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 and NFC

MODEL NUMBER : SM-A166U, SM-A166U1, SM-S166V

FCC ID: A3LSMA166U

REPORT NUMBER: S-4791440365-S3V1

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TL-637

Revision History

Rev.	Date	Revisions	Revised By
V1	2024-10-04	Initial Issue	-

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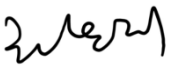
1. Attestation of Test Results

Applicant Name	SAMSUNG ELECTRONICS CO.,LTD.
FCC ID	A3LSMA166U
Model Name	SM-A166U, SM-A166U1, SM-S166V
Applicable Standards	FCC 47 CFR § 20.19 ANSI C63.19-2019
Date Tested	2024-09-02 to 2024-09-24
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 Senior Laboratory 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	3137	2025-07-11
Data Acquisition Electronics	SPEAG	DAE4	1468	2025-08-15
AMMI	SPEAG	SE UMS 010 BB	1161	N/A
Radio Communication Tester	R & S	CMW 500	150314	2025-07-24
Wireless Test Platform	Keysight	E7515B	MY57510596	2025-07-30
Support Device	Samsung	SM-S921U	R3CW80J5ERY	N/A
DAC	Sound Devices	USBPre 2	HB1218172005	N/A
Thermometer	Lutron	MHB-382SD	AK.18789	2025-07-26

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)							**3.90**	**5.97**
Expanded Std. Uncertainty							**7.80**	**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

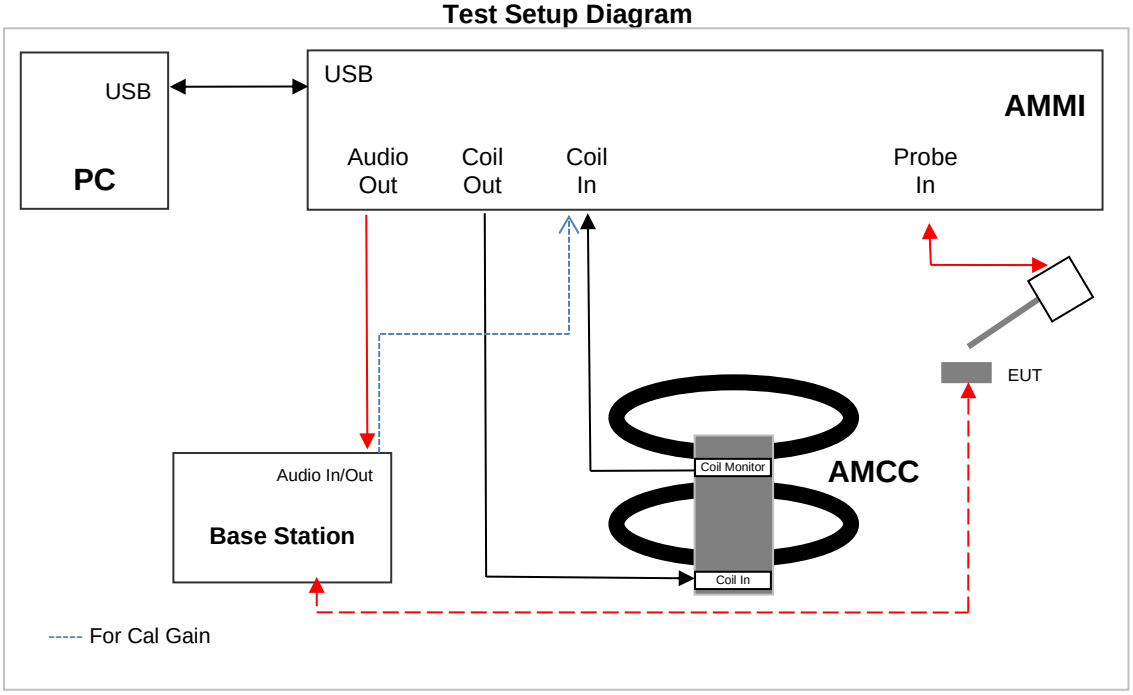
appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB(A/m).) Compare the frequency response found to the requirements of 6.6.3.

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.

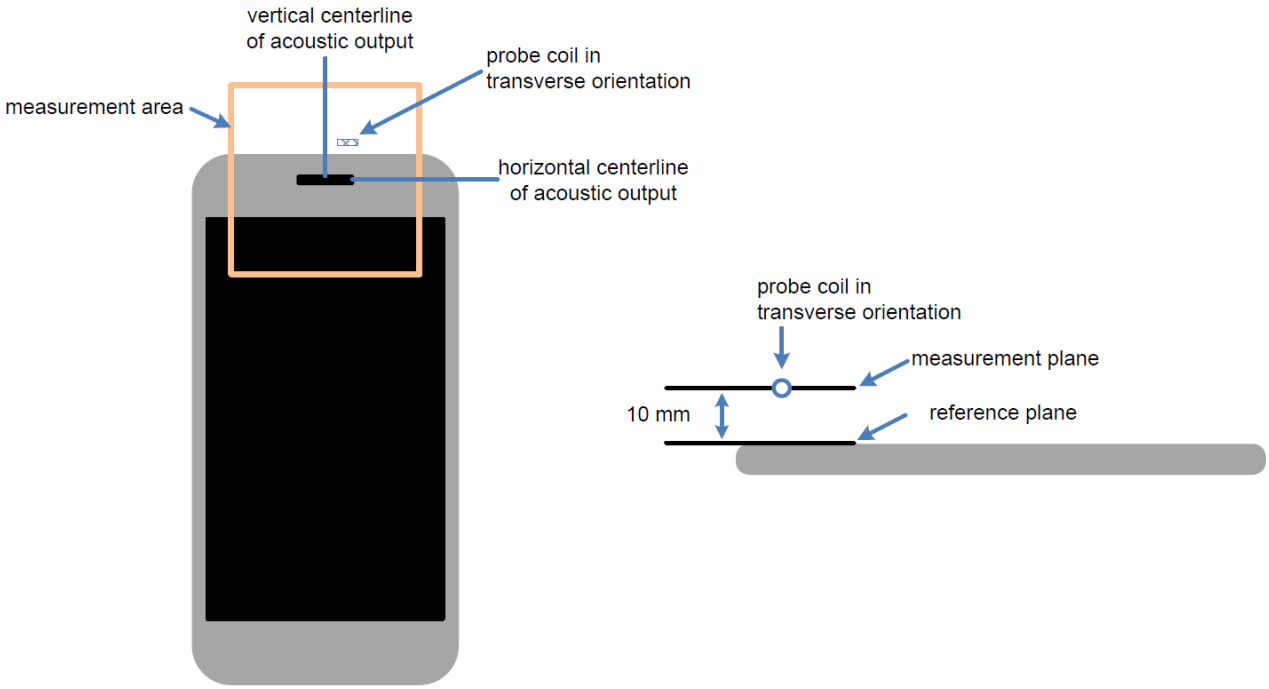
h) Calculate and record the location and number of the measurement points that satisfy both the minimum desired ABM signal level and the maximum undesired ABM field level specified in 6.6.2. Compare this to the requirements in 6.6.4 and record the result.

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.

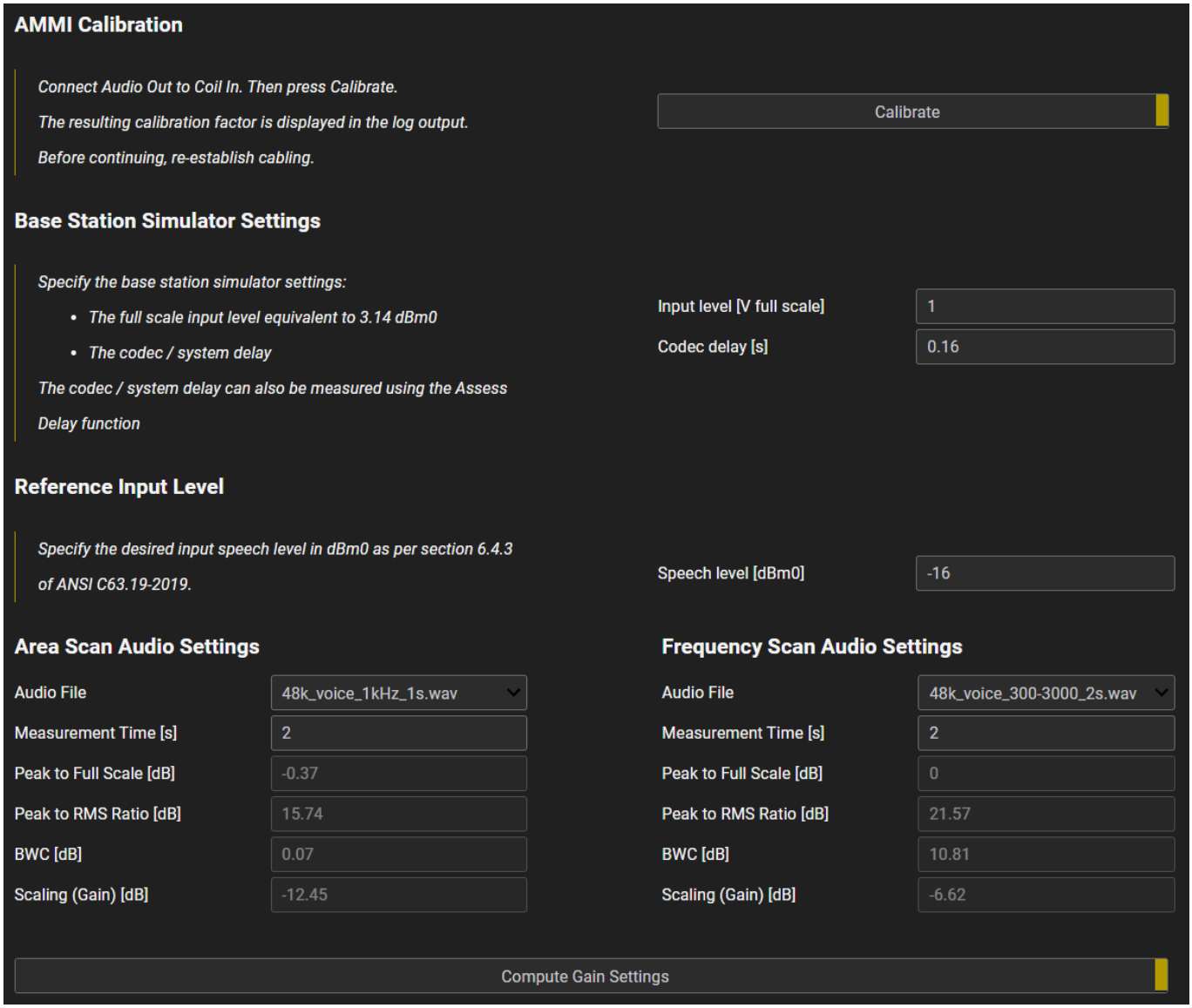
For protocols not listed in Table 6.1, use the normal speech input level per the relevant specifications for that air interface.

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.

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.

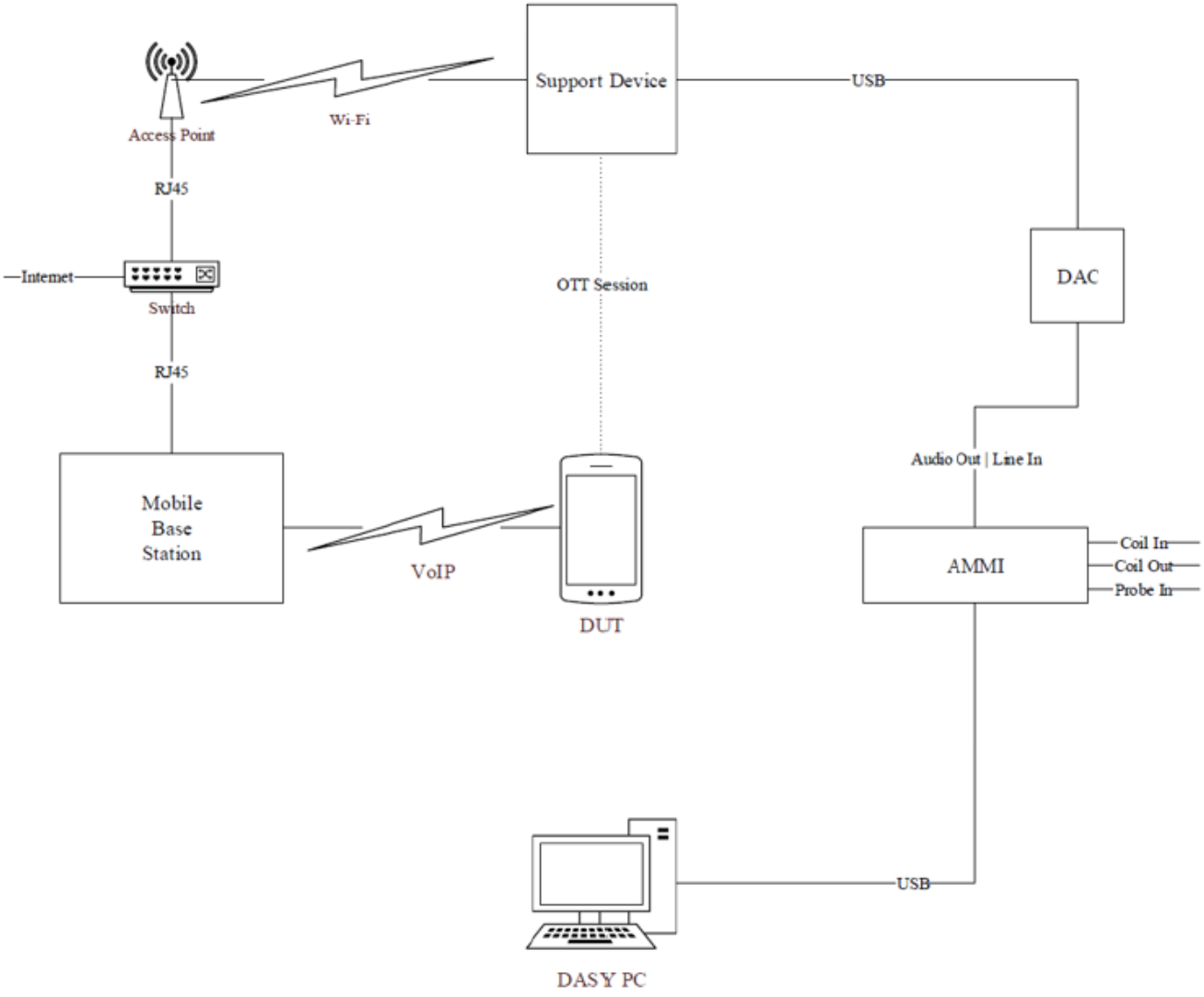
The set up for VoWiFi uses the Base station as described in section 5.1 and 5.3 and the reference level is calibrated using the standard call box calibration procedures. An investigation was performed to determine worst case codec, bit rate and air interface configuration (refer to section 9).

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.

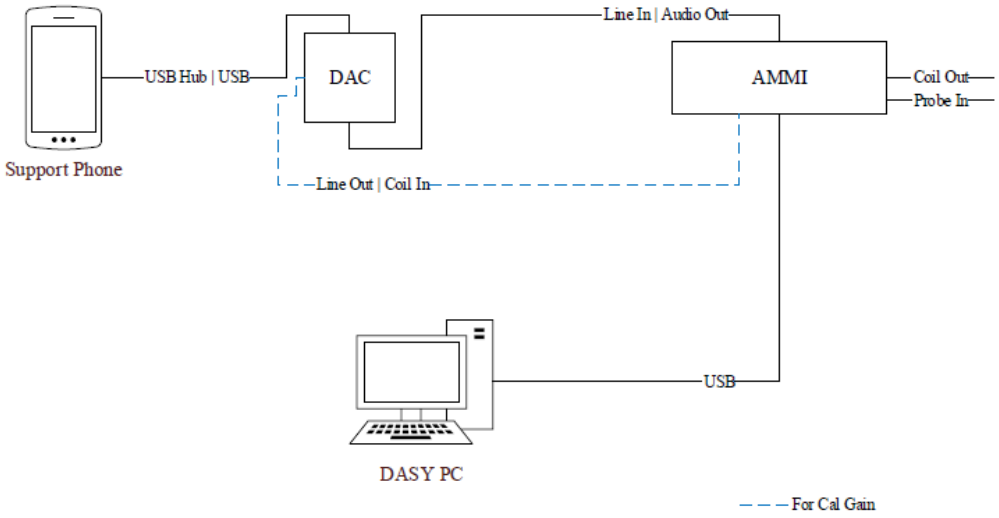
The equipment is set up as shown below with a support device used to originate the call using the IP transport. This support device includes test software that allows the codec bit rate for the IP call to be selected. The support device connects to the cloud-based Google Meet service via a Wi-Fi access 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 IPv6
	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.

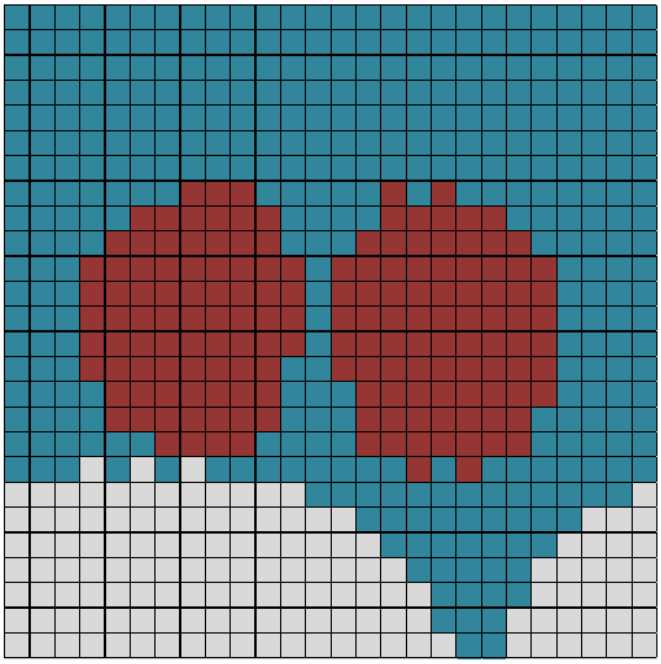
Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

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.

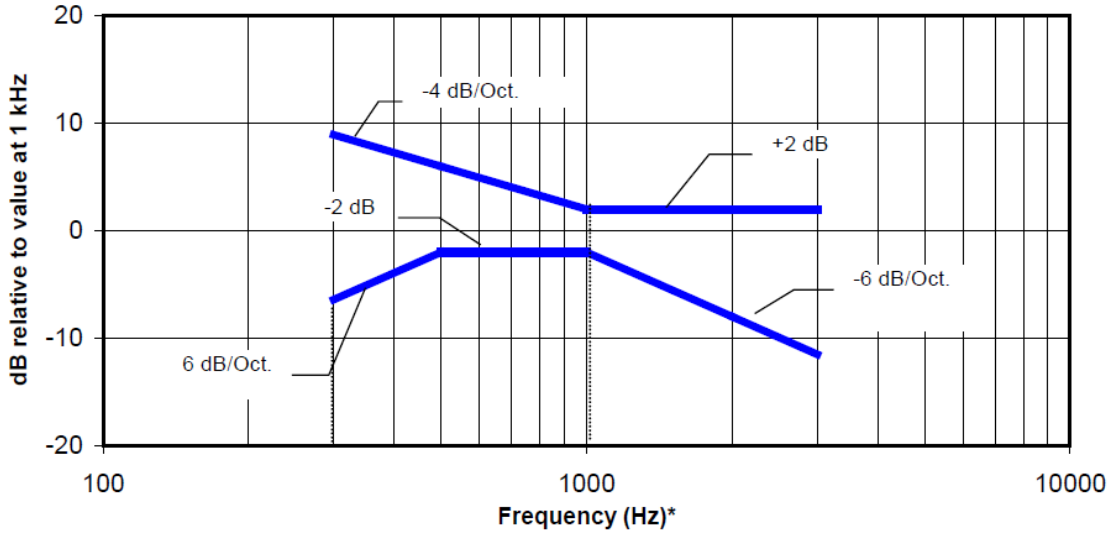
An example of a qualifying desired ABM signal, undesired ABM field scan



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)

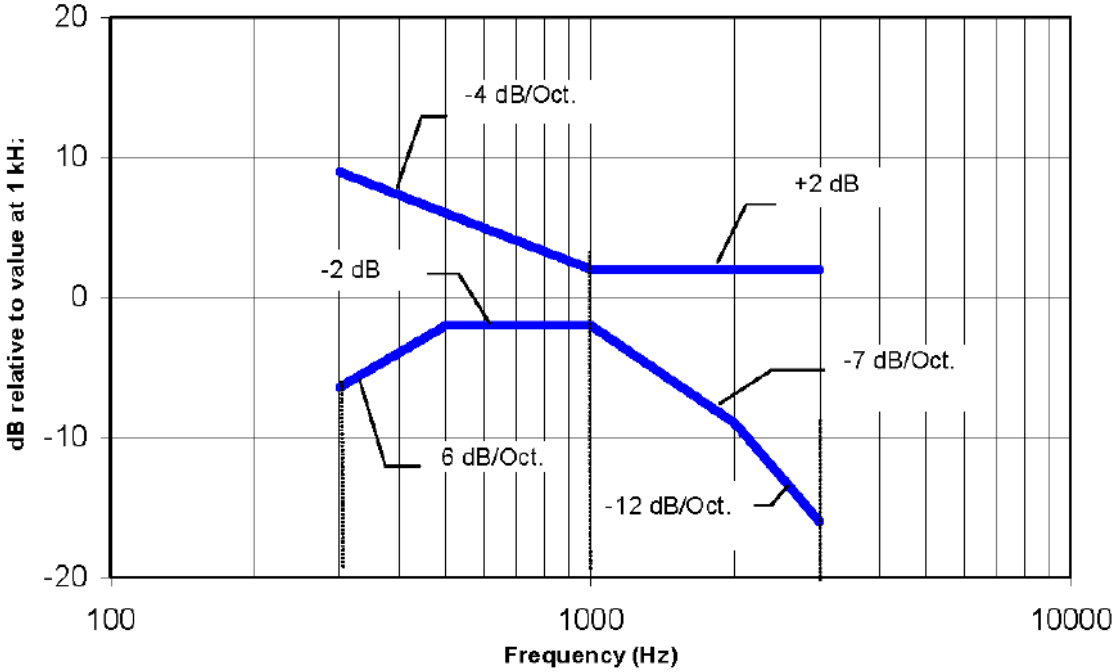
7.3. Frequency Response

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**
	R3CX808NDFT	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
	850 (n5)					
	1700 (n66)					
	1700 (n70)					
	1900 (n2/25)					
	2300 (n30)					
NR - TDD	2600 (n41)	VD	Yes	LTE, Wi-Fi and BT	VoNR Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	3600 (n48)					
	3500 (n77/78 DoD)					
	3700 (n77/78)					
Wi-Fi	2450	VD	Yes	WWAN	VoWiFi Yes Google Meet	AMR-NB, AMR-WB, EVS and OPUS
	5200 (U-NII-1)			WWAN and BT		
	5300 (U-NII-2A)					
	5500 (U-NII-2C)					
	5800 (U-NII-3)					
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:

Note(s):

All tests were performed with the transmit power set to the maximum power for held-to-head conditions (RCV active). For air interfaces with a Time Averaged SAR (TAS) algorithm Pmax is considered the maximum power.

9. HAC (T-coil) Test Results

9.1. Antenna Investigation and full-scan data

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

Determined worst-case antenna in this section was used for single point scan of Codec/Air-interface investigations in LTE FDD and NR FDD.

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)	Hmax Location
LTE Band 66	Ant.A	AMR-WB 6.6	132322 1745 MHz	20 MHz	QPSK	1/0	-56.67	259	626	1.80	26	26	-3.95	(6.0, -4.0)
LTE Band 66	Ant.B	AMR-WB 6.6	132322 1745 MHz	20 MHz	QPSK	1/0	-56.67	264	624	2.00	26	26	-4.34	(6.0, -4.0)
NR Band n66	Ant.A	EVS-swb 9.6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	199	512	2.00	20	26	-4.70	(6.0, -4.0)
NR Band n66	Ant.B	EVS-swb 9.6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	197	516	2.00	21	26	-4.75	(6.0, -4.0)

H-max Location of below full-scan data was used for single point scan of Codec/Air-interface investigations.

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)	Hmax Location
WCDMA V	Ant.A	AMR-WB 6.6	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.63	278	671	1.86	26	26	-4.11	(7.0, -4.0)
LTE Bnad 41	Ant.A	EVS-SWB 9.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.75	168	464	2.00	22	26	-4.75	(6.0, -4.0)
WiFi 2.4GHz 802.11b	Ant.D	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.56	151	473	2.00	23	26	-3.99	(6.0, -4.0)
WiFi 5GHz 802.11a U-NII-1	Ant.D	EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	N/A	-56.56	205	565	2.00	26	26	-4.87	(6.0, -4.0)

Note(s):

1. For mid-high frequency bands in LTE FDD (LTE Band B2/66), it is observed that Ant.A is the worst-case.
2. For mid-high frequency bands in NR FDD (NR Band n2/66), it is observed that Ant.B 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	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
GSM 850	Ant.A	FR V1	CH.190 836.6 MHz	-56.63	116	377	1.56	20	26	-3.09	(6.0, -4.0)
		FR V2		-56.63	121	380	1.86	20	26	-2.63	(6.0, -4.0)
		HR V1		-56.63	139	400	2.00	21	26	-2.77	(6.0, -4.0)

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	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
WCDMA Band V	Ant.A	AMR-NB 4.75	CH.4183 836.6 MHz	-56.69	51.15	-54.27	1.44	-3.12	(7.0, -4.0)
		AMR-NB 7.4		-56.69	48.59	-51.63	1.72	-3.04	(7.0, -4.0)
		AMR-NB 12.2		-56.69	50.95	-53.80	1.92	-2.85	(7.0, -4.0)
		AMR-WB 6.6		-56.69	45.75	-49.71	1.92	-3.96	(7.0, -4.0)
		AMR-WB 15.85		-56.69	47.14	-50.97	1.59	-3.83	(7.0, -4.0)
		AMR-WB 23.85		-56.69	47.47	-51.28	1.87	-3.81	(7.0, -4.0)

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	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
VoLTE FDD Band 66	Ant.A	AMR-NB 4.75	132322 1745 MHz	20 MHz	QPSK	1/0	-56.67	45.97	-49.32	1.60	-3.35	(6.0, -4.0)
		AMR-NB 7.4					-56.67	45.90	-49.27	1.76	-3.37	(6.0, -4.0)
		AMR-NB 12.2					-56.67	46.64	-49.76	1.85	-3.12	(6.0, -4.0)
		AMR-WB 6.6					-56.67	45.30	-49.33	2.00	-4.03	(6.0, -4.0)
		AMR-WB 15.85					-56.67	45.67	-49.22	1.70	-3.55	(6.0, -4.0)
		AMR-WB 23.85					-56.67	46.17	-49.80	1.82	-3.63	(6.0, -4.0)
		EVS-nb 5.9					-56.67	45.71	-49.37	1.32	-3.66	(6.0, -4.0)
		EVS-nb 13.2					-56.67	47.41	-49.91	1.73	-2.50	(6.0, -4.0)
		EVS-nb 24.4					-56.67	46.30	-49.26	1.53	-2.96	(6.0, -4.0)
		EVS-wb 5.9					-56.67	45.39	-48.88	1.45	-3.49	(6.0, -4.0)
		EVS-wb 13.2					-56.67	45.88	-49.17	1.97	-3.29	(6.0, -4.0)
		EVS-wb 24.4					-56.67	46.02	-49.30	1.36	-3.28	(6.0, -4.0)
		EVS-swb 9.6					-56.67	44.96	-49.69	2.00	-4.73	(6.0, -4.0)
		EVS-swb 16.4					-56.67	45.54	-49.98	2.00	-4.44	(6.0, -4.0)
		EVS-swb 24.4					-56.67	45.49	-50.06	2.00	-4.57	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
VoLTE TDD Band 41	Ant.A	AMR-NB 4.75	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.56	38.36	-41.84	1.72	-3.48	(6.0, -4.0)
		AMR-NB 7.4					-56.56	38.51	-42.00	1.66	-3.49	(6.0, -4.0)
		AMR-NB 12.2					-56.56	38.30	-41.61	1.91	-3.31	(6.0, -4.0)
		AMR-WB 6.6					-56.56	37.99	-42.01	1.77	-4.02	(6.0, -4.0)
		AMR-WB 15.85					-56.56	38.09	-42.00	1.56	-3.91	(6.0, -4.0)
		AMR-WB 23.85					-56.56	37.60	-41.57	1.72	-3.97	(6.0, -4.0)
		EVS-nb 5.9					-56.56	37.20	-41.48	1.40	-4.28	(6.0, -4.0)
		EVS-nb 13.2					-56.56	38.76	-41.75	1.74	-2.99	(6.0, -4.0)
		EVS-nb 24.4					-56.56	39.11	-41.94	1.52	-2.83	(6.0, -4.0)
		EVS-wb 5.9					-56.56	37.03	-41.76	2.00	-4.73	(6.0, -4.0)
		EVS-wb 13.2					-56.56	38.14	-41.78	1.86	-3.64	(6.0, -4.0)
		EVS-wb 24.4					-56.56	38.33	-42.06	1.40	-3.73	(6.0, -4.0)
		EVS-swb 9.6					-56.56	36.42	-41.00	2.00	-4.58	(6.0, -4.0)
		EVS-swb 16.4					-56.56	37.17	-41.83	2.00	-4.66	(6.0, -4.0)
		EVS-swb 24.4					-56.56	37.01	-41.78	2.00	-4.77	(6.0, -4.0)

Note(s):

1. For LTE-FDD, it is observed that EVS-SWB 9.6 kbit/s is the worst-case.
2. For LTE-TDD, it is observed that EVS-SWB 9.6 kbit/s is the worst-case.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
VoNR FDD Band n66	Ant.B	AMR-NB 4.75	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.58	-44.92	1.77	-3.34	(6.0, -4.0)
		AMR-NB 7.4					-56.69	42.09	-45.70	1.74	-3.61	(6.0, -4.0)
		AMR-NB 12.2					-56.69	42.41	-45.56	1.86	-3.15	(6.0, -4.0)
		AMR-WB 6.6					-56.69	41.11	-45.48	1.66	-4.37	(6.0, -4.0)
		AMR-WB 15.85					-56.69	41.83	-45.62	1.60	-3.79	(6.0, -4.0)
		AMR-WB 23.85					-56.69	41.07	-45.21	1.64	-4.14	(6.0, -4.0)
		EVS-nb 5.9					-56.69	40.09	-45.40	1.31	-5.31	(6.0, -4.0)
		EVS-nb 13.2					-56.69	41.56	-44.83	1.69	-3.27	(6.0, -4.0)
		EVS-nb 24.4					-56.69	41.73	-44.95	1.49	-3.22	(6.0, -4.0)
		EVS-wb 5.9					-56.69	39.77	-44.98	1.79	-5.21	(6.0, -4.0)
		EVS-wb 13.2					-56.69	40.89	-44.70	1.77	-3.81	(6.0, -4.0)
		EVS-wb 24.4					-56.69	41.44	-45.33	1.60	-3.89	(6.0, -4.0)
		EVS-swb 9.6					-56.69	39.62	-44.87	2.00	-5.25	(6.0, -4.0)
		EVS-swb 16.4					-56.69	40.64	-45.31	2.00	-4.67	(6.0, -4.0)
		EVS-swb 24.4					-56.69	40.45	-45.19	2.00	-4.74	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
VoNR TDD Band n77	Ant.E	AMR-NB 4.75	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.63	100	372	1.54	18	26	-3.61	(6.0, -4.0)
		AMR-NB 7.4					-56.63	101	370	1.47	18	26	-3.12	(6.0, -4.0)
		AMR-NB 12.2					-56.63	104	371	1.72	18	26	-2.80	(6.0, -4.0)
		AMR-WB 6.6					-56.63	90	371	1.61	18	26	-4.14	(6.0, -4.0)
		AMR-WB 15.85					-56.63	89	356	1.65	19	26	-3.83	(6.0, -4.0)
		AMR-WB 23.85					-56.63	94	372	1.80	18	26	-3.82	(6.0, -4.0)
		EVS-nb 5.9					-56.63	89	377	1.39	20	26	-5.34	(7.0, -3.0)
		EVS-nb 13.2					-56.69	103	372	1.37	17	26	-3.01	(6.0, -4.0)
		EVS-nb 24.4					-56.69	104	372	1.56	17	26	-2.72	(6.0, -5.0)
		EVS-wb 5.9					-56.63	86	384	1.33	18	26	-4.99	(6.0, -4.0)
		EVS-wb 13.2					-56.63	92	355	1.65	19	26	-3.72	(6.0, -4.0)
		EVS-wb 24.4					-56.63	96	372	1.24	18	26	-3.53	(6.0, -4.0)
		EVS-swb 9.6					-56.63	88	371	2.00	18	26	-4.39	(6.0, -4.0)
		EVS-swb 16.4					-56.69	86	370	2.00	17	26	-4.48	(6.0, -4.0)
		EVS-swb 24.4					-56.69	87	371	2.00	17	26	-4.61	(6.0, -4.0)

Note(s):

1. For NR-FDD, it is observed that EVS-SWB 9.6 kbit/s is the worst-case.
2. For NR-TDD, it is observed that EVS-SWB 16.4 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	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
GSM 850	Ant.A	FR V1	CH.128 824.2 MHz	-56.63	125	387	1.44	20	26	-2.68	(7.0, -5.0)
			CH.190 836.6 MHz	-56.63	116	377	1.56	20	26	-3.09	(6.0, -4.0)
			CH.251 848.8 MHz	-56.63	127	391	1.36	21	26	-2.60	(6.0, -4.0)
GSM 1900	Ant.A	FR V1	CH.661 1880.0 MHz	-56.63	149	416	1.24	21	26	-2.70	(7.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
WCDMA Band II	Ant.A	AMR-WB 6.6	CH.9400 1880.0 MHz	-56.69	49.43	-52.95	1.83	-3.52	(7.0, -4.0)
WCDMA Band IV	Ant.A	AMR-WB 6.6	CH.1413 1732.6 MHz	-56.69	47.10	-51.05	2.00	-3.95	(7.0, -4.0)
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4132 826.4 MHz	-56.69	48.99	-52.97	2.00	-3.98	(7.0, -4.0)
			CH.4183 836.6 MHz	-56.69	45.75	-49.71	1.92	-3.96	(7.0, -4.0)
			CH.4233 846.6 MHz	-56.69	49.38	-53.18	1.97	-3.80	(7.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4183 836.6 MHz	-56.63	271	663	1.56	26	26	-4.01	(6.0, -4.0)

VoLTE (FDD/TDD) Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
LTE Band 66	Ant.A	EVS-SWB 9.6	132322 1745 MHz	20 MHz	QPSK	1/0	-56.67	44.96	-49.69	2.00	-4.73	(6.0, -4.0)
						1/49	-56.67	45.33	-49.79	1.54	-4.46	(6.0, -4.0)
						1/99	-56.67	45.48	-49.89	2.00	-4.41	(6.0, -4.0)
						50/0	-56.67	45.33	-49.58	2.00	-4.25	(6.0, -4.0)
						50/24	-56.67	45.19	-49.67	2.00	-4.48	(6.0, -4.0)
						50/50	-56.67	45.11	-49.52	2.00	-4.41	(6.0, -4.0)
						100/0	-56.67	45.15	-50.08	2.00	-4.93	(6.0, -4.0)
					16QAM	1/0	-56.67	45.08	-49.63	2.00	-4.55	(6.0, -4.0)
					64QAM	1/0	-56.67	44.06	-49.35	2.00	-5.29	(6.0, -4.0)
					256QAM	1/0	-56.67	44.64	-49.46	2.00	-4.82	(6.0, -4.0)
				15 MHz	64QAM	1/0	-56.67	44.61	-49.15	2.00	-4.54	(6.0, -4.0)
				10 MHz	64QAM	1/0	-56.67	45.65	-50.22	2.00	-4.57	(6.0, -4.0)
				5 MHz	64QAM	1/0	-56.67	45.33	-49.79	2.00	-4.46	(6.0, -4.0)
				3 MHz	64QAM	1/0	-56.67	46.05	-50.46	1.54	-4.41	(6.0, -4.0)
				1.4 MHz	64QAM	1/0	-56.67	45.27	-49.79	2.00	-4.52	(6.0, -4.0)
			132072 1720 MHz	20 MHz	64QAM	1/0	-56.67	44.31	-48.98	2.00	-4.67	(6.0, -4.0)
			132572 1770 MHz	20 MHz	64QAM	1/0	-56.67	44.53	-49.09	2.00	-4.56	(6.0, -4.0)
LTE Band 2	Ant.A	EVS-SWB 9.6	18900 1880 MHz	20 MHz	64QAM	1/0	-56.67	44.31	-48.98	2.00	-4.67	(6.0, -4.0)
LTE Band 4	Ant.A	EVS-SWB 9.6	20175 1732.5 MHz	20 MHz	64QAM	1/0	-56.67	44.21	-48.85	2.00	-4.64	(6.0, -4.0)
LTE Band 5	Ant.A	EVS-SWB 9.6	20525 836.5 MHz	10 MHz	64QAM	1/0	-56.67	45.27	-50.08	2.00	-4.81	(6.0, -4.0)
LTE Band 7	Ant.A	EVS-SWB 9.6	21100 2535 MHz	20 MHz	64QAM	1/0	-56.67	44.27	-48.76	2.00	-4.49	(6.0, -4.0)
LTE Band 12	Ant.A	EVS-SWB 9.6	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.67	45.29	-49.74	1.78	-4.45	(6.0, -4.0)
LTE Band 13	Ant.A	EVS-SWB 9.6	23230 782 MHz	10 MHz	64QAM	1/0	-56.67	44.31	-49.06	2.00	-4.75	(6.0, -4.0)
LTE Band 14	Ant.A	EVS-SWB 9.6	23330 793 MHz	10 MHz	64QAM	1/0	-56.67	45.21	-49.62	2.00	-4.41	(6.0, -4.0)
LTE Band 25	Ant.A	EVS-SWB 9.6	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.67	45.11	-49.6	2.00	-4.49	(6.0, -4.0)
LTE Band 26	Ant.A	EVS-SWB 9.6	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.67	44.56	-49.07	2.00	-4.51	(6.0, -4.0)
LTE Band 30	Ant.A	EVS-SWB 9.6	27710 2310 MHz	10 MHz	64QAM	1/0	-56.67	44.13	-48.89	2.00	-4.76	(6.0, -4.0)
LTE Band 71	Ant.A	EVS-SWB 9.6	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.67	44.64	-49.2	2.00	-4.56	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
LTE Band 66	Ant.A	EVS-SWB 9.6	132322 1745 MHz	20 MHz	64QAM	1/0	-56.77	253	621	2	26	26	-4.79	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
LTE Band 41 PC2	Ant.A	EVS-SWB 9.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.56	36.42	-41.00	2.00	-4.58	(6.0, -4.0)
						1/49	-56.67	36.82	-41.72	2.00	-4.90	(6.0, -4.0)
						1/99	-56.67	36.71	-41.52	2.00	-4.81	(6.0, -4.0)
						50/0	-56.67	37.61	-42.46	2.00	-4.85	(6.0, -4.0)
						50/24	-56.67	37.59	-42.41	2.00	-4.82	(6.0, -4.0)
						50/50	-56.67	37.70	-42.54	2.00	-4.84	(6.0, -4.0)
						100/0	-56.67	37.79	-42.50	2.00	-4.71	(6.0, -4.0)
					16QAM	1/0	-56.67	37.37	-42.23	2.00	-4.86	(6.0, -4.0)
					64QAM	1/0	-56.67	38.37	-43.25	2.00	-4.88	(6.0, -4.0)
					256QAM	1/0	-56.67	40.23	-44.97	2.00	-4.74	(6.0, -4.0)
				15 MHz	QPSK	1/0	-56.67	37.12	-41.89	2.00	-4.77	(6.0, -4.0)
				10 MHz	QPSK	1/0	-56.67	36.66	-41.53	2.00	-4.87	(6.0, -4.0)
				5 MHz	QPSK	1/0	-56.67	36.85	-41.64	2.00	-4.79	(6.0, -4.0)
			CH.39750 2506 MHz	20 MHz	QPSK	1/0	-56.67	38.20	-43.09	2.00	-4.89	(6.0, -4.0)
			CH.41490 2680 MHz	20 MHz	QPSK	1/0	-56.67	39.22	-44.00	2.00	-4.78	(6.0, -4.0)
LTE Band 38	Ant.A	EVS-SWB 9.6	CH.38000 2595 MHz	20 MHz	QPSK	1/0	-56.56	39.87	-44.66	2.00	-4.79	(6.0, -4.0)
LTE Band 41 PC3	Ant.A	EVS-SWB 9.6	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.67	39.51	-44.44	2.00	-4.93	(6.0, -4.0)
LTE Band 48	Ant.E	EVS-SWB 9.6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.77	31.50	-36.27	2.00	-4.77	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
LTE Band 48	Ant.E	EVS-SWB 9.6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.75	123	422	2.00	20	26	-4.83	(6.0, -4.0)

VoNR (FDD/TDD) Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
NR Band n66	Ant.B	EVS-swb 9.6	CH.349000 1745 MHz	40 MHz	CP-OFDM QPSK	1/1	-56.69	40.79	-45.70	2.00	-4.91	(6.0, -4.0)
						1/107	-56.69	42.20	-46.88	2.00	-4.68	(6.0, -4.0)
						1/214	-56.69	41.26	-46.03	2.00	-4.77	(6.0, -4.0)
						108/0	-56.69	42.67	-47.40	2.00	-4.73	(6.0, -4.0)
						108/54	-56.69	42.36	-47.09	2.00	-4.73	(6.0, -4.0)
						108/108	-56.69	42.06	-46.89	2.00	-4.83	(6.0, -4.0)
						216/0	-56.69	42.35	-47.15	2.00	-4.80	(6.0, -4.0)
					CP-OFDM 16QAM	1/1	-56.69	41.11	-45.85	2.00	-4.74	(6.0, -4.0)
					CP-OFDM 64QAM	1/1	-56.69	42.44	-47.20	2.00	-4.76	(6.0, -4.0)
					CP-OFDM 256QAM	1/1	-56.69	43.00	-47.70	2.00	-4.70	(6.0, -4.0)
					DFT-s-OFDM QPSK	1/1	-56.69	39.62	-44.87	2.00	-5.25	(6.0, -4.0)
						1/107	-56.69	40.72	-45.64	2.00	-4.92	(6.0, -4.0)
						1/214	-56.69	40.06	-44.83	2.00	-4.77	(6.0, -4.0)
						108/0	-56.69	41.38	-46.26	2.00	-4.88	(6.0, -4.0)
						108/54	-56.69	41.81	-46.55	2.00	-4.74	(6.0, -4.0)
						108/108	-56.69	42.14	-46.95	2.00	-4.81	(6.0, -4.0)
						216/0	-56.69	42.12	-47.11	2.00	-4.99	(6.0, -4.0)
					DFT-s-OFDM pi/2 BPSK	1/1	-56.69	40.98	-45.73	2.00	-4.75	(6.0, -4.0)
					DFT-s-OFDM 16QAM	1/1	-56.69	40.74	-45.42	2.00	-4.68	(6.0, -4.0)
					DFT-s-OFDM 64QAM	1/1	-56.69	40.49	-45.37	2.00	-4.88	(6.0, -4.0)
					DFT-s-OFDM 256QAM	1/1	-56.69	42.98	-47.74	2.00	-4.76	(6.0, -4.0)
				30 MHz	DFT-s-OFDM QPSK	1/1	-56.69	43.48	-48.37	1.97	-4.89	(6.0, -4.0)
				25 MHz	DFT-s-OFDM QPSK	1/1	-56.69	42.02	-46.68	2.00	-4.66	(6.0, -4.0)
				20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.79	-46.50	2.00	-4.71	(6.0, -4.0)
				15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	42.21	-46.93	2.00	-4.72	(6.0, -4.0)
				10 MHz	DFT-s-OFDM QPSK	1/1	-56.69	42.24	-46.90	2.00	-4.66	(6.0, -4.0)
				5 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.53	-46.30	2.00	-4.77	(6.0, -4.0)
			CH.346000 1730 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.15	-46.12	2.00	-4.97	(6.0, -4.0)
			CH.352000 1760 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.80	-46.61	2.00	-4.81	(6.0, -4.0)
NR Band n2	Ant.B	EVS-swb 9.6	CH.376000 1880 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	40.78	-45.55	2.00	-4.77	(6.0, -4.0)
NR Band n5	Ant.A	EVS-swb 9.6	CH.167300 836.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	42.05	-46.70	2.00	-4.65	(6.0, -4.0)
NR Band n25	Ant.A	EVS-swb 9.6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.17	-45.99	2.00	-4.82	(6.0, -4.0)
NR Band n30	Ant.A	EVS-swb 9.6	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.52	-46.43	2.00	-4.91	(6.0, -4.0)
NR Band n70	Ant.A	EVS-swb 9.6	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.90	-46.79	2.00	-4.89	(6.0, -4.0)
NR Band n71	Ant.A	EVS-swb 9.6	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.69	41.25	-45.93	2.00	-4.68	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
NR Band n66	Ant.B	EVS-swb 9.6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	192	510	2	20	26	-4.80	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
NR Band n77	Ant.E	EVS-swb 16.4	CH.650000 3750 MHz	100 MHz	CP-OFDM QPSK	1/1	-56.74	107	390	1.58	18	26	-3.49	(6.0, -4.0)
						1/136	-56.74	114	400	1.63	19	26	-3.46	(6.0, -4.0)
						1/271	-56.74	116	388	1.29	20	26	-3.46	(6.0, -4.0)
						135/0	-56.74	111	401	1.52	19	26	-3.54	(6.0, -4.0)
						135/69	-56.74	108	379	1.50	20	26	-3.38	(6.0, -4.0)
						135/138	-56.74	115	387	1.51	20	26	-3.40	(6.0, -4.0)
						270/0	-56.74	119	406	1.60	19	26	-3.42	(6.0, -4.0)
					CP-OFDM 16QAM	1/1	-56.74	106	375	1.63	20	26	-3.50	(6.0, -4.0)
					CP-OFDM 64QAM	1/1	-56.74	115	401	1.26	19	26	-3.41	(6.0, -4.0)
					CP-OFDM 256QAM	1/1	-56.74	118	391	1.35	21	26	-3.47	(6.0, -4.0)
					DFT-s-OFDM QPSK	1/1	-56.69	86	370	2.00	17	26	-4.48	(6.0, -4.0)
						1/136	-56.63	104	368	1.48	20	26	-3.32	(6.0, -4.0)
						1/271	-56.63	114	397	1.44	18	26	-3.27	(6.0, -4.0)
						135/0	-56.63	106	373	1.44	20	26	-3.30	(6.0, -4.0)
						135/69	-56.63	105	386	1.81	18	26	-3.40	(6.0, -4.0)
						135/138	-56.63	111	380	1.51	20	26	-3.24	(6.0, -4.0)
						270/0	-56.63	113	397	1.38	19	26	-3.23	(6.0, -4.0)
					DFT-s-OFDM pi/2 BPSK	1/1	-56.74	98	379	1.32	18	26	-3.44	(6.0, -4.0)
					DFT-s-OFDM 16QAM	1/1	-56.63	100	367	1.45	20	26	-3.33	(6.0, -4.0)
					DFT-s-OFDM 64QAM	1/1	-56.63	110	395	1.49	19	26	-3.46	(6.0, -4.0)
					DFT-s-OFDM 256QAM	1/1	-56.74	99	387	1.47	20	26	-3.20	(7.0, -4.0)
				90 MHz	DFT-s-OFDM QPSK	1/1	-56.74	98	378	1.50	18	26	-3.46	(6.0, -4.0)
				80 MHz	DFT-s-OFDM QPSK	1/1	-56.74	113	399	1.57	19	26	-3.57	(6.0, -4.0)
				70 MHz	DFT-s-OFDM QPSK	1/1	-56.74	109	379	1.47	20	26	-3.44	(6.0, -4.0)
				60 MHz	DFT-s-OFDM QPSK	1/1	-56.74	100	381	1.61	18	26	-3.42	(6.0, -4.0)
				50 MHz	DFT-s-OFDM QPSK	1/1	-56.74	102	384	1.32	18	26	-3.41	(6.0, -4.0)
				40 MHz	DFT-s-OFDM QPSK	1/1	-56.74	102	384	1.40	18	26	-3.37	(6.0, -4.0)
				30 MHz	DFT-s-OFDM QPSK	1/1	-56.74	102	386	1.42	18	26	-3.42	(6.0, -4.0)
				25 MHz	DFT-s-OFDM QPSK	1/1	-56.74	108	393	1.44	19	26	-3.43	(6.0, -4.0)
				20 MHz	DFT-s-OFDM QPSK	1/1	-56.74	97	373	1.37	19	26	-3.44	(6.0, -4.0)
				15 MHz	DFT-s-OFDM QPSK	1/1	-56.74	105	373	1.62	21	26	-3.43	(6.0, -4.0)
				10 MHz	DFT-s-OFDM QPSK	1/1	-56.74	114	401	1.48	19	26	-3.44	(6.0, -4.0)
			CH.633334 3500.01 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.63	102	382	1.41	18	26	-3.34	(6.0, -4.0)
			CH.662000 3930 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.63	98	378	1.41	18	26	-3.60	(6.0, -5.0)
NR Band n41	Ant.A	EVS-swb 16.4	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.74	152	439	1.59	18	26	-3.46	(6.0, -4.0)
NR Band n48	Ant.E	EVS-swb 16.4	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.74	106	372	1.28	20	26	-3.42	(6.0, -4.0)
NR Band n78	Ant.E	EVS-swb 16.4	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.74	98	379	1.55	18	26	-3.77	(7.0, -5.0)

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	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
VoWi-Fi 2.4 GHz 802.11b	Ant.D SISO	AMR-NB 4.75	CH.6 2437 MHz	20 MHz	1Mbps	-56.56	30.30	-33.44	1.34	-3.14	(6.0, -4.0)
		AMR-NB 7.4				-56.56	31.24	-34.12	1.72	-2.88	(6.0, -4.0)
		AMR-NB 12.2				-56.56	30.70	-33.49	1.92	-2.79	(6.0, -4.0)
		AMR-WB 6.6				-56.56	29.44	-33.46	2.00	-4.02	(6.0, -4.0)
		AMR-WB 15.85				-56.56	30.60	-34.27	1.88	-3.67	(6.0, -4.0)
		AMR-WB 23.85				-56.56	31.55	-35.09	1.72	-3.54	(6.0, -4.0)
		EVS-nb 5.9				-56.56	36.06	-41.42	1.29	-5.36	(6.0, -4.0)
		EVS-nb 13.2				-56.56	38.63	-41.06	1.50	-2.43	(6.0, -4.0)
		EVS-nb 24.4				-56.56	39.14	-41.60	1.57	-2.46	(6.0, -4.0)
		EVS-wb 5.9				-56.56	35.57	-41.43	2.00	-5.86	(6.0, -4.0)
		EVS-wb 13.2				-56.56	38.73	-42.06	1.87	-3.33	(6.0, -4.0)
		EVS-wb 24.4				-56.56	38.40	-41.80	1.36	-3.40	(6.0, -4.0)
		EVS-swb 9.6				-56.56	34.37	-39.75	2.00	-5.38	(6.0, -4.0)
		EVS-swb 16.4				-56.56	37.90	-42.24	2.00	-4.34	(6.0, -4.0)
		EVS-swb 24.4				-56.56	36.86	-41.25	2.00	-4.39	(6.0, -4.0)
Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
VoWi-Fi 5 GHz 802.11a	Ant.D SISO	AMR-NB 4.75	CH.40 5200 MHz	20 MHz	6Mbps	-56.56	38.98	-41.95	1.27	-2.97	(6.0, -4.0)
		AMR-NB 7.4				-56.56	37.66	-40.40	1.60	-2.74	(6.0, -4.0)
		AMR-NB 12.2				-56.56	37.74	-40.61	1.89	-2.87	(6.0, -4.0)
		AMR-WB 6.6				-56.56	36.75	-40.39	2.00	-3.64	(6.0, -4.0)
		AMR-WB 15.85				-56.56	37.76	-41.33	1.75	-3.57	(6.0, -4.0)
		AMR-WB 23.85				-56.56	37.82	-41.34	1.71	-3.52	(6.0, -4.0)
		EVS-nb 5.9				-56.56	36.81	-41.44	2.00	-4.63	(6.0, -4.0)
		EVS-nb 13.2				-56.56	38.43	-40.98	1.29	-2.55	(6.0, -4.0)
		EVS-nb 24.4				-56.56	38.43	-40.95	1.56	-2.52	(6.0, -4.0)
		EVS-wb 5.9				-56.56	36.89	-41.01	2.00	-4.12	(6.0, -4.0)
		EVS-wb 13.2				-56.56	37.54	-40.94	2.00	-3.40	(6.0, -4.0)
		EVS-wb 24.4				-56.56	37.86	-41.31	1.38	-3.45	(6.0, -4.0)
		EVS-swb 9.6				-56.56	35.71	-40.45	2.00	-4.74	(6.0, -4.0)
		EVS-swb 16.4				-56.56	36.85	-41.13	2.00	-4.28	(6.0, -4.0)
		EVS-swb 24.4				-56.56	36.83	-41.15	2.00	-4.32	(6.0, -4.0)

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 EVS-SWB 9.6 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	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
WiFi 2.4GHz 802.11b	Ant.D SISO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	-56.56	29.44	-33.46	2.00	-4.02	(6.0, -4.0)
					CCK 5.5 Mbps	-56.67	31.27	-35.00	2.00	-3.73	(6.0, -4.0)
					CCK 11 Mbps	-56.67	32.19	-35.96	2.00	-3.77	(6.0, -4.0)
WiFi 2.4GHz 802.11g		AMR-WB 6.6	CH.6 2437 MHz	20 MHz	BPSK 6 Mbps	-56.67	31.00	-35.27	2.00	-4.27	(6.0, -4.0)
WiFi 2.4GHz 802.11n HT20		AMR-WB 6.6	CH.6 2437 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	32.98	-37.29	2.00	-4.31	(6.0, -4.0)
WiFi 2.4GHz 802.11b		AMR-WB 6.6	CH.1 2412 MHz	20 MHz	DSSS 1 Mbps	-56.56	30.50	-33.58	2.00	-3.08	(6.0, -4.0)
		AMR-WB 6.6	CH.11 2462 MHz			-56.56	29.79	-33.56	2.00	-3.77	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
WiFi 2.4GHz 802.11b	Ant.D SISO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	-56.56	144	469	2.00	23	26	-3.86	(6.0, -4.0)

VoWi-Fi 5GHz Air Interface Investigation:

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	Ambient Noise dB(A/m)	S+NNR (dB)	Noise dB(A/m)	Frequency Response (dB)	Signal dB(A/m)	Hmax Location
WiFi 5GHz 802.11a U-NII-1	Ant.D SISO	EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	BPSK 6 Mbps	-56.56	35.71	-40.45	2.00	-4.74	(6.0, -4.0)
					QPSK 18 Mbps	-56.67	39.14	-43.65	2.00	-4.51	(6.0, -4.0)
					64QAM 54 Mbps	-56.67	40.24	-44.99	2.00	-4.75	(6.0, -4.0)
WiFi 5GHz 802.11n HT20 U-NII-1		EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	24.94	-29.79	2.00	-4.85	(6.0, -4.0)
					MCS 3 26 Mbps	-56.67	27.88	-32.50	2.00	-4.62	(6.0, -4.0)
					MCS 7 65 Mbps	-56.67	36.52	-41.24	2.00	-4.72	(6.0, -4.0)
WiFi 5GHz 802.11n HT40 U-NII-1		EVS-SWB 9.6	CH.38 5190 MHz	40 MHz	MCS 0 13.5 Mbps	-56.67	27.10	-31.72	2.00	-4.62	(6.0, -4.0)
					MCS 3 54 Mbps	-56.67	29.12	-33.56	2.00	-4.44	(6.0, -4.0)
					MCS 7 135 Mbps	-56.67	41.13	-45.69	1.92	-4.56	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-1		EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	24.91	-29.36	2.00	-4.45	(6.0, -4.0)
					MCS 4 39 Mbps	-56.67	27.51	-32.01	1.99	-4.50	(6.0, -4.0)
					MCS 8 78 Mbps	-56.67	43.30	-47.90	2.00	-4.60	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT40 U-NII-1		EVS-SWB 9.6	CH.38 5190 MHz	40 MHz	MCS 0 13.5 Mbps	-56.67	26.86	-31.37	2.00	-4.51	(6.0, -4.0)
					MCS 4 108 Mbps	-56.67	29.79	-34.38	2.00	-4.59	(6.0, -4.0)
					MCS 9 180 Mbps	-56.67	41.37	-46.01	2.00	-4.64	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT80 U-NII-1		EVS-SWB 9.6	CH.42 5210 MHz	80 MHz	MCS 0 29.3 Mbps	-56.67	26.55	-31.16	2.00	-4.61	(6.0, -4.0)
					MCS 4 175.5 Mbps	-56.67	28.23	-33.06	2.00	-4.83	(6.0, -4.0)
					MCS 9 390 Mbps	-56.67	42.63	-47.02	2.00	-4.39	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-1		EVS-SWB 9.6	CH.36 5180 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	29.20	-33.78	1.91	-4.58	(6.0, -4.0)
		EVS-SWB 9.6	CH.48 5240 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	28.53	-33.34	2.00	-4.81	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-2A		EVS-SWB 9.6	CH.56 5280 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	27.97	-32.76	2.00	-4.79	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-2C		EVS-SWB 9.6	CH.120 5600 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	25.97	-30.65	2.00	-4.68	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-3		EVS-SWB 9.6	CH.157 5785 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	32.90	-38.44	1.86	-5.54	(6.0, -4.0)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
WiFi 5GHz 802.11ac VHT20 U-NII-1	Ant.D SISO	EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	-56.67	167	488	2.00	24	26	-4.69	(6.0, -4.0)

9.6. OTT Codec Investigation and full-scan data

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.

H-max Location of below full-scan data was used for single point scan of Codec/Air-interface investigations.

Determined worst-case codec in this section was used for single point scan of Air-interface investigations in OTT – GSM, WCDMA, LTE FDD, LTE TDD, NR FDD, WiFi 2.4GHz and WiFi 5GHz.

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group / S+NNR (dB)	Secondary Group / Noise dB(A/m)	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
GSM850 EGPRS 2 Slots	Ant.A	OPUS 6	CH.190 836.6 MHz	N/A	N/A	N/A	-56.64	**136**	458	1.76	20	26	-4.57	(6.0, -3.0)
		OPUS 6		N/A	N/A	N/A	-56.64	37.51	-41.98	1.71	N/A	N/A	-4.47	(6.0, -3.0)
		OPUS 40		N/A	N/A	N/A	-56.64	36.26	-41.56	2.00	N/A	N/A	-5.30	(6.0, -3.0)
		OPUS 75		N/A	N/A	N/A	-56.64	37.47	-42.46	2.00	N/A	N/A	-4.99	(6.0, -3.0)
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 6	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.64	262	622	1.47	26	26	-4.20	(6.0, -4.0)
		OPUS 6		N/A	N/A	N/A	-56.64	43.12	-47.92	1.50	N/A	N/A	-4.80	(6.0, -4.0)
		OPUS 40		N/A	N/A	N/A	-56.64	42.31	-47.62	2.00	N/A	N/A	-5.31	(6.0, -4.0)
		OPUS 75		N/A	N/A	N/A	-56.64	42.55	-47.74	2.00	N/A	N/A	-5.19	(6.0, -4.0)
LTE Band 66	Ant.A	OPUS 6	CH.132322 1745 MHz	20 MHz	64QAM	1/0	-56.77	**257**	607	1.43	26	26	-4.50	(6.0, -4.0)
		OPUS 6					-56.77	43.42	-48.28	1.20	N/A	N/A	-4.86	(6.0, -4.0)
		OPUS 40					-56.77	44.36	-48.99	2.00	N/A	N/A	-4.63	(6.0, -4.0)
		OPUS 75					-56.77	42.11	-46.53	2.00	N/A	N/A	-4.42	(6.0, -4.0)
LTE Band 48	Ant.E	OPUS 6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.77	**125**	428	1.28	22	26	-4.08	(6.0, -4.0)
		OPUS 6					-56.77	31.96	-37.19	1.33	N/A	N/A	-5.23	(6.0, -4.0)
		OPUS 40					-56.77	31.22	-35.84	2.00	N/A	N/A	-4.62	(6.0, -4.0)
		OPUS 75					-56.77	31.04	-35.85	2.00	N/A	N/A	-4.81	(6.0, -4.0)
NR Band n66	Ant.B	OPUS 6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	204	523	1.34	21	26	-4.19	(6.0, -4.0)
		OPUS 6					-56.65	41.61	-46.13	1.89	N/A	N/A	-4.52	(6.0, -4.0)
		OPUS 40					-56.65	42.65	-45.54	2.00	N/A	N/A	-2.89	(6.0, -4.0)
		OPUS 75					-56.65	42.69	-45.53	2.00	N/A	N/A	-2.84	(6.0, -4.0)
NR Band n77	Ant.E	OPUS 6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.65	**100**	386	1.52	18	26	-4.03	(6.0, -4.0)
		OPUS 40					-56.65	108	394	2.00	19	26	-3.68	(6.0, -4.0)
		OPUS 75					-56.65	112	398	2.00	19	26	-3.81	(6.0, -5.0)
Wi-Fi 2.4 GHz 802.11b	Ant.D SISO	OPUS 6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.77	**116**	433	1.99	22	26	-3.89	(7.0, -4.0)
		OPUS 6					-56.77	30.06	-34.51	2.00	N/A	N/A	-4.45	(7.0, -4.0)
		OPUS 40					-56.77	29.84	-34.58	2.00	N/A	N/A	-4.74	(7.0, -4.0)
		OPUS 75					-56.77	30.33	-34.75	2.00	N/A	N/A	-4.42	(7.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-1	Ant.D SISO	OPUS 6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.77	196	539	1.37	26	26	-3.72	(7.0, -5.0)
		OPUS 6					-56.77	34.31	-39.14	2.00	N/A	N/A	-4.83	(7.0, -5.0)
		OPUS 40					-56.77	34.44	-38.82	2.00	N/A	N/A	-4.38	(7.0, -5.0)
		OPUS 75					-56.77	33.96	-38.70	2.00	N/A	N/A	-4.74	(7.0, -5.0)

Note(s):

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

1. For NR FDD/TDD, it is observed that 6 kbit/s is the worst-case.
2. For GSM, WCDMA and Wi-Fi 2.4GHz, it is observed that 40 kbit/s is the worst-case.
3. For LTE FDD/TDD and Wi-Fi 5GHz, 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 / S+NNR (dB)	Secondary Group / Noise dB(A/m)	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location
GSM850 EGPRS 2slots	Ant.A	OPUS 40	CH.190 836.6 MHz	N/A	N/A	N/A	-56.64	36.26	-41.56	2.00	N/A	N/A	-5.30	(6.0, -3.0)
GSM1900 EGPRS 2slots	Ant.A	OPUS 40	CH.661 1880.0 MHz	N/A	N/A	N/A	-56.63	39.78	-44.69	2.00	N/A	N/A	-4.91	(6.0, -3.0)
GSM850 EGPRS 2slots	Ant.A	OPUS 40	CH.190 836.6 MHz	N/A	N/A	N/A	-56.64	169	469	2.00	21	26	-4.02	(6.0, -4.0)
WCDMA Band II HSUPA Subtest1	Ant.A	OPUS 40	CH.9400 1880.0 MHz	N/A	N/A	N/A	-56.64	42.40	-46.87	2.00	N/A	N/A	-4.47	(6.0, -4.0)
WCDMA Band IV HSUPA Subtest1	Ant.A	OPUS 40	CH.1413 1732.6 MHz	N/A	N/A	N/A	-56.64	43.31	-47.64	2.00	N/A	N/A	-4.33	(6.0, -4.0)
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 40	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.64	42.31	-47.62	2.00	N/A	N/A	-5.31	(6.0, -4.0)
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 40	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.64	**262**	615	1.43	26	26	-3.46	(6.0, -4.0)
LTE Band 2	Ant.A	OPUS 75	18900 1880 MHz	20 MHz	64QAM	1/0	-56.77	43.26	-48.10	2.00	N/A	N/A	-4.84	(6.0, -4.0)
LTE Band 4	Ant.A	OPUS 75	20175 1732.5 MHz	20 MHz	64QAM	1/0	-56.77	41.55	-46.00	2.00	N/A	N/A	-4.45	(6.0, -4.0)
LTE Band 5	Ant.A	OPUS 75	20525 836.5 MHz	10 MHz	64QAM	1/0	-56.77	44.13	-48.53	2.00	N/A	N/A	-4.40	(6.0, -4.0)
LTE Band 7	Ant.A	OPUS 75	21100 2535 MHz	20 MHz	64QAM	1/0	-56.77	41.27	-45.85	2.00	N/A	N/A	-4.58	(6.0, -4.0)
LTE Band 12	Ant.A	OPUS 75	23095 707.5 MHz	10 MHz	64QAM	1/0	-56.77	43.93	-48.43	2.00	N/A	N/A	-4.50	(6.0, -4.0)
LTE Band 13	Ant.A	OPUS 75	23230 782 MHz	10 MHz	64QAM	1/0	-56.77	43.60	-47.89	2.00	N/A	N/A	-4.29	(6.0, -4.0)
LTE Band 14	Ant.A	OPUS 75	23330 793 MHz	10 MHz	64QAM	1/0	-56.77	43.34	-47.87	2.00	N/A	N/A	-4.53	(6.0, -4.0)
LTE Band 25	Ant.A	OPUS 75	26365 1882.5 MHz	20 MHz	64QAM	1/0	-56.77	41.57	-46.02	2.00	N/A	N/A	-4.45	(6.0, -4.0)
LTE Band 26	Ant.A	OPUS 75	26865 831.5 MHz	15 MHz	64QAM	1/0	-56.77	41.57	-46.09	2.00	N/A	N/A	-4.52	(6.0, -4.0)
LTE Band 30	Ant.A	OPUS 75	27710 2310 MHz	10 MHz	64QAM	1/0	-56.77	39.95	-44.34	2.00	N/A	N/A	-4.39	(6.0, -4.0)
LTE Band 66	Ant.A	OPUS 75	132322 1745 MHz	20 MHz	64QAM	1/0	-56.77	42.11	-46.53	2.00	N/A	N/A	-4.42	(6.0, -4.0)
LTE Band 71	Ant.A	OPUS 75	133297 680.5 MHz	20 MHz	64QAM	1/0	-56.77	41.58	-46.07	2.00	N/A	N/A	-4.49	(6.0, -4.0)
LTE Band 30	Ant.A	OPUS 75	27710 2310 MHz	10 MHz	64QAM	1/0	-56.77	271	613	2.00	26	26	-3.86	(7.0, -4.0)
LTE Band 38	Ant.A	OPUS 75	CH.38000 2595 MHz	20 MHz	QPSK	1/0	-56.77	40.26	-44.85	2.00	N/A	N/A	-4.59	(6.0, -4.0)
LTE Band 41 PC2	Ant.A	OPUS 75	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.77	36.42	-40.89	2.00	N/A	N/A	-4.47	(6.0, -4.0)
LTE Band 41 PC3	Ant.A	OPUS 75	CH.40620 2593 MHz	20 MHz	QPSK	1/0	-56.77	39.74	-44.34	2.00	N/A	N/A	-4.60	(6.0, -4.0)
LTE Band 48	Ant.E	OPUS 75	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.77	**31.04**	-35.85	2.00	N/A	N/A	-4.81	(6.0, -4.0)
LTE Band 48	Ant.E	OPUS 75	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.77	128	424	2.00	20	26	-3.84	(6.0, -4.0)
NR Band n2	Ant.A	OPUS 6	CH.376000 1880 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	41.44	-43.91	1.94	N/A	N/A	-2.47	(6.0, -4.0)
NR Band n5	Ant.A	OPUS 6	CH.167300 836.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.65	44.29	-47.44	1.70	N/A	N/A	-3.15	(6.0, -4.0)
NR Band n25	Ant.A	OPUS 6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	40.95	-44.71	2.00	N/A	N/A	-3.76	(6.0, -4.0)
NR Band n30	Ant.A	OPUS 6	CH.462000 2310 MHz	10 MHz	DFT-s-OFDM QPSK	1/1	-56.65	44.55	-47.49	1.53	N/A	N/A	-2.94	(6.0, -4.0)
NR Band n66	Ant.A	OPUS 6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	41.61	-46.13	1.89	N/A	N/A	-4.52	(6.0, -4.0)
NR Band n70	Ant.A	OPUS 6	CH.340500 1702.5 MHz	15 MHz	DFT-s-OFDM QPSK	1/1	-56.65	42.48	-45.57	1.54	N/A	N/A	-3.09	(6.0, -4.0)
NR Band n71	Ant.A	OPUS 6	CH.136100 680.5 MHz	20 MHz	DFT-s-OFDM QPSK	1/1	-56.65	43.77	-46.65	1.53	N/A	N/A	-2.88	(6.0, -4.0)
NR Band n25	Ant.A	OPUS 6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	**193**	514	1.11	21	26	-2.52	(9.0, -6.0)
NR Band n41	Ant.A	OPUS 6	CH.518598 2592.99 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.65	150	443	1.40	18	26	-4.26	(6.0, -4.0)
NR Band n48	Ant.E	OPUS 6	CH.641666 3624.99 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	112	403	1.95	20	26	-3.91	(6.0, -4.0)
NR Band n77	Ant.E	OPUS 6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.65	**100**	386	1.52	18	26	-4.03	(6.0, -4.0)
NR Band n78	Ant.E	OPUS 6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.65	104	394	1.38	19	26	-4.02	(6.0, -5.0)
WiFi 2.4GHz 802.11b	Ant.D SISO	OPUS 40	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.77	162	485	2.00	25	26	-3.45	(6.0, -4.0)
WiFi 5GHz 802.11ac VHT20 U-NII-1	Ant.D SISO	OPUS 75	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.77	33.96	-38.70	2.00	N/A	N/A	-4.74	(7.0, -5.0)
WiFi 5GHz 802.11ac VHT20 U-NII-2A	Ant.D SISO	OPUS 75	CH.56 5280 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.64	35.33	-40.10	2.00	N/A	N/A	-4.77	(7.0, -5.0)
WiFi 5GHz 802.11ac VHT20 U-NII-2C	Ant.D SISO	OPUS 75	CH.120 5600 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.64	34.35	-39.16	2.00	N/A	N/A	-4.81	(7.0, -5.0)
WiFi 5GHz 802.11ac VHT20 U-NII-3	Ant.D SISO	OPUS 75	CH.157 5785 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.64	32.53	-37.25	2.00	N/A	N/A	-4.72	(7.0, -5.0)
WiFi 5GHz 802.11ac VHT20 U-NII-3	Ant.D SISO	OPUS 75	CH.157 5785 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.64	**144**	457	2.00	23	26	-3.36	(7.0, -4.0)

9.8. HAC (T-coil) Test Results

CMRS

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location	Plot No.
GSM 850	Ant.A	FR V1	CH.190 836.6 MHz	N/A	N/A	N/A	-56.63	116	377	1.56	20	26	-3.09	(6.0, -4.0)	1,2
WCDMA Band V	Ant.A	AMR-WB 6.6	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.63	271	663	1.56	26	26	-4.01	(6.0, -4.0)	3,4
LTE Band 66	Ant.A	EVS-SWB 9.6	132322 1745 MHz	20 MHz	64QAM	1/0	-56.77	253	621	2.00	26	26	-4.79	(6.0, -4.0)	5,6
LTE Band 48	Ant.E	EVS-SWB 9.6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.75	123	422	2.00	20	26	-4.83	(6.0, -4.0)	7,8
NR Band n66	Ant.B	EVS-swb 9.6	CH.349000 1745 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.69	192	510	2.00	20	26	-4.80	(6.0, -4.0)	9,10
NR Band n77	Ant.E	EVS-swb 16.4	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.69	86	370	2.00	17	26	-4.48	(6.0, -4.0)	11,12
WiFi 2.4GHz 802.11b	Ant.D SISO	AMR-WB 6.6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.56	144	469	2.00	23	26	-3.86	(6.0, -4.0)	13,14
WiFi 5GHz 802.11ac VHT20 U-NII-1	Ant.D SISO	EVS-SWB 9.6	CH.40 5200 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.67	167	488	2.00	24	26	-4.69	(6.0, -4.0)	15,16

OTT(Google Meet)

Mode / Band	Antenna	Voice Codec / Codec bitrate (kbps)	Channel and Frequency	Bandwidth	Waveform / Modulation	RB configuration	Ambient Noise dB(A/m)	Primary Group	Secondary Group	Frequency Response (dB)	Contiguous Longitudinal	Contiguous Transverse	H-max dB(A/m)	Hmax Location	Plot No.
GSM850 EGPRS 2slots	Ant.A	OPUS 6	CH.190 836.6 MHz	N/A	N/A	N/A	-56.64	136	458	1.76	20	26	-4.57	(6.0, -3.0)	17,18
WCDMA Band V HSUPA Subtest1	Ant.A	OPUS 40	CH.4183 836.6 MHz	N/A	N/A	N/A	-56.64	262	615	1.43	26	26	-3.46	(6.0, -4.0)	19,20
LTE Band 66	Ant.A	OPUS 6	132322 1745 MHz	20 MHz	64QAM	1/0	-56.77	257	607	1.43	26	26	-4.50	(6.0, -4.0)	21,22
LTE Band 48	Ant.E	OPUS 6	CH.55773 3603.3 MHz	20 MHz	QPSK	1/0	-56.77	125	428	1.28	22	26	-4.08	(6.0, -4.0)	23,24
NR Band n25	Ant.A	OPUS 6	CH.376500 1882.5 MHz	40 MHz	DFT-s-OFDM QPSK	1/1	-56.65	193	514	1.11	21	26	-2.52	(9.0, -6.0)	25,26
NR Band n77	Ant.E	OPUS 6	CH.650000 3750 MHz	100 MHz	DFT-s-OFDM QPSK	1/1	-56.65	100	386	1.52	18	26	-4.03	(6.0, -4.0)	27,28
WiFi 2.4GHz 802.11b	Ant.D SISO	OPUS 6	CH.6 2437 MHz	20 MHz	DSSS 1 Mbps	N/A	-56.77	116	433	1.99	22	26	-3.89	(7.0, -4.0)	29,30
WiFi 5GHz 802.11ac VHT20 U-NII-3	Ant.D SISO	OPUS 75	CH.157 5785 MHz	20 MHz	MCS 0 6.5 Mbps	N/A	-56.64	144	457	2.00	23	26	-3.36	(7.0, -4.0)	31,32

Note:

The radial longitudinal (x axis), axial (z axis) measurements are no longer required per ANSI C63.19-2019.
Additional tests were performed with folder opened condition using worst case in folder closed for each technology.

9.9. Worst Case T-Coil Test Plot

CMRS_NR TDD n77_Ant.E_EVS-swb 16.4_ch.650000

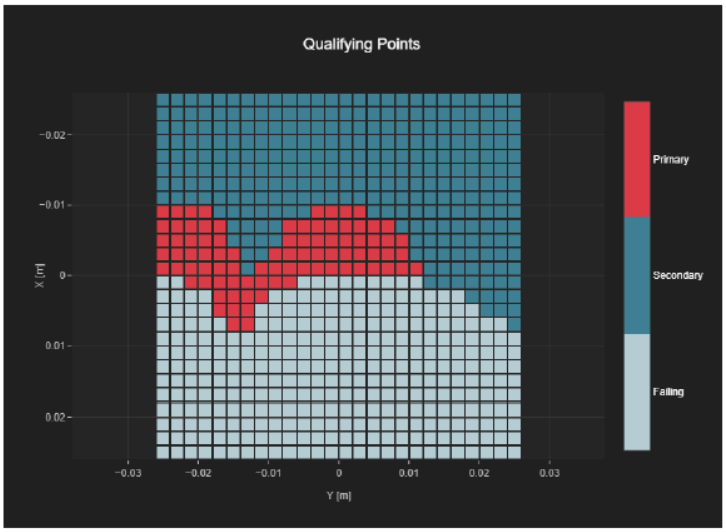
T-Coil Coupling Mode Test Report

Device Under Test

Manufacturer	Model
Samsung Electronics	SM-A166U

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
86	370	17	26



Appendix

Refer to separated files for the following appendixes

S-4791440365-S3 Appendix A_Setup Photo

S-4791440365-S3 Appendix B_Test Plots

S-4791440365-S3 Appendix C_Probe Certificate

END OF REPORT