TEST REPORT CONCERNING THE COMPLIANCE OF A HONEYWELL IMPACT XTREME MULTI GAS DETECTOR IN CONFORMITY WITH SAR (SPECIFIC ABSORPTION RATE) REGULATORY REQUIREMENTS OF THE FCC

IEEE Std C95.1-1999,
IEEE Std 1528-2003,

13050602.s01
May 07, 2013

FCC listed	:	90828
Industry Canada	:	2932G-2
R&TTE, LVD, EMC Notified Body	:	1856

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Description of test item

Test item	:	Multi Gas Detector
Manufacturer	:	Honeywell
Brand	:	Honeywell
Model	:	Impact Xtreme
Receipt date	:	May 6, 2011

Applicant information

Applicant's representative	:	Mr Narasimha Charyulu
Company	:	Honeywell Technologies Solutions LAB PVT. LTD.
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Test(s) performed

Location	:	Niekerk/Leek
Test(s) started	:	May 6, 2011
Test(s) completed	:	June 10, 2011
Purpose of test(s)	:	Conformity Testing with the Regulatory RF Exposure Requirements in Europe and Singapore. This is an re-issue of the testreport with updates to the latest standards.

Project leader	:	L. Koopmans
Test engineer(s)	:	L. Koopmans
Report written by	:	R. van der Meer
Report approved by	:	O.H. Hoekstra
Report date	:	May 07, 2013

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1 General Information

1.1 Purpose of testing

Tests described in this test report have been performed to verify compliance with the (Federal) regulated RF exposure (SAR) requirements in the USA. The tests were executed as a part of a SAR correlation study organized by the applicant.

1.2 Applied standards and related documents.

The Honeywell Impact Xtreme Multi Gas Detector (hereafter mentioned EUT) has been tested in conformity with the following standards and/or publications:

Federal Communications Commission: Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), FCC, 2001.

IEEE Std C95.1-1999: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Inst. of Electrical and Electronics Engineers, Inc.

IEEE Std 1528-2003: Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques. Inst. of Electrical and Electronics Engineers, Inc.

KDB 865644 D01 SAR Measurement 100 MHz to 6 GHz v01 Edition 10/24/2012.

KDB 248227 Federal Communications Commission, Office of Engineering and Technology: SAR Measurement Procedures for 802.11 a/b/g Transmitters, May 2007.

KDB 447498 Federal Communications Commission, Office of Engineering and Technology: Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies, October 24, 2012.

KDB 616217D01 Federal Communications Commission, Office of Engineering and Technology: SAR Evaluation Considerations for Laptop Computers with Antennas Built-in on Display Screens, Update November 2009.

KDB 616217D03 Federal Communications Commission, Office of Engineering and Technology: SAR Evaluation Considerations for Laptop/Notebook/Netbook and Tablet Computers, November 13, 2009.

ICNIRP Guidelines “GUIDELINES FOR LIMITING EXPOSURE TO TIME-VARYING ELECTRIC, MAGNETIC, AND ELECTROMAGNETIC FIELDS (UP TO 300 GHz)”.

2 Summary and Conclusion.

2.1 Exposure category

The EUT supplied for Specific Absorption Rate (SAR) testing according the standards/publications as indicated in section 1.2 is a considered to be a:

Portable Device*. *Body Worn

According to the characteristics of the EUT and typical application and usage in accordance with the relevant product specifications of the manufacturer the EUT is identified to the exposure category:

General population/Uncontrolled exposure

2.2 Summary of results:

In the 2.4 GHz Wifi frequency range, the maximum peak spatial-average SAR could not be measured because the SAR levels fall below the threshold of the SAR measuring system. The EUT was positioned such that the antenna was touching the phantom.

In the 5 GHz Wifi frequency range, the maximum peak spatial-average SAR measured was 0.363 W/kg averaged over 1g with an EUT power level of 13.0 dBm while the EUT was positioned such that the antenna was touching the phantom and transmitting on 5700 MHz (channel 140).

All detailed test results are available **in Annex D and E**.

IEEE 802.11b mode (2412.0 MHz – 2462.0 MHz)			
Test specification(s)	Measurement	Report clause	Compliance results
IEEE-1528, OET 65-C	SAR	Annex D	**PASS**
Frequency	Max Spatial Peak SAR(1g)		
2412 MHz	**< 0.012**		
2442 MHz	**< 0.012**		
2462 MHz	**< 0.012**		

IEEE 802.11a mode (5180.0 MHz – 5805.0 MHz)			
Test specification(s)	Measurement	Report clause	Compliance results
IEEE-1528, OET 65-C	SAR	Annex E	**PASS**
Frequency	Max Spatial Peak SAR(1g)		
5180 MHz	**0.216**		
5320 MHz	**0.277**		
5500 MHz	**0.268**		
5700 MHz	**0.363**		
5805 MHz	**0.274**		

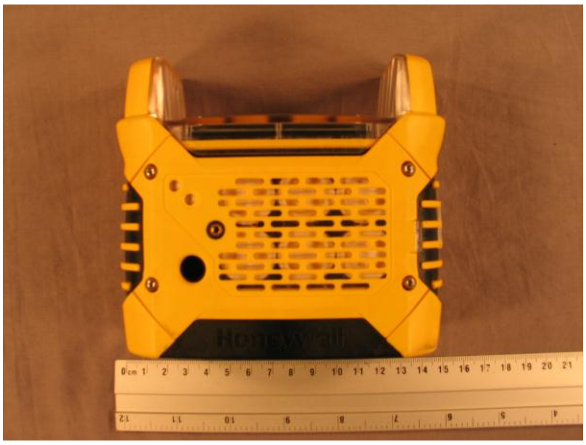
3 Identification of Equipment Under Test (EUT)

3.1 General

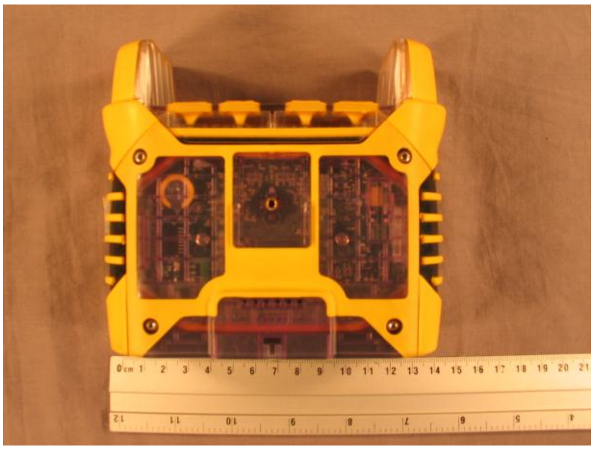
The following information has been provided by the applicant and after verification have been used to identify the equipment under test (EUT).

Test item (EUT)	:	Honeywell Impact Xtreme
Manufacturer	:	Honeywell
Brand	:	Honeywell
Model	:	Impact Xtreme
Transmit output power setting	:	16 dBm at 2.4 GHz and 13 dBm at 5 GHz
Frequency range 802.11b	:	2412.0 MHz – 2462.0 MHz
Frequency range 802.11a	:	5180.0 MHz – 5805.0 MHz

3.2 Photos of the EUT



a) front view



b) rear view

Figure 1: photograph of the Honeywell Impact Xtreme

3.3 EUT Test description.

The EUT is an multi gas detector with an embedded 802.11 b/g/a network adapter operating in the 2.4 GHz and 5 GHz spectrum. The EUT is able to transmit at various transmission bitrates and utilizes DSSS and OFDM modulation techniques.

3.4 Additional operating configurations

Power and signal distribution, grounding, interconnecting cabling and physical placement of the EUT under circumstances of testing at the test system are in accordance with the typical application and usage in so far as is practicable, and is in accordance with the relevant product specifications of the manufacturer.

3.5 Test Conditions

3.5.1 Environmental conditions

Requirement for	Specification	Determined value
Ambient temperature	+18°C to +25°C Temperature shall not exceed ±2 °C during the test	+20 °C at start to +20 °C at end of test
Ambient humidity	20% RH to 75% RH	53% RH
Electro Magnetic environment	the ambient interference power shall be less than 0.012 W/kg	below the required lower detection limit of 0.012 W/kg, checked before and after test

4 Tests results

4.1 Validation and system check

Before tests on the EUT can take place the following checks need to be done first:

System check at 2450 MHz,	see section 5.1.1 and Annex B for data.
System check at 5200 MHz, 5500 MHz and 5800 MHz	see section 5.1.1 and Annex C for data.
Liquid validation,	see section 5.2.

4.2 Test results

4.2.1 SAR measurement execution

The EUT's antenna position is perpendicular with respect to the SAR flat phantom bottom shell with 0 mm separation distance (antenna directly against phantom's surface). From quick scans of the possible placement of the antenna, placing the antenna perpendicular prove to be the worst case situation.
The liquid level in the phantom all cases was 15 cm. For measurements >3 GHz the depth was thus more than the required ≥10.0 cm ±0.5 cm, but it is considered to give improved probe immersion in the liquid.
See Annex D and E for SAR results.

4.2.2 Interpolation and extrapolation

The SAR system uses "cubic B-spline" for interpolation and "4^{th}-order polynomial fitting" for extrapolation.

4.2.3 Validation parameters

The system(s) and materials used for testing are validated as per the relevant standards.

4.2.4 EUT channel selection

The EUT is evaluated at low, mid and high band frequencies at each frequency band according to default channel list mentioned in KDB 248227.

4.2.4.1 EUT position(s)

The EUT, was placed with it's bottom directly placed against the flat phantom bottom shell with 0 mm separation distance. This is illustrated with the photo's in the Test setup photographs report.

Figure 2: Test setup.

4.3 Exposure limits

Limit value for General population / Uncontrolled exposure as mentioned in the references mentioned in section 1.2:

**Spatial Peak SAR shall not exceed 1.6 W/kg,
which is averaged over any one gram of tissue defined as a tissue volume in the shape of a cube.**

4.4 SAR, the basics

Specific Absorption Rate (SAR) is defined as the time derivative of the incremental electromagnetic energy (*dW*) absorbed by (dissipated in) an incremental mass (*dm*) contained in a volume element (*dV*) of given mass density (*ρ*), as given below.

Definition

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho \cdot dV}\right)$$

calculated from electric field strength conductivity and mass density

$$SAR = \sigma \cdot \frac{E_i^2}{\rho}$$

It has units of watts per kilograms. It can be calculated by means shown above, where E_i is the rms value of the electric field strength in the tissue in V/m, σ is the conductivity of head or body tissue in S/m, ρ is the density of head or body tissue in kg/m^3. This method, measuring the electric field, is generally the most convenient and is the method used by the SARA2 system of TR-EPS. The SAR at a point in space is not particularly relevant in assessing biological effects; rather, the SAR should be averaged over a given volume. The SAR standards define the volume to be used for averaging as either a 1g (US) or a 10g (EU) cube. SAR measurements are carried out by scanning a tissue simulating medium along the interior of a phantom shell, using a multi-axis robot to position a miniature E-field probe. Once the region of highest SAR is identified, post-processing algorithms can be used to average the local SAR over this prescribed volume to determine the peak spatial average SAR.

5 System validation

5.1 System validation

The purpose of the system validation (system check) is to verify that the system operates within its specifications at the device test frequency. The system check is to make sure that the system works correctly at the time of the compliance test. The system check has been performed using the specified tissue-equivalent liquid and at a chosen fixed frequency that is within ± 10% of the compliance test mid-band frequency. The system check is performed prior to compliance tests and the result must always be within ±10% of the target value corresponding to the test frequency, liquid and the source used.

The system validation detects possible short-term drift and uncertainties in the system, such as:
a) changes in the liquid parameters (e.g., due to water evaporation or temperature change),
b) test system component failures,
c) test system component drift,
d) operator errors in the set-up or software parameters,
e) other possible adverse conditions in the system configuration, e.g., RF interference.

The system validation was done with an CW signal no additional validation were done with other signal types.
The results show that this system check is within 10% of the expected values.

5.1.1 System check results at 2.4 GHz

At 2450 MHz a system check was executed according IEEE 1528-2003 and KDB 865644 D01 SAR Measurement 100 MHz to 6 GHz v01 Edition 10/24/2012. The setup used is shown in figure 3. The following system performance check results were obtained (referenced to 1W):

Frequency = 2450 MHz	Target value	Measured value	Deviation from Target value	Permissible Deviation from Target value
Peak Spatial-Average SAR 1g	52.4 W/kg	48.896 W/kg	-6.7 %	±10 %

5.1.2 System check results at 5 GHz

At 5 GHz a system check was executed according IEC 62209-2 and KDB 865644 D01 SAR Measurement 100 MHz to 6 GHz v01 Edition 10/24/2012. The setup used is shown in figure 3. The following system performance check results were obtained (referenced to 1W):

Frequency = 5200 MHz	Target value	Measured value	Deviation from Target value	Permissible Deviation from Target value
Peak Spatial-Average SAR 1g	76.5 W/kg	72.728 W/kg	-4.93 %	±10 %

Frequency = 5600 MHz	Target value	Measured value	Deviation from Target value	Permissible Deviation from Target value
Peak Spatial-Average SAR 1g	83.3 W/kg	85.284 W/kg	+2.38 %	±10 %

Frequency = 5800 MHz	Target value	Measured value	Deviation from Target value	Permissible Deviation from Target value
Peak Spatial-Average SAR 1g	78.00 W/kg	82.46 W/kg	+5.72 %	±10 %

Figure 3: 2.4 GHz System check setup

Figure: 5 GHz System check setup

5.2 Tissue simulating liquid dielectric parameters

For the purpose of the tests as described in this report the following tissue dielectric parameters have been determined by use of a Vector Network Analyzer (VNA). The tables indicate the dielectric parameters of the liquids used during the tests. The indicated required values are derived from IEEE-1528 and of IEC-62209-2.
TÜV Rheinland EPS has chosen the IEC-62209-2 for guidance in the procedure for SAR testing at frequencies above 3 GHz, there in that head liquids are used instead of body liquids. TÜV Rheinland EPS believes that this will be the international standard for SAR testing. (Statement from IEC-62209-2 page 57): At close distances, a conservative exposure estimate can be achieved using the parameters for head tissue equivalent liquids as proposed in study by Drossos in the IEEE Trans. Microwave Theory Tech., Nov.2000, vol.48, no.11, pp. 1988-1995.

Deviation of the actual parameters versus the prescribed parameters is calculated according: $D = \left(\frac{A}{T} - 1\right) \cdot 100\%$

where *D* is deviation in %, *A* is the actual value and *T* is the target value.

5.2.1 Mixing procedure

All Tissue Equivalent Liquids are obtained from Bristol University.
Contact details:
Medical Physics Department
University of Bristol, Bristol Haemotology & Oncology Centre
Horfield road, Bristol BS2 8 ED
United Kingdom
Tel. 44 117 928 2469.

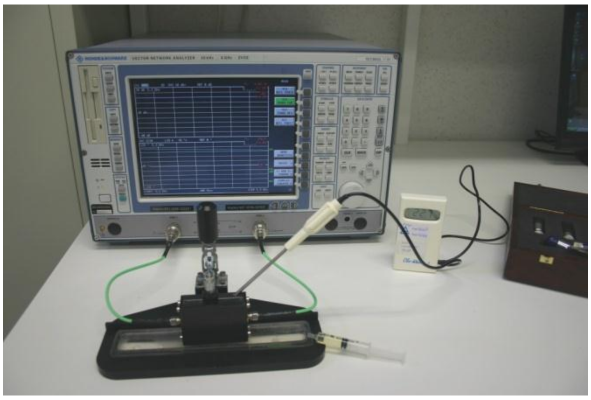


Figure 6: Liquid validation setup

5.2.2 Dielectric parameters for 2450 MHz head tissue

The 2450 MHz head liquid is used for all tests in the EUT's 2.4 GHz band.

The following liquid validation results were obtained, where the maximum deviation should not be more then ± 10 % of the Relative values (standard).

Results for 2.4 GHz:

Liquid type	Frequency (MHz)	Measured Liquid temperature (°C)	Measured Relative Permittivity	Measured Conductivity (S/m)	Relative Permittivity Standard	Conductivity Standard (S/m)	Relative Permittivity Deviation from standard (%)	Conductivity Deviation from standard (%)
Head	2412	19.8	38.27	1.81	39.3	1.81	-2.73	0.00
Head	2442	19.8	38.08	1.85	39.3	1.83	-3.30	0.70
Head	2450	21.0	38.05	1.86	39.2	1.80	-3.20	0.82
Head	2462	19.8	38.03	1.87	39.3	18.5	-3.23	0.87

Table 4: liquid validation results for 2.4 GHz

5.2.3 Dielectric parameters for 5 GHz head tissue

The 5 GHz head liquid is used for all tests in the EUT's 5 GHz band.

The following liquid validation results were obtained, where the maximum deviation should not be more then ± 10 % of the Relative values (standard).

Results for 5 GHz:

Liquid type	Frequency (MHz)	Measured Liquid temperature (°C)	Measured Relative Permittivity	Measured Conductivity (S/m)	Relative Permittivity Standard	Conductivity Standard (S/m)	Relative Permittivity Deviation from standard (%)	Conductivity Deviation from standard (%)
Head	5180	19.8	33.52	5.00	36.2	4.66	-7.4	+4.7
Head	5200	19.8	33.52	5.00	36.2	4.45	-7.4	+4.7
Head	5320	19.8	33.25	5.13	35.9	4.70	-7.4	+9.1
Head	5500	19.8	32.91	5.32	35.7	4.90	-7.8	+8.6
Head	5700	19.8	32.32	5.58	35.4	5.10	-8.7	+9.4
Head	5800	19.8	31.96	5.65	35.3	5.28	-9.4	+7.0
Head	5805	19.8	32.04	5.67	35.3	5.28	-9.2	+7.4

Table 5: liquid validation results for 5 GHz

Allowable deviation according to IEC 62209-2:2010 is for both conductivity and relative permitivity ±10%. Both liquids are within ±10% of the standard value.

6 Additional information supplementary to the test report

6.1 Description of test system

6.1.1 SAR measurement system

The TÜV Rheinland EPS SAR system is accredited according ISO/IEC 17025:2005 (expiration date of the accreditation is 26 July 2012 (extended to 26 July 2016), accreditation number: L385).

6.1.2 Robot System description

The SAR measurement system used by TR EPS is the IndexSAR SARA2 system, which consists of a Mitsubishi RV-2A six-axis robot-arm and controller, IndexSAR probe and amplifier and an appropriate phantom as required and considered appropriate for the applied test. The robot is used to move and manipulate the probe to programmed positions inside the phantom to obtain the SAR readings from the EUT.

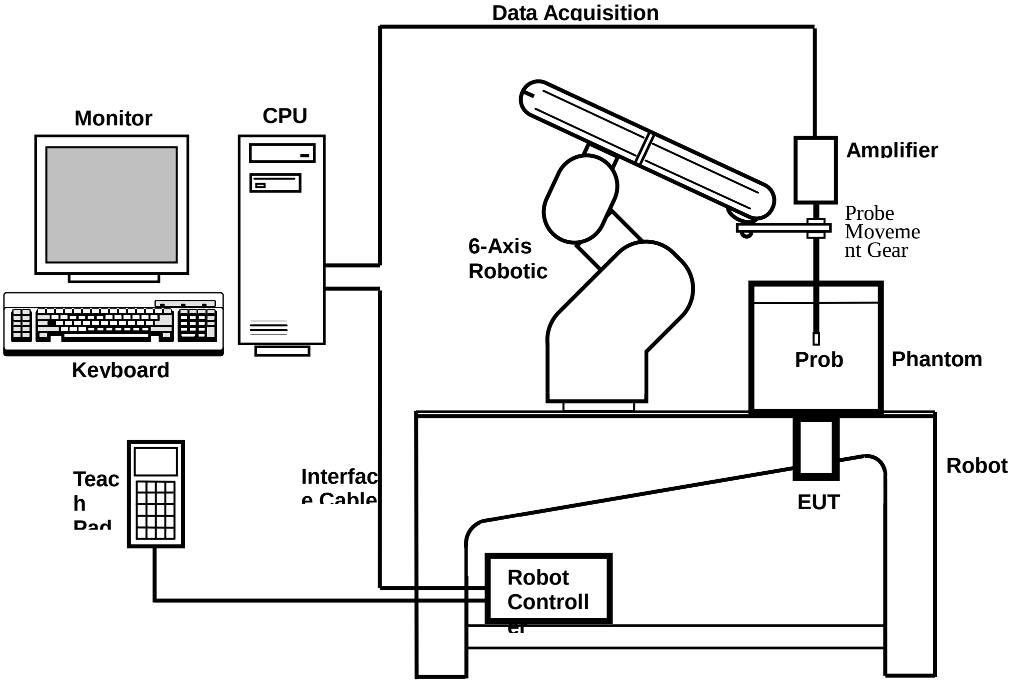


Figure 7: Overview of the SARA2 measurement system

The system is remote controlled by a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans by calculating the measured values into corresponding SAR values based on the currently acceptable calculation methods.

The position and digitized shape of the phantom are made available to the software for accurate positioning of the probe and reduction of set-up time.

E.g. the SAM phantom heads are individually digitized using a Mitutoyo CMM machine to a precision of 0.001mm. The data is then converted into a shape format for the software, providing an accurate description of the phantom shell.

In operation, the system first does an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centered at that point to determine volume averaged SAR level.

6.1.3 Probe description

The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip.

Probe calibration is described in the Probe Calibration Document in Annex A.

6.1.4 Amplifier description

The amplifier unit has a multi-pole connector to connect to the probe and a multiplexer selects between the 3-channel single-ended inputs. A 16-bit A-to-D converter with programmable gain is used along with an on-board micro-controller with non-volatile firmware. Battery life is around 150 hours and data are transferred to the PC via 3m of duplex optical fiber and a self-powered RS232 to optical converter.

6.1.5 Phantom description

Body-worn operating configurations are tested using a flat phantom. The body phantom shell is made of a low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna are within 2.0 ± 0.2 mm. The phantom was filled with the required head equivalent tissue medium to a depth of 15.0 ± 0.5 cm.

For the EUT a flat phantom of dimensions 20 x 20 x 20 cm with a base plate thickness of 2 mm is used.

6.2 Measurement Procedure

During the SAR measurement, the positioning of the probe is performed with sufficient accuracy to obtain repeatable measurements in the presence of rapid spatial attenuation phenomena. The accurate positioning of the E-field probe is accomplished by using the high precision robot. The robot can be taught to position the probe sensor following a specific pattern of points.

After an area scan has been done a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power (SAR) drift during measurement to be assessed.

6.2.1 Step size and scan information

For the EUT's 2.4 GHz band a 30 x 30 mm area is scanned centered around the hotspot using 6 steps of 3 mm in the x-y plane and 10 steps of 3 mm in the z plane. The first area scan is performed with the probe tip 5 mm above the phantom bottom shell. For the EUT's 5 GHz band a 30 x 30 mm area is scanned centered around the hotspot using 10 steps in the x-y plane and 13 steps of 2 mm in the z plane. The first area scan is performed with the probe tip 3 mm above the phantom bottom shell.

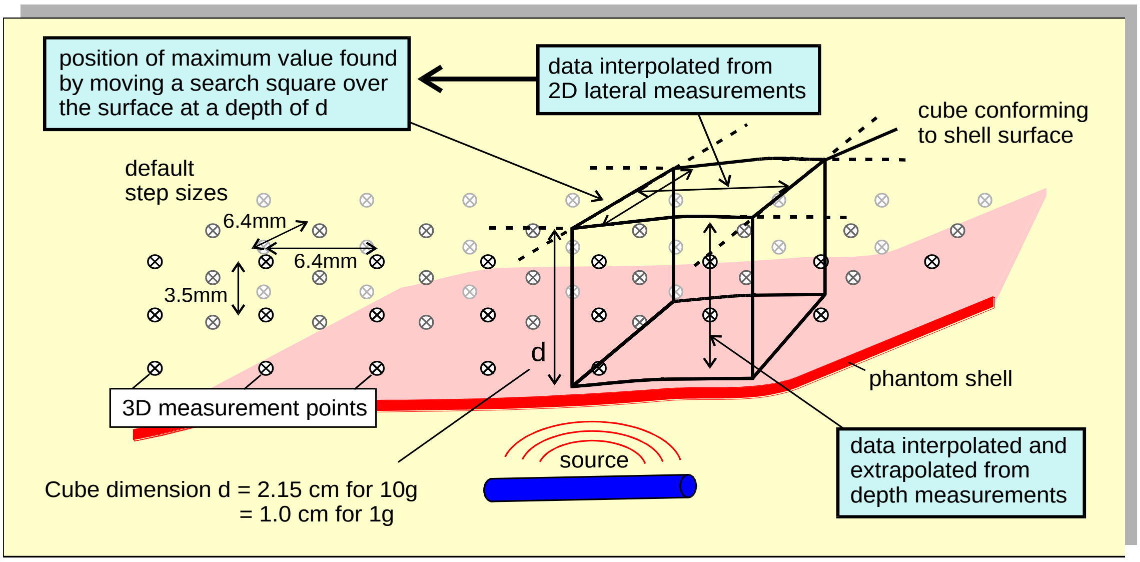


Figure 8: SAR is averaged over a volume of 1g (1.0 cm cube)

6.2.2 SARA2 Interpolation and Extrapolation schemes

SARA2 software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a general n^{th} order polynomial fitting routine is implemented following a singular value decomposition algorithm. A 4^{th} order polynomial fit is used by default for data extrapolation.

6.2.3 Interpolation of 2D area scan

The 2D cubic B-spline interpolation is used after the initial area scan at fixed distance from the phantom shell wall. The initial scan data are collected with approximately 10 mm spatial resolution and spline interpolation is used to find the location of the local maximum to within a 1mm resolution for positioning the subsequent 3D scanning.

6.2.4 Extrapolation of 3D scan

For the 3D scan, data are collected on a spatially regular 3D grid having (by default) 6.4 mm steps in the lateral dimensions and 3.5 mm steps in the depth direction (away from the source). SARA2 enables full control over the selection of alternative step sizes in all directions. The digitized shape of the Flat Phantom is available to the SARA2 software, which decides which points in the 3D array are sufficiently well within the shell wall to be 'visited' by the SAR probe. After the data collection, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

6.2.5 Interpolation of 3D scan and volume averaging

The procedure used for defining the shape of the volumes used for SAR averaging in the SARA2 software follow the method of adapting the surface of the 'cube' to conform with the surface of the phantom. This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated and interpolated to less than 1 mm spacing and average values are calculated from the phantom surface for the row of data over distances corresponding to the requisite depth for 10g and 1g cubes. This results in two 2D arrays of data, which are then cubic B-spline interpolated to sub mm lateral resolution. A search routine then moves an averaging square around through the 2D array and records the maximum value of the corresponding 1g and 10g volume averages. For measurements in rectangular, box phantoms, the distance between the phantom wall and the closest set of gridded data points is entered into the software.

For measurements in box-shaped phantoms, this distance is under the control of the user. The effective distance must be greater than 2.7mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 3 mm. This distance is called dbe.

The default step size (dstep) used is 3.5 mm, but this is under user-control. The compromise is with time of scan, so it is not practical to make it much smaller or scan times become long and power-drop influences become larger. The robot positioning system specification for the repeatability of the positioning (dss) is ± 0.04 mm.

The flat phantom is made from Polymethylmethacrylate (PMMA), a low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna are within 2.0 ± 0.2 mm.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253 mm-diameter base plate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided. This enables the registration of the phantom tip (dmis) to be assured to within approx. 0.2 mm. This alignment is done with reference to the actual probe tip after installation and probe alignment.

7 Measurement uncertainty

7.1 Introduction

A measurement uncertainty assessment has been undertaken following guidance given in IEEE-1528.
IndexSAR Ltd has supplied a generic uncertainty analysis for the SARA2 system in the form of a spreadsheet and the supporting assessments are documented in an IndexSAR document IXS-2028 (available on request).

Some of the uncertainty contributions are site-specific and, for these, TUV Rheinland EPS has assessed the uncertainty contributions arising from local environmental and procedural factors.

The resultant uncertainty budget is shown on the next pages.

7.1.1 Uncertainty calculated for IEEE-1528: standard measurements (2.4 GHz)

Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1 (1g)	Standard Uncertainty (%) 1g
		(dB)		(%)					
Measurement System									
Probe Calibration	7.2.1			8.729	N	1 or k	1	1	8.73
Axial Isotropy (Cal data SN:168)	7.2.1.2	0.07	1.62	1.62	R	√3	1.73	0	0.00
Boundary effect	7.2.1.5		1.7	1.70	R	√3	1.73	1	0.98
Linearity	7.2.1.3	0.04	0.93	0.93	R	√3	1.73	1	0.53
System Detection Limits	7.2.1.4	NA	0	0.00	R	√3	1.73	1	0.00
Readout Electronics	7.2.1.6	NA	0	0.00	N	1 or k	1.00	1	0.00
Response time	7.2.1.7		0	0.00	R	√3	1.73	1	0.00
Measurement drift	7.2.1.9				R	1	1.00	1	0.00
Integration time	7.2.1.8		0	0.00	R	√3	1.73	1	0.00
Measurement drift	7.2.1.9			0.00	R	1	1.00	1	0.00
RF Ambient Conditions (noise and reflections)	7.2.3.4		3	3.00	R	√3	1.73	1	1.73
Probe Positioner Mechanical Tolerance	7.2.2.1		0.57	0.57	R	√3	1.73	1	0.33
Probe Position wrt. Phantom Shell	7.2.2.3		2.86	2.86	R	√3	1.73	1	1.65
SAR Evaluation Algorithms	7.2.4		2.5	2.50	R	√3	1.73	1	1.44
Test Sample Related									
Test Sample Positioning	7.2.5		2	2.00	N	1	1.00	1	2.00
Device Holder Uncertainty	7.2.2.4.2	NA	0	0.00	N	1	1.00	1	0.00
Drift of Output Power	7.2.1.9		5	5.00	R	√3	1.73	1	2.89
Phantom and Setup									
Phantom Uncertainty (shape and thickness)	7.2.2.2		4	4.00	R	√3	1.73	1	2.31
Algorithm for correcting SAR for deviations in permittivity and conductivity	7.2.3.3				N	1	1.00	1	0.00
Liquid conductivity (measurement uncert.)	7.2.3.3		2	2.00	N	1	1.00	0.64	1.28
Liquid permittivity (measurement uncert.)	7.2.3.3		2	2.00	N	1	1.00	0.6	1.20
Combined standard uncertainty	7.3.1				**RSS**				10.3
Expanded uncertainty (95% Confidence Level)	7.3.2				k=2				**20.2**

Table 6: Measurement uncertainty at 2.4 GHz

7.1.2 Uncertainty calculated for IEEE-1528 : standard measurements (5 GHz)

Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1 (10g)	Standard Uncertainty (%) 10g
		(dB)		(%)					
Measurement System									
Probe Calibration	7.2.1			8.729	N	1 or k	1	1	8.73
Axial Isotropy (Cal data SN:168)	7.2.1.2	0.07	1.62	1.62	R	√3	1.73	0	0.00
Boundary effect	7.2.1.5		1.7	1.70	R	√3	1.73	1	0.98
Linearity	7.2.1.3	0.04	0.93	0.93	R	√3	1.73	1	0.53
System Detection Limits	7.2.1.4	NA	0	0.00	R	√3	1.73	1	0.00
Readout Electronics	7.2.1.6	NA	0	0.00	N	1 or k	1.00	1	0.00
Response time	7.2.1.7		0	0.00	R	√3	1.73	1	0.00
Measurement drift	7.2.1.9				R	1	1.00	1	0.00
Integration time	7.2.1.8		0	0.00	R	√3	1.73	1	0.00
Measurement drift	7.2.1.9		5	5.00	R	1	1.00	1	5.00
RF Ambient Conditions (noise and reflections)	7.2.3.4		3	3.00	R	√3	1.73	1	1.73
Probe Positioner Mechanical Tolerance	7.2.2.1		0.57	0.57	R	√3	1.73	1	0.33
Probe Position wrt. Phantom Shell	7.2.2.3		2.86	2.86	R	√3	1.73	1	1.65
SAR Evaluation Algorithms	7.2.4		2.5	2.50	R	√3	1.73	1	1.44
Test Sample Related									
Test Sample Positioning	7.2.5		2	2.00	N	1	1.00	1	2.00
Device Holder Uncertainty	7.2.2.4.2	NA	0	0.00	N	1	1.00	1	0.00
Drift of Output Power	7.2.1.9		5	5.00	R	√3	1.73	1	2.89
Phantom and Setup									
Phantom Uncertainty (shape and thickness)	7.2.2.2		4	4.00	R	√3	1.73	1	2.31
Algorithm for correcting SAR for deviations in permittivity and conductivity	7.2.3.3				N	1	1.00	1	0.00
Liquid conductivity (measurement uncert.)	7.2.3.3		2	2.00	N	1	1.00	0.64	1.28
Liquid permittivity (measurement uncert.)	7.2.3.3		1	1.00	N	1	1.00	0.6	0.60
Combined standard uncertainty	7.3.1				**RSS**				10.2
Expanded uncertainty (95% Confidence Level)	7.3.2				k=2				**20.1**

Table 7: Measurement uncertainty at 5 GHz

8 Test equipment and ancillaries used for tests

8.1 Test Equipment

To facilitate inclusion of the test equipment, used for performing the tests, on each page of this test report, each item of test equipment and ancillaries, such as cables, must be identified (numbered) by the test laboratory.

Number	Description	Brand	Model	Serial No.	Cal. date	Cal. Due date
12612	Power sensor 2GHz-26GHz	Hewlett Packard	8485A	2942A11287	10/2010	10/2011
13526	Signal generator	Hewlett Packard	83620A	3420A01924	04/2011	04/2012
99106	Attenuator 20 dB, 8 GHz	Lucas Weinschel	24-20-43	AW1972	12/2010	12/2011
99540	Directional Coupler (2G4)	Hewlett Packard	779D	1144A02686	NA	NA
99553	Network Analyzer (VNA)	Rohde & Schwarz	ZVCE	100028	02/2010	02/2012
99554	VNA TOSM Calibration Kit	Rohde & Schwarz	ZV-Z21	1085.7099.02	02/2010	02/2012
99555	RF Amplifier (1 Watt)	IndexSAR	VBM-256	0301	12/2010	12/2011
99556	Bench-top Robot	Mitsubishi	RV-2A-S11	AN303007	NA	NA
99557	Calibration dipole 2400	IndexSAR	IXD-245	44	NA	NA
99559	SAR Probe	IndexSAR	IXP-50	0168	01/2011	01/2012
99584	SAR Probe	IndexSAR	IXP-30	M0017	05/2011	05/2012
99610	SAR Fast Probe amplier	IndexSAR	IXA-020 Rev.02	0046	NA	NA
99568	Hygrometer/room temperature meter	Europe Supplies	WS-7082	n.a.	09/2010	09/2011
99569	TEM line liquid measurement kit	IndexSAR	DiLine	n.a.	12/2010	12/2011
99574	Power meter	Hewlett Packard	E4418B	GB43316552	09/2010	09/2011
99585	Waveguide with matching slab	IndexSAR	WR-137 (WG13)	4434	NA	NA
99576	Power meter	Agilent	N1911A	GB44460144	10/2010	10/2011
99577	Power Sensor	Agilent	N1921A	US44510189	10/2010	10/2011

Table 8: List of used test equipment and ancillaries.

8.2 Test software

During the tests as indicated in this test report the TR-EPS SARA2 system was operated with:

SARA2 system v.2.54
Mitsubishi robot controller firmware revision RV-E2 Version C9a
DiLine Dielectric Kit Software v 0.109 (12/6/2003)

Annex A1

Probe calibration data 5 mm probe (5 pages)

Annex A2

Probe calibration data 3 mm probe (7 pages)

Annex B

System check data 2.4 GHz (2 pages)

Annex C

System check data 5 GHz (6 pages)

Annex D

Measurement results (6 pages)

Annex E

Measurement results (10 pages)

NATIONAL PHYSICAL LABORATORY

Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

SAR PROBE
IndexSAR
Model: IXP-050
Serial number: 0168

FOR:. TÜV Rheinland EPS BV
Smidshornerweg 18
9822 TL
P.O. Box 15
Niekerk
9822 ZG
Netherlands

DESCRIPTION: An IndexSAR isotropic electric field probe for determining specific absorption rates (SAR) in dielectric liquids. The probe has three orthogonal sensors, and the output voltage of the sensors is converted to an optical signal by a meter unit containing an analogue to digital (AD) converter. Probe readings are obtained using software via the RS232 port. The probe was calibrated with IndexSAR amplifier model IXA-010 S/N 036 belonging to NPL.

IDENTIFICATION: The probe is marked with the manufacturer's serial number 0168.

MEASUREMENTS COMPLETED ON: 12 January 2011

PREVIOUS NPL CERTIFICATE: None

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

Reference : 2010110446-1

Date of Issue : 12 January 2011

Signed : DG Gentle **(Authorised Signatory)**

Checked by : [signature]

Name : Mr D G Gentle **for Managing Director**

MEASUREMENT PROCEDURE

For frequencies at or above 835 MHz, 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 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 liquid 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 liquid.

For frequencies below 835 MHz, the SAR in the liquid is established by measuring the rate of temperature rise in the liquid at the calibration point. In this case the SAR in the liquid is related to the temperature rise by

$$SAR = c\frac{dT}{dt} \qquad (2)$$

where c is the specific heat of the liquid.

Liquids having the properties specified by SAR measurement standards [2, 3, 4] were used for the calibration. The value of δ for the liquid was obtained by measuring the electric field (E) at a number of distances from the matching window. The calibration was for continuous wave (CW) signals, 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 in 15-degree steps, and the ratio of the calibration factors for the three probe sensors X, Y, & Z were optimized to give the best axial isotropy.

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

ENVIRONMENT

Measurements were made in a temperature-controlled laboratory at 22 ± 2°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

Table 1 give the results for calibration in liquid.

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, 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 1528-2003 "Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques".

[4] Federal Communications Commission, FCC OET Bulletin 65, Supplement C, June 2001, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", David L. Means, Kwok W. Chan.

Table 1
Sensitivity in Liquids.
SAR probe: IXP-050
S/N 0168

Probe settings for calibration		
Sensitivity in free-space[(1)]	**Diode Compression[(1)]**	**Sensor offset from tip of probe[(1)]**
Lin X = 435 $(V/m)^2/(V*200)$ Lin Y = 325 $(V/m)^2/(V*200)$ Lin Z = 440 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z = 20 (V*200)	2.7 mm

Sensitivity in Liquid.

Calibration frequency (MHz)	Liquid [(2)]			Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy (dB)
	Identifier	ε′ [(3)]	σ [(3)] (Sm^{-1})	*ConvF*$_X$	*ConvF*$_Y$	*ConvF*$_Z$	
450	HT0430	41.7	0.81	**0.32**	**0.30**	**0.31**	±0.05
835	UOB900H-2	41.7	0.94	**0.30**	**0.29**	**0.29**	±0.01
900	UOB900H-2	41.2	0.98	**0.31**	**0.29**	**0.30**	±0.01
1800	TWS1800H-2	38.59	1.40	**0.34**	**0.34**	**0.32**	±0.03
1900	TWS2450H-1	39.4	1.34	**0.34**	**0.33**	**0.32**	±0.01
2100	TWS2450H-1	38.5	1.55	**0.36**	**0.35**	**0.34**	±0.01
2450	TWS2450H-3	37.4	1.81	**0.39**	**0.38**	**0.37**	±0.04
3500	UOB5-6H-1	38.6	3.00	**0.47**	**0.48**	**0.45**	±0.03
5200	NPL5-6H-1	35.4	4.87	**0.46**	**0.50**	**0.46**	±0.23
5800	NPL5-6H-1	33.8	5.63	**0.54**	**0.55**	**0.50**	±0.10

Notes.
(1) The manufacturer supplied these figures.
(2) Head Simulating Liquid supplied by NPL.
(3) Measured at NPL at 22 ± 2 ^{0}C.

Checked by :

NATIONAL PHYSICAL LABORATORY
Teddington Middlesex UK TW11 0LW Telephone +44 20 8977 3222

Certificate of Calibration

SAR PROBE
IndexSAR
Model: IXP-030
Serial number: M0017

FOR: TUV Rheinland (EPS) B.V.
Smidshornerweg 18
9822 TL
P.O. box 15
Niekerk
9822 ZG
Neitherlands

DESCRIPTION: An IndexSAR isotropic electric field probe for determining specific absorption rates (SAR) in dielectric liquids. The probe has three orthogonal sensors, and the output voltage of the sensors is converted to an optical signal by a meter unit containing an analogue to digital (AD) converter. Probe readings are obtained using software via the RS232 port. The probe was calibrated with IndexSAR amplifier model IXA-010 S/N 036 belonging to NPL.

IDENTIFICATION: The probe is marked with the manufacturer's serial number M0017

MEASUREMENTS COMPLETED ON: 4 May 2011

DUE DATE: 4 May 2012

Earlier recalibration should be considered where the device usage increases or if the device is damaged, modified or exposed to harsher than normal environments.

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

Reference : 2011020321-1

Date of Issue : 6th May 2011

Signed : B. Loader **(Authorised Signatory)**

Checked by : BGL

Name : Mr B G Loader **on behalf of NPLML**

MEASUREMENT PROCEDURE

For frequencies at or above 835 MHz, 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 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 liquid 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 liquid.

For frequencies below 835 MHz, the SAR in the liquid is established by measuring the rate of temperature rise in the liquid at the calibration point. In this case the SAR in the liquid is related to the temperature rise by

$$SAR = c\frac{dT}{dt} \qquad (2)$$

where c is the specific heat of the liquid.

Liquids having the properties specified by SAR measurement standards [2, 3, 4] were used for the calibration. The value of δ for the liquid was obtained by measuring the electric field (E) at a number of distances from the matching window. The calibration was for continuous wave (CW) signals, 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 in 15-degree steps, and the ratio of the calibration factors for the three probe sensors X, Y, & Z were optimized to give the best axial isotropy.

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

When using the probe in proximity to the boundary of the phantom, an additional correction is applied and this is given by eq. 3.

$$SAR_{corrected} = SAR \times \left(1 - f(0)\exp\left(-\frac{z}{d}\right)\right) \tag{3}$$

where z is the distance to the boundary, in mm. The values of the constants *f(0)* and d were determined by comparing the measured and calculated fields in the calibration waveguide at different distances from the matching window.

ENVIRONMENT

Measurements were made in a temperature-controlled laboratory at 22 ± 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

Tables 1 and 2 give the results for calibration in liquid.

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 and 2.

Table 3 contains the values of the boundary correction factors *f(0)* and *d*, and also the maximum residual error after applying the boundary correction.

REFERENCES:

[1] 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 1528-2003 "Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques".

[4] Federal Communications Commission, FCC OET Bulletin 65, Supplement C, June 2001, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", David L. Means, Kwok W. Chan.

Table 1
Sensitivity in Head Simulating Liquids.
SAR probe: IXP-030
S/N: M0017

Probe settings for calibration		
Sensitivity in free-space[(1)]	**Diode Compression[(2)]**	**Sensor offset from tip of probe[(2)]**
Lin X = 3207 $(V/m)^2/(V*200)$ Lin Y = 4421 $(V/m)^2/(V*200)$ Lin Z = 3476 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z = 20 (V*200)	1.7 mm

Sensitivity in Head Simulating Liquid.						
Calibration frequency	Liquid Phantom[(3)]		Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy
(MHz)	ε' [(3)]	σ [(3)] (Sm^{-1})	*ConvF*$_X$	*ConvF*$_Y$	*ConvF*$_Z$	(dB)
3500	37.52	2.93	**0.44**	**0.32**	**0.43**	±0.02
5200	35.38	5.01	**0.40**	**0.28**	**0.39**	±0.07
5400	34.84	5.25	**0.40**	**0.29**	**0.40**	±0.08
5600	34.27	5.49	**0.39**	**0.29**	**0.40**	±0.12
5800	33.69	5.72	**0.39**	**0.28**	**0.39**	±0.13

Table 2
Sensitivity in Body Simulating Liquids.
SAR probe: IXP-030
S/N: M0017

Probe settings for calibration		
Sensitivity in free-space(1)	**Diode Compression**(2)	**Sensor offset from tip of probe**(2)
Lin X = 3207 $(V/m)^2/(V*200)$ Lin Y = 4421 $(V/m)^2/(V*200)$ Lin Z = 3476 $(V/m)^2/(V*200)$	DCP_X = 20 (V*200) DCP_Y = 20 (V*200) DCP_Z = 20 (V*200)	1.7 mm

Sensitivity in Body Simulating Liquid.						
Calibration frequency	Liquid Phantom(3)		Calibration Factors for E^2_{Liquid} / E^2_{Air}			Axial Isotropy
(MHz)	ε′ (3)	σ (3) (Sm^{-1})	*ConvF*$_X$	*ConvF*$_Y$	*ConvF*$_Z$	(dB)
3500	48.98	3.19	**0.46**	**0.34**	**0.46**	±0.08
5200	50.73	5.57	**0.50**	**0.36**	**0.51**	±0.09
5400	50.20	5.91	**0.47**	**0.34**	**0.48**	±0.15
5600	49.56	6.23	**0.46**	**0.35**	**0.47**	±0.12
5800	48.90	6.54	**0.46**	**0.34**	**0.48**	±0.13

Notes.
(1) Measured at 900 MHz
(2) The manufacturer supplied these figures.
(3) Measured at a temperature of 22 ± 1 ^{0}C.

Table 3
Boundary correction factors.
SAR probe: IXP-030
S/N: M0017

Head Simulating Liquid			
Frequency (MHz)	*f(0)*	*d*	Residual error [1] (%)
3500	0.55	1.21	0.50
5200	1.18	1.09	1.23
5400	1.40	0.92	1.35
5600	1.54	0.88	2.14
5800	1.61	0.92	1.91
Body Simulating Liquid			
Frequency (MHz)	*f(0)*	*d*	Residual error [1] (%)
3500	0.93	1.01	0.40
5200	1.09	1.06	2.01
5400	1.35	0.90	2.79
5600	2.26	0.78	3.21
5800	1.54	0.98	1.81

Notes
[1] The residual error is the maximum percentage difference between the SAR readings and the theoretical values after applying the boundary correction.

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
T: (0594) 50 50 05
F: (0594) 50 48 04

Type	:	System check 2450MHz	Regnr.	:	13050602 (11042002)
Antenna	:	Dipole 2400 MHz		:	
Standard(s)	:	IEC 62209-2 (2008-02)			
TSD	:	SAR_01 v1.2	Date	:	01-06-2011
Ambient Conditions	:	20 °C 45 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	13161
99106	99044	99555	99589	12609	12608	12612

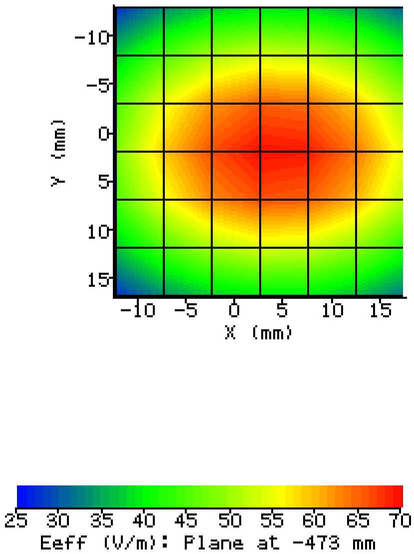
Concerning measurement: **System check 2450 MHz**

System / software:	SARA v2.54	No. of steps x and y	6
Phantom S/No:	Box phantom	Stepsize x and y [mm]	5
Test Frequency [MHz]	2450	No of steps z	10
Position / Channel:	Perpendicular	Stepsize z [mm]	2.5
Antenna Configuration:	External	Dist probe tip – phantom shell [mm]	5
Power level: [W]	0.25 (=+24 dBm)	Probe conversion factor	0.383
Probe Serial Number:	168		
Liquid Simulant:	Head	Max E-field [V/m in liquid]	67.88
Permittivity / Conductivity [S/m]	38.05 / 1.86	Location of max X= [mm]	4.67
Liquid Temperature [°C]	21.0	Location of max Y= [mm]	2.00
SAR Drift: [dB]	20.1	Location of max Z= [mm]	-473.00
Results:			
SAR 1g [W/kg]:			12.224

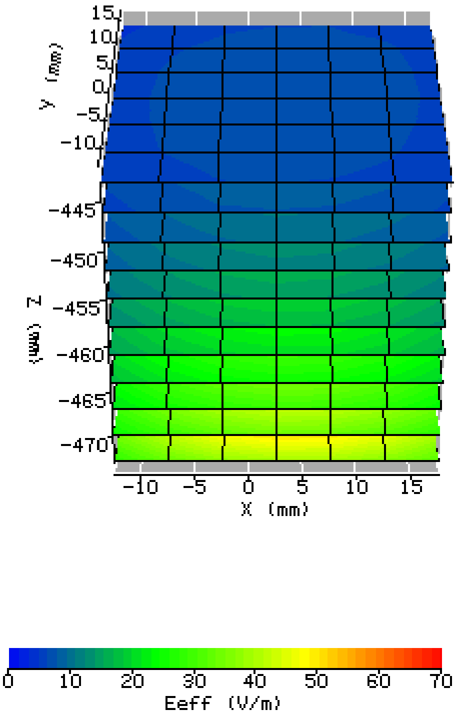
*power drift during validation: 0.0 dB

	Corrected to 1W (W/kg)	Target value (W/kg)	Deviation from target (%)	Permissable Deviation from target (%)
SAR 1g	48.896	52.4	-6.7	±10.0

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
T: (0594) 50 50 05
F: (0594) 50 48 04



2d contour plot of scan closest to EUT.



3d representation of entire scan

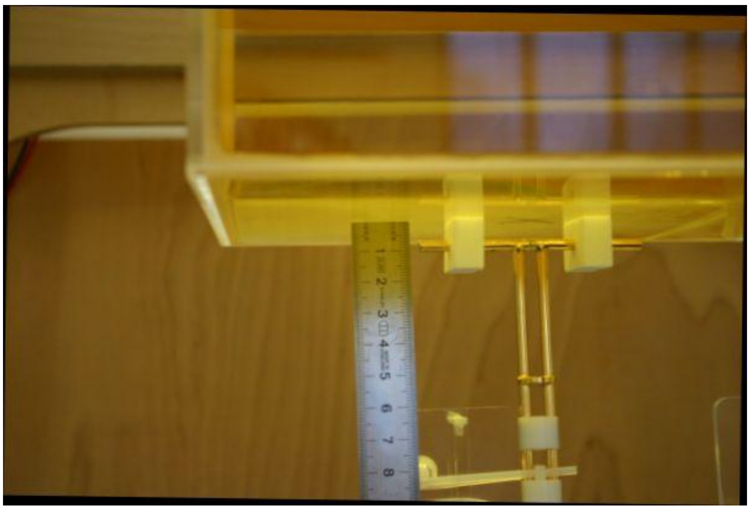


Photo A-2-1: 2400MHz dipole antenna as spaced 10mm from liquid (equals: 8mm between dipole central axis and bottom phantombox+2mm of phantombox bottom thickness

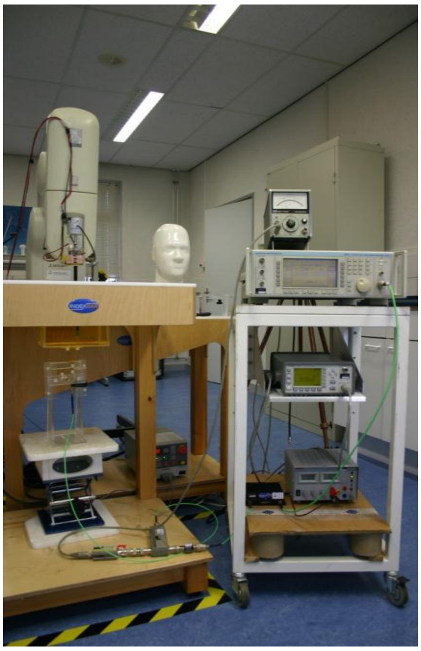


Photo A-2-2: System validation setup for 2450MHz

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
T: (0594) 50 50 05
F: (0594) 50 48 04

Type	:	**System Check**	Regnr.	:	13050602 (11042002)
Antenna	:	**Waveguide**			
Standard(s)	:	IEC 62209-2 (2010)			
TSD	:	SAR v1.1	Date	:	08-06-2011
Ambient Conditions	:	21 °C 51 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	12612
13526	99106	99540	99555	99556	99574	99585
99576	99577					

Concerning measurement: System Check 5GHz

Antenna Port	:	**NA**	Power Control	:	**NA**
Bitrate	:	**NA**	Duty Cycle / Mode	:	**NA**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5200	No of steps z	13
Position Waveguide:	0mm from phantombox bottom	Stepsize z [mm]	2
Power level: [W}	0.25	Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.50/0.36/ 0.51
Probe Serial Number:	M0017		
Liquid Simulant:	body	Max E-field [V/m in liquid]	63.54
Permittivity / Conductivity [S/m]	33.52 / 5.00	Location of max X= [mm]	-12.00
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	2.53
SAR Drift: [dB]	0.00 (0.09%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**18.182**

	Meas Value (W/kg)	Target value (W/kg)	Deviation from target (%)	Permissable Deviation from target (%)
SAR 1g:	72.728	76.5	-4.93	±10

Smidshornerweg 18
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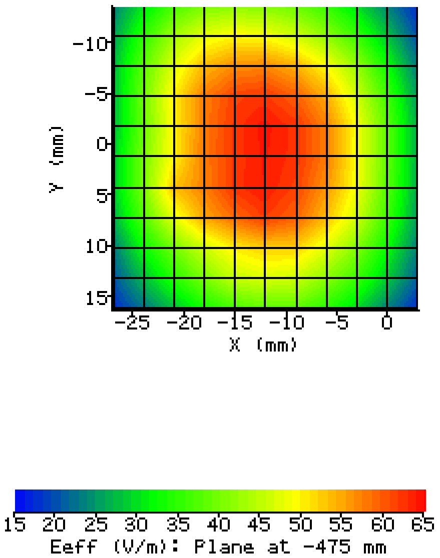
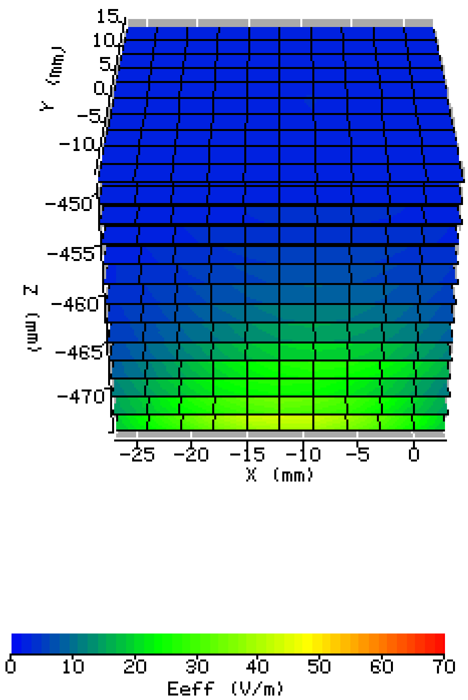


2d contour plot of scan closest to EUT.



3d representation of entire scan

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
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Type	:	**System Check**	Regnr.	:	13050602 (11042002)
Antenna	:	**Waveguide**			
Standard(s)	:	IEC 62209-2 (2010)			
TSD	:	SAR v1.1	Date	:	08-06-2011
Ambient Conditions	:	21 °C 51 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	12612
13526	99106	99540	99555	99556	99574	99585
99576	99577					

Concerning measurement: System Check 5GHz

Antenna Port	:	**NA**	Power Control	:	**NA**
Bitrate	:	**NA**	Duty Cycle / Mode	:	**NA**

System / software:	SARA v2.54	No. of steps x and y	8
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5500	No of steps z	6
Position Waveguide:	0mm from phantombox bottom	Stepsize z [mm]	2
Power level: [W}	0.25	Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.46/0.35/ 0.47
Probe Serial Number:	M0017		
Liquid Simulant:	body	Max E-field [V/m in liquid]	67.92
Permittivity / Conductivity [S/m]	32.91 / 5.32	Location of max X= [mm]	-8.00
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	2.33
SAR Drift: [dB]	0.00 (0.08%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**21.321**

	Meas Value (W/kg)	Target value (W/kg)	Deviation from target (%)	Permissable Deviation from target (%)
SAR 1g:	85.284	83.3	+2.38	±10

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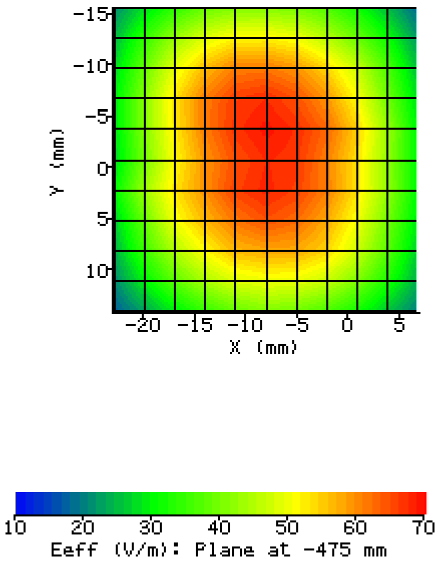
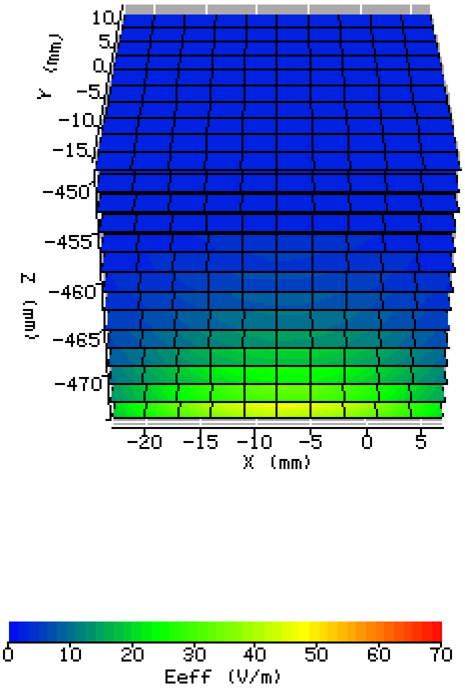


2d contour plot of scan closest to EUT.



3d representation of entire scan

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
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Type	:	**System Check**	Regnr.	:	13050602 (11042002)
Antenna	:	**Waveguide**			
Standard(s)	:	IEC 62209-2 (2010)			
TSD	:	SAR v1.1	Date	:	08-06-2011
Ambient Conditions	:	21 °C 50 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

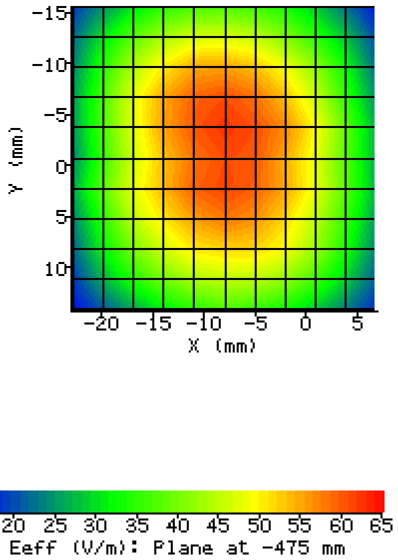
99610	99568	99553	99554	99559	99671	12612
13526	99106	99540	99555	99556	99574	99585
99576	99577					

Concerning measurement: System Check 5GHz

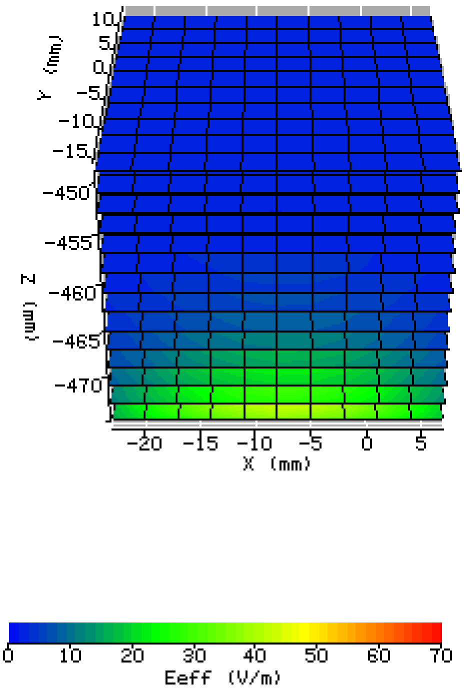
Antenna Port	:	**NA**	Power Control	:	**NA**
Bitrate	:	**NA**	Duty Cycle / Mode	:	**NA**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5800	No of steps z	13
Position Waveguide:	0mm from phantombox bottom	Stepsize z [mm]	2
Power level: [W}	0.25	Dist probe tip – phantom shell [mm]	3
		Probe conversion factor	0.761
Probe Serial Number:	M0017		
Liquid Simulant:	body	Max E-field [V/m in liquid]	61.61
Permittivity / Conductivity [S/m]	31.96 / 5.65	Location of max X= [mm]	-8.00
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	2.33
SAR Drift: [dB]	0.00 (0.06%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:	**20.615**		

	Meas Value (W/kg)	Target value (W/kg)	Deviation from target (%)	Permissable Deviation from target (%)
SAR 1g:	82.46	78.00	+5.72	±10



2d contour plot of scan closest to EUT.



3d representation of entire scan

Smidshornerweg 18
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Type	:	**Honeywell Impact Extreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.3	Date	:	08-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**16.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont. TX**

System / software:	SARA v2.54	No. of steps x and y	6
Phantom S/No:	Box phantom	Stepsize x and y [mm]	5
Test Frequency [MHz]	2412	No of steps z	10
Position / Channel:	Perpendicular / ch 1	Stepsize z [mm]	3
		Dist probe tip – phantom shell [mm]	5
		Probe conversion factor	0.383
Probe Serial Number:	168	Probe battery check [d/m/y]	08-06-2011
Liquid Simulant:	Head	Max E-field [V/m in liquid]	*See note 1
Permittivity / Conductivity [S/m]	38.27 / 1.81	Location of max X= [mm]	*See note 1
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	*See note 1
SAR Drift: [dB]	*See note 1	Location of max Z= [mm]	-473.0
Results:			
SAR 1g [W/kg]:	*See note 1		

*Note 1:

The SAR levels are below the minimum threshold of the SAR measuring system, a hotspot could not be determined.

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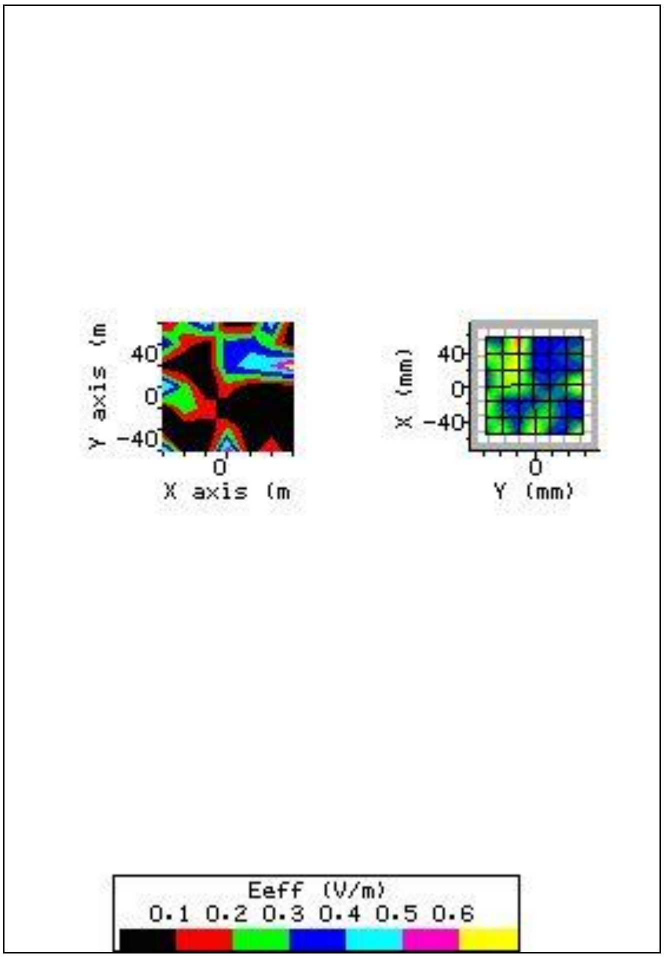

2d contour plot of scan closest to EUT.

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

Smidshornerweg 18
Postbus 15
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Type	:	**Honeywell Impact Extreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.3	Date	:	08-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**16.0 dBm**
Bitrate	:	**6 Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	6
Phantom S/No:	Box phantom	Stepsize x and y [mm]	5
Test Frequency [MHz]	2442	No of steps z	10
Position / Channel:	Perpendicular / ch 7	Stepsize z [mm]	3
		Dist probe tip – phantom shell [mm]	5
		Probe conversion factor	0.383
Probe Serial Number:	168	Probe battery check [d/m/y]	08-06-2011
Liquid Simulant:	Head	Max E-field [V/m in liquid]	*See note 1
Permittivity / Conductivity [S/m]	38.08 / 1.85	Location of max X= [mm]	*See note 1
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	*See note 1
SAR Drift: [dB]	*See note 1	Location of max Z= [mm]	-473.0
Results:			
SAR 1g [W/kg]:	*See note 1		

*Note 1:

The SAR levels are below the minimum threshold of the SAR measuring system, a hotspot could not be determined.

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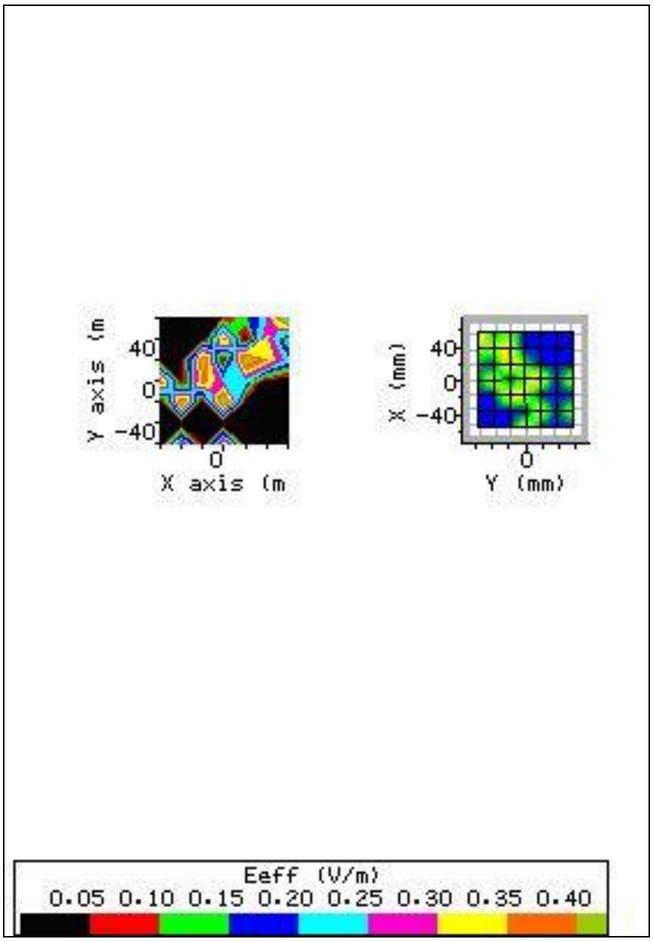

2d contour plot of scan closest to EUT.

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

Smidshornerweg 18
Postbus 15
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F: (0594) 50 48 04

Type	:	**Honeywell Impact Extreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.3	Date	:	08-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**16.0 dBm**
Bitrate	:	**6 Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont. TX**

System / software:	SARA v2.54	No. of steps x and y	6
Phantom S/No:	Box phantom	Stepsize x and y [mm]	5
Test Frequency [MHz]	2462	No of steps z	10
Position / Channel:	Perpendicular / ch 11	Stepsize z [mm]	3
		Dist probe tip – phantom shell [mm]	5
		Probe conversion factor	0.383
Probe Serial Number:	168	Probe battery check [d/m/y]	08-06-2011
Liquid Simulant:	Head	Max E-field [V/m in liquid]	*See note 1
Permittivity / Conductivity [S/m]	38.03 / 1.87	Location of max X= [mm]	*See note 1
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	*See note 1
SAR Drift: [dB]	*See note 1	Location of max Z= [mm]	-473.0
Results:			
SAR 1g [W/kg]:	*See note 1		

*Note 1:

The SAR levels are below the minimum threshold of the SAR measuring system, a hotspot could not be determined.

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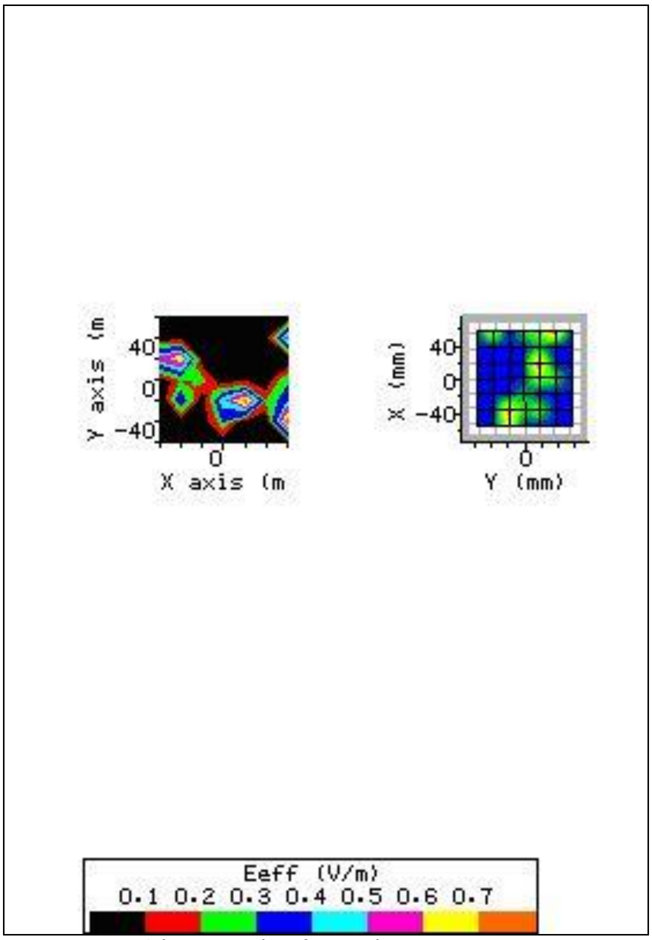

2d contour plot of scan closest to EUT.

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

.

Smidshornerweg 18
Postbus 15
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F: (0594) 50 48 04

Type	:	**Honeywell Impact Xtreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.2	Date	:	09-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**13.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5180	No of steps z	13
Position / Channel:	Perpendicular / ch 36	Stepsize z [mm]	2
		Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.50/0.36/ 0.51
Probe Serial Number:	M0017	Probe battery check [d/m/y]	09-06-2011
Liquid Simulant:	head	Max E-field [V/m in liquid]	4.97
Permittivity / Conductivity [S/m]	33.52 / 5.00	Location of max X= [mm]	-1.73
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	-4.97
SAR Drift: [dB]	0.0 (0%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**0.216**

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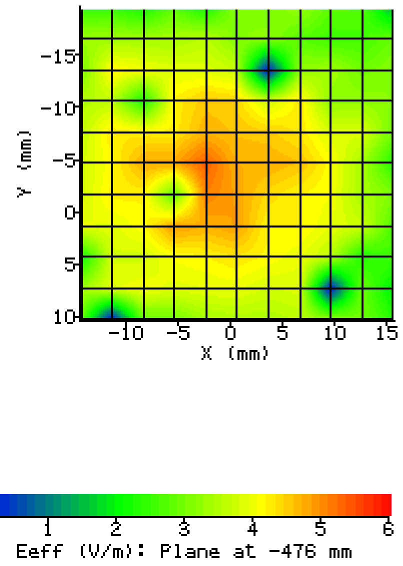
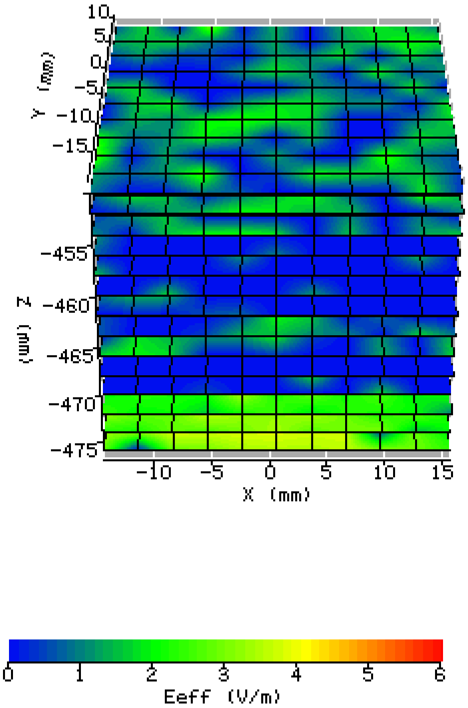


2d contour plot of scan closest to EUT.



3d representation of entire scan

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

Smidshornerweg 18
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Type	:	**Honeywell Impact Xtreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.2	Date	:	09-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**13.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5320	No of steps z	13
Position / Channel:	Perpendicular / ch 58	Stepsize z [mm]	2
		Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.47/0.34/ 0.48
Probe Serial Number:	M0017	Probe battery check [d/m/y]	09-06-2011
Liquid Simulant:	head	Max E-field [V/m in liquid]	6.05
Permittivity / Conductivity [S/m]	33.25 / 5.13	Location of max X= [mm]	-3.20
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	-2.23
SAR Drift: [dB]	0.0 (0%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:	**0.277**		

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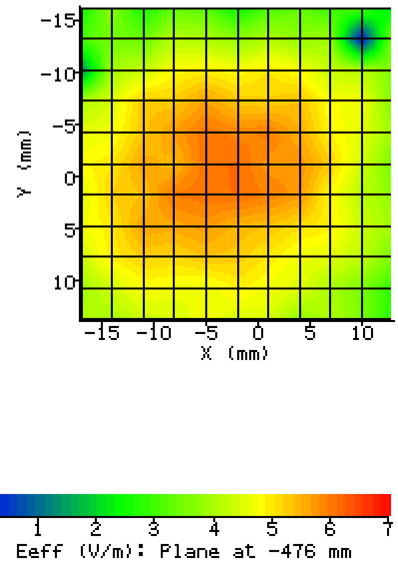
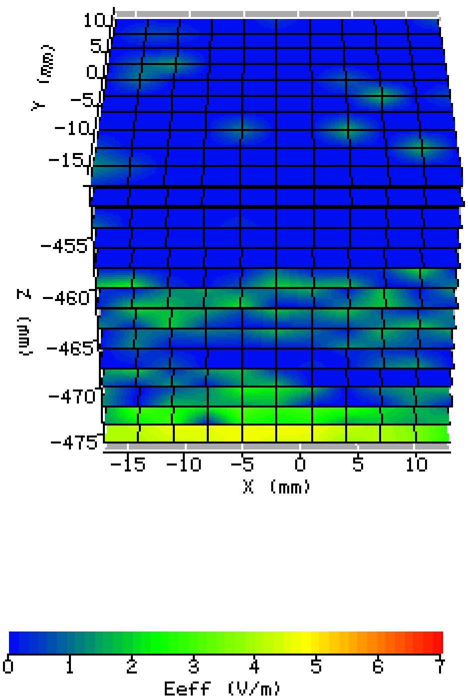


2d contour plot of scan closest to EUT.



3d representation of entire scan

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

Smidshornerweg 18
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Type	:	**Honeywell Impact Xtreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.2	Date	:	09-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**13.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5500	No of steps z	13
Position / Channel:	Perpendicular / ch 100	Stepsize z [mm]	2
		Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.46/0.35/ 0.47
Probe Serial Number:	M0017	Probe battery check [d/m/y]	09-06-2011
Liquid Simulant:	head	Max E-field [V/m in liquid]	5.80
Permittivity / Conductivity [S/m]	32.91 / 5.32	Location of max X= [mm]	-4.60
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	2.90
SAR Drift: [dB]	0.0 (0%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**0.268**

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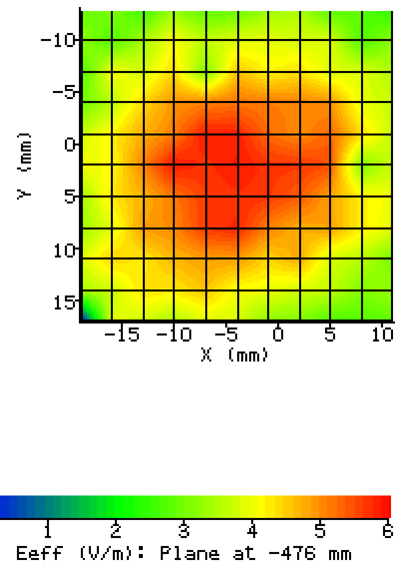
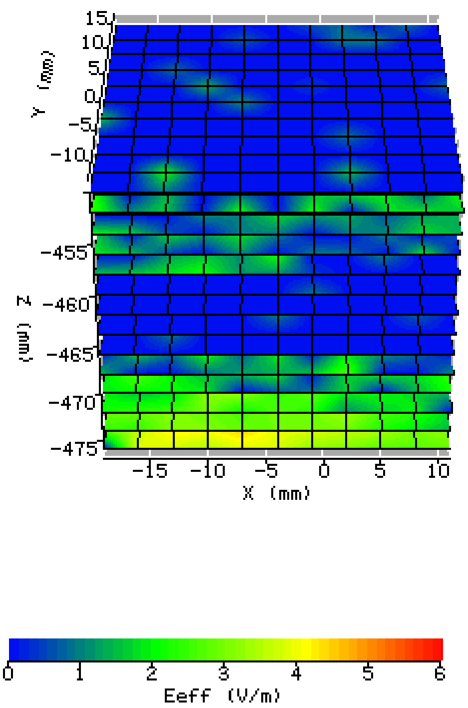


2d contour plot of scan closest to EUT.



3d representation of entire scan

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: As per 1999/519/EC **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
T: (0594) 50 50 05
F: (0594) 50 48 04

Type	:	**Honeywell Impact Xtreme SAR Sample**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.2	Date	:	09-06-2011
Ambient Conditions	:	20 °C 53 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**13.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5700	No of steps z	13
Position / Channel:	Perpendicular / ch 140	Stepsize z [mm]	2
		Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.46/ 0.35/ 0.47
Probe Serial Number:	M0017	Probe battery check [d/m/y]	09-06-2011
Liquid Simulant:	head	Max E-field [V/m in liquid]	7.79
Permittivity / Conductivity [S/m]	32.32 / 5.58	Location of max X= [mm]	-9.73
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	2.97
SAR Drift: [dB]	0.0 (0%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**0.363**

Smidshornerweg 18
Postbus 15
9822 ZG Niekerk
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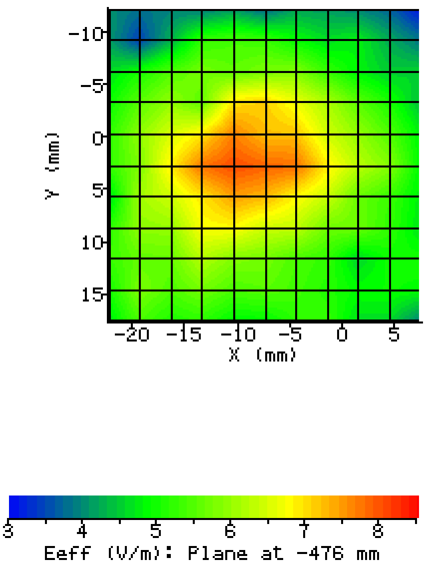
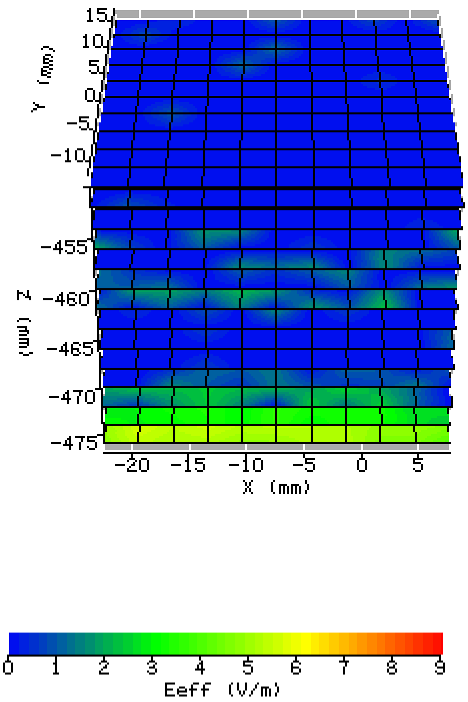
F: (0594) 50 48 04



2d contour plot of scan closest to EUT.



3d representation of entire scan

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: As per 1999/519/EC **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**

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Type	:	**Honeywell Impact Xtreme IP 192.168.0.9**	Regnr.	:	13050602 (11042002)
Antenna	:	**Internal**			
Standard(s)	:	IEEE-1528, OET 65-C			
TSD	:	SAR_01 v1.2	Date	:	09-10-2011
Ambient Conditions	:	20 °C 57 % RH	Test engineer	:	L. Koopmans

Used test equipment and ancillaries:

99610	99568	99553	99554	99559	99671	

Concerning measurement: **SAR**

Antenna Port	:	**-**	Power Control	:	**12.0 dBm**
Bitrate	:	**6Mb DSSS**	Duty Cycle / Mode	:	**99% / Cont.TX**

System / software:	SARA v2.54	No. of steps x and y	10
Phantom S/No:	Box phantom	Stepsize x and y [mm]	3
Test Frequency [MHz]	5805	No of steps z	13
Position / Channel:	Perpendicular / ch 161	Stepsize z [mm]	2
		Dist probe tip – phantom shell [mm]	3
		Probe conversion factor X/Y/Z	0.46/0.34/ 0.48
Probe Serial Number:	M0017	Probe battery check [d/m/y]	09-06-2011
Liquid Simulant:	head	Max E-field [V/m in liquid]	5.60
Permittivity / Conductivity [S/m]	32.04 / 5.67	Location of max X= [mm]	-5.27
Liquid Temperature [°C]	19.8	Location of max Y= [mm]	-0.73
SAR Drift: [dB]	0.0 (0%)	Location of max Z= [mm]	-475.0
Results:			
SAR 1g [W/kg]:			**0.274**

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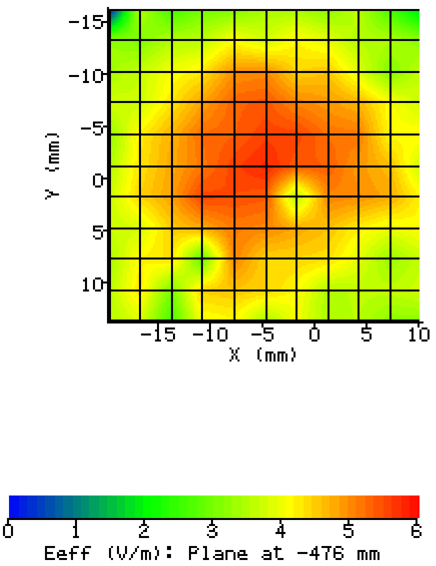
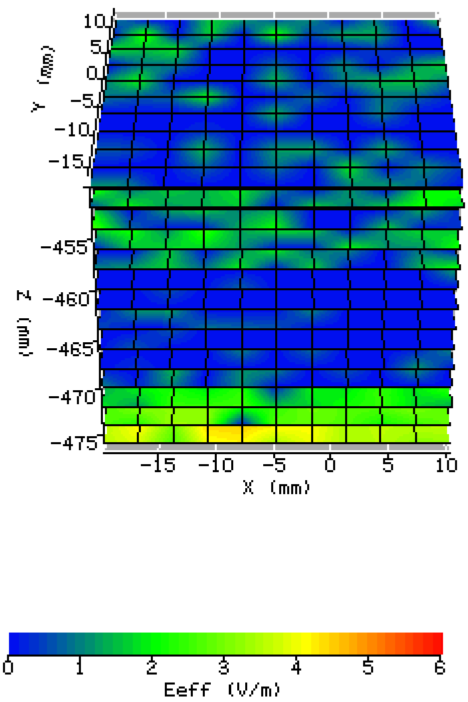


2d contour plot of scan closest to EUT.



3d representation of entire scan

Limits.

Exposure Category and SAR limits	Test Requirements	Compliance (Yes/No/Not Applicable)
Limit for General Public: **1.6 W/kg** (averaged over 1g of tissue)	IEEE-1528, OET 65-C	**YES**