Uppgjord (även faktaansvarig om annan) - *Prepared (also subject responsible if other)*		Nr - *No.*		
KI/ERA/T/UF Christer Törnevik		ERA/T/U-98:442		
Dokansv/Godk - *Doc respons/Approved*	Kontr - *Checked*	Datum - *Date*	Rev	File
ERA/T/UF Christer Törnevik		2000-01-28	G	

Ericsson SAR Measurement Specification

Part	Document name	Document number	Rev
1	Introduction and purpose	ERA/T/U-98:446	B
2	Tissue liquid preparation	ERA/T/U-98:404	B
3	Measurements of dielectric parameters	ERA/T/U-98:405	C
4	Test system validation	EUS/TR/X-98:1585	C
5	Calibration	EUS/TR/X-98:1586	C
6	DUT preparation and characterization	ERA/T/U-98:439	F
7	SAR measurement procedure	ERA/T/U-98:441	F
8	Result documentation	ERA/T/U-98:447	B
9	Bibliography	ERA/T/U-99:047	C
10	Glossary of symbols and acronyms	EUS/TR/X-99:1336	A
Annex 1	Template for SAR test report	ECS/TN/FA-99:515	A
Annex 2	Template for Declaration of Conformity	ERA/T/U-99:094	A

Uppgjord (även faktaansvarig om annan) - *Prepared (also subject responsible if other)*		Nr - *No.*		
ERA/T/UF Christer Törnevik		T/U-98:446		
Dokansv/Godk – *Doc respons/Approved*	Kontr - *Checked*	Datum - *Date*	Rev	File
ERA/T/UF Christer Törnevik		1999-09-02	B	

Ericsson SAR measurement specification, part 1:

Introduction and purpose

1. Introduction

It is an Ericsson policy that all RF transmitting products shall comply with existing recommendations, standards and regulations on human exposure to electromagnetic fields. In the reference section below, the most important RF safety guidelines are listed [1-8]. If no national standard or regulation is available in a country, the international recommendation from ICNIRP [1] shall be applied for Ericsson products.

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 farfield region of a RF source. Measured values greater than the reference levels do not necessarily mean that the basic restrictions are exceeded.

In the nearfield region of mobile communication devices (handsets or base station antennas), field strength values exceeding the reference levels may be observed. Compliance with the basic SAR restrictions has therefor to be verified. SAR (W/kg) is a measure of the rate of RF energy absorption in tissue. The table below shows the *localized* SAR limits for the general public (uncontrolled environment) and workers (controlled environment) in the ICNIRP and ANSI/IEEE guidelines. 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 and 1.6 W/kg averaged in 1 gram in the ANSI/IEEE standard. 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.

The 2.0 W/kg (10 g) SAR limit has also been adopted in a European Prestandard from CENELEC [3] and in guidelines from the Ministry of Post and Telecommunications in Japan [4]. The 1.6 W/kg (1g) SAR limit has been adopted by the FCC as a regulation in the U.S. [6], and also as the basic restriction in preliminary Australian and Canadian standards [5,6]. The FCC requires SAR testing of mobile phones since 1997 [6,10]. Similar requirements were introduced in Australia February 1, 1999 [7] and will be introduced in Canada during 1999. In Europe and Japan regulations are expected within the next few years.

SAR test standards for mobile communication equipment are under development by IEC, CENELEC, IEEE and ARIB. In the year 2000, it is expected that the first international standard will be published. Technical documents describing SAR test methods and procedures are already available from CENELEC, ARIB, ACA and the FCC [7-10].

Standard/Guideline	**Localized SAR limit (W/kg) General public (uncontrolled)**	**Localized SAR limit (W/kg) Workers (controlled)**
ICNIRP (1998)	2.0 (10 g)	10 (10 g)
ANSI/IEEE (1992)	1.6 (1 g)	8.0 (1g)

2. Purpose of the Ericsson SAR measurement specification

The purpose of the Ericsson SAR measurement specification is to describe how SAR tests shall be conducted in the three SAR test laboratories in Ericsson, which are:

- The Ericsson EMF Research Laboratory at Ericsson Research in Kista (Contacts: ERA/T/UF Christer Törnevik or ERA/T/UD Martin Siegbahn)
- The ECS SAR laboratory at Ericsson Mobile Communications in Lund (Contacts: ECS/TN/FAC Thomas Bolin or ECS/TA/FA Ramadan Plicanic)
- The EUS SAR laboratory at Ericsson Inc. in RTP (Contacts: EUS Russ Holshouser or EUS Mark Douglas)

All these laboratories are equipped with the DASY3 SAR test system from Schmid & Partner Engineering AG (SPEAG). Since there is not yet an official standard that defines and describes SAR test procedures, it is necessary to specify internal Ericsson procedures for testing of mobile communication equipment. When an international SAR test standard is available, the Ericsson SAR measurement specification will be partly or completely replaced by this standard.

The Ericsson SAR measurement specification may be submitted to agencies like the FCC (USA), ACA (Australia) and Industry Canada if requested.

3. Applicability of the Ericsson SAR measurement specification

The Ericsson SAR test measurement specification shall always be followed when testing for compliance with SAR limits for handheld radio products or base station antennas in any of the Ericsson SAR laboratories.

Based on results from maximum exposure calculations and experience gained from earlier SAR measurements in Ericsson, it is known that certain low-power products can not exceed the SAR limits in any operational condition. These products do not have to be SAR tested, unless required by national or international standards and regulations.

The table below gives output power levels below which SAR testing is generally not necessary.

Type of equipment	**Output power level in mW, below which SAR testing is generally not required**	**Example of Ericsson products**
Mobile terminal	20	DECT Portable Part
Base station antenna	100	DECT Radio Fixed Part DECT RLL Fixed Access Unit

3. Content of the Ericsson SAR measurement specification

The Ericsson SAR test measurement specification contains the following documents:

Part 1: Introduction and purpose
The current document. It gives a short introduction to exposure limits and SAR, summarizes SAR standards and regulations and explains the purpose of the Ericsson SAR measurement specification.

Part 2: Tissue liquid preparation
This documents describes how the liquid materials used to simulate body tissue in the SAR test phantom should be prepared in order to obtain the correct dielectric properties.

Part 3: Measurements of dielectric parameters
This part describes the procedure used to experimentally verify that the dielecric properties of the tissue liquid is within the specifications given in part 2.

Part 4: Test system validation
This document describes the procedures used to validate that the SAR test system is working properly.

Part 5: Calibration
This document provides calibration information for the equipment used in Ericsson's SAR measurement laboratories.

Part 6: DUT preparation and characterization
This document gives information about how the device under test should be characterized and setup prior to a SAR test.

Part 7: SAR measurement procedure
This part of the specification describes the practical process of measuring SAR for various product types using the test equipment in the Ericsson SAR laboratories.

Part 8: Result documentation
This document describes how SAR test results should be documented and stored.

Part 9: Bibliography
This part contains copies of SAR regulation documents, references to important basic and SAR related research papers, and lists documentation that should be provided with the SAR test equipment and available in the Ericsson SAR test facilities.

Part 10: Glossary of symbols and acronyms
This document explains the meaning of symbols and acronyms used in the other parts of the Ericsson SAR measurement specifications.

Annex 1: Template for SAR test report
Contains an example of a SAR test report. All Ericsson SAR reports should have the same outline and contain the same information.

Annex 2: Template for Declaration of Conformity
Contains an example of a Declaration of Conformity, i.e. a statement that a certain product is in compliance with one or more SAR standards and regulations.

References

[1] 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.

[2] 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, 1991.

[3] 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.

[4] MPT, "Radio-radiation protection guidelines for human exposure to electromagnetic fields", Telecommunications Technology Council, Ministry of Posts and Telecommunications, Japan, April 1997.

[5] 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.

[6] FCC Report and Order, ET Docket 93-62, FCC 96-326, Federal Communications Commission (FCC), August 1996.

[7] Radiocommunications (Electromagnetic Radiation Human Exposure) Standard 1999, Australian Communications Authority (ACA), May 1999.

[8] Safety code 6, Draft Canadian Standard, Health Canada, 1997.

[9] ARIB STD-T56, "Specific Absorption Rate (SAR) estimation for cellular phone", ARIB Standard Version 1.0, Association of Radio Industries and Businesses (ARIB), January 27, 1998.

[10] FCC OET Bulletin 65, Supplement C, "Evaluating compliance with FCC guidelines for human exposure to radiofrequency electromagnetic fields", Edition 97-01, Federal Communications Commission (FCC), 1997.

[11] CENELEC ES 59005, "Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30 MHz – 6 GHz", European Specification, European Committee for Electrotechnical Standardization (CENELEC), September 1998.

Uppgjord (även faktaansvarig om annan) - *Prepared (also subject responsible if other)*		Nr - *No.*	
ERA/T/UD Tomas Persson		T/U-98:404	
Dokansv/Godk – *Doc respons/Approved*	Kontr - *Checked*	Datum - *Date* / Rev	File
ERA/T/UF Christer Törnevik		1999-09-02 B	

Ericsson SAR measurement specification, part 2:

Tissue liquid preparation.

1 Introduction

For the preparation of tissue simulating liquid to be used in the generic twin phantom with DASY3 the following preparation procedure is used. The liquid should have properties similar to the human tissue [1],[2],[3]. In total a minimum of 18 litres of liquid is required.

2 Preparation of liquid

2.1 Ingredients

Water	distilled water
Sugar	as available in food shops
Salt	pure NaCl (>99.9%)
Cellulose	HEC Hydroxyethyl-cellulose medium viscosity (Optional ingredient) (powder 75-125 mPa s, 2% in water 20 ^{o}C)
Preservative	Preventol D7 Bayer AG or similar

2.2 Preparation materials

Scale

Stirrer with hotplate

Glass jar 500 ml

Glass jar 5 l

Glass jar 10 l

Mixing spoon (approx. 12 “)

3. Recipe for tissue simulating liquid

3.1 Recipe at 835 MHz and 900 MHz

Ingredient	**835 MHz**		**900 MHz**	
Distilled water	43.27 %	3725 g	40.16 %	3460 g
HEC	0.93 %	80.1 g	1.00 %	86.0 g
NaCl	0.412%	35.5 g	0.692 %	59.6 g
Preventol	0.10 %	8.5 g	0.10 %	9.0 g
Sugar	55.29 %	4760 g	58.04 %	5000 g
Total amount		6.7 l		6.7 l

3.2 Recipe at 1640 MHz and 1800 MHz

Ingredient	**1640 MHz**		**1800 MHz**	
Distilled water	44.18 %	3765 g	44.97 %	3827 g
HEC	1.00 %	85.5 g	1.0 %	85.4 g
NaCl	-	-	-	-
Preventol	0.10 %	8.4 g	0.10 %	8.3 g
Sugar	54.72 %	4663 g	53.93	4589 g
Total amount		6.7 l		6.7 l

4. Dielectric parameters for the recipes.

Parameter	**835 MHz**	**900 MHz**	**1640 MHz**	**1800 MHz**
Dielectric constant ε'	45.8	42.5	41.3	41.0
Conductivity σ (S/m)	0.76	0.85	1.51	1.65

The parameters are measured according to [5].

5. Preparation procedure

1. Weigh the required amount of distilled water in a large glass jar. Begin heating and stirring and ensure that the water temperature is not more than about 75 ^{O}C.

2. When adding the different ingredients check weight of residues left in weighing containers and correct if appropriate.

3. Add the cellulose. Use about 4 dl of the heated water for mixing with the cellulose in a suitable jar to allow stirring properly with a hand mixer to avoid lumps. Add the solution to the large container on the heating plate. Adjust the speed of the magnetic stirrer and keep the solution below the boiling point. Leave the solution on the heating plate for about two hours which will allow the solution to become fairly transparent.

4. Add the preservative. Add salt if included in the selected recipe.

5. Add the sugar gently in several steps. Hand stirring to some extent is necessary in the beginning in order to allow the magnetic stirrer to work properly.

6. Keep the liquid hot but below about 75 ^{O}C for at least 12 hours. Cover the jar with plastic foam or other lid in order to avoid evaporation.

7. Turn the hotplate off. Let the brain tissue simulating liquid sit for at least 3 hours prior to performing measurement of the electrical parameters. At measurement the temperature of the liquid should be maximum 25 ^{O}C .

8. Once brain tissue simulating liquid has been measured, store mixture in designated storage container/phantom. Record information about mixing procedure and results of calibration measurement.

6. References

[1] Gabriel C., Gabriel S., Corthout, *The dielectric properties of biological tissue: I literature survey*, Phys. Med. Biol., vol 41, pp 2231-2249, 1996.

[2] Gabriel S., Lau R.W., Gabriel C, *The dielectric properties of biological tissues: II measurements in the frequency range 10 Hz to 20 GHz,* Phys. Med. Biol., vol 41, pp 2251-2269, 1996

[3] Gabriel S., Lau R.W., Gabriel C, *The dielectric properties of biological tissues: III parametric models for the dielectric spectrum of tissues*, Phys. Med. Biol., vol 41, pp 2271-2293, 1996

[4] Federal Communications Commission, Office of Engineering & Technology, *Evaluating Compliance with FCC Guidelines for Human exposure to Radiofrequency Electromagnetic Fields.* OET bulletin 65, 1997.

[5] *Ericsson SAR measurement specification, part 3: Measurements of dielectric parameters,* ERA/T/U-98:405

Uppgjord (även faktaansvarig om annan) - *Prepared (also subject responsible if other)*		Nr - *No.*		
ERA/T/UD Tomas Persson		T/U-98:405		
Dokansv/Godk – *Doc respons/Approved*	Kontr - *Checked*	Datum - *Date*	Rev	File
ERA/T/UF Christer Törnevik		2000-01-28	C	

Ericsson SAR measurement specification, part 3:

Measurements of dielectric parameters.

1. Introduction

This document describes measurement procedure using network analyzer for testing tissue simulating liquid to be used with the DASY3 system. The measurement uses coaxial probe technique for evaluating permittivity and conductivity. The tissue liquid parameters shall be measured before testing a device. If the complete test takes more than a week, the liquid parameters shall be re measured at least once per week.

2. Equipment

HP network analyzer HP8752C or similar

HP dielectric probe kit HP85070B or HP85070A

HP 85070 software

PC using GPIB card [3] for communication with network analyzer.

Syringe

small glass jars for liquid samples

3. Procedure for testing brain simulating liquid

1. Turn the NWA (Network analyzer) on and allow at least 30 min 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 B manual. 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 ($\pm$ 1°C).
   - Set start and stop frequency, frequency step and water temperature.
   - Perform measurement with probe in air.
   - Perform measurement using the short circuiting block. 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.
   - Perform measurement with probe in distilled water.
   - Save setup file.

5. Remeasure distilled water to check calibration. Assure that the probe is thoroughly cleaned before performing the measurement. The graph of ε' versus frequency should be flat. The value of ε' should be about 80.1 at 20 ^{o}C and decreasing at approximately 0.4/ ^{o}C.
6. Stir the liquid to be measured. Take a sample (50 ml) with a syringe from the center of the liquid container
7. Measure liquid shortly after calibration of the network analyzer and at most within an hour of this calibration.
8. Pour the sample liquid into a small container.
9. Put the dielectric probe into the small container. Check that there are no air bubbles in front of the opening in the dielectric probe kit.
10. Perform measurements. Repeat measurement three 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.
11. Conductivity σ can be calculated from ε'' according to $\sigma = \omega\varepsilon_o\varepsilon'' \cong \varepsilon''$ f (GHz)/18.
12. Clean the probe thoroughly after use.

4. Dielectric parameters.

The measured value for the dielectric constant ε' is allowed to deviate $\pm$ 5 % from the target value specified in the tissue liquid preparation document [4]. The measured conductivity is allowed to deviate $\pm$ 5 % from the target value specified in the same document [4]. The accuracy specified by the dielectric probe kit manufacturer [2] is $\pm$ 5% for the dielectric constant ε' and $\pm$ 0.05 for the loss tangent $\varepsilon''/\varepsilon'$.

5. References

[1] HP 8572C Network analyzer User's guide. Hewlet Packard part number 08752-90157.
[2] HP 85070B Dielectric probe kit manual, Hewlet Packard part number 85070-90009.
[3] National instrument GPIB-PCII/IIA card.
[4] Ericsson SAR measurement specification , part 2:Tissue liquid preparation ERA/T/U-98:404

Prepared (also subject responsible if other)		No.		
RT/EUS/TR/X Mark Douglas 919-472-6334		EUS/TR/X-98:1585		
Approved	Checked	Date	Rev	File
EUS/TR/XR/P Mark Douglas	MGD	1998-11-08	C	

Ericsson SAR Measurement Specification, part 4:

System Accuracy Verification

1. Introduction

This document is a guide for the accuracy verification of the Dosimetric Assessment System 3 (DASY3). It is a standard guide for use at all Ericsson SAR measurement laboratories. System accuracy verification must be performed at regular and frequent intervals to ensure the accuracy of the system.

The system accuracy verification test consists of measuring the SAR in a flat phantom using a standard dipole antenna and comparing the results to a reference value. Standard dipoles and reference values are provided by the manufacturer of the DASY system, Schmid & Partner Engineering AG (SPEAG). A separate accuracy verification test is necessary for each tissue simulant and frequency range.

In the remainder of this document, a list of necessary equipment is provided, and a detailed procedure for the dipole test is given.

2. Equipment

- DASY3 system from SPEAG
- Flat phantom
- SPEAG Dipole antenna kit:
  - Dipole antenna (one for each tested frequency range)
  - Manual for that antenna
  - Antenna stand
  - Plastic dipole spacers
- 50 ohm coax line
- Coaxial connectors
- Signal generator
- Power amplifier (optional)
- Power meter

3. Dipole Verification Procedure

3.1 Setup of the Tissue Simulant

1. Ensure that the proper tissue simulant is present in the flat phantom.
2. Stir the liquid to ensure that it is homogeneous.
3. Measure the dielectric constant and conductivity of the simulant, as described in part 3, "Measurements of dielectric parameters." The dielectric parameter values of the simulant (permittivity, conductivity) must be within the range of values specified in part 2, "Tissue liquid preparation." Also, the frequency at which the simulant parameters are satisfied must be the same as the resonant frequency of the dipole antenna used.

3.2 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. Connect the dipole antenna to the antenna stand.
3. Place the proper dipole spacer over the center of the dipole antenna.

4. Place the dipole antenna under the flat phantom and adjust the height of the stand until the 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.
5. Connect one end of the coax line to the power meter and the other end to the output of the signal generator (or power amplifier, if used).
6. 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.
7. Set the frequency of the signal generator to the resonant frequency of the dipole antenna.
8. Set the output power of the signal generator (and optionally adjust the gain of the power amplifier) so that one watt of power is delivered to the power meter.
9. Disconnect the coax line from the power meter and connect it to the dipole antenna.

3.3 Measurement Procedure

1. Turn on the robot controller and the computer.
2. Install the 3D electric field probe as shown in the SPEAG manual.
3. Power up the DAE. The LED indicates that the power is on.
4. Start the DASY3 software and set up the communications between the software and the robot.
5. Teach the robot the phantom reference positions.
6. Record the dielectric constant and conductivity of the simulant in the DASY3 software.
7. Choose the appropriate measurement configuration in the DASY3 software for the dipole measurement.
8. Tell the robot to move the probe tip below the surface of the liquid. Stir the liquid again to remove any bubbles trapped under the probe tip.
9. Open a measurement file. Select the predefined dipole test provided by SPEAG. This file includes all of the necessary measurements for the dipole test.
10. Run the reference check.
11. Run the coarse scan, fine scan, and drift measurements.

3.4 Analysis of Measured Data

1. Compare the one-gram and ten-gram averaged peak SAR values to the standard values provided in reference documents. If they do not agree within ±5%, check the system parameters (e.g. antenna output power, dielectric parameters of the simulant, homogeneity of the liquid) and repeat the measurement.
2. Also compare the SAR distribution with that provided in the reference data from the manufacturer.
3. Make sure that the drift measurement is below an acceptable value. If not, check the system parameters and repeat the measurement.
4. Save the measurement data and enter it into the logbook.

Prepared (also subject responsible if other)		No.		
RT/EUS/TR/X Mark Douglas 919-472-6334		EUS/TR/X-98:1586		
Approved	Checked	Date	Rev	File
EUS/TR/XR/P Mark Douglas	MGD	1998-03-16	C	

Ericsson SAR Measurement Specification, part 5:

Calibration of Equipment

1. Introduction

This document provides calibration information for the equipment used in Ericsson's SAR measurement facilities. This document is a standard guide for use at all Ericsson SAR measurement laboratories. In this document, a list of equipment (including manufacturer and frequency of calibration) is provided, and the addresses of the manufacturers are given. It is the responsibility of Ericsson staff to keep track of calibration dates and ensure that the equipment has been sent for calibration. In some cases, the equipment may need to be sent off-site for calibration. Equipment calibration is mandatory according to ISO 9000 rules.

2. Equipment and Calibration Information

Equipment	Manufacturer	Calibrate every…
Network Analyzer	Hewlett-Packard	1 year
Dielectric probe kit	Hewlett-Packard	1 year
Probes (E and H field)	SPEAG	1 year
Data Acquisition Electronics	SPEAG	1 year
Dipole antennas	SPEAG	2 years
Base station simulators	WaveTek, other	1 year
Signal generator	Hewlett-Packard	1 year
Power meters	Hewlett-Packard	1 year
Power sensors	Hewlett-Packard	1 year
Robot	Stäubli	5 years or 10,000 hours of operation (whichever is greater)

3. Addresses of Manufacturers

Hewlett Packard Test & Measurement
Mail Stop 51LSJ
P.O. Box 58199
Santa Clara, CA
95052-9952

SPEAG (Schmid & Partner Engineering AG)
Staffelstrasse 8
8045 Zürich
Switzerland
Tel: +41 1 280 0860

WaveTek Corporation
5808 Churchman Bypass
Indianapolis, IN
46203-6109

Stäubli Faverges
Place Robert Stäubli
F-74210 Faverges, France

Uppgjord - *Prepared*	Tfn - *Telephone*	Datum - *Date*	Rev	Dokumentnr - *Document no*
ERA/T/UD Martin Siegbahn	70811	2000-01-27	F	T/U 98:439
Godkänd - *Approved*	Kontr. - *Checked*	Ert datum - *Your date*		Tillhör referens - *File/reference*
ERA/T/UF Christer Törnevik				

Ericsson SAR Measurement Specification, part 6:

DUT Preparation and Characterization

1 Introduction

This part describes how the properties of the DUT should be characterized and how the DUT is prepared prior to a SAR measurement.

2 DUT type

For practical purposes, the DUTs selected for SAR compliance testing must often be factory prototype units. A statement of compliance for a factory prototype unit of device shall also apply to its corresponding production units. Every effort shall be made to ensure that the factory prototype devices used for SAR compliance testing have SAR values that are not less than those of the production units. Production units shall be tested to verify that their SAR values are not greater than the value listed in the SAR compliance report. Normally, there is no significant difference between a factory prototype unit and its corresponding production unit. In the event that changes are made to production units that result in higher SAR values, a new SAR compliance report shall be created.

3 DUT characterization

3.1 The peak output power level

For SAR compliance measurements, the peak output power level of the DUT is set to the maximum power level of that device. The DUT is also programmed to deliver the highest output power that the production units are expected to deliver, taking into account factory tolerances. If this is not possible for some reason, a lower peak power level can be set but the resulting SAR values must then be normalized to the maximum level after the measurement according to equation 1. The peak power level is either measured with a power meter, with a sensor suitable for the carrier frequency and the duty cycle, or a digital radio tester.

$$SAR_{norm} = SAR_{meas} \cdot \frac{P_{max}}{P_{meas}} \quad (1)$$

3.2 The carrier frequency

SAR measurements shall be performed for three carrier frequencies, the lowest possible, the middle and the highest possible for each transmitter band of the DUT. The carrier frequency is measured with a spectrum analyzer. (A suitable analyzer setup for measuring GSM frequencies is: SPAN=2 MHz, RES BW=30 kHz, VBW=30 kHz and SWEEP=4 seconds).

3.3 The duty-cycle

If the duty-cycle of the signal transmitted by the DUT is not known it can be measured with a spectrum analyzer with the center frequency set equal to the carrier frequency of the transmission and the span set to zero. For TDMA systems, the RF exposure assessment shall always be performed with the maximum possible duty-cycle (denoted d). In a CDMA system, on the other hand, bursting is often introduced gradually when the voice activity of the user changes but during the SAR measurement it has to be fixed and at the maximum value. If the maximum duty-cycle is not possible to obtain, the assessed SAR results have to be normalized to the used duty-cycle according to:

$$SAR_{norm} = SAR_{meas} \cdot \frac{d_{max}}{d_{meas}} \qquad (2)$$

Analog mobile communications systems use continuous transmission and thus the duty-cycle is always equal to one.

3.4 Antenna configuration

- For handset devices with extendable antennas, SAR measurements have to be performed both with the antenna retracted and pulled out.
- Handsets with replaceable antennas must be tested with all available antennas. Antennas that can assume different positions, for instance swivel antennas, are tested for those positions that are defined by the hinge or latch mechanism.
- Base stations with several integrated antennas, for instance micro and pico base stations, are measured for all possible antenna configurations that will be used at the base station site.
- Base station antennas are measured with the radiating elements configured so that the maximum possible exposure situation is obtained.

4 Preparing and setting up the DUT for a SAR measurement

4.1 Handset setup

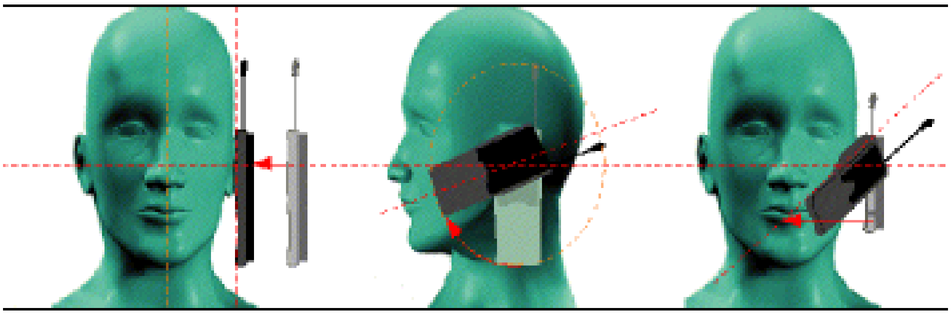
The mobile phone shall be tested in a cheek position and in a tilted position on both the left and right sides of the phantom.

Definition of the cheek position (see Fig. 1, below) :

a) Position the device with the centre of the ear-piece against the ear reference point, and with the vertical centre line of the body of the device in a plane parallel to the sagittal plane of the phantom.

b) While maintaining the device in this plane, align the centre line with the reference plane containing the ear and mouth reference points.

c) While maintaining the device in the reference plane, move it until any point on the front side is in contact with the cheek of the phantom.



a) b) c)

Figure 1. A handheld DUT positioned at the left cheek of the head phantom.

Definition of the tilted position:

a) Position the device in the cheek position described above.

b) While maintaining the device in the reference plane described above, move it outward until the angle between the vertical centre line of the device and the line connecting both auditory openings is 100°.

For push-to-talk handsets, the normal use position is in front of the face and the exposure from such a device is assessed by placing it 5 cm below the flat section of the phantom

4.2 BS antenna setup

Figure 2 shows the base station antenna setup below the flat section of the DASY generic twin phantom. This type of structure is normally to large to be positioned with the stand used for handheld test devices and therefore a larger stand or table of nonconducting material capable of supporting the whole antenna should be used. When testing base stations with integrated antennas this setup is also recommended. The test distance is dependent on the application, for indoor low power basestations a typical test distance is 5 cm.

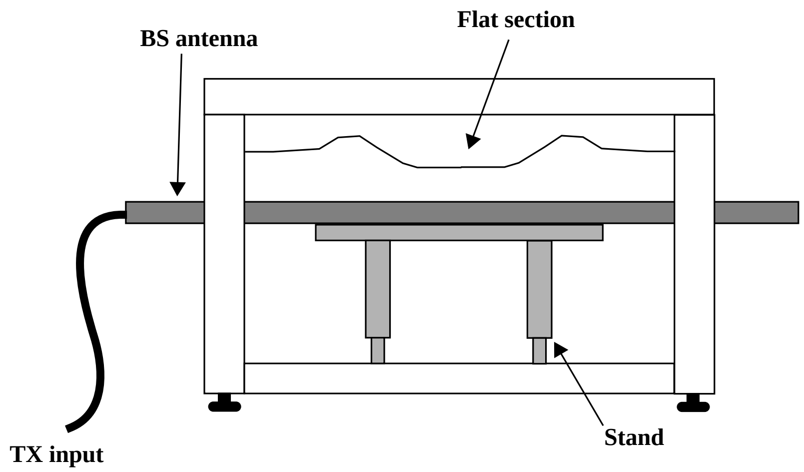


Figure 2. The setup for measurements of SAR in the flat section from base station antennas.

4.3 RF, power supply and control cables

- Handsets operate on battery power and before the SAR measurements the battery must contain enough charge for the measurement time, a fully charged battery is recommended. For compliance testing, no power supply or control cable should be connected to the handset since they will interfere with the fields radiated from the antenna. RF cables connected to prototype handset with no integrated transmitter circuitry must be placed in such a way that the interference with the radiated fields is limited, ferrites on the cable close to the connectors are recommended. Section 5 describes the cable setup when testing devices supplied with external RF power.
- Base stations with integrated antennas are supplied with power from an external power line and this cable shall be connected to the DUT in such a way that interference to the radiated fields is limited. This also applies to control and transmission cables.

- Base station antennas are supplied with RF power from a signal generator and the cables should be connected via a directional coupler giving a possibility of monitoring the reflected power. This setup is explained in section 4.

5 Monitoring the DUT during the SAR measurement

Since handsets operate on batteries it is important to monitor the output signal from the DUT during the exposure assessment and a spectrum analyzer with a sensor antenna placed close to the device is recommended. If a digital radio tester is used for controlling the DUT the reported power level is easily monitored but for DUTs supplied with the RF signal from a generator the cable configurations shown in Fig. 3 should be used.

For the case of a DUT supplied with RF power through a cable, when the antenna is placed close to the phantom a load mismatch is introduced and RF power will be reflected back to the generator. A power meter monitoring this amount of power is connected through a directional coupler to the feeding cable according to Fig 3 (a) or (b). The power meter 1 in figure (a) measures the forward power from the generator, normally this power doesn't change much during a SAR measurement and a setup according to (b) is in most cases sufficient.

Note, before the SAR measurement is started the power delivered from the signal generator to the DUT should be measured at the end connector of the supplying cable.

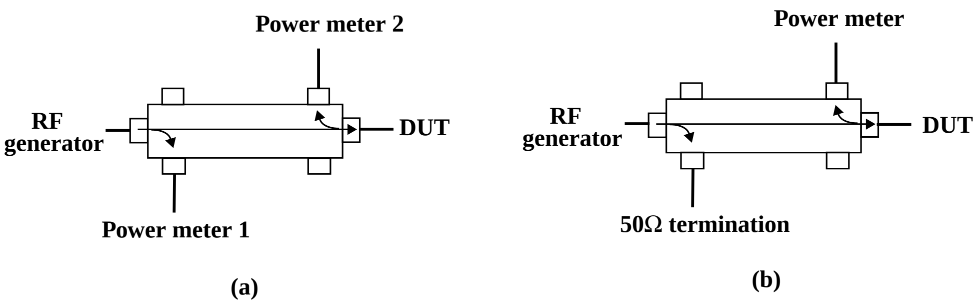


Figure 3. Cable configurations for monitoring forward and reflected power with a directional coupler. (a) shows the setup for monitoring both properties and (b) the reflected power measurement setup.

Uppgjord - *Prepared*	Tfn - *Telephone*	Datum - *Date*	Rev	Dokumentnr - *Document no*
ERA/T/UD Martin Siegbahn	70811	2000-01-25	F	T/U 98:441
Godkänd - *Approved*	Kontr. - *Checked*	Ert datum - *Your date*		Tillhör referens - *File/reference*
ERA/T/UF Christer Törnevik				

Ericsson SAR Measurement Specification, part 7:

SAR Measurement Procedure

1 Introduction

This part of the Ericsson SAR Measurement Specification describes the practical process of assessing the specific absorption rate (SAR) in the head phantom with the SPEAG dosimetric assessment system (DASY) [1]. The requirement for use of this instruction is a basic knowledge of the DASY hardware and software, including probe mounting and powering up the system[2].

2 Measurement system

2.1 Equipment

The main parts of the SPEAG dosimetric assessment system (DASY) are a six axis robot with controller, an E-field probe, a stand incorporating head phantoms with sections for left hand and a right hand side usage and a stand for positioning the mobile phone (DUT) close to the phantom. A computer with a PC card controls the robot and collects the data from the probe. Fig. 1 below shows an overview of the DASY.

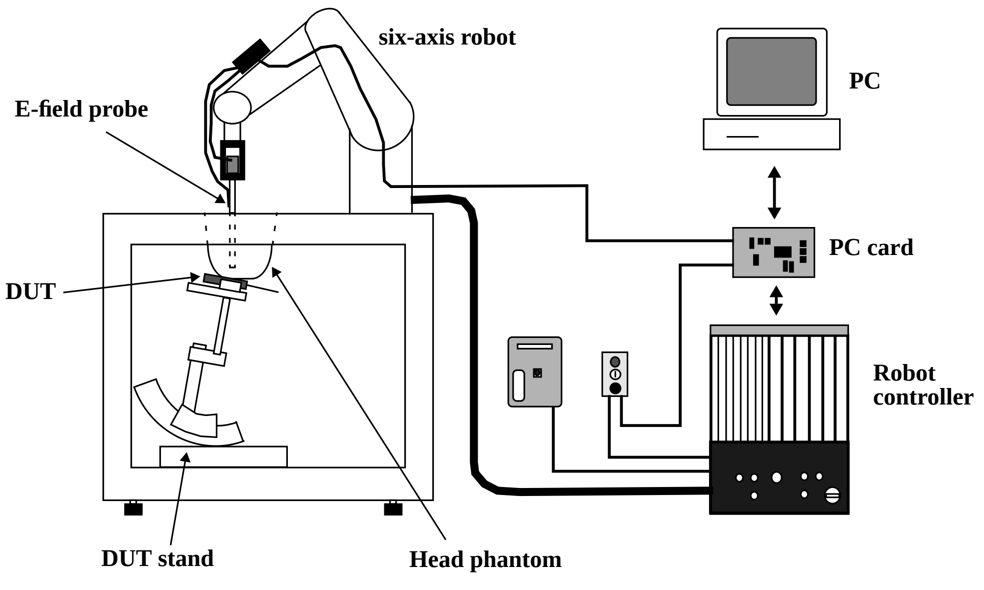


Figure 1. The dosimetric assessment system used for measuring SAR in a head phantom structure.

2.1.1 Probe specification

The ET3DV5/6 probe by Schmid & Partner Engineering AG for measurements of SAR is sensitive to E-fields and thus incorporates three small dipoles, each only 3 mm long, arranged so that the overall response is isotropic [3][4]. The table below summarizes the technical data for the probe which is used at all Ericsson SAR measurement laboratories.

Property	**Data**
Frequency range	30 MHz - 3 GHz
Linearity	±0.2 dB
Dynamic Range	5 mW/kg - 100 W/kg
Directivity (around probe axis)	±0.1 dB
Directivity (normal to probe axis)	±0.4 dB
Spatial resolution	< 0.125 mm^3
Probe positioning repeatability	±0.2 mm

Table 1 The technical data for the SAR probe ET3DV5.

2.1.2 Head phantom and tissue simulating liquid

The head phantom used in the DASY has a shape that is based on anatomical data for the heads of a number of individuals. These persons were chosen so as to represent a cross-section of all mobile phone users. The phantom is a fiberglass shell with a thickness equal to 2 mm and 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. The phantom shell is filled with a liquid that simulates the brain tissue at the frequency of interest. In the middle of the phantom there is a flat section for other exposure measurements including tests of devices held close to the waist. The flat section of the phantom is also used for system validation.

2.2 Peak SAR determination procedure

The DUT is positioned below the head phantom according to the binder part on DUT preparation and characterization and the transmitter is powered on before the SAR measurement starts. The SAR is measured using the following steps:

1. Reference check: the robot moves the probe to a fixed reference position in the tissue liquid and the E-field is recorded.

2. Coarse scan: the probe is moved in a coarse grid following the curved inner surface of the head phantom. In this measurement the robot is guided by the optical sensor in the tip of the probe and the size of the scanned region is selected large enough to guarantee that all possible peak SAR areas are included. 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 conductivity in Siemens/meter and ρ is the density in kg/m^3 of the liquid. Spline interpolation is used to determine the point of maximum SAR.

3. Fine scan: Measurements are taken on a fine grid around the position of the maximum SAR. The grid typically consists of 5x5x7 points with 8x8x5 mm between the individual points and thus contains about 31 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 thus 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 get all points within the measured volume in a 1mm grid (approximately 31 000 points). Finally, the SAR is averaged over a 1g cube (1000 points). The cube is shifted throughout the fine scan area until the highest averaged SAR is found. The same procedure is repeated for a 10 gram cube (10 000 points).

4. Finally, a second reference point measurement is performed for comparison with the measurement performed in 1. From this data the power stability of the transmitter during the SAR measurements is evaluated.

2.3 SAR assessment uncertainty

The uncertainty of the DASY has been determined according to the NIS81 [5] and NIST1297 documents [6]. The total uncertainty of the SAR assessment is composed of three main factors: measurement uncertainty, source uncertainty and phantom uncertainty. Each of these uncertainties consists of a number of individual factors. A detailed breakdown of uncertainties, according to T.Schmid et.al. [7], is provided in the following tables. The combined uncertainty (K=1) of the SAR assessment is ±16% and includes a +15% offset (overestimation). The extended uncertainty (K=2) is ±32% with a +15% offset [8].

A) Measurement uncertainty

Uncertainty description	Error	Distrib.	Weight	Std. Dev.	Offset
Probe uncertainty					
-axial isotropy	± 0.2dB	U-shape	0.5	± 2.4%	
-spherical isotropy	± 0.4dB	U-shape	0.5	± 4.8%	
-isotropy from gradient	± 0.5dB	U-shape	0		
-spatial resolution	± 0.5%	normal	1	± 0.5%	
-linearity error	± 0.2dB	rectang.	1	± 2.7%	
-calibration error	± 3.3%	normal	1	± 3.3%	

Uncertainty description	Error	Distrib.	Weight	Std. Dev.	Offset
SAR Evaluation Unc.					
-data acquisition error	± 1%	rectang.	1	± 0.6%	
-ELF and RF disturbances	± 0.25%	normal	1	± 0.25%	
-conductivity assessment	± 10%	rectang.	1	± 5.8%	
Spatial Peak SAR Evaluation Uncertainty					
-extrapol + boundary effect	± 3%	normal	1	± 3%	
-probe positioning error	±0.1 mm	normal	1	± 1%	
-integrat. and cube orient	± 3%	normal	1	± 3%	
-cube shape inaccuracies	± 2%	rectang.	1	± 1.2%	
Total Measurement Uncertainty				± **10.2%**	

B) Source uncertainty

Uncertainty description	Error	Distrib.	Weight	Std. Dev.	Offset
-device positioning	± 6%	normal	1	± 6%	
-laboratory setup	± 3%	normal	1	± 3%	
Total Source Uncertainty				± **6.7%**	

C) Uncertainties of covering the exposure of 80% of the entire user group

Uncertainty description	Error	Distrib.	Weight	Std. Dev.	Offset
-Internal anatomy (tissue distribution)				(± 7%)	(+ 10%)
-shape				(± 7%)	(+ 5%)
-other influences					(≥ 0%)
Total Phantom Uncertainty				(± **10%**)	(+ **15%**)

D) Combined uncertainties

Uncertainty description	Uncertainty	Offset	min.	max.
-total measurement uncertainty	± 10.2%	+ 5%		
-total source uncertainty	± 6.7%			
-total phantom uncertainty	(± 10%)	(+ 15%)		
Combined uncertainty (K=1)	(± 16%)	(+ 15%)	(– 1%)	(+ 31%)
Extended uncertainty (K=2)	**(± 32%)**	**(+ 15%)**	**(– 17%)**	**(+ 47%)**

3 Measurement setup

Before the measurement is conducted the device under test and the DASY equipment have to be properly setup in order to limit the sources of error.

3.1 DUT setup

Depending on the DUT use the appropriate instructions, i.e either section 3.1.1 or section 3.1.2. For additional instructions see binder part on DUT preparation and characterization.

3.1.1 Handset setup

1. Power up the handset and set the carrier frequency, the power level and if possible the duty-cycle of the transmitter to the appropriate values.

2. Position the device under the proper section of the head phantom. SAR measurements shall be performed for both right and left hand side use.

3.1.2 Base station antenna setup

1. Position the base station antenna below the flat section of the phantom.

2. Connect the cable from the directional coupler and the signal generator.

3. Power up the signal generator and set the carrier frequency and the power level.

4. Let the generator warm up for about 30 minutes without the RF output activated before proceeding with the SAR measurement.

3.2 Additional setup

1. Power up the spectrum analyzer and set the center frequency, span and sweep time to appropriate values considering the DUT transmitter. Let the analyzer warm up for about 30 minutes before proceeding.

2. Take still pictures of the measurement setup and the DUT to be used in the documentation.

3.3 DASY setup

The instructions of this section are only valid under the assumption that the equipment is calibrated and validated.

1. Mount the probe for SAR measurements on the DAE.

2. Remove the plastic cover on the phantom.

3. Power up the DAE. The LED indicates power on.

4. Power up the computer.

5. Power up the robot controller.

6. Start the DASY-software on the computer.

7. Choose the appropriate configuration in the "Setup" menu. NOTE, check that the medium parameters in the "options" window are equal to those measured previously with the dielectric probe kit.

8. Power up the robot arm by pressing the robot button in the toolbar.

9. Align the probe.

10. Check that the system is properly initiated by moving the probe to the three reference points. If the probe has been removed and mounted again on the DAE, the installation process has to be repeated. Otherwise, check the distance between the reference points and the probe tip with the plastic spacer. If ok, move the probe to the resting point above the flat section.

11. Check the optical proximity sensor by moving the probe to the liquid surface.

12. Move the probe back to the resting point.

13. Move the probe to the selected measurement section.

4 Measurement procedure

1. Open the appropriate predefined measurement file and rename it. Or, prepare a new measurement file by selecting jobs from the menu. Do not forget to enter information on the power level and the carrier frequency of the DUT and the name of the operator in the comments window.

2. Check the setup of the DUT.

3. Start the transmitter in the DUT. Check the signal with the spectrum analyzer.

4. Select the desired measurement jobs and start the SAR measurement.

5. When the SAR measurement is finished turn the DUT transmitter off.

6. Save the measurement data.

5 Post measurement procedure

1. When the SAR measurements are finished, power off the DUT.

2. Move the probe to the resting point and clean it with warm water.

3. Power off the robot arm and the DAE.

4. Power off the controller.

6. Exit the DASY software and power off the computer.

7. Power off the additional equipment, spectrum analyzers etc.

8. Enter information on the performed measurements in the laboratory log-book.

6 References

[1] 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.

[2] Schmid&Partner Engineering AG, "DASY3 User Manual", April 1999 Edition, Zurich, Switzerland.

[3] 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.

[4] 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.

[5] NIS 81, "The treatment of uncertainty in EMC measurements", Technical Report, NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, Edition 1, May 1994.

[6] NIST Technical Note 129 Barry N. Taylor and Christ E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Technical Report, National Institute of Standards and Technology, September 1994.

[7] T. Schmid and N. Kuster, "Preliminary uncertainty budget for SAR evaluations with DASY3," contribution to IEEE Standards Coordinating Committee 34, Subcommittee 2, July, 1998.

[8] ISO/IEC Guide Expres (1995-01),"Guide to the expression of uncertainty in measurement (1995)", Ed. 1.0 English, 1995.

Uppgjord (även faktaansvarig om annan) - *Prepared (also subject responsible if other)*		Nr - *No.*		
ERA/T/UF Christer Törnevik		T/U-98:447		
Dokansv/Godk – *Doc respons/Approved*	Kontr - *Checked*	Datum - *Date*	Rev	File
ERA/T/UF Christer Törnevik		1999-09-02	B	

Ericsson SAR measurement specification, part 8:

Documentation of results

1. Introduction

It is very important that a SAR test and the obtained results are well documented and that the data is stored in a safe way. A SAR test should be able to repeat in any of the Ericsson SAR laboratories based on the information in the documentation. Depending on the type of test, different types of reports may be issued. These are described below.

2. SAR test report

A SAR test report shall always be issued when a new product is tested for compliance with RF safety recommendations, standards and regulations. The SAR test report should be an internal and confidential document. If the SAR test is required for type approval, as for handheld mobile telephones in the U.S. and Australia, the SAR test may be sent to the regulator (for example the FCC or ACA) if demanded. Annex 1 shows the template for the report. All Ericsson SAR test reports should follow this template.

3. Declaration of conformity

A Declaration of Conformity (DOC) shall always be written when a SAR test report has been issued. This is normally the only document that is sent to the regulators that require SAR tests (FCC, ACA). The DOC is an open document that can be sent to, for example, customers and authorities that have requested information on SAR compliance test results for a product. Annex 2 shows the template for the document. All Ericsson DOCs should follow this template.

4. Technical report

Results from R&D related SAR measurements, for example of prototypes, modified products and non-Ericsson products, should normally not be documented in a SAR test report, but in a technical report. The format of this report may vary, depending of the type of test. The report should however include all information necessary to repeat the test later. In order to document detailed information from a SAR compliance measurement of a new product, a technical report may be issued in addition to the normal SAR test report. The technical report should be an internal and confidential document.

5. Storage of test data and reports

The test results (raw data) shall be stored in the SAR test laboratory. A backup of the data files shall be stored in a safe place. The SAR test reports, DOC documents and technical reports shall be stored locally where the tests have been conducted. Copies of SAR test reports and DOCs should normally also be stored in the appropriate product compliance folders and also be distributed to the other Ericsson SAR test laboratories.

Uppgjord - *Prepared*	Tfn - *Telephone*	Datum - *Date*	Rev	Dokumentnr - *Document no*
ERA/T/UD Martin Siegbahn	70811	1999-11-15	C	T/U 99:047
Godkänd - *Approved*	Kontr. - *Checked*	Ert datum - *Your date*		Tillhör referens - *File/reference*
ERA/T/UF Christer Törnevik				

Ericsson SAR Measurement Specification, part 9:

Bibliography

Documents provided with the binder:

[1] Federal Communications Commision Office of Engineering & Technology, OET Bulletin 65 (Edition 97-01), Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields".

[2] Radiocommunications (Electromagnetic Radiation Human Exposure) Standard 1999, Australian Communications Authority (ACA), May 1999.

Further literature:

[3] 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.

[4] 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.

[5] 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.

[6] N. Kuster, R. Kästle and T.Schmid, "Dosimetric Evaluation of Handheld Mobile Communications Equipment with Known Precision", *IEICE Transactions on Communications*, vol. E80-B, no. 5, pp. 645-652, May 1997.

[7] S.Gabriel, R.W. Lau and C. Gabriel, "The dielectric properties of biological tissues: II. Measurements in the frequency range 10 Hz to 20 GHz", Phys. Med. Biol. 41 (1996), pp. 2251-2269.

[8] G. Hartsgrove, A. Kraszewski and A. Surowiec, "Simulated biological materials for electromagnetic radiation absorption studies", *Bioelectromagnetics*, vol. 8, pp. 29-36, 1997.

[9] NIS NAMAS, "The treatment of uncertainty in EMC measurements", Technical Report, NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, England, 1994.

[10] Barry N. Taylor and Christ E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Technical Report, National Institute of Standards and Technology, 1994.

User’s manuals and system data provided with the equipment:

[11] Schmid&Partner Engineering AG, "DASY3 User Manual", April 1999 Edition, Zurich, Switzerland.

[12] Hewlett-Packard Company, "HP85070B Dielectric Probe Kit User’s manual", HP part number 85070-90009, 1993.

[13] Dosimetric system calibrations data.

Prepared (also subject responsible if other)		No.		
RT/EUS/TR/X Mark Douglas	919-472-6334	EUS/TR/X-99:1336		
Approved	Checked	Date	Rev	File
EUS/TR/XR/P Mark Douglas	MGD	1999-03-16	A	

Ericsson SAR Measurement Specification, part 10:

Glossary of Symbols and Acronyms

σ	Conductivity (S/m)
ε_0	Permittivity of free space = 8.854×10^{-12} F/m
ε'	Relative real part of complex permittivity (unitless)
ε''	Relative imaginary part of complex permittivity (unitless)
f	Frequency (Hz)
ω	Radial frequency (rad/s)
ACA	Australian Communications Authority
ANSI	American National Standards Institute (USA)
ARIB	Association of Radio Industries and Businesses (Japan)
AS/NZS	Australian Standard / New Zealand Standard
BW	Bandwidth
CDMA	Code-Division Multiple Access
CENELEC	European Committee for Electrotechnical Standardization
CW	Continuous wave
DAE	Data Acquisition Electronics
DASY	Dosimetric Assessment System
DECT	Digital Enhanced Cordless Telephone
DOC	Declaration of Conformity
DUT	Device under test
E-field	Electric field
EMF	Electromagnetic field
ES	European Standard
FCC	Federal Communications Commission (USA)
GPIB	General Purpose Interface Bus
GSM	Global System for Mobile communications
HEC	Hydroxyethyl-cellulose
HP	Hewlett-Packard
ICNIRP	International Commission on Non-Ionizing Radiation Protection (Europe)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers (USA)
LED	Light-emitting diode
MPT	Ministry of Posts and Telecommunications (Japan)
MTE	Mobile Telecommunication Equipment
NWA	Network Analyzer
OET	Office of Engineering and Technology of the FCC
PC	Personal Computer
RLL	Radio Local Loop
RF	Radio Frequency
SAR	Specific Absorption Rate (W/kg)
SPEAG	Schmid and Partner Engineering AG
TDMA	Time-Division Multiple Access

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

ANNEX 1

SAR Test Report: R280d

Date of test: November 19, 1999

Laboratory:
Electromagnetic Near Field and Radio Frequency Dosimetry Laboratory
Ericsson, Inc.
7001 Development Drive, P.O. Box 13969,
Research Triangle Park, NC, 27709, USA

Test Responsible:
Mark Douglas, Ph.D.
Senior Staff Engineer, Antenna Development Group
mark.douglas@ericsson.com
(919) 472-6334

Statement of Compliance

Ericsson, Inc. declares under its sole responsibility that the that the product

Ericsson R280d

to which this declaration relates, is in conformity with the appropriate RF exposure standards, recommendations and guidelines. It also declares that the product was tested in accordance with the appropriate measurement standards, guidelines and recommended practices.

The results and statements contained herein relate only to the items tested. The names of individuals involved may be mentioned only in connection with the statements or results from this report.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas 919-472-6334		EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

Table of Contents

1. Introduction

In this test report, compliance of the Ericsson R280d portable telephone with RF safety guidelines is demonstrated (applicable RF safety guidelines are given in [1]). The device was tested in accordance with the latest available test guidelines [1]. Detailed procedures of the test are described in the *Ericsson SAR Measurement Specification* [2].

2. Device Under Test

2.1 Antenna description

Type	Fixed stub	
Location	Left side	
Dimensions	length	30 mm
	width at base	11 mm
Configuration	Dual-band helix	

2.2 Device description

Device model	R280d		
Serial number	UA20148X59		
Mode	800 AMPS	800 TDMA	1900 TDMA
Multiple Access Scheme	FDMA	TDMA	TDMA
Maximum Output Power Setting [1]	26 dBm	26 dBm	26 dBm
Factory Tolerance in Power Setting	± 0.25	± 0.25	± 0.25 dB
Maximum Peak Output Power [2]	26.25 dBm	26.25 dBm	26.25 dBm
Duty Cycle	1	1 / 3	1 / 3
Transmitting Frequency Range	824 – 849 MHz	824 – 849 MHz	1850-1910 MHz
Prototype or Production Unit [3]	Prototype		

3. Test equipment

3.1 Dosimetric system

SAR measurements were made using the DASY3 professional system (software version 3.1c), manufactured by Schmid & Partner Engineering AG and installed Febuary, 1998. The total SAR assessment uncertainty (K = 1) of the system is ±16% and includes a +15% offset (overestimation). The extended uncertainty (K = 2) is ±32% with a +15% offset. This results in a total uncertainty range of –1% to +31% for K = 1, or –17% to +47% for K = 2. The equipment list is given below.

Description	**Serial Number**	**Due Date**
DASY3 DAE V1	345	10/00
E-field probe ETDV5	1337	3/00
Dipole Validation Kit, D900V2	049	12/00
Dipole Validation Kit, D1800V2	238	12/00

[1] This is the conducted power measured at the antenna port when the device is set to its highest power setting. It is measured at the middle of the transmit frequency band. Note that the output power may be different at other frequencies.
[2] This equals the maximum output power setting plus the factory tolerance.
[3] It shall be understood that a statement of compliance for a prototype unit also applies to production units [3].

3.2 Additional equipment

Description	Serial Number	Due Date
Signal Generator HP8648C	3537A01598	9/00
Dielectric probe kit HP 85070B	US33020390	2/00
Network analyzer HP 8752C	3410A03105	7/00
Power meter HP 437B	3125U13481	12/99
Power sensor HP 8482H	3318A07097	2/00
Radio communications analyzer Anritsu MT8801B	MB12477	10/00

4. Electrical parameters of the tissue simulating liquid

Prior to conducting SAR measurements, the relative permittivity, ε_r, and the conductivity, σ, of the tissue simulating liquids were measured with the dielectric probe kit. These values are shown in the table below. The mass density, ρ, entered into the DASY3 program is also given. Recommended limits for maximum permittivity, minimum conductivity and maximum mass density are also shown [3]. It is seen that the measured parameters satisfy the recommendations, resulting in an overestimation of SAR.

f **(MHz)**	**Limits / Measured**	**Dielectric Parameters**		
		ε_r	σ (S/m)	ρ (g/cm^3)
835	**Measured**	43.9	0.77	1.00
	Recommended Limits [3]	46.1	0.74	1.03
	Difference	**-4.8%**	**+4.1%**	**-2.9%**
1800	**Measured**	39.1	1.70	1.00
	Recommended Limits [3]	43.5	1.15	1.03
	Difference	**-10.1%**	**+47.8%**	**-2.9%**

5. System accuracy verification

A system accuracy verification of the DASY3 was performed using the dipole validation kits listed in Section 3.1. The system verification test was conducted on the same day as the measurement of the DUT. The obtained results are displayed in the table below. It is seen that the system is operating within its specification, as the results are within ±5% of the reference values obtained from the system manufacturer [4]. The distribution of SAR also compares well with that provided by the system manufacturer (see Appendix 1).

f **(MHz)**	**Measured / Reference**	**SAR (W/kg), 1 gram**	**Dielectric Parameters**			**Temp. (°C)**
			ε_r	σ (S/m)	ρ (g/cm^3)	
900	**Measured**	9.04	43.3	0.83	1.00	23
	Reference [4]	9.48	42.0	0.86	1.00	?
1800	**Measured**	40.4	39.1	1.70	1.00	23
	Reference [4]	38.9	41.0	1.70	1.00	?

6. Test results

The measured SAR values and conducted output powers are shown in Table 1. The device was tested on both the right-hand phantom (corresponding to the right side of the head) and the left-hand phantom. The SAR results shown are maximum SAR values averaged over 1 g of tissue.

A base station simulator was used to control the device during the SAR measurements. The phone was supplied with a fully-charged battery for the tests. The temperature of the test facility during the tests was 23.0 ± 1 °C, and the depth of the tissue simulating liquid was 14.0 cm.

Prepared (also subject responsible if other)		No.	
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP	
Approved	Checked	Date / Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22 / B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

mode	*f* (MHz)	Output Power (dBm)	SAR, 1g (W/kg)			
			left-hand		right-hand	
			measured	calculated to max. power[4]	measured	calculated to max. power[4]
800 AMPS	824	26.1	1.36	1.31	1.46	**1.41**
	837	26.4	1.24	1.20	1.36	1.31
	849	26.4	1.17	1.13	1.27	1.23
800 TDMA	824	25.9	0.436	0.484	0.475	0.527
	837	25.8	0.413	0.458	0.498	**0.552**
	849	25.9	0.384	0.426	0.477	0.529
1900 TDMA	1850	25.2	0.589	0.701	0.852	1.01
	1880	25.5	0.633	0.753	0.962	1.14
	1910	25.4	0.661	0.787	0.996	**1.19**

Table 1: SAR measurement results for the Ericsson R280d telephone at highest possible output power.

References

[1] C. Törnevik, “Ericsson SAR measurement specifiction, part 1: Introduction and Purpose,” Internal Document ERA/T/U-98:446, February, 1999.

[2] C. Törnevik, M. Siegbahn, T. Persson, M. Douglas, and R. Plicanic, “Ericsson SAR measurement specification”, Internal Document ERA/T/U-98:442, February 1999.

[3] Federal Communications Commission, “Tissue Dielectric Properties,” http://www.fcc.gov/fcc-bin/dielec.sh.

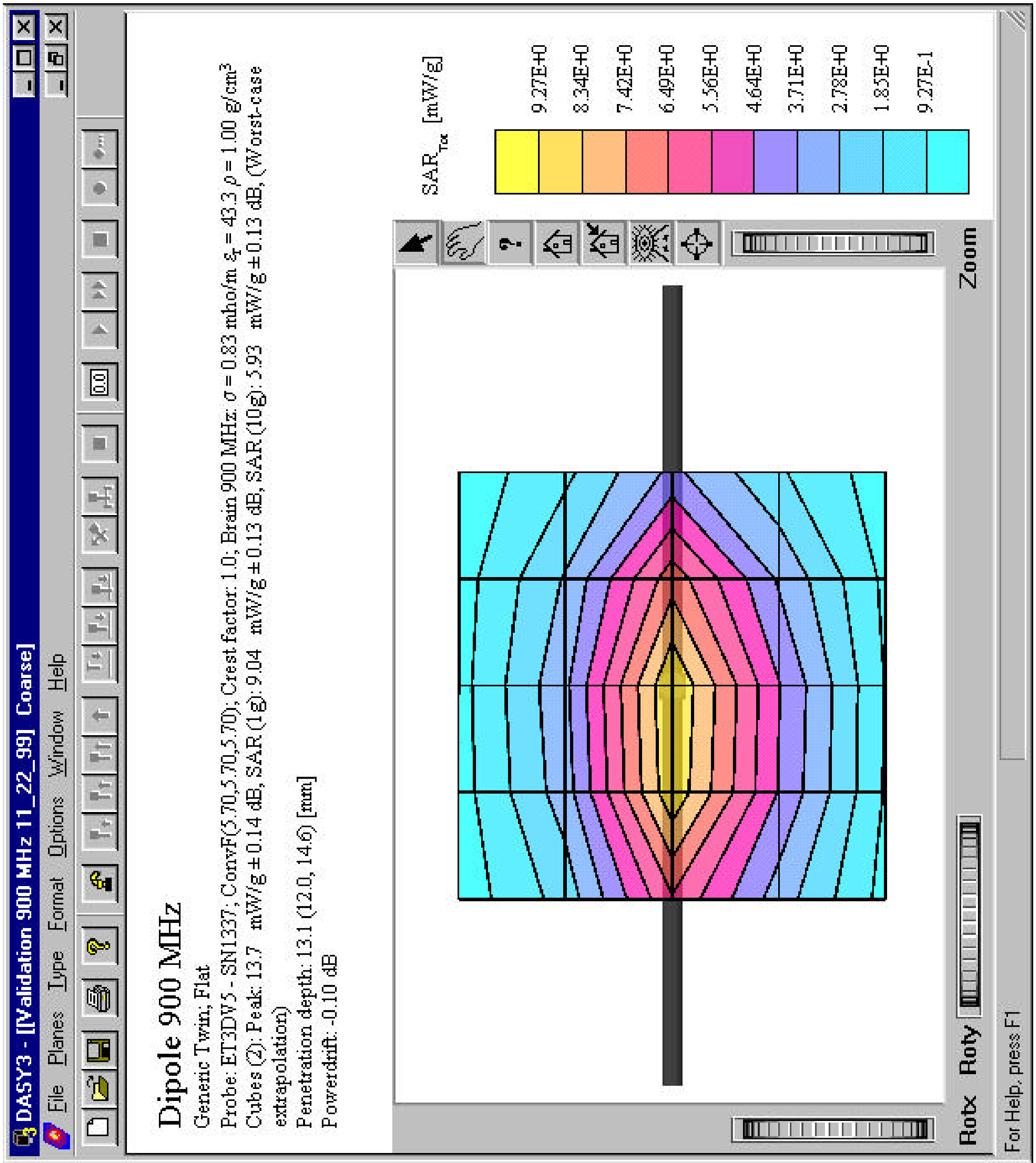
[4] Schmid and Partner Engineering AG, “DASY Dipole Validation Kit,” Type: D1800V2, S/N: 217, November, 1997.

[4] The maximum output power setting for each mode is measured at the middle of the transmit frequency band (see footnote 1). Therefore, the measured SAR is scaled to the maximum power by multiplying it by the ratio of the measured output power in the middle of the transmit band to the maximum output power setting. The same scaling factor applies across the band, regardless of what the output power is at the other frequencies.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas 919-472-6334		EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

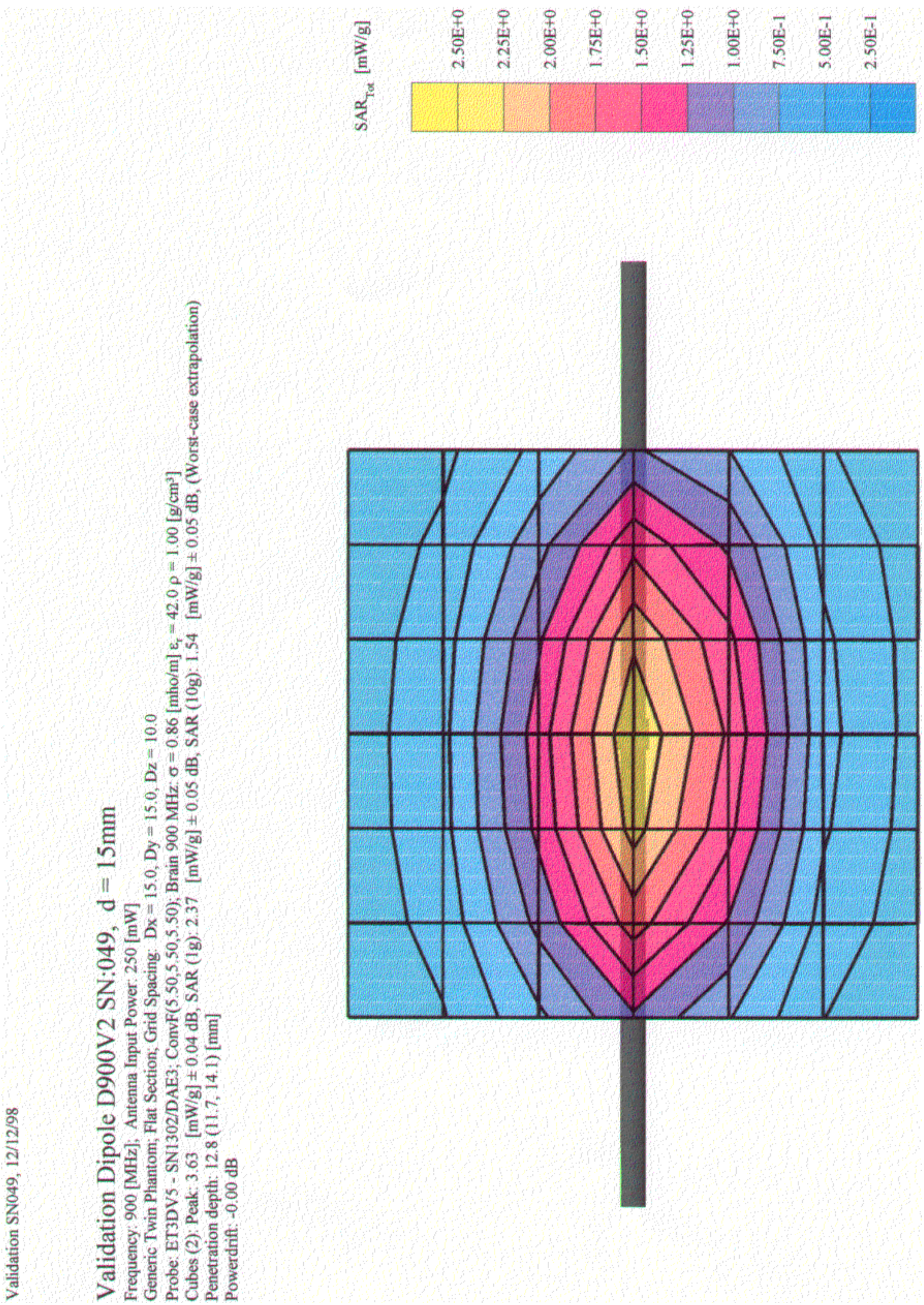
Appendix 1: SAR distribution comparison for system accuracy verification



900 MHz SAR distribution of validation dipole antenna from system accuracy verification test.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

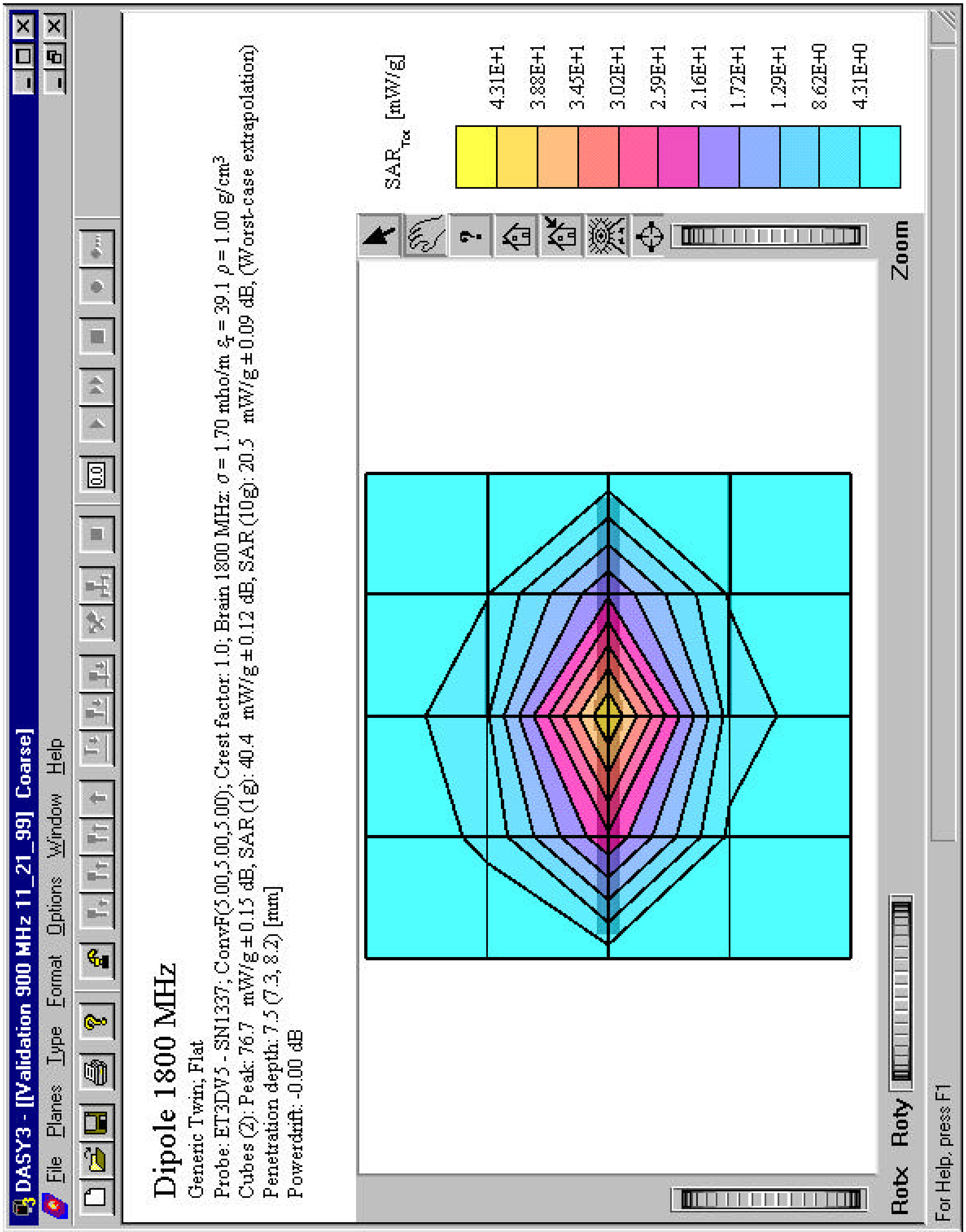
E



900 MHz SAR distribution of validation dipole antenna provided by system manufacturer.

Prepared (also subject responsible if other)		No.
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP

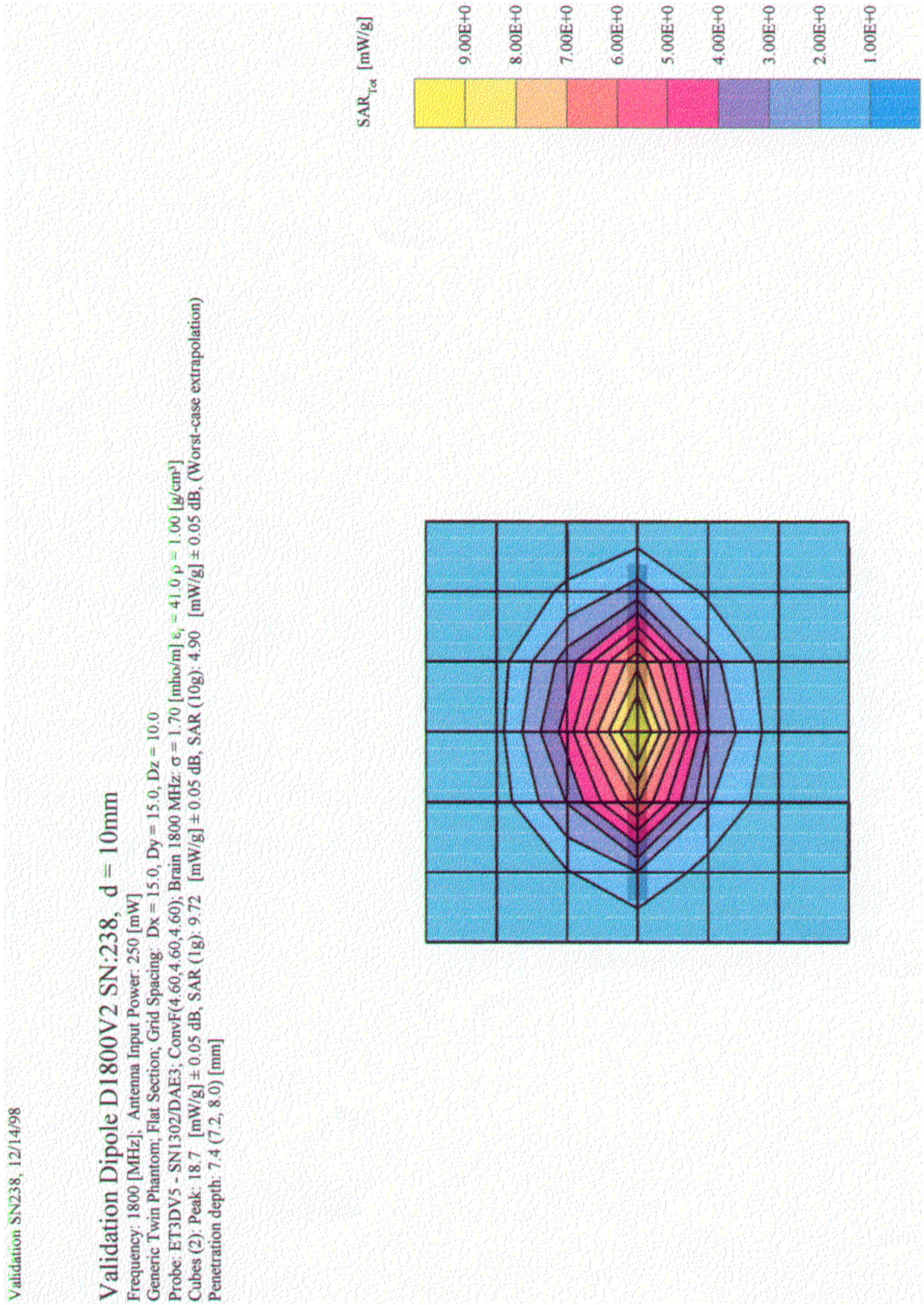
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc



1800 MHz SAR distribution of validation dipole antenna from system accuracy verification test.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

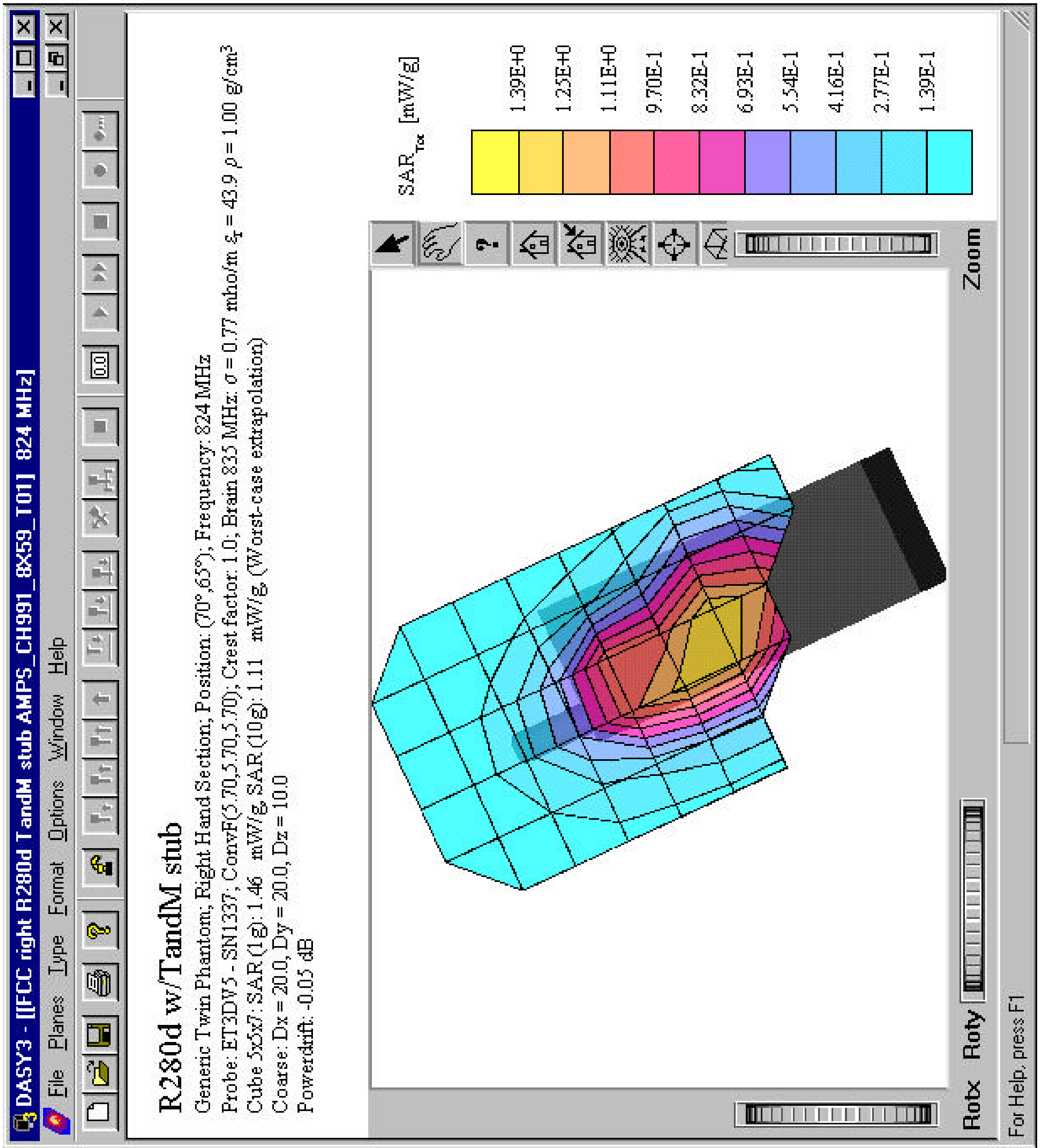


1800 MHz SAR distribution of validation dipole antenna provided by system manufacturer.

Prepared (also subject responsible if other)		No.	File
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP	
Approved	Checked	Date / Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22 / B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

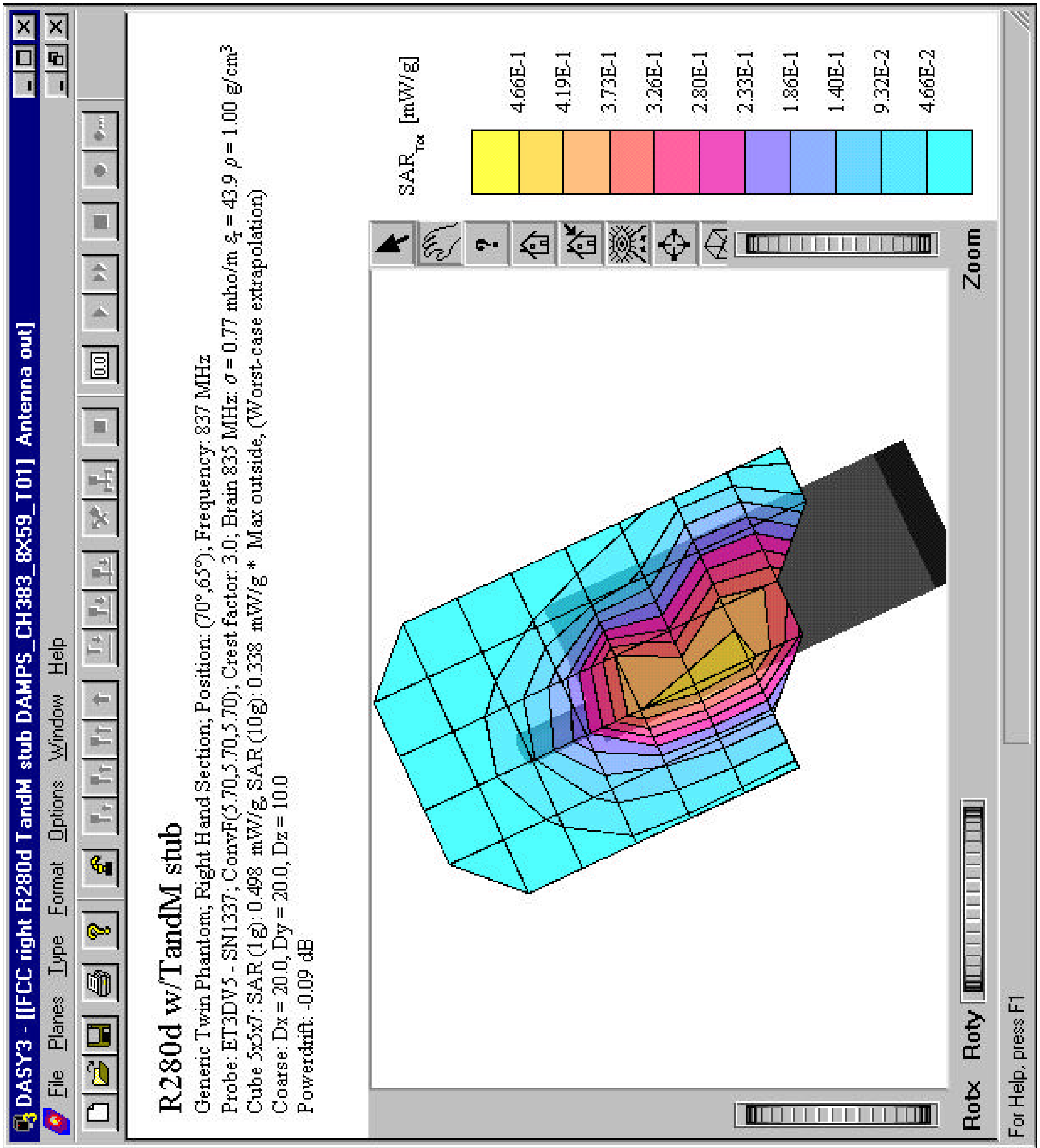
Appendix 2: SAR distribution plots



Distribution of maximum SAR in 800 AMPS band.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

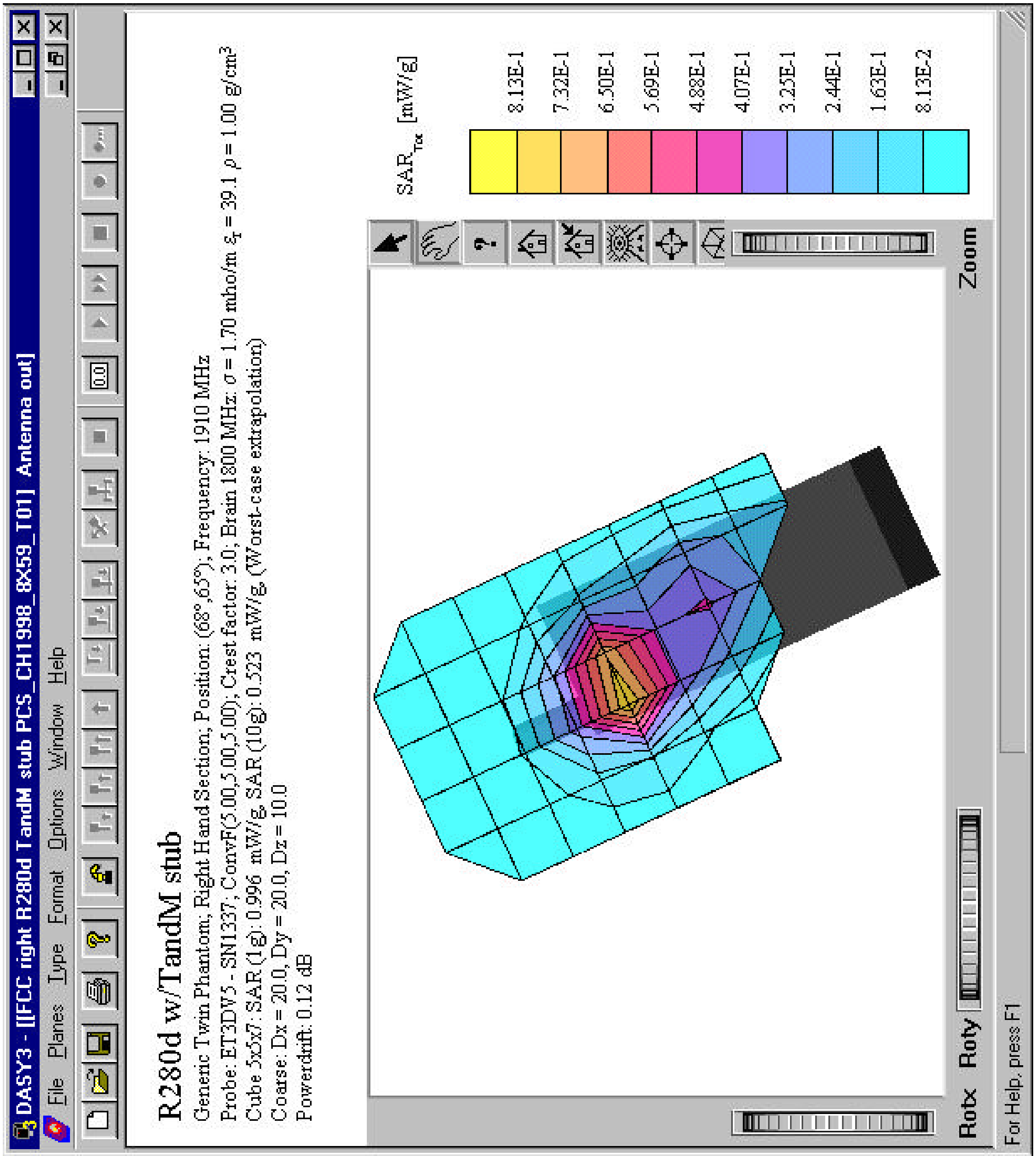
E



Distribution of maximum SAR in 800 TDMA band.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E



Distribution of maximum SAR in 1900 TDMA band.

Appendix 3: Photographs of the device under test

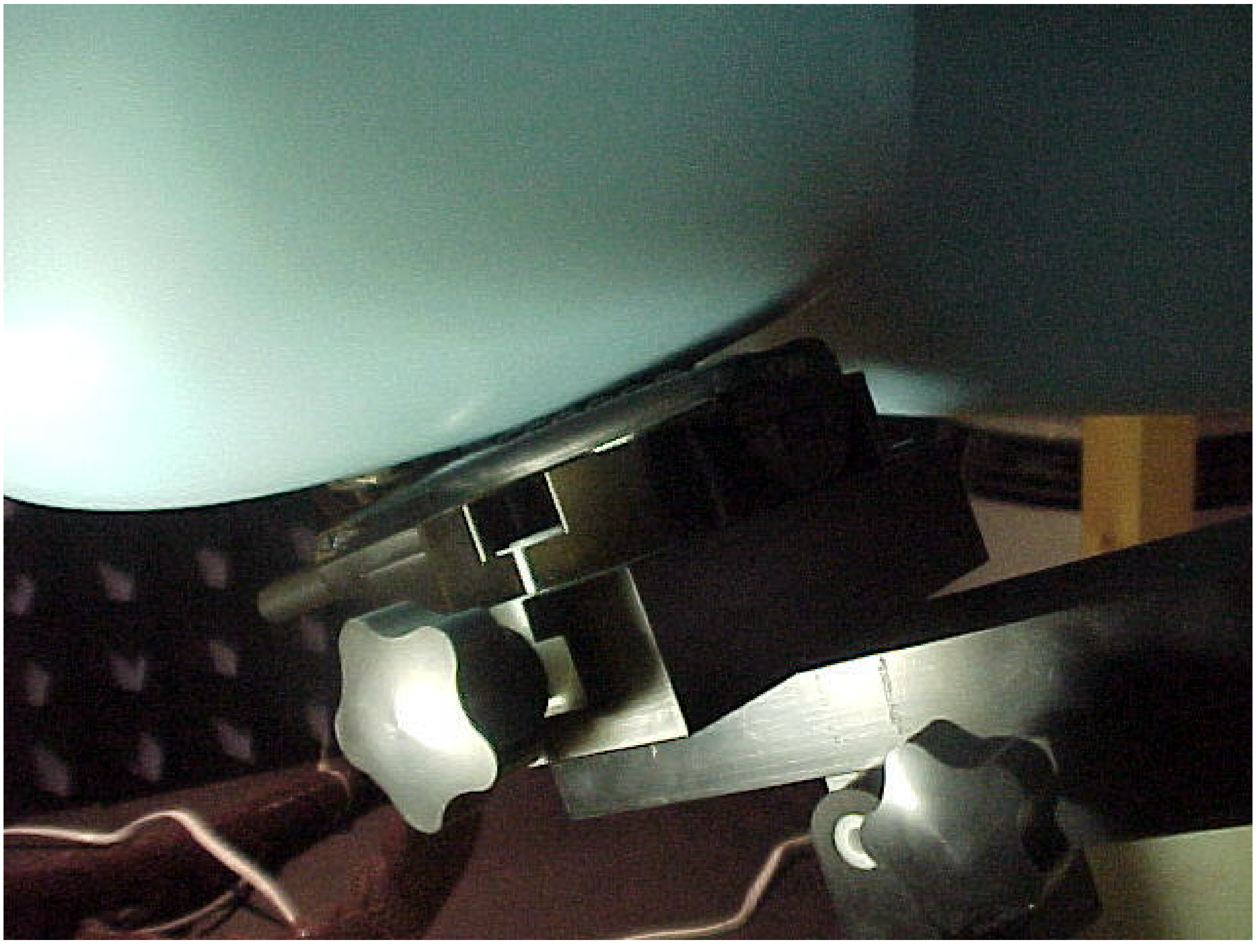
Front view of device.

Side view of device.

Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

Appendix 4: Position of device on Generic Twin Phantom



Prepared (also subject responsible if other)		No.		
RT/EUS/VR/X Mark Douglas	919-472-6334	EUS/VR-99:5507/REP		
Approved	Checked	Date	Rev	File
EUS/VR/X Mark Douglas	MGD	1999-11-22	B	S:\douglas\SAR measurement spec\Sarannex1, Rev B.doc

E

Appendix 5: Probe calibration parameters for ET3DV5 SN:1337

ET3DV SN:1337

DASY3 - Parameters of Probe: ET3DV SN:1337

Sensitivity in Free Space

NormX	**2.32**	$\mu V/(V/m)^2$
NormY	**2.09**	$\mu V/(V/m)^2$
NormZ	**2.16**	$\mu V/(V/m)^2$

Diode Compression

DCP X	**98**	mV
DCP Y	**98**	mV
DCP Z	**98**	mV

Sensitivity in Tissue Simulating Liquid

450 MHz	ConvF X	**6.0**	extrapolated	ε_r = 48 ± 5%
	ConvF Y	**6.0**	extrapolated	σ = 0.50 ± 10% mho/m
	ConvF Z	**6.0**	extrapolated	(brain tissue simulating liquid)
900 MHz	ConvF X	**5.7**	± 10%	ε_r = 42.5 ± 5%
	ConvF Y	**5.7**	± 10%	σ = 0.86 ± 10% mho/m
	ConvF Z	**5.7**	± 10%	(brain tissue simulating liquid)
1500 MHz	ConvF X	**5.3**	interpolated	ε_r = 41 ± 5%
	ConvF Y	**5.3**	interpolated	σ = 1.32 ± 10% mho/m
	ConvF Z	**5.3**	interpolated	(brain tissue simulating liquid)
1800 MHz	ConvF X	**5.0**	± 10%	ε_r = 41 ± 5%
	ConvF Y	**5.0**	± 10%	σ = 1.69 ± 10% mho/m
	ConvF Z	**5.0**	± 10%	(brain tissue simulating liquid)

Sensor Offset

Probe Tip to Sensor Center	**2.7**	mm
Surface to Probe Tip	**1.9 ± 0.2**	mm

ERICSSON

Attending to this matter, name, telephone	*Date*	*Rev*	*Our Reference*
KI/ERA/T/UF C. Törnevik, +46 8 7641235	99-02-22	A	T/U 99:094

DECLARATION OF CONFORMITY

We, Ericsson Radio Systems AB of
Torshamnsgatan 23
164 80 Stockholm

declare under our sole responsibility that the product

KRCNB 403 AA/N
(Ericsson DECT BS230)

to which this declaration relates, is in conformity with the appropriate RF exposure standards, recommendations and guidelines:

IEEE/ANSI C95.1-1992
FCC OET Bulletin 65 (Supplement C)
CENELEC ENV 50166-2:1995
AS/NZS 2772.1 (Int) - 1998
ICNIRP (1998)

Stockholm 1999-02-22

…………………………………………………..….

Name	Christer Törnevik
Position	Expert, Electromagnetic Fields