HAC T-COIL SIGNAL TEST REPORT

FCC 47 CFR § 20.19
ANSI C63.19-2019

For

GSM/WCDMA/LTE 5G NR Phone + BT/BLE, DTS/UNII a/b/g/n/ac/ax, NFC and WPT

MODEL NUMBER : SM-S921U, SM-S921U1

FCC ID: A3LSMS921U

REPORT NUMBER: 4790976523-S6V1

ISSUE DATE: 10/26/2023

Prepared for
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Testing Laboratory

TL-637

Revision History

Rev.	Date	Revisions	Revised By
V1	10/26/2023	Initial Issue	-

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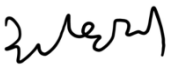
1. Attestation of Test Results

Applicant Name	SAMSUNG ELECTRONICS CO.,LTD.
FCC ID	A3LSMS921U
Model Name	SM-S921U, SM-S921U1
Applicable Standards	FCC 47 CFR § 20.19 ANSI C63.19-2019
Date Tested	10/6/2023 to 10/25/2023
Test Results	Pass

UL Korea, Ltd. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Korea, Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Korea, Ltd. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Korea, Ltd. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by IAS, any agency of the Federal Government, or any agency of any government.

Approved & Released By:	Prepared By:
	
Justin Park Operations Leader UL Korea, Ltd. Suwon Laboratory	Eunji Choi Laboratory Test Engineer UL Korea, Ltd. Suwon Laboratory

2. Test Methodology

The tests documented in this report were performed in accordance with ANSI C63.19-2019 Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids and FCC published procedure.

KDB 285076 D01 HAC Guidance v06r04
KDB 285076 D02 T-Coil testing for CMRS IP v04
KDB 285076 D03 HAC FAQ v01r06
TCB workshop updates

3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

Suwon
SAR 6 Room (HAC)

UL Korea, Ltd. is accredited by IAS, Laboratory Code TL-637.
The full scope of accreditation can be viewed at https://www.iasonline.org/wp-content/uploads/2017/05/TL-637-cert-New.pdf

4. Calibration and Uncertainty

4.1. Measuring Instrument Calibration

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations and is traceable to recognized national standards.

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
ABM Probe	SPEAG	AM1DV3	3140	07-23-2024
Data Acquisition Electronics	SPEAG	DAE4	1343	06-30-2024
AMMI	SPEAG	SE UMS 010 BB	1161	N/A
Radio Communication Tester	R & S	CMW 500	150314	07-26-2024
Wireless Test Platform	Keysight	E7515B	MY57510596	07-27-2024
Support Device	Samsung	SM-G996U	R3CNA04G7LB	N/A
DAC	Sound Devices	USBPre 2	HB1218172005	N/A

4.2. Measurement Uncertainty

Measurement Uncertainty for Audio Band Magnetic Measurement

Error Description	Explanation	Uncertainty value (±%) for ANSI C63.19-2019	Probe Dist.	Divisor	(Ci) ABM1	(Ci) ABM2	Std. Unc.(±%) for ANSI C63.19-2019	
							ABM1	ABM2
Probe Sensitivity								
Reference Level	B.1	**3.00**	Normal	1	1	1	3.00	3.00
AMCC Geometry	B.2	**0.40**	Rectangular	1.732	1	1	0.23	0.23
AMCC Current	B.3	**1.00**	Rectangular	1.732	1	1	0.58	0.58
Probe Positioning during Calibration	B.4	**0.10**	Rectangular	1.732	1	1	0.06	0.06
Noise Contribution	B.5	**0.70**	Rectangular	1.732	0.0143	1	0.01	0.40
Frequency Slope	B.6	**5.90**	Rectangular	1.732	0.1	1	0.34	3.41
Probe System								
Repeatability / Drift	B.7	**1.00**	Rectangular	1.732	1	1	0.58	0.58
Linearity / Dynamic Range	B.8	**0.60**	Rectangular	1.732	1	1	0.35	0.35
Acoustic Noise	B.9	**1.00**	Rectangular	1.732	0.1	1	0.06	0.58
Probe Angle	B.10	**1.00**	Rectangular	1.732	1	1	0.58	0.58
Spectral Processing	B.11	**0.90**	Rectangular	1.732	1	1	0.52	0.52
Integration Time	B.12	**0.60**	Normal	1	1	5	0.60	3.00
Field Disturbation	B.13	**0.20**	Rectangular	1.732	1	1	0.12	0.12
Test Signal								
Ref. Signal Spectral Response	B.14	**0.60**	Rectangular	1.732	0	1	0.00	0.35
Positioning								
Probe Positioning	B.15	**1.90**	Rectangular	1.732	1	1	1.10	1.10
Phantom Thickness	B.16	**0.90**	Rectangular	1.732	1	1	0.52	0.52
DUT Positioning	B.17	**1.90**	Rectangular	1.732	1	1	1.10	1.10
External Contributions								
RF interference	B.18	**0.00**	Rectangular	1.732	1	0.3	0.00	0.00
Test Signal Varistion	B.19	**2.00**	Rectangular	1.732	1	1	1.15	1.15
Combined Std, Uncertainty (ABM Field)							**3.87**	**5.97**
Expanded Std. Uncertainty							**7.73**	**11.95**

Notes for table
1. Ci - is te sensitivity coefficient
2. Expanded Std. Uncertainty, Coverage Factor = 2, > 95% Confidence

4.3. Decision Rule

Decision rule for statement(s) of conformity is based on Procedure 2, Clause 4.4.3 in IEC Guide 115:2021.

5. Test Procedures for all Technologies

5.1. General Procedures C63.19-2019, Section 6

This subclause describes the procedures used to measure the ABM (T-Coil) performance of the WD. Measurements shall be performed over a measurement area 50 mm square in the measurement plane. The measurement area shall be scanned with a uniform measurement point spacing of 2.0 mm ± 0.5 mm in each X-Y axis of the plane, yielding 676 measurement points with approximately even spacing throughout the area.

Optionally, measurement point spacing may be increased to 4 mm, with interpolation employed to yield the required 676 equivalent measurement points distributed uniformly over the 50 mm square measurement area. Interpolated points shall be derived from the average of the linear representations of the field strengths of the nearest two or four equidistant measured points. The area of measurement is increased to a 52 mm square so that edge rows and columns of the required 50 mm square can be either measured or interpolated, with none extrapolated.

In addition to measuring the desired ABM signal levels, the weighted magnitude of the unintended signal shall also be determined. Weighting of the unintended and undesired ABM field shall be by the spectral and temporal weighting.

In order to assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal shall be made at the same locations. Measurements shall not include undesired influence from the WD's RF field. Pre-measurement checks should be made to avoid this possibility. All measurements shall be done with the WD operating on battery power with an appropriate normal speech audio signal input level given in Table 6.1. If the device display can be turned off during a phone call, then that may be done during the measurement as well. If tested with the display in the off state this shall be documented in the test report.

Measurements shall be performed with the probe coil oriented in the transverse direction, that is, aligned in the plane of the measurement area and perpendicular to the long dimension of the WD. A multi-stage sequence consists of first measuring the field strength of the desired T-Coil signal (desired ABM signal) that is useful to a hearing aid T-Coil at each specified measurement point. The undesired magnetic component (undesired ABM field) is then measured in the same transverse orientation at each of the same measurement points. At a single location only, taken at or near the highest desired ABM signal reading, the desired ABM signal frequency response shall be determined in a third measurement stage.

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

a) A validation of the test setup and instrumentation shall be performed. This may be done using a TMFS or Helmholtz Coil. Measure the emissions and confirm that they are within tolerance of the expected values.
b) Confirm that equipment that requires calibration has been calibrated, and that the noise level meets the requirements given in 6.3.2.
c) Position the WD in the test setup and connect the WD RF connector to a base station simulator or a non-radiating load (if necessary to control RF interference in the measurement equipment) as shown in Figure 6.1 or Figure 6.2.
d) The drive level to the WD is set such that the reference input level specified in Table 6.1 is input to the base station simulator (or manufacturer's test mode equivalent) in the 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (desired ABM signal) at $\boldsymbol{f}$ = 1 kHz. Either a sine wave at 1025 Hz, or a voice-like signal, band-limited to the 1 kHz 1/3 octave, as specified in 6.4.3, 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.35 The same drive level will be used for the desired ABM signal 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.
e) At each measurement location over the measurement area and in the transverse orientation, measure and record the desired 1 kHz T-Coil magnetic signal (desired ABM signal) as described in Step c).
f) At or near a location representing a maximum in the just-measured desired ABM signal, measure and record the desired T-Coil magnetic signals (desired ABM signal at f*i*) as described in 6.4.5.2 in each individual ISO 266:1975 R10 standard 1/3 octave band. The desired audio band input frequency (f*i*) shall be centered in each 1/3 octave band maintaining the same drive level as determined in Step c), and the reading taken for that band.
   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 or half-band integrated probe output, as described in D.9, may be used, as long as the

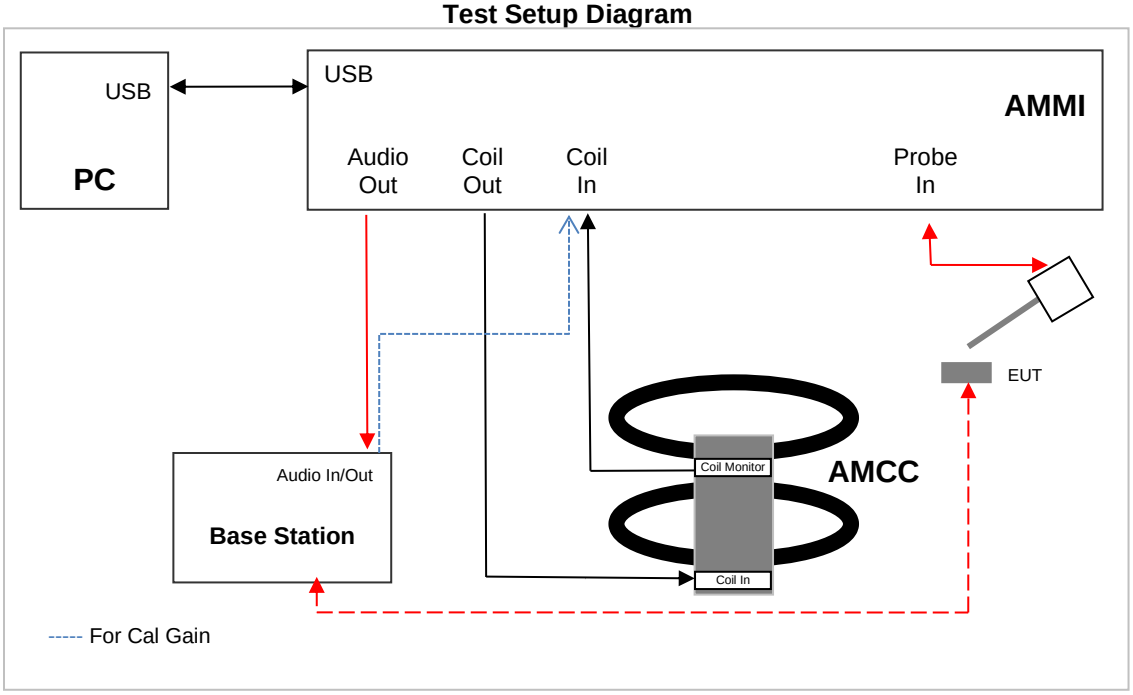
appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB(A/m).) Compare the frequency response found to the requirements of 6.6.3.

g) At the same locations measured in Step d), measure and record the undesired broadband audio magnetic signal (undesired ABM field) with no audio signal applied (or digital zero applied, if appropriate) using the specified spectral weighting, the half-band integrator followed by the temporal weighting.

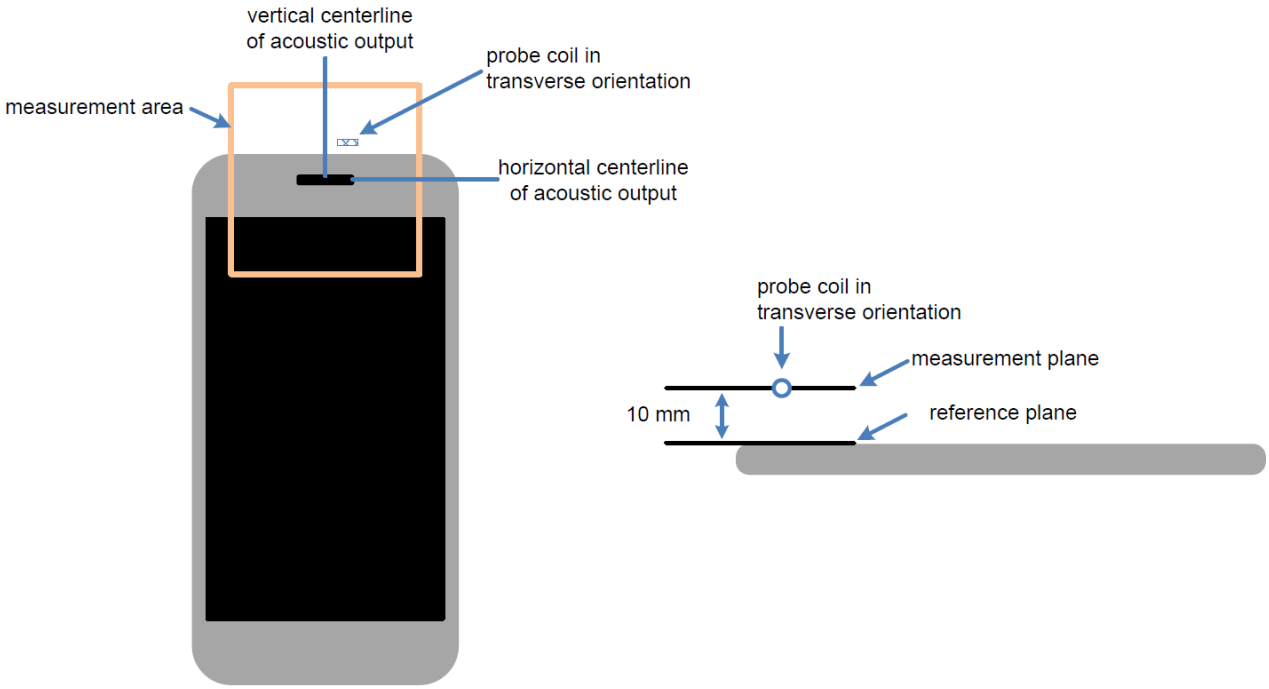
h) Calculate and record the location and number of the measurement points that satisfy both the minimum desired ABM signal level and the maximum undesired ABM field level specified in 6.6.2. Compare this to the requirements in 6.6.4 and record the result.

i) Calculate and record the location and number of the measurement points that satisfy the maximum undesired ABM field level and distribution requirements specified in 6.6.4.

Test Setup Diagram



Measurement locations and reference plane to be used for the T-coil measurement



5.2. Reference Input Level

The following reference input levels (Table 6.1) that correlate to a normal speech input level shall be used for the standard transmission protocols.

Normal speech input level -16 dBm0 is used for all testing: GSM, WCDMA, VoLTE, VoNR, VoWiFi and OTT(Google Meet).

Table 6.1—Normal speech input levels

Standard	Protocol	Input (dBm0)
TIA-2000	CDMA	−18
TIA/EIA-136	TDMA (50 Hz)	−18
J-STD-007	GSM (217 Hz)	−16
T1/T1P1/3GPP (See Note 1)	UMTS (WCDMA)	−16
iDEN®	TDMA (22 Hz and 11 Hz)	−18
VoIP [a] (See Note 2)	Voice over Internet Protocol	−16
NOTE 1—For UMTS (Universal Mobile Telecommunications System), refer to 3GPP TS26.131 and TS26.132 (http://www.3gpp.org). NOTE 2—VoIP is used in this table as a general term specifying a group of voice services that use −16 dBm0 as their normal acoustic level. The group includes a variety of voice services, including Voice-over-LTE (VoLTE), Voice-over-IP-multimedia-subsystem (VoIMS), Voice-over-Wi-Fi (VoWiFi) and similar services. For 3G, LTE, and WLAN terminals used for Commercial Mobile Radio Service (CMRS) based telephony, refer to 3GPP TS26.131 and TS26.132.		

[a] The manufacturer shall establish that −16 dBm0 is the normal acoustic level in order to place it in this category.

For protocols not listed in Table 6.1, use the normal speech input level per the relevant specifications for that air interface.

5.3. AMMI Audio Output Calibration and Gain

SPEAG DASY8 HAC T-Coil Measurement system provides to calibrate and compute the gain automatically for given Input level [V full scale] and Speech level [dBm0]. The Input level using in Base Station Simulator should be set same value as setting in T-Coil Measurement system. Gain value is mostly very similar if test system has same configuration.

CMRS Scaling(gain) [dB]

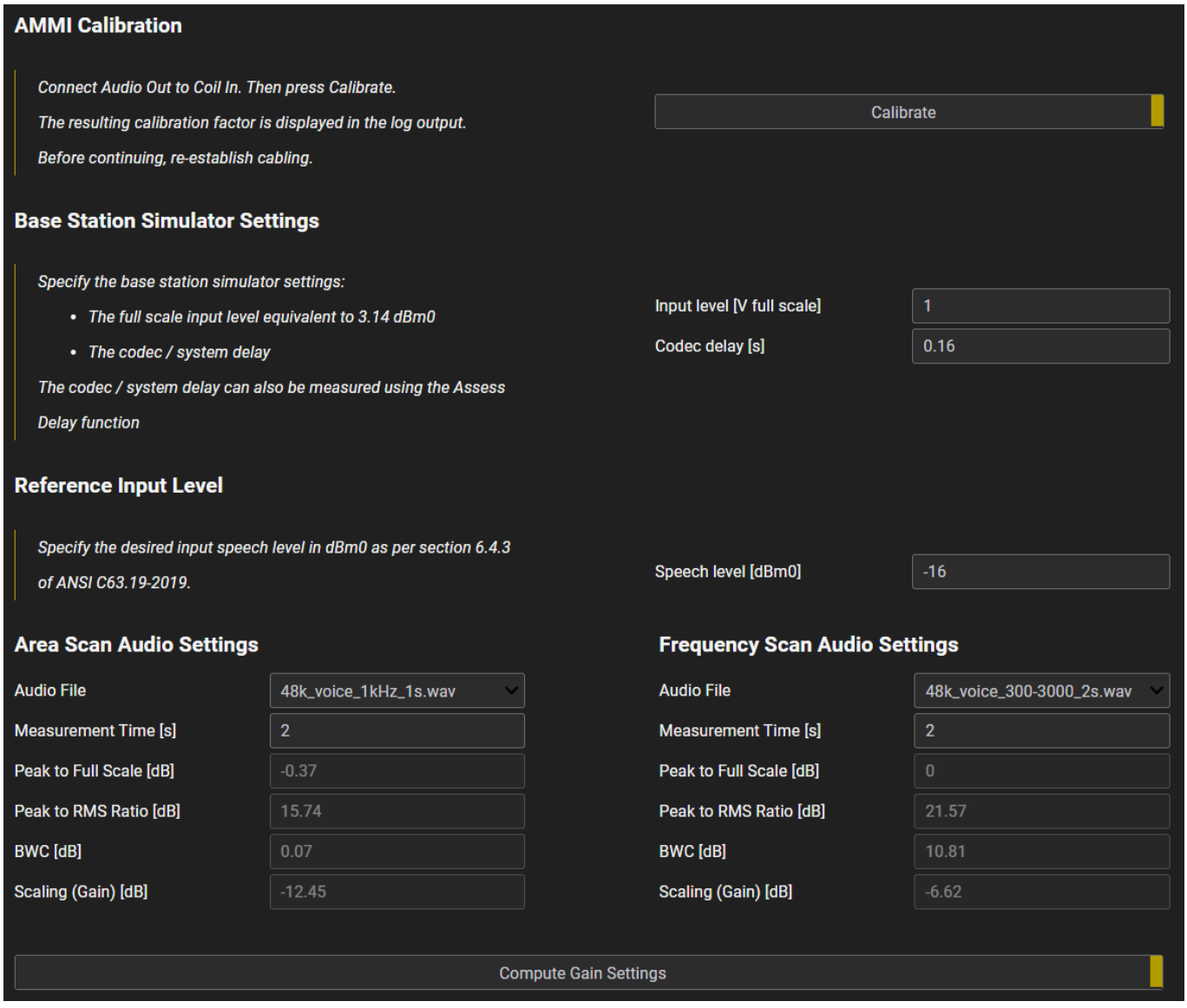
- The Scaling(gain) [dB] values for “Voice_1kHz_1s.wav” were -12.45 to -12.47 dB during period of test.
- The Scaling(gain) [dB] values for “Voice_300-3000_2s.wav” were -6.62 to -6.64 dB during period of test.

OTT – Google Meet Scaling(gain) [dB]

- The Scaling(gain) [dB] values for “Voice_1kHz_1s.wav” were -12.51 to -12.59 dB during period of test.
- The Scaling(gain) [dB] values for “Voice_300-3000_2s.wav” were -6.68 to -6.76 dB during period of test.

The audio output calibration of the AMMI is performed as described below:

- Check the **Input level [V full scale]** and **Speech level [dBm0]**.
- Connect **Audio Out** to **Coil In** on the AMMI for CMRS testing,
  or add the DAC between **Audio Out** and **Coil In** for OTT testing.
- Click on the **Calibrate** button.
- Click on the **Compute Gain Settings**.
- Re-establish the cabling as for regular DUT measurements.



5.4. VoWiFi

This device supports Wi-Fi calling (aka Voice over Wi-Fi or VoWiFi) which is an extended feature of the carriers CMRS service to offload VoLTE calls onto local area networks over WI-FI via the internet and subject to HAC assessment for phones with a HAC rating.

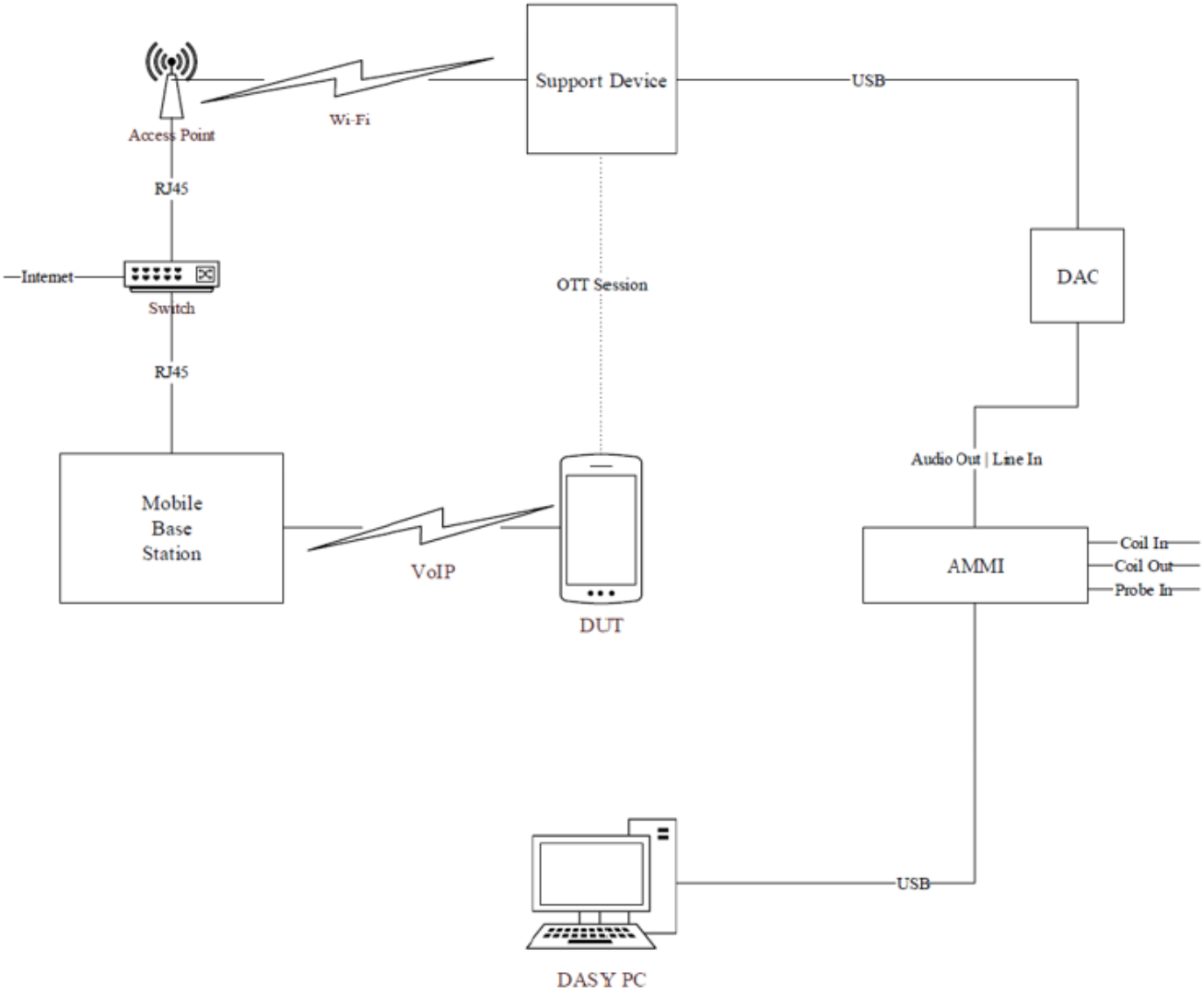
The set up for VoWiFi uses the Base station as described in section 5.1 and 5.3 and the reference level is calibrated using the standard call box calibration procedures. An investigation was performed to determine worst case codec, bit rate and air interface configuration (refer to section 9).

5.5. Over the Top (OTT)

This device supports VoIP via a preinstalled application that uses the **Google Meet service** and related codec "**OPUS**". VoIP capabilities require HAC assessment when voice calls are supported over the cellular data connection via pre-installed applications.

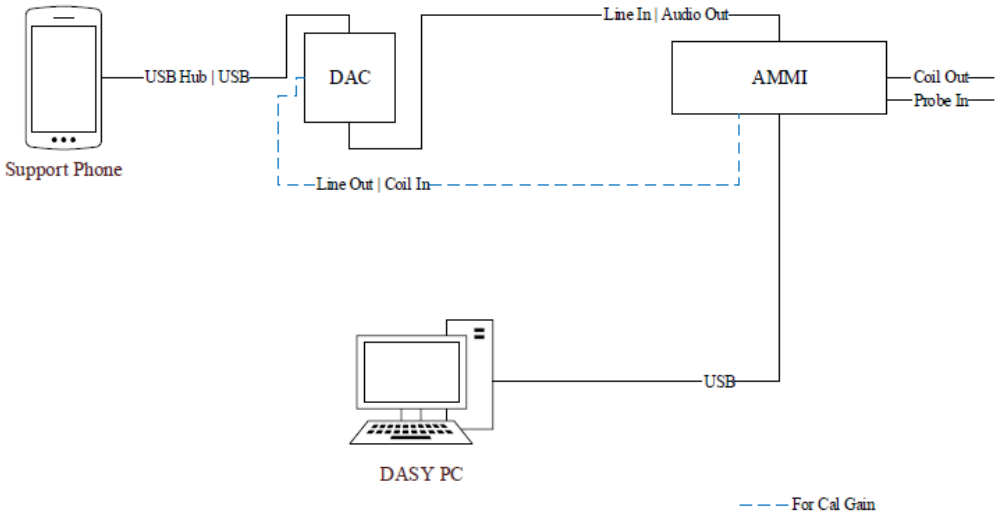
The equipment is set up as shown below with a support device used to originate the call using the IP transport. This support device includes test software that allows the codec bit rate for the IP call to be selected. The support device connects to the cloud-based Google Meet service via a Wi-Fi access point and router. The DUT connects to the VoIP service via a cellular air interface to the call box and an ethernet connection from call box to internet. The various codec bit rate and air interface configurations are evaluated to determine the worst-case configuration (refer to section 9).

Test Setup configuration for OTT Calls



For the OTT call the calibrated audio card cannot be used so the AMMI is connected to an external Digital-Analog Converter (DAC) and the DAC is connected to the Support Device via USB. The test signal is sent from the DASY PC to the AMMI, from the AMMI to the DAC, from the DAC to the Support Device, and, via the VoIP call, to the DUT.

As this test set up uses an external DAC between the AMMI's audio output and support device the appropriate gain factor for the OTT call has to be determined. This is done by connecting the DAC between the AMMI Audio output and Coil input as shown below.



6. Base Station Simulator – software/firmware

6.1. VoLTE

Refer to the below software/firmware License list for measurement VoLTE.

Firmware	License Keys	Software Name (CMW500)
V3.7.70 for LTE	KS500	LTE FDD R8 SIG BASIC
	KS550	LTE TDD R8 SIG BASIC
V3.7.20 for Audio	KA100	IP APPL ENABLING IPv4
	KA150	IP APPL ENABLING IPv4
	KAA20	IP APPL IMS BASIC
	KM050	DATA APPL MEAS
	KS104	EVS SPEECH CODEC

6.2. VoNR

Refer to the below software/firmware License list for measurement VoNR.

License Option	Software Name (Keysight E7515B)
C8700201A	IMS-SIP Emulation
C87350P1A	5G NR IP data

6.3. VoWi-Fi

Refer to the below software/firmware License list for measurement VoWi-Fi.

Firmware	License Keys	Software Name (CMW500)
V3.7.50 for WLAN	KS650	WLAN A/B/G SIG BASIC
	KS651	WLAN N SIG BASIC
	KS656	WLAN IEEE 802.11ac
	KS657	WLAN IEEE 802.11ax
V3.7.20 for Audio	KA100	IP APPL ENABLING IPv4
	KA150	IP APPL ENABLING IPv4
	KAA20	IP APPL IMS BASIC
	KM050	DATA APPL MEAS
	KS104	EVS SPEECH CODEC

7. T-coil Coupling Mode Requirements

In order to comply with the requirements for T-Coil use, a WD's tested operating modes shall simultaneously meet the requirements for minimum desired ABM signal level and maximum undesired ABM field contained in this subclause at the minimum specified number of scanned locations.

7.1. T-Coil Coupling qualifying field strengths

When measured as specified in this standard, there are two groups of qualifying measurement points:

- **Primary group**: A qualifying measurement point shall have its T-Coil signal, desired ABM signal, ≥ -18 dB(A/m) at 1 kHz, in a 1/3 octave band filter. These measurements shall be made with the WD operating at a reference input level as specified. Simultaneously, the qualifying measurement point shall have its weighted magnetic noise, undesired ABM field ≤ -38 dB(A/m).
- **Secondary group**: A qualifying measurement point shall have its weighted magnetic noise, undesired ABM field ≤ -38 dB(A/m). This group inherently includes all the members of the primary group.

7.2. Desired ABM signal, undesired ABM field qualification requirements

a) Non-2G GSM operating modes

The goal of this requirement is to ensure an adequate area where desired ABM signal is sufficiently strong to be heard clearly and a larger area where undesired ABM field is sufficiently low as to avoid undue annoyance. Qualifying measurement points shall fulfill the requirements of 6.6.2; both the primary and secondary group requirements shall be met:

- The primary group shall include at least 75 measurement points.
- The secondary group shall include at least 300 contiguous measurement points.

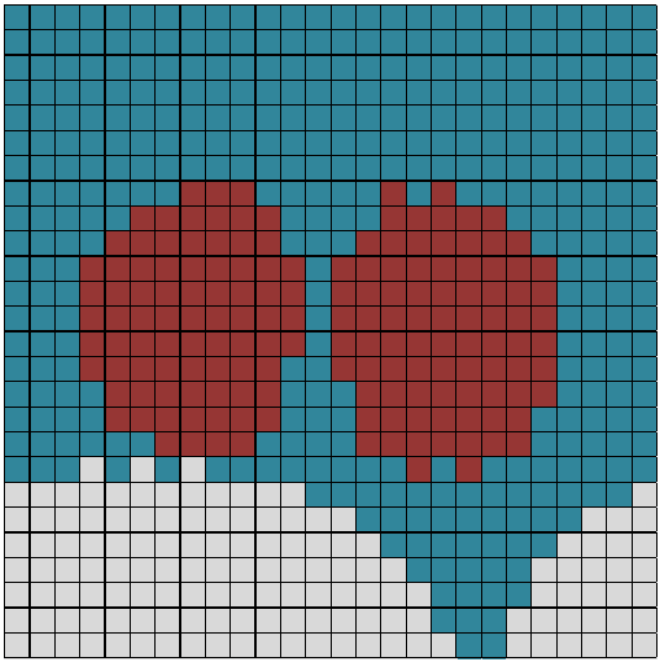
Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

b) 2G GSM operating modes

If the 2G GSM operating mode(s) are selected for qualification, the qualifying measurement points shall fulfil the requirements of 6.6.2; both the primary and secondary group requirements shall be met:

- The primary group shall include at least 25 measurement points.
- The secondary group shall include at least 125 contiguous measurement points.

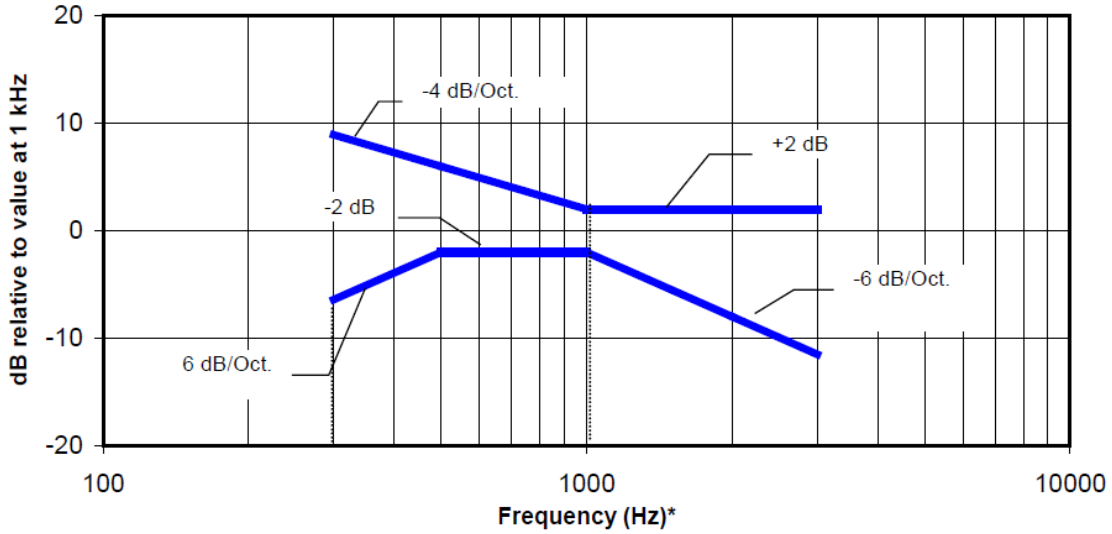
An example of a qualifying desired ABM signal, undesired ABM field scan



Red (primary group): AB desired ABM signal M1 ≥−18 dB(A/m) and undesired ABM field ≤−38 dB(A/m)
Blue and red (secondary group): undesired ABM field ≤−38 dB(A/m)

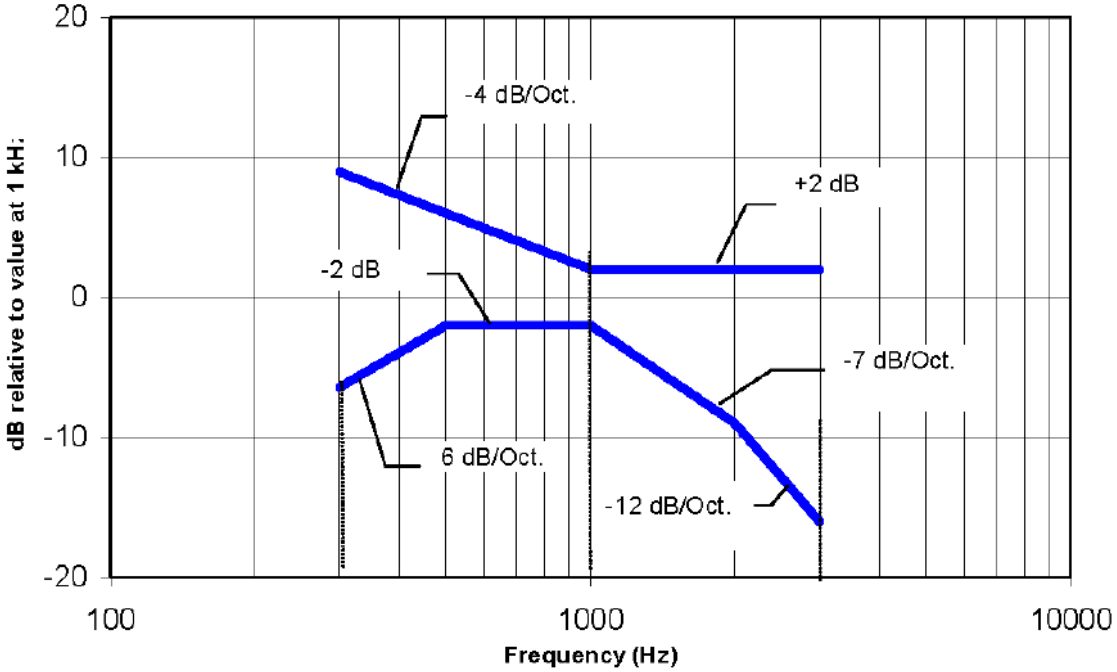
7.3. Frequency Response

The frequency response of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this subclause, over the frequency range 300 Hz to 3 kHz.
Figure 6.4 and Figure 6.5 provide the boundaries for the specified 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—Frequency response is between 300 Hz and 3 kHz.

Figure 6.4—Magnetic field frequency response for WDs with a maximum field ≤−15 dB(A/m) at 1 kHz



NOTE—Frequency response is between 300 Hz and 3000 Hz.

Figure 6.5—Magnetic field frequency response for WDs with a maximum field that exceeds −15 dB(A/m) at 1 kHz

8. Device Under Test

Normal operation	Held to head	
Back Cover	The Back Cover is not removable	
Test sample information	**S/N**	**Notes**
	R3CW80J5G0V	T-coil Signal Test
	R3CW80J5FWJ	T-coil Signal Test

8.1. Air Interfaces and Operating Mode

Air Interface	Bands (MHz)	Type	C63.19 Tested	Simultaneous Transmitter	OTT Testing Required? Name of Voice Service	Audio Codecs Evaluated
GSM	850	VO	Yes	Wi-Fi and BT	CMRS	FR V1, FR V2, HR V1
	1900					
	GPRS/EDGE	VD	Yes	Wi-Fi and BT	Yes Google Meet	OPUS
W-CDMA (UMTS)	850 (V)	VO	Yes	Wi-Fi and BT	CMRS	AMR-NB & AMR-WB
	1750 (IV)					
	1900 (II)					
	HSPA	VD	Yes	Wi-Fi and BT	Yes Google Meet	OPUS
LTE - FDD	680 (B71)	VD	Yes	NR, Wi-Fi and BT	VoLTE Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	700 (B12)					
	780 (B13)					
	790 (B14)					
	850 (B5/26)					
	1700 (B4/66)					
	1900 (B2/25)					
	2300 (B30)					
	2600 (B7)					
LTE - TDD	2600 (B38/41)	VD	Yes	NR, Wi-Fi and BT	VoLTE Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	3600 (B48)					
NR - FDD	680 (n71)	VD	Yes	LTE, Wi-Fi and BT	VoNR Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	700 (n12)					
	850 (n5/26)					
	1700 (n66)					
	1700 (n70)					
	1900 (n2/25)					
	2300 (n30)					
	2600 (n7)					
NR - TDD	2600 (n38/n41)	VD	Yes	LTE, Wi-Fi and BT	VoNR Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	3600 (n48)					
	3500 (n77 DoD)					
	3700 (n77)					
Wi-Fi	2450	VD	Yes	WWAN, BT and U-NII	VoWiFi Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	5200 (U-NII-1)			WWAN, BT and WiFi 2.4GHz		
	5300 (U-NII-2A)					
	5500 (U-NII-2C)					
	5800 (U-NII-3)					
	5900 (U-NII-4)					
	6175 (U-NII-5)	VD	N/A[1]	WWAN, BT and WiFi 2.4GHz	VoWiFi Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	6475 (U-NII-6)					
	6700 (U-NII-7)					
	7000 (U-NII-8)					
BT	2450	DT	N/A	WWAN and U-NII	N/A	N/A

Type

VO: Legacy Cellular Voice Service

DT: Digital Transport only (no voice)

VD: IP Voice Service over Digital Transport

CMRS: Commercial Mobile Radio Service

BT: Bluetooth

Note:

1. ANSI C63.19 only requires HAC evaluations for Frequncies under 6GHz.

9. HAC (T-coil) Test Results

9.1. Antenna Investigation

An investigation was performed to determine the worst-case antenna per technology. All subsequent measurements were determined by this investigation.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB (A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
GSM 850	Ant.A	FR V1	CH.190 836.6 MHz	N/A	N/A	N/A	-56.75	45	217	2.00	16	26	6.10
GSM 850	Ant.E	FR V1	CH.190 836.6 MHz	N/A	N/A	N/A	-56.75	**39**	192	2.00	16	26	5.96
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.82	**315**	676	2.00	26	26	1.83
WCDMA Band V	Ant.E	AMR-WB 6.6	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.82	315	676	1.94	26	26	2.01
LTE Band 26	Ant.A	EVS-wb 5.9	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.75	256	641	2.00	26	26	2.00
LTE Band 26	Ant.E	EVS-wb 5.9	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.75	**240**	676	2.00	26	26	1.31
LTE Band 66	Ant.A	AMR-WB 6.6	132322 1745 MHz	20 MHz	QPSK	1/0	-56.73	276	628	1.98	26	26	3.89
LTE Band 66	Ant.F	AMR-WB 6.6	132322 1745 MHz	20 MHz	QPSK	1/0	-56.73	**271**	628	2.00	26	26	3.73
LTE Band 41 PC2	Ant.B	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.65	**82**	329	2.00	20	26	4.63
LTE Band 41 PC2	Ant.F	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.65	109	417	2.00	22	26	3.69
NR Band n12	Ant.A	EVS-wb 5.9	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	**148**	474	2.00	21	26	1.81
NR Band n12	Ant.E	EVS-wb 5.9	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	165	487	2.00	24	26	2.16
NR Band n25	Ant.A	AMR-WB 6.6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	123	446	2.00	23	26	1.51
NR Band n25	Ant.F	AMR-WB 6.6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	**123**	444	2.00	23	26	1.49
NR Band n41	Ant.F	AMR-WB 6.6	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.67	**105**	383	1.93	21	26	4.01
NR Band n41	Ant.B	AMR-WB 6.6	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.67	136	408	2.00	21	26	4.10
WiFi 2.4GHz 802.11b	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.67	**121**	390	2.00	23	26	5.19
WiFi 2.4GHz 802.11b	SISO Ant.1	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.67	165	457	2.00	26	26	5.13
WiFi 2.4GHz 802.11b	SISO Ant.2	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.67	170	464	2.00	26	26	5.41
WiFi 5GHz 802.11a U-NII-1	MIMO	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	262	588	2.00	26	26	4.20
WiFi 5GHz 802.11a U-NII-1	SISO Ant.1	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	287	608	2.00	26	26	4.19
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	**231**	556	2.00	26	26	4.34

Note(s):

1. For GSM850, it is observed that Ant.E is the worst-case.
2. For WCDMA V, it is observed that Ant.A is the worst-case.
3. For low frequency bands in LTE (LTE Band B12/13/14/26/71), it is observed that Ant.E is the worst-case.
4. For low frequency bands in NR (NR Band n12/26/71), it is observed that Ant.A is the worst-case.
5. For mid-high frequency bands in LTE/NR FDD (LTE Band B7/25/30/66, NR Band n25/30/66/70), it is observed that Ant.F is the worst-case.
6. For LTE Band B41, it is observed that Ant.B is the worst-case.
7. For NR Band n41, it is observed that Ant.F is the worst-case.
8. For Wi-Fi 2.4GHz band, it is observed that MIMO Antenna is the worst-case.
9. For Wi-Fi 5GHz band, it is observed that SISO Ant.2 is the worst-case.

9.2. GSM/WCDMA/VoLTE/VoNR Codec Investigation

An investigation between the various codec configurations (Low/Mid/High bit rates for Narrowband and Wideband) and specific parameters are documented (Primary Group, Secondary Group, frequency response) to determine the worst-case bit rates for each voice service type. The table below compares the varying codec configurations.

A codec investigation was performed on one band of each GSM, W-CDMA, LTE FDD/TDD, NR FDD/TDD. The highlighted results below were determined to be the worst-case codec configuration(s) for GSM, WCDMA, LTE and NR.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
GSM 850	Ant.E	FR V1	CH.190 836.6 MHz	N/A	N/A	N/A	-56.75	**39**	192	2.00	16	26	5.96
		FR V2		N/A	N/A	N/A	-56.75	41	198	2.00	16	26	6.43
		HR V1		N/A	N/A	N/A	-56.75	46	219	2.00	16	26	6.17

Note(s):

1. For GSM, it is observed that FR V1 is the worst-case.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
WCDMA Band V	Ant.A	AMR-NB 4.75	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.82	366	676	2.00	26	26	4.53
		AMR-NB 7.4		N/A	N/A	N/A	-56.82	371	676	2.00	26	26	4.48
		AMR-NB 12.2		N/A	N/A	N/A	-56.82	370	675	2.00	26	26	4.59
		AMR-WB 6.6		N/A	N/A	N/A	-56.82	**315**	676	2.00	26	26	1.83
		AMR-WB 15.85		N/A	N/A	N/A	-56.82	322	676	2.00	26	26	2.12
		AMR-WB 23.85		N/A	N/A	N/A	-56.82	322	676	2.00	26	26	2.14

Note(s):

1. For WCDMA, it is observed that AMR-WB 6.6 kbit/s is the worst-case.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
VoLTE FDD Band 66	Ant.F	AMR-NB 4.75	132322 1745 MHz	20 MHz	QPSK	1/0	-56.73	306	617	1.80	26	26	6.27
		AMR-NB 7.4					-56.73	319	632	2.00	26	26	6.41
		AMR-NB 12.2					-56.73	301	613	2.00	26	26	6.54
		AMR-WB 6.6					-56.73	271	628	2.00	26	26	3.73
		AMR-WB 15.85					-56.73	281	633	2.00	26	26	3.93
		AMR-WB 23.85					-56.73	280	633	2.00	26	26	4.10
		EVS-nb 5.9					-56.73	255	628	1.81	26	26	2.67
		EVS-nb 13.2					-56.73	318	621	2.00	26	26	6.91
		EVS-nb 24.4					-56.73	325	629	2.00	26	26	6.64
		EVS-wb 5.9					-56.73	**232**	628	2.00	26	26	1.78
		EVS-wb 64					-56.73	271	621	2.00	26	26	4.20
		EVS-wb 128					-56.73	263	610	2.00	26	26	4.21
		EVS-swb 9.6					-56.73	321	627	2.00	26	26	6.68
		EVS-swb 64					-56.73	272	619	2.00	26	26	4.18
		EVS-swb 128					-56.73	271	620	2.00	26	26	4.16
VoLTE TDD Band 41	Ant.B	AMR-NB 4.75	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.65	102	338	2.00	22	26	6.99
		AMR-NB 7.4					-56.65	106	336	2.00	22	26	7.11
		AMR-NB 12.2					-56.65	103	335	1.33	22	26	7.33
		AMR-WB 6.6					-56.65	**82**	329	2.00	20	26	4.63
		AMR-WB 15.85					-56.65	93	334	2.00	21	26	5.79
		AMR-WB 23.85					-56.65	94	335	2.00	22	26	5.84
		EVS-nb 5.9					-56.65	90	348	2.00	21	26	2.46
		EVS-nb 13.2					-56.65	112	335	2.00	20	26	7.32
		EVS-nb 24.4					-56.65	111	334	2.00	20	26	7.47
		EVS-wb 5.9					-56.65	85	354	1.93	21	26	4.24
		EVS-wb 64					-56.65	109	353	2.00	21	26	5.54
		EVS-wb 128					-56.65	108	352	2.00	21	26	5.50
		EVS-swb 9.6					-56.65	114	338	2.00	22	26	7.58
		EVS-swb 64					-56.65	96	337	2.00	22	26	5.90
		EVS-swb 128					-56.65	97	336	2.00	22	26	6.02

Note(s):

1. For LTE-FDD, it is observed that EVS-wb 5.9 kbit/s is the worst-case.
2. For LTE-TDD, it is observed that AMR-WB 6.6 kbit/s is the worst-case.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
VoNR FDD Band n25	Ant.F	AMR-NB 4.75	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	152	442	2.00	23	26	4.31
		AMR-NB 7.4					-56.76	143	433	2.00	23	26	4.57
		AMR-NB 12.2					-56.76	157	443	2.00	23	26	4.61
		AMR-WB 6.6					-56.76	123	444	2.00	23	26	1.49
		AMR-WB 15.85					-56.76	130	444	2.00	23	26	2.23
		AMR-WB 23.85					-56.76	123	438	2.00	21	26	2.33
		EVS-nb 5.9					-56.76	113	440	2.00	23	26	1.56
		EVS-nb 13.2					-56.76	156	434	2.00	24	26	4.79
		EVS-nb 24.4					-56.76	157	439	2.00	23	26	4.84
		EVS-wb 5.9					-56.76	**105**	429	2.00	23	26	1.16
		EVS-wb 64					-56.76	123	434	2.00	23	26	2.30
		EVS-wb 128					-56.76	122	432	2.00	23	26	2.30
		EVS-swb 9.6					-56.76	146	441	2.00	23	26	3.67
		EVS-swb 64					-56.76	140	431	2.00	23	26	3.55
		EVS-swb 128					-56.76	141	434	1.88	23	26	3.58
VoNR TDD Band n41	Ant.F	AMR-NB 4.75	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.63	143	402	1.71	21	26	6.60
		AMR-NB 7.4					-56.63	148	402	2.00	21	26	6.54
		AMR-NB 12.2					-56.63	139	394	2.00	20	26	7.03
		AMR-WB 6.6					-56.67	**105**	383	1.93	21	26	4.01
		AMR-WB 15.85					-56.63	131	402	2.00	21	26	5.51
		AMR-WB 23.85					-56.63	130	402	2.00	21	26	5.44
		EVS-nb 5.9					-56.63	117	411	2.00	21	26	3.53
		EVS-nb 13.2					-56.63	143	386	2.00	20	26	7.21
		EVS-nb 24.4					-56.63	143	387	2.00	20	26	7.06
		EVS-wb 5.9					-56.63	107	393	2.00	20	26	3.83
		EVS-wb 64					-56.63	123	386	2.00	20	26	5.71
		EVS-wb 128					-56.63	123	386	2.00	20	26	5.72
		EVS-swb 9.6					-56.63	124	386	2.00	20	26	5.98
		EVS-swb 64					-56.63	125	387	1.62	20	26	5.98
		EVS-swb 128					-56.63	125	387	1.67	20	26	5.91

Note(s):

1. For NR-FDD, it is observed that EVS-wb 5.9 kbit/s is the worst-case.
2. For NR-TDD, it is observed that AMR-WB 6.6 kbit/s is the worst-case.

9.3. GSM/WCDMA/VoLTE/VoNR Air Interface Investigation

Using the worst-case bitrate found in Sec.9.2, a limited set of bands/channels/bandwidths were then tested to confirm that there is no effect to compliance when changing the band/channel/bandwidth.

GSM / W-CDMA (UMTS) Air interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
GSM 850	Ant.E	FR V1	CH.128 824.2 MHz	N/A	N/A	N/A	-56.75	45	210	2.00	16	26	6.16
			CH.190 836.6 MHz	N/A	N/A	N/A	-56.75	39	192	2.00	16	26	5.96
			CH.251 848.8 MHz	N/A	N/A	N/A	-56.75	**34**	172	2.00	15	26	6.08
GSM 1900	Ant.A	FR V1	CH.810 1909.8 MHz	N/A	N/A	N/A	-56.75	75	297	2.00	19	26	6.15
WCDMA Band II	Ant.A	AMR-WB 6.6	CH.9262 1852.4 MHz	N/A	N/A	N/A	-56.82	302	662	2.00	26	26	1.57
WCDMA Band IV	Ant.A	AMR-WB 6.6	CH.1312 1712.4 MHz	N/A	N/A	N/A	-56.82	315	676	2.00	26	26	1.85
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4132 826.4 MHz	N/A	N/A	N/A	-56.82	**312**	676	2.00	26	26	1.65
			CH.4183 836.6 MHz	N/A	N/A	N/A	-56.82	315	676	2.00	26	26	1.83
			CH.4233 846.6 MHz	N/A	N/A	N/A	-56.82	315	676	2.00	26	26	1.66

VoLTE (FDD/TDD) Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
LTE Band 66	Ant.F	EVS-wb 5.9	132322 1745 MHz	20 MHz	QPSK	1/0	-56.73	232	628	2.00	26	26	1.78
						1/49	-56.73	253	636	2.00	26	26	2.58
						1/99	-56.73	242	631	1.87	26	26	3.67
						50/0	-56.73	269	653	1.78	26	26	2.88
						50/24	-56.73	269	645	2.00	26	26	3.02
						50/50	-56.73	281	655	1.94	26	26	3.34
						100/0	-56.73	272	646	1.52	26	26	2.85
					16QAM	1/0	-56.73	181	535	2.00	26	26	2.84
					64QAM	1/0	-56.73	**177**	537	2.00	25	26	4.80
					256QAM	1/0	-56.73	204	575	1.82	26	26	3.91
				15 MHz	64QAM	1/0	-56.75	196	574	1.87	26	26	2.47
				10 MHz	64QAM	1/0	-56.75	205	587	1.99	26	26	2.08
				64QAM	64QAM	1/0	-56.75	214	593	1.95	26	26	2.27
				3 MHz	64QAM	1/0	-56.75	198	585	2.00	26	26	1.82
				1.4 MHz	64QAM	1/0	-56.75	210	595	2.00	26	26	2.37
			132072 1720 MHz	20 MHz	64QAM	1/0	-56.75	204	573	2.00	26	26	0.90
			132572 1770 MHz	20 MHz	64QAM	1/0	-56.75	201	574	1.73	26	26	3.03
LTE Band 7	Ant.F	EVS-wb 5.9	21100 2535 MHz	20 MHz	64QAM	1/0	-56.75	196	566	2.00	26	26	2.43
LTE Band 12	Ant.E	EVS-wb 5.9	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.75	252	624	1.93	26	26	2.04
LTE Band 13	Ant.E	EVS-wb 5.9	23230 782 MHz	10 MHz	64QAM	1/0	-56.75	246	621	2.00	26	26	2.09
LTE Band 14	Ant.E	EVS-wb 5.9	23330 793 MHz	10 MHz	64QAM	1/0	-56.75	207	579	2.00	25	26	1.23
LTE Band 25	Ant.F	EVS-wb 5.9	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.75	241	621	2.00	26	26	1.75
LTE Band 26	Ant.E	EVS-wb 5.9	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.75	240	676	2.00	26	26	1.31
LTE Band 30	Ant.F	EVS-wb 5.9	27710 2310 MHz	10 MHz	64QAM	1/0	-56.75	229	599	2.00	26	26	1.95
LTE Band 71	Ant.E	EVS-wb 5.9	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.75	246	632	1.99	26	26	1.45
LTE Band 41 PC2	Ant.B	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.65	**82**	329	2.00	20	26	4.63
						1/49	-56.65	93	342	2.00	22	26	4.97
						1/99	-56.65	97	351	2.00	22	26	5.00
						50/0	-56.65	86	340	2.00	21	26	4.74
						50/24	-56.65	89	343	2.00	22	26	4.66
						50/50	-56.65	90	345	1.86	22	26	4.74
						100/0	-56.65	94	343	2.00	22	26	4.94
					16QAM	1/0	-56.65	87	342	1.82	21	26	4.73
					64QAM	1/0	-56.65	97	352	1.61	22	26	4.71
					256QAM	1/0	-56.65	121	388	2.00	22	26	4.62
				15 MHz	16QAM	1/0	-56.65	92	345	1.63	22	26	4.64
				10 MHz	QPSK	1/0	-56.65	87	341	1.97	21	26	4.66
				5 MHz	QPSK	1/0	-56.65	86	337	2.00	22	26	4.68
			CH.39750 2506 MHz	20 MHz	QPSK	1/0	-56.65	101	355	1.76	23	26	4.70
			CH.41490 2680 MHz	20 MHz	QPSK	1/0	-56.65	102	357	2.00	23	26	4.65
LTE Band 41 PC3	Ant.B	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.67	113	380	2.00	23	26	5.23
LTE Band 48	Ant.F	AMR-WB 6.6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.67	118	397	2.00	22	26	4.36

VoNR (FDD) Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
NR Band n25	Ant.F	EVS-wb 5.9	CH.376500 1882.5 MHz	40 MHz	CP-OFDM QPSK	1/1	-56.86	133	471	2.00	23	26	0.67
						1/107	-56.86	122	459	2.00	23	26	1.37
						1/214	-56.86	149	494	1.92	24	26	1.56
						108/0	-56.86	175	519	1.95	25	26	1.42
						108/54	-56.86	147	501	1.67	24	26	0.84
						108/108	-56.86	156	514	2.00	25	26	1.66
						216/0	-56.86	172	520	2.00	25	26	0.44
					CP-OFDM 16QAM	1/107	-56.86	156	504	2.00	24	26	0.56
					CP-OFDM 64QAM	1/107	-56.86	144	497	2.00	24	26	0.37
					CP-OFDM 256QAM	1/107	-56.86	177	535	2.00	25	26	1.34
					DFT-s-OFDM QPSK	1/1	-56.76	**105**	429	2.00	23	26	1.16
						1/107	-56.86	107	434	2.00	23	26	1.30
						1/214	-56.86	136	477	1.72	23	26	1.60
						108/0	-56.86	152	503	1.82	24	26	0.24
						108/54	-56.86	137	479	2.00	24	26	1.35
						108/108	-56.86	146	495	1.84	24	26	1.24
						216/0	-56.86	144	494	2.00	24	26	0.49
					DFT-s-OFDM pi/2 BPSK	1/1	-56.86	115	443	2.00	21	26	1.14
					DFT-s-OFDM 16QAM	1/1	-56.86	141	487	1.79	23	26	0.25
					DFT-s-OFDM 64QAM	1/1	-56.86	157	503	2.00	24	26	1.08
					DFT-s-OFDM 256QAM	1/1	-56.86	170	543	2.00	25	26	2.23
				35 MHz	DFT-s-OFDM QPSK	1/1	-56.86	142	485	2.00	24	26	0.89
				30 MHz	DFT-s-OFDM QPSK	1/1	-56.86	133	473	1.99	23	26	2.19
				25 MHz	DFT-s-OFDM QPSK	1/1	-56.86	140	494	2.00	24	26	1.05
				20 MHz	DFT-s-OFDM QPSK	1/1	-56.86	121	478	1.80	24	26	1.52
				15 MHz	DFT-s-OFDM QPSK	1/1	-56.86	142	482	1.91	24	26	0.39
				10 MHz	DFT-s-OFDM QPSK	1/1	-56.86	142	483	1.85	24	26	1.34
			CH.374000 1870 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	118	444	2.00	23	26	2.24
			CH.379000 1895 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	131	458	2.00	23	26	1.36
NR Band n7	Ant.F	EVS-wb 5.9	CH.507000 2535 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.82	101	432	1.72	23	26	1.40
NR Band n12	Ant.A	EVS-wb 5.9	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	148	474	2.00	21	26	1.81
NR Band n26	Ant.A	EVS-wb 5.9	CH.166300 831.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.82	165	497	2.00	23	26	1.72
NR Band n30	Ant.F	EVS-wb 5.9	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.82	89	398	2.00	24	26	0.98
NR Band n66	Ant.F	EVS-wb 5.9	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.82	93	414	2.00	22	26	1.78
NR Band n70	Ant.F	EVS-wb 5.9	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	**82**	417	1.63	22	26	1.58
NR Band n71	Ant.A	EVS-wb 5.9	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.82	125	450	1.62	23	26	1.54

VoNR (TDD) Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
NR Band n41	Ant.F	AMR-WB 6.6	CH.518598 2592.99 MHz	100 MHz	CP-OFDM QPSK	1/1	-56.78	116	408	2.00	21	26	5.13
						1/136	-56.78	145	439	2.00	22	26	5.15
						1/271	-56.78	118	417	2.00	21	26	4.77
						135/0	-56.78	124	403	1.68	21	26	5.18
						135/69	-56.78	139	415	2.00	21	26	5.48
						135/138	-56.78	111	370	1.53	20	26	2.00
						270/0	-56.78	110	383	2.00	20	26	5.04
					CP-OFDM 16QAM	1/1	-56.78	119	410	2.00	21	26	5.27
					CP-OFDM 64QAM	1/1	-56.78	117	379	2.00	20	26	4.80
					CP-OFDM 256QAM	1/1	-56.78	125	417	1.93	22	26	4.80
					DFT-s-OFDM QPSK	1/1	-56.67	**105**	383	1.93	21	26	4.01
						1/136	-56.78	163	434	2.00	23	26	4.54
						1/271	-56.78	141	404	2.00	21	26	4.69
						135/0	-56.78	136	400	2.00	21	26	4.63
						135/69	-56.78	140	406	2.00	21	26	4.78
						135/138	-56.78	109	369	2.00	20	26	4.79
						270/0	-56.78	110	369	2.00	20	26	4.77
					DFT-s-OFDM pi/2 BPSK	1/1	-56.78	129	392	1.92	20	26	5.08
					DFT-s-OFDM 16QAM	1/1	-56.78	121	385	2.00	21	26	4.59
					DFT-s-OFDM 64QAM	1/1	-56.78	115	376	2.00	21	26	4.55
					DFT-s-OFDM 256QAM	1/1	-56.78	123	381	2.00	20	26	5.29
				90 MHz	DFT-s-OFDM QPSK	1/1	-56.78	124	409	2.00	22	26	4.94
				80 MHz	DFT-s-OFDM QPSK	1/1	-56.78	118	399	2.00	21	26	4.70
				70 MHz	DFT-s-OFDM QPSK	1/1	-56.78	131	405	2.00	21	26	5.09
				60 MHz	DFT-s-OFDM QPSK	1/1	-56.78	123	413	1.73	21	26	5.21
				50 MHz	DFT-s-OFDM QPSK	1/1	-56.78	121	411	2.00	21	26	5.44
				40 MHz	DFT-s-OFDM QPSK	1/1	-56.78	125	421	1.78	22	26	4.94
				30 MHz	DFT-s-OFDM QPSK	1/1	-56.78	125	423	2.00	22	26	5.07
				25 MHz	DFT-s-OFDM QPSK	1/1	-56.78	142	445	2.00	23	26	4.94
				20 MHz	DFT-s-OFDM QPSK	1/1	-56.78	156	459	2.00	24	26	5.07
				15 MHz	DFT-s-OFDM QPSK	1/1	-56.78	148	461	2.00	24	26	4.76
				10 MHz	DFT-s-OFDM QPSK	1/1	-56.78	130	436	2.00	22	26	4.83
			CH.509202 2546.01 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.78	115	399	2.00	21	26	4.92
			CH.528000 2640 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.78	133	415	1.68	21	26	4.62
NR Band n48	Ant.F	AMR-WB 6.6	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.67	131	405	2.00	22	26	4.01
NR Band n77	Ant.F	AMR-WB 6.6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.67	172	460	2.00	23	26	4.04

9.4. VoWi-Fi Codec Investigation

An investigation between the various codec configurations (Low/High bit rates for Narrowband and Wideband) and specific parameters are documented (Primary Group, Secondary Group, frequency response) to determine the worst-case bit rates for each voice service type. The table below compares the varying codec configurations. A codec investigation was performed for each Wi-Fi 2.4GHz and 5GHz. The highlighted results below were determined to be the worst-case codec configuration(s) for Wi-Fi 2.4GHz and 5GHz

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
VoWi-Fi 2.4 GHz 802.11b	MIMO	AMR-NB 4.75	CH.6 2437 MHz	20 MHz	1Mbps	N/A	-56.67	135	389	2.00	23	26	6.77
		AMR-NB 7.4					-56.67	144	399	2.00	24	26	6.89
		AMR-NB 12.2					-56.67	141	389	2.00	23	26	7.13
		AMR-WB 6.6					-56.67	**121**	390	2.00	23	26	5.19
		AMR-WB 15.85					-56.67	132	396	2.00	23	26	5.52
		AMR-WB 23.85					-56.67	130	391	2.00	23	26	5.59
		EVS-nb 5.9					-56.67	208	569	2.00	26	26	2.94
		EVS-nb 13.2					-56.67	284	548	2.00	26	26	7.35
		EVS-nb 24.4					-56.67	285	546	2.00	26	26	7.31
		EVS-wb 5.9					-56.67	198	543	2.00	26	26	2.10
		EVS-wb 64					-56.67	249	542	2.00	26	26	5.74
		EVS-wb 128					-56.67	253	546	2.00	26	26	5.76
		EVS-swb 9.6					-56.67	253	540	2.00	26	26	6.04
		EVS-swb 64					-56.67	252	542	1.75	26	26	6.00
		EVS-swb 128					-56.67	252	541	1.74	26	26	5.93
VoWi-Fi 5 GHz 802.11a	SISO Ant.2	AMR-NB 4.75	CH.40 5200 MHz	20 MHz	6Mbps	N/A	-56.68	268	563	2.00	26	26	6.09
		AMR-NB 7.4					-56.68	265	553	2.00	26	26	6.16
		AMR-NB 12.2					-56.68	277	566	2.00	26	26	6.34
		AMR-WB 6.6					-56.68	**231**	556	2.00	26	26	4.34
		AMR-WB 15.85					-56.68	242	562	2.00	26	26	4.76
		AMR-WB 23.85					-56.68	247	562	2.00	26	26	4.77
		EVS-nb 5.9					-56.72	262	618	2.00	26	26	3.28
		EVS-nb 13.2					-56.72	366	642	2.00	26	26	6.56
		EVS-nb 24.4					-56.72	333	611	2.00	26	26	6.55
		EVS-wb 5.9					-56.72	247	620	2.00	26	26	1.57
		EVS-wb 64					-56.72	294	601	2.00	26	26	5.12
		EVS-wb 128					-56.72	289	595	2.00	26	26	5.09
		EVS-swb 9.6					-56.72	285	587	2.00	26	26	5.21
		EVS-swb 64					-56.72	283	586	1.88	26	26	5.20
		EVS-swb 128					-56.72	314	617	1.79	26	26	5.34

Note(s):

1. For Wi-Fi 2.4GHz, it is observed that AMR-WB 6.6 kbit/s is the worst-case.
2. For Wi-Fi 5GHz, it is observed that AMR-WB 6.6 kbit/s is the worst-case.

9.5. VoWi-Fi Air Interface Investigation

Using the data from Sec.9.4, further testing was performed on the remaining 802.11 modes. The objective of these measurements is to ensure that changing the modulation, bandwidth, and data rate, whilst using the worst-case codec configuration measured in Sec.9.4, yields no unexpected variations.

VoWi-Fi 2.4GHz Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
WiFi 2.4GHz 802.11b	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.67	**121**	390	2.00	23	26	5.19
					CCK 5.5 Mbps	N/A	-56.68	123	393	2.00	23	26	5.01
					CCK 11 Mbps	N/A	-56.68	130	407	2.00	26	26	4.93
WiFi 2.4GHz 802.11g	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	226	534	2.00	26	26	5.15
WiFi 2.4GHz 802.11n HT20	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.68	203	506	1.68	26	26	5.20
WiFi 2.4GHz 802.11ac VHT20	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.70	302	594	1.98	26	26	5.04
WiFi 2.4GHz 802.11ax HE20	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	MCS 6 77 Mbps	N/A	-56.68	255	562	2.00	26	26	5.23
WiFi 2.4GHz 802.11b	MIMO	AMR-WB 6.6	CH.1 2412 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.68	129	403	1.90	26	26	5.31
	MIMO	AMR-WB 6.6	CH.11 2462 MHz			N/A	-56.68	131	404	2.00	26	26	5.13

VoWi-Fi 5GHz Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	**231**	556	2.00	26	26	4.34
					QPSK 18 Mbps	N/A	-56.67	269	575	2.00	26	26	5.27
					64QAM 54 Mbps	N/A	-56.67	298	608	2.00	26	26	5.28
WiFi 5GHz 802.11n HT20 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.67	236	543	2.00	26	26	5.13
					MCS 3 26 Mbps	N/A	-56.67	255	564	2.00	26	26	4.96
					MCS 7 65 Mbps	N/A	-56.67	272	580	2.00	26	26	5.28
WiFi 5GHz 802.11n HT40 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.38 5190 MHz	40 MHz	MCS 0 13.5 Mbps	N/A	-56.67	256	564	2.00	26	26	4.95
					MCS 3 54 Mbps	N/A	-56.67	257	562	2.00	26	26	5.11
					MCS 7 135 Mbps	N/A	-56.67	288	598	2.00	26	26	5.25
WiFi 5GHz 802.11ac VHT20 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.67	249	556	2.00	26	26	4.69
					MCS 4 39 Mbps	N/A	-56.67	276	582	2.00	26	26	5.23
					MCS 8 78 Mbps	N/A	-56.67	278	591	2.00	26	26	5.20
WiFi 5GHz 802.11ac VHT40 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.38 5190 MHz	40 MHz	MCS 0 13.5 Mbps	N/A	-56.67	256	569	1.93	26	26	5.17
					MCS 4 108 Mbps	N/A	-56.67	274	584	2.00	26	26	5.21
					MCS 9 180 Mbps	N/A	-56.67	284	594	2.00	26	26	4.90
WiFi 5GHz 802.11ac VHT80 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.42 5210 MHz	80 MHz	MCS 0 29.3 Mbps	N/A	-56.67	261	568	2.00	26	26	4.99
					MCS 4 175.5 Mbps	N/A	-56.67	280	585	1.99	26	26	4.93
					MCS 9 390 Mbps	N/A	-56.67	285	596	2.00	26	26	5.02
WiFi 5GHz 802.11ac VHT160 U-NII-1&2A	SISO Ant.2	AMR-WB 6.6	CH.50 5250 MHz	160 MHz	MCS 0 58.5 Mbps	N/A	-56.67	321	628	1.94	26	26	5.01
					MCS 4 351 Mbps	N/A	-56.67	264	573	2.00	26	26	5.07
					MCS 9 780 Mbps	N/A	-56.67	285	590	1.88	26	26	4.97
WiFi 5GHz 802.11ax HE20 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	MCS 0 8.6 Mbps	N/A	-56.67	277	588	2.00	26	26	5.22
					MCS 6 77 Mbps	N/A	-56.67	271	581	1.75	26	26	4.88
					MCS 11 143 Mbps	N/A	-56.67	274	583	1.75	26	26	5.08
WiFi 5GHz 802.11ax HE40 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.38 5190 MHz	40 MHz	MCS 0 17.2 Mbps	N/A	-56.67	247	554	2.00	26	26	5.23
					MCS 6 155 Mbps	N/A	-56.67	271	579	1.93	26	26	5.08
					MCS 11 287 Mbps	N/A	-56.67	279	588	1.90	26	26	5.17
WiFi 5GHz 802.11ax HE80 U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.42 5210 MHz	80 MHz	MCS 0 36 Mbps	N/A	-56.67	250	558	2.00	26	26	5.12
					MCS 6 324 Mbps	N/A	-56.67	272	582	2.00	26	26	5.26
					MCS 11 600 Mbps	N/A	-56.67	277	589	2.00	26	26	5.13
WiFi 5GHz 802.11ax HE160 U-NII-1&2A	SISO Ant.2	AMR-WB 6.6	CH.50 5250 MHz	160 MHz	MCS 0 72.1 Mbps	N/A	-56.67	242	552	1.63	26	26	4.89
					MCS 6 648.5 Mbps	N/A	-56.67	266	575	1.70	26	26	4.99
					MCS 11 1201 Mbps	N/A	-56.67	277	588	2.00	26	26	5.06
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.36 5180 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	275	584	2.00	26	26	5.24
	SISO Ant.2	AMR-WB 6.6	CH.48 5240 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	279	589	2.00	26	26	5.01
WiFi 5GHz 802.11a U-NII-2A	SISO Ant.2	AMR-WB 6.6	CH.56 5280 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	332	640	1.84	26	26	5.35
WiFi 5GHz 802.11a U-NII-2C	SISO Ant.2	AMR-WB 6.6	CH.120 5600 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	276	583	2.00	26	26	5.20
WiFi 5GHz 802.11a U-NII-3	SISO Ant.2	AMR-WB 6.6	CH.157 5785 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	276	586	2.00	26	26	4.96
WiFi 5GHz 802.11a U-NII-4	SISO Ant.2	AMR-WB 6.6	CH.173 5865 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	323	634	2.00	26	26	5.12

9.6. OTT Codec Investigation

The DUT's nested OTT application supports range of codec bit rate 6 – 75 kbit/s, thus an investigation between the various codec configurations (6/40/75 as Low/Mid/High bit rates) and specific parameters are documented (Primary Group, Secondary Group, frequency response) to determine the worst-case bit rates for each service type. The table below compares the varying codec configurations.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
GSM850 EGPRS 2 Slots	Ant.E	OPUS 6	CH.251 848.8 MHz	N/A	N/A	N/A	-56.69	62	306	1.81	18	26	2.30
		OPUS 40		N/A	N/A	N/A	-56.59	48	276	1.87	17	26	2.73
		OPUS 75		N/A	N/A	N/A	-56.59	**46**	349	1.01	17	26	-0.08
WCDMA Band II HSUPA Subtest1	Ant.A	OPUS 6	CH.9262 1852.4 MHz	N/A	N/A	N/A	-56.59	298	672	1.24	26	26	0.86
		OPUS 40		N/A	N/A	N/A	-56.59	294	667	2.00	26	26	1.25
		OPUS 75		N/A	N/A	N/A	-56.59	**292**	659	2.00	26	26	2.26
LTE Band 66	Ant.F	OPUS 6	CH.132322 1745 MHz	20 MHz	64QAM	1/0	-56.59	226	533	1.16	24	26	3.24
		OPUS 40					-56.59	**225**	530	1.81	24	26	4.09
		OPUS 75					-56.59	226	534	1.73	24	26	4.00
LTE Band 41 PC2	Ant.B	OPUS 6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.59	102	370	1.40	22	26	1.46
		OPUS 40					-56.59	88	359	2.00	21	26	3.81
		OPUS 75					-56.59	**87**	352	1.91	21	26	3.79
NR Band n70	Ant.F	OPUS 6	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	247	563	1.88	24	26	3.31
		OPUS 40					-56.69	258	565	2.00	24	26	4.31
		OPUS 75					-56.69	**229**	582	2.00	24	26	2.53
NR Band n41	Ant.F	OPUS 6	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	100	400	1.55	21	26	3.96
		OPUS 40					-56.69	100	375	2.00	20	26	4.19
		OPUS 75					-56.69	**98**	375	2.00	20	26	4.07
Wi-Fi 2.4 GHz 802.11b	MIMO	OPUS 6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.69	94	371	2.00	22	26	1.51
		OPUS 40					-56.69	**89**	368	2.00	21	26	1.36
		OPUS 75					-56.69	111	369	2.00	21	26	4.62
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	OPUS 6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	**253**	581	1.04	26	26	4.38
		OPUS 40					-56.69	257	571	2.00	26	26	4.72
		OPUS 75					-56.69	263	573	2.00	26	26	4.47

Note(s):

A bitrate investigation was performed on the pre-install phone application to determine the worst-case bitrate;

1. For Wi-Fi 5GHz, it is observed that 6 kbit/s is the worst-case.
2. For LTE FDD and Wi-Fi 2.4GHz, it is observed that 40 kbit/s is the worst-case.
3. For GSM, WCDMA, LTE TDD and NR FDD/TDD, it is observed that 75 kbit/s is the worst-case.

9.7. OTT Air Interface Investigation

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)
GSM850 EGPRS 2slots	Ant.E	OPUS 75	CH.190 836.6 MHz	N/A	N/A	N/A	-56.59	46	349	1.01	17	26	-0.08
GSM1900 EGPRS 2slots	Ant.A	OPUS 75	CH.810 1909.8 MHz	N/A	N/A	N/A	-56.59	67	397	1.51	18	26	-0.29
WCDMA Band II HSUPA Subtest1	Ant.A	OPUS 75	CH.9400 1880.0 MHz	N/A	N/A	N/A	-56.59	292	659	2.00	26	26	2.26
WCDMA Band IV HSUPA Subtest1	Ant.A	OPUS 75	CH.1312 1712.4 MHz	N/A	N/A	N/A	-56.59	283	649	2.00	26	26	1.02
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 75	CH.4132 826.4 MHz	N/A	N/A	N/A	-56.59	287	657	2.00	26	26	1.36
LTE Band 7	Ant.F	OPUS 40	21100 2535 MHz	20 MHz	64QAM	1/0	-56.69	255	561	1.84	26	26	4.23
LTE Band 12	Ant.E	OPUS 40	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.59	211	522	1.86	26	26	4.35
LTE Band 13	Ant.E	OPUS 40	23230 782 MHz	10 MHz	64QAM	1/0	-56.59	232	533	2.00	23	26	4.22
LTE Band 14	Ant.E	OPUS 40	23330 793 MHz	10 MHz	64QAM	1/0	-56.59	295	607	1.84	26	26	4.20
LTE Band 25	Ant.F	OPUS 40	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.59	287	600	1.93	26	26	3.79
LTE Band 26	Ant.E	OPUS 40	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.59	276	587	1.83	26	26	4.28
LTE Band 30	Ant.F	OPUS 40	27710 2310 MHz	10 MHz	64QAM	1/0	-56.69	277	592	1.90	26	26	4.24
LTE Band 66	Ant.F	OPUS 40	132322 1745 MHz	20 MHz	64QAM	1/0	-56.59	225	530	1.81	24	26	4.09
LTE Band 71	Ant.E	OPUS 40	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.69	298	609	2.00	26	26	4.43
LTE Band 41 PC2	Ant.B	OPUS 75	CH.26365 1882.5 MHz	20 MHz	QPSK	1/0	-56.59	87	352	1.91	21	26	3.79
LTE Band 48	Ant.F	OPUS 75	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.59	100	384	1.94	21	26	3.72
NR Band n7	Ant.F	OPUS 75	CH.507000 2535 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	94	420	2.00	21	26	2.71
NR Band n12	Ant.A	OPUS 75	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	226	581	2.00	26	26	2.52
NR Band n25	Ant.F	OPUS 75	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	115	439	2.00	20	26	1.29
NR Band n26	Ant.A	OPUS 75	CH.166300 831.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	230	589	2.00	26	26	2.54
NR Band n30	Ant.F	OPUS 75	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.69	128	444	2.00	23	26	1.45
NR Band n66	Ant.F	OPUS 75	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	99	429	2.00	21	26	2.97
NR Band n70	Ant.F	OPUS 75	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	229	582	2.00	24	26	2.53
NR Band n71	Ant.A	OPUS 75	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	207	558	2.00	24	26	2.33
NR Band n41	Ant.F	OPUS 75	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	98	375	2.00	20	26	4.07
NR Band n48	Ant.F	OPUS 75	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	122	416	2.00	20	26	3.70
NR Band n77	Ant.F	OPUS 75	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	165	459	2.00	22	26	4.25
WiFi 2.4GHz 802.11b	MIMO	OPUS 40	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.69	89	368	2.00	21	26	1.36
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	OPUS 6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	253	581	1.04	26	26	4.38
WiFi 5GHz 802.11a U-NII-2A	SISO Ant.2	OPUS 6	CH.56 5280 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	262	582	1.69	26	26	4.44
WiFi 5GHz 802.11a U-NII-2C	SISO Ant.2	OPUS 6	CH.120 5600 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	226	596	1.75	26	26	2.18
WiFi 5GHz 802.11a U-NII-3	SISO Ant.2	OPUS 6	CH.157 5785 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	225	589	2.00	26	26	3.44
WiFi 5GHz 802.11a U-NII-4	SISO Ant.2	OPUS 6	CH.173 5865 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	229	580	2.00	26	26	1.58

9.8. HAC (T-coil) Test Results

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Plot No.
GSM 850	Ant.E	FR V1	CH.251 848.8 MHz	N/A	N/A	N/A	-56.75	**34**	172	2.00	15	26	6.08	1,2
GSM 1900	Ant.A	FR V1	CH.810 1909.8 MHz	N/A	N/A	N/A	-56.75	75	297	2.00	19	26	6.15	3,4
WCDMA Band II	Ant.A	AMR-WB 6.6	CH.9262 1852.4 MHz	N/A	N/A	N/A	-56.82	302	662	2.00	26	26	1.57	5,6
WCDMA Band IV	Ant.A	AMR-WB 6.6	CH.1312 1712.4 MHz	N/A	N/A	N/A	-56.82	315	676	2.00	26	26	1.85	7,8
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4132 826.4 MHz	N/A	N/A	N/A	-56.82	312	676	2.00	26	26	1.65	9,10
LTE Band 7	Ant.F	EVS-wb 5.9	21100 2535 MHz	20 MHz	64QAM	1/0	-56.75	196	566	2.00	26	26	2.43	11,12
LTE Band 12	Ant.E	EVS-wb 5.9	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.75	252	624	1.93	26	26	2.04	13,14
LTE Band 13	Ant.E	EVS-wb 5.9	23230 782 MHz	10 MHz	64QAM	1/0	-56.75	246	621	2.00	26	26	2.09	15,16
LTE Band 14	Ant.E	EVS-wb 5.9	23330 793 MHz	10 MHz	64QAM	1/0	-56.75	207	579	2.00	25	26	1.23	17,18
LTE Band 25	Ant.F	EVS-wb 5.9	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.75	241	621	2.00	26	26	1.75	19,20
LTE Band 26	Ant.E	EVS-wb 5.9	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.75	240	676	2.00	26	26	1.31	21,22
LTE Band 30	Ant.F	EVS-wb 5.9	27710 2310 MHz	10 MHz	64QAM	1/0	-56.75	229	599	2.00	26	26	1.95	23,24
LTE Band 66	Ant.F	EVS-wb 5.9	132322 1745 MHz	20 MHz	64QAM	1/0	-56.73	177	537	2.00	25	26	4.80	25,26
LTE Band 71	Ant.E	EVS-wb 5.9	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.75	246	632	1.99	26	26	1.45	27,28
LTE Band 41 PC2	Ant.B	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.65	82	329	2.00	20	26	4.63	29,30
LTE Band 41 PC3	Ant.B	AMR-WB 6.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.67	113	380	2.00	23	26	5.23	31,32
LTE Band 48	Ant.F	AMR-WB 6.6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.67	118	397	2.00	22	26	4.36	33,34
NR Band n25	Ant.F	EVS-wb 5.9	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.76	105	429	2.00	23	26	1.16	35,36
NR Band n7	Ant.F	EVS-wb 5.9	CH.507000 2535 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.82	101	432	1.72	23	26	1.40	37,38
NR Band n12	Ant.A	EVS-wb 5.9	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	148	474	2.00	21	26	1.81	39,40
NR Band n26	Ant.A	EVS-wb 5.9	CH.166300 831.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.82	165	497	2.00	23	26	1.72	41,42
NR Band n30	Ant.F	EVS-wb 5.9	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.82	89	398	2.00	24	26	0.98	43,44
NR Band n66	Ant.F	EVS-wb 5.9	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.82	93	414	2.00	22	26	1.78	45,46
NR Band n70	Ant.F	EVS-wb 5.9	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.82	82	417	1.63	22	26	1.58	47,48
NR Band n71	Ant.A	EVS-wb 5.9	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.82	125	450	1.62	23	26	1.54	49,50
NR Band n41	Ant.F	AMR-WB 6.6	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.67	105	383	1.93	21	26	4.01	51,52
NR Band n48	Ant.F	AMR-WB 6.6	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.67	131	405	2.00	22	26	4.01	53,54
NR Band n77	Ant.F	AMR-WB 6.6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.67	172	460	2.00	23	26	4.04	55,56
WiFi 2.4GHz 802.11b	MIMO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.67	121	390	2.00	23	26	5.19	57,58
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	AMR-WB 6.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.68	231	556	2.00	26	26	4.34	59,60
WiFi 5GHz 802.11a U-NII-2A	SISO Ant.2	AMR-WB 6.6	CH.56 5280 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	332	640	1.84	26	26	5.35	61,62
WiFi 5GHz 802.11a U-NII-2C	SISO Ant.2	AMR-WB 6.6	CH.120 5600 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	276	583	2.00	26	26	5.20	63,64
WiFi 5GHz 802.11a U-NII-3	SISO Ant.2	AMR-WB 6.6	CH.157 5785 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	276	586	2.00	26	26	4.96	65,66
WiFi 5GHz 802.11a U-NII-4	SISO Ant.2	AMR-WB 6.6	CH.173 5865 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.67	323	634	2.00	26	26	5.12	67,68

Note:

The radial longitudinal (x axis), axial (z axis) measurements are no longer required per ANSI C63.19-2019.

HAC (T-coil) Test Results (Continued)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration (Allocation/ Offset)	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Plot No.
GSM850 EGPRS 2slots	Ant.E	OPUS 75	CH.190 836.6 MHz	N/A	N/A	N/A	-56.59	**46**	349	1.01	17	26	-0.08	69,70
GSM1900 EGPRS 2slots	Ant.A	OPUS 75	CH.810 1909.8 MHz	N/A	N/A	N/A	-56.59	67	397	1.51	18	26	-0.29	71,72
WCDMA Band II HSUPA Subtest1	Ant.A	OPUS 75	CH.9400 1880.0 MHz	N/A	N/A	N/A	-56.59	292	659	2.00	26	26	2.26	73,74
WCDMA Band IV HSUPA Subtest1	Ant.A	OPUS 75	CH.1312 1712.4 MHz	N/A	N/A	N/A	-56.59	283	649	2.00	26	26	1.02	75,76
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 75	CH.4132 826.4 MHz	N/A	N/A	N/A	-56.59	287	657	2.00	26	26	1.36	77,78
LTE Band 7	Ant.F	OPUS 40	21100 2535 MHz	20 MHz	64QAM	1/0	-56.69	255	561	1.84	26	26	4.23	79,80
LTE Band 12	Ant.E	OPUS 40	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.59	211	522	1.86	26	26	4.35	81,82
LTE Band 13	Ant.E	OPUS 40	23230 782 MHz	10 MHz	64QAM	1/0	-56.59	232	533	2.00	23	26	4.22	83,84
LTE Band 14	Ant.E	OPUS 40	23330 793 MHz	10 MHz	64QAM	1/0	-56.59	295	607	1.84	26	26	4.20	85,86
LTE Band 25	Ant.F	OPUS 40	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.59	287	600	1.93	26	26	3.79	87,88
LTE Band 26	Ant.E	OPUS 40	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.59	276	587	1.83	26	26	4.28	89,90
LTE Band 30	Ant.F	OPUS 40	27710 2310 MHz	10 MHz	64QAM	1/0	-56.69	277	592	1.90	26	26	4.24	91,92
LTE Band 66	Ant.F	OPUS 40	132322 1745 MHz	20 MHz	64QAM	1/0	-56.59	225	530	1.81	24	26	4.09	93,94
LTE Band 71	Ant.E	OPUS 40	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.69	298	609	2.00	26	26	4.43	95,96
LTE Band 41 PC2	Ant.B	OPUS 75	CH.26365 1882.5 MHz	20 MHz	QPSK	1/0	-56.59	87	352	1.91	21	26	3.79	97,98
LTE Band 48	Ant.F	OPUS 75	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.59	100	384	1.94	21	26	3.72	99,100
NR Band n7	Ant.F	OPUS 75	CH.507000 2535 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	94	420	2.00	21	26	2.71	101,102
NR Band n12	Ant.A	OPUS 75	CH.141500 707.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	226	581	2.00	26	26	2.52	103,104
NR Band n25	Ant.F	OPUS 75	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	115	439	2.00	20	26	1.29	105,106
NR Band n26	Ant.A	OPUS 75	CH.166300 831.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	230	589	2.00	26	26	2.54	107,108
NR Band n30	Ant.F	OPUS 75	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.69	128	444	2.00	23	26	1.45	109,110
NR Band n66	Ant.F	OPUS 75	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	99	429	2.00	21	26	2.97	111,112
NR Band n70	Ant.F	OPUS 75	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	229	582	2.00	24	26	2.53	113,114
NR Band n71	Ant.A	OPUS 75	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	207	558	2.00	24	26	2.33	115,116
NR Band n41	Ant.F	OPUS 75	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	98	375	2.00	20	26	4.07	117,118
NR Band n48	Ant.F	OPUS 75	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	122	416	2.00	20	26	3.70	119,120
NR Band n77	Ant.F	OPUS 75	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	165	459	2.00	22	26	4.25	121,122
WiFi 2.4GHz 802.11b	MIMO	OPUS 40	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.69	89	368	2.00	21	26	1.36	123,124
WiFi 5GHz 802.11a U-NII-1	SISO Ant.2	OPUS 6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	253	581	1.04	26	26	4.38	125,126
WiFi 5GHz 802.11a U-NII-2A	SISO Ant.2	OPUS 6	CH.56 5280 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	262	582	1.69	26	26	4.44	127,128
WiFi 5GHz 802.11a U-NII-2C	SISO Ant.2	OPUS 6	CH.120 5600 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	226	596	1.75	26	26	2.18	129,130
WiFi 5GHz 802.11a U-NII-3	SISO Ant.2	OPUS 6	CH.157 5785 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	225	589	2.00	26	26	3.44	131,132
WiFi 5GHz 802.11a U-NII-4	SISO Ant.2	OPUS 6	CH.173 5865 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.69	229	580	2.00	26	26	1.58	133,134

Note:

The radial longitudinal (x axis), axial (z axis) measurements are no longer required per ANSI C63.19-2019.

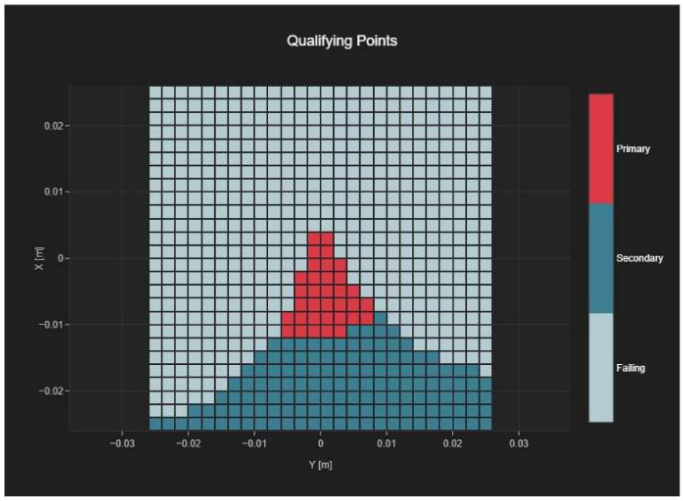
9.9. Worst Case T-Coil Test Plot

CMRS_GSM850_Ant.E_FR V1_ch.251

T-Coil Coupling Mode Test Report

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
34	172	15	26



Appendix

Refer to separated files for the following appendixes

4790976523-S6 Appendix A_Setup Photo

4790976523-S6 Appendix B_Test Plots

4790976523-S6 Appendix C_Probe Certificate

END OF REPORT