ELECTRONICS TEST CENTRE
MPB TECHNOLOGIES INC.

ACCREDITED
TESTING CERT#2750.01

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EMC testing of the Tektelic Communication Inc. Kona Enterprise Gateway in accordance with FCC Part 15.247, ANSI C63.4: 2014 and ANSI C63.10: 2013 as referenced by FCC OET KDB 558074 D01 15.247 Measurement Guidance v05r02.

FCC ID: 2ALEPT0007902

Tested by: Imran Akram, Janet Mijares, Brandon Van Hee

Prepared for: Tektelic Communication Inc.

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REVISION RECORD

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2022-01-10	I. Akram	Initial draft submitted for review.
Release1	2022-01-11	I. Akram	Sign Off

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1.0 INTRODUCTION

1.1 Scope

The purpose of this report is to present the results of compliance testing performed in accordance with FCC Part 15.247, ANSI C63.4-2014 and ANSI C63.10-2013 to gain FCC Certification Authorization for Low-Power License-Exempt transmitters. All test procedures, limits, criteria, and results described in this report apply only to the Tektelic Communication Inc. Kona Enterprise Gateway test sample, referred to herein as the EUT (Equipment Under Test).

The sample has been provided by the customer.

This report does not imply product endorsement by the Electronics Test Centre, A2LA, nor any Canadian Government agency.

1.2 Applicant

This test report has been prepared for Tektelic Communication Inc., located in Calgary, Alberta, Canada.

1.3 Test Sample Description

As provided to ETC (Airdrie) by Tektelic Communication Inc.:

Product Name:			*Kona Enterprise Gateway
LoRa Radio	**Frequency Band**		902 – 928 MHz
	Type of Modulation		Chirp Spread Spectrum
	BW / Frequency Range		DTS 500kHz, 903 – 927.5 MHz
	Associated Antenna	**Internal**	SRF2I019 (flexiiANT), Polarization Linear, PK Gain=1.9dBi
		External	WTTX-OMNI08600930-8-NJ, Polarization Vertical, Gain= 8dBi (highest gain antenna) WTTX-OMNI08600930-6-NJ, Gain = 6dBi WTTX-OMNI08600930-2.5-NJ, Gain = 2.5dBi
	Detachable/Non Detachable		Detachable (Professional Installation)
FCC ID			2ALEPT0007902
Firmware (LoRa Hal)			**4.0.1-r2**
Model# / Serial#			T0007242/ 2144J0018
Power supply:			POE

***** Contain Pre-certified LTE Module

Note: All three channels of LoRa Radio for T0007242 with highest gain external antenna were evaluated. Worse Channel was selected for detail analysis for radiated emission.

1.4 General Test Conditions

The EUT was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. All inputs and outputs to and from other equipment associated with the EUT were adequately simulated.

The environmental conditions are recorded during each test and are reported in the relevant sections of this document.

1.5 References Standards

Standards	Description
FCC, title 47 CFR § 15.247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
FCC, title 47 CFR § 15.207	General Requirements for Compliance of Radio Apparatus
FCC, title 47 CFR § 15.209	Intentional radiator, conducted emission limits
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ANSI C63.10-2014	American National Standard for Methods of Measurement of Radio – Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 KHz to 40 GHz
558074 D01 15.247 Meas Guidance v05r02	Guidance For Compliance Measurements On Digital Transmission System, Frequency Hopping Spread Spectrum System, And Hybrid System Devices Operating Under Section 15.247 Of The FCC Rules

1.5.1 Test Methodology

Test methods are specified in the Basic Standard as referenced and/or modified by the Product Standard in the part of Section 2 of this report associated with each particular test case.

1.5.2 Variations in Test Methodology

Any variance in methodology or deviation from the reference Standard is documented in the part of Section 2 of this report associated with each particular Test Case.

1.5.3 Test Sample Verification, Configuration & Modifications

EUT setup, configuration, protocols for operation and monitoring of EUT functions, and any modifications performed in order to meet the requirements, are detailed in each Test Case of Section 2 of this report.

1.5.4 Uncertainty of Measurement:

The factors contributing to uncertainty of measurement are identified and calculated in accordance with UKAS (United Kingdom Accreditation Service) document “Lab 34, The Expression of Uncertainty in EMC Testing, Aug 2002.” as based on the “ISO Guide to the Expression of Uncertainty in Measurement, 1995.”

This uncertainty estimate represents an expended uncertainty expressed at approximately 95% confidence using a coverage factor of k = 2.

Test Method	Uncertainty
Radiated Emissions Level (9 KHz – 1 GHz)	±4.6 dB
Radiated Emissions Level (1 GHz – 26.5 GHz)	±5.31 dB
Conducted Emissions Level (150 KHz – 30 MHz)	±2.7 dB
Uncertainty Conducted Power level	±0.5 dB
Uncertainty Conducted Spurious emission level	±0.6 dB
Uncertainty for Bandwidth test	±1.5 %

2.0 TEST CONCLUSION

STATEMENT OF COMPLIANCE

The customer equipment referred to in this report was found to comply with the requirements, as summarized below.

The measurement uncertainty is not accounted for determination of the statement of compliance. The statement of compliance is based only on the measurement value recorded.

The EUT was subjected to the following tests. Compliance status is reported as **Compliant** or **Non-compliant**. **N/A** indicates the test was Not Applicable to the EUT.

> **Note:** Maintenance of compliance is the responsibility of the Manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the EUT with respect to the standards detailed in this test report.

The following table summarizes the tests performed in terms of the specification, class or performance criterion applied, and the EUT modification state.

Test Case	Test Type	Specification	Test Sample	Modifications	Config.	Result
Frequency Range = (903 – 927.5) MHz 500 KHz DTS Mode Max. Conducted Tx Power =27.15dBm (0.519)Watt						
2.1	AC Conducted Emissions (Tx)	15.207	Kona Enterprise Gateway	none	see § 2.1	**Compliant**
2.2	6 dB Bandwidth	15.247(a)(1) 15.247(2)(2)	Kona Enterprise Gateway	none	see § 2.2	**Compliant**
2.3	Max Average Output Power (Conducted)	15.247(b)	Kona Enterprise Gateway	none	see § 2.3	**Compliant**
2.4	Power Spectral Density	15.247(e) 15.247(f)	Kona Enterprise Gateway	none	see § 2.4	**Compliant**
2.5	Band Edge	15.247(d)	Kona Enterprise Gateway	none	see § 2.5	**Compliant**
2.6	Conducted Spurious Emission in (Non-Restricted Band)	15.247(d)	Kona Enterprise Gateway	none	see § 2.6	**Compliant**
2.7	EUT Position	ANSI C63.10	Kona Enterprise Gateway	none	see § 2.7	**n/a**
2.8	Radiated Spurious Emission in (Restricted Band)	15.205, 15.209 15.247(d)	Kona Enterprise Gateway	none	see § 2.8	**Compliant**
2.9	RF Exposure	15.247(i)	Kona Enterprise Gateway	none	see § 2.9	**Compliant**

Refer to the test data for applicable test conditions.

2.1 AC Power Line Conducted Emissions

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Branden Van Hee	**Standard: FCC Part 15.207**
Date: 2021-12-28 (18.6°C,4.4% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

Comments: Test is performed at AC port of POE adaptor. Although manufacture is not providing the POE adaptor.

Specification: Part15-207

Frequency (MHz)	Quasi-Peak Limit (dBµV)	Average Limit (dBµV)
0.15 – 0.5	66 – 56	56 – 46
0.5 – 5	56	46
5 – 30	60	50
Criteria: The conducted emissions produced by a device shall not exceed the limits as specified.		

2.1.1 Test Guidance: ANSI C63.4-2014, Clause 7.3.1 & ANSI C63.10: 2013

Before any testing is performed, the Ambient (measurement noise floor) is recorded, and a QC check is performed to show that the system is functioning correctly.
Testing starts with a scan, performed under software control. After this is complete, the list of frequencies of interest is generated. These frequencies are then investigated for quasi-peak and average amplitude, as applicable. Emissions measured with a QP detector that fall below the Average limit are deemed to meet both requirements.

2.1.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.1.3 Test Equipment

Testing was performed with the following equipment:

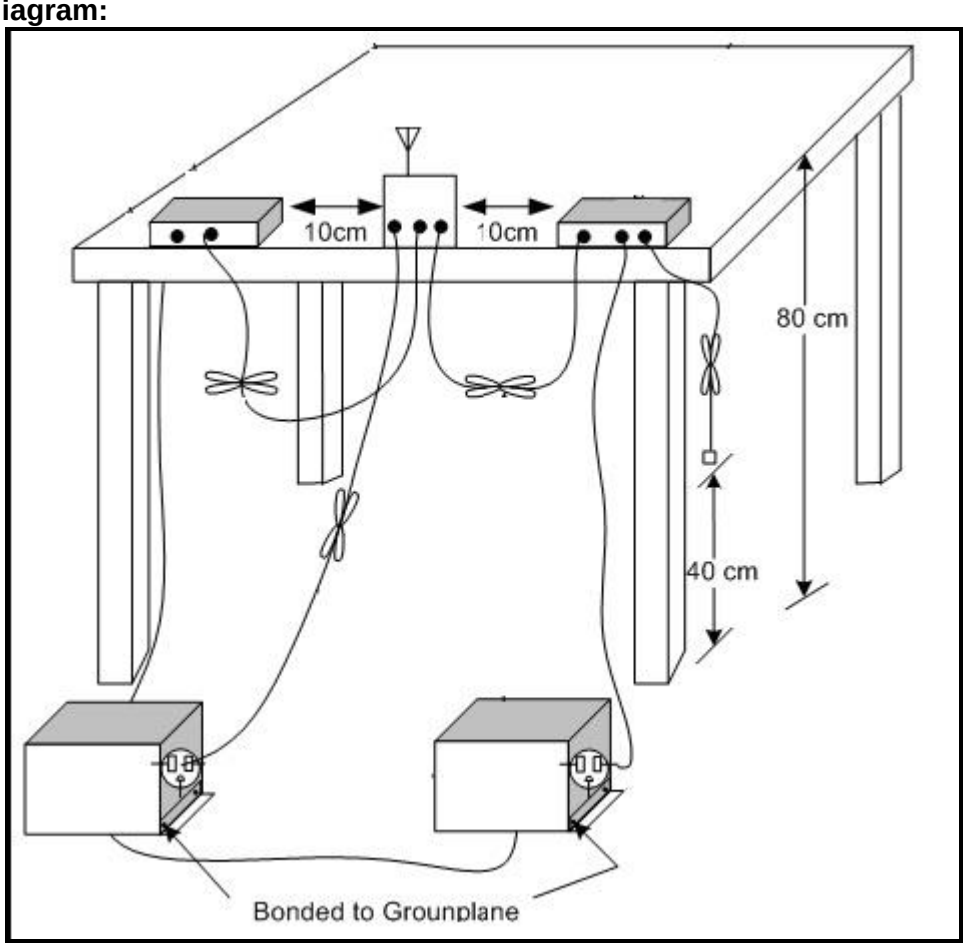
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	N/A
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2021-06-18	2022-06-18
LISN	Com-Power	LI-215A	6180	2020-06-30	2022-06-30
Temp/RH logger	Extech	42270	5892	2021-04-06	2022-04-06

2.1.4 Test Sample Verification, Configuration & Modifications

The EUT was set to selected channels with test-specific software. The output was modulated as in normal operation. Configuration in Tx mode. Test was performed at AC port of POE adaptor model# PD-9501GO-ET/AC Manufacture Microsemi Corp.

The EUT met the requirements without modification.

Test setup diagram:



2.1.5 Conducted Emissions Data:

The EUT was evaluated in all transmit mode. No mode of transmission showed emission worst then another. The plots are from the DTS mode using mid-channel.

Freq. Marker	Freq. (MHz)	Raw reading(dBµv)	Det.	LISN Factor (dB/m)	Cable Loss (dB)	Corrected Reading (dBµV)	FCC 15.207 Limit (dBµV)	Delta (dB)	L / N
1	0.438	43.13	AV	0	.2	43.33	47.1	-3.77	Line
2	0.451	45.02	AV	0	.2	45.22	46.87	-1.65	Line
3	0.468	45.19	AV	0	.2	45.39	46.55	-1.16	Line
4	0.473	46.2	AV	0	.2	46.4	46.46	-0.06	Line
5	0.504	42.69	AV	0	.2	42.89	46	-3.11	Line
1	0.427	41.7	AV	0	.2	41.9	47.31	-5.41	Neutral
2	0.460	45.29	AV	0	.2	45.49	46.7	-1.21	Neutral
3	0.473	46.22	AV	0	.2	46.42	46.45	-0.03	Neutral
4	0.505	42.13	AV	0	.2	46	46.0	-3.67	Neutral

AV = Average Detector

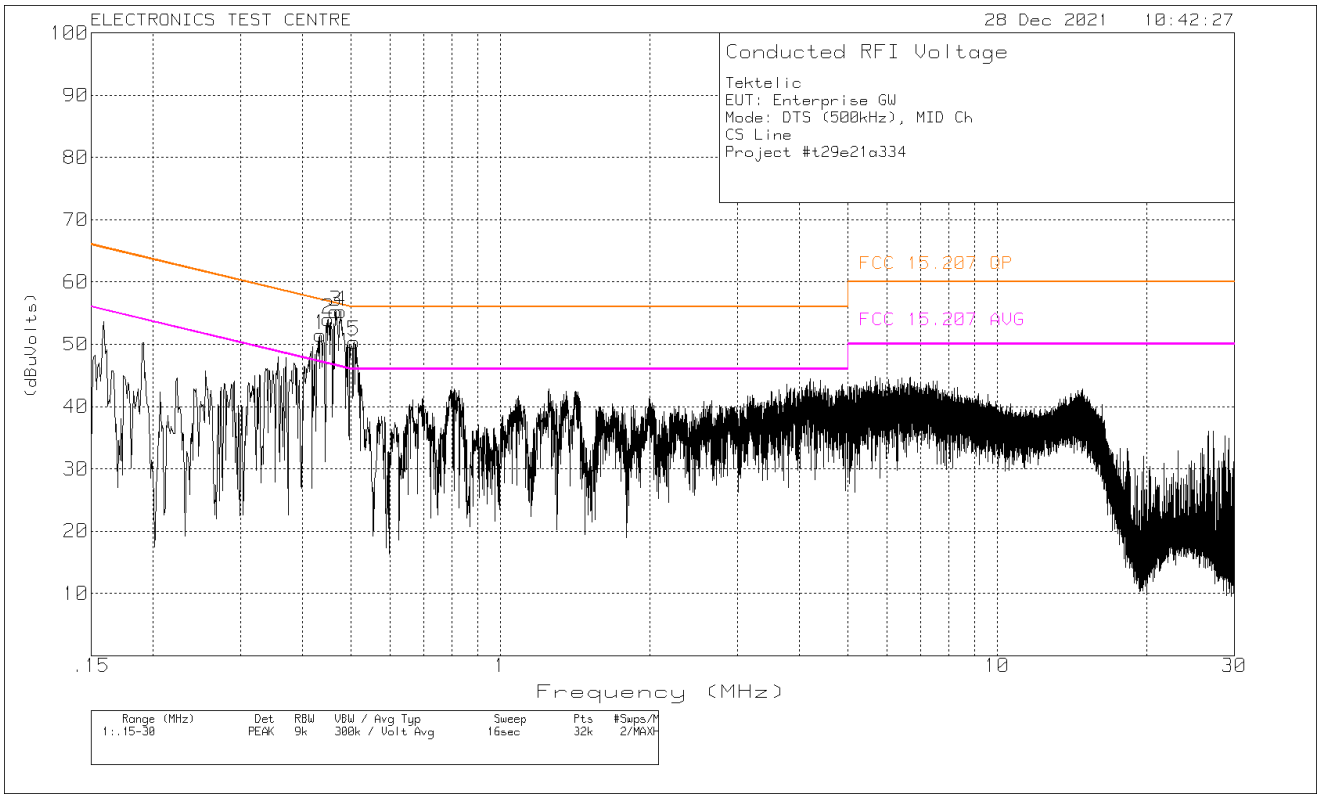
Raw Reading in dBµV + LISN Factor dB + Gain/Loss Factor in dB = Corrected Field Strength in dbµV.

Note: When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.

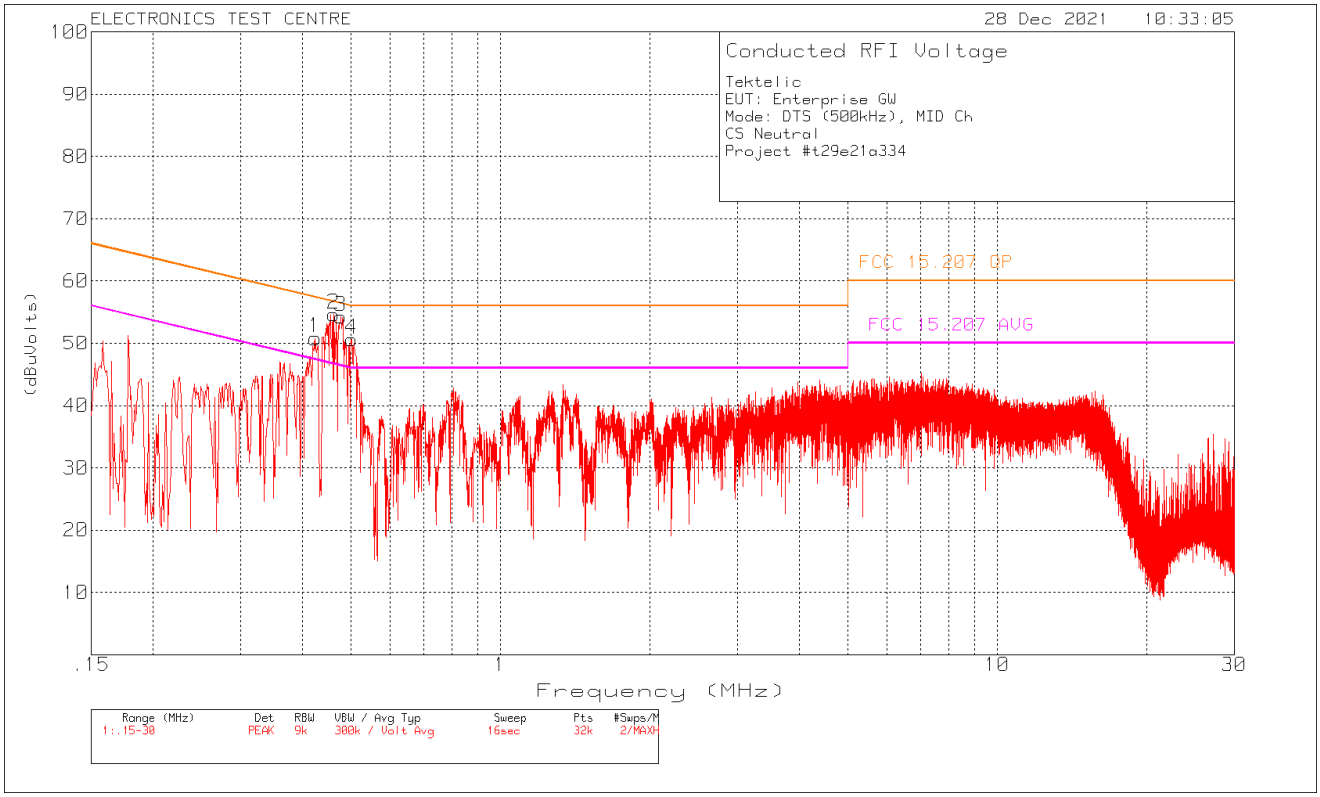
Negative values for Delta indicate compliance.

The Ground Bond was measured and found to be 1.25 mΩ.

Plot of Conducted Emissions: Line



Plot of Conducted Emissions: Neutral



2.2 6 dB Bandwidth

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date:2021-12-29 (21.6°C, 5.3% RH)	**Basic Standard: ANSI C63.10-2013 KDB 558074 D01 15.247 Measurement Guidance v05r02**

EUT status: Compliant

Specification: FCC Part 15.247 (a, 2), FCC 15.215 (c)

Criteria: Systems using digital modulation techniques may operate in the 902-928 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

2.2.1 Test Guidance: FCC KDB 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.2 / ANSI C63.10 clause 11.8

This measurement is performed at low, mid and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

Use the following spectrum analyzer settings: DTS 6 dB BW	
Span	between two times and five times the channel center frequency OBW
RBW	100 KHz
VBW	Set the VBW ≥ [3 × RBW].
Sweep	Auto Couple
Detector function	peak
Trace mode	max hold
Allow the trace to stabilize. The automatic bandwidth measurement capability of an instrument employed using the X dB bandwidth mode with X set to 6 dB	

2.2.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.2.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EXA Signal Analyzer	Agilent	N9010A FW A.14.16	6678	2021-07-22	2022-07-22
Temp/Humidity	Extech	42270	5892	2021-04-05	2022-04-15
Attenuator	Mini-Circuits®	BWS102W263	6932	Cal. before each use	
Coaxial Cables (RF)	Huber+Suhner	Enviroflex 400	-	Cal. before each use	

2.2.4 Test Sample Verification, Configuration & Modifications

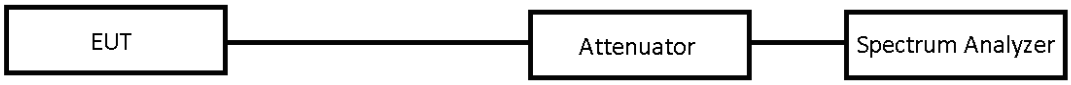
The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation. The EUT modified to provide the direct access to antenna port for conducted measurements.

For compliance purposes EUT met requirements without any modification

There is no Deviation and exclusions from test specifications.

Test setup diagrams for Occupied Bandwidth testing:

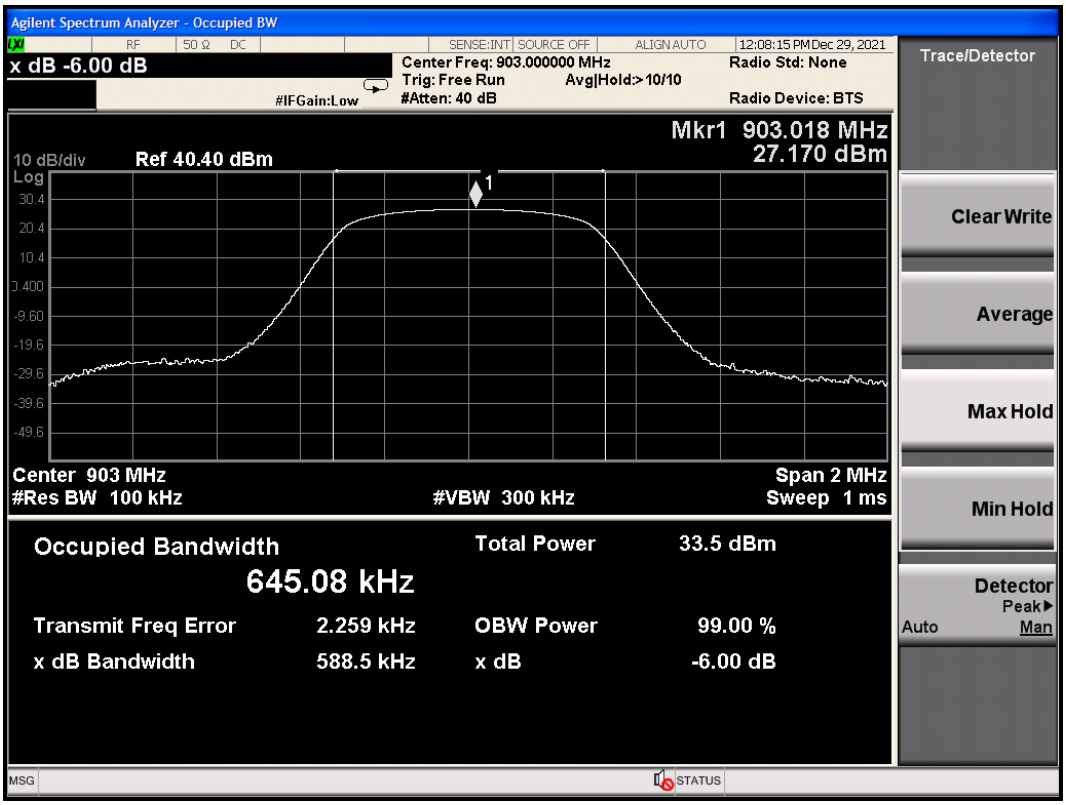
Conducted:



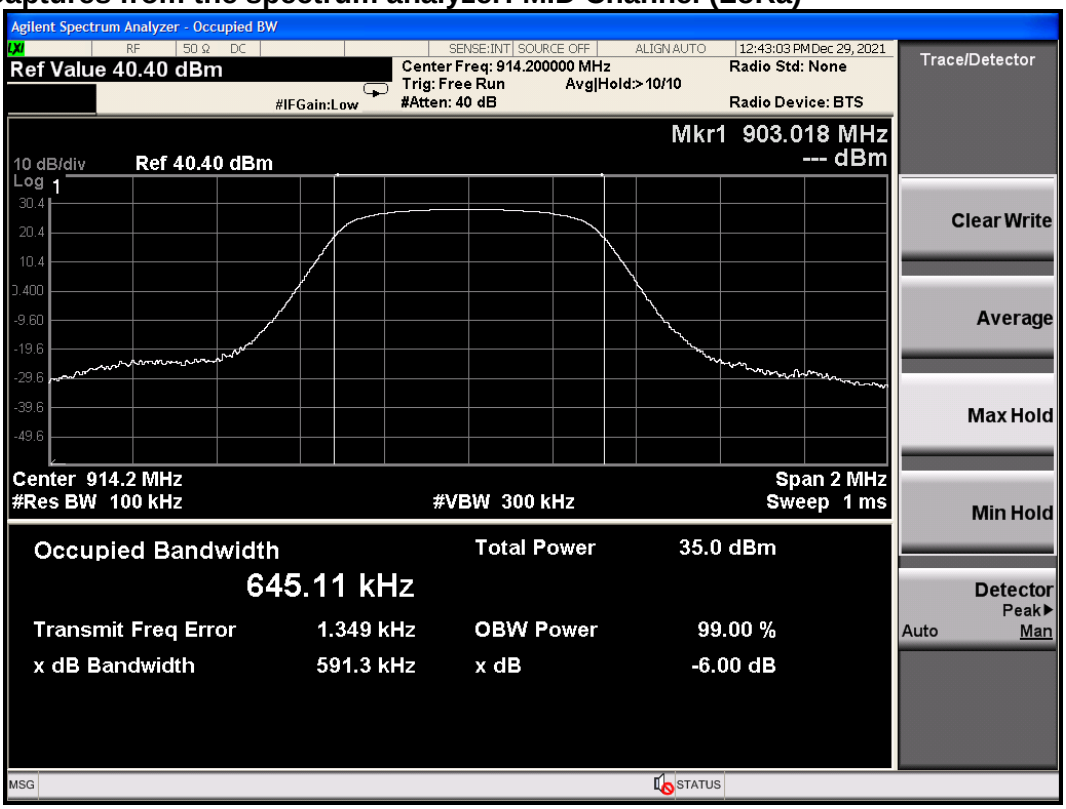
2.2.5 Channel Occupied Bandwidth Data: (LoRa)

Channel	Freq. [MHz]	6 dB OBW [kHz]	Limit 6 dB OBW
Low	903	588.5	≥ 500 KHz
Mid	914.2	591.3	
High	927.5	581.1	

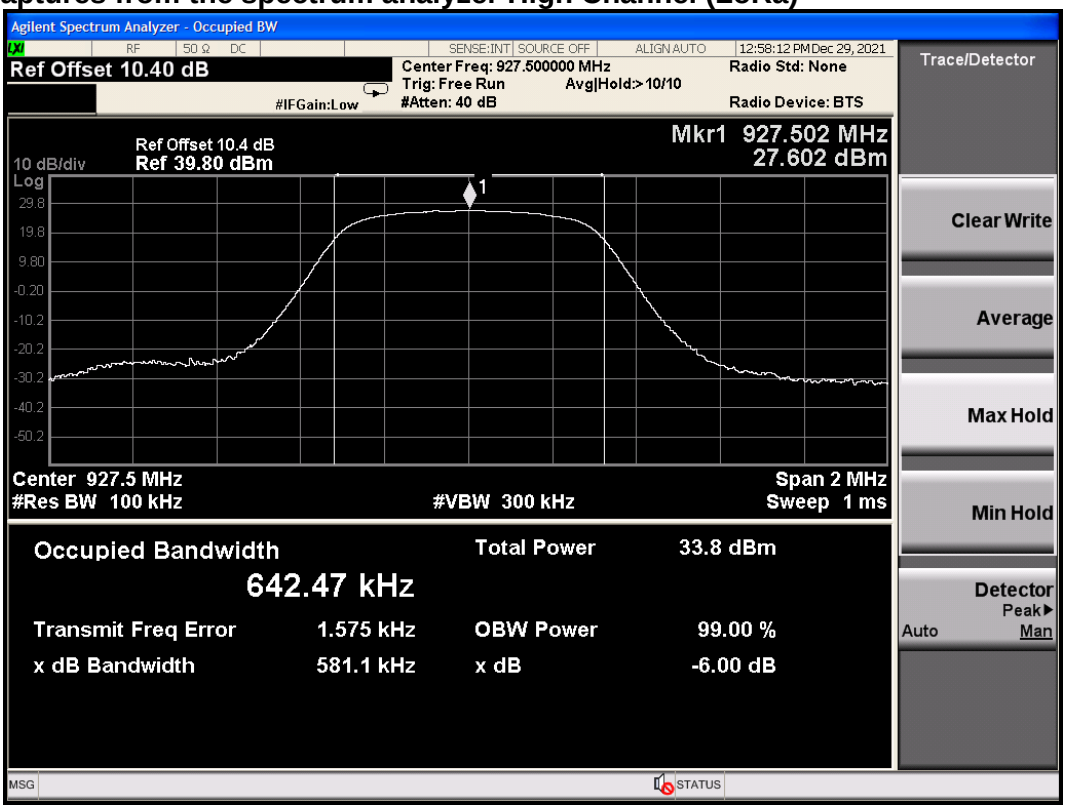
Screen Captures from the spectrum analyzer: Low Channel (LoRa)



Screen Captures from the spectrum analyzer: MID Channel (LoRa)



Screen captures from the spectrum analyzer High Channel (LoRa)



2.3 Maximum conducted (average) output power (DTS Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2021-12-29 (21.6°C, 5.3% RH)	**Basic Standard: ANSI C63.10: 2013 KDB 558074 D01 15.247 Measurement Guidance v05r02**

EUT status: Compliant

Specification: FCC Part 15.247(b, 3)

Criteria	For systems using digital modulation in the 902-928 MHz bands: 1 Watt.

2.3.1 Test Guidance: FCC KDB 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.3.2 / ANSI C63.10 Sub clause 11.9.2.2

This measurement is performed at low, mid and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

Output Power Method AVGSA-1	
Span	≥ 1.5 times the OBW
RBW	1 – 5 % of the OBW, ≤ 1 MHz
VBW	≥ 3 x RBW
Number of Points in sweep	≥ 2 x Span / RBW
Sweep time	Auto
Detector	RMS (Power Averaging)
Sweep trigger	Free Run (If Duty Cycle ≥98%)
Trace Average	At least 100 traces in power Averaging (RMS)
Power measured	Integrated the spectrum across the OBW of the signal using the S/A band power measurement function, with band limit set equal to the OBW band edge.

2.3.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.3.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EXA Signal Analyzer	Agilent	N9010A FW A.14.16	6678	2021-07-22	2022-07-22
Temp/Humidity	Extech	42270	5892	2021-04-05	2022-04-15
Attenuator	Mini-Circuits®	BWS102W263	6932	Cal. before each use	
Coaxial Cables (RF)	Huber+Suhner	Enviroflex 400	-	Cal. before each use	

2.3.4 Test Sample Verification, Configuration & Modifications

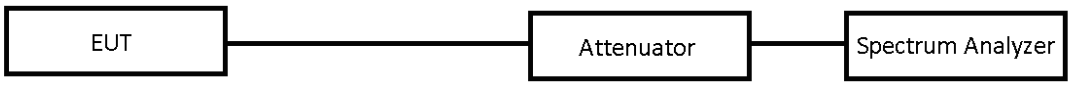
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

The EUT modified to provide the direct access to antenna port for conducted measurements.

For compliance purposes EUT met requirements without any modification

Test setup diagrams for Peak Power testing:

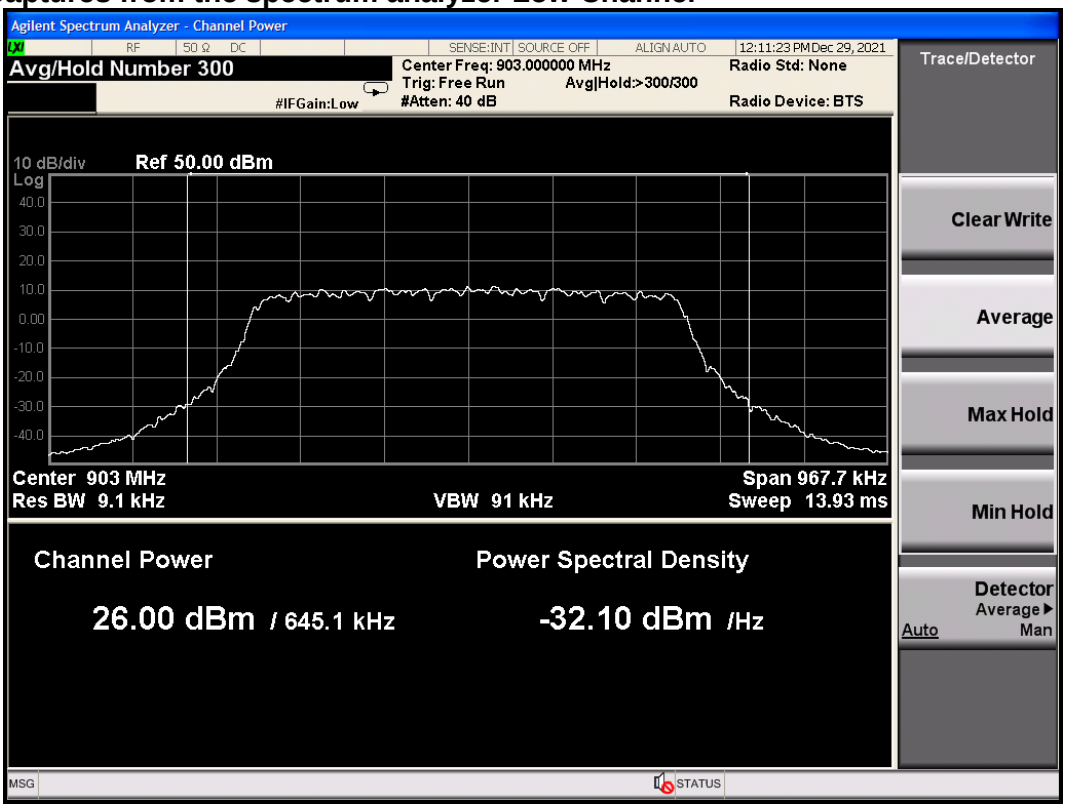
Conducted:



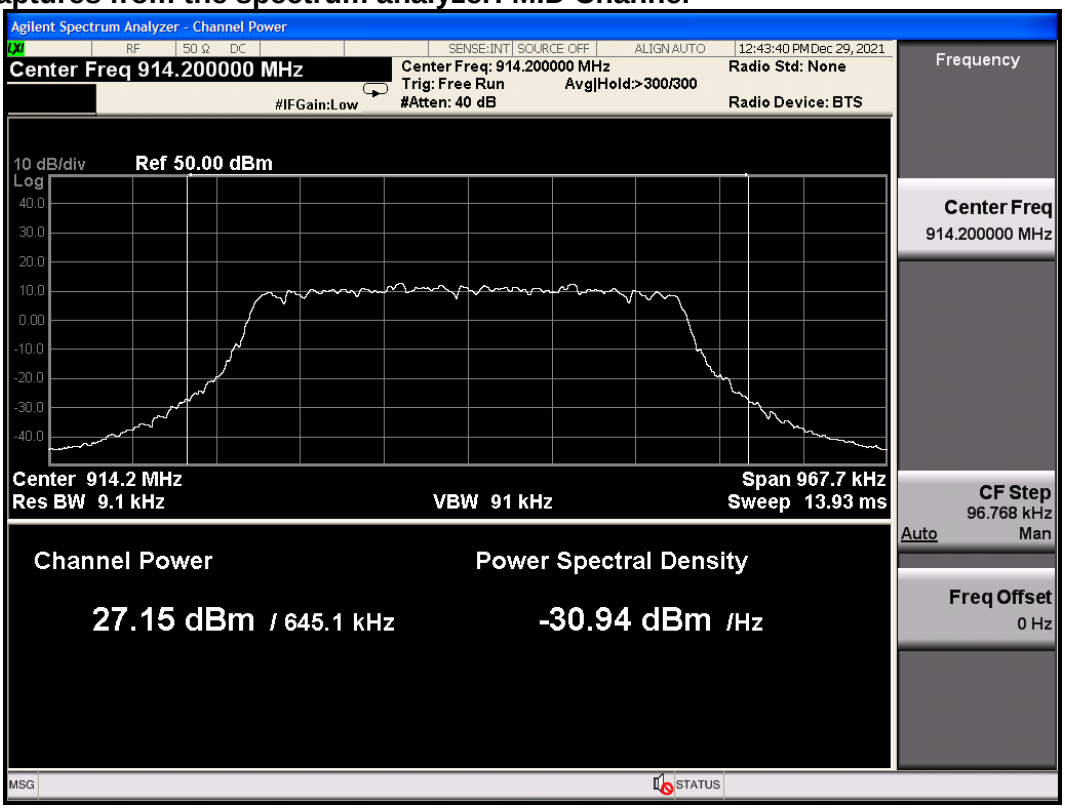
2.3.5 Average Output Power Data (LoRa)

Channel	Freq. [MHz]	Out Put Power (dBm)	Out Put Power Limit (dBm)	Margin (dB)
Low	903	26.0	30	4
Mid	914.2	27.15	30	2.85
High	927.5	25.95	30	4.05

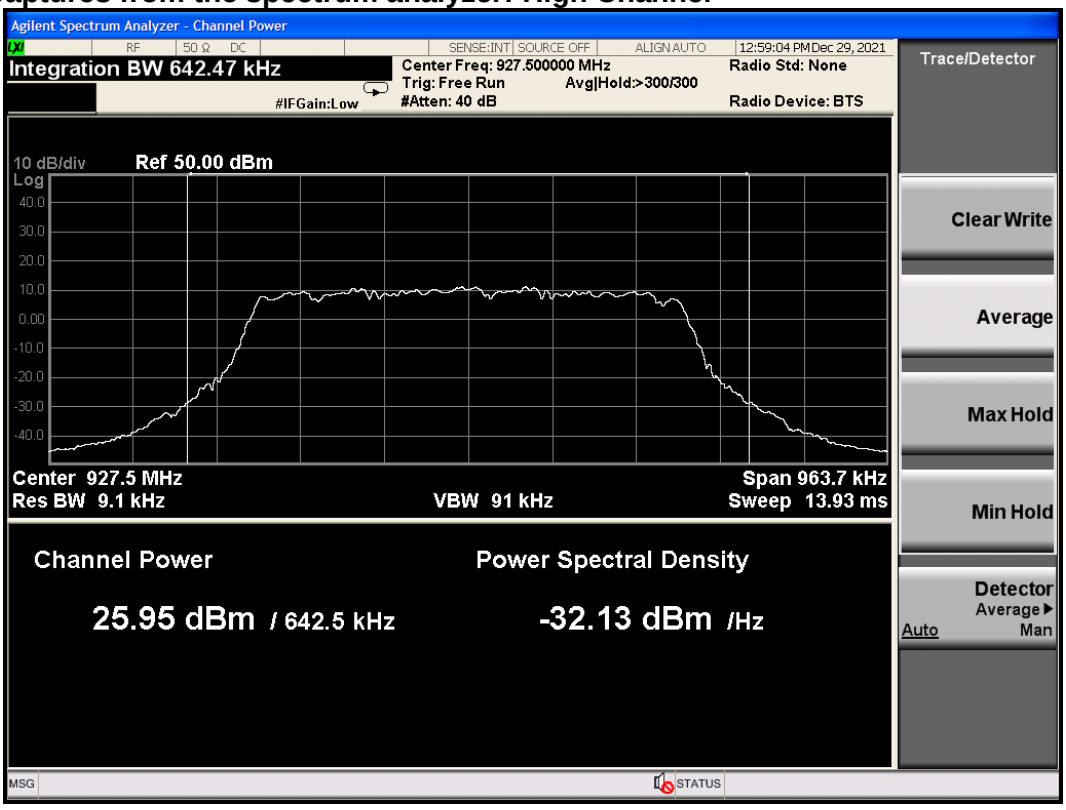
Screen Captures from the spectrum analyzer Low Channel



Screen Captures from the spectrum analyzer: MID Channel



Screen Captures from the spectrum analyzer: High Channel



2.4 Power Spectral Density

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2021-12-29 (21.6°C, 5.3% RH)	**Basic Standard: ANSI C63.10: 2013 KDB 558074 D01 15.247 Measurement Guidance v05r02**

EUT status: Compliant

Specification: FCC Part 15.247(e)

Criteria For digitally modulated systems the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

2.4.1 Test Guidance: FCC KDB 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.4 / Sub clause 11.10 of ANSI C63.10

This measurement is performed at low, mid and high frequencies, in continuous transmission, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

Use the following spectrum analyzer settings:	
Span	At least 1.5 times the OBW.
RBW	3 KHz
VBW	Set the VBW ≥ [3 × RBW].
Sweep	Auto Couple
Detector function	Power averaging (RMS) or sample detector (when RMS not available).
Trace mode	Employ trace averaging (RMS) mode over a minimum of 100 traces.
Allow the trace to stabilize. Use the peak marker function to determine the maximum amplitude level.	

2.4.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.4.3 Test Equipment

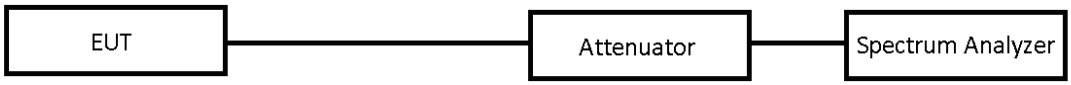
Testing was performed with this equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EXA Signal Analyzer	Agilent	N9010A FW A.14.16	6678	2021-07-22	2022-07-22
Temp/Humidity	Extech	42270	5892	2021-04-05	2022-04-15
Attenuator	Mini-Circuits®	BWS102W263	6932	Cal. before each use	
Coaxial Cables (RF)	Huber+Suhner	Enviroflex 400	-	Cal. before each use	

2.4.4 Test Sample Verification, Configuration & Modifications

The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation. The EUT met the requirements without modification.

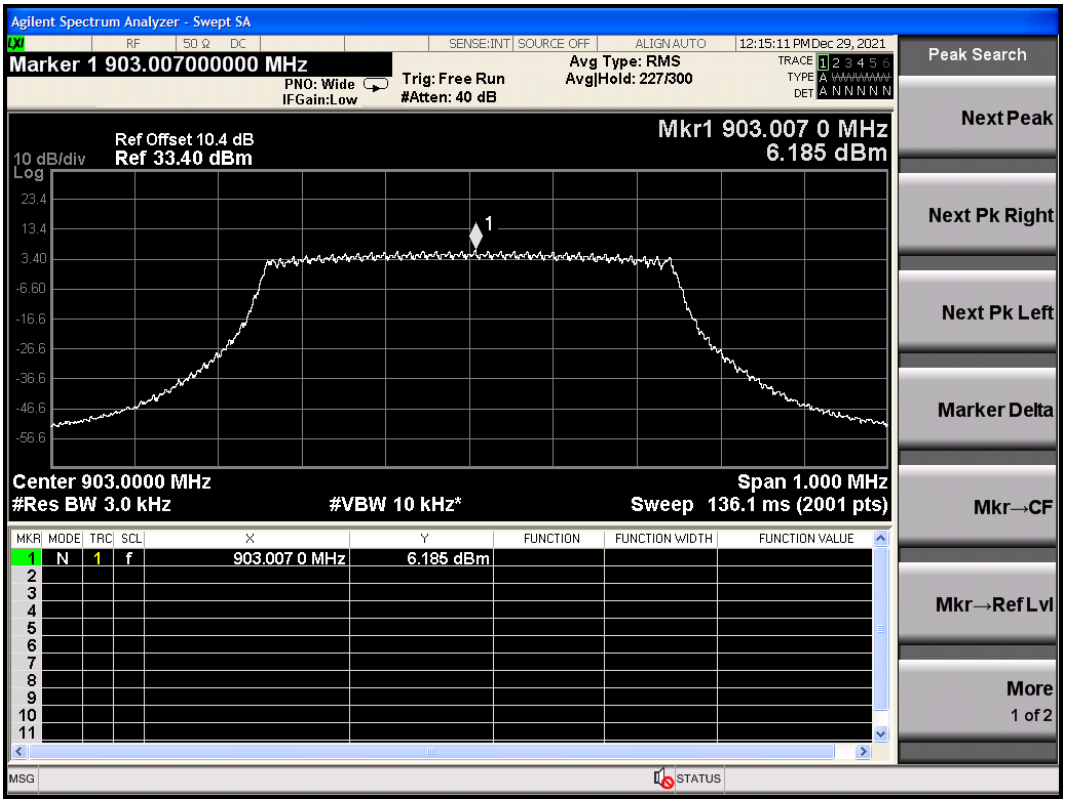
Test setup diagrams for Peak Power Spectral Density testing:
Conducted:



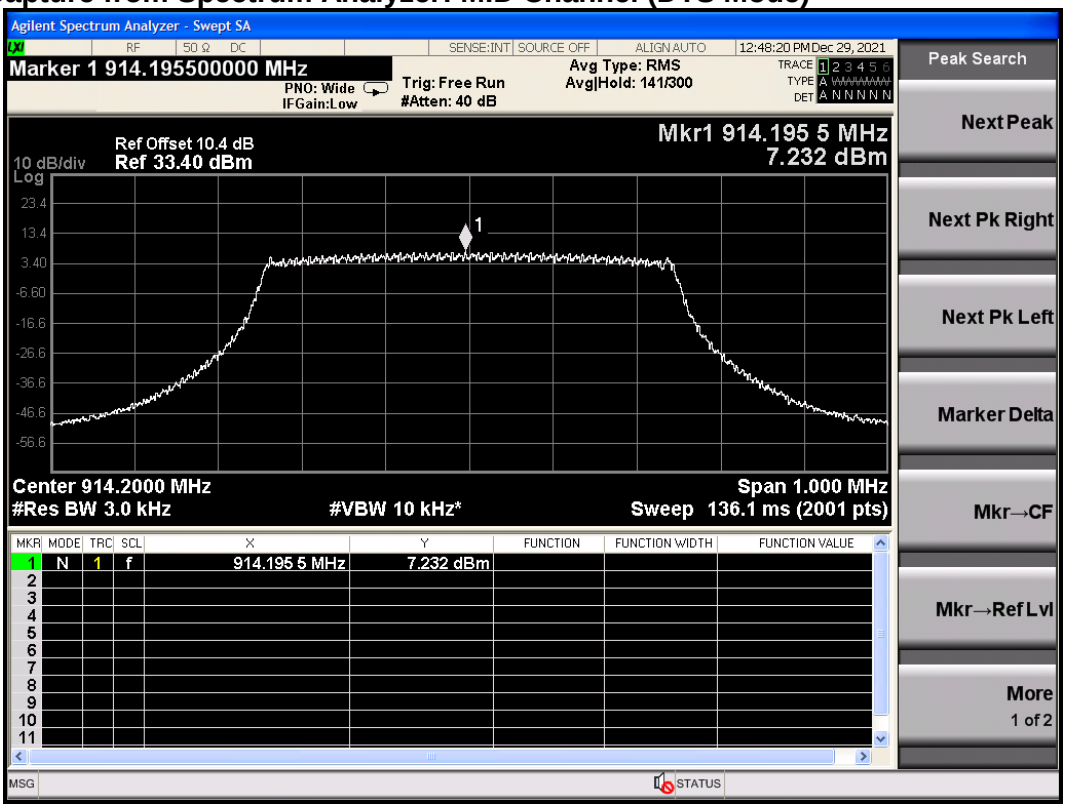
2.4.5 Average PSD Data (LoRa)

Channel	Freq. [MHz]	PSD (dBm/3KHz)	PSD Limit (dBm/3KHz)
Low	903	6.185	8
Mid	914.2	7.232	8
High	927.5	6.083	8

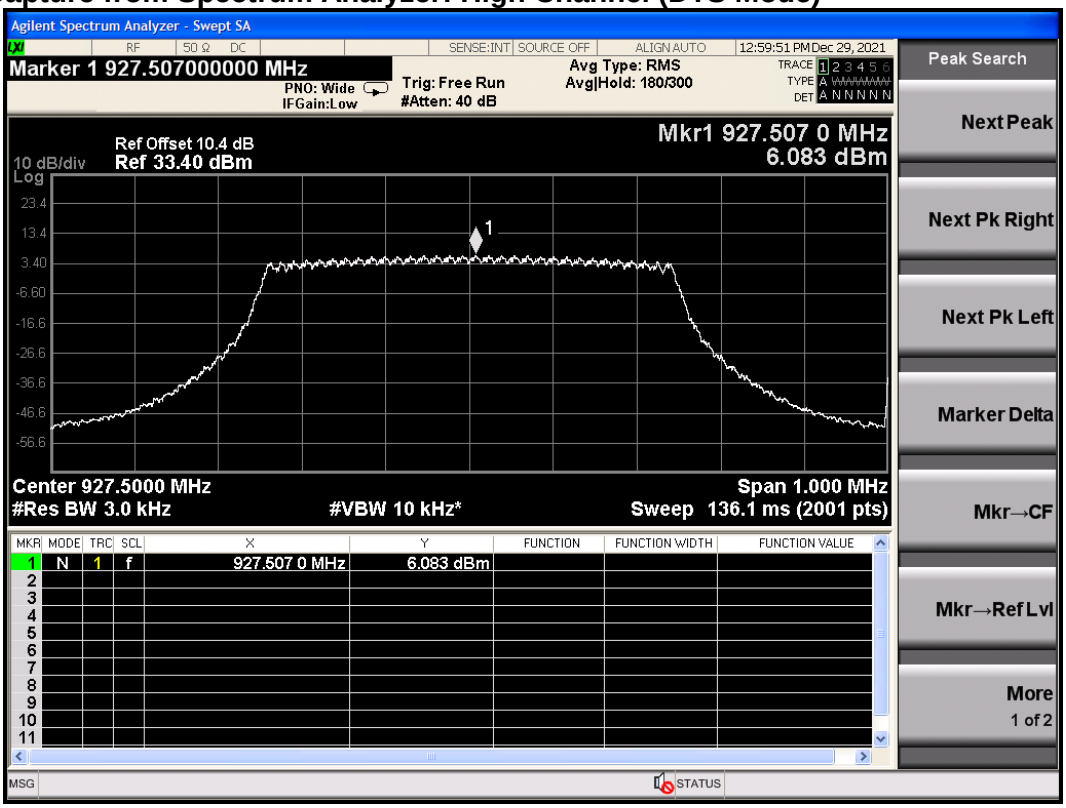
Screen Capture from Spectrum Analyzer: LOW Channel



Screen Capture from Spectrum Analyzer: MID Channel (DTS Mode)



Screen Capture from Spectrum Analyzer: High Channel (DTS Mode)



2.5 Band Edge Attenuation (DTS Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2021-12-29 (21.6°C, 5.3% RH)	**Basic Standard: ANSI C63.10: 2013 KDB 558074 D01 15.247 Measurement Guidance v05r02**

EUT status: Compliant

Specification: FCC Part 15.247(d)

Criteria: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.5.1 Test Guidance: ANSI C63.10-2013 Clause 11.11, 11.13.2, 6.10.4, 6.10.6 / FCC KDB 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.7

This measurement is performed at the low and high frequencies, with modulation.

The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.

Use the following spectrum analyzer settings:	
Span	Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
Attenuation	Auto (at least 10 dB preferred).
RBW	100 kHz
VBW	300 kHz
Sweep	Coupled
Detector function	peak
Trace	max hold
Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.	

2.5.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.5.3 Test Equipment

Testing was performed with the following equipment:

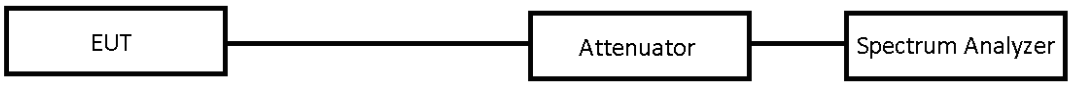
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EXA Signal Analyzer	Agilent	N9010A FW A.14.16	6678	2021-07-22	2022-07-22
Temp/Humidity	Extech	42270	5892	2021-04-05	2022-04-15
Attenuator	Mini-Circuits®	BWS102W263	6932	Cal. before each use	
Coaxial Cables (RF)	Huber+Suhner	Enviroflex 400	-	Cal. before each use	

2.5.4 Test Sample Verification, Configuration & Modifications

The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation. The EUT met the requirements without modification.

Test setup diagrams for Band Edge Attenuation testing:

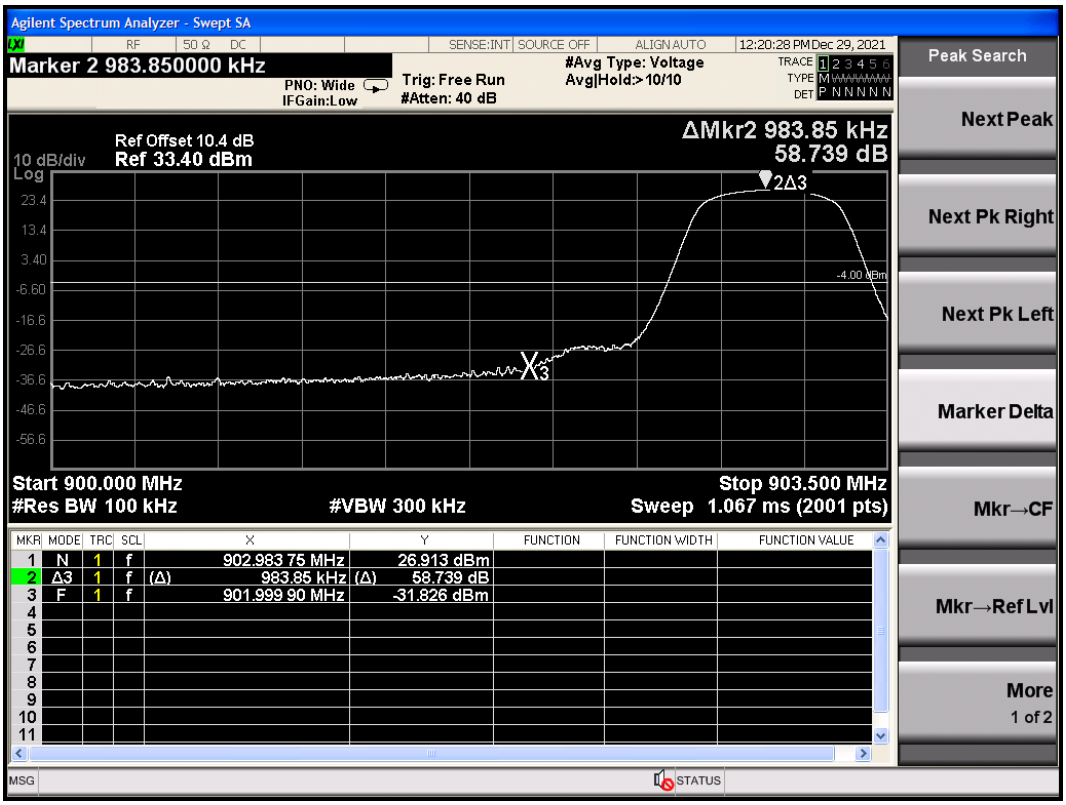
Conducted:



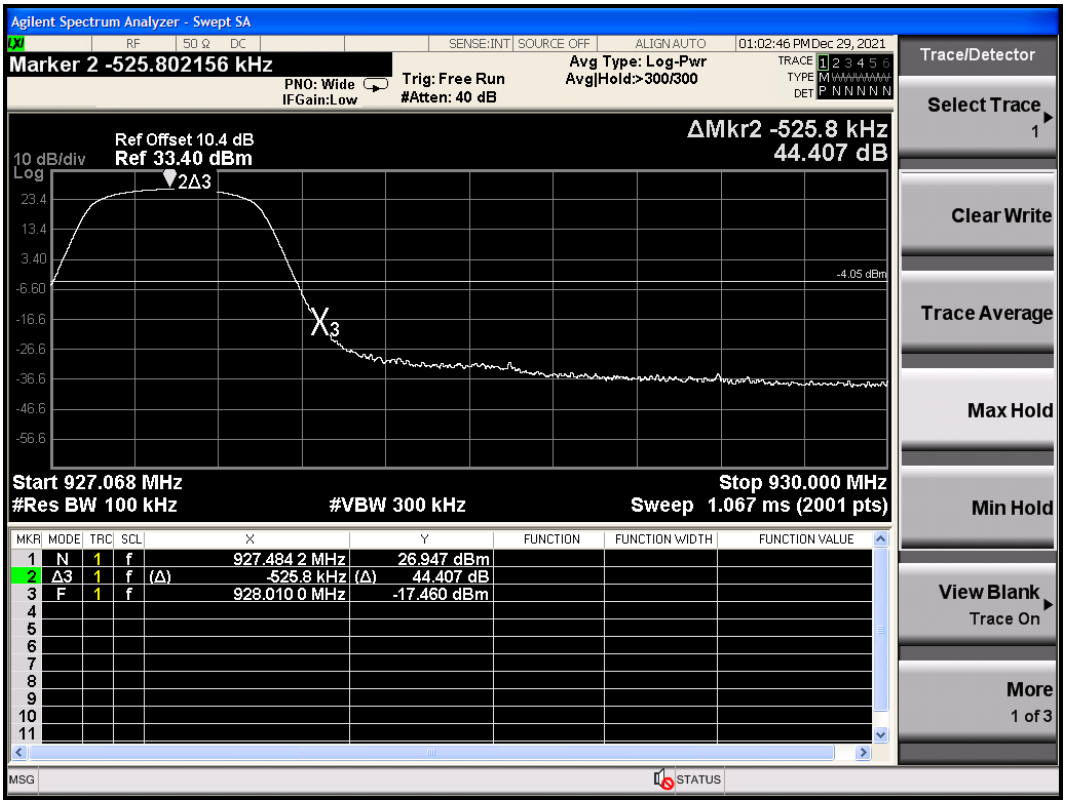
2.5.5 Band Edge Data (DTS MODE)

Modulation	Channel	Attenuation at Band Edge	Attenuation Limit at Band Edge
Lora 500KHz Channels	903	58.739dBc	30 dBc
	927.5	44.407dBc	30 dBc

Screen Capture from the spectrum analyzer: Lower Band Edge (DTS Mode)



Screen Capture from the spectrum analyzer: Upper Band Edge (DTS Mode)



2.6 Conducted Spurious Emissions in non-restricted frequency bands

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2021-12-29 (21.6°C, 5.3% RH)	**Basic Standard: ANSI C63.4-2014 KDB 558074 D01 15.247 Measurement Guidance v05r02**

EUT status: Compliant

Specification: FCC Part 15.247(d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

2.6.1 Test Guidance: ANSI C63.10-2013, Clause 6.7, 7.8.8 / 11.11.1(b) and 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.5

This measurement is performed at the low, mid and high frequencies, with modulation.
The RF output of EUT with an antenna connector is fed to the input of the spectrum analyzer through appropriate attenuation. The loss from the cable and the attenuator were added on the analyzer as gain offset setting there by allowing direct measurements, without the need for any further corrections.
The spectrum analyzer is stepped through the spectrum in frequency spans selected to ensure acceptable frequency resolution. The RBW is set to 100 kHz. The VBW is set to ≥ 300 kHz. The Peak detector is used, with the trace set to Max Hold.

2.6.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.6.3 Test Equipment

Testing was performed with the following equipment:

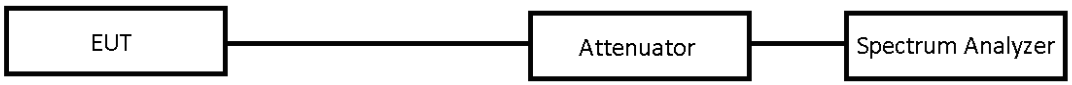
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EXA Signal Analyzer	Agilent	N9010A FW A.14.16	6678	2021-07-22	2022-07-22
Temp/Humidity	Extech	42270	5892	2021-04-05	2022-04-15
Attenuator	Mini-Circuits®	BWS102W263	6932	Cal. before each use	
Coaxial Cables (RF)	Huber+Suhner	Enviroflex 400	-	Cal. before each use	

2.6.4 Test Sample Verification, Configuration & Modifications

The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. The EUT met the requirements without modification.

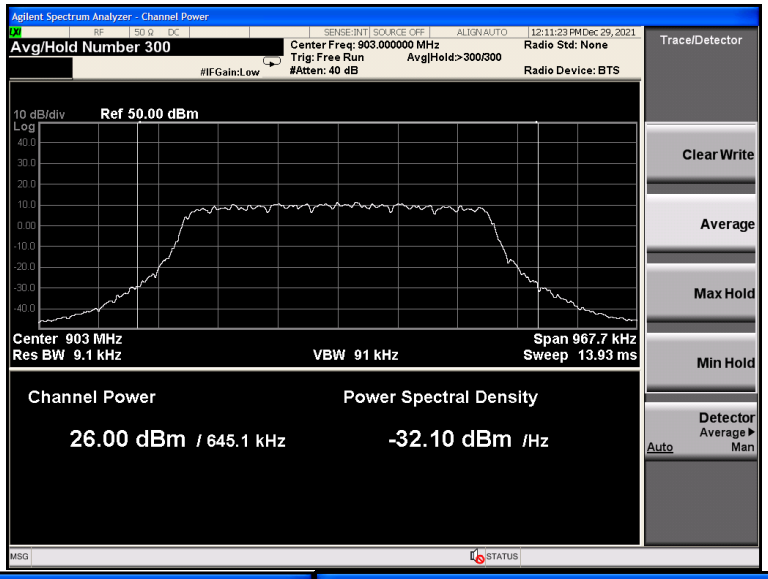
The EUT modified to provide the direct access to antenna port for conducted measurements

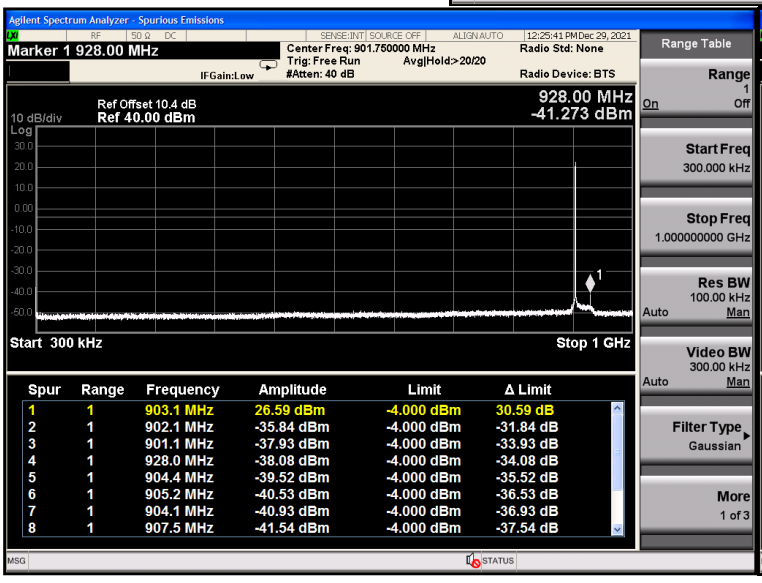
Test setup diagram for Conducted Spurious Emissions testing:

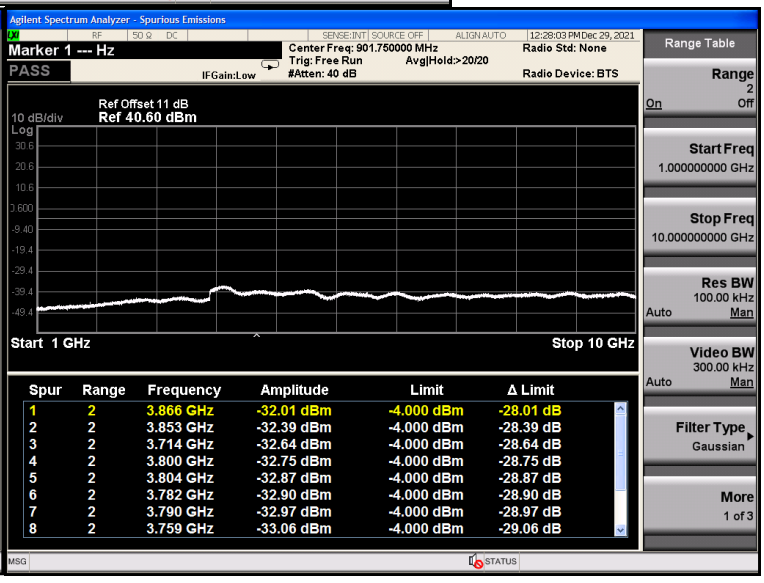


2.6.5 Conducted Spurious Emissions Data: LoRa

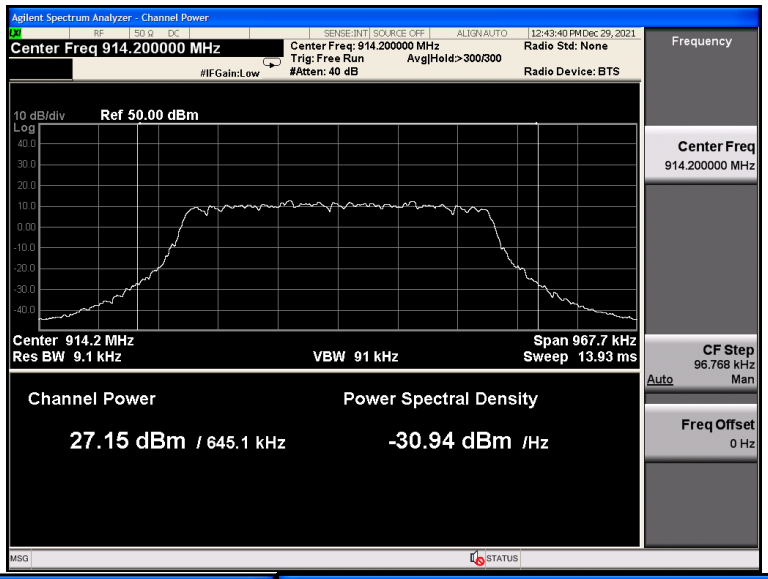
LOW Channel

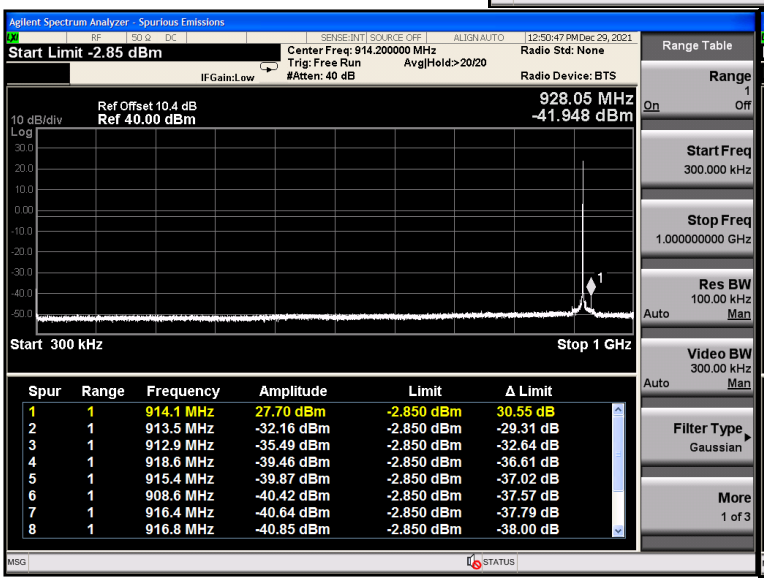


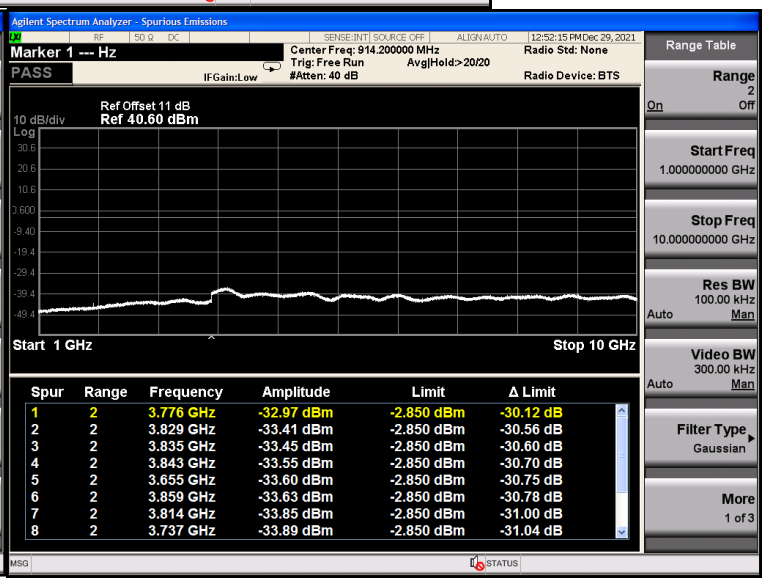




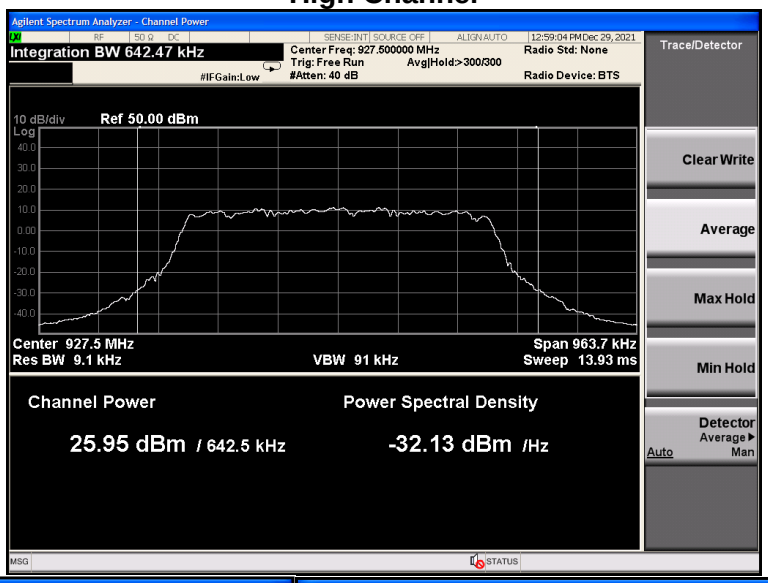
MID Channel

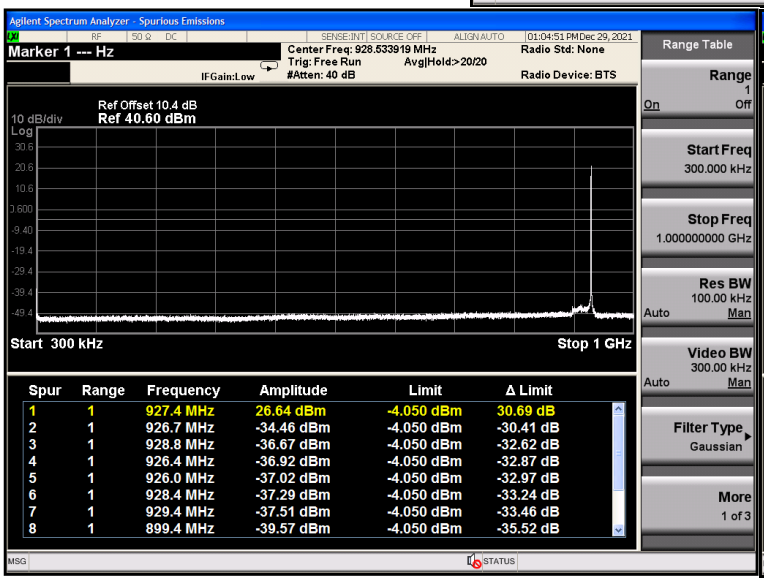

Agilent Spectrum Analyzer - Channel Power
Center Freq 914.200000 MHz
Center Freq: 914.200000 MHz
Trig: Free Run
Avg|Hold:>300/300
#Atten: 40 dB
Radio Std: None
Radio Device: BTS
12:43:40 PM Dec 29, 2021
Frequency
10 dB/div
Ref 50.00 dBm
Center 914.2 MHz
Res BW 9.1 kHz
VBW 91 kHz
Span 967.7 kHz
Sweep 13.93 ms
Channel Power
27.15 dBm / 645.1 kHz
Power Spectral Density
-30.94 dBm /Hz
Center Freq
914.200000 MHz
CF Step
96.768 kHz
Auto
Man
Freq Offset
0 Hz

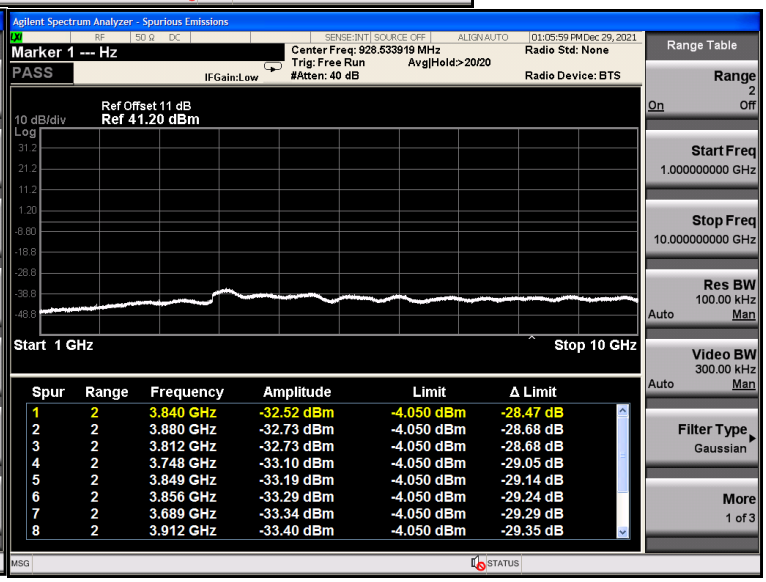

Agilent Spectrum Analyzer - Spurious Emissions
Start Limit -2.85 dBm
Center Freq: 914.200000 MHz
Trig: Free Run
Avg|Hold:>20/20
#Atten: 40 dB
Radio Std: None
Radio Device: BTS
12:50:47 PM Dec 29, 2021
Range Table
Ref Offset 10.4 dB
10 dB/div
Ref 40.00 dBm
928.05 MHz
-41.948 dBm
Start 300 kHz
Stop 1 GHz
Range
Start Freq
300.000 kHz
Stop Freq
1.000000000 GHz
Res BW
100.00 kHz
Video BW
300.00 kHz
Filter Type
Gaussian
More
1 of 3
Spur Range Frequency Amplitude Limit Δ Limit
1 1 914.1 MHz 27.70 dBm -2.850 dBm 30.55 dB
2 1 913.5 MHz -32.16 dBm -2.850 dBm -29.31 dB
3 1 912.9 MHz -35.49 dBm -2.850 dBm -32.64 dB
4 1 918.6 MHz -39.46 dBm -2.850 dBm -36.61 dB
5 1 915.4 MHz -39.87 dBm -2.850 dBm -37.02 dB
6 1 908.6 MHz -40.42 dBm -2.850 dBm -37.57 dB
7 1 916.4 MHz -40.64 dBm -2.850 dBm -37.79 dB
8 1 916.8 MHz -40.85 dBm -2.850 dBm -38.00 dB


Agilent Spectrum Analyzer - Spurious Emissions
Marker 1 --- Hz
PASS
Center Freq: 914.200000 MHz
Trig: Free Run
Avg|Hold:>20/20
#Atten: 40 dB
Radio Std: None
Radio Device: BTS
12:52:15 PM Dec 29, 2021
Range Table
Ref Offset 11 dB
10 dB/div
Ref 40.60 dBm
Start 1 GHz
Stop 10 GHz
Range
Start Freq
1.000000000 GHz
Stop Freq
10.000000000 GHz
Res BW
100.00 kHz
Video BW
300.00 kHz
Filter Type
Gaussian
More
1 of 3
Spur Range Frequency Amplitude Limit Δ Limit
1 2 3.776 GHz -32.97 dBm -2.850 dBm -30.12 dB
2 2 3.829 GHz -33.41 dBm -2.850 dBm -30.56 dB
3 2 3.835 GHz -33.45 dBm -2.850 dBm -30.60 dB
4 2 3.843 GHz -33.55 dBm -2.850 dBm -30.70 dB
5 2 3.655 GHz -33.60 dBm -2.850 dBm -30.75 dB
6 2 3.859 GHz -33.63 dBm -2.850 dBm -30.78 dB
7 2 3.814 GHz -33.85 dBm -2.850 dBm -31.00 dB
8 2 3.737 GHz -33.89 dBm -2.850 dBm -31.04 dB

High Channel







2.7 EUT Positioning Assessment

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel:	**Standard: FCC PART 15.247**
Date:	**Basic Standard: ANSI C63.4-2014**
n/a	
Comments: EUT be in fixed position in final installation.	

2.8 Radiated Spurious Emissions in restricted frequency bands (Co-Location)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel: Janeth Mijares, Brandon Van Hee	**Standard: FCC PART 15.247**
Date: 2021-12-23/27(20.6°C,11.0% RH)	**Basic Standard: ANSI C63.10-2013**

EUT status: Compliant

Specification: FCC PART 15.247(d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.8.1 Test Guidance: ANSI C63.10-2013, Clause 11.12, 6.0 / KDB 558074 D01 15.247 Measurement Guidance v05r02 Clause 8.6

From 9 kHz to 150 kHz (resolution bandwidth of 200 Hz) and from 150 kHz to 30 MHz (resolution bandwidth 9 kHz) measurements are performed with a loop antenna (as per KDB 460108).

From 30 MHz to 1000 MHz, measurements are performed with a broadband biconilog antenna and a resolution bandwidth of 120 kHz.

Above 1000 MHz, measurements are performed with a DRG Horn antenna or a Standard Gain horn, and a resolution bandwidth of 1 MHz. The EUT is raised to 150 cm above the ground plane, and the area between the EUT and the antenna mast is covered with RF absorbent material.

The scan is performed at discrete increments of turntable azimuth and antenna height, which are selected in accordance with the applicable standard in order to assure capture of frequencies of interest. Optimization is performed based on the scan data.

Frequencies having peak emissions within 10dB of the limits are optimized. The EUT is rotated in azimuth over 360 degrees and the direction of maximum emission is noted.

Antenna height is varied from 1 – 4 meters at this azimuth to obtain the maximum emission. Then the maximum level is measured with the appropriate detector and recorded. Up to 1 GHz, measurements are performed with a Quasi-Peak detector. Above 1 GHz, measurements are recorded with Peak and/or Average detectors, as applicable.

2.8.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.8.3 Test Equipment

Testing was performed with the following equipment:

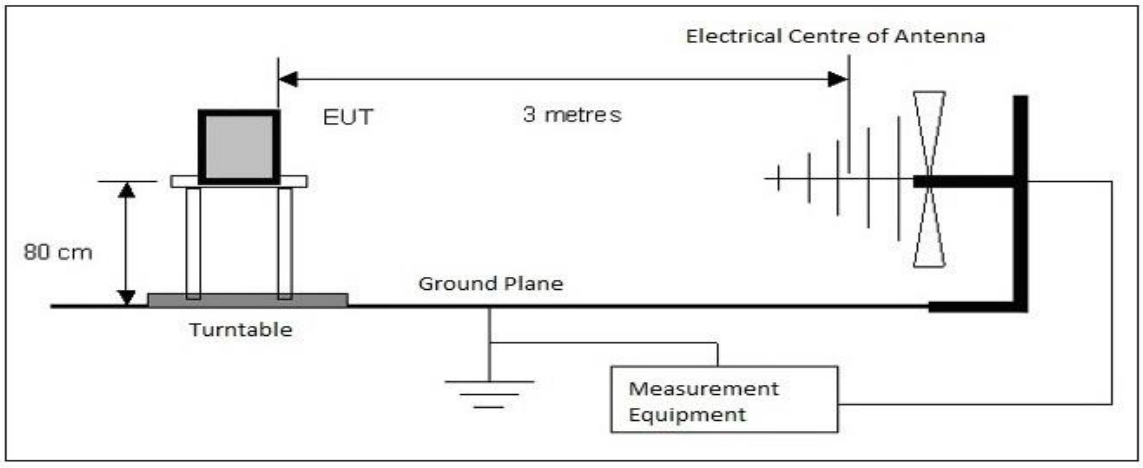
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2021-06-18	2022-06-18
Loop Antenna	EMCO	6502	10868	2021-05-11	2023-05-11
Biconilog Antenna	AR	JB1	6905	2021-10-29	2023-10-29
DRG Horn	EMCO	3115	19357	2020-09-29	2022-09-29
Humidity/Temp Logger	Extech Ins. Corp.	42270	5892	2021-04-06	2022-04-06
Low Noise Amplifier (1 – 18 GHz)	MITEQ	JS43-01001800-21-5P	4354	2021-02-01	2022-02-03
Pre-Amplifier (30 – 1400 MHz)	HP	8447D	9291	2021-02-01	2022-02-03
RE Cable below 1GHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4419	2021-02-01	2022-02-03
Re Cable Above 1 GHz	A.H. System Inc.	SAC-26G-8.23	6187	2021-02-01	2022-02-03
High Pass Filter	K&L	4DH21	-	2021-02-01	2022-02-03

2.8.4 Test Sample Verification, Configuration & Modifications

The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. During spurious emission both LTE pre-certified module and LoRa transmitting simultaneously.

The EUT met the requirements without modification.

Test setup diagram for Radiated Spurious Emissions testing (below 1GHz):



Above 1GHz, the EUT is raised using a low permittivity material (polystyrene) to a height of 1.5m.

FCC Part 15.205 Restricted Bands of Operation:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	*4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	*108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	*2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	*3600 - 4400	([2])
13.36 - 13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz, [2] Above 38.6

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in 15.209 shall be demonstrated based on the average value of the measured emissions.

Specification: FCC15.209 Radiated emission limits.

Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

2.8.5 Radiated Emissions Data: LoRa DTS

The emissions data are presented in tabular form, showing turntable azimuth, antenna height and polarization, the uncorrected spectrum analyzer reading, the correction factors applied, the net result, the value of the limit at the frequency investigated, and the Delta between the result and the limit.

Meter Reading in dBµV + Antenna Factor in dB/m + Gain/Loss Factor in dB = Corrected Field Strength in dbµV/m.

Delta = Field Strength - Limit

Notes: When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.

- Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discrete increments of height and azimuth, while the reported measurement is obtained with the appropriate Quasi Peak or Average detector after the height and azimuth have been adjusted for maximum emission.
- Preliminary scans were performed for all channels in Transmit modes. The MID band channel 914.2 MHz was selected as the worst-case condition for detailed examination.
- In Transmit mode, the EUT was assessed up to 10.0 GHz.

Freq. Marker	Freq. [MHz]	Raw reading[dBµv]	Det	Antenna Factor [dB/m]	Gain / Loss Factor [dB]	Corrected Reading [dBµv/m]	FCC 15.209 Limit [dBµv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	*610.32	556	QP	22.8	5.7	34.06	46.2	-11.96	73	175	Horizontal
2	*38.105	13.24	QP	19	1.6	33.84	40	-6.16	101	112	Vertical
3	*108.81	17.46	QP	16.3	2.6	36.36	43.52	-7.16	285	105	Vertical
4	*149.90	15.22	QP	16.5	3	34.72	53.52	-8.8	298	107	Vertical
5	*612.45	5.56	QP	22.9	5.7	34.16	46.02	-11.86	74	343	Vertical
1	*1.0478	35.41	AV	24.4	-19.5	40.31	54	-13.69	176	282	Vertical
1	*1.0478	46.23	PK	24.4	-19.5	51.13	74	-22.87	176	282	Vertical
1	*1.5596	37.38	AV	25.4	-32.9	29.88	54	-24.12	275	364	Horizontal
1	*1.5596	50.79	PK	25.4	-32.9	43.29	74	-30.71	275	364	Horizontal
2	*1.6958	33.81	AV	26.6	-34.2	26.21	54	-27.79	274	321	Horizontal
2	*1.6958	45.59	PK	26.6	-34.2	37.99	74	-36.01	274	321	Horizontal
3	*2.7426	33.16	AV	29.1	-33.2	29.06	54	-24.94	244	347	Horizontal
3	*2.7426	43.86	PK	29.1	-33.2	39.76	74	-34.24	244	347	Horizontal
4	*1.5599	28.44	AV	25.4	-32.9	20.94	54	-33.06	21	360	Vertical
4	*1.5599	52.99	PK	25.4	-32.9	45.49	74	-28.51	21	360	Vertical
5	*1.695	35.19	AV	26.6	-34.2	27.59	54	-26.41	25	347	Vertical
5	*1.695	46.28	PK	26.6	-34.2	38.68	74	-35.32	25	347	Vertical
6	*3.6564	35.59	AV	31.6	-32.5	34.69	54	-19.31	329	268	Horizontal
6	*3.6564	46.12	PK	31.6	-32.5	45.22	74	-28.78	329	268	Horizontal
7	*4.6519	25.81	AV	32.6	-31.9	26.51	54	-28.49	36	102	Horizontal
7	*4.6519	37.87	PK	32.6	-31.9	38.57	74	-35.43	36	102	Horizontal
8	*9.1413	26.05	AV	37.5	-26.3	37.25	54	-16.75	23	137	Horizontal
8	*9.1413	39.86	PK	37.5	-26.3	51.06	74	-22.94	23	137	Horizontal
9	*8.227	29.64	AV	36.7	-26.3	40.04	54	-13.96	353	141	Vertical
9	*8.227	43.16	PK	36.7	-26.3	53.56	74	-20.44	353	141	Vertical
10	*9.1429	28.47	AV	37.5	-26.3	39.67	54	-14.33	144	144	Vertical
10	*9.1429	42.68	PK	37.5	-26.3	53.88	74	-20.12	144	144	Vertical

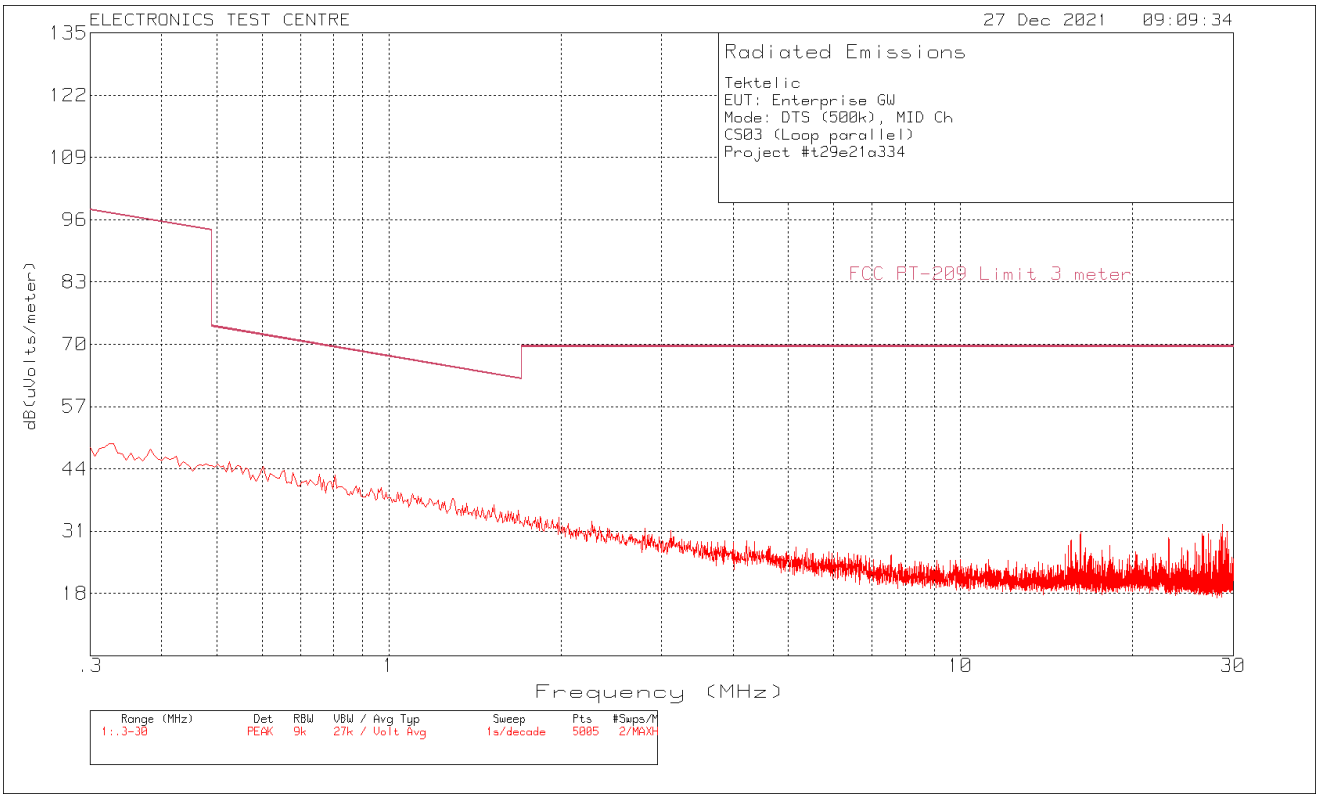
Negative values for Delta indicate compliance.

QP: Quasi Peak Detector, AV: Average Detector

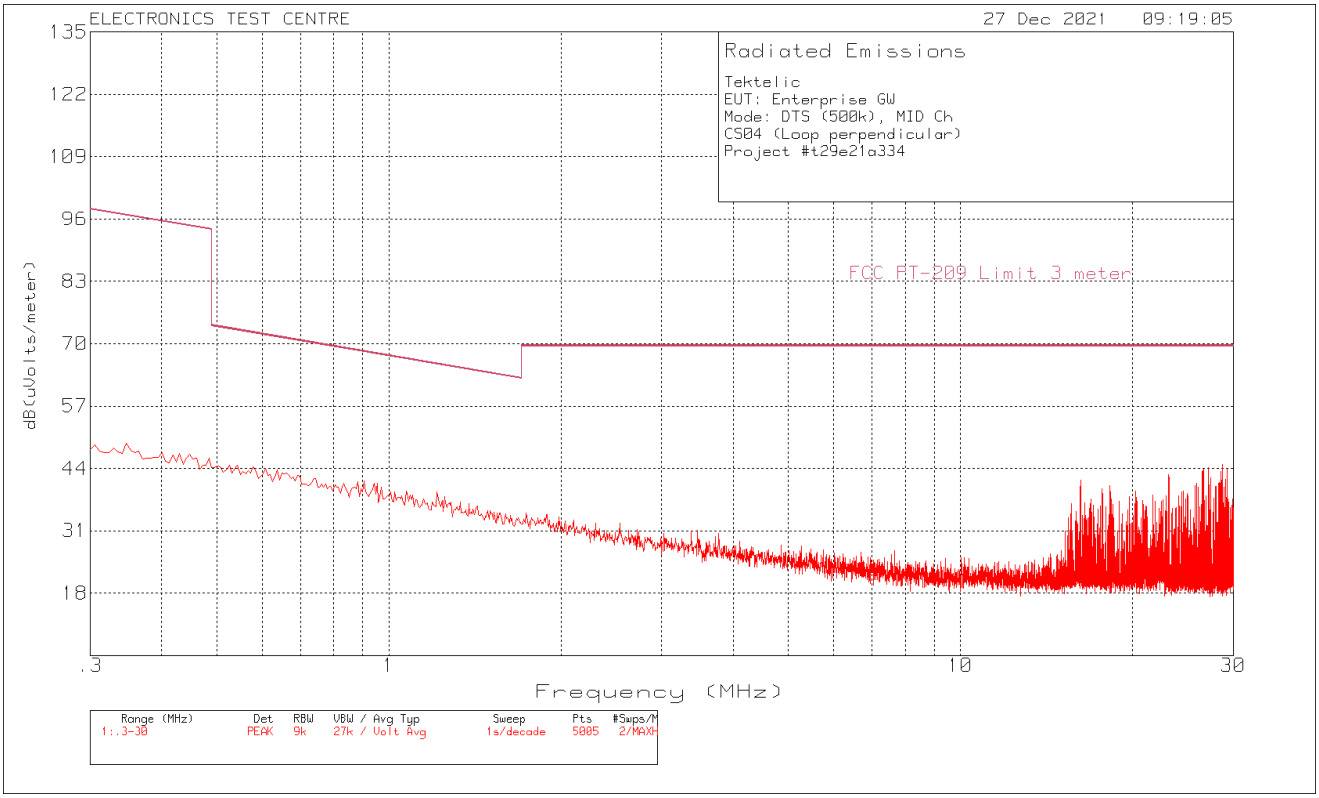
*** Restricted Band (RB)**

Non Restricted Band (NRB)

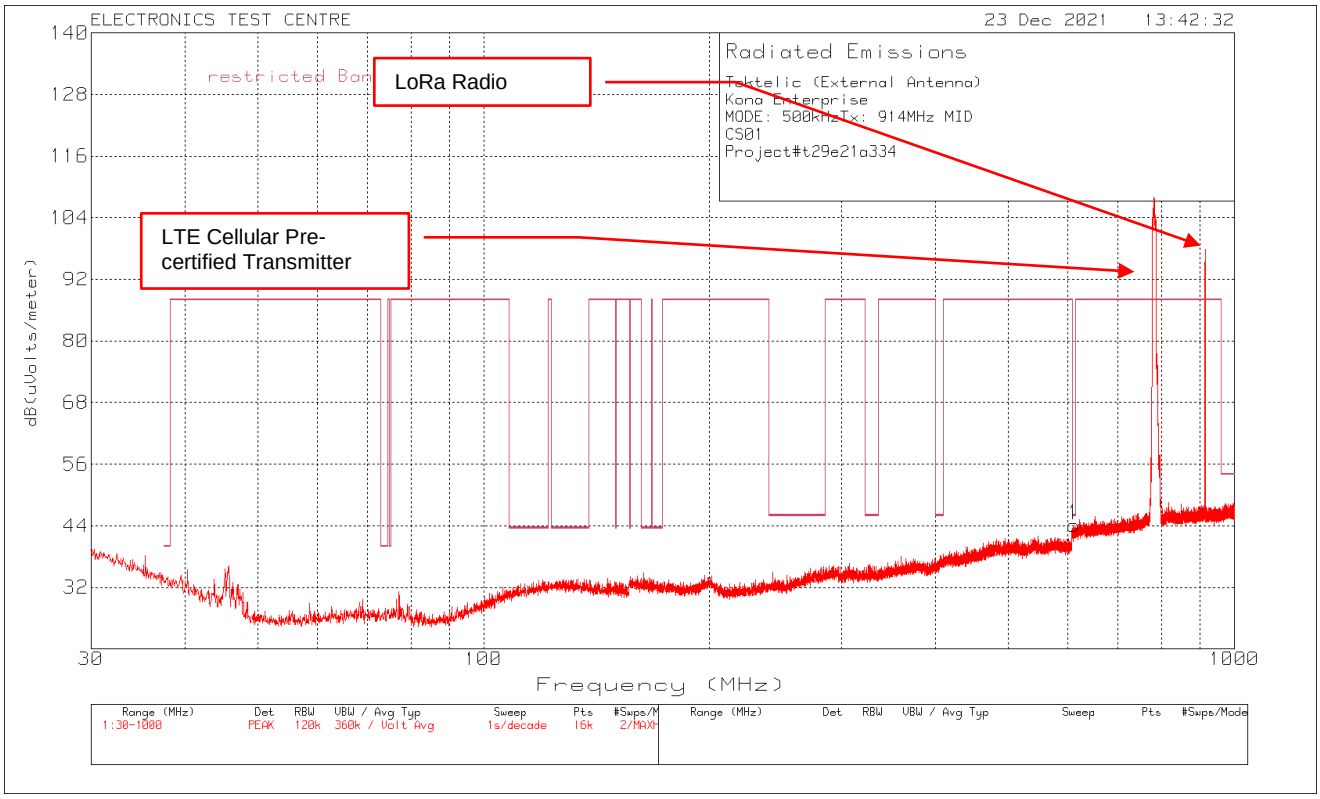
Plot of Radiated Emissions: Measuring Antenna Parallel



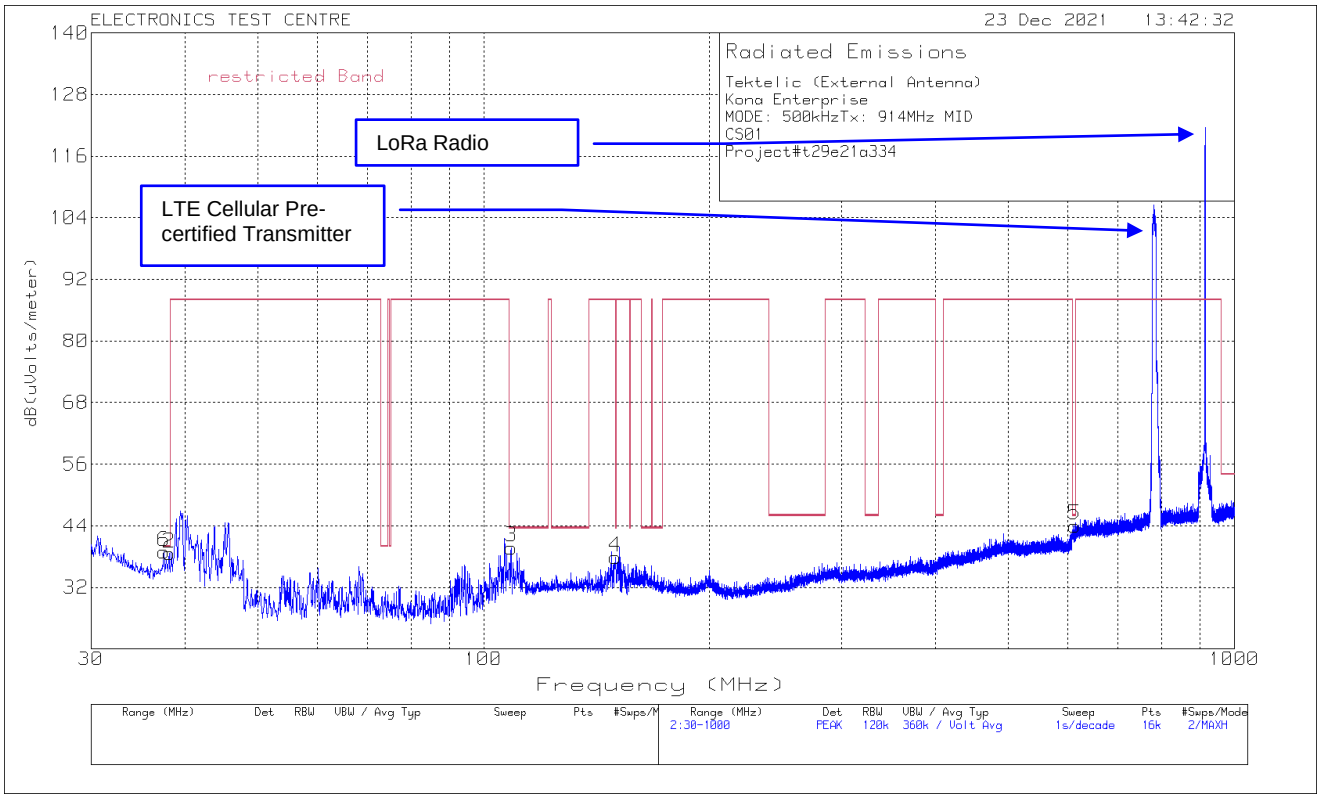
Plot of Radiated Emissions: Measuring Antenna Perpendicular



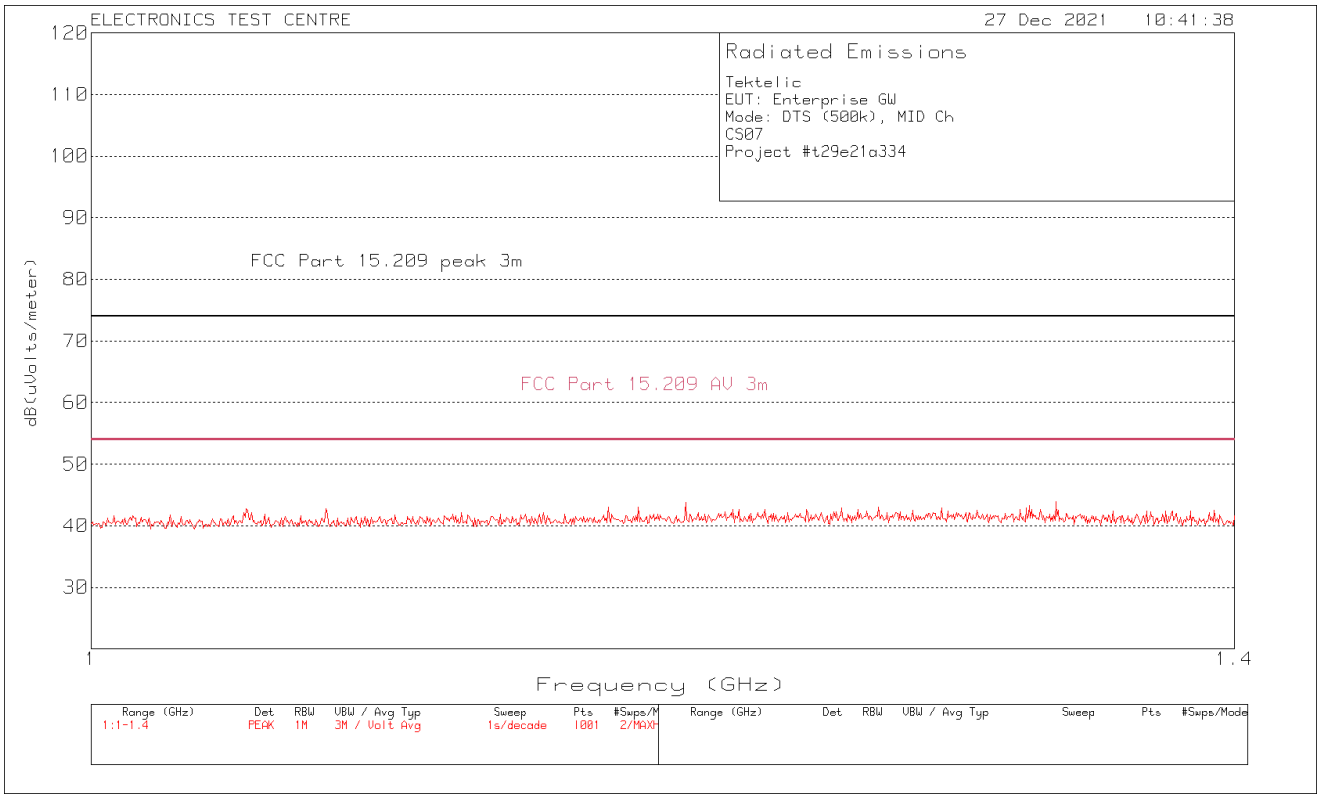
Plot of Radiated Emissions: Horizontal polarization



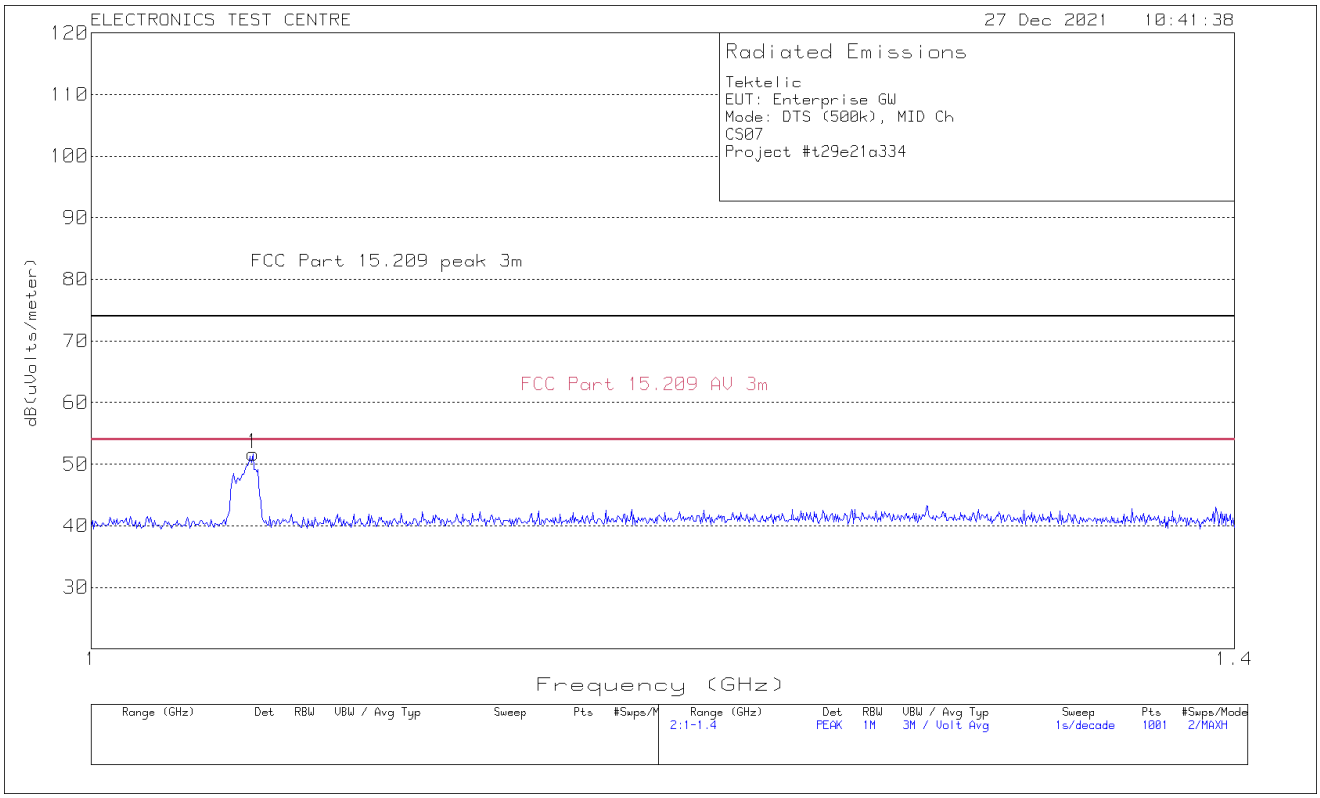
Plot of Radiated Emissions: Vertical polarization



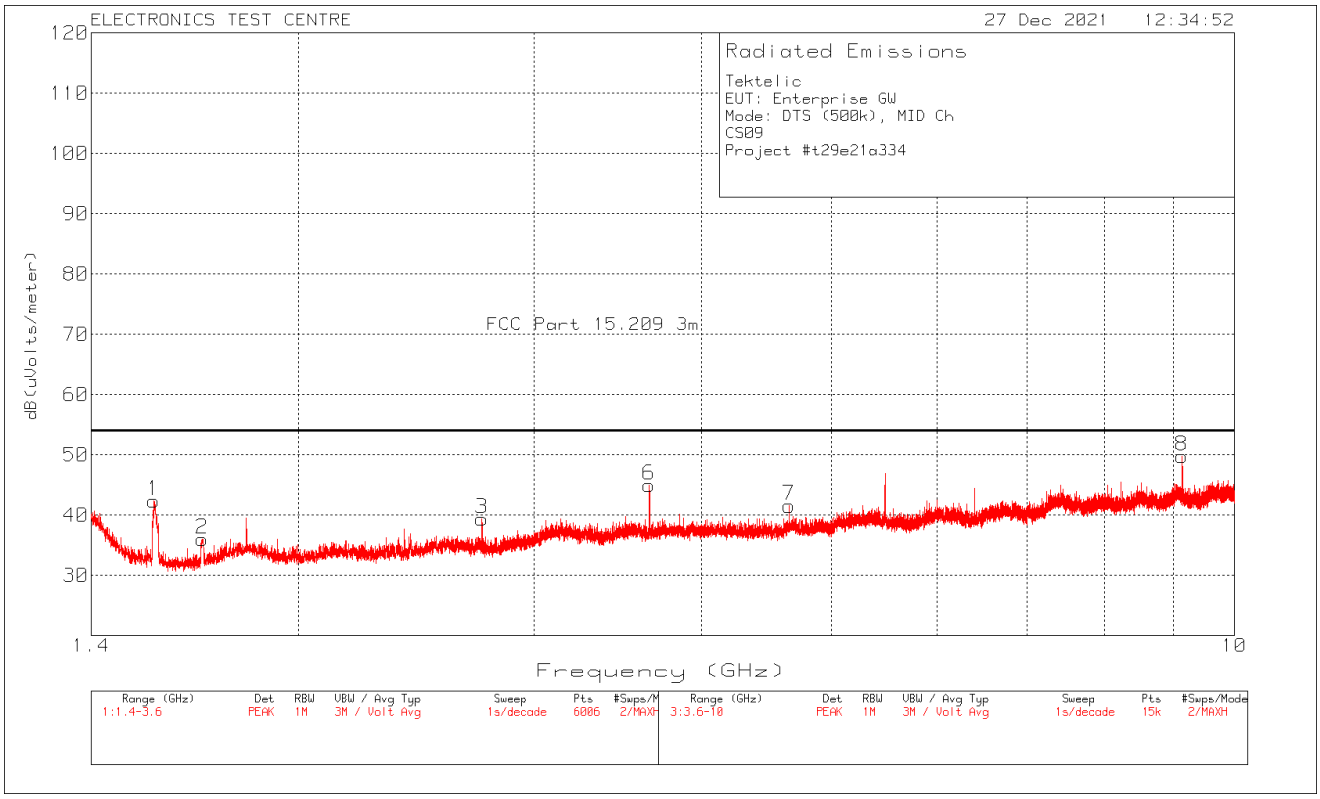
Plot of Radiated Emissions: Horizontal polarization



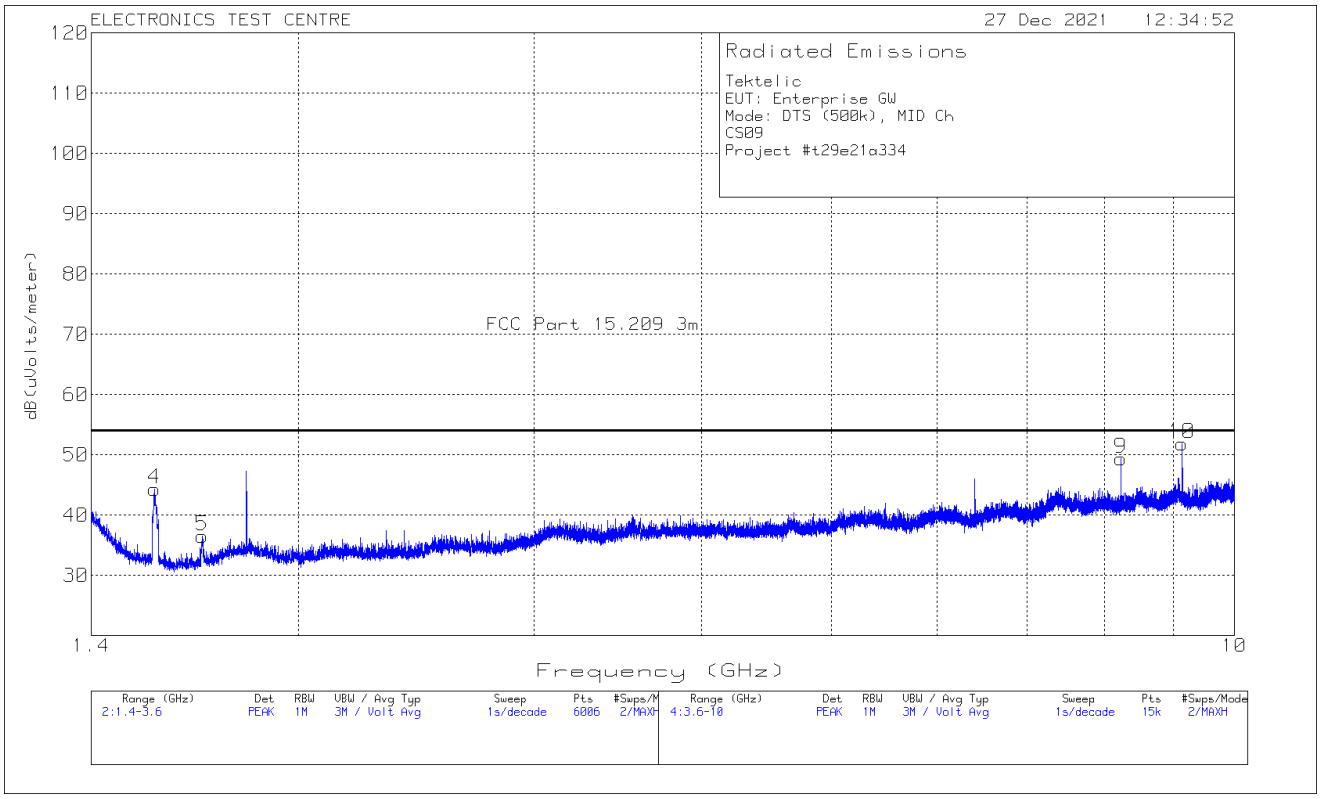
Plot of Radiated Emissions: Vertical polarization



Plot of Radiated Emissions: Horizontal polarization



Plot of Radiated Emissions: Vertical polarization



2.9 RF Exposure

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Enterprise Gateway**
Test Personnel:	**Standard: FCC PART 15.247**
Date:	

EUT status: Complaint

Compliant: RF exposure assessment to be provided in a separate Exhibit.

3.0 TEST FACILITY

3.1 Location

The Kona Enterprise Gateway was tested at the Electronics Test Centre laboratory located in Airdrie, Alberta, Canada. The Radio Frequency Anechoic Chamber (RFAC), identified as Chamber 1, has a usable working space measuring 10.6 m long x 7.3 m wide x 6.5 m high.

Measurements taken at this site are accepted by Industry Canada as evidence of conformity per registration file # 2046A. This site is also listed with the FCC under Registration Number CA2046.

The floor, walls and ceiling consist of annealed steel panels. The walls and ceiling are covered with ferrite tile, augmented by RF absorbant foam material on the end wall nearest the turntable, and on the adjacent walls and the ceiling. The chamber floor supports a 15 cm high internal floor, constructed of annealed steel panels, that forms the ground plane, and is bonded to the chamber walls.

The 3-m diameter turntable is flush-mounted with the floor. A sub-floor cable-way is provided to route cables between the turntable pit and EUT support equipment located in the Control Room. Cables reach the EUT through an opening in the centre of the turntable.

Test instrumentation and EUT support equipment is located in the Control Room, consisting of two shielded vestibules joined together at the side of the main room. Cables are routed through bulkhead panels between the rooms and the test chamber as required. Power feeds are routed into the main room and vestibules through line filters providing at least 100 dB of attenuation between 10 kHz and 10 GHz.

Either floor mounted or table-top equipment can be tested at this facility.

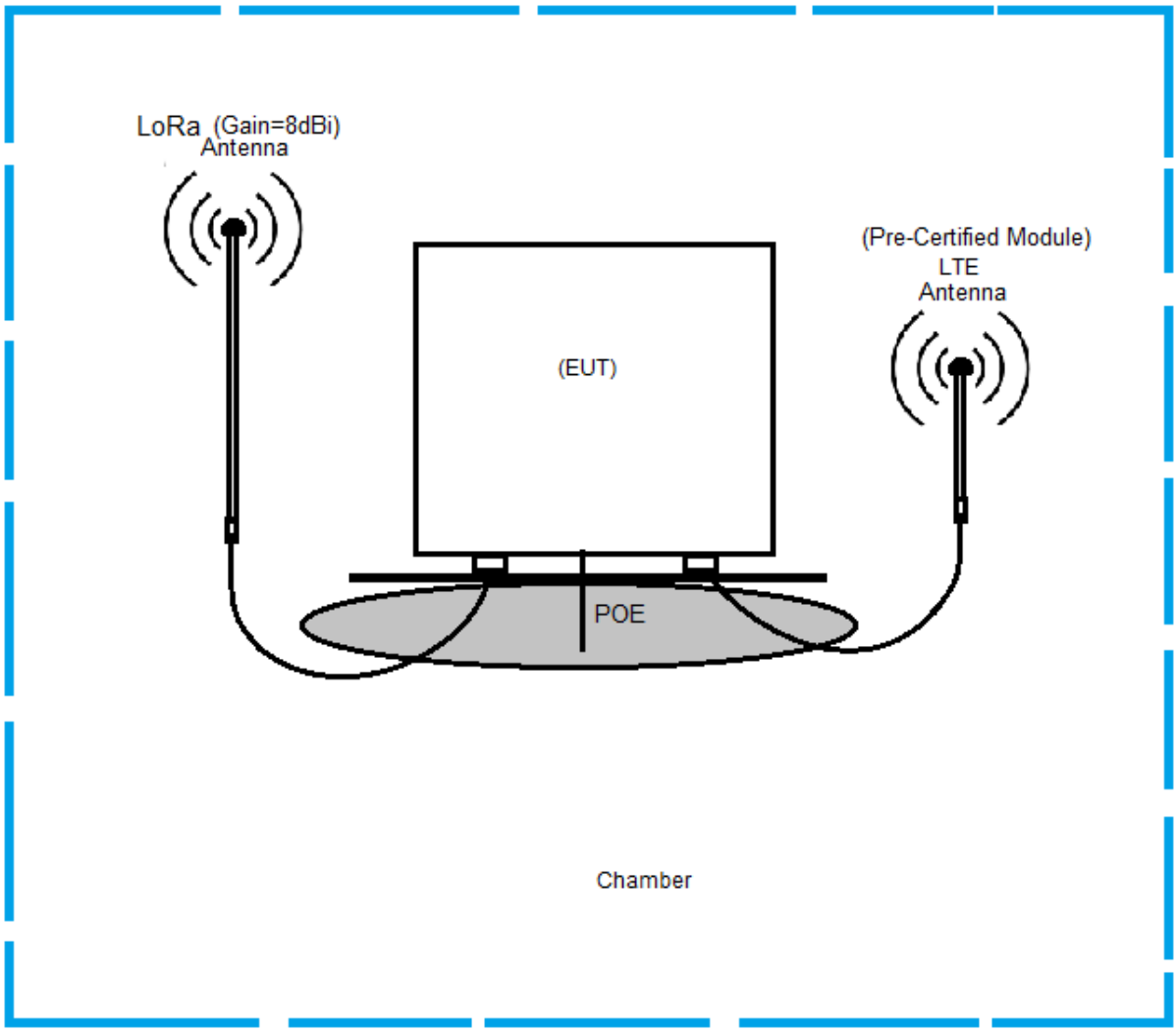
3.2 Grounding Plan

The Kona Enterprise Gateway was placed at the center of the test chamber turntable on top of polystyrene foam table. No provision is made within the Kona Enterprise Gateway for an earth ground connection.

3.3 Power Supply

All EUT power was supplied via Power over Ethernet (POE).

Appendix A (Worse Emission test Setup Block Diagram)



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