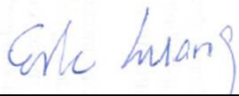


# Hearing Aid Compatibility (HAC) RF Emissions Test Report

APPLICANT : Motorola Mobility, LLC  
EQUIPMENT : Mobile Cellular Phone  
BRAND NAME : Motorola  
MODEL NAME : 9653  
FCC ID : IHDT56WA1  
STANDARD : FCC 47 CFR §20.19  
ANSI C63.19-2011

We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and had been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.



Reviewed by: Eric Huang / Manager



Approved by: Jones Tsai / Manager



## SPORTON INTERNATIONAL INC.

No.52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Taoyuan City, Taiwan (R.O.C.)



**Table of Contents**

- 1. **Attestation of Test Results** ..... 4
- 2. **Administration Data** ..... 4
- 3. **Equipment Under Test Information** ..... 5
  - 3.1 General Information ..... 5
  - 3.2 Air Interface and Operating Mode ..... 6
  - 3.3 Applied Standards ..... 7
- 4. **HAC RF Emission** ..... 7
- 5. **Measurement System Specification** ..... 8
  - 5.1 Test Arch Phantom ..... 8
  - 5.2 E-Field Probe System ..... 9
    - E-Field Probe Specification ..... 9
    - Probe Tip Description: ..... 9
  - 5.3 System Hardware ..... 9
  - 5.4 Data Storage and Evaluation ..... 10
  - 5.5 Test Equipment List ..... 11
- 6. **Measurement System Validation** ..... 12
  - 6.1 Purpose of System Performance Check ..... 12
  - 6.2 System Setup ..... 12
  - 6.3 Verification Results ..... 13
- 7. **RF Emissions Test Procedure** ..... 14
- 8. **Conducted RF Output Power (Unit: dBm)** ..... 17
- 9. **HAC RF Emission Test Results** ..... 17
- 10. **Uncertainty Assessment** ..... 18
- 11. **References** ..... 20

- Appendix A. Plots of System Performance Check
- Appendix B. Plots of RF Emission Measurement
- Appendix C. DASYS Calibration Certificate



### Revision History

| REPORT NO.   | VERSION | DESCRIPTION             | ISSUED DATE   |
|--------------|---------|-------------------------|---------------|
| HA720310-15A | Rev. 01 | Initial issue of report | May. 12, 2017 |
|              |         |                         |               |
|              |         |                         |               |



1. Attestation of Test Results

Table with 2 columns: Field Name and Value. Fields include Applicant Name, Equipment Name, Brand Name, Model Name, FCC ID, S / N, IMEI Code, EUT Stage, Exposure category, HAC Rating, Date Tested, Test Result, and Remark.

This device is compliance with HAC limits specified in guidelines FCC 47 CFR §20.19 and ANSI Standard ANSI C63.19.

2. Administration Data

Table with 2 columns: Field Name and Value. Sections include Testing Laboratory, Applicant, and Manufacturer details.



### 3. Equipment Under Test Information

#### 3.1 General Information

| Product Feature & Specification |  |
|---------------------------------|--|
| Frequency Band                  | GSM850: 824.2 MHz ~ 848.8 MHz<br>GSM1900: 1850.2 MHz ~ 1909.8 MHz<br>WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz<br>WCDMA Band IV: 1712.4 MHz ~ 1752.6 MHz<br>WCDMA Band V: 826.4 MHz ~ 846.6 MHz<br>CDMA2000 BC0: 824.7 MHz ~ 848.31 MHz<br>CDMA 2000 BC1: 1851.25 MHz ~ 1908.75 MHz<br>CDMA 2000 BC10: 817.9 MHz ~ 823.1 MHz<br>LTE Band 2: 1850.7 MHz ~ 1909.3 MHz<br>LTE Band 4: 1710.7 MHz ~ 1754.3 MHz<br>LTE Band 5: 824.7 MHz ~ 848.3 MHz<br>LTE Band 7: 2502.5 MHz ~ 2567.5 MHz<br>LTE Band 12: 699.7 MHz ~ 715.3 MHz<br>LTE Band 13: 779.5 MHz ~ 784.5 MHz<br>LTE Band 17: 706.5 MHz ~ 713.5 MHz<br>LTE Band 25: 1850.7 MHz ~ 1914.3 MHz<br>LTE Band 26: 814.7 MHz ~ 848.3 MHz<br>LTE Band 30: 2307.5 MHz ~ 2312.5 MHz<br>LTE Band 38: 2572.5 MHz ~ 2617.5 MHz<br>LTE Band 41: 2498.5 MHz ~ 2687.5 MHz<br>LTE Band 66: 1710.7 MHz ~ 1779.3 MHz<br>WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz<br>WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz<br>WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz<br>WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz<br>WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz<br>Bluetooth: 2402 MHz ~ 2480 MHz<br>NFC: 13.56 MHz |
| Mode                            | GSM/GPRS/EGPRS<br>AMR / RMC 12.2Kbps<br>HSDPA<br>HSUPA<br>DC-HSDPA<br>CDMA2000 : 1xRTT/1xEv-Do(Rel.0)/1xEv-Do(Rev.A)<br>LTE: QPSK, 16QAM<br>802.11a/b/g/n HT20/HT40<br>Bluetooth BR/EDR/LE<br>NFC:ASK  |



**3.2 Air Interface and Operating Mode**

| Air Interface | Band MHz  | Type | C63.19 Tested      | Simultaneous Transmitter | OTT | Power Reduction |
|---------------|-----------|------|--------------------|--------------------------|-----|-----------------|
| GSM           | 850       | VO   | Yes                | WLAN, BT                 | NA  | No              |
|               | 1900      |      |                    | WLAN, BT                 | NA  | No              |
|               | GPRS/EDGE | DT   | No                 | WLAN, BT                 | Yes | No              |
| WCDMA         | 850       | VO   | Yes <sup>(1)</sup> | WLAN, BT                 | NA  | No              |
|               | 1750      |      |                    | WLAN, BT                 | NA  | No              |
|               | 1900      |      |                    | WLAN, BT                 | NA  | No              |
|               | HSPA      | DT   | No                 | WLAN, BT                 | Yes | No              |
| CDMA          | BC0       | VO   | Yes                | WLAN, BT                 | NA  | No              |
|               | BC1       |      |                    | WLAN, BT                 | NA  | No              |
|               | BC10      |      |                    | WLAN, BT                 | NA  | No              |
|               | EVDO      | DT   | No                 | WLAN, BT                 | Yes | No              |
| LTE           | Band 2    | VD   | Yes <sup>(1)</sup> | WLAN, BT                 | Yes | No              |
|               | Band 4    |      |                    | WLAN, BT                 |     | No              |
|               | Band 5    |      |                    | WLAN, BT                 |     | No              |
|               | Band 7    |      |                    | WLAN, BT                 |     | No              |
|               | Band 12   |      |                    | WLAN, BT                 |     | No              |
|               | Band 13   |      |                    | WLAN, BT                 |     | No              |
|               | Band 17   |      |                    | WLAN, BT                 |     | No              |
|               | Band 25   |      |                    | WLAN, BT                 |     | No              |
|               | Band 26   |      |                    | WLAN, BT                 |     | No              |
|               | Band 30   |      |                    | WLAN, BT                 |     | No              |
|               | Band 38   |      |                    | WLAN, BT                 |     | No              |
|               | Band 41   |      |                    | WLAN, BT                 |     | No              |
|               | Band 66   |      |                    | WLAN, BT                 |     | No              |
| WLAN          | 2450      | VD   | Yes <sup>(2)</sup> | GSM,CDMA WCDMA,LTE       | Yes | No              |
|               | 5200      |      |                    | GSM,CDMA WCDMA,LTE       |     | No              |
|               | 5300      |      |                    | GSM,CDMA WCDMA,LTE       |     | No              |
|               | 5500      |      |                    | GSM,CDMA WCDMA,LTE       |     | No              |
|               | 5800      |      |                    | GSM,CDMA WCDMA,LTE       |     | No              |
| BT            | 2450      | DT   | No                 | GSM,CDMA WCDMA,LTE       | NA  | No              |

VO=CMRS Voice Service  
 DT=Digital Transport  
 VD=CMRS IP Voice Service and Digital Transport

Remark:

- WCDMA and LTE is exempted from testing by low power exemption that its average antenna input power plus its MIF is ≤17 dBm, and is rated as M4
- No Associated T-Coil measurement has been made in accordance with KDB 285076 D02 T-Coil testing for CMRS IP



**3.3 Applied Standards**

- FCC CFR47 Part 20.19
- ANSI C63.19 2011-version
- FCC KDB 285076 D01 HAC Guidance v04r01
- FCC KDB 285076 D02 T Coil testing for CMRS IP v02
- FCC KDB 648474 D03 Wireless Chargers Battery Cover v01r04

**4. HAC RF Emission**

FCC wireless hearing aid compatibility rules ensure that consumers with hearing loss are able to access wireless communications services through a wide selection of handsets without experiencing disabling radio frequency (RF) interference or other technical obstacles.

To define and measure the hearing aid compatibility of handsets, in CFR47 part 20.19 ANSI C63.19 is referenced. A handset is considered hearing aid-compatible for acoustic coupling if it meets a rating of at least M3 under ANSI C63.19, and A handset is considered hearing aid compatible for inductive coupling if it meets a rating of at least T3.

According to ANSI C63.19 2011 version, for acoustic coupling, the RF electric field emissions of wireless communication devices should be measured and rated according to the emission level as below.

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

Table 4.1 Telephone near-field categories in linear units

### 5. Measurement System Specification

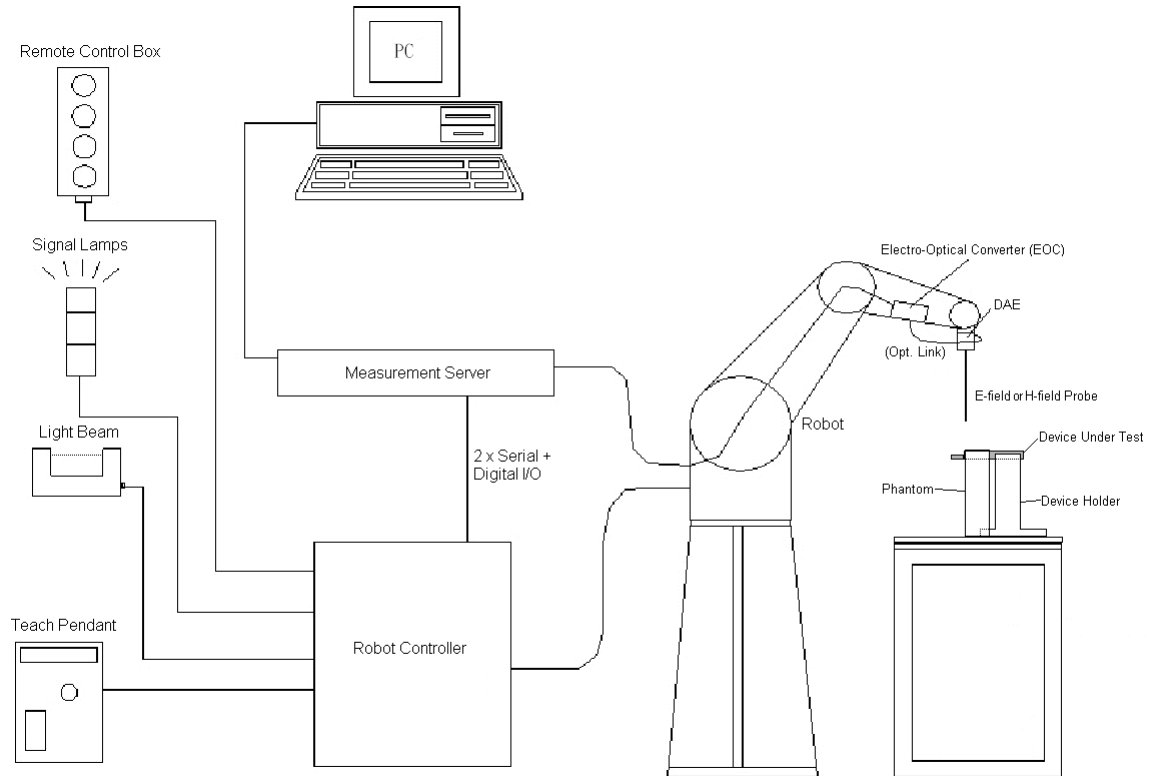
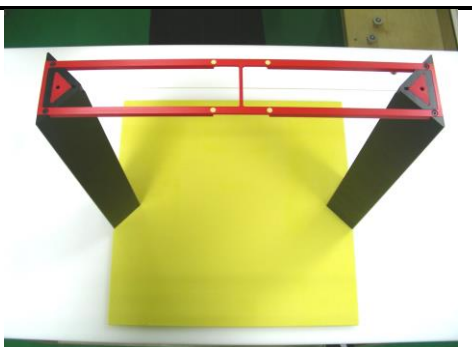


Fig 5.1 SPEAG DASY5 System Configurations

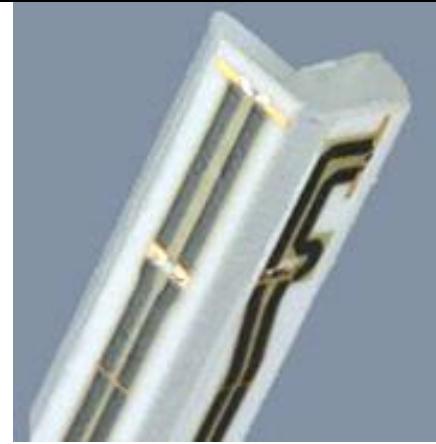
#### 5.1 Test Arch Phantom

|                              |   |   |
|------------------------------|---|---|
| <p><b>Construction :</b></p> | <p>Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.</p> |  <p>Fig 5.8 Photo of Arch Phantom</p> |
| <p><b>Dimensions :</b></p>   | <p>370x 370 x 370 mm</p>  |   |

**5.2 E-Field Probe System**

**E-Field Probe Specification  
<ER3DV6>**

|                      |  |
|----------------------|--|
| <b>Construction</b>  | One dipole parallel, two dipoles normal to probe axis Built-in shielding against static charges                              |
| <b>Calibration</b>   | In air from 100 MHz to 3.0 GHz (absolute accuracy $\pm 6.0\%$ , $k=2$ )  |
| <b>Frequency</b>     | 100 MHz to 6 GHz; Linearity: $\pm 2.0$ dB (100 MHz to 3 GHz)   |
| <b>Directivity</b>   | $\pm 0.2$ dB in air (rotation around probe axis)<br>$\pm 0.4$ dB in air (rotation normal to probe axis)                      |
| <b>Dynamic Range</b> | 2 V/m to 1000 V/m (M3 or better device readings fall well below diode compression point)                                     |
| <b>Linearity</b>     | $\pm 0.2$ dB   |
| <b>Dimensions</b>    | Overall length: 330 mm (Tip: 16 mm)<br>Tip diameter: 8 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.5 mm |



**Fig 5.2 Photo of E-field Probe**

**Probe Tip Description:**

HAC field measurements take place in the close near field with high gradients. Increasing the measuring distance from the source will generally decrease the measured field values (in case of the validation dipole approx. 10% per mm).

**5.3 System Hardware**

**DAE**

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit.

**Robot**

The SPEAG DASY system uses the high precision robots (DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used.

**5.4 Data Storage and Evaluation**

The DASY software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, and device frequency and modulation data) in measurement files.

|                            |                           |   |
|----------------------------|---------------------------|---|
| <b>Probe parameters :</b>  | - Sensitivity             | Norm <sub>i</sub> , a <sub>i0</sub> , a <sub>i1</sub> , a <sub>i2</sub> |
|                            | - Conversion factor       | ConvF <sub>i</sub>  |
|                            | - Diode compression point | dcp <sub>i</sub>  |
| <b>Device parameters :</b> | - Frequency               | f   |
|                            | - Crest factor            | cf  |
| <b>Media parameters :</b>  | - Conductivity            | σ   |
|                            | - Density                 | ρ   |

The formula for each channel can be given as :

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

- with V<sub>i</sub> = compensated signal of channel i, (i = x, y, z)
- U<sub>i</sub> = input signal of channel i, (i = x, y, z)
- cf = crest factor of exciting field (DASY parameter)
- dcp<sub>i</sub> = diode compression point (DASY parameter)

From the compensated input signals, the primary field data for each channel can be evaluated :

$$\text{E-field Probes : } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

- with V<sub>i</sub> = compensated signal of channel i, (i = x, y, z)
- Norm<sub>i</sub> = sensor sensitivity of channel i, (i = x, y, z), μV/(V/m)<sup>2</sup> for E-field Probes
- ConvF = sensitivity enhancement in solution
- f = carrier frequency [GHz]
- E<sub>i</sub> = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermitian magnitude) :

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.



5.5 Test Equipment List

| Manufacturer  | Name of Equipment            | Type/Model | Serial Number | Calibration   |               |
|---------------|------------------------------|------------|---------------|---------------|---------------|
|               |                              |            |               | Last Cal.     | Due Date      |
| SPEAG         | 1880MHz Calibration Dipole   | CD1880V3   | 1038          | Sep. 27, 2016 | Sep. 26, 2017 |
| SPEAG         | Data Acquisition Electronics | DAE3       | 577           | Sep. 28, 2016 | Sep. 27, 2017 |
| SPEAG         | Isotropic E-Field Probe      | ER3DV6     | 2358          | Jan. 19, 2017 | Jan. 18, 2018 |
| Wisewind      | Thermometer                  | HTC-1      | TM225         | Oct. 12, 2016 | Oct. 11, 2017 |
| SPEAG         | Test Arch Phantom            | N/A        | N/A           | NCR           | NCR           |
| SPEAG         | Phone Positoiner             | N/A        | N/A           | NCR           | NCR           |
| Anritsu       | Power Meter                  | ML2495A    | 1419002       | May. 10, 2016 | May. 09, 2017 |
| Anritsu       | Power Sensor                 | MA2411B    | 1339124       | May. 10, 2016 | May. 09, 2017 |
| Anritsu       | Signal Generator             | MG3710A    | 6201502524    | Dec. 09, 2016 | Dec. 08, 2017 |
| R&S           | Base Station                 | CMU200     | 117997        | Aug. 19, 2016 | Aug. 18, 2017 |
| R&S           | Base Station                 | CMW500     | 149637        | Jul. 27, 2016 | Jul. 26, 2017 |
| ATM           | Dual Directional Coupler     | C122H-10   | P610410z-02   | NCR           | NCR           |
| Woken         | Attenuator                   | WK0602-XX  | N/A           | NCR           | NCR           |
| Mini-Circuits | Power Amplifier              | ZVE-8G+    | D120604       | Mar. 09, 2017 | Mar. 08, 2018 |
| Mini-Circuits | Power Amplifier              | ZHL-42W+   | QA1344002     | Mar. 09, 2017 | Mar. 08, 2018 |
| Anritsu       | Spectrum Analyzer            | MS2830A    | 6201396378    | Jun. 21, 2016 | Jun. 20, 2017 |

Table 5.1 Test Equipment List

Note:

- 1. NCR: "No-Calibration Required"

## 6. Measurement System Validation

Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the test Arch and a corresponding distance holder.

### 6.1 Purpose of System Performance Check

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal HAC measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

### 6.2 System Setup

1. In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave which comes from a signal generator.
2. The center point of the probe element(s) is 15mm from the closest surface of the dipole elements.
3. The calibrated dipole must be placed beneath the arch phantom. The equipment setup is shown below:

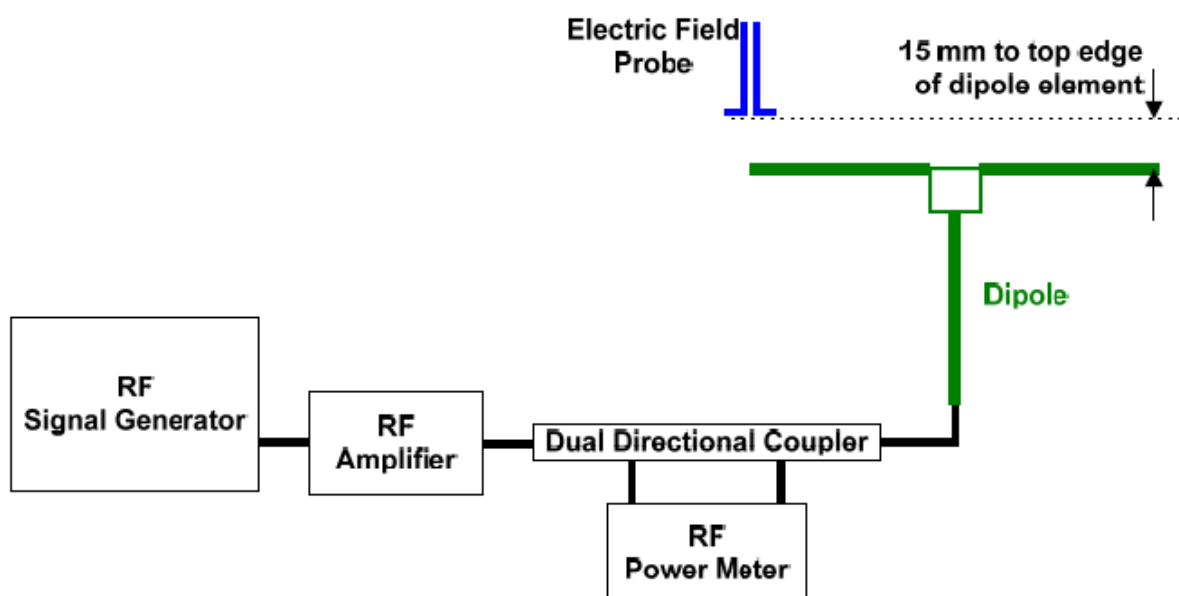
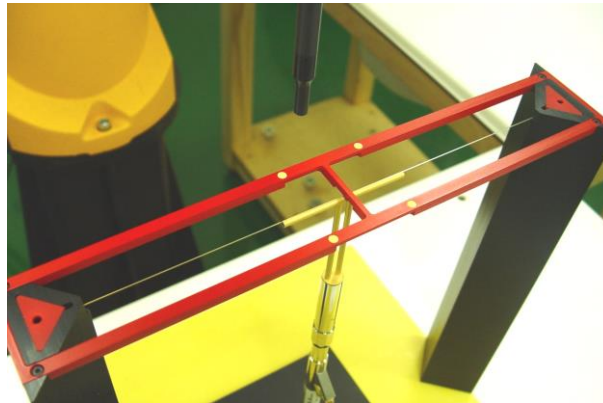


Fig. 6.1 System Validation Setup

The output power on dipole port must be calibrated to 20dBm (100mW) before dipole is connected.



**Fig 7.2 Dipole Setup**

**6.3 Verification Results**

Comparing to the original E-field value provided by SPEAG, the verification data should be within its specification of 25 %. Table 6.1 shows the target value and measured value. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to appendix A of this report.

| Frequency (MHz) | Input Power (dBm) | Target Value (V/m) | E-Field above high end (V/m) | E-Field above low end (V/m) | Average Value (V/m) | Deviation (%) | Date     |
|-----------------|-------------------|--------------------|------------------------------|-----------------------------|---------------------|---------------|----------|
| 1880            | 20                | 89.8               | 90.66                        | 96.24                       | 93.45               | 4.06          | 2017/5/8 |

**Table 6.1 Test Results of System Validation**

**Note: Deviation = ((Average E-field Value) - (Target value)) / (Target value) \* 100%**



## 7. RF Emissions Test Procedure

Referenced from ANSI C63.19 -2011 section 5.5.1

- a) Confirm the proper operation of the field probe, probe measurement system, and other instrumentation and the positioning system.
- b) Position the WD in its intended test position.
- c) Set the WD to transmit a fixed and repeatable combination of signal power and modulation characteristic that is representative of the worst case (highest interference potential) encountered in normal use. Transiently occurring start-up, changeover, or termination conditions, or other operations likely to occur less than 1% of the time during normal operation, may be excluded from consideration.
- d) The center sub-grid shall be centered on the T-Coil mode perpendicular measurement point or the acoustic output, as appropriate. Locate the field probe at the initial test position in the 50 mm by 50 mm grid, which is contained in the measurement plane, refer to illustrated in Figure 8.2. If the field alignment method is used, align the probe for maximum field reception.
- e) Record the reading at the output of the measurement system.
- f) Scan the entire 50 mm by 50 mm region in equality spaced increments and record the reading at each measurement point, The distance between measurement points shall be sufficient to assure the identification of the maximum reading.
- g) Identify the five contiguous sub-grids around the center sub-grid whose maximum reading is the lowest of all available choices. This eliminates the three sub-grids with the maximum readings. Thus, the six areas to be used to determine the WD's highest emissions are identified.
- h) Identify the maximum reading within the non-excluded sub-grids identified in step g).
- i) *Indirect measurement method*  
The RF audio interference level in dB (V/m) is obtained by adding the MIF (in dB) to the maximum steady-state rms field-strength reading, in dB (V/m)
- j) Compare this RF audio interference level with the categories in ANSI C63.19-2011 clause 8 and record the resulting WD category rating.
- k) For the T-Coil perpendicular measurement location is  $\geq 5.0$  mm from the center of the acoustic output, then two different 50 mm by 50 mm areas may need to be scanned, the first for the microphone mode assessment and the second for the T-Coil assessment.
- l) The second for the T-Coil assessment, with the grid shifted so that it is centered on the perpendicular measurement point. Record the WD category rating.

### Test Instructions

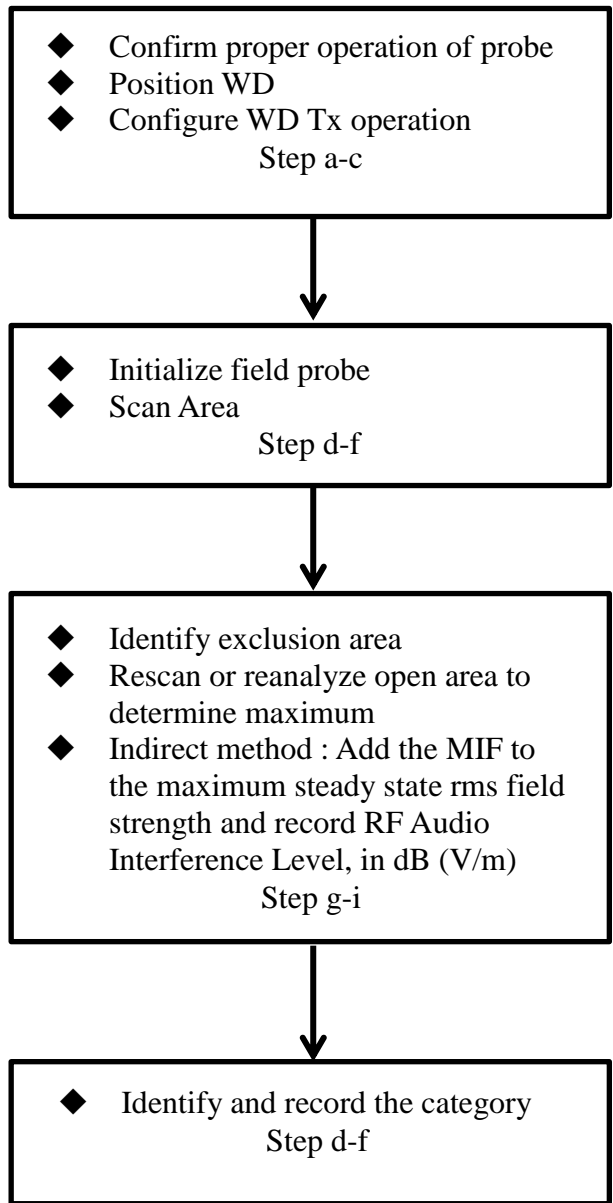


Fig 8.1 Flow Chart of HAC RF Emission



Fig 8.2 EUT reference and plane for HAC RF emission measurements

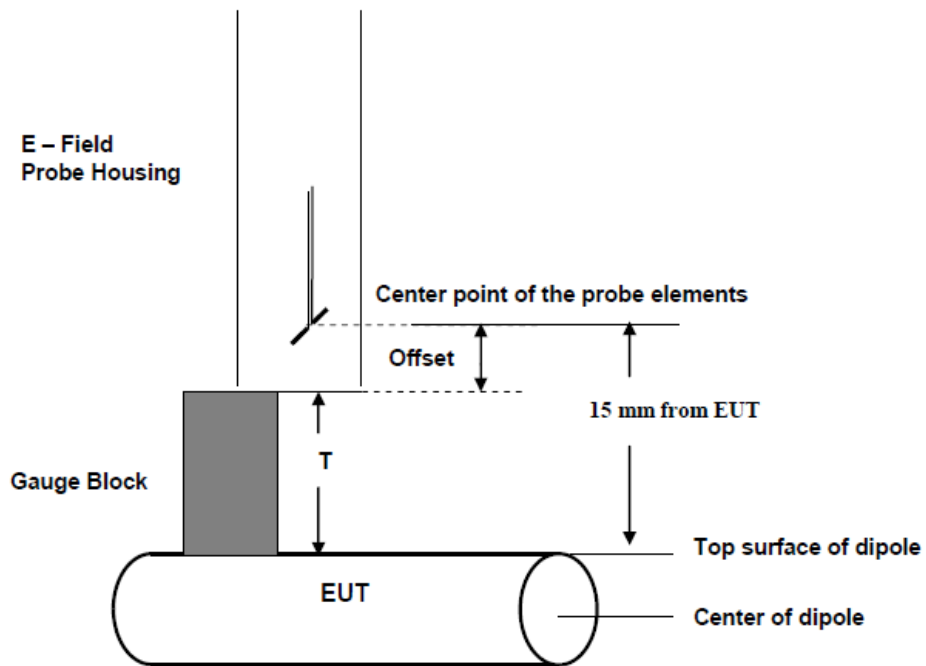


Fig. 8.3 Gauge block with E-field probe



### 8. Conducted RF Output Power (Unit: dBm)

| Average Antenna Input Power(dBm) |         |        |        |
|----------------------------------|---------|--------|--------|
| Band                             | GSM1900 |        |        |
| Channel                          | 512     | 661    | 810    |
| Frequency (MHz)                  | 1850.2  | 1880.0 | 1909.8 |
| GSM (GMSK, 1 Tx slot)            | 29.03   | 29.20  | 29.18  |

### 9. HAC RF Emission Test Results

| Plot No. | Air Interface | Mode      | Channel | Scan center | Average Antenna Input Power (dBm) | MIF  | E-Field (dBV/m) | Margin to FCC M3 limit (dB) | E-Field M Rating |
|----------|---------------|-----------|---------|-------------|-----------------------------------|------|-----------------|-----------------------------|------------------|
| 01       | GSM1900       | GSM Voice | 512     | Acoustic    | 29.03                             | 3.63 | 30.45           | 4.55                        | M3               |

**Remark:**

1. According to KDB 648474 D03v01r04, the handset must be evaluated with both the normal and wireless charging battery cover, for RF emissions is selected worst HAC rating with the worst configuration found in original report (FCC ID: IHDT56WA1, Sporton Report No. HA720310A) to determine the RF Emissions compliance and the worst case is GSM1900.
2. The HAC measurement system applies MIF value onto the measured RMS E-field, which is indirect method in ANSI C63.19 2011 version, and reports the RF audio interference level.
3. The uncertainty is 0.2dB of MIF ranges from -7dB to +5dB. GSM1900 band with rating M3 would not be affected considering the MIF uncertainty.
4. There is special HAC mode software on this EUT.

Test Engineer : Kurt Liu



## **10. Uncertainty Assessment**

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual “root-sum-squares” (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances. Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 12.1.



| Error Description                         | Uncertainty Value (±%) | Probability Distribution | Divisor | Ci (E) | Standard Uncertainty (E) |
|---|------------------------|--------------------------|---------|--------|--------------------------|
| <b>Measurement System</b>                 |                        |                          |         |        |                          |
| Probe Calibration                         | 5.1                    | Normal                   | 1       | 1      | ± 5.1 %                  |
| Axial Isotropy                            | 4.7                    | Rectangular              | √3      | 1      | ± 2.7 %                  |
| Sensor Displacement                       | 16.5                   | Rectangular              | √3      | 1      | ± 9.5 %                  |
| Boundary Effects                          | 2.4                    | Rectangular              | √3      | 1      | ± 1.4 %                  |
| Phantom Boundary Effects                  | 7.2                    | Rectangular              | √3      | 1      | ± 4.1 %                  |
| Linearity                                 | 4.7                    | Rectangular              | √3      | 1      | ± 2.7 %                  |
| Scaling with PMR Calibration              | 10.0                   | Rectangular              | √3      | 1      | ± 5.77 %                 |
| System Detection Limit                    | 1.0                    | Rectangular              | √3      | 1      | ± 0.6 %                  |
| Readout Electronics                       | 0.3                    | Normal                   | 1       | 1      | ± 0.3 %                  |
| Response Time                             | 0.8                    | Rectangular              | √3      | 1      | ± 0.5 %                  |
| Integration Time                          | 2.6                    | Rectangular              | √3      | 1      | ± 1.5 %                  |
| RF Ambient Conditions                     | 3.0                    | Rectangular              | √3      | 1      | ± 1.7 %                  |
| RF Reflections                            | 12.0                   | Rectangular              | √3      | 1      | ± 6.9 %                  |
| Probe Positioner                          | 1.2                    | Rectangular              | √3      | 1      | ± 0.7 %                  |
| Probe Positioning                         | 4.7                    | Rectangular              | √3      | 1      | ± 2.7 %                  |
| Extrap. and Interpolation                 | 1.0                    | Rectangular              | √3      | 1      | ± 0.6 %                  |
| <b>Test Sample Related</b>                |                        |                          |         |        |                          |
| Device Positioning Vertical               | 4.7                    | Rectangular              | √3      | 1      | ± 2.7 %                  |
| Device Positioning Lateral                | 1.0                    | Rectangular              | √3      | 1      | ± 0.6 %                  |
| Device Holder and Phantom                 | 2.4                    | Rectangular              | √3      | 1      | ± 1.4 %                  |
| Power Drift                               | 5.0                    | Rectangular              | √3      | 1      | ± 2.9 %                  |
| <b>Phantom and Setup Related</b>          |                        |                          |         |        |                          |
| Phantom Thickness                         | 2.4                    | Rectangular              | √3      | 1      | ± 1.4 %                  |
| <b>Combined Standard Uncertainty</b>      |                        |                          |         |        | ± 16.30 %                |
| <b>Coverage Factor for 95 %</b>           |                        |                          |         |        | K = 2                    |
| <b>Expanded Std. Uncertainty on Power</b> |                        |                          |         |        | ± 32.6 %                 |
| <b>Expanded Std. Uncertainty on Field</b> |                        |                          |         |        | ± 16.3 %                 |

**Table 12.1 Uncertainty Budget of HAC free field assessment**

**Remark:**

Worst-Case uncertainty budget for HAC free field assessment according to ANSIC63.19 [1], [2]. The budget is valid for the frequency range 700 MHz - 3 GHz and represents a worst case analysis.



## **11. References**

- [1] ANSI C63.19-2011, "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", 27 May 2011.
- [2] FCC KDB 285076 D01v04r01, "Equipment Authorization Guidance for Hearing Aid Compatibility", Apr 2016
- [3] FCC KDB 285076 D02v02, "Guidance for Performing T-Coil tests for Air Interfaces Supporting Voice over IP", Apr 2016
- [4] FCC KDB 648474 D03 v01r04, "Evaluation and Approval Considerations for Handsets with Specific Wireless Charging Battery Covers" Dec 2015
- [5] SPEAG DASY System Handbook