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EMC testing of the Tektelic Communication Inc. BLE Sensor GEN2 in accordance with FCC Part 15.247, ANSI C63.4: 2014 and ANSI C63.10: 2013 as referenced by KDB 558074 D01 15.247 Measurement Guidance v05r02.

FCC ID: 2ALEPT0006940

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REVISION RECORD

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2021-03-03	I. Akram	Initial draft submitted for review.
Release 1	2021-06-17	M. Rousseau 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. BLE Sensor GEN2 test sample, referred to herein as the EUT (Equipment Under Test).

The samples have 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:		BLE Sensor GEN2
LoRa Radio	**Frequency Band**	902 – 928 MHz
	Type of Modulation	Chirp Spread Spectrum
	BW/Frequency Range	Hybrid 125kHz, 902.3 – 914.9 MHz
	Associated Antenna	Mfr: Fractus Antennas S.L, p/n: NN02-224, omni-directional, Gain 2.8dBi
	Detachable/Non Detachable	Internal Non-Detachable (Compliant to 15.203 requirement)
Model# / Serial#		T0007378 / 2048A0224
Power supply:		Internal Battery

Note: All three channels / axis for four worse selected variants (T0007125, T0007128, T0007296, T0007378) were evaluated. Worse Channel / Axis and variant were selected for detail analysis for radiated emission. Differences in variant are given in product family document.

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.

Data presented in this report, is for the 125 kHz Hybrid transmission mode. Test results for DTS 500 kHz transmission mode is provided in the separate report.

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

Modulation mode: Hybrid 125 kHz

Hybrid 125 kHz DTS and frequency hopping system, are meets part 15.247's requirements for hybrid system. The channels selected for the test are around **Low: 902.3 MHz**, **Mid: 908.7 MHz** and **High: 914.9 MHz** in the frequency range.

1.5 Scope of Testing

Tests were performed in accordance with FCC Part 15.247, ANSI C63.4: 2014, ANSI C63.10: 2013 as referenced in KDB 558074 D01 15.247 Measurement Guidance v05r02.

The EUT was also tested as an unintentional radiator, as reported separately.

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 measurement uncertainty are identified and calculated in accordance with CISPR 16-4-2: 2011.

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)	±5.8 dB
Radiated Emissions Level (1 GHz – 18 GHz)	±4.9 dB
Radiated Emissions Level (18 GHz – 26.5 GHz)	±5.0 dB
Conducted Emissions Level (150 KHz – 30 MHz)	±3.0 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 = 902.3 – 914.9 MHz 125 KHz Hybrid Mode Max. Conducted Average Tx Power = 18.68 dBm = (0.074 Watt)						
2.1	AC Conducted Emissions (Tx)	15.207	BLE Sensor GEN2	none	see § 2.1	**n/a**
2.2	Occupied Bandwidth	15.247(a)(1) 15.247(2)(2)	BLE Sensor GEN2	none	see § 2.2	**Compliant**
2.3	Max Output average Power Conducted	15.247(b)	BLE Sensor GEN2	none	see § 2.3	**Compliant**
2.4	Power Spectral Density	15.247(e) 15.247(f)	BLE Sensor GEN2	none	see § 2.4	**Compliant**
2.5	Band Edge	15.247(d)	BLE Sensor GEN2	none	see § 2.5	**Compliant**
2.6	Conducted Spurious Emission (Non-Restricted Band Operation)	15.247(d)	BLE Sensor GEN2	none	see § 2.6	**Compliant**
2.7	Minimum channel separation	15.247(a)(1)	BLE Sensor GEN2	none	see § 2.7	**Compliant**
2.8	Average time of Occupancy for hybrid System	15.247(f)	BLE Sensor GEN2	none	see § 2.8	**Compliant**
2.9	EUT Position	ANSI C63.4	BLE Sensor GEN2	none	see § 2.9	**Assessed**
2.10	Radiated Spurious Emission (Restricted Band Operation) (Tx Mode)	15.205, 15.209 15.247(d)	BLE Sensor GEN2	none	see § 2.10	**Compliant**
2.11	RF Exposure	15.247(i)	BLE Sensor GEN2	none	see § 2.11	**Exempt**

Refer to the test data for applicable test conditions.

2.1 AC Power Line Conducted Emissions – N/A

Test Lab: Electronics Test Centre, Airdrie	**EUT BLE Sensor GEN2**
Test Personnel:	**Standard: FCC Part 15.207**
Date:	**Basic Standard: ANSI C63.10: 2013**

EUT status: Not Applicable

Comments: BLE Sensor GEN2 is internal battery powered and there is no direct connection to Main.

2.2 Channel Occupied Bandwidth (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2020-12-23 (23.1°C,9.0% RH)	**Basic Standard: ANSI C63.10-2013**

EUT status: Compliant

Specification: FCC 15.215 (c)

Criteria: For hybrid system there is no limit for the 20dB or 99% bandwidth.

2.2.1 Test Guidance: ANSI C63.10-2013, Clause 6.9.2, 6.9.3 &7.8.7 / KDB 558074 D01 15.247 Measurement Guidance v05r02

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:	
Span	between two times and five times the channel center frequency OBW
RBW	1% to 5% of the OBW
VBW	approximately three times RBW
Sweep	auto
Detector function	peak
Trace	max hold
Allow the trace to stabilize. The automated 99% BW function of the spectrum analyzer is engaged, 20 dB OBW is measured with the x dB function.	

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 (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 25.05	6130	2020-05-27	2021-05-27
Temp/Humidity	Extech	42270	5892	2020-04-07	2021-04-07
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

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.

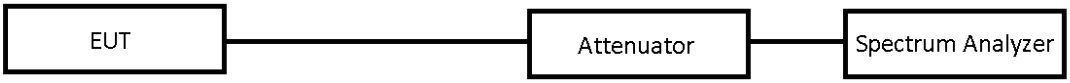
The EUT modified to provide the direct access to antenna port for conducted measurements.

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:

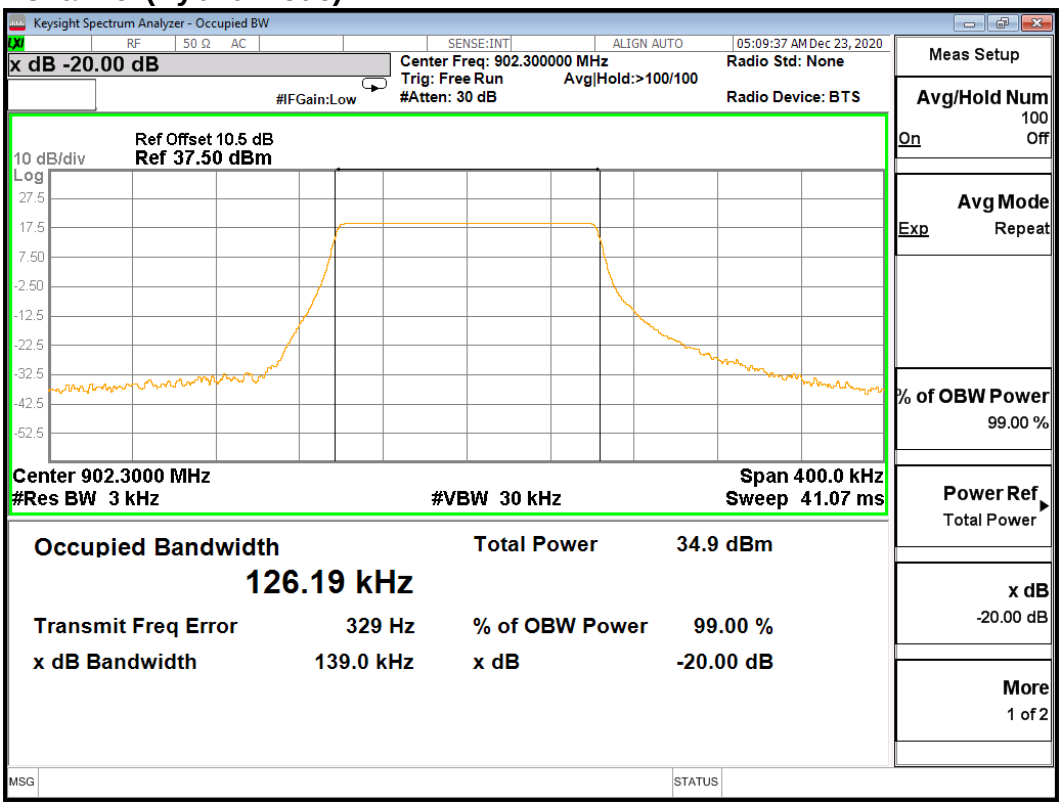


2.2.5 Channel Occupied Bandwidth Data: (Hybrid Mode)

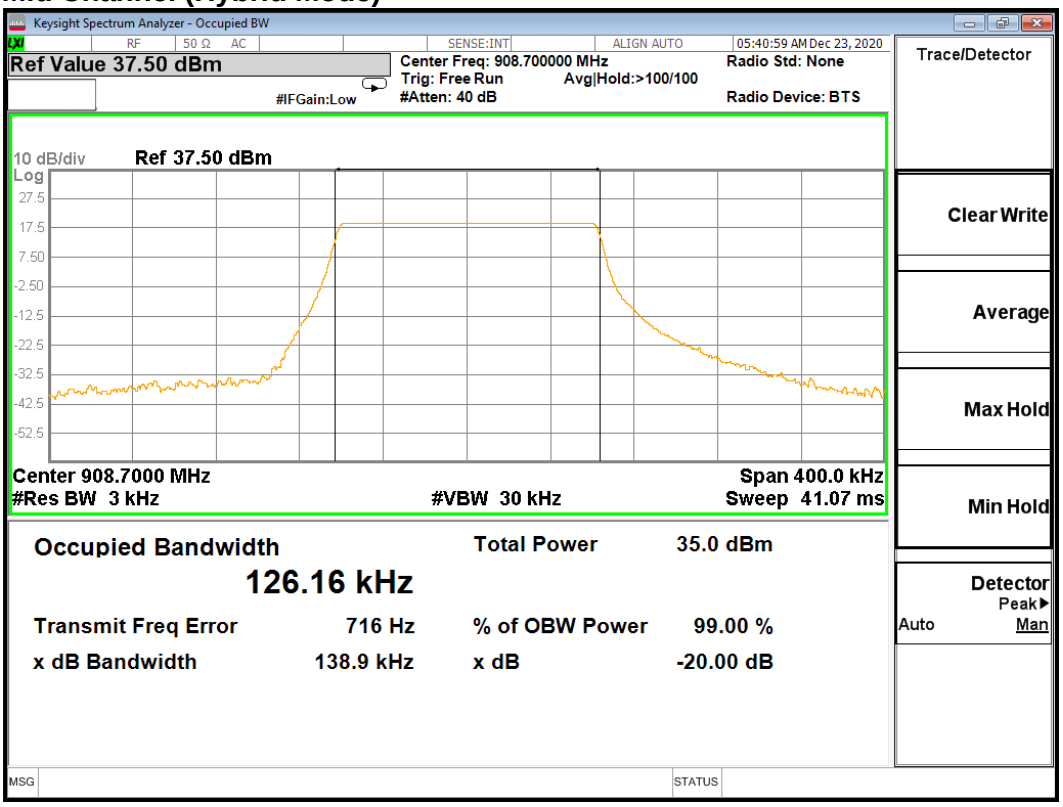
LoRa 125 KHz Channels

Channel	Freq. [MHz]	20 dB OBW [kHz]	99% OBW [KHz]
Low	902.3	139.0	126.19
Mid	908.7	138.9	126.16
High	914.9	138.2	125.93

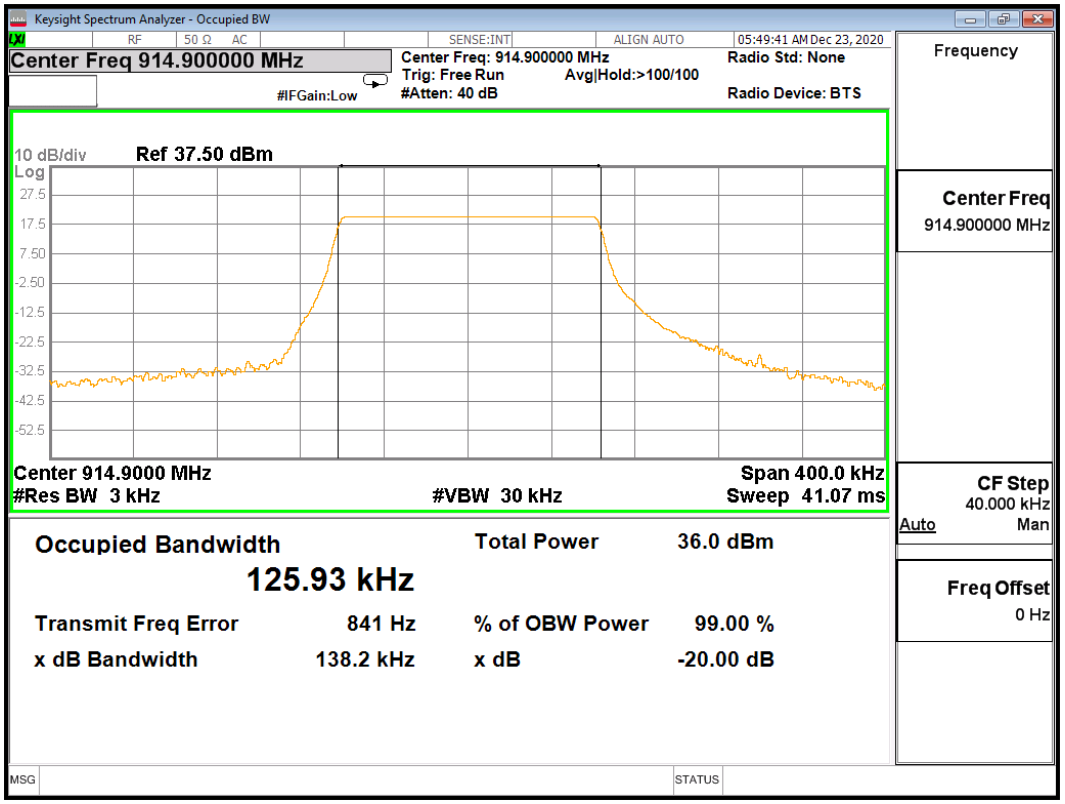
Low Channel (Hybrid Mode)



Mid Channel (Hybrid Mode)



High Channel (Hybrid Mode)



2.3 Max Average Output Power (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2020-12-23 (23.1°C,9.0% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

Specification: FCC Part 15.247(b, 2)

Criteria	For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels

2.3.1 Test Guidance: ANSI C63.10-2013, Clause 11.9.2.2.2, Clause 7.8.5 / 558074 D01 15.247 Measurement Guidance v05r02

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 (Duty Cycle ≥98%)
Trace Average	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 (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 25.05	6130	2020-05-27	2021-05-27
Temp/Humidity	Extech	42270	5892	2020-04-07	2021-04-07
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

2.3.4 Test Sample Verification, Configuration & Modifications

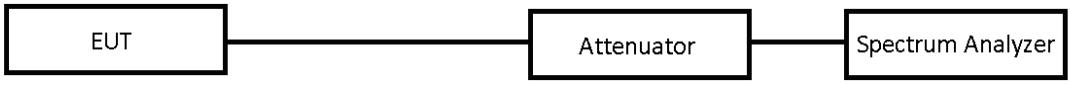
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

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:

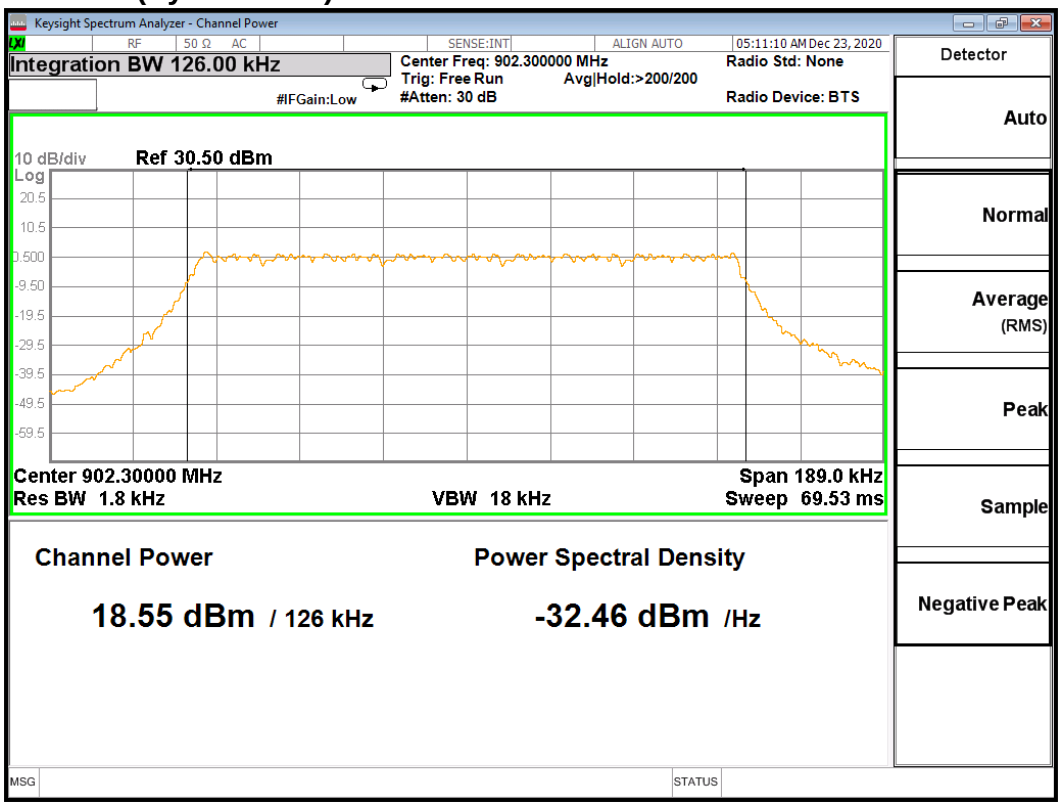


2.3.5 Average Output Power Data (Hybrid Mode)

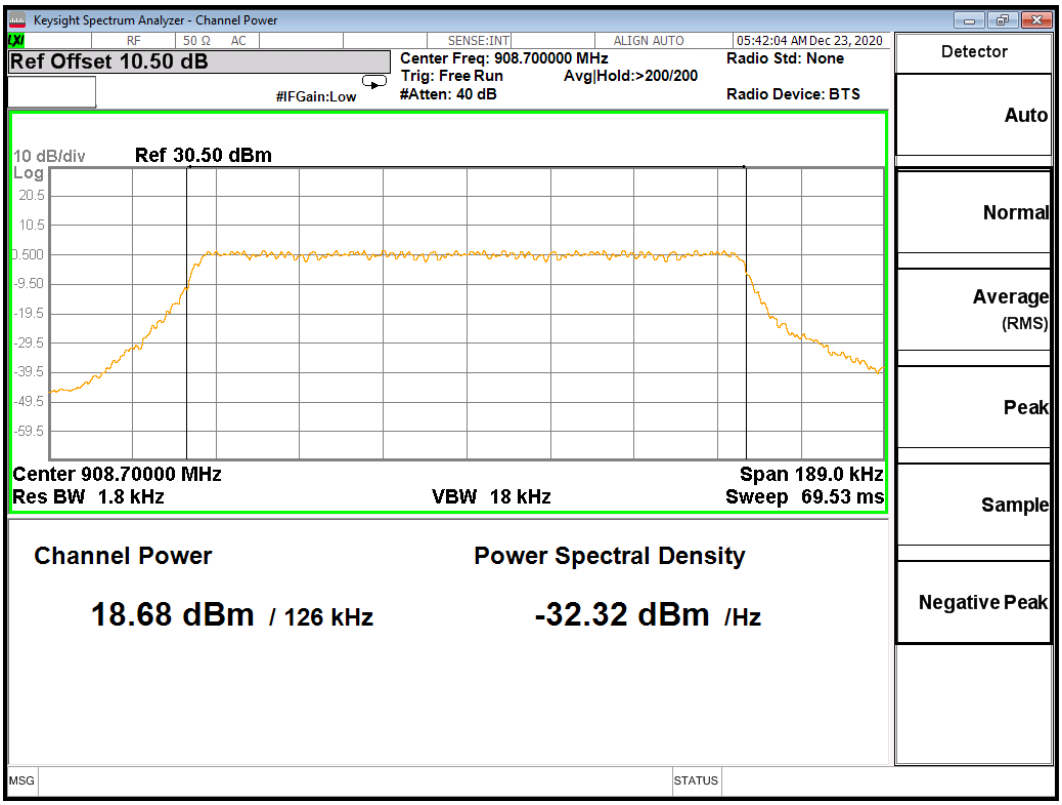
Lora 125 KHz

Channel	Freq. [MHz]	Out Put Power (dBm)	Out Put Power Limit (dBm)	Margin (dB)
Low	902.3	18.55	30	44.45
Mid	908.7	18.68	30	11.32
High	914.9	18.68	30	11.32

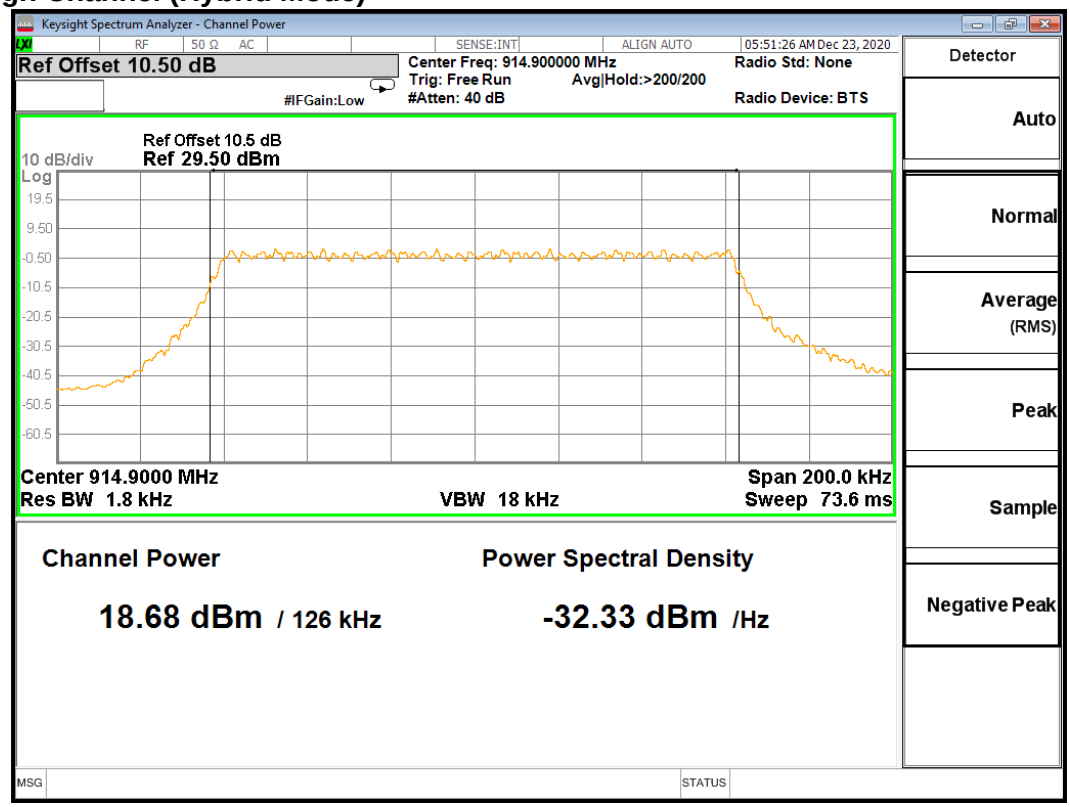
Low Channel (Hybrid Mode)



MID Channel (Hybrid Mode)



High Channel (Hybrid Mode)



2.4 Power Spectral Density (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2020-12-23 (23.1°C,9.0% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

Specification: FCC Part 15.247(f)

Criteria For Hybrid system, 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: ANSI C63.10-2013, Clause 11.10.3 / 558074 D01 15.247 Measurement Guidance v05r02

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 channel center frequency.
RBW	Set RBW to: 3
VBW	Set VBW ≥ 3 × RBW].
Sweep	auto
Detector function	Power averaging (RMS) or sample detector (when RMS not available).
Trace	Employ trace averaging (rms) mode over a minimum of 100 traces.
Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW]. 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

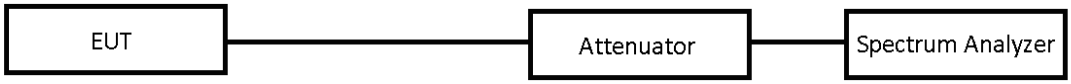
Testing was performed with this equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 25.05	6130	2020-05-27	2021-05-27
Temp/Humidity	Extech	42270	5892	2020-04-07	2021-04-07
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

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:

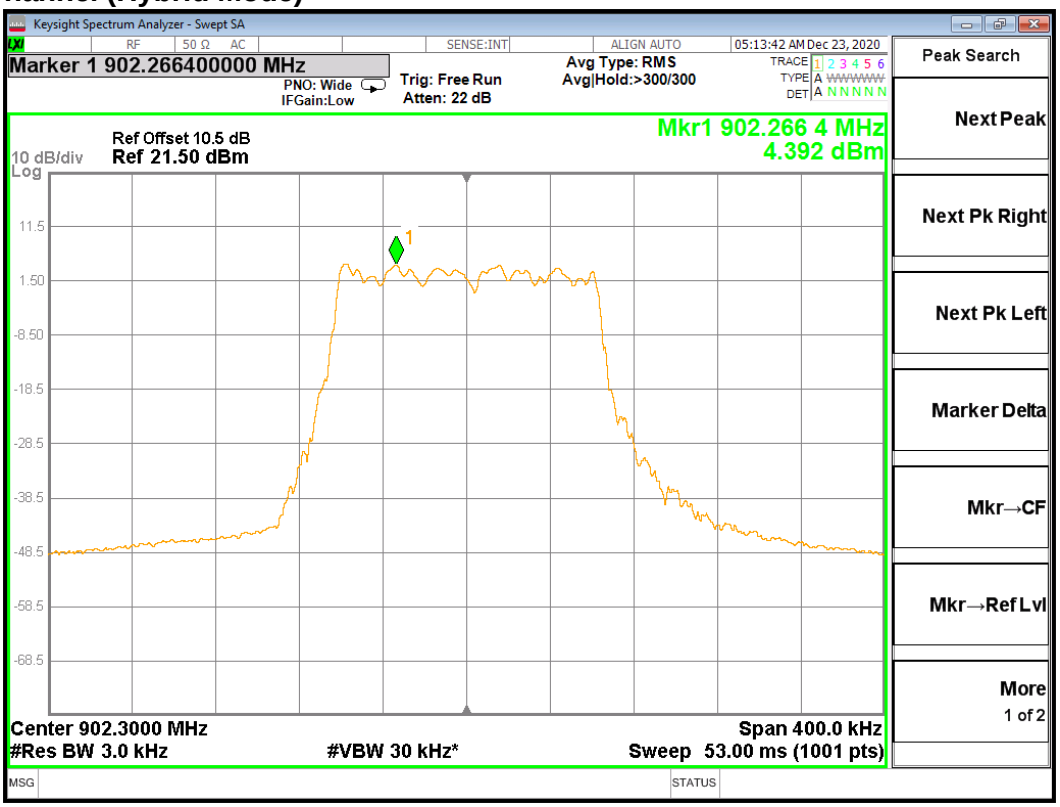


2.4.5 Peak PSD Data (Hybrid Mode)

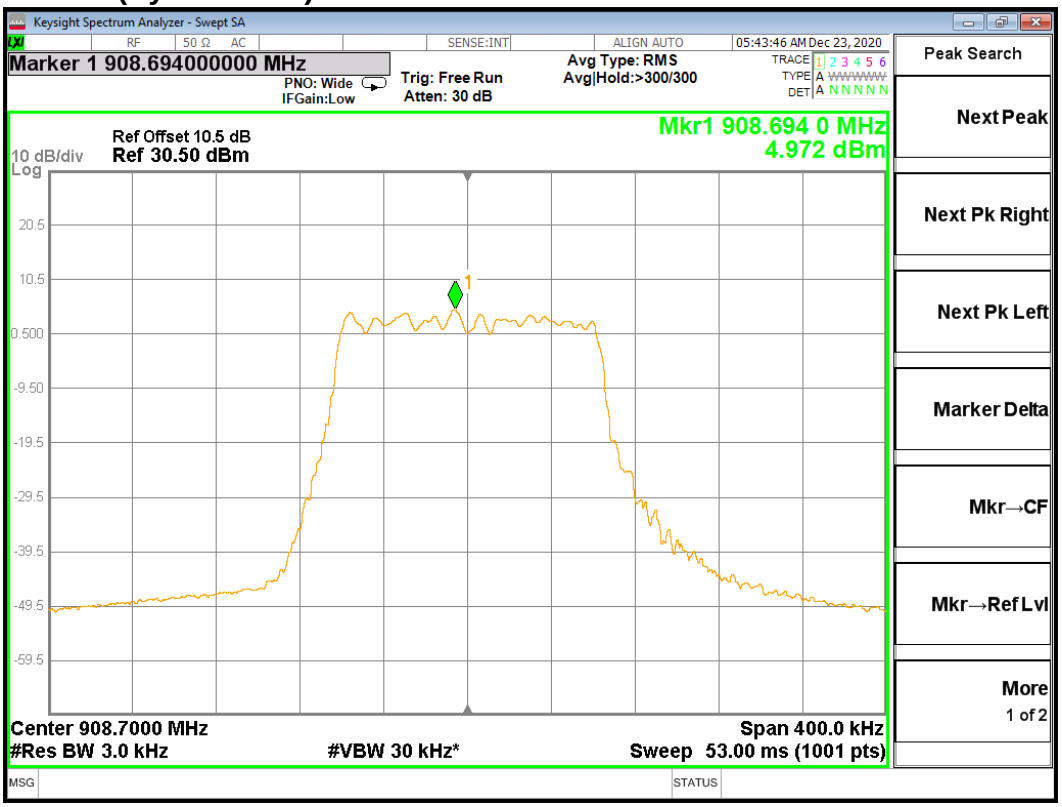
125 KHz Channels

Channel	Freq. [MHz]	PSD (dBm/3kHz)	PSD Limit (dBm/3kHz)
Low	902.3	4.392	8
Mid	908.7	4.972	8
High	914.9	4.431	8

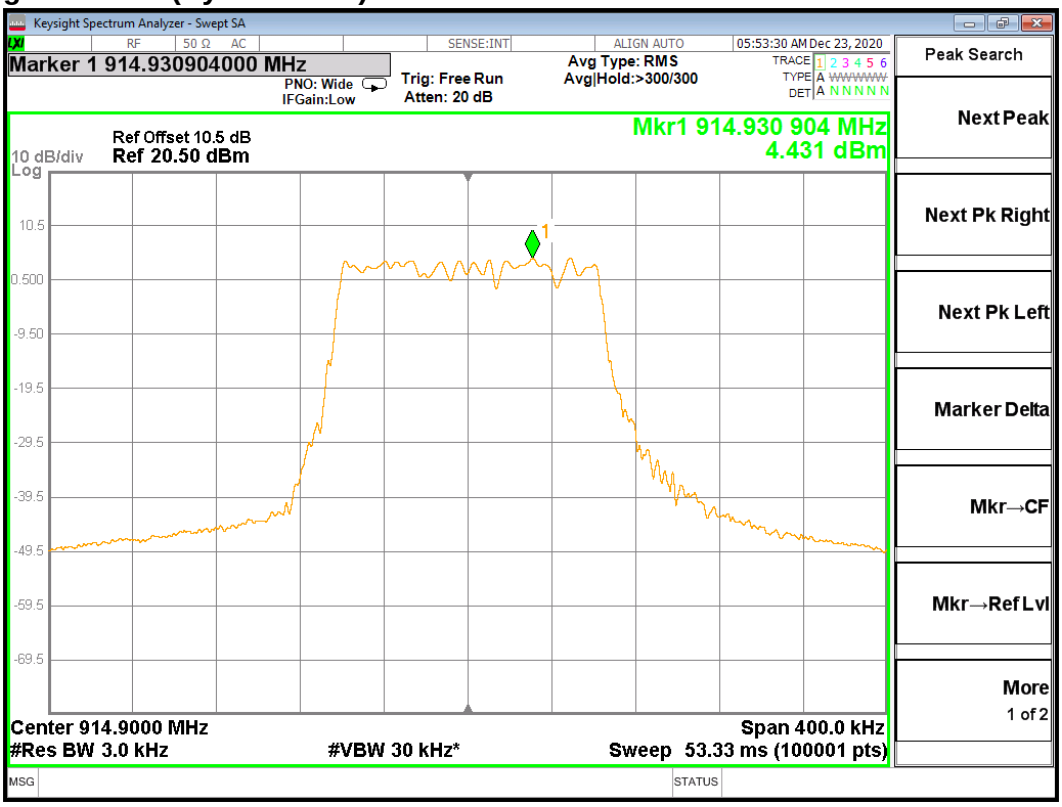
Low Channel (Hybrid Mode)



Mid Channel (Hybrid Mode)



High Channel (Hybrid Mode)



2.5 Band Edge Attenuation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2020-12-23 (23.1°C,9.0% RH) **2021-01-15**	**Basic Standard: ANSI C63.10: 2013**

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 6.10.4, 6.10.6 & 7.8.6 / 558074 D01 15.247 Measurement Guidance v05r02

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:

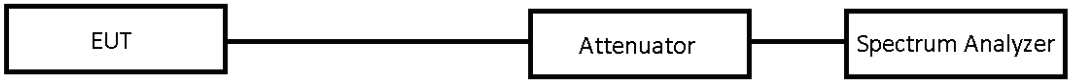
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 25.05	6130	2020-05-27	2021-05-27
Temp/Humidity	Extech	42270	5892	2020-04-07	2021-04-07
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

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:

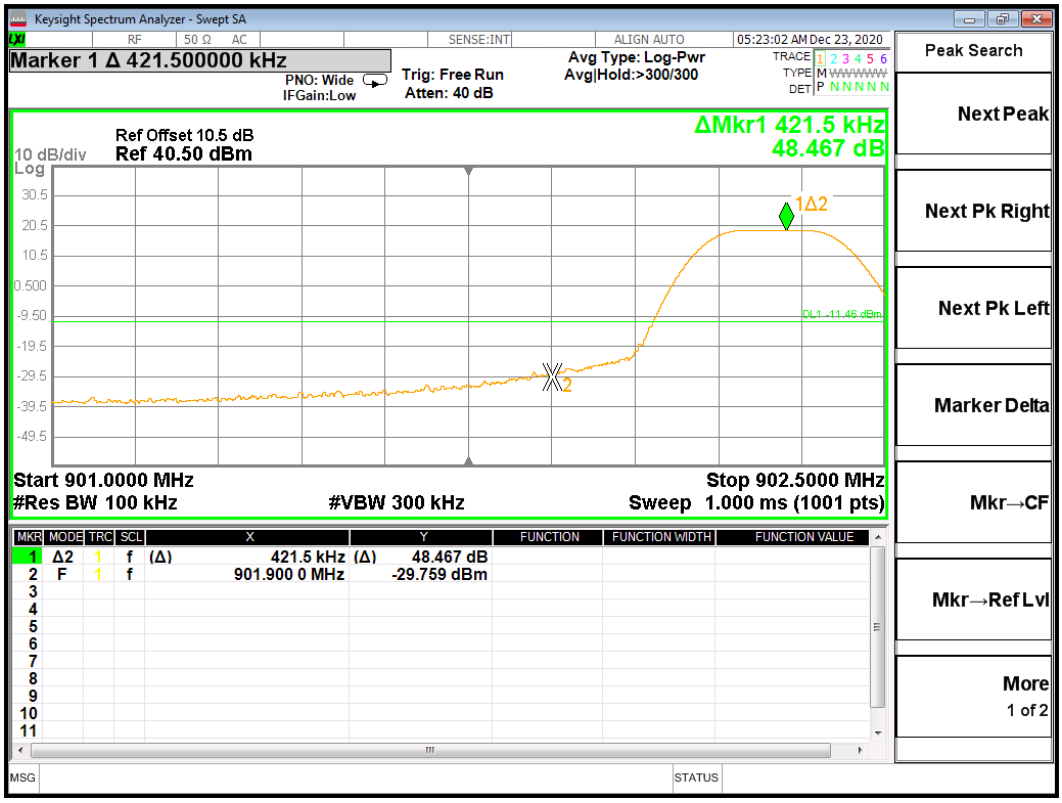
Conducted:



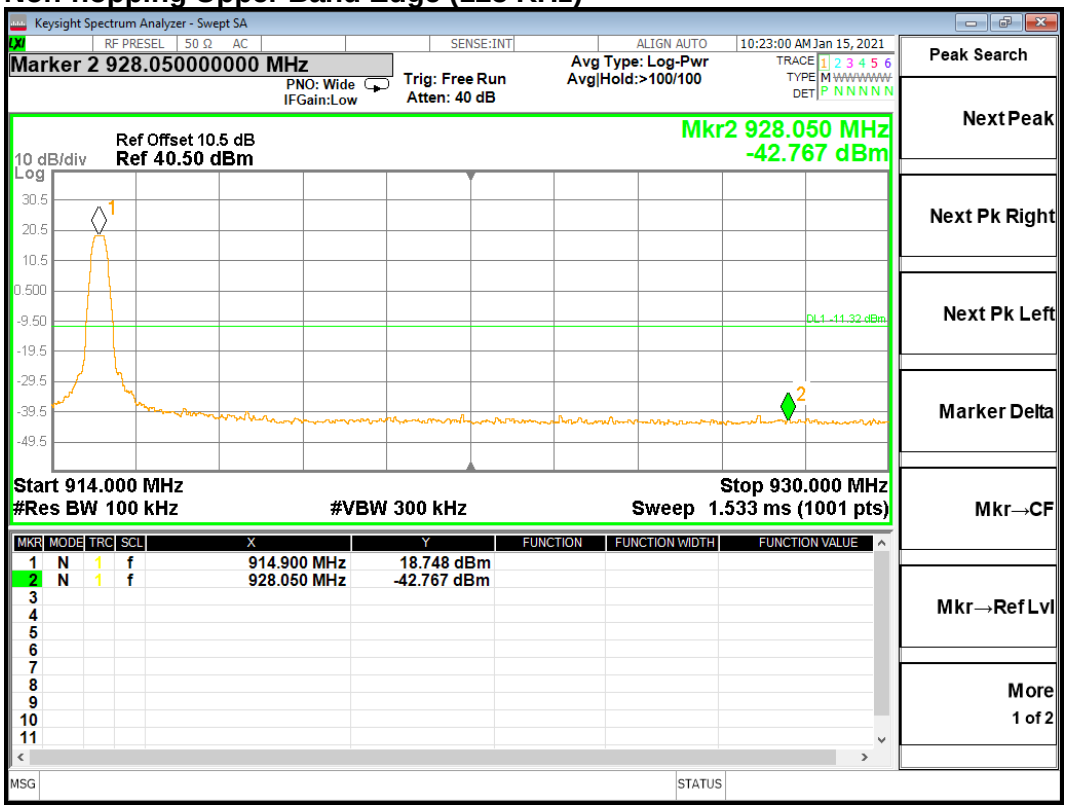
2.5.5 Band Edge Data (Hybrid Mode)

Modulation	Channel	Attenuation at Band Edge	Attenuation Limit at Band Edge
Lora 125KHz Channels	902.3	48.467 dBc	30 dBc
	914.9	61.515 dBc	30 dBc
Lora 125KHz Channels (Hopping)	902.3	59.424 dBc	30 dBc
	914.9	70.417 dBc	30 dBc

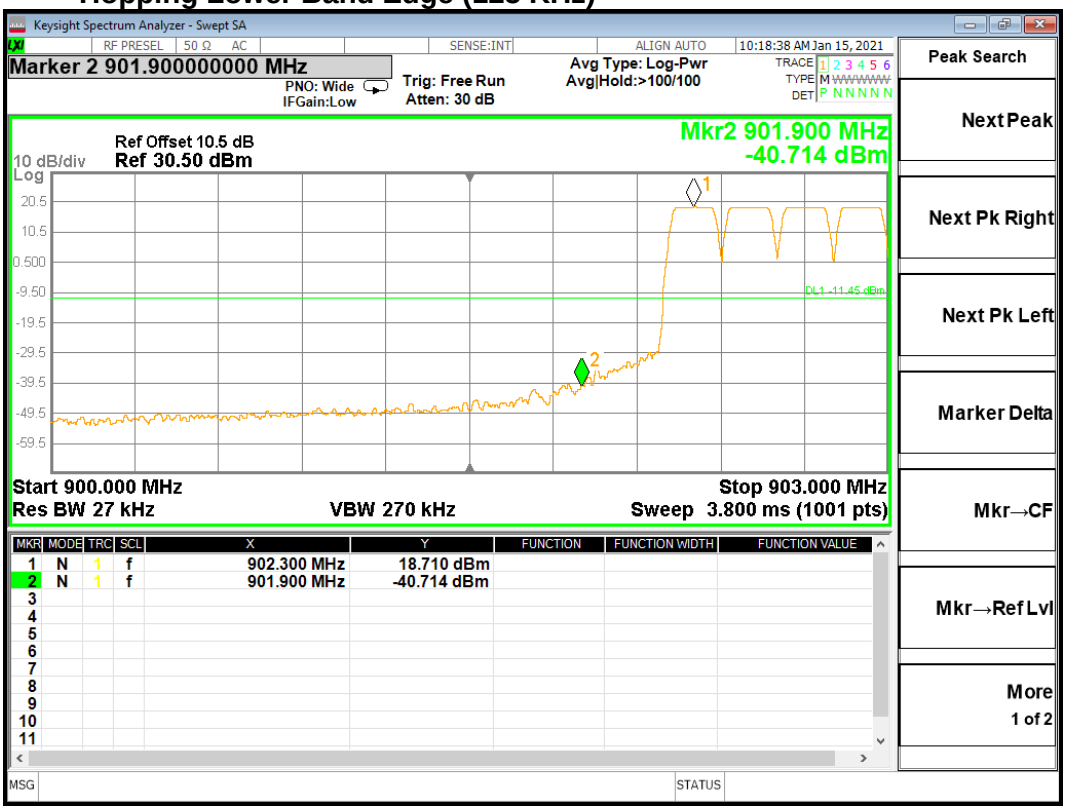
Non-hopping Lower Band Edge (125 KHz)



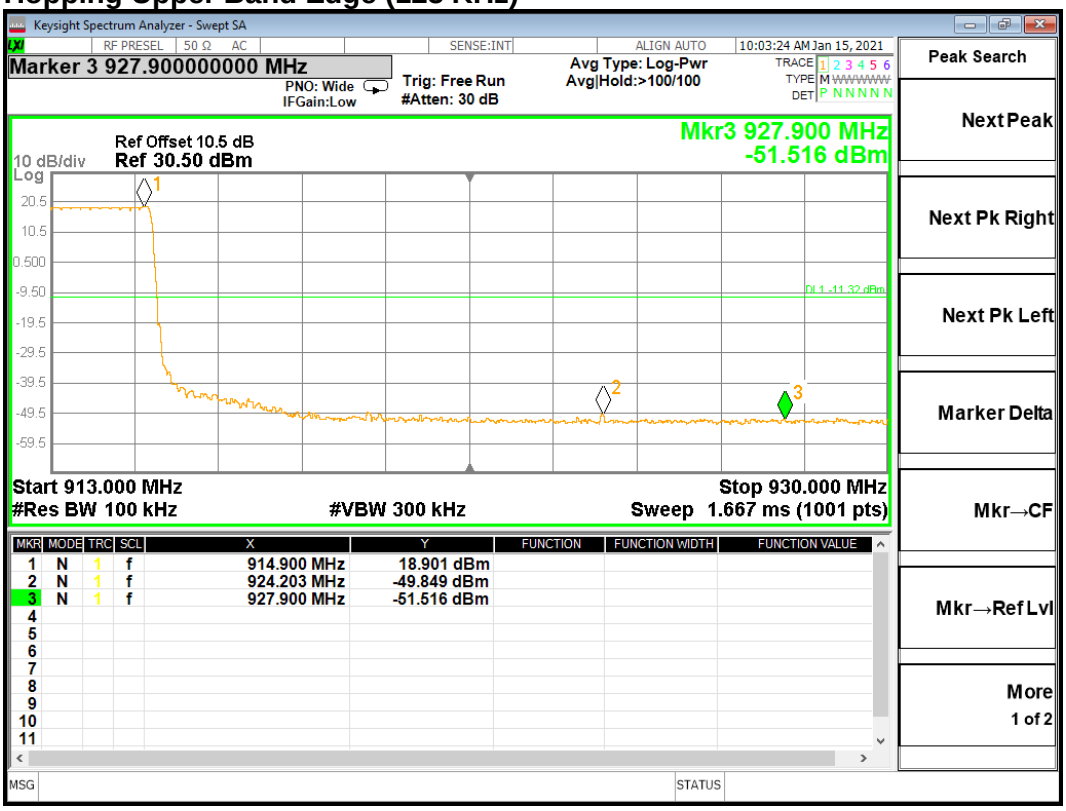
Non-hopping Upper Band Edge (125 KHz)



Hopping Lower Band Edge (125 KHz)



Hopping Upper Band Edge (125 KHz)



2.6 Conducted Spurious Emissions in non-restricted frequency bands (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2020-12-23 (23.1°C,9.0% 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.

2.6.1 Test Guidance: ANSI C63.10-2013, Clause 6.7, 7.8.8 / 558074 D01 15.247 Measurement Guidance v05r02

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.

Use the following spectrum analyzer settings:	
Span	Set the center frequency and span to encompass frequency range to be measured.
RBW	100 kHz
VBW	300 kHz
Sweep	Auto Coupled
Detector function	peak
Trace	max hold
Allow the trace to stabilize. Use the peak marker function to determine the maximum amplitude level. Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in	

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:

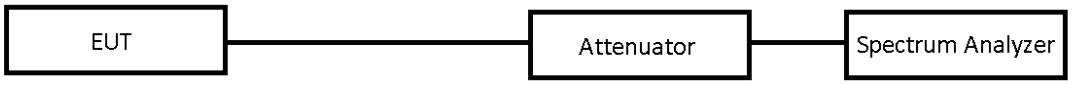
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 25.05	6130	2020-05-27	2021-05-27
Temp/Humidity	Extech	42270	5892	2020-04-07	2021-04-07
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

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.

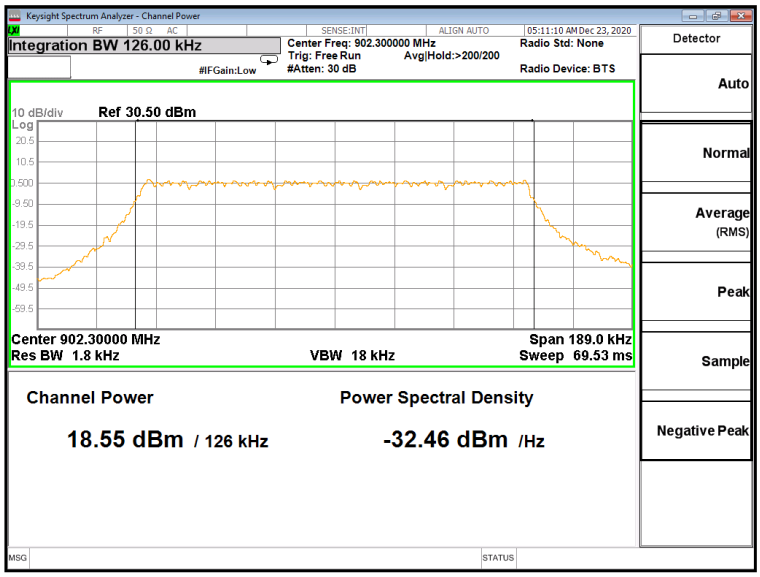
The EUT modified to provide the direct access to antenna trace for conducted measurements.

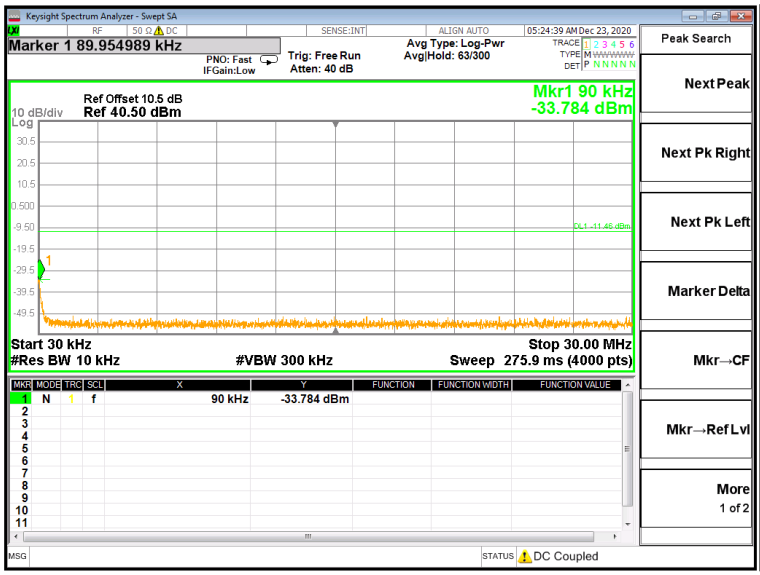
Test setup diagram for Conducted Spurious Emissions testing:

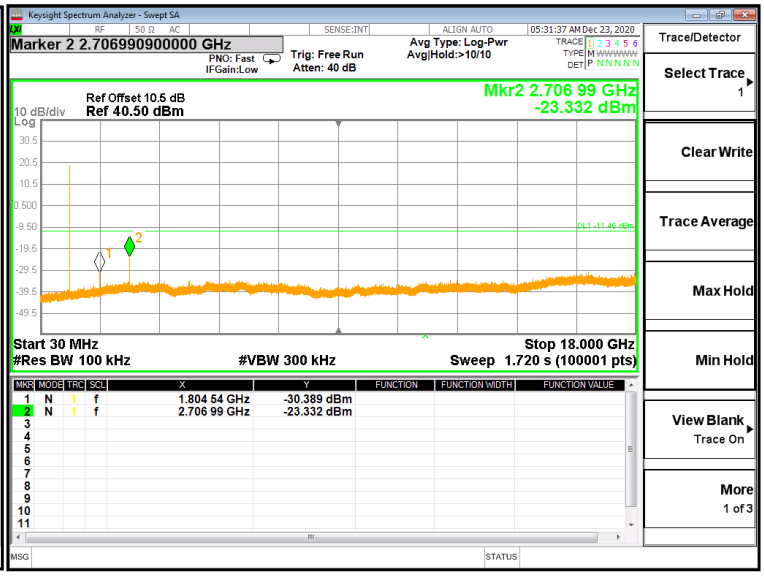


2.6.5 Conducted Emissions Data: (Hybrid Mode)

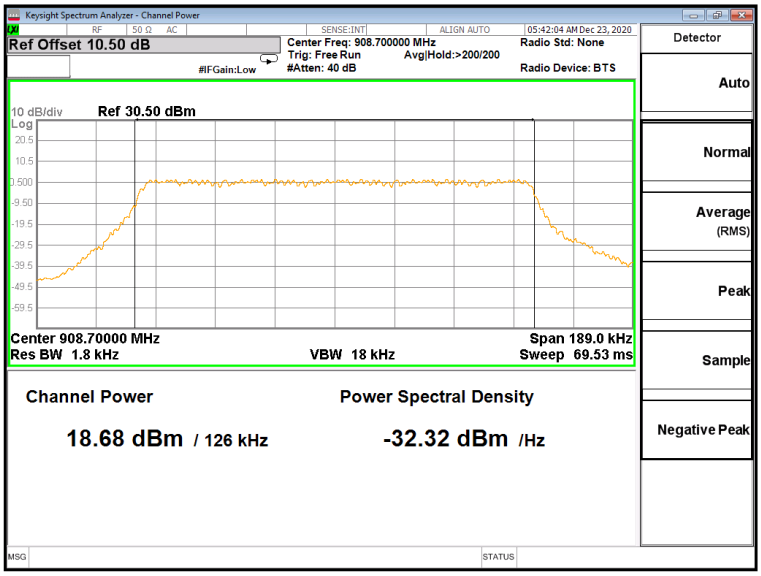
125 KHz Low Channel

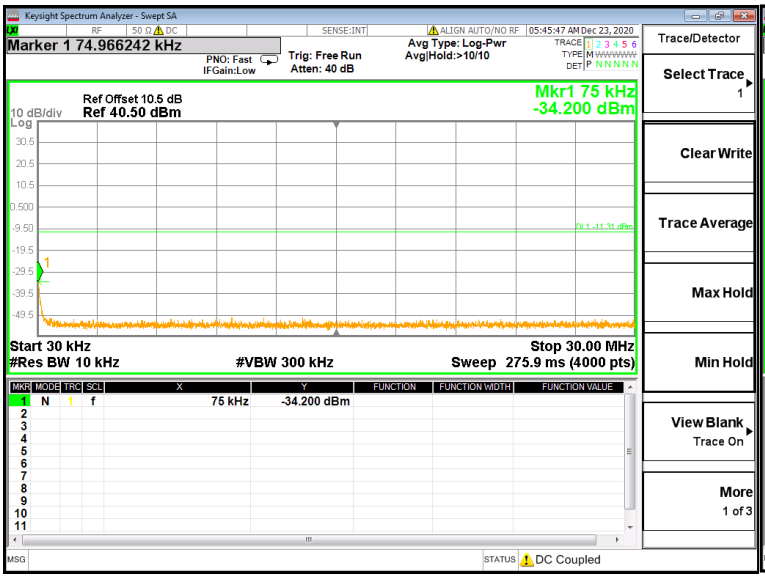


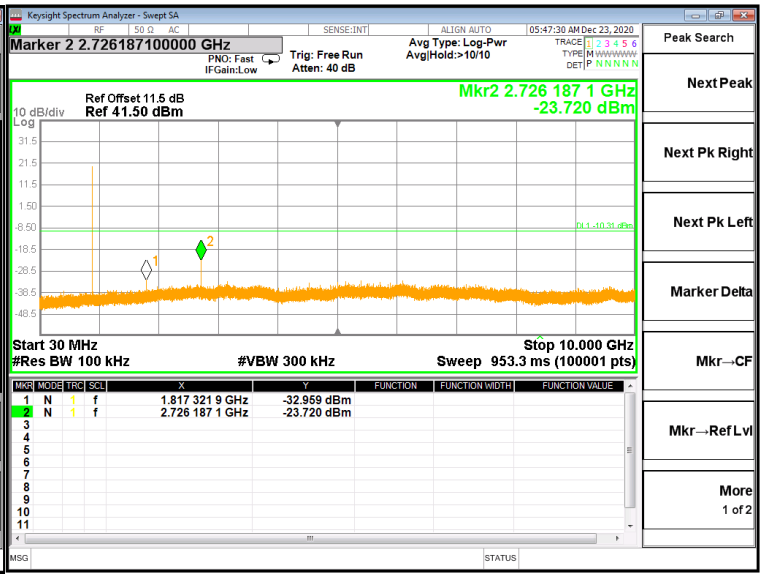




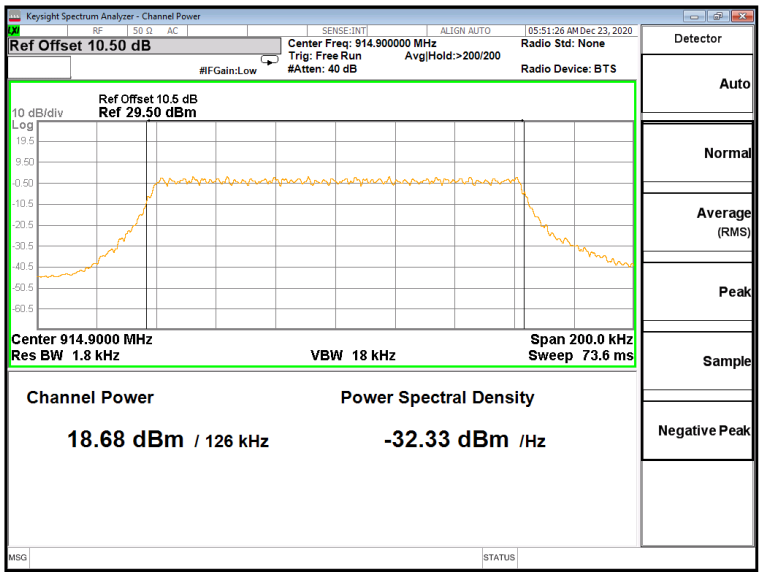
125 KHz MID Channel

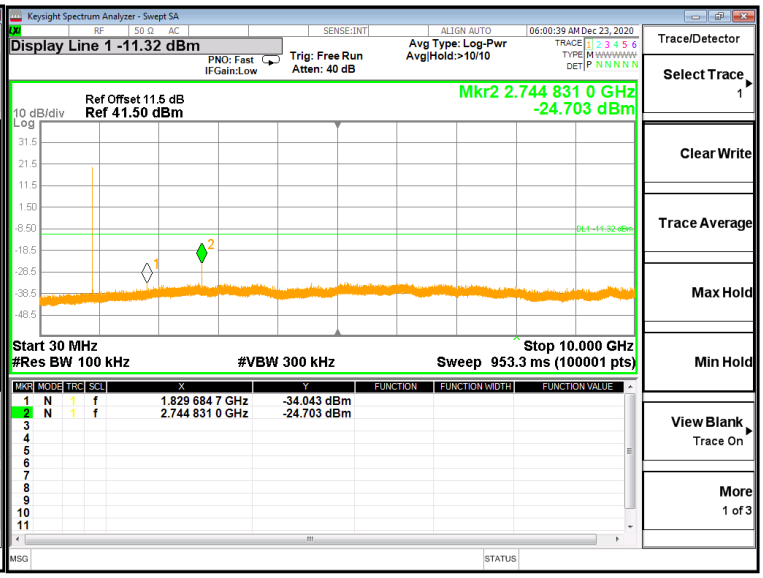






125 KHz High Channel





2.7 Channel Separation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC Part 15.247**
Date: 2021-01-15 (21.0°C,17.8% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

Specification: FCC Part 15.247(a, 1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

2.7.1 Test Guidance: ANSI 63.10 Clause 7.8.2 / 558074 D01 15.247 Measurement Guidance v05r02

This measurement is performed with the EUT transmitter frequency hopping function active.

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 set for a frequency span wide enough to capture at least two adjacent channels. The RBW is set to at least 1% of the span. The Peak detector is used, with the trace set to Max Hold. Channel Separation is displayed with the Marker Delta function.

2.7.2 Deviations From The Standard:

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

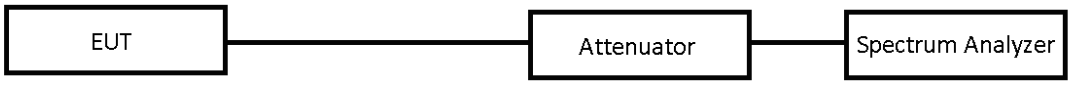
2.7.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 22.08	6906	2019-10-29	2020-10-29
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

2.7.4 Test Sample Verification, Configuration & Modifications

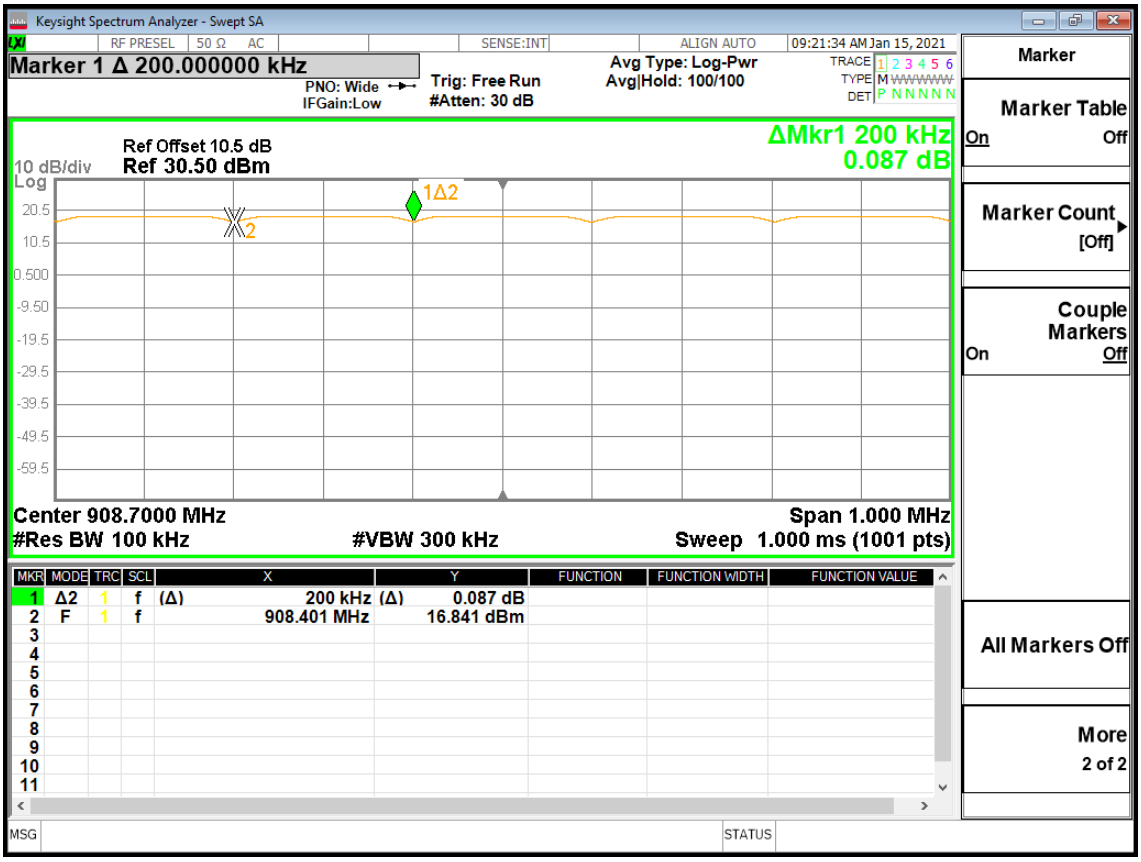
EUT configuration for Channel Separation testing:



2.7.5 Channel Separation Data:

Compliant: The channel separation measured for this device is 200 kHz.

Screen Captures from the spectrum analyzer: Hybrid 125 KHz



2.8 Time of Occupancy (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram	**Standard: FCC PART 15.247**
Date: 2021-01-15 (21.0°C,17.8% RH)	**Basic Standard: ANSI C63.10: 20013**

EUT status: Compliant

Specification: FCC Part 15.247 (f)

The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4

2.8.1 Test Guidance: ANSI 63.10 Clause 7.8.4 / 558074 D01 15.247 Measurement Guidance v05r02

This measurement is performed with the EUT frequency hopping function active.

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 set for Peak detection over a 0 Hz frequency span (time domain) centered on a hopping channel. The RBW shall be ≤ Channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel. VBW ≥ RBW. The sweep time is adjusted to clearly capture one transmission. The Dwell time is measured with the Marker Delta function.

Another sweep is set to capture enough transmission events to calculate the number of events within the specified period of time. The Peak detector is used, with the trace set to Max Hold.

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

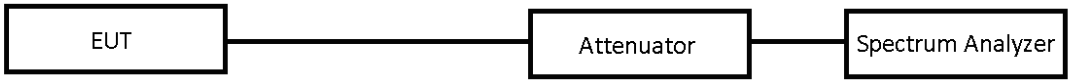
Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 22.08	6906	2019-10-29	2020-10-29
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker	MCL	BLK-89-S+	-	2020-02-01	2021-02-01
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2020-02-01	2021-02-01

2.8.4 Test Sample Verification, Configuration & Modifications

The EUT was operating in normal mode. The EUT met the requirements without modification.

EUT configuration for Dwell Time testing:



2.8.5 Dwell Time Data:

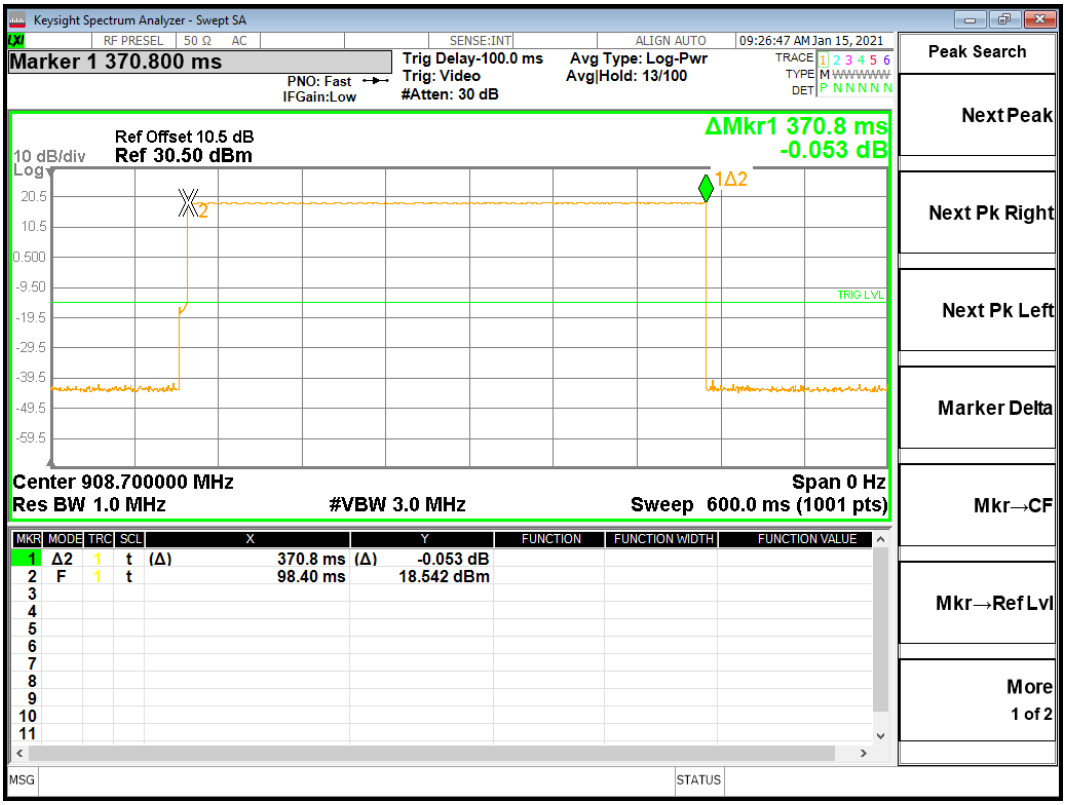
Measured Dwell time = 370.8 ms

Window of measurement is equal to number of hopping channels multiple by 400ms = **0.4 x 64** = 25.6Sec

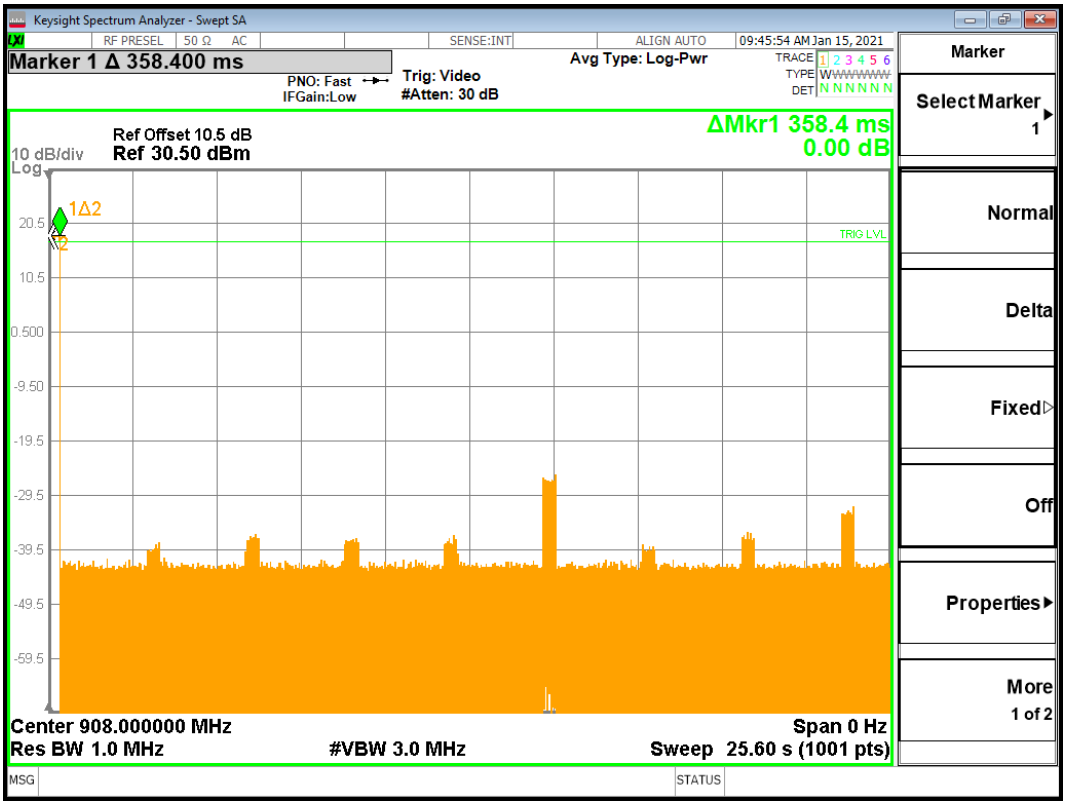
Number of events in 25.6Sec = 1

Margin = 400 – 370.8 = **29.2 ms**

Screen Capture from the spectrum analyzer: sweep time in 600ms



Screen Capture from the spectrum analyzer: sweep Time in 25.6 Sec



Note: sweep time accuracy is +/-12.8ms on this screen.

2.9 EUT Positioning Assessment

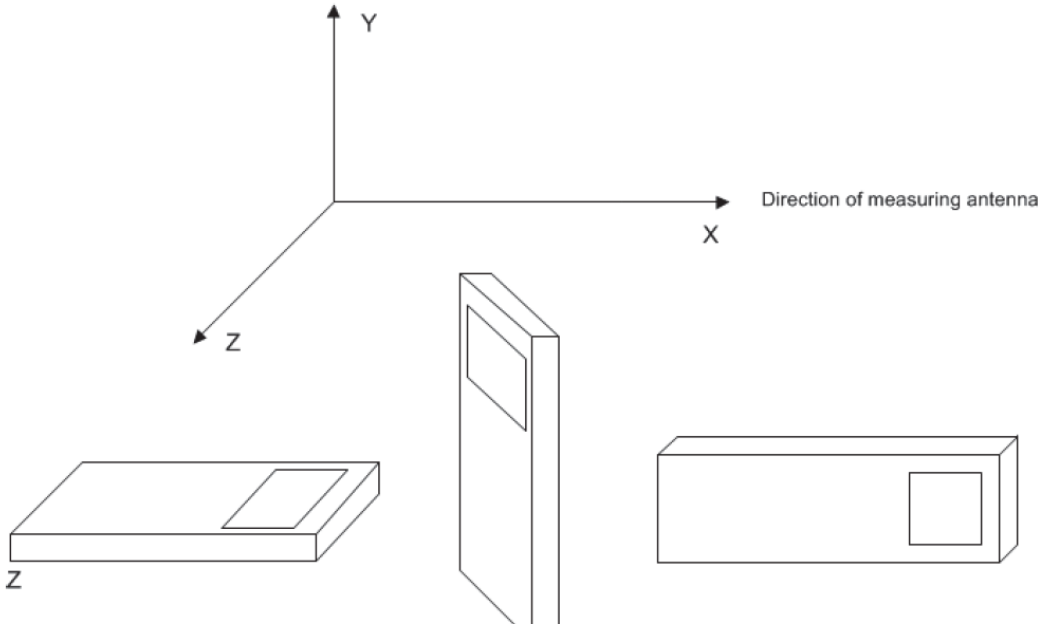
Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: I. Akram /Janet Mijares	**Standard: FCC PART 15.247**
Date: 2020-12-21/22 (20.5°C,8.9% RH)	**Basic Standard: ANSI C63.4-2014**

X-Axis Found worse

Comments: EUT oriented in three axis's and X- axis found to be worse emission axis. .

Specification: ANSI C63.4-2014, Clause 6.3.2.1

Portable, small, lightweight, or modular devices that may be handheld, worn on the body, or placed on a table during operation shall be positioned on a non-conducting platform, the top of which is 80 cm above the reference ground plane. The preferred area occupied by the EUT arrangement is 1 m by 1.5 m, but it may be larger or smaller to accommodate various sized EUTs (see Figure 6, Figure 7, and Figure 9). For testing purposes, ceiling- and wall-mounted devices also shall be positioned on a tabletop (see also 6.3.4 and 6.3.5). In making any tests involving handheld, body-worn, or ceiling-mounted equipment, it is essential to recognize that the measured levels may be dependent on the orientation (attitude) of the three orthogonal axes of the EUT. Thus, exploratory tests as specified in 8.3.1 shall be carried out for various axes orientations to determine the attitude having maximum or near-maximum emission level.



Refer to Test Setup photo exhibit.

2.10 Radiated Spurious Emissions in restricted frequency bands (TX Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel: Imran Akram/ Janet Mijares	**Standard: FCC PART 15.247**
Date: 2021-01-14 (20.1°C,10.7 % 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)).

2.10.1 Test Guidance: ANSI C63.10-2013, Clause 13.4.2

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.

2.10.2 Deviations From The Standard:

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

2.10.3 Test Equipment

Testing was performed with the following equipment:

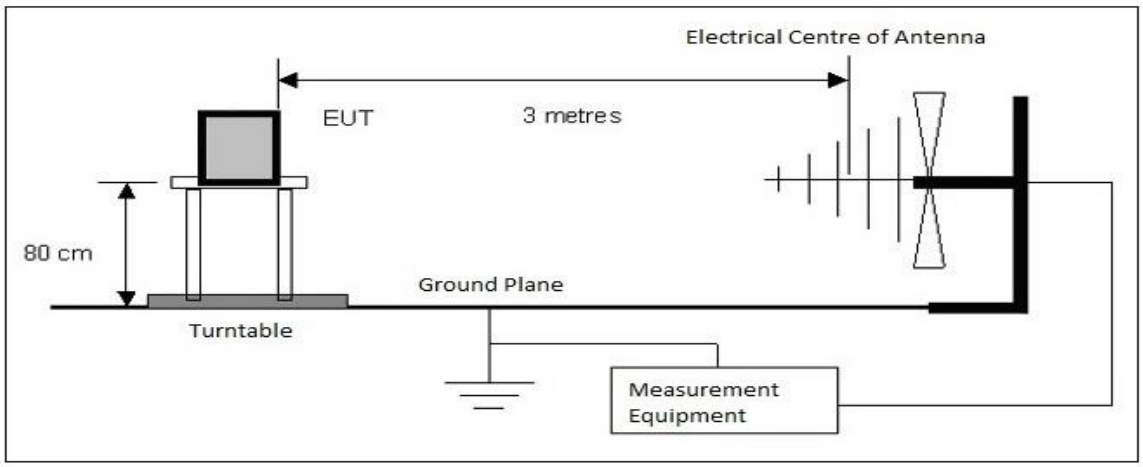
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2019-05-10	2020-05-10
Loop Antenna	EMCO	6502	10868	2019-04-11	2021-04-11
Biconilog Antenna	ARA	LPB-2520/A	4318	2018-09-19	2020-09-19
DRG Horn	EMCO	3115	19357	2018-09-12	2020-09-12
Humidity/Temp Logger	Extech Ins. Corp.	42270	5892	2019-04-05	2020-04-05
Low Noise Amplifier (1 – 18 GHz)	MITEQ	JS43-01001800-21-5P	4354	2020-01-03	2021-01-03
Pre-Amplifier (30 – 1300 MHz)	HP	8447D	9291	2020-01-03	2021-01-03
RE Cable below 1GHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4419	2020-01-03	2021-01-03
Re Cable Above 1 GHz	A.H. System Inc.	SAC-26G-8.23	6187	2020-01-03	2021-01-03
High Pass Filter	K&L	4DH21	-	2020-01-03	2021-01-03

2.10.4 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.

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 (µV/m)	Measurement Distance (m)
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

2.10.5 Radiated Emissions Data:

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 Low band channel 902.3 MHz was selected as the worst-case condition for detailed examination.
- In Transmit mode, the EUT was assessed up to 10.0 GHz.

Negative values for Delta indicate compliance.

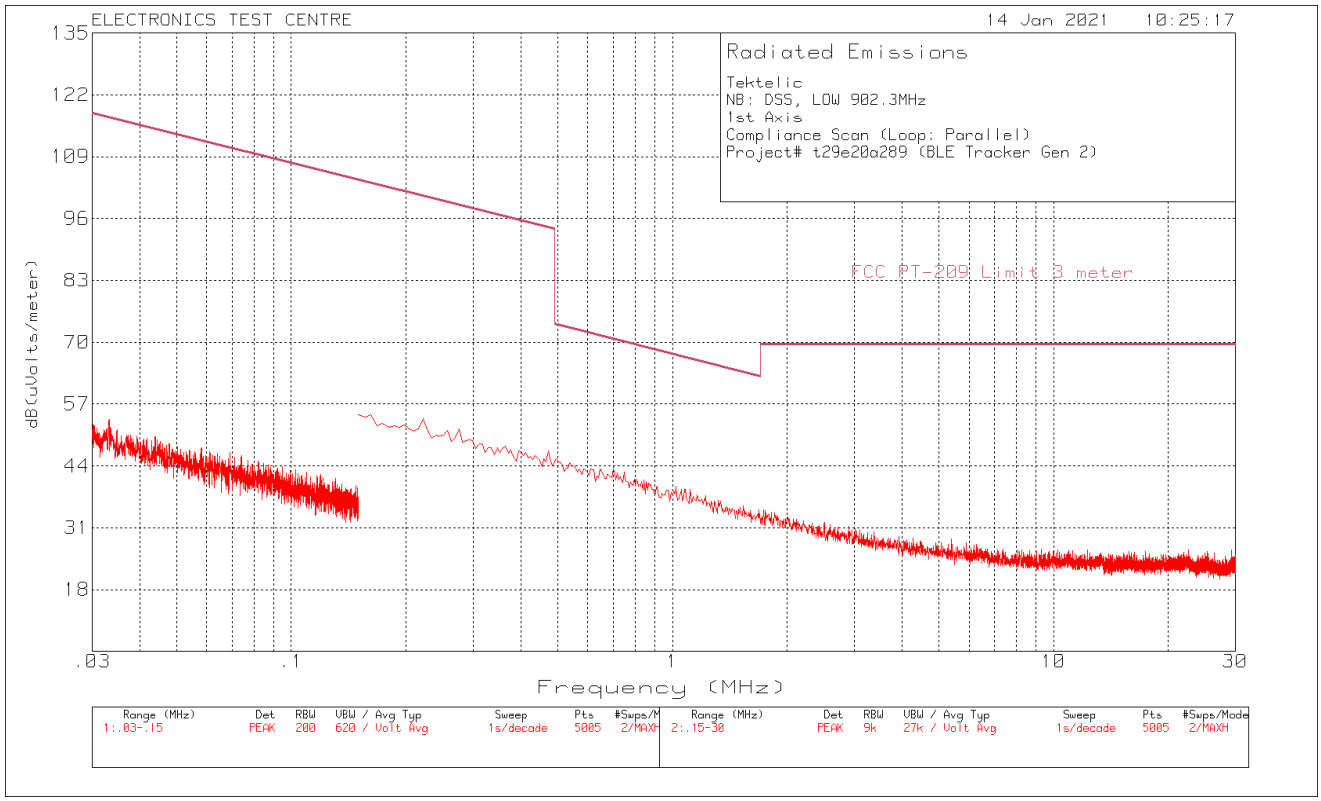
Band	Freq. Marker	Freq. [MHz]	Raw reading [dBμv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBμv/m]	FCC 15.209 Limit [dBμv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
Frequency Range 1400 – 10000 MHz												
RB	2	8121.5	26.77	AV	36.7	-27.3	36.17	54	-17.83	104	318	Horizontal
RB	2	8121.5	39.16	PK	36.7	-27.3	48.56	74	-25.44	104	318	Horizontal
RB	1	5413.8	37.15	AV	34	-31.1	40.05	54	-13.95	142	399	Vertical
RB	1	5413.8	43.15	PK	34	-31.1	46.05	74	-27.95	142	399	Vertical

AV: Average Detector, PK: Peak Detector,

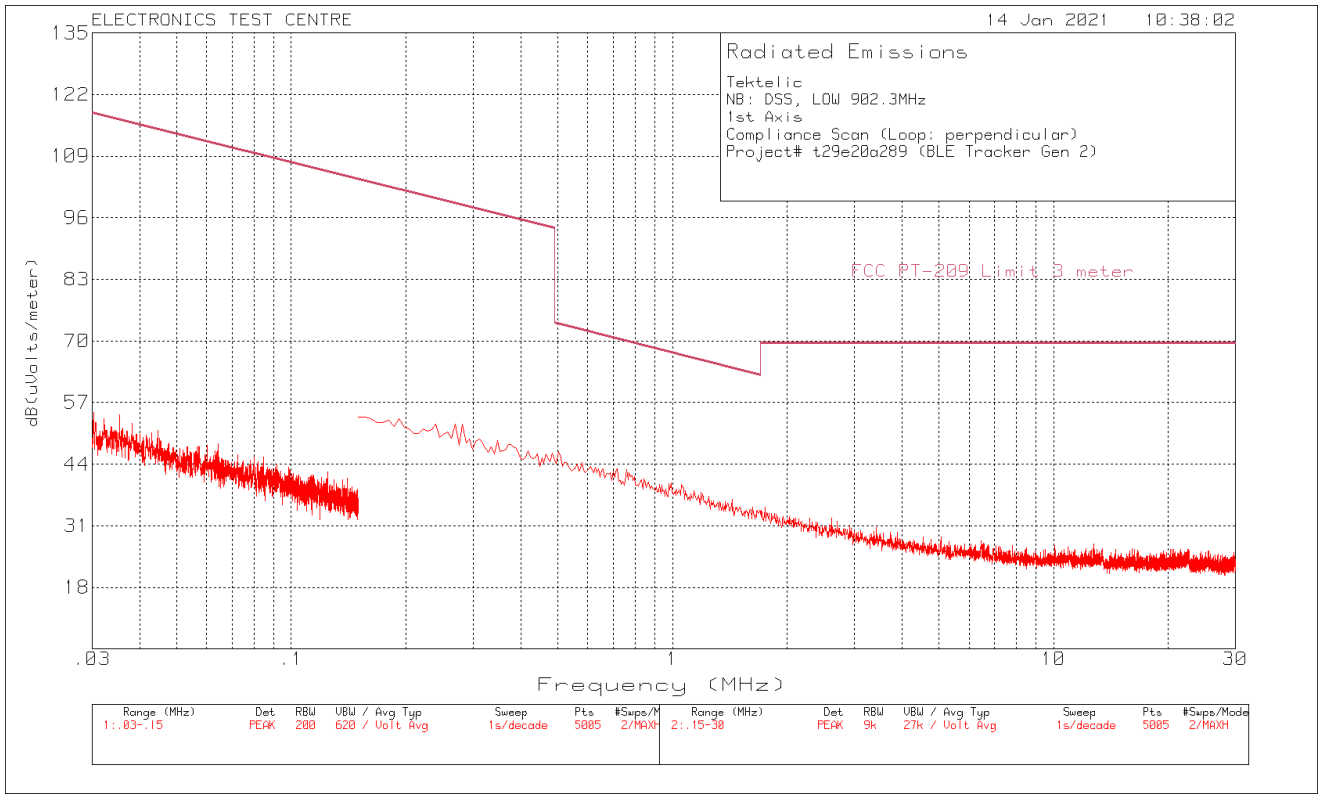
*** Restricted Band (RB)**

Non Restricted Band (NRB)

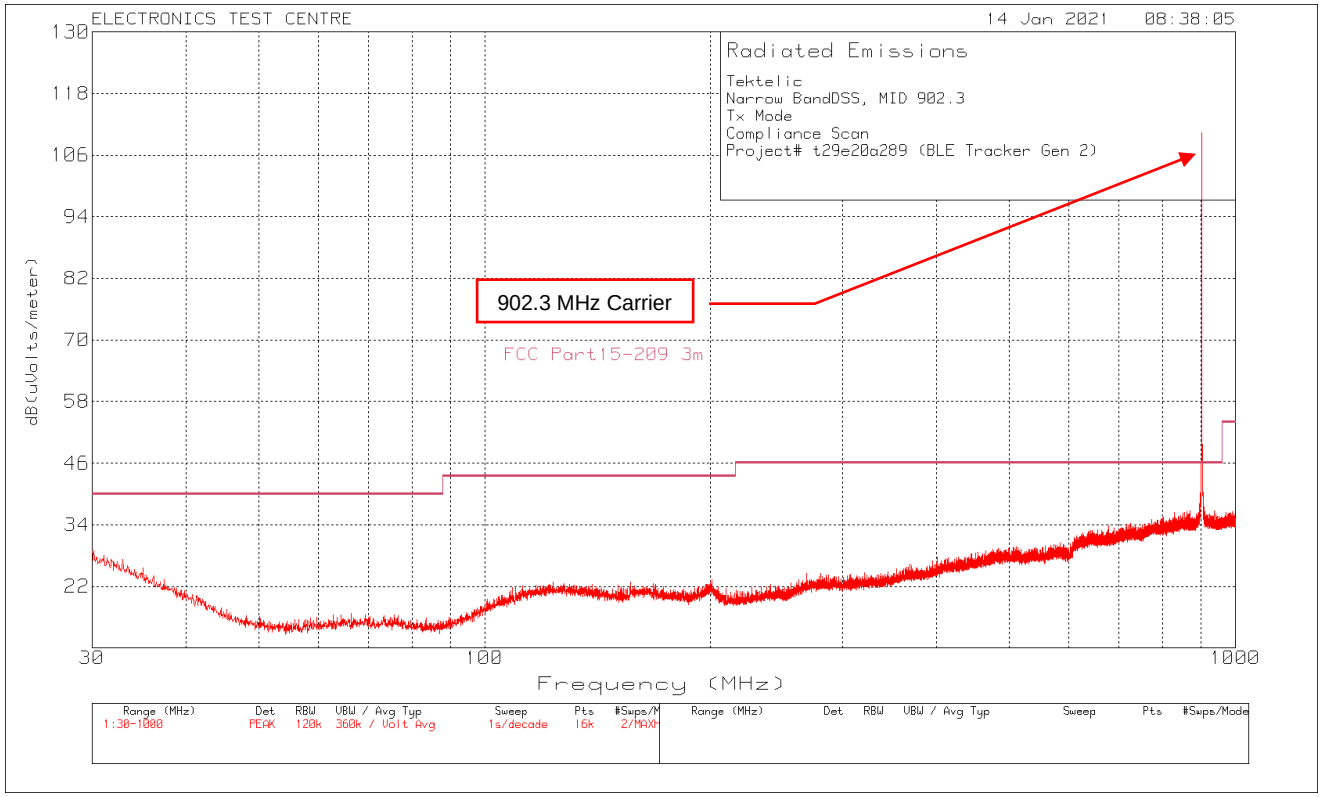
Plot of Radiated Emissions: Measuring Antenna Parallel



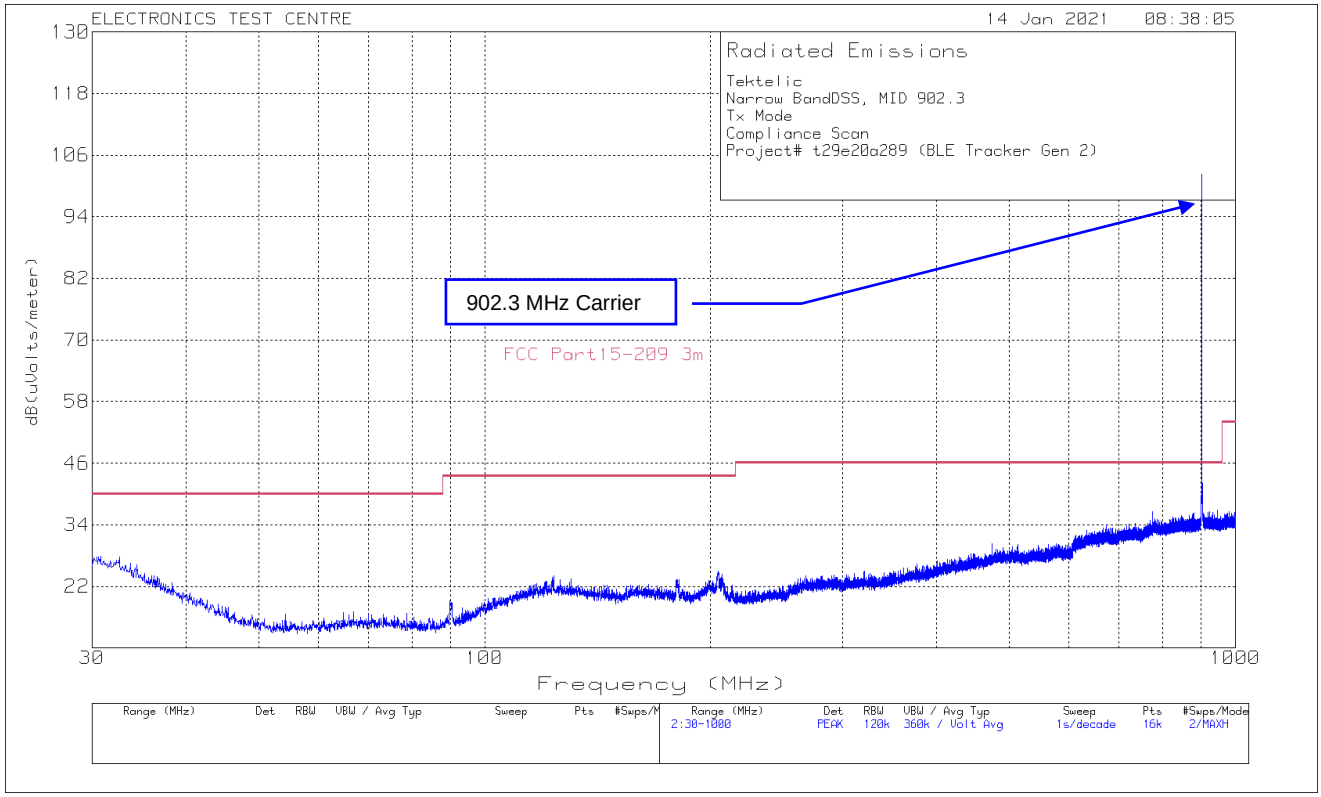
Plot of Radiated Emissions: Measuring Antenna Perpendicular



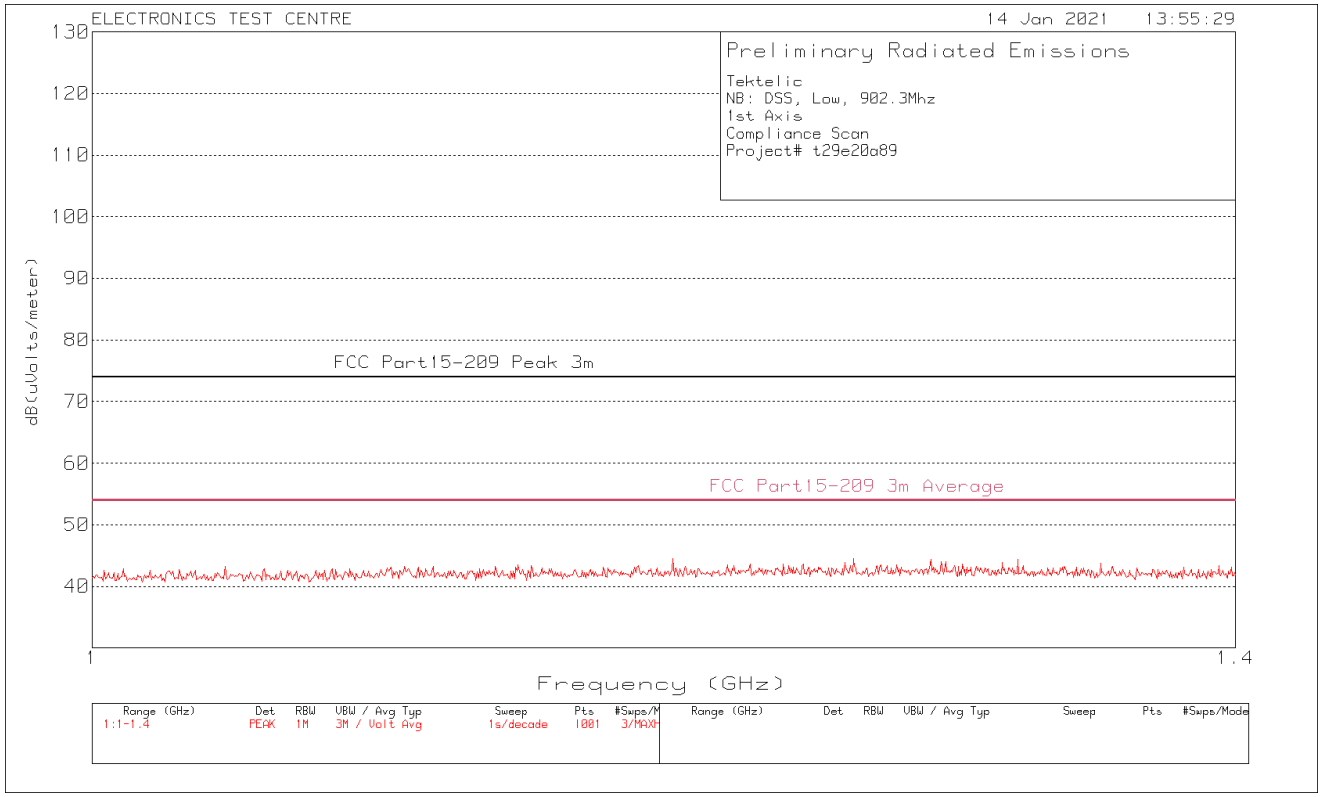
Plot of Radiated Emissions: Horizontal polarization



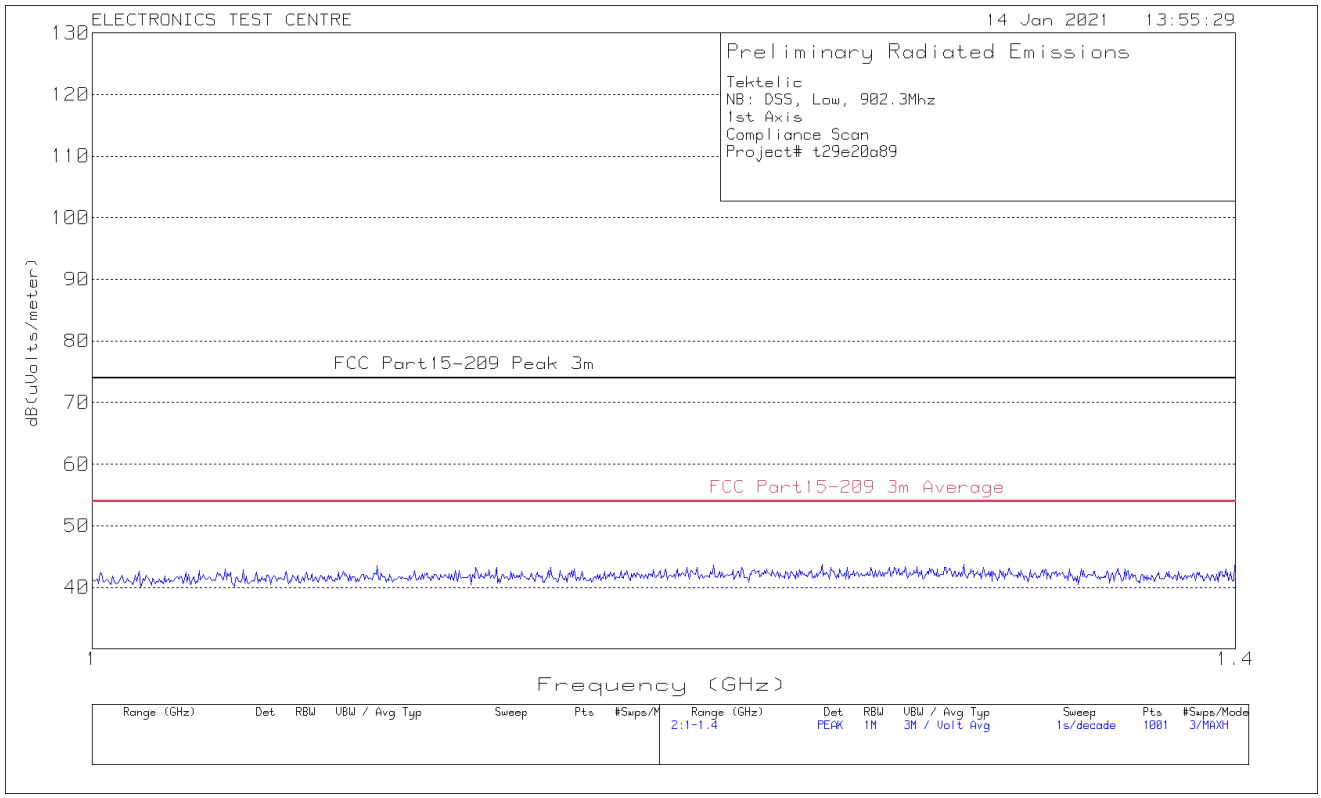
Plot of Radiated Emissions: Vertical polarization



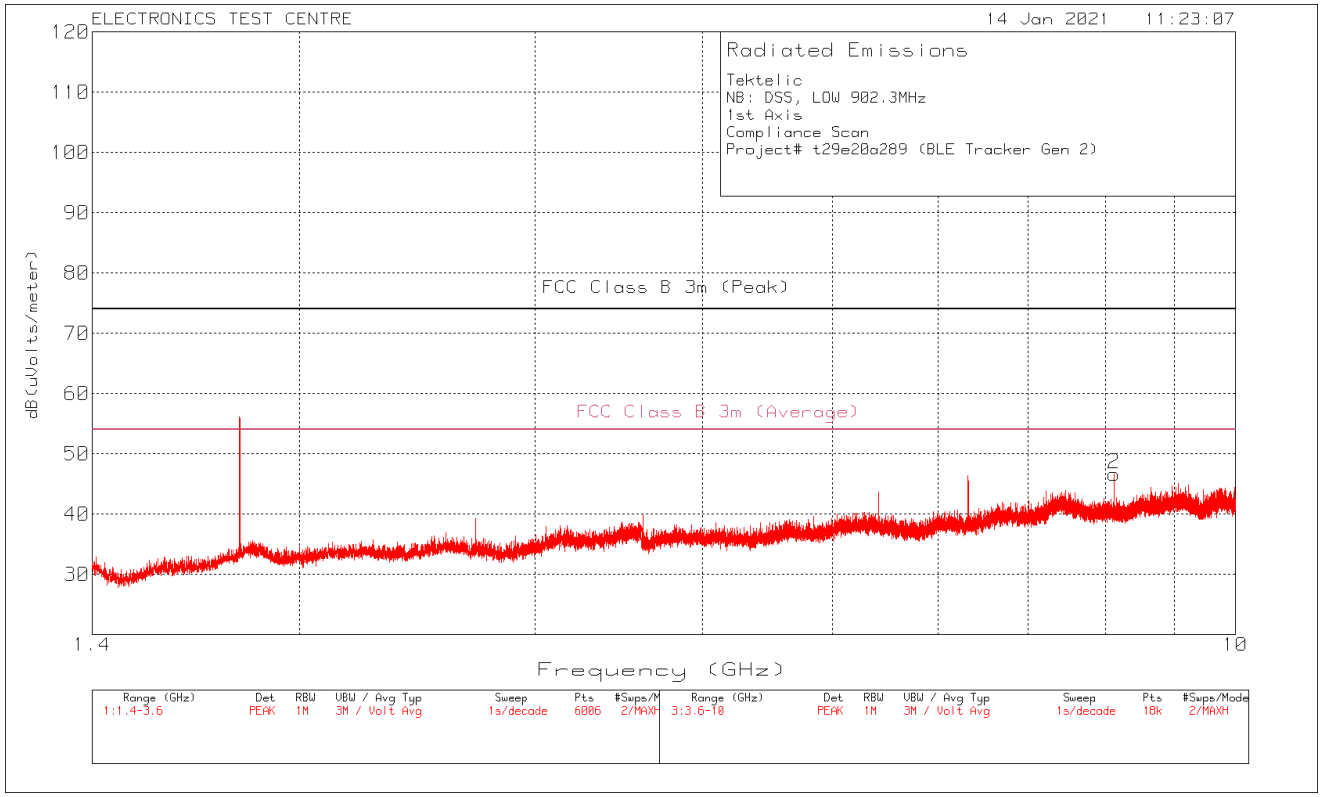
Plot of Radiated Emissions: Horizontal polarization



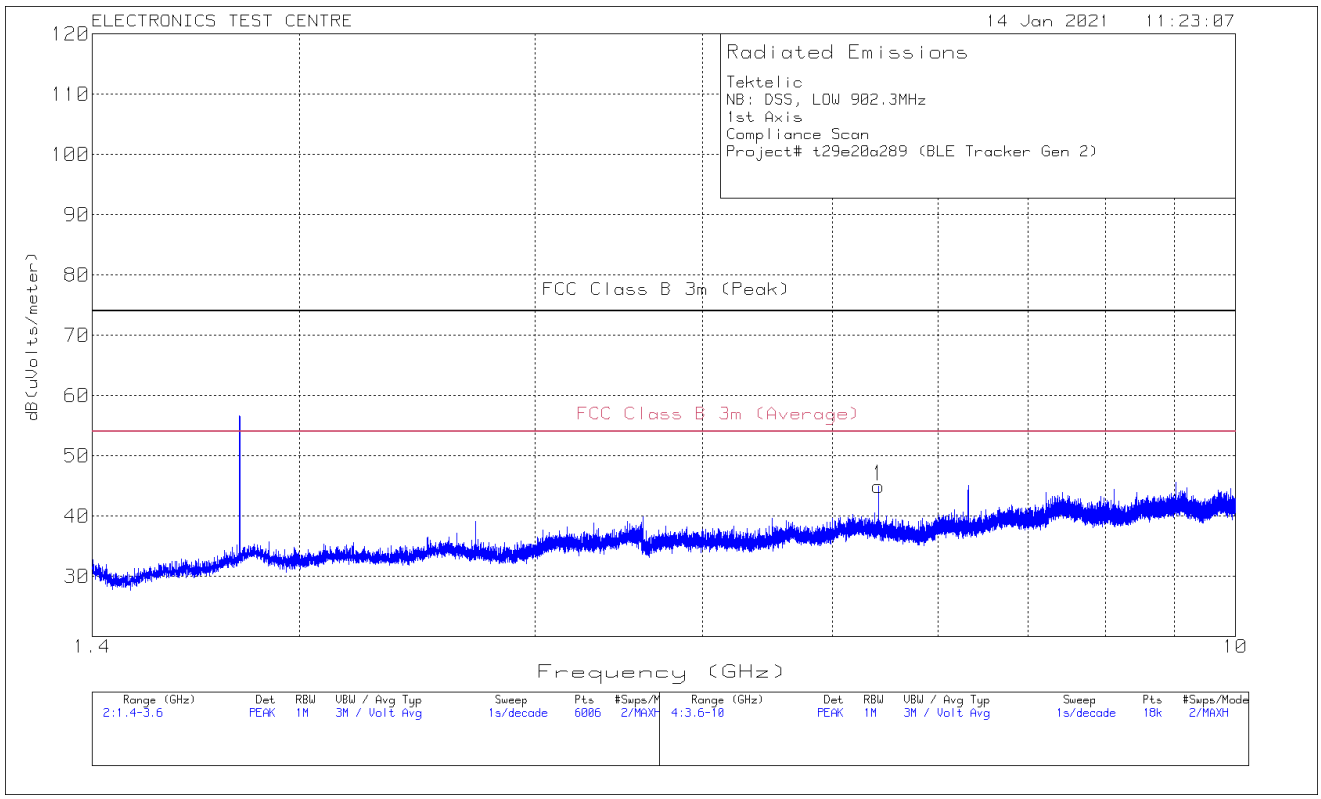
Plot of Radiated Emissions: Vertical polarization



Plot of Radiated Emissions: Horizontal polarization



Plot of Radiated Emissions: Vertical polarization



2.11 RF Exposure

Test Lab: Electronics Test Centre, Airdrie	**EUT: BLE Sensor GEN2**
Test Personnel:	**Standard: FCC PART 15.247**
Date:	

EUT status: Exempt

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

3.0 TEST FACILITY

3.1 Location

The BLE Sensor GEN2 was tested for emissions 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.

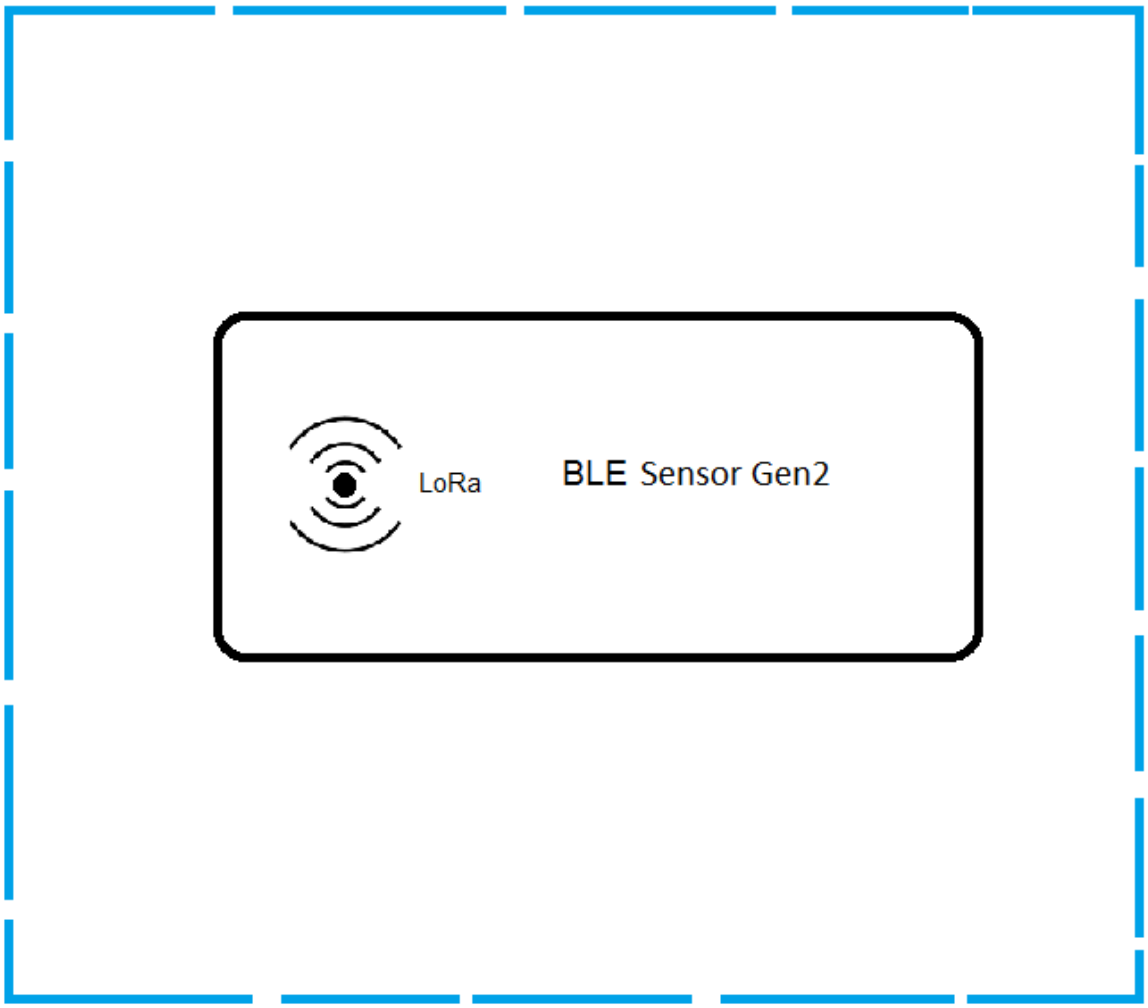
3.2 Grounding Plan

The BLE Sensor GEN2 was placed at the center of the test chamber turntable on top of polystyrene foam table. No provision is made within the BLE Sensor GEN2 for an earth ground connection.

3.3 Power Supply

All EUT power was supplied by a DC power supply (3.6V).

Appendix A (Worse Emission test setup Block Diagram)



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