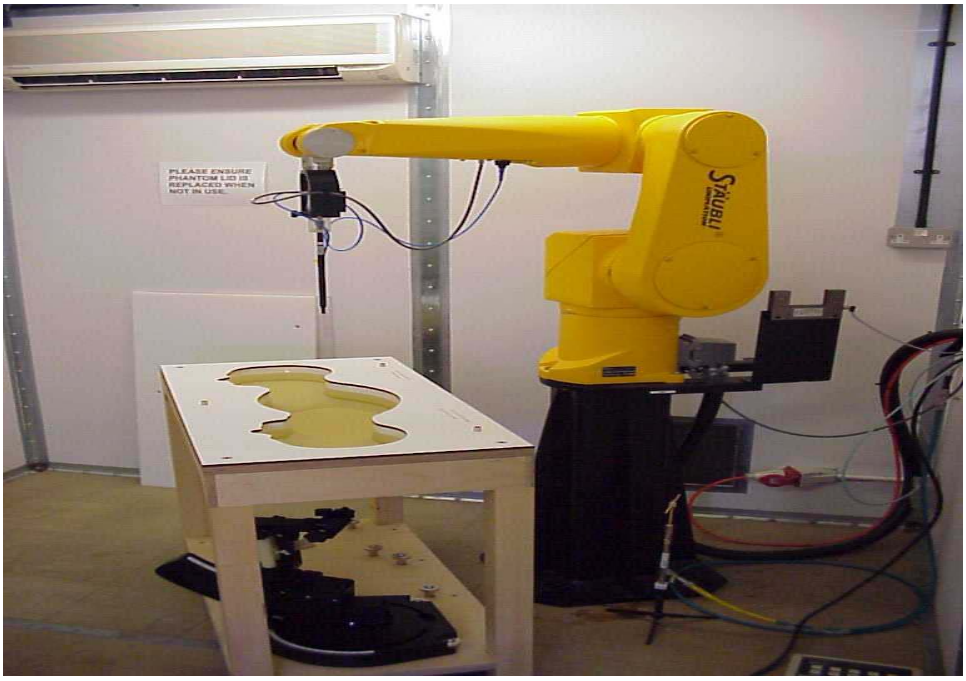
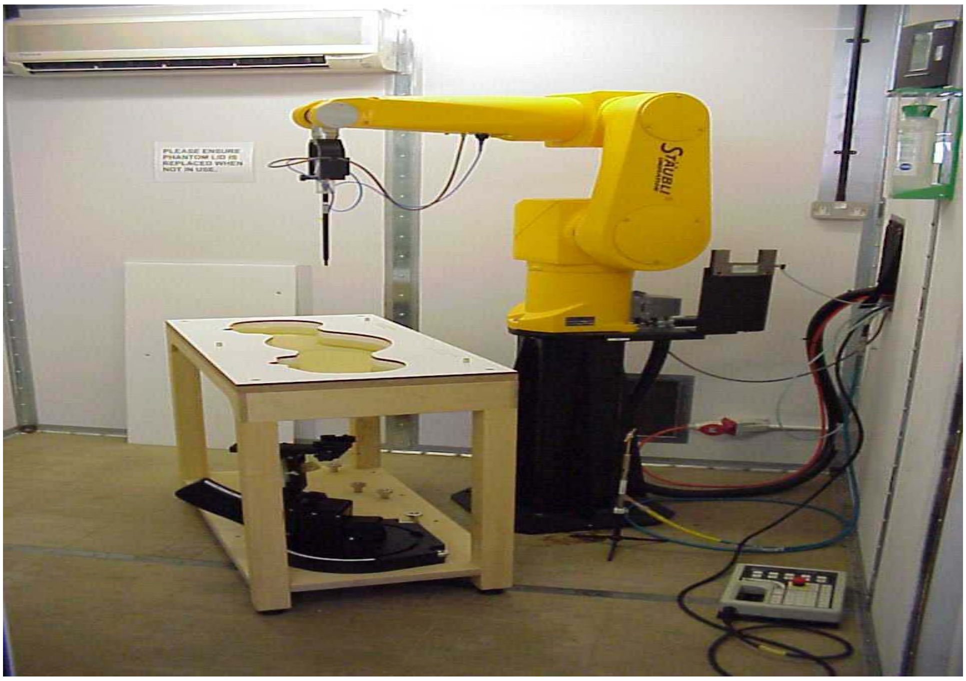
Appendix 3. Test Configuration Photographs

This appendix contains photographs showing the test configuration for the measurement of Specific Absorption Rate (SAR)





Test Configuration Photographs (Continued)

Appendix 4. Calibration Data

This appendix contains the calibration data and certificates.

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A1186

NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Switchboard 020 8977 3222

Certificate of Calibration

SAR PROBE
Model: Schmid & Partner ET3DV6
Serial number: 1529
With Meter Unit DAE 3, Serial number 394

13/04/04

FOR: Radio Frequency Investigations Ltd
Ewhurst Park
Ramsdell
Basingstoke
Hampshire
RG26 5RQ.

For the attention of Scott D Adamo

Order number: 32213

DESCRIPTION: A Schmid & Partner isotropic electric field probe type ET3DV6 (with optical proximity sensor) S/N 1529 for determining specific absorption rates (SAR) in dielectric liquids. The probe has three orthogonal sensors, and the output voltage of each sensor is converted to an optical signal by a Data Acquisition Electronics (DAE) unit. The probe readings are obtained using a personal computer with a dedicated PC card and software. The probe was calibrated with DAE S/N 394.

IDENTIFICATION: The probe is marked with the manufacturer's serial number 1529.

MEASUREMENTS COMPLETED ON: 25 March 2004

PREVIOUS NPL CERTIFICATE: None

The reported uncertainty is based on a coverage factor $k = 2$, providing a level of confidence of approximately 95%

Reference : E04030294

Date of Issue : 5 April 2004 **Signed :** R. N. Clarke **(Authorised Signatory)**

Checked by : **Name : Mr R. N. Clarke for Managing Director**

NPL-C14-99/11

MEASUREMENT PROCEDURE

The calibration method is based on establishing a calculable specific absorption rate (SAR) using a matched waveguide cell [1]. The cell has a feed section and a liquid-filled section separated by a matching window that is designed to minimise reflections at the interface. A TE_{01} mode is launched into the waveguide by means of a N-type-to-waveguide adapter. The power delivered to the liquid section is calculated from the forward power and reflection coefficient measured at the input to the cell. At the centre of the cross-section of the waveguide cell, the volume specific absorption rate (SAR^V) in the liquid as a function of distance from the window is given by

$$SAR^V = \frac{4(P_w)}{ab\delta} e^{-2Z/\delta} \qquad (1)$$

where

a = the larger cross-sectional dimension of the waveguide.
b = the smaller cross-sectional dimension of the waveguide.
δ = the skin depth for the fluid in the waveguide.
z = the distance of the probe's sensors from the liquid to matching window boundary.
P_w = the power delivered to the waveguide.

The value of δ for the liquid is obtained by measuring the electric field (E) at a number of distances from the matching window.

The probe was calibrated at frequencies of 450 MHz, 2450 MHz and 2600 MHz in both Head and Muscle Simulating Liquids, as specified by the CENELEC and IEEE standards [2,3]. The calibration was for continuous wave (CW) signals only, and the axis of the probe was parallel to the direction of propagation of the incident field i.e. end-on to the incident radiation. The probe was rotated about its axis to find the position giving the minimum and maximum readings, and it was calibrated at these positions. The results quoted are for the average of the two measurements.

The probe was calibrated with the free-space correction factors, linearisation and isotropy corrections enabled. Comparing the measured values of E^2 in the liquid to those calculated for the waveguide cell allows the ratio of sensitivity for (E^2_{air}) / (E^2_{liquid}) to be determined, as required by the probe software.

The reference point for the calibration is in the centre of the probe's cross-section at a distance of 2.7 mm from the probe tip in the direction of the DAE unit. A value of 2.7 mm should be used for the tip-to-sensor offset distance in the software.

It is important that the diode compression points and free-space sensitivity factors used in the software are the same as those quoted in the results tables, as these are used to convert the diode output voltages to a SAR value.

ENVIRONMENT

Measurements were made in a temperature-controlled laboratory at 23 ± 1°C. The temperature of the liquid used was measured at the beginning and end of each measurement.

UNCERTAINTIES

The estimated uncertainty in calibration for SAR (W kg^{-1}) is ± 10 %. The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%.

This uncertainty is valid when the probe is used in a liquid with the same dielectric properties as those used for the calibration. No estimate is made for the long-term stability of the device calibrated or of the fluids used in the calibration.

When using the probe for SAR testing, additional uncertainties should be added to account for the spherical isotropy of the probe, proximity effects, linearity, and response to pulsed fields. There will be additional uncertainty if the probe is used in liquids having significantly different electrical properties to those used for the calibration. The electrical properties of the liquids will be related to temperature.

RESULTS

The results of the calibration in liquid are given in Table 1. The calibration factors given are the average of the calibration factors at maximum and minimum sensitivity in the axial rotation.

These calibration factors are only correct when the values for sensitivity in free-space, diode compression and sensor offset from the tip of the probe, as set in the probe software, are the same as those given in Table 1.

REFERENCES:

[1] Pokovic et al 1997, Pokovic, KT, T.Schmid and N.Kuster, "Robust set-up for Precise Calibration of E-field probes in Tissue Simulating Liquids at Mobile Phone Frequencies", Proceedings ICECOM 1997, pp 120 – 124, Dubrovnik, Croatia Oct 12-17, 1997.

[2] British Standard BS EN 503361:2001. "Basic standard for the measurement of specific absorption rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz)".

[3] IEEE Standard 1528 "Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques"

Table 1
Sensitivity in Liquids.
SAR probe: Schmid & Partner ET3DV6, S/N 1529
Measured with DAE3, S/N 394

Probe settings for calibration.		
Sensitivity in free space[1] NormX = 1.67 μV/(V/m^2) NormY = 1.95 μV/(V/m^2) NormZ = 1.71 μV/(V/m^2)	**Diode Compression**[1] DCP X = 93 mV DCP Y = 93 mV DCP Z = 93 mV	**Sensor offset from tip of probe**[1] 2.7 mm

Sensitivity in Liquid.					
Calibration frequency (MHz)	Liquid [2]	Liquid permittivity[3] at the calibration frequency	Liquid conductivity[3] at the calibration frequency (Sm^{-1})	Conversion factor for E^2_{Air} / E^2_{Liquid}	Axial Isotropy (dB)
450	450 HSL[4]	43.8	0.87	**6.64**	± 0.04
450	450 MSL[5]	52.6	0.90	**6.51**	± 0.09
2450	2450 HSL[6]	38.6	1.81	**5.00**	± 0.10
2450	2450 MSL[6]	52.9	1.91	**4.22**	± 0.14
2600	2450 HSL[6]	38.0	1.96	**4.82**	± 0.17
2600	2450 MSL[6]	52.6	2.07	**4.05**	± 0.17

Notes.

[1] The manufacturer supplied these figures.

[2] HSL = Head Simulating Liquid, MSL = Muscle Simulating Liquid.

[3] Measured at NPL at 22.4 ^{0}C.

[4] Supplied by RFI Ltd in container marked “450 HSL (15/03/04)”.

[5] Supplied by RFI Ltd in container marked “450 MSL (15/03/04)”.

[6] Supplied by NPL.

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

Client RFI

CALIBRATION CERTIFICATE

Object(s)	D2450V2 - SN 725
Calibration procedure(s)	QA CAL-05.v2 Calibration procedure for dipole validation kits
Calibration date:	January 17, 2003
Condition of the calibrated item	In Tolerance (according to the specific calibration document)

This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.

All calibrations have been conducted in the closed laboratory facility: environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.

Calibration Equipment used (M&TE critical for calibration)

Model Type	ID #	Cal Date	Scheduled Calibration
RF generator R&S SML-03	100698	27-Mar-2002	In house check: Mar-05
Power sensor HP 8481A	MY41092317	18-Oct-02	Oct-04
Power sensor HP 8481A	US37292783	30-Oct-02	Oct-03
Power meter EPM E442	GB37480704	30-Oct-02	Oct-03
Network Analyzer HP 8753E	US38432426	3-May-00	In house check: May 03

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Laboratory Director	
Approved by:	Niels Kuster	Quality Manager	

Date issued: January 18, 2003

This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.

Schmid & Partner
Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

DASY

Dipole Validation Kit

Type: D2450V2

Serial: 725

Manufactured: October 16, 2002
Calibrated: January 17, 2003

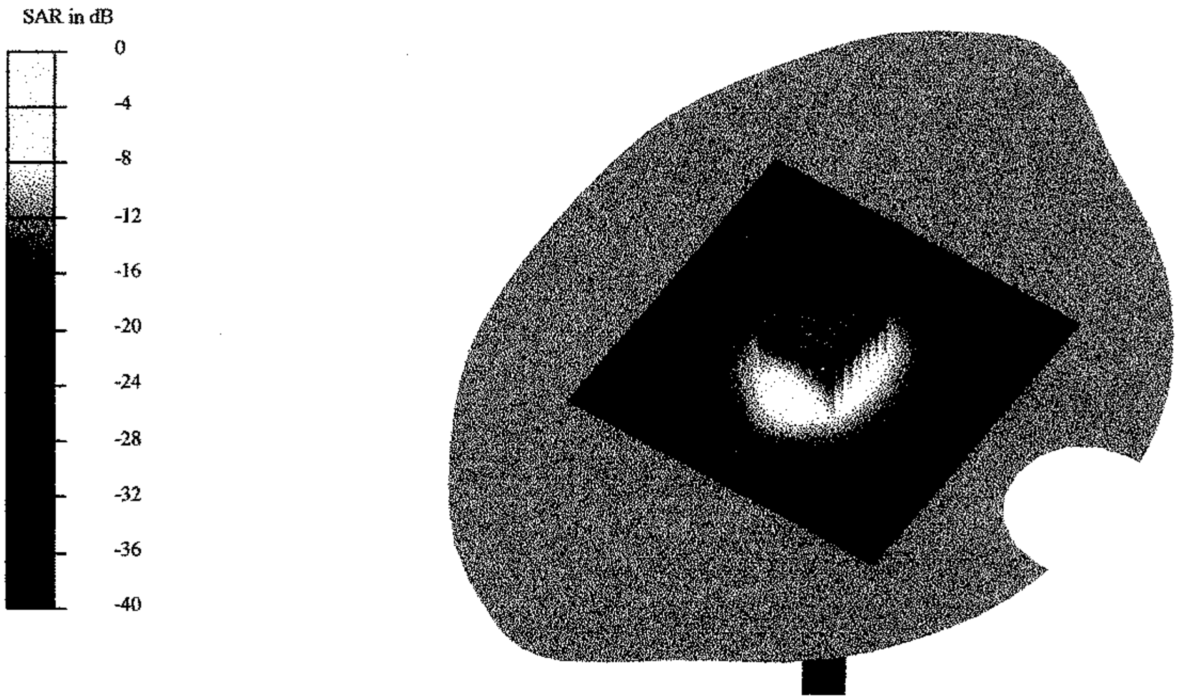
Test Laboratory: SPEAG, Zurich, Switzerland
File Name: SN725_SN1507_M2450_150103.da4

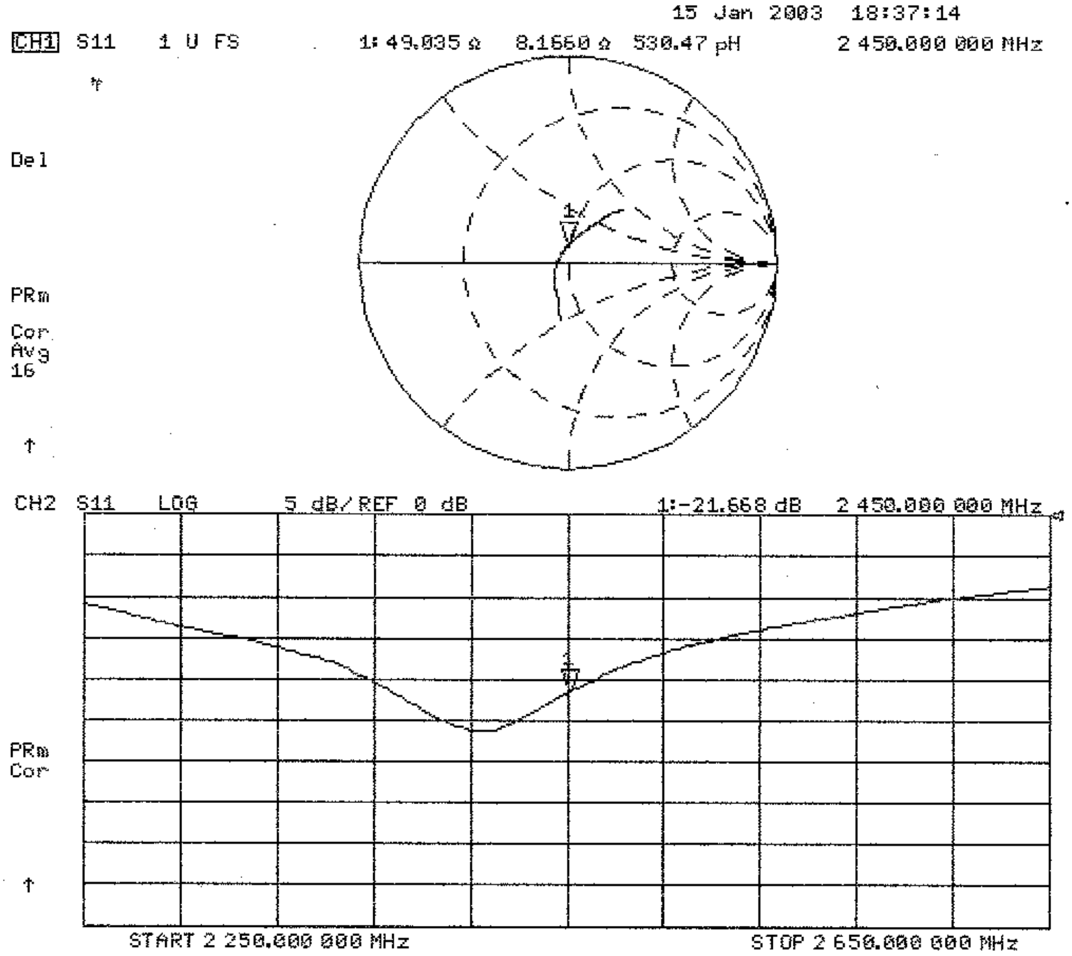
DUT: Dipole 2450 MHz Type & Serial Number: D2450V2 - SN725
Program: Dipole Calibration; Pin = 263 mW; d = 10 mm

Communication System: CW-2450; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: Muscle 2450 MHz (σ = 2.05 mho/m, ε = 51.05, ρ = 1000 kg/m3)
Phantom section: FlatSection

DASY4 Configuration:
- Probe: ET3DV6 - SN1507; ConvF(4.5, 4.5, 4.5); Calibrated: 1/24/2002
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 - SN410; Calibrated: 7/18/2002
- Phantom: SAM 4.0 - TP:1006
- Software: DASY4, V4.0 Build 51

Area Scan (81x81x1): Measurement grid: dx=15mm, dy=15mm
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm
Reference Value = 94.8 V/m
Peak SAR = 27.2 mW/g
SAR(1 g) = 13.7 mW/g; SAR(10 g) = 6.33 mW/g
Power Drift = -0.02 dB

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Del
PRm
Cor
Avg
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CH2 S11 LOG 5 dB/ REF 0 dB
1:-21.668 dB 2 450.000 000 MHz
PRm
Cor
START 2 250.000 000 MHz
STOP 2 650.000 000 MHz

Muscle

1. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with head simulating solution of the following electrical parameters at 2450 MHz:

Relative permitivity	**37.4**	± 5%
Conductivity	**1.88 mho/m**	± 10%

The DASY4 System with a dosimetric E-field probe ET3DV6 (SN:1507, conversion factor 5.0 at 2450 MHz) was used for the measurements.

The dipole feedpoint was positioned below the center marking and oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center 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 7x7x7 fine cube was chosen for cube integration.
The dipole input power (forward power) was 263mW ± 3 %. The results are normalized to 1W input power.

2. SAR Measurement with DASY4 System

Standard SAR-measurements were performed according to the measurement conditions described in section 1. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue:	**54.7 mW/g**
averaged over 10 cm^3 (10 g) of tissue:	**24.5 mW/g**

3. Dipole impedance and return loss

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

Electrical delay:	**1.151 ns**	(one direction)
Transmission factor:	**0.997**	(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 2450 MHz:	Re{Z} = **53.0 Ω**
	Im {Z} = **7.0 Ω**
Return Loss at 2450 MHz	**- 22.6 dB**

4. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with body simulating solution of the following electrical parameters at 2450 MHz:

Relative permitivity	**51.1**	± 5%
Conductivity	**2.05 mho/m**	± 10%

The DASY4 System with a dosimetric E-field probe ET3DV6 (SN:1507, conversion factor 4.5 at 2450 MHz) was used for the measurements.

The dipole feedpoint was positioned below the center marking and oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center 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 7x7x7 fine cube was chosen for cube integration.
The dipole input power (forward power) was 263mW ± 3 %. The results are normalized to 1W input power.

5. SAR Measurement with DASY4 System

Standard SAR-measurements were performed according to the measurement conditions described in section 4. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the advanced extrapolation are:

averaged over 1 cm^3 (1 g) of tissue:	**52.1 mW/g**
averaged over 10 cm^3 (10 g) of tissue:	**24.1 mW/g**

6. Dipole impedance and return loss

The dipole was positioned at the flat phantom sections according to section 4 (with body tissue inside the phantom) and the distance holder was in place during impedance measurements.

Feedpoint impedance at 2450 MHz:	Re{Z} = **49.0 Ω**
	Im {Z} = **8.1Ω**
Return Loss at 2450 MHz	**- 21.7 dB**

7. Handling

Do not apply excessive force to the dipole arms, because they might bend. Bending of the dipole arms stresses the soldered connections near the feedpoint leading to a damage of the dipole.

8. Design

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

Small end caps have been added to the dipole arms in order to improve matching when loaded according to the position as explained in Section 1. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

9. Power Test

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

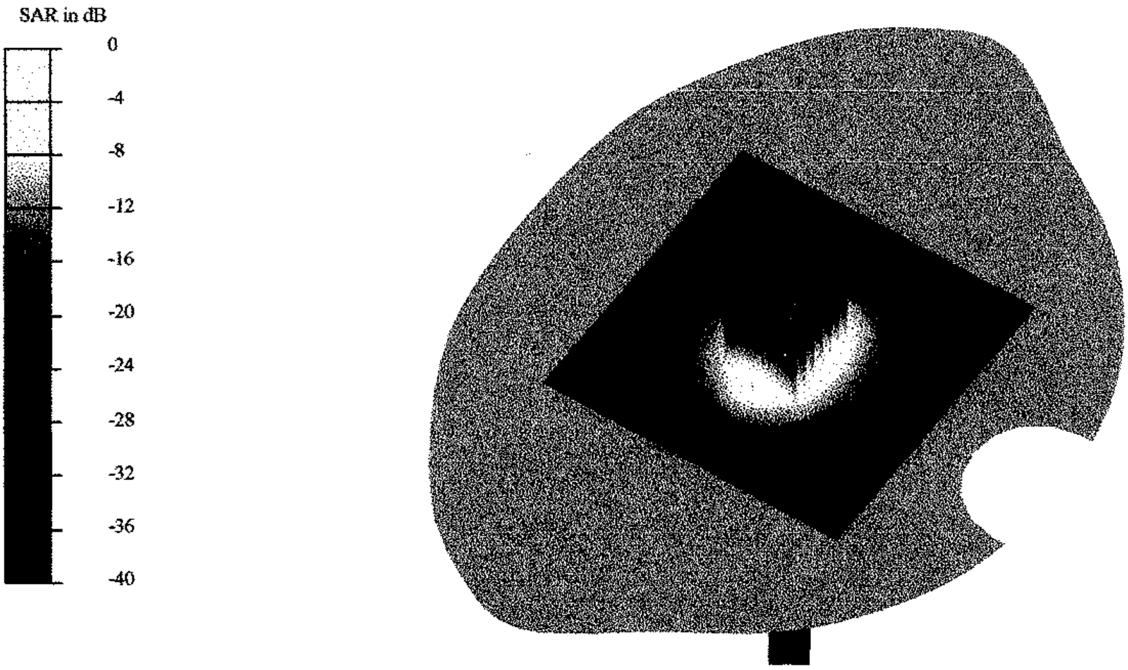
Test Laboratory: SPEAG, Zurich, Switzerland
File Name: SN725_SN1507_HSL2450_150103.da4

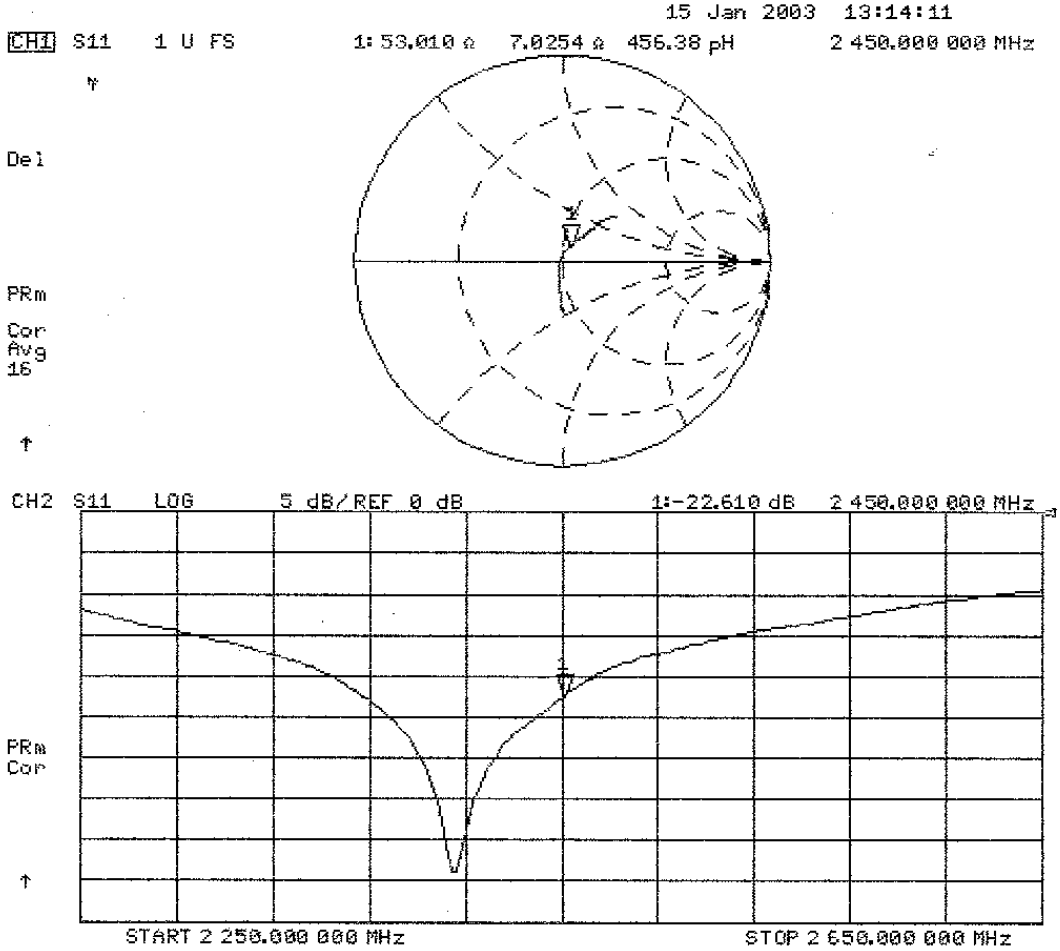
DUT: Dipole 2450 MHz Type & Serial Number: D2450V2 - SN725
Program: Dipole Calibration; Pin = 263 mW; d = 10 mm

Communication System: CW-2450; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: HSL 2450 MHz (σ = 1.88 mho/m, ε = 37.4, ρ = 1000 kg/m3)
Phantom section: FlatSection

DASY4 Configuration:
- Probe: ET3DV6 - SN1507; ConvF(5, 5, 5); Calibrated: 1/24/2002
- *Sensor-Surface: 4mm (Mechanical Surface Detection)*
- Electronics: DAE3 - SN410; Calibrated: 7/18/2002
- Phantom: SAM 4.0 - TP:1006
- Software: DASY4, V4.0 Build 51

Area Scan (81x81x1): Measurement grid: dx=15mm, dy=15mm
Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm
Reference Value = 97.1 V/m
Peak SAR = 31.6 mW/g
SAR(*1 g*) = 14.4 mW/g; SAR(*10 g*) = 6.45 mW/g
Power Drift = 0.02 dB

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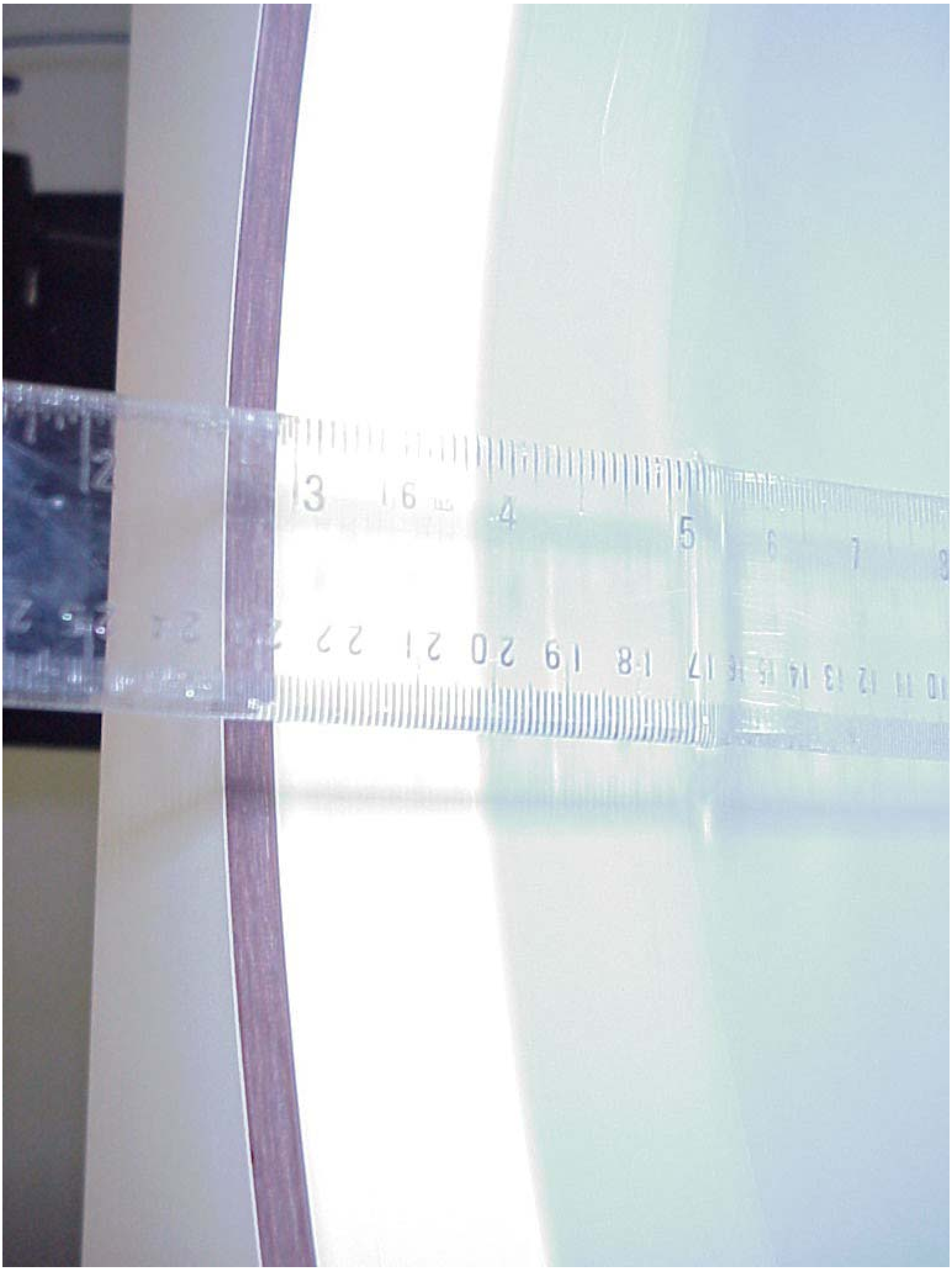
Del
PRm
Cor
Avg
16
CH2 S11 LOG 5 dB/REF 0 dB 1:-22.610 dB 2 450.000 000 MHz
PRm
Cor
START 2 250.000 000 MHz
STOP 2 650.000 000 MHz

Appendix 5 Photographs of EUT

This appendix contains the following photographs:

Photo Reference Number	Title
PHT/45219/001	2450 MHz MSL Fluid Level
PHT/45219/002	ACer Host Laptop with PCMCIA Modem in Bottom Slot, 0 Degrees to Phantom
PHT/45219/003	ACer Host Laptop with PCMIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/004	ACer Host Laptop with PCMCIA Modem, 90 Degrees to Phantom
PHT/45219/005	Close-up View of ACer Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/006	Close-up View of ACer Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/007	Close-up View of PCMCIA Modem
PHT/45219/008	Close-up View of Sony Host Laptop with PCMCIA Modem, 0 Degrees to Phantom
PHT/45219/009	Close-up View of UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/010	Close-up View of UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/011	PCMCIA Modem View 1
PHT/45219/012	PCMCIA Modem View 2
PHT/45219/013	Sony Host Laptop with PCMCIA Modem, 0 Degrees to Phantom
PHT/45219/014	Sony Host Laptop with PCMCIA Modem, 90 Degrees to Phantom
PHT/45219/015	UMAX Host Laptop with PCMCIA Modem in Bottom Slot, 0 Degrees to Phantom
PHT/45219/016	UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom
PHT/45219/017	UMAX Host Laptop with PCMCIA Modem, 90 Degrees to Phantom

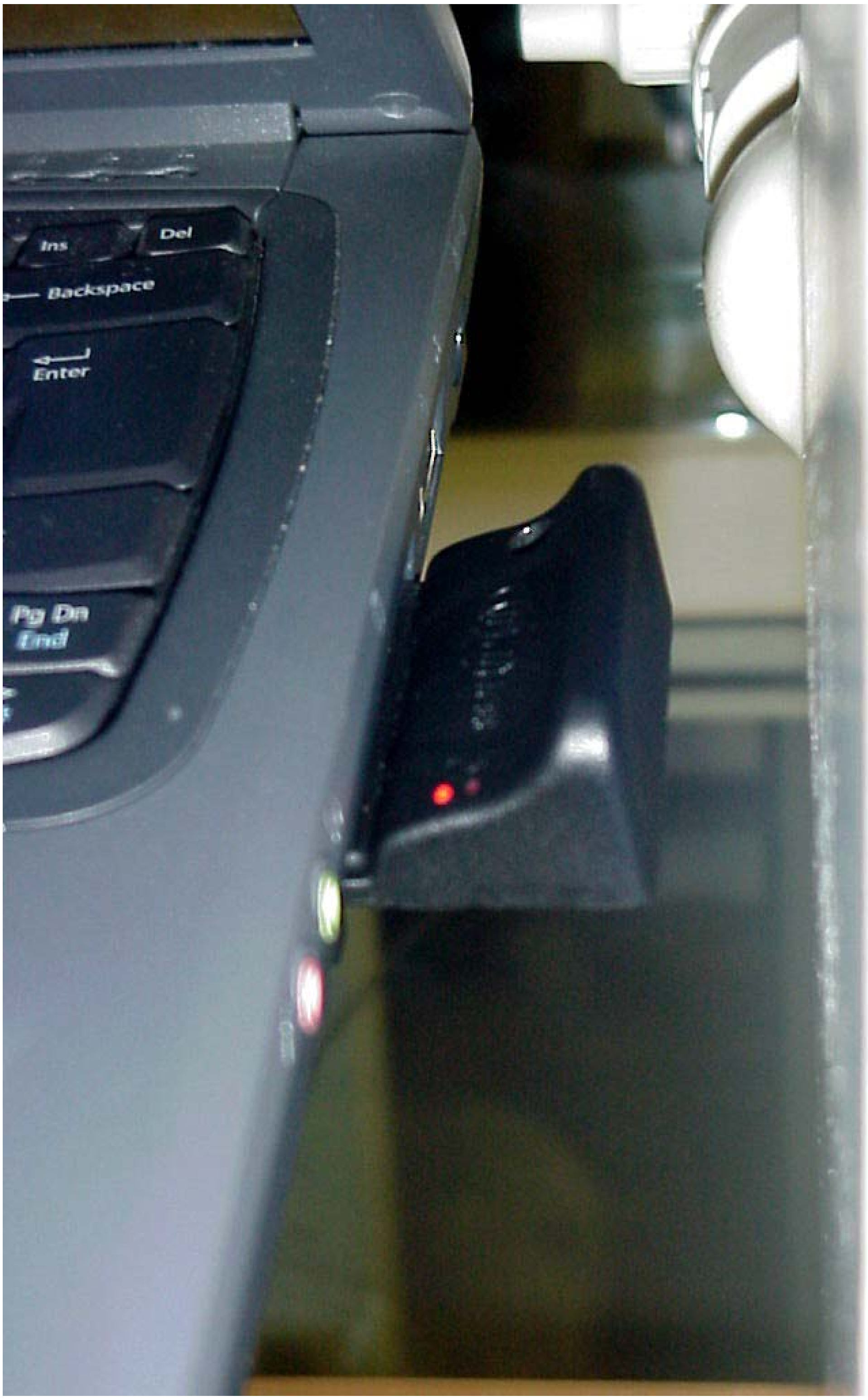
PHT/45219/001 2450 MHz MSL Fluid Level



PHT/45219/002 ACer Host Laptop with PCMCIA Modem in Bottom Slot, 0 Degrees to Phantom

PHT/45219/003 ACer Host Laptop with PCMIA Modem in Top Slot, 0 Degrees to Phantom

PHT/45219/004 ACer Host Laptop with PCMCIA Modem, 90 Degrees to Phantom



PHT/45219/005 Close-up View of ACer Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom

PHT/45219/006 Close-up View of ACer Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom

<u>PHT/45219/007 Close-up View of PCMCIA Modem</u>

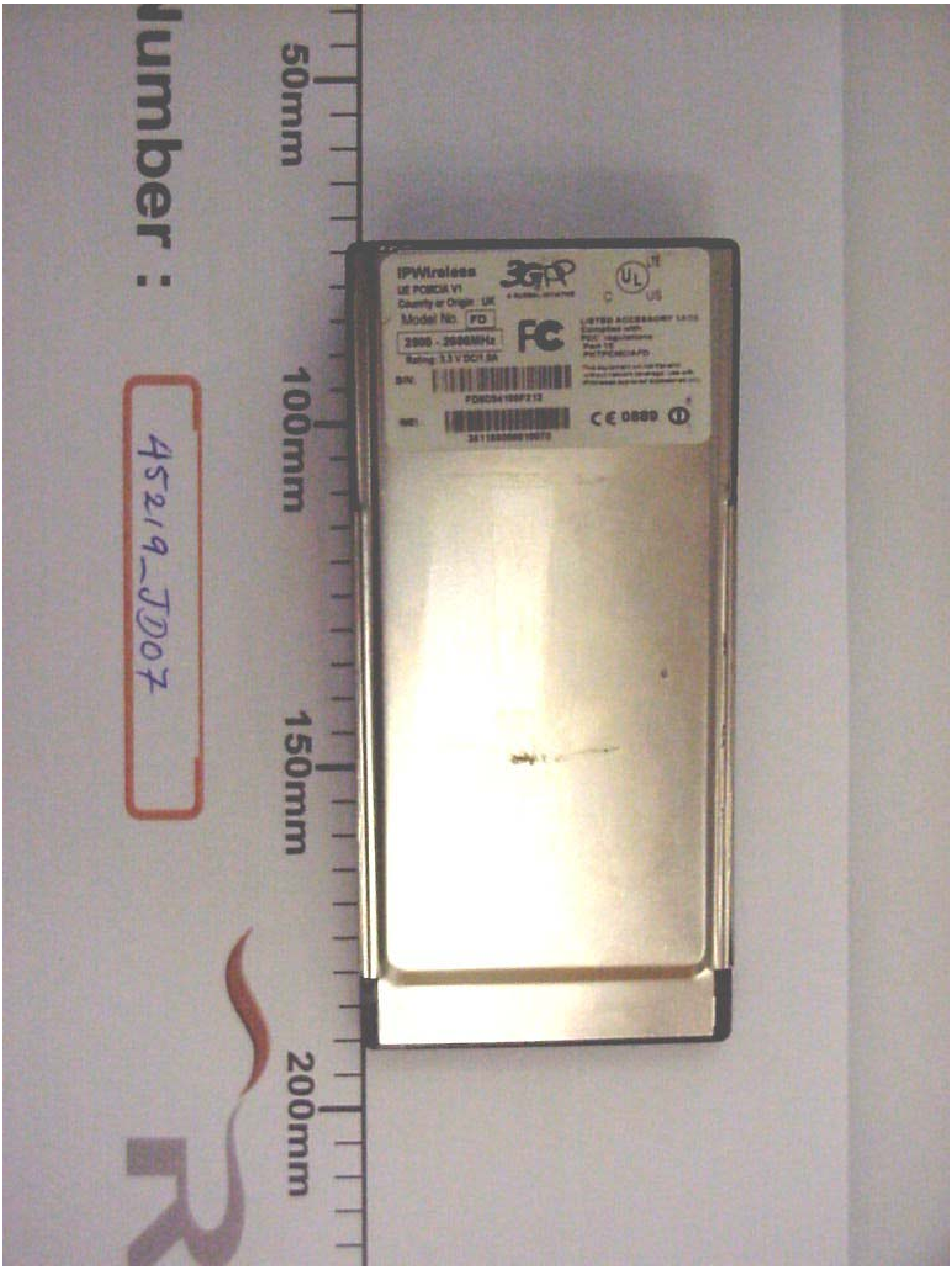
PHT/45219/008 Close-up View of SONY Host Laptop with PCMCIA Modem, 0 Degrees to Phantom

PHT/45219/009 Close-up View of UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom

PHT/45219/010 Close-up View of UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom

PHT/45219/011 PCMCIA Modem View 1

PHT/45219/012 PCMCIA Modem View 2



PHT/45219/013 SONY Host Laptop with PCMCIA Modem, 0 Degrees to Phantom

PHT/45219/014 SONY Host Laptop with PCMCIA Modem, 90 Degrees to Phantom

PHT/45219/015 UMAX Host Laptop with PCMCIA Modem in Bottom Slot, 0 Degrees to Phantom

PHT/45219/016 UMAX Host Laptop with PCMCIA Modem in Top Slot, 0 Degrees to Phantom

PHT/45219/017 UMAX Host Laptop with PCMCIA Modem, 90 Degrees to Phantom