NORTHWEST EMC

# Walt Disney Parks and Resorts US, Inc.

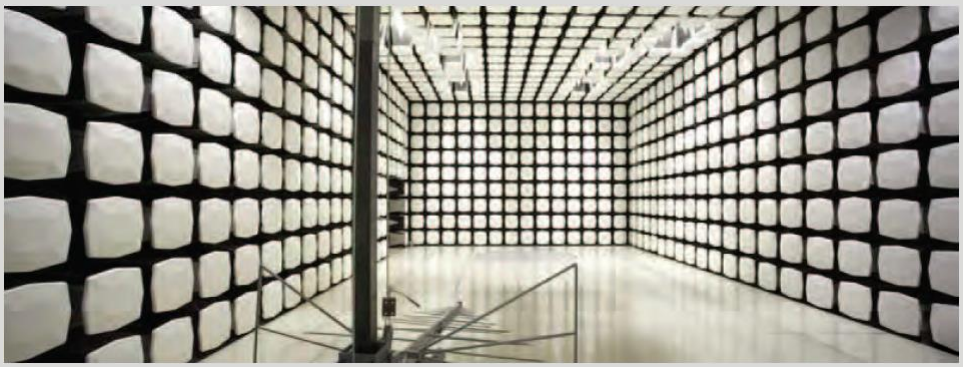
**TPv2 (DAP 2)**

**SAR Evaluation Report # SYNA0197 Rev 01**

**Evaluated to the following SAR specification:**

**FCC 2.1093:2016**

**FCC 15.247:2016**



NVLAP TESTING

NVLAP Lab Code: 200630-0

# CERTIFICATE OF TEST

**Last Date of Test: September 15, 2016**
**Walt Disney Parks and Resorts US, Inc.**
**Model: TPv2 (DAP 2)**

## Applicable Standard

| Test Description | Specification | Test Method | Pass/Fail |
|---|---|---|---|
| SAR Evaluation | FCC 15.247:2016<br>FCC 2.1093:2016 | FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>FCC KDB 248227 D01 V02r02<br>FCC KDB 447498 D01 v06<br>IEEE Std 1528:2013 | Pass |

## Highest SAR Values:

| Frequency (MHz) | Extremity (W/kg) | Limit (W/kg) | Exposure Environment |
|---|---|---|---|
| | 10g | 10g | |
| 902.75 | 0.23 | 4.0 | General Population |

## Deviations From Test Standards

None

## Approved By:

*Don Facteau, IS Manager*

# REVISION HISTORY

NORTHWEST EMC
REV 2014.10.14

| Revision Number | Description | Date | Page Number |
|---|---|---|---|
| 01 | Updated to correct the system description | 3/3/17 | 6 |

# ACCREDITATIONS AND AUTHORIZATIONS

REV 2016.7.25

## 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

## Canada

**ISED** - Recognized by Innovation, Science and Economic Development Canada as a Certification Body (CB). Certification chambers and Open Area Test Sites are filed with ISED.

## European Union

**European Commission** – Validated by the European Commission as a Notified Body under the R&TTE Directive.

## Australia/New Zealand

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

## Korea

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

## Japan

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

## 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.

## Singapore

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

## Israel

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

## Hong Kong

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

## Vietnam

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

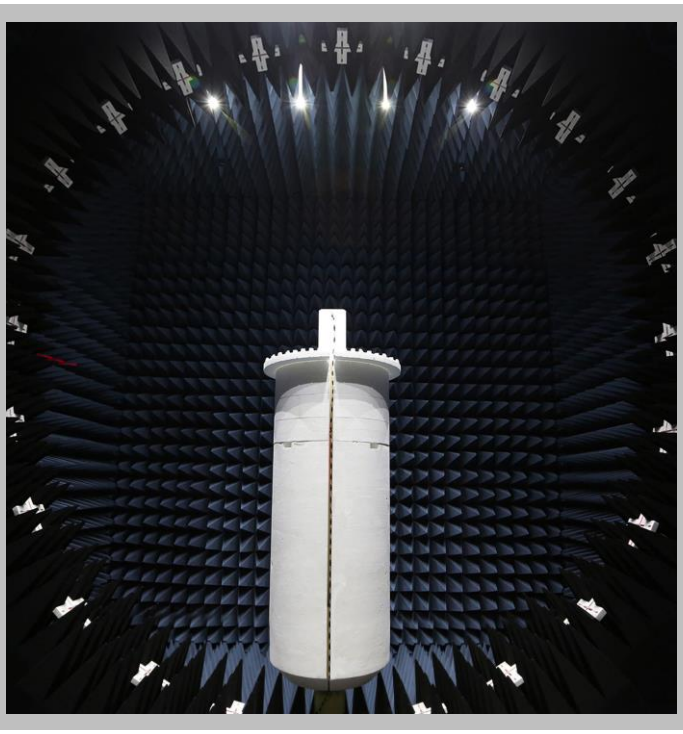
## SCOPE

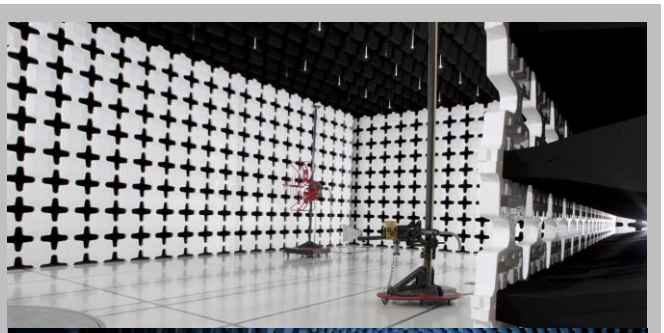
For details on the Scopes of our Accreditations, please visit:
http://www.nwemc.com/accreditations/
http://gsi.nist.gov/global/docs/cabs/designations.html

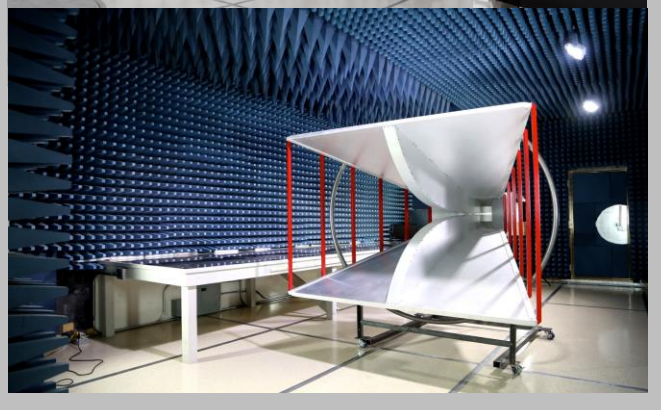
# FACILITIES

REV 2016.7.25

| California | Minnesota | New York | Oregon | Texas | Washington |
|---|---|---|---|---|---|
| Labs OC01-13<br>41 Tesla<br>Irvine, CA 92618<br>(949) 861-8918 | Labs MN01-08, MN10<br>9349 W Broadway Ave.<br>Brooklyn Park, MN 55445<br>(612)-638-5136 | Labs NY01-04<br>4939 Jordan Rd.<br>Elbridge, NY 13060<br>(315) 554-8214 | Labs EV01-12<br>22975 NW Evergreen Pkwy<br>Hillsboro, OR 97124<br>(503) 844-4066 | Labs TX01-09<br>3801 E Plano Pkwy<br>Plano, TX 75074<br>(469) 304-5255 | Labs NC01-05<br>19201 120th Ave NE<br>Bothell, WA 98011<br>(425)984-6600 |
| **NVLAP** | | | | | |
| 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 |
| **Innovation, Science and Economic Development Canada** | | | | | |
| 2834B-1, 2834B-3 | 2834E-1 | N/A | 2834D-1, 2834D-*2* | 2834G-1 | 2834F-1 |
| **BSMI** | | | | | |
| SL2-IN-E-1154R | SL2-IN-E-1152R | N/A | SL2-IN-E-1017 | SL2-IN-E-1158R | SL2-IN-E-1153R |
| **VCCI** | | | | | |
| A-0029 | A-0109 | N/A | A-0108 | A-0201 | A-0110 |
| **Recognized Phase I CAB for ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA** | | | | | |
| US0158 | US0175 | N/A | US0017 | US0191 | US0157 |







# PRODUCT DESCRIPTION

## Client and Equipment Under Test (EUT) Information

| | |
|---|---|
| **Company Name:** | Walt Disney Parks and Resorts US, Inc. |
| **Address:** | PO Box 10000 |
| **City, State, Zip:** | Lake Buena Vista, FL 32830 |
| **Test Requested By:** | Brian Piquette of Synapse Product Development LLC |
| **Model:** | TPv2 (DAP 2) |
| **First Date of Test:** | September 15, 2016 |
| **Last Date of Test:** | September 15, 2016 |
| **Receipt Date of Samples:** | September 15, 2016 |
| **Equipment Design Stage:** | Production |
| **Equipment Condition:** | No Damage |

## Information Provided by the Party Requesting the Test

**Functional Description of the EUT:**

The TPv2 (DAP2) Multi-Media Reader is part of a proprietary data acquisition system. It provides an HF RFID reader, UHF RFID reader, Bluetooth LE Host interface and a 2.4GHz RF interface to read data from proprietary RFID and RF media that are held in the hand or worn on the wrist. This RFID/RF tag data can be then sent over an Ethernet connection to a data collection/concentration object. The TPv2 (DAP2) is designed to be mounted in several known stanchions which provide the final weatherproof enclosure for the product.

Please see the external photos exhibit, the internal photos exhibit, and the antenna info exhibit for details regarding the EUT configuration and antenna location. These exhibits are part of the FCC application filed for this product.

Compliance with 2.1093 for the Class II Permissive change of the UHF RFID radio, FCC ID: TWYPJRS500 also contained in the system is shown in this document.

Compliance with FCC RF exposure requirements for 2.1093 portable devices for the TPv2 (DAP 2) which includes the 2.4 GHz DTS radio and for the Class II Permissive Change to the Bluetooth/Bluetooth Low Energy radio, FCC ID: SQGBT800 contained in the system are not shown in this document. A separate SAR extremity exclusion will be part of the FCC certification filing.

# PRODUCT DESCRIPTION

## Testing Requirements

### Testing Locations

The EUT will be mounted in stanchions where only the face of the product is exposed to users. This face is also the side closest to the transmitting antenna.

### Simultaneous Transmission

The EUT does have simultaneous transmission capability. Simultaneous SAR exposure assessment will be included as part of the FCC Certification filing.

### Testing Objective:

Only a user's hand or wrist will be closer than 20cm to the transmit antenna. The 900 MHz RFID radio failed the extremity SAR exclusion, so this SAR report was necessary. Therefore, this testing is to demonstrate compliance of the radio with the extremity SAR requirements of FCC 2.1093.

### Scope

The stand-alone SAR evaluation documented in this report is for the 900 MHz UHF RFID radio in the EUT.

# CONFIGURATIONS

NORTHWEST EMC 2014-12-10

## Configuration SYNA0197- 1

| Software/Firmware Running during test | |
|---|---|
| **Description** | **Version** |
| UHFTool (900 MHz) | 0.0 |

| EUT | | | |
|---|---|---|---|
| **Description** | **Manufacturer** | **Model/Part Number** | **Serial Number** |
| Access Point | Walt Disney Parks and Resorts US, Inc. | TPv2 | 850-1631035 |

| Cables | | | | | |
|---|---|---|---|---|---|
| **Cable Type** | **Shield** | **Length (m)** | **Ferrite** | **Connection 1** | **Connection 2** |
| DC Power Cable | No | 2m | No | Access Point | DC Power Supply |

# MODIFICATIONS

NORTHWEST EMC
2014-12-10

## Equipment Modifications

| Item | Date | Test | Modification | Note | Disposition of EUT |
|---|---|---|---|---|---|
| 1 | 9/15/2016 | SAR Evaluation | 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) | $\varepsilon_r$ | $\sigma$ (S/m) | $\varepsilon_r$ | $\sigma$ (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 |

($\varepsilon_r$ = relative permittivity, $\sigma$ = conductivity and $\rho$ = 1000 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] |
| Ingredients (% by weight) | | | | | | | | | | |
| 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] |
| Ingredients (% by weight) | | | | | | | | | | |
| 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

NORTHWEST EMC VERSION

**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] | | |
| **Ingredients (% by weight)** | | | | | | | |
| 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 |
| Diethylenglycol 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 |
| **Ingredients (% by weight)** | | | | | | | | | | |
| 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 |
| Diethylenglycol 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 |
| **Ingredients (% by weight)** | | | | | | | | |
| Deionised water | 54,23 | 56 | 56 | 56 | 56 | 65,53 | 65,53 | 56 |
| Tween | 45,27 | | | | | | | |
| Oxidised mineral oil | | 44 | 44 | 44 | 44 | | | 44 |
| Diethylenglycol monohexylether | | | | | | 17,24 | 17,24 | |
| Triton X-100 | | | | | | 17,24 | 17,24 | |
| Diacetin | | | | | | | | |
| DGBE | | | | | | | | |
| NaCl | 0,50 | | | | | | | |
| Additives and salt | | | | | | | | |

# TISSUE – EQUIVALENT LIQUID

| | | | |
|---|---|---|---|
| Date: | 09/15/2016 | Temperature: | 23.8°C |
| Tissue: | Body, MSL900, 900MHz | Liquid Temperature: | 22°C |
| Tested By: | Pick One | Relative Humidity: | 43.1% |
| Job Site: | EV08 | Bar. Pressure: | 1016.8 mb |

## TEST SPECIFICATIONS

| Specification: | Method: |
|---|---|
| FCC 15.247:2016<br>FCC 2.1093:2016 | FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>FCC KDB 248227 D01 V02r02<br>FCC KDB 447498 D01 v06<br>IEEE Std 1528:2013 |

## RESULTS

| | Actual Values | | Target Values | | Deviation (%) | |
|---|---|---|---|---|---|---|
| Frequency (MHz) | Relative Permittivity | Conductivity | Relative Permittivity | Conductivity | Relative Permittivity | Conductivity |
| 900 | 56.69 | 1.052 | 55.0 | 1.05 | -3.07 | -0.19 |

| Frequency (MHz) | Relative Permittivity | Conductivity |
|---|---|---|
| 800 | 57.38 | 0.954 |
| 800 | 57.38 | 0.954 |
| 810 | 57.41 | 0.963 |
| 820 | 57.35 | 0.972 |
| 820 | 57.35 | 0.972 |
| 830 | 57.24 | 0.978 |
| 840 | 57.15 | 0.992 |
| 850 | 57.04 | 1.001 |
| 850 | 57.04 | 1.001 |
| 860 | 57.01 | 1.013 |
| 870 | 56.96 | 1.021 |
| 880 | 56.82 | 1.035 |
| 880 | 56.82 | 1.035 |
| 890 | 56.74 | 1.041 |
| 900 | 56.69 | 1.052 |
| 910 | 56.61 | 1.059 |
| 910 | 56.61 | 1.059 |
| 920 | 56.55 | 1.068 |
| 930 | 56.4 | 1.08 |
| 940 | 56.4 | 1.09 |
| 940 | 56.4 | 1.09 |
| 950 | 56.3 | 1.102 |
| 960 | 56.17 | 1.111 |
| 970 | 56.14 | 1.121 |
| 970 | 56.14 | 1.121 |
| 980 | 56.02 | 1.129 |
| 990 | 55.94 | 1.141 |

# SAR SYSTEM VERIFICATION DESCRIPTION

NORTHWEST EMC
WSSV.2013.09.09

## REQUIREMENT

Per IEEE 1528, Section 8.2.1, “System checks are performed prior to compliance tests and the results must always be within ± 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.”

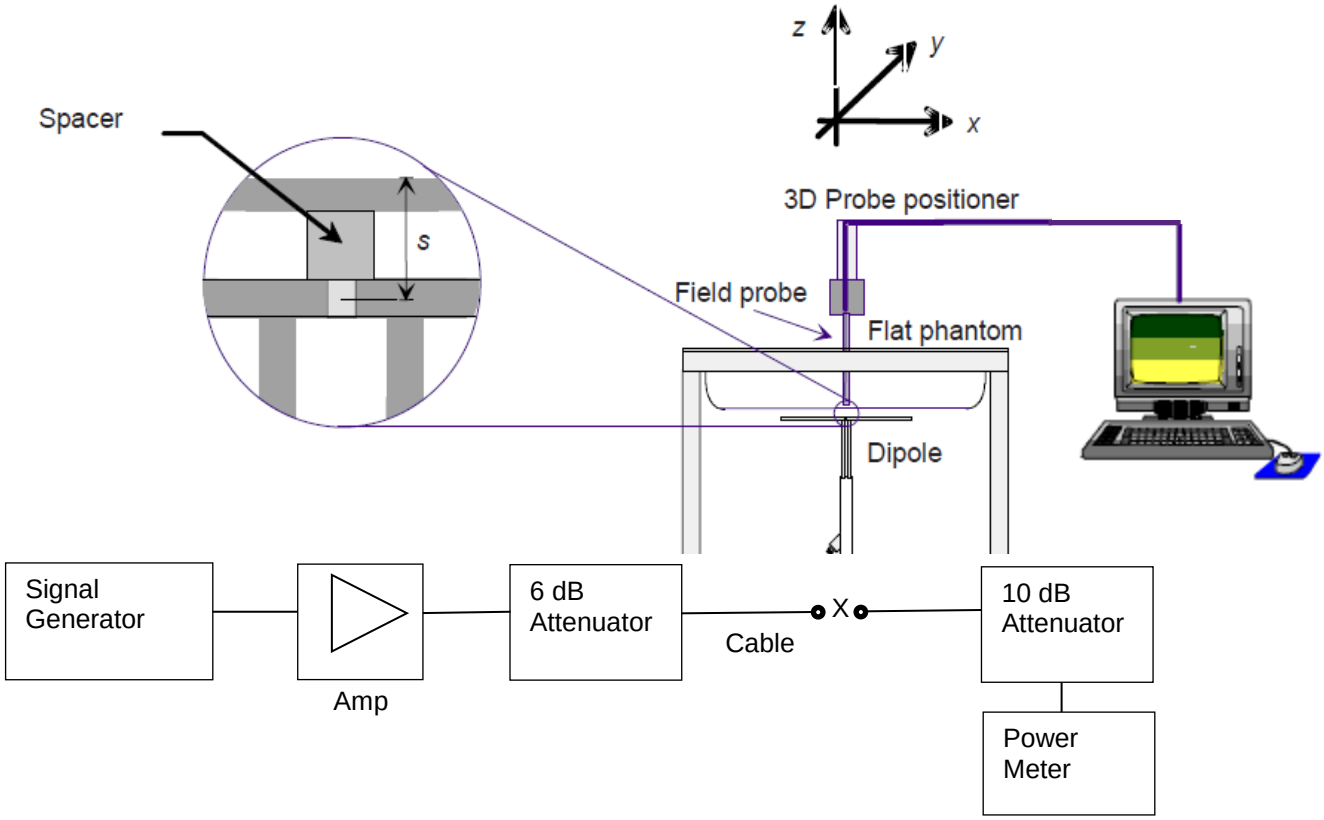
## TEST DESCRIPTION

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 = 15mm, +/- 0.2mm for 300MHz ≤ f ≥ 1000 MHz:
s = 10mm, +/- 0.2mm for 1000MHz ≤ f ≥ 6000MHz

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

NORTHWEST EMC
WSSV.2013.09.09

## TEST SPECIFICATIONS

| Specification: | Method: |
|---|---|
| FCC 15.247:2016<br>FCC 2.1093:2016 | FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>FCC KDB 248227 D01 V02r02<br>FCC KDB 447498 D01 v06<br>IEEE Std 1528:2013 |

## RESULTS

| Date | Liquid part number and frequency | Conducted Power into the Dipole (dBm) | Correction Factor | Measured | | Normalized to 1W | | Target (Normalized to 1W) Get from Dipole Calibration Certificate | | % Difference | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1g | 10g | 1g | 10g | 1g | 10g | 1g | 10g |
| 9/15/2016 | MSL 900 (900 MHz) | 24.83 | 3.29 | 3.33 | 2.21 | 10.96 | 7.27 | 10.90 | 7.07 | 0.55 | 2.83 |

# SAR SYSTEM VERIFICATION

NORTHWEST EMC
WSSV.2013.09.09

| | | | |
|---|---|---|---|
| Tested By: | Luke Richardson | Room Temperature (°C): | 23.6°C |
| Date: | 9/15/2016 | Liquid Temperature (°C): | 21.8°C |
| Configuration: | | Humidity (%RH): | 43.6% |
| | | Bar. Pressure (mb): | 1016.3 mb |

**MSL900 System Check_900MHz 9-15-16**
**DUT: Dipole 900 MHz D900V2; Type: D900V2; Serial: D900V2 - SN:xxx**
Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz); Frequency: 900 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used: $\sigma$ = 0 S/m, $\varepsilon_r$ = 1; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: f = 900 MHz; $\sigma$ = 1.052 S/m; $\varepsilon_r$ = 56.692; $\rho$ = 1000 kg/m$^3$
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)

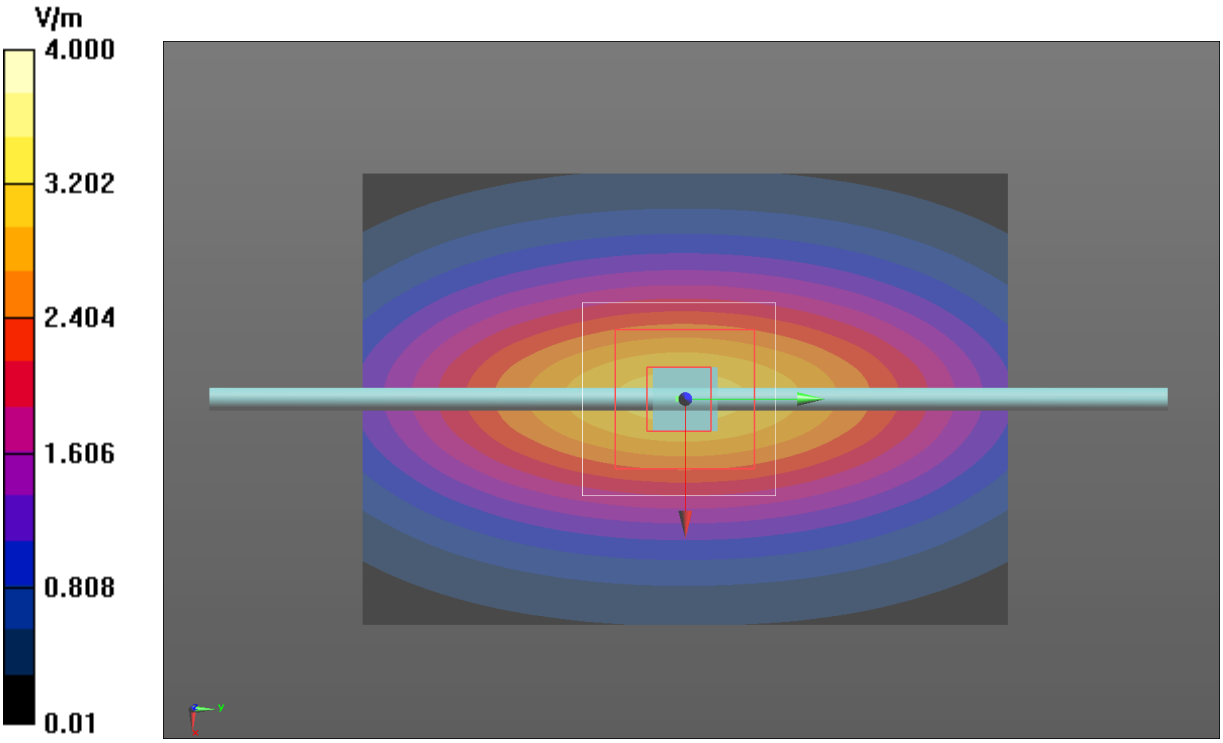
**System Check/System Check/Z Scan (1x1x21):** Measurement grid: dx=20mm, dy=20mm, dz=5mm
Maximum value of Total (measured) = 60.00 V/m

**System Check/System Check/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.98 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 4.88 W/kg
**SAR(1 g) = 3.33 W/kg; SAR(10 g) = 2.21 W/kg**
Maximum value of SAR (measured) = 3.34 W/kg

**System Check/System Check/Area Scan (71x101x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 3.34 W/kg
Maximum value of SAR (measured) = 3.79 W/kg

Approved By

**MSL900 System Check_900MHz 9-15-16**



# OUTPUT POWER DESCRIPTION

WSTD.2013.09.09

### 900 MHz Band

The UHF Radio was tested at the channel with the highest conducted output power unless the reported SAR was greater than 2.0 W/kg for 10-g, then the other required channels would have been measured.

Output power measurements are on the following pages.

# OUTPUT POWER DATA

| | | | |
|---|---|---|---|
| EUT: | TPv2 (DAP 2) | Work Order: | SYNA0197 |
| Serial Number: | 850-1631035 | Date: | 09/15/16 |
| Customer: | Walt Disney Parks and Resorts US, Inc. | Temperature: | 23.6 |
| Attendees: | None | Relative Humidity: | 43.2% |
| Customer Project: | None | Bar. Pressure: | 1016..1 |
| Tested By: | Luke Richardson | Job Site: | EV08 |
| Power: | 24 VDC | Configuration: | SYNA0197-1 |

## TEST SPECIFICATIONS

| Specification: | Method: |
|---|---|
| FCC 15.247:2016<br>FCC 2.1093:2016 | FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>FCC KDB 248227 D01 V02r02<br>FCC KDB 447498 D01 v06<br>IEEE Std 1528:2013 |

## COMMENTS

None

## DEVIATIONS FROM TEST STANDARD

None

## RESULTS

| Channel | Frequency (MHz) | Modulation Type | Conducted Output Power | |
|---|---|---|---|---|
| | | | dBm | mW |
| Low | 902.750 | ASK | 18.11 | 64.674 |
| Mid | 915.250 | ASK | 17.94 | 62.169 |
| High | 927.250 | ASK | 17.69 | 58.859 |

# TEST RESULTS

## Test Configurations

### Test Locations

The EUT is intended to be mounted with only the device face exposed to users. Many of the units are mounted in a “stanchion”. This limits the RF exposure cases to the top (face) of the product. All other sides will have a distance greater than 20cm away from the body or head.

## Summary

The following table summarizes the measured SAR values. The EUT was transmitting at nearly 100% duty cycle.

Per FCC KDB 447498, the measured SAR values were scaled to the maximum tune-up tolerance limit. The results are referred to as the “Reported SAR” values The following formula was used to calculate the linear SAR scaling factor:

SAR scaling factor = 10^((Maximum Rated Power[1] (dBm) - Measured Power (dBm)) / 10)

SAR scaling factor = 10^((23-18.1) / 10)

SAR scaling factor = 3.09

# SAR TEST DATA

| | | | |
|---|---|---|---|
| EUT: | TPv2 (DAP 2) | Work Order: | SYNA0197 |
| Customer: | Walt Disney Parks and Resorts US, Inc. | Job Site: | EV08 |
| Attendees: | None | Customer Project: | None |

## TEST SPECIFICATIONS

| Specification: | Method: |
|---|---|
| FCC 15.247:2016<br>FCC 2.1093:2016 | FCC KDB 865664 D01 v01r04<br>FCC KDB 865664 D02 v01r02<br>FCC KDB 248227 D01 V02r02<br>FCC KDB 447498 D01 v06<br>IEEE Std 1528:2013 |

## COMMENTS

None

## DEVIATIONS FROM TEST STANDARD

None

## RESULTS

| Frequency Band | Transmit Frequency (MHz) | Transmit Channel | Transmit Mode | Body-Worn Accessory | EUT Position | SAR Drift During Test (dB) | Measured 1g SAR Level (mW/g) | Measured 10g SAR Level (mW/g) | Scaled 1g SAR Level (mW/g) | Scaled 10g SAR Level (mW/g) | Test# |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 900 | 902.75 | Low | ASK | None | Front | 0.02 | 0.124 | 0.074 | 0.38 | 0.23 | 1a |

# SAR TEST DATA

NORTHWEST EMC
WSTD.2013.09.09

| | | | |
|---|---|---|---|
| Tested By: | Luke Richardson | Room Temperature (°C): | 23.6°C |
| Date: | 9/15/2016 1:15:55 PM | Liquid Temperature (°C): | 21.8°C |
| Serial Number: | 850-1631035 | Humidity (%RH): | 43.1% |
| Configuration: | SYNA0197-1 | Bar. Pressure (mb): | 1016.2 mb |
| Comments: | None | | |

**Test 1a**
**DUT: Access Point; Type: Sample; Serial: 850-1631035**
Communication System: UID 0, CW (0); Communication System Band: D900 (900.0 MHz); Frequency: 902.75 MHz;Communication System PAR: 0 dB; PMF: 1
Medium parameters used (interpolated): f = 902.75 MHz; $\sigma$ = 1.054 S/m; $\varepsilon_r$ = 56.671; $\rho$ = 1000 kg/m$^3$ , Medium parameters used: $\sigma$ = 0 S/m, $\varepsilon_r$ = 1; $\rho$ = 1000 kg/m$^3$
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/Reference scan (71x71x1):** Interpolated grid: dx=3.000 mm, dy=3.000 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.132 W/kg

**Body/Body/Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 12.17 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.216 W/kg
**SAR(1 g) = 0.124 W/kg; SAR(10 g) = 0.074 W/kg**

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (measured) = 0.146 W/kg

**Body/Body/Area scan (81x41x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of SAR (interpolated) = 0.176 W/kg

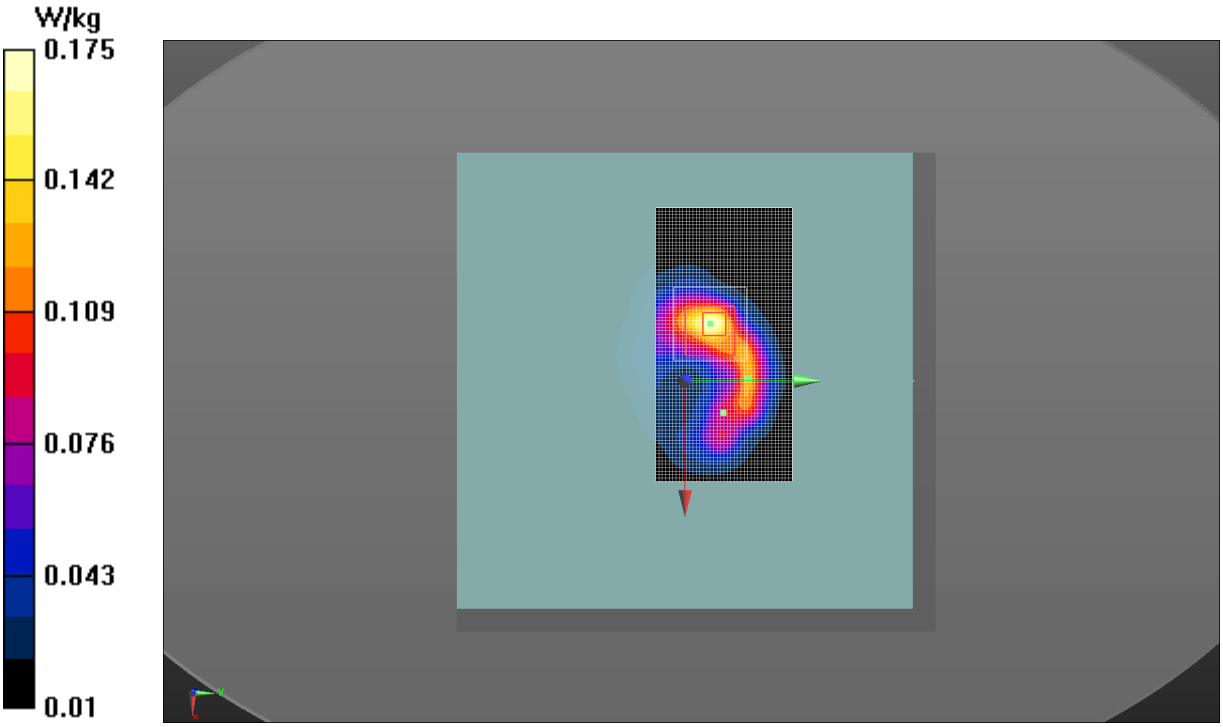
**Body/Body/Z Scan (1x1x21):** Measurement grid: dx=20mm, dy=20mm, dz=5mm

Info: Interpolated medium parameters used for SAR evaluation.
Maximum value of Total (measured) = 9.424 V/m
Maximum value of SAR (measured) = 0.0936 W/kg

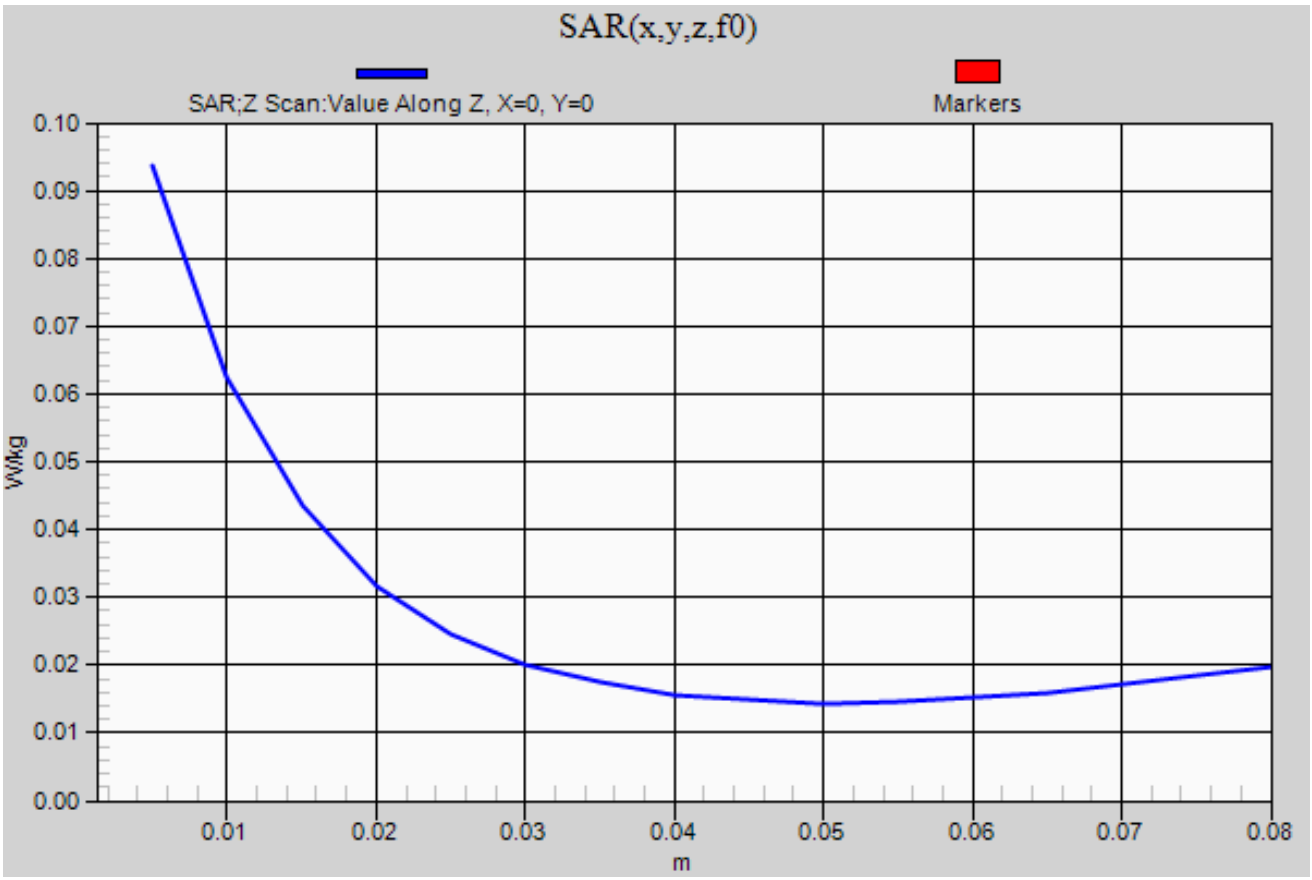
Approved By

# SAR TEST DATA

**Test 1a**



**Z-SCAN**

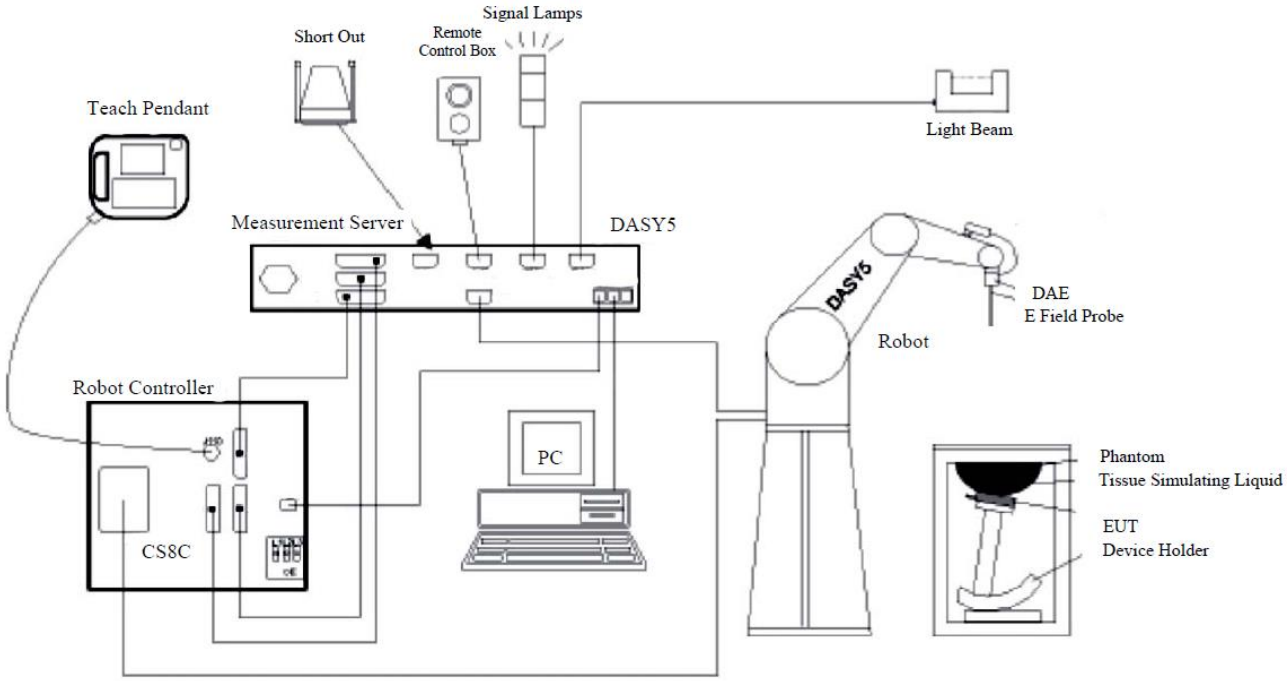

SAR(x,y,z,f0)
SAR;Z Scan:Value Along Z, X=0, Y=0
Markers
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
W/kg
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
m

## 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

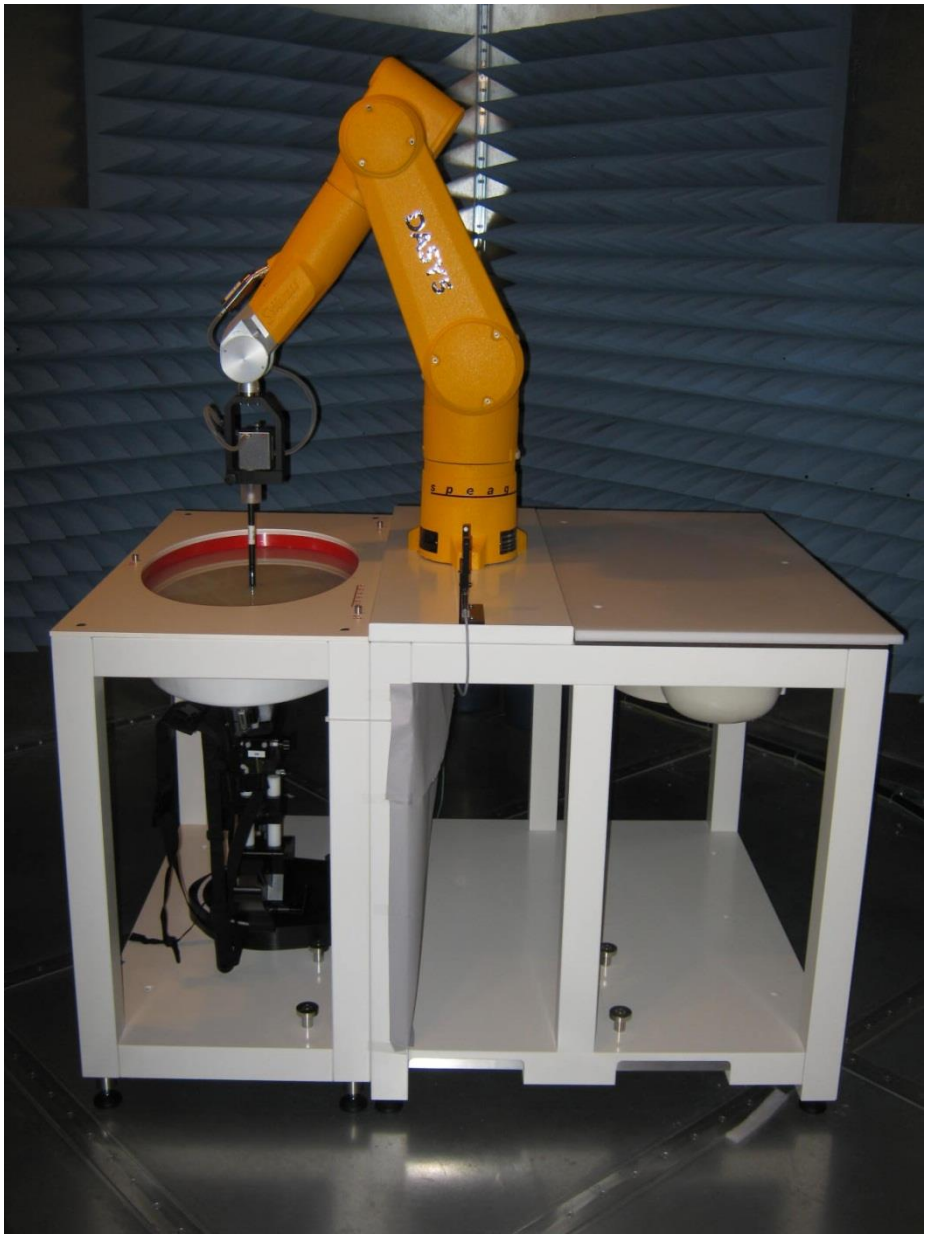


## TEST SITE

**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

NORTHWEST EMC
WSEQ.13.09.09

**TEST EQUIPMENT**

| Description | Manufacturer | Model | ID | Last Cal. | Interval |
|---|---|---|---|---|---|
| Amplifier | Mini Circuits | ZHL-5W-2G-S+ | TRZ | NCR [1] | 0 mo |
| Antenna - Dipole | SPEAG | D900V2 | ADP | 10/26/2015 | 12 mo |
| DAE | SPEAG | SD 000 D04 EJ | SAH | 10/8/2015 | 12 mo |
| Device Holder | SPEAG | N/A | SAW | NCR | 0 mo |
| Fixture/Kit - Calibration/Verification | SPEAG | DAKS:200 | IPR | 3/17/2016 | 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 |
| Probe | SPEAG | DAKS-3.5 | IPRA | 11/17/2015 | 36 mo |
| SAR - Tissue Test Solution | SPEAG | MSL 900 | SAT | At start of testing | |
| SAR Probe | SPEAG | ES3DV3 | SAF | 11/12/2015 | 12 mo |
| SAR Test System | Staeubli | DAYS5 | 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 |
| Universal Radio Communication Tester | Agilent | E5515C | BSV | NCR | 0 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 (+/- %) | Probability Distribution | Divisor | $c_i$ (1g) | $c_i$ (10g) | $u_i$ (1g) (+/-%) | $u_i$ (10g) (+/-%) | $v_i$ |
|---|---|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | | | |
| Probe calibration (k=1) | 5.5 | normal | 1 | 1 | 1 | 5.5 | 5.5 | ∞ |
| Axial isotropy | 4.7 | rectangular | 1.732 | 0.707 | 0.707 | 1.9 | 1.9 | ∞ |
| Hemispherical isotropy | 9.6 | rectangular | 1.732 | 0.707 | 0.707 | 3.9 | 3.9 | ∞ |
| Boundary effect | 1.0 | rectangular | 1.732 | 1 | 1 | 0.6 | 0.6 | ∞ |
| Linearity | 4.7 | rectangular | 1.732 | 1 | 1 | 2.7 | 2.7 | ∞ |
| System detection limits | 1.0 | rectangular | 1.732 | 1 | 1 | 0.6 | 0.6 | ∞ |
| Readout electronics | 0.3 | normal | 1 | 1 | 1 | 0.3 | 0.3 | ∞ |
| Response time | 0.8 | rectangular | 1.732 | 1 | 1 | 0.5 | 0.5 | ∞ |
| Integration time | 2.6 | rectangular | 1.732 | 1 | 1 | 1.5 | 1.5 | ∞ |
| RF ambient conditions - noise | 1.7 | rectangular | 1.732 | 1 | 1 | 1.0 | 1.0 | ∞ |
| RF Ambient Reflections | 0.0 | rectangular | 1.732 | 1 | 1 | 0.0 | 0.0 | ∞ |
| Probe positioner mechanical tolerance | 0.4 | rectangular | 1.732 | 1 | 1 | 0.2 | 0.2 | ∞ |
| Probe positioner with respect to phantom shell | 2.9 | rectangular | 1.732 | 1 | 1 | 1.7 | 1.7 | ∞ |
| Extrapolation, interpolation, and integration algorithms for max. SAR evaluation | 1.0 | rectangular | 1.732 | 1 | 1 | 0.6 | 0.6 | ∞ |
| **Test Sample Related** | | | | | | | | |
| 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 | ∞ |
| **Phantom and tissue parameters** | | | | | | | | |
| Phantom Uncertainty - shell thickness tolerances | 4.0 | rectangular | 1.732 | 1 | 1 | 2.3 | 2.3 | ∞ |
| Liquid conductivity - deviation from target values | 5.0 | rectangular | 1.732 | 0.64 | 0.43 | 1.8 | 1.2 | ∞ |
| Liquid conductivity - measurement uncertainty | 6.5 | normal | 1 | 0.64 | 0.43 | 4.2 | 2.8 | ∞ |
| Liquid permittivity - deviation from target values | 5.0 | rectangular | 1.732 | 0.6 | 0.49 | 1.7 | 1.4 | ∞ |
| Liquid permittivity - measurement uncertainty | 3.2 | normal | 1 | 0.6 | 0.49 | 1.9 | 1.6 | ∞ |
| Combined Standard Uncertainty | | RSS | | | | 11.2 | 10.6 | 387 |
| Expanded Measurement Uncertainty (95% Confidence/ | | normal (k=2) | | | | 22.5 | 21.2 | |

# DIPOLE CALIBRATION

## Dipole Calibration

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 Ω 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.

ADP

NORTHWEST
**EMC**

# Calibration Certificate/Report

10/2015cbe

| | | | | | |
|---|---|---|---|---|---|
| Decriiption: | Antenna, Dipole 900MHz SAR | | | Cal Date: | 102615 |
| Equipment Code: | ADP | | | Temperature: | 21.0°C |
| Model: | D900V2 | | | Humidity: | 48% |
| Manufacturer: | SPEAG | Tester: | Carl Engholm | Pressure: | 1016mb |
| Certificate No.: | ADP 102615 | Power: | N/A | Calibration Site: | EV CAL |

**TEST SPECIFICATIONS**

| | | | |
|---|---|---|---|
| Calibration Procedure: | KDB 450824 D02 Dipole SAR Validation Verification v01r01 | Version: | 2013 |

**TEST PARAMETERS**

| | | | | | |
|---|---|---|---|---|---|
| Device Received In Tolerance: | Yes | Calibration Frequency : | 900 MHz | | |

**Equipment Used to perform calibration**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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: | SAS | Model: | HSL 900 | Last Cal Date: | 24 Hours |
| Item: | Body TSL | Identifier: | SAT | Model: | MSL 900 | Last Cal Date: | 24 Hours |

**COMMENTS, OPINIONS and INTERPRETATIONS**

Body TSL only

**Measurement Uncertainty**

| | 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 |

**DEVIATIONS FROM TEST STANDARD**

None

**RESULTS**

Pass

**This measurement was a calibration verification. (Instrument parameters are within tolerances.)**

**CALIBRATION DATA ATTACHED**

## Verification Data - Head

| | |
|---|---|
| **DUT** | Antenna, Dipole 900MHz SAR |
| Model | D900V2 |
| S/N | **ADP** |
| | |
| Date | 102615 |
| Temperature | 21.0°C |
| Humidity | 48% |
| Pressure | 1016mb |
| | |
| Operator | Carl Engholm |

**Antenna Parameters with Head TSL**
**900 MHz**

| | Real | Imaginary (j) |
|---|---|---|
| Impedance (ohms) | 50.5 | -6.7 |
| Return Loss (dB) | -24.2 | |

**Manufacturer's Cal Data from 11-03-2014**

| | | |
|---|---|---|
| Impedance (ohms) | 51.0 | -5.7 |
| Return Loss (dB) | -24.9 | |

## Verification Data - Body

| | |
|---|---|
| **DUT** | Antenna, Dipole 900MHz SAR |
| Model | D900V2 |
| S/N | **ADP** |
| | |
| Date | 102615 |
| Temperature | 21.0°C |
| Humidity | 48% |
| Pressure | 1016mb |
| | |
| Operator | Carl Engholm |

**Antenna Parameters with Body TSL**
**900 MHz**

| | Real | Imaginary (j) |
|---|---|---|
| Impedance (ohms) | 45.1 | -8.2 |
| Return Loss (dB) | -21.2 | |

**Manufacturer's Cal Data from 11-03-2014**

| | | |
|---|---|---|
| Impedance (ohms) | 46.4 | -7.9 |
| Return Loss (dB) | -20.9 | |

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

**Accreditation No.: SCS 108**

**Client** **Northwest EMC**

**Certificate No: D900V2-1d106_Nov14**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D900V2 - SN: 1d106 |
| Calibration procedure(s) | QA CAL-05.v9<br>Calibration procedure for dipole validation kits above 700 MHz |
| Calibration date: | November 03, 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 ± 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: | Michael Weber | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 7, 2014

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

**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:

a) 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
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Additional Documentation:

d) 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** | 15 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy, dz = 5 mm | |
| **Frequency** | 900 MHz ± 1 MHz | |

## Head TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 41.5 | 0.97 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 41.0 ± 6 % | 0.93 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 cm$^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.57 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **10.6 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.65 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **6.75 W/kg ± 16.5 % (k=2)** |

## Body TSL parameters

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Body TSL parameters** | 22.0 °C | 55.0 | 1.05 mho/m |
| **Measured Body TSL parameters** | (22.0 ± 0.2) °C | 54.3 ± 6 % | 1.03 mho/m ± 6 % |
| **Body TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Body TSL

| **SAR averaged over 1 cm$^3$ (1 g) of Body TSL** | Condition | |
|---|---|---|
| SAR measured | 250 mW input power | 2.69 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **10.9 W/kg ± 17.0 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Body TSL** | condition | |
|---|---|---|
| SAR measured | 250 mW input power | 1.75 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | **7.07 W/kg ± 16.5 % (k=2)** |

# Appendix (Additional assessments outside the scope of SCS108)

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.0 Ω - 5.7 jΩ |
| Return Loss | - 24.9 dB |

## Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 46.4 Ω - 7.9 jΩ |
| Return Loss | - 20.9 dB |

## General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.412 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 | September 22, 2009 |

## DASY5 Validation Report for Head TSL

Date: 03.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN: 1d106**

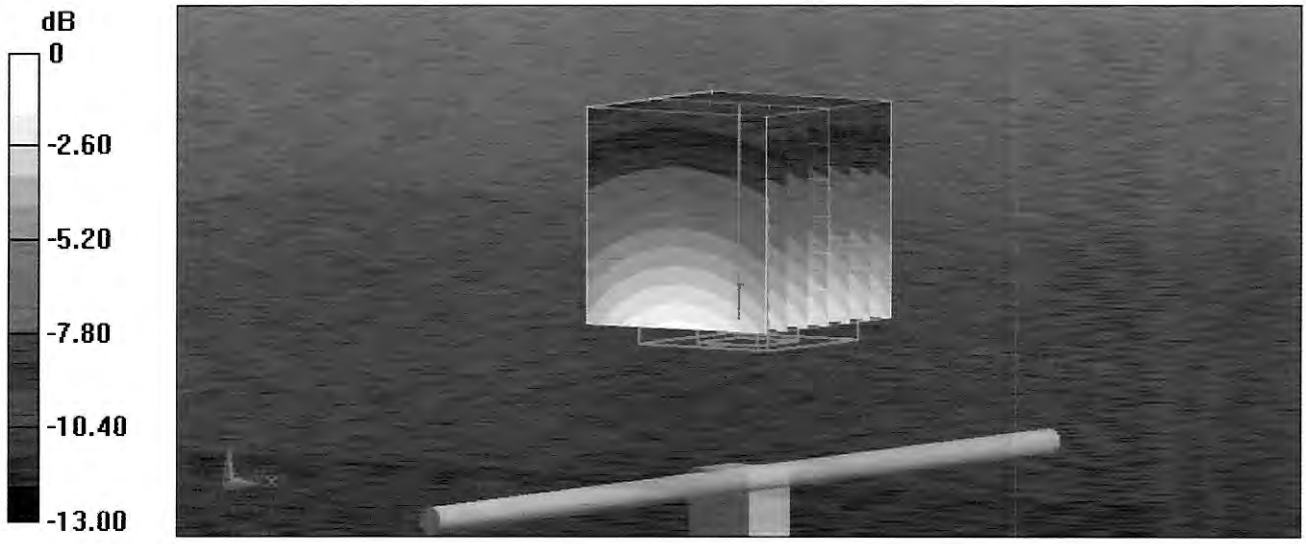
Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; $\sigma$ = 0.93 S/m; $\varepsilon_r$ = 41; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.09, 6.09, 6.09); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

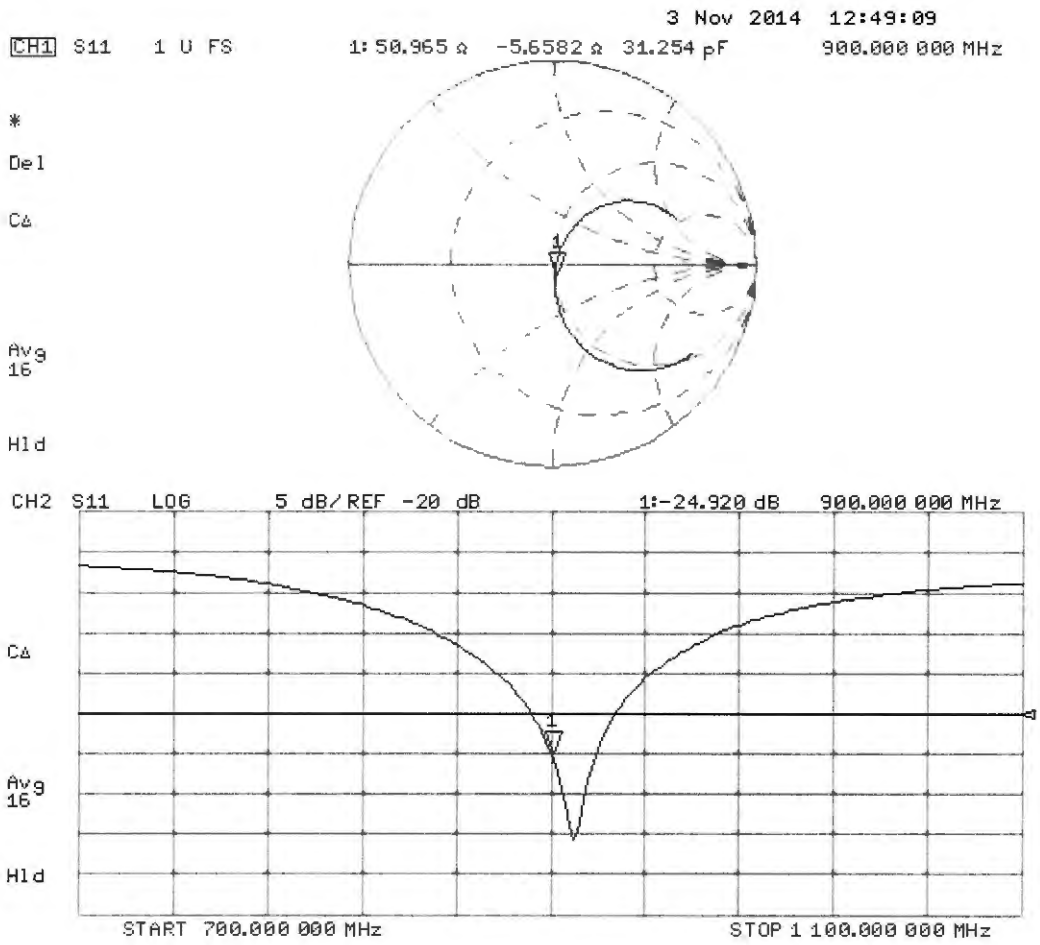
### Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 58.77 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 3.85 W/kg
**SAR(1 g) = 2.57 W/kg; SAR(10 g) = 1.65 W/kg**
Maximum value of SAR (measured) = 3.02 W/kg




0 dB = 3.02 W/kg = 4.80 dBW/kg

## Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 03.11.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 900 MHz; Type: D900V2; Serial: D900V2 - SN: 1d106**

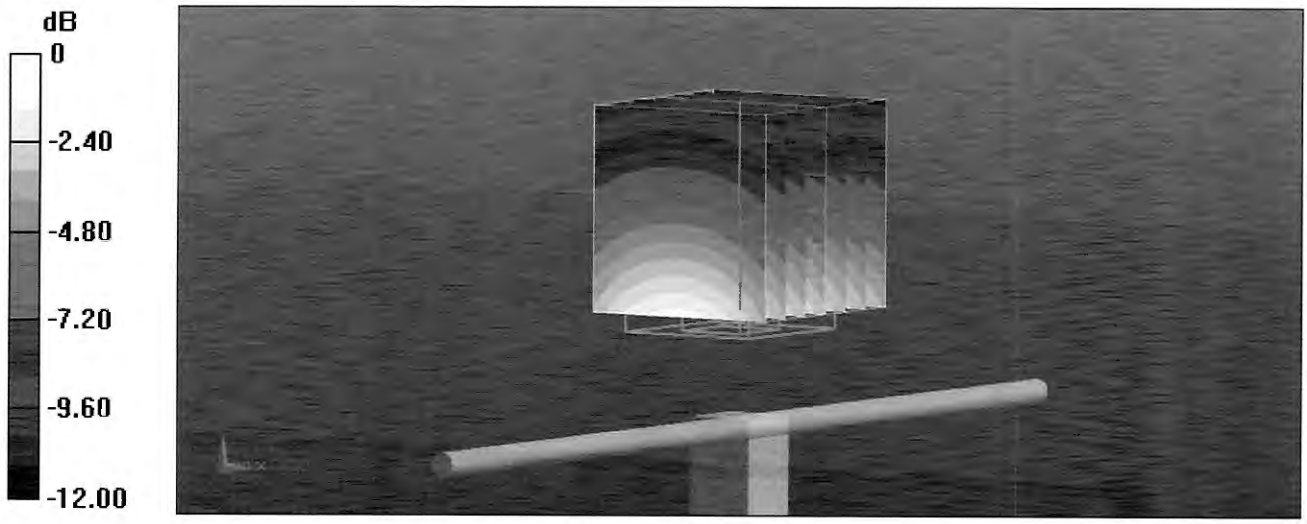
Communication System: UID 0 - CW; Frequency: 900 MHz
Medium parameters used: f = 900 MHz; $\sigma$ = 1.03 S/m; $\varepsilon_r$ = 54.3; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.98, 5.98, 5.98); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

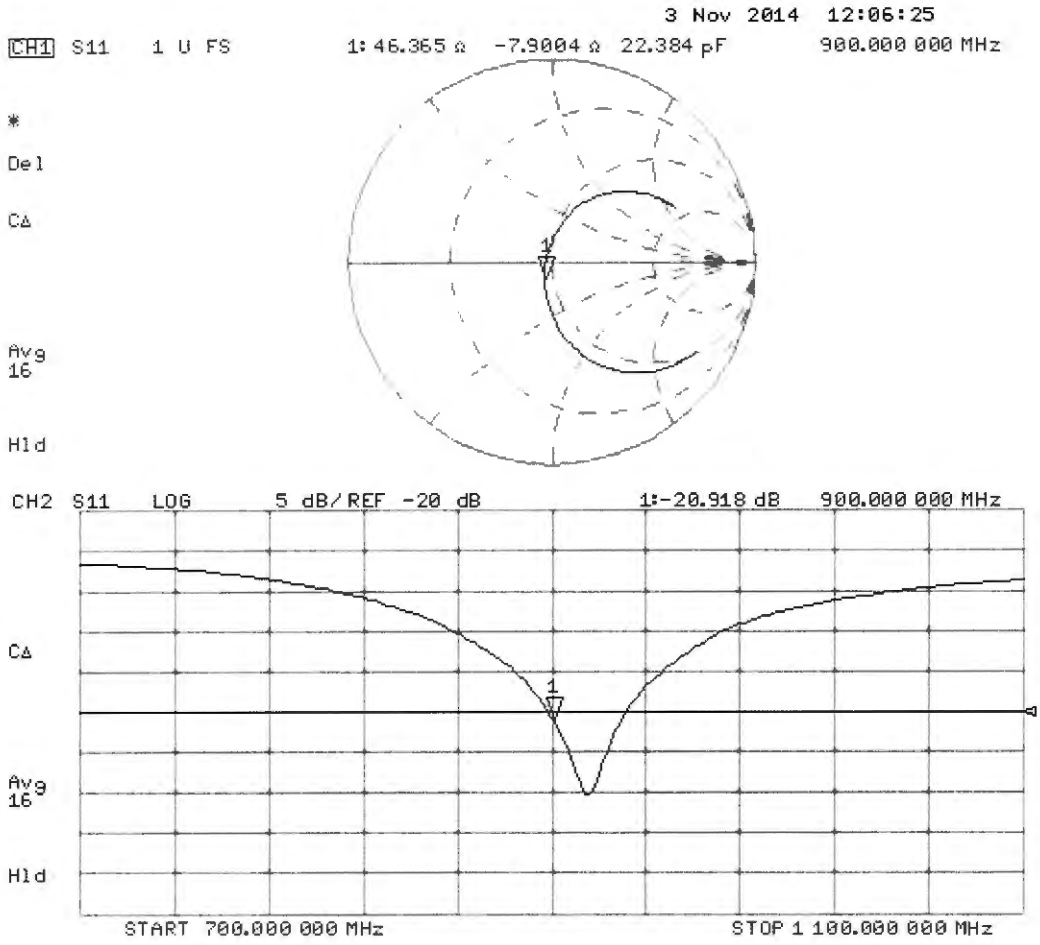
### Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.08 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 3.97 W/kg
**SAR(1 g) = 2.69 W/kg; SAR(10 g) = 1.75 W/kg**
Maximum value of SAR (measured) = 3.15 W/kg




0 dB = 3.15 W/kg = 4.98 dBW/kg

## Impedance Measurement Plot for Body TSL



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

**Accreditation No.: SCS 0108**

**Client** Northwest EMC

**Certificate No: ES3-3246_Nov15**

# CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3246

Calibration procedure(s): QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes

Calibration date: November 12, 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 ± 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: | Claudio Leubler | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 14, 2015

**Calibration Laboratory of**
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## Glossary:

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

a) 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
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
c) 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
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

## Methods Applied and Interpretation of Parameters:

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

# Probe ES3DV3

# SN:3246

Manufactured: May 5, 2009
Calibrated: November 12, 2015

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3246

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$)[A] | 1.41 | 1.17 | 1.17 | ± 10.1 % |
| DCP (mV)[B] | 106.0 | 105.9 | 106.7 | |

## Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB√μV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 229.8 | ±3.5 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 200.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 203.2 | |

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

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3246

## Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 750 | 41.9 | 0.89 | 6.47 | 6.47 | 6.47 | 0.24 | 2.32 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 6.27 | 6.27 | 6.27 | 0.23 | 2.37 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 6.15 | 6.15 | 6.15 | 0.42 | 1.58 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 5.33 | 5.33 | 5.33 | 0.61 | 1.28 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 5.14 | 5.14 | 5.14 | 0.49 | 1.44 | ± 12.0 % |

[C] 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.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] 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: ES3DV3 - SN:3246

## Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) [C] | Relative Permittivity [F] | Conductivity (S/m) [F] | ConvF X | ConvF Y | ConvF Z | Alpha [G] | Depth [G] (mm) | Unc (k=2) |
|---|---|---|---|---|---|---|---|---|
| 450 | 56.7 | 0.94 | 7.22 | 7.22 | 7.22 | 0.15 | 1.80 | ± 13.3 % |
| 750 | 55.5 | 0.96 | 6.40 | 6.40 | 6.40 | 0.37 | 1.69 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 6.26 | 6.26 | 6.26 | 0.32 | 1.89 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 6.23 | 6.23 | 6.23 | 0.80 | 1.14 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 4.96 | 4.96 | 4.96 | 0.35 | 1.97 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 4.79 | 4.79 | 4.79 | 0.49 | 1.63 | ± 12.0 % |

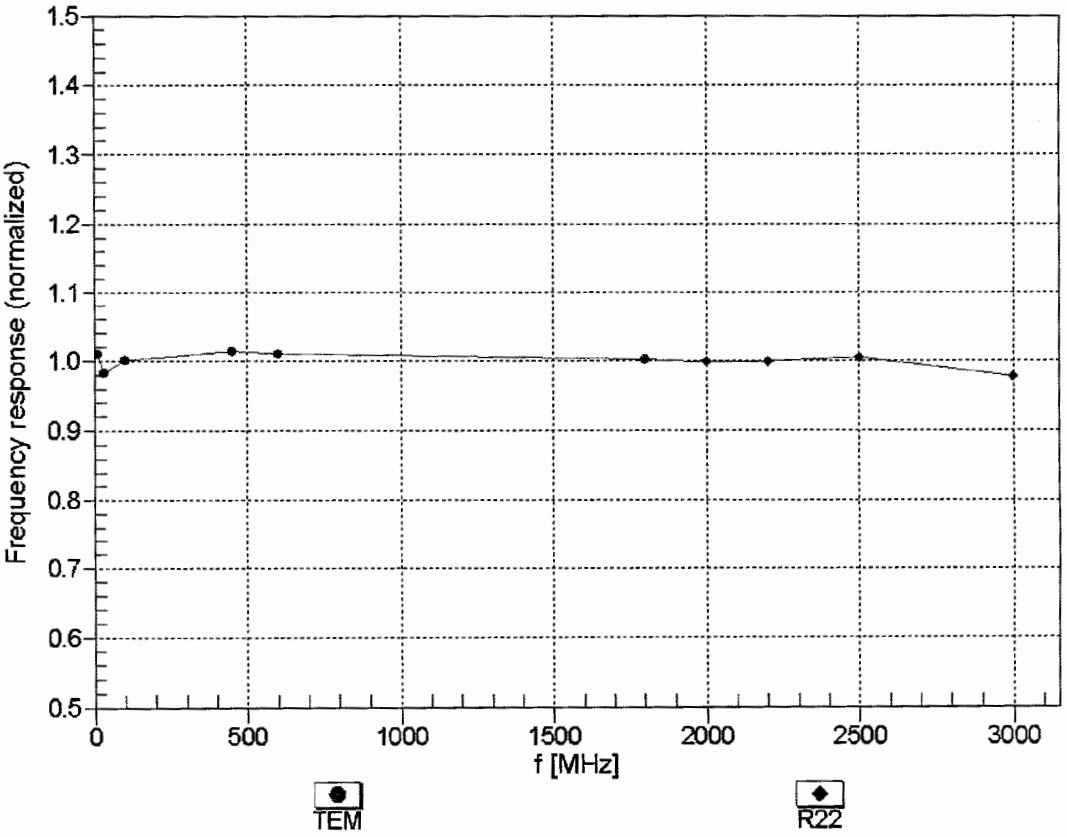
[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz 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.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] 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

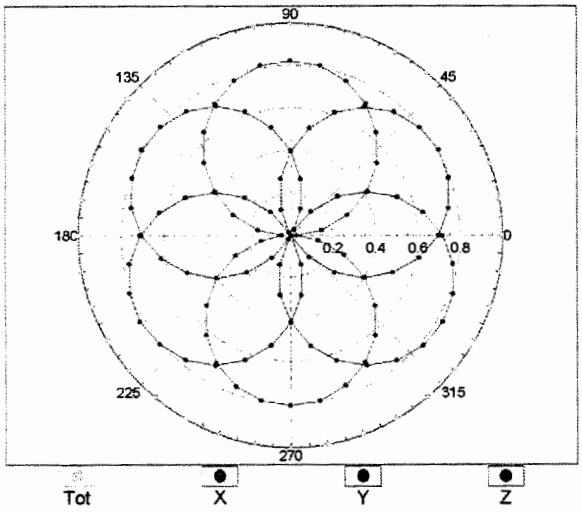
**(TEM-Cell:ifi110 EXX, Waveguide: R22)**



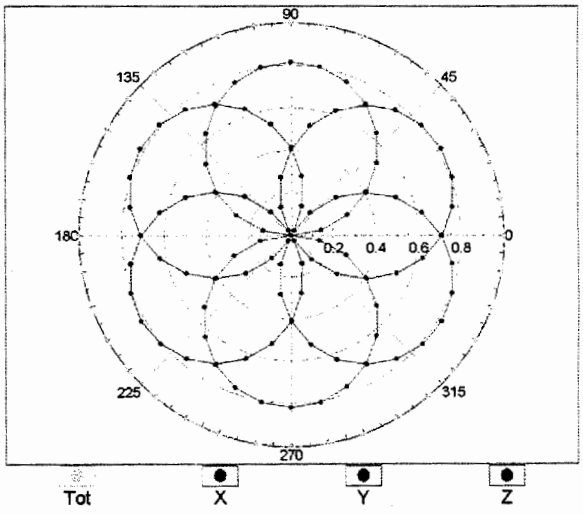

**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

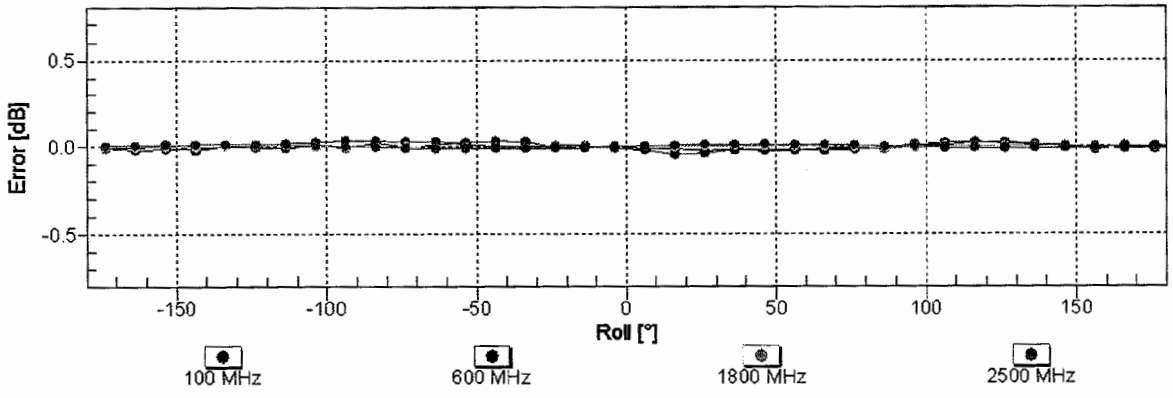
# Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM




f=1800 MHz,R22

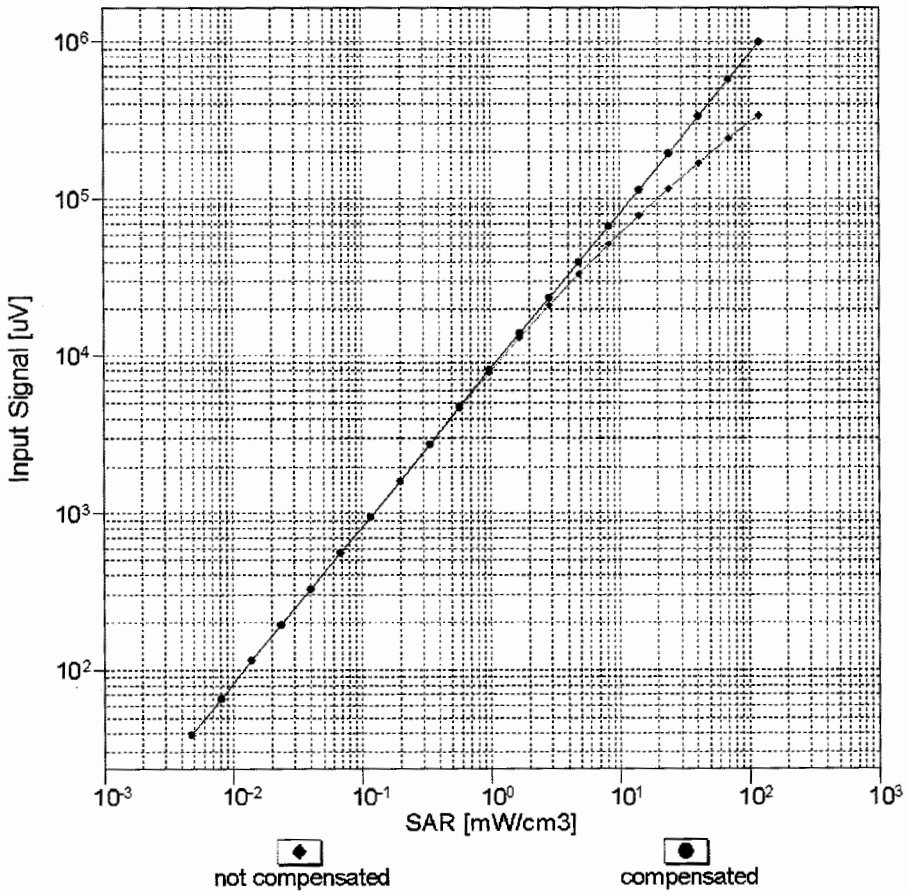


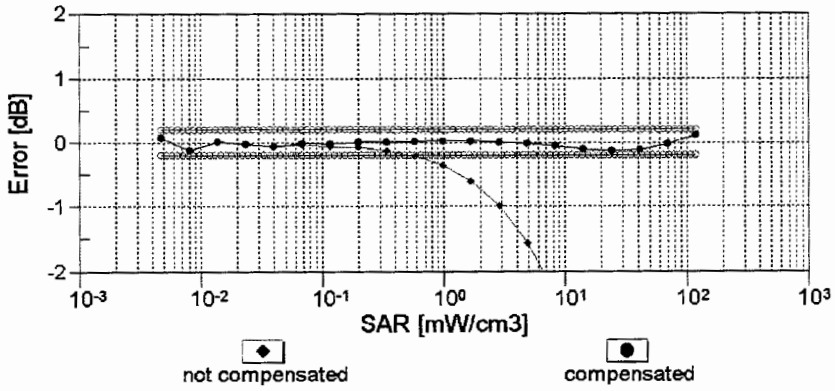




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f($SAR_{head}$)

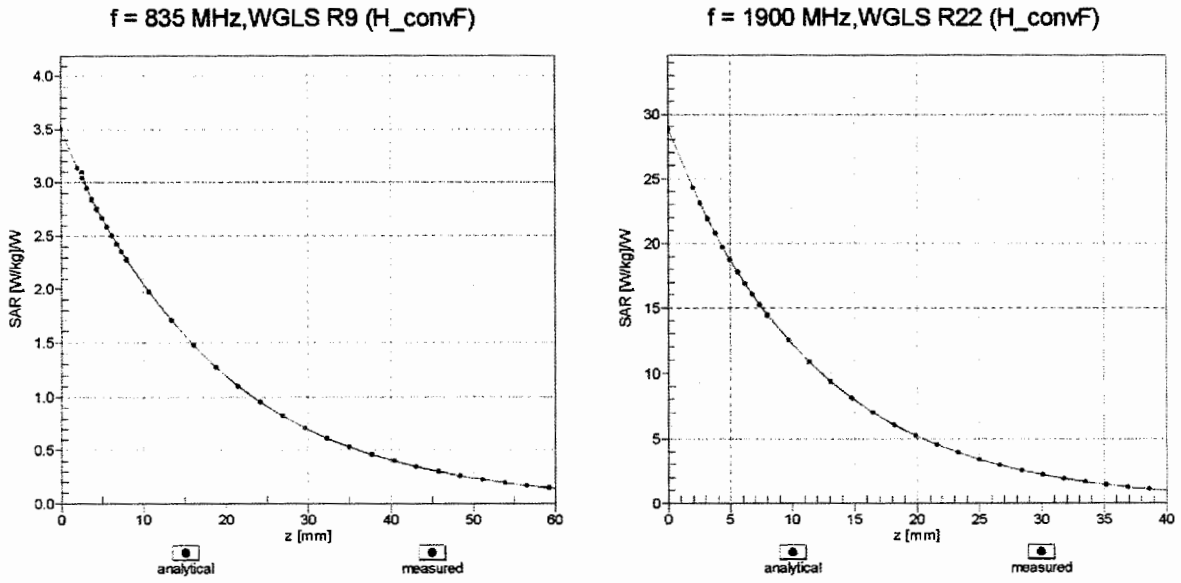
**(TEM cell , $f_{eval}$= 1900 MHz)**



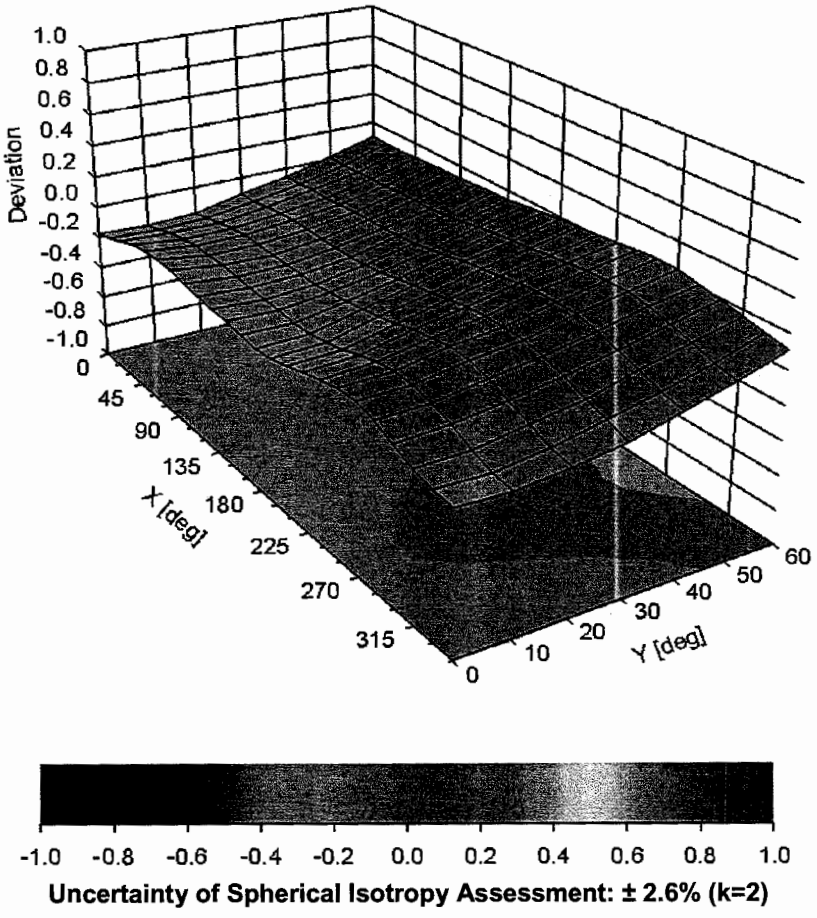

**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Conversion Factor Assessment




# Deviation from Isotropy in Liquid

**Error (ϕ, ϑ), f = 900 MHz**




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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3246

## Other Probe Parameters

| | |
|---|---|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -3.7 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 4 mm |
| Probe Tip to Sensor X Calibration Point | 2 mm |
| Probe Tip to Sensor Y Calibration Point | 2 mm |
| Probe Tip to Sensor Z Calibration Point | 2 mm |
| Recommended Measurement Distance from Surface | 3 mm |