SAR TEST REPORT

No. I15Z40884-SEM02

For

Novatel Wireless, Inc.

MiFi Hotspot, LTE Only, Bands 2, 4, 5 , 12, 17

Model name: MiFi M100

With

Hardware Version: P2

Software Version: NVTL_USC_1.05

FCC ID: PKRNVWM100

Issued Date: 2015-06-25

TESTING
CNAS L0570

Note:

The test results in this test report relate only to the devices specified in this report. This report shall not be reproduced except in full without the written approval of CTTL.

Test Laboratory:

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REPORT HISTORY

Report Number	Revision	Issue Date	Description
I15Z40884-SEM02	Rev.0	2015-05-12	Initial creation of test report
I15Z40884-SEM02	Rev.1	2015-06-16	1. Update the model name 2. Add the conducted power for MIMO in section 11.3 on page 30 3. Remove the SAR values of unnecessary channels for LTE B4&B17 in table 13.1 on page 32 and table 13.3 on page 34 4. Update the SAR evaluation for WLAN based on the new version of KDB 248227 D01 in section 13 on page 35&36
I15Z40884-SEM02	Rev.2	2015-06-25	1. Add the tune up of MIMO in table 11.2 on page 21 2. Add the SAR test of MIMO in section 13 on page 37

TABLE OF CONTENT

1 Test Laboratory

1.1 Testing Location

Company Name:	CTTL(Shouxiang)
Address:	No. 51 Shouxiang Science Building, Xueyuan Road, Haidian District, Beijing, P. R. China100191

1.2 Testing Environment

Temperature:	18°C~25 °C,
Relative humidity:	30%~ 70%
Ground system resistance:	< 0.5 Ω
Ambient noise & Reflection:	< 0.012 W/kg

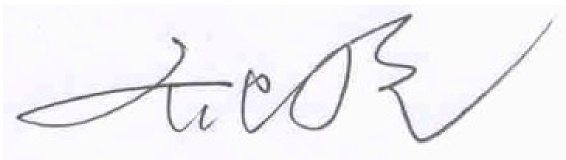
1.3 Project Data

Project Leader:	Qi Dianyuan
Test Engineer:	Lin Xiaojun
Testing Start Date:	April 17, 2015
Testing End Date:	April 25, 2015

1.4 Signature

Lin Xiaojun

(Prepared this test report)



Qi Dianyuan

(Reviewed this test report)

Xiao Li

Deputy Director of the laboratory

(Approved this test report)

2 Statement of Compliance

The maximum results of SAR found during testing for Novatel Wireless, Inc. MiFi Hotspot, LTE Only, Bands 2, 4, 5 , 12, 17 MiFi M100 are as follows:

Table 2.1: Highest Reported SAR (1g)

Exposure Configuration	Technology Band	Highest Reported SAR 1g (W/Kg)	Equipment Class
Body-worn (Separation Distance 10mm)	LTE Band 4	1.45	PCE
	LTE Band 12	0.80	
	LTE Band 17	0.88	
	WLAN antenna a	0.24	DTS
	WLAN antenna b	0.03	
	WLAN MIMO	0.01	

The SAR values found for the Mobile Phone are below the maximum recommended levels of 1.6 W/Kg as averaged over any 1g tissue according to the ANSI C95.1-1999.

For body worn operation, this device has been tested and meets FCC RF exposure guidelines when used with any accessory that contains no metal and which provides a minimum separation distance of 10 mm between this device and the body of the user. Use of other accessories may not ensure compliance with FCC RF exposure guidelines.

The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output.

The measurement together with the test system set-up is described in annex C of this test report. A detailed description of the equipment under test can be found in chapter 4 of this test report.
The highest reported SAR value is obtained at the case of **(Table 2.1),** and the values are**: 1.45 W/kg (1g).**

Table 2.2: The sum of reported SAR values for main antenna and WLAN

	Position	**LTE**	**WLAN**	**Sum**
Highest reported SAR value for Body	Front	0.88	0.24	**1.12**
	Rear	1.33	0.13	**1.46**
	Bottom	1.45	0.02	**1.47**

According to the above tables, the highest sum of reported SAR values is **1.47 W/kg (1g)**. The detail for simultaneous transmission consideration is described in chapter 13.

3 Client Information

3.1 Applicant Information

Company Name:	Novatel Wireless, Inc.
Address /Post:	9645 Scranton Road, Suite 205, San Diego, CA 92121, USA
City:	San Diego
Postal Code:	92121
Country:	USA
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Email:	bbabbitt@nvtl.com
Telephone:	+1 858-812-3420
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3.2 Manufacturer Information

Company Name:	Asia Telco Technologies Co.
Address /Post:	#289 Bisheng Road, Building-8,3F,Zhangjiang Hi-Tech Park,Pudong,Shanghai 201204,China
City:	Shanghai
Postal Code:	201204
Country:	China
Contact:	Shen Chao
Email:	cshen@asiatelco.com
Telephone:	+82-21-51688806-179
Fax:	+86-21-33932687

4 Equipment Under Test (EUT) and Ancillary Equipment (AE)

4.1 About EUT

Description:	MiFi Hotspot, LTE Only, Bands 2, 4, 5 , 12, 17
Model name:	MiFi M100
Operating mode(s):	LTE Band 2/4/5/12/17, WLAN
Tested Tx Frequency:	1720 – 1745 MHz (LTE Band 4)
	699.7 – 715.3 MHz (LTE Band 12)
	709 – 711 MHz (LTE Band 17)
	2412 – 2462 MHz (Wi-Fi 2.4G)
Test device Production information:	Production unit
Device type:	Portable device
Antenna type:	Integrated antenna

4.2 Internal Identification of EUT used during the test

EUT ID*	IMEI	HW Version	SW Version
EUT1	990003319901308	P2	NVTL_USC_1.05
EUT2	990003319901274	P2	NVTL_USC_1.05
EUT3	990003319901266	P2	NVTL_USC_1.05

*EUT ID: is used to identify the test sample in the lab internally.

Note: It is performed to test SAR with the EUT1&2 and conducted power with the EUT 3.

4.3 Internal Identification of AE used during the test

AE ID*	Description	Model	SN	Manufacturer
AE1	Battery	40115126	/	BYD

*AE ID: is used to identify the test sample in the lab internally.

5 TEST METHODOLOGY

5.1 Applicable Limit Regulations

ANSI C95.1–1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

It specifies the maximum exposure limit of **1.6 W/kg** as averaged over any 1 gram of tissue for portable devices being used within 20 cm of the user in the uncontrolled environment.

5.2 Applicable Measurement Standards

IEEE 1528–2003: Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques.

KDB447498 D01: General RF Exposure Guidance v05r02: Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.

KDB648474 D04 Handset SAR v01r02: SAR Evaluation Considerations for Wireless Handsets.

KDB941225 D05 SAR for LTE Devices v02r03: SAR Evaluation Considerations for LTE Devices

KDB941225 D06 Hotspot Mode SAR v02: SAR Evaluation Procedures for Portable Devices with Wireless Router Capabilities

KDB248227 D01 802.11 Wi-Fi SAR v02: SAR GUIDANCE FOR IEEE 802.11 (Wi-Fi) TRANSMITTERS

KDB 865664 D01SAR measurement 100 MHz to 6 GHz v01r03: SAR Measurement Requirements for 100 MHz to 6 GHz.

KDB865664 D02RF Exposure Reporting v01r01: RF Exposure Compliance Reporting and Documentation Considerations

6 Specific Absorption Rate (SAR)

6.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

6.2 SAR Definition

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ) . The equation description is as below:

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dv}\right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be either related to the temperature elevation in tissue by

$$SAR = c\left(\frac{\delta T}{\delta t}\right)$$

Where: C is the specific head capacity, δT is the temperature rise and δt is the exposure duration, or related to the electrical field in the tissue by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of tissue and E is the RMS electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

7 Tissue Simulating Liquids

7.1 Targets for tissue simulating liquid

Table 7.1: Targets for tissue simulating liquid

Frequency(MHz)	Liquid Type	Conductivity(σ)	± 5% Range	Permittivity(ε)	± 5% Range
750	Head	0.89	0.85～0.93	41.94	39.8～44.0
750	Body	0.96	0.91～1.01	55.5	52.7～58.3
1750	Head	1.37	1.30～1.44	40.08	38.1～42.1
1750	Body	1.49	1.42～1.56	53.4	50.7～56.1
2450	Head	1.80	1.71～1.89	39.2	37.2～41.2
2450	Body	1.95	1.85～2.05	52.7	50.1～55.3

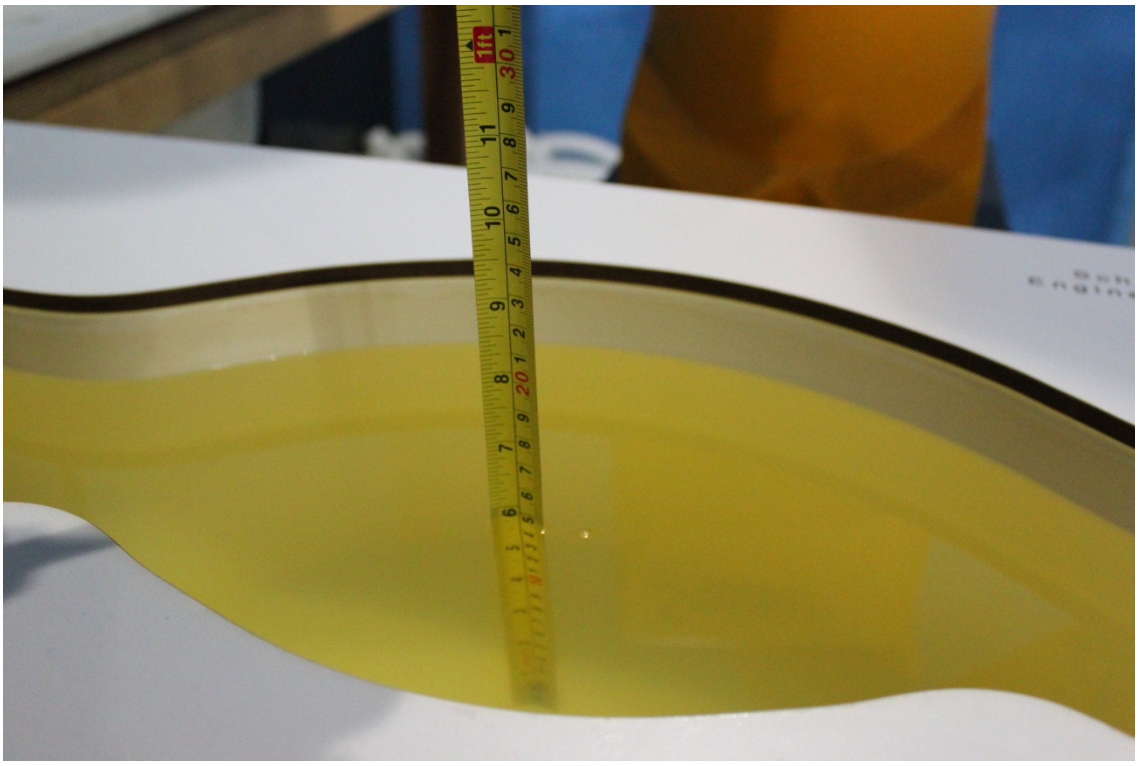
7.2 Dielectric Performance

Table 7.2: Dielectric Performance of Tissue Simulating Liquid

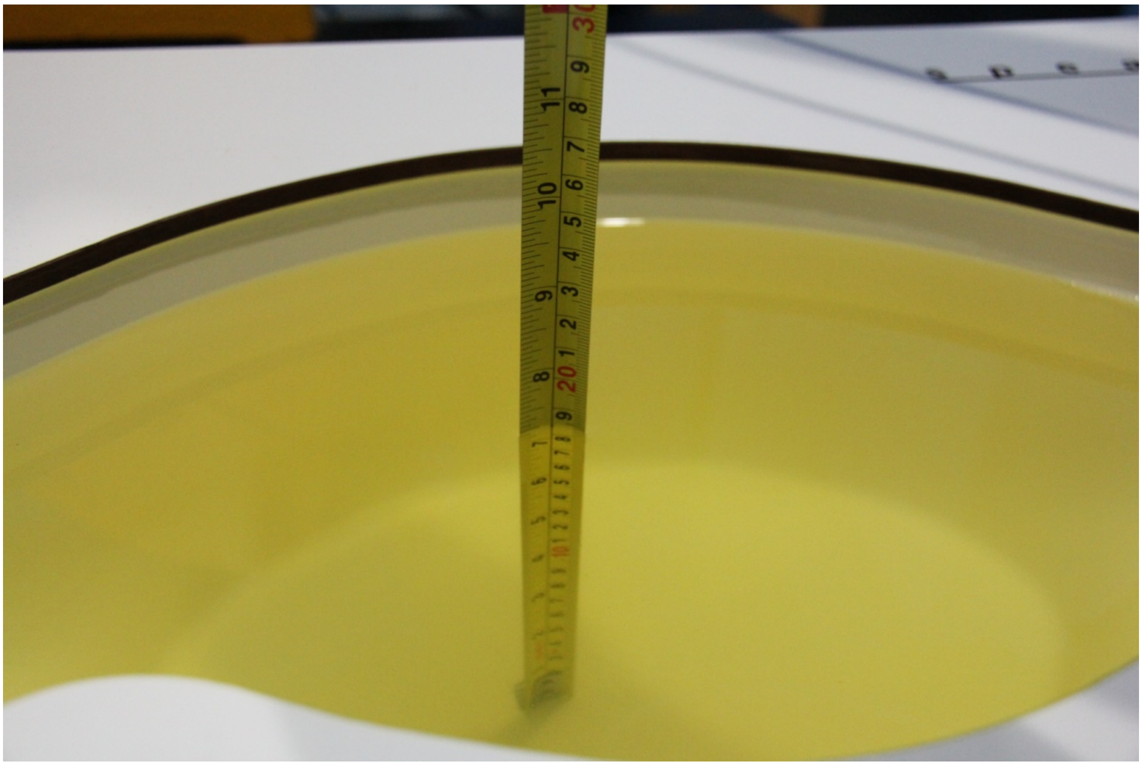
Measurement Date (yyyy-mm-dd)	Type	Frequency	Permittivity ε	Drift (%)	Conductivity σ (S/m)	Drift (%)
2015-04-24	Body	750 MHz	57.38	3.39	0.936	-2.50
2015-04-17	Body	1750 MHz	54.54	2.13	1.493	0.20
2015-04-25	Body	2450 MHz	50.62	-3.95	2.02	3.59

Note: The liquid temperature is 22.0℃

Picture 7-1: Liquid depth in the Flat Phantom (750 MHz)



Picture 7-2 Liquid depth in the Flat Phantom (1750MHz)

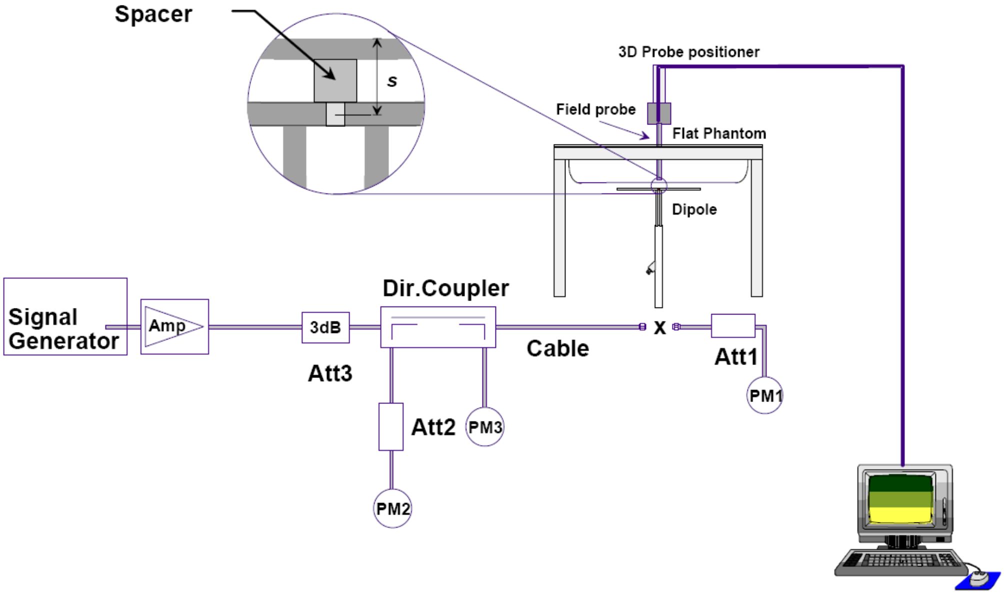


Picture 7-3 Liquid depth in the Flat Phantom (2450MHz)

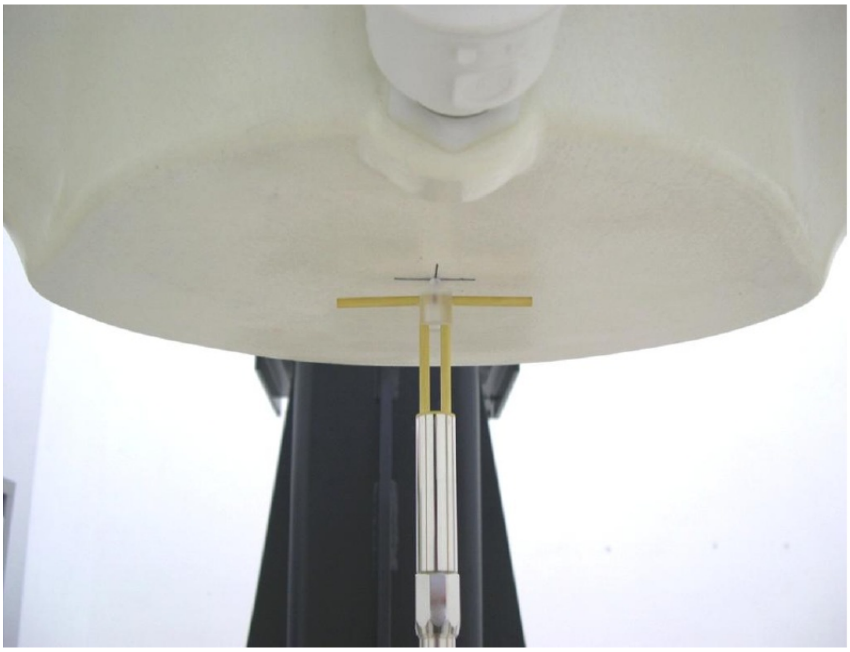
8 System verification

8.1 System Setup

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



Picture 8.1 System Setup for System Evaluation



Picture 8.2 Photo of Dipole Setup

8.2 System Verification

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device.

The system verification results are required that the area scan estimated 1-g SAR is within 3% of the zoom scan 1-g SAR. The details are presented in annex B.

Table 8.1: System Verification of Body

Measurement Date (yyyy-mm-dd)	Frequency	Target value (W/kg)		Measured value (W/kg)		Deviation	
		10 g Average	1 g Average	10 g Average	1 g Average	10 g Average	1 g Average
2015-04-24	750 MHz	5.85	8.75	5.92	8.92	1.20%	1.94%
2015-04-17	1750 MHz	20.3	37.7	20.04	37.28	-1.28%	-1.11%
2015-04-25	2450 MHz	23.9	51.3	23.52	50.40	-1.59%	-1.75%

9 Measurement Procedures

9.1 Tests to be performed

In order to determine the highest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes shall be tested for each frequency band according to steps 1 to 3 below. A flowchart of the test process is shown in picture 9.1.

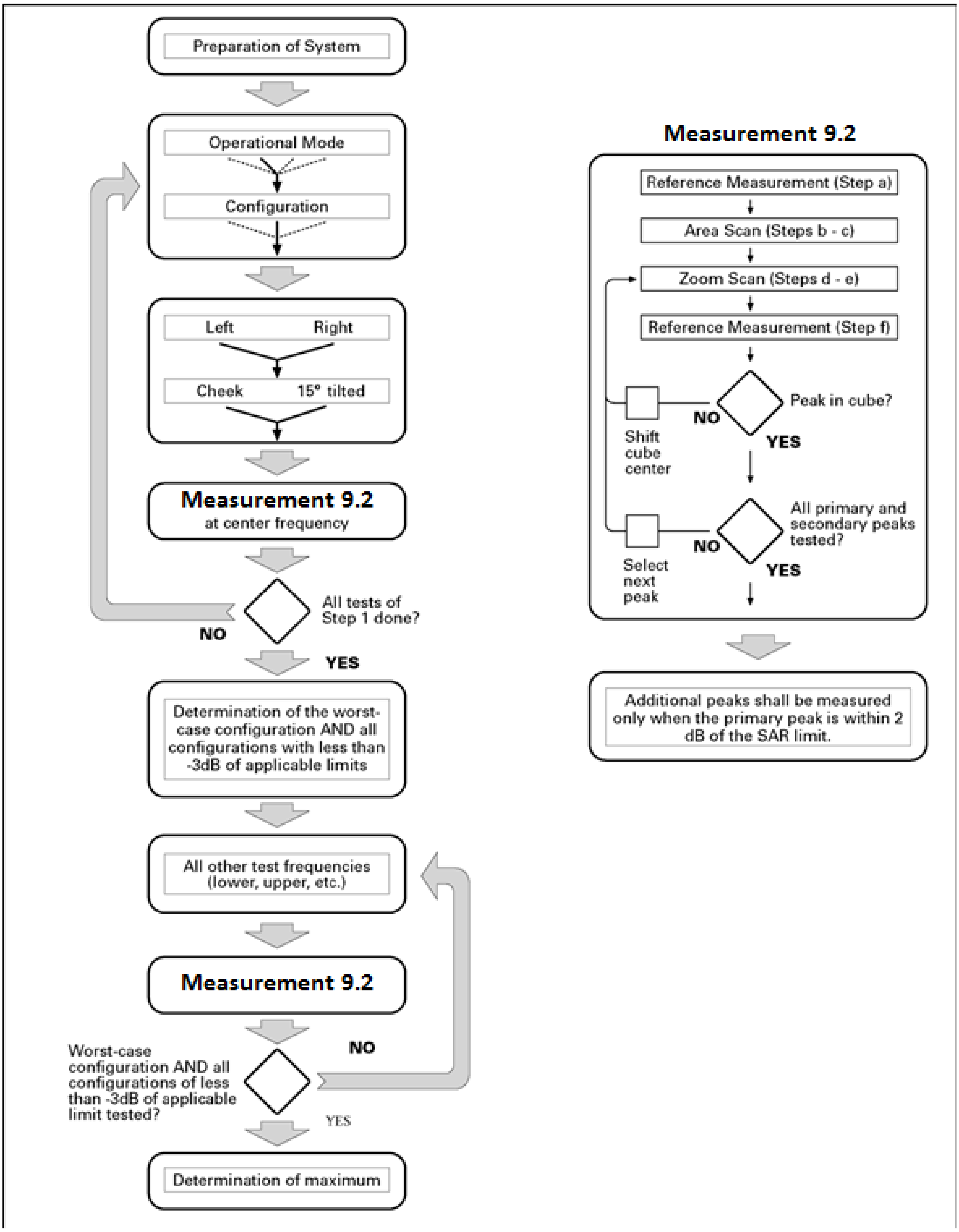
Step 1: The tests described in 9.2 shall be performed at the channel that is closest to the centre of the transmit frequency band (f_c) for:

a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom, as described in annex D),
b) all configurations for each device position in a), e.g., antenna extended and retracted, and
c) all operational modes, e.g., analogue and digital, for each device position in a) and configuration in b) in each frequency band.

If more than three frequencies need to be tested according to 11.1 (i.e., N_c > 3), then all frequencies, configurations and modes shall be tested for all of the above test conditions.

Step 2: For the condition providing highest peak spatial-average SAR determined in Step 1, perform all tests described in 9.2 at all other test frequencies, i.e., lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the peak spatial-average SAR value determined in Step 1 is within 3 dB of the applicable SAR limit, it is recommended that all other test frequencies shall be tested as well.

Step 3: Examine all data to determine the highest value of the peak spatial-average SAR found in Steps 1 to 2.



Picture 9.1 Block diagram of the tests to be performed

9.2 General Measurement Procedure

The area and zoom scan resolutions specified in the table below must be applied to the SAR measurements and fully documented in SAR reports to qualify for TCB approval. Probe boundary effect error compensation is required for measurements with the probe tip closer than half a probe tip diameter to the phantom surface. Both the probe tip diameter and sensor offset distance must satisfy measurement protocols; to ensure probe boundary effect errors are minimized and the higher fields closest to the phantom surface can be correctly measured and extrapolated to the phantom surface for computing 1-g SAR. Tolerances of the post-processing algorithms must be verified by the test laboratory for the scan resolutions used in the SAR measurements, according to the reference distribution functions specified in IEEE Std 1528-2003. The results should be documented as part of the system validation records and may be requested to support test results when all the measurement parameters in the following table are not satisfied.

<table>
<tr><td colspan="3"></td><td>≤ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 ± 1 mm</td><td>$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>≤ 2 GHz: ≤ 15 mm
2 – 3 GHz: ≤ 12 mm</td><td>3 – 4 GHz: ≤ 12 mm
4 – 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>≤ 2 GHz: ≤ 8 mm
2 – 3 GHz: ≤ 5 mm*</td><td>3 – 4 GHz: ≤ 5 mm*
4 – 6 GHz: ≤ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>≤ 5 mm</td><td>3 – 4 GHz: ≤ 4 mm
4 – 5 GHz: ≤ 3 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>≤ 4 mm</td><td>3 – 4 GHz: ≤ 3 mm
4 – 5 GHz: ≤ 2.5 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>≥ 30 mm</td><td>3 – 4 GHz: ≥ 28 mm
4 – 5 GHz: ≥ 25 mm
5 – 6 GHz: ≥ 22 mm</td></tr>
<tr><td colspan="5">Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details.
* When zoom scan is required and the <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</td></tr>
</table>

9.3 SAR Measurement for LTE

SAR tests for LTE are performed with a base station simulator, Rohde & Rchwarz CMW500. Closed loop power control was used so the UE transmits with maximum output power during SAR testing. All powers were measured with the CMW 500.

It is performed for conducted power and SAR based on the KDB941225 D05.

SAR is evaluated separately according to the following procedures for the different test positions in each exposure condition – head, body, body-worn accessories and other use conditions. The procedures in the following subsections are applied separately to test each LTE frequency band.

1) QPSK with 1 RB allocation
   Start with the largest channel bandwidth and measure SAR for QPSK with 1 RB allocation, using the RB offset and required test channel combination with the highest maximum output power among RB offsets at the upper edge, middle and lower edge of each required test channel. When the reported SAR is ≤ 0.8 W/kg, testing of the remaining RB offset configurations and required test channels is not required for 1 RB allocation; otherwise, SAR is required for the remaining required test channels and only for the RB offset configuration with the highest output power for that channel. When the reported SAR of a required test channel is > 1.45 W/kg, SAR is required for all three RB offset configurations for that required test channel.
2) QPSK with 50% RB allocation
   The procedures required for 1 RB allocation in 1) are applied to measure the SAR for QPSK with 50% RB allocation.
3) QPSK with 100% RB allocation
   For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations and the highest reported SAR for 1 RB and 50% RB allocation in 1) and 2) are ≤ 0.8 W/kg. Otherwise, SAR is measured for the highest output power channel; and if the reported SAR is > 1.45 W/kg, the remaining required test channels must also be tested.

9.4 Bluetooth & Wi-Fi Measurement Procedures for SAR

Normal network operating configurations are not suitable for measuring the SAR of 802.11 transmitters in general. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure that the results are consistent and reliable.

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in a test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements.

9.5 Power Drift

To control the output power stability during the SAR test, DASY4 system calculates the power drift by measuring the E-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in Table 13.1 to Table 13.5 labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

10 Area Scan Based 1-g SAR

10.1 Requirement of KDB

According to the KDB447498 D01 v05, when the implementation is based the specific polynomial fit algorithm as presented at the 29th Bioelectromagnetics Society meeting (2007) and the estimated 1-g SAR is ≤ 1.2 W/kg, a zoom scan measurement is not required provided it is also not needed for any other purpose; for example, if the peak SAR location required for simultaneous transmission SAR test exclusion can be determined accurately by the SAR system or manually to discriminate between distinctive peaks and scattered noisy SAR distributions from area scans.

There must not be any warning or alert messages due to various measurement concerns identified by the SAR system; for example, noise in measurements, peaks too close to scan boundary, peaks are too sharp, spatial resolution and uncertainty issues etc. The SAR system verification must also demonstrate that the area scan estimated 1-g SAR is within 3% of the zoom scan 1-g SAR (See Annex B). When all the SAR results for each exposure condition in a frequency band and wireless mode are based on estimated 1-g SAR, the 1-g SAR for the highest SAR configuration must be determined by a zoom scan.

10.2 Fast SAR Algorithms

The approach is based on the area scan measurement applying a frequency dependent attenuation parameter. This attenuation parameter was empirically determined by analyzing a large number of phones. The MOTOROLA FAST SAR was developed and validated by the MOTOROLA Research Group in Ft. Lauderdale.

In the initial study, an approximation algorithm based on Linear fit was developed. The accuracy of the algorithm has been demonstrated across a broad frequency range (136-2450 MHz) and for both 1- and 10-g averaged SAR using a sample of 264 SAR measurements from 55 wireless handsets. For the sample size studied, the root-mean-squared errors of the algorithm are 1.2% and 5.8% for 1- and 10-g averaged SAR, respectively. The paper describing the algorithm in detail is expected to be published in August 2004 within the Special Issue of Transactions on MTT.

In the second step, the same research group optimized the fitting algorithm to an Polynomial fit whereby the frequency validity was extended to cover the range 30-6000MHz. Details of this study can be found in the BEMS 2007 Proceedings.

Both algorithms are implemented in DASY software.

11 Conducted Output Power

11.1 Manufacturing tolerance

Table 11.1: LTE

Mode	Bandwidth (MHz)	RB allocation	QPSK		16QAM	
			Target (dBm)	Tune-up dBm)	Target (dBm)	Tune-up (dBm)
LTE Band 4	1.4	1RB&50%RB	23	25	22	24
		100%RB	22	24	21	23
	3&5&10&15	1RB&50%RB	23	25	22	24
		100%RB	22	24	21	23
	20	1RB	22	24	22	24
		50%RB&100%RB	22	24	21	23
LTE Band 12	1.4	1RB&50%RB	23	25	23	25
		100%RB	23	25	22	24
	3&5&10	1RB	23	25	23	25
		50%RB&100%RB	23	25	22	24
LTE Band 17	5&10	1RB	23	25	23	25
		50%RB&100%RB	23	25	22	24

Table 11.2: WiFi

Antenna a		
Mode	Target (dBm)	Tune-up (dBm)
802.11b	13.5	15.5
802.11g	8	10
802.11n-20M MCS0~MCS7	8	10
802.11n-20M MCS8~MCS13	7	9
802.11n-20M MCS14~MCS15	6	8
802.11n-40M MCS0~MCS7	6.5	8.5
802.11n-40M MCS8~MCS12	6	8
802.11n-40M MCS13~MCS15	5	7
Antenna b		
802.11b	13.5	15.5
802.11g 6Mbps~12Mbps	9	11
802.11g 18Mbps~36Mbps	8	10
802.11g 48Mbps~54Mbps	7	9
802.11n-20M MCS0~MCS2; MCS8~MCS11	8.5	10.5
802.11n-20M MCS3~MCS5; MCS12~MCS15	7.5	9.5
802.11n-20M MCS6~MCS7	7	9
802.11n-40M MCS0~MCS1	8	10
802.11n-40M MCS2~MCS4; MCS8~MCS11	7	9
802.11n-40M MCS5~MCS6; MCS12~MCS15	6	8
802.11n-40M MCS7	5	7
MIMO		
802.11n-20M/40M MCS0	10.5	12.5

11.2 LTE Measurement result

Table 11.3: The conducted Power for LTE

Band 4				
Bandwidth (MHz)	RB allocation / RB offset	Frequency (MHz)	Actual output power (dBm)	
			QPSK	16QAM
1.4 MHz	1RB_High	1754.3	23.32	22.50
		1732.5	23.69	22.87
		1710.7	23.25	22.39
	1RB_Middle	1754.3	23.36	22.69
		1732.5	23.70	23.05
		1710.7	23.35	22.60
	1RB_Low	1754.3	23.42	22.59
		1732.5	23.77	22.86
		1710.7	23.21	22.33
	3RB_High	1754.3	23.49	22.74
		1732.5	23.67	22.80
		1710.7	23.32	22.45
	3RB_Middle	1754.3	23.32	22.43
		1732.5	23.64	22.72
		1710.7	23.35	22.28
	3RB_Low	1754.3	23.51	22.76
		1732.5	23.78	22.82
		1710.7	23.36	22.47
	6RB	1754.3	22.37	21.65
		1732.5	22.69	21.97
		1710.7	22.26	21.52
3 MHz	1RB_High	1753.5	23.42	23.09
		1732.5	23.75	23.37
		1711.5	23.23	22.97
	1RB_Middle	1753.5	23.55	22.72
		1732.5	23.74	23.06
		1711.5	23.37	23.15
	1RB_Low	1753.5	23.64	23.16
		1732.5	23.69	23.32
		1711.5	23.20	22.99
	8RB_High	1753.5	22.45	21.49
		1732.5	22.67	21.68
		1711.5	22.36	21.55
	8RB_Middle	1753.5	22.30	21.59
		1732.5	22.58	21.78
		1711.5	22.09	21.31

	8RB_Low	1753.5	22.68	21.65
		1732.5	22.63	21.80
		1711.5	22.31	21.53
	15RB	1753.5	22.44	21.62
		1732.5	22.61	21.77
		1711.5	22.23	21.34
5 MHz	1RB_High	1752.5	23.32	22.62
		1732.5	23.68	23.06
		1712.5	23.19	22.37
	1RB_Middle	1752.5	23.61	23.05
		1732.5	23.88	23.23
		1712.5	23.39	22.66
	1RB_Low	1752.5	23.71	22.80
		1732.5	23.82	22.94
		1712.5	23.13	22.27
	12RB_High	1752.5	22.35	21.30
		1732.5	22.71	21.78
		1712.5	22.57	21.72
	12RB_Middle	1752.5	22.45	21.55
		1732.5	22.58	21.74
		1712.5	22.29	21.37
	12RB_Low	1752.5	22.53	21.55
		1732.5	22.69	21.70
		1712.5	22.36	21.57
	25RB	1752.5	22.37	21.62
		1732.5	22.72	21.87
		1712.5	22.25	21.46
10MHz	1RB_High	1750	23.23	23.23
		1732.5	23.85	23.36
		1715	23.48	23.10
	1RB_Middle	1750	23.33	22.75
		1732.5	23.70	22.79
		1715	23.45	23.23
	1RB_Low	1750	23.66	23.37
		1732.5	23.61	23.36
		1715	23.23	22.83
	25RB_High	1750	22.41	21.34
		1732.5	22.91	22.00
		1715	22.51	21.61
	25RB_Middle	1750	22.38	21.46
		1732.5	22.62	21.75
		1715	22.43	21.46

	25RB_Low	1750	22.77	21.74
		1732.5	22.76	21.78
		1715	22.68	21.56
	50RB	1750	22.41	21.49
		1732.5	22.73	21.80
		1715	22.37	21.50
15MHz	1RB_High	1747.5	23.24	23.12
		1732.5	23.67	23.46
		1717.5	23.54	23.20
	1RB_Middle	1747.5	23.48	23.12
		1732.5	23.72	22.67
		1717.5	23.43	23.34
	1RB_Low	1747.5	23.61	23.33
		1732.5	23.53	23.33
		1717.5	23.37	22.82
	36RB_High	1747.5	22.56	21.44
		1732.5	22.97	21.61
		1717.5	22.49	21.42
	36RB_Middle	1747.5	22.61	21.68
		1732.5	22.56	21.87
		1717.5	22.35	21.49
	36RB_Low	1747.5	22.89	21.63
		1732.5	22.65	21.57
		1717.5	22.69	21.54
	75RB	1747.5	22.55	21.66
		1732.5	22.68	21.83
		1717.5	22.43	21.62
20MHz	1RB_High	1745	23.55	22.82
		1732.5	23.84	23.20
		1720	23.53	23.09
	1RB_Middle	1745	23.63	22.96
		1732.5	23.86	23.70
		1720	23.52	23.19
	1RB_Low	1745	23.59	23.02
		1732.5	23.58	23.09
		1720	23.33	22.68
	50RB_High	1745	22.80	21.81
		1732.5	22.64	21.64
		1720	22.68	21.56
	50RB_Middle	1745	22.78	21.83
		1732.5	22.49	21.60
		1720	22.38	21.55

	50RB_Low	1745	22.62	21.72
		1732.5	22.70	21.66
		1720	22.79	21.43
	100RB	1745	22.59	21.75
		1732.5	22.67	21.87
		1720	22.31	21.59
Band 12				
Bandwidth (MHz)	RB allocation	Frequency (MHz)	Actual output power (dBm)	
	RB offset		QPSK	16QAM
1.4 MHz	1RB_High	715.3	24.37	23.40
		707.5	24.59	23.71
		699.7	24.49	23.52
	1RB_Middle	715.3	24.33	23.52
		707.5	24.95	24.05
		699.7	24.75	23.80
	1RB_Low	715.3	24.14	23.25
		707.5	24.84	23.85
		699.7	24.54	23.63
	3RB_High	715.3	24.32	23.61
		707.5	24.69	23.77
		699.7	24.66	23.70
	3RB_Middle	715.3	24.04	23.06
		707.5	24.59	23.64
		699.7	24.36	23.40
	3RB_Low	715.3	24.38	23.48
		707.5	24.68	23.80
		699.7	24.93	23.90
	6RB	715.3	23.31	22.49
		707.5	23.54	22.75
		699.7	23.49	22.69
3 MHz	1RB_High	714.5	24.49	23.66
		707.5	24.34	23.98
		700.5	24.46	23.88
	1RB_Middle	714.5	24.32	23.59
		707.5	24.69	23.94
		700.5	24.57	24.18
	1RB_Low	714.5	24.37	23.67
		707.5	24.58	24.14
		700.5	24.71	24.26
	8RB_High	714.5	23.69	22.69
		707.5	23.63	22.68
		700.5	23.97	22.86

	8RB_Middle	714.5	23.16	22.34
		707.5	23.47	22.65
		700.5	23.41	22.55
	8RB_Low	714.5	23.42	22.44
		707.5	23.76	22.73
		700.5	23.77	22.84
	15RB	714.5	23.25	22.35
		707.5	23.51	22.60
		700.5	23.52	22.61
5 MHz	1RB_High	713.5	24.28	23.33
		707.5	24.53	23.62
		701.5	24.33	23.44
	1RB_Middle	713.5	24.44	23.84
		707.5	24.72	23.96
		701.5	24.64	23.74
	1RB_Low	713.5	24.31	23.43
		707.5	24.47	23.65
		701.5	24.58	23.60
	12RB_High	713.5	23.35	22.58
		707.5	23.60	22.52
		701.5	23.77	22.64
	12RB_Middle	713.5	23.14	22.23
		707.5	23.71	22.70
		701.5	23.64	22.49
	12RB_Low	713.5	23.47	22.64
		707.5	23.66	22.62
		701.5	23.91	22.73
	25RB	713.5	23.27	22.41
		707.5	23.50	22.62
		701.5	23.36	22.53
10MHz	1RB_High	711	24.20	23.76
		707.5	24.35	23.87
		704	24.73	24.23
	1RB_Middle	711	24.97	24.00
		707.5	24.88	24.14
		704	24.96	24.16
	1RB_Low	711	24.79	24.30
		707.5	24.70	24.25
		704	24.40	24.06
	25RB_High	711	23.73	22.69
		707.5	23.84	22.77
		704	23.86	23.24

	25RB_Middle	711	23.48	22.59
		707.5	23.77	22.72
		704	23.68	22.70
	25RB_Low	711	24.20	23.09
		707.5	24.03	22.93
		704	23.87	22.95
	50RB	711	23.40	22.50
		707.5	23.50	22.54
		704	23.67	22.72
Band 17				
Bandwidth (MHz)	RB allocation	Frequency (MHz)	Actual output power (dBm)	
	RB offset		QPSK	16QAM
5 MHz	1RB_High	713.5	24.34	23.36
		710	24.37	23.48
		706.5	24.66	23.56
	1RB_Middle	713.5	24.51	23.95
		710	24.81	23.98
		706.5	24.80	23.74
	1RB_Low	713.5	24.49	23.53
		710	24.61	23.51
		706.5	24.38	23.50
	12RB_High	713.5	23.39	22.33
		710	23.58	22.55
		706.5	23.56	22.60
	12RB_Middle	713.5	23.24	22.18
		710	23.27	22.27
		706.5	23.64	22.56
	12RB_Low	713.5	23.48	22.50
		710	23.59	22.57
		706.5	23.47	22.36
	25RB	713.5	23.43	22.52
		710	23.36	22.42
		706.5	23.58	22.59
10MHz	1RB_High	711	24.35	23.71
		710	24.40	23.75
		709	24.41	23.75
	1RB_Middle	711	24.77	23.67
		710	24.73	23.68
		709	24.88	23.80
	1RB_Low	711	24.58	24.09
		710	24.59	23.86
		709	24.59	23.73

	25RB_High	711	23.45	22.52
		710	23.62	22.55
		709	23.55	22.48
	25RB_Middle	711	23.43	22.43
		710	23.61	22.57
		709	23.61	22.56
	25RB_Low	711	23.84	22.80
		710	23.53	22.65
		709	23.82	22.75
	50RB	711	23.31	22.29
		710	23.36	22.33
		709	23.31	22.27

11.3 Wi-Fi Measurement result

Antenna a

802.11b (dBm)

Channel\data rate	1Mbps	2Mbps	5.5Mbps	11Mbps
1	14.21	14.16	13.91	13.85
6	14.20	/	/	/
11	14.01	/	/	/

802.11g (dBm)

Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
1	9.50	9.32	9.19	9.07	8.92	8.56	8.34	8.24
6	9.49	/	/	/	/	/	/	/
11	9.38	/	/	/	/	/	/	/

802.11n (dBm) - HT20 (2.4G)

Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
1	9.49	9.31	9.06	8.85	8.42	8.23	8.14	8.15
6	9.48	/	/	/	/	/	/	/
11	9.35	/	/	/	/	/	/	/
Channel\data rate	MCS8	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15
1	8.53	8.06	7.82	8.18	7.60	7.59	7.29	7.14
6	/	/	/	/	/	/	/	/
11	/	/	/	/	/	/	/	/

802.11n (dBm) – HT40 (2.4G)

Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
3	8.49	8.13	7.86	7.57	7.12	6.79	6.65	6.53
6	8.47	/	/	/	/	/	/	/
9	8.41	/	/	/	/	/	/	/
Channel\data rate	MCS8	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15
3	7.52	7.01	6.89	6.60	6.83	6.23	6.04	5.95
6	/	/	/	/	/	/	/	/
9	/	/	/	/	/	/	/	/

Antenna b

802.11b (dBm)

Channel\data rate	1Mbps	2Mbps	5.5Mbps	11Mbps
1	15.24	14.59	14.16	14.07
6	14.67	/	/	/
11	15.12	/	/	/

802.11g (dBm)

Channel\data rate	6Mbps	9Mbps	12Mbps	18Mbps	24Mbps	36Mbps	48Mbps	54Mbps
1	9.79	/	/	/	/	/	/	/
6	10.05	/	/	/	/	/	/	/
11	10.52	9.31	9.81	9.13	8.49	8.56	8.65	7.70

802.11n (dBm) - HT20 (2.4G)

Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
1	10.15	9.42	9.07	8.47	8.67	8.29	8.16	8.06
6	10.13	/	/	/	/	/	/	/
11	9.44	/	/	/	/	/	/	/
Channel\data rate	MCS8	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15
1	9.32	9.08	8.99	8.81	8.46	8.38	8.23	8.22
6	/	/	/	/	/	/	/	/
11	/	/	/	/	/	/	/	/

802.11n (dBm) – HT40 (2.4G)

Channel\data rate	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	MCS7
3	9.53	8.51	8.00	7.37	7.13	6.89	6.32	5.69
6	8.69	/	/	/	/	/	/	/
9	9.23	/	/	/	/	/	/	/
Channel\data rate	MCS8	MCS9	MCS10	MCS11	MCS12	MCS13	MCS14	MCS15
3	8.68	7.85	7.61	7.36	7.37	7.06	6.94	6.79
6	/	/	/	/	/	/	/	/
9	/	/	/	/	/	/	/	/

MIMO

802.11n (dBm) - HT20 (2.4G) – MCS0

Test Result (dBm)								
2412MHz (Ch1)			2437MHz (Ch6)			2462MHz (Ch11)		
Antenna a	Antenna b	Sum	Antenna a	Antenna b	Sum	Antenna a	Antenna b	Sum
8.53	9.32	11.95	8.55	9.35	11.98	8.24	9.92	12.17

802.11n (dBm) – HT40 (2.4G) – MCS0

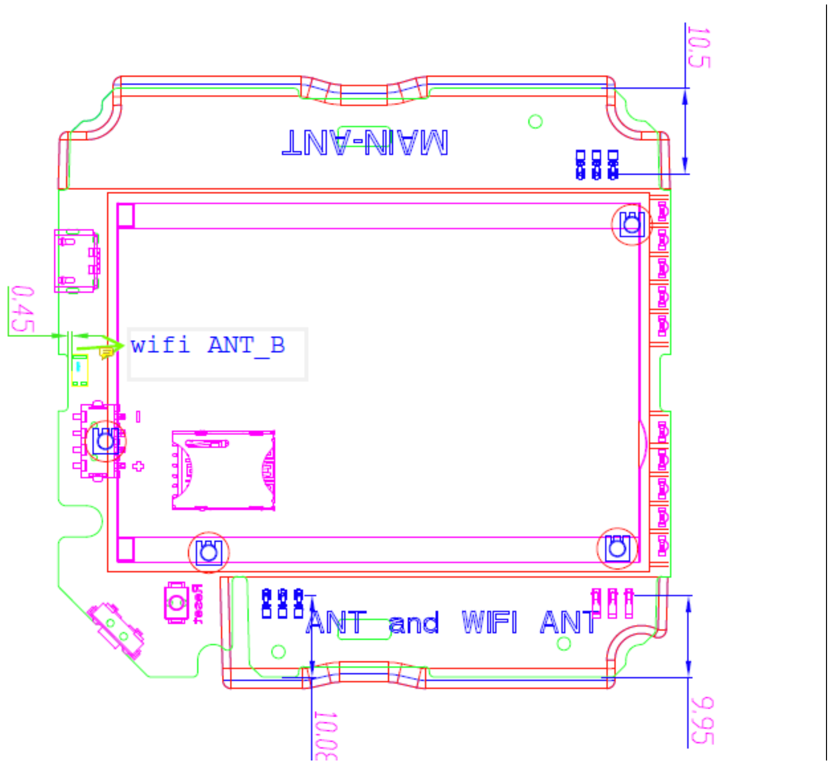
Test Result (dBm)								
2422MHz (Ch3)			2437MHz (Ch6)			2452MHz (Ch9)		
Antenna a	Antenna b	Sum	Antenna a	Antenna b	Sum	Antenna a	Antenna b	Sum
7.52	8.68	11.15	7.76	8.41	11.11	7.56	8.85	11.26

12 Simultaneous TX SAR Considerations

12.1 Introduction

The following procedures adopted from “FCC SAR Considerations for Cell Phones with Multiple Transmitters” are applicable to handsets with built-in unlicensed transmitters such as 802.11 a/b/g and Bluetooth devices which may simultaneously transmit with the licensed transmitter. For this device, the Wi-Fi can transmit simultaneous with other transmitters.

12.2 Transmit Antenna Separation Distances



Picture 12.1 Antenna Locations

Table 12.1: The sum of reported SAR values for main antenna and WLAN

	Position	LTE	WLAN	Sum
Highest reported SAR value for Body	Front	0.88	0.24	**1.12**
	Rear	1.33	0.13	**1.46**
	Bottom	1.45	0.02	**1.47**

Conclusion:

According to the above tables, the sum of reported SAR values is<1.6W/kg. So the simultaneous transmission SAR with volume scans is not required.

13 SAR Test Result

It is determined by user manual for the distance between the EUT and the phantom bottom.
The distance is 10mm and just applied to the condition of body worn accessory.
It is performed for all SAR measurements with area scan based 1-g SAR estimation (Fast SAR). A zoom scan measurement is added when the estimated 1-g SAR is the highest measured SAR in each exposure configuration, wireless mode and frequency band combination or > 1.2W/kg.
The calculated SAR is obtained by the following formula:

$$\text{Reported SAR} = \text{Measured SAR} \times 10^{(P_{Target} - P_{Measured})/10}$$

Where P_{Target} is the power of manufacturing upper limit;
$P_{Measured}$ is the measured power in chapter 11.

Table 13.1: SAR Values (LTE Band4 - Body)

Ambient Temperature: 22.6 °C							Liquid Temperature: 22.1 °C				
Frequency		Mode	Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.										
1732.5	20175	1RB_Mid	Front	/	23.86	24.0	0.396	**0.41**	0.669	**0.69**	-0.19
1745	20300	1RB_Mid	Rear	/	23.63	24.0	0.675	**0.74**	1.09	**1.19**	-0.17
1732.5	20175	1RB_Mid	Rear	/	23.86	24.0	0.754	**0.78**	1.25	**1.29**	0.03
1720	20050	1RB_Mid	Rear	/	23.52	24.0	0.743	**0.83**	1.19	**1.33**	0.04
1732.5	20175	1RB_Mid	Left	/	23.86	24.0	0.340	**0.35**	0.581	**0.60**	0.01
1732.5	20175	1RB_Mid	Right	/	23.86	24.0	0.079	**0.08**	0.128	**0.13**	0.12
1732.5	20175	1RB_Mid	Top	/	23.86	24.0	0.087	**0.09**	0.136	**0.14**	0.16
1745	20300	1RB_Mid	Bottom	/	23.63	24.0	0.678	**0.74**	1.26	**1.37**	-0.06
1732.5	20175	1RB_Mid	Bottom	Fig.1	23.86	24.0	0.759	**0.78**	1.40	**1.45**	-0.09
1720	20050	1RB_Mid	Bottom	/	23.52	24.0	0.703	**0.79**	1.30	**1.45**	0.05
1732.5	20175	1RB_Mid	Upper Right	/	23.86	24.0	0.029	**0.03**	0.044	**0.05**	0.01
1745	20300	50RB_Mid	Front	/	22.80	24.0	0.327	**0.43**	0.522	**0.69**	0.05
1745	20300	50RB_Mid	Rear	/	22.80	24.0	0.483	**0.64**	0.773	**1.02**	-0.09
1732.5	20175	50RB_Mid	Rear	/	22.64	24.0	0.482	**0.66**	0.768	**1.05**	-0.05
1720	20050	50RB_Mid	Rear	/	22.68	24.0	0.515	**0.70**	0.819	**1.11**	0.00
1745	20300	50RB_Mid	Left	/	22.80	24.0	0.277	**0.37**	0.474	**0.62**	0.07
1745	20300	50RB_Mid	Right	/	22.80	24.0	0.053	**0.07**	0.086	**0.11**	0.20
1745	20300	50RB_Mid	Top	/	22.80	24.0	0.070	**0.09**	0.110	**0.15**	-0.02
1745	20300	50RB_Mid	Bottom	/	22.80	24.0	0.536	**0.71**	0.997	**1.31**	0.07
1732.5	20175	50RB_Mid	Bottom	/	22.64	24.0	0.540	**0.74**	1.01	**1.38**	0.04
1720	20050	50RB_Mid	Bottom	/	22.68	24.0	0.576	**0.78**	1.07	**1.45**	-0.07
1745	20300	50RB_Mid	Upper Right	/	22.80	24.0	0.022	**0.03**	0.034	**0.04**	0.09
1732.5	20175	100RB	Rear	/	22.67	24.0	0.522	**0.71**	0.831	**1.13**	-0.04
1732.5	20175	100RB	Bottom	/	22.67	24.0	0.552	**0.75**	1.03	**1.40**	-0.13

Note1: The distance between the EUT and the phantom bottom is 10mm. Note2: The LTE mode is QPSK_20MHz.

Table 13.2: SAR Values (LTE Band12 - Body)

Ambient Temperature: 22.6 °C Liquid Temperature: 22.1 °C											
Frequency		Mode	Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.										
711	23130	1RB_Mid	Front	Fig.2	24.97	25.0	0.510	**0.51**	0.797	**0.80**	0.03
711	23130	1RB_Mid	Rear	/	24.97	25.0	0.397	**0.40**	0.587	**0.59**	0.09
711	23130	1RB_Mid	Left	/	24.97	25.0	0.125	**0.13**	0.187	**0.19**	0.01
711	23130	1RB_Mid	Right	/	24.97	25.0	0.075	**0.08**	0.106	**0.11**	-0.01
711	23130	1RB_Mid	Top	/	24.97	25.0	0.060	**0.06**	0.089	**0.09**	0.08
711	23130	1RB_Mid	Bottom	/	24.97	25.0	0.083	**0.08**	0.138	**0.14**	-0.07
711	23130	1RB_Mid	Upper Right	/	24.97	25.0	0.019	**0.02**	0.027	**0.03**	-0.04
711	23130	25RB_Low	Front	/	24.20	25.0	0.427	**0.51**	0.654	**0.79**	0.01
711	23130	25RB_Low	Rear	/	24.20	25.0	0.297	**0.36**	0.439	**0.53**	0.06
711	23130	25RB_Low	Left	/	24.20	25.0	0.091	**0.11**	0.136	**0.16**	-0.02
711	23130	25RB_Low	Right	/	24.20	25.0	0.056	**0.07**	0.080	**0.10**	0.01
711	23130	25RB_Low	Top	/	24.20	25.0	0.042	**0.05**	0.062	**0.07**	0.15
711	23130	25RB_Low	Bottom	/	24.20	25.0	0.061	**0.07**	0.101	**0.12**	-0.06
711	23130	25RB_Low	Upper Right	/	24.20	25.0	0.013	**0.02**	0.019	**0.02**	-0.03

Note1: The distance between the EUT and the phantom bottom is 10mm.

Note2: The LTE mode is QPSK_10MHz.

Table 13.3: SAR Values (LTE Band17 - Body)

Ambient Temperature: 22.5 °C Liquid Temperature: 22.0 °C											
Frequency		Mode	Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.										
711	23800	1RB_Mid	Front	/	24.77	25.0	0.551	**0.58**	0.833	**0.88**	-0.11
710	23790	1RB_Mid	Front	/	24.73	25.0	0.549	**0.58**	0.831	**0.88**	-0.10
709	23780	1RB_Mid	Front	Fig.3	24.88	25.0	0.548	**0.56**	0.859	**0.88**	0.10
709	23780	1RB_Mid	Rear	/	24.88	25.0	0.379	**0.39**	0.562	**0.58**	0.03
709	23780	1RB_Mid	Left	/	24.88	25.0	0.116	**0.12**	0.174	**0.18**	0.04
709	23780	1RB_Mid	Right	/	24.88	25.0	0.068	**0.07**	0.097	**0.10**	0.13
709	23780	1RB_Mid	Top	/	24.88	25.0	0.055	**0.06**	0.082	**0.08**	0.04
709	23780	1RB_Mid	Bottom	/	24.88	25.0	0.080	**0.08**	0.134	**0.14**	-0.08
709	23780	1RB_Mid	Upper Right	/	24.88	25.0	0.016	**0.02**	0.023	**0.02**	0.13
711	23800	25RB_Low	Front	/	23.84	25.0	0.403	**0.53**	0.611	**0.80**	-0.01
711	23800	25RB_Low	Rear	/	23.84	25.0	0.295	**0.39**	0.436	**0.57**	0.07
711	23800	25RB_Low	Left	/	23.84	25.0	0.088	**0.11**	0.131	**0.17**	0.02
711	23800	25RB_Low	Right	/	23.84	25.0	0.054	**0.07**	0.077	**0.10**	0.03
711	23800	25RB_Low	Top	/	23.84	25.0	0.042	**0.05**	0.062	**0.08**	0.02
711	23800	25RB_Low	Bottom	/	23.84	25.0	0.059	**0.08**	0.099	**0.13**	-0.01
711	23800	25RB_Low	Upper Right	/	23.84	25.0	0.008	**0.01**	0.011	**0.01**	-0.12
710	23790	50RB	Front	/	23.36	25.0	0.368	**0.54**	0.581	**0.85**	0.09

Note1: The distance between the EUT and the phantom bottom is 10mm.

Note2: The LTE mode is QPSK_10MHz.

WLAN Evaluation

According to the KDB248227 D01, SAR is measured for 2.4GHz 802.11b DSSS using the initial test position procedure.

Antenna a

Table 13.4: SAR Values (WLAN - Body) – 802.11b 1Mbps (Fast SAR)

Ambient Temperature: 22.5 °C Liquid Temperature: 22.0 °C										
Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2412	1	Front	/	14.21	15.5	0.080	**0.11**	0.163	**0.22**	-0.10
2412	1	Rear	/	14.21	15.5	0.045	**0.06**	0.094	**0.13**	0.16
2412	1	Left	/	14.21	15.5	0.014	**0.02**	0.025	**0.03**	0.11
2412	1	Right	/	14.21	15.5	0.008	**0.01**	0.018	**0.02**	0.01
2412	1	Top	/	14.21	15.5	0.052	**0.07**	0.104	**0.14**	0.01
2412	1	Bottom	/	14.21	15.5	0.005	**0.01**	0.012	**0.02**	0.15
2412	1	Upper Right	/	14.21	15.5	0.018	**0.02**	0.032	**0.04**	0.18

As shown above table, the initial test position for antenna a is "Front". So the body SAR of WLAN is presented as below:

Table 13.5: SAR Values (WLAN - Body) – 802.11b 1Mbps (Full SAR)

Ambient Temperature: 22.5 °C Liquid Temperature: 22.0 °C										
Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2412	1	Front	Fig.4	14.21	15.5	0.089	**0.12**	0.182	**0.24**	-0.10

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. A maximum transmission duty factor of 98.2% is achievable for WLAN in this project and the scaled reported SAR is presented as below.

Table 13.6: SAR Values (WLAN - Body) – 802.11b 1Mbps (Scaled Reported SAR)

Ambient Temperature: 22.5 °C Liquid Temperature: 22.0 °C						
Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g) (W/kg)	Scaled reported SAR (1g) (W/kg)
MHz	Ch.					
2412	1	Front	98.2%	100%	**0.24**	**0.24**

SAR is not required for OFDM because the 802.11b adjusted SAR ≤ 1.2 W/kg.

Antenna b

Table 13.7: SAR Values (WLAN - Body) – 802.11b 1Mbps (Fast SAR)

Ambient Temperature: 22.5 °C										
Liquid Temperature: 22.0 °C										
Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2412	1	Front	/	15.24	15.5	0.009	**0.01**	0.021	**0.02**	0.14
2412	1	Rear	/	15.24	15.5	0.001	**0.00**	0.002	**0.00**	0.10
2412	1	Left	/	15.24	15.5	0.000	**0.00**	0.001	**0.00**	-0.13
2412	1	Right	/	15.24	15.5	0.016	**0.02**	0.043	**0.05**	0.13
2412	1	Top	/	15.24	15.5	0.000	**0.00**	0.001	**0.00**	0.11
2412	1	Bottom	/	15.24	15.5	0.001	**0.00**	0.002	**0.00**	0.17
2412	1	Upper Right	/	15.24	15.5	0.003	**0.00**	0.007	**0.01**	-0.15

As shown above table, the initial test position for antenna b is “Right”. So the body SAR of WLAN is presented as below:

Table 13.8: SAR Values (WLAN - Body) – 802.11b 1Mbps (Full SAR)

Ambient Temperature: 22.5 °C										
Liquid Temperature: 22.0 °C										
Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2412	1	Right	Fig.5	15.24	15.5	0.010	**0.01**	0.024	**0.03**	0.13

According to the KDB248227 D01, The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit. A maximum transmission duty factor of 98.2% is achievable for WLAN in this project and the scaled reported SAR is presented as below.

Table 13.9: SAR Values (WLAN - Body) – 802.11b 1Mbps (Scaled Reported SAR)

Ambient Temperature: 22.5 °C						
Liquid Temperature: 22.0 °C						
Frequency		Test Position	Actual duty factor	maximum duty factor	Reported SAR (1g) (W/kg)	Scaled reported SAR (1g) (W/kg)
MHz	Ch.					
2412	1	Right	98.2%	100%	**0.03**	**0.03**

SAR is not required for OFDM because the 802.11b adjusted SAR ⩽ 1.2 W/kg.

MIMO

Table 13.10: SAR Values (WLAN - Body) – 802.11n-20M MCS0

Ambient Temperature: 22.5 °C Liquid Temperature: 22.0 °C										
Frequency		Test Position	Figure No.	Conducted Power (dBm)	Max. tune-up Power (dBm)	Measured SAR(10g) (W/kg)	Reported SAR(10g) (W/kg)	Measured SAR(1g) (W/kg)	Reported SAR(1g) (W/kg)	Power Drift (dB)
MHz	Ch.									
2462	11	Front	/	12.17	12.5	0.004	**0.00**	0.011	**0.01**	0.18
2462	11	Rear	/	12.17	12.5	0.002	**0.00**	0.004	**0.00**	-0.17

14 SAR Measurement Variability

SAR measurement variability must be assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium.

The following procedures are applied to determine if repeated measurements are required.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.

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

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

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

Table 14.1: SAR Measurement Variability for Body LTE Band 4 (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
MHz	Ch.						
1732.5	20175	Bottom	10	1.40	1.39	1.01	/

Table 14.2: SAR Measurement Variability for Body LTE Band 17 (1g)

Frequency		Test Position	Spacing (mm)	Original SAR (W/kg)	First Repeated SAR (W/kg)	The Ratio	Second Repeated SAR (W/kg)
MHz	Ch.						
709	23780	Front	10	0.859	0.851	1.01	/

15 Measurement Uncertainty

15.1 Measurement Uncertainty for Normal SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	5.5	N	1	1	1	5.5	5.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521

Combined standard uncertainty	$u_c^{'} = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$					9.25	9.12	257
Expanded uncertainty (confidence interval of 95 %)	$u_e = 2u_c$					18.5	18.2	

15.2 Measurement Uncertainty for Normal SAR Tests (3~6GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6.5	N	1	1	1	6.5	6.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	2.0	R	$\sqrt{3}$	1	1	1.2	1.2	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. restrictions	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
12	Probe positioning with respect to phantom shell	B	6.7	R	$\sqrt{3}$	1	1	3.9	3.9	∞
13	Post-processing	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
Test sample related										
14	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
15	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
16	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
17	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
18	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
19	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43

20	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
21	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c' = \sqrt{\sum_{i=1}^{21} c_i^2 u_i^2}$						10.8	10.7	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						21.6	21.4	

15.3 Measurement Uncertainty for Fast SAR Tests (300MHz~3GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	5.5	N	1	1	1	5.5	5.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. Restrictions	B	0.4	R	$\sqrt{3}$	1	1	0.2	0.2	∞
12	Probe positioning with respect to phantom shell	B	2.9	R	$\sqrt{3}$	1	1	1.7	1.7	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
14	Fast SAR z-Approximation	B	7.0	R	$\sqrt{3}$	1	1	4.0	4.0	∞
Test sample related										
15	Test sample positioning	A	3.3	N	1	1	1	3.3	3.3	71
16	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
17	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										

18	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
19	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
20	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
21	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
22	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c^{'} = \sqrt{\sum_{i=1}^{22} c_i^2 u_i^2}$						10.1	9.95	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						20.2	19.9	

15.4 Measurement Uncertainty for Fast SAR Tests (3~6GHz)

No.	Error Description	Type	Uncertainty value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement system										
1	Probe calibration	B	6.5	N	1	1	1	6.5	6.5	∞
2	Isotropy	B	4.7	R	$\sqrt{3}$	0.7	0.7	1.9	1.9	∞
3	Boundary effect	B	2.0	R	$\sqrt{3}$	1	1	1.2	1.2	∞
4	Linearity	B	4.7	R	$\sqrt{3}$	1	1	2.7	2.7	∞
5	Detection limit	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
6	Readout electronics	B	0.3	R	$\sqrt{3}$	1	1	0.3	0.3	∞
7	Response time	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
8	Integration time	B	2.6	R	$\sqrt{3}$	1	1	1.5	1.5	∞
9	RF ambient conditions-noise	B	0	R	$\sqrt{3}$	1	1	0	0	∞
10	RF ambient conditions-reflection	B	0	R	$\sqrt{3}$	1	1	0	0	∞
11	Probe positioned mech. Restrictions	B	0.8	R	$\sqrt{3}$	1	1	0.5	0.5	∞
12	Probe positioning with respect to phantom shell	B	6.7	R	$\sqrt{3}$	1	1	3.9	3.9	∞
13	Post-processing	B	1.0	R	$\sqrt{3}$	1	1	0.6	0.6	∞
14	Fast SAR z-Approximation	B	14.0	R	$\sqrt{3}$	1	1	8.1	8.1	∞
Test sample related										
15	Test sample	A	3.3	N	1	1	1	3.3	3.3	71

	positioning									
16	Device holder uncertainty	A	3.4	N	1	1	1	3.4	3.4	5
17	Drift of output power	B	5.0	R	$\sqrt{3}$	1	1	2.9	2.9	∞
Phantom and set-up										
18	Phantom uncertainty	B	4.0	R	$\sqrt{3}$	1	1	2.3	2.3	∞
19	Liquid conductivity (target)	B	5.0	R	$\sqrt{3}$	0.64	0.43	1.8	1.2	∞
20	Liquid conductivity (meas.)	A	2.06	N	1	0.64	0.43	1.32	0.89	43
21	Liquid permittivity (target)	B	5.0	R	$\sqrt{3}$	0.6	0.49	1.7	1.4	∞
22	Liquid permittivity (meas.)	A	1.6	N	1	0.6	0.49	1.0	0.8	521
Combined standard uncertainty		$u_c^{'} = \sqrt{\sum_{i=1}^{22} c_i^2 u_i^2}$						13.3	13.2	257
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$						26.6	26.4	

16 MAIN TEST INSTRUMENTS

Table 16.1: List of Main Instruments

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Network analyzer	E5071C	MY46110673	February 03, 2015	One year
02	Power meter	NRVD	102196	March 03, 2015	One year
03	Power sensor	NRV-Z5	100596		
04	Signal Generator	E4438C	MY49071430	February 02, 2015	One Year
05	Amplifier	60S1G4	0331848	No Calibration Requested	
06	BTS	CMW500	129942	March 03, 2015	One year
07	E-field Probe	SPEAG EX3DV4	3846	September 24, 2014	One year
08	DAE	SPEAG DAE4	777	September 17, 2014	One year
09	Dipole Validation Kit	SPEAG D750V3	1017	August 28, 2014	One year
10	Dipole Validation Kit	SPEAG D1750V2	1003	August 18, 2014	One year
11	Dipole Validation Kit	SPEAG D2450V2	853	July 24, 2014	One year

END OF REPORT BODY

ANNEX A Graph Results

LTE Band4 Body Bottom Middle with QPSK_20M_1RB_Middle

Date: 2015-4-17
Electronics: DAE4 Sn777
Medium: Body 1750 MHz
Medium parameters used (interpolated): f = 1732.5 MHz; σ = 1.477 mho/m; εr = 54.631; ρ = 1000 kg/m^3
Ambient Temperature: 22.6°C Liquid Temperature: 22.1°C
Communication System: LTE Band4 Frequency: 1732.5 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(7.43, 7.43, 7.43)

Bottom Middle/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.76 W/kg

Bottom Middle/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 31.61 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 2.42 W/kg
SAR(1 g) = 1.40 W/kg; SAR(10 g) = 0.759 W/kg
Maximum value of SAR (measured) = 1.76 W/kg

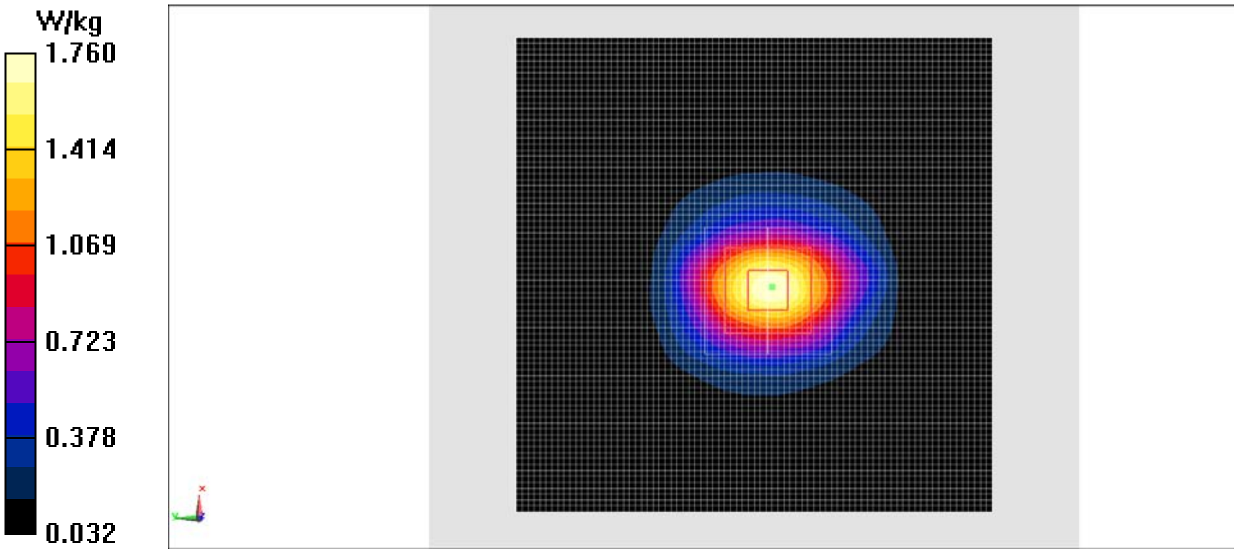


Fig.1 LTE Band4

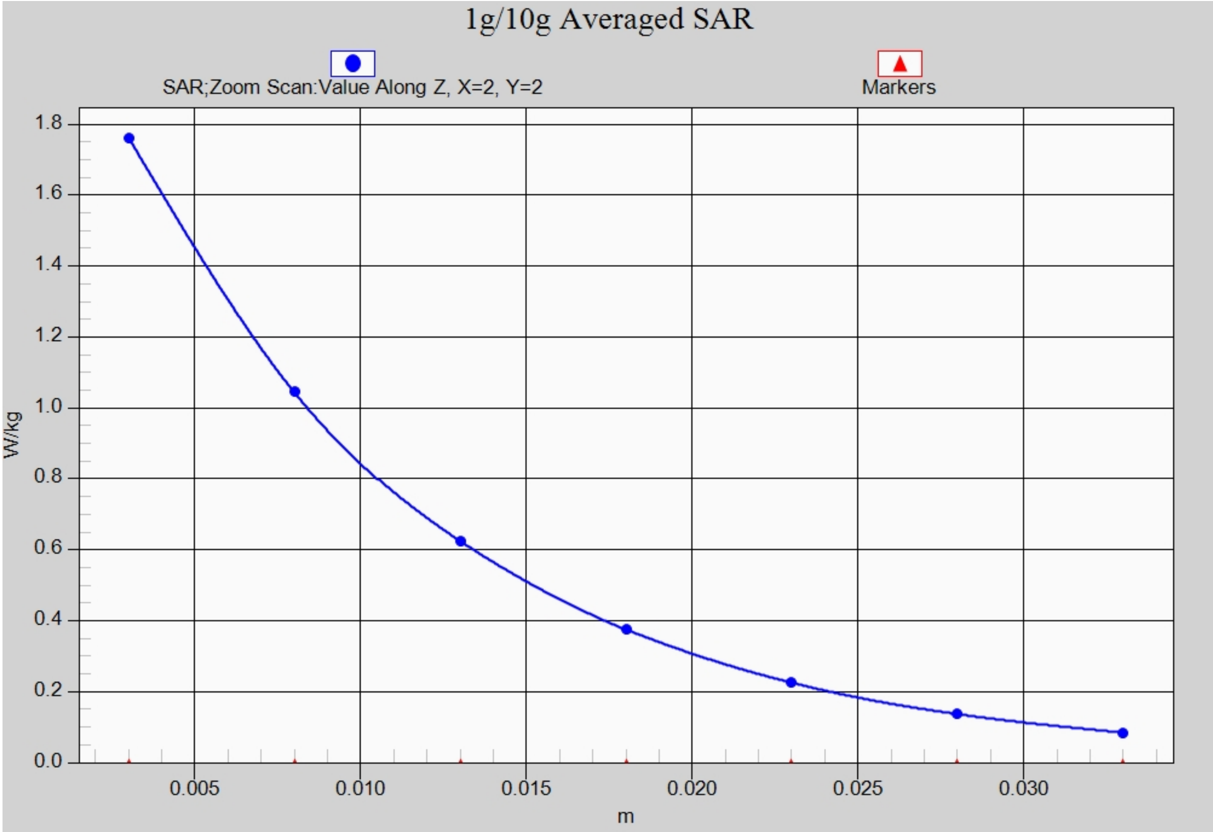


Fig. 1-1 Z-Scan at power reference point (LTE Band4)

LTE Band12 Body Front High with QPSK_10M_1RB_Middle

Date: 2015-4-24
Electronics: DAE4 Sn777
Medium: Body 750 MHz
Medium parameters used (interpolated): f = 711 MHz; σ = 0.905 mho/m; εr = 57.842; ρ = 1000 kg/m^3
Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C
Communication System: LTE Band12 Frequency: 711 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(9.18, 9.18, 9.18)

Front High/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Reference Value = 18.75 V/m; Power Drift = 0.03 dB
Maximum value of SAR (interpolated) = 0.920 W/kg

Front High/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 18.75 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 1.23 W/kg
SAR(1 g) = 0.797 W/kg; SAR(10 g) = 0.510 W/kg
Maximum value of SAR (measured) = 0.926 W/kg

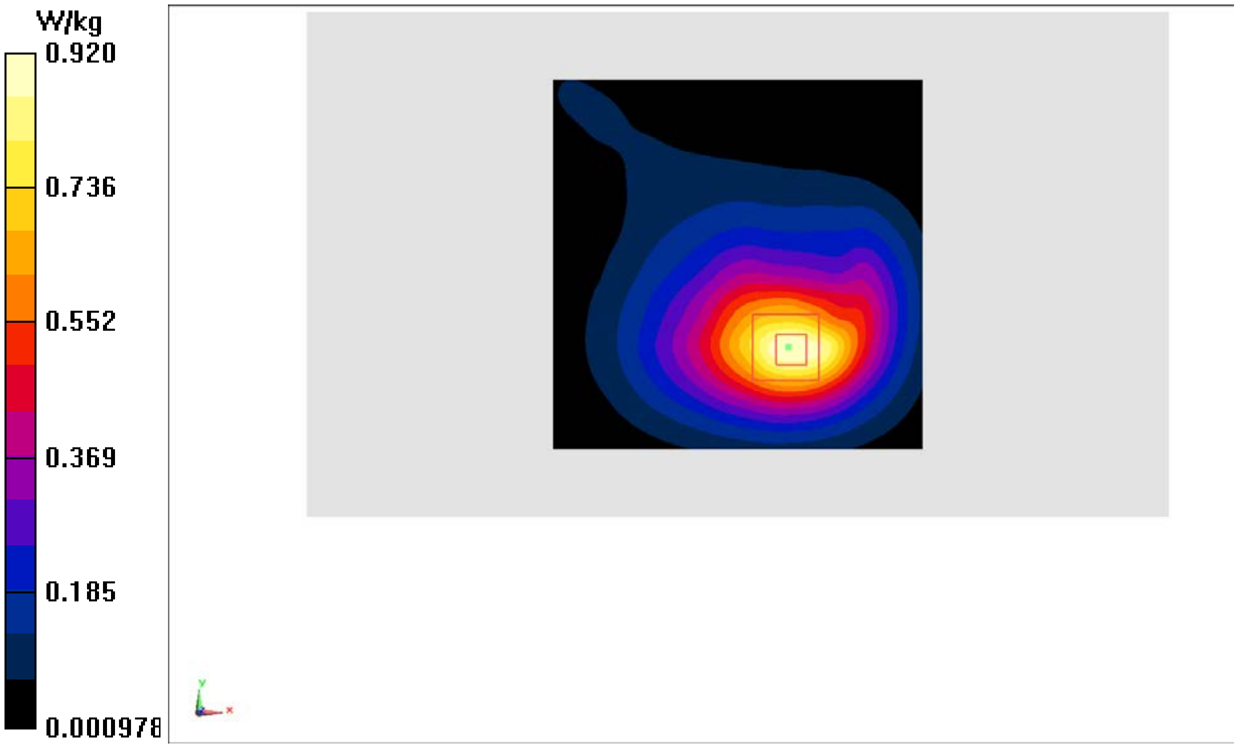


Fig.2 LTE Band12

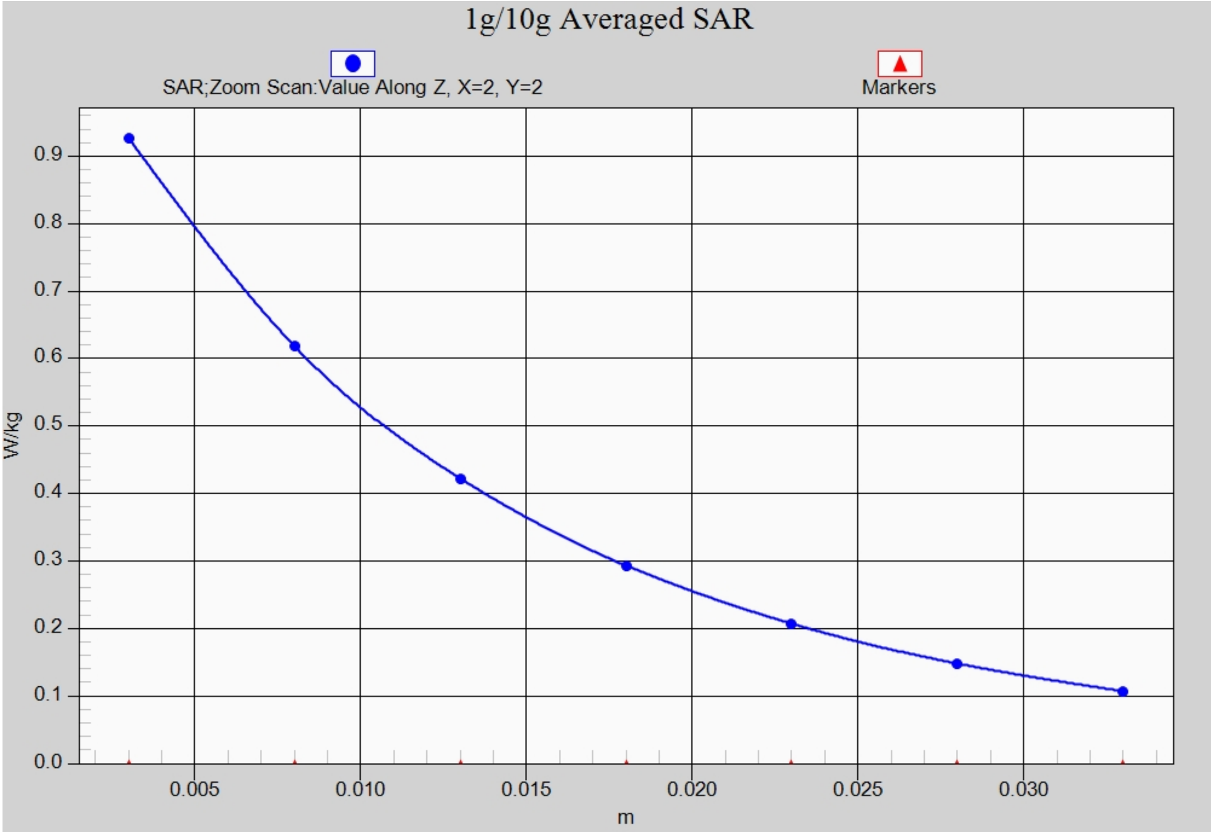


Fig. 2-1 Z-Scan at power reference point (LTE Band12)

LTE Band17 Body Front Low with QPSK_10M_1RB_Middle
Date: 2015-4-24
Electronics: DAE4 Sn777
Medium: Body 750 MHz
Medium parameters used (interpolated): f = 709 MHz; σ = 0.903 mho/m; εr = 57.852; ρ = 1000 kg/m^3
Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C
Communication System: LTE Band17 Frequency: 709 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(9.18, 9.18, 9.18)

Front Low/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 1.01 W/kg

Front Low/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 19.37 V/m; Power Drift = 0.10 dB
Peak SAR (extrapolated) = 1.33 W/kg
SAR(1 g) = 0.859 W/kg; SAR(10 g) = 0.548 W/kg
Maximum value of SAR (measured) = 1.00 W/kg

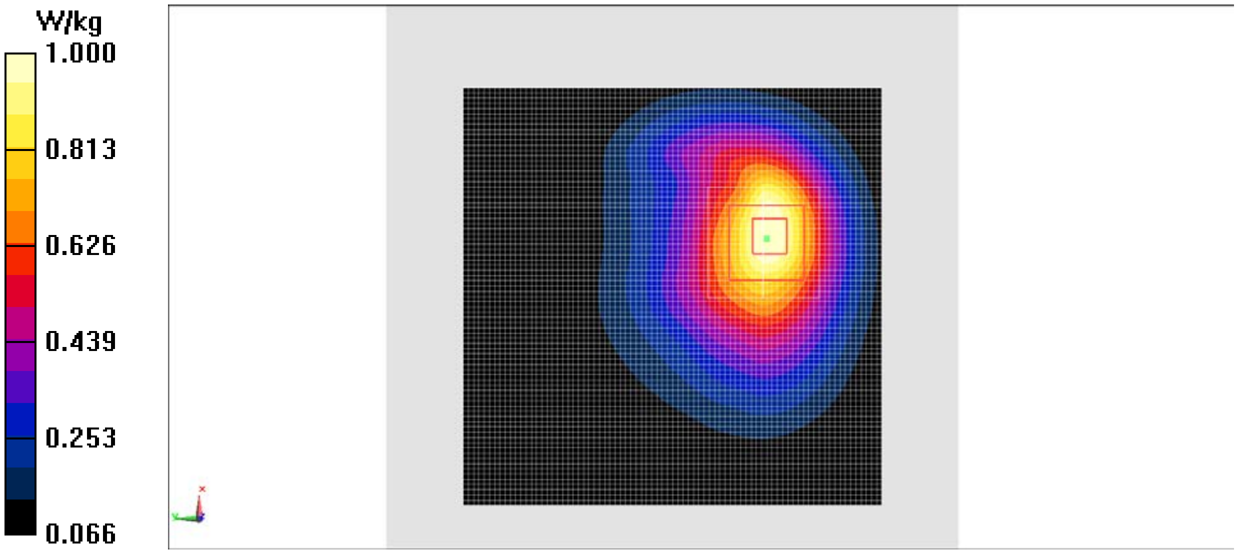


Fig.3 LTE Band17

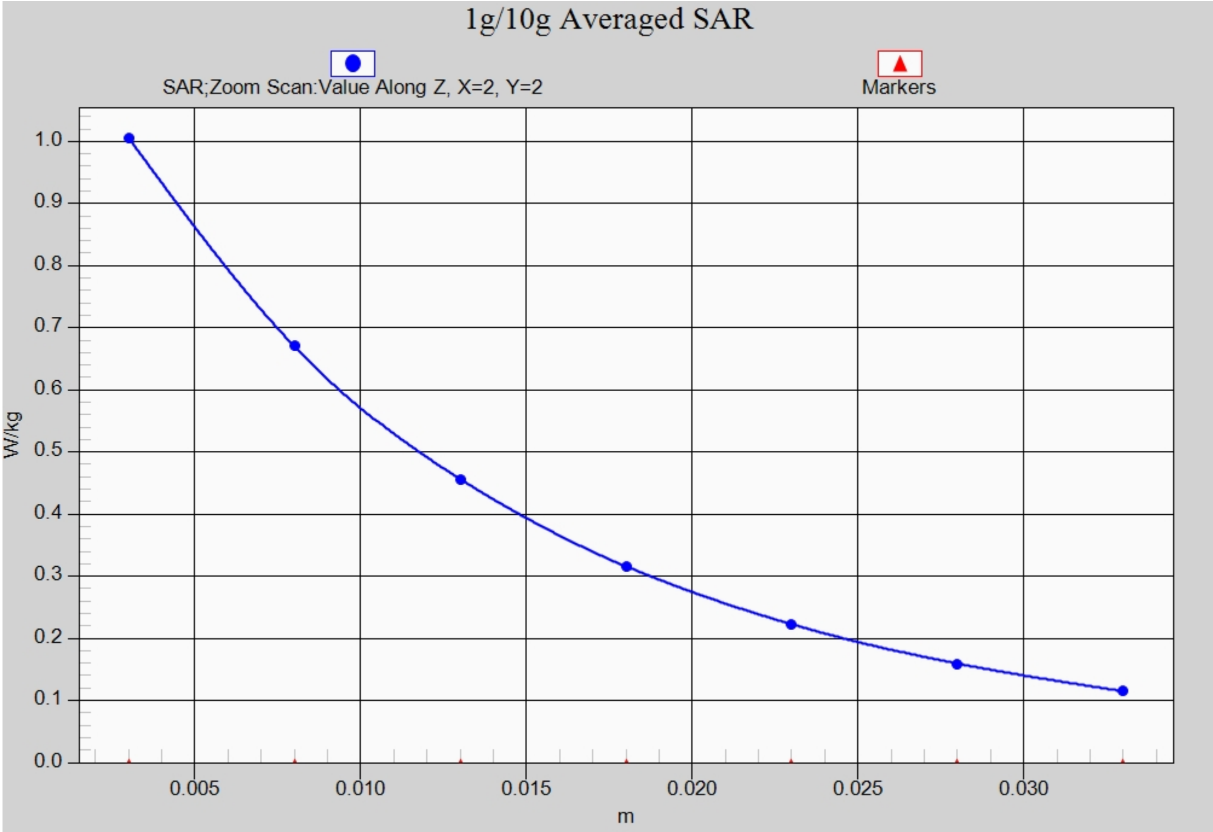


Fig. 3-1 Z-Scan at power reference point (LTE Band17)

Wifi 802.11b Body Front Channel 1 – Antenna a

Date: 2015-4-25

Electronics: DAE4 Sn777

Medium: Body 2450 MHz

Medium parameters used (interpolated): f = 2412 MHz; σ = 1.993 mho/m; ε_r = 50.753; ρ = 1000 kg/m^3

Ambient Temperature: 22.5^{o}C   Liquid Temperature: 22.0^{o}C

Communication System: WLan 2450 Frequency: 2412 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN3846 ConvF(6.90, 6.90, 6.90)

Front Low/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.214 W/kg

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

Reference Value = 4.894 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 0.371 W/kg

SAR(1 g) = 0.182 W/kg; SAR(10 g) = 0.089 W/kg

Maximum value of SAR (measured) = 0.224 W/kg

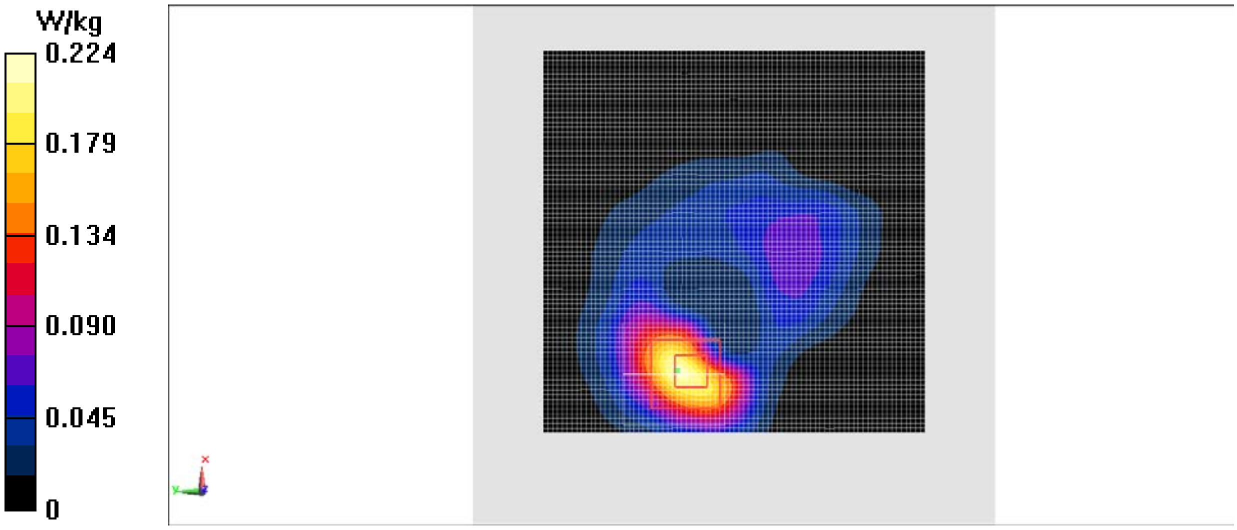


Fig.4 2450 MHz

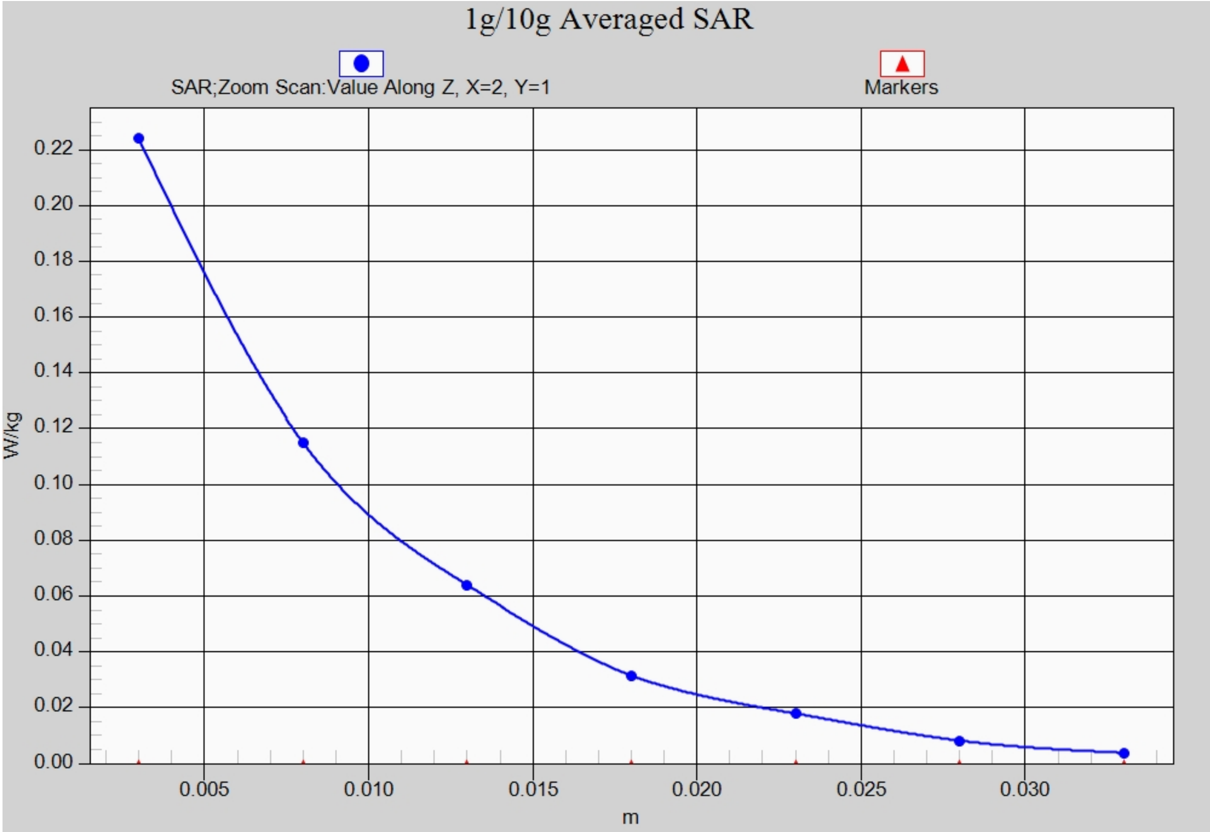


Fig. 4-1 Z-Scan at power reference point (2450 MHz)

Wifi 802.11b Body Right Channel 1 – Antenna b

Date: 2015-4-25

Electronics: DAE4 Sn777

Medium: Body 2450 MHz

Medium parameters used (interpolated): f = 2412 MHz; σ = 1.993 mho/m; ε_r = 50.753; ρ = 1000 kg/m^3

Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C

Communication System: WLan 2450 Frequency: 2412 MHz Duty Cycle: 1:1

Probe: EX3DV4 - SN3846 ConvF(6.90, 6.90, 6.90)

Right Low/Area Scan (81x91x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.0771 W/kg

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

Reference Value = 2.871 V/m; Power Drift = 0.13 dB

Peak SAR (extrapolated) = 0.0510 W/kg

SAR(1 g) = 0.024 W/kg; SAR(10 g) = 0.010 W/kg

Maximum value of SAR (measured) = 0.0284 W/kg

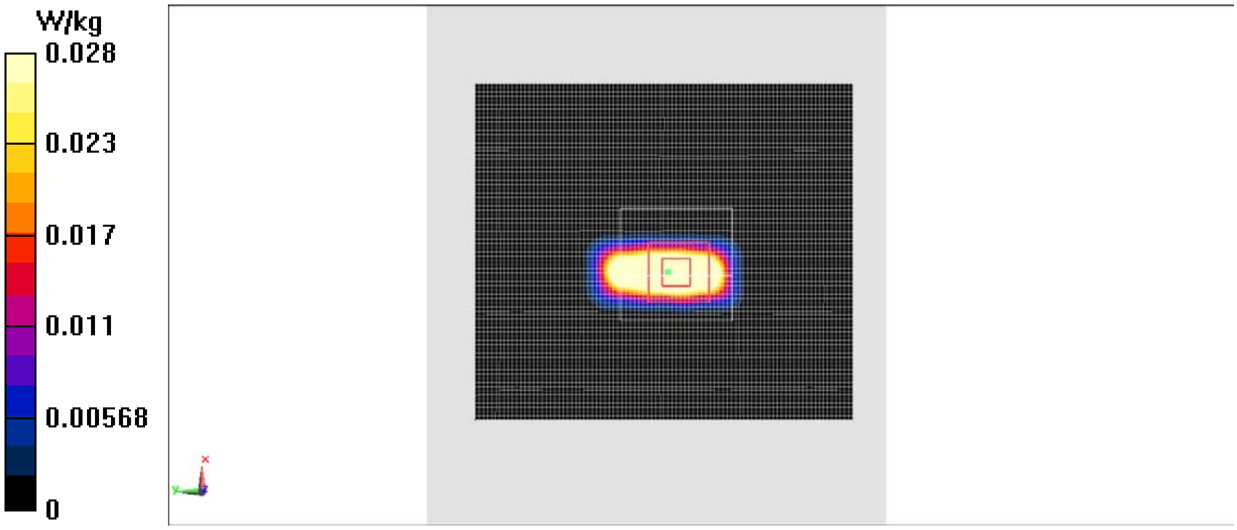


Fig.5 2450 MHz

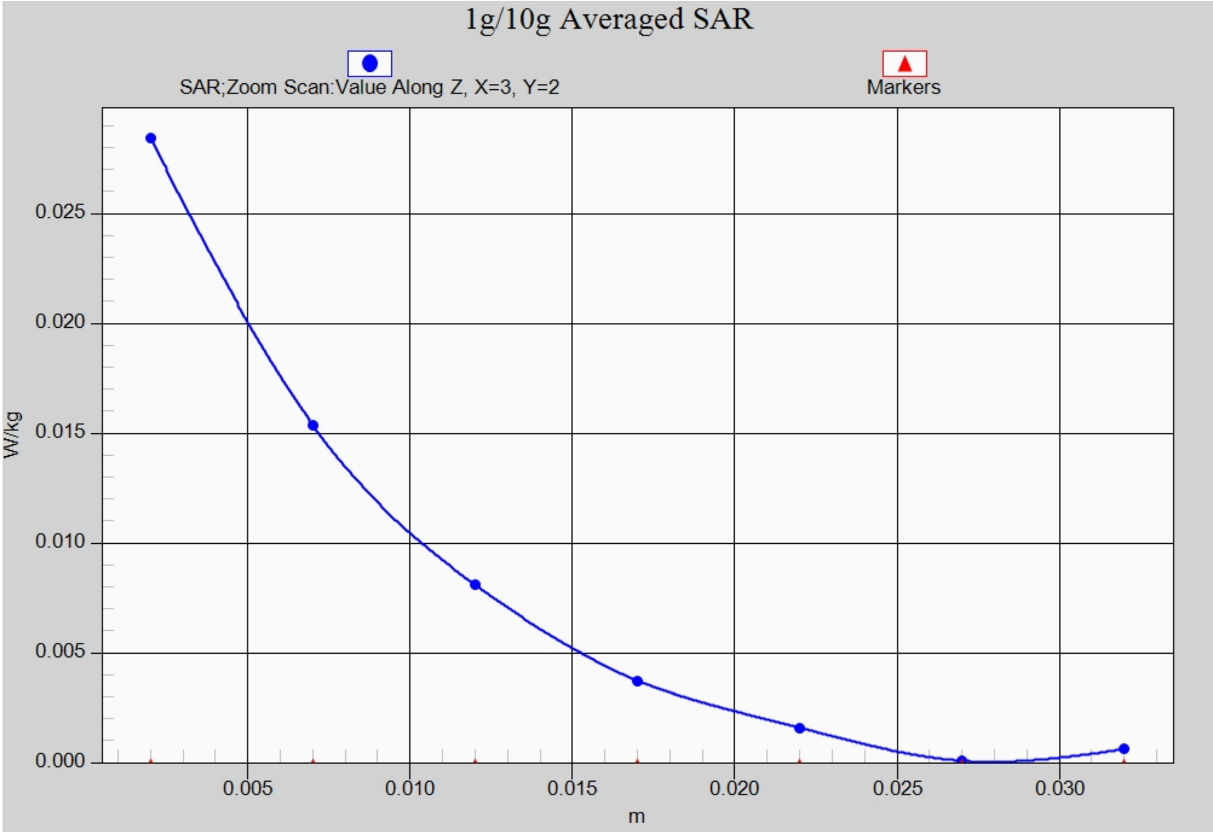


Fig. 5-1 Z-Scan at power reference point (2450 MHz)

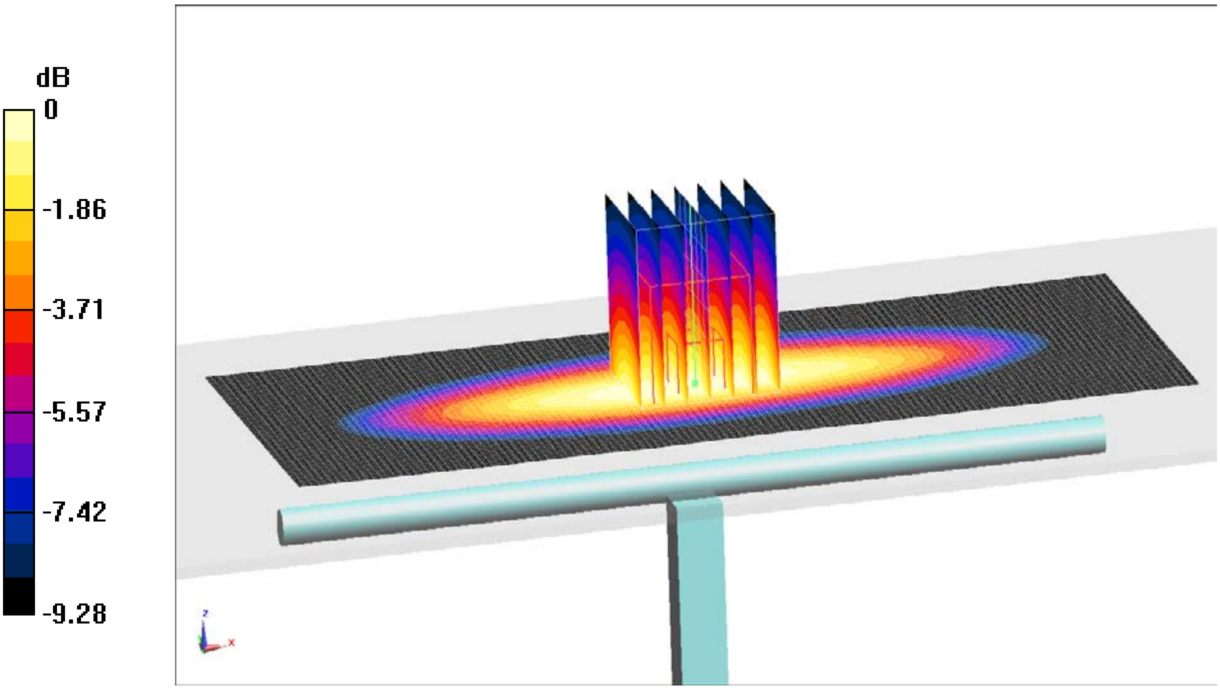
ANNEX B System Verification Results

750MHz

Date: 2015-4-24
Electronics: DAE4 Sn777
Medium: Body750 MHz
Medium parameters used: f = 750 MHz; σ = 0.936 mho/m; ε_r = 57.38; ρ = 1000 kg/m^3
Ambient Temperature: 22.5^{o}C Liquid Temperature: 22.0^{o}C
Communication System: CW Frequency: 750 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(9.18, 9.18, 9.18)

System Validation/Area Scan (81x191x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Reference Value = 51.913 V/m; Power Drift = -0.03 dB
Fast SAR: SAR(1 g) = 2.26 W/kg; SAR(10 g) = 1.50 W/kg
Maximum value of SAR (interpolated) = 2.40 W/kg

System Validation/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 51.913 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 3.13 W/kg
SAR(1 g) = 2.23 W/kg; SAR(10 g) = 1.48 W/kg
Maximum value of SAR (measured) = 2.38 W/kg



0 dB = 2.38 W/kg = 3.77 dB W/kg

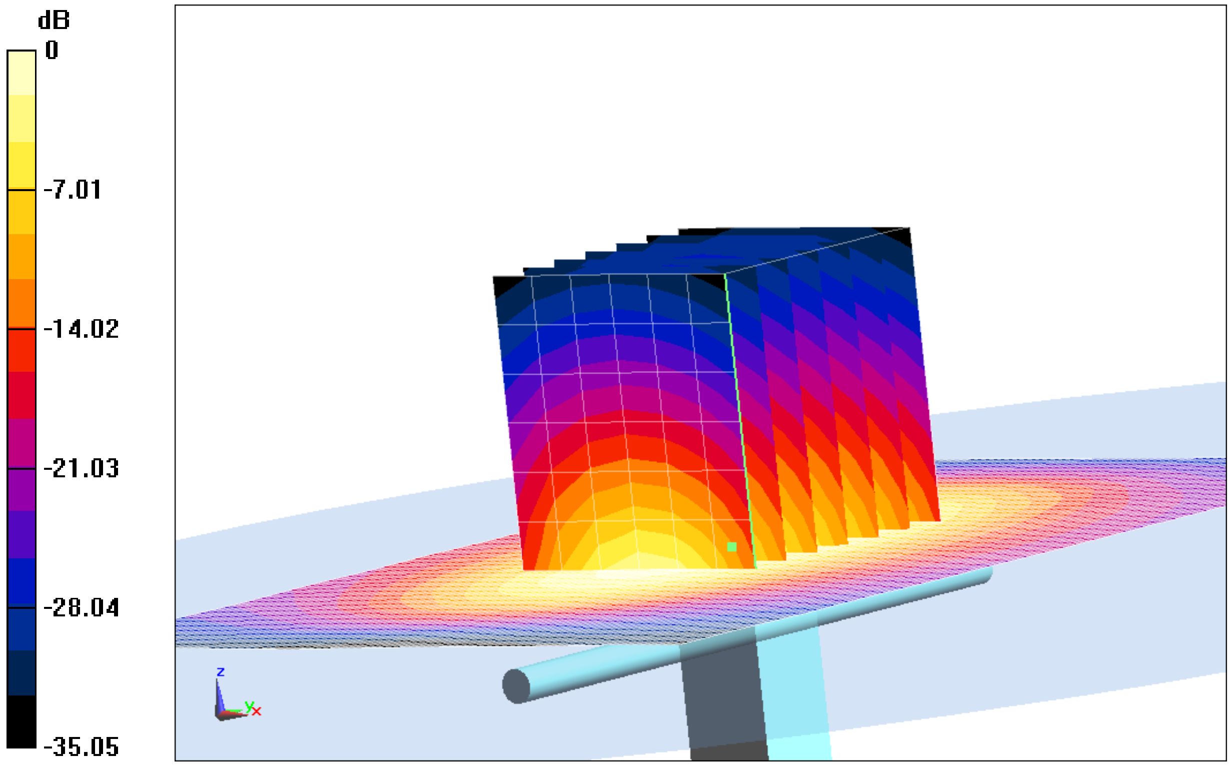
Fig.B.1 validation 750MHz 250mW

1750MHz

Date: 2015-4-17
Electronics: DAE4 Sn777
Medium: Body 1750 MHz
Medium parameters used: f=1750 MHz; σ = 1.493 mho/m; εr = 54.54; ρ = 1000 kg/m^3
Ambient Temperature: 22.6°C Liquid Temperature: 22.1°C
Communication System: CW Frequency: 1750 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(7.43, 7.43, 7.43)

System Validation/Area Scan (81x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Reference Value = 94.977 V/m; Power Drift = -0.02 dB
Fast SAR: SAR(1 g) = 9.41 W/kg; SAR(10 g) = 5.10 W/kg
Maximum value of SAR (interpolated) = 10.3 W/kg

System Validation/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 94.977 V/m; Power Drift = -0.02 dB
Peak SAR (extrapolated) = 16.30 W/kg
SAR(1 g) = 9.32 W/kg; SAR(10 g) = 5.01 W/kg
Maximum value of SAR (measured) = 10.2 W/kg



0 dB = 10.2 W/kg = 10.09 dB W/kg

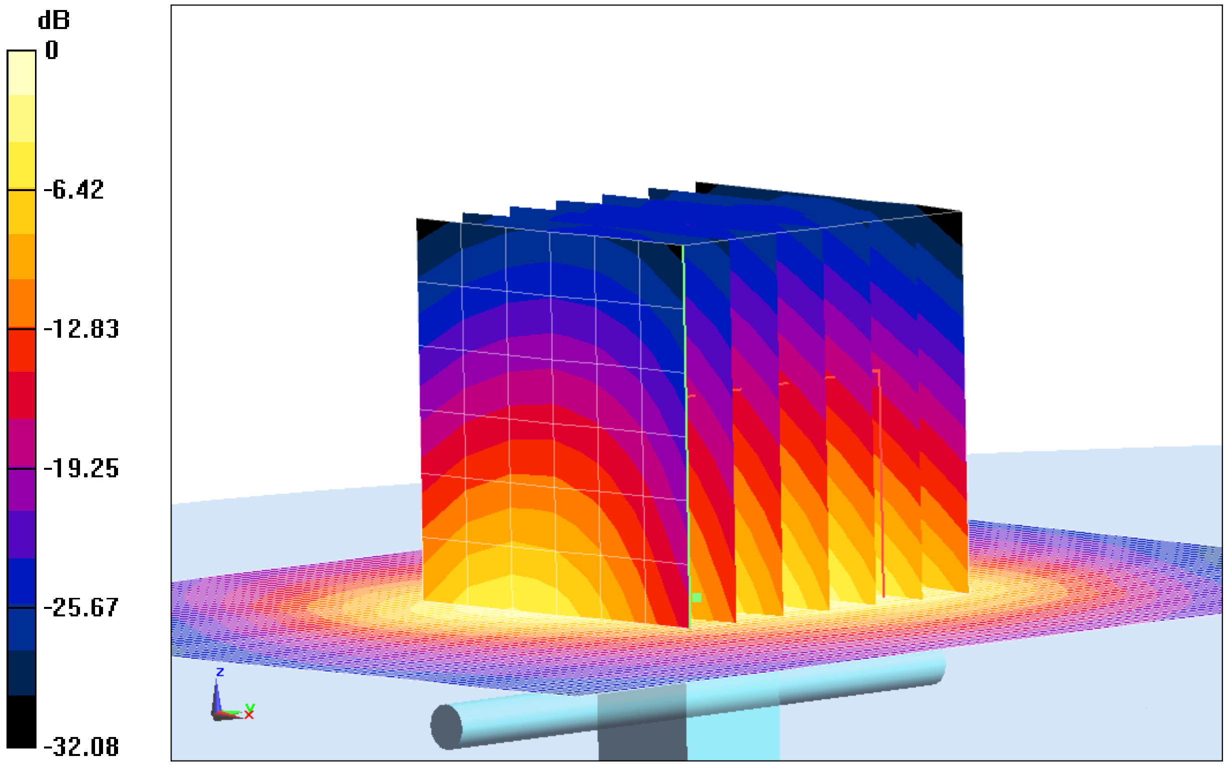
Fig.B.2 validation 1750MHz 250mW

2450MHz

Date: 2015-4-25
Electronics: DAE4 Sn777
Medium: Body 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.02 S/m; ε_r = 50.62; ρ = 1000 kg/m^3
Ambient Temperature: 22.5°C Liquid Temperature: 22.0°C
Communication System: CW Frequency: 2450 MHz Duty Cycle: 1:1
Probe: EX3DV4 - SN3846 ConvF(6.90, 6.90, 6.90)

System Validation/Area Scan (81x101x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Reference Value = 88.795 V/m; Power Drift = 0.03 dB
SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.78 W/kg
Maximum value of SAR (interpolated) = 14.6 W/kg

System Validation/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 88.795 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 24.81 W/kg
SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.88 W/kg
Maximum value of SAR (measured) = 14.7 W/kg



0 dB = 14.7 W/kg = 11.67 dB W/kg

Fig.B.3 validation 2450MHz 250mW

The SAR system verification must be required that the area scan estimated 1-g SAR is within 3% of the zoom scan 1-g SAR.

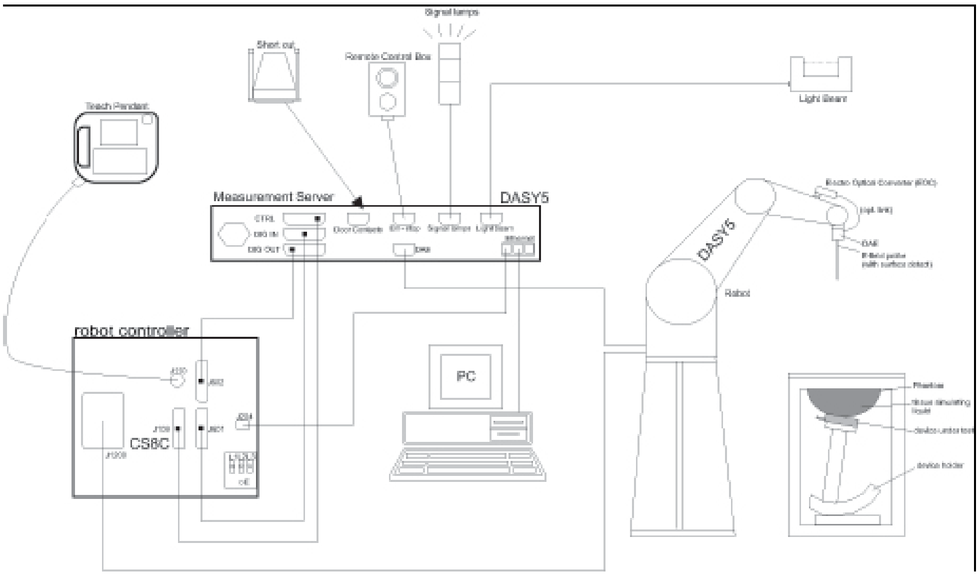
Table B.1 Comparison between area scan and zoom scan for system verification

Band	Position	Area scan (1g)	Zoom scan (1g)	Drift (%)
750	Body	2.26	2.23	1.35
1750	Body	9.41	9.32	0.97
2450	Body	12.5	12.6	-0.79

ANNEX C SAR Measurement Setup

C.1 Measurement Set-up

The Dasy4 or DASY5 system for performing compliance tests is illustrated above graphically. This system consists of the following items:



Picture C.1 SAR Lab Test Measurement Set-up

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY4 or DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as
- warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

C.2 Dasy4 or DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe designed in the classical triangular configuration 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 multifiber line ending at the front of the probe tip. 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 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 or DASY5 software reads the reflection durning a software approach and looks for the maximum using 2^{nd} ord curve fitting. The approach is stopped at reaching the maximum.

Probe Specifications:

Model: ES3DV3, EX3DV4
Frequency Range: 10MHz — 6.0GHz(EX3DV4)
10MHz — 4GHz(ES3DV3)
Calibration: In head and body simulating tissue at Frequencies from 835 up to 5800MHz
Linearity: ± 0.2 dB(30 MHz to 6 GHz) for EX3DV4
± 0.2 dB(30 MHz to 4 GHz) for ES3DV3
Dynamic Range: 10 mW/kg — 100W/kg
Probe Length: 330 mm
Probe Tip Length: 20 mm
Body Diameter: 12 mm
Tip Diameter: 2.5 mm (3.9 mm for ES3DV3)
Tip-Center: 1 mm (2.0mm for ES3DV3)
Application: SAR Dosimetry Testing
Compliance tests of mobile phones
Dosimetry in strong gradient fields

Picture C.2 Near-field Probe

Picture C.3 E-field Probe

C.3 E-field Probe Calibration

Each E-Probe/Probe Amplifier combination has unique calibration parameters. A TEM cell calibration procedure is conducted to determine the proper amplifier settings to enter in the probe parameters. The amplifier settings are determined for a given frequency by subjecting the probe to a known E-field density (1 mW/cm^2) using an RF Signal generator, TEM cell, and RF Power Meter.

The free space E-field from amplified probe outputs is determined in a test chamber. This calibration can be performed in a TEM cell if the frequency is below 1 GHz and inn a waveguide or other methodologies above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/ cm^2.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The E-field in the medium correlates with the temperature rise in the dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C\frac{\Delta T}{\Delta t}$$

Where:

Δt = Exposure time (30 seconds),

C = Heat capacity of tissue (brain or muscle),

ΔT = Temperature increase due to RF exposure.

$$SAR = \frac{|E|^2 \cdot \sigma}{\rho}$$

Where:

σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m^3).

C.4 Other Test Equipment

C.4.1 Data Acquisition Electronics(DAE)

The data acquisition electronics consist of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder with a control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information, as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

PictureC.4: DAE

C.4.2 Robot

The SPEAG DASY system uses the high precision robots (DASY4: RX90XL; DASY5: RX160L) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability 0.02mm)
- High reliability (industrial design)
- Low maintenance costs (virtually maintenance free due to direct drive gears; no belt drives)
- Jerk-free straight movements (brushless synchron motors; no stepper motors)
- Low ELF interference (motor control fields shielded via the closed metallic construction shields)

Picture C.5 DASY 4

Picture C.6 DASY 5

C.4.3 Measurement Server

The Measurement server is based on a PC/104 CPU broad with CPU (dasy4: 166 MHz, Intel Pentium; DASY5: 400 MHz, Intel Celeron), chipdisk (DASY4: 32 MB; DASY5: 128MB), RAM (DASY4: 64 MB, DASY5: 128MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O broad, which is directly connected to the PC/104 bus of the CPU broad.

The measurement server performs all real-time data evaluation of field measurements and surface detection, controls robot movements and handles safety operation. The PC operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with an expansion port which is reserved for future applications. Please note that this expansion port does not have a standardized pinout, and therefore only devices provided by SPEAG can be connected. Devices from any other supplier could seriously damage the measurement server.

Picture C.7 Server for DASY 4

Picture C.8 Server for DASY 5

C.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

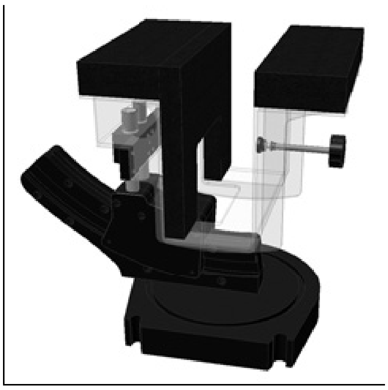
The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity ε=3 and loss tangent δ=0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.

Picture C.9-1: Device Holder



Picture C.9-2: Laptop Extension Kit

C.4.5 Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to

Represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. 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. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness: 2 ± 0. 2 mm
Filling Volume: Approx. 25 liters
Dimensions: 810 x l000 x 500 mm (H x L x W)
Available: Special

Picture C.10: SAM Twin Phantom

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

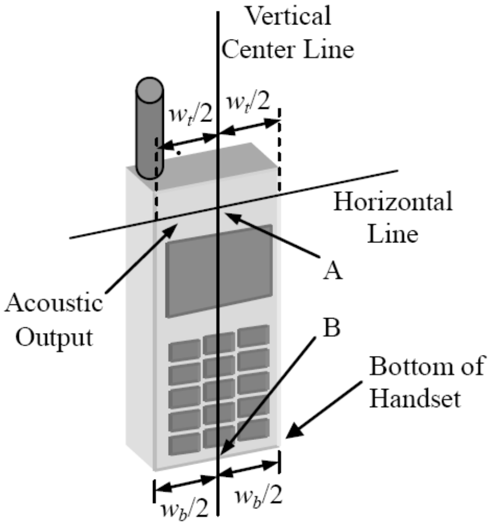
Shell Thickness: 2 ± 0. 2 mm
Filling Volume: Approx. 30 liters
Dimensions: Major axis: 600 mm, Minor axis: 400 mm

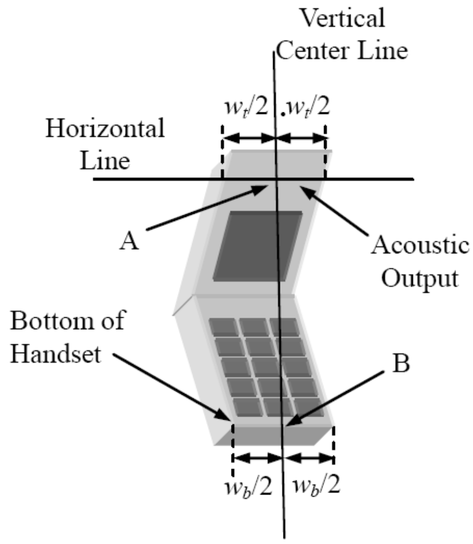
Picture C.11: ELI Phantom

ANNEX D Position of the wireless device in relation to the phantom

D.1 General considerations

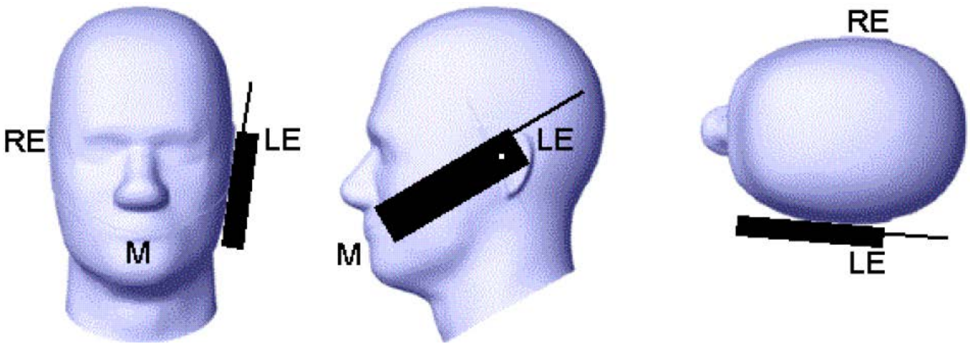
This standard specifies two handset test positions against the head phantom – the “cheek” position and the “tilt” position.



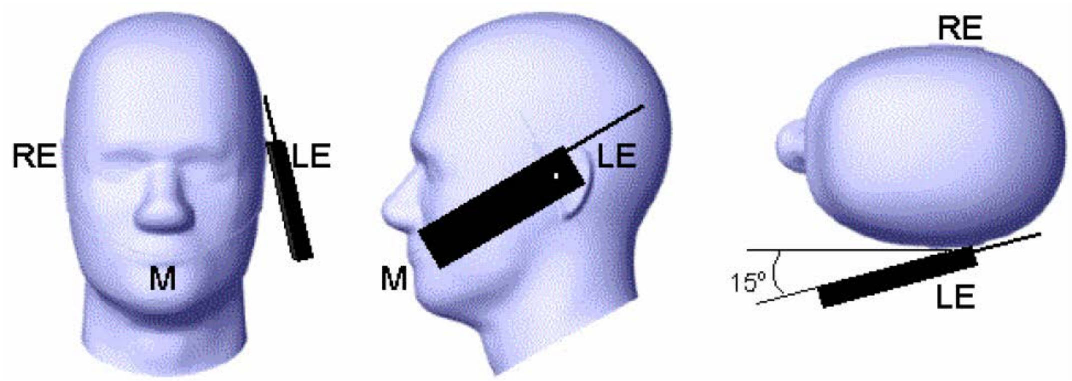


w_t	Width of the handset at the level of the acoustic
w_b	Width of the bottom of the handset
A	Midpoint of the width w_t of the handset at the level of the acoustic output
B	Midpoint of the width w_b of the bottom of the handset

Picture D.1-a Typical “fixed” case handset **Picture D.1-b Typical “clam-shell” case handset**



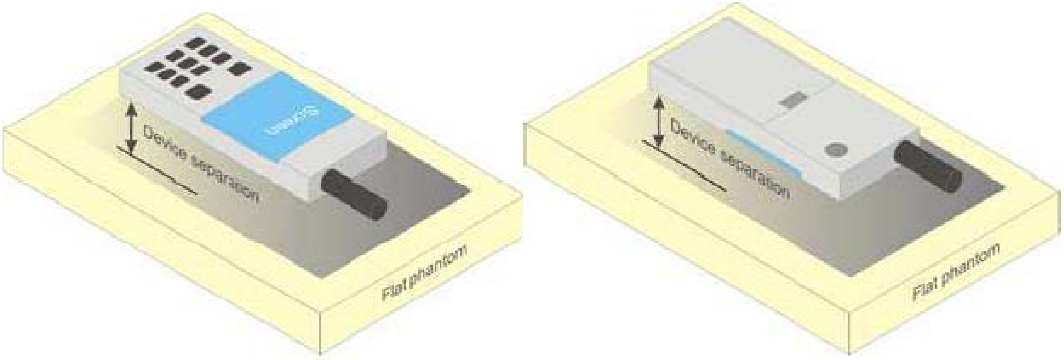
Picture D.2 Cheek position of the wireless device on the left side of SAM



Picture D.3 Tilt position of the wireless device on the left side of SAM

D.2 Body-worn device

A typical example of a body-worn device is a mobile phone, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person's body using a carry accessory approved by the wireless device manufacturer.

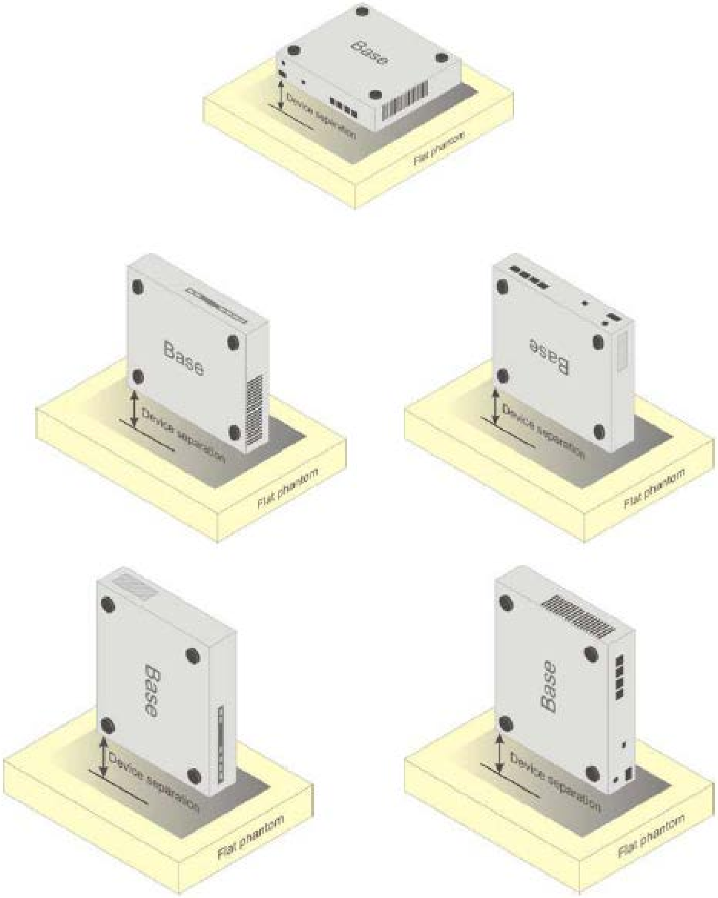


Picture D.4 Test positions for body-worn devices

D.3 Desktop device

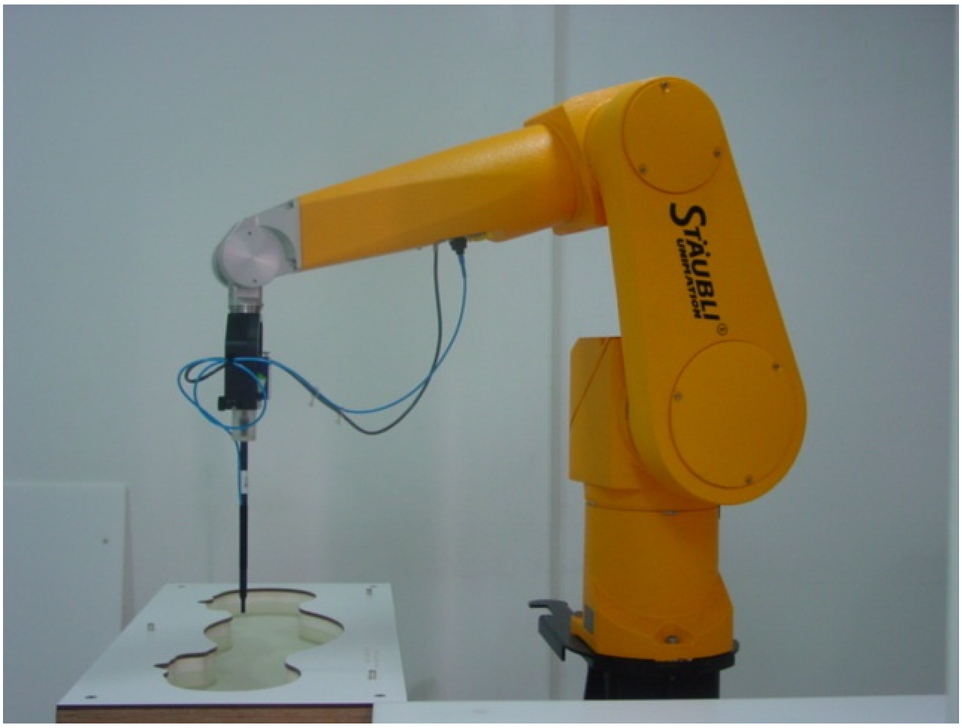
A typical example of a desktop device is a wireless enabled desktop computer placed on a table or desk when used.

The DUT shall be positioned at the distance and in the orientation to the phantom that corresponds to the intended use as specified by the manufacturer in the user instructions. For devices that employ an external antenna with variable positions, tests shall be performed for all antenna positions specified. Picture 8.5 show positions for desktop device SAR tests. If the intended use is not specified, the device shall be tested directly against the flat phantom.



Picture D.5 Test positions for desktop devices

D.4 DUT Setup Photos



Picture D.6

ANNEX E Equivalent Media Recipes

The liquid used for the frequency range of 800-3000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

Table E.1: Composition of the Tissue Equivalent Matter

Frequency (MHz)	835 Head	835 Body	1900 Head	1900 Body	2450 Head	2450 Body	5800 Head	5800 Body
Ingredients (% by weight)								
Water	41.45	52.5	55.242	69.91	58.79	72.60	65.53	65.53
Sugar	56.0	45.0	\	\	\	\	\	\
Salt	1.45	1.4	0.306	0.13	0.06	0.18	\	\
Preventol	0.1	0.1	\	\	\	\	\	\
Cellulose	1.0	1.0	\	\	\	\	\	\
Glycol Monobutyl	\	\	44.452	29.96	41.15	27.22	\	\
Diethylenglycol monohexylether	\	\	\	\	\	\	17.24	17.24
Triton X-100	\	\	\	\	\	\	17.24	17.24
Dielectric Parameters Target Value	ε=41.5 σ=0.90	ε=55.2 σ=0.97	ε=40.0 σ=1.40	ε=53.3 σ=1.52	ε=39.2 σ=1.80	ε=52.7 σ=1.95	ε=35.3 σ=5.27	ε=48.2 σ=6.00

Note: There are a little adjustment respectively for 750, 1750, 2600, 5200, 5300 and 5600 based on the recipe of closest frequency in table E.1.

ANNEX F System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table F.1: System Validation

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
3846	Head 750MHz	Oct.25,2014	750 MHz	OK
3846	Head 850MHz	Oct.25,2014	850 MHz	OK
3846	Head 900MHz	Oct.26,2014	900 MHz	OK
3846	Head 1750MHz	Oct.27,2014	1750 MHz	OK
3846	Head 1810MHz	Oct.27,2014	1810 MHz	OK
3846	Head 1900MHz	Oct.28,2014	1900 MHz	OK
3846	Head 1950MHz	Oct.28,2014	1950 MHz	OK
3846	Head 2000MHz	Oct.28,2014	2000 MHz	OK
3846	Head 2100MHz	Oct.28,2014	2100 MHz	OK
3846	Head 2300MHz	Oct.29,2014	2300 MHz	OK
3846	Head 2450MHz	Oct.29,2014	2450 MHz	OK
3846	Head 2550MHz	Oct.29,2014	2550 MHz	OK
3846	Head 2600MHz	Oct.29,2014	2600 MHz	OK
3846	Head 3500MHz	Oct.30,2014	3500 MHz	OK
3846	Head 3700MHz	Oct.30,2014	3700 MHz	OK
3846	Head 5200MHz	Oct.24,2014	5200 MHz	OK
3846	Head 5500MHz	Oct.24,2014	5500 MHz	OK
3846	Head 5800MHz	Oct.24,2014	5800 MHz	OK
3846	Body 750MHz	Oct.25,2014	750 MHz	OK
3846	Body 850MHz	Oct.25,2014	850 MHz	OK
3846	Body 900MHz	Oct.26,2014	900 MHz	OK
3846	Body 1750MHz	Oct.27,2014	1750 MHz	OK
3846	Body 1810MHz	Oct.27,2014	1810 MHz	OK
3846	Body 1900MHz	Oct.28,2014	1900 MHz	OK
3846	Body 1950MHz	Oct.28,2014	1950 MHz	OK
3846	Body 2000MHz	Oct.28,2014	2000 MHz	OK
3846	Body 2100MHz	Oct.28,2014	2100 MHz	OK
3846	Body 2300MHz	Oct.29,2014	2300 MHz	OK
3846	Body 2450MHz	Oct.29,2014	2450 MHz	OK
3846	Body 2550MHz	Oct.29,2014	2550 MHz	OK
3846	Body 2600MHz	Oct.29,2014	2600 MHz	OK
3846	Body 3500MHz	Oct.30,2014	3500 MHz	OK
3846	Body 3700MHz	Oct.30,2014	3700 MHz	OK
3846	Body 5200MHz	Oct.24,2014	5200 MHz	OK
3846	Body 5500MHz	Oct.24,2014	5500 MHz	OK
3846	Body 5800MHz	Oct.24,2014	5800 MHz	OK

ANNEX G Probe Calibration Certificate

Probe 3846 Calibration Certificate

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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Swiss Calibration Service

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

Accreditation No.: **SCS 108**

Client **CTTL (Auden)**

Certificate No: **EX3-3846_Sep14**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3846
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 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: September 24, 2014

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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Swiss Calibration Service

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

Accreditation No.: **SCS 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 $\vartheta = 0$ ($f \leq 900$ 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 $f \leq 800$ 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:3846

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

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3846

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (μV/(V/m)^2)[A]	0.39	0.42	0.49	± 10.1 %
DCP (mV)[B]	103.8	100.3	98.5	

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	141.2	±3.8 %
		Y	0.0	0.0	1.0		146.9	
		Z	0.0	0.0	1.0		139.6	

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:3846

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	9.53	9.53	9.53	0.80	0.62	± 12.0 %
835	41.5	0.90	9.18	9.18	9.18	0.39	0.87	± 12.0 %
900	41.5	0.97	9.00	9.00	9.00	0.38	0.91	± 12.0 %
1450	40.5	1.20	7.90	7.90	7.90	0.60	0.75	± 12.0 %
1640	40.3	1.29	7.57	7.57	7.57	0.62	0.74	± 12.0 %
1750	40.1	1.37	7.64	7.64	7.64	0.46	0.91	± 12.0 %
1810	40.0	1.40	7.40	7.40	7.40	0.56	0.80	± 12.0 %
1900	40.0	1.40	7.26	7.26	7.26	0.39	0.98	± 12.0 %
2000	40.0	1.40	7.24	7.24	7.24	0.57	0.79	± 12.0 %
2100	39.8	1.49	7.33	7.33	7.33	0.40	0.93	± 12.0 %
2300	39.5	1.67	6.94	6.94	6.94	0.32	1.16	± 12.0 %
2450	39.2	1.80	6.56	6.56	6.56	0.31	1.18	± 12.0 %
2600	39.0	1.96	6.50	6.50	6.50	0.30	1.30	± 12.0 %
3500	37.9	2.91	6.75	6.75	6.75	0.81	0.65	± 13.1 %
3700	37.7	3.12	6.32	6.32	6.32	0.23	1.60	± 13.1 %
5200	36.0	4.66	5.00	5.00	5.00	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.79	4.79	4.79	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.64	4.64	4.64	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.25	4.25	4.25	0.50	1.80	± 13.1 %
5800	35.3	5.27	4.44	4.44	4.44	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:3846

Calibration Parameter Determined in Body Tissue Simulating Media

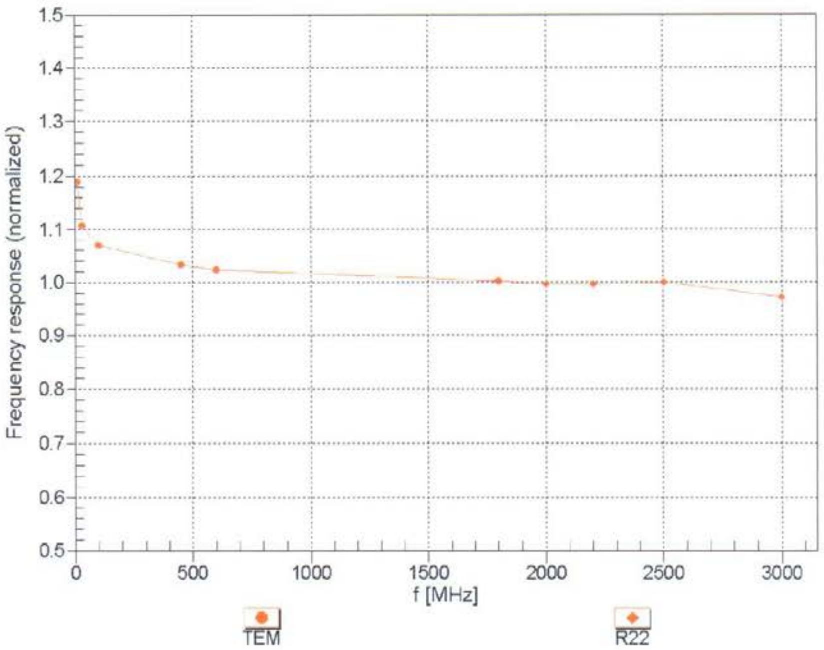
f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unct. (k=2)
750	55.5	0.96	9.18	9.18	9.18	0.52	0.82	± 12.0 %
835	55.2	0.97	9.09	9.09	9.09	0.80	0.64	± 12.0 %
900	55.0	1.05	8.93	8.93	8.93	0.65	0.72	± 12.0 %
1450	54.0	1.30	7.79	7.79	7.79	0.60	0.70	± 12.0 %
1640	53.8	1.40	7.93	7.93	7.93	0.35	0.91	± 12.0 %
1750	53.4	1.49	7.43	7.43	7.43	0.63	0.69	± 12.0 %
1810	53.3	1.52	7.27	7.27	7.27	0.30	0.98	± 12.0 %
1900	53.3	1.52	7.15	7.15	7.15	0.38	0.87	± 12.0 %
2000	53.3	1.52	7.31	7.31	7.31	0.50	0.76	± 12.0 %
2100	53.2	1.62	7.42	7.42	7.42	0.31	0.94	± 12.0 %
2300	52.9	1.81	7.07	7.07	7.07	0.43	0.82	± 12.0 %
2450	52.7	1.95	6.90	6.90	6.90	0.80	0.50	± 12.0 %
2600	52.5	2.16	6.68	6.68	6.68	0.80	0.50	± 12.0 %
3500	51.3	3.31	6.25	6.25	6.25	0.41	1.04	± 13.1 %
3700	51.0	3.55	6.12	6.12	6.12	0.46	0.98	± 13.1 %
5200	49.0	5.30	4.32	4.32	4.32	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.18	4.18	4.18	0.40	1.90	± 13.1 %
5500	48.6	5.65	3.80	3.80	3.80	0.45	1.90	± 13.1 %
5600	48.5	5.77	3.76	3.76	3.76	0.40	1.90	± 13.1 %
5800	48.2	6.00	3.86	3.86	3.86	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.

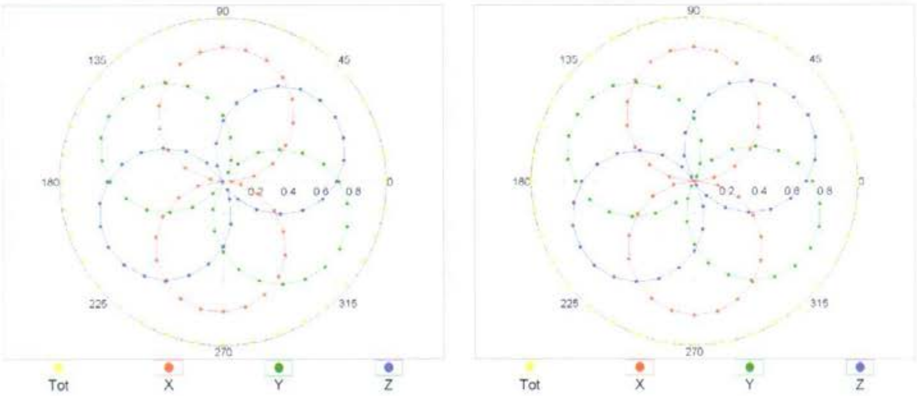
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)

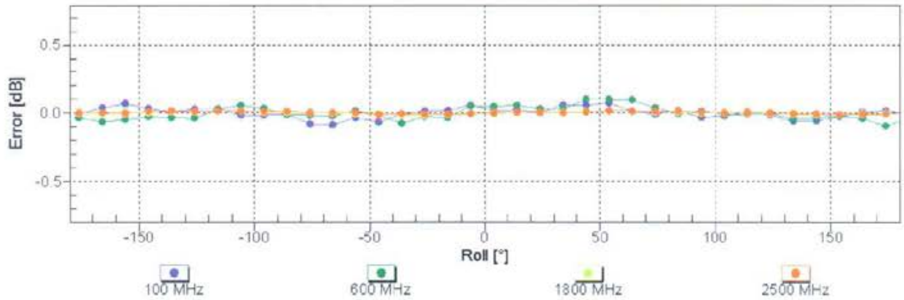


Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

Receiving Pattern (ϕ), ϑ = 0°

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

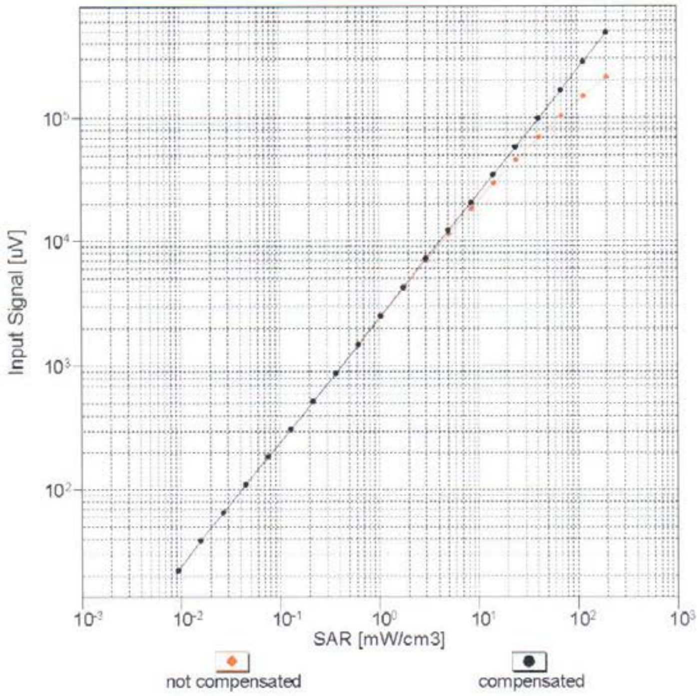


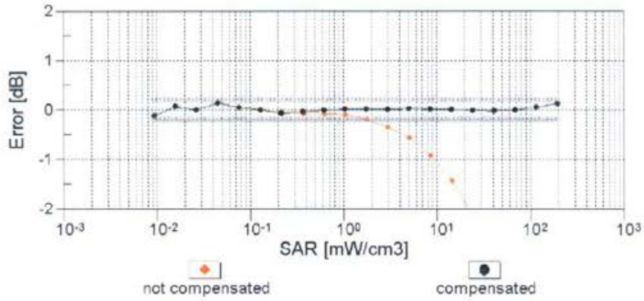


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR_{head})

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

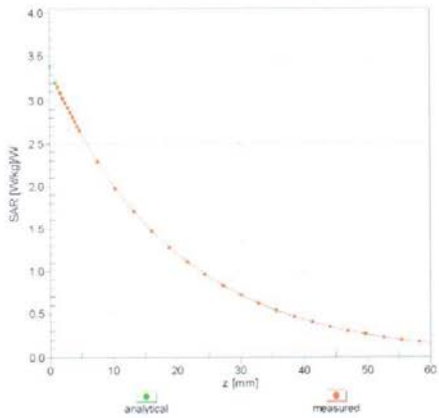




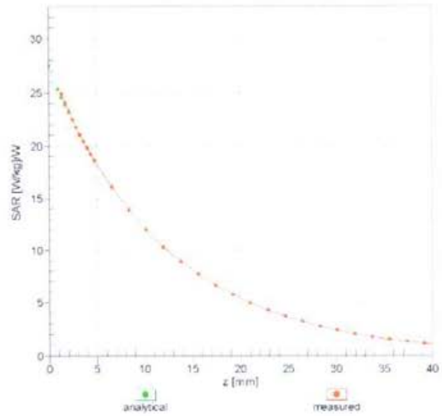
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

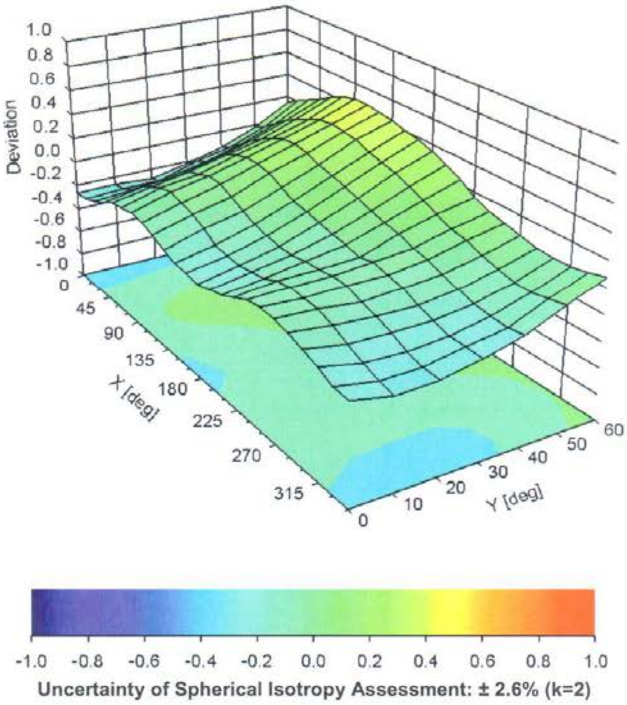


f = 1900 MHz,WGLS R22 (H_convF)



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:3846

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	4
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