

CALIBRATION REPORT

E.1 E-Field Probe



COMOHAC E-Field Probe Calibration Report

Ref : ACR.71.19.19.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
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PROVINCE, P.R. CHINA 518055
MVG COMOHAC E-FIELD PROBE
SERIAL NO.: SN 24/13 EPH41

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



11/16/2019

Summary:

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



COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.71.19.19.SATULA

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/6/2019	
Checked by :	Jérôme LUC	Product Manager	11/6/2019	
Approved by :	Kim RUTKOWSKI	Quality Manager	11/6/2019	

	Customer Name
Distribution :	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

Issue	Date	Modifications
A	11/6/2019	Initial release



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COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.71.19.19.SATU.A

1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOHAC E FIELD PROBE
Manufacturer	MVG
Model	SCE
Serial Number	SN 24/13 EPH41
Product Condition (new / used)	Used
Frequency Range of Probe	0.7GHz-2.5GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=1.139 MΩ Dipole 2: R2=1.139 MΩ Dipole 3: R3=1.104 MΩ

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOHAC E field Probes are built in accordance to the ANSI C63.19 and IEEE 1309 standards.



Figure 1 – MVG COMOHAC E field Probe

Probe Length	330 mm
Length of Individual Dipoles	3.3 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	5 mm
Distance between dipoles / probe extremity	3 mm

3 MEASUREMENT METHOD

All methods used to perform the measurements and calibrations comply with the ANSI C63.19 and IEEE 1309 standards.

3.1 LINEARITY

The linearity was determined using a standard dipole with the probe positioned 10 mm above the dipole. The input power of the dipole was adjusted from -15 to 36 dBm using a 1dB step (to cover the range 2V/m to 1000A/m).



COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.71.19.19.SATU.A

3.2 SENSITIVITY

The sensitivity factors of the three dipoles were determined using the waveguide method outlined in the fore mentioned standards.

3.3 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole. The probe was rotated along its main axis from 0 - 360 degrees in 15 degree steps.

3.4 PROBE MODULATION RESPONSE

The modulation factor was determined by illuminating the probe with a reference wave from a standard dipole 10 mm away, applying first a CW signal and then a modulated signal (both at same power level). The modulation factor is the ratio, in linear units, of the CW to modulated signal reading.

4 MEASUREMENT UNCERTAINTY

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

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	ci	Standard Uncertainty (%)
Incident or forward power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Reflected power	3.00%	Rectangular	$\sqrt{3}$	1	1.732%
Field homogeneity	3.00%	Rectangular	$\sqrt{3}$	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%
Combined standard uncertainty					4.509%
Expanded uncertainty 95 % confidence level k = 2					9.0%

5 CALIBRATION MEASUREMENT RESULTS

Calibration Parameters	
Lab Temperature	21 °C

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COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.71.19.SATU.A

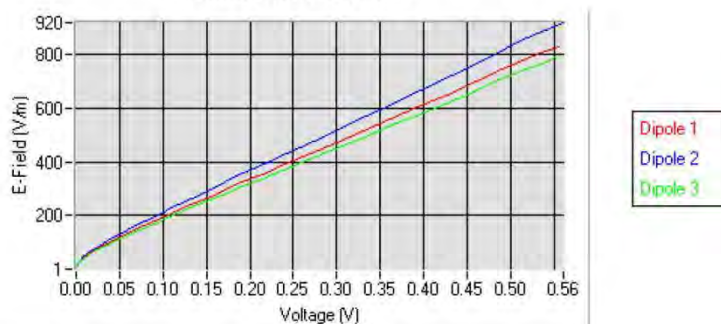
Lab Humidity	45 %
--------------	------

5.1 SENSITIVITY IN AIR

Normx dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normy dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$)
5.19	5.27	5.14

DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
95	97	91

Calibration curves

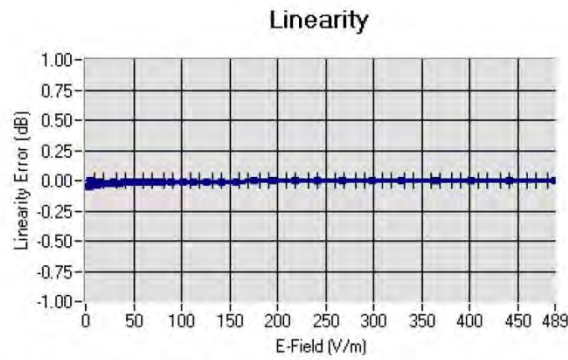




COMOHAC E-FIELD PROBE CALIBRATION REPORT

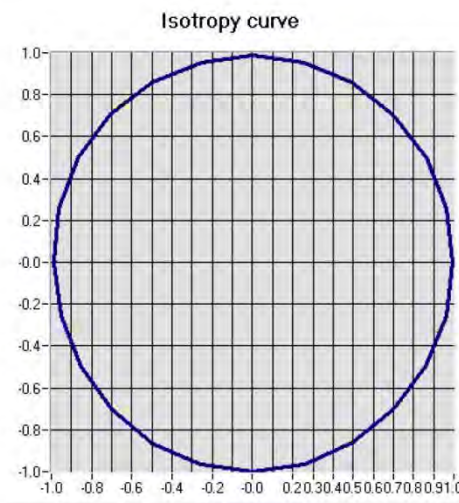
Ref: ACR.71.19.SATU.A

5.2 LINEARITY



Linearity: $\pm 1.10\%$ ($\pm 0.05\text{dB}$)

5.3 ISOTROPY



Isotropy: $\pm 0.71\%$ ($\pm 0.03\text{dB}$)



COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR-71.19.19.SATU.A

6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
HAC positioning ruler	MVG	TABH12 SN 42/09	Validated. No cal required.	Validated. No cal required.
COMOHAC Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2019	02/2022
Reference Probe	MVG	EPH28 SN 08/11	10/2019	10/2020
Reference Probe	MVG	HPH38 SN31/10	10/2019	10/2020
Multimeter	Keithley 2000	1188656	01/2017	01/2020
Signal Generator	Agilent E4438C	MY49070581	01/2017	01/2020
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	01/2017	01/2020
Power Sensor	HP ECP-E26A	US37181460	01/2017	01/2020
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Waveguide	Mega Industries	069Y7-158-13-712	Validated. No cal required.	Validated. No cal required.
Waveguide Transition	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Waveguide Termination	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Control Company	150798832	11/2017	11/2020



E.2 Dipole DHA41

Report No.: BL-SZ2090180-702



HAC Reference Dipole Calibration Report

Ref : ACR.71.20.19.SATU.A

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PROVINCE, P.R. CHINA 518055
MVG COMOHAC REFERENCE DIPOLE
FREQUENCY: 800-950MHZ
SERIAL NO.: SN 18/12 DHA41

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



11/16/2019

Summary:

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



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.20.19.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/16/2019	<i>JS</i>
Checked by :	Jérôme LUC	Product Manager	11/16/2019	<i>JS</i>
Approved by :	Kim RUTKOWSKI	Quality Manager	11/16/2019	<i>Kim Rutkowski</i>

	Customer Name
Distribution :	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

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A	11/16/2019	Initial release



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1 INTRODUCTION

This document contains a summary of the requirements set forth by the ANSI C63.19 standard for reference dipoles used for HAC 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	COMOHAC 800-950 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SIDB835
Serial Number	SN 18/12 DHA41
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOHAC Validation Dipoles are built in accordance to the ANSI C63.19 standard. The product is designed for use with the COMOHAC system only.



Figure 1 – MVG COMOHAC Validation Dipole

4 MEASUREMENT METHOD

The ANSI C63.19 standard outlines the requirements for reference dipoles to be used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standard.

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HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR,71.20.19.SATU.A

4.1 RETURN LOSS REQUIREMENTS

The dipole used for HAC system validation measurements and checks must have a return loss of -10 dB or better. The return loss measurement shall be performed in free space.

4.2 REFERENCE DIPOLE CALIBRATION

The IEEE ANSI C63-19 standard states that the dipole used for validation measurements and checks must be scanned with the E and H field probe, with the dipole 10 mm below the probe. The E and H field strength plots are compared to the simulation results obtained by MVG.

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 Gain
400-6000MHz	0.1 dB

5.2 VALIDATION MEASUREMENT

The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	Uncertainty (dB)	Standard Uncertainty (%)
RF reflections	0.1	R	$\sqrt{3}$	0.06	
Field probe conv. Factor	0.4	R	$\sqrt{3}$	0.23	
Field probe anisotropy	0.25	R	$\sqrt{3}$	0.14	
Positioning accuracy	0.2	R	$\sqrt{3}$	0.12	
Probe cable placement	0.1	R	$\sqrt{3}$	0.06	
System repeatability	0.2	R	$\sqrt{3}$	0.12	
EUT repeatability	0.4	N	1	0.40	
Combined standard uncertainty				0.52	
Expanded uncertainty 95 % confidence level k = 2				1.00	13.0

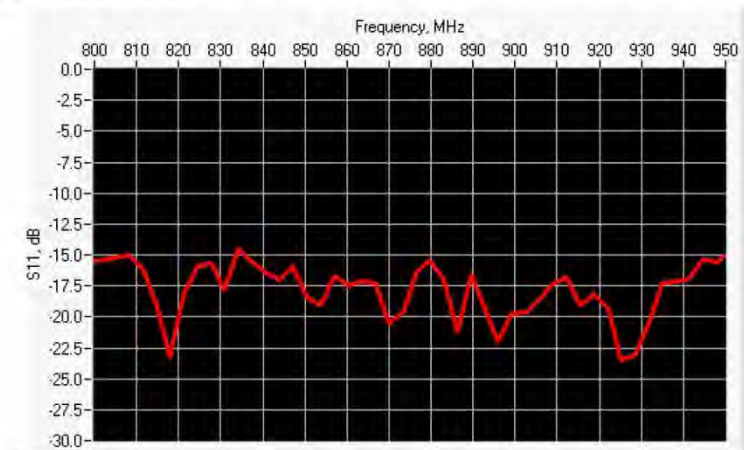


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.20.19.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS



Frequency (MHz)	Worst Case Return Loss (dB)	Requirement (dB)
800-950 MHz	-14.53	-10

6.2 VALIDATION MEASUREMENT

The IEEE ANSI C63.19 standard states that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss requirements. The system validations measurement results are then compared to MVG's simulated results.

Measurement Condition

Software Version	OpenHAC V2
HAC positioning ruler	SN 42/09 TABH12
E-Field probe	SN 08/11 EPH28
H-Field probe	SN 31/10 HPH38
Distance between dipole and sensor center	10 mm
E-field scan size	X=150mm/Y=20mm
H-field scan size	X=40mm/Y=20mm
Scan resolution	dx=5mm/dy=5mm
Frequency	835 MHz
Input power	20 dBm
Lab Temperature	21°C
Lab Humidity	45%

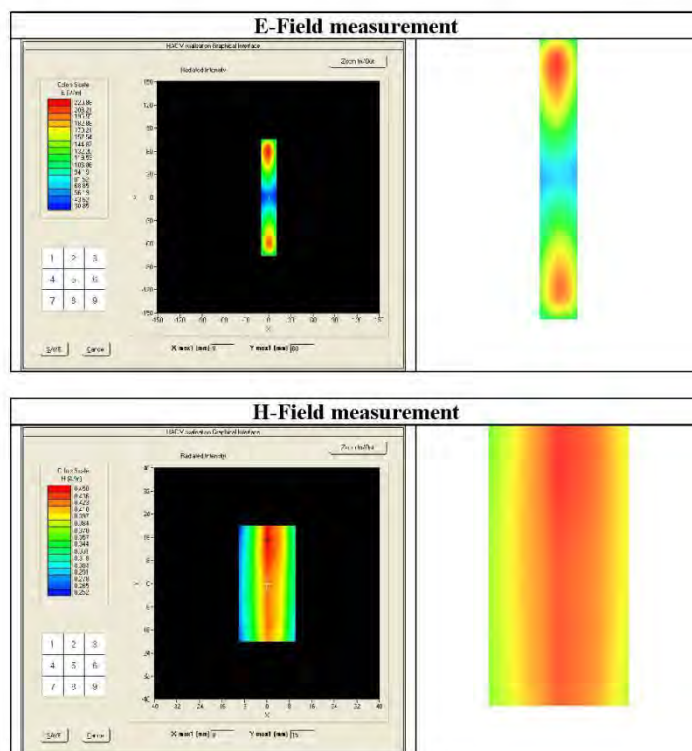


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.20.19.SATU.A

Measurement Result

	Measured	Internal Requirement
E field (V/m)	220.88	220.4
H field (A/m)	0.45	0.445





HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.20.19.SATU.A

7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
HAC positioning ruler	MVG	TABH12 SN 42/09	Validated. No cal required.	Validated. No cal required.
COMOHAC Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2019	02/2022
Reference Probe	MVG	EPH28 SN 08/11	10/2019	10/2020
Reference Probe	MVG	HPH38 SN31/10	10/2019	10/2020
Multimeter	Keithley 2000	1188656	01/2017	01/2020
Signal Generator	Agilent E4438C	MY49070581	01/2017	01/2020
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	01/2017	01/2020
Power Sensor	HP ECP-E26A	US37181460	01/2017	01/2020
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	150798832	11/2017	11/2020



E.3 Dipole DHB46

Report No.: BL-SZ2090180-702



HAC Reference Dipole Calibration Report

Ref : ACR.71.21.19.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
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NANSHAN DISTRICT, SHENZHEN, GUANGDONG
PROVINCE, P.R. CHINA 518055
MVG COMOHAC REFERENCE DIPOLE
FREQUENCY: 1700-2000MHZ
SERIAL NO.: SN 18/12 DHB46

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



11/16/2019

Summary:

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



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/16/2019	
Checked by :	Jérôme LUC	Product Manager	11/16/2019	
Approved by :	Kim RUTKOWSKI	Quality Manager	11/16/2019	

	Customer Name
Distribution :	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

Issue	Date	Modifications
A	11/16/2019	Initial release



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

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HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

1 INTRODUCTION

This document contains a summary of the requirements set forth by the ANSI C63.19 standard for reference dipoles used for HAC 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	COMOHAC 1700-2000 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SIDB1900
Serial Number	SN 18/12 DHB46
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOHAC Validation Dipoles are built in accordance to the ANSI C63.19 standard. The product is designed for use with the COMOHAC system only.



Figure 1 – MVG COMOHAC Validation Dipole

4 MEASUREMENT METHOD

The ANSI C63.19 standard outlines the requirements for reference dipoles to be used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standard.

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HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

4.1 RETURN LOSS REQUIREMENTS

The dipole used for HAC system validation measurements and checks must have a return loss of -10 dB or better. The return loss measurement shall be performed in free space.

4.2 REFERENCE DIPOLE CALIBRATION

The IEEE ANSI C63-19 standard states that the dipole used for validation measurements and checks must be scanned with the E and H field probe, with the dipole 10 mm below the probe. The E and H field strength plots are compared to the simulation results obtained by MVG.

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 Gain
400-6000MHz	0.1 dB

5.2 VALIDATION MEASUREMENT

The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	Uncertainty (dB)	Standard Uncertainty (%)
RF reflections	0.1	R	$\sqrt{3}$	0.06	
Field probe conv. Factor	0.4	R	$\sqrt{3}$	0.23	
Field probe anisotropy	0.25	R	$\sqrt{3}$	0.14	
Positioning accuracy	0.2	R	$\sqrt{3}$	0.12	
Probe cable placement	0.1	R	$\sqrt{3}$	0.06	
System repeatability	0.2	R	$\sqrt{3}$	0.12	
EUT repeatability	0.4	N	1	0.40	
Combined standard uncertainty				0.52	
Expanded uncertainty 95 % confidence level k = 2				1.00	13.0

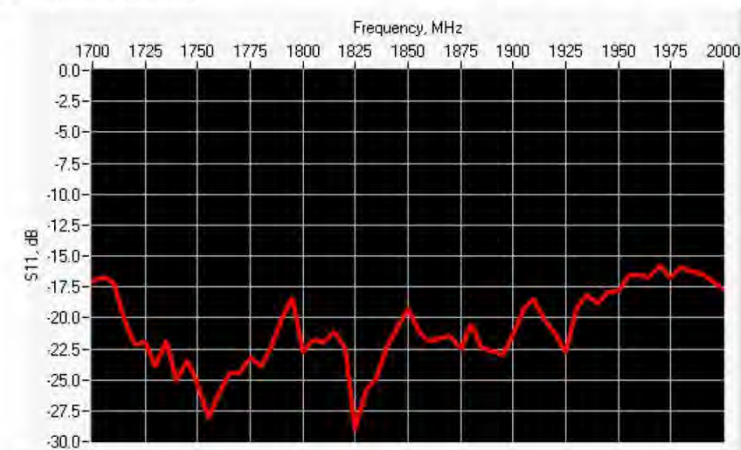


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS



Frequency (MHz)	Worst Case Return Loss (dB)	Requirement (dB)
1700-2000 MHz	-15.78	-10

6.2 VALIDATION MEASUREMENT

The IEEE ANSI C63.19 standard states that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss requirements. The system validations measurement results are then compared to MVG's simulated results.

Measurement Condition

Software Version	OpenHAC V2
HAC positioning ruler	SN 42/09 TABH12
E-Field probe	SN 08/11 EPH28
H-Field probe	SN 31/10 HPH38
Distance between dipole and sensor center	10 mm
E-field scan size	X=150mm/Y=20mm
H-field scan size	X=40mm/Y=20mm
Scan resolution	dx=5mm/dy=5mm
Frequency	1900 MHz
Input power	20 dBm
Lab Temperature	21°C
Lab Humidity	45%

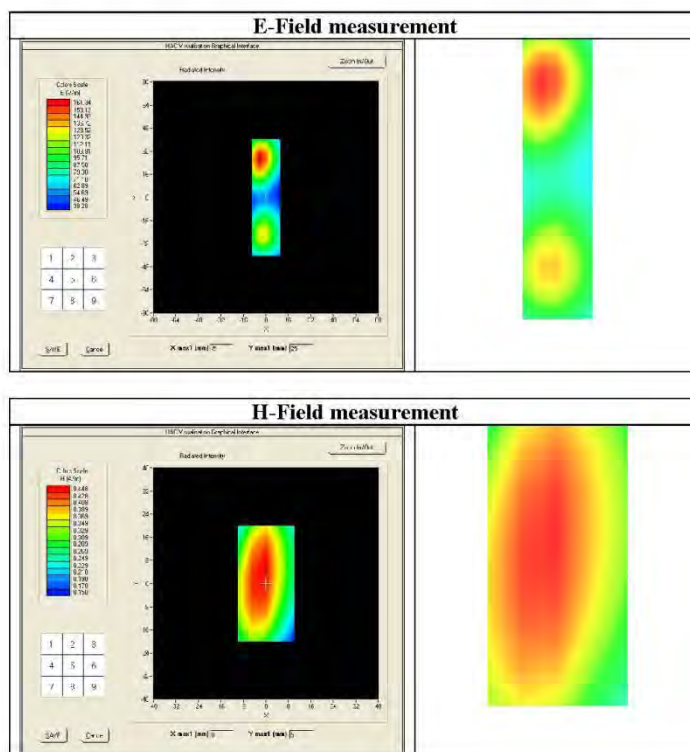


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

Measurement Result

	Measured	Internal Requirement
E field (V/m)	161.34	153.4
H field (A/m)	0.45	0.445





HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.21.19.SATU.A

7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
HAC positioning ruler	MVG	TABH12 SN 42/09	Validated. No cal required.	Validated. No cal required.
COMOHAC Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2019	02/2022
Reference Probe	MVG	EPH28 SN 08/11	10/2019	10/2020
Reference Probe	MVG	HPH38 SN31/10	10/2019	10/2020
Multimeter	Keithley 2000	1188656	01/2017	01/2020
Signal Generator	Agilent E4438C	MY49070581	01/2017	01/2020
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	01/2017	01/2020
Power Sensor	HP ECP-E26A	US37181460	01/2017	01/2020
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	150798832	11/2017	11/2020



E.4 Dipole DHC48

Report No.: BL-SZ2090180-702



HAC Reference Dipole Calibration Report

Ref : ACR.71.22.19.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
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PROVINCE, P.R. CHINA 518055
MVG COMO HAC REFERENCE DIPOLE
FREQUENCY: 2100-2600MHZ
SERIAL NO.: SN 18/12 DHC48

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



11/16/2019

Summary:

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



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.22.19.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	11/16/2019	<i>JS</i>
Checked by :	Jérôme LUC	Product Manager	11/16/2019	<i>JS</i>
Approved by :	Kim RUTKOWSKI	Quality Manager	11/16/2019	<i>Kim Rutkowski</i>

	Customer Name
Distribution :	SHENZHEN BALUN TECHNOLOGY Co.,Ltd.

Issue	Date	Modifications
A	11/16/2019	Initial release



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.22.19.SATU.A

1 INTRODUCTION

This document contains a summary of the requirements set forth by the ANSI C63.19 standard for reference dipoles used for HAC 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	COMOHAC 2100-2600 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SIDB2450
Serial Number	SN 18/12 DHC48
Product Condition (new / used)	Used

A yearly calibration interval is recommended.

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOHAC Validation Dipoles are built in accordance to the ANSI C63.19 standard. The product is designed for use with the COMOHAC system only.



Figure 1 – MVG COMOHAC Validation Dipole

4 MEASUREMENT METHOD

The ANSI C63.19 standard outlines the requirements for reference dipoles to be used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standard.

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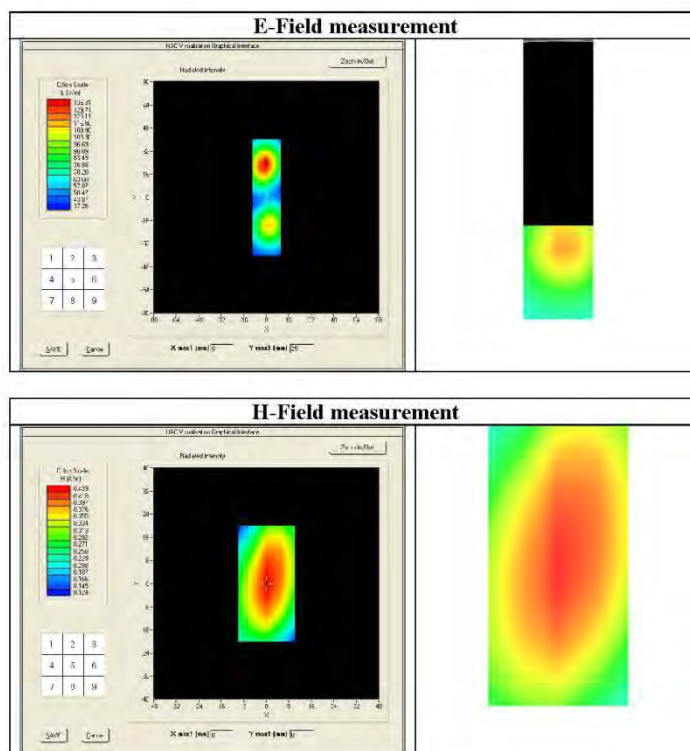


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.22.19.SATU.A

Measurement Result

	Measured	Internal Requirement
E field (V/m)	136.31	134.7
H field (A/m)	0.44	0.439



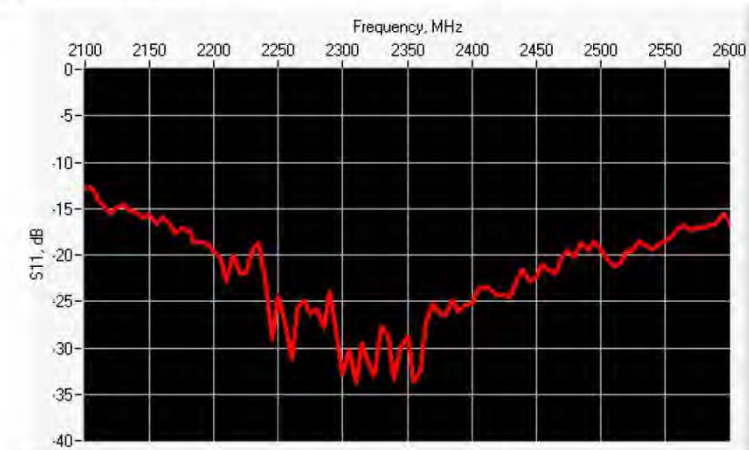


HAC REFERENCE DIPOLE CALIBRATION REPORT

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6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS



Frequency (MHz)	Worst Case Return Loss (dB)	Requirement (dB)
2100-2600 MHz	-12.80	-10

6.2 VALIDATION MEASUREMENT

The IEEE ANSI C63.19 standard states that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss requirements. The system validations measurement results are then compared to MVG's simulated results.

Measurement Condition

Software Version	OpenHAC V2
HAC positioning ruler	SN 42/09 TABH12
E-Field probe	SN 08/11 EPH28
H-Field probe	SN 31/10 HPH38
Distance between dipole and sensor center	10 mm
E-field scan size	X=150mm/Y=20mm
H-field scan size	X=40mm/Y=20mm
Scan resolution	dx=5mm/dy=5mm
Frequency	2450 MHz
Input power	20 dBm
Lab Temperature	21°C
Lab Humidity	45%



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.22.19.SATU.A

4.1 RETURN LOSS REQUIREMENTS

The dipole used for HAC system validation measurements and checks must have a return loss of -10 dB or better. The return loss measurement shall be performed in free space.

4.2 REFERENCE DIPOLE CALIBRATION

The IEEE ANSI C63-19 standard states that the dipole used for validation measurements and checks must be scanned with the E and H field probe, with the dipole 10 mm below the probe. The E and H field strength plots are compared to the simulation results obtained by MVG.

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 Gain
400-6000MHz	0.1 dB

5.2 VALIDATION MEASUREMENT

The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	Uncertainty (dB)	Standard Uncertainty (%)
RF reflections	0.1	R	$\sqrt{3}$	0.06	
Field probe conv. Factor	0.4	R	$\sqrt{3}$	0.23	
Field probe anisotropy	0.25	R	$\sqrt{3}$	0.14	
Positioning accuracy	0.2	R	$\sqrt{3}$	0.12	
Probe cable placement	0.1	R	$\sqrt{3}$	0.06	
System repeatability	0.2	R	$\sqrt{3}$	0.12	
EUT repeatability	0.4	N	1	0.40	
Combined standard uncertainty				0.52	
Expanded uncertainty 95 % confidence level $k = 2$				1.00	13.0



HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.71.22.19.SATU.A

7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
HAC positioning ruler	MVG	TABH12 SN 42/09	Validated. No cal required.	Validated. No cal required.
COMOHAC Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rhode & Schwarz ZVA	SN100132	02/2019	02/2022
Reference Probe	MVG	EPH28 SN 08/11	10/2019	10/2020
Reference Probe	MVG	HPH38 SN31/10	10/2019	10/2020
Multimeter	Keithley 2000	1188656	01/2017	01/2020
Signal Generator	Agilent E4438C	MY49070581	01/2017	01/2020
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	HP E4418A	US38261498	01/2017	01/2020
Power Sensor	HP ECP-E26A	US37181460	01/2017	01/2020
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	150798832	11/2017	11/2020

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--END OF REPORT--