Report No.: AGC04183150401FH01

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# **COMOSAR E-Field Probe Calibration Report**

Ref: ACR.337.1.14.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR DOSIMETRIC E-FIELD PROBE

SERIAL NO.: SN 04/13 EP165

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



12/03/14

# Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric E-Field Probe calibration performed in SATIMO USA using the CALISAR / CALIBAIR test bench, for use with a SATIMO COMOSAR system only. All calibration results are traceable to national metrology institutions.

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# COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	12/3/2014	JS
Checked by :	Jérôme LUC	Product Manager	12/3/2014	JS
Approved by :	Kim RUTKOWSKI	Quality Manager	12/3/2014	frim Putthourshi

	Customer Name
	ATTESTATION
Distribution:	OF GLOBAL
Distribution:	COMPLIANCE
	CO. LTD.

Issue	Date	Modifications
A	12/3/2014	Initial release

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# COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

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#### COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

# 1 DEVICE UNDER TEST

Device Under Test			
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE		
Manufacturer	Satimo		
Model	SSE5		
Serial Number	SN 04/13 EP165		
Product Condition (new / used)	Used		
Frequency Range of Probe	0.7 GHz-3GHz		
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.238 MΩ		
	Dipole 2: R2=0.224 MΩ		
	Dipole 3: R3=0.223 MΩ		

A yearly calibration interval is recommended.

# 2 PRODUCT DESCRIPTION

## 2.1 GENERAL INFORMATION

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



Figure 1 - Satimo COMOSAR Dosimetric E field Dipole

Probe Length	330 mm
Length of Individual Dipoles	4.5 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	5 mm
Distance between dipoles / probe extremity	2.7 mm

## 3 MEASUREMENT METHOD

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

## 3.1 LINEARITY

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

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#### COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

## 3.2 SENSITIVITY

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

#### 3.3 LOWER DETECTION LIMIT

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

#### 3.4 ISOTROPY

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

#### 3.5 BOUNDARY EFFECT

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

## 4 MEASUREMENT UNCERTAINTY

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

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

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## COMOSAR E-FIELD PROBE CALIBRATION REPORT

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Combined standard uncertainty			5.831%
Expanded uncertainty 95 % confidence level k = 2			12.0%

# 5 CALIBRATION MEASUREMENT RESULTS

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

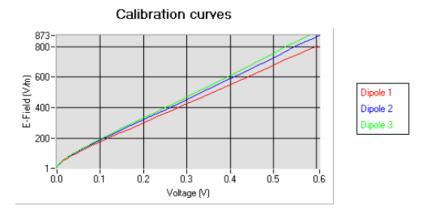
# 5.1 SENSITIVITY IN AIR

Normx dipole 1 (μV/(V/m) <sup>2</sup> )		
5.89	6.07	5.72

DCP dipole 1	DCP dipole 2	DCP dipole 3
(mV)	(mV)	(mV)
94	90	91

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

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



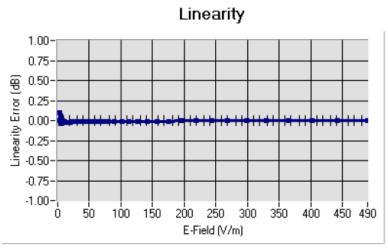
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## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

# 5.2 LINEARITY



Linearity: II+/-2.19% (+/-0.10dB)

# 5.3 SENSITIVITY IN LIQUID

<u>Liquid</u>	Frequency (MHz +/-	<u>Permittivity</u>	Epsilon (S/m)	<u>ConvF</u>
	100MHz)			
HL750	750	41.85	0.90	4.31
BL750	750	56.28	0.98	4.43
HL2300	2300	38.75	1.64	4.01
BL2300	2300	51.66	1.77	4.16
HL2600	2600	38.16	1.93	3.79
BL2600	2600	51.55	2.21	3.91
HL3500	3500	37.20	2.87	3.20
BL3500	3500	52.65	3.21	3.27
HL3700	3700	37.50	3.01	3.07
BL3700	3700	51.62	3.46	3.16

LOWER DETECTION LIMIT: 9mW/kg

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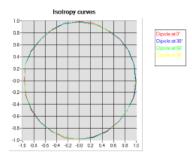
# COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

# 5.4 ISOTROPY

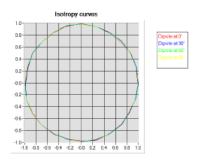
# HL750 MHz

- Axial isotropy: 0.04 dB - Hemispherical isotropy: 0.07 dB



# HL3500 MHz

- Axial isotropy: 0.05 dB - Hemispherical isotropy: 0.08 dB





# COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.337.1.14.SATU.A

# 6 LIST OF EQUIPMENT

	Equipment Summary Sheet						
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date			
Flat 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			
Reference Probe	Satimo	EP 94 SN 37/08	10/2014	10/2015			
Multimeter	Keithley 2000	1188656	12/2013	12/2016			
Signal Generator	Agilent E4438C	MY49070581	12/2013	12/2016			
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.			
Power Meter	HP E4418A	US38261498	12/2013	12/2016			
Power Sensor	HP ECP-E26A	US37181460	12/2013	12/2016			
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.			
Waveguide	Mega Industries	069Y7-158-13-712	Validated. No cal required.	Validated. No cal required.			
Waveguide Transition	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.			
Waveguide Termination	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.			
Temperature / Humidity Sensor	Control Company	11-661-9	8/2012	8/2015			

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# APPENDIX E. DIPOLE CALIBRATION DATA



# SAR Reference Dipole Calibration Report

Ref: ACR.318.10.13.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 835 MHZ

SERIAL NO.: SN 46/11 DIP 0G835-190

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





10/02/2014

#### Summary:

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

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref : ACR.318.10.13.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	10/02/2014	JES
Checked by :	Jérôme LUC	Product Manager	10/02/2014	Jes
Approved by :	Kim RUTKOWSKI	Quality Manager	10/02/2014	Acm Authoushi

Customer Name
ATTESTATION
OF GLOBAL
COMPLIANCE
CO. LTD.

Date	Modifications	
10/02/2014	Initial release	
	3,890,365,36	



Ref : ACR.318.10.13.SATU.A

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#### 1 INTRODUCTION

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

#### 2 DEVICE UNDER TEST

Device Under Test				
Device Type	COMOSAR 835 MHz REFERENCE DIPOLE			
Manufacturer	Satimo			
Model	SID835			
Serial Number	SN 46/11 DIP 0G835-190			
Product Condition (new / used)	New			

A yearly calibration interval is recommended.

# 3 PRODUCT DESCRIPTION

#### 3.1 GENERAL INFORMATION

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



Figure 1 - Satimo COMOSAR Validation Dipole

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# 4 MEASUREMENT METHOD

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

#### 4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constucted 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 Los		
400-6000MHz	0.1 dB		

## 5.2 <u>DIMENSION MEASUREMENT</u>

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
l g	20.3 %
10 g	20.1 %

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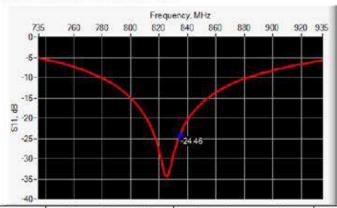


# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.318.10.13.SATU.A

# 6 CALIBRATION MEASUREMENT RESULTS

# 6.1 RETURN LOSS AND IMPEDANCE



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
835	-24.46	-20	$55.4 \Omega + 2.4 j\Omega$

# 6.2 MECHANICAL DIMENSIONS

Frequency MHz	Ln	nm	h m	m	d r	nm
	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 %.	PASS	89.8 ±1 %.	PASS	3.6 ±1 %.	PASS
900	149.0 ±1 %.		83.3 ±1 %.		3.6 ±1 %.	
1450	89.1 ±1 %.	E.	51.7 ±1 %.		3.6 ±1 %.	
1500	80.5 ±1 %.		50.0 ±1 %.		3.6 ±1 %.	
1640	79.0 ±1 %.	ń i	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 %.	0	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	415±1%		25.0 ±1 %.		3.6 ±1 %.	
3500	37.0±1%.		26.4 ±1 %.		3.6 ±1 %.	
3700	34.7±1 %.	5	26.4 ±1 %.		3.6 ±1 %.	

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## 7 VALIDATION MEASUREMENT

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

## 7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ε,')		Conductivity (a) S/m		
	required	measured	required	measured	
300	45.3 ±5 %		0.87 ±5 %		
450	43.5 ±5 %		0.87 ±5 %		
750	41,9 ±5 %		0.89 ±5 %		
835	41.5 ±5 %	PASS	0.90 ±5 %	PASS	
900	41.5 ±5 %		0.97 ±5 %		
1450	40.5 ±5 %		1.20 ±5 %		
1500	40.4 ±5 %		1.23 ±5 %		
1640	40.2 ±5 %		1.31 ±5 %		
1750	40.1 ±5 %		1.37 ±5 %		
1800	40.0 ±5 %		1.40 ±5 %		
1900	40.0 ±5 %		1.40 ±5 %		
1950	40.0 ±5 %		1.40 ±5 %		
2000	40.0 ±5 %		1.40 ±5 %		
2100	39.8 ±5 %		1.49 ±5 %		
2300	39.5 ±5 %		1.67 ±5 %		
2450	39.2 ±5 %		1.80 ±5 %		
2600	39.0 ±5 %	i	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: eps': 42.3 sigma: 0.92
Distance between dipole center and liquid	15.0 mm
Area scan resolution	dx=8mm/dy=8mm

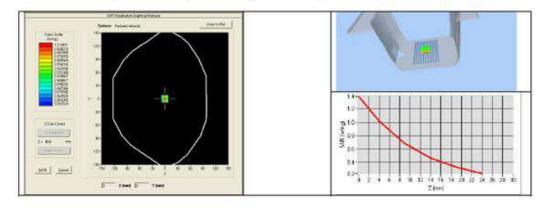
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Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm	
Frequency	835 MHz	
Input power	20 dBm	
Liquid Temperature	21 °C	
Lab Temperature	21 °C	
Lab Humidity	45 %	

Frequency 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	9.60 (0.96)	6.22	6.20 (0.62)
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3500	67.1		25	
		-		



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# SAR REFERENCE DIPOLE CALIBRATION REPORT

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# 7.3 BODY LIQUID MEASUREMENT

Frequency MHz	Relative per	mittivity (ε,')	Conductiv	ity (σ) 5/m
382.53.9	required	measured	required	measured
150	61.9 ±5 %		0.80 ±5 %	
300	58.2 ±5 %		0.92 ±5 %	
450	56.7 ±5 %		0.94 ±5 %	
750	55.5 ±5 %		0.96 ±5 %	Č.
835	55.2 ±5 %	PASS	0.97 ±5 %	PASS
900	55.0 ±5 %		1.05 ±5 %	į.
915	55.0 ±5 %		1.06 ±5 %	
1450	54.0 ±5 %		1.30 ±5 %	
1610	53.8 ±5 %		1.40 ±5 %	V.
1800	53.3 ±5 %		1.52 ±5 %	
1900	53.3 ±5 %		1.52 ±5 %	j.
2000	53.3 ±5 %		1.52 ±5 %	
2100	53.2 ±5 %		1.62 ±5 %	
2450	52.7 ±5 %		1.95 ±5 %	
2600	52.5 ±5 %		2.16 ±5 %	
3000	52.0 ±5 %		2,73 ±5 %	
3500	51.3 ±5 %		3.31 ±5 %	2
5200	49.0 ±10 %		5.30 ±10 %	
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %		5.53 ±10 %	
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %		5.77 ±10 %	
5800	48.2 ±10 %		6.00 ±10 %	6

# 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'; 54.1 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 %

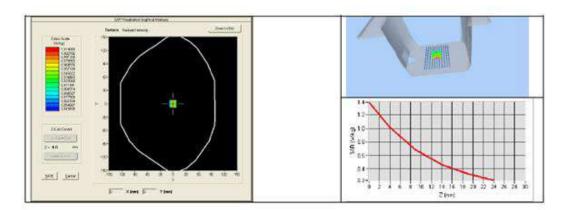
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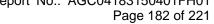
# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref : ACR.318.10.13.SATU.A

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
835	9.90 (0.99)	6.39 (0.64)



Report No.: AGC04183150401FH01





## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.318.10.13.SATU.A

# 8 LIST OF EQUIPMENT

Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration		
SAM Phantom	Satimo	SN-20/09-SAM71	Validated. No cal required.	Date Validated. No ca		
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No ca 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		

Report No.: AGC04183150401FH01

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# SAR Reference Dipole Calibration Report

Ref: ACR.318.7.13.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 1900 MHZ

SERIAL NO.: SN 46/11 DIP 1G900-187

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



# 11/14/13

## 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.

Report No.: AGC04183150401FH01 Page 184 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.7.13 SATU A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/14/2013	25
Checked by :	Jérôme LUC	Product Manager	11/14/2013	25
Approved by :	Kim RUTKOWSKI	Quality Manager	11/14/2013	ALM ALETANOSHI

Customer Name	
ATTESTATION	
OF GLOBAL	
COMPLIANCE	
CO. LTD.	

Issue	Date	Modifications	
A	11/14/2013	Initial release	



Ref: ACR 318 7 13 SATU A

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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 46/11 DIP 1G900-187		
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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BWF ACR 312 7 13 SATH 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 L		
400-6000MHz	0.1 dB		
	100 00000000000000000000000000000000000		

# 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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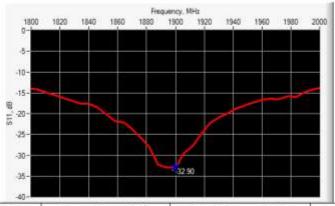


## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.3187.13 SATU A

# 6 CALIBRATION MEASUREMENT RESULTS

# 6.1 RETURN LOSS AND IMPEDANCE



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1900	-32.90	-20	$48.9 \Omega + 2.3 j\Omega$

# 6.2 MECHANICAL DIMENSIONS

Frequency MHz	Ln	nm	h m	im	d r	nm
	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 %.	PASS	39.5 ±1 %.	PASS	3.6 ±1 %.	PASS
1950	66.3 ±1 %.		38.5 ±1 %.		3.6 ±1 %.	
2800	64.5 ±1 %.		37.5 ±1 %		3.6 ±1 %.	
2100	61.0 ±1 %.		35.7±1%		3.6 ±1 %.	
2300	55.5 ±1 %.		32.6 ±1 %.		3.6 ±1 %.	
2450	51.5 ±1 %.		30.4±1%.		3.6 ±1 %.	
2600	48.5 ±1 %.		28.8 ±1 %.		3.6 ±1 %.	
3000	41.5 ±1 %.		25.0 ±1 %.		3.6 ±1 %.	
3500	37.0±1 %.		26.4±1%.		3.6 ±1 %.	
3700	34.7±1 %.		26.4±1 %.		3.6 ±1 %.	

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#### SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.7.13 SATU A

## 7 VALIDATION MEASUREMENT

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

#### 7.1 MEASUREMENT CONDITION

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' : 39.8 sigma : 1.43
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm
Frequency	1900 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45%

## 7.2 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative per	mittivity (e,')	Conductiv	ity (ø) 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%	
1.450	40.5 ±5 %		1.20 ±5 %	
1500	40.4 ±5 %		1.23 ±5 %	
1640	40.2 ±5 %		1.31 ±5 %	
1750	40.1 ±5 %		1.37±5%	
1800	40.0 ±5 %		1.40 ±5 %	
1900	40.0 ±5 %	PASS	1.40 ±5 %	PASS
1950	40.0 ±5 %		1.40 ±5 %	
2000	40.0 ±5 %		1.40 ±5 %	
2100	39.8 ±5 %		1.49 ±5 %	
2300	39.5 ±5 %		1.67±5%	
2450	35.2 ±5 %		1.80 ±5 %	
2600	39.0 ±5 %		1.96 ±5 %	
3000	38.5 ±5 %		2,40 ±5 %	
3500	37.9 ±5 %		2.91 ±5 %	

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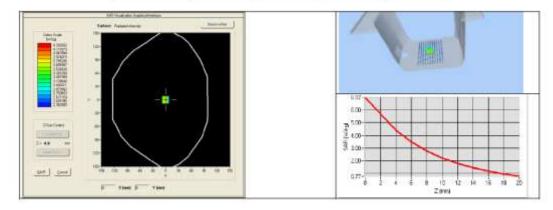


Ref: ACR 318.7.13.3ATU.A

# 7.3 MEASUREMENT RESULT

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

Frequency MHz	1 g SAR	(W/kg/W)	10 g SAR	(W/kg/W)
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8,49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34,2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7	39.65 (3.96)	20.5	20.24 (2.02)
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3500	67.1		25	



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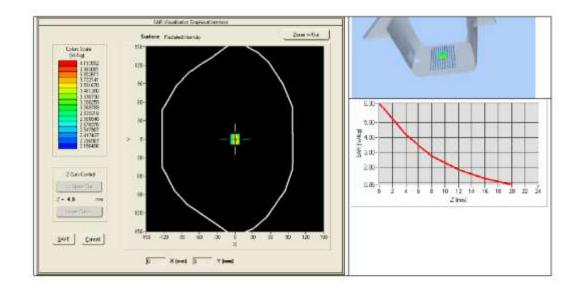


Ref ACR.318.7.13.SATU.A

# 7.4 BODY MEASUREMENT RESULT

Software	OPENSAR V4		
Phantom	SN 20/09 SAM71		
Probe	SN 18/11 EPG122		
Liquid	Body Liquid Values: eps' 52.5 sigma: 1.50		
Distance between dipole center and liquid	10.0 mm		
Area scan resolution	dx=8mm/dy=8mm		
Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm		
Frequency	1900 MHz		
Input power	20 dBm		
Liquid Temperature	21 °C		
Lab Temperature	21 °C		
Lab Humidity	45%		

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
1900	40.74 (4.07)	21.43 (2.14)



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## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.318.7.13.SATU.A

# 8 LIST OF EQUIPMENT

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	12/2010	12/2013			
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	11/2010	11/2013			
Signal Generator	Agilent E4438C	MY49070581	12/2010	12/2013			
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.			
Power Meter	HP E4418A	US38261498	11/2010	11/2013			
Power Sensor	HP ECP-E26A	US37181460	11/2010	11/2013			
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	3/2012	3/2014			

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# **SAR Reference Dipole Calibration Report**

Ref: ACR.318.6.13.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 1800 MHZ

SERIAL NO.: SN 46/11 DIP 1G800-186

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



# 11/14/13

# 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.

Report No.: AGC04183150401FH01 Page 194 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR 318.6.13 SATU A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/14/2013	JES
Checked by :	Jérôme LUC	Product Manager	11/14/2013	JES
Approved by :	Kim RUTKOWSKI	Quality Manager	11/14/2013	Aum Puthowski

	Customer Name
Distribution:	ATTESTATION
	OF GLOBAL
	COMPLIANCE
	CO. LTD.

Date	Modifications
11/14/2013	Initial release
	100000000000000000000000000000000000000
	11/14/2013



Ref ACR 318.6.13 SATU A

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7	Va	lidation measurement	
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	7.2	Head Liquid Measurement	7
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Ref. ACR 318 6 13 SATU A

# 1 INTRODUCTION

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

#### 2 DEVICE UNDER TEST

Device Under Test				
Device Type	COMOSAR 1800 MHz REFERENCE DIPOLE			
Manufacturer	Satimo			
Model	SID1800			
Serial Number	SN 46/11 DIP 1G800-186			
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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Ref. ACR 318 6 13 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 constucted 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 CEL/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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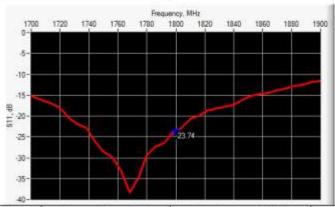


## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.6.13 SATU A

# 6 CALIBRATION MEASUREMENT RESULTS

# 6.1 RETURN LOSS AND IMPEDANCE



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1800	-23.74	-20	43.8 Ω0.1 jΩ

# 6.2 MECHANICAL DIMENSIONS

Frequency MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	m ea sure o
300	420.0 ±1 %.		250.0 ±1 %.		6.35 ±1 %	
450	290,0 ±1 %.		166.7±1%.		6.35 ±1 %.	
750	176.0 ±1 %.		108.0 ±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 %.	PASS	41.7±1%.	PAS5	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 %.		3.5 ±1 %.	
2100	61.0 ±1 %		35.7±1 %		3.6 ±1 %.	
2300	55.5 ±1 %		32.6 ±1 %.		3.6 ±1 %.	
2450	51.5±1 %		30.4±1 %		3.6 ±1 %.	
2600	48.5 ±1 %.		28.8 ±1 %.		3.6 ±1 %.	
3000	41.5 ±1 %		25.0 ±1 %		3.6 ±1 %.	
3500	37.0±1 %.		26.4±1 %.		3.6 ±1 %.	
3700	34.7±1 %.		26.4±1 %.		3.6 ±1 %.	

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#### SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.6.13 SATU A

# 7 VALIDATION MEASUREMENT

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

# 7.1 MEASUREMENT CONDITION

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' 40.2 sigma 1.38
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=9mm
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%

# 7.2 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative per	mittivity ( <b>c</b> ,')	Conductiv	ity (c) \$/m
W2E/2. 1	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 %	i i
1750	40.1 ±5 %		1.37±5%	
1800	40.0 ±5 %	PASS	1.40 ±5 %	PASS
1900	40.0 ±5 %		1.40 ±5 %	
1950	40.0 ±5 %		1.40 ±5 %	
2000	40.0 ±5 %		1.40 ±5 %	
2100	39.8 ±5 %		1.49 ±5 %	
2300	39.5 ±5 %		1.67±5%	l.
2450	39.2 ±5 %		1.80 ±5 %	
2600	39.0 ±5 %		1.96 ±5 %	
3000	38.5 ±5 %		2,40 ±5 %	
3500	37.9 ±5 %		2.91 ±5 %	

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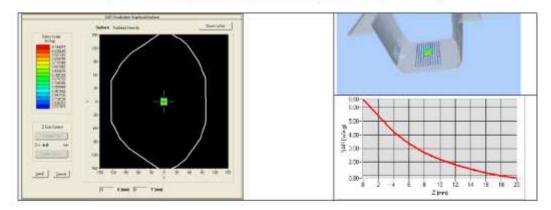


Ref: ACR 318.6.13 SATU.A

# 7.3 MEASUREMENT RESULT

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

Frequency MHz	1 g SAR	(W/kg/W)	10 g SAR	(W/kg/W)
2000-2	required	measured	required	m ea sured
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	38.17 (3.82)	20.1	19.98 (2.00)
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21,1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2680	55.3		24.6	
3000	63.8		25.7	
9580	67.1		25	



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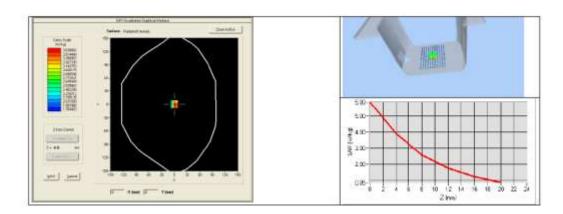


Ref ACR 318.6.13 SATU.A

# 7.4 BODY MEASUREMENT RESULT

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Body Liquid Values: eps' : 52.0 sigma : 1.48
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%
Dio month on the control of the cont	1.55.70

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
3320	measured	measured
1800	38.28 (3.83)	20.89 (2.09)



Report No.: AGC04183150401FH01 Page 202 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.6.13 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	12/2010	12/2013		
Reference Probe	Satimo	EPG122 SN 18/11	Characterized prior to test. No call required.	Characterized prior to test. No cal required.		
Multimeter	Keithley 2000	1188656	11/2010	11/2013		
Signal Generator	Agilent E4438C	MY49070581	12/2010	12/2013		
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.		
Power Meter	HP E4418A	US38261498	11/2010	11/2013		
Power Sensor	HP ECP-E26A	US37181460	11/2010	11/2013		
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No call required.	Characterized prior to test. No cal required.		
Temperature and Humidity Sensor	Control Company	11-661-9	3/2012	3/2014		

Report No.: AGC04183150401FH01 Page 203 of 221



# SAR Reference Dipole Calibration Report

Ref : ACR.337.2.14.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR REFERENCE DIPOLE

> FREQUENCY: 750 MHZ SERIAL NO.: SN 47/14 DIP 0G750-340

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



12/03/14

Summary

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

Report No.: AGC04183150401FH01 Page 204 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

Bell ACR SP2145AYU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	12/3/2014	25
Clucked by z	Jérôme I,UC	Product Manager	12/3/2014	195
Approved by :	Kim RUTKOWSKI	Quality Manager	12/3/2014	No. Policy No.

	Customer Name
Distribution :	OF GLOBAL COMPLIANCE CO. LTD.

tome	Date	Modifications
A	12/3/2014	Initial release
-		

Page: 2/11

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### SAR REFERENCE DIPOLE CALBRATION REPORT

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

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# 1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528, OET 65 Bulletin C and CEFIEC 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

### 2 DEVICE UNDER TEST

D	evice Under Test
Device Type	COMOSAR 750 MHz REFERENCE DIPOLE
Munufacturer	Satimo
Model	SID750
Serial Number	SN 47/14 DIP 0G750-340
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 secondance 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 - Satismo COMOSAR Validation Dipole

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#### SAR REFERENCE DIPOLE CALIBRATION REPORT.

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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 constucted 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 Leng	
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 amortuinty for validation measurements.

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

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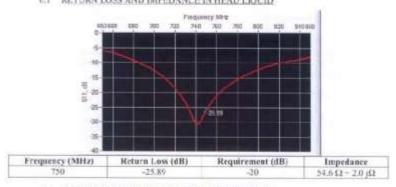


### SAR REFERENCE DIPOLE CALIBRATION REPORT

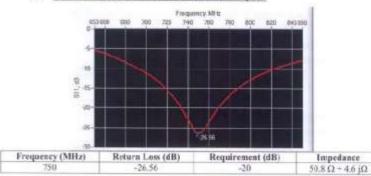
Bull ACE DITZ H SATULA

### 6 CALIBRATION MEASUREMENT RESULTS

# 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



# 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



# 6.3 MECHANICAL DIMENSIONS

Frequency MHz	L r	nen.	h =	1000	d	may.
	required	measured	required	measured	required	measured
300	420.011%		250.0 ±1.%		5/0/11%	
450	190 0 + 1 %		1867 62 %		9-35-3276	
750	170.0 21 %	PASS	300.0 ±3 %	7A05	635.11%	PASS
833	101.0:15		89.833%		36:1%	

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### SAR REFERENCE DIPOLE CALIBRATION REPORT

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900	149.0±1%	83.3 x 1 %	2641%
3450	B9.T 82.%	51.741%	16.01%
1500	835 t1 %.	50.0 ±1 %	5.6 et %.
1640	79.0 x 3 %.	45.7 ±1 %	16:15.
1750	75311%	42.9±1%	25125
1800	72.0 ±1 %.	41.7±1%	16 #1%
1900	68.0 ±2 %.	39.5 ±1 %	35 45%.
1950	663x1%	38.5 ±1%	1891%
2000	645 22%	37.5±1%	25 12 %
2100	61.0±1%.	39.7 ±3.%	16 #1%.
2300	55.5 11%	32.61%	26.41%.
2450	33.5 12%	30.4 (1.5)	3641%
2100	48311%	28.8 ±1.%	3541%
3000	41313%	25/0:13/%	5513.
3100	37.0:1%	79.4±3 %	3841%
3700	34.7±2%	26.4 11 %	3.6 ±1 %.

# 7 VALIDATION MEASUREMENT

The IEEE Std. 1528, OET 65 Bulletin C and CEVIEC 62209 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned eturn 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 Milks	Relative per	mitrivity (c/)	Conductiv	Wy (c) 5/m
	required	measured	required	measured
300	453.45%		0.87±5.%	
450	41.5 15%		0.87±5%	
. 250	41.9 (5.76	PASI	0.89±5.%	PASS:
835	41.5 x5 %		0.50±534	
900	41.5.15%		0.97 ±5 %	
1450	40.5 15%		1.20 (5.%	
1500	40.4 (5.90		1.21:55	
1640	45.3 15%		1.11.15%	
1750	40.1 15%		1.37±5%	
1800	40.0 15%		1.40 15 %	
1900	43.0 (5.%		1.40±5%	
1950	40.0 15%		1.40±5%	
2000	40.0 (5.%		1.40:15%	

Page: 7/27

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Report No.: AGC04183150401FH01 Page 210 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

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33.00	25.8 (5.%	1.49 (5%)	
2300	39.5 15.55	\$ 07 (5%)	
2450	39.2 ±5 %	1.80 ±5 %	
2600	39.0 ±5.76	13615%	
8000	38.3 ±5.%	2.40±5%	
3500	37.9 ±1.%	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 plantom 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.

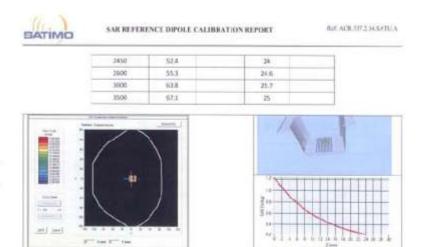
Software	OPENSAR V4
Pleature	SN 20:00 SAM71
Pening	SN 10/11 EPG122
Engrid.	Head Liquid Values: eps.'; \$1.8 sigma; 0.90
Distance between dipole center and biquid	15.0 mm
Arm som resolution	dx=8mm-dy=8mm
Zoca Scan Resolution	dx=fmm/dy=fim/dz=5mm
Frequency	750 MHz
Inpit power	20 dBm
Liquid Temperature	31.°C
Lab Temperature	21 °C
Lub Humidity	45%

Frequency MHz	1 g SAR	(W/kg/W)	10 g SAR	(W/kg/W)
	required	mensured	required	measured
300	2.65		1.94	
450	4.58		3.05	
750	8.49	8.55 (0.85)	5.55	5.62 (0.56)
835	9.5%		1.22	
900	10.5		639	
1450	29		.10	
1900	30.5		16.0	
1640	34.2		28.6	
1750	36.4		19.3	
1900	38.4		20.3	
1900	39,3		20.5	
1950	40.5		20.9	
1000	41.1		21.1	
7100	43.6		21.9	
3300	48.7		23.3	

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# 2.3 BODY LIQUID MEASUREMENT

Frequency MHz	Relative per	automate, [e-]	Conductiv	try (r) s/m
	required	measured	required	теаште
150	61.915%		0.8015%	
300	58.2 (5%		0.92±5.5	
450	96.715.%		0.94±5%	
750	55.5 15 %	PASS	0.9615.5	PASS
835	55.2 15%		0.9735 %	
900	35.0 ±5.50		L03 ±5 %	
915	55.0 ±5.%		1.06 ±5.%	
1450	54.0 ±5 %		1.3015 %	
1610	58.8 ±5.%		1.40355	
1800	53.3.555		13715%	
1900	33.315%		1.52 15 %	
2000	33.315.%		152±5-5	
2100	33.215.%		1.67.15 %	
2450	32.7 15 %		1,9575.5	
2600	57.5 (5.9)		11615%	
3000	12.015%		3.7115 %	
3500	31.725%		13115 %	
5200	43.8 418%		5.30 i 10 h	
5300	48.9 (10%		5.42 (XD N.	
5400	43.7 (10.5		5.53 (10 N	

Page: 9/11

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Report No.: AGC04183150401FH01 Page 212 of 221



# SAR REFERENCE DIPOLE CALIBRATIOS REPORT

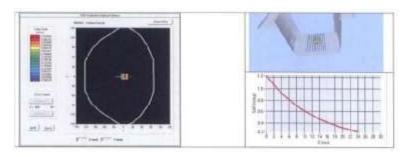
Bolt ACK 537-2-10 SATU-A

5500	48.6 (10.%)	1.05 (10%
5600	48.5 110 %	1.77.150%
5800	46.7 (10%)	£00±10%

# 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V4
Phanton	SN 20/99 SAM71
Pyelac	SN 18/11 EPG 122
Liquid	Body Usprif Values: eps' : 56.3 sigma : 0.98
Distance between dipole corner and liquid	15.0 mm
Arra scan resolution	ds-8mm/dy-8mm
Zoon Scan Reselution	ds:/kmm/dy-/fm/da=5mm
Frequency	750 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45%

Frequency MHz	LgSAR(W/kg/W)	IS a SAN (W/vg/W)
	menured	measured
750	8.78 (0.86)	3.88 (0.59)



Propr. 10/11

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# SAR REFERENCE DIPOLE CALIBRATION REPORT

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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	Satino	SN-20/09-SAM71	Validated, No cal required.	Validated. No ca required.	
COMOSAR Test Bench	Version 3	NA.	Validated. No cail required.	Validated No car 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	10/2014	10/2015	
Multimeter	Kelthley 2000	1188856	12/2013	12/2016	
Signal Generator	Agilent E4438C	MY49070561	12/2013	12/2016	
Amplifier	Aethercomm	SN 046	Characterized prior to lest. No call required.	Characterized prior to test. No cal required.	
Power Meter	H6F E4418A	US38261468	12/2013	12/2016	
Power Sensor	HP ECP-E26A	US37181460	12/2013	12/2016	
Directional Coupler	Narda 4216-20	D1386	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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Report No.: AGC04183150401FH01

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# SAR Reference Dipole Calibration Report

Ref: ACR.318.9.13.SATU.A

# ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1&2F, NO.2 BUILDING, HUAFENG NO.1 INDUSTRIAL PARK, GUSHU COMMUNITY XIXIANG STREET BAOAN DISTRICT, SHENZHEN, P.R. CHINA SATIMO COMOSAR REFERENCE DIPOLE

FREQUENCY: 2450 MHZ

SERIAL NO.: SN 46/11 DIP 2G450-189

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



11/14/13

# 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.

Report No.: AGC04183150401FH01 Page 215 of 221



# SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR 318.9.13 SATU A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/14/2013	JES
Checked by :	Jérôme LUC	Product Manager	11/14/2013	25
Approved by :	Kim RUTKOWSKI	Quality Manager	11/14/2013	ALM ALETRANATI

	Customer Name
Distribution:	ATTESTATION
	OF GLOBAL
	COMPLIANCE
	CO. LTD.

Issue	Date	Modifications
A	11/14/2013	Initial release



Ref. ACR.318.9.13.SATU.A

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Ref. ACR 318.9 13.SATU.A

### 1 INTRODUCTION

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

# 2 DEVICE UNDER TEST

Device Under Test		
COMOSAR 2450 MHz REFERENCE DIPOLE		
Satimo		
SID2450		
SN 46/11 DIP 2G450-189		
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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Ref. ACR 318 9 13 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 constucted 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	Exp anded Uncertainty
1 g	20.3 %
10 g	20.1 %

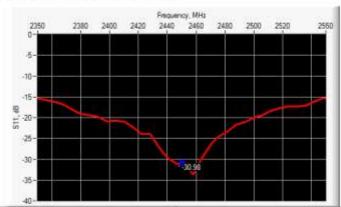
Page: 5/10



Ref. ACR.318.9.13.SATU.A

# 6 CALIBRATION MEASUREMENT RESULTS

# 6.1 RETURN LOSS AND IMPEDANCE



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2450	-30.98	-20	47.3 Ω + 0.1 jΩ

# 6.2 MECHANICAL DIMENSIONS

Frequency MHz	Lmm		hmm		<b>d</b> mm	
	required	measured	required	measured	required	measure
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	90.5 ±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	69.0 ±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 %.	PASS	30.4±1 %.	PASS	3.6 ±1 %.	PAS5
2600	48.5 ±1 %.		28.8 ±1 %.		3.6 ±1 %.	
3000	41.5 ±1 %		25,0 ±1 %.		3.6 ±1 %.	
3500	37.0±1 %,		26.4±1 %.		3.6 ±1 %.	
3700	34.7±1 %.		26.4±1%		3.6 ±1 %.	

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### SAR REFERENCE DIPOLE CALIBRATION REPORT

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# 7 VALIDATION MEASUREMENT

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

# 7.1 MEASUREMENT CONDITION

Software	OPENSAR V4
Phantom	SN 20/09 SAM71
Probe	SN 18/11 EPG122
Liquid	Head Liquid Values: eps' : 38.6 sigma : 1,82
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=8mm/dy=8m/dz=5mm
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	21 °C
Lab Temperature	21 °C
Lab Humidity	45%

# 7.2 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (e,')		Conductivity (s) 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%	
1.450	40.5 ±5 %		1.20 ±5 %	
1500	40.4±5%		1.23 ±5 %	
1640	40.2 ±5 %		1.31 ±5 %	
1758	40.1 ±5 %		1.37±5%	
1800	40.0 ±5 %		1.40 ±5 %	
1900	40.0 ±5 %		1.40 ±5 %	
1950	40.0 ±5 %		1.40 ±5 %	
2000	40.0 ±5 %		1.40 ±5 %	
2100	99.8 ±5 %		1,49 ±5 %	
2300	39.5 ±5 %		1.67±5%	
2450	39.2 ±5 %	PASS	1.80 ±5 %	PASS
2600	39.0 ±5 %		1.96 ±5 %	
3000	38.5 ±5 %		2.40 ±5 %	
3500	37.9 ±5 %		2.91 ±5 %	

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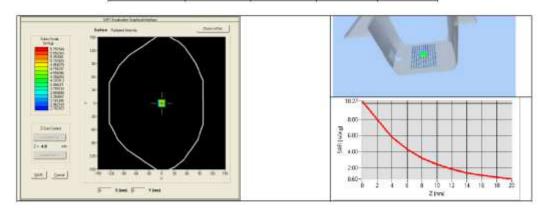


Ref. ACR 318.9.13 SATU.A

# 7.3 MEASUREMENT RESULT

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

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	J.
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	54.40 (5.44)	2.4	23.75 (2.38
2600	55.3		24.6	
3000	63.8		25.7	1
3500	67.1		25	



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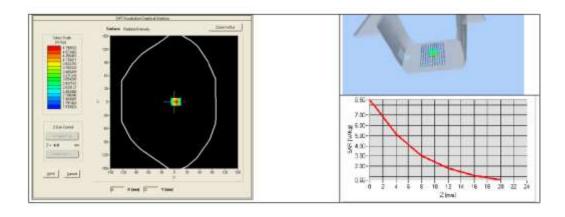


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# 7.4 BODY MEASUREMENT RESULT

Software	OPENSAR V4	
Phantom	SN 20/09 SAM71	
Probe	SN 18/11 EPG122	
Liquid	Body Liquid Values eps' : 52.0 sigma : 1.94	
Distance between dipole center and liquid	10.0 mm	
Area scan resolution	dx=8mm/dy=8mm	
Zoon Scan Resolution	dx=9mm/dy=9m/dz=5mm	
Frequency	2450 MHz	
Input power	20 dBm	
Liquid Temperature	21 °C	
Lab Temperature	21 °C	
Lab Humidity	45%	

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)	
	measured	measured	
2450	54.19 (5.42)	24.96 (2.50)	



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# 8 LIST OF EQUIPMENT

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 ca required.		
COMOSAR Test Bench	Version 3	NA	Validated, No cal required.	Validated. No ca required.		
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2013	02/2016		
Calipers	Carrera	CALIPER-01	12/2010	12/2013		
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	11/2010	11/2013		
Signal Generator	Agilent E4438C	MY49070581	12/2010	12/2013		
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required	Characterized prior to test. No cal required.		
Power Meter	HP E4418A	US38261498	11/2010	11/2013		
Power Sensor	HP ECP-E26A	US37181460	11/2010	11/2013		
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	3/2012	3/2014		