SAR EXPERIMENT REPORT

Test standard : **FCC47CFR 2.1093**
FCC OET Bulletin 65, Supplement C

SAR value from 0 cm gap to 3 cm gap

Date of test: March 14,2003

Tested by:
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EMC Head Office Division

Approved by:
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SECTION 1 : Identification of Dipole

Manufacture	:	Schmid & Partner Engineering AG
Type of Equipment	:	Dipole Antenna
Frequency	:	2450MHz
Model No.	:	D2450V2
Serial No.	:	713
Forward Conducted Power	:	250mW

SECTION 2 : Requirements for compliance testing defined by the FCC

The US Federal Communications Commission has released the report and order “Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996. The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 mW/g for an uncontrolled environment and 8.0 mW/g for an occupational/controlled environment as recommended by the ANSI/IEEE standard C95.1-1992. According to the Supplement C of OET Bulletin 65 “Evaluating Compliance with FCC Guide-lines for Human Exposure to Radio frequency Electromagnetic Fields", released on Jun 29, 2001 by the FCC, the device should be evaluated at maximum output power (radiated from the antenna) under “worst-case” conditions for normal or intended use, incorporating normal antenna operating positions, device peak performance frequencies and positions for maximum RF energy coupling.

1 Specific Absorption Rate (SAR) is a measure of the rate of energy absorption due to exposure to an RF transmitting source (wireless portable device).
2 IEEE/ANSI Std. C95.1-1992 limits are used to determine compliance with FCC ET Docket 93-62.

SECTION 3 : Dosimetry assessment setup

These measurements were performed with the automated near-field scanning system DASY3 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9 m), which positions the probes with a positional repeatability of better than +/- 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The SAR measurements were conducted with the dosimetry probe ET3DV6, SN: 1684 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in [2] with accuracy of better than +/-10%. The spherical isotropy was evaluated with the procedure described in [3] and found to be better than +/-0.25 dB. The phantom used was the SAM Twin Phantom as described in FCC supplement C, IEE P1528 and CENELEC EN50361.

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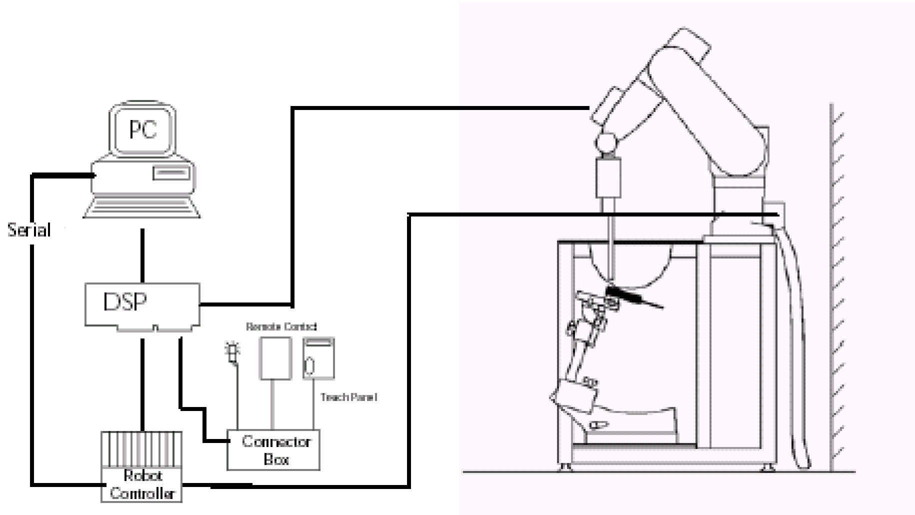
3.1 Configuration and peripherals



The DASY3 system for performing compliance tests consist of the following items:

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software.

2. An arm extension for accommodating the data acquisition electronics (DAE).

3. A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

4. A data acquisition electronic (DAE), which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

5. A unit to operate the optical surface detector, which is connected to the EOC.

6. The Electro-optical coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the PC plug-in card.

7. The functions of the PC plug-in card based on a DSP is to perform the time critical task such as signal filtering, surveillance of the robot operation fast movement interrupts.

8. A computer operating Windows 95 or larger

9. DASY3 software

10. Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.

11. The SAM phantom enabling testing left-hand and right-hand usage.

12. The device holder for handheld EUT.

13. Tissue simulating liquid mixed according to the given recipes (see Application Note).

14. System validation dipoles to validate the proper functioning of the system.

3.2 System components

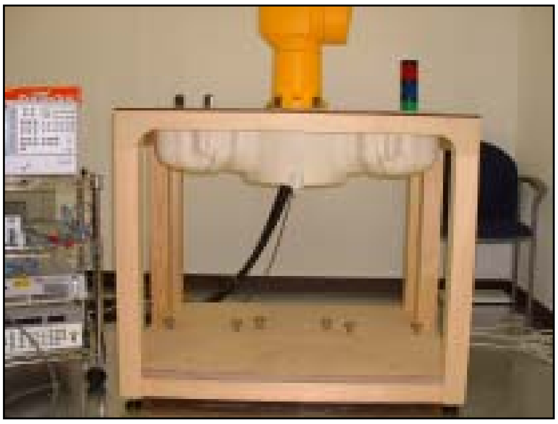
3.2.1 ET3DV6 Probe Specification

Construction:
Symmetrical design with triangular core
Built-in optical fiber for surface detection System
Built-in shielding against static charges
PEEK enclosure material (resistant to organic solvents, e.g., glycol ether)
Calibration:
Basic Broad Band calibration in air from 10 MHz to 2.5 GHz
In brain and muscle simulating tissue at
Frequencies of 450 MHz, 900 MHz, 1.8 GHz and 2.45GHz (accuracy +/- 8%)
Frequency:
10 MHz to 3GHz; Linearity: +/-0.2 dB
(30 MHz to 3 GHz)
Directivity:
+/-0.2 dB in brain tissue (rotation around probe axis)
+/-0.4 dB in brain tissue (rotation normal probe axis)
Dynamic Range:
5 mW/g to > 100 mW/g;Linearity: +/-0.2 dB
Optical Surface Detection:
+/-0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces.
Dimensions:
Overall length: 330 mm (Tip: 16 mm)
Tip length: 16 mm
Body diameter: 12 mm (Body: 12 mm)
Tip diameter: 6.8 mm
Distance from probe tip to dipole centers: 2.7 mm
Application:
General dosimetric up to 3 GHz
Compliance tests of mobile phones
Fast automatic scanning in arbitrary phantoms

Inside view of ET3DV6 E-field Probe

3.2.2 SAM Phantom

Construction:
The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528-200X, CENELEC 50361 and IEC 62209.
It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.
Shell Thickness:
2 +/-0.2 mm
Filling Volume:
Approx. 25 liters
Dimensions:(H x L x W): 810 x 1000 x 500 mm



SAM Phantom

3.2.3 Device Holder for Transmitters

In combination with the SAM Twin Phantom V4.0, the Mounting Device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatedly positioned according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head,flat phantom).
* Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produced infinite number of configurations.
To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

Device holder couldn't be used at this SAR measurement.

Device Holder

SECTION 4 : Test system specifications

Positioner

Robot:	Stäubli Unimation Corp. Robot Model: RX60L
Repeatability:	0.02 mm
No. of axis:	6

Data Acquisition Electronic (DAE) System

Cell Controller

Processor:	Pentium III
Clock Speed:	450 MHz
Operating System:	Windows 98
Data Card:	DASY3 PC-Board

Data Converter

Features:	Signal Amplifier, multiplexer, A/D converter, and control logic
Software:	DASY3 software
Connecting Lines:	Optical downlink for data and status info. Optical uplink for commands and clock

PC Interface Card

Function:	24 bit (64 MHz) DSP for real time processing Link to DAE3 16-bit A/D converter for surface detection system serial link to robot direct emergency stop output for robot

E-Field Probe

Model:	ET3DV6
Serial No.:	1684
Construction:	Triangular core fiber optic detection system
Frequency:	10 MHz to 6 GHz
Linearity:	+/-0.2 dB (30 MHz to 3 GHz)

Phantom

Type:	SAM Twin Phantom V4.0
Shell Material:	Fiberglass
Thickness:	2.0 +/-0.2 mm
Volume:	Approx. 20 liters

SECTION 5 : Test setup of Dipole

5.1 Photographs of test setup

We performed the test at the following positions. Please refer to "APPENDIX 1" for more details.

1. Separation Distance 0mm	: We performed the test with Dipole touching to the center of flat phantom.
2. Separation Distance 5mm	: We performed the test with Dipole distanced 5mm from the center of flat phantom.
3. Separation Distance 10mm	: We performed the test with Dipole distanced 10mm from the center of flat phantom.
4. Separation Distance 15mm	: We performed the test with Dipole distanced 15mm from the center of flat phantom.
5. Separation Distance 20mm	: We performed the test with Dipole distanced 20mm from the center of flat phantom.
6. Separation Distance 25mm	: We performed the test with Dipole distanced 25mm from the center of flat phantom.

5.2 Measurement procedure

We tested 0mm,5mm ,10mm ,15mm,20mm and 25mm distance between the surface of the flat phantom and the top of dipole at each of head and Body. We inputted 2450MHz and 250mW to the dipole.
Value of Crest Factor = 1 was used.

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SECTION 6 : Measurement uncertainty

The uncertainty budget has been determined for the DASY3 measurement system according to the NIS81 [13] and the NIST1297 [6] documents and is given in the following Table.

Error Description	Uncertainty value ± %	Probability distribution	divisor	(ci)1 1g	Standard Uncertainty (1g)	vi or veff
Measurement System						
Probe calibration	±4.8	Normal	1	1	±4.8	∞
Axial isotropy of the probe	±4.7	Rectangular	√3	$(1-c_p)^{1/2}$	±1.9	∞
Spherical isotropy of the probe	±9.6	Rectangular	√3	$(c_p)^{1/2}$	±3.9	∞
Boundary effects	±5.5	Rectangular	√3	1	±3.2	∞
Probe linearity	±4.7	Rectangular	√3	1	±2.7	∞
Detection limit	±1.0	Rectangular	√3	1	±0.6	∞
Readout electronics	±1.0	Normal	1	1	±1.0	∞
Response time	±0.8	Rectangular	√3	1	±0.5	∞
Integration time	±1.4	Rectangular	√3	1	±0.8	∞
RF ambient conditions	±3.0	Rectangular	√3	1	±1.7	∞
Mech. constraints of robot	±0.4	Rectangular	√3	1	±0.2	∞
Probe positioning	±2.9	Rectangular	√3	1	±1.7	∞
Extrap. and integration	±3.9	Rectangular	√3	1	±2.3	∞
Test Sample Related						
Device positioning	±6.0	Rectangular	√3	1	±6.7	5
Input Power and SAR Drift Measurement	±4.7	Rectangular	√3	1	±2.7	∞
Phantom and Setup						
Phantom uncertainty	±4.0	Rectangular	√3	1	±2.3	∞
Liquid conductivity (target)	±5.0	Rectangular	√3	0.64	±1.8	∞
Liquid conductivity (meas.)	±10.0	Rectangular	√3	0.64	±3.7	∞
Liquid permittivity (target)	±5.0	Rectangular	√3	0.6	±1.7	∞
Liquid permittivity (meas.)	±5.0	Rectangular	√3	0.6	±1.7	∞
Combined Standard Uncertainty					**±13.1**	
Expanded Uncertainty (k=2)					**±26.2**	

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SECTION 7: Simulated tissue liquid parameter

7.1 Simulated Tissue Liquid Parameter confirmation

The dielectric parameters were checked prior to assessment using the HP85070A dielectric probe kit.
The dielectric parameters measured are reported in each correspondent section.

7.2 Head 2450MHz

Type of liquid : **Head 2450 MHz**
Ambient temperature (deg.c.) : **24.5**
Relative Humidity (%) : **31**
Lquid depth (cm) : **15.3**

Date : March 14,2003
Measured By : Miyo Ikuta

DIELECTRIC PARAMETERS MEASUREMENT RESULTS						
Liquid Temp [deg.c]		Parameters	Target Value	Measured	Deviation [%]	Limit [%]
Before	After					
23.8	23.8	Relative Permittivity εr	39.2	35.5	-9.4	+/-10
		Coductivity σ [mho/m]	1.80	1.87	+3.9	+/-5

7.3 Muscle 2450MHz

Type of liquid : **Muscle 2450 MHz**
Ambient temperature (deg.c.) : **23.8**
Relative Humidity (%) : **31**
Liquid depth (cm) : **15.3**

Date :March 14,2003
Measured By : Miyo Ikuta

DIELECTRIC PARAMETERS MEASUREMENT RESULTS						
Liquid Temp [deg.c]		Parameters	Target Value	Measured	Deviation [%]	Limit [%]
Before	After					
22.8	22.8	Relative Permittivity εr	52.7	48.6	-7.8	+/-10
		Conductivity σ [mho/m]	1.95	2.02	+3.6	+/-5

7.4 Simulated Tissues

Ingredient	MiXTURE(%)	
	Head 2450MHz	Muscle 2450MHz
Water	45.0	69.83
DGMBE	55.0	30.17

Note:DGMBE(Diethylenglycol-monobuthyl ether)

SECTION 8: System validation data

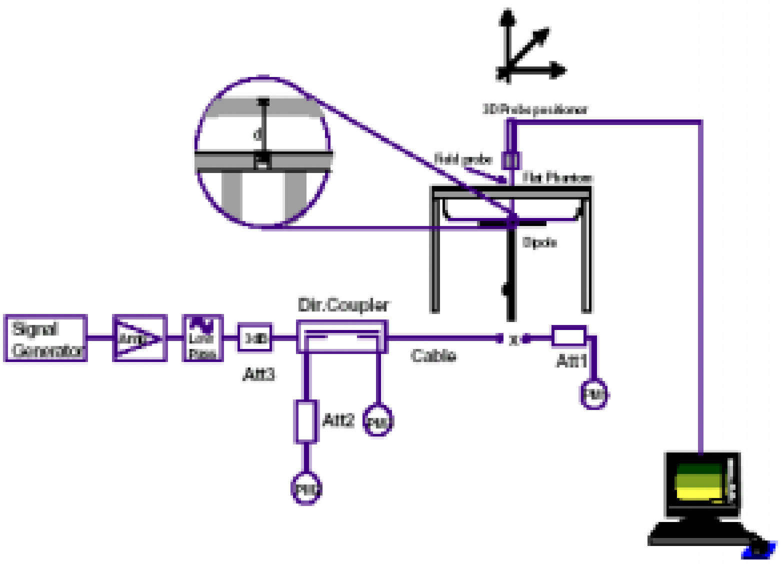
Prior to the assessment, the system validation kit was used to test whether the system was operating within its specifications of +/-10%. The validation results are tabulated below. And SAR plot is attached in the APPENDIX 3. IEEE P1528 Recommended Reference Value

Type of liquid	:	**HEAD 2450MHz**
Frequency	:	**2450MHz**
Liquid depth (cm)	:	**15.3**
Ambient temperature (deg.c.)	:	**24.5**
Relative Humidity (%)	:	**31**
Dipole	:	**D2450V2 SN:713**
Power	:	**250mW**

Date :March 14,2003
Measured By : Miyo Ikuta

SYSTEM PERFORMANCE CHECK									
Liquid (HEAD 2450MHz)						System dipole validation target & measured			
temperature (deg.c.)		Relative Permittivity εr		Conductivity σ [mho/m]		SAR 1g [W/kg]		Deviation [%]	Limit [%]
Before	After	Target	Measured	Target	Measured	Target	Measured		
23.6	23.6	39.2	35.5	1.80	1.87	13.1	13.8	5.3	+/-10

Note: Please refer to Attachment for the result representation in plot format



2450MHz System performance check setup

Test system for the system performance check setup diagram

SECTION 9 : Evaluation procedure

The evaluation was performed with the following procedure:

Step 1: Measurement of the SAR value at a fixed location above the ear point or central position of flat phantom was used as a reference value for assessing the power drop.

Step 2: The SAR distribution at the exposed side of head or body position was measured at a distance of each device from the inner surface of the shell. The area covered the entire dimension of the head or EUT and the horizontal grid spacing was 20 mm x 20 mm. Based on these data, the area of the maximum absorption was determined by spline interpolation.

Step 3: Around this point, a volume of 32 mm x 32 mm x 30 mm was assessed by measuring 5 x5 x 7 points. On the basis of this data set, the spatial peak SAR value was evaluated under the following procedure:

1. The data at the surface were extrapolated, since the center of the dipoles is 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is 1.2 mm. The extrapolation was based on a least square algorithm [4]. A polynomial of the fourth order was calculated through the points in z-axes. This polynomial was then used to evaluate the points between the surface and the probe tip.

2. The maximum interpolated value was searched with a straightforward algorithm. Around this maximum the SAR values averaged over the spatial volumes (1 g or 10 g) were computed by the 3D-Spline interpolation algorithm. The 3D-Spline is composed of three one-dimensional splines with the “Not a knot"-condition (in x, y and z-directions) [4], [5]. The volume was integrated with the trapezoidal-algorithm. One thousand points (10 x 10 x 10) were interpolated to calculate the average.

3. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

Step 4: Re-measurement of the SAR value at the same location as in Step 1. If the value changed by more than 5%, the evaluation was repeated.

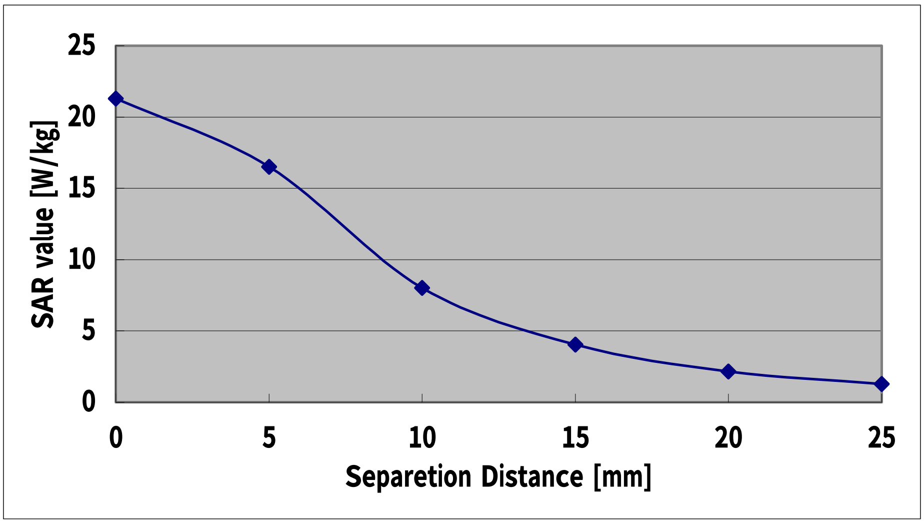
SECTION 10 : SAR Measurement results

10.1 Head 2450MHz SAR

Type of liquid	:	**Head 2450MHz**
Frequency	:	**2450MHz**
Liquid depth (cm)	:	**15.3**
Ambient temperature (deg.c.)	:	**24.5**
Relative Humidity (%)	:	**31**
Parameters	:	ε_r =**35.5**, σ =**1.87**
Crest factor	:	**1**
Dipole	:	**D2450V2 SN:713**
Power	:	**250mW**

Date :March 14,2003
Measured By : Miyo Ikuta

SAR MEASUREMENT				
temperature (deg.c.)		Separation Distance[mm]	Drift [dB]	SAR 1g [W/kg]
Before	After			
23.6	23.6	0	-0.02	**21.3**
23.6	23.5	5	-0.03	**16.5**
23.6	23.6	10	-0.00	**8.03**
23.6	23.6	15	-0.03	**4.05**
23.6	23.7	20	0.02	**2.16**
23.8	23.8	25	-0.04	**1.27**

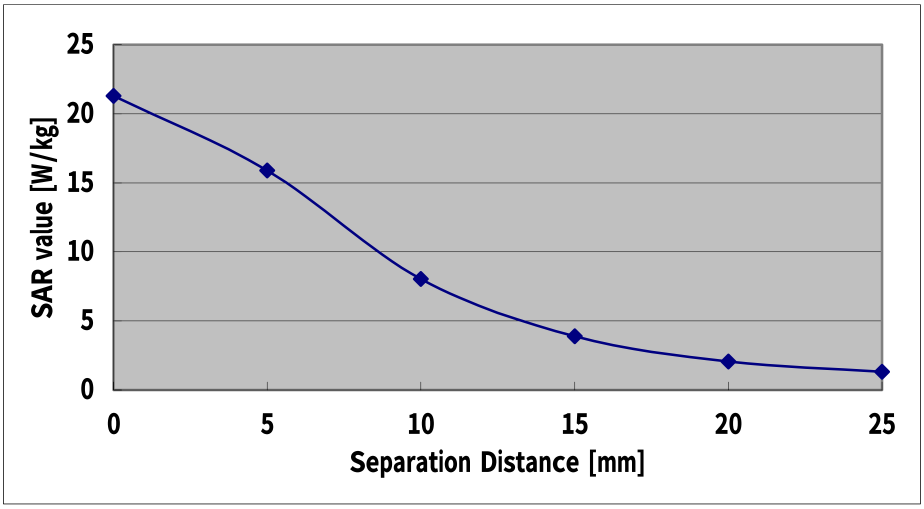


10.2 Body 2450MHz SAR

Type of liquid	:	**Body 2450MHz**
Frequency	:	**2450MHz**
Liquid depth (cm)	:	**15.3**
Ambient temperature (deg.c.)	:	**23.8**
Relative Humidity (%)	:	**31**
Parameters	:	ε_r =**48.6**, σ =**2.02**
Crest factor	:	**1**
Dipole	:	**D2450V2 SN:713**
Power	:	**250mW**

Date :March 14,2003
Measured By : Miyo Ikuta

temperature (deg.c.)		Separation[mm]	Drift [dB]	SAR 1g [W/kg]
Before	After			
22.8	22.8	0	-0.05	**21.3**
22.8	22.8	5	-0.08	**15.9**
22.8	22.8	10	-0.04	**8.05**
22.8	22.9	15	-0.01	**3.90**
22.9	23.1	20	0.03	**2.06**
23.0	22.8	25	-0.04	**1.32**



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SECTION 11 : Equipment & calibration information

Name of Equipment	Manufacture	Model number	Serial number	Calibration	
				Last Cal	due date
Power Meter	Agilent	E4417A	GB41290639	2002/11/08	2003/11/07
Power Sensor	Agilent	E9300B	US40010300	2002/11/14	2003/11/13
Power Sensor	Agilent	8487D	3318A02202	2002/11/11	2003/11/10
S-Parameter Network Analyzer	Agilent	8753ES	US39174808	2000/10/5	2003/10/04
Signal Generator	Rohde&Schwarz	SML03	100332	2002/08/28	2003/08/27
RF Amplifier	OPHIR	5056F	1005	2002/2/7	2003/02/06
Dosimetric E-Field Probe	Schmid&Partner Engineering AG	ET3DV6	1684	2002/11/20	2003/11/19
Data Acquisition Electronics	Schmid&Partner Engineering AG	DAE3 V1	509	2002/4/10	2003/04/09
Robot,SAM Phantom	Schmid&Partner Engineering AG	DASY3	I021834	N/A	N/A
Attenuator	HIROSE ELECTRIC CO.,LTD.	AT-110	N/A	2002/02/04	2003/02/03
2450MHz System Validation Dipole	Schmid&Partner Engineering AG	D2450V2	713	2002/11/15	2004/11/14
Dual Directional Coupler	N/A	Narda	3702	N/A	N/A
Head 2450MHz	N/A	N/A	N/A	N/A	N/A
Body 2450MHz	N/A	N/A	N/A	N/A	N/A

SECTION 12 : References

[1]ANSI, ANSI/IEEE C95.1-1992: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, The Institute of Electrical and Electronics Engineers, Inc., New York, NY 10017, 1992.
[2] Katja Pokovic, Thomas Schmid, and Niels Kuster, "Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies", in ICECOM '97, Dubrovnik, October 15-17, 1997, pp. 120-124.
[3] Katja Pokovic, Thomas Schmid, and Niels Kuster, "E-_field probe with improved isotropy in brain simulating liquids", in Proceedings of the ELMAR, Zadar, Croatia, 23-25 June, 1996, pp.172-175.
[4] W. Gander, Computermathematik, Birkhaeuser, Basel, 1992.
[5] W. H. Press, S. A. Teukolsky,W. T. Vetterling, and B. P. Flannery, Numerical Recepies in C, The Art of Scientific Computing, Second Edition, Cambridge University Press, 1992.
[6] Barry N. Taylor and Christ E. Kuyatt, "Guidelines for evaluating and expressing the uncertainty of NIST measurement results", Tech. Rep., National Institute of Standards and Technology,1994.

SECTION 13 : APPENDIX

APPENDIX 1 : Photographs of test setup

APPENDIX 2 : SAR Measurement based on Supplement C of OET Bulletin 65

APPENDIX 3 : Validation Measurement data

APPENDIX 4 : System Validation Dipole (D2450V2,S/N: 713)

APPENDIX 5 : Dosimetric E-Field Probe (ET3DV6,S/N: 1684)

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APPENDIX 1: Photographs of test setup

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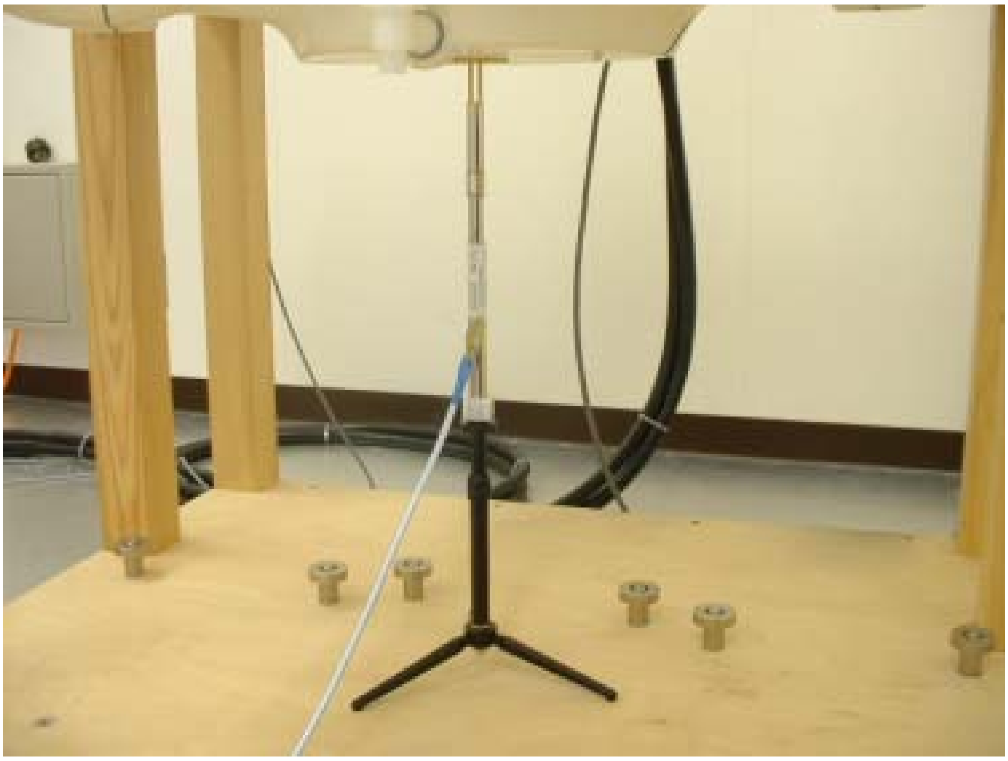
Separation Distance 0mm



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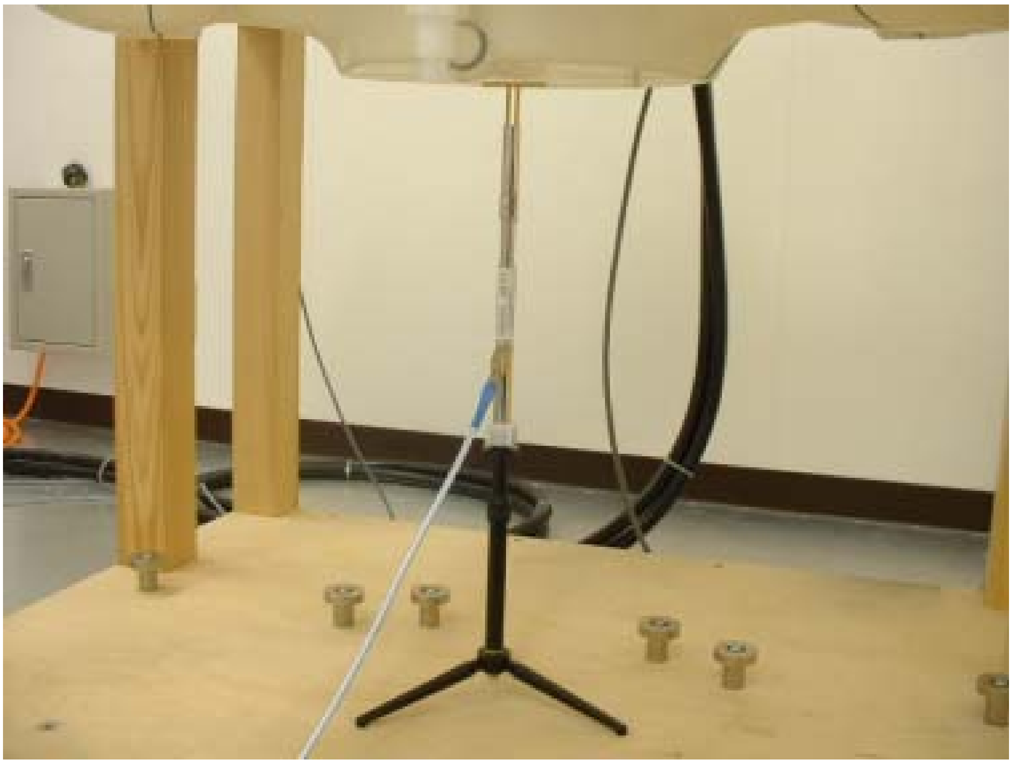
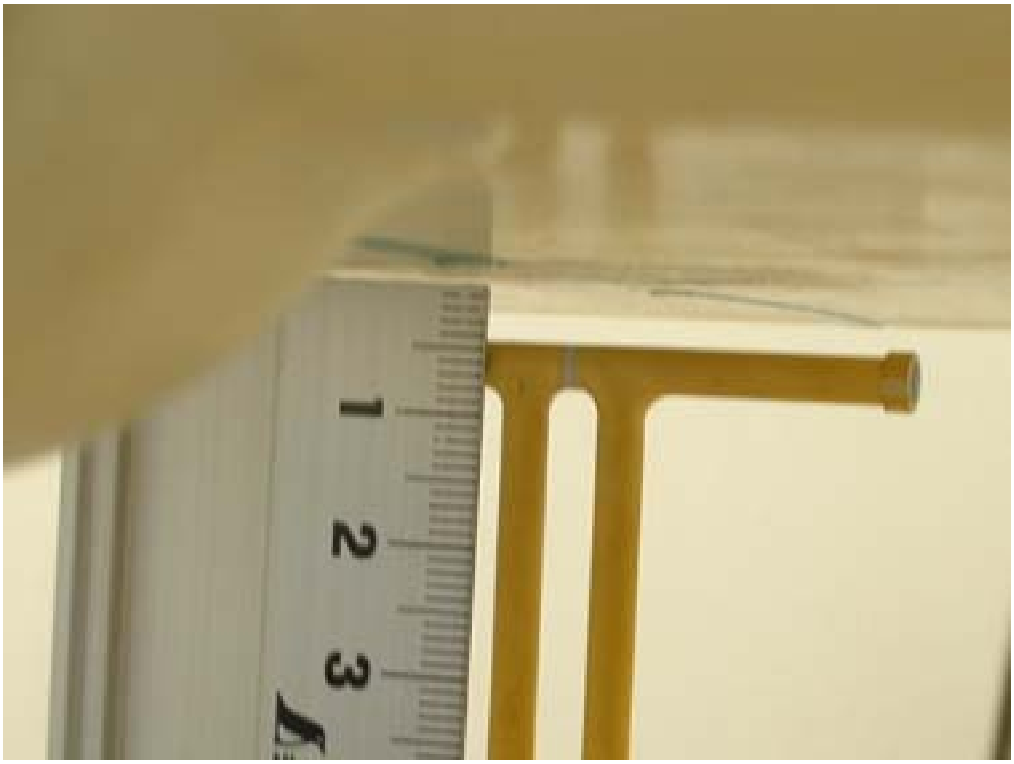
Separation Distance 5mm





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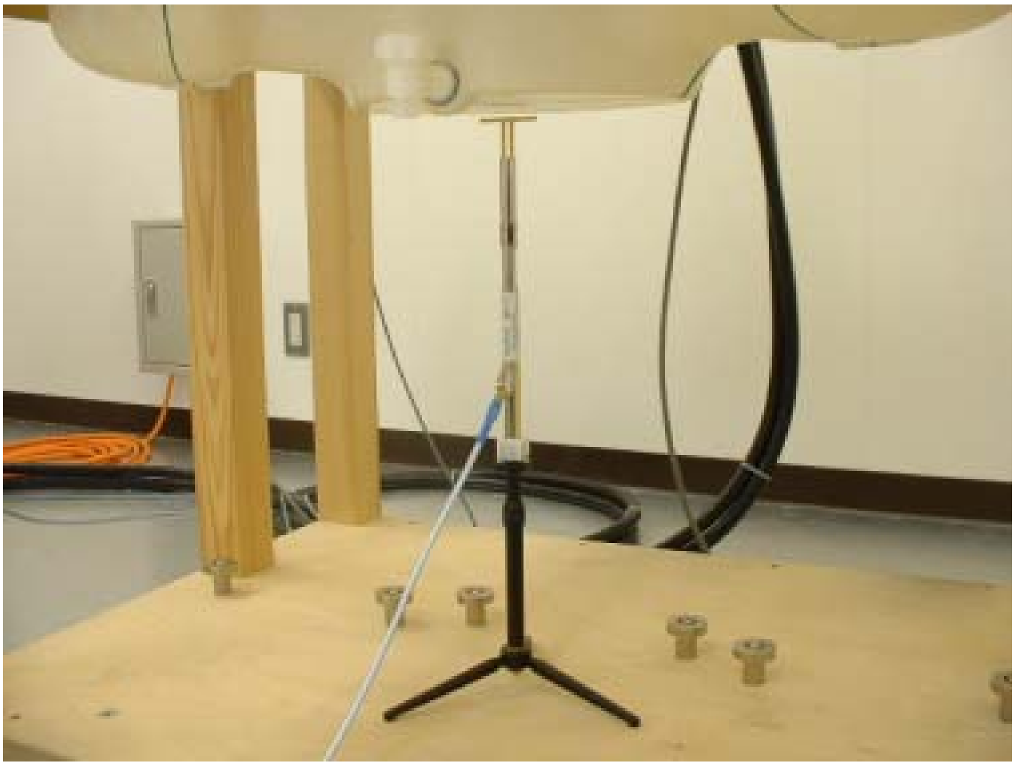
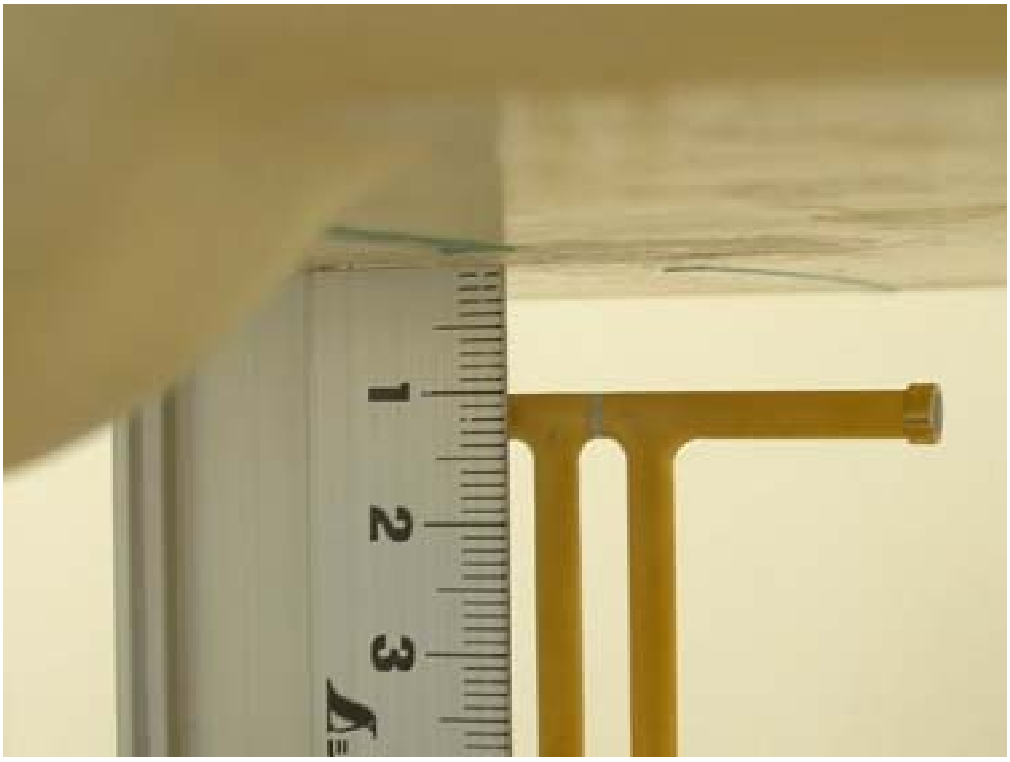
Separation Distance 10mm





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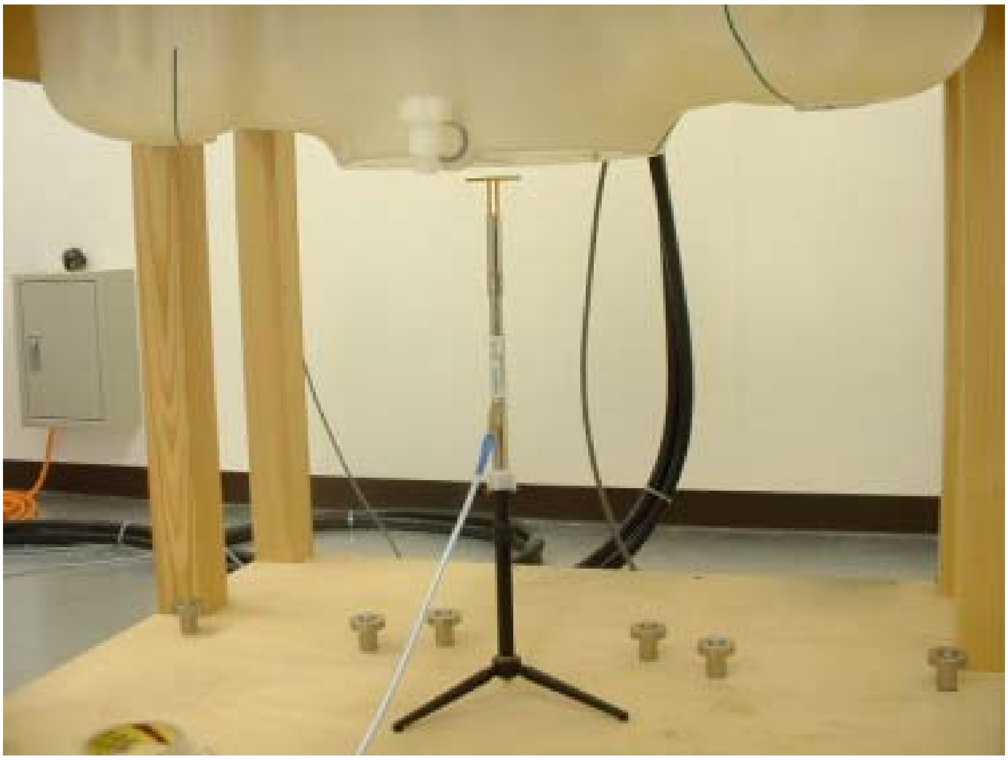
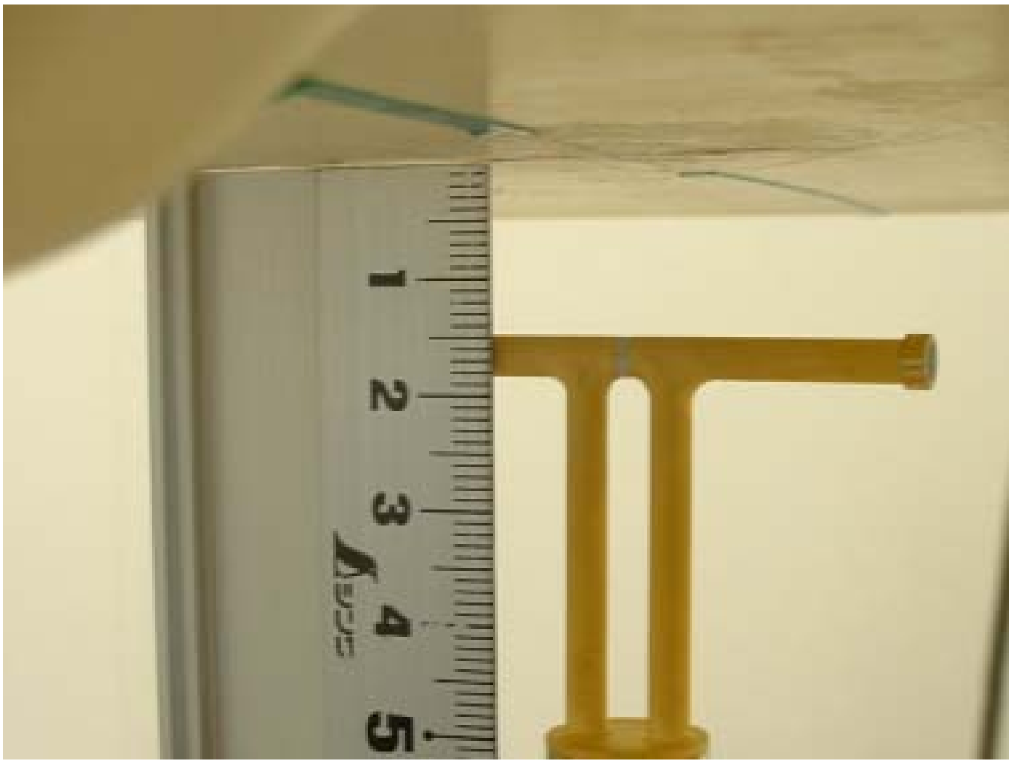
Separation Distance 15mm





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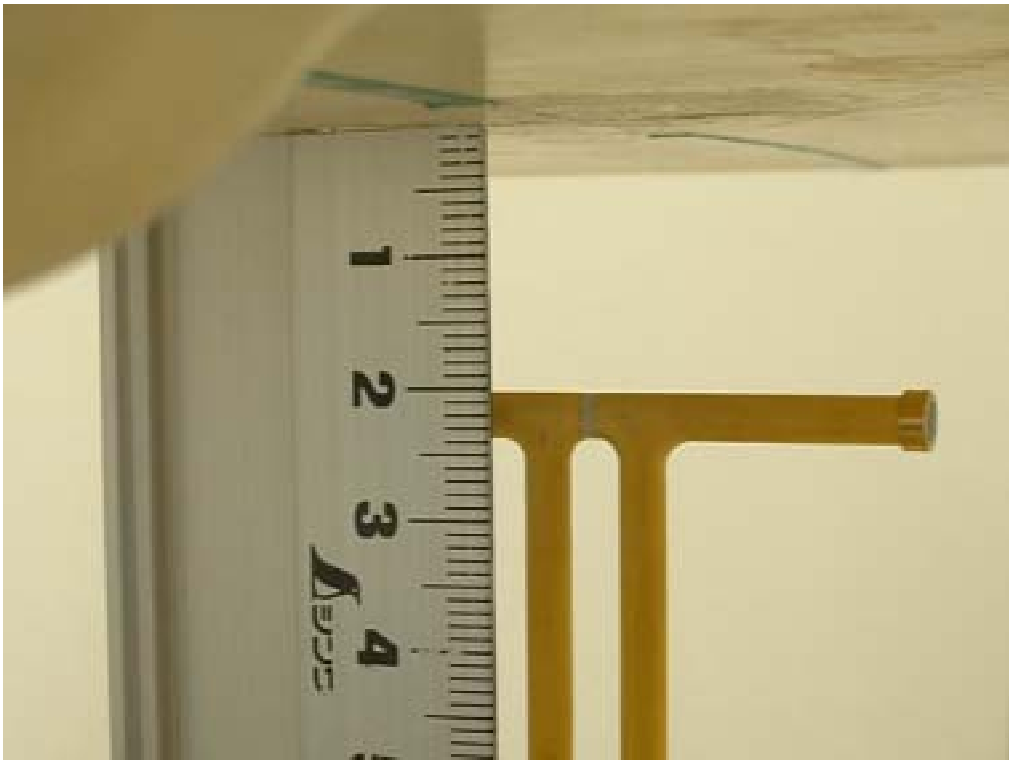
Separation Distance 20mm



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Separation Distance 25mm