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## Hearing Aid Compatibility (HAC)

### RF Emissions TEST REPORT

Report No: STS1506089H01

Issued for

**NOITAVONNE INSTRUMENTS INC**

**11104 W.Airport Blvd.#225 Stafford, TX 77477, USA**

|                       |                   |
|-----------------------|-------------------|
| <b>Product Name:</b>  | WCDMA smart phone |
| <b>Brand Name:</b>    | noitavonne        |
| <b>Model No.:</b>     | NOIT 21           |
| <b>Series Model:</b>  | N/A               |
| <b>FCC ID:</b>        | 2AE4519NOIT21     |
| <b>Test Standard:</b> | ANSI C63.19:2011  |
| <b>Test Result:</b>   | Pass              |

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## Test Report Certification

**Applicant's name** ..... : NOITAVONNE INSTRUMENTS INC

Address ..... : 11104 W.Airport Blvd.#225 Stafford,TX 77477,USA

**Manufacture's Name** ..... : Shenzhen Siecom Communication Technology Development Co., Ltd.

Address ..... : Wanrong building A 6F,4th Industry road,Net valley, Shekou, Shenzhen, China

### Product description

Product name ..... : WCDMA smart phone

Trademark ..... : noitavonne

Model and/or type reference : NOIT 21

Serial Model : N/A

**Standards** ..... : ANSI C63.19:2011

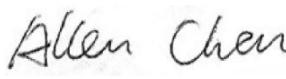
The device was tested by Shenzhen STS Test Services Co., Ltd. in accordance with the measurement methods and procedures specified in KDB 865664. The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

**Date of Test** ..... :

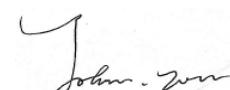
Date (s) of performance of tests ..... : 24 Jun. 2015

Date of Issue ..... : 25 Jun. 2015

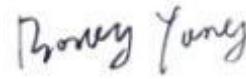
Test Result ..... : **Pass**

Testing Engineer : 

(Allen Chen)

Technical Manager : 

(John Zou)

Authorized Signatory : 

(Bovey Yang)





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## 1. General Information

### 1.1 EUT Description

|                          |   |
|--------------------------|---|
| Equipment                | WCDMA smart phone   |
| Brand Name               | noitavonne  |
| Model No.                | NOIT 21   |
| Serial Model             | N/A   |
| FCC ID                   | 2AE4519NOIT21   |
| Model Difference         | N/A   |
| Hardware Version         | N/A   |
| Software Version         | N/A   |
| Frequency Range          | GSM 850: 824.2 ~ 848.8 MHz<br>PCS1900: 1850.2 ~ 1909.8 MHz<br>WCDMA II: 1852.4~1907.6 MHz<br>WCDMA V: 826.4~846.6 MHz<br>WLAN 802.11 b/g/n(HT20):2412-2462 MHz<br>WLAN 802.11 n(HT40):2422-2452 MHz<br>Bluetooth : 2402~2480MHz |
| Transmit Power(Average): | GSM 850: 32.36dBm<br>GSM 1900: 27.38dBm<br>WCDMA II: 23.12dBm<br>WCDMA V: 21.49dBm  |
| M category               | M4  |
| Test Result              | Pass  |
| Operating Mode:          | GSM: GSM Voice, GPRS, Class 12;<br>WCDMA: RMC, HSDPA, HSUPA Release 6;<br>WLAN: 802.11 b/g/n;<br>Bluetooth: V2.1+EDR (GFSK+ $\pi$ /4DQPSK+8DPSK)  |
| Antenna Specification:   | GSM/WCDMA: PIFA Antenna<br>BT/WIFI: PIFA Antenna  |
| Hotspot Mode:            | Support   |
| DTM Mode:                | Not Support   |



## 1.2 Test Environment

Ambient conditions in the SAR laboratory:

| Items            | Required | Actual |
|------------------|----------|--------|
| Temperature (°C) | 15-30    | 21~23  |
| Humidity (%RH)   | 30-70    | 55~65  |

## 1.3 Test Facility

Shenzhen STS Test Services Co., Ltd.

Add. : 1/F., Building B, Zhuoke Science Park, No.190, Chongqing Road,

Fuyong Street, Bao'an District, Shenzhen, Guangdong, China

CNAS Registration No.: L7649

FCC Registration No.: 842334; IC Registration No.: 12108A-1



## 2. System components

### 2.1 SATIMO System Description

SATIMO is fully compliant with the technical and scientific requirements of IEEE 1528, IEC 62209, CENELEC, ARIB, ACA, and the Federal Communications Commission. The system comprises of a six axes articulated robot which utilizes a dedicated controller.

SATIMO uses the latest methodologies and FDTD order to provide a platform which is repeatable with minimum uncertainty.



### 2.2 E-Field Probe Specification

| Device Under Test                        |   |
|--|---|
| Device Type                              | COMOHAC E FIELD PROBE   |
| Manufacturer                             | Satimo  |
| Model                                    | SCE   |
| Serial Number                            | SN 06/14 EPH42  |
| Product Condition (new / used)           | new   |
| Frequency Range of Probe                 | 0.7GHz-2.5GHz   |
| Resistance of Three Dipoles at Connector | Dipole 1: R1=0.214 MΩ<br>Dipole 2: R2=0.213 MΩ<br>Dipole 3: R3=0.204 MΩ |



### 2.3 H-Field Probe Specification

| Device Under Test                      |   |
|--|---|
| Device Type                            | COMOHAC H FIELD PROBE   |
| Manufacturer                           | Satimo  |
| Model                                  | SCH   |
| Serial Number                          | SN 06/14 HPH51  |
| Product Condition (new / used)         | New   |
| Frequency Range of Probe               | 0.7GHz-2.5GHz   |
| Resistance of Three Loops at Connector | Loop 1: R1=0.280 MΩ<br>Loop 2: R2=0.309 MΩ<br>Loop 3: R3=0.297 MΩ |



## 2.4 Axis Articulated Robot



SATIMO utilizes a six articulated robot, which is controlled using a Pentium based real-time movement controller. The movement kinematics engine utilizes proprietary (Thermo CRS) interpolation and extrapolation algorithms, which allow full freedom of movement for each of the six joints within the working envelop. Utilization of joint 6 allows for full probe rotation with a tolerance better than 0.05mm around the central axis.

|                                |                                   |
|--------------------------------|-----------------------------------|
| Robot /Controller Manufacturer | KUKA                              |
| Number of Axis                 | Six independently controlled axis |
| Positioning Repeatability      | $< \pm 0.03\text{mm}$             |
| Controller Type                | KR C4 compact                     |
| Robot Reach                    | 901mm                             |
| Communication                  | RS232 and LAN compatible          |

## 2.5 Universal Device Positioner

The universal device positioner allows complete freedom of movement of the EUT. Developed to hold a EUT in a free-space scenario any additional loading attributable to the material used in the construction of the positioner has been eliminated. Repeatability has been enhanced through the linear scales which form the design used to indicate positioning for any given test scenario in all major axes.



## 2.6 Test Equipment List

| NO. | Instrument                          | Manufacturer | Model                               | S/N             | Cal. Date                  | Cal. Due Date              |
|-----|-------------------------------------|--------------|-------------------------------------|-----------------|----------------------------|----------------------------|
| 1   | E-Field Probe                       | SATIMO       | SCE                                 | SN 06/14 EPH42  | 2014.09.01                 | 2015.08.31                 |
| 2   | Reference Validation Dipole 850MHz  | SATIMO       | SID835                              | SN 13/14 DHA55  | 2014.09.01                 | 2015.08.31                 |
| 3   | Reference Validation Dipole 1900MHz | SATIMO       | SIDB1900                            | SN 13/14 DHB59  | 2014.09.01                 | 2015.08.31                 |
| 4   | Dielectric Probe Kit                | SATIMO       | SCLMP                               | SN 32/14 OCPG52 | 2014.09.01                 | 2015.08.31                 |
| 5   | Device Holder                       | SATIMO       | SCLMP                               | SN 32/14 TABH37 | 2014.09.01                 | 2015.08.31                 |
| 6   | Waveguide                           | SATIMO       | SWG5500                             | SN 13/14 WGA32  | 2014.09.01                 | 2015.08.31                 |
| 7   | COMHAC Test Bench                   | SATIMO       | Version 2                           | NA              | Validated. No cal required | Validated. No cal required |
| 8   | HAC positioning ruler               | SATIMO       | TABH12 SN 42/09                     | NA              | Validated. No cal required | Validated. No cal required |
| 9   | SAR TEST BENCH                      | SATIMO       | 3G MOBILE PHONE POSITIONNING SYSTEM | SN 32/14 MSH97  | 2014.09.01                 | 2015.08.31                 |
| 10  | SAR TEST BENCH                      | SATIMO       | LAPTOP POSITIONNING SYSTEM          | SN 32/14 LSH29  | 2014.09.01                 | 2015.08.31                 |
| 11  | Temperature/Humidity sensor         | Mieo         | HH660                               | STS-H025        | 2014.10.28                 | 2015.10.27                 |
| 12  | Multi Meter                         | Keithley     | Multi Meter 2000                    | 4050073         | 2014.11.20                 | 2015.11.19                 |
| 13  | Amplifier                           | Mini-Circuit | ZHL-42                              | 22374           | 2014.11.20                 | 2015.11.19                 |
| 14  | Signal Generator                    | R&S          | SMF100A                             | 104260          | 2014.10.27                 | 2015.10.26                 |
| 15  | Power Meter                         | R&S          | NRP                                 | 100510          | 2014.10.25                 | 2015.10.24                 |
| 16  | Power Sensor                        | R&S          | NRP-Z11                             | 101919          | 2014.10.25                 | 2015.10.24                 |
| 17  | Network Analyzer                    | R&S          | 5071C                               | EMY46103472     | 2014.12.12                 | 2015.12.11                 |
| 18  | KUKA Robot                          | KUKA         | 10012265                            | 501821          | 2014.09.01                 | 2015.08.31                 |

Note: All equipment upon which need to be calibrated are with calibration period of 1 year.



## 2.7 Measurement Uncertainty

## UNCERTAINTY EVALUATION FOR RF HAC MEASUREMENT

| Uncertainty Component   | Tol.<br>( $\pm$ dB) | Prob.<br>Dist. | Div.       | Uncertainty<br>(dB) | Uncertainty<br>(%) |
|---|---------------------|----------------|------------|---------------------|--------------------|
| <b>Measurement System</b>   |                     |                |            |                     |                    |
| 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                |                    |
| <b>Combined Standard Uncertainty</b>                                      |                     | N              | 1          | 0.52                |                    |
| <b>Expanded Uncertainty<br/>(95% CONFIDENCE INTERVAL)</b>                 |                     |                | N          | k=2                 | 1.03               |
| <b>REPORTED Expanded uncertainty<br/>(confidence level of 95%, k = 2)</b> |                     |                | N          | k=2                 | 1.00               |
|   |                     |                |            |                     | 13.00              |

## UNCERTAINTY EVALUATION FOR AUDIO HAC MEASUREMENT

| Uncertainty Component   | Tol.<br>( $\pm$ dB) | Prob.<br>Dist. | Div.       | Uncertainty<br>(dB) | Uncertainty<br>(%) |
|---|---------------------|----------------|------------|---------------------|--------------------|
| <b>Measurement System</b>   |                     |                |            |                     |                    |
| RF 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  | 0.4                 | R              | $\sqrt{3}$ | 0.23                |                    |
| Cable loss  | 0.1                 | N              | 2          | 0.05                |                    |
| Frequency analyzer  | 0.15                | R              | $\sqrt{3}$ | 0.09                |                    |
| System repeatability  | 0.2                 | N              | 1          | 0.20                |                    |
| Repeatability of the WD   | 0.4                 | N              | 1          | 0.40                |                    |
| <b>Combined Standard Uncertainty</b>                                      |                     | N              | 1          | 0.61                |                    |
| <b>Expanded uncertainty<br/>(confidence level of 95%, k = 2)</b>          |                     |                | N          | k=2                 | 1.22               |
| <b>REPORTED Expanded uncertainty<br/>(confidence level of 95%, k = 2)</b> |                     |                | N          | k=2                 | 1.20               |
|   |                     |                |            |                     | 15.00              |

### 3. HAC RF Emission Measurement Evaluation

#### 3.1 System Check

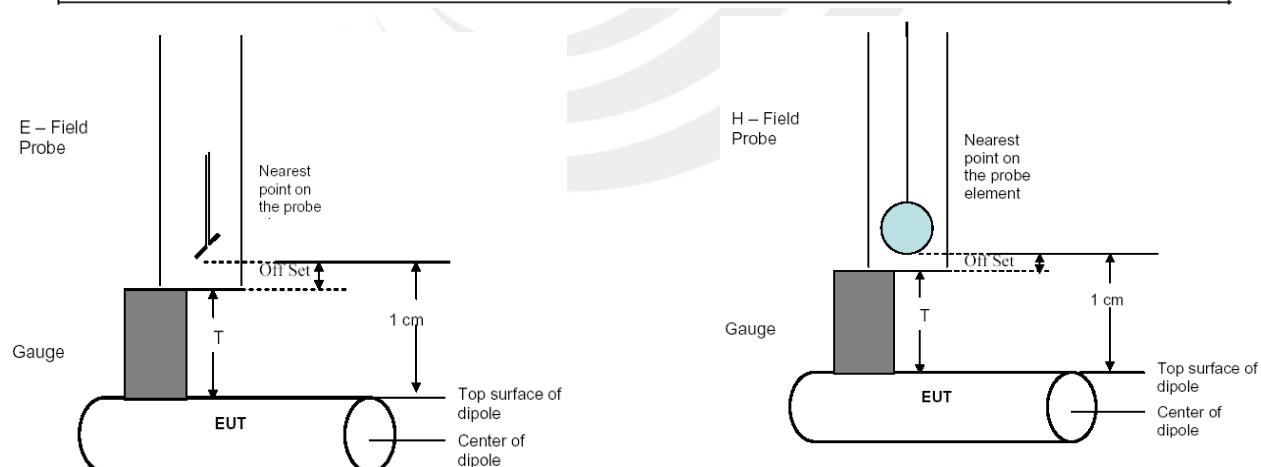
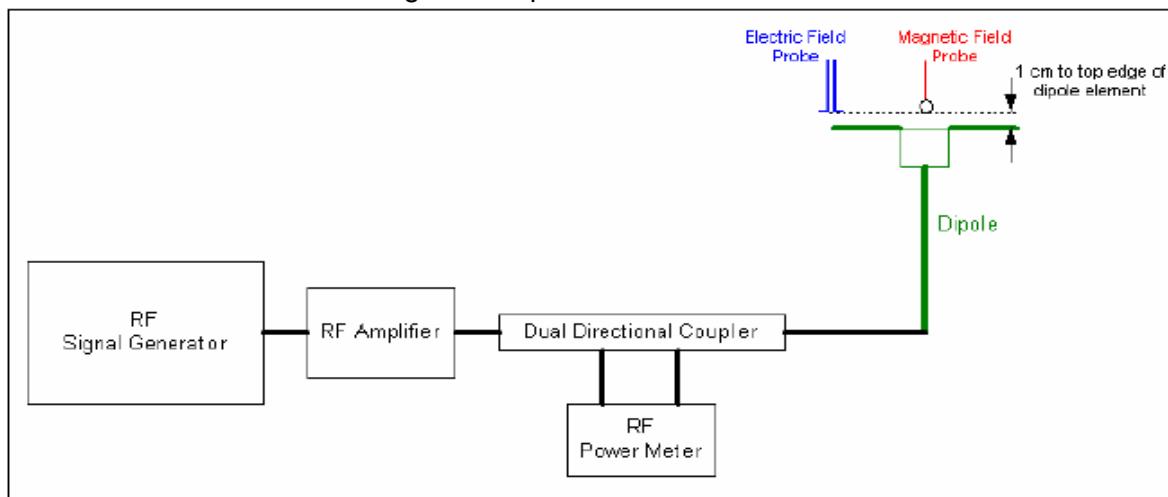
The test setup should be validated when first configured and verified periodically thereafter to ensure proper function. The procedure consists of two parts: dipole validation and determination of probe modulation factor

#### 3.2 Dipole validation

The HAC validation dipole antenna serves as a known source for an electrical and magnetic RF output. Figure 2 shows the setup used for the dipole validation.

1. The dipole antenna was placed in the position normally occupied by the WD.
2. The dipole was energized with a 20 dBm un-modulated continuous-wave signal.
3. The length of the dipole was scanned with both E-field and H-field probes and the maximum value for each scan was recorded.
4. The readings were compared with the values provided by the probe manufacturer and were found to agree within the allowed tolerance of 10%.

Figure 2: Dipole Validation Procedure



The probe is positioned over the illuminated dipole at 10 mm distance from the nearest point on the probe sensor element to the top surface (edge) of the dipole element.

#### 3.3 System Validation Results

Lab Temperature: 21°C, Lab Humidity: 45%.

| Date      | Calibration Dipole | Frequency (MHz) | Input Power (dBm) | Target Value(V/m) | Measured (V/m) | Deviation(%) |
|-----------|--------------------|-----------------|-------------------|-------------------|----------------|--------------|
| 2015/6/24 | SN 06/14           | 850             | 20                | 220.4             | 218.15         | -0.01        |
| 2015/6/24 | EPH42 E-field      | 1900            | 20                | 153.4             | 156.32         | 0.02         |

Note: Deviation=(( Measured Result)-(Target Value))/(Target Value)\*100%



## 4. Device Under Test

|                   |                |
|-------------------|----------------|
| Mobile model:     | NOIT 21        |
| Normal operation: | Held to head   |
| Accessory:        | Standard cover |

List of air interfaces/bands & operating modes for model NOIT 21

| air interfaces | Bands (MHz) | Type | C63.19/ Tested | Simultaneous Transmissions<br>Note:Not to be tested | OTT | Reduced power 20.19(c)(1) |
|----------------|-------------|------|----------------|---|-----|---------------------------|
| GSM            | 850         | VO   | Yes            | Bluetooth,WLAN                                      | N/A | N/A                       |
|                | 1900        |      | Yes            |   |     |                           |
|                | GPRS/ FDGE  | DT   | N/A            | Bluetooth,WLAN                                      | N/A | No                        |
| WCDMA          | 850         | VO   | No             | Bluetooth,WLAN                                      | N/A | N/A                       |
|                | 1900        |      |                |   |     |                           |
|                | HSPA        | DT   | N/A            | Bluetooth,WLAN                                      | N/A | N/A                       |
| WLAN           | 2412        | DT   | N/A            | GSM,WCDMA   | N/A | N/A                       |
|                | 2437        |      |                | GSM,WCDMA   | N/A | N/A                       |
|                | 2462        |      |                | GSM,WCDMA   | N/A | N/A                       |
| Bluetooth      | 2450        | DT   | N/A            | GSM,WCDMA   | N/A | N/A                       |

VO: Voice CMRS/PTSN Service Only  
V/D: Voice CMRS/PTSN and Data Service  
DT: Digital Transport



## 5. 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 1 kHz, 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.

As a check on the procedure, the MIF for the specific modulation consisting of a 1 kHz, 80% AM signal is -1.2 dB, which is the ratio in dB of the average power of the unmodulated carrier to the average power of the modulated carrier ( $10 \times \log(P_{unmod}/P_{mod})$ ), or equivalently the ratio in dB of the rms level of the unmodulated carrier to the rms level of the modulated carrier ( $20 \times \log(L_{unmod} / L_{mod})$ ). The MIF for a 1/8 duty cycle, 217 Hz pulse-modulated signal (similar to basic GSM) is +3.3 dB. (Actual GSM WD measurements could vary due to differences in implementation or network protocol.)

MIF results for a given amplitude modulation characteristic should remain consistent at any signal level within the operating dynamic range of the test system. Caution should be used when measuring modulations that have large-magnitude MIF measurements as these place greater requirements on the test system dynamic range.

Typical MIF levels are presented in Table D.1. The results shown may be considered representative for the specified protocols, but they are not intended to substitute for measurements of actual devices under test and their respective operating modes.

| Transmission protocol                              | Modulation interference factor |
|--|--------------------------------|
| GSM; full-rate version 2; speech codec/handset low | +3.63 dB                       |
| WCDMA; speech; speech codec low; AMR 12.2 kb/s     | -27.23 dB                      |
| CDMA; speech; SO3; RC3; full frame rate: 8kEVRC    | -19.75 dB                      |
| CDMA; speech; SO3; RC1; 1/8th frame rate; 8kEVRC   | +3.10 dB                       |

Table D.1—Sample MIF values for sine-wave modulations



## 6. HAC TEST PROCEDURES

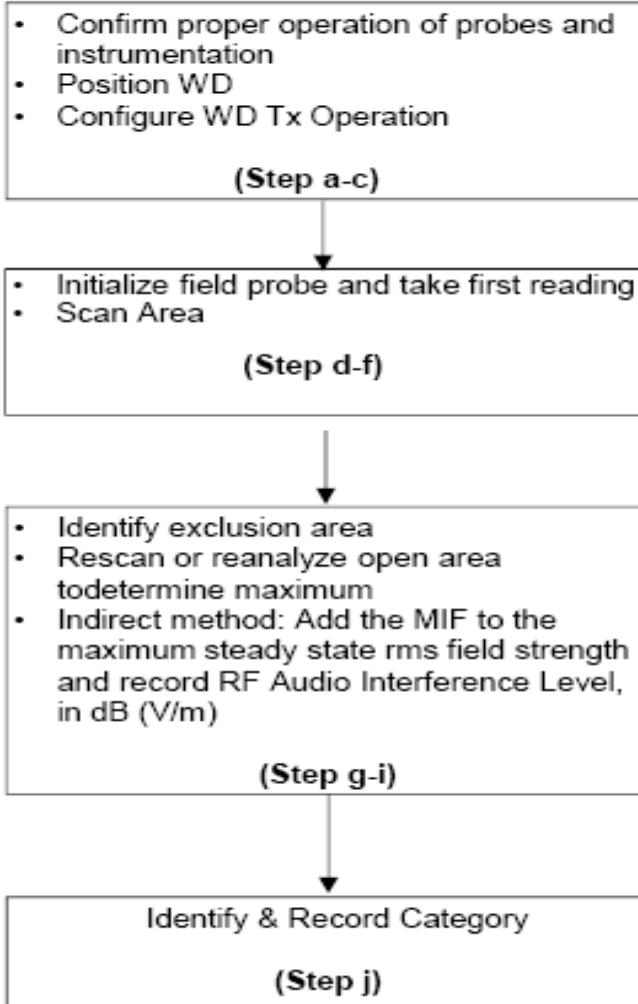
The following illustrate a typical RF emissions test scan over a wireless communications device:

1. Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.
2. DUT is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
3. The DUT 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.
4. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The DUT audio output was positioned tangent (as physically possible) to the measurement plane.
5. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the test Arch.
6. The measurement system measured the field strength at the reference location.
7. Measurements at 5 mm increments in the 5 x 5 cm region were performed and recorded. A 360° rotation about the azimuth axis at the maximum interpolated position was measured. For the worst-case condition, the peak reading from this rotation was used in re-evaluating the HAC category.
8. The system performed a drift evaluation by measuring the field at the reference location.
9. Steps 1 ~ 8 were done for both the E and H-Field measurements.



## 7. Test flowchart Per ANSI-PC63.19 2011

### Test Instructions





## 8. RF EMISSIONS

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

| Emission Categories | E-field emissions |                   |
|---------------------|-------------------|-------------------|
|                     | < 960 MHz         | > 960 MHz         |
| Category M1         | 50 to 55 dB (V/m) | 40 to 45 dB (V/m) |
| Category M2         | 45 to 50 dB (V/m) | 35 to 40 dB (V/m) |
| Category M3         | 40 to 45 dB (V/m) | 30 to 35 dB (V/m) |
| Category M4         | <40 dB (V/m)      | <30 dB (V/m)      |

## 9 HAC RF Emission Test Results

### 9.1 Test Result

| Band                 | GSM 850 |       |       | GSM 1900 |        |        |
|----------------------|---------|-------|-------|----------|--------|--------|
| Channel              | 128     | 190   | 251   | 512      | 661    | 810    |
| Frequency(MHz)       | 824.2   | 836.6 | 848.8 | 1850.2   | 1880.0 | 1909.8 |
| RF Output power(dBm) | 32.36   | 32.27 | 32.16 | 27.38    | 27.19  | 27.12  |
| Result(dB V/m)       | 11.59   | 11.39 | 11.26 | 0.62     | 0.48   | 0.85   |
| M-Rating             | M4      | M4    | M4    | M4       | M4     | M4     |

| Band                 | WCDMA 850 |       |       | WCDMA 1900 |        |        |
|----------------------|-----------|-------|-------|------------|--------|--------|
| Channel              | 4133      | 4175  | 4232  | 9263       | 9400   | 9537   |
| Frequency(MHz)       | 826.6     | 8.35  | 846.4 | 1852.6     | 1880.0 | 1907.4 |
| RF Output power(dBm) | 21.15     | 21.49 | 21.13 | 22.48      | 22.84  | 23.12  |
| Result(dB V/m)       | 11.49     | 10.78 | 10.80 | 5.63       | 5.53   | 4.99   |
| M-Rating             | M4        | M4    | M4    | M4         | M4     | M4     |

## 9.2 E-Field Emission for GSM:

|               |               |               |  |
|---------------|---------------|---------------|--|
| Grid 1: 9.88  | Grid 2: 10.00 | Grid 3: 9.69  |  |
| Grid 4: 11.66 | Grid 5: 11.59 | Grid 6: 11.29 |  |
| Grid 7: 11.47 | Grid 8: 11.38 | Grid 9: 11.07 |  |

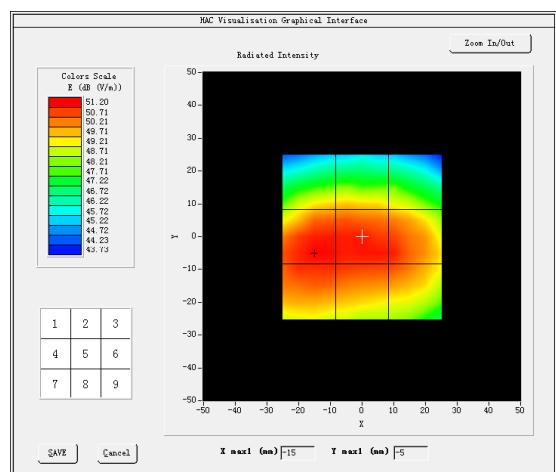
  

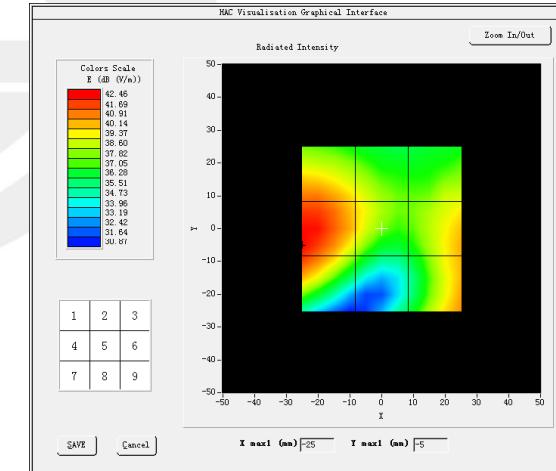
| Operation mode | MIF(dB) | Channel | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
|----------------|---------|---------|--------|---------------------------------------|----------|
| GSM 850        | 3.63    | 128     | 824.2  | 11.59                                 | M4       |

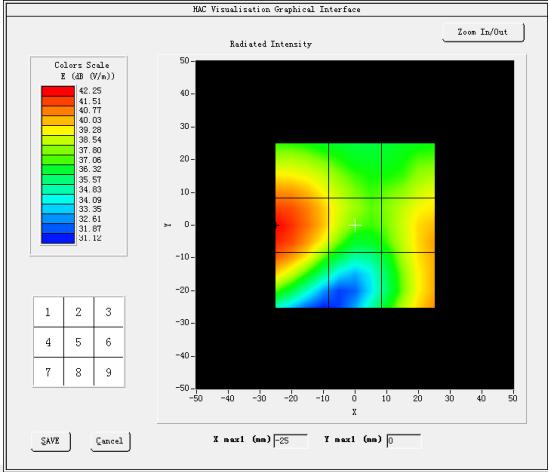
|               |               |               |  |
|---------------|---------------|---------------|--|
| Grid 1: 9.66  | Grid 2: 9.80  | Grid 3: 9.40  |  |
| Grid 4: 11.39 | Grid 5: 11.39 | Grid 6: 10.95 |  |
| Grid 7: 11.39 | Grid 8: 11.28 | Grid 9: 10.89 |  |

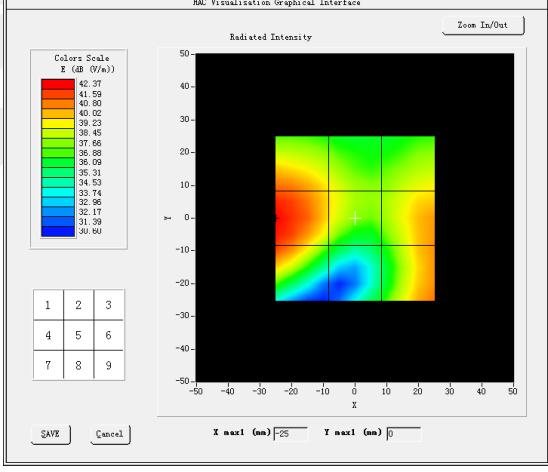
  

| Operation mode | MIF(dB) | Channel | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
|----------------|---------|---------|--------|---------------------------------------|----------|
| GSM 850        | 3.63    | 189     | 836.4  | 11.39                                 | M4       |

| Grid 1: 9.71   | Grid 2: 9.78  | Grid 3: 9.22  |  <p>Grid 4: 11.39   Grid 5: 11.26</p> <p>Grid 7: 11.18   Grid 8: 11.08</p> |                                       |          |
|----------------|---------------|---------------|--|---------------------------------------|----------|
| Grid 4: 11.39  | Grid 5: 11.26 | Grid 6: 11.15 |  |                                       |          |
| Grid 7: 11.18  | Grid 8: 11.08 | Grid 9: 10.94 |  |                                       |          |
| Operation mode | MIF(dB)       | Channel       | f(MHz)   | Maximum value of total field (dB V/m) | M-Rating |
| GSM 850        | 3.63          | 250           | 848.6  | 11.26                                 | M4       |

| Grid 1: 0.98   | Grid 2: -0.83 | Grid 3: -1.23 |  <p>Grid 4: 2.45</p> <p>Grid 7: 2.00</p> <p>Grid 8: -2.44   Grid 9: 0.62</p> |                                       |          |
|----------------|---------------|---------------|--|---------------------------------------|----------|
| Grid 4: 2.45   | Grid 5: -0.43 | Grid 6: 0.22  |  |                                       |          |
| Grid 7: 2.00   | Grid 8: -2.44 | Grid 9: 0.62  |  |                                       |          |
| Operation mode | MIF(dB)       | Channel       | f(MHz)   | Maximum value of total field (dB V/m) | M-Rating |
| GSM 1900       | 3.63          | 512           | 1850.4   | 0.62                                  | M4       |

| <b>Grid 1: 0.55</b> | Grid 2: -1.30 | Grid 3: -0.99       |  |
|---------------------|---------------|---------------------|--|
| <b>Grid 4: 2.20</b> | Grid 5: -0.80 | Grid 6: 0.29        |  |
| <b>Grid 7: 1.41</b> | Grid 8: -2.71 | <b>Grid 9: 0.48</b> |  |
| Operation mode      | MIF(dB)       | Channel             | f(MHz)   |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>661</b>          | <b>1880.0</b>  |
| Operation mode      | MIF(dB)       | Channel             | Maximum value of total field (dB V/m)  |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>661</b>          | <b>0.48</b>  |
| Operation mode      | MIF(dB)       | Channel             | M-Rating   |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>661</b>          | <b>M4</b>  |

| <b>Grid 1: 0.94</b> | Grid 2: -1.07 | Grid 3: -0.89       |  |
|---------------------|---------------|---------------------|--|
| <b>Grid 4: 2.32</b> | Grid 5: -0.78 | Grid 6: 0.43        |  |
| <b>Grid 7: 1.75</b> | Grid 8: -2.93 | <b>Grid 9: 0.85</b> |  |
| Operation mode      | MIF(dB)       | Channel             | f(MHz)   |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>810</b>          | <b>1909.8</b>  |
| Operation mode      | MIF(dB)       | Channel             | Maximum value of total field (dB V/m)  |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>810</b>          | <b>0.85</b>  |
| Operation mode      | MIF(dB)       | Channel             | M-Rating   |
| <b>GSM 1900</b>     | <b>3.63</b>   | <b>810</b>          | <b>M4</b>  |



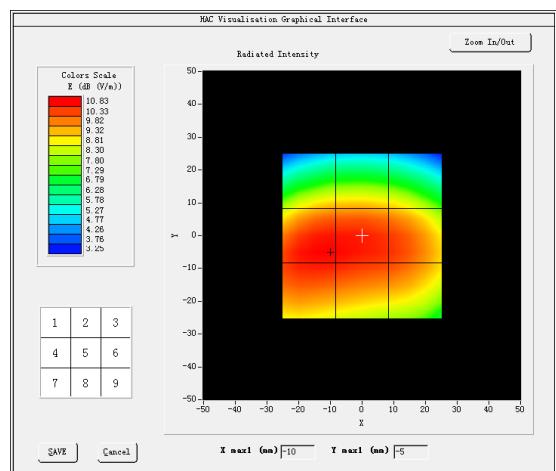
|                      |                      |               |  |
|----------------------|----------------------|---------------|--|
| Grid 1: 9.81         | Grid 2: 9.85         | Grid 3: 9.54  |  |
| <b>Grid 4: 11.50</b> | <b>Grid 5: 11.49</b> | Grid 6: 11.15 |  |
| <b>Grid 7: 11.40</b> | <b>Grid 8: 11.36</b> | Grid 9: 11.01 |  |

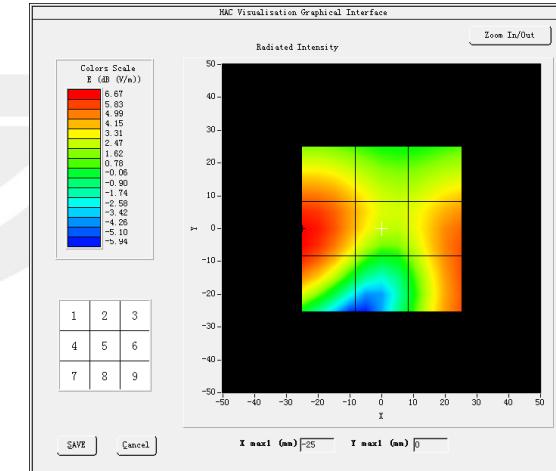
| Operation mode | MIF(dB) | Channel | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
|----------------|---------|---------|--------|---------------------------------------|----------|
| WCDMA 850      | -27.23  | 4133    | 826.6  | 11.49                                 | M4       |

|                      |                      |               |  |
|----------------------|----------------------|---------------|--|
| Grid 1: 9.10         | Grid 2: 9.18         | Grid 3: 8.75  |  |
| <b>Grid 4: 10.79</b> | <b>Grid 5: 10.78</b> | Grid 6: 10.37 |  |
| <b>Grid 7: 10.73</b> | <b>Grid 8: 10.62</b> | Grid 9: 10.21 |  |

| Operation mode | MIF(dB) | Channel | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
|----------------|---------|---------|--------|---------------------------------------|----------|
| WCDMA 850      | -27.23  | 4175    | 835.0  | 10.78                                 | M4       |

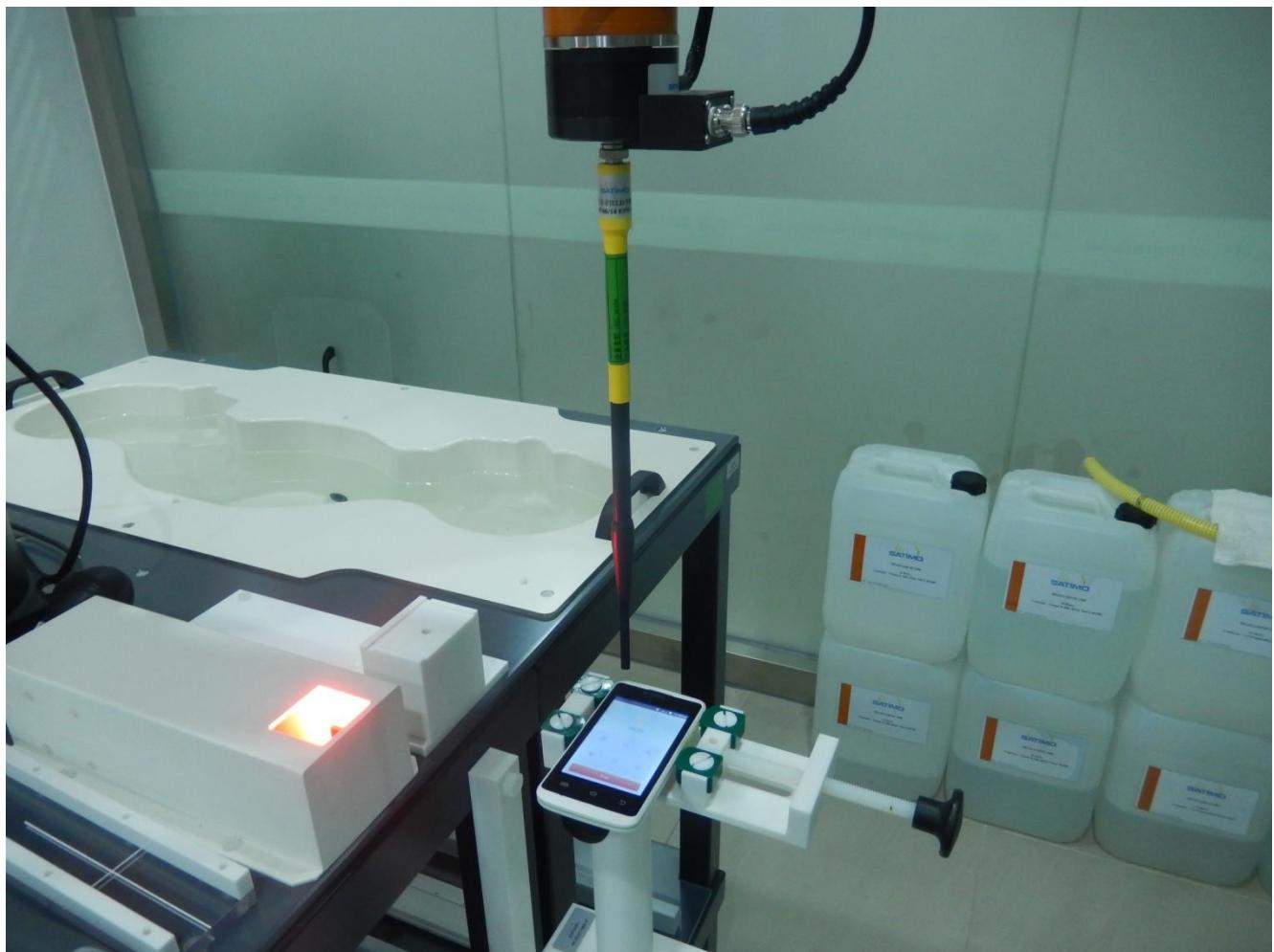
| Grid 1: 9.12                          | Grid 2: 9.17         | Grid 3: 8.85  |  |
|---------------------------------------|----------------------|---------------|--|
| <b>Grid 4: 10.84</b>                  | <b>Grid 5: 10.80</b> | Grid 6: 10.44 |  |
| <b>Grid 7: 10.72</b>                  | <b>Grid 8: 10.65</b> | Grid 9: 10.29 |  |
| Operation mode                        | MIF(dB)              | Channel       | f(MHz)   |
| WCDMA 850                             | -27.23               | 4232          | 846.4  |
| Maximum value of total field (dB V/m) | M-Rating             |               |  |
| 10.80                                 | M4                   |               |  |

| Grid 1: 5.18                          | Grid 2: 3.55 | Grid 3: 3.86        |  |
|---------------------------------------|--------------|---------------------|--|
| <b>Grid 4: 6.72</b>                   | Grid 5: 3.98 | Grid 6: 5.61        |  |
| <b>Grid 7: 6.34</b>                   | Grid 8: 2.11 | <b>Grid 9: 5.63</b> |  |
| Operation mode                        | MIF(dB)      | Channel             | f(MHz)   |
| WCDMA 1900                            | -27.23       | 9263                | 1852.6   |
| Maximum value of total field (dB V/m) | M-Rating     |                     |  |
| 5.63                                  | M4           |                     |  |

| <b>Grid 1: 4.63</b> | Grid 2: 3.00 | Grid 3: 3.64        |        |                                       |          |
|---------------------|--------------|---------------------|--------|---------------------------------------|----------|
| <b>Grid 4: 6.24</b> | Grid 5: 3.48 | Grid 6: 5.52        |        |                                       |          |
| <b>Grid 7: 5.85</b> | Grid 8: 1.76 | <b>Grid 9: 5.53</b> |        |                                       |          |
| Operation mode      | MIF(dB)      | Channel             | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
| WCDMA 1900          | -27.23       | 9400                | 1880.0 | 5.53                                  | M4       |

| <b>Grid 1: 4.42</b> | Grid 2: 2.63 | Grid 3: 3.29        |        |                                       |          |
|---------------------|--------------|---------------------|--------|---------------------------------------|----------|
| <b>Grid 4: 6.04</b> | Grid 5: 3.10 | <b>Grid 6: 4.99</b> |        |                                       |          |
| <b>Grid 7: 5.64</b> | Grid 8: 1.11 | Grid 9: 4.99        |        |                                       |          |
| Operation mode      | MIF(dB)      | Channel             | f(MHz) | Maximum value of total field (dB V/m) | M-Rating |
| WCDMA 1900          | -27.23       | 9537                | 1907.4 | 4.99                                  | M4       |

## 10. HAC Test Photographs



**E-field**

## 11. System VALIDATION RESULTS

|               |               |               |
|---------------|---------------|---------------|
| #1<br>125.495 | #2<br>127.052 | #3<br>92.282  |
| #4<br>172.750 | #5<br>176.757 | #6<br>121.142 |
| #7<br>133.195 | #8<br>133.841 | #9<br>96.000  |

V/m

**HAC E-Field**  
2D Plot

X Axis (mm)      Y (mm)

| Frequency(MHz) | Input power (dBm) | Target Value (dB V/m) | E-Field (dB V/m) | Deviation(%) | data        |
|----------------|-------------------|-----------------------|------------------|--------------|-------------|
| 835            | 20                | 220.4                 | 218.15           | -0.01        | Jun.24.2015 |

|               |               |              |
|---------------|---------------|--------------|
| #1<br>94.368  | #2<br>99.291  | #3<br>68.469 |
| #4<br>138.307 | #5<br>144.484 | #6<br>87.539 |
| #7<br>114.989 | #8<br>117.448 | #9<br>75.501 |

V/m

**HAC E-Field**  
2D Plot

X Axis (mm)      Y (mm)

| Frequency(MHz) | Input power (dBm) | Target Value (dB V/m) | E-Field (dB V/m) | Deviation(%) | data        |
|----------------|-------------------|-----------------------|------------------|--------------|-------------|
| 1880           | 20                | 153.4                 | 156.32           | 0.02         | Jun.24.2015 |



## 12. Probe Calibration And Dipole Calibration Report

The following pages include the probe calibration used to evaluate HAC for the DUT.



### COMOHAC E-Field Probe Calibration Report

Ref : ACR.262.14.14.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 E-FIELD PROBE**  
**SERIAL NO.: SN 06/14 EPH42**

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 E-Field Probe calibration performed in SATIMO USA using the CALIBAIR test bench, for use with a SATIMO COMOHAC system only. All calibration results are traceable to national metrology institutions.



## COMORHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR 262.14.14.SATUA

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

|                | Customer Name                        |
|----------------|--------------------------------------|
| Distribution : | Shenzhen STS Test Services Co., Ltd. |

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

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## 1 DEVICE UNDER TEST

| Device Under Test                        |   |
|--|---|
| Device Type                              | COMOHAC E FIELD PROBE   |
| Manufacturer                             | Satimo  |
| Model                                    | SCE   |
| Serial Number                            | SN 06/14 EPH42  |
| Product Condition (new / used)           | new   |
| Frequency Range of Probe                 | 0.7GHz-2.5GHz   |
| Resistance of Three Dipoles at Connector | Dipole 1: R1=0.214 MΩ<br>Dipole 2: R2=0.213 MΩ<br>Dipole 3: R3=0.204 MΩ |

A yearly calibration interval is recommended.

## 2 PRODUCT DESCRIPTION

### 2.1 GENERAL INFORMATION

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



Figure 1 – Satimo 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).

### 3.2 SENSITIVITY

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

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### 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<br>95 % confidence level $k = 2$      |                       |                          |            |    | 9.0%                     |

## 5 CALIBRATION MEASUREMENT RESULTS

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

## COMOHAC E-FIELD PROBE CALIBRATION REPORT

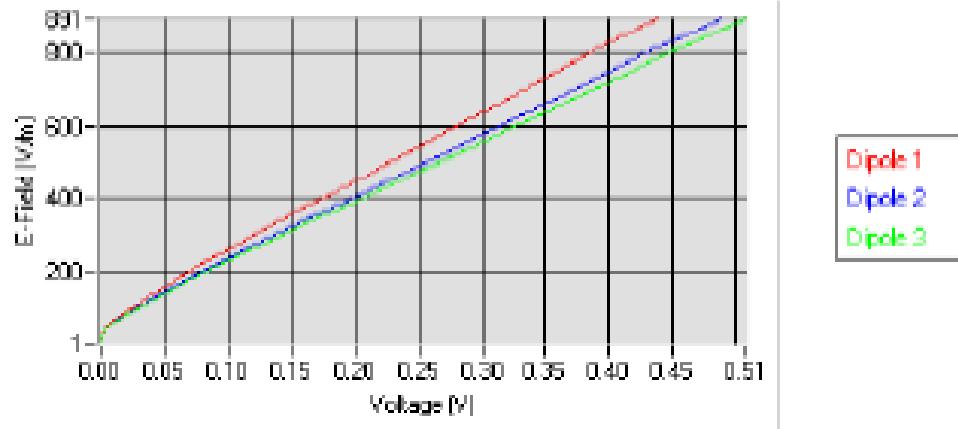
Ref. ACR.262.14.14.SAT.U.A

### 5.1 SENSITIVITY IN AIR

| Normx dipole 1<br>( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normy dipole 2<br>( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normz dipole 3<br>( $\mu\text{V}/(\text{V}/\text{m})^2$ ) |
|---|---|---|
| 3.06  | 3.86  | 4.00  |

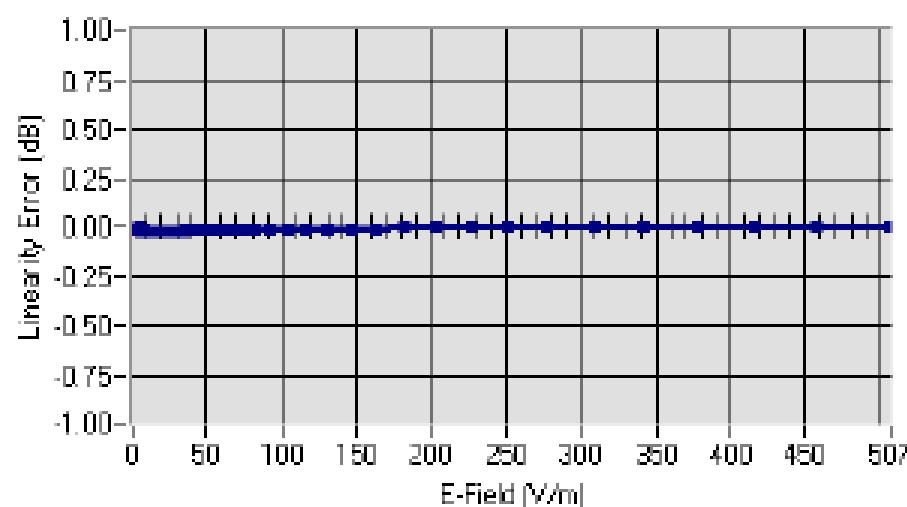
| DCP dipole 1<br>(mV) | DCP dipole 2<br>(mV) | DCP dipole 3<br>(mV) |
|----------------------|----------------------|----------------------|
| 96                   | 92                   | 96                   |

### Calibration curves



## 5.2 LINEARITY

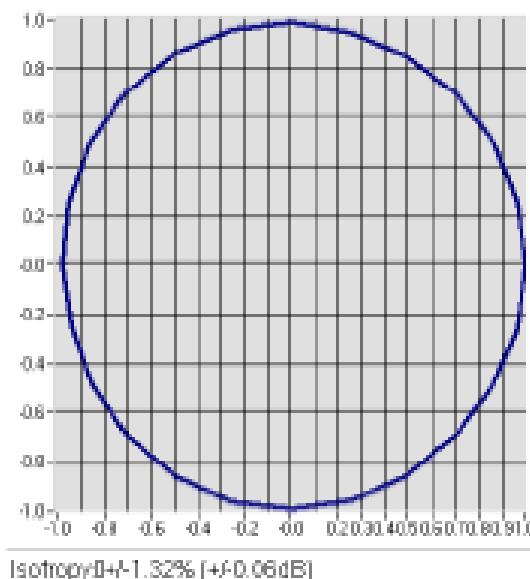
Linearity



Linearity: +/-0.68% (+/-0.03dB)

## 5.3 ISOTROPY

Isotropy curve



Isotropy: +/-1.32% (+/-0.06dB)

## COMOHAC E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.262.14.14.SATU.A

## 6 LIST OF EQUIPMENT

| Equipment Summary Sheet       |                      |                    |   |   |
|-------------------------------|----------------------|--------------------|---|---|
| Equipment Description         | Manufacturer / Model | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| HAC positioning ruler         | Satimo               | 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               | Satimo               | EPH26 SN 08/11     | 10/2013                                       | 10/2014                                       |
| Reference Probe               | Satimo               | HPH38 SN31/10      | 10/2013                                       | 10/2014                                       |
| Multimeter                    | Keithley 2000        | 1188656            | 12/2013                                       | 12/2016                                       |
| Signal Generator              | Agilent E4438C       | MY49070581         | 12/2013                                       | 12/2016                                       |
| Amplifier                     | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                   | HP E4416A            | US38261498         | 12/2013                                       | 12/2016                                       |
| Power Sensor                  | HP ECP-E26A          | US37181460         | 12/2013                                       | 12/2016                                       |
| Directional Coupler           | Narda 4216-20        | 01366              | 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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## COMOHAC H-Field Probe Calibration

Ref : ACR.262.15.14.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 H-FIELD PROBE**  
**SERIAL NO.: SN 06/14 HPH51**

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 H-Field Probe calibration performed in SATIMO USA using the CALIBAIR test bench, for use with a SATIMO COMOHAC system only. All calibration results are traceable to national metrology institutions.



## COMOHAC H-FIELD PROBE CALIBRATION REPORT

Ref. ACR.262.15.14.SATU.A

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

|                | Customer Name                        |
|----------------|--------------------------------------|
| Distribution : | Shenzhen STS Test Services Co., Ltd. |

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

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## COMOHAC H-FIELD PROBE CALIBRATION REPORT

Ref: ACR.262.15.14.SATU.A

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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                   | Satimo                               |
| Model                          | SIDB835                              |
| Serial Number                  | SN 13/14 DHA55                       |
| Product Condition (new / used) | New                                  |

A yearly calibration interval is recommended.

## 3 PRODUCT DESCRIPTION

### 3.1 GENERAL INFORMATION

Satimo'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 – Satimo 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.

## 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                   | Satimo                               |
| Model                          | SIIDB835                             |
| Serial Number                  | SN 13/14 DHA55                       |
| Product Condition (new / used) | New                                  |

A yearly calibration interval is recommended.

## 3 PRODUCT DESCRIPTION

### 3.1 GENERAL INFORMATION

Satimo'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 – Satimo 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.



#### 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 SATIMO.

### 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

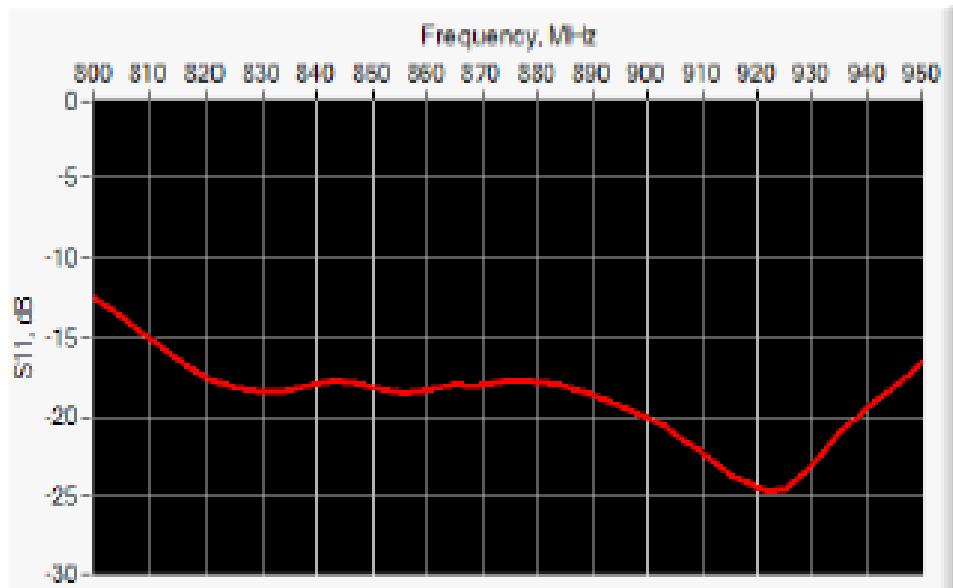
The guideline outlined in the IEEE ANSI C63.19 standard was followed to generate the measurement uncertainty for validation measurements.

| 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<br>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     | -12.94                      | -10              |

### 6.2 VALIDATION MEASUREMENT

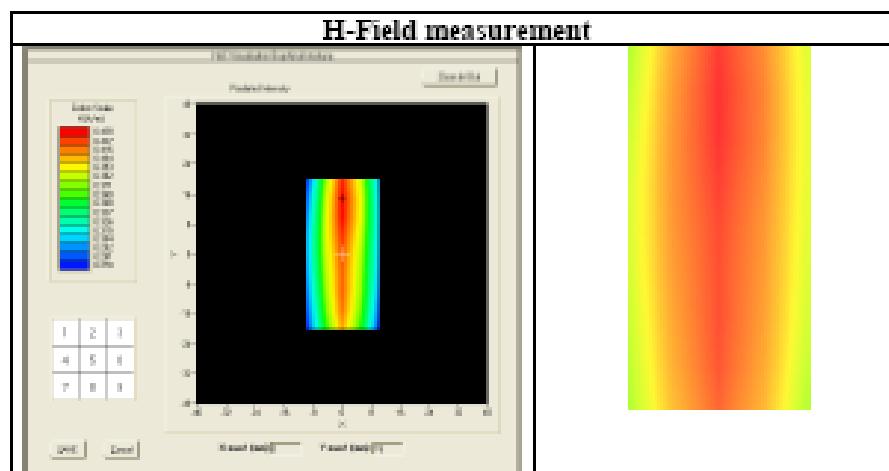
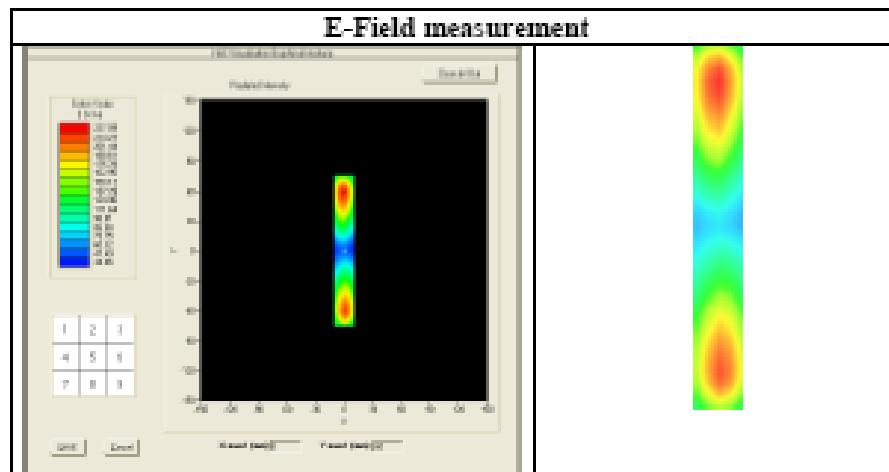
The IEEE ANSI C63.19 standard states that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss requirements. The system validations measurement results are then compared to SATIMO's simulated results.

#### 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%             |

### Measurement Result

|               | Measured | Internal Requirement |
|---------------|----------|----------------------|
| E field (V/m) | 227.09   | 220.4                |
| H field (A/m) | 0.44     | 0.445                |





## 7 LIST OF EQUIPMENT

| Equipment Summary Sheet         |                      |                    |   |   |
|---------------------------------|----------------------|--------------------|---|---|
| Equipment Description           | Manufacturer / Model | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| HAC positioning ruler           | Satimo               | 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                 | Satimo               | EPH26 SN 08/11     | 10/2013                                       | 10/2014                                       |
| Reference Probe                 | Satimo               | HPH38 SN31/10      | 10/2013                                       | 10/2014                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 12/2013                                       | 12/2016                                       |
| Signal Generator                | Agilent E4438C       | MY49070581         | 12/2013                                       | 12/2016                                       |
| Amplifier                       | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                     | HP E4418A            | US38261498         | 12/2013                                       | 12/2016                                       |
| Power Sensor                    | HP ECP-E26A          | US37181460         | 12/2013                                       | 12/2016                                       |
| Directional Coupler             | Narda 4216-20        | 01386              | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company      | 11-661-9           | 6/2012  | 6/2015  |



## HAC Reference Dipole Calibration Report

Ref : ACR.262.18.14.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 REFERENCE DIPOLE**  
**FREQUENCY: 1700-2000MHZ**  
**SERIAL NO.: SN 13/14 DHB59**

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 HAC reference dipole calibration performed in SATIMO USA using the COMOHAC test bench. All calibration results are traceable to national metrology institutions.



## HAC REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.262.18.14.SAT.UA

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

|                | Customer Name                        |
|----------------|--------------------------------------|
| Distribution : | Shenzhen STS Test Services Co., Ltd. |

| Issue | Date      | Modifications   |
|-------|-----------|-----------------|
| A     | 9/19/2014 | 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 1700-2000 MHz REFERENCE DIPOLE |
| Manufacturer                   | Satimo                                 |
| Model                          | SIDB1900                               |
| Serial Number                  | SN 13/14 DHB59                         |
| Product Condition (new / used) | New                                    |

A yearly calibration interval is recommended.

## 3 PRODUCT DESCRIPTION

### 3.1 GENERAL INFORMATION

Satimo'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 – Satimo 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.



#### 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 SATIMO.

### 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                       |

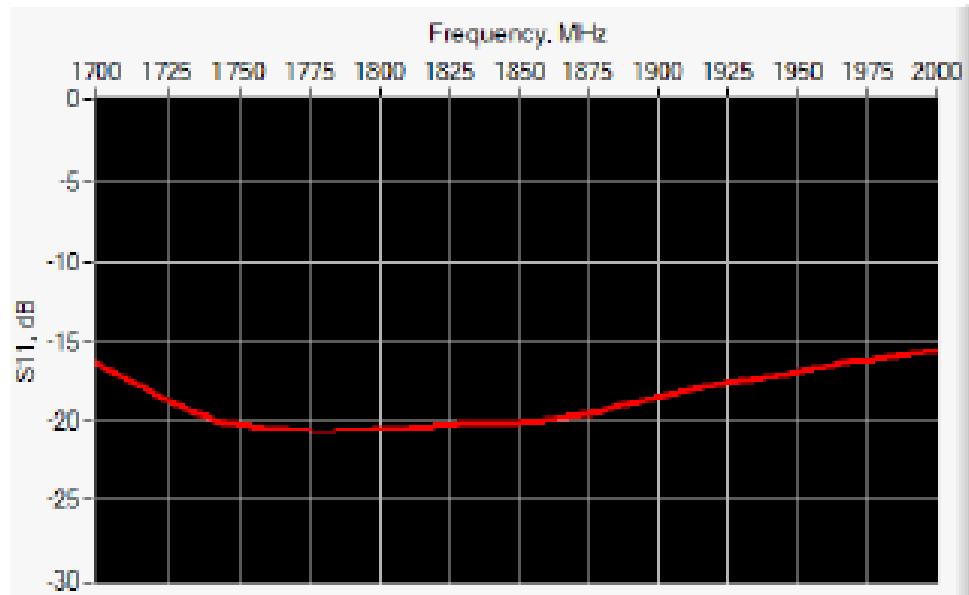
#### 5.2 VALIDATION MEASUREMENT

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<br>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   | -15.74                      | -10              |

### 6.2 VALIDATION MEASUREMENT

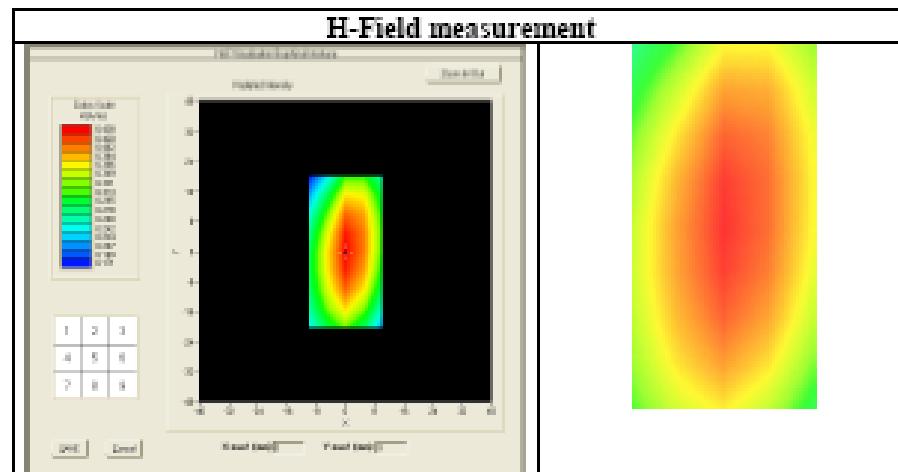
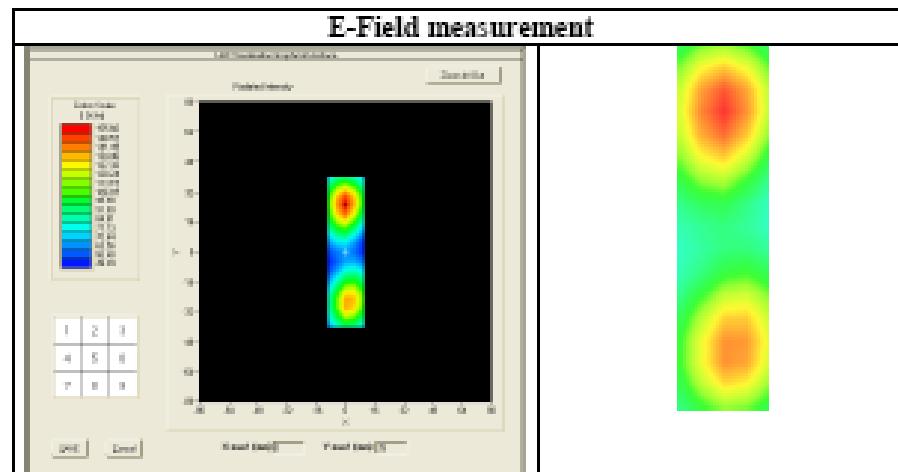
The IEEE ANSI C63.19 standard states that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss requirements. The system validations measurement results are then compared to SATIMO's simulated results.

#### 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%             |

### Measurement Result

|               | Measured | Internal Requirement |
|---------------|----------|----------------------|
| E field (V/m) | 155.66   | 153.4                |
| H field (A/m) | 0.44     | 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           | Satimo               | 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                 | Satimo               | EPH28 SN 08/11     | 10/2013                                       | 10/2014                                       |
| Reference Probe                 | Satimo               | HPH38 SN31/10      | 10/2013                                       | 10/2014                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 12/2013                                       | 12/2016                                       |
| Signal Generator                | Agilent E4438C       | MY49070581         | 12/2013                                       | 12/2016                                       |
| Amplifier                       | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                     | HP E4416A            | US36261498         | 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  |



## 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.



## COMORAC TMFS PROBE CALIBRATION REPORT

Ref: ACR 262.1R14.SATU.A

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

|                | Customer Name                        |
|----------------|--------------------------------------|
| Distribution : | Shenzhen STS Test Services Co., Ltd. |

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

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## COMOHAC TMFS™ PROBE CALIBRATION REPORT

Ref. ACR.262.19.14.RATU.A

## 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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## COMONIAC TMFS: PROBE CALIBRATION REPORT

Ref. ACR.262.19.14.SATU.A

## Uncertainty analysis of the probe calibration in Helmholtz Coil

| Uncertainty Component                               | Tol.<br>( $\pm$ 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                |                 |
| Combined standard uncertainty                       |                     | N           | 1          | 0.43                |                 |
| Expanded uncertainty<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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## 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 16 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                      |