CETECOM™

SAR Test Report

No.: SAR_NOVAT_010_06002_XU870_FCC_850_1900rev1

for the

Novatel Wireless

PCMCIA EXPRESS CARD with quadband GSM/GPRS and UMTS

Model Number: Merlin XU870

FCC ID: NBZNRM-XU870

IC-ID: 3229A-XU870

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IC recognized # 3925

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1 Assessment

The Novatel Wireless Merlin XU870
PCMCIA EXPRESS CARD with quadband GSM/GPRS and UMTS, FCC ID: NBZNRM-XU870, is in compliance with the limits for general population uncontrolled exposure specified in FCC 2.1093. The device was tested according to measurement standards and procedures specified in FCC OET Bulletin 65, Supplement C (Edition 01-01) and IEEE P1528/D1.2, April 21, 2003.

8/28/2006
Pete Krebill
EMC/SAR Project Engineer

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the SAR Assessment Report

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2.2 Identification of the Client

Applicant's Name:	Novatel Wireless
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e-mail:	MTOOSSI@NVTL.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as applicant

3 Equipment under Investigation (EUI)

3.1 Identification of the Equipment under Investigation

Product Type	PCMCIA EXPRESS CARD with quadband GSM/GPRS and UMTS
Marketing Name:	Merlin XU870
Model No:	XU870
FCC-ID:	NBZNRM-XU870
IC-ID :	3229A-XU870
Frequency Range:	824 MHz to 849 MHz & 1850MHz to 1910 MHz
Type(s) of Modulation:	GMSK, 8PSK, UMTS
Antenna Type:	integral
Output Power[1]:	29.74 dBm (0.942 W) ERP 850 GPRS 27.83 dBm (0.593 W) ERP 850 EGPRS 21.99 dBm (0.158 W) ERP 850 FDD5 29.05 dBm (0.804 W) EIRP 1900 GPRS 27.85 dBm (0.610 W) EIRP 1900 EGPRS 26.47 dBm (0.444 W) EIRP 1900 FDD2

[1] For complete power measurements see section 8.1 of this report

4 Subject of Investigation

The XU870 is a new PCMCIA EXPRESS CARD with quadband GSM/GPRS and UMTS from Novatel Wireless operating in the 824 MHz to 849 MHz & 1850MHz to 1910 MHz frequency ranges. The objective of the measurements done by Cetecom Inc. was the dosimetric assessment of the device. The tests were performed in configurations for devices operated next to a person's body. Testing was performed with the device configured in 3 laptop PCs. The examinations were carried out with the dosimetric assessment system SARA2 described below.

4.1 The IEEE Standard C95.1 and the FCC Exposure Criteria

In the USA the recent FCC exposure criteria [FCC 2001] are based upon the IEEE Standard C95.1 [IEEE 1999]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.

4.2 Distinction Between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE 1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered. Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the
limits in general vary with frequency.

4.3 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength *E* inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0+}$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity *c* of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric *E* and magnetic field strength *H* and power density S, derived from the SAR limits. The limits for E, *H* and *S* have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

4.4 SAR Limit

In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR_{1g}) with the shape of a cube.

Standard	Status	SAR limit (W/kg)
IEEE C95.1	In force	1.6

Table 1: Relevant spatial peak SAR limit averaged over a mass of 1 g

5 The FCC Measurement Procedure

The Federal Communications Commission (FCC) has published a report and order on the 1st of August 1996 [FCC 1996], which requires routine dosimetric assessment of mobile telecom-communications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65. This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [FCC 2001].

5.1 General Requirements

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity.

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5.2 Test Positions

5.3 Body-worn and Other Configurations

Phantom Requirements
For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

Test Position
The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset.

Test to be Performed
For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body. For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested. If the manufacturer provides none body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

5.4 Procedure for assessing the peak spatial-average SAR

Step 1*: Power reference measurement:*

Prior to the SAR test, a local SAR measurement should be taken at a user-selected spatial reference point to monitor power variations during testing. For example, this power reference point can be spaced 10 mm or less in the normal direction from the liquid-shell interface and within ± 10 mm transverse to the normal line at the ear reference point.

Step 2: Area scan

The measurement procedures for evaluating SAR associated with wireless handsets typically start with a coarse measurement grid in order to determine the approximate location of the local peak SAR values. This is referred to as the "area scan" procedure. The SAR distribution is scanned along the inside surface of typically half of the head of the phantom but at least larger than the areas projected (normal to the phantom's surface) by the handset and antenna. An example grid is given in Figure 4. The distance between the measured points and phantom surface should be less than 8 mm, and should remain constant (variation less than ± 1 mm) during the entire scan in order to determine the locations of the local peak SAR with sufficient precision. The distance between the measurement points should enable the detection of the location of local maximum with an accuracy of better than half the linear dimension of the tissue cube after interpolation. The resolution can also be tested using the functions in Annex E (see E.5.2). The approximate locations of the peak SARs should be determined from area scan. Since a given amplitude local peak with steep gradients may produce lower spatial-average SAR than slightly lower amplitude peaks with less steep gradients, it is necessary to evaluate the other peaks as well. However, since the spatial gradients of local SAR peaks are a function of wavelength inside the tissue simulating liquid and incident magnetic field strength, it is not necessary to evaluate peaks that are less than –2dB of the local maximum. Two-dimensional spline algorithms [Press, et al, 1996], [Brishoual, 2001] are typically used to determine the peaks and gradients within the scanned area. If the peak is closer than one-half of the linear dimension of the 1 g or 10 g tissue cube to the scan border, the measurement area should be enlarged if possible, e.g., by tilting the probe or the phantom (see Figure 5).

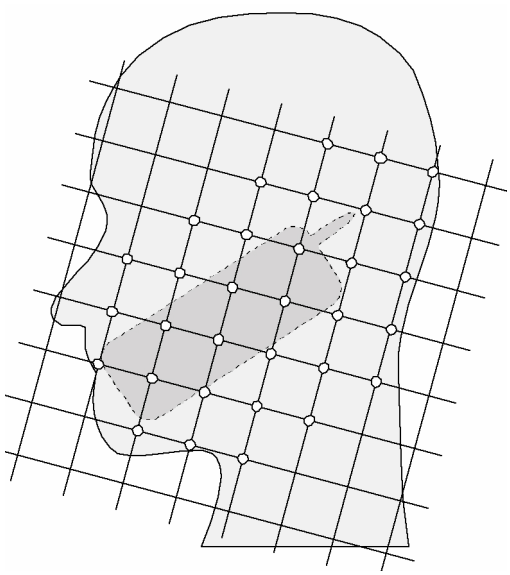


Figure 4 – Example of an area scan including the position of the handset. The scanned area (white dots) should be larger than the area projected by the handset and antenna.

5.4.1.1 Step 3: Zoom scan

In order to assess the peak spatial SAR values averaged over a 1 g and 10 g cube, fine resolution volume scans, called "zoom scans", are performed at the peak SAR locations determined during the "area scan." The zoom scan volume should have at least 1.5 times the linear dimension of either a 1 g or a 10 g tissue cube for whichever peak spatial-average SAR is being evaluated. The

peak local SAR locations that were determined in the area scan (interpolated value) should be on the centerline of the zoom scans. The centerline is the line that is normal to the surface and in the center of the volume scan. If this is not possible, the zoom scan can be shifted but not by more than half the dimension of the 1 g or a 10 g tissue cube.

The maximum spatial-average SAR is determined by a numerical analysis of the SAR values obtained in the volume of the zoom scan, whereby interpolation (between measured points) and extrapolation (between surface and closest measured points) routines should be applied. A 3-D-spline algorithm [Press, et al, 1996], [Kreyszig, 1983], [Brishoual, 2001] can be used for interpolation and a trapezoidal algorithm for the integration (averaging). Scan resolutions of larger than 2 mm can be used provided the uncertainty is evaluated according to E (see E.5).
In some areas of the phantom, such as the jaw and upper head region, the angle of the probe with respect to the line normal to the surface might become large, e.g., at angles larger than ± 30º (see Figure 5), which may increase the boundary effect to an unacceptable level. In these cases, a change in the orientation of the probe and/or the phantom is recommended during the zoom scan so that the angle between the probe housing tube and the line normal to the surface is significantly reduced (<30º).

5.4.1.2 Step 4: Power reference measurement

The local SAR should be measured at exactly the same location as in Step 1. The absolute value of the measurement drift (the difference between the SAR measured in Step 4 and Step 1) should be recorded in the uncertainty budget. It is recommended that the drift be kept within ± 5%. If this is not possible, even with repeat testing, additional information may be used to demonstrate the power stability during the test. Power reference measurements can be taken after each zoom scan, if more than one zoom scan is needed. However, the drift should always be referred to the initial state with fully charged battery.

5.5 Determination of the largest peak spatial-average SAR

In order to determine the largest value of the peak spatial-average SAR of a handset, all device positions, configurations and operational modes should be tested for each frequency band according to steps 1 to 3 below.
Step 1: The tests of 6.4 should be conducted at the channel that is closest to the center of the transmit frequency band (*fc*) for:
all device positions (cheek and tilt, for both left and right sides of the SAM phantom,
all configurations for each device position in (a), e.g. antenna extended and retracted, and
all operational modes for each device position in (a) and configuration in (b) in each frequency band, e.g. analog and digital.
If more than three frequencies need to be tested, (i.e., Nc > 3), then all frequencies, configurations and modes must be tested for all of the above positions.
Step 2: For the condition providing highest spatial peak SAR determined in Step 1 conduct all tests of 6.4 at all other test frequencies, e.g. lowest and highest frequencies. In addition, for all other conditions (device position, configuration and operational mode) where the spatial peak

SAR value determined in Step 1 is within 3dB of the applicable SAR limit, it is recommended that all other test frequencies should be tested as well[2].

Step 3: Examine all data to determine the largest value of the peak spatial-average SAR found in Steps 1 to 2.

6 The Measurement System

6.1 Robot system specification

The SAR measurement system being used is the IndexSAR SARA2 system, which consists of a Mitsubishi RV-E2 6-axis robot arm and controller, IndexSAR probe and amplifier and SAM phantom Head Shape. The robot is used to articulate the probe to programmed positions inside the phantom head to obtain the SAR readings from the DUT.

The system is controlled remotely from a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans.

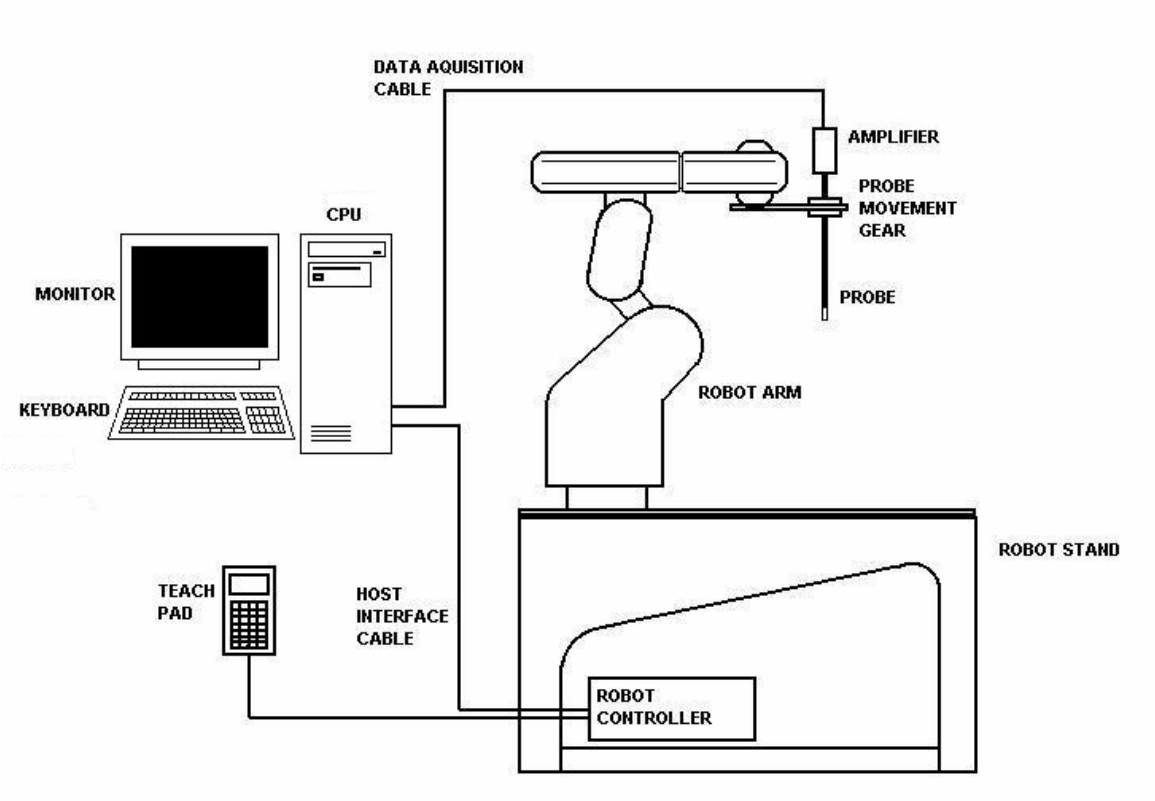


Figure 5: Schematic diagram of the SAR measurement system

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

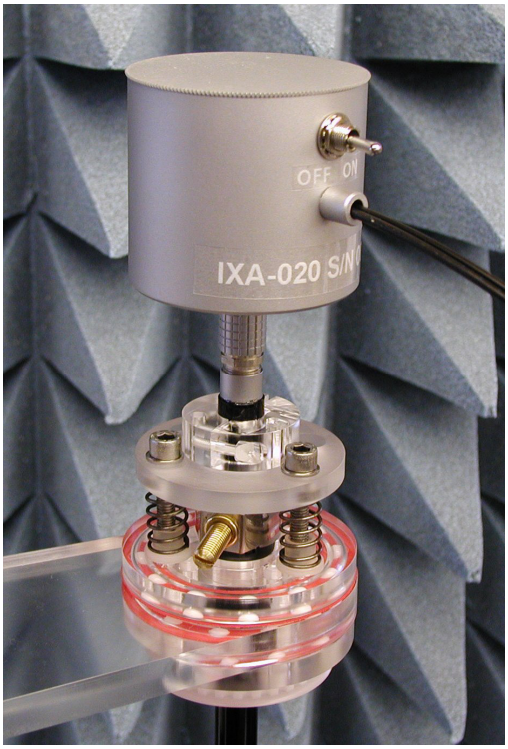
In operation, the system first does an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centred at that point to determine volume averaged SAR level.

6.2 Probe and amplifier specification

6.2.1 IXP-030 Indexsar isotropic immersible SAR probe

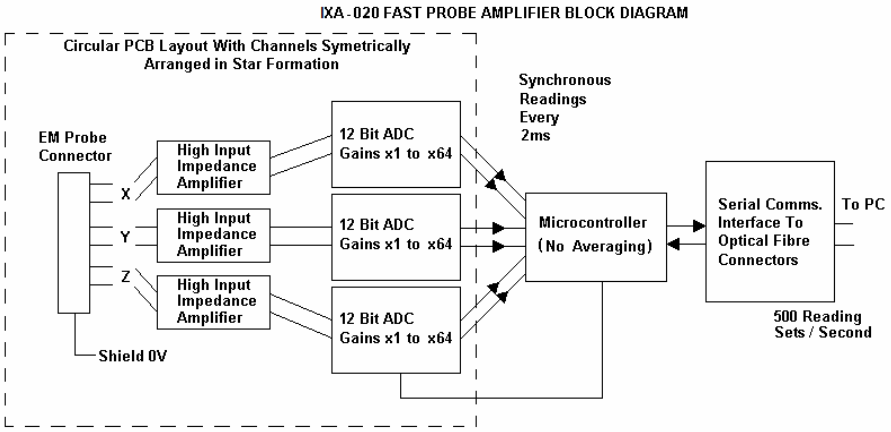
The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip. Probe calibration is described in the probe's calibration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

6.2.2 The IXA-020 probe amplifier

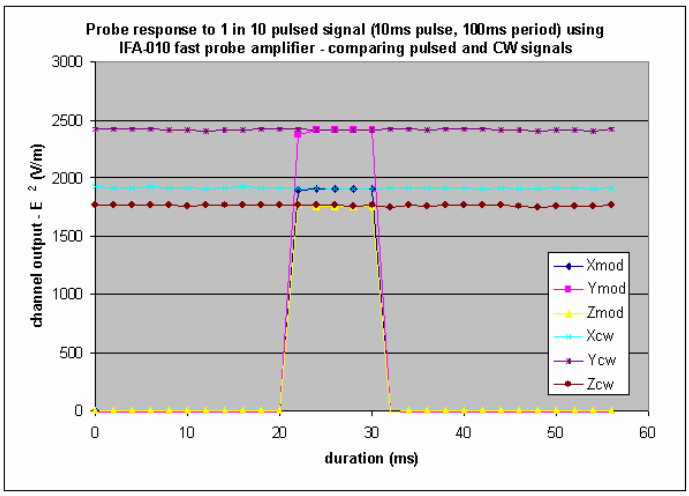


This component is a key component of the measurement system having the basic capability of making simultaneous synchronized measurements of each of the three sensor outputs 500 times per second.

A block diagram of the fast probe amplifier electronics is shown below.



This amplifier has a time constant of approx. 50µs, which is much faster than the SAR probe response time. The overall system time constant is therefore that of the probe (<1ms) and reading sets for all three channels (simultaneously) are returned every 2ms to the PC. The conversion period is approx. 1 µs at the start of each 2ms period. This enables the probe to follow pulse modulated signals of periods >>2ms. The PC software applies the linearisation procedure separately to each reading, so no linearisation corrections for the averaging of modulated signals are needed in this case. It is important to ensure that the probe reading frequency and the pulse period are not synchronised and the behaviour with pulses of short duration in comparison with the measurement interval need additional consideration.



6.3 Phantoms

The box phantom used for body testing and for validation is manufactured from Perspex. The material is 2 mm in thickness on the test surfaces and 4 mm in thickness on the other surfaces. Its dimensions are: X=21 cm., Y=20.5 cm., Z=17 cm.

6.4 SAR measurement procedure

The major components of the test bench are shown in the picture above.

6.5 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 presented in [4]. A 4th order polynomial fit is used by default for data extrapolation, but a linear-logarithmic fitting function can be selected as an option. The polynomial fitting procedures have been tested by comparing the fitting coefficients generated by the SARA2 procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

6.6 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 approx. 10mm 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.

6.7 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 digitised shape of the head 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.

6.8 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 curved inner surface of the phantom (see Appendix D in FCC Supplement C edition 01-01 to OET Bulletin 65 edition 97-01). 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 1mm 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 the definition of the surface in this procedure, the digitised position of the headshell surface is used for measurement in head-shaped phantoms. 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 2.5mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 5mm. A value of 6 or 8mm is recommended. This distance is called **dbe**.

For automated measurements inside the head, the distance cannot be less than 2.5mm, which is the radius of the probe tip and to avoid interface proximity effects, a minimum clearance distance of x mm is retained. The actual value of dbe will vary from point to point depending upon how

the spatially-regular 3D grid points fit within the shell. The greatest separation is when a grid point is just not visited due to the probe tip dimensions. In this case the distance could be as large as the step-size plus the minimum clearance distance (i.e with x=5 and a step size of 3.5, **dbe** will be between 3.5 and 8.5mm).

The default step size (**dstep**) used is 3.5mm, 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 +/- 0.04mm.

The phantom shell is made by an industrial moulding process from the CAD files of the SAM shape, with both internal and external moulds. For the upright phantoms, the external shape is subsequently digitised on a Mitutoyo CMM machine (Euro an ultrasonic sensor indicate that the shell thickness (**dph**) away from the ear is 2.0 +/- 0.1mm. The ultrasonic measurements were calibrated using additional mechanical measurements on available cut surfaces of the phantom shells.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253mm diameter baseplate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided (procedure detailed elsewhere). This enables the registration of the phantom tip (**dmis**) to be assured to within approx. 0.2mm. This alignment is done with reference to the actual probe tip after installation and probe alignment. The rotational positioning of the phantom is variable – offering advantages for special studies, but locating pins ensure accurate repositioning at the principal positions (LH and RH ears).

7 Uncertainty Assessment

Measurement uncertainty values were evaluated for SAR measurements performed by Cetecom Inc. The uncertainty values for components specified in *FCC Supplement C (01-01) to OET Bulletin 65 (97-01)* were evaluated according to the procedures of *IEEE P1528/D1.2 April 21, 2003, NIST 1297 1994 edition and ISO Guide to the Expression of Uncertainty in Measurements (GUM)*.

7.1 Table of Measurement Uncertainty Values of SAR Evaluations

a	*b*	*c*	*d*	*e = f(d,k)*	*f*	*g = c x f / e*	*k*
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1-g)**	**1-g u_i (±%)**	**v_i**
Measurement System							
Probe Calibration	E2.1	3.6	N	1	1	3.6	∞
Axial Isotropy	E2.2	4.23	R	√3	$(1\text{-cp})^{1/2}$	0.00	∞
Hemispherical Isotropy	E2.2	10.7	R	√3	$\sqrt{c_p}$	6.18	∞
Boundary Effect	E2.3	1.7	R	√3	1	0.98	∞
Linearity	E2.4	2.92	R	√3	1	1.69	∞
System Detection Limits	E2.5	0.00	R	√3	1	0.00	∞
Readout Electronics	E2.6	0.00	N	1	1	0.00	∞
Response Time	E2.7	0.00	R	√3	1	0.00	∞
Integration Time	E2.8	0.0	R	√3	1	0.23	∞
RF Ambient Conditions	E6.1	0.00	R	√3	1	0.00	∞
Probe Positioner Mechanical Tolerance	E6.2	0.57	R	√3	1	0.33	∞
Probe Positioning with respect to Phantom Shell	E6.3	1.43	R	√3	1	0.83	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5.2	3.6	R	√3	1	2.08	∞
Test sample Related							
Test Sample Positioning	E4.2	4.81	N	1	1	4.81	*29*
Device Holder Uncertainty	E4.1	0.00	N	1	1	0.00	*0*
Output Power Variation - SAR drift measurement	6.6.2	5.0	R	√3	1	2.89	∞
Phantom and Tissue Parameters							
Phantom Uncertainty (shape and thickness tolerances)	E3.1	1.43	R	√3	1	0.83	∞
Liquid Conductivity Target - tolerance	E3.2	5.0	R	√3	0.7	2.02	∞
Liquid Conductivity - measurement uncertainty	E3.3	2.0	R	√3	0.7	0.81	∞
Liquid Permittivity Target tolerance	E3.2	5.0	R	√3	0.6	1.73	∞
Liquid Permittivity - measurement uncertainty	E3.3	1.0	R	√3	0.6	0.35	∞
Combined Standard Uncertainty			RSS			**± 10.0%**	
Expanded Uncertainty (95% CONFIDENCE INTERVAL)			*k*= 2.00705			**± 20.1%**	

When there is more than one tolerance for an item the highest tolerance is listed in the table above.

7.2 Table of Measurement Uncertainty Values for SAR System Verification

a	*b*	*c*	*d*	*e = f(d,k)*	*f*	*g = c x f / e*	*k*
Uncertainty Component	**Sec.**	**Tol. (± %)**	**Prob. Dist.**	**Div.**	**c_i (1-g)**	**1-g u_i (±%)**	**v_i or v_{eff}**
Measurement System							
Probe Calibration	E2.1	3.6	N	1	1	3.6	∞
Axial Isotropy	E2.2	4.23	R	√3	$(1\text{-cp})^{1/2}$	0.00	∞
Hemispherical Isotropy	E2.2	10.7	R	√3	$\sqrt{c_p}$	6.18	∞

Boundary Effect	E2.3	1.7	R	√3	1	0.98	∞
Linearity	E2.4	2.92	R	√3	1	1.69	∞
System Detection Limits	E2.5	0.00	R	√3	1	0.00	∞
Readout Electronics	E2.6	0.00	N	1	1	0.00	∞
Response Time	E2.7	0.00	R	√3	1	0.00	∞
Integration Time	E2.8	0.0	R	√3	1	0.23	∞
RF Ambient Conditions	E6.1	0.00	R	√3	1	0.00	∞
Probe Positioner Mechanical Tolerance	E6.2	0.57	R	√3	1	0.33	∞
Probe Positioning with respect to Phantom Shell	E6.3	1.43	R	√3	1	0.83	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5.2	3.6	R	√3	1	2.08	∞
Dipole							
Dipole Axis to Liquid Distance	8, E4.2	1.0	R	√3	1	0.58	∞
Input Power and SAR Drift Measurement	8, 6.6.2	2.9	R	√3	1	1.67	∞
Phantom and Tissue Parameters							
Phantom Uncertainty - shell thickness tolerance	E3.1	1.43	R	√3	1	0.83	∞
Liquid Conductivity - deviation from target values	E3.2	5.0	R	√3	0.7	2.02	∞
Liquid Conductivity - measurement uncertainty	E3.3	2.0	R	√3	0.7	0.81	∞
Liquid Permittivity - deviation from target values	E3.2	5.0	R	√3	0.6	1.73	∞
Liquid Permittivity - measurement uncertainty	E3.3	1.0	R	√3	0.6	0.35	∞
Combined Standard Uncertainty			RSS			**± 8.47%**	
Expanded Uncertainty (95% CONFIDENCE INTERVAL)			*k*=2			**± 16.95%**	

8 Test results summary

8.1 Radiated Output Power

Prior to testing the radiated was measured. The results are shown below.

ERP 850 MHz GPRS band:

824.2 MHz:	28.51 dBm
836.6 MHz:	29.37 dBm
848.8 MHz:	29.74 dBm

ERP 850 MHz EGPRS band:

824.2 MHz:	26.96 dBm
836.6 MHz:	27.52 dBm
848.8 MHz:	27.83 dBm

ERP 850 MHz FDD5 band:

826.4 MHz:	21.99 dBm
836.6 MHz:	21.46 dBm
846.6 MHz:	21.40 dBm

EIRP 1900 MHz GPRS band:

1850.2 MHz:	27.39 dBm
1880.0 MHz:	29.05 dBm
1909.8 MHz:	27.37 dBm

EIRP 1900 MHz EGPRS band:

1850.2 MHz:	25.80 dBm
1880.0 MHz:	27.85 dBm
1909.8 MHz:	27.04 dBm

EIRP 1900 MHz FDD2 band:

1852.4 MHz:	25.02 dBm
1880.0 MHz:	25.27 dBm
1907.6 MHz:	26.47 dBm

8.2 Test Positions and Configurations

The EUT was configured in 3 laptop PCs with PCMCIA express slots. The models and distances from the bottom surface of the EUT to the phantom are shown below. During testing the bottom surface of the laptop PCs were directly against the phantom.

Laptop 1.	Sony SZ-3	13mm
Laptop 2.	Dell XPS 1710	18mm
Laptop 3.	Dell Inspiron 6400	16mm

8.3 GPRS Operating Mode

The device is a multislot class 12 device capable of 4 uplink timeslots. All GPRS testing was performed with the EUT transmitting on 4 simultaneous timeslots. The EUT does not use power reduction when transmitting on multiple timeslots.

8.4 EGPRS Operating Mode

The device is a multislot class 12 device capable of 4 uplink timeslots. All EGPRS testing was performed with the EUT transmitting on 4 simultaneous timeslots. The EUT does not use power reduction when transmitting on multiple timeslots,

8.5 UMTS Operating Mode

A radio link was established between the EUT and a communication test set. The link was set using 12.2 kbps RMC with TPC bits configured to all 1s. The maximum average output power of each channel for all other spread codes supported by the EUT were not more than ¼ dB higher than those measured in 12.2 kbps RMC (see second table below). All spread codes and channel configurations that were displayed on the communication test set as being supported were tested (see first table below).

UL RMC (kbps)	DPDCH Channel Bit Rate (kbps)	Spread Code
12.2	60	16
64	240	4
144	480	2
384	960	1

UL RMC	Maximum Average Conducted Power (dBm)		
	Ch. 4132 826.64 MHz	Ch. 4183 836.6 MHz	Ch. 4233 846.6 MHz
12.2	24.75	24.83	24.97
64	24.71	24.86	24.77
144	24.65	25.01	24.81
384	24.66	24.87	24.83
UL RMC	Maximum Average Conducted Power (dBm)		
	Ch. 9262 1852.4 MHz	Ch. 9400 1880 MHz	Ch. 9538 1907.6 MHz
12.2	24.02	25.11	24.62
64	24.05	25.20	24.70
144	24.07	25.00	24.61
384	24.04	24.98	24.60

8.6 HSDPA Operating Mode

SAR was measured in HSDPA with an FRC, together with a 12.2 kbps RMC configured in Test Loop Mode 1, using the highest body SAR configuration in 12.2 kbps RMC without HSDPA.

8.7 Laptop PC #1 Sony SZ-3

8.7.1 850 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	1.252	Plot 1	Photo 4
Lap	Closed	192 / 836.6	0.922	Plot 2	Photo 5
Lap	Opened	128 / 824.2	1.327	Plot 3	Photo 4
Lap	Opened	251 / 848.8	1.143	Plot 4	Photo 4

8.7.2 850 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	0.528	Plot 5	Photo 4
Lap	Closed	192 / 836.6	0.451	Plot 6	Photo 5
Lap	Opened	128 / 824.2	0.508	Plot 7	Photo 4
Lap	Opened	251 / 848.8	0.471	Plot 8	Photo 4

8.7.3 850 MHz FDD5 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	4183 / 836.6	0.477	Plot 9	Photo 4
Lap	Closed	4183 / 836.6	0.437	Plot 10	Photo 5
Lap	Opened	4132 / 826.4	0.466	Plot 11	Photo 4
Lap	Opened	4233 / 846.6	0.462	Plot 12	Photo 4

8.7.4 1900 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.509	Plot 13	Photo 4
Lap	Closed	661 / 1880	0.426	Plot 14	Photo 5
Lap	Opened	512 / 1850.2	0.473	Plot 15	Photo 4
Lap	Opened	810 / 1909.8	0.546	Plot 16	Photo 4

8.7.5 1900 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.323	Plot 17	Photo 4
Lap	Closed	661 / 1880	0.297	Plot 18	Photo 5
Lap	Opened	512 / 1850.2	0.231	Plot 19	Photo 4
Lap	Opened	810 / 1909.8	0.306	Plot 20	Photo 4

8.7.6 1900 MHz FDD2 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	9400 / 1880	0.405	Plot 21	Photo 4
Lap	Closed	9400 / 1880	0.266	Plot 22	Photo 5
Lap	Opened	9262/1852.4	0.404	Plot 23	Photo 4
Lap	Opened	9538/1907.6	0.449	Plot 24	Photo 4

8.8 Laptop PC #2 Dell XPS 1710

8.8.1 850 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	0.771	Plot 25	Photo 6
Lap	Closed	192 / 836.6	0.712	Plot 26	Photo 7
Lap	Opened	128 / 824.2	0.757	Plot 27	Photo 6
Lap	Opened	251 / 848.8	0.710	Plot 28	Photo 6

8.8.2 850 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	0.338	Plot 29	Photo 6
Lap	Closed	192 / 836.6	0.281	Plot 30	Photo 7
Lap	Opened	128 / 824.2	0.274	Plot 31	Photo 6
Lap	Opened	251 / 848.8	0.366	Plot 32	Photo 6

8.8.3 850 MHz FDD5 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	4183 / 836.6	0.263	Plot 33	Photo 6
Lap	Closed	4183 / 836.6	0.247	Plot 34	Photo 7
Lap	Opened	4132 / 826.4	0.267	Plot 35	Photo 6
Lap	Opened	4233 / 846.6	0.254	Plot 36	Photo 6

8.8.4 1900 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.703	Plot 37	Photo 6
Lap	Closed	661 / 1880	0.509	Plot 38	Photo 7
Lap	Opened	512 / 1850.2	0.605	Plot 39	Photo 6
Lap	Opened	810 / 1909.8	0.553	Plot 40	Photo 6

8.8.5 1900 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.348	Plot 41	Photo 6
Lap	Closed	661 / 1880	0.300	Plot 42	Photo 7
Lap	Opened	512 / 1850.2	0.349	Plot 43	Photo 6
Lap	Opened	810 / 1909.8	0.429	Plot 44	Photo 6

8.8.6 1900 MHz FDD2 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	9400 / 1880	0.286	Plot 45	Photo 6
Lap	Closed	9400 / 1880	0.203	Plot 46	Photo 7
Lap	Opened	9262/1852.4	0.208	Plot 47	Photo 6
Lap	Opened	9538/1907.6	0.383	Plot 48	Photo 6

8.9 Laptop PC #3 Dell Inspiron 6400

8.9.1 850 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	1.580	Plot 49	Photo 8
Lap	Closed	192 / 836.6	0.719	Plot 50	Photo 9
Lap	Opened	128 / 824.2	1.212	Plot 51	Photo 8
Lap	Opened	251 / 848.8	1.364	Plot 52	Photo 8

8.9.2 850 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	192 / 836.6	0.611	Plot 53	Photo 8
Lap	Closed	192 / 836.6	0.567	Plot 54	Photo 9
Lap	Opened	128 / 824.2	0.602	Plot 55	Photo 8
Lap	Opened	251 / 848.8	0.813	Plot 56	Photo 8

8.9.3 850 MHz FDD5 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	4183 / 836.6	0.581	Plot 57	Photo 8
Lap	Closed	4183 / 836.6	0.542	Plot 58	Photo 9
Lap	Opened	4132 / 826.4	0.563	Plot 59	Photo 8
Lap	Opened	4233 / 846.6	0.561	Plot 60	Photo 8

8.9.4 1900 MHz GPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.939	Plot 61	Photo 8
Lap	Closed	661 / 1880	0.522	Plot 62	Photo 9
Lap	Opened	512 / 1850.2	0.940	Plot 63	Photo 8
Lap	Opened	810 / 1909.8	0.931	Plot 64	Photo 8

8.9.5 1900 MHz EGPRS band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	661 / 1880	0.365	Plot 65	Photo 8
Lap	Closed	661 / 1880	0.273	Plot 66	Photo 9
Lap	Opened	512 / 1850.2	0.374	Plot 67	Photo 8
Lap	Opened	810 / 1909.8	0.344	Plot 68	Photo 8

8.9.6 1900 MHz FDD2 band SAR Results for Merlin XU870

Position	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap	Opened	9400 / 1880	0.406	Plot 69	Photo 8
Lap	Closed	9400 / 1880	0.267	Plot 70	Photo 9
Lap	Opened	9262/1852.4	0.402	Plot 71	Photo 8
Lap	Opened	9538/1907.6	0.376	Plot 72	Photo 8

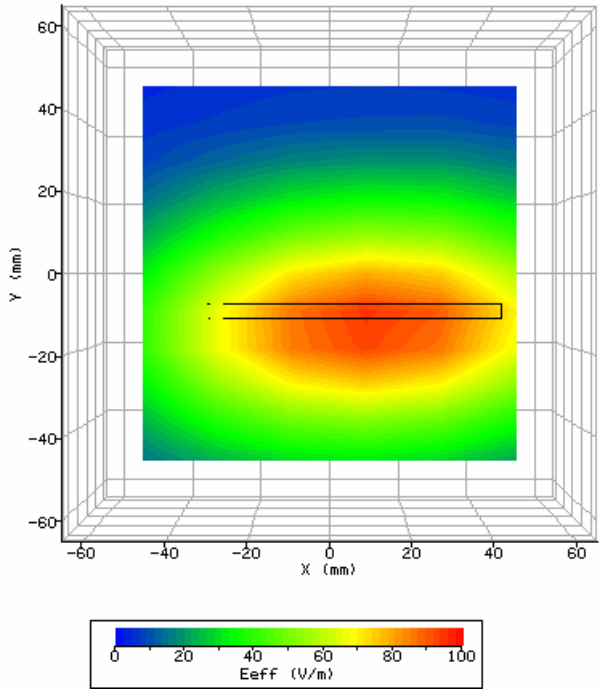
8.10 HSDPA FDD2 & FDD5 SAR Results for Merlin XU870

Position / Laptop PC	Antenna	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
Lap/ Dell Inspiron 6400	Opened	4183 / 836.6	0.574	Plot 73	Photo 8
Lap / Sony SZ-3	Opened	9538/1907.6	0.458	Plot 74	Photo 4

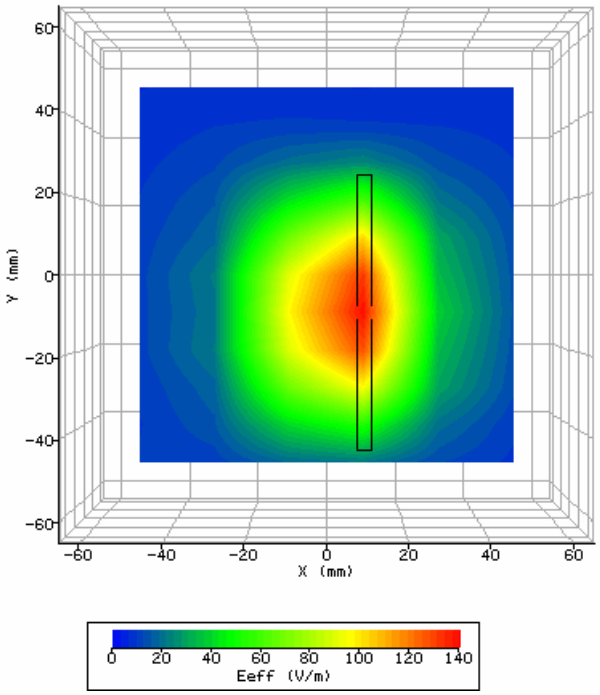
8.11 Validation Check Results

Prior to formal testing at each frequency a system verification was performed in accordance with IEEE 1528. The balanced dipole source was placed at the specified distance in horizontal orientation. All of the testing described in this report was performed within 24 hours of the system verification. The following results were obtained:

Date	Frequency (MHz)	CW input at dipole feed (Watts)	Max measured 1g SAR (W/kg)	Max measured 1g SAR normalized to 1 Watt (W/kg)	1 Watt reference SAR value from IEEE 1528 (W/kg)	Difference reference SAR value to normalized SAR
8/9/2006	900	1.0	10.52	10.52	10.8	-2.6%
8/21/2006	900	1.0	10.43	10.43	10.8	-3.4%
9/7/2006	900	1.0	10.28	10.28	10.8	-4.82%
9/11/2006	900	1.0	11.02	11.02	10.8	2.04%
8/22/2006	1900	1.0	40.05	40.05	39.7	+0.9%
8/25/2006	1900	1.0	39.12	39.12	39.7	-1.5%
9/12/2006	1900	1.0	39.53	39.53	39.7	-0.43%



900 MHz


60
40
20
0
-20
-40
-60
Y (mm)
-60
-40
-20
0
20
40
60
X (mm)
0
20
40
60
80
100
120
140
Eeff (V/m)

1900 MHz

9 References

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