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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). 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 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.

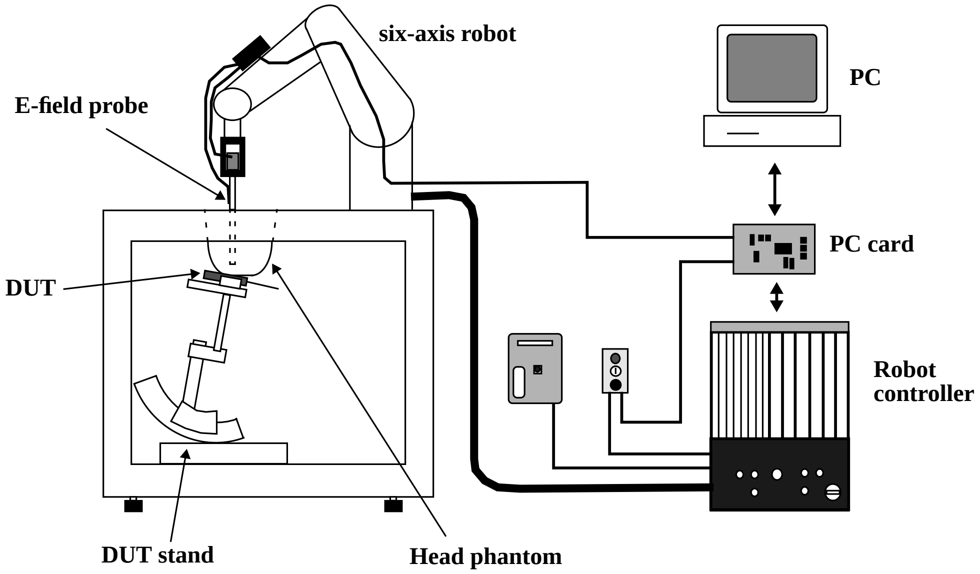

Figure 1. The dosimetric assessment system used for measuring SAR in a head phantom structure.

2.1.1 Probe specification

The ET3DV5 probe by Schmid & Parther 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. 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 which cannot be reached with the E-field probe. 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 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).

in this position for comparison with an identical measurement after the actual SAR scan; this for ensuring the power stability of the transmitter. Finally, the second reference point measurement is performed.

2.3 SAR assessment uncertainty

The uncertainty of the DASY has been determined according to the NIS81 and NIST1297 documents. 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 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.

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%	± 5%
-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				(± 3%)	(± 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.