Test Result

Mode:800MHz Analog

Frequency	<Left position>		<Right position>	
	Extended	Retracted	Extended	Retracted
824MHz	0.773 mW/g	1.13 mW/g	0.708 mW/g	1.02 mW/g
836MHz	0.751 mW/g	1.04 mW/g	0.815 mW/g	1.11 mW/g
849MHz	0.513 mW/g	0.919 mW/g	0.472 mW/g	0.851 mW/g

Mode:800MHz Digital

Frequency	<Left position>		<Right position>	
	Extended	Retracted	Extended	Retracted
824MHz	0.466 mW/g	0.663 mW/g	0.442 mW/g	0.637 mW/g
836MHz	0.383 mW/g	0.548 mW/g	0.394 mW/g	0.58 mW/g
849MHz	0.29 mW/g	0.504 mW/g	0.27 mW/g	0.486 mW/g

Mode:1900MHz Digital

Frequency	<Left position>		<Right position>	
	Extended	Retracted	Extended	Retracted
1850MHz	0.706 mW/g	0.923 mW/g	0.651 mW/g	0.823 mW/g
1880MHz	0.717 mW/g	0.939 mW/g	0.618 mW/g	0.769 mW/g
1910MHz	0.812 mW/g	1 mW/g	0.724 mW/g	0.867 mW/g

Temperature:22 degrees C

SAR for
L-battery
([illegible])

SAR was measured with the DASY3 system show in Figure 5.7 1.

Probe: ET3DV5-SN1340
Data Acquisition: DAE3SN340
Medium: Brain 900MHz
Device: MT253XF0R6A
Phantom: Generic Twin

Frequency(MHz)	824	836	849
ε r(permittivity)	40.48	40.23	39.86
σ (conductivity:mho/m)	0.705	0.712	0.72

Probe: ET3DV5-SN1340
Data Acquisition: DAE3SN340
Medium: Brain 1800MHz
Device: MT253XF0R6A
Phantom: Generic Twin

Frequency(MHz)	1850	1880	1910
ε r(permittivity)	37.41	37.34	37.03
σ (conductivity:mho/m)	1.86	1.89	1.94

Facsimile Transmission

MITSUBISHI ELECTRIC CORPORATION
COMMUNICATION SYSTEMS BUSINESS DIVISION

FAX : 81-6-497- 5226

TEL : 81-6-497-

DATE : 3 / 24 / 99

REF : E -

CC :

TO: MWCI

ATTN: Mr. Sims , Mr. Toko

FROM: Tanaka
Andoh

TOTAL No. of pages transmitted including this sheet: 62

RE: Description of DASY system

Please see attached descriptions.

1. Validation data based on Dipole : Attachment 1 (P2 ~ P15)(14 pages)
2. Field scan, documents : Attachment 2 (P.16 ~ P.22) (7 pages)
3. Data analysis and extrapolation (= Technical Info) : Attachment 3 (13 pages) (P.23 ~ P.35)
4. E-field probe calibration data : Attachment 4 (17 pages) (P.36 ~ P.52)
5. Standard procedures or protocol (= SAR measurement, Phantom, etc.) : Attachment 5 (6 pages) (P.53 ~ P.58)
6. Characterizing the tissue material :
   This description is included in Attachment 3, 5.5 Recipes For Brain Tissue Simulating Liquid.

And, we also send "System Description" in Attachment 6. (P.59 ~ P.62) (4 page)

Please check if these are enough or not.

Thank you,

Schmid & Partner
Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

Calibration Certificate

900 MHz System Validation Dipole

Type:	D900V2
Serial Number:	027
Place of Calibration:	Zurich
Date of Calibration:	Jan. 4, 1998
Calibration Interval:	24 months

Schmid & Partner Engineering AG hereby certifies, that this device has been calibrated on the date indicated above. The calibration was performed in accordance with specifications and procedures of Schmid & Partner Engineering AG.

Whereever applicable, the standards used in the calibration process are traceable to international standards. In all other cases the standards of the Laboratory for EMF and Microwave Electronics at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland have been applied.

Calibrated by:

Approved by:

Schmid & Partner
Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

DASY

Dipole Validation Kit

Type: D900V2

Serial: 027

Manufactured: December 1997
Calibrated: January 1998

1. Measurement Conditions

The measurements were performed in the flat section of the new generic twin phantom (shell thickness 2mm) filled with brain simulating sugar solution of the following electrical parameters at 900 MHz:

Relative Dielectricity	**42.3**	± 5%
Conductivity	**0.85 mho/m**	± 5%

The DASY3 System (Software version 1.0a) with a dosimetric E-field probe ET3DV4 (SN:1302, Conversion factor 5.5) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the centre marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15mm from dipole centre to the solution surface. The included distance holder was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 15mm was aligned with the dipole. The 5x5x7 fine cube was chosen for cube integration. Probe isotropy errors were cancelled by measuring the SAR with normal and 90° turned probe orientations and averaging. The dipole input power (forward power) was 250mW ± 3 %. The results are normalised to 1W input power.

2. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 1. The results have been normalised to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm^3 (1 g) of tissue:	**9.32 mW/g**
averaged over 10 cm^3 (10 g) of tissue:	**6.12 mW/g**

Note: If the liquid parameters for validation are slightly different from the ones used for initial calibration, the SAR-values will be different as well. The estimated sensitivities of SAR-values and penetration depths to the liquid parameters are listed in the DASY Application Note 4: 'SAR Sensitivities'.

3. Dipole Impedance and return loss

The impedance was measured at the SMA-connector with a network analyser and numerically transformed to the dipole feedpoint. The transformation parameters from the SMA-connector to the dipole feedpoint are:

Electrical delay:	**1.406 ns**	(one direction)
Transmission factor:	**0.987**	(voltage transmission, one direction)

The dipole was positioned at the flat phantom sections according to section 1 and the distance holder was in place during impedance measurements.

Feedpoint impedance at 900 MHz:	Re{Z} = **50.04 Ω**
	Im {Z} = **-0.01 Ω**
Return Loss at 900 MHz	**- 54.5 dB**

4. Handling

The dipole is made of standard semirigid coaxial cable. The centre conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

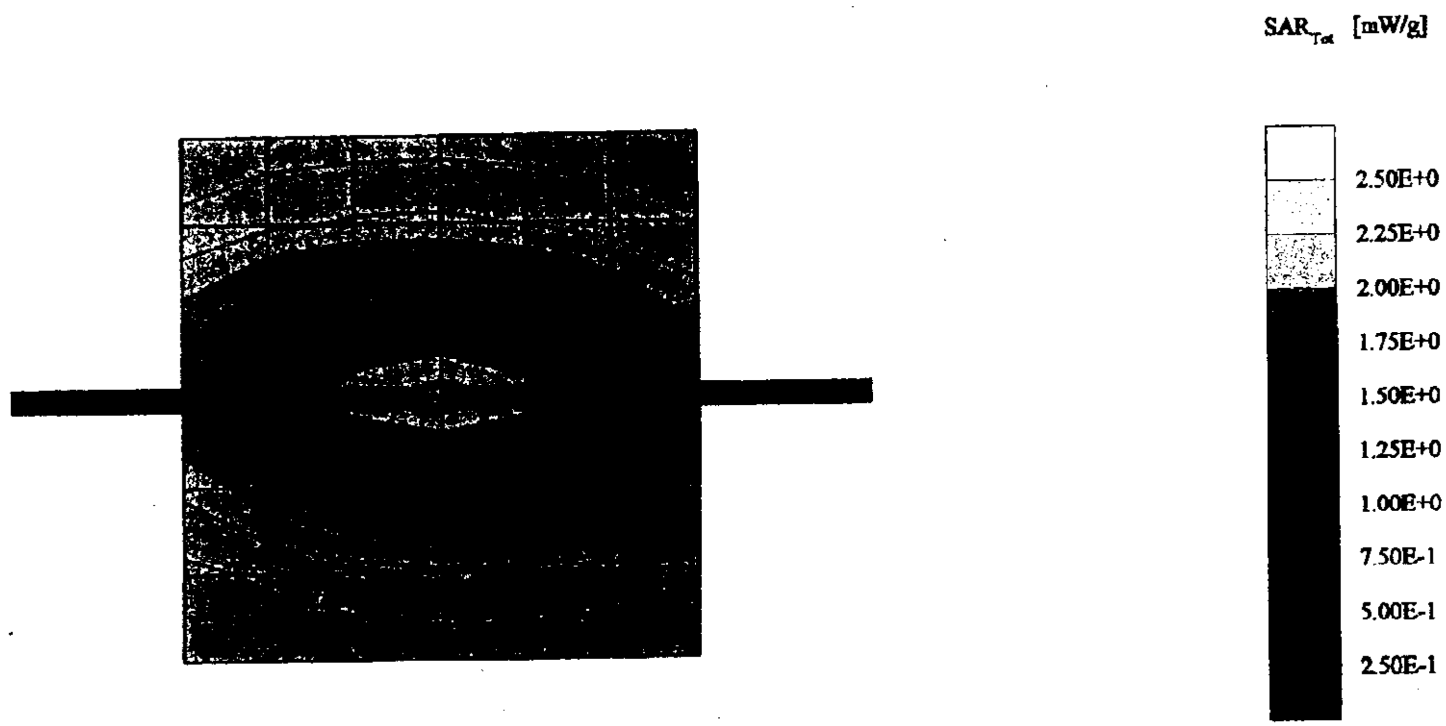
Do not apply excessive force to the dipole arms, because they might bend. If the dipole arms have to be bent back, take care to release stress to the soldered connections near the feedpoint; they might come off.

After prolonged use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

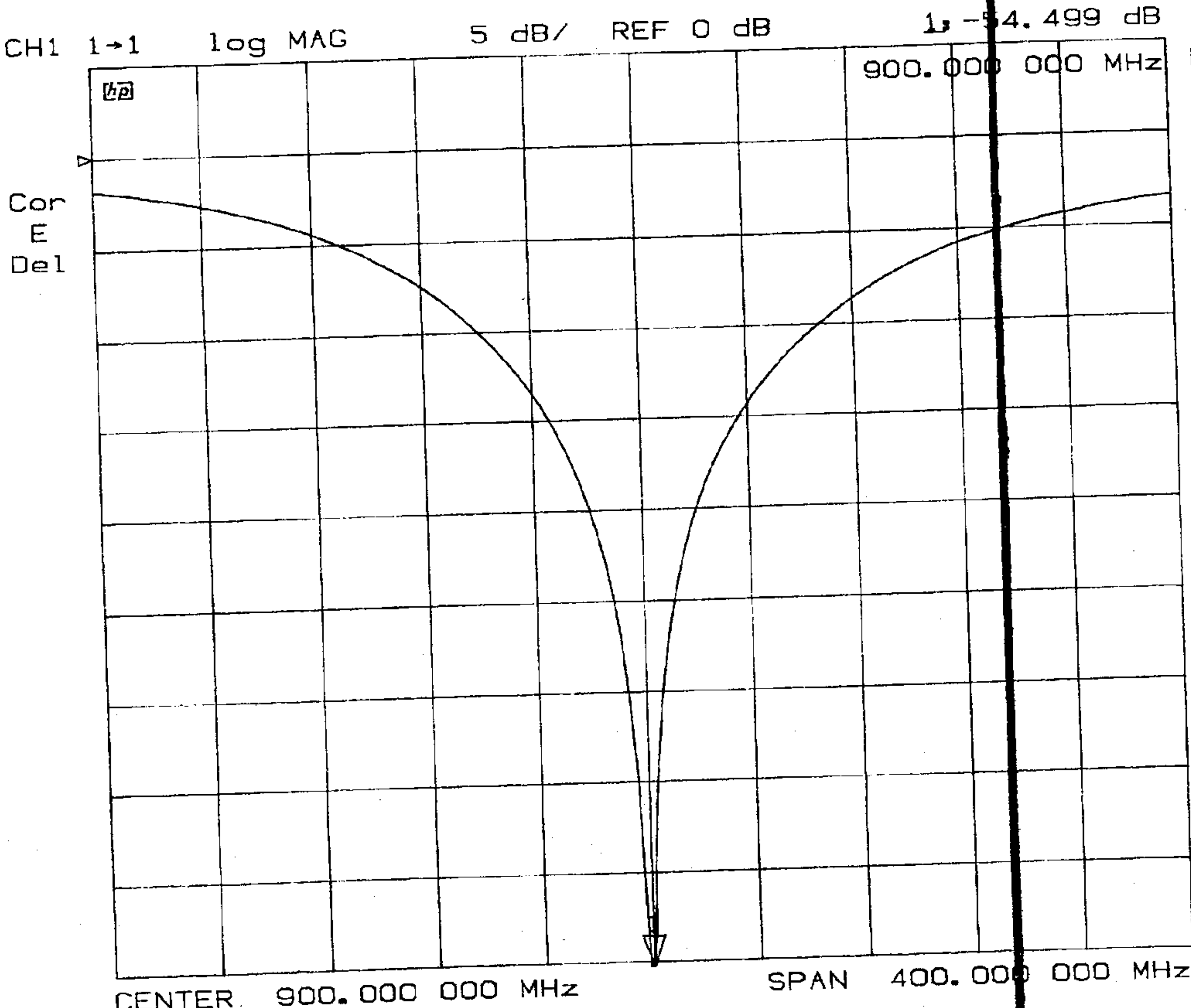
File: Validation SN027, 11/29/97

Validation Dipole D900V2 SN:027, d = 15mm

Frequency: 900 [MHz]; Antenna Input Power: 250 [mW]
Generic Twin Phantom; Flat Section; Grid Spacing: Dx = 15.0, Dy = 15.0, Dz = 10.0 [mm]
Probe: ET3DV5 - SN1302 DAE3; ConvF(5.40,5.40,5.40); Crest factor: 1.0; }: σ = 0.85 [mho/m] ε_r = 42.3 ρ = 1.00 [g/cm³]
Cubes (2): Peak: 3.54 [mW/g] ± 0.03 dB, SAR (1g): 2.33 [mW/g] ± 0.03 dB, SAR (10g): 1.53 [mW/g] ± 0.04 dB, (Worst-case extrapolation)
Penetration depth: 13.0 (12.0, 14.4) [mm]
Powerdrift: 0.03 dB



Schmid & Partner Engineering AG. Zürich Switzerland



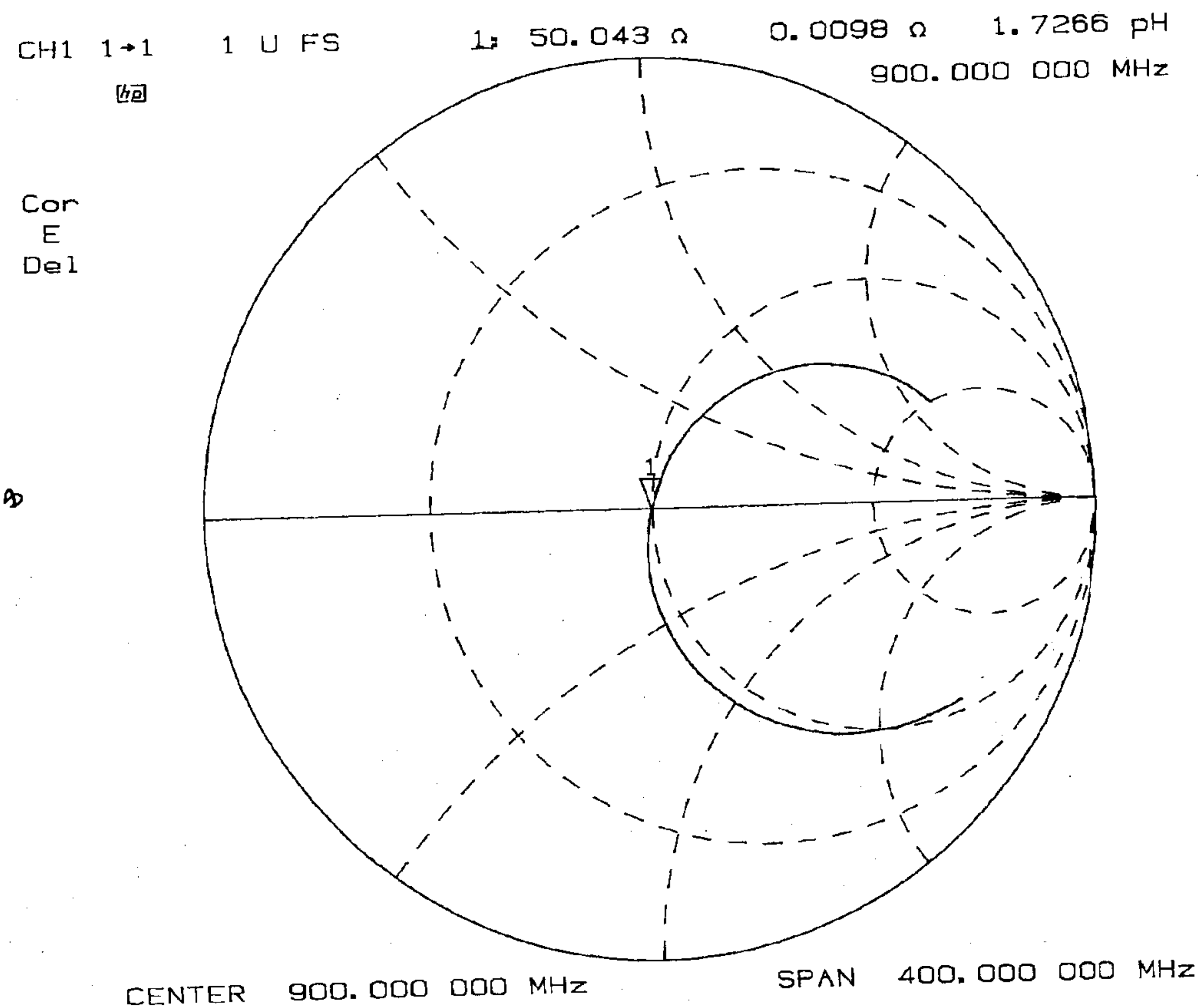
D900V2 SN: 027

S11

Flat phantom with brain simulating solution

d = 15mm

(distance from dipole center to solution)



D900V2 SN: 027

S11

Flat phantom with brain simulating solution

d = 15mm

(distance from dipole center to solution)

Schmid & Partner Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

Calibration Certificate

1800 MHz System Validation Dipole

Type:	D1800V2
Serial Number:	222
Place of Calibration:	Zurich
Date of Calibration:	Jan. 2, 1998
Calibration Interval:	24 months

Schmid & Partner Engineering AG hereby certifies, that this device has been calibrated on the date indicated above. The calibration was performed in accordance with specifications and procedures of Schmid & Partner Engineering AG.

Whereever applicable, the standards used in the calibration process are traceable to international standards. In all other cases the standards of the Laboratory for EMF and Microwave Electronics at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland have been applied.

Calibrated by: Thomas Schmid

Approved by: N. Kuster

Schmid & Partner
Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

DASY3

Dipole Validation Kit

Type: D1800V2

Serial: 222

Manufactured: December 1997
Calibrated: January 1998

1. Measurement Conditions

The measurements were performed in the flat section of the new generic twin phantom (shell thickness 2mm) filled with brain simulating sugar solution of the following electrical parameters at 1800 MHz:

Relative Dielectricity	**39.5**	± 5%
Conductivity	**1.70 mho/m**	± 10%

The DASY3 System (Software version 3.0b) with a dosimetric E-field probe ET3DV4 (SN:1302, conversion factor 4.6) was used for the measurements.

The dipole feedpoint was positioned below the centre marking and oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole centre to the solution surface. The included distance holder was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 15mm was aligned with the dipole. The 5x5x7 fine cube was chosen for cube integration. Probe isotropy errors were cancelled by measuring the SAR with normal and 90° turned probe orientations and averaging. The dipole input power (forward power) was 250mW ± 3 %. The results are normalised to 1W input power.

2. SAR Measurement

Standard SAR-measurements were performed with the head phantom according to the measurement conditions described in section 1. The results (see figure) have been normalised to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm^3 (1 g) of tissue:	**39.4 mW/g**
averaged over 10 cm^3 (10 g) of tissue:	**19.9 mW/g**

Note: If the liquid parameters for validation are slightly different from the ones used for initial calibration, the SAR-values will be different as well. The estimated sensitivities of SAR-values and penetration depths to the liquid parameters are listed in the DASY Application Note 4: 'SAR Sensitivities'.

3. Dipole Impedanc and return loss

The impedance was measured at the SMA-connector with a network analyser and numerically transformed to the dipole feedpoint. The transformation parameters from the SMA-connector to the dipole feedpoint are:

Electrical delay:	**1.193 ns**	(one direction)
Transmission factor:	**0.990**	(voltage transmission, one direction)

The dipole was positioned at the flat phantom sections according to section 1 and the distance holder was in place during impedance measurements.

Feedpoint impedance at 1800 MHz:	Re{Z} = **49.8 Ω**
	Im {Z} = **-1.0 Ω**
Return Loss at 1800 MHz	**- 39.6 dB**

4. Handling

The dipole is made of standard semirigid coaxial cable. The centre conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

Do not apply excessive force to the dipole arms, because they might bend. If the dipole arms have to be bent back, take care to release stress to the soldered connections near the feedpoint; they might come off.

After prolonged use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

File: Validation SN222, 01/03/98

Validation Dipole D1800V2 SN:222, d = 10mm

Frequency: 1800 [MHz]; Antenna Input Power: 250 [mW]
Generic Twin Phantom; Flat Section; Grid Spacing: Dx = 15.0, Dy = 15.0, Dz = 10.0 [mm]
Probe: ET3DV5 - SN1302 DAE3; ConvF(4.60,4.60,4.60); Crest factor: 1.0; }: σ = 1.70 [mho/m] ε_r = 39.5 ρ = 1.00 [g/cm³]
Cubes (2): Peak: 18.9 [mW/g] ± 0.00 dB, SAR (1g): 9.86 [mW/g] ± 0.01 dB, SAR (10g): 4.98 [mW/g] ± 0.02 dB, (Worst-case extrapolation)
Penetration depth: 7.4 (7.2, 7.9) [mm]
Powerdrift: 0.03 dB

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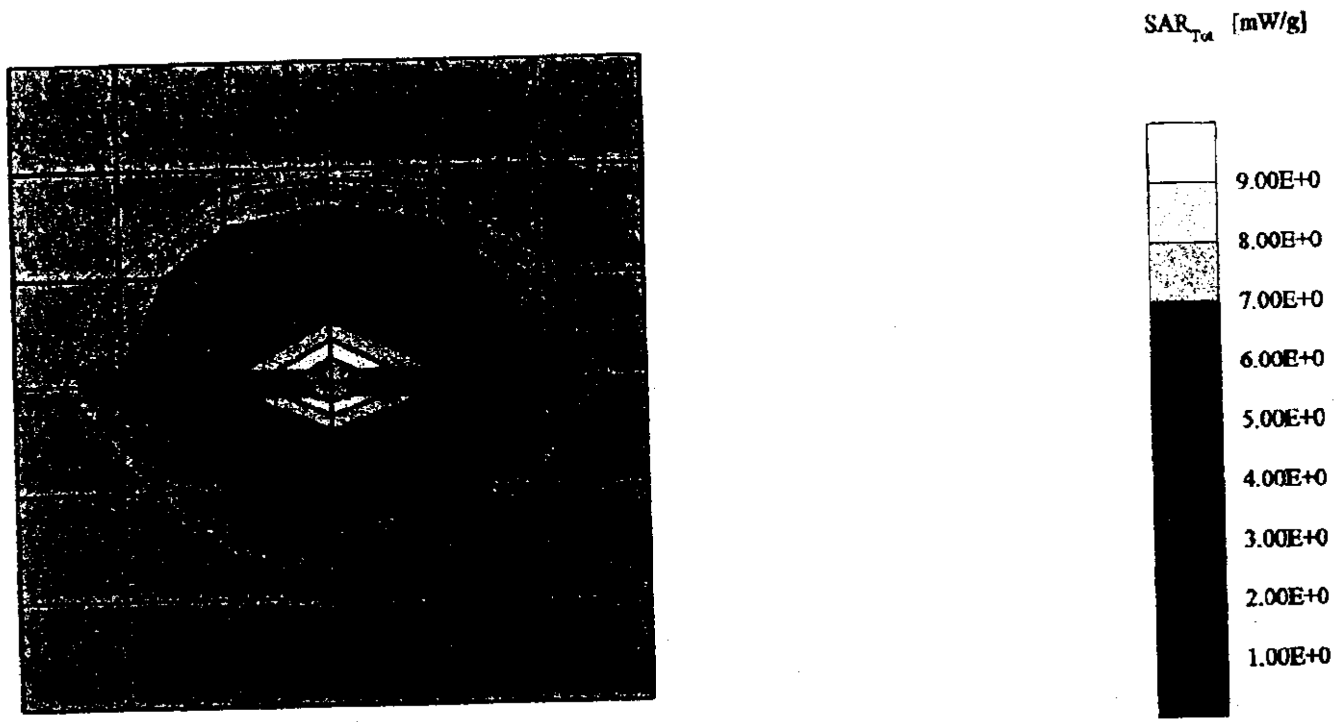
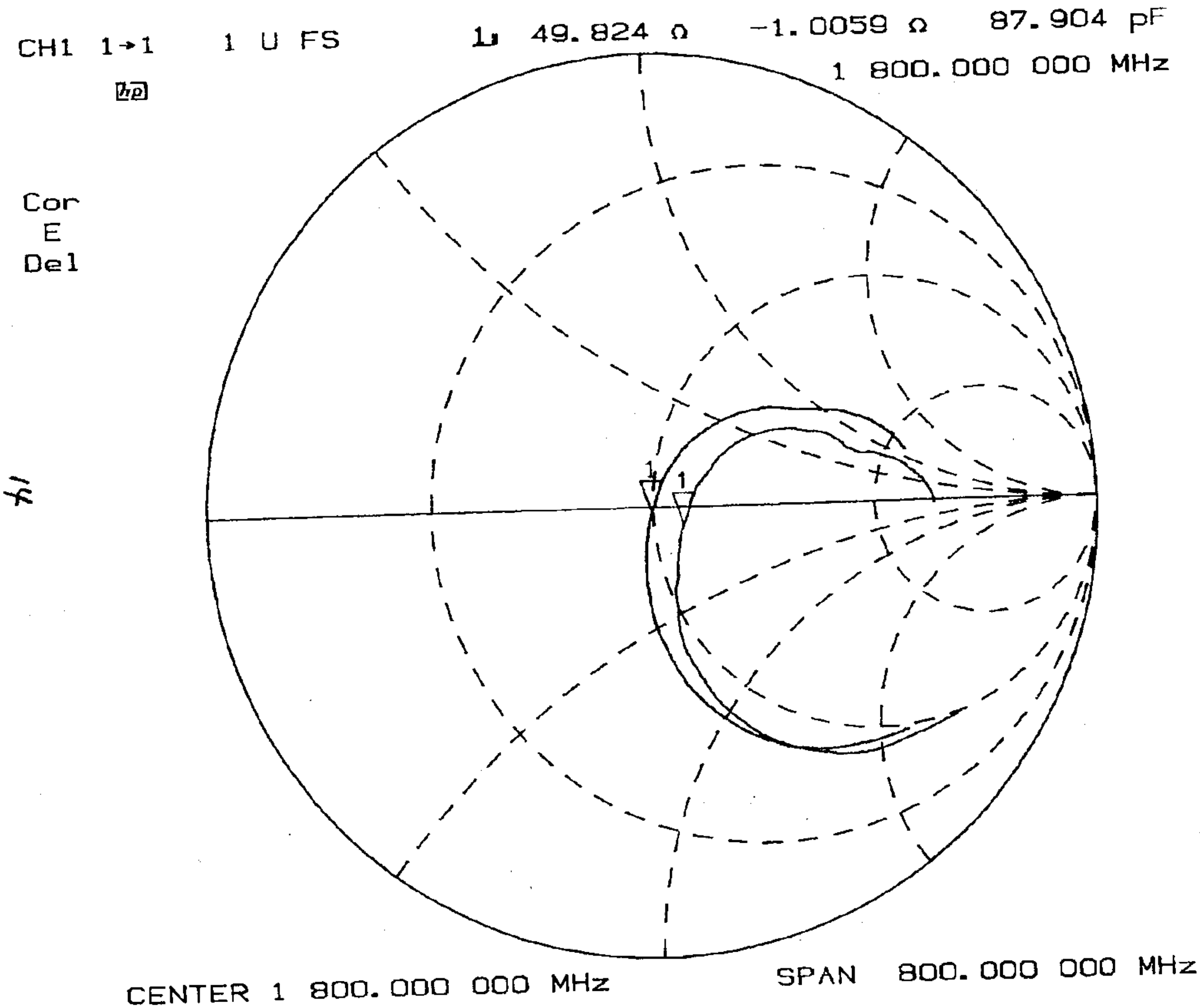


Schmid & Partner Engineering AG. Zürich Switzerland



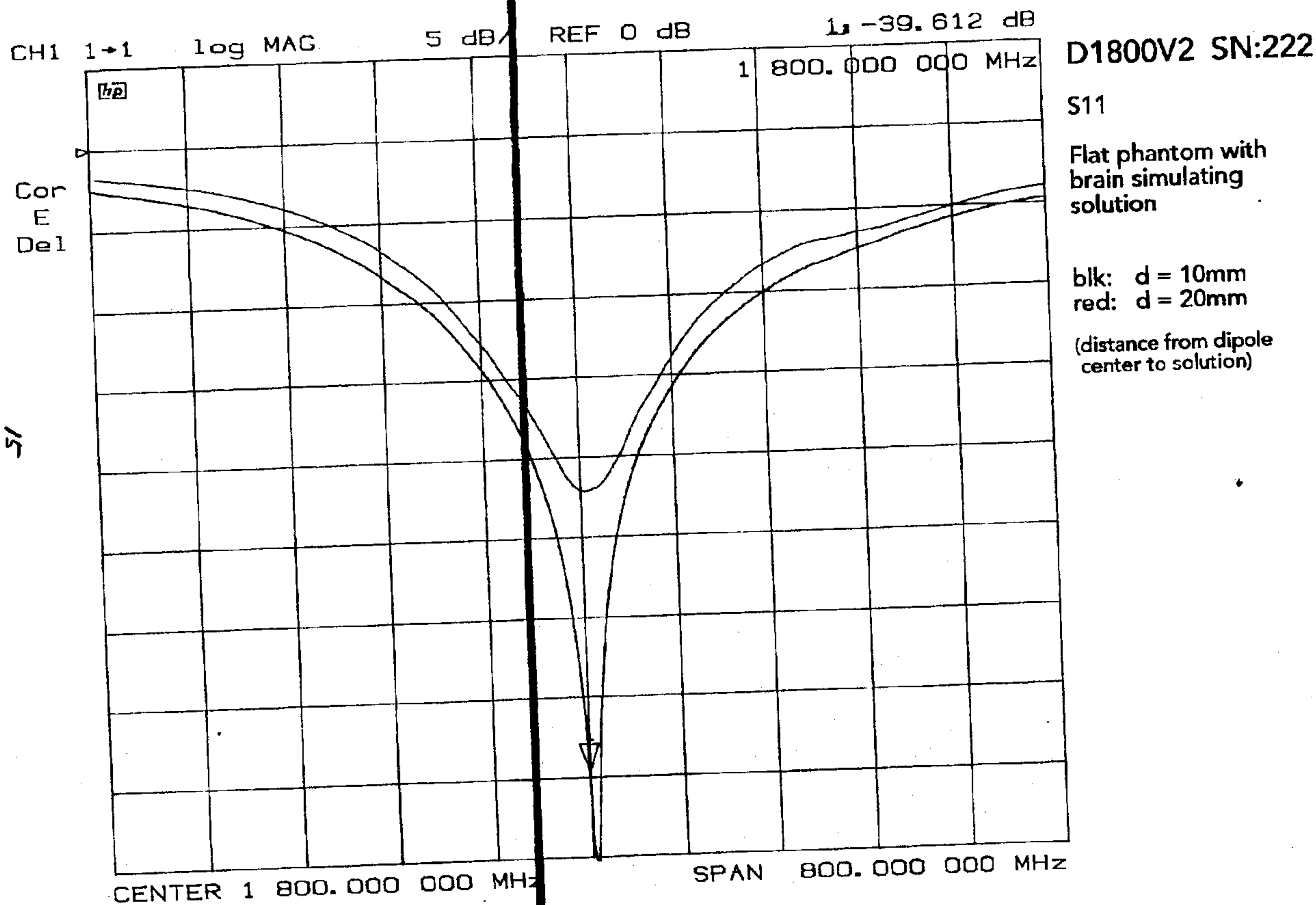
D1800V2 SN:222

S11

Flat phantom with brain simulating solution

blk: d = 10mm
red: d = 20mm

(distance from dipole center to solution)


CH1 1→1 log MAG 5 dB/ REF 0 dB 1; -39.612 dB
1 800.000 000 MHz
Cor
E
Del
CENTER 1 800.000 000 MHz
SPAN 800.000 000 MHz
D1800V2 SN:222
S11
Flat phantom with brain simulating solution
blk: d = 10mm
red: d = 20mm
(distance from dipole center to solution)

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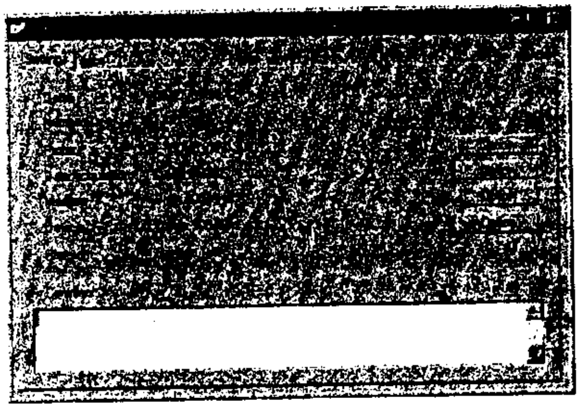
3.5 Field Scans, Documents

Select 'File New' to create a new measurement document. The document has two pages, a 'Settings' – page and a 'Jobs'-page.



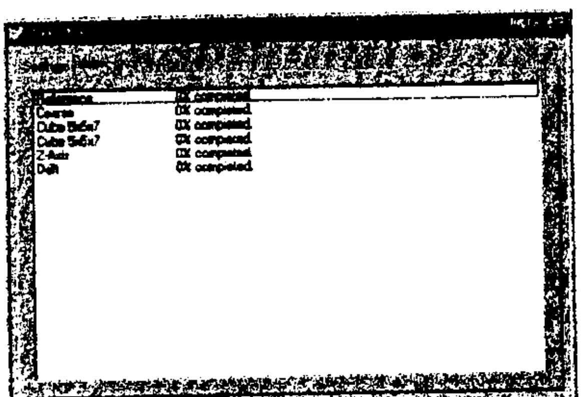
The 'Settings'-page displays the measurement date, measurement number and measurement environment.

Each measurement document is limited to a set of one of each of the following: probe, data acquisition, medium, and phantom. (e.g. for two different frequencies two measurement documents are required).

When a measurement document is opened the configuration of the setup are copied into the document and continually updated until the actual measurement has been performed.

Pressing 'Option' displays the parameters of each resource.

Any written comment can be entered into the 'Comment' field.



The 'Jobs'-page contains a list of the various tasks that have to be performed for a given measurement. The example shows the first task to be a reference measurement above the device point (Reference), search for a maximum (Coarse), and then two cube scans to determine average SAR-values; and finally a z-Axis measurement followed uup by a drift measurement to check the power drift of the device. An explantion of the jobs is given in the next chapter.

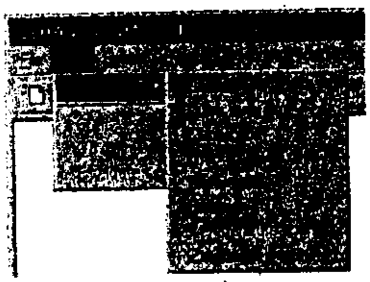
Jobs can be removed with the 'Delete'-Key.

3.5.1 Scans

The position enables automated field scans to be made along lines, across planes or within volumes. The field is measured at discrete points, and the raw data from the probe is stored together with the position information from the robot and all involved calibration parameters.

A field scan can be defined as a free space scan or can be related to a phantom using automatic grid adaptation to the phantom boundary, automatic detection of the phantom surface, etc.

To start scans or jobs select the scans to measure and select 'Job Start'. A dialog will display a statistics of the scan (estimated time, values of last measured point). Pressing the 'stop' – button will stop the current scan, and the percentage of the points measured will be shown. A scan can be resumed if 'Job Start' is pressed again.



New Scans (and Jobs) can be inserted with the 'Job Scan ...' menu. Scans can be inserted depending on the measuring setup (e.g. Temperature scan is not possible with an E-field probe).

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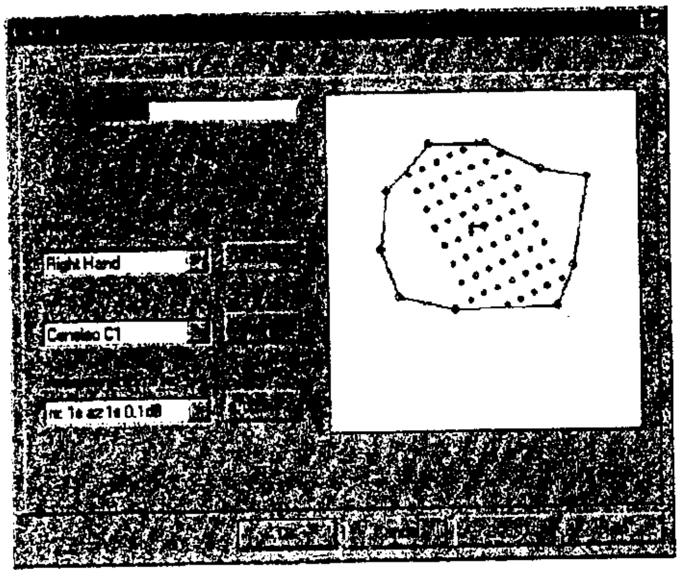
3.5.1.1 Coarse Scan

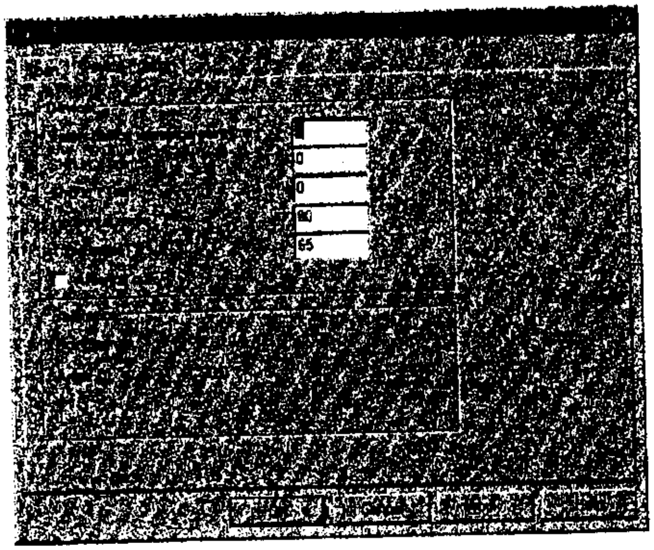
Coarse scans are used for the quick measurement of the field distribution in a wider area and the determination for the interpolated maximum.



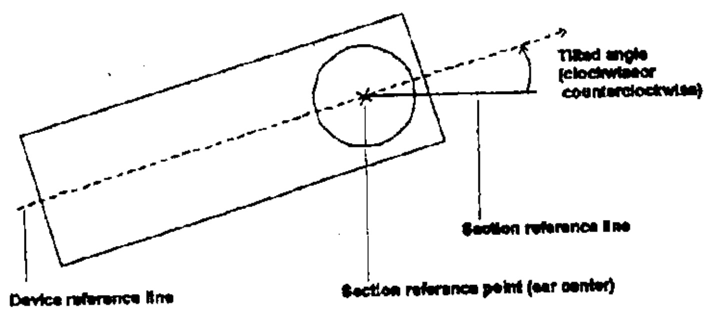
In the 'Scan'-page of the section, the grid to measure and the measurement profile (time and accuracy settings) have to be selected (current section and grid are displayed on the right).

If you press option the parameters of the section, grid and measurement profile can be examined at and changed (see Phantom, page 33 and Measurement Profiles, page 31). To define new grids for coarse scan measurements change to the phantom setup.

If a device with graphics has been defined the parameters for the device position can be defined:



Grid coordinate angle and offset with respect to the reference point and direction are defined in the grid menu (e.g. if you want to have the grid the same alignment as the device, the tilted angle of the device position should correspond to the grid rotation).



The reference point of the section determines the location of the device in the graphics. Device angles can be changed for each scan.

Example positions:

Position	horizontal angle	tilted angle
intended use	80°	65° (C1)
touching position	until touching head (<80°)	65° (C1)
100° position	100°	65° (C1)
30° tilted position	90°	35° (C2)

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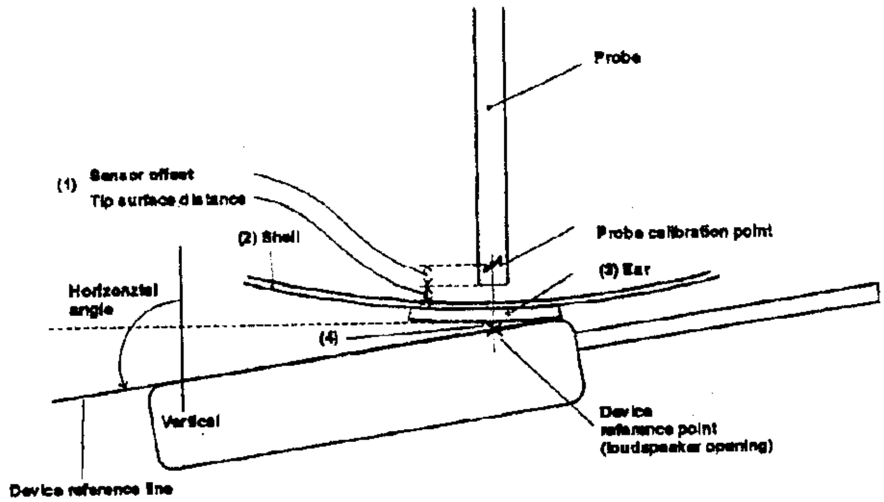
The device will be shown below the reference point of the section. The distance can be calculated approximately as follows:



Probe dipole point to surface of phantom (1): (Depends on how the device point was teached)	ca 4 mm
Thickness of phantom shell (2):	2 mm
Thickness of ear (3):	2 mm
Distance of device ear point to phantom (4): (Depending on position of device)	0 mm
Total	8 mm

If the device should be shifted, change the device reference point (e.g. if a free space grid should be centered at the antenna feed point, use the antenna feed point as device reference point and shift the ear center position to the antenna feed point).

If only small shifts are needed you can add a shift in x-direction and y-direction (***Note:** coordinate system is that of the phantom for these distances*).

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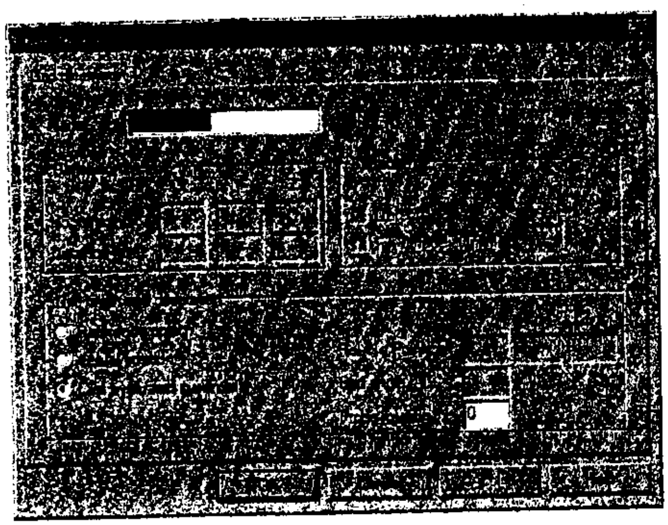
3.5.1.2 Cube Scan (4x4x7, 5x5x7)

Cube Scans are used to determine the averaged SAR-distribution for 1g and 10g. These two scans (Cube 5x5x7 whole frequency range, Cube 4x4x7 frequency smaller than one 1 GHz) can only be used when an E-field probe is selected and the medium is a tissue simulating liquid.

If you press 'Options' on the grid page, the following dialog is displayed:



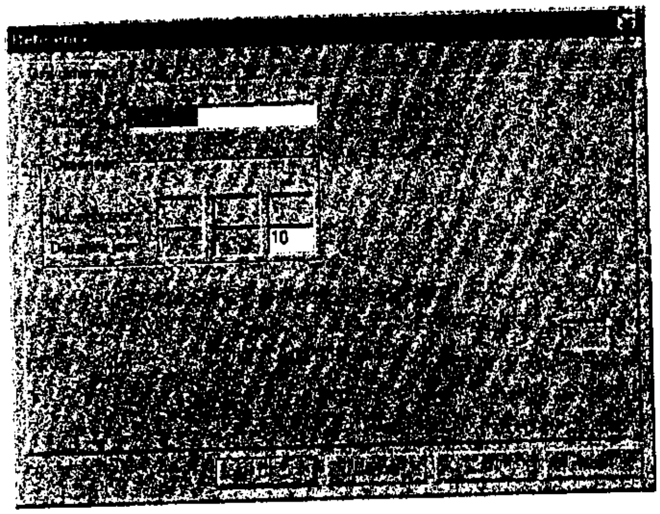
If 'Last evaluated maximum' is checked, the cube will be centered at the last evaluated maximum in a previous scan and the surface detection parameters will be adjusted accordingly. An additional probe rotation can be added (e.g. see System Validation, page 72).

If a cube has to be measured at the current position or reference point the grid angle and surface detection have to be adjusted.

2/

3.5.1.3 Reference and Drift scan

DASY3 supports the measurement of the power drift of the device over different scans. To measure the power drift, the reference scan has to be first selected. If you press options on the grid page, the following dialog is displayed:



The power reference measurement will move the probe the z-distance (e.g. 10 mm) above the reference point of the section. Therefore it is important that the reference point has been chosen at the proper height.

To measure the power drift add the drift scan after the end of the measurement scan. A reference scan has to be inserted previously. The probe will move to the same location of the reference scan and then the difference in dB of the previous and the current values will be calculated.

Reference	8.24 V/m
Coarse	Max at 46.0, 52.0, 3.9
Cube 4x4x7	SAR (1g): 0.380 [mW/g], SAR (10g): 0.225 [mW/g]
Drift	0.29 dB
Cube 5x5x7	SAR (1g): 0.388 [mW/g], SAR (10g): 0.226 [mW/g]
Drift	0.27 dB
Reference	8.50 V/m
Drift	-0.01 dB

5. TECHNICAL INFO

The following chapters are appended to the User manual to add a deeper understanding of how DASY3 works, and what steps are necessary to guarantee exact measurements.

- Data Evaluation
- Cube Evaluation
- Software Verification
- Grounding Problems
- Recipes For Brain Tissue Simulating Liquids

5.1 Data Evaluation

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. This compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for the peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with V_i = compensated signal of channel i (i = x,y,z)
$U_i[\mu V]$ = input signal of channel i (i = x,y,z)
cf = crest factor of exciting field (DASY parameter)
dcp_i = diode compression point in mV (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated as follows, depending on the probe type:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}} \qquad H_i = \sqrt{Vi} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$$

with V_i = compensated signal of channel i (i = x,y,z)
$Norm_i$ = sensor sensitivity of channel i (i = x,y,z) $\mu V/(V/m)^2$ for E-field Probes
a_{ij} = sensor sensitivity at 1 GHz for H-field probes
ConvF = sensitivity enhancement in solution
f = carrier frequency [GHz]
E_i = electric field strength of channel i in V/m
H_i = magnetic field strength of channel i in A/m

The total field strength (Hermitic magnitude) can be calculated by taking the RSS value of the field components.

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with SAR = local specific absorption rate in mW/g
E_{tot} = total field strength in V/m
σ = solution conductivity in Siemens (mho)
ρ = solution density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for the actual brain density. (Parameter simulating tissue density).

The power flow density is calculated assuming the exciting field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^{2}}{3770}$$

with P_{pwe} = equivalent power density of a plane wave in mW/cm^2
E_{tot} = total field strength in V/m

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5.2 Cube Evaluation

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube - measurements have been done. If you change any parameter afterwards with 'File Modify' (for example crest factor or medium factors) you will have to reevaluate the measurements. This evaluation can be repeated, if your press Job Evaluation on the selected scans. The algorithm that finds the maximal averaged volume is divided into three different stages.

(1) The data between the dipole center of the probe and the surface of the phantom is extrapolated. This data cannot be measured, since the center of the dipoles is 2.7 mm away form the tip of the probe and the distance between the surface and the lowest measuring point is ca 1 mm (see probe calibration sheet). You can visualize the extrapolated data from a cube measurement if you select Graph Evaluated.

(2) The maximal interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.

(3) All neighboring volumes are evaluated until no neighboring volume with a higher average value is found.

Extrapolation
The extrapolation is based on a least square algorithm [W. Gander, Computermathematik, p.168-180]. Through the points in all z-axis polynomials of order four are calculated. This polynomial is then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from one another.

Interpolation
The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computermathematik, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff].

Volume Averaging
Firstly the size of the cube is calculated. The volume is integrated with the trapezoidal - algorithm. 1000 points (10x10x10) are interpolated to calculate the average.

Advanced Extrapolation
The BIOEMC group of the ETH Zurich is currently investigating the boundary effects on E-field probes. As soon as the research is finished DASY3 will

allow to compensate for these boundary effects. But until then we do not encourage to use the 'Advanced Extrapolation' – option.

5.3 Software Verification

The Software DASY3 V3 has been written specifically for the measurement of SAR in liquid filled shell phantoms and has been thoroughly tested. During SAR measurements, the software performs the following tasks:

- Generates a measurement grid and sends the grid positions to the robot controller. The robot will perform a slow downward movement at each grid position.
- Filters and evaluates the signal from the surface detector to stop the surface approach within a defined distance from the surface.
- Reads the data from the data acquisition electronics (DAE2 or DAE3) and evaluates the field strength using the software parameters from the probe, liquid and device.
- During a fine cube measurement (for integrated SAR-values), moves the probe backward from the surface in several steps and measures the field values are.
- Extrapolates the measured fine cube values to the surface. A numerical process then searches within the measured and extrapolated cube for the 1g and 10g volume which yields the highest averaged SAR values. Integrated SAR values are calculated in mW/g using the parameter for tissue density.

All of these procedures influence the final integrated SAR value and are specifically adapted and tested for the specified task. To make the whole measurement process transparent and accessible for validation, the data are stored in the measurement file (.DA3 extension) in the following format:

- The assessed data from the data acquisition electronics are stored as raw data (as microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data). The evaluation is done at the moment of data visualization or export of the evaluated data to other file formats. The measurement file can be used to check (or change in case of erroneous values) the correct parameter settings and repeat the evaluation. Raw data can also be exported to perform the evaluation with other software packages.
- The surface positions stored in the measurement file are the actual robot positions read from the robot controller as well as the measurement grid positions sent to the robot. Visualization is based on actual robot positions. Any failure in the software to calculate or transmit the correct positions would be visible in the graphics and traceable in the exported data.

The standard system validation procedure uses a calibrated dipole at a specified distance (with spacer) and position from the phantom. The dipole

5.4.2 Measurement of the System Noise and Offset

The multimeter in the DASY3 software lets you access the DAE. You can directly measure the input signals of the three channels in microvolts.

The statistics beside the channel signal values provide maximum values, minimum values and standard deviations. The standard deviation is taken from the filtered signals; with no filtering, the standard deviation is a direct measure of the input noise.

The filter is a notch filter on the power line frequency and all its harmonics. (The power line frequency can be set in the options of the PC-Board).

To check the setup, measure the offset voltage of the input channels in microvolts when everything is in place but the signal source is switched off. In ideal situations the offset in each channel should be within ± 1 µV; under realistic measuring conditions offset values within ± 3 µV should be reached. If this value is exceeded, it is most likely due to interference from high field strengths in the probe area. These fields can often be considerably reduced by proper grounding of the systems components. The disturbing fields can have many sources, which can be different in each laboratory.

- Static charges in the setup
- ELF-fields from power lines
- other RF-fields

It is therefore not possible to indicate a general method for grounding. The best strategy must be determined at each site. In the following sections we indicate some measures which might prove helpful in the above mentioned situations. A grounding point is provided in the system (2mm connector in the front of the data acquisition electronic box).

If you encounter a constant offset independent of the probe position, you can compensate for it via the software in the multimeter-offset page.

5.4.3 Strategies to Reduce System Noise (Offset)

Laboratory
If the offset is too high (> ± 3 µV) and the probe is freestanding, check the laboratory for disturbing field sources (ELF or RF).

Static charges
People are excellent vehicles for static charges. Do not move around within about 50cm of the measurement site when you want to do very sensitive measurements. Never touch the phantom during a measurement, even from the outside - the charge you carry around will likely produce an AD-overflow and abort the measurement. If you have to touch the phantom during a

measurement, you must ground the phantom and yourself beforehand. (Use resistive cable or antistatic arm wrists to ground yourself.)

Measurements without phantom
When the measured device is floating (no ground connection, e.g., mobile phones), there is generally no further problem. If you use grounded radiating systems, the different grounding systems normally used for robot and exposure systems can produce high signals between the probe and measured device due to ground loops.

If the measured field is confined within an exposure system (e.g., measurements in small TEM-cells or in Waveguides), the DAE can be directly connected to the outside metallic structures of the exposure system.

In open field situations such a direct connection might influence the field to be measured. If the offset is still too high, connect the exposure equipment to a power line outlet (electrically) near the power connection.

Measurements in phantoms
Regarding ground loop problems, everything said in the last section applies here as well. Additionally, there might be some problems with static charges when moving the probe around in liquid. In that case you should connect the liquid to a grounding point. If this is not sufficient, the DAE can be connected with a resistive line to a grounding point as well.

5.5 Recipes For Brain Tissue Simulating Liquids

5.5.1 Dielectric Parameters of Brain Tissue

For the measurements of the field distribution inside the generic twin phantom with DASY3, the phantom must be filled with 20 liters of homogeneous brain tissue simulating liquid. The liquid should have dielectric parameters as similar as possible to those of the human brain. The table below lists the dielectric parameters of brain tissue as measured by C. Gabriel [1]. More detailed information about the dielectric parameters of tissues can be found in the literature [2][3][4].

brain tissue	880 MHz		1780MHz	
	ε_r±SD	σ±SD in S/m	ε_r±SD	σ±SD in S/m
Gray brain matter	51.4±3.6	1.06±0.11	49.5±3.6	1.44±0.12
White brain matter	34.0±3.1	0.59±0.09	32.6±2.9	0.84±0.11
Cerebellum	49.8±3.0	1.06±0.07	48.0±2.9	1.43±0.07
Cerebrospinal fluid	78.1±0.1	1.97±0.01	77.3±0.1	2.55±0.01

5.5.2 Ingredients

Water: deionized water (pure H_2O) — as basis for the liquid

Sugar: refined sugar in crystals, as available in food shops — to reduce relative permittivity

Salt: pure NaCl — increase conductivity

Cellulose: Hydroxyethyl-cellulose, medium viscosity (powder, 75-125 mPa s, 2% in water, 20°) — to increase viscosity and to keep sugar in solution

Preservative substance: Preventol D-7, Bayer AG, D-51368 Leverkusen — to prevent the spread of bacteria and molds

5.5.3 Recipes

Ingredient	900 MHz			1800 MHz		
Water	40.16 %	3.46 l	10.30 l	53.93 %	4.17 l	11.44 l
Cellulose	1.00 %	86.0 g	256.0 g	1.00 %	93.0 g	255.1 g
Salt	0.69 %	59.6 g	177.4 g	-	-	-
Preventol	0.10 %	9.0 g	26.8 g	0.10 %	9.0 g	24.7 g
Sugar	58.04 %	5.00 kg	14.88 kg	44.97 %	5.00 kg	13.72 kg
Total amount	-	6.71	20.0 l	-	7.3 l	20.0 l
Dielectric Parameters at 20°	$\varepsilon_r = 42.5$ $\sigma = 0.85$ S/m			$\varepsilon_r = 41.0$ $\sigma = 1.65$ S/m		

5.5.4 Preparation

The following sequence of steps has been tried and tested and is therefore recommended for the preparation of the liquid. A hotplate/magnetic stirrer should be used, and a glass container is recommended. Both items are standard chemical laboratory equipment and can be purchased by corresponding companies.

1. Fill the **water** into the container. Begin heating and stirring.
2. Add the **cellulose**, the **preservative substance** and the **salt** (only for the 900 MHz liquid). After some hours, the liquid will become more transparent again. The container must be covered to prevent evaporation.
3. Add the **sugar**. Hand stirring will probably be necessary at the beginning until the sugar is sufficiently dissolved.
4. Keep the liquid hot but below the boiling point for at least 12 hours, while continuously stirring. The container must be covered to prevent evaporation.

5.5.5 Tips and Remarks

- The brain tissue simulating liquid can be used for several months. If the liquid begins to become lumpy, heating and stirring is recommended to redissolve the lumps.
- The dielectric parameters may change slightly with time. Therefore, periodic measurement of the parameters is recommended.

- If another preservative substance is used instead of Preventol, the required amount of salt may change, since Preventol increases the conductivity.
- If an organic preservative substance is used, it must be verified that the substance does not dissolve the Epoxy used in the probes.
- If the measured dielectric parameters are not within the required range, additional salt can be used to increase the conductivity, sugar to reduce the relative permittivity and water to increase the relative permittivity.

References

[1] C. Gabriel, *private communications*, 1995.

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

[3] 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.*, vol. 41, pp. 2251-2269, 1996.

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

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5.5.6 Testing Brain Simulating Liquid

1. Turn NWA on and allow at least 30 min. warm up.
2. Mount dielectric probe kit so that interconnecting cable to NWA will not be moved during measurements or calibration.
3. Pour de-ionized water and measure water temperature (±1°).
4. Set water temperature in HP-Software (Calibration Setup).
5. Perform calibration.
6. Validate calibration with dielectric material of known properties (e.g. polished ceramic slab with >8mm thickness $\varepsilon'=10.0$, $\varepsilon''=0.0$). If measured parameters do not fit within tolerance, repeat calibration (±0.2 for ε': ±0.1 for ε'').
   Conductivity can be calculated from ε'' by $\sigma = \omega \varepsilon_0 \varepsilon'' = \varepsilon'' f\,[\mathrm{GHz}] / 18$.
7. Measure liquid shortly after calibration. Repeat calibration every hour.
8. Stir the liquid to be measured. Take a sample (~50ml) with a syringe from the center of the liquid container.
9. Pour the liquid into a small glas flask. Hold the syringe at the bottom of the flask to avoid air bubbles.
10. Put the dielectric probe in the glas flask. Check that there are no air bubbles in front of the opening in the dielectric probe kit.
11. Perform measurements.
12. Adjust medium parameters in DASY3 for the frequencies necessary for the measurements ('Setup Config', select medium (e.g. Brain 900 MHz') and press 'Option'-button.
13. Select the current medium for the frequency of the validation (e.g. Setup Medium Brain 900 MHz).

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Probe ET3DV5

SN:1331

Manufactured:	December 97
Calibrated:	January 98

ET3DV5 SN:1331

Introduction

The performance of all probes is measured before delivery. This includes an assessment of the characteristic parameters, receiving patterns as a function of frequency, frequency response and relative accuracy. Furthermore, each probe is tested in use according to a dosimetric assessment protocol. The sensitivity parameters (NormX, NormY, NormZ), the diode compresion parameter (DCP) and the conversion factor (ConvF) of the probe and some of the measurement diagrams are given in the following.

The performance of the individual probes varies slightly due to tolerances arising from the manufacturing process. Since the lines are highly resistive (several MOhms), the offset and noise problem is greatly increased if signals in the low µV range are measured. Accurate measurement below 10 µW/g are possible if the following precautions are taken. 1) check the current grounding with the *multimeter*[1], i.e., low noise levels, 2) compensate the current *offset*[1], 3) use long integration time (approx. 10 seconds), 4) *calibrate*[1] before each measurement, 5) persons should avoid moving around the lab while measuring.

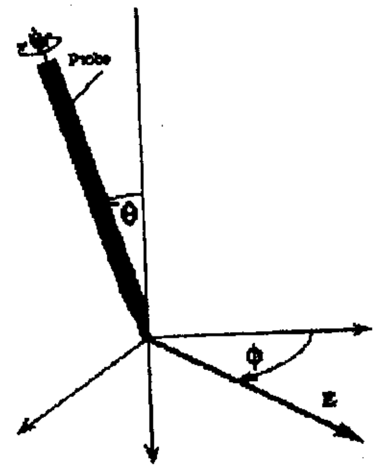


Fig 1: Due to the field distortion caused by the supporting material, the probe has two characteristic directions, referred to as angle ψ and θ.

Since the field distortion caused by the supporting material and the sheath is quite high in the θ direction, the receiving pattern is poor in air. However, the distortion in tissue equivalent material is much less because of its high dielectricity. In addition, the fields induced in the phantoms by dipole structures close to the body are dominently parallel to the surface. Thus, the error due to non-isotropy is much better than 1 dB for dosimetric assessments.

The probes are calibrated in the TEM cell ifi 110 although the field distribution in the cell is not very uniform and the frequency response is not very flat. To ensure consistency, a strict protocol is followed. The conversion factor (ConF) between this calibration and the measurement in the tissue simulation solution is performed by comparison with temperature measurements and computer simulations. This conversion factor is only valid for the specified tissue simulating liquids at the specified frequencies. If measurements have to be performed in solutions with other electrical properties or at other frequencies, the conversion factor has to be assessed by the same procedure.

As the probes have been constructed with printed resistive lines on ceramic substrates (thick film technique), the probe is very delicate with respect to mechanical shocks.

Attention:

Do not drop the probe or let the probe collide with any solid object. Never let the robot move without first activating the emergency stop feature (i.e., without first turning the data acquisition electronics on).

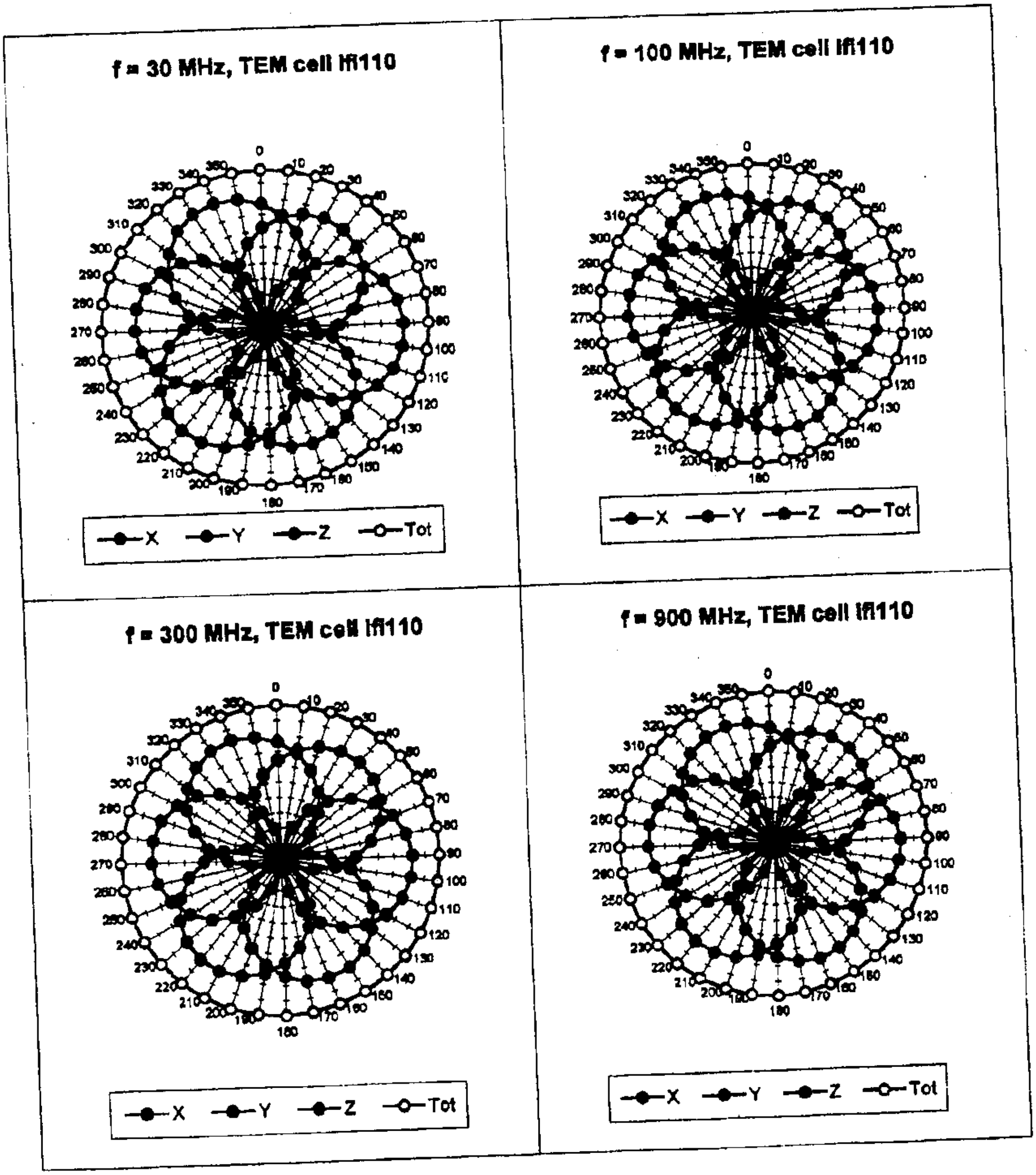
[1] Feature of the DASY2 Software Tool.

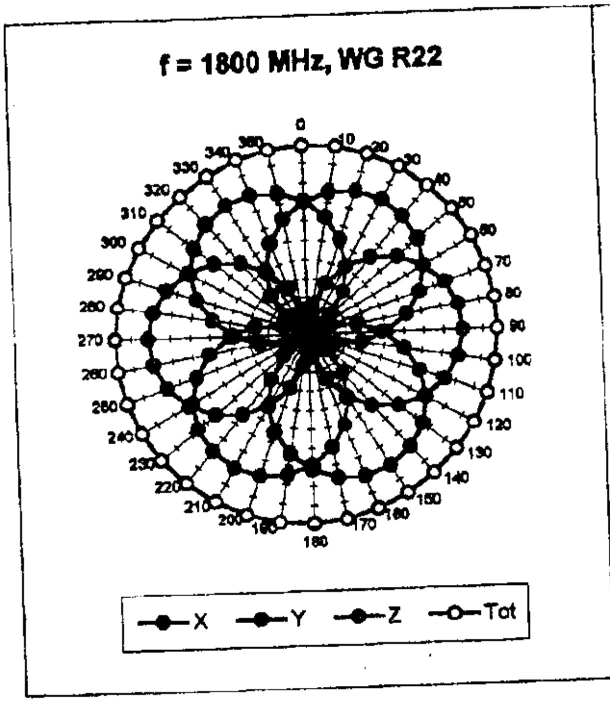
Parameters of Probe ET3DV5 SN:1331

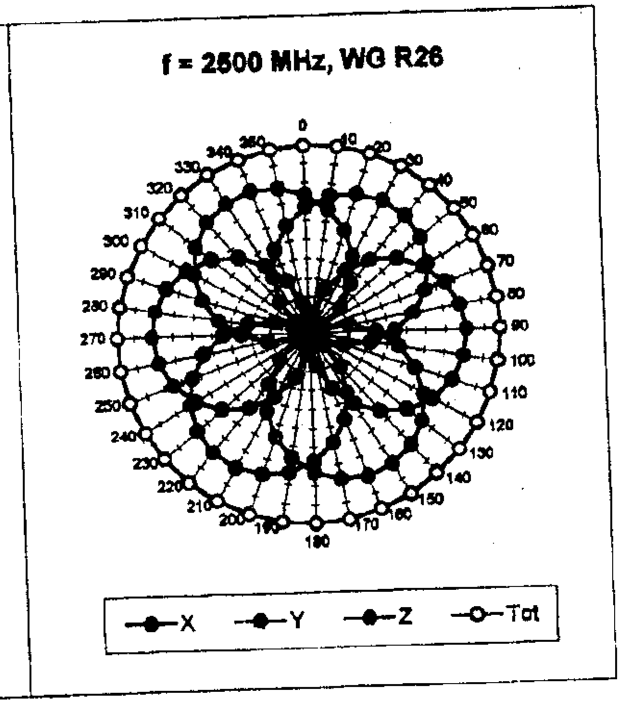
NormX	1.04	$\mu V/(V/m)^2$
NormY	1.29	$\mu V/(V/m)^2$
NormZ	1.29	$\mu V/(V/m)^2$
DCP	102	mV
ConvF(450MHz)	5.28 ± 10%	ε_r=47.2 ± 5%; σ=0.45 ± 10% mho/m[1]
ConvF(900MHz)	4.93 ± 10%	ε_r=42.5 ± 5%; σ=0.85 ± 10% mho/m[1]
ConvF(1800MHz)	4.22 ± 10%	ε_r=41.0 ± 5%; σ=1.7 ± 10% mho/m[1]
$d_{probe\_tip - center\_dipoles}$	2.7	mm
$d_{surface - probe\_tip}$	1.4 ± 0.2	mm

[1] Brain tissue simulating liquids

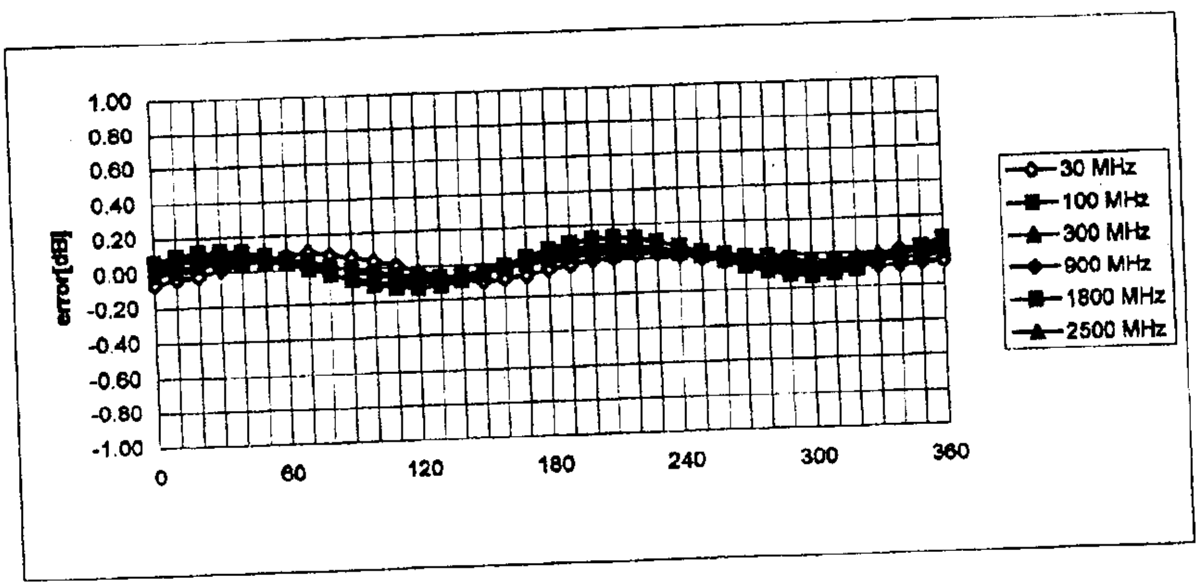
Receiving Pattern (ϕ), θ = 0°



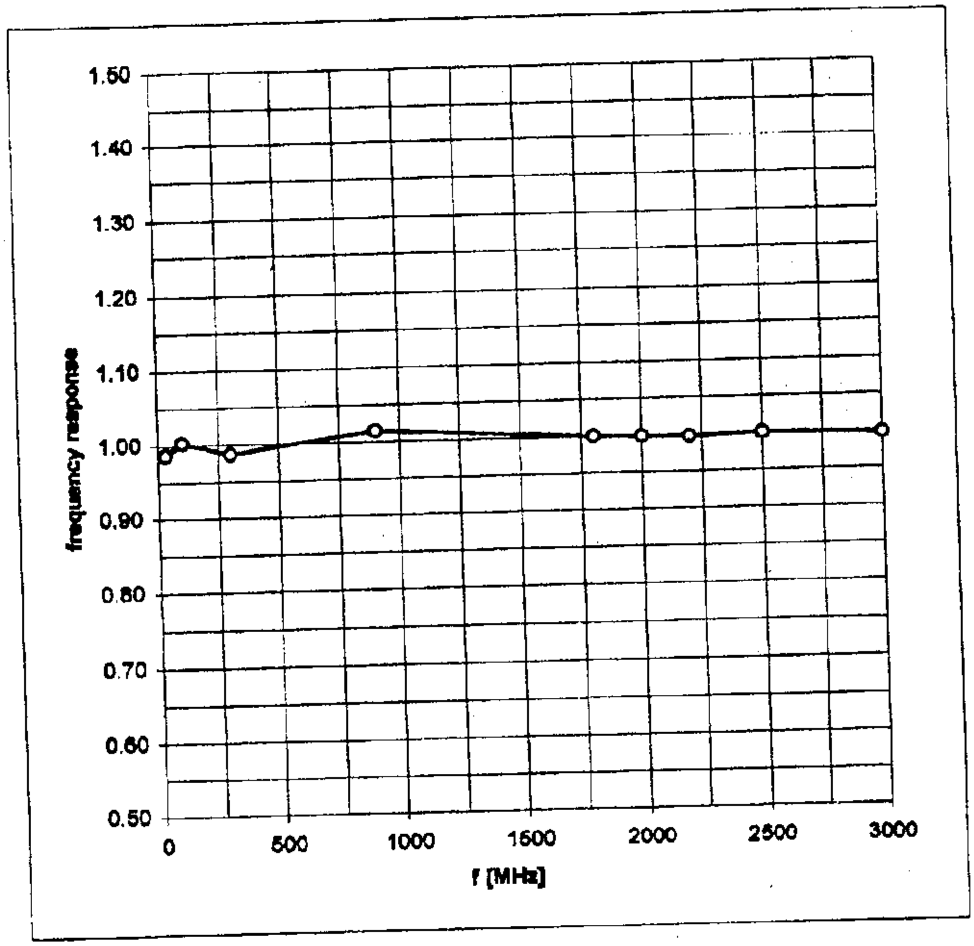




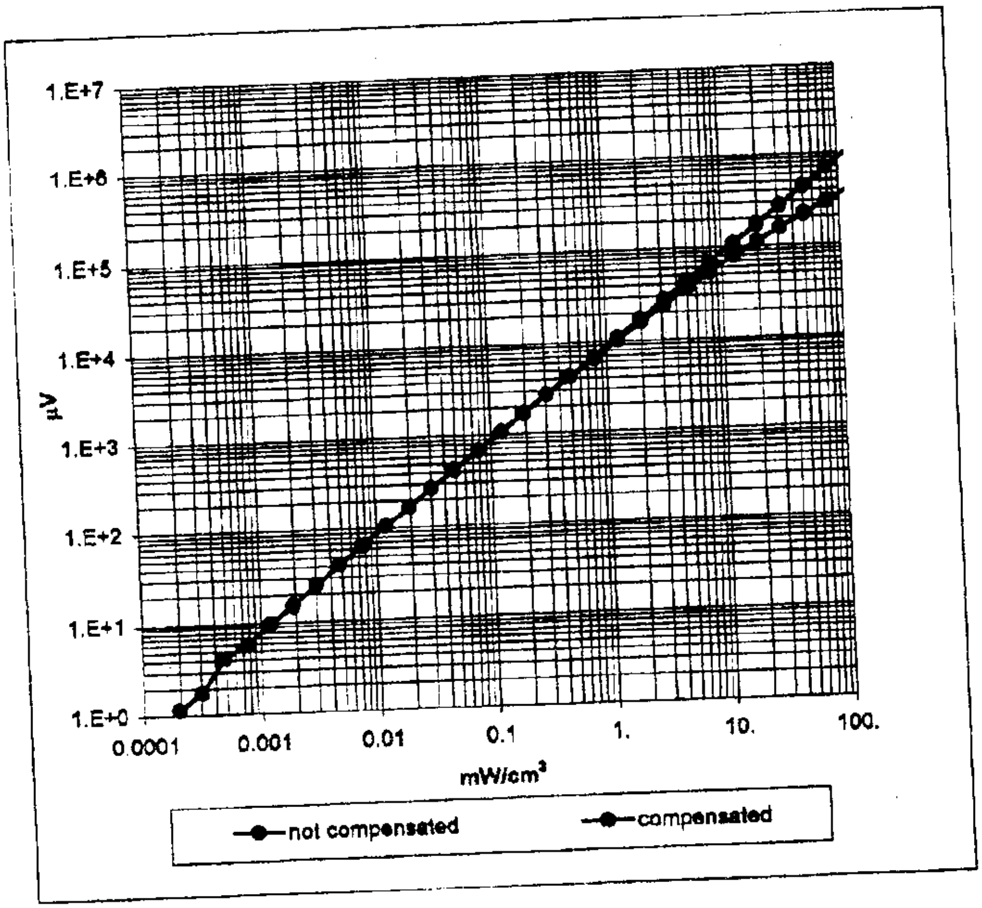
Isotropy Error (ϕ), θ = 0°

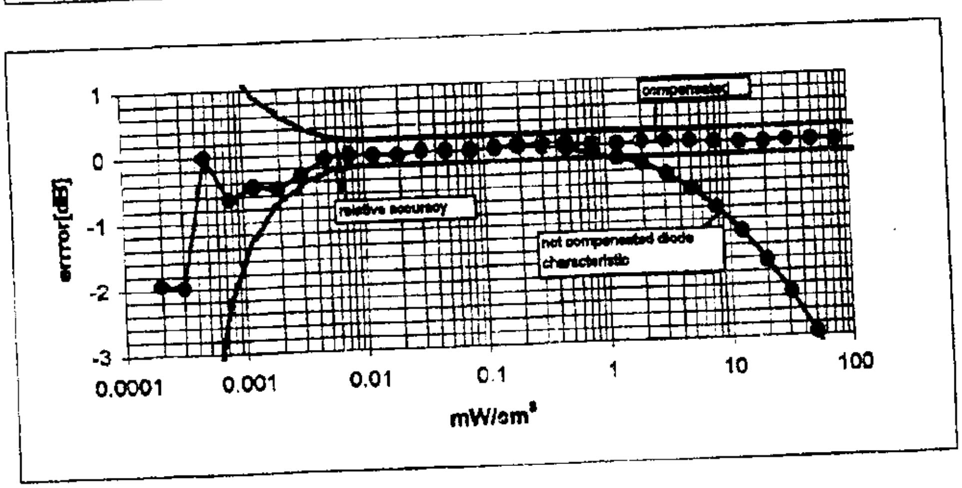


Frequency Response of E-Field
(TEM-Cell:ifi110, Waveguide R22, R26)



Dynamic Range f(SAR_{brain})
(TEM-Cell:ifi110)





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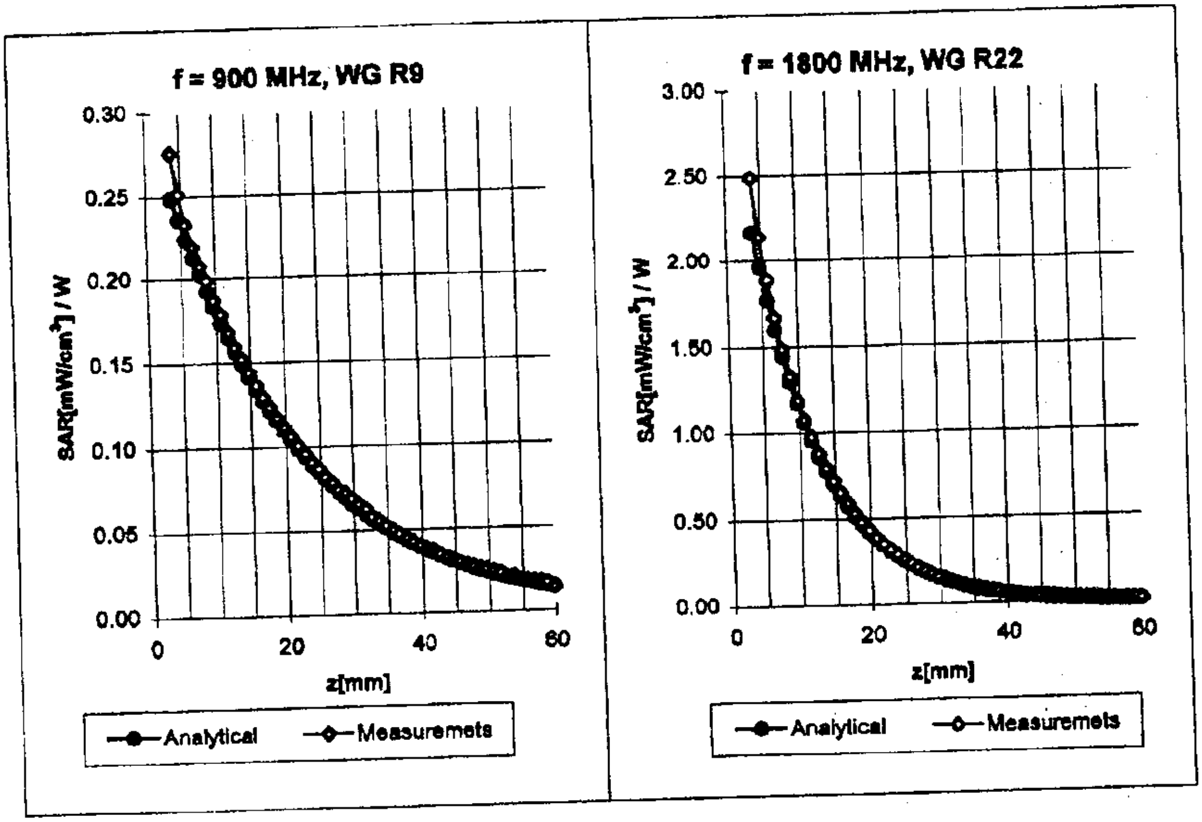
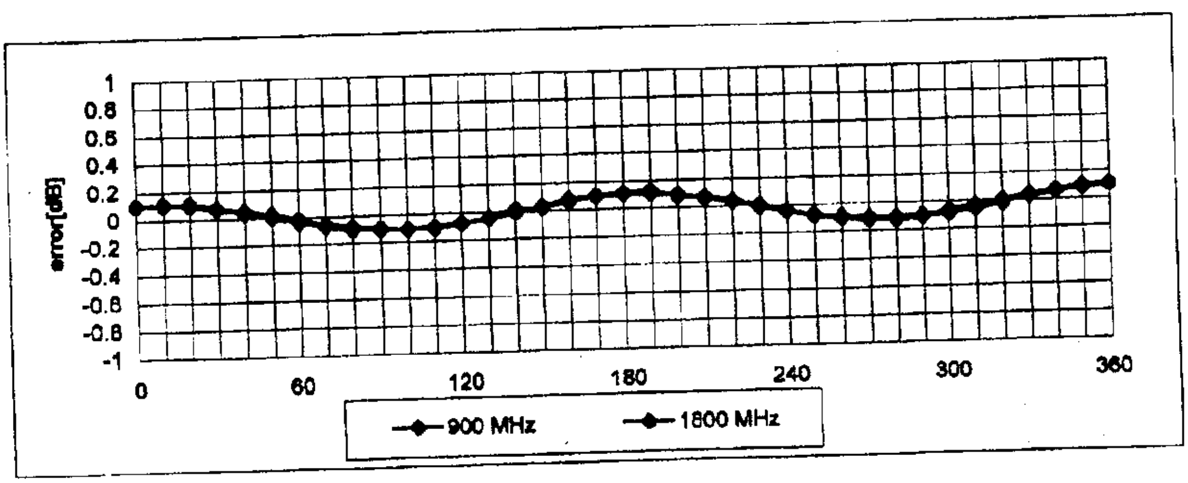
Conversion Factor Assessment



Receiving Pattern (ϕ)

(in brain tissue, z = 5 mm)



K3

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Calibration Certificate

Dosimetric E-Field Probe

Type:	**ET3DV5**
Serial Number:	**1340**
Place of Calibration:	**Zurich**
Date of Calibration:	**Jan. 26, 1998**
Calibration Interval:	**12 months**

Schmid & Partner Engineering AG hereby certifies, that this device has been calibrated on the date indicated above. The calibration was performed in accordance with specifications and procedures of Schmid & Partner Engineering AG.

Whereever applicable, the standards used in the calibration process are traceable to international standards. In all other cases the standards of the Laboratory for EMF and Microwave Electronics at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland have been applied.

Calibrated by: Pokovic Katja

Approved by:

Schmid & Partner
Engineering AG

Staffelstrasse 8, 8045 Zurich, Switzerland, Telefon +41 1 280 08 60, Fax +41 1 280 08 64

Probe ET3DV5

SN:1340

Manufactured:	January, 20 1998
Calibrated:	January, 26 1998

Calibrated for System DASY3

Introduction

The performance of all probes is measured before delivery. This includes an assessment of the characteristic parameters, receiving patterns as a function of frequency, frequency response and relative accuracy. Furthermore, each probe is tested in use according to a dosimetric assessment protocol. The sensitivity parameters (NormX, NormY, NormZ), the diode compresion parameter (DCP) and the conversion factor (ConvF) of the probe and some of the measurement diagrams are given in the following.

The performance of the individual probes varies slightly due to tolerances arising from the manufacturing process. Since the lines are highly resistive (several MOhms), the offset and noise problem is greatly increased if signals in the low µV range are measured. Accurate measurement below 10 µW/g are possible if the following precautions are taken. 1) check the current grounding with the *multimeter*[1], i.e., low noise levels, 2) compensate the current *offset*[1], 3) use long integration time (approx. 10 seconds), 4) *calibrate*[1] before each measurement, 5) persons should avoid moving around the lab while measuring.

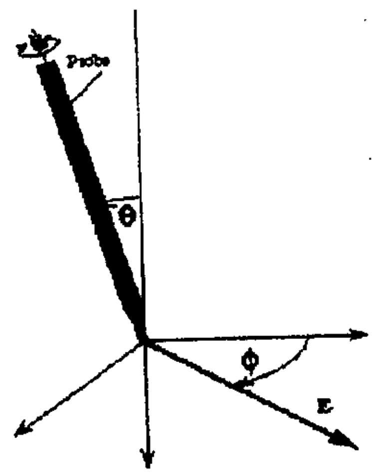

Fig 1: Due to the field distortion caused by the supporting material, the probe has two characteristic directions, referred to as angle ψ and θ.

Since the field distortion caused by the supporting material and the sheath is quite high in the θ direction, the receiving pattern is poor in air. However, the distortion in tissue equivalent material is much less because of its high dielectricity. In addition, the fields induced in the phantoms by dipole structures close to the body are dominently parallel to the surface. Thus, the error due to non-isotropy is much better than 1 dB for dosimetric assessments.

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As the probes have been constructed with printed resistive lines on ceramic substrates (thick film technique), the probe is very delicate with respect to mechanical shocks.

Attention:

Do not drop the probe or let the probe collide with any solid object. Never let the robot move without first activating the emergency stop feature (i.e., without first turning the data acquisition electronics on).

[1] Feature of the DASY2 Software Tool.

DASY3 - Parameters of Probe: ET3DV5 SN:1340

Sensitivity in Free Space

NormX	**2.1**	$\mu V/(V/m)^2$
NormY	**2.2**	$\mu V/(V/m)^2$
NormZ	**2.1**	$\mu V/(V/m)^2$

Diode Compression

DCP X	**100**	mV
DCP Y	**100**	mV
DCP Z	**100**	mV

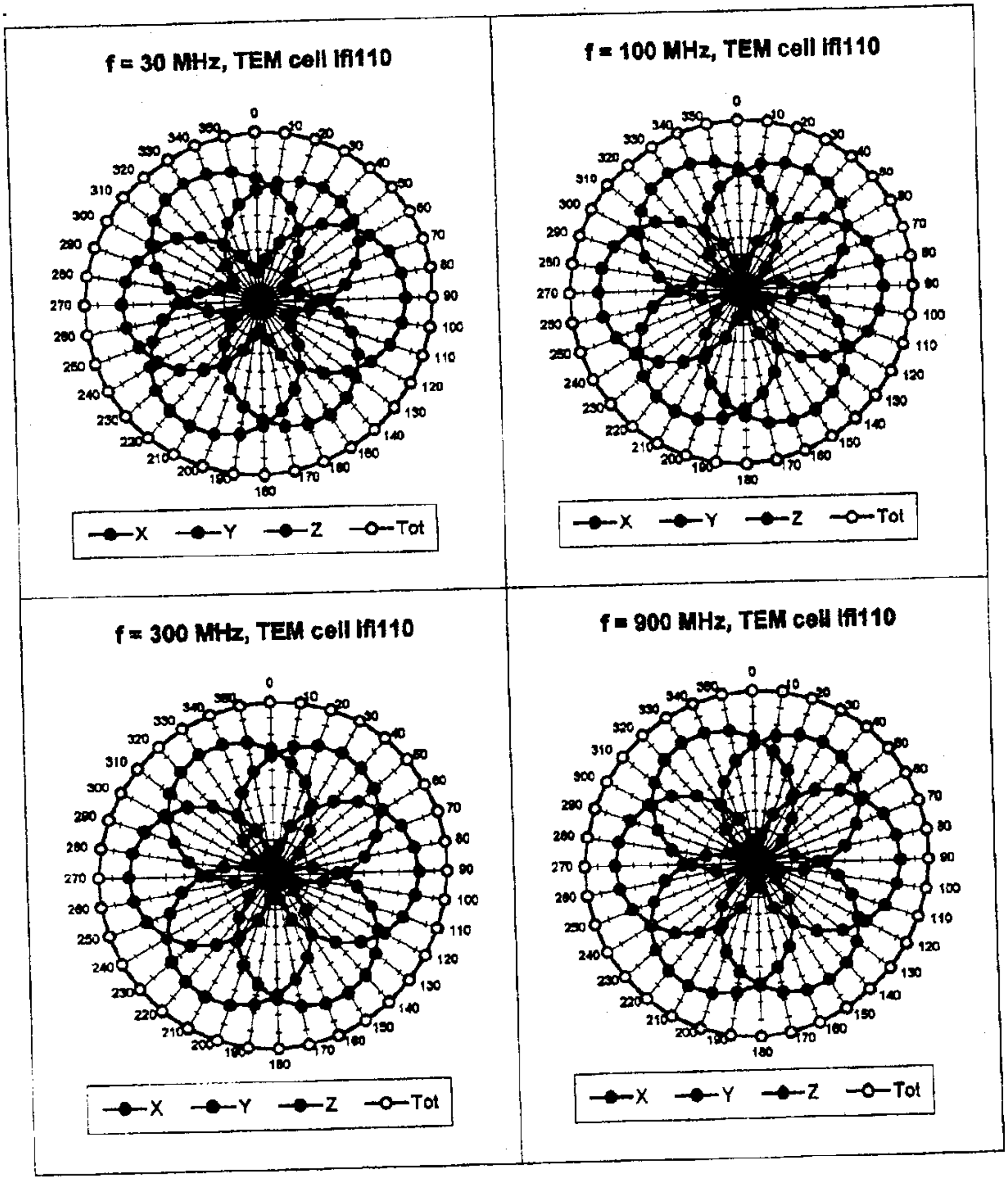
Sensitivity in Tissue Simulating Liquid

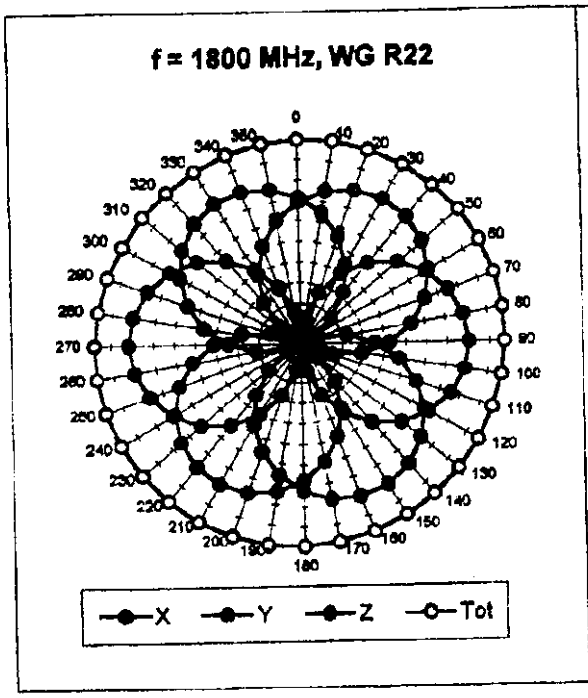
450 MHz	ConvF X	**6.15**	extrapolated	ε_r = 48 ± 5%
	ConvF Y	**6.15**	extrapolated	σ = 0.50 ± 10% mho/m
	ConvF Z	**6.15**	extrapolated	(brain tissue simulating liquid)
900 MHz	ConvF X	**5.81**	± 10%	ε_r = 42.5 ± 5%
	ConvF Y	**5.81**	± 10%	σ = 0.85 ± 10% mho/m
	ConvF Z	**5.81**	± 10%	(brain tissue simulating liquid)
1500 MHz	ConvF X	**5.36**	interpolated	ε_r = 41 ± 5%
	ConvF Y	**5.36**	interpolated	σ = 1.32 ± 10% mho/m
	ConvF Z	**5.36**	interpolated	(brain tissue simulating liquid)
1800 MHz	ConvF X	**5.13**	± 10%	ε_r = 41 ± 5%
	ConvF Y	**5.13**	± 10%	σ = 1.70 ± 10% mho/m
	ConvF Z	**5.13**	± 10%	(brain tissue simulating liquid)

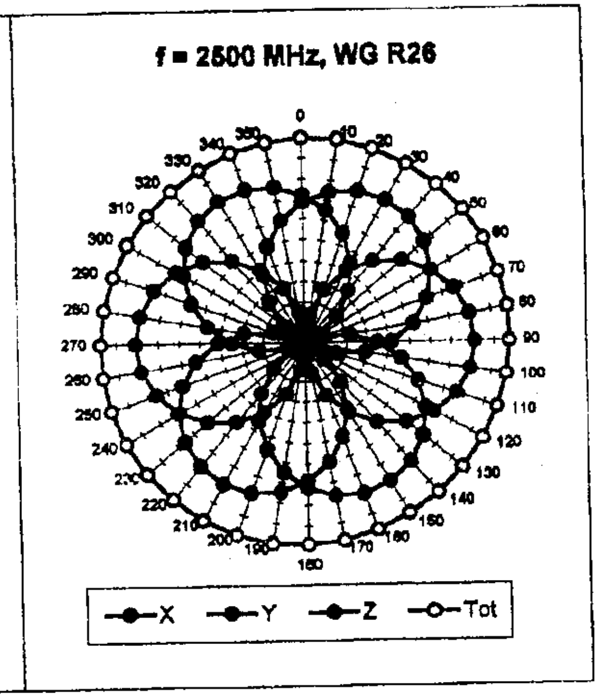
Sensor Offset

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

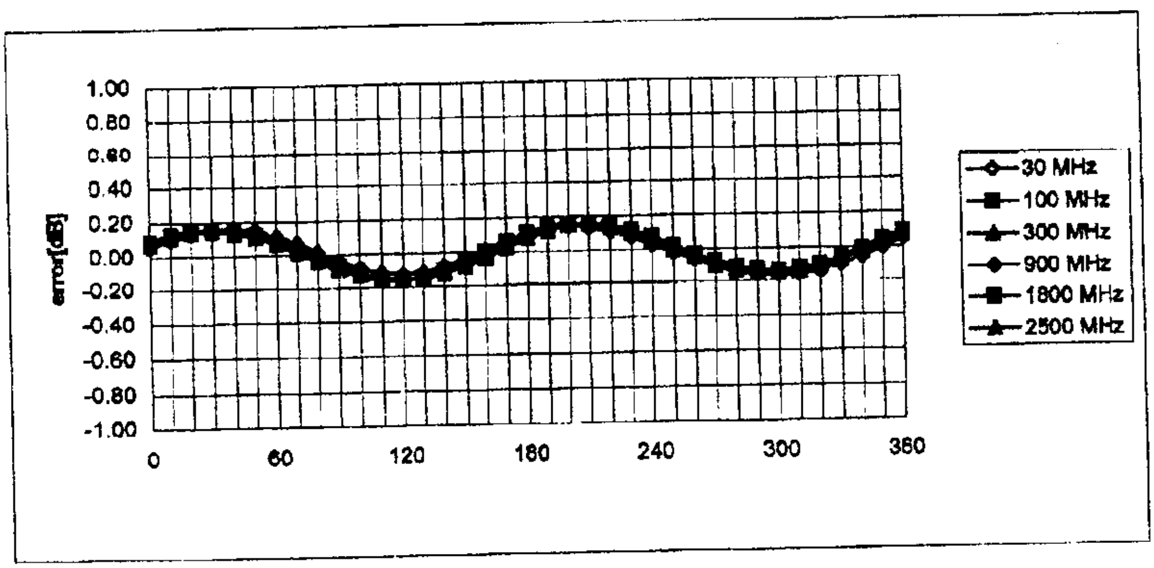
Receiving Pattern (ϕ), θ = 0°





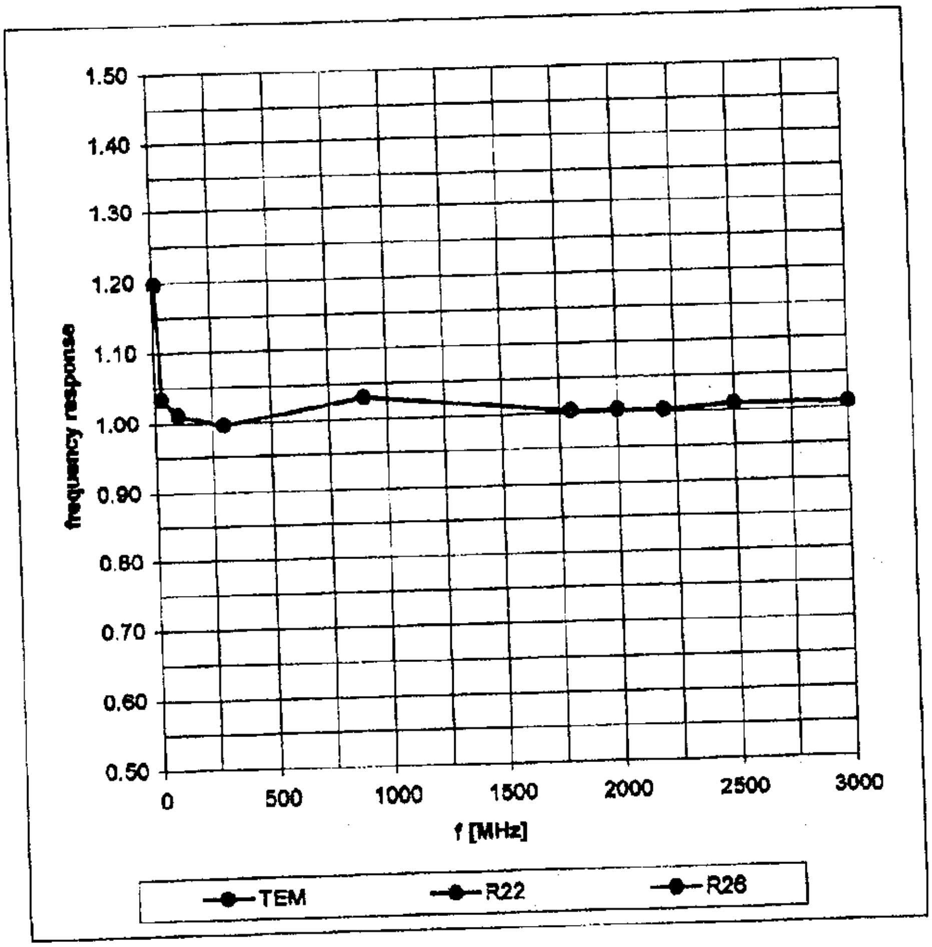


Isotropy Error (ϕ), θ = 0°



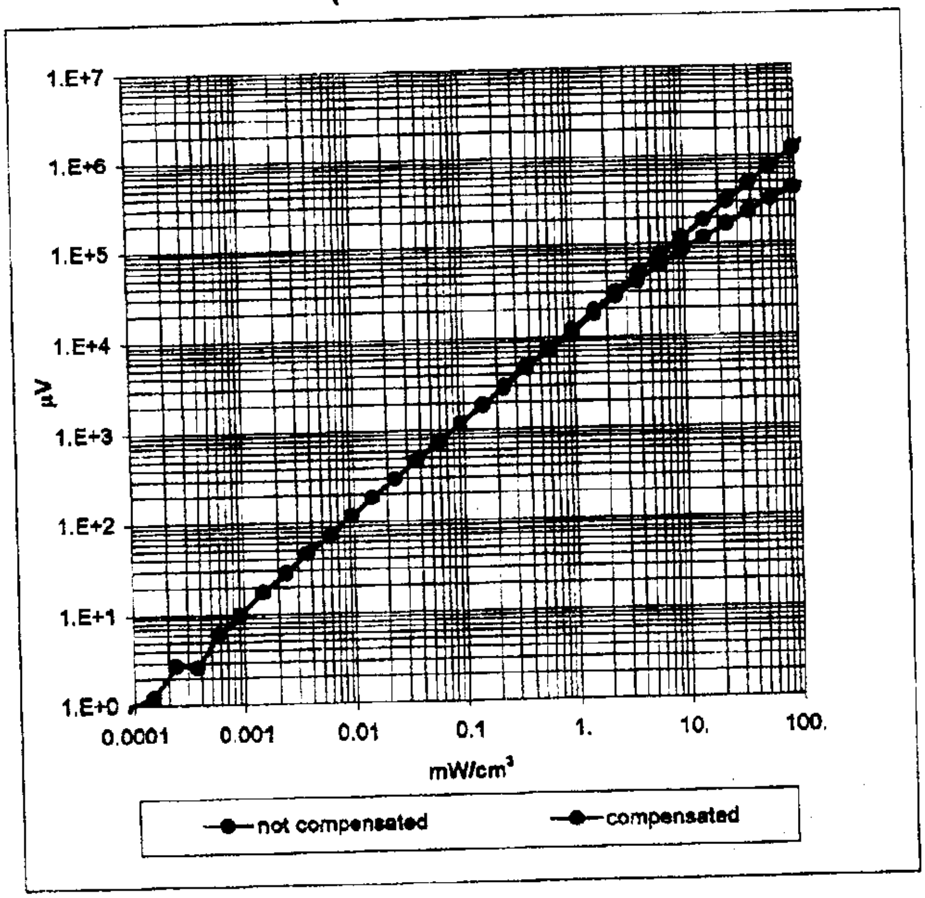
Frequency Response of E-Field

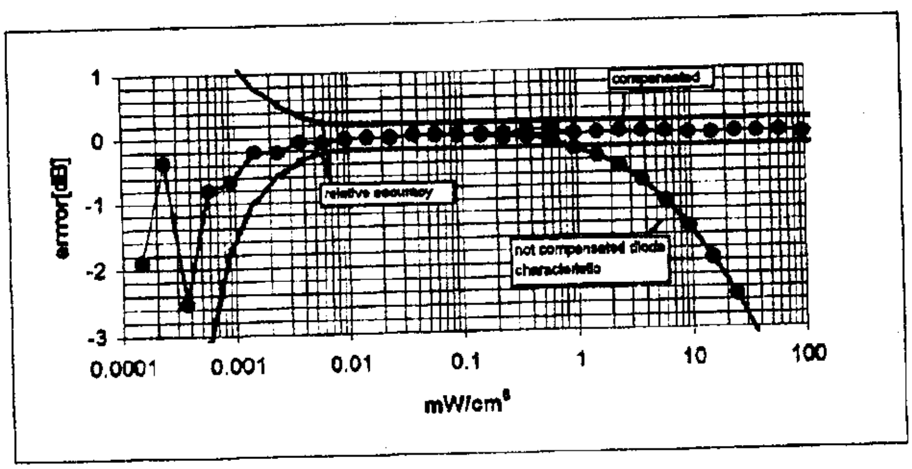
(TEM-Cell:ifi110, Waveguide R22, R26)



Dynamic Range f(SAR_{brain})

(TEM-Cell:ifi110)





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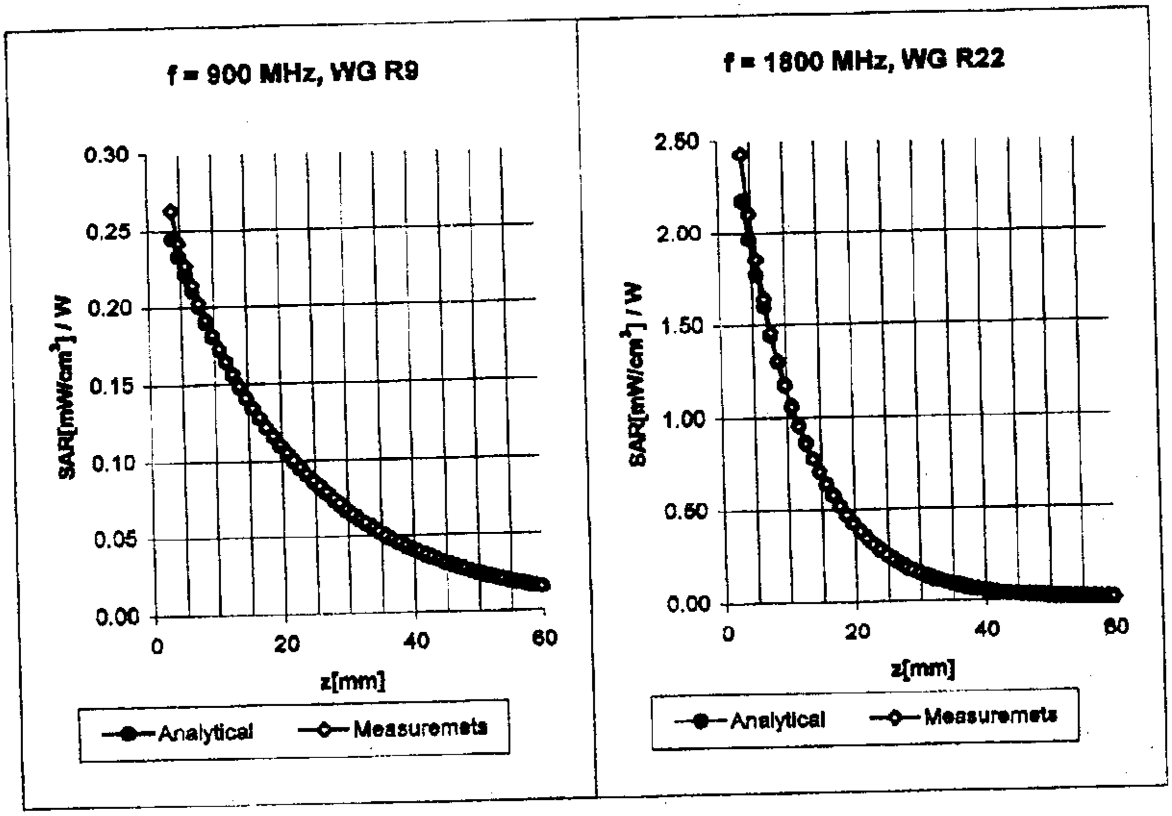
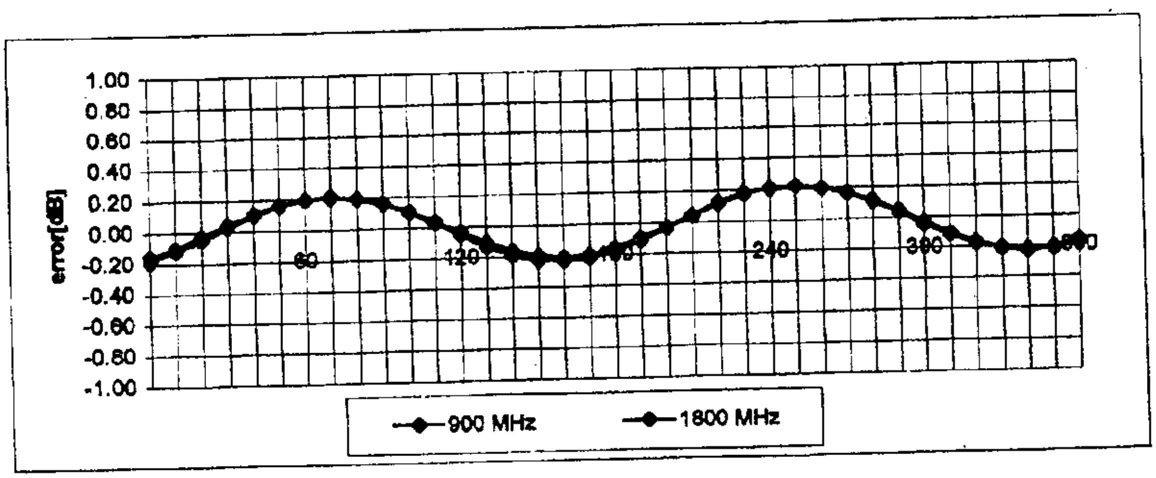
Conversion Factor Assessment



Receiving Pattern (φ)

(In brain tissue, z = 5 mm)



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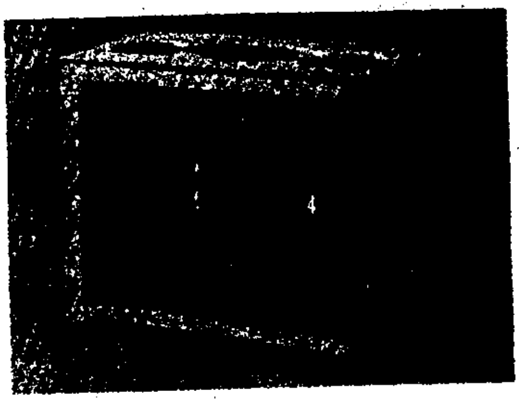
2.5 Phantom



The generic twin phantom is a fiberglass shell phantom with 2 mm shell thickness. It has three measurement areas:

- Left hand
- Right hand
- Flat phantom

The device holder can be fixed in any of these: a 100x50x85 cm (BxTxH) support for free standing robots and a 100x75x85 cm (BxTxH) version for table mounted robots.

A white cover is provided to tap the phantom during off-periods to prevent water evaporation and change in liquid parameters. Free space scans of devices on the cover are possible; however the optical surface detector is not working properly at the cover surface. Place a white paper on the cover when using optical surface detection.

Three reference markers are provided to identify the phantom position with respect to the robot (see Installing the Generic Twin Phantom, page 52):

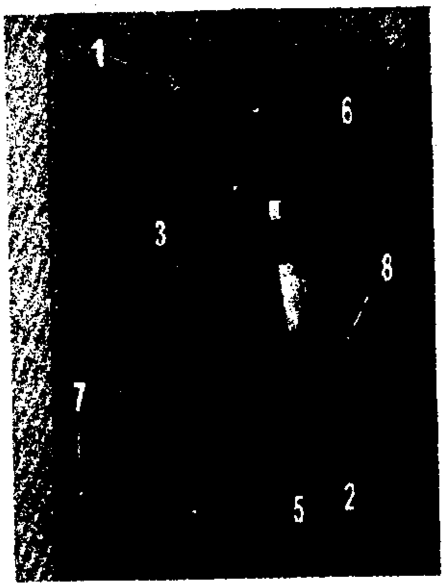
Phantom use with tissue simulating liquids:

- Water-sugar-solutions can be left permanently in the phantom. Always cover the liquid if the system is not used, otherwise the parameters will change due to water evaporation (see Recipes For Brain Tissue Simulating Liquids, page 82).

- Buthyldiglycol-solutions should be used with care. As glycol is a softener for most plastics, the solution should be taken out of the phantom and the phantom should be dried when the system is not used (also overnight!). A test has shown a slight coloring of the inner surface after 3 months on continuously being filled with 1.8 GHz Buthyldiglycol solution.

- Do not use other organic solvents without testing the phantom resistively previously.

2.6 Device Holder for Generic Twin Phantom



1. Put the phone in the clamp mechanism (1) and hold it straight while tightening. (Curved phones or phones with asymmetrical ear pieces should be positioned so that the ear piece is in the symmetry plane of the clamp).

2. Adjust the sliding carriage (2) to 90°. Then adjust the phone holder angle (3) until the reference line of the phone is horizontal (parallel to the flat phantom bottom). The phone reference line is defined as the front tangential line between the ear piece and the center of the device bottom (or the center of the flip hinge).

3. Place the device holder at the desired phantom section and move it securely against the positioning pins (4) (see picture on previous page). The screw in front of the turning plate can be applied for correct positioning (5). (Do not tighten it too strongly).

4. Shift the phone clamp (6) so that the ear piece is exactly below the ear marking of the phantom. The phone is now correctly positioned in the holder for all standard phantom measurements, even after changing the phantom or phantom section.

5. Adjust the device position angles to the desired measurement position. The rotation scale (7) gives the tilt angle from the body axis. C1 denotes the intended use position (plane through ear openings and mouth); C2 is the 30°-tilt position according to CENELEC. The angle of the sliding carriage (8) gives the inclination angle of the phone (80° = intended use position).

6. After fixing the device angles, move the phone fixture up until the phone touches the ear marking. (The point of contact depends on the design of the device and the positioning angle).

Note:
Always lower the phone fixture prior to changing the device angles.

If the ear piece of the phone is shifted horizontally after changing the device angles, the phone or the device holder is not correctly positioned.

2.7 Validation kit

The validation dipole is a highly symmetric dipole. It comes with a special support and a snap-on distance holder.
Using the dipole at the specified frequency with support and distance holder at the flat section of the generic twin phantom filled with tissue simulating liquid produces a repeatable and specified situation in which the dipole is matched and characterized with respect to SAR.

See the dipole documents and the section system validation for more information.

4.1 SAR – Measurement

1. Stir liquid until it shows no effects of inhomogeneity.
2. Measure dielectric parameters. If the parameters are outside of tolerances adjust or change the liquid.
3. Mount probe on electronics box. Make sure that the connector catches properly and the probe is mounted straight.
4. Mount electronics box on robot arm. Turn electronics box on (allow 15 min. warm up for sensitive measurements).
5. Select mounted probe from menu 'Setup Probe'.
6. Open robot-window in DASY3, select 'Generic Twin' from the 'Setup Phantom' menu and move to the Point ('Move Start').
7. Check for interference while the arm power is on: Open multimeter window. Select profile 'm4s az4s' in the 'Option' page of the multimeter. If the measured voltage is out of the acceptable range (± 2.5 µV) check grounding system (see Grounding Problems, page 79).
8. Check phantom position via reference points. If the phantom has been moved or if the difference in the x-,y- or z – direction is grater than 2 mm, reinstall the Phantom (Installing the Generic Twin Phantom, page 52).
9. Stir liquid if necessary. The liquid should be homogeneous. If the liquid shows effects of inhomogeneity, remeasure the liquid and or replace the liquid.
10. Check surface detector using the 'Move surface'. The probe should stop ca 1 mm above the surface. (If not, move probe up and clean the probe tip, repeat surface detect).
11. Move probe into selected phantom section.
12. Check for interference in liquid (analogue point 5).
13. Set up device.
14. The following files exist as predefined templates in the directory:

FCC left.da3	Intended use position, left hand
FCC right.da3	Intended use position, right hand
CEN intended left.da3	Intended use position, left hand
CEN intended right.da3	Intended use position, right hand
CEN touch left.da3	Touching position, left hand
CEN touch right.da3	Touching position, right hand
CEN 100° left.da3	100° position, left hand
CEN 100° right.da3	100° position, right hand
CEN 30° tilted left.da3	30°-tilted position, left hand
CEN 30° tilted right.da3	30°-tilted position, right hand

Open the file, save it under a different file name and start the measurement.

4.2 H-Field Scan

1. Mount probe on electronics box. Make sure that the connector catches properly and the probe is mounted straight.
2. Mount electronics box on robot arm. Turn electronics box on (allow 15 min. warm up for sensitive measurements).
3. Select mounted probe from 'Setup Probe' - menu.
4. Open the robot-window in DASY3, select 'Free Space' from the 'Setup Phantom' menu and move to the Point ('Move Start').
5. Check for interference while arm power is on: Open multimeter window. Select profile 'm4s az4s' in the 'Option' page of the multimeter. If the measured voltage is out of the acceptable range (± 2.5 μV) check grounding system (see Grounding Problems, page 79).
6. Reteach the section reference point and angle to the antenna feedpoint of the device.
7. Create the device with ear angle radius set to zero and the position of the ear set to the antenna feedpoint.
8. Open a new file and measure a coarse scan with no surface detection.

4.3 System Validation

1. Perform steps 1-12 described in SAR – Measurement, page 70.
2. Set up validation dipole at flat section of generic twin phantom using the distance holder.
3. Apply input power to dipole (10mW - 10W). The input power to the dipole should be measured at the dipole input with a 50Ω measuring device to an accuracy of 0.1 dB or better.
4. Select dipole from 'Setup Device' (e.g. 'Setup Device Dipole 900 MHz').
5. In the directory predefined the following files exists as templates:

Validation 900MHz.DA3	Validation with Dipole 900 MHz
Validation 1800MHz.DA3	Validation with Dipole 1800 MHz

   Open the file, save it under a different file name and start the measurement.

6. Use the 'Validation' – graphics format for the graphics. Since there are two cubes (probe is 90° rotated to the other), the average and the deviation of the evaluated values are displayed.

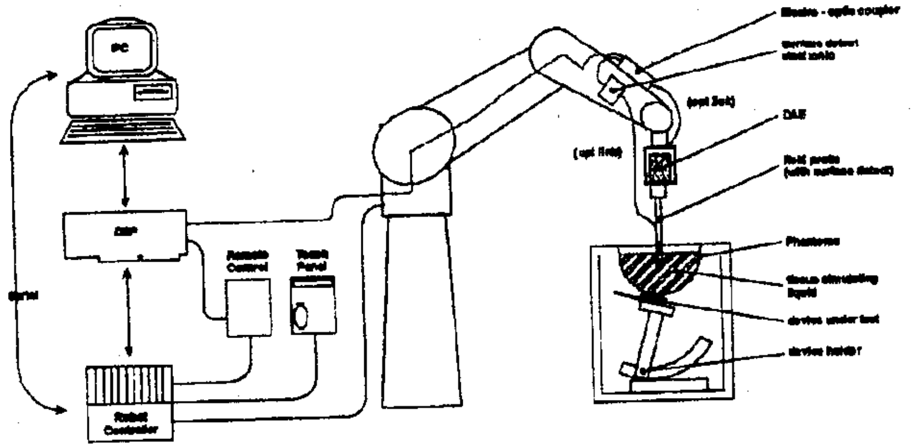
4.3.1 Additional System and Probe Checks

7. Move probe to interpolated maximum and perform z-axis measurement (using surface detection, ca 30 points @ 2mm spacing). Compare the measured decay in the liquid with the expected decay (see AN about SAR-sensitivities); check for standing waves and layering within the liquid. However, the extrapolated data will not be comparable with the extrapolated data for the cube measurement).
8. Move probe to interpolated maximum, move to surface and retire the probe ca 5mm ("do departs 5"). Perform a probe rotation scan. (Check first that the cables to the electronics box allow for rotational movement. Watch probe movements and abort operation if cables are stressed). Check the result for isotropy within specifications.
9. Perform SAR-measurements, Z-scan or probe rotation with different input power levels (<100mW and >10W). Normalize both results to 1W and compare (linearity). Check for correct compression point setting if results differ.

1. SYSTEM DESCRIPTION

1.1 System setup

The DASY3 system consists of at least:



- Miniaturized field probes
- Highly sensitive probe output measuring system split into data acquisition unit (DAE) (see figure 2) and a PC plug-in card with Signal processor for time-critical evaluations (see figure 3)
- A probe positioning system (six-axis robot) for automatic field scans with its own robot controller
- Remote control with teach pendant and warning lamp for safe operation of the robot.
- A surface detect system that permits automatic positioning of the probe within a known distance to a phantom, surface, or device
- A shell phantom for body related SAR-measurements
- A system validation kit which allows to validate the whole system

To perform a SAR-measurement the customer must supply the following components (see figure 1):

- Device to be measured. It must be in a known and stable state during measurements (output power level, frequency, and modulation).
- Medium (tissue simulating liquid) with known dielectric parameters. Since the parameters might change with time (due to water evaporation) the customer must be able to assess the actual parameters and to mix or change the liquid composition to adjust the parameters.

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For system validation a source with specified frequency and accurately known forward power at the validation kits SMA connector must be available (signal source (>=10 dBm output power), power meter (<5% accuracy), cables).

1.2 Software

The DASY3 software is destined to work with DASY2 or DASY3 hardware. It is written in Visual C++ (full 32-bit version) and is runs under Windows 95 or Windows NT. The software is built in a modular way with dynamic link libraries. This allows new components easily to be appended and to be changed according existing components to special customer needs without the necessity of rewrite the whole software.

The DASY3-Software makes use of all system components to allow field measurements on these hierarchical complexity levels.

1.2.1 Field measurements

These are standard field measurements at the location of the probe tip. The software reads the output of each probe sensor and uses the calibration parameters of all involved components to calculate the correct field strength (The probe positioning system can be used manually to position the probe but no information from the robot is used in the evaluation). The output can be in many different units, by component or as a total, as a single value with statistics or as a function of time (scope).

Different measurement profiles (time, auto-zero cycles, accuracy, filter) can be used. The data can be exported to text files. For more information Field Measurements with Multimeter Option, page 42.

1.2.2 Field Scans

Using the positioning system, automatic field scans over lines, planes or volumes can be performed. The field is measured at discrete points, and the raw data from the probe is stored together with the position information from the robot and all involved calibration parameters. This allows utilization of the stored data for all possible selections or evaluations at the moment of visualizing or exporting the data. To visualize the data graphic-tools for 1D, 2D and 3D are included in the software.

A field scan can be defined as a free space scan or can be related to a phantom using automatic grid adaptation to the phantom boundary, automatic detection of the phantom surface, etc. If the device outline and position is specified in the scan, a simple picture of the device can be included in the graphic.

1.2.3 Documents

Several scans can be combined in one measurement document. The scans can be measured individually or automatically (e.g. reference point measurement, surface scan for maximum, fine cube measurement, power drift measurement). Sophisticated evaluation and documentation is possible by using data simultaneously from several scans in the document.

In order to work properly, the system requires a good deal of information from the user:

- Probe calibration parameters
- Data acquisition electronics parameters
- PC-Card parameters
- Device or source parameters (frequency, modulation)
- Scan parameters (grid size and orientation, phantom position, type)
- Measurement profile (filtering, time)
- Graphic format and evaluation

Many parameters are absolutely necessary to operate the system, others are optional and only necessary for special features (e.g. the device dimensions are necessary if the device shall be shown in the graphic; otherwise they can be omitted). Some parameters are coupled to components and do not change (e.g. probe calibration parameters), others might differ between measurements (e.g. liquid parameters, scans and evaluation). To make work easy, the parameters are arranged in data sets, and each data set is stored in the system under a specific name (e.g. each field probe has a set of calibration parameters stored under a unique name. Instead of entering the parameters the user has to select the corresponding parameter set each time a component (e.g. probe) is changed in the system. The necessary selections are:

- PC-Card
- DAE (only if several data acquisition electronics are available)
- Probe
- Liquid
- Device
- Phantom (including defined scans)
- Graphic formats

Selecting new parameter sets is only necessary when components are changed when different grids or graphic formats are desired. The last selected set is always the default for new measurements. However, sometimes it is necessary to add or change existing data sets. The parameters in the system can be manipulated in different ways:

- Import data file with factory-settings (electronic, probe, phantom)
- Change parameters in setup options dialog
- Enter completely new data set in the options menu

Changed or entered data sets can be stored in the system or exported to configuration-files (e.g. for use in other systems). Each system component from SPEAG comes with a configuration file including all necessary system data. To prevent accidental changes in the crucial parameters, all configuration files with manufacturer's settings have the read-only attribute.

If several people will use the system, it is recommended to have one system operator who defines all measurement procedures and phantom settings. This prevents incorrect measurement data due to improper parameter settings from users who are not very familiar with the system.

Several procedures are supported from SPEAG based on our experience with the system, but more might be added.

Predefined procedures:

- FCC measurement procedures (for one position and one frequency), including the following scans: reference measurement, maximum search, fine cube measurement and drift measurement.
- FCC graphic format
- Validation measurement procedure with: power reference measurement, maximum search, fine cube measurement, rotated fine cube measurement, z-axis measurement, drift measurement.
- Validation graphics format