RF Exposure Lab

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CERTIFICATE OF COMPLIANCE
SAR EVALUATION

Intel Corporation		Dates of Test:	Nov. 27-Dec. 1, 2012
100 Center Point Circle, Suite 200		Test Report Number:	SAR.20121205
Columbia, SC 29210			Revision A

FCC ID:	PD92230BNH
IC Certificate:	1000M-2230BNH
Model(s):	Intel® Centrino® Wireless-N 2230 (Model 2230BNHMW)
SKU(s):	2230BN.HMWLPSG; 2230BN.HMWLPSGC; 2230BN.HMWLPSGP
Test Sample:	Engineering Unit Same as Production
MAC Address:	0015008250CD
Equipment Type:	Wireless Module
Classification:	Portable Transmitter Next to Body
TX Frequency Range:	2412 – 2462 MHz
Frequency Tolerance:	± 2.5 ppm
Maximum RF Output:	2450 MHz (b) – 15.00 dB, 2450 MHz (g) – 15.00 dB, 2450 MHz (n20) – 15.00 dB, 2450 MHz (n40) – 13.52 dB Conducted
Signal Modulation:	DSSS, OFDM
Antenna Type:	Shanghai Universe Communications Electron Co., Ltd., PIFA Antenna
Application Type:	Certification
FCC Rule Parts:	Part 2, 15C, 15E
KDB Test Methodology:	KDB 447498 D01 v05, KDB 248227 v01r02, KDB 616217 D04 v01
Industry Canada:	RSS-102, Safety Code 6
Maximum SAR Value:	0.788 W/kg
Separation Distance:	5 mm

This wireless mobile and/or portable device has been shown to be compliant for localized specific absorption rate (SAR) for uncontrolled environment/general exposure limits specified in ANSI/IEEE Std. C95.1-1992 and had been tested in accordance with the measurement procedures specified in IEEE 1528-2003, IEC 62209-2 and OET Bulletin 65 Supp. C (See test report).

I attest to the accuracy of the data. All measurements were performed by myself or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RF Exposure Lab, LLC certifies that no party to this application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. 853(a).

Jay M. Moulton
Vice President

ACCREDITED
Certificate # 2387.01

Table of Contents

1. Introduction

This measurement report shows compliance of the Intel Corporation Model Intel® Centrino® Wireless-N 2230 (Model 2230BNHMW) FCC ID: PD92230BNH with FCC Part 2, 1093, ET Docket 93-62 Rules for mobile and portable devices and IC Certificate: 1000M-2230BNH with RSS102 & Safety Code 6. The FCC have adopted the guidelines for evaluating the environmental effects of radio frequency radiation in ET Docket 93-62 on August 6, 1996 to protect the public and workers from the potential hazards of RF emissions due to FCC regulated portable devices. [1], [6]

The test results recorded herein are based on a single type test of Intel Corporation Model Intel® Centrino® Wireless-N 2230 (Model 2230BNHMW) and therefore apply only to the tested sample.

The module is sold under two different FCC/IC ID numbers. The ID's ending in "U" are intended to allow user install conditions and host systems must be provided with a BIOS locking feature that prevents installation of unauthorized devices.

The test procedures, as described in ANSI C95.1 – 1999 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz [2], ANSI C95.3 – 2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields [3], FCC OET Bulletin 65 Supp. C – 2001 [4], IEEE Std.1528 – 2003 Recommended Practice [5], and Industry Canada Safety Code 6 Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz were employed.

The following table indicates all the wireless technologies operating in the Intel® Centrino® Wireless-N 2230 (Model 2230BNHMW) wireless modem. The table also shows the tolerance for the power level for each mode.

Band	Technology	Class	3GPP Nominal Power dBm	Setpoint Nominal Power dBm	Tolerance dBm	Lower Tolerance dBm	Upper Tolerance dBm
WLAN – 2.4 GHz	802.11b	N/A	N/A	13.5	±1.5	12.5	15.0
WLAN – 2.4 GHz	802.11g/n(Ch. 1 and 11)	N/A	N/A	11.0	±1.5	9.5	12.5
WLAN – 2.4 GHz	802.11 g/n(Ch. 2-10	N/A	N/A	13.5	±1.5	12.0	15.0

SAR Definition [5]

Specific Absorption Rate is defined as 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).

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

SAR is expressed in units of watts per kilogram (W/kg). *SAR* can be related to the electric field at a point by

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

where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m^3)

E = rms electric field strength (V/m)

2. SAR Measurement Setup

Robotic System

These measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Intel Core2 computer, near-field probe, probe alignment sensor, and the generic twin phantom containing the brain equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF) (see Fig. 2.1).

System Hardware

A cell controller system contains the power supply, robot controller teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the HP Intel Core2 computer with Windows XP system and SAR Measurement Software DASY52, A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

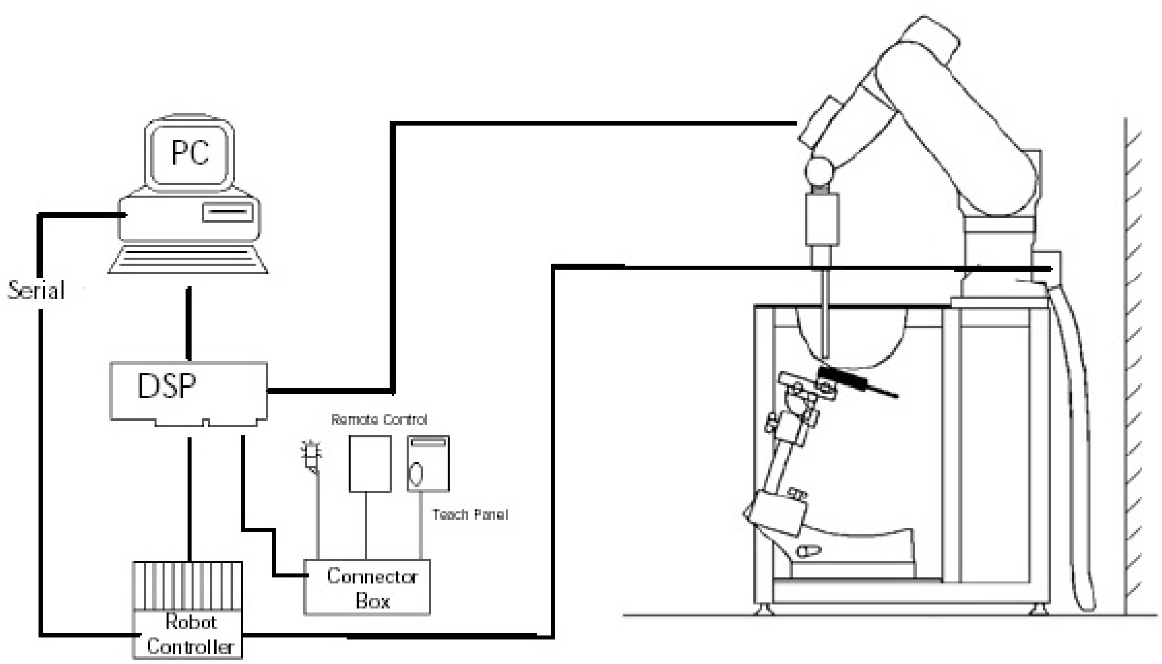


Figure 2.1 SAR Measurement System Setup

System Electronics

The 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 PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer. The system is described in detail in.

Probe Measurement System

The SAR measurements were conducted with the dosimetric probe EX3DV4, designed in the classical triangular configuration (see Fig. 2.2) and optimized for dosimetric evaluation. The probe is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi fiber line ending at the front of the probe tip. (see Fig. 2.3) It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY52 software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped at reaching the maximum.

DAE System

Probe Specifications

Calibration: In air from 10 MHz to 6.0 GHz
In brain and muscle simulating tissue at Frequencies of 450 MHz, 835 MHz, 1750 MHz, 1900 MHz, 2450 MHz, 2600 MHz, 3500 MHz, 5200 MHz, 5300 MHz, 5600 MHz, 5800 MHz

Frequency: 10 MHz to 6 GHz

Linearity: ±0.2dB (30 MHz to 6 GHz)

Dynamic: 10 mW/kg to 100 W/kg

Range: Linearity: ±0.2dB

Dimensions: Overall length: 330 mm

Tip length: 20 mm

Body diameter: 12 mm

Tip diameter: 2.5 mm

Distance from probe tip to sensor center: 1 mm

Application: SAR Dosimetry Testing
Compliance tests of wireless device

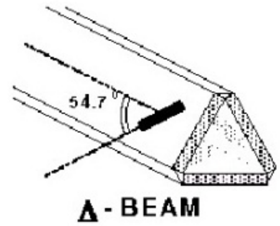


Figure 2.2 Triangular Probe Configurations

Figure 2.3 Probe Thick-Film Technique

Probe Calibration Process

Dosimetric Assessment Procedure

Each probe is calibrated according to a dosimetric assessment procedure described in with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in and found to be better than +/-0.25dB. The sensitivity parameters (Norm X, Norm Y, Norm Z), the diode compression parameter (DCP) and the conversion factor (Conv F) of the probe is tested.

Free Space Assessment

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies below 1 GHz, and in a waveguide above 1GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity at the proper orientation with the field. The probe is then rotated 360 degrees until the three channels show the maximum reading. The power density readings equates to 1 mW/cm^2.

Temperature Assessment *

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium, correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor based temperature probe is used in conjunction with the E-field probe

$$SAR = C\frac{\Delta T}{\Delta t}$$

where:

Δt = exposure time (30 seconds),

C = heat capacity of tissue (brain or muscle),

ΔT = temperature increase due to RF exposure.

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

where:

σ = simulated tissue conductivity,

ρ = Tissue density (1.25 g/cm^3 for brain tissue)

SAR is proportional to $\Delta T / \Delta t$, the initial rate of tissue heating, before thermal diffusion takes place.
Now it's possible to quantify the electric field in the simulated tissue by equating the thermally derived SAR to the E- field;

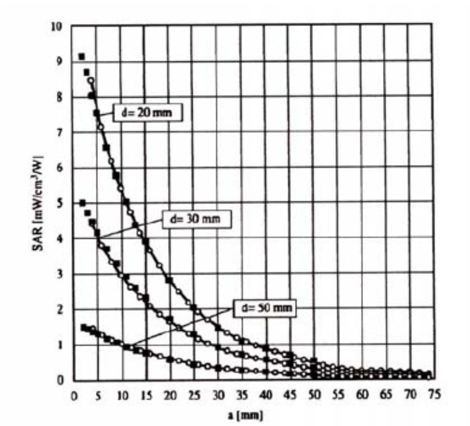


Figure 2.4 E-Field and Temperature Measurements at 900MHz

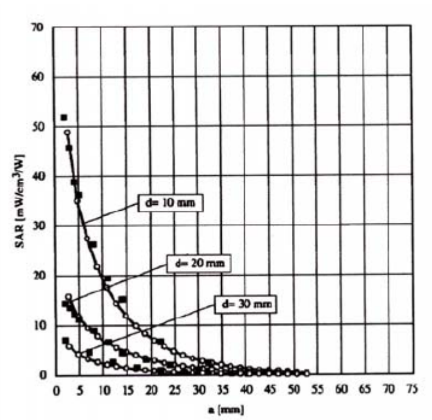


Figure 2.5 E-Field and Temperature Measurements at 1800MHz

Data Extrapolation

The DASY52 software automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. 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 like below;

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

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:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

with V_i = compensated signal of channel i (i = x,y,z)
$Norm_i$ = sensor sensitivity of channel i (i = x,y,z) $\mu V/(V/m)^2$ for E-field probes
ConvF = sensitivity of enhancement in solution
E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermetian 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.

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

with SAR = local specific absorption rate in W/g
E_{tot} = total field strength in V/m
σ = conductivity in [mho/m] or [Siemens/m]
ρ = equivalent tissue density in g/cm^3

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

$$P_{pwe} = \frac{E_{tot}^2}{3770}$$

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

SAM PHANTOM

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90% of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. (see Fig. 2.6)

Phantom Specification

Phantom: SAM Twin Phantom (V4.0)
Shell Material: Vivac Composite
Thickness: 2.0 ± 0.2 mm

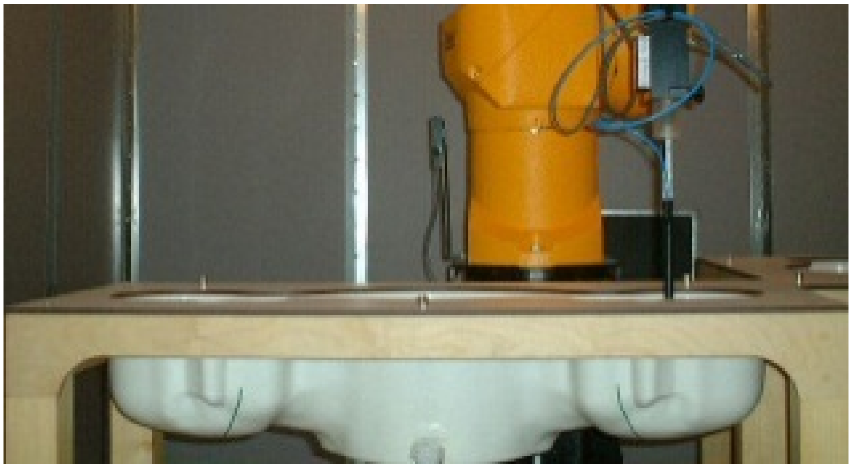


Figure 2.6 SAM Twin Phantom

Device Holder for Transmitters

In combination with the SAM Twin Phantom V4.0 the Mounting Device (see Fig. 2.7), enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation point is the ear opening. The devices can be easily, accurately, and repeat ably be positioned according to the FCC, CENELEC, IEC and IEEE specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

Figure 2.7 Mounting Device

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations. To produce the worst-case condition (the hand absorbs antenna output power), the hand is omitted during the tests.

3. Probe and Dipole Calibration

See Appendix D and E.

4. Phantom & Simulating Tissue Specifications

Head & Body Simulating Mixture Characterization

The head and body mixtures consist of the material based on the table listed below. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. Body tissue parameters that have not been specified in P1528 are derived from the issue dielectric parameters computed from the 4-Cole-Cole equations.

Table 4.1 Typical Composition of Ingredients for Tissue

Ingredients		Simulating Tissue
		2450 MHz Body
Mixing Percentage		
Water		73.20
Sugar		0.00
Salt		0.04
HEC		0.00
Bactericide		0.00
DGBE		26.70
Dielectric Constant	Target	52.70
Conductivity (S/m)	Target	1.95

5. ANSI/IEEE C95.1 – 1992 RF Exposure Limits [2]

Uncontrolled Environment

Uncontrolled Environments are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

Controlled Environment

Controlled Environments are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

Table 5.1 Human Exposure Limits

	UNCONTROLLED ENVIRONMENT General Population (W/kg) or (mW/g)	CONTROLLED ENVIROMENT Professional Population (W/kg) or (mW/g)
SPATIAL PEAK SAR[1] Head	1.60	8.00
SPATIAL AVERAGE SAR[2] Whole Body	0.08	0.40
SPATIAL PEAK SAR[3] Hands, Feet, Ankles, Wrists	4.00	20.00

[1] The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
[2] The Spatial Average value of the SAR averaged over the whole body.
[3] The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

6. Measurement Uncertainty

Exposure Assessment Measurement Uncertainty

Source of Uncertainty	Tolerance Value	Probability Distribution	Divisor	c_i^1 (1-g)	c_i^1 (10-g)	Standard Uncertainty (1-g) %	Standard Uncertainty (10-g) %	v_i
Measurement System								
Probe Calibration	3.5	normal	1	1	1	3.5	3.5	∞
Axial Isotropy	3.7	rectangular	√3	0.7	0.7	1.5	1.5	∞
Hemispherical Isotropy	10.9	rectangular	√3	0.7	0.7	4.4	4.4	∞
Boundary Effect	1.0	rectangular	√3	1	1	0.6	0.6	∞
Linearity	4.7	rectangular	√3	1	1	2.7	2.7	∞
Detection Limit	1.0	rectangular	√3	1	1	0.6	0.6	∞
Readout Electronics	1.0	normal	1	1	1	1.0	1.0	∞
Response Time	0.8	rectangular	√3	1	1	0.5	0.5	∞
Integration Time	1.7	rectangular	√3	1	1	1.0	1.0	∞
RF Ambient Condition	3.0	rectangular	√3	1	1	1.7	1.7	∞
Probe Positioner Mech. Restriction	0.4	rectangular	√3	1	1	0.2	0.2	∞
Probe Positioning with respect to Phantom Shell	2.9	rectangular	√3	1	1	1.7	1.7	∞
Extrapolation and Integration	3.7	rectangular	√3	1	1	2.1	2.1	∞
Test Sample Positioning	4.0	normal	1	1	1	4.0	4.0	7
Device Holder Uncertainty	2.0	normal	1	1	1	2.0	2.0	2
Drift of Output Power	4.2	rectangular	√3	1	1	2.4	2.4	∞
Phantom and Setup								
Phantom Uncertainty(shape & thickness tolerance)	3.4	rectangular	√3	1	1	2.0	2.0	∞
Liquid Conductivity(target)	5.0	rectangular	√3	0.7	0.5	2.0	1.4	∞
Liquid Conductivity(meas.)	0.5	normal	1	0.7	0.5	0.4	0.3	5
Liquid Permittivity(target)	5.0	rectangular	√3	0.6	0.5	1.7	1.4	∞
Liquid Permittivity(meas.)	1.0	normal	1	0.6	0.5	0.6	0.5	5
Combined Uncertainty		RSS				9.6	9.4	>500
Combined Uncertainty (coverage factor=2)		Normal(k=2)				19.1	18.8	>500

7. System Validation

Tissue Verification

Table 7.1 Measured Tissue Parameters

		2450 MHz Body	
Date(s)		Nov. 30, 2012	
Liquid Temperature (˚C)	20.0	Target	Measured
Dielectric Constant: ε		52.70	51.28
Conductivity: σ		1.95	1.92

See Appendix A for data printout.

Test System Verification

Prior to assessment, the system is verified to the ±10% of the specifications at the test frequency by using the system kit. Power is normalized to 1 watt. (Graphic Plots Attached)

Table 7.2 System Dipole Validation Target & Measured

	Test Frequency	Targeted SAR_{1g} (W/kg)	Measure SAR_{1g} (W/kg)	Tissue Used for Verification	Deviation Target and Fast SAR to SAR (%)	Plot Number
30-Nov-2012	2450 MHz	51.50	51.70	Body	+ 0.39	1
30-Nov-2012	2450 MHz	Fast SAR	51.60	Body	- 0.19	2

See Appendix A for data plots.

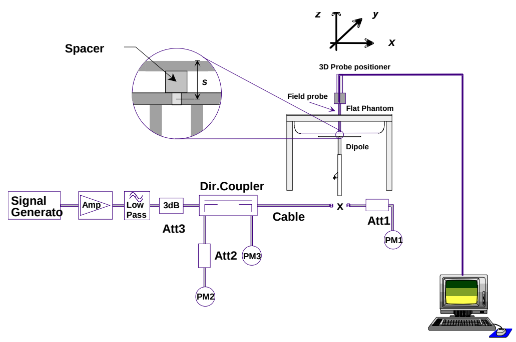


Figure 7.1 Dipole Validation Test Setup

8. SAR Test Data Summary

See Measurement Result Data Pages

See Appendix B for SAR Test Data Plots.
See Appendix C for SAR Test Setup Photos.

Procedures Used To Establish Test Signal

The device was either placed into simulated transmit mode using the manufacturer's test codes or the actual transmission is activated through a base station simulator or similar equipment. See data pages for actual procedure used in measurement.

Device Test Condition

In order to verify that the device was tested at full power, conducted output power measurements were performed before and after each SAR measurement to confirm the output power unless otherwise noted. If a conducted power deviation of more than 5% occurred, the test was repeated. The power drift of each test is measured at the start of the test and again at the end of the test. The drift percentage is calculated by the formula ((end/start)-1)*100 and rounded to three decimal places. The drift percentage is calculated into the resultant SAR value on the data sheet for each test.

The EUT was installed into a laptop computer. The laptop computer was used to configure the EUT to continuously transmit at a maximum output power on the channel specified in the test data.

The data rates used when evaluating the WiFi transmitter were the lowest data rates for each mode. The device was operating at its maximum output power at the lowest data rate for all measurements.

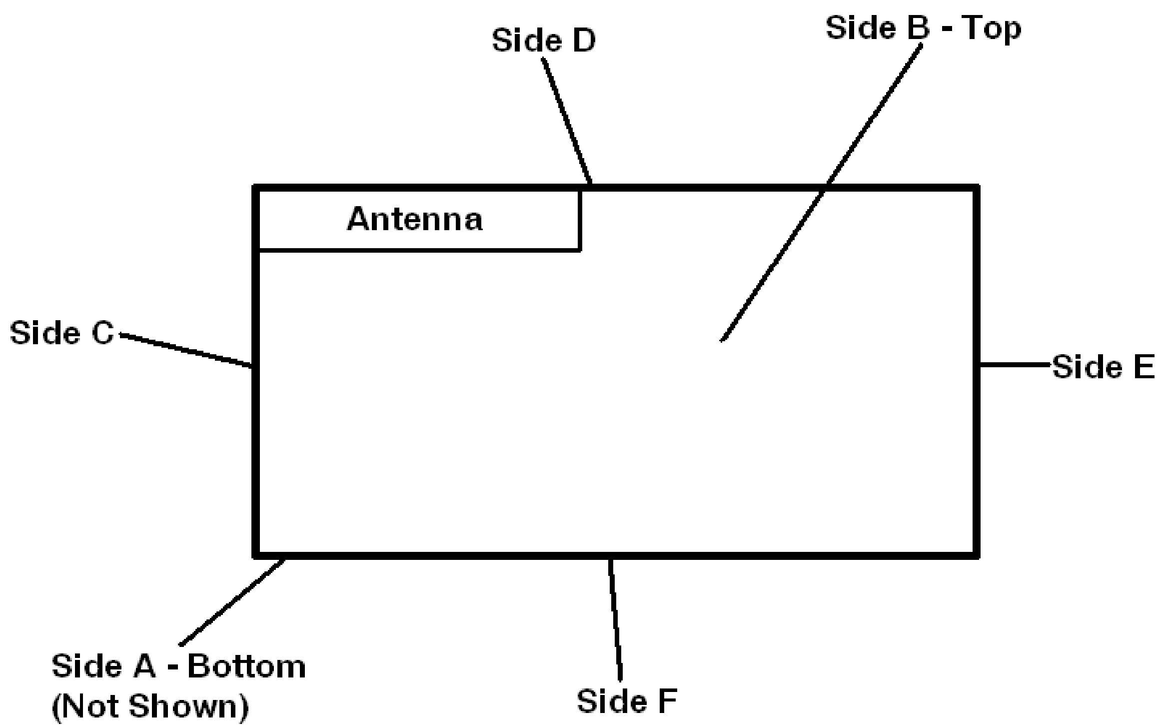
Bluetooth operation was not evaluated as the power level of the BT transmitter was less than 10 mW per KDB 447498 Appendix A. The Bluetooth transmitter does simultaneously transmit with the WiFi transmitter. When the BT is turned on, it transmits on Chain 1 and the WiFi transmits on Chain 2. The installation guide has instructions to the installer to set the two antennas with a minimum of 50 mm separation. Simultaneous transmission is evaluated on page 21.

The PC was using the Intel test utility DRTU Version 1.5.3-0320 and the device driver was version 15.0.0.51.

The EUT antenna is a two-antenna PIFA antenna system – Shanghai Universe Communication Electron Co., Ltd. The antenna connects to the EUT via a non-standard antenna connector.

The antenna was tested on all six sides of the antenna device. During each test, the antenna was on a minimum of 10 cm of Styrofoam during the test. The coaxial cable from the module to the antenna was 500 mm in length. The laptop was set to be >10 cm from the antenna during the test. The following is a pictorial drawing of the locations.

SAR Location Diagram



802.11b						2450 GHz n HT20				
Freq	Channel	Data Rate	Antenna	Power		Freq	Channel	Data Rate	Antenna	Power
2412	1	1	Chain 1	14.95		2412	1	6	Chain 1	12.48
2437	6	1	Chain 1	15.00		2437	6	6	Chain 1	15.00
2462	11	1	Chain 1	14.98		2462	11	6	Chain 1	12.50
2412	1	1	Chain 2	14.92		2412	1	6	Chain 2	12.45
2437	6	1	Chain 2	15.00		2437	6	6	Chain 2	15.00
2462	11	1	Chain 2	14.96		2462	11	6	Chain 2	12.49
802.11g						2450 GHz n HT40				
Freq	Channel	Data Rate	Antenna	Power		Freq	Channel	Data Rate	Antenna	Power
2412	1	6	Chain 1	12.49		2422	3	6	Chain 1	9.58
2437	6	6	Chain 1	15.00		2437	6	6	Chain 1	13.52
2462	11	6	Chain 1	12.50		2452	9	6	Chain 1	10.01
2412	1	6	Chain 2	12.48		2422	3	6	Chain 2	9.04
2437	6	6	Chain 2	15.00		2437	6	6	Chain 2	12.55
2462	11	6	Chain 2	12.47		2452	9	6	Chain 2	9.07

Figure 8.1 Test Reduction Table – WiFi

Mode	Side	Required Channel	Tested/Reduced
802.11b	Side A	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
	Side B	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
	Side C	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
	Side D	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
	Side E	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
	Side F	1 – 2412 MHz	Reduced[1]
		6 – 2437 MHz	Tested
		11 – 2462 MHz	Reduced[1]
802.11g	Side A	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side B	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side C	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side D	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side E	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side F	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
802.11n	Side A	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side B	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side C	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side D	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side E	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]
	Side F	1 – 2412 MHz	Reduced[2]
		6 – 2437 MHz	Reduced[2]
		11 – 2462 MHz	Reduced[2]

Both Chains 1 and 2 were tested per these test reduction requirements.
Reduced[1] – When the mid channel is 3 dB below the limit, the remaining channels are not required per KDB 447498 D01 v05 section 4.3.3 page 13.
Reduced[2] – When the conducted power in this mode is less than 0.25 dB higher than the b mode, testing is not required per KDB 248227 page 5.

SAR Data Summary – 2450 MHz Body 802.11b

MEASUREMENT RESULTS

Gap	Plot	Position	Frequency		Modulation	Antenna	End Power	SAR (W/kg)
			MHz	Ch.			(dBm)	
5 mm	-----	Side A	2437	6	DSSS	Chain 1	15.00	0.625
	-----	Side B	2437	6	DSSS	Chain 1	15.00	0.645
	-----	Side C	2437	6	DSSS	Chain 1	15.00	0.587
	-----	Side D	2437	6	DSSS	Chain 1	15.00	0.714
	-----	Side E	2437	6	DSSS	Chain 1	15.00	0.399
	-----	Side F	2437	6	DSSS	Chain 1	15.00	0.133
	-----	Side A	2437	6	DSSS	Chain 2	15.00	0.609
	-----	Side B	2437	6	DSSS	Chain 2	15.00	0.618
	-----	Side C	2437	6	DSSS	Chain 2	15.00	0.605
	2	Side D	2437	6	DSSS	Chain 2	15.00	0.784
	-----	Side E	2437	6	DSSS	Chain 2	15.00	0.406
	-----	Side F	2437	6	DSSS	Chain 2	15.00	0.139
	1	Side D	2437	6	DSSS	Chain 2	15.00	0.788*

Body
1.6 W/kg (mW/g)
averaged over 1 gram

1. Battery is fully charged for all tests.
   Power Measured ☒Conducted ☐ERP ☐EIRP
2. SAR Measurement
   Phantom Configuration ☐Left Head ☒Uniphantom ☐Right Head
   SAR Configuration ☐Head ☒Body
3. Test Signal Call Mode ☒Test Code ☐Base Station Simulator
4. Test Configuration ☐With Belt Clip ☐Without Belt Clip ☒N/A
5. Tissue Depth is at least 15.0 cm

Jay M. Moulton
Vice President

Note: SAR Tested on the Highest output power channel. All SAR values are the fast SAR evaluation of the DASY5 system. See the photo in Appendix C and diagram on page 14 for a pictorial of the setup and labeling of the test locations.

* The highest value was re-tested doing a complete SAR evaluation per KDB 447498 D01 v05.

SAR Data Summary – Simultaneous Evaluation

MEASUREMENT RESULTS								
Frequency		Modulation	Frequency		Modulation	SAR_1	SAR_2	SAR Total
MHz	Ch.		MHz	Ch.				
2437	6	DSSS	2480	79	GFSK	0.788	0.265	1.053
					Body 1.6 W/kg (mW/g) averaged over 1 gram			

To calculate the separation ratio the following formula is used:

$(SAR_1 + SAR_2)^{1.5}/R_i$ where R_i is in mm

For each of the pairs, the following calculations show the separation ratio at the 50 mm separation stated in the installation guide.

2.4 GHz Band: $(0.791+0.265)^{1.5}/50 = 0.02$

9. Enhanced Energy Coupling

Worst-case test configuration	Band	Antenna-to-person distance (mm)		Peak SAR (W/kg)	Percent Change
Side A	2450 MHz	Initial	5	0.71	-----
		1	10	0.53	-25.5
		2	15	0.29	-58.5
Side B	2450 MHz	Initial	5	0.70	-----
		1	10	0.54	-23.9
		2	15	0.29	-59.0
Side C	2450 MHz	Initial	5	0.73	-----
		1	10	0.53	-26.7
		2	15	0.33	-54.3
Side D	2450 MHz	Initial	5	1.00	-----
		1	10	0.69	-30.5
		2	15	0.51	-49.3
		3	20	0.29	-71.1
Side E	2450 MHz	Initial	5	0.50	-----
		1	10	0.39	-22.7
		2	15	0.25	-49.4
		3	20	0.14	-72.6
Side F	2450 MHz	Initial	5	0.16	-----
		1	10	0.11	-29.1
		2	15	0.07	-54.8

10. Test Equipment List

Table 10.1 Equipment Specifications

Type	Calibration Due Date	Calibration Done Date	Serial Number
Staubli Robot TX60L	N/A	N/A	F07/55M6A1/A/01
Measurement Controller CS8c	N/A	N/A	1012
ELI4 Flat Phantom	N/A	N/A	1065
Device Holder	N/A	N/A	N/A
Data Acquisition Electronics 4	08/15/2013	08/15/2012	759
SAR Software V52.8.2.969	N/A	N/A	N/A
SPEAG E-Field Probe EX3DV4	08/20/2013	08/20/2012	3693
Aprel Validation Dipole ALS-D-2450-S-2 Body	11/18/2013	11/18/2010	RFE-278
Agilent N1911A Power Meter	03/29/2013	03/29/2012	GB45100254
Agilent N1922A Power Sensor	03/29/2013	03/29/2012	MY45240464
Advantest R3261A Spectrum Analyzer	03/29/2013	03/29/2012	31720068
Agilent (HP) 8350B Signal Generator	03/29/2013	03/29/2012	2749A10226
Agilent (HP) 83525A RF Plug-In	03/29/2013	03/29/2012	2647A01172
Agilent (HP) 8753C Vector Network Analyzer	03/29/2013	03/29/2012	3135A01724
Agilent (HP) 85047A S-Parameter Test Set	04/03/2013	04/03/2012	2904A00595
Agilent (HP) 8960 Base Station Sim.	04/05/2014	04/05/2012	MY48360364
Anritsu MT8820C	08/03/2014	08/03/2012	6201176199
Aprel Dielectric Probe Assembly	N/A	N/A	0011
Body Equivalent Matter (2450 MHz)	N/A	N/A	N/A

11. Conclusion

The SAR measurement indicates that the EUT complies with the RF radiation exposure limits of the FCC. These measurements are taken to simulate the RF effects exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters subject to the test. The test results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape, and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because innumerable factors may interact to determine the specific biological outcome of an exposure to electromagnetic fields, any protection guide shall consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

12. References

[1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radio Frequency Radiation, August 1996

[2] ANSI/IEEE C95.1 – 1992, American National Standard Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300kHz to 100GHz, New York: IEEE, 1992.

[3] ANSI/IEEE C95.3 – 1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, 1992.

[4] Federal Communications Commission, OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01), Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, June 2001.

[5] IEEE Standard 1528 – 2003, IEEE Recommended Practice for Determining the Peak-Spatial Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques, October 2003.

[6] Industry Canada, RSS – 102e, Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands), March 2010.

[7] Health Canada, Safety Code 6, Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3kHz to 300 GHz, 2009.

Appendix A – System Validation Plots and Data

****
Test Result for UIM Dielectric Parameter
Fri 30/Nov/2012 11:09:07
Freq Frequency(GHz)
FCC_eH FCC Bulletin 65 Supplement C (June 2001) Limits for Head Epsilon
FCC_sH FCC Bulletin 65 Supplement C (June 2001) Limits for Head Sigma
FCC_eB FCC Limits for Body Epsilon
FCC_sB FCC Limits for Body Sigma
Test_e Epsilon of UIM
Test_s Sigma of UIM
****

Freq	FCC_eB	FCC_sB	Test_e	Test_s
2.4000	52.77	1.90	51.35	1.90
2.4100	52.75	1.91	51.33	1.91
2.4200	52.74	1.92	51.32	1.91
2.4300	52.73	1.93	51.31	1.91
2.4370	52.71	1.94	51.296	1.917*
2.4400	52.71	1.94	51.29	1.92
2.4500	52.70	1.95	51.28	1.92
2.4600	52.69	1.96	51.26	1.93
2.4700	52.67	1.98	51.24	1.94
2.4800	52.66	1.99	51.23	1.94
2.4900	52.65	2.01	51.21	1.95
2.5000	52.64	2.02	51.17	1.96

RF Exposure Lab

Plot 1

DUT: Dipole 2450 MHz; Type: ALS-D-2450-S-2; SN:RFE-278

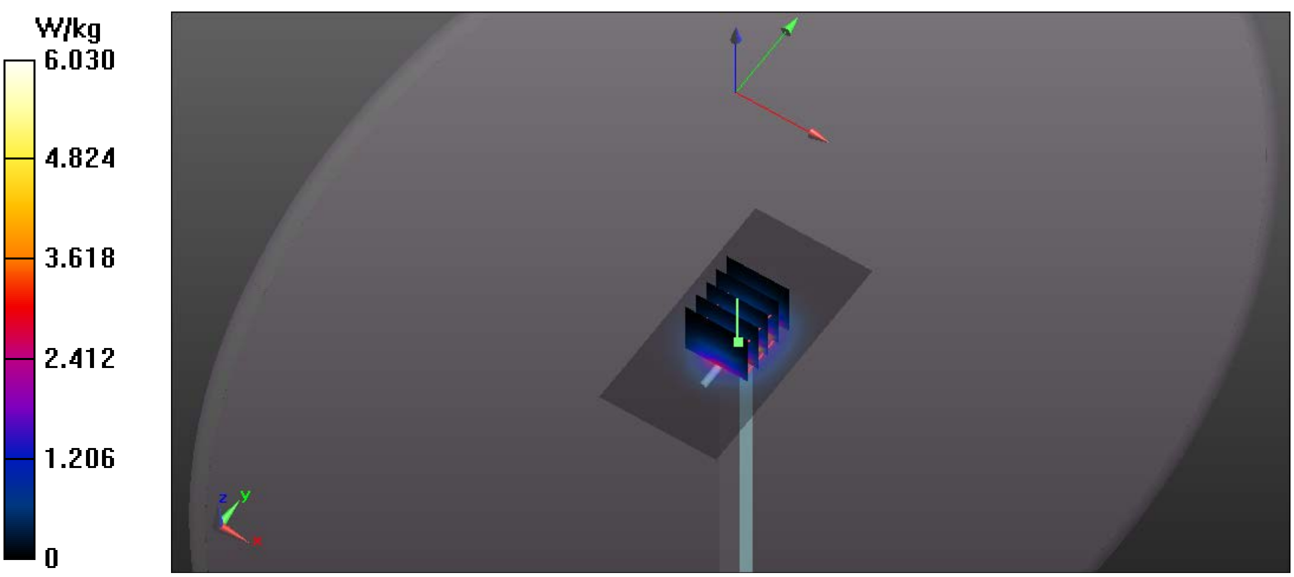
Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: MSL2450; Medium parameters used: f = 2450 MHz; σ = 1.93 mho/m; ε_r = 51.68; ρ = 1000 kg/m^3
Phantom section: Flat Section

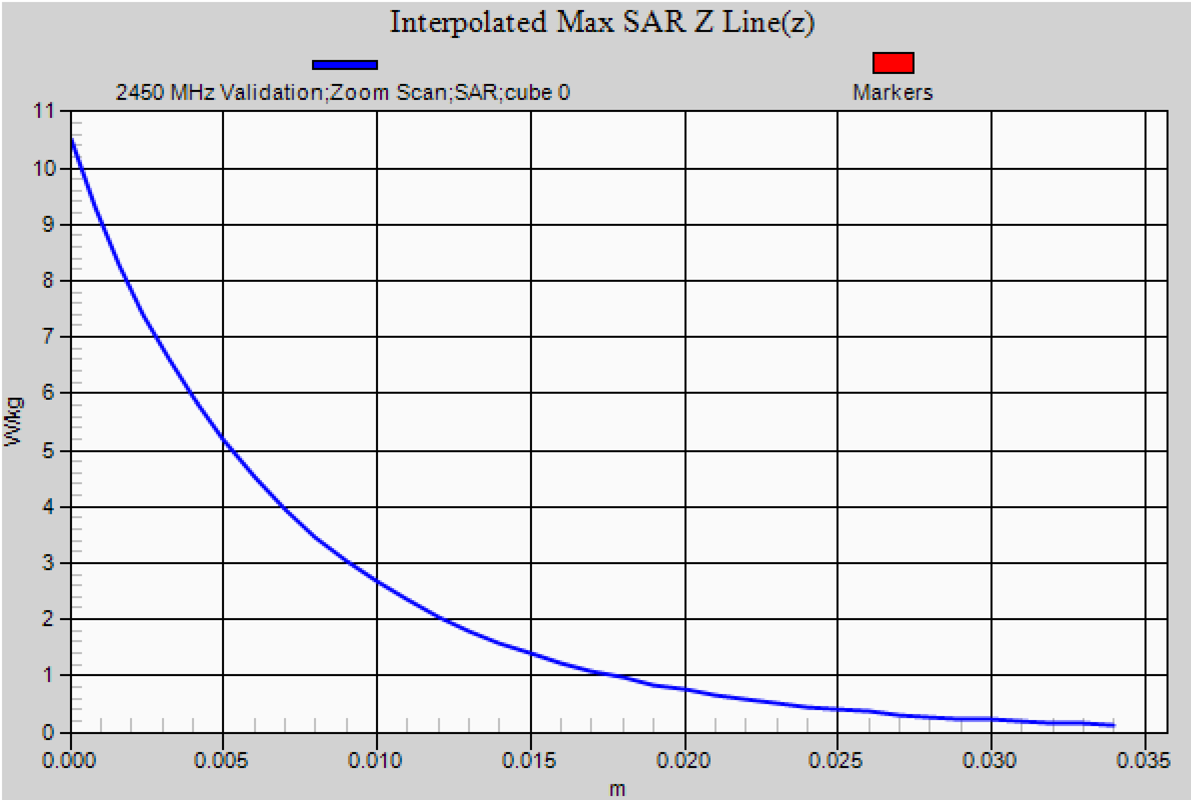
Test Date: Date: 11/30/2012; Ambient Temp: 23 °C; Tissue Temp: 21 °C
Probe: EX3DV4 - SN3693; ConvF(6.76, 6.76, 6.76); Calibrated: 8/20/2012;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn759; Calibrated: 8/15/2012
Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1065
Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Procedure Notes:

2450 MHz Body Verification/Area Scan (41x81x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 6.03 W/kg

2450 MHz Body Verification/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 54.345 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 10.504 mW/g
SAR(1 g) = 5.17 mW/g; SAR(10 g) = 2.39 mW/g
Maximum value of SAR (measured) = 5.90 W/kg




Interpolated Max SAR Z Line(z)
2450 MHz Validation;Zoom Scan;SAR;cube 0
Markers
W/kg
11
10
9
8
7
6
5
4
3
2
1
0
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
m

RF Exposure Lab

Plot 2

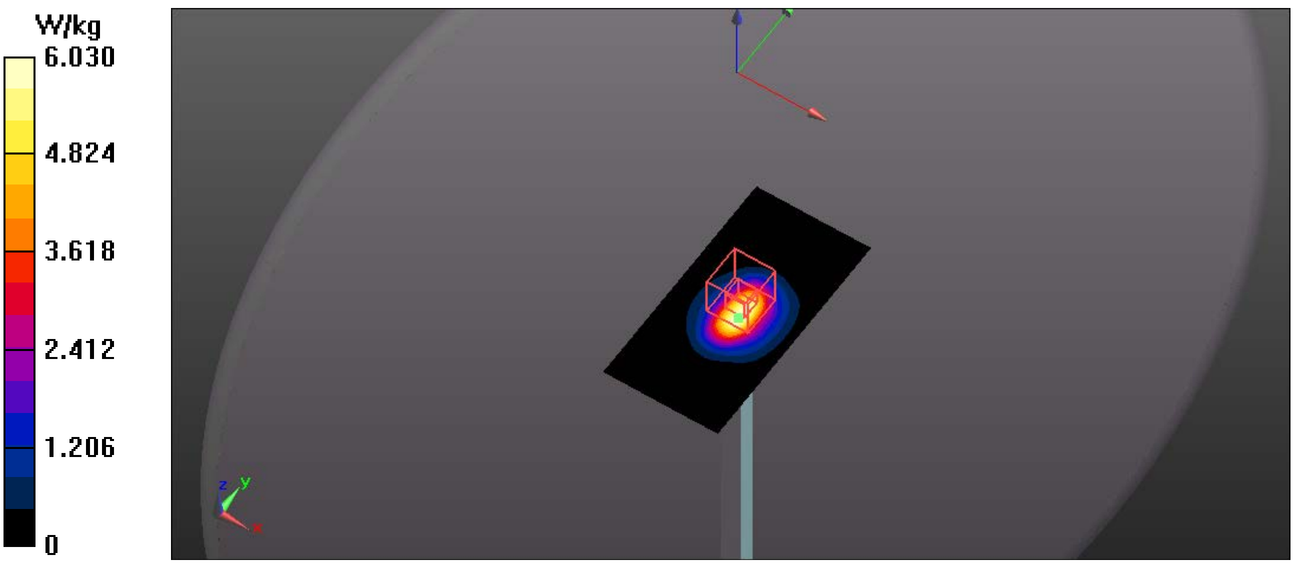
DUT: Dipole 2450 MHz; Type: ALS-D-2450-S-2; SN:RFE-278

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1
Medium: MSL2450; Medium parameters used: f = 2450 MHz; σ = 1.93 mho/m; ε_r = 51.68; ρ = 1000 kg/m^3
Phantom section: Flat Section

Test Date: Date: 11/30/2012; Ambient Temp: 23 °C; Tissue Temp: 21 °C
Probe: EX3DV4 - SN3693; ConvF(6.76, 6.76, 6.76); Calibrated: 8/20/2012;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn759; Calibrated: 8/15/2012
Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1065
Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

Procedure Notes:

2450 MHz Body Verification/Area Scan (41x81x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Reference Value = 54.345 V/m; Power Drift = -0.03 dB
Fast SAR: SAR(1 g) = 5.16 mW/g; SAR(10 g) = 2.3 mW/g
Maximum value of SAR (interpolated) = 6.03 W/kg



Appendix B – SAR Test Data Plots

RF Exposure Lab

Plot 1

DUT: 2230BNHMW; Type: Modular; Serial: 0015008250CD

Communication System: WiFi 802.11b (DSSS, 1 Mbps); Frequency: 2437 MHz; Duty Cycle: 1:1
Medium: MSL2450; Medium parameters used (interpolated): f = 2437 MHz; σ = 1.917 mho/m; ε_r = 51.296; ρ = 1000 kg/m^3
Phantom section: Flat Section

Test Date: Date: 11/30/2012; Ambient Temp: 23 °C; Tissue Temp: 21 °C
Probe: EX3DV4 - SN3693; ConvF(6.76, 6.76, 6.76); Calibrated: 8/20/2012;
Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 1.4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn759; Calibrated: 8/15/2012
Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1065
Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

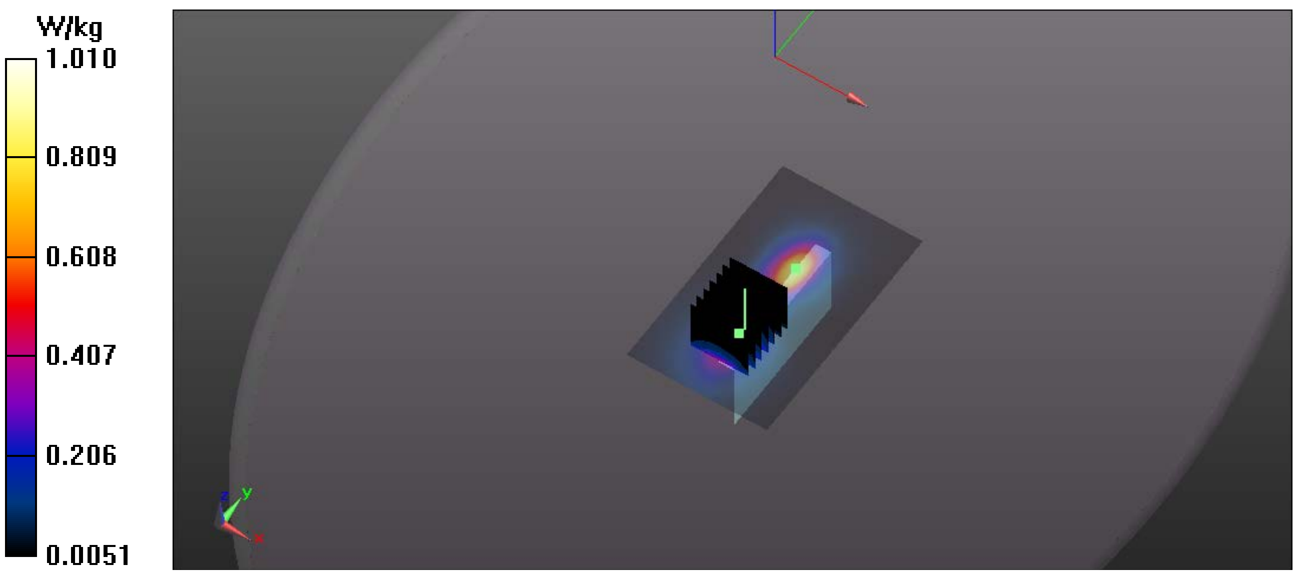
Procedure Notes:

2450 MHz - WiFi/Chain B Side D Mid/Area Scan (61x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 1.01 W/kg

2450 MHz - WiFi/Chain B Side D Mid/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 14.665 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 2.669 mW/g
SAR(1 g) = 0.788 mW/g; SAR(10 g) = 0.327 mW/g

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 1.82 W/kg



RF Exposure Lab

Plot 2

DUT: 2230BNHMW; Type: Modular; Serial: 0015008250CD

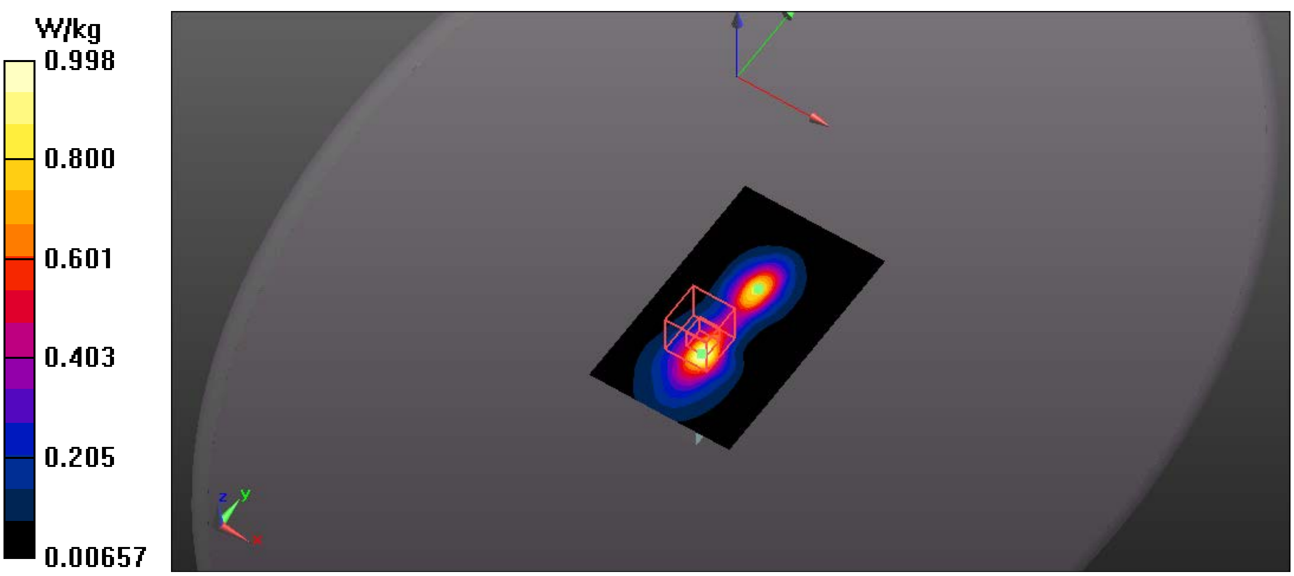
Communication System: WiFi 802.11b (DSSS, 1 Mbps); Frequency: 2437 MHz; Duty Cycle: 1:1
Medium: MSL2450; Medium parameters used (interpolated): f = 2437 MHz; σ = 1.917 mho/m; ε_r = 51.296; ρ = 1000 kg/m^3
Phantom section: Flat Section

Test Date: Date: 11/30/2012; Ambient Temp: 23 °C; Tissue Temp: 21 °C
Probe: EX3DV4 - SN3693; ConvF(6.76, 6.76, 6.76); Calibrated: 8/20/2012;
Sensor-Surface: 4mm (Mechanical Surface Detection)
Electronics: DAE4 Sn759; Calibrated: 8/15/2012
Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1065
Measurement SW: DASY52, Version 52.8 (2); SEMCAD X Version 14.6.6 (6824)

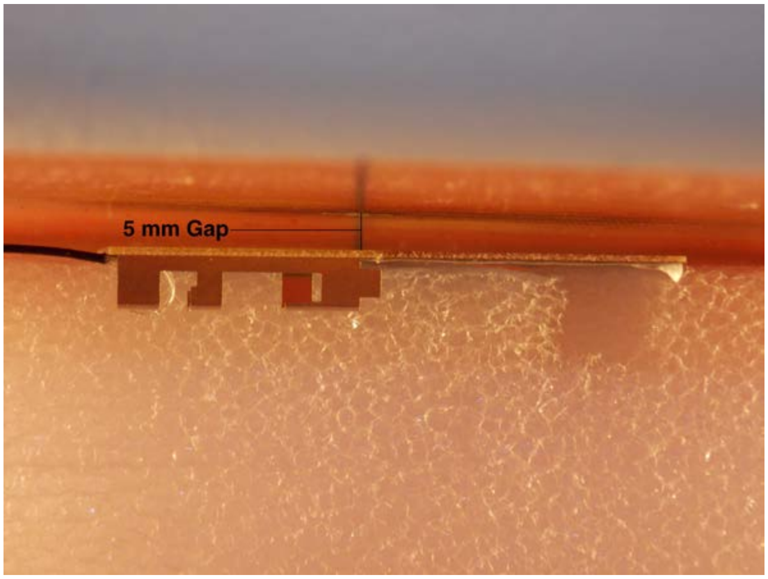
Procedure Notes:

2450 MHz - WiFi/Chain B Side D Mid/Area Scan (61x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Reference Value = 14.692 V/m; Power Drift = 0.04 dB
Fast SAR: SAR(1 g) = 0.784 mW/g; SAR(10 g) = 0.324 mW/g

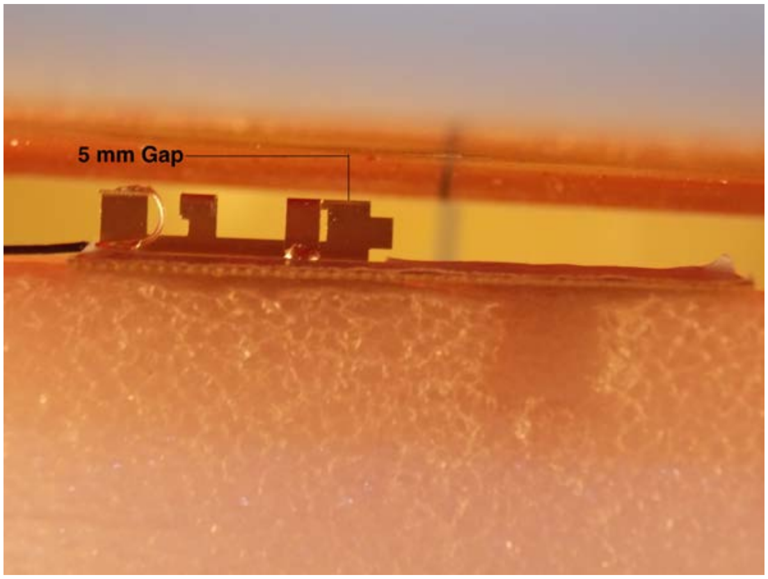
Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.998 W/kg



Appendix C – SAR Test Setup Photos

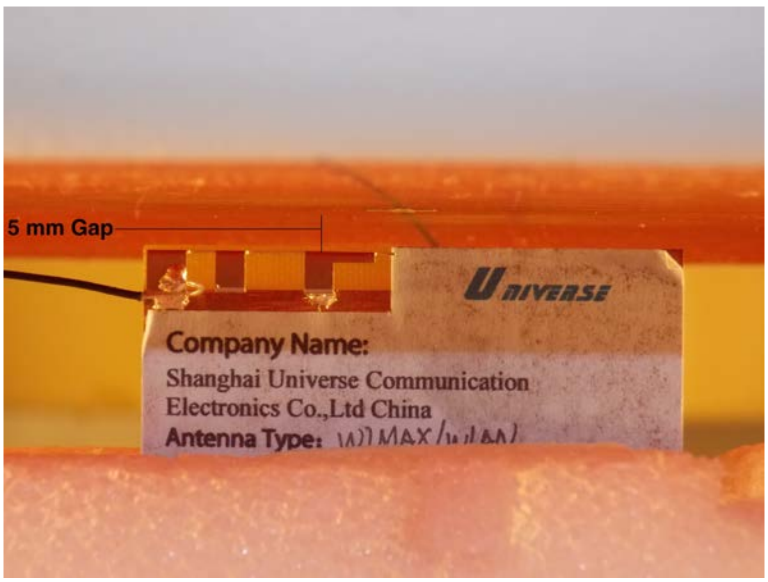


Test Position Side A 5 mm Gap

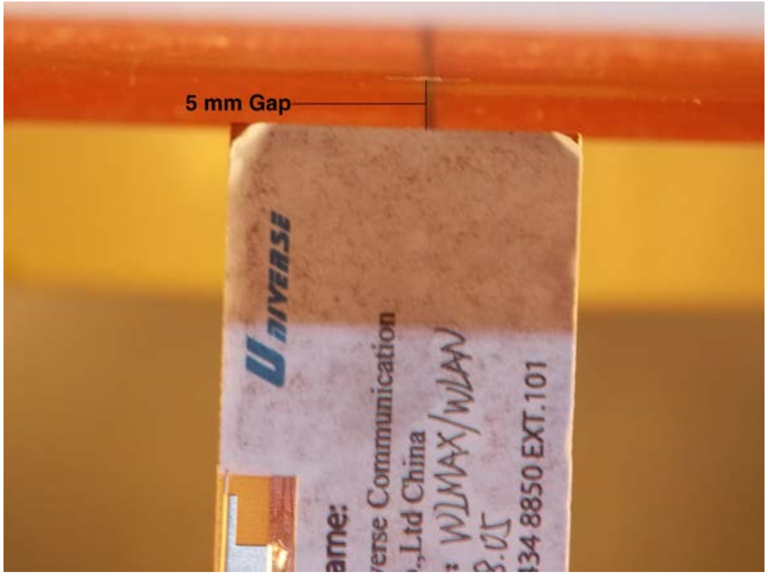


Test Position Side B 5 mm Gap

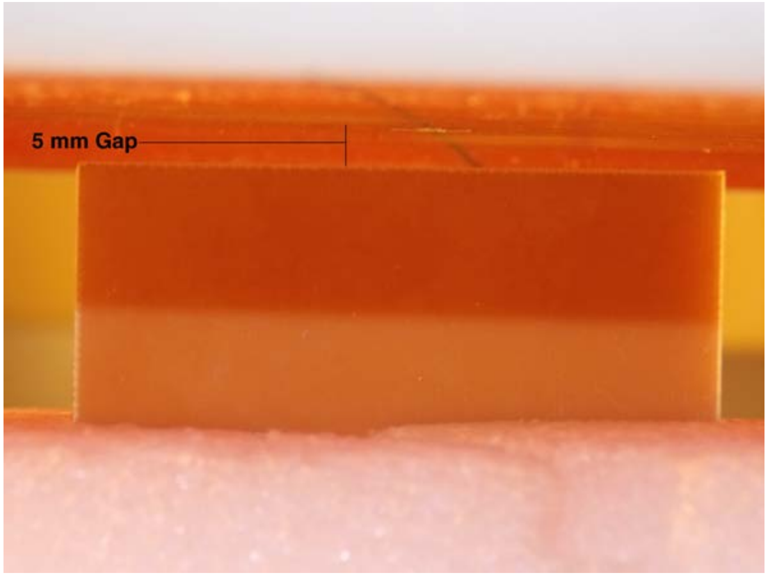
Test Position Side C 5 mm Gap



Test Position Side D 5 mm Gap



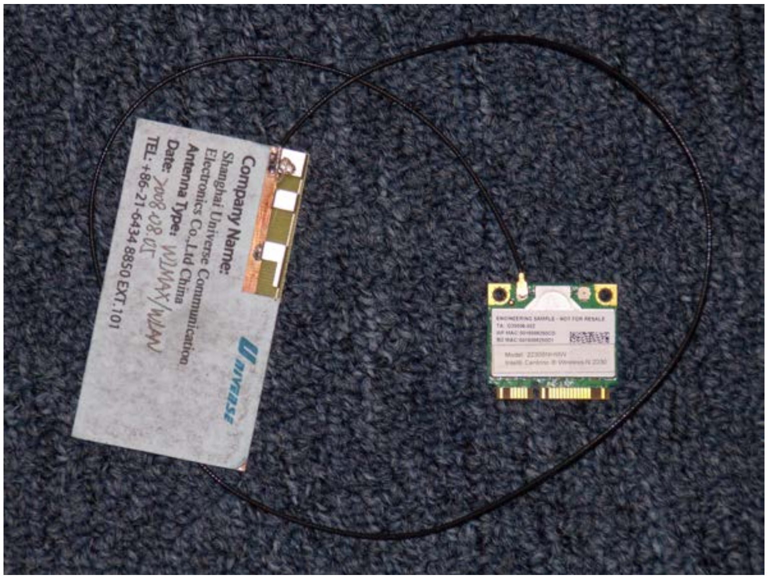
Test Position Side E 5 mm Gap



Test Position Side F 5 mm Gap

Test Locations

Module


Company Name:
Shanghai Universe Communication
Electronics Co.,Ltd China
Antenna Type: WIMAX/WLAN
Date:
TEL: +86-21-6434 8850 EXT.101
Universe

Test System

Appendix D – Probe Calibration Data Sheets

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

Client **RF Exposure Lab**

Certificate No: EX3-3693_Aug12

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3693
Calibration procedure(s)	QA CAL-01.v8, QA CAL-14.v3, QA CAL-23.v4, QA CAL-25.v4 Calibration procedure for dosimetric E-field probes
Calibration date:	August 20, 2012

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe ES3DV2	SN: 3013	29-Dec-11 (No. ES3-3013_Dec11)	Dec-12
DAE4	SN: 660	20-Jun-12 (No. DAE4-660_Jun12)	Jun-13
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: August 20, 2012

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z, VRx,y,z: A, B, C* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

Probe EX3DV4

SN:3693

Manufactured: April 22, 2009
Calibrated: August 20, 2012

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3693

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.49	0.48	0.46	± 10.1 %
DCP (mV)[B]	98.3	100.5	98.2	

Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc[E] (k=2)
0	CW	0.00	X	0.00	0.00	1.00	161.4	±3.0 %
			Y	0.00	0.00	1.00	154.4	
			Z	0.00	0.00	1.00	158.9	

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3693

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	8.99	8.99	8.99	0.23	1.20	± 12.0 %
835	41.5	0.90	8.55	8.55	8.55	0.18	1.56	± 12.0 %
1750	40.1	1.37	8.00	8.00	8.00	0.51	0.76	± 12.0 %
1900	40.0	1.40	7.67	7.67	7.67	0.75	0.63	± 12.0 %
2450	39.2	1.80	6.72	6.72	6.72	0.29	1.09	± 12.0 %
2550	39.1	1.91	6.55	6.55	6.55	0.39	0.93	± 12.0 %
5200	36.0	4.66	4.97	4.97	4.97	0.30	1.80	± 13.1 %
5300	35.9	4.76	4.78	4.78	4.78	0.30	1.80	± 13.1 %
5600	35.5	5.07	4.22	4.22	4.22	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.34	4.34	4.34	0.40	1.80	± 13.1 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

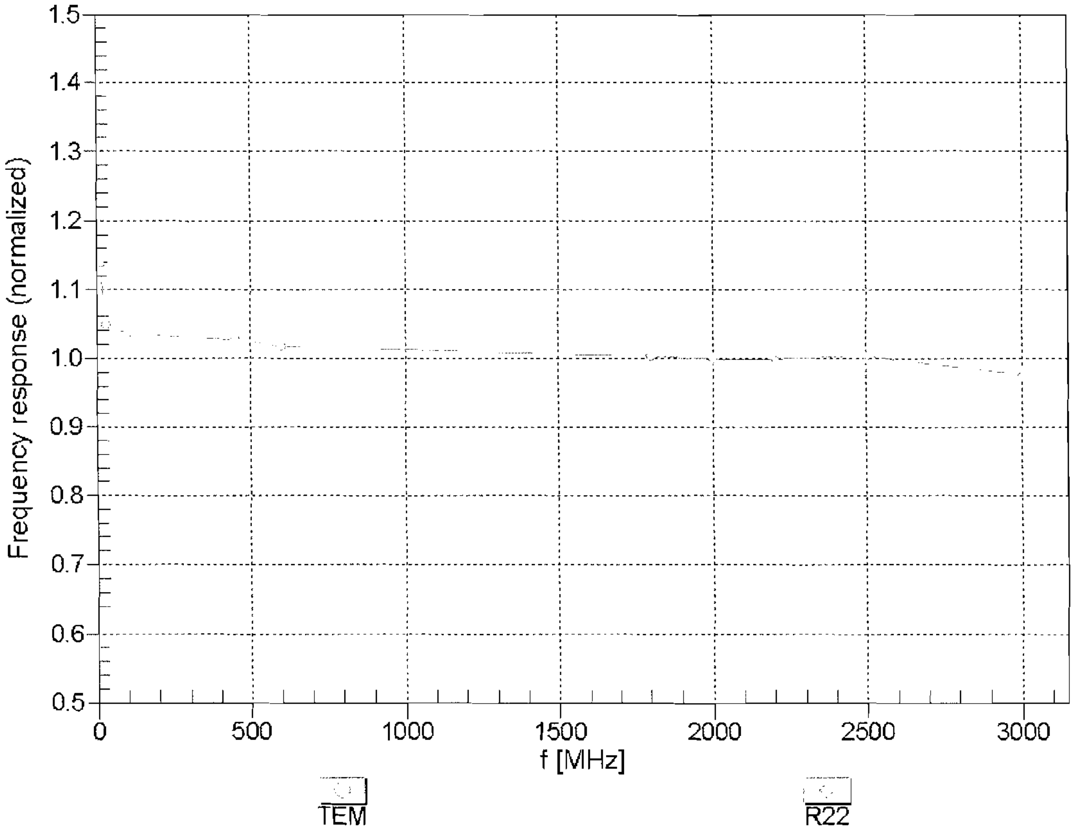
DASY/EASY - Parameters of Probe: EX3DV4 - SN:3693

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	8.84	8.84	8.84	0.29	1.09	± 12.0 %
835	55.2	0.97	8.87	8.87	8.87	0.60	0.71	± 12.0 %
1750	53.4	1.49	7.43	7.43	7.43	0.41	0.85	± 12.0 %
1900	53.3	1.52	7.13	7.13	7.13	0.41	0.82	± 12.0 %
2450	52.7	1.95	6.76	6.76	6.76	0.80	0.50	± 12.0 %
2550	52.6	2.09	6.75	6.75	6.75	0.80	0.50	± 12.0 %
5200	49.0	5.30	4.31	4.31	4.31	0.45	1.90	± 13.1 %
5300	48.9	5.42	4.24	4.24	4.24	0.40	1.90	± 13.1 %
5600	48.5	5.77	3.76	3.76	3.76	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.08	4.08	4.08	0.50	1.90	± 13.1 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

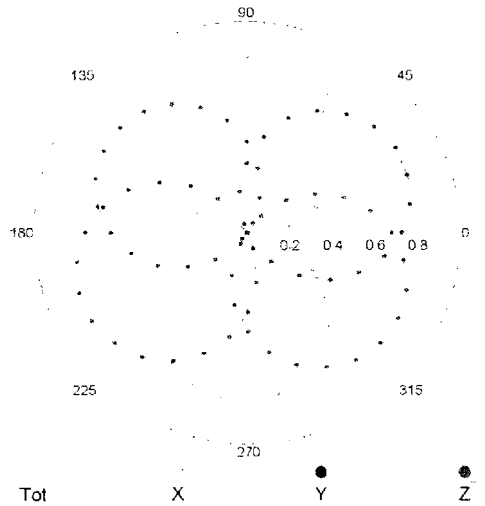
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



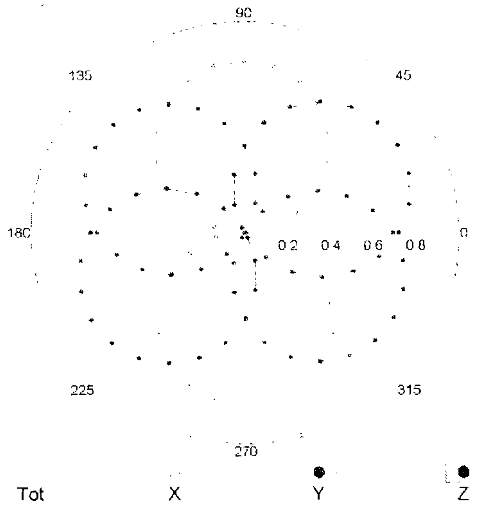
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

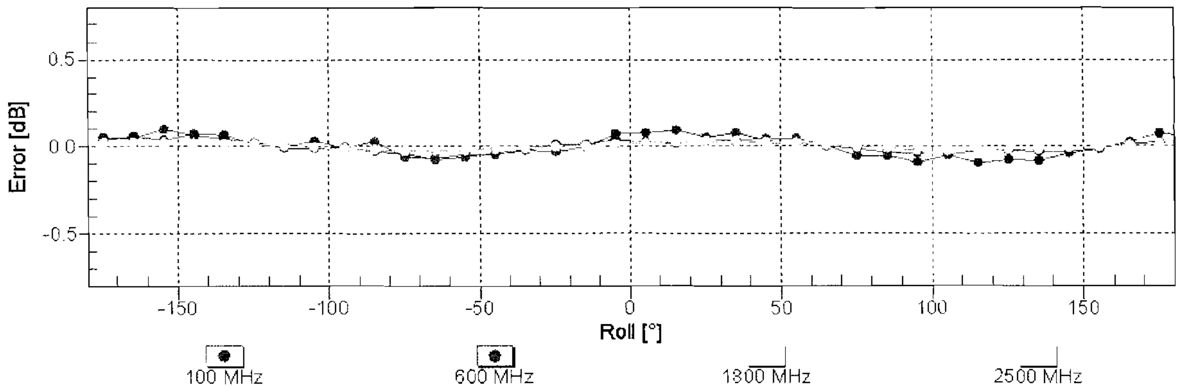
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



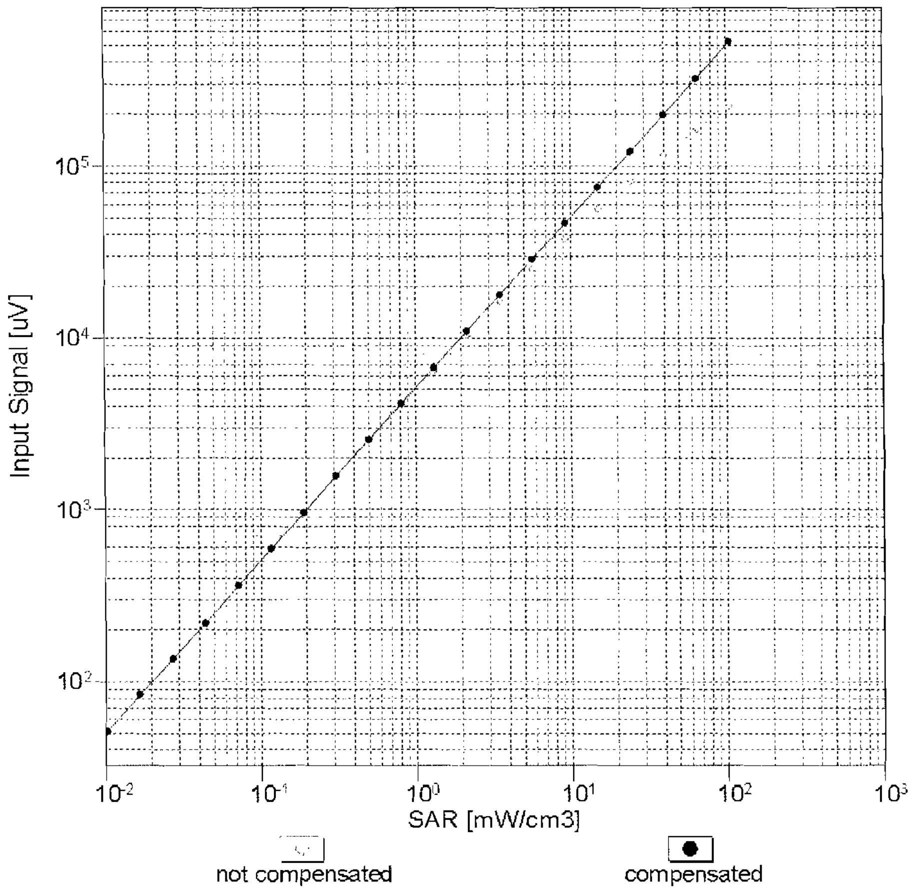
f=1800 MHz,R22

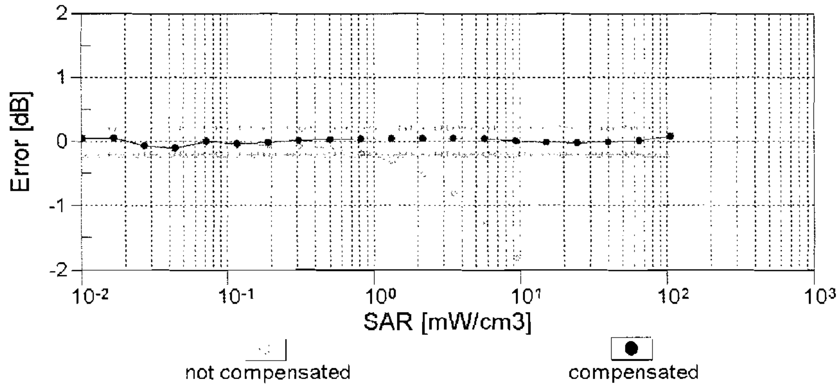




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR_{head})
(TEM cell , f = 900 MHz)

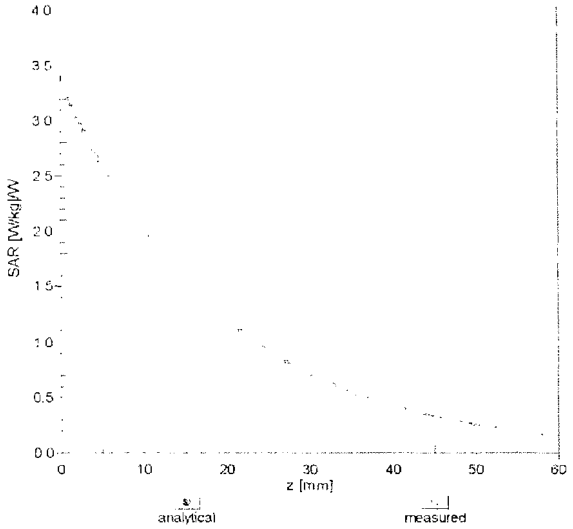




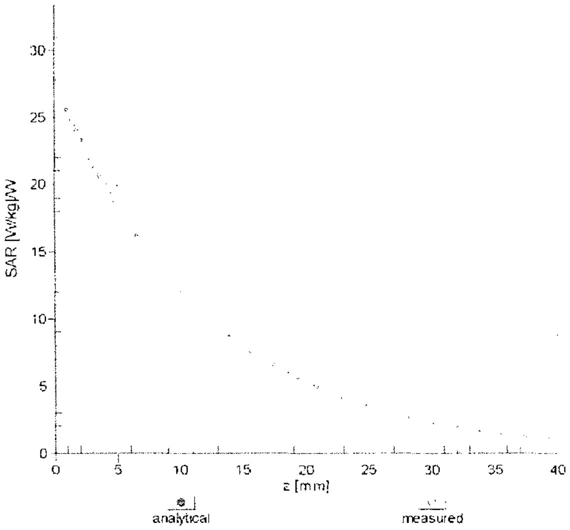
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

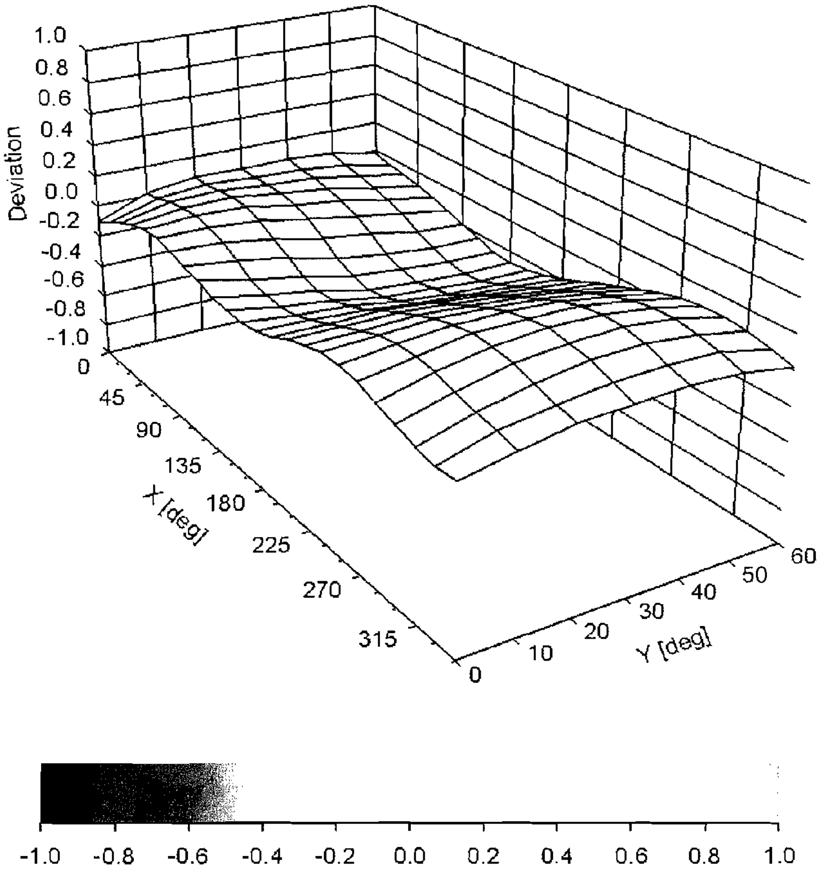


f = 1900 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3693

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	155.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	2 mm

Appendix E – Dipole Calibration Data Sheets

NCL CALIBRATION LABORATORIES

Calibration File No: DC-1182
Project Number: RFEB-5552

CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the **NCL CALIBRATION LABORATORIES** by qualified personnel following recognized procedures and using transfer standards traceable to NRC/NIST.

Validation Dipole

Manufacturer: APREL Laboratories
Part number: ALS-D-2450-S-2
Frequency: 2450 MHz Body
Serial No: RFE-278

Customer: RFEL
Body Calibration

Calibrated: 18th November 2010
Released on: 19th November 2010

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: ______________________

NCL CALIBRATION LABORATORIES

51 SPECTRUM WAY
NEPEAN, ONTARIO
CANADA K2R 1E6

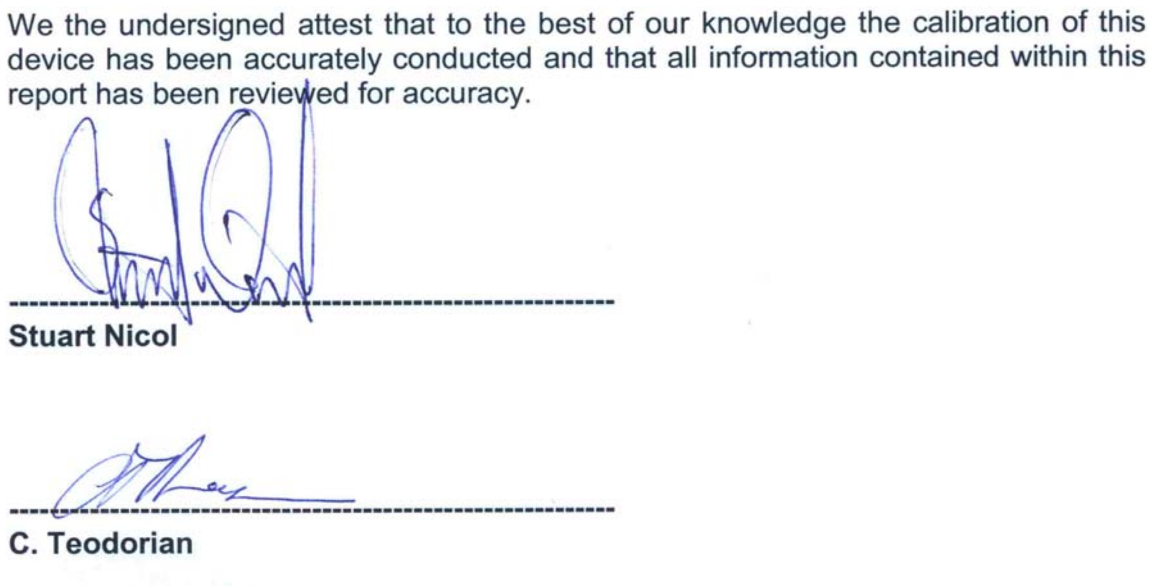
Division of APREL Lab.
TEL: (613) 820-4988
FAX: (613) 820-4162

Conditions

Dipole RFE-278 was a new calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 21 °C +/- 0.5°C

We the undersigned attest that to the best of our knowledge the calibration of this device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.


We the undersigned attest that to the best of our knowledge the calibration of this device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.

Stuart Nicol

C. Teodorian

Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

Mechanical Dimensions

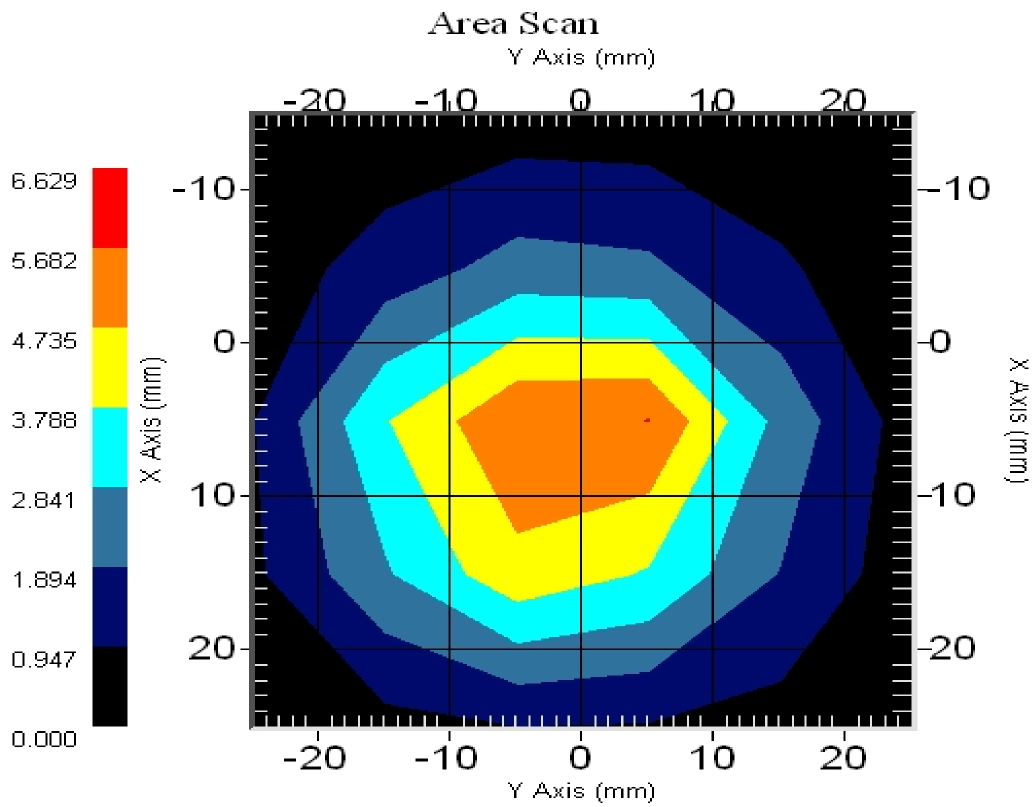
Length: 51.5 mm
Height: 30.4 mm

Electrical Specification

SWR: 1.249 U
Return Loss: -19.170 dB
Impedance: 42.223 Ω

System Validation Results @ 100mW

Frequency	1 Gram	10 Gram	Peak
2450 MHz	5.15	2.31	10.01



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Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole RFE-278. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 130 MHz to 26 GHz E-Field Probe Serial Number 226.

References

SSI-TP-018-ALSAS Dipole Calibration Procedure
SSI-TP-016 Tissue Calibration Procedure
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"

Conditions

Dipole RFE-278 was a re-calibration.

Ambient Temperature of the Laboratory: 22 °C +/- 0.5°C
Temperature of the Tissue: 20 °C +/- 0.5°C

Dipole Calibration uncertainty

The calibration uncertainty for the dipole is made up of various parameters presented below.

Mechanical	1%
Positioning Error	1.22%
Electrical	1.7%
Tissue	2.2%
Dipole Validation	2.2%
TOTAL	**8.32% (16.64% K=2)**

Dipole Calibration Results

Mechanical Verification

APREL Length	APREL Height	Measured Length	Measured Height
51.5 mm	30.4 mm	52.1 mm	31.0 mm

Tissue Validation

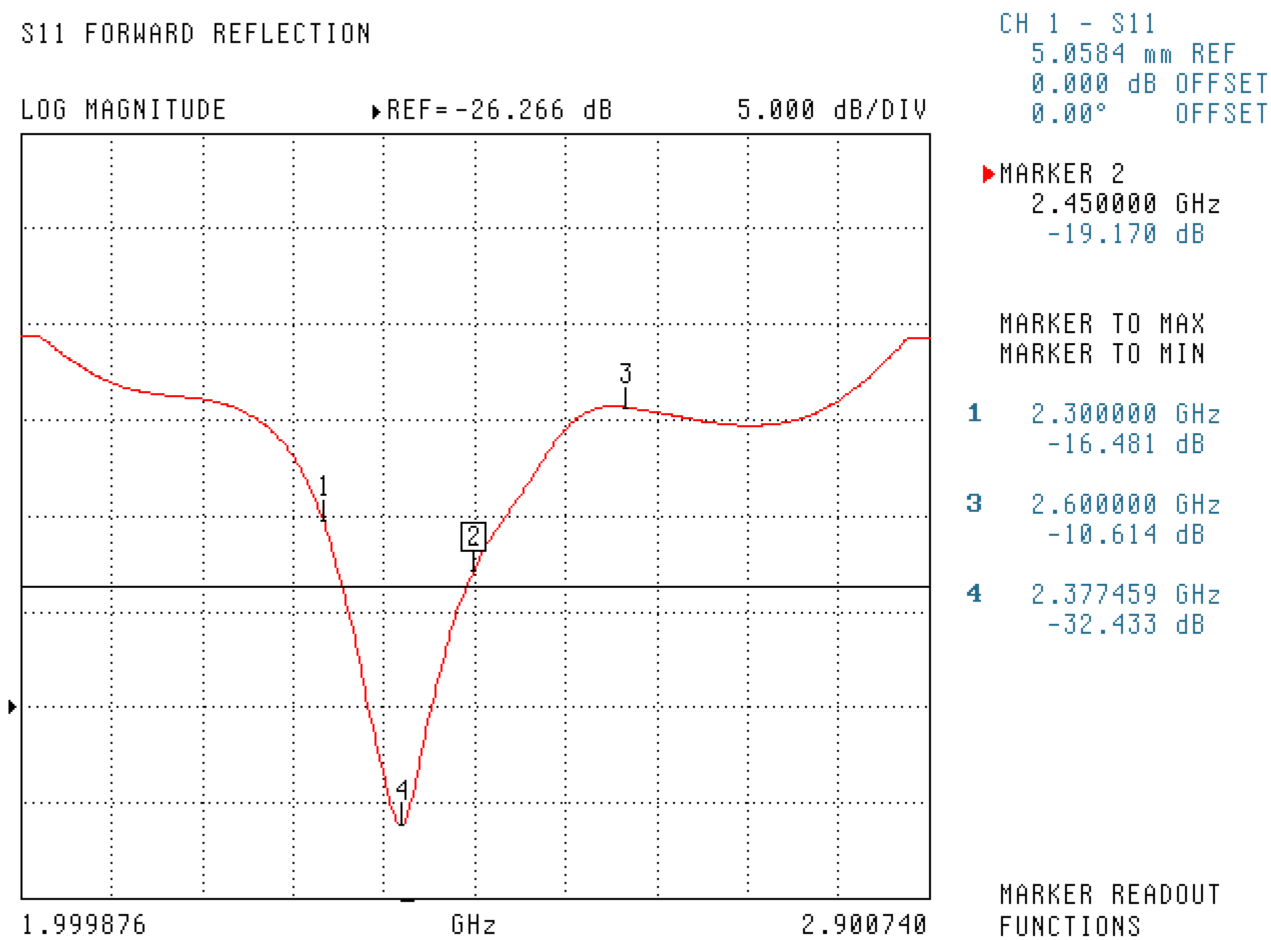
Body Tissue 2450 MHz	Measured
Dielectric constant, ε_r	52.0
Conductivity, σ [S/m]	1.92

Electrical Calibration

Test	Result
S11 R/L	-19.170 dB
SWR	1.249 U
Impedance	42.223 Ω

The Following Graphs are the results as displayed on the Vector Network Analyzer.

S11 Parameter Return Loss



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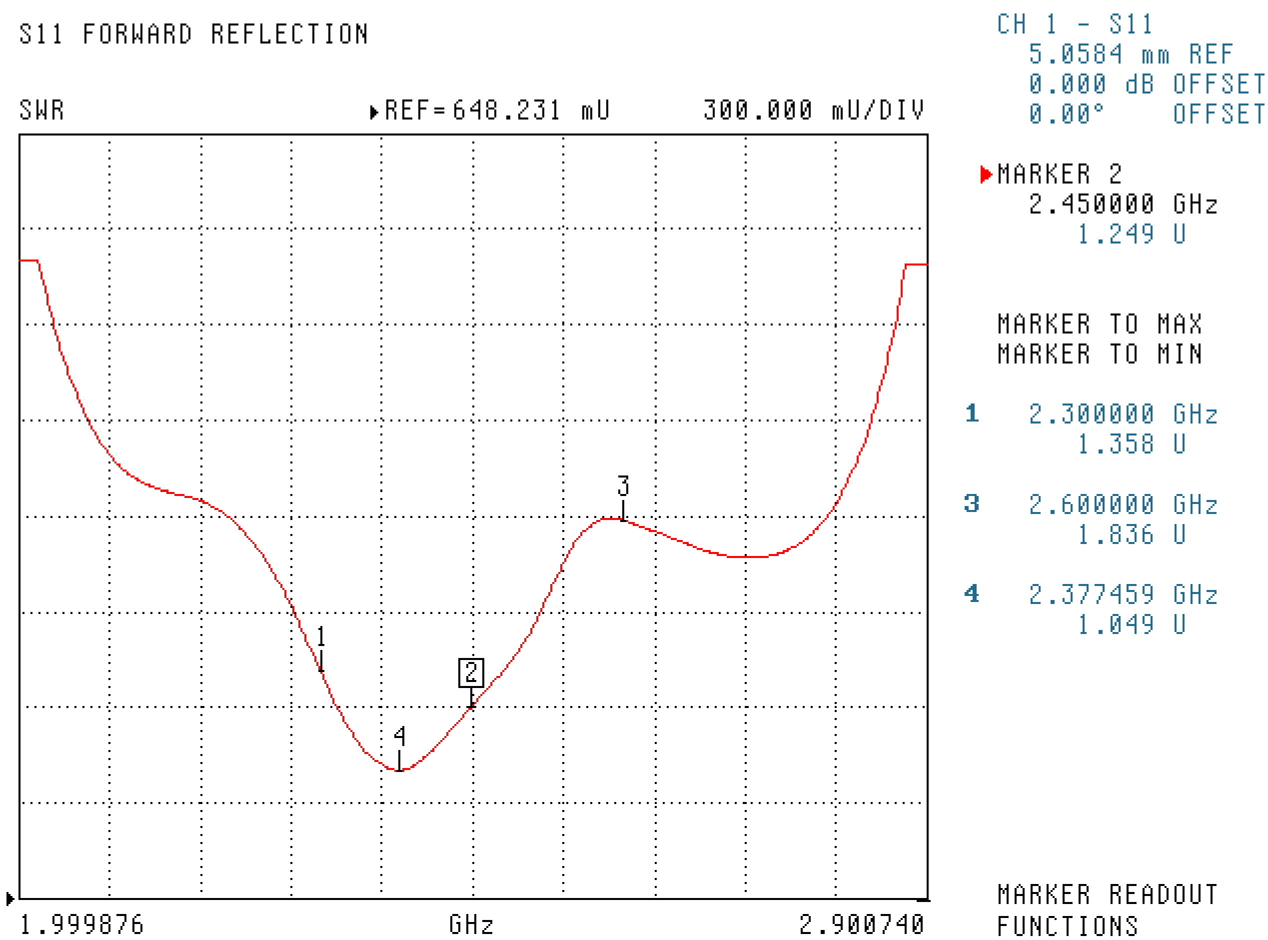
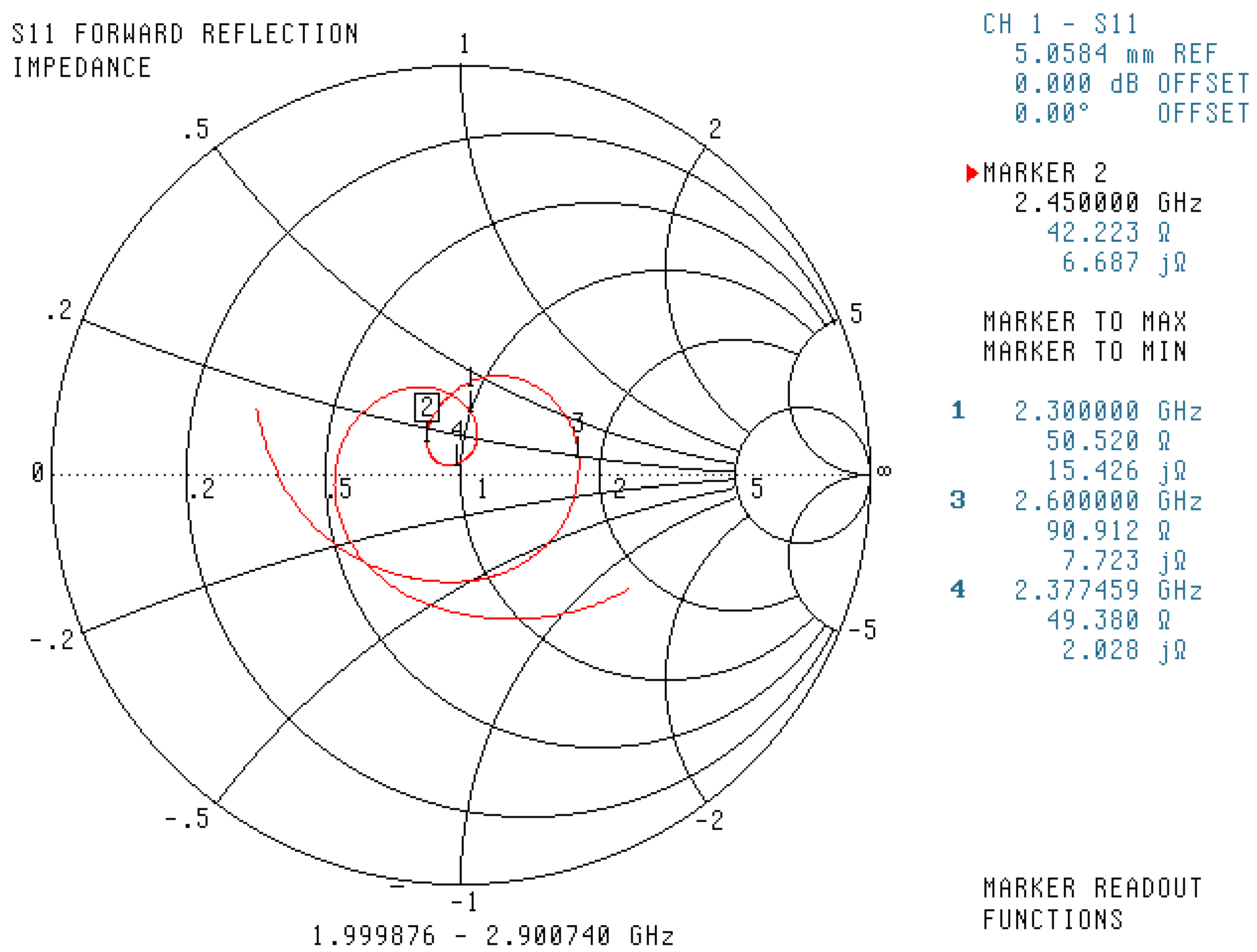
SWR


S11 FORWARD REFLECTION
SWR
REF=648.231 mU
300.000 mU/DIV
1.999876
GHz
2.900740
CH 1 - S11
5.0584 mm REF
0.000 dB OFFSET
0.00° OFFSET
MARKER 2
2.450000 GHz
1.249 U
MARKER TO MAX
MARKER TO MIN
1 2.300000 GHz
1.358 U
3 2.600000 GHz
1.836 U
4 2.377459 GHz
1.049 U
MARKER READOUT
FUNCTIONS

Smith Chart Dipole Impedance

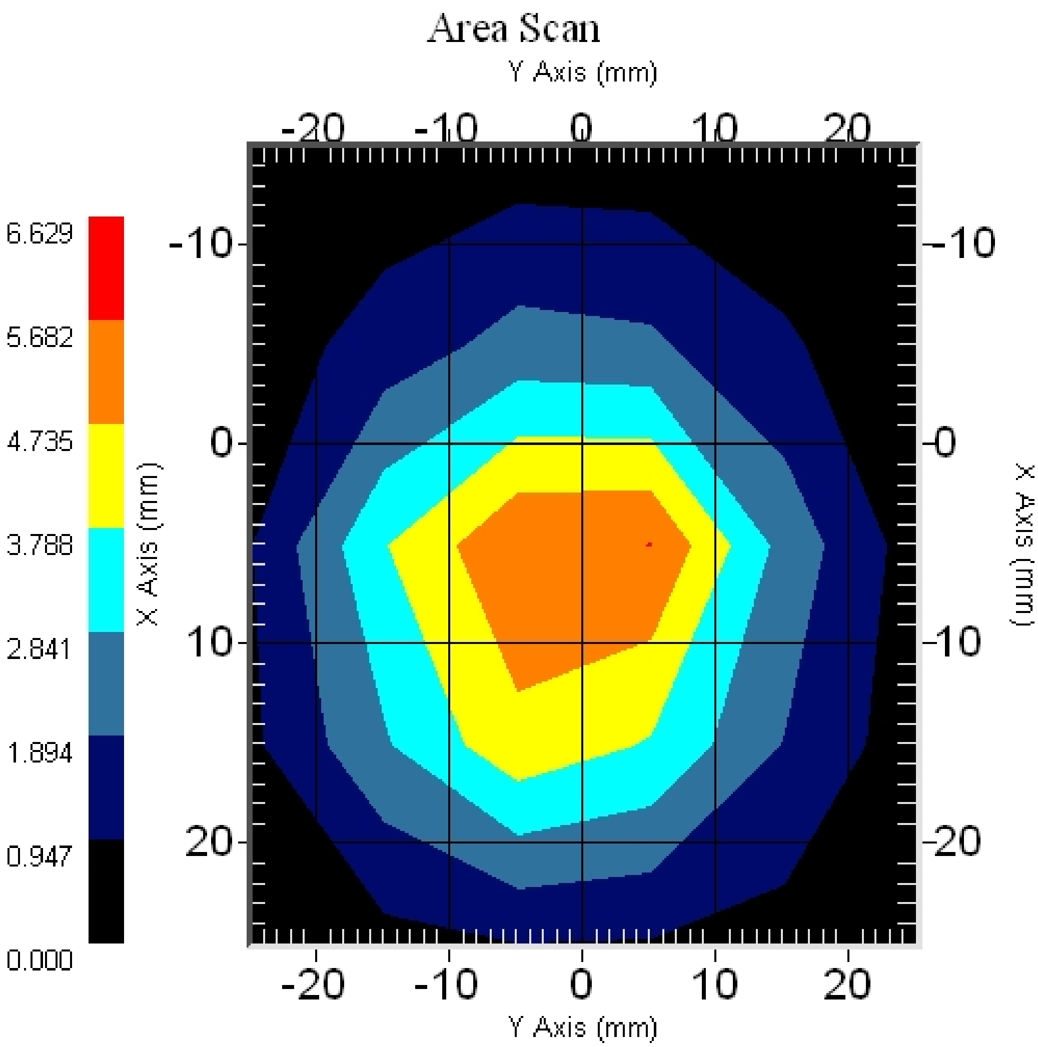


This page has been reviewed for content and attested to by signature within this document.

System Validation Results Using the Electrically Calibrated Dipole

Results @ 100mW

Body Tissue Frequency	1 Gram	10 Gram	Peak Above Feed Point
2450 MHz	5.15	2.31	10.01



Test Equipment

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2010.

Usage of SAR dipoles calibrated less than 2 years ago but more than 1 year ago were confirmed in maintaining return loss (< -20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB Publication 450824:

ALS-D-2450-S-2 SN: RFE-278				
Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
11/18/2010	-19.17		42.223	
11/17/2011	-20.046	4.6	41.259	0.96
11/19/2012	-20.128	5	42.597	-0.37

Appendix F – Phantom Calibration Data Sheets

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 4.0
Type No	QD OVA 001 B
Series No	1003 and higher
Manufacturer	Untersee Composites Knebelstrasse 8 CH-8268 Mannenbach, Switzerland

Tests
Complete tests were made on the prototype units QD OVA 001 AA 1001, QD OVA 001 AB 1002, pre-series units QD OVA 001 BA 1003-1005 as well as on the series units QD OVA 001 BB, 1006 ff.

Test	Requirement	Details	Units tested
Material thickness	Compliant with the standard requirements	Bottom plate: 2.0mm +/- 0.2mm	all
Material parameters	Dielectric parameters for required frequencies	< 6 GHz: Rel. permittivity = 4 +/-1, Loss tangent ≤ 0.05	Material sample
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions.	DGBE based simulating liquids. Observe Technical Note for material compatibility.	Equivalent phantoms, Material sample
Shape	Thickness of bottom material, Internal dimensions, Sagging compatible with standards from minimum frequency	Bottom elliptical 600 x 400 mm Depth 190 mm, Shape is within tolerance for filling height up to 155 mm, Eventual sagging is reduced or eliminated by support via DUT	Prototypes, Sample testing

Standards

[1] CENELEC EN 50361-2001, « Basic standard for the measurement of the Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones (300 MHz – 3 GHz) », July 2001

[2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003

[3] IEC 62209 – 1, "Specific Absorption Rate (SAR) in the frequency range of 300 MHz to 3 GHz – Measurement Procedure, Part 1: Hand-held mobile wireless communication devices", February 2005

[4] IEC 62209 – 2, Draft, "Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices – Human models, Instrumentation and Procedures – Part 2: Procedure to determine the Specific Absorption Rate (SAR) in the head and body for 30 MHz to 6 GHz Handheld and Body-Mounted Devices used in close proximity to the Body.", February 2005

[5] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition January 2001

Based on the tests above, we certify that this item is in compliance with the standards [1] to [5] if operated according to the specific requirements and considering the thickness. The dimensions are fully compliant with [4] from 30 MHz to 6 GHz. For the other standards, the minimum lower frequency limit is limited due to the dimensional requirements ([1]: 450 MHz, [2]: 300 MHz, [3]: 800 MHz, [5]: 375 MHz) and possibly further by the dimensions of the DUT.

Date 28.4.2008 **Signature / Stamp**

s p e a g
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