# FCC SAR Test Report

## FCC ID: 2AAD3AA1D1

**Project No.** : 1406119
**Equipment** : module
**Model Name** WM-N-BM-02_D-REF1
**Applicant** : ABILITY ENTERPRISE CO.,LTD.
**Address** : 4F., No. 8, Ln. 7, Wuquan Rd., Wugu Dist., New Taipei City 24886, Taiwan(R.O.C.)

**Tested by:** Neutron Engineering Inc.
**Date of Receipt:** Jun. 11, 2014
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## REPORT ISSUED HISTORY

| Issued No. | Description | Issued Date |
|---|---|---|
| NEI-FCC-SAR-1406119 | Original Issue. | Jul. 02, 2014 |

## 1. GENERAL SUMMARY

| | |
|---|---|
| Equipment | module |
| Model Name | WM-N-BM-02_D-REF1 |
| Brand Name | USI |
| Model Difference | N/A |
| Manufacturer | CASIO COMPUTER CO., LTD. (Japan) |
| Address | 6-2, Hon-machi 1-chome, Shibuya-ku, Tokyo 151-8543, Japan |
| Standard(s) | **FCC 47CFR §2.1093** Radio frequency Radiation Exposure Evaluation: Portable Devices<br><br>**ANSI C95.1, 1999** Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.(IEEE Std C95.1-1999)<br><br>**IEEE 1528 2013:** IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques<br><br>**KDB 248227 D01 v01r02 SAR meas for 802 11 a b g v01r02:** SAR Measurement Procedures for 802.11a/b/g Transmitters<br><br>**KDB 447498 D01 General RF Exposure Guidance v05r02**: Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies.<br><br>**KDB 865664 D01 SAR measurement 100 MHz to 6GHz v01r03:** SAR Measurement Requirements for 100MHz to 6GHz |

The above equipment has been tested and found compliance with the requirement of the relative standards by Neutron Engineering Inc.
The test data, data evaluation, and equipment configuration contained in our test report (Ref No. NEI-FCC-SAR-1406119) were obtained utilizing the test procedures, test instruments, test sites that has been accredited by the Authority of TAF according to the ISO-17025 quality assessment standard and technical standard(s).

## 2. RF EMISSIONS MEASUREMENT

### 2.1 TEST FACILITY

The test facilities used to collect the test data in this report is **SAR room** at the location of No.3,Jinshagang 1st Road, ShiXia, Dalang Town, Dong Guan, China.523792

### 2.2 MEASUREMENT UNCERTAINTY

| Uncertainty Conponent | Uncertainty Value | Probability Distribution | Divisor | $C_i$ (1g) | Standard Uncertainty ±1% | $V_i$ or $V_{eff}$ |
|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | |
| Probe Calibration (*k*=1) | 5.9 | Normal | 1 | 1 | 5.9 | ∞ |
| Axial Isotropy | 4.7 | Rectangular | $\sqrt{3}$ | $\sqrt{0.5}$ | 1.9 | ∞ |
| Hemispherical Isotropy | 9.6 | Rectangular | $\sqrt{3}$ | $\sqrt{0.5}$ | 3.9 | ∞ |
| Boundary Effect | 1.0 | Rectangular | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| Linearity | 4.7 | Rectangular | $\sqrt{3}$ | 1 | 2.7 | ∞ |
| System Detection Limit | 1.0 | Rectangular | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| Readout Electronics | 0.3 | Normal | 1 | 1 | 0.3 | ∞ |
| Response Time | 0.8 | Rectangular | $\sqrt{3}$ | 1 | 0.5 | ∞ |
| Integration Time | 2.6 | Rectangular | $\sqrt{3}$ | 1 | 1.5 | ∞ |
| RF Ambient Conditions-Noise | 3.0 | Rectangular | $\sqrt{3}$ | 1 | 1.7 | ∞ |
| RF Ambient Reflections | 3.0 | Rectangular | $\sqrt{3}$ | 1 | 1.7 | ∞ |
| Probe Positioner Mechanical Tolerance | 0.4 | Rectangular | $\sqrt{3}$ | 1 | 0.2 | ∞ |
| Probe Positioning with respect to Phantom Shell | 2.9 | Rectangular | $\sqrt{3}$ | 1 | 1.7 | ∞ |
| Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation | 1.0 | Rectangular | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| **Test Sample Related** | | | | | | |
| Test sample Positioning | 2.9 | Normal | 1 | 1 | 2.9 | 145 |
| Device Holder Uncertainty | 3.6 | Normal | 1 | 1 | 3.6 | 5 |
| Output Power Variation - SAR drift measurement | 5.0 | Rectangular | $\sqrt{3}$ | 1 | 2.9 | ∞ |
| **Phantom and Setup** | | | | | | |
| Phantom Uncertainty ( shape and thickness tolerances) | 4.0 | Rectangular | $\sqrt{3}$ | 1 | 2.3 | ∞ |
| Liquid Conductivity - deviation from target values | 5.0 | Rectangular | $\sqrt{3}$ | 0.64 | 1.8 | ∞ |
| Liquid Conductivity - measurement uncertainty | 2.5 | Normal | 1 | 0.64 | 1.6 | ∞ |
| Liquid Permittivity - deviation from target values | 5.0 | Rectangular | $\sqrt{3}$ | 0.6 | 1.7 | ∞ |
| Liquid Permittivity - measurement uncertainty | 2.5 | Normal | 1 | 0.6 | 1.5 | ∞ |
| **Combined standard uncertainty** | | RSS | - | - | 10.9 | 387 |
| **Expanded uncertainty** | | *k*=2 | - | - | 21.9 | - |

# 3. GENERAL INFORMATION

## 3.1 GENERAL DESCRIPTION OF EUT

| | |
|---|---|
| Tested Mode(s) | WiFi(802.11b/g/n) |
| Operation Frequency | 2412 MHz ~2462 MHz |
| Modulation Technology<br><br>And Bit Rate of Transmitter | 802.11b: (CCK, DQPSK,DBPSK) 1, 2, 5.5, 11 Mbps<br>802.11g: (OFDM) 6, 9, 12, 18, 24, 36, 48, 54 Mbps<br>802.11n: (OFDM) MCS 0-7 |
| Number Of Channel | Please refer to note 1 |
| Antenna Type | Please refer to note 2 |
| Power Source | DC voltage supplied from AC adapter.<br>Brand / Model: CASIO/AD-C53U |
| Power Rating | I/P: AC100-240V~50/60Hz 100mA<br>O/P:DC5V 650mA |

Note:

1. Check List:

| 802.11b / g / n 20MHz | | | | | | | |
|---|---|---|---|---|---|---|---|
| CH 01 – CH 11 for 802.11b, 802.11g, 802.11n(20MHz) | | | | | | | |
| Channel | Frequency (MHz) | Channel | Frequency (MHz) | Channel | Frequency (MHz) | Channel | Frequency (MHz) |
| 01 | 2412 | 04 | 2427 | 07 | 2442 | 10 | 2457 |
| 02 | 2417 | 05 | 2432 | 08 | 2447 | 11 | 2462 |
| 03 | 2422 | 06 | 2437 | 09 | 2452 | | |

2.Table for Filed Antenna

| Ant. | Brand | Model Name | Antenna Type | Connector | Gain (dBi) | Note |
|---|---|---|---|---|---|---|
| 1 | NA | NA | NA | N/A | -3.04 | NA |

## 3.2 THE MAXIMUM $SAR_{1G}$ VALUES

Body SAR Configuration

| Test Mode | Frequency (MHz) | Test Position | Separation Distance | Limit $SAR_{1g}$ 1.6W/kg | |
|---|---|---|---|---|---|
| | | | | Measured Result $SAR_{1g}$ (W/kg) | Reported Result $SAR_{1g}$ (W/kg) |
| 802.11b | 2437 | Test Position 2 | 2mm | 0.275 | 0.310 |

## 3.3 LABORATORY ENVIRONMENT

| | |
|---|---|
| Temperature | Min. = 18ºC, Max. = 25ºC |
| Relative humidity | Min. = 30%, Max. = 70% |
| Ground system resistance | < 0.5Ω |
| Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards. | |

## 3.4 MAIN TEST INSTRUMENTS

| Item | Kind of Equipment | Manufacturer | Type No. | Serial No. | Calibrated until |
|---|---|---|---|---|---|
| 1 | Data Acquisition Electronics | Speag | DAE4 | 1390 | Sep. 09, 2014 |
| 2 | E-field Probe | Speag | EX3DV4 | 3932 | Sep. 15, 2014 |
| 3 | Electro Optical Converter | Speag | ECO90 | 1151 | N/A |
| 4 | SAM Twin Phantom | Speag | SAM | 1784 | N/A |
| 5 | System Validation Dipole | Speag | D2450V2 | 919 | Sep. 05, 2014 |
| 6 | Power Amplifier | Speag | ZHL-42W | N/A | N/A |
| 7 | Power Amplifier | Speag | ZVE-8G | N/A | N/A |
| 8 | ENA Network Analyzer | Agilent | E5071C | MY46102965 | Mar. 29, 2015 |
| 9 | Dielectric Probe Kit | Agilent | 85070E | 2593 | N/A |
| 10 | P-series power meter | Agilent | N1911A | MY45100473 | Mar. 29, 2015 |
| 11 | wideband power sensor | Agilent | N1921A | MY51100041 | Mar. 29, 2015 |
| 12 | Power Meter | Anritsu | ML2487A | 6K00004714 | Mar. 16, 2015 |
| 13 | Power Meter Sensor | Anritsu | MA2491A | 34138 | Mar. 16, 2015 |
| 14 | MXG Analog Signal Generator | Agilent | N5181A | MY49060710 | Nov. 09, 2014 |

Remark: ” N/A” denotes no model name, serial No. or calibration specified.
All calibration period of equipment list is one year.

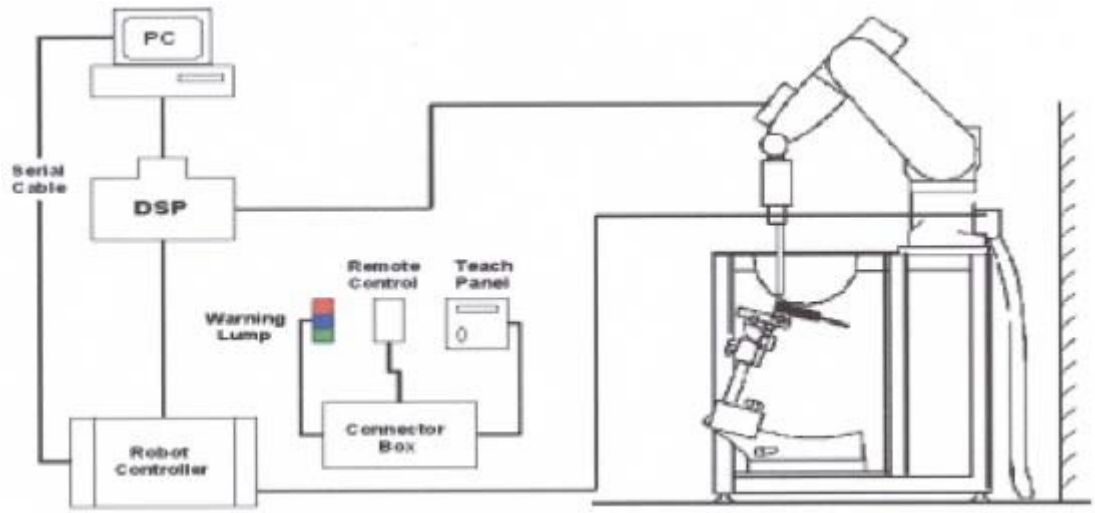
# 4. SAR MEASUREMENTS SYSTEM CONFIGURATION

## 4.1 SAR MEASUREMENT SET-UP

The DASY5 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
3. A data acquisition electronic (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
4. A unit to operate the optical surface detector which is connected to the EOC.
5. The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
6. The DASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows 7
7. DASY5 software and SEMCAD data evaluation software.
8. Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
9. The generic twin phantom enabling the testing of left-hand and right-hand usage.
10. The device holder for handheld mobile phones.
11. Tissue simulating liquid mixed according to the given recipes.
12. System validation dipoles allowing to validate the proper functioning of the system.

### 4.1.1 Test Setup Layout



## 4.2 DASY5 E-FIELD PROBE SYSTEM

The SAR measurements were conducted with the dosimetric probe ES3DV3 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation.

### 4.2.1 ES3DV3 PROBE SPECIFICATION

| | |
|---|---|
| Construction | Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE) |
| Calibration | ISO/IEC 17025 calibration service available |
| Frequency | 10 MHz to 4 GHz<br>Linearity: ± 0.2 dB (30 MHz to 4 GHz) |
| Directivity | ± 0.2 dB in HSL (rotation around probe axis)<br>± 0.3 dB in tissue material (rotation normal to probe axis) |
| Dynamic Range | 5 µW/g to > 100 mW/g<br>Linearity: ± 0.2dB |
| Dimensions | Overall length: 330 mm (Tip: 20 mm)<br>Tip diameter: 3.9 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm |

**EX3DV4 E-field Probe**

### 4.2.2 E-FIELD PROBE CALIBRATION

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

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, and in a wave guide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

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.

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

Where: $\Delta t$ = Exposure time (30 seconds),

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

$\Delta T$ = Temperature increase due to RF exposure.

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

Where: σ = Simulated tissue conductivity,

ρ = Tissue density (kg/m3).

### 4.2.3 OTHER TEST EQUIPMENT

#### 4.2.3.1. Device Holder for Transmitters

**Construction:** Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices (e.g., laptops, cameras, etc.) It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI4 and SAM v6.0 Phantoms.
**Material:** POM, Acrylic glass, Foam

#### 4.2.3.2 Phantom

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

_ Left hand
_ Right hand
_ Flat phantom

The bottom plate contains three pairs 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 cover the phantom during o -periods to prevent water evaporation and changes in the liquid parameters. Free space scans of devices on top of this phantom cover are possible.

**SAM twin Phantom**

### 4.2.4 SCANNING PROCEDURE

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT’s output power and should vary max. ± 5 %.

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

- Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot.Before starting the area scan a grid spacing of 10 mm x 10 mm is set. During the scan the distance of the probe to the phantom remains unchanged. After finishing area scan, the field maxima within a range of 2 dB will be ascertained.

- Zoom Scan

Zoom Scans are used to estimate the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The default Zoom Scan is done by 7x7x7 points within a cube whose base is centered around the maxima found in the preceding area scan.

- Spatial Peak Detection

The procedure for spatial peak SAR evaluation has been implemented and can determine values of masses of 1g and 10g, as well as for user-specific masses.The DASY5 system allows evaluations that combine measured data and robot positions, such as:
• maximum search
• extrapolation
• boundary correction
• peak search for averaged SAR

During a maximum search, global and local maxima searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard’s method. The algorithm will find the global maximum and all local maxima within -2 dB of the global maxima for all SAR distributions.

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. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space. They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard’s method for extrapolation. For a grid using 7x7x7 measurement points with 5mm resolution amounting to 343 measurement points, the uncertainty of the extrapolation routines is less than 1% for 1g and 10g cubes.

### 4.2.5 DATA STORAGE AND EVALUATION

#### 4.2.5.1 Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension “.DAE4”. The 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 incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

### 4.4.2 Data Evaluation by SEMCAD

The SEMCAD software 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 | Normi, $a_{i0}$, $a_{i1}$, $a_{i2}$ |
| | Conversion factor | $ConvF_i$ |
| | Diode compression point | $Dcp_i$ |
| Device parameters: | Frequency | f |
| | Crest factor | cf |
| Media parameters: | Conductivity | |
| | Density | |

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 DASY5 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:

$$V_i = U_i + U_i^2 \cdot cf / dcp_i$$

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: $E_i = ( V_i / Norm_i \cdot ConvF )^{1/2}$

H-field probes: $H_i = ( V_i )^{1/2} \cdot ( a_{i0} + a_{i1} f + a_{i2} f^2 ) / f$

With $V_i$ = compensated signal of channel i ( i = x, y, z )

$Norm_i$ = sensor sensitivity of channel i ( i = x, y, z )
[mV/(V/m)$^2$] for E-field Probes

ConvF = sensitivity enhancement in solution

aij = 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):

$$E_{tot} = (E_X^2 + E_Y^2 + E_Z^2)^{1/2}$$

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

$$SAR = (E_{tot})^2 \cdot \sigma / (\rho \cdot 1000)$$

With SAR = local specific absorption rate in mW/g

$E_{tot}$ = total field strength in V/m
= conductivity in [mho/m] or [Siemens/m]
= equivalent tissue density in g/cm$^3$

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

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

With $P_{pwe}$ = equivalent power density of a plane wave in mW/cm$^2$

$E_{tot}$ = total field strength in V/m

$H_{tot}$ = total magnetic field strength in A/m

# 5. TISSUE-EQUIVALENT LIQUID

## 5.1 TISSUE-EQUIVALENT LIQUID INGREDIENTS

The liquid is consisted of water, salt and Glycol. The liquid has previously been proven to be suited for worst-case. The Table 2 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed

**Composition of the Tissue Equivalent Matter**

| MIXTURE% | FREQUENCY 2450MHz |
|---|---|
| Water | 62.7 |
| Glycol | 36.8 |
| Salt | 0.5 |
| Dielectric Parameters Target Value | f=2450MHz ε=39.20 σ=1.80 |

## 5.2 TISSUE-EQUIVALENT LIQUID PROPERTIES

**Dielectric Performance of Tissue Simulating Liquid**

| Frequency (MHz) | Description | Dielectric Parameters | | Temp ℃ |
|---|---|---|---|---|
| | | $\varepsilon_r$ | σ(s/m) | |
| 2450 | Target value ±5% within | 52.70 50.07-55.34 | 1.95 1.85-2.048 | 22.0 |
| | Measurement value 2014-06-25 | 51.40 | 2.00 | 21.8 |

# 6. SYSTEM CHECK

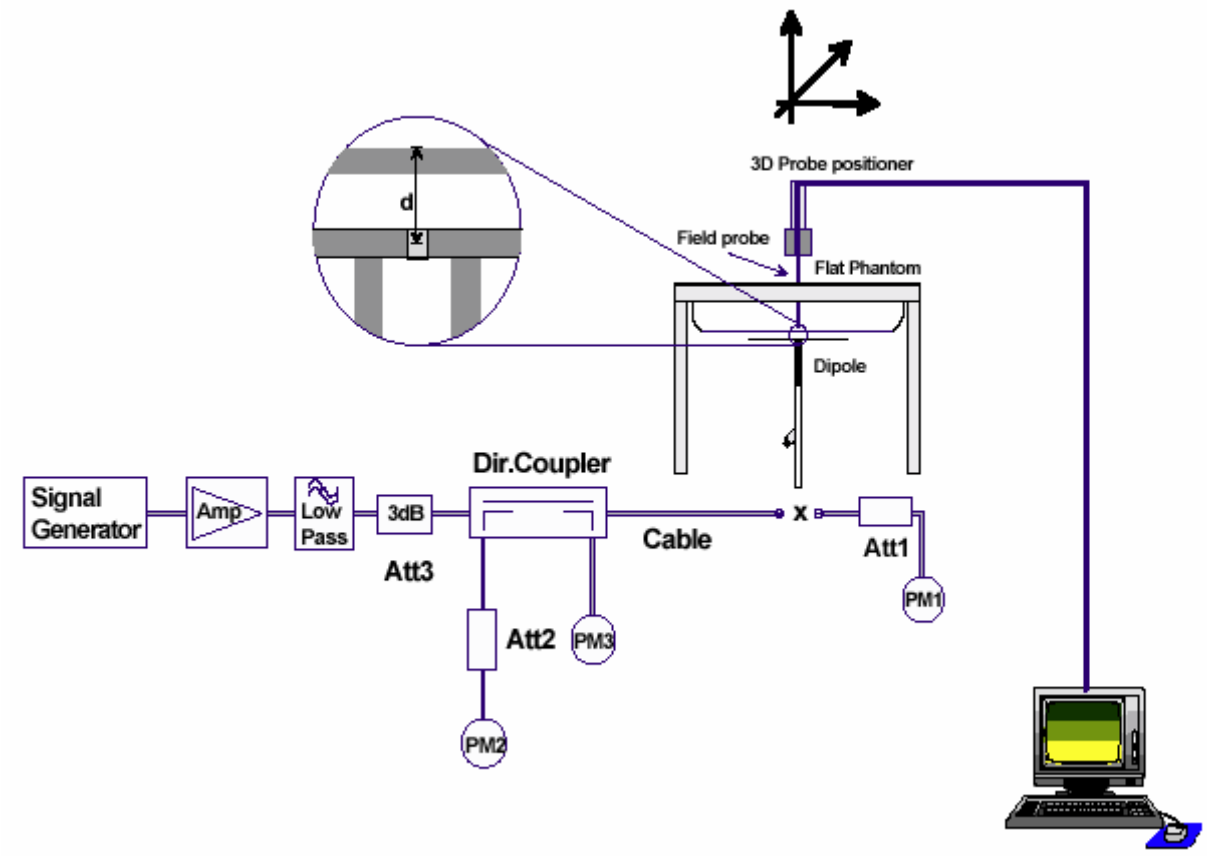
## 6.1 DESCRIPTION OF SYSTEM CHECK

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulants were measured every day using the dielectric probe kit and the network analyzer. A system check measurement was made following the determination of the dielectric parameters of the simulant, using the dipole validation kit. A power level of 250 mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The system check results (dielectric parameters and SAR values) are given in the 6.2.

System check results have to be equal or near the values determined during dipole calibration with the relevant liquids and test system (±10 %).

System check is performed regularly on all frequency bands where tests are performed with the DASY5 system.

**System Check Set-up**



## 6.2 DESCRIPTION OF SYSTEM CHECK

**System Check in Tissue Simulating Liquid**

| Frequency (MHz) | Test Date | Dielectric Parameters | | Temp | 250mW Measured $SAR_{1g}$ | 1W Normalized $SAR_{1g}$ | 1W Target $SAR_{1g}$ (±10% deviation) |
|---|---|---|---|---|---|---|---|
| | | εr | σ(s/m) | (℃) | (W/kg) | | |
| 2450 | 2014-06-25 | 51.40 | 2.00 | 21.80 | 12.6 | 50.40 | 49.30 (44.37~54.23) |
| | | | | | | | |

Note: 1. The graph results see Appendix 2.
2. Target Value derives from the calibration certificate

# 7. OPERATIONAL CONDITIONS DURING TEST

## 7.1 General Description of Test Procedures

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal. This RF signal utilized in SAR measurement has almost 100% duty cycle and its crest factor is 1.

For the 802.11b/g/n SAR tests, a communication link is set up with the test mode software for WIFI mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. Each channel should be tested at the lowest data rate. Testing at higher data rates is not required when the maximum average output power is less than 0.25dB higher than those measured at the lowest data rate.

802.11b/g operating modes are tested independently according to the service requirements in each frequency band.802.11b/g modes are tested on channels1,6,11; however, if output power reduction is necessary for channels 1 and /or 11 to meet restricted band requirements the highest output channels closest to each of these channels must be tested instead.

SAR is not required for 802.11g/n channels when the maximum average output power is less than 0.25dB higher than that measured on the corresponding 802.11b channels.

## 7.2 Test Position

SAR testing for this module has performed all six surfaces with 2mm air gap.

**Test Position 1:** The front side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 1 )

**Test Position 2:** The rear side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 2)

**Test Position 3:** The top side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 3)

**Test Position 4:** The bottom side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 4)

**Test Position 5:** The left side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 5)

**Test Position 6:** The right side of the EUT towards the bottom of the flat phantom distance 2mm. (APPENDIX 7 Picture 6)

# 8. TEST RESULT

## 8.1 CONDUCTED POWER RESULTS

The average output power of WiFi antenna is as following:

| Test Mode | Data Rate (Mbps) | Test Results (dBm) | | |
|---|---|---|---|---|
| | | Conducted AV | | |
| | | 2412MHz | 2437MHz | 2462MHz |
| 802.11b | 1 | 11.95 | 11.98 | 11.95 |
| | 2 | 11.76 | 11.76 | 11.83 |
| | 5.5 | 11.64 | 11.54 | 11.68 |
| | 11 | 11.46 | 11.41 | 11.52 |

| Test Mode | Data Rate (Mbps) | Test Results (dBm) | | |
|---|---|---|---|---|
| | | Conducted AV | | |
| | | 2412MHz | 2437MHz | 2462MHz |
| 802.11g | 6 | 9.97 | 10.12 | 10.09 |
| | 9 | 9.43 | 9.67 | 9.83 |
| | 12 | 8.99 | 9.13 | 9.46 |
| | 18 | 8.53 | 8.94 | 9.03 |
| | 24 | 8.04 | 8.65 | 8.84 |
| | 36 | 7.62 | 8.12 | 8.54 |
| | 48 | 7.53 | 7.83 | 8.04 |
| | 54 | 7.42 | 7.72 | 7.44 |

| Test Mode | Data Rate (Mbps) | Test Results (dBm) | | |
|---|---|---|---|---|
| | | Conducted AV | | |
| | | 2412MHz | 2437MHz | 2462MHz |
| 802.11n HT20 | MCS0 | 10.12 | 10.11 | 10.12 |
| | MCS1 | 9.76 | 9.77 | 9.71 |
| | MCS2 | 9.34 | 9.24 | 9.26 |
| | MCS3 | 8.89 | 8.84 | 8.83 |
| | MCS4 | 8.45 | 8.4 | 8.5 |
| | MCS5 | 8.03 | 8 | 8.04 |
| | MCS6 | 7.76 | 7.6 | 7.75 |
| | MCS7 | 7.47 | 7.52 | 7.33 |

## 8.2 SAR TEST RESULTS

| 802.11b | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test Position | Channel Frequency (MHz) | Duty Cycle | Maximum Allowed Power (dBm) | Conducted power (dBm) | Drift ±0.21dB | Limit of SAR 1.6 W/kg | | | |
| | | | | | Drift (dB) | Measured SAR (W/kg) | Scaling factor | Reported SAR (W/kg) | Graph Results |
| Test Position of Body(Distance=2mm) | | | | | | | | | |
| 1 | 2437 | 1:1 | 12.5 | 11.98 | -0.01 | 0.216 | 1.127 | 0.243 | 1 |
| **2** | **2437** | **1:1** | **12.5** | **11.98** | **-0.04** | **0.275** | **1.127** | **0.310** | **2** |
| 3 | 2437 | 1:1 | 12.5 | 11.98 | -0.11 | 0.011 | 1.127 | 0.012 | 3 |
| 4 | 2437 | 1:1 | 12.5 | 11.98 | -0.07 | 0.028 | 1.127 | 0.032 | 4 |
| 5 | 2437 | 1:1 | 12.5 | 11.98 | 0.06 | 0.052 | 1.127 | 0.059 | 5 |
| 6 | 2437 | 1:1 | 12.5 | 11.98 | -0.07 | 0.044 | 1.127 | 0.050 | 6 |

Note: 1.The value with boldface is the maximum SAR Value of each test band.

2. Per FCC KDB Publication 447498 D01, if the reported (scaled) SAR measured at the middle channel or highest output power channel for each test configuration is ≤ 0.8 W/kg then testing at the other channels is not required for such test configuration(s).

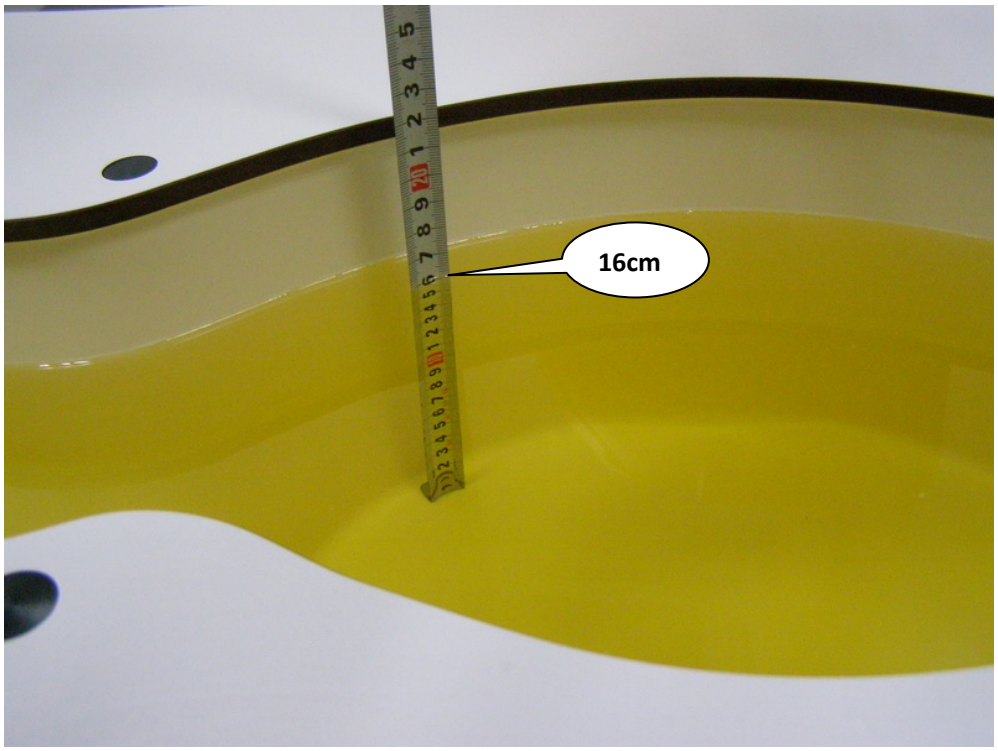
3. KDB 248227-SAR is not required for 802.11g/n channels when the maximum average output power is less than 1/4dB higher than measured on the corresponding 802.11b channels.

# APPENDIX

## 1. Test Layout

**Specific Absorption Rate Test Layout**

**Liquid depth in the flat Phantom (≥15cm depth)**



## 2. System Check Results

Date/Time: 06/25/2014 09:38:32

**Test Laboratory: Neutron Engineering Inc.**

**System Performance Check Body 2450MHz**

**DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:919**

Communication System: UID 0, CW (0); Frequency: 2450 MHz

Medium parameters used: f = 2450 MHz; σ = 2.0 S/m; εr = 51.4; ρ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**System Performance Check at 2450MHz/d=10mm, Pin=250 mW, dist=2.0mm (EX-Probe)/Area Scan (5x7x1):** Measurement grid: dx=15mm, dy=15mm

Maximum value of SAR (measured) = 20.2 W/kg

**System Performance Check at 2450MHz/d=10mm, Pin=250 mW, dist=2.0mm (EX-Probe)/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement

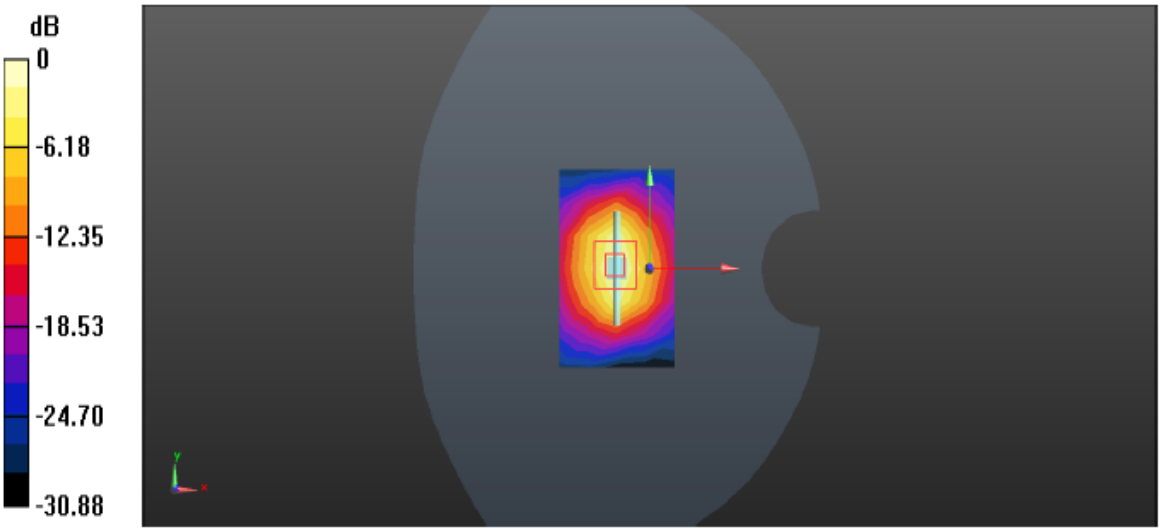
grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.1 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 27.5 W/kg

**SAR(1 g) = 12.6 W/kg; SAR(10 g) = 6.01 W/kg**

Maximum value of SAR (measured) = 20.1 W/kg




0 dB = 20.2 W/kg = 13.05 dBW/kg

## 3. Graph Results

Date/Time: 06/25/2014 14:11:10

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 1**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; σ = 1.997 S/m; εr = 51.745; ρ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 1/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.366 W/kg

**Test Position 1/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:**

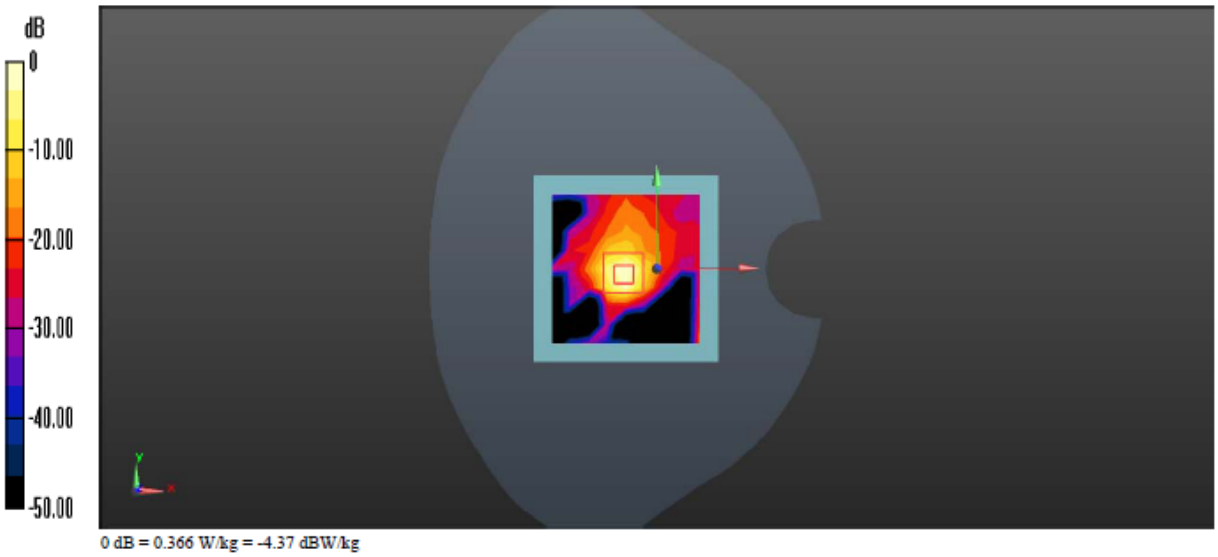
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 14.131 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 0.621 W/kg

**SAR(1 g) = 0.216 W/kg; SAR(10 g) = 0.063 W/kg**

Maximum value of SAR (measured) = 0.378 W/kg



Date/Time: 06/25/2014 19:14:21

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 2**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; σ = 1.997 S/m; εr = 51.745; ρ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 2/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.326 W/kg

**Test Position 2/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:**

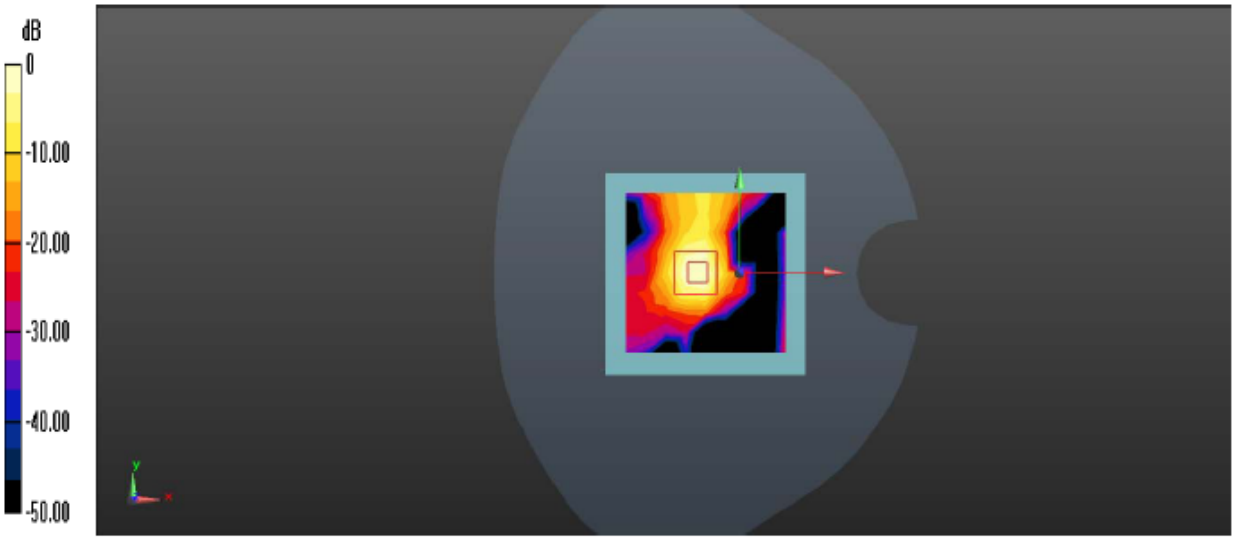
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 13.291 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 0.650 W/kg

**SAR(1 g) = 0.275 W/kg; SAR(10 g) = 0.096 W/kg**

Maximum value of SAR (measured) = 0.454 W/kg




0 dB = 0.326 W/kg = -4.87 dBW/kg

Date/Time: 06/25/2014 17:50:07

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 3**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; σ = 1.997 S/m; εr = 51.745; ρ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 3/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.0215 W/kg

**Test Position 3/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:**

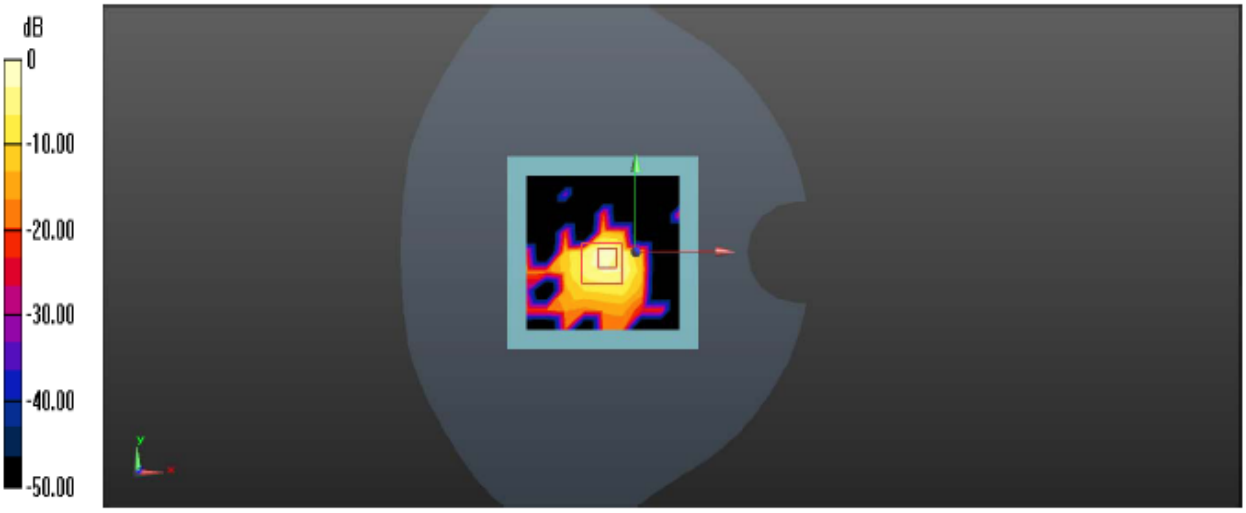
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 3.630 V/m; Power Drift = -0.11 dB

Peak SAR (extrapolated) = 0.0260 W/kg

**SAR(1 g) = 0.011 W/kg; SAR(10 g) = 0.00271 W/kg**

Maximum value of SAR (measured) = 0.0184 W/kg




0 dB = 0.0215 W/kg = -16.68 dBW/kg

Date/Time: 06/25/2014 18:24:20

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 4**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; σ = 1.997 S/m; εr = 51.745; ρ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 4/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.0459 W/kg

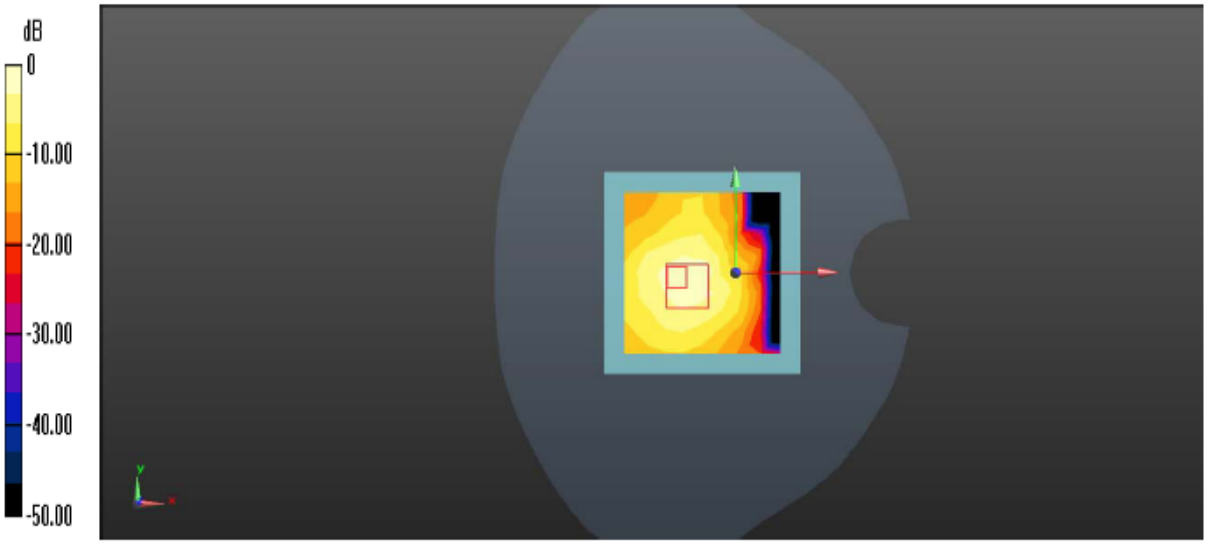
**Test Position 4/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 5.066 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 0.121 W/kg

**SAR(1 g) = 0.028 W/kg; SAR(10 g) = 0.012 W/kg**

Maximum value of SAR (measured) = 0.0451 W/kg




0 dB = 0.0459 W/kg = -13.38 dBW/kg

Date/Time: 06/25/2014 19:47:56

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 5**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; $\sigma$ = 1.997 S/m; $\varepsilon r$ = 51.745; $\rho$ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 5/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.0943 W/kg

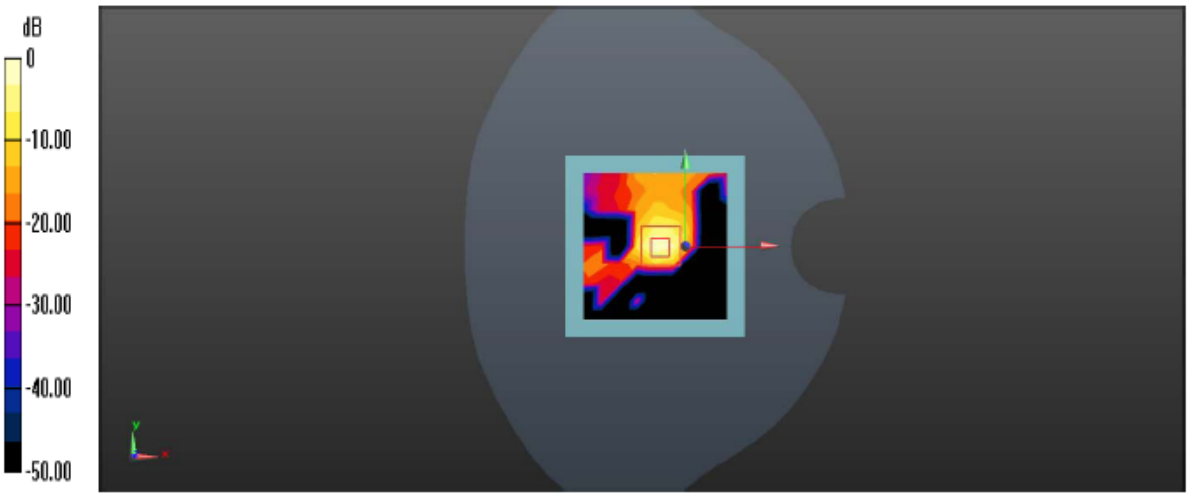
**Test Position 5/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 6.677 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 0.159 W/kg

**SAR(1 g) = 0.052 W/kg; SAR(10 g) = 0.015 W/kg**

Maximum value of SAR (measured) = 0.0977 W/kg




0 dB = 0.0943 W/kg = -10.25 dBW/kg

Date/Time: 06/25/2014 20:57:46

**Test Laboratory: Neutron Engineering Inc.**

**module WM-N-BM-02_D-REF1 802.11b 2437MHz CH6 Test Position 6**

**DUT: module ; Type: WM-N-BM-02_D-REF1 ; Serial: NA**

Communication System: UID 0, IEEE 802.11b WiFi 2.4GHz (DSSS,1Mbps) (0); Frequency: 2437 MHz

Medium parameters used (interpolated): f = 2437 MHz; $\sigma$ = 1.997 S/m; $\varepsilon r$ = 51.745; $\rho$ = 1000 kg/m3

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY Configuration:

- Probe: EX3DV4 - SN3932; ConvF(7.34, 7.34, 7.34); Calibrated: 09/16/2013;
- Sensor-Surface: 2mm (Mechanical Surface Detection), z = 1.0, 31.0
- Electronics: DAE4 Sn1390; Calibrated: 09/10/2013
- Phantom: SAM 1; Type: SAM; Serial: 1784
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

**Test Position 6/WM-N-BM-02_D-REF1 802.11b CH6/Area Scan (9x9x1):** Measurement grid: dx=10mm, dy=10mm

Maximum value of SAR (measured) = 0.0772 W/kg

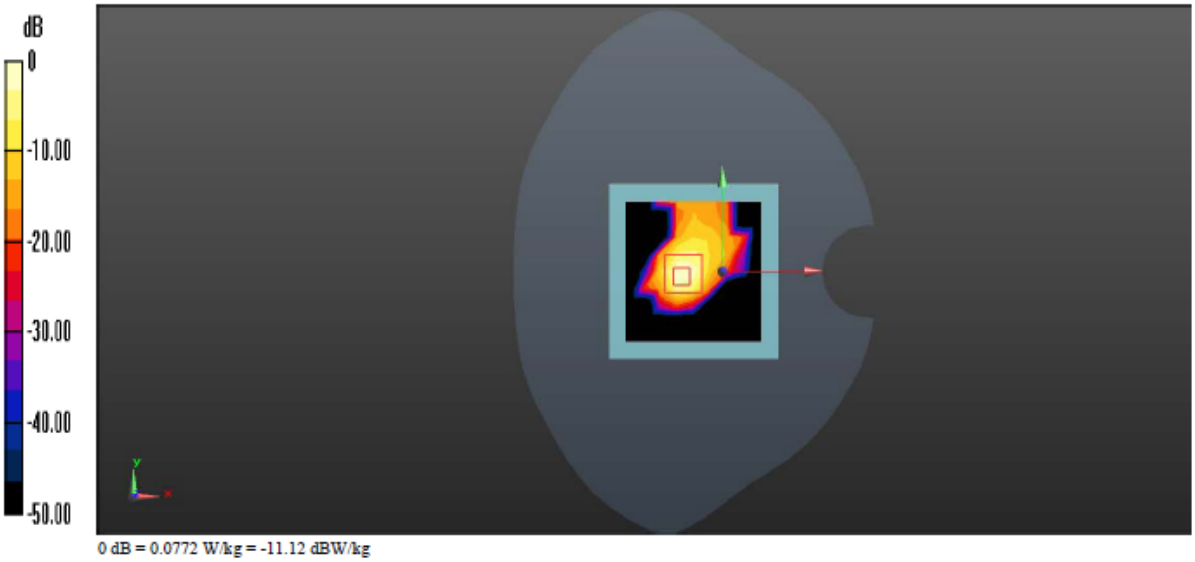
**Test Position 6/WM-N-BM-02_D-REF1 802.11b CH6/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 6.260 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 0.0980 W/kg

**SAR(1 g) = 0.044 W/kg; SAR(10 g) = 0.014 W/kg**

Maximum value of SAR (measured) = 0.0749 W/kg



## 4. Probe Calibration Certificate

### EX3DV4

**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 **Neutron Engineering (Auden)**

Certificate No: **EX3-3932_Sep13**

# CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:3932

Calibration procedure(s): QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: September 16, 2013

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 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Power sensor E4412A | MY41498087 | 04-Apr-13 (No. 217-01733) | Apr-14 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 04-Apr-13 (No. 217-01737) | Apr-14 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 04-Apr-13 (No. 217-01735) | Apr-14 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 04-Apr-13 (No. 217-01738) | Apr-14 |
| Reference Probe ES3DV2 | SN: 3013 | 28-Dec-12 (No. ES3-3013_Dec12) | Dec-13 |
| DAE4 | SN: 660 | 4-Sep-13 (No. DAE4-660_Sep13) | Apr-14 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-15 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: September 17, 2013

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: EX3-3932_Sep13 Page 1 of 11

**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

Accreditation No.: **SCS 108**

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**

## 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, D | 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; Dx,y,z; VRx,y,z: A, B, C, D* 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:3932

Manufactured: July 24, 2013
Calibrated: September 16, 2013

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

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3932

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 0.52 | 0.55 | 0.46 | ± 10.1 % |
| DCP (mV)[B] | 102.3 | 102.8 | 101.8 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 167.8 | ±3.0 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 179.9 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 157.1 | |

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:3932

## 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 | 10.36 | 10.36 | 10.36 | 0.20 | 1.35 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 9.89 | 9.89 | 9.89 | 0.29 | 1.02 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 9.67 | 9.67 | 9.67 | 0.21 | 1.33 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.47 | 8.47 | 8.47 | 0.33 | 0.89 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.21 | 8.21 | 8.21 | 0.12 | 1.47 | ± 12.0 % |
| 2100 | 39.8 | 1.49 | 8.31 | 8.31 | 8.31 | 0.80 | 0.50 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.75 | 7.75 | 7.75 | 0.43 | 0.70 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.40 | 7.40 | 7.40 | 0.36 | 0.81 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.16 | 7.16 | 7.16 | 0.44 | 0.78 | ± 12.0 % |

[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:3932

## 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 | 9.92 | 9.92 | 9.92 | 0.21 | 1.47 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.92 | 9.92 | 9.92 | 0.30 | 1.12 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 9.67 | 9.67 | 9.67 | 0.51 | 0.79 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.14 | 8.14 | 8.14 | 0.56 | 0.73 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 7.80 | 7.80 | 7.80 | 0.42 | 0.80 | ± 12.0 % |
| 2100 | 53.2 | 1.62 | 8.12 | 8.12 | 8.12 | 0.29 | 1.01 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.57 | 7.57 | 7.57 | 0.59 | 0.68 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.34 | 7.34 | 7.34 | 0.80 | 0.50 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.08 | 7.08 | 7.08 | 0.80 | 0.50 | ± 12.0 % |
| 5200 | 49.0 | 5.30 | 4.69 | 4.69 | 4.69 | 0.45 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.48 | 4.48 | 4.48 | 0.45 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.15 | 4.15 | 4.15 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.07 | 4.07 | 4.07 | 0.45 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.19 | 4.19 | 4.19 | 0.55 | 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.

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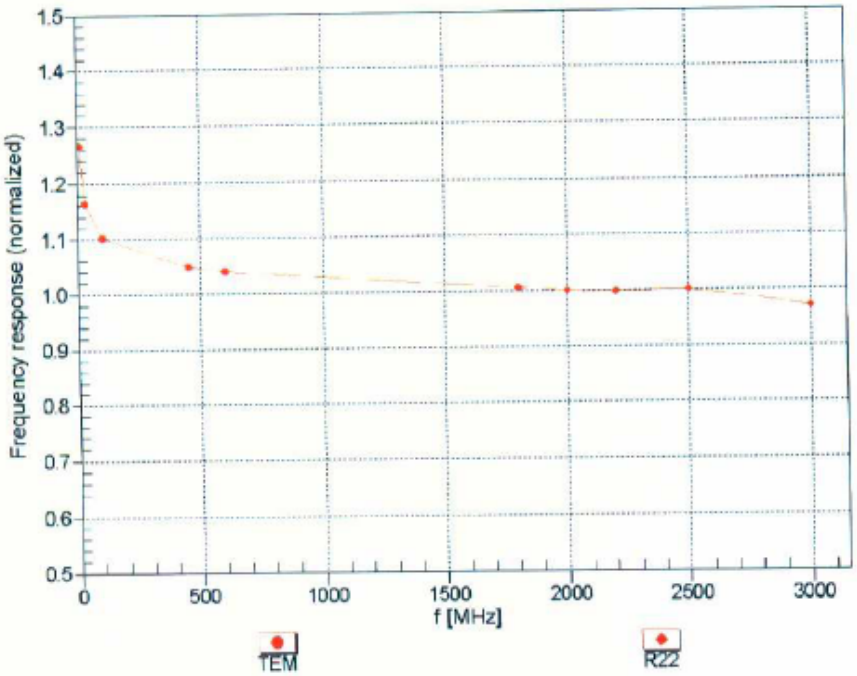
September 16, 2013

## Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide: R22)




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

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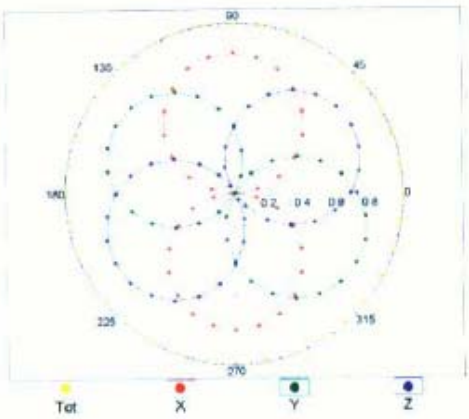
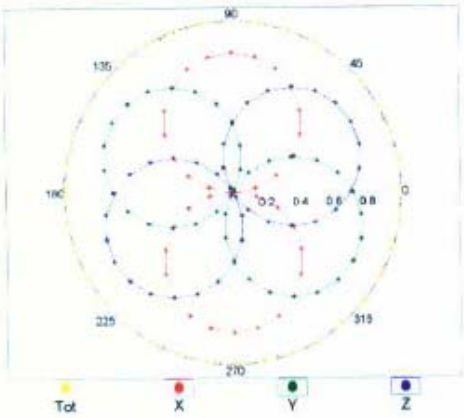
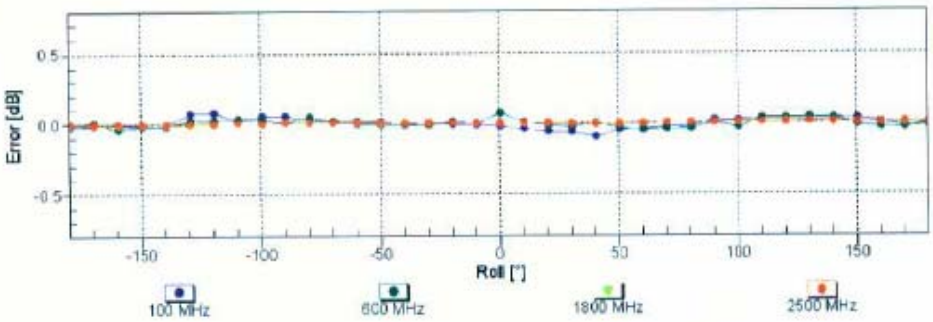
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22




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

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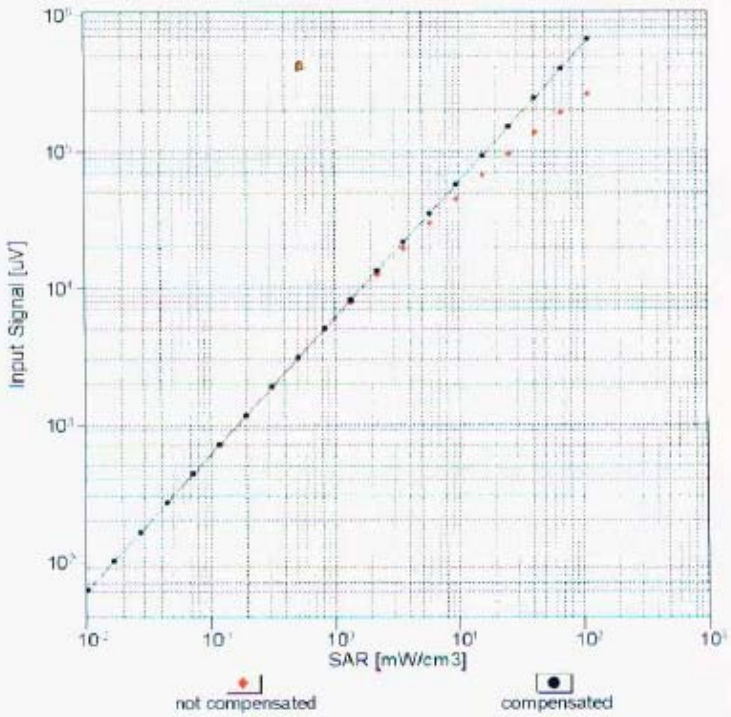
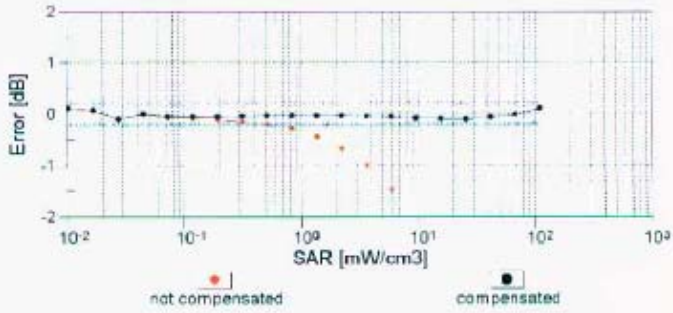
## Dynamic Range f($SAR_{head}$)
(TEM cell , f = 900 MHz)




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

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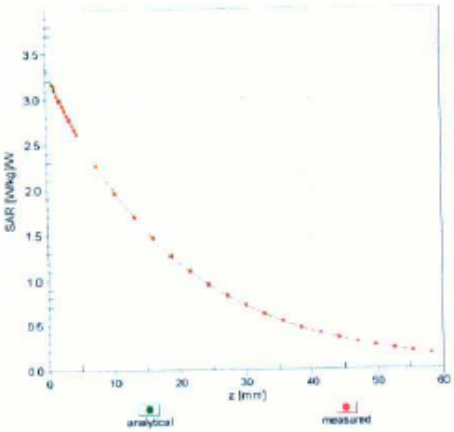
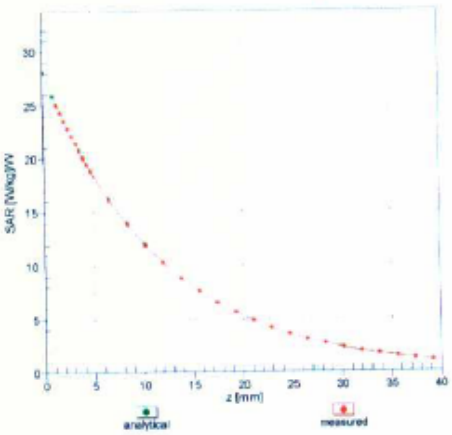
## Conversion Factor Assessment

f = 835 MHz,WGLS R9 (H_convF)

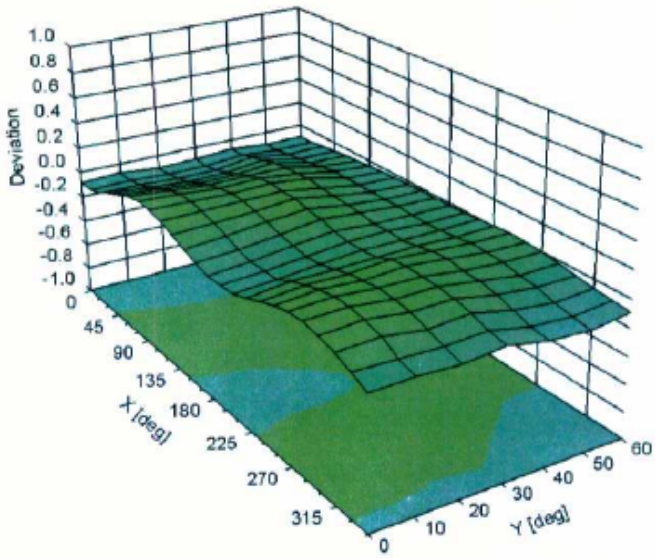


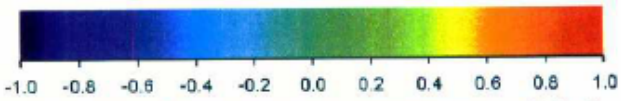

f = 1900 MHz,WGLS R22 (H_convF)




## Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




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

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