SAR Evaluation Report

APPLICANT	**: SAMSUNG MEDISON CO., LTD.**
FCC ID	**: 2ADCFWLM720B**
IC	**: 12432A-WLM720B**
Product Type	**: WiFi Module**
Brand Name	**: SAMSUNG**
Model	**: WLM720B**
Tested According to	**: FCC Part 2(Section 2.1093) / OET Bulletin 65 Supplement C**
Tested Period	**: November. 13. 2014 to November 25. 2014**

June 8. 2015

Tested by: Seungyong Shin
Engineer

Deokha Ryu June 8. 2015

Verified by: Deokha Ryu
Technical Manager

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Contents of This Report

1. General Information

1.1 Applicant

Company Name:	SAMSUNG MEDISON CO., LTD.
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Contact Name:	Hyungwook. Lee

1.2 Manufacturer

Company Name:	SAMSUNG MEDISON CO., LTD.
Company Address:	42, Teheran-ro 108-gil, Gangnam-gu, Seoul, Korea
Phone/e-mail:	+82-2-2194-1053 / +82-2-556-3974
Contact Name:	Hyungwook. Lee

1.3 Other Information

- No Comment

2. Equipment Under Test (EUT)

2.1. Identification of EUT

Category	WiFi module
Category(host)	Transducer
Model Name	WLM720B
Model Name(host)	L3-12W
Brand Name	SAMSUNG
Frequency of Operation	2412 MHz ~ 2462 MHz
RF Conducted Powers (IEEE 802.11b Average Power)	802.11b : 14.55 dBm 802.11g : 13.26 dBm 802.11n(20 MHz) : 13.94 dBm 802.11n(40 MHz) : 11.42 dBm
Channels	11 ch
Antenna Gain (peak)	Ant 1 / Ant 2: 3.29 dBi
Modulation type:	CCK, BPSK, QPSK, 16QAM, 64QAM
Temperature Range:	-10 ℃ ~ +45 ℃
Voltage:	3.3 Vdc
Size (W x H)	(22 mm x 20 mm)
Weight	(About 2 g)
Remarks	-

2.2. Description of change

● No Comment

2.3. Modifications

● No Comment

2.4. Additional Information Related to Testing

- EUT is the module transceiver supporting the 802.11b/g mode(1TX/1RX) and 802.11n mode(2TX/2RX).
- SAR testing was performed with a host device (L3-12W) manufactured by Samsung Medison Co., Ltd.
- According to KDB248227 D01v01, SAR is not required for 802.11g/HT20/HT40 channel when the maximum average output power is highter than that measured on the corresponding 802.11b channels but increase less than 1/4 dB.

2.5. Applied Standard

The Specific Absorption Rate(SAR)testing specification, method, and procedure for this device is in Accordance with the following standards:

- FCC 47 CFR Part 2(2.1093)
- OET Bulletin 65 Supplement C
- RSS-102 Issue 5
- IEEE 1528-2013
- IEC 62209:2010
- FCC KDB Publication 447498 D01 v05r02
- FCC KDB Publication 248227 D01 v02r01
- FCC KDB Publication 865664 D01 v01r03
- FCC KDB Publication 865664 D02 v01r01

3. General Test Conditions

3.1 Location

Nemko Korea
155 & 159, Osan-Ro, Mohyeon-Myeon, Cheoin-Gu, Yongin-Si, Gyeonggi-Do, Korea
Phone : 82-31-330-1700 Fax : 82-31-322-2332

3.2 Operating Environment

Parameters	Recording during test	Accepted deviation
Ambient temperature	(21.8 ~ 23.1) ℃	(20 ~ 26) ℃
Relative Humidity	(45 ~ 47) %	(30 ~ 70) %

3.3. Test Frequency

Channel	Frequency (MHz)
Low	2412
Middle	2437
High	2462

3.4 Support Equipment

Equipment	Manufacturer	Model Name	Serial Number
Laptop Computer	HP	G62-355TU	CNF0489WDT
Laptop Computer	MSI	MS-1738	N/A

3.4. Maximum Target power among production units

IEEE 802.11 average power(dBm)					
Normal					
Mode/Band	a	b	g	n-HT20	n-GH-40
WLAN 2.4 GHz		16.5	15.2	15.9	13.5
5 GHz Band 1 WIFI					
5 GHz Band 4 WIFI					

4. Description of Test Equipment

4.1 SAR Measurement Setup

Robotic System

Measurements are performed using the DASY4 automated dosimetric assessment system. Which is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Stäubli), robot controller, measurement server, H/P computer, nearfield probe, probe alignment sensor, and the SAM twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 4.1).

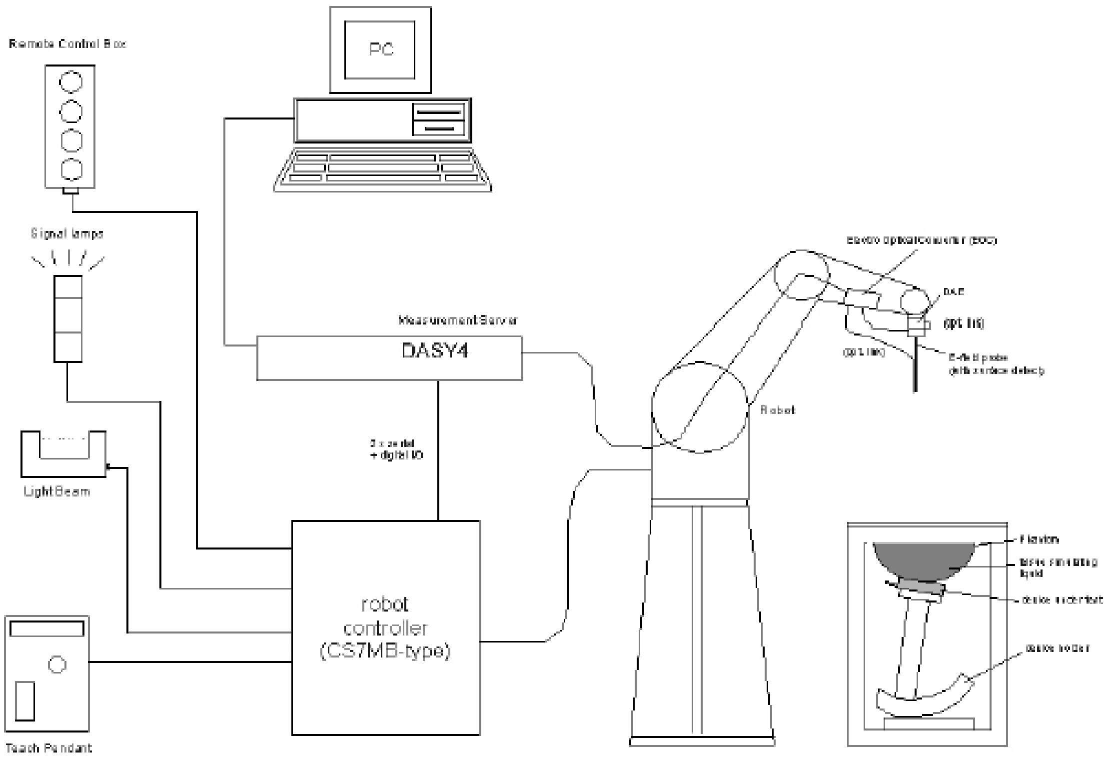


Figure 4.1 SAR Measurement System Setup

System Hardware

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and a remote control is used to drive the robot motors. The PC consists of the H/P computer with Windows XP system and SAR Measurement Software DASY4, LCD monitor, mouse and keyboard. The Stäubli Robot is connected to the cell controller to allow software manipulation of the robot.
A Data Acquisition Electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc.
Is connected to the Electro-Optical Coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the measurement server.

System Electronics

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with autozeroing, a channel and gain-switching multiplexer, a fast 16-bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer.

4.2 E-field Probe

The SAR measurement were conducted with the dosimetric probe designed in the classical triangular configuration (see Fig.4.3) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates.

The probe is equipped with an optical multi-fiber line ending at the front of the probe tip (see Fig.4.4). It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface.

Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches a System maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY4 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting (see Fig.4.2). The approach is stopped at reaching the maximum.

Figure 4.2 DAE System

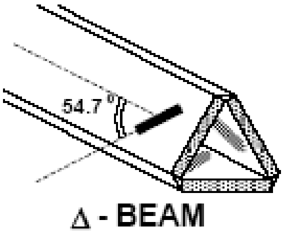


Figure 4.3 Triangular Probe Configuration

Figure 4.4 Probe Thick-Film Technique

Probe Specifications

Manufacturer : SPEAG

model name: EX3DV4

Serial number : 3910

Probe spec : refer to the Appendix

Probe calibration : September 29, 2014

4.3 SAM Phantom

The SAM Twin Phantom V4.0C is constructed of a fiberglass shell Integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users.
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 the 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 in the robot.
(See Figure 4.5)

Figure 4.5 SAM Twin Phantom

2 GHz(Body) Tissue Simulating Liquid, Depth: 150 mm

Phantom Specification

Construction : The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528-2013, OET65 supplement C. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.

Shell Thickness : 2 ± 0.2 mm
Filling Volume : Approx. 25 liters
Dimensions : Height; 830 mm; Length: 1000 mm; Width: 500 mm

4.4 Simulating Mixture Characterization

The brain mixture consists of a viscous gel using hydroxethyl-cellullose (HEC) gelling agent and saline solution(see Table 4.1). Preservation with a bacteriacide is added and visual inspection is made to make sure air Bubbles are not trapped during the mixing process.
The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 have been incorporated in the following table.

Table 4.1 Composition of the Brain Tissue Equivalent Matter

INGREDIENTS	SIMULATING TISSUE
	2450 MHz Body
De-ionised water	73.3 %
DGBE	26.7 %
Salt	0.0 %
Sum	100 %

4.5 Device Holder for Transmitters

In combination with the SAM Twin Phantom V4.0, the Mounting Device (see Fig. 4.6) enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening.
The device holder can be locked at different phantom locations (left head, right head, flat phantom).
* Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations .
To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

Figure 4.6 Device Holder

5. SAR Measurement Procedure

EUT at the maximum power level is placed by a non metallic device holder in the above described positions at a shell phantom of a human being.
The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom.
For this miniaturized field probes with high sensitivity and low field disturbance are used.
Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density *p* of the tissue in the SEMCAD software.
The software is able to determine the averaged SAR values (averaging region 1g or 10g) for compliance testing.

The measurements are done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the averaged SAR is measured in a second scan within the sharp of a cube. The measurement times takes about 20 minutes.

The following steps are used for each test position:

STEP 1
Establish a call with the maximum output power with a base station simulator.
The connection between the mobile phone and the base station simulator is established via air interface.

STEP 2
Measurement of the local E-Field value at a fixed location (P1).
This value serves as a reference value for calculating a possible power drift.

STEP 3
Measurement of the SAR distribution with a grid spacing of 15mm × 15mm and a constant distance to the inner surface of the phantom.
Since the sensors cannot directly measure at the inner surface of the phantom.
Since the sensors can not directly measure at the inner phantom surface, the values between the sensors and the inner phantom surface are extrapolated. With this values the area of the maximum SAR is calculated by a interpolation scheme (combination of a least-square fitted function and a weighted average method). Additional peaks within 3dB of the maximum SAR are searched.

STEP 4
Around this points, a cube of 30mm×30mm×30mm is assessed by measuring 5×5×5 points. With these data, the peak spatial-average SAR value can be calculated with the SEMCAD software.

STEP 5
The used extrapolation and interpolation routines are all based on the modified Quadratic Shepard's method [DASY4].

STEP 6
Repetition of the E-Field measurement at the fixed location(P1) and repetition of the whole procedure if the two results differ by more than ±0.223dB.

6. Definition of Reference Points

6.1 EAR Reference Point

Figure 6.1 shows the front, back and side views of SAM. The point "M" is the reference point
For the center of mouth, "LE" is the left ear reference point (ERP), and "RE" is the right ERP.
The ERPs are 15 mm posterior to the entrance to ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 6.2.

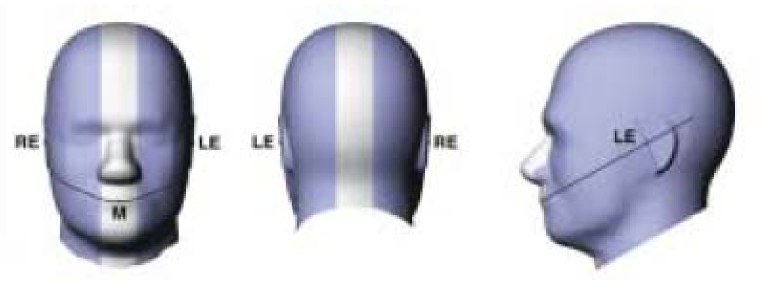


Figure 6.1 Front, back and side view of SAM

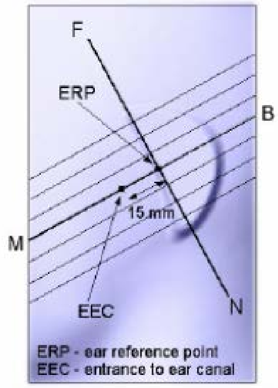


Figure 6.2 Close up side view

The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front)perpendicular to the reference plane and passing through the RE(or LE) is called the Reference Pivoting Line (see Figure 6.3).
Line B-M is perpendicular to the N-F line. Both N-F and B-M Lines should be marked on the external phantom shell to Facilitate handset positioning. Posterior to the N-F line, the thickness of the phantom shell with the shape of an ear is a flat surface 6 mm thick at the ERPs.

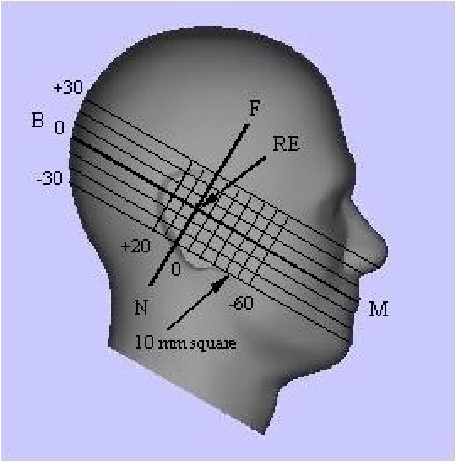


Figure 6.3 Side view of the phantom showing relevant markings

6.2 Handset Reference Points

Two imaginary lines on the handset were established: the vertical centerline and the horizontal line. The test device was placed in a normal operating position with the “test device reference point” located along the “vertical centerline” on the front of the device aligned to the “ear reference point” (see Fig. 6.4).
The “test device reference point” was than located at the same level as the center of the eat reference point. The test device was positioned so that the “vertical centerline” was bisecting the front surface of the handset at it’s tip and bottom edges, positioning the “ear reference point” on the outer surface of the both the left and right head phantoms on the ear reference point.

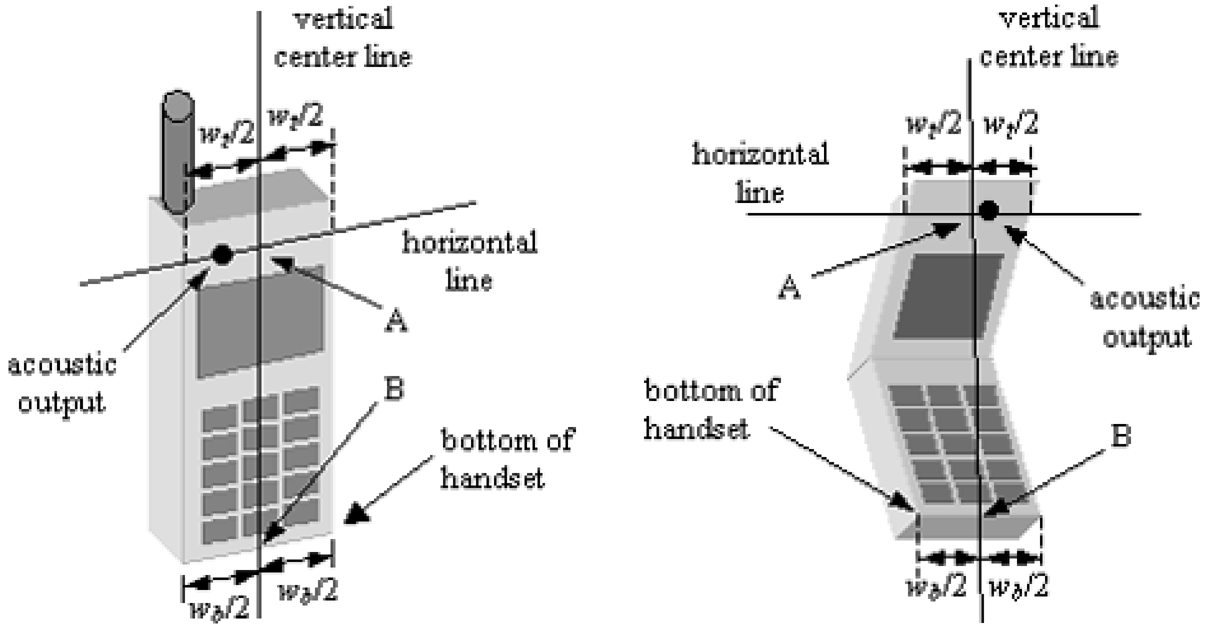


Figure 6.4 Handset vertical and horizontal reference lines

7. Test Configuration Positions

7.1 Cheek/Touch Position

Step 1
The test device was positioned with the handset close to the surface of the phantom such that point. A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 7.1), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom.

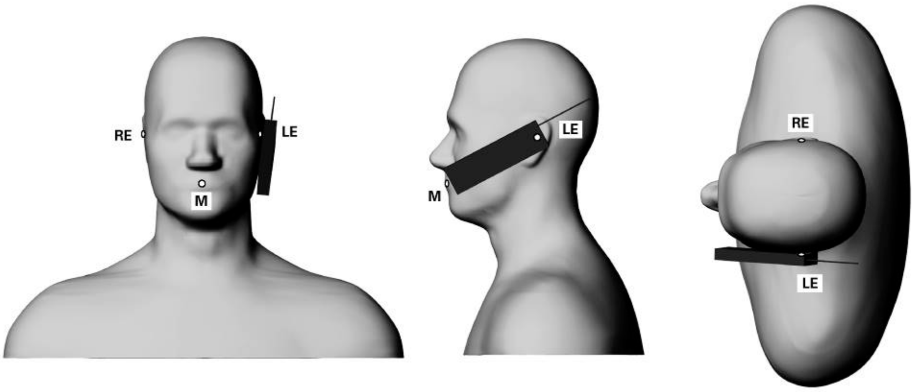


Figure 7.1 Front Side and Top View of Cheek/Touch Position

Step 2
The handset was translated towards the phantom along the line passing through RE & LE until the handset touches the ear.

Step 3
While maintaining the handset in this plane, the handset was rotated around the LE-RE line Until the vertical centerline was in the plane normal to MB-NF including the line MB (reference plane).

Step 4
Rotate the handset around the vertical centerline until the phone (horizontal line) was symmetrical was respect to the line NF.

Step 5
While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, the handset was rotated about the line NF until any point on the handset made contact with a phantom point below the ear cheek.(See Figure 6.2)

7.2 EAR/Tilt 15° Position

With the test device aligned in the “Cheek/Touch Position”:

Step 1
Repeat steps 1 to 5 of 6.2 to place the device in the “Cheek/Touch Position”

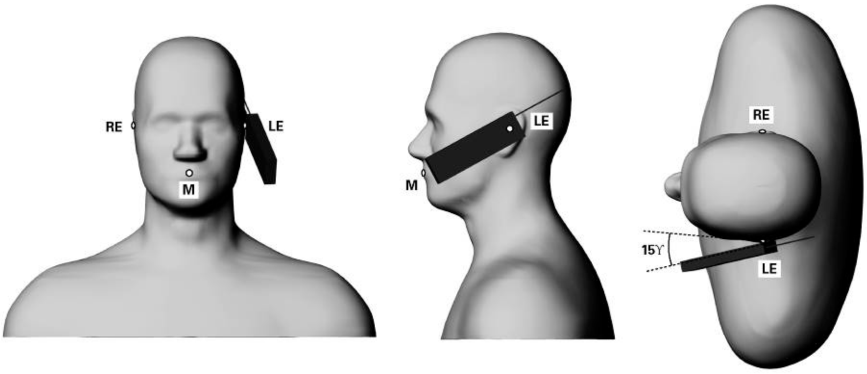


Figure 7.2 Front, side and Top View of Ear/Tilt 15° Position

Step 2
While maintaining the orientation of the phone, the phone was retracted parallel to the reference plane far enough to enable a rotation of the phone by 15 degree.

Step 3
The phone was then rotated around the horizontal line by 15 degree.

Step 4
While maintaining the orientation of the phone, the phone was moved parallel to the reference plane until any part of the phone touches the head.
(In this position, point A was located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact was at any location other than the pinna, the angle of the phone would then be reduced.
The tilted position was obtained when any part of the phone was in contact of the ear as well as a second part of the phone was in contact with the head. (See Figure 7.2)

7.3 Body-worn and Other Configurations

7.3.1 Phantom Requirement

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

7.3.2 Test Position

The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset. Since the Supplement C to OET Bulletin 65 was mainly issued for mobile phones it is only a guideline and therefore some requirements are not usable or practical for devices other than mobile phones.

7.3.3 Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closet spacing to the body.
For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closet spacing to the body must be tested.
If the manufacturer provides none body accessories, a separation distance of 0 cm between the back of the device and the flat phantom is recommended to cover the worst-case usage scenarios. Other separation distances may be used, but they shall not exceed 2.5cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.
For devices with retractable antenna, the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.
The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 3.0dB lower than the SAR limit, testing at the high and low channel is optional.

8. Limits for Specific Absorption Rate (SAR)

HUMAN EXPOSURE	SAR (W/kg)	
	General Population / Uncontrolled Exposure Environment	Occupational / Controlled Exposure Environment
Spatial Peak SAR (Brain)	1.6	8.0
Spatial Average SAR (Whole Body)	0.08	0.4
Spatial Peak SAR (Hands, Wrists, Feet and Ankles)	4.0	20

1. This limits accord to SAR Human Exposure Specified in ANSI/IEEE C95.3-2003 and Health Canada Safety Code 6
2. The Spatial Peak value of the SAR averaged over any 1g of tissue and over the appropriate averaging time.
3. The Spatial average value of the SAR averaged over the whole body.
4. The Spatial Peak value of the SAR averaged over any 10g of tissue and over the appropriate averaging time.

9. Measurement Uncertainty

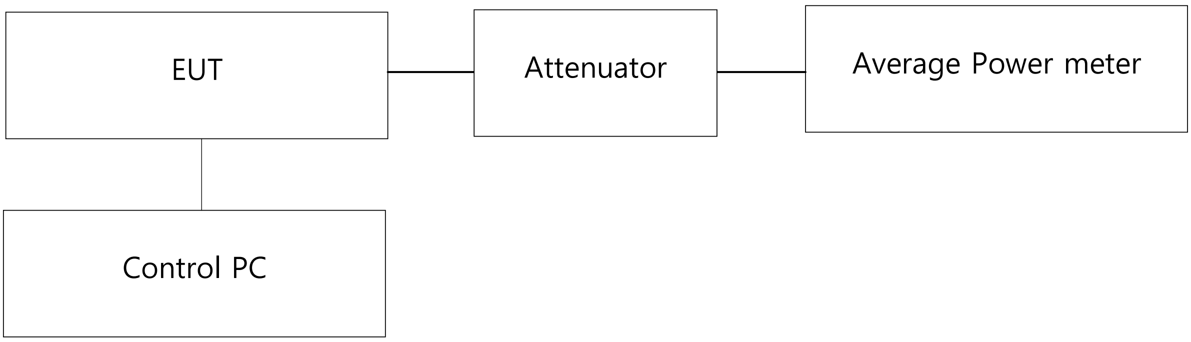
Uncertainty Component	Tolerance (±%)	Prob. Dist.	Divisor	(Ci)		Standard Uncertainty (±%)		(Vi)
				(1g)	(10g)	(1g)	(10g)	
Measurement System								
Probe Calibration	6.00	Normal	1	1	1	6.55	6.55	∞
Axial Isotropy	4.70	Rectangular	1.73	0.7	0.7	1.90	1.90	∞
Hemispherical Isotropy	9.60	Rectangular	1.73	0.7	0.7	3.88	3.88	∞
Hboundary Effects	1.00	Rectangular	1.73	1	1	0.58	0.58	∞
Linearity	4.70	Rectangular	1.73	1	1	2.72	2.72	∞
System Detection Limits	1.00	Rectangular	1.73	1	1	0.58	0.58	∞
Readout Electronics	1.00	Normal	1	1	1	1.00	1.00	∞
Response Time	0.80	Rectangular	1.73	1	1	0.46	0.46	∞
Intergration Time	2.60	Rectangular	1.73	1	1	1.50	1.50	∞
RF Ambient Conditions	3.00	Rectangular	1.73	1	1	1.73	1.73	∞
Probe Positioner	0.40	Rectangular	1.73	1	1	0.23	0.23	∞
Probe Positioning	2.90	Rectangular	1.73	1	1	1.68	1.68	∞
Max. SAR Eval.	1.00	Rectangular	1.73	1	1	0.58	0.58	∞
Test Sample Related								
Device Positioning	0.86	Normal	1	1	1	0.86	0.86	11
Device Holder	2.80	Normal	1	1	1	2.80	2.80	5
Power Drift	5.00	Rectangular	1.73	1	1	2.90	2.90	∞
Phantom and Setup								
Phantom Uncertainty	4.00	Rectangular	1.73	1	1	2.31	2.31	∞
Liquid Conductivity(target)	5.00	Rectangular	1.73	0.64	0.43	1.85	1.24	∞
Liquid Conductivity(Meas.)	3.17	Normal	1	0.64	0.43	2.03	1.36	5
Liquid Permittivity(target)	5.00	Rectangular	1.73	0.6	0.49	1.73	1.42	∞
Liquid Permittivity(meas.)	2.99	Normal	1	0.6	0.49	1.79	1.47	5
Combined Std. Uncertainty		RSS				**10.74**	**10.45**	790
Expanded STD Uncertainty		$k = 2$				**21.5**	**20.9**	

The above measurement uncertainties are according to EN 62209-2 and IEEE 1528.

10. Output Power Measurement

10.1 Measurement procedure for Output Power

EUTs average output power was measured at low, middle, high channels with an average power meter connected to the antenna terminal while the EUTs operating at its maximum power control level.



Power measurement Test Setup

10.2 Conducted RF Output Power (Unit: dBm)

mode	Measured Frequency (MHz)	TX antenna configuration	Data rage (Mbps)	Measured Output Power (dBm)	
				Chain A	Chain B
802.11b	2412	SISO	1	14.45	14.42
			2	14.39	14.33
			5.5	13.87	13.74
			11	14.12	13.99
	2437	SISO	1	14.21	13.72
			2	14.12	13.77
			5.5	13.63	13.30
			11	13.84	13.56
	2462	**SISO**	**1**	14.23	**14.55**
			2	14.18	14.47
			5.5	13.72	13.96
			11	13.91	14.14
802.11g	2412	SISO	6	13.26	12.81
			9	13.24	12.91
			12	13.25	12.88
			18	13.16	12.84
			24	13.20	12.90
			36	13.03	12.74
			48	13.01	12.71
			54	12.97	12.74
	2437	SISO	6	12.67	12.44
			9	12.66	12.48
			12	12.71	12.54
			18	12.68	12.46
			24	12.75	12.52
			36	12.56	12.30
			48	12.55	12.28
			54	12.57	12.32
	2462	SISO	6	12.59	12.99
			9	12.66	13.08
			12	12.69	13.10
			18	12.61	13.05
			24	12.68	13.13
			36	12.53	12.96
			48	12.50	12.94
			54	12.53	12.98

mode	Measured Frequency (MHz)	TX antenna configuration	Data rage (Mbps)	Measured Output Power (dBm)	
				Chain A	Chain B
802.11n (HT20)	2412	SISO	MCS0	13.07	11.76
			MCS1	13.10	11.77
			MCS2	13.03	11.70
			MCS3	13.03	11.89
			MCS4	12.96	11.84
			MCS5	12.92	11.75
			MCS6	12.99	11.86
			MCS7	12.88	11.72
		MIMO	MCS8	13.46	
			MCS9	13.41	
			MCS10	13.41	
			MCS11	13.49	
			MCS12	13.39	
			MCS13	13.34	
			MCS14	13.34	
			MCS15	13.37	
	2437	SISO	MCS0	12.63	12.45
			MCS1	12.68	12.50
			MCS2	12.57	12.41
			MCS3	12.60	12.39
			MCS4	12.55	12.39
			MCS5	12.54	12.36
			MCS6	12.58	12.44
			MCS7	12.56	12.33
		MIMO	MCS8	13.47	
			MCS9	13.46	
			MCS10	13.48	
			MCS11	13.52	
			MCS12	13.45	
			MCS13	13.36	
			MCS14	13.43	
			MCS15	13.42	
	2462	SISO	MCS0	12.62	13.05
			MCS1	12.66	13.10
			MCS2	12.58	13.02
			MCS3	12.62	12.99
			MCS4	12.57	12.97
			MCS5	12.59	12.95
			MCS6	12.63	13.03
			MCS7	12.55	12.94
		MIMO	MCS8	13.80	
			MCS9	13.84	
			MCS10	13.84	
			MCS11	13.94	
			MCS12	13.88	
			MCS13	13.79	
			MCS14	13.81	
			MCS15	13.83	

mode	Measured Frequency (MHz)	TX antenna configuration	Data rage (Mbps)	Measured Output Power (dBm)	
				Chain A	Chain B
802.11n (HT40)	2422	SISO	MCS0	10.70	10.18
			MCS1	10.67	10.03
			MCS2	10.66	9.98
			MCS3	10.69	10.01
			MCS4	10.68	9.98
			MCS5	10.74	10.00
			MCS6	10.70	9.91
			MCS7	10.59	9.84
		MIMO	MCS8	11.02	
			MCS9	11.02	
			MCS10	11.05	
			MCS11	11.14	
			MCS12	11.12	
			MCS13	11.04	
			MCS14	11.01	
			MCS15	10.99	
	2442	SISO	MCS0	10.40	10.25
			MCS1	10.38	10.21
			MCS2	10.35	10.20
			MCS3	10.41	10.24
			MCS4	10.39	10.23
			MCS5	10.46	10.27
			MCS6	10.41	10.21
			MCS7	10.27	10.15
		MIMO	MCS8	11.05	
			MCS9	11.04	
			MCS10	11.07	
			MCS11	11.13	
			MCS12	11.11	
			MCS13	11.03	
			MCS14	10.98	
			MCS15	11.00	
	2462	SISO	MCS0	10.68	10.82
			MCS1	10.66	10.71
			MCS2	10.66	10.68
			MCS3	10.68	10.75
			MCS4	10.70	10.75
			MCS5	10.72	10.80
			MCS6	10.67	10.71
			MCS7	10.54	10.65
		MIMO	MCS8	11.35	
			MCS9	11.36	
			MCS10	11.34	
			MCS11	11.42	
			MCS12	11.36	
			MCS13	11.33	
			MCS14	11.30	
			MCS15	11.28	

11. System Verification

11.1 Tissue Verification

For the measurement of the following parameters the 85070E dielectric probe kit was used, representing the open-ended slim form probe measurement procedure. The measured values should be within ±5% of the recommended values given by IEEE 1528-2013.

Table 11.1 Measured Tissue Parameters

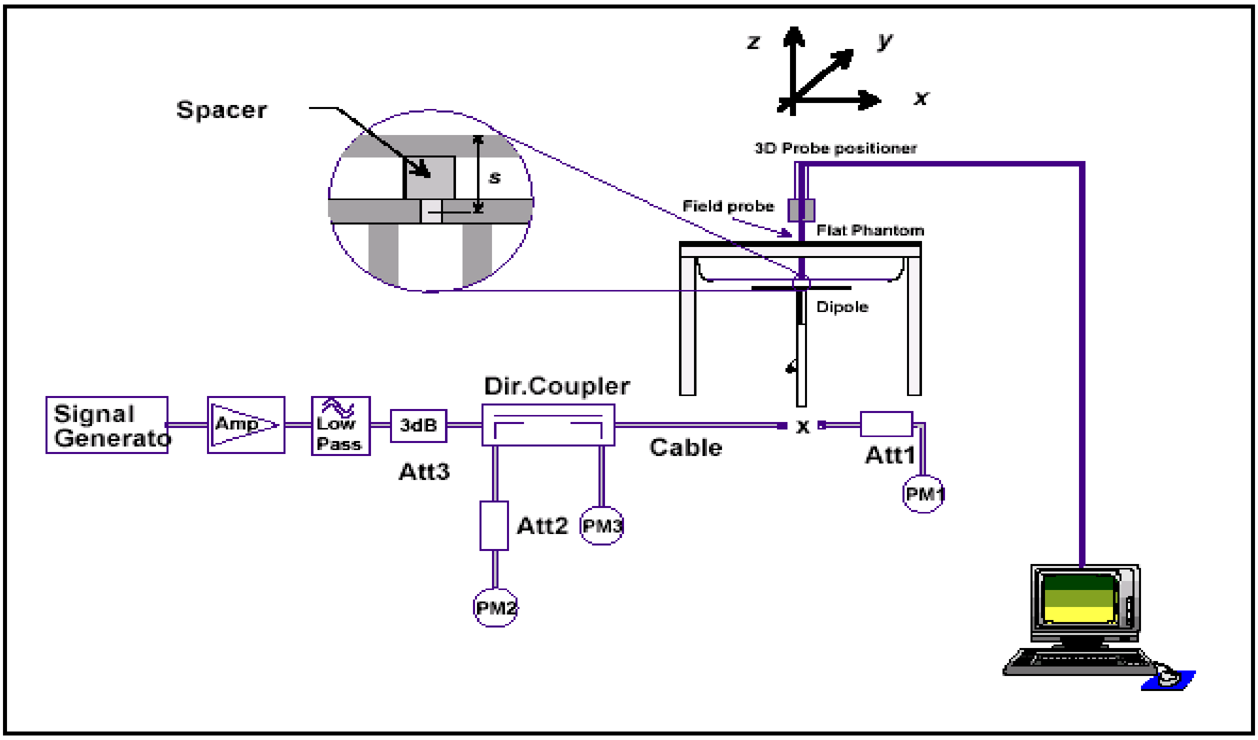
Date	Liquid Type	Liquid Temp. (℃)	Frequency (MHz)	Measured Dielectric Constant (ε)	Measured Conductivity (S/m)	Recommended Dielectric Constant (ε)	Recommended Conductivity (S/m)	Dielectric Constant Error (%)	Conductivity Error (%)
November 23.2014	2G /Body	23.1	2450	54.90	1.95	52.70	1.95	4.17	-0.15
November 25.2014	2G /Body	21.8	2450	53.88	2.01	52.70	1.95	2.24	3.13

11.2 Test System Validation

A complete 1 g and/or 10 g averaged SAR measurement is performed using a standard source. The input power of the standard source is adjusted to produce a 1 g and/or 10 g averaged SAR value falling in the range of 0,4 W/kg to 10 W/kg. The 1 g and/or 10 g averaged SAR is measured at frequencies in Table 11.2 within the range to be used in compliance tests. The dipole input power was 250 mW. The SAR results are normalized to 1 Watt input power.
Compared the normalized the SAR results to the dipole calibration results.

Table 11.2 System Validation Results

Date	Liquid Temperature (°C)	Measured Frequency (MHz)	Targeted 1 g SAR (W/kg)	Measured 1 g SAR (W/kg)	Normalized 1 g SAR (W/kg)	Deviation (%)	Plot No.
November 23.2014	22.90	2450	49.6	12.3	49.2	-0.81	#S09
November 25.2014	22.20	2450	49.6	12.5	50.0	0.81	#S10



System Validation Test Setup

12. SAR Measurement Results

Note:

1. Per KDB 447498 D01v05, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance.
   Scaling Factor = Tune-up limit power (mW) / EUT RF Power (mW), Where tune-up limit is the maximum rated power among all production units.
   Reported SAR (W/kg) = Scaling Factor * Measured SAR (W/kg)
2. Per KDB 447498 D01v05, for each exposure position, if the highest output channel reported SAR ≤0.8w/kg, other Channels SAR testing is not necessary.

<For 2 GHz, TX Chain B>

Measured Frequency		Mode	Data Rate	Gap (mm)	Duty Cycle	Average Power (dBm)	Tune-Up Limit pwr (dBm) *)	Scaling Factor	EUT Configuration	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Plot No.
MHz	CH											
2437	6	802.11b	1 Mbps	0 mm	1:1	13.72	16.5	1.896	Front	0.0071	0.013	#S01
					1:1	13.72	16.5	1.896	Back	0.167	0.316	#S02
					1:1	13.72	16.5	1.896	Top side	0.0042	0.007	#S03
					1:1	13.72	16.5	1.896	Bottom	0.012	0.022	#S04
					1:1	13.72	16.5	1.896	Left	0.012	0.022	#S05
					1:1	13.72	16.5	1.896	Right	0.007	0.013	#S06
2412	1				1:1	14.42	16.5	1.614	Back	0.141	0.022	#S07
2462	11				1:1	14.55	16.5	1.566	Back	0.204	0.319	#S08

*) 2 GHz B Mode Tune-up Limit : 14.5 dBm ±2.0 dB = Max. target pwr

<For 2 GHz, TX Chain A>

Measured Frequency		Mode	Data Rate	Gap (mm)	Duty Cycle	Average Power (dBm)	Tune-Up Limit pwr (dBm) *)	Scaling Factor	EUT Configuration	Measured SAR 1g (W/kg)	Reported SAR 1g (W/kg)	Plot No.
MHz	CH											
2437	6	802.11b	1 Mbps	0 mm	1:1	14.21	16.5	1.695	Front	0.0235	0.040	-
					1:1	14.21	16.5	1.695	Back	0.0604	0.102	-
					1:1	14.21	16.5	1.695	Top side	0.0075	0.013	-
					1:1	14.21	16.5	1.695	Bottom	0.0196	0.033	-
					1:1	14.21	16.5	1.695	Left	0.0139	0.024	-
					1:1	14.21	16.5	1.695	Right	0.0171	0.029	
2412	1				1:1	14.45	16.5	1.603	Back	0.0556	0.123	-
2462	11				1:1	14.23	16.5	1.686	Back	0.0769	0.094	-

*) 2 GHz B Mode Tune-up Limit : 14.5 dBm ±2.0 dB = Max. target pwr

13. Test Equipments

Description	Model	Serial No.	Data of next Calibration	Used Equipment
Staubli Robot Unit	RX60L	F05/51E1A1/A/01	N/A	√
Electro-Optical Converter	EOC3	398	N/A	√
SAM Twin Phantom V4.0C	TP-1358	SM 000 T02 DA	N/A	√
Dielectric Probe Kit	85070E	MY44300121	N/A	√
Data Acquisition Electronics	DAE4	672	2015.02.25	√
E-Field Probe	ES3DV3	3068	2015.04.22	
E-Field Probe	EX3DV4	3910	2015.09.29	√
Validation Dipole Antenna	D450V2	1022	2015.01.23	
Validation Dipole Antenna	D835V2	4d017	2016.01.22	
Validation Dipole Antenna	D900V2	1d016	2016.01.22	
Validation Dipole Antenna	D1800V2	2d111	2015.01.25	
Validation Dipole Antenna	D1900V2	5d059	2016.08.26	
Validation Dipole Antenna	D2450V2	774	2016.04.23	√
Validation Dipole Antenna	D5GHzV2	1146	2015.02.08	
Power Amplifier	5800842	-	2015.01.19	√
Power Amplifier	RWHPA	-	2015.01.19	
Network Analyzer	8753E	JP38161044	2015.10.06	√
Radio Communication Analyzer	MT8820C	6200985423	2015.04.02	
Dual Directional Coupler	778D	15550	2015.01.09	
Dual Directional Coupler	11692D	1212A02175	2015.07.17	√
VSA Series Transmitter Tester	E4406A	US39480757	2015.07.17	
PSA Series Spectrum Analyzer	E4440A	MY44022567	2015.04.02	
Power Meter	NRVS	835360/002	2015.01.09	√
Power Sensor	NRV-Z5	833722/006	2015.01.09	√
Power Meter	437B	2349A20798	2015.10.07	√
Power Sensor	8481A	3318A83210	2015.07.16	√
Power Meter	ML2437A	97310060	2015.07.16	√
Power Sensor	MA2474A	181289	2015.07.17	√
Wideband Power Sensor	NRP-Z81	100634	2015.07.17	
Vector Signal Generator	SMBV100A	257152	2015.10.07	
Vector Signal Generator	N5182A	MY5014918	2015.07.16	√
Dielectric Field probe	DAK 3.5	1128	2015.08.19	√
Vector Signal Analyzer	N9020A	MY51110087	2015.07.17	√

14. Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of the **FCC and Industry Canada,**, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. The results and statements relate only to the item(s) tested.

APPENDIX A: Plots of SAR Results

#S01

Date/Time: 2014-11-24 PM 12:34:30

Test Laboratory: Nemko Korea   File Name: Front CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM   Type: N/A   Serial: N/A

Communication System: WLAN 2.4G   Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.93 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Front Gap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.009 mW/g

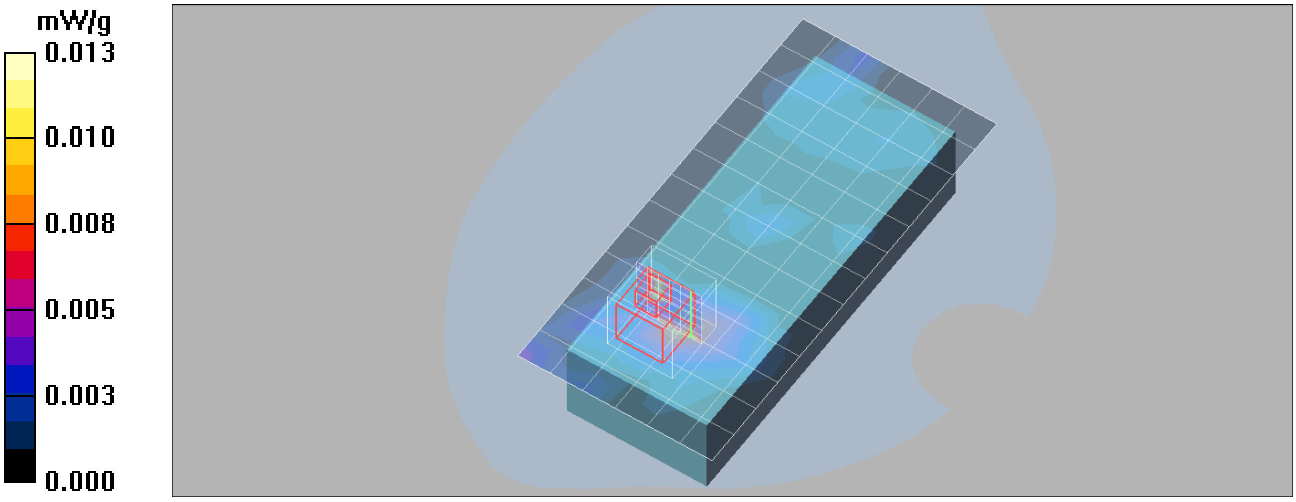
SSM Front Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0.982 V/m; Power Drift = 0.113 dB

Peak SAR (extrapolated) = 0.017 W/kg

SAR(1 g) = 0.00714 mW/g; SAR(10 g) = 0.00463 mW/g

Maximum value of SAR (measured) = 0.013 mW/g



#S02

Date/Time: 2014-11-24 AM 2:24:26

Test Laboratory: Nemko Korea   File Name: Back CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM   Type: N/A   Serial: N/A

Communication System: WLAN 2.4G   Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.93 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Back Gap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.173 mW/g

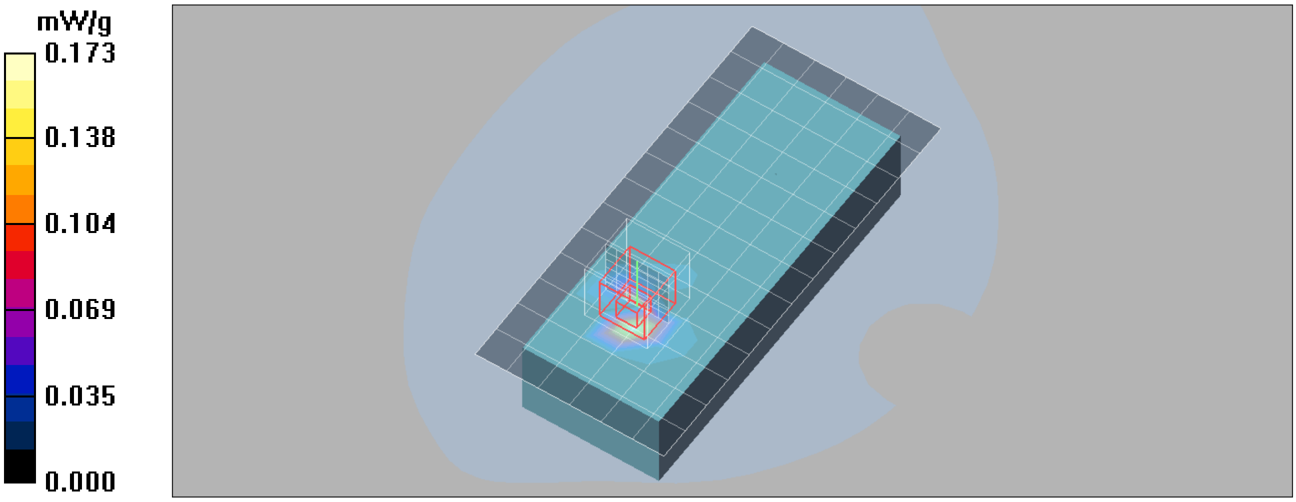
SSM Back Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0.645 V/m; Power Drift = -0.032 dB

Peak SAR (extrapolated) = 0.460 W/kg

SAR(1 g) = 0.167 mW/g; SAR(10 g) = 0.059 mW/g

Maximum value of SAR (measured) = 0.296 mW/g



#S03

Date/Time: 2014-11-24 AM 8:20:01

Test Laboratory: Nemko Korea   File Name: Top side CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM   Type: N/A   Serial: N/A

Communication System: WLAN 2.4G   Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.93 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Top side Gap 0mm Position/Area Scan (7x11x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.006 mW/g

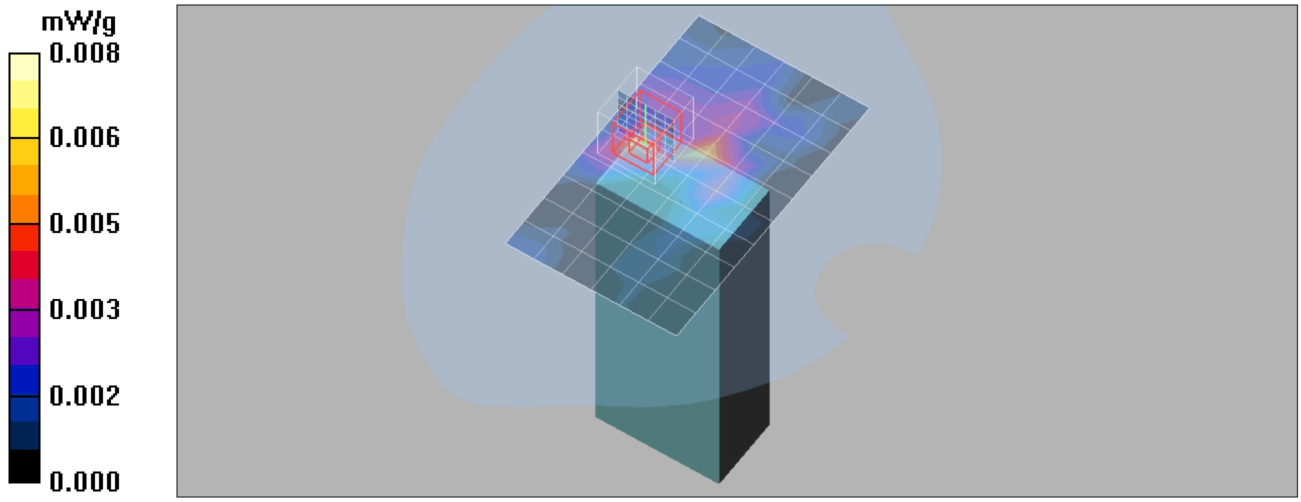
SSM Top side Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 1.17 V/m; Power Drift = 0.047 dB

Peak SAR (extrapolated) = 0.013 W/kg

SAR(1 g) = 0.00422 mW/g; SAR(10 g) = 0.00141 mW/g

Maximum value of SAR (measured) = 0.008 mW/g



#S04

Date/Time: 2014-11-25 PM 5:17:05

Test Laboratory: Nemko Korea File Name: Bottom side CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM Type: N/A Serial: N/A

Communication System: WLAN 2.4G Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.99 mho/m; ε_r = 54; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Bottom Gap 0mm Position/Area Scan (7x11x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.015 mW/g

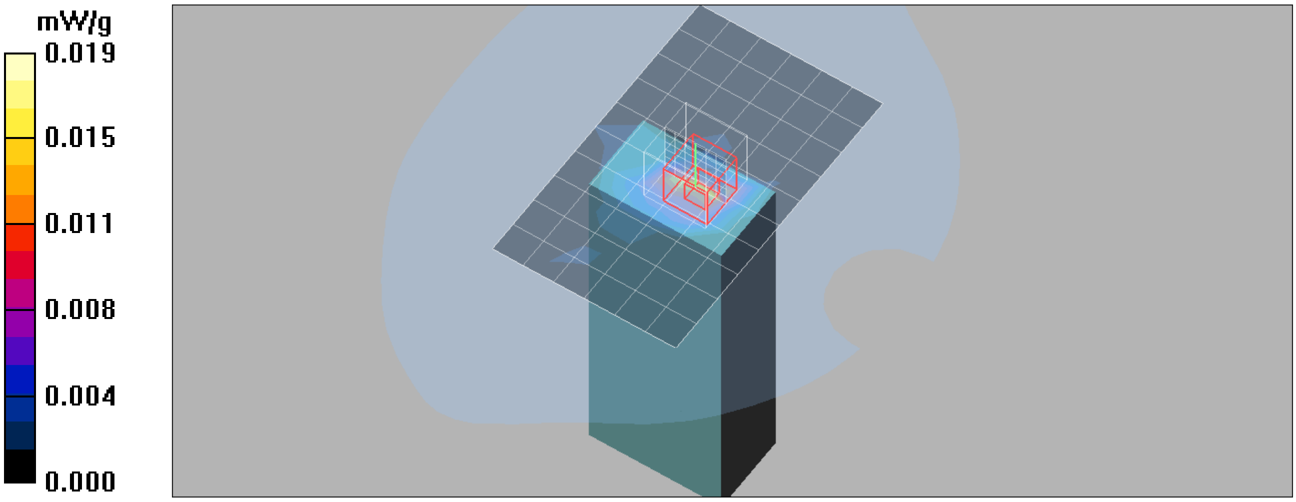
SSM Bottom Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 2.58 V/m; Power Drift = 0.122 dB

Peak SAR (extrapolated) = 0.051 W/kg

SAR(1 g) = 0.012 mW/g; SAR(10 g) = 0.00505 mW/g

Maximum value of SAR (measured) = 0.019 mW/g



#S05

Date/Time: 2014-11-24 AM 6:44:36

Test Laboratory: Nemko Korea   File Name: Left side CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM   Type: N/A   Serial: N/A

Communication System: WLAN 2.4G   Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.93 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Left Gap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.014 mW/g

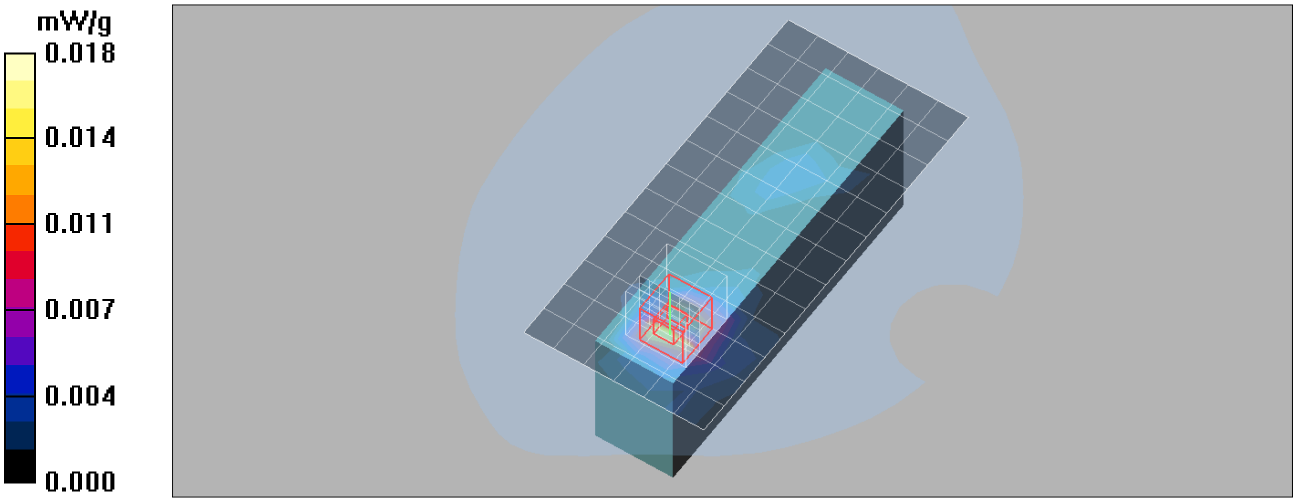
SSM Left Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 1.18 V/m; Power Drift = 0.035 dB

Peak SAR (extrapolated) = 0.038 W/kg

SAR(1 g) = 0.012 mW/g; SAR(10 g) = 0.00622 mW/g

Maximum value of SAR (measured) = 0.018 mW/g



#S06

Date/Time: 2014-11-24 AM 7:54:55

Test Laboratory: Nemko Korea   File Name: Right side CH6 gap 0mm position_2437_1Mbps_B.da4

DUT: SSM   Type: N/A   Serial: N/A

Communication System: WLAN 2.4G   Frequency: 2437 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2437 MHz; σ = 1.93 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Right sideGap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.013 mW/g

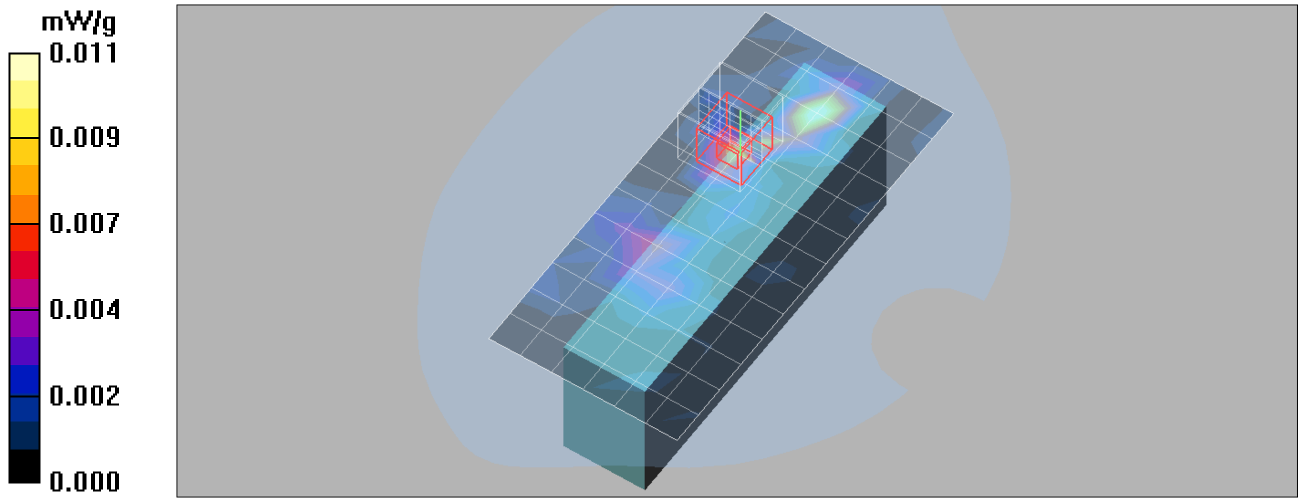
SSM Right sideGap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 0.848 V/m; Power Drift = -0.081 dB

Peak SAR (extrapolated) = 0.017 W/kg

SAR(1 g) = 0.00703 mW/g; SAR(10 g) = 0.00219 mW/g

Maximum value of SAR (measured) = 0.011 mW/g



#S07

Date/Time: 2014-11-25 PM 1:24:03

Test Laboratory: Nemko Korea File Name: Back CH1 gap 0mm position_2412_1Mbps_B.da4

DUT: SSM Type: N/A Serial: N/A

Communication System: WLAN 2.4G Frequency: 2412 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2412 MHz; σ = 1.96 mho/m; ε_r = 54.1; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Back Gap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.151 mW/g

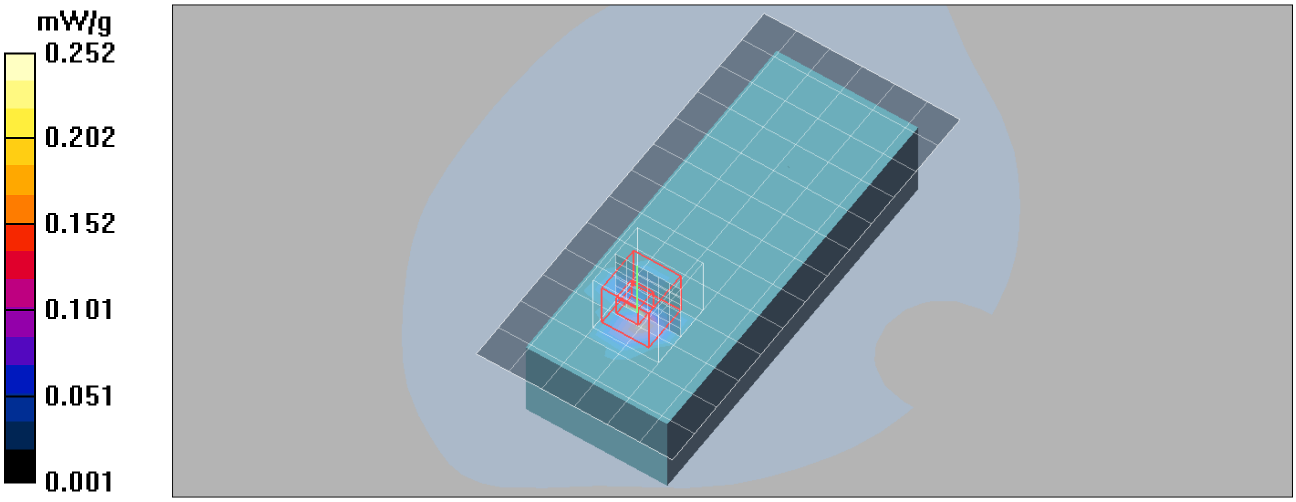
SSM Back Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 1.41 V/m; Power Drift = -0.165 dB

Peak SAR (extrapolated) = 0.386 W/kg

SAR(1 g) = 0.141 mW/g; SAR(10 g) = 0.051 mW/g

Maximum value of SAR (measured) = 0.252 mW/g



#S08

Date/Time: 2014-11-25 PM 2:28:27

Test Laboratory: Nemko Korea File Name: Back CH11 gap 0mm position_2462_1Mbps_B.da4

DUT: SSM Type: N/A Serial: N/A

Communication System: WLAN 2.4G Frequency: 2462 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2462 MHz; σ = 2.03 mho/m; ε_r = 53.8; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

SSM Back Gap 0mm Position/Area Scan (7x14x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 0.264 mW/g

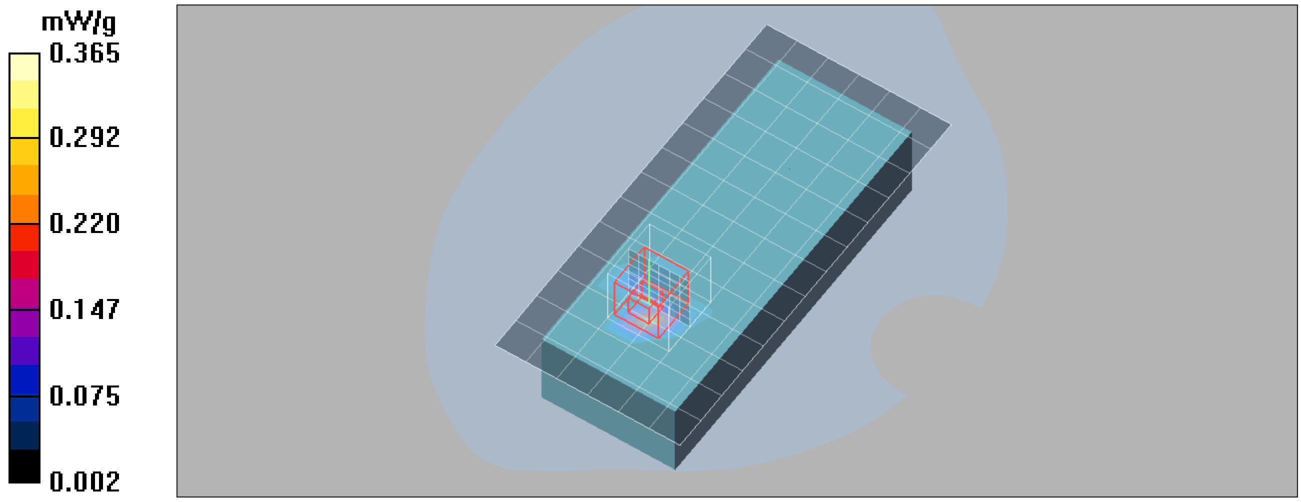
SSM Back Gap 0mm Position/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 1.46 V/m; Power Drift = -0.170 dB

Peak SAR (extrapolated) = 0.564 W/kg

SAR(1 g) = 0.204 mW/g; SAR(10 g) = 0.072 mW/g

Maximum value of SAR (measured) = 0.365 mW/g



APPENDIX B: Plots of System Validation

#S09

Date/Time: 2014-11-23 PM 10:41:35

Test Laboratory: Nemko Korea   File Name: System Validation for 2.45GHz_2014-11-23FCC.da4

DUT: Dipole 2450 MHz   Type: D2450V2   Serial: D2450V2 - SN:774

Communication System: CW   Frequency: 2450 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2450 MHz; σ = 1.95 mho/m; ε_r = 54.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

2.45GHz Dipole Validation/Area Scan (7x7x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 19.0 mW/g

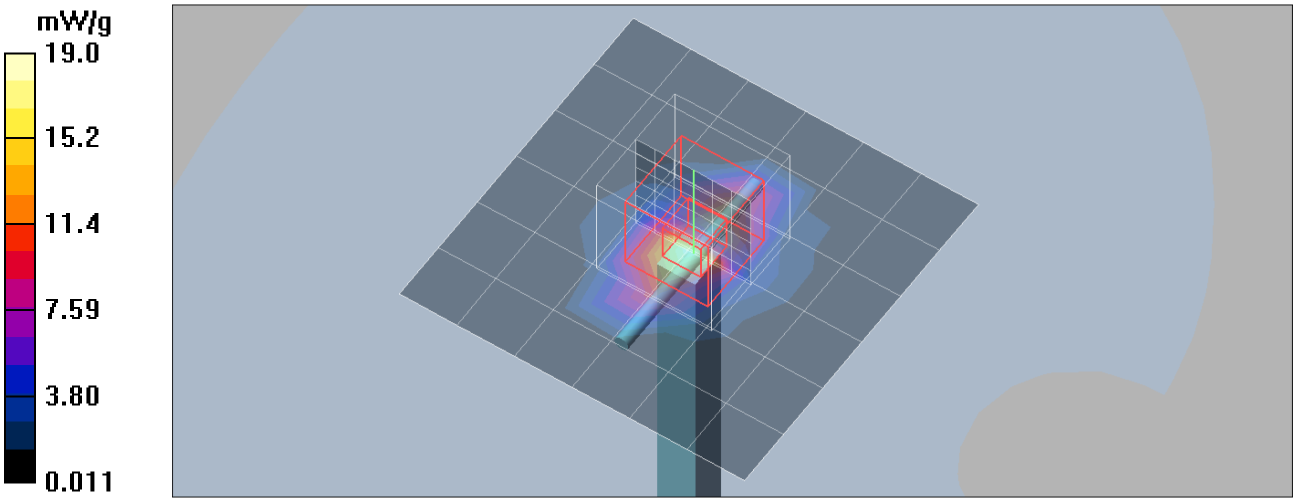
2.45GHz Dipole Validation/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 100.2 V/m; Power Drift = 0.005 dB

Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 12.3 mW/g; SAR(10 g) = 5.63 mW/g

Maximum value of SAR (measured) = 18.6 mW/g



#S10

Date/Time: 2014-11-25 AM 11:04:56

Test Laboratory: Nemko Korea   File Name: System Validation for 2.45GHz_2014-11-25FCC.da4

DUT: Dipole 2450 MHz   Type: D2450V2   Serial: D2450V2 - SN:774

Communication System: CW   Frequency: 2450 MHz

Duty Cycle: 1:1 Phantom section: Flat Section

Medium parameters used: f = 2450 MHz; σ = 2.01 mho/m; ε_r = 53.9; ρ = 1000 kg/m^3

DASY4 Configuration:

Probe: EX3DV4 - SN3910; ConvF(7.33, 7.33, 7.33); Calibrated: 2014-09-29

Sensor-Surface: 2mm (Mechanical Surface Detection)

Electronics: DAE4 Sn672; Calibrated: 2014-02-25

Phantom: SAM with Flat_20131029; Type: SAM; Serial: SM 000 T02 DA

Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

2.45GHz Dipole Validation/Area Scan (7x7x1): Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 19.4 mW/g

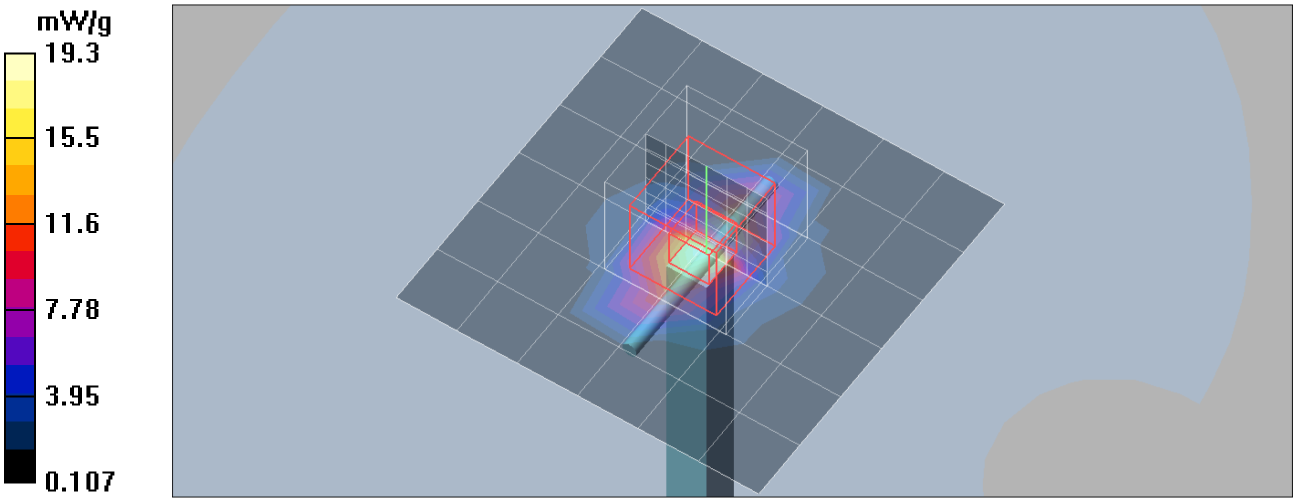
2.45GHz Dipole Validation/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.1 V/m; Power Drift = -0.020 dB

Peak SAR (extrapolated) = 26.7 W/kg

SAR(1 g) = 12.5 mW/g; SAR(10 g) = 5.65 mW/g

Maximum value of SAR (measured) = 19.3 mW/g



APPENDIX C: Calibration report of the Probe

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

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Swiss Calibration Service

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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 Nemko (Dymstec)

Certificate No: EX3-3910_Sep14

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3910

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: September 29, 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: September 29, 2014

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

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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).

Probe EX3DV4

SN:3910

Manufactured: September 4, 2012
Repaired: September 23, 2014
Calibrated: September 29, 2014

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3910

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.47	0.48	0.55	± 10.1 %
DCP (mV)[B]	101.6	96.5	100.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	134.2	±3.5 %
		Y	0.0	0.0	1.0		138.6	
		Z	0.0	0.0	1.0		147.2	

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.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3910

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)
2450	39.2	1.80	7.42	7.42	7.42	0.50	0.70	± 12.0 %
5200	36.0	4.66	5.17	5.17	5.17	0.35	1.80	± 13.1 %
5300	35.9	4.76	4.98	4.98	4.98	0.35	1.80	± 13.1 %
5500	35.6	4.96	4.83	4.83	4.83	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.70	4.70	4.70	0.35	1.80	± 13.1 %
5800	35.3	5.27	4.49	4.49	4.49	0.40	1.80	± 13.1 %

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3910

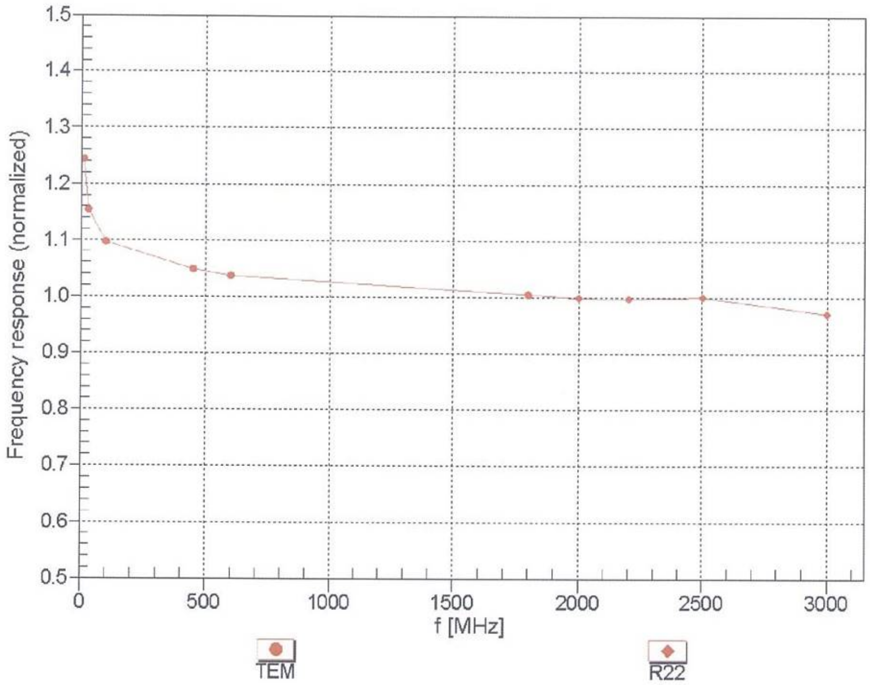
Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unct. (k=2)
2450	52.7	1.95	7.33	7.33	7.33	0.80	0.50	± 12.0 %
5200	49.0	5.30	4.37	4.37	4.37	0.45	1.90	± 13.1 %
5300	48.9	5.42	4.20	4.20	4.20	0.45	1.90	± 13.1 %
5500	48.6	5.65	4.04	4.04	4.04	0.45	1.90	± 13.1 %
5600	48.5	5.77	3.93	3.93	3.93	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.03	4.03	4.03	0.50	1.90	± 13.1 %

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

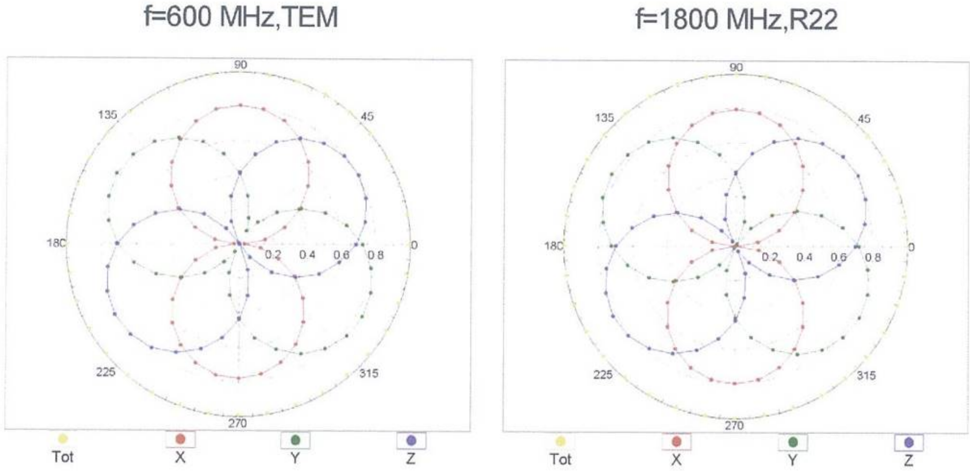
Frequency Response of E-Field

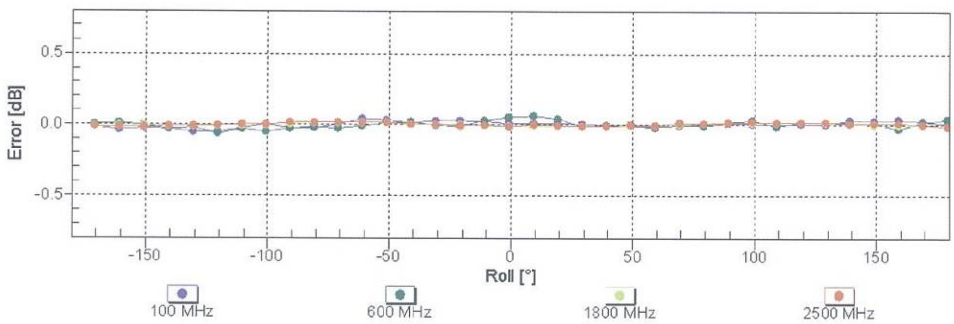
(TEM-Cell:ifi110 EXX, Waveguide: R22)



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

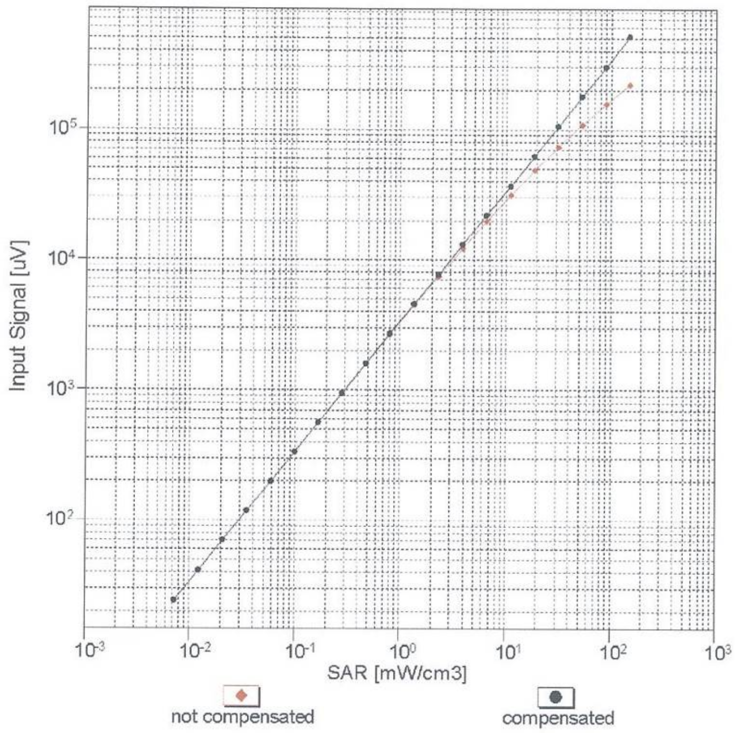
Receiving Pattern (ϕ), ϑ = 0°

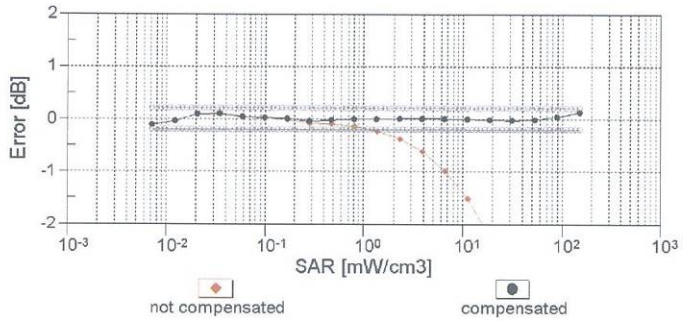




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

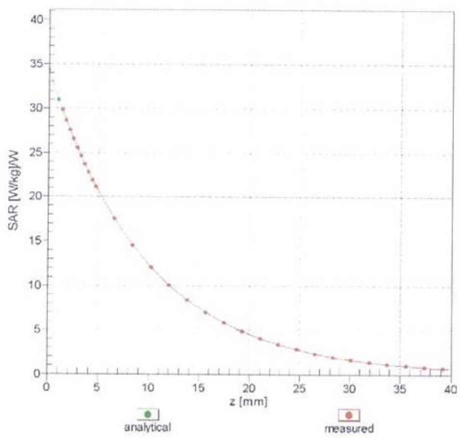
Dynamic Range f(SAR_{head})
(TEM cell , f_{eval}= 1900 MHz)

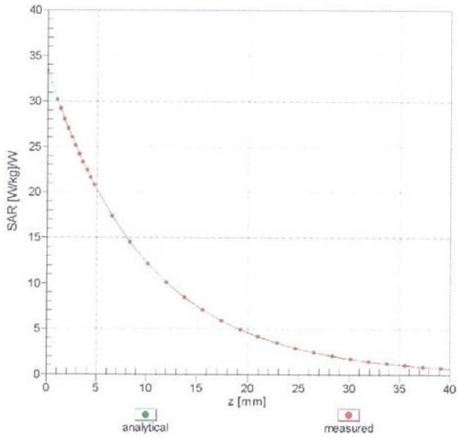




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

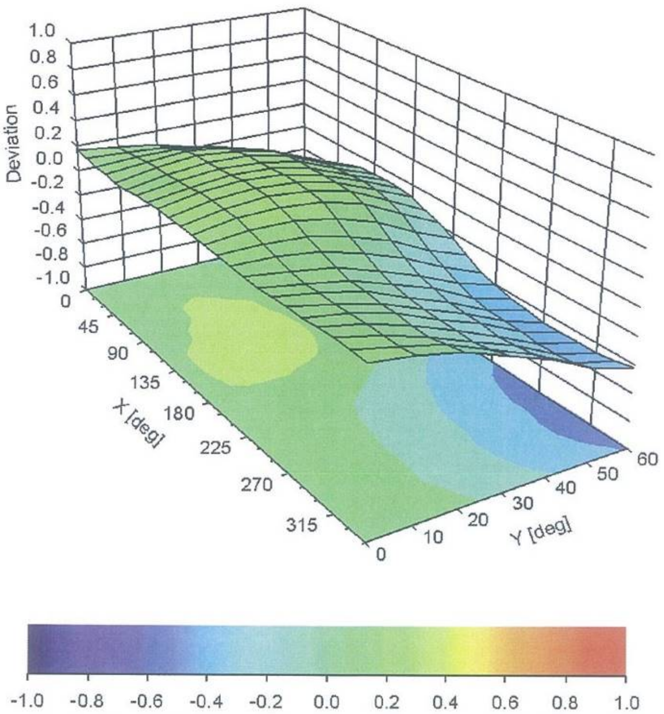
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3910

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-50.9
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

APPENDIX D: Calibration report of the Dipole Antenna

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

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Accreditation No.: SCS 108

Client Nemko (Dymstec)

Certificate No: D2450V2-774_Apr14

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 774
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: D2450V2-774_Apr14 Page 1 of 8

Calibration Laboratory of
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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) 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%.

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	13.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**51.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.01 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.9 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	12.7 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**49.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.85 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.1 W/kg ± 16.5 % (k=2)**

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.0 Ω + 2.3 jΩ
Return Loss	- 25.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.8 Ω + 4.3 jΩ
Return Loss	- 26.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.151 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 20, 2005

DASY5 Validation Report for Head TSL

Date: 23.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

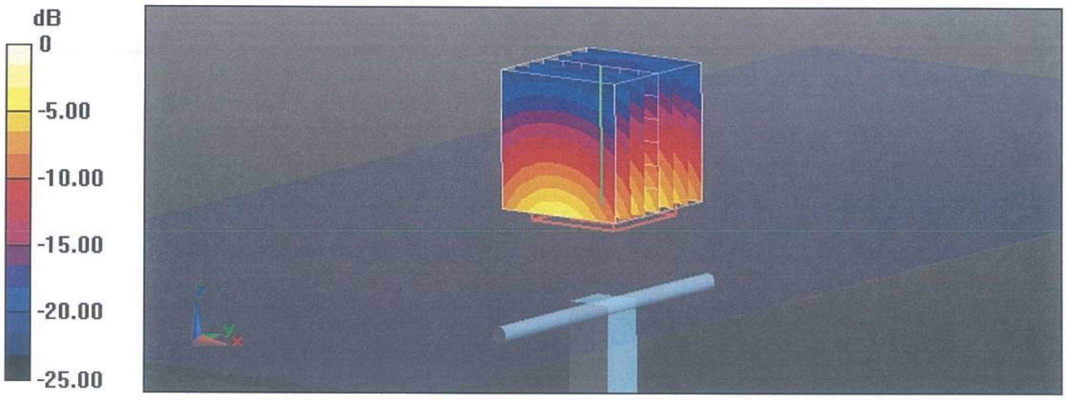
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 774

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:

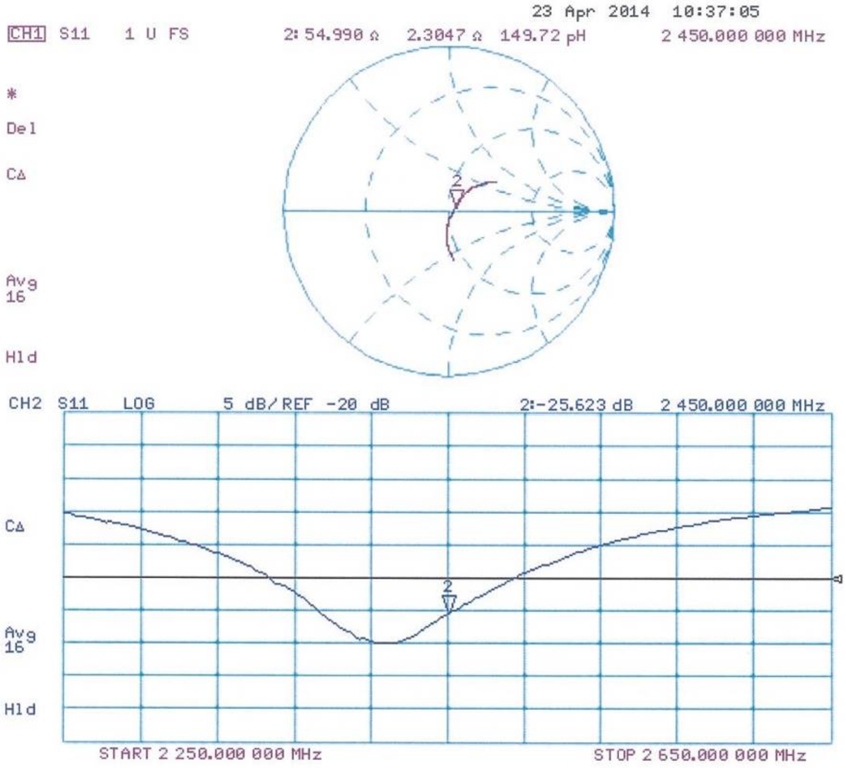
- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 100.79 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 26.9 W/kg
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.01 W/kg
Maximum value of SAR (measured) = 17.0 W/kg



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

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 23.04.2014

Test Laboratory: SPEAG, Zurich, Switzerland

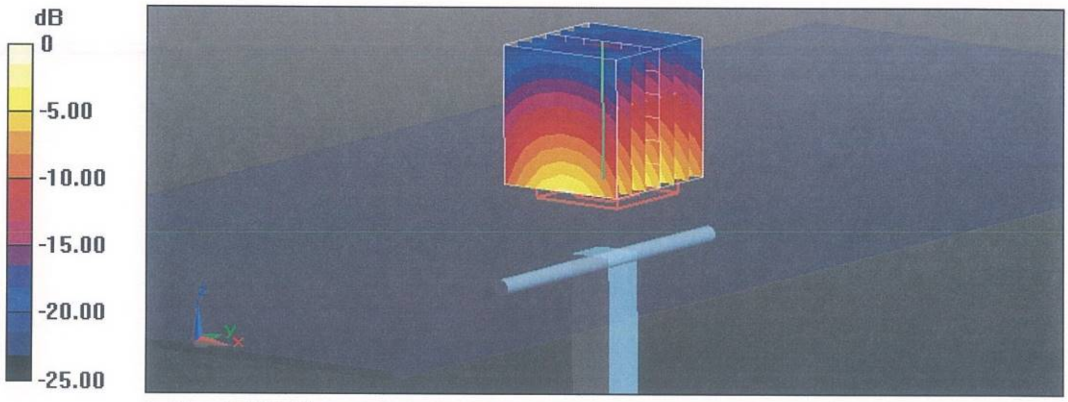
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 774

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

DASY52 Configuration:

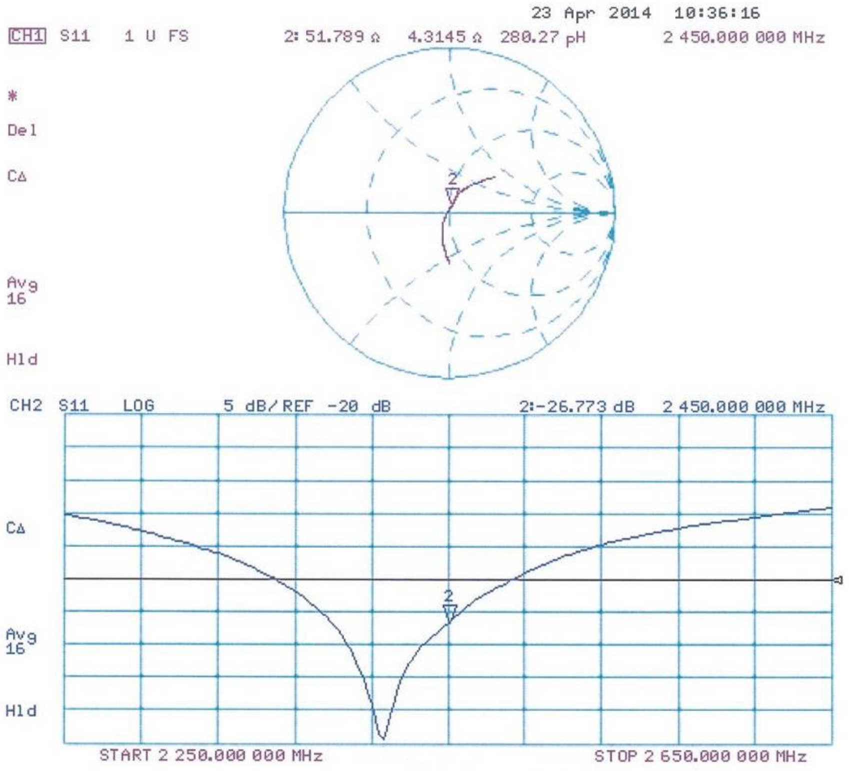
- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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 = 94.319 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 26.6 W/kg
SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.85 W/kg
Maximum value of SAR (measured) = 16.7 W/kg

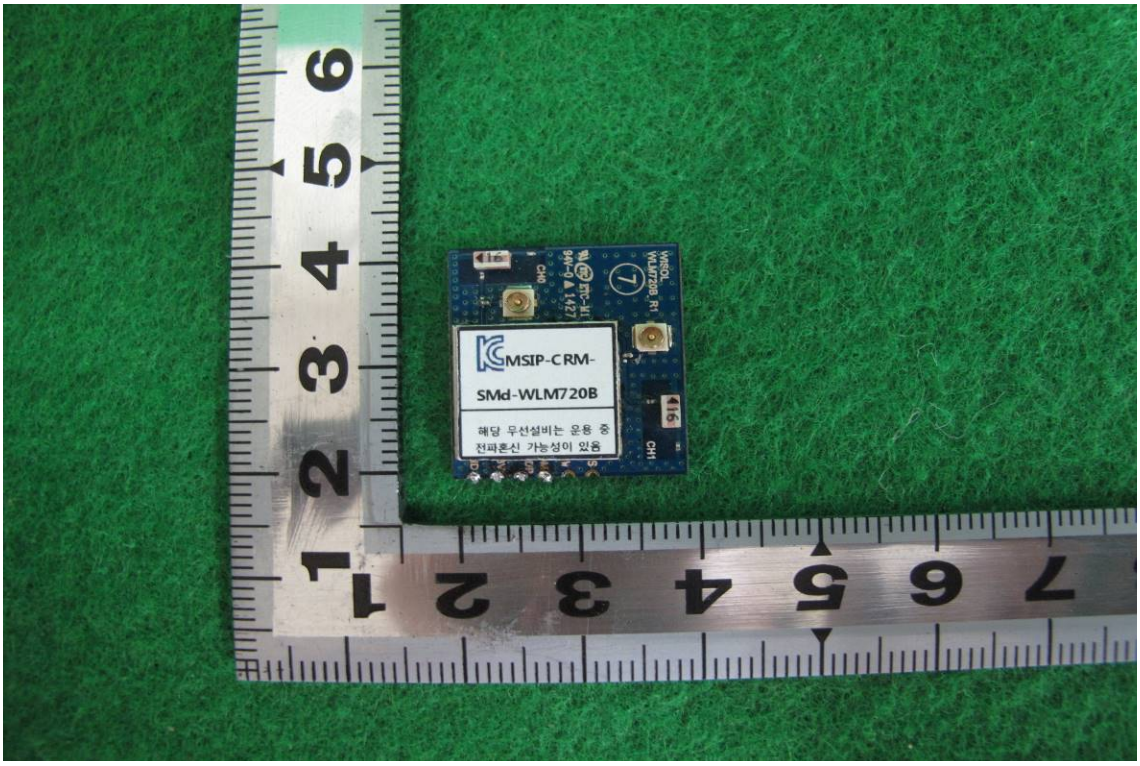


0 dB = 16.7 W/kg = 12.23 dBW/kg

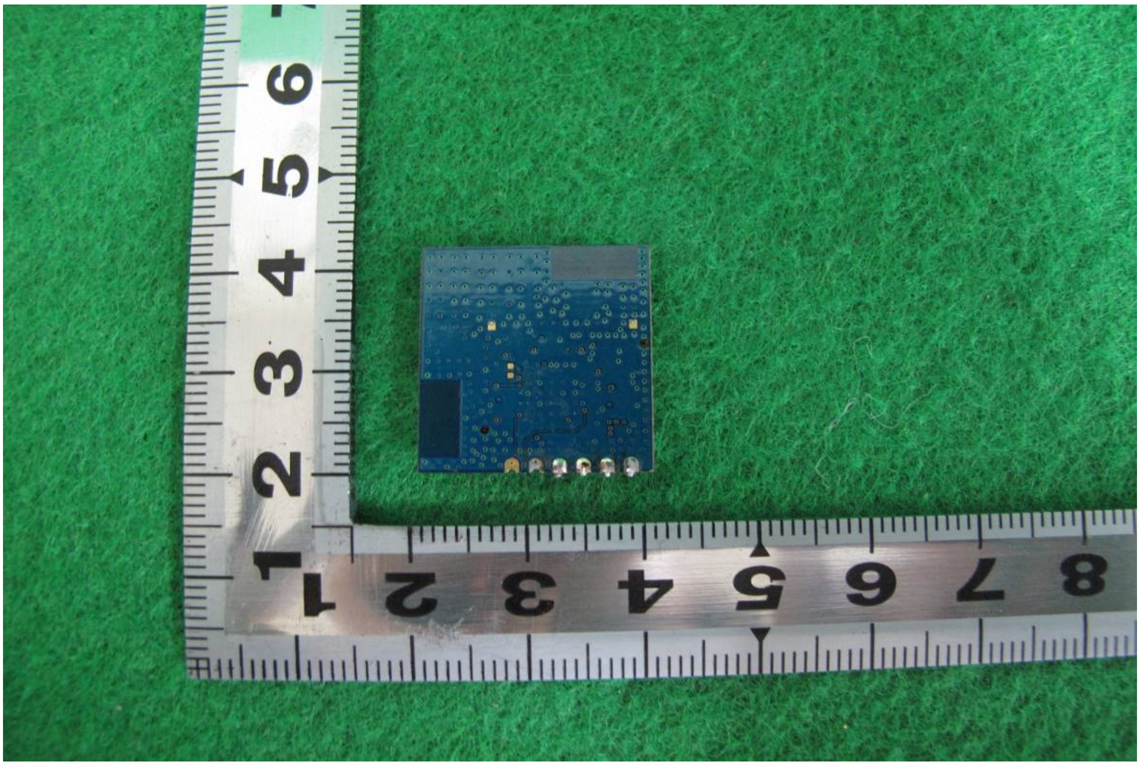
Impedance Measurement Plot for Body TSL



APPENDIX E: Photos of EUT

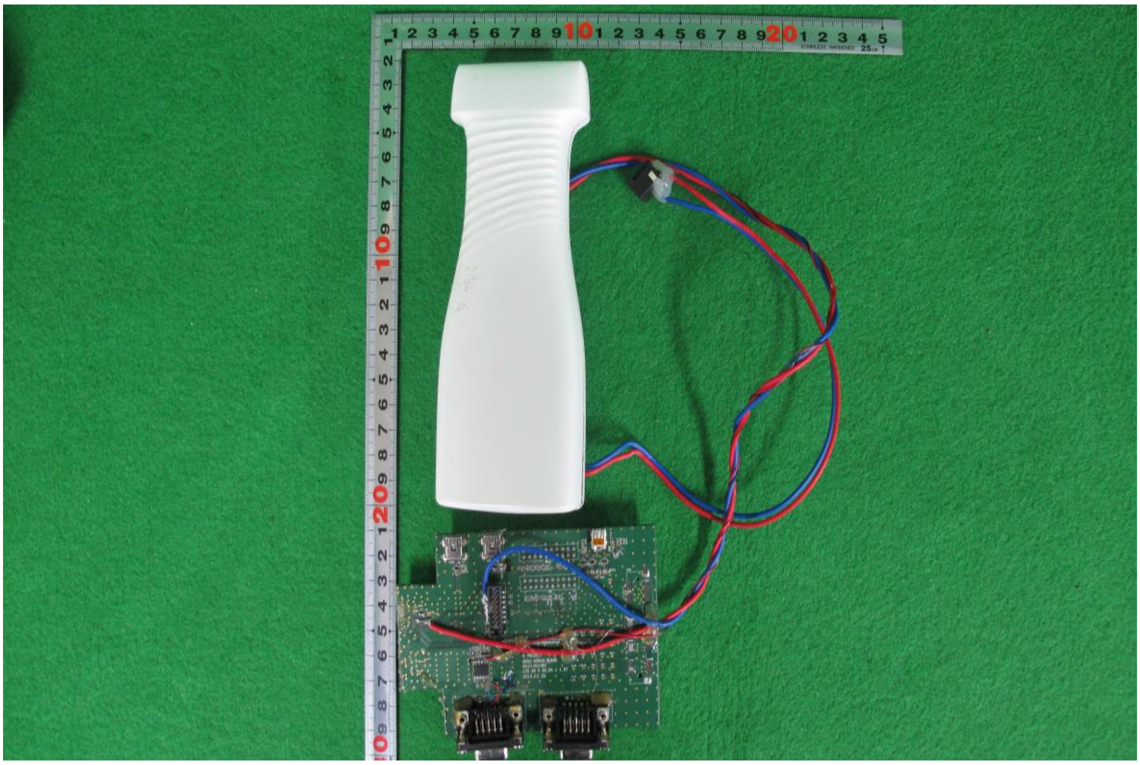


Front Side

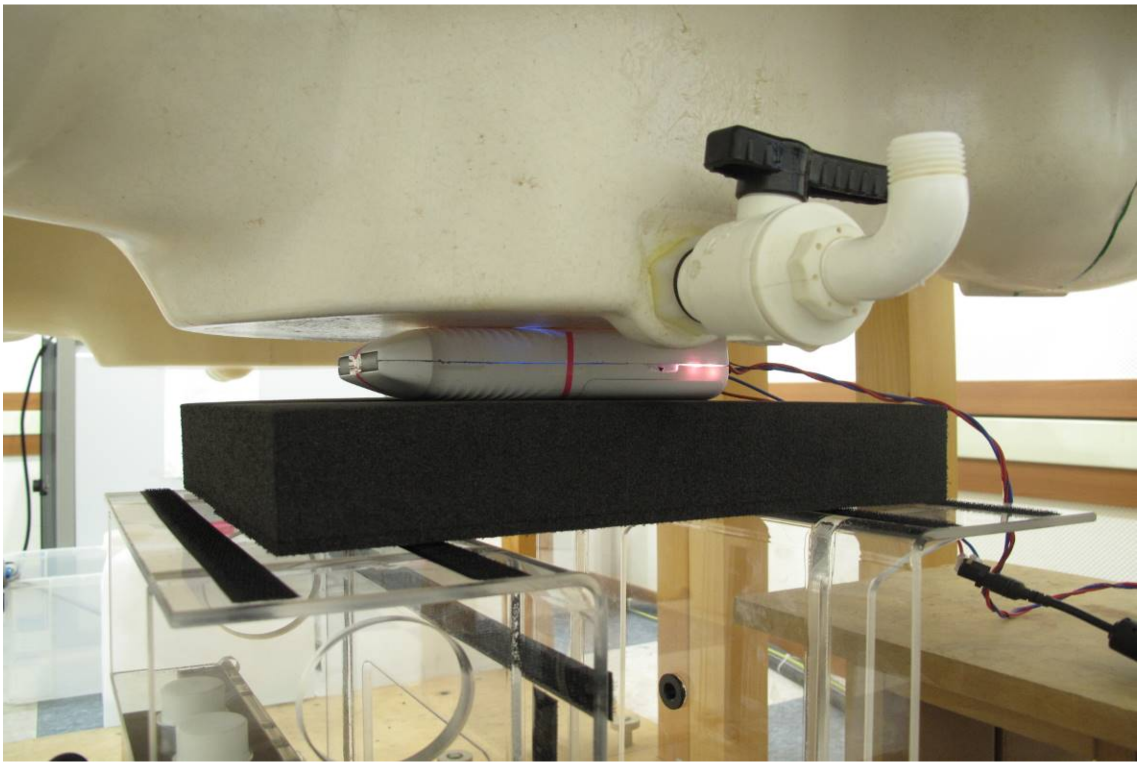


Back Side

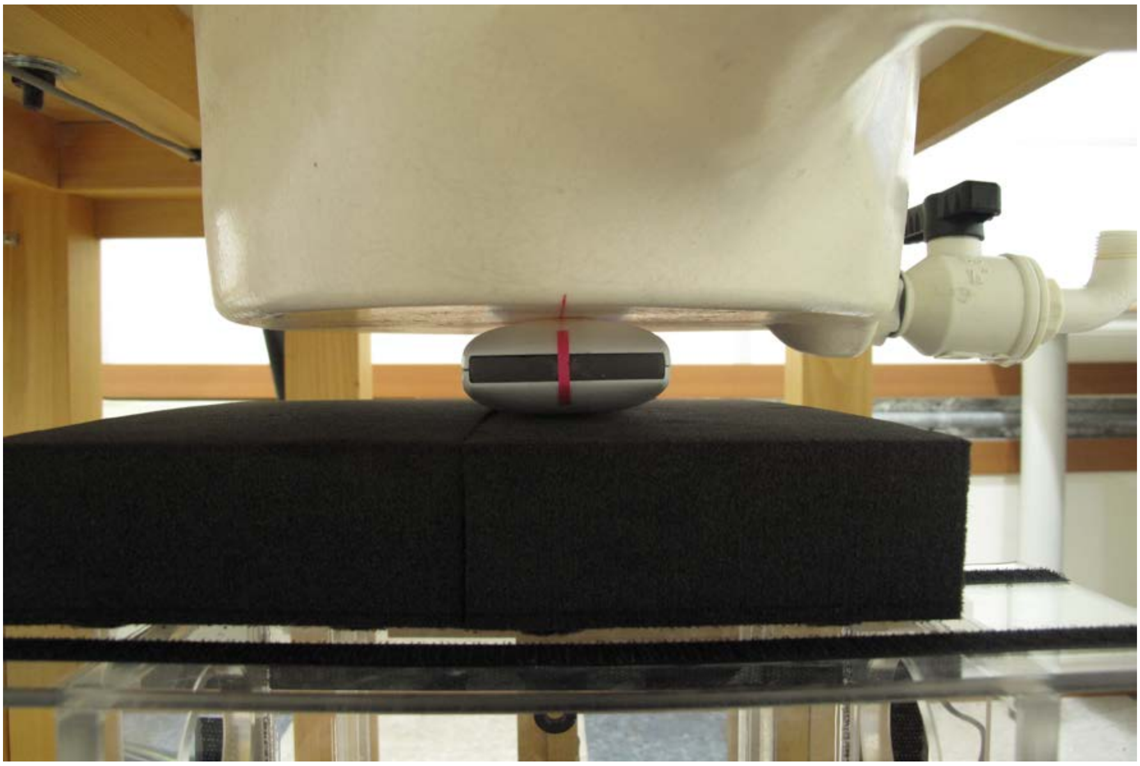
APPENDIX F: Photos of Test Set-up



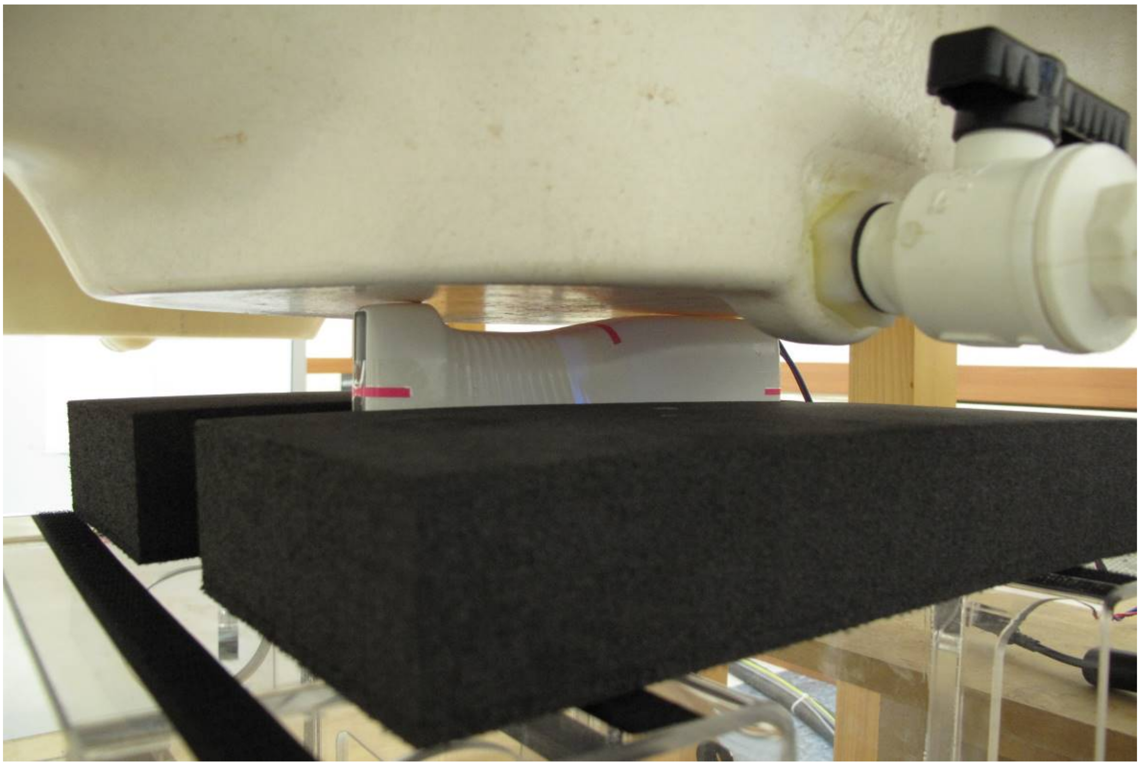
Test Jig (Lead wire length : 580mm)



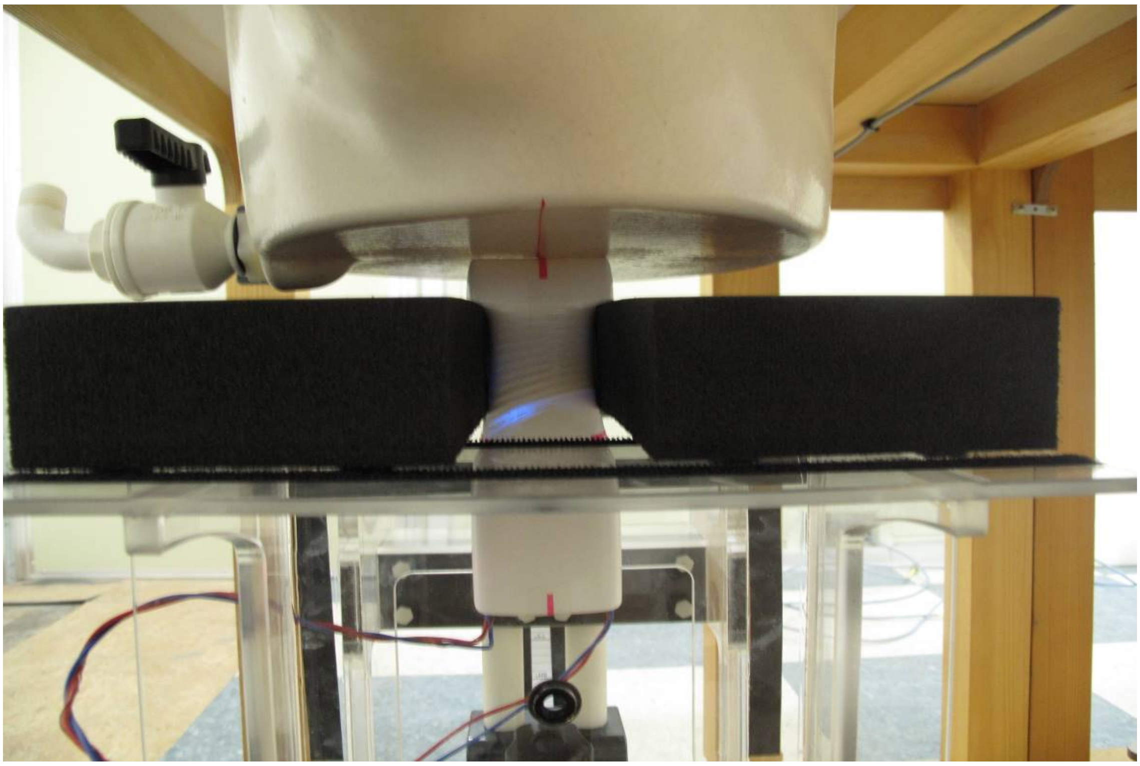
Body 0 mm, Front Side



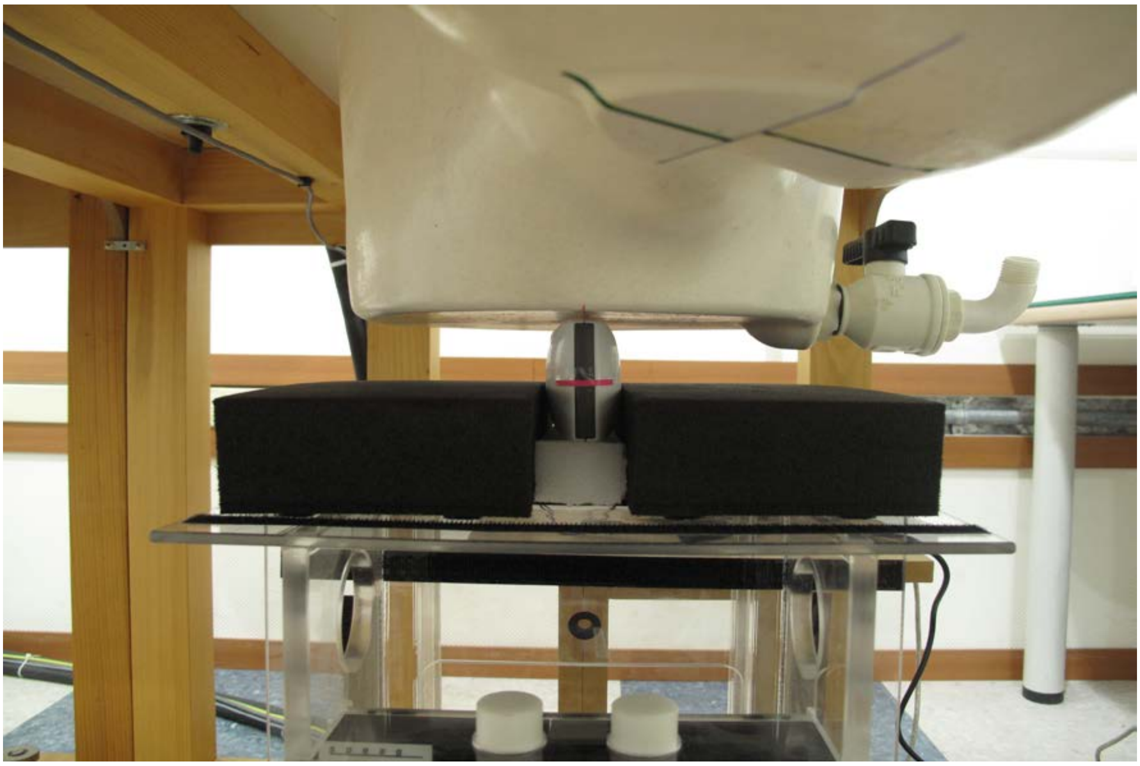
Body 0 mm. Back Side



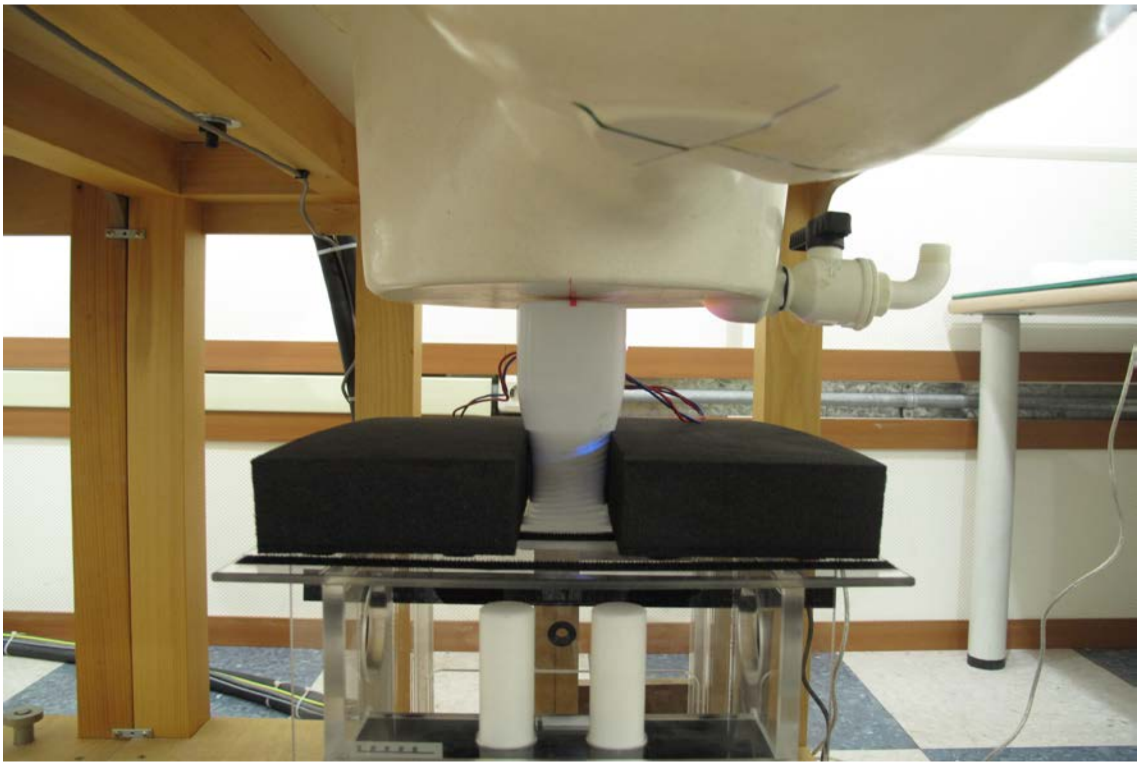
Body 0 mm, Right Side



Body 0 mm, Top Side



Body 0 mm, Left Side



Body 0 mm, Bottom Side