SAR Test Report

No. SAR_400_2002_FCC_2450

for the

Broadcom Corporation

802.11a/g/b WLAN MiniPCI card

Model Number: BCM94309MP

FCC ID: QDS-BRCM1007

Date of Report:	**12/23/2002**
Date of issue:	**12/23/2002**
Report Copy No.:	**01**

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1. Assessment

This assessment only applies to the device functions in the 2400 MHz to 2483.5 MHz band, as described in this report.

The Broadcom Corporation BCM94309MP 802.11a/g/b WLAN MiniPCI card is in compliance with the exposure criteria specified in Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure.

12/23/2002	**12/23/2002**
Pete Krebill	**Lothar Schmidt**
Project Leader	**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:	Broadcom Corporation
Adress:	190 Mathilda Place Sunnyvale, 94086,
Contact Person:	David Boldy
Phone No.	408 9225905
Fax:	418 543 3399
e-mail:	dboldy@broadcom.com

2.3. Identification of the Manufacturer

Manufactured by client shown above.

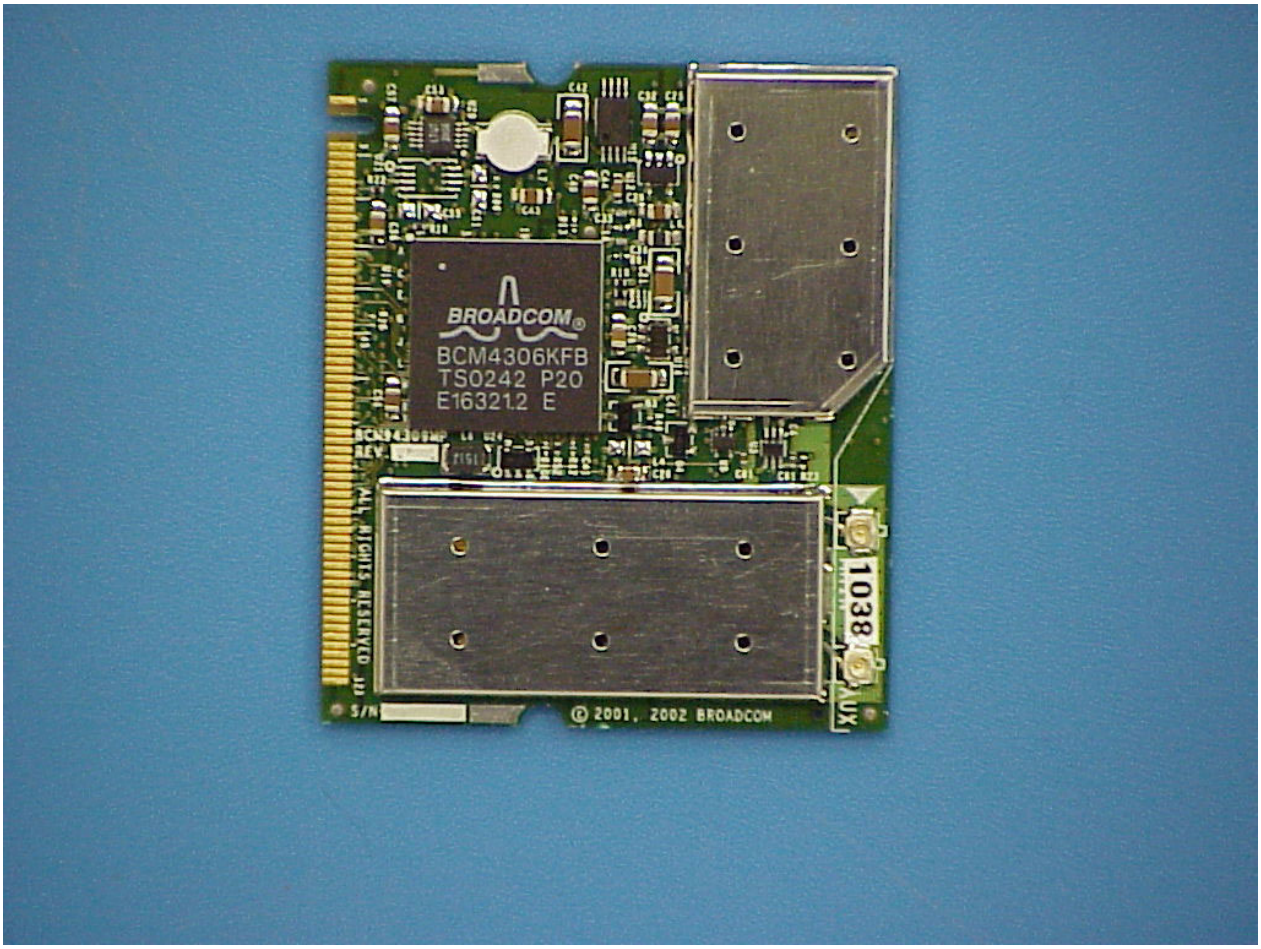
3. Equipment under Investigation (EUI)

3.1. Identification of the Equipment under Investigation

Product Type	802.11a/g/b WLAN MiniPCI card
Marketing Name:	The Broadcom Wireless LAN mini-PCI card
Model No:	BCM94309MP
Serial Number:	1038
FCC-ID:	QDS-BRCM1007
Frequency Range:	2400-2483.5MHz & 5150MHz to 5350MHz
Type(s) of Modulation:	As per 802.11a , 802.11b and 802.11g specifications (Direct sequence, OFDM)
Number of Channels:	1-11, 36-64
Antenna Type:	Integral to PC See antenna specifications supplied
Accessories:	None
Battery Options:	None
Rated Output Power[1]:	15dBm average packet power

[1] For measured output power see section 8.1 of this report.

3.2. Front View of the Equipment under Investigation



4. Subject of Investigation

The BCM94309MP is a new 802.11a/g/b WLAN MiniPCI card from Broadcom Corporation operating in the 2400-2483.5MHz & 5150MHz to 5350MHz frequency ranges. The device has two diversity antennas. The device will be installed in Dell Latitude D600 laptop PCs. The Dell Latitude D600s also contain a Bluetooth transmitter.

The objective of the measurements done by Cetecom Inc. was the dosimetric assessment of one device. The tests were performed in configurations for devices operated next to a person's body. The SAR resulting from co-location of the Broadcom transmitter and the Bluetooth transmitter was also assessed. 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

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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. Device Operating Next to a Person's Ear

Phantom Requirements

The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues. The physical characteristics of the phantom model shall resemble the head and the neck of a user since the shape is a dominant parameter for exposure.

5.3. Test Positions

5.4. Test positions of device relative to head

FCC's OET Bulletin supplement C requires two test positions for the handset against the head phantom, the "cheek" position and the "tilted" position. These two test positions are defined below. The handset should be tested in both positions on the left and right sides of the SAM phantom.

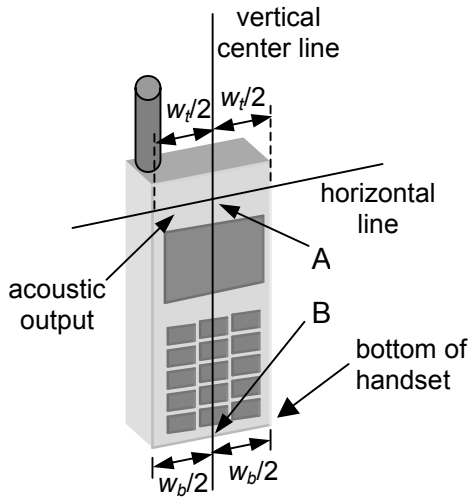

Figure 1a – Handset vertical and horizontal reference lines – fixed case

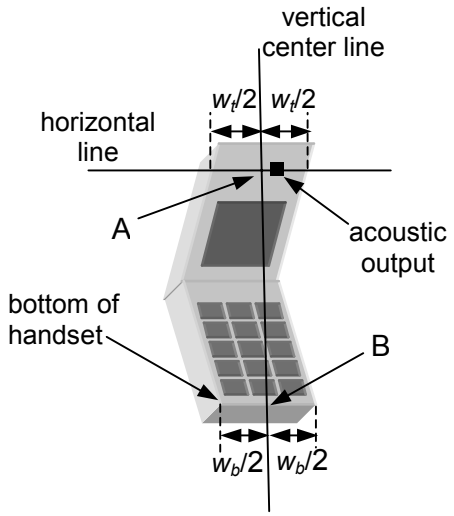

Figure 1b – Handset vertical and horizontal reference lines – "clam-shell"

Definition of the "cheek" position

The "cheek" position is defined as follows:

a) Ready the handset for talk operation.

b) Define two imaginary lines on the handset: the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width wt of the handset at the level of the acoustic output (point A on Figures 1a and 1b), and the midpoint of the width wb of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Figure 1a). The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output. However, the acoustic output may be located elsewhere on the horizontal line. Also note that the vertical centerline is not necessarily parallel to the front face of the handset (see Figure 1b), especially for clamshell handsets, handsets with flip pieces, and other irregularly-shaped handsets.

c) Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure 2), such that the plane defined by the vertical center line and the horizontal line of the handset is approximately parallel to the sagittal plane of the phantom.

d) Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the pinna.

e) While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane).

f) Rotate the handset around the vertical centerline until the handset (horizontal line) is symmetrical with respect to the line NF.

g) While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE and maintaining the handset contact with the pinna, rotate the handset about the line NF until any point on the handset is in contact with a phantom point below the pinna (cheek). See Figure 2. The physical angles of rotation should be noted.

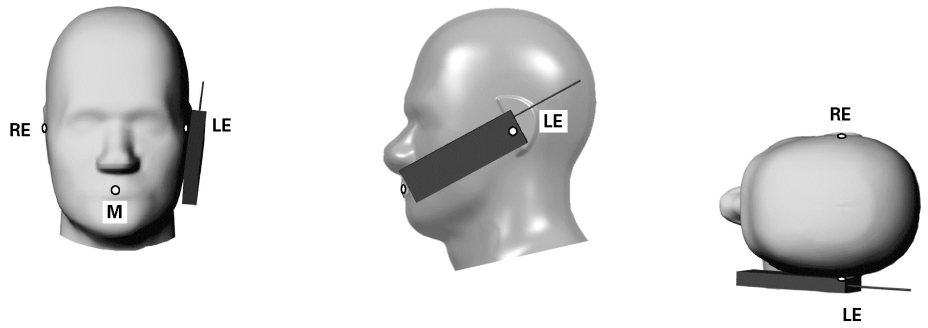

Figure 2 – Phone position 1, "cheek" or "touch" position. The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for handset positioning, are indicated.

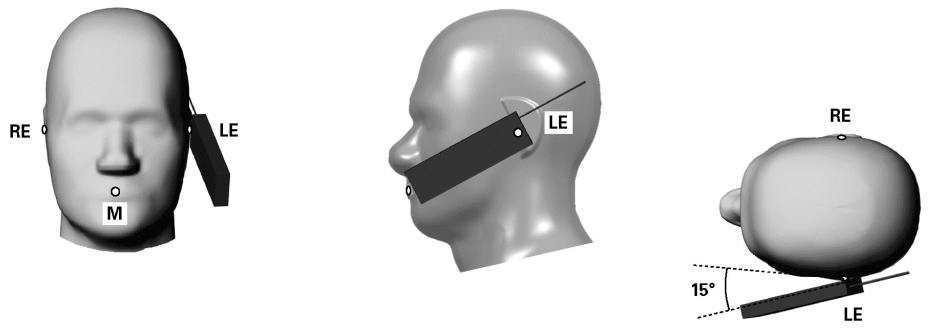

Figure 3 – Phone position 2, "tilted" position. The reference points for the right ear (RE), left ear (LE) and mouth (M), which define the reference plane for handset positioning, are indicated.

Definition of the "tilted" position

The "tilted" position is defined as follows:

a) Repeat steps (a) – (g) of cheek position section above to place the device in the "cheek position."

b) While maintaining the orientation of the handset move the handset away from the pinna along the line passing through RE and LE in order to enable a rotation of the handset by 15 degrees.

c) Rotate the handset around the horizontal line by 15 degrees.

d) While maintaining the orientation of the handset, move the handset towards the phantom on a line passing through RE and LE until any part of the handset touches the ear. The tilted position is obtained when the contact is on the pinna. If the contact is at any location other than the pinna, e.g., the antenna with the back of the phantom head, the angle of the handset should be reduced. In this case, the tilted position is obtained if any part of the handset is in contact with the pinna as well as a second part of the handset is contact with the phantom, e.g., the antenna with the back of the head.

5.5. Test to be Performed

The SAR test shall be performed with both phone positions described above, on the left and right side of the phantom. The device shall be measured for all modes operating when the device is next to the ear, even if the different modes operate in the same frequency band.

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.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

5.6. 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.

5.7. 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).

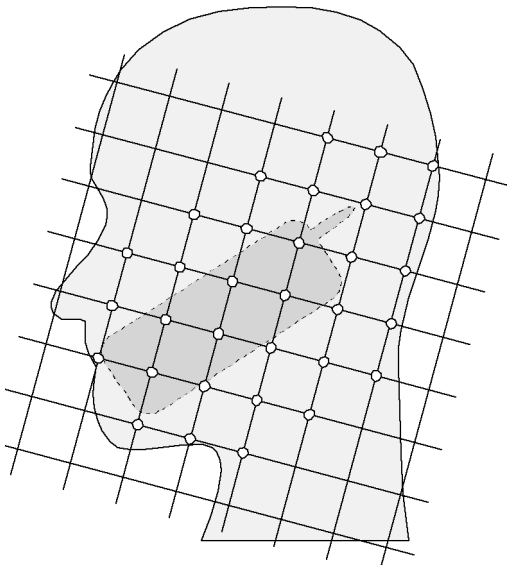

Figure 4 – Example of an area scan including the position of the handset. The scanned area (white dots) should be larger than the area projected by the handset and antenna.

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.

5.8. 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.

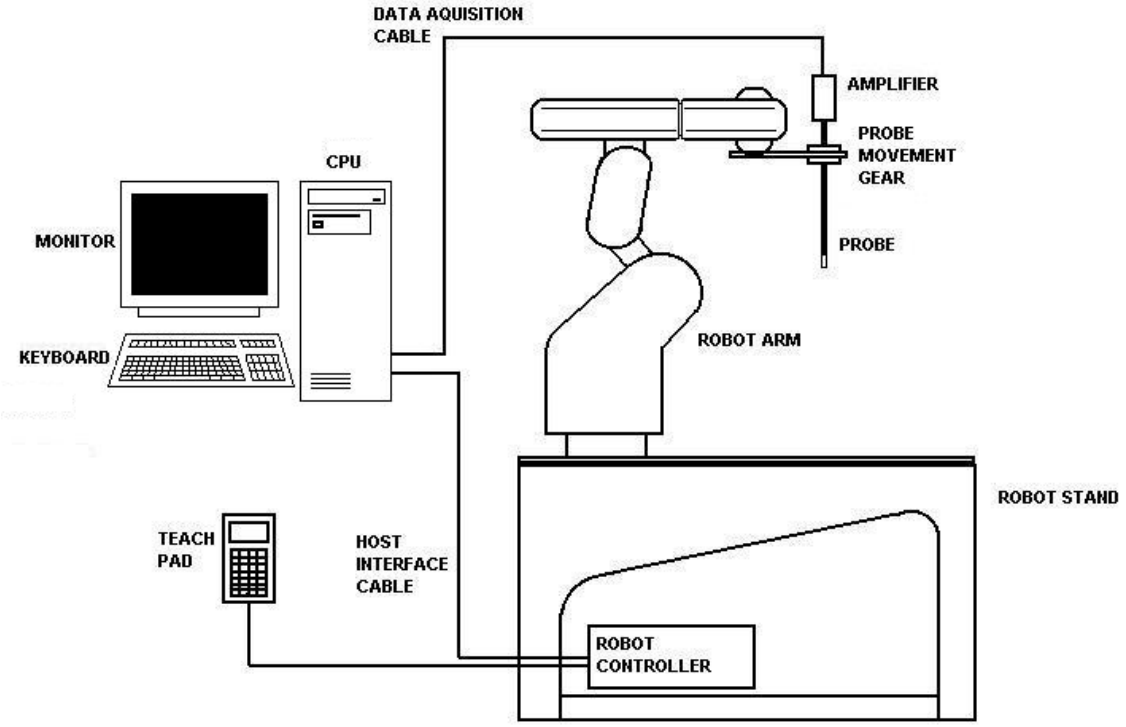

Figure 5: Schematic diagram of the SAR measurement system

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

A measurement uncertainty assessment has been undertaken following guidance given in draft IEEE 1528. Indexsar Ltd has supplied a generic uncertainty analysis for the SARA2 system in the form of a spreadsheet and the supporting assessments are documented in an Indexsar document IXS-2028. Additionally, uncertainties resulting from the probe positioning system and the upright phantom geometry are discussed in additional documents.

Some of the uncertainty contributions are site-specific and, for these, Cetecom, Inc. have assessed the uncertainty contributions arising from local environmental and procedural factors.

The resultant uncertainty budget, following the assessment template given in draft IEEE 1528 is shown below:

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7.1. Measurement Uncertainty Budget

Error Sources	Description	Uncertainty			Probability Distribution	Divisor (descrip)	Divisor (value)	ci	ci^2	Standard Uncertainty (%)	Stand Uncert^2	Stand Uncert^2
		(dB)		(%)								
Measurement equipment												
Calibration	7.2.1.1			10	Normal	1 or k	2	1	1	5.00	25.00	25.00
Isotropy	7.2.1.2	0.5	12.20	5.30	Rectangular	√3	1.73	1.00	1	3.06	9.36	9.36
Linearity	7.2.1.3	0.04	0.93	2.92	Rectangular	√2	1.73	1.00	1	1.69	2.84	2.84
Probe Stability				2.50	Rectangular	√3	1.73	1.00	1	1.44	2.08	2.08
Detection limits	7.2.1.4			0	Rectangular	√3	1.73	1.00	1	0.00	0.00	0.00
Boundary effects	7.2.1.5			1.7	Rectangular	√3	1.73	1.00	1	0.98	0.96	0.96
Measurement device	7.2.1.6			0	Normal	1 or k	1.96	1.00	1	0.00	0.00	0.00
Response time	7.2.1.7			0	Normal	1	1.00	1.00	1	0.00	0.00	0.00
Noise	7.2.1.8			0	Normal	1	1.00	1.00	1	0.00	0.00	0.00
Intergration time	7.2.1.9			0.4	Normal	1	1.00	1.00	1	0.40	0.16	0.16
Mechanical Constraints												
Scanning system	7.2.2.1			0.57	Rectangular	√3	1.73	1.00	1	0.33	0.11	0.11
Phantom shell	7.2.2.2			1.43	Rectangular	√3	1.73	1.00	1	0.83	0.68	0.68
Matching between probe and phantom	7.2.2.3			2.86	Rectangular	√3	1.73	1.00	1	1.65	2.73	2.73
Positioning of the phone	7.2.2.4			10	Normal	1	1	1.00	1	10.00	100.00	100.00
Physical parameters												
Liquid conductivity (Deviation from target)	7.2.3.2			5	Rectangular	√3	1.73	0.50	0.25	1.44	2.08	0.52
Liquid conductivity (measurement error)	7.2.3.2			5	Rectangular	√3	1.73	0.50	0.25	1.44	2.08	0.52
Liquid permittivity (Deviation from target)	7.2.3.3			5	Rectangular	√3	1.73	0.50	0.25	1.44	2.08	0.52
Liquid permittivity (measurement error)	7.2.3.3			5	Rectangular	√3	1.73	0.50	0.25	1.44	2.08	0.52
Drifts in output power of the phone, probe, temperature and humidity	7.2.3.4			5	Rectangular	√3	1.73	1.00	1	2.89	8.33	8.33
Perturbation by the environment	7.2.3.5			3	Rectangular	√3	1.73	1.00	1	1.73	3.00	3.00
Post processing												
SAR interpolation and extrapolation	7.2.4.1			8	Rectangular	√3	1.73	1.00	1	4.62	21.33	21.33
Maximum SAR evaluation	7.2.4.2			2.4	Rectangular	√3	1.73	1.00	1	1.39	1.92	1.92
Other factors												
				0	Normal	1 or k	1.96	1.00	1	0.00	0.00	0.00
				0	Normal	1 or k	1.96	1.00	1	0.00	0.00	0.00
				0	Rectangular	√3	1.73	1.00	1	0.00	0.00	0.00
				0	Normal	1	1.00	1.00	1	0.00	0.00	0.00
Combined standard uncertainty	$uc = \sqrt{\sum_{i=1}^{m} ci2 \cdot ui2}$						13.67					
Expanded uncertainty (confidence interval of 95%)	Normal k= 1.96 **ue=k* uc** **26.79** %											

8. Test results summary

The highest SAR measured is shown highlited below.

8.1. Conducted Output Power

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

Channel 1: 17.6dBm
Channel 6: 17.3dBm
Channel 11: 16.8dBm

8.2. Test Positions and Configurations

The device was installed in a Dell Latitude D600 laptop PC. The device was set to transmit without antenna diversity. Measurements were conducted with the device transmitting on antenna 0 or antenna 1 (see: *Antenna Locations* in Appendix C of this report). The area scan of each measurement was centered near the transmitting antenna. These measurements were then repeated with the PC's Bluetooth function also transmitting. The Bluetooth hopping function was disabled during testing.

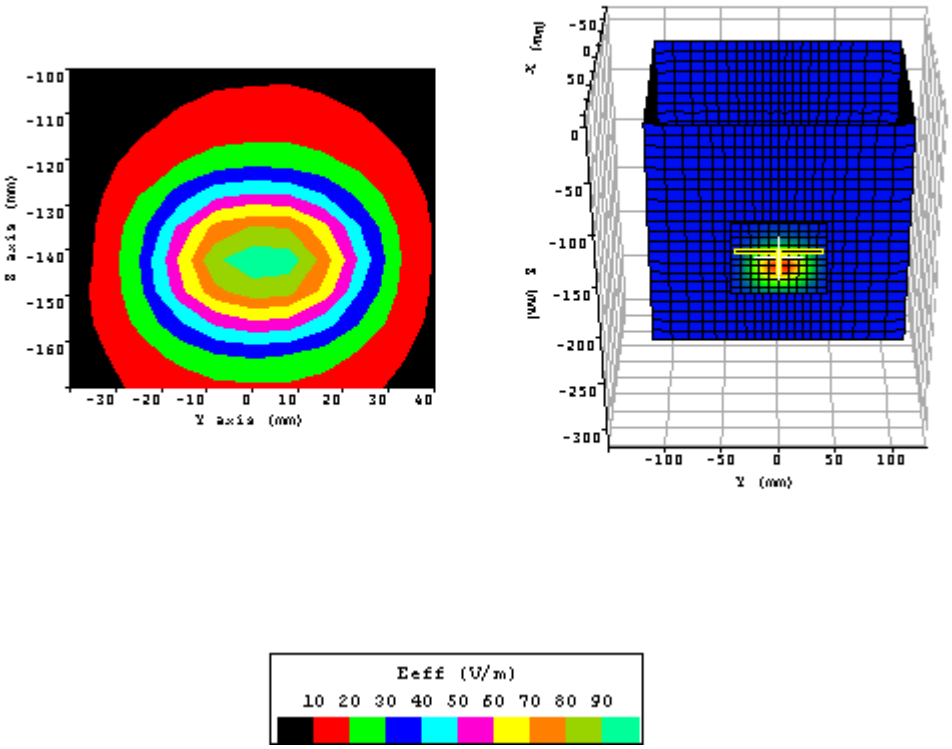
8.3. SAR Results for BCM94309MP

Transmit Antenna / Bluetooth Function	Device Channel Number / Frequency (MHz)	Bluetooth Frequency (MHz)	Max. 1g SAR (W/kg)	Area scan (See Appendix A)	Positioning photo (See Appendix B)
0 / off	Mid #6 / 2437	N/A	0.163	Plot 1	Photo 7
0 / on	Mid #6 / 2437	2480	0.190	Plot 2	Photo.7
1 / off	Mid #6 / 2437	N/A	0.234	Plot 3	Photo 8
1 / on	Mid #6 / 2437	2480	0.237	Plot 4	Photo 8
1 / on	Low #1 / 2412	2480	0.198	Plot 5	Photo 8
1 / on	High #11 / 2462	2402	0.296	Plot 6	Photo 8

8.4. 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 an horizontal orientation with 0.5W CW feed at 2450 MHz. All of the testing described in this report was performed within 24 hours of the system verification. The following results were obtained:

DATE	CHECK CONFIGURATION	FREQUENCY (MHz)	Max. 1g Volume averaged SAR (W/kg)	Percentage drift on reference (%)
12/20/2002	2450MHz dipole	2450	26.95	+2.86



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.