

# NORTHWEST EMC

**Electronic Technologies, LLC**

**Marcum RT-9**

**SAR Evaluation Report # ELTL0004.3**

**Evaluated to the following SAR specification:**

**FCC 2.1093:2015**

**FCC 15.247:2015**

**802.11 bgn Radio**



NVLAP Lab Code: 200881-0

*This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government of the United States of America. This Report may only be duplicated in its entirety*

# CERTIFICATE OF TEST

**Last Date of Test: December 08, 2015**  
**Electronic Technologies, LLC**  
**Model: Marcum RT-9**

**802.11 bgn Radio**

## Applicable Standard

| Test Description | Specification                      | Test Method                                                                                                                                                      | Pass/Fail |
|------------------|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| SAR Evaluation   | FCC 2.1093:2015<br>FCC 15.247:2015 | FCC KDB 248227 D01 v02r02<br>FCC KDB 447498 D01 v06<br>FCC KDB 616217 D04 v01r02<br>FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>IEEE Std 1528:2013 | Pass      |

## Highest SAR Values:

| Frequency Bands (GHz) | Body (W/kg) 1g | Limit (W/kg) 1g | Exposure Environment |
|-----------------------|----------------|-----------------|----------------------|
| 2.4                   | 0.093          | 1.6             | General Population   |

## Deviations From Test Standards

None

## Approved By:



Donald Facticeau, IT Manager

*Product compliance is the responsibility of the client; therefore, the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test. This report reflects only those tests from the referenced standards shown in the certificate of test. It does not include inspection or verification of labels, identification, marking or user information.*

# REVISION HISTORY

| Revision Number |  | Description | Date | Page Number |
|-----------------|--|-------------|------|-------------|
| 00              |  | None        |      |             |

# ACCREDITATIONS AND AUTHORIZATIONS

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## United States

**FCC** - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

**A2LA** - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Northwest EMC to certify transmitters to FCC and IC specifications.

**NVLAP** - Each laboratory is accredited by NVLAP to ISO 17025

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## Canada

**IC** - Recognized by Industry Canada as a Certification Body (CB). Certification chambers and Open Area Test Sites are filed with IC.

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## European Union

**European Commission** – Validated by the European Commission as a Conformity Assessment Body (CAB) under the EMC directive and as a Notified Body under the R&TTE Directive.

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## Australia/New Zealand

**ACMA** - Recognized by ACMA as a CAB for the acceptance of test data.

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## Korea

**MSIP / RRA** - Recognized by KCC's RRA as a CAB for the acceptance of test data.

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## Japan

**VCCI** - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

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## Taiwan

**BSMI** – Recognized by BSMI as a CAB for the acceptance of test data.

**NCC** - Recognized by NCC as a CAB for the acceptance of test data.

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## Singapore

**IDA** – Recognized by IDA as a CAB for the acceptance of test data.

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## Israel

**MOC** – Recognized by MOC as a CAB for the acceptance of test data.

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## Hong Kong

**OFCA** – Recognized by OFCA as a CAB for the acceptance of test data.

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## Vietnam

**MIC** – Recognized by MIC as a CAB for the acceptance of test data.

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## SCOPE

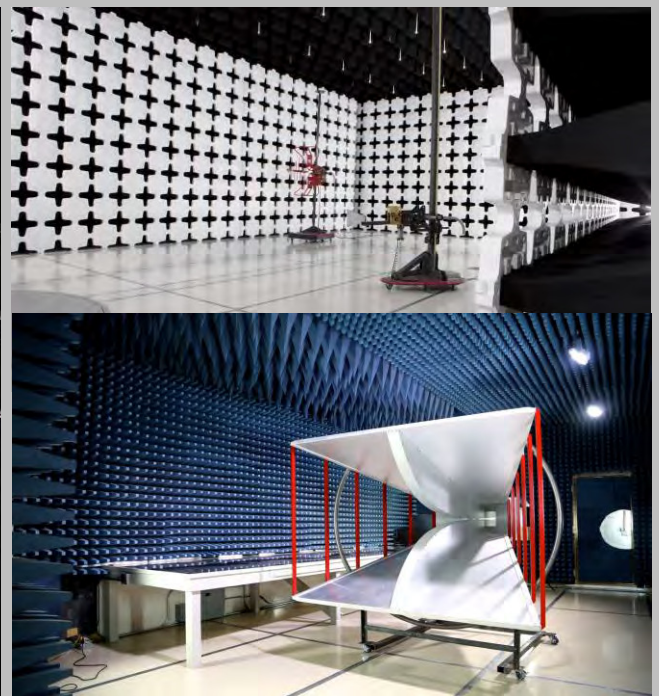
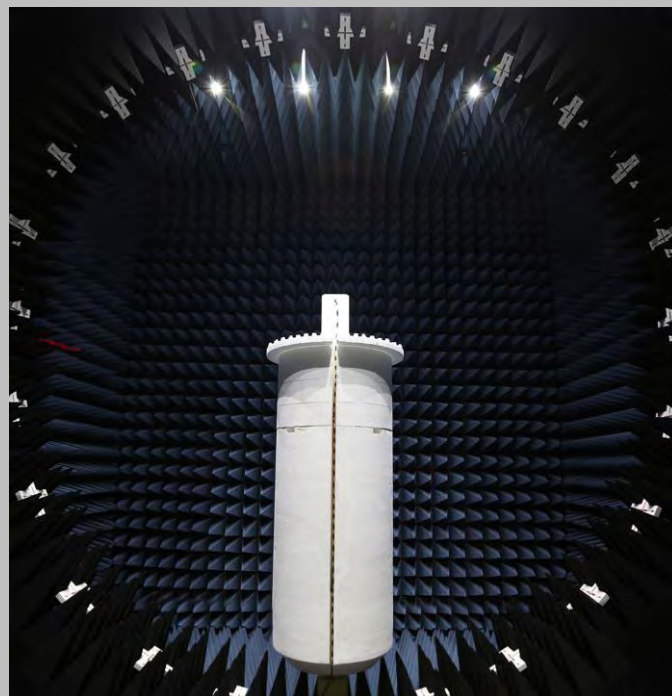
For details on the Scopes of our Accreditations, please visit:

<http://www.nwemc.com/accreditations/>  
<http://gsi.nist.gov/global/docs/cabs/designations.html>

# FACILITIES



|                                                                                     |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| <b>California</b><br>Labs OC01-13<br>41 Tesla<br>Irvine, CA 92618<br>(949) 861-8918 | <b>Minnesota</b><br>Labs MN01-08, MN10<br>9349 W Broadway Ave.<br>Brooklyn Park, MN 55445<br>(612)-638-5136 | <b>New York</b><br>Labs NY01-04<br>4939 Jordan Rd.<br>Elbridge, NY 13060<br>(315) 554-8214 | <b>Oregon</b><br>Labs EV01-12<br>22975 NW Evergreen Pkwy<br>Hillsboro, OR 97124<br>(503) 844-4066 | <b>Texas</b><br>Labs TX01-09<br>3801 E Plano Pkwy<br>Plano, TX 75074<br>(469) 304-5255 | <b>Washington</b><br>Labs NC01-05<br>19201 120 <sup>th</sup> Ave NE<br>Bothell, WA 9801<br>(425)984-6600 |
| <b>NVLAP</b>                                                                        |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
| NVLAP Lab Code: 200676-0                                                            | NVLAP Lab Code: 200881-0                                                                                    | NVLAP Lab Code: 200761-0                                                                   | NVLAP Lab Code: 200630-0                                                                          | NVLAP Lab Code:201049-0                                                                | NVLAP Lab Code: 200629-0                                                                                 |
| <b>Industry Canada</b>                                                              |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
| 2834B-1, 2834B-3                                                                    | 2834E-1                                                                                                     | N/A                                                                                        | 2834D-1, 2834D-2                                                                                  | 2834G-1                                                                                | 2834F-1                                                                                                  |
| <b>BSMI</b>                                                                         |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
| SL2-IN-E-1154R                                                                      | SL2-IN-E-1152R                                                                                              | N/A                                                                                        | SL2-IN-E-1017                                                                                     | SL2-IN-E-1158R                                                                         | SL2-IN-E-1153R                                                                                           |
| <b>VCCI</b>                                                                         |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
| A-0029                                                                              | A-0109                                                                                                      | N/A                                                                                        | A-0108                                                                                            | A-0201                                                                                 | A-0110                                                                                                   |
| <b>Recognized Phase I CAB for ACMA, BSMI, IDA, KCC/RRR, MIC, MOC, NCC, OFCA</b>     |                                                                                                             |                                                                                            |                                                                                                   |                                                                                        |                                                                                                          |
| US0158                                                                              | US0175                                                                                                      | N/A                                                                                        | US0017                                                                                            | US0191                                                                                 | US0157                                                                                                   |



# PRODUCT DESCRIPTION

## Client and Equipment Under Test (EUT) Information

|                                 |                              |
|---------------------------------|------------------------------|
| <b>Company Name:</b>            | Electronic Technologies, LLC |
| <b>Address:</b>                 | 3943 Quebec Ave North        |
| <b>City, State, Zip:</b>        | New Hope, MN 55427           |
| <b>Test Requested By:</b>       | Deb See                      |
| <b>Model:</b>                   | Marcum RT-9                  |
| <b>First Date of Test:</b>      | December 08, 2015            |
| <b>Last Date of Test:</b>       | December 08, 2015            |
| <b>Receipt Date of Samples:</b> | November 18, 2015            |
| <b>Equipment Design Stage:</b>  | Production                   |
| <b>Equipment Condition:</b>     | No Damage                    |

## Information Provided by the Party Requesting the Test

### Functional Description of the EUT:

The RT9 is a ruggedized Android tablet. It has normal Android behavior and an ice fishing application. The RT9 can be used on its own as a tablet, or mounted in a docking station for recharge/mount. The tablet is powered by an internal Li-Ion battery and will also ship with a standard 12 V battery that is the recharging station. The 12V battery has an external wall charger. The external battery should not be recharged while operating the tablet and documentation will state that. The tablet has 3 mounting attachment locations on its back where accessories for underwater cameras, ice fishing sonar, and open water sonars.

Connectors are custom to the modules. The unit may operate with a maximum of 3 modules. The unit contains a GPS receiver, Wifi transmitter (2.4 GHz only is enabled ). It has connections for HDMI, audio out, mini USB in for keyboard accessory, speakers, backlight, touchscreen LCD.

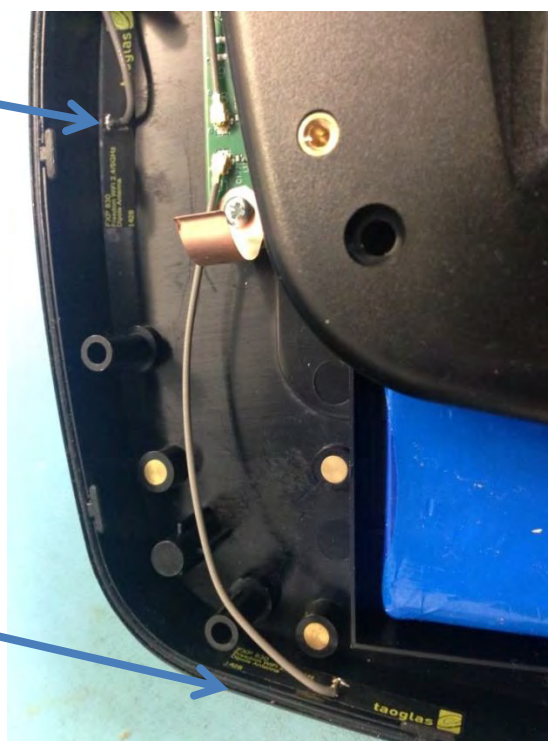


# PRODUCT DESCRIPTION



Auxiliary Antenna,  
Port B

Main Antenna,  
Port A



# PRODUCT DESCRIPTION

## Testing Requirements

### Testing Locations

After a review of the usage scenarios displayed above, the following positions were tested for the WLAN radio; left edge, bottom edge, and back side adjacent to the antennas. The diagonal screen size is greater than 20cm (7.9) inches therefore KDB 941225 is not applicable; instead, KDB 616217 is applicable. There is no usage model for operation near the head. There are no authorized accessories to wear the device on the body. Testing was done with a 0 cm spacing to the phantom.

KDB 447498 D01 General RF Exposure Guidance v06 is the FCC's starting point for RF exposure policy. Section 4.3.1, Item #1 provides the SAR test exclusion thresholds for test separation distances  $\leq 50\text{mm}$ :

$$\left[ \frac{(\text{max. power of channel, including tune-up tolerance, mW})}{(\text{min. test separation distance, mm})} \right] * \sqrt{f(\text{GHz})} \leq 3.0 \text{ for 1-g SAR and } \leq 7.5 \text{ for 10-g extremity SAR, where}$$

- $f(\text{GHz})$  is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- 3.0 and 7.5 are referred to as the numeric thresholds in the step 2 below

The test exclusions are applicable only when the minimum test separation distance is  $\leq 50 \text{ mm}$  and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is  $< 5 \text{ mm}$ , a distance of 5 mm according to 5) in section 4.1 is applied to determine SAR test exclusion.

Using the formula above, sides or edges with greater than 10 mm (0.4 inches) separation from the Main antenna are excluded from stand-alone SAR testing. Sides or edges with greater than 13 mm (0.5 inches) separation from the Aux antenna are excluded from stand-alone SAR testing.

The WLAN MAIN antenna is closest to the bottom edge of the display. The WLAN AUX antenna is closest to the left edge of the display. The back side of the display can be used next to the torso. Since they are all closer than 12 mm to the antennas, the left and bottom edges as well as the back side adjacent to the antennas were tested.

The right and top edges have greater than 50 mm separation from the antenna and is excluded from SAR testing. The front surface of the tablet is excluded from SAR testing per Section 4.3 of KDB 616217 D04 v01r02.

### Simultaneous Transmission

### MIMO Evaluation

The FCC's Guidance for SAR testing of 802.11 a/b/g device is found in KDB 248227. It states:

"Unless the antennas are spatially separated and SAR distributions do not overlap, when antennas transmit simultaneously in the same frequency band and within the frequency range covered by a single SAR probe calibration point, SAR is generally measured with all applicable antennas transmitting simultaneously at maximum output power in a single SAR measurement."

MIMO SAR evaluations were conducted in the 2.4 GHz band to show that with a 30 cm antenna spacing, there were no overlapping SAR regions. The zoom scans of each hot spot were centered on the individual antennas.

# PRODUCT DESCRIPTION

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**Testing Objective:**

To demonstrate compliance with the SAR requirements of FCC 2.1093

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**Scope**

The stand-alone SAR evaluation documented in this report is for the 802.11bgn portion of the EUT.

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# CONFIGURATIONS

## Configuration ELTL0004- 5

| EUT               |                              |                   |               |
|-------------------|------------------------------|-------------------|---------------|
| Description       | Manufacturer                 | Model/Part Number | Serial Number |
| Ruggedized Tablet | Electronic Technologies, LLC | Marcum RT-9       | RTS0123456811 |
| AC Adapter        | Universal Power Group, Inc.  | 12BC0500D-1       | None          |

| Peripherals in test setup boundary |              |                   |                              |
|------------------------------------|--------------|-------------------|------------------------------|
| Description                        | Manufacturer | Model/Part Number | Serial Number                |
| Keyboard                           | Dell         | 0U473D            | CN-0U473D-44751-162-02NT-A02 |

| Cables               |        |            |         |                   |                   |
|----------------------|--------|------------|---------|-------------------|-------------------|
| Cable Type           | Shield | Length (m) | Ferrite | Connection 1      | Connection 2      |
| DC Power Cable       | No     | 1.95m      | Yes     | AC Adapter        | Ruggedized Tablet |
| USB Cable (Keyboard) | Yes    | 2.0m       | Yes     | Ruggedized Tablet | Keyboard          |

## Configuration ELTL0004- 6

| EUT               |                              |                   |               |
|-------------------|------------------------------|-------------------|---------------|
| Description       | Manufacturer                 | Model/Part Number | Serial Number |
| Ruggedized Tablet | Electronic Technologies, LLC | Marcum RT-9       | RTS0123456811 |

| Peripherals in test setup boundary |              |                   |                              |
|------------------------------------|--------------|-------------------|------------------------------|
| Description                        | Manufacturer | Model/Part Number | Serial Number                |
| Keyboard                           | Dell         | 0U473D            | CN-0U473D-44751-162-02NT-A02 |
| Earbud Headphones                  | Unknown      | None              | None                         |

| Cables               |        |            |         |                   |                   |
|----------------------|--------|------------|---------|-------------------|-------------------|
| Cable Type           | Shield | Length (m) | Ferrite | Connection 1      | Connection 2      |
| USB Cable (Keyboard) | Yes    | 2.0m       | Yes     | Ruggedized Tablet | Keyboard          |
| Headphone Cable      | No     | 2.0m       | No      | Earbud Headphones | Ruggedized Tablet |
| HDMI Cable           | Yes    | 1.8m       | No      | Unterminated      | Ruggedized Tablet |

# MODIFICATIONS

## Equipment Modifications

| Item | Date      | Test | Modification                         | Note                                                                | Disposition of EUT               |
|------|-----------|------|--------------------------------------|---------------------------------------------------------------------|----------------------------------|
| 1    | 12/8/2015 | SAR  | Tested as delivered to Test Station. | No EMI suppression devices were added or modified during this test. | Scheduled testing was completed. |

# TISSUE – EQUIVALENT LIQUID DESCRIPTION

## Characterization of tissue-equivalent liquid dielectric properties

Per IEEE 1528: 2013, Section 5.3.2, the permittivity and conductivity of the tissue material should be measured at least within 24 hours of any full-compliance test. The measured values must be within +/- 5% of the target values. The temperature variation in the liquid during SAR measurements must be within +/- 2 degrees C of that recorded when the dielectric properties were measured.

The dielectric parameters of the tissue-equivalent liquids were measured within 24 hours of the start of testing using the SPEAG DAKS:200 dielectric assessment kit. The dielectric measurements were made across the frequency range of the liquid. The attached data sheets show that the dielectric parameters of the liquid were within the required 5% tolerances.

## Target values of dielectric parameters

Per KDB 865664 D01 v01r04, Appendix A:

“The head tissue dielectric parameters recommended by IEEE Std 1528-2013 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in IEEE Std 1528 are derived from tissue dielectric parameters computed from the 4-Cole-Cole equations described above and extrapolated according to the head parameters specified in IEEE Std 1528.”

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

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

# TISSUE – EQUIVALENT LIQUID DESCRIPTION

## Composition of Ingredients for Liquid Tissue Phantoms

Northwest EMC uses tissue-equivalent liquids prepared by SPEAG and confirmed by them to be within +/- 5% from the target values. Their recipes are based upon the following formulations as found in IEEE 1528:2013 Annex C (head) and IEC 62209-2:2010 Annex E (body):

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

### HEAD

**Table C.1—Suggested recipes for achieving target dielectric parameters:  
300 MHz to 900 MHz**

| Frequency (MHz)                  | 300    | 450    | 450    | 450   | 835    | 835   | 900    | 900    | 900    | 900   |
|----------------------------------|--------|--------|--------|-------|--------|-------|--------|--------|--------|-------|
| Reference                        | [B118] | [B118] | [B172] | [B74] | [B118] | [B74] | [B118] | [B196] | [B172] | [B74] |
| <b>Ingredients (% by weight)</b> |        |        |        |       |        |       |        |        |        |       |
| 1,2-Propanediol                  | —      | —      | —      | —     | —      | —     | —      | 64.81  | —      | —     |
| Bactericide                      | 0.19   | 0.19   | 0.50   | —     | 0.10   | —     | 0.10   | —      | 0.50   | —     |
| Diacetin                         | —      | —      | 48.90  | —     | —      | —     | —      | —      | 49.20  | —     |
| DGBE                             | —      | —      | —      | —     | —      | —     | —      | —      | —      | —     |
| HEC                              | 0.98   | 0.98   | —      | —     | 1.00   | —     | 1.00   | —      | —      | —     |
| NaCl                             | 5.95   | 3.95   | 1.70   | 1.96  | 1.45   | 1.25  | 1.48   | 0.79   | 1.10   | 1.35  |
| Sucrose                          | 55.32  | 56.32  | —      | —     | 57.00  | —     | 56.50  | —      | —      | —     |
| Triton X-100                     | —      | —      | —      | —     | —      | —     | —      | —      | —      | —     |
| Tween 20                         | —      | —      | —      | 49.51 | —      | 48.39 | —      | —      | —      | 48.34 |
| Water                            | 37.56  | 38.56  | 48.90  | 48.53 | 40.45  | 50.36 | 40.92  | 34.40  | 49.20  | 50.31 |

**Table C.2—Suggested recipes for achieving target dielectric parameters:  
1450 MHz to 2000 MHz**

| Frequency (MHz)                  | 1450   | 1800   | 1800   | 1800   | 1800   | 1800  | 1900   | 1900   | 1950  | 2000   |
|----------------------------------|--------|--------|--------|--------|--------|-------|--------|--------|-------|--------|
| Reference                        | [B118] | [B118] | [B196] | [B196] | [B172] | [B74] | [B118] | [B196] | [B74] | [B118] |
| <b>Ingredients (% by weight)</b> |        |        |        |        |        |       |        |        |       |        |
| 1,2-Propanediol                  | —      | —      | —      | —      | —      | —     | —      | —      | —     | —      |
| Bactericide                      | —      | —      | —      | —      | 0.50   | —     | —      | —      | —     | —      |
| Diacetin                         | —      | —      | —      | —      | 49.43  | —     | —      | —      | —     | —      |
| DGBE                             | 45.51  | 47.00  | 13.84  | 44.92  | —      | —     | 44.92  | 13.84  | 45.00 | 50.00  |
| HEC                              | —      | —      | —      | —      | —      | —     | —      | —      | —     | —      |
| NaCl                             | 0.67   | 0.36   | 0.35   | 0.18   | 0.64   | 0.50  | 0.18   | 0.35   | —     | —      |
| Sucrose                          | —      | —      | —      | —      | —      | —     | —      | —      | —     | —      |
| Triton X-100                     | —      | —      | 30.45  | —      | —      | —     | —      | 30.45  | —     | —      |
| Tween 20                         | —      | —      | —      | —      | —      | 45.27 | —      | —      | —     | —      |
| Water                            | 53.82  | 52.64  | 55.36  | 54.90  | 49.43  | 54.23 | 54.90  | 55.36  | 55.00 | 50.00  |

# TISSUE – EQUIVALENT LIQUID DESCRIPTION

**Table C.3—Suggested recipes for achieving target dielectric parameters:  
2100 MHz to 5800 MHz**

| Frequency (MHz)                  | 2100   | 2100   | 2450   | 2450   | 3000   | 5200  | 5800  |
|----------------------------------|--------|--------|--------|--------|--------|-------|-------|
| Reference                        | [B118] | [B196] | [B196] | [B172] | [B196] |       |       |
| <b>Ingredients (% by weight)</b> |        |        |        |        |        |       |       |
| 1,2-Propanediol                  | —      | —      | —      |        | —      | —     | —     |
| Bactericide                      | —      | —      | —      | 0.50   | —      | —     | —     |
| Diacetin                         | —      | —      | —      | 49.75  | —      | —     | —     |
| DGBE                             | 50.00  | 7.99   | 7.99   | —      | 7.99   | —     | —     |
| HEC                              | —      | —      | —      | —      | —      | —     | —     |
| NaCl                             | —      | 0.16   | 0.16   | —      | 0.16   | —     | —     |
| Sucrose                          | —      | —      | —      | —      | —      | —     | —     |
| Triton X-100                     | —      | 19.97  | 19.97  | —      | 19.97  | 17.24 | 17.24 |
| Diethyleneglycol monohexylether  | —      | —      | —      | —      | —      | 17.24 | 17.24 |
| Water                            | 50.00  | 71.88  | 71.88  | 49.75  | 71.88  | 65.52 | 65.52 |

## **BODY**

| Frequency (MHz)                  | 30    | 50    |       | 144   |       | 450   |    | 835   | 900   |    |
|----------------------------------|-------|-------|-------|-------|-------|-------|----|-------|-------|----|
| Recipe source number             | 3     | 3     | 2     | 2     | 3     | 2     | 4  | 2     | 2     | 4  |
| <b>Ingredients (% by weight)</b> |       |       |       |       |       |       |    |       |       |    |
| Deionised water                  | 48,30 | 48,30 | 53,53 | 55,12 | 48,30 | 48,53 | 56 | 50,36 | 50,31 | 56 |
| Tween                            |       |       | 44,70 | 43,31 |       | 49,51 |    | 48,39 | 48,34 |    |
| Oxidised mineral oil             |       |       |       |       |       |       | 44 |       |       | 44 |
| Diethyleneglycol monohexylether  |       |       |       |       |       |       |    |       |       |    |
| Triton X-100                     |       |       |       |       |       |       |    |       |       |    |
| Diacetin                         | 50,00 | 50,00 |       |       | 50,00 |       |    |       |       |    |
| DGBE                             |       |       |       |       |       |       |    |       |       |    |
| NaCl                             | 1,60  | 1,60  | 1,77  | 1,57  | 1,60  | 1,96  |    | 1,25  | 1,35  |    |
| Additives and salt               | 0,10  | 0,10  |       |       | 0,10  |       |    |       |       |    |

| Frequency (MHz)                  | 1 800 |    | 2 450 | 4 000 | 5 000 | 5 200 | 5 800 | 6 000 |
|----------------------------------|-------|----|-------|-------|-------|-------|-------|-------|
| Recipe source number             | 2     | 4  | 4     | 4     | 4     | 1     | 1     | 4     |
| <b>Ingredients (% by weight)</b> |       |    |       |       |       |       |       |       |
| Deionised water                  | 54,23 | 56 | 56    | 56    | 56    | 65,53 | 65,53 | 56    |
| Tween                            | 45,27 |    |       |       |       |       |       |       |
| Oxidised mineral oil             |       | 44 | 44    | 44    | 44    |       |       | 44    |
| Diethyleneglycol monohexylether  |       |    |       |       |       | 17,24 | 17,24 |       |
| Triton X-100                     |       |    |       |       |       | 17,24 | 17,24 |       |
| Diacetin                         |       |    |       |       |       |       |       |       |
| DGBE                             |       |    |       |       |       |       |       |       |
| NaCl                             | 0,50  |    |       |       |       |       |       |       |
| Additives and salt               |       |    |       |       |       |       |       |       |

# TISSUE – EQUIVALENT LIQUID

|            |                 |                     |           |
|------------|-----------------|---------------------|-----------|
| Date:      | 12/07/2015      | Temperature:        | 21.8°C    |
| Tissue:    | Body, MSL2450   | Liquid Temperature: | 22°C      |
| Tested By: | Luke Richardson | Relative Humidity:  | 49.8%     |
| Job Site:  | EV08            | Bar. Pressure:      | 1004.1 mb |

## TEST SPECIFICATIONS

|                                    |                                                                                                                                                                  |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Specification:                     | Method:                                                                                                                                                          |
| FCC 15.247:2015<br>FCC 2.1093:2015 | FCC KDB 248227 D01 v02r02<br>FCC KDB 447498 D01 v06<br>FCC KDB 616217 D04 v01r02<br>FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>IEEE Std 1528:2013 |

## RESULTS

|                 | Actual Values         |              | Target Values         |              | Deviation (%)         |              |
|-----------------|-----------------------|--------------|-----------------------|--------------|-----------------------|--------------|
| Frequency (MHz) | Relative Permittivity | Conductivity | Relative Permittivity | Conductivity | Relative Permittivity | Conductivity |
| 2450            | 51.16                 | 1.944        | 52.7                  | 1.95         | 2.92                  | 0.31         |

| Frequency (MHz) | Relative Permittivity | Conductivity |
|-----------------|-----------------------|--------------|
| 2000            | 52.57                 | 1.368        |
| 2025            | 52.5                  | 1.397        |
| 2050            | 52.44                 | 1.426        |
| 2100            | 52.37                 | 1.487        |
| 2125            | 52.28                 | 1.519        |
| 2175            | 52.16                 | 1.584        |
| 2200            | 52.09                 | 1.61         |
| 2250            | 52.02                 | 1.678        |
| 2275            | 51.93                 | 1.706        |
| 2325            | 51.71                 | 1.773        |
| 2350            | 51.63                 | 1.808        |
| 2400            | 51.4                  | 1.871        |
| 2425            | 51.25                 | 1.911        |
| 2450            | 51.16                 | 1.944        |
| 2475            | 51.05                 | 1.982        |
| 2500            | 50.97                 | 2.021        |
| 2550            | 50.85                 | 2.087        |
| 2575            | 50.74                 | 2.123        |
| 2625            | 50.58                 | 2.206        |
| 2650            | 50.5                  | 2.242        |
| 2700            | 50.21                 | 2.297        |
| 2725            | 50.15                 | 2.331        |
| 2775            | 49.88                 | 2.403        |
| 2800            | 49.79                 | 2.438        |
| 2850            | 49.51                 | 2.504        |
| 2875            | 49.37                 | 2.542        |
| 2925            | 49.17                 | 2.61         |
| 2950            | 49.05                 | 2.641        |
| 2975            | 48.94                 | 2.678        |

# SAR SYSTEM VERIFICATION DESCRIPTION

## REQUIREMENT

Per IEEE 1528, Section 8.2.1, "System checks are performed prior to compliance tests and the results must always be within  $\pm 10\%$  of the target value corresponding to the test frequency, liquid, and the source used. The target values are 1 g or 10 g averaged SAR values measured on systems having current system validation and calibration status, and using the system check setup as shown in Figure 14. These target values should be determined using a standard source."

## TEST DESCRIPTION

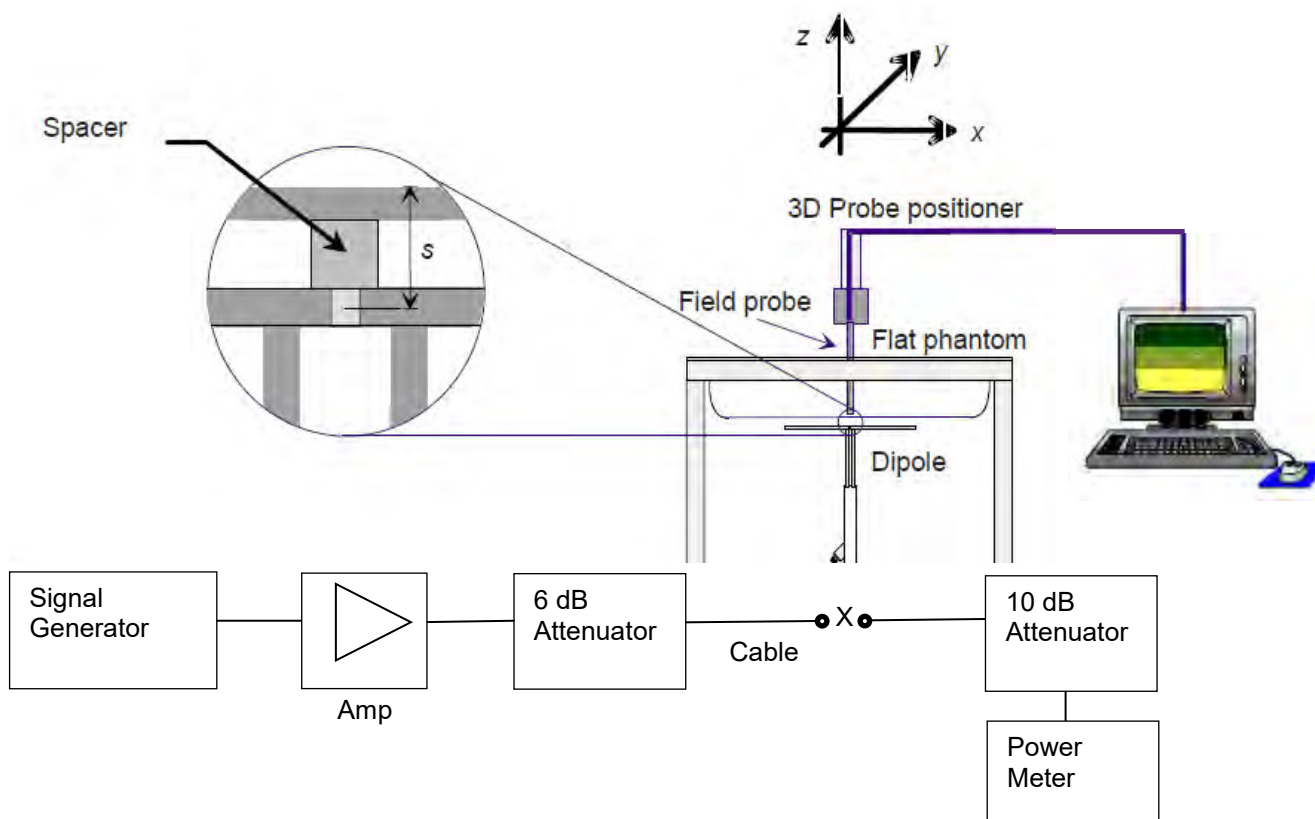
Within 24 hours of a measurement, then every 72 hours thereafter, Northwest EMC used the system validation kit (calibrated reference dipole) to test whether the system was operating within its specifications. The validation was performed in the indicated bands by making SAR measurements of the reference dipole with the phantom filled with the tissue-equivalent liquid. First, a signal generator and power amplifier were used to produce a 100mW level as measured with a power meter at the antenna terminals of the dipole (X). Then, the reference dipole was positioned below the bottom of the phantom and centered with its axis parallel to the longest side of the phantom. A low loss and low relative permittivity spacer was used to establish the correct distance between the center axis of the reference dipole and the liquid.

For the reference dipoles, the spacing distance  $s$  is given by:

$s = 15\text{mm}$ ,  $\pm 0.2\text{mm}$  for  $300\text{MHz} \leq f \leq 1000 \text{ MHz}$ :

$s = 10\text{mm}$ ,  $\pm 0.2\text{mm}$  for  $1000\text{MHz} \leq f \leq 6000\text{MHz}$

The measured 1 g and 10 g spatial average SAR values were normalized to a 1W dipole input power for comparison to the calibration data. The results are summarized in the attached table. The deviation is less than 10% in all cases, indicating that the system performance check was within tolerance.



# SAR SYSTEM VERIFICATION

## TEST SPECIFICATIONS

| Specification:                     | Method:                                                                                                                                                          |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FCC 15.247:2015<br>FCC 2.1093:2015 | FCC KDB 248227 D01 v02r02<br>FCC KDB 447498 D01 v06<br>FCC KDB 616217 D04 v01r02<br>FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>IEEE Std 1528:2013 |

## RESULTS

| Date      | Liquid part<br>number and<br>frequency | Conducted<br>Power into<br>the Dipole<br>(dBm) | Correction<br>Factor | Measured |      | Normalized to<br>1W |       | Target<br>(Normalized to 1W)<br>Get from Dipole<br>Calibration Certificate |       | % Difference |      |
|-----------|----------------------------------------|------------------------------------------------|----------------------|----------|------|---------------------|-------|----------------------------------------------------------------------------|-------|--------------|------|
|           |                                        |                                                |                      | 1g       | 10g  | 1g                  | 10g   | 1g                                                                         | 10g   | 1g           | 10g  |
| 12/7/2015 | MSL 2450<br>(2450 MHz)                 | 19.78                                          | 10.52                | 5.07     | 2.36 | 53.34               | 24.83 | 50.60                                                                      | 23.70 | 5.42         | 4.77 |

# SAR SYSTEM VERIFICATION

|                |                 |                          |           |
|----------------|-----------------|--------------------------|-----------|
| Tested By:     | Luke Richardson | Room Temperature (°C):   | 22.3°C    |
| Date:          | 12/7/2015       | Liquid Temperature (°C): | 21.3°C    |
| Configuration: | Body            | Humidity (%RH):          | 49.1%     |
|                |                 | Bar. Pressure (mb):      | 1004.1 mb |

## Test 1

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

Communication System: UID 10000, CW; Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 52.875$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $\sigma = 0$  S/m,  $\epsilon_r = 1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY Configuration:

- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**System Check/System Check/Area Scan (51x61x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm  
Maximum value of SAR (interpolated) = 5.45 W/kg

**System Check/System Check/Z Scan (1x1x21):** Measurement grid: dx=20mm, dy=20mm, dz=5mm  
Maximum value of Total (measured) = 65.50 V/m

**System Check/System Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 50.44 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 10.1 W/kg

**SAR(1 g) = 5.07 W/kg; SAR(10 g) = 2.36 W/kg**

Maximum value of SAR (measured) = 5.08 W/kg

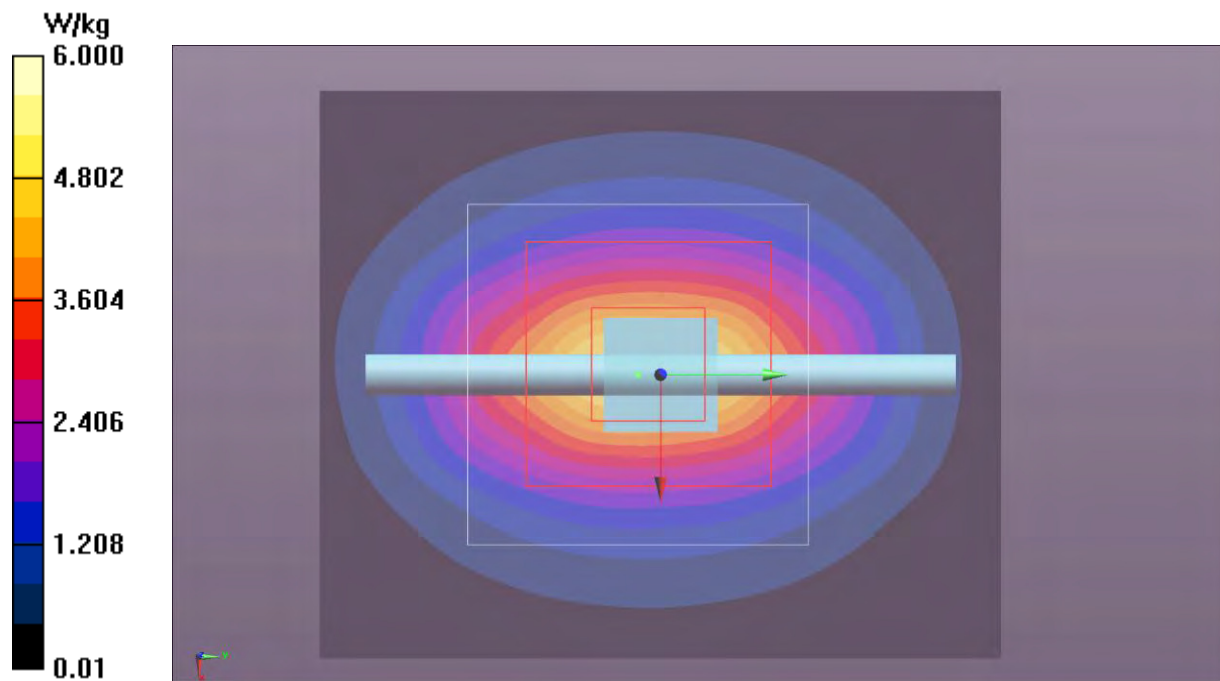
Maximum value of SAR (measured) = 8.58 W/kg



Approved By

# SAR SYSTEM VERIFICATION

Test 1



# OUTPUT POWER DESCRIPTION

## 2.4 GHz Bands

Per FCC KDB 248227, the conducted output power was measured at the lowest, a middle, and highest channel in each band. Measurements were made while the EUT transmitted at the lowest, middle and the highest data rates for each channel. When the SAR measured on the highest output channel was  $>0.8$  W/kg, SAR evaluation for the other required test channels was necessary.

Output power measurements are on the following pages

# OUTPUT POWER

|                                        |                             |                              |                        |
|----------------------------------------|-----------------------------|------------------------------|------------------------|
| EUT: Marcum RT-9                       |                             | Work Order: ETL0004          |                        |
| Serial Number: RTS0123456811           |                             | Date: 12/04/15               |                        |
| Customer: Electronic Technologies, LLC |                             | Temperature: 22.2°C          |                        |
| Attendees: Rocky Holmes, Deb See       |                             | Humidity: 25%                |                        |
| Project: None                          |                             | Barometric Pres.: 998.9      |                        |
| Tested by: Trevor Buls                 |                             | Power: 110VAC/60Hz           |                        |
| TEST SPECIFICATIONS                    |                             | Test Method                  |                        |
| FCC 15.247:2015                        |                             | ANSI C63.10:2013             |                        |
| COMMENTS                               |                             |                              |                        |
| None                                   |                             |                              |                        |
| DEVIATIONS FROM TEST STANDARD          |                             |                              |                        |
| None                                   |                             |                              |                        |
| Configuration #                        | 5                           | Signature <i>Trevor Buls</i> |                        |
|                                        |                             | Avg Cond Pwr (dBm)           | Duty Cycle Factor (dB) |
|                                        |                             | Value (dBm)                  | Limit (dBm)            |
|                                        |                             |                              | Results                |
| Chain A                                |                             |                              |                        |
| 20 MHz                                 |                             |                              |                        |
| 802.11(b) 1 Mbps                       |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | 6.953                        | 0.5                    |
|                                        | Mid Channel 6, 2437 MHz     | 8.674                        | 0.5                    |
|                                        | High Channel 11, 2462 MHz   | 8.053                        | 0.5                    |
| 802.11(b) 11 Mbps                      |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | 5.449                        | 2.6                    |
|                                        | Mid Channel 6, 2437 MHz     | 6.812                        | 2.7                    |
|                                        | High Channel 11, 2462 MHz   | 6.227                        | 2.7                    |
| 802.11(g) 6 Mbps                       |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | 1.068                        | 2.3                    |
|                                        | Mid Channel 6, 2437 MHz     | 2.609                        | 2.3                    |
|                                        | High Channel 11, 2462 MHz   | 2.014                        | 2.3                    |
| 802.11(g) 36 Mbps                      |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | -3.382                       | 6.8                    |
|                                        | Mid Channel 6, 2437 MHz     | -1.453                       | 6.8                    |
|                                        | High Channel 11, 2462 MHz   | -2.357                       | 6.8                    |
| 802.11(g) 54 Mbps                      |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | -4.548                       | 7.9                    |
|                                        | Mid Channel 6, 2437 MHz     | -2.811                       | 7.9                    |
|                                        | High Channel 11, 2462 MHz   | -3.416                       | 7.9                    |
| 802.11(n) MCS0                         |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | 0.836                        | 2.6                    |
|                                        | Mid Channel 6, 2437 MHz     | 2.485                        | 2.6                    |
|                                        | High Channel 11, 2462 MHz   | 1.893                        | 2.6                    |
| 802.11(n) MCS7                         |                             |                              |                        |
|                                        | Low Channel 1, 2412 MHz     | -4.426                       | 8.1                    |
|                                        | Mid Channel 6, 2437 MHz     | -2.765                       | 8.1                    |
|                                        | High Channel 11, 2462 MHz   | -3.389                       | 8.1                    |
| 40 MHz                                 |                             |                              |                        |
| 802.11(n) MCS0                         |                             |                              |                        |
|                                        | Low Channel 1/5, 2422 MHz   | 3.204                        | 1.2                    |
|                                        | Mid Channel 4/8, 2437 MHz   | 3.597                        | 1.2                    |
|                                        | High Channel 7/11, 2452 MHz | 3.288                        | 1.2                    |
| 802.11(n) MCS7                         |                             |                              |                        |
|                                        | Low Channel 1/5, 2422 MHz   | -1.95                        | 6.1                    |
|                                        | Mid Channel 4/8, 2437 MHz   | -1.58                        | 6.1                    |
|                                        | High Channel 7/11, 2452 MHz | -1.892                       | 6.1                    |

# OUTPUT POWER 2x2



XMR 2015.01.14

|                                        |                           |                              |                        |
|----------------------------------------|---------------------------|------------------------------|------------------------|
| EUT: Marcum RT-9                       |                           | Work Order: ETL0004          |                        |
| Serial Number: RTS0123456811           |                           | Date: 12/04/15               |                        |
| Customer: Electronic Technologies, LLC |                           | Temperature: 22.2°C          |                        |
| Attendees: Rocky Holmes, Deb See       |                           | Humidity: 25%                |                        |
| Project: None                          |                           | Barometric Pres.: 998.9      |                        |
| Tested by: Trevor Buls                 | Power: 110VAC/60Hz        | Job Site: MN08               |                        |
| TEST SPECIFICATIONS                    |                           | Test Method                  |                        |
| FCC 15.247:2015                        |                           | ANSI C63.10:2013             |                        |
| COMMENTS                               |                           |                              |                        |
| None                                   |                           |                              |                        |
| DEVIATIONS FROM TEST STANDARD          |                           |                              |                        |
| None                                   |                           |                              |                        |
| Configuration #                        | 5                         | Signature <i>Trevor Buls</i> |                        |
|                                        |                           | Avg Cond Pwr (dBm)           | Duty Cycle Factor (dB) |
|                                        |                           | Value (dBm)                  | Limit (dBm)            |
|                                        |                           |                              | Results                |
| Chain A                                |                           |                              |                        |
| 20 MHz                                 |                           |                              |                        |
| 2400 MHz - 2483.5 MHz Band             |                           |                              |                        |
| 802.11(n) MCS8                         |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | 0.979                        | 1.8                    |
|                                        | Mid Channel 6, 2437 MHz   | 0.695                        | 1.9                    |
|                                        | High Channel 11, 2462 MHz | -0.072                       | 1.8                    |
| 802.11(n) MCS15                        |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | -4.62                        | 4.9                    |
|                                        | Mid Channel 6, 2437 MHz   | -2.915                       | 4.9                    |
|                                        | High Channel 11, 2462 MHz | -3.392                       | 4.9                    |
| Chain B                                |                           |                              |                        |
| 20 MHz                                 |                           |                              |                        |
| 2400 MHz - 2483.5 MHz Band             |                           |                              |                        |
| 802.11(n) MCS8                         |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | 4.874                        | 1.9                    |
|                                        | Mid Channel 6, 2437 MHz   | 4.951                        | 1.9                    |
|                                        | High Channel 11, 2462 MHz | 4.886                        | 1.9                    |
| 802.11(n) MCS15                        |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | 1.937                        | 4.9                    |
|                                        | Mid Channel 6, 2437 MHz   | 2.352                        | 4.9                    |
|                                        | High Channel 11, 2462 MHz | 1.99                         | 4.9                    |
| Chain AB                               |                           |                              |                        |
| 20 MHz                                 |                           |                              |                        |
| 2400 MHz - 2483.5 MHz Band             |                           |                              |                        |
| 802.11(n) MCS8                         |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | 1.90                         | 4.76                   |
|                                        | Mid Channel 6, 2437 MHz   | 1.82                         | 4.84                   |
|                                        | High Channel 11, 2462 MHz | 1.49                         | 4.77                   |
| 802.11(n) MCS15                        |                           |                              |                        |
|                                        | Low Channel 1, 2412 MHz   | 1.07                         | 4.83                   |
|                                        | Mid Channel 6, 2437 MHz   | 1.58                         | 5.31                   |
|                                        | High Channel 11, 2462 MHz | 1.42                         | 4.89                   |

## Test Locations

Per FCC KDB 447498, section 4.3.1, Item #1, the left and bottom edges as well as the back side adjacent to the antennas were tested. Testing was done with a 0 cm spacing to the phantom.

The front surface of the tablet is excluded from SAR testing per Section 4.3 of KDB 616217.

## Simultaneous Transmission

### MIMO Evaluation

MIMO SAR evaluations were conducted in the 2.4 GHz band to show that with a 30 cm antenna spacing, there were no overlapping SAR regions. The zoom scans of each hot spot were centered on the individual antennas.

## Operating Mode

All testing was performed with the EUT configured in a worst – case configuration and operating mode to produce the highest SAR levels. The EUT used client provided test software that permitted the selection of transmit channel, modulation type, and data rate. The radio module operated continuously at nearly 100% duty cycle at the maximum rated power.

## Summary

The following tables summarize the measured SAR values.

Per FCC KDB 248227, among the channels required for normal testing, SAR must be measured on the channel with the highest conducted output power. When the SAR measured on the highest output channel is  $>0.8$  W/kg, SAR evaluation for the other required test channels is necessary.

Also, when the measured SAR is  $>0.8$  W/kg, SAR measurement variability is assessed per FCC KDB 865664 D01 v01r04, Section 2.8.1.

# SAR TEST DATA

|            |                              |                   |          |
|------------|------------------------------|-------------------|----------|
| EUT:       | Marcum RT-9                  | Work Order:       | ELTL0004 |
| Customer:  | Electronic Technologies, LLC | Job Site:         | EV08     |
| Attendees: | Deb See                      | Customer Project: | None     |

## TEST SPECIFICATIONS

| Specification:                     | Method:                                                                                                                                                          |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FCC 15.247:2015<br>FCC 2.1093:2015 | FCC KDB 248227 D01 v02r02<br>FCC KDB 447498 D01 v06<br>FCC KDB 616217 D04 v01r02<br>FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>IEEE Std 1528:2013 |

## COMMENTS

None

## DEVIATIONS FROM TEST STANDARD

None

## RESULTS

| Test Configuration | Frequency Band | Transmit Frequency (MHz) | Transmit Channel | Data Rate (Mbps) | Channel Bandwidth | Antenna Port | EUT Position | SAR Drift During Test (dB) | Measured 1g SAR Level (mW/g) | Measured 10g SAR Level (mW/g) | Test# |
|--------------------|----------------|--------------------------|------------------|------------------|-------------------|--------------|--------------|----------------------------|------------------------------|-------------------------------|-------|
| Body               | 2.4GHz         | 2437                     | 6                | 1Mbit            | 20                | A            | Bottom       | -0.07                      | 0.093                        | 0.045                         | 1     |
| Body               | 2.4GHz         | 2437                     | 6                | 1Mbit            | 20                | A            | Back         | N/A                        | 0.048                        | 0.0244                        | 2     |
| Body               | 2.4GHz         | 2437                     | 6                | 1Mbit            | 20                | A            | Left         | N/A                        | 0.0063                       | 0.0037                        | 3     |
| Body               | 2.4GHz         | 2437                     | 4-8              | MCS0             | 40                | A            | Bottom       | N/A                        | 0.034                        | 0.015                         | 4     |
| Body               | 2.4GHz         | 2437                     | 4-8              | MCS0             | 40                | A            | Back         | N/A                        | 0.015                        | 0.00774                       | 5     |
| Body               | 2.4GHz         | 2437                     | 4-8              | MCS0             | 40                | A            | Left         | N/A                        | 0.0057                       | 0.00299                       | 6     |
| Body               | 2.4GHz         | 2437                     | 6                | MCS15            | 20                | A&B          | Bottom       | N/A                        | 0.00951                      | 0.0039                        | 7     |
| Body               | 2.4GHz         | 2437                     | 6                | MCS15            | 20                | A&B          | Left         | N/A                        | 0.00924                      | 0.00525                       | 8     |
| Body               | 2.4GHz         | 2437                     | 6                | MCS15            | 20                | A&B          | Back         | N/A                        | 0.00391                      | 0.00195                       | 9     |
| Body               | 2.4GHz         | 2437                     | 6                | MCS15            | 20                | A&B          | Back         | N/A                        | 0.00563                      | 0.00268                       | 10    |

# SAR TEST DATA

|                |                      |                          |           |
|----------------|----------------------|--------------------------|-----------|
| Tested By:     | Luke Richardson      | Room Temperature (°C):   | 22.2°C    |
| Date:          | 12/8/2015 9:27:30 AM | Liquid Temperature (°C): | 2.4°C     |
| Serial Number: | RTS0123456811        | Humidity (%RH):          | 50.3%     |
| Configuration: | ELTL0004-6           | Bar. Pressure (mb):      | 1008.1 mb |
| Comments:      | None                 |                          |           |

## Test 1

**DUT: Tablet; Type: Marcum RT-9; Serial: RTS0123456811**

Communication System: UID 0, CW; Communication System Band: D2450 (2450.0 MHz); Frequency: 2437 MHz; Communication System PAR: 0 dB; PMF: 1

Medium parameters used (interpolated):  $f = 2437$  MHz;  $\sigma = 1.977$  S/m;  $\epsilon_r = 52.927$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used:  $\sigma = 0$  S/m,  $\epsilon_r = 1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY Configuration:

- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Body/Body/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 7.685 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 0.182 W/kg

**SAR(1 g) = 0.093 W/kg; SAR(10 g) = 0.045 W/kg**

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

Maximum value of SAR (measured) = 0.136 W/kg

**Body/Body/Area scan (51x51x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

Maximum value of SAR (interpolated) = 0.124 W/kg

**Body/Body/Z Scan (1x1x21):** Measurement grid: dx=20mm, dy=20mm, dz=5mm

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

Maximum value of Total (measured) = 5.600 V/m

**Body/Body/Reference scan (41x71x1):** Interpolated grid: dx=3.000 mm, dy=3.000 mm

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

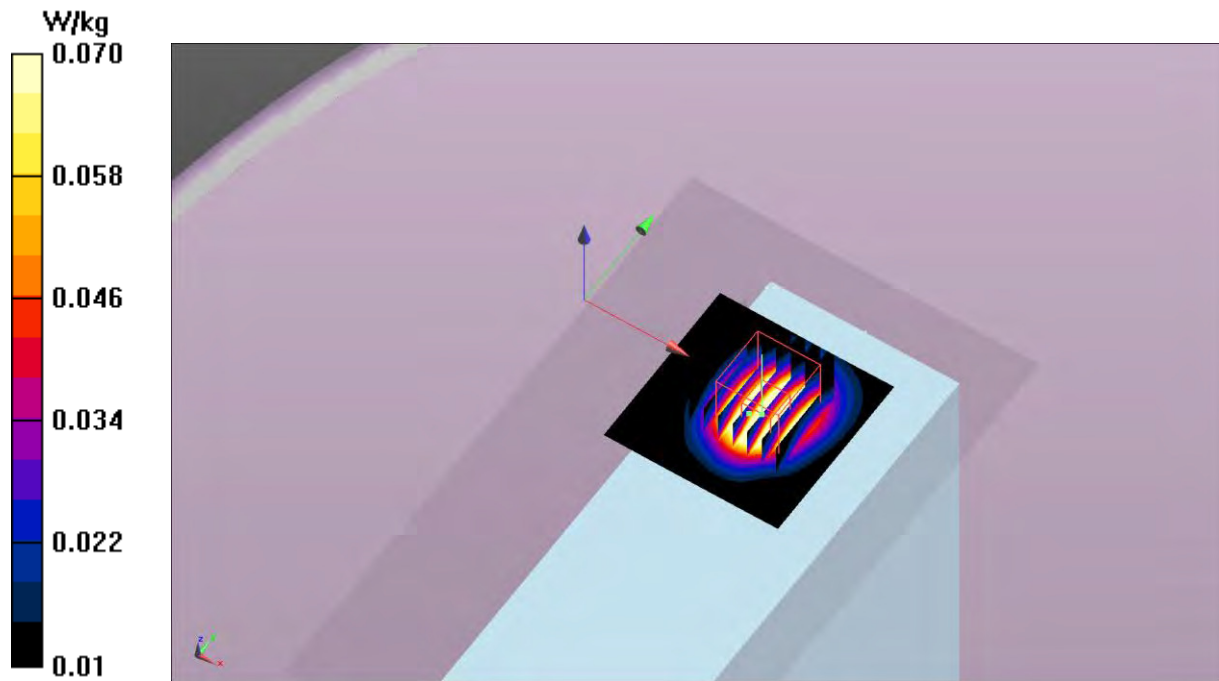
Maximum value of SAR (interpolated) = 0.118 W/kg

Maximum value of SAR (measured) = 0.0620 W/kg

  
Approved By

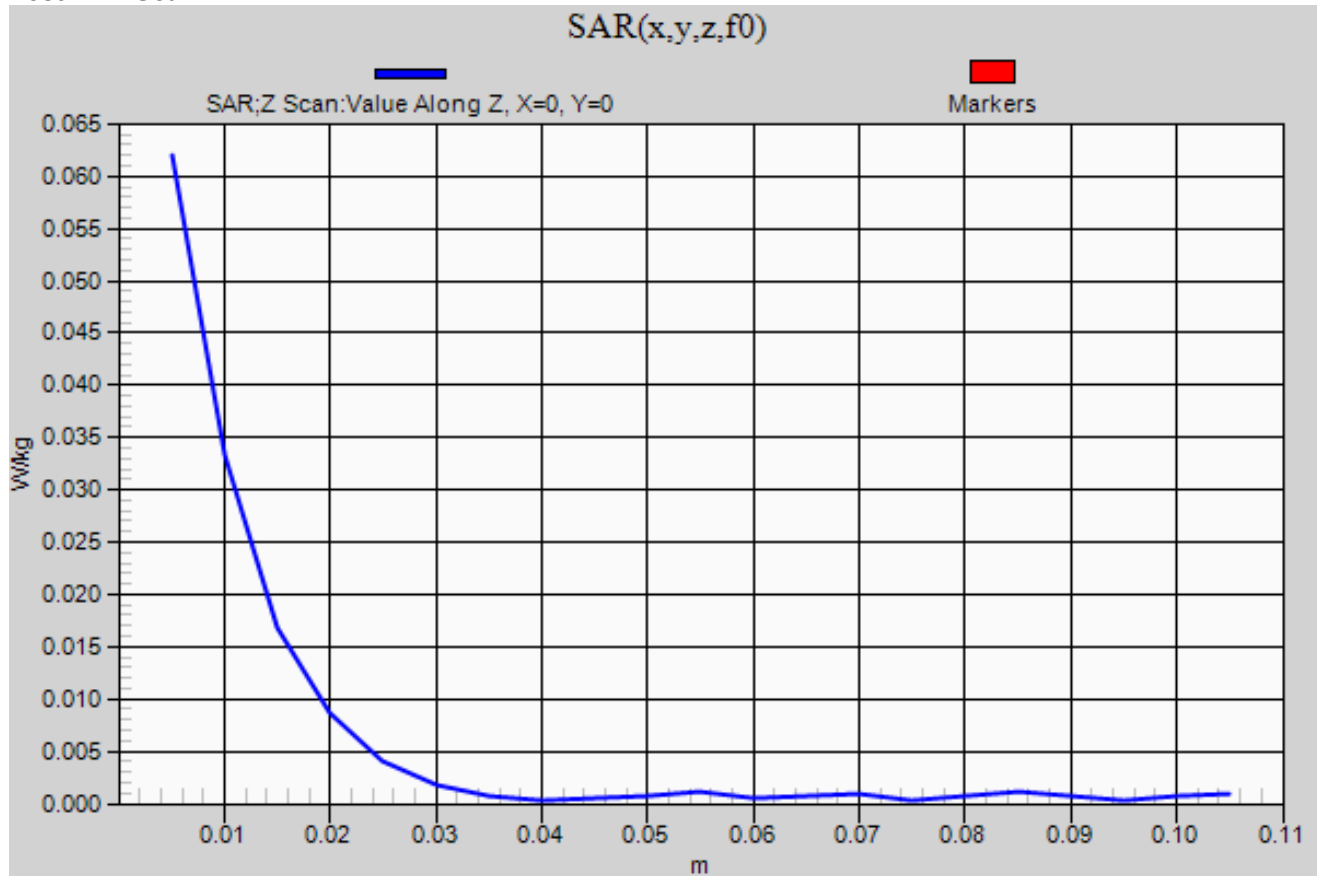
# SAR TEST DATA

Test 1



# SAR TEST DATA

## Test 1: Z Scan



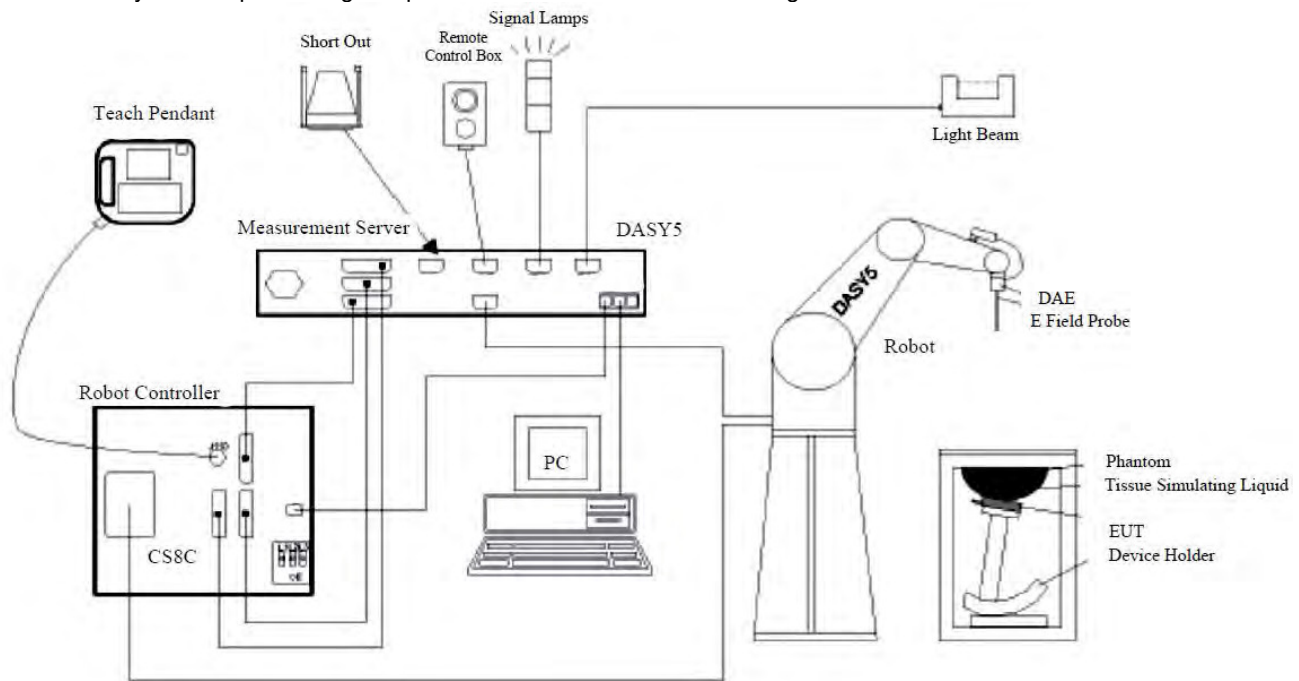
# SYSTEM AND TEST SITE DESCRIPTION

## SAR MEASUREMENT SYSTEM

### Schmid & Partner Engineering AG, DASY52

Northwest EMC selected the leader in SAR evaluation systems to provide the measurement tools for this evaluation. SPEAG's DASY52 is the fastest and most accurate scanner on the market. It is fully compatible with all world-wide standards for transmitters operating at the ear or within 20cm of the body. It provides full compatibility with IEC 62209-1, IEC 62209-2, IEEE 1528 as well as national adaptations such as FCC OET-65c and Korean Std. MIC #2000-93

The DASY52 system for performing compliance tests consists of the following items:



- A standard high precision 6-axis robot (Staubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running WinXP and the DASY5 software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom, oval flat phantom, device holder, tissue simulating liquids, and validation dipole kits.

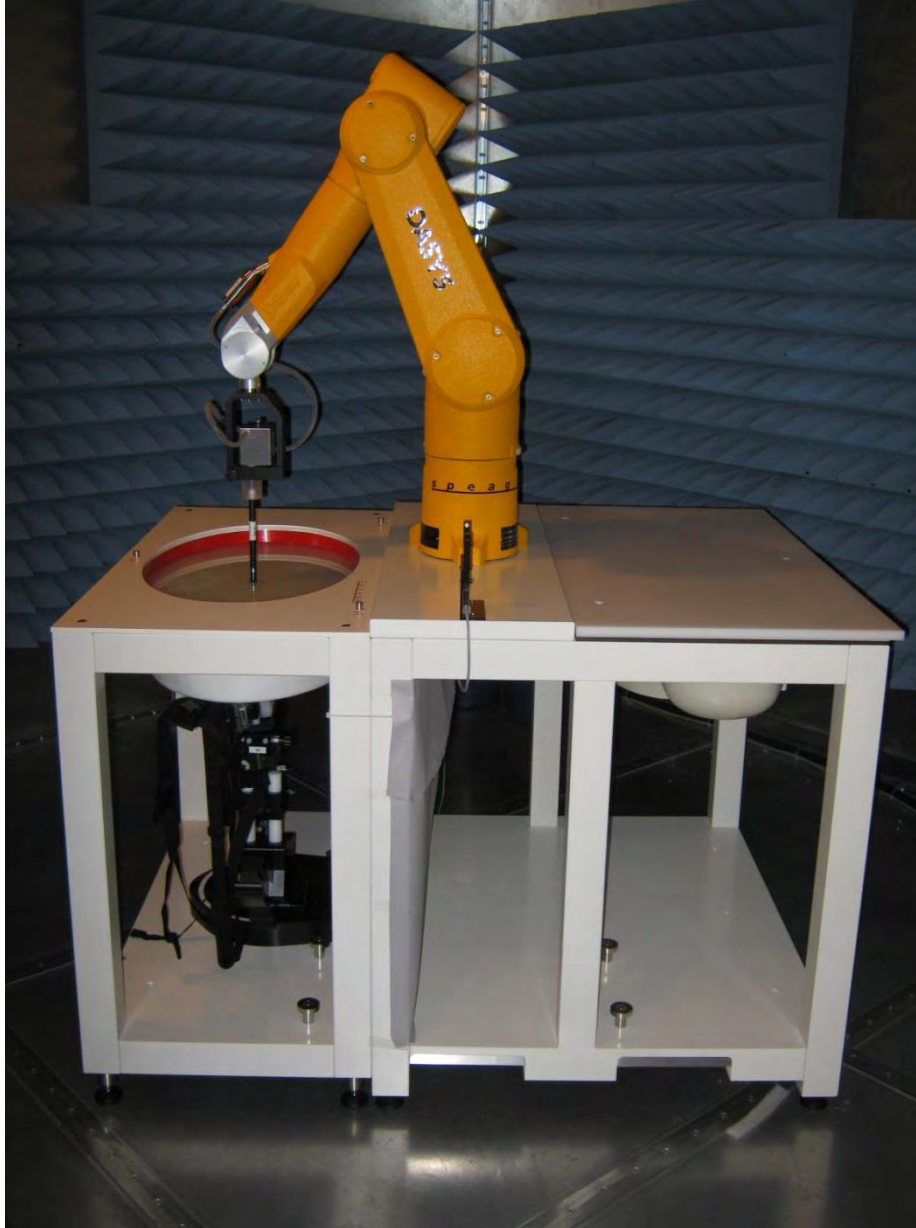
# SYSTEM AND TEST SITE DESCRIPTION

## TEST SITE

### Northwest EMC, Lab EV08

The SAR measurement system is located in a semi-anechoic chamber. This provides an ambient free environment that also eliminates reflections.

The chamber is 12 ft wide by 16 ft long x 8 ft high. A dedicated HVAC unit provides +/- 1 degree C temperature control.



# TEST EQUIPMENT

## TEST EQUIPMENT

| Description                            | Manufacturer            | Model         | ID  | Last Cal.           | Interval |
|----------------------------------------|-------------------------|---------------|-----|---------------------|----------|
| Amplifier                              | Mini Circuits           | ZVE-3W-83+    | TTA | NCR <sup>1</sup>    | 0 mo     |
| Antenna - Dipole                       | SPEAG                   | D2450V2       | ADL | 10/26/2015          | 12 mo    |
| DAE                                    | SPEAG                   | SD 000 D04 EJ | SAH | 10/28/2015          | 12 mo    |
| Device Holder                          | SPEAG                   | N/A           | SAW | NCR                 | 0 mo     |
| Fixture/Kit - Calibration/Verification | SPEAG                   | DAKS:200      | IPR | 3/6/2014            | 36 mo    |
| Generator - Signal                     | Agilent                 | V2920A        | TIH | NCR                 | 0 mo     |
| Light Beam Unit                        | SPEAG                   | SE UKS 030 AA | SAD | NCR                 | 0 mo     |
| Meter - Power                          | Agilent                 | N1913A        | SQR | 10/30/2015          | 12 mo    |
| Power Sensor                           | Agilent                 | E9300H        | SQO | 10/30/2015          | 12 mo    |
| SAR - Tissue Test Solution             | SPEAG                   | MSL 2450      | SAM | At start of testing |          |
| SAR Probe                              | SPEAG                   | EX3DV4        | SAG | 11/18/2015          | 12 mo    |
| SAR Test System                        | Staeubli                | DASY52        | SAK | 11/1/2013           | 36 mo    |
| SAR Test System                        | SPEAG                   | QD OVA 001 BB | SAC | NCR                 | 0 mo     |
| SAR Test System                        | Staeubli                | TX60LSPEAG    | SAA | NCR                 | 0 mo     |
| SAR Test System                        | Staeubli                | N/A           | SAJ | NCR                 | 0 mo     |
| SAR Test System                        | Staeubli                | CS8C          | SAI | NCR                 | 0 mo     |
| Thermometer                            | Omega Engineering, Inc. | HH311         | DUI | 1/26/2015           | 36 mo    |

Note 1: The output of the signal generator / amplifier is verified with the calibrated power meter listed above.

# MEASUREMENT UNCERTAINTY

## MEASUREMENT UNCERTAINTY BUDGETS PER IEEE 1528:2013

### 300-3000 MHz Range

| Uncertainty Component                                                            | Tolerance<br>(+/- %) | Probability<br>Distribution | Divisor | $c_i$ (1g) | $c_i$ (10g) | $u_i$ (1g)<br>(+/-%) | $u_i$ (10g)<br>(+/-%) | $v_i$    |
|----------------------------------------------------------------------------------|----------------------|-----------------------------|---------|------------|-------------|----------------------|-----------------------|----------|
| <b>Measurement System</b>                                                        |                      |                             |         |            |             |                      |                       |          |
| Probe calibration (k=1)                                                          | 5.5                  | normal                      | 1       | 1          | 1           | 5.5                  | 5.5                   | $\infty$ |
| Axial isotropy                                                                   | 4.7                  | rectangular                 | 1.732   | 0.707      | 0.707       | 1.9                  | 1.9                   | $\infty$ |
| Hemispherical isotropy                                                           | 9.6                  | rectangular                 | 1.732   | 0.707      | 0.707       | 3.9                  | 3.9                   | $\infty$ |
| Boundary effect                                                                  | 1.0                  | rectangular                 | 1.732   | 1          | 1           | 0.6                  | 0.6                   | $\infty$ |
| Linearity                                                                        | 4.7                  | rectangular                 | 1.732   | 1          | 1           | 2.7                  | 2.7                   | $\infty$ |
| System detection limits                                                          | 1.0                  | rectangular                 | 1.732   | 1          | 1           | 0.6                  | 0.6                   | $\infty$ |
| Readout electronics                                                              | 0.3                  | normal                      | 1       | 1          | 1           | 0.3                  | 0.3                   | $\infty$ |
| Response time                                                                    | 0.8                  | rectangular                 | 1.732   | 1          | 1           | 0.5                  | 0.5                   | $\infty$ |
| Integration time                                                                 | 2.6                  | rectangular                 | 1.732   | 1          | 1           | 1.5                  | 1.5                   | $\infty$ |
| RF ambient conditions - noise                                                    | 1.7                  | rectangular                 | 1.732   | 1          | 1           | 1.0                  | 1.0                   | $\infty$ |
| RF Ambient Reflections                                                           | 0.0                  | rectangular                 | 1.732   | 1          | 1           | 0.0                  | 0.0                   | $\infty$ |
| Probe positioner mechanical tolerance                                            | 0.4                  | rectangular                 | 1.732   | 1          | 1           | 0.2                  | 0.2                   | $\infty$ |
| Probe positioner with respect to phantom shell                                   | 2.9                  | rectangular                 | 1.732   | 1          | 1           | 1.7                  | 1.7                   | $\infty$ |
| Extrapolation, interpolation, and integration algorithms for max. SAR evaluation | 1.0                  | rectangular                 | 1.732   | 1          | 1           | 0.6                  | 0.6                   | $\infty$ |
| <b>Test Sample Related</b>                                                       |                      |                             |         |            |             |                      |                       |          |
| Device Positioning                                                               | 2.9                  | normal                      | 1       | 1          | 1           | 2.9                  | 2.9                   | 145      |
| Device Holder                                                                    | 3.6                  | normal                      | 1       | 1          | 1           | 3.6                  | 3.6                   | 5        |
| Power Drift                                                                      | 5.0                  | rectangular                 | 1.732   | 1          | 1           | 2.9                  | 2.9                   | $\infty$ |
| <b>Phantom and tissue parameters</b>                                             |                      |                             |         |            |             |                      |                       |          |
| Phantom Uncertainty - shell thickness tolerances                                 | 4.0                  | rectangular                 | 1.732   | 1          | 1           | 2.3                  | 2.3                   | $\infty$ |
| Liquid conductivity - deviation from target values                               | 5.0                  | rectangular                 | 1.732   | 0.64       | 0.43        | 1.8                  | 1.2                   | $\infty$ |
| Liquid conductivity - measurement uncertainty                                    | 6.5                  | normal                      | 1       | 0.64       | 0.43        | 4.2                  | 2.8                   | $\infty$ |
| Liquid permittivity - deviation from target values                               | 5.0                  | rectangular                 | 1.732   | 0.6        | 0.49        | 1.7                  | 1.4                   | $\infty$ |
| Liquid permittivity - measurement uncertainty                                    | 3.2                  | normal                      | 1       | 0.6        | 0.49        | 1.9                  | 1.6                   | $\infty$ |
| Combined Standard Uncertainty                                                    | RSS                  |                             |         |            |             | 11.2                 | 10.6                  | 387      |
| Expanded Measurement Uncertainty (95% Confidence/                                | normal (k=2)         |                             |         |            |             | 22.5                 | 21.2                  |          |

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## Dipole Calibration

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Key points:

1. Dipoles need to be sent to the manufacturer for calibration every 3 years.
2. For those years where they are not sent to the manufacturer the following two parameters are verified annually:
  - a. The return-loss. If it deviates by more than 20% from the calibration data or does not meet the required -20 dB return-loss specification, then it fails the verification and must be sent to the manufacturer for repair and calibration.
  - b. The real and imaginary parts of the impedance. If it deviates by more than 5  $\Omega$  from the calibration data, then it fails the verification and must be sent to the manufacturer for repair and calibration.

The return loss and complex impedance were verified to meet the FCC's criteria within one year of the manufacturer's calibration. The calibration data is used for the SAR system verification. The verification data shows that the dipole characteristics have not changed and the calibration data continues to be valid.

Please see attached calibration and verification data.

---

## **Dipole Verification**

Performed by Northwest EMC, Inc.

ADL

|                                                                                                        |                          |                                       |                     |                          |                     |                |           |
|--------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------|---------------------|--------------------------|---------------------|----------------|-----------|
| NORTHWEST<br><b>EMC</b>                                                                                |                          | <b>Calibration Certificate/Report</b> |                     |                          |                     | 10/2015cbe     |           |
| Description: Antenna, Dipole 2450MHz SAR                                                               |                          | Cal Date: 102615                      |                     |                          |                     |                |           |
| Equipment Code: ADL                                                                                    |                          | Temperature: 21.0°C                   |                     |                          |                     |                |           |
| Model: D2450V2                                                                                         |                          | Humidity: 48%                         |                     |                          |                     |                |           |
| Manufacturer: SPEAG                                                                                    |                          | Tester: Carl Engholm                  |                     | Pressure: 1016mb         |                     |                |           |
| Certificate No.: ADL 102615                                                                            |                          | Power: N/A                            |                     | Calibration Site: EV CAL |                     |                |           |
| <b>TEST SPECIFICATIONS</b>                                                                             |                          |                                       |                     |                          |                     |                |           |
| Calibration Procedure: KDB 450824 D02 Dipole SAR Validation Verification v01r01                        |                          |                                       |                     | Version: 2013            |                     |                |           |
| <b>TEST PARAMETERS</b>                                                                                 |                          |                                       |                     |                          |                     |                |           |
| Device Received In Tolerance: Yes                                                                      |                          | Calibration Frequency: 2450 MHz       |                     |                          |                     |                |           |
| <b>Equipment Used to perform calibration</b>                                                           |                          |                                       |                     |                          |                     |                |           |
| Item:                                                                                                  | Network Analyzer         | Identifier:                           | NAP                 | Model:                   | Agilent E5061B      | Last Cal Date: | 6/12/2014 |
| Item:                                                                                                  | 50 Ohm Termination       | Identifier:                           | NAHA                | Model:                   | Agilent 85032-60017 | Last Cal Date: | 5/17/2015 |
| Item:                                                                                                  | Short                    | Identifier:                           | N/A                 | Model:                   | Agilent 54202       | Last Cal Date: | NCR       |
| Item:                                                                                                  | Open                     | Identifier:                           | N/A                 | Model:                   | Agilent 54266       | Last Cal Date: | NCR       |
| Item:                                                                                                  | Head TSL                 | Identifier:                           | SAL                 | Model:                   | HSL 2450            | Last Cal Date: | 24 Hours  |
| Item:                                                                                                  | Body TSL                 | Identifier:                           | SAM                 | Model:                   | MSL 2450            | Last Cal Date: | 24 Hours  |
| <b>COMMENTS, OPINIONS and INTERPRETATIONS</b>                                                          |                          |                                       |                     |                          |                     |                |           |
| Body TSL only                                                                                          |                          |                                       |                     |                          |                     |                |           |
| <b>Measurement Uncertainty</b>                                                                         |                          |                                       |                     |                          |                     |                |           |
|                                                                                                        | Probability Distribution | Impedance (dB)                        | Insertion Loss (dB) | Value (dB)               | Value (+/- %)       |                |           |
| Expanded uncertainty U (level of confidence = 95%)                                                     | normal (k=2)             | +/- 0.80                              | +/- 0.80            | N/A                      | N/A                 |                |           |
| <b>DEVIATIONS FROM TEST STANDARD</b>                                                                   |                          |                                       |                     |                          |                     |                |           |
| None                                                                                                   |                          |                                       |                     |                          |                     |                |           |
| <b>RESULTS</b>                                                                                         |                          |                                       |                     |                          |                     |                |           |
| Pass                                                                                                   |                          |                                       |                     |                          |                     |                |           |
| <p>This measurement was a calibration verification. (Instrument parameters are within tolerances.)</p> |                          |                                       |                     |                          |                     |                |           |
| CALIBRATION DATA ATTACHED                                                                              |                          |                                       |                     |                          |                     |                |           |

| Verification Data - Head |                             |                                                            |                         |
|--------------------------|-----------------------------|------------------------------------------------------------|-------------------------|
| <b>DUT</b>               | Antenna, Dipole 2450MHz SAR | <b>Antenna Parameters with Head TSL</b><br><b>2450 MHz</b> |                         |
| Model                    | D2450V2                     |                                                            |                         |
| S/N                      | <b>ADL</b>                  |                                                            |                         |
| Date                     | 102615                      | Impedance (ohms)                                           | Real      Imaginary (j) |
| Temperature              | 21.0°C                      | Return Loss (dB)                                           | 55.0      3.1           |
| Humidity                 | 48%                         |                                                            |                         |
| Pressure                 | 1016mb                      |                                                            |                         |
| Operator                 | Carl Engholm                |                                                            |                         |
| Verification Data - Body |                             |                                                            |                         |
| <b>DUT</b>               | Antenna, Dipole 2450MHz SAR | <b>Antenna Parameters with Body TSL</b><br><b>2450 MHz</b> |                         |
| Model                    | D2450V2                     |                                                            |                         |
| S/N                      | <b>ADL</b>                  |                                                            |                         |
| Date                     | Last Cal Date:              | Impedance (ohms)                                           | Real      Imaginary (j) |
| Temperature              | Last Cal Date:              | Return Loss (dB)                                           | 49.1      4.6           |
| Humidity                 | Last Cal Date:              |                                                            |                         |
| Pressure                 | Last Cal Date:              |                                                            |                         |
| Operator                 | Carl Engholm                |                                                            |                         |

**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  
**S** Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Client **Northwest EMC**

Certificate No: **D2450V2-855\_Nov14**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 855**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **November 04, 2014**

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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)     | Scheduled Calibration |
|-----------------------------|--------------------|--------------------------------|-----------------------|
| Power meter EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)      | Oct-15                |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)      | Oct-15                |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)      | Oct-15                |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)      | Apr-15                |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)      | Apr-15                |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13) | Dec-14                |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14) | Aug-15                |

| Secondary Standards       | ID #             | Check Date (in house)             | Scheduled Check        |
|---------------------------|------------------|-----------------------------------|------------------------|
| RF generator R&S SMT-06   | 100005           | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

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

Issued: November 4, 2014

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

Report No. **ELTL0004.3**



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Accreditation No.: **SCS 108**

### Glossary:

|       |                                 |
|-------|---------------------------------|
| TSL   | tissue simulating liquid        |
| ConvF | sensitivity in TSL / NORM x,y,z |
| N/A   | not applicable or not measured  |

### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 10 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 2450 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 39.0 $\pm$ 6 % | 1.86 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 13.3 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 52.3 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 6.15 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 24.4 W/kg $\pm$ 16.5 % (k=2) |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 52.7           | 1.95 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 50.9 $\pm$ 6 % | 2.03 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 13.0 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 50.6 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 6.01 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 23.7 W/kg $\pm$ 16.5 % (k=2) |

## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | $53.0\ \Omega + 3.2\ j\Omega$ |
| Return Loss                          | - 27.3 dB                     |

### Antenna Parameters with Body TSL

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | $49.2\ \Omega + 5.3\ j\Omega$ |
| Return Loss                          | - 25.4 dB                     |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.156 ns |
|----------------------------------|----------|

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

|                 |                   |
|-----------------|-------------------|
| Manufactured by | SPEAG             |
| Manufactured on | November 10, 2009 |

## DASY5 Validation Report for Head TSL

Date: 04.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 855**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 39$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

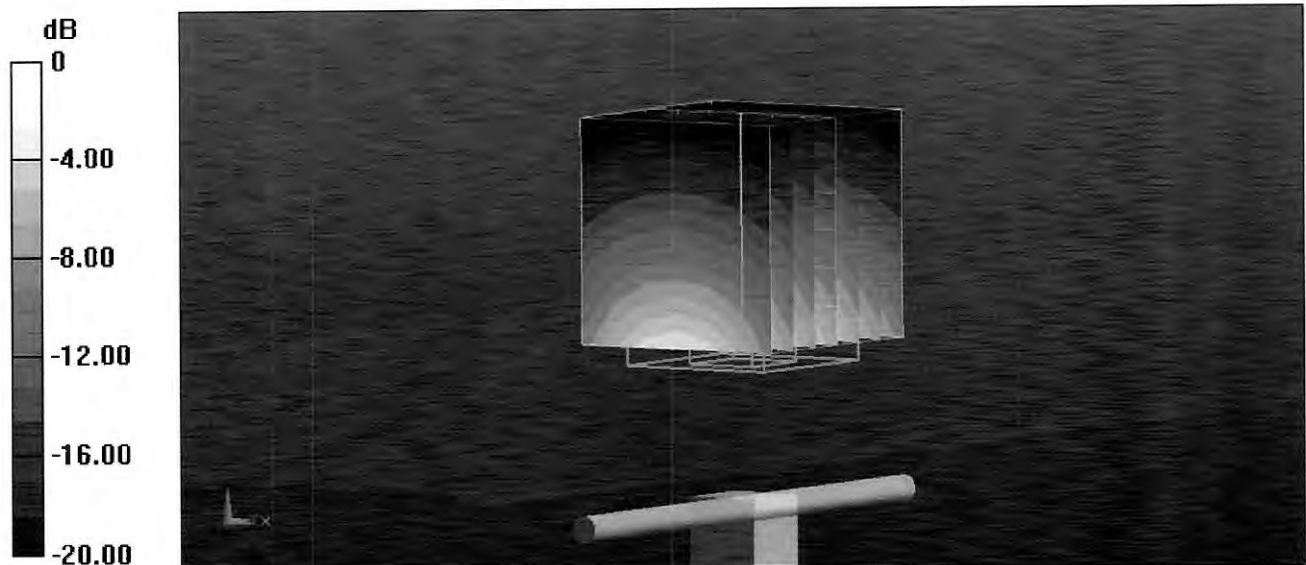
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 100.9 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 27.3 W/kg

**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.15 W/kg**

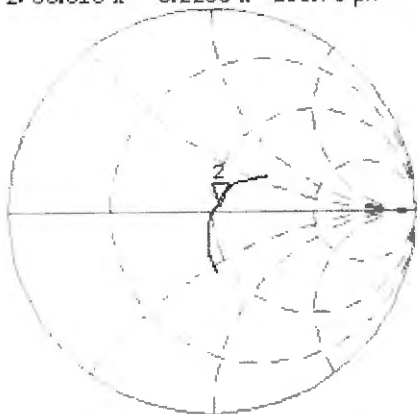
Maximum value of SAR (measured) = 17.6 W/kg



Impedance Measurement Plot for Head TSL

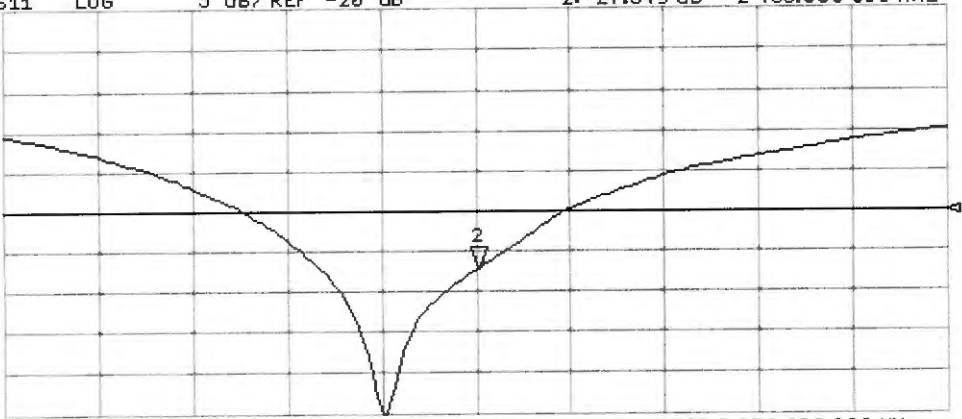
4 Nov 2014 12:09:29  
CH1 S11 1 U FS 2: 53.016  $\Omega$  3.2285  $\mu$  209.73 pH 2 450.000 000 MHz

\*  
Del  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 2:-27.349 dB 2 450.000 000 MHz

CA  
Avg  
16  
H1d



START 2 250.000 000 MHz STOP 2 650.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 04.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 855**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 50.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

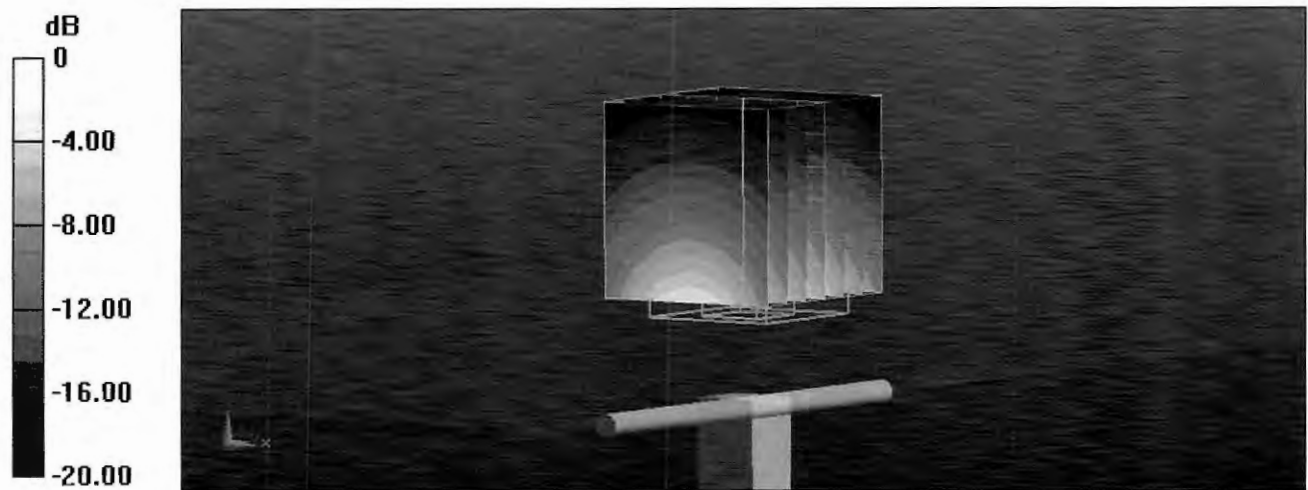
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.95 V/m; Power Drift = -0.01 dB

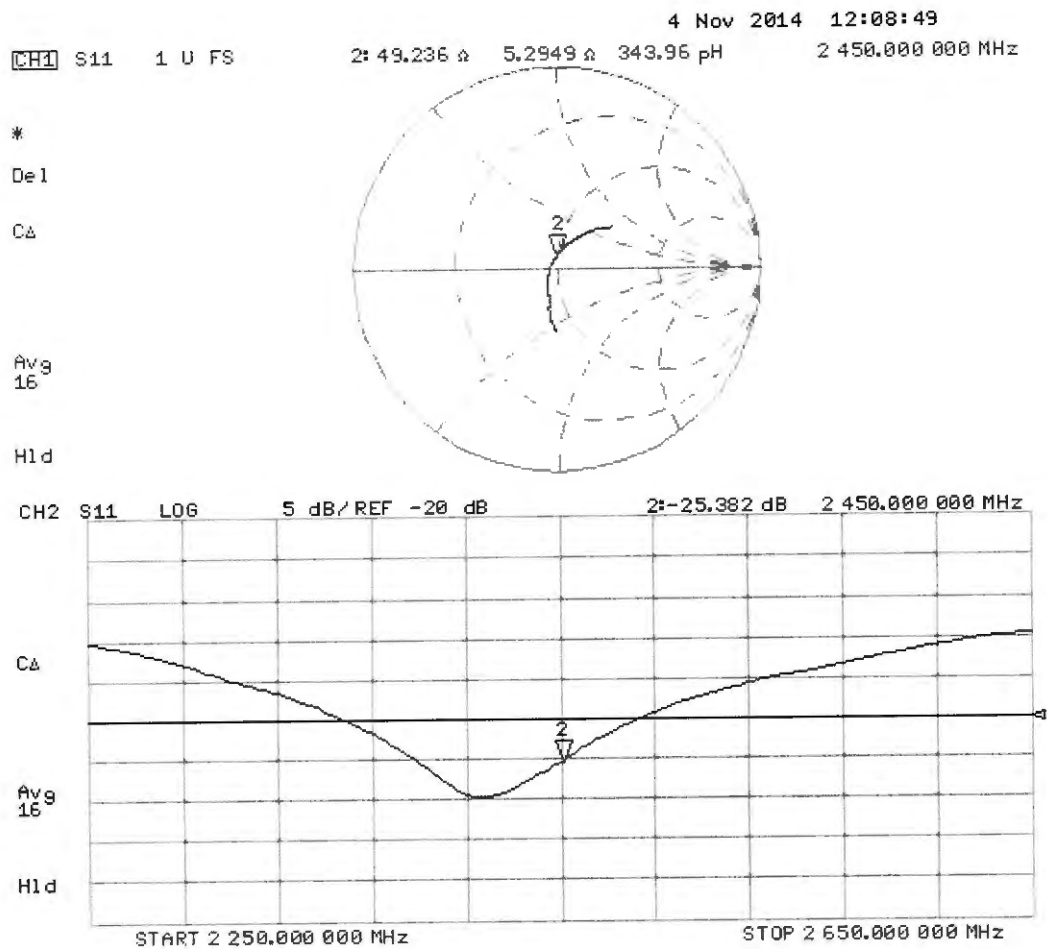
Peak SAR (extrapolated) = 27.2 W/kg

**SAR(1 g) = 13 W/kg; SAR(10 g) = 6.01 W/kg**

Maximum value of SAR (measured) = 17.2 W/kg



# Impedance Measurement Plot for Body TSL



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**S** Schweizerischer Kalibrierdienst  
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 Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Client **Northwest EMC**

Certificate No: **EX3-3746 Nov15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3746**

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: **November 18, 2015**

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 ( $22 \pm 3$ )°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      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| 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-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

|                                                                                                                 | Name          | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|---------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Leif Klysner  | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic | Technical Manager     |           |
| Issued: November 18, 2015                                                                                       |               |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |               |                       |           |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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                                                                                                                                |
| NORM <sub>x,y,z</sub>    | sensitivity in free space                                                                                                                               |
| ConvF                    | sensitivity in TSL / NORM <sub>x,y,z</sub>                                                                                                              |
| DCP                      | diode compression point                                                                                                                                 |
| CF                       | crest factor (1/duty_cycle) of the RF signal                                                                                                            |
| A, B, C, D               | modulation dependent linearization parameters                                                                                                           |
| Polarization $\varphi$   | $\varphi$ rotation around probe axis                                                                                                                    |
| Polarization $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ is normal to probe axis |
| Connector Angle          | information used in DASY system to align probe sensor X to the robot coordinate system                                                                  |

## Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- 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
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* 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.
- DCP<sub>x,y,z</sub>**: 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
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>**: 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  $f \leq 800$  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 NORM<sub>x,y,z</sub> \* 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  $\pm 50$  MHz to  $\pm 100$  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.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

# Probe EX3DV4

## SN:3746

Manufactured: March 26, 2010  
Calibrated: November 18, 2015

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

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.49     | 0.46     | 0.49     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 100.7    | 101.3    | 100.1    |               |

## Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB $\sqrt{\mu\text{V}}$ | C   | D<br>dB | VR<br>mV | Unc <sup>E</sup><br>(k=2) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|---------------------------|
| 0   | CW                        | X | 0.0     | 0.0                          | 1.0 | 0.00    | 151.7    | $\pm 3.5 \%$              |
|     |                           | Y | 0.0     | 0.0                          | 1.0 |         | 149.0    |                           |
|     |                           | Z | 0.0     | 0.0                          | 1.0 |         | 146.1    |                           |

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 5 and 6).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<sup>E</sup> 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:3746

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 2450                 | 39.2                               | 1.80                            | 6.77    | 6.77    | 6.77    | 0.38               | 0.80                    | ± 12.0 %  |
| 2550                 | 39.1                               | 1.91                            | 6.68    | 6.68    | 6.68    | 0.41               | 0.80                    | ± 12.0 %  |
| 5200                 | 36.0                               | 4.66                            | 5.01    | 5.01    | 5.01    | 0.35               | 1.80                    | ± 13.1 %  |
| 5300                 | 35.9                               | 4.76                            | 4.75    | 4.75    | 4.75    | 0.40               | 1.80                    | ± 13.1 %  |
| 5500                 | 35.6                               | 4.96                            | 4.56    | 4.56    | 4.56    | 0.40               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.21    | 4.21    | 4.21    | 0.45               | 1.80                    | ± 13.1 %  |
| 5800                 | 35.3                               | 5.27                            | 4.31    | 4.31    | 4.31    | 0.45               | 1.80                    | ± 13.1 %  |

<sup>C</sup> Frequency validity above 300 MHz 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. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

### Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth (mm) <sup>G</sup> | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 2450                 | 52.7                               | 1.95                            | 7.00    | 7.00    | 7.00    | 0.31               | 0.80                    | ± 12.0 %  |
| 2550                 | 52.6                               | 2.09                            | 6.66    | 6.66    | 6.66    | 0.43               | 0.80                    | ± 12.0 %  |
| 5200                 | 49.0                               | 5.30                            | 4.17    | 4.17    | 4.17    | 0.50               | 1.90                    | ± 13.1 %  |
| 5300                 | 48.9                               | 5.42                            | 3.99    | 3.99    | 3.99    | 0.50               | 1.90                    | ± 13.1 %  |
| 5500                 | 48.6                               | 5.65                            | 3.70    | 3.70    | 3.70    | 0.55               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.55    | 3.55    | 3.55    | 0.55               | 1.90                    | ± 13.1 %  |
| 5800                 | 48.2                               | 6.00                            | 3.84    | 3.84    | 3.84    | 0.55               | 1.90                    | ± 13.1 %  |

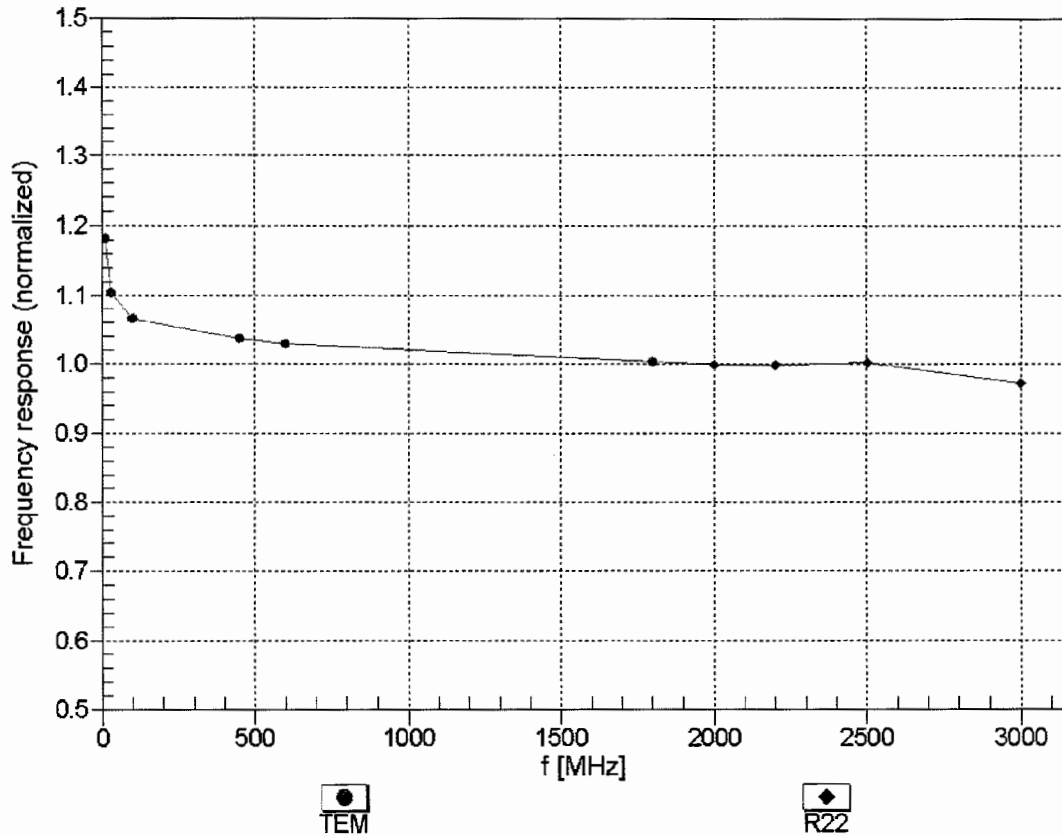
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) 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 ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

## Frequency Response of E-Field

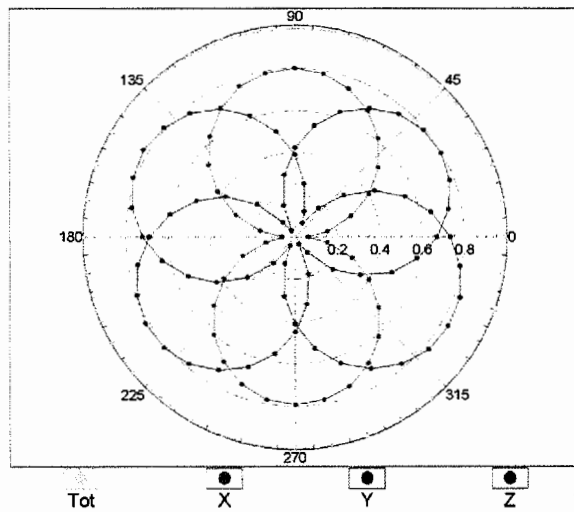
(TEM-Cell:ifi110 EXX, Waveguide: R22)



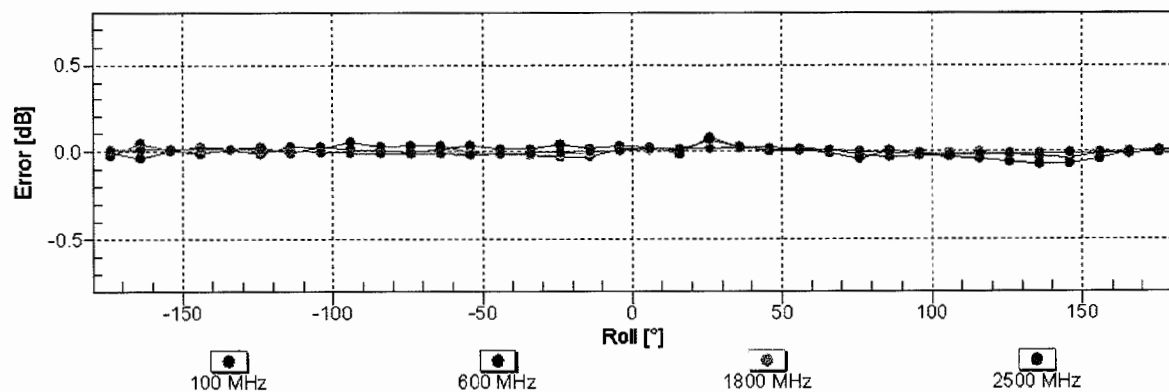
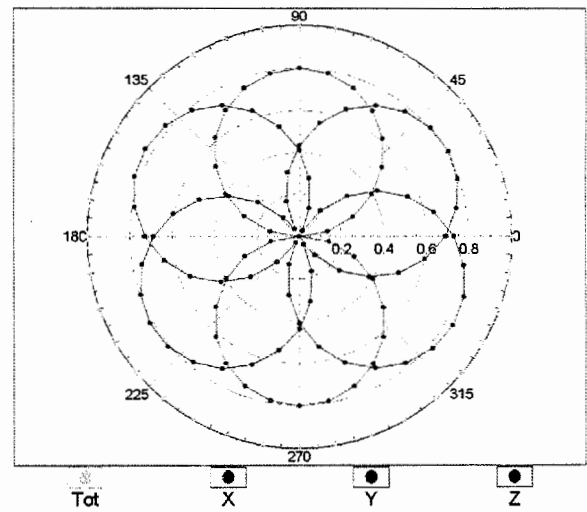
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

## Receiving Pattern ( $\phi$ ), $\theta = 0^\circ$

f=600 MHz,TEM

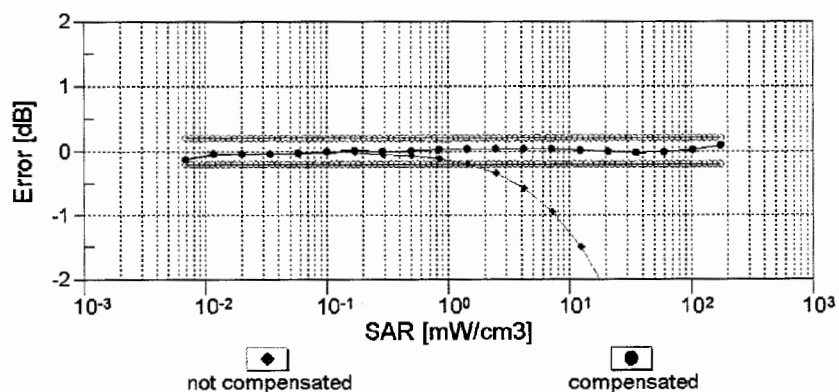
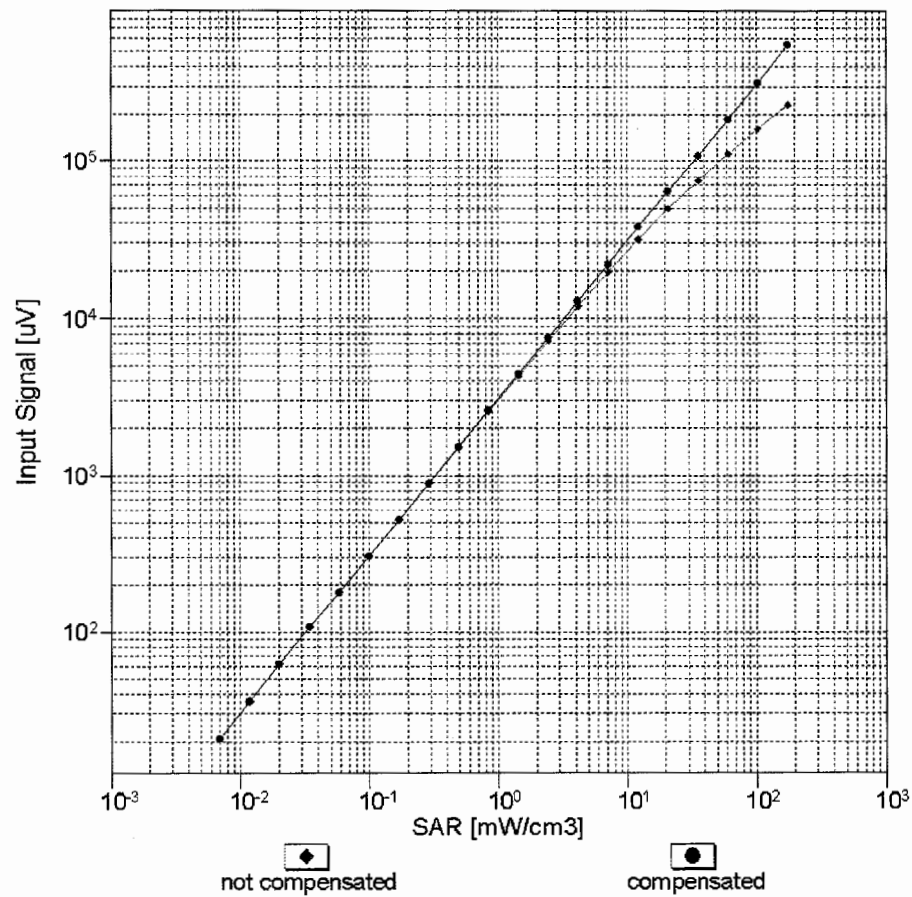


f=1800 MHz,R22



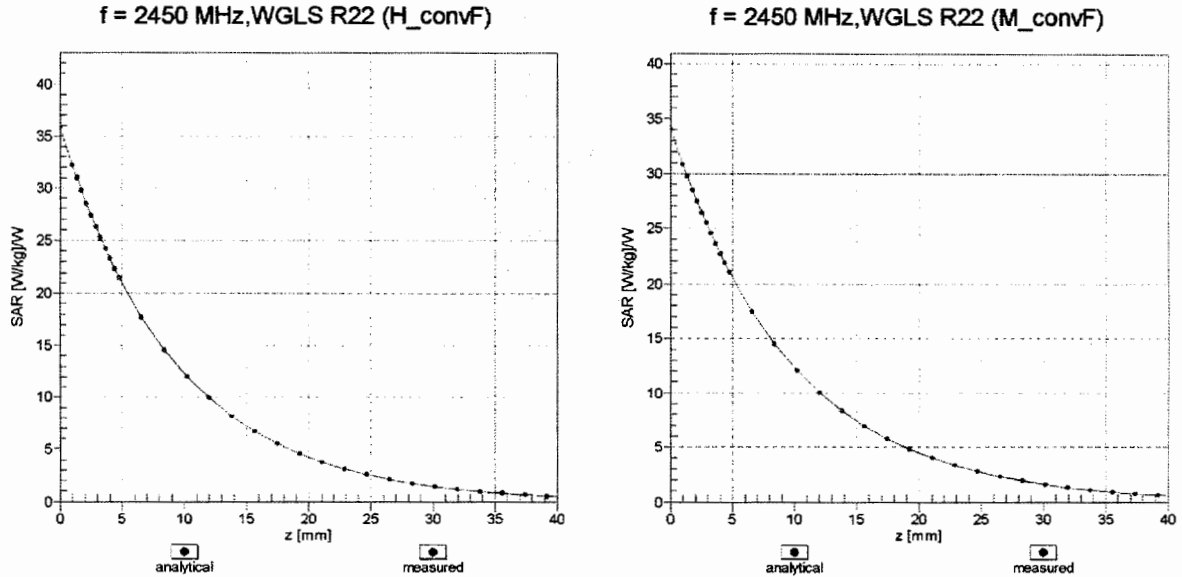
**Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )**

## Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$ )



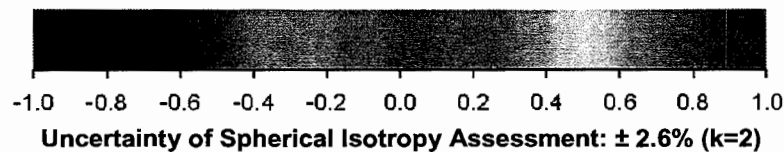
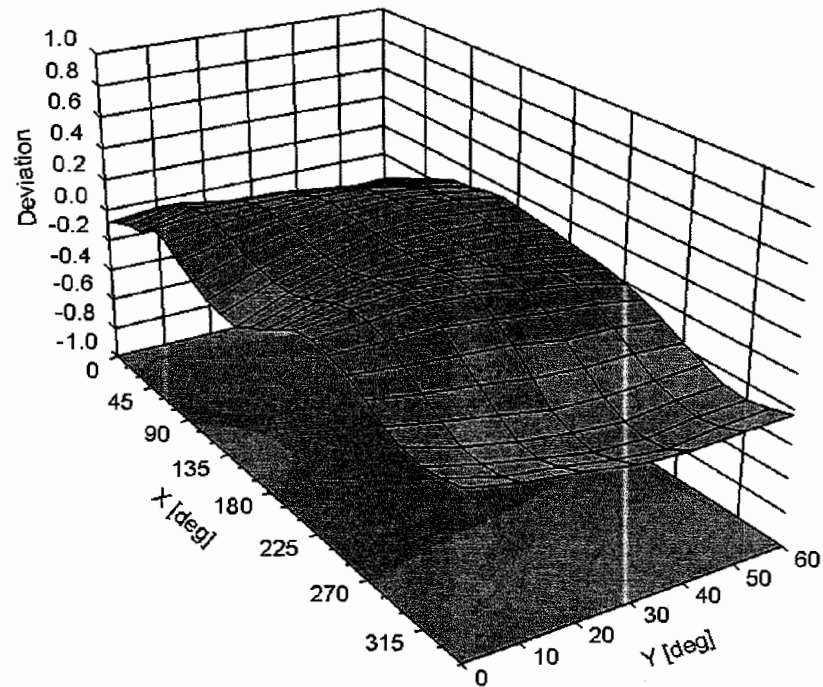
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3746

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 45.9       |
| 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 | 1.4 mm     |