



**FCC OET BULLETIN 65 SUPPLEMENT C  
CLASS II PERMISSIVE CHANGE  
IC RSS-102 ISSUE 2**

**SAR EVALUATION REPORT**

**FOR**

**Broadcom 802.11g WLAN PCI-E Mini Card  
(Tested inside of Dell Notebook PC, PP19S)**

**MODEL: BCM94312HMG**

**FCC ID: QDS-BRCM1030**

**IC: 4324A-BRCM1030**

**REPORT NUMBER: 09U12429-2**

**ISSUE DATE: March 16, 2009**

*Prepared for*

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**NVLAP LAB CODE 200065-0**

Revision History

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--	March 16, 2009	Initial Issue	--

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# 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** BROADCOM CORPORATION  
190 MATHILDA PLACE  
SUNNYVALE, CA 94086

**EUT DESCRIPTION:** Broadcom 802.11g WLAN PCI-E Mini Card  
(Tested inside of Dell Notebook PC, PP19S)

**MODEL NUMBER:** BCM94312HMG

**DEVICE CATEGORY:** Portable

**EXPOSURE CATEGORY:** General Population/Uncontrolled Exposure

**DATE TESTED:** March 16, 2009

### MAX SAR VALUE:

FCC / IC Rule Parts	Frequency Range [MHz]	The Highest SAR Values (1g_mW/g)	Limit (mW/g)
15.247 / RSS-102	2400 – 2483.5	0.028	1.6

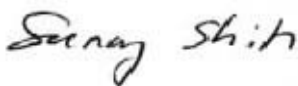
### APPLICABLE STANDARDS:

STANDARD	TEST RESULTS
FCC OET BULLETIN 65 SUPPLEMENT C	Pass
RSS-102 ISSUE 2	Pass

Compliance Certification Services, Inc. (CCS) tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by CCS based on interpretations and/or observations of test results. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by CCS and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by CCS will constitute fraud and shall nullify the document. No part of this report may be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any government agency.

Approved & Released For CCS By:



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SUNNY SHIH  
ENGINEERING SUPERVISOR  
COMPLIANCE CERTIFICATION SERVICES

## 2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC OET Bulletin 65 Supplement C, Specific FCC Procedure KDB 248227 SAR Measurement Procedure for 820.11abg Transmitters and IC RSS 102 Issue 2.

## 3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://ts.nist.gov/Standards/scopes/2000650.htm>.

## 4. CALIBRATION AND UNCERTAINTY

### 4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

Name of Equipment	Manufacturer	Type/Model	Serial Number	Cal. Due date		
				MM	DD	Year
Robot - Six Axes	Stäubli	RX90BL	N/A	N/A		
Robot Remote Control	Stäubli	CS7MB	3403-91535	N/A		
DASY4 Measurement Server	SPEAG	SEUMS001BA	1041	N/A		
Probe Alignment Unit	SPEAG	LB (V2)	261	N/A		
SAM Phantom (SAM1)	SPEAG	QD000P40CA	1185	N/A		
SAM Phantom (SAM2)	SPEAG	QD000P40CA	1050	N/A		
Oval Flat Phantom (ELI 4.0)	SPEAG	QD OVA001 B	1003	N/A		
Electronic Probe kit	HP	85070C	N/A	N/A		
S-Parameter Network Analyzer	Agilent	8753ES-6	MY40001647	11	14	2009
Signal Generator	Agilent	8753ES-6	MY40001647	11	14	2009
E-Field Probe	SPEAG	EX3DV3	3531	4	23	2009
Thermometer	ERTCO	639-1S	1718	5	28	2009
Data Acquisition Electronics	SPEAG	DAE3 V1	427	10	20	2009
System Validation Dipole	SPEAG	D2450V2	748	4	14	2009
System Validation Dipole	SPEAG	D5GHzV2	1003	11	21	2009
MXA Signal Analyzer	Agilent	N9020A	US48350984	10	23	2009
ESG Vector Signal Generator	Agilent	E4438C	US44271090	9	17	2010
Power Meter	Giga-tronics	8651A	8651404	1	11	2010
Power Sensor	Giga-tronics	80701A	1834588	1	11	2010
Amplifier	Mini-Circuits	ZVE-8G	90606	N/A		
Amplifier	Mini-Circuits	ZHL-42W	D072701-5	N/A		
Simulating Liquid	CCS	M2450	N/A	Within 24 hrs of first test		

## 4.2. MEASUREMENT UNCERTAINTY

Measurement uncertainty for 300 MHz – 3000 MHz

Uncertainty component	Tol. (±%)	Probe Dist.	Div.	Ci (1g)	Ci (10g)	Std. Unc.(±%)	
						Ui (1g)	Ui(10g)
<b>Measurement System</b>							
Probe Calibration	4.80	N	1	1	1	4.80	4.80
Axial Isotropy	4.70	R	1.732	0.707	0.707	1.92	1.92
Hemispherical Isotropy	9.60	R	1.732	0.707	0.707	3.92	3.92
Boundary Effects	1.00	R	1.732	1	1	0.58	0.58
Linearity	4.70	R	1.732	1	1	2.71	2.71
System Detection Limits	1.00	R	1.732	1	1	0.58	0.58
Readout Electronics	1.00	N	1	1	1	1.00	1.00
Response Time	0.80	R	1.732	1	1	0.46	0.46
Integration Time	2.60	R	1.732	1	1	1.50	1.50
RF Ambient Conditions - Noise	1.59	R	1.732	1	1	0.92	0.92
RF Ambient Conditions - Reflections	0.00	R	1.732	1	1	0.00	0.00
Probe Positioner Mechanical Tolerance	0.40	R	1.732	1	1	0.23	0.23
Probe Positioning With Respect to Phantom Shell	2.90	R	1.732	1	1	1.67	1.67
algorithms for max. SAR evaluation	3.90	R	1.732	1	1	2.25	2.25
<b>Test sample Related</b>							
Test Sample Positioning	1.10	N	1	1	1	1.10	1.10
Device Holder Uncertainty	3.60	N	1	1	1	3.60	3.60
Power and SAR Drift Measurement	5.00	R	1.732	1	1	2.89	2.89
<b>Phantom and Tissue Parameters</b>							
Phantom Uncertainty	4.00	R	1.732	1	1	2.31	2.31
Liquid Conductivity - Target	5.00	R	1.732	0.64	0.43	1.85	1.24
Liquid Conductivity - Meas.	8.60	N	1	0.64	0.43	5.50	3.70
Liquid Permittivity - Target	5.00	R	1.732	0.6	0.49	1.73	1.41
Liquid Permittivity - Meas.	3.30	N	1	0.6	0.49	1.98	1.62
<b>Combined Standard Uncertainty</b>						RSS	
<b>Expanded Uncertainty (95% Confidence Interval)</b>						K=2	
<b>Notes for table</b>						11.44	10.49
1. Tol. - tolerance in influence quantity						22.87	20.98
2. N - Nomal							
3. R - Rectangular							
4. Div. - Divisor used to obtain standard uncertainty							
5. Ci - is te sensitivity coefficient							

## 5. EQUIPMENT UNDER TEST

Broadcom 802.11g WLAN PCI-E Mini Card (Tested inside of Dell Notebook PC, PP19S)

**Normal operation:**

Lap-held only

Note: SAR test with display open at 90° to the keyboard

**Host device:**

Dell Notebook PC, PP19S

**Antenna tested:**

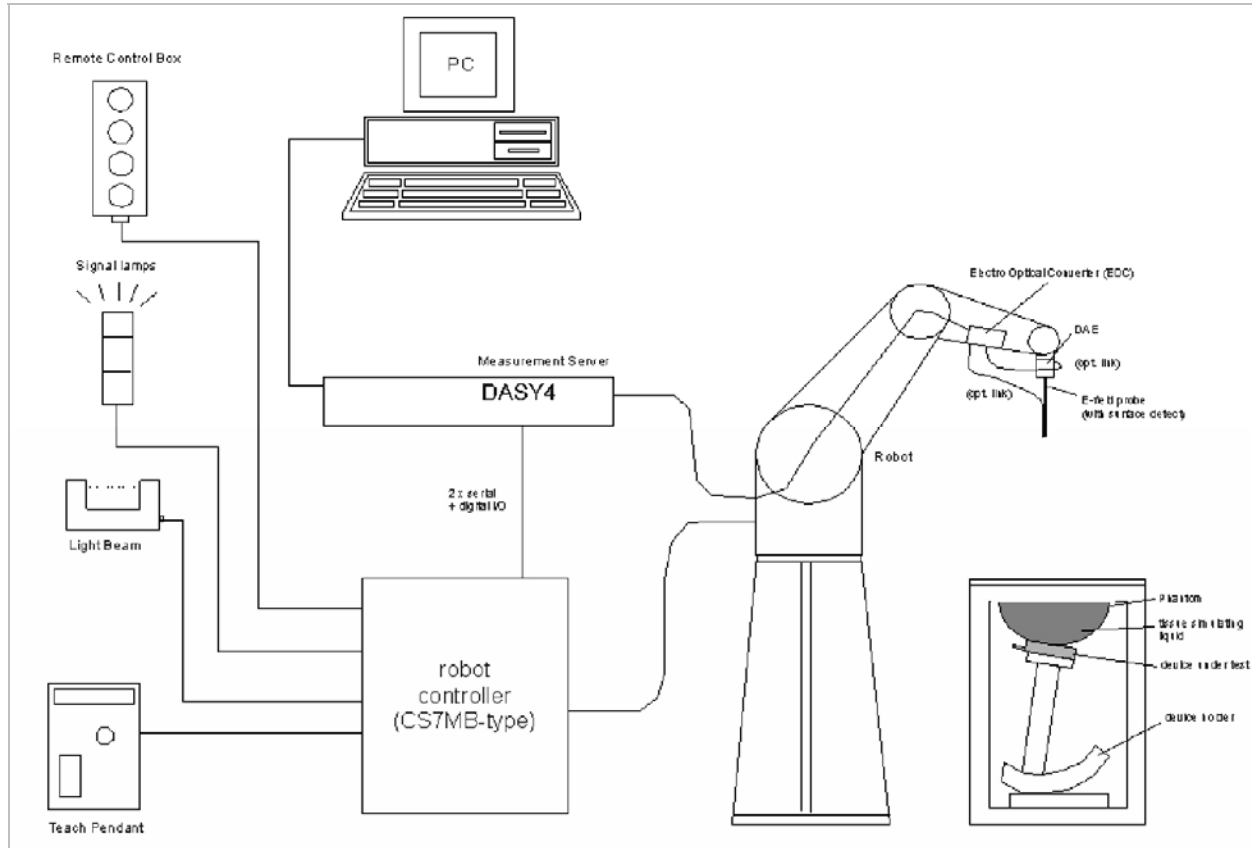
<u>Manufactured</u>	<u>Model Number</u>	<u>Max Peak Gain (dBi)</u>
WNC	Main: 81.EJU15.G06	0.35 (Main)
	Aux: 81.EJU15.G07	
Tyco	TX1: 2023775-1	0.98 (TX1)
	TX2: 2023776-1	
Yageo	*TX1: CAN4313887032501B	1.34 (TX1)
	TX2: WDAN-DQZM1001-DF	

\* Antenna under testing (with highest antenna gain 1.34 dBi).

**Power supply:**

Power supplied through laptop computer (host device)

## 6. SYSTEM SPECIFICATIONS



### The DASY4 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 2000 or Windows XP.
- DASY4 software.
- Remote controls with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing to validate the proper functioning of the system.



## 7. COMPOSITION OF INGREDIENTS FOR TISSUE SIMULATING LIQUIDS

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

Salt: 99+% Pure Sodium Chloride

Sugar: 98+% Pure Sucrose

Water: De-ionized, 16 MΩ+ resistivity

HEC: Hydroxyethyl Cellulose

DGBE: 99+% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]

Triton X-100 (ultra pure): Polyethylene glycol mono [4-(1,1, 3, 3-tetramethylbutyl)phenyl]ether

## 8. LIQUID PARAMETERS CHECK

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine if the dielectric parameters are within the tolerances of the specified target values. The relative permittivity and conductivity of the tissue material should be within  $\pm 5\%$  of the values given in the table below.

### Reference Values of Tissue Dielectric Parameters for Head and Body Phantom (for 150 – 3000 MHz and 5800 MHz)

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in IEEE Standard 1528 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in IEEE Standard 1528.

Target Frequency (MHz)	Head		Body	
	$\epsilon_r$	$\sigma$ (S/m)	$\epsilon_r$	$\sigma$ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	<b>55.0</b>	<b>1.05</b>
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	<b>53.3</b>	<b>1.52</b>
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

( $\epsilon_r$  = relative permittivity,  $\sigma$  = conductivity and  $\rho = 1000 \text{ kg/m}^3$ )

### 8.1. LIQUID CHECK RESULTS

Simulating Liquid Dielectric Parameter Check Result @ Muscle 2450 MHz

Room Ambient Temperature = 23°C; Relative humidity = 40%

Measured by: Sunny Shih

Simulating Liquid		Parameters		Measured	Target	Deviation (%)	Limit (%)	
f (MHz)	Depth (cm)	e'						
2450	15	e'	53.4268	Relative Permittivity (ε <sub>r</sub> ):	53.4268	52.7	1.38	± 5
		e''	14.9123	Conductivity (σ):	2.03250	1.95	4.23	± 5

March 16, 2009 08:14 AM

Frequency	e'	e''
2400000000.	53.5774	14.6924
2405000000.	53.5594	14.7272
2410000000.	53.5381	14.7350
2415000000.	53.5392	14.7687
2420000000.	53.5187	14.7916
2425000000.	53.5038	14.8153
2430000000.	53.4824	14.8398
2435000000.	53.4585	14.8679
2440000000.	53.4580	14.8927
2445000000.	53.4446	14.9073
<b>2450000000.</b>	<b>53.4268</b>	<b>14.9123</b>
2455000000.	53.3868	14.9508
2460000000.	53.3613	14.9702
2465000000.	53.3513	14.9772
2470000000.	53.3302	14.9993
2475000000.	53.3121	15.0174
2480000000.	53.2943	15.0473
2485000000.	53.2753	15.0670
2490000000.	53.2501	15.0995
2495000000.	53.2373	15.1232
2500000000.	53.2281	15.1463

The conductivity (σ) can be given as:

$$\sigma = \omega \epsilon_0 e'' = 2 \pi f \epsilon_0 e''$$

where  $f = \text{target } f * 10^6$

$$\epsilon_0 = 8.854 * 10^{-12}$$

## 9. SYSTEM PERFORMANCE

The system performance check is performed prior to any usage of the system in order to guarantee reproducible results. The system performance check verifies that the system operates within its specifications of  $\pm 10\%$ .

### System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the SAM twin phantom filled with Body simulating liquid of the following parameters.
- The DASY4 system with an Isotropic E-Field Probe EX3DV3-SN: 3531 was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.  
 For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (2.4 GHz) fine cube was chosen for cube integration and Special 8x8x10 (5 GHz) fine cube was chosen for cube integration
- Distance between probe sensors and phantom surface was set to 4 mm.  
 For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5mm
- The dipole input power (forward power) was 250 mW $\pm 3\%$ .
- The results are normalized to 1 W input power.

### 450 to 2450 MHz Reference SAR Values for body-tissue

In the table below, the numerical reference SAR values of a SPEAG validation dipoles placed below the flat phantom filled with body-tissue simulating liquid are given. The reference SAR values were calculated using the finite-difference time-domain method and the geometry parameters.

Dipole Type	Distance (mm)	Frequency (MHz)	SAR (1g) [W/kg]	SAR (10g) [W/kg]	SAR (peak) [W/kg]
D450V2	15	450	5.01	3.36	7.22
D835V2	15	835	9.71	6.38	14.1
D900V2	15	900	<b>11.1</b>	<b>7.17</b>	16.3
D1450V2	10	1450	29.6	16.6	49.8
D1800V2	10	1800	<b>38.5</b>	<b>20.3</b>	67.5
D1900V2	10	1900	39.8	20.8	69.6
D2000V2	10	2000	<b>40.9</b>	<b>21.2</b>	71.5
D2450V2	10	2450	51.2	23.7	97.6

Note: All SAR values normalized to 1 W forward power.

### 9.1. SYSTEM PERFORMANCE CHECK RESULTS

**System Validation Dipole: D2450V2 SN: 748**

**Results**

Date: March 16, 2009

Ambient Temperature = 23°C; Relative humidity = 40%

Measured by: Sunny Shih

Body Simulating Liquid			Normalized to 1 W		Target	Deviation (%)	Lim it (%)
f (MHz)	Temp. (°C)	Depth (cm)					
2450	22	15	1g	50.07	51.2	-2.21	± 10
			10g	23.5	23.7	-0.84	± 10

## **10. OUTPUT POWER VERIFICATION**

The following procedures had been used to prepare the EUT for the SAR test.  
The client provided a special driver and program, wl\_tools, which enable a user to control the frequency and output power of the module.

### **RF Conducted Output Power Measurement Results:**

**See Broadcom's Operational Description document for Average Power information.**

## 11. SUMMARY OF TEST RESULTS

### 11.1. SAR TEST RESULT FOR THE BAND 2400 – 2483.5 MHZ

#### 11.1.1. LAPHELD POSITION

Mode	Channel	f (MHz)	Antenna	Measured SAR 1g (mW/g)	Limit (mW/g)
802.11b	1	2412			1.6
	6	2437	TX1	0.018	
	11	2462			
802.11b	1	2412			1.6
	6	2437	TX2	0.028	
	11	2462			

Notes:

1. The modes with highest output power channel were chosen for the testing.
2. Test configuration: Lapheld with display open at 90° to the keyboard.
3. The SAR measured at the middle channel for this configuration is at least 3 dB lower (0.8 mW/g) than SAR limit (1.6 mW/g), thus testing at low & high channel is optional.

## 12. SAR TEST PLOTS

### SAR PLOT for TX1

Date/Time: 3/16/2009 1:46:05 PM

Test Laboratory: Compliance Certification Services

#### Lapheld Position - Dell Notebook PC PP19S

DUT: Dell Notebook PC; Type: PP19S; Serial: n/a

Communication System: 802.11bg; Frequency: 2437 MHz; Duty Cycle: 1:1  
Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 2.02$  mho/m;  $\epsilon_r = 53.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Room Ambient Temperature: 23.0 deg. C; Liquid Temperature: 22.0 deg. C

DASY4 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV3 - SN3531; ConvF(7.91, 7.91, 7.91); Calibrated: 4/23/2008
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

#### 802.11b M-ch TX1 Antenna/Area Scan (13x18x1): Measurement grid: dx=15mm, dy=15mm

Info: [Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.019 mW/g

#### 802.11b M-ch TX1 Antenna/Zoom Scan (7x7x9)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=3mm

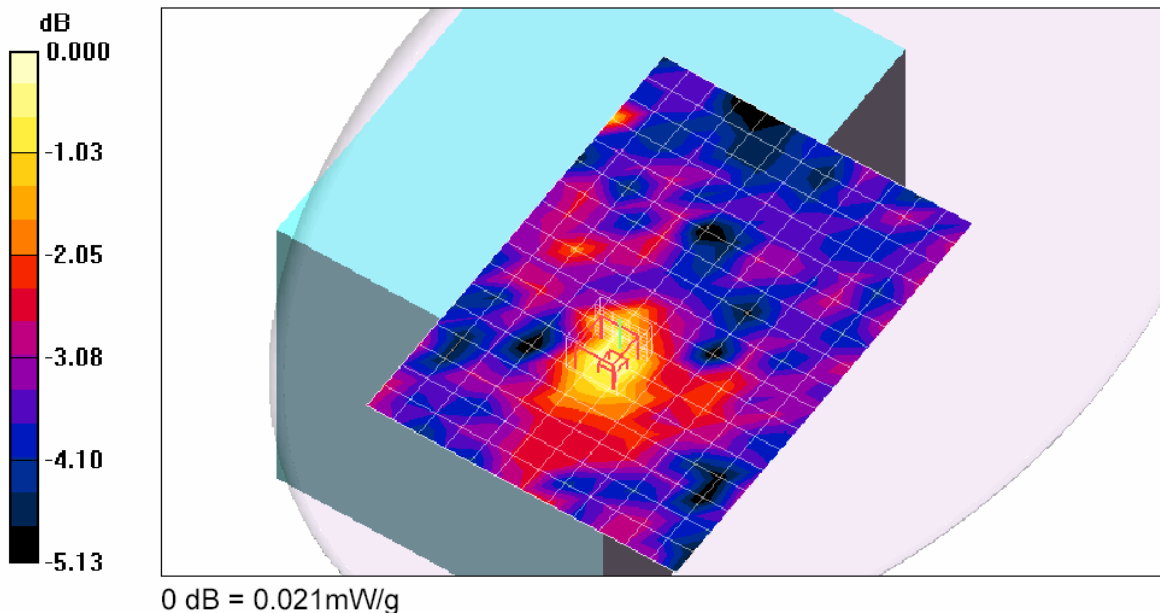
Reference Value = 1.87 V/m; Power Drift = 1.21 dB

Peak SAR (extrapolated) = 0.032 W/kg

**SAR(1 g) = 0.018 mW/g; SAR(10 g) = 0.014 mW/g**

Info: [Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.021 mW/g





SAR PLOT for TX2

Date/Time: 3/16/2009 2:59:08 PM

Test Laboratory: Compliance Certification Services

**Lapheld Position - Dell Notebook PC PP19S**

DUT: Dell Notebook PC; Type: PP19S; Serial: n/a

Communication System: 802.11bg; Frequency: 2437 MHz; Duty Cycle: 1:1  
Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 2.02$  mho/m;  $\epsilon_r = 53.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

Room Ambient Temperature: 23.0 deg. C; Liquid Temperature: 22.0 deg. C

DASY4 Configuration:

- Area Scan setting - Find Secondary Maximum Within: 2.0 dB and with a peak SAR value greater than 0.0012W/kg
- Probe: EX3DV3 - SN3531; ConvF(7.91, 7.91, 7.91); Calibrated: 4/23/2008
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn427; Calibrated: 10/20/2008
- Phantom: Flat Phantom ELI4.0; Type: QDOVA001BA; Serial: SN:XXXX
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**802.11b M-ch TX2 Antenna/Area Scan (11x15x1):** Measurement grid: dx=15mm, dy=15mm

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.029 mW/g

**802.11b M-ch TX2 Antenna/Zoom Scan (7x7x9)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=3mm

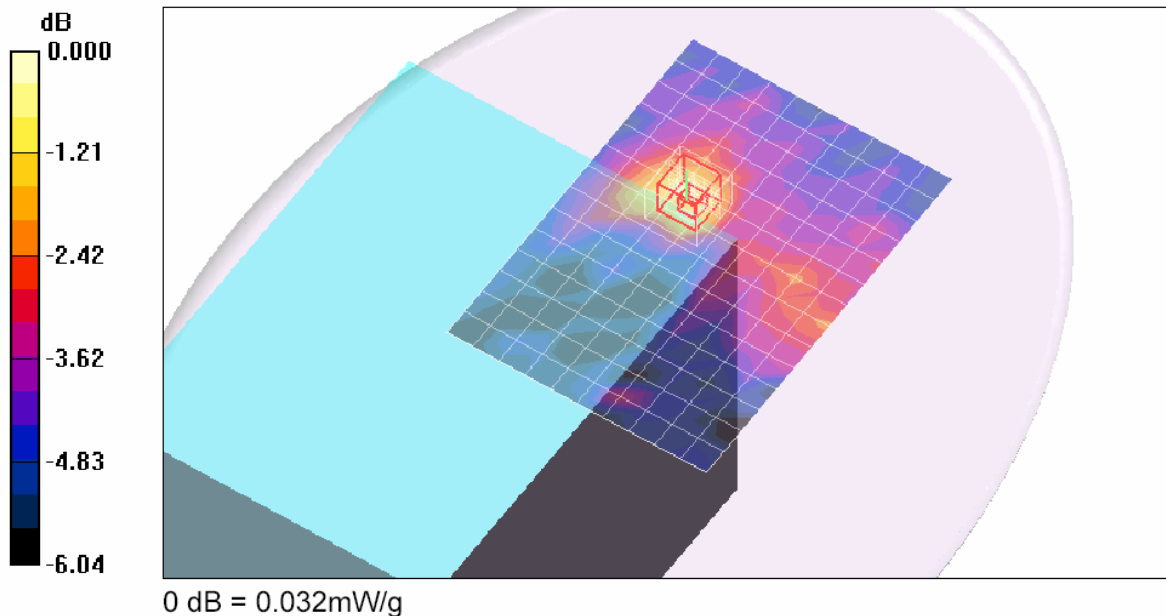
Reference Value = 2.12 V/m; Power Drift = 0.480 dB

Peak SAR (extrapolated) = 0.043 W/kg

**SAR(1 g) = 0.028 mW/g; SAR(10 g) = 0.019 mW/g**

[Info: Interpolated medium parameters used for SAR evaluation.](#)

Maximum value of SAR (measured) = 0.032 mW/g



### 13. ATTACHMENTS

No.	Contents	No. of page (s)
1	System Validation Plots	2
2	Certificate of E-Field Probe - EX3DV3SN3531	10
3	Certificate of System Validation Dipole D2450V2	6