

RF Emission

HAC

TEST REPORT

ISSUED BY
Shenzhen BALUN Technology Co., Ltd.



FOR
TD LTE digital mobile phone

ISSUED TO
Lemobile Information Technology (Beijing) Co., Ltd.

WENHUAYING NORTH (NO.1, LINKONG 2ND ST), GAOLIYING,
SHUNYI DISTRICT, BEIJING, CHINA



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Date: Nov. 19, 2015

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(Chief Engineer)

Date: Nov. 19, 2015



Report No.: BL-SZ1590187-701
EUT Type: TD LTE digital mobile phone
Model Name: Le Max
Brand Name: Letv
FCC ID: 2AFWMLEMAX
Test Standard: FCC 47 CFR Part 20.19
ANSI C63.19: 2011
KDB 285076 D01 HAC Guidance v04
M-Rating: E-Field: M3
Test conclusion: Pass
Test Date: Nov. 9, 2015
Date of Issue: Nov. 19, 2015

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Revision History

| <u>Version</u> | <u>Issue Date</u> | <u>Revisions</u> |
|----------------|----------------------|----------------------|
| <u>Rev. 01</u> | <u>Nov. 16, 2015</u> | <u>Initial Issue</u> |
| <u>Rev. 02</u> | <u>Nov. 19, 2015</u> | <u>Second Issue</u> |

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1 GENERAL INFORMATION

1.1 Identification of the Testing Laboratory

| | |
|--------------|---|
| Company Name | Shenzhen BALUN Technology Co., Ltd. |
| Address | Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China |
| Phone Number | +86 755 6685 0100 |
| Fax Number | +86 755 6182 4271 |

1.2 Identification of the Responsible Testing Location

| | |
|---------------------------|---|
| Test Location | Shenzhen BALUN Technology Co., Ltd. |
| Address | Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China |
| Accreditation Certificate | <p>The laboratory has been listed by Industry Canada to perform electromagnetic emission measurements. The recognition numbers of test site are 11524A-1.</p> <p>The laboratory has been listed by US Federal Communications Commission to perform electromagnetic emission measurements. The recognition numbers of test site are 832625.</p> <p>The laboratory has met the requirements of the IAS Accreditation Criteria for Testing Laboratories (AC89), has demonstrated compliance with ISO/IEC Standard 17025:2005. The accreditation certificate number is TL-588.</p> <p>The laboratory is a testing organization accredited by China National Accreditation Service for Conformity Assessment (CNAS) according to ISO/IEC 17025. The accreditation certificate number is L6791.</p> |
| Description | All measurement facilities used to collect the measurement data are located at Block B, FL 1, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China 518055 |

1.3 Test Environment Condition

| | |
|---------------------------|----------------|
| Ambient Temperature | 21 to 23 °C |
| Ambient Relative Humidity | 40 to 50% |
| Ambient Pressure | 100 to 102 KPa |

1.4 Announce

- (1) The test report reference to the report template version v1.0.
- (2) The test report is invalid if not marked with the signatures of the persons responsible for preparing and approving the test report.
- (3) The test report is invalid if there is any evidence and/or falsification.
- (4) The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein.
- (5) This document may not be altered or revised in any way unless done so by BALUN and all revisions are duly noted in the revisions section.
- (6) Content of the test report, in part or in full, cannot be used for publicity and/or promotional purposes without prior written approval from the laboratory.

2 PRODUCT INFORMATION

2.1 Applicant

| | |
|-----------|---|
| Applicant | Lemobile Information Technology (Beijing) Co., Ltd. |
| Address | WENHUAYING NORTH (NO.1, LINKONG 2ND ST), GAOLIYING, SHUNYI DISTRICT, BEIJING, CHINA |

2.2 Manufacturer

| | |
|--------------|---|
| Manufacturer | Lemobile Information Technology (Beijing) Co., Ltd. |
| Address | WENHUAYING NORTH (NO.1, LINKONG 2ND ST), GAOLIYING, SHUNYI DISTRICT, BEIJING. |

2.3 Factory Information

| | |
|---------|---|
| Factory | Lemobile Information Technology (Beijing) Co., Ltd. |
| Address | WENHUAYING NORTH (NO.1, LINKONG 2ND ST), GAOLIYING, SHUNYI DISTRICT, BEIJING. |

2.4 General Description for Equipment under Test (EUT)

| | |
|---|--|
| EUT Type | TD LTE digital mobile phone |
| Model Name Under Test | Le Max |
| Series Model Name | N/A |
| Description of Model Name Differentiation | N/A |
| Hardware Version | N/A |
| Software Version | N/A |
| Dimensions | 83×165×6 mm |
| Weight | 202.8 g(with battery) |
| Network and Wireless connectivity | 2G Network GSM 850/ 900/ 1800/ 1900, GPRS, EGPRS; 3G Network WCDMA Band 2/ 5, HSDPA, HSUPA; 4G Network LTE FDD Band 1/ 3/ 7; LTE TDD Band 38/ 39/ 40/ 41; WLAN; Bluetooth; GPS |

2.5 Technical Information

The requirement for the following technical information of the EUT was tested in this report:

| | | | |
|---------------------|---|-------------------------|-------------------------|
| Operating Mode | GSM; WCDMA; LTE; WLAN; Bluetooth | | |
| Frequency Range | GSM 850 | TX: 824 MHz ~849 MHz | RX: 869 MHz ~ 894 MHz |
| | GSM 1900 | TX: 1850 MHz ~ 1910 MHz | RX: 1930 MHz ~ 1990 MHz |
| | WCDMA Band 2 | TX: 1850 MHz ~ 1910 MHz | RX: 1930 MHz ~ 1990 MHz |
| | WCDMA Band 5 | TX: 824 MHz ~ 849 MHz | RX: 869 MHz ~ 894 MHz |
| | LTE Band 7 | TX: 2500 MHz ~ 2570 MHz | RX: 2620 MHz ~ 2690 MHz |
| | LTE Band 41 | TX: 2469 MHz ~ 2690 MHz | RX: 2469 MHz ~ 2690 MHz |
| | 802.11b/g | 2400 MHz ~2483.5 MHz | |
| | 802.11 n(HT20/HT40) | 2400 MHz ~2483.5 MHz | |
| | 802.11a | 5150 MHz ~ 5250 MHz | |
| | | 5725 MHz ~ 5850 MHz | |
| | 802.11 n(HT20/HT40) | 5150 MHz ~ 5250 MHz | |
| | | 5725 MHz ~ 5850 MHz | |
| | 802.11ac(HT20 /HT40/HT80) | 5150 MHz ~ 5250 MHz | |
| 5725 MHz ~ 5850 MHz | | | |
| Bluetooth | 2400 MHz ~ 2483.5 MHz | | |
| Antenna Type | WWAN: PIFA Antenna WLAN: PIFA Antenna Bluetooth: PIFA Antenna | | |
| DTM | Not Support | | |
| Hotspot Function | Support | | |
| Exposure Category | General Population/Uncontrolled exposure | | |
| EUT Stage | Portable Device | | |

2.6 EUT Air Interface Description

| Air Interface | Band | Type | C63.19 Tested | Simultaneous Transmitter | OTT | Power Reduction |
|---------------|---------|-------|---------------------|--------------------------|-----|-----------------|
| GSM | GSM850 | Voice | Yes | Bluetooth/WLAN | N/A | Not Support |
| | GSM1900 | Voice | Yes | Bluetooth/WLAN | N/A | Not Support |
| WCDMA | Band 2 | RMC | Yes | Bluetooth/WLAN | N/A | Not Support |
| | Band 5 | RMC | Yes | Bluetooth/WLAN | N/A | Not Support |
| LTE | FDD B7 | VOIP | Yes ^{Note} | Bluetooth/WLAN | N/A | Not Support |
| | TDD B41 | VOIP | Yes ^{Note} | Bluetooth/WLAN | N/A | Not Support |

Note: Testing the T-coil for LTE VOIP is not required according with KDB 285076 D02 T Coil testing for CMRS IP v01r01.

2.7 Ancillary Equipment

| | | |
|-----------------------|----------------------------------|-----------------------------|
| Ancillary Equipment 1 | Battery | |
| | Brand Name | LeTV |
| | Model No. | LT633 |
| | Serial No. | N/A |
| | Capacitance | 3400 mAh |
| | Rated Voltage | 3.8 V |
| | Extreme Voltage | 4.35 V |
| Ancillary Equipment 2 | AC Adapter (Charger for Battery) | |
| | Brand Name | CHENYANG |
| | Model Number | LSUUL050200-A00 |
| | Rated Input | 100-240 V~, 50/60 Hz, 0.5 A |
| | Rated Output | 5 V~, 2000 mA |

3 SUMMARY OF TEST RESULTS

3.1 Test Standards

| No. | Identity | Document Title |
|-----|---------------------------------------|--|
| 1 | FCC 47 CFR Part 20.19 | Hearing aid-compatible mobile handsets. |
| 2 | ANSI C 63.19:2011 | American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids |
| 3 | KDB 285076 D01 HAC Guidance v04 | Provides equipment authorization guidance for mobile handsets subject to the requirements of Section 20.19 for hearing aid compatibility |

3.2 HAC Test Configuration and Setting

For HAC RF emission testing, the EUT was linked and controlled by wireless communication test set. Communication between the EUT and the wireless communication test set was established by air link. The distance between the EUT and the communicating antenna of the test set is larger than 50 cm and the output power radiated from the wireless communication test set antenna is at least 30 dB smaller than the output power of EUT. The EUT was set from the wireless communication test set to radiate maximum output power during HAC testing.

3.3 Summary Of HAC M-Rating

| Band | Measurement Result | | M-Rating |
|----------------------|--------------------|-------|----------|
| GSM 850 | E-Field dB (V/m) | 36.19 | M4 |
| GSM 1900 | E-Field dB (V/m) | 34.59 | M3 |
| WCDAMA Band 2 | E-Field dB (V/m) | 6.17 | M4 |
| WCDAMA Band 5 | E-Field dB (V/m) | 6.13 | M4 |
| LTE Band 7 | E-Field dB (V/m) | 19.53 | M4 |
| LTE Band 41 | E-Field dB (V/m) | 18.08 | M4 |

3.4 ANSI C63.19 HAC RF Categories

3.4.1 RF Emissions

The ANSI Standard presents performance requirements for acceptable interoperability of hearing with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

WD RF audio interference level categories:

| Category | Limits for E-Field Emission (V/m) | |
|----------|-----------------------------------|----------|
| | <960MHz | >960MHz |
| M1 | 50 to 55 | 40 to 45 |
| M2 | 45 to 50 | 35 to 40 |
| M3 | 40 to 45 | 30 to 35 |
| M4 | <40 | <30 |

3.5 HAC Test Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in ANSI C 63.19:2011. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$.

| Uncertainty Component | Uncertainty Value | Prob. 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 Displacement | 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 limits | 1.30 | R | 1.732 | 1 | 1 | 0.75 | 0.75 |
| Readout Electronics | 0.25 | R | 1.732 | 1 | 1 | 0.14 | 0.14 |
| Response 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 |
| Test sample Related | | | | | | | |
| 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 |
| Combined Std. Uncertainty($k=1$) | | | | | | 16.18 | 13.25 |
| Expanded Uncertainty on Power | | | | | | 32.35 | 26.50 |
| Expanded Uncertainty on Field | | | | | | 16.18 | 13.25 |

4 SATIMO HSC MEASUREMENT SYSTEM

4.1 Definition of Hearing Aid Compatibility (HAC)

On July 10, 2003, the Federal Communications Commission (FCC) adopted new rules requiring wireless manufacturers and service providers to provide digital wireless phones that are compatible with hearing aids. The FCC has modified the exemption for wireless phones under the Hearing Aid Compatibility Act of 1998 (HAC Act) in WT Docket 01-309 RM-8658 to extend the benefits of wireless telecommunications to individuals with hearing disabilities. These benefits encompass business, social and emergency communications, which increase the value of the wireless network for everyone. An estimated more than 10% of the population in the United States show signs of hearing impairment and of that fraction, almost 80% use hearing aids. Approximately 500 million people worldwide suffer from hearing loss.

Compatibility Tests involved:

The standard calls for wireless communications devices to be measured for:

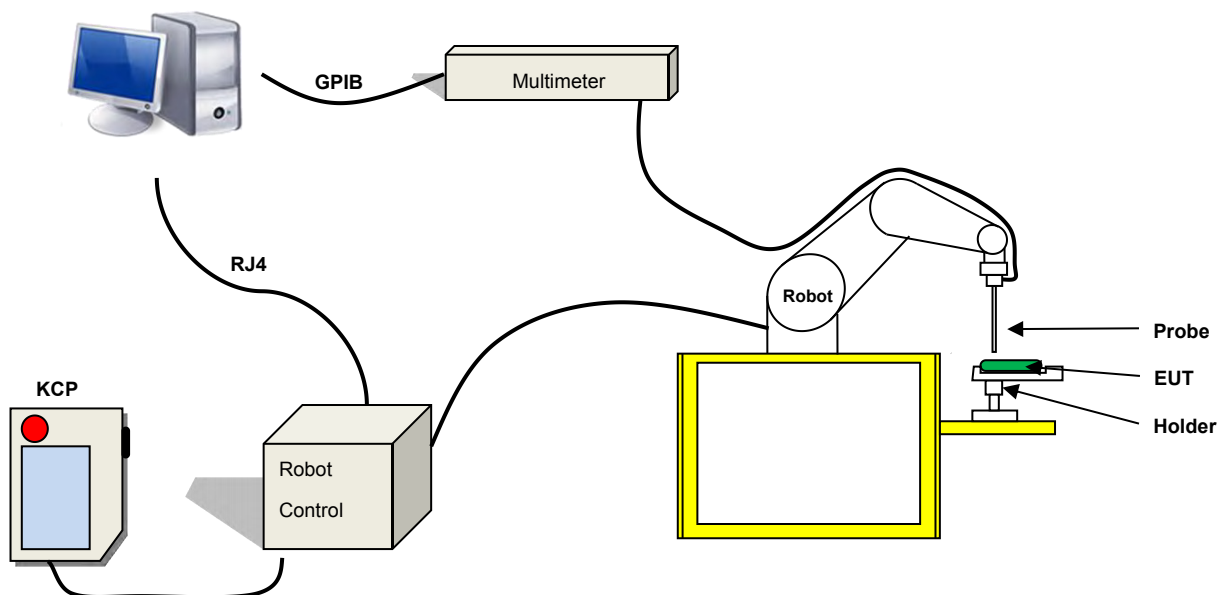
- RF Electric-field emissions.
- RF Magnetic- field emissions.
- T-coil mode, magnetic-signal strength in the audio band.
- T-coil mode, magnetic-signal frequency response through the audio band.
- T-coil mode, magnetic-signal and noise articulation index.

The hearing aid must be measured for:

- RF immunity in microphone mode
- RF immunity in T-coil mode

4.2 SATIMO HAC System

SATIMO HAC System Diagram:



4.2.1 Robot

The SATIMO HAC system uses the high precision robots from KUKA. For the 6-axis controller system, the robot controller version (KUKA) from KUKA is used. The KUKA robot series have many features that are important for our application:



- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

4.2.2 HAC E-Field Probe



| | |
|---|--|
| Serial Number: | SN 24/13 EPH41 |
| Frequency: | 0.7GHz – 2.5GHz |
| Probe length: | 330mm |
| Length of one dipole: | 3.3mm |
| Maximum external diameter: | 8mm |
| Probe extremity diameter: | 5mm |
| Distance between dipoles/probe extremity: | 3mm |
| Resistance of the three dipole (at the connector): | Dipole 1:R1=2.1807 M Dipole 2:R1=2.0612 M Dipole 3:R3=2.1892 M |
| Connector (HIROSE series SR30) | 6 wire male (Hirose SR30series) |

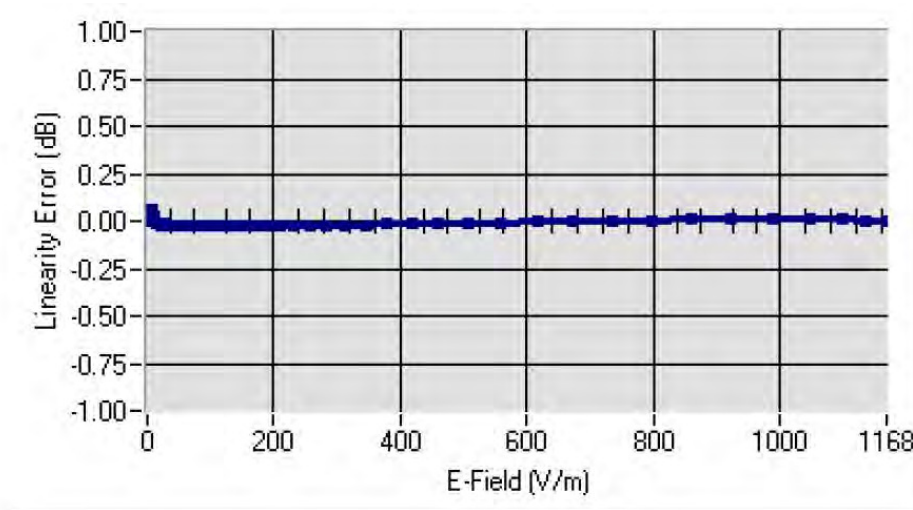
E-Field Probe Calibration Process

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

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 1000V/m).

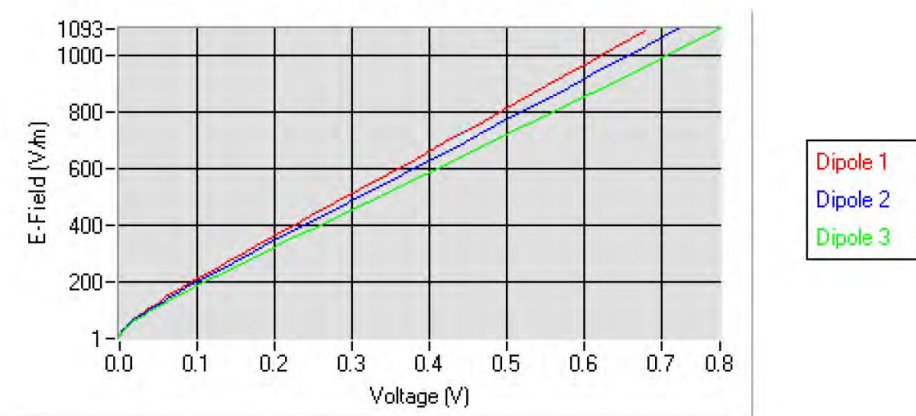
Linearity: +/- 1.49% (+/- 0.07 dB)



SENSITIVITY

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

Calibration curves

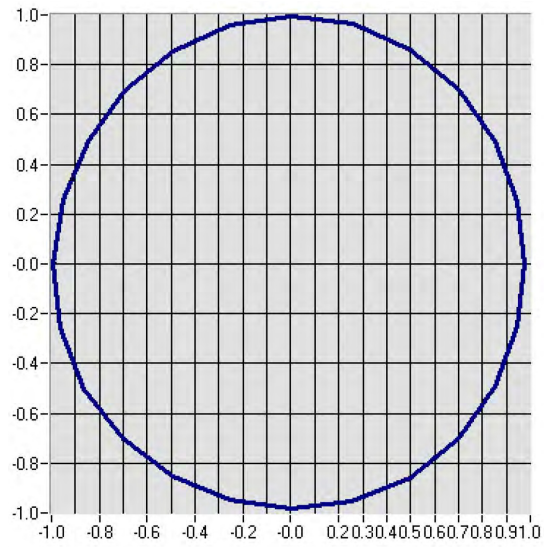


| Frequency (GHz) | Normz dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normz dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$) |
|-----------------|--|--|--|
| 0.7GHz-2.5GHz | 6.54 | 4.86 | 5.80 |
| Frequency (GHz) | DCP dipole 1 (mV) | DCP dipole 2 (mV) | DCP dipole 3 (mV) |
| 0.7GHz-2.5GHz | 96 | 96 | 92 |

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.

Isotropy: +/- 1.22% (+/- 0.05 dB)

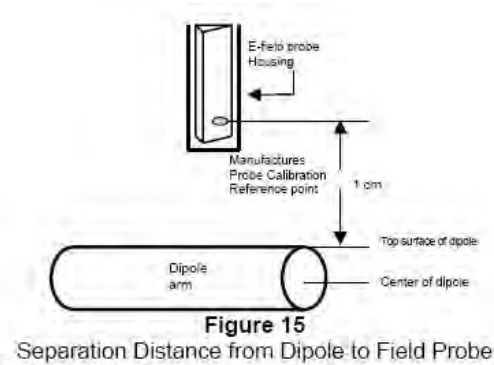


5 SYSTEM VERIFICATION

5.1 System Check Procedure

The input signal was an unmodulated continuous wave. The following points were taken into consideration in performing this check:

- Average Input Power $P = 100\text{mW RMS}$ (20dBm RMS) after adjustment for return loss
- The test fixture must meet the 2 wavelength separation criterion
- The proper measurement of the 1 cm probe to dipole separation, which is measured from top surface of the dipole to the calibration reference point of the sensor, defined by the probe manufacturer is shown in the following diagram:

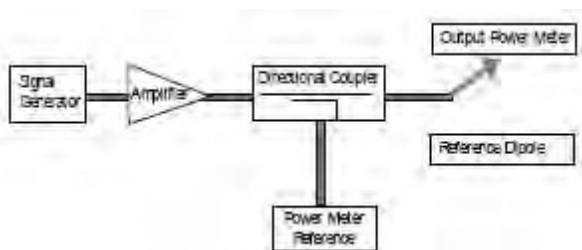


RF power was recorded using both an average reading meter and a peak reading meter. Readings of the probe are provided by the measurement system. To assure proper operation of the near-field measurement probe the input power to the dipole shall be commensurate with the full rated output power of the wireless device (e.g. - for a cellular phone wireless device the average peak antenna input power will be on the order of 100mW (i.e. - 20dBm) RMS after adjustment for any mismatch.

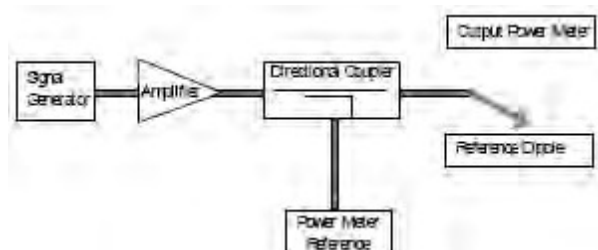
5.2 Validation Procedure

A dipole antenna meeting the requirements given in PC63.19 was placed in the position normally occupied by the WD. The length of the dipole was scanned with both E-field and H-field probes and the maximum values for each were recorded. Using the near-field measurement system, scan the antenna over the radiating dipole and record the greatest field reading observed. Due to the nature of E-fields about free-space dipoles, the two E-field peaks measured over the dipole are averaged to compensate for non-parallelity of the setup see manufacturer method on dipole calibration certificates, Field strength measurements shall be made only when the probe is stationary. RF power was recorded using both an average and a peak power reading meter.

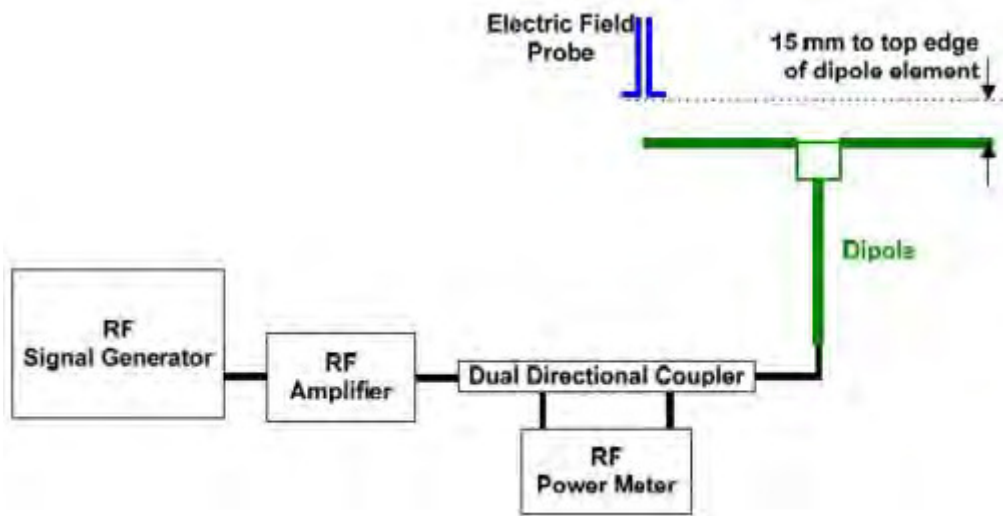
Setup for Desired Output Power to Dipole



Setup to Dipole



5.3 System Validation Setup



Using this setup configuration, the signal generator was adjusted for the desired output power 20dBm (100mW) at a specified frequency. The reference power from the coupled port of the directional coupler is recorded. Next, the output cable is connected to the reference dipole

5.4 System Validation Results

Comparing to the original HAC value provided by SATIMO, the validation data should be within its specification of 10 %.

| Date | Frequency | Input Power (dBm) | E-field Result (V/m) | Target Field (V/m) | Tolerance (%) |
|------------|-----------|-------------------|----------------------|--------------------|---------------|
| 2015/11/09 | 835 MHz | 20.0 | 214.10 | 220.4 | -2.86 |
| 2015/11/09 | 1880MHz | 20.0 | 155.88 | 153.4 | 1.62 |
| 2015/11/09 | 2450MHz | 20.0 | 141.91 | 134.7 | 5.35 |

6 Modulation Interference Factor (MIF)

The HAC Standard ANSI C63.19-2011 defines a new scaling using the Modulation Interference Factor (MIF). For any specific fixed and repeatable modulated signal, a modulation interference factor (MIF, expressed in dB) may be developed that relates its interference potential to its steady-state rms signal level or average power level. This factor is a function only of the audio-frequency amplitude modulation characteristics of the signal and is the same for field-strength and conducted power measurements. It is important to emphasize that the MIF is valid only for a specific repeatable audio-frequency amplitude modulation characteristic. Any change in modulation characteristic requires determination and application of a new MIF.

The MIF may be determined using a radiated RF field, a conducted RF signal, or in a preliminary stage, a mathematical analysis of a modeled RF signal:

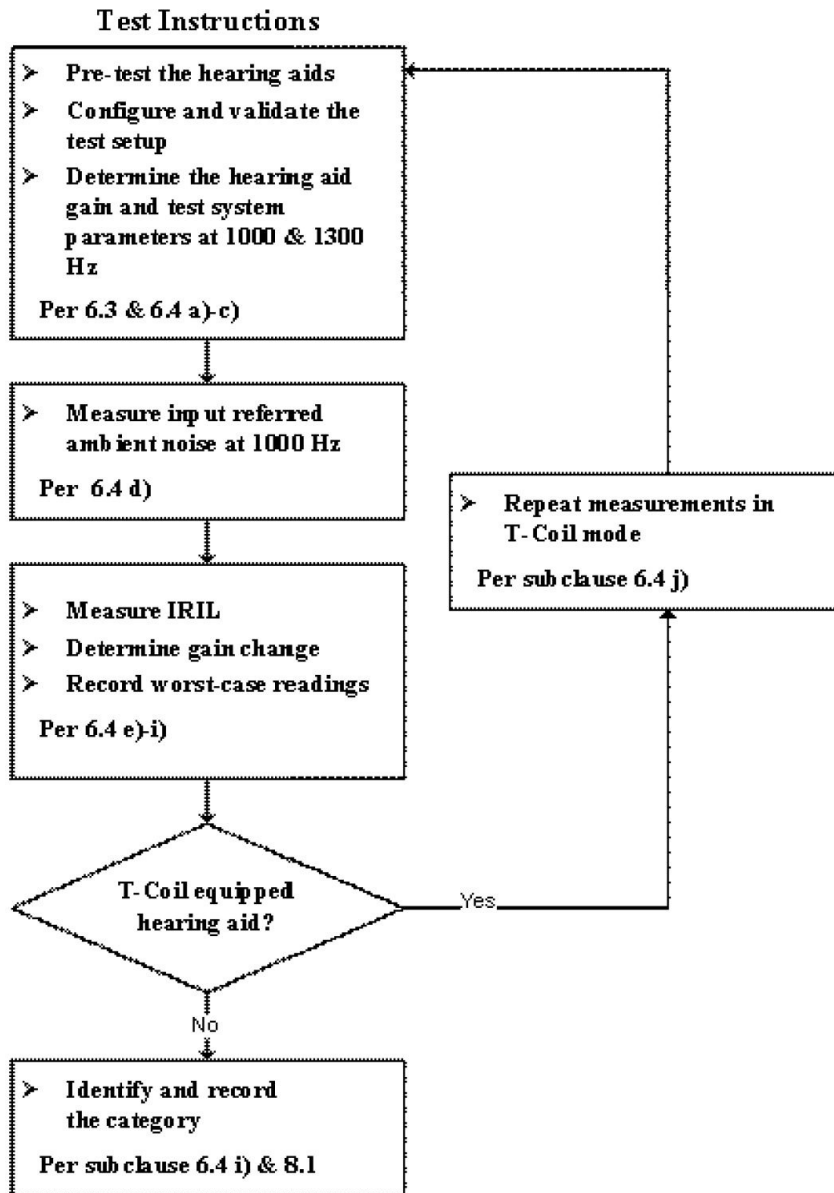
- a) Verify the slope accuracy and dynamic range capability over the desired operating frequency band of a fast probe or sensor, square-law detector, as specified in D.3, and weighting system as specified in D.4 and D.5. For the probe and instrumentation included in the measurement of MIF, additional calibration and application of calibration factors are not required.
- b) Using RF illumination or conducted coupling, apply the specific modulated signal in question to the measurement system at a level within its confirmed operating dynamic range.
- c) Measure the steady-state rms level at the output of the fast probe or sensor.
- d) Measure the steady-state average level at the weighting output.
- e) Without changing the square-law detector or weighting system, and using RF illumination or conducted coupling, substitute for the specific modulated signal a 1kHz, 80% amplitude-modulated carrier at the same frequency and adjust its strength until the level at the weighting output equals the step d) measurement.
- f) Without changing the carrier level from step e), remove the 1 kHz modulation and again measure the steady-state rms level indicated at the output of the fast probe or sensor.
- g) The MIF for the specific modulation characteristic is provided by the ratio of the step f) measurement to the step c) measurement, expressed in dB ($20 \times \log(\text{step f})/\text{step c}$)).

In practice, step e) and step f) need not be repeated for each MIF determination if the relationship between the two measurements has been preestablished for the measurement system over the operating frequency and dynamic ranges.

| Probe | Signal Type | MIF |
|---------------|-------------|---------|
| E-Field Probe | CW | -100.00 |
| | GSM | 3.63 |
| | WCDMA | -27.23 |
| | CDMA2000 | -19.75 |
| | TD-SCDMA | 3.10 |
| | FDD-LTE | -15.6 |
| | TDD-LTE | -1.6 |

7 HAC RF IMMUNITY MEASUREMENT PROCEDURES

7.1 HAC Measurement Process Diagram



7.2 HAC RF Test Setup



Reference and plane for RF emission measurements

7.3 RF Emission Measurement Procedure

The following illustrate a typical RF emissions test scan over a wireless communications device:

- Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.
- WD is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
- The WD operation for maximum rated RF output power was configured and confirmed with the base station simulator, at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test.
- The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The WD audio output was positioned tangent (as physically possible) to the measurement plane.
- A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the HAC Phantom.
- The measurement system measured the field strength at the reference location.

8 CONDUCTED RF OUPUT POWER

8.1 GSM

| Test Band | Test Mode | Test Channel | Measured (dBm) |
|-----------|-----------|--------------|----------------|
| 850 | GSM | LCH | 33.69 |
| | | MCH | 33.47 |
| | | HCH | 33.37 |
| | GSM/GPRS | LCH_Slot1 | 33.61 |
| | | LCH_Slot2 | 31.98 |
| | | LCH_Slot3 | 31.10 |
| | | LCH_Slot4 | 29.36 |
| | | MCH_Slot1 | 33.44 |
| | | MCH_Slot2 | 32.27 |
| | | MCH_Slot3 | 30.98 |
| | | MCH_Slot4 | 29.82 |
| | | HCH_Slot1 | 33.33 |
| | | HCH_Slot2 | 31.96 |
| | | HCH_Slot3 | 30.57 |
| | | HCH_Slot4 | 29.47 |
| | GSM/EDGE | LCH_Slot1 | 27.91 |
| | | LCH_Slot2 | 25.72 |
| | | LCH_Slot3 | 24.01 |
| | | LCH_Slot4 | 23.34 |
| | | MCH_Slot1 | 27.69 |
| | | MCH_Slot2 | 25.57 |
| | | MCH_Slot3 | 23.91 |
| | | MCH_Slot4 | 23.25 |
| | | HCH_Slot1 | 27.37 |
| HCH_Slot2 | | 25.21 | |
| HCH_Slot3 | | 23.59 | |
| HCH_Slot4 | | 22.95 | |

| Test Band | Test Mode | Test Channel | Measured (dBm) |
|-----------|-----------|--------------|----------------|
| 1900 | GSM/TM1 | LCH | 30.13 |
| | | MCH | 30.54 |
| | | HCH | 30.61 |
| | GSM/TM2 | LCH_Slot1 | 30.63 |
| | | LCH_Slot2 | 29.48 |
| | | LCH_Slot3 | 27.15 |
| | | LCH_Slot4 | 25.90 |
| | | MCH_Slot1 | 30.93 |
| | | MCH_Slot2 | 29.53 |
| | | MCH_Slot3 | 27.38 |
| | | MCH_Slot4 | 26.12 |
| | | HCH_Slot1 | 30.85 |
| | | HCH_Slot2 | 29.44 |
| | | HCH_Slot3 | 27.78 |
| | | HCH_Slot4 | 25.96 |
| | GSM/TM3 | LCH_Slot1 | 25.67 |
| | | LCH_Slot2 | 24.25 |
| | | LCH_Slot3 | 22.86 |
| | | LCH_Slot4 | 20.83 |
| | | MCH_Slot1 | 26.07 |
| | | MCH_Slot2 | 24.73 |
| | | MCH_Slot3 | 23.37 |
| | | MCH_Slot4 | 21.43 |
| | | HCH_Slot1 | 26.22 |
| | | HCH_Slot2 | 24.94 |
| | | HCH_Slot3 | 23.58 |
| | | HCH_Slot4 | 21.57 |

8.2 WCDMA

| Test Band | Test Mode | Test Channel | Measured (dBm) |
|-----------|----------------|--------------|----------------|
| WCDMA850 | UMTS/TM1 | LCH_RMC12 | 24.15 |
| | | MCH_RMC12 | 24.95 |
| | | HCH_RMC12 | 24.69 |
| WCDMA850 | UMTS/HSD PA | LCH_Case1 | 23.12 |
| | | LCH_Case2 | 22.36 |
| | | LCH_Case3 | 22.31 |
| | | LCH_Case4 | 22.22 |
| | | MCH_Case1 | 23.92 |
| | | MCH_Case2 | 23.06 |
| | | MCH_Case3 | 23.03 |
| | | MCH_Case4 | 23.01 |
| | | HCH_Case1 | 23.62 |
| | | HCH_Case2 | 22.84 |
| | | HCH_Case3 | 22.80 |
| | | HCH_Case4 | 22.79 |
| WCDMA850 | UMTS/HSU PA | LCH_Case1 | 22.70 |
| | | LCH_Case2 | 21.69 |
| | | LCH_Case3 | 21.68 |
| | | LCH_Case4 | 22.23 |
| | | LCH_Case5 | 22.36 |
| | | MCH_Case1 | 23.70 |
| | | MCH_Case2 | 22.15 |
| | | MCH_Case3 | 21.82 |
| | | MCH_Case4 | 23.16 |
| | | MCH_Case5 | 22.45 |
| | | HCH_Case1 | 23.27 |
| | | HCH_Case2 | 21.87 |
| | | HCH_Case3 | 21.60 |
| | | HCH_Case4 | 22.95 |

| | | | |
|--|--|-----------|-------|
| | | HCH_Case5 | 22.26 |
|--|--|-----------|-------|

| Test Band | Test Mode | Test Channel | Measured (dBm) |
|-----------|-----------|--------------|----------------|
| WCDMA1900 | UMTS/TM1 | LCH_RMC12 | 23.44 |
| | | MCH_RMC12 | 23.60 |
| | | HCH_RMC12 | 23.23 |
| WCDMA1900 | UMTS/TM2 | LCH_Case1 | 22.62 |
| | | LCH_Case2 | 21.89 |
| | | LCH_Case3 | 22.18 |
| | | LCH_Case4 | 22.17 |
| | | MCH_Case1 | 23.19 |
| | | MCH_Case2 | 22.45 |
| | | MCH_Case3 | 22.39 |
| | | MCH_Case4 | 22.36 |
| | | HCH_Case1 | 22.67 |
| | | HCH_Case2 | 21.89 |
| | | HCH_Case3 | 21.84 |
| | | HCH_Case4 | 21.82 |
| WCDMA1900 | UMTS/TM3 | LCH_Case1 | 22.63 |
| | | LCH_Case2 | 21.70 |
| | | LCH_Case3 | 21.68 |
| | | LCH_Case4 | 21.86 |
| | | LCH_Case5 | 21.84 |
| | | MCH_Case1 | 22.83 |
| | | MCH_Case2 | 21.95 |
| | | MCH_Case3 | 21.93 |
| | | MCH_Case4 | 22.12 |
| | | MCH_Case5 | 21.86 |
| | | HCH_Case1 | 22.35 |
| | | HCH_Case2 | 20.91 |
| | | HCH_Case3 | 20.97 |
| | | HCH_Case4 | 21.63 |
| HCH_Case5 | 21.62 | | |

8.3 LTE

Channel Bandwidth: 5 MHz

| Modulation | Channel | RB Configuration | | Average Power [dBm] | Verdict |
|------------|---------|------------------|--------|---------------------|---------|
| | | Size | Offset | | |
| QPSK | LCH | 1 | 0 | 21.57 | PASS |
| | | 1 | 12 | 21.64 | PASS |
| | | 1 | 24 | 21.65 | PASS |
| | | 12 | 0 | 20.52 | PASS |
| | | 12 | 6 | 20.57 | PASS |
| | | 12 | 13 | 20.57 | PASS |
| | | 25 | 0 | 20.54 | PASS |
| | MCH | 1 | 0 | 23.95 | PASS |
| | | 1 | 12 | 23.73 | PASS |
| | | 1 | 24 | 24.04 | PASS |
| | | 12 | 0 | 22.97 | PASS |
| | | 12 | 6 | 23.06 | PASS |
| | | 12 | 13 | 23.01 | PASS |
| | | 25 | 0 | 23.00 | PASS |
| | HCH | 1 | 0 | 23.04 | PASS |
| | | 1 | 12 | 22.83 | PASS |
| | | 1 | 24 | 22.59 | PASS |
| | | 12 | 0 | 22.15 | PASS |
| | | 12 | 6 | 22.09 | PASS |
| | | 12 | 13 | 21.93 | PASS |
| | | 25 | 0 | 22.04 | PASS |
| 16QAM | LCH | 1 | 0 | 20.81 | PASS |
| | | 1 | 12 | 20.90 | PASS |
| | | 1 | 24 | 20.92 | PASS |
| | | 12 | 0 | 19.61 | PASS |
| | | 12 | 6 | 19.67 | PASS |
| | | 12 | 13 | 19.65 | PASS |
| | | 25 | 0 | 19.52 | PASS |
| | MCH | 1 | 0 | 23.20 | PASS |
| | | 1 | 12 | 23.51 | PASS |
| | | 1 | 24 | 23.47 | PASS |
| | | 12 | 0 | 22.04 | PASS |
| | | 12 | 6 | 22.13 | PASS |
| | | 12 | 13 | 22.09 | PASS |
| | | 25 | 0 | 22.05 | PASS |
| | HCH | 1 | 0 | 22.05 | PASS |
| | | 1 | 12 | 21.84 | PASS |
| | | 1 | 24 | 21.59 | PASS |
| | | 12 | 0 | 21.18 | PASS |
| | | 12 | 6 | 21.13 | PASS |
| | | 12 | 13 | 20.96 | PASS |

| | | | | | |
|--|--|----|---|-------|------|
| | | 25 | 0 | 21.09 | PASS |
|--|--|----|---|-------|------|

Channel Bandwidth: 10 MHz

| Modulation | Channel | RB Configuration | | Average Power [dBm] | Verdict | |
|------------|---------|------------------|--------|---------------------|---------|------|
| | | Size | Offset | | | |
| QPSK | LCH | 1 | 0 | 21.67 | PASS | |
| | | 1 | 24 | 21.95 | PASS | |
| | | 1 | 49 | 21.91 | PASS | |
| | | 25 | 0 | 20.88 | PASS | |
| | | 25 | 12 | 21.02 | PASS | |
| | | 25 | 25 | 20.91 | PASS | |
| | | 50 | 0 | 20.94 | PASS | |
| | MCH | 1 | 0 | 24.03 | PASS | |
| | | 1 | 24 | 24.21 | PASS | |
| | | 1 | 49 | 24.00 | PASS | |
| | | 25 | 0 | 22.95 | PASS | |
| | | 25 | 12 | 22.94 | PASS | |
| | | 25 | 25 | 22.89 | PASS | |
| | | 50 | 0 | 23.00 | PASS | |
| | HCH | 1 | 0 | 23.05 | PASS | |
| | | 1 | 24 | 22.99 | PASS | |
| | | 1 | 49 | 22.43 | PASS | |
| | | 25 | 0 | 22.45 | PASS | |
| | | 25 | 12 | 22.38 | PASS | |
| | | 25 | 25 | 22.03 | PASS | |
| | | 50 | 0 | 22.20 | PASS | |
| | 16QAM | LCH | 1 | 0 | 20.85 | PASS |
| | | | 1 | 24 | 21.15 | PASS |
| | | | 1 | 49 | 21.10 | PASS |
| 25 | | | 0 | 19.84 | PASS | |
| 25 | | | 12 | 20.00 | PASS | |
| 25 | | | 25 | 19.88 | PASS | |
| 50 | | | 0 | 19.89 | PASS | |
| MCH | | 1 | 0 | 23.40 | PASS | |
| | | 1 | 24 | 23.54 | PASS | |
| | | 1 | 49 | 23.40 | PASS | |
| | | 25 | 0 | 21.94 | PASS | |
| | | 25 | 12 | 22.03 | PASS | |
| | | 25 | 25 | 21.88 | PASS | |
| | | 50 | 0 | 21.92 | PASS | |
| HCH | | 1 | 0 | 22.36 | PASS | |
| | | 1 | 24 | 22.33 | PASS | |
| | | 1 | 49 | 21.74 | PASS | |
| | | 25 | 0 | 21.46 | PASS | |
| | | 25 | 12 | 21.41 | PASS | |

| | | | | | |
|--|--|----|----|-------|------|
| | | 25 | 25 | 21.06 | PASS |
| | | 50 | 0 | 21.21 | PASS |

Channel Bandwidth: 15 MHz

| Modulation | Channel | RB Configuration | | Average Power [dBm] | Verdict | |
|------------|---------|------------------|--------|---------------------|---------|------|
| | | Size | Offset | | | |
| QPSK | LCH | 1 | 0 | 22.02 | PASS | |
| | | 1 | 37 | 21.99 | PASS | |
| | | 1 | 74 | 22.36 | PASS | |
| | | 37 | 0 | 21.13 | PASS | |
| | | 37 | 18 | 21.06 | PASS | |
| | | 37 | 38 | 21.26 | PASS | |
| | | 75 | 0 | 21.22 | PASS | |
| | MCH | 1 | 0 | 23.84 | PASS | |
| | | 1 | 37 | 23.88 | PASS | |
| | | 1 | 74 | 24.09 | PASS | |
| | | 37 | 0 | 23.02 | PASS | |
| | | 37 | 18 | 23.01 | PASS | |
| | | 37 | 38 | 22.88 | PASS | |
| | | 75 | 0 | 23.02 | PASS | |
| | HCH | 1 | 0 | 23.50 | PASS | |
| | | 1 | 37 | 23.06 | PASS | |
| | | 1 | 74 | 22.69 | PASS | |
| | | 37 | 0 | 22.53 | PASS | |
| | | 37 | 18 | 22.50 | PASS | |
| | | 37 | 38 | 22.27 | PASS | |
| | | 75 | 0 | 22.48 | PASS | |
| | 16QAM | LCH | 1 | 0 | 21.26 | PASS |
| | | | 1 | 37 | 21.18 | PASS |
| | | | 1 | 74 | 21.58 | PASS |
| 37 | | | 0 | 20.12 | PASS | |
| 37 | | | 18 | 20.02 | PASS | |
| 37 | | | 38 | 20.23 | PASS | |
| 75 | | | 0 | 20.20 | PASS | |
| MCH | | 1 | 0 | 23.23 | PASS | |
| | | 1 | 37 | 23.39 | PASS | |
| | | 1 | 74 | 23.37 | PASS | |
| | | 37 | 0 | 21.99 | PASS | |
| | | 37 | 18 | 22.03 | PASS | |
| | | 37 | 38 | 21.88 | PASS | |
| | | 75 | 0 | 22.00 | PASS | |
| HCH | | 1 | 0 | 22.91 | PASS | |
| | | 1 | 37 | 22.46 | PASS | |
| | | 1 | 74 | 22.05 | PASS | |
| | | 37 | 0 | 21.46 | PASS | |
| | | 37 | 18 | 21.49 | PASS | |

| | | | | | |
|--|--|----|----|-------|------|
| | | 37 | 38 | 21.32 | PASS |
| | | 75 | 0 | 21.55 | PASS |

Channel Bandwidth: 20 MHz

| Modulation | Channel | RB Configuration | | Average Power [dBm] | Verdict |
|------------|---------|------------------|--------|---------------------|---------|
| | | Size | Offset | | |
| QPSK | LCH | 1 | 0 | 22.12 | PASS |
| | | 1 | 49 | 22.35 | PASS |
| | | 1 | 99 | 22.57 | PASS |
| | | 50 | 0 | 21.28 | PASS |
| | | 50 | 25 | 21.36 | PASS |
| | | 50 | 50 | 21.37 | PASS |
| | | 100 | 0 | 21.29 | PASS |
| | MCH | 1 | 0 | 23.85 | PASS |
| | | 1 | 49 | 24.11 | PASS |
| | | 1 | 99 | 23.79 | PASS |
| | | 50 | 0 | 22.98 | PASS |
| | | 50 | 25 | 23.23 | PASS |
| | | 50 | 50 | 23.01 | PASS |
| | | 100 | 0 | 22.99 | PASS |
| | HCH | 1 | 0 | 23.38 | PASS |
| | | 1 | 49 | 23.31 | PASS |
| | | 1 | 99 | 22.87 | PASS |
| | | 50 | 0 | 22.68 | PASS |
| | | 50 | 25 | 22.64 | PASS |
| | | 50 | 50 | 22.34 | PASS |
| | | 100 | 0 | 22.51 | PASS |
| 16QAM | LCH | 1 | 0 | 21.34 | PASS |
| | | 1 | 49 | 21.58 | PASS |
| | | 1 | 99 | 21.80 | PASS |
| | | 50 | 0 | 20.42 | PASS |
| | | 50 | 25 | 20.31 | PASS |
| | | 50 | 50 | 20.33 | PASS |
| | | 100 | 0 | 20.39 | PASS |
| | MCH | 1 | 0 | 23.57 | PASS |
| | | 1 | 49 | 23.64 | PASS |
| | | 1 | 99 | 23.71 | PASS |
| | | 50 | 0 | 22.02 | PASS |
| | | 50 | 25 | 22.18 | PASS |
| | | 50 | 50 | 21.97 | PASS |
| | | 100 | 0 | 22.01 | PASS |
| | HCH | 1 | 0 | 22.91 | PASS |
| | | 1 | 49 | 22.78 | PASS |
| | | 1 | 99 | 22.29 | PASS |
| | | 50 | 0 | 21.73 | PASS |

| | | | | | |
|--|--|-----|----|-------|------|
| | | 50 | 25 | 21.64 | PASS |
| | | 50 | 50 | 21.33 | PASS |
| | | 100 | 0 | 21.54 | PASS |

9 HAC RF Emission Test Results

9.1 E-Filled Emission Test Results

| Band | Mode | Ch. | Freq. (MHz) | Peak E-Field dB (V/m) | M-Rating | Meas.No. |
|--------------|-------|-------|-------------|-----------------------|----------|----------|
| GSM 850 | Voice | 128 | 824.2 | 35.84 | M4 | 1# |
| | | 189 | 836.4 | 36.19 | M4 | 2# |
| | | 251 | 848.8 | 35.84 | M4 | 3# |
| GSM 1900 | Voice | 512 | 1850.2 | 26.52 | M4 | 4# |
| | | 661 | 1880.0 | 26.43 | M4 | 5# |
| | | 810 | 1909.8 | 34.59 | M3 | 6# |
| WCDMA Band 2 | RMC | 9262 | 1852.5 | 5.84 | M4 | 7# |
| | | 9400 | 1880.0 | 6.17 | M4 | 8# |
| | | 9538 | 1907.4 | 5.32 | M4 | 9# |
| WCDMA Band 5 | RMC | 4132 | 826.4 | 4.43 | M4 | 10# |
| | | 4182 | 836.4 | 6.13 | M4 | 11# |
| | | 4232 | 846.6 | 5.79 | M4 | 12# |
| LTE Band 7 | QPSK | 20850 | 2510.0 | 19.47 | M4 | 13# |
| | | 21100 | 2535.0 | 19.51 | M4 | 14# |
| | | 21350 | 2560.0 | 19.53 | M4 | 15# |
| LTE Band 41 | QPSK | 39750 | 2506.0 | 17.87 | M4 | 16# |
| | | 40620 | 2593.0 | 18.08 | M4 | 17# |
| | | 41490 | 2680.0 | 17.93 | M4 | 18# |

10 TEST EQUIPMENTS LIST

| Description | Manufacturer | Model | Serial No. | Cal. Date | Cal. Due |
|-------------------------------------|--------------|--------------------|---------------------|------------|------------|
| PC | Dell | N/A | N/A | N/A | N/A |
| 800-950MHz Dipole | SATIMO | SIDB835 | SN 18/12 DHA41 | 2015/03/16 | 2016/03/15 |
| 1700-2000MHz Dipole | SATIMO | SIDB1900 | SN 18/12 DHB46 | 2015/03/16 | 2016/03/15 |
| 2100-2600MHz Dipole | SATIMO | SIDB2450 | SN 18/12 DHC48 | 2015/03/16 | 2016/03/15 |
| E-Field Probe | SATIMO | SCE | SN 24/13 EPH41 | 2015/03/16 | 2016/03/15 |
| Antenna | SATIMO | ANTA3 | SN 17/13 ZNTA45 | N/A | N/A |
| MultiMeter | Keithley | MultiMeter 2000 | 4024022 | 2015/02/13 | 2016/02/12 |
| Signal Generator | R&S | SMF100A | 1167.0000k02/104260 | 2015/02/17 | 2016/02/16 |
| Power Meter | Agilent | E4419B | GB40201833 | 2015/10/14 | 2016/10/13 |
| Power Sensor | R&S | NRP-Z21 | 103971 | 2015/07/16 | 2016/07/15 |
| Power Amplifier | SATIMO | 6552B | 22374 | N/A | N/A |
| Wireless Communication Test Set | R&S | CMU 200 | 123666 | 2015/10/15 | 2016/10/14 |
| Wireless Communications Test Set | R&S | CMW 500 | 138884 | 2015/07/16 | 2016/07/15 |

11 REFERENCES

- 1 FCC 47 CFR Part 20.19 "Hearing aid-compatible mobile handsets."
- 2 ANSI C 63.19:2011 "American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", 27 May 2011
- 3 KDB 285076 D01 HAC Guidance v04, "provides equipment authorization guidance for mobile handsets subject to the requirements of Section 20.19 for hearing aid compatibility
- 4 KDB 285076 D02, T-Coil testing for CMRS IP v01r01 provides guidance for T-Coil tests for voice-over-IP (e.g. LTE and Wi-Fi) CMRS based Telephone Services.
- 4 SATIMO COMOHAC_V4
- 5 SATIMO OPENHAC_V4

ANNEX A HAC TEST RESULT OF SYSTEM VERIFICATION

E-Field System Check Data(835MHz Head)

Experimental conditions.

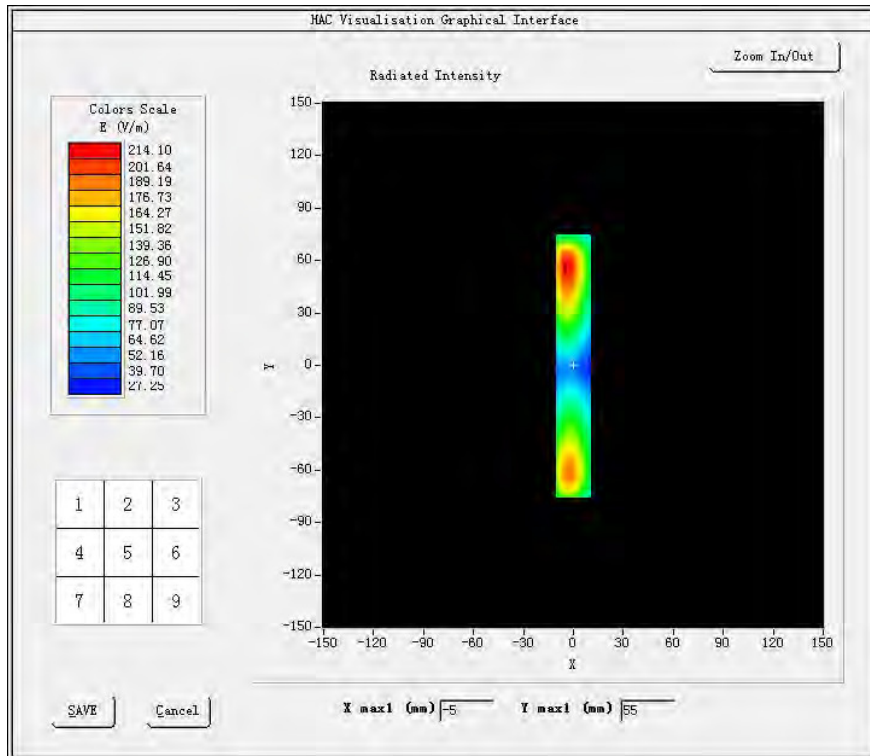
| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | 835MHz |
| Channel | |
| Signal | CW |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Frequency (MHz): 880.200000

Maximum value of total field = 214.10 V/m

SURFACE E-Field



E-Filed System Check Data (1880MHz)

Experimental conditions

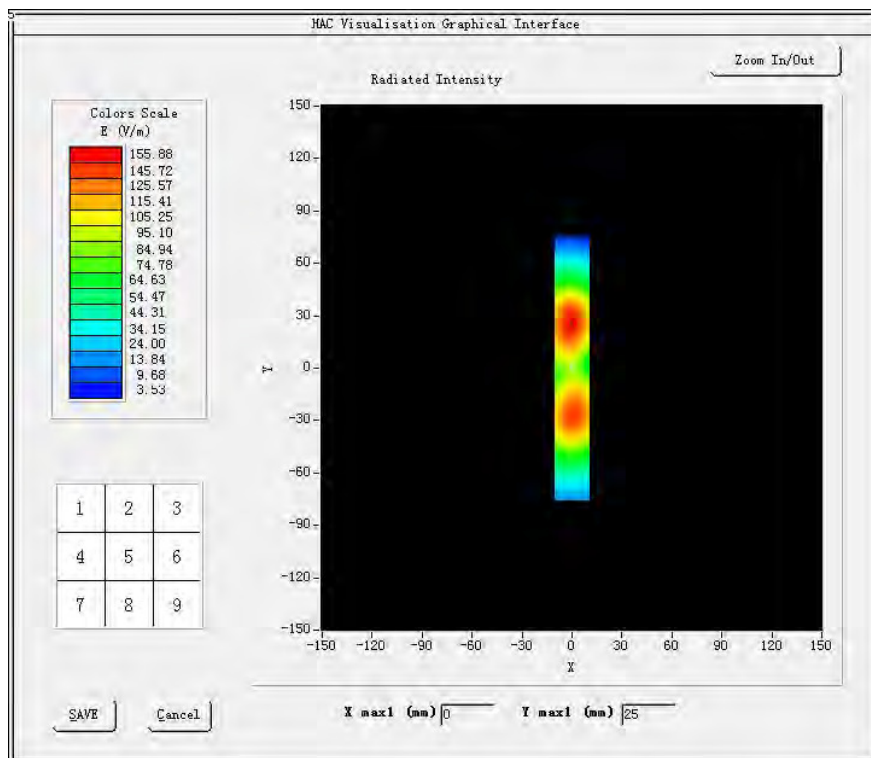
| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | 1880 MHz |
| Channel | |
| Signal | CW |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Frequency (MHz): 1880.000000

Maximum value of total field = 155.88V/m

SURFACE HAC



E-Filed System Check Data (2450MHz)

Experimental conditions

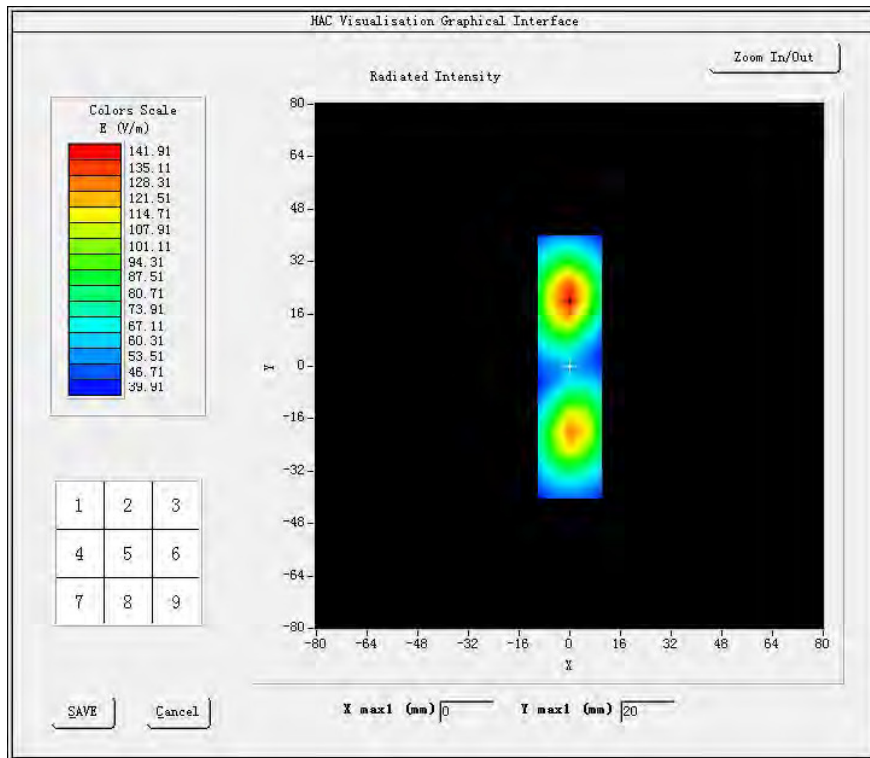
| | |
|----------------------------|------------|
| Grid size (mm x mm) | 20.0, 80.0 |
| Step (mm) | 5 |
| Band | 2450 MHz |
| Channel | |
| Signal | CW |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Frequency (MHz): 2450.000000

Maximum value of total field = 141.91V/m

SURFACE HAC



ANNEX B HAC RF MEASUREMENT RESULT

TABLE OF MEASUREMENT RESULT LIST

| <u>Band</u> | <u>Mode</u> | <u>PARAMETERS</u> |
|---------------------|--------------|--|
| GSM 850 | Voice | <u>Measurement 1: E-field on Low Channel</u> |
| | | <u>Measurement 2: E-field on Middle Channel</u> |
| | | <u>Measurement 3: E-field on High Channel</u> |
| GSM 1900 | Voice | <u>Measurement 4: E-field on Low Channel</u> |
| | | <u>Measurement 5: E-field on Middle Channel</u> |
| | | <u>Measurement 6: E-field on High Channel</u> |
| WCDMA Band 2 | RMC | <u>Measurement 7: E-field on Low Channel</u> |
| | | <u>Measurement 8: E-field on Middle Channel</u> |
| | | <u>Measurement 9: E-field on High Channel</u> |
| WCDMA Band 5 | RMC | <u>Measurement 10: E-field on Low Channel</u> |
| | | <u>Measurement 11: E-field on Middle Channel</u> |
| | | <u>Measurement 12: E-field on High Channel</u> |
| LTE Band 7 | QPSK | <u>Measurement 13: E-field on Low Channel</u> |
| | | <u>Measurement 14: E-field on Middle Channel</u> |
| | | <u>Measurement 15: E-field on High Channel</u> |
| LTE Band 41 | QPSK | <u>Measurement 16: E-field on Low Channel</u> |
| | | <u>Measurement 17: E-field on Middle Channel</u> |
| | | <u>Measurement 18: E-field on High Channel</u> |

MEASUREMENT 1

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM 850 |
| Channel | Low |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 128):

Frequency (MHz): 824.200000

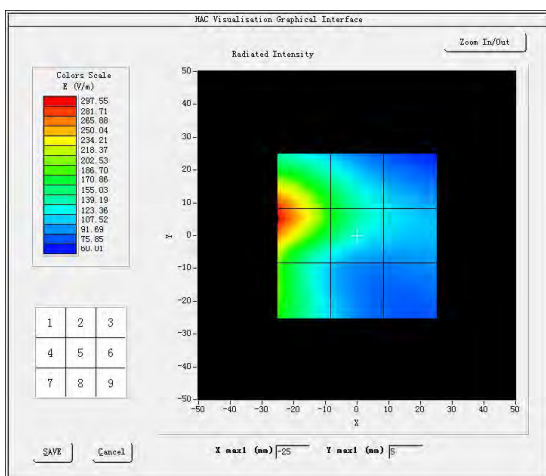
Modulation Interference Factor (MIF) = 3.630000

Maximum value of total field = 35.84 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 39.95 | Grid 2: 35.61 | Grid 3: 31.84 |
| Grid 4: 40.43 | Grid 5: 35.84 | Grid 6: 32.18 |
| Grid 7: 36.93 | Grid 8: 31.53 | Grid 9: 30.27 |

MEASUREMENT 2

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM 850 |
| Channel | Middle |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Middle Band (Channel 189):

Frequency (MHz): 836.400000

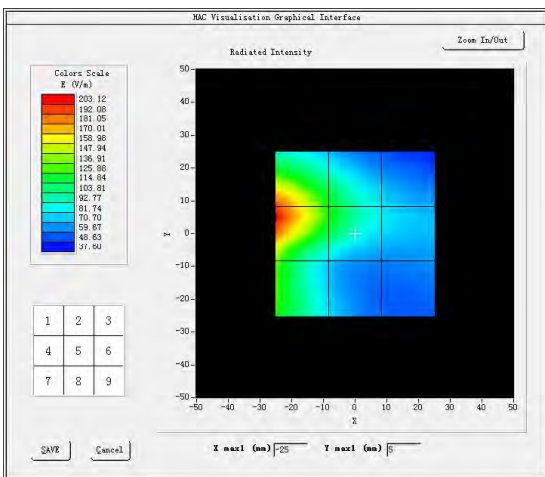
Modulation Interference Factor (MIF) = 3.630000

Maximum value of total field = 36.19 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 39.97 | Grid 2: 35.78 | Grid 3: 31.70 |
| Grid 4: 40.72 | Grid 5: 36.19 | Grid 6: 32.21 |
| Grid 7: 37.24 | Grid 8: 31.72 | Grid 9: 30.15 |

MEASUREMENT 3

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM850 |
| Channel | High |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Higher Band (Channel 251):

Frequency (MHz): 848.800000

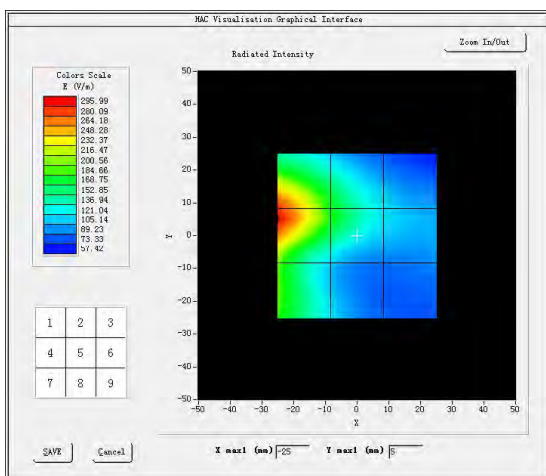
Modulation Interference Factor (MIF) = 3.630000

Maximum value of total field = 35.84 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 39.86 | Grid 2: 35.52 | Grid 3: 31.42 |
| Grid 4: 40.37 | Grid 5: 35.84 | Grid 6: 31.69 |
| Grid 7: 36.87 | Grid 8: 31.53 | Grid 9: 29.69 |

MEASUREMENT 4

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM 1900 |
| Channel | Low |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 512):

Frequency (MHz): 1850.200000

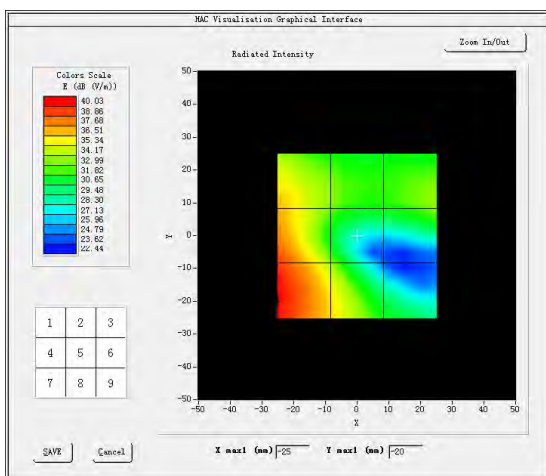
Modulation Interference Factor (MIF) = 3.630000

Maximum value of total field = 26.52 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 27.53 | Grid 2: 23.93 | Grid 3: 24.35 |
| Grid 4: 29.86 | Grid 5: 23.64 | Grid 6: 24.21 |
| Grid 7: 31.07 | Grid 8: 26.52 | Grid 9: 22.28 |

MEASUREMENT 5

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM 1900 |
| Channel | Middle |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 661):

Frequency (MHz): 1880.000000

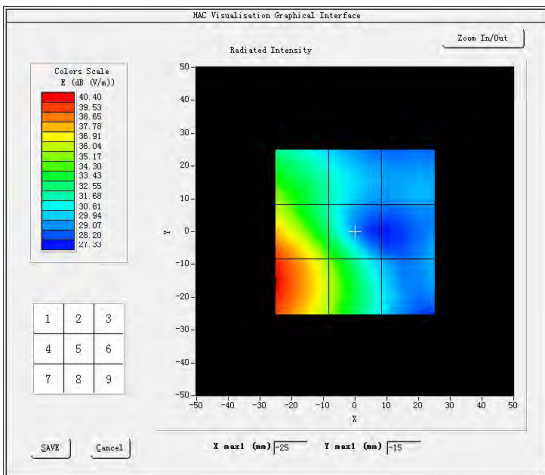
Modulation Interference Factor (MIF) =3.63000

Maximum value of total field = 26.43 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 26.43 | Grid 2: 22.29 | Grid 3: 20.60 |
| Grid 4: 30.52 | Grid 5: 25.23 | Grid 6: 20.48 |
| Grid 7: 31.39 | Grid 8: 26.53 | Grid 9: 21.15 |

MEASUREMENT 6

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | GSM 1900 |
| Channel | High |
| Signal | GSM |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 810):

Frequency (MHz): 1909.800000

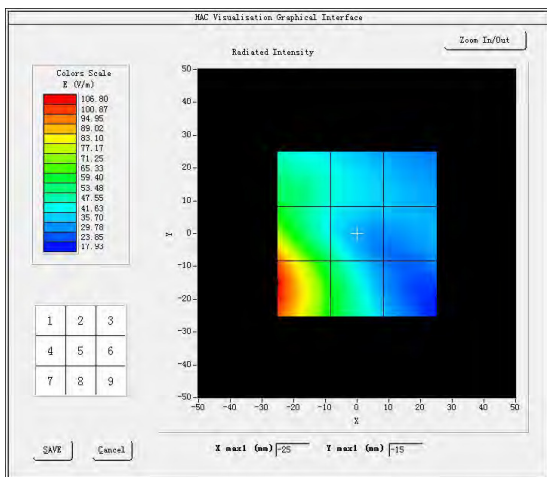
Modulation Interference Factor (MIF) =3.630000

Maximum value of total field =34.59 dB (V/m)

Hearing Aid Near-Field Category: M3

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 25.53 | Grid 2: 23.37 | Grid 3: 20.66 |
| Grid 4: 34.96 | Grid 5: 34.59 | Grid 6: 21.42 |
| Grid 7: 34.49 | Grid 8: 28.74 | Grid 9: 21.67 |

MEASUREMENT 7

Experimental conditions

| | |
|----------------------------|--------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCDMA Band 2 |
| Channel | Low |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 9262):

Frequency (MHz): 1852.500000

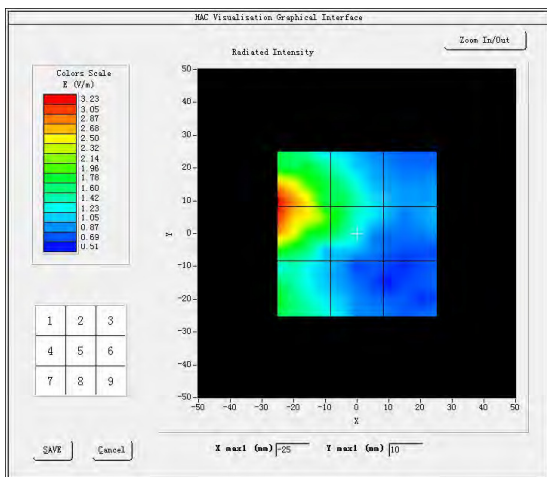
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 5.84 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|---------------------|---------------|
| Grid 1: 10.44 | Grid 2: 5.08 | Grid 3: 0.08 |
| Grid 4: 10.47 | Grid 5: 5.84 | Grid 6: 0.27 |
| Grid 7: 5.60 | Grid 8: 1.96 | Grid 9: -1.93 |

MEASUREMENT 8

Experimental conditions

| | |
|----------------------------|--------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCDMA Band 2 |
| Channel | Middle |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Middle Band (Channel 9400):

Frequency (MHz): 1880.000000

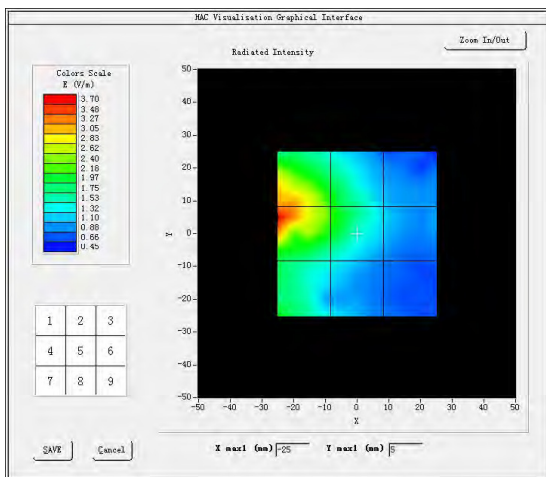
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 6.17 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|---------------------|---------------|
| Grid 1: 9.83 | Grid 2: 6.17 | Grid 3: -0.15 |
| Grid 4: 11.23 | Grid 5: 6.00 | Grid 6: 0.75 |
| Grid 7: 6.42 | Grid 8: 1.88 | Grid 9: -1.72 |

MEASUREMENT 9

Experimental conditions

| | |
|----------------------------|--------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCDMA Band 2 |
| Channel | High |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Higher Band (Channel 9538):

Frequency (MHz): 1907.400000

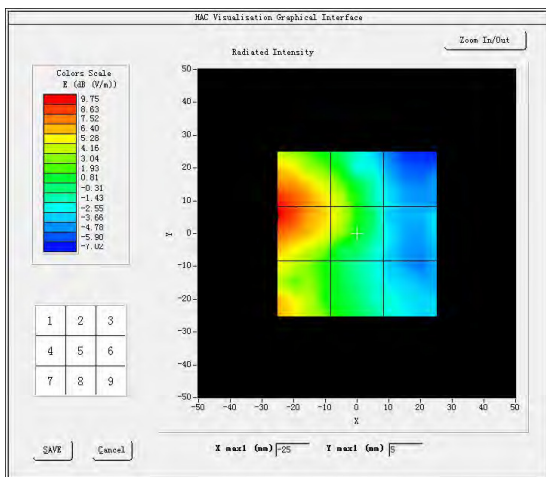
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 5.32 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|---------------------|---------------|
| Grid 1: 9.66 | Grid 2: 4.92 | Grid 3: -2.68 |
| Grid 4: 10.11 | Grid 5: 5.32 | Grid 6: -2.59 |
| Grid 7: 6.90 | Grid 8: 2.36 | Grid 9: -2.01 |

MEASUREMENT 10

Experimental conditions

| | |
|----------------------------|--------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCDMA Band 5 |
| Channel | Low |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 4132):

Frequency (MHz): 826.400000

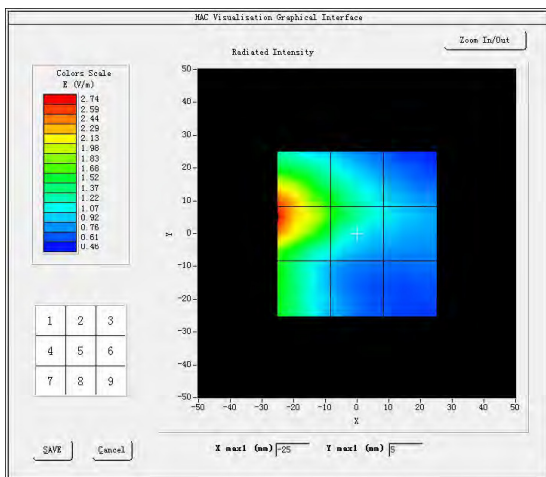
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 4.43 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|---------------------|---------------------|---------------|
| Grid 1: 8.36 | Grid 2: 4.05 | Grid 3: -0.29 |
| Grid 4: 8.94 | Grid 5: 4.43 | Grid 6: 0.13 |
| Grid 7: 4.72 | Grid 8: -0.94 | Grid 9: -2.78 |

MEASUREMENT 11

Experimental conditions

| | |
|----------------------------|--------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCDMA Band 5 |
| Channel | Middle |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 4182):

Frequency (MHz): 836.400000

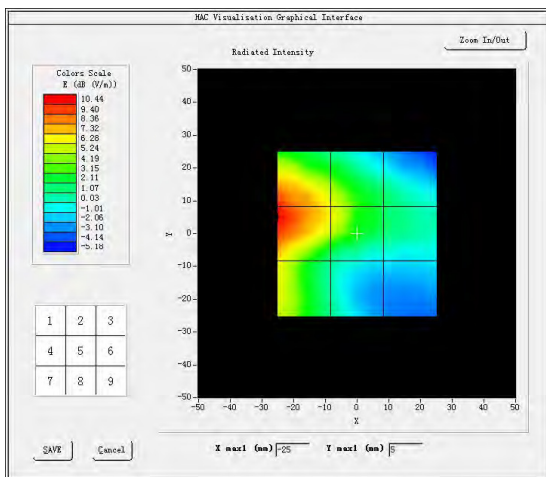
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 6.13 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|---------------------|---------------|
| Grid 1: 9.90 | Grid 2: 5.67 | Grid 3: 1.34 |
| Grid 4: 10.62 | Grid 5: 6.13 | Grid 6: 1.39 |
| Grid 7: 6.70 | Grid 8: 0.56 | Grid 9: -1.32 |

MEASUREMENT 12

Experimental conditions

| | |
|----------------------------|-------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | WCMA Band 5 |
| Channel | High |
| Signal | WCDMA |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 4233):

Frequency (MHz): 846.600000

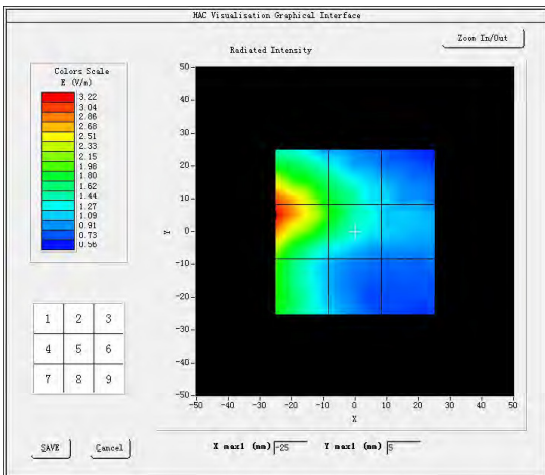
Modulation Interference Factor (MIF) = 27.230000

Maximum value of total field = 5.79 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|---------------------|---------------|
| Grid 1: 9.74 | Grid 2: 5.27 | Grid 3: 1.33 |
| Grid 4: 10.34 | Grid 5: 5.79 | Grid 6: 1.20 |
| Grid 7: 6.56 | Grid 8: 0.76 | Grid 9: -1.11 |

MEASUREMENT 13

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 7 |
| Channel | Low |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 20850):

Frequency (MHz): 2510.000000

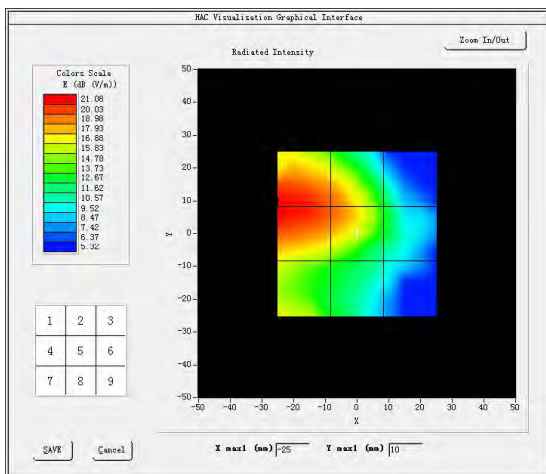
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 19.47 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 21.15 | Grid 2: 19.27 | Grid 3: 11.56 |
| Grid 4: 21.26 | Grid 5: 19.47 | Grid 6: 12.84 |
| Grid 7: 17.07 | Grid 8: 14.08 | Grid 9: 9.94 |

MEASUREMENT 14

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 7 |
| Channel | Middle |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Middle Band (Channel 21100):

Frequency (MHz): 2535.000000

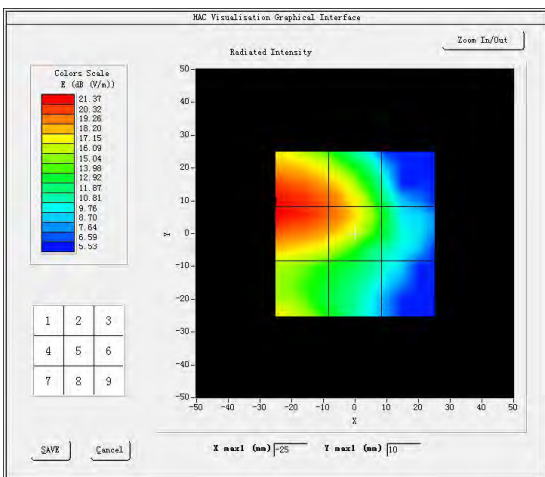
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 19.51 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 21.22 | Grid 2: 19.30 | Grid 3: 11.50 |
| Grid 4: 21.35 | Grid 5: 19.51 | Grid 6: 12.81 |
| Grid 7: 17.16 | Grid 8: 14.12 | Grid 9: 10.04 |

MEASUREMENT 15

Experimental conditions

| | |
|----------------------------|------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 7 |
| Channel | High |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Higher Band (Channel 21350):

Frequency (MHz): 2560.000000

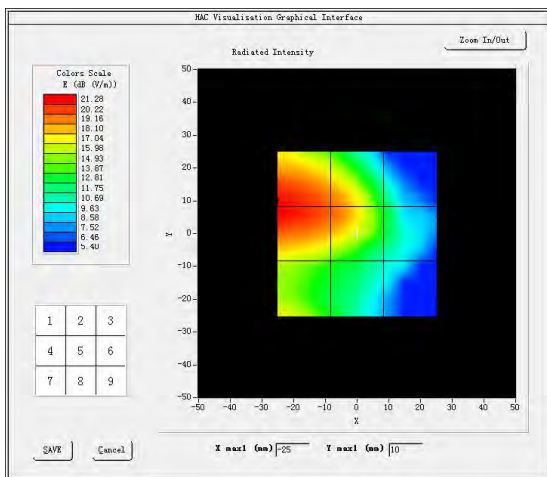
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 19.53 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 21.26 | Grid 2: 19.29 | Grid 3: 11.35 |
| Grid 4: 21.39 | Grid 5: 19.53 | Grid 6: 12.61 |
| Grid 7: 17.14 | Grid 8: 14.09 | Grid 9: 10.11 |

MEASUREMENT 16

Experimental conditions

| | |
|----------------------------|-------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 41 |
| Channel | Low |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 39750):

Frequency (MHz): 2506.000000

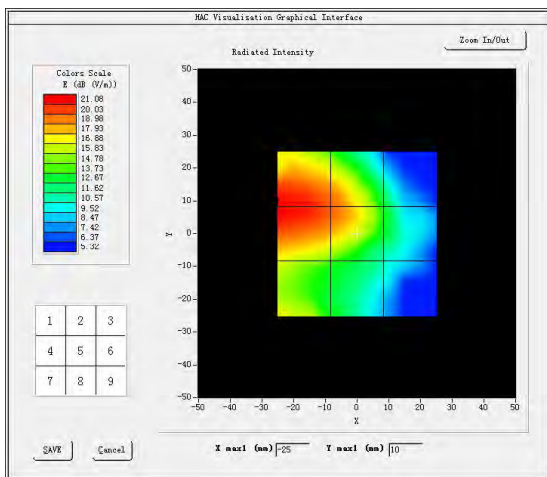
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 17.87 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 19.55 | Grid 2: 17.67 | Grid 3: 9.96 |
| Grid 4: 19.66 | Grid 5: 17.87 | Grid 6: 11.24 |
| Grid 7: 15.47 | Grid 8: 12.48 | Grid 9: 8.34 |

MEASUREMENT 17

Experimental conditions

| | |
|----------------------------|-------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 41 |
| Channel | Middle |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 40620):

Frequency (MHz): 2593.000000

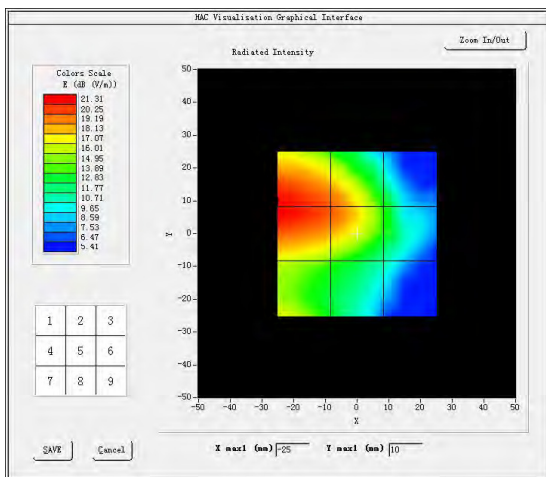
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 18.08 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 19.68 | Grid 2: 17.84 | Grid 3: 11.00 |
| Grid 4: 19.80 | Grid 5: 18.08 | Grid 6: 11.85 |
| Grid 7: 15.23 | Grid 8: 12.77 | Grid 9: 8.73 |

MEASUREMENT 18

Experimental conditions

| | |
|----------------------------|-------------|
| Grid size (mm x mm) | 50.0, 50.0 |
| Step (mm) | 5 |
| Band | LTE Band 41 |
| Channel | High |
| Signal | LTE |
| Date of measurement | 09/11/2015 |

HAC Measurement Results

Lower Band (Channel 41490):

Frequency (MHz): 2680.000000

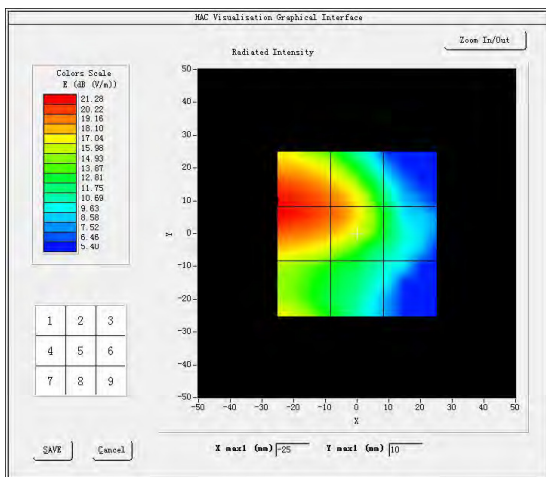
Modulation Interference Factor (MIF) = -1.6000

Maximum value of total field = 17.93 dB (V/m)

Hearing Aid Near-Field Category: M4

SURFACE HAC

E in dB (V/m)



| | | |
|----------------------|----------------------|---------------|
| Grid 1: 19.66 | Grid 2: 17.69 | Grid 3: 9.75 |
| Grid 4: 19.79 | Grid 5: 17.93 | Grid 6: 11.01 |
| Grid 7: 15.54 | Grid 8: 12.49 | Grid 9: 8.51 |

ANNEX C EUT EXTERNAL PHOTOS

Please refer the document “ BL-SZ1590187-AW. PDF”.

ANNEX D HAC E-Field TEST SETUP PHOTOS

Please refer the document “ BL-SZ1590187-E-Field. PDF”.

ANNEX E CALIBRATION FOR PROBE AND DIPOLEF

F.1 E-Field Probe



COMOHAC E-Field Probe Calibration Report

Ref: ACR.75.16.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
NANSHAN DISTRICT, SHENZHEN, GUANGDONG
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



03/16/2015

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.75.18.15.SATU.A

| | <i>Name</i> | <i>Function</i> | <i>Date</i> | <i>Signature</i> |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Checked by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 3/16/2015 | <i>Kim Rutkowski</i> |

| | <i>Customer Name</i> |
|-----------------------|---|
| <i>Distribution :</i> | SHENZHEN BALUN TECHNOLOGY Co.,Ltd. |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A | 3/16/2015 | Initial release |
| | | |
| | | |



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COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.75.18.15.SATUA

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).

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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

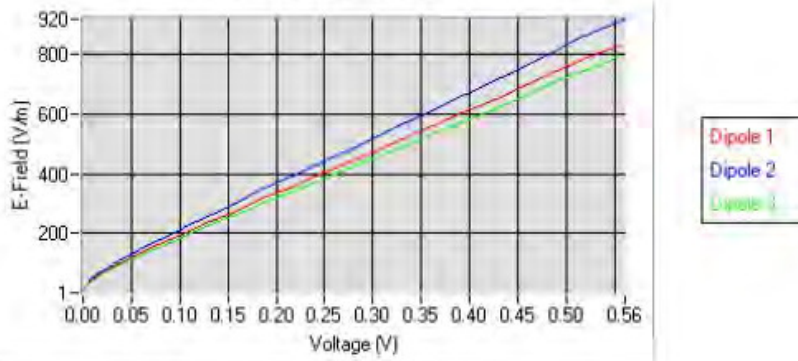
Ref: ACR.75.16.15.SATUA

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

5.1 SENSITIVITY IN AIR

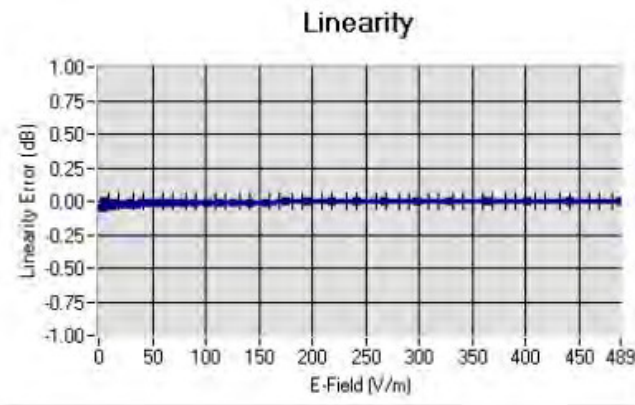
| Normx dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normy dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$) | Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$) |
|---|---|---|
| 5.19 | 5.27 | 5.14 |

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

Calibration curves


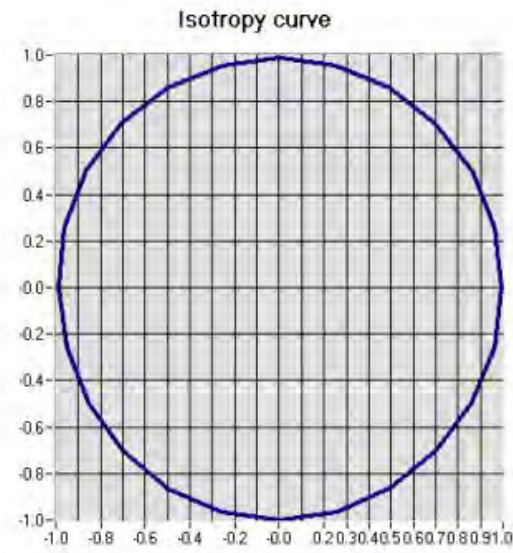


5.2 LINEARITY



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.75.18.15.SATJLA

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 | 02/2013 | 02/2016 |
| Reference Probe | MVG | EPH28 SN 08/11 | 10/2014 | 10/2015 |
| Reference Probe | MVG | HPH38 SN31/10 | 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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F.2 800-950 MHz Dipole



HAC Reference Dipole Calibration Report

Ref: ACR.75.19.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
NANSHAN DISTRICT, SHENZHEN, GUANGDONG
PROVINCE, P.R. CHINA 518055
MVG COMO HAC REFERENCE DIPOLE
FREQUENCY: 800-950MHZ
SERIAL NO.: SN 18/12 DHA41

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



03/16/2015

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.75.19.15.SATU.A

| | <i>Name</i> | <i>Function</i> | <i>Date</i> | <i>Signature</i> |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Checked by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 3/16/2015 | <i>Kim Rutkowski</i> |

| | <i>Customer Name</i> |
|-----------------------|---|
| <i>Distribution :</i> | SHENZHEN BALUN TECHNOLOGY Co.,Ltd. |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A | 3/16/2015 | 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 DHA4I |
| 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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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

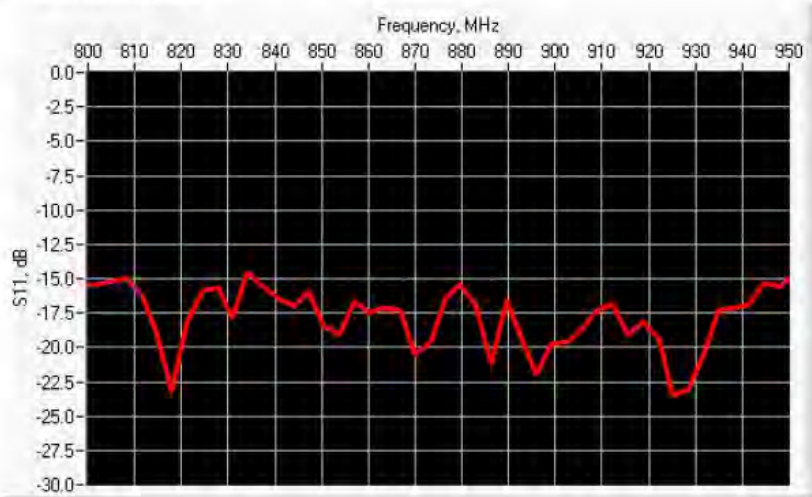
The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

| 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 |



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% |

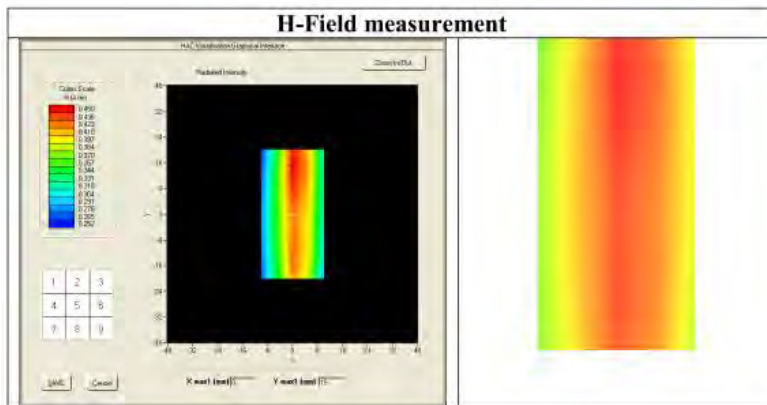
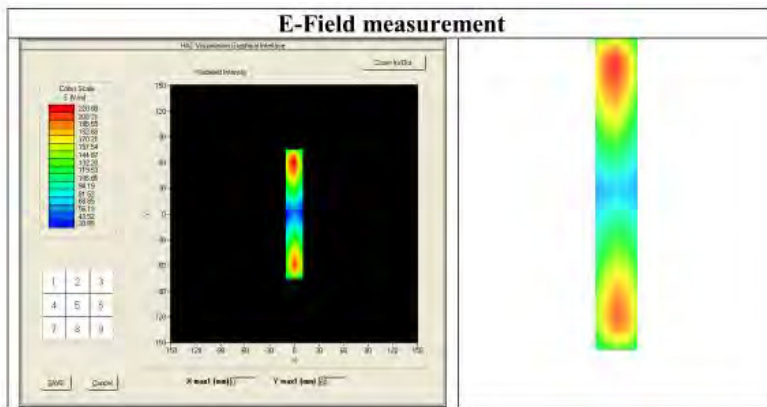


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.19.15.SATU.A

Measurement Result

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



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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 | 02/2013 | 02/2016 |
| Reference Probe | MVG | EPH28 SN 08/11 | 10/2014 | 10/2015 |
| Reference Probe | MVG | HPH38 SN31/10 | 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. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |

F.3 1700-2000 MHz Dipole



HAC Reference Dipole Calibration Report

Ref: ACR.75.20.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
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



03/16/2015

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.



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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 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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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

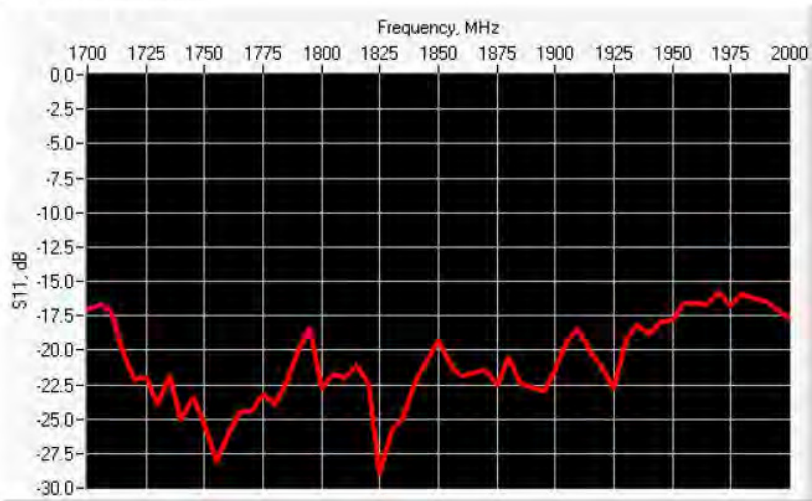
The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

| 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 |



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% |

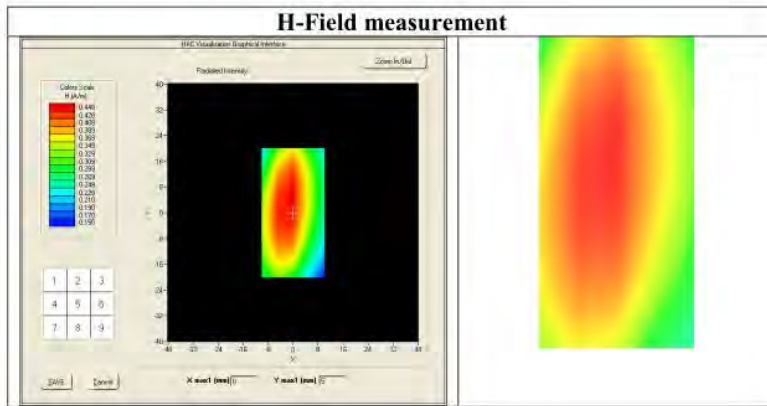
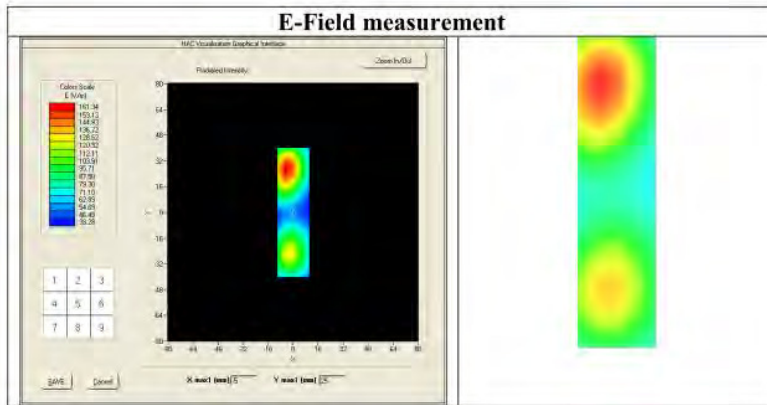


HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.75.20.15.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.75.20.15.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 | 02/2013 | 02/2016 |
| Reference Probe | MVG | EPH28 SN 08/11 | 10/2014 | 10/2015 |
| Reference Probe | MVG | HPH38 SN31/10 | 10/2015 | 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. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |

F.3 2100-2600 MHz Dipole



HAC Reference Dipole Calibration Report

Ref : ACR.75.21.15.SATU.A

SHENZHEN BALUN TECHNOLOGY CO.,LTD.
BLOCK B, FL 1, BAISHA SCIENCE AND TECHNOLOGY
PARK, SHAHE XI ROAD,
NANSHAN DISTRICT, SHENZHEN, GUANGDONG
PROVINCE, P.R. CHINA 518055
MVG COMOHAC REFERENCE DIPOLE
FREQUENCY: 2100-2600MHZ
SERIAL NO.: SN 18/12 DHC48

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



03/16/2015

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.75.21.15.SATU.A

| | <i>Name</i> | <i>Function</i> | <i>Date</i> | <i>Signature</i> |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Checked by :</i> | Jérôme LUC | Product Manager | 3/16/2015 | <i>JS</i> |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 3/16/2015 | <i>Kim Rutkowski</i> |

| | <i>Customer Name</i> |
|-----------------------|---|
| <i>Distribution :</i> | SHENZHEN BALUN TECHNOLOGY Co.,Ltd. |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A | 3/16/2015 | 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 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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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

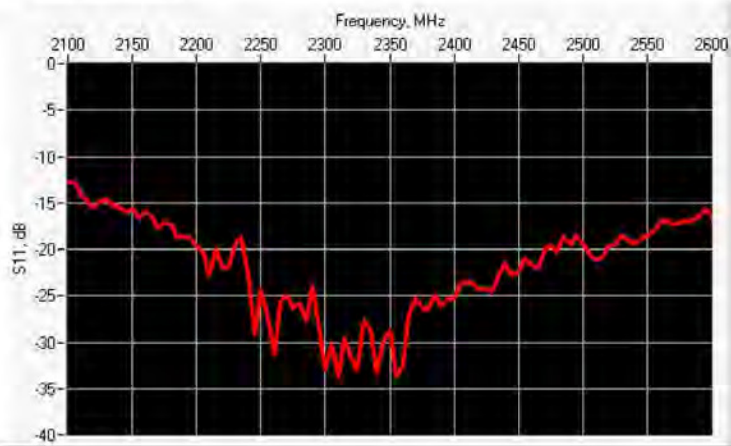
The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

| 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 |



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.

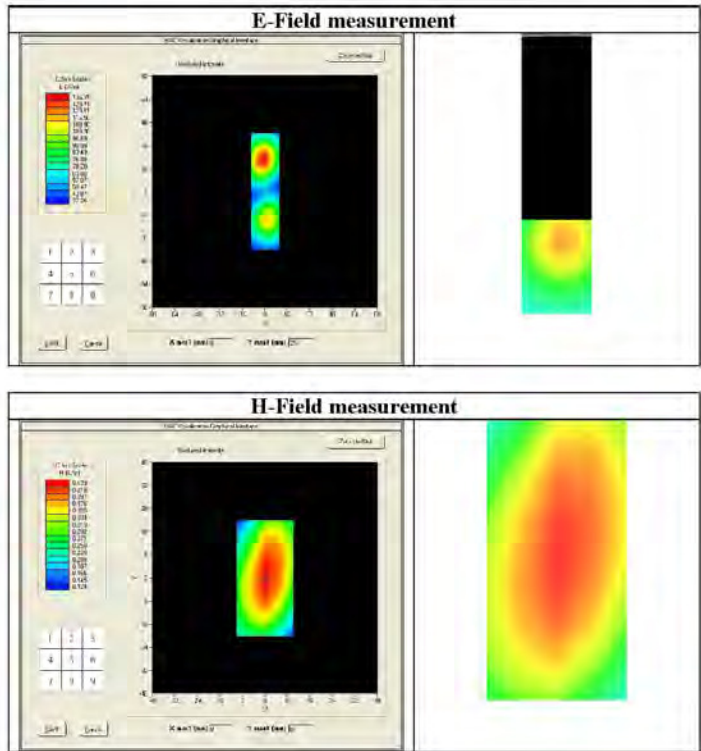
Measurement Condition

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



Measurement Result

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





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 | 02/2013 | 02/2016 |
| Reference Probe | MVG | EPH26 SN 08/11 | 10/2014 | 10/2015 |
| Reference Probe | MVG | HPH38 SN31/10 | 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. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 8/2012 | 8/2015 |