

# HEARING AID COMPATIBILITY RF EMISSIONS TEST REPORT

FCC ID : MSQZ01QD  
Equipment : ASUS Phone (Mobile Phone)  
Brand Name : ASUS  
Model Name : ASUS\_Z01QD  
M-Rating : M4  
Applicant : ASUSTeK COMPUTER INC.  
4F, No. 150, LI-TE RD., PEITOU, TAIPEI, TAIWAN  
Manufacturer : Arima Communications (Jiangsu) Co., LTD  
No.168,Jiao Tong North Road,Wu Jiang, Su  
Zhou,Jiang Su,PRC.  
Standard : FCC 47 CFR §20.19  
ANSI C63.19-2011

The product was received on Jun. 21, 2018 and testing was started from Jul. 09, 2018 and completed on Jul. 09, 2018. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.

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



Approved by: Jones Tsai / Manager

**SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory**  
No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)



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## History of this test report

| Report No. | Version | Description             | Issued Date   |
|------------|---------|-------------------------|---------------|
| HA852405A  | Rev. 01 | Initial issue of report | Jul. 24, 2018 |
|            |         |                         |               |
|            |         |                         |               |

**1. General Information**

| Product Feature & Specification |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Applicant Name                  | ASUSTeK COMPUTER INC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Equipment Name                  | ASUS Phone (Mobile Phone)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Brand Name                      | ASUS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Model Name                      | ASUS_Z01QD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| FCC ID                          | MSQZ01QD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| HW Version                      | R2.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| EUT Stage                       | Identical Prototype                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Date Tested                     | 2018/7/9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 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>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 26: 814.7 MHz ~ 848.3 MHz<br>LTE Band 38: 2572.5 MHz ~ 2617.5 MHz<br>LTE Band 41: 2498.5 MHz ~ 2687.5 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 ~ 5700 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>LTE: QPSK, 16QAM<br>802.11a/b/g/n/ac HT20/HT40/VHT20/VHT40/VHT80<br>Bluetooth BR/EDR/LE<br>NFC:ASK                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

**Reviewed by: Eric Huang****Report Producer: Wan Liu**



## **2. Testing Location**

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 1190) and the FCC designation No. TW1190 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC test.

| Testing Laboratory |                                                                                                                     |
|--------------------|---------------------------------------------------------------------------------------------------------------------|
| Test Site          | SPORTON INTERNATIONAL INC.                                                                                          |
| Test Site Location | No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)<br>TEL: +886-3-327-3456<br>FAX: +886-3-328-4978 |
| Test Site No.      | Sporton Site No.:<br><b>SAR04-HY</b>                                                                                |

## **3. Applied Standards**

- FCC CFR47 Part 20.19
- ANSI C63.19-2011
- FCC KDB 285076 D01 HAC Guidance v05
- FCC KDB 285076 D02 T Coil testing v03
- FCC KDB 285076 D03 HAC FAQ v01

## **4. RF Audio Interference Level**

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 5.1 Telephone near-field categories in linear units**



## 5. Air Interface and Operating Mode

| Air Interface | Band MHz | Type | C63.19 Tested     | Simultaneous Transmitter | Name of Voice Service                                 | Power Reduction |
|---------------|----------|------|-------------------|--------------------------|-------------------------------------------------------|-----------------|
| GSM           | GSM850   | VO   | Yes               | WLAN, BT                 | CMRS Voice                                            | No              |
|               | GSM1900  |      |                   | WLAN, BT                 |                                                       | No              |
|               | EDGE850  | VD   | Yes               | WLAN, BT                 | SIP Calling <sup>(2)</sup><br>/ Google Duo            | No              |
|               | EDGE1900 |      |                   | WLAN, BT                 |                                                       |                 |
| WCDMA         | 850      | VO   | No <sup>(1)</sup> | WLAN, BT                 | CMRS Voice                                            | No              |
|               | 1750     |      |                   | WLAN, BT                 |                                                       | No              |
|               | 1900     |      |                   | WLAN, BT                 |                                                       | No              |
|               | HSPA     | VD   | No <sup>(1)</sup> | WLAN, BT                 | SIP Calling <sup>(2)</sup><br>/ Google Duo            | No              |
| LTE (FDD)     | Band 2   | VD   | No <sup>(1)</sup> | WLAN, BT                 | VoLTE<br>/ SIP Calling <sup>(2)</sup><br>/ Google Duo | 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 26  |      |                   | WLAN, BT                 |                                                       | No              |
| LTE (TDD)     | Band 38  | VD   | Yes               | WLAN, BT                 | VoLTE<br>/ SIP Calling <sup>(2)</sup><br>/ Google Duo | No              |
|               | Band 41  |      |                   | WLAN, BT                 |                                                       | No              |
| Wi-Fi         | 2450     | VD   | No <sup>(1)</sup> | GSM,WCDMA,LTE            | SIP Calling <sup>(2)</sup><br>/ Google Duo            | Yes             |
|               | 5200     |      |                   | GSM,WCDMA,LTE            |                                                       | No              |
|               | 5300     |      |                   | GSM,WCDMA,LTE            |                                                       | No              |
|               | 5500     |      |                   | GSM,WCDMA,LTE            |                                                       | No              |
|               | 5800     |      |                   | GSM,WCDMA,LTE            |                                                       | No              |
| BT            | 2450     | DT   | No                | GSM,WCDMA,LTE            | NA                                                    | No              |

**Type Transport:**

VO= Voice only

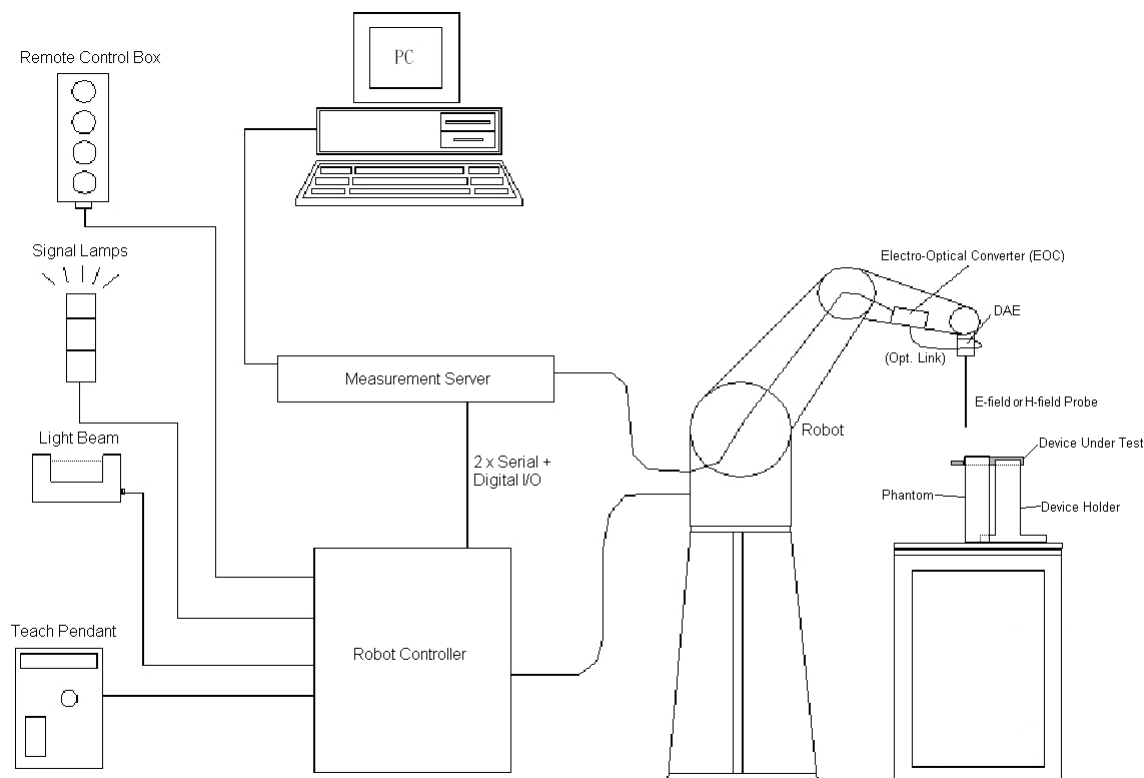
DT= Digital Transport only (no voice)

VD= CMRS and IP Voice Service over Digital Transport

**Remark:**

- The air interface is exempted from testing by low power exemption that its average antenna input power plus its MIF is  $\leq 17$  dBm, and is rated as M4.
- The SIP calling is android internal auxiliary functions under the dialing program.
- The device have similar frequency in some LTE bands: 38/41, since the supported frequency spans for the smaller LTE bands are completely covered by the larger LTE bands, therefore, only larger LTE bands were required to be tested for hearing-aid compliance.

## 6. Measurement System Specification



**Fig 5.1 System Configurations**

### 6.1 E-Field Probe System

#### E-Field Probe Specification

<ER3DV6>

|                      |                                                                                                                              |
|----------------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>Construction</b>  | One dipole parallel, two dipoles normal to probe axis<br>Built-in shielding against static charges                           |
| <b>Calibration</b>   | In air from 100 MHz to 3.0 GHz<br>(absolute accuracy $\pm 6.0\%$ , $k=2$ )                                                   |
| <b>Frequency</b>     | 100 MHz to 6 GHz;<br>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<br>(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).

## **6.2 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  $V_i$  = compensated signal of channel i, (i = x, y, z)  
 $U_i$  = 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  $V_i$  = compensated signal of channel i, (i = x, y, z)  
 Norm<sub>i</sub> = sensor sensitivity of channel i, (i = x, y, z),  $\mu\text{V}/(\text{V/m})^2$  for E-field Probes  
 ConvF = sensitivity enhancement in solution  
 f = carrier frequency [GHz]  
 $E_i$  = electric field strength of channel i in V/m

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

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

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



## **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
- j. 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)
- k. Compare this RF audio interference level with the categories in ANSI C63.19-2011 clause 8 and record the resulting WD category rating.
- l. 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.
- m. 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

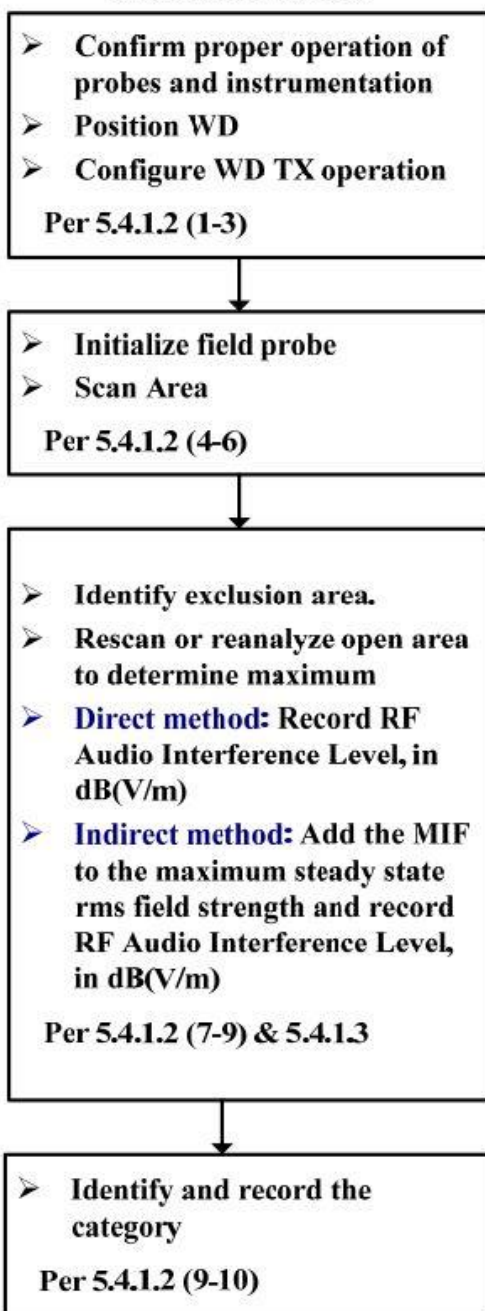
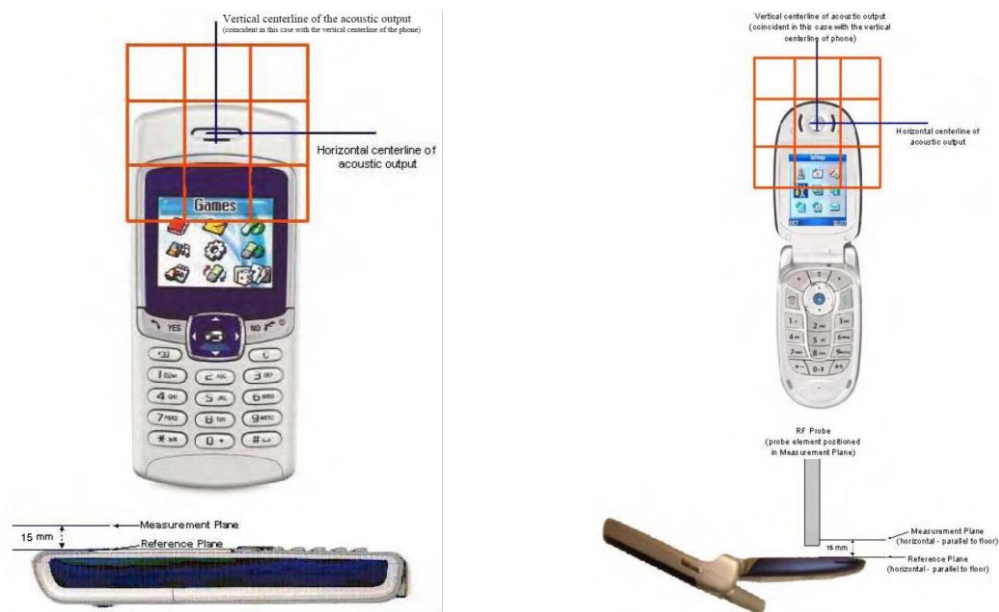
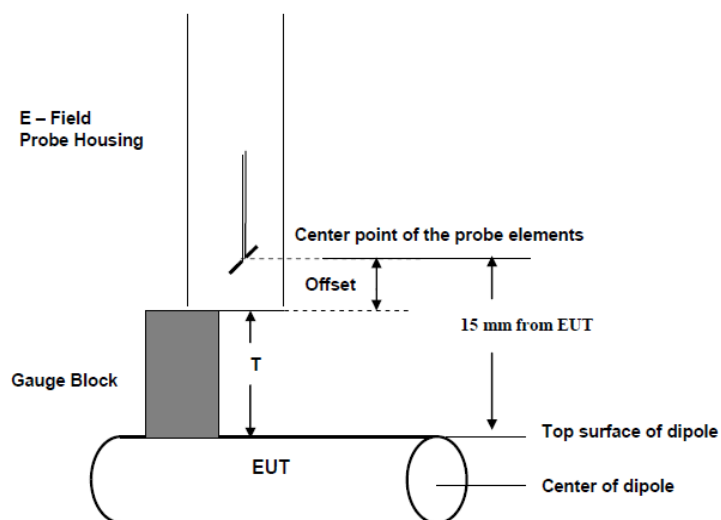


Figure 8.1 RF Emissions Flow Chart



**Fig 8.2 EUT reference and plane for HAC RF emission measurements**



**Fig. 8.3 Gauge block with E-field probe**

**8. Test Equipment List**

| Manufacturer  | Name of Equipment            | Type/Model | Serial Number | Calibration   |               |
|---------------|------------------------------|------------|---------------|---------------|---------------|
|               |                              |            |               | Last Cal.     | Due Date      |
| SPEAG         | 835MHz Calibration Dipole    | CD835V3    | 1045          | Sep. 27, 2017 | Sep. 26, 2018 |
| SPEAG         | 1880MHz Calibration Dipole   | CD1880V3   | 1038          | Sep. 27, 2017 | Sep. 26, 2018 |
| SPEAG         | 2600Mhz Calibration Dipole   | CD2600V3   | 1010          | Nov. 22, 2017 | Nov. 21, 2018 |
| SPEAG         | Data Acquisition Electronics | DAE4       | 1399          | Nov. 16, 2017 | Nov. 15, 2018 |
| SPEAG         | Isotropic E-Field Probe      | ER3DV6     | 2358          | Jan. 19, 2018 | Jan. 18, 2019 |
| Gencom        | Thermometer                  | TE1        | TM685-1       | Mar. 16, 2018 | Mar. 15, 2019 |
| 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. 18, 2018 | May. 19, 2019 |
| Anritsu       | Power Sensor                 | MA2411B    | 1339124       | May. 18, 2018 | May. 19, 2019 |
| Anritsu       | Signal Generator             | MG3710A    | 6201502524    | Dec. 07, 2017 | Dec. 06, 2018 |
| R&S           | Base Station                 | CMW500     | 149637        | Jul. 26, 2017 | Jul. 25, 2018 |
| 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. 12, 2018 | Mar. 11, 2019 |
| Mini-Circuits | Power Amplifier              | ZHL-42W+   | QA1344002     | Mar. 12, 2018 | Mar. 11, 2019 |

**Note:**

1. NCR: "No-Calibration Required"

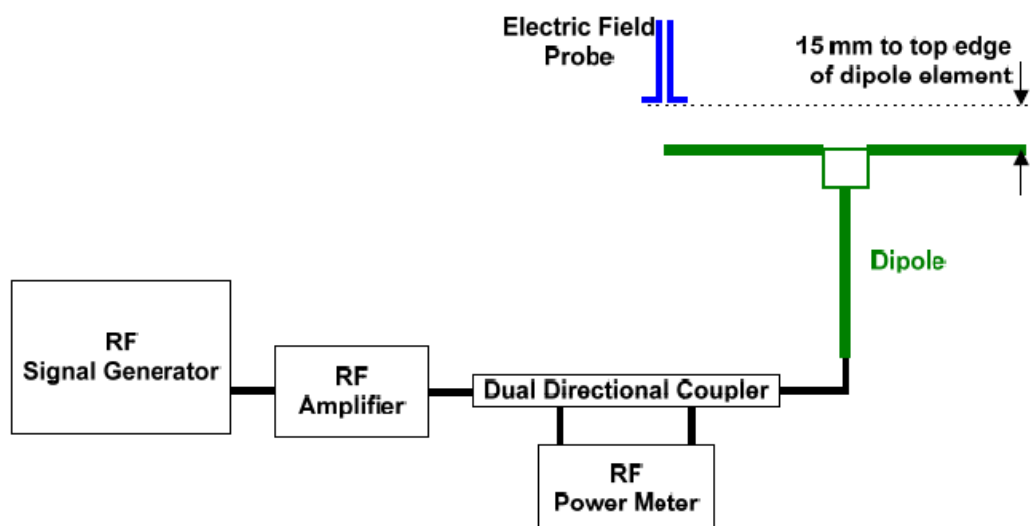
## 9. Measurement System Validation

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.

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.

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



**Fig. 7.1 Setup Diagram**

### <Validation 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.

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

| 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         |
|-----------------|-------------------|--------------------|------------------------------|-----------------------------|---------------------|---------------|--------------|
| 835             | 20                | 106.8              | 109.8                        | 112.5                       | 111.15              | 4.07          | Jul 09, 2018 |
| 1880            | 20                | 96                 | 88.89                        | 94.67                       | 91.78               | -4.40         | Jul 09, 2018 |
| 2600            | 20                | 85.4               | 87.99                        | 96.49                       | 92.24               | 8.01          | Jul 09, 2018 |

## 10. Modulation Interference Factor

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

The Modulation Interference factor (MIF, in dB) is added to the measured average E-field (in dBV/m) and converts it to the RF Audio Interference level (in dBV/m). This level considers the audible amplitude modulation components in the RF E-field. CW fields without amplitude modulation are assumed to not interfere with the hearing aid electronics. Modulations without time slots and low fluctuations at low frequencies have low MIF values, TDMA modulations with narrow transmission and repetition rates of few 100 Hz have high MIF values and give similar classifications as ANSI C63.19-2011.

ER3D, EF3D and EU2D E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the indirect measurement method according to ANSI C63.19-2011 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by PMR calibration in order to not overestimate the field reading. Probe Modulation Response (PMR) calibration linearizes the probe response over its dynamic range for specific modulations which are characterized by their UID and result in an uncertainty specified in the probe calibration certificate. The MIF is characteristic for a given waveform envelope and can be used as a constant conversion factor if the probe has been PMR calibrated.

The evaluation method for the MIF is defined in ANSI C63.19-2011 section D.7. An RMS demodulated RF signal is fed to a spectral filter (similar to an A weighting filter) and forwarded to a temporal filter acting as a quasi-peak detector. The averaged output of these filtering is scaled to a 1 kHz 80% AM signal as reference. MIF measurement requires additional instrumentation and is not well suited for evaluation by the end user with reasonable uncertainty. It may alternatively be determined through analysis and simulation, because it is constant and characteristic for a communication signal. DASY52 uses well-defined signals for PMR calibration. The MIF of these signals has been determined by simulation and it is automatically applied.

The MIF measurement uncertainty is estimated as follows, declared by HAC equipment provider SPEAG, for modulation frequencies from slotted waveforms with fundamental frequency and at least 2 harmonics within 10 kHz:

1. 0.2 dB for MIF: -7 to +5 dB
2. 0.5 dB for MIF: -13 to +11 dB
3. 1 dB for MIF: > -20 dB

MIF values applied in this test report were provided by the HAC equipment provider of SPEAG, and the worst values for all air interface are listed below to determine the Low-power Exemption.

| UID   | Communication System Name                         | MIF(dB) |
|-------|---------------------------------------------------|---------|
| 10021 | GSM-FDD(TDMA,GMSK)                                | 3.63    |
| 10025 | EDGE-FDD (TDMA, 8PSK, TN 0)                       | 3.75    |
| 10460 | UMTS-FDD(WCDMA, AMR)                              | -25.43  |
| 10225 | UMTS-FDD (HSPA+)                                  | -20.39  |
| 10170 | LTE-FDD(SC-FDMA,1RB,20MHz,16-QAM)                 | -9.76   |
| 10172 | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)             | -1.62   |
| 10173 | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)           | -1.44   |
| 10174 | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM)           | -1.54   |
| 10061 | IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)         | -2.02   |
| 10077 | IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)    | 0.12    |
| 10427 | IEEE 802.11n (HT Greenfield, 150 Mbps, 64-QAM)    | -13.44  |
| 10069 | IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps)         | -3.15   |
| 10616 | IEEE 802.11ac WiFi (40MHz, MCS0, 90pc duty cycle) | -5.57   |

## 11. Low-power Exemption

<Max Tune-up Limit>

| Frequency Band   |              | Max Power (dBm) |      |
|------------------|--------------|-----------------|------|
| Transmit Antenna |              | UAT             | LAT  |
| GSM              | GSM850       |                 | 33.0 |
|                  | EDGE850      |                 | 27.0 |
|                  | GSM1900      |                 | 30.0 |
|                  | EDGE1900     |                 | 25.0 |
| WCDMA            | Band II      |                 | 24.5 |
|                  | Band IV      |                 | 24.5 |
|                  | Band V       | 24.0            | 24.0 |
|                  | HSPA         | 24.0            | 24.0 |
| FDD LTE          | Band 2       |                 | 24.5 |
|                  | Band 4       |                 | 24.5 |
|                  | Band 5 / 26  | 24.5            | 24.5 |
|                  | Band 7       |                 | 21.5 |
|                  | Band 12 / 17 | 24.5            | 24.5 |
| FDD LTE          | Band 41      | Band 13         | 24.5 |
|                  |              | QPSK            | 24.5 |
|                  |              | 16QAM           | 23.5 |
|                  |              | 64QAM           | 22.5 |

| Frequency Band       |                | Max Power (dBm) |
|----------------------|----------------|-----------------|
| 2.4GHz WLAN<br>Ant 1 | 802.11b        | 14.0            |
|                      | 802.11g        | 14.0            |
|                      | 802.11n-HT20   | 14.0            |
| 2.4GHz WLAN<br>Ant 2 | 802.11b        | 14.0            |
|                      | 802.11g        | 14.0            |
|                      | 802.11n-HT20   | 14.0            |
| 5GHz WLAN<br>Ant 1   | 802.11a        | 18.0            |
|                      | 802.11n-HT20   | 18.0            |
|                      | 802.11n-HT40   | 18.0            |
|                      | 802.11ac-VHT20 | 18.0            |
|                      | 802.11ac-VHT40 | 18.0            |
|                      | 802.11ac-VHT80 | 15.0            |
| 5GHz WLAN<br>Ant 2   | 802.11a        | 18.0            |
|                      | 802.11n-HT20   | 18.0            |
|                      | 802.11n-HT40   | 18.0            |
|                      | 802.11ac-VHT20 | 18.0            |
|                      | 802.11ac-VHT40 | 18.0            |
|                      | 802.11ac-VHT80 | 15.0            |



## <Low Power Exemption>

| Transmit Antenna  | Air Interface  |       | Max Average Antenna Input Power (dBm) | Worst Case MIF (dB) | Power + MIF(dB) | C63.19 test required |
|-------------------|----------------|-------|---------------------------------------|---------------------|-----------------|----------------------|
| WWNA UAT          | WCDMA          |       | 22.0                                  | -25.43              | -3.43           | No                   |
|                   | WCDMA - HSPA   |       | 21.5                                  | -20.39              | 1.11            | No                   |
|                   | LTE - FDD      |       | 24.5                                  | -9.76               | 14.74           | No                   |
| WWAN LAT          | GSM850         |       | 33.0                                  | 3.63                | 36.63           | Yes                  |
|                   | EDGE850        |       | 27.0                                  | 3.75                | 30.75           | Yes <sup>(1)</sup>   |
|                   | GSM1900        |       | 30.0                                  | 3.63                | 33.63           | Yes                  |
|                   | EDGE1900       |       | 25.0                                  | 3.75                | 28.75           | Yes <sup>(1)</sup>   |
|                   | WCDMA          |       | 24.5                                  | -25.43              | -0.93           | No                   |
|                   | WCDMA - HSPA   |       | 24.0                                  | -20.39              | 3.61            | No                   |
|                   | LTE - FDD      |       | 24.5                                  | -9.76               | 14.74           | No                   |
|                   | LTE – TDD      | QPSK  | 24.5                                  | -1.62               | 22.88           | Yes                  |
|                   |                | 16QAM | 23.5                                  | -1.44               | 22.06           | Yes <sup>(1)</sup>   |
|                   |                | 64QAM | 22.5                                  | -1.54               | 20.96           | Yes <sup>(1)</sup>   |
| 2.4GHz WLAN Ant 1 | 802.11b        |       | 14.0                                  | -2.02               | 11.98           | No                   |
|                   | 802.11g        |       | 14.0                                  | 0.12                | 14.12           | No                   |
|                   | 802.11n-HT20   |       | 14.0                                  | -13.44              | 0.56            | No                   |
| 2.4GHz WLAN Ant 2 | 802.11b        |       | 14.0                                  | -2.02               | 11.98           | No                   |
|                   | 802.11g        |       | 14.0                                  | 0.12                | 14.12           | No                   |
|                   | 802.11n-HT20   |       | 14.0                                  | -13.44              | 0.56            | No                   |
| 5GHz WLAN Ant 1   | 802.11a        |       | 18.0                                  | -3.15               | 14.85           | No                   |
|                   | 802.11n-HT20   |       | 18.0                                  | -13.44              | 4.56            | No                   |
|                   | 802.11n-HT40   |       | 18.0                                  | -13.44              | 4.56            | No                   |
|                   | 802.11ac-VHT20 |       | 18.0                                  | -5.57               | 12.43           | No                   |
|                   | 802.11ac-VHT40 |       | 18.0                                  | -5.57               | 12.43           | No                   |
|                   | 802.11ac-VHT80 |       | 15.0                                  | -5.57               | 9.43            | No                   |
|                   | 802.11a        |       | 18.0                                  | -3.15               | 14.85           | No                   |
| 5GHz WLAN Ant 2   | 802.11n-HT20   |       | 18.0                                  | -13.44              | 4.56            | No                   |
|                   | 802.11n-HT40   |       | 18.0                                  | -13.44              | 4.56            | No                   |
|                   | 802.11ac-VHT20 |       | 18.0                                  | -5.57               | 12.43           | No                   |
|                   | 802.11ac-VHT40 |       | 18.0                                  | -5.57               | 12.43           | No                   |
|                   | 802.11ac-VHT80 |       | 15.0                                  | -5.57               | 9.43            | No                   |

### General Note:

- EDGE data modes and TDD 16QAM/64QAM is not necessary due the GSM Voice mode and TDD QPSK is the worst case.
- According to ANSI C63.19 2011-version, for the air interface technology of a device is exempt from testing when its average antenna input power plus its MIF is  $\leq 17$  dBm for any of its operating modes.
- HAC RF rating is M4 for the air interface which meets the low power exemption.

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

| Average Antenna Input Power(dBm) |        |       |       |         |        |        |
|----------------------------------|--------|-------|-------|---------|--------|--------|
| Band                             | GSM850 |       |       | GSM1900 |        |        |
| Channel                          | 128    | 189   | 251   | 512     | 661    | 810    |
| Frequency (MHz)                  | 824.2  | 836.4 | 848.8 | 1850.2  | 1880.0 | 1909.8 |
| GSM (GMSK, 1 Tx slot)            | 32.51  | 32.71 | 32.60 | 29.40   | 29.54  | 29.67  |

### <TDD LTE Band 41>

| BW [MHz]        | Modulation | RB Size | RB Offset | Power Low Ch. / Freq. | Power Low Middle Ch. / Freq. | Power Middle Ch. / Freq. | Power High Middle Ch. / Freq. | Power High Ch. / Freq. |
|-----------------|------------|---------|-----------|-----------------------|------------------------------|--------------------------|-------------------------------|------------------------|
| Channel         |            |         |           | 39750                 | 40185                        | 40620                    | 41055                         | 41490                  |
| Frequency (MHz) |            |         |           | 2506                  | 2549.5                       | 2593                     | 2636.5                        | 2680                   |
| 20              | QPSK       | 1       | 0         | 23.72                 | 24.15                        | 24.26                    | 24.32                         | 24.33                  |
| 20              | QPSK       | 1       | 49        | 23.42                 | 23.75                        | 23.81                    | 24.08                         | 24.23                  |
| 20              | QPSK       | 1       | 99        | 23.41                 | 23.73                        | 23.78                    | 24.02                         | 23.26                  |
| 20              | QPSK       | 50      | 0         | 22.51                 | 22.92                        | 22.99                    | 23.09                         | 23.38                  |
| 20              | QPSK       | 50      | 24        | 22.51                 | 22.96                        | 22.86                    | 23.16                         | 23.31                  |
| 20              | QPSK       | 50      | 50        | 22.45                 | 22.83                        | 22.76                    | 23.07                         | 23.01                  |
| 20              | QPSK       | 100     | 0         | 22.45                 | 22.90                        | 22.88                    | 23.03                         | 23.04                  |

**13. HAC RF Emission Test Results**

| Plot No. | Air Interface | Mode         | Channel | Sample | Transmit Ant. | Average Antenna Input Power (dBm) | MIF   | E-Field (dBV/m) | Margin to FCC M3 limit (dB) | E-Field M Rating |
|----------|---------------|--------------|---------|--------|---------------|-----------------------------------|-------|-----------------|-----------------------------|------------------|
| 1        | GSM850        | Voice        | 128     | 158    | LAT           | 32.51                             | 3.63  | 34.95           | 10.05                       | M4               |
| 2        | GSM850        | Voice        | 189     | 158    | LAT           | 32.71                             | 3.63  | 34.82           | 10.18                       | M4               |
| 3        | GSM850        | Voice        | 251     | 158    | LAT           | 32.6                              | 3.63  | 34.30           | 10.70                       | M4               |
| 4        | GSM1900       | Voice        | 512     | 156    | LAT           | 29.4                              | 3.63  | 24.54           | 10.46                       | M4               |
| 5        | GSM1900       | Voice        | 661     | 156    | LAT           | 29.54                             | 3.63  | 24.60           | 10.40                       | M4               |
| 6        | GSM1900       | Voice        | 810     | 156    | LAT           | 29.67                             | 3.63  | 25.38           | 9.62                        | M4               |
| 7        | LTE Band 41   | 20M_QPSK_1_0 | 39750   | 158    | LAT           | 23.72                             | -1.62 | 23.86           | 11.14                       | M4               |
| 8        | LTE Band 41   | 20M_QPSK_1_0 | 40185   | 158    | LAT           | 24.15                             | -1.62 | 21.90           | 13.10                       | M4               |
| 9        | LTE Band 41   | 20M_QPSK_1_0 | 40620   | 158    | LAT           | 24.26                             | -1.62 | 24.42           | 10.58                       | M4               |
| 10       | LTE Band 41   | 20M_QPSK_1_0 | 41055   | 158    | LAT           | 24.32                             | -1.62 | 21.92           | 13.08                       | M4               |
| 11       | LTE Band 41   | 20M_QPSK_1_0 | 41490   | 158    | LAT           | 24.33                             | -1.62 | 23.03           | 11.97                       | M4               |

**Remark:**

1. 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.
2. Phone Condition: Mute on; Backlight off; Max Volume

Test Engineer : Steven Chang.



## **14. 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              | $\sqrt{3}$ | 1      | ± 2.7 %                  |
| Sensor Displacement                       | 16.5                   | Rectangular              | $\sqrt{3}$ | 1      | ± 9.5 %                  |
| Boundary Effects                          | 2.4                    | Rectangular              | $\sqrt{3}$ | 1      | ± 1.4 %                  |
| Phantom Boundary Effects                  | 7.2                    | Rectangular              | $\sqrt{3}$ | 1      | ± 4.1 %                  |
| Linearity                                 | 4.7                    | Rectangular              | $\sqrt{3}$ | 1      | ± 2.7 %                  |
| Scaling with PMR Calibration              | 10.0                   | Rectangular              | $\sqrt{3}$ | 1      | ± 5.77 %                 |
| System Detection Limit                    | 1.0                    | Rectangular              | $\sqrt{3}$ | 1      | ± 0.6 %                  |
| Readout Electronics                       | 0.3                    | Normal                   | 1          | 1      | ± 0.3 %                  |
| Response Time                             | 0.8                    | Rectangular              | $\sqrt{3}$ | 1      | ± 0.5 %                  |
| Integration Time                          | 2.6                    | Rectangular              | $\sqrt{3}$ | 1      | ± 1.5 %                  |
| RF Ambient Conditions                     | 3.0                    | Rectangular              | $\sqrt{3}$ | 1      | ± 1.7 %                  |
| RF Reflections                            | 12.0                   | Rectangular              | $\sqrt{3}$ | 1      | ± 6.9 %                  |
| Probe Positioner                          | 1.2                    | Rectangular              | $\sqrt{3}$ | 1      | ± 0.7 %                  |
| Probe Positioning                         | 4.7                    | Rectangular              | $\sqrt{3}$ | 1      | ± 2.7 %                  |
| Extrap. and Interpolation                 | 1.0                    | Rectangular              | $\sqrt{3}$ | 1      | ± 0.6 %                  |
| <b>Test Sample Related</b>                |                        |                          |            |        |                          |
| Device Positioning Vertical               | 4.7                    | Rectangular              | $\sqrt{3}$ | 1      | ± 2.7 %                  |
| Device Positioning Lateral                | 1.0                    | Rectangular              | $\sqrt{3}$ | 1      | ± 0.6 %                  |
| Device Holder and Phantom                 | 2.4                    | Rectangular              | $\sqrt{3}$ | 1      | ± 1.4 %                  |
| Power Drift                               | 5.0                    | Rectangular              | $\sqrt{3}$ | 1      | ± 2.9 %                  |
| <b>Phantom and Setup Related</b>          |                        |                          |            |        |                          |
| Phantom Thickness                         | 2.4                    | Rectangular              | $\sqrt{3}$ | 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 ANSI C63.19 [1], [2]. The budget is valid for the frequency range 700 MHz - 3 GHz and represents a worst case analysis.



## **15. 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 D01v05, "Equipment Authorization Guidance for Hearing Aid Compatibility", Sep 2017
- [3] FCC KDB 285076 D02v03, "Guidance for performing T-Coil tests for air interfaces supporting voice over IP (e.g., LTE and WiFi) to support CMRS based telephone services", Sep 2017
- [4] FCC KDB 285076 D03v01, "Hearing aid compatibility frequently asked questions", Sep 2017
- [5] SPEAG DASY System Handbook