



COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.264.3.16.SATU.A

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1 DEVICE UNDER TEST

| Device Under Test | |
|--|---|
| Device Type | COMOSAR DOSIMETRIC E FIELD PROBE |
| Manufacturer | MVG |
| Model | SSE2 |
| Serial Number | SN 27/15 EPGO262 |
| Product Condition (new / used) | Used |
| Frequency Range of Probe | 0.7 GHz-6GHz |
| Resistance of Three Dipoles at Connector | Dipole 1: R1=0.221 MΩ Dipole 2: R2=0.199 MΩ Dipole 3: R3=0.199 MΩ |

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards.



Figure 1 – MVG COMOSAR Dosimetric E field Dipole

| | |
|--|--------|
| Probe Length | 330 mm |
| Length of Individual Dipoles | 2 mm |
| Maximum external diameter | 8 mm |
| Probe Tip External Diameter | 2.5 mm |
| Distance between dipoles / probe extremity | 1 mm |

3 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their affect. All calibrations / measurements performed meet the fore mentioned standards.

3.1 LINEARITY

The evaluation of the linearity was done in free space using the waveguide, performing a power sweep to cover the SAR range 0.01W/kg to 100W/kg.

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3.2 SENSITIVITY

The sensitivity factors of the three dipoles were determined using a two step calibration method (air and tissue simulating liquid) using waveguides as outlined in the standards.

3.3 LOWER DETECTION LIMIT

The lower detection limit was assessed using the same measurement set up as used for the linearity measurement. The required lower detection limit is 10 mW/kg.

3.4 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole with the dipole mounted under the flat phantom in the test configuration suggested for system validations and checks. The probe was rotated along its main axis from 0 - 360 degrees in 15 degree steps. The hemispherical isotropy is determined by inserting the probe in a thin plastic box filled with tissue-equivalent liquid, with the plastic box illuminated with the fields from a half wave dipole. The dipole is rotated about its axis (0°–180°) in 15° increments. At each step the probe is rotated about its axis (0°–360°).

3.5 BOUNDARY EFFECT

The boundary effect is defined as the deviation between the SAR measured data and the expected exponential decay in the liquid when the probe is oriented normal to the interface. To evaluate this effect, the liquid filled flat phantom is exposed to fields from either a reference dipole or waveguide. With the probe normal to the phantom surface, the peak spatial average SAR is measured and compared to the analytical value at the surface.

4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty associated with an E-field probe calibration using the waveguide technique. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

| Uncertainty analysis of the probe calibration in waveguide | | | | | |
|--|-----------------------|--------------------------|------------|----|--------------------------|
| ERROR SOURCES | Uncertainty value (%) | Probability Distribution | Divisor | ci | Standard Uncertainty (%) |
| Incident or forward power | 3.00% | Rectangular | $\sqrt{3}$ | 1 | 1.732% |
| Reflected power | 3.00% | Rectangular | $\sqrt{3}$ | 1 | 1.732% |
| Liquid conductivity | 5.00% | Rectangular | $\sqrt{3}$ | 1 | 2.887% |
| Liquid permittivity | 4.00% | Rectangular | $\sqrt{3}$ | 1 | 2.309% |
| Field homogeneity | 3.00% | Rectangular | $\sqrt{3}$ | 1 | 1.732% |
| Field probe positioning | 5.00% | Rectangular | $\sqrt{3}$ | 1 | 2.887% |

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| | | | | | |
|--|-------|-------------|------------|---|--------|
| Field probe linearity | 3.00% | Rectangular | $\sqrt{3}$ | 1 | 1.732% |
| Combined standard uncertainty | | | | | 5.831% |
| Expanded uncertainty 95 % confidence level k = 2 | | | | | 12.0% |

5 CALIBRATION MEASUREMENT RESULTS

| Calibration Parameters | |
|------------------------|-------|
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

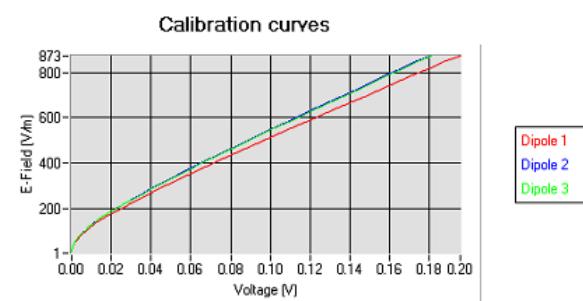
5.1 SENSITIVITY IN AIR

| Normx dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normy dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$) |
|---|---|---|
| 0.80 | 0.71 | 0.72 |

| DCP dipole 1 (mV) | DCP dipole 2 (mV) | DCP dipole 3 (mV) |
|----------------------|----------------------|----------------------|
| 92 | 90 | 91 |

Calibration curves $e_i=f(V)$ ($i=1,2,3$) allow to obtain H-field value using the formula:

$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$

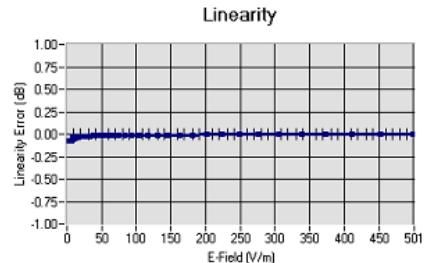




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5.2 LINEARITY



Linearity +/-1.69% (+/-0.07dB)

5.3 SENSITIVITY IN LIQUID

| Liquid | Frequency (MHz +/- 100MHz) | Permittivity | Epsilon (S/m) | ConvF |
|--------|----------------------------------|--------------|---------------|-------|
| HL750 | 750 | 40.03 | 0.93 | 1.57 |
| BL750 | 750 | 56.83 | 1.00 | 1.62 |
| HL850 | 835 | 42.19 | 0.90 | 1.74 |
| BL850 | 835 | 54.67 | 1.01 | 1.81 |
| HL900 | 900 | 42.08 | 1.01 | 1.67 |
| BL900 | 900 | 55.25 | 1.08 | 1.73 |
| HL1800 | 1800 | 41.68 | 1.46 | 1.81 |
| BL1800 | 1800 | 53.86 | 1.46 | 1.87 |
| HL1900 | 1900 | 38.45 | 1.45 | 2.01 |
| BL1900 | 1900 | 53.32 | 1.56 | 2.05 |
| HL2000 | 2000 | 38.26 | 1.38 | 1.86 |
| BL2000 | 2000 | 52.70 | 1.51 | 1.91 |
| HL2450 | 2450 | 37.50 | 1.80 | 2.04 |
| BL2450 | 2450 | 53.22 | 1.89 | 2.12 |
| HL2600 | 2600 | 39.80 | 1.99 | 2.05 |
| BL2600 | 2600 | 52.52 | 2.23 | 2.12 |
| HL3500 | 3500 | 38.21 | 2.98 | 2.02 |
| BL3500 | 3500 | 52.95 | 3.43 | 2.08 |
| HL5200 | 5200 | 35.64 | 4.67 | 1.51 |
| BL5200 | 5200 | 48.64 | 5.51 | 1.55 |
| HL5400 | 5400 | 36.44 | 4.87 | 1.56 |
| BL5400 | 5400 | 46.52 | 5.77 | 1.61 |
| HL5600 | 5600 | 36.66 | 5.17 | 1.55 |
| BL5600 | 5600 | 46.79 | 5.77 | 1.60 |
| HL5800 | 5800 | 35.31 | 5.31 | 1.44 |
| BL5800 | 5800 | 47.04 | 6.10 | 1.48 |

LOWER DETECTION LIMIT: 7mW/kg

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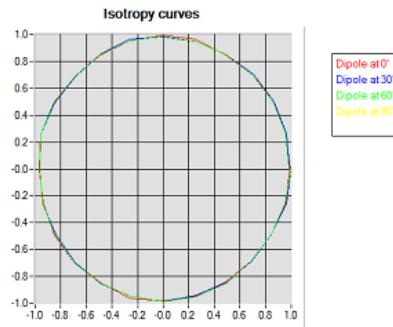
COMOSAR E-FIELD PROBE CALIBRATION REPORT

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5.4 ISOTROPY

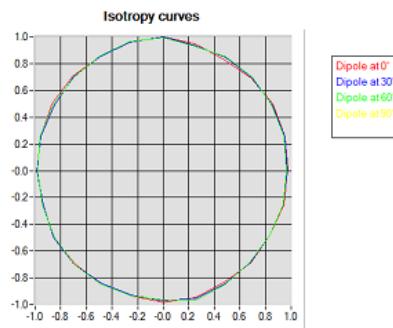
HL900 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.05 dB



HL1800 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.06 dB



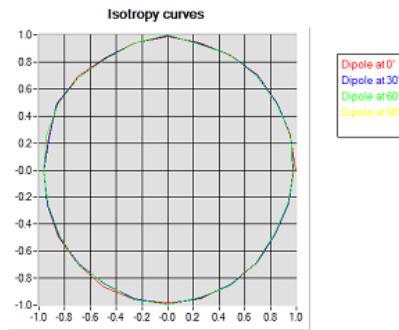


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HL5600 MHz

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.08 dB





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6 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|-------------------------------|----------------------|--------------------|---|---|
| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
| Flat Phantom | MVG | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2016 | 02/2019 |
| Reference Probe | MVG | EP 94 SN 37/08 | 10/2015 | 10/2016 |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Waveguide | Mega Industries | 069Y7-158-13-712 | Validated. No cal required. | Validated. No cal required. |
| Waveguide Transition | Mega Industries | 069Y7-158-13-701 | Validated. No cal required. | Validated. No cal required. |
| Waveguide Termination | Mega Industries | 069Y7-158-13-701 | Validated. No cal required. | Validated. No cal required. |
| Temperature / Humidity Sensor | Control Company | 150798832 | 10/2015 | 10/2017 |



SAR Reference Dipole Calibration Report

Ref : ACR.188.1.14.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

775 MONTAGUE EXPRESSWAY
MILPITAS, CA 95035, USA

SATIMO COMOSAR REFERENCE DIPOLE
FREQUENCY: 750 MHZ
SERIAL NO.: SN 26/14 DIP 0G750-325

Calibrated at SATIMO US
2105 Barrett Park Dr. - Kennesaw, GA 30144



07/03/2014

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.188.1.14.SATU.A

| | Name | Function | Date | Signature |
|---------------|---------------|-----------------|----------|---|
| Prepared by : | Jérôme LUC | Product Manager | 7/7/2014 |  |
| Checked by : | Jérôme LUC | Product Manager | 7/7/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 7/7/2014 |  |

| | Customer Name |
|----------------|---|
| Distribution : | SIEMIC Testing and Certification Services |

| Issue | Date | Modifications |
|-------|----------|-----------------|
| A | 7/7/2014 | Initial release |
| | | |
| | | |
| | | |



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SAR REFERENCE DIPOLE CALIBRATION REPORT

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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

| Device Under Test | |
|--------------------------------|----------------------------------|
| Device Type | COMOSAR 750 MHz REFERENCE DIPOLE |
| Manufacturer | Satimo |
| Model | SID750 |
| Serial Number | SN 26/14 DIP 0G750-325 |
| Product Condition (new / used) | New |

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – Satimo COMOSAR Validation Dipole



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4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz | 0.1 dB |

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300 | 0.05 mm |

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g | 20.3 % |
| 10 g | 20.1 % |

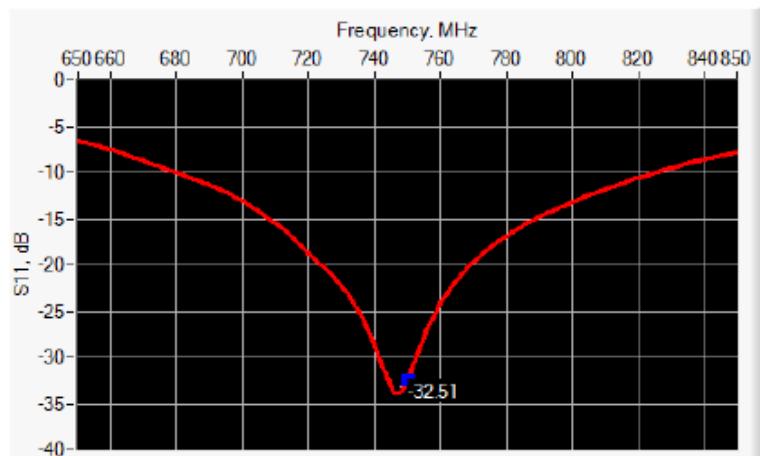


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6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|-----------------|------------------|------------------|-----------------------------|
| 750 | -32.51 | -20 | $52.1 \Omega + 1.1 j\Omega$ |

6.2 MECHANICAL DIMENSIONS

| Frequency MHz | L mm | | h mm | | d mm | |
|---------------|-------------|----------|-------------|----------|------------|----------|
| | required | measured | required | measured | required | measured |
| 300 | 420.0 ±1 %. | | 250.0 ±1 %. | | 6.35 ±1 %. | |
| 450 | 290.0 ±1 %. | | 166.7 ±1 %. | | 6.35 ±1 %. | |
| 750 | 176.0 ±1 %. | PASS | 100.0 ±1 %. | PASS | 6.35 ±1 %. | PASS |
| 835 | 161.0 ±1 %. | | 89.8 ±1 %. | | 3.6 ±1 %. | |
| 900 | 149.0 ±1 %. | | 83.3 ±1 %. | | 3.6 ±1 %. | |
| 1450 | 89.1 ±1 %. | | 51.7 ±1 %. | | 3.6 ±1 %. | |
| 1500 | 80.5 ±1 %. | | 50.0 ±1 %. | | 3.6 ±1 %. | |
| 1640 | 79.0 ±1 %. | | 45.7 ±1 %. | | 3.6 ±1 %. | |
| 1750 | 75.2 ±1 %. | | 42.9 ±1 %. | | 3.6 ±1 %. | |
| 1800 | 72.0 ±1 %. | | 41.7 ±1 %. | | 3.6 ±1 %. | |
| 1900 | 68.0 ±1 %. | | 39.5 ±1 %. | | 3.6 ±1 %. | |
| 1950 | 66.3 ±1 %. | | 38.5 ±1 %. | | 3.6 ±1 %. | |
| 2000 | 64.5 ±1 %. | | 37.5 ±1 %. | | 3.6 ±1 %. | |
| 2100 | 61.0 ±1 %. | | 35.7 ±1 %. | | 3.6 ±1 %. | |
| 2300 | 55.5 ±1 %. | | 32.6 ±1 %. | | 3.6 ±1 %. | |
| 2450 | 51.5 ±1 %. | | 30.4 ±1 %. | | 3.6 ±1 %. | |
| 2600 | 48.5 ±1 %. | | 28.8 ±1 %. | | 3.6 ±1 %. | |
| 3000 | 41.5 ±1 %. | | 25.0 ±1 %. | | 3.6 ±1 %. | |
| 3500 | 37.0 ±1 %. | | 26.4 ±1 %. | | 3.6 ±1 %. | |
| 3700 | 34.7 ±1 %. | | 26.4 ±1 %. | | 3.6 ±1 %. | |



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7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: ϵ_r' : 42.1 sigma : 0.88 |
| Distance between dipole center and liquid | 15.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=8mm/dy=8m/dz=5mm |
| Frequency | 750 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ϵ_r') | | Conductivity (σ) S/m | |
|------------------|---|----------|-------------------------------|----------|
| | required | measured | required | measured |
| 300 | 45.3 ± 5 % | | 0.87 ± 5 % | |
| 450 | 43.5 ± 5 % | | 0.87 ± 5 % | |
| 750 | 41.9 ± 5 % | PASS | 0.89 ± 5 % | PASS |
| 835 | 41.5 ± 5 % | | 0.90 ± 5 % | |
| 900 | 41.5 ± 5 % | | 0.97 ± 5 % | |
| 1450 | 40.5 ± 5 % | | 1.20 ± 5 % | |
| 1500 | 40.4 ± 5 % | | 1.23 ± 5 % | |
| 1640 | 40.2 ± 5 % | | 1.31 ± 5 % | |
| 1750 | 40.1 ± 5 % | | 1.37 ± 5 % | |
| 1800 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1900 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1950 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2000 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2100 | 39.8 ± 5 % | | 1.49 ± 5 % | |
| 2300 | 39.5 ± 5 % | | 1.67 ± 5 % | |
| 2450 | 39.2 ± 5 % | | 1.80 ± 5 % | |
| 2600 | 39.0 ± 5 % | | 1.96 ± 5 % | |
| 3000 | 38.5 ± 5 % | | 2.40 ± 5 % | |
| 3500 | 37.9 ± 5 % | | 2.91 ± 5 % | |



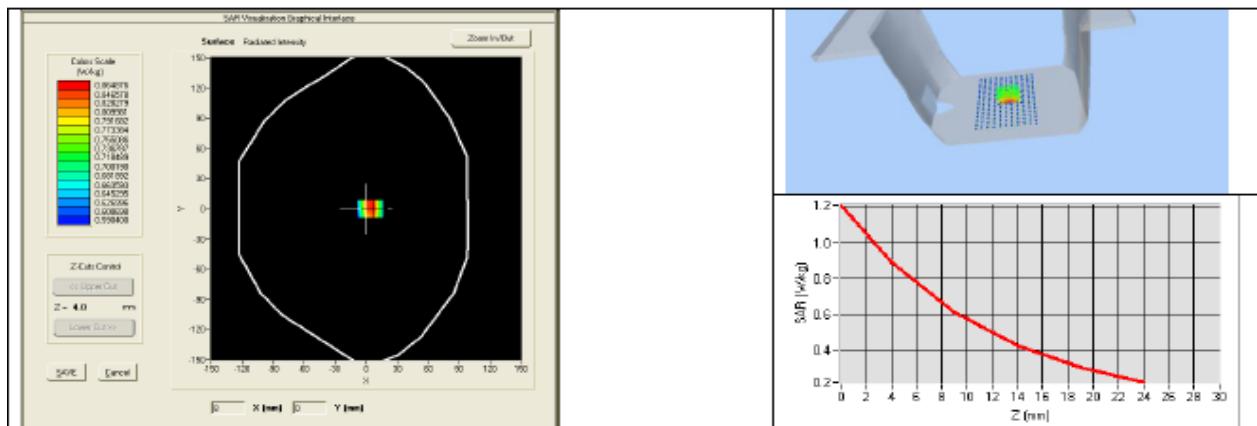
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7.3 MEASUREMENT RESULT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|------------------|------------------|-------------|-------------------|-------------|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | 8.46 (0.85) | 5.55 | 5.52 (0.55) |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | | 24 | |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |



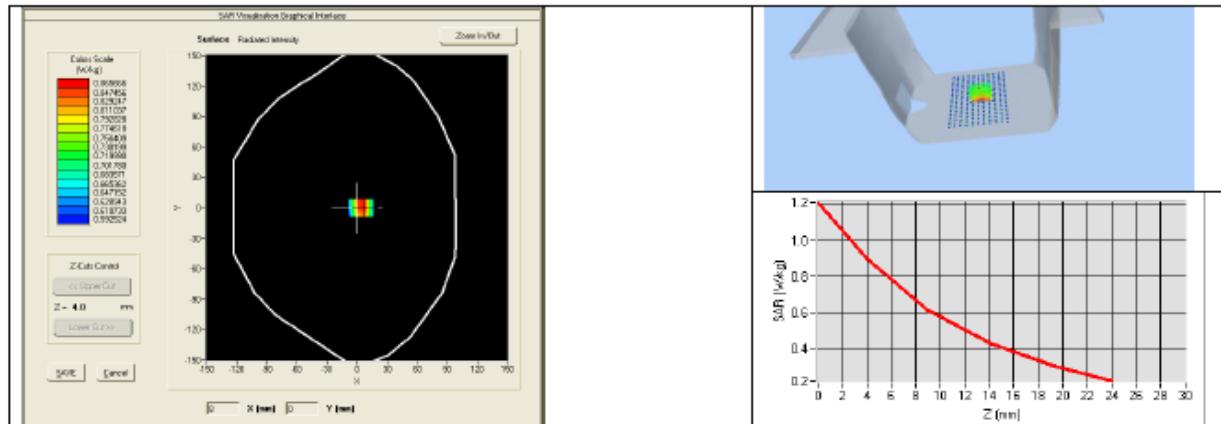

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7.4 BODY MEASUREMENT RESULT

| | |
|---|--|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Body Liquid Values: ϵ_s^* : 54.8 sigma : 0.96 |
| Distance between dipole center and liquid | 15.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 750 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
| | measured | measured |
| 750 | 8.79 (0.88) | 5.73 (0.57) |





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8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---------------------------------|----------------------|--------------------|---|---|
| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
| SAM Phantom | Satimo | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2013 | 02/2016 |
| Calipers | Carrera | CALIPER-01 | 12/2013 | 12/2016 |
| Reference Probe | Satimo | EPG122 SN 18/11 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |



SAR Reference Dipole Calibration Report

Ref : ACR.170.1.14.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,
GUANGDONG , P.R.C.

SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 835 MHZ

SERIAL NO.: SN 18/11 DIPC150

Calibrated at SATIMO US

2105 Barrett Park Dr. - Kennesaw, GA 30144



06/18/2014

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.

| | |
|-------------|----------------|
| Test Report | 17070102-FCC-H |
| Page | 140 of 184 |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.1.14.SATU.A

| | Name | Function | Date | Signature |
|---------------|---------------|-----------------|-----------|---|
| Prepared by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Checked by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 6/19/2014 |  |

| Distribution : | Customer Name |
|----------------|---|
| | SIEMIC Testing and Certification Services |

| Issue | Date | Modifications |
|-------|-----------|-----------------|
| A | 6/19/2014 | Initial release |
| | | |
| | | |
| | | |



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1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

| Device Under Test | |
|--------------------------------|----------------------------------|
| Device Type | COMOSAR 835 MHz REFERENCE DIPOLE |
| Manufacturer | Satimo |
| Model | SID835 |
| Serial Number | SN 18/11 DIPC150 |
| Product Condition (new / used) | |

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – Satimo COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz | 0.1 dB |

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300 | 0.05 mm |

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g | 20.3 % |
| 10 g | 20.1 % |

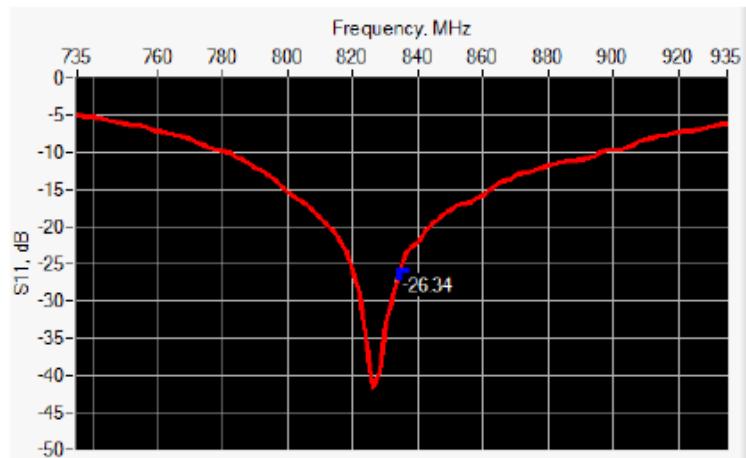


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.1.14.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|-----------------|------------------|------------------|-----------------------------|
| 835 | -26.34 | -20 | $54.8 \Omega + 1.3 j\Omega$ |

6.2 MECHANICAL DIMENSIONS

| Frequency MHz | L mm | | h mm | | d mm | |
|---------------|-------------------|----------|-------------------|----------|------------------|----------|
| | required | measured | required | measured | required | measured |
| 300 | $420.0 \pm 1\%$. | | $250.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 450 | $290.0 \pm 1\%$. | | $166.7 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 750 | $176.0 \pm 1\%$. | | $100.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 835 | $161.0 \pm 1\%$. | PASS | $89.8 \pm 1\%$. | PASS | $3.6 \pm 1\%$. | PASS |
| 900 | $149.0 \pm 1\%$. | | $83.3 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1450 | $89.1 \pm 1\%$. | | $51.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1500 | $80.5 \pm 1\%$. | | $50.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1640 | $79.0 \pm 1\%$. | | $45.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1750 | $75.2 \pm 1\%$. | | $42.9 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1800 | $72.0 \pm 1\%$. | | $41.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1900 | $68.0 \pm 1\%$. | | $39.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1950 | $66.3 \pm 1\%$. | | $38.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2000 | $64.5 \pm 1\%$. | | $37.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2100 | $61.0 \pm 1\%$. | | $35.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2300 | $55.5 \pm 1\%$. | | $32.6 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2450 | $51.5 \pm 1\%$. | | $30.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2600 | $48.5 \pm 1\%$. | | $28.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3000 | $41.5 \pm 1\%$. | | $25.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3500 | $37.0 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3700 | $34.7 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.170.1.14.SATU.A

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: ϵ_s' : 43.8 sigma : 0.91 |
| Distance between dipole center and liquid | 15.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=8mm/dy=8m/dz=5mm |
| Frequency | 835 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ϵ_s') | | Conductivity (σ) S/m | |
|------------------|---|----------|-------------------------------|----------|
| | required | measured | required | measured |
| 300 | 45.3 ±5 % | | 0.87 ±5 % | |
| 450 | 43.5 ±5 % | | 0.87 ±5 % | |
| 750 | 41.9 ±5 % | | 0.89 ±5 % | |
| 835 | 41.5 ±5 % | PASS | 0.90 ±5 % | PASS |
| 900 | 41.5 ±5 % | | 0.97 ±5 % | |
| 1450 | 40.5 ±5 % | | 1.20 ±5 % | |
| 1500 | 40.4 ±5 % | | 1.23 ±5 % | |
| 1640 | 40.2 ±5 % | | 1.31 ±5 % | |
| 1750 | 40.1 ±5 % | | 1.37 ±5 % | |
| 1800 | 40.0 ±5 % | | 1.40 ±5 % | |
| 1900 | 40.0 ±5 % | | 1.40 ±5 % | |
| 1950 | 40.0 ±5 % | | 1.40 ±5 % | |
| 2000 | 40.0 ±5 % | | 1.40 ±5 % | |
| 2100 | 39.8 ±5 % | | 1.49 ±5 % | |
| 2300 | 39.5 ±5 % | | 1.67 ±5 % | |
| 2450 | 39.2 ±5 % | | 1.80 ±5 % | |
| 2600 | 39.0 ±5 % | | 1.96 ±5 % | |
| 3000 | 38.5 ±5 % | | 2.40 ±5 % | |
| 3500 | 37.9 ±5 % | | 2.91 ±5 % | |

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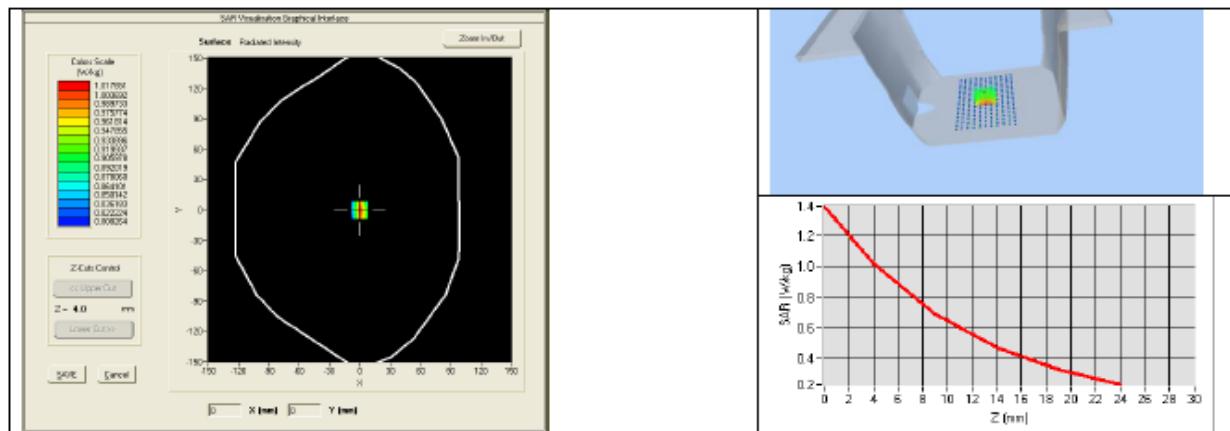
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.1.14.SATU.A

7.3 MEASUREMENT RESULT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|------------------|------------------|-------------|-------------------|-------------|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | 9.65 (0.96) | 6.22 | 6.17 (0.62) |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | | 24 | |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |





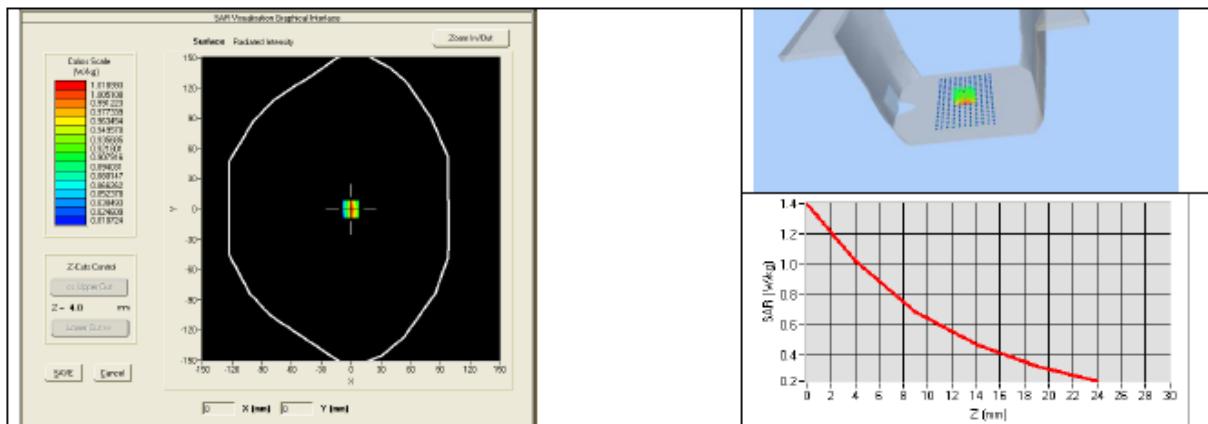
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.1.14.SATU.A

7.4 BODY MEASUREMENT RESULT

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Body Liquid Values: ϵ_s' : 54.4 sigma : 0.94 |
| Distance between dipole center and liquid | 15.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 835 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
| | measured | measured |
| 835 | 9.98 (1.00) | 6.38 (0.64) |





SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.1.14.SATU.A

8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---------------------------------|----------------------|--------------------|---|---|
| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
| SAM Phantom | Satimo | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2013 | 02/2016 |
| Calipers | Carrera | CALIPER-01 | 12/2013 | 12/2016 |
| Reference Probe | Satimo | EPG122 SN 18/11 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |



SAR Reference Dipole Calibration Report

Ref : ACR.170.4.14.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,
GUANGDONG , P.R.C.

SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 1900 MHZ

SERIAL NO.: SN 18/11 DIPG153

Calibrated at SATIMO US

2105 Barrett Park Dr. - Kennesaw, GA 30144



06/18/2014

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.4.14.SATU.A

| | Name | Function | Date | Signature |
|---------------|---------------|-----------------|-----------|---|
| Prepared by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Checked by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 6/19/2014 |  |

| | Customer Name |
|----------------|---|
| Distribution : | SIEMIC Testing and Certification Services |

| Issue | Date | Modifications |
|-------|-----------|-----------------|
| A | 6/19/2014 | Initial release |
| | | |
| | | |
| | | |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.4.14.SATU.A

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| 5.3 | Validation Measurement | 5 |
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| 7 | Validation measurement | 7 |
| 7.1 | Measurement Condition | 7 |
| 7.2 | Head Liquid Measurement | 7 |
| 7.3 | Measurement Result | 8 |
| 7.4 | Body Measurement Result | 9 |
| 8 | List of Equipment | 10 |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.4.14.SATU.A

1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

| Device Under Test | |
|--------------------------------|-----------------------------------|
| Device Type | COMOSAR 1900 MHz REFERENCE DIPOLE |
| Manufacturer | Satimo |
| Model | SID1900 |
| Serial Number | SN 18/11 DIPG153 |
| Product Condition (new / used) | used |

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – Satimo COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz | 0.1 dB |

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300 | 0.05 mm |

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

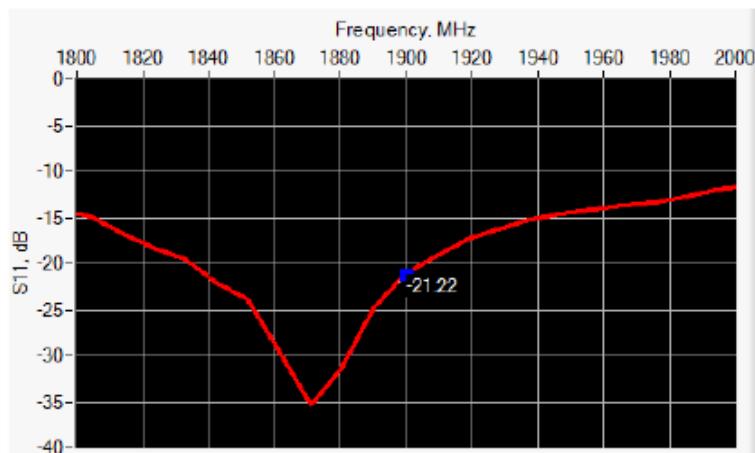
| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g | 20.3 % |
| 10 g | 20.1 % |


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.170.4.14.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|-----------------|------------------|------------------|-----------------------------|
| 1900 | -21.22 | -20 | $52.7 \Omega + 8.6 j\Omega$ |

6.2 MECHANICAL DIMENSIONS

| Frequency MHz | L mm | | h mm | | d mm | |
|---------------|-------------------|----------|-------------------|----------|------------------|----------|
| | required | measured | required | measured | required | measured |
| 300 | $420.0 \pm 1\%$. | | $250.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 450 | $290.0 \pm 1\%$. | | $166.7 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 750 | $176.0 \pm 1\%$. | | $100.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 835 | $161.0 \pm 1\%$. | | $89.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 900 | $149.0 \pm 1\%$. | | $83.3 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1450 | $89.1 \pm 1\%$. | | $51.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1500 | $80.5 \pm 1\%$. | | $50.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1640 | $79.0 \pm 1\%$. | | $45.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1750 | $75.2 \pm 1\%$. | | $42.9 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1800 | $72.0 \pm 1\%$. | | $41.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1900 | $68.0 \pm 1\%$. | PASS | $39.5 \pm 1\%$. | PASS | $3.6 \pm 1\%$. | PASS |
| 1950 | $66.3 \pm 1\%$. | | $38.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2000 | $64.5 \pm 1\%$. | | $37.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2100 | $61.0 \pm 1\%$. | | $35.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2300 | $55.5 \pm 1\%$. | | $32.6 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2450 | $51.5 \pm 1\%$. | | $30.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2600 | $48.5 \pm 1\%$. | | $28.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3000 | $41.5 \pm 1\%$. | | $25.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3500 | $37.0 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3700 | $34.7 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |

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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref ACR.170.4.14.SATU.A

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPEN SAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: ϵ_r' : 40.9 sigma : 1.45 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=8mm/dy=8m/dz=5mm |
| Frequency | 1900 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ϵ_r') | | Conductivity (σ) S/m | |
|------------------|---|----------|-------------------------------|----------|
| | required | measured | required | measured |
| 300 | 45.3 ± 5 % | | 0.87 ± 5 % | |
| 450 | 43.5 ± 5 % | | 0.87 ± 5 % | |
| 750 | 41.9 ± 5 % | | 0.89 ± 5 % | |
| 835 | 41.5 ± 5 % | | 0.90 ± 5 % | |
| 900 | 41.5 ± 5 % | | 0.97 ± 5 % | |
| 1450 | 40.5 ± 5 % | | 1.20 ± 5 % | |
| 1500 | 40.4 ± 5 % | | 1.23 ± 5 % | |
| 1640 | 40.2 ± 5 % | | 1.31 ± 5 % | |
| 1750 | 40.1 ± 5 % | | 1.37 ± 5 % | |
| 1800 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1900 | 40.0 ± 5 % | PASS | 1.40 ± 5 % | PASS |
| 1950 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2000 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2100 | 39.8 ± 5 % | | 1.49 ± 5 % | |
| 2300 | 39.5 ± 5 % | | 1.67 ± 5 % | |
| 2450 | 39.2 ± 5 % | | 1.80 ± 5 % | |
| 2600 | 39.0 ± 5 % | | 1.96 ± 5 % | |
| 3000 | 38.5 ± 5 % | | 2.40 ± 5 % | |
| 3500 | 37.9 ± 5 % | | 2.91 ± 5 % | |

Page: 7/10



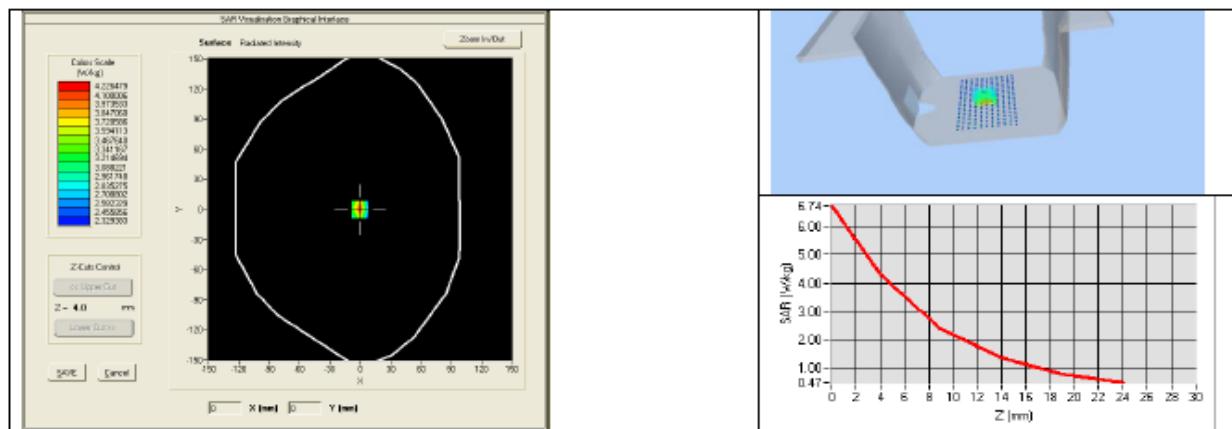
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.170.4.14.SATU.A

7.3 MEASUREMENT RESULT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|------------------|------------------|--------------|-------------------|--------------|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | 39.52 (3.95) | 20.5 | 20.03 (2.00) |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | | 24 | |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |





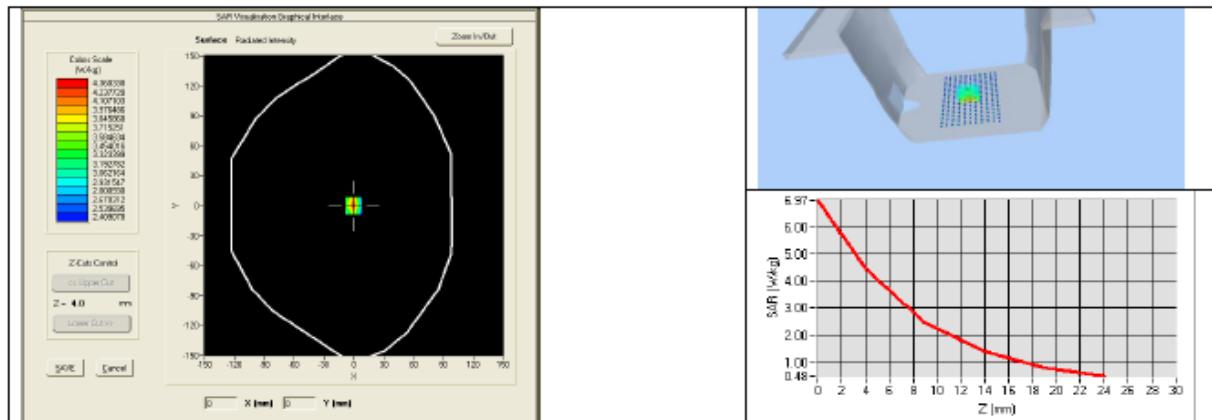
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref ACR.170.4.14.SATU.A

7.4 BODY MEASUREMENT RESULT

| | |
|---|--|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Body Liquid Values: ϵ_s^* : 53.6 sigma : 1.52 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 1900 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
| | measured | measured |
| 1900 | 42.88 (4.29) | 21.39 (2.14) |




SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.4.14.SATU.A

8 LIST OF EQUIPMENT

Equipment Summary Sheet

| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
|---------------------------------|-----------------------------|---------------------------|---|---|
| SAM Phantom | Satimo | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2013 | 02/2016 |
| Calipers | Carrera | CALIPER-01 | 12/2013 | 12/2016 |
| Reference Probe | Satimo | EPG122 SN 18/11 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |



SAR Reference Dipole Calibration Report

Ref : ACR.170.3.14.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,
GUANGDONG , P.R.C.

SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 1800 MHZ

SERIAL NO.: SN 18/11 DIPF152

Calibrated at SATIMO US

2105 Barrett Park Dr. - Kennesaw, GA 30144



06/18/2014

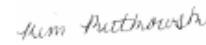
Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.170.3.14.SATU.A

| | Name | Function | Date | Signature |
|---------------|---------------|-----------------|-----------|---|
| Prepared by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Checked by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 6/19/2014 |  |

| Distribution : | Customer Name |
|----------------|---|
| | SIEMIC Testing and Certification Services |

| Issue | Date | Modifications |
|-------|-----------|-----------------|
| A | 6/19/2014 | Initial release |
| | | |
| | | |
| | | |



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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.3.14.SATU.A

1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

| Device Under Test | |
|--------------------------------|-----------------------------------|
| Device Type | COMOSAR 1800 MHz REFERENCE DIPOLE |
| Manufacturer | Satimo |
| Model | SID1800 |
| Serial Number | SN 18/11 DIPF152 |
| Product Condition (new / used) | used |

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – Satimo COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz | 0.1 dB |

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300 | 0.05 mm |

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g | 20.3 % |
| 10 g | 20.1 % |

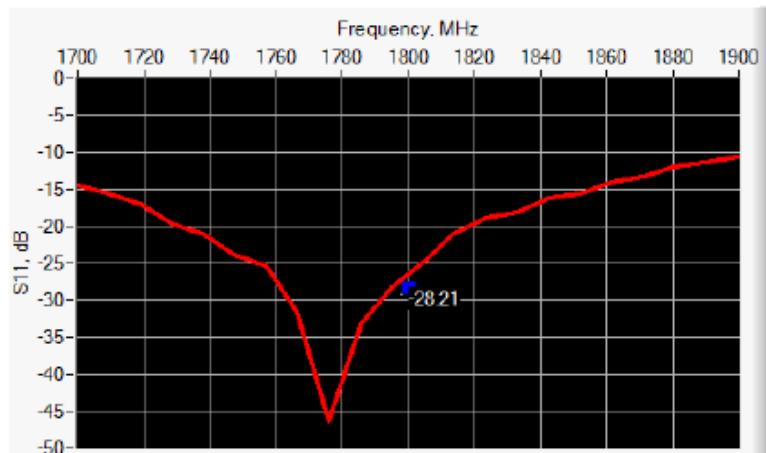


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.170.3.14.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|-----------------|------------------|------------------|-----------------------------|
| 1800 | -28.21 | -20 | $46.5 \Omega + 1.0 j\Omega$ |

6.2 MECHANICAL DIMENSIONS

| Frequency MHz | L mm | | h mm | | d mm | |
|---------------|-------------------|----------|-------------------|----------|------------------|----------|
| | required | measured | required | measured | required | measured |
| 300 | $420.0 \pm 1\%$. | | $250.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 450 | $290.0 \pm 1\%$. | | $166.7 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 750 | $176.0 \pm 1\%$. | | $100.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 835 | $161.0 \pm 1\%$. | | $89.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 900 | $149.0 \pm 1\%$. | | $83.3 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1450 | $89.1 \pm 1\%$. | | $51.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1500 | $80.5 \pm 1\%$. | | $50.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1640 | $79.0 \pm 1\%$. | | $45.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1750 | $75.2 \pm 1\%$. | | $42.9 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1800 | $72.0 \pm 1\%$. | PASS | $41.7 \pm 1\%$. | PASS | $3.6 \pm 1\%$. | PASS |
| 1900 | $68.0 \pm 1\%$. | | $39.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1950 | $66.3 \pm 1\%$. | | $38.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2000 | $64.5 \pm 1\%$. | | $37.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2100 | $61.0 \pm 1\%$. | | $35.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2300 | $55.5 \pm 1\%$. | | $32.6 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2450 | $51.5 \pm 1\%$. | | $30.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2600 | $48.5 \pm 1\%$. | | $28.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3000 | $41.5 \pm 1\%$. | | $25.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3500 | $37.0 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3700 | $34.7 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |

| | |
|-------------|----------------|
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SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.3.14.SATU.A

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: ϵ_s' : 40.9 sigma : 1.36 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 1800 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ϵ_s') | | Conductivity (σ) S/m | |
|------------------|---|----------|-------------------------------|----------|
| | required | measured | required | measured |
| 300 | 45.3 ± 5 % | | 0.87 ± 5 % | |
| 450 | 43.5 ± 5 % | | 0.87 ± 5 % | |
| 750 | 41.9 ± 5 % | | 0.89 ± 5 % | |
| 835 | 41.5 ± 5 % | | 0.90 ± 5 % | |
| 900 | 41.5 ± 5 % | | 0.97 ± 5 % | |
| 1450 | 40.5 ± 5 % | | 1.20 ± 5 % | |
| 1500 | 40.4 ± 5 % | | 1.23 ± 5 % | |
| 1640 | 40.2 ± 5 % | | 1.31 ± 5 % | |
| 1750 | 40.1 ± 5 % | | 1.37 ± 5 % | |
| 1800 | 40.0 ± 5 % | PASS | 1.40 ± 5 % | PASS |
| 1900 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1950 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2000 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2100 | 39.8 ± 5 % | | 1.49 ± 5 % | |
| 2300 | 39.5 ± 5 % | | 1.67 ± 5 % | |
| 2450 | 39.2 ± 5 % | | 1.80 ± 5 % | |
| 2600 | 39.0 ± 5 % | | 1.96 ± 5 % | |
| 3000 | 38.5 ± 5 % | | 2.40 ± 5 % | |
| 3500 | 37.9 ± 5 % | | 2.91 ± 5 % | |

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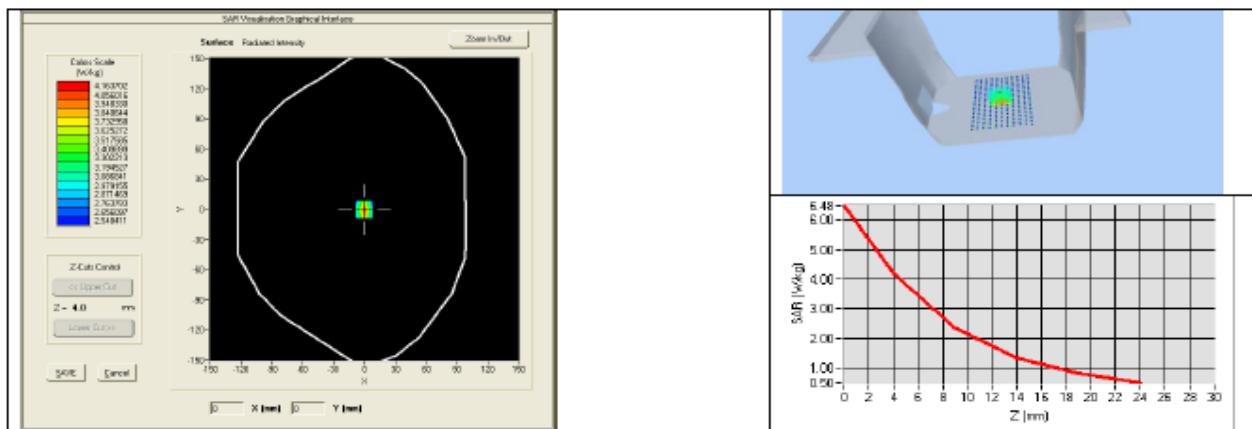

SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.3.14.SATU.A

7.3 MEASUREMENT RESULT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|------------------|------------------|--------------|-------------------|--------------|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | 38.44 (3.84) | 20.1 | 19.96 (2.00) |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | | 24 | |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |





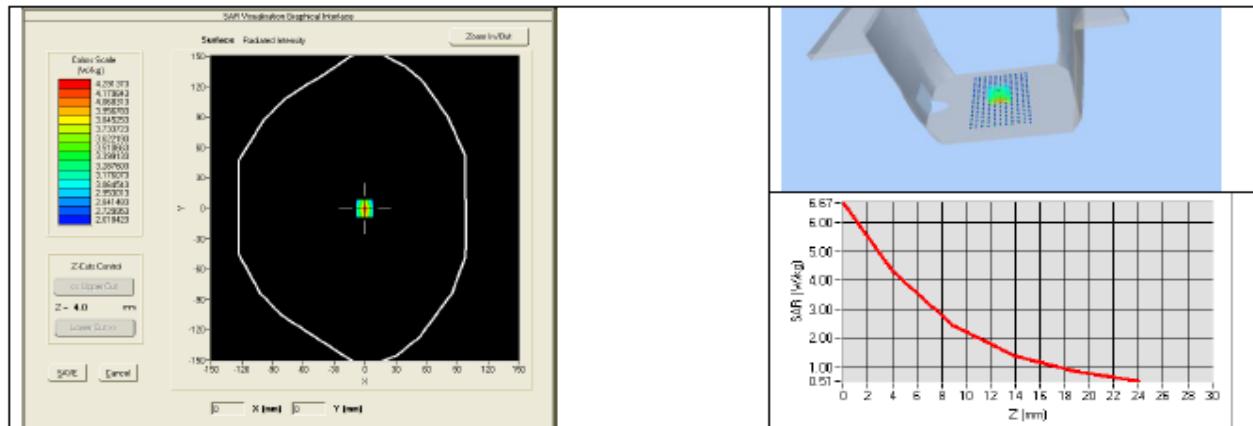
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.3.14.SATU.A

7.4 BODY MEASUREMENT RESULT

| | |
|---|--|
| Software | OPEN SAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Body Liquid Values: ϵ_r^* : 52.6 sigma : 1.47 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 1800 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
| | measured | measured |
| 1800 | 39.59 (3.96) | 20.55 (2.05) |





8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---------------------------------|----------------------|--------------------|---|---|
| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
| SAM Phantom | Satimo | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2013 | 02/2016 |
| Calipers | Carrera | CALIPER-01 | 12/2013 | 12/2016 |
| Reference Probe | Satimo | EPG122 SN 18/11 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |



SAR Reference Dipole Calibration Report

Ref : ACR.170.6.14.SATU.A

SIEMIC TESTING AND CERTIFICATION SERVICES

**ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,
GUANGDONG , P.R.C.**

**SATIMO COMOSAR REFERENCE DIPOLE
FREQUENCY: 2450 MHZ
SERIAL NO.: SN 18/11 DIPJ155**

Calibrated at SATIMO US

2105 Barrett Park Dr. - Kennesaw, GA 30144



06/18/2014

Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in SATIMO USA using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

| | Name | Function | Date | Signature |
|---------------|---------------|-----------------|-----------|---|
| Prepared by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Checked by : | Jérôme LUC | Product Manager | 6/19/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 6/19/2014 |  |

| | Customer Name |
|----------------|---|
| Distribution : | SIEMIC Testing and Certification Services |

| Issue | Date | Modifications |
|-------|-----------|-----------------|
| A | 6/19/2014 | Initial release |
| | | |
| | | |
| | | |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

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| 8 | List of Equipment | 10 |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

| Device Under Test | |
|--------------------------------|-----------------------------------|
| Device Type | COMOSAR 2450 MHz REFERENCE DIPOLE |
| Manufacturer | Satimo |
| Model | SID2450 |
| Serial Number | SN 18/11 DIPJ155 |
| Product Condition (new / used) | used |

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

Satimo's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – Satimo COMOSAR Validation Dipole



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz | 0.1 dB |

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300 | 0.05 mm |

5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g | 20.3 % |
| 10 g | 20.1 % |

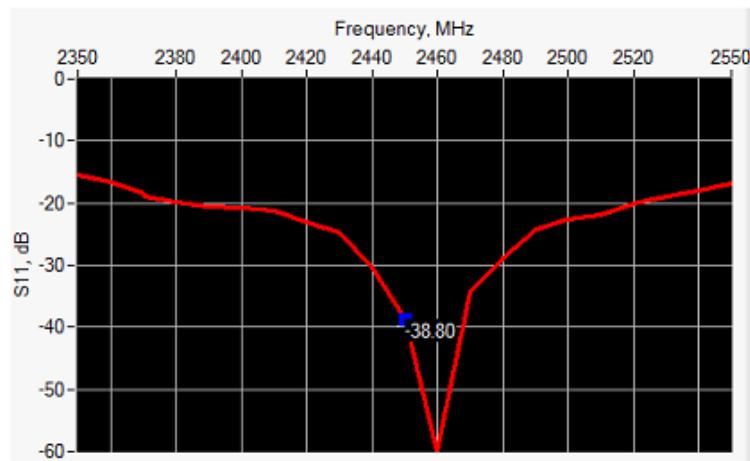


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|-----------------|------------------|------------------|-----------------------------|
| 2450 | -38.80 | -20 | $49.9 \Omega + 1.2 j\Omega$ |

6.2 MECHANICAL DIMENSIONS

| Frequency MHz | L mm | | h mm | | d mm | |
|---------------|-------------------|----------|-------------------|----------|------------------|----------|
| | required | measured | required | measured | required | measured |
| 300 | $420.0 \pm 1\%$. | | $250.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 450 | $290.0 \pm 1\%$. | | $166.7 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 750 | $176.0 \pm 1\%$. | | $100.0 \pm 1\%$. | | $6.35 \pm 1\%$. | |
| 835 | $161.0 \pm 1\%$. | | $89.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 900 | $149.0 \pm 1\%$. | | $83.3 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1450 | $89.1 \pm 1\%$. | | $51.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1500 | $80.5 \pm 1\%$. | | $50.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1640 | $79.0 \pm 1\%$. | | $45.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1750 | $75.2 \pm 1\%$. | | $42.9 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1800 | $72.0 \pm 1\%$. | | $41.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1900 | $68.0 \pm 1\%$. | | $39.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 1950 | $66.3 \pm 1\%$. | | $38.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2000 | $64.5 \pm 1\%$. | | $37.5 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2100 | $61.0 \pm 1\%$. | | $35.7 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2300 | $55.5 \pm 1\%$. | | $32.6 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 2450 | $51.5 \pm 1\%$. | PASS | $30.4 \pm 1\%$. | PASS | $3.6 \pm 1\%$. | PASS |
| 2600 | $48.5 \pm 1\%$. | | $28.8 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3000 | $41.5 \pm 1\%$. | | $25.0 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3500 | $37.0 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |
| 3700 | $34.7 \pm 1\%$. | | $26.4 \pm 1\%$. | | $3.6 \pm 1\%$. | |



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.

7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: ϵ'_r : 39.1 sigma : 1.78 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | $dx=8mm/dy=8mm$ |
| Zoon Scan Resolution | $dx=8mm/dy=8m/dz=5mm$ |
| Frequency | 2450 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ϵ'_r) | | Conductivity (σ) S/m | |
|------------------|---|----------|-------------------------------|----------|
| | required | measured | required | measured |
| 300 | 45.3 ± 5 % | | 0.87 ± 5 % | |
| 450 | 43.5 ± 5 % | | 0.87 ± 5 % | |
| 750 | 41.9 ± 5 % | | 0.89 ± 5 % | |
| 835 | 41.5 ± 5 % | | 0.90 ± 5 % | |
| 900 | 41.5 ± 5 % | | 0.97 ± 5 % | |
| 1450 | 40.5 ± 5 % | | 1.20 ± 5 % | |
| 1500 | 40.4 ± 5 % | | 1.23 ± 5 % | |
| 1640 | 40.2 ± 5 % | | 1.31 ± 5 % | |
| 1750 | 40.1 ± 5 % | | 1.37 ± 5 % | |
| 1800 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1900 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 1950 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2000 | 40.0 ± 5 % | | 1.40 ± 5 % | |
| 2100 | 39.8 ± 5 % | | 1.49 ± 5 % | |
| 2300 | 39.5 ± 5 % | | 1.67 ± 5 % | |
| 2450 | 39.2 ± 5 % | PASS | 1.80 ± 5 % | PASS |
| 2600 | 39.0 ± 5 % | | 1.96 ± 5 % | |
| 3000 | 38.5 ± 5 % | | 2.40 ± 5 % | |
| 3500 | 37.9 ± 5 % | | 2.91 ± 5 % | |

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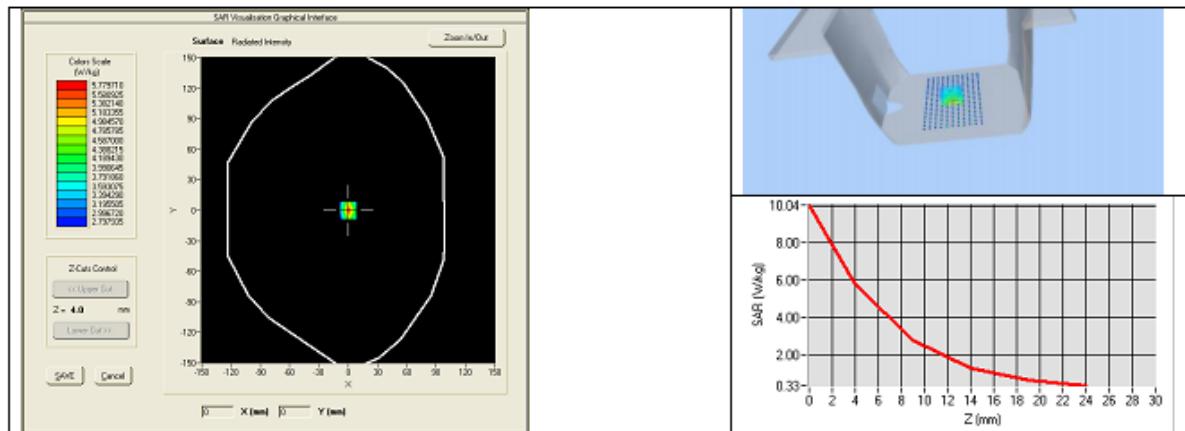
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

7.3 MEASUREMENT RESULT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|------------------|------------------|--------------|-------------------|--------------|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | 55.06 (5.51) | 24 | 24.17 (2.42) |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |





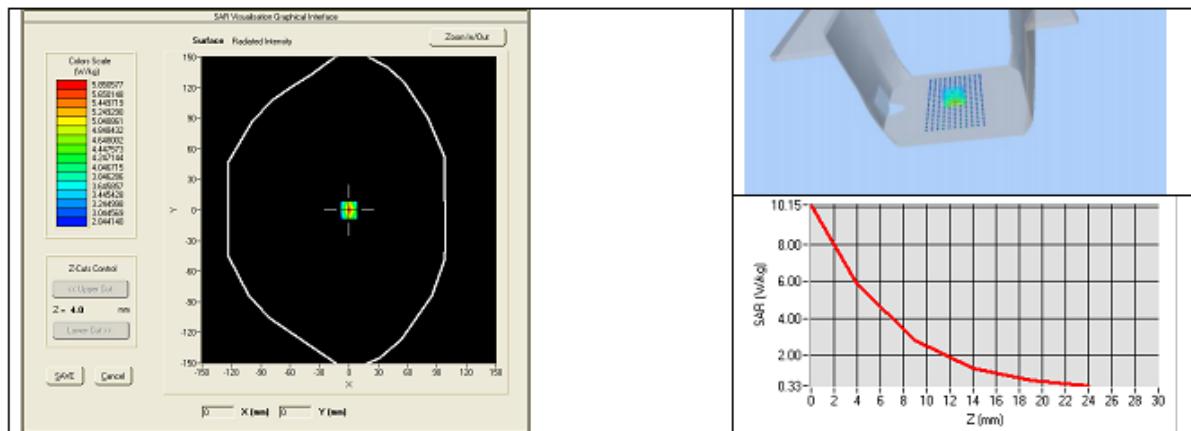
SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

7.4 BODY MEASUREMENT RESULT

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Body Liquid Values: $\epsilon_s' : 52.2$ sigma : 1.90 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | $dx=8\text{mm}/dy=8\text{mm}$ |
| Zoon Scan Resolution | $dx=8\text{mm}/dy=8\text{m}/dz=5\text{mm}$ |
| Frequency | 2450 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
| | measured | measured |
| 2450 | 56.05 (5.60) | 24.71 (2.47) |





SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.170.6.14.SATU.A

8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---------------------------------|----------------------|--------------------|---|---|
| Equipment Description | Manufacturer / Model | Identification No. | Current Calibration Date | Next Calibration Date |
| SAM Phantom | Satimo | SN-20/09-SAM71 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rhode & Schwarz ZVA | SN100132 | 02/2013 | 02/2016 |
| Calipers | Carrera | CALIPER-01 | 12/2013 | 12/2016 |
| Reference Probe | Satimo | EPG122 SN 18/11 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Multimeter | Keithley 2000 | 1188656 | 12/2013 | 12/2016 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2013 | 12/2016 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2013 | 12/2016 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2013 | 12/2016 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |

Annex B SAR System PHOTOGRAPHS

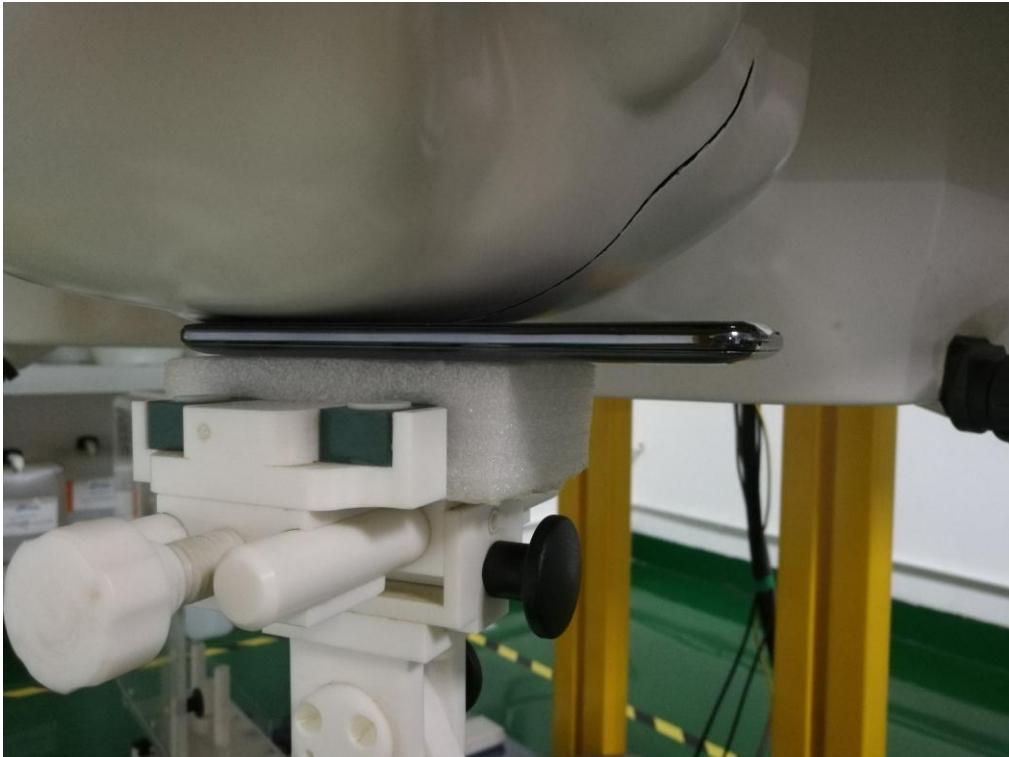


Liquid depth \geq 15cm



Annex C SETUP PHOTOGRAPHS

Right Head Touch View



Right Head Tilt View



Left Head Touch View



Left Head Tilt View



Body Setup Photo (LCD UP)



Body Setup Photo (LCD DOWN)



Body Setup Photo (LEFT EDGE)



Body Setup Photo (RIGHT EDGE)



Body Setup Photo (BOTTOM EDGE)



Body Setup Photo (TOP EDGE)

