SAR Test Report

No.: SAR_958_2005_FCC_2450_144

for the

Xplore Technologies

Tablet Computer

Model Number: iX104-EVDO+2915+TM60

FCC ID: Q2GIX104-144

IC-ID: 4596A-IX104WBC

Date of Report:	**01/17/2006**
Date of issue:	**01/17/2006**
Report Copy No.:	**01**

Deutscher Akkreditierungs Rat

TTI-P-G 081/94-A0

Accredited according to **ISO/IEC 17025**

Bluetooth Qualification Test Facility (BQTF)

FCC listed # 101450

IC recognized # 3925

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1 Assessment

The Xplore Technologies iX104-EVDO+2915+TM60 Tablet Computer, FCC ID: Q2GIX104-144, 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.

01/17/2006
Lothar Schmidt
Deputy Test Lab Manager

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:	Xplore Technologies
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2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as manufacturer

3 Equipment under Investigation (EUI)

3.1 Identification of the Equipment under Investigation

Product Type	Tablet Computer
Marketing Name:	iX104-EVDO+2915+TM60
WLAN Manufacturer:	Intel
Model No. (WLAN):	2915ABG
BT Manufacturer:	Ambit
Model No. (BT):	TM60M665
Model No (EUT):	iX104-EVDO+2915+TM60
FCC-ID:	Q2GIX104-144
IC-ID:	4596A-IX104WBC
Frequency Range:	2400 MHz to 2483.5 MHz
Type(s) of Modulation:	WLAN: DSSS / OFDM BT: FHSS
Antenna Type:	integral
Output Power[1]:	WLAN: 17.10 dBm (51.3 mW) conducted average power BT: 3.54 dBm (2.26 mW) peak conducted

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

4 Subject of Investigation

The iX104-EVDO+2915+TM60 is a new Tablet Computer from Xplore Technologies operating in the 2400 MHz to 2483.5 MHz frequency range. 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. The effects of co-locating two transmitters are also evaluated. 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.

5.2 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.

5.3 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).

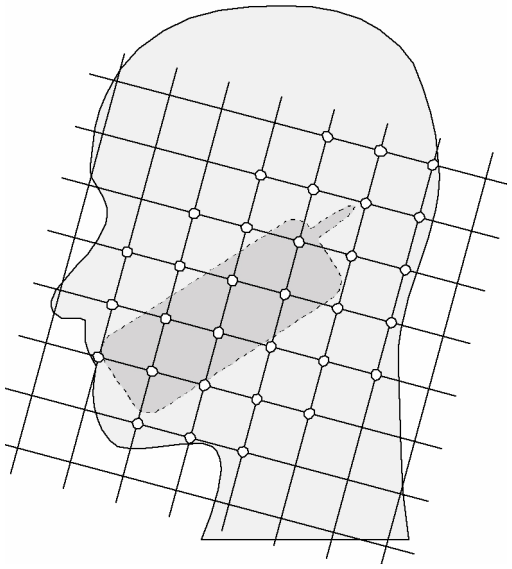

Figure 4 – Example of an area scan including the position of the handset. The scanned area (white dots) should be larger than the area projected by the handset and antenna.

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).

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.

5.4 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:

a) all device positions (cheek and tilt, for both left and right sides of the SAM phantom,

b) all configurations for each device position in (a), e.g. antenna extended and retracted, and

c) 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.

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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.

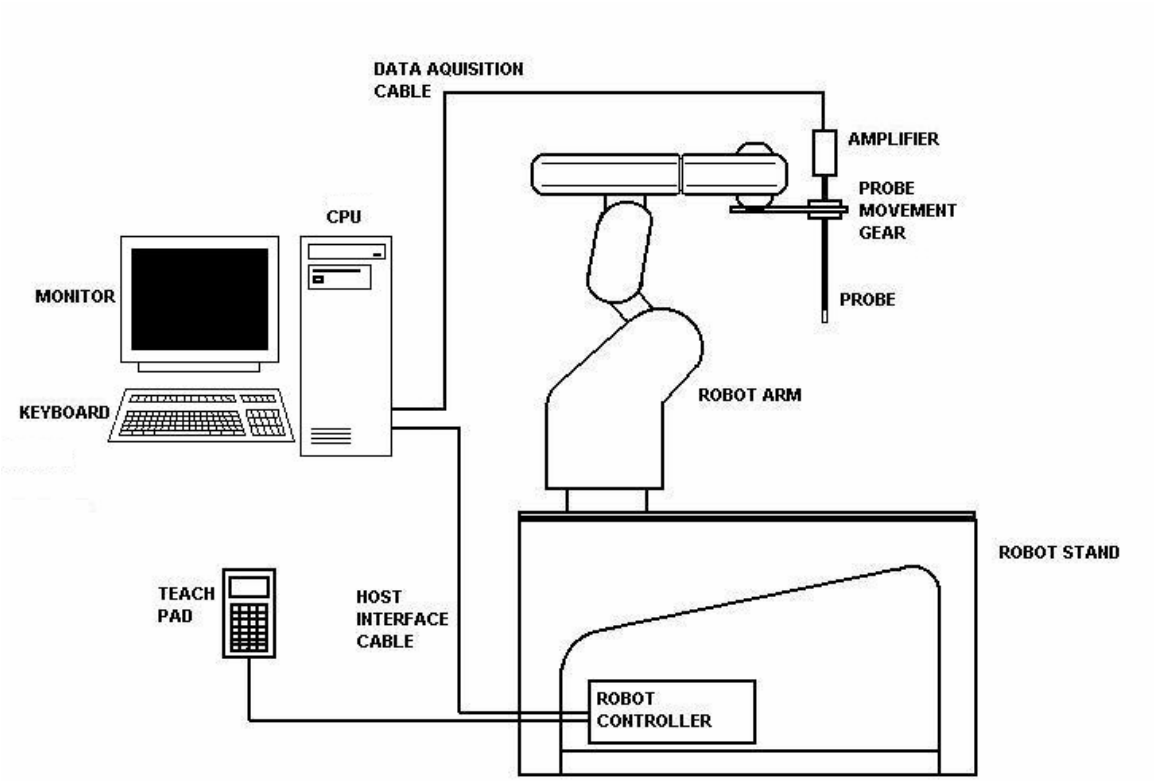


Figure 5: Schematic diagram of the SAR measurement system

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

IXP-050 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 (see appendix C.). The system uses diode compression potential (DCP) to determine SAR values for different types of modulation. Crest factor is not used for determining SAR values. The DCP for different types of modulation is determined during the probe calibration procedure. For a more detailed explanation see *IndexSAR Immesible SAR Probe Calibration Report* included in Appendix C of this report.

IXP-010 Amplifier

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 AtoD 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 fibre and a self-powered RS232 to optical converter.

6.3 Phantoms

The Specific Anthropomorphic Mannequin (SAM) Upright Phantom is fabricated using moulds generated from the CAD files as specified by CENELEC EN50361. It is mounted via a rotation base to a supporting table, which also holds the robotic positioner. The phantom and robot alignment is assured by both mechanical and laser registration systems. 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=16 cm.

6.4 SAR measurement procedure

Figure 6: Principal components of the SAR measurement test bench

The major components of the test bench are shown in the picture above. A test set and dipole antenna control the handset via an air link and a low-mass phone holder can position the phone at either ear. Graduated scales are provided to set the phone in the 15 degree position. The upright phantom head holds approx. 7 litres of simulant liquid. The phantom is filled and emptied through a 45mm diameter penetration hole in the top of the head.

After an area scan has been done at a fixed distance of 8mm from the surface of the phantom on the source side, 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 drift during measurement to be assessed.

6.5 SARA2 Interpolation and Extrapolation schemes

(see support document IXS-0202)

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. See support document IXS-020x.

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 Conducted Output Power

Prior to testing the conducted average power was measured. The results are shown below.

2450 MHz band 802.11b mode with 1 Mbps:

Ch 1 - 2412 MHz:	15.05 dBm
Ch 6 - 2437 MHz:	16.80 dBm
Ch 11 - 2462 MHz:	17.10 dBm

2450 MHz band 802.11g mode with 6 Mbps:

Ch 1 - 2412 MHz:	15.40 dBm
Ch 6 - 2437 MHz:	15.30 dBm
Ch 11 - 2462 MHz:	15.35 dBm

Prior to testing the conducted peak power was measured. The results are shown below.

Conducted BT 2450 MHz band:

2441 MHz:	3.54 dBm

The values reported are for the operation modes described in section 8.3 of this report.

8.2 Test Positions and Configurations

The EUT contains an Intel 2915ABG transmitter, which operates in the 2450 ISM band. SAR measurements were performed with the device in the lap positions with the bottom of the EUT touching the phantom. SAR scans were performed with the transmitting antenna in the center of the scan.

8.3 WLAN Operating Mode

WLAN operating in 802.11b mode with a data rate of 1 Mb/sec resulted in the highest output power. SAR test were performed at the high, mid and low channel for 802.11b with a data rate of 1 Mb/sec. Channel powers for WLAN operating in 802.11g mode with a data rate of 6 Mb/sec were lower by more than 0.25 dB on all channels except the low channel. SAR tests were performed at the low channel for 802.11g with a data rate of 6 Mb/sec. Power levels measured at other data rates were more than 0.25 dB lower than the power levels reported above.

8.4 BT Operating Mode

The device was set to transmit maximum power. Channel hopping was disabled.

8.5 2450 MHz band SAR Results for iX104-EVDO+2915+TM60 with Intel 2915ABG

WLAN Operating Mode	Position	Device Channel Number / Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
802.11b @ 1 Mb/S	Lap	1 / 2412	0.017	Plot 1	Photo 4
802.11b @ 1 Mb/S	Lap	6 / 2437	0.035	Plot 2	Photo 4
802.11b @ 1 Mb/S	Lap	11 / 2462	0.042	Plot 3	Photo 4
802.11g @ 6 Mb/S	Lap	1 / 2412	0.022	Plot 4	Photo 4

8.6 BT 2450 MHz band SAR Results for iX104-EVDO+2915+TM60 with TM60M665

Note: There was no SAR measurable above the ambient SAR level that was produced by the host PC. The value listed below is the ambient SAR produced by the host PC. No plot was produced since the hosts ambient levels were not constant in power or location. Many individual measurements were used to estimate the maximum ambient level.

Position	Device Frequency (MHz)	Max. 1g SAR (W/kg)	Positioning photo (See Appendix A)
Lap	2441	0.007	Photo 4

8.7 Co-location Test plan and results evaluation methods

The Xplore Technologies iX104-EVDO+2915+TM60 has a WLAN 2450 MHz transmitter and a BT 2450 MHz transmitter. Accurate measurements can not be made with both transmitters on at the same time. This is due to the two transmitters differences in both frequency and modulation type. To determine the effects of co-locating the two transmitters measurements will be made with one transmitter active at a time. A complete set of measurements were performed for each transmitter and frequency band. The highest resulting SAR value for each was used for the co-location evaluation. Since the maximum SAR values were located around the transmitting antenna and the two antennas are 15 cm apart the evaluation below will give an over-estimation of the co-location SAR values.

8.7.1 Co-location results evaluation:

Step 1.1. Intel 2915ABG only

The maximum 1 gram averaged SAR value measured is compared to the SAR limit of 1.6 W/kg. The value's percentage of the limit is calculated.

(0.042 W/kg ÷ 1.6 W/kg) x 100 = 2.625%

Step 1.2. Ambit TM60M665 only

The maximum 1 gram averaged SAR value measured is compared to the SAR limit of 1.6 W/kg. The value's percentage of the limit is calculated.

(0.007 W/kg ÷ 1.6 W/kg) x 100 = 0.4375%

Step 1.3. Intel 2200BG and Ambit TM60M665

The percentage of the limit determined in steps 1.1 and 1.2. are added together, the result must be less than 100%.

2.625% + 0.4375% = 3.0625%; 0.049 W/kg

8.8 Validation Check Results

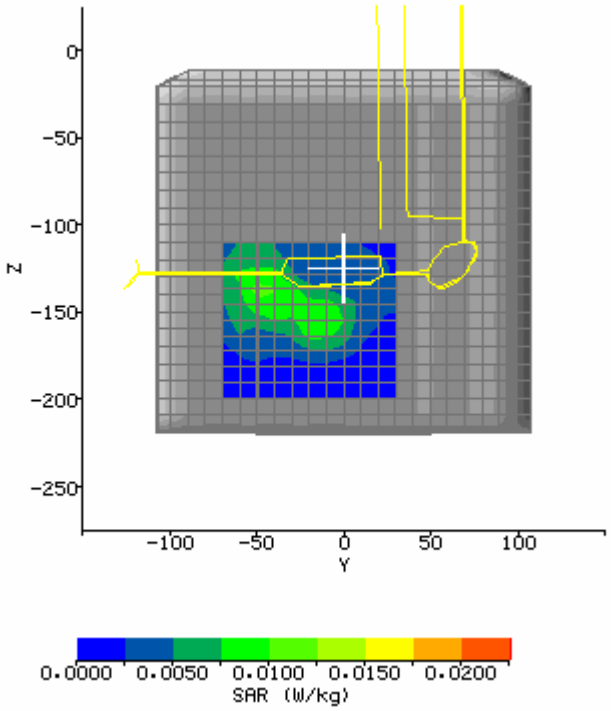
Prior to formal testing at each frequency a system verification was performed in accordance with IEEE 1528. The balanced dipole source was placed at the specified distance in horizontal orientation. All of the testing described in this report was performed within 24 hours of the system verification.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

Date	Frequency (MHz)	CW input at dipole feed (Watts)	Max measured1g SAR (W/kg)	Max measured1g SAR normalized to 1 Watt (W/kg)	1 Watt reference SAR value from IEEE 1528 (W/kg)	Difference reference SAR value to normalized SAR
6/17/2005	2450	1	52.07	52.07	52.4	-0.63%

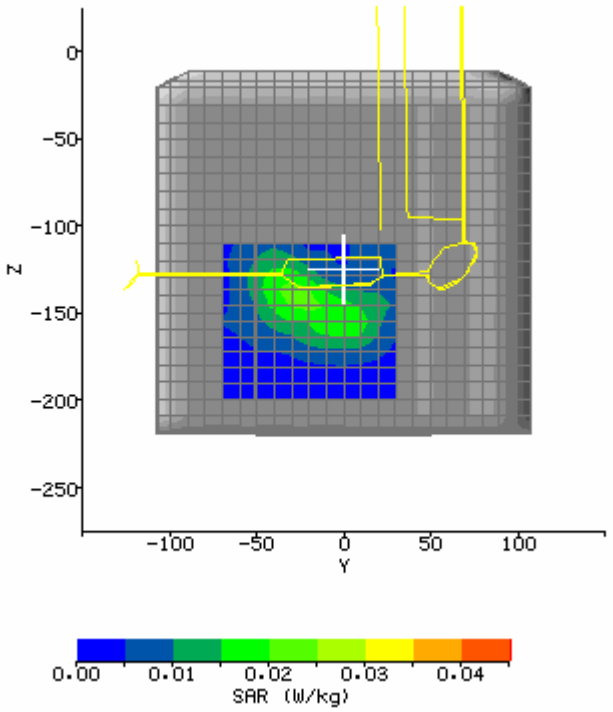
9 References

[FCC 2001] 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 1999] 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., 1999.
[IEEE 200x] IEEE Std 1528-200x: DRAFT Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques. Draft 6.2, Inst. of Electrical and Electronics Engineers, Inc., 2000.
[NIST 1994] NIST: Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, Technical Note 1297 (TN1297), United States Department of Commerce Technology Administration, National Institute of Standards and Technology, 1994.

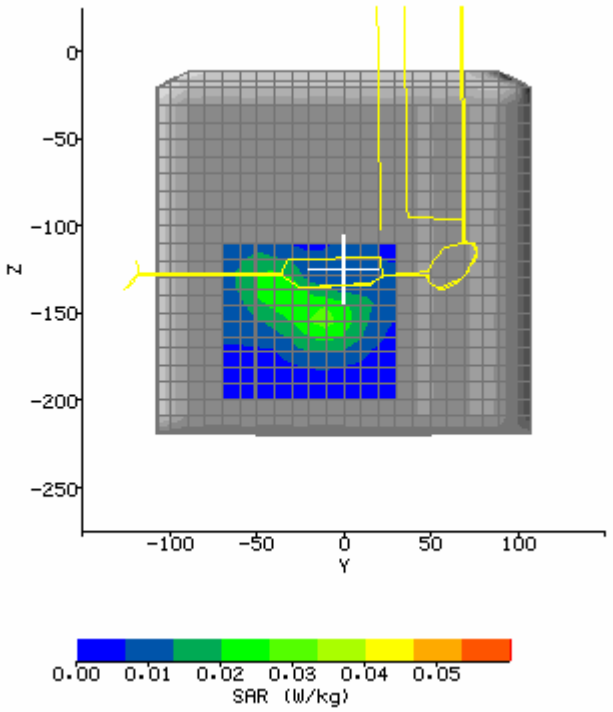
System / software:	SARA2 / 2.3 VPM		**Input Power Drift:**	
Date / Time:	6/17/2005 3:01:38 PM		**DUT Battery Model/No:**	
Filename:	temp.txt		**Probe Serial Number:**	0123
Ambient Temperature:	22.0°C		**Liquid Simulant:**	2450
Device Under Test:	Xplore		**Relative Permittivity:**	51.35
Relative Humidity:	50%		**Conductivity:**	1.947
Phantom S/No:	HeadBox_new_spout.csv		**Liquid Temperature:**	22.0°C
Phantom Rotation:	0°		**Max SAR Y-axis Location:**	-45.00 mm
DUT Position:	lap		**Max SAR Z-axis Location:**	-138.80 mm
Antenna Configuration:	WLAN		**Max E Field:**	3.29 V/m
Test Frequency:	2412MHz 802.11b 1Mb		**SAR 1g:**	0.017 W/kg
Air Factors:	346 / 318 / 386		**SAR 10g:**	0.009 W/kg
Conversion Factors:	0.705 / 0.705 / 0.705		**SAR Start:**	0.006 W/kg
Type of Modulation:			**SAR End:**	0.006 W/kg
Modn. Duty Cycle:			**SAR Drift during Scan:**	0.00 dB
Diode Compression Factors (V*200):	19 / 19 / 19		**Probe battery last changed:**	5/27/05
Input Power Level:	max		**Extrapolation:**	poly4



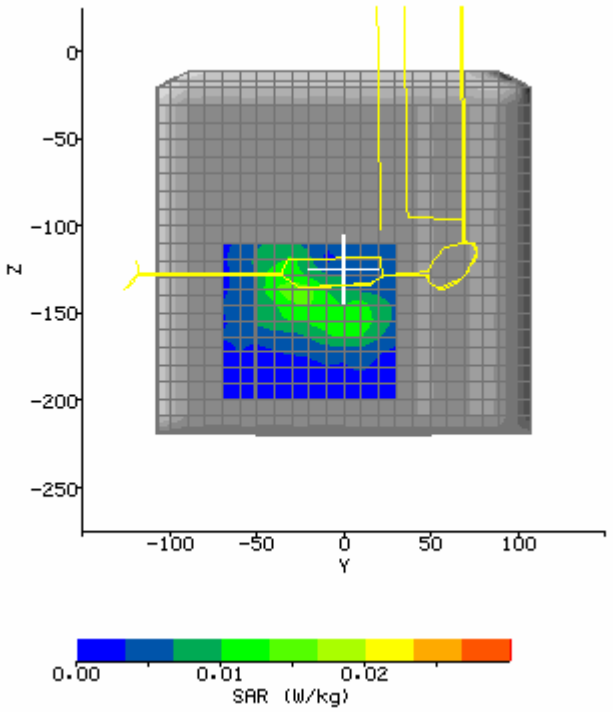
System / software:	SARA2 / 2.3 VPM		**Input Power Drift:**	
Date / Time:	6/17/2005 3:35:38 PM		**DUT Battery Model/No:**	
Filename:	lap2412_3d.txt		**Probe Serial Number:**	0123
Ambient Temperature:	22.0°C		**Liquid Simulant:**	2450
Device Under Test:	Xplore		**Relative Permittivity:**	51.70
Relative Humidity:	50%		**Conductivity:**	1.959
Phantom S/No:	HeadBox_new_spout.csv		**Liquid Temperature:**	22.0°C
Phantom Rotation:	0°		**Max SAR Y-axis Location:**	-26.00 mm
DUT Position:	lap		**Max SAR Z-axis Location:**	-140.60 mm
Antenna Configuration:	WLAN		**Max E Field:**	4.67 V/m
Test Frequency:	2437 802.11b 1Mb/SMHz		**SAR 1g:**	0.035 W/kg
Air Factors:	346 / 318 / 386		**SAR 10g:**	0.020 W/kg
Conversion Factors:	0.705 / 0.705 / 0.705		**SAR Start:**	0.009 W/kg
Type of Modulation:			**SAR End:**	0.009 W/kg
Modn. Duty Cycle:			**SAR Drift during Scan:**	-0.01 dB
Diode Compression Factors (V*200):	19 / 19 / 19		**Probe battery last changed:**	5/27/05
Input Power Level:	max		**Extrapolation:**	poly4



System / software:	SARA2 / 2.3 VPM		**Input Power Drift:**	
Date / Time:	6/17/2005 4:16:39 PM		**DUT Battery Model/No:**	
Filename:	lap2437_3d.txt		**Probe Serial Number:**	0123
Ambient Temperature:	22.0°C		**Liquid Simulant:**	2450
Device Under Test:	Xplore		**Relative Permittivity:**	51.09
Relative Humidity:	50%		**Conductivity:**	1.957
Phantom S/No:	HeadBox_new_spout.csv		**Liquid Temperature:**	22.0°C
Phantom Rotation:	0°		**Max SAR Y-axis Location:**	-12.00 mm
DUT Position:	lap		**Max SAR Z-axis Location:**	-153.20 mm
Antenna Configuration:	WLAN		**Max E Field:**	5.23 V/m
Test Frequency:	2462 802.11b 1Mb/SMHz		**SAR 1g:**	0.042 W/kg
Air Factors:	346 / 318 / 386		**SAR 10g:**	0.024 W/kg
Conversion Factors:	0.705 / 0.705 / 0.705		**SAR Start:**	0.011 W/kg
Type of Modulation:			**SAR End:**	0.011 W/kg
Modn. Duty Cycle:			**SAR Drift during Scan:**	-0.02 dB
Diode Compression Factors (V*200):	19 / 19 / 19		**Probe battery last changed:**	5/27/05
Input Power Level:	max		**Extrapolation:**	poly4



System / software:	SARA2 / 2.3 VPM		**Input Power Drift:**	
Date / Time:	6/17/2005 4:52:30 PM		**DUT Battery Model/No:**	
Filename:	lap2462_3d.txt		**Probe Serial Number:**	0123
Ambient Temperature:	22.0°C		**Liquid Simulant:**	2450
Device Under Test:	Xplore		**Relative Permittivity:**	51.35
Relative Humidity:	50%		**Conductivity:**	1.947
Phantom S/No:	HeadBox_new_spout.csv		**Liquid Temperature:**	22.0°C
Phantom Rotation:	0°		**Max SAR Y-axis Location:**	-26.00 mm
DUT Position:	lap		**Max SAR Z-axis Location:**	-138.80 mm
Antenna Configuration:	WLAN		**Max E Field:**	3.79 V/m
Test Frequency:	2412 802.11g 6Mb/SMHz		**SAR 1g:**	0.022 W/kg
Air Factors:	346 / 318 / 386		**SAR 10g:**	0.013 W/kg
Conversion Factors:	0.705 / 0.705 / 0.705		**SAR Start:**	0.008 W/kg
Type of Modulation:			**SAR End:**	0.008 W/kg
Modn. Duty Cycle:			**SAR Drift during Scan:**	0.34 dB
Diode Compression Factors (V*200):	19 / 19 / 19		**Probe battery last changed:**	5/27/05
Input Power Level:	max		**Extrapolation:**	poly4



Appendix B: Photos

EUT Photos:

Photo 1. EUT front

Photo 2. EUT back

Setup Photos

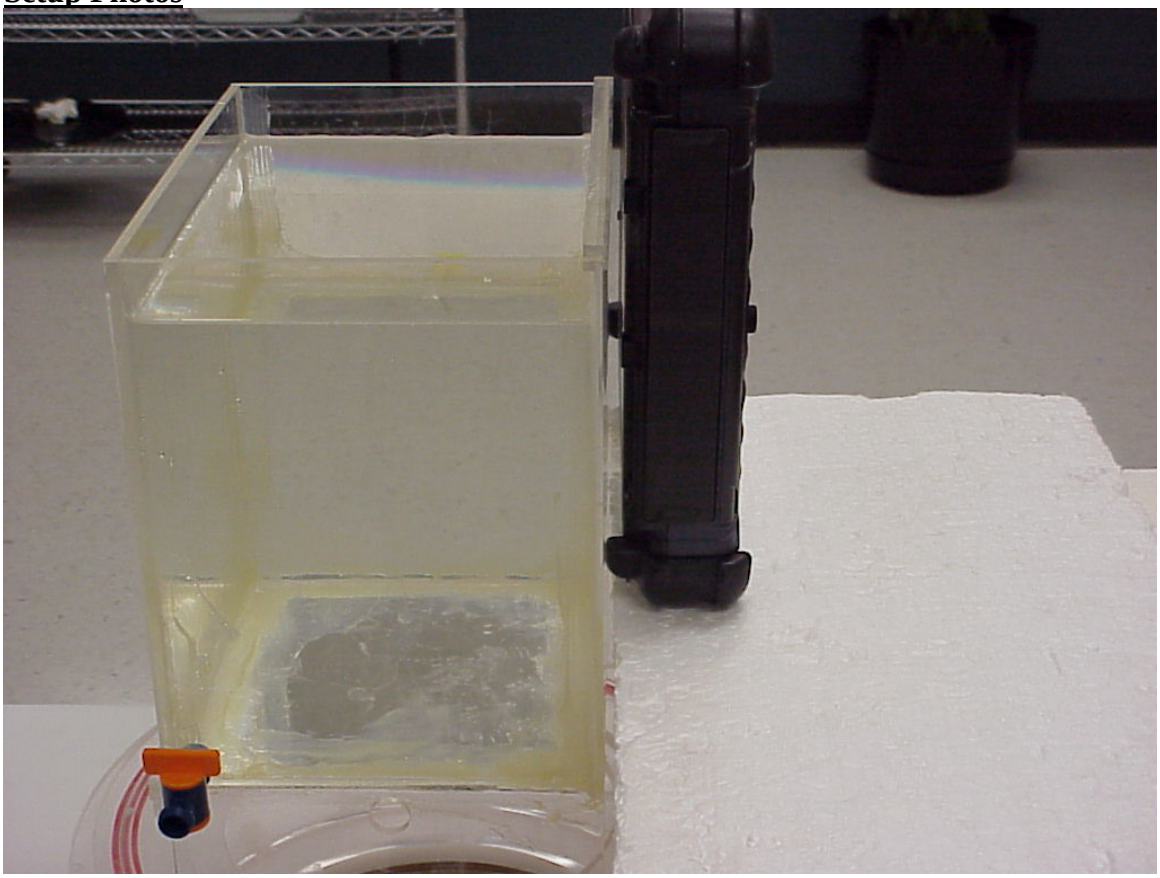


Photo 3. CDMA antenna lap position

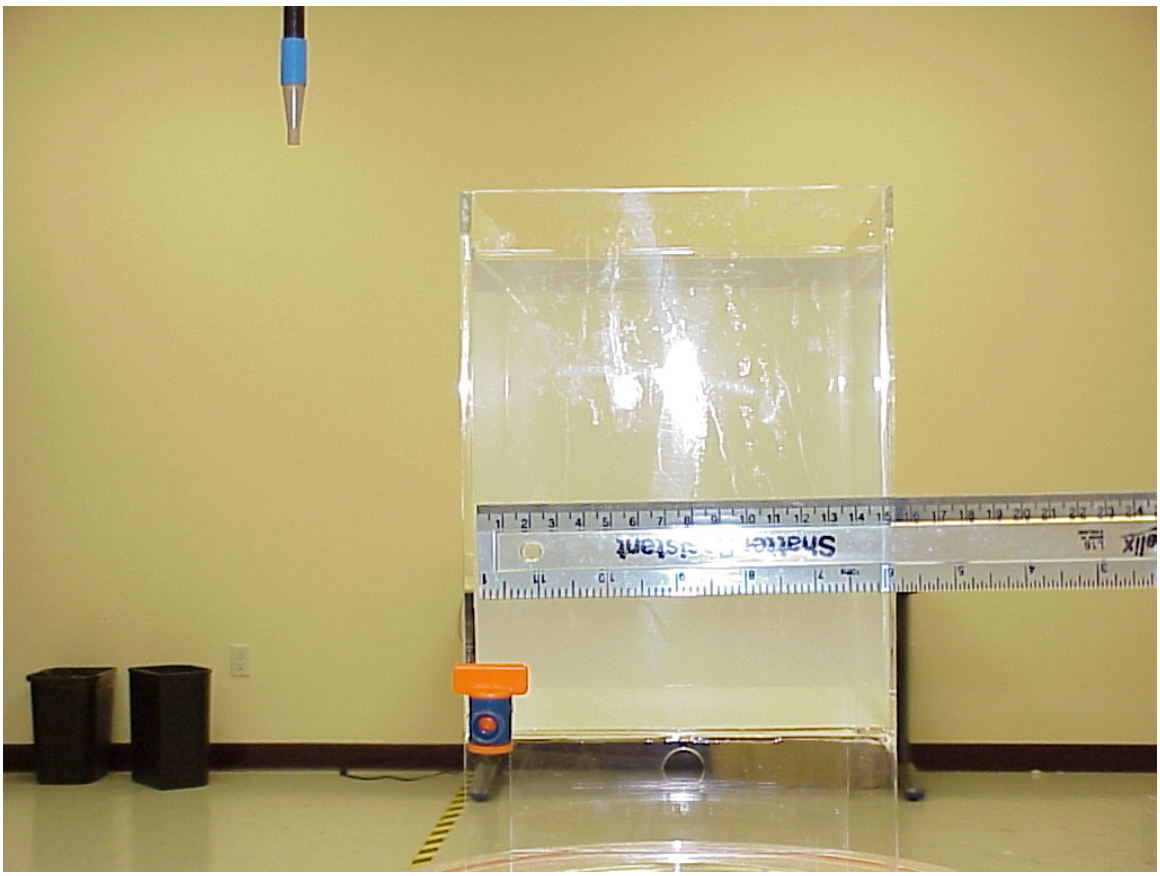


Photo 4. Photo to demonstrate 15 cm Z-axis flat phantom

Appendix C Miscellaneous

Tissue Parameters

2450MHz Head liquid:

Recipe:

53.74% distilled water
22.59% DGBE
22.59% triton X-100
0.98% salt
0.1% bactericide

Di-electric constants measured on 06/17/2005. SAR measurements were made within 24 hours of the measurement of liquid parameters.

Freq. (MHz)	Rel. Perm.	Condy (S/m)
2450	38.51	1.738

2450MHz Body Liquid:

Recipe:

73.3% distilled water
12.88% DGBE
12.88% triton X-100
0.84% salt
0.1% bactericide

Di-electric constants measured on 06/17/2005. SAR measurements were made within 24 hours of the measurement of liquid parameters.

Freq. (MHz)	Rel. Perm.	Condy (S/m)
2412	51.35	1.947
2437	51.70	1.959
2462	51.309	1.957

Environment: 06/17/2005:

Temperature: **20.1 °C – 23.9°C**
Humidity: **45% _ 55 %**

Appendix C Miscellaneous

Test Equipment

Instrument description	Supplier / Manufacturer	Model	Serial No.	Calibration (date)	Calibration Due (date)
Bench top Robot	Mitsubishi supplied by IndexSAR	RV-E2	EA1030108	N/A	N/A
SAM Phantom	Upright shell phantom made by Antennessa digitized and mounted by IndexSAR	SAM	03FT26	04/03	N/A
Flat Phantom	IndexSAR	HeadBox_Spout	N/A	N/A	N/A
Software	IndexSAR	SARA2 v0.420	N/A	N/A	N/A
2450 MHz Head Tissue Simulant	Cetecom Inc.	2450 Head	N/A	6/17/2005	N/A
2450 MHz body Tissue Simulant	Cetecom Inc.	2450 Body	N/A	6/17/2005	N/A
2450 MHz Dipole	IndexSAR – IEEE 1528 design	IXD-245	0016	07/20/2004	07/20/2005
Directional coupler	Werlatone	C6529	11249	N/A	N/A
RF Amplifier	Vectawave	VTL5400	N/A	N/A	N/A
SAR Probe	IndexSAR	IXP-050	S/N 0123	10/07/2004	10/07/2005
Probe amplifier	IndexSAR	IXA-010	S/N 043	N/A	N/A
Thermometer	Control Company	4039	20410549	11/20/2001	11/20/2005
Dielectric Measurement Kit	IndexSAR	Di-Line	N/A	N/A	N/A

Appendix C Miscellaneous

Equipment Calibration/Performance Documents:

Validation Dipoles Performance Measurements: Pages 4 to 9

Please Note:
(The following pages of Appendix C show calibration documents. These calibration documents are inserted into this appendix. The header information with page numbering scheme is a part of this report and is included on all pages of the report and appendixes. This header is used to track all of the contents of this report.)

Appendix C Miscellaneous

Report No. SN0016_090-180-190-245

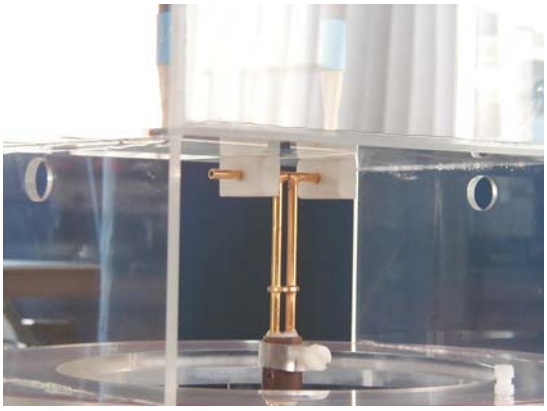
July 1st 2002
Revised 7/20/2004

INDEXSAR
Validation Dipoles
Type IXD-090, IXD-180, IXD-190 & IXD-245

Performance measurements

S/N: 090-0016
S/N: 180-0016
S/N: 245-0016
S/N: 190-0016

MI Manning



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Appendix C Miscellaneous

1. Measurement Conditions

Measurements were performed using a box-shaped phantom made of PMMA with dimensions designed to meet the accuracy criteria for reasonably-sized phantoms that do not have liquid capacities substantially in excess of the volume of liquid required to fill the Indexsar upright SAM phantoms used for SAR testing of handsets against the ear.

An HP 8753B vector network analyser was used for the return loss measurements. The dipole was placed in a special holder made of low-permittivity, low-loss materials. This holder enables the dipole to be positioned accurately in the centre of the base of the Indexsar box-phantom used for flat-surface testing and validation checks.

The validation dipoles are supplied with special spacers made form a low-permittivity, low-loss foam material. These spacers are fitted to the dipole arms to ensure that, when the dipole is offered up to the phantom surface, the spacing between the dipole and the liquid surface is accurately aligned according to the guidance in the relevant standards documentation. The spacers are rectangular with a central hole equal to the dipole arm diameter and dimensioned so that the longer side can be used to ensure a spacing of 15mm from the liquid in the phantom (for tests at 900MHz and below) and the shorter side can be used for tests at 1800MHz and above to ensure a spacing of 10mm from the liquid in the phantom. The spacers are made on a CNC milling machine with an accuracy of $1/40^{th}$ mm but they may suffer wear and tear and need to be replaced periodically. The material used is Rohacell, which has a relative permittivity of approx. 1.05 and a negligible loss tangent.

The apparatus supplied by Indexsar for dipole validation tests thus includes:

Balanced dipoles for each frequency required are dimensioned according to the guidelines given in IEEE 1528 [1]. The dipoles are made from semi-rigid 50 ohm co-ax, which is joined by soldering and is gold-plated subsequently. The constructed dipoles are easily deformed, if mis-handled, and periodic checks need to be made of their symmetry.

Rohacell foam spacers designed for presenting the dipoles to 2mm thick PMMA box phantoms. These components also suffer wear and tear and should be replaced when the central hole is a loose-fit on the dipole arms or if the edges are too worn to ensure accurate alignment. The standard spacers are dimensioned for use with 2mm wall thickness (additional spacers are available for 4mm wall thickness).

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2. SAR Measurement

SAR validation checks using the dipoles can be performed with the box-phantom located on the SARA2 phantom support base on the SARA2 robot system. Tests may be conducted at a feed power level of 0.25W. However, the actual power level should be recorded and used to normalise the results obtained to the standard input power conditions of 1W (forward power). The results can then be compared with Table 8.1 in [1]. Brain liquids should be used so that measurement results can be compared with the (computed) reference values tabulated in IEEE 1528.

3. Dipole handling

The dipoles are made from standard, copper-sheathed coaxial cable. In assembly, the sections are joined using ordinary soft-soldering. This is necessary to avoid excessive heat input in manufacture, which would destroy the polythene dielectric used for the cable. The consequence of the construction material and the assembly technique is that the dipoles are fragile and can be deformed by rough handling. Conversely, they can be straightened quite easily as described below:

If a dipole is suspected of being deformed, a normal workshop lathe can be used as an alignment jig to restore the symmetry. To do this, the dipole is first placed in the headstock of the lathe (centred on the plastic or brass spacers) and the headstock is rotated by hand (do NOT use the motor). A marker (lathe tool or similar) is brought up close to the end of one dipole arm and then the headstock is rotated by 0.5 rev. to check the opposing arm. If they are not balanced, judicious deformation of the arms can be used to restore the symmetry.

If a dipole has a failed solder joint, the dipole can be fixed down in such a way that the arms are co-linear and the joint re-soldered with a reasonably-powerful electrical soldering iron. Do not use gas soldering irons. After such a repair, electrical tests must be performed as described below.

Please note that, because of their construction, the dipoles are short-circuited for DC signals.

4. Performance Measurement

The dipoles are individually tested at their nominal frequency to ensure that they exhibit a return loss of less than -20dB when used with brain or body liquids.

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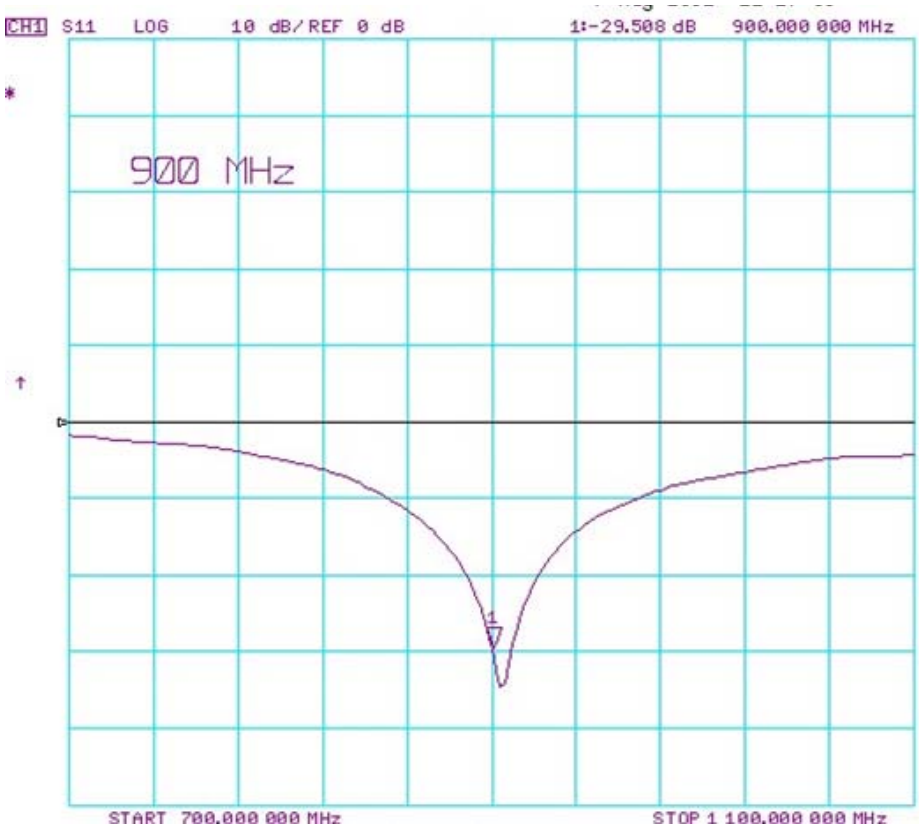
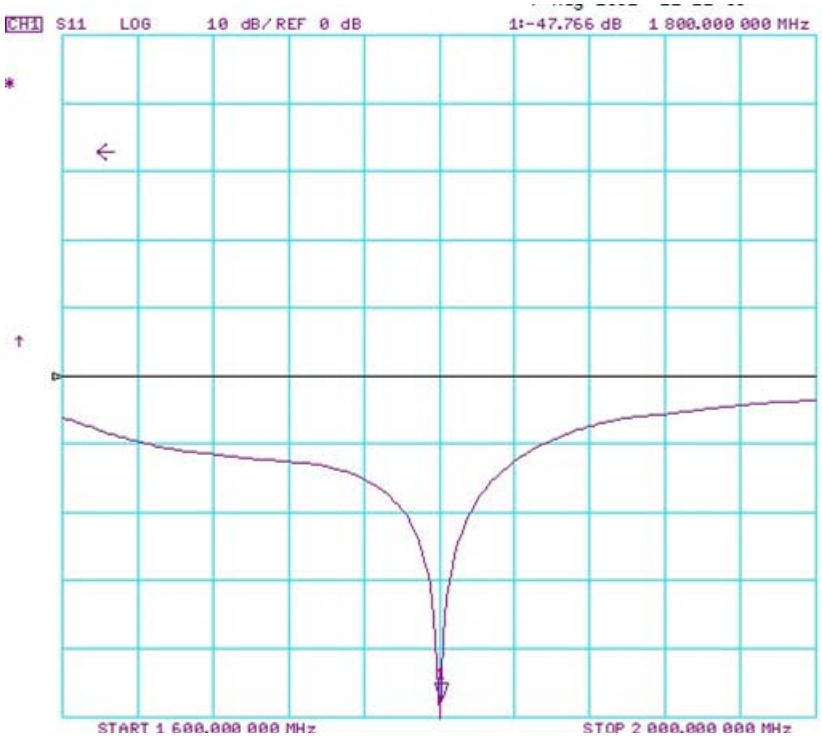
The dipoles are designed to have low return loss ONLY when presented against a lossy-phantom at the specified distance. If the user has a Vector Network Analyser (VNA) it is best to perform a return loss measurement on a specific dipole when it is in a measurement-location against a box phantom. If this is not the case, the return loss should be measured with the dipole positioned at the specified distance from a suitable container of lossy liquid. The distances specified in the standards are 15mm from the lossy liquid (900MHz and below) and 10mm from the liquid (1500MHz and above). The Indexsar foam spacers (described above) should be used to ensure this condition during measurement.

S11 plots for the dipoles with nominal frequencies of 900MHz, 1800MHz and 2450MHz are shown below.
Please note: plots below were recorded on 7/20/2004.

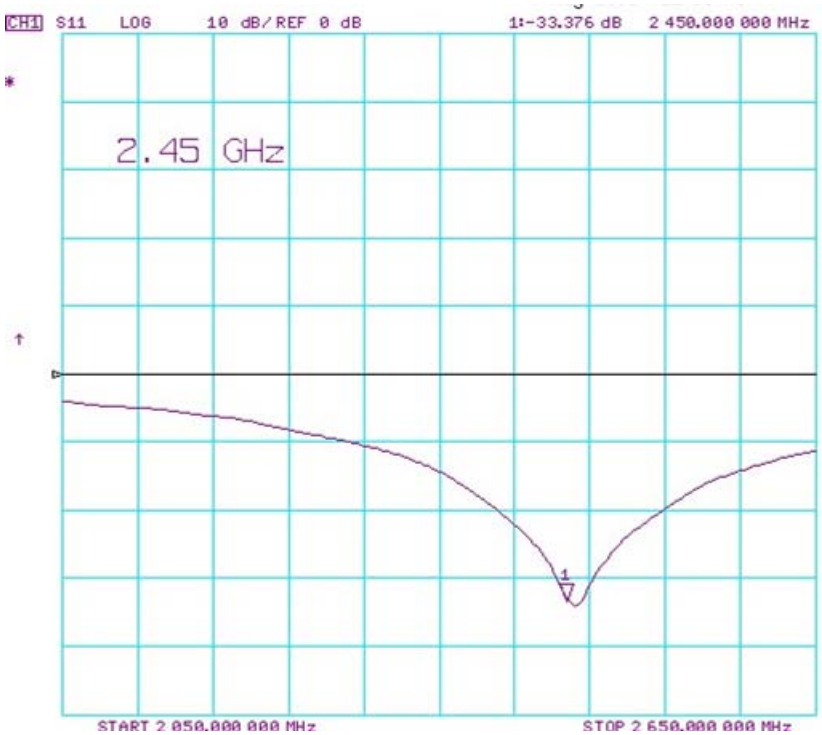


IXD-090

Appendix C Miscellaneous

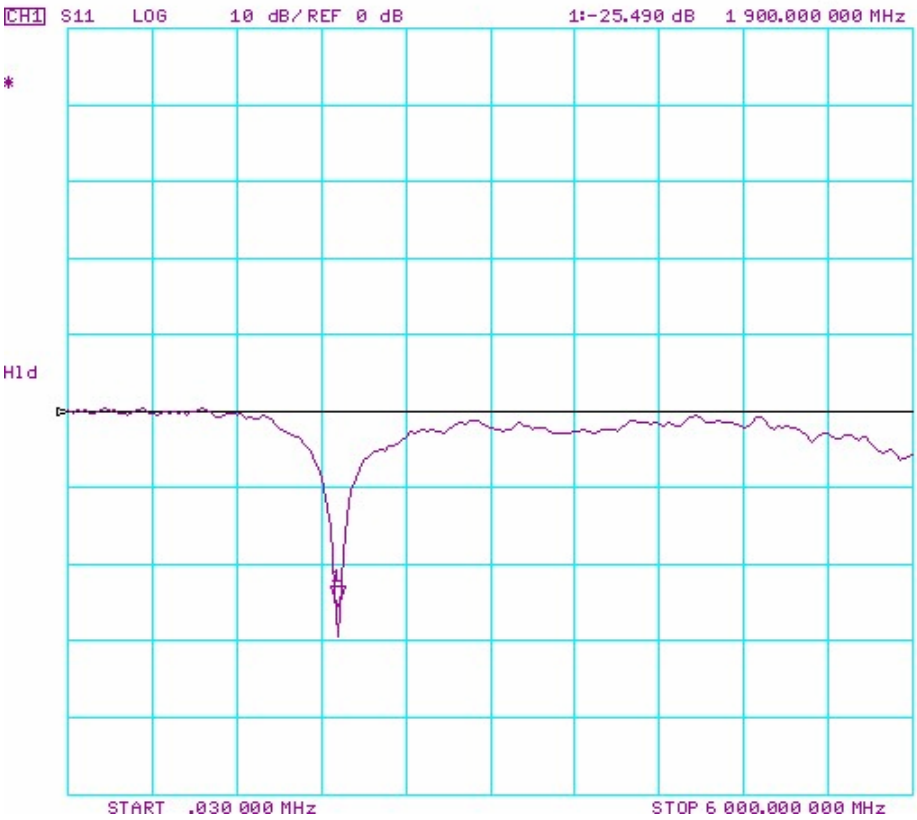


IXD-180



IXD-245

Appendix C Miscellaneous



IXD-190

5. Tuning the dipole

The dipole dimensions are based on calculations that assumed specific liquid dielectric properties. If the liquid dielectric properties are somewhat different, the dipole tuning will also vary. A pragmatic way of accounting for variations in liquid properties is to 'tune' the dipole (by applying minor variations to its effective length). For this purpose, Indexsar can supply short brass tube lengths to extend the length of the dipole and thus 'tune' the dipole. It cannot be made shorter without removing a bit from the arm. An alternative way to tune the dipole is to use copper shielding tape to extend the effective length of the dipole. Do both arms equally.

It should be possible to tune a dipole as described, whilst in place in the measurement position as long as the user has access to a VNA for determining the return loss.

6. Reference

[1] Draft recommended practice for determining the peak spatial-average specific absorption rate (SAR) in the human body due to wireless communications devices: Experimental Techniques.