Hearing Aid Compatibility (HAC) TEST REPORT

<For T-Coil Measurement>

Applicant Name	TCL Communication Ltd.
Address of Applicant	7/F, Block F4, TCL Communication Technology Building, TCL International E City, Zhong Shan Yuan Road, Nanshan District, Shenzhen, Guangdong, P.R. China 518052
Model No.	5059S
FCC ID	2ACCJH102
Date of Receive	Dec. 11, 2018
Date of Test(s)	Dec. 14, 2018 ~ Dec. 18, 2018
Date of Issue	Jan. 02, 2019

Standards:

ANSI C63.19-2011

FCC RULE PART(S): 47 CFR PART 20.19(B)
HAC RATE CATEGORY: T3 (T Category)

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS Taiwan Electronics & Communication Laboratory or testing done by SGS Taiwan Electronics & Communication Laboratory in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Electronics & Communication Laboratory in writing.

Signed on behalf of SGS

Sr. Engineer	**Asst. Manager**
Matt Kuo (signed: Matt Kuo)	**John Yeh** (signed: John Yeh)
Date: Jan. 02, 2019	**Date: Jan. 02, 2019**

SGS Taiwan Ltd. 台灣檢驗科技股份有限公司
No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路 134 號
t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

Revision History

Report Number	Revision	Description	Issue Date
E5/2018/C0011	Rev.00	Initial creation of document	Jan. 02, 2019

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

Table of Contents

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

1. Introduction

The purpose of this standard is to establish categories for hearing aids and for WD (wireless communications devices) that can indicate to health care practitioners and hearing aid users which hearing aids are compatible with which WD, and to provide tests that can be used to assess the electromagnetic characteristics of hearing aids and WD and assign them to these categories. The various parameters required, in order to demonstrate compatibility and accessibility are measured. The design of the standard is such that when a hearing aid and WD achieve one of the categories specified, as measured by the methodology of this standard, the indicated performance is realized.
In order to provide for the usability of a hearing aid with a WD, several factors must be coordinated:

a) Radio frequency (RF) measurements of the near-field electric and magnetic fields emitted by a WD to categorize these emissions for correlation with the RF immunity of a hearing aid.
b) Magnetic field measurements of a WD emitted via the audio transducer associated with the T-coil mode of the hearing aid, for assessment of hearing aid performance.
c) Measurements with the hearing aid and a simulation of the categorized WD T-coil emissions to assess the hearing aid RF immunity in the T-coil mode.

The WD radio frequency (RF) and audio band emissions are measured.
Hence, the following are measurements made for the WD:

a) RF E-Field emissions
b) T-coil mode, magnetic signal strength in the audio band
c) T-coil mode, magnetic signal and noise articulation index
d) T-coil mode, magnetic signal frequency response through the audio band

Corresponding to the WD measurements, the hearing aid is measured for:

a) RF immunity in microphone mode
b) RF immunity in T-coil mode

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

2. Testing Laboratory

Company Name	SGS Taiwan Ltd. Electronics & Communication Laboratory
Company address	No.2, Keji 1st Rd., Guishan Township, Taoyuan County 333, Taiwan (R.O.C.)
Telephone	+886-2-2299-3279
Fax	+886-2-2298-0488
Website	http://www.tw.sgs.com/

3. Details of Applicant

Applicant Name	TCL Communication Ltd.
Applicant Address	7/F, Block F4, TCL Communication Technology Building, TCL International E City, Zhong Shan Yuan Road, Nanshan District, Shenzhen, Guangdong, P.R. China 518052

4. Description of EUT

Model No.	5059S			
FCC ID	2ACCJH102			
Mode of Operation	☒GSM ☒GPRS ☒EDGE ☒WCDMA ☒LTE FDD ☒Bluetooth ☒WLAN802.11b/g/n/(20M/40M)			
Duty Cycle	GSM (DTM multi class B)	1/8.3		
	GPRS (support multi class 12 max)	1/2 (1Dn4UP) 1/2.76 (1Dn3UP) 1/4.1 (1Dn2UP) 1/8.3 (1Dn1UP)		
	EDGE (support multi class 12 max)	1/2 (1Dn4UP) 1/2.76 (1Dn3UP) 1/4.1 (1Dn2UP) 1/8.3 (1Dn1UP)		
	WCDMA	1		
	LTE FDD	1		
	WLAN802.11b/g/n(20M/40M)	1		
	Bluetooth	1		
TX Frequency Range (MHz)	GSM850	824	–	849
	GSM1900	1850	–	1910
	WCDMA Band II	1850	–	1910
	WCDMA Band V	824	–	849
	LTE FDD Band 2	1850	–	1910
	LTE FDD Band 4	1710	–	1755
	LTE FDD Band 5	824	–	849
	LTE FDD Band 13	777	–	787
	LTE FDD Band 66	1710	–	1780
	WLAN802.11 b/g/n(20M)	2412	–	2462
	WLAN802.11 n(40M)	2422	–	2452
	Bluetooth	2402	–	2480

Channel Number (ARFCN)	GSM850	128	–	251
	GSM1900	512	–	810
	WCDMA Band II	9262	–	9538
	WCDMA Band V	4132	–	4233
	LTE FDD Band 2	18607	–	19193
	LTE FDD Band 4	19957	–	20393
	LTE FDD Band 5	20407	–	20643
	LTE FDD Band 13	23205	–	23255
	LTE FDD Band 66	131979	–	132665
	WLAN802.11 b/g/n(20M)	1	–	11
	WLAN802.11 n(40M)	3	–	9
	Bluetooth	0	–	78

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

5. Air Interfaces and Bands

Air Interface	Band (MHz)	Type	ANSI C63.19 Tested	Simultaneous Transmitter	Name of Voice Service	Power Reduction
GSM	850	VO	Yes	BT and Wi-Fi	CMRS Voice*	NA
	1900					
	GPRS/EDGE	VD	Yes		Google Duo**	
WCDMA	850	VO	Yes	BT and Wi-Fi	CMRS Voice*	NA
	1900					
	HSPA	VD	Yes		Google Duo**	
LTE	Band 2/4/5/13/66	VD	Yes	BT and Wi-Fi	VoLTE* Google Duo**	NA
Wi-Fi	2450	VD	Yes	BT, GSM, WCDMA and LTE	Wi-Fi calling** Google Duo**	NA
BT	2450	DT	NA	Wi-Fi, GSM, WCDMA and LTE	NA	NA

VO: Legacy Cellular Voice Service from Table 7.1 in 7.4.2.1 of ANSI C63.19-2011
DT: Digital Transport (no voice)
VD: IP Voice Service over Digital Transport
* Ref Lev in accordance with 7.4.2.1 of ANSI C63.19-2011 and the July 2012 VoLTE interpretation
** Ref Lev −20 dBm0

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

6. Test Environment

Ambient Temperature	21.7° C
Relative Humidity	<80 %

7. Description of test system

7.1 Measurement System Diagram for SPEAG Robotic

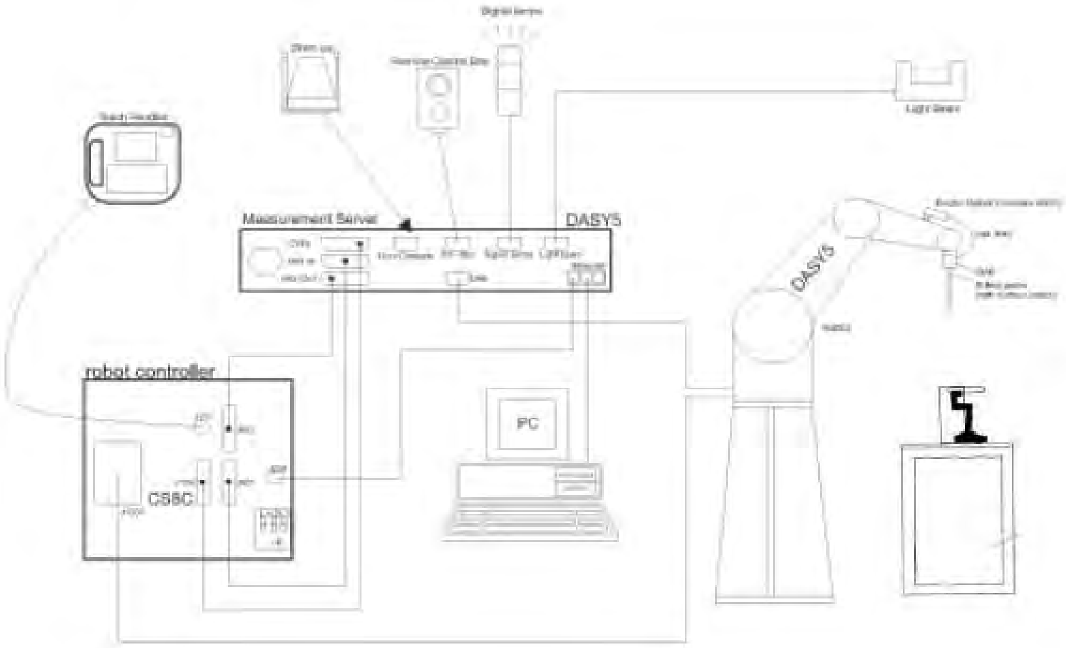


Fig. 1. The SPEAG Robotic Diagram

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stabile RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
- An Audio Magnetic probe.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The Test Arch SAM phantom
- The device holder for handheld mobile phones.
- Validation dipole kits allowing to validate the proper functioning of the system.

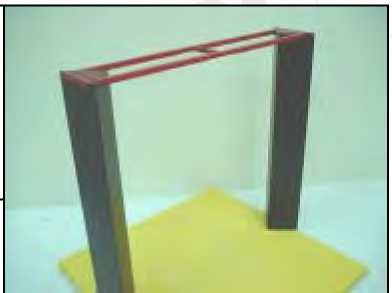
7.2 Audio Magnetic Probe AM1DV3

Description	- Active single sensor probe for both axial and radial measurement scans- Fully RF shielded, compatible with DAE, with adapted probe cup
Dynamic Range	0.1 KHz to 20 KHz
Sensitivity	<-50dB A/m @ 1KHz
Internal Amp	20dB
Dimensions	300X18mm


AM1DV3 Audio Probe

7.3 Test Arch

Description	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.
Dimensions	length: 370 mm width: 370 mm height: 370 mm


Test Arch

7.4 AMCC- Audio Magnetic Calibration Coil

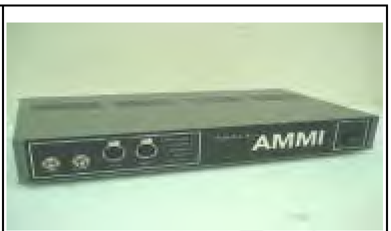
Description	Allows calibration of the complete measurement setup, The two horizontal coils create a homogeneous magnetic field in the z direction. Refer to Appendix 5 for more detail on AMCC coil

AMCC

7.5 Phone Holder

Description	Supports accurate and reliable positioning of any phone Effect on near field <+/- 0.5 dB	 Phone Holder

7.6 AMMI - Audio Magnetic Measurement Instrument

Description	-USB interface to PC - Probe signal digitization and power supply- Test signal generation for wireless device (via base station simulator)-Auto-calibration and interfaces to AMCC for complete setup-calibration	 AMMI
Data Rate	48 KHz / 24bit	
Dynamic Range	85 dB	
Dimensions:	19" X 65 X 270mm	

SGS Taiwan Ltd.
台灣檢驗科技股份有限公司
No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

8. Measurement Procedure

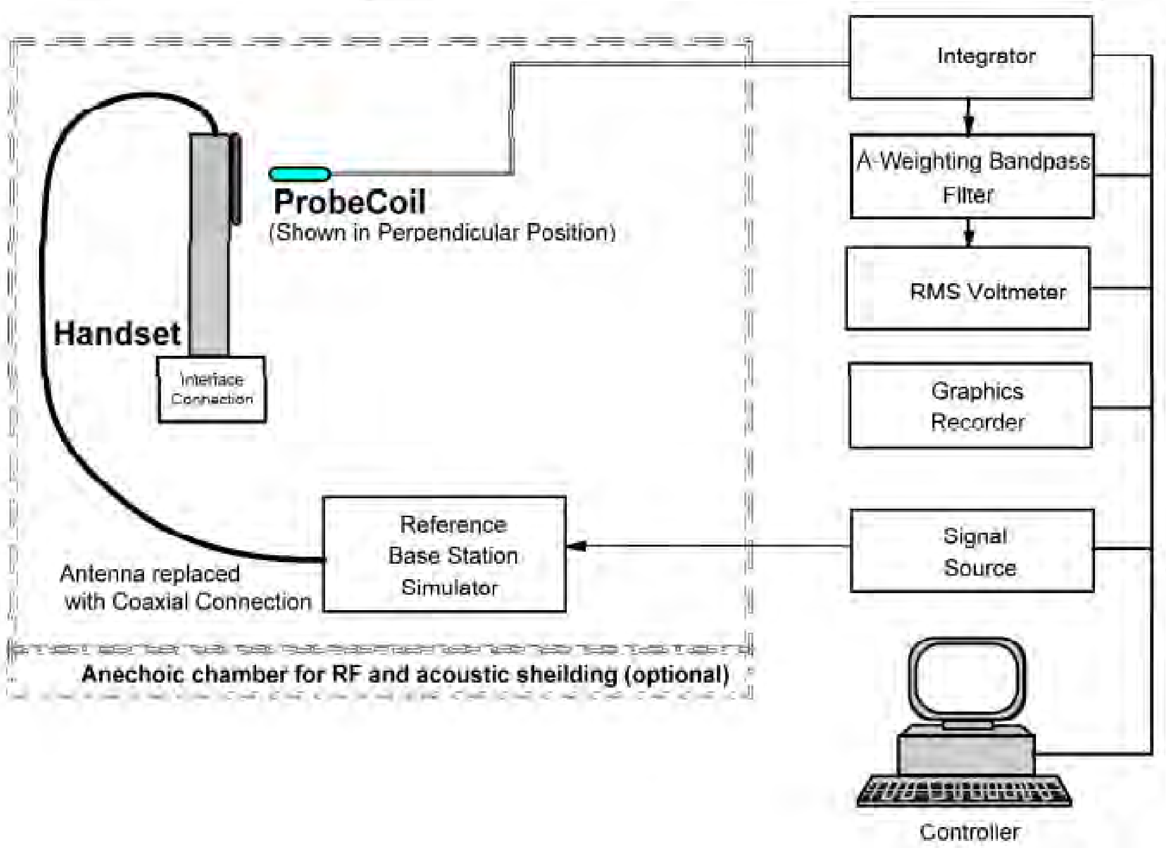


Fig. 2. T-coil signal measurement test setup

The sequence of the measurement is T-Coil testing procedure over a wireless communication device:

1. Confirm Geometry & signal check. Probe phantom alignment and check of accuracy.
2. Background noise measurement in the area of the WD.
3. Perform 50x50mm area scan with narrow band signal to determine ABM1, ABM2 and SNR for axial and radial orientation positions.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

4. For Axial position, perform optimal SNR point measurement with a broadband signal – determine Frequency Response

Note.

#. The EUT do not use the special HAC SW.

#. Setting the maximum volume for EUT during the measurement.

#. For the measurement, it don't use the "post-test measurement processing of results".

#. Per KDB 285076 D01v05, handsets that that have the ability to support concurrent connections using simultaneous transmissions shall be independently tested for each air interface/band given in ANSI C63.19-2011. At the present time ANSI C63.19 does not provide simultaneous transmission test procedures.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

9. System calibration

For correct and calibrated measurement of the voltages and ABM field, DASY will perform a calibration job as below.

In phase 1, the audio output is switched off, and a 200 mVpp symmetric rectangular signal of 1 kHz is generated and internally connected directly to both channels of the sampling unit (Coil in, Probe in).

In phase 2, the audio output is off, and a 20 mVpp symmetric 100 Hz signal is internally connected. The signals during phases 1 and 2 are available at the output on the rear panel of the AMMI. However, the output must not be loaded, in order to avoid influencing the calibration. An RMS voltmeter would indicate 100 mVRMS during the first phase and 10 mVRMS during the second phase. After the first two phases, the two input channels are both calibrated for absolute measurements of voltages. The resulting factors are displayed above the multi-meter window.

After phases 1 and 2, the input channels are calibrated to measure exact voltages. This is required to use the inputs for measuring voltages with their peak and RMS value.

In phase 3, a multi-sine signal covering each third-octave band from 50 Hz to 10 kHz is generated and applied to both audio outputs. The probe should be positioned in the center of the AMCC and aligned in the z-direction, the field orientation of the AMCC. The “Coil In” channel is measuring the voltage over the AMCC internal shunt, which is proportional to the magnetic field in the AMCC. At the same time, the “Probe In" channel samples the amplified

signal picked up by the probe coil and provides it to a numerical integrator. The ratio of the two voltages in each third-octave filter leads to the spectral representation over the frequency band of interest. The Coil signal is scaled in dBV, and the Probe signal is first integrated and normalized to show dB A/m. The ratio probe-to-coil at the frequency of 1 kHz is the sensitivity which will be used in the consecutive T-Coil jobs.

10. T-coil testing for GSM

1. Codec investigation
   An investigation was performed to determine the audio codec to be used for testing by SNR comparison. The FR V1 setting was used for the testing as the worst-case codec.

Codec Investigation - GSM					
Codec Setting:	**FR V1**	**HR V1**	**Orientation**	**Band**	**Channel**
ABM1 (dBA/m)	7.11	8.65	Axial	GSM 850	190
ABM2 (dBA/m)	-27.07	-25.73			
Frequency Response	Pass	Pass			
Signal Quality (dB)	**34.18**	34.38			

2. Air Interface Investigation
   Using the worst case codec to test low/middle/high channels in each band.

11. T-coil testing for WCDMA

1. Codec investigation
   An investigation was performed to determine the audio codec to be used for testing by SNR comparison. The AMR 12.2kbps setting was used for the testing as the worst-case codec.

Codec Investigation - WCDMA						
Codec Setting:	**AMR 12.2kbps**	**AMR 7.95kbps**	**AMR 4.75kbps**	**Orientation**	**Band**	**Channel**
ABM1 (dBA/m)	-6.14	-5.75	-5.41	Axial	Band II	9400
ABM2 (dBA/m)	-37.96	-38.58	-37.97			
Frequency Response	Pass	Pass	Pass			
Signal Quality (dB)	**31.82**	32.83	32.56			

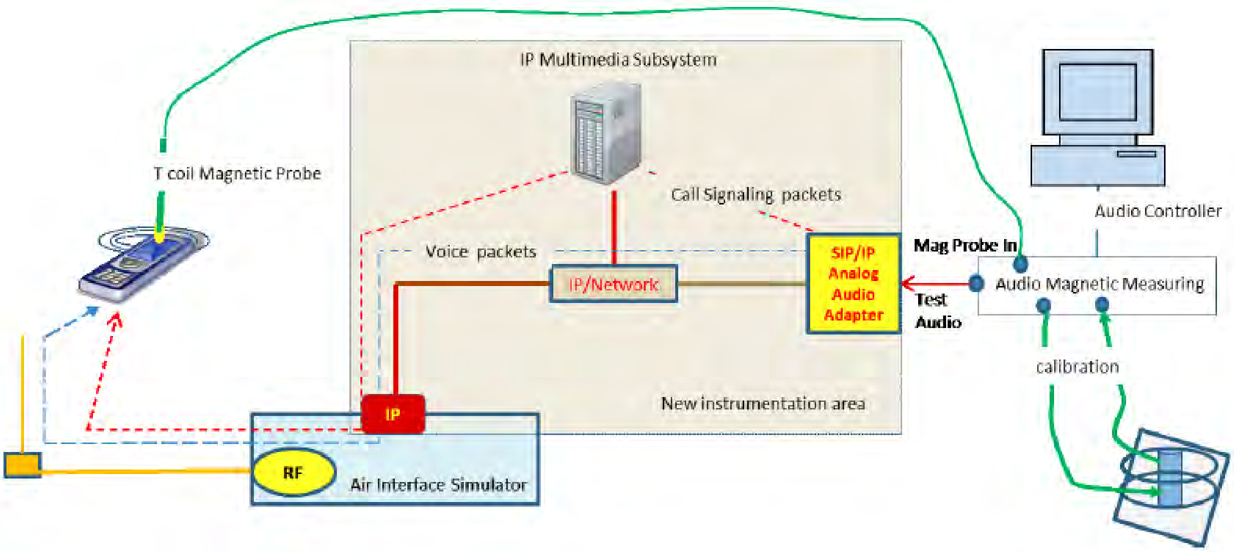
2. Air Interface Investigation
   Using the worst case codec to test low/middle/high channels in each band.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

12. T-coil testing for VoLTE

I. Test setup for VoLTE over IMS T-coil Testing

1. Test setup
   The general test setup used for VoLTE over IMS is shown below. The call box used when performing VoLTE over IMS T-coil measurement is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.



2. Audio level setting
   According to the July 2012 interpretations by the C63 Committee regarding the appropriate audio levels to be used for VoLTE over IMS T-coil testing, -16dBm0 shall be used for the normal speech input level. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -16dBm0 speech input level to the DUT for the VoLTE over IMS connection.

II. DUT configuration for VoLTE over IMS T-coil Testing

1.Radio configuration investigation

An investigation was performed to determine the modulation and RB configuration to be used for testing. QPSK, 1RB, 0RB offset was used for the testing as the worst-case configuration.

Radio Configuration Investigation

VoLTE over IMS SNNR by Radio Configuration								
Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Signal Quality [dB]
1880	18900	20	QPSK	1	0	-8.14	-35.36	**27.22**
1880	18900	20	QPSK	1	50	-6.89	-35.22	28.33
1880	18900	20	QPSK	1	99	-6.87	-34.44	27.57
1880	18900	20	QPSK	50	0	-6.26	-34.94	28.68
1880	18900	20	QPSK	50	25	-6.40	-34.28	27.88
1880	18900	20	QPSK	50	50	-7.82	-35.89	28.07
1880	18900	20	QPSK	100	0	-6.81	-34.61	27.80
1880	18900	20	16QAM	1	0	-6.84	-34.79	27.95
1880	18900	20	16QAM	1	50	-6.34	-35.21	28.87
1880	18900	20	16QAM	1	99	-7.40	-36.04	28.64
1880	18900	20	16QAM	50	0	-6.36	-34.46	28.10
1880	18900	20	16QAM	50	25	-7.38	-35.00	27.62
1880	18900	20	16QAM	50	50	-7.64	-36.04	28.40
1880	18900	20	16QAM	100	0	-7.00	-35.72	28.72

2.Codec investigation

An investigation was performed to determine the audio codec to be used for testing. The WB AMR 6.60kbps setting was used for the audio codec on the CMW500 for VoLTE over IMS T-coil testing.

AMR Codec Investigation - VoLTE over IMS							
Codec Setting:	WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Band / BW	Channel
ABM1 (dBA/m)	-8.14	-9.4	-9.29	-7.58	Axial	Band 2 / 20MHz	18900
ABM2 (dBA/m)	-35.36	-35.93	-35.95	-34.52			
Frequency Response	Pass	Pass	Pass	Pass			
Signal Quality (dB)	27.22	**26.53**	26.66	26.94			

EVS Codec Investigation - VoLTE over IMS							
Codec Setting:	WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Band / BW	Channel
ABM1 (dBA/m)	-8.52	-9.03	-7.61	-9.09	Axial	Band 2 / 20MHz	18900
ABM2 (dBA/m)	-36.94	-37.12	-34.37	-37			
Frequency Response	Pass	Pass	Pass	Pass			
Signal Quality (dB)	28.42	28.09	26.76	27.91			

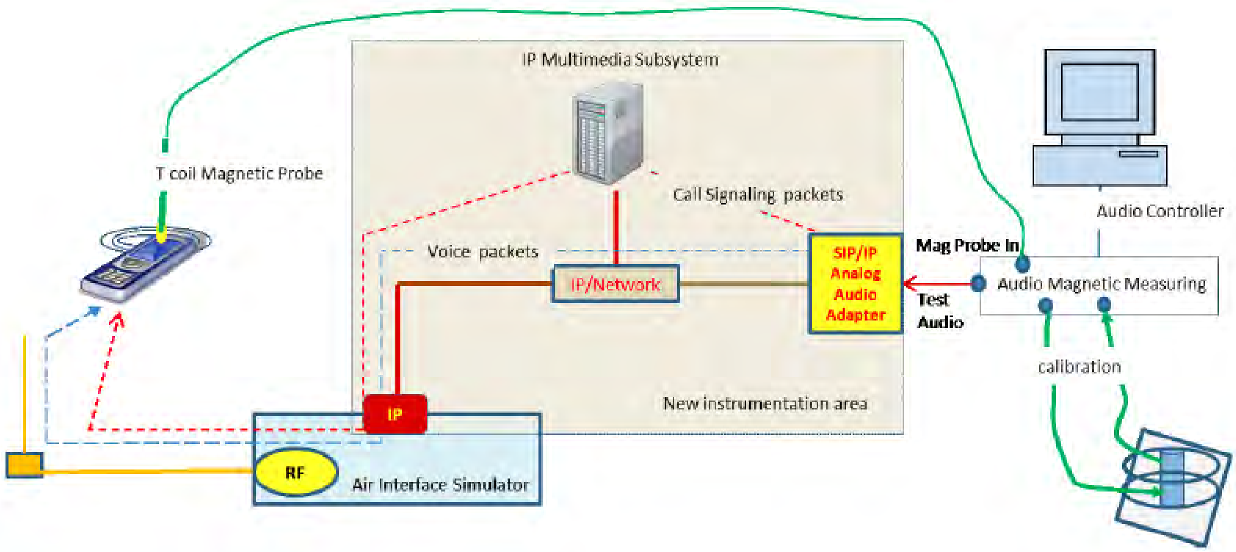
3.Air Interface Investigation

The worst case band for each probe orientation is additionally tested on all bandwidth combination. LTE B2 at 20MHz is the worst case for the Axial and Radial probe orientation.

13. T-coil testing for VoWIFI

I. Test setup for VoWIFI over IMS T-coil Testing

1. Test setup
   The general test setup used for VoWIFI over IMS, or CMRS WIFI calling, is shown below. The call box used when performing VoWIFI over IMS T-coil measurement is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.



2. Audio level setting
   According to the KDB285076 D02, regarding the appropriate audio levels to be used for WIFI over IMS T-coil testing, -20dBm0 shall be used for the normal speech input level. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 speech input level to the DUT for the VoWIFI over IMS connection.

II. DUT configuration for VoWIFI over IMS T-coil Testing

1. Radio configuration investigation

Investigate the lowest and highest data rates and modulation to determine worst radio configuration to be used for testing by SNR comparison.

802.11b Radio configuration investigation					
Mode	Channel	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Signal Quality [dB]
802.11b	6	1	-13.34	-40.18	**26.84**
802.11b	6	11	-12.31	-40.00	27.69

802.11g Radio configuration investigation					
Mode	Channel	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Signal Quality [dB]
802.11g	6	6	-11.95	-40.26	28.31
802.11g	6	54	-11.58	-39.47	27.89

802.11n(20M) Radio configuration investigation					
Mode	Channel	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Signal Quality [dB]
802.11n(20M)	6	MCS0	-13.18	-40.60	27.42
802.11n(20M)	6	MCS7	-11.99	-40.00	28.01

802.11n(40M) Radio configuration investigation					
Mode	Channel	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Signal Quality [dB]
802.11n(40M)	6	MCS0	-12.52	-39.88	27.36
802.11n(40M)	6	MCS7	-11.79	-40.60	28.81

2. Codec investigation

Determine the worst-case codec by SNR comparison.

The WB AMR 6.60kbps setting was used for the audio codec on the CMW500 for VoWIFI over IMS T-coil testing.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

AMR Codec Investigation - VoWIFI over IMS								
Codec Setting:	**WB AMR 23.85kbps**	**WB AMR 6.60kbps**	**NB AMR 12.2kbps**	**NB AMR 4.75kbps**	**Orientation**	**Band**	**Standard**	**Channel**
ABM1 (dBA/m)	-13.34	-13.75	-11.92	-13.46	Axial	2.4GHz	802.11b	6
ABM2 (dBA/m)	-40.18	-40.2	-39.05	-40.08				
Frequency Response	Pass	Pass	Pass	Pass				
Signal Quality (dB)	26.84	26.45	27.13	26.62				

EVS Codec Investigation - VoWIFI over IMS								
Codec Setting:	**WB AMR 23.85kbps**	**WB AMR 6.60kbps**	**NB AMR 12.2kbps**	**NB AMR 4.75kbps**	**Orientation**	**Band**	**Standard**	**Channel**
ABM1 (dBA/m)	-13.32	-13.6	-13.07	-13.42	Axial	2.4GHz	802.11b	6
ABM2 (dBA/m)	-39.93	-41.22	-40.6	-41.85				
Frequency Response	Pass	Pass	Pass	Pass				
Signal Quality (dB)	26.61	27.62	27.53	28.43				

3. Air Interface Investigation

Using the worst case codec to proceed T-coil test of worst case mode for axial and radial orientations.

(802.11b is the worst case mode)

14. Justification of held to ear modes tested

a. The device supports VoLTE/VoWLAN, so T-coil test for VoLTE/VoWLAN is required.

b. There is one OTT voice service (Google Duo) pre-installed (installed and delivered) by the manufacturer.

c. There is one OTT voice service (Google Duo) pre-installed (installed and delivered) by the manufacturer for the operating system manufacturer’s software partner.

d. There is one OTT voice service (Google Duo) installed and delivered by the manufacturer at the direction of the service provider.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

15. Test Standards and Limits

The measurements were performed to ensure compliance to the ANSI C63.19-2011 standard.
The limit values please follow in Table 2

Category	Telephone parameters WD signal quality
T1	0 dB to 10 dB
T2	10 dB to 20 dB
T3	20 dB to 30 dB
T4	> 30 dB

Table 2. Signal Quality Range

Signal strength

Axial field intensity

The axial component of the magnetic field, directed along the measurement axis and located at the measurement plane, shall be ≥ -18 dB (A/m) at 1 kHz, in 1/3 octave band filter.

Radial(Y) field intensity

The radial component of the magnetic field, as measured at the radial, measurement points shall be ≥ -18 dB (A/m) at 1 kHz, in 1/3 octave band filter.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

16. Instruments List

Manufacturer	Device	Type	Serial Number	Date of Last Calibration	Date of Next Calibration
Schmid & Partner Engineering AG	Data acquisition Electronics	DAE4	1336	Aug.06,2018	Aug.05,2019
Schmid & Partner Engineering AG	Software	DASY52 52.10.1	N/A	Calibration not required	Calibration not required
Schmid & Partner Engineering AG	Audio Magnetic 1D Field Probe	AM1DV3	3115	Mar.15.2018	Mar.14.2019
Schmid & Partner Engineering AG	AMMI	010 AB	1028	Calibration not required	Calibration not required
Schmid & Partner Engineering AG	AMCC SD HAC	P01 BA	1026	N/A	N/A
Schmid & Partner Engineering AG	Test Arch SD HAC	P01	1047	N/A	N/A
R&S	Radio Communication Test	CMU200	113505	Dec.20.2017	Dec.19.2018
R&S	Radio Communication Tester	CMW 500	143913	Apr.29.2018	Apr.28.2019

17. Summary of Results

Air interface investigation for GSM										
Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
GSM 850	Axial	-	128	8.68	-26.70	-59.04	1.31	35.38	T4	-
		-	190	7.11	-27.07		1.32	**34.18**	T4	29
		-	251	7.52	-26.89		1.48	34.41	T4	-
	Radial	-	128	0.09	-37.44	-58.49	N/A	37.53	T4	-
		-	190	0.04	-36.35			**36.39**	T4	30
		-	251	0.10	-38.17			38.27	T4	-
GSM 1900	Axial	-	512	7.63	-28.31	-59.04	1.39	35.94	T4	-
		-	661	7.22	-28.52		1.29	**35.74**	T4	32
		-	810	7.66	-29.27		1.44	36.93	T4	-
	Radial	-	512	0.08	-39.28	-58.49	N/A	39.36	T4	-
		-	661	0.01	-37.75			**37.76**	T4	33
		-	810	0.04	-39.08			39.12	T4	-

Air interface investigation for WCDMA										
Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
WCDMA Band Ⅱ	Axial	-	9262	-5.79	-37.71	-58.43	1.93	31.92	T4	-
		-	9400	-6.14	-37.96		1.83	**31.82**	T4	35
		-	9538	-5.55	-38.36		1.99	32.81	T4	-
	Radial	-	9262	-15.80	-48.55	-58.72	N/A	32.75	T4	-
		-	9400	-16.06	-46.84			**30.78**	T4	36
		-	9538	-15.72	-48.26			32.54	T4	-
WCDMA Band V	Axial	-	4132	-12.67	-36.28	-58.43	1.35	23.61	T3	-
		-	4183	-14.25	-37.35		1.21	**23.10**	T3	38
		-	4233	-13.70	-38.47		1.32	24.77	T3	-
	Radial	-	4132	-16.80	-44.75	-58.72	N/A	27.95	T3	-
		-	4183	-17.57	-44.00			**26.43**	T3	41
		-	4233	-15.98	-44.23			28.25	T3	-

Air interface investigation for LTE B2

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
LTE Band 2	Axial	20	18900	-9.40	-35.93	-58.91	2.00	**26.53**	T3	41
		15	18900	-8.93	-35.64		2.00	26.71	T3	-
		10	18900	-8.55	-35.24		2.00	26.69	T3	-
		5	18900	-7.60	-35.20		2.00	27.60	T3	-
		3	18900	-9.04	-37.20		2.00	28.16	T3	-
		1.4	18900	-8.29	-35.97		2.00	27.68	T3	-
	Radial	20	18900	-14.13	-38.81	-58.56	N/A	**24.68**	T3	42
		15	18900	-12.52	-38.65			26.13	T3	-
		10	18900	-12.20	-37.25			25.05	T3	-
		5	18900	-12.79	-39.38			26.59	T3	-
		3	18900	-13.68	-39.99			26.31	T3	-
		1.4	18900	-13.87	-39.49			25.62	T3	-

Air interface investigation for LTE B4

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
LTE Band 4	Axial	20	20175	-6.29	-33.76	-58.91	2.00	27.47	T3	44
	Radial	20	20175	-14.67	-40.11	-58.56	N/A	25.44	T3	45

Air interface investigation for LTE B5

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
LTE Band 5	Axial	10	20525	-6.22	-33.91	-58.91	2.00	27.69	T3	47
	Radial	10	20525	-14.92	-40.59	-58.56	N/A	25.67	T3	48

Air interface investigation for LTE B13

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
LTE Band 13	Axial	10	23230	-6.31	-33.11	-58.91	2.00	26.80	T3	50
	Radial	10	23230	-16.82	-43.22	-58.56	N/A	26.40	T3	51

Air interface investigation for LTE B66

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
LTE Band 66	Axial	20	132322	-6.18	-34.02	-58.91	2.00	27.84	T3	53
	Radial	20	132322	-16.87	-41.60	-58.56	N/A	24.73	T3	54

Air interface investigation for 2.4GHz WIFI

Mode	Orientation	Bandwidth (MHz)	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Variation(dB)	Signal Quality (dB)	C63.19-2011 Rating	Plot page
WLAN 802.11b	Axial	20	6	-13.75	-40.20	-59.61	2.00	26.45	T3	56
	Radial	20	6	-16.92	-42.04	-59.47	N/A	25.12	T3	57

18. Measurement Data

Date: 2018/12/14

T-Coil-GSM 850 CH 190

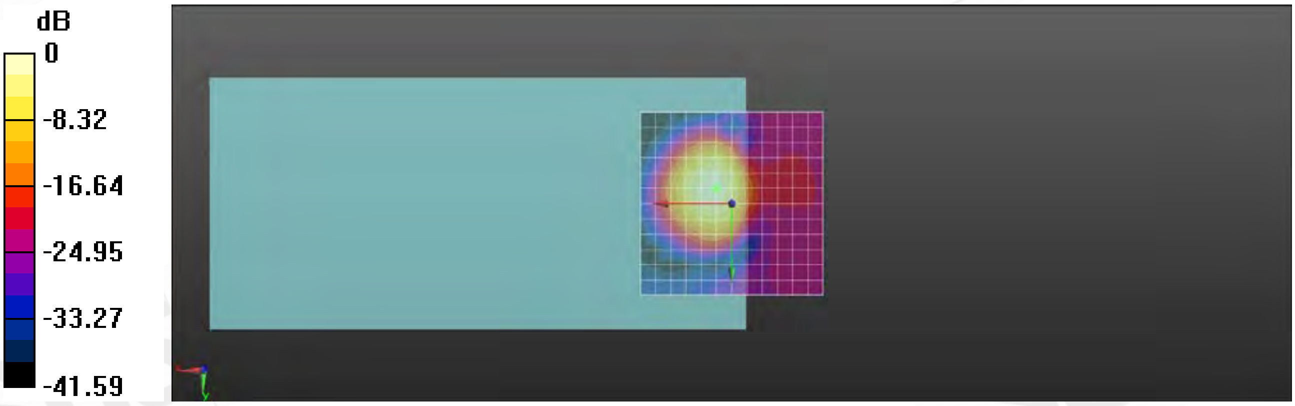
Communication System: GSM; Frequency: 836.6 MHz; Duty Cycle: 1:8.30042
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 34.18 dB
ABM1 comp = 7.11 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, -4.2, 3.7 mm



0 dB = 51.15 = 34.18 dB

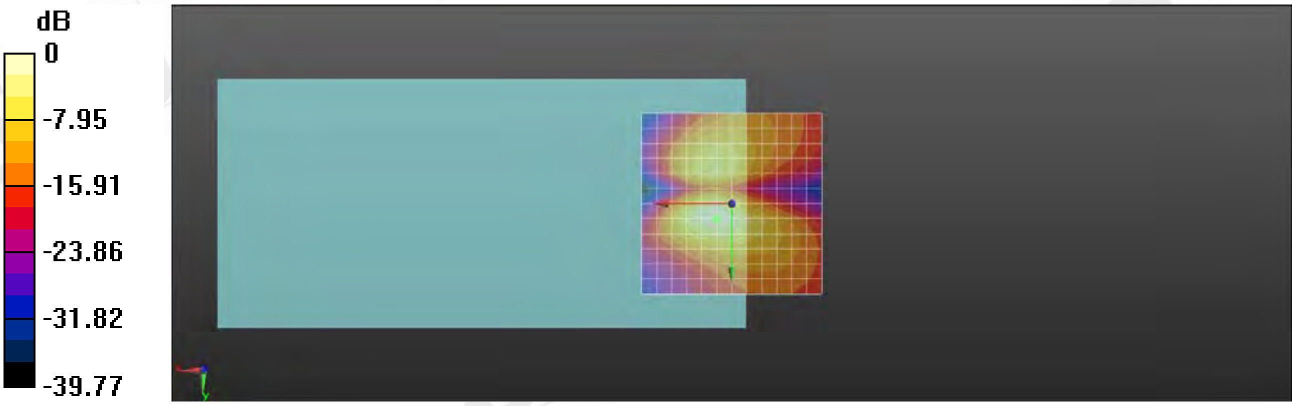
Date: 2018/12/14

T-Coil-GSM 850 CH 190
Communication System: GSM; Frequency: 836.6 MHz; Duty Cycle: 1:8.30042
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m^3
Phantom section: TCoil Section

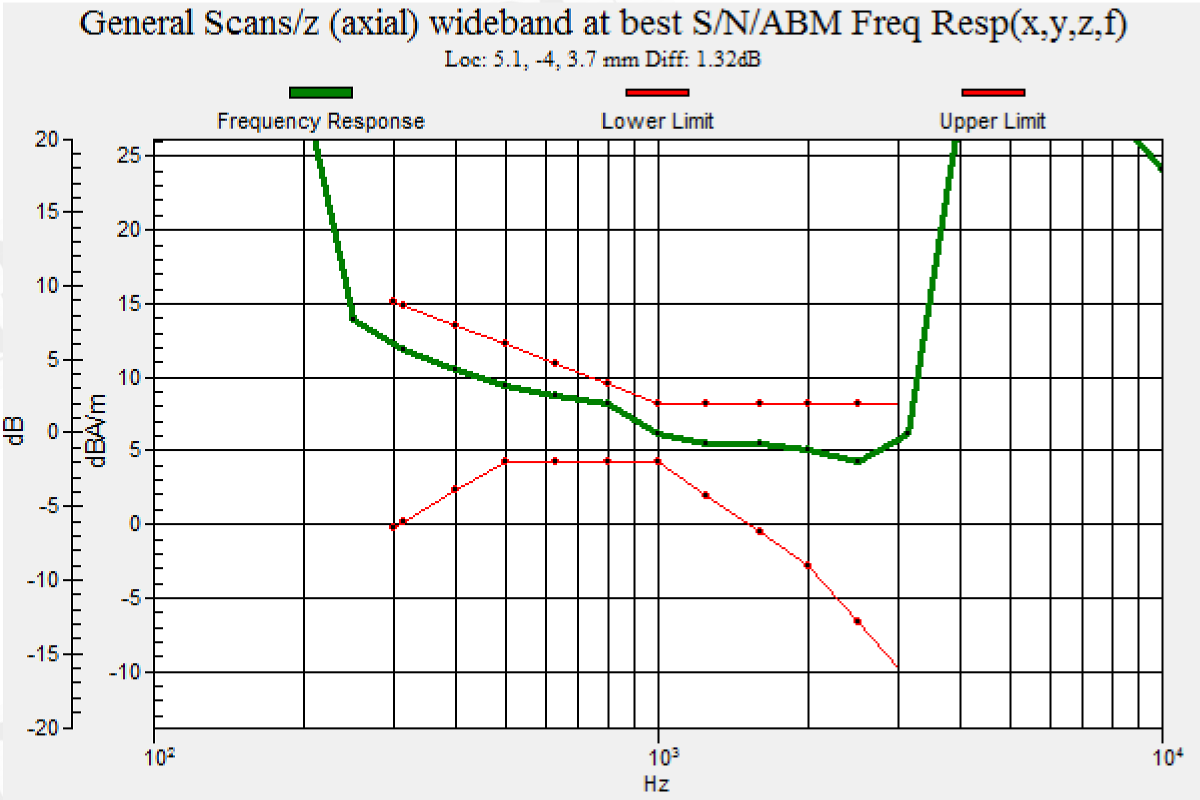
DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 36.39 dB
ABM1 comp = 0.04 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, 4.2, 3.7 mm



0 dB = 65.99 = 36.39 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 5.1, -4, 3.7 mm Diff: 1.32dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

Date: 2018/12/14

T-Coil-GSM 1900 CH 661

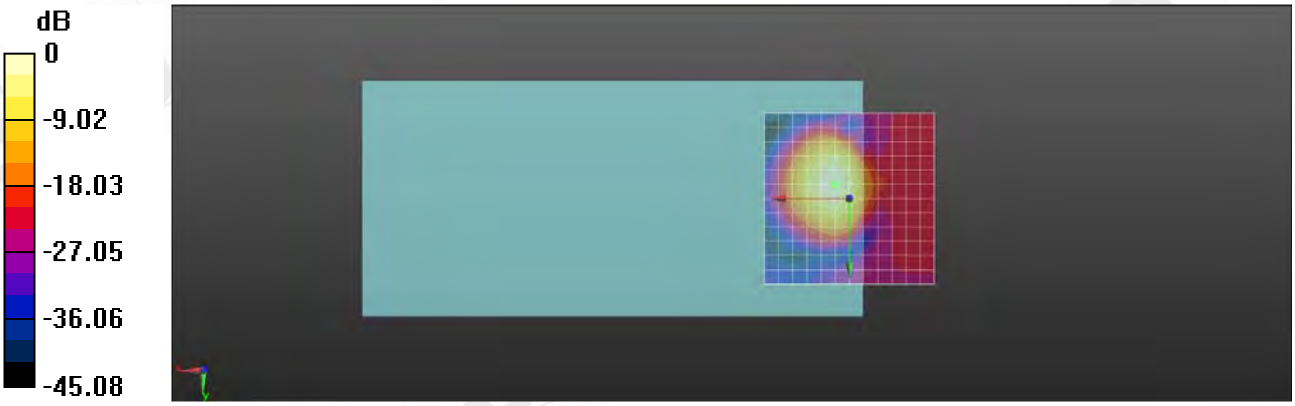
Communication System: GSM; Frequency: 1880 MHz; Duty Cycle: 1:8.30042
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 35.74 dB
ABM1 comp = 7.22 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, -4.2, 3.7 mm



0 dB = 61.23 = 35.74 dB

Date: 2018/12/14

T-Coil-GSM 1900 CH 661

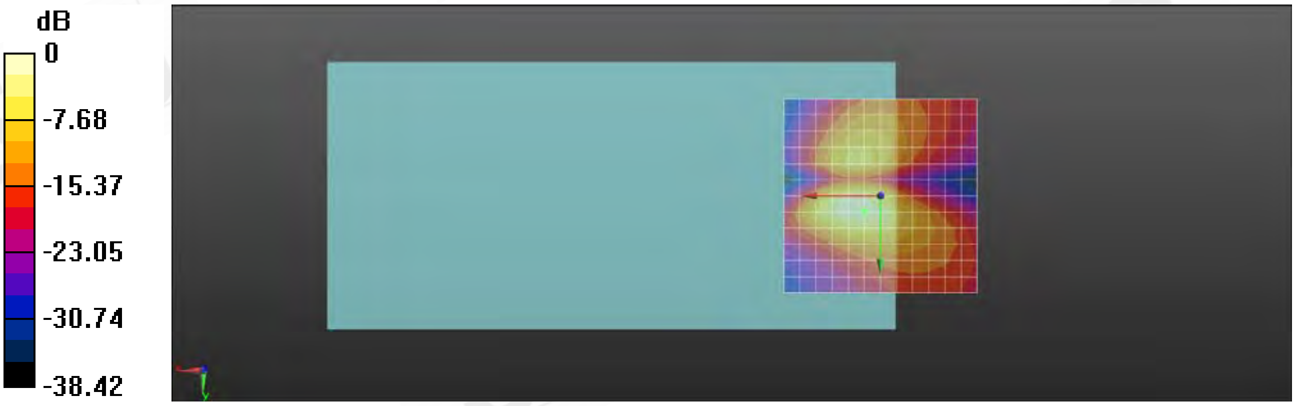
Communication System: GSM; Frequency: 1880 MHz; Duty Cycle: 1:8.30042
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

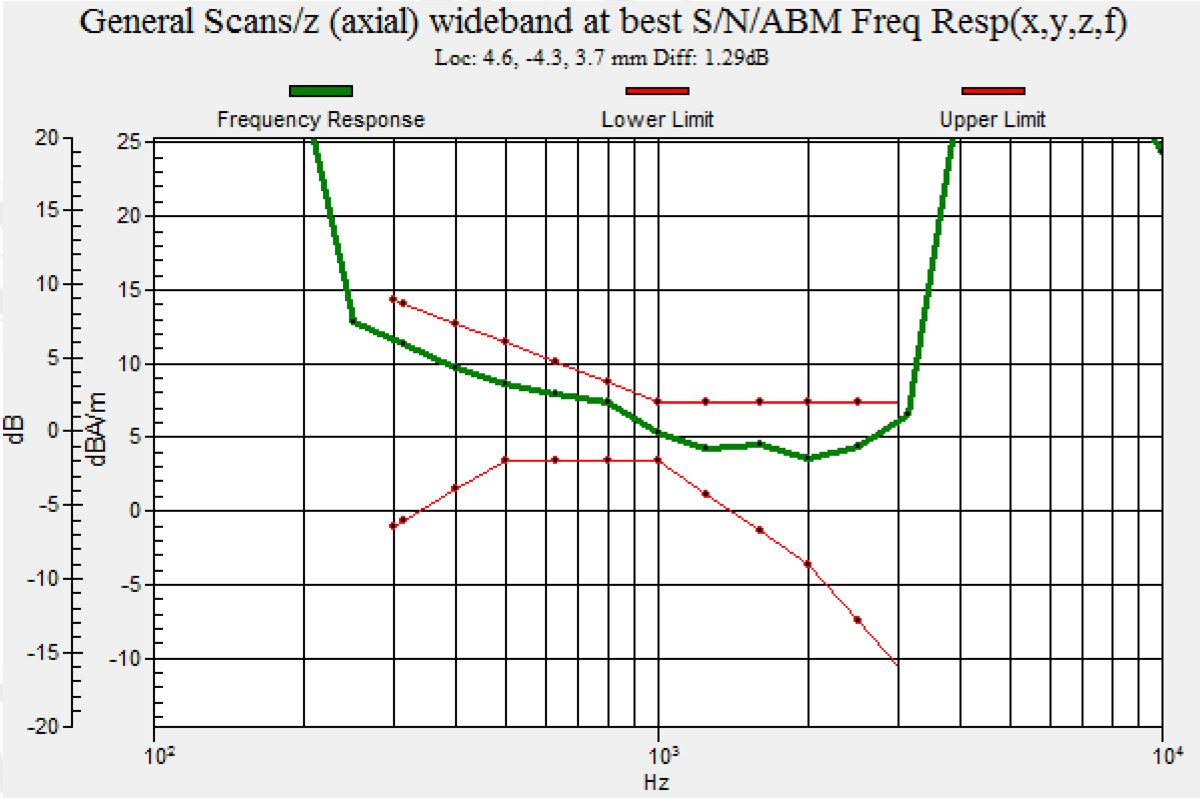
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 37.76 dB
ABM1 comp = 0.01 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, 4.2, 3.7 mm



0 dB = 77.31 = 37.76 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.6, -4.3, 3.7 mm Diff: 1.29dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
20
15
10
5
0
-5
-10
-15
-20
25
20
15
10
5
0
-5
-10
10²
10³
10⁴

Date: 2018/12/15

T-Coil-WCDMA Band II CH 9400

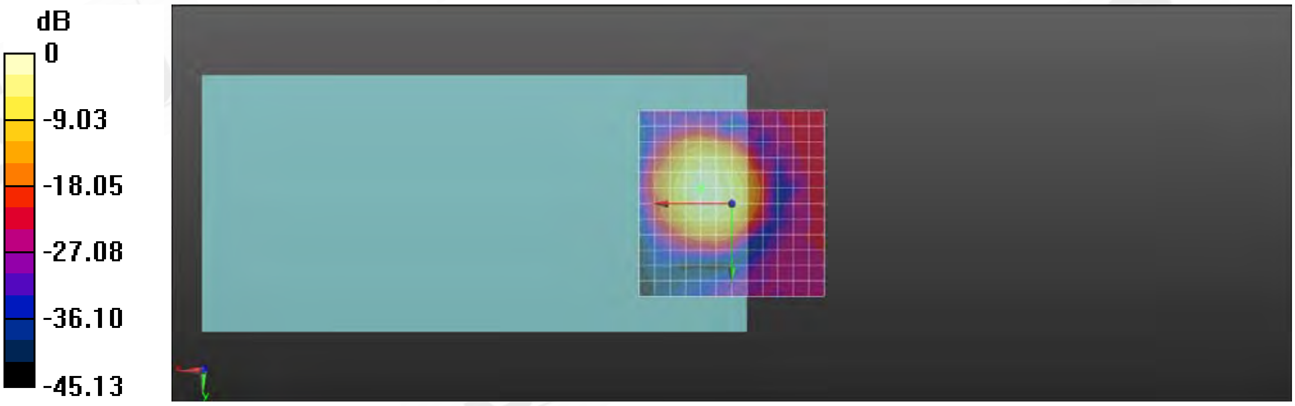
Communication System: WCDMA; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 31.82 dB
ABM1 comp = -6.14 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -4.2, 3.7 mm



0 dB = 39.00 = 31.82 dB

Date: 2018/12/15

T-Coil-WCDMA Band II CH 9400

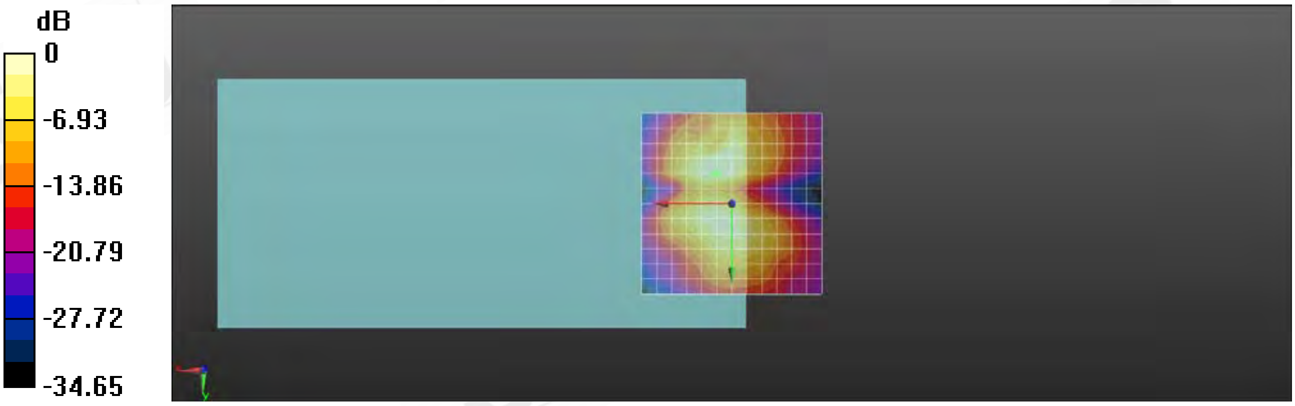
Communication System: WCDMA; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

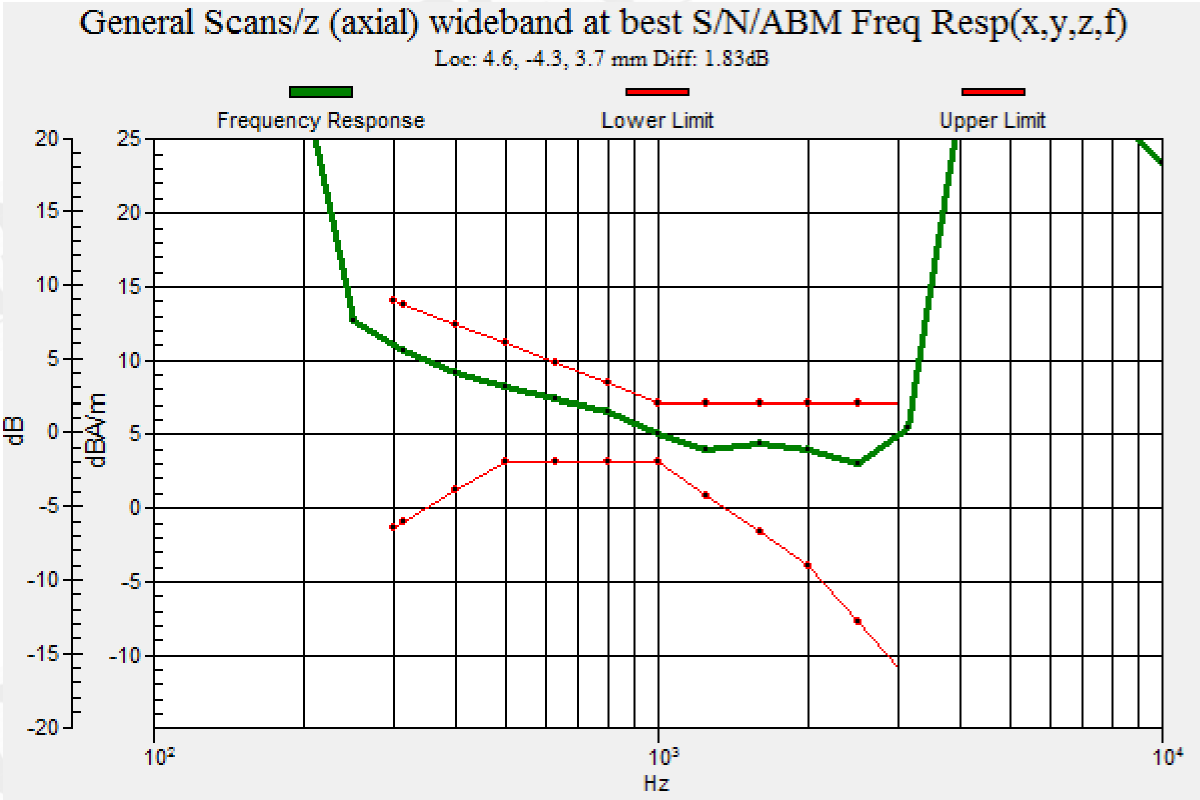
General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 30.78 dB
ABM1 comp = -16.06 dBA/m
BWC Factor = 0.15 dB
Location: 4.2, -8.3, 3.7 mm



0 dB = 34.60 = 30.78 dB

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.6, -4.3, 3.7 mm Diff: 1.83dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
20
15
10
5
0
-5
-10
-15
-20
25
20
15
10
5
0
-5
-10
10²
10³
10⁴

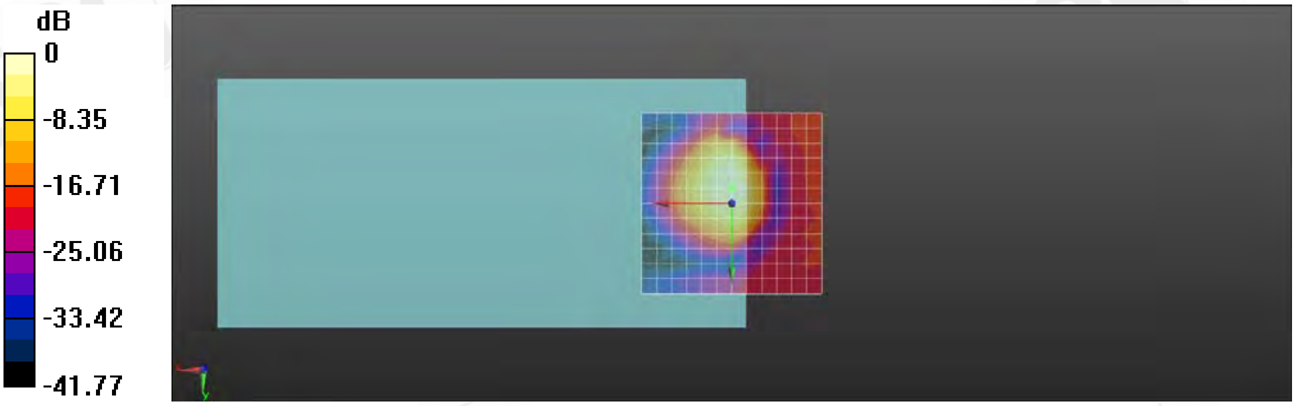
Date: 2018/12/15

T-Coil-WCDMA Band V CH 4183
Communication System: WCDMA; Frequency: 836.6 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
Signal Type: Audio File (.wav) 48k_voice_1kHz_1s.wav
ABM1/ABM2 = 23.10 dB
ABM1 comp = -14.25 dBA/m
BWC Factor = 0.16 dB
Location: 0, -4.2, 3.7 mm



0 dB = 14.28 = 23.09 dB

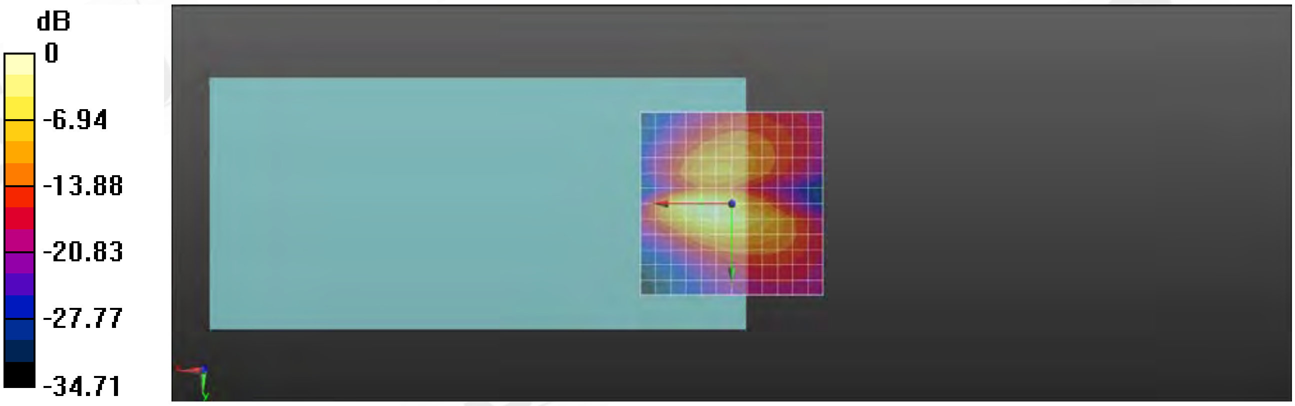
Date: 2018/12/15

T-Coil-WCDMA Band V CH 4183
Communication System: WCDMA; Frequency: 836.6 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

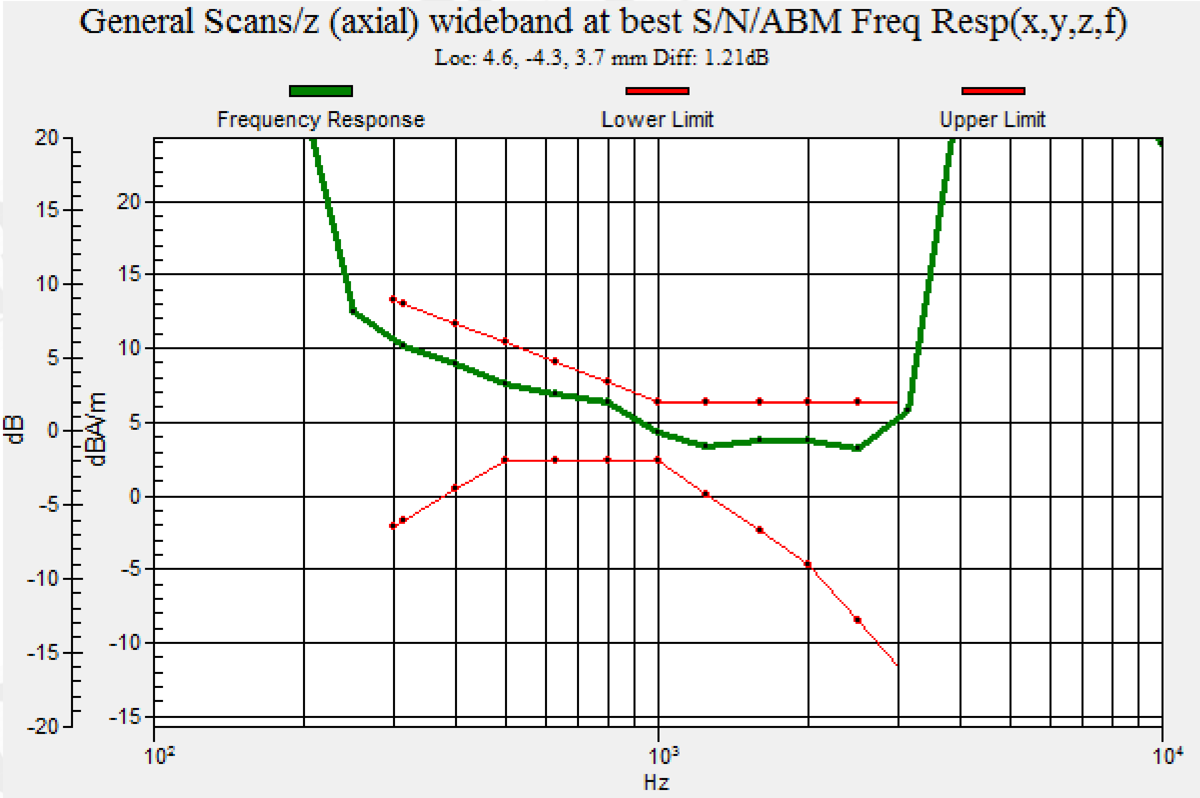
DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.43 dB
ABM1 comp = -17.57 dBA/m
BWC Factor = 0.16 dB
Location: 8.3, 0, 3.7 mm



0 dB = 20.97 = 26.43 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.6, -4.3, 3.7 mm Diff: 1.21dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
10²
10³
10⁴

Date: 2018/12/18

T-Coil-LTE Band 2 (20MHz)_CH 18900_QPSK_1-0

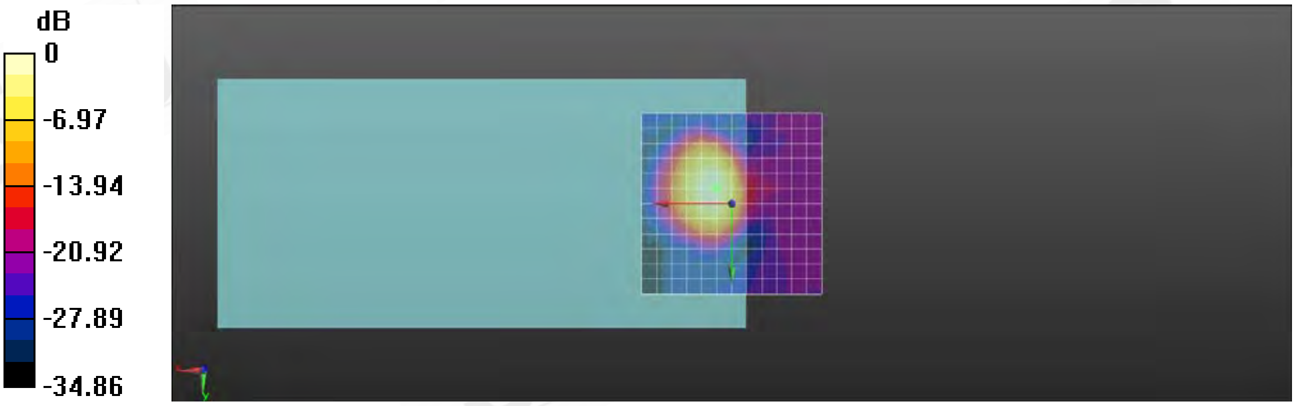
Communication System: LTE; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.53 dB
ABM1 comp = -9.40 dBA/m
BWC Factor = 0.15 dB
Location: 4.2, -4.2, 3.7 mm



0 dB = 21.21 = 26.53 dB

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

Date: 2018/12/18

T-Coil-LTE Band 2 (20MHz)_CH 18900_QPSK_1-0

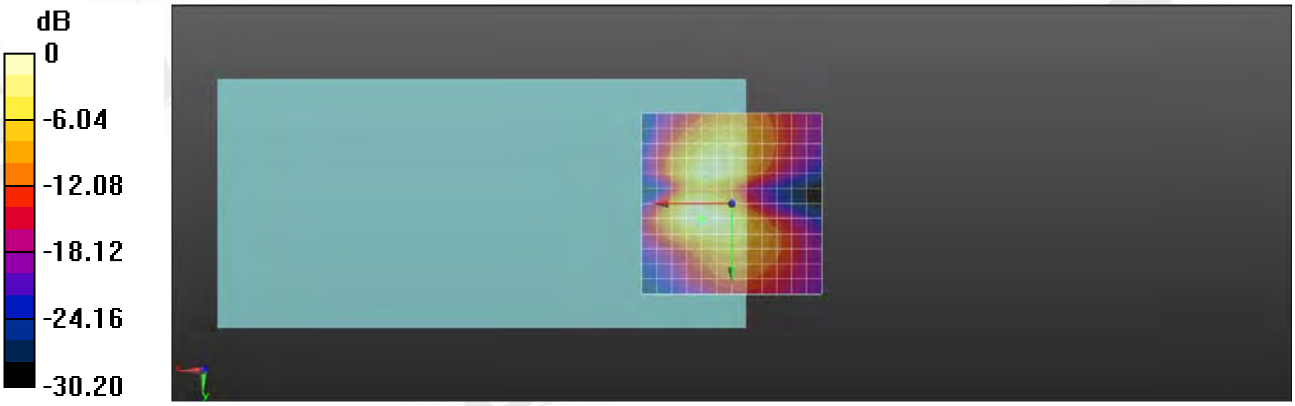
Communication System: LTE; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

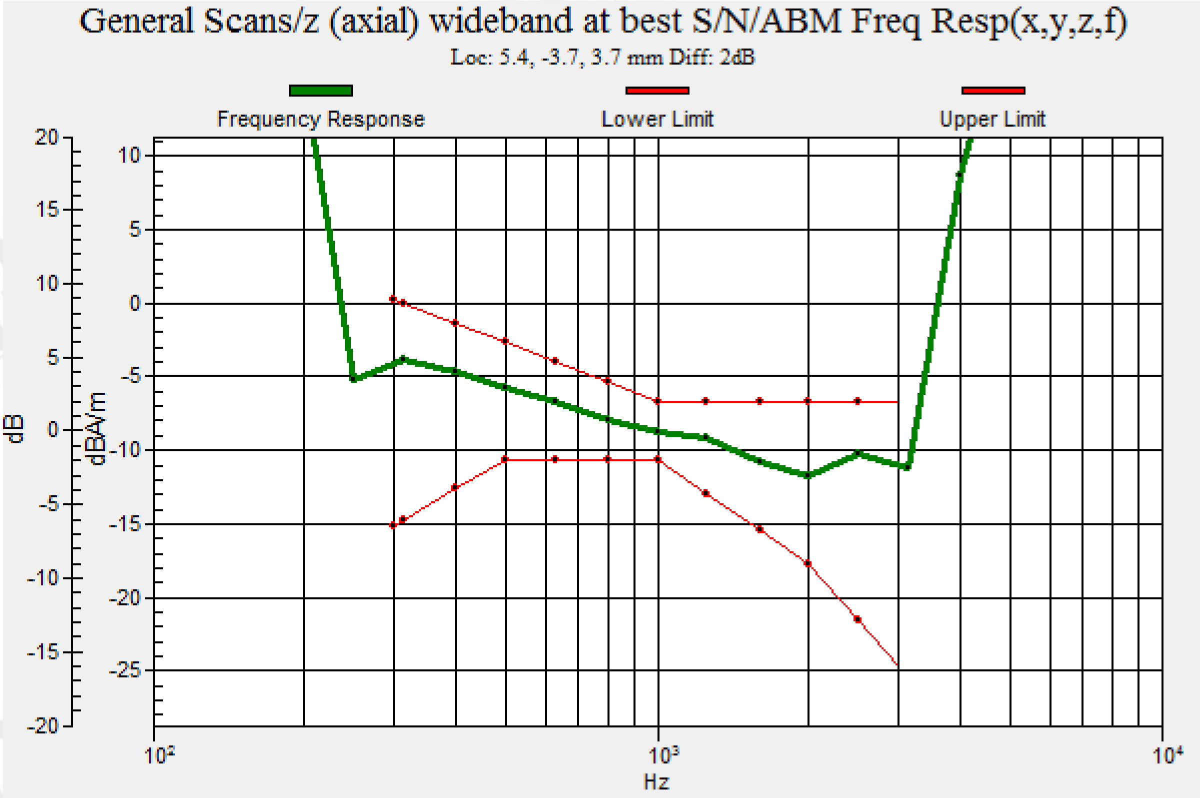
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 24.68 dB
ABM1 comp = -14.13 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, 4.2, 3.7 mm



0 dB = 17.15 = 24.69 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 5.4, -3.7, 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
5
0
-5
-10
-15
-20
-25
10^2
10^3
10^4

Date: 2018/12/18

T-Coil-LTE Band 4 (20MHz)_CH 20175_QPSK_1-0

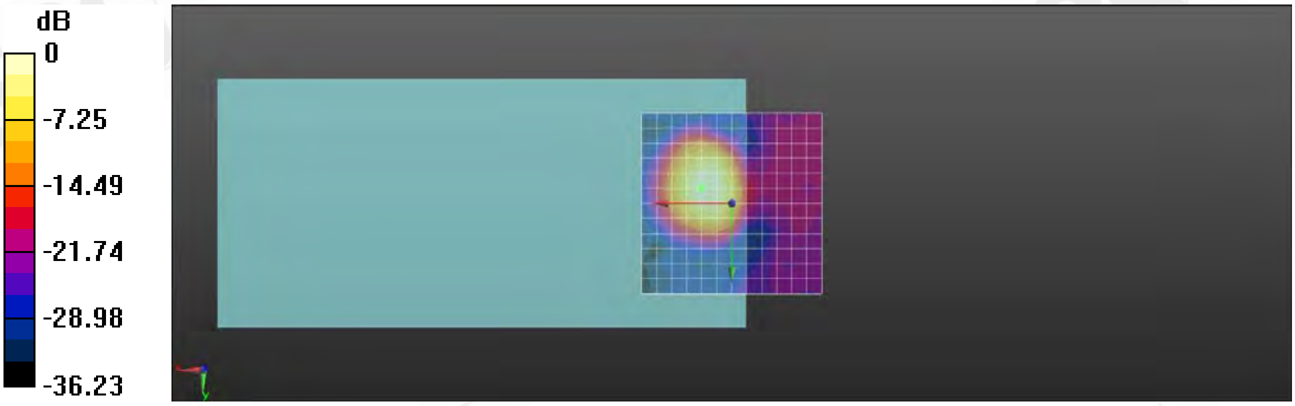
Communication System: LTE; Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
Signal Type: Audio File (.wav) 48k_voice_1kHz_1s.wav
ABM1/ABM2 = 27.47 dB
ABM1 comp = -6.29 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -4.2, 3.7 mm



0 dB = 23.63 = 27.47 dB

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

Date: 2018/12/18

T-Coil-LTE Band 4 (20MHz)_CH 20175_QPSK_1-0

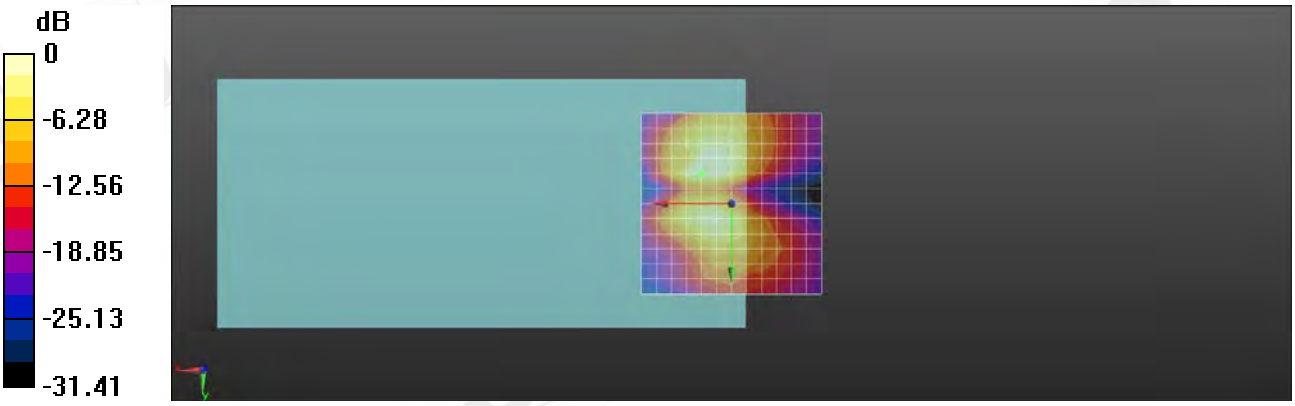
Communication System: LTE; Frequency: 1732.5 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

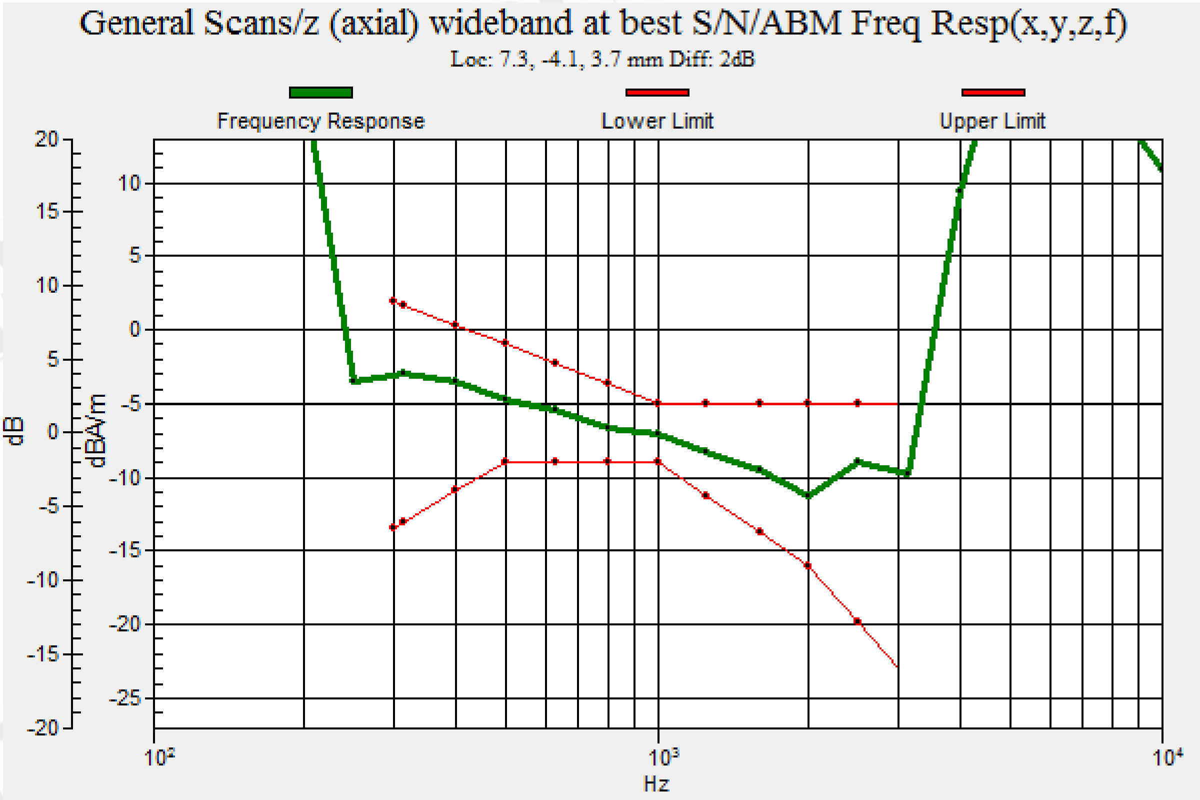
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.44 dB
ABM1 comp = -14.67 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -8.3, 3.7 mm



0 dB = 18.71 = 25.44 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 7.3, -4.1, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10
5
0
-5
-10
-15
-20
-25
10²
10³
10⁴
Hz

Date: 2018/12/18

T-Coil-LTE Band 5 (10MHz)_CH 20525_QPSK_1-0

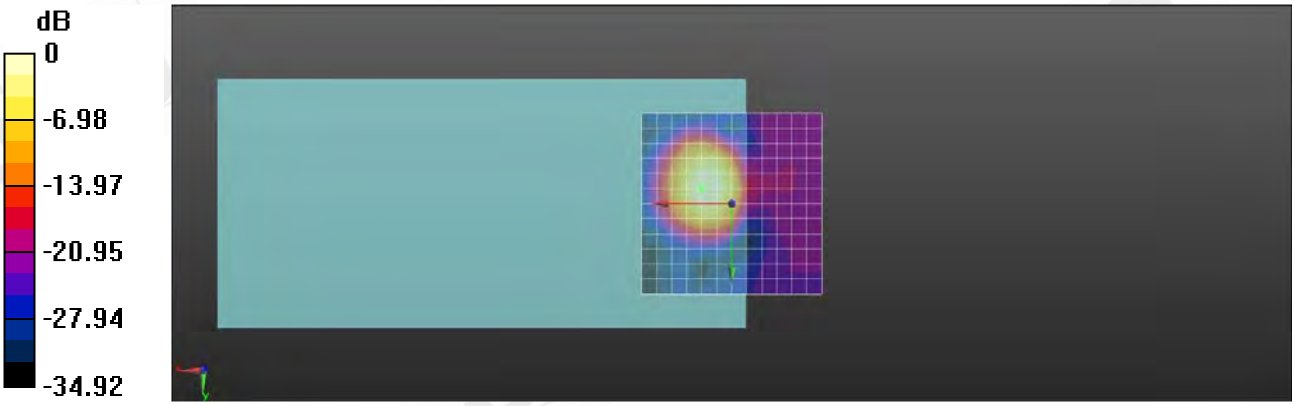
Communication System: LTE; Frequency: 836.5 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.69 dB
ABM1 comp = -6.22 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -4.2, 3.7 mm



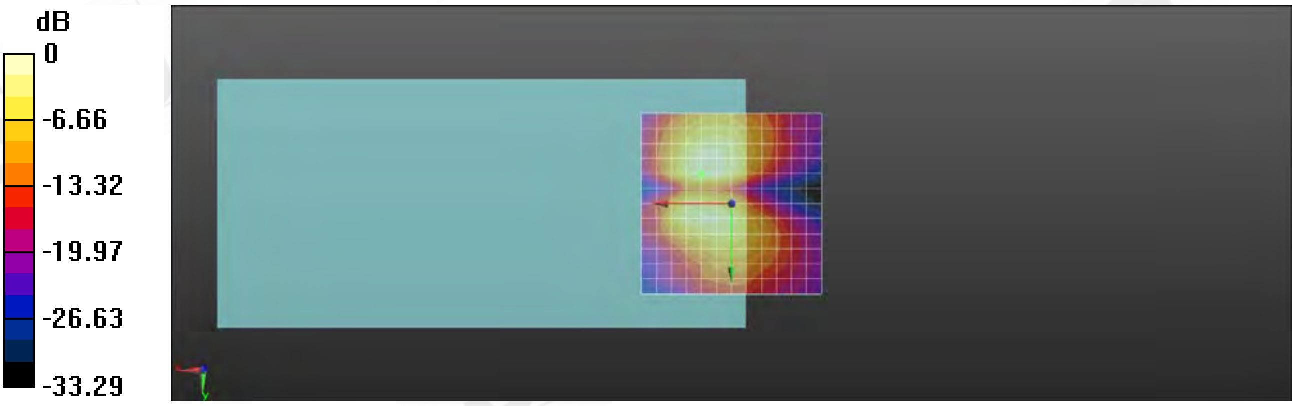
0 dB = 24.23 = 27.69 dB

Date: 2018/12/18

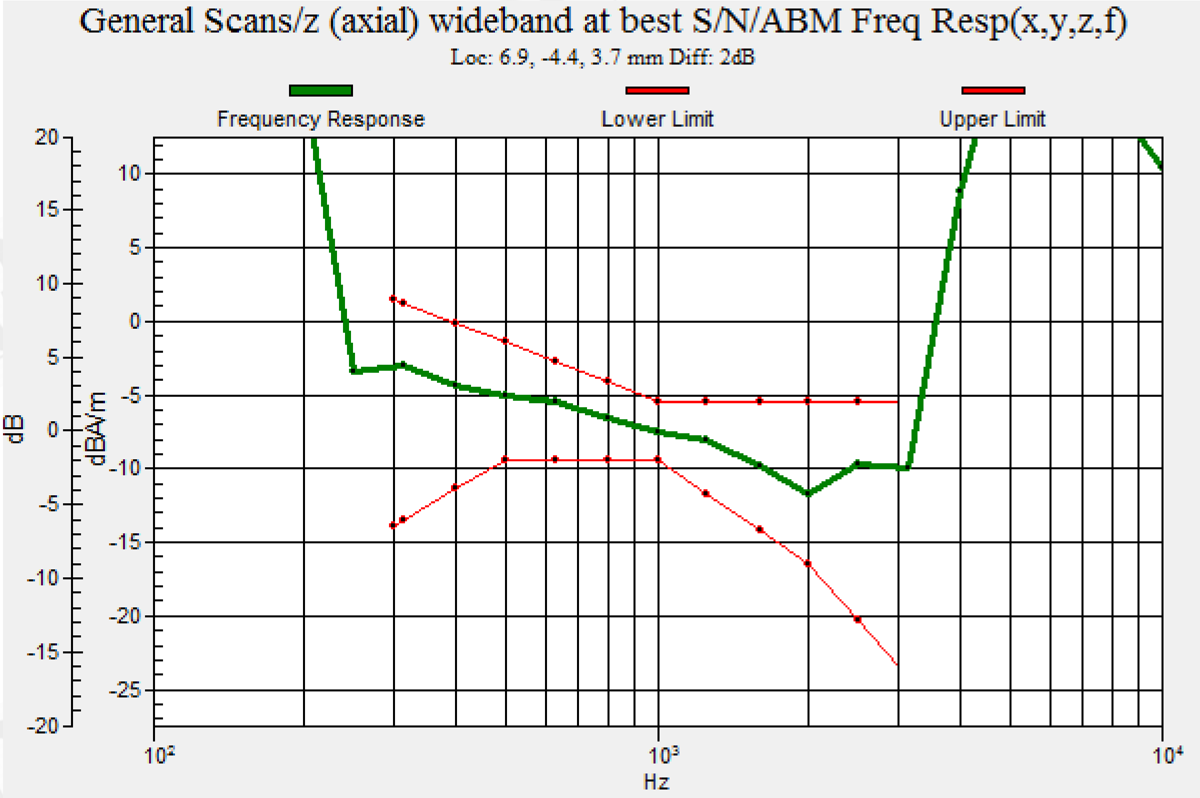
T-Coil-LTE Band 5 (10MHz)_CH 20525_QPSK_1-0
Communication System: LTE; Frequency: 836.5 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.67 dB
ABM1 comp = -14.92 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -8.3, 3.7 mm



0 dB = 19.20 = 25.67 dB



SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

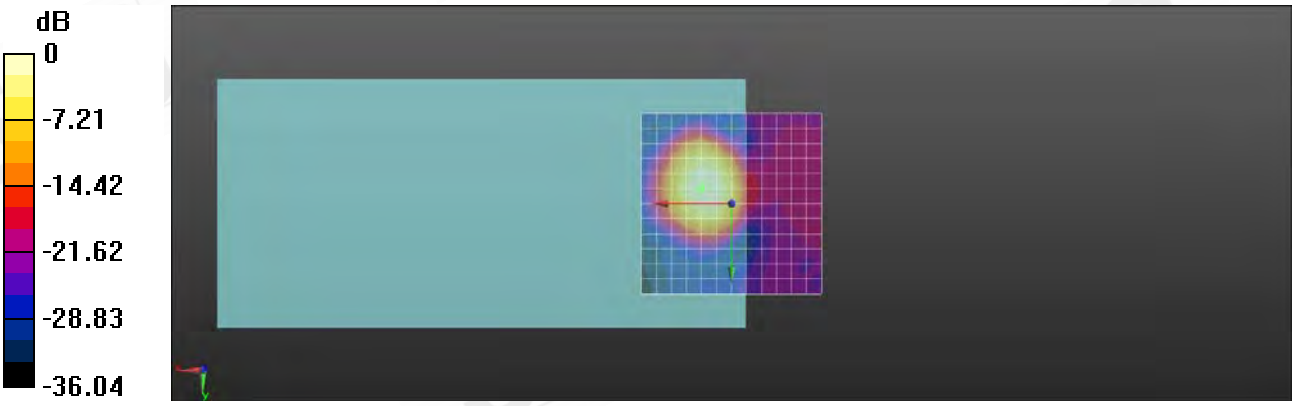
Date: 2018/12/18

T-Coil-LTE Band 13 (10MHz)_CH 23230_QPSK_1-0
Communication System: LTE; Frequency: 782 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.80 dB
ABM1 comp = -6.31 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -4.2, 3.7 mm



0 dB = 21.88 = 26.80 dB

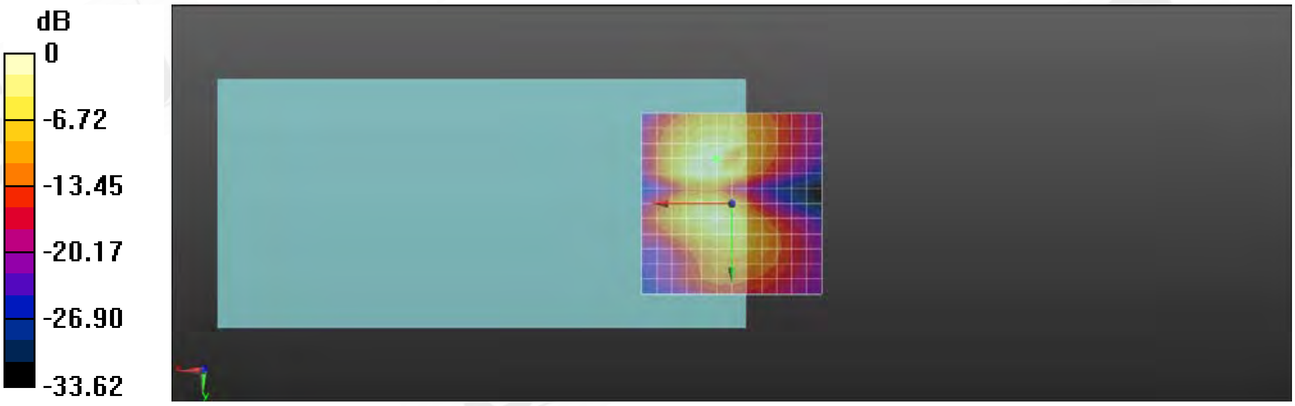
Date: 2018/12/18

T-Coil-LTE Band 13 (10MHz)_CH 23230_QPSK_1-0
Communication System: LTE; Frequency: 782 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

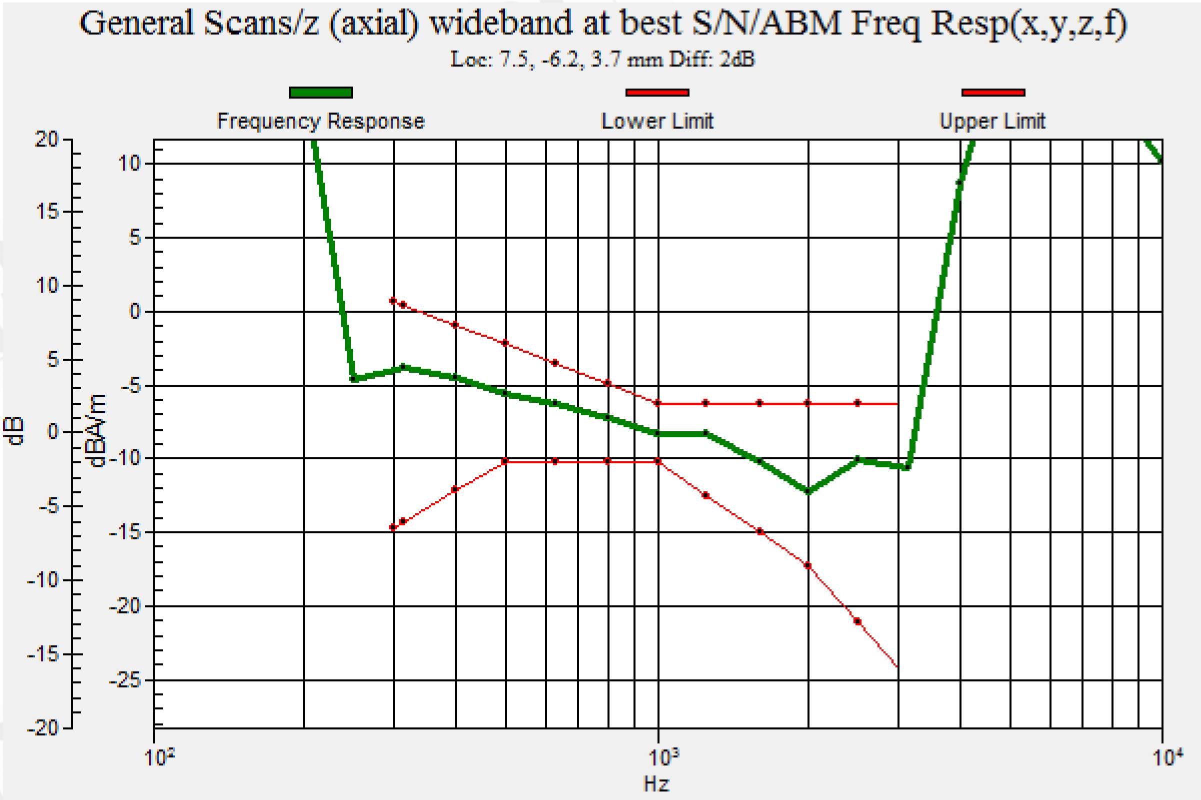
DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.40 dB
ABM1 comp = -16.82 dBA/m
BWC Factor = 0.15 dB
Location: 4.2, -12.5, 3.7 mm



0 dB = 20.90 = 26.40 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 7.5, -6.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

Date: 2018/12/18

T-Coil-LTE Band 66 (20MHz)_CH 132322_QPSK_1-0

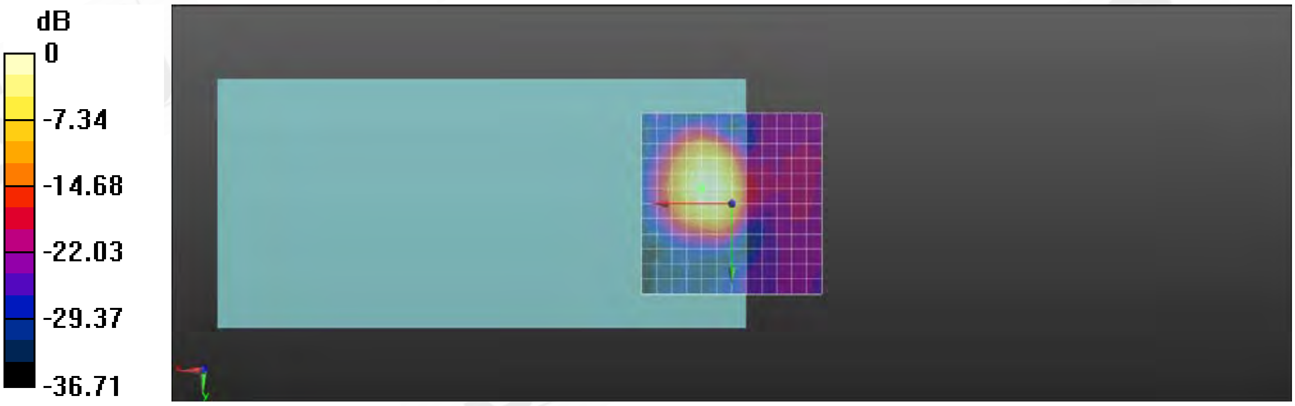
Communication System: LTE; Frequency: 1745 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.84 dB
ABM1 comp = -6.18 dBA/m
BWC Factor = 0.15 dB
Location: 8.3, -4.2, 3.7 mm



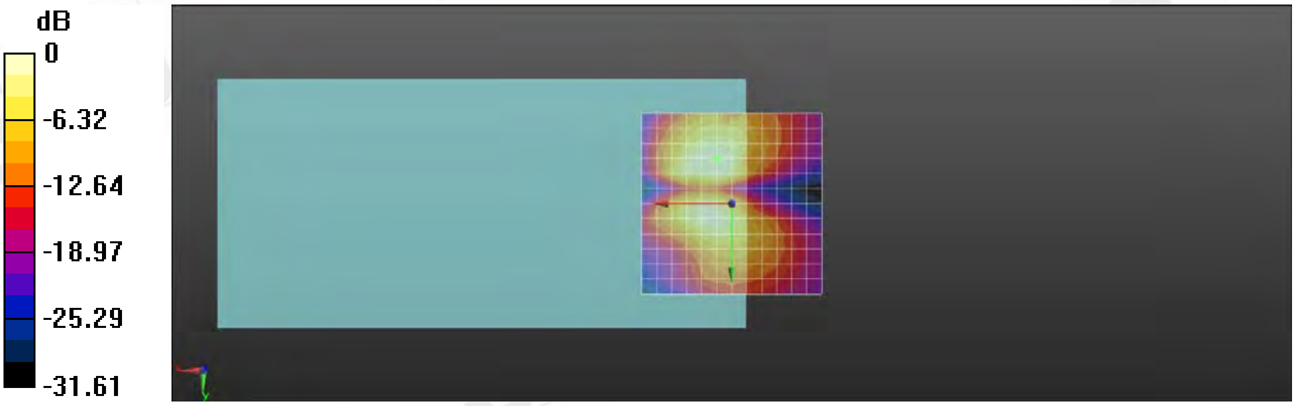
0 dB = 24.67 = 27.84 dB

Date: 2018/12/18

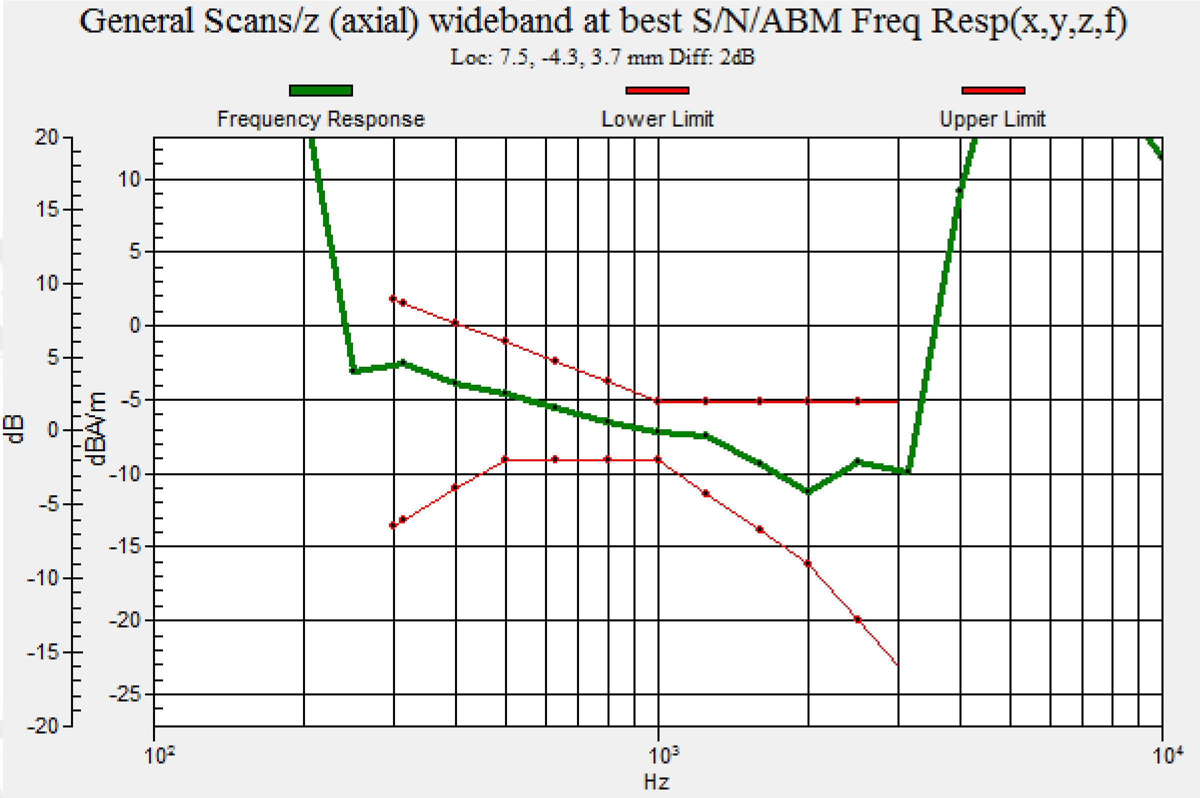
T-Coil-LTE Band 66 (20MHz)_CH 132322_QPSK_1-0
Communication System: LTE; Frequency: 1745 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 24.73 dB
ABM1 comp = -16.87 dBA/m
BWC Factor = 0.15 dB
Location: 4.2, -12.5, 3.7 mm



0 dB = 17.23 = 24.73 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 7.5, -4.3, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

Date: 2018/12/17

T-Coil-WLAN 802.11b_CH 6

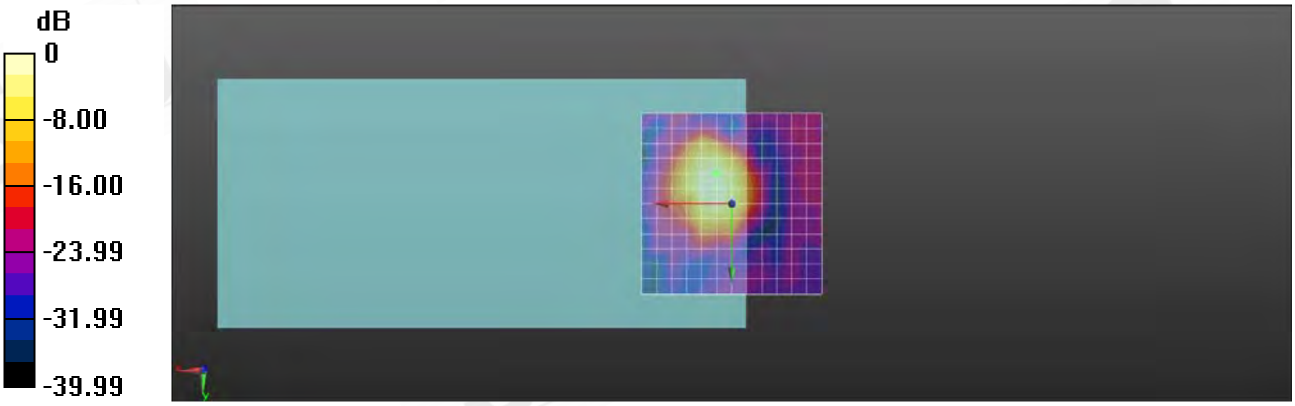
Communication System: WLAN 2.45G; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1 kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.45 dB
ABM1 comp = -13.75 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, -8.3, 3.7 mm



0 dB = 21.01 = 26.45 dB

Date: 2018/12/17

T-Coil-WLAN 802.11b_CH 6

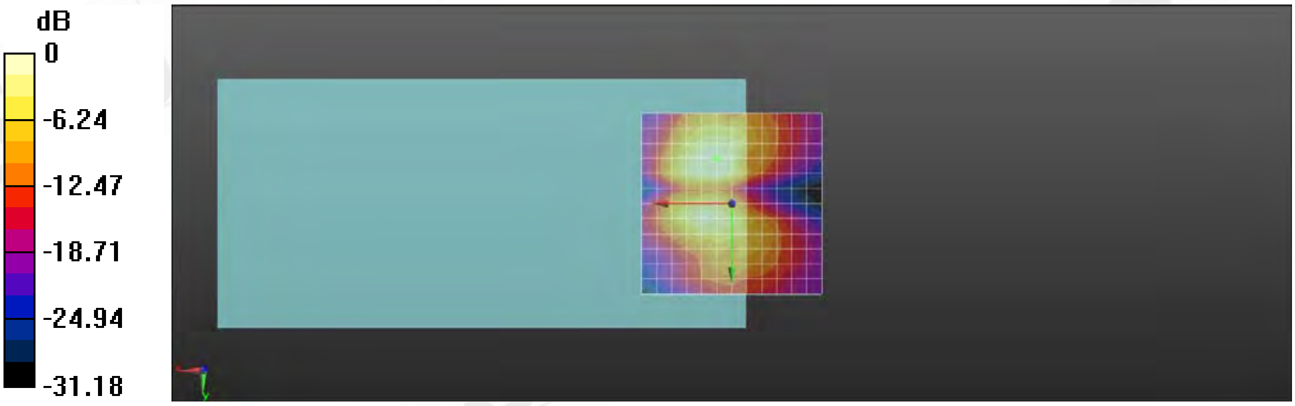
Communication System: WLAN 2.45G; Frequency: 2437 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m^3
Phantom section: TCoil Section

DASY5 Configuration:

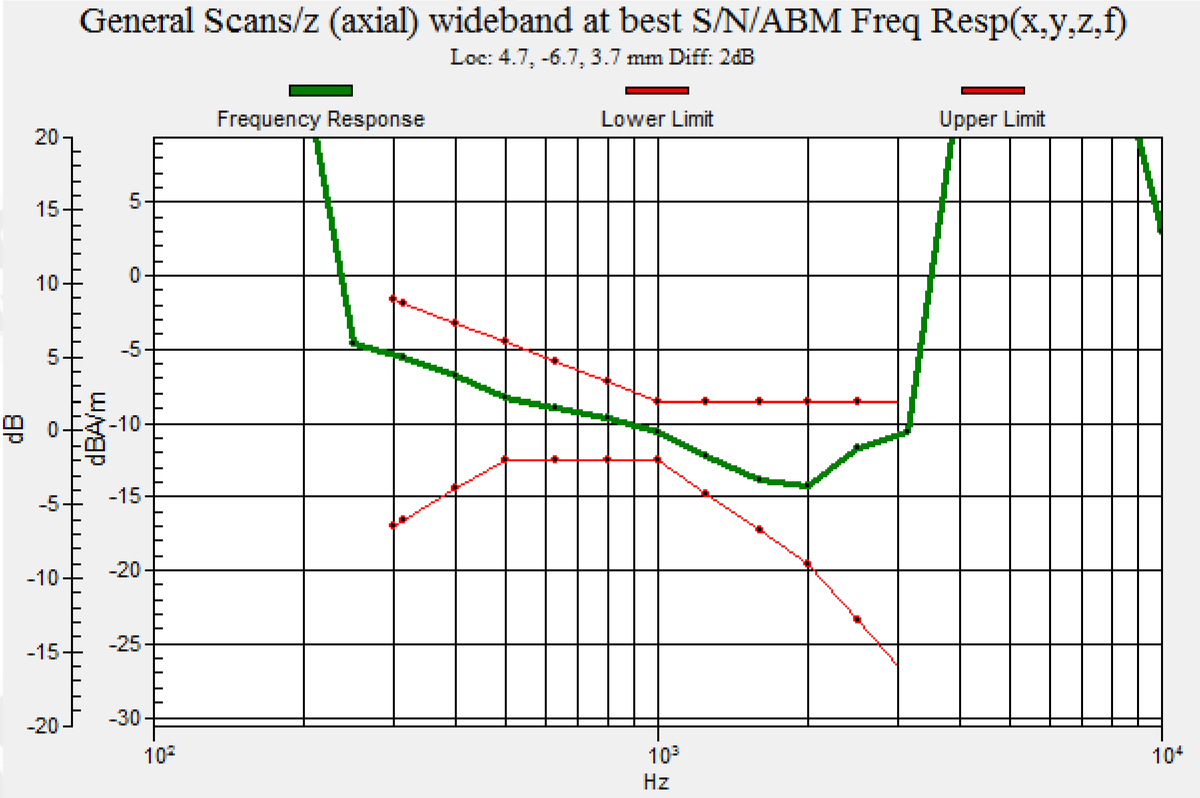
- Probe: AM1DV3 - 3115; ; Calibrated: 2018/8/16
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.12 dB
ABM1 comp = -16.92 dBA/m
BWC Factor = 0.15 dB
Location: 4.2, -12.5, 3.7 mm



0 dB = 18.02 = 25.12 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.7, -6.7, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
20
15
10
5
0
-5
-10
-15
-20
5
0
-5
-10
-15
-20
-25
-30
10²
10³
10⁴

19. DAE & Probe Calibration Certificate

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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 **SGS-TW (Auden)**

Certificate No: **DAE4-1336_Aug18**

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 1336
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	August 06, 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	04-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	04-Jan-18 (in house check)	In house check: Jan-19

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

Issued: August 6, 2018

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

Certificate No: DAE4-1336_Aug18 Page 1 of 5

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

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

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

Accreditation No.: **SCS 0108**

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.

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

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	403.344 ± 0.02% (k=2)	403.624 ± 0.02% (k=2)	403.107 ± 0.02% (k=2)
Low Range	3.95102 ± 1.50% (k=2)	3.98703 ± 1.50% (k=2)	3.99683 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	287.0 ° ± 1 °

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	200042.98	8.65	0.00
Channel X	+ Input	20006.34	1.11	0.01
Channel X	- Input	-20005.65	-0.58	0.00
Channel Y	+ Input	200034.32	0.12	0.00
Channel Y	+ Input	20003.47	-1.57	-0.01
Channel Y	- Input	-20006.39	-1.21	0.01
Channel Z	+ Input	200032.22	-2.06	-0.00
Channel Z	+ Input	20002.78	-2.14	-0.01
Channel Z	- Input	-20007.34	-2.09	0.01

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	2001.47	0.30	0.01
Channel X	+ Input	201.92	0.79	0.39
Channel X	- Input	-198.26	0.59	-0.30
Channel Y	+ Input	2001.55	0.37	0.02
Channel Y	+ Input	200.87	-0.11	-0.05
Channel Y	- Input	-199.34	-0.43	0.22
Channel Z	+ Input	2001.12	0.04	0.00
Channel Z	+ Input	200.15	-0.88	-0.44
Channel Z	- Input	-200.14	-1.15	0.58

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	6.04	4.72
	- 200	-4.13	-4.79
Channel Y	200	-3.65	-3.78
	200	2.68	2.45
Channel Z	200	22.40	22.16
	- 200	-24.83	-25.10

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	-	6.12	-1.64
Channel Y	200	9.19	-	5.46
Channel Z	200	8.44	6.31	-

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

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	15666	16509
Channel Y	15907	15587
Channel Z	15855	15507

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	0.87	-0.00	2.62	0.36
Channel Y	3.53	2.67	4.59	0.34
Channel Z	-0.18	-1.34	1.53	0.54

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

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
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: SGS-TW (Auden)

Certificate No: AM1DV3-3115_Mar18

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3115
Calibration procedure(s)	QA CAL-24.v4 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	March 15, 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
Reference Probe AM1DV3	SN: 3000	24-Aug-17 (No. AM1DV3-3000_Aug17)	Aug-18
DAE4	SN: 781	17-Jan-18 (No. DAE4-781_Jan18)	Jan-19

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Oct-17)	Oct-19
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Oct-17)	Oct-19

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 20, 2018

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

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

[References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[3] DASY5 manual, Chapter: Hearing Aid Compatibility (HAC) T-Coil Extension

Description of the AM1D probe

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

Handling of the item

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

Methods Applied and Interpretation of Parameters

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

Sensitivity: With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BB
Serial No	**3115**

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

Manufacturer / Origin	Schmid & Partner Engineering AG, Zurich, Switzerland
Manufacturing date	November 15, 2011

Calibration data

Connector rotation angle	(in DASY system)	**263.0°**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**0.32 °**	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00791 V / (A/m)**	+/- 2.2 % (k=2)

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

Certificate No: AM1DV3-3115_Mar18 Page 3 of 3

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group

20. Uncertainty Budget

Uncertainty of Audio Band Magnetic Measurements

Error Description	Unc. Value	Prob. Dist.	Div.	(c_i) ABM1	(c_i) ABM2	Std. Unc. ABM1	Std. Unc. ABM2
Probe Sensitivity							
Reference Level	±3.0 %	N	1	1	1	±3.0 %	±3.0 %
AMCC Geometry	±0.4 %	R	$\sqrt{3}$	1	1	±0.2 %	±0.2 %
AMCC Current	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %
Probe Positioning during Calibr.	±0.1 %	R	$\sqrt{3}$	1	1	±0.1, %	±0.1 %
Noise Contribution	±0.7 %	R	$\sqrt{3}$	0.0143	1	±0.0 %	±0.4 %
Frequency Slope	±5.9 %	R	$\sqrt{3}$	0.1	1.0	±0.3 %	±3.5 %
Probe System							
Repeatability / Drift	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %
Linearity / Dynamic Range	±0.6 %	R	$\sqrt{3}$	1	1	±0.4 %	±0.4 %
Acoustic Noise	±1.0 %	R	$\sqrt{3}$	0.1	1	±0.1 %	±0.6 %
Probe Angle	±2.3 %	R	$\sqrt{3}$	1	1	±1.4 %	±1.4 %
Spectral Processing	±0.9 %	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %
Integration Time	±0.6 %	N	1	1	5	±0.6 %	±3.0 %
Field Disturbation	±0.2 %	R	$\sqrt{3}$	1	1	±0.1 %	±0.1 %
Test Signal							
Ref. Signal Spectral Response	±0.6 %	R	$\sqrt{3}$	0	1	±0.0 %	±0.4 %
Positioning							
Probe Positioning	±1.9 %	R	$\sqrt{3}$	1	1	±1.1 %	±1.1 %
Phantom Thickness	±0.9 %	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %
DUT Positioning	±1.9 %	R	$\sqrt{3}$	1	1	±1.1 %	±1.1 %
External Contributions							
RF Interference	±0.0 %	R	$\sqrt{3}$	1	0.3	±0.0 %	±0.0 %
Test Signal Variation	±2.0 %	R	$\sqrt{3}$	1	1	±1.2 %	±1.2 %
Combined Uncertainty							
Combined Std. Uncertainty (ABM Field)						±4.1 %	±6.1 %
Expanded Std. Uncertainty						**±8.1 %**	**±12.3 %**

End of report

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan 24803/新北市五股區新北產業園區五工路134號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.tw.sgs.com
Member of SGS Group