SAR TEST REPORT

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

Equipment Under Test of Host	Notebook
Brand Name of Host	acer
Model No. of Host	MS2391
Model No. of Module	QCNFA222
Company Name	Acer Incorporated
Company Address	8F., No.88, Sec. 1, Hsintai 5th Rd., Hsichih, New Taipei City 22181, Taiwan (R.O.C.)
Standards	FCC OET 65 supplement C,IEEE /ANSI C95.1 , C95.3, IEEE 1528
Module FCC ID	PPD-QCNFA222
Date of Receipt	Jul. 16, 2014
Date of Test(s)	Jul. 18, 2014 ~ Jul. 22, 2014
Date of Issue	Aug. 21, 2014

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

Engineer	**Sr. Engineer**
Afu Chen	**John Yeh**
Date: Aug. 21, 2014	**Date: Aug. 21, 2014**

Version

Report Number	Revision	Date	Memo
EN/2014/70013	00	2014/07/25	Initial creation of test report.
EN/2014/70013	01	2014/08/13	1st Modification
EN/2014/70013	02	2014/08/21	2nd Modification

This test report contains a reference to the previous version test report that it replaces.

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Contents

1. General Information

1.1 Testing Laboratory

SGS Taiwan Ltd. Electronics & Communication Laboratory	
No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan	
Tel	+886-2-2299-3279
Fax	+886-2-2298-0488
Internet	http://www.tw.sgs.com/
Testing Location	1F, No.8, Alley 15, Lane 120, Sec .1, NeiHu Road NeiHu District Taipei City 114, Taiwan

1.2 Details of Applicant

Company Name	Acer Incorporated
Company Address	8F., No.88, Sec. 1, Hsintai 5th Rd., Hsichih, New Taipei City 22181, Taiwan (R.O.C.)

1.3 Description of EUT

Equipment Under Test of Host	Notebook			
Brand Name of Host	acer			
Model No. of Host	MS2391			
Model No. of Module	QCNFA222			
Module FCC ID	PPD-QCNFA222			
Antenna Designation (Maximum Gain)	PIFA Antenna 1. Antenna Main: 2.4GHz: -3.01dBi / 5GHz: 2.54dBi 2. Antenna Aux: 2.4GHz: -1.67dBi / 5GHz: 1.37dBi			
Mode of Operation	☒ WLAN802.11 a/b/g/n (20M/40M) band			
Duty Cycle	WLAN802.11 a/b/g/n(20M/40M)	1		
TX Frequency Range (MHz)	WLAN802.11 b/g/n(20M)	2412	—	2462
	WLAN802.11 n(40M)	2422	—	2452
	WLAN802.11 a 5.2G	5180	—	5240
	WLAN802.11 n (20M) 5.2G	5180	—	5240
	WLAN802.11 n (40M) 5.2G	5190	—	5230
	WLAN802.11 a 5.3G	5260	—	5320
	WLAN802.11 n (20M) 5.3G	5260	—	5320
	WLAN802.11 n (40M) 5.3G	5270	—	5310
	WLAN802.11 a 5.6G	5500	—	5700
	WLAN802.11 n (20M) 5.6G	5500	—	5700
	WLAN802.11 n (40M) 5.6G	5510	—	5670
	WLAN802.11 a 5.8G	5745	—	5825
	WLAN802.11 n (20M) 5.8G	5745	—	5825
	WLAN802.11 n (40M) 5.8G	5755	—	5795

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Channel Number (ARFCN)	WLAN802.11 b/g/n(20M)	1	—	11
	WLAN802.11 n(40M)	3	—	9
	WLAN802.11 a 5.2G	36	—	48
	WLAN802.11 n (20M) 5.2G	36	—	48
	WLAN802.11 n (40M) 5.2G	38	—	46
	WLAN802.11 a 5.3G	52	—	64
	WLAN802.11 n (20M) 5.3G	52	—	64
	WLAN802.11 n (40M) 5.3G	54	—	62
	WLAN802.11 a 5.6G	100	—	140
	WLAN802.11 n (20M) 5.6G	100	—	140
	WLAN802.11 n (40M) 5.6G	102	—	134
	WLAN802.11 a 5.8G	149	—	165
	WLAN802.11 n (20M) 5.8G	149	—	165
	WLAN802.11 n (40M) 5.8G	151	—	159

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Max. SAR (1 g) (Unit: W/Kg)					
Antenna	Band	Measured	Reported	Channel	Position
Main	WLAN802.11b	0.341	0.402	11	Lap-held
	WLAN802.11a 5.2G	0.371	0.409	40	Lap-held
	WLAN802.11a 5.3G	0.391	0.453	60	Lap-held
	WLAN802.11a 5.6G	0.69	0.69	132	Lap-held
	WLAN802.11a 5.8G	0.398	0.477	161	Lap-held
Aux	WLAN802.11b	0.203	0.223	11	Lap-held
	WLAN802.11a 5.2G	0.14	0.154	36	Lap-held
	WLAN802.11a 5.3G	0.38	0.436	52	Lap-held
	WLAN802.11a 5.6G	0.495	0.516	132	Lap-held
	WLAN802.11a 5.8G	0.241	0.339	153	Lap-held
MIMO	WLAN802.11b	0.332	0.388	1	Lap-held
	WLAN802.11a 5.2G	0.254	0.308	44	Lap-held
	WLAN802.11a 5.3G	0.496	0.577	52	Lap-held
	WLAN802.11a 5.6G	0.748	0.765	132	Lap-held
	WLAN802.11a 5.8G	0.61	0.678	157	Lap-held

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

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

Main Antenna (CH0)

802.11 b		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output (dBm)			
			Data Rate (Mbps)			
CH	Frequency (MHz)		1	2	5.5	11
1	2412	17	16.41	16.34	16.31	16.20
6	2437	17	16.07	16.02	15.97	15.83
11	2462	17	16.29	16.28	16.18	16.15

802.11 g		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
1	2412	14	12.44	12.43	12.39	12.32	12.23	12.12	12.03	11.91
6	2437	16.5	16.26	16.12	16.00	15.96	15.86	15.77	15.70	15.63
11	2462	13	11.66	11.63	11.54	11.49	11.48	11.42	11.41	11.41

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Main Antenna (CH0)

802.11 n (20M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
1	2412	13	11.33	11.21	11.19	11.15	11.13	11.10	11.00	10.94
6	2437	15.5	15.14	15.00	14.89	14.78	14.67	14.65	14.52	14.46
11	2462	12	10.44	10.42	10.41	10.36	10.31	10.22	10.17	10.07

802.11 n (40M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
3	2422	12.5	11.15	11.09	11.01	10.95	10.85	10.75	10.68	10.67
6	2437	14.5	13.99	13.87	13.81	13.81	13.67	13.56	13.54	13.48
9	2452	12	10.6	10.51	10.45	10.35	10.22	10.20	10.07	10.04

Main Antenna (CH0)

802.11 a		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
5.2/5.3/5.6/5.8G			Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
36	5180	13.5	12.81	12.79	12.71	12.71	12.62	12.50	12.44	12.44
40	5200	13.5	13.08	12.97	12.86	12.84	12.74	12.62	12.58	12.50
44	5220	13.5	13.38	13.35	13.29	13.26	13.13	12.99	12.85	12.75
48	5240	13.5	12.75	12.64	12.60	12.59	12.47	12.33	12.24	12.22
52	5260	15	14.42	14.33	14.28	14.16	14.09	13.98	13.85	13.81
56	5280	15	13.59	13.51	13.47	13.35	13.33	13.19	13.18	13.09
60	5300	15	14.36	14.22	14.08	13.96	13.96	13.96	13.89	13.87
64	5320	15	14.03	13.90	13.81	13.67	13.55	13.44	13.38	13.29
100	5500	14.5	14.46	14.46	14.36	14.28	14.22	14.14	14.01	13.94
104	5520	14.5	14.4	14.37	14.23	14.13	14.03	13.93	13.89	13.77
108	5540	14.5	14.3	14.19	14.09	14.02	13.97	13.89	13.78	13.70
112	5560	14.5	14.14	14.03	14.01	13.98	13.89	13.82	13.74	13.69
116	5580	14.5	14.28	14.15	14.10	14.08	13.97	13.92	13.86	13.81
132	5660	14.5	14.5	14.47	14.40	14.40	14.34	14.30	14.24	14.13
136	5680	14.5	14.46	14.35	14.28	14.16	14.08	14.08	14.03	13.92
140	5700	14.5	12.69	12.68	12.67	12.62	12.51	12.48	12.38	12.33
149	5745	15	14.27	14.25	14.12	14.12	13.99	13.99	13.96	13.83
153	5765	15	14.03	13.95	13.91	13.88	13.78	13.71	13.59	13.46
157	5785	15	14.79	14.67	14.63	14.54	14.46	14.42	14.32	14.24
161	5805	15	14.21	14.10	13.96	13.92	13.89	13.78	13.67	13.54
165	5825	15	14.04	13.91	13.84	13.72	13.72	13.68	13.67	13.54

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Main Antenna (CH0)

802.11 n(20M) 5.2/5.3/5.6/5.8G		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm) Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
36	5180	13	12.04	12.00	12.00	11.96	11.92	11.82	11.78	11.67
40	5200	13	11.99	11.93	11.92	11.92	11.91	11.88	11.79	11.71
44	5220	13	11.31	11.28	11.20	11.15	11.09	11.05	11.01	10.96
48	5240	13	12.42	12.37	12.37	12.28	12.19	12.07	12.04	11.92
52	5260	13	12.65	12.57	12.48	12.41	12.35	12.31	12.18	12.14
56	5280	13	11.47	11.46	11.41	11.38	11.37	11.24	11.12	11.08
60	5300	13	11.78	11.78	11.65	11.61	11.55	11.48	11.44	11.44
64	5320	13	12.34	12.20	12.14	12.02	11.98	11.88	11.81	11.80
100	5500	12.5	12.15	12.02	11.91	11.81	11.78	11.71	11.65	11.56
104	5520	12.5	11.51	11.50	11.49	11.36	11.30	11.24	11.19	11.16
108	5540	12.5	12.10	12.10	12.00	11.96	11.82	11.75	11.69	11.57
112	5560	12.5	12.06	12.01	11.98	11.84	11.78	11.71	11.60	11.59
116	5580	12.5	11.91	11.84	11.77	11.70	11.60	11.46	11.33	11.28
132	5660	12.5	11.97	11.84	11.76	11.72	11.58	11.47	11.42	11.35
136	5680	12.5	12.15	12.14	12.06	12.03	11.94	11.91	11.86	11.77
140	5700	13	11.44	11.32	11.25	11.16	11.13	11.02	10.92	10.88
149	5745	12.5	12.19	12.14	12.03	12.00	11.94	11.80	11.66	11.52
153	5765	12.5	12.06	11.98	11.85	11.84	11.76	11.74	11.66	11.66
157	5785	12.5	12.10	12.02	11.90	11.88	11.77	11.73	11.64	11.64
161	5805	12.5	12.33	12.20	12.14	12.09	12.03	11.94	11.83	11.71
165	5825	12.5	12.12	12.05	11.91	11.79	11.75	11.72	11.63	11.53

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Main Antenna (CH0)

802.11 n(40M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output (dBm)							
5.2/5.3/5.6/5.8G										
CH	Frequency (MHz)		Data Rate (Mbps)							
			mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
38	5190	12.5	10.3	10.28	10.28	10.24	10.19	10.06	10.00	9.96
46	5230	12.5	11.88	11.83	11.70	11.59	11.57	11.53	11.45	11.32
54	5270	13	12.71	12.65	12.55	12.41	12.39	12.35	12.35	12.22
62	5310	13	10.04	9.97	9.90	9.82	9.81	9.71	9.64	9.53
102	5510	13	9.51	9.39	9.27	9.19	9.19	9.11	9.11	9.07
110	5550	13	12.49	12.38	12.29	12.16	12.06	11.96	11.90	11.88
134	5670	13	12.31	12.30	12.29	12.20	12.12	12.10	12.05	12.05
151	5755	12.5	12.33	12.33	12.33	12.23	12.18	12.10	12.09	11.97
159	5795	12.5	12.34	12.34	12.24	12.15	12.02	11.98	11.88	11.82

#. Per FCC KDB443999, transmission on channels which overlap the 5600-5650 MHz is prohibited as a client.

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Aux Antenna (CH1)

802.11 b		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output (dBm)			
			Data Rate (Mbps)			
CH	Frequency (MHz)		1	2	5.5	11
1	2412	17	16.32	16.20	16.17	16.09
6	2437	17	16.39	16.32	16.22	16.17
11	2462	17	16.6	16.46	16.42	16.38

802.11 g		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
1	2412	14	12.36	12.31	12.21	12.11	12.04	11.95	11.83	11.77
6	2437	16.5	16.1	16.01	16.00	15.94	15.81	15.73	15.62	15.52
11	2462	13	11.36	11.29	11.26	11.12	11.11	11.04	10.90	10.83

802.11 n (20M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
1	2412	13	11.4	11.34	11.29	11.23	11.12	11.11	11.05	11.00
6	2437	15.5	15.04	14.90	14.86	14.72	14.72	14.72	14.71	14.59
11	2462	12	10.01	9.93	9.89	9.78	9.75	9.75	9.75	9.64

802.11 n (40M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
3	2422	12.5	10.78	10.71	10.62	10.51	10.38	10.25	10.19	10.07
6	2437	14.5	14.00	13.91	13.79	13.67	13.53	13.43	13.42	13.41
9	2452	12	10.11	10.03	9.92	9.83	9.82	9.80	9.72	9.68

Aux Antenna (CH1)

802.11 a		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
5.2/5.3/5.6/5.8G			Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
36	5180	13.5	13.1	13.02	12.94	12.90	12.84	12.71	12.67	12.58
40	5200	13.5	13.1	12.99	12.85	12.77	12.73	12.73	12.72	12.66
44	5220	13.5	13.42	13.36	13.22	13.14	13.05	12.94	12.89	12.75
48	5240	13.5	12.45	12.40	12.38	12.25	12.22	12.18	12.11	12.01
52	5260	15	14.4	14.35	14.33	14.23	14.21	14.14	14.13	14.00
56	5280	15	13.86	13.86	13.77	13.75	13.74	13.64	13.62	13.59
60	5300	15	14.34	14.34	14.30	14.20	14.09	14.09	14.04	13.97
64	5320	15	14.01	13.89	13.84	13.72	13.72	13.67	13.56	13.51
100	5500	14.5	14.05	14.03	14.03	13.96	13.92	13.86	13.73	13.62
104	5520	14.5	13.48	13.39	13.26	13.18	13.13	13.09	13.00	13.00
108	5540	14.5	13.16	13.05	12.96	12.88	12.83	12.80	12.79	12.71
112	5560	14.5	13.34	13.24	13.14	13.03	12.95	12.92	12.89	12.77
116	5580	14.5	14.1	14.10	13.99	13.88	13.87	13.73	13.65	13.59
132	5660	14.5	14.32	14.19	14.12	14.12	14.00	13.87	13.77	13.77
136	5680	14.5	13.03	12.95	12.81	12.68	12.64	12.58	12.58	12.54
140	5700	14.5	12.75	12.69	12.59	12.50	12.44	12.35	12.22	12.13
149	5745	15	13.19	13.15	13.04	12.91	12.79	12.79	12.71	12.69
153	5765	15	13.52	13.46	13.34	13.25	13.16	13.14	13.12	13.06
157	5785	15	13.83	13.77	13.77	13.72	13.65	13.63	13.63	13.57
161	5805	15	13.87	13.78	13.68	13.57	13.45	13.45	13.45	13.36
165	5825	15	13.55	13.43	13.31	13.22	13.13	13.06	13.04	12.98

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Aux Antenna (CH1)

802.11 n(20M) 5.2/5.3/5.6/5.8G		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm) Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
36	5180	13	12.33	12.19	12.08	12.08	11.98	11.98	11.97	11.84
40	5200	13	12.45	12.37	12.31	12.22	12.20	12.12	12.06	11.99
44	5220	13	12.21	12.15	12.07	12.02	11.89	11.81	11.81	11.68
48	5240	13	12.43	12.39	12.32	12.19	12.17	12.16	12.08	12.04
52	5260	13	12.45	12.37	12.31	12.17	12.06	11.99	11.88	11.76
56	5280	13	12.42	12.30	12.28	12.14	12.07	11.93	11.90	11.83
60	5300	13	12.12	12.10	11.97	11.85	11.75	11.70	11.62	11.57
64	5320	13	12.10	11.99	11.96	11.89	11.76	11.71	11.69	11.68
100	5500	12.5	12.23	12.17	12.05	12.03	12.03	11.95	11.93	11.87
104	5520	12.5	11.50	11.37	11.36	11.32	11.28	11.15	11.01	10.97
108	5540	12.5	11.40	11.26	11.12	11.05	11.02	11.01	10.96	10.84
112	5560	12.5	11.55	11.49	11.46	11.36	11.33	11.29	11.26	11.16
116	5580	12.5	11.95	11.92	11.87	11.87	11.85	11.85	11.74	11.68
132	5660	12.5	12.38	12.33	12.21	12.08	12.07	12.06	11.99	11.96
136	5680	12.5	10.88	10.84	10.74	10.73	10.62	10.59	10.50	10.43
140	5700	13	11.04	10.91	10.83	10.81	10.76	10.71	10.58	10.48
149	5745	12.5	11.62	11.61	11.55	11.55	11.49	11.39	11.39	11.28
153	5765	12.5	11.71	11.58	11.46	11.38	11.37	11.34	11.24	11.23
157	5785	12.5	11.50	11.42	11.31	11.30	11.20	11.12	11.04	11.02
161	5805	12.5	11.70	11.62	11.59	11.47	11.46	11.38	11.29	11.21
165	5825	12.5	11.85	11.78	11.65	11.60	11.55	11.41	11.30	11.23

Aux Antenna (CH1)

802.11 n(40M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output (dBm)							
5.2/5.3/5.6/5.8G			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs0	mcs1	mcs2	mcs3	mcs4	mcs5	mcs6	mcs7
38	5190	12.5	10.64	10.61	10.48	10.46	10.39	10.25	10.12	10.09
46	5230	12.5	12.24	12.21	12.14	12.03	12.01	11.99	11.88	11.77
54	5270	13	12.33	12.22	12.16	12.13	12.03	11.93	11.84	11.82
62	5310	13	10.44	10.38	10.27	10.14	10.01	9.90	9.86	9.73
102	5510	13	10.04	9.99	9.86	9.77	9.70	9.56	9.42	9.40
110	5550	13	12.44	12.32	12.21	12.08	11.96	11.86	11.73	11.64
134	5670	13	12.57	12.48	12.47	12.36	12.25	12.25	12.24	12.10
151	5755	12.5	11.63	11.63	11.62	11.53	11.45	11.41	11.31	11.22
159	5795	12.5	11.29	11.18	11.09	11.09	10.97	10.86	10.82	10.80

#. Per FCC KDB443999, transmission on channels which overlap the 5600-5650 MHz is prohibited as a client.

MIMO (CH0 + CH1)

802.11 b		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output (dBm)			
			Data Rate (Mbps)			
CH	Frequency (MHz)		1	2	5.5	11
1	2412	20	19.32	19.25	19.23	19.14
6	2437	20	19.24	19.15	19.15	19.07
11	2462	20	19.54	19.44	19.50	19.35

802.11 g		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
1	2412	17	15.52	15.50	15.43	15.39	15.29	15.23	15.10	15.01
6	2437	19.5	19.28	19.24	19.15	19.06	18.98	18.89	18.81	18.77
11	2462	16	14.47	14.40	14.39	14.27	14.21	14.15	14.03	14.02

802.11n(20M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs8	mcs9	mcs10	mcs11	mcs12	mcs13	mcs14	mcs15
1	2412	16	14.46	14.40	14.37	14.25	14.12	14.03	13.95	13.89
6	2437	18.5	18.08	18.00	17.89	17.83	17.73	17.71	17.67	17.64
11	2462	15	13.39	13.31	13.23	13.16	13.07	13.01	12.95	12.82

802.11n(40M)		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs8	mcs9	mcs10	mcs11	mcs12	mcs13	mcs14	mcs15
3	2422	15.5	13.77	13.64	13.57	13.53	13.47	13.40	13.38	13.30
6	2437	17.5	16.99	16.95	16.89	16.82	16.75	16.71	16.67	16.59
9	2452	15	13.35	13.34	13.24	13.21	13.10	13.00	12.97	12.87

MIMO (CH0 + CH1)

802.11 a 5.2/5.3/5.6/5.8G		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm) Data Rate (Mbps)							
CH	Frequency (MHz)		6	9	12	18	24	36	48	54
36	5180	16.5	15.78	15.70	15.67	15.58	15.57	15.51	15.46	15.40
40	5200	16.5	16.17	16.06	15.98	15.92	15.85	15.84	15.78	15.70
44	5220	16.5	15.66	15.55	15.49	15.46	15.39	15.29	15.27	15.16
48	5240	16.5	15.58	15.54	15.49	15.37	15.28	15.17	15.12	15.09
52	5260	18	17.34	17.28	17.24	17.23	17.20	17.12	17.07	16.95
56	5280	18	16.92	16.87	16.80	16.76	16.73	16.66	16.60	16.54
60	5300	18	17.02	17.02	16.93	16.90	16.79	16.73	16.69	16.61
64	5320	18	16.83	16.72	16.63	16.59	16.56	16.55	16.47	16.41
100	5500	17.5	17.12	17.05	17.01	16.97	16.89	16.82	16.75	16.70
104	5520	17.5	17.18	17.12	17.02	16.97	16.90	16.86	16.85	16.83
108	5540	17.5	16.83	16.75	16.74	16.66	16.61	16.59	16.53	16.47
112	5560	17.5	16.95	16.84	16.80	16.73	16.69	16.68	16.60	16.56
116	5580	17.5	17.11	17.07	17.05	17.00	16.95	16.84	16.76	16.67
132	5660	17.5	17.40	17.36	17.27	17.18	17.07	17.05	16.99	16.93
136	5680	17.5	16.90	16.88	16.80	16.72	16.62	16.54	16.44	16.42
140	5700	17.5	15.89	15.79	15.77	15.67	15.60	15.54	15.49	15.41
149	5745	18	16.93	16.85	16.74	16.74	16.72	16.62	16.52	16.41
153	5765	18	16.99	16.92	16.85	16.82	16.75	16.68	16.56	16.47
157	5785	18	17.54	17.50	17.43	17.32	17.25	17.17	17.12	17.03
161	5805	18	17.09	17.00	16.92	16.87	16.77	16.68	16.62	16.54
165	5825	18	17.02	16.93	16.84	16.75	16.67	16.60	16.55	16.44

MIMO (CH0 + CH1)

802.11n(20M) 5.2/5.3/5.6/5.8G		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm) Data Rate (Mbps)							
CH	Frequency (MHz)		mcs8	mcs9	mcs10	mcs11	mcs12	mcs13	mcs14	mcs15
36	5180	16	15.15	15.06	14.99	14.93	14.87	14.81	14.74	14.65
40	5200	16	15.06	15.05	15.02	14.97	14.94	14.89	14.84	14.74
44	5220	16	14.93	14.82	14.73	14.68	14.59	14.54	14.49	14.46
48	5240	16	15.12	15.04	14.96	14.83	14.71	14.67	14.60	14.48
52	5260	16	15.38	15.24	15.14	15.05	14.97	14.90	14.83	14.74
56	5280	16	15.15	15.10	15.08	15.02	14.97	14.85	14.75	14.68
60	5300	16	14.86	14.76	14.68	14.61	14.58	14.53	14.50	14.44
64	5320	16	15.12	15.07	14.96	14.90	14.85	14.78	14.71	14.65
100	5500	15.5	14.93	14.84	14.78	14.71	14.66	14.56	14.54	14.44
104	5520	15.5	14.77	14.67	14.61	14.51	14.45	14.38	14.34	14.33
108	5540	15.5	14.95	14.86	14.84	14.73	14.65	14.57	14.53	14.48
112	5560	15.5	14.88	14.82	14.78	14.74	14.70	14.58	14.50	14.47
116	5580	15.5	15.05	15.04	14.96	14.89	14.82	14.74	14.65	14.57
132	5660	15.5	14.97	14.89	14.79	14.70	14.64	14.56	14.51	14.47
136	5680	15.5	14.65	14.62	14.58	14.56	14.43	14.31	14.19	14.18
140	5700	16	13.83	13.81	13.73	13.68	13.61	13.51	13.43	13.40
149	5745	15.5	15.13	15.06	15.02	15.01	14.88	14.79	14.75	14.69
153	5765	15.5	15.14	15.06	15.04	14.92	14.90	14.85	14.78	14.72
157	5785	15.5	14.85	14.80	14.74	14.66	14.55	14.48	14.41	14.35
161	5805	15.5	15.14	15.11	15.05	15.04	14.96	14.88	14.76	14.64
165	5825	15.5	15.08	15.01	14.91	14.78	14.72	14.59	14.58	14.52

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MIMO (CH0 + CH1)

802.11n(40M) 5.2/5.3/5.6/5.8G		Max. Rated Avg. Power + Max. Tolerance (dBm)	Average Power Output(dBm)							
			Data Rate (Mbps)							
CH	Frequency (MHz)		mcs8	mcs9	mcs10	mcs11	mcs12	mcs13	mcs14	mcs15
38	5190	15.5	13.38	13.29	13.27	13.22	13.15	13.03	12.99	12.92
46	5230	15.5	15.03	14.99	14.91	14.89	14.80	14.78	14.70	14.67
54	5270	16	15.47	15.46	15.44	15.36	15.27	15.18	15.16	15.10
62	5310	16	12.93	12.87	12.81	12.76	12.68	12.62	12.50	12.45
102	5510	16	12.63	12.57	12.51	12.44	12.37	12.31	12.22	12.21
110	5550	16	12.62	12.59	12.52	12.42	12.36	12.32	12.24	12.17
134	5670	16	15.24	15.14	15.02	14.93	14.83	14.77	14.66	14.55
151	5755	15.5	15.19	15.08	15.03	14.98	14.95	14.85	14.82	14.71
159	5795	15.5	14.89	14.77	14.68	14.59	14.49	14.43	14.35	14.34

#. Per FCC KDB443999, transmission on channels which overlap the 5600-5650 MHz is prohibited as a client.

#. Bluetooth maximum power table:

Mode	Max. tune-up power(dBm)	Max. tune-up power(mW)	Lap-held		
			Test exclusion threshold	Calculated result	Require SAR testing
BT	5	3.162	3	0.996	No

#.According to KDB447498 D01v05 – The 1-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances≤ 50 mm are determined by: [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR. Based on the maximum power of Bluetooth and the min. test separation distance, Bluetooth SAR for Lap-held of the laptop is not required.
(Max. tune-up power=3.162mW, min. test separation distance=5mm, f=2480MHz, [(3.162/5)* √2.48]=0.996 ≤ 3.0)

#. For Bluetooth operational modes the transmission is at Aux output. Bluetooth can only be transmitted simultaneously with Main antenna according to client's operation description.

#.According to KDB447498 D01v05 – 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: [(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz) / 7.5] for test separation distances≤ 50 mm.

#. Estimated Bluetooth SAR in Lap-held mode:

Mode	Max. tune-up power(dBm)	Max. tune-up power(mW)	Min. Separation distance (mm)	Estimated SAR (W/kg)
BT	5	3.162	5	0.133

#. Simultaneous Transmission SAR test exclusion:

Simul Tx	Configuration	Maximum **BT** SAR at Aux output(Estimated)	Maximum **WLAN** SAR at Main output(Reported)	∑ SAR (W/kg)
Body	Lap-held	0.133	0.690	0.823<limit 1.6

#. Simultaneous Transmission SAR test exclusion can be applied since the sum of the 1-g SAR for all the simultaneous transmitting antennas in the same test configuration is ≤ 1.6 W/kg.
#. Per FCC KDB443999, transmission on channels which overlap the 5600-5650 MHz is prohibited as a client.

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1.4 Test Environment

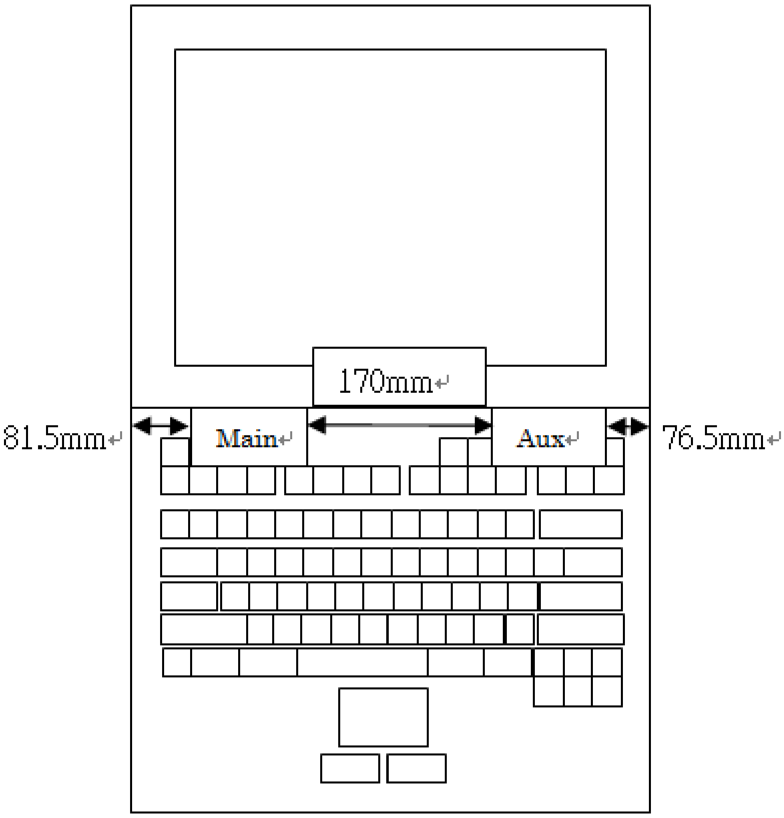
Ambient Temperature: 22±2° C
Tissue Simulating Liquid: 22±2° C

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.

We test this laptop in one configuration:

Configuration 1: Lap-held mode with test separation distance 0mm. (The screen portion of the laptop is in an open position at a 90° angle, and the laptop is positioned with its bottom of keyboard against the flat phantom.)



Front view of the laptop

Note:

#. According to KDB616217 D04, the screen portion of the laptop is in an open position at a 90° angle, and the laptop is positioned with its bottom of keyboard against the flat phantom to test lap-held SAR.

#. SAR testing for 802.11g/n is not required when its maximum power is less than 1/4 dBm higher than 802.11b.

#. According to FCC KDB248227 D01, for each band, testing at higher data rates and higher order modulation is not required when the maximum power for each of these configurations is less than 1/4 dB higher than those measured at the lowest data rate.

#. Since the maximum power of higher data rates is less than 1/4 dB higher than lowest data rate, thus only lowest data rate is required for SAR test.

#. SAR testing for 802.11n is not required when its maximum power is less than 1/4 dBm higher than 802.11a.

#. 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.

#. According to KDB447498 D01, testing of other required channels is not required when the reported 1-g SAR for the highest output channel is ≤ 0.6 W/kg, when the transmission band is between 100 MHz and 200MHz.

#. According to KDB447498 D01, testing of other required channels is not required when the reported 1-g SAR for the highest output channel is ≤ 0.4 W/kg, when the transmission band is ≥ 200MHz.

#. 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)

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:

- 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).
- 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.
- 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.

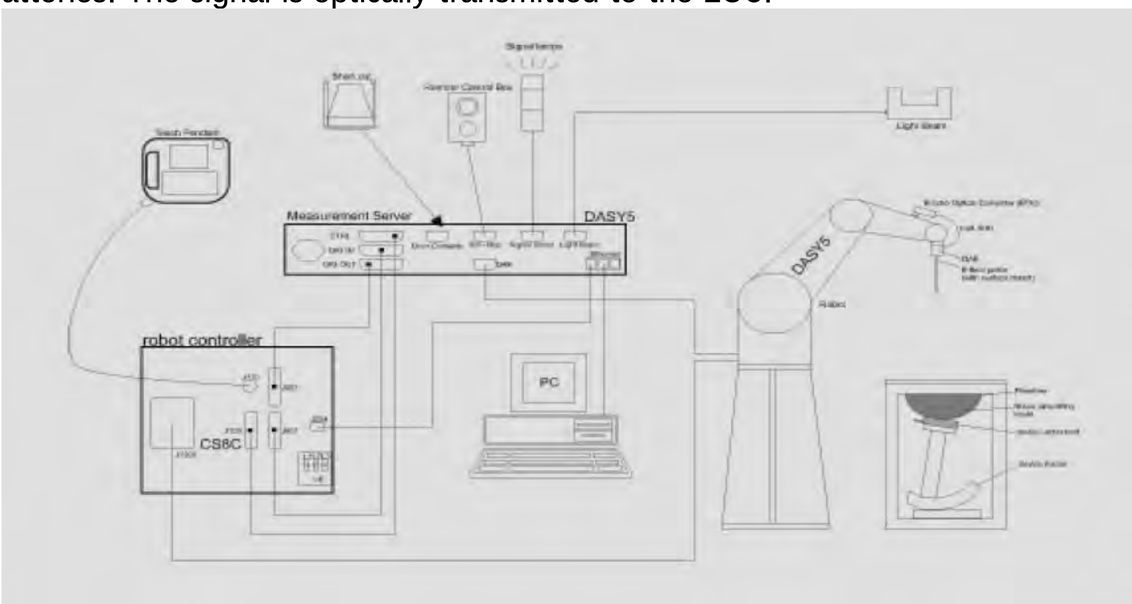


Fig. a The block diagram of SAR system

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- 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.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY 5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- 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%.

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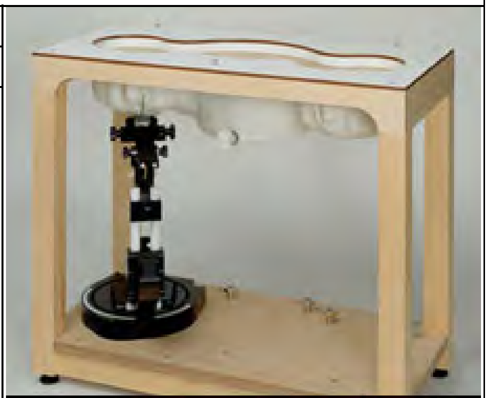
SAM PHANTOM V4.0C

Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528-200X, CENELEC 50361 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Height: 850 mm; Length: 1000 mm; Width: 500 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 ambient temperature of the laboratory was 21.7°C, the relative humidity was 62% and 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.

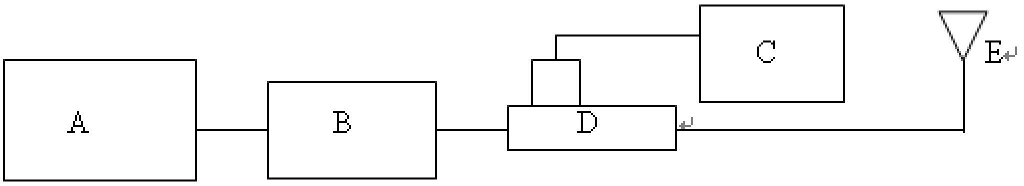
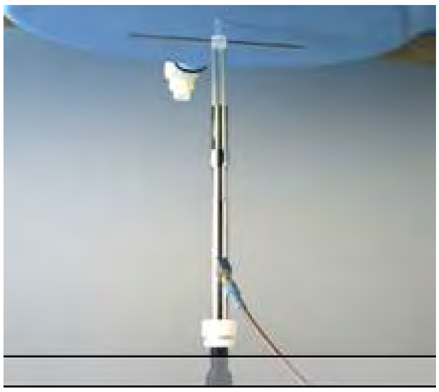


Fig. b The block diagram of system verification

A. Signal generator
B. Amplifier
C. Power meter
D. Dual directional coupling
E. Reference dipole antenna



Photograph of the dipole Antenna

Validation Kit	S/N	Frequency (MHz)		Target SAR (1g) (mW/g)	Measured SAR (1g)(mW/g)	Deviation (%)	Measured Date
D2450V2	727	2450	Body	12.8	12.7	0.78%	Jul. 18, 2014
D5GHzV2	1023	5200	Body	7.39	7.51	-1.62%	Jul. 21, 2014
		5300	Body	7.62	7.65	-0.39%	Jul. 21, 2014
		5600	Body	8.04	8.12	-1.00%	Jul. 22, 2014
		5800	Body	7.44	7.8	-4.84%	Jul. 22, 2014

Table 1. Results of system validation

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1.9 Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this body-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 (30 KHz-6000 MHz).

All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. 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	Jul. 18, 2014	2412	52.751	1.914	50.258	1.991	4.73%	-4.02%
		2437	52.717	1.938	50.164	2.026	4.84%	-4.56%
		2450	52.700	1.950	50.123	2.044	4.89%	-4.82%
		2462	52.685	1.967	50.080	2.062	4.94%	-4.83%
	Jul. 21, 2014	5180	49.041	5.276	48.510	5.152	1.08%	2.35%
		5200	49.014	5.299	48.460	5.164	1.13%	2.55%
		5220	48.987	5.323	48.395	5.198	1.21%	2.35%
		5260	48.933	5.369	48.294	5.275	1.31%	1.75%
		5300	48.879	5.416	48.192	5.331	1.41%	1.57%
	Jul. 22,2014	5500	48.607	5.650	47.678	5.642	1.91%	0.14%
		5520	48.580	5.673	47.606	5.674	2.00%	-0.02%
		5580	48.499	5.743	47.471	5.767	2.12%	-0.42%
		5600	48.471	5.766	47.429	5.789	2.15%	-0.40%
		5660	48.390	5.837	47.270	5.879	2.31%	-0.72%
		5680	48.363	5.860	47.222	5.912	2.36%	-0.89%
		5745	48.275	5.936	47.058	5.963	2.52%	-0.45%
		5765	48.248	5.959	47.006	5.994	2.57%	-0.59%
		5785	48.220	5.982	46.966	6.025	2.60%	-0.72%
		5800	48.200	6.000	46.936	6.041	2.62%	-0.68%
		5805	48.193	6.006	46.918	6.049	2.65%	-0.72%

Table 2. Dielectric Parameters of Tissue Simulant Fluid

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The composition of the body 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.

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The measured volume of 30x30x30mm contains about 30g of tissue.

The first procedure is an extrapolation (incl. Boundary correction) to get the points between the lowest measured plane and the surface. The next step uses 3D interpolation to get all points within the measured volume. In the last step, a 1g cube is placed numerically into the volume and its averaged SAR is calculated. This cube is the moved around until the highest averaged SAR is found. If the highest SAR is found at the edge of the measured volume, the system will issue a warning: higher SAR values might be found outside of the measured volume. In that case the cube measurement can be repeated, using the new interpolated maximum as the center.

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.

$$SAR = \frac{\sigma}{\rho}\left|E\right|^2 = c\,\frac{\delta T}{\delta t}$$

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:

- 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.

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- 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 setups might be above the resonant cutoff frequencies. The field distribution in the setup must be carefully checked for conformity with the theoretical field distribution.

References

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

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

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

1.12 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 C95.1–1992, Copyright 1992 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 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 m W/g	8.00 m W/g
Spatial Average SAR (Whole Body)	0.08 m W/g	0.40 m W/g
Spatial Peak SAR (Hands/Feet/Ankle/Wrist)	4.00 m W/g	20.00 m W/g

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

Main Antenna

Band	Position	Antenna	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	
WLAN802.11b	Lap-held	Main	0	1	2412	17.00	16.41	14.55%	0.322	0.369	-
	Lap-held	Main	0	6	2437	17.00	16.07	23.88%	0.313	0.388	-
	Lap-held	Main	0	11	2462	17.00	16.29	17.76%	0.341	0.402	41
WLAN802.11a 5.2G	Lap-held	Main	0	40	5200	13.5	13.08	10.15%	0.371	0.409	42
	Lap-held	Main	0	44	5220	13.5	13.38	2.80%	0.347	0.357	-
WLAN802.11a 5.3G	Lap-held	Main	0	52	5260	15	14.42	14.29%	0.389	0.445	-
	Lap-held	Main	0	60	5300	15	14.36	15.88%	0.391	0.453	43
WLAN802.11a 5.6G	Lap-held	Main	0	100	5500	14.5	14.46	0.93%	0.487	0.492	-
	Lap-held	Main	0	132	5660	14.5	14.5	0.00%	0.69	0.690	44
	Lap-held	Main	0	136	5680	14.5	14.46	0.93%	0.596	0.602	-
WLAN802.11a 5.8G	Lap-held	Main	0	149	5745	15	14.27	18.30%	0.39	0.461	-
	Lap-held	Main	0	157	5785	15	14.79	4.95%	0.431	0.452	45
	Lap-held	Main	0	161	5805	15	14.21	19.95%	0.398	0.477	-

Aux Antenna

Band	Position	Antenna	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	
WLAN802.11b	Lap-held	Aux	0	1	2412	17.00	16.32	16.95%	0.184	0.215	-
	Lap-held	Aux	0	6	2437	17.00	16.39	15.08%	0.186	0.214	-
	Lap-held	Aux	0	11	2462	17.00	16.6	9.65%	0.203	0.223	46
WLAN802.11a 5.2G	Lap-held	Aux	0	36	5180	13.5	13.1	9.65%	0.14	0.154	-
	Lap-held	Aux	0	44	5220	13.5	13.42	1.86%	0.142	0.145	47
WLAN802.11a 5.3G	Lap-held	Aux	0	52	5260	15	14.4	14.82%	0.38	0.436	48
	Lap-held	Aux	0	60	5300	15	14.34	16.41%	0.218	0.254	-
WLAN802.11a 5.6G	Lap-held	Aux	0	100	5500	14.5	14.05	10.92%	0.453	0.502	-
	Lap-held	Aux	0	116	5580	14.5	14.1	9.65%	0.469	0.514	-
	Lap-held	Aux	0	132	5660	14.5	14.32	4.23%	0.495	0.516	49
WLAN802.11a 5.8G	Lap-held	Aux	0	153	5765	15	13.52	40.60%	0.241	0.339	-
	Lap-held	Aux	0	157	5785	15	13.83	30.92%	0.244	0.319	-
	Lap-held	Aux	0	161	5805	15	13.87	29.72%	0.249	0.323	50

MIMO

Band	Position	Antenna	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	
WLAN802.11b	Lap-held	MIMO	0	1	2412	20.00	19.32	16.95%	0.332	0.388	51
	Lap-held	MIMO	0	6	2437	20.00	19.24	19.12%	0.288	0.343	-
	Lap-held	MIMO	0	11	2462	20.00	19.54	11.17%	0.291	0.324	-
WLAN802.11a 5.2G	Lap-held	MIMO	0	40	5200	16.5	16.17	7.89%	0.222	0.240	-
	Lap-held	MIMO	0	44	5220	16.5	15.66	21.34%	0.254	0.308	52
WLAN802.11a 5.3G	Lap-held	MIMO	0	52	5260	18	17.34	16.41%	0.496	0.577	53
	Lap-held	MIMO	0	60	5300	18	17.02	25.31%	0.09	0.113	-
WLAN802.11a 5.6G	Lap-held	MIMO	0	104	5520	17.5	17.18	7.65%	0.341	0.367	-
	Lap-held	MIMO	0	116	5580	17.5	17.11	9.40%	0.607	0.664	-
	Lap-held	MIMO	0	132	5660	17.5	17.4	2.33%	0.748	0.765	54
WLAN802.11a 5.8G	Lap-held	MIMO	0	153	5765	18	16.99	26.18%	0.473	0.597	-
	Lap-held	MIMO	0	157	5785	18	17.54	11.17%	0.61	0.678	55
	Lap-held	MIMO	0	161	5805	18	17.09	23.31%	0.536	0.661	-

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3. Instruments List

Manufacturer	Device	Type	Serial number	Date of last calibration	Date of next calibration
Schmid & Partner Engineering AG	Dosimetric E-Field Probe	EX3DV4	3848	Apr.24,2014	Apr.23,2015
Schmid & Partner Engineering AG	2450 / 5G System Validation Dipole	D2450V2	727	Apr.23,2014	Apr.22,2015
		D5GHzV2	1023	Jan.30,2014	Jan.29,2015
Schmid & Partner Engineering AG	Data acquisition Electronics	DAE4	1336	Sep.24,2013	Sep.23,2014
Schmid & Partner Engineering AG	Software	DASY 52 V52.8.8	N/A	Calibration not required	Calibration not required
Schmid & Partner Engineering AG	Phantom	SAM	N/A	Calibration not required	Calibration not required
Agilent	Network Analyzer	E5071C	MY46107530	Feb.14,2014	Feb.13,2015
Agilent	Dielectric Probe Kit	85070E	MY44300677	Calibration not required	Calibration not required
Agilent	Dual-directional coupler	772D	MY52180142	Sep.19,2013	Sep.18,2014
Agilent	RF Signal Generator	N5181A	MY50145142	Oct.03,2013	Oct.02,2014
Agilent	Power Meter	E4417A	MY51410006	Oct.25,2013	Oct.24,2015
Agilent	Power Sensor	E9301H	MY51470001	Dec.16,2013	Dec.15,2014
TECPEL	Digital thermometer	DTM-303A	TP130077	Mar.17,2014	Mar.16,2015

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4. Measurements

Date: 2014/7/18

WLAN802.11b_Body_Lap-held_CH 11_Main

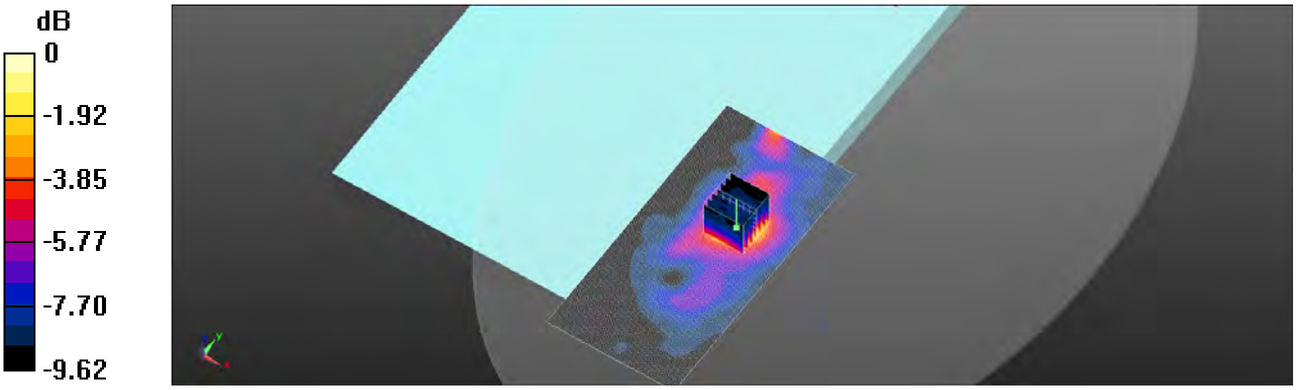
Communication System:, WLAN 2.45G; Frequency: 2462 MHz
Medium parameters used: f = 2462 MHz; σ = 2.062 S/m; ε_r = 50.08; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(6.93, 6.93, 6.93); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x171x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.498 W/kg

Configuration/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 4.867 V/m; Power Drift = 0.12 dB
Peak SAR (extrapolated) = 0.638 W/kg
SAR(1 g) = 0.341 W/kg; SAR(10 g) = 0.188 W/kg
Maximum value of SAR (measured) = 0.470 W/kg



0 dB = 0.470 W/kg = -3.28 dBW/kg

Date: 2014/7/21

WLAN802.11a 5.2G_Body_Lap-held_CH 40_Main

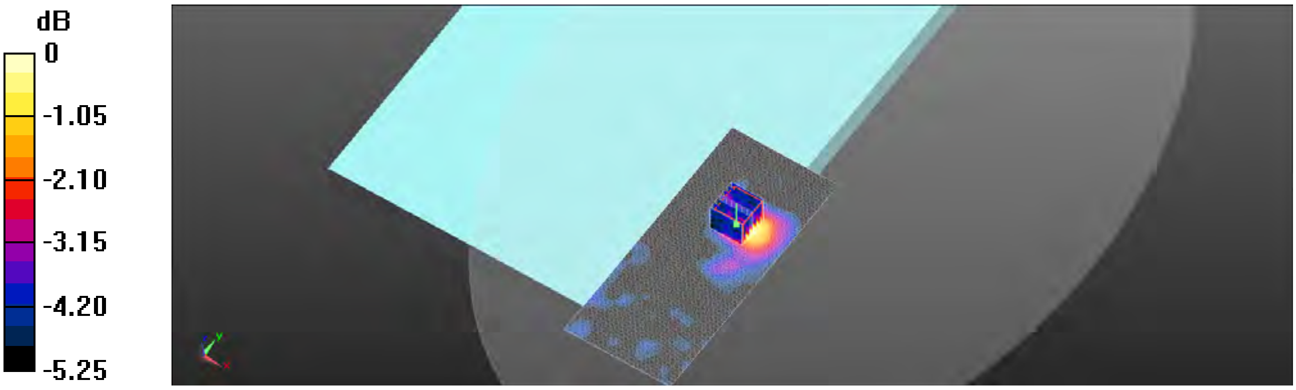
Communication System:, WLAN 5G; Frequency: 5200 MHz
Medium parameters used: f = 5200 MHz; σ = 5.164 S/m; ε_r = 48.46; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.83, 4.83, 4.83); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x191x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.554 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.107 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 0.968 W/kg
SAR(1 g) = 0.371 W/kg; SAR(10 g) = 0.259 W/kg
Maximum value of SAR (measured) = 0.536 W/kg



0 dB = 0.536 W/kg = -2.71 dBW/kg

WLAN802.11a 5.3G_Body_Lap-held_CH 60_Main

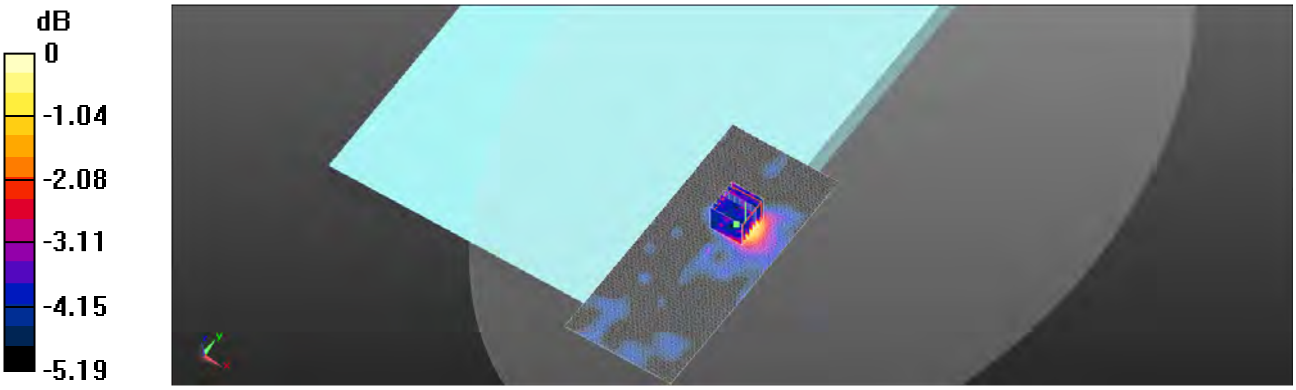
Communication System:, WLAN 5G; Frequency: 5300 MHz
Medium parameters used: f = 5300 MHz; σ = 5.331 S/m; ε_r = 48.192; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.66, 4.66, 4.66); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x191x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.551 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 4.084 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 1.60 W/kg
SAR(1 g) = 0.391 W/kg; SAR(10 g) = 0.268 W/kg
Maximum value of SAR (measured) = 0.539 W/kg



0 dB = 0.539 W/kg = -2.68 dBW/kg

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Date: 2014/7/22

WLAN802.11a 5.6G_Body_Lap-held_CH 132_Main

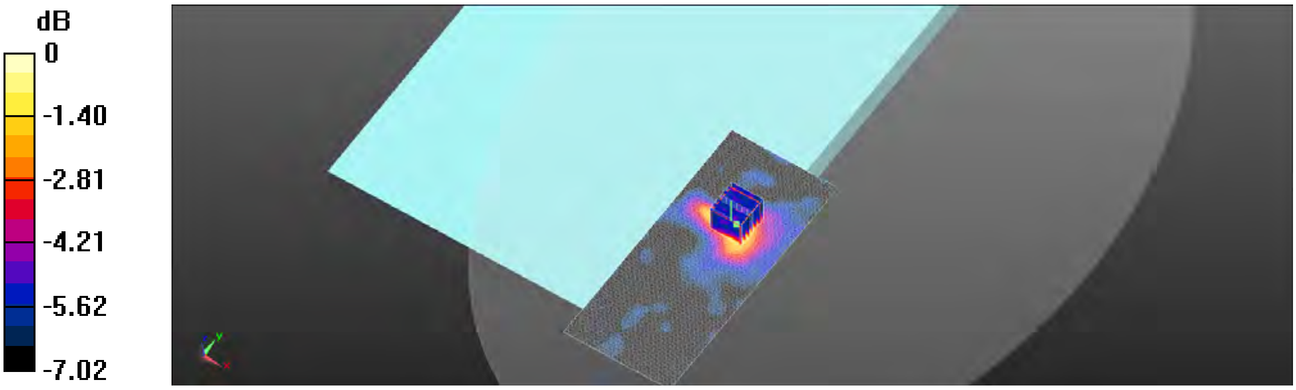
Communication System:, WLAN 5G; Frequency: 5660 MHz
Medium parameters used: f = 5660 MHz; σ = 5.879 S/m; ε_r = 47.27; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(3.98, 3.98, 3.98); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x191x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.03 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.760 V/m; Power Drift = 0.11 dB
Peak SAR (extrapolated) = 1.96 W/kg
SAR(1 g) = 0.690 W/kg; SAR(10 g) = 0.428 W/kg
Maximum value of SAR (measured) = 1.02 W/kg



0 dB = 1.02 W/kg = 0.09 dBW/kg

Date: 2014/7/22

WLAN802.11a 5.8G_Body_Lap-held_CH 157_Main

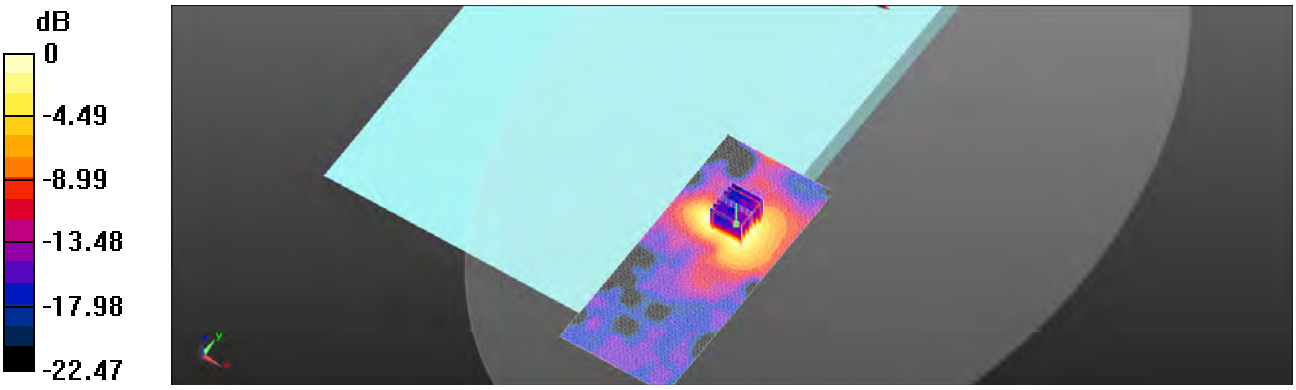
Communication System:, WLAN 5G; Frequency: 5785 MHz
Medium parameters used: f = 5785 MHz; σ = 6.025 S/m; ε_r = 46.966; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.22, 4.22, 4.22); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x191x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.911 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.2542 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 1.64 W/kg
SAR(1 g) = 0.431 W/kg; SAR(10 g) = 0.167 W/kg
Maximum value of SAR (measured) = 0.805 W/kg



0 dB = 0.805 W/kg = -0.94 dBW/kg

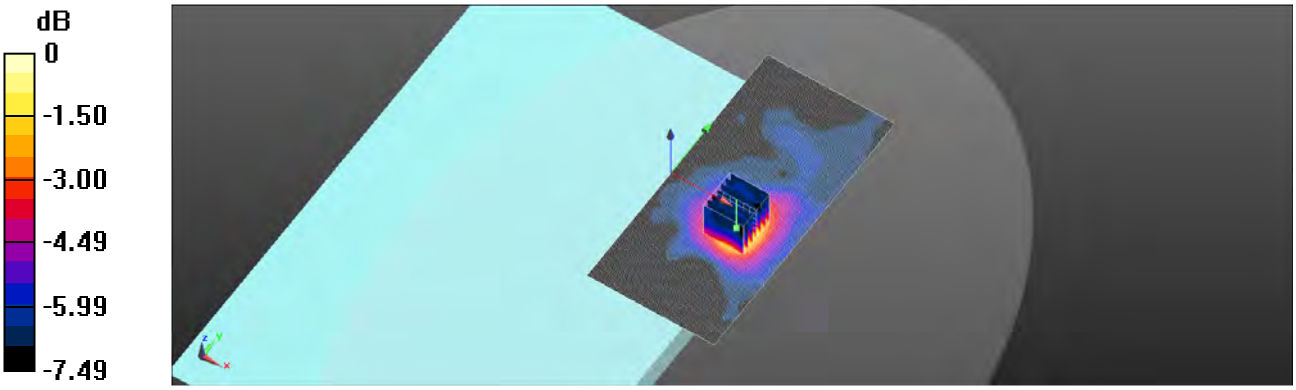
WLAN802.11b_Body_Lap-held_CH 11_Aux
Communication System:, WLAN 2.45G; Frequency: 2462 MHz
Medium parameters used: f = 2462 MHz; σ = 2.062 S/m; ε_r = 50.08; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(6.93, 6.93, 6.93); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x171x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.267 W/kg

Configuration/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 5.567 V/m; Power Drift = 0.18 dB
Peak SAR (extrapolated) = 0.352 W/kg
SAR(1 g) = 0.203 W/kg; SAR(10 g) = 0.129 W/kg
Maximum value of SAR (measured) = 0.271 W/kg



0 dB = 0.271 W/kg = -5.67 dBW/kg

Date: 2014/7/21

WLAN802.11a 5.2G_Body_Lap-held_CH 44_Aux

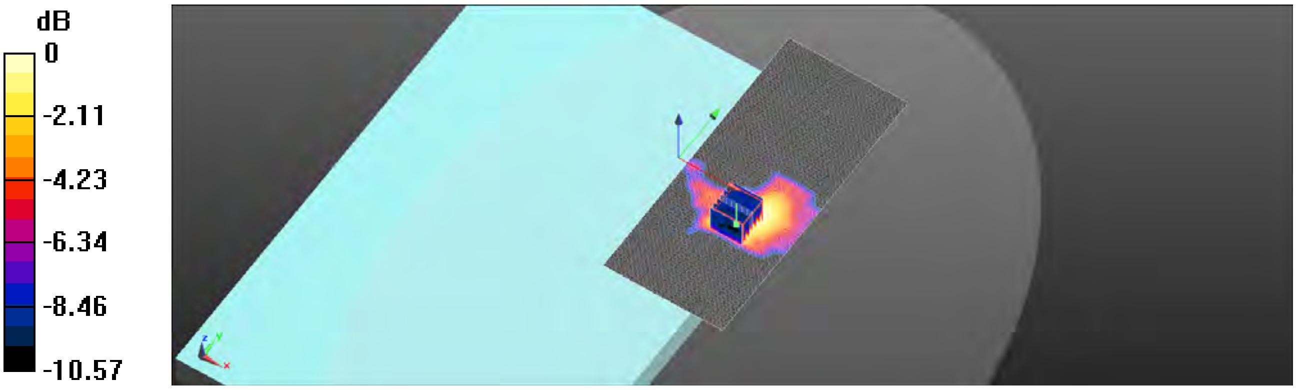
Communication System:, WLAN 5G; Frequency: 5220 MHz
Medium parameters used: f = 5220 MHz; σ = 5.198 S/m; ε_r = 48.395; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.83, 4.83, 4.83); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x211x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.264 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.262 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.546 W/kg
SAR(1 g) = 0.142 W/kg; SAR(10 g) = 0.071 W/kg
Maximum value of SAR (measured) = 0.235 W/kg



0 dB = 0.235 W/kg = -6.29 dBW/kg

Date: 2014/7/21

WLAN802.11a 5.3G_Body_Lap-held_CH 52_Aux

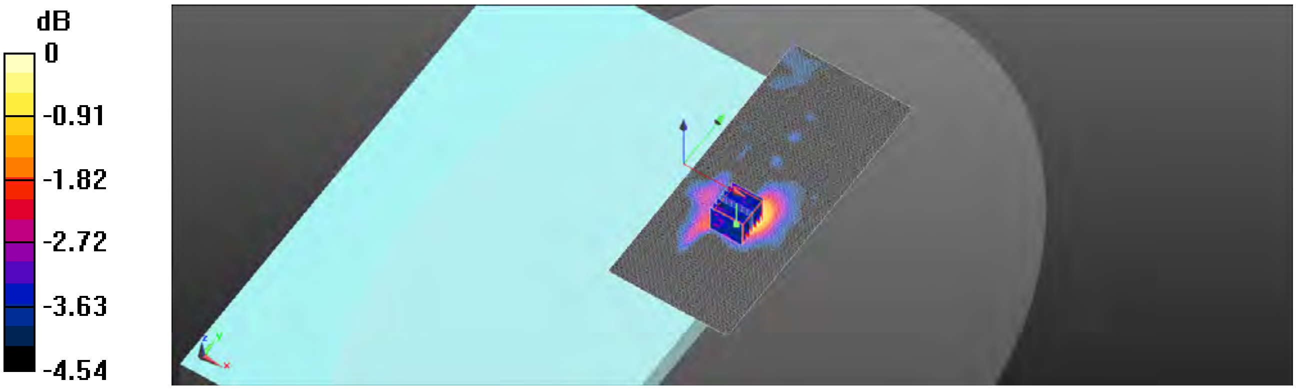
Communication System:, WLAN 5G; Frequency: 5260 MHz
Medium parameters used: f = 5260 MHz; σ = 5.275 S/m; ε_r = 48.294; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.66, 4.66, 4.66); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x211x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.493 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 3.950 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 1.16 W/kg
SAR(1 g) = 0.380 W/kg; SAR(10 g) = 0.275 W/kg
Maximum value of SAR (measured) = 0.530 W/kg



0 dB = 0.530 W/kg = -2.76 dBW/kg

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Date: 2014/7/22

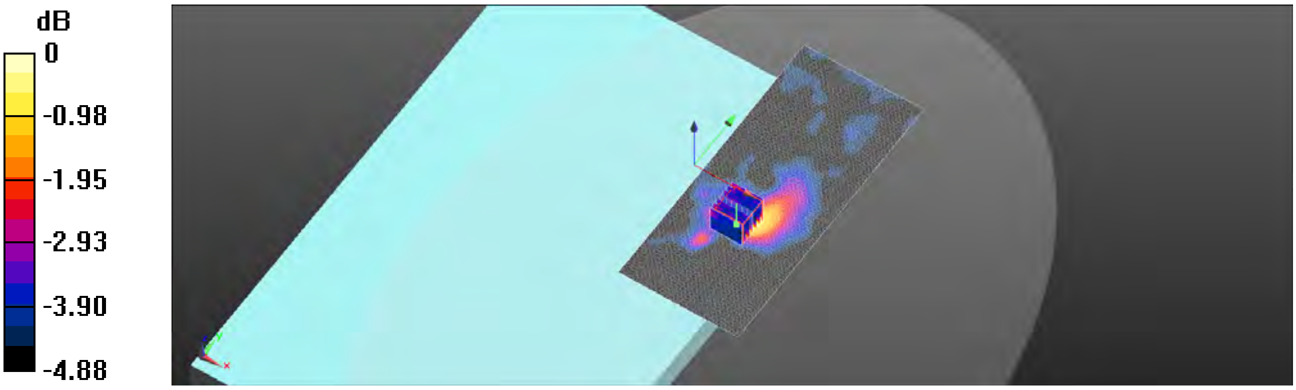
WLAN802.11a 5.6G_Body_Lap-held_CH 132_Aux
Communication System:, WLAN 5G; Frequency: 5660 MHz
Medium parameters used: f = 5660 MHz; σ = 5.879 S/m; ε_r = 47.27; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(3.98, 3.98, 3.98); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x211x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.738 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.515 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 1.65 W/kg
SAR(1 g) = 0.495 W/kg; SAR(10 g) = 0.356 W/kg
Maximum value of SAR (measured) = 0.723 W/kg



0 dB = 0.723 W/kg = -1.41 dBW/kg

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WLAN802.11a 5.8G_Body_Lap-held_CH 161_Aux

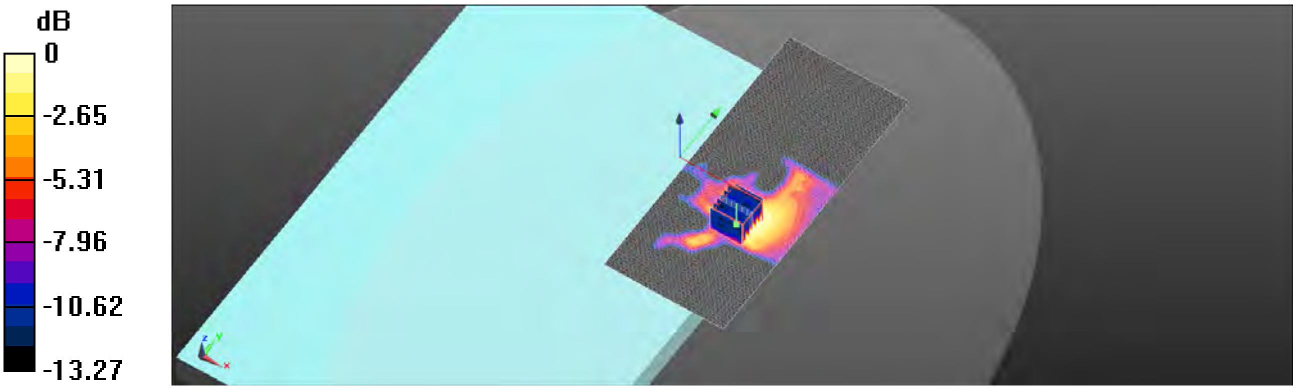
Communication System:, WLAN 5G; Frequency: 5805 MHz
Medium parameters used: f = 5805 MHz; σ = 6.049 S/m; ε_r = 46.918; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.22, 4.22, 4.22); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x211x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.497 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.123 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 0.984 W/kg
SAR(1 g) = 0.249 W/kg; SAR(10 g) = 0.109 W/kg
Maximum value of SAR (measured) = 0.460 W/kg



0 dB = 0.460 W/kg = -3.37 dBW/kg

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Date: 2014/7/18

WLAN802.11b_Body_Lap-held_CH 1_MIMO

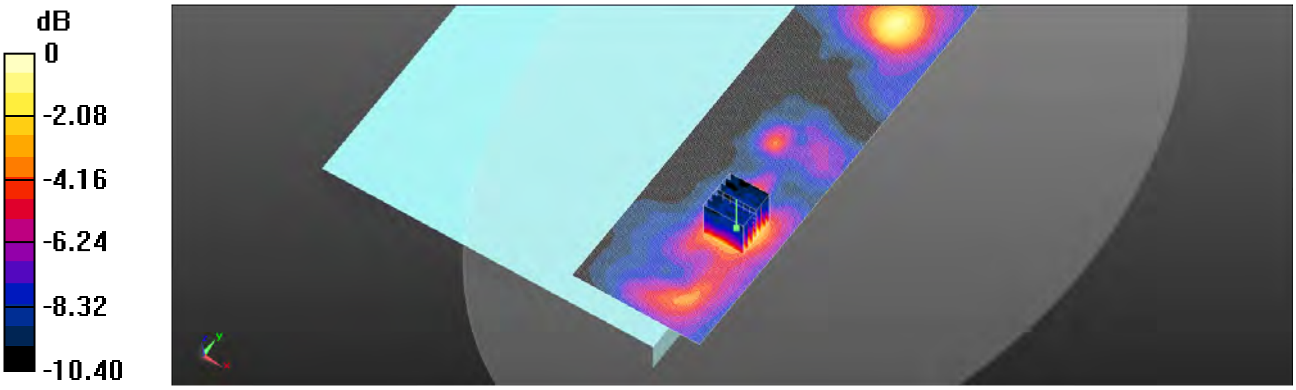
Communication System:, WLAN 2.45G; Frequency: 2412 MHz
Medium parameters used: f = 2412 MHz; σ = 1.991 S/m; ε_r = 50.258; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(6.93, 6.93, 6.93); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (81x301x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 0.472 W/kg

Configuration/Body/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 6.347 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 0.633 W/kg
SAR(1 g) = 0.332 W/kg; SAR(10 g) = 0.184 W/kg
Maximum value of SAR (measured) = 0.461 W/kg



0 dB = 0.461 W/kg = -3.36 dBW/kg

Date: 2014/7/21

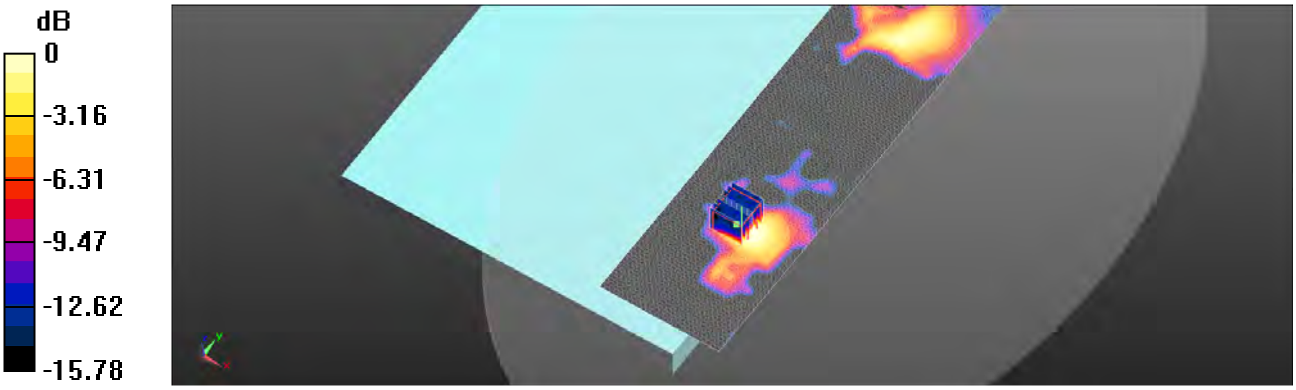
WLAN802.11a 5.2G_Body_Lap-held_CH 44_MIMO
Communication System:, WLAN 5G; Frequency: 5220 MHz
Medium parameters used: f = 5220 MHz; σ = 5.198 S/m; ε_r = 48.395; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.83, 4.83, 4.83); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x361x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.472 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 0.9090 V/m; Power Drift = 0.11 dB
Peak SAR (extrapolated) = 0.913 W/kg
SAR(1 g) = 0.254 W/kg; SAR(10 g) = 0.093 W/kg
Maximum value of SAR (measured) = 0.441 W/kg



0 dB = 0.441 W/kg = -3.56 dBW/kg

Date: 2014/7/21

WLAN802.11a 5.3G_Body_Lap-held_CH 52_MIMO

Communication System:, WLAN 5G; Frequency: 5260 MHz
Medium parameters used: f = 5260 MHz; σ = 5.275 S/m; ε_r = 48.294; ρ = 1000 kg/m^3
Phantom section: Flat Section

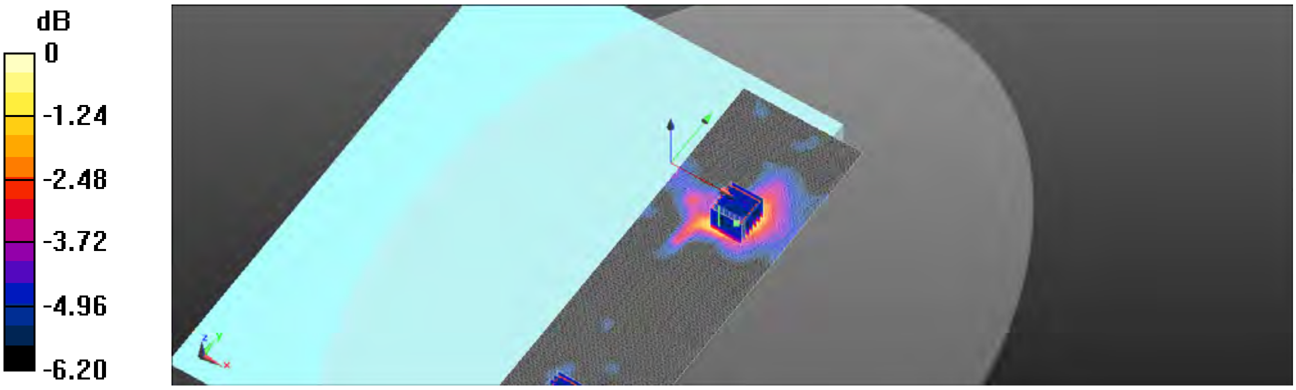
DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.66, 4.66, 4.66); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x361x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 0.723 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.268 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 1.54 W/kg
SAR(1 g) = 0.496 W/kg; SAR(10 g) = 0.323 W/kg
Maximum value of SAR (measured) = 0.724 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 1: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.268 V/m; Power Drift = 0.17 dB
Peak SAR (extrapolated) = 1.32 W/kg
SAR(1 g) = 0.483 W/kg; SAR(10 g) = 0.317 W/kg
Maximum value of SAR (measured) = 0.749 W/kg



0 dB = 0.749 W/kg = -1.26 dBW/kg

WLAN802.11a 5.6G_Body_Lap-held_CH 132_MIMO

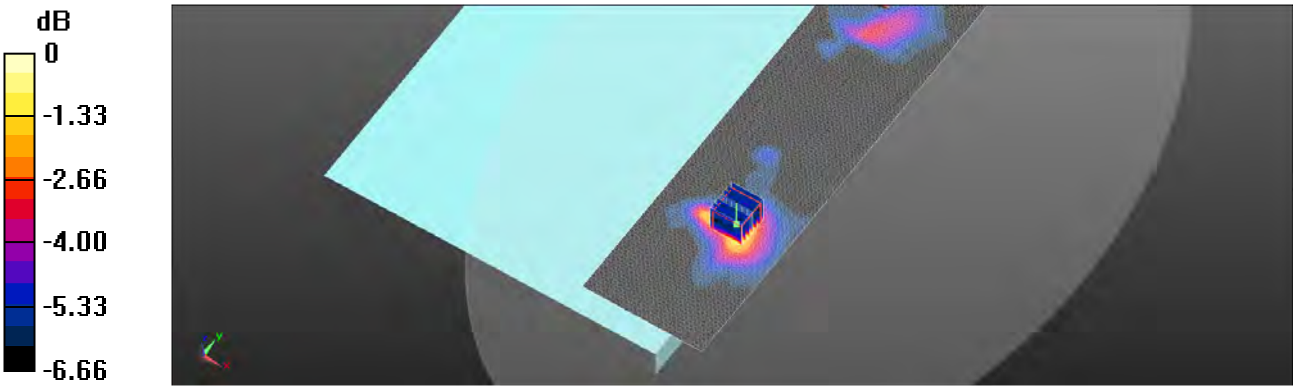
Communication System:, WLAN 5G; Frequency: 5660 MHz
Medium parameters used: f = 5660 MHz; σ = 5.879 S/m; ε_r = 47.27; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(3.98, 3.98, 3.98); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x361x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.18 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.591 V/m; Power Drift = 0.12 dB
Peak SAR (extrapolated) = 2.50 W/kg
SAR(1 g) = 0.748 W/kg; SAR(10 g) = 0.459 W/kg
Maximum value of SAR (measured) = 1.12 W/kg



0 dB = 1.12 W/kg = 0.49 dBW/kg

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Date: 2014/7/22

WLAN802.11a 5.8G_Body_Lap-held_CH 157_MIMO

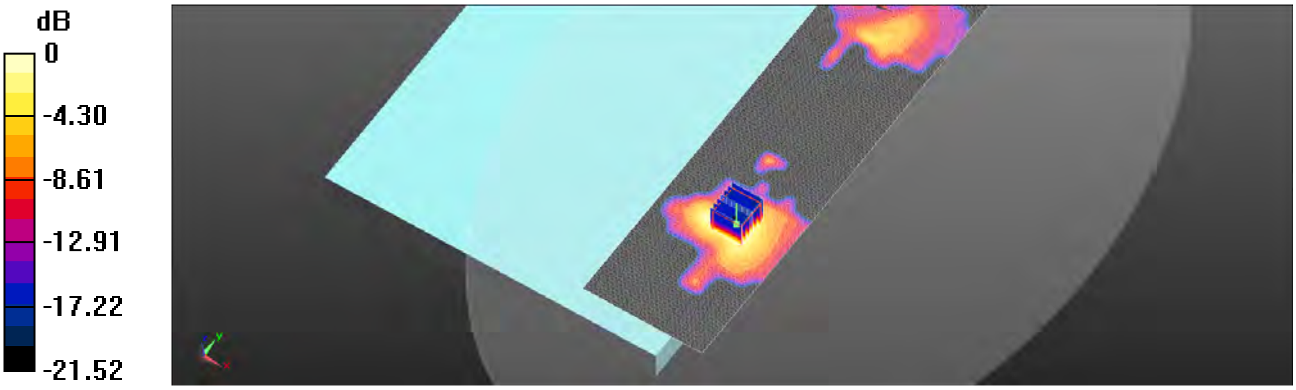
Communication System:, WLAN 5G; Frequency: 5785 MHz
Medium parameters used: f = 5785 MHz; σ = 6.025 S/m; ε_r = 46.966; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.22, 4.22, 4.22); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Body/Area Scan (91x361x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 1.30 W/kg

Configuration/Body/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 1.222 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 2.44 W/kg
SAR(1 g) = 0.610 W/kg; SAR(10 g) = 0.231 W/kg
Maximum value of SAR (measured) = 1.14 W/kg



0 dB = 1.14 W/kg = 0.57 dBW/kg

5. SAR System Performance Verification

Date: 2014/7/18

Dipole 2450 MHz_SN:727_Body

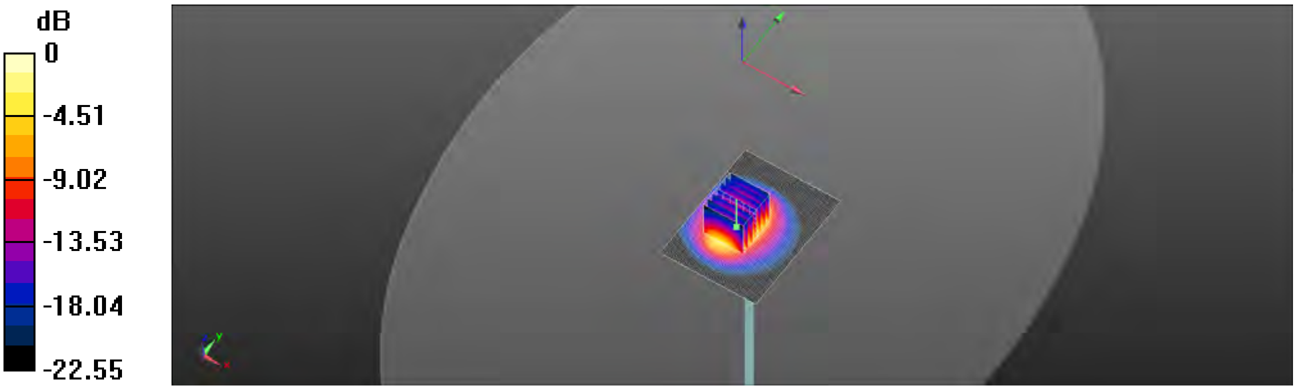
Communication System: CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.044 S/m; ε_r = 50.123; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(6.93, 6.93, 6.93); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Pin=250mW/Area Scan (61x81x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 23.6 W/kg

Configuration/Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 102.0 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 30.8 W/kg
SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.86 W/kg
Maximum value of SAR (measured) = 22.4 W/kg



0 dB = 22.4 W/kg = 13.50 dBW/kg

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Date: 2014/7/21

Dipole 5.2GHz_SN:1023_Body

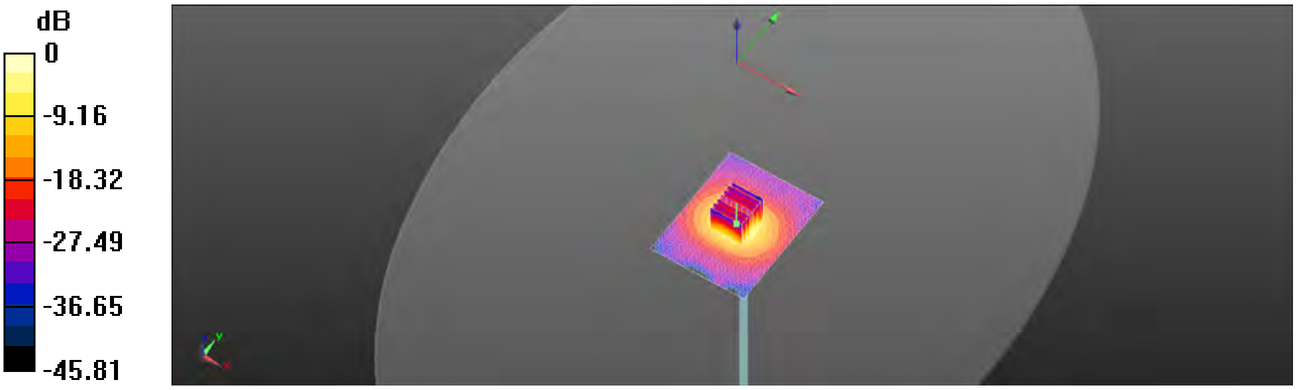
Communication System: CW; Frequency: 5200 MHz
Medium parameters used: f = 5200 MHz; σ = 5.164 S/m; ε_r = 48.46; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.83, 4.83, 4.83); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Pin=100mW/Area Scan (71x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 15.5 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 57.90 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 28.3 W/kg
SAR(1 g) = 7.51 W/kg; SAR(10 g) = 2.14 W/kg
Maximum value of SAR (measured) = 15.2 W/kg



0 dB = 15.2 W/kg = 11.82 dBW/kg

Date: 2014/7/21

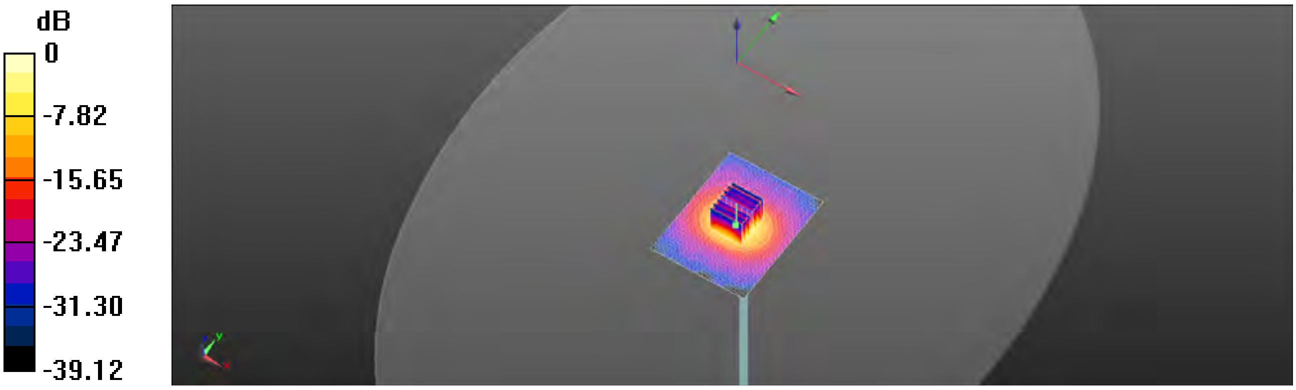
Dipole 5.3GHz_SN:1023_Body
Communication System: CW; Frequency: 5300 MHz
Medium parameters used: f = 5300 MHz; σ = 5.331 S/m; ε_r = 48.192; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.66, 4.66, 4.66); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Pin=100mW/Area Scan (71x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 16.1 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 58.02 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 29.9 W/kg
SAR(1 g) = 7.65 W/kg; SAR(10 g) = 2.16 W/kg
Maximum value of SAR (measured) = 15.8 W/kg



0 dB = 15.8 W/kg = 11.99 dBW/kg

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Dipole 5.6GHz_SN:1023_Body

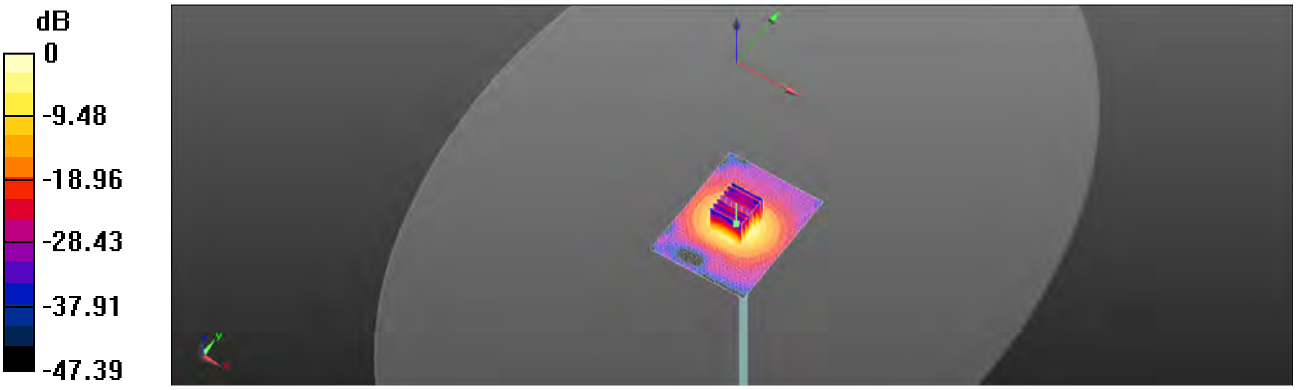
Communication System: CW; Frequency: 5600 MHz
Medium parameters used: f = 5600 MHz; σ = 5.789 S/m; ε_r = 47.429; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(3.98, 3.98, 3.98); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Pin=100mW/Area Scan (71x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 19.1 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 61.54 V/m; Power Drift = -0.19 dB
Peak SAR (extrapolated) = 31.8 W/kg
SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.27 W/kg
Maximum value of SAR (measured) = 17.0 W/kg



0 dB = 17.0 W/kg = 12.30 dBW/kg

Date: 2014/7/22

Dipole 5.8GHz_SN:1023_Body

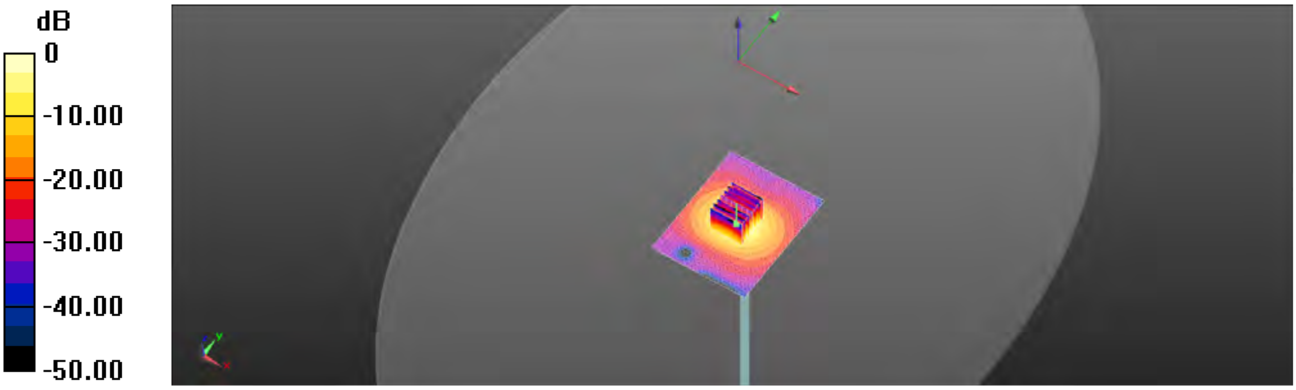
Communication System: CW; Frequency: 5800 MHz
Medium parameters used: f = 5800 MHz; σ = 6.041 S/m; ε_r = 46.936; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3848; ConvF(4.22, 4.22, 4.22); Calibrated: 2014/4/24;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1336; Calibrated: 2013/9/24
- Phantom: Body;
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Configuration/Pin=100mW/Area Scan (71x91x1): Interpolated grid: dx=10 mm, dy=10 mm
Maximum value of SAR (interpolated) = 17.2 W/kg

Configuration/Pin=100mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 57.66 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 31.3 W/kg
SAR(1 g) = 7.8 W/kg; SAR(10 g) = 2.11 W/kg
Maximum value of SAR (measured) = 16.5 W/kg



0 dB = 16.5 W/kg = 12.17 dBW/kg

6. DAE & Probe Calibration Certificate

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Client **SGS-TW (Auden)**

Certificate No: **DAE4-1336_Sep13**

CALIBRATION CERTIFICATE

Object: DAE4 - SD 000 D04 BM - SN: 1336

Calibration procedure(s): QA CAL-06.v26
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: September 24, 2013

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	02-Oct-12 (No:12728)	Oct-13
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-13 (in house check)	In house check: Jan-14
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-13 (in house check)	In house check: Jan-14

	Name	Function	Signature
Calibrated by:	R.Mayoraz	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: September 24, 2013

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Certificate No: DAE4-1336_Sep13 Page 1 of 5

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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	403.237 ± 0.02% (k=2)	403.535 ± 0.02% (k=2)	403.020 ± 0.02% (k=2)
Low Range	3.94960 ± 1.50% (k=2)	3.98537 ± 1.50% (k=2)	3.98528 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	122.0 ° ± 1 °

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Appendix

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199994.85	-1.00	-0.00
Channel X	+ Input	20000.28	0.26	0.00
Channel X	- Input	-20000.96	0.29	-0.00
Channel Y	+ Input	199996.21	0.09	0.00
Channel Y	+ Input	19997.62	-2.55	-0.01
Channel Y	- Input	-20001.68	-0.35	0.00
Channel Z	+ Input	199997.48	1.52	0.00
Channel Z	+ Input	19999.63	-0.39	-0.00
Channel Z	- Input	-20002.39	-0.92	0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.21	0.11	0.01
Channel X	+ Input	200.88	0.37	0.18
Channel X	- Input	-198.82	0.54	-0.27
Channel Y	+ Input	2000.00	-0.03	-0.00
Channel Y	+ Input	199.76	-0.69	-0.35
Channel Y	- Input	-200.27	-0.83	0.41
Channel Z	+ Input	2000.02	0.03	0.00
Channel Z	+ Input	199.72	-0.71	-0.36
Channel Z	- Input	-200.25	-0.80	0.40

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	6.37	4.62
	- 200	-3.40	-4.67
Channel Y	200	-3.98	-4.36
	- 200	2.07	2.00
Channel Z	200	22.00	21.75
	- 200	-23.78	-23.80

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	-	5.20	-1.05
Channel Y	200	8.91	-	7.14
Channel Z	200	9.03	6.60	-

Certificate No: DAE4-1336_Sep13 Page 4 of 5

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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	15652	15053
Channel Y	15907	15561
Channel Z	15891	15503

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	0.97	0.18	1.87	0.34
Channel Y	0.06	-1.23	0.94	0.40
Channel Z	1.25	0.46	2.02	0.34

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 108**

Client **SGS-TW (Auden)**

Certificate No: **EX3-3848_Apr14**

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3848

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: April 24, 2014

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 E4419B	GB41293874	03-Apr-14 (No. 217-01911)	Apr-15
Power sensor E4412A	MY41498087	03-Apr-14 (No. 217-01911)	Apr-15
Reference 3 dB Attenuator	SN: S5054 (3c)	03-Apr-14 (No. 217-01915)	Apr-15
Reference 20 dB Attenuator	SN: S5277 (20x)	03-Apr-14 (No. 217-01919)	Apr-15
Reference 30 dB Attenuator	SN: S5129 (30b)	03-Apr-14 (No. 217-01920)	Apr-15
Reference Probe ES3DV2	SN: 3013	30-Dec-13 (No. ES3-3013_Dec13)	Dec-14
DAE4	SN: 660	13-Dec-13 (No. DAE4-660_Dec13)	Dec-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

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

Issued: April 24, 2014

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Certificate No: EX3-3848_Apr14 Page 1 of 11

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Accreditation No.: **SCS 108**

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, "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

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).

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Probe EX3DV4

SN:3848

Manufactured: October 25, 2011
Calibrated: April 24, 2014

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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3848

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (µV/(V/m)^2)[A]	0.41	0.41	0.45	± 10.1 %
DCP (mV)[B]	98.6	97.4	97.6	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√µV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	141.5	±3.0 %
		Y	0.0	0.0	1.0		143.4	
		Z	0.0	0.0	1.0		127.9	

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 NormX,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:3848

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)	Unct. (k=2)
750	41.9	0.89	9.57	9.57	9.57	0.65	0.67	± 12.0 %
835	41.5	0.90	9.19	9.19	9.19	0.46	0.79	± 12.0 %
900	41.5	0.97	8.98	8.98	8.98	0.25	1.08	± 12.0 %
1450	40.5	1.20	8.10	8.10	8.10	0.62	0.73	± 12.0 %
1750	40.1	1.37	7.91	7.91	7.91	0.80	0.58	± 12.0 %
1900	40.0	1.40	7.65	7.65	7.65	0.59	0.67	± 12.0 %
2000	40.0	1.40	7.68	7.68	7.68	0.43	0.79	± 12.0 %
2450	39.2	1.80	6.91	6.91	6.91	0.43	0.76	± 12.0 %
2600	39.0	1.96	6.71	6.71	6.71	0.34	0.94	± 12.0 %
5200	36.0	4.66	5.35	5.35	5.35	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.14	5.14	5.14	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.53	4.53	4.53	0.35	1.80	± 13.1 %
5800	35.3	5.27	4.78	4.78	4.78	0.40	1.80	± 13.1 %

[C] Frequency validity 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.
[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:3848

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)	Unct. (k=2)
750	55.5	0.96	9.45	9.45	9.45	0.46	0.83	± 12.0 %
835	55.2	0.97	9.29	9.29	9.29	0.47	0.79	± 12.0 %
900	55.0	1.05	9.13	9.13	9.13	0.43	0.83	± 12.0 %
1450	54.0	1.30	7.82	7.82	7.82	0.43	0.81	± 12.0 %
1750	53.4	1.49	7.58	7.58	7.58	0.53	0.76	± 12.0 %
1900	53.3	1.52	7.29	7.29	7.29	0.34	0.98	± 12.0 %
2000	53.3	1.52	7.46	7.46	7.46	0.52	0.76	± 12.0 %
2450	52.7	1.95	6.93	6.93	6.93	0.80	0.56	± 12.0 %
2600	52.5	2.16	6.70	6.70	6.70	0.76	0.58	± 12.0 %
5200	49.0	5.30	4.83	4.83	4.83	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.66	4.66	4.66	0.40	1.90	± 13.1 %
5600	48.5	5.77	3.98	3.98	3.98	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.22	4.22	4.22	0.50	1.90	± 13.1 %

[C] Frequency validity 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.
[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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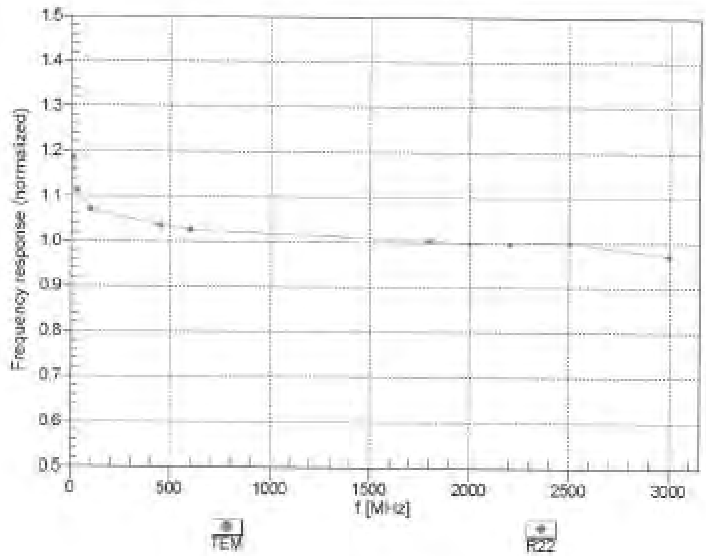
EX3DV4 – SN:3848 April 24, 2014

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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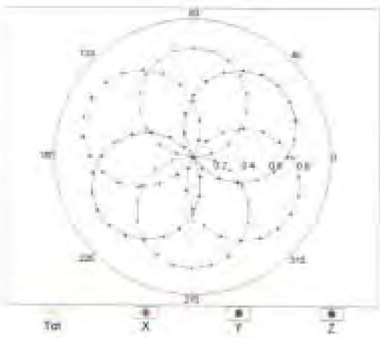
EX3DV4– SN:3848

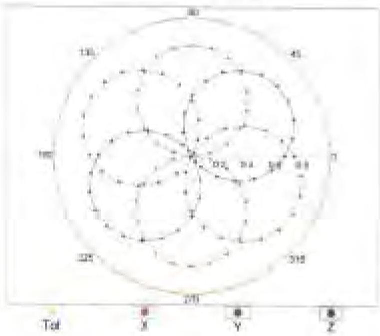
April 24, 2014

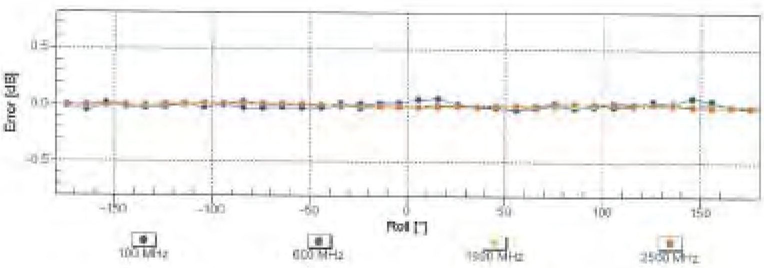
Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM



f=1800 MHz,R22





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

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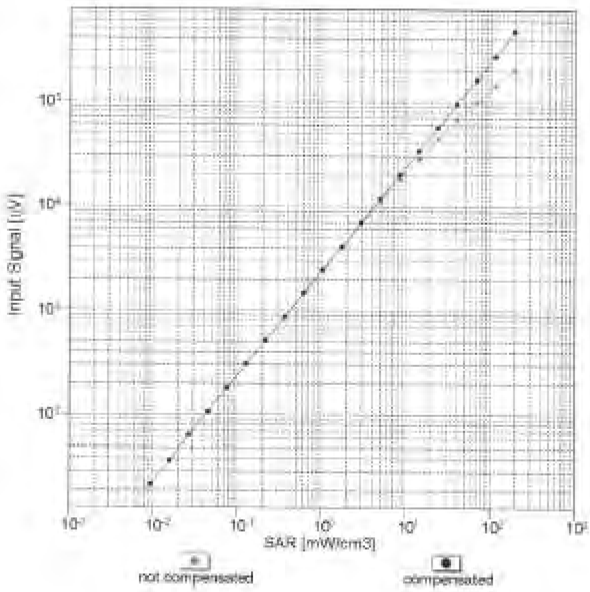
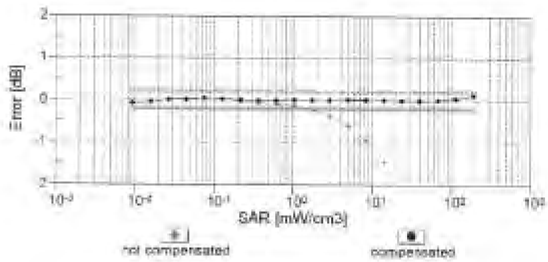
Dynamic Range f(SAR$_{head}$)

(TEM cell , f_{eval}= 1900 MHz)





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

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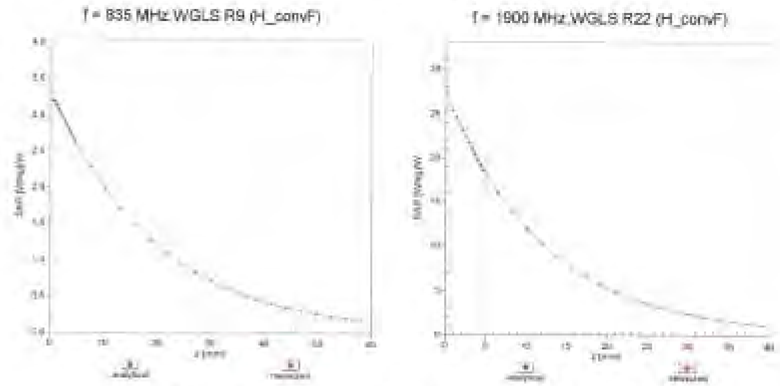
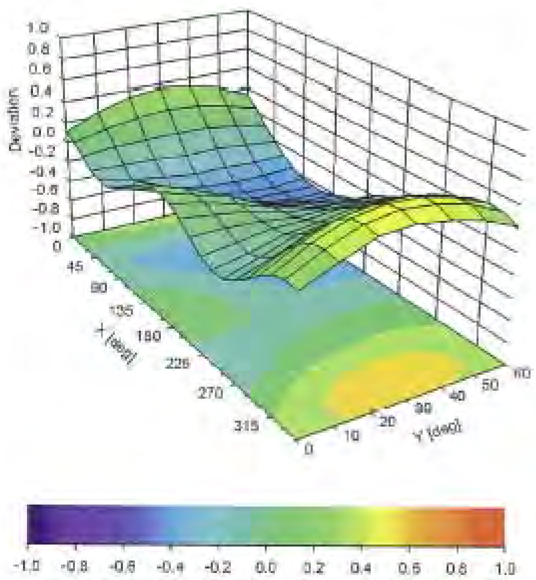
Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

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EX3DV4– SN:3848 April 24, 2014

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3848

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-54.3
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	2 mm

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7. Uncertainty Budget

Measurement Uncertainty evaluation template for DUT SAR test
IEEE 1528

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributioi	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%	∞
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%	∞
Deviation from reference liquid target ε 'r(Body)	4.94%	N	1	1	0.64	0.43	3.16%	2.12%	M
Deviation from reference liquid target σ (Body)	4.83%	N	1	1	0.6	0.49	2.90%	2.37%	M
Combined standard uncertainty		RSS					12.34%	12.00%	
Expant uncertainty (95% confidence interval), K=2							24.68%	24.00%	

8. Phantom Description

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info@speag.com, http://www.speag.com

Certificate of Conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 C
Series No	TP-1150 and higher
Manufacturer	SPEAG Zeughausstrasse 43 CH-8004 Zürich Switzerland

Tests

The series production process used allows the limitation to test of first articles.
Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series items (called samples) or are tested at each item.

Test	Requirement	Details	Units tested
Dimensions	Compliant with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness of shell	Compliant with the requirements according to the standards	2mm +/- 0.2mm in flat and specific areas of head section	First article, Samples, TP-1314 ff.
Material thickness at ERP	Compliant with the requirements according to the standards	6mm +/- 0.2mm at ERP	First article, All items
Material parameters	Dielectric parameters for required frequencies	300 MHz – 6 GHz: Relative permittivity < 5, Loss tangent < 0.05	Material samples
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions. Observe technical Note for material compatibility.	DEGMBE based simulating liquids	Pre-series, First article, Material samples
Sagging	Compliant with the requirements according to the standards. Sagging of the flat section when filled with tissue simulating liquid.	< 1% typical < 0.8% if filled with 155mm of HSL900 and without DUT below	Prototypes, Sample testing

Standards

[1] CENELEC EN 50361
[2] IEEE Std 1528-2003
[3] IEC 62209 Part I
[4] FCC OET Bulletin 65, Supplement C, Edition 01-01
(*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of the other documents.

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standards [1] to [4].

Date 07.07.2005

Signature / Stamp s p e a g — Schmid & Partner Engineering AG, Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 9700, Fax +41 1 245 9779, info@speag.com, http://www.speag.com

Doc No 881 – QD 000 P40 C – F   Page 1 (1)

9. 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 108**

Client **SGS-TW (Auden)**

Certificate No: **D2450V2-727_Apr14**

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 23, 2014

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 EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

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

Issued: April 23, 2014

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

Certificate No: D2450V2-727_Apr14 Page 1 of 8

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 108**

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) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

d) 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	V52.8.7
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	38.2 ± 6 %	1.81 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	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.0 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.2 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	50.6 ± 6 %	2.01 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	12.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.0 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.90 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.3 W/kg ± 16.5 % (k=2)**

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Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.6 Ω + 1.9 jΩ
Return Loss	- 26.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.1 Ω + 3.5 jΩ
Return Loss	- 28.7 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: 23.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

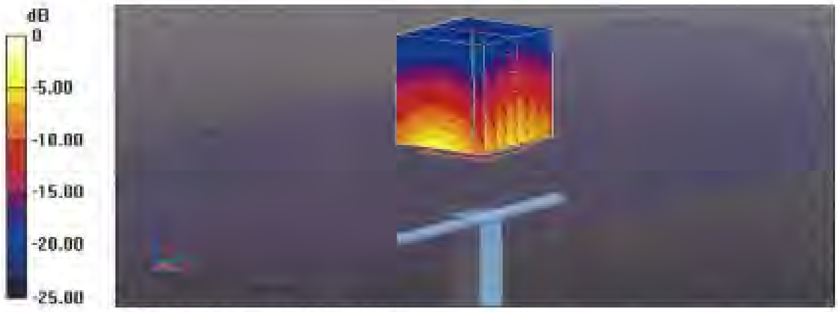
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 727

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.81 S/m; ε_r = 38.2; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 100.01 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 27.0 W/kg
SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.09 W/kg
Maximum value of SAR (measured) = 17.1 W/kg



0 dB = 17.1 W/kg = 12.33 dBW/kg

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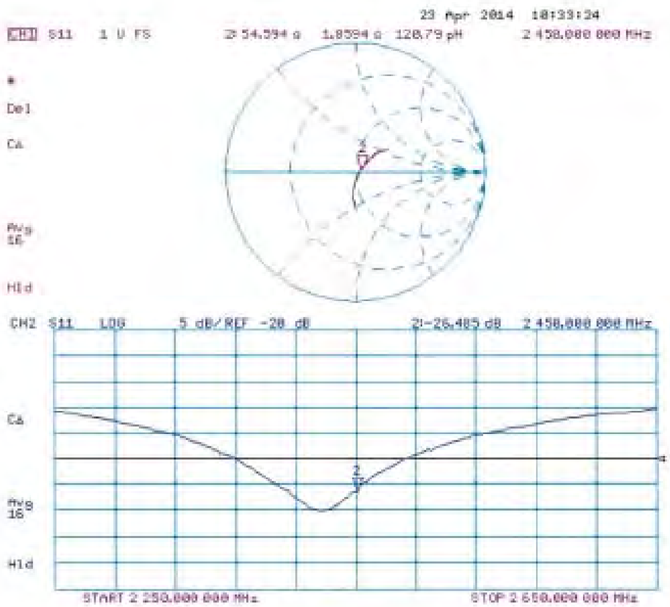
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 23.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

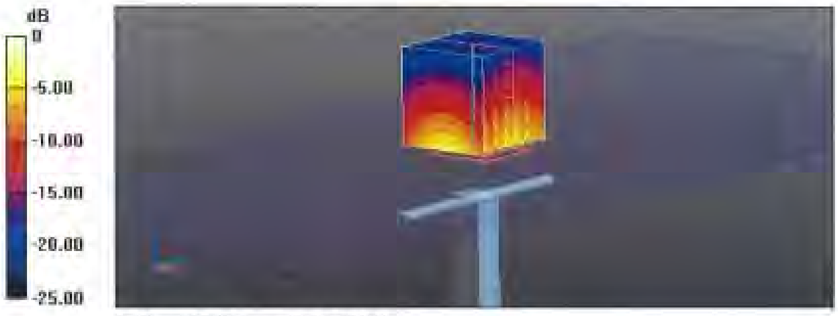
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 727

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.01 S/m; ε_r = 50.6; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 94.356 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 26.9 W/kg
SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.9 W/kg
Maximum value of SAR (measured) = 16.7 W/kg



0 dB = 16.7 W/kg = 12.23 dBW/kg

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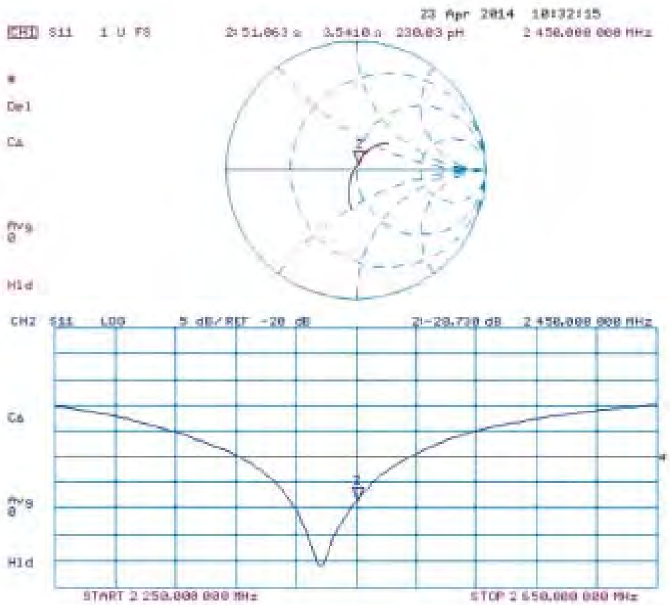
Impedance Measurement Plot for Body TSL



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **SGS-TW (Auden)**

Certificate No: **D5GHzV2-1023_Jan14**

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 30, 2014

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 EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe EX3DV4	SN: 3503	30-Dec-13 (No. EX3-3503_Dec13)	Dec-14
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

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

Issued: January 31, 2014

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

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Accreditation No.: **SCS 108**

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) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
c) 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

Additional Documentation:

d) 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%.

Measurement Conditions

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

DASY Version	DASY5	V52.8.7
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	37.2 ± 6 %	4.54 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.67 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.2 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.1 W/kg ± 19.5 % (k=2)**

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	37.0 ± 6 %	4.65 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.6 W / kg ± 19.9 % (k=2)**

SAR averaged over 10 cm³ (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	**23.4 W/kg ± 19.5 % (k=2)**

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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	36.6 ± 6 %	4.96 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	8.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.2 W/kg ± 19.5 % (k=2)**

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	36.3 ± 6 %	5.18 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	7.77 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.1 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	47.8 ± 6 %	5.40 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	7.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.6 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.5 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	47.6 ± 6 %	5.53 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	7.62 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**75.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.2 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	47.1 ± 6 %	5.93 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	8.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**80.0 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.2 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	46.8 ± 6 %	6.21 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	7.44 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	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.4 W/kg ± 19.5 % (k=2)**

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Appendix

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	49.9 Ω - 7.7 jΩ
Return Loss	- 22.3 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.2 Ω - 4.0 jΩ
Return Loss	- 27.6 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.8 Ω - 2.5 jΩ
Return Loss	- 27.1 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.5 Ω + 0.5 jΩ
Return Loss	- 24.3 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	50.0 Ω - 6.1 jΩ
Return Loss	- 24.3 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	51.3 Ω - 1.9 jΩ
Return Loss	- 32.7 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	54.3 Ω - 0.4 jΩ
Return Loss	- 27.6 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	57.1 Ω + 3.3 jΩ
Return Loss	- 22.7 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: 30.01.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.54 S/m; ε_r = 37.2; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 4.65 S/m; ε_r = 37; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 4.96 S/m; ε_r = 36.6; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 5.18 S/m; ε_r = 36.3; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.52, 5.52, 5.52); Calibrated: 30.12.2013, ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2013, ConvF(4.86, 4.86, 4.86); Calibrated: 30.12.2013, ConvF(4.91, 4.91, 4.91); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 62.583 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 28.2 W/kg
SAR(1 g) = 7.67 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 18.2 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 = 63.619 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 30.8 W/kg
SAR(1 g) = 8.14 W/kg; SAR(10 g) = 2.32 W/kg
Maximum value of SAR (measured) = 19.4 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 = 61.852 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 32.3 W/kg
SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.3 W/kg
Maximum value of SAR (measured) = 19.7 W/kg

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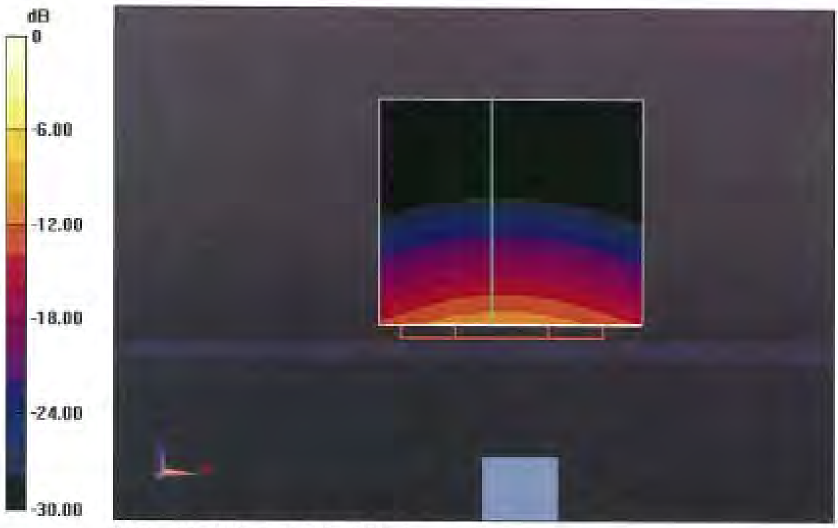
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 59.398 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 32.6 W/kg
SAR(1 g) = 7.77 W/kg; SAR(10 g) = 2.2 W/kg
Maximum value of SAR (measured) = 19.2 W/kg



0 dB = 19.2 W/kg = 12.83 dBW/kg

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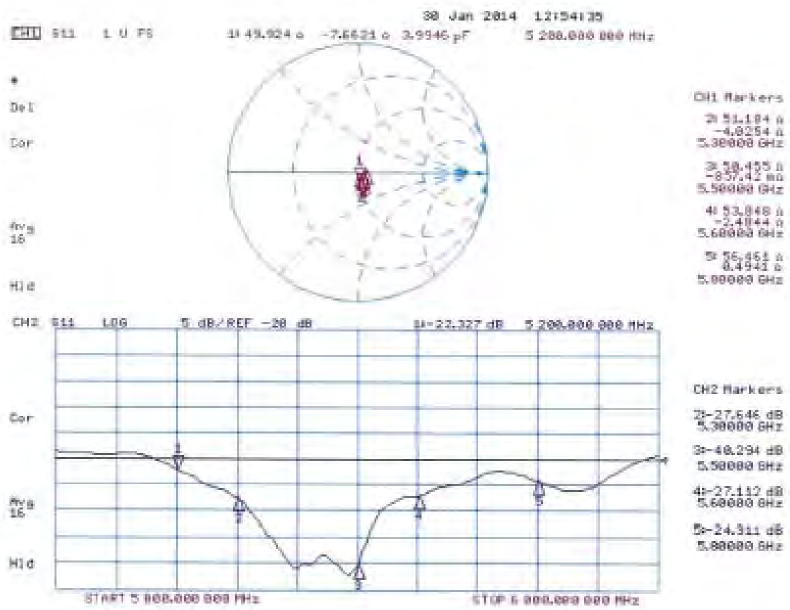
Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 29.01.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.4 S/m; ε_r = 47.8; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 5.53 S/m; ε_r = 47.6; ρ = 1000 kg/m^3, Medium parameters used: f = 5600 MHz; σ = 5.93 S/m; ε_r = 47.1; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 6.21 S/m; ε_r = 46.8; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2013, ConvF(4.3, 4.3, 4.3); Calibrated: 30.12.2013, ConvF(4.47, 4.47, 4.47); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 57.977 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 29.2 W/kg
SAR(1 g) = 7.39 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=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 58.404 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 30.9 W/kg
SAR(1 g) = 7.62 W/kg; SAR(10 g) = 2.13 W/kg
Maximum value of SAR (measured) = 18.5 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 = 58.115 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 35.7 W/kg
SAR(1 g) = 8.04 W/kg; SAR(10 g) = 2.23 W/kg
Maximum value of SAR (measured) = 20.0 W/kg

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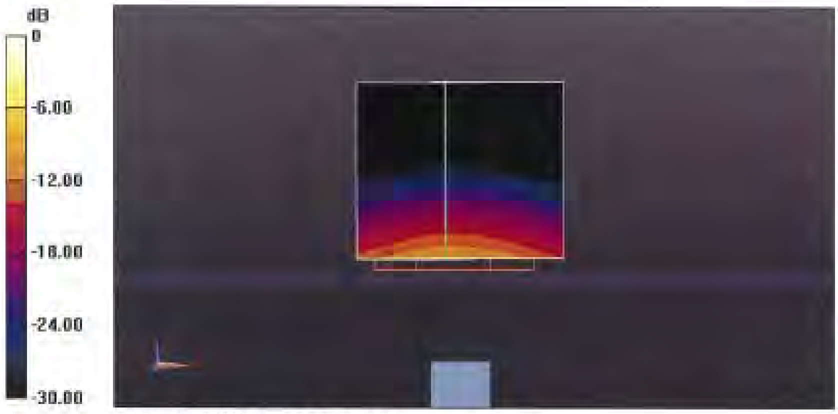
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 54.877 V/m; Power Drift = 0.00 dB
Peak SAR (extrapolated) = 34.9 W/kg
SAR(1 g) = 7.44 W/kg; SAR(10 g) = 2.05 W/kg
Maximum value of SAR (measured) = 19.0 W/kg



0 dB = 19.0 W/kg = 12.79 dBW/kg

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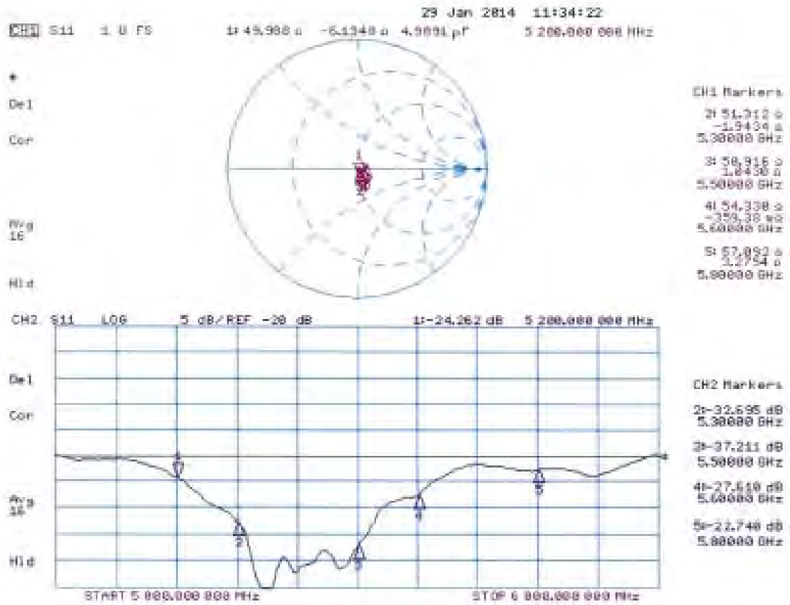
Impedance Measurement Plot for Body TSL



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- End of 1st part of report -

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