

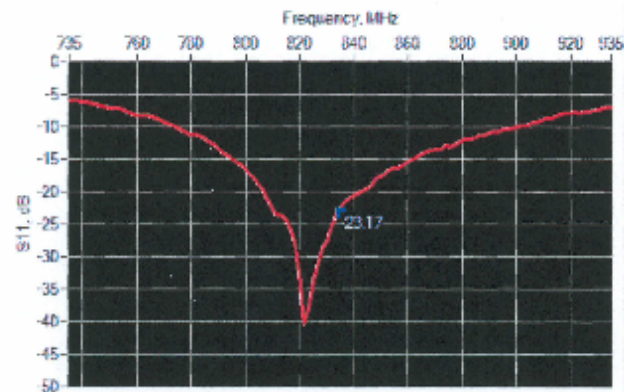


## SAR REFERENCE DIPOLE CALIBRATION REPORT

R&amp;E ACR.240.1.14.SATULA

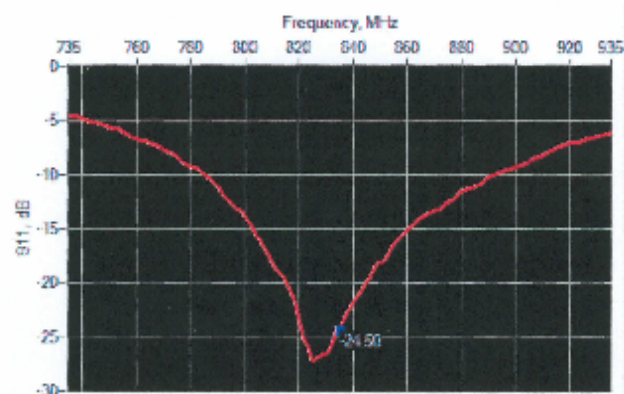
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 835             | -23.17           | -20              | $57.4 \Omega - 0.2 j\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 835             | -24.50           | -20              | $55.0 \Omega + 3.9 j\Omega$ |

#### 6.3 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 % |          | 156.7 ±1 % |          | 6.35 ±1 % |          |
| 750           | 176.0 ±1 % |          | 100.0 ±1 % |          | 6.35 ±1 % |          |
| 835           | 161.0 ±1 % | PASS     | 89.8 ±1 %  | PASS     | 3.6 ±1 %  | PASS     |

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|      |            |  |           |  |          |  |
|------|------------|--|-----------|--|----------|--|
| 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 % |  |

## 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 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) 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 %                     |          |

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|      |           |  |           |  |
|------|-----------|--|-----------|--|
| 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 % |  |

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

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.

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPEN SAR V4                                             |
| Phantom                                   | SN 20/09 SAM71                                          |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Head Liquid Values: $\epsilon_r$ : 42.3 $\sigma$ : 0.92 |
| Distance between dipole center and liquid | 15.0 mm                                                 |
| Area scan resolution                      | $dx=8mm/dy=8mm$                                         |
| Zoon Scan Resolution                      | $dx=8mm/dy=8mm/dz=5mm$                                  |
| Frequency                                 | 835 MHz                                                 |
| Input power                               | 20 dBm                                                  |
| Liquid Temperature                        | 21 °C                                                   |
| Lab Temperature                           | 21 °C                                                   |
| Lab Humidity                              | 45 %                                                    |

| Frequency<br>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             | 9.72 (0.98) | 6.22              | 6.30 (0.63) |
| 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              |             |

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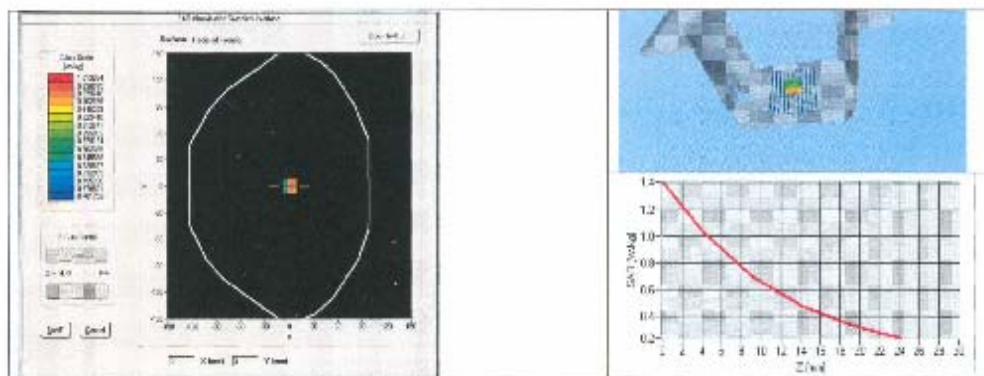
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|      |      |  |      |
|------|------|--|------|
| 2450 | 52.4 |  | 24   |
| 2600 | 55.3 |  | 24.6 |
| 3000 | 63.8 |  | 25.7 |
| 3500 | 67.1 |  | 25   |



## 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                         |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                         |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                         |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                         |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                         | PASS     | 0.97 $\pm$ 5 %                | PASS     |
| 900              | 55.0 $\pm$ 5 %                         |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                         |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                         |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                         |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                         |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                         |          | 1.95 $\pm$ 5 %                |          |
| 2600             | 52.5 $\pm$ 5 %                         |          | 2.16 $\pm$ 5 %                |          |
| 3000             | 52.0 $\pm$ 5 %                         |          | 2.73 $\pm$ 5 %                |          |
| 3500             | 51.3 $\pm$ 5 %                         |          | 3.31 $\pm$ 5 %                |          |
| 5200             | 49.0 $\pm$ 10 %                        |          | 5.30 $\pm$ 10 %               |          |
| 5300             | 48.9 $\pm$ 10 %                        |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                        |          | 5.53 $\pm$ 10 %               |          |

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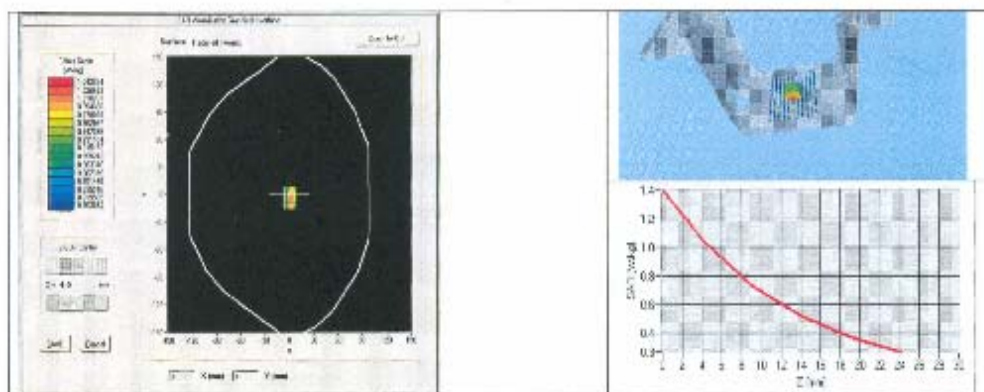
Ref: ACR 340 1 14 SATULA

|      |            |  |            |  |
|------|------------|--|------------|--|
| 5500 | 48.5 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 6.00 ±10 % |  |

## 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                           |
|-------------------------------------------|-----------------------------------------------------------|
| Software                                  | OPENSAR V4                                                |
| Phantom                                   | SN 20:09 SAM71                                            |
| Probe                                     | SN 18:11 EPG122                                           |
| Liquid                                    | Body Liquid Values: $\epsilon_{ps}^1$ : 54.1 sigma : 0.97 |
| 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 %                                                      |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 835              | 10.31 (1.03)     | 6.74 (0.67)       |



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Ref: ACR 340.1.14 SATUJA

## 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    | 10/2013                                       | 10/2014                                       |
| 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      | 11-861-9           | 8/2012                                        | 8/2015                                        |

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**SID1800 Dipole Calibration Certificate****SAR Reference Dipole Calibration Report**

Ref : ACR.240.3.14.SATU.A

**CCIC SOUTHERN ELECTRONIC PRODUCT  
TESTING (SHENZHEN) CO., LTD**  
ELECTRONIC TESTING BUILDING, SHAHE ROAD, XILI  
TOWN  
SHENZHEN, P.R. CHINA (POST CODE:518055)  
**SATIMO COMOSAR REFERENCE DIPOLE**  
FREQUENCY: 1800 MHZ  
SERIAL NO.: SN 09/13 DIP1G800-216

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



08/28/14

*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.240.3.14.SATU.A

|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>                                                                    |
|----------------------|---------------|-----------------|-------------|-------------------------------------------------------------------------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 8/29/2014   |  |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 8/29/2014   |  |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 8/29/2014   |  |

|                       | <i>Customer Name</i>                                                        |
|-----------------------|-----------------------------------------------------------------------------|
| <i>Distribution :</i> | CCIC SOUTHERN<br>ELECTRONIC<br>PRODUCT<br>TESTING<br>(SHENZHEN) Co.,<br>Ltd |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 8/29/2014   | 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 1800 MHz REFERENCE DIPOLE |
| Manufacturer                   | Satimo                            |
| Model                          | SID1800                           |
| Serial Number                  | SN 09/13 DIP1G800-216             |
| 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.

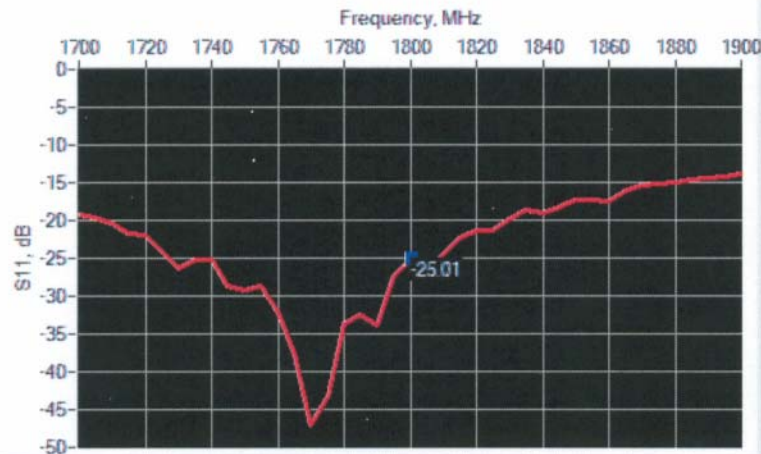
| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 20.3 %               |
| 10 g        | 20.1 %               |

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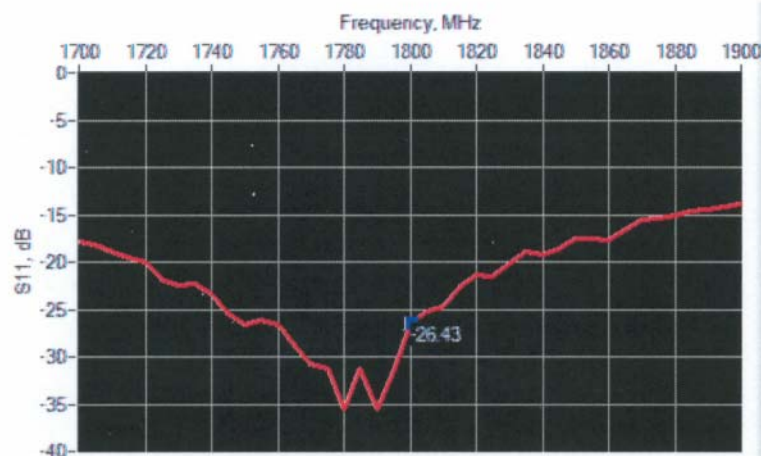
## 6 CALIBRATION MEASUREMENT RESULTS

### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 1800            | -25.01           | -20              | $46.7 \Omega + 4.5 j\Omega$ |

### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 1800            | -26.43           | -20              | $45.8 \Omega + 1.3 j\Omega$ |

### 6.3 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           | $161.0 \pm 1 \%$ |          | $89.8 \pm 1 \%$  |          | $3.6 \pm 1 \%$  |          |



## SAR REFERENCE DIPOLE CALIBRATION REPORT

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|      |             |      |            |      |           |      |
|------|-------------|------|------------|------|-----------|------|
| 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 %.  | PASS | 41.7 ±1 %. | PASS | 3.6 ±1 %. | PASS |
| 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 %. |      |

## 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 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) 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 %                     |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.240.3.14.SATU.A

|      |           |  |           |  |
|------|-----------|--|-----------|--|
| 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 % |  |

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

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.

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPENSAR V4                                              |
| Phantom                                   | SN 20/09 SAM71                                          |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Head Liquid Values: $\epsilon_p$ : 41.3 $\sigma$ : 1.38 |
| 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                                 | 1800 MHz                                                |
| Input power                               | 20 dBm                                                  |
| Liquid Temperature                        | 21 °C                                                   |
| Lab Temperature                           | 21 °C                                                   |
| Lab Humidity                              | 45 %                                                    |

| Frequency<br>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             | 38.67 (3.87) | 20.1              | 20.30 (2.03) |
| 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              |              |

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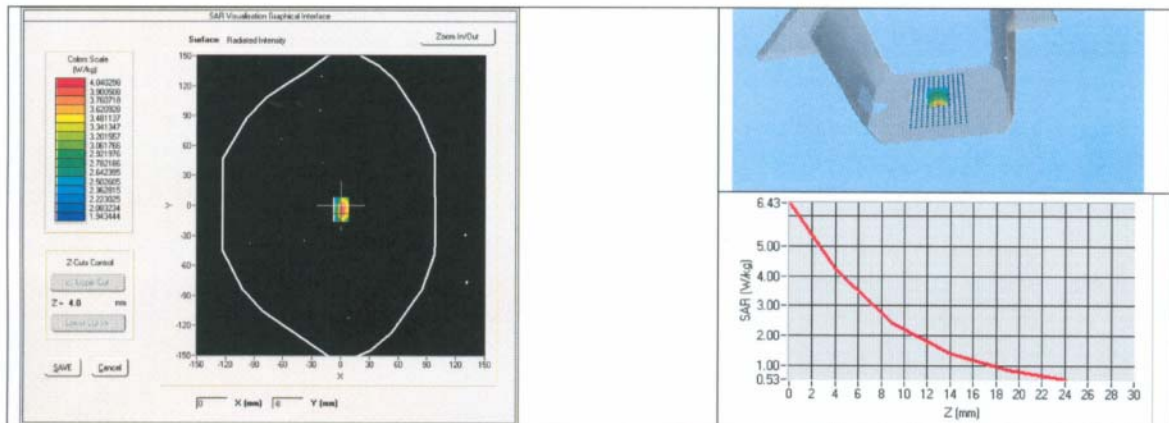
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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.240.3.14.SATU.A

|      |      |  |      |  |
|------|------|--|------|--|
| 2450 | 52.4 |  | 24   |  |
| 2600 | 55.3 |  | 24.6 |  |
| 3000 | 63.8 |  | 25.7 |  |
| 3500 | 67.1 |  | 25   |  |



## 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|-----------------------------------------|----------|-------------------------------|----------|
|                  | required                                | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                          |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                          |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                          |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                          |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                          |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                          |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                          |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                          |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                          |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                          | PASS     | 1.52 $\pm$ 5 %                | PASS     |
| 1900             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                          |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                          |          | 1.95 $\pm$ 5 %                |          |
| 2600             | 52.5 $\pm$ 5 %                          |          | 2.16 $\pm$ 5 %                |          |
| 3000             | 52.0 $\pm$ 5 %                          |          | 2.73 $\pm$ 5 %                |          |
| 3500             | 51.3 $\pm$ 5 %                          |          | 3.31 $\pm$ 5 %                |          |
| 5200             | 49.0 $\pm$ 10 %                         |          | 5.30 $\pm$ 10 %               |          |
| 5300             | 48.9 $\pm$ 10 %                         |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                         |          | 5.53 $\pm$ 10 %               |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

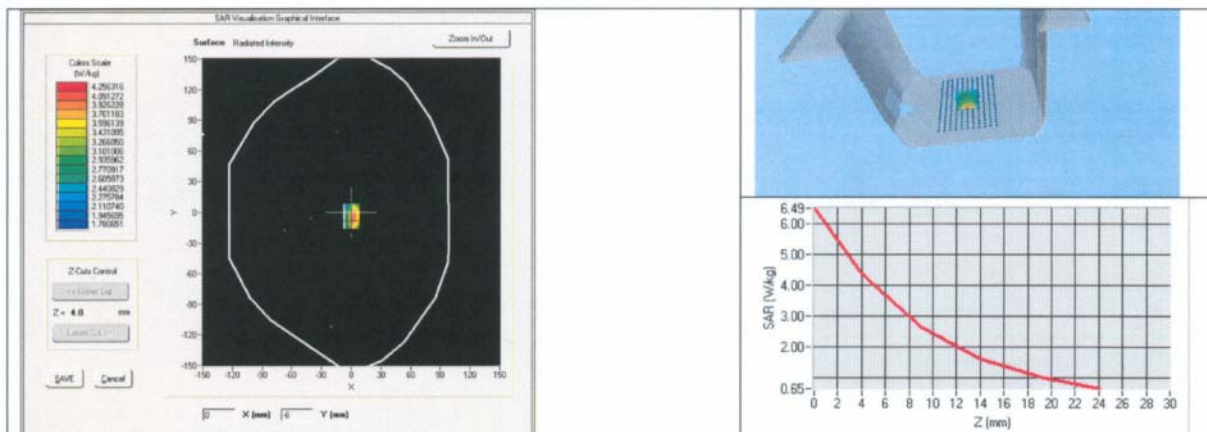
Ref: ACR.240.3.14.SATU.A

|      |            |  |            |  |
|------|------------|--|------------|--|
| 5500 | 48.6 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 6.00 ±10 % |  |

## 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPENSAR V4                                              |
| Phantom                                   | SN 20/09 SAM71                                          |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Body Liquid Values: $\epsilon_p$ : 53.3 $\sigma$ : 1.51 |
| 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                                 | 1800 MHz                                                |
| Input power                               | 20 dBm                                                  |
| Liquid Temperature                        | 21 °C                                                   |
| Lab Temperature                           | 21 °C                                                   |
| Lab Humidity                              | 45 %                                                    |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 1800             | 40.07 (4.01)     | 21.27 (2.13)      |



## 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    | 10/2013                                       | 10/2014                                       |
| 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                                        |

**SID1900 Dipole Calibration Certificate****SAR Reference Dipole Calibration Report**

Ref : ACR.240.4.14.SATU.A

**CCIC SOUTHERN ELECTRONIC PRODUCT  
TESTING (SHENZHEN) CO., LTD**  
ELECTRONIC TESTING BUILDING, SHAHE ROAD, XILI  
TOWN  
SHENZHEN, P.R. CHINA (POST CODE:518055)  
**SATIMO COMOSAR REFERENCE DIPOLE**  
FREQUENCY: 1900 MHZ  
SERIAL NO.: SN 09/13 DIP1G900-218

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



08/28/14

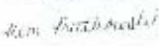
*Summary:*

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.240.4.14.SATU.A

|               | Name          | Function        | Date      | Signature                                                                           |
|---------------|---------------|-----------------|-----------|-------------------------------------------------------------------------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 8/29/2014 |  |
| Checked by :  | Jérôme LUC    | Product Manager | 8/29/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 8/29/2014 |  |

|                | Customer Name                                                               |
|----------------|-----------------------------------------------------------------------------|
| Distribution : | CCIC SOUTHERN<br>ELECTRONIC<br>PRODUCT<br>TESTING<br>(SHENZHEN) Co.,<br>Ltd |

| Issue | Date      | Modifications   |
|-------|-----------|-----------------|
| A     | 8/29/2014 | 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 1900 MHz REFERENCE DIPOLE |
| Manufacturer                   | Satimo                            |
| Model                          | SID1900                           |
| Serial Number                  | SN 09/13 DIP1G900-218             |
| 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 %               |

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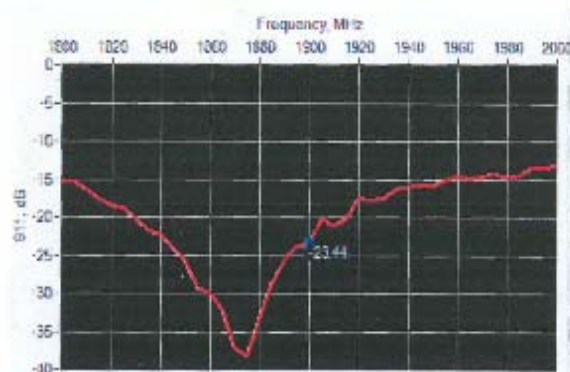


## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR200.614.SAT...A

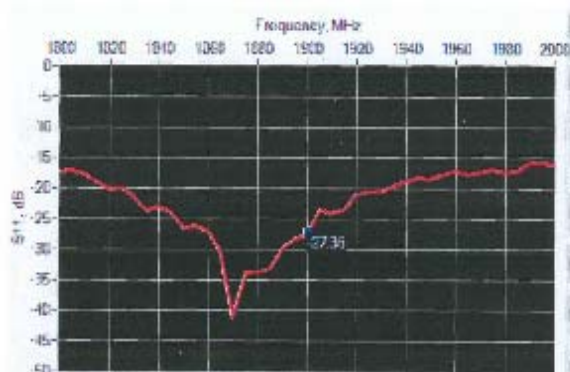
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 1900            | -23.44           | -20              | $55.4 \Omega + 5.2 j\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 1900            | -27.36           | -20              | $51.7 \Omega + 4.4 j\Omega$ |

#### 6.3 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           | $250.0 \pm 1 \%$ |          | $166.7 \pm 1 \%$ |          | $6.35 \pm 1 \%$ |          |
| 750           | $176.0 \pm 1 \%$ |          | $100.0 \pm 1 \%$ |          | $6.35 \pm 1 \%$ |          |
| 835           | $161.0 \pm 1 \%$ |          | $89.8 \pm 1 \%$  |          | $3.5 \pm 1 \%$  |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR2003.15 SATU.A

|      |            |      |           |      |          |      |
|------|------------|------|-----------|------|----------|------|
| 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 %  | PASS | 39.5 ±1 % | PASS | 3.6 ±1 % | PASS |
| 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 % |      |

## 7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEM/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 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) 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 %                              |          | 1.70 ±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 %                     |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR2016-14 SATU.A

|      |           |           |
|------|-----------|-----------|
| 2100 | 59.8 ±5 % | 1.49 ±5 % |
| 2300 | 59.5 ±5 % | 1.67 ±5 % |
| 2450 | 59.2 ±5 % | 1.80 ±5 % |
| 2600 | 59.0 ±5 % | 1.96 ±5 % |
| 3000 | 58.5 ±5 % | 2.40 ±5 % |
| 3500 | 57.9 ±5 % | 2.81 ±5 % |

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CENELEC 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.

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPENSAR V4                                              |
| Phantom                                   | SN 2009 SAM71                                           |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Head Liquid Values: $\epsilon_{ps}$ : 41.1 sigma : 1.42 |
| Distance between dipole center and liquid | 13.0 mm                                                 |
| Area scan resolution                      | $dx=8mm/dy=8mm$                                         |
| Zoon Scan Resolution                      | $dx=8mm/dy=8mm/dz=5mm$                                  |
| Frequency                                 | 1900 MHz                                                |
| Input power                               | 20 dBm                                                  |
| Liquid Temperature                        | 21 °C                                                   |
| Lab Temperature                           | 21 °C                                                   |
| Lab Humidity                              | 45 %                                                    |

| Frequency<br>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             |              | 3.26              |              |
| 750              | 8.49             |              | 5.55              |              |
| 835              | 9.56             |              | 5.22              |              |
| 900              | 10.9             |              | 5.99              |              |
| 1450             | 29               |              | 16                |              |
| 1500             | 30.5             |              | 16.8              |              |
| 1640             | 34.2             |              | 18.4              |              |
| 1750             | 36.4             |              | 19.2              |              |
| 1800             | 38.4             |              | 20.1              |              |
| 1900             | 39.7             | 40.87 (4.04) | 20.5              | 20.62 (2.06) |
| 1950             | 40.5             |              | 20.9              |              |
| 2000             | 41.1             |              | 21.1              |              |
| 2100             | 43.6             |              | 21.9              |              |
| 2300             | 48.7             |              | 23.3              |              |

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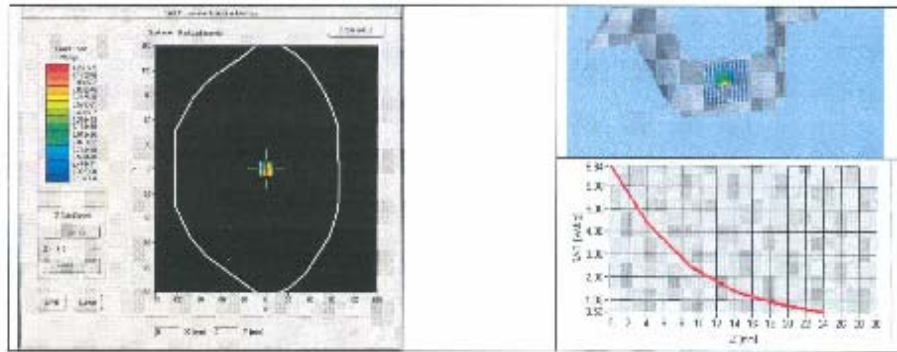
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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR240.1.14 SATULA

|      |      |  |      |  |
|------|------|--|------|--|
| 2450 | 52.4 |  | 24   |  |
| 2600 | 55.3 |  | 24.6 |  |
| 3000 | 63.8 |  | 25.7 |  |
| 3500 | 67.1 |  | 25   |  |



## 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                         |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                         |          | 0.93 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                         |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                         |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                         |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                         |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                         |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                         |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                         |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                         | PASS     | 1.52 $\pm$ 5 %                | PASS     |
| 2000             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                         |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                         |          | 1.95 $\pm$ 5 %                |          |
| 2600             | 52.5 $\pm$ 5 %                         |          | 2.16 $\pm$ 5 %                |          |
| 3000             | 52.0 $\pm$ 5 %                         |          | 2.73 $\pm$ 5 %                |          |
| 3500             | 51.3 $\pm$ 5 %                         |          | 3.31 $\pm$ 5 %                |          |
| 5200             | 49.0 $\pm$ 10 %                        |          | 5.30 $\pm$ 10 %               |          |
| 5300             | 48.9 $\pm$ 10 %                        |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                        |          | 5.53 $\pm$ 10 %               |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

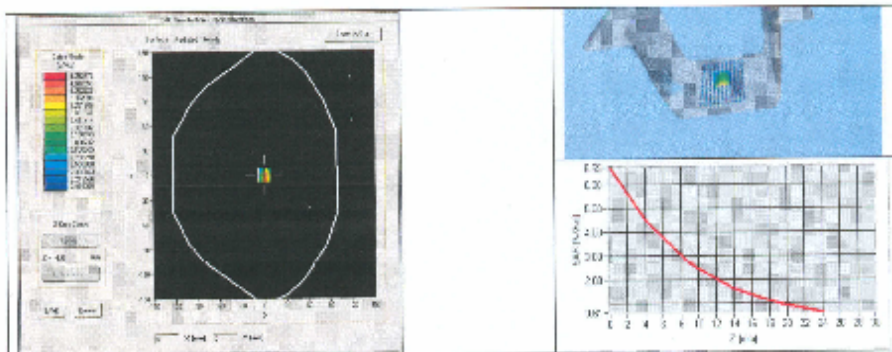
Ref: ACR 160-4-14-SATUJA

|      |            |  |            |  |
|------|------------|--|------------|--|
| 5500 | 48.6 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 5.80 ±10 % |  |

## 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                              |
|-------------------------------------------|----------------------------------------------|
| Software                                  | OPENSAR V4                                   |
| Phantom                                   | SN 20/09 SAM71                               |
| Probe                                     | SN 18/11 EPG122                              |
| Liquid                                    | Body Liquid Values: eps' : 54.2 sigma : 1.54 |
| Distance between dipole center and liquid | 10.0 mm                                      |
| Area scan resolution                      | dx=8mm/dy=8mm                                |
| Zona Scan Resolution                      | dx=8mm/dy=8mm/dz=5mm                         |
| Frequency                                 | 1900 MHz                                     |
| Input power                               | 20 dHm                                       |
| Liquid Temperature                        | 21 °C                                        |
| Lab Temperature                           | 21 °C                                        |
| Lab Humidity                              | 45 %                                         |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 1900             | 40.81 [4.08]     | 21.21 [2.12]      |



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## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR249.4.14.SATIMA

## 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.                   |
| CCOMOSAR Test Bench             | Version 3            | NA                 | Validated. No cal required.                   | Validated. No cal required.                   |
| Network Analyzer                | Rhode & Schwarz ZVA  | SN100132           | 02/2013                                       | 02/2016                                       |
| Calipers                        | Camera               | CALIPER-01         | 12/2013                                       | 12/2016                                       |
| Reference Probe                 | Satimo               | EPG122 SN 18/11    | 10/2013                                       | 10/2014                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 12/2013                                       | 12/2016                                       |
| Signal Generator                | Agilent E4438C       | MY48070581         | 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-E28A          | US37181480         | 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                                        |

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**SID2450 Dipole Calibration Certificate****SAR Reference Dipole Calibration Report**

Ref : ACR.240.6.14.SATU.A

**CCIC SOUTHERN ELECTRONIC PRODUCT  
TESTING (SHENZHEN) CO., LTD**  
ELECTRONIC TESTING BUILDING, SHAHE ROAD, XILI  
TOWN

SHENZHEN, P.R. CHINA (POST CODE:518055)

**SATIMO COMOSAR REFERENCE DIPOLE****FREQUENCY: 2450 MHZ****SERIAL NO.: SN 09/13 DIP2G450-220**

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

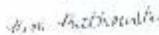
**08/28/14***Summary:*

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 240 e 14 SATJJA

|               | Name          | Function        | Date      | Signature                                                                           |
|---------------|---------------|-----------------|-----------|-------------------------------------------------------------------------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 8/29/2014 |  |
| Checked by :  | Jérôme LUC    | Product Manager | 8/29/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 8/29/2014 |  |

|                | Customer Name                                                               |
|----------------|-----------------------------------------------------------------------------|
| Distribution : | CCIC SOUTHERN<br>ELECTRONIC<br>PRODUCT<br>TESTING<br>(SHENZHEN) Co.,<br>Ltd |

| Issue | Date      | Modifications   |
|-------|-----------|-----------------|
| A     | 8/29/2014 | 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 2450 MHz REFERENCE DIPOLE |
| Manufacturer                   | Satimo                            |
| Model                          | SID2450                           |
| Serial Number                  | SN 09/13 DIP2G450-220             |
| 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

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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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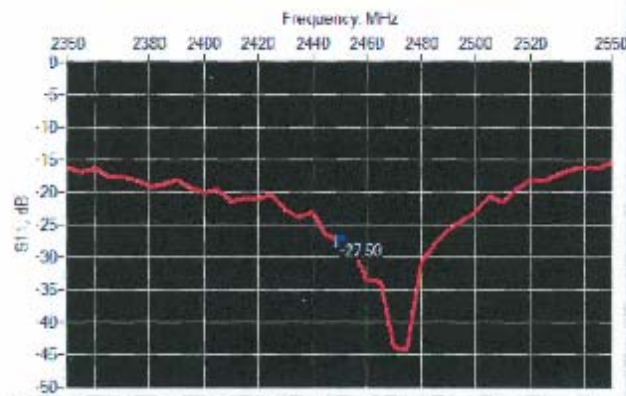


## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR 246.6.14.SATU.A

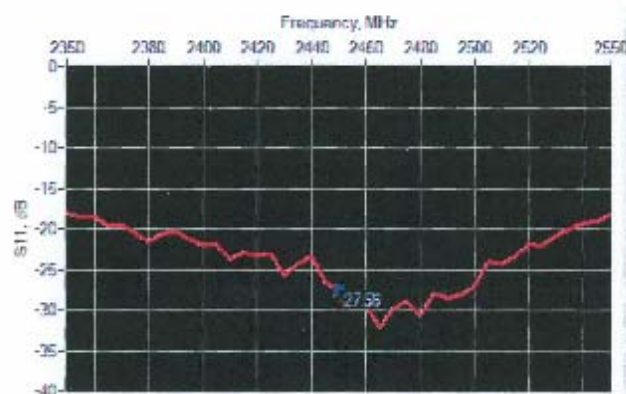
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 2450            | -27.50           | -20              | $51.7 \Omega + 3.8 j\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 2450            | -27.56           | -20              | $54.3 \Omega + 0.9 j\Omega$ |

#### 6.3 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           | $161.0 \pm 1 \%$ |          | $89.8 \pm 1 \%$  |          | $3.6 \pm 1 \%$  |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.240.6.14.SATU.A

|      |            |      |           |      |          |      |
|------|------------|------|-----------|------|----------|------|
| 900  | 149.0 ±1 % |      | 83.3 ±1 % |      | 3.6 ±1 % |      |
| 1450 | 88.1 ±1 %  |      | 51.7 ±1 % |      | 3.6 ±1 % |      |
| 1500 | 80.5 ±1 %  |      | 50.0 ±1 % |      | 3.6 ±1 % |      |
| 1640 | 75.0 ±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 %  |      | 32.5 ±1 % |      | 3.6 ±1 % |      |
| 2450 | 51.5 ±1 %  | PASS | 30.4 ±1 % | PASS | 3.6 ±1 % | PASS |
| 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 % |      |

## 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 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) 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 %                     |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR 24C.6.14 SATU.A

|      |           |      |           |      |
|------|-----------|------|-----------|------|
| 2100 | 35.8 ±5 % |      | 1.49 ±5 % |      |
| 2300 | 35.5 ±5 % |      | 1.67 ±5 % |      |
| 2450 | 36.2 ±5 % | PASS | 1.80 ±5 % | PASS |
| 2600 | 35.0 ±5 % |      | 1.96 ±5 % |      |
| 3000 | 38.5 ±5 % |      | 2.40 ±5 % |      |
| 3500 | 37.9 ±5 % |      | 2.91 ±5 % |      |

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

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.

|                                           |                                                                    |
|-------------------------------------------|--------------------------------------------------------------------|
| Software                                  | OPENSAR V4                                                         |
| Phantom                                   | SN 20/09 SAM71                                                     |
| Probe                                     | SN 18/11 EPG122                                                    |
| Liquid                                    | Head Liquid Values: $\epsilon_{\text{eff}} : 39.0$ $\sigma : 1.77$ |
| Distance between dipole center and liquid | 10.0 mm                                                            |
| Area scan resolution                      | $dx=8\text{mm}/dy=8\text{mm}$                                      |
| Zoon Scan Resolution                      | $dx=8\text{mm}/dy=8\text{mm}/dz=5\text{mm}$                        |
| Frequency                                 | 2450 MHz                                                           |
| Input power                               | 20 cBm                                                             |
| 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] |          |
|-----------------|------------------|----------|-------------------|----------|
|                 | 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              |          |

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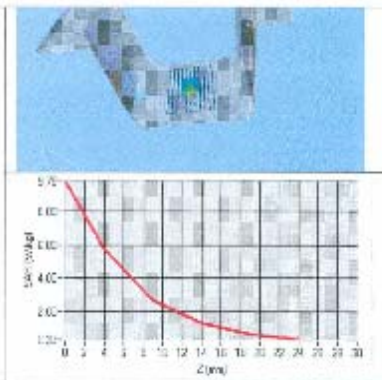
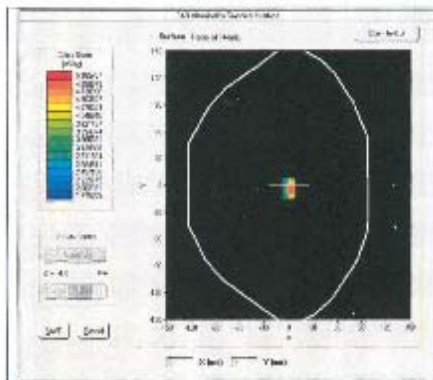
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Ref: ACR.240.6.14.SATU.A

|      |      |              |      |              |
|------|------|--------------|------|--------------|
| 2450 | 52.4 | 53.60 (5.36) | 24   | 23.77 (2.38) |
| 2600 | 55.3 |              | 24.6 |              |
| 3000 | 63.8 |              | 25.7 |              |
| 3500 | 67.1 |              | 25   |              |



## 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                         |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                         |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                         |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                         |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                         |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                         |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                         |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                         |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                         |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                         |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                         | PASS     | 1.95 $\pm$ 5 %                | PASS     |
| 2600             | 52.5 $\pm$ 5 %                         |          | 2.16 $\pm$ 5 %                |          |
| 3000             | 52.0 $\pm$ 5 %                         |          | 2.73 $\pm$ 5 %                |          |
| 3500             | 51.3 $\pm$ 5 %                         |          | 3.31 $\pm$ 5 %                |          |
| 5200             | 49.0 $\pm$ 10 %                        |          | 5.30 $\pm$ 10 %               |          |
| 5300             | 48.9 $\pm$ 10 %                        |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                        |          | 5.53 $\pm$ 10 %               |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

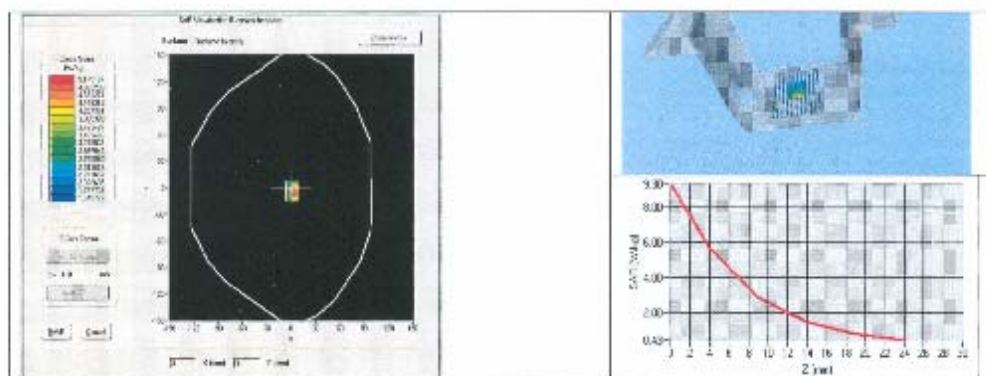
Ref: ACR.240.6.14.SATU.A

|      |            |  |            |  |
|------|------------|--|------------|--|
| 5500 | 48.6 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 6.00 ±10 % |  |

## 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                           |
|-------------------------------------------|-----------------------------------------------------------|
| Software                                  | OPENSAR V4                                                |
| Phantom                                   | SN 20/09 SAM71                                            |
| Probe                                     | SN 18/11 EPG122                                           |
| Liquid                                    | Body Liquid Values: $\epsilon_{ps}^*$ : 53.0 sigma : 1.93 |
| Distance between dipole center and liquid | 10.0 mm                                                   |
| Area scan resolution                      | dx=8mm/dy=8mm                                             |
| Zoom Scan Resolution                      | dx=8mm/dy=8mm/dz=5mm                                      |
| Frequency                                 | 2450 MHz                                                  |
| Input power                               | 20 dBm                                                    |
| Liquid Temperature                        | 21 °C                                                     |
| Lab Temperature                           | 21 °C                                                     |
| Lab Humidity                              | 45 %                                                      |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 2450             | 52.66 (5.27)     | 23.73 (2.37)      |



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## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.240.6.14.SATULA

## 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    | 10/2013                                       | 10/2014                                       |
| 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 ECF-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                                        |

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## SID2600 Dipole Calibration Certificate



### SAR Reference Dipole Calibration Report

Ref : ACR.224.1.14.SATU.A

**CCIC SOUTHERN ELECTRONIC PRODUCT  
TESTING (SHENZHEN) CO., LTD**  
ELECTRONIC TESTING BUILDING, SHAHE ROAD, XILI  
TOWN  
SHENZHEN, P.R. CHINA (POST CODE:518055)  
**SATIMO COMOSAR REFERENCE DIPOLE**  
FREQUENCY: 2600 MHZ  
SERIAL NO.: SN 32/14 DIP2G600-338

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



08/12/14

#### *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.224.1.14.SATU.A

|               | Name          | Function        | Date      | Signature                                                                           |
|---------------|---------------|-----------------|-----------|-------------------------------------------------------------------------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 8/12/2014 |  |
| Checked by :  | Jérôme LUC    | Product Manager | 8/12/2014 |  |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 8/12/2014 |  |

|                | Customer Name                                                               |
|----------------|-----------------------------------------------------------------------------|
| Distribution : | CCIC SOUTHERN<br>ELECTRONIC<br>PRODUCT<br>TESTING<br>(SHENZHEN) Co.,<br>Ltd |

| Issue | Date      | Modifications   |
|-------|-----------|-----------------|
| A     | 8/12/2014 | 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 2600 MHz REFERENCE DIPOLE |
| Manufacturer                   | Satimo                            |
| Model                          | SID2600                           |
| Serial Number                  | SN 32/14 DIP2G600-338             |
| 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



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.224.1.14.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 %               |

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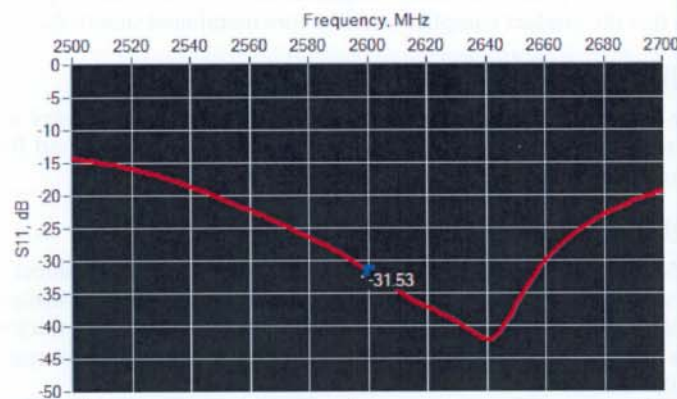


## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.224.1.14.SATU.A

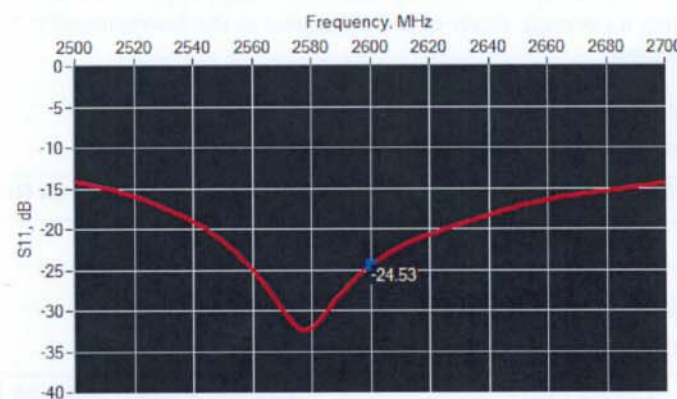
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2600            | -31.53           | -20              | 51.3 $\Omega$ - 2.3 j $\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2600            | -24.53           | -20              | 45.0 $\Omega$ + 3.2 j $\Omega$ |

#### 6.3 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 %  |          |

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.224.1.14.SATU.A

|      |             |      |            |      |           |      |
|------|-------------|------|------------|------|-----------|------|
| 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 %.  | PASS | 28.8 ±1 %. | PASS | 3.6 ±1 %. | PASS |
| 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 %. |      |

## 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 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) 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 %                     |          |

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|      |           |      |           |      |
|------|-----------|------|-----------|------|
| 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 % | PASS | 1.96 ±5 % | PASS |
| 3000 | 38.5 ±5 % |      | 2.40 ±5 % |      |
| 3500 | 37.9 ±5 % |      | 2.91 ±5 % |      |

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

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.

|                                           |                                                      |
|-------------------------------------------|------------------------------------------------------|
| Software                                  | OPENSAR V4                                           |
| Phantom                                   | SN 20/09 SAM71                                       |
| Probe                                     | SN 18/11 EPG122                                      |
| Liquid                                    | Head Liquid Values: $\epsilon_r$ : 39.0 sigma : 1.95 |
| 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                                 | 2600 MHz                                             |
| Input power                               | 20 dBm                                               |
| Liquid Temperature                        | 21 °C                                                |
| Lab Temperature                           | 21 °C                                                |
| Lab Humidity                              | 45 %                                                 |

| Frequency<br>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              |          |

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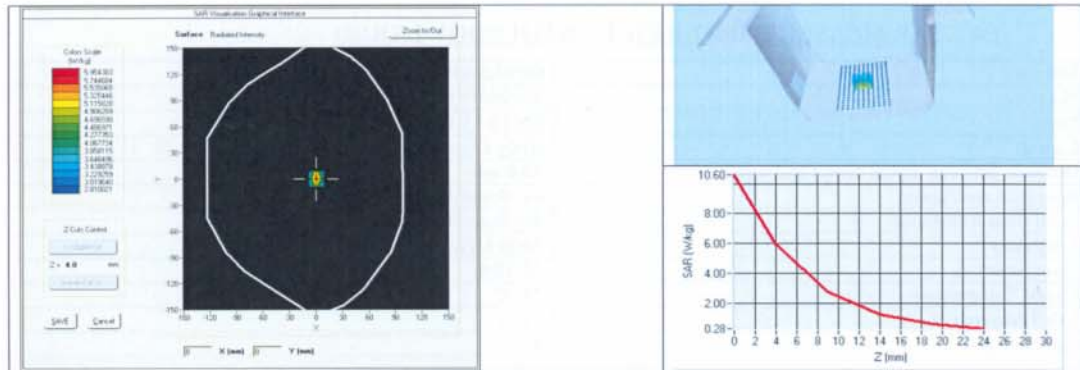
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|      |      |              |      |              |
|------|------|--------------|------|--------------|
| 2450 | 52.4 |              | 24   |              |
| 2600 | 55.3 | 56.19 (5.62) | 24.6 | 24.07 (2.41) |
| 3000 | 63.8 |              | 25.7 |              |
| 3500 | 67.1 |              | 25   |              |



## 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|-----------------------------------------|----------|-------------------------------|----------|
|                  | required                                | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                          |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                          |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                          |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                          |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                          |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                          |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                          |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                          |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                          |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                          |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                          |          | 1.95 $\pm$ 5 %                |          |
| 2600             | 52.5 $\pm$ 5 %                          | PASS     | 2.16 $\pm$ 5 %                | PASS     |
| 3000             | 52.0 $\pm$ 5 %                          |          | 2.73 $\pm$ 5 %                |          |
| 3500             | 51.3 $\pm$ 5 %                          |          | 3.31 $\pm$ 5 %                |          |
| 5200             | 49.0 $\pm$ 10 %                         |          | 5.30 $\pm$ 10 %               |          |
| 5300             | 48.9 $\pm$ 10 %                         |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                         |          | 5.53 $\pm$ 10 %               |          |

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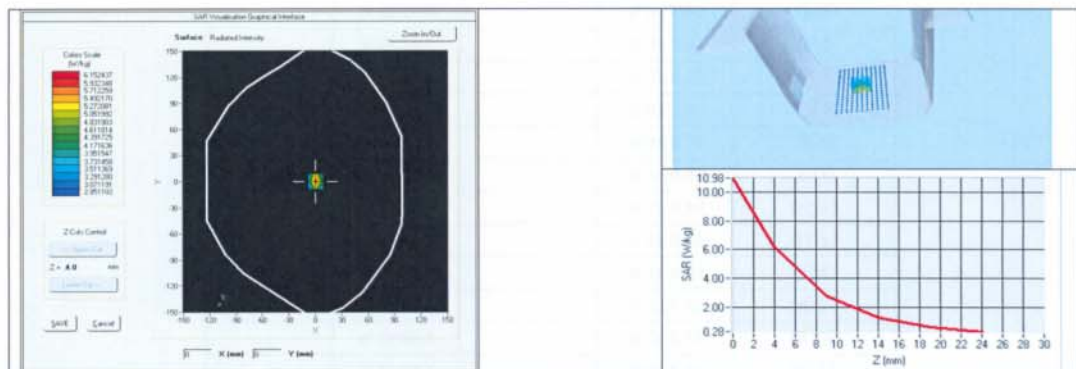
Ref: ACR.224.1.14.SATU.A

|      |            |  |            |  |
|------|------------|--|------------|--|
| 5500 | 48.6 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 6.00 ±10 % |  |

## 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                        |
|-------------------------------------------|--------------------------------------------------------|
| Software                                  | OPENSAR V4                                             |
| Phantom                                   | SN 20/09 SAM71                                         |
| Probe                                     | SN 18/11 EPG122                                        |
| Liquid                                    | Body Liquid Values: $\epsilon_p^*$ : 52.4 sigma : 2.22 |
| Distance between dipole center and liquid | 10.0 mm                                                |
| Area scan resolution                      | dx=8mm/dy=8mm                                          |
| Zoon Scan Resolution                      | dx=8mm/dy=8mm/dz=5mm                                   |
| Frequency                                 | 2600 MHz                                               |
| Input power                               | 20 dBm                                                 |
| Liquid Temperature                        | 21 °C                                                  |
| Lab Temperature                           | 21 °C                                                  |
| Lab Humidity                              | 45 %                                                   |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 2600             | 57.55 (5.76)     | 24.86 (2.49)      |



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## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.224.1.14.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                                        |

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### <Justification of the extended calibration>

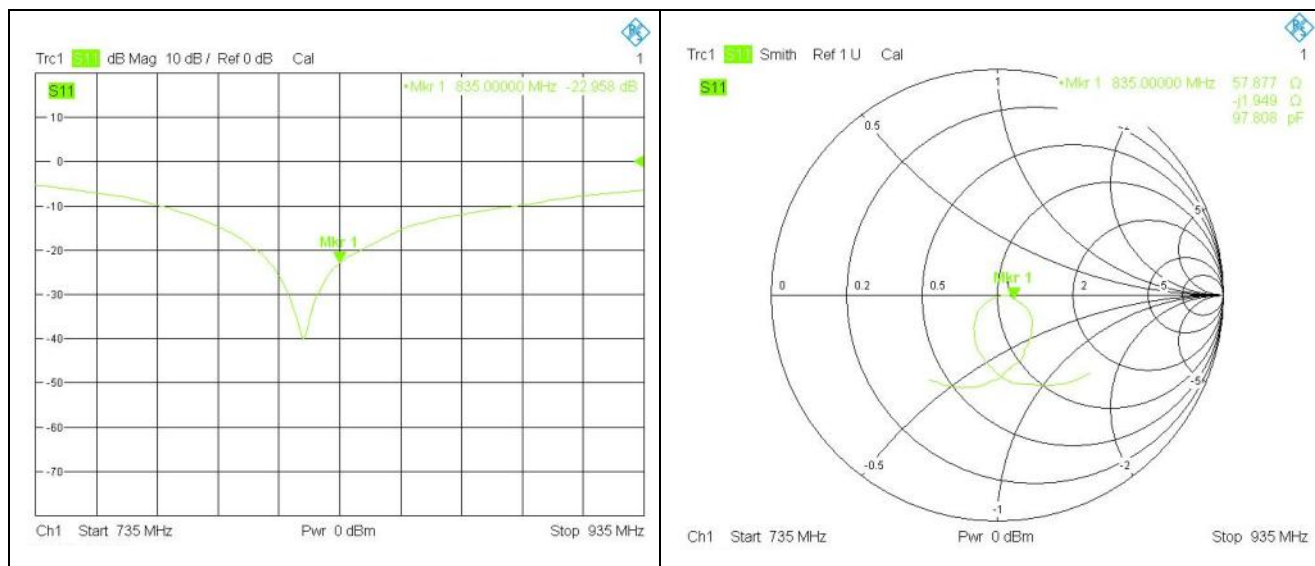
Referring to KDB 865664 D01v01r04, if dipoles are verified in return loss(<-20dB, within 20% of prior calibration),and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

| Head 835MHz         |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -23.17           | -         | 57.40     | -          |
| 2015.08.26          | -22.96           | 4.95      | 57.88     | 0.48       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Head 835MHz

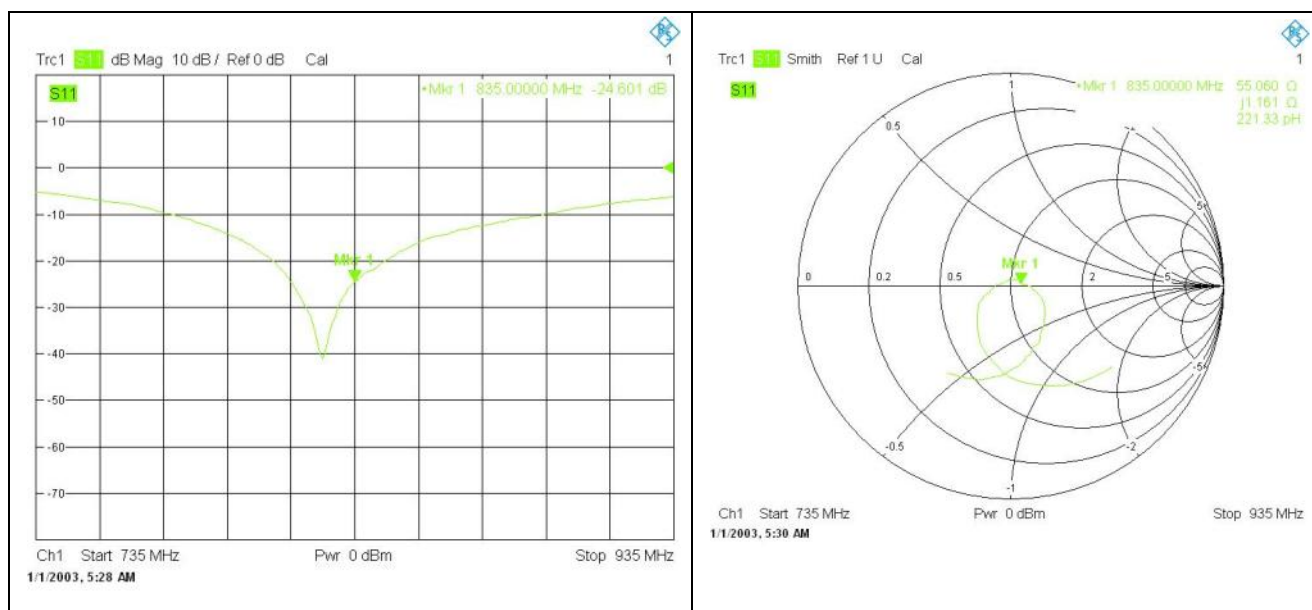


| Body 835MHz         |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -24.50           | -         | 55.00     | -          |
| 2015.08.26          | -24.60           | -2.28     | 55.06     | 0.06       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

#### <Dipole Verification Data>

#### Body 835MHz

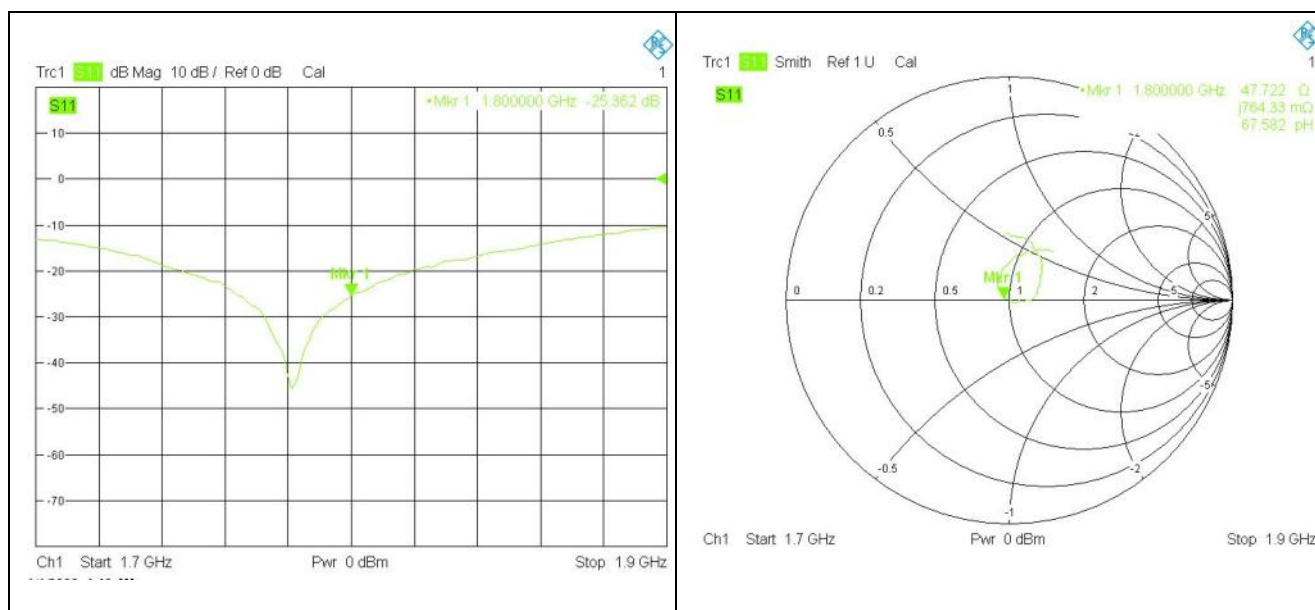


| Head 1800MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -25.01           | -         | 46.70     | -          |
| 2015.08.26          | -25.36           | -7.74     | 47.72     | 1.02       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Head 1800MHz

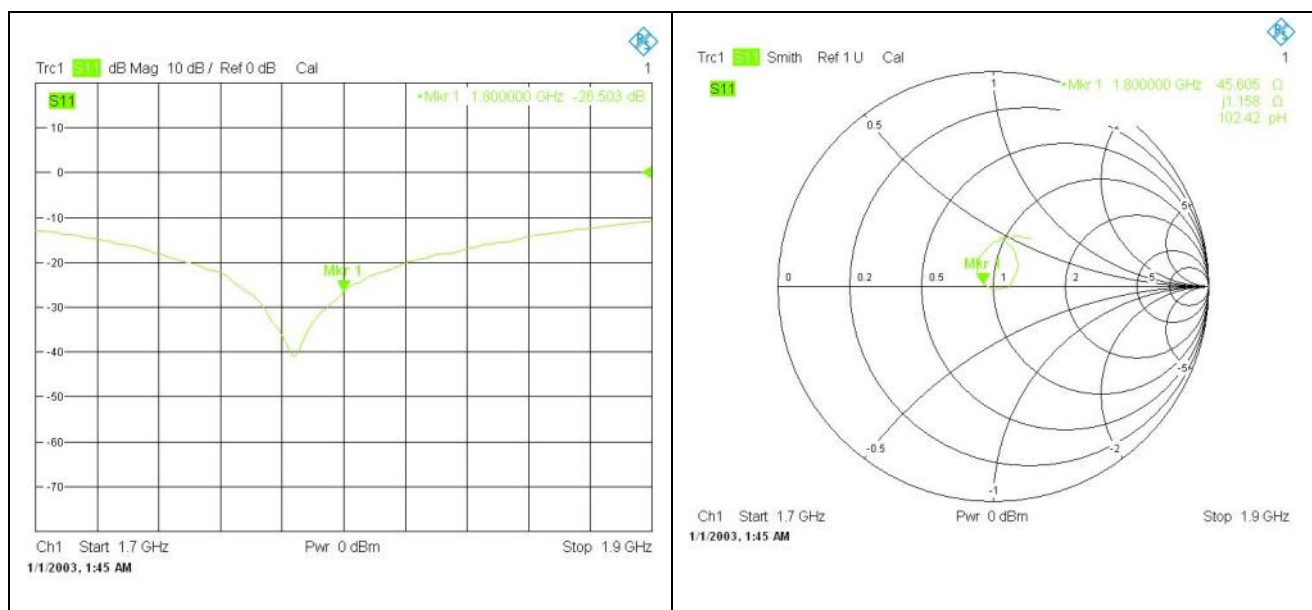


| Body 1800MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -26.43           | -         | 45.80     | -          |
| 2015.08.26          | -26.50           | -1.60     | 45.60     | -0.2       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

#### <Dipole Verification Data>

#### Body 1800MHz

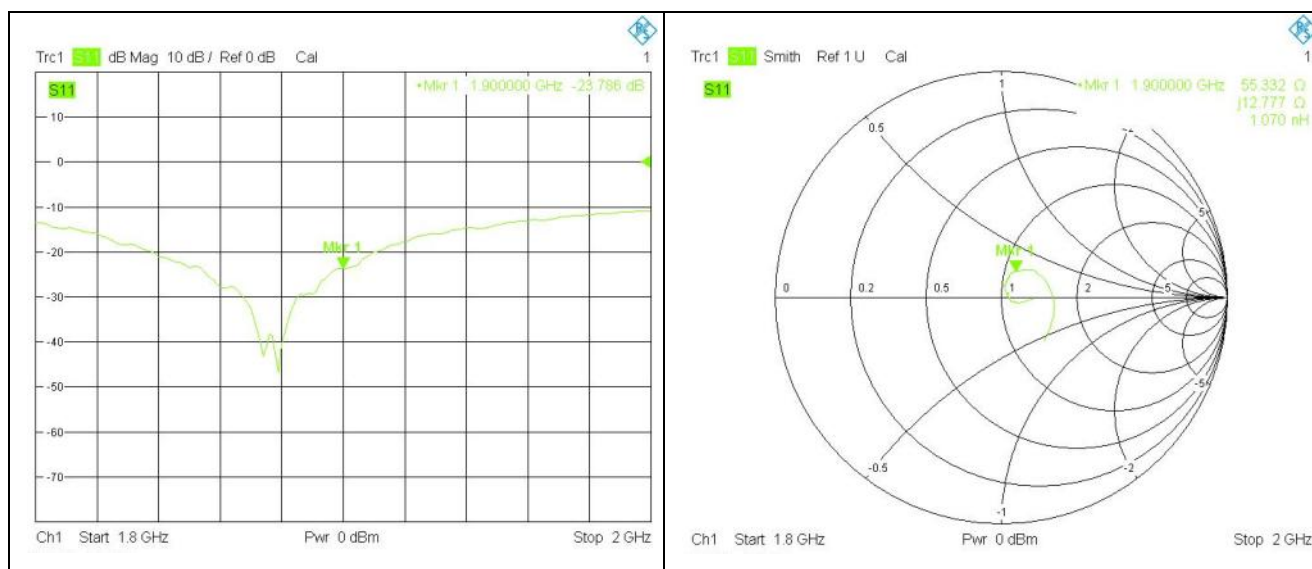


| Head 1900MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -23.44           | -         | 55.40     | -          |
| 2015.08.26          | -23.79           | -7.74     | 55.33     | -0.07      |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Head 1900MHz

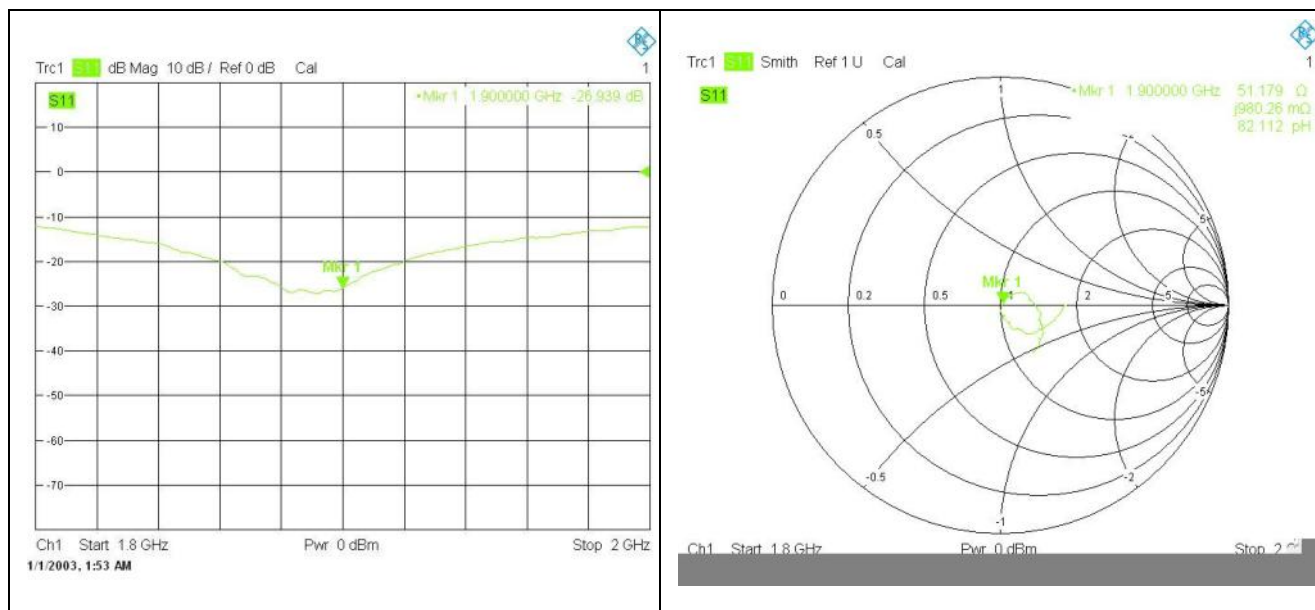


| Body 1900MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -27.36           | -         | 51.70     | -          |
| 2015.08.26          | -26.94           | 10.15     | 51.18     | -0.52      |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Body 1900MHz

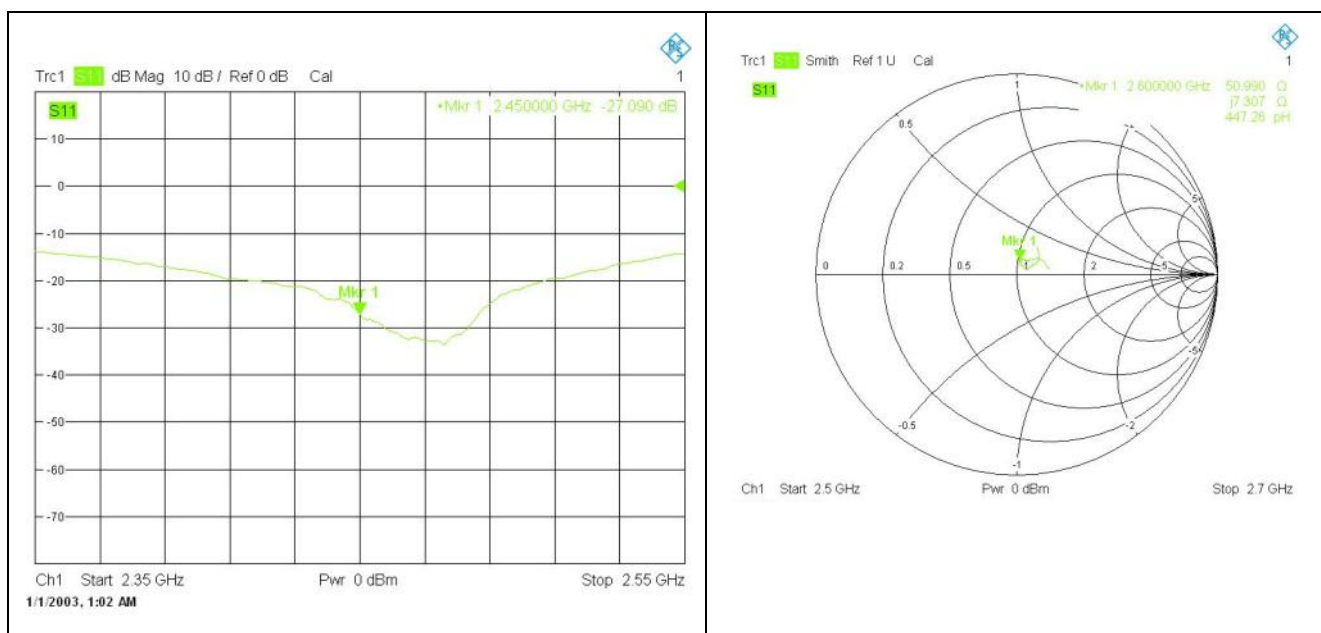


| Head 2450MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -27.50           | -         | 51.70     | -          |
| 2015.08.26          | -27.09           | 9.90      | 50.99     | -0.71      |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Head 2450MHz

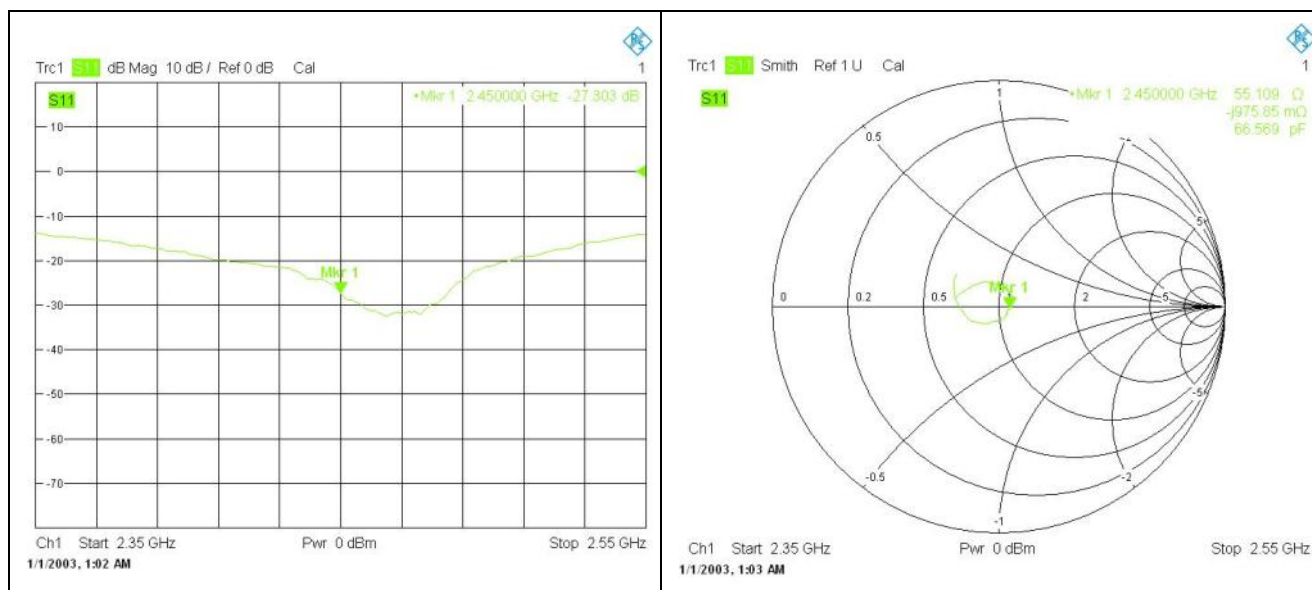


| Body 2450MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -27.56           | -         | 54.30     | -          |
| 2015.08.26          | -27.30           | 6.17      | 55.11     | 0.81       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Body 2450MHz

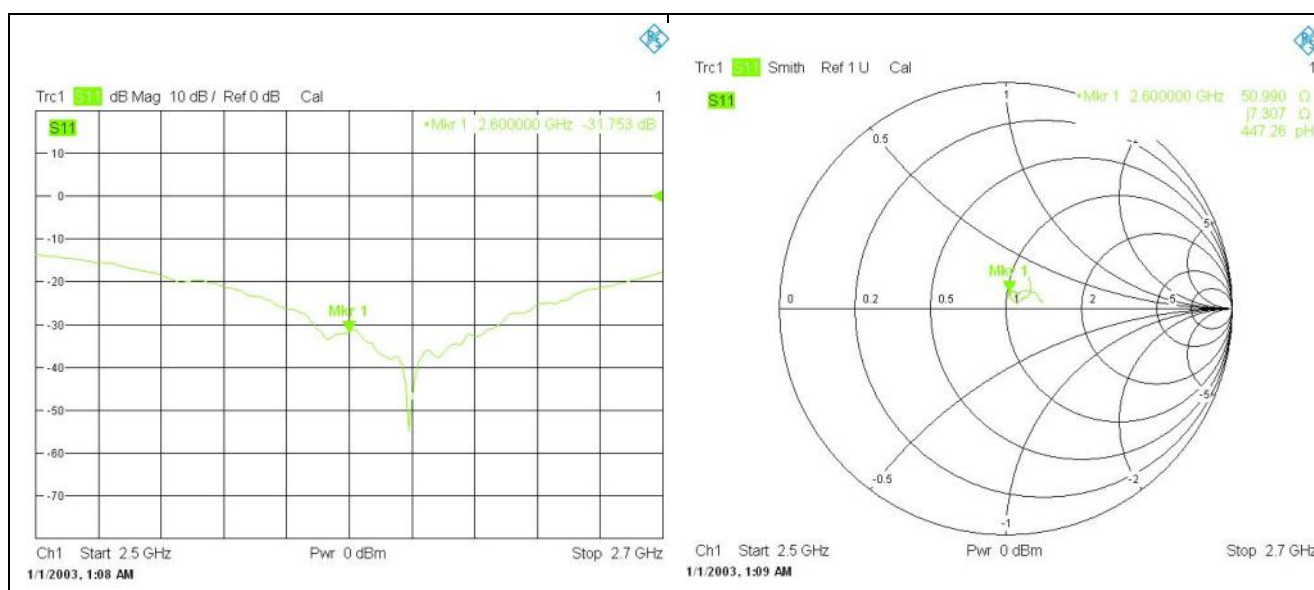


| Head 2600MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -31.53           | -         | 51.30     | -          |
| 2015.08.26          | -31.75           | -4.94     | 50.99     | -0.31      |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Head 2600MHz

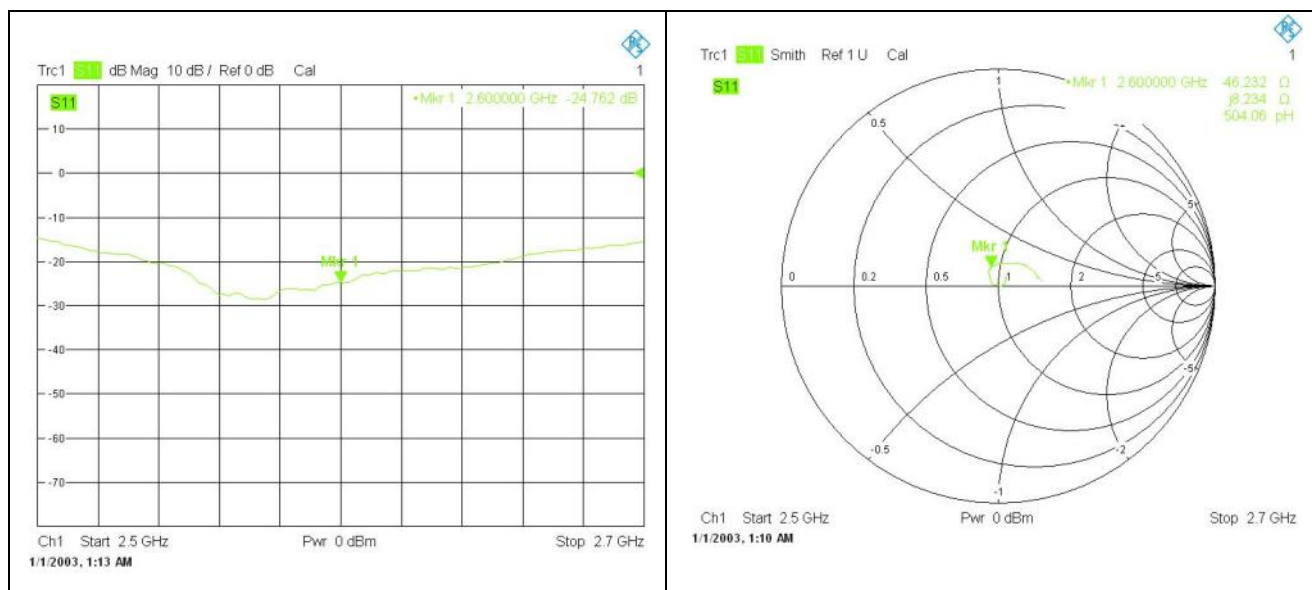


| Body 2600MHz        |                  |           |           |            |
|---------------------|------------------|-----------|-----------|------------|
| Date of Measurement | Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) |
| 2014.08.28          | -24.53           | -         | 45.00     | -          |
| 2015.08.26          | -24.76           | -5.16     | 46.23     | 1.23       |

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

### <Dipole Verification Data>

#### Body 2600MHz



————End of the Report————