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ENAC ENSAYOS Nº 51/LE342

TEST REPORT

REFERENCE STANDARDS:

FCC 47CFR Part 2.1093 (10-1-10 Edition)

FCC OET Bulletin 65, Supplement C (Edition 01-01)

NIE .... :	36851RRF.001
Approved by (name / position & signature) .... :	A. Llamas / RF Lab Manager — Francisco Rincón Ferrer (Firmado digitalmente por Francisco Rincón Ferrer Fecha: 2012.08.24 11:25:45 +02'00') p.a. ....
Elaboration date .... :	2012-08-24
Identification of item tested .... :	Intel® Centrino® Wireless-N + WiMAX 6150 inside a host laptop
Trademark .... :	Intel
Model and/or type reference .... :	612BNXHMW
Serial number .... :	MAC 802.11: 4025C2B518C4
	MAC 802.16e: 502DA20031B9
Other identification of the product .... :	FCC ID: PD9612BNXHU
Features .... :	802.11 b/g/n + 802.16e
Description .... :	Wireles Module: Intel® Centrino® Wireless-N + WiMAX 6150
	Antenna Type: Speed F-0G-FH-0004-000-KA / F-0G-FH-0005-000-WA
	Host platform: Lenovo U510
Applicant .... :	Intel Corporation
Address.. :	100 Center Point Circle, Suite 200, Columbia, SC 29210, USA
CIF/NIF/Passport.................................. :	---
Contact person:	Steven C. Hackett (Wireless Regulatory Engineer)
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Test samples supplier .... :	Same as applicant
Manufacturer .... :	Same as applicant

Test method requested .... :	See Standard
Standard .... :	1. FCC 47 CFR Part 2.1093 (10-1-10 Edition). Radiofrequency radiation exposure evaluation: portable devices. 2. FCC OET Bulletin 65, Supplement C (Edition 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".
Application Notes .... :	1. FCC OET KDB 248227 – SAR Measurements Procedures 802.11a/b/g Transmitters (May 2007 – Revised). 2. FCC OET KDB 616217 D03 – SAR Evaluation Considerations for Laptop/Notebook/Netbook and Tablet Computers – Supplement to KDB 616217 (November 2009). 3. FCC OET KDB 615223 D01 – 802.16e/WiMax SAR Measurement Guidance (November 2009). 4. FCC OET KDB 865664 – SAR Measurements Requirements for 3-6 GHz (October 2006). 5. FCC OET KDB 450824 – SAR Probe Calibration and System Verification Considerations for measurements at 150 MHz – 3 GHz (January 2007).
Test procedure .... :	PERF019
Non-standardized test method .... :	N/A
Used instrumentation .... :	1. Dosimetric E-field probe SPEAG ES3DV3 2. Data acquisition device SPEAG DAE4 3. Electro-optical converter SPEAG EOC3 4. 2450 MHz dipole validation kit SPEAG D2450V2 5. 2600 MHz dipole validation kit SPEAG D2600V2 6. Robot Stäubli RX60BL 7. Robot controller Stäubli CM7MB 8. Oval flat phantom SPEAG ELI 4 9. SAR measurement software SPEAG DASY52 V52.6.2.424 10. Measurement server SPEAG DASY5 SE UMS 011 BS 11. Body Tissue Equivalent Liquids for 2450MHz and 2600MHz bands 12. Vector network analyzer Agilent E5071C 13. Dielectric probe kit Agilent 85070C 14. Power meter R&S NRVD 15. Power Sensor R&S NRV-Z51 16. Power Sensor R&S NRV-Z1 17. Vector singal analyzer R&S FSQ8 18. RF Generator Agilent ESG E4438C 19. Dual directional coupler NARDA 4227-16 20. Power amplifier MITEQ AMF-4D-00400600-50-30P 21. Laptop positioning extension SPEAG Laptop Holder
Report template No. .... :	FDT08_13

INDEX

Competences and guarantees 4
General conditions 4
Uncertainty 4
Usage of samples 5
Testing period 5
Environmental conditions 5
Summary 6
Remarks and comments 6
Testing veredicts 6
APPENDIX A: Test Configuration 7
APPENDIX B: Test results 15
APPENDIX C: Measurements Reports 29
APPENDIX D: Calibration Data 35
APPENDIX E: Photographs 52

Competences and guarantees

AT4 wireless is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 342.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance programme for its measurement equipment.

AT4 wireless guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at AT4 wireless at the time of performance of the test.

AT4 wireless is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of AT4 wireless.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor k=2) was calculated according to the following documents:

1. FCC OET Bulletin 65, Supplement C (Edition 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".
2. FCC OET KDB 865664 – SAR Measurements Requirements for 3-6 GHz (October 2006).

Usage of samples

Samples undergoing test have been selected by: **the client**.

Sample M/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
36851/04	WiFi/WiMax module inside a laptop	Intel® Centrino® Wireless-N + WiMAX 6150 / Lenovo U510 / Speed Antennas	MAC 802.16e: 502DA20031B9	2012-07-04

Sample M/02 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
36851/07	WiFi/WiMax module inside a laptop	Intel® Centrino® Wireless-N + WiMAX 6150 / Lenovo U510 / Speed Antennas	MAC 802.11: 4025C2B518C4	2012-08-07

1. Sample M/01 has undergone the test(s) specified in subclause “Test method requested” for the 802.16e transmission mode.
2. Sample M/02 has undergone the test(s) specified in subclause “Test method requested” for the 802.11 transmission mode.

Testing period

The performed test started on 2012-07-10 and finished on 2012-08-09.

The tests have been performed at AT4 wireless.

Environmental conditions

In the laboratory for measurements, the following limits were not exceeded during the test:

Temperature	Min. = 23.21 ºC Max. = 25.33 ºC
Relative humidity	Min. = 27.97 % Max. = 66.18 %

Summary

Considering the results of the performed test according to standard FCC 47CFR Part 2.1093, the item/s under test is/are **IN COMPLIANCE** with the requested specifications specified in the standard.

The maximum 1g volume averaged SAR found during this test has been 0.815 W/kg for the 2600 MHz band and 802.16e with 5 MHz BW mode.

NOTE: The results presented in this Test Report apply only to the particular item under test established in page 1 of this document, as presented for test on the date(s) shown in section, "USAGE OF SAMPLES, TESTING PERIOD AND ENVIRONMENTAL CONDITIONS".

Remarks and comments

1: 802.11n20 = 20MHz BW / 802.11n40 = 40MHz BW.

2: Testing of 802.11b, 802.11g and 802.11n with 20MHz BW is not required due to the testing reductions mentioned in FCC OET KDB 248227 – SAR Measurements Procedures 802.11a/b/g Transmitters (May 2007 – Revised), paragraph "Frequency Channel Configurations".

3: Testing of other channels in each band is optional when the maximum output channel SAR fulfills the testing reductions mentioned in FCC OET KDB 248227 – SAR Measurements Procedures 802.11a/b/g Transmitters (May 2007 – Revised), paragraph "Frequency Channel Configurations".

4: Testing of other channels in each band is optional when the maximum output channel SAR fulfills the testing reductions mentioned in FCC OET KDB 447498 – Mobile and Portable device – RF Exposure procedures and equipment authorization policies, paragraph 1) e).

5: Only the plots of the highest SAR for each test configuration and each chain is included in appendix C, according to FCC OET Bulletin 65, Supplement C (Edition 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields", appendix B.

Testing verdicts

Not applicable ....: NA

Pass..: P

Fail: F

Not measured...: NM

2450 MHz band

FCC 47CFR Part 2.1093 Paragraph	VERDICT			
	NA	P	F	NM
(d)(2) 802.11b				NM[2]
(d)(2) 802.11g				NM[2]
(d)(2) 802.11n20 [1]				NM[2]
(d)(2) 802.11n40 [1]		P		

1 and 2: See Remarks and Comments.

802.16 - 2600 MHz band

FCC 47CFR Part 2.1093 Paragraph	VERDICT			
	NA	P	F	NM
(d)(2) 5 MHz – QPSK		P		
(d)(2) 5 MHz – 16QAM		P		
(d)(2) 10 MHz – QPSK		P		
(d)(2) 10 MHz – 16QAM		P		

APPENDIX A: Test Configuration

INDEX

1. GENERAL INTRODUCTION 9
1.1. Application Standard 9
1.2. General requirements 9
1.3. Measurement system and phantom requirements 9
1.4. Measurement Liquids requirements. 9

2. MEASUREMENT SYSTEM 10
2.1. Measurement System 10
2.2. Test Positions of device relative to body 11
2.3. Test to be performed 11
2.4. Description of interpolation/extrapolation scheme 11
2.5. Determination of the largest peak spatial-average SAR 11
2.6. System Validation 12

3. UNCERTAINTY 13

4. SAR LIMIT 14

1. GENERAL INTRODUCTION

1.1. Application Standard

The Federal Communications Commission (FCC) sets the limits for General Population / Uncontrolled exposure to radio frequency electromagnetic fields for transmitting devices designed to be used within 20 centimetres of the user body under FCC 47 CFR Part 2.1093 - "Radiofrequency radiation exposure evaluation: portable devices", paragraph (d)(2).

Specific requirements and procedure for SAR assessment are describe under FCC OET Bulletin 65, Supplement C (Edition 01-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields", and all the FCC OET Knowledge Database documents referred at the beginning of this document.

1.2. General requirements

The SAR measurement has been performed continuing the following considerations and environment conditions:

- The ambient temperature shall be in the range of 18ºC to 25ºC and the variation shall not exceed +/-2ºC during the test.
- The ambient humidity shall be in the range of and 30% - 70%.
- The device battery shall be fully charged before each measurement.

1.3. Measurement system and phantom requirements

The measurement system used for SAR tests fulfils the procedural and technical requirements described at the reference standards used.

The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues in human body.

1.4. Measurement Liquids requirements.

The liquids used to simulate the human tissues, must fulfils the requirements of the dielectric properties required. These target dielectric properties per FCC OET KDB 450824 instructions come from the dipole and probe calibration data which are included in Appendix B, Section 2, of this document (the values for 2600 MHz are linearly interpolated between the specified values in FCC OET Bulletin 65 – Supplement C, Appendix C, 'Tissue Dielectric Parameters').

As indicated in FCC OET KDB 450824, it is allowed a 5% variation of the above mentioned level at the 2450 MHz and 2600 MHz bands.

2. MEASUREMENT SYSTEM

2.1. Measurement System

Manufacturer	Device	Type
Schmid & Partner Engineering AG	Dosimetric E-Fiel Probe	ES3DV3
Schmid & Partner Engineering AG	Data Acquisition Electronics	DAE4
Schmid & Partner Engineering AG	Electro-Optical Converter	EOC5
Schmid & Partner Engineering AG	2450 MHz System Validation Dipole	D2450V2
Schmid & Partner Engineering AG	2600 MHz System Validation Dipole	D2600V2
Stäubli	Robot	RX60BL
Stäubli	Robot controller	CM7MB
Schmid & Partner Engineering AG	Oval flat phantom	ELI 4
Schmid & Partner Engineering AG	Measurement Software	DASY52 V52.6.2.424
Schmid & Partner Engineering AG	Measurement Server	DASY5 SE UMS 011 BS
Agilent	Vector Network Analyser	E5071C
Agilent	Dielectric Probe Kit	85070C
Rohde & Schwarz	Power Meter	NRVD
Rohde & Schwarz	Power Sensor	NRV-Z51
Rohde & Schwarz	Power Sensor	NRV-Z1
Rohde & Schwarz	Vector Signal Analyzer	FSQ8
Agilent	RF Generator	ESG E4438C
NARDA	Dual directional coupler	4227-16
MITEQ	Power amplifier	AMF-4D-00400600-50-30P
Schmid & Partner Engineering AG	Laptop Holder	SM LH1 001 AC

Table 1: Measurement Equipment

2.2. Test Positions of device relative to body

The laptop device was tested in one position for all tests, with the bottom face placed directly against the phantom so the position of the laptop would be used (normal use condition). Further analysis was performed to determine the location which showed the highest SAR.

The antennas on the laptop are located within the edge screen. According to FCC OET Bulletin 65 – Supplement C, the antennas which would applied in the test are antennas or radiating structures in direct contact with the user's body within 20 centimetres of the body of a user under normal operating conditions.

2.3. Test to be performed

For the 802.11 transmitter, in all operating modes and bands the measurements have to be performed on the "default test channels" defined at FCC OET KDB 248227 – SAR Measurements Procedures 802.11a/b/g Transmitters (May 2007 – Revised), except those channels defined as "required test channels" at the same document.

For the 802.16e/Wimax transmitter, the measurements must be done on lowest, middle and highest channels for QPSK and 16QAM modulation using the applicable channel bandwidths.

2.4. Description of interpolation/extrapolation scheme

The local SAR inside the Phantom is measured using small dipole sensing elements inside a probe element. The probe tip must not be in contact with the Phantom's surface in order to minimise measurement errors, but the highest local SAR is obtained from measurements at a certain distances from the shell trough extrapolation. The accurate assessment of the maximum SAR averaged over 1 gr. and 10 gr. requires a very fine resolution in the three dimensional scanned data array. Since the measurements have to be performed over a limited time, the measured data have to be interpolated to provide an array of sufficient resolution.

The interpolation of 2D area scan is used after the initial area scan, at a fixed distance from the Phantom shell wall. The initial scan data is collected with a proper spatial resolution and this interpolation is used to find the location of the local maximum for positioning the subsequent 3D scanning to within a 1mm resolution.

For the 3D scan, data is collected on a spatially regular 3D grid having 5mm steps in both lateral directions, and 5mm in depth direction for the 2450MHz and 2600MHz bands. After the data collection by the SAR probe, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will de applicable right up to the shell wall boundary.

2.5. Determination of the largest peak spatial-average SAR

To determine the maximum value of the peak spatial-average SAR of a EUT, all device positions, configurations and operational modes should be tested for each frequency band.

According to FCC 47 CFR Part 2.1093, the averaging volume shall be chosen as 1 g of contiguous tissue. The cubic volumes, over which the SAR measurements are averaged after extrapolation and interpolation, are chosen in order to include the highest values of local SAR.

The maximum SAR level for the EUT will be the maximum level obtained of the performed measurements, and indicated in the previous points.

2.6. System Validation

Prior to the SAR measurements, system verification is done daily to verify the system accuracy. As FCC OET Bulletin 65 – Supplement C, Appendix D “SAR measurement procedures” Paragraph “System Verification” specifies, a complete SAR evaluation is done using a half-wavelength dipole as source with the frequency of the mid-band channel of the operating band, or within 100MHz of this channel.

The measured one-gram SAR should be within 10% of the expected target values specified in the calibration certificate of the dipole, for the specific tissue and frequency used.

3. UNCERTAINTY

Uncertainty for 300 MHz – 6 GHz

ERROR SOURCES	Uncertainty value (%)	Probability distribution	Divisor	(c_i) 1g	(c_i) 10g	Standard uncertainty (1g) (%)	Standard uncertainty (10g) (%)	v_i v_{eff}
Measurement Equipment								
Probe Calibration	±4.480	Normal	1	1	1	±4.480	±4.480	∞
Axial Isotropy	±7.558	Rectangular	$\sqrt{3}$	1	1	±4.364	±4.364	∞
Hemispherical Isotropy	±2.000	Rectangular	$\sqrt{3}$	1	1	±1.155	±1.155	∞
Boundary effect	±4.700	Rectangular	$\sqrt{3}$	1	1	±2.714	±2.714	∞
Linearity	±1.000	Rectangular	$\sqrt{3}$	1	1	±0.577	±0.577	∞
System detection limits	±0.300	Rectangular	$\sqrt{3}$	1	1	±0.300	±0.300	∞
Readout electronics	±1.010	Normal	1	1	1	±0.583	±0.583	∞
Response time	±2.600	Rectangular	$\sqrt{3}$	1	1	±1.501	±1.501	∞
Integration time	±3.000	Rectangular	$\sqrt{3}$	1	1	±1.732	±1.732	∞
RF Ambien conditions	±3.000	Rectangular	$\sqrt{3}$	1	1	±1.732	±1.732	∞
Probe positioner	±0.800	Rectangular	$\sqrt{3}$	1	1	±0.462	±0.462	∞
Probe positioning	±9.900	Rectangular	$\sqrt{3}$	1	1	±5.716	±5.716	∞
Maximum SAR evaluation	±1.000	Rectangular	$\sqrt{3}$	1	1	±0.577	±0.577	∞
Test Sample Related								
Device positioning	±2.900	Normal	1	1	1	±2.900	±2.900	145
Device Holder	±3.600	Normal	1	1	1	±3.600	±3.600	5
Power Drift	±5.000	Rectangular	$\sqrt{3}$	1	1	±2.887	±2.887	∞
Phantom and Setup								
Phantom uncertainty	±4.000	Rectangular	$\sqrt{3}$	1	1	±2.309	±2.309	∞
Liquid conductivity (deviation from target)	±5.000	Rectangular	$\sqrt{3}$	0.64	0.43	±1.848	±1.241	∞
Liquid conductivity (measurement error)	±3.100	Normal	1	0.64	0.43	±1.984	±1.333	∞
Liquid permittivity (deviation from target)	±5.000	Rectangular	$\sqrt{3}$	0.64	0.43	±1.848	±1.241	∞
Liquid permittivity (measurement error)	±4.410	Normal	1	0.64	0.43	±2.822	±1.896	∞
Combined standard uncertainty	$u_c = \sqrt{\sum_{1=1}^{m} c_i^2 \cdot u_i^2}$					**±11.99**	**±11.56**	330
Expanded uncertainty (confidence interval of 95%)	*ue =2.00 uc*					**±23.98**	**±23.11**	

Table 2: Uncertainty Assessment for 300 MHz - 6 GHz

4. SAR LIMIT

Having a worst case measurement, the SAR limit is valid for general population/uncontrolled exposure.

The SAR values have to be averaged over a mass of 1 gr. ($SAR_{1\ gr.}$) with the shape of a cube. This level couldn't exceed the values indicated in the application Standard:

Standard	SAR	SAR Limit (W/Kg)
FCC 47 CFR Part 2.1093 Paragraph (d)(2)	$SAR_{1\ gr.}$	1.6

Table 3: SAR limit

APPENDIX B: Test results

INDEX

1. TEST CONDITIONS 17
1.1. Temperature (ºC): 17
1.2. DUT information 17
2. Test signal, Output Power and Frequencies 17
2.1. 802.11b/g/n Transmitter 17
2.2. 802.16e/WiMax Transmitter 18
2.2.1. WiMax Zone Types 18
2.2.2. Duty factor considerations 18
2.2.3. Duty factor and Crest factor calculations 20
2.2.4. Test Software 20
2.2.5. Signal generator details 20
2.2.6. Communication test set details 21

3. TISSUE PARAMETERS MEASUREMENTS 22

4. SYSTEM VALIDATION MEASUREMENTS 22
4.1. Validation results in 2450 MHz Band for Body TSL 22
4.2. Validation results in 2600 MHz Band for Body TSL 22

5. CONDUCTED AVERAGE POWER MEASUREMENTS 23
5.1. 802.11b/g/n transmitter 23
5.2. 802.16e/WiMax transmitter 23
5.2.1. Average Output Power 23
5.2.2. Peak to average ratio 24

6. MEASUREMENT RESULTS FOR SAR (SPECIFIC ABSORPTION RATE) 25
6.1. Summary maximum results 25
6.2. Results for 2450 MHz Band 25
6.2.1. Lapheld Mode 25
6.3. Results for 2600 MHz Band 26
6.3.1. Lapheld Mode 26
6.4. PAR and SAR error considerations 27
6.4.1. 5MHz – QPSK 27
6.4.2. 5MHz – 16QAM 27
6.4.3. 10MHz – QPSK 28
6.4.4. 10MHz – 16QAM 28

1. TEST CONDITIONS

1.1. Temperature (ºC):

T_n = +23.21 to +25.33

The subscript n indicates normal test conditions.

1.2. DUT information

The device under test was the Intel® Centrino® Wireless-N + WiMAX 6150 card located inside a host laptop (Lenovo U510) computer which utilises a set of Speed antennas (F-0G-FH-0004-000-KA / F-0G-FH-0005-000-WA). The Intel® Centrino® Wireless-N + WiMAX 6150 card is an embedded IEEE 802.16e and 802.11b/g/n wireless network adapter that operates in the 2.4 GHz spectra for WiFi and 2.6 GHz for WiMax.

According to host device manufacturer, the source-based time-averaged output power of the Bluetooth device is far bellow the SAR threshold (60/f(GHz) mW). Therefore, neither SAR testing nor co-transmission evaluation is required for the Bluetooth transmitter, following the guidelines stated at FCC OET KDB 616217 D03 – SAR Evaluation Considerations for Laptop/Notebook/Netbook and Tablet Computers – Supplement to KDB 616217 (November 2009), paragraph 4).

The 802.16e/WiMax and 802.11a/b/g/n radio will not transmit simultaneously. Once the network is chosen by the end user during WiMax/WiFi network, only the WiMax radio or WiFi radio will transmit.

Collocation with WWAN transmitter has not been considered following grantee request because this collocation will be considered in the WWAN transmitter SAR testing.

2. Test signal, Output Power and Frequencies

2.1. 802.11b/g/n Transmitter

The device was put into operation by using an own control software (DRTU version 1.5.3-0335) to program the test mode required for select the continuous transmission with 100% duty cycle.

In all operating bands the measurements were performed on the "default test channels" defined at FCC OET KDB 248227 – SAR Measurements Procedures 802.11a/b/g Transmitters (May 2007 – Revised), except those that fulfil the frequency channel selection criteria mentioned on paragraph "Frequency Channel Configuration" at the same document.

The output power of the device was set to maximum power level for all tests; a fully charged battery was used for every test sequence.

The maximum average conducted power of the device was measured with a Power meter R&S NRVD and a thermocoupled Power sensor NRV-Z51.

2.2. 802.16e/WiMax Transmitter

612BNXHMW transmits on 5ms frames using 5 MHz and 10 MHz channels. The 10 MHz channel bandwidth uses 1024 sub-carriers and 35 sub-channels, with 184 null sub-carries and 840 available for transmission, consisting of 560 data sub-carriers and 280 pilot sub-carriers. The 5 MHz channel bandwidth uses 512 sub-carriers and 17 sub-channels, with 104 null sub-carriers and 408 available for transmission, consisting 272 data sub-carriers and 136 pilot sub-carriers.

2.2.1. WiMax Zone Types

The device and its system are both transmitting using only PUSC zone type. This enables multiple users to transmit simultaneously within the system. FUSC, AMC and other zone types are not used by WiMax 6150 for uplink transmission. The maximum DL:UL symbol ratio can be determined according to the PUSC requirements. The system transmit an odd number of symbols using DL-PUSC consisting of even multiples of traffics and control symbols plus one symbol for the preamble. Multiples of three sysmbols are transmitted by the device using UL-PUSC. The OFDMA symbol time allows up to 48 downlink and uplink symbols in each 5 ms frame. TTG and RTG are also included in each frame as DL/UL transmission gaps; therefore, the system can only allow 47 or less symbols per frame. The maximum DL:UL symbol ratio is determined according to these PUSC parameters for evaluating SAR compliance.

WiMax chipset is capable of supporting the following Downlink / Uplink based upon 802.16e

Description	Downlink	Uplink
Number of OFDM Symbols in Downlink and Uplink for 5 MHz and 10 MHZ bandwidth	35	12
	34	13
	32	15
	31	16
	30	17
	29	18
	28	19
	27	20
	26	21

2.2.2. Duty factor considerations

1. All test vectors are performing with all UL symbols at maximum power.
2. Although the chipset can supply higher downlink-to-uplink (DL/UL) symbol ratios, WiMax 6150 is only supplied to BRS/EBS WiMax operators with agreements to transmit at a maximum DL/UL symbol ratio of 29:18. WiMax 6150 is limited by firmware and the corresponding WiMax system to operate at or below this maximum duty factor. Therefore, the maximum transmission duty factor supported by the chipset is not applicable for this device. The system can transmit up to 48 OFDMA symbols in each frame, including 1.6 symbols for TTG and RTG.
3. UL Burst maximum average power was measured using a spectrum analyzer gated to measure the power only during Tx “On” stage.

Mode	Test Vector file name	CH / freq.	Max. Average Power	
			dBm	mW
QPSK 5MHz	DQ4_28S_UQ4_C_5	378 / 2593	23.99	250.61
16QAM 5MHz	DQ4_28S_UQ16_C_5	378 / 2593	23.90	245.47
QPSK 10MHz	DQ4_28S_UQ4_C_10	368 / 2593	23.58	228.03
16QAM 10MHz	DQ64_28S_UQ16_C_10	368 / 2593	23.32	214.78

4. The control channels may occupy up to 5 slots during normal operation. A slot is a sub-channel with the duration of 3 symbols. There are a total of 17 slots in the 5 MHz channel configuration, and 35 slots in the 10 MHz channel configuration.
5. Max. Rated / Certified Power.

Modulation	Channel Bandwidth	Power (mW)
QPSK	5 MHz	251.00
16QAM	5 MHz	251.00
QPSK	10 MHz	224.00
16QAM	10 MHz	224.00

6. When the device is transmitting at max rated power, the output power for the control symbol and the target output power for the DL:L ratio of 29:18 is calculated as follows:

Modulation	BW	Max. power (mW)	Max. power of control symbol (max. pwr x 5 / 17)	29:18 DL:UL ratio pwr (mW) (ctrl_symb_pwr x 3) + (max_pwr x 15)
QPSK	5 MHz	251.00	73.82	3986.47
16QAM	5 MHz	251.00	73.82	3986.47
Modulation	BW	Max. power (mW)	Max. power of control symbol (max. pwr x 5 / 35)	29:18 DL:UL ratio pwr (mW) (ctrl_symb_pwr x 3) + (max_pwr x 15)
QPSK	10 MHz	224.00	32.00	3456.00
16QAM	10 MHz	224.00	32.00	3456.00

7. Test Vector waveform power and scaling factor to DL:UL ratio of 29:18.

5 MHz / QPSK: DQ4_28S_UQ4_C_5 (29:18)

Channel number	Freq. (MHz)	Meas. Power (mW)	Number of Traffic Symbols	Traffic Symbols Power (mW)	29:18 Rated Power	Scaling Factor
0	2498.5	248.89	15	3733.29	3986.47	1.07
378	2593	250.61	15	3759.16	3986.47	1.06
756	2687.5	246.04	15	3690.55	3986.47	1.08

5 MHz / 16QAM: DQ4_28S_UQ16_C_5 (29:18)

Channel number	Freq. (MHz)	Meas. Power (mW)	Number of Traffic Symbols	Traffic Symbols Power (mW)	29:18 Rated Power	Scaling Factor
0	2498.5	243.22	15	3648.31	3986.47	1.09
378	2593	245.47	15	3682.06	3986.47	1.08
756	2687.5	239.88	15	3598.25	3986.47	1.11

10 MHz / QPSK: DQ4_28S_UQ4_C_10 (29:18)

Channel number	Freq. (MHz)	Meas. Power (mW)	Number of Traffic Symbols	Traffic Symbols Power (mW)	29:18 Rated Power	Scaling Factor
0	2501	220.80	15	3312.01	3518.24	1.06
368	2593	223.87	15	3358.08	3456.00	1.03
736	2685	218.27	15	3274.09	3518.24	1.07

10 MHz / 16QAM: DQ64_28S_UQ16_C_10 (29:18)

Channel number	Freq. (MHz)	Meas. Power (mW)	Number of Traffic Symbols	Traffic Symbols Power (mW)	29:18 Rated Power	Scaling Factor
0	2501	211.84	15	3177.54	3456.00	1.09
368	2593	214.78	15	3221.75	3456.00	1.07
736	2685	211.84	15	3177.54	3456.00	1.09

2.2.3. Duty factor and Crest factor calculations

Mode	Test Vector file name	DL:UL ratio	Duty factor (%)	Crest Factor (100 / duty cycle)
QPSK 5MHz	DQ4_28S_UQ4_C_5	29 : 18	30.9	2.70
16QAM 5MHz	DQ4_28S_UQ16_C_5	29 : 18	30.9	2.70
QPSK 10MHz	DQ4_28S_UQ4_C_10	29 : 18	30.9	2.70
16QAM 10MHz	DQ64_28S_UQ16_C_10	29 : 18	30.9	2.70

Note: The duty factor can be given as: (number of traffic symbols * 102.857µs) / 5000µs

2.2.4. Test Software

The test software tool (WiMax VaTU 5.0.0.2) is installed on the host device to transmit at max. output power. During normal operation, the output power of WiMax client is controlled by a WiMax basestation, which also determines the characteristics of the transmission. For testing purposes, the device output power is kept at this maximum using the test software tool loaded in the host device. The uplink transmission is maintained at a stable condition by the radio profile loaded in a vector signal generator. This enables the WiMax module to transmit at max. power with a constant duty factor according to the specific radio profile. The test software serves only one purpose, to configure the WiMax module to transmit at the max. power during SAR measurement.

2.2.5. Signal generator details

Agilent ESG Vector Signal Generator (Model: E4438C) is used in conjunction with Intel supplied radio profile to configure de WiMax module for the SAR evaluation. ESG Vector Signal Generator is loaded with the downlink signal, containing the respective FCH, DL-MAP and UL-MAP required by the test device to configure the uplink transmission. The waveform is configured for a DL:UL symbol ratio of 29:18 using Intel signal waveform software for 802.16 WiMax on the PC, and downloaded to the VSG. The test device can synchronize itself to the signal received from VSG, both in frequency and time. It then demodulates the DL-MAP and UL-MAP transmitted in the downlink sub-frame and determine the DL:UL symbol ratio. The downlink burst is repeated in each frame, every 5ms, to simulate the normal transmission from a WiMax base station. The UL-MAP received by the device is used to configure the uplink burst with all data symbols and sub-carriers active. Since this is a one-way communication configuration, control channel transmission is neither requested nor transmitted.

For TDD systems, both uplink and downlink transmission are at the same frequency. The output power of the VSG is kept at least 80dB lower than the test device to avoid interfering with the SAR measurements. In addition, a horn antenna is used for the VSG and it is kept more than 1 meter away from the test device to further minimize unnecessary pickup by the SAR probe.

2.2.6. Communication test set details

Frame definition for 5 MHz RCT		
Parameter / Value	Test vector name	
	DQ4_28S_UQ4_C_5	DQ4_28S_UQ16_C_5
Bandwidth	5 MHz	5 MHz
FFT size	512	512
UL traffic symbols	15	15
Downlink		
Zone profile	Zone 1 - PUSC	Zone 1 – PUSC
Burst profile / MCS	MCS: QPSK R1/2	MCS: QPSK R1/2
Uplink		
Zone profile	Zone 1 - PUSC	Zone 1 - PUSC
Burst profile / MCS	MCS: QPSK R1/2	MCS: QAM16 R3/4

Frame definition for 10 MHz RCT		
Parameter / Value	Test vector name	
	DQ4_28S_UQ4_C_10	DQ64_28S_UQ16_C_10
Bandwidth	10 MHz	10 MHz
FFT size	1024	1024
UL traffic symbols	15	15
Downlink		
Zone profile	Zone 1 – PUSC	Zone 1 – PUSC
Burst profile / MCS	MCS: QPSK R1/2	MCS: QAM64 R5/6
Uplink		
Zone profile	Zone 1 – PUSC	Zone 1 – PUSC
Burst profile / MCS	MCS: QPSK R1/2	MCS: QAM16 R3/4

3. TISSUE PARAMETERS MEASUREMENTS

Frequency (MHz)	Target Body Tissue: Parameters used in Probe Calibration		Target Body Tissue: Parameters used in Dipole Calibration		Measured Body Tissue		Measured Date
	Permittivity	Conductivity [S/m]	Permittivity	Conductivity [S/m]	Permittivity	Conductivity [S/m]	
2450	52.7 ± 5%	1.95 ± 5%	53.2 ± 6%	2.00 ± 6%	51.28	1.89	2012-08-08
2600	52.5 ± 5%	2.16 ± 5%	53.9 ± 6%	2.14 ± 6%	50.85	2.06	2012-07-10

Note: The dielectric properties have been measured by the contact probe method at 24° C.

4. SYSTEM VALIDATION MEASUREMENTS

4.1. Validation results in 2450 MHz Band for Body TSL

SAR	Target SAR (W/kg)	Measured SAR (W/kg)	Drift (%)	Limit (%)
1 gr.	52.10	55.58	6.68	± 10
10 gr.	24.40	25.11	2.91	± 10

4.2. Validation results in 2600 MHz Band for Body TSL

SAR	Target SAR (W/kg)	Measured SAR (W/kg)	Drift (%)	Limit (%)
1 gr.	56.40	61.34	8.76	± 10
10 gr.	25.20	26.66	5.79	± 10

5. CONDUCTED AVERAGE POWER MEASUREMENTS

5.1. 802.11b/g/n transmitter

Band	Mode	Channel	Frequency (MHz)	Conducted Power (dBm)
2450 MHz	802.11b	1	2412	16.57
		6	2437	16.75
		11	2462	16.36
	802.11g	1	2412	16.55
		6	2437	16.41
		11	2462	15.04
	802.11n20 [1]	1	2417	16.46
		6	2437	16.35
		11	2457	14.50
	802.11n40 [1]	3	2422	13.80
		6	2437	16.83
		9	2452	11.54

1: See Remarks and Comments.

5.2. 802.16e/WiMax transmitter

5.2.1. Average Output Power

Band	Mode	Channel	Frequency (MHz)	Conducted Power	
				dBm	mW
2600 MHz	5MHz QPSK	0	2498.5	23.96	248.89
		378	2593	23.99	250.61
		756	2687.5	23.91	246.04
	5MHz 16QAM	0	2498.5	23.86	243.22
		378	2593	23.90	245.47
		756	2687.5	23.80	239.88
	10MHz QPSK	0	2501	23.44	220.80
		368	2593	23.50	223.87
		736	2685	23.39	218.27
	10MHz 16QAM	0	2501	23.26	211.84
		368	2593	23.32	214.78
		736	2685	23.26	211.84

5.2.2. Peak to average ratio

Band	Mode	Channel	Frequency (MHz)	Conducted Power (dBm)		PAR
				Average	Peak	
2600 MHz	5MHz QPSK	0	2498.5	23.96	29.69	5.73
		378	2593	23.99	29.93	5.94
		756	2687.5	23.91	30.07	6.16
	5MHz 16QAM	0	2498.5	23.86	29.60	5.74
		378	2593	23.90	29.77	5.87
		756	2687.5	23.80	30.10	6.30
	10MHz QPSK	0	2501	23.44	29.58	6.14
		368	2593	23.50	29.69	6.19
		736	2685	23.39	30.04	6.65
	10MHz 16QAM	0	2501	23.26	29.66	6.40
		368	2593	23.32	29.74	6.42
		736	2685	23.26	30.10	6.84

6. MEASUREMENT RESULTS FOR SAR (SPECIFIC ABSORPTION RATE)

6.1. Summary maximum results

Band	Chain	Mode	Channel	Frequency (MHz)	Measured SAR 1g (W/Kg)	SAR limit 1g (W/Kg)
2450 MHz	A	802.11n40 [1]	6	2437	0.308	1.6
2600 MHz	A	802.16e 5MHz QPSK	0	2498.5	0.743	1.6
	B	802.16e 5MHz QPSK	756	2687.5	0.815	1.6

1: See Remarks and Comments.

6.2. Results for 2450 MHz Band

6.2.1. Lapheld Mode

Mode	Chain	Channel	Frequency (MHz)	SAR averaged over 1g (W/Kg)	Power Drift (%)
802.11b	A	1	2412	NM[2]	-
		6	2437	NM[2]	-
		11	2462	NM[2]	-
802.11g	A	1	2412	NM[2]	-
		6	2437	NM[2]	-
		11	2462	NM[2]	-
802.11n20 [1]	A	1	2412	NM[2]	-
		6	2437	NM[2]	-
		11	2462	NM[2]	-
802.11n40 [1]	A	3	2422	NM[3]	-
		6	2437	0.308	-0.88
		9	2452	NM[3]	-

1, 2 and 3: See Remarks and Comments.

6.3. Results for 2600 MHz Band

6.3.1. Lapheld Mode

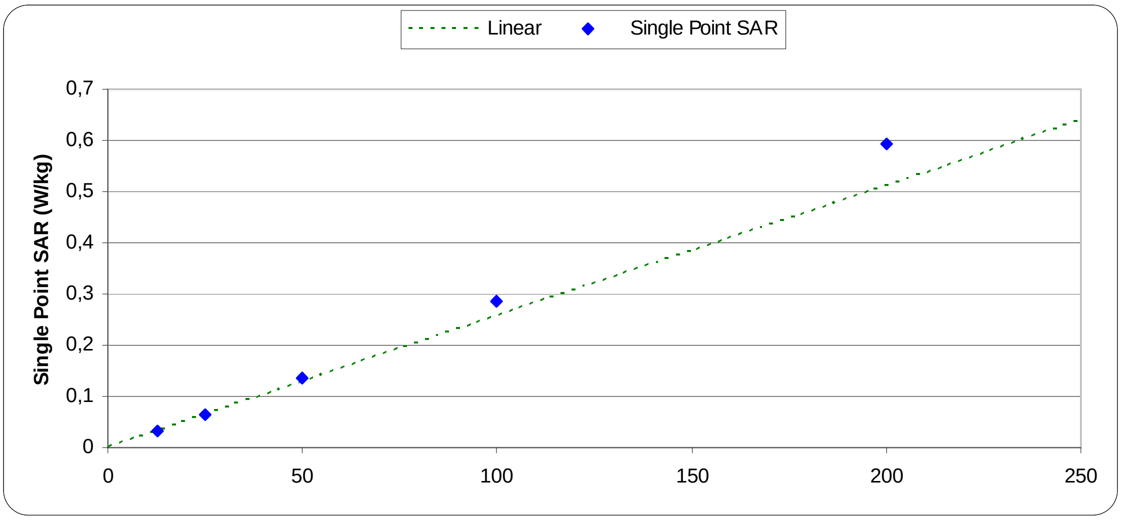
Chain	Mode	Channel	Frequency (MHz)	SAR averaged over 1g (W/Kg)	Scaling Factor	Corrected SAR 1g (W/kg)	Power Drift (%)
A	802.16e 5MHz QPSK	0	2498.5	0.694	1.07	0.743	0.59
		378	2593	0.641	1.06	0.680	-0.26
		756	2687.5	0.649	1.08	0.701	0.64
	802.16e 5MHz 16QAM	0	2498.5	0.677	1.07	0.724	0.61
		378	2593	0.585	1.06	0.620	-0.01
		756	2687.5	0.585	1.08	0.632	-1.60
	802.16e 10MHz QPSK	0	2501	0.633	1.09	0.690	0.79
		368	2593	0.562	1.08	0.607	0.09
		736	2685	0.502	1.11	0.557	-0.36
	802.16e 10MHz 16QAM	0	2501	0.534	1.09	0.582	0.36
		368	2593	0.523	1.08	0.565	-2.61
		736	2685	0.486	1.11	0.540	1.11
B	802.16e 5MHz QPSK	0	2498.5	0.739	1.06	0.783	0.89
		378	2593	0.445	1.03	0.458	1.74
		756	2687.5	0.762	1.07	0.815	0.01
	802.16e 5MHz 16QAM	0	2498.5	0.717	1.06	0.760	-0.78
		378	2593	0.618	1.03	0.637	2.21
		756	2687.5	0.697	1.07	0.746	1.86
	802.16e 10MHz QPSK	0	2501	0.683	1.09	0.751	-0.95
		368	2593	0.556	1.07	0.595	0.48
		736	2685	0.616	1.09	0.671	-1.26
	802.16e 10MHz 16QAM	0	2501	0.583	1.09	0.636	0.82
		368	2593	0.378	1.07	0.405	0.40
		736	2685	0.628	1.09	0.685	-1.60

6.4. PAR and SAR error considerations

In order to estimate the measurement error in 802.16e/WiMax mode due to PAR issues, the configuration with the highest SAR in each channel bandwidth and frequency band is measured at various power levels, form approximately 12.5mW at approx. 3dB steps, until the maximum power is reached.

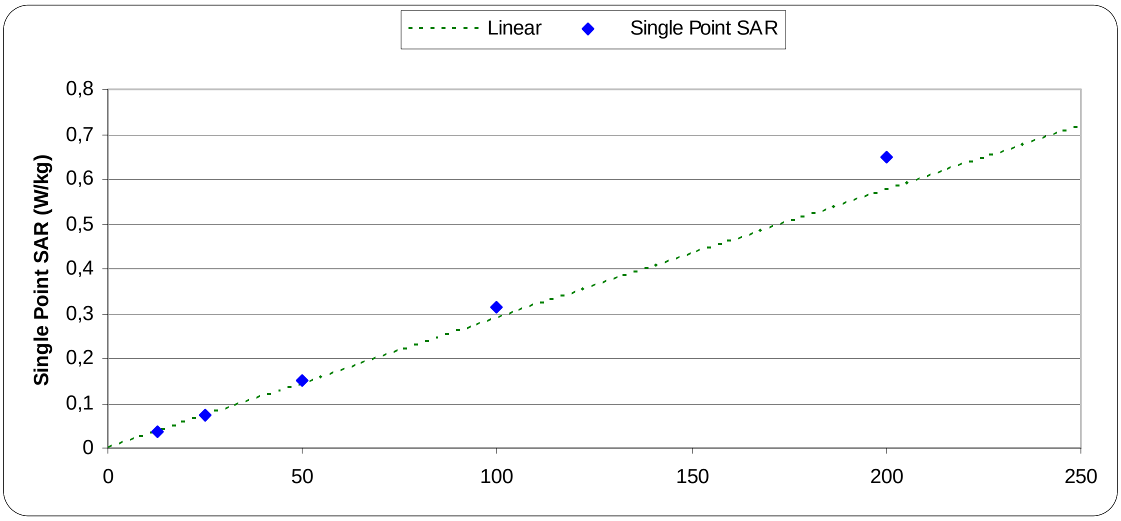
6.4.1. 5MHz – QPSK

Average Power (mW)	12.5	25.0	50.0	100.0	200.0
Single Point SAR (W/kg)	0.032	0.066	0.135	0.284	0.593
Linear line (SAR)	0.032	0.064	0.128	0.256	0.512
Estimation (%)	0.00	3.03	5.19	9.86	13.66



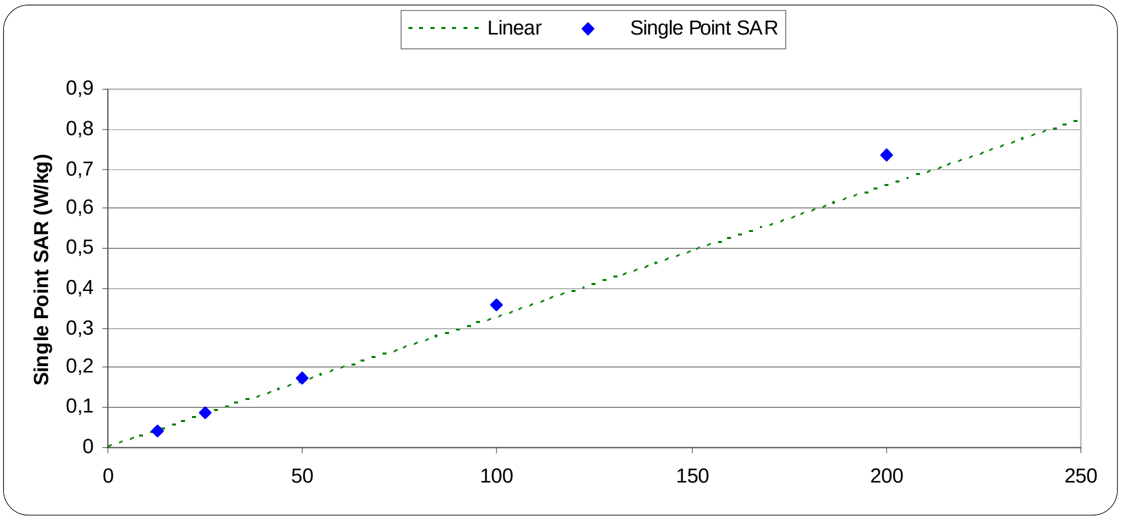
6.4.2. 5MHz – 16QAM

Average Power (mW)	12.5	25.0	50.0	100.0	200.0
Single Point SAR (W/kg)	0.036	0.074	0.150	0.315	0.647
Linear line (SAR)	0.036	0.072	0.144	0.288	0.576
Estimation (%)	0.00	2.70	4.00	8.57	10.97



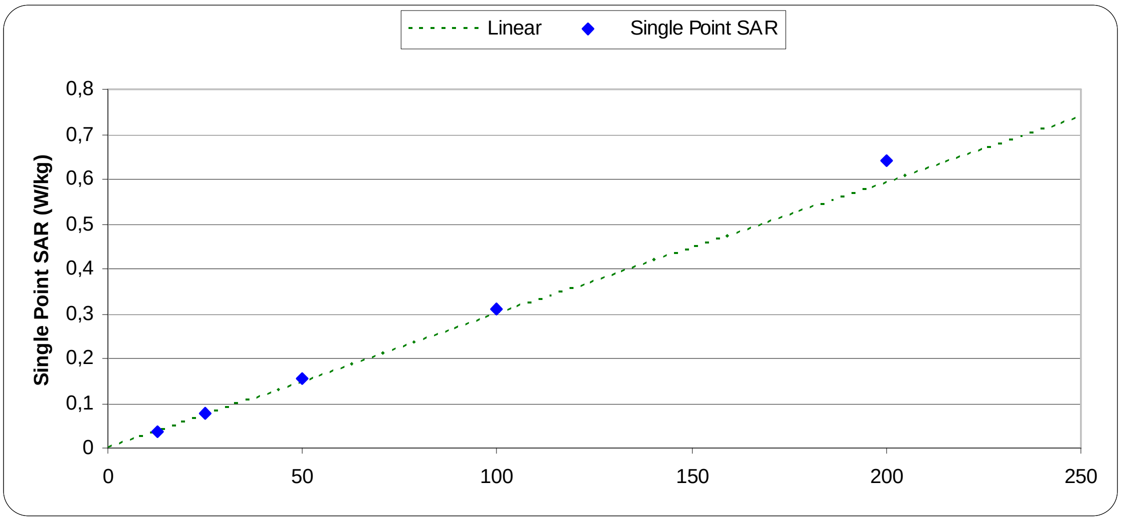
6.4.3. 10MHz – QPSK

Average Power (mW)	12.5	25.0	50.0	100.0	200.0
Single Point SAR (W/kg)	0.041	0.085	0.174	0.357	0.735
Linear line (SAR)	0.041	0.082	0.164	0.328	0.656
Estimation (%)	0.00	3.53	5.75	8.12	10.75



6.4.4. 10MHz – 16QAM

Average Power (mW)	12.5	25.0	50.0	100.0	200.0
Single Point SAR (W/kg)	0.037	0.076	0.154	0.309	0.639
Linear line (SAR)	0.037	0.074	0.148	0.296	0.592
Estimation (%)	0.00	2.63	3.90	4.21	7.36



APPENDIX C: Measurements Reports

2450 MHz Band – 802.11n* Channel 6 – Chain A

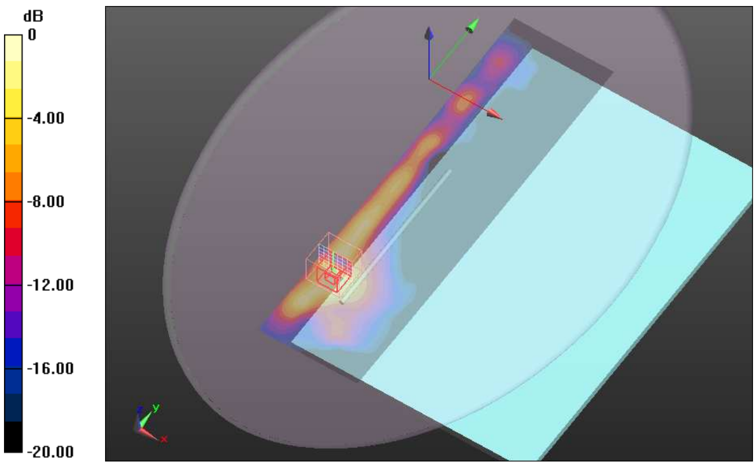
DUT: Lenovo U510 + 612BNXHMW + Speed; Type: Laptop; Serial: -

Communication System: IEEE 802.11; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used (interpolated): f = 2437 MHz; σ = 1.874 mho/m; ε_r = 51.309; ρ = 1000 kg/m^3
Phantom section: Flat Section

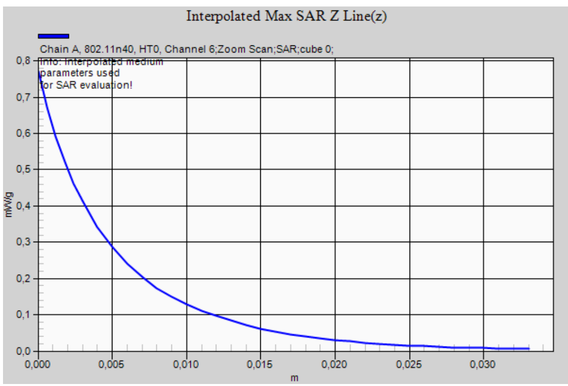
DASY5 Configuration:
- Probe: ES3DV3 - SN3052; ConvF(4.15, 4.15, 4.15); Calibrated: 23/11/2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn669; Calibrated: 23/11/2011
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:1060
- Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.4.4 (2829)

SAR 2450MHz band/Chain A, 802.11n40, HT0, Channel 6/Area Scan (71x271x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.333 mW/g

SAR 2450MHz band/Chain A, 802.11n40, HT0, Channel 6/Zoom Scan (8x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 12.337 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 0.771 W/kg
SAR(1 g) = 0.308 mW/g; SAR(10 g) = 0.142 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.395 mW/g



0 dB = 0.390mW/g



2600 MHz Band – 802.16e 5MHz QPSK Channel 0 – Chain A

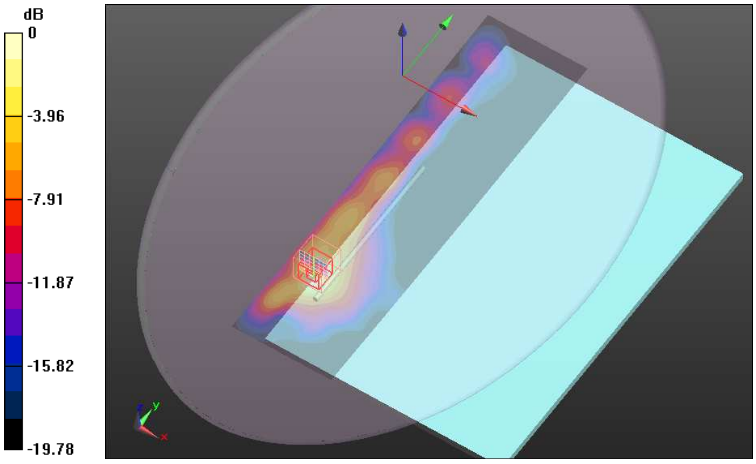
DUT: Lenovo U510 + 612BNXHMW + Speed; Type: Laptop; Serial: QB04286064

Communication System: IEEE 802.16e WiMAX (29:18, 5ms, 5MHz); Frequency: 2498.5 MHz; Duty Cycle: 1:2.70271
Medium parameters used (interpolated): f = 2498.5 MHz; σ = 1.938 mho/m; ε_r = 51.154; ρ = 1000 kg/m^3
Phantom section: Flat Section

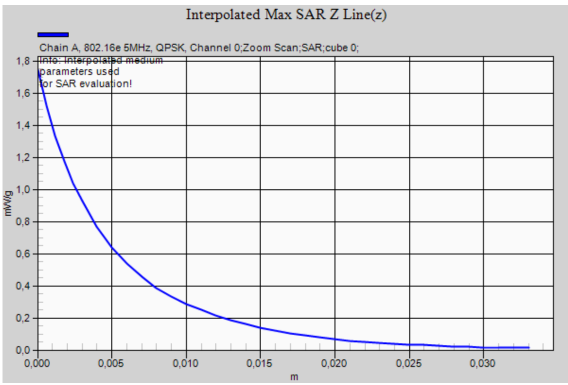
DASY5 Configuration:
- Probe: ES3DV3 - SN3052; ConvF(4.15, 4.15, 4.15); Calibrated: 23/11/2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn669; Calibrated: 23/11/2011
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:1060
- Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.4.4 (2829)

SAR 2600MHz band/Chain A, 802.16e 5MHz, QPSK, Channel 0/Area Scan (71x271x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.895 mW/g

SAR 2600MHz band/Chain A, 802.16e 5MHz, QPSK, Channel 0/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 21.534 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 1.743 W/kg
SAR(1 g) = 0.694 mW/g; SAR(10 g) = 0.325 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.904 mW/g



0 dB = 0.900mW/g



2600 MHz Band – 802.16e 10MHz QPSK Channel 0 – Chain A

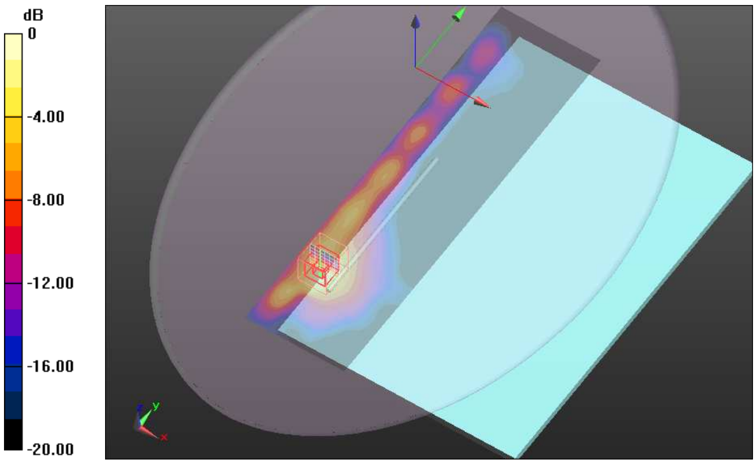
DUT: Lenovo U510 + 612BNXHMW + Speed; Type: Laptop; Serial: QB04286064

Communication System: IEEE 802.16e WiMAX (29:18, 5ms, 10MHz); Frequency: 2501 MHz; Duty Cycle: 1:2.70271
Medium parameters used (interpolated): f = 2501 MHz; σ = 1.941 mho/m; ε_r = 51.147; ρ = 1000 kg/m^3
Phantom section: Flat Section

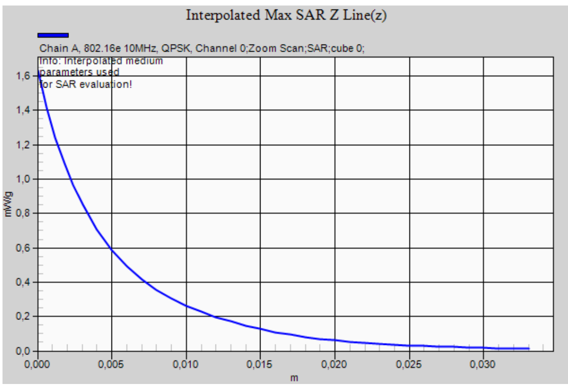
DASY5 Configuration:
- Probe: ES3DV3 - SN3052; ConvF(3.97, 3.97, 3.97); Calibrated: 23/11/2011
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn669; Calibrated: 23/11/2011
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:1060
- Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.4.4 (2829)

SAR 2600MHz band/Chain A, 802.16e 10MHz, QPSK, Channel 0/Area Scan (71x271x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.766 mW/g

SAR 2600MHz band/Chain A, 802.16e 10MHz, QPSK, Channel 0/Zoom Scan (7x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 19.805 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 1.632 W/kg
SAR(1 g) = 0.633 mW/g; SAR(10 g) = 0.294 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.851 mW/g



0 dB = 0.850mW/g



2600 MHz Band – 802.16e 5MHz QPSK Channel 756 – Chain B

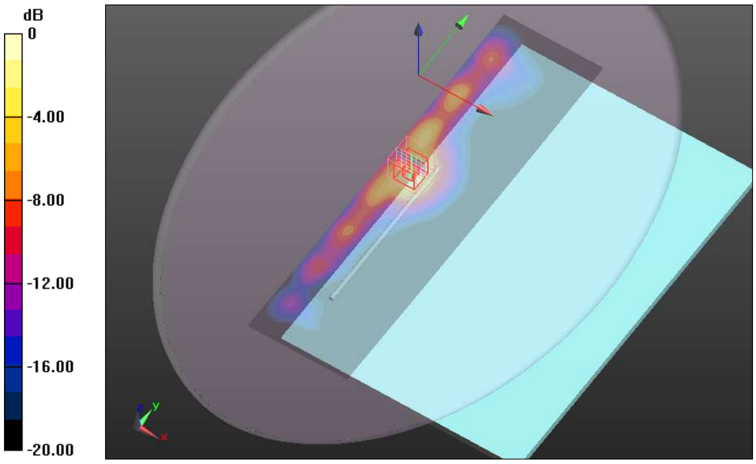
DUT: Lenovo U510 + 612BNXHMW + Speed; Type: Laptop; Serial: QB04286064

Communication System: IEEE 802.16e WiMAX (29:18, 5ms, 5MHz); Frequency: 2687.5 MHz; Duty Cycle: 1:2.70271
Medium parameters used (interpolated): f = 2687.5 MHz; σ = 2.14 mho/m; ε_r = 50.547; ρ = 1000 kg/m^3
Phantom section: Flat Section

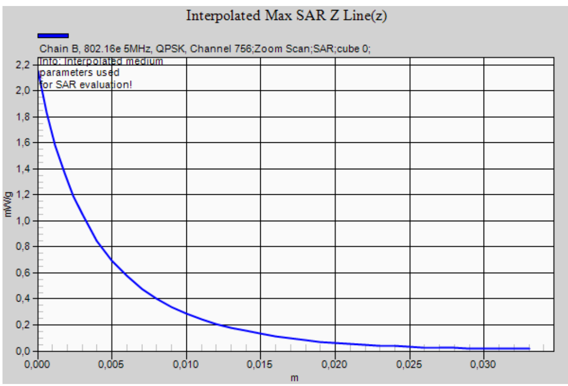
DASY5 Configuration:
- Probe: ES3DV3 - SN3052; ConvF(3.97, 3.97, 3.97); Calibrated: 23/11/2011
- Sensor-Surface: 3mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn669; Calibrated: 23/11/2011
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:1060
- Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.4.4 (2829)

SAR 2600MHz band/Chain B, 802.16e 5MHz, QPSK, Channel 756/Area Scan (71x271x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.877 mW/g

SAR 2600MHz band/Chain B, 802.16e 5MHz, QPSK, Channel 756/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 15.118 V/m; Power Drift = 0.0012 dB
Peak SAR (extrapolated) = 2.152 W/kg
SAR(1 g) = 0.762 mW/g; SAR(10 g) = 0.327 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 1.017 mW/g



0 dB = 1.020mW/g



2600 MHz Band – 802.16e 10MHz QPSK Channel 0 – Chain B

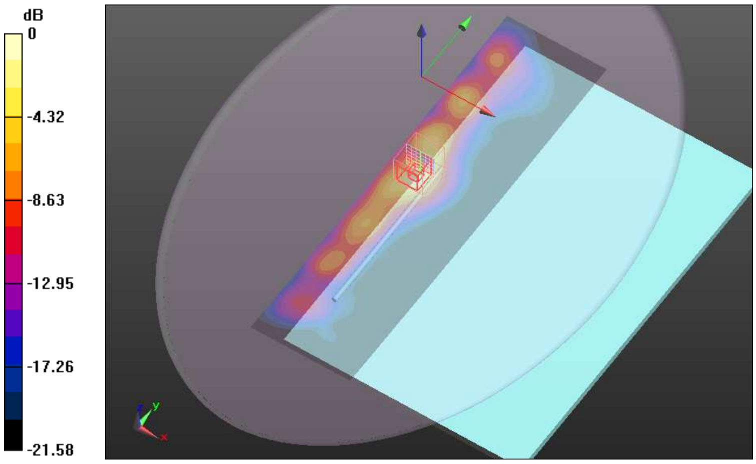
DUT: Lenovo U510 + 612BNXHMW + Speed; Type: Laptop; Serial: QB04286064

Communication System: IEEE 802.16e WiMAX (29:18, 5ms, 10MHz); Frequency: 2501 MHz; Duty Cycle: 1:2.70271
Medium parameters used (interpolated): f = 2501 MHz; σ = 1.941 mho/m; ε_r = 51.147; ρ = 1000 kg/m^3
Phantom section: Flat Section

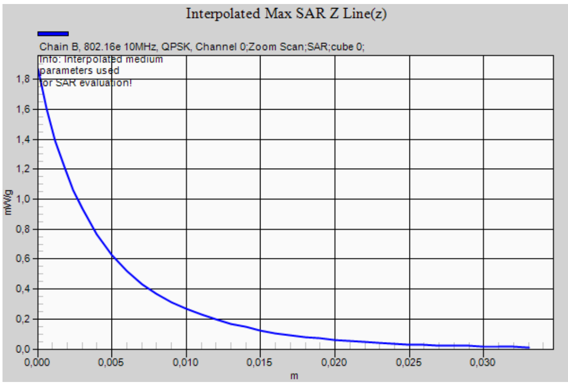
DASY5 Configuration:
- Probe: ES3DV3 - SN3052; ConvF(3.97, 3.97, 3.97); Calibrated: 23/11/2011
- Sensor-Surface: 3mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn669; Calibrated: 23/11/2011
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:1060
- Measurement SW: DASY52, Version 52.8 (1); SEMCAD X Version 14.4.4 (2829)

SAR 2600MHz band/Chain B, 802.16e 10MHz, QPSK, Channel 0/Area Scan (71x271x1): Measurement grid: dx=15mm, dy=15mm
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.921 mW/g

SAR 2600MHz band/Chain B, 802.16e 10MHz, QPSK, Channel 0/Zoom Scan (7x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 13.886 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 1.869 W/kg
SAR(1 g) = 0.683 mW/g; SAR(10 g) = 0.299 mW/g
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.907 mW/g



0 dB = 0.910mW/g



APPENDIX D: Calibration Data

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

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Accreditation No.: SCS 108

Client AT4 wireless

Certificate No: **ES3-3052_Nov11**

CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3052

Calibration procedure(s): QA CAL-01.v8, QA CAL-23.v4, QA CAL-25.v4
Calibration procedure for dosimetric E-field probes

Calibration date: November 23, 2011

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	31-Mar-11 (No. 217-01372)	Apr-12
Power sensor E4412A	MY41498087	31-Mar-11 (No. 217-01372)	Apr-12
Reference 3 dB Attenuator	SN: S5054 (3c)	29-Mar-11 (No. 217-01369)	Apr-12
Reference 20 dB Attenuator	SN: S5086 (20b)	29-Mar-11 (No. 217-01367)	Apr-12
Reference 30 dB Attenuator	SN: S5129 (30b)	29-Mar-11 (No. 217-01370)	Apr-12
Reference Probe ES3DV2	SN: 3013	29-Dec-10 (No. ES3-3013_Dec10)	Dec-11
DAE4	SN: 654	3-May-11 (No. DAE4-654_May11)	May-12
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

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

Issued: November 23, 2011

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

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Accreditation No.: **SCS 108**

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C	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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

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

Probe ES3DV3

SN:3052

Manufactured: September 30, 2003
Calibrated: November 23, 2011

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

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3052

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (μV/(V/m)^2)[A]	1.11	1.16	1.17	± 10.1 %
DCP (mV)[B]	103.1	100.4	101.0	

Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc[E] (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	300.0	±1.5 %
			Y	0.00	0.00	1.00	300.0	
			Z	0.00	0.00	1.00	300.0	
10011	UMTS-FDD (WCDMA)	3.40	X	3.50	65.9	18.3	111.8	±0.5 %
			Y	3.49	65.3	17.7	119.9	
			Z	3.53	65.8	18.2	117.0	
10012	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)	1.87	X	2.98	68.7	18.9	114.9	±0.7 %
			Y	3.27	69.4	18.7	123.6	
			Z	3.11	69.2	18.9	119.9	
10013	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps)	11.13	X	12.63	72.1	25.3	109.4	±4.6 %
			Y	12.98	72.6	25.4	120.8	
			Z	12.85	72.9	25.9	113.7	
10021	GSM-FDD (TDMA, GMSK)	9.20	X	25.22	99.4	28.3	136.4	±1.2 %
			Y	16.15	90.8	25.7	103.3	
			Z	24.23	99.8	28.2	133.6	
10023	GPRS-FDD (TDMA, GMSK, TN 0)	9.40	X	15.00	89.2	24.4	129.8	±1.7 %
			Y	17.74	91.6	25.5	99.4	
			Z	13.38	87.9	23.6	128.5	
10024	GPRS-FDD (TDMA, GMSK, TN 0-1)	6.40	X	41.65	99.6	24.9	110.1	±2.2 %
			Y	42.81	99.6	25.1	127.5	
			Z	44.23	99.6	24.2	110.8	
10025	EDGE-FDD (TDMA, 8PSK, TN 0)	9.40	X	9.23	79.5	19.6	124.8	±2.5 %
			Y	10.50	80.0	19.8	141.5	
			Z	6.55	74.4	16.8	123.8	
10026	EDGE-FDD (TDMA, 8PSK, TN 0-1)	6.40	X	4.19	67.4	12.6	107.7	±1.4 %
			Y	6.66	71.8	14.7	127.3	
			Z	6.26	72.2	14.0	109.9	
10027	GPRS-FDD (TDMA, GMSK, TN 0-1-2)	4.60	X	62.82	99.7	22.8	121.3	±2.5 %
			Y	59.26	99.9	23.3	137.6	
			Z	16.58	84.6	18.3	123.3	
10028	GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)	3.40	X	57.16	99.9	22.6	128.1	±2.2 %
			Y	8.77	77.0	15.7	144.3	
			Z	76.33	99.6	21.3	131.3	
10029	EDGE-FDD (TDMA, 8PSK, TN 0-1-2)	7.80	X	18.77	99.5	33.3	121.9	±2.5 %
			Y	14.93	92.1	30.2	140.8	
			Z	17.43	99.3	33.5	124.2	

10048	DECT (TDD, TDMA/FDM, GFSK, Full Slot, 24)	13.80	X	15.82	96.5	31.7	102.6	±1.9 %
			Y	14.21	92.7	30.4	80.8	
			Z	14.80	96.9	31.8	99.8	
10049	DECT (TDD, TDMA/FDM, GFSK, Double Slot, 12)	10.80	X	18.15	94.2	27.8	122.6	±1.2 %
			Y	17.25	92.1	27.2	137.0	
			Z	18.28	95.5	28.0	121.1	
10058	EDGE-FDD (TDMA, 8PSK, TN 0-1-2-3)	6.60	X	14.90	93.9	30.4	129.8	±1.7 %
			Y	12.30	87.5	27.5	148.3	
			Z	17.73	99.4	32.7	133.0	
10098	UMTS-FDD (HSUPA)	5.23	X	5.38	66.1	19.1	118.4	±0.9 %
			Y	5.48	66.2	18.9	128.4	
			Z	5.48	66.4	19.2	124.5	
10108	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	8.22	X	8.27	68.4	21.9	123.0	±2.7 %
			Y	8.41	68.5	21.8	134.0	
			Z	8.43	69.0	22.3	129.6	
10109	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	9.07	X	9.60	69.8	23.0	130.5	±3.5 %
			Y	9.71	69.8	22.9	142.6	
			Z	9.75	70.3	23.4	137.7	
10110	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	7.24	X	7.21	67.4	20.8	120.4	±1.9 %
			Y	7.30	67.4	20.6	130.6	
			Z	7.27	67.6	21.0	126.5	
10111	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	7.91	X	8.26	68.4	21.6	126.6	±2.5 %
			Y	8.43	68.6	21.5	138.6	
			Z	8.39	68.8	21.8	133.6	
10112	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM)	8.95	X	9.63	69.8	23.0	132.3	±3.5 %
			Y	9.76	70.0	22.9	144.8	
			Z	9.77	70.4	23.3	139.2	
10113	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM)	9.15	X	9.50	69.7	23.1	128.3	±3.5 %
			Y	9.64	69.7	22.9	140.3	
			Z	9.66	70.2	23.5	135.1	
10117	IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)	10.60	X	12.56	71.7	24.6	113.2	±4.1 %
			Y	12.60	71.6	24.4	124.1	
			Z	12.79	72.3	25.0	119.7	
10154	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	7.40	X	7.32	67.4	20.9	120.4	±1.9 %
			Y	7.43	67.5	20.8	130.8	
			Z	7.42	67.7	21.1	126.6	
10155	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM)	8.10	X	8.46	68.6	21.9	127.1	±2.7 %
			Y	8.57	68.6	21.7	138.4	
			Z	8.55	68.9	22.0	133.7	
10156	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, QPSK)	7.40	X	7.08	67.1	20.8	117.5	±1.9 %
			Y	7.21	67.2	20.7	127.6	
			Z	7.17	67.4	21.0	123.3	
10157	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM)	8.37	X	8.34	68.4	22.0	122.3	±2.7 %
			Y	8.52	68.7	21.9	134.1	
			Z	8.49	69.0	22.3	128.7	

10158	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM)	9.15	X	9.50	69.7	23.1	128.2	±3.5 %
			Y	9.62	69.7	22.9	140.1	
			Z	9.65	70.2	23.4	135.1	
10159	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 64-QAM)	8.40	X	8.47	68.7	22.1	123.3	±2.7 %
			Y	8.63	68.8	22.0	134.8	
			Z	8.58	69.1	22.4	129.3	
10175	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	6.50	X	5.83	68.1	21.1	146.3	±1.4 %
			Y	5.52	66.0	19.6	114.5	
			Z	5.46	66.3	20.0	110.2	
10176	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	7.20	X	6.60	69.4	22.1	146.3	±1.9 %
			Y	6.25	67.1	20.6	114.6	
			Z	6.15	67.4	21.0	109.6	
10177	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	6.53	X	5.84	68.0	21.1	146.1	±1.4 %
			Y	5.57	66.1	19.7	114.5	
			Z	5.52	66.4	20.2	109.8	
10178	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	7.73	X	7.03	69.6	22.6	145.8	±2.5 %
			Y	6.68	67.4	21.1	114.5	
			Z	6.58	67.6	21.4	109.5	
10179	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM)	7.62	X	6.96	69.6	22.5	146.0	±2.2 %
			Y	6.59	67.4	21.0	114.2	
			Z	6.48	67.6	21.3	109.7	
10180	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM)	7.62	X	6.97	69.6	22.5	146.2	±2.2 %
			Y	6.57	67.3	20.9	113.8	
			Z	6.47	67.5	21.3	109.7	
10196	IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)	10.20	X	11.73	70.7	23.9	108.2	±3.8 %
			Y	11.83	70.7	23.7	118.4	
			Z	11.89	71.2	24.2	113.8	
10225	UMTS-FDD (HSPA+)	6.70	X	7.71	67.8	20.5	133.7	±1.7 %
			Y	7.91	68.2	20.5	146.6	
			Z	7.79	68.1	20.6	140.1	

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: ES3DV3 - SN:3052

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	Depth (mm)	Unct. (k=2)
750	41.9	0.89	6.10	6.10	6.10	0.34	1.62	± 12.0 %
835	41.5	0.90	5.85	5.85	5.85	0.23	2.15	± 12.0 %
900	41.5	0.97	5.83	5.83	5.83	0.50	1.33	± 12.0 %
1750	40.1	1.37	5.07	5.07	5.07	0.31	2.06	± 12.0 %
1900	40.0	1.40	4.85	4.85	4.85	0.41	1.68	± 12.0 %
2000	40.0	1.40	4.80	4.80	4.80	0.48	1.50	± 12.0 %
2450	39.2	1.80	4.23	4.23	4.23	0.72	1.25	± 12.0 %
2600	39.0	1.96	4.10	4.10	4.10	0.80	1.15	± 12.0 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

DASY/EASY - Parameters of Probe: ES3DV3- SN:3052

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	Depth (mm)	Unct. (k=2)
750	55.5	0.96	6.05	6.05	6.05	0.45	1.44	± 12.0 %
835	55.2	0.97	5.92	5.92	5.92	0.34	1.77	± 12.0 %
900	55.0	1.05	5.90	5.90	5.90	0.68	1.20	± 12.0 %
1750	53.4	1.49	4.77	4.77	4.77	0.28	2.52	± 12.0 %
1900	53.3	1.52	4.55	4.55	4.55	0.28	2.81	± 12.0 %
2000	53.3	1.52	4.60	4.60	4.60	0.37	2.04	± 12.0 %
2450	52.7	1.95	4.15	4.15	4.15	0.80	0.66	± 12.0 %
2600	52.5	2.16	3.97	3.97	3.97	0.80	0.50	± 12.0 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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Accreditation No.: SCS 108

Client AT4 wireless

Certificate No: D2450V2-756_Aug11

CALIBRATION CERTIFICATE

Object	D2450V2 - SN: 756
Calibration procedure(s)	QA CAL-05.v8 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	August 25, 2011

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Reference 20 dB Attenuator	SN: S5086 (20b)	29-Mar-11 (No. 217-01367)	Apr-12
Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12
Reference Probe ES3DV3	SN: 3205	29-Apr-11 (No. ES3-3205_Apr11)	Apr-12
DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-09)	In house check: Oct-11
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

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

Issued: August 25, 2011

Calibration Laboratory of
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Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

Measurement Conditions

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

DASY Version	DASY5	V52.6.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.8 ± 6 %	2.02 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.3 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**52.1 mW / g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.17 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**24.4 mW / g ± 16.5 % (k=2)**

Appendix

Antenna Parameters with Body TSL

Impedance, transformed to feed point	52.1 Ω + 4.1 jΩ
Return Loss	- 26.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.126 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	April 22, 2004

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

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
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 AT4 Wireless

Certificate No: D2600V2-1023_Jul11

CALIBRATION CERTIFICATE

Object	D2600V2 - SN: 1023
Calibration procedure(s)	QA CAL-05.v8 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	July 12, 2011

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Reference 20 dB Attenuator	SN: S5086 (20b)	29-Mar-11 (No. 217-01367)	Apr-12
Type-N mismatch combination	SN: 5047.2 / 06327	29-Mar-11 (No. 217-01371)	Apr-12
Reference Probe ES3DV3	SN: 3205	29-Apr-11 (No. ES3-3205_Apr11)	Apr-12
DAE4	SN: 601	04-Jul-11 (No. DAE4-601_Jul11)	Jul-12

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-09)	In house check: Oct-11
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

	Name	Function	Signature
Calibrated by:	Dimce Iliev	Laboratory Technician	D. Iliev
Approved by:	Katja Pokovic	Technical Manager	[signature]

Issued: July 12, 2011

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

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

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

Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

Additional Documentation:

d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

Measurement Conditions

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

DASY Version	DASY5	V52.6.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.3 ± 6 %	2.01 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.9 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**58.7 mW /g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.61 mW / g
SAR for nominal Head TSL parameters	normalized to 1W	**26.3 mW /g ± 16.5 % (k=2)**

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.2 ± 6 %	2.20 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	14.3 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**56.4 mW / g ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.34 mW / g
SAR for nominal Body TSL parameters	normalized to 1W	**25.2 mW / g ± 16.5 % (k=2)**

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.5 Ω - 4.6 jΩ
Return Loss	- 26.1 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.0 Ω - 3.9 jΩ
Return Loss	- 23.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.149 ns

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 13, 2008