

# HAC T-COIL TEST




## REPORT

**Report No.:** SET2015-12511  
**Product:** M3620  
**Model No.:** M3620  
**Brand Name:** AT&T  
**Applicant:** TeleEpoch Limited  
**Address:** 5A, B1 Building, Digital Tech Zone, High-Tech Park(south),  
Nanshan district Shenzhen, P.R.China  
**Issued by:** CCIC-SET  
**Test date** September 08<sup>th</sup>, 2015  
**Issued Date** September 08<sup>th</sup>, 2015  
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## Test Report

|                                   |   |
|-----------------------------------|---|
| <b>Product.....:</b>              | M3620   |
| <b>Model No. ....:</b>            | M3620   |
| <b>Brand Name.....:</b>           | AT&T  |
| <b>FCC ID.....:</b>               | U46-M3620   |
| <b>Applicant.....:</b>            | TeleEpoch Limited   |
| <b>Applicant Address.....:</b>    | 5A, B1 Building, Digital Tech Zone, High-Tech Park(south), Nanshan district Shenzhen, P.R.China   |
| <b>Manufacturer.....:</b>         | TeleEpoch Limited   |
| <b>Manufacturer Address.....:</b> | 5A, B1 Building, Digital Tech Zone, High-Tech Park(south), Nanshan district Shenzhen, P.R.China   |
| <b>Test Standards.....:</b>       | ANSI C63.19-2011 American National Standard<br>Methods of Measurement of Compatibility between<br>Wireless Communications Devices and Hearing Aids<br><br>FCC 47CFR § 20.19 American National Standard<br>Methods of Measurement of Compatibility between<br>Wireless Communications Devices and Hearing Aids<br><br>KDB 285076 D02 v01r01 T-Coil testing for CMRS IP . |
| <b>Rating.....:</b>               | T-Coil : T3   |
| <b>Test Result.....:</b>          | Pass  |
| <b>Tested by .....</b>            |    |
|                                   | Mei chun , Test EGINEER   |
| <b>Reviewed by.....:</b>          |    |
|                                   | Shuangwen Zhang, Senior EGINEER   |
| <b>Approved by.....:</b>          |    |
|                                   | Wu Li'an , Manager  |

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## **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.**

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## 2. Administrative Date

### 2.1. Identification of the Responsible Testing Laboratory

**Company Name:** CCIC-SET

**Department:** EMC & RF Department

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**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.:** SET2015-12511

**CCIC-SET Project Leader:** Mr. Li Sixiong

**CCIC-SET Responsible for accreditation scope:** Mr. Wu Li'an

**Start of Testing:** 2015-09-08

**End of Testing:** 2015-09-08

### 2.4. Identification of Applicant

**Company Name:** TeleEpoch Limited

**Address:** 5A, B1 Building, Digital Tech Zone, High-Tech Park(south), Nanshan district Shenzhen, P.R.China

**Manufacturer Name:** TeleEpoch Limited

**Address:** 5A, B1 Building, Digital Tech Zone, High-Tech Park(south), Nanshan district Shenzhen, 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:** M3620

**Type Name:** M3620

**Brand Name:** AT&T

|                             |                   |  |
|-----------------------------|-------------------|--|
| <b>General description:</b> | Support Band      | GSM850MHz/1900MHz/900MHz/1800MHz<br>WCDMA 850MHz/ 1900MHz<br>Bluetooth 2.1+EDR |
|                             | Test Band         | GSM 850MHz/ GSM 1900MHz<br>WCDMA 850MHz/ 1900MHz                               |
|                             | Development Stage | Identical Prototype  |
|                             | Accessories       | Power Supply   |
|                             | Antenna type      | Inner Antenna  |
|                             | Operation mode    | GSM/WCDMA  |
|                             | Modulation mode   | GMSK, 8PSK, QPSK, 16QAM  |

#### NOTE:

- The EUT is a model of /operating in GSM 850 / 1900, WCDMA 850 /1900 MHz band, Bluetooth 2.4 GHz.
- 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   | ANSI C63.19:2011                | American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids              |
| 3   | KDB 285076 D02 HAC Guidance v04 | Provides equipment authorization guidance for mobile handsets subject to the requirements of Section 20.19 for hearing aid compatibility |

#### 3.2.2 Summary Of HAC Rating

##### Summary of T-Rating

| Band      | T-Rating | Frequency response |
|-----------|----------|--------------------|
| GSM850    | T3       | PASS               |
| GSM1900   | T3       | PASS               |
| WCDMA850  | 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:   | 860.6Ω                        |
| 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 Absolute Radio Frequency Channel Number (ARFCN) was allocated to 128, 190 and 251 respectively in the case of GSM 850MHz, or to 512, 661 and 810 respectively in the case of PCS 1900MHz, or to 4132, 4183 and 4233 respectively in the case of WCDMA 850MHz, or to 9262, 9400 and 9538 respectively in the case of WCDMA 1900MHz. The EUT was commanded to operate at maximum transmitting power.

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 Scenarios invoice (Not to be tested) | Reduced power | VOIP |
|---------------|------------|-------|--------------------|---|---------------|------|
| GSM           | 850        | Voice | Yes                | Yes: BT   | N/A           | N/A  |
|               | 1900       | Voice | Yes                | Yes: BT   | N/A           | N/A  |
|               | GPRS       | Data  | N/A                | Yes: BT   | N/A           | N/A  |
| WCDMA         | 850        | Voice | Yes                | Yes: BT   | N/A           | N/A  |
|               | 1900       | Voice | Yes                | Yes: BT   | N/A           | N/A  |
|               | HSDPA      | Data  | N/A                | Yes: BT   | N/A           | N/A  |
|               | HSUPA      | Data  | N/A                | Yes: BT   | N/A           | N/A  |
| BT            | 2450       | Data  | N/A                | Yes GSM or WCDMA  | N/A           | N/A  |

The volume is at the maximum value, and the backlight of the phone is turned off. The Manufacturer doesn't design HAC mode software on the EUT

## 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 a 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.



WD reference and plane for RF emission measurements

## 5.3 Magnetic measurement locations for the WD

T-Coil measurement points and reference plane The following figure illustrates the three standard probe orientations. Position 1 is the axial orientation of the probe coil; orientation 2 and orientation 3 are radial orientations. The space between the measurement positions is not fixed. It is recommended that a scan of the EUT be done for each probe coil orientation and that the maximum level recorded be used as the reading for that orientation of the probe coil.

1) The reference plane is 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 EUT handset,

which, in normal handset use, rest against the ear.

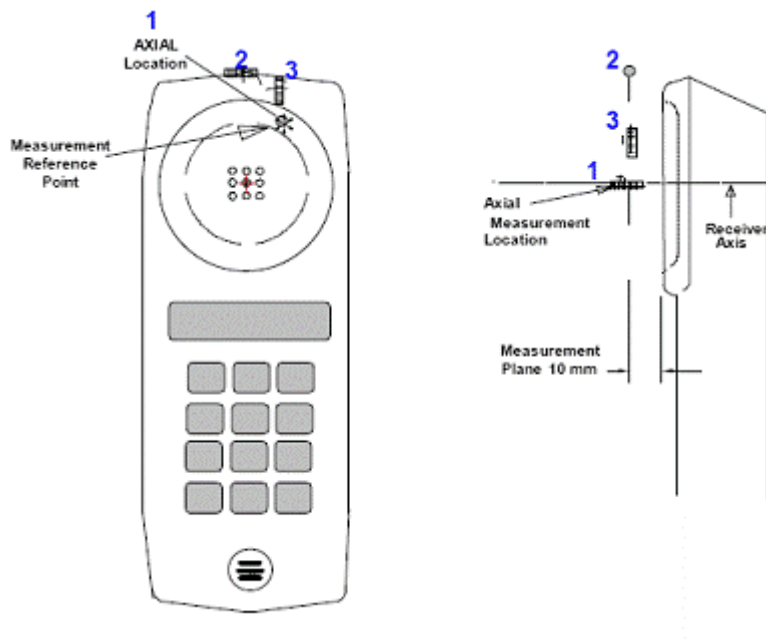
2) The measurement plane is parallel to, and 10 mm in front of, the reference plane.

3) The reference axis is normal to the reference plane and passes through the center of the receiver speaker section (or the center of the hole array); or may be centered on a secondary inductive source. The actual location of the measurement point shall be noted in the test report as the measurement reference point.

4) The measurement points may be located where the axial and radial field intensity measurements are optimum with regard to the requirements. However, the measurement points should be near the acoustic output of the EUT and shall be located in the same half of the phone as the EUT receiver. In a EUT handset with a centered receiver and a circularly symmetrical magnetic field, the measurement axis and the reference axis would coincide.

5) The relative spacing of each measurement orientation is not fixed. The axial and two radial orientations should be chosen to select the optimal position.

6) The measurement point for the axial position is located 10 mm from the reference plane on the measurement axis. The actual location of the measurement point shall be noted in test reports and designated as the measurement reference point.



Axis and planes for EUT audio frequency magnetic field measurements

## 5.4 Equipments and results of validation testing

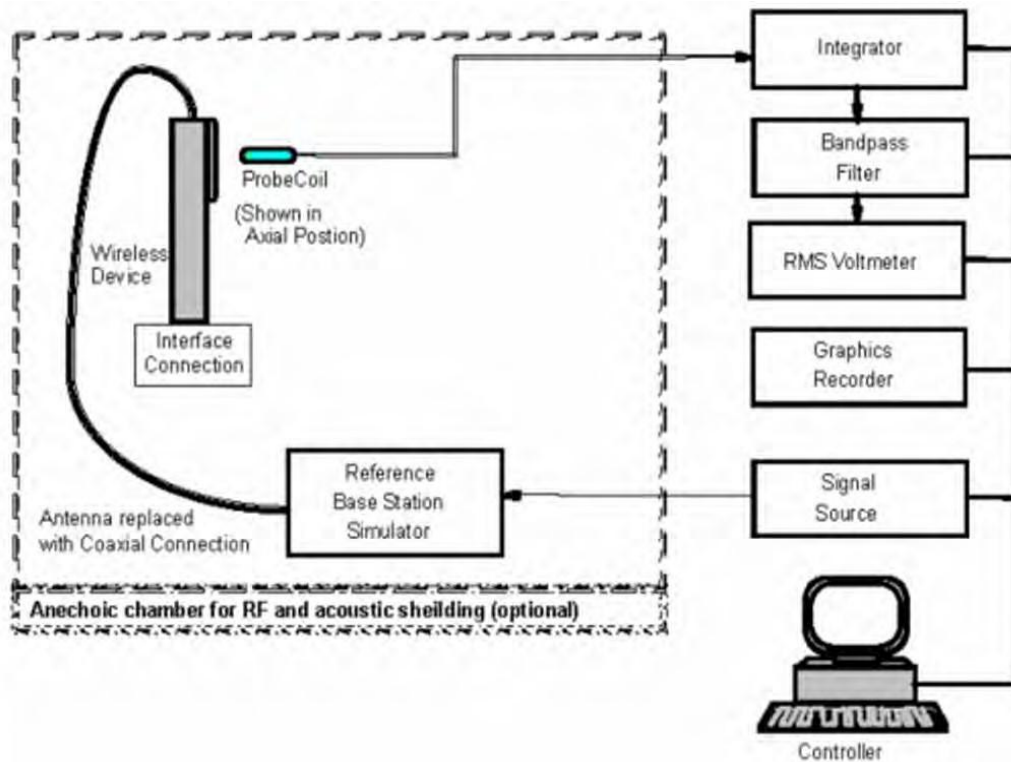
### System Audio Validation

Put the phone on call and select the CMU decoder cal. When the decoder cal is selected, a full scale (3.14 dBm) signal is provided to the speech port. Measure the voltage from the speech connector using the provided CMU speech cable. For this connect the GSM/WCDMA 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

### T-Coil Measurement Procedure

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

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

### 5.4.3 Test System Validation

#### T-coil system validation Results

| Input Level<br>(mV)                                       | Axial<br>Description | Location | Magnetic Field (dB<br>A/m) |
|---|----------------------|----------|----------------------------|
| 500   | Axial                | Max      | -15.23                     |
|   | Radial H             | Right    | -22.24                     |
|   |                      | Left     | -20.38                     |
|   | Radial V             | Upper    | -22.26                     |
|   |                      | Lower    | -19.48                     |
| Note: The tolerance limit of System validation $\pm 25\%$ |                      |          |                            |

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



## 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  $\geq -18$  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.

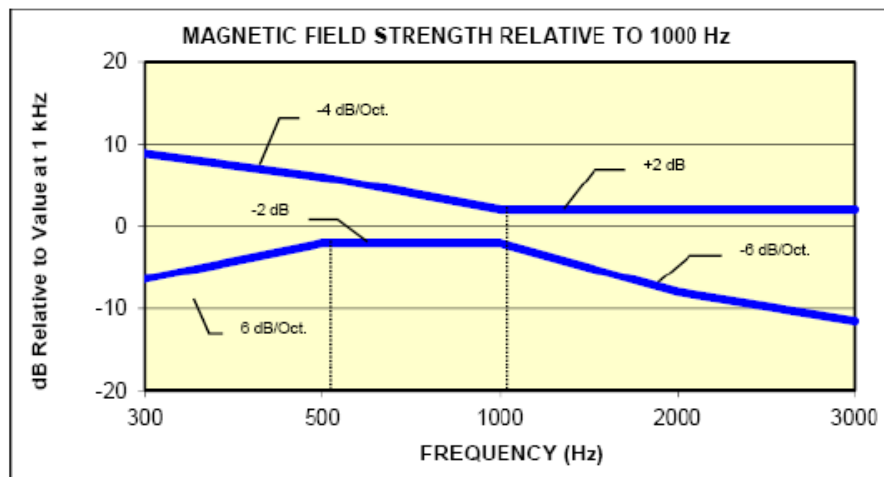


Figure 4-1

Magnetic field frequency response for Wireless Devices with an axial field  $\leq -15$  dB (A/m) at 1 kHz

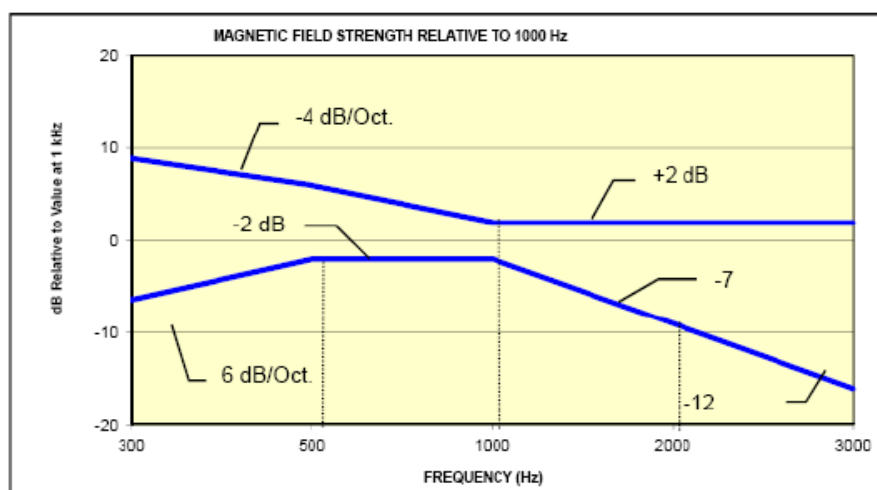


Figure 4-2

Magnetic Field frequency response for wireless devices with an axial field that exceeds  $-15$  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<br>(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 ° C, Max. = 25 ° C |
| Relative humidity  | Min. = 30%, Max. = 70%       |
| Ground system resistance   | < 0.5 $\Omega$               |
| <p>Ambient noise is checked and found very low and in compliance with requirement of standards.</p> <p>Reflection of surrounding objects is minimized and in compliance with requirement of standards.</p> |                              |

## 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       | 32.34   | 32.33 | 32.45 | 29.59    | 29.51  | 29.44  |

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        | 22.61     | 22.51 | 22.49 | 22.85     | 22.73  | 22.67  |

### 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                    |
| 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 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 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  |
| 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  |
| 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  |
| 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 |

Note:

N-Nominal

R-Rectangular

Div.- Divisor used to obtain standard uncertainty

Table 10: Measurement Uncertainty of T-Coil Test

| No.                       | Uncertainty Component                          | Type | Uncertainty Value (%) | Probability Distribution | k     | ci  | Standard Uncertainty (%) $u_i(\%)$ | Degree of freedom $\nu_{eff}$ or $\nu_i$ |
|---------------------------|--|------|-----------------------|--------------------------|-------|-----|------------------------------------|--|
| <b>Measurement System</b> |  |      |                       |                          |       |     |                                    |  |
| 1                         | — Probe Calibration                            | B    | 6                     | N                        | 3     | 1   | 3.5                                | $\infty$                                 |
| 2                         | — Axial isotropy                               | B    | 4.7                   | R                        | 1.732 | 0.5 | 4.3                                | $\infty$                                 |
| 3                         | — Hemispherical Isotropy                       | B    | 9.4                   | R                        | 1.732 | 0.5 | 4.3                                | $\infty$                                 |
| 4                         | — Boundary Effect                              | B    | 11.0                  | R                        | 1.732 | 1   | 6.4                                | $\infty$                                 |
| 5                         | — Linearity                                    | B    | 4.7                   | R                        | 1.732 | 1   | 2.7                                | $\infty$                                 |
| 6                         | — System Detection Limits                      | B    | 1.0                   | R                        | 1.732 | 1   | 0.6                                | $\infty$                                 |
| 7                         | — Probe Coil Sensitivity                       | B    | 0.49                  | R                        | 1.732 | 1   | 0.28                               | $\infty$                                 |
| 8                         | — Response Time                                | B    | 0.00                  | R                        | 1.732 | 1   | 0.00                               | $\infty$                                 |
| 9                         | — Integration Time                             | B    | 0.00                  | R                        | 1.732 | 1   | 0.00                               | $\infty$                                 |
| 10                        | — RF Ambient Conditions                        | B    | 3.0                   | R                        | 1.732 | 1   | 1.73                               | $\infty$                                 |
| 11                        | — Probe Position Mechanical tolerance          | B    | 0.4                   | R                        | 1.732 | 1   | 0.2                                | $\infty$                                 |
| 12                        | — Probe Position with respect to Phantom Shell | B    | 2.9                   | R                        | 1.732 | 1   | 1.7                                | $\infty$                                 |

|  |                           |   |      |     |       |   |       |          |
|--|---------------------------|---|------|-----|-------|---|-------|----------|
| <b>Uncertainties of the DUT</b>                              |                           |   |      |     |       |   |       |          |
| 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   | $\infty$ |
| <b>Acoustic noise</b>  |                           |   |      |     |       |   |       |          |
| 16   | — Acoustic noise          | B | 1.0  | R   | 1.732 | 1 | 0.6   | $\infty$ |
| 21   | — Cable loss              | B | 0.46 | N   | 1.732 | 1 | 0.46  | $\infty$ |
| <b>Combined Standard Uncertainty</b>                         |                           |   |      | RSS |       |   | 17.26 | 42.33    |
| <b>Expanded uncertainty</b><br>(Confidence interval of 95 %) |                           |   |      | K=2 |       |   | 34.52 |          |

**10. MAIN TEST INSTRUMENTS**

| No | EQUIPMENT                          | TYPE            | Series No.      | Due Date   |
|----|------------------------------------|-----------------|-----------------|------------|
| 1  | T-Coil Probe                       | SATIMO/STCOIL   | SN 24/11 TCP23  | 2016/05/05 |
| 2  | TMFS                               | SATIMO/STMFS    | SN 07/14 TMFS24 | 2016/09/01 |
| 3  | Vector Network Analyzer            | ZVB8            | 1145.1010.08    | 2016/06/13 |
| 4  | Amplifier                          | Nucletudes      | 143060          | 2016/04/04 |
| 5  | Power Meter                        | NRVS            | 1020.1809.02    | 2016/06/13 |
| 6  | Multimeter                         | Keithley - 2000 | 4014020         | 2016/04/04 |
| 7  | Power Sensor                       | NRV-Z4          | 100069          | 2016/06/10 |
| 8  | Wireless<br>Communication Test Set | CMU200          | A0304212        | 2016/06/10 |

## 11. ANNEX A SYSTEM SETUP



Fig.1 Testing Photo



## 12. ANNEX B EUT PHOTO



**Appearance and size (obverse)**



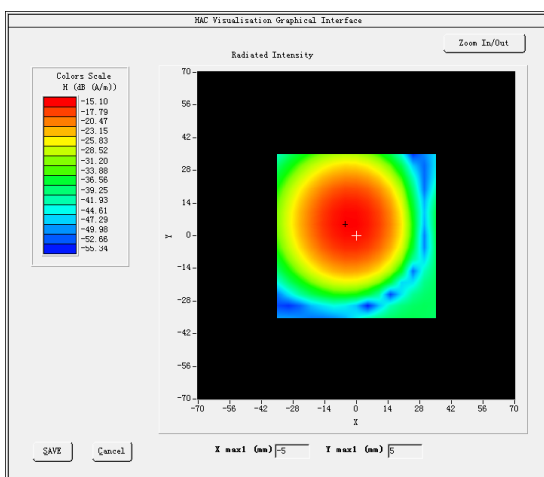
**Appearance and size (reverse)**

## 13. ANNEX C SYSTEM VERIFICATION (TMFS)

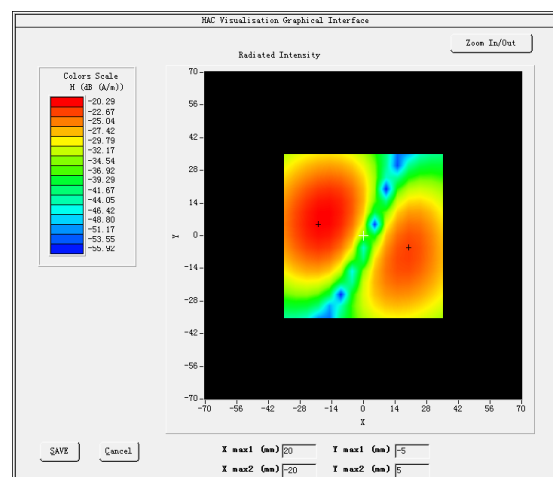
### Test Summary

| 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        | -15.23   | -        | -         |
| 7.3.1.2 |      |      | Intensity, RadialH | -             | Right side | -22.24   | -        | -         |
|         |      |      |                    | -             | Left side  | -20.38   | -        | -         |
| 7.3.1.2 |      |      | Intensity, RadialV | -             | Upper side | -22.26   | -        | -         |
|         |      |      |                    | -             | Lower side | -19.48   | -        | -         |

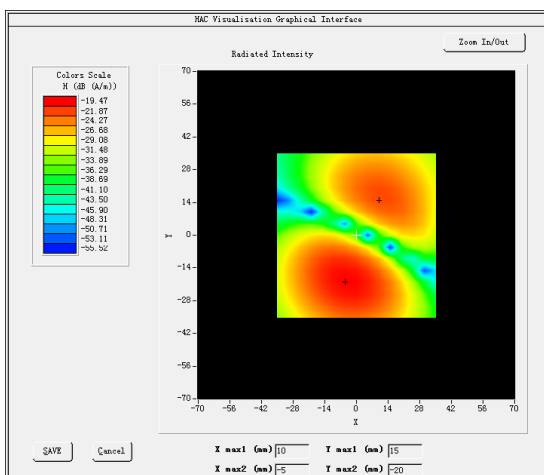
AXIAL ABM1



RADIAL H ABM1



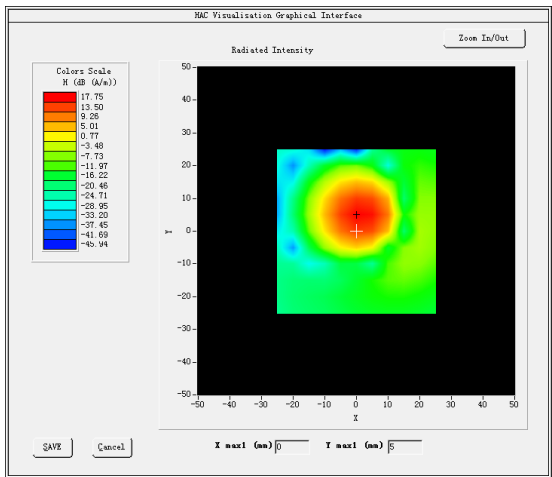
RADIAL V ABM1



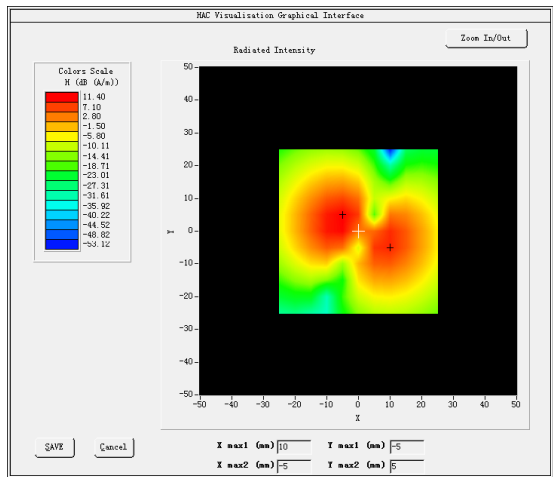
14. ANNEX D TEST PLOTS

Measurement Results GSM850 Frequency (MHz): 836.400000

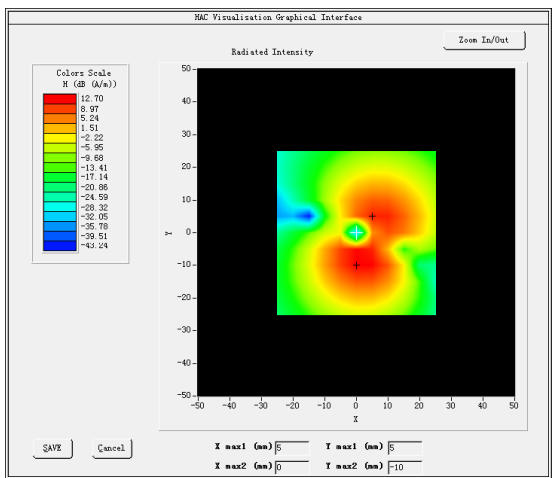
AXIAL ABM1



RADIAL H ABM1



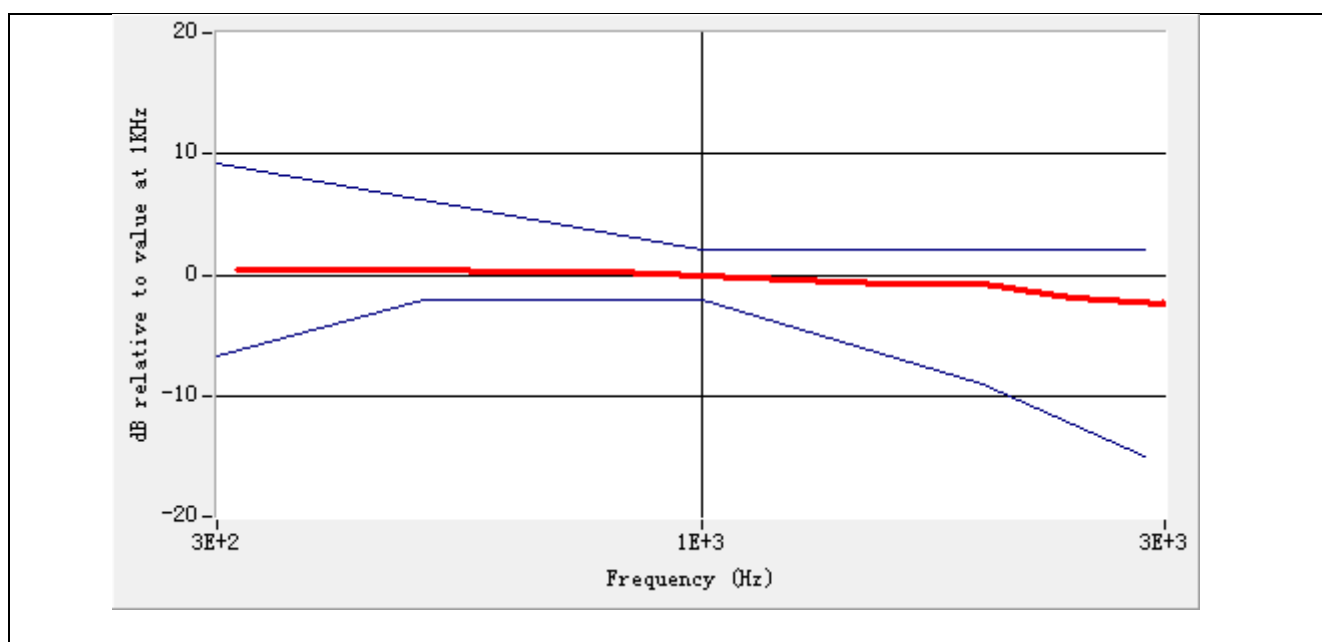
RADIAL V ABM1



## 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      | Max        | Max        | Max        | Left       | Right      | Left       |
|                               |            |            |            |            | t          |            | t          |            | t          |            |            |            |            | t          |            |
| ABM1, dBA/m                   | NUL<br>L   | 17.7<br>5  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 8.86<br>0  | 11.4<br>0  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 10.7<br>4  | 12.7<br>0  | NUL<br>L   | NUL<br>L   |
| ABM2, dBA/m                   | NUL<br>L   | -27.<br>56 | NUL<br>L   | NUL<br>L   | NUL<br>L   | -34.<br>50 | -31.<br>53 | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | -33.<br>05 | -32.<br>55 | NUL<br>L   | NUL<br>L   |
| Ambient noise, dBA/m          | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 |
| Freq Reponse Margin<br>(dB)   | -          | 2.00       | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| S+N/N(dB)                     | NUL<br>L   | 45.5<br>1  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 43.5<br>6  | 43.1<br>9  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 43.9<br>6  | 45.4<br>2  | NUL<br>L   | NUL<br>L   |
| S+N/N per orientation<br>(dB) | 45.51      |            |            | 43.19      |            |            |            |            |            | 43.96      |            |            |            |            |            |

## Magnetic field frequency response (field that exceeds -15 dB)

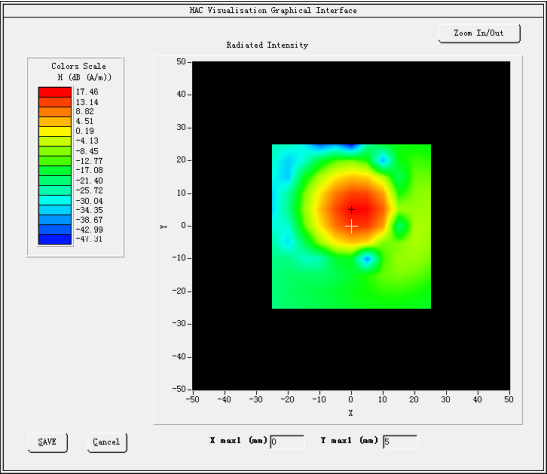


## Test Summary

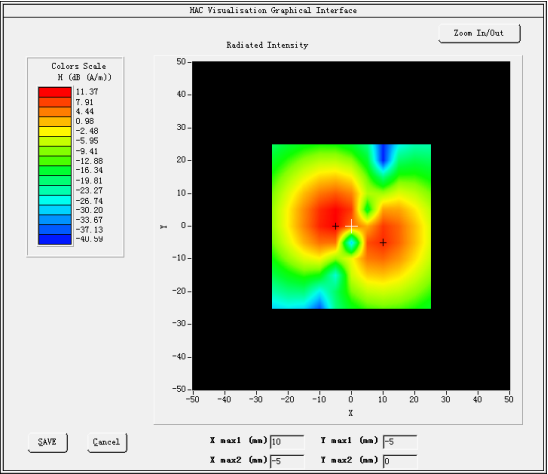
| C63.19  | Mode | Band   | Test Description               | Minimum Limit | Location   | Measured | Category | Verdict   |
|---------|------|--------|--------------------------------|---------------|------------|----------|----------|-----------|
|         |      |        |                                | dBa/m         | -          | dBa/m    | -        | Pass/Fail |
| 7.3.1.1 | GSM  | GSM850 | Intensity, Axial               | -18           | Max        | 20.25    | -        | PASS      |
| 7.3.1.2 |      |        | Intensity, RadialH             | -18           | Right side | 14.96    | -        | PASS      |
|         |      |        |                                | -18           | Left side  | 8.36     | -        | PASS      |
| 7.3.1.2 |      |        | Intensity, RadialV             | -18           | Upper side | 14.19    | -        | PASS      |
|         |      |        |                                | -18           | Lower side | 21.60    | -        | PASS      |
| 7.3.3   |      |        | Signal to noise/noise, Axial   | 20            | Max        | 38.09    | T4       | PASS      |
| 7.3.3   |      |        | Signal to noise/noise, RadialH | 20            | Right side | 29.35    | T3       | PASS      |
|         |      |        |                                | 20            | Left side  | 36.21    | T4       | PASS      |
| 7.3.3   |      |        | Signal to noise/noise, RadialV | 20            | Upper side | 21.55    | T3       | PASS      |
|         |      |        |                                | 20            | Lower side | 35.85    | T4       | PASS      |
| 7.3.2   |      |        | Frequency response, Axial      | 0             | -          | 2.00     | -        | PASS      |

**Measurement Results GSM1900** Frequency (MHz): 1880.00000

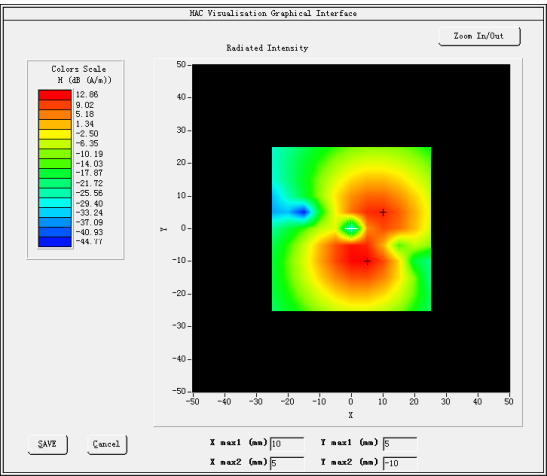
**AXIAL ABM1**



**RADIAL H ABM1**



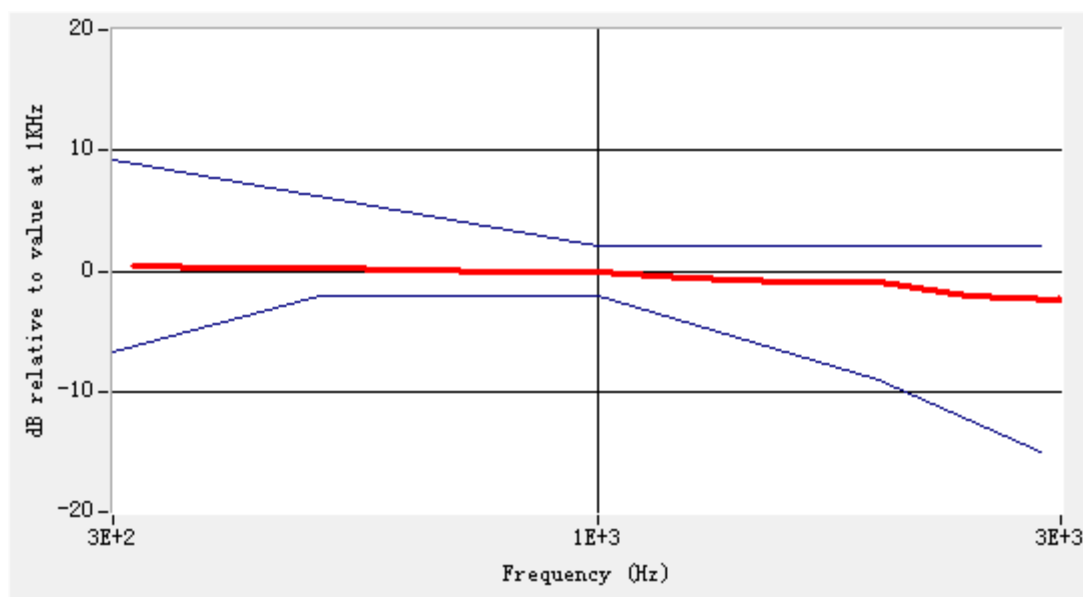
**RADIAL V ABM1**



## 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      | Up         | Down       | Up         | Down       | Up         | Down       |
| ABM1, dBA/m                   | NUL<br>L   | 17.4<br>6  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 9.05<br>7  | 11.3<br>7  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 10.7<br>0  | 12.8<br>6  | NUL<br>L   | NUL<br>L   |
| ABM2, dBA/m                   | NUL<br>L   | -32.<br>12 | NUL<br>L   | NUL<br>L   | NUL<br>L   | -37.<br>67 | -34.<br>15 | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | -38.<br>15 | -36.<br>34 | NUL<br>L   | NUL<br>L   |
| Ambient noise, dBA/m          | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 |
| Freq Reponse Margin<br>(dB)   | -          | 2.00       | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| S+N/N(dB)                     | NUL<br>L   | 49.7<br>4  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 46.9<br>2  | 45.7<br>7  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 48.9<br>9  | 49.3<br>6  | NUL<br>L   | NUL<br>L   |
| S+N/N per orientation<br>(dB) | 49.74      |            |            | 45.77      |            |            |            |            |            | 48.99      |            |            |            |            |            |

## Magnetic field frequency response (field that exceeds -15 dB)



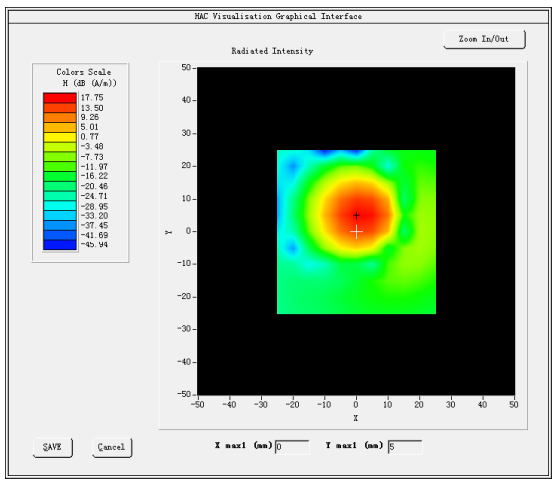
## Test Summary

| 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        | 20.15    | -        | PASS      |
| 7.3.1.2 |      |         | Intensity, RadialH             | -18           | Right side | 14.92    | -        | PASS      |
|         |      |         |                                | -18           | Left side  | 8.37     | -        | PASS      |
| 7.3.1.2 |      |         | Intensity, RadialV             | -18           | Upper side | 14.15    | -        | PASS      |
|         |      |         |                                | -18           | Lower side | 21.58    | -        | PASS      |
| 7.3.3   |      |         | Signal to noise/noise, Axial   | 20            | Max        | 40.64    | T4       | PASS      |
| 7.3.3   |      |         | Signal to noise/noise, RadialH | 20            | Right side | 31.98    | T4       | PASS      |
|         |      |         |                                | 20            | Left side  | 38.12    | T4       | PASS      |
| 7.3.3   |      |         | Signal to noise/noise, RadialV | 20            | Upper side | 24.30    | T3       | PASS      |
|         |      |         |                                | 20            | Lower side | 38.46    | T4       | PASS      |
| 7.3.2   |      |         | Frequency response, Axial      | 0             | -          | 2.00     | -        | PASS      |

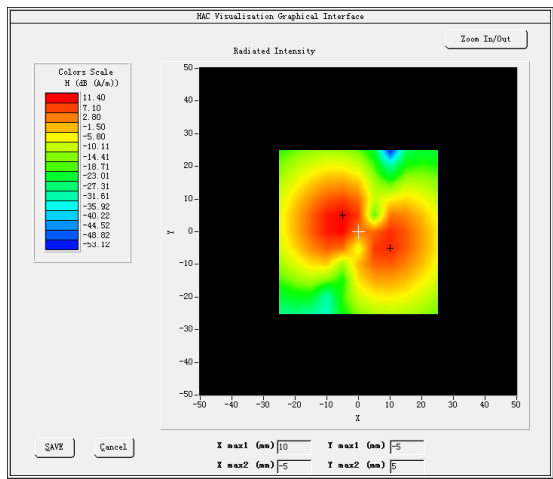


**Measurement Results WCDMA 850** Frequency (MHz): 836.60000

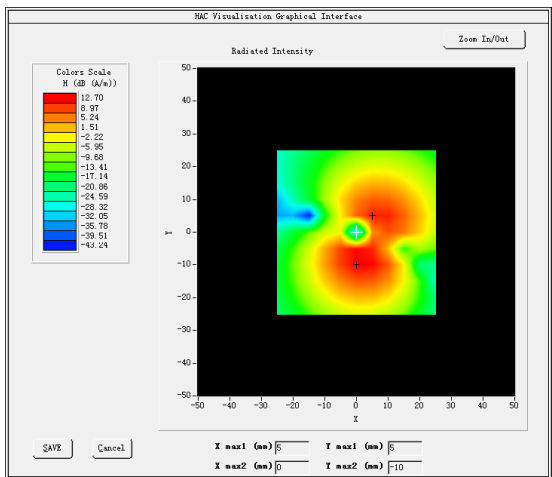
AXIAL ABM1



RADIAL H ABM1



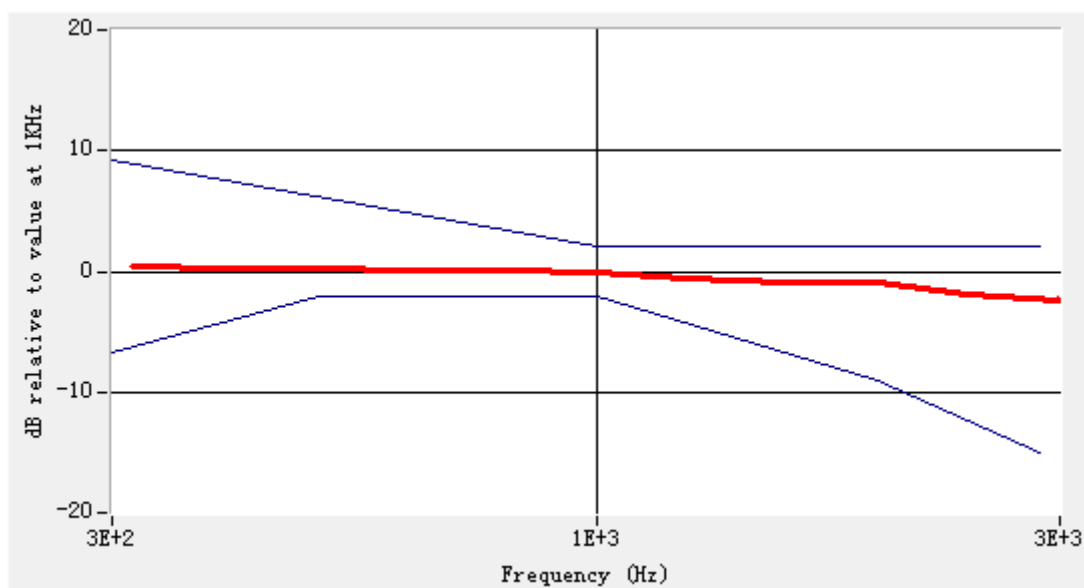
RADIAL V ABM1



## 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 |
|                               |       |      |      |          | t     |      | t     |      | t     |          |      |      |      | t     |      |
| ABM1, dBA/m                   | NUL   | 17.7 | NUL  | NUL      | NUL   | 8.86 | 11.4  | NUL  | NUL   | NUL      | NUL  | 10.7 | 12.7 | NUL   | NUL  |
|                               | L     | 5    | L    | L        | L     |      | 0     | L    | L     | L        | L    | 4    | 0    | L     | L    |
| ABM2, dBA/m                   | NUL   | -27. | NUL  | NUL      | NUL   | -34. | -31.  | NUL  | NUL   | NUL      | NUL  | -33. | -32. | NUL   | NUL  |
|                               | L     | 56   | L    | L        | L     | 50   | 53    | L    | L     | L        | L    | 05   | 55   | L     | L    |
| Ambient noise, dBA/m          | -50.  | -50. | -50. | -50.     | -50.  | -50. | -50.  | -50. | -50.  | -50.     | -50. | -50. | -50. | -50.  | -50. |
|                               | 00    | 00   | 00   | 00       | 00    | 00   | 00    | 00   | 00    | 00       | 00   | 00   | 00   | 00    | 00   |
| Freq Reponse Margin<br>(dB)   | -     | 2.00 | -    | -        | -     | -    | -     | -    | -     | -        | -    | -    | -    | -     | -    |
| S+N/N(dB)                     | NUL   | 45.5 | NUL  | NUL      | NUL   | 43.5 | 43.1  | NUL  | NUL   | NUL      | NUL  | 43.9 | 45.4 | NUL   | NUL  |
|                               | L     | 1    | L    | L        | L     | 6    | 9     | L    | L     | L        | L    | 6    | 2    | L     | L    |
| S+N/N per orientation<br>(dB) | 45.51 |      |      | 43.19    |       |      |       |      |       | 43.96    |      |      |      |       |      |

## Magnetic field frequency response (field that exceeds -15 dB)

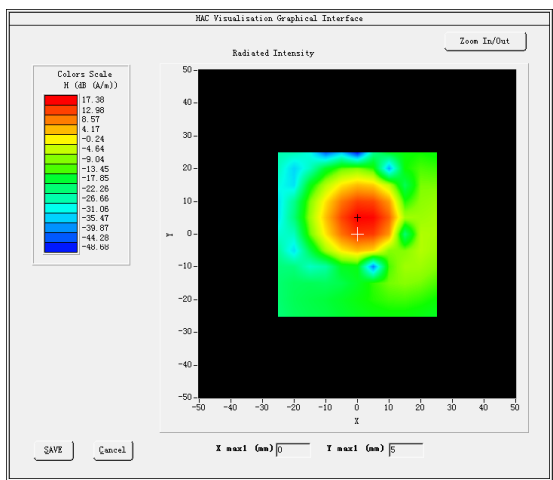


## Test Summary

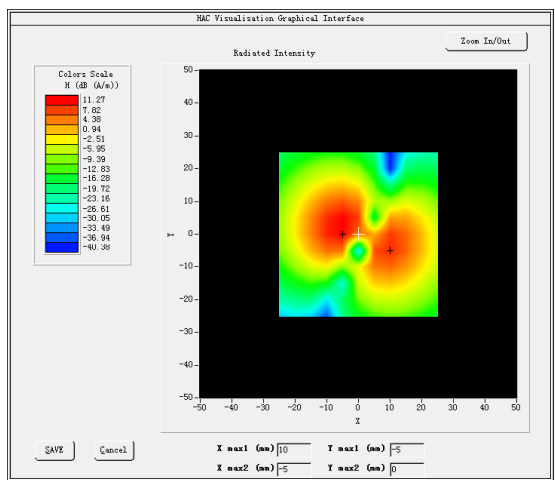
| C63.19  | Mode  | Band      | Test Description               | Minimum Limit | Location   | Measured | Category | Verdict   |
|---------|-------|-----------|--------------------------------|---------------|------------|----------|----------|-----------|
|         |       |           |                                | dBa/m         | -          | dBa/m    | -        | Pass/Fail |
| 7.3.1.1 | WCDMA | WCDMA 850 | Intensity, Axial               | -18           | Max        | 19.92    | -        | PASS      |
| 7.3.1.2 |       |           | Intensity, RadialH             | -18           | Right side | 14.65    | -        | PASS      |
|         |       |           |                                | -18           | Left side  | 8.50     | -        | PASS      |
| 7.3.1.2 |       |           | Intensity, RadialV             | -18           | Upper side | 13.83    | -        | PASS      |
|         |       |           |                                | -18           | Lower side | 21.74    | -        | PASS      |
| 7.3.3   |       |           | Signal to noise/noise, Axial   | 20            | Max        | 48.97    | T4       | PASS      |
| 7.3.3   |       |           | Signal to noise/noise, RadialH | 20            | Right side | 48.46    | T4       | PASS      |
|         |       |           |                                | 20            | Left side  | 47.83    | T4       | PASS      |
| 7.3.3   |       |           | Signal to noise/noise, RadialV | 20            | Upper side | 41.34    | T4       | PASS      |
|         |       |           |                                | 20            | Lower side | 50.25    | T4       | PASS      |
| 7.3.2   |       |           | Frequency response, Axial      | 0             | -          | 2.00     | -        | PASS      |

**Measurement Results WCDMA1900** Frequency (MHz): 1880.00000

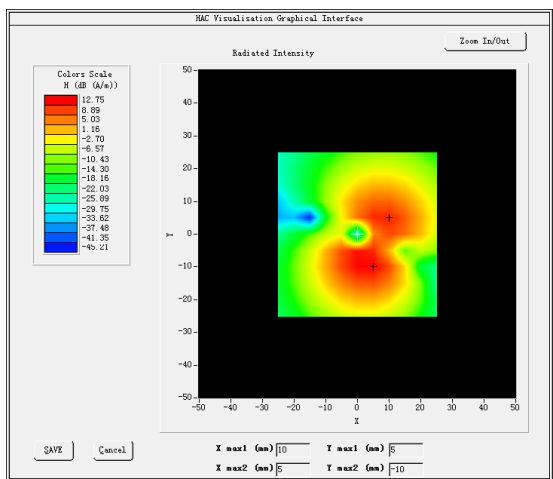
**AXIAL ABM1**



**RADIAL H ABM1**



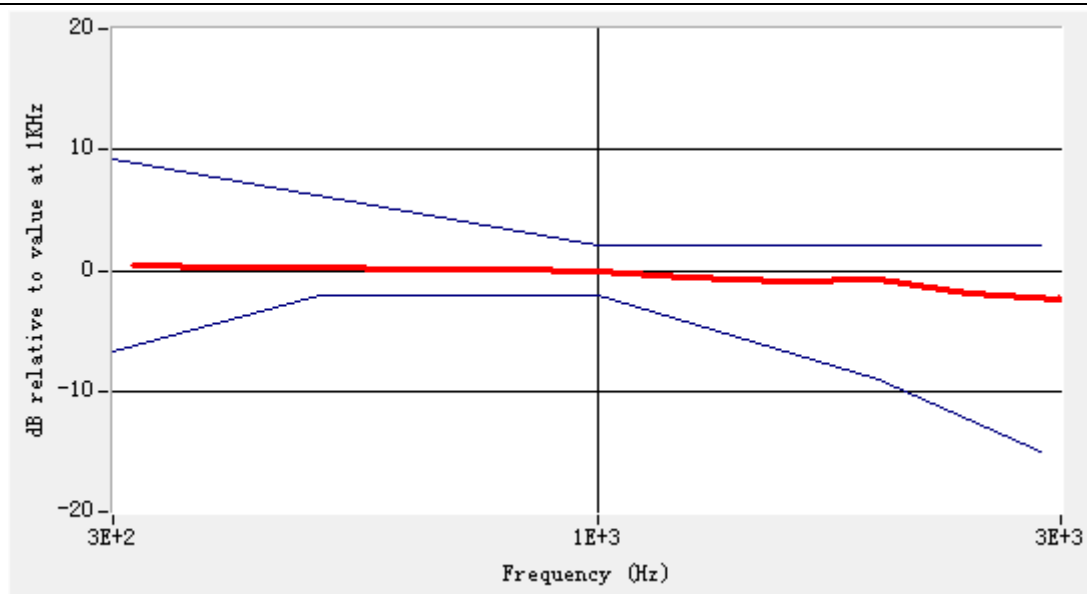
**RADIAL V ABM1**



## 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      | Up         | Down       | Up         | Down       | Up         | Down       |
| ABM1, dBA/m                   | NUL<br>L   | 17.3<br>8  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 8.99<br>7  | 11.2<br>7  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 10.6<br>0  | 12.7<br>5  | NUL<br>L   | NUL<br>L   |
| ABM2, dBA/m                   | NUL<br>L   | -29.<br>99 | NUL<br>L   | NUL<br>L   | NUL<br>L   | -38.<br>21 | -34.<br>21 | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | -37.<br>28 | -37.<br>64 | NUL<br>L   | NUL<br>L   |
| Ambient noise, dBA/m          | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 | -50.<br>00 |
| Freq Reponse Margin<br>(dB)   | -          | 2.00       | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          | -          |
| S+N/N(dB)                     | NUL<br>L   | 47.5<br>5  | NUL<br>L   | NUL<br>L   | NUL<br>L   | 47.4<br>0  | 45.7<br>3  | NUL<br>L   | NUL<br>L   | NUL<br>L   | NUL<br>L   | 48.0<br>1  | 50.5<br>7  | NUL<br>L   | NUL<br>L   |
| S+N/N per orientation<br>(dB) | 47.55      |            |            | 45.73      |            |            |            |            |            | 48.01      |            |            |            |            |            |

## Magnetic field frequency response (field that exceeds -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        | 19.85    | -        | PASS      |
| 7.3.1.2 |       |                 | Intensity, RadialH             | -18           | Right side | 14.59    | -        | PASS      |
|         |       |                 |                                | -18           | Left side  | 8.47     | -        | PASS      |
| 7.3.1.2 |       |                 | Intensity, RadialV             | -18           | Upper side | 13.80    | -        | PASS      |
|         |       |                 |                                | -18           | Lower side | 21.72    | -        | PASS      |
| 7.3.3   |       |                 | Signal to noise/noise, Axial   | 20            | Max        | 49.11    | T4       | PASS      |
| 7.3.3   |       |                 | Signal to noise/noise, RadialH | 20            | Right side | 48.66    | T4       | PASS      |
|         |       |                 |                                | 20            | Left side  | 47.76    | T4       | PASS      |
| 7.3.3   |       |                 | Signal to noise/noise, RadialV | 20            | Upper side | 41.85    | T4       | PASS      |
|         |       |                 |                                | 20            | Lower side | 50.20    | T4       | PASS      |
| 7.3.2   |       |                 | Frequency response, Axial      | 0             | -          | 2.00     | -        | PASS      |

**15. ANNEX E CALIBRATION REPORT****COMOHAC T-coil Probe Calibration Report**

Ref : ACR.125.4.15.SATU.A

**CCIC SOUTHERN ELECTRONIC PRODUCT  
TESTING (SHENZHEN) CO., LTD**  
ELECTRONIC TESTING BUILDING, SHAHE ROAD, XILI  
TOWN  
SHENZHEN, P.R. CHINA (POST CODE:518055)  
**MVG COMOHAC T-COIL PROBE**  
SERIAL NO.: SN 24/11 TCP23

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

**05/05/15***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.125.4.15.SATU.A

|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>     |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 5/5/2015    | <i>JS</i>            |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 5/5/2015    | <i>JS</i>            |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 5/5/2015    | <i>Kim Rutkowski</i> |

|                       | <i>Customer Name</i>  |
|-----------------------|---|
| <i>Distribution :</i> | CCIC SOUTHERN<br>ELECTRONIC<br>PRODUCT<br>TESTING<br>(SHENZHEN) Co.,<br>Ltd |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 5/5/2015    | Initial release      |
|              |             |                      |
|              |             |                      |
|              |             |                      |

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## 1 DEVICE UNDER TEST

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

A yearly calibration interval is recommended.

## 2 PRODUCT DESCRIPTION

### 2.1 GENERAL INFORMATION

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



Figure 1 – Satimo COMOHAC T-coil Probe

|                     |                                   |
|---------------------|-----------------------------------|
| Coil Dimension      | 6.55 mm length * 2.29 mm diameter |
| DC resistance       | 860.6 $\Omega$                    |
| Wire size           | 51AWG                             |
| 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).

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## COMOHAC T-COIL PROBE CALIBRATION REPORT

Ref: ACR.125.4.15.SATU.A

## 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 $\Omega$                    |
| Wire size           | 51AWG                             |
| 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).

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## COMOHAC T-COIL PROBE CALIBRATION REPORT

Ref: ACR.125.4.15.SATU.A

### 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 -50 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.<br>( $\pm$ dB) | Prob. Dist. | Div.       | Uncertainty<br>(dB) | Uncertainty (%) |
| Current/Voltage Accuracy  | 0.224               | R           | $\sqrt{3}$ | 0.13                |                 |
| Acoustic/ Signal Source drift   | 0.008               | R           | $\sqrt{3}$ | 0.00                |                 |
| Probe coil sensitivity  | 0.2                 | R           | $\sqrt{3}$ | 0.12                |                 |
| Positioning accuracy  | 0.4                 | R           | $\sqrt{3}$ | 0.23                |                 |
| Acoustic Signal Receive Accuracy  | 0.03                | R           | $\sqrt{3}$ | 0.02                |                 |
| Acoustic Signal Receive Linearity   | 0.006               | R           | $\sqrt{3}$ | 0.00                |                 |
| System repeatability  | 0.4                 | N           | 1          | 0.40                |                 |
| <b>Combined Standard Uncertainty</b>  |                     | N           | 1          | 0.49                |                 |
| <b>Expanded uncertainty<br/>(confidence level of 95%, <math>k = 2</math>)</b> |                     | N           | $k=2$      | 1.00                | 12.0            |

## 5 CALIBRATION MEASUREMENT RESULTS

| Calibration Parameters |      |
|------------------------|------|
| Lab Temperature        | 21°C |
| Lab Humidity           | 45%  |

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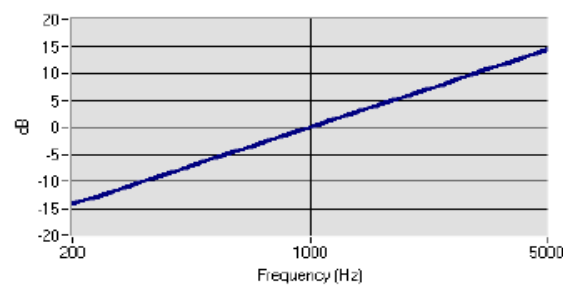


## COMOHAC T-COIL PROBE CALIBRATION REPORT

Ref: ACR.125.4.15.SATU.A

## 5.1 SENSITIVITY

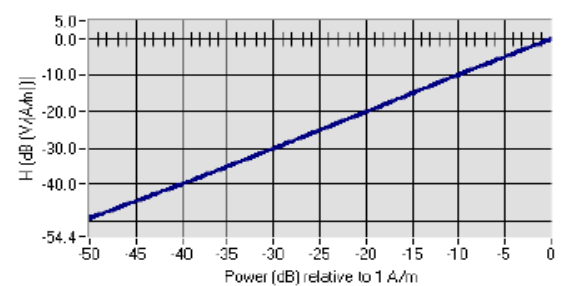
Probe coil sensitivity relative to sensitivity at 1000 Hz



|                                 | Measured          | Required                 |
|---------------------------------|-------------------|--------------------------|
| Sensitivity at 1 kHz            | -60.22 dB (V/A/m) | -60.5 +/- 0.5 dB (V/A/m) |
| Max. deviation from Sensitivity | 0.39 dB           | +/- 0.5 dB               |

## 5.2 LINEARITY

Linearity



|                 | Measured | Required   |
|-----------------|----------|------------|
| Linearity Slope | 0.35 dB  | +/- 0.5 dB |

## 5.3 SIGNAL TO NOISE MEASUREMENT OF THE CALIBRATION SYSTEM

|                 | Measured      | Required   |
|-----------------|---------------|--|
| Signal to Noise | -61.69 dB A/m | 'Reading with -50 dB A/m in coil' –<br>'no signal applied' > 10 dB |

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## COMOHAC T-COIL PROBE CALIBRATION REPORT

Ref: ACR.125.4.15.SATU.A

## 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. |
| Audio Generator               | National Instruments | 15222AE            | 01/2014                     | 01/2017                     |
| Reference Probe               | MVG                  | TCP 18 SN 47/10    | 10/2014                     | 10/2015                     |
| Multimeter                    | Keithley 2000        | 1188656            | 12/2013                     | 12/2016                     |
| Helmholtz Coil                | MVG                  | HC07 SN47/10       | Validated. No cal required. | Validated. No cal required. |
| Temperature / Humidity Sensor | Control Company      | 11-661-9           | 8/2012                      | 8/2015                      |

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## COMOHAC TMFS Calibration Report

Ref : ACR.262.19.14.SATU.A

**SHENZHEN STS TEST SERVICES CO., LTD.**  
**1/F, BUILDING 2, ZHUOKE SCIENCE PARK, CHONGQING**  
**ROAD**  
**FUYONG, BAO' AN DISTRICT, SHENZHEN, CHINA**  
**SATIMO COMOHAC MAGNETIC FIELD**  
**SIMULATOR**  
**SERIAL NO.: SN 07/14 TMFS24**

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



**09/01/2014**

### *Summary:*

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

COMOHAC TMFS<sup>®</sup> PROBE CALIBRATION REPORT

Ref: ACR.262.19.14.SATU.A

|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>     |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 9/19/2014   | <i>JS</i>            |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 9/19/2014   | <i>JS</i>            |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 9/19/2014   | <i>Kim Rutkowski</i> |

|                       | <i>Customer Name</i>                 |
|-----------------------|--------------------------------------|
| <i>Distribution :</i> | Shenzhen STS Test Services Co., Ltd. |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 9/19/2014   | Initial release      |
|              |             |                      |
|              |             |                      |
|              |             |                      |

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## 1 DEVICE UNDER TEST

| Device Under Test              |                                  |
|--------------------------------|----------------------------------|
| Device Type                    | COMOHAC Magnetic Field Simulator |
| Manufacturer                   | Satimo                           |
| Model                          | STMFS                            |
| Serial Number                  | SN 07/14 TMFS24                  |
| Product Condition (new / used) | New                              |
| Frequency Range                | 200-5000 Hz                      |

A yearly calibration interval is recommended.

## 2 PRODUCT DESCRIPTION

### 2.1 GENERAL INFORMATION

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



**Figure 1 – Satimo 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.

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COMOHAC TMFS<sup>®</sup> PROBE CALIBRATION REPORT

Ref: ACR.262.19.14.SATU.A

| Uncertainty analysis of the probe calibration in Helmholtz Coil |                |             |            |                     |                 |
|---|----------------|-------------|------------|---------------------|-----------------|
| Uncertainty Component   | Tol.<br>(± dB) | Prob. Dist. | Div.       | Uncertainty<br>(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                |                 |
| <b>Combined standard uncertainty</b>                            |                | N           | 1          | 0.43                |                 |
| <b>Expanded uncertainty</b><br>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                     | -12.06             |
| Radial H         | Right side              | -19.27             |
|                  | Left side               | -19.03             |

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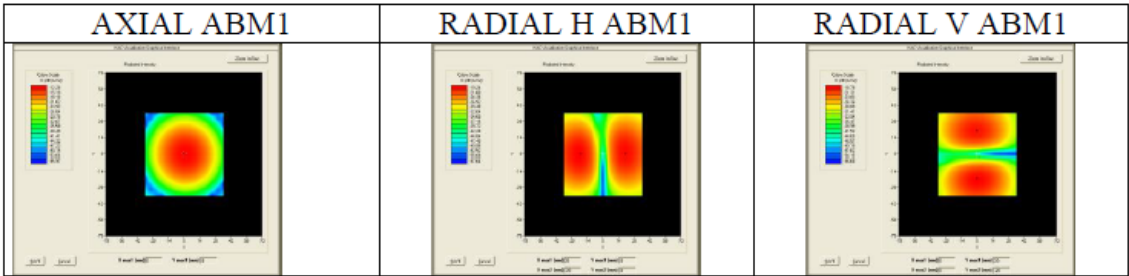
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COMOHAC TMFS<sup>®</sup> PROBE CALIBRATION REPORT

Ref: ACR.262.19.14.SATU.A

|          |            |        |
|----------|------------|--------|
| Radial V | Upper side | -19.12 |
|          | Lower side | -18.56 |





## 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         | Satimo               | TABH12 SN 42/09    | Validated. No cal required. | Validated. No cal required. |
| Audio Generator               | National Instruments | 15222AE            | 01/2014                     | 01/2017                     |
| Reference Probe               | Satimo               | TCP 18 SN 47/10    | 10/2013                     | 10/2014                     |
| Multimeter                    | Keithley 2000        | 1188656            | 12/2013                     | 12/2016                     |
| Temperature / Humidity Sensor | Control Company      | 11-661-9           | 8/2012                      | 8/2015                      |

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—————End of the Report—————