

APPENDIX 8 : The 5-6GHz Extension (SPEAG information)

Chapter 26

The 5-6 GHz Extension

26.1 Introduction

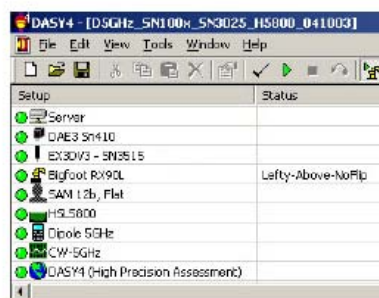
In July 2003, the SPEAG calibration laboratory and its service center released extension for conducting SAR assessments with DASY4 in the frequency range 5-6 GHz. In addition, in January 2004, SPEAG released the smallest dosimetric probe EX3DV3 which allowed a significant improvement of the extension with respect to the measurement accuracy.

These new items and services enable the user to perform routine evaluations of compliance with exposure guidelines operating in the 5 GHz frequency band, as defined in the supplement IEEE 802.11a (1999) and HiperLAN/2 standards with an uncertainty of less than $\pm 30\%$.

The new extension for the higher frequency range meets the same requirements for SAR evaluations as described in IEEE 1528 [1], CENELEC EN50361 [2], IEC 62209 [3] for lower frequencies (300 MHz - 3 GHz). The performance of the new setup has been validated by the Foundation for Research on Information Technologies in Society IT²IS.

DASY Software Settings

The recommended usage of a DASY system and its components in the frequency range 300 MHz - 3 GHz is described in detail in the previous Chapters. This Chapter provides all additions and deviations needed for the frequency range 5-6 GHz. If nothing is stated in this Chapter, the requirements, procedures and methods of the previous Chapters are applicable.

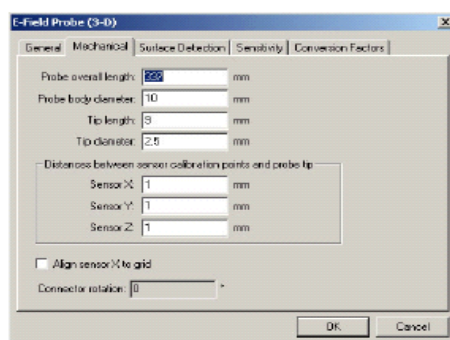


Most of the DASY items and requirements do not deviate from those for the frequency range below 3 GHz. However, due to the stronger gradients of the field distribution in the 5-6 GHz frequency range, adaptation is required for the scanning method as well as for the dosimetric probe type.

26.2 Smallest Dosimetric Probe (EX3DV3)

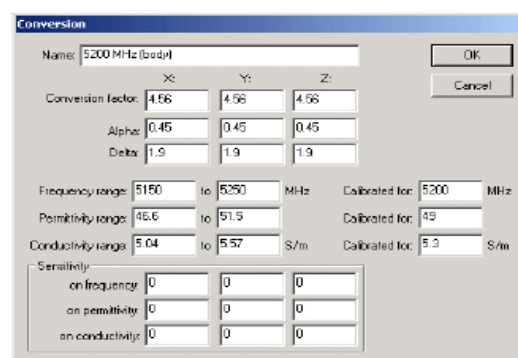
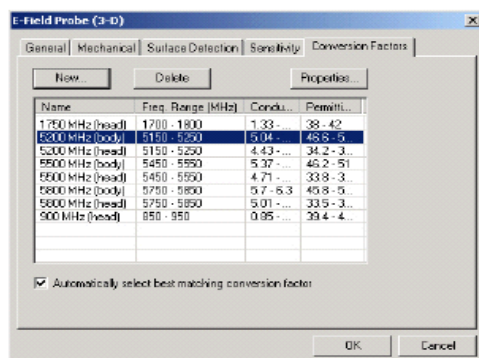
Within the framework of the new EUREKA project No. 2915 (SARSYS-BWP), SPEAG developed a new probe optimized for this frequency range. The new probe has a Tip diameter of 2.5 mm and a distance between sensor calibration point and probe tip (Sensor X,Y and Z) of 1.0 mm. With these dimensions, the EX3DV3 probe has superior performance for high precision measurements in field distributions with steep gradients.

The EX3DV3 probe is fully compatible with the latest draft of IEC 62209 Part 2. It is the only probe enabling measurements at 5-6 GHz with a precision of better than 30% (uncertainty assessed according to the standards). The EX3DV3 probe is universally applicable for dosimetric assessments and is fully compatible with the mechanical detection system of DASY4.



The dimensions of the smallest dosimetric EX3DV3 probe are shown in the Mechanical tab in the dialog. Compared to the standard dosimetric probe, the EX3DV3 type has a reduced Tip diameter as well as smaller distance between sensor calibration point and probe tip (Sensor X,Y and Z) enabling SAR assessments as close as 1.5 mm from the shell-liquid interface.

Note: Please note that the standard ES3DV3 and especially the ET3DV6 dosimetric probes are not suitable for this frequency range. With these probes, the SAR measurement uncertainty can significantly exceed $\pm 30\%$.



The probe conversion factors in the 5-6 GHz frequency range were assessed in the setup based on the vertically standing waveguide type R58 (frequency band: 4.9 - 7.05 GHz). Due to the small waveguide dimensions, field disturbance by the probe could not be excluded and needs to be added to the uncertainty budget. Together with other error sources, the resulting probe calibration uncertainty for the EX3DV3 probe type was assessed to be $\pm 6.6\%$ ($k=1$) at Calibration Frequency and $\pm 13.6\%$ ($k=1$) for a narrow-band conversion factor (± 50 MHz).

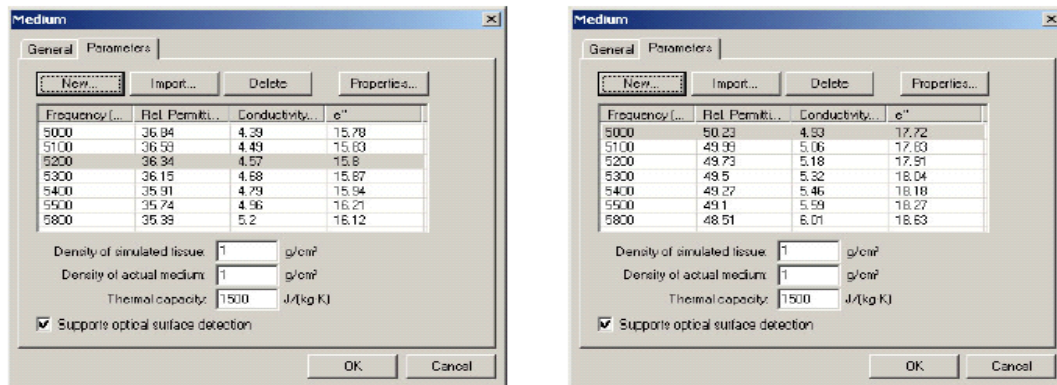
26.3 Tissue Simulating Liquids

In the current guidelines and draft standards for compliance testing of mobile phones (e.g., IEEE P1528, OET 65 Supplement C), the dielectric parameters suggested for head and body tissue simulating liquid are given only at 3.0 GHz and 5.8 GHz. As an intermediate solution, dielectric parameters for the frequencies between 5 to 5.8 GHz were obtained using linear interpolation (see Table 26.1).

SPEAG has developed suitable head (HSL5800) and body (MSL5800) tissue simulating liquids consisting of the following ingredients: deionized water, salt and a special composition including mineral oil and an emulgator. Dielectric parameters of these liquids were measured using a HP 85070B Dielectric Probe Kit in conjunction with HP 8753E Network Analyzer (30 kHz - 6 GHz). The differences with respect to the interpolated values were well within desired $\pm 5\%$ for the whole 5 to 5.8 GHz range.

f (GHz)	Head Tissue		Body Tissue		Reference
	ϵ	σ	ϵ	σ	
3.0	38.5	2.40	52.0	2.73	Standard
5.8	35.3	5.27	48.2	6.00	Standard
5.0	36.2	4.45	49.3	5.07	Interpolated
5.1	36.1	4.55	49.1	5.18	Interpolated
5.2	36.0	4.66	49.0	5.30	Interpolated
5.3	35.9	4.76	48.9	5.42	Interpolated
5.4	35.8	4.86	48.7	5.53	Interpolated
5.5	35.6	4.96	48.6	5.65	Interpolated
5.6	35.5	5.07	48.5	5.77	Interpolated
5.7	35.4	5.17	48.3	5.88	Interpolated

Table 26.1: Standard and interpolated dielectric parameters for head and body tissue simulating liquid in the frequency range 3 to 5.8 GHz.



26.4 SAR Evaluation

26.4.1 Area Scan job

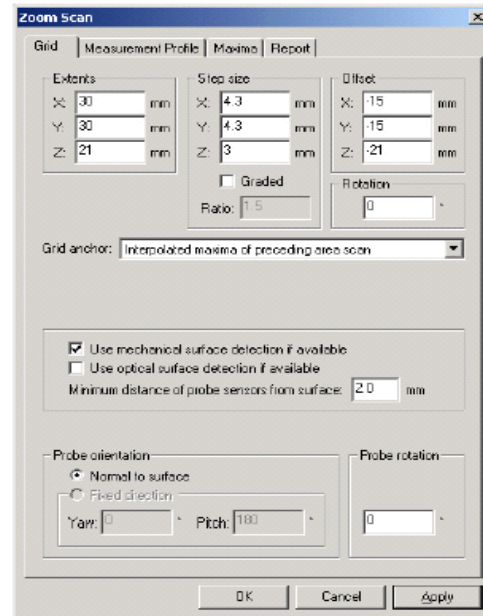
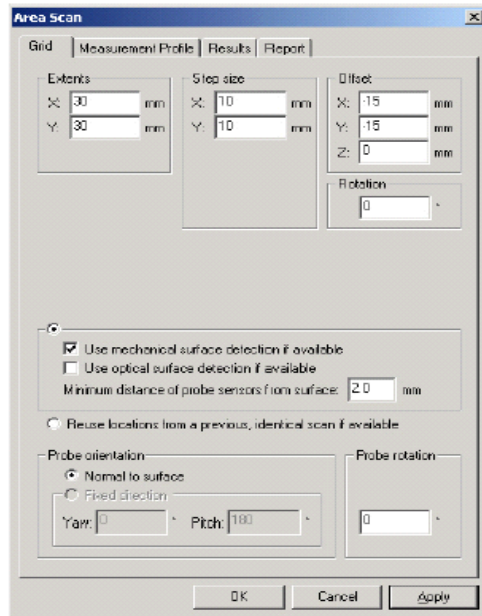
Due to the reduced penetration depth in the corresponding liquid (6.0 mm at 6 GHz), the distance between the measured points and phantom surface during the Area Scan needs to be reduced as well as the tolerance, i.e., it should be less than 4.0 mm with a variation of less than ± 0.5 mm during the entire scan.

The recommend distance between the probe sensor and phantom surface is 1.5-2.0 mm.

26.4.2 Zoom Scan job

The strong decay would require that at least two measurement points are taken within the first 5 mm from the liquid-shell interface. The following setting for the Zoom Scan job are recommended for the best time vs. accuracy ratio:

- Grid Step size X and Y 4.3 mm
- Grid Step size Z 3.0 mm
- Grid Extent Z 21.0 mm
- Minimum distance of probe sensor to surface 1.5-2.0 mm



26.5 System Performance Check

For the preparation of the setup please refer to Chapter 15 [System Performance Check](#).

Reference SAR values

The reference SAR values were calculated using finite-difference time-domain FDTD method (feed-point impedance set to 50 Ω) and the mechanical dimensions of the D5GHzV2 dipole (manufactured by SPEAG).

f (GHz)	Head Tissue			Body Tissue		
	SAR_{1g}	SAR_{10g}	SAR_{peak}	SAR_{1g}	SAR_{10g}	SAR_{peak}
5.0	72.9	20.7	285.6	68.1	19.2	260.3
5.1	74.6	21.1	297.5	78.8	19.6	272.3
5.2	76.5	21.6	310.3	71.8	20.1	284.7
5.8	78.0	21.9	340.9	74.1	20.5	324.7

Table 26.2: Numerical reference SAR values for D5GHzV2 dipole and flat phantom.

Uncertainty Budget for System Performance Check

The extended frequency range requires the same documentation including evaluation of the same uncertainty sources. In the following table, an updated uncertainty budget for the system performance check in the frequency range between 5-6 GHz is given.

System Performance Check for the 5 - 6 GHz range								
Error Description	Tol. (± %)	Prob. dist.	Div.	(c_i) (1g)	(c_i) (10g)	Std. unc. (1g)	Std. unc. (10g)	(v_i)
Measurement System								
Probe Calibration	±6.6	N	1	1	1	±4.8 %	±6.6 %	∞
Axial Isotropy	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
Hemispherical Isotropy	0	R	$\sqrt{3}$	1	1	0	0	∞
Boundary Effects	2.0	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %	∞
Linearity	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
System Detection Limit	±1.0	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %	∞
Readout Electronics	±1.0	N	1	1	1	±1.0 %	±1.0 %	∞
Response Time	0	R	$\sqrt{3}$	1	1	0	0	∞
Integration Time	0	R	$\sqrt{3}$	1	1	0	0	∞
RF Ambient Conditions	±3.0	R	$\sqrt{3}$	1	1	±1.7 %	±1.7 %	∞
Probe Positioner	±0.8	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %	∞
Probe Positioning	±5.7	N	1	1	1	±5.7 %	±5.7 %	∞
Algorithms for Max. SAR Eval.	±4.0	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Dipole								
Dipole Axis to Liquid Distance	±2.0	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %	∞
Input power and SAR drift meas.	±4.7	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %	∞
Phantom and Tissue Param.								
Phantom Uncertainty	±4.0	R	$\sqrt{3}$	1	1	±2.3 %	±2.3 %	∞
Liquid Conductivity (target)	±5.0	R.	$\sqrt{3}$	0.64	0.43	±1.8 %	±1.2 %	∞
Liquid Conductivity (meas.)	±2.5	N	1	0.64	0.43	±1.6 %	±1.1 %	∞
Liquid Permittivity (target)	±5.0	R	$\sqrt{3}$	0.6	0.49	±1.7 %	±1.4 %	∞
Liquid Permittivity (meas.)	±2.5	N	1	0.6	0.49	±1.5 %	±1.2 %	∞
Combined Standard Uncertainty						±11.3 %	±11.1 %	∞
Coverage Factor for 95%		kp=2						
Expanded Uncertainty						±22.6 %	±22.1 %	

Table 26.3: Uncertainty of the system performance check in the 5-6 GHz range. Probe calibration error reflects uncertainty of the EX3DV3 probe conversion factor at Calibration Frequency.

26.6 Uncertainty Budget for Compliance Testings

The updated uncertainty budget for the compliance testing in the frequency range between 5-6 GHz is given in the table below.

DASY4 Uncertainty Budget for the 5 - 6 GHz range								
Error Description	Uncertainty value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v_i) v_{eff}
Measurement System								
Probe Calibration	$\pm 6.8\%$	N	1	1	1	$\pm 6.8\%$	$\pm 6.8\%$	∞
Axial Isotropy	$\pm 4.7\%$	R	$\sqrt{3}$	0.7	0.7	$\pm 1.9\%$	$\pm 1.9\%$	∞
Hemispherical Isotropy	$\pm 9.6\%$	R	$\sqrt{3}$	0.7	0.7	$\pm 3.9\%$	$\pm 3.9\%$	∞
Boundary Effects	$\pm 2.0\%$	R	$\sqrt{3}$	1	1	$\pm 1.2\%$	$\pm 1.2\%$	∞
Linearity	$\pm 4.7\%$	R	$\sqrt{3}$	1	1	$\pm 2.7\%$	$\pm 2.7\%$	∞
System Detection Limits	$\pm 1.0\%$	R	$\sqrt{3}$	1	1	$\pm 0.6\%$	$\pm 0.6\%$	∞
Readout Electronics	$\pm 1.0\%$	N	1	1	1	$\pm 1.0\%$	$\pm 1.0\%$	∞
Response Time	$\pm 0.8\%$	R	$\sqrt{3}$	1	1	$\pm 0.5\%$	$\pm 0.5\%$	∞
Integration Time	$\pm 2.6\%$	R	$\sqrt{3}$	1	1	$\pm 1.5\%$	$\pm 1.5\%$	∞
RF Ambient Conditions	$\pm 3.0\%$	R	$\sqrt{3}$	1	1	$\pm 1.7\%$	$\pm 1.7\%$	∞
Probe Positioner	$\pm 0.8\%$	R	$\sqrt{3}$	1	1	$\pm 0.5\%$	$\pm 0.5\%$	∞
Probe Positioning	$\pm 5.7\%$	N	1	1	1	$\pm 5.7\%$	$\pm 5.7\%$	∞
Max. SAR Eval.	$\pm 4.0\%$	R	$\sqrt{3}$	1	1	$\pm 2.3\%$	$\pm 2.3\%$	∞
Test Sample Related								
Device Positioning	$\pm 2.9\%$	N	1	1	1	$\pm 2.9\%$	$\pm 2.9\%$	145
Device Holder	$\pm 3.6\%$	N	1	1	1	$\pm 3.6\%$	$\pm 3.6\%$	5
Power Drift	$\pm 5.0\%$	R	$\sqrt{3}$	1	1	$\pm 2.9\%$	$\pm 2.9\%$	∞
Phantom and Setup								
Phantom Uncertainty	$\pm 4.0\%$	R	$\sqrt{3}$	1	1	$\pm 2.3\%$	$\pm 2.3\%$	∞
Liquid Conductivity (target)	$\pm 5.0\%$	R	$\sqrt{3}$	0.64	0.43	$\pm 1.8\%$	$\pm 1.2\%$	∞
Liquid Conductivity (meas.)	$\pm 2.5\%$	N	1	0.64	0.43	$\pm 1.6\%$	$\pm 1.1\%$	∞
Liquid Permittivity (target)	$\pm 5.0\%$	R	$\sqrt{3}$	0.6	0.49	$\pm 1.7\%$	$\pm 1.4\%$	∞
Liquid Permittivity (meas.)	$\pm 2.5\%$	N	1	0.6	0.49	$\pm 1.5\%$	$\pm 1.2\%$	∞
Combined Std. Uncertainty						$\pm 12.8\%$	$\pm 12.7\%$	330
Expanded STD Uncertainty						$\pm 25.7\%$	$\pm 25.3\%$	

Table 26.4: Worst-Case uncertainty budget for DASY4 valid for the frequency range 5 - 6 GHz. Probe calibration error reflects uncertainty of the narrow-bandwidth EX3DV3 probe conversion factor (± 50 MHz).

26.7 References

- [1] IEEE Std. 1528-200X, *Draft CD 1.1* "Recommended Practice for Determining the Spatial-Peak Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques", December 2002.
- [2] CENELEC EN 50361, "Basic Standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones", July 2001.
- [3] IEC 62209, *Draft CD* "Procedure to measure the Specific Absorption Rate (SAR) for hand-held mobile wireless devices in the frequency range of 300 MHz to 3 GHz", November 2002.
- [4] NIST, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Technical Note 1297 (TN 1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, Gaithersburg, MD, 1994.
- [5] NIS 81, "The Treatment of Uncertainty in EMC measurements", Edition 1, NAMAS Executive, National Physical Laboratory, Teddington, Middlesex, TW11 0LW, England, 1994.

APPENDIX 9 : Power drift measurement

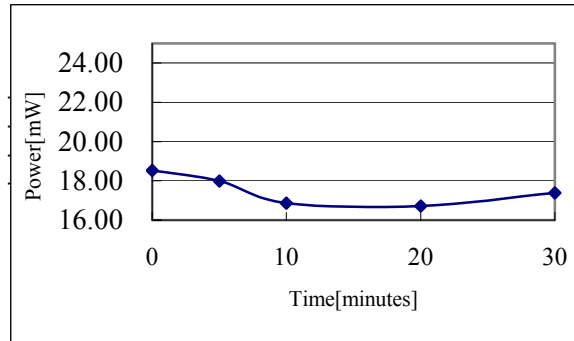
The power drift in the elapsed time was performed because the power drift effects the uncertainty of SAR measurement.

The average power was measured under the condition of Max. power of each frequency band.

The test result shows that the power drift exceeded 5%. Therefore, the uncertainty of power drift expanded to 10%.

5210 MHz Turbo mode

Time [Minutes]	Result [dBm]	Converted [mW]	Diviation [%]
0	12.68	18.54	-
5	12.55	17.99	-2.9
10	12.27	16.87	-9.0
20	12.23	16.71	-9.8
30	12.4	17.38	-6.2



5745 MHz Normal mode

Time [Minutes]	Result [dBm]	Converted [mW]	Diviation [%]
0	10.52	11.27	-
5	10.46	11.12	-1.4
10	10.09	10.21	-9.4
20	10.29	10.69	-5.2
30	10.11	10.26	-9.0

