HEARING AID COMPATIBILITY T-COIL TEST REPORT

FCC ID : 2ALJJP63L
Equipment : Smartphone
Brand Name : PCD
Model Name : P63L
T-Rating : T3
Applicant : PCD, LLC
1500 Tradeport Drive, Suite A, Orlando. Fl 32824
Manufacturer : SHENZHEN TOPWELL TECHNOLOGY CO., LTD.
15/F, Building A1, Qiaode Science & Technology Park, No.7 Road, Hi-Tech Industry Park ,Guangming new district, Shenzhen, China.
Standard : FCC 47 CFR §20.19
ANSI C63.19-2011

We, Sporton International Inc. (Kunshan), 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 test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International Inc. (Kunshan), the test report shall not be reproduced except in full.

Si Zhang

Approved by: Si Zhang

ilac-MRA
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Cert #5145.02

Sporton International Inc. (Kunshan)
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China

Table of Contents

1. Attestation of Test Results 4
2. General Information 5
3. Testing Location 6
4. Applied Standards 6
5. Air Interface and Operating Mode 7
6. Measurement standards for T-Coil 8
6.1 Frequency Response 8
6.2 T-Coil Signal Quality Categories 8
6.3 Description of EUT Test Position 9
7. T-Coil Test Procedure 10
7.1 Test Flow Chart 11
7.2 Test Setup Diagram for GSM/UMTS/VoLTE 12
8. Test Equipment List 14
9. T-Coil testing for CMRS Voice 15
9.1 GSM Tests Results 15
9.2 UMTS Tests Results 16
10. T-Coil testing for CMRS IP Voice 17
10.1 VoLTE Tests Results 17
11. Uncertainty Assessment 19
12. References 20

Appendix A. Plots of T-Coil Measurement
Appendix B. DASY Calibration Certificate
Appendix C. Test Setup Photos

History of this test report

Report No.	Version	Description	Issued Date
HA311701B	Rev. 01	Initial issue of report	Feb. 15, 2023

1. Attestation of Test Results

Air Interface	Band MHz	T-Rating	Frequency Response	Magnetic Intensity
GSM CMRS Voice	GSM850	T3	Pass	Pass
	GSM1900	T4	Pass	Pass
UMTS CMRS Voice	Band II	T4	Pass	Pass
	Band IV	T4	Pass	Pass
	Band V	T4	Pass	Pass
VoLTE	Band 2	T4	Pass	Pass
	Band 12	T3	Pass	Pass
	Band 66/4	T4	Pass	Pass
	Band 71	T3	Pass	Pass
Date Tested	2023/2/3 ~ 2023/2/4			

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

2. General Information

Product Feature & Specification	
Applicant Name	PCD, LLC
Equipment Name	Smartphone
Brand Name	PCD
Model Name	P63L
IMEI Code	352472093320476
FCC ID	2ALJJP63L
HW	P63_M_V2.1
SW	PCD_P63L_iWIRELESS_US_V1.0_20230206
EUT Stage	Production Unit
Frequency Band	GSM850: 824 MHz ~ 849 MHz GSM1900: 1850 MHz ~ 1910 MHz WCDMA Band II: 1850 MHz ~ 1910 MHz WCDMA Band IV: 1710 MHz ~ 1755 MHz WCDMA Band V: 824 MHz ~ 849 MHz LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 4: 1710 MHz ~ 1755 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 66: 1710 MHz ~ 1780 MHz LTE Band 71: 663 MHz ~ 698 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	GSM/GPRS/EGPRS AMR / RMC 12.2Kbps HSDPA HSUPA HSPA+ (16QAM uplink is supported) LTE: QPSK, 16QAM WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 5GHz 802.11a/n/ac HT20/HT40/VHT20/VHT40 Bluetooth BR/EDR/LE

3. Testing Location

Sporton International Inc. (Kunshan) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Testing Laboratory			
Test Firm	Sporton International Inc. (Kunshan)		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	SAR01-KS	CN1257	314309

4. Applied Standards

- FCC CFR47 Part 20.19
- ANSI C63.19-2011
- FCC KDB 285076 D01 HAC Guidance v06r02
- FCC KDB 285076 D02 T-Coil testing v04
- FCC KDB 285076 D03 HAC FAQ v01r06

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	DT	No	WLAN, BT	NA	No
	EDGE1900					
UMTS	Band II	VO	Yes	WLAN, BT	CMRS Voice	No
	Band IV			WLAN, BT		No
	Band V			WLAN, BT		No
	HSPA	DT	No	WLAN, BT	NA	No
LTE (FDD)	Band 2	VD	Yes	WLAN, BT	VoLTE	No
	Band 4			WLAN, BT		No
	Band 12			WLAN, BT		No
	Band 66			WLAN, BT		No
	Band 71			WLAN, BT		No
Wi-Fi	2450	DT	No	GSM,WCDMA,LTE	NA	No
	5200	DT	No	GSM,WCDMA,LTE		No
	5300					No
	5800					No
BT	2450	DT	No	GSM,WCDMA,LTE	NA	No

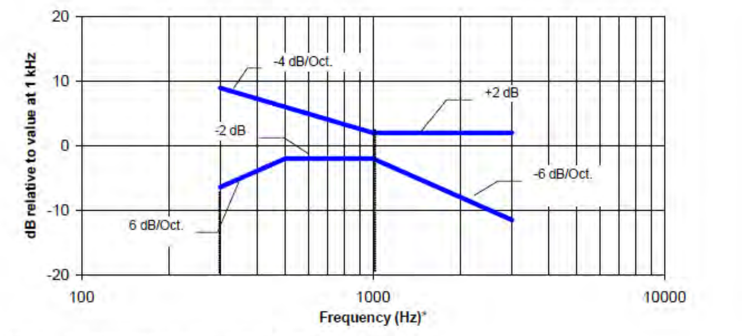
Type Transport:
VO= Voice only
DT= Digital Transport only (no voice)
VD= CMRS and IP Voice Service over Digital Transport

Remark:
1. For protocols not listed in Table 7.1 of ANSI C63.19-2011 or the ANSI C63.19-2011 VoLTE interpretation, the average speech level of −20 dBm0 should be used.
2. The device have similar frequency in some LTE bands: LTE B4/B66, since the supported frequency spans for the smaller LTE bands are completely cover by the larger LTE bands, therefore, only larger LTE bands were required to be tested for hearing-aid compliance.
3. The device has no VOIP function.

6. Measurement standards for T-Coil

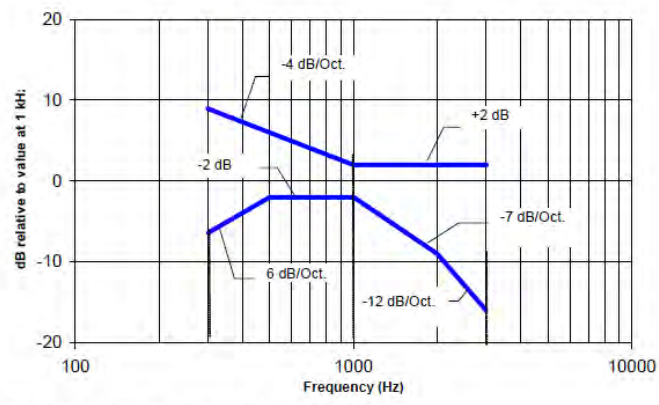
6.1 Frequency Response

The frequency response of the perpendicular component of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this sub-clause, over the frequency range 300 Hz to 3000 Hz.
Figure 1.1 and Figure 1.2 provide the boundaries as a function of frequency. These response curves are for true field-strength measurements of the T-Coil signal. Thus, the 6 dB/octave probe response has been corrected from the raw readings.



NOTE—The frequency response is between 300 Hz and 3000 Hz.

Fig. 1.1 Magnetic field frequency response for WDs with field strength≤-15dB at 1 KHz



NOTE—The frequency response is between 300 Hz and 3000 Hz.

Fig. 1.2 Magnetic field frequency response for WDs with a field that exceeds –15 dB(A/m) at 1 kHz

6.2 T-Coil Signal Quality Categories

This section provides the signal quality requirement for the intended T-Coil signal from a WD. Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. A device is assessed beginning by determining the category of the RF environment in the area of the T-Coil source.
The RF measurements made for the T-Coil evaluation are used to assign the category T1 through T4. The limitation is given in Table 1. This establishes the RF environment presented by the WD to a hearing aid.

Category	Telephone parameters WD signal quality ((signal + noise) to noise ratio in dB)
Category T1	0 to 10 dB
Category T2	10 to 20 dB
Category T3	20 to 30 dB
Category T4	> 30 dB

Table 1 T-Coil Signal Quality Categories

6.3 Description of EUT Test Position

Fig.3 illustrate the references and reference plane that shall be used in a typical EUT emissions measurement. The principle of this section is applied to EUT with similar geometry. Please refer to Appendix C for the setup photographs.

- The area is 5 cm by 5 cm.
- The area is centered on the audio frequency output transducer of the EUT.
- The area is in a reference plane, which is defined as the planar area that contains the highest point in the area of the phone that normally rests against the user's ear. It is parallel to the centerline of the receiver area of the phone and is defined by the points of the receiver-end of the EUT handset, which, in normal handset use, rest against the ear.
- The measurement plane is parallel to, and 10 mm in front of, the reference plane.

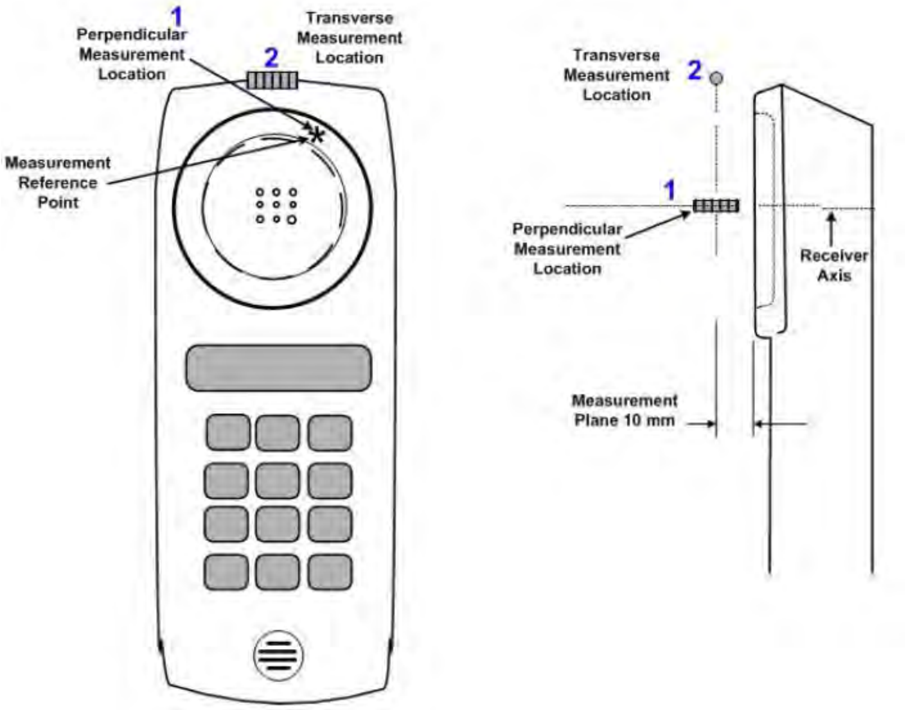


Fig.3 A typical EUT reference and plane for T-Coil measurements

7. T-Coil Test Procedure

Referenced to ANSI C63.19-2011, Section 7.4

This section describes the procedures used to measure the ABM (T-Coil) performance of the WD. In addition to measuring the absolute signal levels, the A-weighted magnitude of the unintended signal shall also be determined. To assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal must be made at the same location for each measurement position. In addition, the RF field strength at each measurement location must be at or below that required for the assigned category.

Measurements shall not include undesired properties from the WD's RF field; therefore, use of a coaxial connection to a base station simulator or non-radiating load, there might still be RF leakage from the WD, which can interfere with the desired measurement. Pre-measurement checks should be made to avoid this possibility. All measurements shall be performed with the WD operating on battery power with an appropriate normal speech audio signal input level given in ANSI C63.19-2011 Table 7.1. If the device display can be turned off during a phone call, then that may be done during the measurement as well,

Measurement shall be performed at two locations specified in ANSI C63.19-2011 A.3, with the correct probe orientation for a particular location, in a multistage sequence by first measuring the field intensity of the desired T-Coil signal the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired magnetic components (ABM2) must be measured at the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired ABM signals must be calculated. For the perpendicular field location, only the ABM1 frequency response shall be determined in a third measurement stage.

The following steps summarize the basic test flow for determining ABM1 and ABM2. These steps assume that a sine wave or narrowband 1/3 octave signal can be used for the measurement of ABM1.

a. A validation of the test setup and instrumentation may be performed using a TMFS or Helmholtz coil Measure the emissions and confirm that they are within the specified tolerance.
b. Position the WD in the test setup and connect the WD RF connector to a base station simulator or a non-radiating load. Confirm that equipment that requires calibration has been calibrated, and that the noise level meets the requirements given in ANSI C63.19-2011 clause 7.3.1.
c. The drive level to the WD ise set such that the reference input level specified in ANSI C63.19-2011 Table 7.1 is input to the base station simulator (or manufacturer's test mode equivalent) in 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (ABM1) at f = 1 kHz. Either a sine wave at 1025 Hz or a voice-like signal, band-limited to the 1 kHz 1/3 octave, as defined in ANSI C63.19-2011 clause 7.4.2, shall be used for the reference audio signal. If interference is found at 1025 Hz an alternative nearby reference audio signal frequency may be used. The same drive level shall be used for the ABM1 frequency response measurements at each 1/3 octave band center frequency. The WD volume control may be set at any level up to maximum, provided that a signal at any frequency at maximum modulation would not result in clipping or signal overload.
d. Determine the magnetic measurement locations for the WD device (A.3), if not already specified by the manufacturer, as described in ANSI C63.19-2011 clause 7.4.4.1.1 and 7.4.4.2.
e. At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at fi) as described in ANSI C63.19-2011 clause 7.4.4.2 in each individual ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (fi) shall be centered in each 1/3 octave band maintaining the same drive level as determined in item c) and the reading taken for that band.
f. Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input-output comparison using simulated speech. The full-band integrated probe output, as specified in D.9, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB A/m.)
g. All Measurements of the desired signal shall be shown to be of the desired signal and not of an undesired signal. This may be shown by turning the desired signal ON and OFF with the probe measuring the same location. If the scanning method is used the scans shall show that all measurement points selected for the ABM1 measurement meet the ambient and test system noise criteria in ANSI C63.19-2011 clause 7.3.1.
h. At the measurement location for each orientation, measure and record the undesired broadband audio magnetic signal (ABM2) as specified in ANSI C63.19-2011 clause 7.4.4.4 with no audio signal applied (or digital zero applied, if appropriate) using A-weighting and the half-band integrator. Calculate the ratio of the desired to undesired signal strength (i,e., signal quality).
i. Obtain the data from the postprocessor, SEMCAD, and determine the category that properly classifies the signal quality based on ANSI C63.19-2011 Table 8.5.

7.1 Test Flow Chart

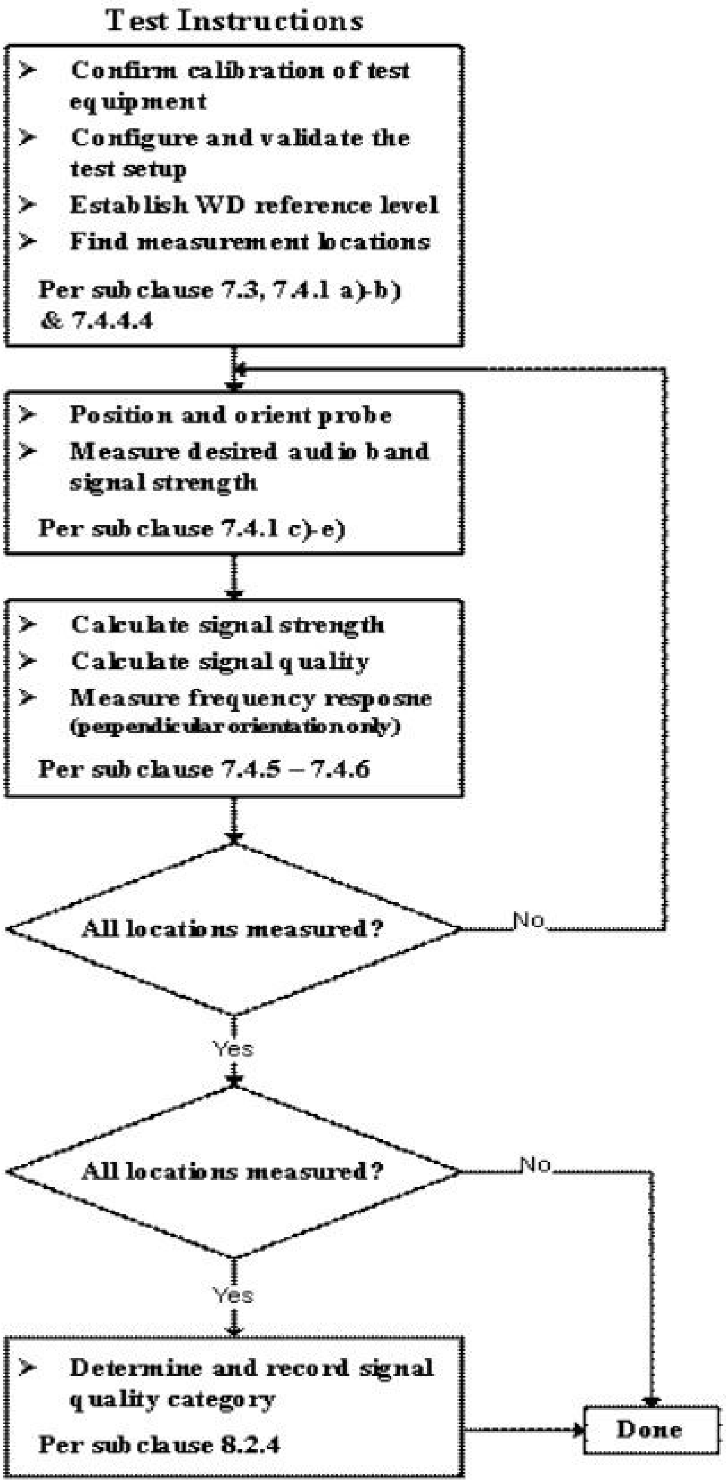
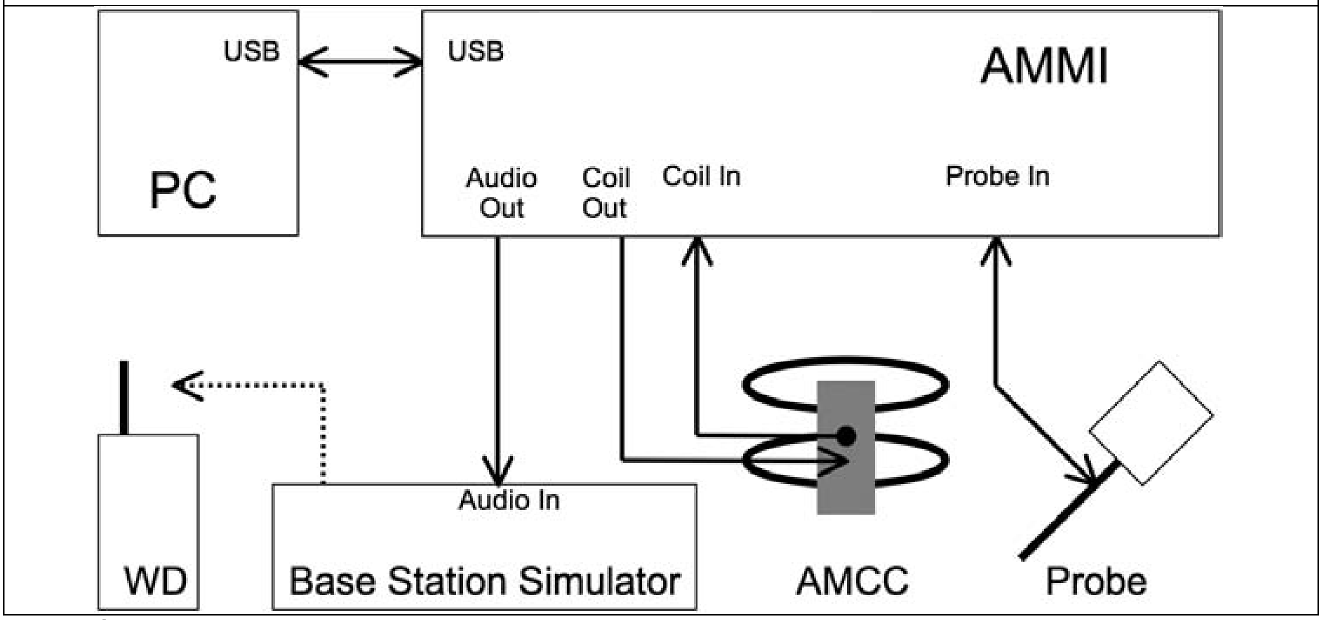


Fig. 2 T-Coil Signal Test flowchart

7.2 Test Setup Diagram for GSM/UMTS/VoLTE

Test Setup for GSM / UMTS/ VoLTE



General Note:

1. Define the all applicable input audio level as below according to C63 and KDB 285076 D02v04:
   - GSM input level: -16dBm0
   - UMTS input level: -16dBm0
   - VoLTE input level: -16dBm0
2. For GSM / UMTS test setup and input level, the correct input level definition is via a communication tester CMU200's "Decoder Cal" and "Codec Cal" with audio option B52 and B85 to set the correct audio input levels.
3. CMU200 is able to output 1kHz audio signal equivalent to 3.14dBm0 at "Decoder Cal." confuguration, the signal reference is used to adjust the AMMI gain setting to reach -16dBm0 for GSM/UMTS. CMW500 input is calibrated and the relation between the analog input voltage and the internal level in dBm0 can be determined
4. Voice over Long-Term Evolution (VoLTE) is a standard for high-speed wireless communication for mobile phones and data terminals — including IoT devices and wearables. It is based on the IP Multimedia Subsystem (IMS) network, with specific profiles for control and media planes of voice service on LTE defined by GSMA in PRD IR.92. This approach results in the voice service (control and media planes) being delivered as data flows within the LTE data bearer. This means that there is no dependency on the legacy circuit-switched voice network to be maintained
5. The test setup used for VoLTE over IMS is via the callbox of CMW500 for T-coil measurement, The data application unit of the CMW500 was used to simulate the IP multimedia subsystem server. The CMW500 can be manually configured to ensure and control the speech input level result is -16dBm0 for VoLTE when the device during the IMS connection.
6. According to KDB 285076 D02, T-Coil testing for VoLTE requires test instrumentation that can (1) for the system to be able to establish an IP call from/to the handset under test, (2) through an IMS (IP Multimedia Subsystem) and SIP/IP server, (3) to an analog audio adapter containing the permissible set of codecs used by the device under test, and (4) inject the necessary C63.19 test tones at the average speech level for the measurement The test setup is illustrated in Figure 3.9. The R&S CMW500 was used as system simulator for VoLTE T-Coil testing. The DAU (Data Application Unit) in CMW500 integrates IMS and SIP/IP server that can establish VoLTE calling, and transport the test tones from AMMI (Audio Magnetic Measuring Instrument) to EUT.

<Define the input level for GSM/UMTS>

1. The Required gain factor for the specific signal shall typically be multiplied by this factor to achieve approx. the same level as for the 1kHz sine signal
2. The below calculation formula is an example and showing how to determine the input level for the device.

The predefined signal types have the following differences / factors compared to the 1kHz sine signal:

Signal [file name]	Duration [s]	Peak-to-RMS [dB]	RMS [dB]	Required gain factor *)	Gain setting
1kHz sine	---	3.0	0.0	1.00	
48k_1.025kHz_10s.wav	10	3.0	0.0	1.00	
48k_1kHz_3.15kHz_10s.wav	10	6.0	-3.0	1.42	
48k_315Hz_1kHz_10s.wav	10	6.0	-2.9	1.40	
48k_csek_8k_441_white_10s.wav	10	13.8	-10.5	3.34	
48k_multisine_50-5000_10s.wav	10	11.1	-7.9	2.49	
48k_voice_1kHz_1s.wav	1	16.2	-12.7	4.33	
48k_voice_300-3000_2s.wav	2	21.6	-18.6	8.48	

(*) The gain for the specific signal shall typically be multiplied by this factor to acheive approx. the same level as for the 1kHz sine signal.

Insert the gain applicable for your setup in the last column of the table.

<Example define the input level for GSM/UMTS >

Gain Value	20* log(gain)	AMCC Coil In	Level
(linear)	dB	(dBv RMS)	dBm0
		-2.47	3.14
10	20	-19.85	-14.24
8.17	18.24	-21.61	-16

Signal Type	Duration (s)	Peak to RMS (dB)	RMS (dB)	Required Gain Factor	Calculated Gain Setting
1kHz sine	-	3	0	1	8.17
48k_voice_1kHz	1	16.2	-12.7	4.33	35.36
48k_voice_300Hz ~ 3kHz	2	21.6	-18.6	8.48	69.25

<Example define the input level for VoLTE>

Gain Value	dBm0	Full scal Voltage	dB	AMMI audio out dBv (RMS)	AMCC Coil Out (dBv (RMS)
	3.14	1.5		0.51	
100	5.57		40	2.94	3.09
8.35	-16		18.43		-18.48
Signal Type	**Duration (s)**	**Peak to RMS (dB)**	**RMS (dB)**	**Gain Factor**	**Gain Setting**
1kHz sine	-	3	0	1	8.35
48k_voice_1kHz	1	16.2	-12.7	4.33	36.15
48k_voice_300-3000	2	21.6	-18.6	8.48	70.79

8. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Audio Magnetic 1D Field Probe	AM1DV3	3106	2022/12/13	2023/12/12
SPEAG	Data Acquisition Electronics	DAE4	1650	2022/8/5	2023/8/4
SPEAG	Audio Magnetic Calibration Coil	AMCC	1049	NCR	NCR
SPEAG	Audio Measuring Instrument	AMMI	1041	NCR	NCR
Testo	Thermo-Hygrometer	608-H1	1241332126	2023/1/5	2024/1/4
R&S	Base Station	CMW500	143030	2022/7/14	2023/7/13
SPEAG	Test Arch Phantom	N/A	N/A	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR

Note:
1. NCR: “No-Calibration Required”

9. T-Coil testing for CMRS Voice

General Note:

1. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following worst investigation codec would be remarked to be used for the testing for the handset.
2. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.
   b. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

9.1 GSM Tests Results

<Codec Investigation>

GSM Codec					
Codec	**AMR NB FR**	**AMR WB FR**	**GSM EFR (FR V2)**	**Orientation**	**Band / Channel**
ABM 1 (dBA/m)	-1.16	-1.03	-1.01	Axial	GSM850 / 189
ABM 2 (dBA/m)	-27.07	-27.09	-27.1		
Signal Quality (dB)	25.91	26.06	26.09		
Freq. Response	PASS	PASS	PASS		

Remark: According to codec investigation, the worst codec is AMR NB FR.

<Air Interface Investigation>

Plot No.	Air Interface	Mode	Channel	Probe Position	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality dB	T Rating	Ambient Noise dB (A/m)	Freq. Response Variation dB	Frequency Response
1	GSM850	Voice	189	Axial (Z)	-1.16	-27.07	25.91	T3	-56.62	0.6	PASS
				Transversal (Y)	-15.02	-48.25	33.23	T4	-56.55		
2	GSM1900	Voice	661	Axial (Z)	-1.00	-36.50	35.50	T4	-56.49	1.19	PASS
				Transversal (Y)	-13.91	-48.34	34.43	T4	-56.56		

9.2 UMTS Tests Results

<Codec Investigation>

UMTS AMR Codec						
Codec	NB AMR 4.75Kbps	WB AMR 6.60Kbps	NB AMR 12.2Kbps	WB AMR 23.85Kbps	Orientation	Band / BW / Channel
ABM 1 (dBA/m)	-0.56	-0.83	-0.71	-0.48	Axial	B5 / 4182
ABM 2 (dBA/m)	-52.13	-51.4	-51.19	-50.38		
Signal Quality (dB)	51.57	50.57	50.48	49.9		
Freq. Response	PASS	PASS	PASS	PASS		

Remark: According to codec investigation, the worst codec is WB AMR 23.85Kbps

<Air Interface Investigation>

Plot No.	Air Interface	Mode	Channel	Probe Position	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality dB	T Rating	Ambient Noise dB (A/m)	Freq. Response Variation dB	Frequency Response
3	WCDMA II	Voice	9400	Axial (Z)	1.56	-53.61	55.17	T4	-56.56	1.94	PASS
				Transversal (Y)	-6.84	-54.50	47.66	T4	-56.48		
4	WCDMA IV	Voice	1413	Axial (Z)	1.81	-53.46	55.27	T4	-56.53	1.79	PASS
				Transversal (Y)	-8.25	-55.35	47.10	T4	-56.49		
5	WCDMA V	Voice	4182	Axial (Z)	-0.48	-50.38	49.90	T4	-56.57	0.27	PASS
				Transversal (Y)	-6.57	-54.13	47.56	T4	-56.56		

10. T-Coil testing for CMRS IP Voice

10.1 VoLTE Tests Results

General Note:

1. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel / band, the following worst investigation codec would be remarked to be used for the testing for the handset.
2. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands / channel / bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface and the following worst configure would be remarked to be used for the testing for the handset.
   b. Select LTE FDD one frequency band to do measurement at the worst SNR position was additionally performed with varying the BWs/Modulations/RB size to verify the variation to find out worst configuration , the observed variation is very little to be within 1.5 dB which is much less than the margin from the rating threshold.
   c. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

<Codec Investigation>

LTE FDD

VoLTE AMR Codec						
Codec	**NB AMR 4.75Kbps**	**WB AMR 6.60Kbps**	**NB AMR 12.2Kbps**	**WB AMR 23.85Kbps**	**Orientation**	**Band / BW / Channel**
ABM 1 (dBA/m)	-3.56	-3.21	-3.19	-3.25	Axial	B2 / 20M / 18900
ABM 2 (dBA/m)	-50.36	-50.32	-50.19	-50.3		
Signal Quality (dB)	46.8	47.11	47	47.05		
Freq. Response	PASS	PASS	PASS	PASS		

VoLTE EVS Codec								
Codec	**EVS SWB 9.6Kbps**	**EVS SWB 128Kbps**	**EVS WB 5.9Kbps**	**EVS WB 128Kbps**	**EVS NB 5.9Kbps**	**EVS NB 24.4Kbps**	**Orientation**	**Band / BW / Channel**
ABM 1 (dBA/m)	-4.26	-2.58	-4.22	-2.93	-3.81	-3.38	Axial	B2 / 20M / 18900
ABM 2 (dBA/m)	-49.85	-47.47	-46.95	-47.8	-50.78	-51.02		
Signal Quality (dB)	45.59	44.89	42.73	44.87	46.97	47.64		
Freq. Response	PASS	PASS	PASS	PASS	PASS	PASS		

Remark: According to codec investigation, the worst codec is EVS WB 5.9Kbps

<Air Interface Investigation>

Air Interface		BW (MHz)	Modulation	RB Size	RB offset	Channel	UL-DL Configuration	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality dB
FDD	LTE B2	20	QPSK	1	0	18900		-2.45	-45.25	42.80
	LTE B2	20	QPSK	50	0	18900		-2.59	-45.45	42.86
	LTE B2	20	QPSK	100	0	18900		-3.30	-46.25	42.95
	LTE B2	20	16QAM	1	0	18900		-2.45	-45.22	42.77
	LTE B2	15	16QAM	1	0	18900		-2.57	-45.53	42.96
	LTE B2	10	16QAM	1	0	18900		-2.44	-45.52	43.08
	LTE B2	5	16QAM	1	0	18900		-2.61	-45.82	43.21
	LTE B2	3	16QAM	1	0	18900		-2.57	-45.52	42.95
	LTE B2	1.4	16QAM	1	0	18900		-2.58	-45.39	42.81

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality dB	T Rating	Ambient Noise dB (A/m)	Freq. Response Variation dB	Frequency Response
6	LTE Band 2	20	16QAM	1RB	0	18900	Axial (Z)	-4.22	-46.95	42.73	T4	-55.62	2	PASS
							Transversal (Y)	-14.36	-45.83	31.47	T4	-55.72		
7	LTE Band 12	10	16QAM	1RB	0	23095	Axial (Z)	-4.92	-41.77	36.85	T4	-55.49	1.26	PASS
							Transversal (Y)	-14.76	-44.15	29.39	T3	-55.18		
8	LTE Band 66	20	16QAM	1RB	0	132322	Axial (Z)	-5.12	-43.66	38.54	T4	-55.49	1.85	PASS
							Transversal (Y)	-14.09	-44.68	30.59	T4	-55.76		
9	LTE Band 71	20	16QAM	1RB	0	133322	Axial (Z)	-4.98	-42.51	37.53	T4	-55.37	1.43	PASS
							Transversal (Y)	-15.97	-43.84	27.87	T3	-55.44		

Remark:

1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.

Test Engineer： Martin Li, Varus Wang, Light Wang, Ricky Gu

11. Uncertainty Assessment

The evaluation of uncertainly 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 8.2.
The judgment of conformity in the report is based on the measurement results excluding the measurement uncertainty.

Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) ABM1	(Ci) ABM2	Standard Uncertainty (ABM1) (±%)	Standard Uncertainty (ABM2) (±%)
Probe Sensitivity							
Reference Level	3.0	N	1	1	1	3.0	3.0
AMCC Geometry	0.4	R	1.732	1	1	0.2	0.2
AMCC Current	1.0	R	1.732	1	1	0.6	0.6
Probe Positioning during Calibr.	0.1	R	1.732	1	1	0.1	0.1
Noise Contribution	0.7	R	1.732	0.014	1	0.0	0.4
Frequency Slope	5.9	R	1.732	0.1	1	0.3	3.4
Probe System							
Repeatability / Drift	1.0	R	1.732	1	1	0.6	0.6
Linearity / Dynamic Range	0.6	R	1.732	1	1	0.3	0.3
Acoustic Noise	1.0	R	1.732	0.1	1	0.1	0.6
Probe Angle	2.3	R	1.732	1	1	1.3	1.3
Spectral Processing	0.9	R	1.732	1	1	0.5	0.5
Integration Time	0.6	N	1	1	5	0.6	3.0
Field Distribution	0.2	R	1.732	1	1	0.1	0.1
Test Signal							
Ref. Signal Spectral Response	0.6	R	1.732	0	1	0.0	0.3
Positioning							
Probe Positioning	1.9	R	1.732	1	1	1.1	1.1
Phantom Thickness	0.9	R	1.732	1	1	0.5	0.5
DUT Positioning	1.9	R	1.732	1	1	1.1	1.1
External Contributions							
RF Interference	0.0	R	1.732	1	0.3	0.0	0.0
Test Signal Variation	2.0	R	1.732	1	1	1.2	1.2
Combined Std. Uncertainty						4.0%	6.1%
Coverage Factor for 95 %						K=2	K=2
Expanded STD Uncertainty						8.1%	12.2%

Table 8.2 Uncertainty Budget of audio band magnetic measurement

12. 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 D01v06r02, “Equipment Authorization Guidance for Hearing Aid Compatibility”, September 19, 2022

[3] FCC KDB 285076 D02 v04, “Guidance for performing T-Coil tests for air interfaces supporting voice over IP (e.g., LTE and WiFi) to support CMRS based telephone services”, Feb. 23, 2022

[4] FCC KDB 285076 D03v01r06, “Hearing aid compatibility frequently asked questions”, July 20, 2022

[5] SPEAG DASY System Handbook

------THE END------

Appendix A. Plots of T-Coil Measurement

The plots are shown as follows.

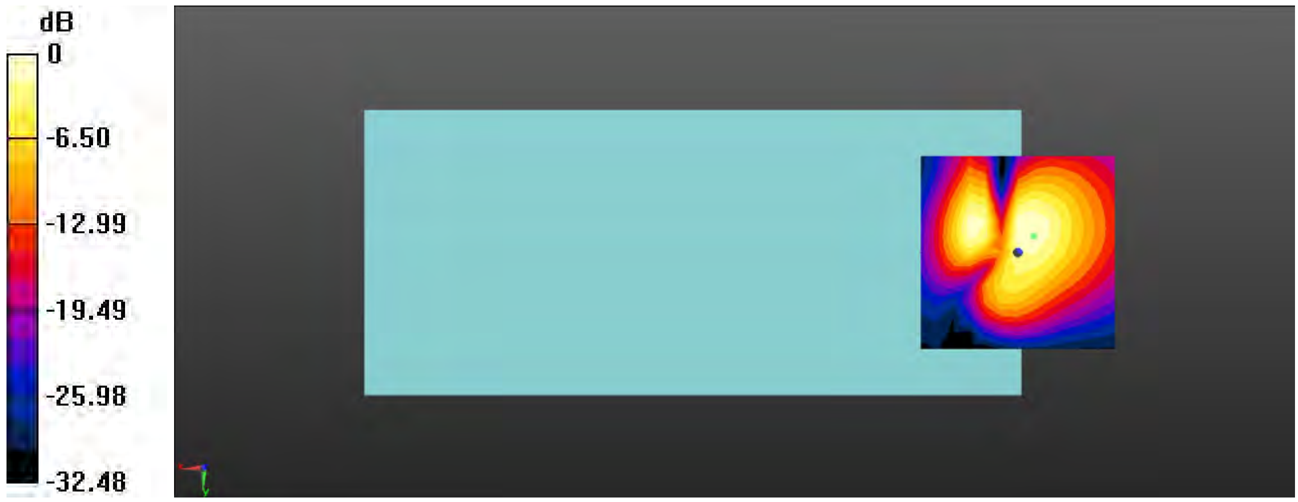
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil GSM850_Voice_Ch189(Z)

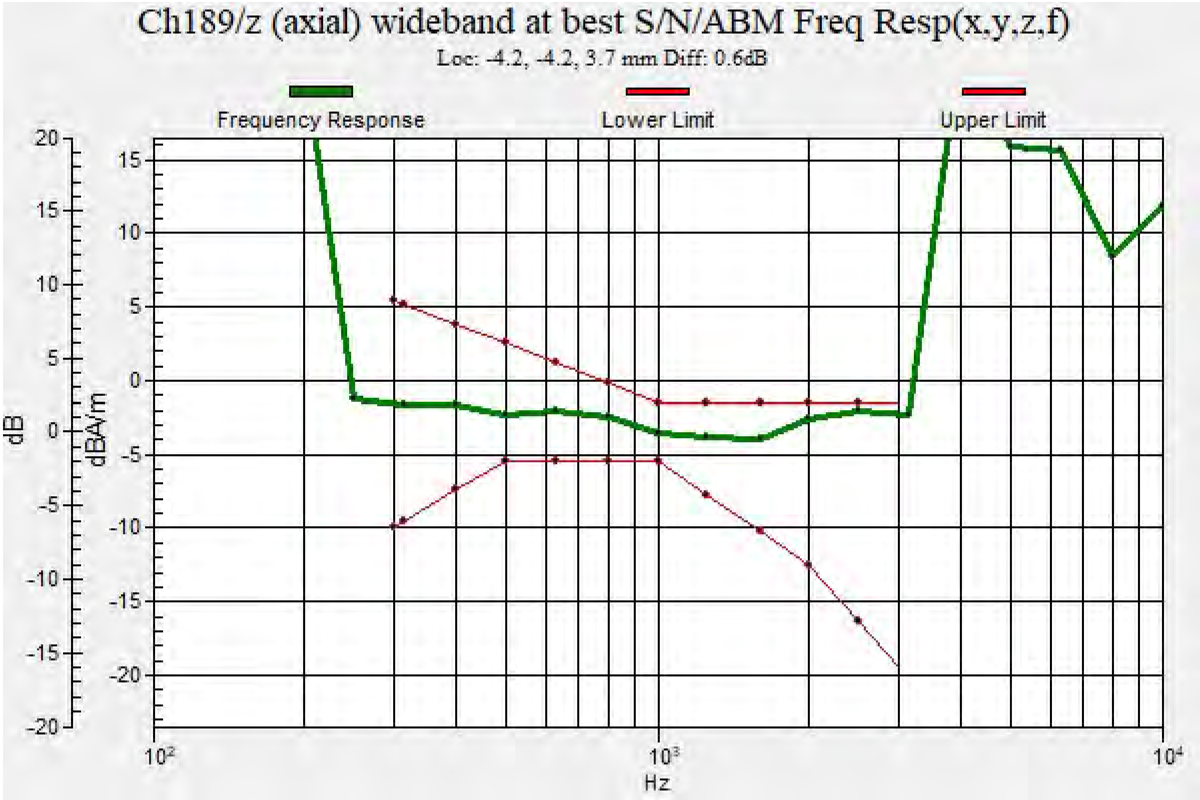
Communication System: UID 0, GSM850 (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch189/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.91 dB
ABM1 comp = -1.16 dBA/m
Location: -4.2, -4.2, 3.7 mm



0 dB = 19.74 = 25.91 dB



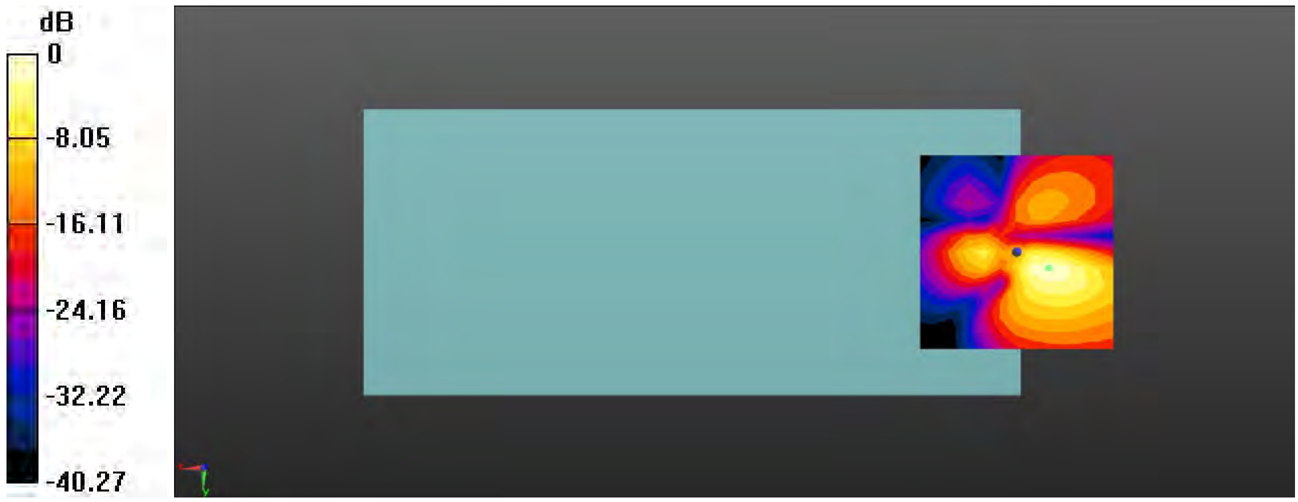
Ch189/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 0.6dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

HAC T-Coil GSM850_Voice_Ch189(Y)

Communication System: UID 0, GSM850 (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: σ = 0 S/m, $\varepsilon_r = 1$; ρ = 0 kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch189/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 33.23 dB
ABM1 comp = -15.02 dBA/m
Location: -8.3, 4.2, 3.7 mm



0 dB = 45.88 = 33.23 dB

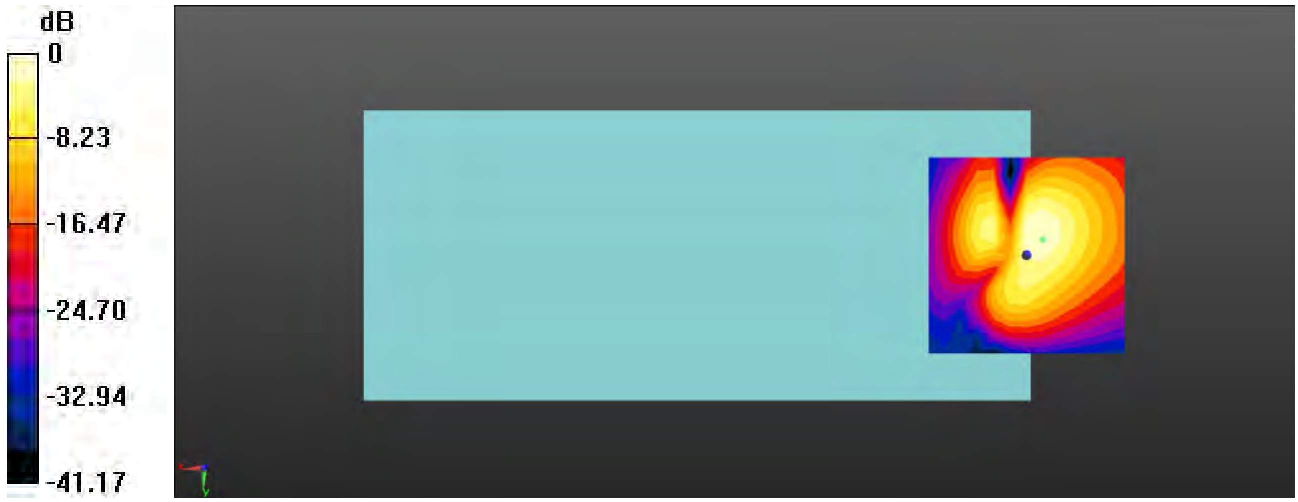
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab   Date: 2023/2/3

HAC T-Coil GSM1900_Voice_Ch661(Z)

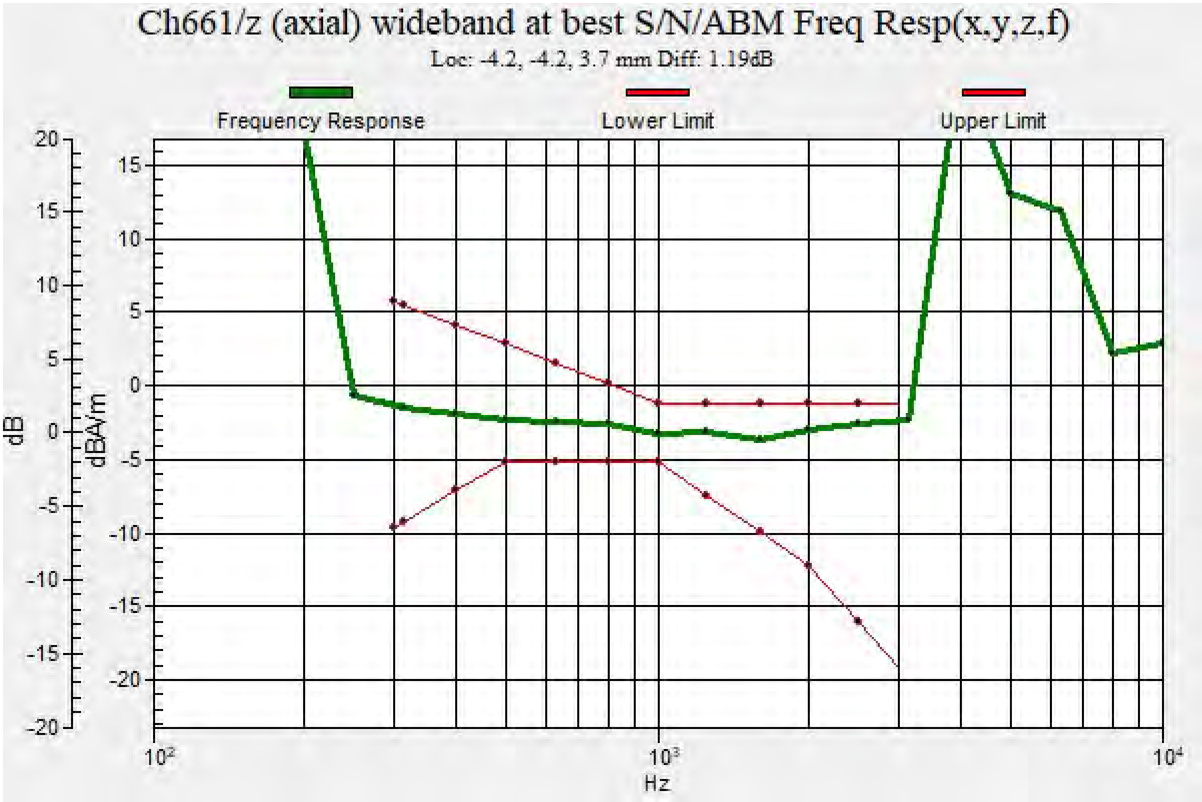
Communication System: UID 0, PCS (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch661/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 35.50 dB
ABM1 comp = -1.00 dBA/m
Location: -4.2, -4.2, 3.7 mm



0 dB = 59.57 = 35.50 dB


Ch661/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 1.19dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
10²
10³
10⁴

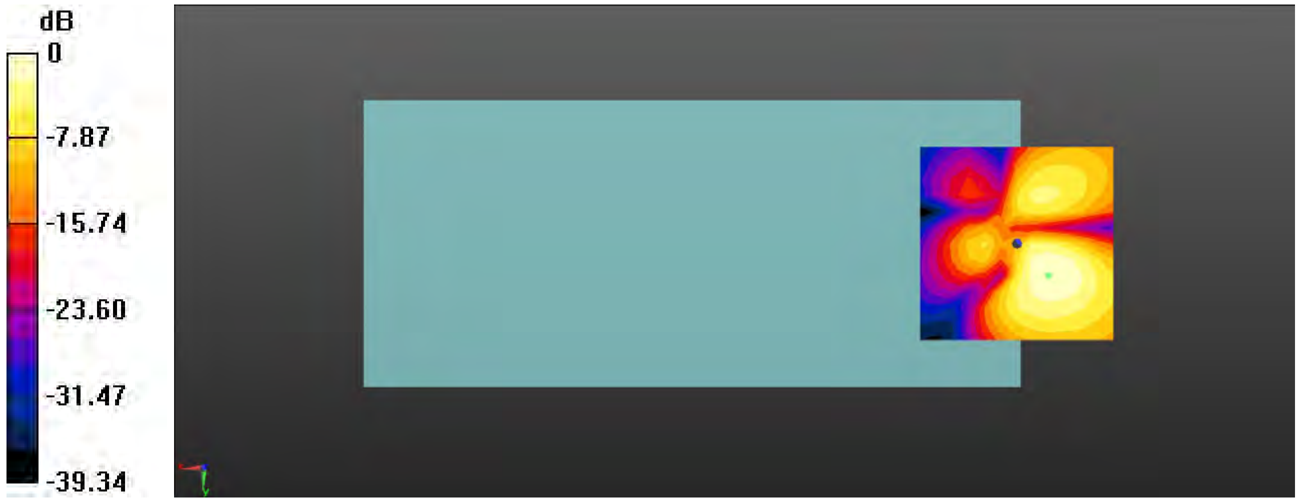
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil GSM1900_Voice_Ch661(Y)

Communication System: UID 0, PCS (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature : 23.3 °C;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch661/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 34.43 dB
ABM1 comp = -13.91 dBA/m
Location: -8.3, 8.3, 3.7 mm



0 dB = 52.68 = 34.43 dB

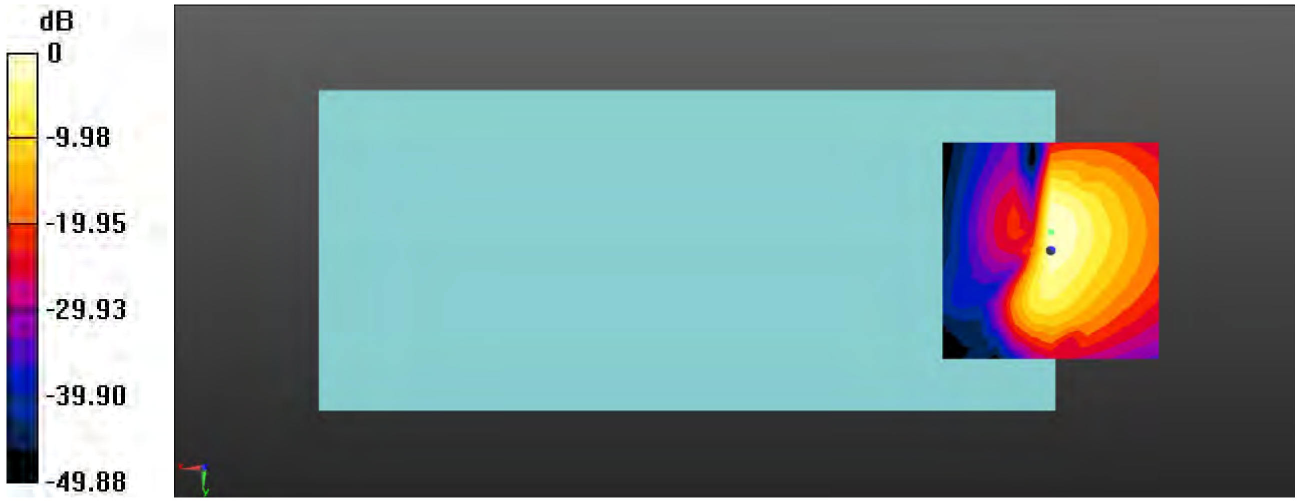
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil WCDMA II_Voice_Ch9400(Z)

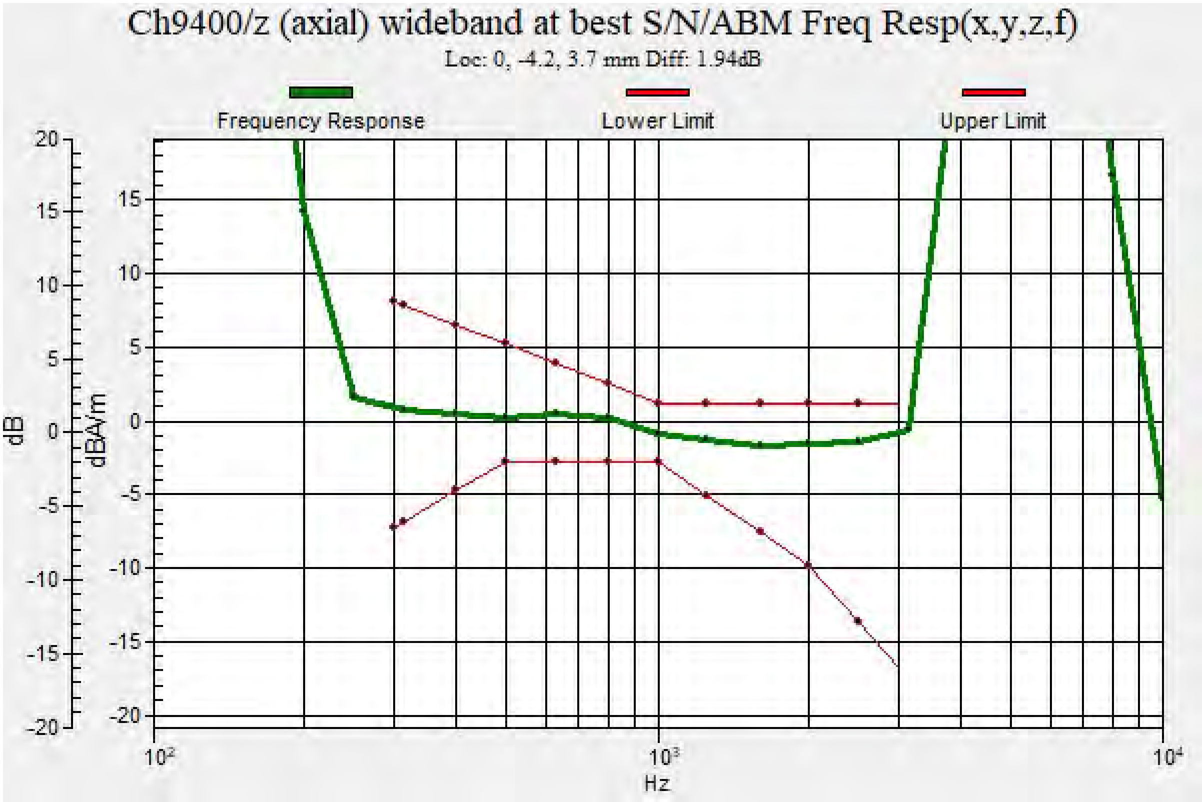
Communication System: UID 0, WCDMA (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch9400/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 55.17 dB
ABM1 comp = 1.56 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 573.2 = 55.17 dB

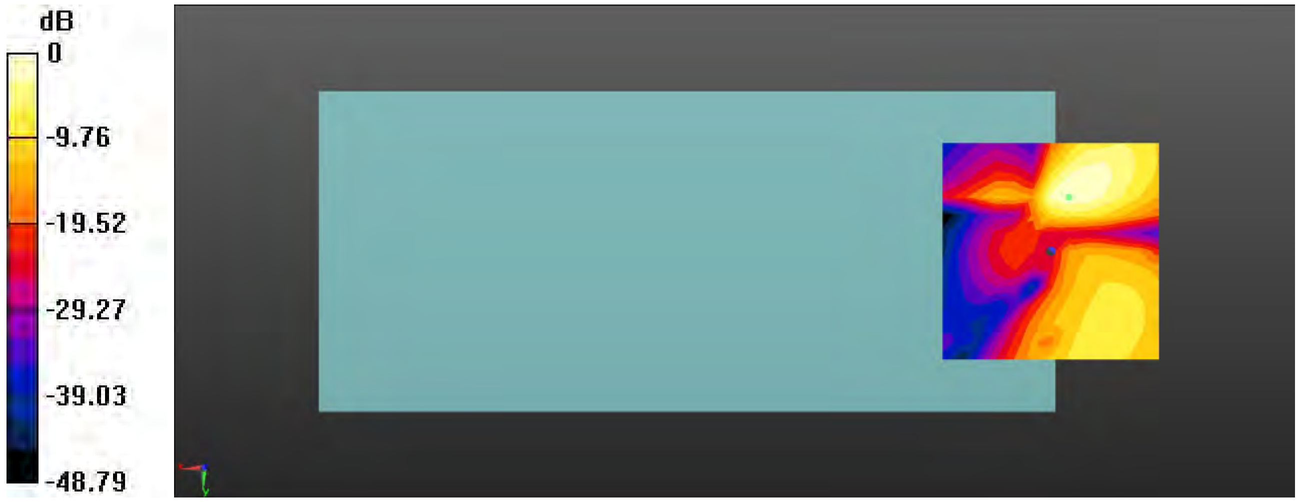

Ch9400/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 1.94dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

HAC T-Coil WCDMA II_Voice_Ch9400(Y)

Communication System: UID 0, WCDMA (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch9400/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 47.66 dB
ABM1 comp = -6.84 dBA/m
Location: -4.2, -12.5, 3.7 mm



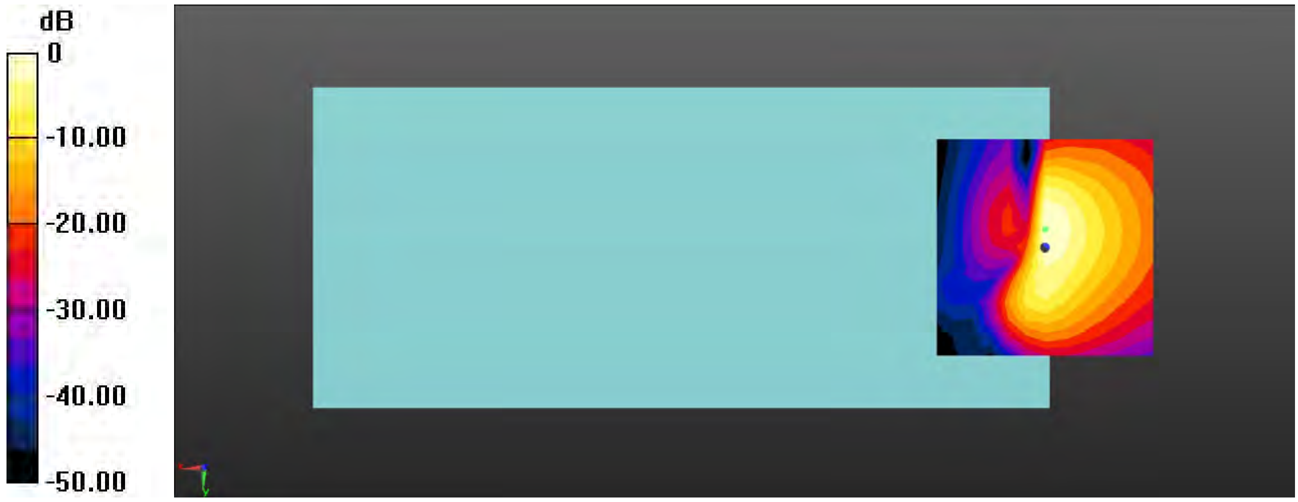
0 dB = 241.6 = 47.66 dB

HAC T-Coil WCDMA IV_Voice_Ch1413(Z)

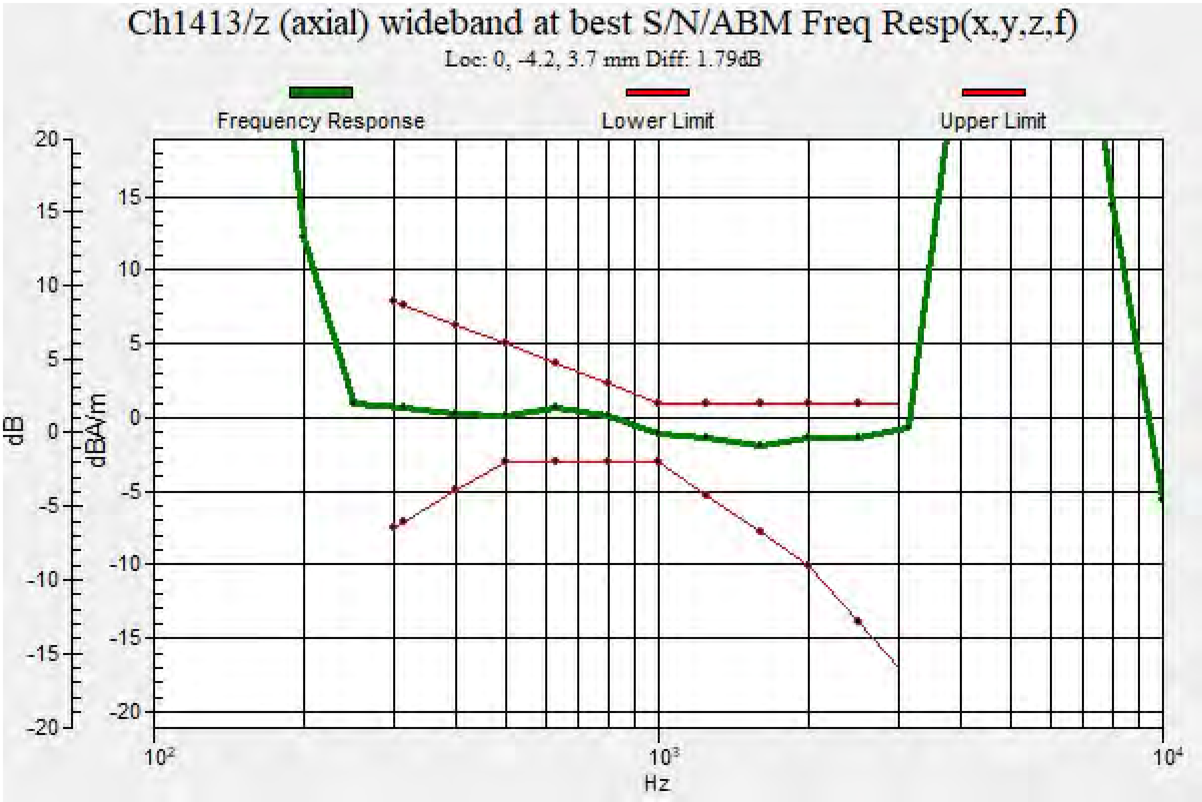
Communication System: UID 0, WCDMA (0); Frequency: 1732.6 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch1413/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 55.27 dB
ABM1 comp = 1.81 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 580.2 = 55.27 dB



Ch1413/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 1.79dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

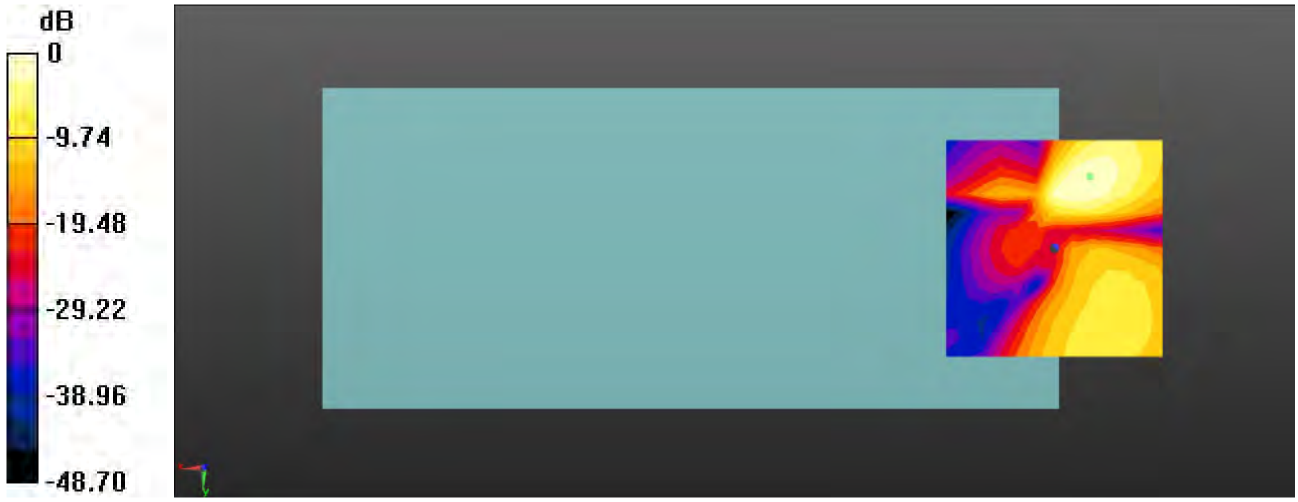
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab   Date: 2023/2/3

HAC T-Coil WCDMA IV_Voice_Ch1413(Y)

Communication System: UID 0, WCDMA (0); Frequency: 1732.6 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch1413/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 47.10 dB
ABM1 comp = -8.25 dBA/m
Location: -8.3, -16.7, 3.7 mm



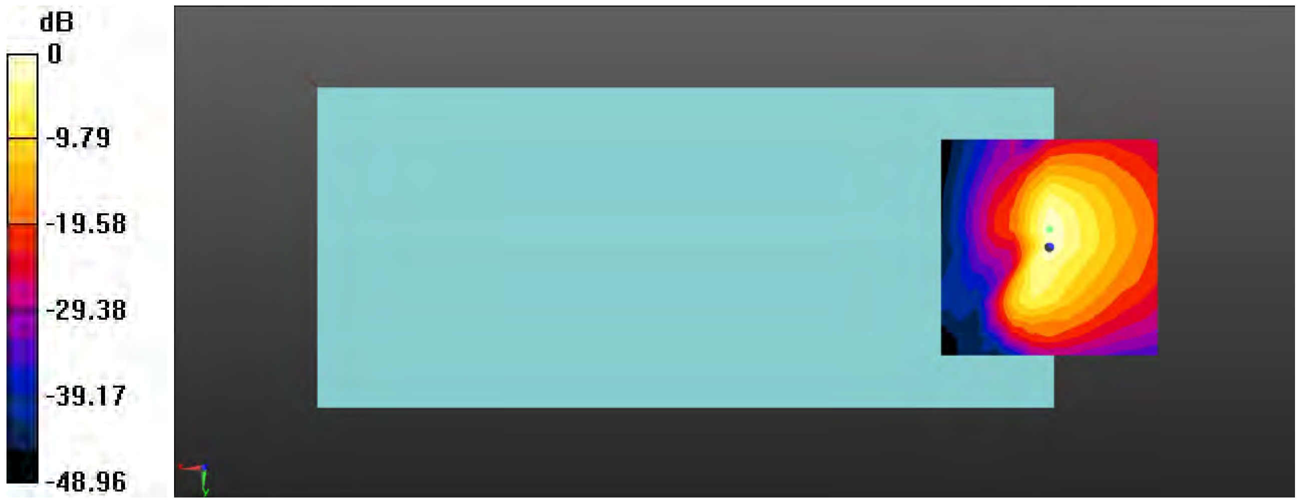
0 dB = 226.4 = 47.10 dB

HAC T-Coil WCDMA V_Voice_Ch4182(Z)

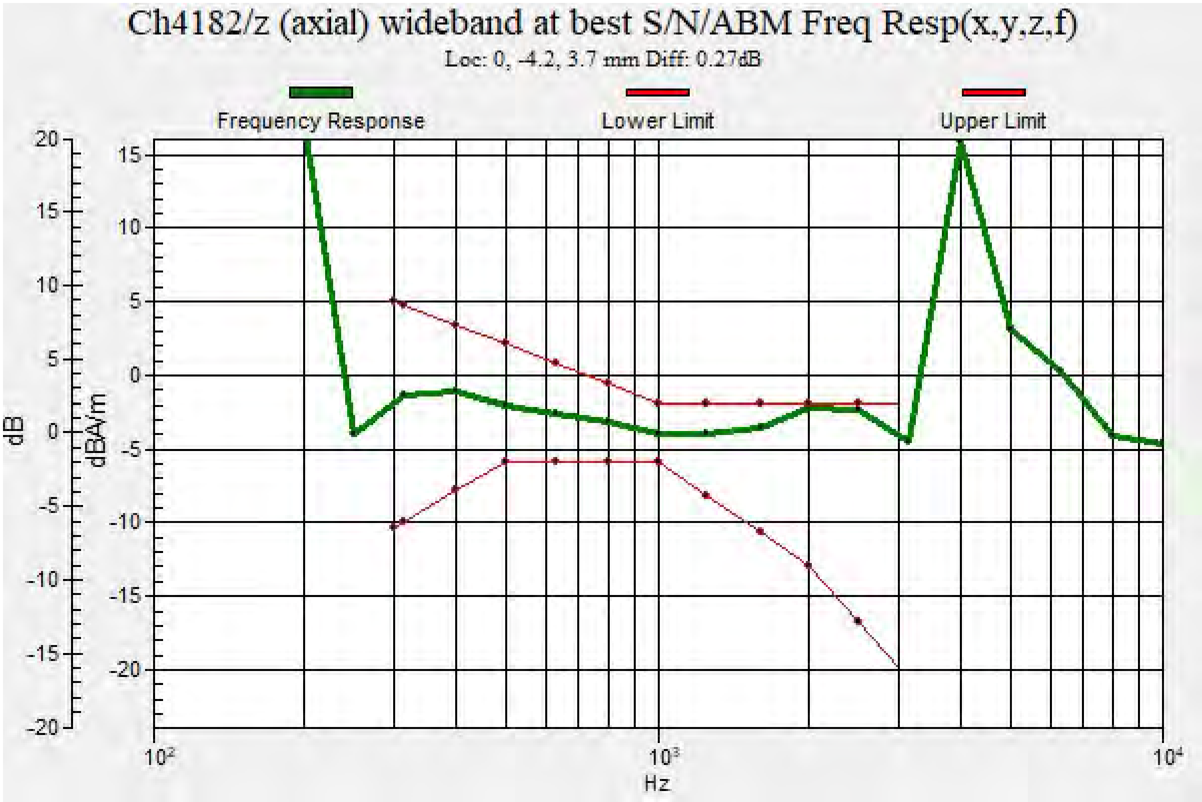
Communication System: UID 0, WCDMA (0); Frequency: 836.4 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch4182/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 49.90 dB
ABM1 comp = -0.48 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 312.5 = 49.90 dB



Ch4182/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 0.27dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

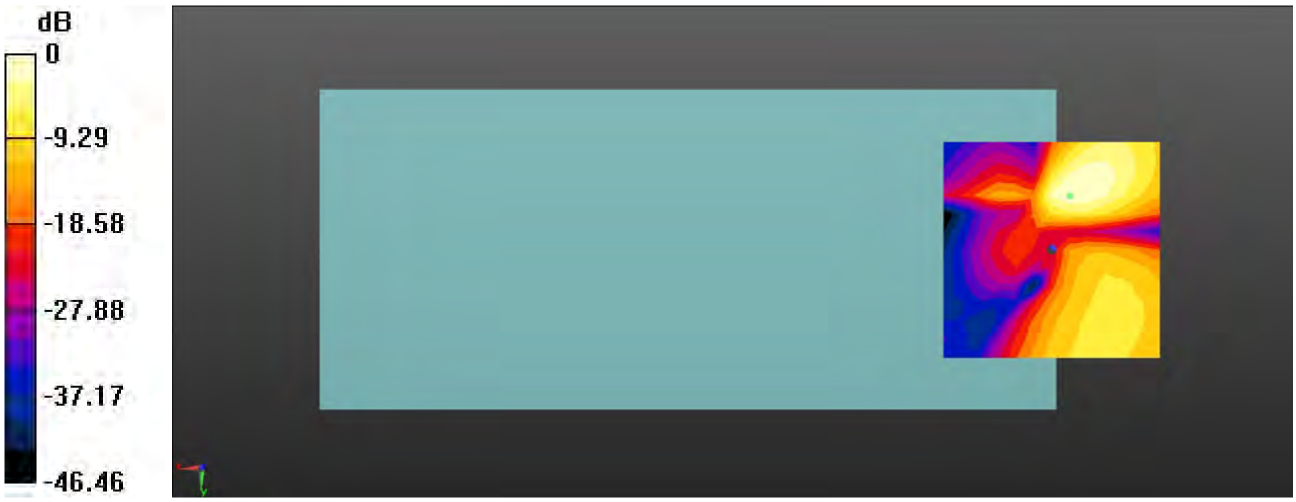
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil WCDMA V_Voice_Ch4182(Y)

Communication System: UID 0, WCDMA (0); Frequency: 836.4 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch4182/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 47.56 dB
ABM1 comp = -6.57 dBA/m
Location: -4.2, -12.5, 3.7 mm



0 dB = 238.8 = 47.56 dB

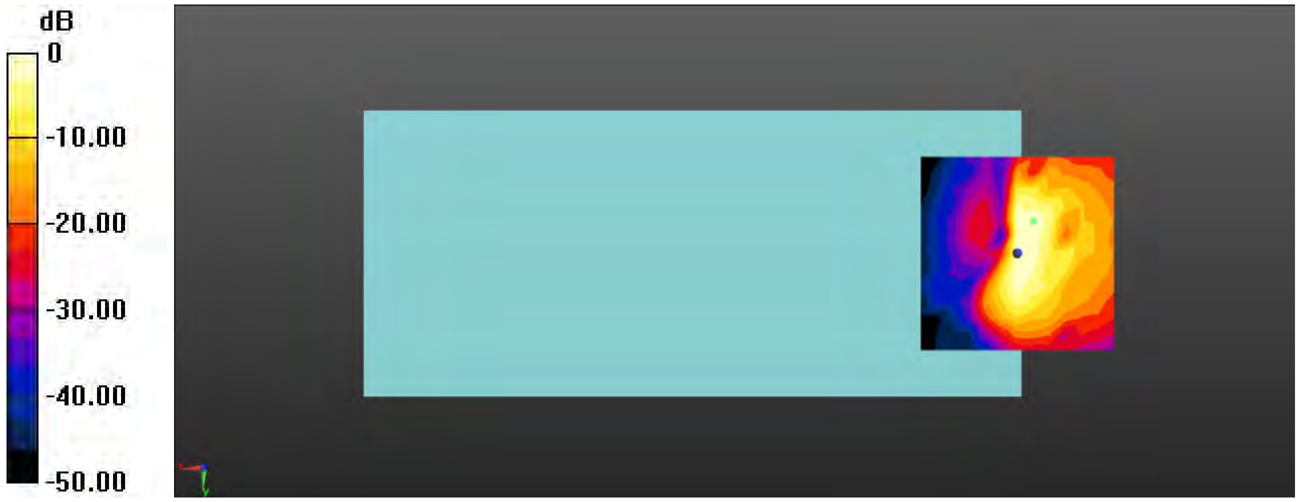
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil_LTE Band 2_20M_16QAM_1RB_0Offset_Ch18900(Z)

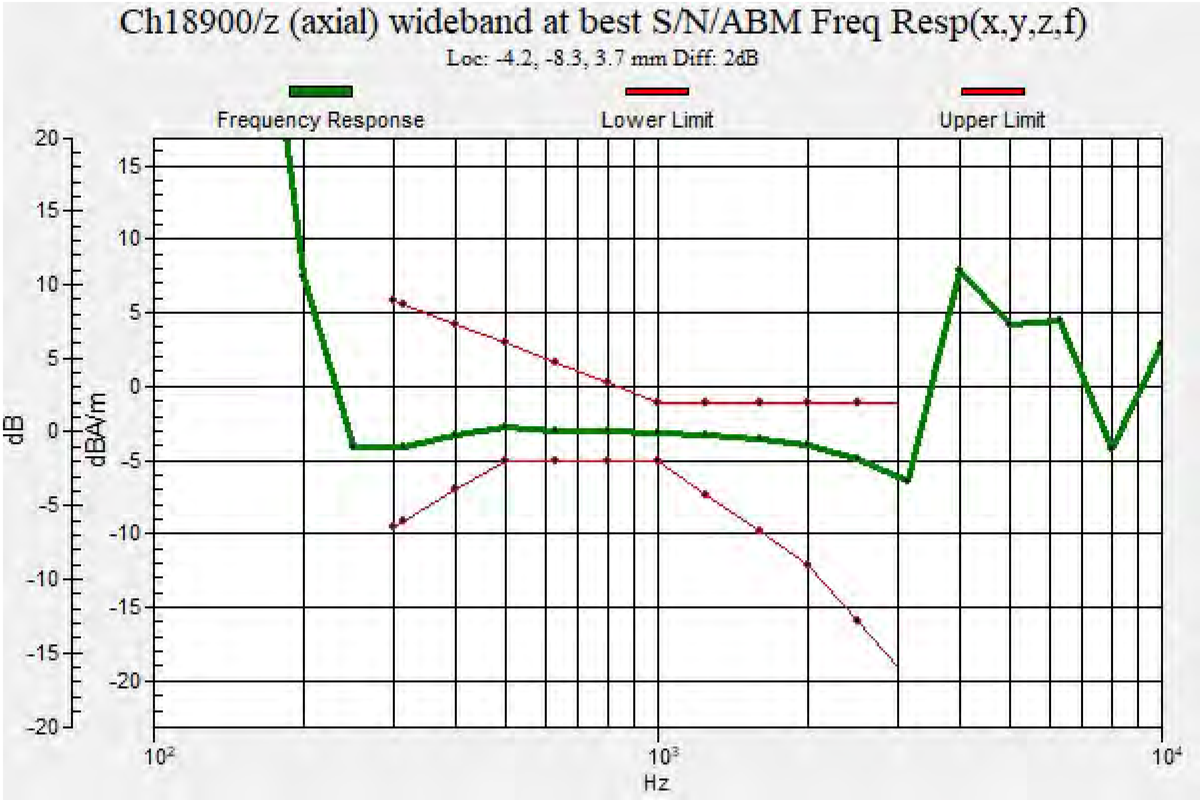
Communication System: UID 0, LTE-FDD (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch18900/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 42.73 dB
ABM1 comp = -4.22 dBA/m
Location: -4.2, -8.3, 3.7 mm



0 dB = 137.0 = 42.73 dB


Ch18900/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -8.3, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4

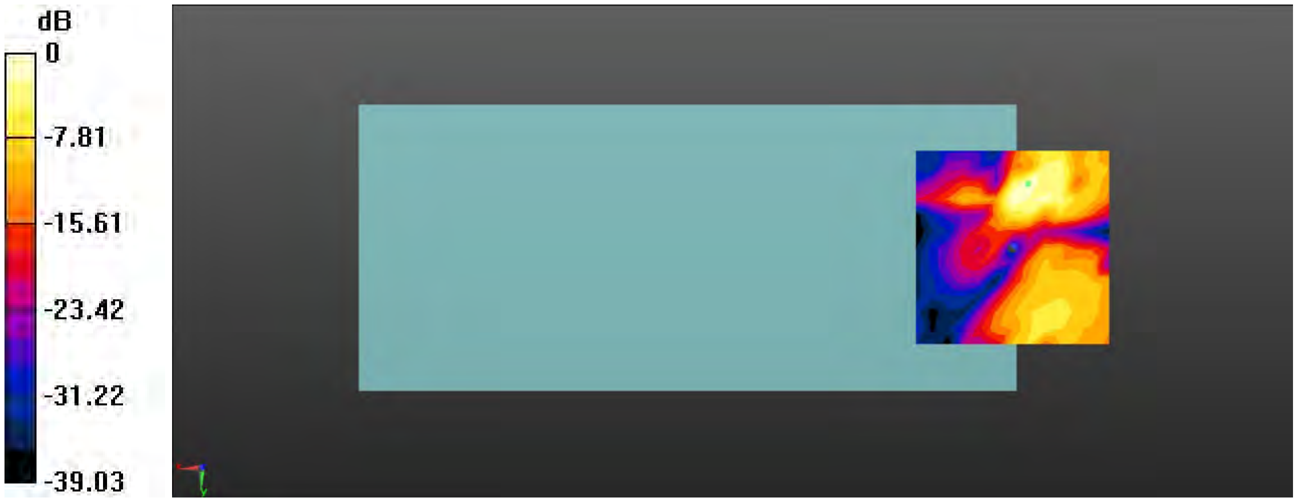
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab   Date: 2023/2/3

HAC T-Coil_LTE Band 2_20M_16QAM_1RB_0Offse_Ch18900(Y)

Communication System: UID 0, LTE-FDD (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch18900/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 31.47 dB
ABM1 comp = -14.36 dBA/m
Location: -4.2, -16.7, 3.7 mm



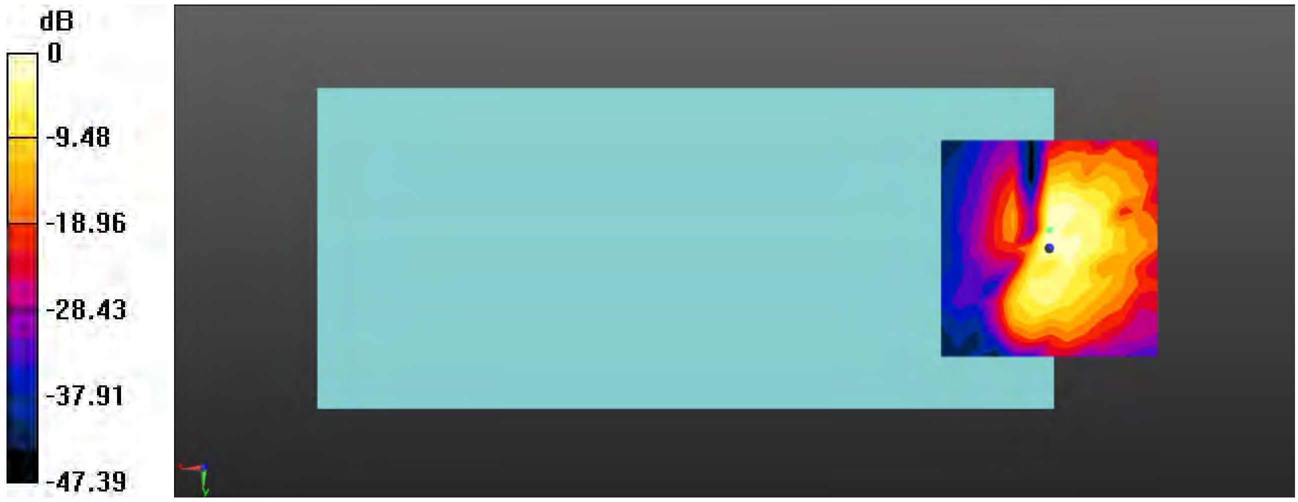
0 dB = 37.46 = 31.47 dB

HAC T-Coil_LTE Band 12_10M_16QAM_1RB_0Offset_Ch23095(Z)

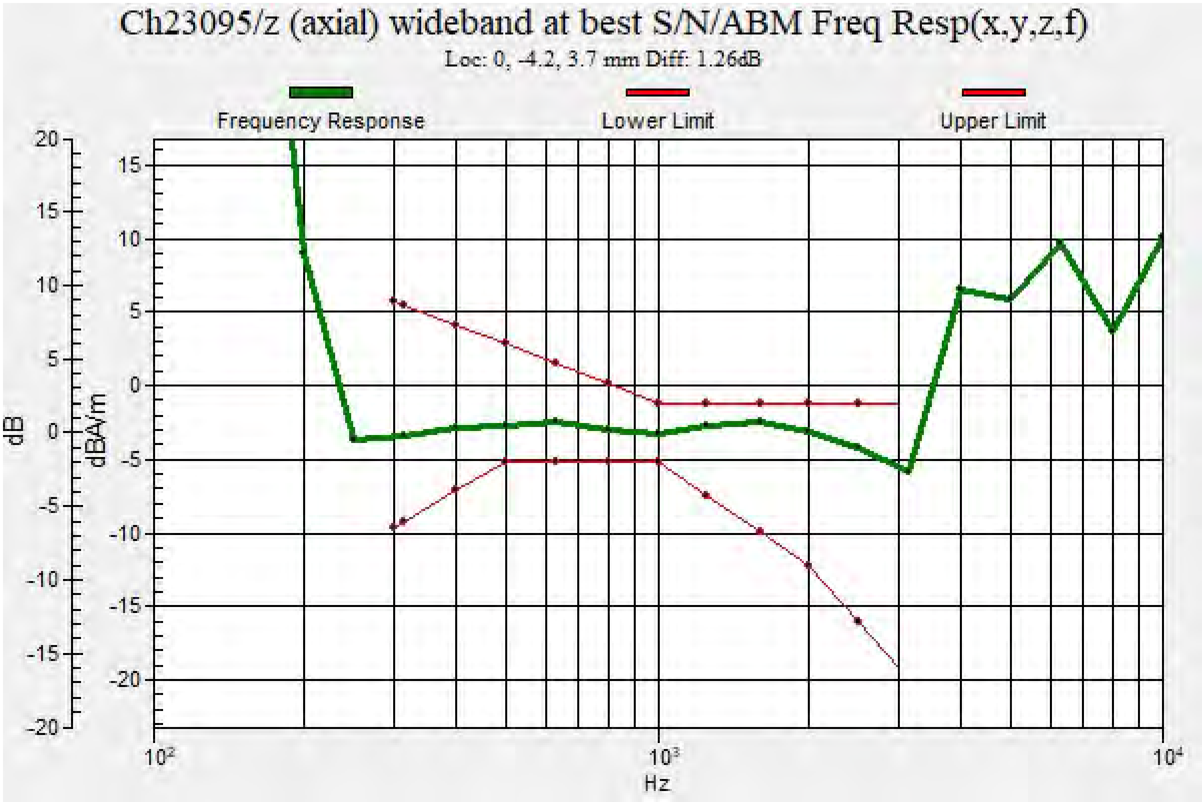
Communication System: UID 0, LTE-FDD (0); Frequency: 707.5 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 °C;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch23095/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 36.85 dB
ABM1 comp = -4.92 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 69.60 = 36.85 dB



Ch23095/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 1.26dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

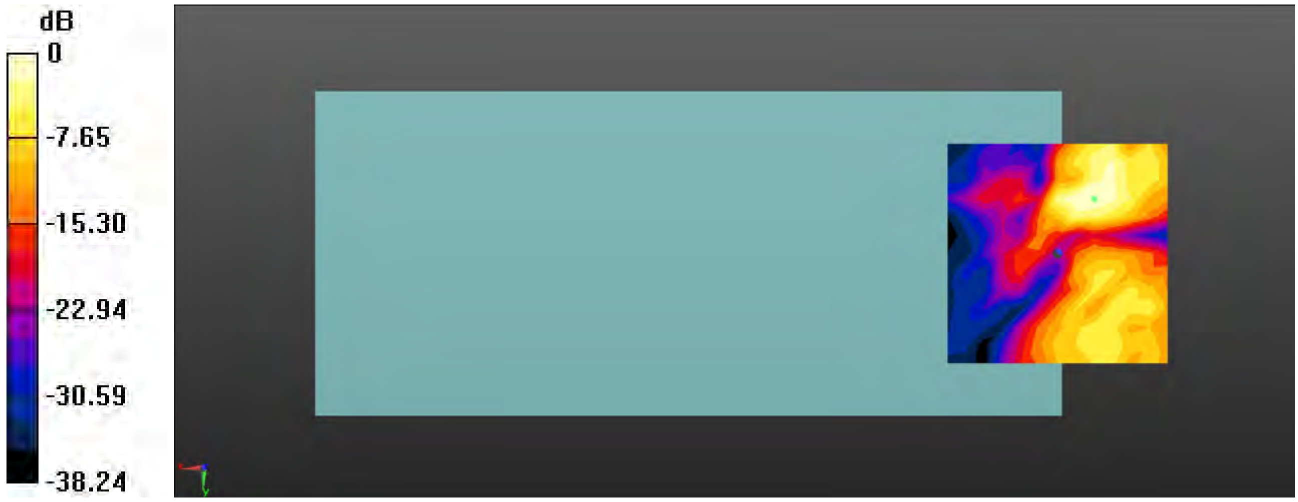
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab   Date: 2023/2/4

HAC T-Coil_LTE Band 12_10M_16QAM_1RB_0Offset_Ch23095(Y)

Communication System: UID 0, LTE-FDD (0); Frequency: 707.5 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch23095/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 29.39 dB
ABM1 comp = -14.76 dBA/m
Location: -8.3, -12.5, 3.7 mm



0 dB = 29.49 = 29.39 dB

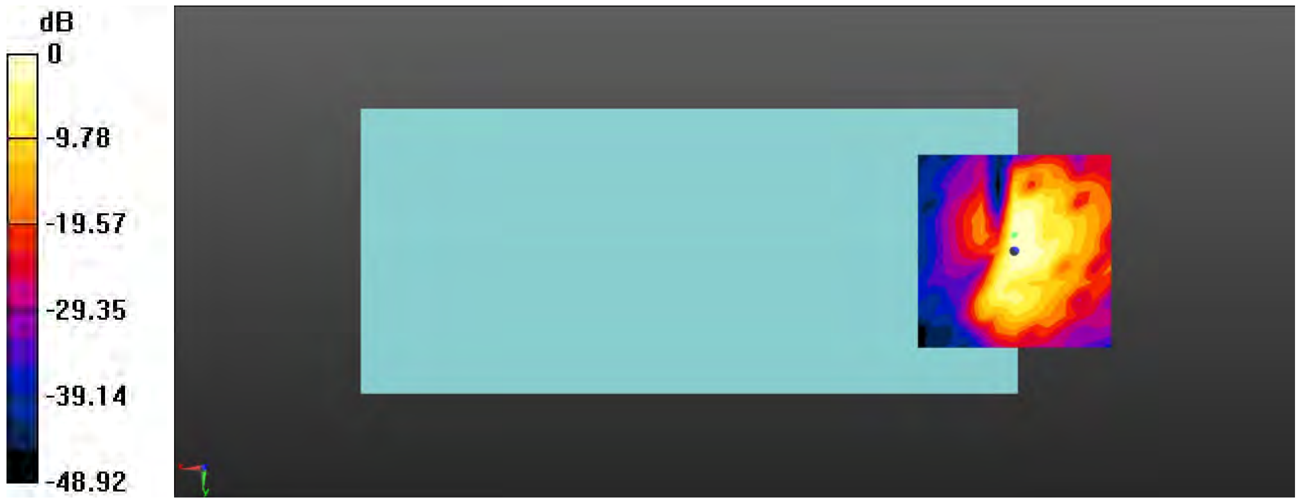
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil_LTE Band 66_20M_16QAM_1RB_0Offset_Ch132322(Z)

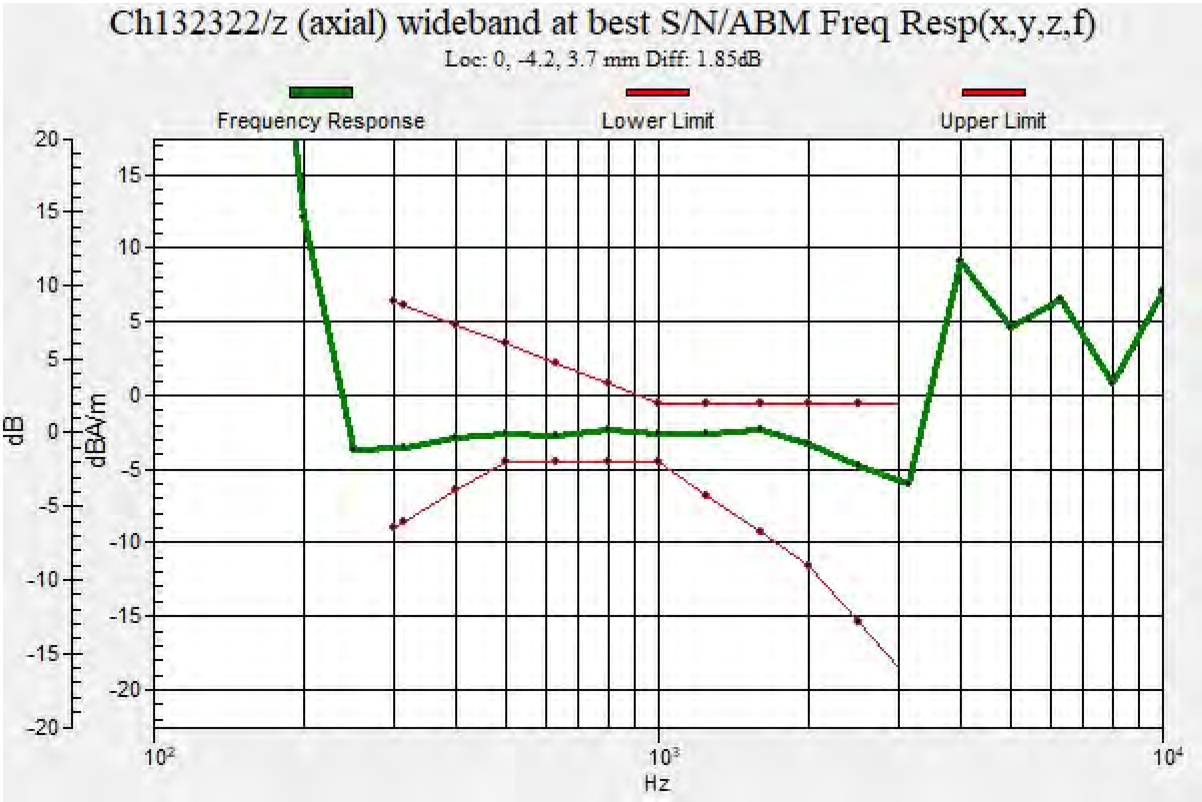
Communication System: UID 0, LTE-FDD (0); Frequency: 1745 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch132322/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 38.54 dB
ABM1 comp = -5.12 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 84.54 = 38.54 dB



Ch132322/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 1.85dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

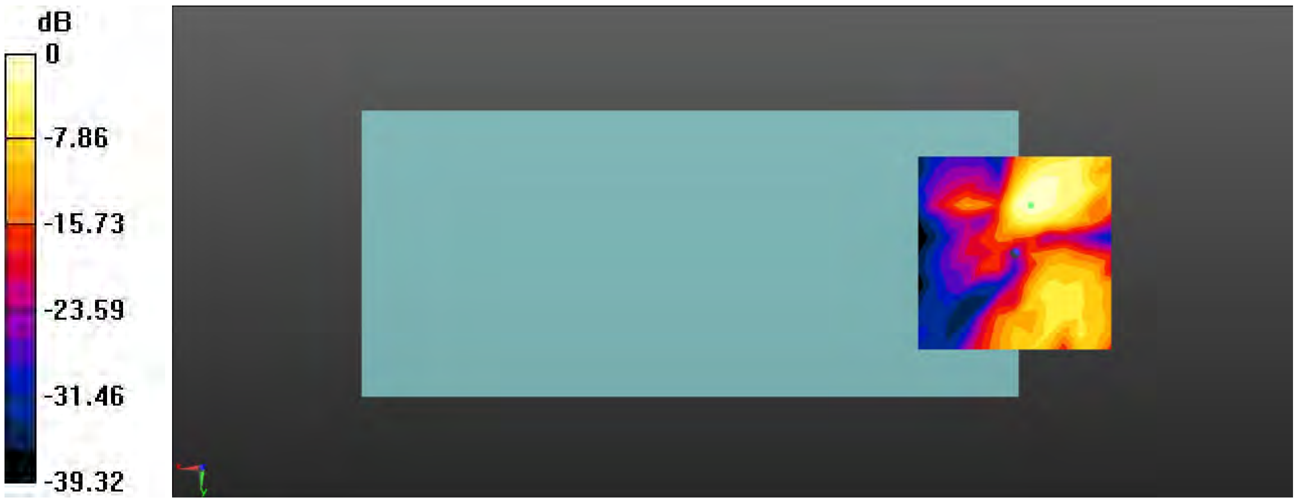
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/3

HAC T-Coil_LTE Band 66_20M_16QAM_1RB_0Offset_Ch132322(Y)

Communication System: UID 0, LTE-FDD (0); Frequency: 1745 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 0 kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch132322/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 30.59 dB
ABM1 comp = -14.09 dBA/m
Location: -4.2, -12.5, 3.7 mm



0 dB = 33.85 = 30.59 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2023/2/4

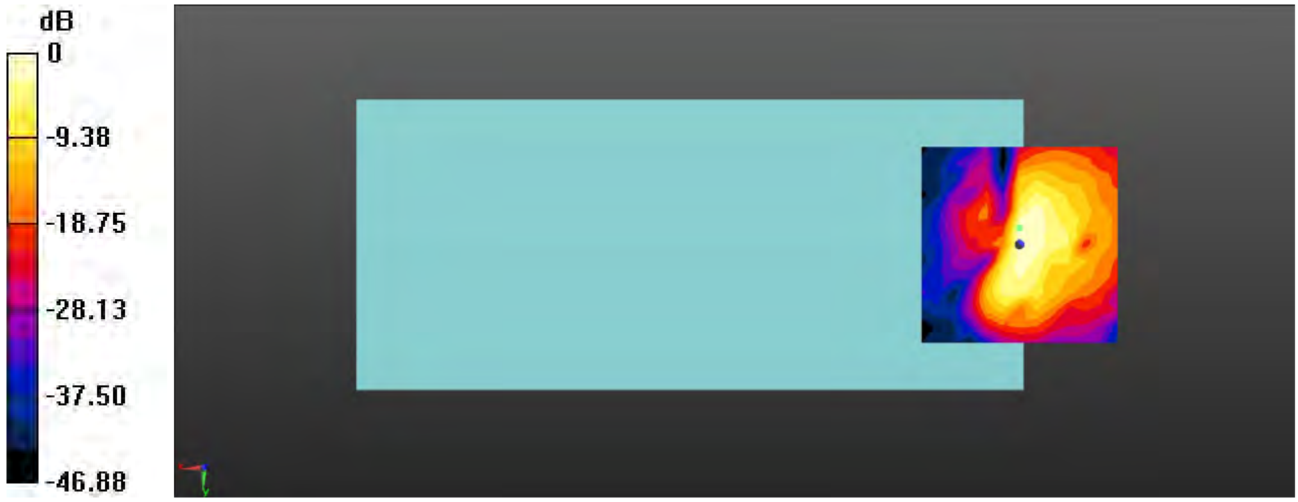
HAC T-Coil_LTE Band 71_20M_16QAM_1RB_0Offset_Ch133322(Z)

Communication System: UID 0, LTE-FDD (0); Frequency: 683 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3

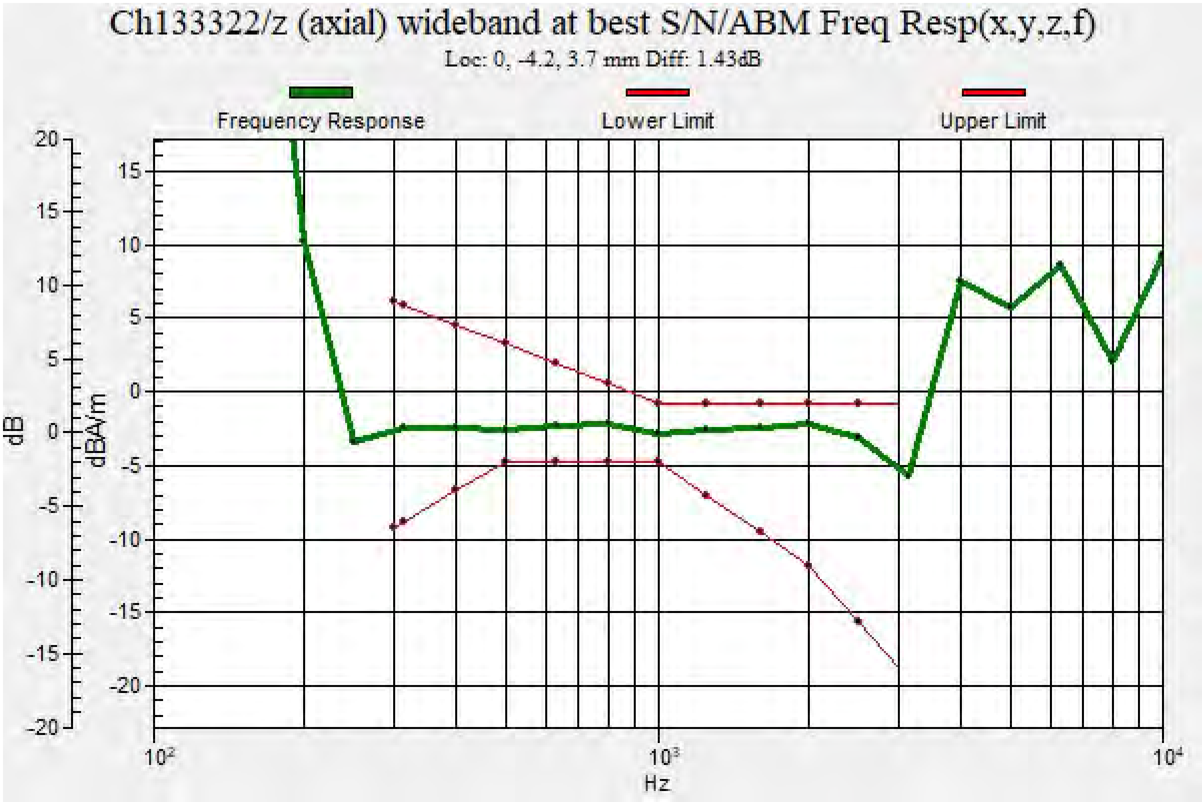
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch133322/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 37.53 dB
ABM1 comp = -4.98 dBA/m
Location: 0, -4.2, 3.7 mm



0 dB = 75.28 = 37.53 dB

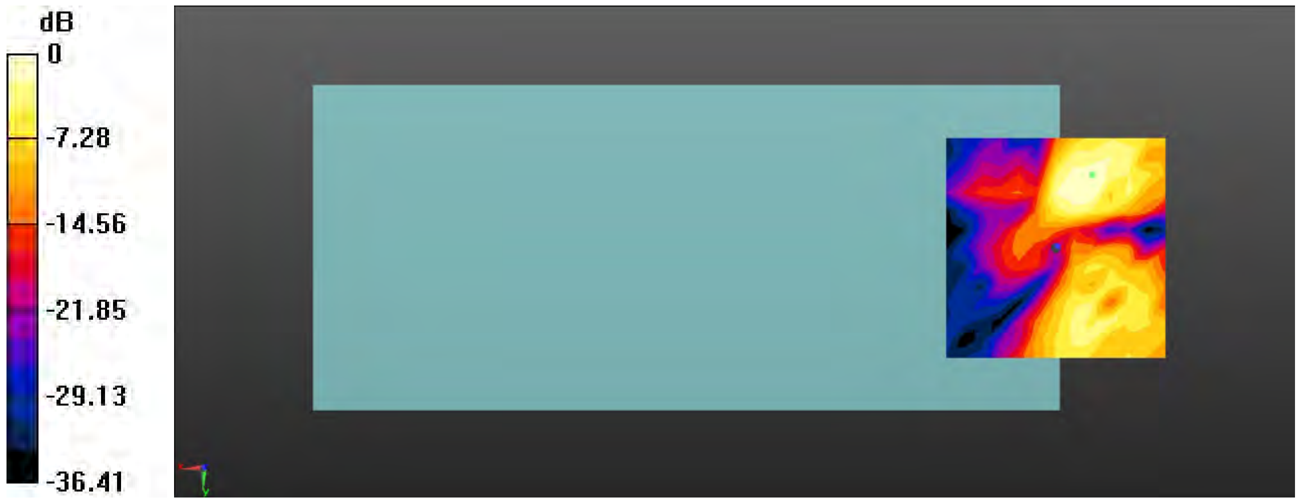

Ch133322/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, -4.2, 3.7 mm Diff: 1.43dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

HAC T-Coil_LTE Band 71_20M_16QAM_1RB_0Offset_Ch133322(Y)

Communication System: UID 0, LTE-FDD (0); Frequency: 683 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.3 ℃;

DASY5 Configuration:
- Probe: AM1DV3 - 3106; Calibrated: 2022/12/13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1650; Calibrated: 2022/8/5
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7501)

Ch133322/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.87 dB
ABM1 comp = -15.97 dBA/m
Location: -8.3, -16.7, 3.7 mm



0 dB = 24.75 = 27.87 dB

Appendix B. Calibration Data

The DASY calibration certificates are shown as follows.

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Sporton**

Certificate No: AM1DV3-3106_Dec22

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3106
Calibration procedure(s)	QA CAL-24.v4 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	December 13, 2022

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	29-Aug-22 (No. 34389)	Aug-23
Reference Probe AM1DV3	SN: 3000	29-Jul-22 (No. AM1DV3-3000_Jul22)	Jul-23
DAE4	SN: 781	22-Dec-21 (No. DAE4-781_Dec21)	Dec-22

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Oct-20)	Oct-23
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Oct-20)	Oct-23

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	[signature]
Approved by:	Sven Kühn	Technical Manager	[signature]

Issued: December 13, 2022

References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] ANSI-C63.19-2019 (ANSI-C63.19-2011)
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[3] DASY System Handbook

Description of the AM1D probe

The AM1D Audio Magnetic Field Probe is a fully shielded magnetic field probe for the frequency range from 100 Hz to 20 kHz. The pickup coil is compliant with the dimensional requirements of [1+2]. The probe includes a symmetric low noise amplifier for the signal available at the shielded 3 pin connector at the side. Power is supplied via the same connector (phantom power supply) and monitored via the LED near the connector. The 7 pin connector at the end of the probe does not carry any signals, but determines the angle of the sensor when mounted on the DAE. The probe supports mechanical detection of the surface.
The single sensor in the probe is arranged in a tilt angle allowing measurement of 3 orthogonal field components when rotating the probe by 120° around its axis. It is aligned with the perpendicular component of the field, if the probe axis is tilted nominally 35.3° above the measurement plane, using the connector rotation and sensor angle stated below.
The probe is fully RF shielded when operated with the matching signal cable (shielded) and allows measurement of audio magnetic fields in the close vicinity of RF emitting wireless devices according to [1+2] without additional shielding.

Handling of the item

The probe is manufactured from stainless steel. In order to maintain the performance and calibration of the probe, it must not be opened. The probe is designed for operation in air and shall not be exposed to humidity or liquids. For proper operation of the surface detection and emergency stop functions in a DASY system, the probe must be operated with the special probe cup provided (larger diameter).

Methods Applied and Interpretation of Parameters

- *Coordinate System:* The AM1D probe is mounted in the DASY system for operation with a HAC Test Arch phantom with AMCC Helmholtz calibration coil according to [3], with the tip pointing to "southwest" orientation.
- *Functional Test:* The functional test preceding calibration includes test of Noise level RF immunity (1kHz AM modulated signal). The shield of the probe cable must be well connected. Frequency response verification from 100 Hz to 10 kHz.
- *Connector Rotation:* The connector at the end of the probe does not carry any signals and is used for fixation to the DAE only. The probe is operated in the center of the AMCC Helmholtz coil using a 1 kHz magnetic field signal. Its angle is determined from the two minima at nominally +120° and –120° rotation, so the sensor in the tip of the probe is aligned to the vertical plane in z-direction, corresponding to the field maximum in the AMCC Helmholtz calibration coil.
- *Sensor Angle:* The sensor tilting in the vertical plane from the ideal vertical direction is determined from the two minima at nominally +120° and –120°. DASY system uses this angle to align the sensor for radial measurements to the x and y axis in the horizontal plane.
- *Sensitivity:* With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BB
Serial No	**3106**

Overall length	296 mm
Tip diameter	6.0 mm (at the tip)
Sensor offset	3.0 mm (centre of sensor from tip)
Internal Amplifier	20 dB

Manufacturer / Origin	Schmid & Partner Engineering AG, Zurich, Switzerland

Calibration data

Connector rotation angle	(in DASY system)	**53.5 °**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**-0.02 °**	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00787 V/(A/m)**	+/- 2.2 % (k=2)

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Schmid & Partner Engineering AG

s p e a g

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
www.speag.swiss, info@speag.swiss

IMPORTANT NOTICE

USAGE OF THE DAE4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE4 unit is fixed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:
Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:
Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:
To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S **Schweizerischer Kalibrierdienst**
C **Service suisse d'étalonnage**
S **Servizio svizzero di taratura**
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Sporton**

Certificate No: DAE4-1650_Aug22

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BO - SN: 1650
Calibration procedure(s)	QA CAL-06.v30 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	August 05, 2022

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-21 (No:31368)	Aug-22
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	24-Jan-22 (in house check)	In house check: Jan-23
Calibrator Box V2.1	SE UMS 006 AA 1002	24-Jan-22 (in house check)	In house check: Jan-23

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	i. V.

Issued: August 5, 2022

Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
    - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
    - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
    - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
    - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
    - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
    - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
    - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
    - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
    - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1μV , full range = -100...+300 mV

Low Range: 1LSB = 61nV , full range = -1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.915 ± 0.02% (k=2)	404.065 ± 0.02% (k=2)	404.330 ± 0.02% (k=2)
Low Range	3.99919 ± 1.50% (k=2)	4.00142 ± 1.50% (k=2)	3.99960 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	188.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199994.20	-1.16	-0.00
Channel X	+ Input	20003.06	0.84	0.00
Channel X	- Input	-19999.99	1.66	-0.01
Channel Y	+ Input	199996.79	1.29	0.00
Channel Y	+ Input	20001.52	-0.60	-0.00
Channel Y	- Input	-20002.28	-0.50	0.00
Channel Z	+ Input	199995.79	0.63	0.00
Channel Z	+ Input	20001.62	-0.44	-0.00
Channel Z	- Input	-20003.13	-1.35	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.56	0.20	0.01
Channel X	+ Input	201.63	0.01	0.01
Channel X	- Input	-198.11	0.08	-0.04
Channel Y	+ Input	2000.91	-0.25	-0.01
Channel Y	+ Input	200.92	-0.60	-0.30
Channel Y	- Input	-198.38	-0.02	0.01
Channel Z	+ Input	2001.03	-0.15	-0.01
Channel Z	+ Input	200.33	-1.12	-0.55
Channel Z	- Input	-199.16	-0.76	0.38

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-11.22	-12.84
	- 200	13.47	12.68
Channel Y	200	-6.04	-6.43
	- 200	4.95	5.26
Channel Z	200	-28.59	-28.64
	- 200	26.99	27.11

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	0.03	-2.62
Channel Y	200	4.74	-	0.86
Channel Z	200	8.90	3.18	-

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16116	16307
Channel Y	16150	16605
Channel Z	16180	15950

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.50	-0.67	2.34	0.53
Channel Y	-0.12	-1.08	0.89	0.35
Channel Z	-2.60	-3.51	-1.59	0.41

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

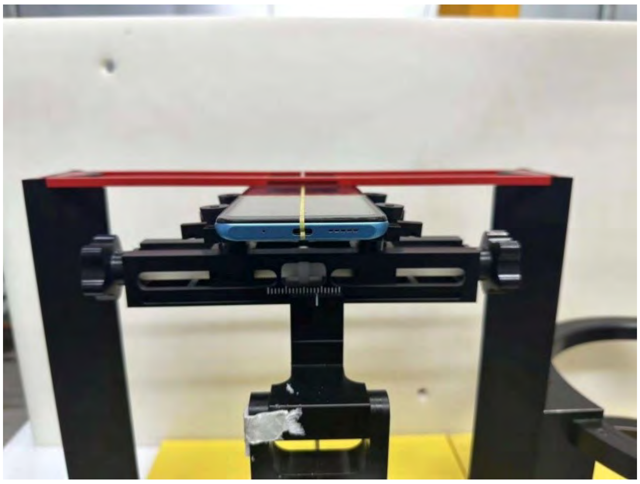
8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

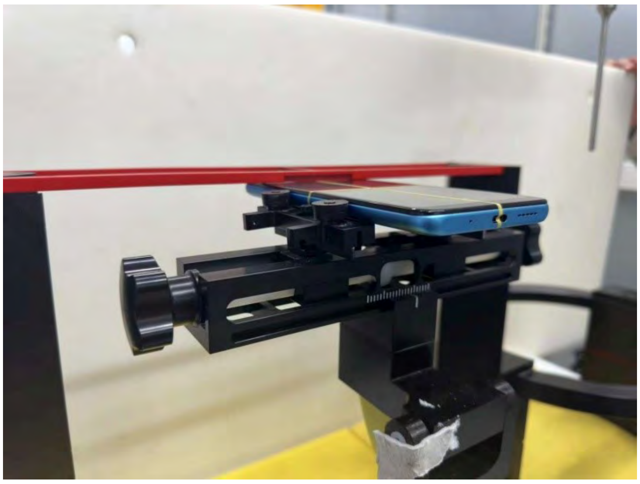
9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	–0.01	-8	-9

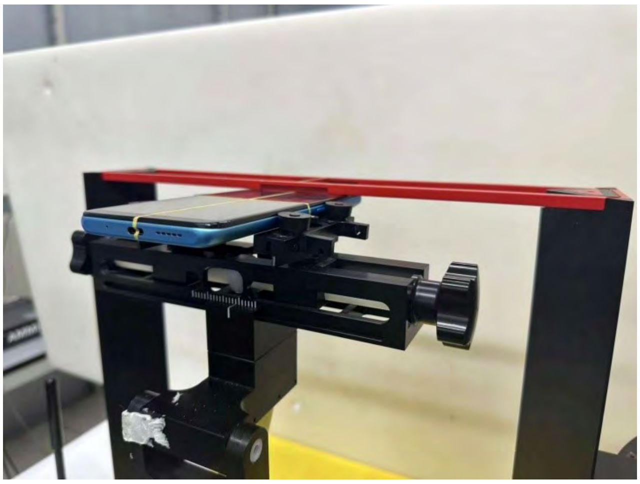
Appendix C. Test Setup Photos



Front View



Left Side View



Right Side View