## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---|---|---|---|---|
| **Equipment Description** | **Manufacturer / Model** | **Identification No.** | **Current Calibration Date** | **Next Calibration Date** |
| SAM Phantom | MVG | SN-13/09-SAM68 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rohde & Schwarz ZVM | 100203 | 05/2019 | 05/2022 |
| Network Analyzer – Calibration kit | Rohde & Schwarz ZV-Z235 | 101223 | 05/2019 | 05/2022 |
| Calipers | Mitutoyo | SN 0009732 | 10/2019 | 10/2022 |
| Reference Probe | MVG | EPGO333 SN 41/18 | 05/2020 | 05/2021 |
| Multimeter | Keithley 2000 | 1160271 | 02/2020 | 02/2023 |
| Signal Generator | Rohde & Schwarz SMB | 106589 | 04/2019 | 04/2022 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | NI-USB 5680 | 170100013 | 05/2019 | 05/2022 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature / Humidity Sensor | Testo 184 H1 | 44220687 | 05/2020 | 05/2023 |



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# SAR Reference Dipole Calibration Report

Ref : ACR.60.8.21.MVGB.A

**SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD.**

**BUILDING E, FENDA SCIENCE PARK, SANWEI COMMUNITY, XIXIANG STREET,**

**BAO'AN DISTRICT, SHENZHEN GUANGDONG, CHINA**

**MVG COMOSAR REFERENCE DIPOLE**

**FREQUENCY: 2450 MHZ**

**SERIAL NO.: SN 03/15 DIP2G450-352**

**Calibrated at MVG**

**Z.I. de la pointe du diable**

**Technopôle Brest Iroise – 295 avenue Alexis de Rochon**

**29280 PLOUZANE - FRANCE**

**Calibration date: 03/01/2021**

Accreditations #2-6789 and #2-6814
Scope available on www.cofrac.fr

*Summary:*

This document presents the method and results from an accredited SAR reference dipole calibration performed at MVG, using the COMOSAR test bench. The test results covered by accreditation are traceable to the International System of Units (SI).

**SAR REFERENCE DIPOLE CALIBRATION REPORT**

Ref: ACR.60.8.21.MVGB.A

| | *Name* | *Function* | *Date* | *Signature* |
|---|---|---|---|---|
| *Prepared by :* | Jérôme LUC | Technical Manager | 3/1/2021 | |
| *Checked by :* | Jérôme LUC | Technical Manager | 3/1/2021 | |
| *Approved by :* | Yann Toutain | Laboratory Director | 3/1/2021 | Yann Toutain 2021.03.01 13:13:40 +01'00' |

| | *Customer Name* |
|---|---|
| *Distribution :* | SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD. |

| *Issue* | *Name* | *Date* | *Modifications* |
|---|---|---|---|
| A | Jérôme LE GALL | 3/1/2021 | Initial release |
| | | | |
| | | | |
| | | | |



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# 1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, FCC KDBs 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 | MVG |
| Model | SID2450 |
| Serial Number | SN 03/15 DIP2G450-352 |
| Product Condition (new / used) | Used |

# 3 PRODUCT DESCRIPTION

## 3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.

**Figure 1** – *MVG COMOSAR Validation Dipole*



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## 4 MEASUREMENT METHOD

The IEEE 1528, FCC KDBs 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. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

### 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 dimension's 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. A direct method is used with a ISO17025 calibrated caliper.

## 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 | 0.08 LIN |

### 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|---|---|
| 0 - 300 | 0.20 mm |
| 300 - 450 | 0.44 mm |

### 5.3 VALIDATION MEASUREMENT

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

| Scan Volume | Expanded Uncertainty |
|---|---|



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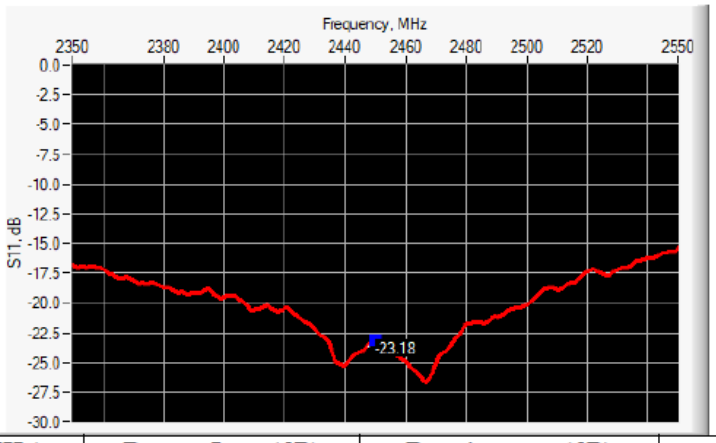
| | |
|---|---|
| 1 g | 19 % (SAR) |
| 10 g | 19 % (SAR) |

# 6 CALIBRATION MEASUREMENT RESULTS

## 6.1 RETURN LOSS AND IMPEDANCE




| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|---|---|---|---|
| 2450 | -23.18 | -20 | 56.3 Ω - 2.9 jΩ |

## 6.2 MECHANICAL DIMENSIONS

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



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

### 7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V5 |
| Phantom | SN 13/09 SAM68 |
| Probe | SN 41/18 EPGO333 |
| Liquid | Head Liquid Values: eps' : 41.9 sigma : 1.88 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=5mm/dy=5mm/dz=5mm |
| Frequency | 24502450 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 20 +/- 1 °C |
| Lab Temperature | 20 +/- 1 °C |
| Lab Humidity | 30-70 % |

### 7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ε,') | | Conductivity (σ) S/m | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 300 | 45.3 ±10 % | | 0.87 ±10 % | |
| 450 | 43.5 ±10 % | | 0.87 ±10 % | |
| 750 | 41.9 ±10 % | | 0.89 ±10 % | |
| 835 | 41.5 ±10 % | | 0.90 ±10 % | |
| 900 | 41.5 ±10 % | | 0.97 ±10 % | |
| 1450 | 40.5 ±10 % | | 1.20 ±10 % | |
| 1500 | 40.4 ±10 % | | 1.23 ±10 % | |
| 1640 | 40.2 ±10 % | | 1.31 ±10 % | |
| 1750 | 40.1 ±10 % | | 1.37 ±10 % | |
| 1800 | 40.0 ±10 % | | 1.40 ±10 % | |
| 1900 | 40.0 ±10 % | | 1.40 ±10 % | |
| 1950 | 40.0 ±10 % | | 1.40 ±10 % | |
| 2000 | 40.0 ±10 % | | 1.40 ±10 % | |



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| | | | | |
|---|---|---|---|---|
| 2100 | 39.8 ±10 % | | 1.49 ±10 % | |
| 2300 | 39.5 ±10 % | | 1.67 ±10 % | |
| 2450 | 39.2 ±10 % | 41.9 | 1.80 ±10 % | 1.88 |
| 2600 | 39.0 ±10 % | | 1.96 ±10 % | |
| 3000 | 38.5 ±10 % | | 2.40 ±10 % | |
| 3500 | 37.9 ±10 % | | 2.91 ±10 % | |

## 7.3 MEASUREMENT RESULT

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

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | 53.69 (5.37) | 24 | 23.94 (2.39) |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |



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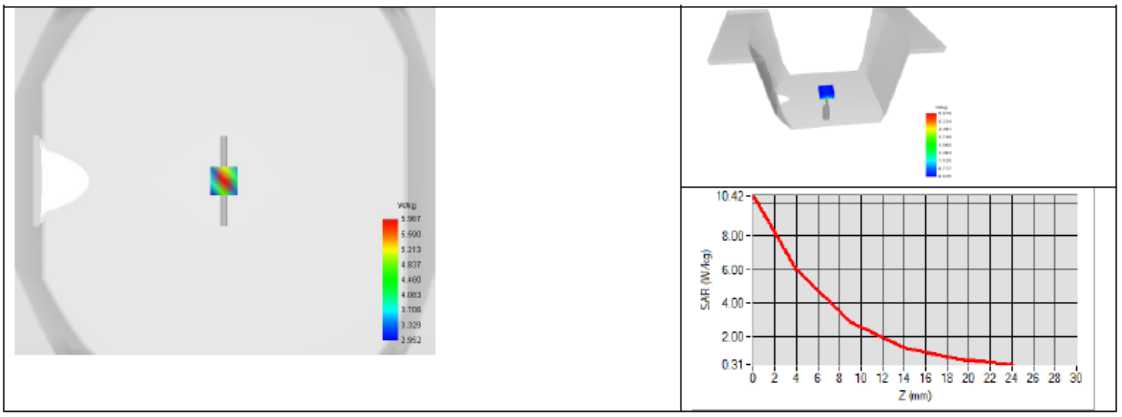




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## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---|---|---|---|---|
| **Equipment Description** | **Manufacturer / Model** | **Identification No.** | **Current Calibration Date** | **Next Calibration Date** |
| SAM Phantom | MVG | SN-13/09-SAM68 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rohde & Schwarz ZVM | 100203 | 05/2019 | 05/2022 |
| Network Analyzer – Calibration kit | Rohde & Schwarz ZV-Z235 | 101223 | 05/2019 | 05/2022 |
| Calipers | Mitutoyo | SN 0009732 | 10/2019 | 10/2022 |
| Reference Probe | MVG | EPGO333 SN 41/18 | 05/2020 | 05/2021 |
| Multimeter | Keithley 2000 | 1160271 | 02/2020 | 02/2023 |
| Signal Generator | Rohde & Schwarz SMB | 106589 | 04/2019 | 04/2022 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | NI-USB 5680 | 170100013 | 05/2019 | 05/2022 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature / Humidity Sensor | Testo 184 H1 | 44220687 | 05/2020 | 05/2023 |



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# SAR Reference Dipole Calibration Report

Ref : ACR.60.9.21.MVGB.A

**SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD.**

**BUILDING E, FENDA SCIENCE PARK, SANWEI COMMUNITY, XIXIANG STREET,**

**BAO'AN DISTRICT, SHENZHEN GUANGDONG, CHINA**

**MVG COMOSAR REFERENCE DIPOLE**

**FREQUENCY: 2600 MHZ**

**SERIAL NO.: SN 03/15 DIP2G600-356**

**Calibrated at MVG**

**Z.I. de la pointe du diable**

**Technopôle Brest Iroise – 295 avenue Alexis de Rochon**

**29280 PLOUZANE - FRANCE**

**Calibration date: 03/01/2021**

Accreditations #2-6789 and #2-6814
Scope available on www.cofrac.fr

*Summary:*

This document presents the method and results from an accredited SAR reference dipole calibration performed at MVG, using the COMOSAR test bench. The test results covered by accreditation are traceable to the International System of Units (SI).

**SAR REFERENCE DIPOLE CALIBRATION REPORT**

Ref: ACR.60.9.21.MVGB.A

| | *Name* | *Function* | *Date* | *Signature* |
|---|---|---|---|---|
| *Prepared by :* | Jérôme Luc | Technical Manager | 3/1/2021 | |
| *Checked by :* | Jérôme Luc | Technical Manager | 3/1/2021 | |
| *Approved by :* | Yann Toutain | Laboratory Director | 3/1/2021 | Yann Toutain 2021.03.01 13:14:51 +01'00' |

| | *Customer Name* |
|---|---|
| *Distribution :* | SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD. |

| *Issue* | *Name* | *Date* | *Modifications* |
|---|---|---|---|
| A | Jérôme Luc | 3/1/2021 | Initial release |
| | | | |
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| | | | |



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# 1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, FCC KDBs 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 | MVG |
| Model | SID2600 |
| Serial Number | SN 03/15 DIP2G600-356 |
| Product Condition (new / used) | Used |

# 3 PRODUCT DESCRIPTION

## 3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEEE 1528, FCC KDBs and CEI/IEC 62209 standards. The product is designed for use with the COMOSAR test bench only.

**Figure 1** – *MVG COMOSAR Validation Dipole*



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# 4 MEASUREMENT METHOD

The IEEE 1528, FCC KDBs 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. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

## 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 dimension's 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. A direct method is used with a ISO17025 calibrated caliper.

# 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 | 0.08 LIN |

## 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|---|---|
| 0 - 300 | 0.20 mm |
| 300 - 450 | 0.44 mm |

## 5.3 VALIDATION MEASUREMENT

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

| Scan Volume | Expanded Uncertainty |
|---|---|



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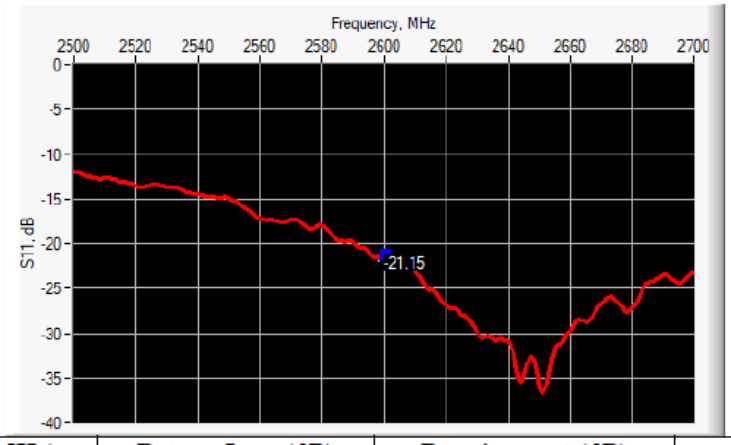
| | |
|---|---|
| 1 g | 19 % (SAR) |
| 10 g | 19 % (SAR) |

# 6 CALIBRATION MEASUREMENT RESULTS

## 6.1 RETURN LOSS AND IMPEDANCE




| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|---|---|---|---|
| 2600 | -21.15 | -20 | 52.7 Ω - 8.3 jΩ |

## 6.2 MECHANICAL DIMENSIONS

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



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

### 7.1 MEASUREMENT CONDITION

| | |
|---|---|
| Software | OPENSAR V5 |
| Phantom | SN 13/09 SAM68 |
| Probe | SN 41/18 EPGO333 |
| Liquid | Head Liquid Values: eps' : 41.5 sigma : 2.03 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=5mm/dy=5mm/dz=5mm |
| Frequency | 26002600 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 20 +/- 1 °C |
| Lab Temperature | 20 +/- 1 °C |
| Lab Humidity | 30-70 % |

### 7.2 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (ε,') | | Conductivity (σ) S/m | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 300 | 45.3 ±10 % | | 0.87 ±10 % | |
| 450 | 43.5 ±10 % | | 0.87 ±10 % | |
| 750 | 41.9 ±10 % | | 0.89 ±10 % | |
| 835 | 41.5 ±10 % | | 0.90 ±10 % | |
| 900 | 41.5 ±10 % | | 0.97 ±10 % | |
| 1450 | 40.5 ±10 % | | 1.20 ±10 % | |
| 1500 | 40.4 ±10 % | | 1.23 ±10 % | |
| 1640 | 40.2 ±10 % | | 1.31 ±10 % | |
| 1750 | 40.1 ±10 % | | 1.37 ±10 % | |
| 1800 | 40.0 ±10 % | | 1.40 ±10 % | |
| 1900 | 40.0 ±10 % | | 1.40 ±10 % | |
| 1950 | 40.0 ±10 % | | 1.40 ±10 % | |
| 2000 | 40.0 ±10 % | | 1.40 ±10 % | |



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| | | | | |
|---|---|---|---|---|
| 2100 | 39.8 ±10 % | | 1.49 ±10 % | |
| 2300 | 39.5 ±10 % | | 1.67 ±10 % | |
| 2450 | 39.2 ±10 % | | 1.80 ±10 % | |
| 2600 | 39.0 ±10 % | 41.5 | 1.96 ±10 % | 2.03 |
| 3000 | 38.5 ±10 % | | 2.40 ±10 % | |
| 3500 | 37.9 ±10 % | | 2.91 ±10 % | |

## 7.3 MEASUREMENT RESULT

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

| Frequency MHz | 1 g SAR (W/kg/W) | | 10 g SAR (W/kg/W) | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 300 | 2.85 | | 1.94 | |
| 450 | 4.58 | | 3.06 | |
| 750 | 8.49 | | 5.55 | |
| 835 | 9.56 | | 6.22 | |
| 900 | 10.9 | | 6.99 | |
| 1450 | 29 | | 16 | |
| 1500 | 30.5 | | 16.8 | |
| 1640 | 34.2 | | 18.4 | |
| 1750 | 36.4 | | 19.3 | |
| 1800 | 38.4 | | 20.1 | |
| 1900 | 39.7 | | 20.5 | |
| 1950 | 40.5 | | 20.9 | |
| 2000 | 41.1 | | 21.1 | |
| 2100 | 43.6 | | 21.9 | |
| 2300 | 48.7 | | 23.3 | |
| 2450 | 52.4 | | 24 | |
| 2600 | 55.3 | 55.83 (5.58) | 24.6 | 24.19 (2.42) |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |



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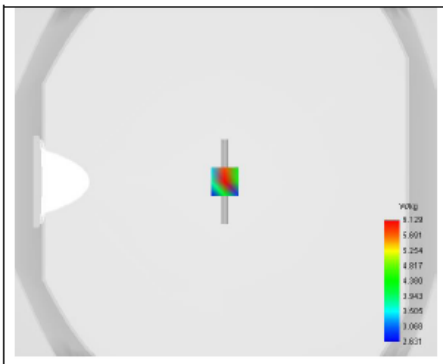

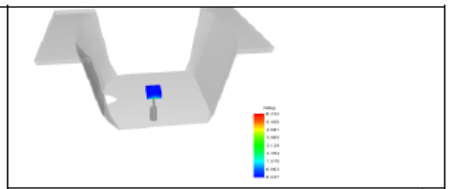

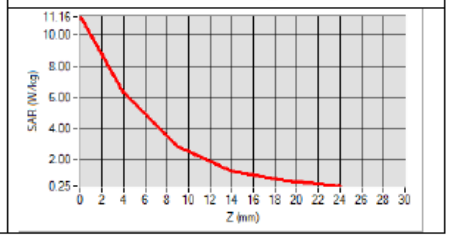




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## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---|---|---|---|---|
| **Equipment Description** | **Manufacturer / Model** | **Identification No.** | **Current Calibration Date** | **Next Calibration Date** |
| SAM Phantom | MVG | SN-13/09-SAM68 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rohde & Schwarz ZVM | 100203 | 05/2019 | 05/2022 |
| Network Analyzer – Calibration kit | Rohde & Schwarz ZV-Z235 | 101223 | 05/2019 | 05/2022 |
| Calipers | Mitutoyo | SN 0009732 | 10/2019 | 10/2022 |
| Reference Probe | MVG | EPGO333 SN 41/18 | 05/2020 | 05/2021 |
| Multimeter | Keithley 2000 | 1160271 | 02/2020 | 02/2023 |
| Signal Generator | Rohde & Schwarz SMB | 106589 | 04/2019 | 04/2022 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | NI-USB 5680 | 170100013 | 05/2019 | 05/2022 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature / Humidity Sensor | Testo 184 H1 | 44220687 | 05/2020 | 05/2023 |



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# SAR Reference Waveguide Calibration Report

Ref : ACR.60.10.21.MVGB.A

**SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD.**

**BUILDING E, FENDA SCIENCE PARK, SANWEI COMMUNITY, XIXIANG STREET,**

**BAO'AN DISTRICT, SHENZHEN GUANGDONG, CHINA**

**SATIMO COMOSAR REFERENCE WAVEGUIDE**

**FREQUENCY: 5000-6000 MHZ**

**SERIAL NO.: SN 13/14 WGA33**

**Calibrated at MVG**

**Z.I. de la pointe du diable**

**Technopôle Brest Iroise – 295 avenue Alexis de Rochon**

**29280 PLOUZANE - FRANCE**

**Calibration date: 03/01/2021**

Accreditations #2-6789 and #2-6814
Scope available on www.cofrac.fr

*Summary:*

This document presents the method and results from an accredited SAR reference waveguide calibration performed at MVG, using the COMOSAR test bench. The test results covered by accreditation are traceable to the International System of Units (SI).

**SAR REFERENCE WAVEGUIDE CALIBRATION REPORT**

Ref: ACR.60.10.21.MVGB.A

| | *Name* | *Function* | *Date* | *Signature* |
|---|---|---|---|---|
| *Prepared by :* | Jérôme Luc | Technical Manager | 3/1/2021 | |
| *Checked by :* | Jérôme Luc | Technical Manager | 3/1/2021 | |
| *Approved by :* | Yann Toutain | Laboratory Director | 3/1/2021 | Yann Toutain 2021.03.01 13:15:44 +01'00' |

| | *Customer Name* |
|---|---|
| *Distribution :* | SHENZHEN NTEK TESTING TECHNOLOGY CO., LTD. |

| *Issue* | *Name* | *Date* | *Modifications* |
|---|---|---|---|
| A | Jérôme Luc | 3/1/2021 | Initial release |
| | | | |
| | | | |
| | | | |



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# 1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528 and CEI/IEC 62209 standards for reference waveguides 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 5000-6000 MHz REFERENCE WAVEGUIDE |
| Manufacturer | MVG |
| Model | SWG5500 |
| Serial Number | SN 13/14 WGA33 |
| Product Condition (new / used) | Used |

# 3 PRODUCT DESCRIPTION

## 3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Waveguides are built in accordance to the IEEE 1528 and CEI/IEC 62209 standards.

# 4 MEASUREMENT METHOD

The IEEE 1528 and CEI/IEC 62209 standards provide requirements for reference waveguides 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 waveguide used for SAR system validation measurements and checks must have a return loss of -8 dB or better. The return loss measurement shall be performed with matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

## 4.2 MECHANICAL REQUIREMENTS

The IEEE 1528 and CEI/IEC 62209 standards specify the mechanical dimensions of the validation waveguide, the specified dimensions are as shown in Section 6.2. Figure 1 shows how the dimensions relate to the physical construction of the waveguide. A direct method is used with a ISO17025 calibrated caliper.



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# 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 | 0.08 LIN |

## 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|---|---|
| 0 - 300 | 0.20 mm |

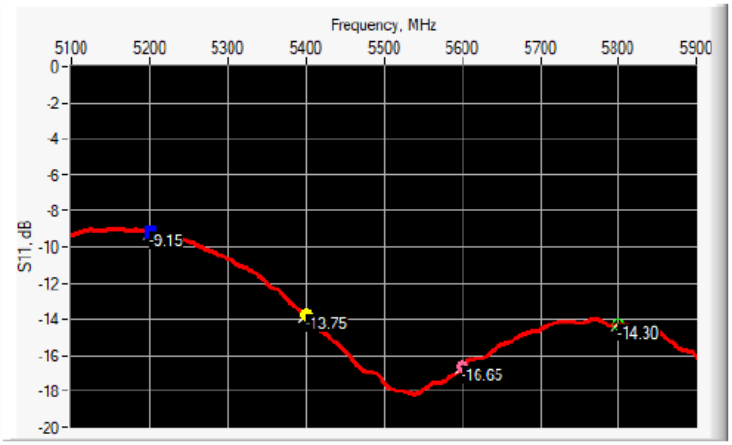
## 5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|---|---|
| 1 g | 19 % (SAR) |
| 10 g | 19 % (SAR) |

# 6 CALIBRATION MEASUREMENT RESULTS

## 6.1 RETURN LOSS



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| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|---|---|---|---|
| 5200 | -9.15 | -8 | 21.17 Ω + 13.26 jΩ |
| 5400 | -13.75 | -8 | 68.57 Ω + 6.68 jΩ |
| 5600 | -16.65 | -8 | 35.76 Ω - 2.15 jΩ |
| 5800 | -14.30 | -8 | 54.74 Ω + 18.27 jΩ |

## 6.2 MECHANICAL DIMENSIONS

| Frequency (MHz) | L (mm) | | W (mm) | | $L_f$ (mm) | | $W_f$ (mm) | |
|---|---|---|---|---|---|---|---|---|
| | Required | Measured | Required | Measured | Required | Measured | Required | Measured |
| 5800 | 40.39 ± 0.13 | - | 20.19 ± 0.13 | - | 81.03 ± 0.13 | - | 61.98 ± 0.13 | - |

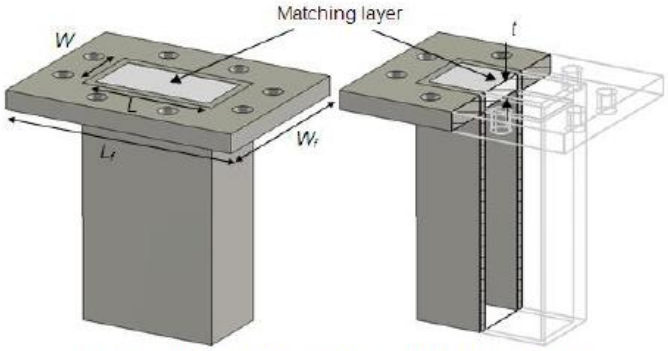


**Figure 1: Validation Waveguide Dimensions**

## 7 VALIDATION MEASUREMENT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference waveguide meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed with the matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell.



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Measurement Condition

| | |
|---|---|
| Software | OPENSAR V5 |
| Phantom | SN 13/09 SAM68 |
| Probe | SN 41/18 EPGO333 |
| Liquid | Head Liquid Values 5200 MHz: eps' :34.06 sigma : 4.70<br>Head Liquid Values 5400 MHz: eps' :33.39 sigma : 4.91<br>Head Liquid Values 5600 MHz: eps' :32.77 sigma : 5.13<br>Head Liquid Values 5800 MHz: eps' :32.40 sigma : 5.34 |
| Distance between dipole waveguide and liquid | 0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=4mm/dy=4m/dz=2mm |
| Frequency | 5200 MHz<br>5400 MHz<br>5600 MHz<br>5800 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 20 +/- 1 °C |
| Lab Temperature | 20 +/- 1 °C |
| Lab Humidity | 30-70 % |



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## 7.1 HEAD LIQUID MEASUREMENT

| Frequency MHz | Relative permittivity (εr') | | Conductivity (σ) S/m | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 5000 | 36.2 ±10 % | | 4.45 ±10 % | |
| 5100 | 36.1 ±10 % | | 4.56 ±10 % | |
| 5200 | 36.0 ±10 % | 34.06 | 4.66 ±10 % | 4.70 |
| 5300 | 35.9 ±10 % | | 4.76 ±10 % | |
| 5400 | 35.8 ±10 % | 33.39 | 4.86 ±10 % | 4.91 |
| 5500 | 35.6 ±10 % | | 4.97 ±10 % | |
| 5600 | 35.5 ±10 % | 32.77 | 5.07 ±10 % | 5.13 |
| 5700 | 35.4 ±10 % | | 5.17 ±10 % | |
| 5800 | 35.3 ±10 % | 32.40 | 5.27 ±10 % | 5.34 |
| 5900 | 35.2 ±10 % | | 5.38 ±10 % | |
| 6000 | 35.1 ±10 % | | 5.48 ±10 % | |

## 7.2 MEASUREMENT RESULT

At those frequencies, the target SAR value can not be generic. Hereunder is the target SAR value defined by Satimo, within the uncertainty for the system validation. All SAR values are normalized to 1 W net power. In bracket, the measured SAR is given with the used input power.

| Frequency (MHz) | 1 g SAR (W/kg) | | 10 g SAR (W/kg) | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 5200 | 159.00 | 162.34 (16.23) | 56.90 | 55.42 (5.54) |
| 5400 | 166.40 | 168.48 (16.85) | 58.43 | 57.03 (5.70) |
| 5600 | 173.80 | 174.92 (17.49) | 59.97 | 58.63 (5.86) |
| 5800 | 181.20 | 178.89 (17.89) | 61.50 | 59.32 (5.93) |



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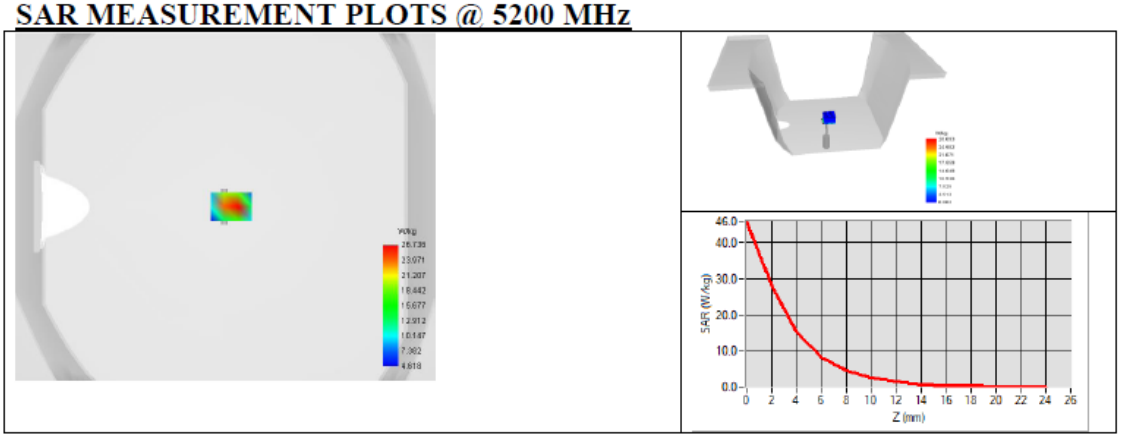
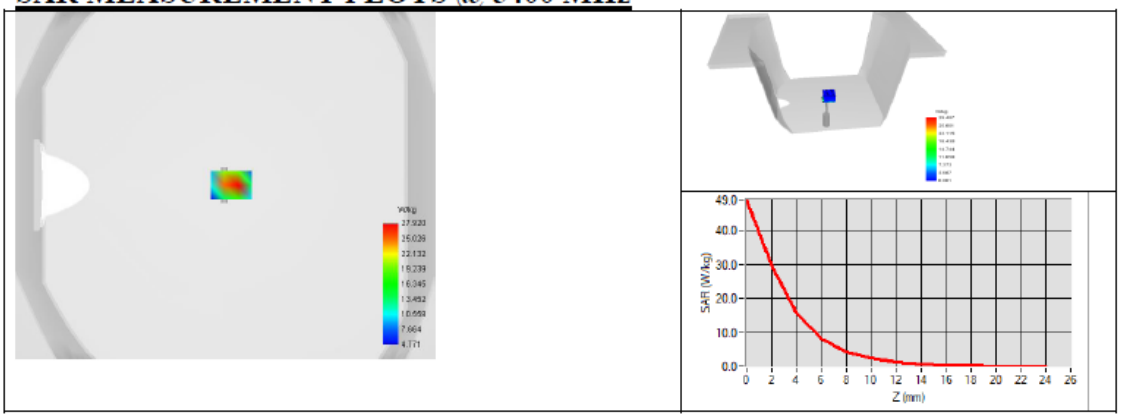
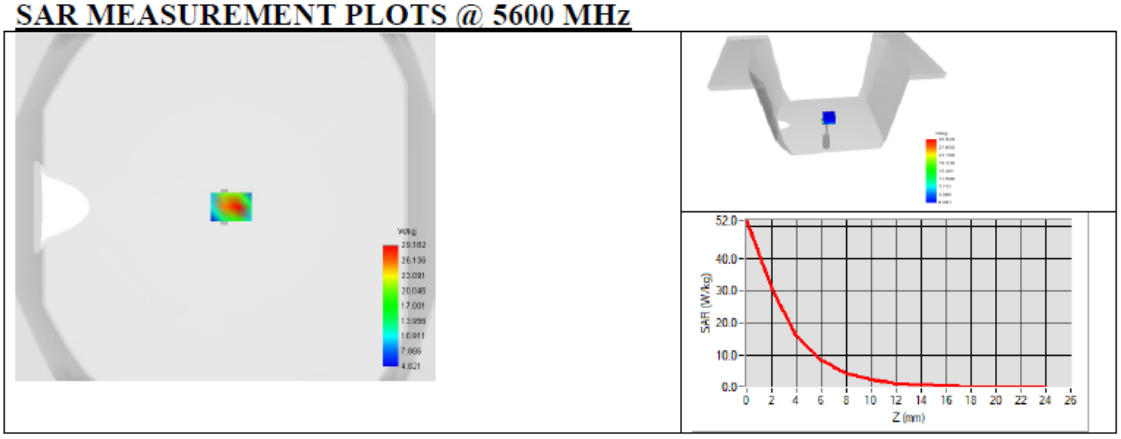
## SAR MEASUREMENT PLOTS @ 5200 MHz




## SAR MEASUREMENT PLOTS @ 5400 MHz




## SAR MEASUREMENT PLOTS @ 5600 MHz



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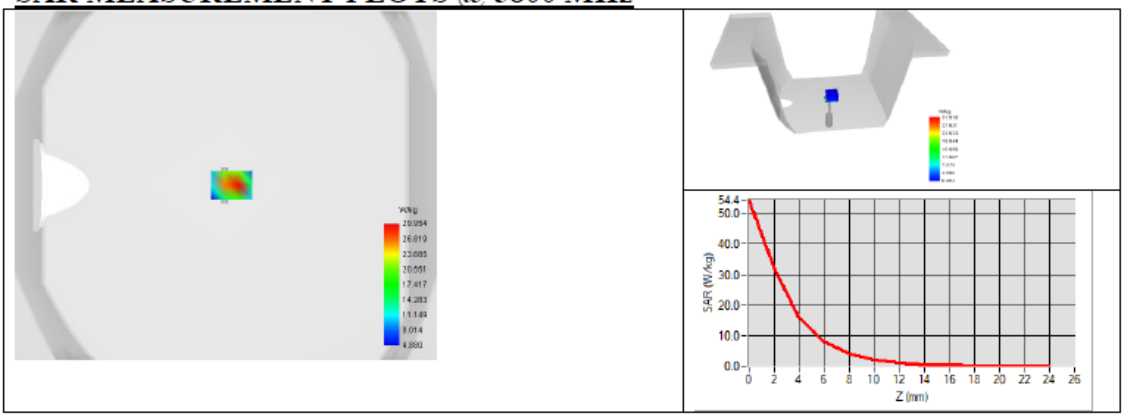
## SAR MEASUREMENT PLOTS @ 5800 MHz



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## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---|---|---|---|---|
| **Equipment Description** | **Manufacturer / Model** | **Identification No.** | **Current Calibration Date** | **Next Calibration Date** |
| Flat Phantom | MVG | SN-13/09-SAM68 | Validated. No cal required. | Validated. No cal required. |
| COMOSAR Test Bench | Version 3 | NA | Validated. No cal required. | Validated. No cal required. |
| Network Analyzer | Rohde & Schwarz ZVM | 100203 | 05/2019 | 05/2022 |
| Network Analyzer – Calibration kit | Rohde & Schwarz ZV-Z235 | 101223 | 05/2019 | 05/2022 |
| Calipers | Mitutoyo | SN 0009732 | 10/2019 | 10/2022 |
| Reference Probe | MVG | EPGO333 SN 41/18 | 05/2020 | 05/2021 |
| Multimeter | Keithley 2000 | 1160271 | 02/2020 | 02/2023 |
| Signal Generator | Rohde & Schwarz SMB | 106589 | 04/2019 | 04/2022 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | NI-USB 5680 | 170100013 | 05/2019 | 05/2022 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature / Humidity Sensor | Testo 184 H1 | 44220687 | 05/2020 | 05/2023 |



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**<Justification of the extended calibration>**

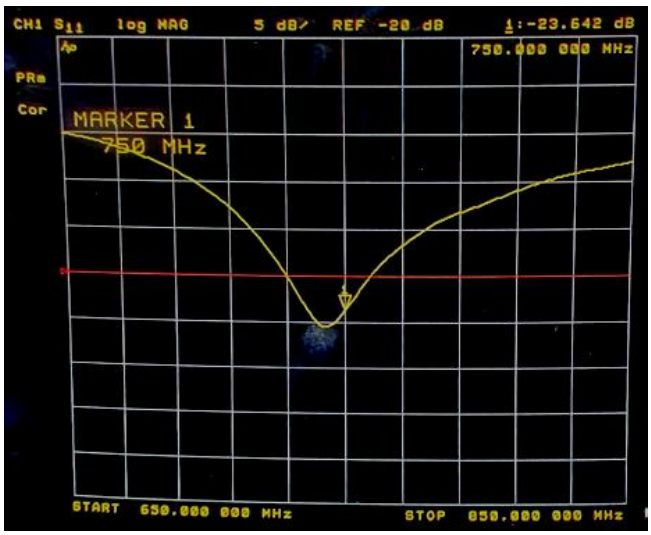
If dipoles are verified in return loss (<-20dB, within 20% of prior calibration for below 3GHz, and <-8dB, within 20% of prior calibration for 5GHz to 6GHz), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

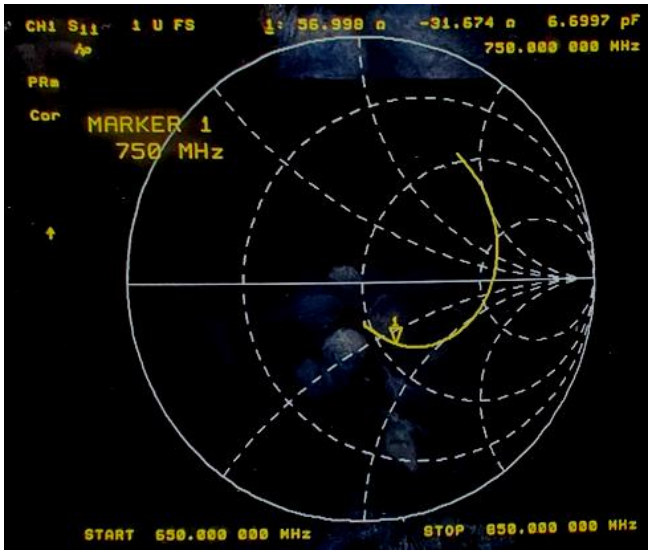
**<Head 750MHz>**

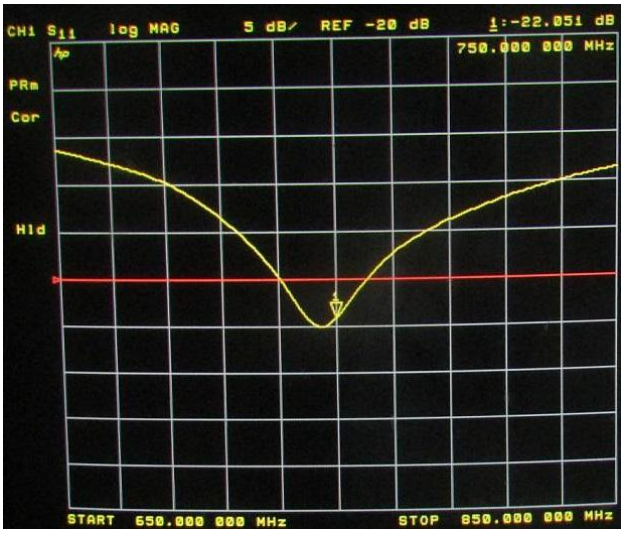
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -23.80 | - | 56.4 | - | Mar. 01, 2021 |
| -23.642 | 0.66 | 56.998 | 0.598 | Feb. 28, 2022 |
| -22.051 | 7.35 | 51.838 | 4.562 | Feb. 18, 2023 |

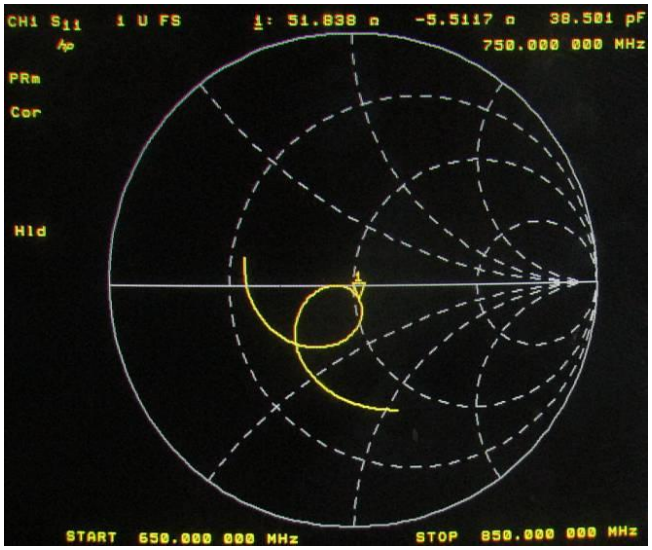
The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data



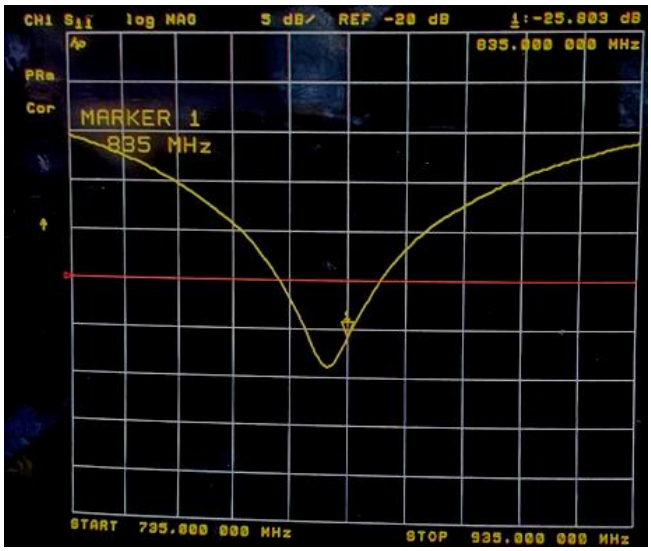



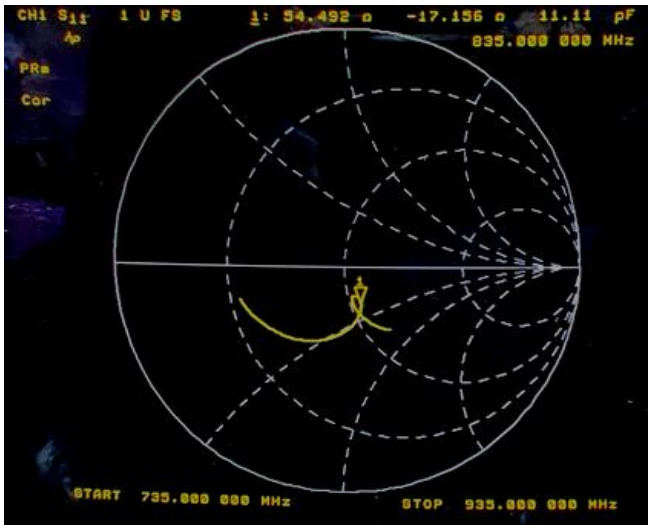
**<Head 835MHz>**

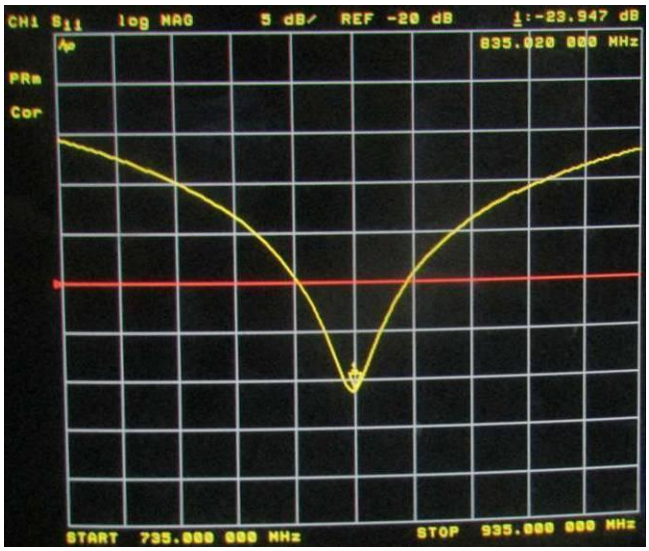
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -25.44 | - | 54.40 | - | Mar. 01, 2021 |
| -25.803 | 1.43 | 54.492 | 0.092 | Feb. 28, 2022 |
| -23.947 | 5.87 | 56.615 | 2.215 | Feb. 18, 2023 |

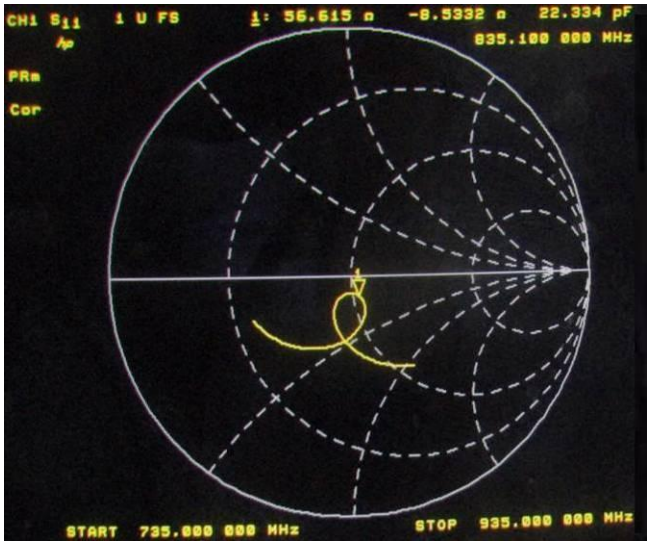
The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data



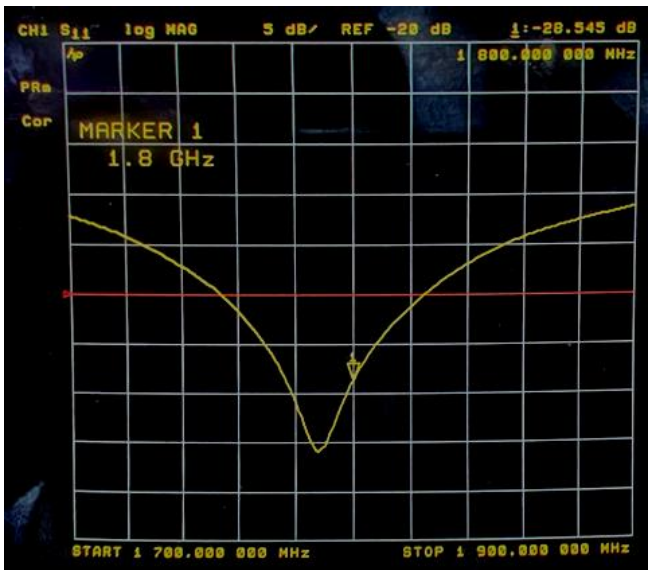



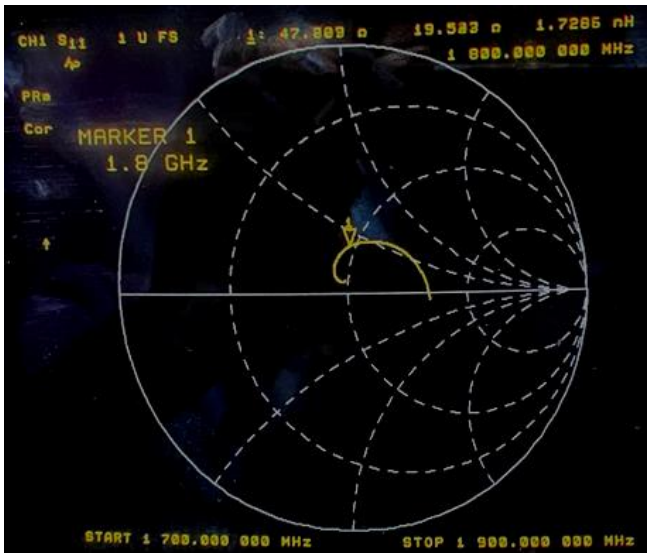
**<Head 1800MHz>**

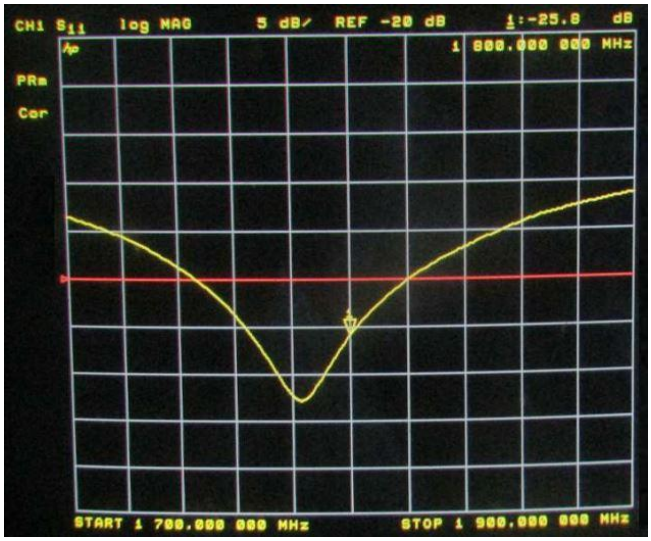
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -28.85 | - | 47.90 | - | Mar. 01, 2021 |
| -28.545 | 1.06 | 47.809 | 0.091 | Feb. 28, 2022 |
| -25.8 | 10.57 | 45.156 | 2.744 | Feb. 18, 2023 |

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



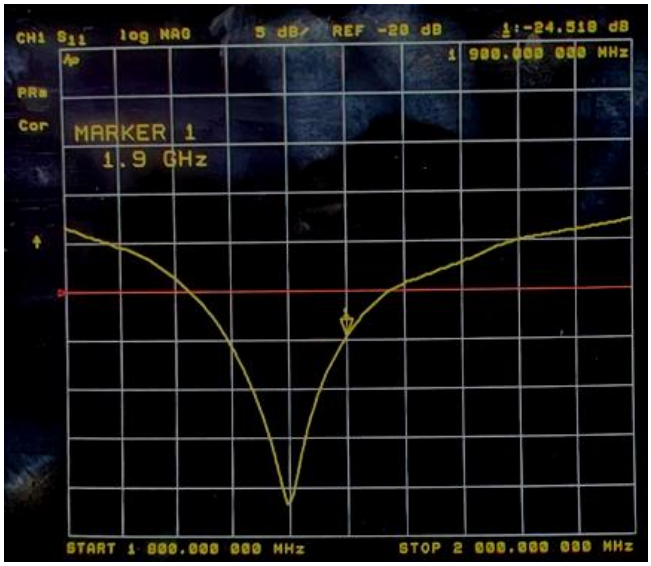



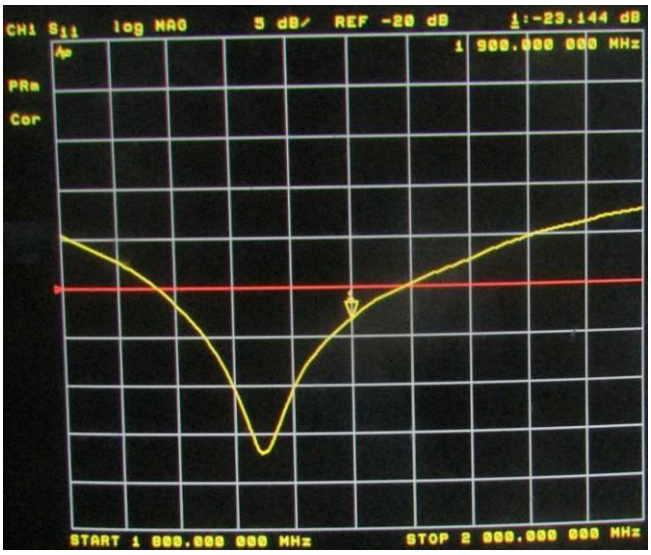
**<Head 1900MHz>**

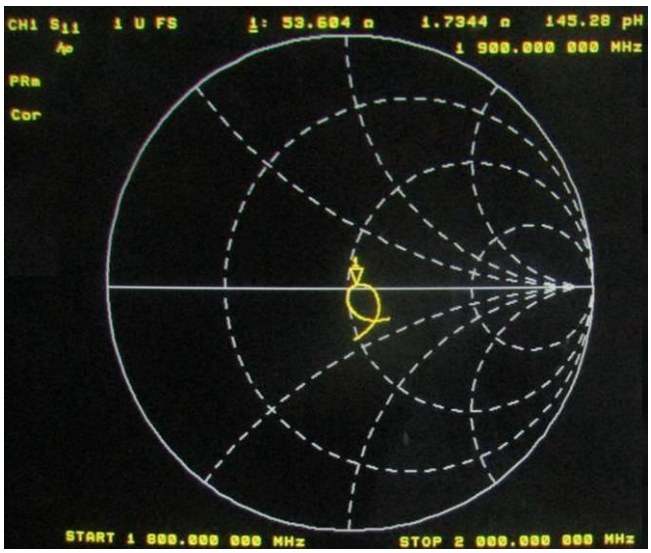
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -24.79 | - | 50.80 | - | Mar. 01, 2021 |
| -24.518 | 1.10 | 50.516 | 0.284 | Feb. 28, 2022 |
| -23.144 | 6.64 | 53.604 | 2.804 | Feb. 20, 2023 |

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





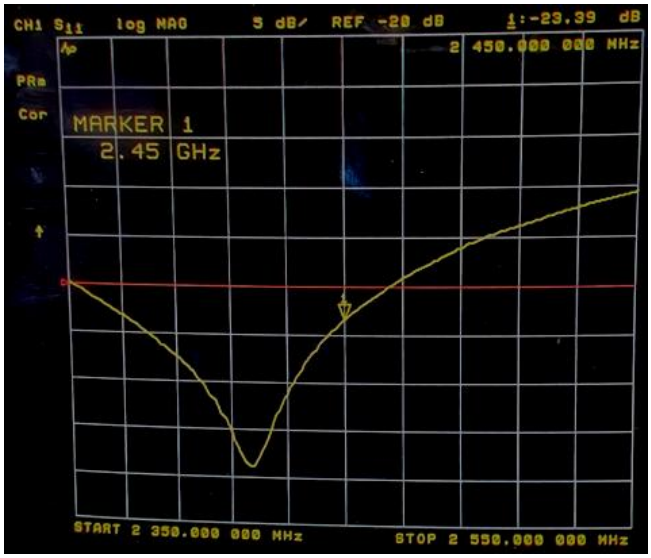



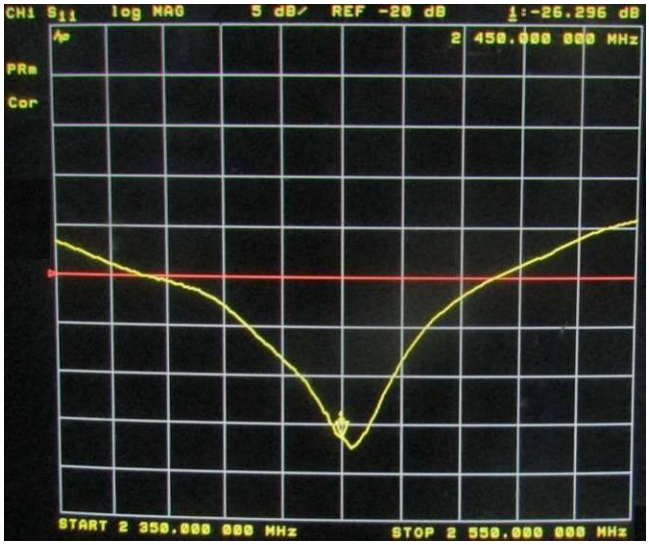
**<Head 2450MHz>**

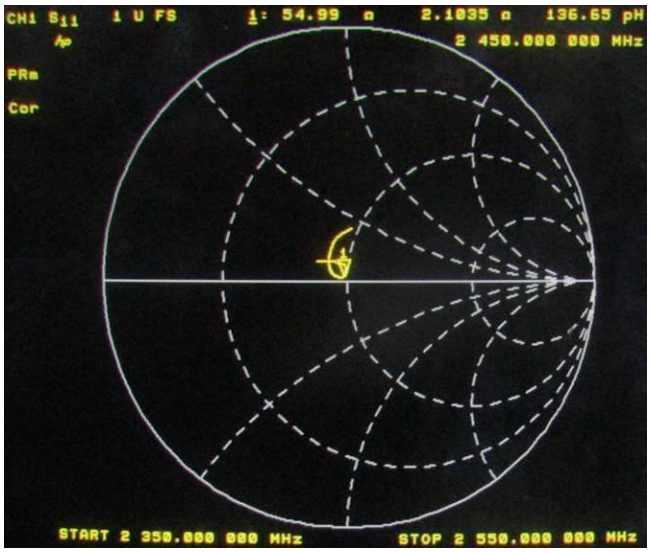
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -23.18 | - | 56.30 | - | Mar. 01, 2021 |
| -23.39 | 0.91 | 56.342 | 0.042 | Feb. 28, 2022 |
| -26.296 | 13.44 | 54.99 | 1.310 | Feb. 20, 2023 |

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





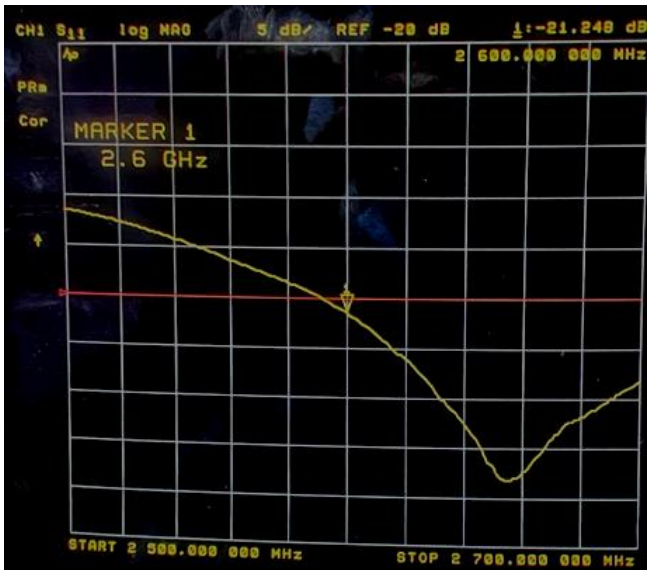



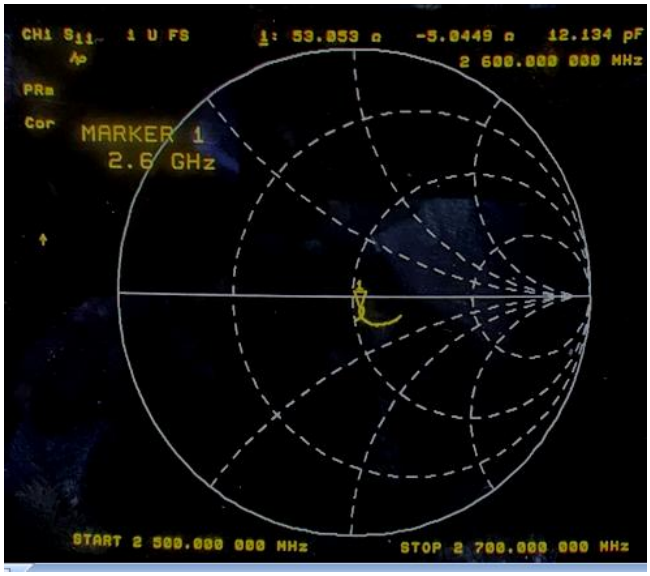
**<Head 2600MHz>**

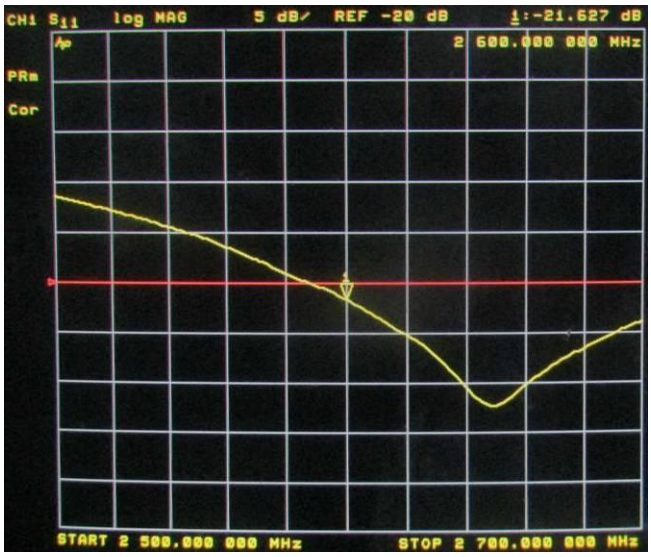
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -21.15 | - | 52.70 | - | Mar. 01, 2021 |
| -21.248 | 0.46 | 53.053 | 0.353 | Feb. 28, 2022 |
| -21.627 | 2.25 | 54.412 | 1.712 | Feb. 20, 2023 |

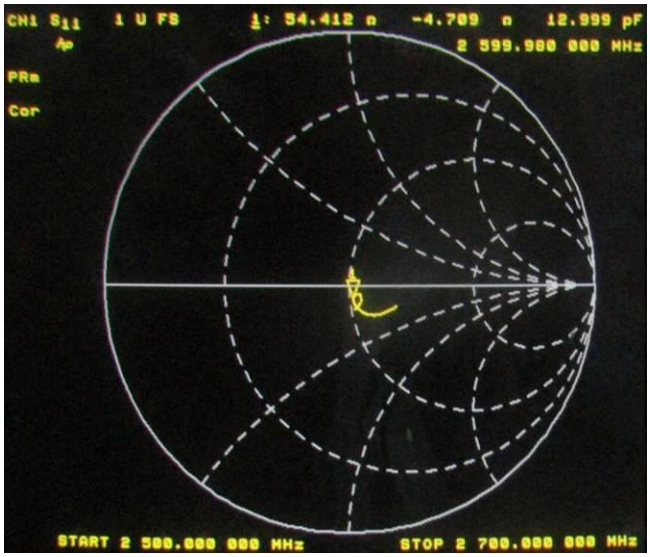
The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data



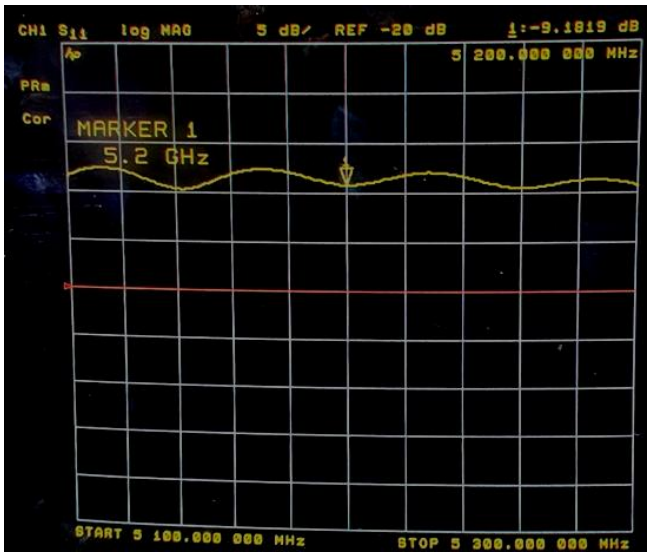



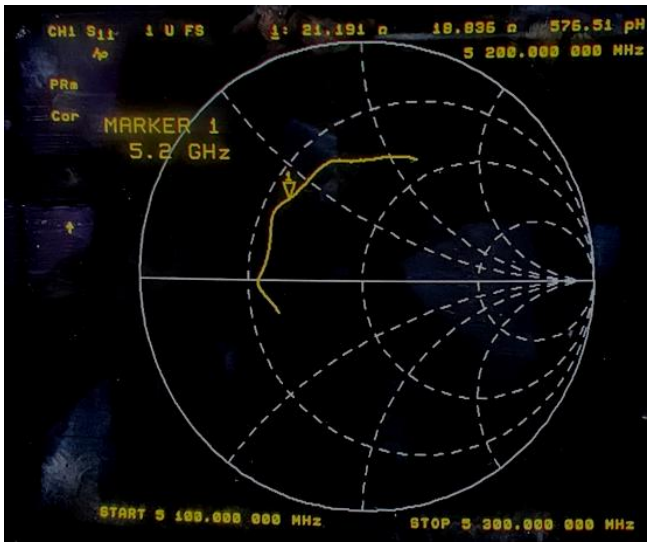
**<Head 5200MHz>**

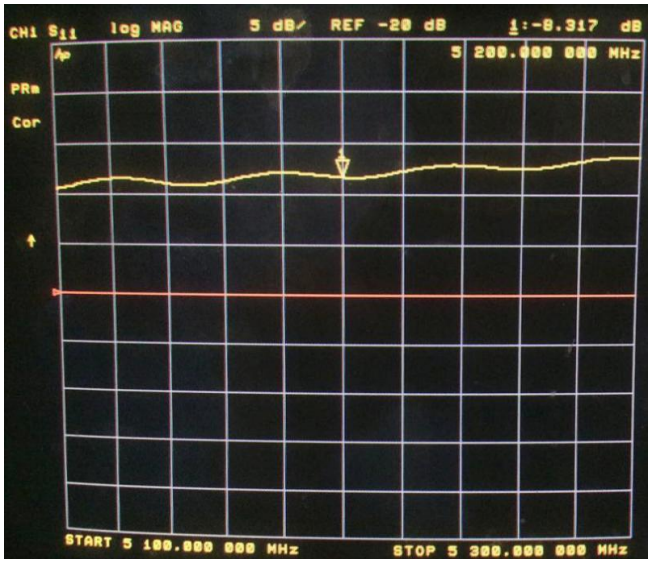
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -9.15 | - | 21.17 | - | Mar. 01, 2021 |
| -9.1819 | 0.35 | 21.191 | 0.021 | Feb. 28, 2022 |
| -8.317 | 9.10 | 25.673 | 4.503 | Feb. 20, 2023 |

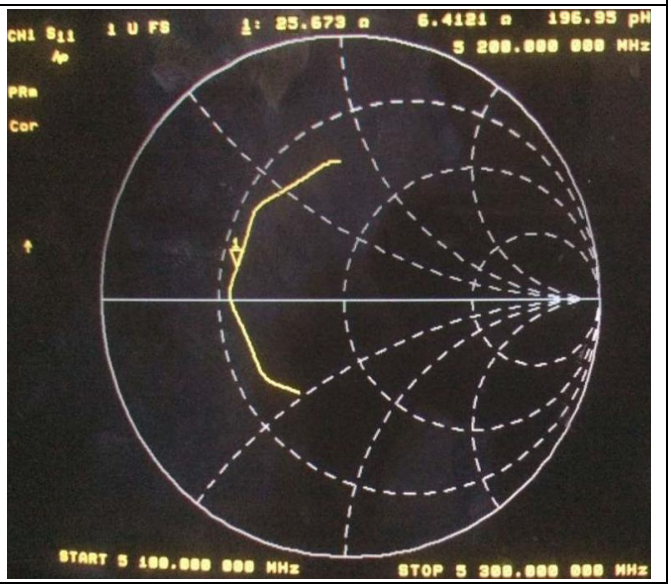
The return loss is <-8dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data



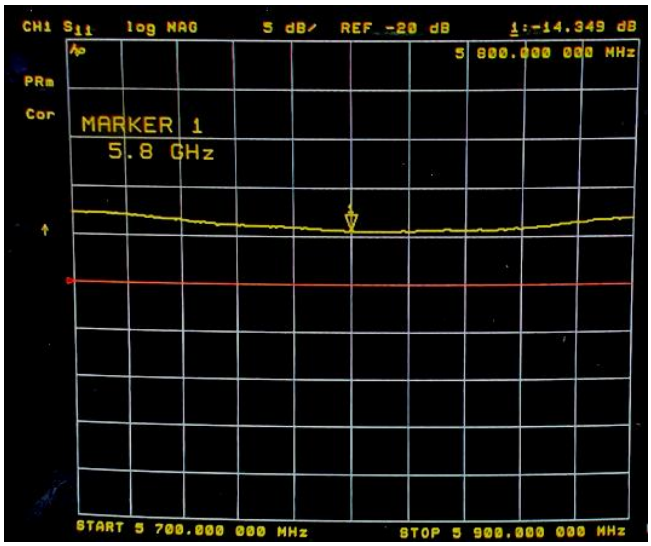



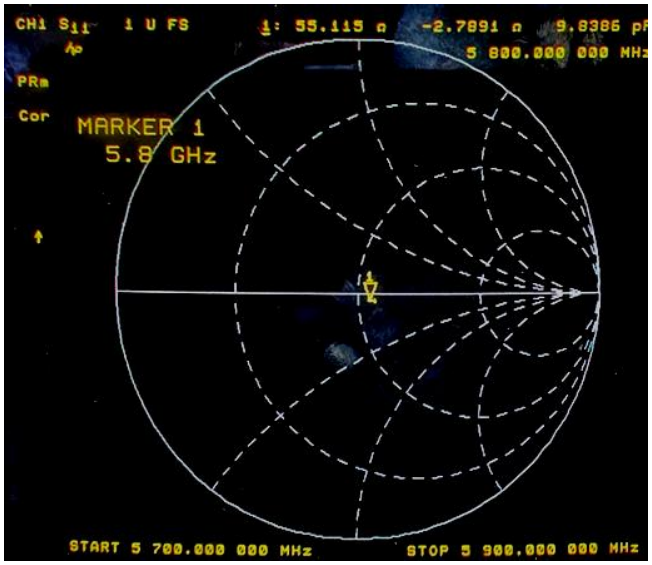
**<Head 5800MHz>**

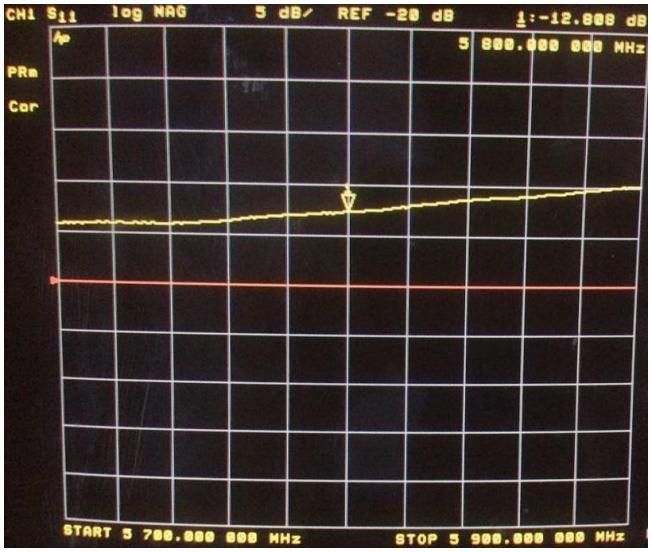
| Return Loss (dB) | Delta (%) | Impedance | Delta(ohm) | Date of Measurement |
|---|---|---|---|---|
| -14.30 | - | 54.74 | - | Mar. 01, 2021 |
| -14.349 | 0.34 | 55.115 | 0.375 | Feb. 28, 2022 |
| -12.808 | 10.43 | 55.289 | 0.549 | Feb. 27, 2023 |

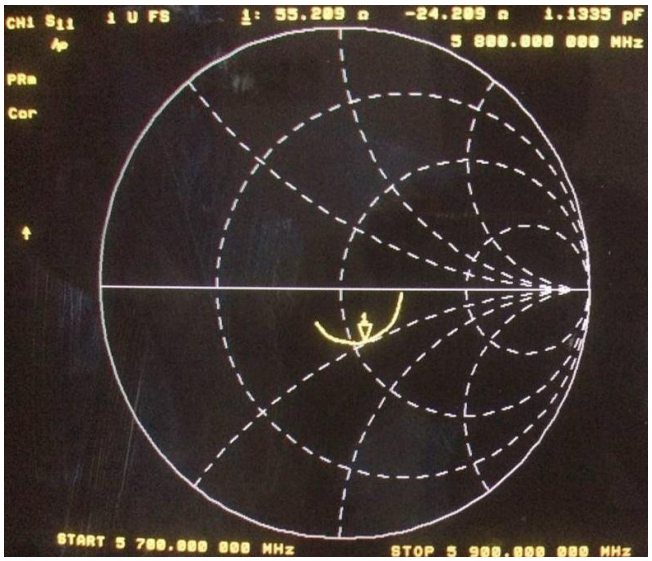
The return loss is <-8dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data




END