

Uppgjord – Prepared EAB/TFF Martin Siegbahn	Tfn-Telephone +46 8 7570811	Datum – Date 2003-03-20	Rev D	Dokumentnr – Document no TF-01:126
Godkänd – Approved EAB/TF (Christer Törnevik)	Kontr – Checked	Ert datum – Your date	Tillhör reference – File/reference	

Ericsson SAR Measurement Specification of Wireless Terminals

Contents

1	Introduction and scope	2
2	References	2
3	Physical quantities, units and constants	4
4	Definitions.....	4
5	Measurement system specifications	4
5.1	General.....	4
5.2	Phantom.....	5
5.3	SAR measurement equipment	5
5.4	Scanning system	6
5.5	Wireless device holder.....	6
5.6	Other equipment	6
6	Protocol for SAR assessment	7
6.1	Measurement preparation	7
6.2	Tests to be performed	7
6.3	Measurement procedure.....	8
6.4	Post processing	8
7	Measurement uncertainty	9
Annex A	Tissue simulating material preparation.....	10
Annex B	Measurement of dielectric parameters	13
Annex C	SAR measurement procedure	14
Annex D	Measurement system performance check and validation	16

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

1 Introduction and scope

It is an Ericsson policy that all RF transmitting product models shall comply with relevant recommendations, standards and regulations on human exposure to electromagnetic fields. In the reference section below, the most important RF safety guidelines are listed [7-13]. If no national standard or regulation is available in a country, the international recommendation from ICNIRP [7] shall be applied.

The RF safety guidelines specify *basic restrictions* and *reference levels*. In the frequency range of interest for mobile communications, the basic restrictions are expressed as Specific Absorption Rate (SAR) limits and the reference levels as field strength or power density limits. The reference levels are provided for the purpose of simple measurements of compliance with the basic restrictions, and they are primarily applicable in the far-field region of a RF source. Measured values greater than the reference levels do not necessarily mean that the basic restrictions are exceeded.

In the near-field region of mobile communication devices (wireless terminals or base station antennas), field strength values exceeding the reference levels may be observed. Compliance with the basic SAR restrictions has therefore to be verified. SAR (W/kg) is a measure of the rate of RF energy absorption in tissue. The localized SAR limits depend on whether the device is classified for use by the general public (uncontrolled environment) or workers (controlled environment). Mobile communication equipment are usually used by the general public and should consequently be in compliance with the general public limits, which are 2.0 W/kg averaged in 10 gram of tissue in the ICNIRP guidelines [7] and 1.6 W/kg averaged in 1 gram in the ANSI/IEEE standard [8]. Because of the lower limit and the smaller averaging mass, the ANSI/IEEE limit is slightly more conservative than the ICNIRP limit. The averaging times are also different, 6 minutes in the ICNIRP recommendations and 30 minutes in the IEEE guidelines.

This document describes the SAR measurement procedures used by the SAR testing laboratories of Ericsson. SAR measurement standardization is currently evolving. Many standards and guidelines have recently been released [1, 2] or are in progress (e.g. [3, 4]). Ericsson Research is firmly committed to using the latest technology and the latest standards to ensure that the SAR measurements are of the highest quality.

2 References

SAR measurement standards and guidelines

The following standards and guidelines are used as a basis for the SAR measurement specification described herein. Although these documents are well harmonized, some differences exist. References [1] and [2] are approved European standards, [3] and [4] draft measurement standards and references [5] and [6] are published guidelines. This measurement specification closely conforms to these documents.

- [1] European Standard EN 50360, "Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz – 3 GHz)", CENELEC, July 2001.
- [2] European Standard EN 50361, "Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz)", CENELEC, July 2001.
- [3] IEC 62209-Committee Draft (CD), "Procedure to determine the Specific Absorption Rate (SAR) for hand-held mobile wireless devices in the frequency range of 300 MHz to 3 GHz", IEC, November 2002.
- [4] IEC 62209 Part 2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures, Part 2: Procedure to measure the Specific Absorption Rate (SAR) for two-way radios, palmtop terminals, laptop terminals, desktop terminals, and body-mounted devices including accessories and multiple transmitters", Draft Version 0.6, October 2002.
- [5] Standard 1528-200X, Draft 6.5, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques", IEEE, August 20, 2001.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

- [6] Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), "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", FCC, June 2001.
- [7] Radiocommunications (Electromagnetic Radiation Human Exposure) Standard 1999, Australian Communications Authority (ACA), May 1999.
- [8] ARIB Standard STD-T56, "Method of Measuring the Specific Absorption Rate from Portable Wireless Terminals", 2nd Edition, Association of Radio Industries and Businesses, January 24th, 2002. (Translation by Asia Technical Translation Pty Ltd 10/04/02).

Other references

- [9] ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)", International Commission on Non-Ionizing Radiation Protection (ICNIRP), Health Physics, vol. 74, pp 494-522, April 1998.
- [10] ANSI/IEEE C95.1-1992, "Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz", The Institute of Electrical and Electronics Engineers Inc., New York, 1992.
- [11] CENELEC ENV 50166-2, "Human exposure to electromagnetic fields: High-frequency (10 kHz – 300 GHz)", European Prestandard, European Committee for Electrotechnical Standardization (CENELEC), January 1995.
- [12] MPT, "Radio-radiation protection guidelines for human exposure to electromagnetic fields", Telecommunications Technology Council, Ministry of Posts and Telecommunications, Japan, April 1997.
- [13] AS/NZS 2772.1(Int):1998, Interim Australian/New Zealand Standard, "Radiofrequency fields, Part 1: Maximum exposure levels – 3 kHz to 300 GHz", Standards Australia/Standards New Zealand, 1998.
- [14] FCC Report and Order, ET Docket 93-62, FCC 96-326, Federal Communications Commission (FCC), August 1996.
- [15] Safety code 6, Canadian Standard, Health Canada, 1999.
- [16] Thomas Schmid, Oliver Egger, Niels Kuster, "Automated E-field scanning system for dosimetric assessments", *IEEE Transactions on Microwave Theory and Techniques*, vol. 44, pp. 105-113, January 1996.
- [17] Schmid & Partner Engineering AG, "DASY4 Manual V4.1", March 2003 Edition, Zurich, Switzerland.
- [18] Klaus Meier, Michael Burkhardt, Thomas Schmid and Niels Kuster, "Broadband calibration of E-field probes in lossy media", *IEEE transactions on Microwave Theory and Techniques*, vol. 44, no. 10, pp. 1954-1962, October 1996.
- [19] K. Pokovic, T Schmid and N. Kuster, "E-field Probe with Improved Isotropy in Brain Simulating Liquids", *Proceedings ELMAR*, Zadar, Croatia, June 23-25, 1996.
- [20] NIS 81, "The treatment of uncertainty in EMC measurements", Technical Report, NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, Edition 1, May 1994.
- [21] Barry N. Taylor and Christ E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", NIST Technical Report 1297, National Institute of Standards and Technology, September 1994.
- [22] ISO/IEC Guide Expres (1995-01), "Guide to the expression of uncertainty in measurement (1995)", Ed. 1.0 English, 1995.
- [23] HP 8752C Network analyzer User's guide. Hewlett Packard part number 08752-90157.
- [24] HP 85070C Dielectric probe kit manual, Hewlett Packard part number 85070-90009.
- [25] M. Siegbahn, "Instruction: Interlaboratory comparison procedure for the Ericsson SAR test laboratories", EAB/TF-03:007, Rev A, January 10, 2000.
- [26] M. Siegbahn, "A SAR test procedure for wireless devices with simultaneous multi-band transmission", EAB/TF-02:118, Rev. A, November 19, 2002.

Datum - Date 2003-03-20	Rev D	Dokumentnr - Document no TF-01:126
----------------------------	----------	---------------------------------------

3 Physical quantities, units and constants

The physical quantities, units and constants given in section 3 of [2] and section 4 of [3] are applicable for this procedure document.

4 Definitions

The definitions given in section 4 of [2], section 3 of [3], section 2 of [5] and section 7 of [8] apply.

5 Measurement system specifications

Requirements and recommendations are listed in section 5 of [2] and [3], in sections 3, 4 of 5 of [5] and in section 2 of [8].

5.1 General

Requirements and recommendations are listed in section 5.1 of [2] and [3], in section 5.6.1.1 of [5] and in section 2.2 of [8].

Tests are performed using a miniature electric field probe that is positioned by a robot whose movements are software controlled. The probes are positioned to measure the internal electric field of a liquid-filled phantom representing the human head while the phantom is exposed to electromagnetic energy from a wireless device. The software processes the electric field data to determine the SAR distribution and the highest mass-averaged SAR.

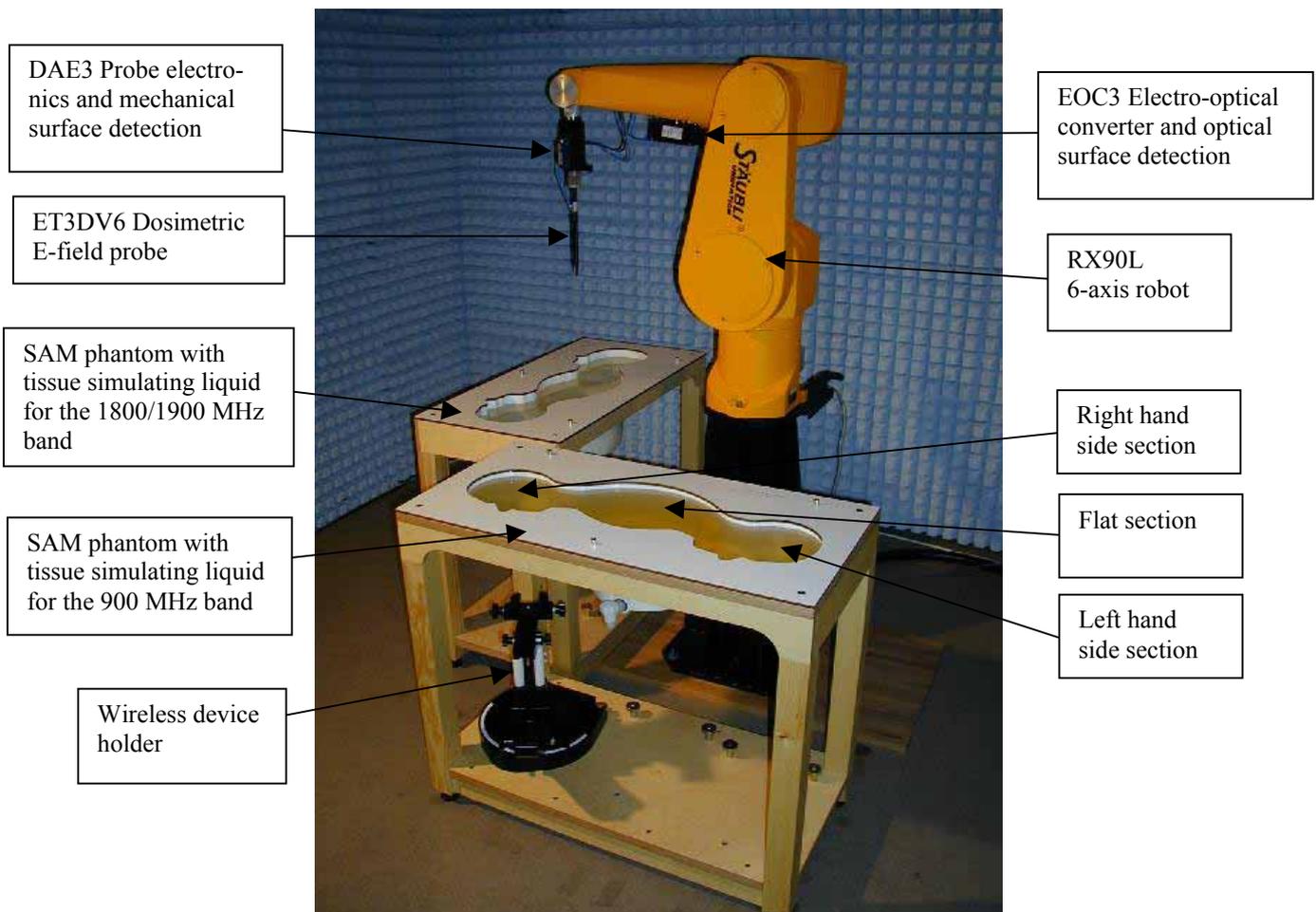


Figure 5.1. SAR measurement system. Picture from the Ericsson EMF Research Laboratory in Kista, Sweden.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

The SAR measurement system used in the Ericsson SAR testing laboratories is the DASY4 near-field scanner manufactured by Schmid & Partner Engineering AG (SPEAG). The system is based on the E-field probe technique and includes a high precision 6-axis robot, liquid-filled plastic phantoms and miniature electric field probes [18,19]. The specifications of the system are further described below. Figure 5.1 is a picture of the SAR measurement system in the Ericsson EMF Research Laboratory, an Ericsson SAR testing laboratory.

The Ericsson SAR testing laboratories conform to the following environmental conditions:

- Measurements are conducted in a metal screen room, which is designed to provide shielding from external radiofrequency signals and to prevent devices under test from interfering with local wireless networks.
- The ambient temperature is kept in the range 20 – 25°C (this simultaneously satisfies several recommendations and requirements [2-5, 8], which are 15 – 30°C, 18 – 25°C and 20 – 26°C, respectively).
- The relative humidity of the laboratory is kept within 30 – 70% [6].
- During measurements, the temperature of the liquid is kept within ± 2 °C of the temperature at which the dielectric parameters were measured [2-5, 8].
- The ambient noise level is kept low so that the 1-gram averaged SAR is below 12 mW/kg when the device under test (DUT) is turned off (this simultaneously satisfies the requirements of [2] and [5]).
- The electromagnetic field reflections in the laboratory are kept low.

5.2 Phantom

Phantom requirements and specifications are provided in section 5.2 of [2] and [3], in section 4 of [5] and in section 2.3 of [8].

The phantom used is an implementation of the Specific Anthropomorphic Mannequin (SAM) model [2-5]. It consists of three measurement areas or sections, one section corresponding to right hand side use and an identical but mirrored section for the left-hand side. In the middle of the phantom there is a flat section for tests of mobile phones when worn on the body [4, 6]. The flat section is also used for system validation.

The phantom shell was manufactured by SPEAG to meet stringent shape, thickness and material requirements [2-5]. The length and width of the flat section are at least $0.75 \lambda_0$ and $0.6 \lambda_0$ respectively at frequencies of 824 MHz and above (λ_0 = wavelength in air).

The phantom is filled with a tissue simulating liquid to a depth of at least 15 cm at each ear reference point [2-5]. The dielectric properties of the liquid conform to all the tabulated values [2-5]. Liquids are prepared according to Annex A and dielectric properties are measured according to Annex B.

5.3 SAR measurement equipment

Measurement equipment requirements and specifications are provided in section 5.3 of [2] and [3], in section 3 of [5] and in section 2.4 of [8].

The Dosimetric Assessment System 4 (DASY4) Professional by Schmid & Partner Engineering AG consists of the dosimetric probe ET3DV6 connected to the readout electronics DAE3 that is attached to the tool joint of a Stäubli RX90L 6-axis high precision robot. The measurement signal is transferred via a fiber optical link from the DAE3 to the electro-optical converter EOC3 that is connected to the measurement server unit in the robot controller rack.

The ET3DV6 probe is sensitive to E-fields and incorporates three 3 mm long dipoles arranged so that the overall response is close to isotropic [16, 18, 19]. The probe sensors are covered by an outer protective shell made of plastic, which is resistant to organic solvents i.e. glycol. In the center line of the probe an optical fiber for surface detection is located. The table below summarizes the technical data of this probe. Other probe parameters are provided in the uncertainty budget in Section 7.

The DAE3 probe electronics incorporates one measurement amplifier for each sensor dipole and a mechanical surface detection system that automatically stops the robot in a probe collision emergency. The fiber optical surface detection system is located in the EOC3. Either the mechanical surface or the detection system is used for controlling the distance between the probe and the inner surface of the phantom shell.

Datum - Date 2003-03-20	Rev D	Dokumentnr - Document no TF-01:126
----------------------------	----------	---------------------------------------

Property	Data
Frequency range	30 MHz – 3 GHz
Linearity	± 0.2 dB
Dynamic Range	5 µW/kg - >100 W/kg
Tip diameter (including protective cover)	6.8 mm
Distance from probe tip to sensors	2.7 mm
Length of sensor dipoles	3 mm
Mechanical surface detection repeatability	± 0.2 mm

Table 5.1 The technical data for the SAR probe ET3DV6.

The dosimetric electric field probes and data acquisition electronics are calibrated by SPEAG at regular intervals. System performance check is conducted for the complete system for each relevant tissue equivalent liquid at the appropriate frequency.

5.4 Scanning system

Requirements and recommendations are listed in section 5.4 of [2] and [3], in section 5.5 of [5] and in section 2.5 of [8].

The robotic scanning system works in such a way that the system identifies the measurement areas in the phantom shell by three reference points located on the phantom table and a laser beam on the robot stand which determines the alignment of the probe. The coordinates of the three reference points are entered into the system by manually steering the robotic arm so that the probe tip is above each of these points. Measurement grids can then be defined in each of the available measurement sections of the phantom, the right ear section, the left ear section and in the middle of the shell, the flat section. The robotic arm automatically positions the probe in the selected measurement grid with the probe axis normal to the phantom inner surface. The distance from the probe tip to the inner surface of the phantom shell is controlled by the mechanical surface detection system. The measurement grids are defined so that the whole tested device is covered. During the measurement the local SAR results can be continuously monitored.

5.5 Wireless device holder

Requirements and recommendations are listed in section 5.5 of [2] and [3], in section 4.1.4 of [5] and in section 2.6 of [8].

The wireless device holder is a positioning system that allows for very accurate and repeatable device positioning [16]. Tilt and rotation angles have a positioning repeatability better than 1°. Care is taken at the laboratory to ensure that the wireless device is placed in the holder in such a way that the holder has a minimal effect on the measured results. Test personnel are trained on proper positioning techniques.

5.6 Other equipment

Requirements and recommendations are listed in section 5.6 of [2] and [3] and in section 5.5 of [5].

The measurement system also includes dipole antennas for system performance checking and system validation procedures at frequency bands of interest. The dipole antennas conform to the specifications of Annex G of [3] and Annex F of [5]. These dipole antennas are checked yearly according to the following items:

- dipole arms are parallel to a flat surface with a tolerance of 2°.
- return loss at the center frequency is below -20 dB while the dipole is positioned under the flat phantom according to Section 7 of [5].
- current distribution along the dipole is symmetric within 5%, as measured using an H-field probe.
- SAR is measured in a flat phantom and compared with reference SAR values in Table D.1 of [3] or in Table 7.1 of [5].

SAR measurement system performance check is described in detail in Annex D.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

6 Protocol for SAR assessment

Requirements and recommendations are listed in section 6 of [2] and [3], in section 5 of [5] and in section 3 of [8].

This section presents an overview of the process of assessing SAR for a wireless terminal in Ericsson SAR testing laboratories, the setup of the tested device and the measurement system, which tests are performed and how the test results are processed.

6.1 Measurement preparation

Requirements and recommendations are listed in section 6.1 of [2] and [3], in section 5.4 and 5.6 of [5] and in section 3.1 of [8].

Prior to conducting SAR measurements of the DUT, the dielectric properties of the tissue simulating liquid are measured (see Annex B). System performance check (see Annex D) is performed prior to the SAR measurements or when any part of the SAR testing system has been altered, which includes change of probe and calibration of tissue simulating liquid etc.

For SAR compliance measurements, the peak output power level of the wireless terminal is set to the maximum power level of that device with a digital radio tester acting as a base station. The peak power level is measured with either a power meter, a sensor suitable for the carrier frequency and the duty cycle, or a digital radio tester.

Tests are conducted for each of the test configurations of the device (operational modes, test frequencies, and configurations).

If the device is intended to be used next to the ear, it is positioned next to the SAM head phantom in the “cheek” and “tilt” positions on both the left and right sides of the phantom according to section 5.4 of [5].

If the device is intended to be used while placed against the body, the phone is tested on the flat section of the phantom. The device, with its original carry case(s) and with hands-free accessories, shall be positioned on the phantom simulating the intended use position, i.e. with the case placed against the phantom shell. Alternatively, the device can be placed against the phantom using a spacer that separates the device from the phantom by the minimum distance allowable using all carry cases. Additional guidance given in [4, 6] on conducting body-worn measurements should be followed.

If the device is intended to be used in other positions than at the head or against the body, it shall be tested according to instructions given in [5]. If however the intended use position for such a device is specified in the user manual testing shall be conducted for this position against the flat phantom.

6.2 Tests to be performed

Requirements and recommendations are listed in section 6.2 of [2] and [3], in section 5.6.4 of [5] and in section 3.2.1 of [8].

A wireless handset can have many test conditions (operational modes, test frequencies, configurations and test positions against the phantom). At a minimum, the steps outlined in the above listed sections are followed to determine the maximum spatial-averaged SAR of the device.

For devices incorporating several transmitters that can be in operation at the same time, SAR testing shall be conducted according to the procedure outlined in [26]. For instance, the Bluetooth transmitter of a mobile phone is tested for the configuration giving the maximum SAR in the assessment of the main cellular transmitter.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

6.3 Measurement procedure

Requirements and recommendations are listed in section 6.3 of [2] and [3], in section 5.6.3 of [5] and in section 3.2.2 of [8].

The measurement procedure is described in detail in Annex C. The measurement procedure can be summarized in the following steps:

1. Setup of DASY4: liquid parameters, test device properties, probe, DAE and measurement areas are specified in the system setup window.
2. Setup of the device: positioning on the phantom, output power level and test channel are selected and checked.
3. SAR measurement, the following measurement steps are conducted:
 - Power reference measurement where the robot moves the probe to a fixed reference position in the tissue liquid and the E-field is recorded.
 - Area scan with grid covering the whole device for finding maximum SAR.
 - Zoom scan around SAR maximum for obtaining mass averaged SAR.
 - Second reference measurement for checking device output power drift. Repeat the SAR measurement if the drift is higher than $\pm 5\%$ ($\pm 0.21\text{dB}$).
 - Surface checks (optional) where the robot repeatedly moves the probe to the phantom surface at a specified point to check the repeatability of the mechanical and optical surface detection are conducted before the reference measurements if needed. If the repeatability is greater than $\pm 0.1\text{ mm}$, the system should be inspected (e.g. check for air bubbles trapped under the probe) and the surface check procedure should be repeated.

6.4 Post processing

Requirements and recommendations are listed in section 6.4 of [2] and [3], in section 5.5 of [5] and in section 3.2.3 of [8].

The specific absorption rate (SAR) is calculated from the recorded E-fields by the following expression:

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

Where σ is the measured electric conductivity (S/m) of the liquid, E is the measured root-mean-squared E field (V/m), and ρ is the chosen tissue density ($\rho = 1000\text{ kg/m}^3 = 1\text{ g/cm}^3$ should always be used [2,5,8]). The SAR distribution of the tested device is determined by a coarse scan where the probe is moved in a coarse grid following the inner surface of the phantom. The size of the scanned region should be large enough to guarantee that all possible SAR peaks are included. The distance between adjacent measured points should be 10 – 20 mm [2-5, 8]. Spline interpolation is then used to determine the point of maximum SAR.

The mass averaged SAR is determined by a fine cubical scan, a measurement taken on a fine grid around the position of the maximum SAR. The grid typically consists of $7 \times 7 \times 7$ points with 5 mm between the individual points [2] and thus contains about 27 grams of tissue. Numerical extrapolation is then used to determine the SAR values between measurement points in the cube and in the small region between the cube and the inner surface of the phantom where the E-field sensors cannot be positioned. The extrapolation distance is the sum of the probe tip - sensor offset, the surface detection distance and the grid offset. The extrapolation is based on fourth-order polynomial functions. Next, a 3D-spline interpolation algorithm is used to interpolate the measured data to a 1g cube ($20 \times 20 \times 20 = 8000$ points) over which the SAR is averaged. The cube is shifted throughout the fine scan area until the highest averaged SAR is found. The same procedure is repeated for the 10 gram cube (also $20 \times 20 \times 20 = 8000$ points).

Datum - <i>Date</i>	Rev	Dokumentnr - <i>Document no</i>
2003-03-20	D	TF-01:126

7 Measurement uncertainty

Requirements and recommendations are listed in section 7 of [2] and [3], in sections 3 and 4 of [5] and in section 4 and Appendix 4 of [8].

The measurement uncertainty of the DASY has been determined according to the NIS81 [20] and NIST1297 documents [21]. The total uncertainty is below 30% and a detailed breakdown of the uncertainties is provided in [17].

Datum - Date 2003-03-20	Rev D	Dokumentnr - Document no TF-01:126
----------------------------	----------	---------------------------------------

Annex A Tissue simulating material preparation

This section describes the preparation procedure for the tissue simulating liquids used in SAR testing.

A.1 Liquid parameters

The liquids prepared for the SAR testing meet both the requirements of [2] in table 1 and the requirements of [3], [5] and [8] in table 2. The parameters below are applicable to average head tissue simulating material. Since dielectric parameters for average body tissue have not yet been developed, liquids meeting the below stated data are also used for measurements of body SAR. The parameters for a liquid used in SAR measurements have to be within $\pm 5\%$ of the target values.

Frequency (MHz)	ϵ_r	σ (S/m)
300	45	0.85
450	44	0.88
900	42	0.99
1450	41	1.20
1800	40	1.38
2450	39	1.84
3000	39	2.40

Table A.1. The dielectric properties of tissue simulating material given in [2].

Frequency (MHz)	ϵ_r	σ (S/m)
300	45.3	0.87
450	43.5	0.87
835	41.5	0.90
900	41.5	0.97
1450	40.5	1.20
1800	40.0	1.40
1900	40.0	1.40
2000	40.0	1.40
2450	39.2	1.80
3000	38.5	2.40

Table A.2. The dielectric properties of tissue simulating material given in [3], [5] and [8].

A.2 Liquid recipes

Ingredients

Water	tap water with low ion content or distilled water
Sugar	as available in food shops
Salt	as available in food shops (Note, no iodine!)
Cellulose	HEC Hydroxyethyl-cellulose (Optional ingredient)
Preservative	Preventol D7 Bayer AG or Sodium Nitrate
DGBE	Diethyleneglycolbutylether (CAS No. 112-34-5)

Note 1: Similar materials can also be substituted for the ones above (e.g. deionized water instead of distilled water). The specifications of the materials (e.g. purity) are not critical (although they may change the recipes below), because the after the tissue simulating liquid is made, its dielectric parameters must be verified to be within the target ranges.

Datum - Date 2003-03-20	Rev D	Dokumentnr - Document no TF-01:126
----------------------------	----------	---------------------------------------

Preparation equipment

- Balance (range: 0-6000 g, accuracy: ± 0.1 g)
- Stirrer with hotplate
- Jars and beakers
- Mixing spoon

Liquid for the 835 MHz and 900 MHz bands

Ingredient	835 MHz and 900 MHz head	
	% Weight	Amount (g)
Water	40.58	10549
HEC	0.90	233
NaCl	1.40	367
Preservative	0.19	50
Sugar	56.92	14800
Total amount		20 l

Liquids for the 1800 MHz and 1900 MHz bands

Ingredient	1800 MHz head		1900 MHz head	
	% Weight	Amount (g)	% Weight	Amount (g)
DGBE	47.00	9204	44.92	8798
Water	52.64	10309	54.90	10752
NaCl	0.36	70.5	0.18	35.3
Total amount		20 l		20 l

Liquid for the 2450 MHz band

Ingredient	2450 MHz head	
	% Weight	Amount (g)
DGBE	45	9000
Water	55	11000
Total amount		20 l

A.2 Preparation procedure**Sugar-based liquids**

1. Add the water to a large container. Begin heating and stirring.
2. Add the cellulose, preservative and salt (if required). While keeping the container covered, leave the solution on the heating plate until the mixture becomes sufficiently transparent and homogeneous. The temperature of the mixture should be hot enough to aid in mixing the ingredients but cool enough to prevent a significant amount of water evaporation.
3. Add the sugar. Hand stirring may be necessary at the beginning until the sugar is sufficiently dissolved.
4. Keep the liquid hot and the container covered until the solids are dissolved and the liquid is homogenous.
5. Turn the hotplate off and allow the liquid to cool off to room temperature prior to performing dielectric measurements.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

Alcohol-based liquids

1. Add all the ingredients in a large container.
2. Stir until the liquids are solved.

Safety note: when handling the DGBE chemical and the tissue simulating liquids based on it, protective gloves and breathing mask shall be used. This includes preparation of liquids as well as filling, emptying and cleaning of phantoms.

A.3 Tissue liquid maintenance

In order to keep the dielectric parameters of the tissue simulating liquids within their target ranges, ingredients may be added to adjust the parameters. For example, one can add water to increase the permittivity, sugar to reduce the permittivity or salt to increase the conductivity. Parameters should each be within a $\pm 5\%$ range of target values.

A batch of tissue simulating liquid may last several months or more but regular maintenance is necessary in order to keep the dielectric properties within target ranges. The electrical parameters of the tissue simulating liquids are assessed prior to SAR compliance testing and checked that they are within tolerance of the specified values (see tables above). The parameters are subject to small variations due to evaporation, and ingredients have to be added on a regular basis in order to adjust the parameters. The amount of ingredient to add depends on the parameter deviations and the total liquid volume and is therefore not easily calculated. However, based on experience, for sugar-salt-water liquids a rule of thumb can be applied: to a 25-liter liquid with a permittivity deviation of about -7% and a conductivity deviation around -3% to -7%, 200 – 400 grams of water should be added. It is recommended that a batch be disposed of and replaced with a new batch when it becomes difficult to keep its dielectric parameters within the ranges specified.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

Annex B Measurement of dielectric parameters

This annex describes the procedures used to measure the dielectric properties of the tissue simulating liquid.

B.1 Equipment

- HP network analyzer, models in the HP8753 series, HP8752C or similar
- HP dielectric probe kit HP85070 of versions A, B or C [24]
- HP 85070 software (any software version)
- PC using GPIB card [23] for communication with network analyzer
- Syringe
- Small glass jars for liquid samples
- Thermometer

B.2 Procedure for testing tissue simulating liquid

1. Turn the NWA (Network analyzer) on and allow it to warm up.
2. Start the PC and run the HP 85070 software.
3. Mount dielectric probe kit so that interconnecting cable to NWA will not be moved during measurement or calibration.
4. Perform calibration according to the HP85070 manual [24]. In short the following steps are covered:
 - Inspect the probe and ensure that it is properly cleaned.
 - Pour distilled water in a sample container and measure the water temperature.
 - Set start and stop frequency, frequency step and water temperature.
 - Perform calibration measurement with probe in air, connected to short circuiting block and in distilled water. Assure proper contact which requires attaching the block firmly. Monitor the polar chart on the network analyzer to assure good contact as explained in the manual.
5. Assure that the probe is thoroughly cleaned before performing the measurement.
6. Inspect the liquid for inhomogeneities. Surface bubbles can be moved to one side, but if there are numerous bubbles throughout the liquid (e.g. as happens after a new liquid has been poured into a phantom), wait until the bubbles have floated to the surface before proceeding. Also remove any debris or lumps in the liquid.
7. Stir the liquid to be measured.
8. Measure the temperature of the tissue simulating liquid in the phantom. Save value for reference, SAR measurements are only conducted for temperatures $\pm 2^{\circ}\text{C}$ from this reference temperature.
9. Extract a sample (approximately 50 ml or more).
10. Measure liquid shortly after calibration of the network analyzer and at most within an hour of this calibration. It is also important to measure the liquid sample soon after extracting it so that evaporation and temperature variation do not affect the results.
11. Immerse the dielectric probe in the liquid sample. Check that there are no air bubbles in front of the opening in the dielectric probe kit.
12. Perform measurements. Repeat measurement five times to increase reliability and use average value for comparison with target value. If a single measurement deviates substantially from the rest then redo that measurement to reject possible artifact. The accuracy specified by the dielectric probe kit manufacturer [23] is $\pm 5\%$ for the dielectric constant ϵ' and ± 0.05 for the loss tangent ϵ''/ϵ' .
13. Conductivity σ can be calculated from ϵ'' according to
$$\sigma = \omega \epsilon_0 \epsilon'' \cong \epsilon'' f (\text{GHz}) / 18.$$
14. Clean the probe thoroughly after use.
15. Pour the sample back into the phantom.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

Annex C SAR measurement procedure

This section gives a step-by-step procedure for measuring the DUT. The instructions of this section are only valid under the assumption that the measurement equipment is calibrated. More information is found in the user manual for the measurement system [17].

C.1 Initial setup

1. Ensure that the computer, robot controller, the DASY4 measurement server and DAE are turned on, and that the DASY software is running.
2. Choose and import the appropriate test configuration in the "setup" window.
3. Remove the plastic cover on the phantom.
4. Power up the robotic arm and align the probe with the laser beam unit. Check the status of the setup; all items must have a green indicator for the measurement system to be fully ready.
5. Verify that the system knows the reference points on the phantom. Check the distance between the reference points and the probe tip with the plastic spacer. If it does not accurately locate one or more of the points, uninstall and install the reference points. Should the installation fail to give results within the tolerances set out in the factory settings for the phantom, the procedure will give an error and the user will have to reinstall the reference points. Afterwards, move the probe to the resting point above the flat section.
6. Stir the liquid in the phantom to ensure that it is homogeneous. Surface bubbles can be moved to one side, but if there are numerous bubbles throughout the liquid (e.g. as happens after a new liquid has been poured into a phantom), wait until the bubbles have floated to the surface before proceeding. Also remove any debris or lumps in the liquid.
7. Measure the temperature of the tissue simulating liquid in the phantom. The liquid temperature has to be within ± 2 °C of the temperature recorded when the electrical parameters were measured.

C.2 Measurement procedure

The following steps should be carried out for each of the test conditions described in Section 6.2.

1. Open the appropriate predefined measurement file or prepare a new measurement file by selecting jobs from the menu. The measurement file contains the following jobs: power reference measurement, area scan covering the whole device, zoom scan and a final power reference measurement. The recording time for the area and zoom scans is 0.5 second, which gives sufficient accuracy, but for reference/drift measurements 4 seconds giving increased noise-reduction. Additionally, a surface check can be inserted before the power reference measurements. During this check, the robot repeatedly moves the probe to the phantom surface at a specified point to check the repeatability of the mechanical and optical surface detection. If the repeatability is worse than ± 0.1 mm, the system should be inspected (e.g. check for air bubbles trapped under the probe) and the surface check procedure should be repeated. "Check" the measurement jobs to get assurance that all measurement points can be reached by the robotic arm. Save the measurement file under an appropriate name.
2. Move the probe to the section park point. Stir the liquid again to remove any bubbles.
3. Power on the DUT and set it to transmit at full power in one of the operational configurations (as described in Section 6.1). Check the signal with the spectrum analyzer.
4. Position the DUT against the phantom in one of the required test positions (as described in Section 6.1).
5. Select and start the measurement jobs when the device has warmed up, after 3 minutes.
6. When the measurement jobs have been carried out, check the DUT power drift. If the drift is not within $\pm 5\%$ (± 0.21 dB), check the DUT and change battery if necessary, check the DASY and repeat the measurement. If the drift cannot be maintained within 5%, add the drift to the measured SAR value.
7. Save the measurement data.

Datum - <i>Date</i>	Rev	Dokumentnr - <i>Document no</i>
2003-03-20	D	TF-01:126

C.3 Post measurement procedure

When the SAR measurements are finished, do the following:

1. Power off the DUT.
2. Move the probe to the resting point and clean it with water.
3. Put the plastic cover on the phantom.
4. Power off all measurement equipment.
5. Enter a short description of the conducted work in the DASYS logbook.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

Annex D Measurement system performance check and validation

D.1 General

Measurement system validation consists of three procedures:

1. System performance checking
2. System validation
3. Interlaboratory comparison

These three procedures are defined in section 7 of [4]. System performance checking and interlaboratory comparison are also described in Annex D of [2] (they are called Simplified performance checking and system validation, respectively) and in Annex D of [3]. Section 5 and Appendix 6 of [8] provide information on the above listed procedures.

System performance checking is conducted prior to the SAR testing of a wireless device with a reference dipole antenna and the flat section of the SAM phantom. The results are compared to reference data provided in [4]. The DASY4 manufacturer conducts system validation. Interlaboratory comparison between the Ericsson SAR testing laboratories is conducted according to a separate procedure [25].

D.2 System performance check procedure

System performance check is conducted according to the following steps.

Setup of the dipole antenna

1. Turn on the signal generator, power meter and power amplifier (if used). Allow them sufficient time to warm up, to reduce drift.
2. Position the dipole antenna under the flat phantom and adjust the height of the stand until the specified spacer is touching the shell of the flat phantom. The center of the dipole antenna should be positioned under the middle of the flat phantom, as indicated by a mark on the flat phantom.
3. Connect one end of the coax line to the power meter sensor and the other end to the output of the signal generator. If the power amplifier is used, connect it between the signal generator and the power meter sensor.
4. Set the signal generator to transmit in CW mode and ensure that any signal modulation is turned off. This ensures that the power amplifier will transmit a pure sinusoid.
5. Set the frequency of the signal generator to the resonant frequency of the dipole antenna.
6. Set the output power of the signal generator (and optionally adjust the gain of the power amplifier) so that the same amount of power as used by the system manufacturer at calibration is delivered to the power meter.
7. Disconnect the coax line from the power meter and connect it to the dipole antenna.

Setup of the DASY

1. Mount the 3D electric field probe, as shown in the SPEAG manual.
2. Remove the plastic cover on the phantom.
3. Power up the DAE. The LED indicates that the power is on.
4. Power up the computer.
5. Turn on the robot controller and measurement server.
6. Start the DASY4 software on the computer.
5. Choose and import the appropriate test configuration in the "setup" window.
6. Power up the robotic arm and align the probe with the laser beam unit. Check the status of the setup; all items must have a green indicator for the measurement system to be fully ready.

Datum - Date	Rev	Dokumentnr - Document no
2003-03-20	D	TF-01:126

7. Verify that the robot knows the reference points on the phantom. Check the distance between the reference points and the probe tip with the plastic spacer. If it does not accurately locate one or more of the reference points to within ± 5 mm, install the reference points. Should the installation fail to give results within the tolerances set out in the factory settings for the phantom, the procedure will give an error and the user will have to reinstall the reference points. Afterward, move the probe to the resting point above the flat section.
8. Measure the temperature of the tissue simulating liquid in the phantom. The liquid temperature has to be within ± 2 °C of the temperature recorded when the electrical parameters were measured.

Measurement procedure

1. Open the predefined system performance check test file. This file includes all of the necessary measurements for the dipole test. Rename the file with an appropriate name and save it in the appropriate directory.
2. Move the probe to the section park point. Stir the liquid again to remove any bubbles.
3. Select and start the measurement jobs in the file. These include the power reference measurement, area scan, zoom scan, and final power reference measurements.

Analysis of measured data

1. Normalize the measurement data to 1 Watt and compare the one-gram and ten-gram averaged peak SAR values to the standard values provided in the reference documents. If they do not agree within $\pm 10\%$, check the system parameters (e.g. antenna output power, dielectric parameters of the tissue simulating liquid, homogeneity of the liquid) and repeat the measurement.
2. Also check that the distribution of measured SAR agrees with that provided in the reference data. The peak SAR should be located over the center of the dipole, and the SAR should monotonically decrease away from this point. If the SAR distribution does not compare well with the reference data, repeat the measurement.
3. Make sure that the power reference measurement is within $\pm 5\%$ (± 0.21 dB). If not, check the system parameters and repeat the measurement.
4. Save the measurement data and enter it into the logbook.
5. Move the probe out of the liquid and clean it with warm water.

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

Client **Ericsson ERA, Kista**

CALIBRATION CERTIFICATE

Object(s) **DAE3 - SN:422**

Calibration procedure(s) **QA CAL-06.v2
Calibration procedure for the data acquisition unit (DAE)**

Calibration date: **May 6, 2003**

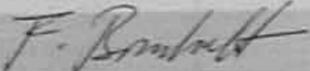
Condition of the calibrated item **In Tolerance (according to the specific calibration document)**

This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.

All calibrations have been conducted in the closed laboratory facility: environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date	Scheduled Calibration
Fluke Process Calibrator Type 702	SN: 6295803	3-Sep-01	Sep-03

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Technician	
Approved by:	Fin Bornholt	R&D Director	

Date issued: May 6, 2003

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

1. DC Voltage Measurement

DA - Converter Values from DAE

High Range: 1LSB = $6.1\mu\text{V}$, full range = 400 mV
 Low Range: 1LSB = 61nV , full range = 4 mV

Software Set-up: Calibration time: 3 sec Measuring time: 3 sec

Setup	X	Y	Z
High Range	405.3348	405.1077	405.6337
Low Range	3.93626	3.97337	4.39044
Connector Position	83 °		

High Range	Input	Reading in μV	% Error
Channel X + Input	200mV	199999	0.00
	20mV	19998.8	-0.01
Channel X - Input	20mV	-19994.1	-0.03
	200mV	200000	0.00
Channel Y + Input	20mV	19997.1	-0.01
	20mV	-19997.9	-0.01
Channel Y - Input	200mV	200000	0.00
	20mV	19998.7	-0.01
Channel Z + Input	20mV	-19998.8	-0.01
	20mV	-19998.8	-0.01

Low Range	Input	Reading in μV	% Error
Channel X + Input	2mV	2000	0.00
	0.2mV	200	0.00
Channel X - Input	0.2mV	-200.3	0.15
	2mV	1999.9	0.00
Channel Y + Input	0.2mV	-200.73	0.36
	0.2mV	-200.71	0.36
Channel Y - Input	2mV	2000	0.00
	0.2mV	199.38	-0.31
Channel Z + Input	0.2mV	-201.31	0.66
	0.2mV	-201.31	0.66

2. Common mode sensitivity

Software Set-up

Calibration time: 3 sec, Measuring time: 3 sec

High/Low Range

in μV	Common mode Input Voltage	High Range Reading	Low Range Reading
Channel X	200mV	9.5352	8.8843
	- 200mV	-8.3521	-8.9287
Channel Y	200mV	-6.5992	-6.8855
	- 200mV	6.5049	5.9412
Channel Z	200mV	-9.9692	-9.3404
	- 200mV	8.1885	7.5601

3. Channel separation

Software Set-up

Calibration time: 3 sec, Measuring time: 3 sec

High Range

in μV	Input Voltage	Channel X	Channel Y	Channel Z
Channel X	200mV	-	3.5211	-0.11189
Channel Y	200mV	0.15938	-	6.2396
Channel Z	200mV	-1.8896	-0.51988	-

4. AD-Converter Values with inputs shorted

in LSB	Low Range	High Range
Channel X	17421	16193
Channel Y	15930	16204
Channel Z	15867	16048

5. Input Offset Measurement

Measured after 15 min warm-up time of the Data Acquisition Electronic.
Every Measurement is preceded by a calibration cycle.

Software set-up:

Calibration time: 3 sec
Measuring time: 3 sec
Number of measurements: 100, Low Range

Input 10M Ω

in μV	Average	min. Offset	max. Offset	Std. Deviation
Channel X	-0.73	-1.59	0.05	0.34
Channel Y	-1.57	-2.37	-0.70	0.37
Channel Z	0.06	-0.67	0.85	0.30

Input shorted

in μV	Average	min. Offset	max. Offset	Std. Deviation
Channel X	-0.01	-0.95	1.26	0.38
Channel Y	-0.81	-1.48	0.44	0.32
Channel Z	-0.93	-2.01	0.35	0.29

6. Input Offset Current

in fA	Input Offset Current
Channel X	< 25
Channel Y	< 25
Channel Z	< 25

7. Input Resistance

	Calibrating	Measuring
Channel X	200 k Ω	200 M Ω
Channel Y	200 k Ω	200 M Ω
Channel Z	200 k Ω	200 M Ω

8. Low Battery Alarm Voltage

in V	Alarm Level
Supply (+ Vcc)	7.51 V
Supply (- Vcc)	-7.70 V

9. Power Consumption

in mA	Switched off	Stand by	Transmitting
Supply (+ Vcc)	0.000	5.40	14.2
Supply (- Vcc)	-0.012	-7.57	-8.87

10. Functional test

Touch async pulse 1	ok
Touch async pulse 2	ok
Touch status bit 1	ok
Touch status bit 2	ok
Remote power off	ok
Remote analog Power control	ok
Modification Status	B - C

Client **Ericsson ERA, Kista**

CALIBRATION CERTIFICATE

Object(s) **ET3DV6 - SN:1572**

Calibration procedure(s) **QA CAL-01.v2
Calibration procedure for dosimetric E-field probes**

Calibration date: **May 15, 2003**

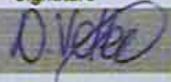
Condition of the calibrated item **In Tolerance (according to the specific calibration document)**

This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.

All calibrations have been conducted in the closed laboratory facility, environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
RF generator HP 8684C	US3642U01700	4-Aug-99 (SPEAG, in house check Aug-02)	In house check: Aug-05
Power sensor E4412A	MY41495277	2-Apr-03 (METAS, No 252-0250)	Apr-04
Power sensor HP 8481A	MY41092180	18-Sep-02 (Agilent, No. 20020918)	Sep-03
Power meter EPM E4419B	GB41293874	2-Apr-03 (METAS, No 252-0250)	Apr-04
Network Analyzer HP 8753E	US38432426	3-May-00 (Agilent, No. 8702K064602)	In house check: May 03
Fluke Process Calibrator Type 702	SN: 6295803	3-Sep-01 (ELCAL, No.2360)	Sep-03

	Name	Function	Signature
Calibrated by:	Nico Vetterli	Technician	
Approved by:	Katja Pokovic	Laboratory Director	

Date issued: May 15, 2003

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

Probe ET3DV6

SN:1572

Manufactured:	April 6, 2001
Last calibration:	April 25, 2002
Recalibrated:	May 15, 2003

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

DASY - Parameters of Probe: ET3DV6 SN:1572

Sensitivity in Free Space

NormX	1.92 $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	1.81 $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	1.98 $\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression

DCP X	95	mV
DCP Y	95	mV
DCP Z	95	mV

Sensitivity in Tissue Simulating Liquid

Head 900 MHz $\epsilon_r = 41.5 \pm 5\%$ $\sigma = 0.97 \pm 5\%$ mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1 528-200X

ConvF X	7.1 $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	7.1 $\pm 9.5\%$ (k=2)	Alpha	0.34
ConvF Z	7.1 $\pm 9.5\%$ (k=2)	Depth	2.41

Head 1800 MHz $\epsilon_r = 40.0 \pm 5\%$ $\sigma = 1.40 \pm 5\%$ mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1 528-200X

ConvF X	5.5 $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	5.5 $\pm 9.5\%$ (k=2)	Alpha	0.42
ConvF Z	5.5 $\pm 9.5\%$ (k=2)	Depth	2.76

Boundary Effect

Head 900 MHz Typical SAR gradient: 5 % per mm

Probe Tip to Boundary		1 mm	2 mm
SAR ₉₅ [%]	Without Correction Algorithm	8.3	4.7
SAR ₉₅ [%]	With Correction Algorithm	0.2	0.4

Head 1800 MHz Typical SAR gradient: 10 % per mm

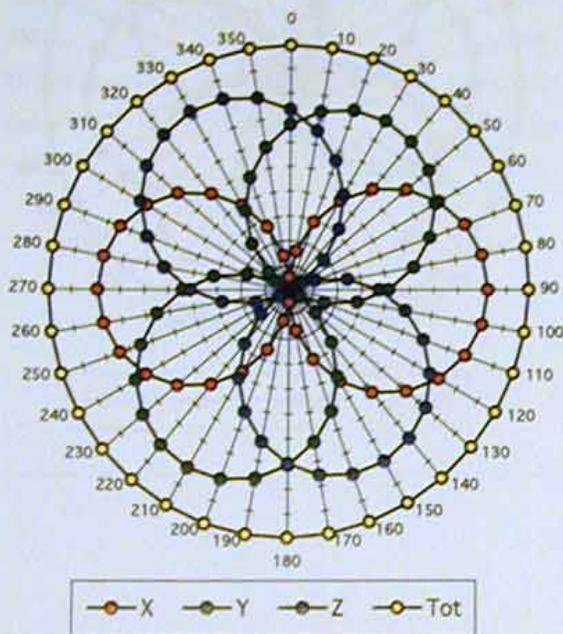
Probe Tip to Boundary		1 mm	2 mm
SAR ₉₅ [%]	Without Correction Algorithm	12.2	8.6
SAR ₉₅ [%]	With Correction Algorithm	0.2	0.2

Sensor Offset

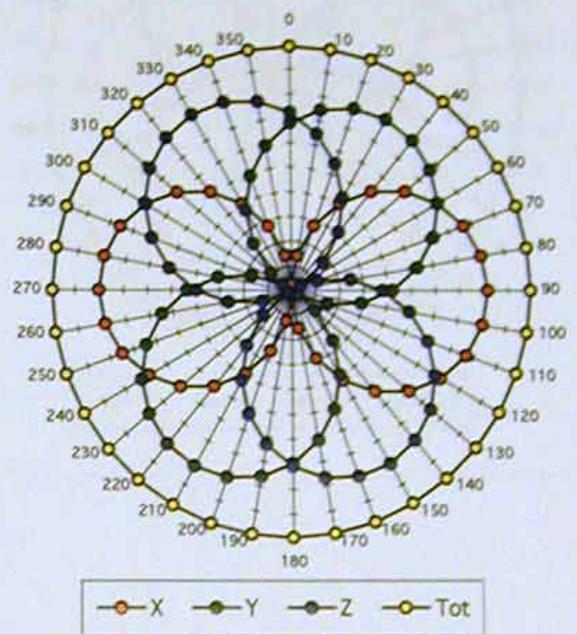
Probe Tip to Sensor Center	2.7	mm
Optical Surface Detection	1.4 ± 0.2	mm

Receiving Pattern (ϕ), $\theta = 0^\circ$

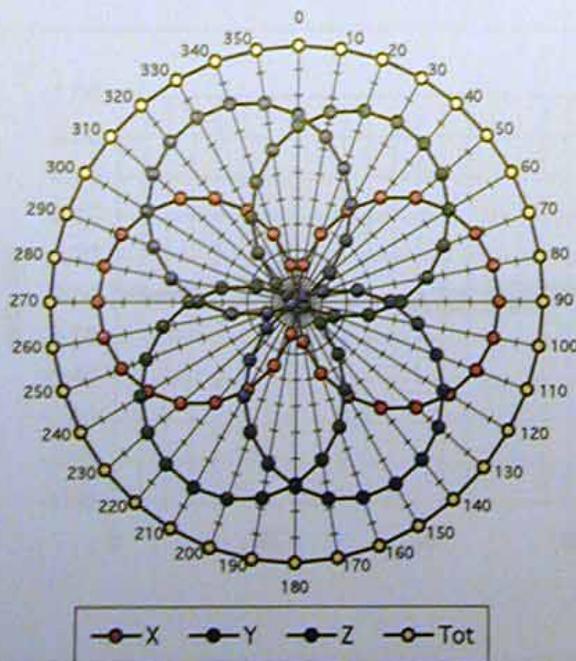
f = 30 MHz, TEM cell ifi110



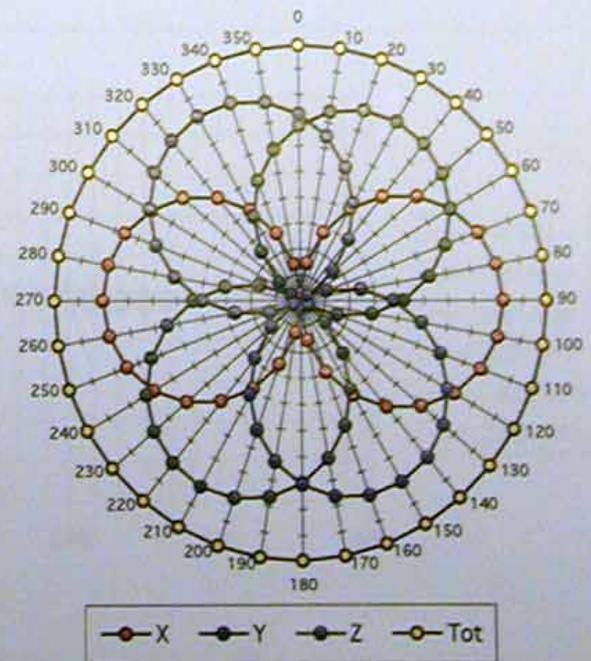
f = 100 MHz, TEM cell ifi110

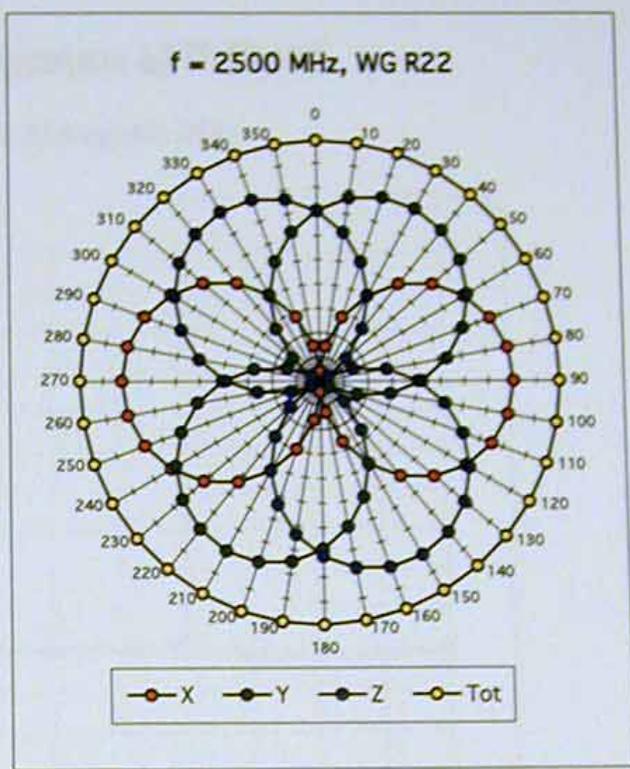
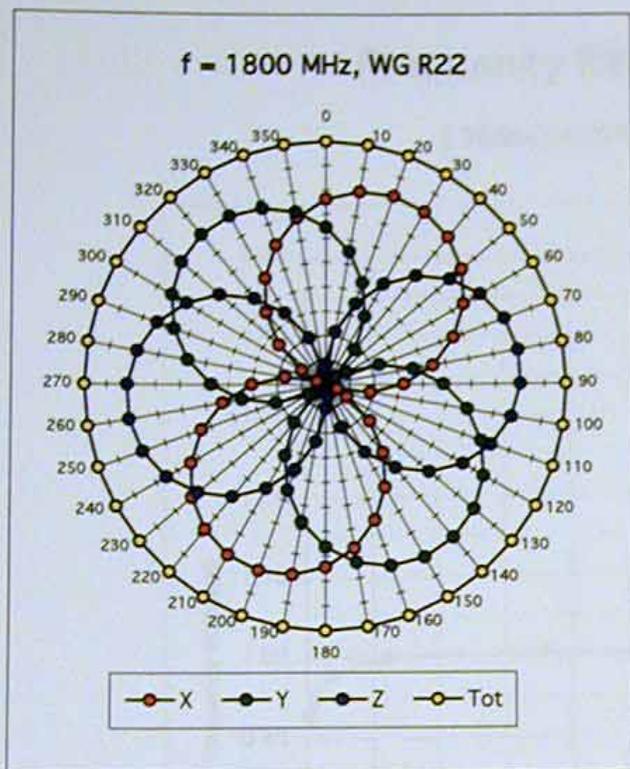


f = 300 MHz, TEM cell ifi110

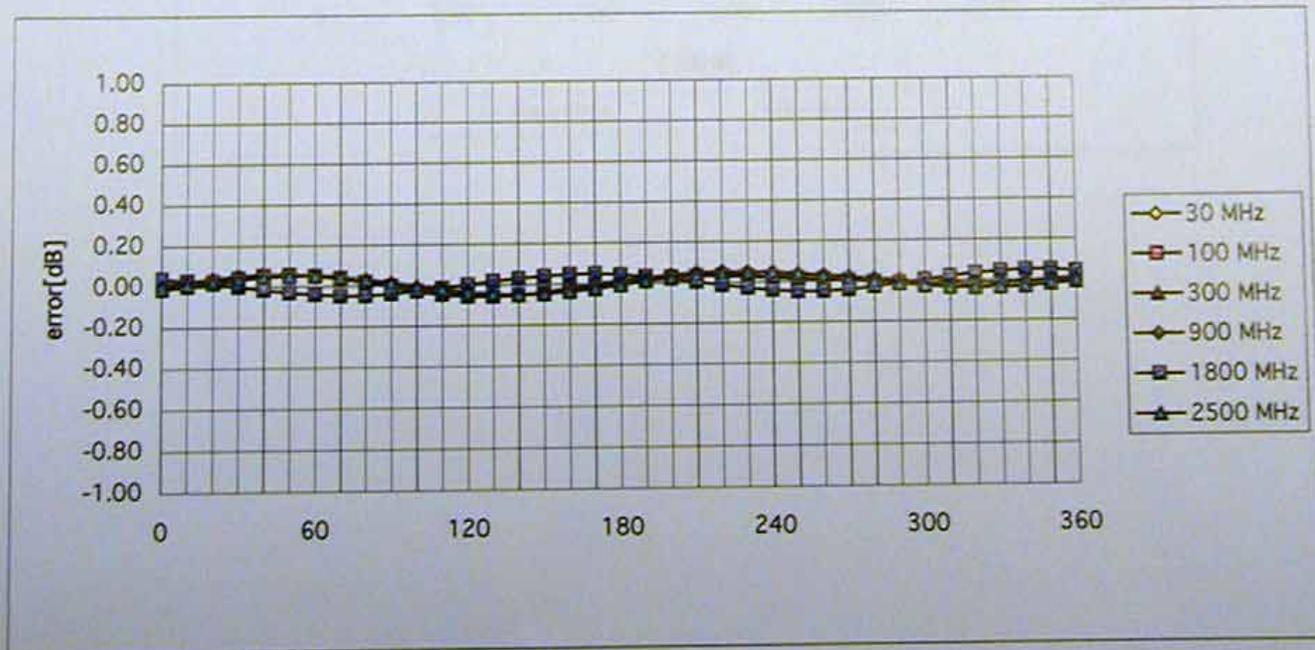


f = 900 MHz, TEM cell ifi110



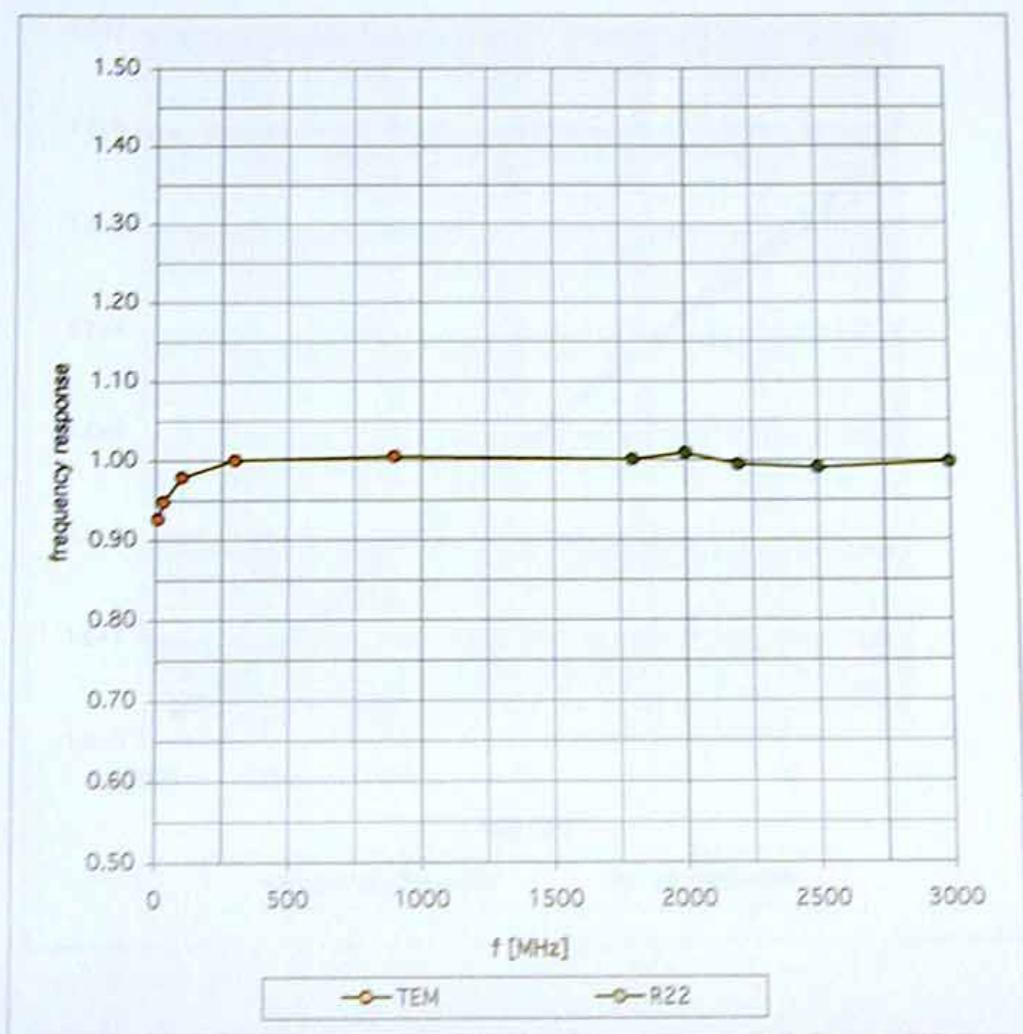


Isotropy Error (ϕ), $\theta = 0^\circ$



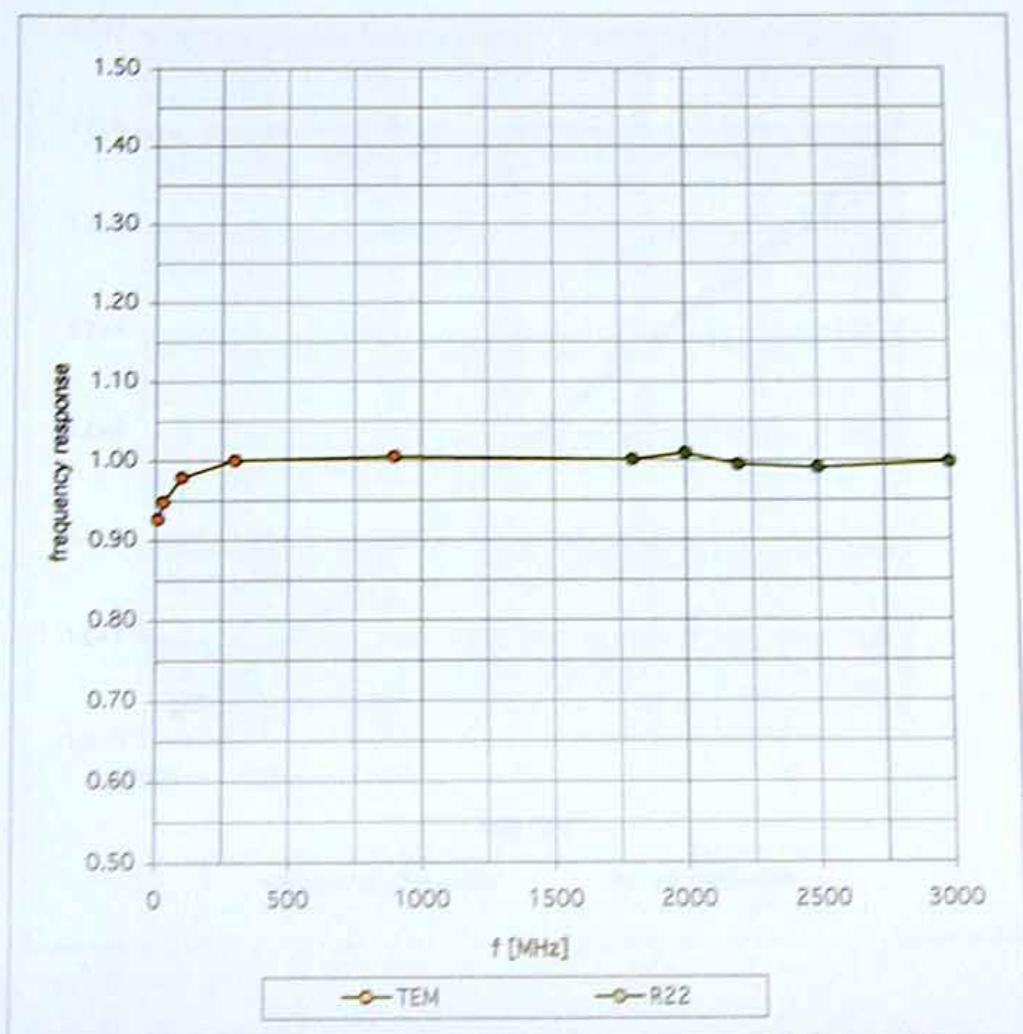
Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)



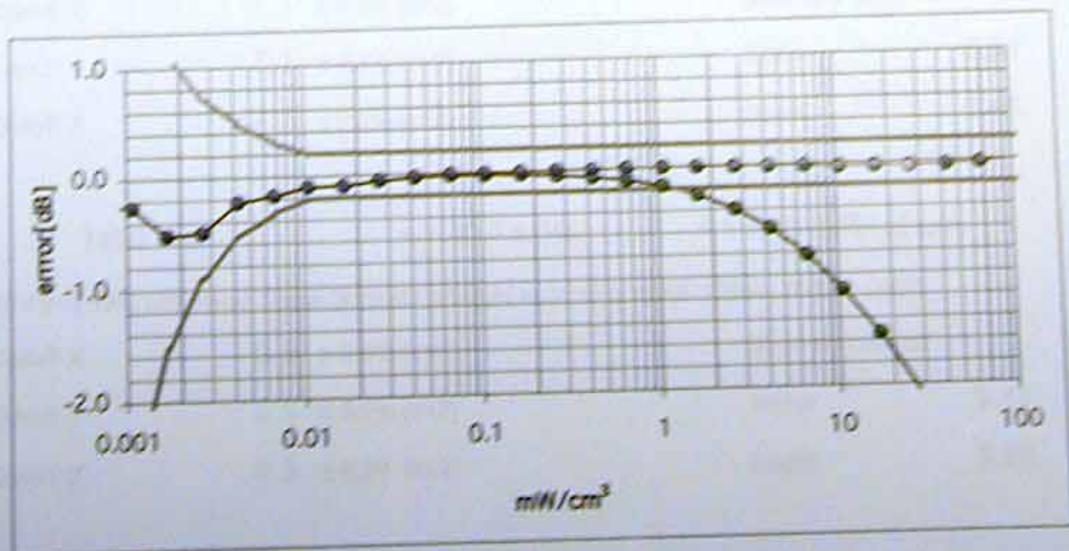
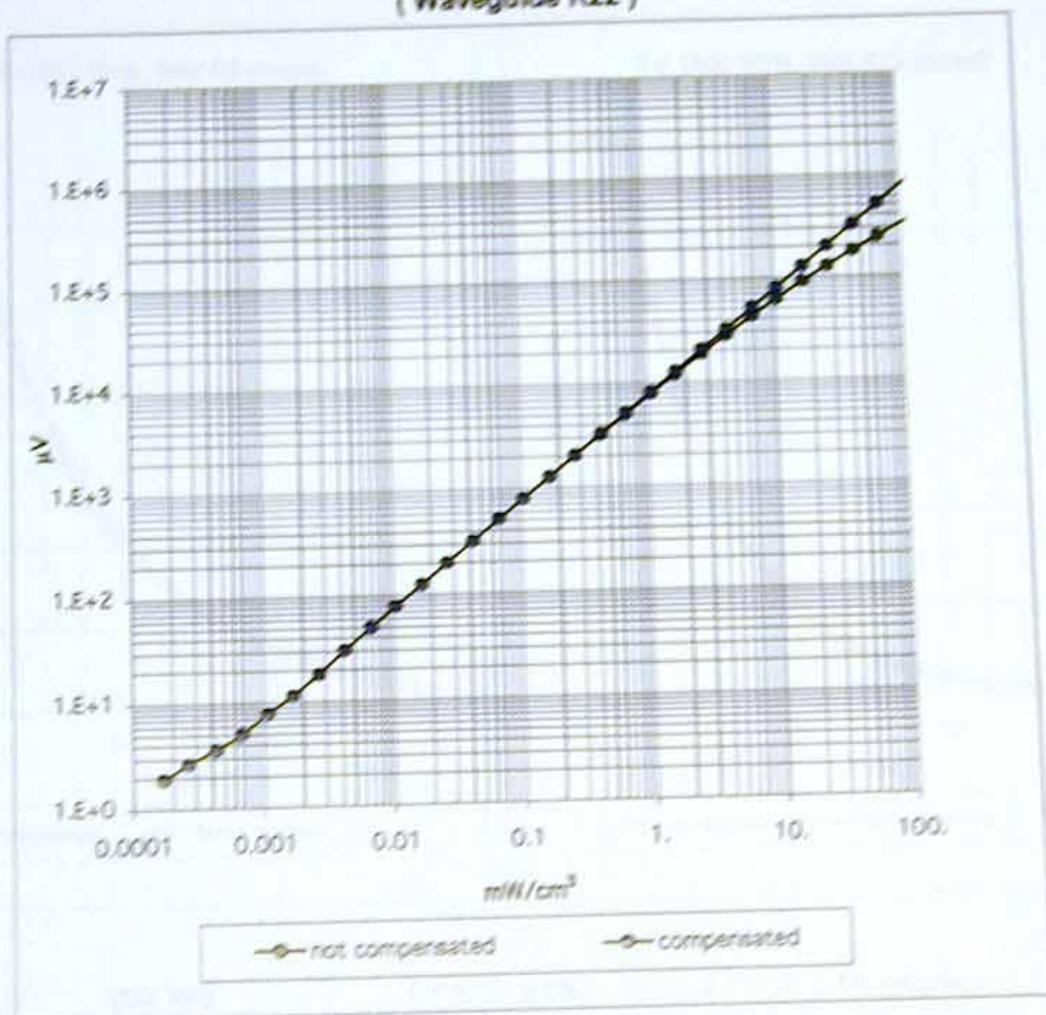
Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)

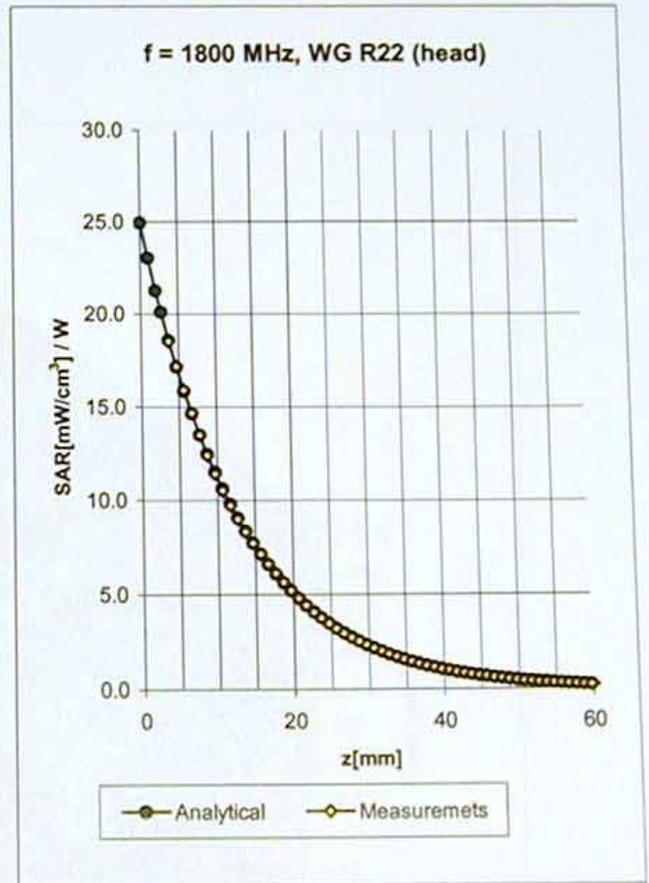
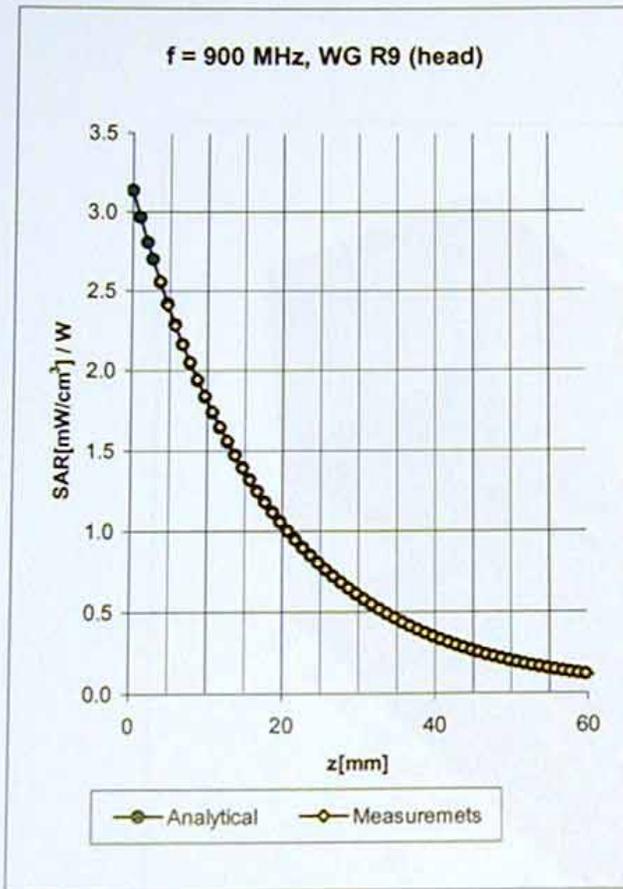


Dynamic Range f(SAR_{brain})

(Waveguide R22)



Conversion Factor Assessment



Head 900 MHz $\epsilon_r = 41.5 \pm 5\%$ $\sigma = 0.97 \pm 5\%$ mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	7.1 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	7.1 ± 9.5% (k=2)	Alpha	0.34
ConvF Z	7.1 ± 9.5% (k=2)	Depth	2.41

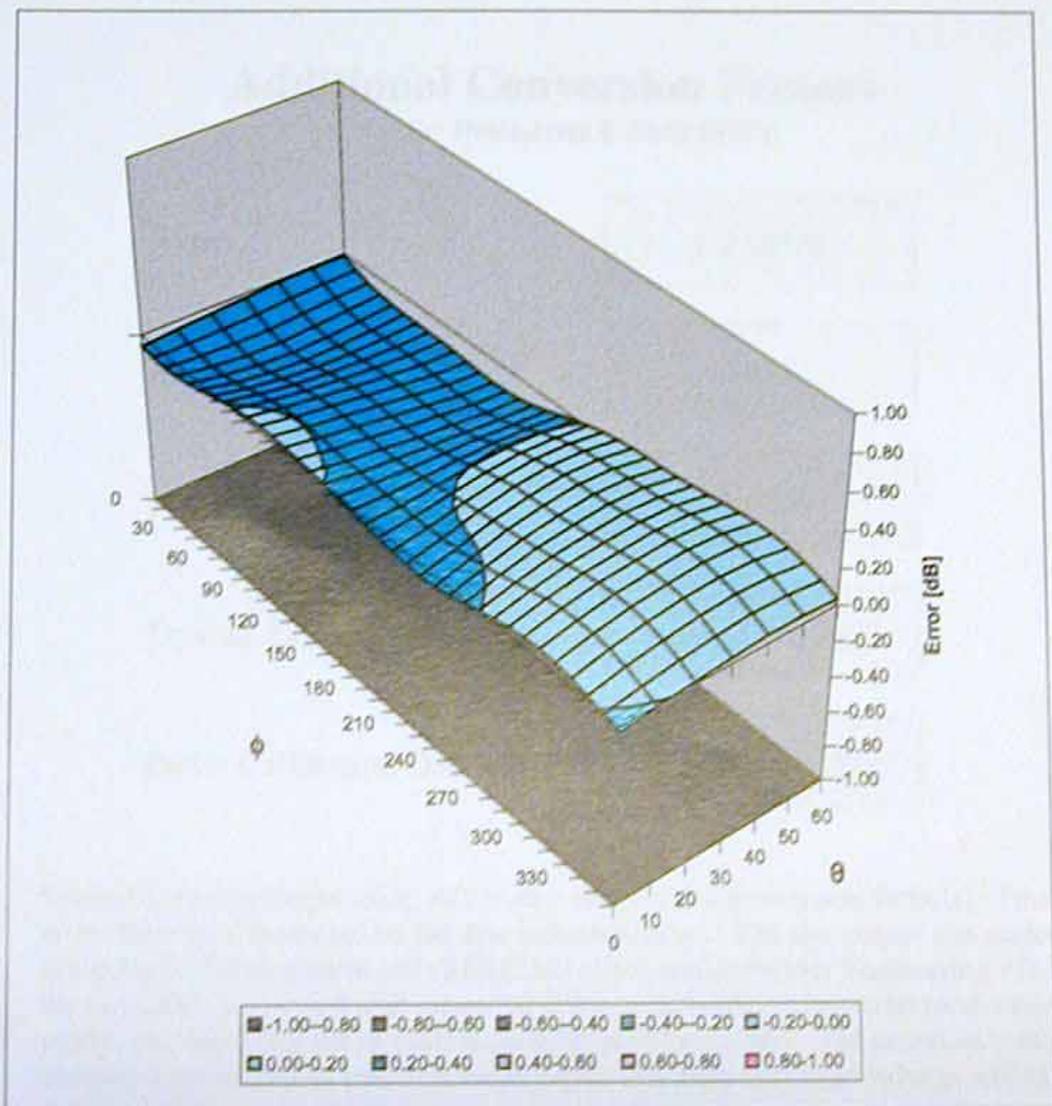
Head 1800 MHz $\epsilon_r = 40.0 \pm 5\%$ $\sigma = 1.40 \pm 5\%$ mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	5.5 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	5.5 ± 9.5% (k=2)	Alpha	0.42
ConvF Z	5.5 ± 9.5% (k=2)	Depth	2.76

Deviation from Isotropy in HSL

Error (θ, ϕ), $f = 900$ MHz



Additional Conversion Factors for Dosimetric E-Field Probe

Type:

ET3DV6

Serial Number:

1572

Place of Assessment:

Zurich

Date of Assessment:

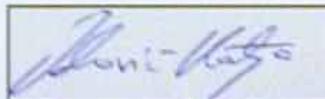
August 20, 2003

Probe Calibration Date:

May 15, 2003

Schmid & Partner Engineering AG hereby certifies that conversion factor(s) of this probe have been evaluated on the date indicated above. The assessment was performed using the FDTD numerical code SEMCAD of Schmid & Partner Engineering AG. Since the evaluation is coupled with measured conversion factors, it has to be recalculated yearly, i.e., following the re-calibration schedule of the probe. The uncertainty of the numerical assessment is based on the extrapolation from measured value at 900 MHz or at 1800 MHz.

Assessed by:



Dosimetric E-Field Probe ET3DV6 SN:1572Conversion factor (\pm standard deviation)900 MHz ConvF $6.8 \pm 8\%$ $\epsilon_r = 55.0 \pm 5\%$
 $\sigma = 1.05 \pm 5\% \text{ mho/m}$
(body tissue)1900 MHz ConvF $4.9 \pm 8\%$ $\epsilon_r = 53.3 \pm 5\%$
 $\sigma = 1.52 \pm 5\% \text{ mho/m}$
(body tissue)

Client **Ericsson ERA, Kista**

CALIBRATION CERTIFICATE

Object(s) **ET3DV6 - SN:1572**

Calibration procedure(s) **QA CAL-01.v2
Calibration procedure for dosimetric E-field probes**

Calibration date: **May 15, 2003**

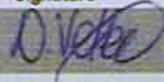
Condition of the calibrated item **In Tolerance (according to the specific calibration document)**

This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.

All calibrations have been conducted in the closed laboratory facility, environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
RF generator HP 8684C	US3642U01700	4-Aug-99 (SPEAG, in house check Aug-02)	In house check: Aug-05
Power sensor E4412A	MY41495277	2-Apr-03 (METAS, No 252-0250)	Apr-04
Power sensor HP 8481A	MY41092180	18-Sep-02 (Agilent, No. 20020918)	Sep-03
Power meter EPM E4419B	GB41293874	2-Apr-03 (METAS, No 252-0250)	Apr-04
Network Analyzer HP 8753E	US38432426	3-May-00 (Agilent, No. 8702K064602)	In house check: May 03
Fluke Process Calibrator Type 702	SN: 6295803	3-Sep-01 (ELCAL, No.2360)	Sep-03

	Name	Function	Signature
Calibrated by:	Nico Vetterli	Technician	
Approved by:	Katja Pokovic	Laboratory Director	

Date issued: May 15, 2003

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

Probe ET3DV6

SN:1572

Manufactured:	April 6, 2001
Last calibration:	April 25, 2002
Recalibrated:	May 15, 2003

Calibrated for DASYS Systems

(Note: non-compatible with DASYS2 system!)

DASY - Parameters of Probe: ET3DV6 SN:1572

Sensitivity in Free Space

NormX	1.92 $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	1.81 $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	1.98 $\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression

DCP X	95	mV
DCP Y	95	mV
DCP Z	95	mV

Sensitivity in Tissue Simulating Liquid

Head 900 MHz $\epsilon_r = 41.5 \pm 5\%$ $\sigma = 0.97 \pm 5\%$ mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1 528-200X

ConvF X	7.1 $\pm 9.5\%$ (k=2)	Boundary effect:
ConvF Y	7.1 $\pm 9.5\%$ (k=2)	Alpha 0.34
ConvF Z	7.1 $\pm 9.5\%$ (k=2)	Depth 2.41

Head 1800 MHz $\epsilon_r = 40.0 \pm 5\%$ $\sigma = 1.40 \pm 5\%$ mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1 528-200X

ConvF X	5.5 $\pm 9.5\%$ (k=2)	Boundary effect:
ConvF Y	5.5 $\pm 9.5\%$ (k=2)	Alpha 0.42
ConvF Z	5.5 $\pm 9.5\%$ (k=2)	Depth 2.76

Boundary Effect

Head 900 MHz Typical SAR gradient: 5 % per mm

Probe Tip to Boundary		1 mm	2 mm
SAR ₉₅ [%]	Without Correction Algorithm	8.3	4.7
SAR ₉₅ [%]	With Correction Algorithm	0.2	0.4

Head 1800 MHz Typical SAR gradient: 10 % per mm

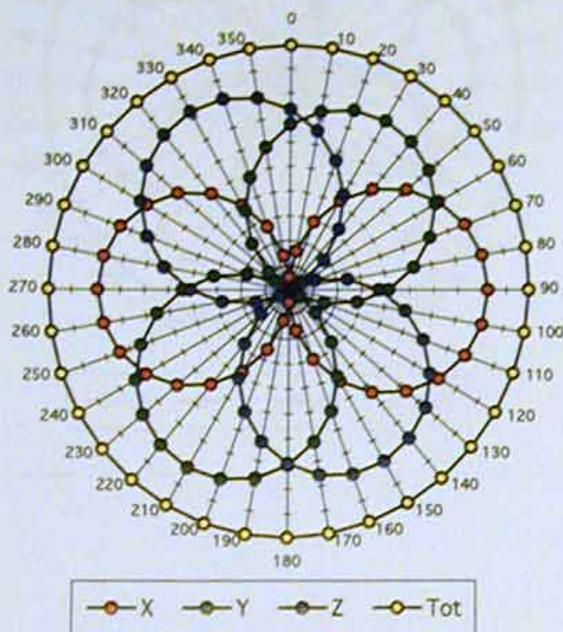
Probe Tip to Boundary		1 mm	2 mm
SAR ₉₅ [%]	Without Correction Algorithm	12.2	8.6
SAR ₉₅ [%]	With Correction Algorithm	0.2	0.2

Sensor Offset

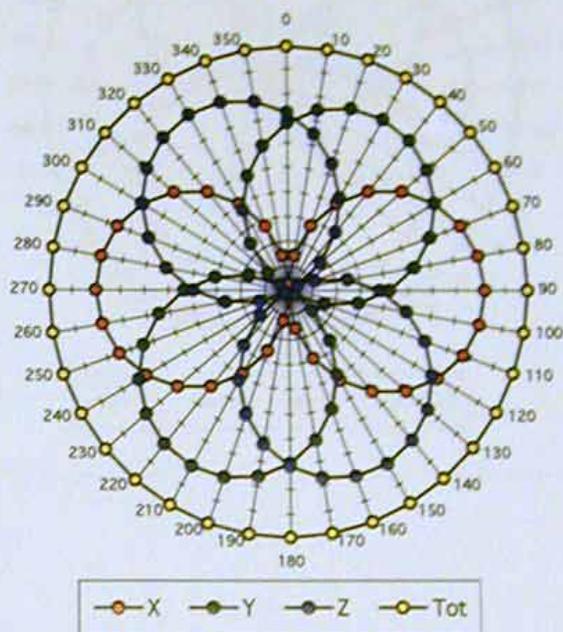
Probe Tip to Sensor Center	2.7	mm
Optical Surface Detection	1.4 ± 0.2	mm

Receiving Pattern (ϕ), $\theta = 0^\circ$

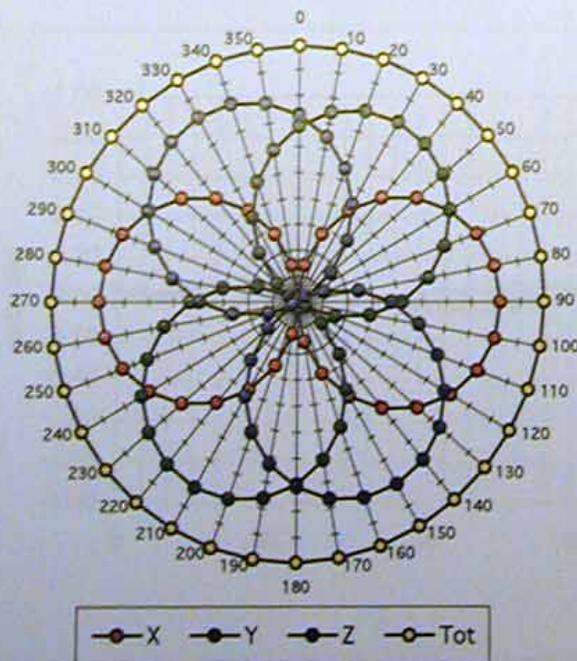
f = 30 MHz, TEM cell ifi110



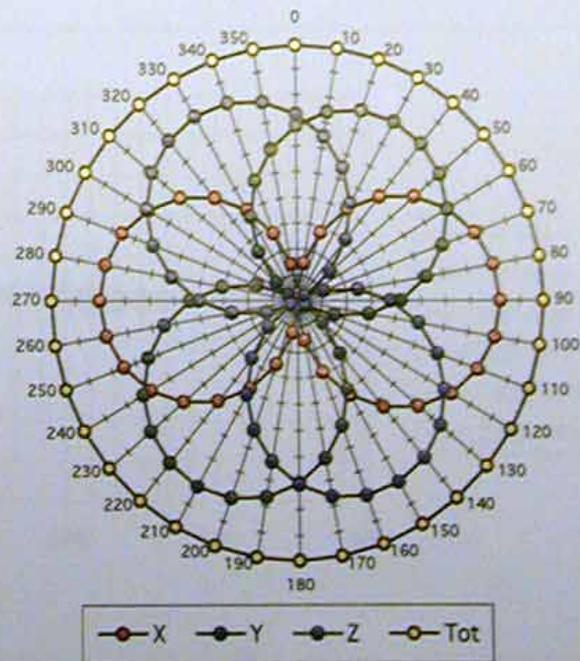
f = 100 MHz, TEM cell ifi110

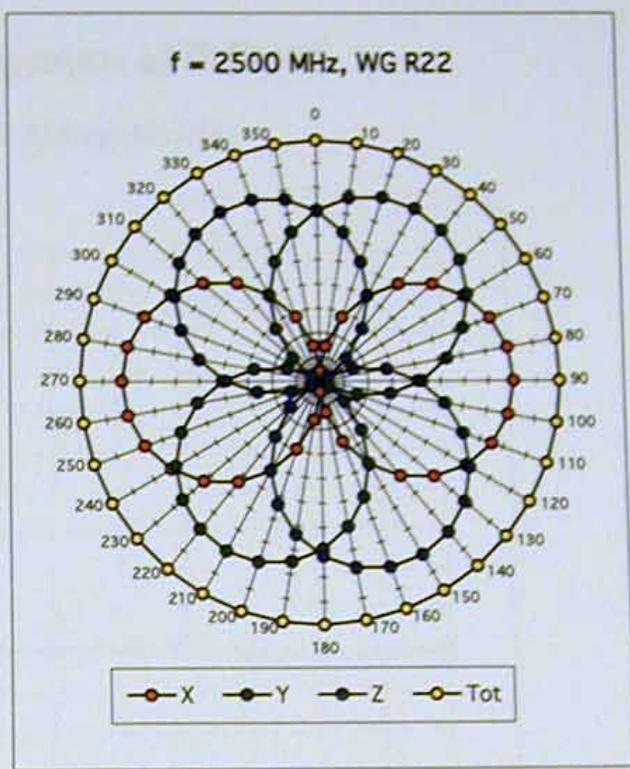
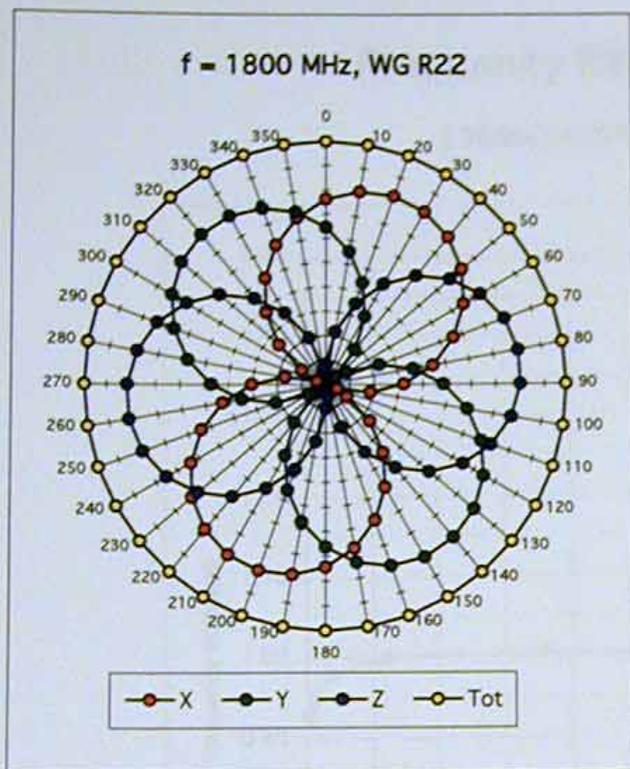


f = 300 MHz, TEM cell ifi110

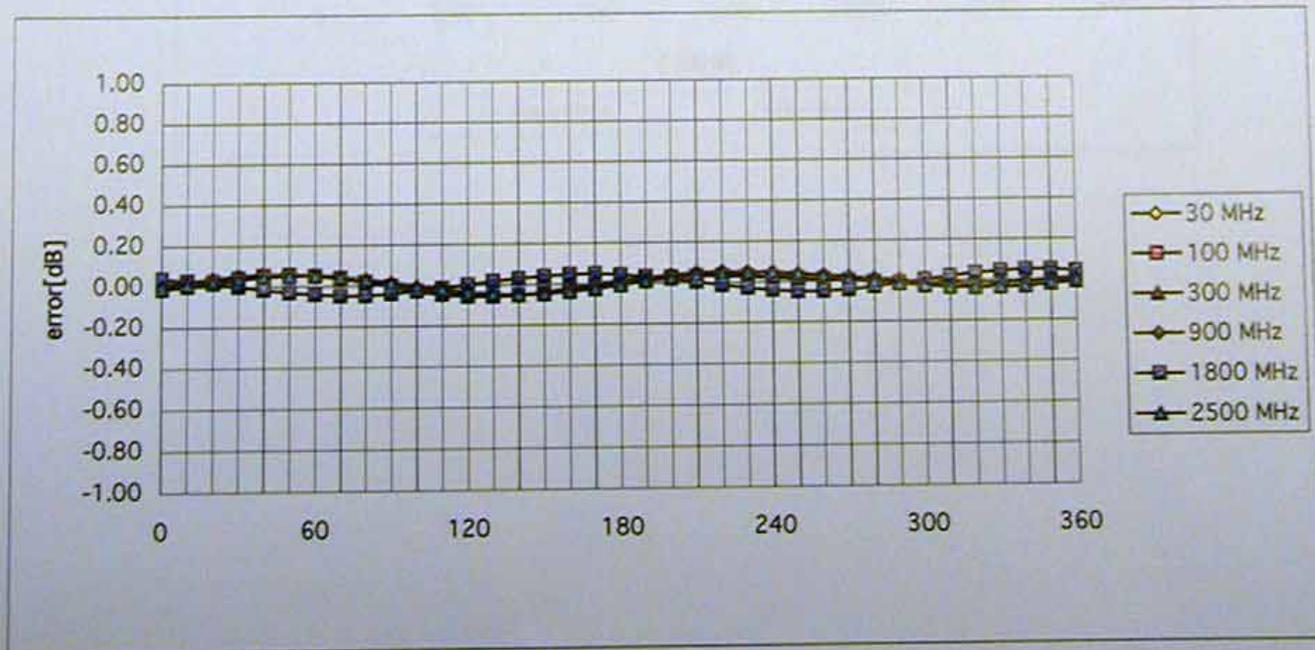


f = 900 MHz, TEM cell ifi110



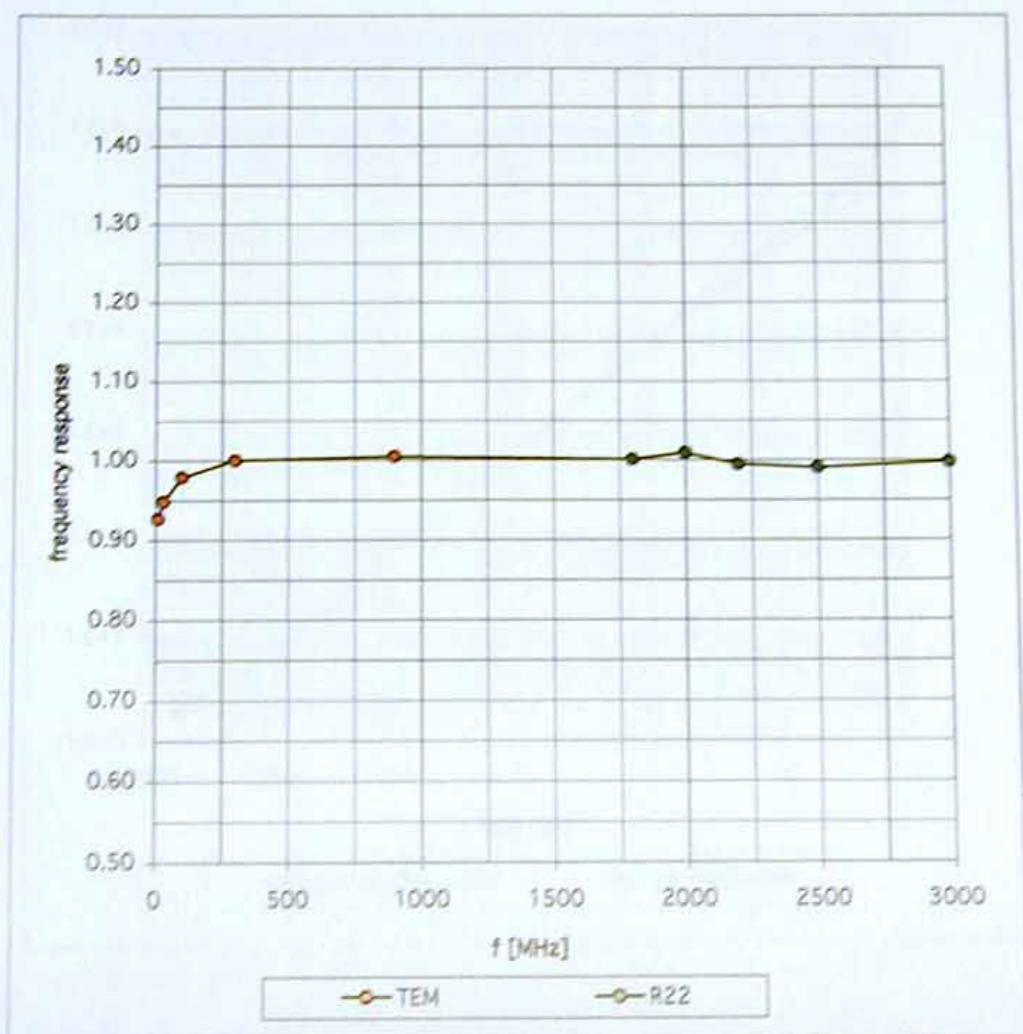


Isotropy Error (ϕ), $\theta = 0^\circ$



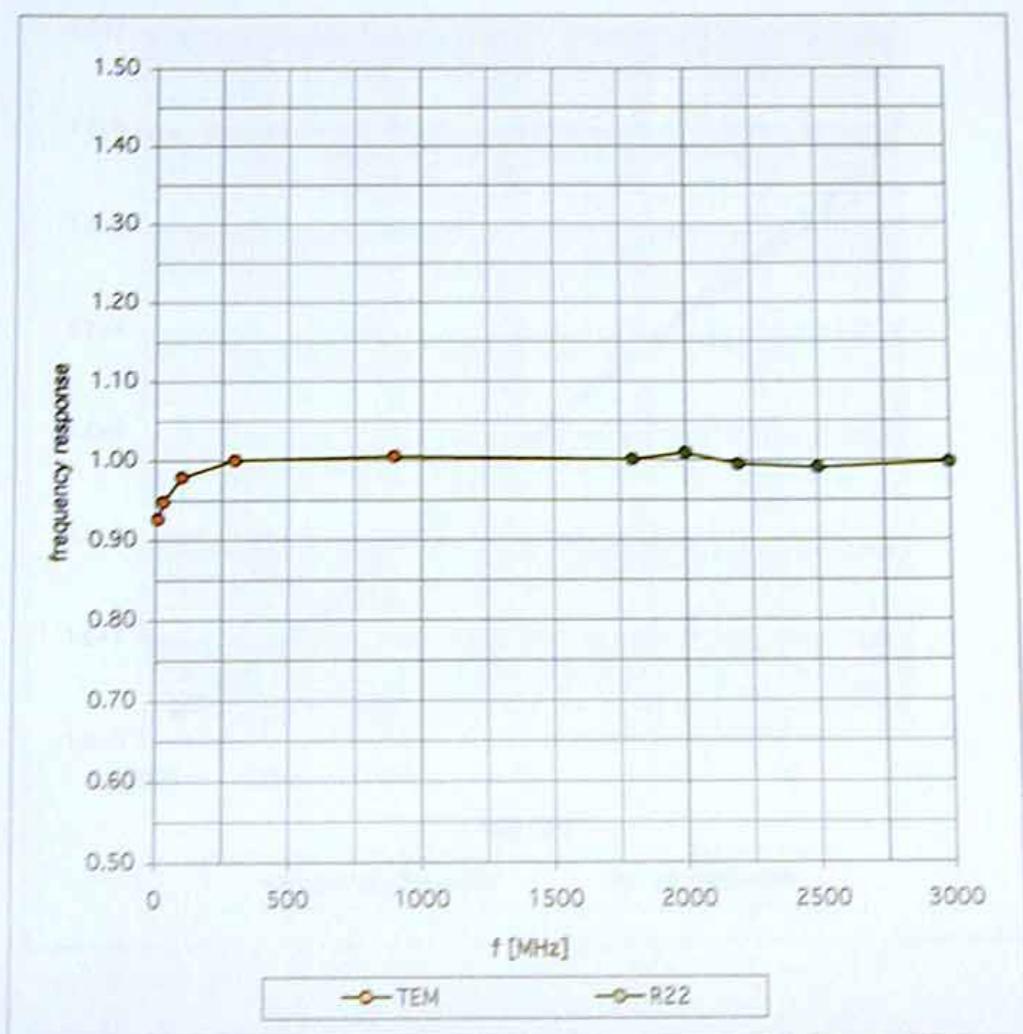
Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)



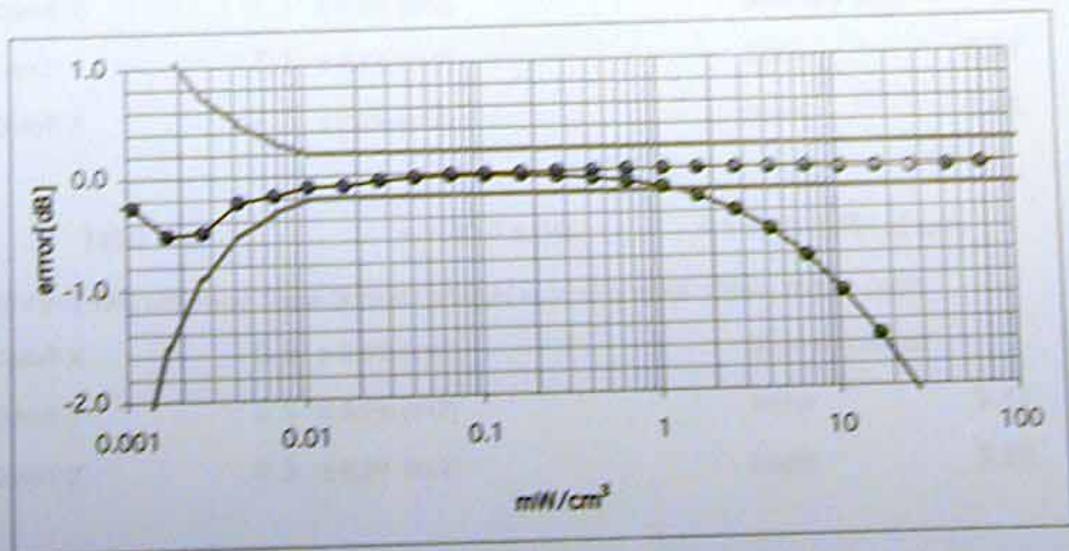
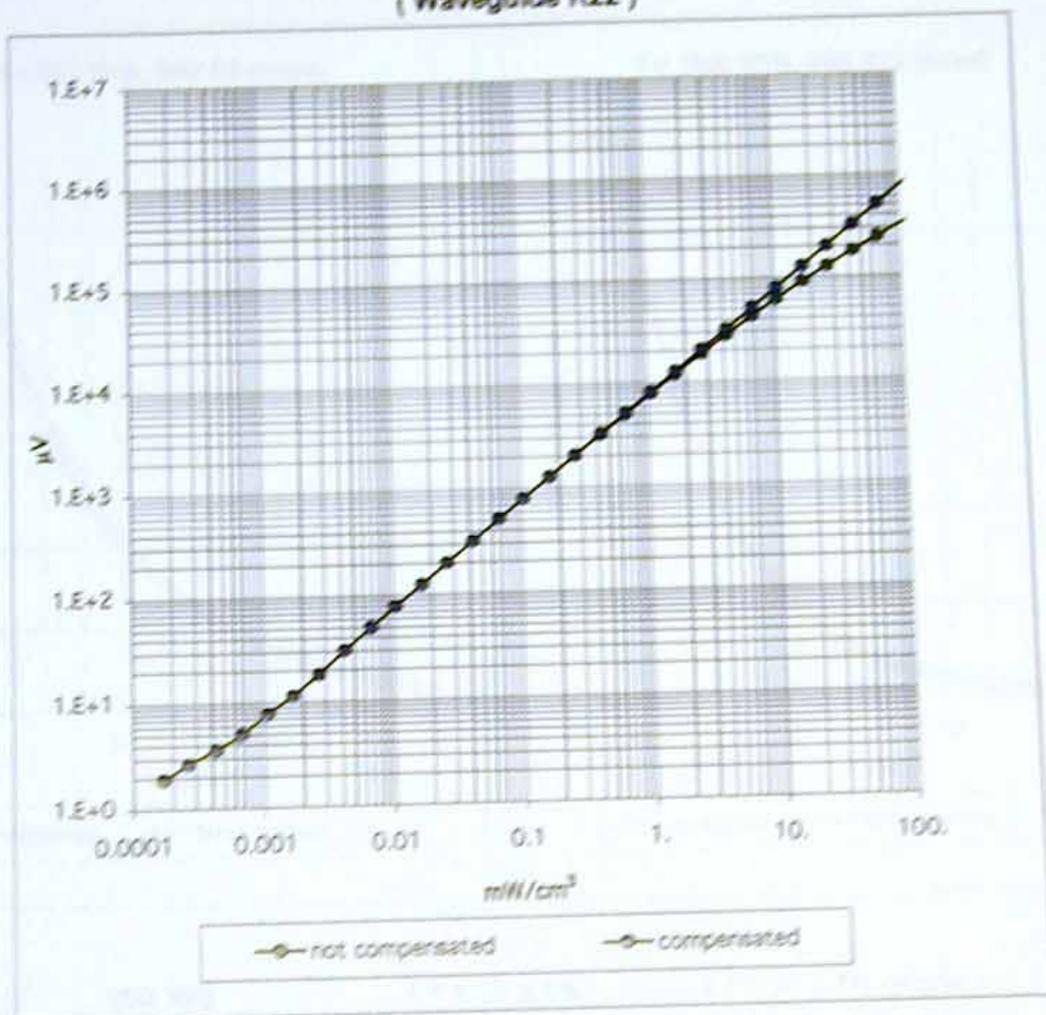
Frequency Response of E-Field

(TEM-Cell:ifi110, Waveguide R22)

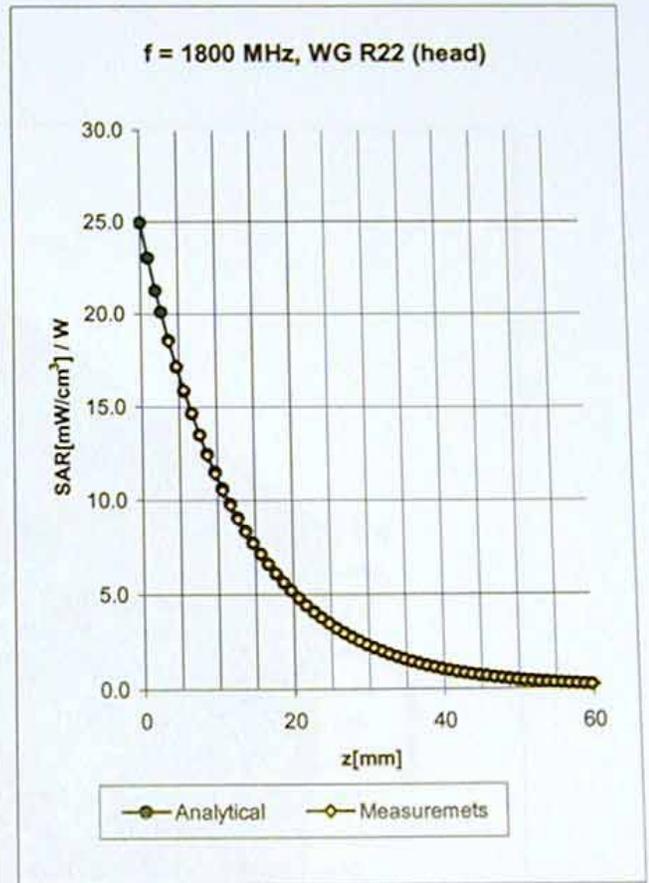
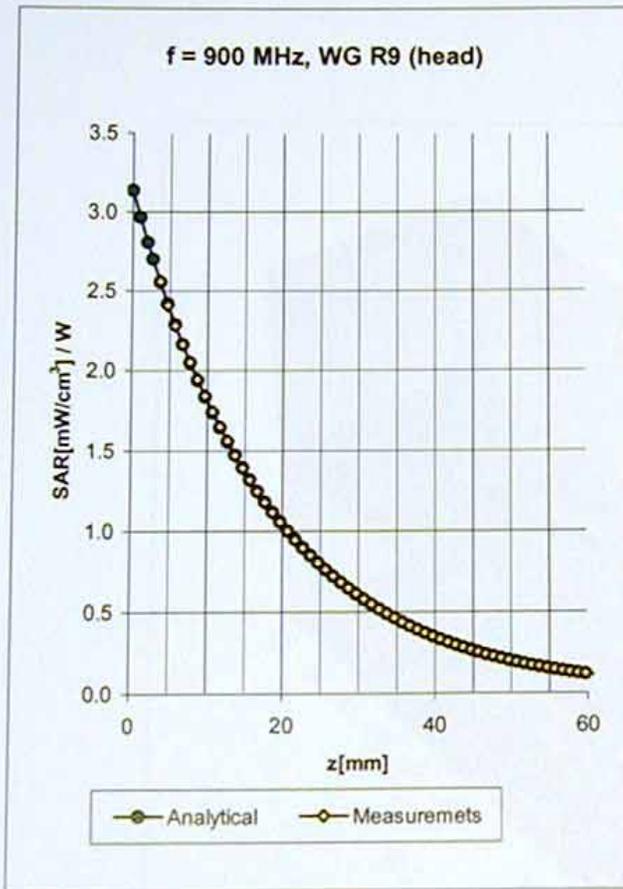


Dynamic Range f(SAR_{brain})

(Waveguide R22)



Conversion Factor Assessment



Head 900 MHz $\epsilon_r = 41.5 \pm 5\%$ $\sigma = 0.97 \pm 5\%$ mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	7.1 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	7.1 ± 9.5% (k=2)	Alpha	0.34
ConvF Z	7.1 ± 9.5% (k=2)	Depth	2.41

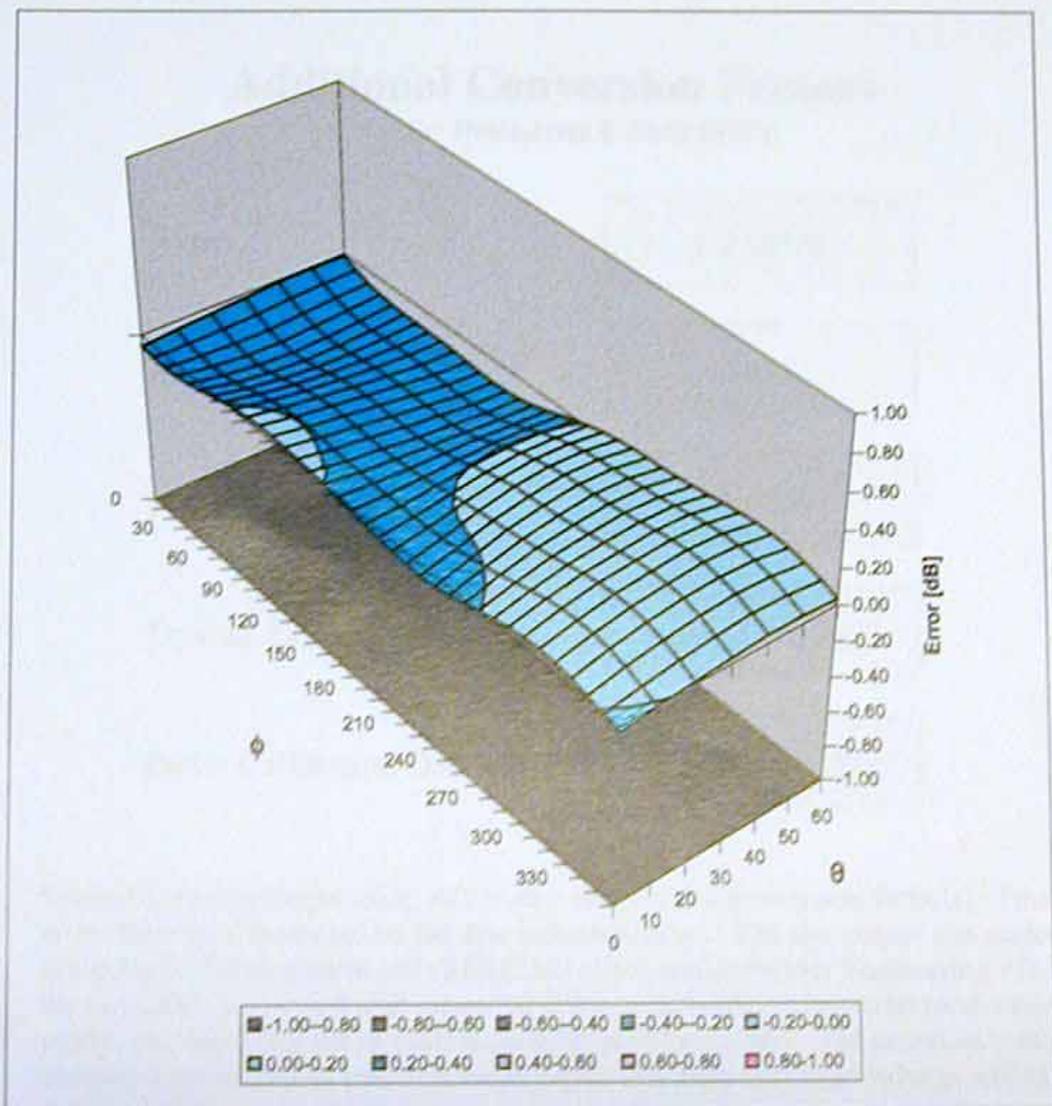
Head 1800 MHz $\epsilon_r = 40.0 \pm 5\%$ $\sigma = 1.40 \pm 5\%$ mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	5.5 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	5.5 ± 9.5% (k=2)	Alpha	0.42
ConvF Z	5.5 ± 9.5% (k=2)	Depth	2.76

Deviation from Isotropy in HSL

Error (θ, ϕ), $f = 900$ MHz



Additional Conversion Factors for Dosimetric E-Field Probe

Type:

ET3DV6

Serial Number:

1572

Place of Assessment:

Zurich

Date of Assessment:

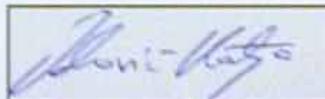
August 20, 2003

Probe Calibration Date:

May 15, 2003

Schmid & Partner Engineering AG hereby certifies that conversion factor(s) of this probe have been evaluated on the date indicated above. The assessment was performed using the FDTD numerical code SEMCAD of Schmid & Partner Engineering AG. Since the evaluation is coupled with measured conversion factors, it has to be recalculated yearly, i.e., following the re-calibration schedule of the probe. The uncertainty of the numerical assessment is based on the extrapolation from measured value at 900 MHz or at 1800 MHz.

Assessed by:



Dosimetric E-Field Probe ET3DV6 SN:1572Conversion factor (\pm standard deviation)900 MHz ConvF $6.8 \pm 8\%$ $\epsilon_r = 55.0 \pm 5\%$
 $\sigma = 1.05 \pm 5\% \text{ mho/m}$
(body tissue)1900 MHz ConvF $4.9 \pm 8\%$ $\epsilon_r = 53.3 \pm 5\%$
 $\sigma = 1.52 \pm 5\% \text{ mho/m}$
(body tissue)

Prepared (also subject responsible if other) KI/EAB/TFF Lennart Hamberg		No. EAB/TF-03:000126 Uen		
Approved EAB/TF [Christer Tornevik]	Checked	Date 2003-11-27	Rev B	Reference

Addendum to SAR Test Report: Sony Ericsson PY7FAB1021011-XX mobile phone for GSM900, GSM1800 and GSM1900

Contents

This addendum contains figures showing SAR distributions for the Sony Ericsson PY7FAB1021011-XX mobile phone in the GSM1900 band¹. The distributions for the maximum 1g averaged SAR value in the following configurations are shown:

- 1) Left hand side, cheek
- 2) Left hand side, tilt
- 3) Right hand side, cheek
- 4) Right hand side, tilt
- 5-6) Body worn position (two distributions giving equal 1g averaged SAR)

Note, the name "P810" shown in the following figures was a temporary working name for the tested product.

¹ SAR Test Report: Sony Ericsson FAB 1021011-XX mobile phone for GSM900, GSM1800 and GSM1900, EAB/TF-03:091, Rev B, Ericsson Limited Internal, Report, August 2003.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

1 Left hand side, cheek

Date/Time: 08/01/03 12:43:22

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Left Cheek Closed

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
Medium: Head 1900 MHz ($\sigma = 1.47$ mho/m, $\epsilon_r = 38$, $\rho = 1000$ kg/m³)
Phantom section: Left Section

DASY4 Configuration:

- Probe: ET3DV6 - SN1572; ConvF(5.5, 5.5, 5.5); Calibrated: 5/15/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn422; Calibrated: 5/6/2003
- Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Touch Left Closed Middle/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm

Reference Value = 23.7 V/m

Power Drift = -0.08 dB

Maximum value of SAR = 0.984 mW/g

Touch Left Closed Middle/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Peak SAR (extrapolated) = 1.51 W/kg

SAR(1 g) = 0.866 mW/g; SAR(10 g) = 0.481 mW/g

Reference Value = 23.7 V/m

Power Drift = -0.08 dB

Maximum value of SAR = 0.951 mW/g

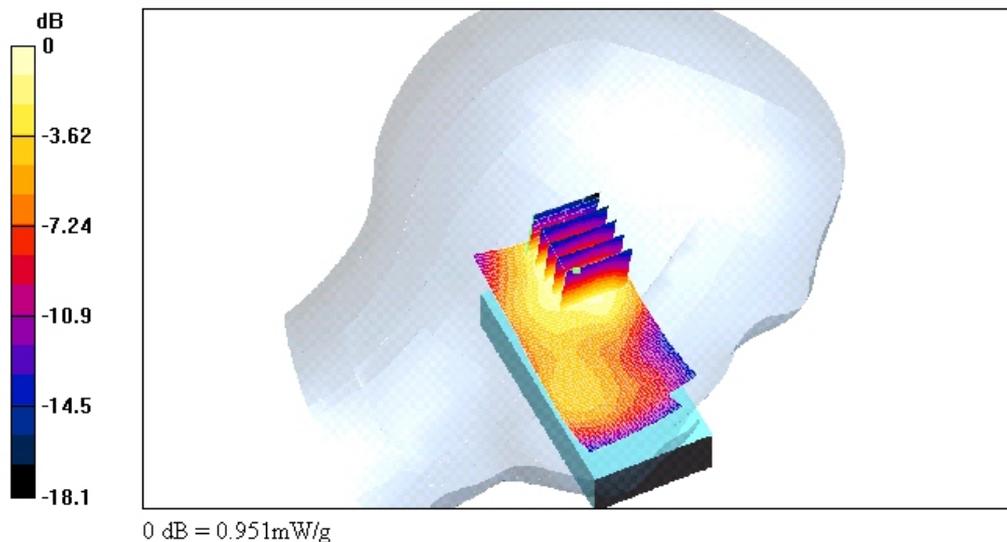


Figure 1) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in the left hand side phantom for the cheek position.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

2 Left hand side, tilt

Date/Time: 08/01/03 12:43:22

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Left Tilt Closed

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3

Medium: Head 1900 MHz ($\sigma = 1.47$ mho/m, $\epsilon_r = 38$, $\rho = 1000$ kg/m³)

Phantom section: Left Section

DASY4 Configuration:

- Probe: ET3DV6 - SN1572; ConvF(5.5, 5.5, 5.5); Calibrated: 5/15/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn422; Calibrated: 5/6/2003
- Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Tilt Left Closed Middle/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm

Reference Value = 26.4 V/m

Power Drift = -0.09 dB

Maximum value of SAR = 1.12 mW/g

Tilt Left Closed Middle/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Peak SAR (extrapolated) = 1.81 W/kg

SAR(1 g) = 1.01 mW/g; SAR(10 g) = 0.541 mW/g

Reference Value = 26.4 V/m

Power Drift = -0.09 dB

Maximum value of SAR = 1.08 mW/g

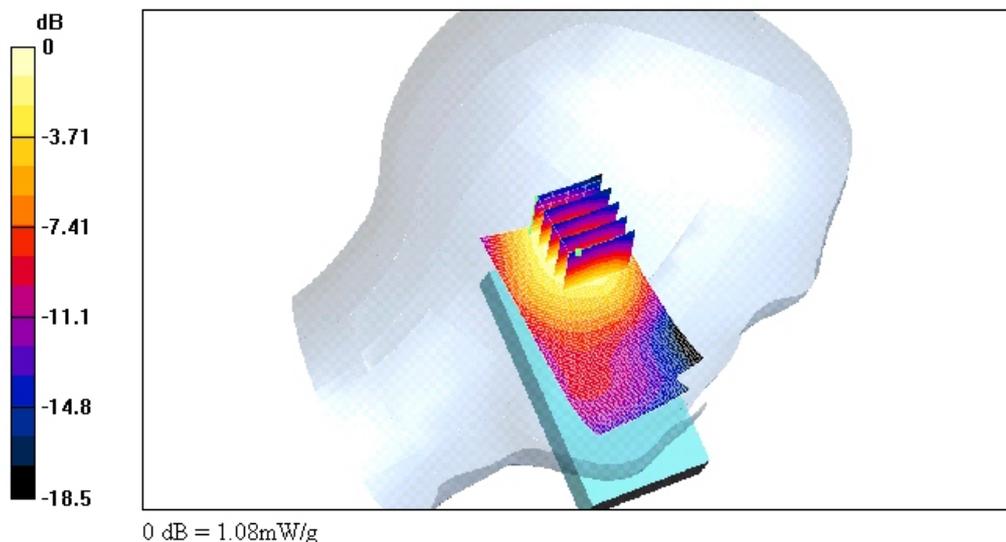


Figure 2) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in the left hand side phantom for the tilt position.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

3 Right hand side, cheek

Date/Time: 07/31/03 17:31:06

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Right Cheek Removed

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
Medium: Head 1900 MHz ($\sigma = 1.47$ mho/m, $\epsilon_r = 38.1$, $\rho = 1000$ kg/m³)
Phantom section: Right Section

DASY4 Configuration:

- Probe: ET3DV6 - SN1572; ConvF(5.5, 5.5, 5.5); Calibrated: 5/15/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn422; Calibrated: 5/6/2003
- Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Touch Right Removed Middle/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm

Reference Value = 21.4 V/m

Power Drift = -0.1 dB

Maximum value of SAR = 0.965 mW/g

Touch Right Removed Middle/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Peak SAR (extrapolated) = 1.36 W/kg

SAR(1 g) = 0.886 mW/g; SAR(10 g) = 0.52 mW/g

Reference Value = 21.4 V/m

Power Drift = -0.1 dB

Maximum value of SAR = 0.952 mW/g

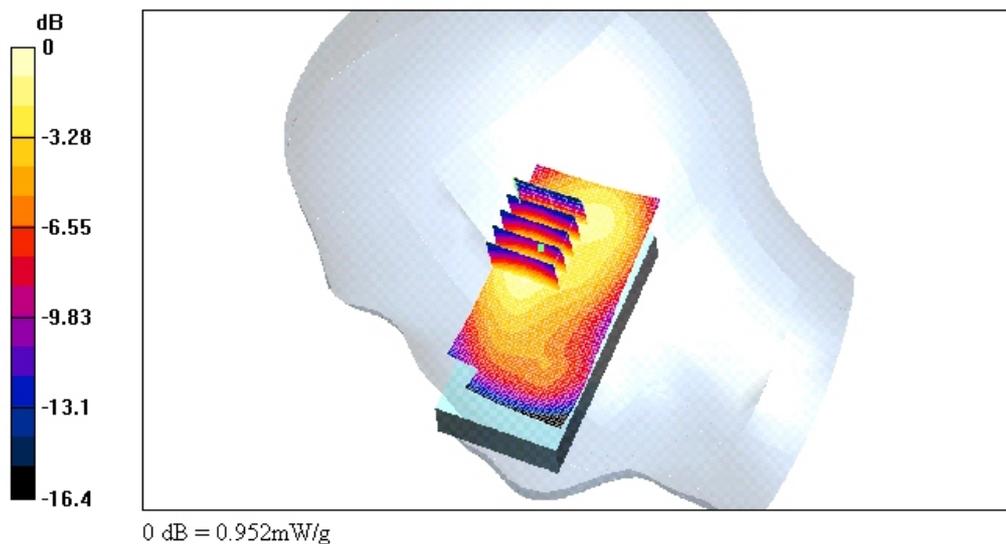


Figure 3) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in the right hand side phantom for the cheek position.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

4 Right hand side, tilt

Date/Time: 08/01/03 10:54:43

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Right Tilt Closed

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
Medium: Head 1900 MHz ($\sigma = 1.47$ mho/m, $\epsilon_r = 38$, $\rho = 1000$ kg/m³)
Phantom section: Right Section

DASY4 Configuration:

- Probe: ET3DV6 - SN1572; ConvF(5.5, 5.5, 5.5); Calibrated: 5/15/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn422; Calibrated: 5/6/2003
- Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Tilt Right Closed Middle/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm
Reference Value = 26.3 V/m
Power Drift = -0.08 dB
Maximum value of SAR = 1.05 mW/g

Tilt Right Closed Middle/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Peak SAR (extrapolated) = 1.69 W/kg
SAR(1 g) = 0.972 mW/g; SAR(10 g) = 0.538 mW/g
Reference Value = 26.3 V/m
Power Drift = -0.08 dB
Maximum value of SAR = 1.02 mW/g

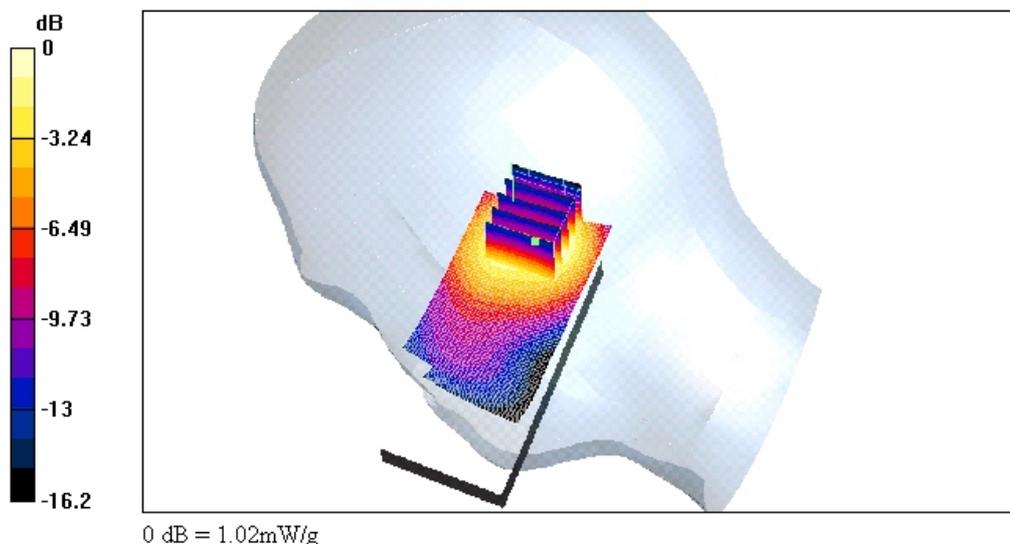


Figure 4) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in the right hand side phantom for the tilt position.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

5 Body worn position, A

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Body Flip Closed 15mm Stereo

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900 Muscle

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
 Medium: Muscle 1900 ($\sigma = 1.57 \text{ mho/m}$, $\epsilon_r = 52.6$, $\rho = 1000 \text{ kg/m}^3$)
 Phantom section: Flat Section

DASY4 Configuration:
 - Probe: ET3DV6 - SN1572; ConvF(4.9, 4.9, 4.9); Calibrated: 5/15/2003
 - Sensor-Surface: 4mm (Mechanical Surface Detection)
 - Electronics: DAE3 Sn422; Calibrated: 5/6/2003
 - Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
 - Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Back to Phantom - Flip Closed - Middle - Stereo/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm
 Reference Value = 11.7 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.485 mW/g

Back to Phantom - Flip Closed - Middle - Stereo/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
 Peak SAR (extrapolated) = 0.69 W/kg
 SAR(1 g) = 0.445 mW/g, SAR(10 g) = 0.274 mW/g
 Reference Value = 11.7 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.476 mW/g

Back to Phantom - Flip Closed - Middle - Stereo/Zoom Scan (5x5x7)/Cube 1: Measurement grid: dx=8mm, dy=8mm, dz=5mm
 Peak SAR (extrapolated) = 0.386 W/kg
 SAR(1 g) = 0.257 mW/g, SAR(10 g) = 0.164 mW/g
 Reference Value = 11.7 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.272 mW/g

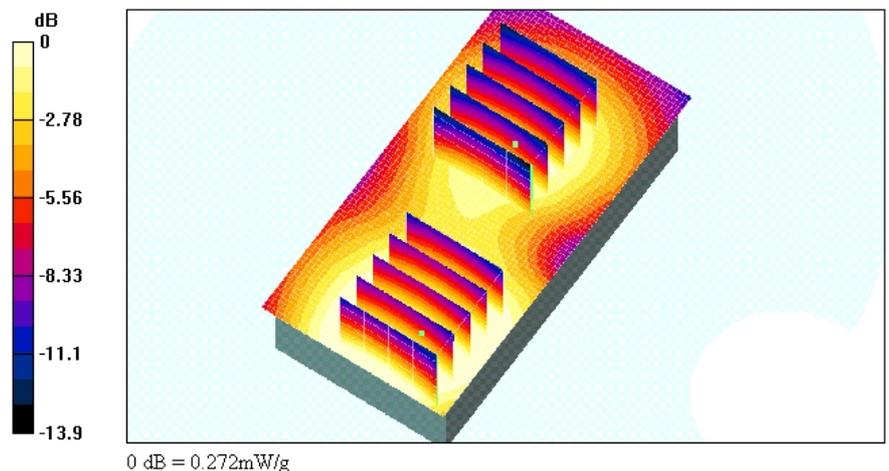


Figure 5) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in body worn position (15 mm separation) with the back of the device facing the phantom. The flip was closed and the device was equipped with the stereo handset.

Date	Rev	Document no
2003-11-27	B	EAB/TF-03:000126 Uen

6 Body worn position, B

Date/Time: 08/21/03 15:02:54

Lab: Ericsson EMF Research Laboratory

P810 ALS2P7ASZ7B GSM1900 Body Removed 15mm Stereo

DUT: P810; Type: Mobile Terminal; Serial: ALS2P7ASZ7B
Program: P810 GSM1900 Muscle

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
 Medium: Muscle 1900 ($\sigma = 1.57$ mho/m, $\epsilon_r = 52.6$, $\rho = 1000$ kg/m³)
 Phantom section: Flat Section

DASY4 Configuration:

- Probe: ET3DVB6 - SN1572; ConvF(4.9, 4.9, 4.9); Calibrated: 5/15/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn422; Calibrated: 5/6/2003
- Phantom: SAM 2; Type: **Not Specified**; Serial: **Not Specified**
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

Back to Phantom - Removed - Middle - Stereo/Area Scan (41x81x1): Measurement grid: dx=15mm, dy=15mm
 Reference Value = 11.1 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.482 mW/g

Back to Phantom - Removed - Middle - Stereo/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
 Peak SAR (extrapolated) = 0.702 W/kg
 SAR(1 g) = 0.445 mW/g; SAR(10 g) = 0.273 mW/g
 Reference Value = 11.1 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.475 mW/g

Back to Phantom - Removed - Middle - Stereo/Zoom Scan (5x5x7)/Cube 1: Measurement grid: dx=8mm, dy=8mm, dz=5mm
 Peak SAR (extrapolated) = 0.345 W/kg
 SAR(1 g) = 0.233 mW/g; SAR(10 g) = 0.151 mW/g
 Reference Value = 11.1 V/m
 Power Drift = -0.01 dB
 Maximum value of SAR = 0.246 mW/g

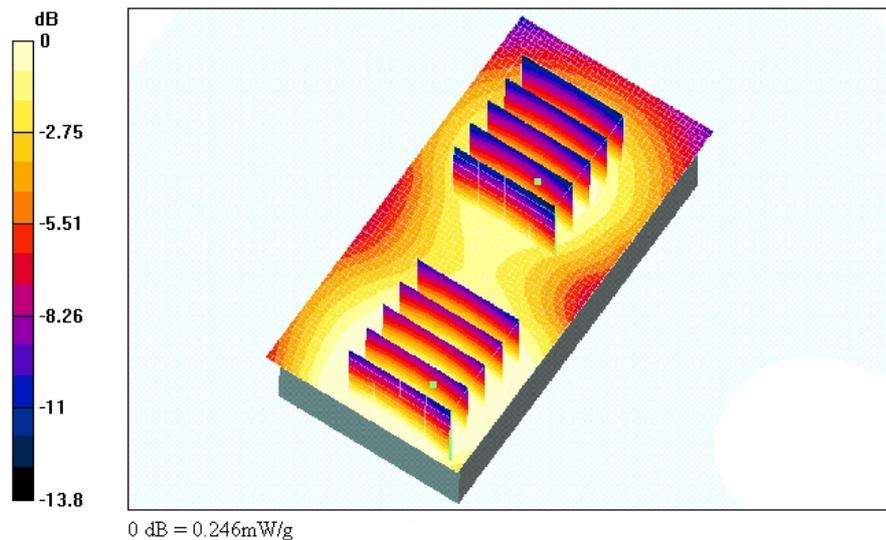


Figure 6) Distribution of SAR in the GSM1900 mode giving the maximum 1g SAR in body worn position (15 mm separation) with the back of the device facing the phantom. The flip was removed and the device was equipped with the stereo handset.