HEARING AID COMPATIBILITY T-COIL TEST REPORT

FCC ID	: 2AJOTTA-1093
Equipment	: GSM/WCDMA/LTE Mobile Phone
Brand Name	: Nokia
T-Rating	: T3
Applicant	: HMD Global Oy Karaportti 2 02610 Espoo FINLAND
Manufacturer	: HMD Global Oy Karaportti 2 02610 Espoo FINLAND
Standard	: FCC 47 CFR §20.19 ANSI C63.19-2011

We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the 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 INTERTIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.

Jones Tsai

Approved by: Jones Tsai / Manager

SPORTON INTERTIONAL 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
HA832104-01B	Rev. 01	Initial issue of report	Jun. 13, 2018

1. General Information

Product Feature & Specification	
Applicant Name	HMD Global Oy
Equipment Name	GSM/WCDMA/LTE Mobile Phone
Brand Name	Nokia
FCC ID	2AJOTTA-1093
HW Version	HW0343
SW Version	000C_0_146
EUT Stage	Identical prototype
Exposure category	General Population/Uncontrolled Exposure
Date Tested	2018/05/17 ~ 2018/06/08
Frequency Band	GSM850: 824.2 MHz ~ 848.8 MHz GSM1900: 1850.2 MHz ~ 1909.8 MHz WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz WCDMA Band IV: 1712.4 MHz ~ 1752.6 MHz WCDMA Band V: 826.4 MHz ~ 846.6 MHz LTE Band 2: 1850.7 MHz ~ 1909.3 MHz LTE Band 4 : 1710.7 MHz ~ 1754.3 MHz LTE Band 5: 824.7 MHz ~ 848.3 MHz LTE Band 7: 2502.5 MHz ~ 2567.5 MHz LTE Band 12: 699.7 MHz ~ 715.3 MHz LTE Band 13: 779.5 MHz ~ 784.5 MHz LTE Band 17: 706.5 MHz ~ 713.5 MHz LTE Band 38: 2572.5 MHz ~ 2617.5 MHz LTE Band 66: 1710.7 MHz ~ 1779.3 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Mode	GSM/GPRS/EGPRS RMC/AMR 12.2Kbps HSDPA HSUPA HSPA+ (16QAM uplink is not supported) LTE: QPSK, 16QAM WLAN 2.4GHz : 802.11b/g/n HT20/HT40 Bluetooth v3.0+EDR, Bluetooth v4.0 LE, Bluetooth v4.1 LE, Bluetooth v4.2 LE

Remark: This is a change ID application base on FCC ID: 2AJOTTA-1084(Sporton report number HA832104B), TA-1093 is single SIM card mobile and original model TA-1084 is dual SIM cards mobile. We evaluate that there has no effect on HAC distribution, so all the test results release from original report which can be referred to Sporton report number HA832104B, FCC ID: 2AJOTTA-1084).

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.) TEL: +886-3-327-3456 FAX: +886-3-328-4978
Test Site No.	Sporton Site No.: **SAR04-HY**

3. Applied Standards

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

4. 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	Google Duo(1) / SIP calling(1,2)	No
	EDGE1900					
UMTS	850	VO	Yes	WLAN, BT	CMRS Voice	No
	1750			WLAN, BT		No
	1900			WLAN, BT		No
	HSPA	VD	Yes	WLAN, BT	Google Duo(1) / SIP calling(1,2)	No
LTE (FDD)	Band 2	VD	Yes	WLAN, BT	VoLTE / Google Duo(1) / SIP calling(1,2)	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 66			WLAN, BT		No
LTE (TDD)	Band 38	VD	Yes	WLAN, BT	VoLTE / Google Duo(1) / SIP calling(1,2)	No
Wi-Fi	2450	VD	Yes	GSM,WCDMA,LTE	Google Duo(1) / SIP calling(1,2)	No
						No
BT	2450	DT	No	GSM,WCDMA,LTE	NA	No

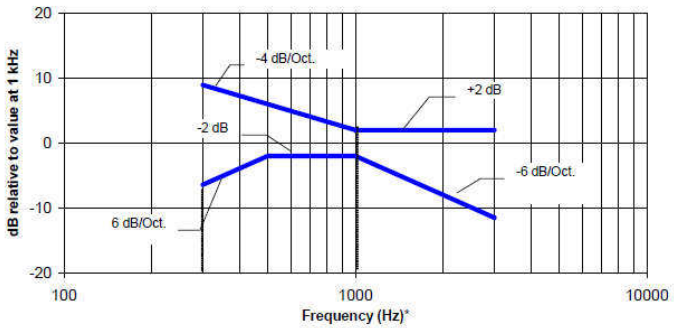
Type Transport:
VO= Voice only
DT= Digital Transport only (no voice)
VD= CMRS and IP Voice Service over Digital Transport

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 SIP calling is android internal auxiliary functions under the dialing program.

5. Measurement standards for T-Coil

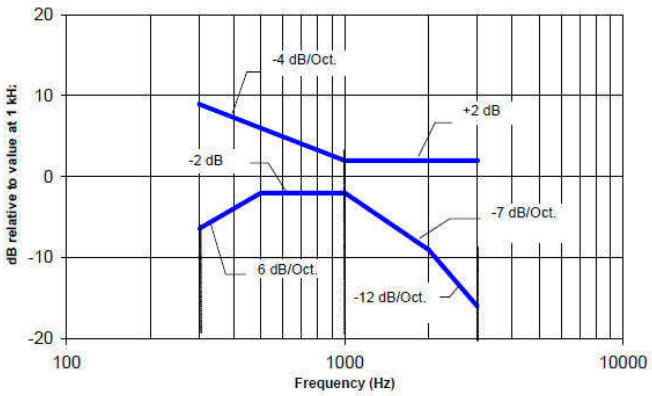
5.1 Frequency Response

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

5.2 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. 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.

6.1 Test Flow Chart

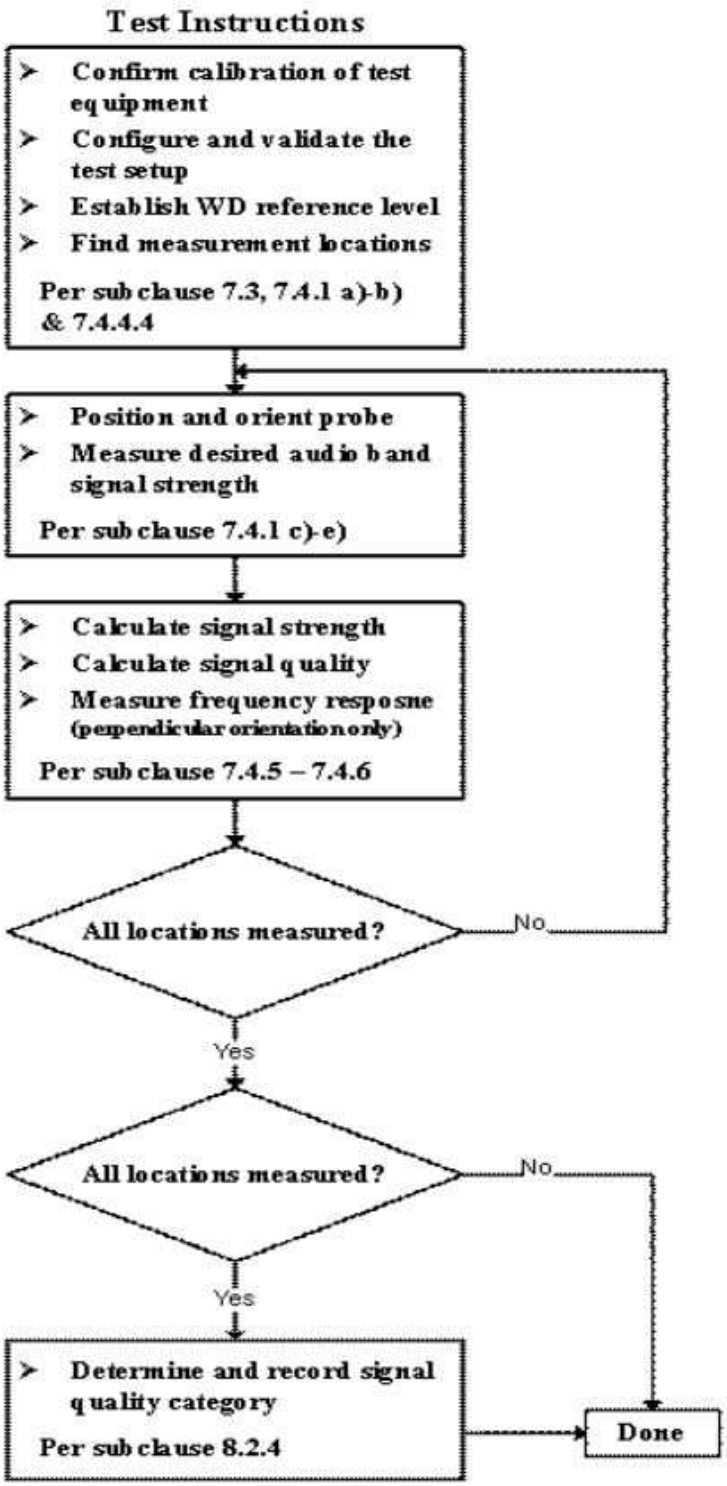
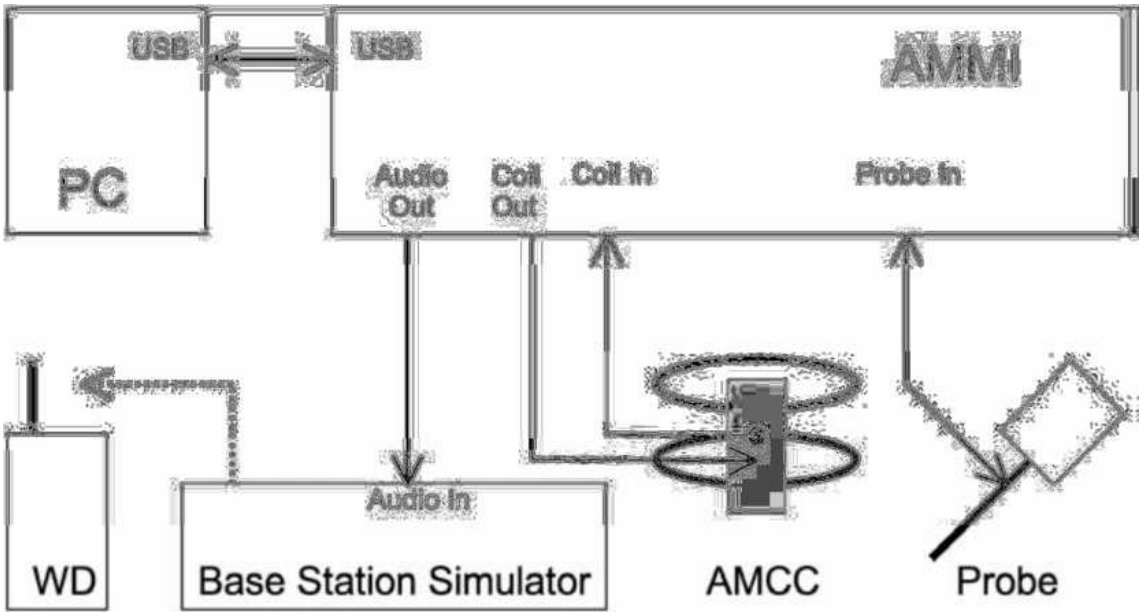


Fig. 2 T-Coil Signal Test flowchart

6.2 Test Setup Diagram



General Note:

1. Define the all applicable input audio level as below according to C63.19 and KDB 285076 D02v03:
   - GSM input level: -16dBm0
   - UMTS input level: -16dBm0
   - VoLTE input level: -16dBm0
   - OTT VoIP input Level: -20dBm0
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. 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.
5. The test setup used for Google DUO VoIP call is via the data application unit on CMW500 connection to the Internet, also connection to the other auxiliary VoIP unit which is used to configure the audio codec and bit rate and also monitor the audio input level of -20dBm0.

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.

Calculation formula:
- Audio Level at -16dBm0 = ((-16dBm0) – (3.14dBm0)) + X dBv
- Calculated Gain at -16dBm0 = 10((audio level at -16dBm0 – Y dBm0) / 20) * 10
- Gatting setting at -16dBm0 = required gain factor * calculated gain

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

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.

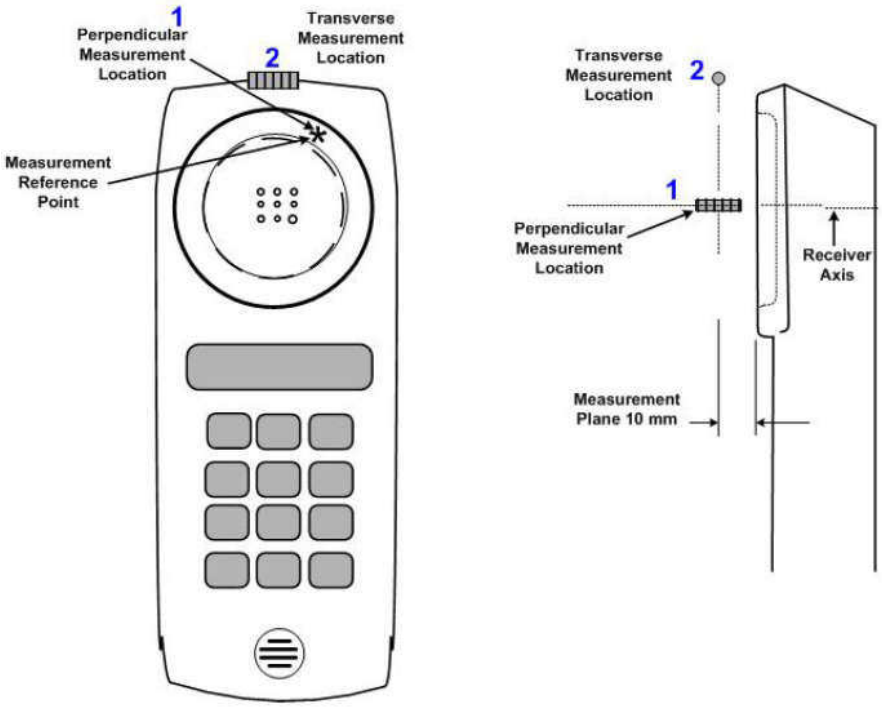


Fig.3 A typical EUT reference and plane for T-Coil measurements

7. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Data Acquisition Electronics	DAE4	1386	Jul. 20, 2017	Jul. 19, 2018
SPEAG	Data Acquisition Electronics	DAE4	1279	Jan. 03, 2018	Jan. 02, 2019
SPEAG	Data Acquisition Electronics	DAE4	1424	Jan. 18, 2018	Jan. 17, 2019
SPEAG	Audio Magnetic 1D Field Probe	AM1DV3	3106	Nov. 28, 2017	Nov. 27, 2018
SPEAG	Active Audio Magnetic Field Probe	AM1DV3	3128	Dec. 20, 2017	Dec. 19, 2018
SPEAG	Audio Magnetic 1D Field Probe	AM1DV3	3130	Nov. 21, 2017	Nov. 20, 2018
SPEAG	Audio Magnetic Calibration Coil	AMCC	1049	NCR	NCR
SPEAG	Audio Measuring Instrument	AMMI	1041	NCR	NCR
VICTOR	Temperature and humidity meter	VC230	H-3	Apr. 15, 2018	Apr. 14, 2019
SPEAG	Test Arch Phantom	N/A	N/A	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR
Anritsu	Power Senor	MA2411B	1306099	Aug. 21, 2017	Aug. 20, 2018
Anritsu	Power Meter	ML2495A	1349001	Jul. 19, 2017	Jul. 18, 2018
Anritsu	Radio communication analyzer	MT8820C	6201300653	Jul. 19, 2017	Jul. 18, 2018
R&S	Base Station(Measure)	CMU200	112569	Sep. 10, 2017	Sep. 09, 2018
R&S	Base Station(Measure)	CMU500	S110702JGE02	Jul. 19, 2017	Jul. 18, 2018

Note: NCR: “No-Calibration Required”

8. T-Coil testing for CMRS Voice

General Note:

1. The middle channel of each frequency band is used for T-Coil testing according ANSI C63.19 2011.
2. For VoLTE radio configuration investigation is choose either one codec and an investigation was performed on all frequency band, data rates and modulations and RB configuration to determine the radio configuration to be used for testing, the following tests results which the worst case configuration would be remarked to be used for the testing for the handset.
3. Choose worst case from radio configuration investigation. After investigation was performed to determine the audio codec configuration to be used for testing, the following tests results which the worst case codec would be remarked to be used for the testing for the handset.

8.1 GSM Tests Results

<Codec Investigation>

Codec	FR V1	HR V1	Orientation	Band / Channel
ABM 1 (dBA/m)	4.00	3.40	Axial	GSM850 / 189
ABM 2 (dBA/m)	-20.74	-21.62		
Freq. Response	Pass	Pass		
Signal Quality (dB)	24.74	25.02		

<Summary Tests Results>

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(speech codec handset low)	189	Axial (Z)	4.00	-20.74	24.74	T3	-50.33	2	Pass
				Transversal (Y)	-10.05	-36.60	26.55	T3	-50.23		
2	GSM1900	Voice(speech codec handset low)	661	Axial (Z)	4.13	-23.26	27.39	T3	-50.29	2	Pass
				Transversal (Y)	-9.64	-39.05	29.41	T3	-50.18		

8.2 UMTS Tests Results

<Codec Investigation>

Codec	AMR 4.75Kbps	AMR 7.95Kbps	AMR 12.2Kbps	Orientation	Band / Channel
ABM 1 (dBA/m)	-2.94	-3.03	-3.06	Axial	Band 5 / 4182
ABM 2 (dBA/m)	-46.45	-46.45	-46.4		
Freq. Response	Pass	Pass	Pass		
Signal Quality (dB)	43.51	43.42	43.34		

<Summary Tests Results>

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 V	Voice (speech codec low)	4182	Axial (Z)	2.49	-42.82	45.31	T4	-50.30	1.86	Pass
				Transversal (Y)	-5.77	-48.03	42.26	T4	-50.25		
4	WCDMA IV	Voice (speech codec low)	1413	Axial (Z)	2.91	-41.97	44.88	T4	-50.21	1.65	Pass
				Transversal (Y)	-6.17	-47.93	41.76	T4	-50.27		
5	WCDMA II	Voice (speech codec low)	9400	Axial (Z)	-5.32	-43.10	37.78	T4	-50.35	1.92	Pass
				Transversal (Y)	-10.02	-44.40	34.38	T4	-50.23		

8.3 VoLTE Tests Results

<Radio Configuration Investigation>

Air Interface	Bandwidth (MHz)	Modulation	RB size	RB offset	channel	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality (dB)
LTE Band 2	20	QPSK	1	0	18900	0.56	-42.23	42.79
LTE Band 2	20	QPSK	50	0	18900	1.96	-41.03	42.99
LTE Band 2	20	QPSK	100	0	18900	1.70	-43.17	44.87
LTE Band 2	20	16QAM	1	0	18900	1.98	-42.22	44.20
LTE Band 2	15	QPSK	1	0	18900	2.14	-42.83	44.97
LTE Band 2	10	QPSK	1	0	18900	2.00	-43.08	45.08
LTE Band 2	5	QPSK	1	0	18900	1.93	-43.20	45.13
LTE Band 2	3	QPSK	1	0	18900	1.91	-42.85	44.76
LTE Band 2	1.4	QPSK	1	0	18900	2.08	-42.68	44.76

<AMR Codec Investigation>

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	0.35	1.78	-0.03	Axial	B2 / 20M / 18900
ABM 2 (dBA/m)	-42.23	-42.95	-42.94	-43.02		
Freq. Response	Pass	Pass	Pass	Pass		
Signal Quality (dB)	42.79	43.30	44.72	42.99		

<EVS Codec Investigation>

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)	0.03	1.67	0.64	0.81	0.73	1.58	Axial	B2 / 20M / 18900
ABM 2 (dBA/m)	-43.51	-41.68	-42.13	-42.16	-42.56	-41.49		
Freq. Response	Pass	Pass	Pass	Pass	Pass	Pass		
Signal Quality (dB)	43.54	43.35	42.77	42.97	43.29	43.07		

<Summary Tests Results>

Plot No.	Air Interface	BW (MHz)	Modulation	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	QPSK	1	0	18900	Axial (Z)	0.64	49.35	42.77	T4	-48.71	2	Pass
							Transversal (Y)	-5.57	42.98	38.28	T4	-48.55		
7	LTE Band 4	20	QPSK	1	0	20175	Axial (Z)	1.09	50.10	42.76	T4	-49.01	2	Pass
							Transversal (Y)	-8.02	40.93	36.86	T4	-48.95		
8	LTE Band 5	10	QPSK	1	0	20525	Axial (Z)	-0.05	48.63	43.45	T4	-48.68	2	Pass
							Transversal (Y)	-8.45	40.31	38.61	T4	-48.76		
9	LTE Band 7	20	QPSK	1	0	21100	Axial (Z)	0.84	49.79	43.05	T4	-48.95	2	Pass
							Transversal (Y)	-6.11	42.61	38.42	T4	-48.72		
10	LTE Band 12	10	QPSK	1	0	23095	Axial (Z)	2.25	51.30	42.45	T4	-49.05	2	Pass
							Transversal (Y)	-7.91	40.85	38.64	T4	-48.76		
11	LTE Band 13	10	QPSK	1	0	23230	Axial (Z)	1.52	50.22	42.57	T4	-48.70	2	Pass
							Transversal (Y)	-7.45	41.10	38.74	T4	-48.55		
12	LTE Band 17	10	QPSK	1	0	23790	Axial (Z)	0.60	49.51	42.04	T4	-48.91	2	Pass
							Transversal (Y)	-10.37	38.43	37.61	T4	-48.80		
13	LTE Band 66	20	QPSK	1	0	132322	Axial (Z)	0.36	49.43	42.33	T4	-49.07	2	Pass
							Transversal (Y)	-8.84	39.94	36.67	T4	-48.78		
14	LTE Band 38	20	QPSK	1	0	38000	Axial (Z)	3.69	52.48	35.63	T4	-48.79	1.98	Pass
							Transversal (Y)	-12.87	35.82	30.20	T4	-48.69		

9. T-Coil testing for OTT VoIP Calling

General Notes:

1. The Google Duo VoIP call software is pre-installed on this device and head-to-ear scenario should be consideration, the Google Duo only support OPUS audio codec and support 6Kbpa to 75Kbps bitrate. According to KDB 285076 D02, all air interfaces via a data connection with google hangouts VoIP calling would be consideration to be tested.
2. The test setup used for Google Duo VoIP call is via the data application unit on CMW500 connection to the Internet, also connection to the other auxiliary VoIP unit which is used to configure the audio codec and bit rate and also monitor the audio input level of -20dBm0.
3. The SIP VoIP application software is pre-installed on this device and head-to-ear scenario should be consideration, the SIP VoIP application support several audio codecs as below table. According to KDB 285076 D02, all air interfaces via a data connection with SIP VoIP calling would be consideration to be tested.
4. The test setup used for SIP VoIP application is via the data application unit on CMW500 connection to the Internet, also connection to the other auxiliary VoIP unit which is used to configure the audio codec and bit rate and can be determined the audio input level of -20dBm0.
5. According to VoLTE radio configuration investigation, the worst case radio configuration is used for OTT over LTE testing.
6. For OTT over WiFi radio configuration investigation is choose either one codec and an investigation was performed on in each data rates and modulations to determine the radio configuration to be used for testing, the following tests results which the worst case configuration would be remarked to be used for the testing for the handset.
7. For OTT VoIP codec investigation test reduction, due to all air interface have the same codec configuration, therefore, the codec investigation was choose UMTS Band 2 to determine the audio codec configuration to be used for others air interfaces testing.

9.1 OTT over GSM

<Google Duo Codec Investigation>

Codec	Bitrate 6Kbps	Bitrate 40Kbps	Bitrate 75Kbps	Orientation	Band / Channel
ABM 1 (dBA/m)	0.46	0.89	0.4	Axial	UMTS B2 / 9400
ABM 2 (dBA/m)	-35.96	-35.03	-35.3		
Signal Quality (dB)	36.42	35.92	35.7		
Freq. Response	PASS	PASS	PASS		

<SIP Codec Investigation>

VoIP Codec(SIP)							
Codec	GSM 8 kHz	GSM -EFR	AMR 8 kHz	G.711 A-law	G.711 u-law	Orientation	Band / Channel
ABM 1 (dBA/m)	-1.87	-2.88	-2.71	-0.41	-1.7	Axial	UMTS B2 / 9400
ABM 2 (dBA/m)	-36.23	-37.32	-37.44	-35.32	-35.81		
Signal Quality (dB)	34.36	34.44	34.73	34.91	34.11		
Freq. Response	PASS	PASS	PASS	PASS	PASS		

<Radio Configuration Investigation>

Air Interface	Bandwidth (MHz)	Data Rate	channel	ABM1 dB (A/m)	ABM2 dB (A/m)	Signal Quality (dB)
WLAN2.4GHz	802.11b	1Mbps	6	-1.70	-33.14	31.44
WLAN2.4GHz	802.11b	11Mbps	6	-1.21	-33.70	32.49
WLAN2.4GHz	802.11g	6Mbps	6	-1.73	-33.64	31.91
WLAN2.4GHz	802.11g	54Mbps	6	-1.94	-33.63	31.69
WLAN2.4GHz	802.11n-HT20	MCS0	6	-1.78	-33.42	31.64
WLAN2.4GHz	802.11n-HT20	MCS7	6	-1.38	-33.19	31.81
WLAN2.4GHz	802.11n-HT40	MCS0	6	-1.65	-33.23	31.58
WLAN2.4GHz	802.11n-HT40	MCS7	6	-1.15	-33.14	31.99

<Summary Tests Results>

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
15	GSM850	EDGE 2 Tx slots	189	Axial (Z)	-1.65	-25.29	23.64	T3	-50.28	2	Pass
				Transversal (Y)	-10.02	-34.61	24.59	T3	-50.18		
16	GSM1900	EDGE 2 Tx slots	661	Axial (Z)	-2.19	-26.00	23.81	T3	-50.30	2	Pass
				Transversal (Y)	-10.18	-34.82	24.64	T3	-50.21		
17	WCDMA II	HSPA	9400	Axial (Z)	-1.70	-35.81	34.11	T4	-50.33	2	Pass
				Transversal (Y)	-11.22	-43.97	32.75	T4	-50.22		
18	WCDMA IV	HSPA	1413	Axial (Z)	-4.42	-36.42	32.00	T4	-50.35	2	Pass
				Transversal (Y)	-11.91	-43.69	31.78	T4	-50.25		
19	WCDMA V	HSPA	4182	Axial (Z)	-2.92	-37.12	34.20	T4	-50.29	1.89	Pass
				Transversal (Y)	-9.53	-43.12	33.59	T4	-50.18		
20	LTE Band 66	20M_QPSK_1_0	132322	Axial (Z)	-2.54	-33.73	31.19	T4	-50.25	2	Pass
				Transversal (Y)	-9.15	-40.14	30.99	T4	-50.15		
21	LTE Band 38	20M_ QPSK_1_0	38000	Axial (Z)	-2.02	-29.18	27.16	T3	-50.36	1.86	Pass
				Transversal (Y)	-8.95	-32.16	23.21	T3	-50.24		
22	WLAN2.4GHz	802.11b 1Mbps	6	Axial (Z)	-1.57	-34.11	32.54	T4	-50.36	2	Pass
				Transversal (Y)	-10.26	-37.93	27.67	T3	-50.22		

Remark:

1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.
3. Test Engineer: Tom Jiang Galen Chang Iran Wang and Steven Chang

10. 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.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (ABM1)	Ci (ABM2)	Standard Uncertainty (ABM1)	Standard Uncertainty (ABM2)
Probe Sensitivity							
Reference Level	3.0	Normal	1	1	1	± 3.0 %	± 3.0 %
AMCC Geometry	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %
AMCC Current	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Probe Positioning During Calibrate	0.1	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Noise Contribution	0.7	Rectangular	√3	0.0143	1	± 0.0 %	± 0.4 %
Frequency Slope	5.9	Rectangular	√3	0.1	1	± 0.3 %	± 3.5 %
Probe System							
Repeatability / Drift	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Linearity / Dynamic Range	0.6	Rectangular	√3	1	1	± 0.4 %	± 0.4 %
Acoustic Noise	1.0	Rectangular	√3	0.1	1	± 0.1 %	± 0.6 %
Probe Angle	2.3	Rectangular	√3	1	1	± 1.4 %	± 1.4 %
Spectral Processing	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	0.6	Normal	1	1	5	± 0.6 %	± 3.0 %
Field Disturbation	0.2	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Test Signal							
Reference Signal Spectral Response	0.6	Rectangular	√3	0	1	± 0.0 %	± 0.4 %
Positioning							
Probe Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
Phantom Thickness	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
EUT Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
External Contributions							
RF Interference	0.0	Rectangular	√3	1	0.3	± 0.0 %	± 0.0 %
Test Signal Variation	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %
Combined Standard Uncertainty						± 4.1 %	± 6.1 %
Coverage Factor for 95 %						K = 2	
Expanded Uncertainty						± 8.1 %	± 12.3 %

Table 8.2 Uncertainty Budget of audio band magnetic measurement

11. References

[1] ANSI C63.19-2011, “American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids”, 27 May 2011.

[2] FCC KDB 285076 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

Appendix A. Plots of T-Coil Measurement

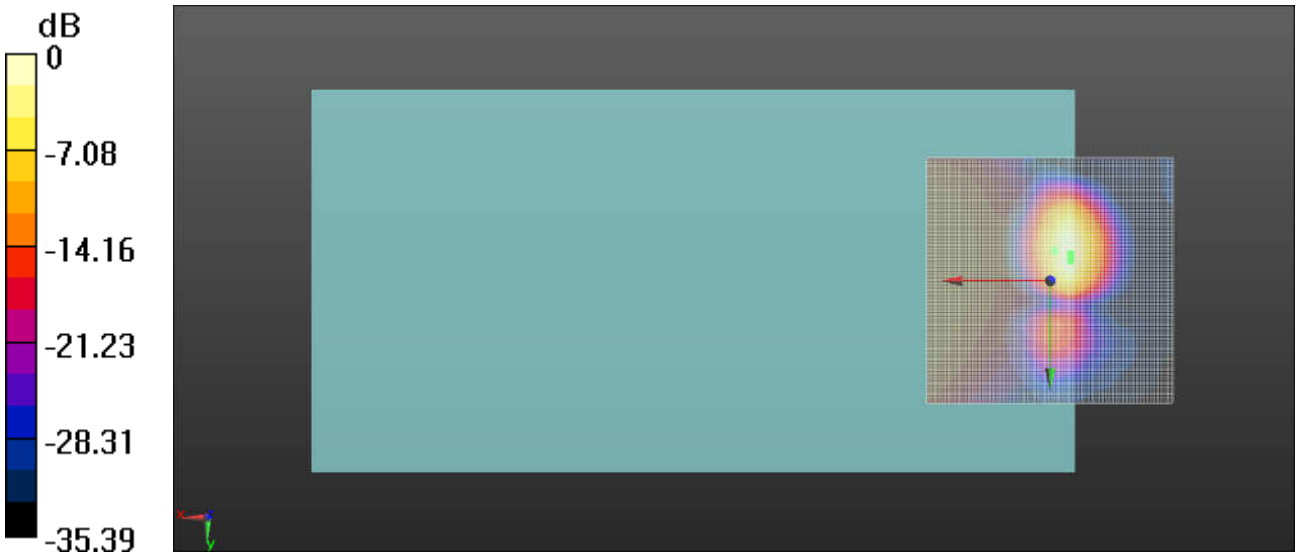
The plots are shown as follows.

01_HAC T-Coil_GSM850_Voice_Ch189_Z

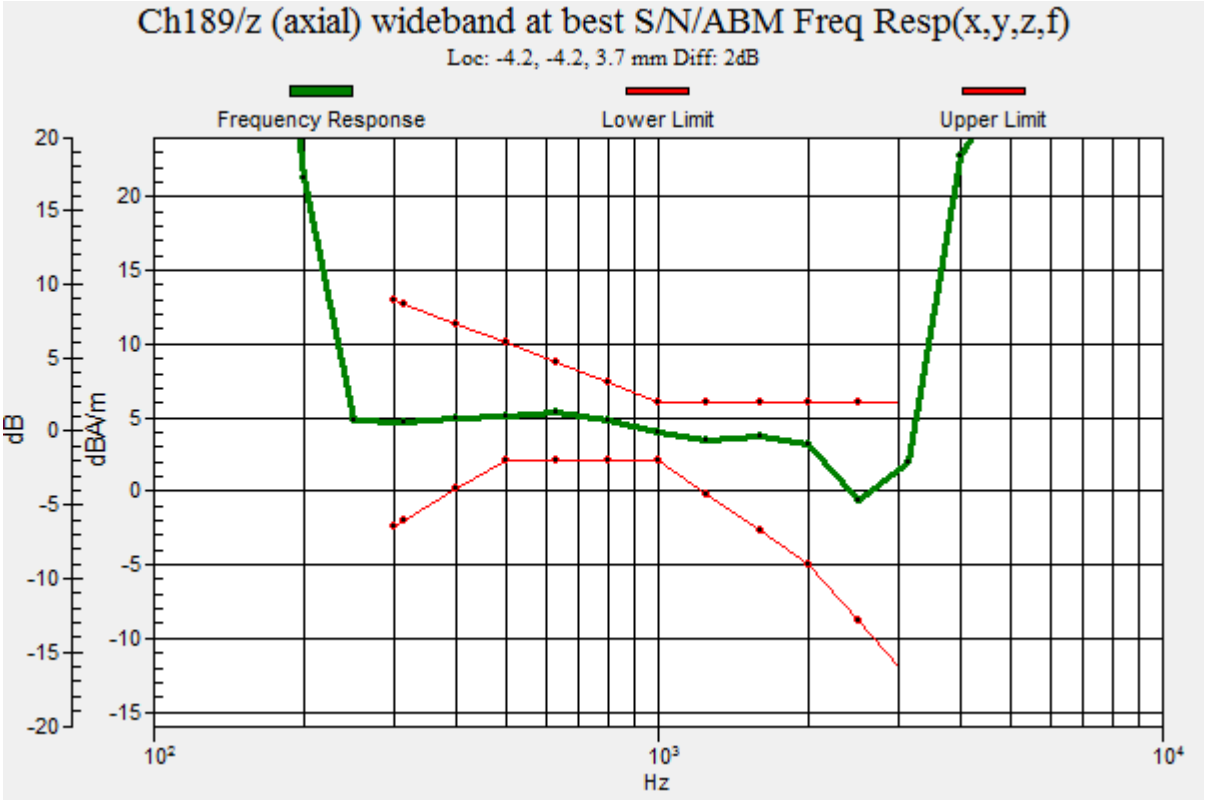
Communication System: UID 0, Generic GSM (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch189/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 24.74 dB
ABM1 comp = 4.00 dBA/m
BWC Factor = 0.16 dB
Location: -4.2, -5.4, 3.7 mm



0 dB = 1.831 A/m = 5.25 dBA/m


Ch189/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

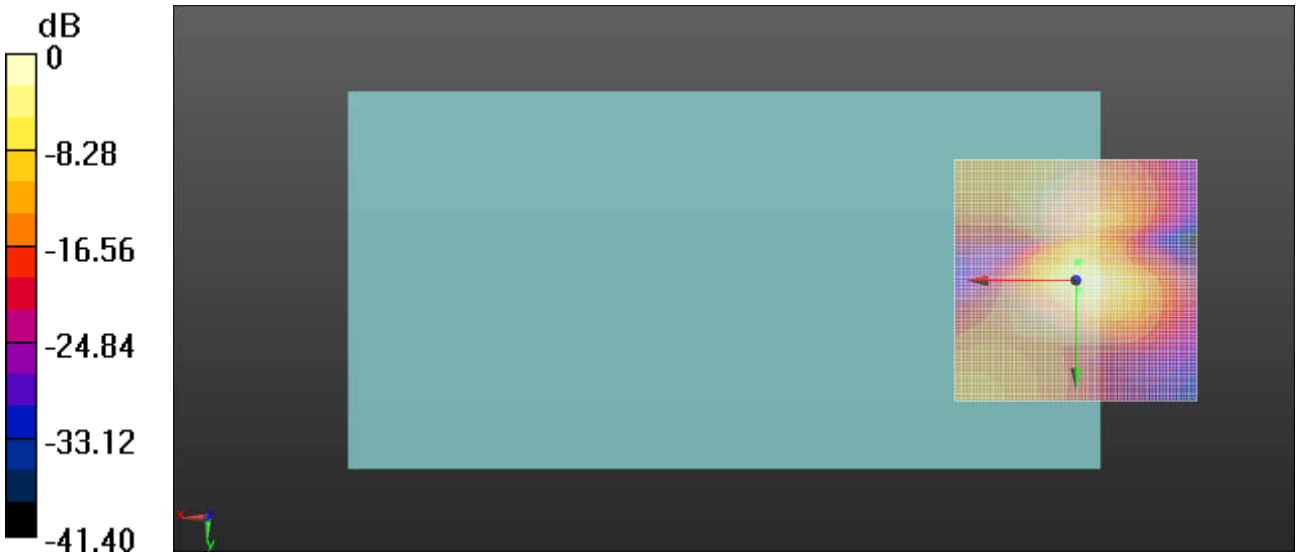
01_HAC T-Coil_GSM850_Voice_Ch189_Y

Communication System: UID 0, Generic GSM (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：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch189/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.55 dB
ABM1 comp = -10.05 dBA/m
BWC Factor = 0.16 dB
Location: -0.4, -3.8, 3.7 mm



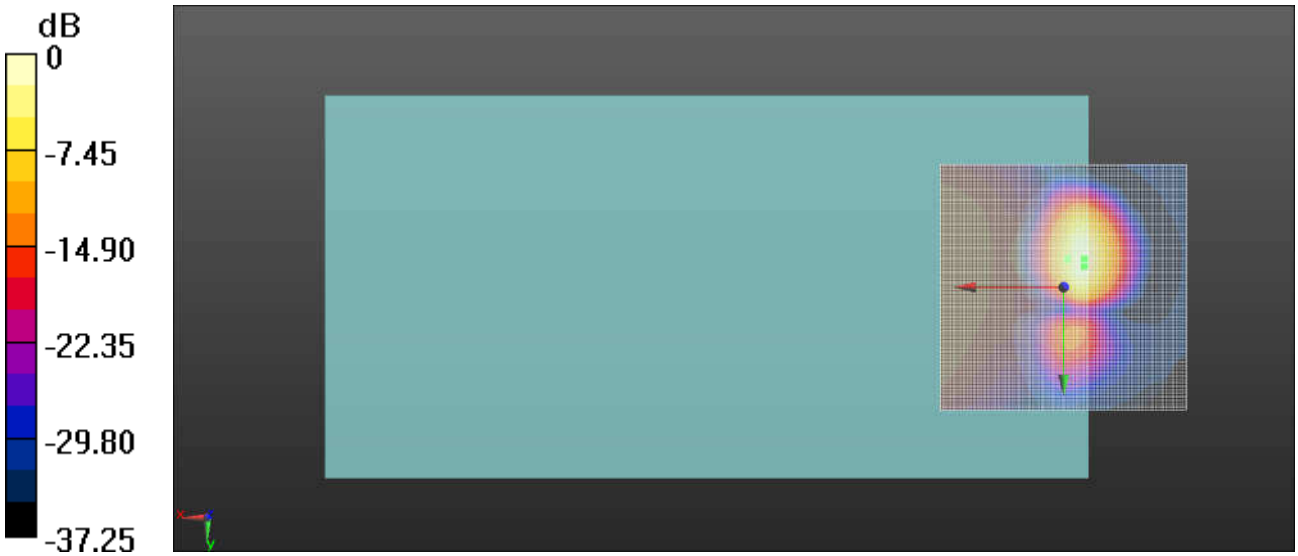
0 dB = 0.8431 A/m = -1.48 dBA/m

02_HAC T-Coil_GSM1900_Voice_Ch661_Z

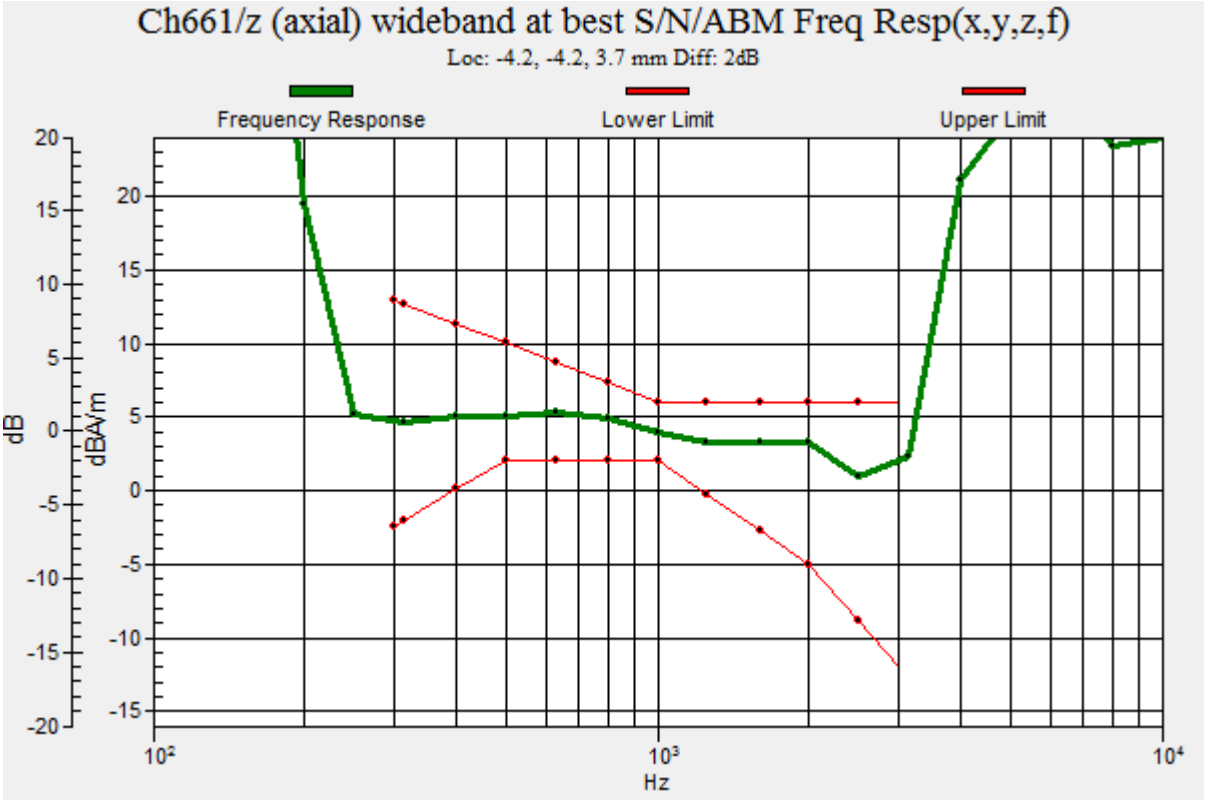
Communication System: UID 0, Generic GSM (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch661/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.39 dB
ABM1 comp = 4.13 dBA/m
BWC Factor = 0.16 dB
Location: -4.2, -5.8, 3.7 mm



0 dB = 1.845 A/m = 5.32 dBA/m


Ch661/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

02_HAC T-Coil_GSM1900_Voice_Ch661_Y

Communication System: UID 0, Generic GSM (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：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch661/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 29.41 dB
ABM1 comp = -9.64 dBA/m
BWC Factor = 0.16 dB
Location: -0.8, -3.8, 3.7 mm

0 dB = 0.8508 A/m = -1.40 dBA/m

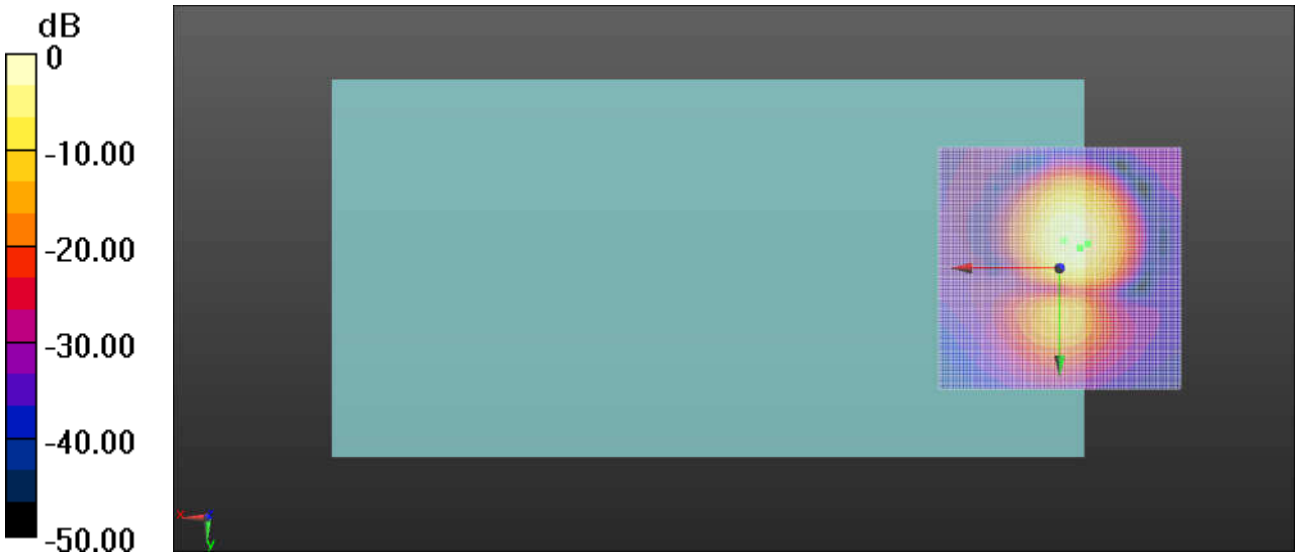
03_HAC T-Coil_WCDMA V_AMR_12.2Kbps_Ch4182_Z

Communication System: UID 0, UMTS (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：23.4 ℃

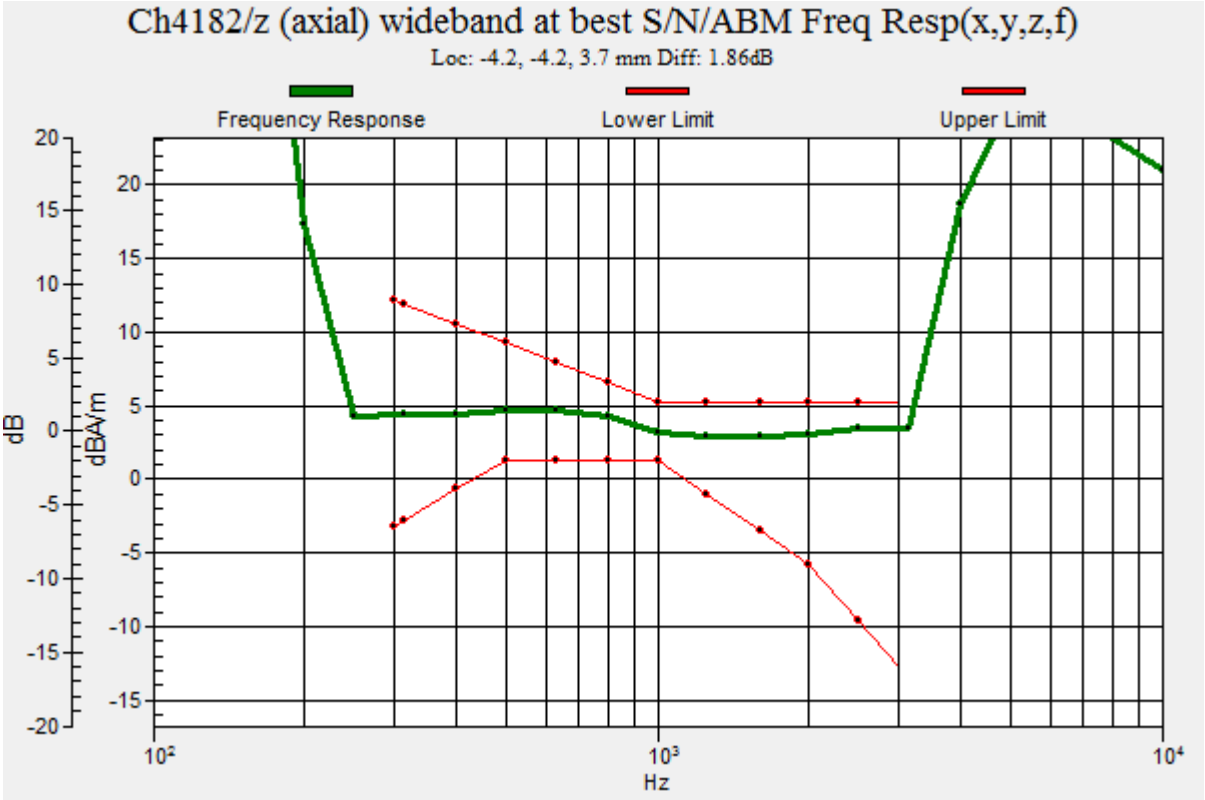
DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch4182/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 45.31 dB
ABM1 comp = 2.49 dBA/m
BWC Factor = 0.16 dB
Location: -5.8, -5, 3.7 mm



0 dB = 1.876 A/m = 5.46 dBA/m


Ch4182/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 1.86dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

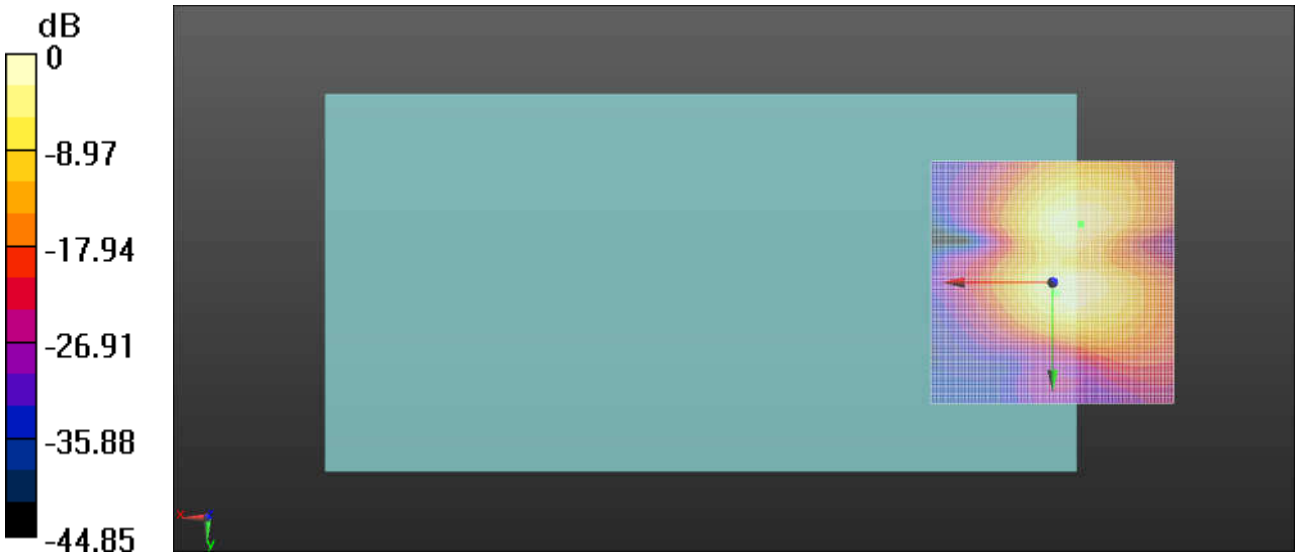
03_HAC T-Coil_WCDMA V_AMR_12.2Kbps_Ch4182_Y

Communication System: UID 0, UMTS (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：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch4182/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 42.26 dB
ABM1 comp = -5.77 dBA/m
BWC Factor = 0.16 dB
Location: -5.8, -12.1, 3.7 mm



0 dB = 0.8728 A/m = -1.18 dBA/m

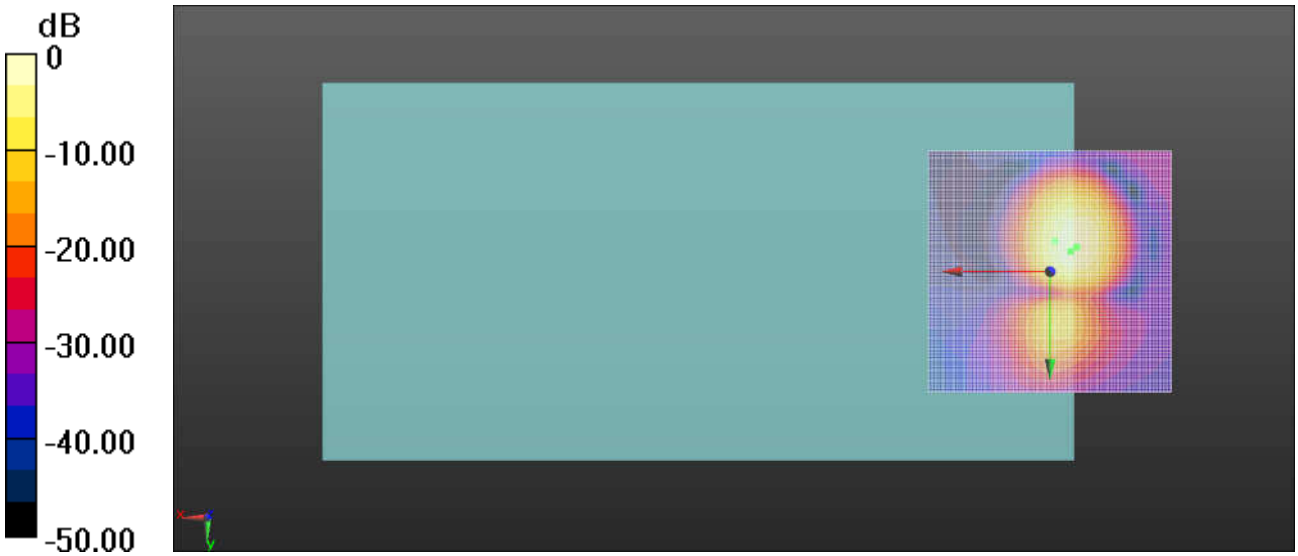
04_HAC T-Coil_WCDMA IV_AMR_12.2Kbps_Ch1413_Z

Communication System: UID 0, UMTS (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：23.4 ℃

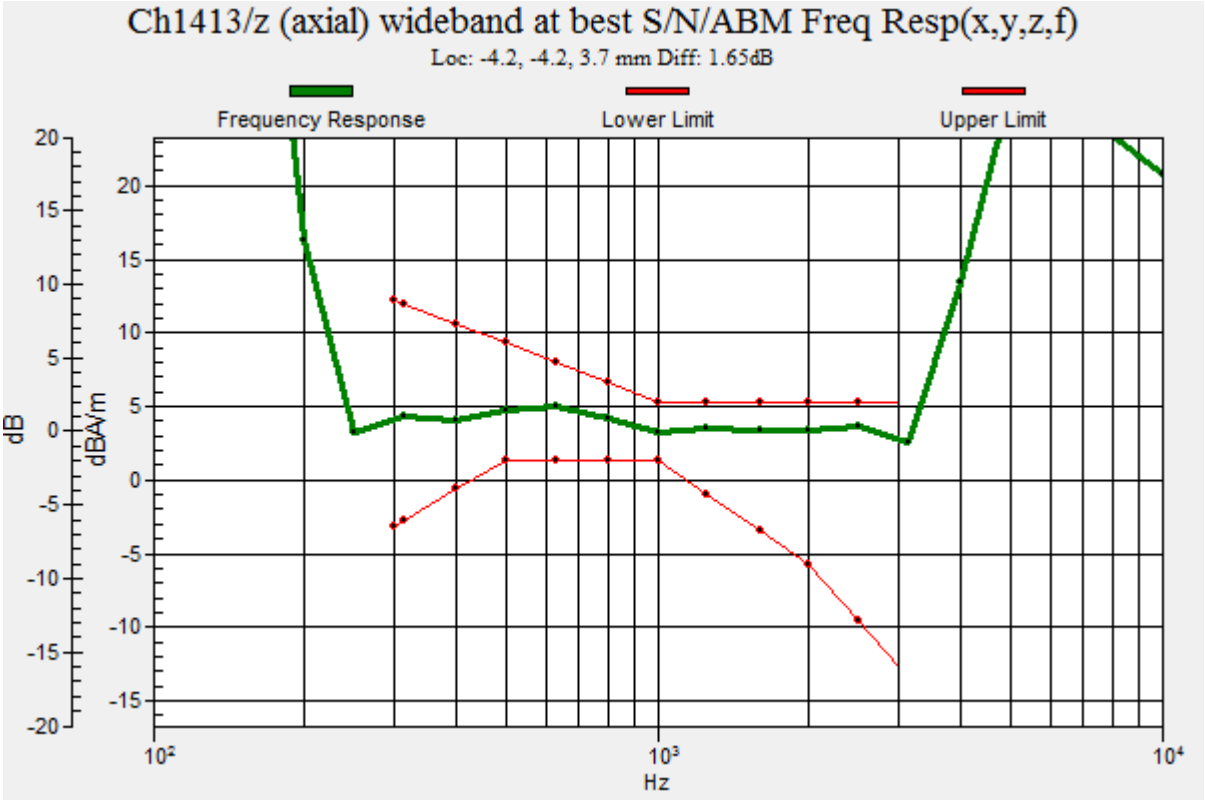
DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch1413/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 44.88 dB
ABM1 comp = 2.91 dBA/m
BWC Factor = 0.16 dB
Location: -5.4, -5, 3.7 mm



0 dB = 1.828 A/m = 5.24 dBA/m


Ch1413/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 1.65dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

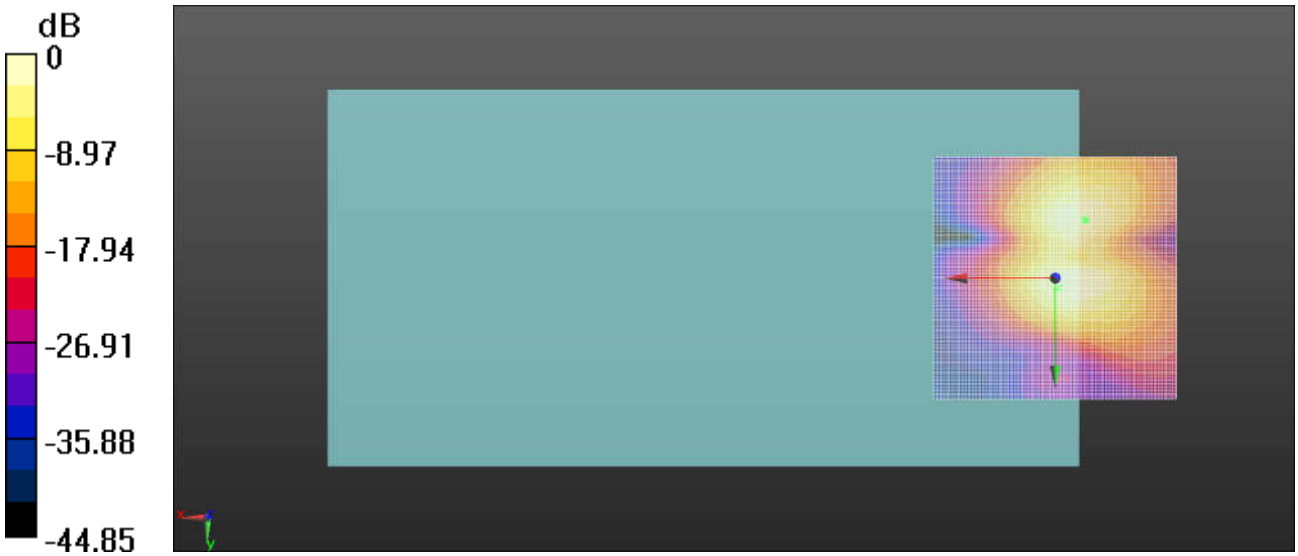
04_HAC T-Coil_WCDMA IV_AMR_12.2Kbps_Ch1413_Y

Communication System: UID 0, UMTS (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：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch1413/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 41.76 dB
ABM1 comp = -6.17 dBA/m
BWC Factor = 0.16 dB
Location: -6.2, -12.1, 3.7 mm



0 dB = 0.8699 A/m = -1.21 dBA/m

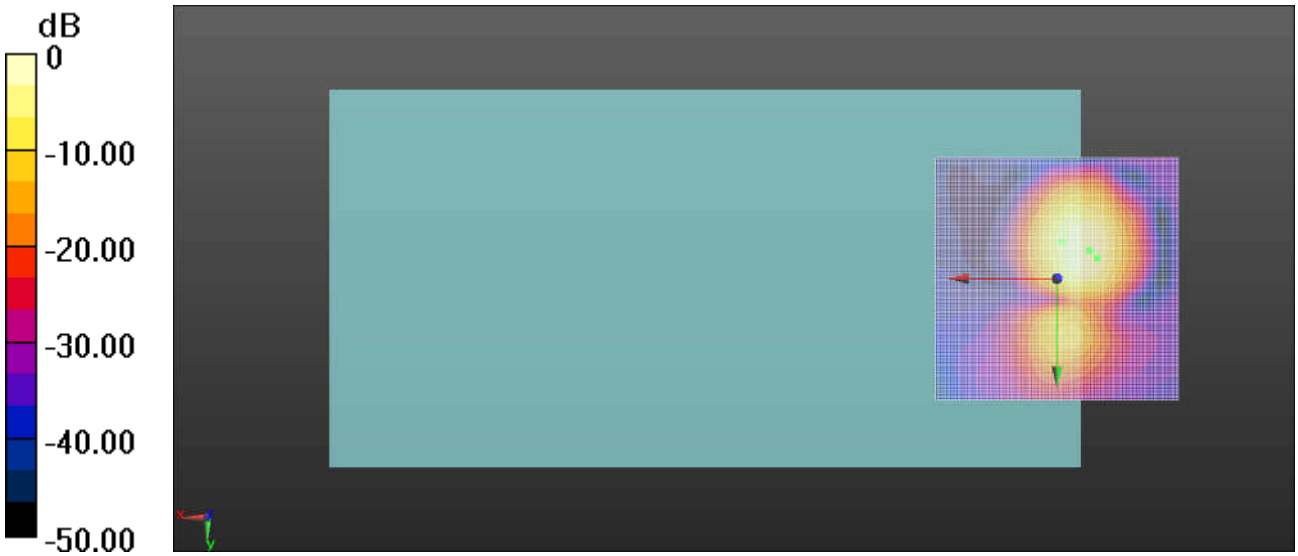
05_HAC T-Coil_WCDMA II_AMR_12.2Kbps_Ch9400_Z

Communication System: UID 0, UMTS (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：23.4 ℃

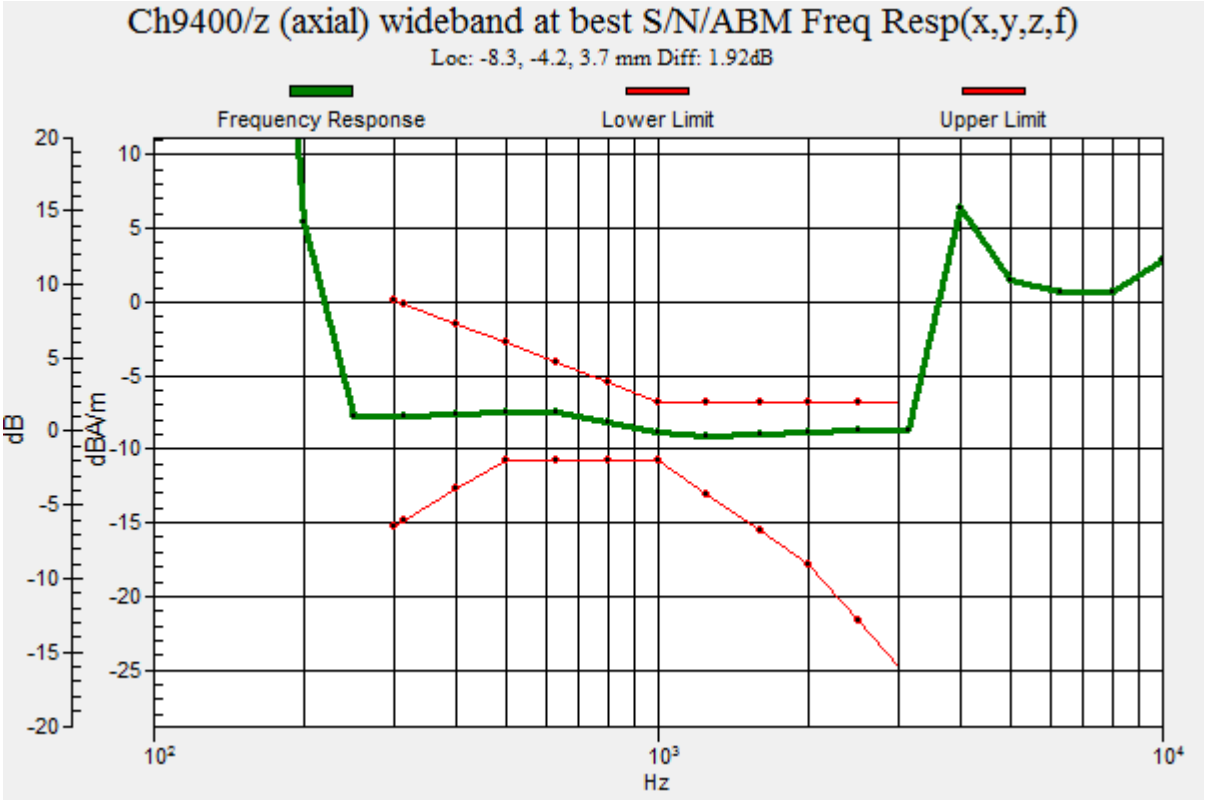
DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch9400/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 37.78 dB
ABM1 comp = -5.32 dBA/m
BWC Factor = 0.16 dB
Location: -6.7, -5.8, 3.7 mm



0 dB = 0.8166 A/m = -1.76 dBA/m


Ch9400/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -8.3, -4.2, 3.7 mm Diff: 1.92dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

05_HAC T-Coil_WCDMA II_AMR_12.2Kbps_Ch9400_Y

Communication System: UID 0, UMTS (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：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2017.11.28
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1386; Calibrated: 2017.07.20
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Ch9400/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=10mm, dy=10mm
ABM1/ABM2 = 34.38 dB
ABM1 comp = -10.02 dBA/m
BWC Factor = 0.16 dB
Location: -5, 0.8, 3.7 mm

0 dB = 0.4110 A/m = -7.72 dBA/m

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

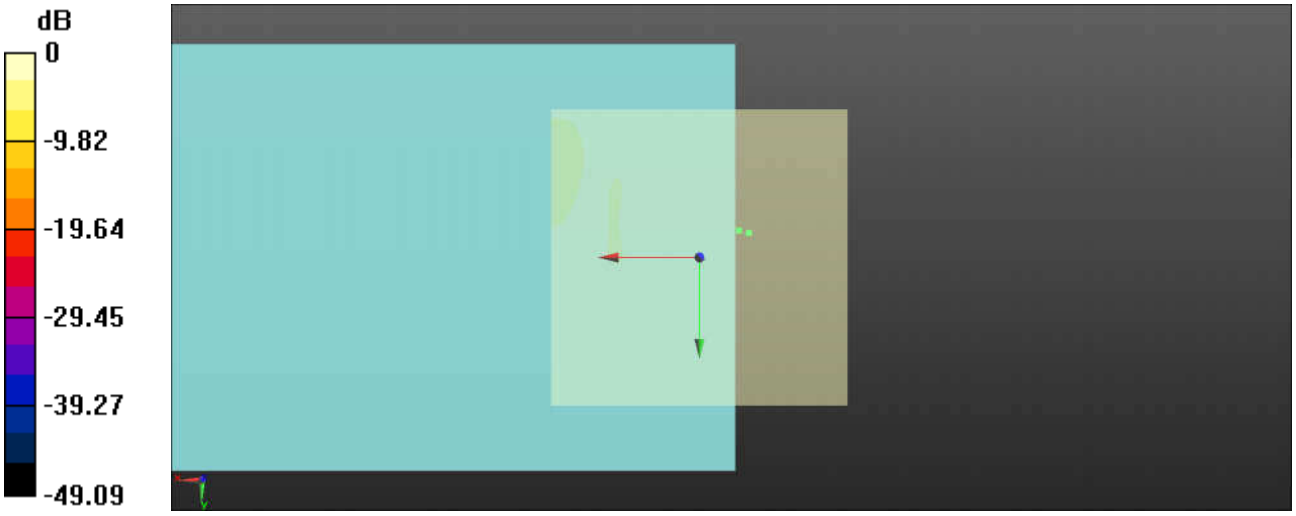
06_HAC_T-Coil_LTE Band 2_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch18900(Z)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

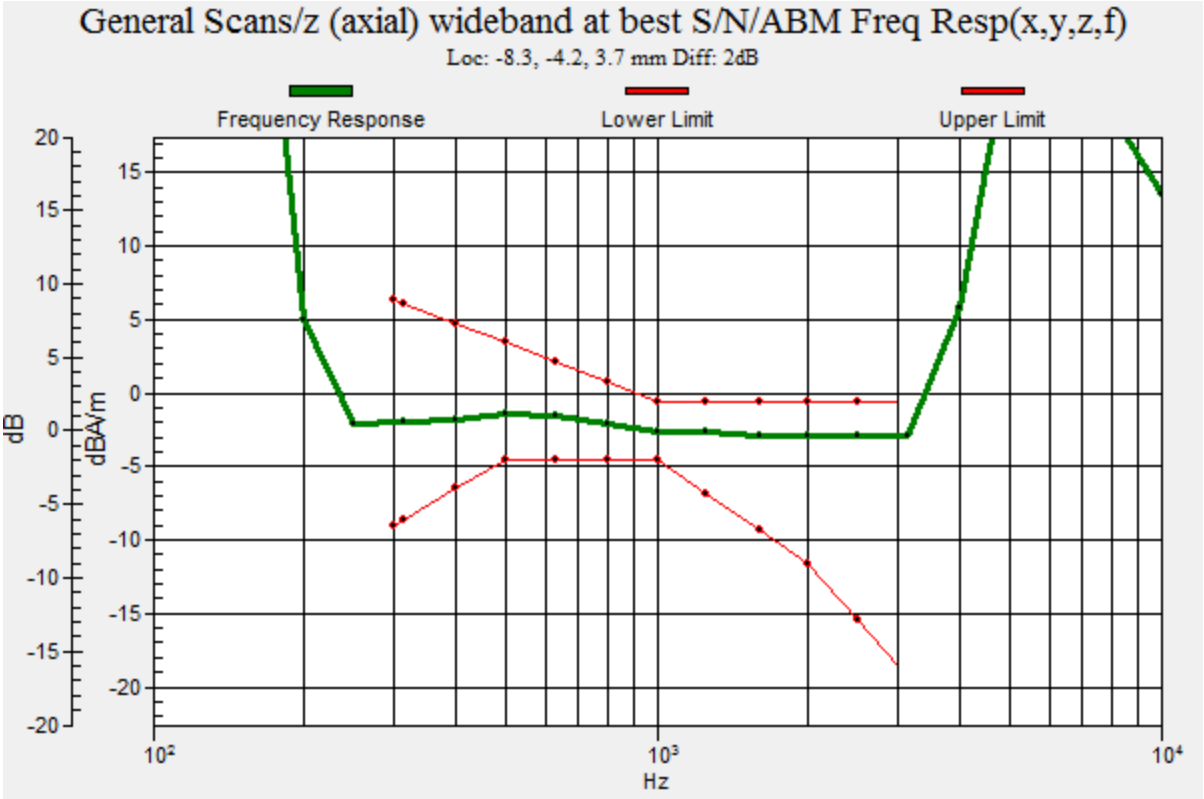
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.77 dB
ABM1 comp = 0.64 dBA/m
Location: -6.7, -4.6, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -8.3, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

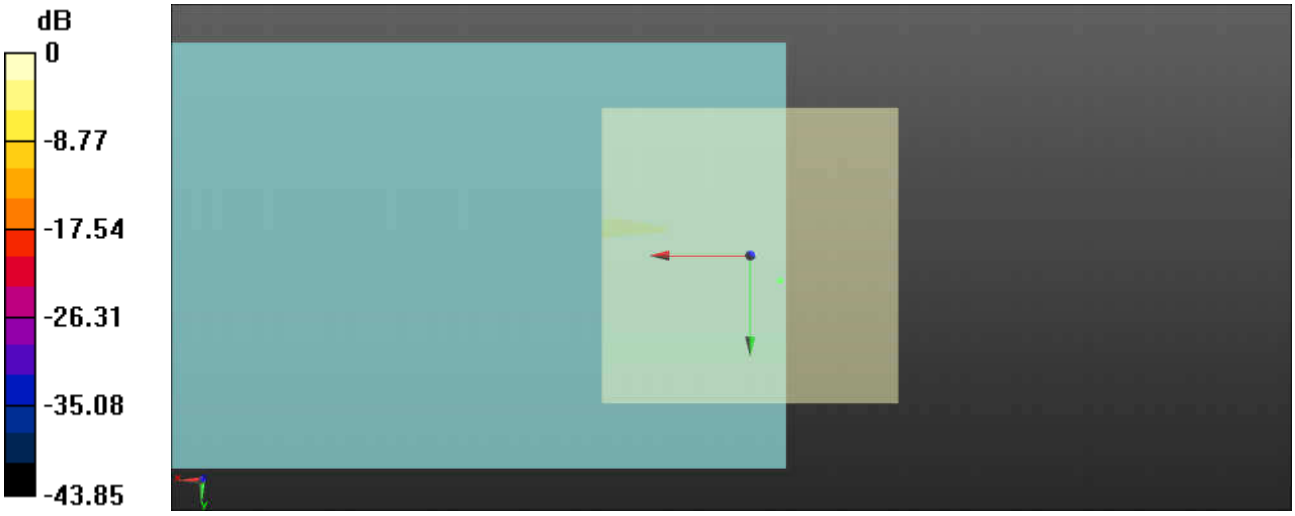
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

06_HAC_T-Coil_LTE Band 2_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch18900(Y)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 38.28 dB
ABM1 comp = -5.57 dBA/m
Location: -5, 4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

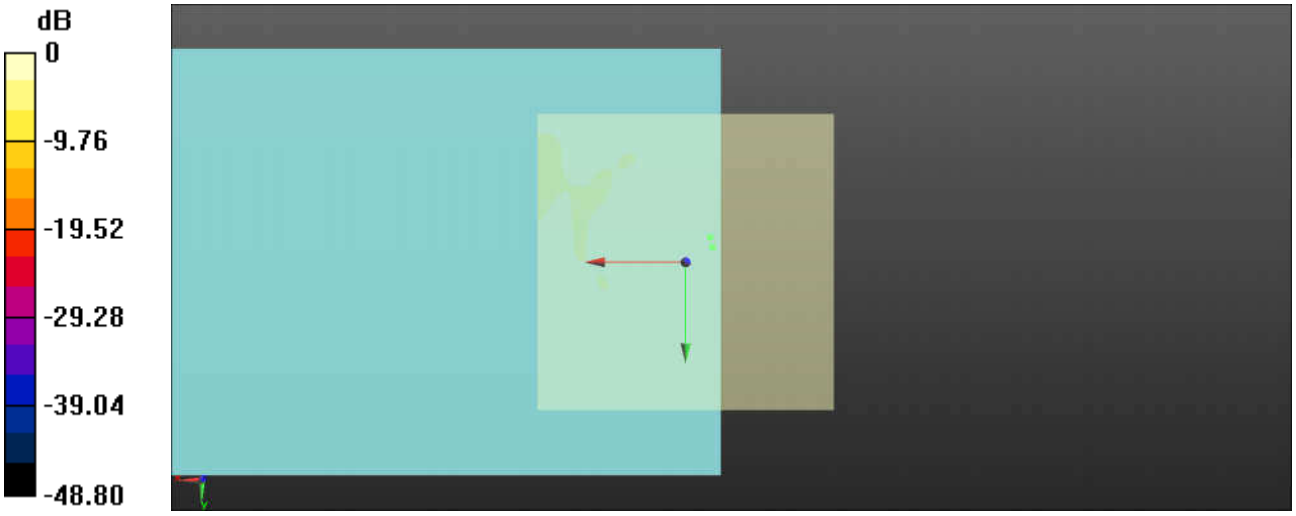
07_HAC_T-Coil_LTE Band 4_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch20175(Z)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

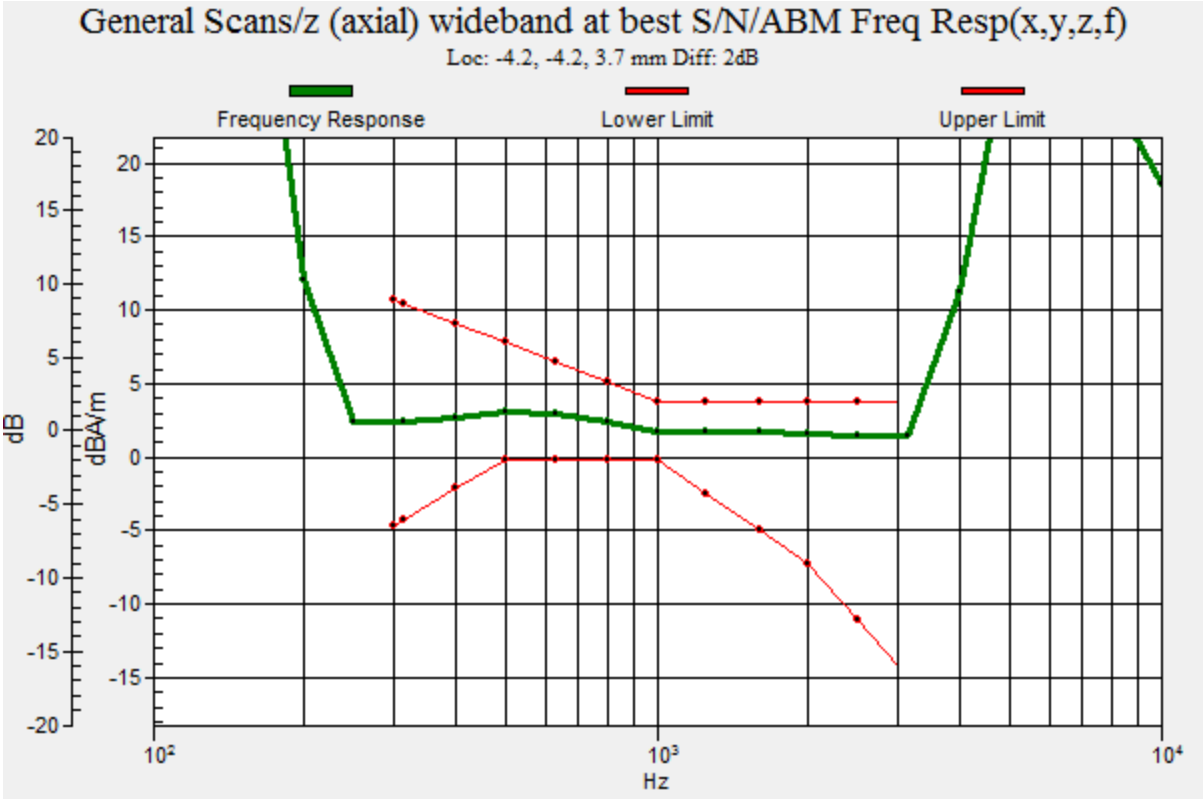
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.76 dB
ABM1 comp = 1.09 dBA/m
Location: -4.6, -2.5, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

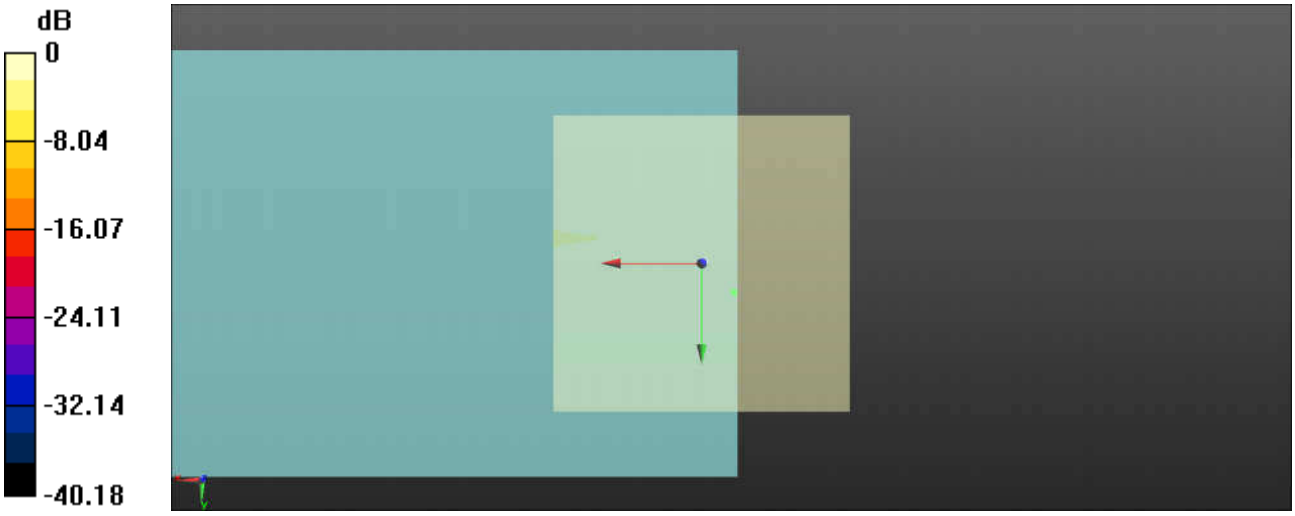
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

07_HAC_T-Coil_LTE Band 4_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch20175(Y)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 36.86 dB
ABM1 comp = -8.02 dBA/m
Location: -5.4, 5, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

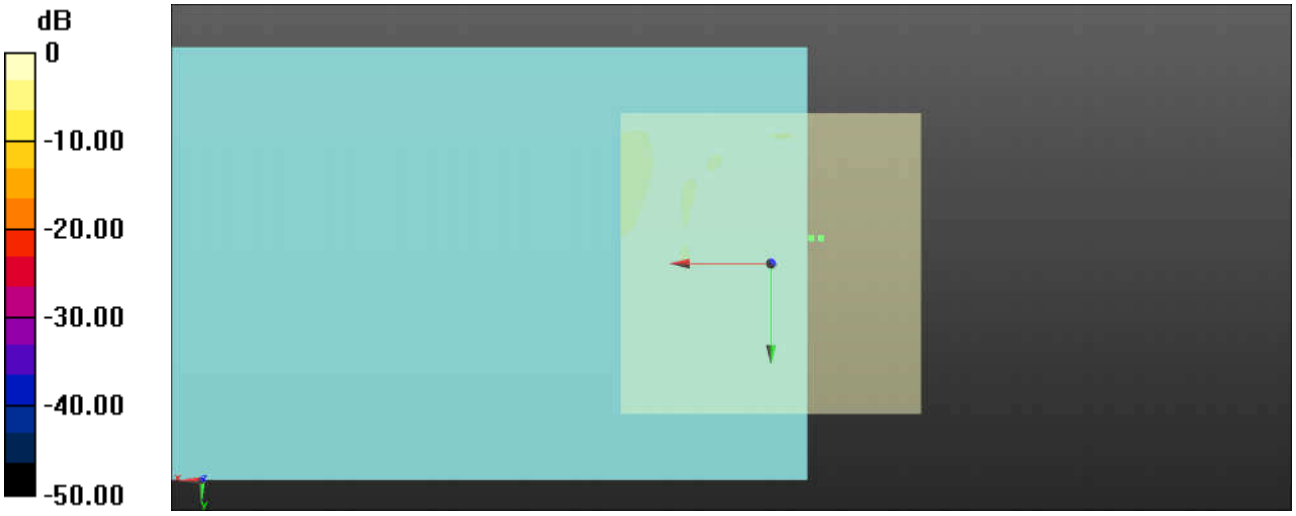
08_HAC_T-Coil_LTE Band 5_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch20525(Z)

Communication System: UID 0, FDD_LTE (0); Frequency: 836.5 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

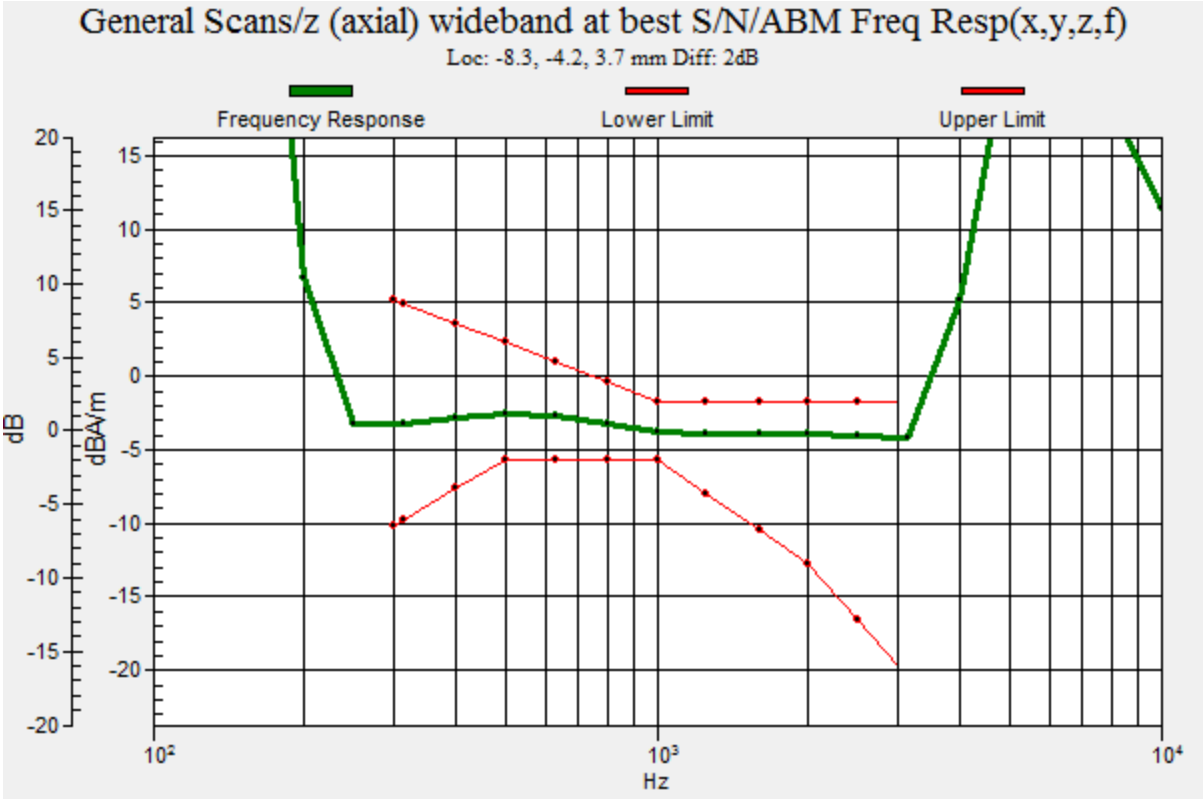
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.45 dB
ABM1 comp = -0.05 dBA/m
Location: -6.7, -4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -8.3, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

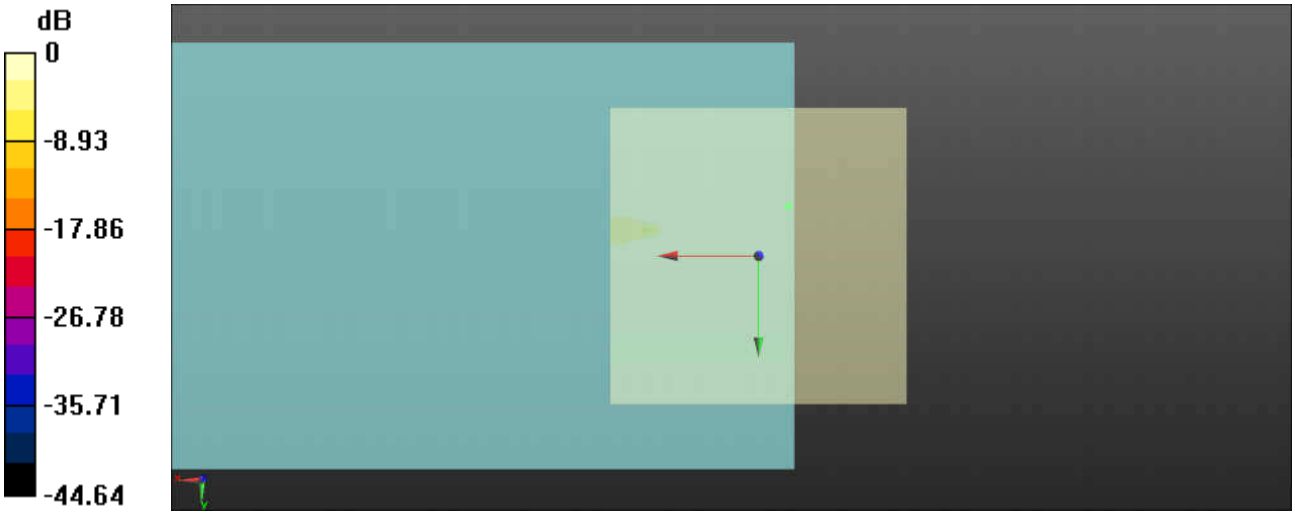
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

08_HAC_T-Coil_LTE Band 5_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch20525(Y)

Communication System: UID 0, FDD_LTE (0); Frequency: 836.5 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 38.61 dB
ABM1 comp = -8.45 dBA/m
Location: -5, -8.3, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

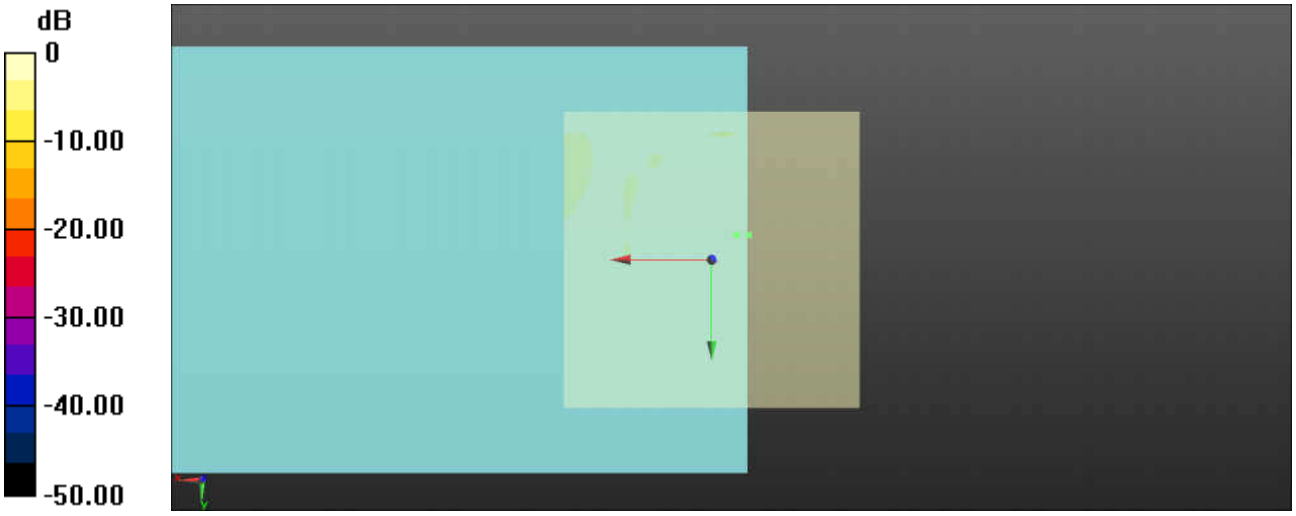
09_HAC_T-Coil_LTE Band 7_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch21100(Z)

Communication System: UID 0, FDD_LTE (0); Frequency: 2535 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

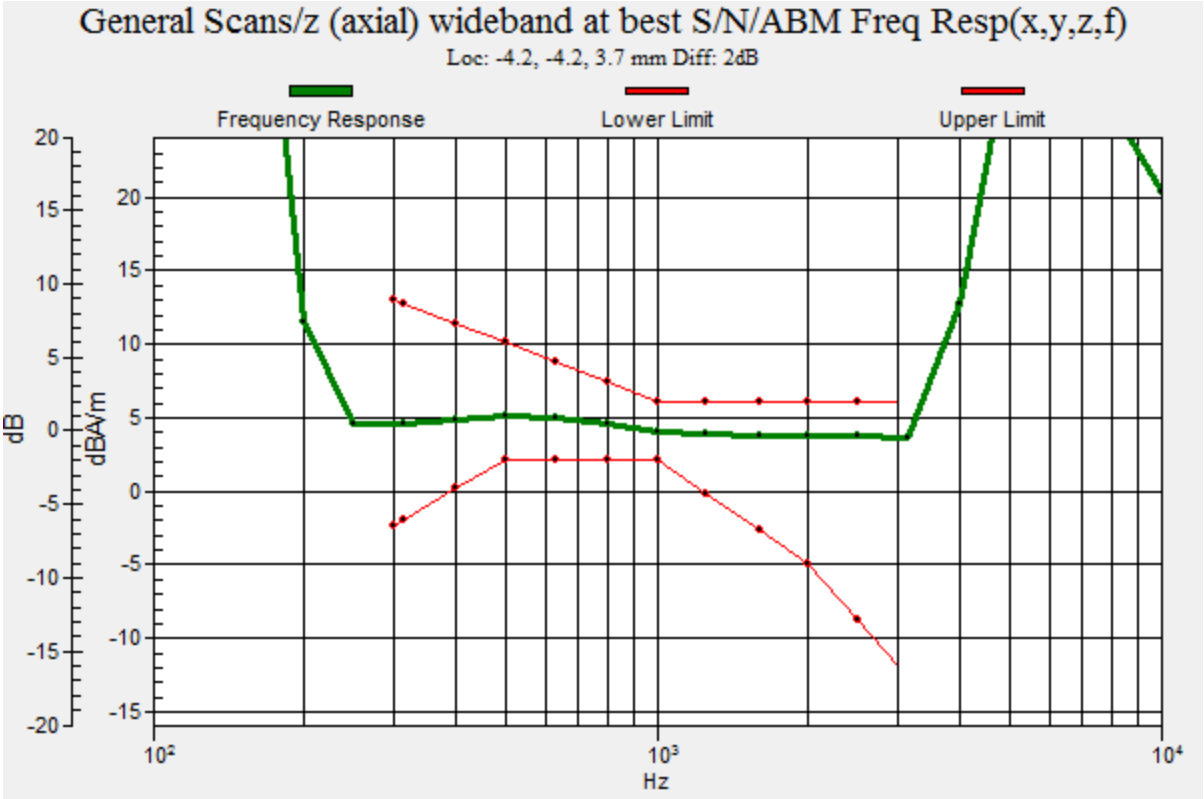
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.05 dB
ABM1 comp = 0.84 dBA/m
Location: -6.2, -4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

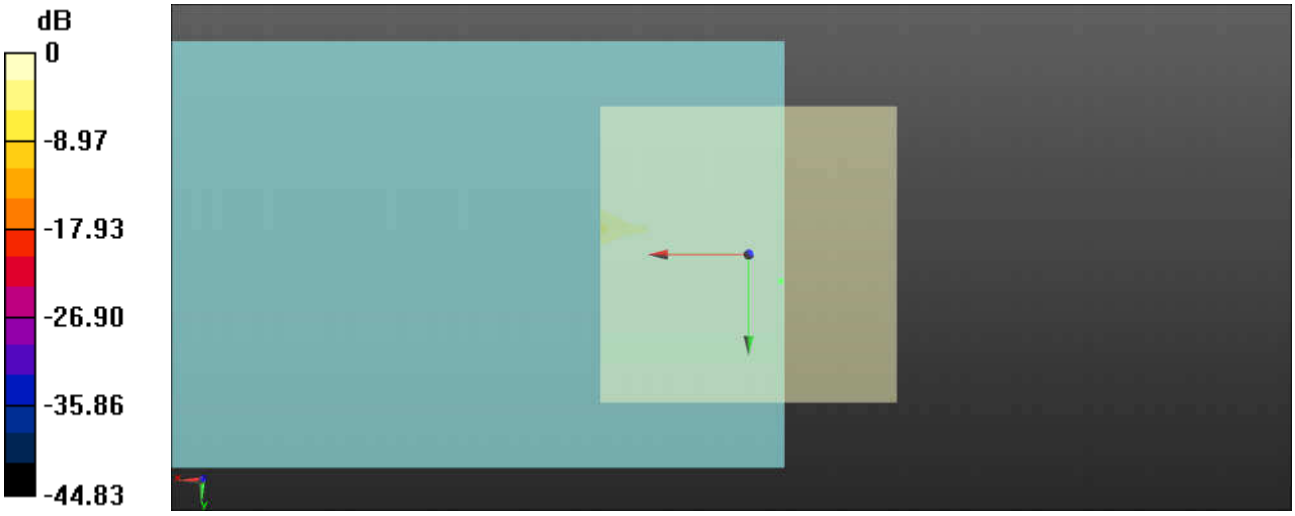
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

09_HAC_T-Coil_LTE Band 7_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch21100(Y)

Communication System: UID 0, FDD_LTE (0); Frequency: 2535 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 38.42 dB
ABM1 comp = -6.11 dBA/m
Location: -5.4, 4.6, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

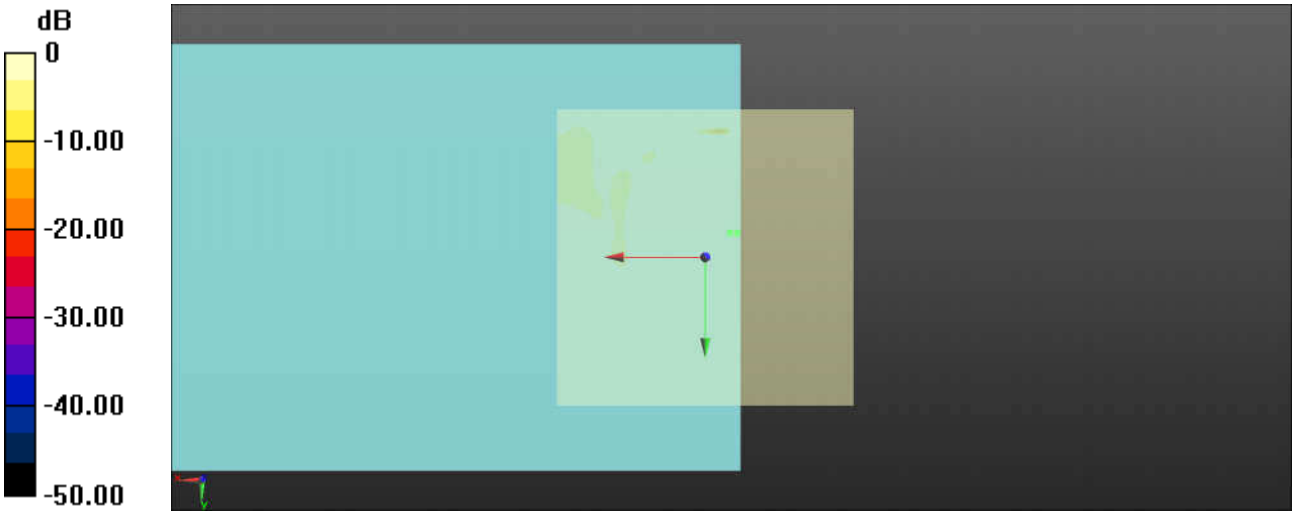
10_HAC_T-Coil_LTE Band 12_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23095(Z)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

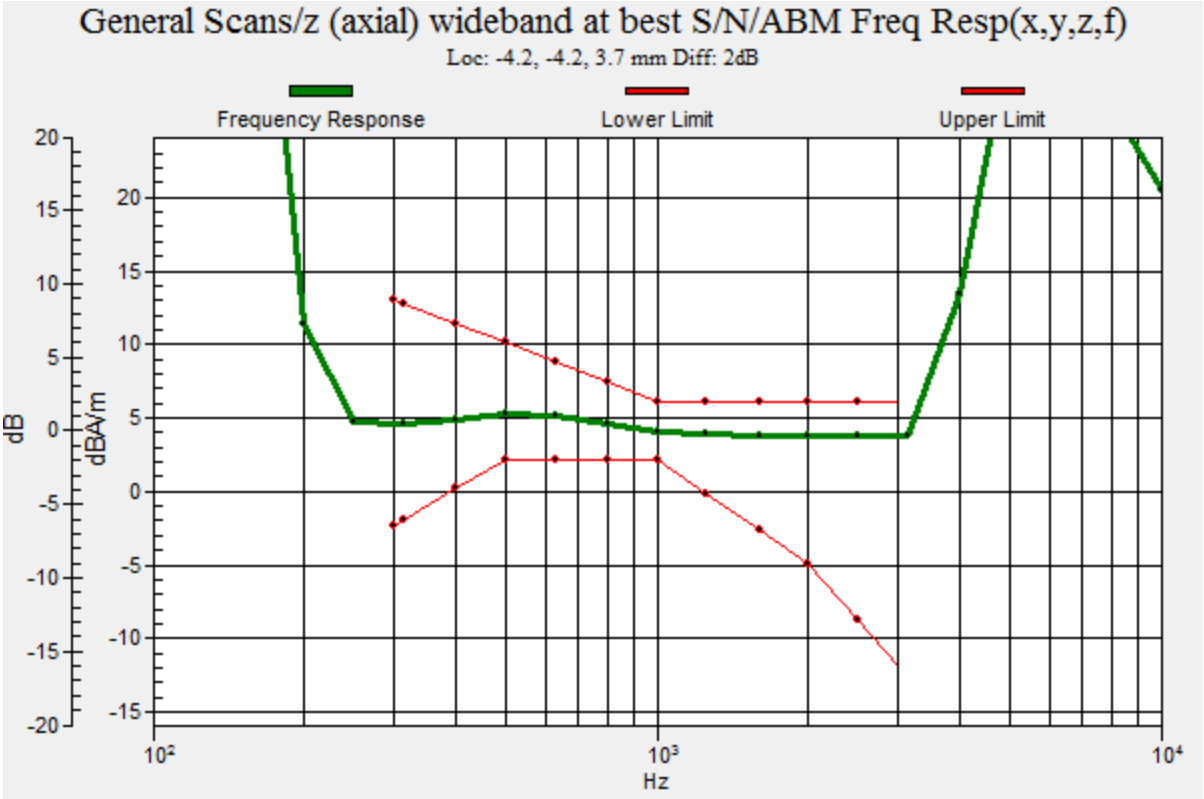
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.45 dB
ABM1 comp = 2.25 dBA/m
Location: -5.4, -4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

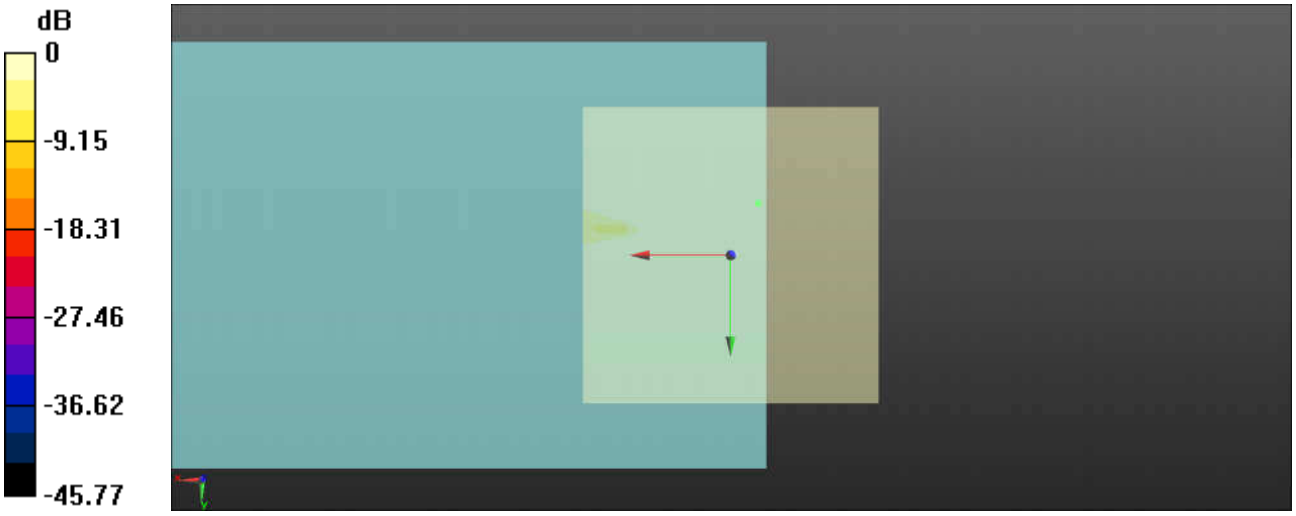
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

10_HAC_T-Coil_LTE Band 12_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23095(Y)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 38.64 dB
ABM1 comp = -7.91 dBA/m
Location: -4.6, -8.8, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

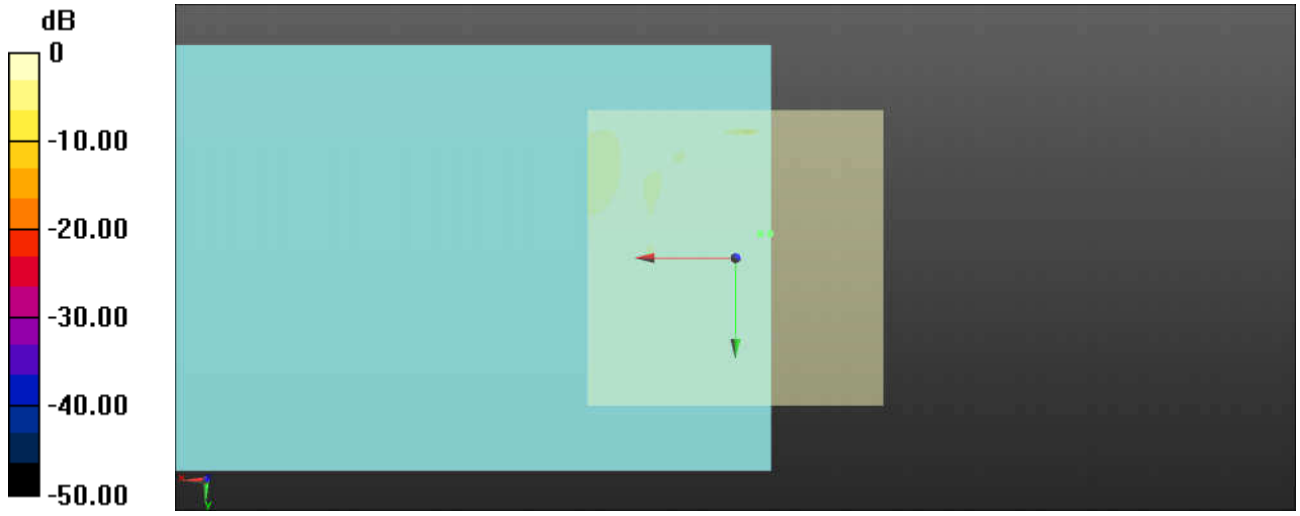
11_HAC_T-Coil_LTE Band 13_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23230(Z)

Communication System: UID 0, FDD_LTE (0); Frequency: 782 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

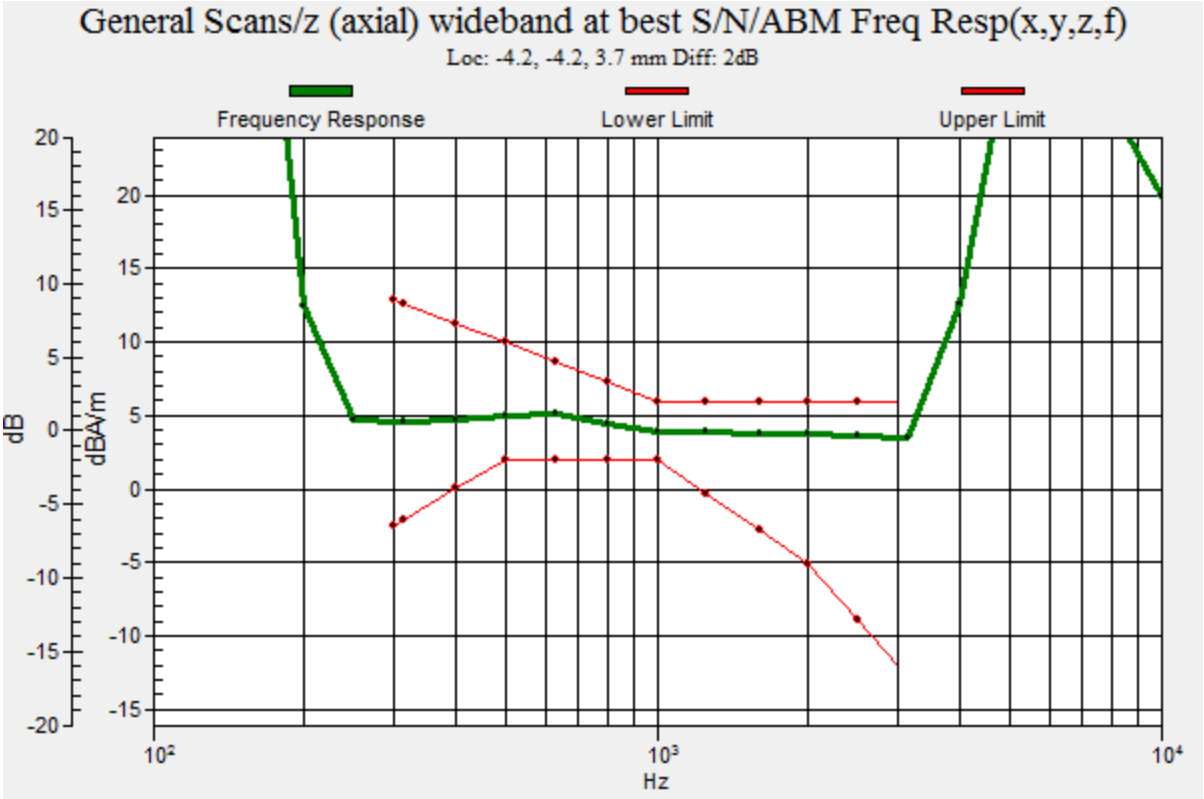
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.57 dB
ABM1 comp = 1.52 dBA/m
Location: -5.8, -4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB

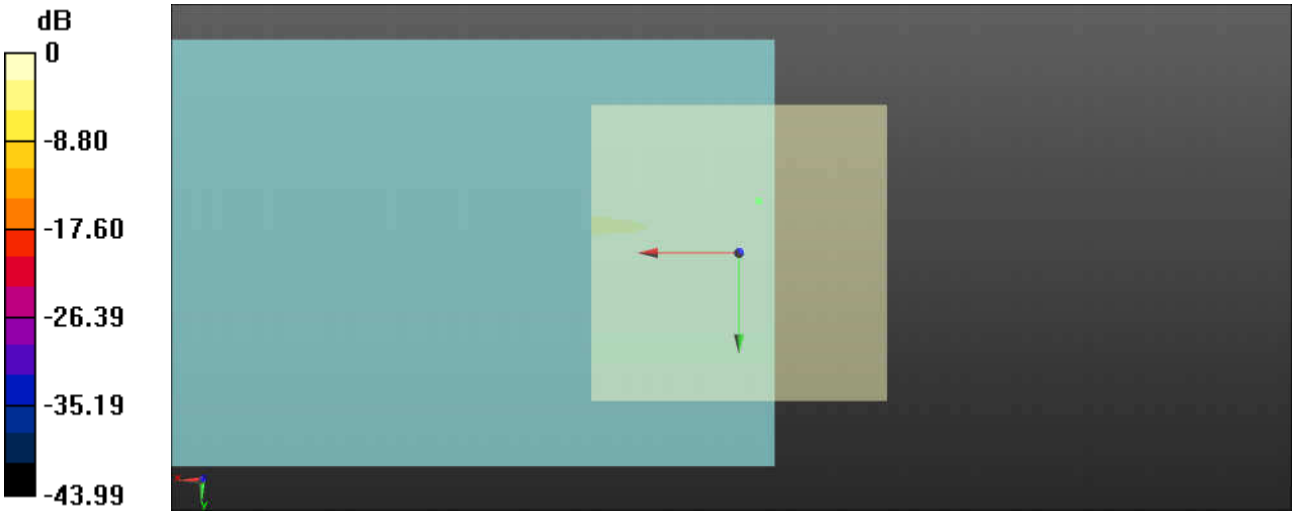

General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

11_HAC_T-Coil_LTE Band 13_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23230(Y)

Communication System: UID 0, FDD_LTE (0); Frequency: 782 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 38.74 dB
ABM1 comp = -7.45 dBA/m
Location: -3.3, -8.8, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

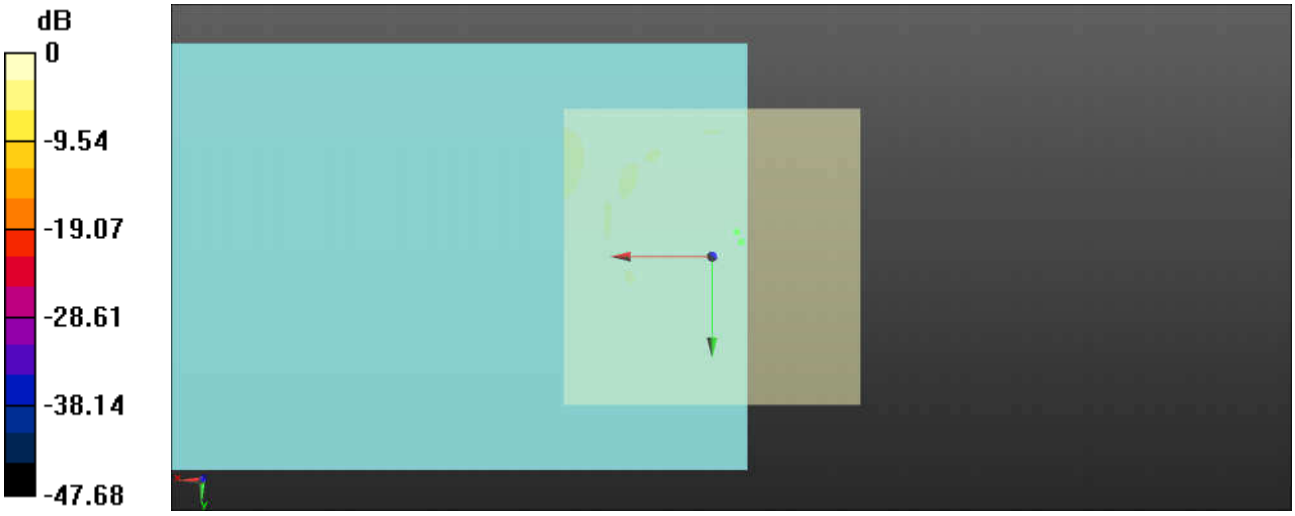
12_HAC_T-Coil_LTE Band 17_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23790(Z)

Communication System: UID 0, FDD_LTE (0); Frequency: 710 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

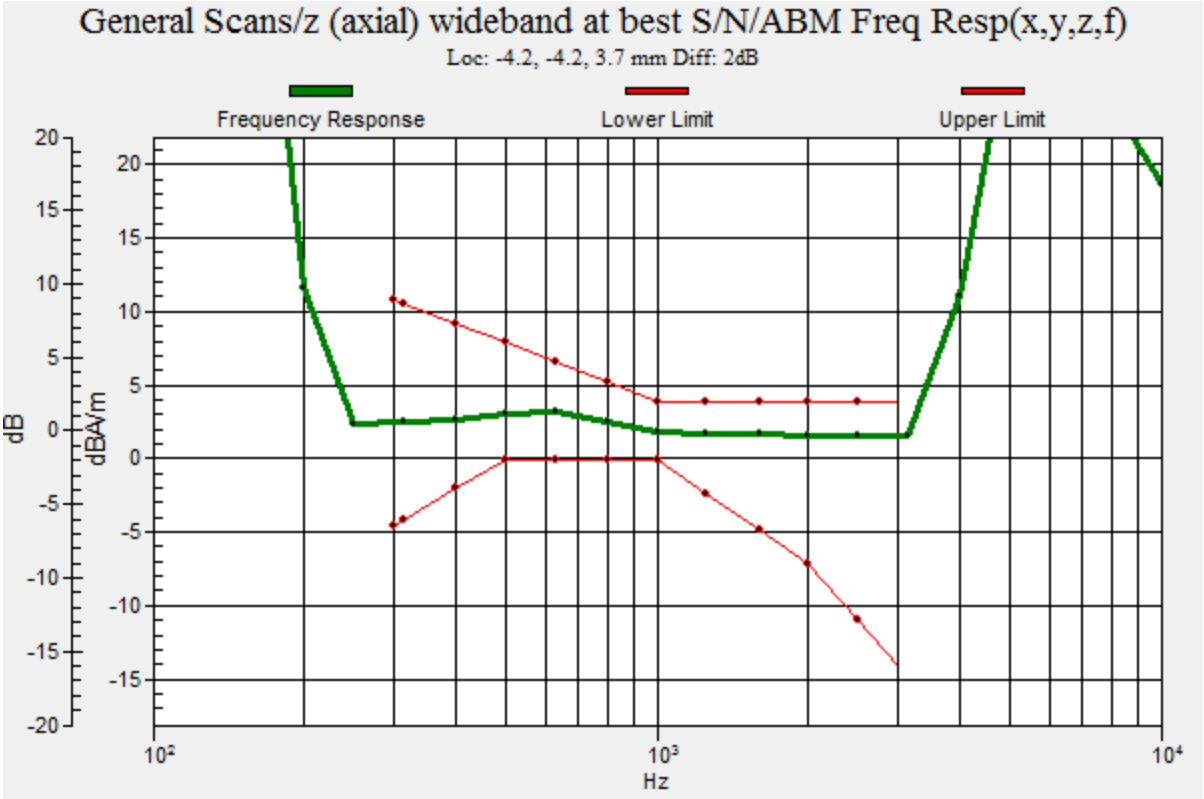
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.04 dB
ABM1 comp = 0.60 dBA/m
Location: -5, -2.5, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

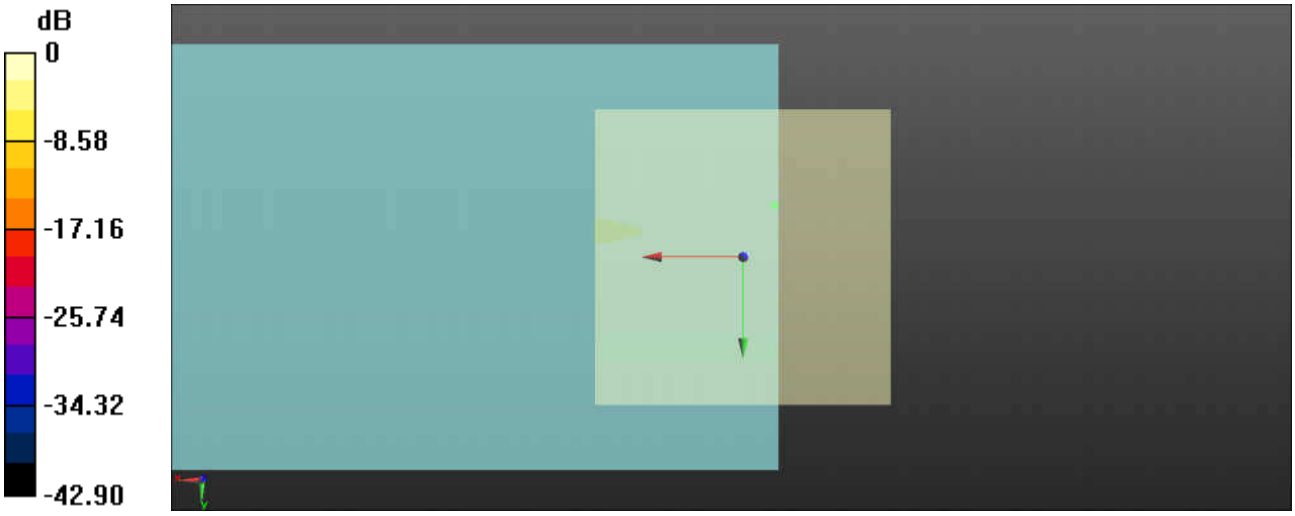
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

12_HAC_T-Coil_LTE Band 17_10M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch23790(Y)

Communication System: UID 0, FDD_LTE (0); Frequency: 710 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 37.61 dB
ABM1 comp = -10.37 dBA/m
Location: -5.4, -8.8, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

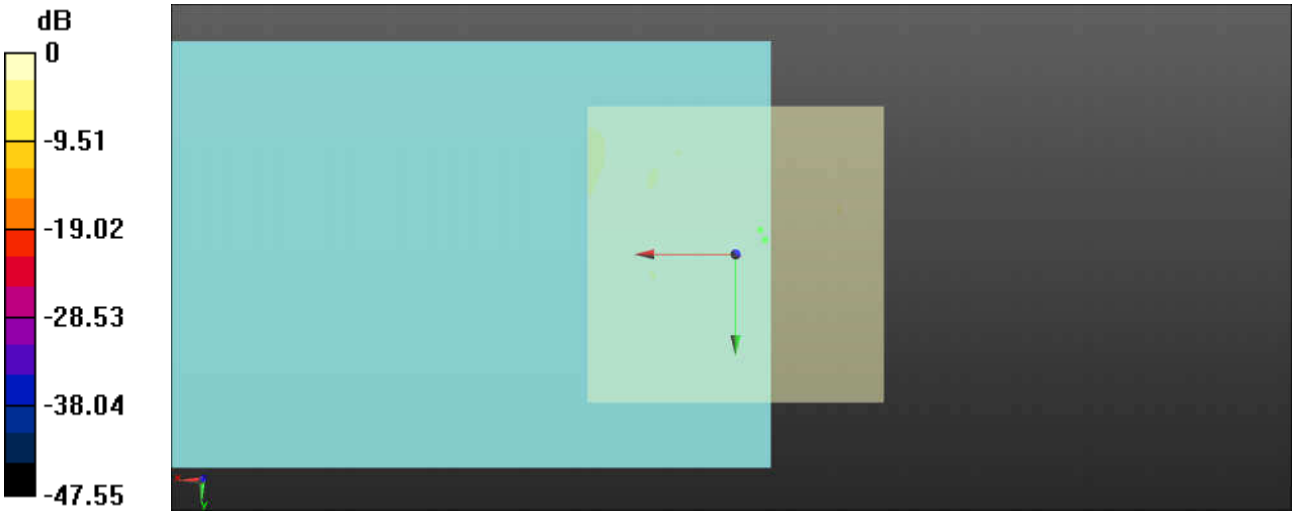
13_HAC_T-Coil_LTE Band 66_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch132322(Z)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

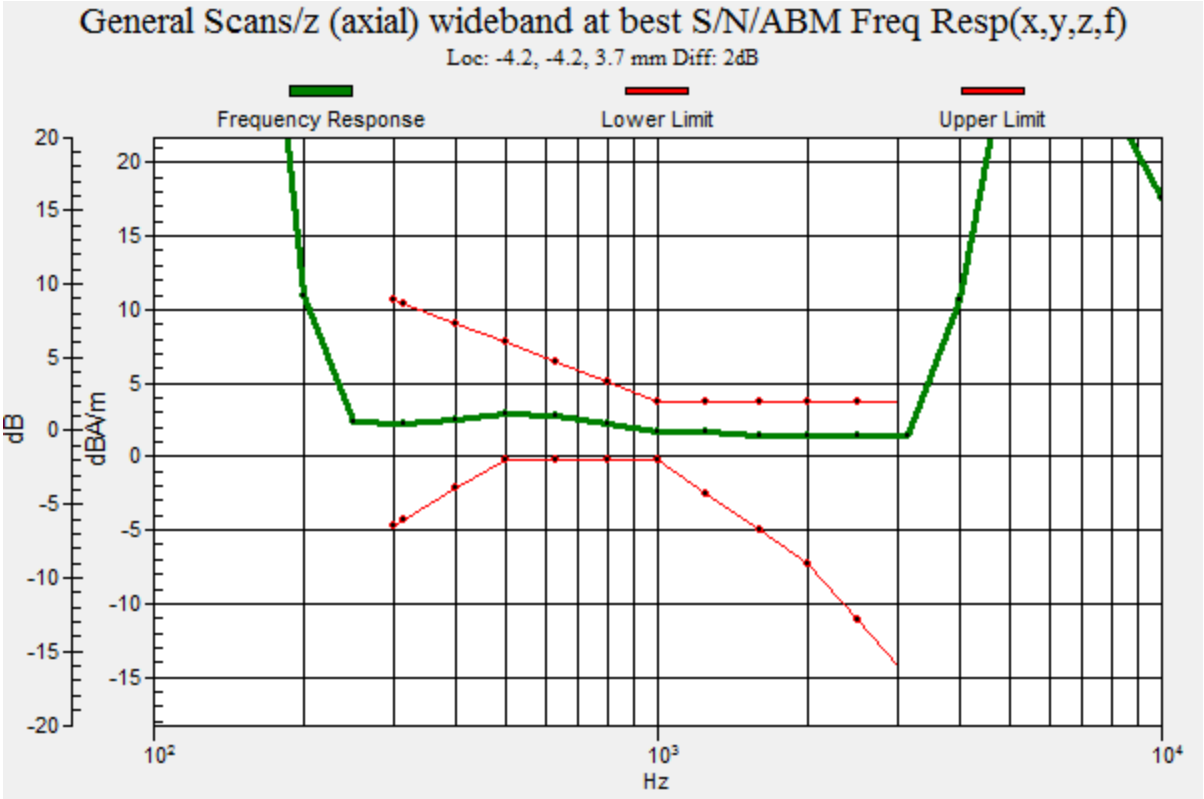
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 42.33 dB
ABM1 comp = 0.36 dBA/m
Location: -5, -2.5, 3.7 mm



0 dB = 1.000 = 0.00 dB


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

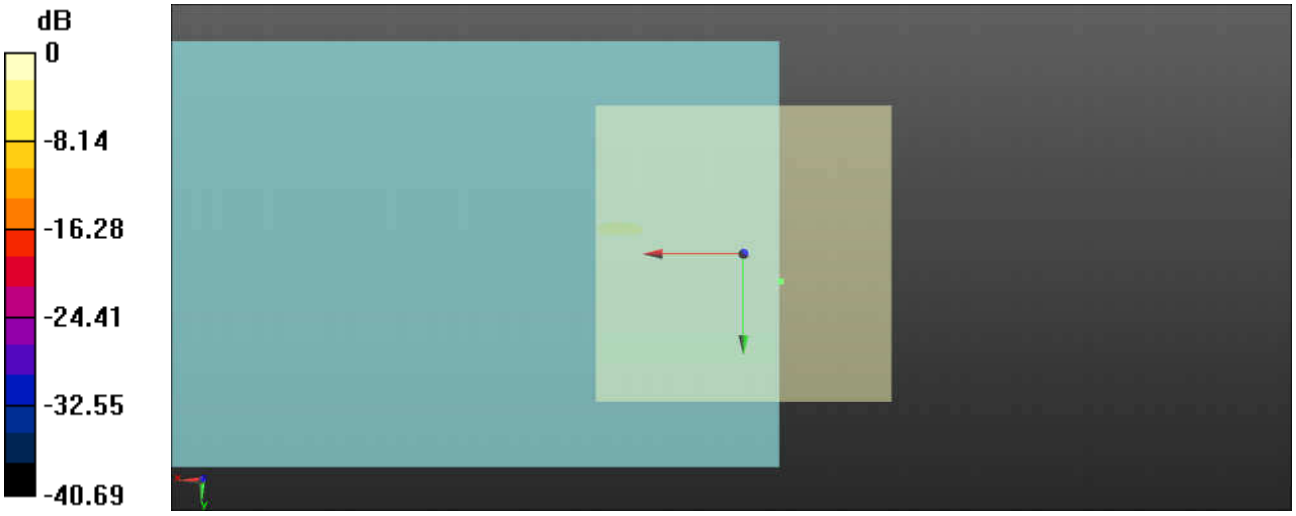
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

13_HAC_T-Coil_LTE Band 66_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch132322(Y)

Communication System: UID 0, FDD_LTE (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：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 36.67 dB
ABM1 comp = -8.84 dBA/m
Location: -6.2, 4.6, 3.7 mm



0 dB = 1.000 = 0.00 dB

Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

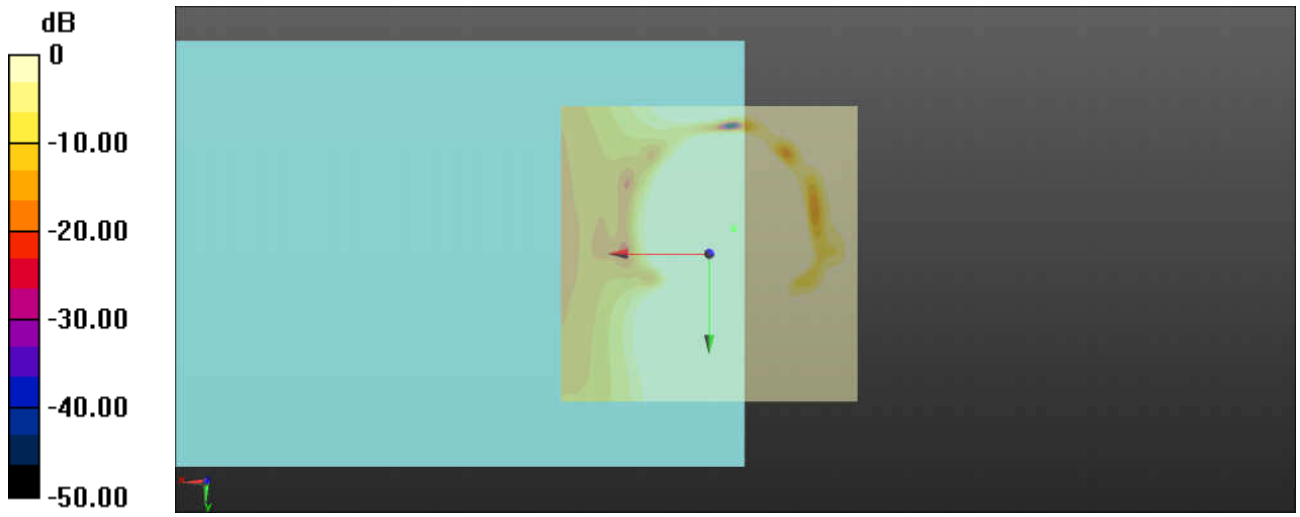
14_HAC_T-Coil_LTE Band 38_20M_QPSK_1RB_0Offset_EVS-WB5.9Kbps_Ch38000(Z)

Communication System: UID 0, TDD_LTE (0); Frequency: 2595 MHz;Duty Cycle: 1:1.59
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

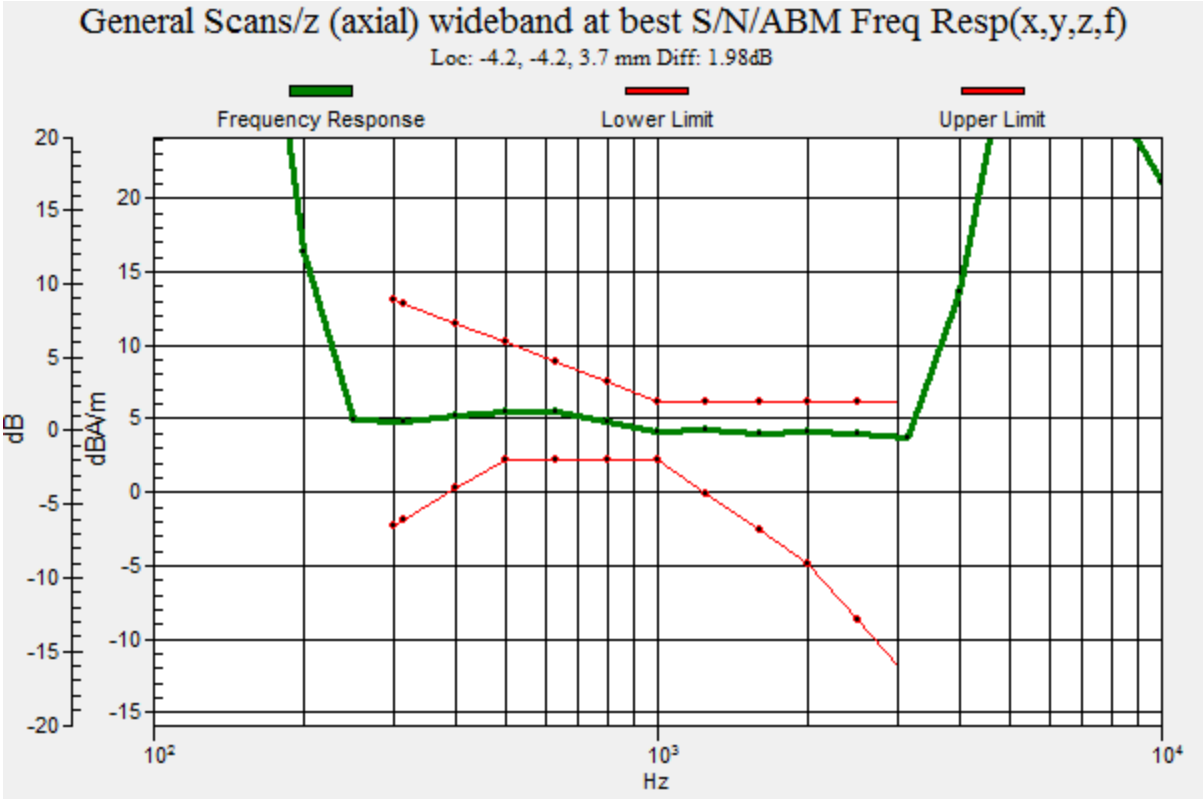
DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 35.63 dB
ABM1 comp = 3.69 dBA/m
Location: -4.2, -4.2, 3.7 mm



0 dB = 1.000 = 0.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, -4.2, 3.7 mm Diff: 1.98dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

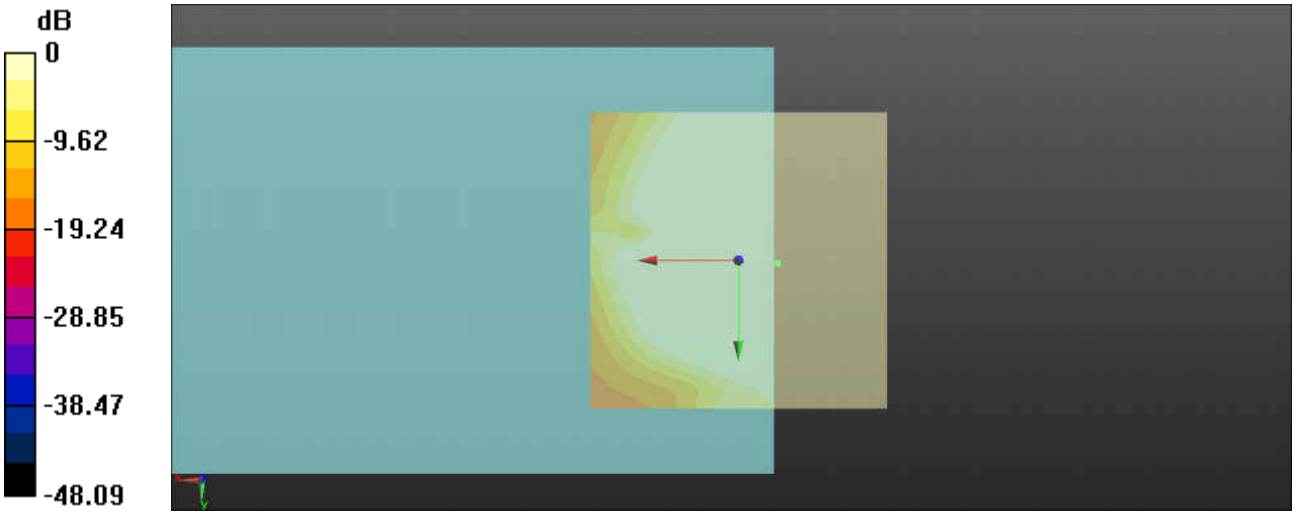
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2018.6.2

14_HAC_T-Coil_LTE Band 38_20M_QPSK_1RB_0Offset_EVS-WB 5.9Kbps_Ch38000(Y)

Communication System: UID 0, TDD_LTE (0); Frequency: 2595 MHz;Duty Cycle: 1:1.59
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.2 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3128; ; Calibrated: 2017.12.20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1279; Calibrated: 2018.1.3
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 30.20 dB
ABM1 comp = -12.87 dBA/m
Location: -6.7, 0.4, 3.7 mm



0 dB = 1.000 = 0.00 dB

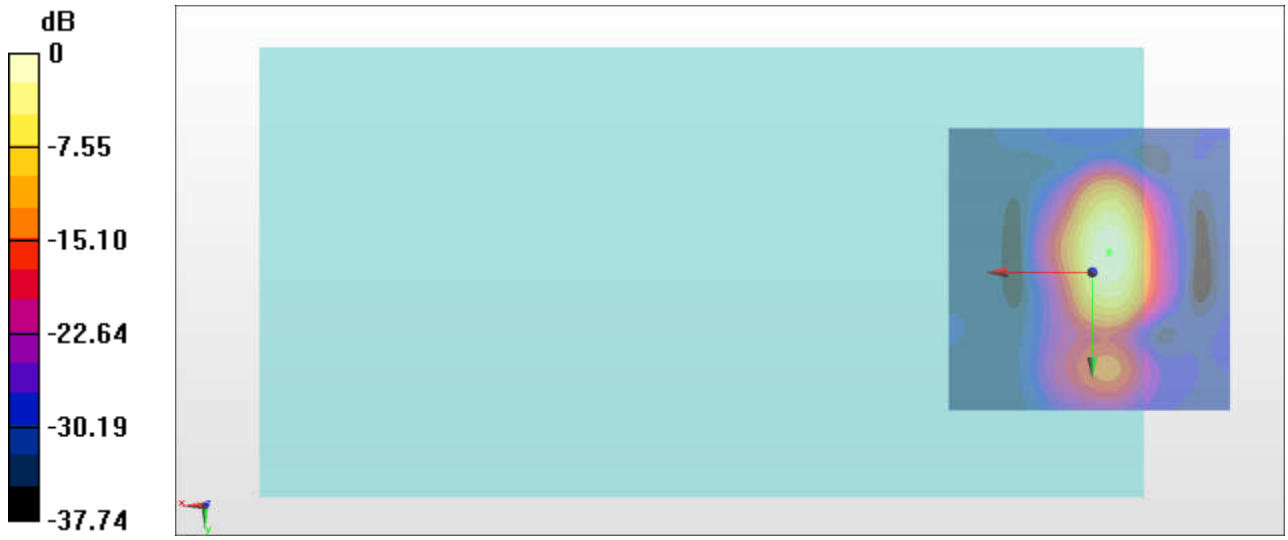
15_HAC_T-Coil_GSM850_EDGE 2 Tx slots_Ch189_Axial (Z)

Communication System: GSM850 ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

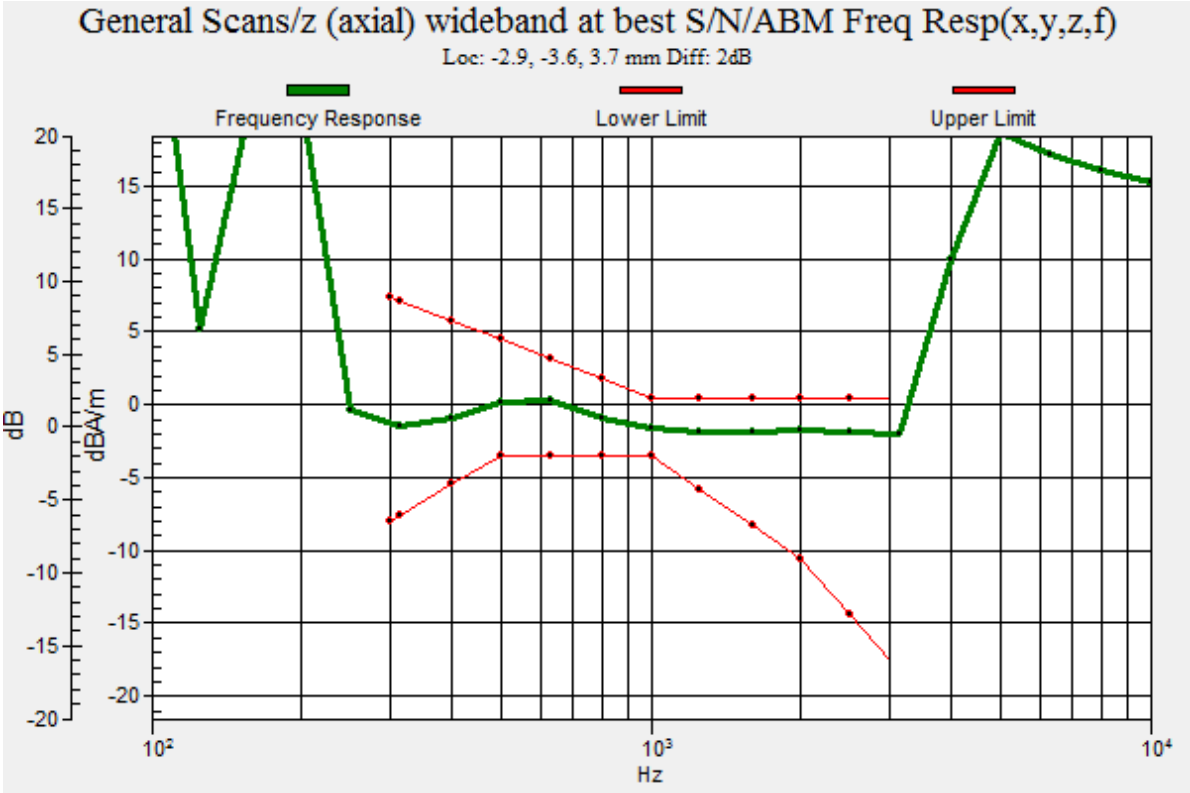
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 23.64 dB
ABM1 comp = -1.65 dBA/m
Location: -3, -3.3, 3.7 mm



0 dB = 15.21 = 23.64 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -2.9, -3.6, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

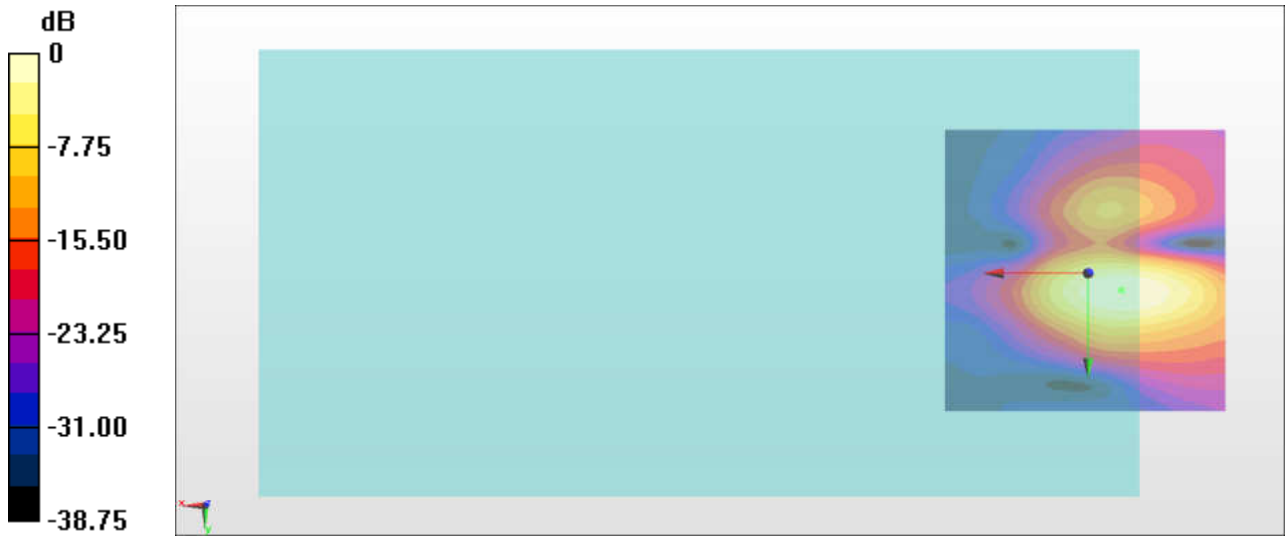
15_HAC_T-Coil_GSM850_EDGE 2 Tx slots_Ch189_Transversal (Y)

Communication System: GSM850 ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 24.59 dB
ABM1 comp = -10.02 dBA/m
Location: -5.8, 3, 3.7 mm



0 dB = 16.97 = 24.59 dB

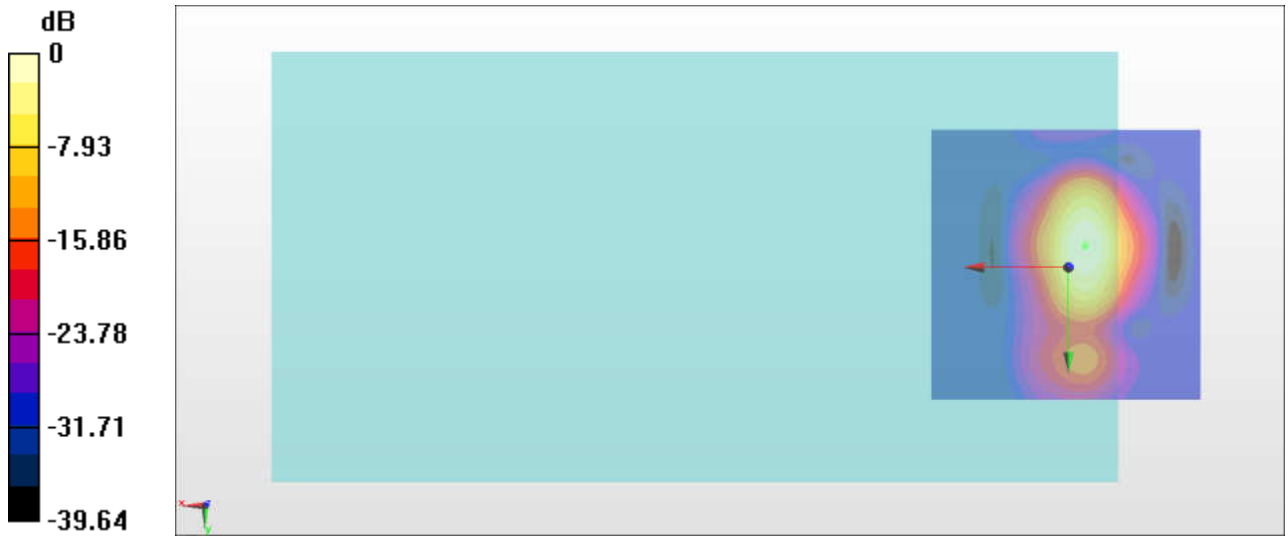
16_HAC_T-Coil_GSM1900_EDGE 2 Tx slots_Ch661_Axial (Z)

Communication System: PCS ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

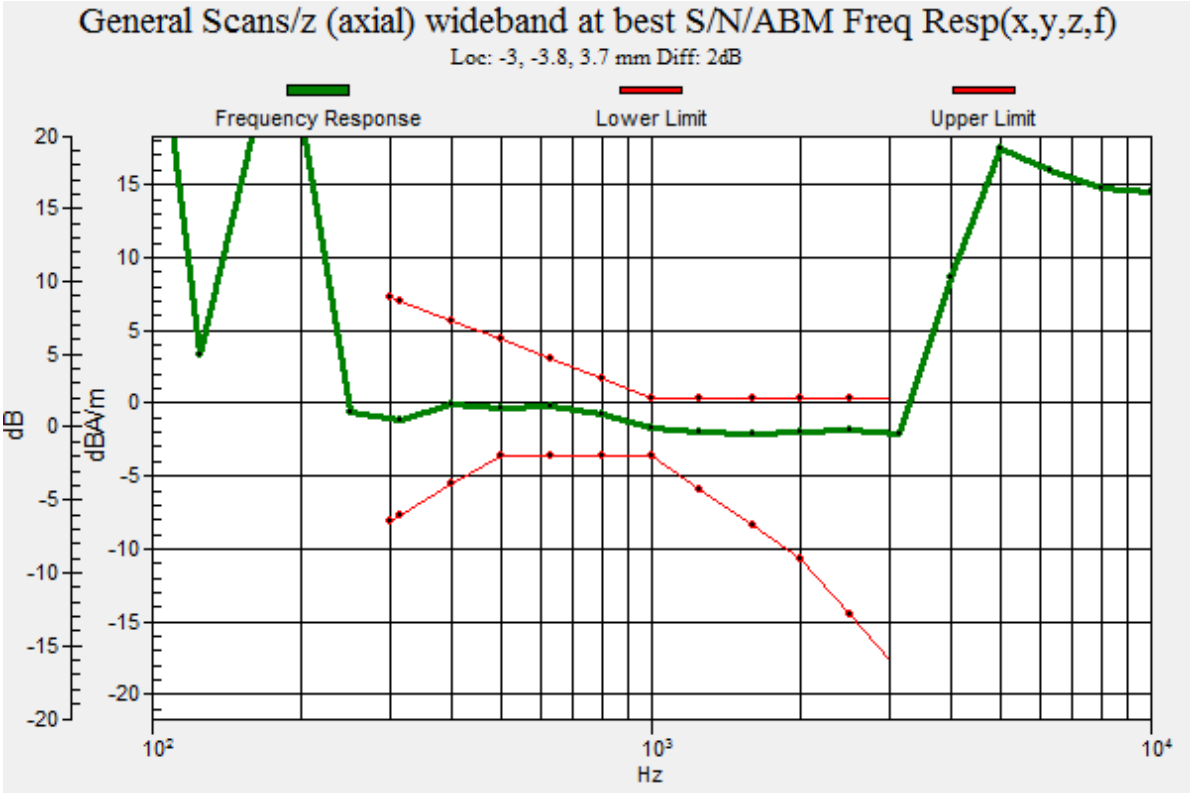
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 23.81 dB
ABM1 comp = -2.19 dBA/m
Location: -3, -4, 3.7 mm



0 dB = 15.50 = 23.81 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -3, -3.8, 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

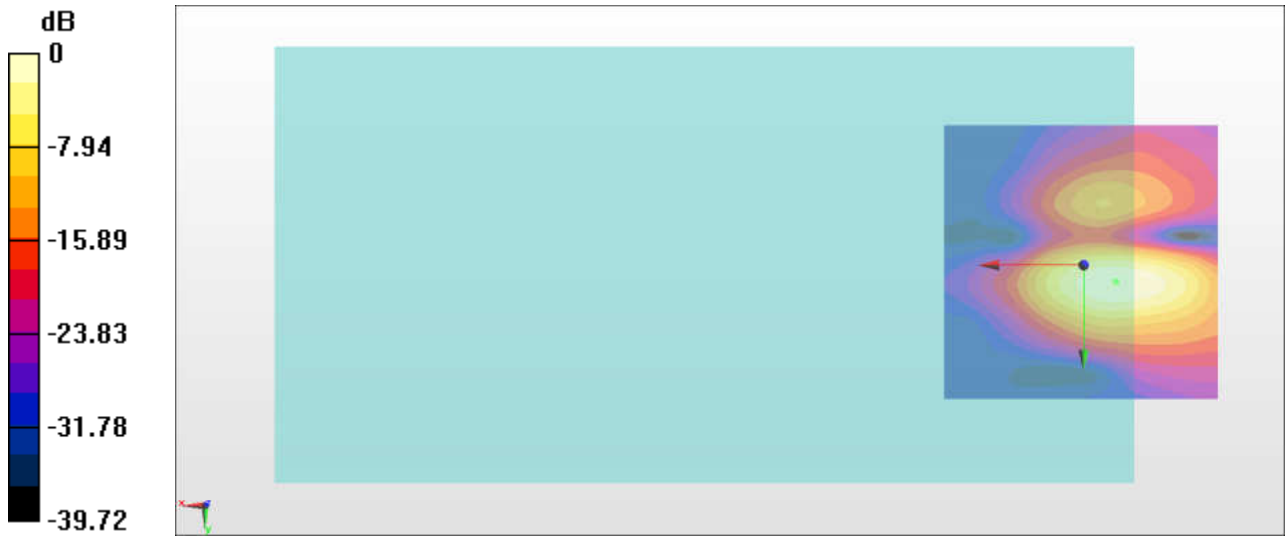
16_HAC_T-Coil_GSM1900_EDGE 2 Tx slots_Ch661_Transversal (Y)

Communication System: PCS ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 24.64 dB
ABM1 comp = -10.18 dBA/m
Location: -5.8, 3, 3.7 mm



0 dB = 17.07 = 24.64 dB

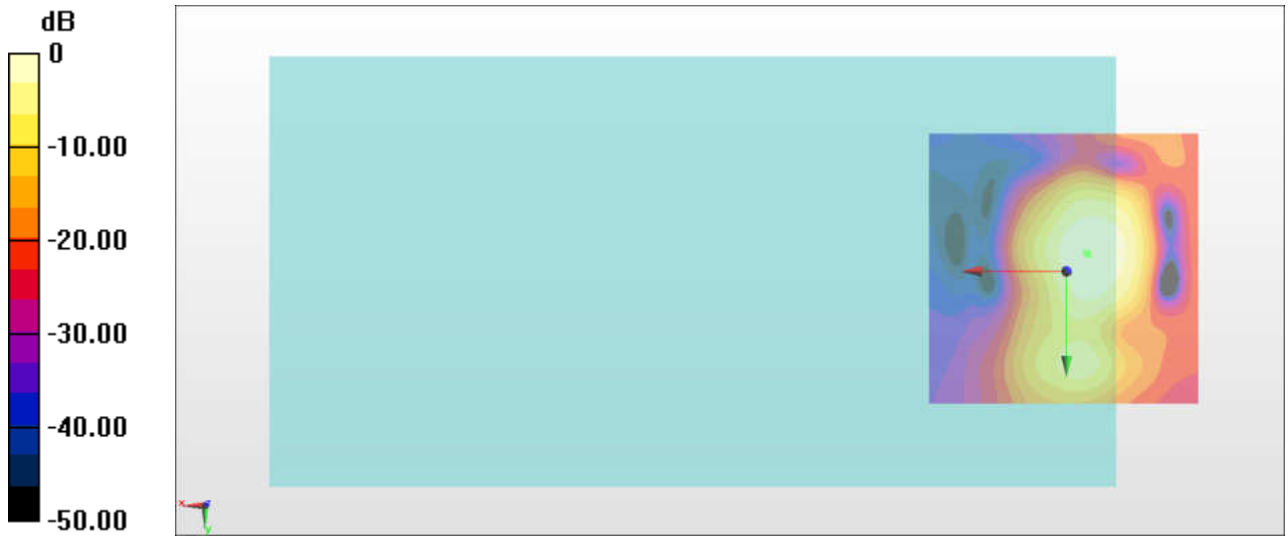
17_HAC_T-Coil_WCDMA II_HSPA_Ch9400_Axial (Z)

Communication System: WCDMA ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

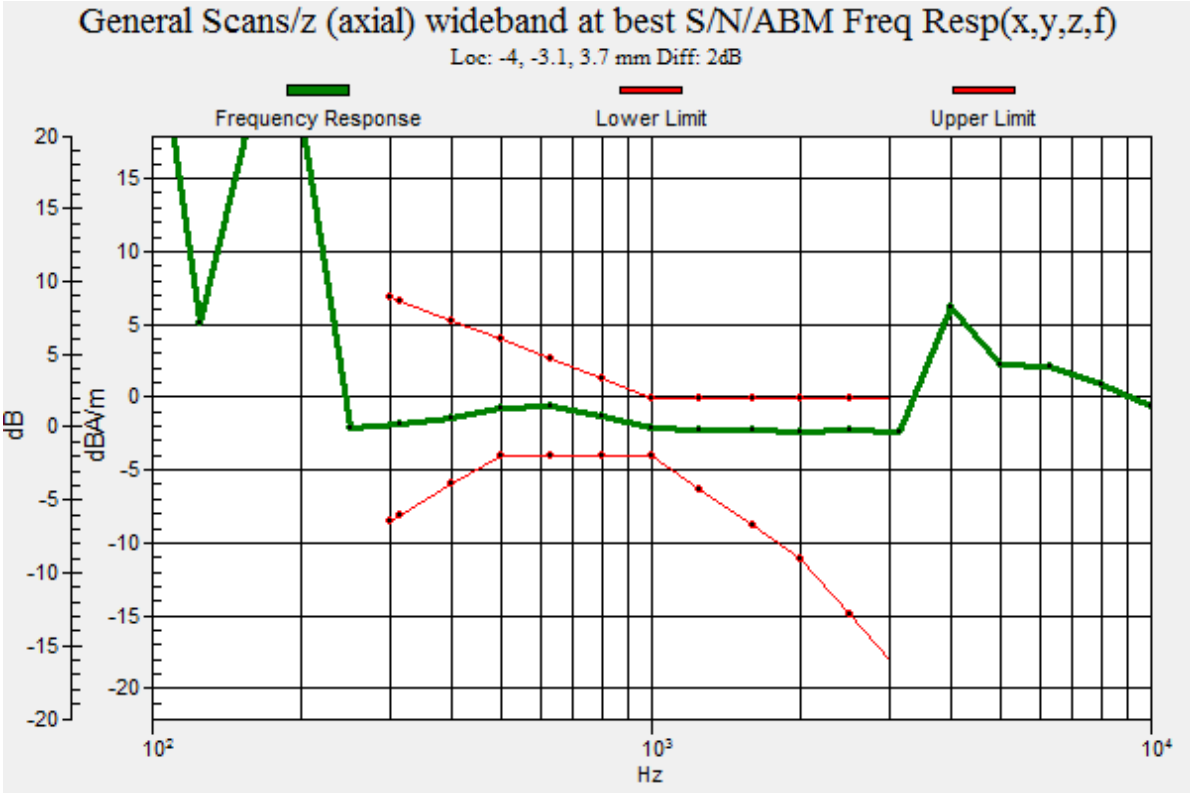
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 34.11 dB
ABM1 comp = -1.70 dBA/m
Location: -3.7, -3.3, 3.7 mm



0 dB = 50.74 = 34.11 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4, -3.1, 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

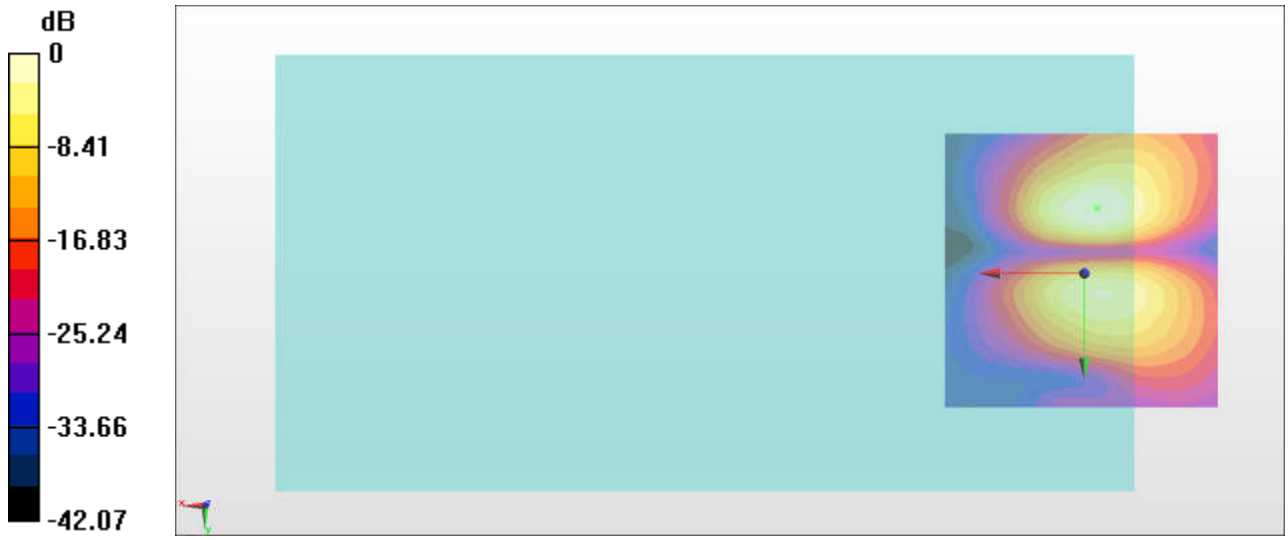
17_HAC_T-Coil_WCDMA II_HSPA_Ch9400_Transversal (Y)

Communication System: WCDMA ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 32.75 dB
ABM1 comp = -11.22 dBA/m
Location: -2.3, -11.7, 3.7 mm



0 dB = 43.42 = 32.75 dB

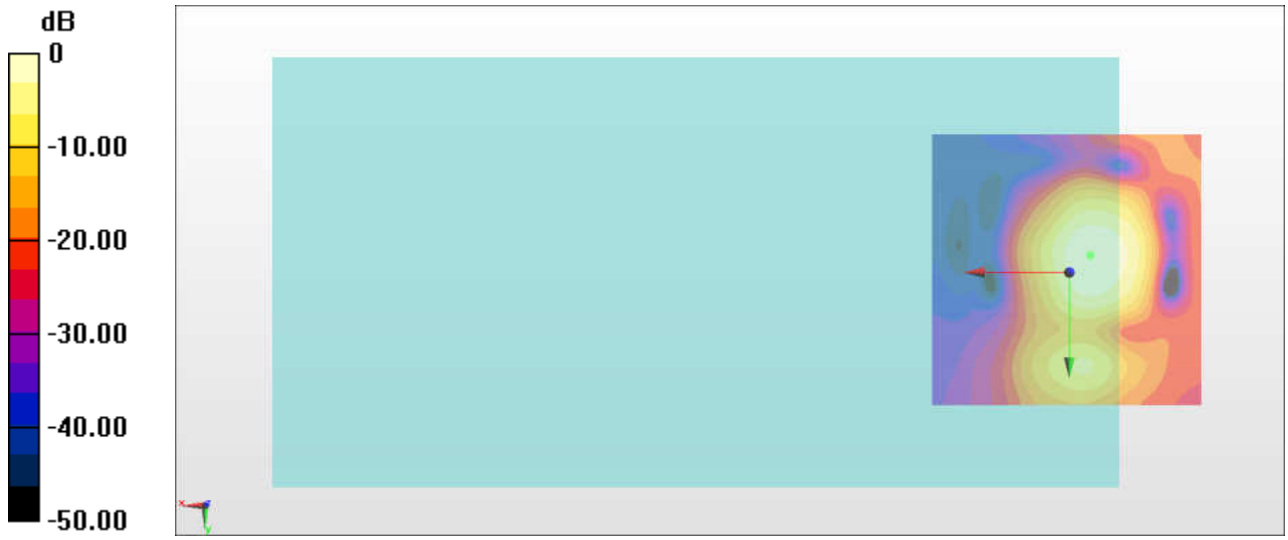
18_HAC_T-Coil_WCDMA IV_HSPA_Ch1413_Axial (Z)

Communication System: WCDMA ; Frequency: 1732.6 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

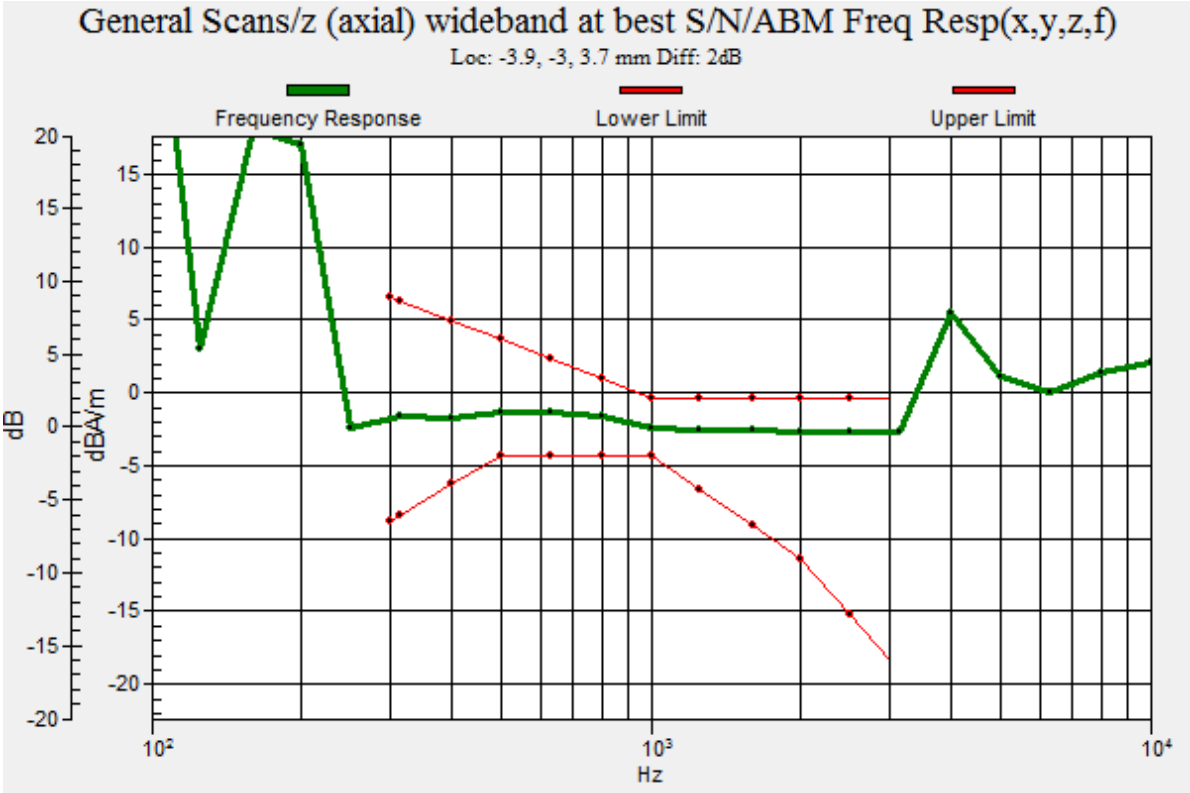
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 32.00 dB
ABM1 comp = -4.42 dBA/m
Location: -3.7, -3.3, 3.7 mm



0 dB = 39.80 = 32.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -3.9, -3, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

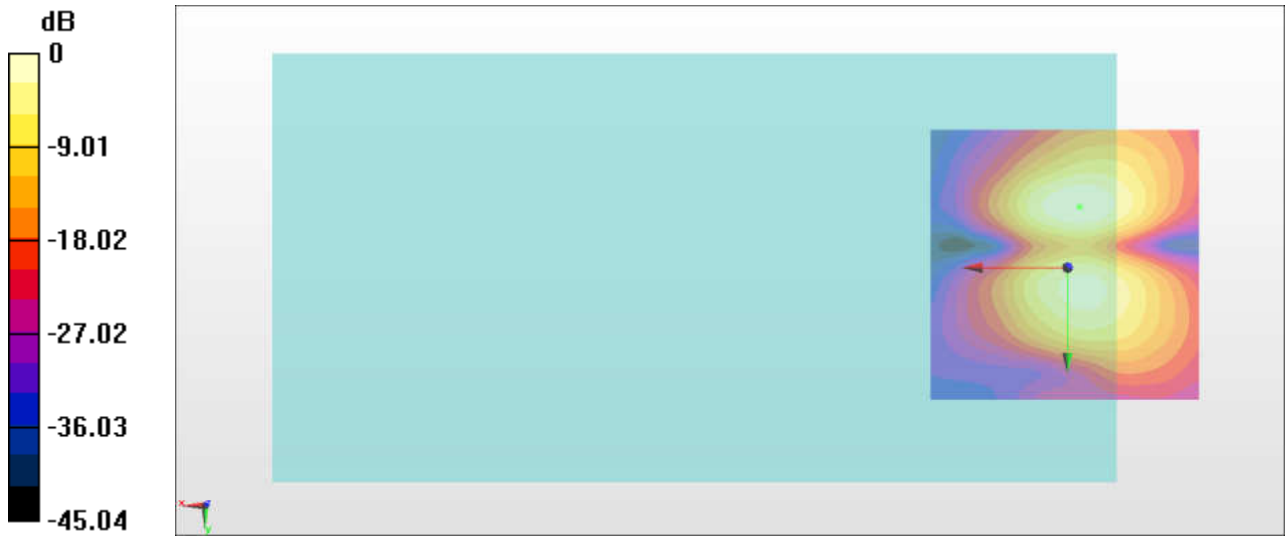
18_HAC_T-Coil_WCDMA IV_HSPA_Ch1413_Transversal (Y)

Communication System: WCDMA ; Frequency: 1732.6 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 31.78 dB
ABM1 comp = -11.91 dBA/m
Location: -2.3, -11, 3.7 mm



0 dB = 38.83 = 31.78 dB

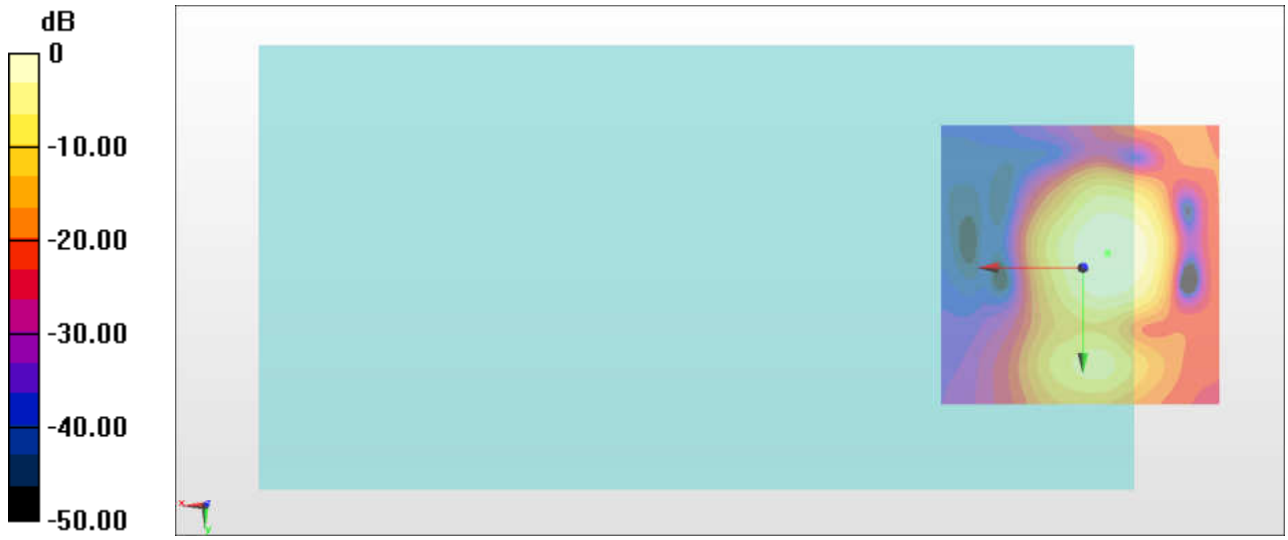
19_HAC_T-Coil_WCDMA V_HSPA_Ch4182_Axial (Z)

Communication System: WCDMA ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

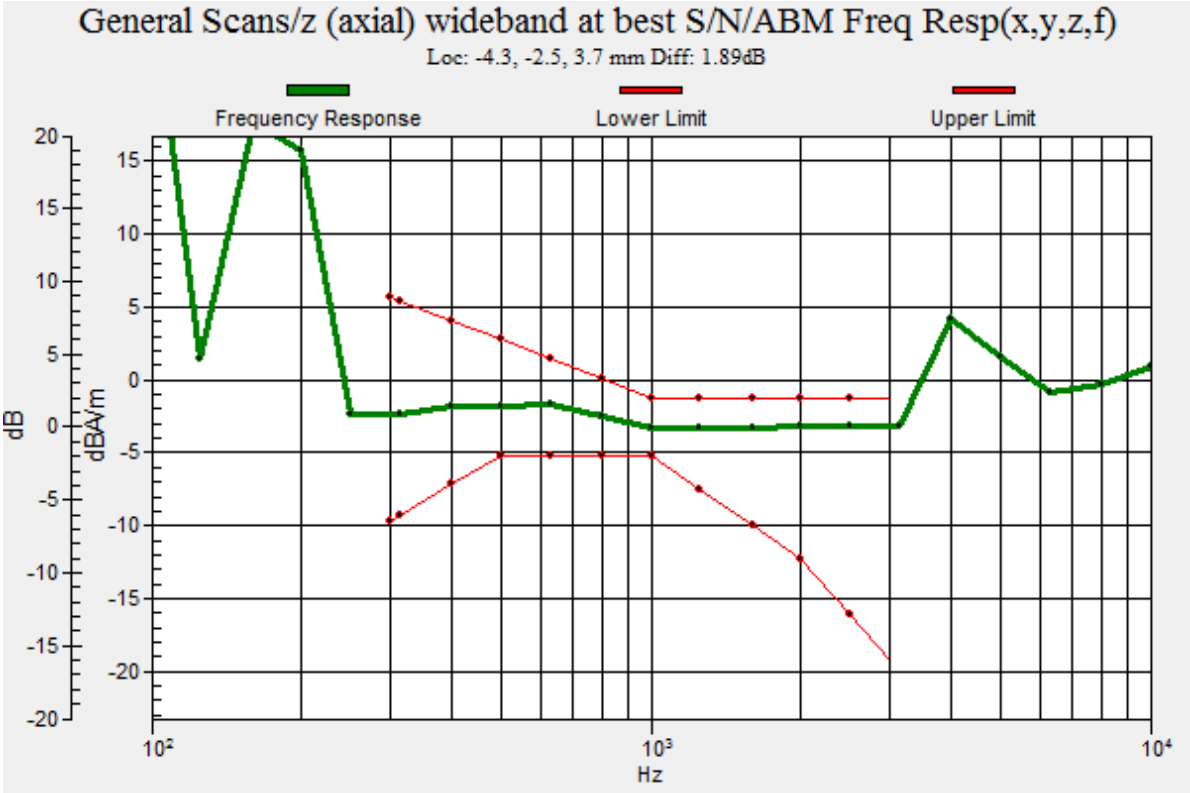
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 34.20 dB
ABM1 comp = -2.92 dBA/m
Location: -4.4, -2.6, 3.7 mm



0 dB = 51.31 = 34.20 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.3, -2.5, 3.7 mm Diff: 1.89dB
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

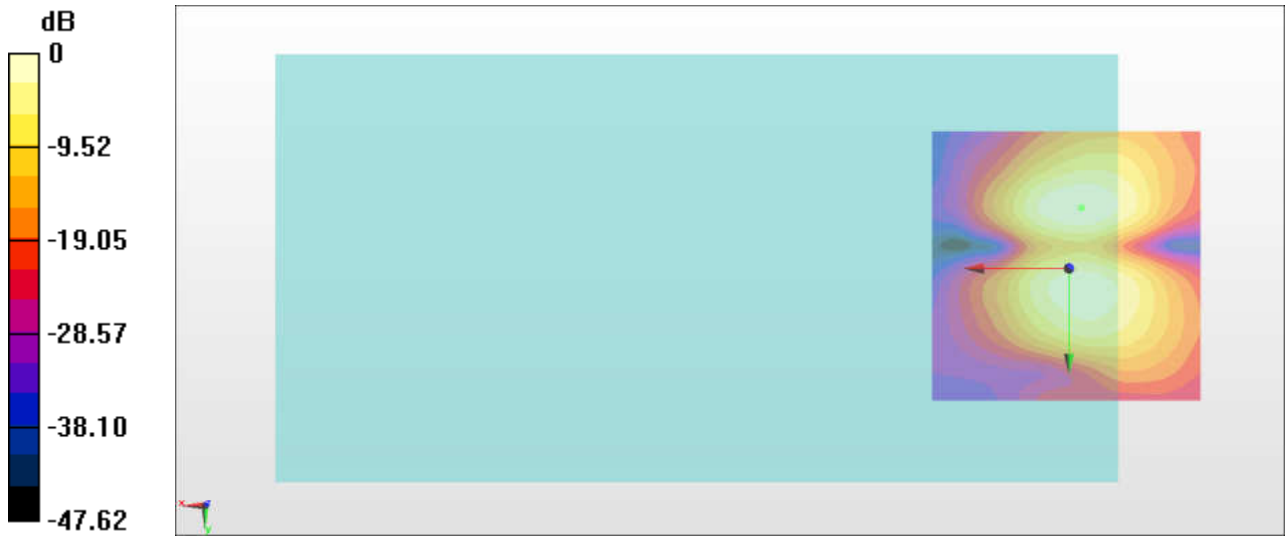
19_HAC_T-Coil_WCDMA V_HSPA_Ch4182_Transversal (Y)

Communication System: WCDMA ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 33.59 dB
ABM1 comp = -9.53 dBA/m
Location: -2.3, -11, 3.7 mm



0 dB = 47.83 = 33.59 dB

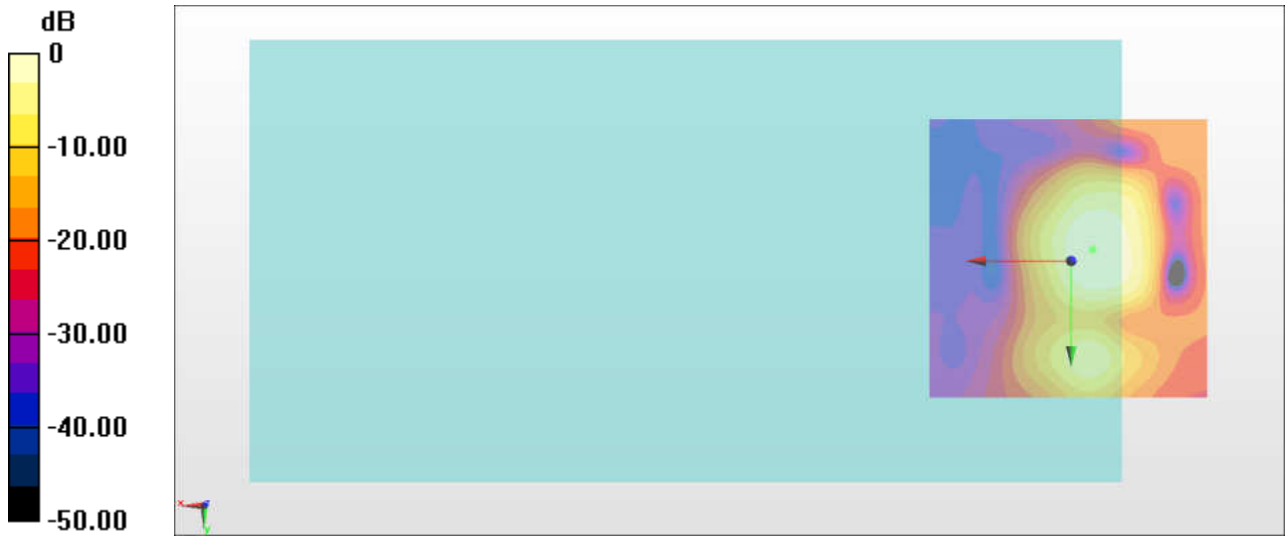
20_HAC_T-Coil_LTE Band 66_20M_QPSK_1RB_0Offset_Ch132322_Axial (Z)

Communication System: LTE ; Frequency: 1745 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

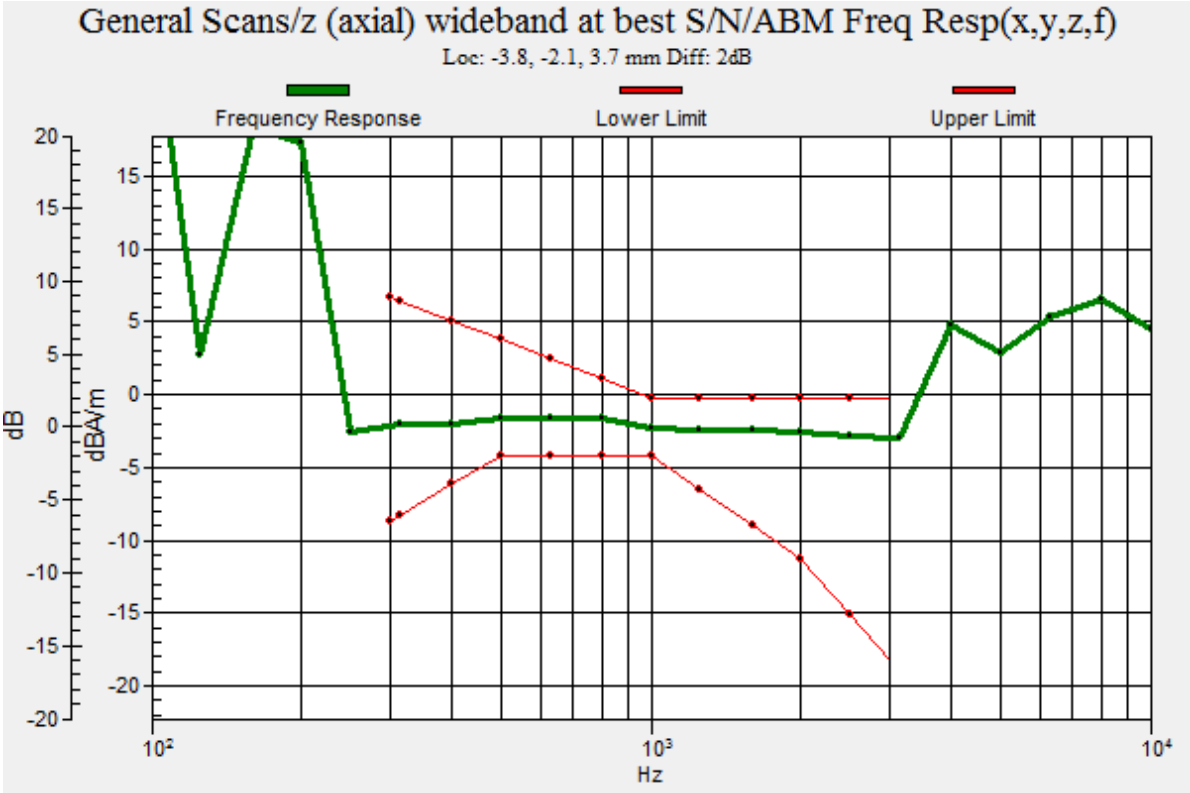
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 31.19 dB
ABM1 comp = -2.54 dBA/m
Location: -3.7, -1.9, 3.7 mm



0 dB = 36.25 = 31.19 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -3.8, -2.1, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

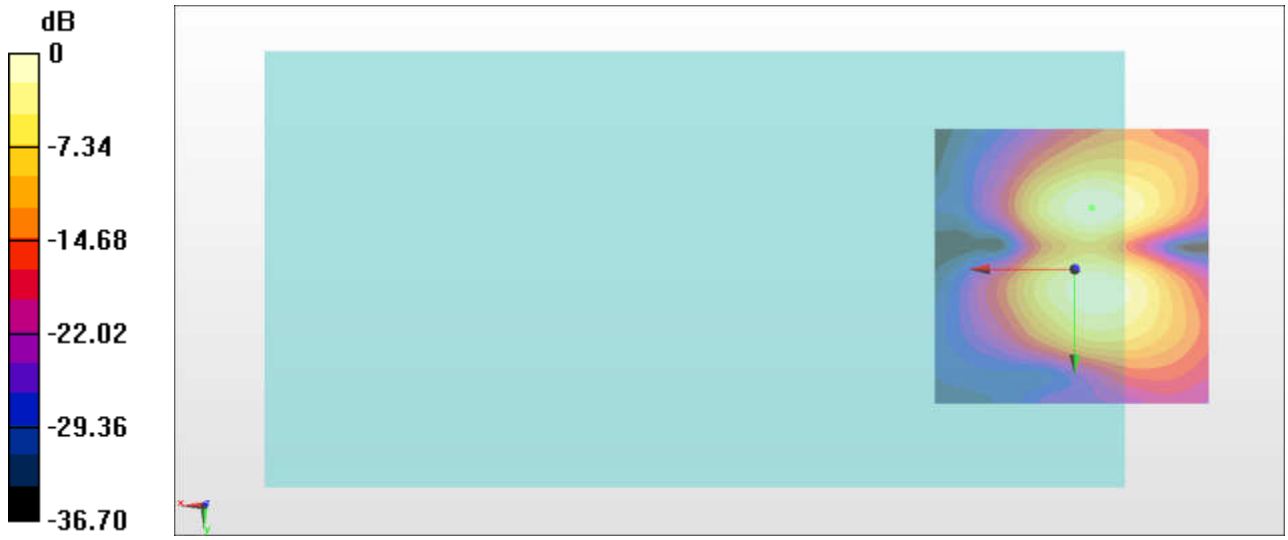
20_HAC_T-Coil_LTE Band 66_20M_QPSK_1RB_0Offset_Ch132322_Transversal (Y)

Communication System: LTE ; Frequency: 1745 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 30.99 dB
ABM1 comp = -9.15 dBA/m
Location: -3, -11, 3.7 mm



0 dB = 35.44 = 30.99 dB

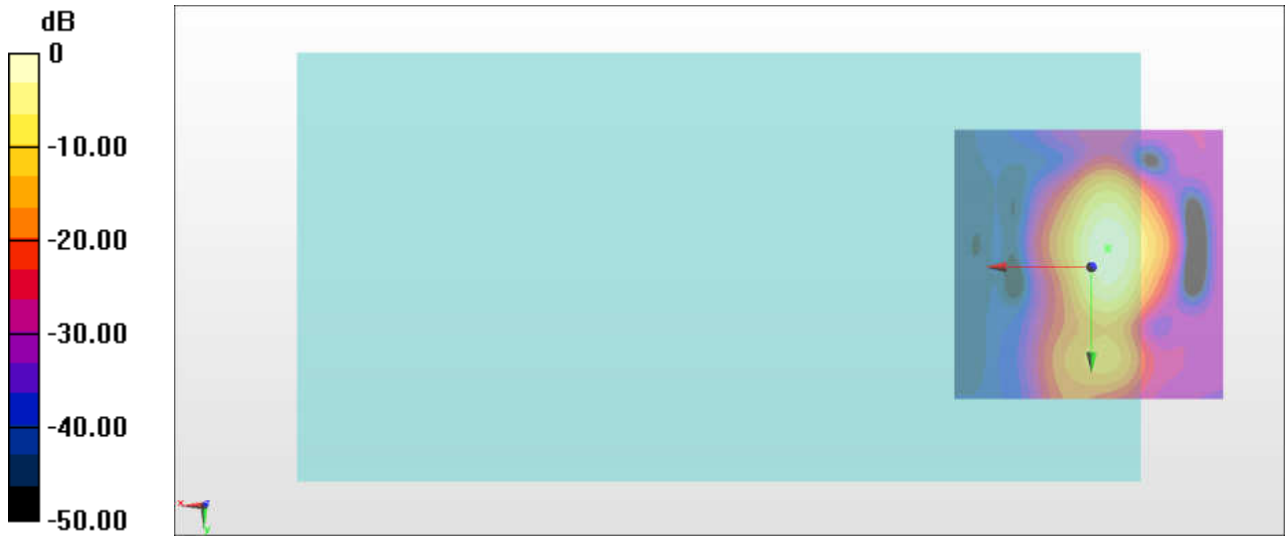
21_HAC_T-Coil_LTE Band 38_20M_QPSK_1RB_0Offset_Ch38000_Axial (Z)

Communication System: LTE TDD ; Frequency: 2595 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

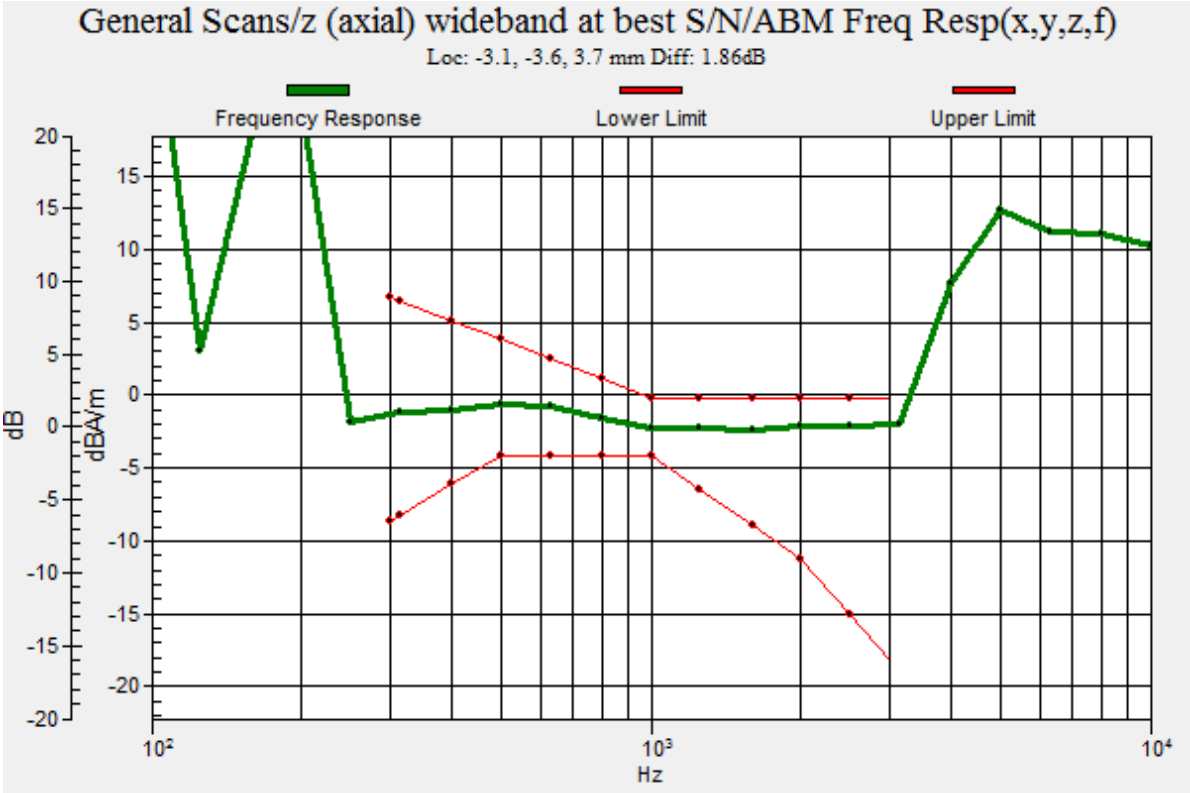
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 27.16 dB
ABM1 comp = -2.02 dBA/m
Location: -3, -3.3, 3.7 mm



0 dB = 22.80 = 27.16 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -3.1, -3.6, 3.7 mm Diff: 1.86dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

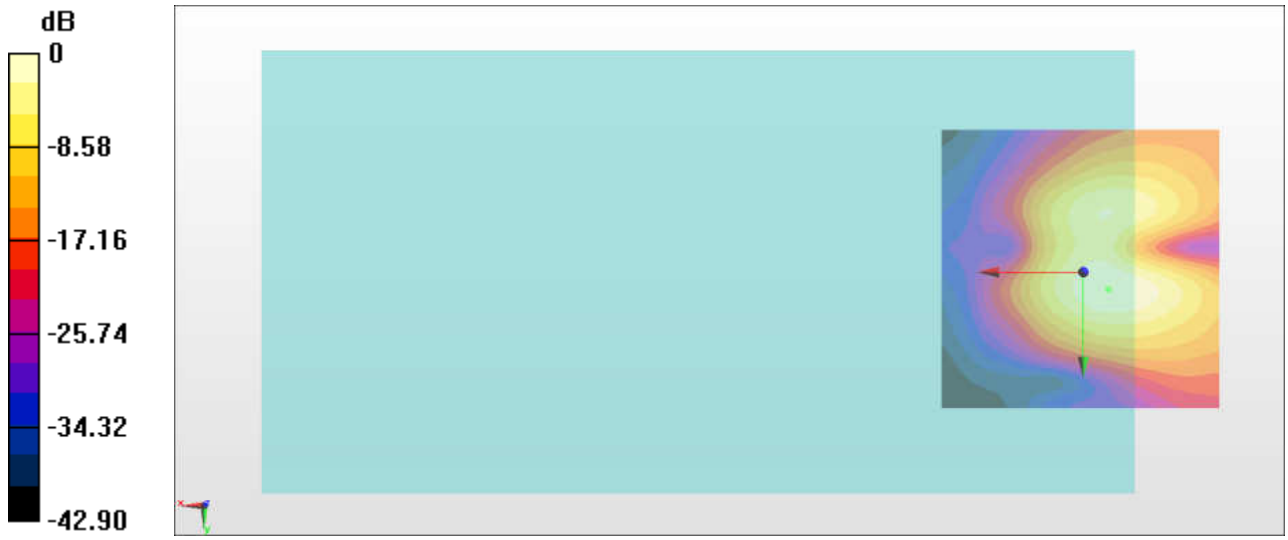
21_HAC_T-Coil_LTE Band 38_20M_QPSK_1RB_0Offset_Ch38000_Transversal (Y)

Communication System: LTE TDD ; Frequency: 2595 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 23.21 dB
ABM1 comp = -8.95 dBA/m
Location: -4.4, 3, 3.7 mm



0 dB = 14.47 = 23.21 dB

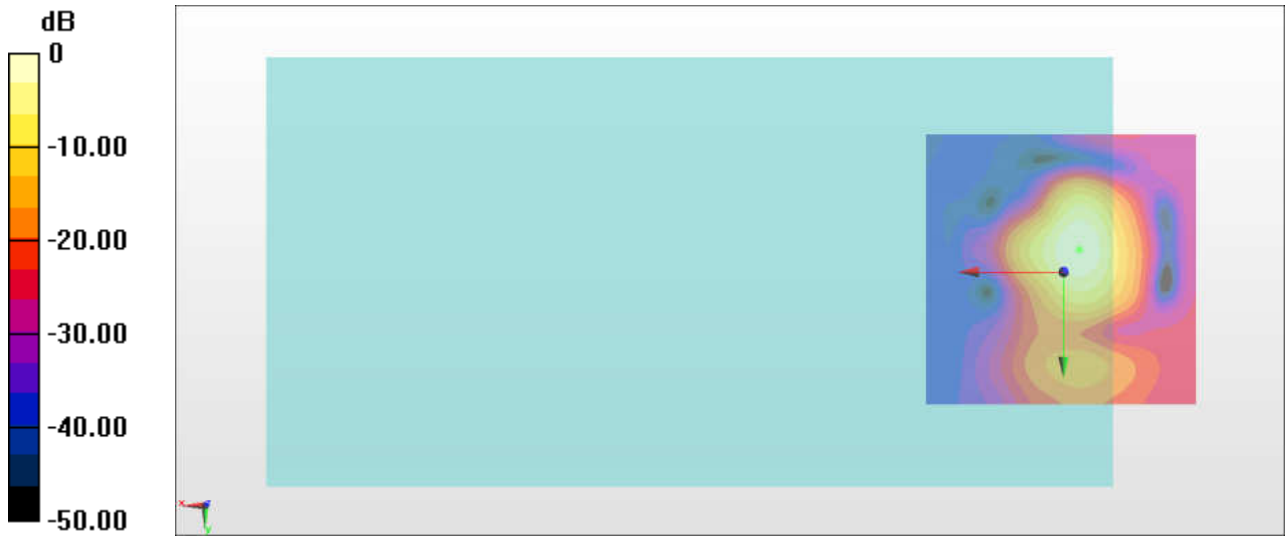
22_HAC_T-Coil_WLAN2.4GHz_802.11b 1Mbps_Ch6_Axial (Z)

Communication System: 802.11b ; Frequency: 2437 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

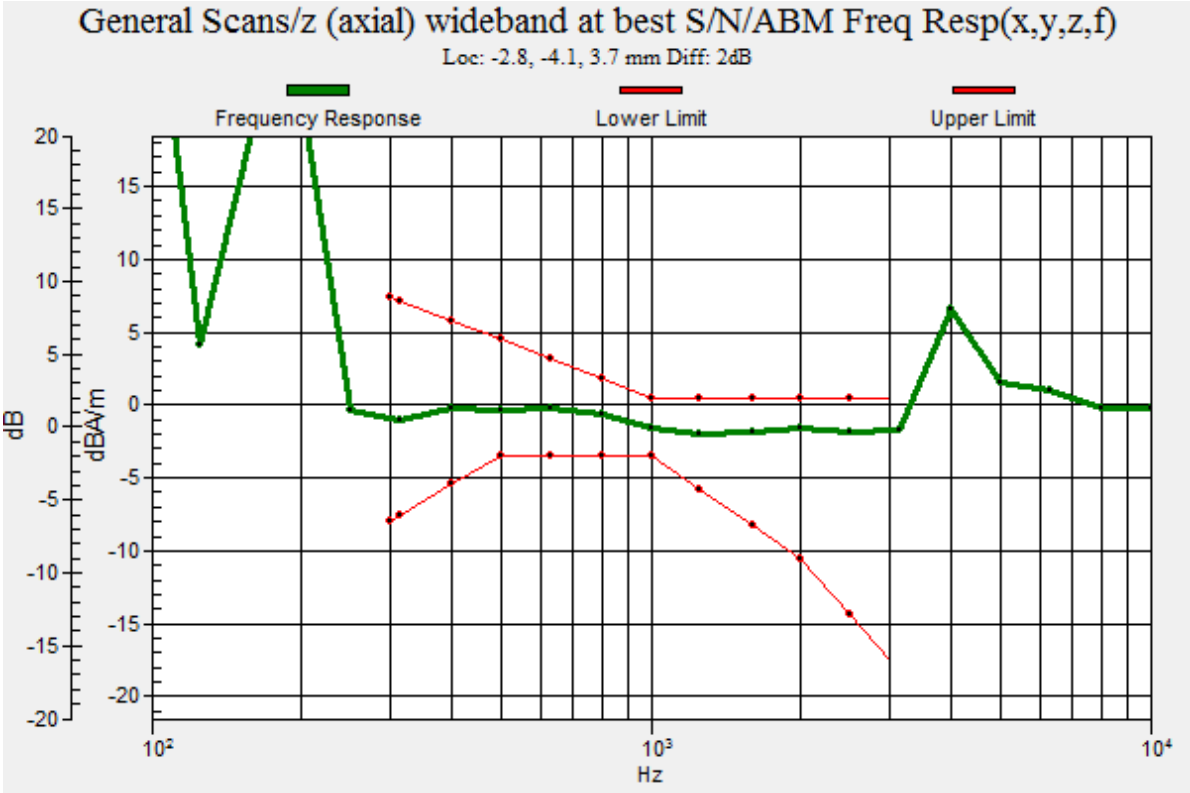
DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 32.54 dB
ABM1 comp = -1.57 dBA/m
Location: -3, -4, 3.7 mm



0 dB = 42.36 = 32.54 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -2.8, -4.1, 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

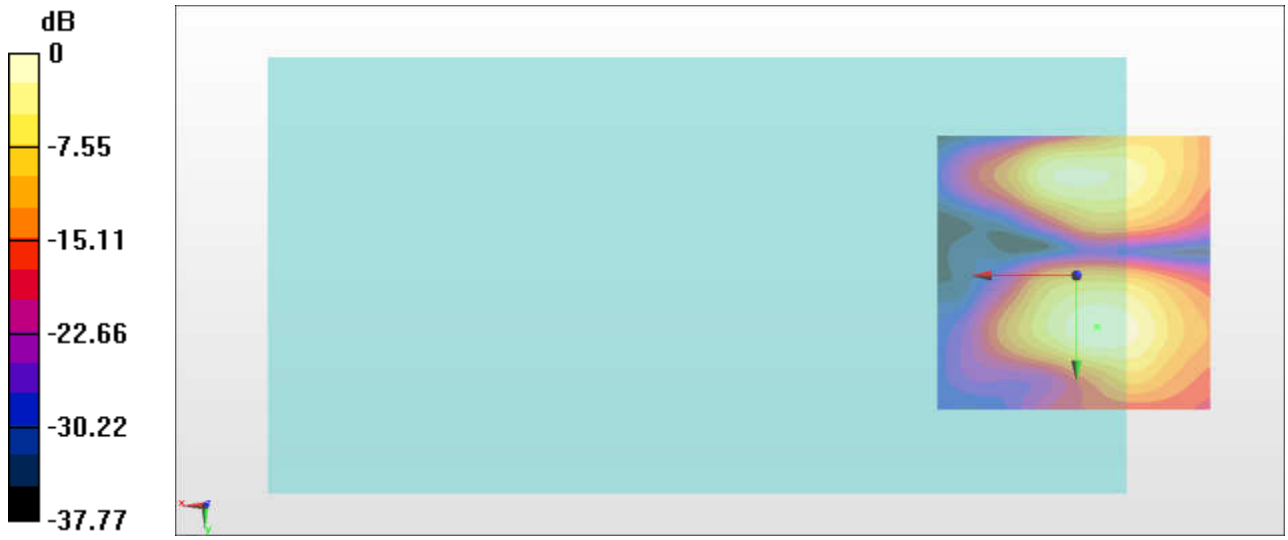
22_HAC_T-Coil_WLAN2.4GHz_802.11b 1Mbps_Ch6_Transversal (Y)

Communication System: 802.11b ; Frequency: 2437 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1424; Calibrated: 2018/1/18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 27.67 dB
ABM1 comp = -10.26 dBA/m
Location: -3.7, 9.3, 3.7 mm



0 dB = 24.17 = 27.67 dB

Appendix B. Calibration Data

The DASY calibration certificates are shown as follows.

Schmid & Partner Engineering AG

s p e a g

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

1386

IMPORTANT NOTICE

USAGE OF THE DAE 4

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 closed 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
Servizio svizzero di taratura
S 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 (Auden) - SZ

Certificate No: DAE4-1386_Jul17

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 1386
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	July 20, 2017

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	09-Sep-16 (No:19065)	Sep-17
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-17 (in house check)	In house check: Jan-18
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-17 (in house check)	In house check: Jan-18

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

Issued: July 20, 2017

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

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	404.509 ± 0.02% (k=2)	404.603 ± 0.02% (k=2)	404.122 ± 0.02% (k=2)
Low Range	4.02033 ± 1.50% (k=2)	4.01280 ± 1.50% (k=2)	4.01256 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	203.5 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	199994.40	-0.87	-0.00
Channel X	+ Input	20001.09	-0.18	-0.00
Channel X	- Input	-19999.53	1.66	-0.01
Channel Y	+ Input	199994.93	-0.61	-0.00
Channel Y	+ Input	19999.47	-2.07	-0.01
Channel Y	- Input	-20000.82	0.10	-0.00
Channel Z	+ Input	199995.00	-0.63	-0.00
Channel Z	+ Input	19998.80	-2.56	-0.01
Channel Z	- Input	-20001.96	-0.74	0.00

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	2001.10	-0.11	-0.01
Channel X	+ Input	201.26	-0.29	-0.14
Channel X	- Input	-198.71	-0.32	0.16
Channel Y	+ Input	2001.16	-0.00	-0.00
Channel Y	+ Input	201.19	-0.33	-0.17
Channel Y	- Input	-199.21	-0.81	0.41
Channel Z	+ Input	2001.08	0.00	0.00
Channel Z	+ Input	200.18	-1.28	-0.64
Channel Z	- Input	-199.68	-1.29	0.65

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	-15.85	-17.49
	- 200	17.99	16.50
Channel Y	200	-9.26	-9.27
	- 200	8.70	7.82
Channel Z	200	-5.99	-5.99
	- 200	3.29	3.53

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	-	4.71	-2.87
Channel Y	200	8.35	-	6.11
Channel Z	200	8.05	6.94	-

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	16015	15075
Channel Y	16073	17190
Channel Z	16065	13429

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	-0.11	-0.95	0.83	0.36
Channel Y	0.05	-0.80	0.87	0.39
Channel Z	-0.02	-1.22	0.80	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

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IMPORTANT NOTICE

USAGE OF THE DAE 4

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 closed 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
Servizio svizzero di taratura
S 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 (Auden)**

Certificate No: DAE4-1279_Jan18

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 1279
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	January 03, 2018

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-17 (No:21092)	Aug-18
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	05-Jan-17 (in house check)	In house check: Jan-18
Calibrator Box V2.1	SE UMS 006 AA 1002	05-Jan-17 (in house check)	In house check: Jan-18

	Name	Function	Signature
Calibrated by:	Adrian Gehring	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	i.V.

Issued: January 3, 2018

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

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	403.936 ± 0.02% (k=2)	403.884 ± 0.02% (k=2)	404.618 ± 0.02% (k=2)
Low Range	3.94927 ± 1.50% (k=2)	3.99010 ± 1.50% (k=2)	3.98938 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	354.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	199997.64	1.92	0.00
Channel X	+ Input	20004.80	2.86	0.01
Channel X	- Input	-19998.76	2.17	-0.01
Channel Y	+ Input	199997.83	1.78	0.00
Channel Y	+ Input	20003.36	1.57	0.01
Channel Y	- Input	-20002.72	-1.82	0.01
Channel Z	+ Input	199997.69	1.96	0.00
Channel Z	+ Input	20001.39	-0.37	-0.00
Channel Z	- Input	-20003.42	-2.35	0.01

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	2002.48	0.98	0.05
Channel X	+ Input	202.86	1.08	0.53
Channel X	- Input	-196.92	1.17	-0.59
Channel Y	+ Input	2001.79	0.30	0.02
Channel Y	+ Input	201.96	0.09	0.04
Channel Y	- Input	-198.07	0.01	-0.00
Channel Z	+ Input	2002.13	0.68	0.03
Channel Z	+ Input	201.17	-0.61	-0.30
Channel Z	- Input	-199.15	-0.81	0.41

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	-18.51	-19.43
	- 200	22.51	20.73
Channel Y	200	5.49	5.17
	- 200	-5.84	-6.15
Channel Z	200	6.57	6.24
	- 200	-7.96	-7.86

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	-	3.48	-3.85
Channel Y	200	8.57	-	4.96
Channel Z	200	10.34	5.90	-

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	15969	18140
Channel Y	15962	17206
Channel Z	15703	15717

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	1.05	-0.22	2.54	0.42
Channel Y	-0.28	-1.59	0.65	0.42
Channel Z	-0.08	-1.35	2.05	0.57

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