Specific Absorption Rate (SAR) Test Report

for
Cameo Communications, Inc.
on the
802.11n Wireless USB2.0 Adapter

Report No. : FA740305-01-1-2-01
Trade Name : Cameo / ENCORE
Model Name : WLN-1502 / ENUWI-N
FCC ID : NHPWLN1502
Date of Testing : Apr. 23, 2007
Date of Report : Oct. 17, 2007
Date of Review : Oct. 17, 2007

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- Report Version: Rev. 01

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1. *Statement of Compliance*

The Specific Absorption Rate (SAR) maximum result found during testing for the Cameo Communications, Inc. 802.11n Wireless USB2.0 Adapter Cameo WLN-1502, ENCORE ENUWI-N is 0.419 W/Kg on the WLAN 2.4GHz body SAR with expanded uncertainty 21.9%. It is in compliance with Specific Absorption Rate (SAR) for general population/uncontrolled exposure limits specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1999 and had been tested in accordance with the measurement methods and procedures specified in OET Bulletin 65 Supplement C (Edition 01-01) and IEEE 1528-2003.

Approved by

Jones Tsai
Manager

2. *Administration Data*

2.1 *Testing Laboratory*

Company Name : Sporton International Inc.
Department : Antenna Design/SAR
Address : No.52, Hwa-Ya 1st RD., Hwa Ya Technology Park, Kwei-Shan Hsiang, TaoYuan Hsien, Taiwan, R.O.C.
Telephone Number : 886-3-327-3456
Fax Number : 886-3-327-0973

2.2 *Detail of Applicant*

Company Name : Cameo Communications, Inc.
Address : No. 42, Sec. 6, Mincyuan E. Rd., Neihu District, Taipei City 114, Taiwan

2.3 *Detail of Manufacturer*

Company Name : Cameo Communications, Inc.
Address : No. 42, Sec. 6, Mincyuan E. Rd., Neihu District, Taipei City 114, Taiwan

2.4 *Application Detail*

Date of reception of application: Apr. 03, 2007
Start of test : Apr. 23, 2007
End of test : Apr. 23, 2007

3. *Scope*

3.1 *Description of Device Under Test (DUT)*

DUT Type :	802.11n Wireless USB2.0 Adapter
Trade Name :	Cameo / ENCORE
Model Name :	WLN-1502 / ENUWI-N
FCC ID :	NHPWLN1502
Frequency Range :	2400 ~ 2483.5 MHz
Number of Channels :	11 for 20MHz bandwidth; 7 for 40MHz bandwidth
Carrier Frequency of Each Channel :	2412 + (n - 1) * 5 MHz; n = 1 ~ 11
Antenna Type :	Ant-0 : PIFA Ant-1 : Printed
Antenna Gain :	Ant-0 : 0 dBi Ant-1 : 2 dBi

Maximum Output Power to Antenna :	802.11b : 16.86 dBm
	802.11g : 16.34 dBm
	802.11n (BW 20MHz) : 17.86 dBm (Ant-0), 16.48 dBm (Ant-1),
	                  20.10 dBm (Total)
	802.11n (BW 40MHz) : 16.28 dBm (Ant-0), 15.44 dBm (Ant-1),
	                  18.84 dBm (Total)

Type of Modulation :	802.11b : DSSS 802.11g : OFDM 802.11n : OFDM
DUT Stage :	Identical Prototype
Application Type :	Certification

Remark: Ant-0 and Ant-1 can transmit simultaneously.

3.2 Product Photo

3.3 *Applied Standards:*

The Specific Absorption Rate (SAR) testing specification, method and procedure for this 802.11n Wireless USB2.0 Adapter is in accordance with the following standards:

47 CFR Part 2 (2.1093),
IEEE C95.1-1999,
IEEE C95.3-2002,
IEEE P1528 -2003, and
OET Bulletin 65 Supplement C (Edition 01-01)

3.4 *Device Category and SAR Limits*

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user.

Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

3.5 *Test Conditions*

3.5.1   *Ambient Condition:*

Item	MSL_2450
Ambient Temperature (℃)	20-24℃
Tissue simulating liquid temperature (℃)	21.2℃
Humidity (%)	<60

3.5.2   *Test Configuration:*

The data rates for SAR testing are 11Mbps for 802.11b and 6Mbps for 802.11g and 802.11n. Engineering testing software installed on the EUT can provide continuous transmitting RF signal. This RF signal utilized in SAR measurement has almost 100% duty cycle and its crest factor is 1. The measurements were performed on the lowest, middle, and highest channel, i.e. channel 1, channel 6, and channel 11 for BW 20MHz; channel 3, channel 6, channel 9 for BW 40MHz. However, measurements were performed only on the middle channel if the SAR is below 3 dB of limit.

4. *Specific Absorption Rate (SAR)*
4.1 *Introduction*

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The FCC recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

4.2 *SAR Definition*

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density.
ρ). The equation description is as below:

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

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be either related to the temperature elevation in tissue by

$$\textbf{SAR} = C\frac{\delta T}{\delta t}$$

, where C is the specific head capacity, δT is the temperature rise and δt the exposure duration,

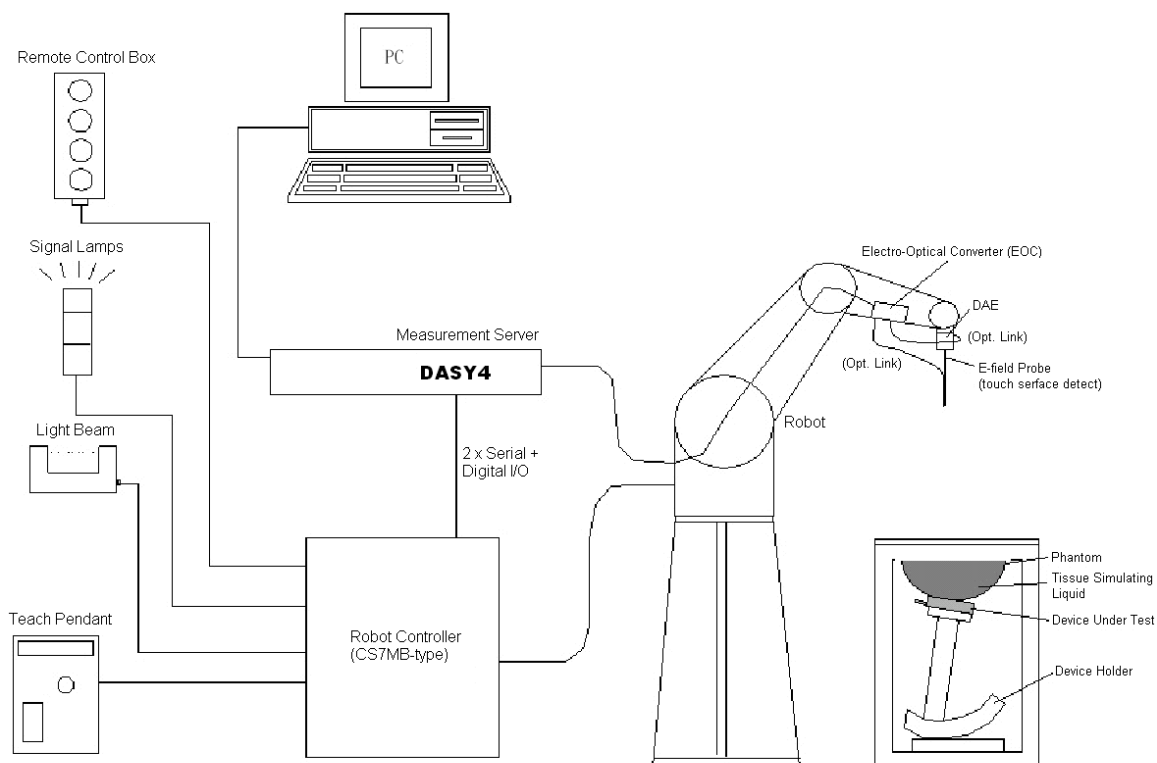or related to the electrical field in the tissue by

$$\textbf{SAR} = \frac{\sigma |E|^2}{\rho}$$

, where σ is the conductivity of the tissue, ρ is the mass density of the tissue and $\boldsymbol{E}$ is the rms electrical field strength.

However for evaluating SAR of low power transmitter, electrical field measurement is typically applied.

5. SAR Measurement Setup

Fig. 5.1 DASY4 system

The DASY4 system for performance compliance tests is illustrated above graphically. This system consists of the following items:

➢ A standard high precision 6-axis robot with controller, a teach pendant and software
➢ A data acquisition electronic (DAE) attached to the robot arm extension
➢ A dosimetric probe equipped with an optical surface detector system
➢ The electro-optical converter (ECO) performs the conversion between optical and electrical signals
➢ A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
➢ A probe alignment unit which improves the accuracy of the probe positioning
➢ A computer operating Windows XP
➢ DASY4 software
➢ Remove control with teach pendant and additional circuitry for robot safety such as warming lamps, etc.
➢ The SAM twin phantom
➢ A device holder
➢ Tissue simulating liquid
➢ Dipole for evaluating the proper functioning of the system

Some of the components are described in details in the following sub-sections.

5.1 *DASY4 E-Field Probe System*

The SAR measurement is conducted with the dosimetric probe ET3DV6 (manufactured by SPEAG). The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency. This probe has a built in optical surface detection system to prevent from collision with phantom.

5.1.1 ET3DV6 E-Field Probe Specification

Construction	Symmetrical design with triangular core
	Built-in optical fiber for surface detection system
	Built-in shielding against static charges
	PEEK enclosure material (resistant to organic solvents)
Calibration	Simulating tissue at frequencies of 900MHz, 1.8GHz and 2.45GHz for brain and muscle (accuracy ±8%)
Frequency	10 MHz to > 3 GHz
Directivity	± 0.2 dB in brain tissue (rotation around probe axis)
	± 0.4 dB in brain tissue (rotation perpendicular to probe axis)
Dynamic Range	5 μ W/g to > 100mW/g; Linearity: ±0.2dB
Surface Detection	± 0.2 mm repeatability in air and clear liquids on reflecting surface
Dimensions	Overall length: 330mm
	Tip length: 16mm
	Body diameter: 12mm
	Tip diameter: 6.8mm
	Distance from probe tip to dipole centers: 2.7mm
Application	General dosimetry up to 3GHz
	Compliance tests for mobile phones and Wireless LAN
	Fast automatic scanning in arbitrary phantoms

Fig. 5.2 Probe setup on robot

5.1.2 ET3DV6 E-Field Probe Calibration

Each probe needs to be calibrated according to a dosimetric assessment procedure with accuracy better than ± 10%. The spherical isotropy shall be evaluated and within ± 0.25dB. The sensitivity parameters (NormX, NormY, and NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested. The calibration data are as below:

Sensitivity	X axis : 1.73 μV	Y axis : 1.67 μV		Z axis : 1.70 μV
Diode compression point	X axis : 95 mV	Y axis : 101 mV		Z axis : 93 mV
Conversion factor (Head / Body)	Frequency (MHz)	X axis	Y axis	Z axis
	2350~2550	4.66 / 4.11	4.66 / 4.11	4.66 / 4.11
Boundary effect (Head / Body)	Frequency (MHz)	Alpha	Depth	
	2350~2550	0.68 / 0.60	1.96 / 1.70	

NOTE:

1. The probe parameters have been calibrated by the SPEAG.

5.2 DATA Acquisition Electronics (DAE)

The data acquisition electronics (DAE4) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection.

The input impedance of the DAE4 is 200M Ohm; the inputs are symmetrical and floating. Common mode rejection is above 80dB.

5.3 *Robot*

The DASY4 system uses the high precision robots RX90BL type out of the newer series from Stäubli SA (France). For the 6-axis controller DASYS system, the CS7MB robot controller version from Stäubli is used. The RX robot series have many features that are important for our application:

➢ High precision (repeatability 0.02 mm)
➢ High reliability (industrial design)
➢ Jerk-free straight movements
➢ Low ELF interference (the closed metallic construction shields against motor control fields)
➢ 6-axis controller

5.4 *Measurement Server*

The DASY4 measurement server is based on a PC/104 CPU board with
166 MHz CPU
32 MB chipset and
64 MB RAM.

Communication with
the DAE4 electronic box
the 16-bit AD-converter system for optical detection and digital I/O interface.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.

5.5 *SAM Twin Phantom*

The SAM twin phantom is a fiberglass shell phantom with 2mm shell thickness (except the ear region where shell thickness increases to 6mm). It has three measurement areas:

➢ Left head
➢ Right head
➢ Flat phantom

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections.

A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters.

On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

The phantom can be used with the following tissue simulating liquids:
*Water-sugar based liquid
*Glycol based liquids
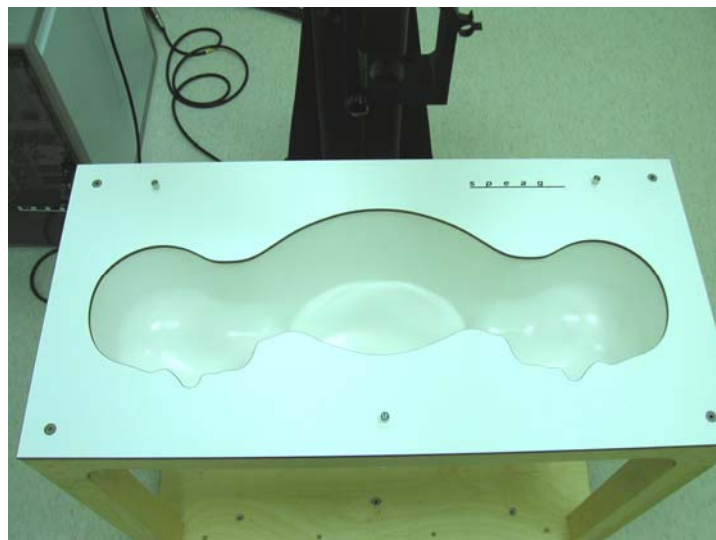
Fig. 5.3 Top view of twin phantom

Fig. 5.4 Bottom view of twin phantom

5.6 Data Storage and Evaluation

5.6.1 Data Storage

The DASY4 software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension .DA4. The postprocessing software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of erroneous parameter settings. For example, if a measurement has been performed with an incorrect crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be reevaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type (e.g., [V/m], [A/m], [mW/g]). Some of these units are not available in certain situations or give meaningless results, e.g., a SAR-output in a loseless media, will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

5.6.2 Data Evaluation

The DASY4 postprocessing software (SEMCAD) automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software：

Probe parameters：	- Sensitivity	Norm_i, a_{i0}, a_{i1}, a_{i2}
	- Conversion factor	ConvF_i
	- Diode compression point	dcp_i
Device parameters：	- Frequency	f
	- Crest factor	cf
Media parameters：	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY components. In the direct measuring mode of the multimeter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.
The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel

can be given as：

$$Vi \;=\; U_i + \; U_i^2 \cdot \frac{cf}{dcp_i}$$

with　　　　V_i = *compensated signal of channel i (i = x, y, z)*
　　　　　　U_i = *input signal of channel i (i = x, y, z)*
　　　　　　cf = crest factor of exciting field (DASY parameter)
　　　　　　dcp_i = *diode compression point (DASY parameter)*

From the compensated input signals, the primary field data for each channel can be evaluated：

E-field probes： $E_i \;=\; \sqrt{\dfrac{V_i}{Norm_i ConvF}}$

H-field probes： $H_i \;=\; \sqrt{V_i} \dfrac{a_{i0+} a_{i1} f + a_{i2} f^2}{f}$

with　　　　V_i = compensated signal of channel i (i = x, y, z)
　　　　　　$Norm_i$ = sensor sensitivity of channel i (i = x, y, z)
　　　　　　　　μ V/(V/m)2 for E-field Probes
　　　　　　$ConvF$ = sensitivity enhancement in solution
　　　　　　a_{ij} = sensor sensitivity factors for H-field probes
　　　　　　f = carrier frequency [GHz]
　　　　　　E_i = electric field strength of channel i in V/m
　　　　　　H_i = magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude)：

$$E_{tot} \;=\; \sqrt{E_X^2 + E_Y^2 + E_Z^2}$$

The primary field data are used to calculate the derived field units.

$$\text{SAR} = \; E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with　　　　SAR = local specific absorption rate in mW/g
　　　　　　$Etot$ = total field strength in V/m
　　　　　　σ = conductivity in [mho/m] or [Siemens/m]
　　　　　　ρ = equivalent tissue density in g/ cm^3

＊Note that the density is set to 1, to account for actual head tissue density rather than the density of the tissue simulating liquid.

The power flow density is calculated assuming the excitation field to be a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770} \qquad \text{or} \qquad P_{pwe} = H_{tot}^2 \cdot 37.7$$

with P_{pwe} = equivalent power density of a plane wave in mW/cm^2
            E_{tot} = total electric field strength in V/m
            H_{tot} = total magnetic field strength in A/m

5.7 *Test Equipment List*

Manufacture	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	**Due Date**
SPEAG	Dosimetric E-Filed Probe	ET3DV6	1788	Sep. 19, 2006	Sep. 19, 2007
SPEAG	2450MHz System Validation Kit	D2450V2	736	Jul. 12, 2005	Jul. 12, 2007
SPEAG	Data Acquisition Electronics	DAE3	577	Nov. 21, 2006	Nov. 21, 2007
SPEAG	Device Holder	N/A	N/A	NCR	NCR
SPEAG	Phantom	QD 000 P40 C	TP-1150	NCR	NCR
SPEAG	Robot	Staubli RX90BL	F03/5W15A1/A/01	NCR	NCR
SPEAG	Software	DASY4 V4.7 Build 53	N/A	NCR	NCR
SPEAG	Software	SEMCAD V1.8 Build 172	N/A	NCR	NCR
SPEAG	Measurement Server	SE UMS 001 BA	1021	NCR	NCR
Agilent	ENA Series Network Analyzer	E5071C	MY46100746	Feb. 21, 2007	Feb. 21, 2008
Agilent	Dielectric Probe Kit	85070D	US01440205	NCR	NCR
Agilent	Dual Directional Coupler	778D	50422	NCR	NCR
Agilent	Power Amplifier	8449B	3008A01917	NCR	NCR
R&S	Radio Communication Tester	CMU200	105513	Jul. 25, 2006	Jul. 25, 2007
Agilent	Power Meter	E4416A	GB41292344	Feb. 08, 2007	Feb. 08, 2008
Agilent	Power Sensor	E9327A	US40441548	Feb. 08, 2007	Feb. 08, 2008
Agilent	Signal Generator	E8247C	MY43320596	Mar. 01, 2006	Mar. 01, 2008

Table 5.1 Test Equipment List

6. *Tissue Simulating Liquids*

For the measurement of the field distribution inside the SAM phantom with DASY4, the phantom must be filled with around 25 liters of homogeneous body tissue simulating liquid. The liquid height from the bottom of the phantom body is 15.2 centimeters, which is shown in Fig. 6.1.

The following ingredients for tissue simulating liquid are used:

➢ **Water**: deionized water (pure H_2O), resistivity ≧16MΩ- as basis for the liquid
➢ **Sugar**: refined sugar in crystals, as available in food shops – to reduce relative permittyvity
➢ **Salt**: pure NaCl – to increase conductivity
➢ **Cellulose**: Hydroxyethyl-cellulose, medium viscosity (75-125 mPa.s, 2% in water, 20°C), CAS#54290-to increase viscosity and to keep sugar in solution.
➢ **Preservative**: Preventol D-7 Bayer AG, D-51368 Leverkusen, CAS#55965-84-9- to prevent the spread of bacteria and molds.
➢ **DGMBE**: Deithlenglycol-monobuthyl ether (DGMBE), Fluka Chemie GmbH, CAS#112-34-5 – to reduce relative permittivity.

Table 6.1 gives the recipes for one liter of tissue simulating liquid for frequency band 2450 MHz.

Ingredient	MSL-2450
Water	698.3 ml
DGMBE	301.7 ml
Total amount	1 liter (1.0 kg)
Dielectric Parameters at 22°	f = 2450MHz
	ε_r= 52.7±5%, σ = 1.95±5% S/m

Table 6.1

The dielectric parameters of the liquids were verified prior to the SAR evaluation using an Agilent 85070D Dielectric Probe Kit and an Agilent Network Analyzer.

Table 6.2 shows the measuring results for muscle simulating liquid.

Bands	Frequency(MHz)	Permittivity (ε_r)	Conductivity (σ)	Measurement Date
2450 MHz	2412	52.5	1.90	Apr. 23, 2007
	2437	52.4	1.94	
	2462	52.4	1.96	

Table 6.2

The measuring data are consistent with $\varepsilon_r = 52.7 \pm 5\%$ and $\sigma = 1.95 \pm 5\%$ for body 2450 band.

Fig. 6.1

7. *Uncertainty Assessment*

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 7.1

Uncertainty Distributions	Normal	Rectangular	Triangular	U-shape
Multiplying factor[a]	$1/k$ [b]	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a)   standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) κ is the coverage factor

Table 7.1

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY4 uncertainty Budget is showed in Table 7.2.

Error Description	Uncertainty Value ± %	Probability Distribution	Divisor	Ci (1g)	Standard Unc. (1g)	vi or Veff
Measurement Equipment						
Probe Calibration	±5.9 %	Normal	1	1	±5.9 %	∞
Axial Isotropy	±4.7 %	Rectangular	√3	0.7	±1.9 %	∞
Hemispherical Isotropy	±9.6 %	Rectangular	√3	0.7	±3.9 %	∞
Boundary Effects	±1.0 %	Rectangular	√3	1	±0.6 %	∞
Linearity	±4.7 %	Rectangular	√3	1	±2.7 %	∞
System Detection Limits	±1.0 %	Rectangular	√3	1	±0.6 %	∞
Readout Electronics	±0.3 %	Normal	1	1	±0.3 %	∞
Response Time	±0.8 %	Rectangular	√3	1	±0.5 %	∞
Integration Time	±2.6 %	Rectangular	√3	1	±1.5 %	∞
RF Ambient Noise	±3.0 %	Rectangular	√3	1	±1.7 %	∞
RF Ambient Reflections	±3.0 %	Rectangular	√3	1	±1.7 %	∞
Probe Positioner	±0.4 %	Rectangular	√3	1	±0.2 %	∞
Probe Positioning	±2.9 %	Rectangular	√3	1	±1.7 %	∞
Max. SAR Eval.	±1.0 %	Rectangular	√3	1	±0.6 %	∞
Test Sample Related						
Device Positioning	±2.9 %	Normal	1	1	±2.9	145
Device Holder	±3.6 %	Normal	1	1	±3.6	5
Power Drift	±5.0 %	Rectangular	√3	1	±2.9	∞
Phantom and Setup						
Phantom Uncertainty	±4.0 %	Rectangular	√3	1	±2.3	∞
Liquid Conductivity (target)	±5.0 %	Rectangular	√3	0.64	±1.8	∞
Liquid Conductivity (meas.)	±2.5 %	Normal	1	0.64	±1.6	∞
Liquid Permittivity (target)	±5.0 %	Rectangular	√3	0.6	±1.7	∞
Liquid Permittivity (meas.)	±2.5 %	Normal	1	0.6	±1.5	∞
Combined Standard Uncertainty					**±10.9**	**387**
Coverage Factor for 95 %		K=2				
Expanded uncertainty (Coverage factor = 2)					**±21.9**	

Table 7.2 Uncertainty Budget of DASY

8. *SAR Measurement Evaluation*

Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the flat phantom and a corresponding distance holder.

8.1 *Purpose of System Performance check*

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

8.2 *System Setup*

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave which comes from a signal generator at frequency 2450 MHz. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:
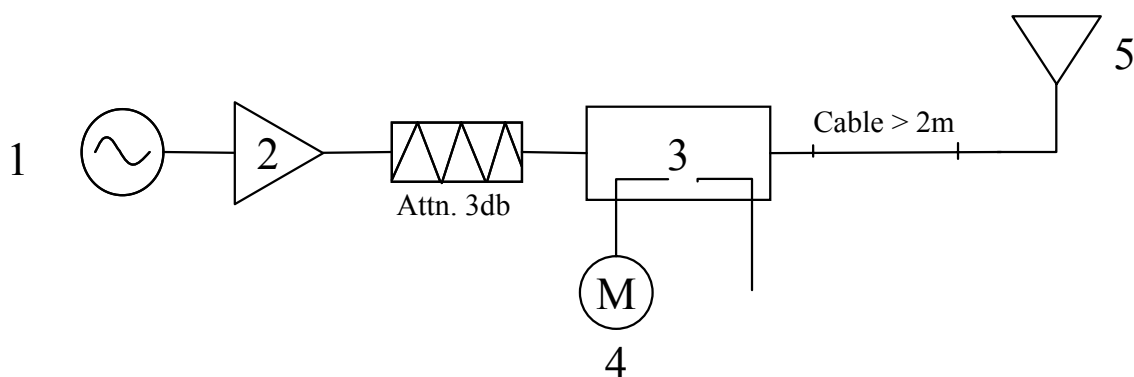
Fig. 8.1

1. Signal Generator
2. Amplifier
3. Directional Coupler
4. Power Meter
5. 2450 MHz Dipole

The output power on dipole port must be calibrated to 100 mW (20 dBm) before dipole is connected.

Fig 8.2 Dipole Setup

8.3 *Validation Results*

Comparing to the original SAR value provided by Speag, the validation data should within its specification of 10 %. Table 8.1 shows the target SAR and measured SAR after normalized to 1W input power.

Band	SAR	Target (W/kg)	Measurement data (W/kg)	Variation	Measurement date
ISM band (2450 MHz)	SAR (1g)	52.8	57.4	8.7 %	Apr. 23, 2007
	SAR (10g)	24.5	26.8	9.4 %	

Table 8.1

The table above indicates the system performance check can meet the variation criterion.

9. *Description for DUT Testing Position*

This DUT was tested in 6 different positions. They are "DELL D410 Notebook Bottom Touch with Horizontal USB Port", "DELL D410 Notebook Bottom Touch with Vertical USB Port", "DELL D500 Notebook Bottom Touch with Horizontal USB Port", "DELL D500 Notebook Bottom Touch with Vertical USB Port", "DELL D505 Notebook Bottom Touch with Horizontal USB Port", "DELL D505 Notebook Bottom Touch with Vertical USB Port".

Fig. 9.1 DELL D410 Notebook Bottom Touch with Horizontal USB Port

Fig. 9.2 DELL D410 Notebook Bottom Touch with Vertical USB Port

Fig. 9.3 DELL D500 Notebook Bottom Touch with Horizontal USB Port

Fig. 9.4 DELL D500 Notebook Bottom Touch with Vertical USB Port

Fig. 9.5 DELL D505 Notebook Bottom Touch with Horizontal USB Port

Fig. 9.6 DELL D505 Notebook Bottom Touch with Vertical USB Port

10. *Measurement Procedures*

The measurement procedures are as follows:

➢ Using engineering software to transmit RF power continuously (continuous Tx) in the middle channel
➢ Placing the DUT in the positions described in the last section
➢ Setting scan area, grid size and other setting on the DASY4 software
➢ Taking data for the low channel
➢ Repeat the previous steps for the low and high channels.

According to the IEEE P1528 draft standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:
➢ Power reference measurement
➢ Area scan
➢ Zoom scan
➢ Power reference measurement

10.1 *Spatial Peak SAR Evaluation*

The procedure for spatial peak SAR evaluation has been implemented according to the IEEE1528-2003 standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The DASY4 software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

Base on the Draft: SCC-34, SC-2, WG-2-Computational Dosimetry, P1528/D1.2 (Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques), a new algorithm has been implemented. The spatial-peak SAR can be computed over any required mass.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose , the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the postprocessing engine (SEMCAD). The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

- extraction of the measured data (grid and values) from the Zoom Scan
- calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- generation of a high-resolution mesh within the measured volume
- interpolation of all measured values form the measurement grid to the high-resolution grid
- extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- calculation of the averaged SAR within masses of 1g and 10g

10.2 *Scan Procedures*

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures 5x5x7 points with step size 8, 8 and 5 mm. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 1 g.

10.3 *SAR Averaged Methods*

In DASY4, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. The uncertainty increases with the extrapolation distance. To keep the uncertainty within 1% for the 1 g and 10 g cubes, the extrapolation distance should not be larger than 5 mm.

11. SAR Test Results

11.1 Notebook Bottom Touch with Horizontal USB Port

Notebook	Mode	Chan.	Freq. (MHz)	Modulation type	Conducted Power (dBm)	Power Drift (dB)	Measured 1g SAR (W/kg)	Limits (W/Kg)	Results
DELL D410	802.11b (Ant-0)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	0.108	0.24	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-0.145	0.358	1.6	Pass
		6	2437(Mid)	CCK	16.58	-0.14	0.304	1.6	Pass
		11	2462(High)	CCK	16.69	-0.127	0.419	1.6	Pass
DELL D500	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-0.014	0.289	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
DELL D505	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-0.12	0.177	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
DELL D410	802.11g (Ant-0)	1	2412(Low)	OFDM	16.05	-	-	-	-
		6	2437(Mid)	OFDM	16.34	-0.04	0.061	1.6	Pass
		11	2462(High)	OFDM	15.91	-	-	-	-
	802.11g (Ant-1)	1	2412(Low)	OFDM	16.05	-	-	-	-
		6	2437(Mid)	OFDM	16.34	-0.133	0.096	1.6	Pass
		11	2462(High)	OFDM	15.91	-	-	-	-
	802.11n (BW 20)	1	2412(Low)	OFDM	16.78(Ant-0) 16.30(Ant-1) 19.56(Total)	-	-	-	-
		6	2437(Mid)	OFDM	17.62(Ant-0) 16.48(Ant-1) 20.10(Total)	0.03	0.157	1.6	Pass
		11	2462(High)	OFDM	17.86(Ant-0) 16.02(Ant-1) 20.05(Total)	-	-	-	-
	802.11n (BW 40)	3	2422(Low)	OFDM	15.86(Ant-0) 15.44(Ant-1) 18.67(Total)	-	-	-	-
		6	2437(Mid)	OFDM	16.24(Ant-0) 15.37(Ant-1) 18.84(Total)	-0.152	0.149	1.6	Pass
		9	2452(High)	OFDM	16.28(Ant-0) 15.12(Ant-1) 18.75(Total)	-	-	-	-

11.2 Notebook Bottom Touch with Vertical USB Port

Notebook	Mode	Chan.	Freq. (MHz)	Modulation type	Conducted Power (dBm)	Power Drift (dB)	Measured 1g SAR (W/kg)	Limits (W/Kg)	Results
DELL D410	802.11b (Ant-0)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-0.129	0.197	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-	-	-	-
		11	2462(High)	CCK	16.69	-	-	-	-
DELL D500	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-0.034	0.235	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
DELL D505	802.11b (Ant-1)	1	2412(Low)	CCK	16.86	-	-	-	-
		6	2437(Mid)	CCK	16.58	-0.177	0.218	1.6	Pass
		11	2462(High)	CCK	16.69	-	-	-	-
DELL D410	802.11g (Ant-0)	1	2412(Low)	OFDM	16.05	-	-	-	-
		6	2437(Mid)	OFDM	16.34	-	-	-	-
		11	2462(High)	OFDM	15.91	-	-	-	-
	802.11g (Ant-1)	1	2412(Low)	OFDM	16.05	-	-	-	-
		6	2437(Mid)	OFDM	16.34	-	-	-	-
		11	2462(High)	OFDM	15.91	-	-	-	-
	802.11n (BW 20)	1	2412(Low)	OFDM	16.78(Ant-0) 16.30(Ant-1) 19.56(Total)	-	-	-	-
		6	2437(Mid)	OFDM	17.62(Ant-0) 16.48(Ant-1) 20.10(Total)	-	-	-	-
		11	2462(High)	OFDM	17.86(Ant-0) 16.02(Ant-1) 20.05(Total)	-	-	-	-
	802.11n (BW 40)	3	2422(Low)	OFDM	15.86(Ant-0) 15.44(Ant-1) 18.67(Total)	-	-	-	-
		6	2437(Mid)	OFDM	16.24(Ant-0) 15.37(Ant-1) 18.84(Total)	-	-	-	-
		9	2452(High)	OFDM	16.28(Ant-0) 15.12(Ant-1) 18.75(Total)	-	-	-	-

Test Engineer： John Tsai

12.References

[1] FCC 47 CFR Part 2 "Frequency Allocations and Radio Treaty Matters; General Rules and Regulations"

[2] IEEE Std. P1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", April 21,2003.

[3] Supplement C (Edition 01-01) to OET Bulletin 65 (Edition 97-01), "Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to RF Emissions", June 2001

[4] IEEE Std. C95.3-2002, "IEEE Recommended Practice for the Meaurement of Potentially Hazardous Electromagnetic Fields-RF and Microwave", 2002

[5] 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", 1999

[6] Robert J. Renka, "Multivariate Interpolation Of Large Sets Of Scattered Data", University of Noth Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148

[7] DAYS4 System Handbook

Appendix A - System Performance Check Data

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

System Check_Body_2450MHz

DUT: Dipole 2450 MHz

Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2450 MHz; σ = 1.95 mho/m; ε_r = 52.4; ρ = 1000 kg/m³
Ambient Temperature：22.7 ℃；Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical And Optical Surface Detection)Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Pin=100mW/Area Scan (91x91x1): Measurement grid: dx=10mm, dy=10mm
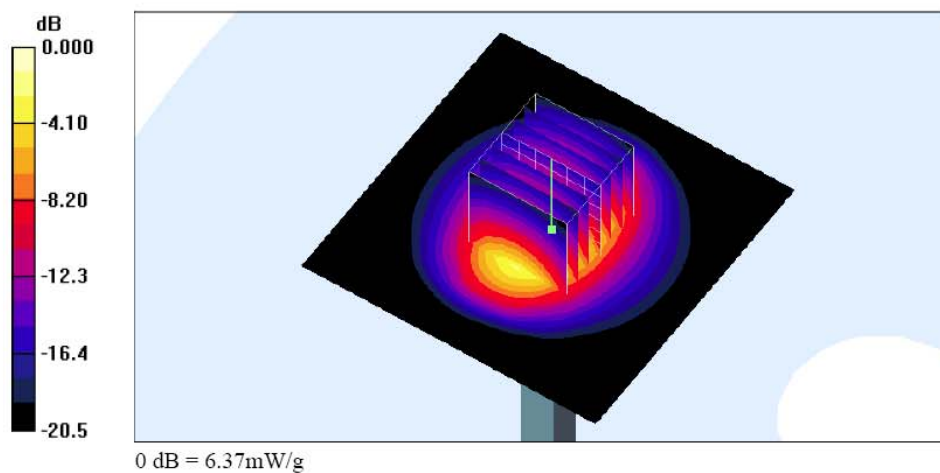Maximum value of SAR (interpolated) = 6.64 mW/g

Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 59.1 V/m; Power Drift = 0.003 dB
Peak SAR (extrapolated) = 13.4 W/kg
SAR(1 g) = 5.74 mW/g; SAR(10 g) = 2.68 mW/g
Maximum value of SAR (measured) = 6.37 mW/g

0 dB = 6.37mW/g

Appendix B - SAR Measurement Data

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

Body_802.11b Ch6_DELL D410 Notebook Bottom Touch_Ant-0_Horizontal USB

DUT: 740305

Communication System: 802.11b ; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2437 MHz; σ = 1.94 mho/m; ε_r = 52.4; ρ = 1000 kg/m³
Ambient Temperature：22.5 ℃; Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Ch6/Area Scan (41x61x1): Measurement grid: dx=15mm, dy=15mm
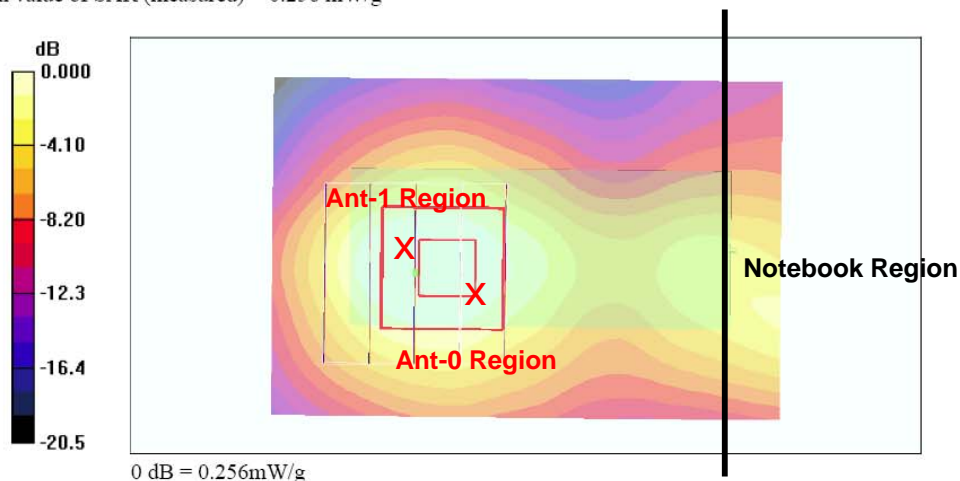Maximum value of SAR (interpolated) = 0.296 mW/g

Ch6/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 7.78 V/m; Power Drift = 0.108 dB
Peak SAR (extrapolated) = 0.523 W/kg
SAR(1 g) = 0.240 mW/g; SAR(10 g) = 0.125 mW/g
Maximum value of SAR (measured) = 0.256 mW/g

0 dB = 0.256mW/g

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

Body_802.11b Ch11_DELL D410 Notebook Bottom Touch_Ant-1_Horizontal USB

DUT: 740305

Communication System: 802.11b ; Frequency: 2462 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2462 MHz; σ = 1.96 mho/m; ε_r = 52.4; ρ = 1000 kg/m^3
Ambient Temperature：22.5 ℃；Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Ch11/Area Scan (41x61x1): Measurement grid: dx=15mm, dy=15mm
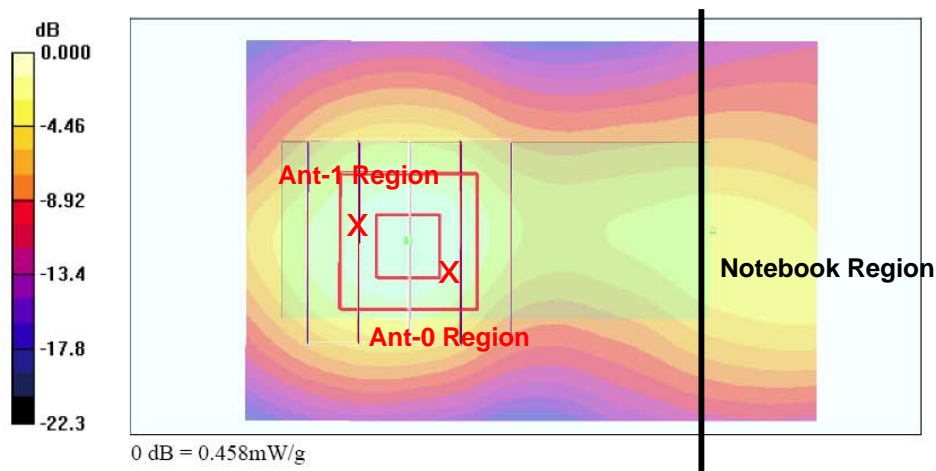Maximum value of SAR (interpolated) = 0.480 mW/g

Ch11/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 11.1 V/m; Power Drift = -0.127 dB
Peak SAR (extrapolated) = 0.983 W/kg
SAR(1 g) = 0.419 mW/g; SAR(10 g) = 0.200 mW/g
Maximum value of SAR (measured) = 0.458 mW/g

0 dB = 0.458mW/g

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

Body_802.11g Ch6_DELL D410 Notebook Bottom Touch_Ant-0_Horizontal USB

DUT: 740305

Communication System: 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2437 MHz; σ = 1.94 mho/m; ε_r = 52.4; ρ = 1000 kg/m^3
Ambient Temperature：22.4 ℃；Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Ch6/Area Scan (41x61x1): Measurement grid: dx=15mm, dy=15mm
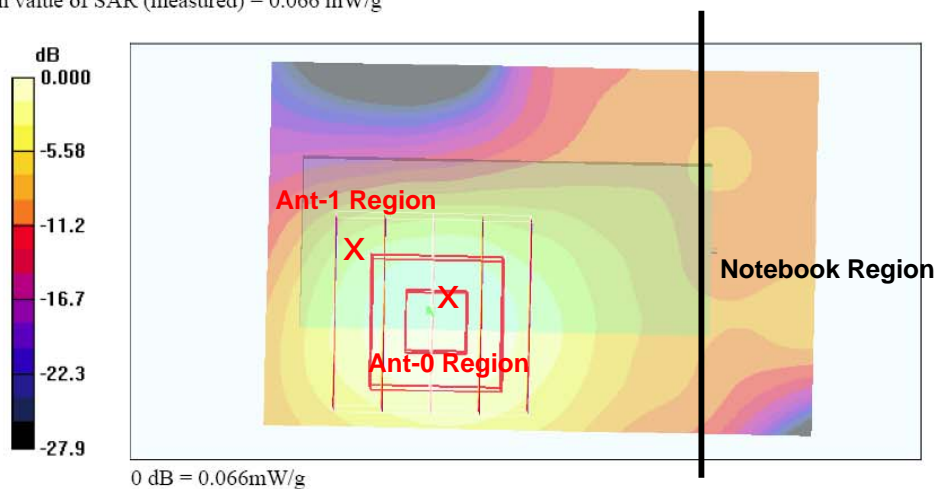Maximum value of SAR (interpolated) = 0.067 mW/g

Ch6/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 1.91 V/m; Power Drift = -0.040 dB
Peak SAR (extrapolated) = 0.126 W/kg
SAR(1 g) = 0.061 mW/g; SAR(10 g) = 0.031 mW/g
Maximum value of SAR (measured) = 0.066 mW/g

0 dB = 0.066mW/g

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

Body_802.11g Ch6_DELL D410 Notebook Bottom Touch_Ant-1_Horizontal USB

DUT: 740305

Communication System: 802.11g; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2437 MHz; σ = 1.94 mho/m; $ε_r$ = 52.4; ρ = 1000 kg/m^3
Ambient Temperature：22.3 ℃；Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Ch6/Area Scan (41x61x1): Measurement grid: dx=15mm, dy=15mm
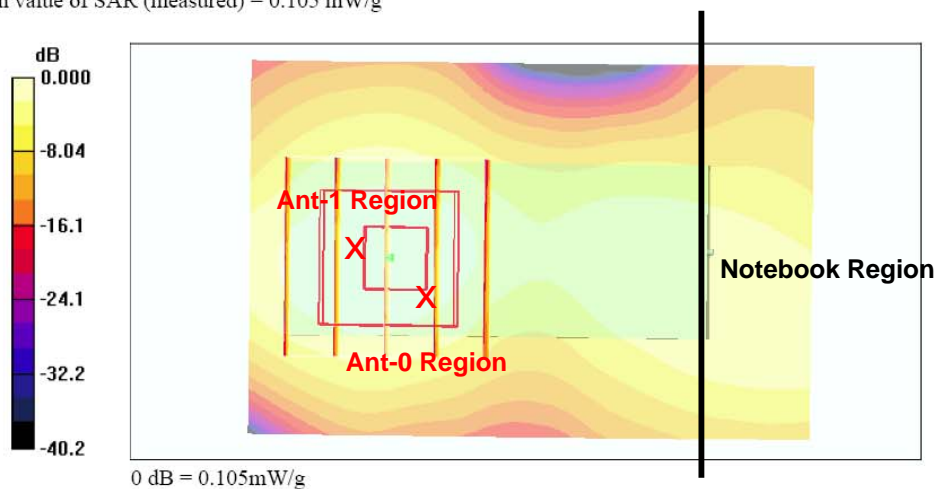Maximum value of SAR (interpolated) = 0.101 mW/g

Ch6/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 5.33 V/m; Power Drift = -0.133 dB
Peak SAR (extrapolated) = 0.220 W/kg
SAR(1 g) = 0.096 mW/g; SAR(10 g) = 0.046 mW/g
Maximum value of SAR (measured) = 0.105 mW/g

0 dB = 0.105mW/g

Test Laboratory: Sporton International Inc. SAR Testing Lab   Date: 4/23/2007

Body_802.11n Ch6_DELL D410 Notebook Bottom Touch_BW 20M_Horizontal USB

DUT: 740305

Communication System: 802.11n; Frequency: 2437 MHz;Duty Cycle: 1:1
Medium: MSL_2450 Medium parameters used: f = 2437 MHz; σ = 1.94 mho/m; ε_r = 52.4; ρ = 1000 kg/m^3
Ambient Temperature：22.6 ℃；Liquid Temperature：21.2 ℃

DASY4 Configuration:
- Probe: ET3DV6 - SN1788; ConvF(4.11, 4.11, 4.11); Calibrated: 9/19/2006
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn577; Calibrated: 11/21/2006
- Phantom: SAM-B; Type: QD 000 P40 C; Serial: TP-1383
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

Ch6/Area Scan (41x61x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (interpolated) = 0.162 mW/g

Ch6/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 6.23 V/m; Power Drift = 0.030 dB
Peak SAR (extrapolated) = 0.358 W/kg
SAR(1 g) = 0.157 mW/g; SAR(10 g) = 0.076 mW/g
Maximum value of SAR (measured) = 0.174 mW/g

0 dB = 0.174mW/g