**NO**
Back side	Test separation distance	less than 5	less than 5	less than 5
	Calculation value	19.800	27.144	1.118
	Require SAR testing?	**YES**	**YES**	**YES**

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Mode		WLAN Main 2.45GHz	WLAN Main 5GHz
Max. tune-up power(dBm)		18	17.5
Max. tune-up power(mW)		63.096	56.234
Bottom side	Test separation distance	217.32	217.32
	>20cm	YES	YES
	Require SAR testing?	**NO**	**NO**

Mode		WLAN Aux 2.45GHz	WLAN Aux 5GHz	BT
Max. tune-up power(dBm)		18	17.5	5.5
Max. tune-up power(mW)		63.096	56.234	3.548
Bottom side	Test separation distance	217.32	217.32	217.32
	>20cm	YES	YES	YES
	Require SAR testing?	**NO**	**NO**	**NO**

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1.6 The SAR Measurement System

A block diagram of the SAR measurement System is given in Fig. a. This SAR Measurement System uses a Computer-controlled 3-D stepper motor system (SPEAG DASY 5 professional system). The model EX3DV4 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-simulant.

The DASY 5 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Staubli RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage intissue simulating liquid. The probe is equipped with an optical surface detector system.
3. 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.

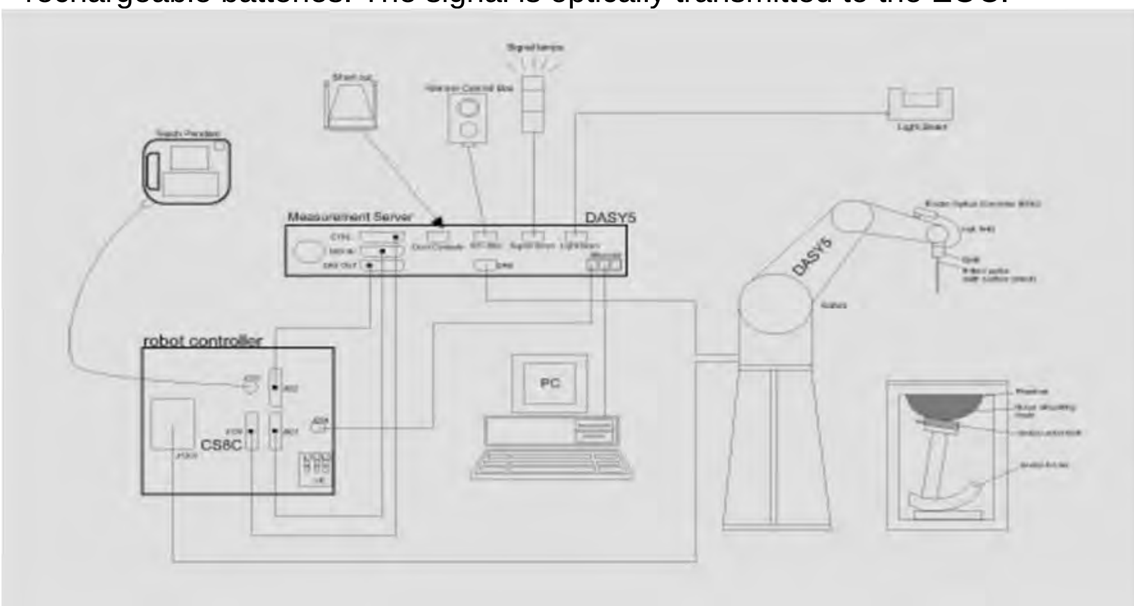

Fig. a The block diagram of SAR system

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4. The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
5. 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.
6. A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
7. A computer operating Windows 7.
8. DASY 5 software.
9. Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
10. The SAM twin phantom enabling testing left-hand and right-hand usage.
11. The device holder for handheld mobile phones.
12. Tissue simulating liquid mixed according to the given recipes.
13. Validation dipole kits allowing to validate the proper functioning of the system.

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1.7 System Components

EX3DV4 E-Field Probe

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 2450/5200/5300/5600/5800 MHz Additional CF for other liquids and frequencies upon request	
Frequency	10 MHz to > 6 GHz	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)	
Dimensions	Tip diameter: 2.5 mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

PHANTOM

Model	ELI	
Construction	The ELI phantom is used 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.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 30 liters	
Dimensions	Major axis: 600 mm Minor axis: 400 mm	

DEVICE HOLDER

Construction	The device holder (Supporter) for Notebook is made by POM (polyoxymethylene resin) , which is non-metal and non-conductive. The height can be adjusted to fit varies kind of notebooks.	 Device Holder

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1.8 SAR System Verification

The microwave circuit arrangement for system verification is sketched in Fig. b. 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. These tests were done at 2450/5200/5300/5600/5800 MHz. The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed in the table 1 (SAR values are normalized to 1W forward power delivered to the dipole). During the tests, the liquid depth above the ear reference points was ≥ 15 cm ± 5 mm (frequency ≤ 3 GHz) or ≥ 10 cm ± 5 mm (frequency > 3 G Hz) 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.

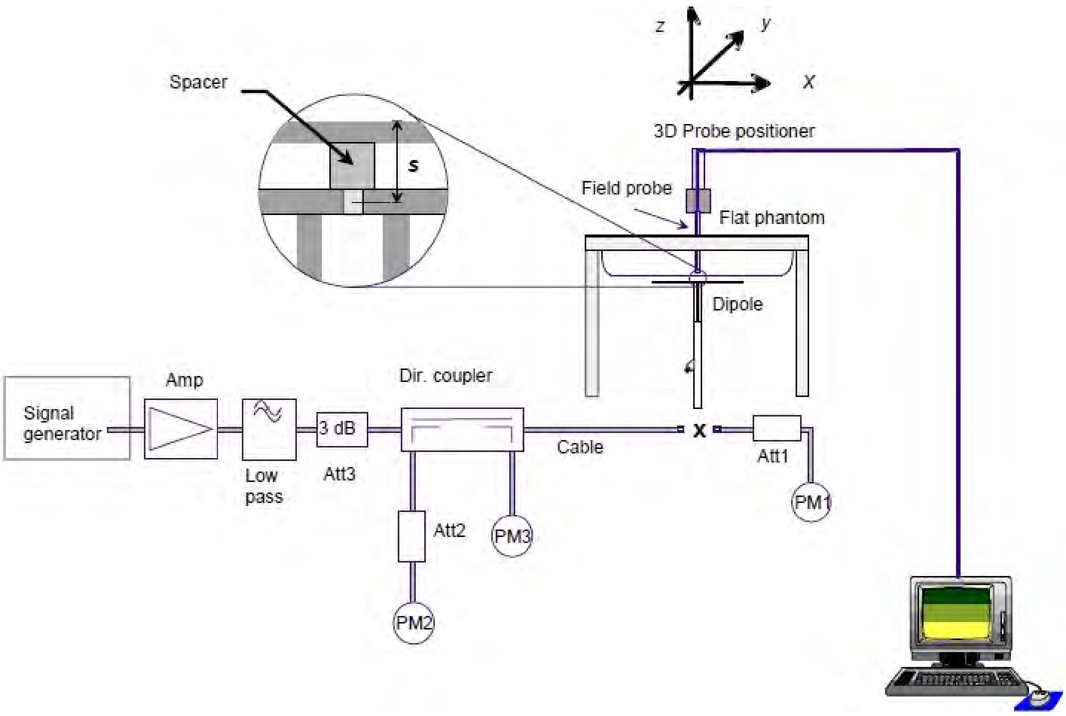

Fig. b The block diagram of system verification

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Validation Kit	S/N	Frequency (MHz)		1W Target SAR-1g (mW/g)	Measured SAR-1g (mW/g)	Measured SAR-1g normalized to 1W (mW/g)	Deviation (%)	Measured Date
D2450V2	727	2450	Body	50.6	12.8	51.2	1.19%	Mar. 08, 2018
D5GHzV2	1023	5200	Body	72.8	7.15	71.5	-1.79%	Mar. 09, 2018
		5300	Body	76.1	7.32	73.2	-3.81%	Mar. 10, 2018
		5600	Body	79.6	7.85	78.5	-1.38%	Mar. 11, 2018
		5800	Body	75.9	7.43	74.3	-2.11%	Mar. 12, 2018

Table 1. Results of system validation

1.9 Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this Head-simulant fluid were measured by using the Agilent Model 85070E Dielectric Probe (rates frequency band 200 MHz to 20 GHz) in conjunction with Network Analyzer.
All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. The measured conductivity and permittivity are all within ± 5% of the target values.
The depth of the tissue simulant in the flat section of the phantom was ≥ 15 cm ± 5 mm (Frequency ≤3G) or ≥ 10 cm ± 5 mm (Frequency >3G) during all tests. (Fig. 2)

Tissue Type	Measurement Date	Measured Frequency (MHz)	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	% dev εr	% dev σ
Body	Mar. 08, 2018	2402	52.764	1.904	52.885	1.939	-0.23%	-1.83%
		2412	52.751	1.914	52.847	1.953	-0.18%	-2.05%
		2417	52.744	1.918	52.814	1.962	-0.13%	-2.27%
		2437	52.717	1.938	52.739	1.986	-0.04%	-2.50%
		2441	52.712	1.941	52.745	1.993	-0.06%	-2.66%
		2450	52.700	1.950	52.699	2.006	0.00%	-2.87%
		2457	52.691	1.960	52.670	2.016	0.04%	-2.86%
		2462	52.685	1.967	52.648	2.021	0.07%	-2.74%
		2480	52.662	1.993	52.576	2.047	0.16%	-2.73%
	Mar. 09, 2018	5200	49.014	5.299	49.568	5.141	-1.13%	2.99%
		5220	48.987	5.323	49.548	5.187	-1.14%	2.55%
		5240	48.960	5.346	49.679	5.207	-1.47%	2.60%
	Mar. 10, 2018	5260	48.933	5.369	49.620	5.177	-1.40%	3.58%
		5280	48.906	5.393	49.370	5.273	-0.95%	2.22%
		5300	48.879	5.416	49.301	5.258	-0.86%	2.92%
	Mar. 11, 2018	5520	48.580	5.673	48.758	5.618	-0.37%	0.97%
		5580	48.499	5.743	48.530	5.679	-0.06%	1.12%
		5600	48.471	5.766	48.560	5.759	-0.18%	0.13%
		5680	48.363	5.860	48.213	5.895	0.31%	-0.60%
	Mar. 12, 2018	5745	48.275	5.936	47.990	5.956	0.59%	-0.34%
		5785	48.220	5.982	47.821	6.017	0.83%	-0.58%
		5800	48.200	6.000	47.917	5.991	0.59%	0.15%
		5825	48.166	6.029	47.823	6.049	0.71%	-0.33%

Table 2. Dielectric Parameters of Tissue Simulant Fluid

The composition of the tissue simulating liquid:

Frequency (MHz)	Mode	Ingredient						Total amount
		DGMBE	Water	Salt	Preventol D-7	Cellulose	Sugar	
2450M	Body	301.7ml	698.3ml	—	—	—	—	1.0L(Kg)

Body Simulating Liquids for 5 GHz, Manufactured by SPEAG:

Ingredients	Water	Esters, Emulsifiers, Inhibitors	Sodium and Salt
(% by weight)	60-80	20-40	0-1.5

Table 3. Recipes for Tissue Simulating Liquid

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1.10 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

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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.

1.11 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:

1.11.1 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.

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:

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- 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.
- 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%.
- 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].

1.11.2 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:

- The setup must enable accurate determination of the incident power.
- The accuracy of the calculated field strength will depend on the assessment of the dielectric parameters of the liquid.
- Due to the small wavelength in liquids with high permittivity, even small

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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.
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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.

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1.12 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 an 10 grams of tissue (defined as a tissue volume in the shape of a cube).

(2) 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.

(3) 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

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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.

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2. Summary of Results

WLAN Antenna

Antenna	Mode	Position	Distance (mm)	CH	Freq. (MHz)	Max. Rated Avg. Power + Max. Tolerance (dBm)	Measured Avg. Power (dBm)	Scaling	Averaged SAR over 1g (W/kg)		Plot page
									Measured	Reported	
Main	WLAN802.11 b	Back side	0	1	2412	17.00	16.98	100.46%	0.033	0.033	-
		Top side	0	1	2412	17.00	16.98	100.46%	0.491	0.493	43
		Left side	0	1	2412	17.00	16.98	100.46%	0.033	0.033	-
	WLAN802.11 g	Back side	0	2	2417	18.00	17.98	100.46%	0.041	0.041	-
		Top side	0	2	2417	18.00	17.98	100.46%	0.607	0.610	44
		Left side	0	2	2417	18.00	17.98	100.46%	0.052	0.052	-
	WLAN802.11 a 5.2G	Back side	0	48	5240	17.50	17.49	100.23%	0.044	0.044	-
		Top side	0	48	5240	17.50	17.49	100.23%	0.516	0.517	45
		Left side	0	48	5240	17.50	17.49	100.23%	0.166	0.166	-
	WLAN802.11 a 5.3G	Back side	0	56	5280	17.50	17.43	101.62%	0.045	0.046	-
		Top side	0	56	5280	17.50	17.43	101.62%	0.573	0.582	46
		Left side	0	56	5280	17.50	17.43	101.62%	0.160	0.163	-
	WLAN802.11 a 5.6G	Back side	0	116	5580	17.50	17.49	100.23%	0.041	0.045	-
		Top side	0	116	5580	17.50	17.49	100.23%	0.654	0.656	47
		Left side	0	116	5580	17.50	17.49	100.23%	0.249	0.250	-
	WLAN802.11 a 5.8G	Back side	0	157	5785	17.50	17.44	101.39%	0.052	0.053	-
		Top side	0	157	5785	17.50	17.44	101.39%	0.587	0.595	48
		Left side	0	157	5785	17.50	17.44	101.39%	0.274	0.278	-

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WLAN Aux Antenna

Antenna	Mode	Position	Distance (mm)	CH	Freq. (MHz)	Max. Rated Avg. Power + Max. Tolerance (dBm)	Measured Avg. Power (dBm)	Scaling	Averaged SAR over 1g (W/kg)		Plot page
									Measured	Reported	
Aux	WLAN802.11 b	Back side	0	1	2412	17.00	16.91	102.09%	0.050	0.051	-
		Top side	0	1	2412	17.00	16.91	102.09%	0.215	0.220	49
	WLAN802.11 g	Back side	0	6	2437	18.00	17.99	100.23%	0.071	0.071	-
		Top side	0	2	2417	18.00	17.96	100.93%	0.342	0.345	-
		Top side	0	6	2437	18.00	17.99	100.23%	0.350	0.351	-
		Top side	0	10	2457	18.00	17.97	100.69%	0.413	0.416	50
	Bluetooth (GFSK)	Back side	0	39	2441	5.50	5.34	103.75%	0.004	0.004	-
		Top side	0	39	2441	5.50	5.34	103.75%	0.016	0.017	51
	WLAN802.11 a 5.2G	Back side	0	44	5220	17.50	17.49	100.23%	0.118	0.118	-
		Top side	0	44	5220	17.50	17.49	100.23%	0.411	0.412	52
	WLAN802.11 a 5.3G	Back side	0	56	5280	17.50	17.45	101.16%	0.082	0.083	-
		Top side	0	56	5280	17.50	17.45	101.16%	0.377	0.381	53
	WLAN802.11 a 5.6G	Back side	0	136	5680	17.50	17.49	100.23%	0.042	0.042	-
		Top side	0	136	5680	17.50	17.49	100.23%	0.457	0.458	54
	WLAN802.11 a 5.8G	Back side	0	149	5745	17.50	17.47	100.69%	0.101	0.102	-
		Top side	0	149	5745	17.50	17.47	100.69%	0.949	0.956	55
		Top side*	0	149	5745	17.50	17.47	100.69%	0.928	0.934	-
		Top side	0	157	5785	17.50	17.42	101.86%	0.897	0.914	-
		Top side	0	165	5825	17.50	17.43	101.62%	0.914	0.929	-

* - repeated at the highest SAR measurement according to the KDB 865664 D01

Note:

$$\text{Scaling} = \frac{\text{reported SAR}}{\text{measured SAR}} = \frac{P2(mW)}{P1(mW)} = 10^{\left(\frac{P2-P1}{10}\right)(dBm)}$$

Reported SAR = measured SAR * (scaling)

Where P2 is maximum specified power, P1 is measured conducted power

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3. Simultaneous Transmission Analysis

Simultaneous Transmission Scenarios:

Simultaneous Transmit Configurations	Body
2.4GHz WLAN MIMO	Yes
5GHz WLAN MIMO	Yes
BT + 2.4GHz WLAN Main	Yes
BT + 5GHz WLAN Main	Yes

Note:
1. Bluetooth and WLAN Aux share the same antenna path, and BT can transmit with WLAN Main simultaneously.
2. For 2.4/5GHz WLAN Main and Aux antennas, the maximum output power of each antenna during simultaneous transmission is the same with that used in standalone transmission, and we used the sum of 1-g SAR provision in KDB447498D01 to exclude the simultaneous transmitted SAR measurement.

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3.1 Estimated SAR calculation

According to KDB447498 D01v06 – When standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

$$\text{Estimated SAR} = \frac{\text{Max. tune up power (mW)}}{\text{Min. test separation distance(mm)}} \times \frac{\sqrt{\text{f(GHz)}}}{7.5}$$

If the minimum test separation distance is < 5mm, a distance of 5mm is used for estimated SAR calculation. When the test separation distance is >50mm, the 0.4W/kg is used for SAR-1g.

3.1 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.

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2.4 GHz WLAN MIMO

No.	Conditions	Position	Max. WLAN Main	Max. WLAN Aux	SAR Sum	SPLSR
1	2.4 GHz WLAN Main + WLAN Aux	Back side	0.041	0.071	0.112	ΣSAR<1.6, Not required
		Top side	0.610	0.416	1.026	ΣSAR<1.6, Not required
		Left side	0.052	-	-	ΣSAR<1.6, Not required

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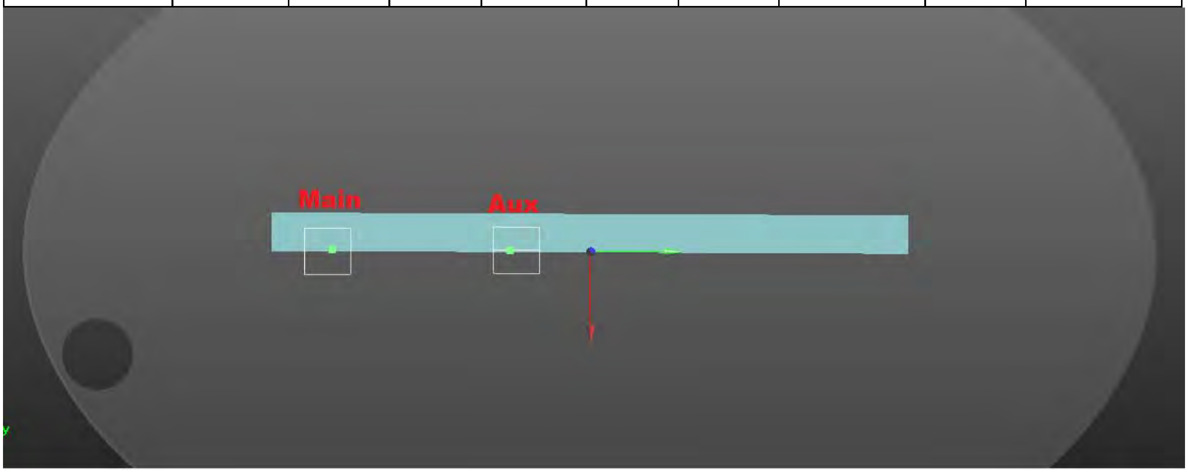
5 GHz WLAN MIMO

No.	Conditions	Position	Max. WLAN Main	Max. WLAN Aux	SAR Sum	SPLSR
2	5 GHz WLAN Main + WLAN Aux	Back side	0.053	0.118	0.171	ΣSAR<1.6, Not required
		Top side	0.655	0.956	**1.611**	Analyzed as below
		Left side	0.278	-	-	ΣSAR<1.6, Not required

WWAN + WLAN Main

Conditions	Position	SAR Value (W/kg)	Coordinates (cm)			ΣSAR (W/kg)	Peak Location Separation Distance (mm)	SPLSR	Simultaneous Transmission SAR Test
			x	y	z				
WLAN Main	Top side	0.655	-0.08	-13.36	-0.38	1.611	92.4	0.022	SPLSR<0.04, Not required
WLAN Aux		0.956	-0.10	-4.12	-0.37				



BT+ 2.4GHz WLAN Main

No.	Conditions	Position	Max. WLAN Main	BT	SAR Sum	SPLSR
3	2.4 GHz WLAN Main + BT	Back side	0.041	0.004	0.045	ΣSAR<1.6, Not required
		Top side	0.610	0.017	0.627	ΣSAR<1.6, Not required
		Left side	0.052	-	-	ΣSAR<1.6, Not required

BT+ 5GHz WLAN Main

No.	Conditions	Position	Main	BT	SAR Sum	SPLSR
4	5 GHz WLAN Main + BT	Back side	0.053	0.004	0.057	ΣSAR<1.6, Not required
		Top side	0.655	0.017	0.672	ΣSAR<1.6, Not required
		Left side	0.278	-	-	ΣSAR<1.6, Not required

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4. Instruments List

Manufacturer	Device	Type	Serial number	Date of last calibration	Date of next calibration
SPEAG	Dosimetric E-Field Probe	EX3DV4	7466	Jul.04,2017	Jul.03,2018
SPEAG	System Validation Dipole	D2450V2	727	Apr.21,2017	Apr.20,2018
		D5GHzV2	1023	Jan.25,2018	Jan.24,2019
SPEAG	Data acquisition Electronics	DAE4	393	Aug.10,2017	Aug.10,2018
SPEAG	Software	DASY 52 V52.8.8	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	ELI	N/A	Calibration not required	Calibration not required
Agilent	Network Analyzer	E5071C	MY46107530	Jan.20,2017	Jan.19,2018
Agilent	Dielectric Probe Kit	85070E	MY44300677	Calibration not required	Calibration not required
Agilent	Dual-directional coupler	772D	MY52180142	Apr.13,2017	Apr.12,2018
Agilent	Signal Generator	N5181A	MY50141235	Mar.20,2017	Mar.19,2018
Agilent	Power Meter	E4417A	MY52240003	Dec.21,2017	Dec.20,2018
Agilent	Power Sensor	E9301H	MY52200003	Dec.21,2017	Dec.20,2018
			MY52200004	Dec.21,2017	Dec.20,2018
Changzhou Xinwang	Digital thermometer	PT1	EC14011603-1	Jun.05,2017	Jun.04,2018

5. Measurements

Date: 2018/3/8

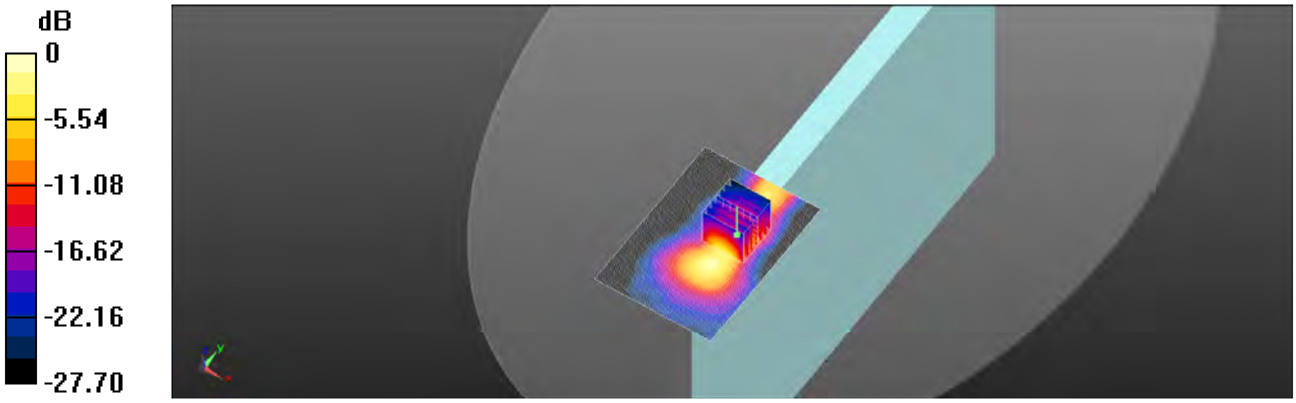
WLAN 802.11b_Body_Top side_CH 1_0mm_Main
Communication System: WLAN 2.45G; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2412 MHz; σ = 1.953 S/m; ε_r = 52.847; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (71x101x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.767 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 0.6790 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 1.24 W/kg
SAR(1 g) = 0.491 W/kg; SAR(10 g) = 0.180 W/kg
Maximum value of SAR (measured) = 0.841 W/kg



0 dB = 0.841 W/kg = -0.75 dBW/kg

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Date: 2018/3/8

WLAN 802.11g_Body_Top side_CH 2_0mm_Main

Communication System: WLAN 2.45G; Frequency: 2417 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2417 MHz; σ = 1.962 S/m; ε_r = 52.814; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

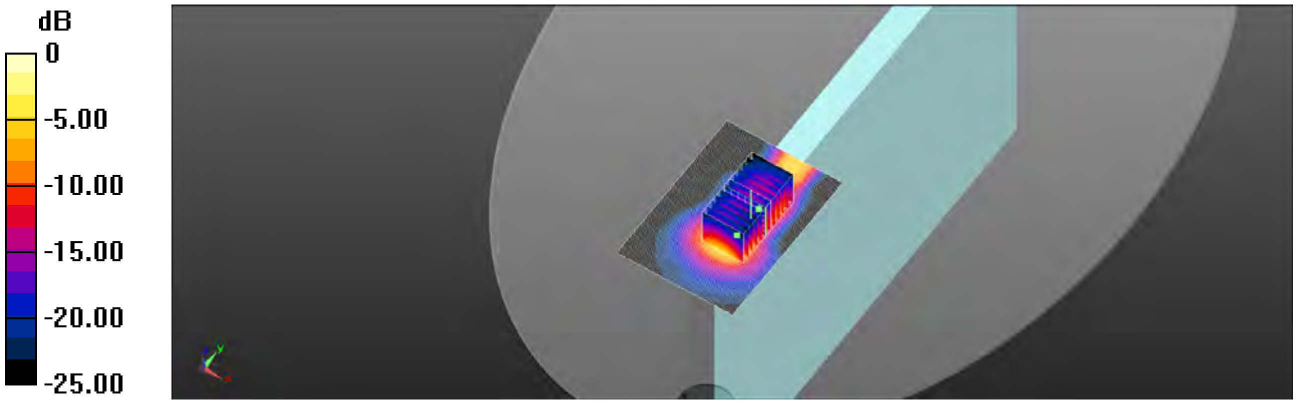
DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (71x101x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.912 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 1.251 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 1.74 W/kg
SAR(1 g) = 0.607 W/kg; SAR(10 g) = 0.236 W/kg
Maximum value of SAR (measured) = 1.11 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 1: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 1.251 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 1.33 W/kg
SAR(1 g) = 0.416 W/kg; SAR(10 g) = 0.177 W/kg
Maximum value of SAR (measured) = 0.926 W/kg



0 dB = 0.926 W/kg = -0.33 dBW/kg

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Date: 2018/3/9

WLAN 802.11a 5.2G_Body_Top side_CH 48_0mm_Main

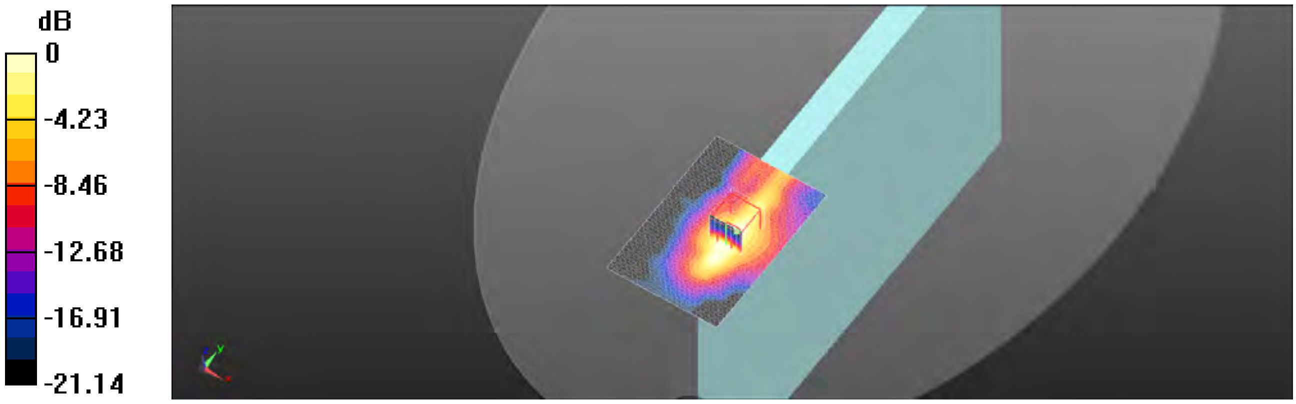
Communication System: WLAN 5G; Frequency: 5240 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5240 MHz; σ = 5.207 S/m; ε_r = 49.679; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.9°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(5.2, 5.2, 5.2); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.10 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.546 V/m; Power Drift = 0.15 dB
Peak SAR (extrapolated) = 2.27 W/kg
SAR(1 g) = 0.516 W/kg; SAR(10 g) = 0.189 W/kg
Maximum value of SAR (measured) = 1.05 W/kg



0 dB = 1.05 W/kg = 0.22 dBW/kg

Date: 2018/3/10

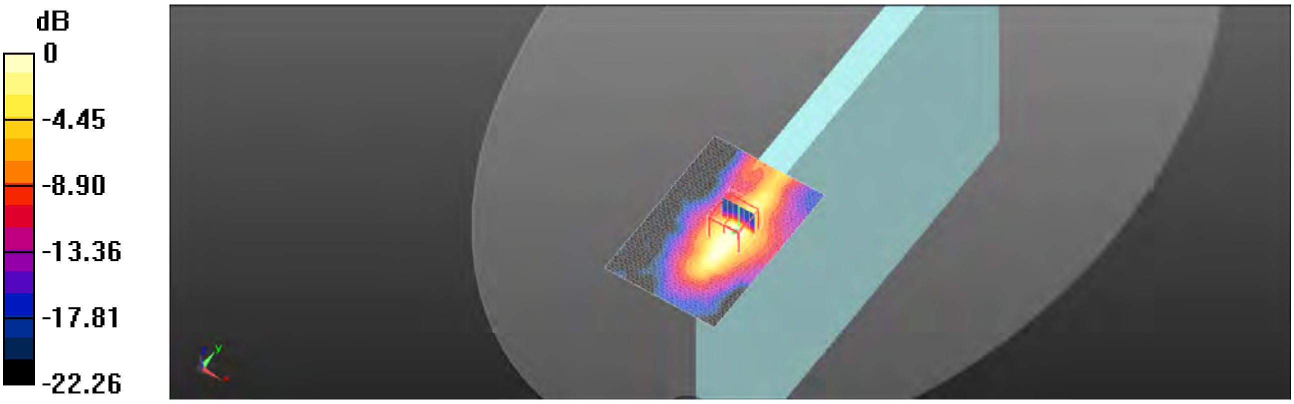
WLAN 802.11a 5.3G_Body_Top side_CH 56_0mm_Main
Communication System: WLAN 5G; Frequency: 5280 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5280 MHz; σ = 5.273 S/m; ε_r = 49.37; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.2°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(5.1, 5.1, 5.1); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.20 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.375 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 2.44 W/kg
SAR(1 g) = 0.573 W/kg; SAR(10 g) = 0.207 W/kg
Maximum value of SAR (measured) = 1.13 W/kg



0 dB = 1.13 W/kg = 0.55 dBW/kg

Date: 2018/3/11

WLAN 802.11a 5.6G_Body_Top side_CH 116_0mm_Main

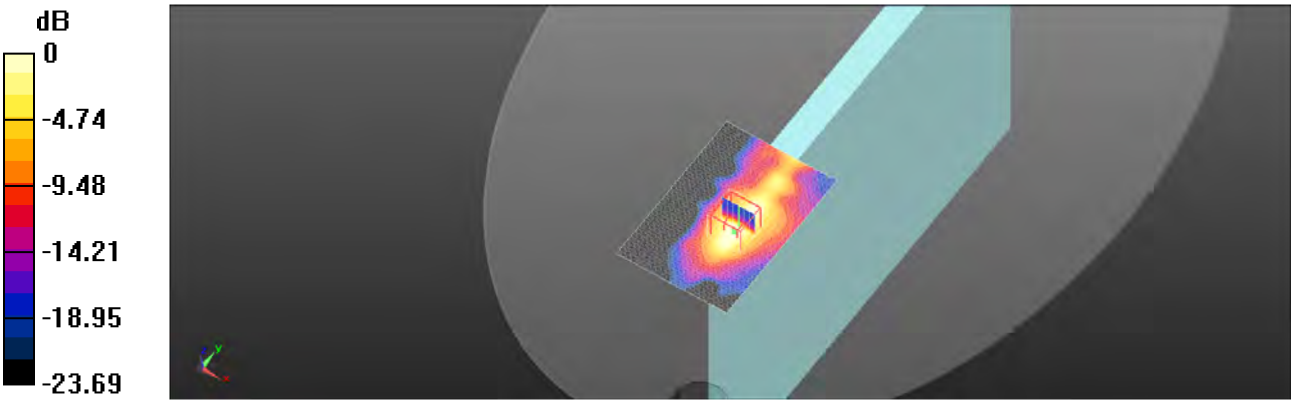
Communication System: WLAN 5G; Frequency: 5580 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5580 MHz; σ = 5.679 S/m; ε_r = 48.53; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.5°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(4.27, 4.27, 4.27); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.24 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.170 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 2.93 W/kg
SAR(1 g) = 0.654 W/kg; SAR(10 g) = 0.228 W/kg
Maximum value of SAR (measured) = 1.32 W/kg



0 dB = 1.32 W/kg = 1.20 dBW/kg

Date: 2018/3/12

WLAN 802.11a 5.8G_Body_Top side_CH 157_0mm_Main

Communication System: WLAN 5G; Frequency: 5785 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5785 MHz; σ = 6.017 S/m; ε_r = 47.821; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.7°C; Liquid temperature: 21.8°C

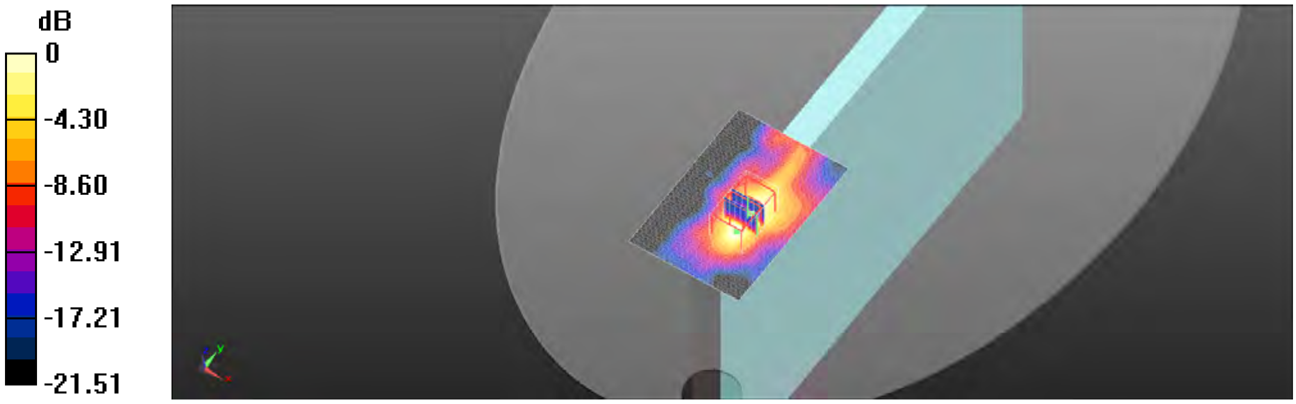
DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(4.48, 4.48, 4.48); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.14 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.8660 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 2.64 W/kg
SAR(1 g) = 0.587 W/kg; SAR(10 g) = 0.214 W/kg
Maximum value of SAR (measured) = 1.18 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 1: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.8660 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 2.48 W/kg
SAR(1 g) = 0.506 W/kg; SAR(10 g) = 0.172 W/kg
Maximum value of SAR (measured) = 1.07 W/kg



0 dB = 1.07 W/kg = 0.28 dBW/kg

Date: 2018/3/8

WLAN 802.11b_Body_Top side_CH 1_0mm_Aux

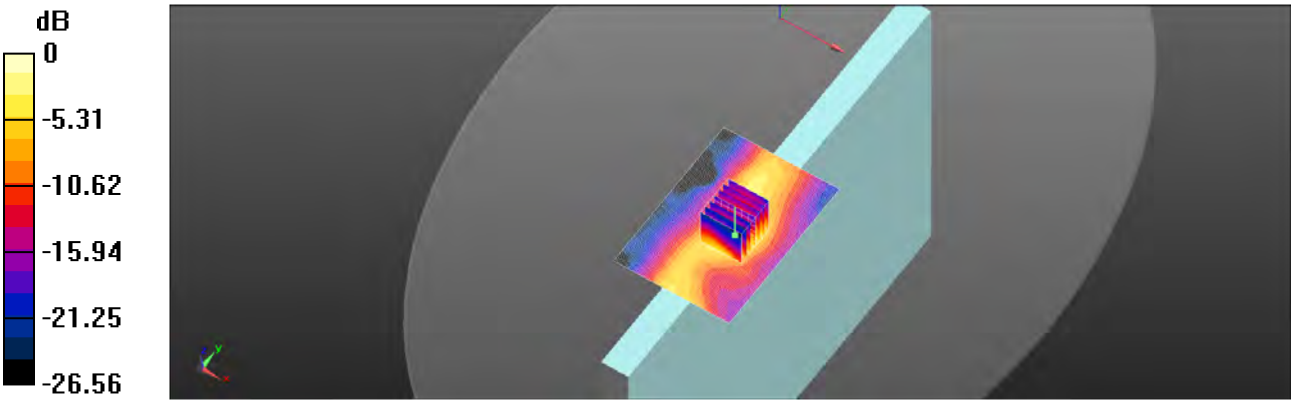
Communication System: WLAN 2.45G; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2412 MHz; σ = 1.953 S/m; ε_r = 52.847; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (71x101x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.306 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 5.454 V/m; Power Drift = 0.12 dB
Peak SAR (extrapolated) = 0.458 W/kg
SAR(1 g) = 0.215 W/kg; SAR(10 g) = 0.097 W/kg
Maximum value of SAR (measured) = 0.333 W/kg



0 dB = 0.333 W/kg = -4.77 dBW/kg

Date: 2018/3/8

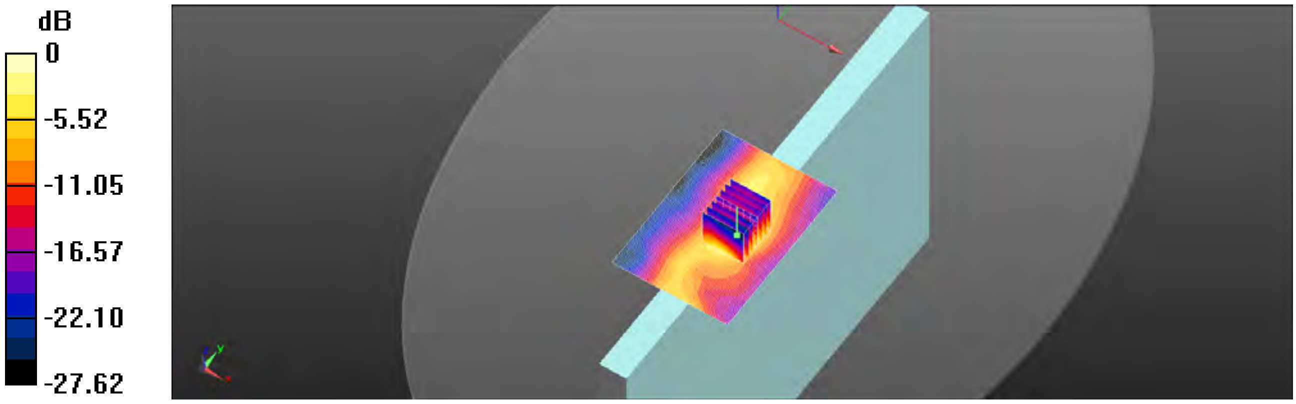
WLAN 802.11g_Body_Top side_CH 10_0mm_Aux
Communication System: WLAN 2.45G; Frequency: 2457 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2457 MHz; σ = 2.016 S/m; ε_r = 52.67; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (71x101x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.610 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.149 V/m; Power Drift = -0.15 dB
Peak SAR (extrapolated) = 0.925 W/kg
SAR(1 g) = 0.413 W/kg; SAR(10 g) = 0.182 W/kg
Maximum value of SAR (measured) = 0.655 W/kg



0 dB = 0.655 W/kg = -1.84 dBW/kg

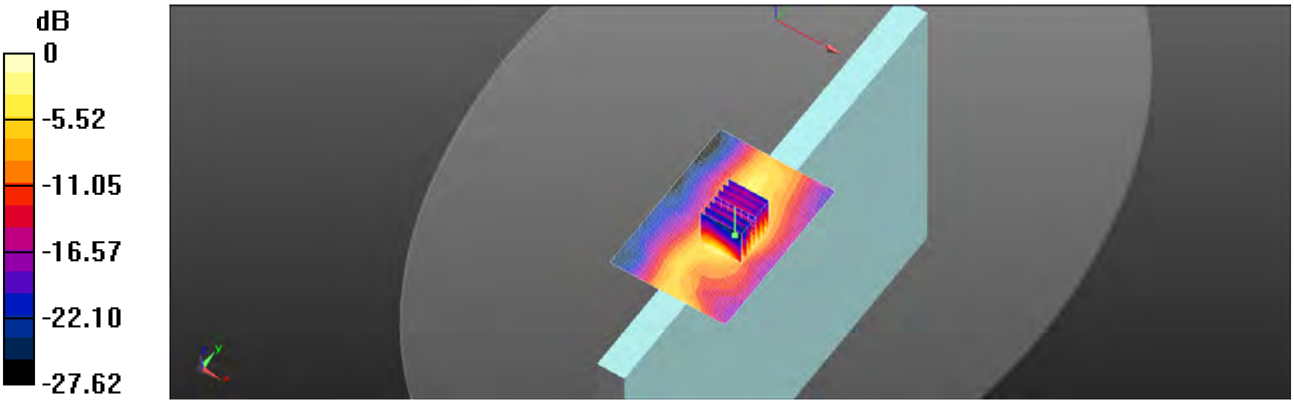
Date: 2018/3/8

Bluetooth(GFSK)_Body_Top side_CH 39_0mm_Aux
Communication System: WLAN 2.45G; Frequency: 2441 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2441 MHz; σ = 1.993 S/m; ε_r = 52.745; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

DASY5 Configuration:
- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (71x101x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.019 W/kg

Configuration/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 0.2149 V/m; Power Drift = -0.15 dB
Peak SAR (extrapolated) = 0.0225 W/kg
SAR(1 g) = 0.016 W/kg; SAR(10 g) = 0.00413 W/kg
Maximum value of SAR (measured) = 0.019 W/kg



0 dB = 0.019 W/kg = -11.84 dBW/kg

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Date: 2018/3/9

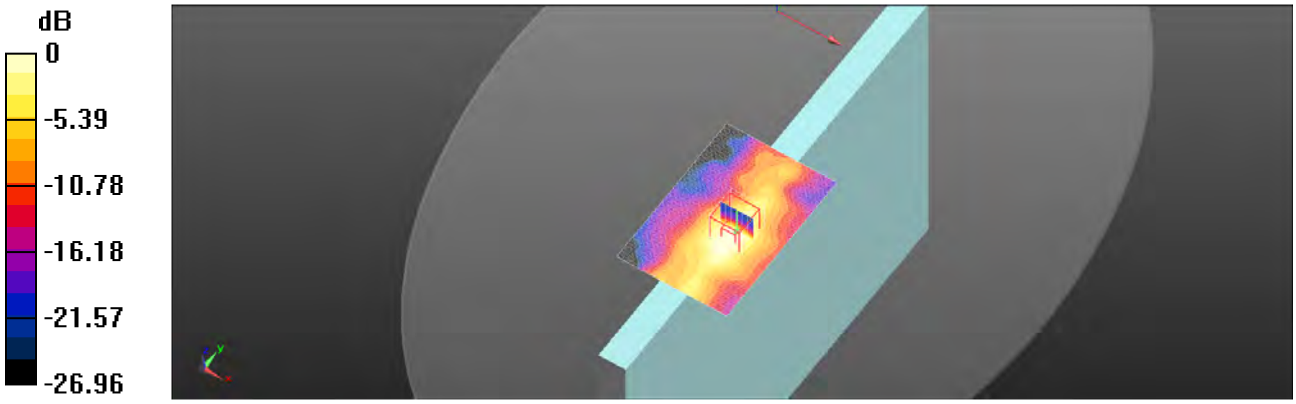
WLAN 802.11a 5.2G_Body_Top side_CH 44_0mm_Aux
Communication System: WLAN 5G; Frequency: 5220 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5220 MHz; σ = 5.187 S/m; ε_r = 49.548; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.9°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(5.2, 5.2, 5.2); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.892 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 6.043 V/m; Power Drift = -0.19 dB
Peak SAR (extrapolated) = 1.73 W/kg
SAR(1 g) = 0.411 W/kg; SAR(10 g) = 0.149 W/kg
Maximum value of SAR (measured) = 0.812 W/kg



0 dB = 0.812 W/kg = -0.91 dBW/kg

Date: 2018/3/10

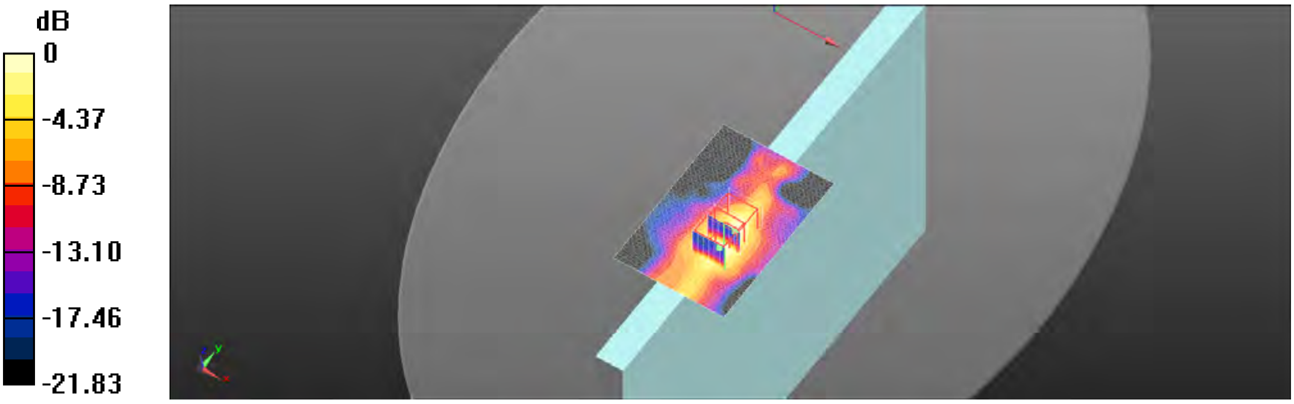
WLAN 802.11a 5.3G_Body_Top side_CH 56_0mm_Aux
Communication System: WLAN 5G; Frequency: 5280 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5280 MHz; σ = 5.273 S/m; ε_r = 49.37; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.2°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(5.1, 5.1, 5.1); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.724 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 4.361 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 1.55 W/kg
SAR(1 g) = 0.377 W/kg; SAR(10 g) = 0.139 W/kg
Maximum value of SAR (measured) = 0.723 W/kg
Configuration/Zoom Scan (7x7x12)/Cube 1: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 4.361 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 1.42 W/kg
SAR(1 g) = 0.326 W/kg; SAR(10 g) = 0.120 W/kg
Maximum value of SAR (measured) = 0.674 W/kg



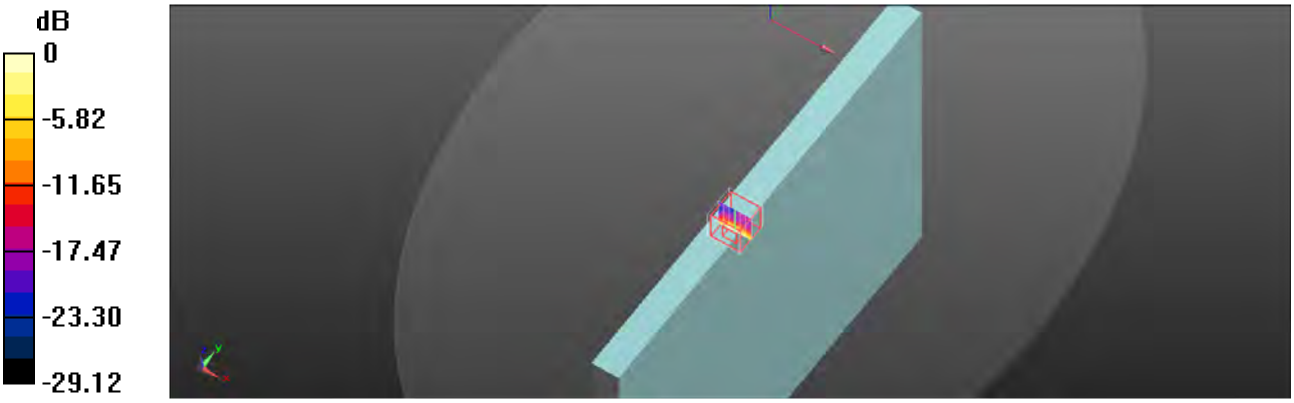
0 dB = 0.674 W/kg = -1.71 dBW/kg

Date: 2018/3/11

WLAN 802.11a 5.6G_Body_Top side_CH 136_0mm_Aux
Communication System: WLAN 5G; Frequency: 5680 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5680 MHz; σ = 5.895 S/m; ε_r = 48.213; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.5°C

DASY5 Configuration:
- Probe: EX3DV4 - SN7466; ConvF(4.27, 4.27, 4.27); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.766 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 2.02 W/kg
SAR(1 g) = 0.457 W/kg; SAR(10 g) = 0.156 W/kg
Maximum value of SAR (measured) = 0.922 W/kg



0 dB = 0.922 W/kg = -0.35 dBW/kg

Date: 2018/3/12

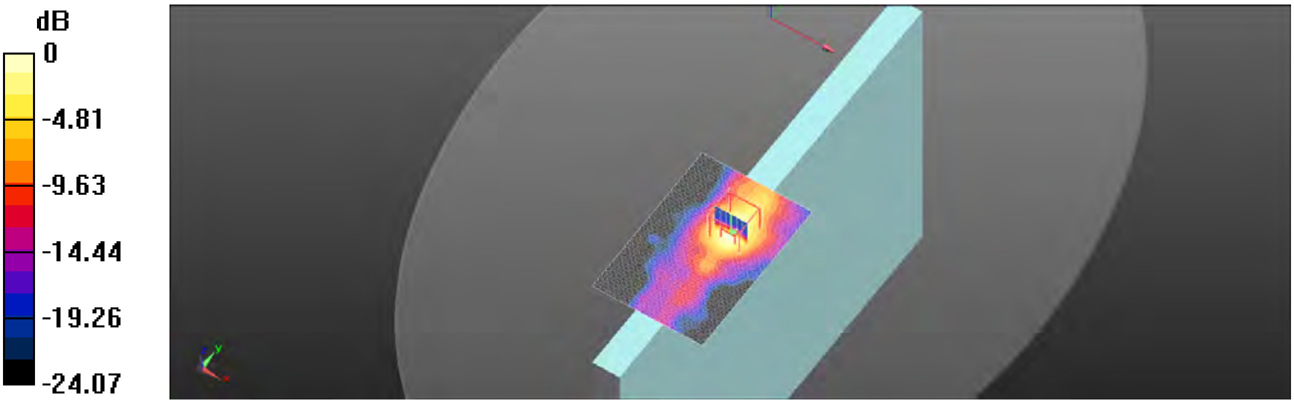
WLAN 802.11a 5.8G_Body_Top side_CH 149_0mm_Aux
Communication System: WLAN 5G; Frequency: 5745 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5745 MHz; σ = 5.956 S/m; ε_r = 47.99; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.7°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(4.48, 4.48, 4.48); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Area Scan (81x121x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.96 W/kg

Configuration/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 8.537 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 4.22 W/kg
SAR(1 g) = 0.949 W/kg; SAR(10 g) = 0.326 W/kg
Maximum value of SAR (measured) = 1.96 W/kg



0 dB = 1.96 W/kg = 2.91 dBW/kg

6. SAR System Performance Verification

Date: 2018/3/8

Dipole 2450 MHz_SN:727

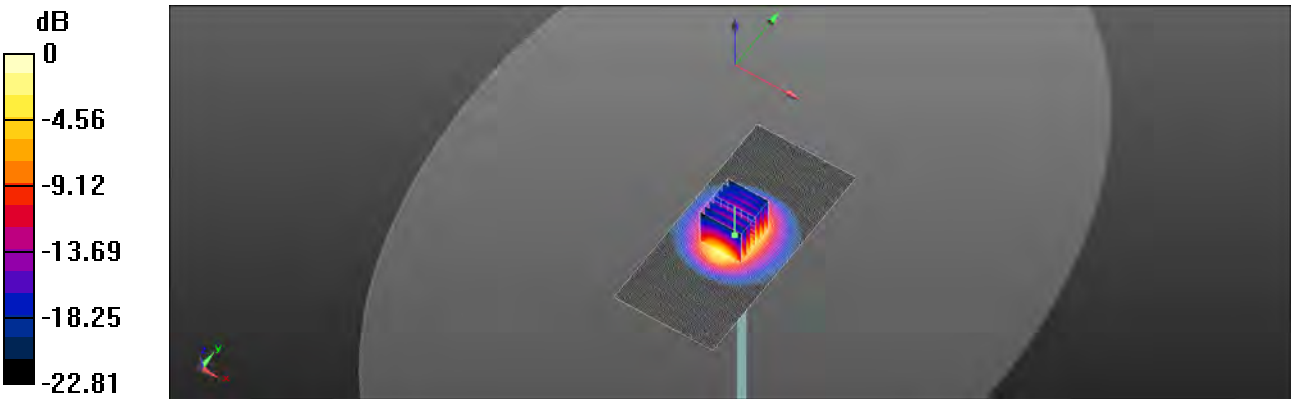
Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium parameters used: f = 2450 MHz; σ = 2.006 S/m; ε_r = 52.699; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(7.94, 7.94, 7.94); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Pin=250mW/Area Scan (61x131x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 20.7 W/kg

Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 99.09 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 27.2 W/kg
SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.96 W/kg
Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 19.8 W/kg = 12.98 dBW/kg

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Date: 2018/3/9

Dipole 5200 MHz_SN:1023

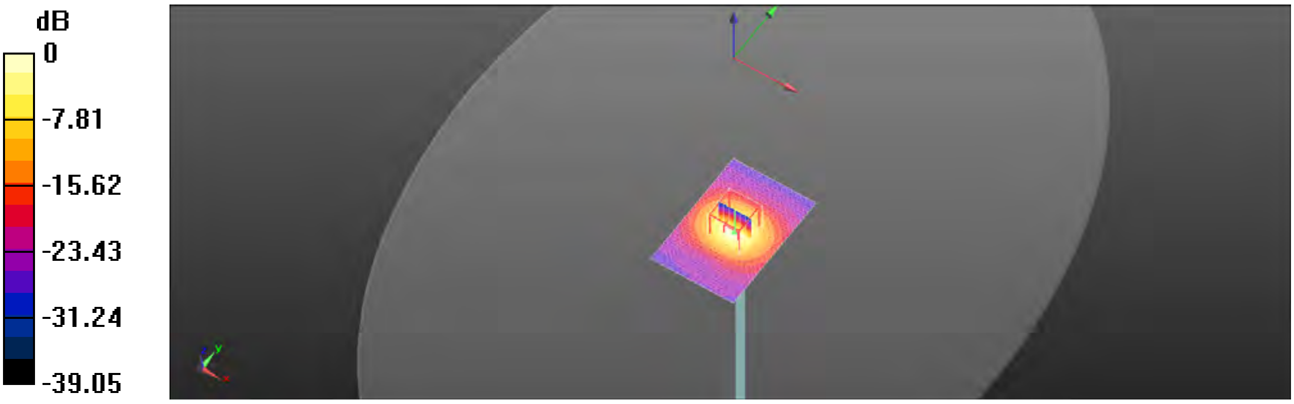
Communication System: CW; Frequency: 5200 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5200 MHz; σ = 5.141 S/m; ε_r = 49.568; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.9°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(5.2, 5.2, 5.2); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Pin=100mW/Area Scan (61x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 16.0 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 58.01 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 30.2 W/kg
SAR(1 g) = 7.15 W/kg; SAR(10 g) = 2.01 W/kg
Maximum value of SAR (measured) = 15.3 W/kg



0 dB = 15.3 W/kg = 11.84 dBW/kg

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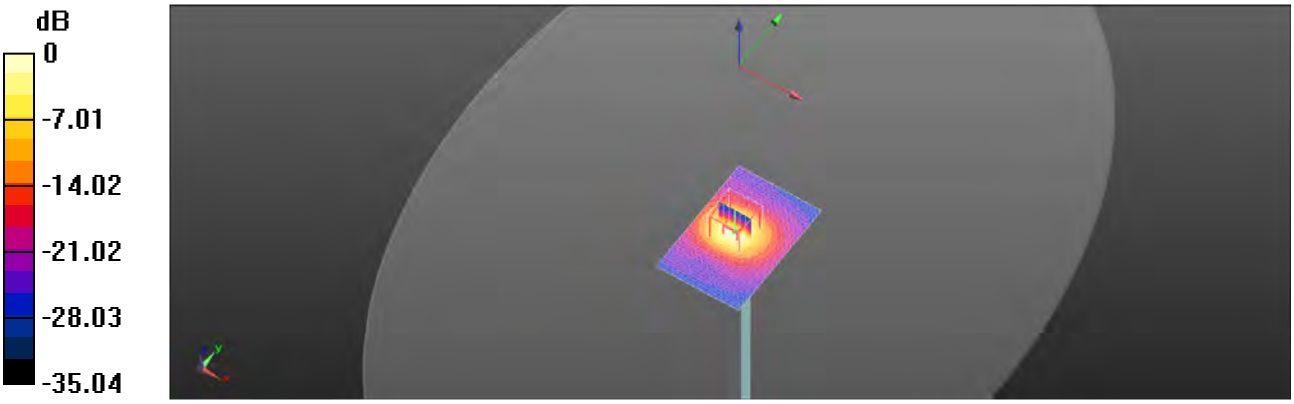
Date: 2018/3/10

Dipole 5300 MHz_SN:1023
Communication System: CW; Frequency: 5300 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5300 MHz; σ = 5.258 S/m; ε_r = 49.301; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.2°C; Liquid temperature: 21.8°C

DASY5 Configuration:
- Probe: EX3DV4 - SN7466; ConvF(5.1, 5.1, 5.1); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Pin=100mW/Area Scan (61x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 16.4 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 47.69 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 32.6 W/kg
SAR(1 g) = 7.32 W/kg; SAR(10 g) = 2.07 W/kg
Maximum value of SAR (measured) = 16.6 W/kg



0 dB = 16.6 W/kg = 12.21 dBW/kg

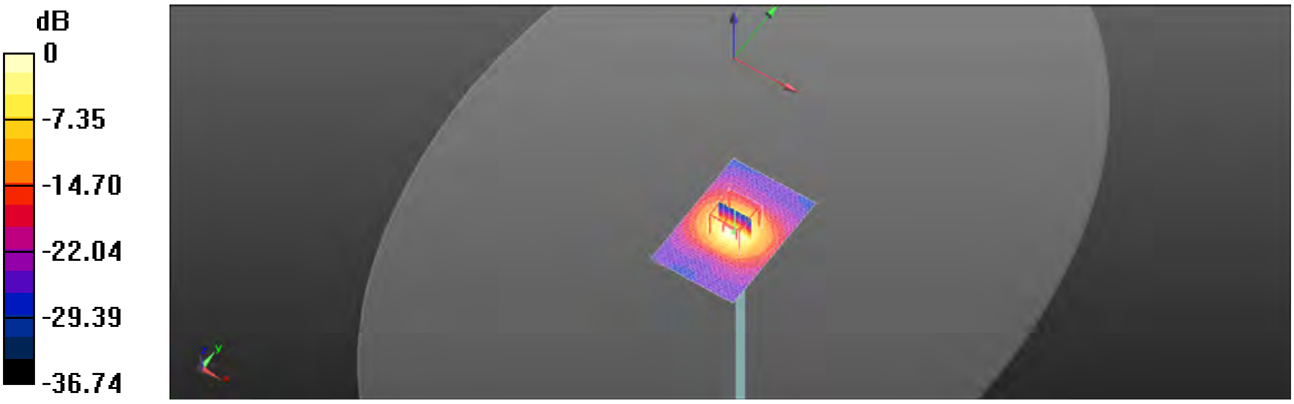
Date: 2018/3/11

Dipole 5600 MHz_SN:1023
Communication System: CW; Frequency: 5600 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5600 MHz; σ = 5.579 S/m; ε_r = 48.56; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.1°C; Liquid temperature: 21.5°C

DASY5 Configuration:
- Probe: EX3DV4 - SN7466; ConvF(4.27, 4.27, 4.27); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Pin=100mW/Area Scan (61x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 17.9 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 57.36 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 34.0 W/kg
SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.16 W/kg
Maximum value of SAR (measured) = 16.6 W/kg



0 dB = 16.6 W/kg = 12.19 dBW/kg

Date: 2018/3/12

Dipole 5800 MHz_SN:1023

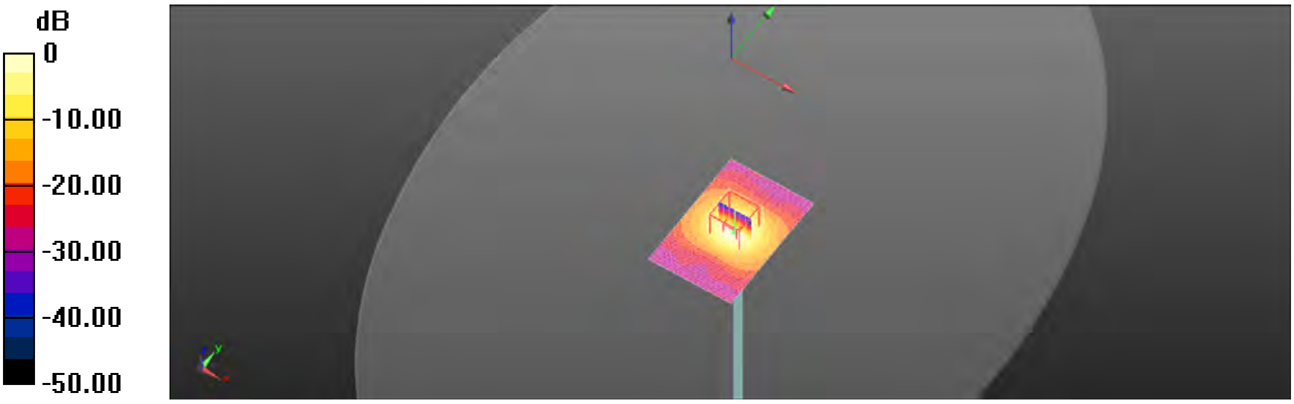
Communication System: CW; Frequency: 5800 MHz; Duty Cycle: 1:1
Medium parameters used: f = 5800 MHz; σ = 5.991 S/m; ε_r = 47.917; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.7°C; Liquid temperature: 21.8°C

DASY5 Configuration:

- Probe: EX3DV4 - SN7466; ConvF(4.48, 4.48, 4.48); Calibrated: 2017/7/4;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn393; Calibrated: 2017/8/10
- Phantom: Body
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

Configuration/Pin=100mW/Area Scan (61x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 15.7 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 51.17 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 31.7 W/kg
SAR(1 g) = 7.43 W/kg; SAR(10 g) = 2.06 W/kg
Maximum value of SAR (measured) = 14.8 W/kg



0 dB = 14.8 W/kg = 11.70 dBW/kg

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7. DAE & Probe Calibration Certificate

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Accreditation No.: **SCS 0108**

Client: **ATL (Auden)**

Certificate No: **DAE3-393_Aug17**

CALIBRATION CERTIFICATE

Object	DAE3 - SD 000 D03 AA - SN: 393
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	August 10, 2017

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	09-Sep-16 (No.19065)	Sep-17
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-17 (in house check)	In house check: Jan-18
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-17 (in house check)	In house check: Jan-18

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	i.V.

Issued: August 10, 2017

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Certificate No: DAE3-393_Aug17 Page 1 of 5

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Accreditation No.: **SCS 0108**

Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV , full range = -100...+300 mV

Low Range: 1LSB = 61nV , full range = -1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.860 ± 0.02% (k=2)	404.093 ± 0.02% (k=2)	403.957 ± 0.02% (k=2)
Low Range	3.96834 ± 1.50% (k=2)	3.95811 ± 1.50% (k=2)	3.95315 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	105.0 ° ± 1 °

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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199997.55	-0.01	-0.00
Channel X	+ Input	20001.34	-0.16	-0.00
Channel X	- Input	-19993.86	7.38	-0.04
Channel Y	+ Input	199996.71	-0.50	-0.00
Channel Y	+ Input	19999.84	-1.63	-0.01
Channel Y	- Input	-19995.60	5.72	-0.03
Channel Z	+ Input	199998.09	0.93	0.00
Channel Z	+ Input	19999.41	-2.02	-0.01
Channel Z	- Input	-19999.84	1.65	-0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.01	-0.20	-0.01
Channel X	+ Input	201.75	0.12	0.06
Channel X	- Input	-198.21	0.15	-0.07
Channel Y	+ Input	2001.27	-0.03	-0.00
Channel Y	+ Input	200.85	-0.69	-0.34
Channel Y	- Input	-199.00	-0.68	0.34
Channel Z	+ Input	2001.02	-0.08	-0.00
Channel Z	+ Input	200.68	-0.77	-0.38
Channel Z	- Input	-199.29	-0.89	0.45

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	11.42	9.45
	- 200	-8.06	-10.54
Channel Y	200	9.16	8.74
	- 200	-10.16	-10.29
Channel Z	200	3.54	3.31
	- 200	-4.47	-5.07

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	3.14	-2.48
Channel Y	200	8.58	-	4.93
Channel Z	200	9.12	5.00	-

Certificate No: DAE3-393_Aug17 Page 4 of 5

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16141	15835
Channel Y	16015	15863
Channel Z	16526	16237

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.46	-0.23	1.12	0.28
Channel Y	0.32	-0.36	1.25	0.28
Channel Z	0.78	-1.13	2.18	0.53

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **EX3-7466_Jul17**

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7466

Calibration procedure(s): QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: July 4, 2017

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02525)	Apr-18
Reference 20 dB Attenuator	SN: S5277 (20x)	07-Apr-17 (No. 217-02528)	Apr-18
Reference Probe ES3DV2	SN: 3013	31-Dec-16 (No. ES3-3013_Dec16)	Dec-17
DAE4	SN: 660	7-Dec-16 (No. DAE4-660_Dec16)	Dec-17
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	Leif Klysner
Approved by:	Katja Pokovic	Technical Manager	

Issued: July 6, 2017

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Certificate No: EX3-7466_Jul17 Page 1 of 11

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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, ", "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z:* A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy):* in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset:* The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle:* The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

Certificate No: EX3-7466_Jul17 Page 2 of 11

Probe EX3DV4

SN:7466

Manufactured: October 25, 2016
Calibrated: July 4, 2017

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7466

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.46	0.40	0.63	± 10.1 %
DCP (mV)[B]	96.7	100.3	93.7	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	145.9	±3.0 %
		Y	0.0	0.0	1.0		148.6	
		Z	0.0	0.0	1.0		130.0	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7466

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
835	41.5	0.90	10.20	10.20	10.20	0.60	0.84	± 12.0 %
900	41.5	0.97	9.95	9.95	9.95	0.42	0.94	± 12.0 %
1750	40.1	1.37	8.84	8.84	8.84	0.34	0.80	± 12.0 %
1900	40.0	1.40	8.52	8.52	8.52	0.35	0.80	± 12.0 %
2000	40.0	1.40	8.47	8.47	8.47	0.35	0.80	± 12.0 %
2450	39.2	1.80	7.81	7.81	7.81	0.35	0.99	± 12.0 %
2600	39.0	1.96	7.58	7.58	7.58	0.37	0.95	± 12.0 %
5200	36.0	4.66	5.81	5.81	5.81	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.56	5.56	5.56	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.98	4.98	4.98	0.40	1.80	± 13.1 %
5800	35.3	5.27	5.17	5.17	5.17	0.40	1.80	± 13.1 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7466

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
835	55.2	0.97	10.24	10.24	10.24	0.39	0.96	± 12.0 %
900	55.0	1.05	10.06	10.06	10.06	0.34	1.01	± 12.0 %
1750	53.4	1.49	8.52	8.52	8.52	0.39	0.87	± 12.0 %
1900	53.3	1.52	8.14	8.14	8.14	0.34	0.91	± 12.0 %
2000	53.3	1.52	8.30	8.30	8.30	0.33	0.94	± 12.0 %
2450	52.7	1.95	7.94	7.94	7.94	0.28	1.10	± 12.0 %
2600	52.5	2.16	7.66	7.66	7.66	0.27	1.15	± 12.0 %
5200	49.0	5.30	5.20	5.20	5.20	0.40	1.90	± 13.1 %
5300	48.9	5.42	5.10	5.10	5.10	0.40	1.90	± 13.1 %
5600	48.5	5.77	4.27	4.27	4.27	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.48	4.48	4.48	0.50	1.90	± 13.1 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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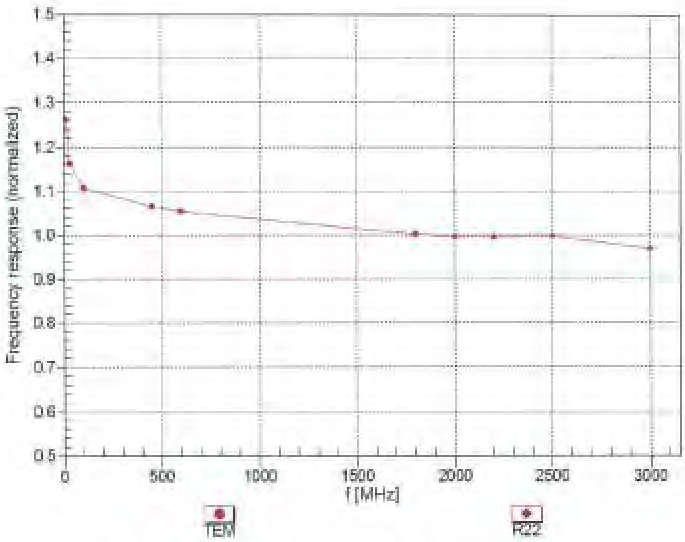
Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

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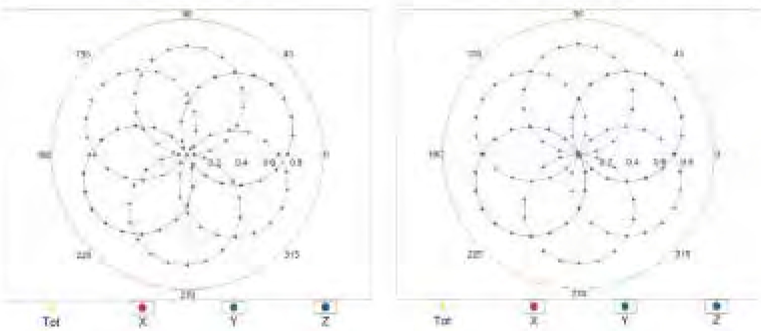
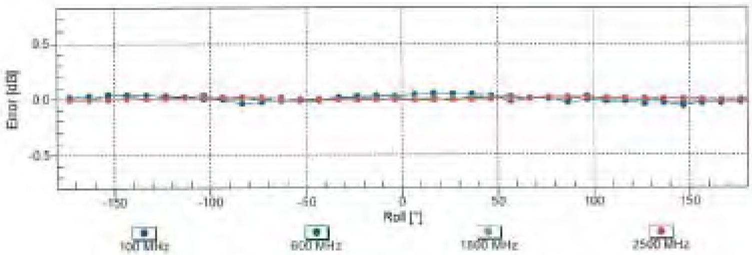
Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM f=1800 MHz,R22





Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

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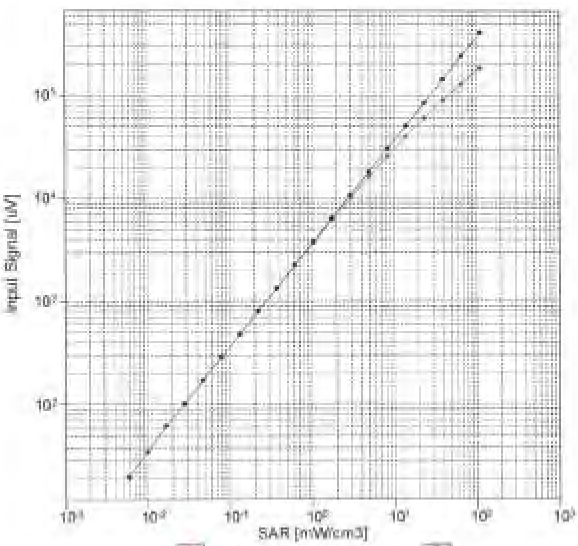
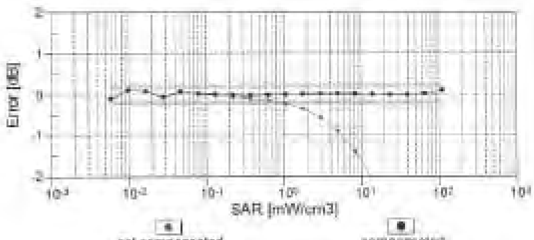
Dynamic Range f(SAR$_{head}$)
(TEM cell , f_{eval}= 1900 MHz)





Uncertainty of Linearity Assessment: ± 0.6% (k=2)

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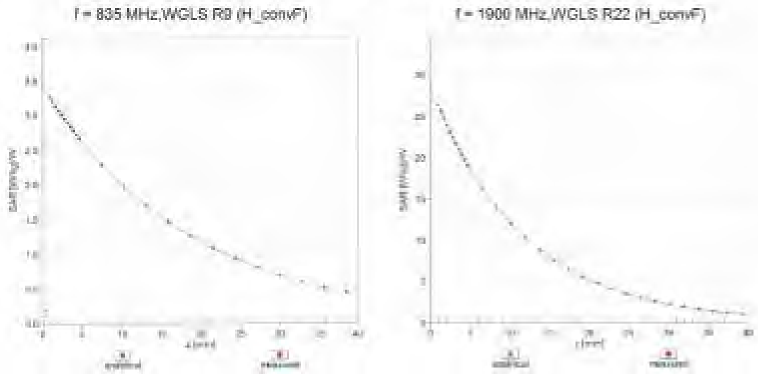
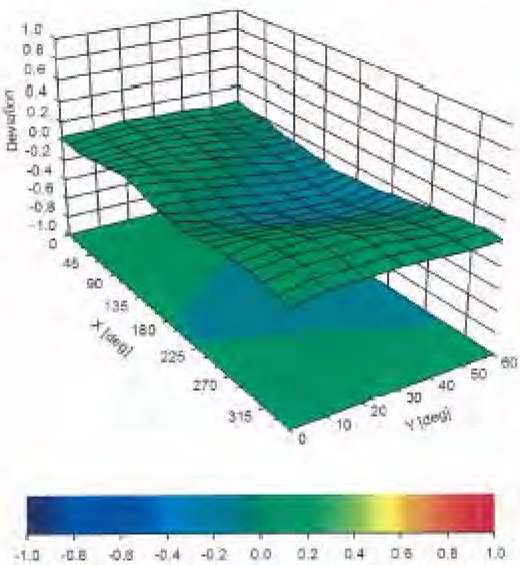
EX3DV4– SN:7466 July 4, 2017

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (φ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7466

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-3.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

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8. Uncertainty Budget

Measurement Uncertainty evaluation template for DUT SAR test (3-6G)

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributio	Div	Div Value	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	6.55%	N	1	1	1	1	6.55%	6.55%	∞
Isotropy , Axial	3.50%	R	√3	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	√3	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	√3	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	√3	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Readout Electronics	0.30%	N	1	1	1	1	0.30%	0.30%	∞
Response time	0.80%	R	√3	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	√3	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	√3	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	√3	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	√3	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Test Sample related									
Test sample positioning	2.90%	N	1	1	1	1	2.90%	2.90%	M-1
Device Holder Uncertainty	3.60%	N	1	1	1	1	3.60%	3.60%	M-1
Drift of output power	5.00%	R	√3	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	√3	1.732	1	1	2.31%	2.31%	∞
Liquid permittivity (mea.)	1.47%	N	1	1	0.64	0.43	0.94%	0.63%	M
Liquid Conductivity (mea.)	3.58%	N	1	1	0.6	0.49	2.15%	1.75%	M
Combined standard uncertainty		RSS					11.95%	11.85%	
Expant uncertainty (95% confidence interval), K=2							23.90%	23.71%	

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Measurement Uncertainty evaluation template for DUT SAR test (0.3-3G)

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributio	Div	Div Value	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	6.00%	N	1	1	1	1	6.00%	6.00%	∞
Isotropy , Axial	3.50%	R	$\sqrt{3}$	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	$\sqrt{3}$	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	$\sqrt{3}$	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	$\sqrt{3}$	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Readout Electronics	0.30%	N	1	1	1	1	0.30%	0.30%	∞
Response time	0.80%	R	$\sqrt{3}$	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	$\sqrt{3}$	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	$\sqrt{3}$	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	$\sqrt{3}$	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	$\sqrt{3}$	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	$\sqrt{3}$	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	$\sqrt{3}$	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Test Sample related									
Test sample positioning	2.90%	N	1	1	1	1	2.90%	2.90%	M-1
Device Holder Uncertainty	3.60%	N	1	1	1	1	3.60%	3.60%	M-1
Drift of output power	5.00%	R	$\sqrt{3}$	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	$\sqrt{3}$	1.732	1	1	2.31%	2.31%	∞
Liquid permittivity (mea.)	0.23%	N	1	1	0.64	0.43	0.15%	0.10%	M
Liquid Conductivity (mea.)	2.87%	N	1	1	0.6	0.49	1.72%	1.41%	M
Combined standard uncertainty		RSS					11.55%	11.49%	
Expant uncertainty (95% confidence interval), K=2							23.10%	22.99%	

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9. Phantom Description

Schmid & Partner Engineering AG
s p e a g
Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 5.0
Type No	QD OVA 002 A
Series No	1108 and higher
Manufacturer	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland

Tests
Complete tests were made on the prototype units QD OVA 001 A, pre-series units QD OVA 001 B as well as on some series units QD OVA 001 B. Some tests are made on all series units QD OVA 002 A.

Test	Requirement	Details	Units tested
Shape	Internal dimensions, depth and sagging are compatible with standards	Bottom elliptical 600 x 400 mm, Depth 190 mm, dimension compliant with [1] for f > 375 MHz	Prototypes
Material thickness	Bottom: 2.0mm +/- 0.2mm	dimension compliant with [3] for f > 800 MHz	all
Material parameters	rel. permittivity 2 – 5, loss tangent ≤ 0.05, at f ≤ 6 GHz	rel. permittivity 3.5 +/- 0.5 loss tangent ≤ 0.05	Material samples
Material resistivity	Compatibility with tissue simulating liquids .	Compatible with SPEAG liquids. **	Phantoms, Material sample
Sagging	Sagging of the flat section in tolerance when filled with tissue simulating liquid.	within tolerance for filling height up to 155 mm	Prototypes, samples

** Note: Compatibility restrictions apply certain liquid components mentioned in the standard, containing e.g. DGBE, DGMHE or Triton X-100. Observe technical note on material compatibility.

Standards
[1] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 01-01
[2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003
[3] IEC 62209–1 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", 2005-02-18
[4] IEC 62209–2 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", 2010-03-30

Conformity
Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of body-worn SAR measurements and system performance checks as specified in [1 – 4] and further standards.

Date 25.7.2011

Signature / Stamp

s p e a g
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Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Doc No 881 – QD OVA 002 A - A   Page 1 (1)

10. System Validation from Original Equipment Supplier

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **SGS -TW (Auden)**

Certificate No: **D2450V2-727_Apr17**

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 727
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	April 21, 2017

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-Dec-16 (No. EX3-7349_Dec16)	Dec-17
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M.Weber
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 21, 2017

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D2450V2-727_Apr17 Page 1 of 8

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
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Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

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Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.7 ± 6 %	1.87 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.2 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.3 W/kg ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.5 ± 6 %	2.03 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.8 W/kg ± 16.5 % (k=2)**

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	56.3 Ω + 2.1 jΩ
Return Loss	- 24.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.1 Ω + 4.1 jΩ
Return Loss	- 27.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.148 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	January 09, 2003

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DASY5 Validation Report for Head TSL

Date: 21.04.2017

Test Laboratory: SPEAG, Zurich, Switzerland

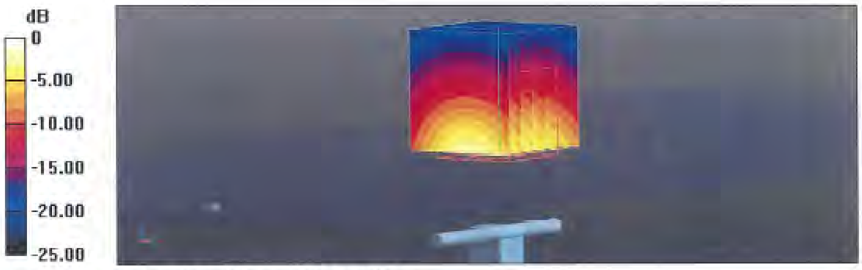
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 727

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.87 S/m; ε_r = 37.7; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 109.8 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 27.3 W/kg
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.18 W/kg
Maximum value of SAR (measured) = 21.1 W/kg



0 dB = 21.1 W/kg = 13.24 dBW/kg

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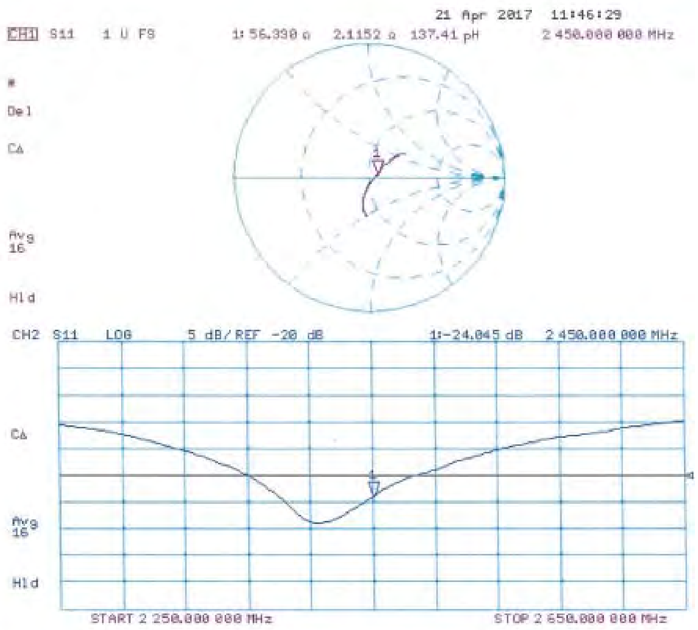
Impedance Measurement Plot for Head TSL



Certificate No: D2450V2-727_Apr17 Page 6 of 8

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DASY5 Validation Report for Body TSL

Date: 21.04.2017

Test Laboratory: SPEAG, Zurich, Switzerland

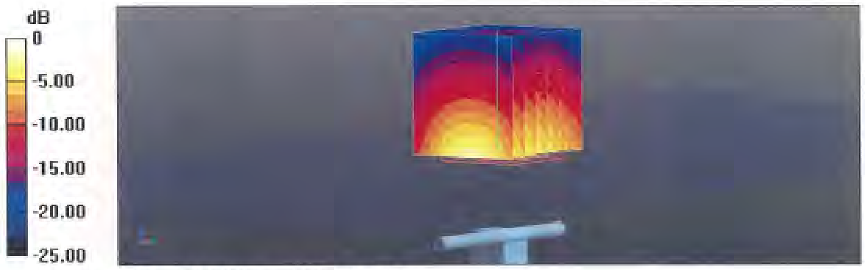
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 727

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.03 S/m; ε_r = 52.5; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:
Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 105.0 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 25.4 W/kg
SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.01 W/kg
Maximum value of SAR (measured) = 20.0 W/kg



0 dB = 20.0 W/kg = 13.01 dBW/kg

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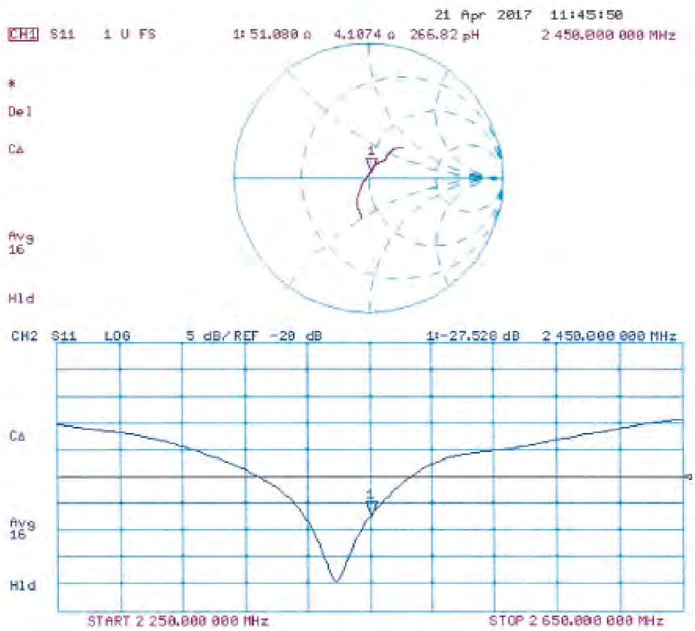
Impedance Measurement Plot for Body TSL



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **D5GHzV2-1023_Jan18**

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1023
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	January 25, 2018

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 3503	30-Dec-17 (No. EX3-3503_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: January 25, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D5GHzV2-1023_Jan18 Page 1 of 15

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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

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Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.3 ± 6 %	4.50 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.72 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.2 W/kg ± 19.5 % (k=2)**

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Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.2 ± 6 %	4.60 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**80.9 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.2 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.8 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.4 W/kg ± 19.5 % (k=2)**

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Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.90 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**79.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.5 W/kg ± 19.5 % (k=2)**

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Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.3 ± 6 %	5.41 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**70.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**19.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.54 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.34 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**72.9 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.4 W/kg ± 19.5 % (k=2)**

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Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.6 ± 6 %	5.94 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.81 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**77.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.7 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.2 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.46 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**74.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.07 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.5 W/kg ± 19.5 % (k=2)**

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	50.1 Ω - 8.1 jΩ
Return Loss	- 21.9 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	50.5 Ω - 2.3 jΩ
Return Loss	- 32.7 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.9 Ω - 0.7 jΩ
Return Loss	- 28.4 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	55.3 Ω + 2.6 jΩ
Return Loss	- 25.1 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	49.8 Ω - 6.9 jΩ
Return Loss	- 23.2 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	50.9 Ω - 0.9 jΩ
Return Loss	- 37.9 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.0 Ω + 0.5 jΩ
Return Loss	- 24.9 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	56.6 Ω + 2.3 jΩ
Return Loss	- 23.7 dB

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General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	February 05, 2004

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DASY5 Validation Report for Head TSL

Date: 25.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.5 S/m; ε_r = 36.3; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5300 MHz; σ = 4.6 S/m; ε_r = 36.2; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 4.9 S/m; ε_r = 35.8; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 5.11 S/m; ε_r = 35.5; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.75, 5.75, 5.75); Calibrated: 30.12.2017, ConvF(5.5, 5.5, 5.5); Calibrated: 30.12.2017, ConvF(5.05, 5.05, 5.05); Calibrated: 30.12.2017, ConvF(4.96, 4.96, 4.96); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.47 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 27.5 W/kg
SAR(1 g) = 7.72 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 17.7 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.63 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 29.6 W/kg
SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.32 W/kg
Maximum value of SAR (measured) = 18.6 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.79 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 31.5 W/kg
SAR(1 g) = 8.19 W/kg; SAR(10 g) = 2.34 W/kg
Maximum value of SAR (measured) = 19.6 W/kg

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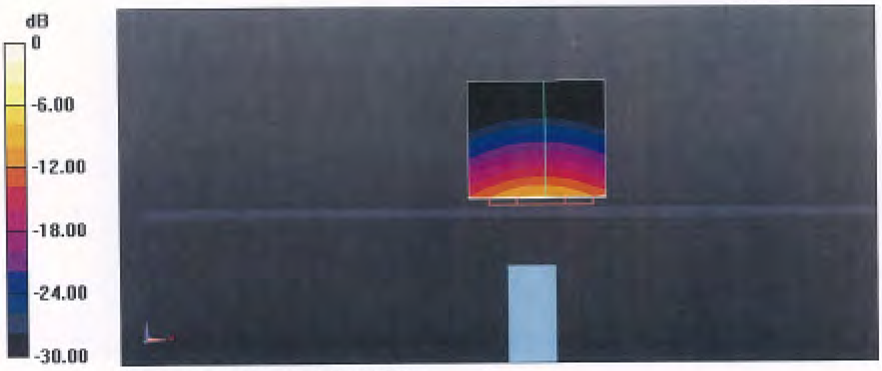
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 69.22 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 31.2 W/kg
SAR(1 g) = 7.9 W/kg; SAR(10 g) = 2.25 W/kg
Maximum value of SAR (measured) = 19.0 W/kg



0 dB = 17.7 W/kg = 12.48 dBW/kg

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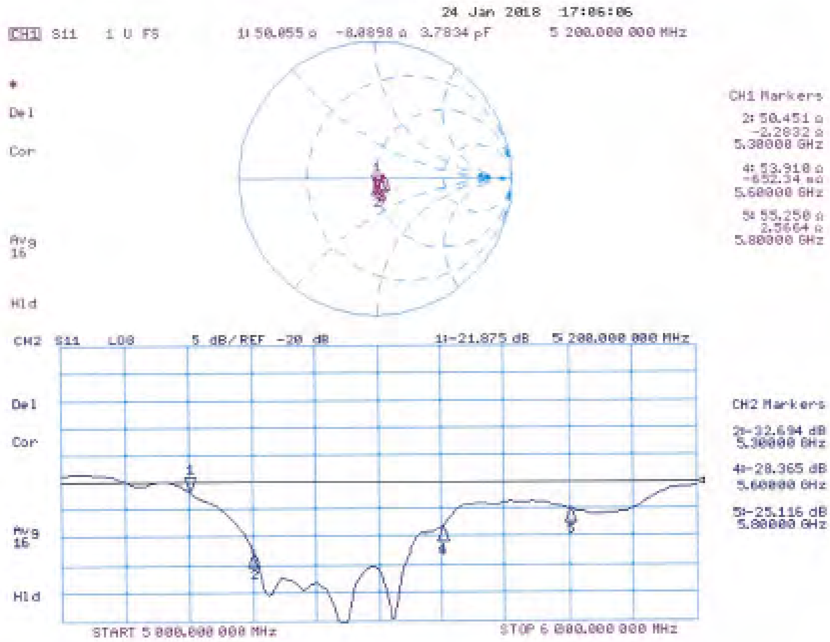
Impedance Measurement Plot for Head TSL



SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
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DASY5 Validation Report for Body TSL

Date: 23.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.41 S/m; ε_r = 47.3; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5300 MHz; σ = 5.54 S/m; ε_r = 47.1; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 5.94 S/m; ε_r = 46.6; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 6.22 S/m; ε_r = 46.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.35, 5.35, 5.35); Calibrated: 30.12.2017, ConvF(5.15, 5.15, 5.15); Calibrated: 30.12.2017, ConvF(4.65, 4.65, 4.65); Calibrated: 30.12.2017, ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.00 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 26.4 W/kg
SAR(1 g) = 7.14 W/kg; SAR(10 g) = 2 W/kg
Maximum value of SAR (measured) = 16.8 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.19 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 28.4 W/kg
SAR(1 g) = 7.34 W/kg; SAR(10 g) = 2.06 W/kg
Maximum value of SAR (measured) = 17.6 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.21 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 32.8 W/kg
SAR(1 g) = 7.81 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 19.1 W/kg

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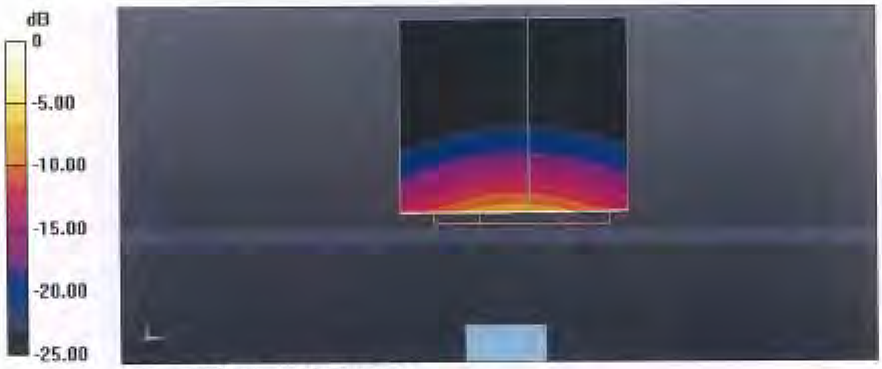
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.05 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 32.3 W/kg
SAR(1 g) = 7.46 W/kg; SAR(10 g) = 2.07 W/kg
Maximum value of SAR (measured) = 18.8 W/kg



0 dB = 18.8 W/kg = 12.74 dBW/kg

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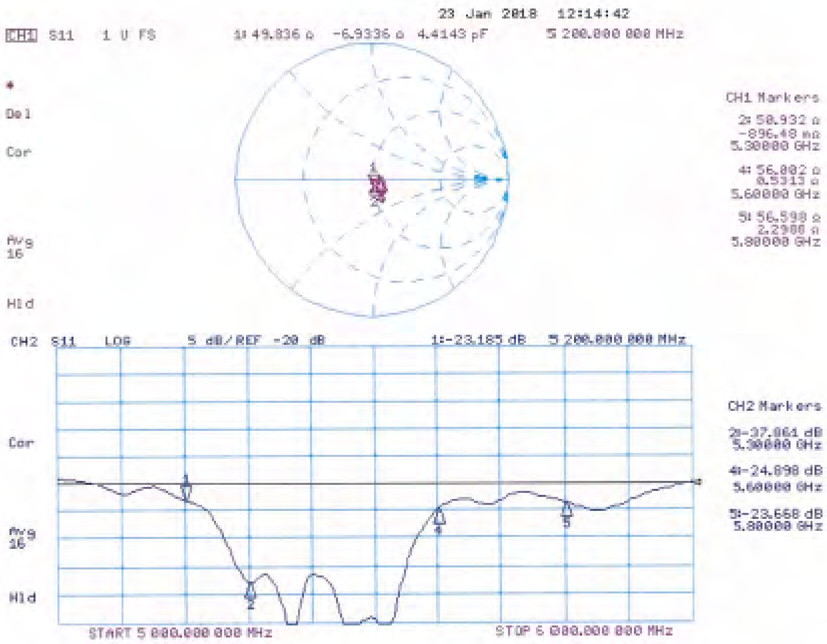
Impedance Measurement Plot for Body TSL



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- End of 1st part of report -

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