
Report

Dosimetric Assessment of the Portable Device Option GT Max World (FCC ID: NCMOGTMAX-W) tested in three host products

According to the FCC Requirements

January 18, 2006
IMST GmbH
Carl-Friedrich-Gauß-Str. 2
D-47475 Kamp-Lintfort

Customer
7layer AG
Borsigstrass 11
D-40880 Ratingen

The test results only relate to the items tested.
This report shall not be reproduced except in full without the written
approval of the testing laboratory.

Executive Summary

The device GT Max World is a new PCMCIA card from Option operating in the 850 MHz, 900 MHz, 1800 MHz and 1900 MHz frequency range. The device has a extractable foil antenna and the system concepts used are the GPRS 850 (Class 10), GPRS (Class 10), GPRS 1800 (Class 10), GPRS 1900 (Class 10) and WCDMA I,II,V (FDD) standards.

The objective of the measurements done by IMST was the dosimetric assessment of one device in body worn configuration in the GPRS 850 (Class 10), GPRS 1900 (Class 10) and WCDMA II,V (FDD) standards. The measurements were performed in combination with three different host products (DELL Latitude C810, Packard Bell Easy Note and Fujitsu Siemens Amilo Pro). The positions were tested with a closest distance of 15 mm between antenna of the PCMCIA card and phantom. The examinations have been carried out with the dosimetric assessment system „DASY4“.

The measurements were made according to the Supplement C to OET Bulletin 65 of the Federal Communications Commission (FCC) Guidelines [OET 65] for evaluating compliance of mobile and portable devices with FCC limits for human exposure (general population) to radiofrequency emissions. All measurements have been performed in accordance to the recommendations given by SPEAG.

The Option GT Max World PCMCIA card (FCC ID: NCMOGTMAX-W) is in compliance with the Federal Communications Commission (FCC) Guidelines [OET 65] for uncontrolled exposure.

The PCMCIA card was tested for the following configurations:

Body Worn on GPRS 850 (Class 10), GPRS 1900 (Class 10) and WCDMA II, V (FDD) in five different positions with a closest distance of 15 mm between PCMCIA card and phantom, tested with three host products (DELL Latitude C810, Packard Bell Easy Note and Fujitsu Siemens Amilo Pro).

prepared by:

Alexander Rahn
test engineer

reviewed by:

André van den Bosch
quality assurance engineer

IMST GmbH

Carl-Friedrich-Gauß-Straße 2
D-47475 Kamp-Lintfort

Tel. +49- 2842-981 378

Fax +49- 2842-981 399

email: vandenBosch@imst.de

Table of Contents

1	SUBJECT OF INVESTIGATION.....	4
2	THE IEEE STANDARD C95.1 AND THE FCC EXPOSURE CRITERIA.....	4
2.1	<i>DISTINCTION BETWEEN EXPOSED POPULATION, DURATION OF EXPOSURE AND FREQUENCIES.....</i>	4
2.2	<i>DISTINCTION BETWEEN MAXIMUM PERMISSIBLE EXPOSURE AND SAR LIMITS.....</i>	5
2.3	<i>SAR LIMIT.....</i>	5
3	THE FCC MEASUREMENT PROCEDURE.....	6
3.1	<i>GENERAL REQUIREMENTS.....</i>	6
3.2	<i>DEVICE OPERATING NEXT TO A PERSON'S EAR.....</i>	6
3.3	<i>BODY-WORN AND OTHER CONFIGURATIONS.....</i>	9
4	THE MEASUREMENT SYSTEM.....	10
4.1	<i>PHANTOM.....</i>	12
4.2	<i>PROBE.....</i>	12
4.3	<i>MEASUREMENT PROCEDURE.....</i>	13
4.4	<i>UNCERTAINTY ASSESSMENT.....</i>	14
5	SAR RESULTS.....	15
6	EVALUATION.....	20
7	APPENDIX.....	23
7.1	<i>ADMINISTRATIVE DATA.....</i>	23
7.2	<i>DEVICE UNDER TEST AND TEST CONDITIONS.....</i>	23
7.3	<i>TISSUE RECIPES.....</i>	24
7.4	<i>MATERIAL PARAMETERS.....</i>	24
7.5	<i>SIMPLIFIED PERFORMANCE CHECKING.....</i>	25
7.6	<i>ENVIRONMENT.....</i>	29
7.7	<i>TEST EQUIPMENT.....</i>	29
7.8	<i>CERTIFICATES OF CONFORMITY.....</i>	31
7.9	<i>PICTURES OF THE DEVICE UNDER TEST.....</i>	32
7.10	<i>TEST POSITIONS FOR THE DEVICE UNDER TEST.....</i>	34
7.11	<i>PICTURES TO DEMONSTRATE THE REQUIRED LIQUID DEPTH.....</i>	38
8	REFERENCES.....	39

1 Subject of Investigation

The device GT Max World is a new PCMCIA card from Option operating in the 850 MHz, 900 MHz, 1800 MHz and 1900 MHz frequency range. The device has a extractable foil antenna and the system concepts used are the GPRS 850 (Class 10), GPRS (Class 10), GPRS 1800 (Class 10), GPRS 1900 (Class 10) and WCDMA I, II, V (FDD) standards.



Fig. 1: Picture of the device under test

The objective of the measurements done by IMST was the dosimetric assessment of one device in body worn configuration in the GPRS 850 (Class 10), GPRS 1900 (Class 10) and WCDMA II, V (FDD) standards. The measurements were performed in combination with three different host products (DELL Latitude C810, Packard Bell Easy Note and Fujitsu Siemens Amilo Pro). The positions were tested with a closest distance of 15 mm between PCMCIA card and phantom. The examinations have been carried out with the dosimetric assessment system „DASY4“ describes below.

2 The IEEE Standard C95.1 and the FCC Exposure Criteria

In the USA the recent FCC exposure criteria [OET 65] are based upon the IEEE Standard C95.1 [IEEE C95.1]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.

2.1 Distinction Between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE C95.1] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered.

Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \frac{\partial T}{\partial t} \Big|_{t \rightarrow 0+} \quad (1)$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric E and magnetic field strength H and power density S , derived from the SAR limits. The limits for E , H and S have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

2.3 SAR Limit

In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR_{1g}) with the shape of a cube.

Standard	Status	SAR limit [W/kg]
IEEE C95.1	In force	1.6

Table 1: Relevant spatial peak SAR limit averaged over a mass of 1 g.

3 The FCC Measurement Procedure

The Federal Communications Commission (FCC) has published a report and order on the 1st of August 1996 [FCC 96-326], which requires routine dosimetric assessment of mobile telecommunications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65. This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [OET 65].

3.1 General Requirements

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity.

3.2 Device Operating Next to a Person's Ear

3.2.1 Phantom Requirements

The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues. The physical characteristics of the phantom model shall resemble the head and the neck of a user since the shape is a dominant parameter for exposure.

3.2.2 Test Positions

As it cannot be expected that the user will hold the mobile phone exactly in one well defined position, different operational conditions shall be tested. The Supplement C to OET Bulletin 65 requires two test positions. For an exact description helpful geometrical definitions are introduced and shown in Fig. 2 - 3.

There are two imaginary lines on the mobile, the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width w_t of the handset at the level of the acoustic output (point A on Fig. 2), and the midpoint of the width w_b of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Fig. 2). The two lines intersect at point A.

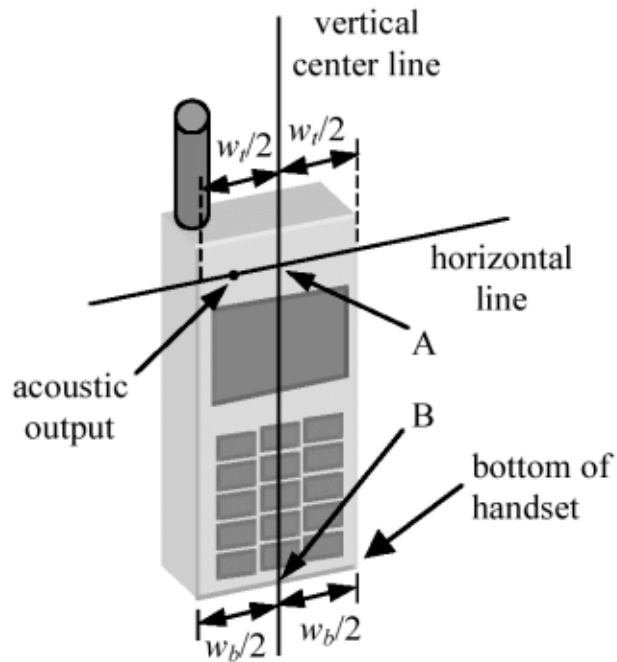


Fig. 2: Handset vertical and horizontal reference lines.

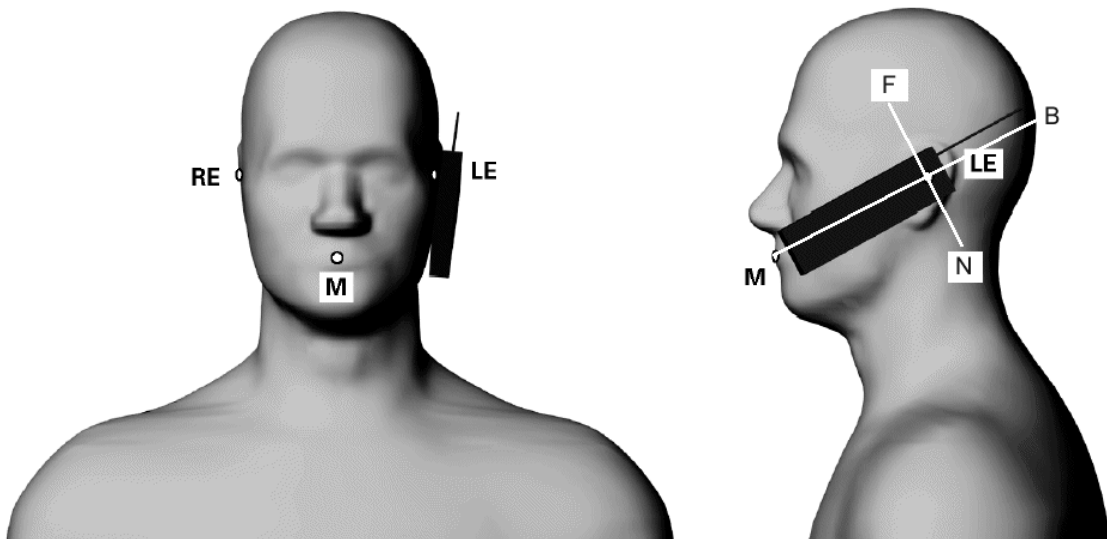


Fig. 3: Phantom reference points.

According to Fig. 3 the human head position is given by means of the following three reference points: auditory canal opening of both ears (RE and LE) and the center of the closed mouth (M). The ear reference points are 15-17 mm above the entrance to the ear canal along the BM line (back-mouth), as shown in Fig. 3. The plane passing through the two ear canals and M is defined as the reference plane. The line NF (Neck-Front) perpendicular to the reference plane and passing through the RE (or LE) is called the reference pivoting line. Line BM is perpendicular to the NF line. With this definitions the test positions are given by

- **Cheek position (see Fig. 4):**

Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Fig. 3), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom. Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the ear. While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane). Rotate the phone around the vertical centerline until the phone (horizontal line) is symmetrical with respect to the line NF. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, rotate the handset about the line NF until any point on the handset is in contact with a phantom point below the ear.

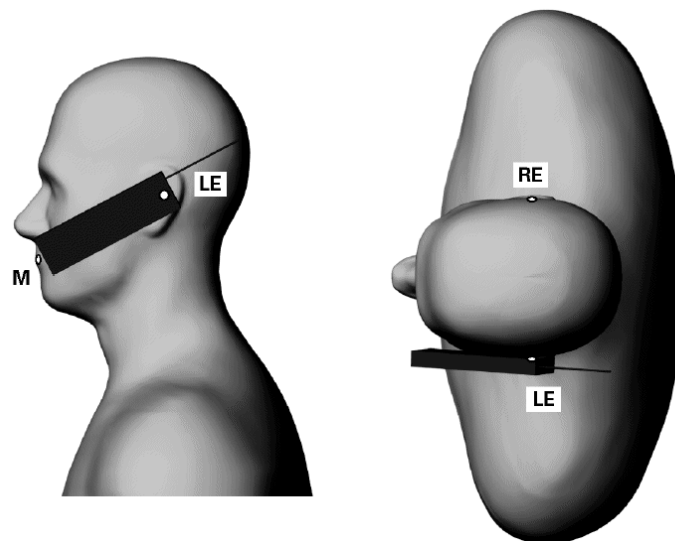


Fig. 4: The cheek position.

- **Tilted position (see Fig. 5):**

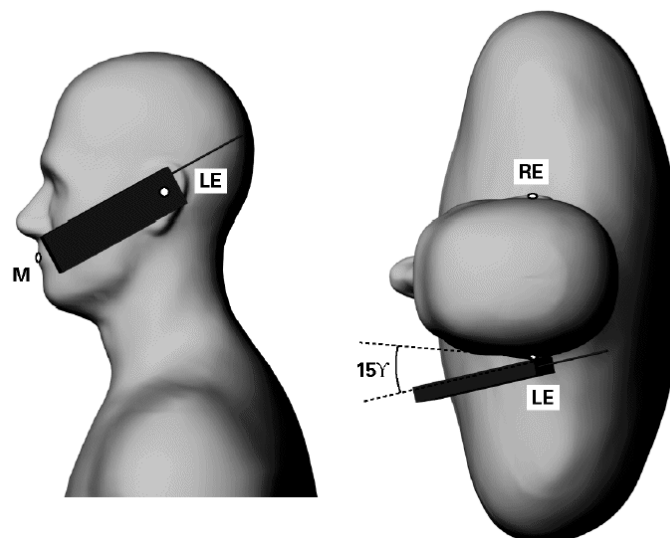


Fig. 5: The tilted position.

While maintaining the orientation of the phone retract the phone parallel to the reference plane far enough to enable a rotation of the phone by 15°. Rotate the phone around the horizontal line by 15°. While maintaining the orientation of the phone, move the phone parallel to the reference plane until any part of the phone touches the head. In this position, point A will be located on the line RE-LE.

3.2.3 Test to be Performed

The SAR test shall be performed with both phone positions described above, on the left and right side of the phantom. The device shall be measured for all modes operating when the device is next to the ear, even if the different modes operate in the same frequency band.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional.

3.3 Body-worn and Other Configurations

3.3.1 Phantom Requirements

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

3.3.2 Test Position

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

3.3.3 Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

If the manufacturer provides none body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. The DASY4 system consists of the following items as shown in Fig: 6. Additional Fig: 7 shows the equipment, similar to the installations in other laboratories [DASY 1995].

- High precision robot with controller
- Measurement server (for surveillance of the robot operation and signal filtering)
- Data acquisition electronics DAE (for signal amplification and filtering)
- Field probes calibrated for use in liquids
- Electro-optical converter EOC (conversion from the optical into a digital signal)
- Light beam (improving of the absolute probe positioning accuracy)
- Two SAM phantoms filled with tissue simulating liquid
- DASY4 software
- SEMCAD

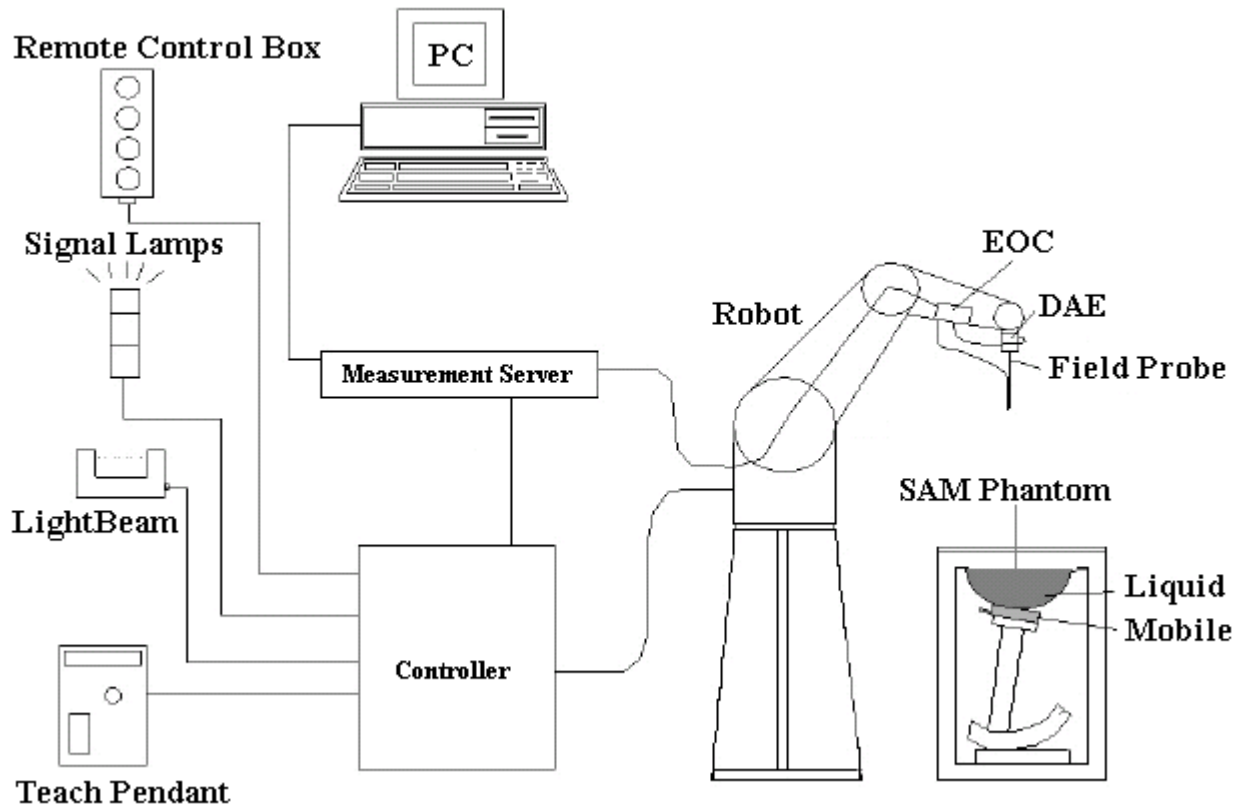


Fig. 6: The DASY4 measurement system.



Fig. 7: The measurement set-up with two SAM phantoms containing tissue simulating liquid.

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

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

4.1 Phantom

For the measurements the Specific Anthropomorphic Mannequin (SAM Twin Phantom V4.0) defined by the IEEE SCC-34/SC2 group and delivered by Schmid & Partner Engineering AG is used. The phantom is a fibreglass shell integrated in a wooden table. The thickness of the phantom amounts to $2 \text{ mm} \pm 0.2 \text{ mm}$. It enables the dosimetric evaluation of left and right hand phone usage and includes an additional flat phantom part for the simplified performance check. The phantom set-up includes a coverage (polyethylene), which prevents the evaporation of the liquid. The details and the Certificate of conformity can be found in Fig. 14.

4.2 Probe

For the measurements the Dosimetric E-Field Probes ET3DV6 or EX3DV4 with following specifications are used. They are manufactured and calibrated in accordance with FCC [OET 65] and IEEE [IEEE 1528-2003] recommendations annually by Schmid & Partner Engineering AG.

ET3DV6:

- Dynamic range: $5 \mu\text{W/g}$ to $> 100 \text{mW/g}$
- Tip diameter: 6.8 mm
- Probe linearity: $\pm 0.2 \text{ dB}$ (30 MHz to 3 GHz)
- Axial isotropy: $\pm 0.2 \text{ dB}$
- Spherical isotropy: $\pm 0.4 \text{ dB}$
- Distance from probe tip to dipole centers: 2.7 mm
- Calibration range: 900MHz / 1800MHz / 1900MHz / 1950 MHz / 2450MHz for head and body simulating liquid
- Angle between probe axis (evaluation axis) and surface normal line: less than 30°

EX3DV4:

- Dynamic range: 10 μ W/g to > 100mW/g (noise typically < 1 μ W/g)
- Tip diameter: 2.5 mm
- Probe linearity: \pm 0.2 dB (30 MHz to 3 GHz)
- Axial isotropy: \pm 0.2 dB
- Spherical isotropy: \pm 0.4 dB
- Distance from probe tip to dipole centers: 1.0 mm
- Calibration range: : 900MHz / 1800MHz / 1900MHz / 1950 MHz / 2450MHz for head and body simulating liquid
- Angle between probe axis (evaluation axis) and surface normal line: less than 30°

4.3 Measurement Procedure

The following steps are used for each test position:

- Establish a call with the maximum output power with a base station simulator. The connection between the mobile phone and the base station simulator is established via air interface.
- Measurement of the local E-field value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid spacing of 15 mm x 15 mm and a constant distance to the inner surface of the phantom. Since the sensors can not directly measure at the inner phantom surface, the values between the sensors and the inner phantom surface are extrapolated. With this values the area of the maximum SAR is calculated by a interpolation scheme (combination of a least-square fitted function and a weighted average method). Additional all peaks within 2 dB of the maximum SAR are searched.
- Around this points, a cube of 30 mm x 30 mm x 30 mm is assessed by measuring 7 x 7 x 7 points whereby the first two measurement points are within the required 10 mm of the surface. With these data, the peak spatial-average SAR value can be calculated within the SEMCAD software.
- The used extrapolation and interpolation routines are all based on the modified Quadratic Shepard's method [DASY4].
- Repetition of the E-field measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than \pm 0.21dB.

4.4 Uncertainty Assessment

Table 2 includes the uncertainty budget suggested by the [IEEE 1528-2003] and determined by Schmid & Partner Engineering AG. The expanded uncertainty (K=2) is assessed to be $\pm 20.6\%$.

Error Sources	Uncertainty Value	Probability Distribution	Divisor	c_i	Standard Uncertainty	v_i^2 or v_{eff}
Measurement System						
Probe calibration	$\pm 4.8 \%$	Normal	1	1	$\pm 4.8 \%$	∞
Axial isotropy	$\pm 4.7 \%$	Rectangular	$\sqrt{3}$	0.7	$\pm 1.9 \%$	∞
Hemispherical isotropy	$\pm 9.6 \%$	Rectangular	$\sqrt{3}$	0.7	$\pm 3.9 \%$	∞
Boundary effects	$\pm 1.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 0.6 \%$	∞
Linearity	$\pm 4.7 \%$	Rectangular	$\sqrt{3}$	1	$\pm 2.7 \%$	∞
System detection limit	$\pm 1.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 0.6 \%$	∞
Readout electronics	$\pm 1.0 \%$	Normal	1	1	$\pm 1.0 \%$	∞
Response time	$\pm 0.8 \%$	Rectangular	$\sqrt{3}$	1	$\pm 0.5 \%$	∞
Integration time	$\pm 2.6\%$	Rectangular	$\sqrt{3}$	1	$\pm 1.5 \%$	∞
RF ambient conditions	$\pm 3.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 1.7 \%$	∞
Probe positioner	$\pm 0.4 \%$	Rectangular	$\sqrt{3}$	1	$\pm 0.2 \%$	∞
Probe positioning	$\pm 2.9 \%$	Rectangular	$\sqrt{3}$	1	$\pm 1.7 \%$	∞
Algorithms for max SAR eval.	$\pm 1.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 0.6 \%$	∞
Test Sample Related						
Device positioning	$\pm 2.9 \%$	Normal	1	1	$\pm 2.9 \%$	145
Device holder	$\pm 3.6 \%$	Normal	1	1	$\pm 3.6 \%$	5
Power drift	$\pm 5.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 2.9 \%$	∞
Phantom and Set-up						
Phantom uncertainty	$\pm 4.0 \%$	Rectangular	$\sqrt{3}$	1	$\pm 2.3 \%$	∞
Liquid conductivity (target)	$\pm 5.0 \%$	Rectangular	$\sqrt{3}$	0.64	$\pm 1.8 \%$	∞
Liquid conductivity (meas.)	$\pm 2.5 \%$	Normal	1	0.64	$\pm 1.6 \%$	∞
Liquid permittivity (target)	$\pm 5.0 \%$	Rectangular	$\sqrt{3}$	0.6	$\pm 1.7 \%$	∞
Liquid permittivity (meas.)	$\pm 2.5 \%$	Normal	1	0.6	$\pm 1.5 \%$	∞
Combined Uncertainty					$\pm 10.3 \%$	

Table 2: Uncertainty budget of DASY4.

5 SAR Results

The Tables below contain the measured SAR values averaged over a mass of 1 g.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 128 824.2 MHz 31.96 dBm	Channel 190 836.4 MHz 31.89 dBm	Channel 251 848.8 MHz 31.82 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.149* ^(-0.143)		21.2	20.3
Position 2		0.142 (0.174)		21.2	20.3
Position 3		0.047 (-0.191)		21.2	20.3

Table 3: Measurement results for GPRS 850 (Class 10) for the Option GT Max World in combination with the DELL Latitude C810 Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 128 824.2 MHz 31.96 dBm	Channel 190 836.4 MHz 31.89 dBm	Channel 251 848.8 MHz 31.82 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.191 (-0.169)		21.2	20.3
Position 2		0.135 (0.109)		21.3	20.3
Position 3		0.062 (0.098)		21.3	20.4

Table 4: Measurement results for GPRS 850 (Class 10) for the Option GT Max World in combination with the Packard Bell Easy Note Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 128 824.2 MHz 31.96 dBm	Channel 190 836.4 MHz 31.89 dBm	Channel 251 848.8 MHz 31.82 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.165 (-0.198)		21.3	20.3
Position 2		0.109 (-0.176)		21.3	20.4
Position 3		0.052 (-0.199)		21.4	20.3

Table 5: Measurement results for GPRS 850 (Class 10) for the Option GT Max World in combination with the Fujitsu Siemens Amilo Pro Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 512 1850.2 MHz 28.61 dBm	Channel 661 1880.0 MHz 28.59 dBm	Channel 810 1909.6 MHz 28.66 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.415 (0.200)		21.2	20.4
Position 2		0.133 (0.131)		21.3	20.4
Position 3		0.061*(-0.171)		21.4	20.4

Table 6: Measurement results for GPRS 1900 (Class 10) for the Option GT Max World in combination with the DELL Latitude C810 Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 512 1850.2 MHz 28.61 dBm	Channel 661 1880.0 MHz 28.59 dBm	Channel 810 1909.6 MHz 28.66 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.4430(-0.130)		21.0	20.4
Position 2		0.0076 (-0.043)		21.1	20.4
Position 3		0.0610*(0.200)		21.1	20.4

Table 7: Measurement results for GPRS 1900 (Class 10) for the Option GT Max World in combination with the Packard Bell Easy Note Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 512 1850.2 MHz 28.61 dBm	Channel 661 1880.0 MHz 28.59 dBm	Channel 810 1909.6 MHz 28.66 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.0120 (-0.123)		21.0	20.4
Position 2		0.0055 (-0.113)		21.2	20.3
Position 3		0.0027*(0.114)		21.2	20.3

Table 8: Measurement results for GPRS 1900 (Class 10) for the Option GT Max World in combination with the Fujitsu Siemens Amilo Pro Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 9262 1852.4 MHz 25.20 dBm	Channel 187 1887.5 MHz 25.10 dBm	Channel 9538 1907.6 MHz 24.60 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.299* (-0.157)		21.2	20.3
Position 2		0.121 (-0.195)		21.2	20.4
Position 3		0.051* (0.193)		21.3	20.4

Table 9: Measurement results for WCDMA II (FDD) for the Option GT Max World in combination with the DELL Latitude C810 Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 9262 1852.4 MHz 25.20 dBm	Channel 187 1887.5 MHz 25.10 dBm	Channel 9538 1907.6 MHz 24.60 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.390 (0.200)		21.0	20.5
Position 2		0.171 (0.072)		21.0	20.5
Position 3		0.076 (-0.019)		21.1	20.6

Table 10: Measurement results for WCDMA II (FDD) for the Option GT Max World in combination with the Packard Bell Easy Note Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 9262 1852.4 MHz 25.20 dBm	Channel 187 1887.5 MHz 25.10 dBm	Channel 9538 1907.6 MHz 24.60 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.274* (0.046)		21.4	20.5
Position 2		0.149 (-0.199)		21.4	20.5
Position 3		0.039* (0.191)		21.4	20.5

Table 11: Measurement results for WCDMA II (FDD) for the Option GT Max World in combination with the Fujitsu Siemens Amilo Pro Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 4132 826.4 MHz 25.7 dBm	Channel 4183 836.6 MHz 24.80 dBm	Channel 4233 846.6 MHz 25.80 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.053* (0.199)		21.4	20.5
Position 2		0.025 (0.198)		21.4	20.5
Position 3		0.013 (0.187)		21.4	20.5

Table 12: Measurement results for WCDMA V (FDD) for the Option GT Max World in combination with the DELL Latitude C810 Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 4132 826.4 MHz 25.7 dBm	Channel 4183 836.6 MHz 24.80 dBm	Channel 4233 846.6 MHz 25.80 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.091 (0.180)		21.4	20.5
Position 2		0.046 (0.127)		21.4	20.5
Position 3		0.030 (0.026)		21.4	20.5

Table 13: Measurement results for WCDMA V (FDD) for the Option GT Max World in combination with the Packard Bell Easy Note Notebook.

Test Position	SAR _{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 4132 826.4 MHz 25.7 dBm	Channel 4183 836.6 MHz 24.80 dBm	Channel 4233 846.6 MHz 25.80 dBm	Ambient [° C]	Liquid [° C]
Position 1		0.068* (0.075)		21.3	20.4
Position 2		0.050 (0.190)		21.3	20.4
Position 3		0.018 (0.007)		21.4	20.4

Table 14: Measurement results for WCDMA V (FDD) for the Option GT Max World in combination with the Fujitsu Siemens Amilo Pro Notebook.

The “* Max Cube” labeling indicates that during the grid scanning an additional peak was found which was within 2.0 dB of the highest peak. The value of the highest cube is given in the tables above, the value from the second assessed cube is given in the SAR distribution plots (see appendix).

The above mentioned power values are “conducted” power values, they were measured on the same sample which was prepared for the FCC approval. The values were delivered by 7layers AG, Ratingen and also verified during the SAR test.

To control the output power stability during the SAR test the used 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 the above tables labeled as: (Drift[dB]). This ensures that the power drift during one measurement is within 5%. Please note that we add the measured “power drift” values from the DASY4 system since the used CMU 200 delivers only 1 usable position after decimal point and therefore only one power level is listed in the above tables.

6 Evaluation

In Fig. 8 - 11 the head phantom SAR results for GPRS 850, GPRS 1900 and WCDMA II,V (FDD) given in Table 3 - 14 are summarized and compared to the limit..

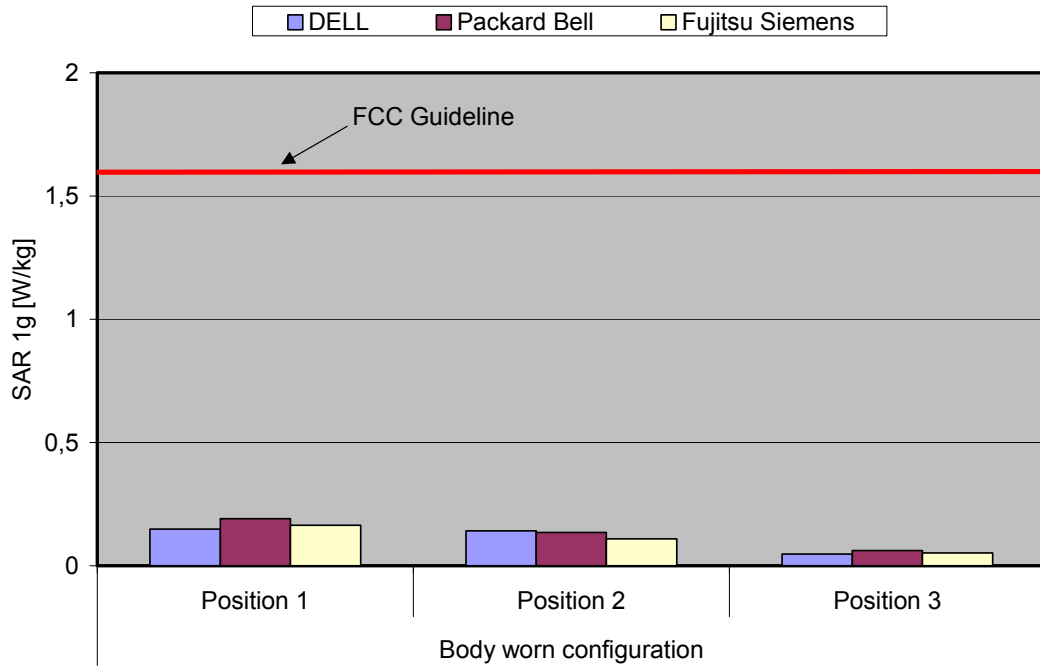


Fig. 8: The measured SAR values for the Option GT Max World in combination with the three host devices for GPRS 850 at channel 190 in comparison to the FCC exposure limit.

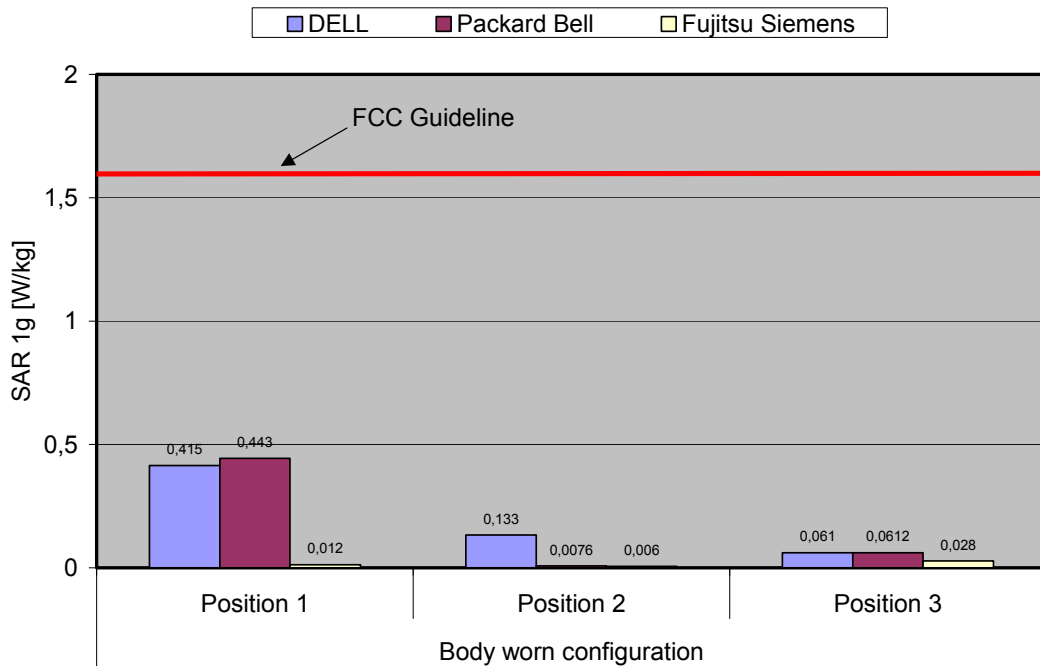


Fig. 9: The measured SAR values for the Option GT Max World in combination with the three host devices for GPRS 1900 at channel 661 in comparison to the FCC exposure limit.

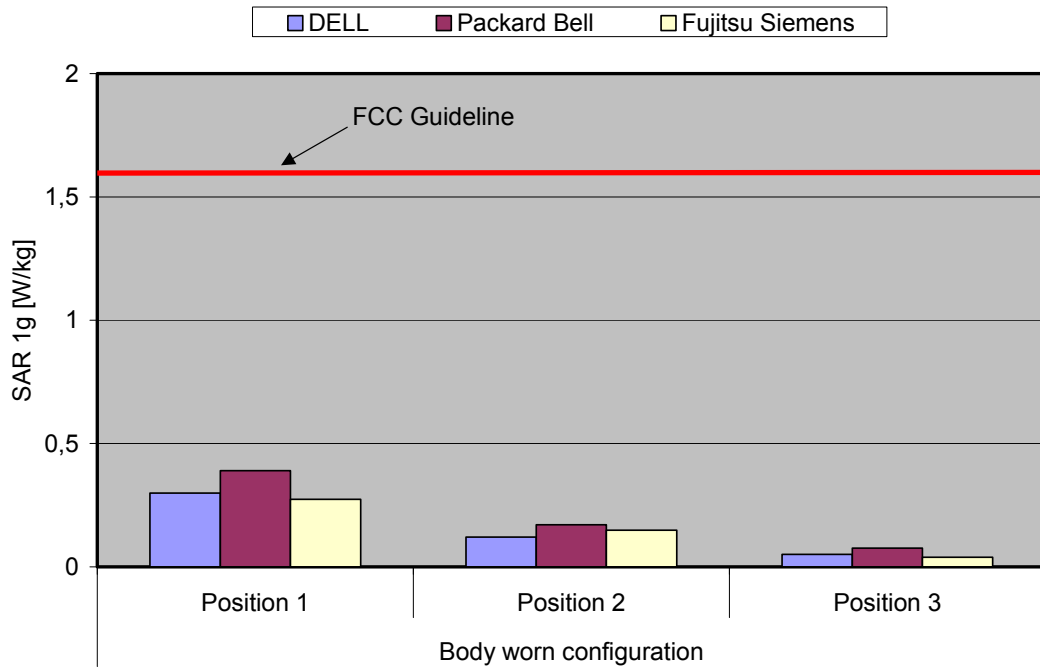


Fig. 10: The measured SAR values for the Option GT Max World in combination with the three host devices WCDMA II (FDD) at channel 187 in comparison to the FCC exposure limit.

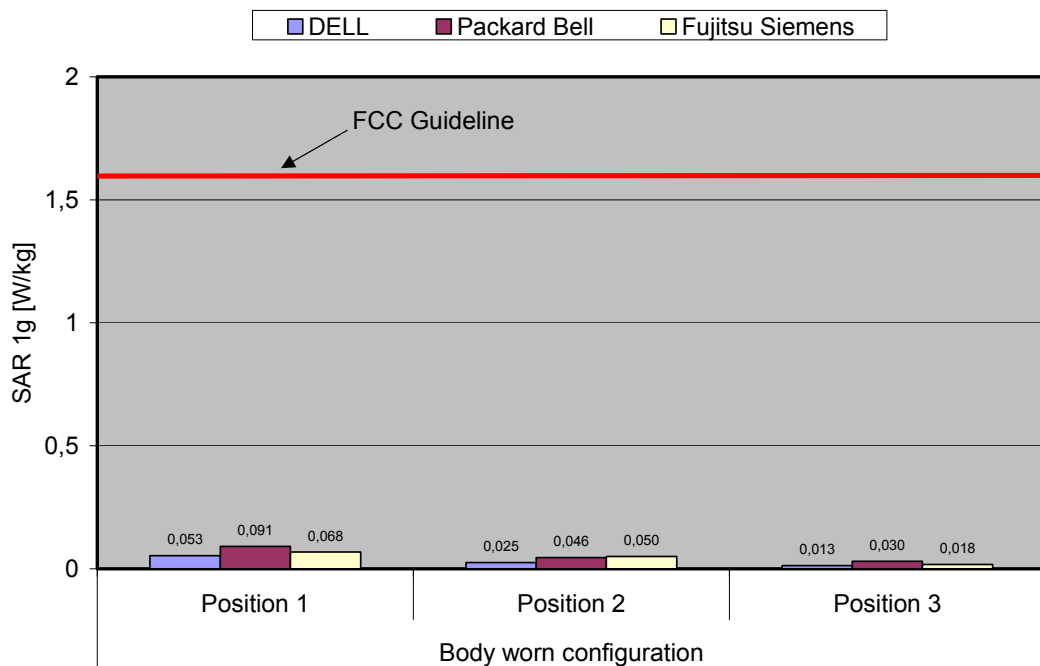


Fig. 11: The measured SAR values for the Option GT Max World in combination with the three host devices for ECDMA V (FDD) at channel 4183 in comparison to the FCC exposure limit.

The Option GT Max World PCMCIA card (FCC ID: NCMOGTMAX-W) is in compliance with the Federal Communications Commission (FCC) Guidelines [OET 65] for uncontrolled exposure.

The PCMCIA card was tested for the following configurations:

Body Worn on GPRS 850 (Class 10), GPRS 1900 (Class 10) and WCDMA II, V (FDD) in five different positions with a closest distance of 15 mm between PCMCIA card and phantom, tested with three host products (DELL Latitude C810, Packard Bell Easy Note and Fujitsu Siemens Amilo Pro).

7 Appendix

7.1 Administrative Data

Date of validation: 835 MHz: January 16, 2006
 1900 MHz: January 12, 2006
 Date of measurement: January 12, 2006 – January 16, 2006
 Data stored: 7layers_6620_567

7.2 Device under Test and Test Conditions

MTE: Option GT Max World
 Date of receipt: January 10, 2006
 IMEI: 004400017317189
 FCC ID: NCMOGTMAX-W
 Equipment class: Portable device
 Power Class: GPRS 850: 4, tested with power level 5
 GPRS 1900: 1, tested with power level 0
 WCDMA II (FDD) 1900: 3, tested with max.allow. UE
 Power of 33dBm
 WCDMA V (FDD) 850: 3, tested with max.allow. UE
 Power of 33dBm
 RF exposure environment: General Population/Uncontrolled
 Power supply: Host Device
 Antenna: Antenna Type: extractable foil
 Measured Standards: GPRS 850, GPRS 1900, WCDMA II, WCDMA V
 Method to establish a call: GPRS 850, GPRS 1900 WCDMA II,V: Basestation
 simulator, using the air interface
 Modulation: GPRS: GMSK; WCDMA (FDD): QPSK
 Crest Factor: GPRS: 4; WCDMA (FDD): 1
 TX range: GPRS 850: 824.2 MHz – 848.8 MHz
 GPRS 1900: 1850.2 MHz – 1909.8 MHz
 WCDMA II: 1852.4 MHz – 1907.6 MHz
 WCDMA V: 826.4 MHz – 846.6 MHz
 RX range: GPRS 850: 869.2 MHz – 893.8 MHz
 GPRS 1900: 1930.2 MHz – 1989.8 MHz
 WCDMA II: 1932.4 MHz – 1987.6 MHz
 WCDMA V: 871.4 MHz – 891.6 MHz
 Used TX Channels: GPRS 850: low: ch. 128, center: ch. 190, high: ch. 251
 GPRS 1900: low: ch. 512, center: ch. 661, high: ch. 810
 WCDMAII: low: ch. 9262, center: ch. 187, high: ch. 9538
 WCDMAV: low: ch. 4132, center: ch. 4183, high: ch. 4233
 Used Phantom: SAM Twin Phantom V4.0, as defined by the IEEE SCC-34/SC2 group and delivered by Schmid & Partner Engineering AG

7.3 Tissue Recipes

The following recipes are provided in percentage by weight.

835 MHz, Body:

52.40 %	De-Ionized Water
01.50 %	Salt
45.00 %	Sugar
00.10 %	Preventol D7
01.00 %	Hydroxyetyl-Cellulose

1900 MHz, Body:

29.68%	Diethylenglykol-monobutylether
70.00%	De-Ionized Water
0.32%	Salt

7.4 Material Parameters

For the measurement of the following parameters the HP 85070B dielectric probe kit is used, representing the open-ended coaxial probe measurement procedure. The measured values should be within $\pm 5\%$ of the recommended values given by the FCC.

Frequency		ϵ_r	σ [S/m]
835 MHz Body	Recommended Value	55.2 ± 2.76	1.05 ± 0.05
	Measured Value	53.00	1.01
1900 MHz Body	Recommended Value	53.30 ± 2.66	1.52 ± 0.07
	Measured Value	54.80	1.52

Table 15: Parameters of the tissue simulating liquid.

7.5 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kits. The input power of the dipole antennas were 250 mW and they were placed under the flat part of the SAM phantoms. The target and measured results are listed in the Table 16 - 17 and shown in Fig. 12 - 13. The target values were adopted from the manufactures calibration certificates.

Available Dipoles		SAR _{1g} [W/kg]	ϵ_r	σ [S/m]
D835V2, SN #437	Target Values Body	2.49	55.10	0.99
D1900V2, SN #535		10.20	53.00	1.53
D1900V2, SN #5d051		9.80	53.30	1.60

Table 16: Dipole target results.

Used Dipoles		SAR _{1g} [W/kg]	ϵ_r	σ [S/m]
835 MHz, SN: 437 (GSM 850)	Measured Values Body	2.60	53.00	1.01
835 MHz, SN: 437 (WCDMA V)		2.60	53.00	1.01
1900 MHz, SN: 535 (PCS 1900)		9.98	54.80	1.52
1900 MHz, SN: 535 (WCDMA II)		9.98	54.80	1.52

Table 17: Measured dipole validation results.

Test Laboratory: IMST GmbH, DASY Blue (I); File Name: [160106_b_1669.da4](#)

DUT: Dipole 835 MHz SN437; Type: D835V2; Serial: D835V2 - SN:437
 Program Name: System Performance Check at 835 MHz

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
 Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 1.01 \text{ mho/m}$; $\epsilon_r = 53$; $\rho = 1000 \text{ kg/m}^3$
 Phantom section: Flat Section

DASY4 Configuration:

- Probe: ET3DV6R - SN1669; ConvF(6.39, 6.39, 6.39); Calibrated: 13.01.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn631; Calibrated: 07.07.2005
- Phantom: SAM Sugar 1059; Type: Speag; Serial: 1059
- Measurement SW: DASY4, V4.6 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 159

d=10mm, Pin=250mW/Area Scan (7x7x1): Measurement grid: $dx=15\text{mm}$, $dy=15\text{mm}$

Maximum value of SAR (measured) = 2.81 mW/g

d=10mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 54.4 V/m; Power Drift = 0.000 dB

Peak SAR (extrapolated) = 3.80 W/kg

SAR(1 g) = 2.6 mW/g; SAR(10 g) = 1.7 mW/g

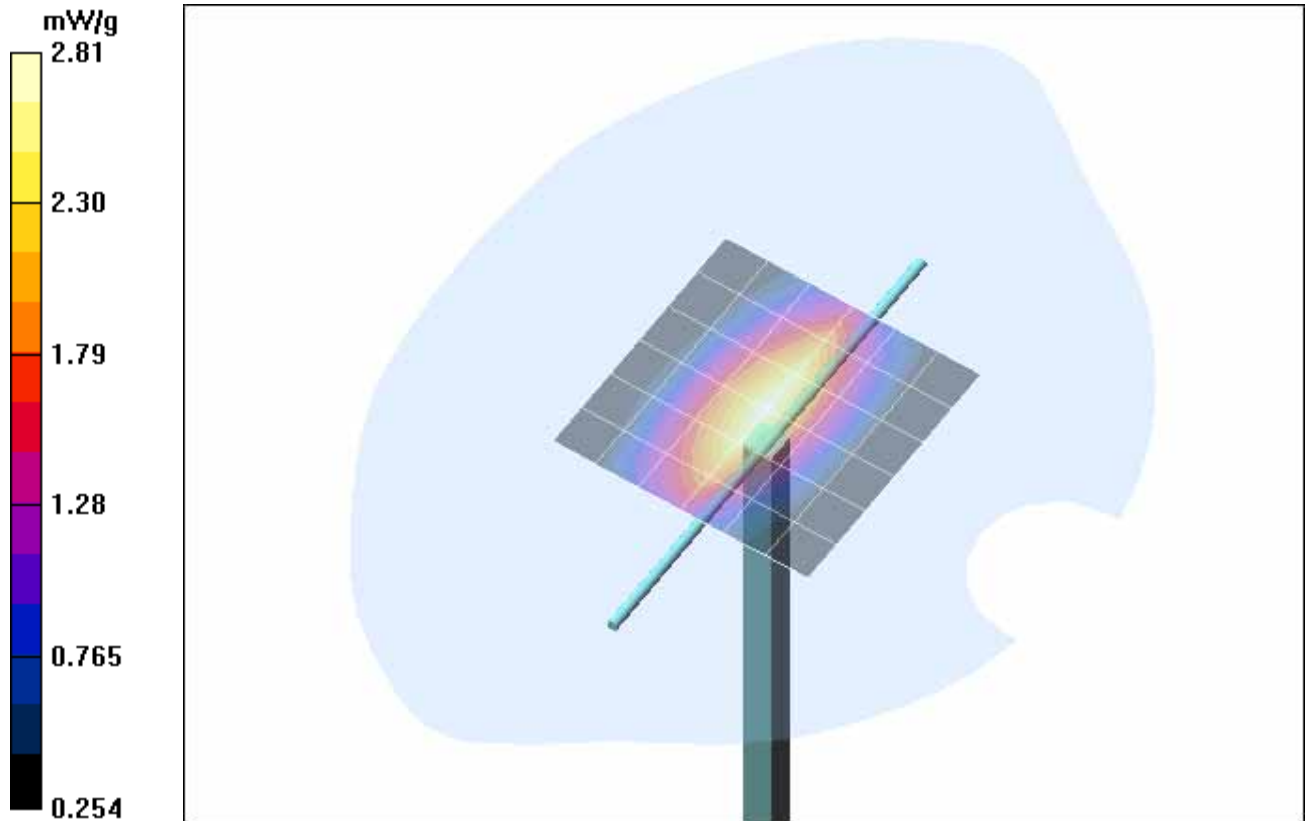


Fig. 12: Validation measurement 835MHz Body (GSM 850 and WCDMA V, January 16, 2006), coarse grid. Ambient Temperature: 21.2°C, Liquid Temperature: 20.1°C.

Test Laboratory: IMST GmbH, DASY Blue (I); File Name: [120106_b_1669.da4](#)

DUT: Dipole 1900 MHz SN: 535; Type: D1900V2; Serial: D1900V2 - SN535
 Program Name: System Performance Check at 1900 MHz

Communication System: CW; Frequency: 1900 MHz; Duty Cycle: 1:1
 Medium parameters used: $f = 1900$ MHz; $\sigma = 1.52$ mho/m; $\epsilon_r = 54.8$; $\rho = 1000$ kg/m³
 Phantom section: Flat Section

DASY4 Configuration:

- Probe: ET3DV6R - SN1669; ConvF(4.52, 4.52, 4.52); Calibrated: 13.01.2005
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn631; Calibrated: 07.07.2005
- Phantom: SAM Glycol 1176; Type: Speag; Serial: 1176
- Measurement SW: DASY4, V4.6 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 159

d=10mm, Pin=250mW/Area Scan (7x7x1): Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 11.4 mW/g

d=10mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.0 V/m; Power Drift = -0.005 dB

Peak SAR (extrapolated) = 16.6 W/kg

SAR(1 g) = 9.98 mW/g; SAR(10 g) = 5.28 mW/g

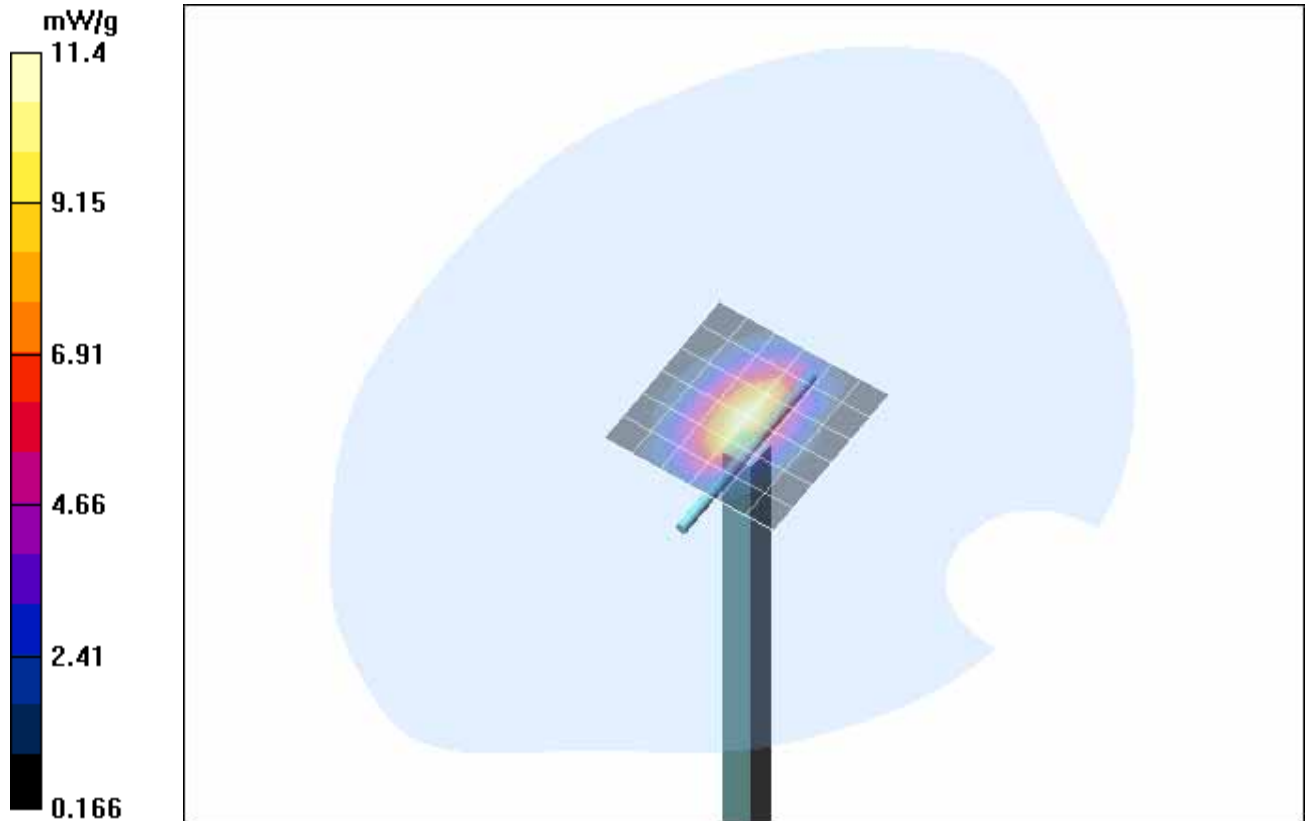


Fig. 13: Validation measurement 1900 MHz Body (PCS 1900 and WCDMA II January 12, 2006), coarse grid. Ambient Temperature: 21.2° C, Liquid Temperature: 20.4° C.

Error Sources	Uncertainty Value	Probability Distribution	Divisor	c_i	Standard Uncertainty	v_i^2 or v_{eff}
Measurement System						
Probe calibration	± 4.8 %	Normal	1	1	± 4.8 %	∞
Axial isotropy	± 4.7 %	Rectangular	√3	1	± 2.7 %	∞
Hemispherical isotropy	± 0 %	Rectangular	√3	1	± 0 %	∞
Boundary effects	± 1.0 %	Rectangular	√3	1	± 0.6 %	∞
Linearity	± 4.7 %	Rectangular	√3	1	± 2.7 %	∞
System detection limit	± 1.0 %	Rectangular	√3	1	± 0.6 %	∞
Readout electronics	± 1.0 %	Normal	1	1	± 1.0 %	∞
Response time	± 0 %	Rectangular	√3	1	± 0 %	∞
Integration time	± 0 %	Rectangular	√3	1	± 0 %	∞
RF ambient conditions	± 3.0 %	Rectangular	√3	1	± 1.7 %	∞
Probe positioner	± 0.4 %	Rectangular	√3	1	± 0.2 %	∞
Probe positioning	± 2.9 %	Rectangular	√3	1	± 1.7 %	∞
Algorithms for max SAR eval.	± 1.0 %	Rectangular	√3	1	± 0.6 %	∞
Dipole						
Dipole Axis to Liquid Distance	± 2.0 %	Rectangular	1	1	± 1.2 %	∞
Input power and SAR drift mea.	± 4.7 %	Rectangular	√3	1	± 2.7 %	∞
Phantom and Set-up						
Phantom uncertainty	± 4.0 %	Rectangular	√3	1	± 2.3 %	∞
Liquid conductivity (target)	± 5.0 %	Rectangular	√3	0.64	± 1.8 %	∞
Liquid conductivity (meas.)	± 2.5 %	Normal	1	0.64	± 1.6 %	∞
Liquid permittivity (target)	± 5.0 %	Rectangular	√3	0.6	± 1.7 %	∞
Liquid permittivity (meas.)	± 2.5 %	Normal	1	0.6	± 1.5 %	∞
Combined Uncertainty					± 8.4 %	

Table 18: Uncertainty budget for the system performance check.

7.6 Environment

To comply with the required noise level (less than 12 mW/kg) periodically measurements without a DUT were conducted. Humidity: $37\% \pm 5\%$

7.7 Test Equipment

Test Equipment	Model	Serial Number	Last Calibration	Next Calibration
DASY4 Systems				
Software Versions DASY4	V4.6	N/A	N/A	N/A
Software Versions SEMCAD	V1.8	N/A	N/A	N/A
Dosimetric E-Field Probe	ET3DV6	1669	01/2005	01/2006
Data Acquisition Electronics	DAE 4	631	07/2005	07/2006
Phantom	SAM	1059	N/A	N/A
Phantom	SAM	1176	N/A	N/A
Phantom	SAM	1340	N/A	N/A
Phantom	SAM	1341	N/A	N/A
Dipoles				
Validation Dipole	D835V2	437	11/2005	11/2006
Validation Dipole	D1900V2	535	11/2005	11/2006
Material Measurement				
Network Analyzer	HP8753D	3410A06555	12/2005	12/2006
Dielectric Probe Kit	HP85070 B	US33020263	N/A	N/A

Table 19: SAR equipment.

Test Equipment	Model	Serial Number	Last Calibration	Next Calibration
Power Meters				
Power Meter, Agilent	E4416A	GB41050414	12/2004	12/2006
Power Meter, Agilent	E4417A	GB41050441	09/2004	12/2006
Power Meter, Anritsu	ML2487A	6K00002319	09/2005	09/2007
Power Meter, Anritsu	ML2488A	6K00002078	09/2005	09/2007
Power Sensors				
Power Sensor, Agilent	E9301H	US40010212	12/2004	12/2006
Power Sensor, Agilent	E9301A	MY41495584	12/2004	12/2006
Power Sensor, Anritsu	MA2481B	031600	09/2005	09/2007
Power Sensor, Anritsu	MA2490A	031565	09/2005	09/2007
RF Sources				
Network Analyzer	HP8753D	3410A06555	12/2006	12/2006
Rohde & Schwarz	SME300	100142	N/A	N/A
Amplifiers				
Mini Circuits	ZHL-42	D012296	N/A	N/A
Mini Circuits	ZHL-42	D031104#01	N/A	N/A
Mini Circuits	ZVE-8G	D031004	N/A	N/A
Radio Tester				
Radio Tester, Rohde & Schwarz	CMU200	11908682/000	06/2005	06/2006
Radio Tester, Willtek	4202S	0813151	N/A	N/A

Table 20: Test equipment, General.

7.8 Certificates of conformity

Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

Certificate of conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 BA
Series No	TP-1002 and higher
Manufacturer / Origin	Untersee Composites Hauptstr. 69 CH-8559 Fruthwilen Switzerland

Tests

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

Test	Requirement	Details	Units tested
Shape	Compliance with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness	Compliant with the requirements according to the standards	2mm +/- 0.2mm in specific areas	First article, Samples
Material parameters	Dielectric parameters for required frequencies	200 MHz – 3 GHz Relative permittivity < 5 Loss tangent < 0.05.	Material sample TP 104-5
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards	Liquid type HSL 1800 and others according to the standard.	Pre-series, First article

Standards

- [1] CENELEC EN 50361
- [2] IEEE P1528-200x draft 6.5
- [3] IEC PT 62209 draft 0.9
- (*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of [1] and [3].

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standard [1] and draft standards [2] and [3].

Date 18.11.2001

Signature / Stamp  Schmid & Partner Engineering AG 
 Zeughausstrasse 43, CH-8004 Zurich
 Tel. +41 1 245 97 00, Fax +41 1 245 97 79

Fig. 14: Certificate of conformity for the used SAM phantom

7.9 Pictures of the device under test

Fig. 15 – 17 show the device under test.



Fig. 15: Front view of the DELL Latitude C810 Notebook



Fig. 16: Front view of the Packard Bell Easy Note Notebook.



Fig. 17: Front view of the Fujitsu Siemens Amilo Pro.

7.10 Test Positions for the Device under Test

Fig. 18 – Fig. 26 shown the test positions for the SAR measurements.

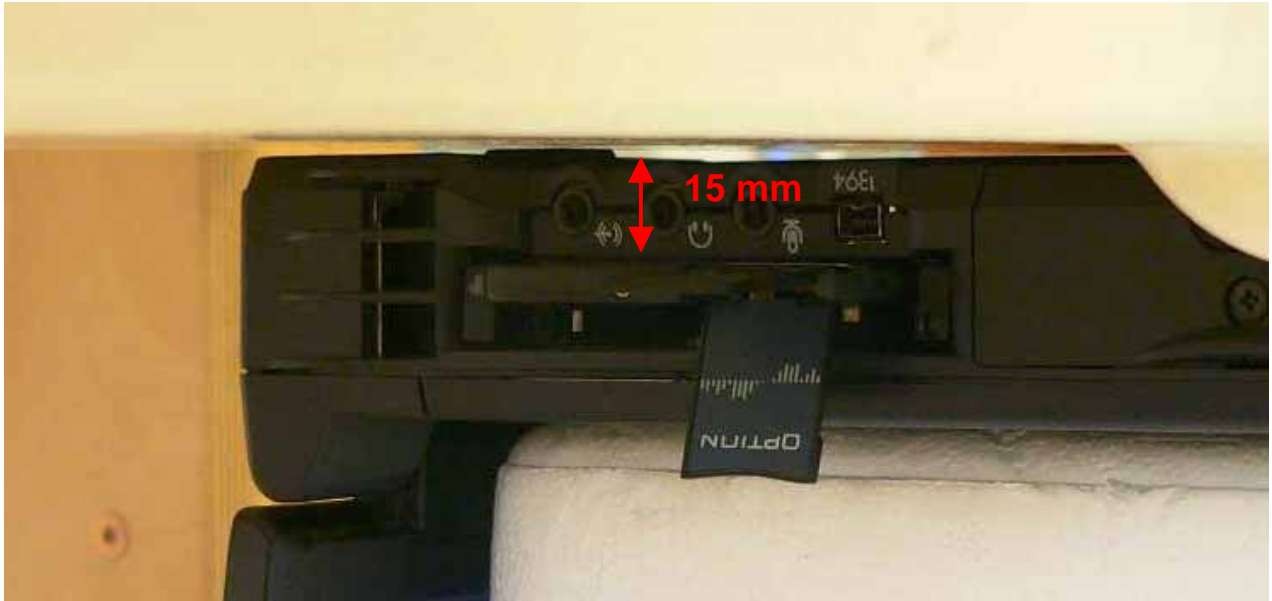


Fig. 18: Position 1 with a DELL Latitude C810 Notebook.

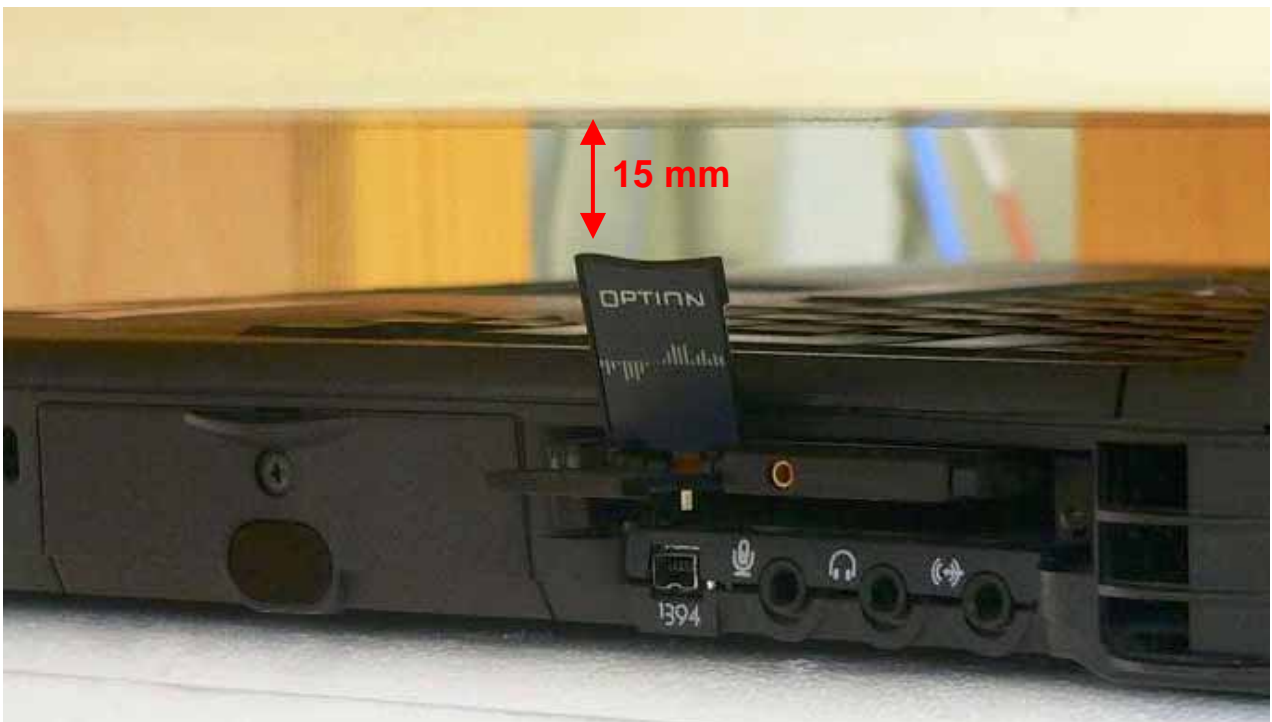


Fig. 19: Position 2 with a DELL Latitude C810 Notebook.



Fig. 20: Position 3 with a DELL Latitude C810 Notebook.

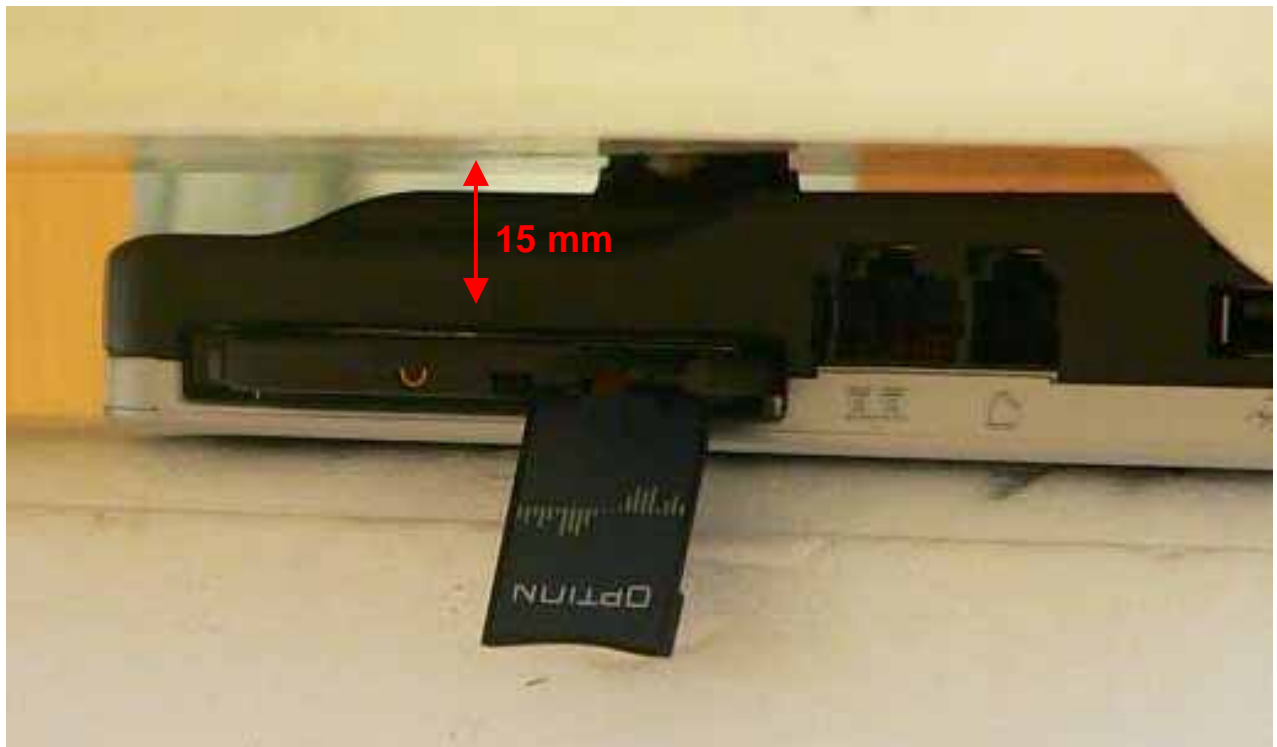


Fig. 21: Position 1 with a Packard Bell Easy Note Notebook.

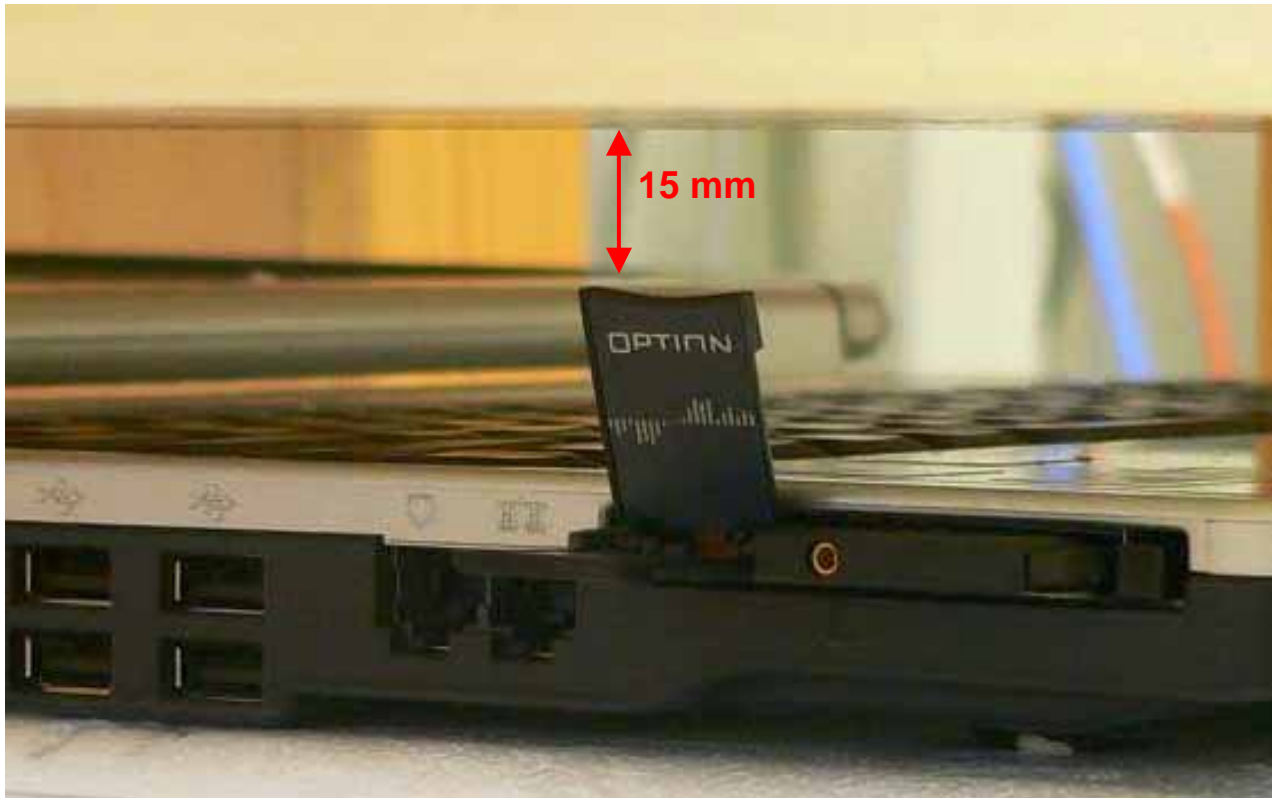


Fig. 22: Position 2 with a Packard Bell Easy Note Notebook.

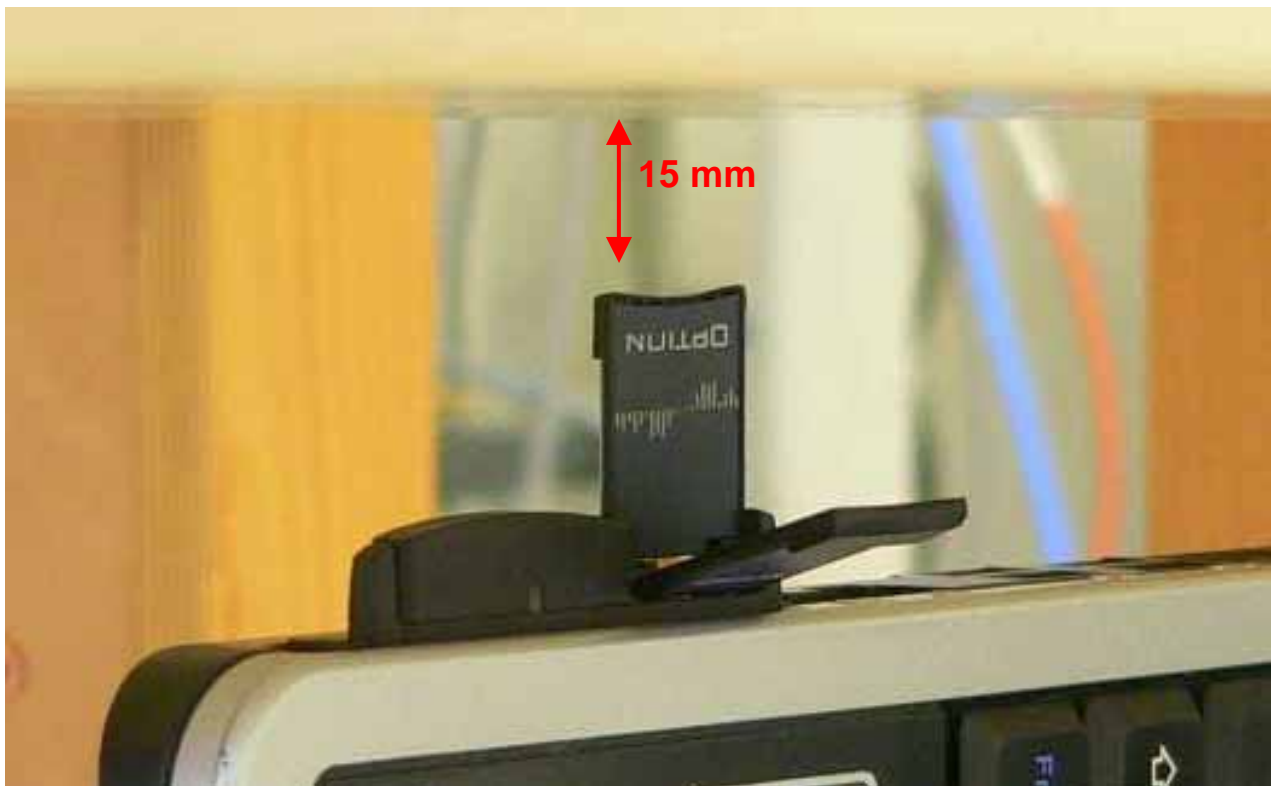


Fig. 23: Position 3 with a Packard Bell Easy Note Notebook.

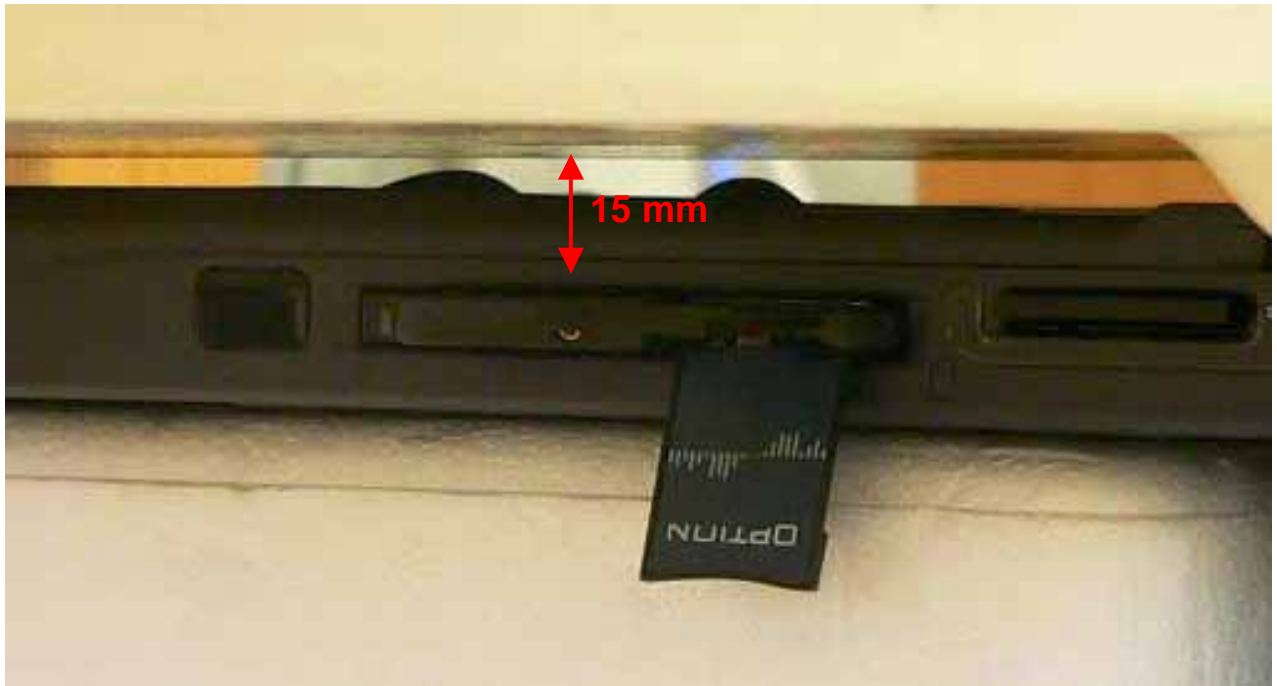


Fig. 24: Position 1 with a Fujitsu Siemens Amilo Pro.

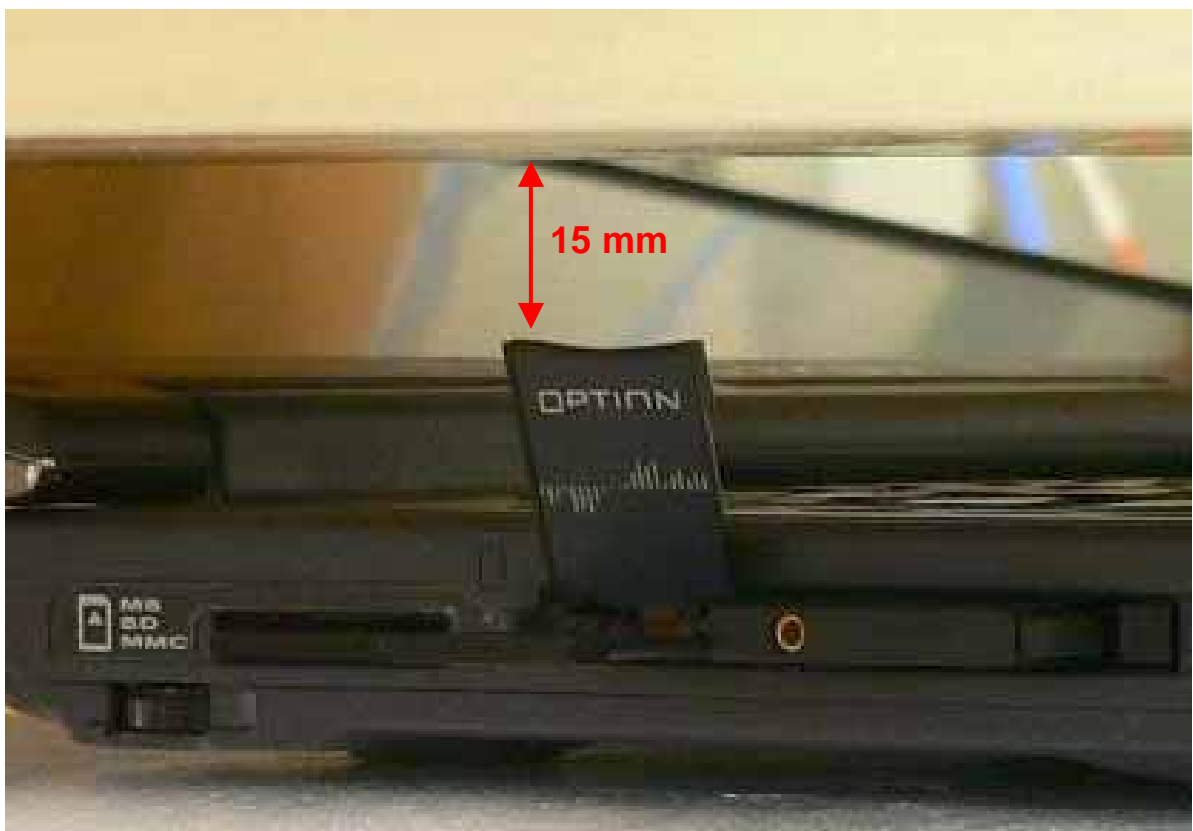


Fig. 25: Position 2 with a Fujitsu Siemens Amilo Pro.



Fig. 26: Position 3 with a Fujitsu Siemens Amilo Pro.

7.11 Pictures to demonstrate the required liquid depth

Fig. 27 - 28 show the liquid depth in the used SAM phantom.

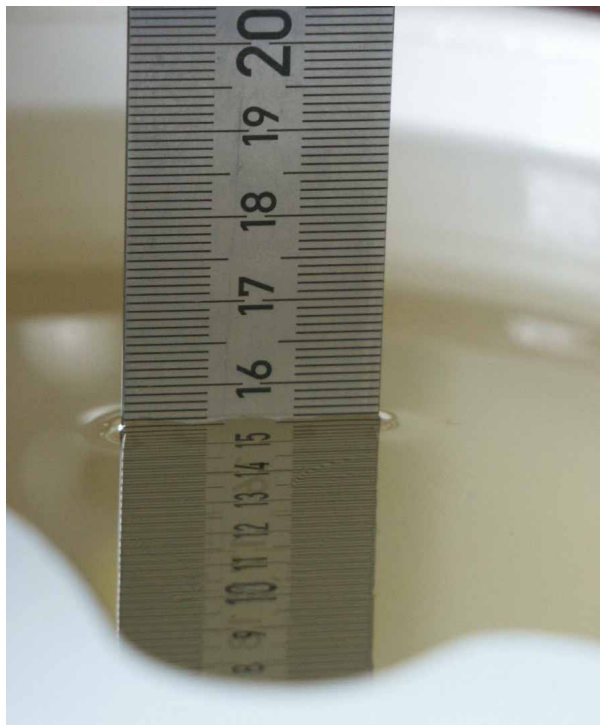


Fig. 27: Liquid depth for GPRS 850 Body measurements.



Fig. 28: Liquid depth for GPRS 1900 Body measurements.

8 References

- [OET 65] Federal Communications Commission: Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), FCC, 2001.
- [IEEE C95.1] IEEE Std C95.1-1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Inst. of Electrical and Electronics Engineers, Inc., 1999.
- [IEEE 1528-2003] IEEE Std 1528-2003: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques. 1528-2003, December 19, 2003, The Institute of Electrical and Electronics Engineers.
- [NIST 1994] NIST: Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Technical Note 1297 (TN1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, 1994.
- [DASY4] Schmid & Partner Engineering AG: DASY4 Manual. August 2004
- [FCC 96-326] FCC 96-326, ET Docket No. 93-62, Report and Order, August 1, 1996