HAC T-COIL TEST

REPORT

Report No.:	SET2017-05261
Product:	4G Smart Phone
Model No.:	L500U
Brand Name:	N/A
Applicant:	Hyundai Corporation
Address:	25, Yulgok-ro 2-Gil, Jongno-gu, Seoul, South Korea
Issued by:	CCIC-SET
Test date	April 18th, 2017
Issued Date	April 20th, 2017
Lab Location:	Electronic Testing Building, Shahe Road，Xili, Nanshan District, Shenzhen, 518055, P. R. China
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Test Report

Product. ..... :	4G Smart Phone
Model No. ……..:	L500U
Brand Name……..:	N/A
FCC ID……:	RQQHLT-FSL500C
Applicant……..:	Hyundai Corporation
Applicant Address……:	25, Yulgok-ro 2-Gil, Jongno-gu, Seoul, South Korea
Manufacturer……..:	Guizhou Fortuneship Technology Co., Ltd
Manufacturer Address……:	(No. 4 Plant, High-tech Industrial Park, Xinpu Economic Development Zone) Jingkai Road, Xinpu Jingkai District, Xinpu New District, Zunyi City, Guizhou Province, P. R. China
Test Standards……..:	ANSI C63.19-2011 American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids FCC 47CFR § 20.19 American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids
Rating……:	T-Coil : T3
Test Result……:	Pass
Tested by ……..:	Zhou Gao yu , Test Engineer
Reviewed by……:	Chris You, Senior Engineer
Approved by……:	Zhuqi, Department Manager

Contents

1. GENERAL CONDITIONS

1.1 This report only refers to the item that has undergone the test.

1.2 This report standalone dose not constitute or imply by its own an approval of the product by the certification Bodies or competent Authorities.

1.3 This document is only valid if complete; no partial reproduction can be made without written approval of CCIC-SET

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1.5 CNAS-Lab Code: L1659

CCIC Southern Electronic Product Testing (Shenzhen) Co., Ltd. CCIC is a third party testing organization accredited by China National Accreditation Service for Conformity Assessment (CNAS) according to ISO/IEC 17025. The accreditation certificate number is L1659. A 12.8*6.8*6.4 (m) fully anechoic chamber was used for the radiated spurious emissions test.

2. Administrative Date

2.1. Identification of the Responsible Testing Laboratory

Company Name:	CCIC-SET
Department:	EMC & RF Department
Address:	Electronic Testing Building, Shahe Road, Nanshan District, ShenZhen, P. R. China
Telephone:	+86-755-26629676
Fax:	+86-755-26627238
Responsible Test Lab Managers:	Mr. Wu Li'an

2.2. Identification of the Responsible Testing Location(s)

Company Name:	CCIC-SET
Address:	Electronic Testing Building, Shahe Road, Nanshan District, Shenzhen, P. R. China

2.3. Organization Item

CCIC-SET Report No.:	SET2017-05261
CCIC-SET Project Leader:	Mr. Li Sixiong
CCIC-SET Responsible for accreditation scope:	Mr. Wu Li'an
Start of Testing:	2017-04-18
End of Testing:	2017-04-18

2.4. Identification of Applicant

Company Name:	Hyundai Corporation
Address:	25, Yulgok-ro 2-Gil, Jongno-gu, Seoul, South Korea
Manufacturer Name:	Guizhou Fortuneship Technology Co., Ltd
Address:	(No. 4 Plant, High-tech Industrial Park, Xinpu Economic Development Zone) Jingkai Road, Xinpu Jingkai District, Xinpu New District, Zunyi City, Guizhou Province, P. R. China

Notes: This data is based on the information by the applicant.

3. Equipment Under Test (EUT)

3.1. Identification of the Equipment under Test

Sample Name: 4G Smart Phone

Type Name: L500U

Brand Name: /

General description:	Support Band	GSM850MHz/1900MHz WCDMA 850MHz/ 1700MHz/1900MHz LTE Band 2/4/5/7/12/17 Bluetooth 2.4GHz/ WIFI 2.4GHz
	Test Band	GSM 850MHz/ GSM 1900MHz WCDMA 850MHz/ 1700MHz/1900MHz
	Development Stage	Identical Prototype
	Accessories	Power Supply
	Antenna type	PIFA Antenna
	Operation mode	GSM/WCDMA
	Modulation mode	GMSK, 8PSK, QPSK, 16QAM

NOTE:

a. The EUT is a model of /operating in GSM 850 / 1900, WCDMA 850 /1700/1900 MHz LTE band2/4/5/7/12/17, 2.4 GHz WIFI, BT.

b. Please refer to Appendix C for the photographs of the EUT. For a more detailed features description about the EUT, please refer to User's Manual.

3.2 Summary of test results

3.2.1 Test Standards

No.	Identity	Document Title
1	FCC 47 CFR Part 20.19	Hearing aid-compatible mobile handsets.
2	ANCI C63.19:2011	American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids
3	285076 D01 HAC Guidance v04r01	EQUIPMENT AUTHORIZATION GUIDANCE FOR HEARING AID COMPATIBILITY
4	285076 D02 T-Coil testing for CMRS IP v02	GUIDANCE FOR PERFORMING T-COIL TESTS FOR AIR INTERFACES SUPPORTING VOICE OVER IP (E.G., LTE AND WI-FI) TO SUPPORT CMRS BASED TELEPHONE SERVICES

3.2.2 Summary Of HAC Rating

Summary of T-Rating

Band	T-Rating	Frequency response
GSM850	T3	PASS
GSM1900	T4	PASS
WCDMA850	T4	PASS
WCDMA1700	T4	PASS
WCDMA1900	T4	PASS

4. Hearing Aid Compatibility (HAC)

4.1 Introduction

The purpose of the Hearing Aid Compatibility extension is to enable measurements of the near electric and magnetic fields generated by wireless communication devices in the region controlled for use by a hearing aid in accordance with ANSI-C63.19-2011 FCC has granted a request for waiver of the HAC rules in section 20.19 for dual band GSM handsets. The waiver has specific conditions, as stated in the order (FCC 05-166) and expires 1 August 2007.

The purpose of this standard is to establish categories for hearing aids and for WD (wireless communications devices) that can indicate to health care practitioners and hearing aid users which hearing aids are compatible with which WD, and to provide tests that can be used to assess the electromagnetic characteristics of hearing aids and WD and assign them to these categories. The various parameters required, in order to demonstrate compatibility and accessibility are measured. The design of the standard is such that when a hearing aid and WD achieve one of the categories specified, as measured by the methodology of this standard, the indicated performance is realized.

In order to provide for the usability of a hearing aid with a WD, several factors must be coordinated:

a) Radio frequency (RF) measurements of the near-field electric and magnetic fields emitted by a WD to categorize these emissions for correlation with the RF immunity of a hearing aid.
b) Magnetic field measurements of a WD emitted via the audio transducer associated with the T-coil mode of the hearing aid, for assessment of hearing aid performance.
c) Measurements with the hearing aid and a simulation of the categorized WD T-coil emissions to assess the hearing aid RF immunity in the T-coil mode.

The WD radio frequency (RF) and audio band emissions are measured.

Hence, the following are measurements made for the WD:

a) RF E-Field emissions
c) T-coil mode, magnetic signal strength in the audio band
d) T-coil mode, magnetic signal and noise articulation index
e) T-coil mode, magnetic signal frequency response through the audio band

Corresponding to the WD measurements, the hearing aid is measured for:

a) RF immunity in microphone mode
b) RF immunity in T-coil mode

4.2 Description of Test System

4.2.1 COMOHAC T-COIL PROBE

Serial Number:	SN 24/11 TCP23
Frequency range:	200 Hz -5000 Hz
Dimensions:	6.55mm length*2.29mm diameter
DC resistance:	860.6 Ω
Wire size:	51 AWG
Inductance:	132.1 mH at 1kHz
Sensitivity:	-60.20 dB (V/A/m) at 1kHz

4.2.4 System Hardware

The HAC positioning ruler is used to position the phone properly with the regard to the position of the probe during a measurement. The positioning system is made of a dedicated frame that can be fixed on the table. The tip of the probe is positioned on a reference point located on the top of the positioning ruler. The distance between this reference point and the cross located on the ruler being known, the speaker of the phone is positioned on this cross in order to make sure both probe and phone are positioned properly.

During the measurement, the HAC ruler has to be removed so that it does not interfere with the measurement.

Position device

5. OPERATIONAL CONDITIONS DURING TEST

5.1 Schematic Test Configuration

During SAR test, EUT was operating in Traffic Mode (Channel Allocated) at Normal Voltage Condition. A communication link is set up with a System Simulator (SS) by air link, and a call is established.

The EUT should use its internal transmitter. The antenna(s), battery and accessories shall be those specified by the manufacturer. The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power output. If a wireless link was used, the antenna connected to the output of the base station simulator shall be placed at least 50 cm away from the handset.

The signal transmitted by the simulator to the antenna feeding point should be lower than the output power level of the handset by at least 35 dB

Air-interface	Band (MHz)	Type	C63.19-2011 Tested	Simultaneous Transmissions	Reduced power	OTT
GSM	850	VO	Yes	WIFI and BT	N/A	N/A
	1900	VO	Yes	WIFI and BT	N/A	N/A
	GPRS/EDGE	DT	N/A	WIFI and BT	N/A	YES
WCDMA	850	VO	Yes	WIFI and BT	N/A	N/A
	1700	VO	Yes	WIFI and BT	N/A	N/A
	1900	VO	Yes	WIFI and BT	N/A	N/A
	HSDPA	DT	N/A	WIFI and BT	N/A	YES
LTE	2/4/5/7/12/17	VD	N/A	WIFI and BT	N/A	YES
WIFI	2450	VD	N/A	GSM or WCDMA or LTE	N/A	YES
BT	2450	DT	N/A	GSM or WCDMA or LTE	N/A	N/A
VO=CMRS Voice Service DT – Digital Transport VD=CMRS IP Voice Service and Digital Transport						

Note: 1. No associated T-coil measurement has been made in accordance with guidance issued by KDB285076 D02 T-Coil for CMRS IP

5.2 HAC Measurement System

The HAC measurement system being used is the COMO HAC system, the system is controlled remotely from a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans.

In operation, the system first does an 2D scan at a fixed depth within a 50mm*50mm area. When the maximum HAC point has been found, the system will then carry out a 3D scan centred at that point to determine volume averaged HAC level.

5.3 Equipments and results of validation testing

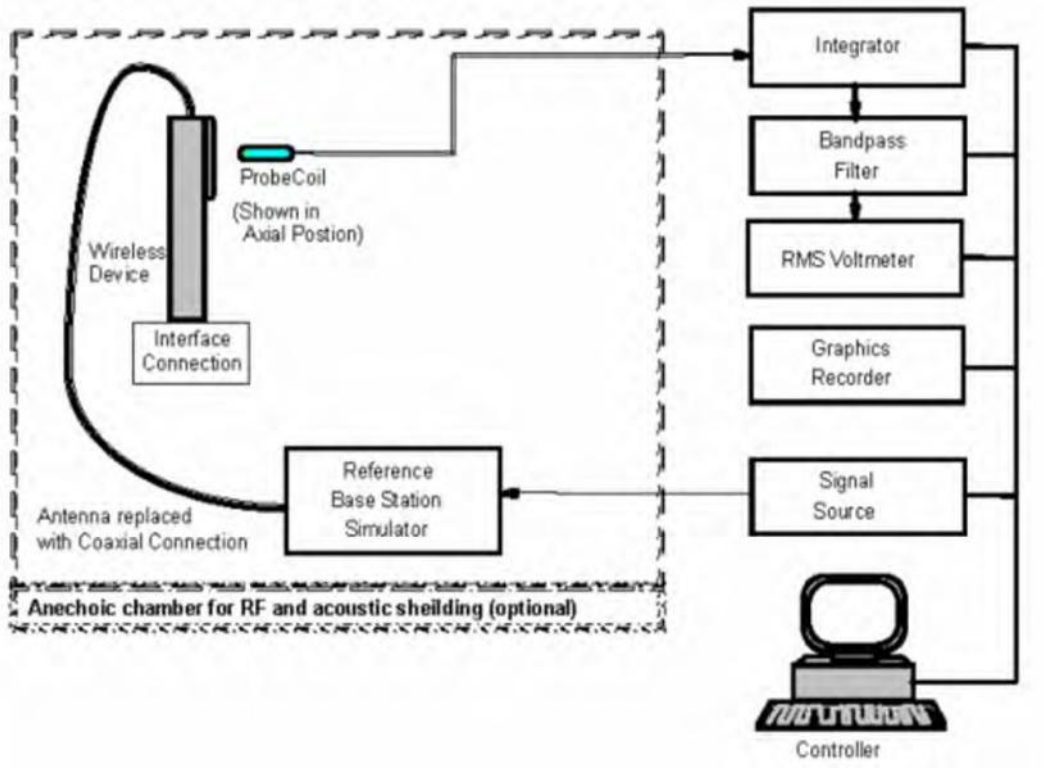
System Audio Validation

Put the phone on call and select the CMU decoder cal. When the decoder cal is selected, a full sacle(3.14 dBm) signal is provided to the speech port. Measure the voltage form the speech connector using the provided CMU speech cable. For this connect the GSM/WCMDA out connector (or CDMA2K OUT connector) to the front panel of the keithley and read the AC voltage. With the speech cable provided by satiom, the GSM/WCDMA OUT connector 2 and the CDMA2K OUT connector is the connector 4.

Put the phone on call and select the CMU encoder cal. And send a signal to the CMU and check to avoid influencing the calibration. An RMS voltmeter would indicate 100 mV RMS during the first phase and 10 mV RMS during the second phase. After the first two phases, the two input channels are both calibrated for absolute measurements of voltages. The resulting factors are displayed above the multi-meter window.

After phases 1 and 2, the input channels are calibrated to measure exact voltages. This is required to use the inputs for measuring voltages with their peak and RMS value.

In phase 3, a multi-sine signal covering each third-octave band from 50 Hz to 10 kHz is generated and applied to both audio outputs. The probe should be positioned in the center of the AMCC and aligned in the z-direction, the field orientation of the AMCC. The “Coil In” channel is measuring the voltage over the AMCC internal shunt, which is proportional to the magnetic field in the AMCC. At the same time, the “Probe In" channel samples the amplified signal picked up by the probe coil and provides it to a numerical integrator. The ratio of the two voltages in each third-octave filter leads to the spectral representation over the frequency band of interest. The Coil signal is scaled in dBV, and the Probe signal is first integrated and normalized to show dB A/m. The ratio probe-to-coil at the frequency of 1 kHz is the sensitivity which will be used in the consecutive T-Coil jobs..



T-Coil measurement test setup

5.4 T-Coil Measurement Procedure

The following illustrate a typical T-Coil signal test scan over a wireless communications device:

a. Position the EUT in the test setup and connect the EUT RF connector to a base station simulator.

b. The drive level to the EUT is set such that the reference input level defined in 6.3.2.1, Table 6.1 is input to the base station simulator in the 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (ABM1) at f = 1 kHz. Either a sine wave at 1025 Hz or a voice-like signal, band-limited to the 1 kHz 1/3 octave, as defined in 6.3.2, shall be used for the reference audio signal. If interference is found at 1025 Hz an alternate nearby reference audio signal frequency may be used. The same drive level will be used for the ABM1 frequency response measurements at each 1/3 octave band center frequency. The EUT volume control may be set at any level up to maximum, provided that a signal at any frequency at maximum modulation would not result in clipping or signal overload.

c. Determine the magnetic measurement locations for the EUT, if not already specified by the manufacturer, as described in 6.3.4.1.1 and 6.3.4.4.

d. At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at f i) as described in 6.3.4.2 in each individual ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (f i) shall be centered in each 1/3

octave band maintaining the same drive level as determined in Step 2) and the reading taken for that band. Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input–output comparison using simulated speech. The full-band integrated or half-band integrated probe output, as described in D.18, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB A/m.) All measurements of the desired signal shall be shown to be of the desired signal and not of an undesired signal. This may be shown by turning the desired signal on and off with the probe measuring the same location. If the scanning method is used the scans shall show that all measurement points selected for the ABM1 measurement meet the ambient and test system noise criterion in 6.2.1.

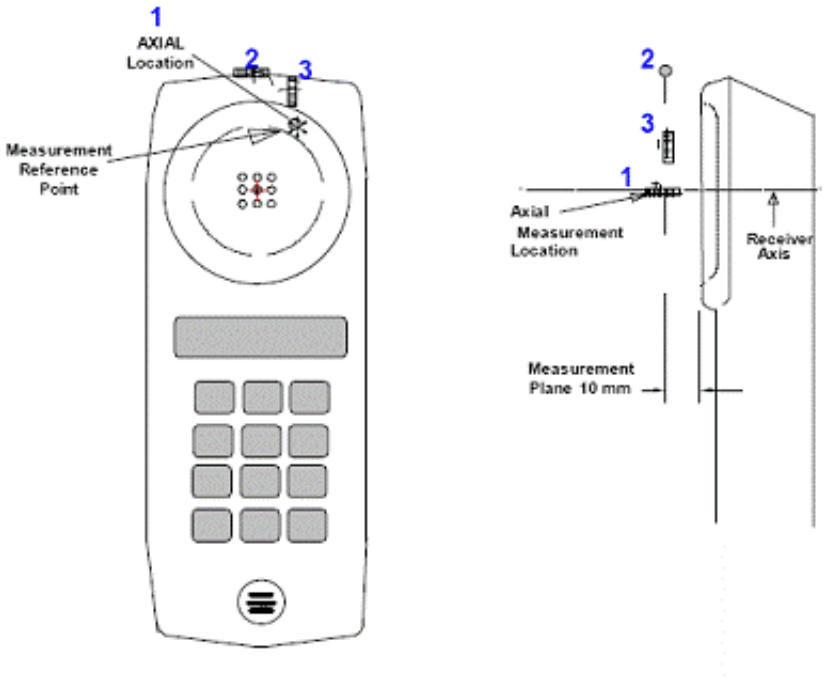
e. At each measurement location measure and record the undesired broadband audio magnetic signal (ABM2) as described in 6.3.4.3 with no audio signal applied (or digital zero applied, if appropriate) using A-weighting, and the half-band integrator. Calculate the ratio of the desired to undesired signal strength (i.e., signal quality).

f. Change the probe orientation to one of the two remaining orientations. At both measurement orientations, measure and record ABM1 using either a sine wave at 1025 Hz or a voice-like signal for the reference audio input signal.

g. Determine the category that properly classifies the signal quality.

Note:

- The area is 5 cm by 5 cm.
- The area is centered on the audio frequency output transducer of the DUT.
- The area is in a reference plane, which is defined as the planar area that contains the highest point in the area of the phone that normally rests against the user's ear. It is parallel to the centerline of the receiver area of the phone and is defined by the points of the receiver-end of the DUT handset, which, in normal handset use, rest against the ear.
- The measurement plane is parallel to, and 10 mm in front of, the reference plane.



Typical DUT reference and plane for T-Coil measurements

5.5 Test System Validation

T-coil system validation Results

Input Level （mV)	Axial Description	Location	Magnetic Field (dB A/m)	Target (dB A/m)	Deviation(%)
500	Axial	Max	-14.28	-14.51	5.4
	Radial H	Right	-21.38	-21.54	3.7
		Left	-21.88	-21.37	-12.46
	Radial V	Upper	-21.56	-21.27	-6.9
		Lower	-20.96	-20.25	-17.7
Note: The tolerance limit of System validation ±25%					

Note: Target value was referring to the Measurement value in the calibration certificate of reference dipole.

6. CHARACTERISTICS OF THE TEST

6.1 Applicable Limit Regulations

Axial and Radial Field Intensity

All orientations of the magnetic field, in the axial and radial position along the measurement plane shall be ⩾ -18 dB(A/m) at 1 kHz in a 1/3 octave band filter per § 8.3.1.

Frequency Response

The frequency response of the axial component of the magnetic field shall follow the response curve specified in EIA RS-504-1983, over the frequency range 300 Hz – 3000 Hz per § 8.3.2.

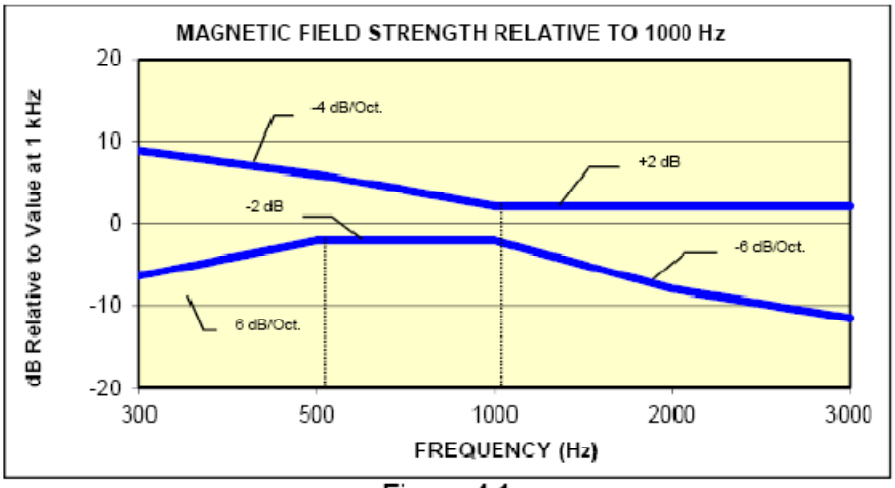


Figure 4-1
Magnetic field frequency response for Wireless Devices with an axial field ≤-15 dB (A/m) at 1 kHz

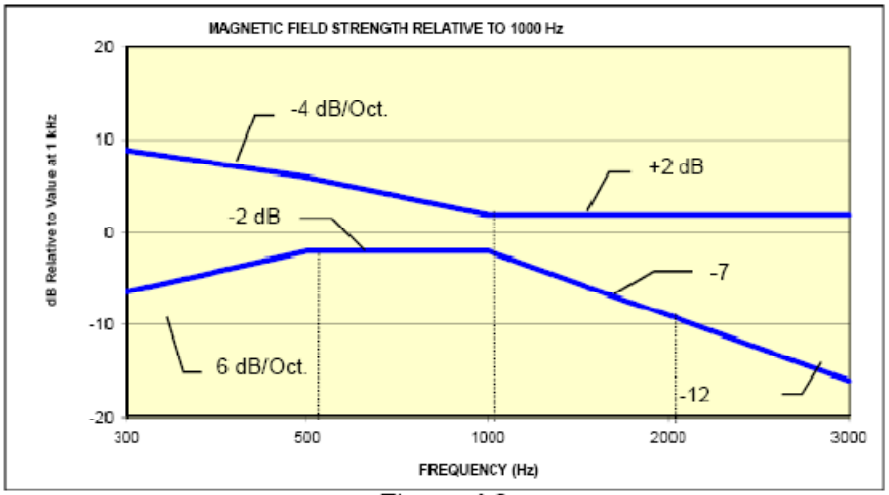


Figure 4-2
Magnetic Field frequency response for wireless devices with an axial field that exce -15 dB(A/m) at 1 kHz

Signal Quality

The table below provides the signal quality requirement for the intended audio magnetic signal from a wireless device. Only the RF immunity of the hearing aid is measured in T-coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. The only criterion that can be measured is the RF immunity in T-coil mode. This is measured using the same procedure as the audio coupling mode at the same levels.

The signal quality of the axial and radial components of the magnetic field was used to determine the T-coil mode category.

Table 3 T-Coil Mode Categories

Category	Telephone RF Parameter
	Wireless Device Signal Quality (Signal + Noise-to-noise ratio in dB)
T1	0 to 10 dB
T2	10 to 20 dB
T3	20 to 30 dB
T4	＞30 dB

6.2 Applicable Measurement Standards

ANSI C63.19-2011: American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

FCC 47CFR § 20.19 American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids

It specifies the measurement method for demonstration of compliance with the HAC limits for such equipments.

7. LABORATORY ENVIRONMENT

Table 4: The Ambient Conditions during HAC Test

Temperature	Min. = 20 ℃, Max. = 25 ℃
Relative humidity	Min. = 30%, Max. = 70%
Ground system resistance	< 0.5 Ω
Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards.	

8. TEST RESULTS

8.1 Summary of Power Measurement Results

The power level results were listed in the following two tables:

Table 5: Conducted RF Power of GSM850

Band	GSM 850			GSM 1900		
Channel	128	190	251	512	661	810
Frequency	824.2	836.4	848.8	1850.2	1880.0	1909.8
GSM	32.64	32.68	32.59	29.26	28.75	28.20

Table 6: Conducted RF Power of WCDMA

Band	WCDMA 850			WCDMA1900		
TX Channel	4132	4182	4233	9262	9400	9538
Frequency	826.4	836.6	846.6	1852.4	1880.0	1907.6
ARM	22.62	22.59	22.69	22.69	22.82	22.65
Band	WCDMA 1700					
TX Channel	1312	1412	1513			
Frequency	1712.4	1732	1752.6			
ARM	22.54	22.71	22.56			

8.2 Summary of Measurement Results

Table 8: T-Coil Values of the EUT

Temperature: 23.0~23.5°C, humidity: 62~64%.			
Band	Channel	Frequency (MHz)	Test Results Category
GSM850	190	836.4	T3
GSM1900	661	1880.0	T3
WCDMA850	4182	836.6	T4
WCDMA1700	1412	1732.0	T4
WCDMA1900	9400	1880.0	T4

9. Measurement Uncertainty

Table 9: Measurement Uncertainty of RF Emission Test

Uncertainty Component	Uncertainty value	Probe Dist.	Div	(Ci) E	(Ci) H	Std. Unc.(+-%)	
						E	H
Measurement System							
Probe calibration	6.00	N	1.000	1	1	6.00	6.00
Axial Isotropy	2.02	R	1.732	1	1	1.17	1.17
Sensor Displacemant	14.30	R	1.732	1	0.217	8.26	1.79
Boundary effect	2.50	R	1.732	1	1	0.87	0.87
Phantom Boundary effect	6.89	R	1.732	1	0	3.52	0.00
Linearity	2.58	R	1.732	1	1	1.49	1.49
Scaling to PMR Calibration	9.02	N	1.000	1	1	9.02	9.02
System Detection Limit	1.30	R	1.732	1	1	0.75	0.75
Readout Electronics	0.25	R	1.732	1	1	0.14	0.14
Reponse Time	1.23	R	1.732	1	1	0.71	0.71
Integration Time	2.15	R	1.732	1	1	1.24	1.24
RF Ambient Conditions	2.03	R	1.732	1	1	1.17	1.17
RF Reflections	9.09	R	1.732	1	1	5.25	5.25
Probe positioner	0.63	N	1.000	1	0.71	0.63	0.45
Probe positioning	3.12	N	1.000	1	0.71	3.12	2.22
Extrapolation and Interpolation	1.18	R	1.732	1	1	0.68	0.68
Uncertainties of the EUT							
Test sample positioning Vertical	2.73	R	1.732	1	0.71	1.58	1.12
Test sample positioning Lateral	1.19	R	1.732	1	1	0.69	0.69
Device Holder and Phantom	2.20	N	1.000	1	1	2.20	2.20
Power Drift	4.08	R	1.732	1	1	2.36	2.36
Phantom and Setup Related							
Phantom Thickness	2.00	N	1.000	1	0.6	2.00	1.20
Conbined Std. Uncertainty(k=1)						16.18	13.25
Expanded Uncertainty on Power						32.35	26.50
Expanded Uncertainty on Field						16.18	13.25

Note:

N-Nomal

R-Rectangular

Div.- Divisor used to obataion standard uncertanty

Table 10: Measurement Uncertainty of T-Coil Test

No.	Uncertainty Component	Type	Uncertainty Value (%)	Probability Distribution	k	ci	Standard Uncertainty (%) ui(%)	Degree of freedom Veff or vi
	Measurement System							
1	– Probe Calibration	B	6	N	3	1	3.5	∞
2	– Axial isotropy	B	4.7	R	1.732	0.5	4.3	∞
3	– Hemispherical Isotropy	B	9.4	R	1.732	0.5	4.3	∞
4	– Boundary Effect	B	11.0	R	1.732	1	6.4	∞
5	– Linearity	B	4.7	R	1.732	1	2.7	∞
6	– System Detection Limits	B	1.0	R	1.732	1	0.6	∞
7	– Probe Coil Sensitivity	B	0.49	R	1.732	1	0.28	∞
8	– Response Time	B	0.00	R	1.732	1	0.00	∞
9	– Integration Time	B	0.00	R	1.732	1	0.00	∞
10	– RF Ambient Conditions	B	3.0	R	1.732	1	1.73	∞
11	– Probe Position Mechanical tolerance	B	0.4	R	1.732	1	0.2	∞
12	– Probe Position with respect to Phantom Shell	B	2.9	R	1.732	1	1.7	∞
	Uncertainties of the DUT							
13	– Position of the DUT	A	4.8	N	3	1	4.8	5
14	– Holder of the DUT	A	7.1	N	3	1	7.1	5
15	– Repeatability of the WD	B	5.0	R	1.732	1	2.9	∞
	Acoustic noise							
16	– Acoustic noise	B	1.0	R	1.732	1	0.6	∞
21	– Cable loss	B	0.46	N	1.732	1	0.46	∞
Combined Standard Uncertainty				RSS			17.26	42.33
Expanded uncertainty (Confidence interval of 95 %)				K=2			34.52	

10. MAIN TEST INSTRUMENTS

No	EQUIPMENT	TYPE	Series No.	Cal. Date	Due Date
1	T-Coil Probe	SATIMO/STCOIL	SN 24/11 TCP23	2016/12/16	2017/12/15
2	TMFS	SATIMO/STMFS	SN 22/12 TMFS15	2016/12/16	2017/12/15
3	Vector Network Analyzer	ZVB8	1145.1010.08	2016/06/13	2017/06/12
4	Amplifier	Nucletudes	143060	2017/04/04	2018/04/03
5	Power Meter	NRVS	1020.1809.02	2016/06/13	2017/06/12
6	Multimeter	Keithley - 2000	4014020	2017/04/04	2018/04/03
7	Power Sensor	NRV-Z4	100069	2016/06/10	2017/06/09
8	Wireless Communication Test Set	CMU200	A0304212	2016/06/10	2017/06/09

11. ANNEX A TEST SETUP

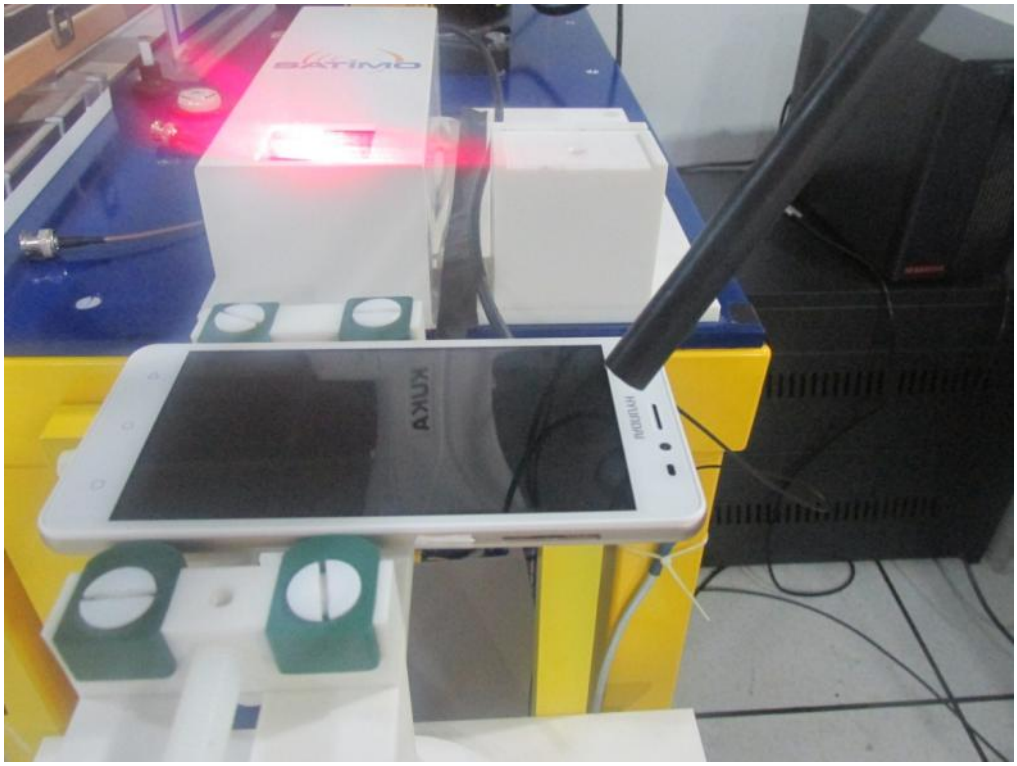


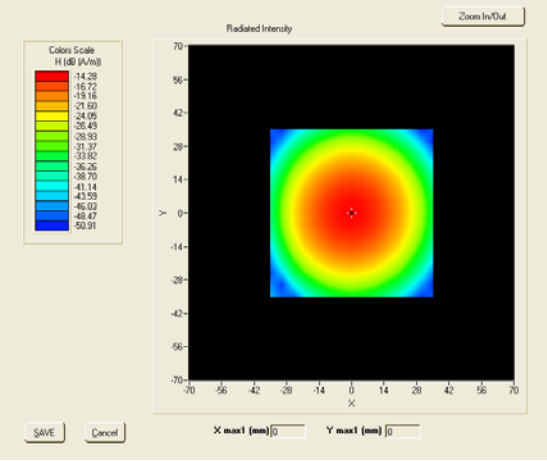
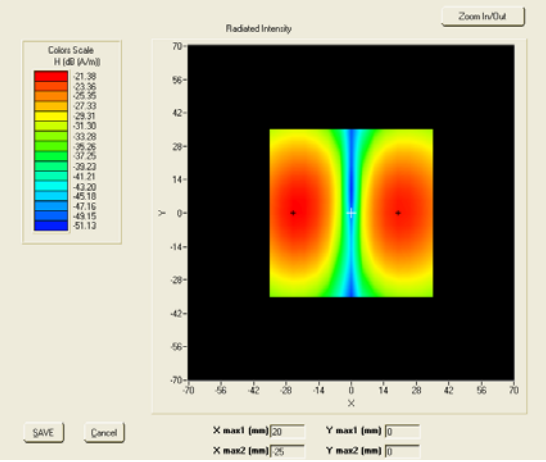
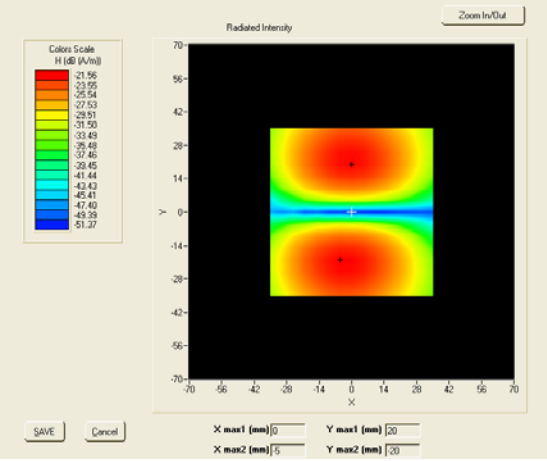
Fig.1 Testing Photo

12. ANNEX B EUT PHOTO

13. ANNEX C SYSTEM VERIFICATION (TMFS)

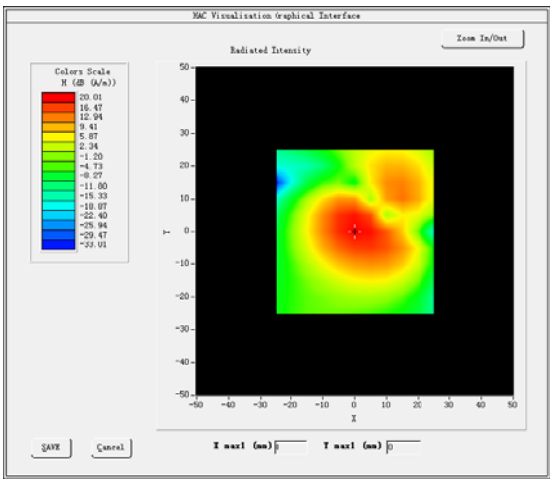
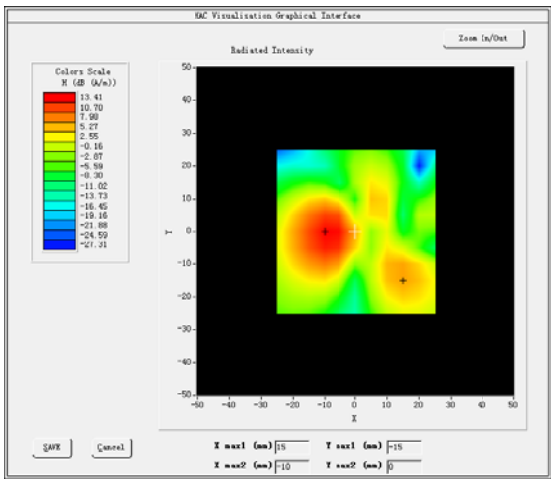
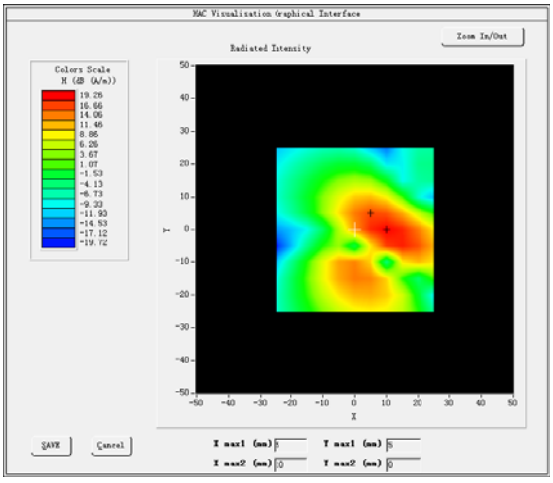
Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	Val		Intensity, Axial	-	Max	-14.28	-	-
7.3.1.2			Intensity, RadialH	-	Right side	-21.38	-	-
				-	Left side	-21.88	-	-
7.3.1.2			Intensity, RadialV	-	Upper side	-21.56	-	-
				-	Lower side	-20.96	-	-

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

14. ANNEX D TEST PLOTS

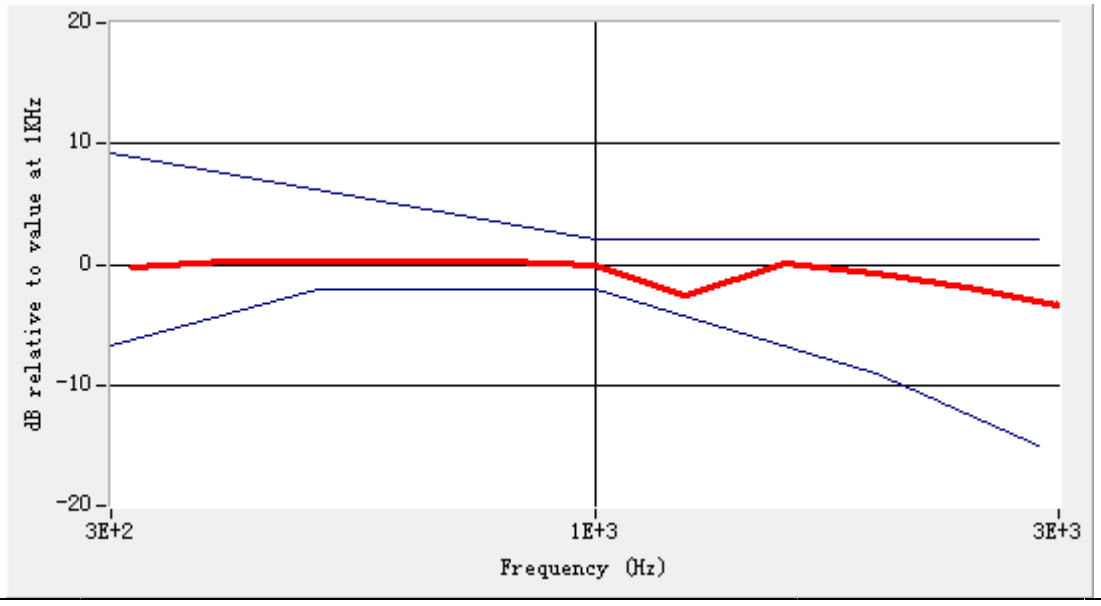
Measurement Results GSM850 Frequency (MHz): 836.400000

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

Raw Data Results

	Axial			Radial H						Radial V					
	128	189	250	128		189		250		128		189		250	
	Max	Max	Max	Left	Right	Left	Right	Left	Right	Up	Down	Up	Down	Up	Down
ABM1, dBA/m	NULL	20.01	NULL	NULL	NULL	6.31	13.41	NULL	NULL	NULL	NULL	16.32	19.26	NULL	NULL
ABM2, dBA/m	NULL	-10.32	NULL	NULL	NULL	-20.07	-7.84	NULL	NULL	NULL	NULL	-7.11	-4.42	NULL	NULL
Ambient noise, dBA/m	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00
Freq Reponse Margin (dB)	-	1.84	-	-	-	-	-	-	-	-	-	-	-	-	-
S+N/N(dB)	NULL	30.48	NULL	NULL	NULL	26.84	21.97	NULL	NULL	NULL	NULL	22.84	23.60	NULL	NULL
S+N/N per orientation (dB)	30.48			21.97						22.84					

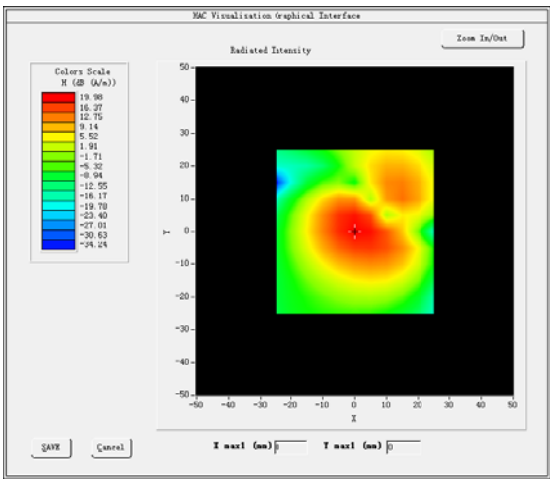
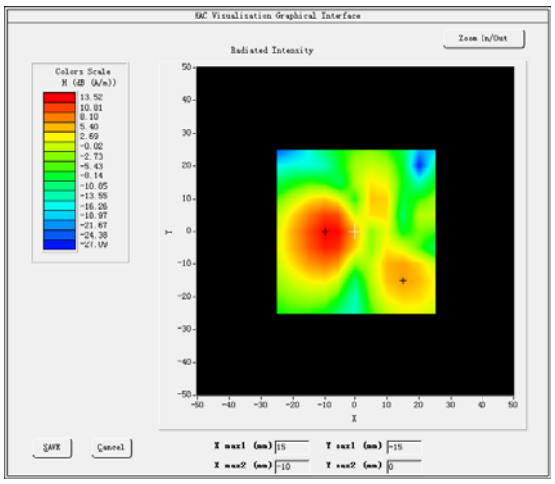
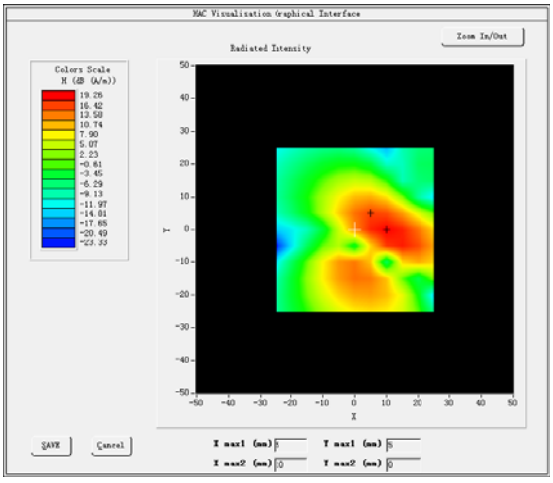
Magnetic field frequency response (field that exeeds -15 dB)



Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	GSM	GSM850	Intensity, Axial	-18	Max	20.01	-	PASS
7.3.1.2			Intensity, RadialH	-18	Right side	6.31	-	PASS
				-18	Left side	13.41	-	PASS
7.3.1.2			Intensity, RadialV	-18	Upper side	16.32	-	PASS
				-18	Lower side	19.26	-	PASS
7.3.3			Signal to noise/noise, Axial	20	Max	30.48	T4	PASS
7.3.3			Signal to noise/noise, RadialH	20	Right side	26.84	T3	PASS
				20	Left side	21.97	T3	PASS
7.3.3			Signal to noise/noise, RadialV	20	Upper side	22.84	T3	PASS
				20	Lower side	23.60	T3	PASS
7.3.2			Frequency reponse, Axial	0	-	1.84	-	PASS

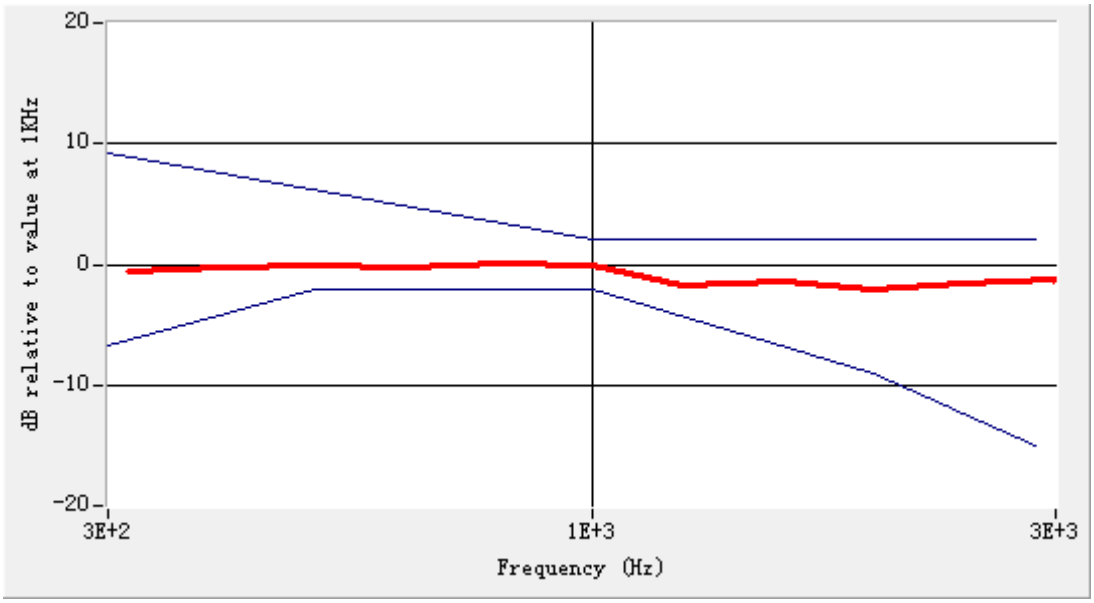
Measurement Results GSM1900 Frequency (MHz): 1880.00000

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

Raw Data Results

	Axial			Radial H						Radial V					
	513	661	809	513		661		809		513		661		809	
	Max	Max	Max	Left	Right	Left	Right	Left	Right	Max	Max	Max	Left	Right	Left
ABM1, dBA/m	NULL	19.98	NULL	NULL	NULL	6.53	13.52	NULL	NULL	NULL	19.98	NULL	NULL	NULL	6.53
ABM2, dBA/m	NULL	-14.47	NULL	NULL	NULL	-24.18	-12.17	NULL	NULL	NULL	-14.47	NULL	NULL	NULL	-24.18
Ambient noise, dBA/m	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00
Freq Reponse Margin (dB)	-	1.68	-	-	-	-	-	-	-	-	1.68	-	-	-	-
S+N/N(dB)	NULL	34.77	NULL	NULL	NULL	31.13	25.65	NULL	NULL	NULL	34.77	NULL	NULL	NULL	31.13
S+N/N per orientation (dB)	34.77			25.65						27.48					

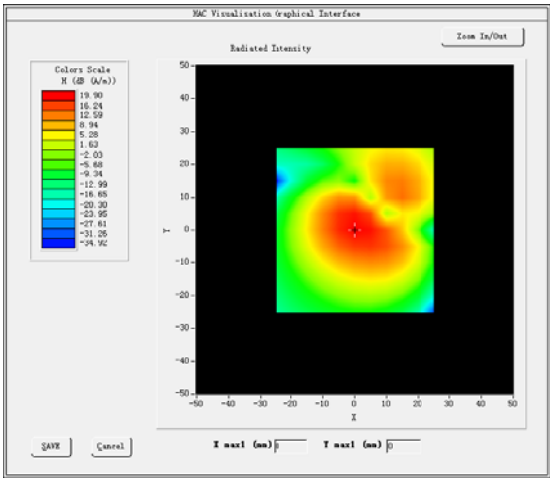
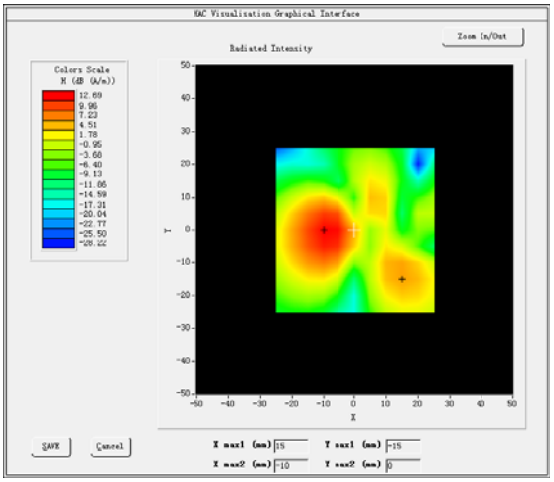
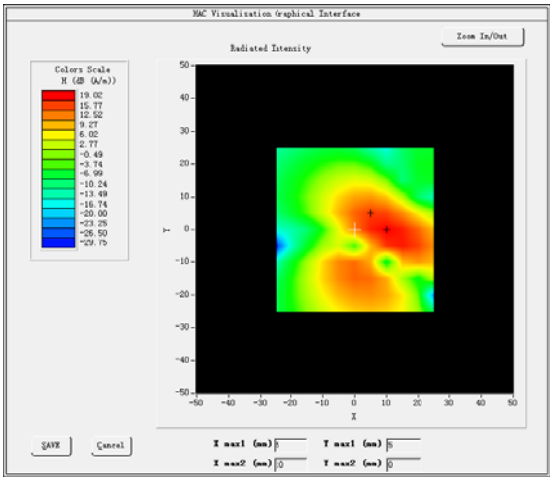
Magnetic field frequency response (field that exeeds -15 dB)



Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	GSM	GSM1900	Intensity, Axial	-18	Max	19.98	-	PASS
7.3.1.2			Intensity, RadialH	-18	Right side	6.53	-	PASS
				-18	Left side	13.52	-	PASS
7.3.1.2			Intensity, RadialV	-18	Upper side	16.30	-	PASS
				-18	Lower side	19.26	-	PASS
7.3.3			Signal to noise/noise, Axial	20	Max	34.77	T4	PASS
7.3.3			Signal to noise/noise, RadialH	20	Right side	31.13	T4	PASS
				20	Left side	25.65	T3	PASS
7.3.3			Signal to noise/noise, RadialV	20	Upper side	27.48	T3	PASS
				20	Lower side	27.96	T3	PASS
7.3.2			Frequency reponse, Axial	0	-	1.68	-	PASS

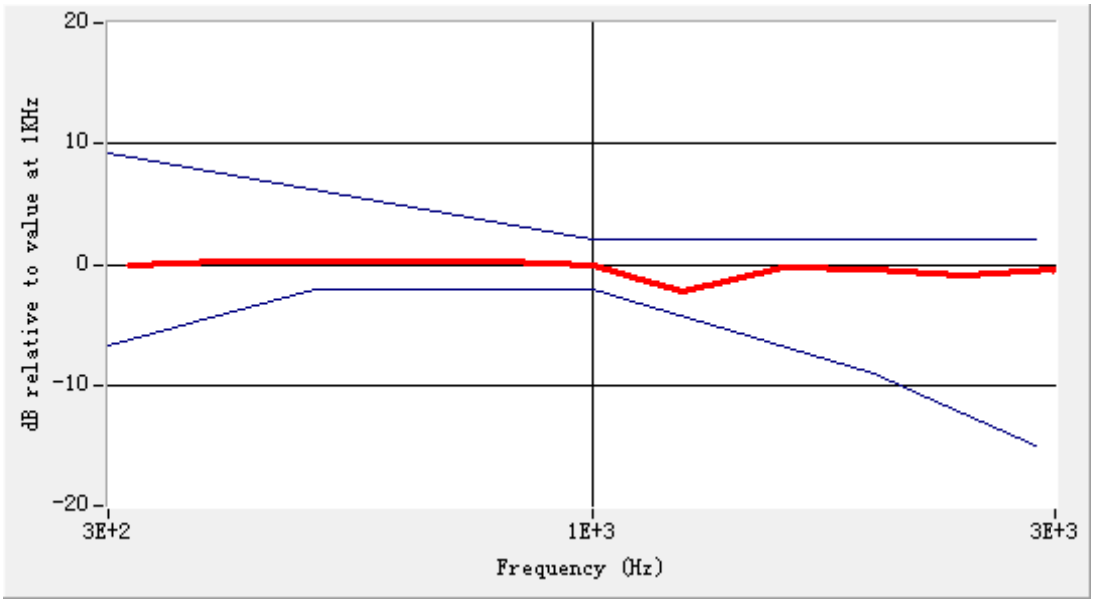
Measurement Results WCDMA 850 Frequency (MHz): 836.60000

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

Raw Data Results

	Axial			Radial H						Radial V					
	4132	4182	4233	4132		4182		4233		4132		4182		4233	
	Max	Max	Max	Left	Right	Left	Right	Left	Right	Max	Max	Max	Left	Right	Left
ABM1, dBA/m	NULL	19.90	NULL	NULL	NULL	5.60	12.69	NULL	NULL	NULL	19.90	NULL	NULL	NULL	5.60
ABM2, dBA/m	NULL	-33.21	NULL	NULL	NULL	-34.35	-38.67	NULL	NULL	NULL	-33.21	NULL	NULL	NULL	-34.35
Ambient noise, dBA/m	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00
Freq Reponse Margin (dB)	-	2.00	-	-	-	-	-	-	-	-	2.00	-	-	-	-
S+N/N(dB)	NULL	53.29	NULL	NULL	NULL	40.11	51.51	NULL	NULL	NULL	53.29	NULL	NULL	NULL	40.11
S+N/N per orientation (dB)	53.29			40.11						53.48					

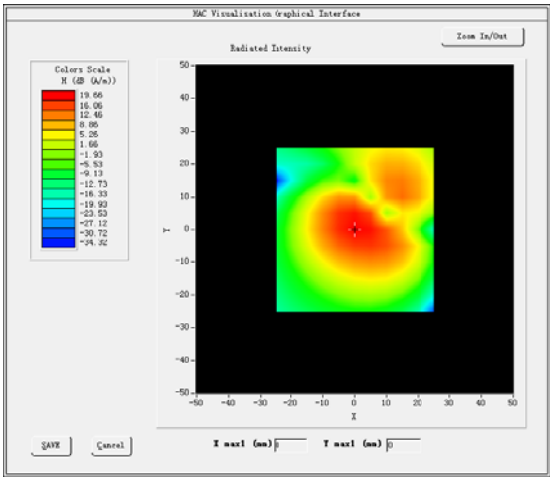
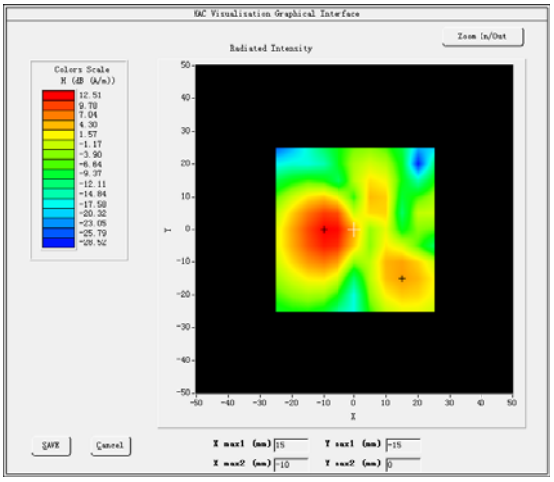
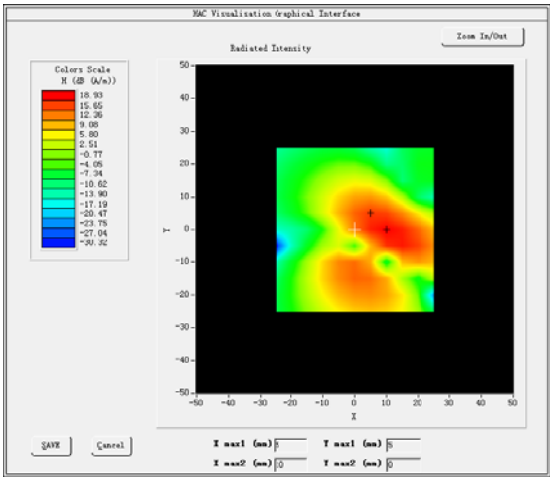
Magnetic field frequency response (field that exeeds -15 dB)



Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	WCDMA	WCDMA 850	Intensity, Axial	-18	Max	19.90	-	PASS
7.3.1.2			Intensity, RadialH	-18	Right side	5.60	-	PASS
				-18	Left side	12.69	-	PASS
7.3.1.2			Intensity, RadialV	-18	Upper side	16.05	-	PASS
				-18	Lower side	19.02	-	PASS
7.3.3			Signal to noise/noise, Axial	20	Max	53.29	T4	PASS
7.3.3			Signal to noise/noise, RadialH	20	Right side	40.11	T4	PASS
				20	Left side	51.51	T4	PASS
7.3.3			Signal to noise/noise, RadialV	20	Upper side	53.48	T4	PASS
				20	Lower side	55.70	T4	PASS
7.3.2			Frequency reponse, Axial	0	-	2.00	-	PASS

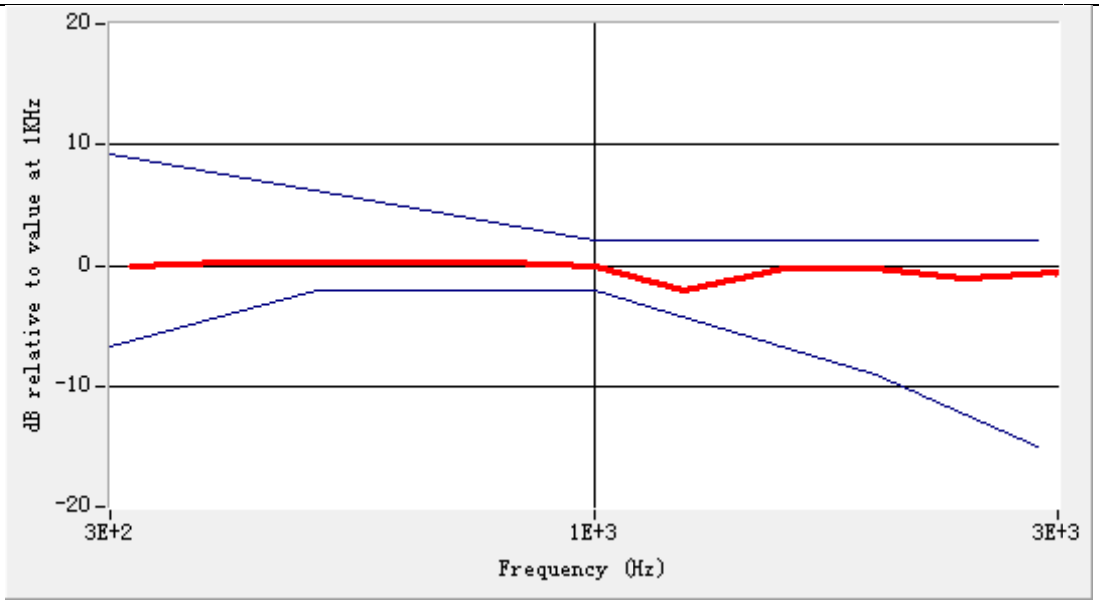
Measurement Results WCDMA1700 Frequency (MHz): 1732.00000

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

Raw Data Results

	Axial			Radial H						Radial V					
	1312	1412	1513	1312		1412		1513		1312		1412		1513	
	Max	Max	Max	Left	Right	Left	Right	Left	Right	Max	Max	Max	Left	Right	Left
ABM1, dBA/m	NULL	19.66	NULL	NULL	NULL	5.47	12.51	NULL	NULL	NULL	19.66	NULL	NULL	NULL	5.47
ABM2, dBA/m	NULL	-30.69	NULL	NULL	NULL	-35.84	-38.21	NULL	NULL	NULL	-30.69	NULL	NULL	NULL	-35.84
Ambient noise, dBA/m	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00
Freq Reponse Margin (dB)	-	2.00	-	-	-	-	-	-	-	-	2.00	-	-	-	-
S+N/N(dB)	NULL	50.57	NULL	NULL	NULL	41.47	50.90	NULL	NULL	NULL	50.57	NULL	NULL	NULL	41.47
S+N/N per orientation (dB)	50.57			41.47						53.23					

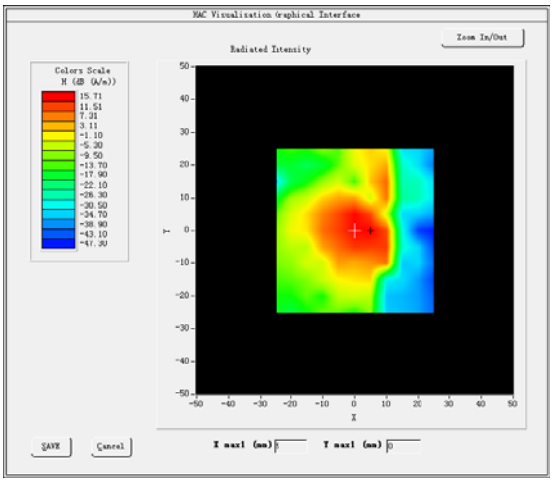
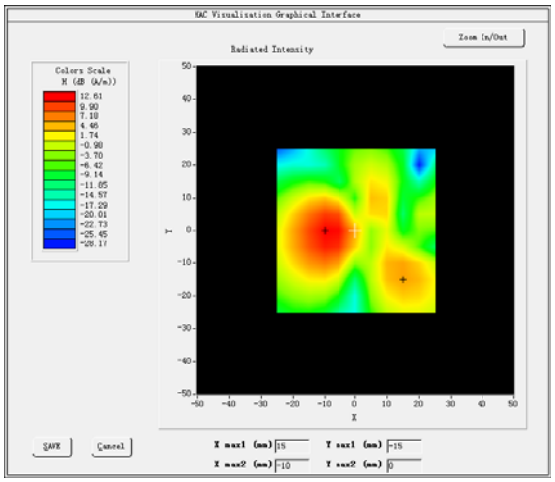
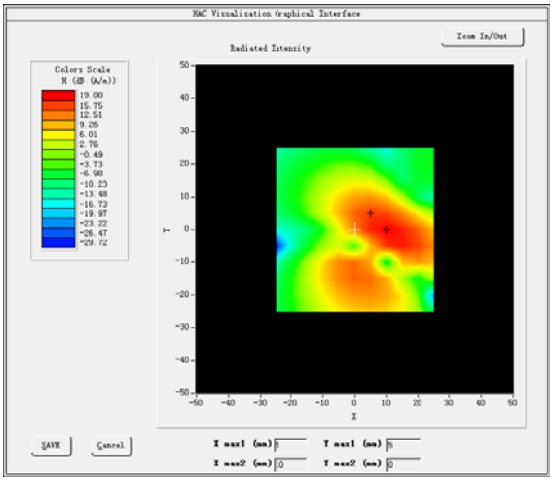
Magnetic field frequency response (field that exeeds -15 dB)



Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	WCDMA	Band4_WCDMA1700	Intensity, Axial	-18	Max	19.66	-	PASS
7.3.1.2			Intensity, RadialH	-18	Right side	5.47	-	PASS
				-18	Left side	12.51	-	PASS
7.3.1.2			Intensity, RadialV	-18	Upper side	15.96	-	PASS
				-18	Lower side	18.93	-	PASS
7.3.3			Signal to noise/noise, Axial	20	Max	50.57	T4	PASS
7.3.3			Signal to noise/noise, RadialH	20	Right side	41.47	T4	PASS
				20	Left side	50.90	T4	PASS
7.3.3			Signal to noise/noise, RadialV	20	Upper side	53.23	T4	PASS
				20	Lower side	55.92	T4	PASS
7.3.2			Frequency reponse, Axial	0	-	2.00	-	PASS

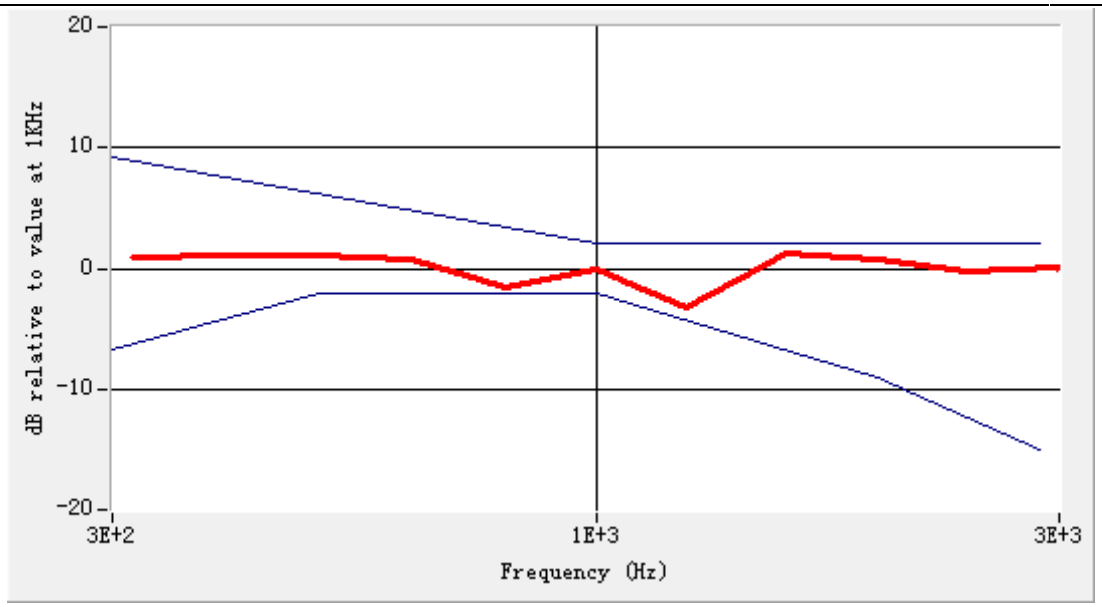
Measurement Results WCDMA1900 Frequency (MHz): 1880.00000

AXIAL ABM1	RADIAL H ABM1
	
RADIAL V ABM1	
	

Raw Data Results

	Axial			Radial H						Radial V					
	9262	9400	9538	9262		9400		9538		9262		9400		9538	
	Max	Max	Max	Left	Right	Left	Right	Left	Right	Max	Max	Max	Left	Right	Left
ABM1, dBA/m	NULL	15.71	NULL	NULL	NULL	5.55	12.61	NULL	NULL	NULL	15.71	NULL	NULL	NULL	5.55
ABM2, dBA/m	NULL	-28.42	NULL	NULL	NULL	-35.97	-38.18	NULL	NULL	NULL	-28.42	NULL	NULL	NULL	-35.97
Ambient noise, dBA/m	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00	-50.00
Freq Reponse Margin (dB)	-	0.39	-	-	-	-	-	-	-	-	0.39	-	-	-	-
S+N/N(dB)	NULL	46.14	NULL	NULL	NULL	41.68	50.97	NULL	NULL	NULL	46.14	NULL	NULL	NULL	41.68
S+N/N per orientation (dB)	46.14			41.68						53.75					

Magnetic field frequency response (field that exeeds -15 dB)



Test Summary

C63.19	Mode	Band	Test Description	Minimum Limit	Location	Measured	Category	Verdict
				dBA/m	-	dBA/m	-	Pass/Fail
7.3.1.1	WCDMA	Band2_WCDMA1900	Intensity, Axial	-18	Max	15.71	-	PASS
7.3.1.2			Intensity, RadialH	-18	Right side	5.55	-	PASS
				-18	Left side	12.61	-	PASS
7.3.1.2			Intensity, RadialV	-18	Upper side	16.04	-	PASS
				-18	Lower side	19.00	-	PASS
7.3.3			Signal to noise/noise, Axial	20	Max	46.14	T4	PASS
7.3.3			Signal to noise/noise, RadialH	20	Right side	41.68	T4	PASS
				20	Left side	50.97	T4	PASS
7.3.3			Signal to noise/noise, RadialV	20	Upper side	53.75	T4	PASS
				20	Lower side	57.16	T4	PASS
7.3.2			Frequency reponse, Axial	0	-	0.39	-	PASS

15. ANNEX E CALIBRATION REPORT

COMOHAC TMFS Calibration Report

Ref: ACR.351.6.16.SATU.A

CCIC SOUTHERN ELECTRONIC PRODUCT TESTING (SHENZHEN) CO.,LTD

BUILDING 28/ 29, EAST OF SHIGU, XILI INDUSTRIAL ZONE XILI ROAD, NANSHAN DISTRICT, SHENZHEN GUANGDONG, CHINA

MVG COMOHAC E-FIELD PROBE

SERIAL NO.: SN 22/12 TMFS15

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144

Calibration Date: 12/16/16

Summary:

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

COMOHAC TM FS PROBE CALIBRATION REPORT

Ref: ACR.351.6.16.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	12/16/2016	
Checked by :	Jérôme LUC	Product Manager	12/16/2016	
Approved by :	Kim RUTKOWSKI	Quality Manager	12/16/2016	

	Customer Name
Distribution :	Shenzhen EMC-united Co., Ltd

Issue	Date	Modifications
A	12/16/2016	Initial release

TABLE OF CONTENTS

1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOHAC Magnetic Field Simulator
Manufacturer	MVG
Model	STMFS
Serial Number	SN 22/12 TMFS15
Product Condition (new / used)	Used
Frequency Range	200-5000 Hz

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOHAC T-coil Probes are built in accordance to the ANSI C63.19 and ANSI S3.22-2003 standards.

Figure 1 – *MVG COMOHAC Magnetic Field Simulator*

3 MEASUREMENT METHOD

All methods used to perform the measurements and calibrations comply with the ANSI C63.19. All measurements were performed with the TMFS in the standard device test configuration, with the TMFS in free space, 10 mm below the coil center.

3.1 MAXIMUM AXIAL AND RADIAL MAGNETIC FIELD VALUES

An audio signal was fed into the TMFS and the magnetic field measured and recorded over an area scan with the T-coil probe in three orientations; axial and two radial. The maximum magnetic field is recorded for all three T-coil orientations.

4 MEASUREMENT UNCERTAINTY

The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements. 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 Helmholtz Coil					
Uncertainty Component	Tol. (± dB)	Prob. Dist.	Div.	Uncertainty (dB)	Uncertainty (%)
Reflections	0.1	R	$\sqrt{3}$	0.06	
Acoustic noise	0.1	R	$\sqrt{3}$	0.06	
Probe coil sensitivity	0.49	R	$\sqrt{3}$	0.28	
Reference signal level	0.25	R	$\sqrt{3}$	0.14	
Positioning accuracy	0.2	R	$\sqrt{3}$	0.12	
Cable loss	0.1	N	1	0.05	
Frequency analyzer	0.15	R	$\sqrt{3}$	0.09	
System repeatability	0.2	N	1	0.20	
Repeatability of the WD	0.1	N	1	0.10	
Combined standard uncertainty		N	1	0.43	
Expanded uncertainty 95 % confidence level k = 2		N	2	0.85	10.3%

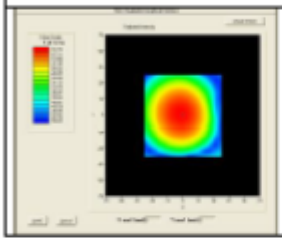
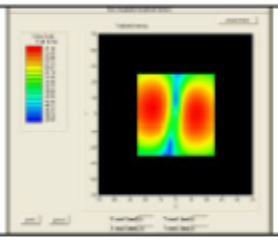
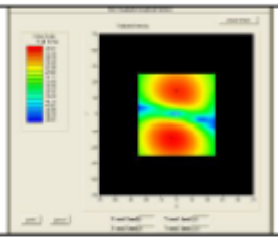
5 CALIBRATION MEASUREMENT RESULTS

Calibration Parameters	
Software	OpenHAC V2
HAC positioning ruler	SN 42/09 TABH12
T-Coil probe	SN 47/10 TCP18
Distance between TMFS and coil center	10 mm
Frequency	1025 Hz
Scan Size	X=70mm/Y=70mm
Scan Resolution	dx=5mm/dy=5mm
Output level	0.5 VAC
Lab Temperature	21°C
Lab Humidity	45%

5.1 MAXIMUM AXIAL AND RADIAL MAGNETIC FIELD VALUES

Test Description	Measured Magnetic Field	
	Location	Intensity (dB A/m)

Axial	Max	-14.51
Radial H	Right side	-21.54
	Left side	-21.37
Radial V	Upper side	-21.27
	Lower side	-20.25

AXIAL ABM1	RADIAL H ABM1	RADIAL V ABM1
		

6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
COMOHAC Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
HAC positioning ruler	MVG	TABH12 SN 42/09	Validated. No cal required.	Validated. No cal required.
Audio Generator	National Instruments	15222AE	01/2014	01/2017
Reference Probe	MVG	TCP 18 SN 47/10	10/2016	10/2017
Multimeter	Keithley 2000	1188656	12/2013	12/2016
Temperature / Humidity Sensor	Control Company	150798832	10/2015	10/2017

COMOHAC T-coil Probe Calibration Report

Ref : ACR.351.3.16.SATU.A

CCIC SOUTHERN ELECTRONIC PRODUCT TESTING (SHENZHEN) CO.,LTD

BUILDING 28/ 29, EAST OF SHIGU, XILI INDUSTRIAL ZONE XILI ROAD, NANSHAN DISTRICT, SHENZHEN GUANGDONG, CHINA

MVG COMOHAC E-FIELD PROBE

SERIAL NO.: SN 24/11 TCP23

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw , GA 30144

ACCREDITED

Calibration Date: 12/16/16

Summary:

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

COMOHAC T-COIL PROBE CALIBRATION REPORT Ref: ACR.3513.16.SATU.A

	Name	Function	Date	Signature
Prepared by :	Jérôme LUC	Product Manager	12/16/2016	
Checked by :	Jérôme LUC	Product Manager	12/16/2016	
Approved by :	Kim RUTKOWSKI	Quality Manager	12/16/2016	

	Customer Name
Distribution :	Shenzhen EMC-united Co., Ltd

Issue	Date	Modifications
A	12/16/2016	Initial release

TABLE OF CONTENTS

1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOHAC T-COIL PROBE
Manufacturer	MVG
Model	STCOIL
Serial Number	SN 24/11 TCP23
Product Condition (new / used)	Used
Frequency Range of Probe	200-5000 Hz

A yearly calibration interval is recommended.

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOHAC T-coil Probes are built in accordance to the ANSI C63.19 and IEEE 1027 standards.

Figure 1 – *MVG COMOHAC T-coil Probe*

Coil Dimension	6.55 mm length * 2.29 mm diameter
DC resistance	860.6 Ω
Wire size	51 AWG
Inductance at 1 kHz	132.1 mH at 1 kHz

3 MEASUREMENT METHOD

All methods used to perform the measurements and calibrations comply with the ANSI C63.19 and IEEE 1027 standards. All measurements were performed using a Helmholtz coil built according to the specifications outlined in ANSI C63.19 and IEEE 1027.

3.1 SENSITIVITY

The T-coil was positioned within the Helmholtz coil in axial orientation. Using an audio generator connected to the input of the Helmholtz coil, a known field (1 A/m) was generated within the coil and the T-coil probe reading recorded over the frequency range of 100 Hz to 1000 Hz.

3.2 LINEARITY

The T-coil probe was positioned within the Helmholtz coil in axial orientation. The audio generator connected to the input of the Helmholtz coil was adjusted to obtain a field within the coil from 0 dB A/m to -50 dB A/m and the T-coil reading recorded at each power level (10 dB steps).

3.3 SIGNAL TO NOISE MEASUREMENT OF THE CALIBRATION SYSTEM

The T-coil probe was positioned within the Helmholtz coil in axial orientation. The audio generator connected to the input of the Helmholtz coil was adjusted to obtain a field of -30 dB A/m. The T-coil reading was recorded. The audio generator is then turned off and the T-coil reading recorded.

4 MEASUREMENT UNCERTAINTY

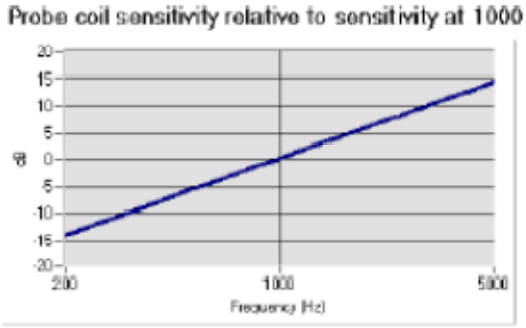
The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

Uncertainty analysis of the T-coil probe calibration					
Uncertainty Component	Tol. (± dB)	Prob. Dist.	Div.	Uncertainty (dB)	Uncertainty (%)
Current/Volage Accuracy	0.224	R	√3	0.13	
Acoustic/ Signal Source drift	0.008	R	√3	0.00	
Probe coil sensitivity	0.2	R	√3	0.12	
Positioning accuracy	0.4	R	√3	0.23	
Acoustic Signal Receive Accuracy	0.03	R	√3	0.02	
Acoustic Signal Receive Linearity	0.006	R	√3	0.00	
System repeatability	0.4	N	1	0.40	
Combined Standard Uncertainty		N	1	0.49	
Expanded uncertainty (confidence level of 95%, k = 2)		N	k=2	1.00	12.0

5 CALIBRATION MEASUREMENT RESULTS

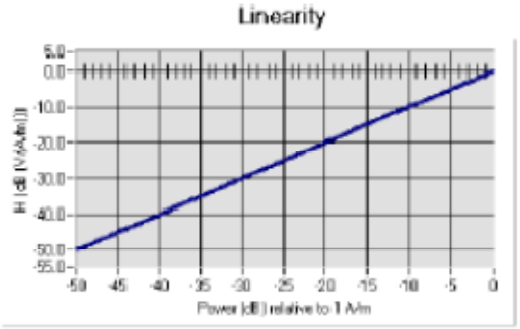
Calibration Parameters	
Lab Temperature	21°C
Lab Humidity	45%

5.1 SENSITIVITY



	Measured	Required
Sensitivity at 1 kHz	-60.26 dB (V/A/m)	–60.5 +/- 0.5 dB (V/A/m)
Max. deviation from Sensitivity	0.40 dB	+/- 0.5 dB

5.2 LINEARITY



	Measured	Required
Linearity Slope	0.04 dB	+/ 0.5 dB

5.3 SIGNAL TO NOISE MEASUREMENT OF THE CALIBRATION SYSTEM

	Measured	Required
Signal to Noise	-79.32 dB A/m	'Reading with -50 dB A/m in coil' – 'no signal applied' > 10 dB

6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
COMOHAC Test Bench	Version 2	N.A	Validated. No cal required.	Validated. No cal required.
Audio Generator	National Instruments	15222AE	01/2014	01/2017
Reference Probe	MVG	TCP 18 SN 47/10	10/2016	10/2017
Multimeter	Keithley 2000	1188656	12/2013	12/2016
Helmholtz Coil	MVG	HC 07 SN47/10	Validated. No cal required.	Validated. No cal required.
Temperature /Humidity Sensor	Control Company	150798832	10/2015	10/2017

End of the Report