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EMC testing of the Tektelic Communication Inc. Kona Industrial Sensor

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: 2ALEPT0005485

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REVISION RECORD

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2019-06-18	I. Akram	Initial draft submitted for review.
Release 1	2019-06-21	M. Rousseau	Sign off
Release 2	2019-06-26	M. Rousseau	Correct version for KDB 558074 D01 from v05r01 to v05r02

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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 Industrial Sensor 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 Industrial Sensor
LoRa Radio	**Frequency Band**	902 – 928 MHz
	Type of Modulation	Chirp Spread Spectrum
	BW/Frequency Range	DTS 500kHz, 903 – 914.9 MHz
	Associated Antenna	Pulse Electronics W3907 LTE 698-3600MHz FPC Antenna Peak Gain(698-960MHz) = 2.9dBi
	Detachable/Non Detachable	Non-Detachable
Model# / Serial#		T0005500 / 1915N0016
Power supply:		Internal Battery

Note: All three channels and axis for T0005500 (DN) in DTS mode were evaluated. Worse Chanel and Axis was selected for detail analysis for radiated emission.

1.4 General Test Conditions and Assumptions

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.

In this report, the EUT is only tested for the DTS 500 kHz transmission. Test results regarding Hybrid 125 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.

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 FCC OET KDB 558074 D01 15.247 Measurement Guidance v05r02.

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 %

Modulation mode: DTS 500 kHz:
DTS modulation system operating in non-frequency hopping. The channels used for the tests are:

Low = 903 MHz

MID = 909.4 MHz

High. = 914.9 MHz

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 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 – 914.2) MHz 500 KHz DTS Mode Max. Conducted Tx Power = 18.45 dBm (0.07 Watt)						
2.1	AC Conducted Emissions (Tx)	15.207	Kona Industrial Sensor	none	see § 2.1	**Compliant**
2.2	Occupied Bandwidth	15.247(a)(1) 15.247(2)(2)	Kona Industrial Sensor	none	see § 2.2	**Compliant**
2.3	Max Average Output Power Conducted	15.247(b)	Kona Industrial Sensor	none	see § 2.3	**Compliant**
2.4	Power Spectral Density	15.247(e) 15.247(f)	Kona Industrial Sensor	none	see § 2.4	**Compliant**
2.5	Band Edge	15.247(d)	Kona Industrial Sensor	none	see § 2.5	**Compliant**
2.6	Conducted Spurious Emission in Non-Restricted Band	15.247(d)	Kona Industrial Sensor	none	see § 2.6	**Compliant**
2.7	EUT Position	ANSI C63.4	Kona Industrial Sensor	none	see § 2.7	**Assessed**
2.8	Radiated Spurious Emission in Restricted Band (Tx Mode)	15.205, 15.209 15.247(d)	Kona Industrial Sensor	none	see § 2.8	**Compliant**
2.9	RF Exposure	15.247(i)	Kona Industrial Sensor	none	see § 2.9	**Exempt**

Refer to the test data for applicable test conditions.

2.1 AC Power Line Conducted Emissions: Transmit Mode

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Imran Akram	**Standard: FCC Part 15.207**
Date: 2019-06-18 (22.6°C,42.5% RH)	**Basic Standard: ANSI C63.10: 2013**

EUT status: Compliant

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

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 #	Calibration Date	Calibration Due
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	N/A
EMI receiver	Agilent	N9038A	6130	2019-05-10	2020-05-10
LISN	Com-Power	LI-215A	6180	2018-06-06	2020-06-06
Temp/RH logger	Extech	42270	5892	2019-04-05	2020-04-05
RE Cable below 30MHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4436	2019-01-03	2020-01-03

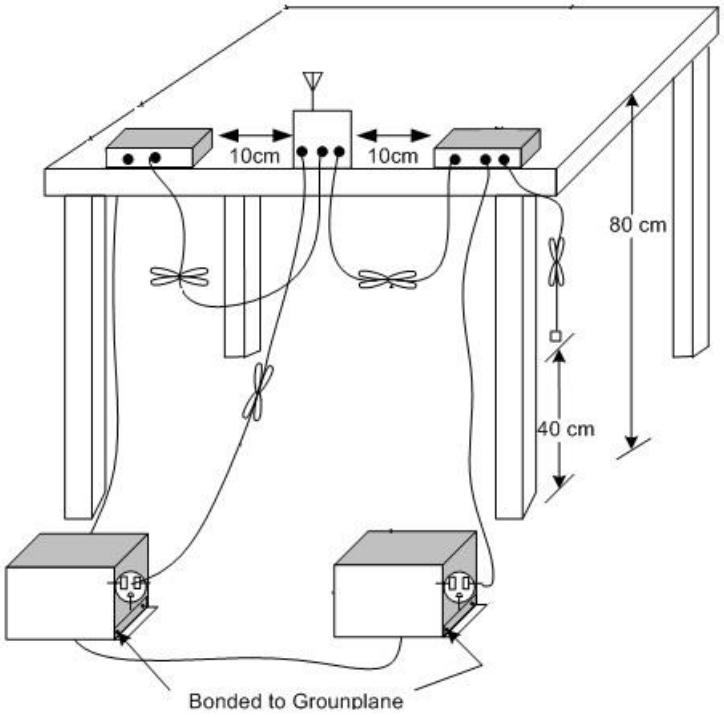
2.1.4 Test Sample Verification, Configuration & Modifications

The EUT was set to selected channels with test-specific software. The output was modulated as in normal operation. Configuration in Tx mode radios are transmitting at High channel.

The EUT was powered via analog DC power supply.

The EUT met the requirements without modification.

Test setup diagram:



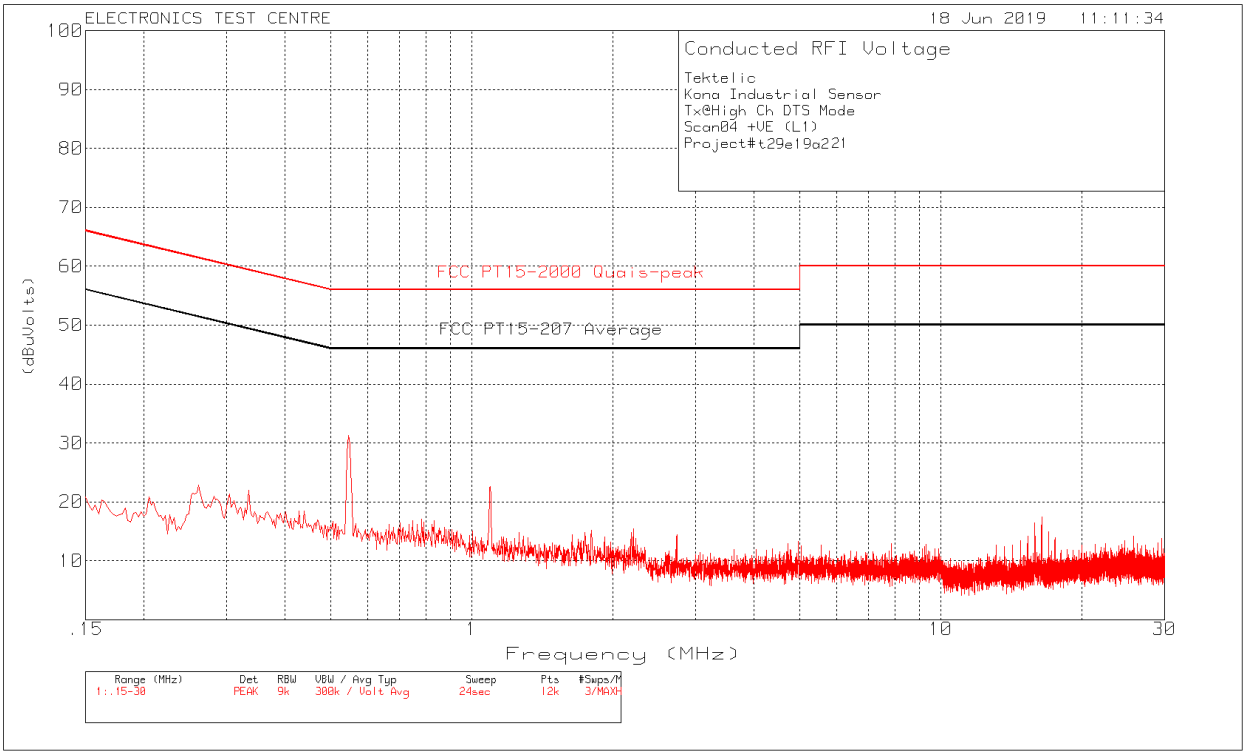
2.1.5 Conducted Emissions Data:

The EUT was evaluated in all channels. No channel showed emission worst then another. The plots are from the DTS mode using High-channel.

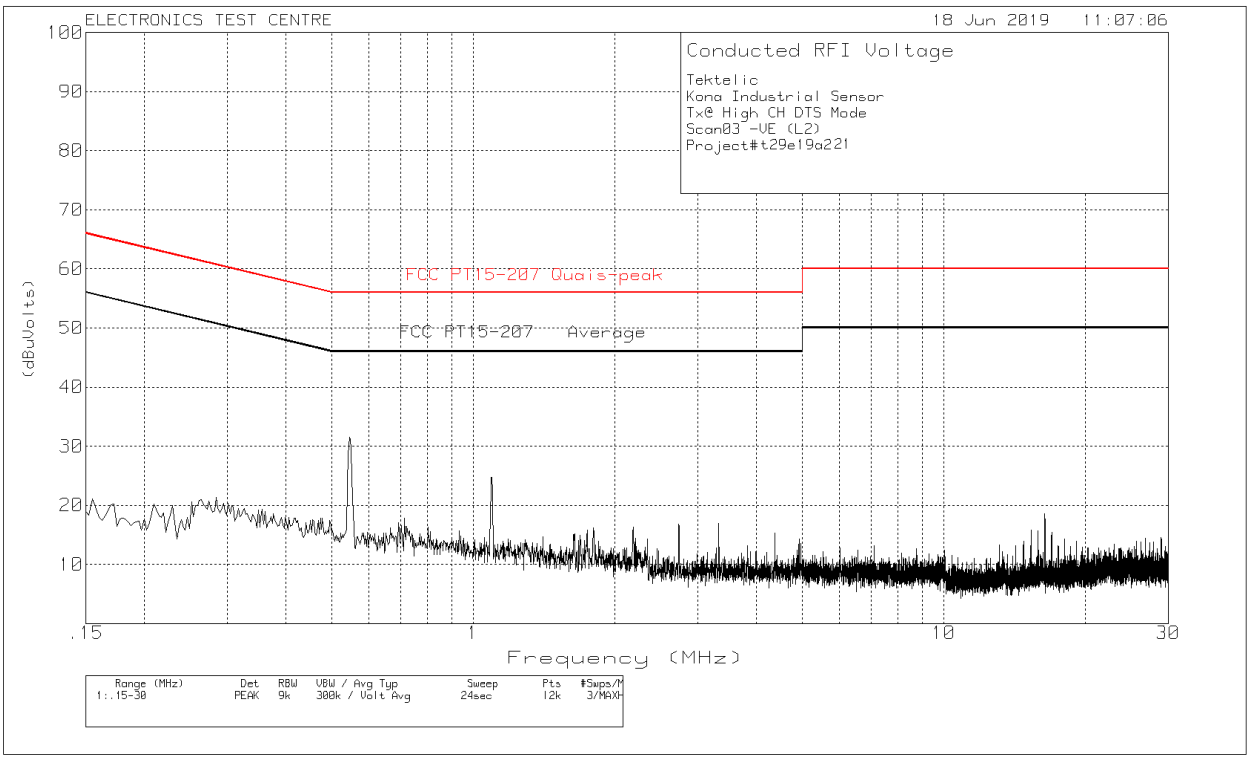
All emission more than 10 dB below the average limit

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

Plot of Conducted Emissions: Line1



Plot of Conducted Emissions: Line2



2.2 Channel Occupied Bandwidth (DTS Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-06 (26.4°C,21.7 % 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/ 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:	
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
Signal Analyzer	Agilent	N9010A	6678	2018-07-16	2019-07-16
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2018-11-23	2019-11-23
DC Blocker	MCL	BLK-89-S+	-	2019-01-15	2020-01-15
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2019-01-15	2020-01-15

2.2.4 Test Sample Verification, Configuration & Modifications

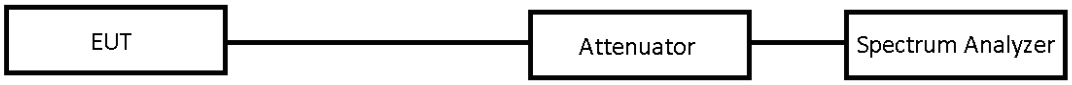
The EUT was set to transmit continuously on a selected channel with test-specific software. The output was modulated as in normal operation. The EUT modified to provide the direct access to antenna trace for conducted measurements.

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:

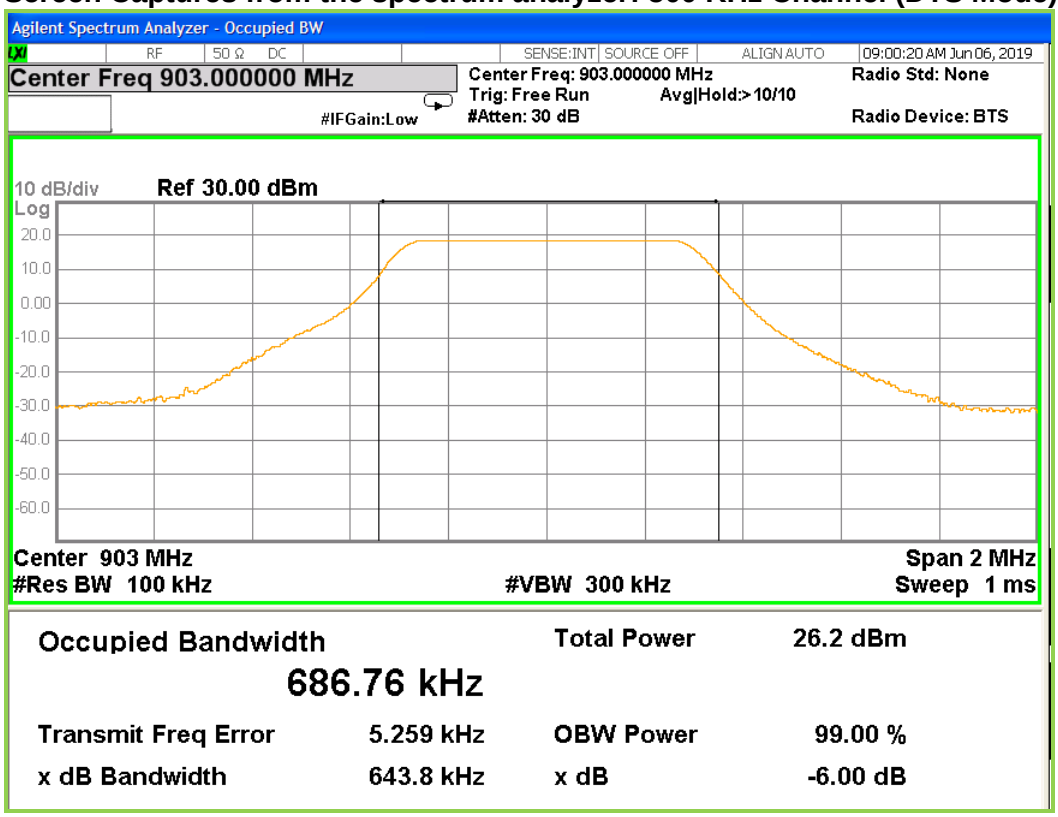


2.2.5 Channel Occupied Bandwidth Data: (DTS Mode)

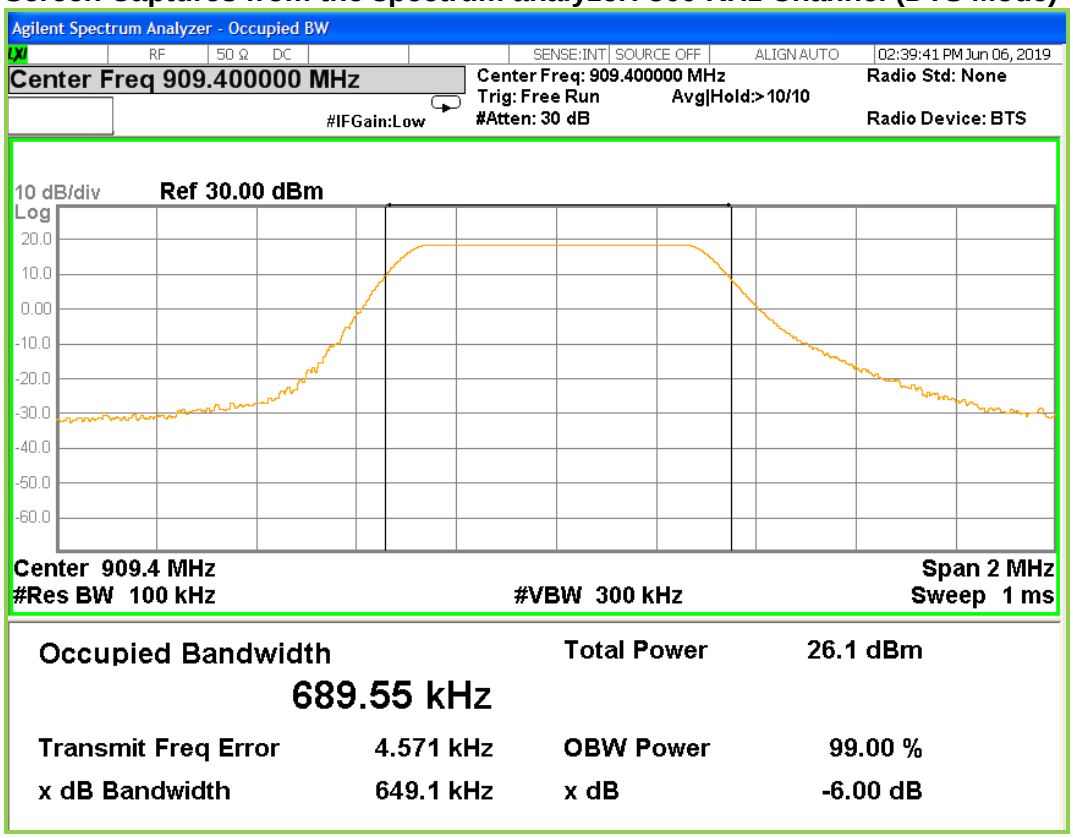
Lora 500 KHz Channels

Channel	Freq. [MHz]	6 dB OBW [kHz]	99% OBW [KHz]	Limit 6 dB OBW
Low	903	643.8	686.76	≥ 500 KHz
Mid	909.4	649.1	689.55	≥ 500 KHz
High	914.9	644.2	679.97	≥ 500 KHz

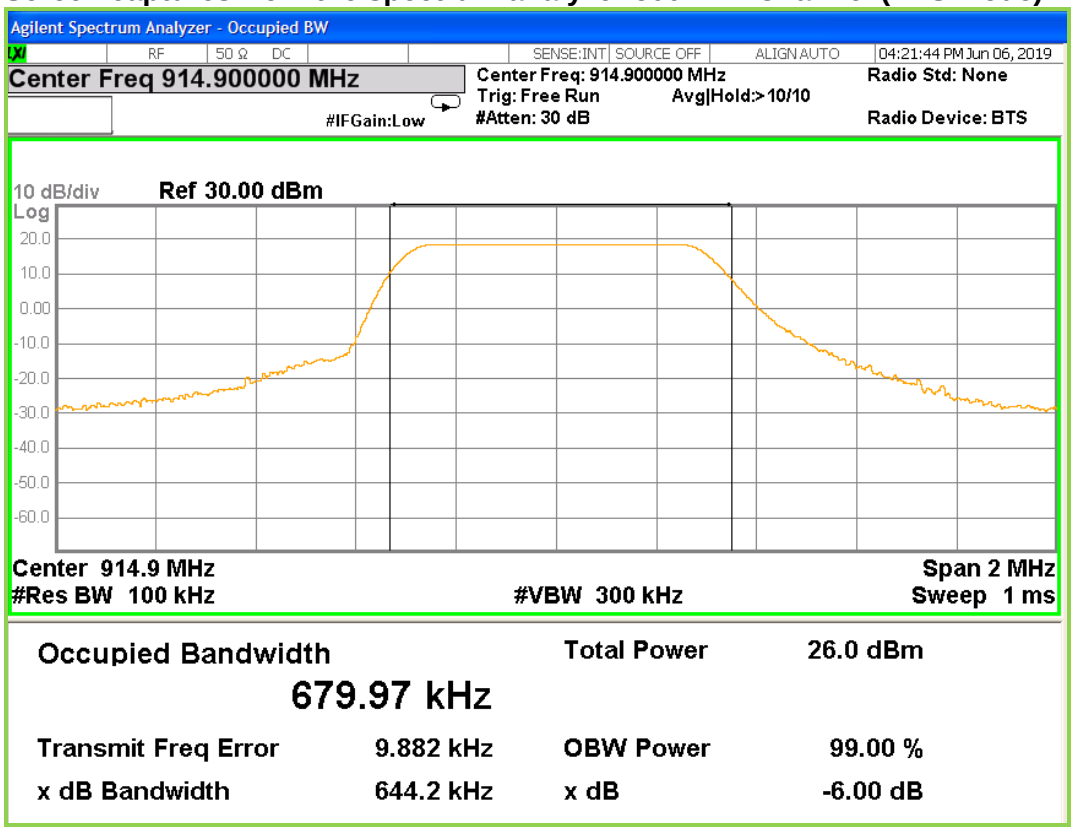
Screen Captures from the spectrum analyzer: 500 KHz Channel (DTS Mode)



Screen Captures from the spectrum analyzer: 500 KHz Channel (DTS Mode)



Screen captures from the spectrum analyzer 500 KHz Channel (DTS Mode)



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

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-06 (26.4°C,21.7 % RH)	**Basic Standard: ANSI C63.10: 2013 FCC OET KDB 558074**

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/ 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
Signal Analyzer	Agilent	N9010A	6678	2018-07-16	2019-07-16
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2018-11-23	2019-11-23
DC Blocker	MCL	BLK-89-S+	-	2019-01-15	2020-01-15
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2019-01-15	2020-01-15

2.3.4 Test Sample Verification, Configuration & Modifications

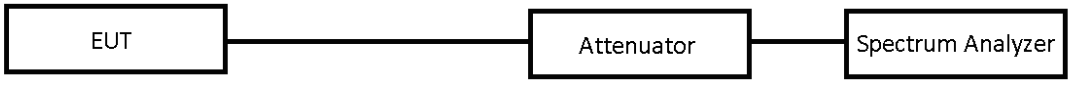
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

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

For compliance purposes EUT met requirements without any modification

Test setup diagrams for Peak Power testing:

Conducted:

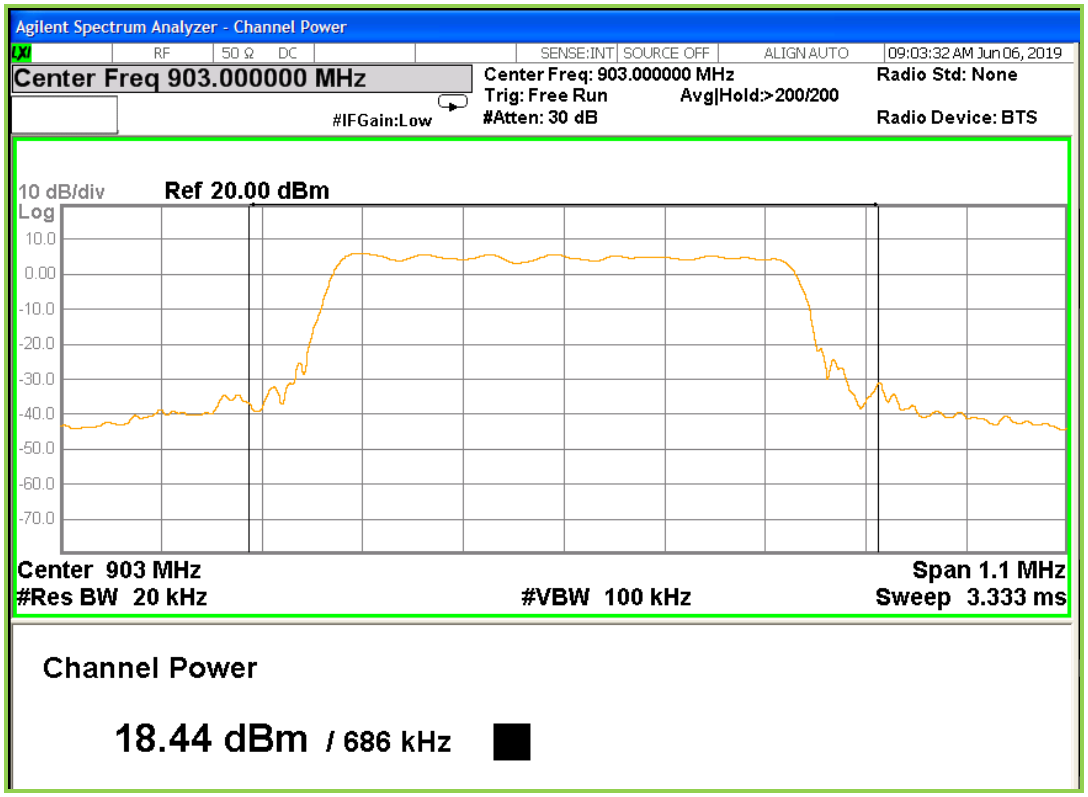


2.3.5 Peak Output Power Data (DTS Mode)

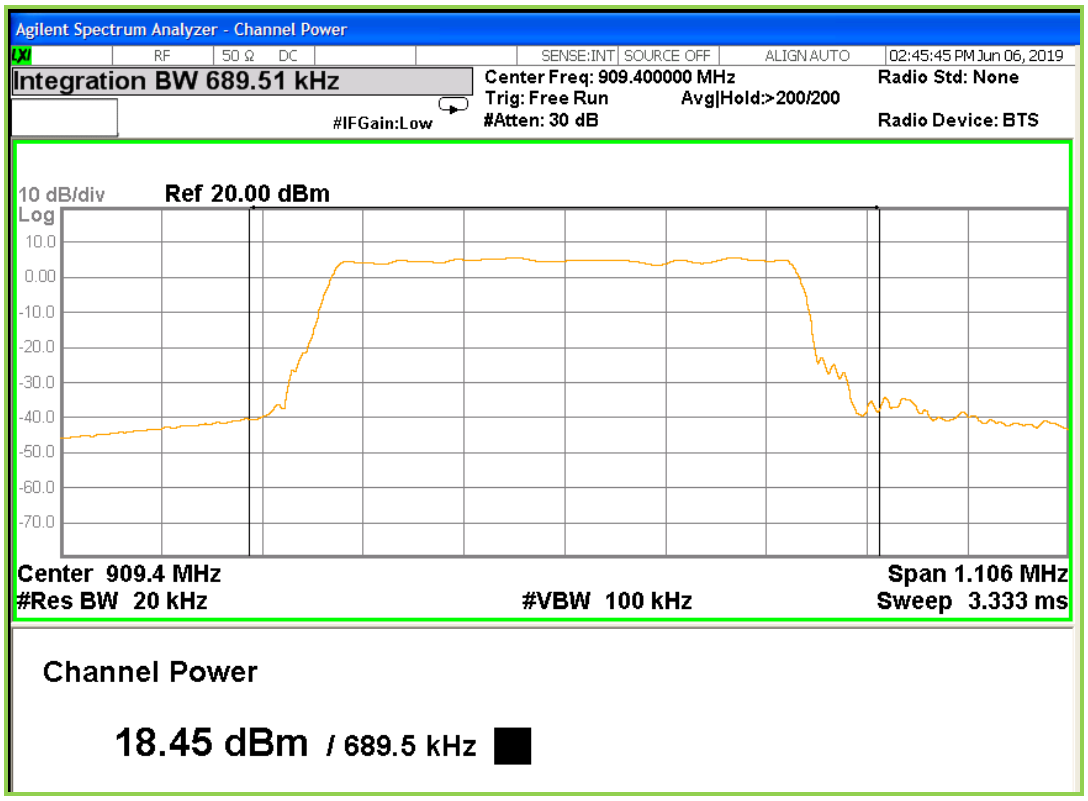
LoRa 500 KHz

Channel	Freq. [MHz]	Out Put Power (dBm)	Out Put Power Limit (dBm	Margin (dB)
Low	903	18.44	30	11.56
Mid	909.4	18.45	30	11.55
High	914.9	18.41	30	11.59

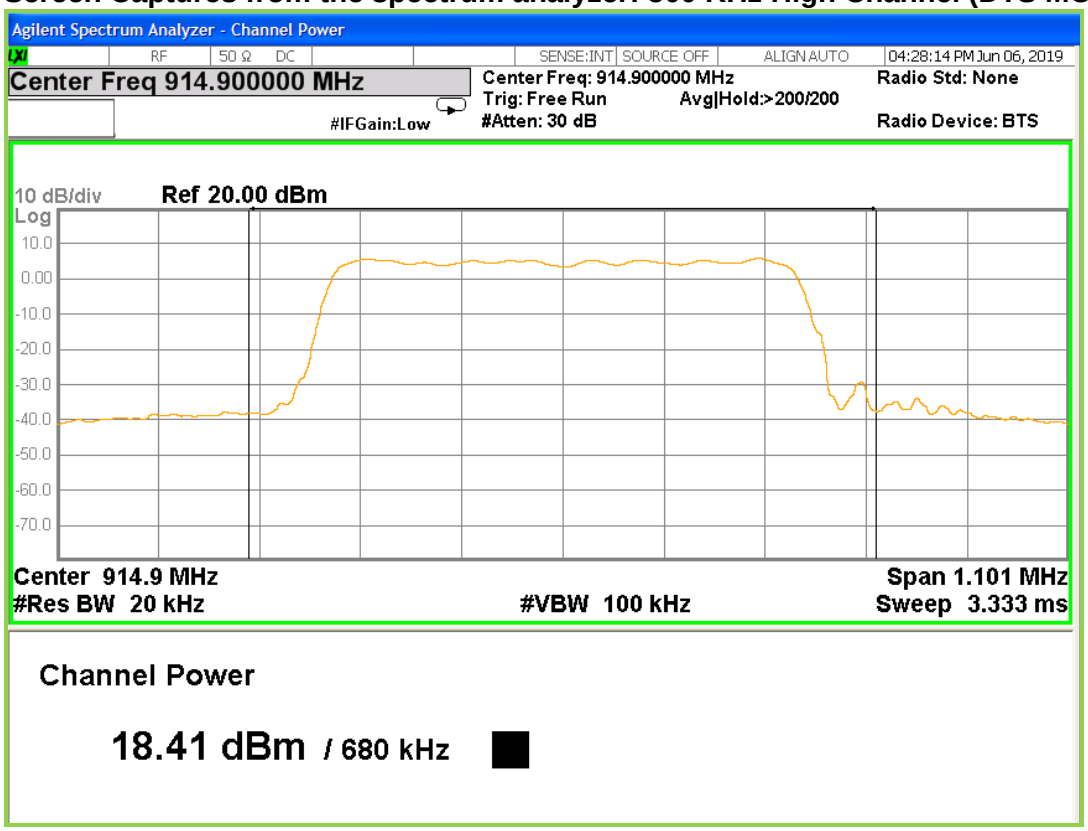
Screen Captures from the spectrum analyzer 500 KHz Low Channel (DTS Mode)



Screen Captures from the spectrum analyzer: 500 KHz MID Channel (DTS MOD)



Screen Captures from the spectrum analyzer: 500 KHz High Channel (DTS MOD)



2.4 Power Spectral Density (DTS Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-(06/07) (20.4°C,30.2 % RH)	**Basic Standard: ANSI C63.10: 2013** **FCC OET KDB 558074**

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/ 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

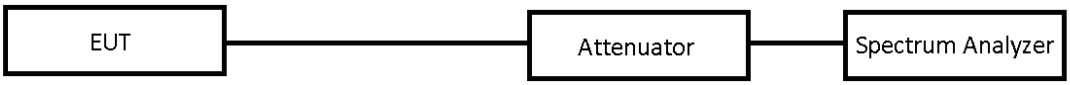
Testing was performed with this equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
Signal Analyzer	Agilent	N9010A	6678	2018-07-16	2019-07-16
Temp/Humidity	Extech	42270	5892	2017-04-06	2018-04-06
Attenuator	JFW	50FH-020-10	-	2018-01-15	2019-01-15
DC Blocker	MCL	BLK-89-S+	-	2018-01-15	2019-01-15
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2018-01-15	2019-01-15

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:

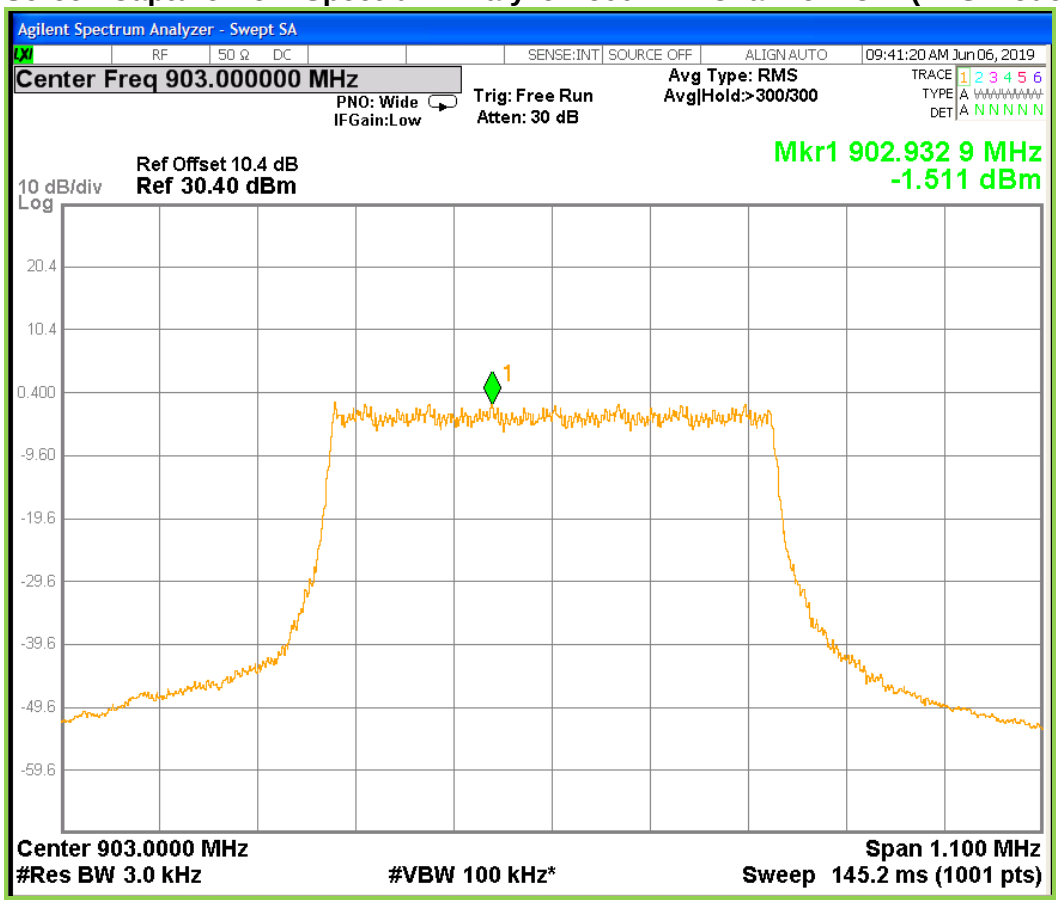


2.4.5 Peak PSD Data (DTS MODE)

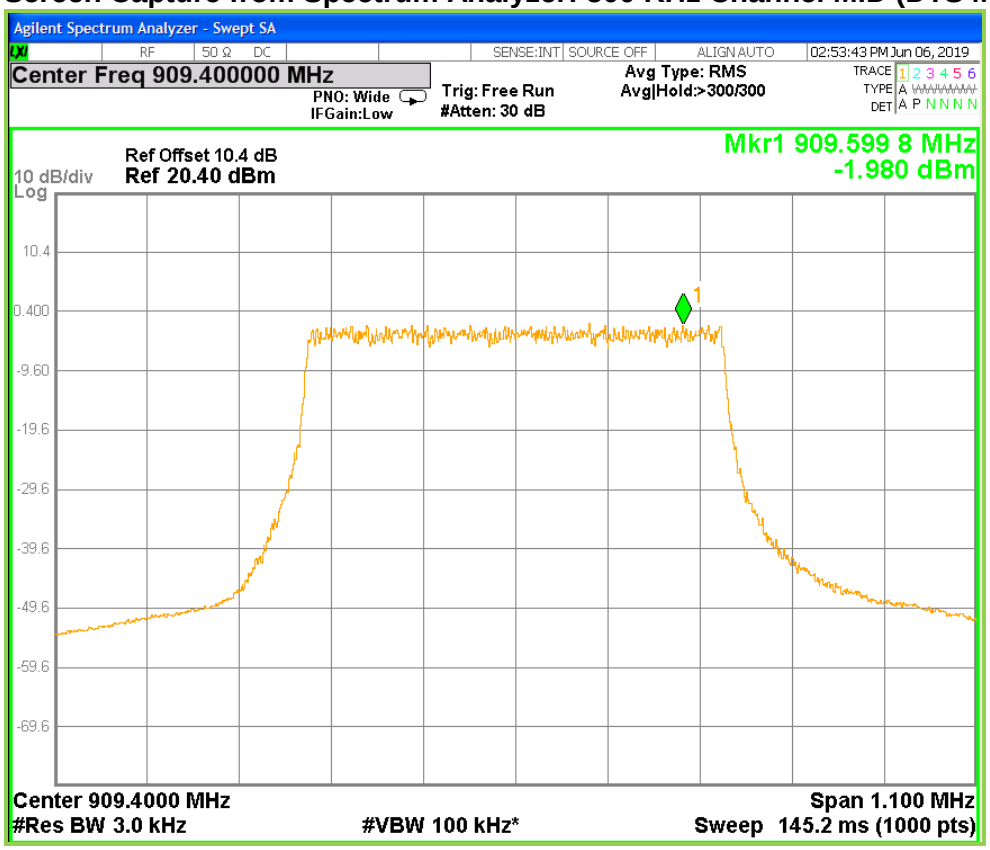
500 KHZ Channels

Channel	Freq. [MHz]	PSD (dBm/3KHz)	PSD Limit (dBm/3KHz)
Low	903	-1.511	8
Mid	909.4	-1.980	8
High	914.9	-1.933	8

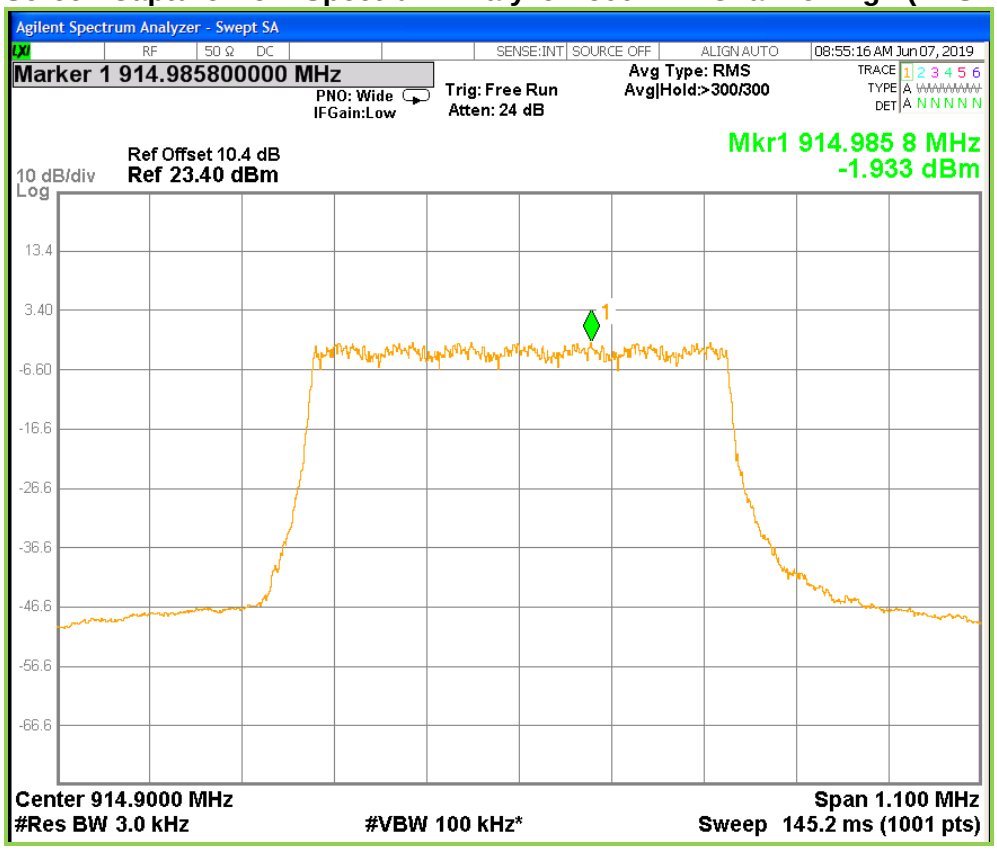
Screen Capture from Spectrum Analyzer: 500 KHz Channel LOW (DTS Mode)



Screen Capture from Spectrum Analyzer: 500 KHz Channel MID (DTS Mode)



Screen Capture from Spectrum Analyzer: 500 KHz Channel High (DTS Mode)



2.5 Band Edge Attenuation (DTS Mode)

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-(06/07) (20.4°C,30.2 % RH)	**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 11.11, 11.13.2 / 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	That encompasses both the peak of the fundamental emission and the band-edge emission under investigation.
RBW	1% of the total span
VBW	Set the VBW ≥ [3 × RBW].
Sweep	Auto Couple
Detector function	Peak
Trace mode	Max Hold.
Allow the trace to stabilize. Use the peak marker function to determine the maximum amplitude level.	

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:

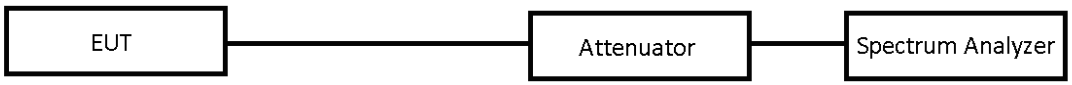
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
Signal Analyzer	Agilent	N9010A	6678	2018-07-16	2019-07-16
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2018-11-23	2019-11-23
DC Blocker	MCL	BLK-89-S+	-	2019-01-15	2020-01-15
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2019-01-15	2020-01-15

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:

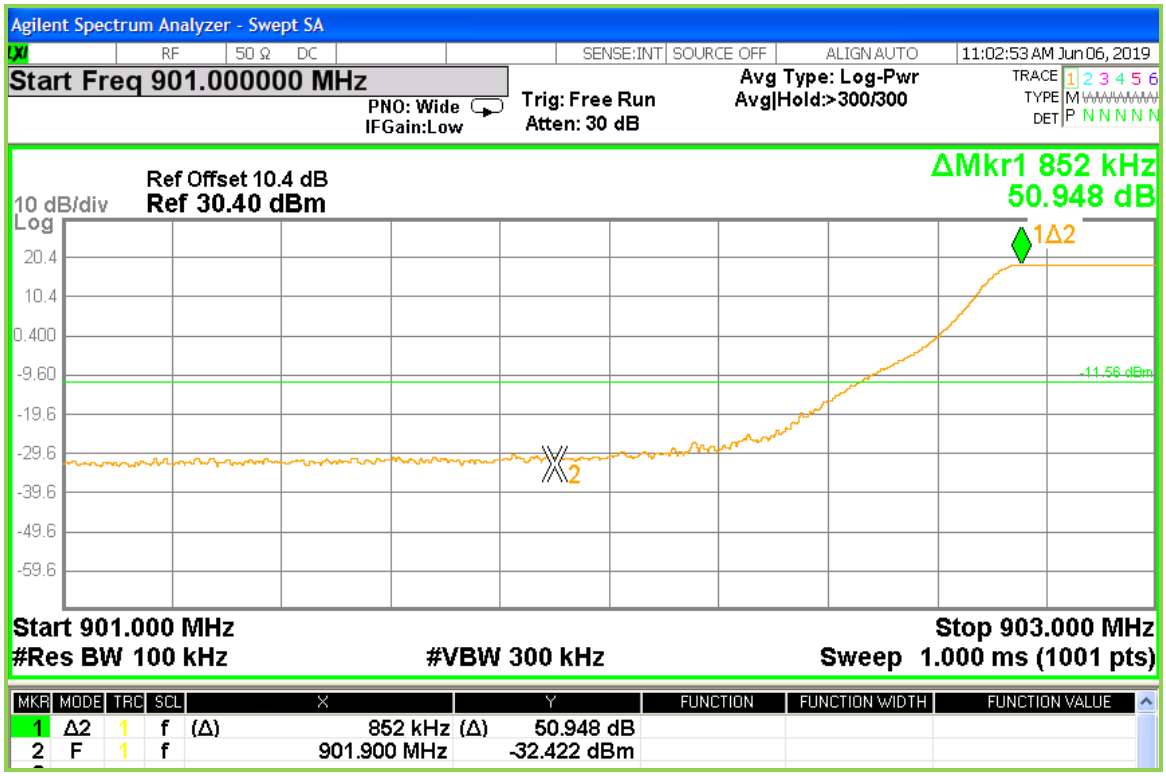
Conducted:



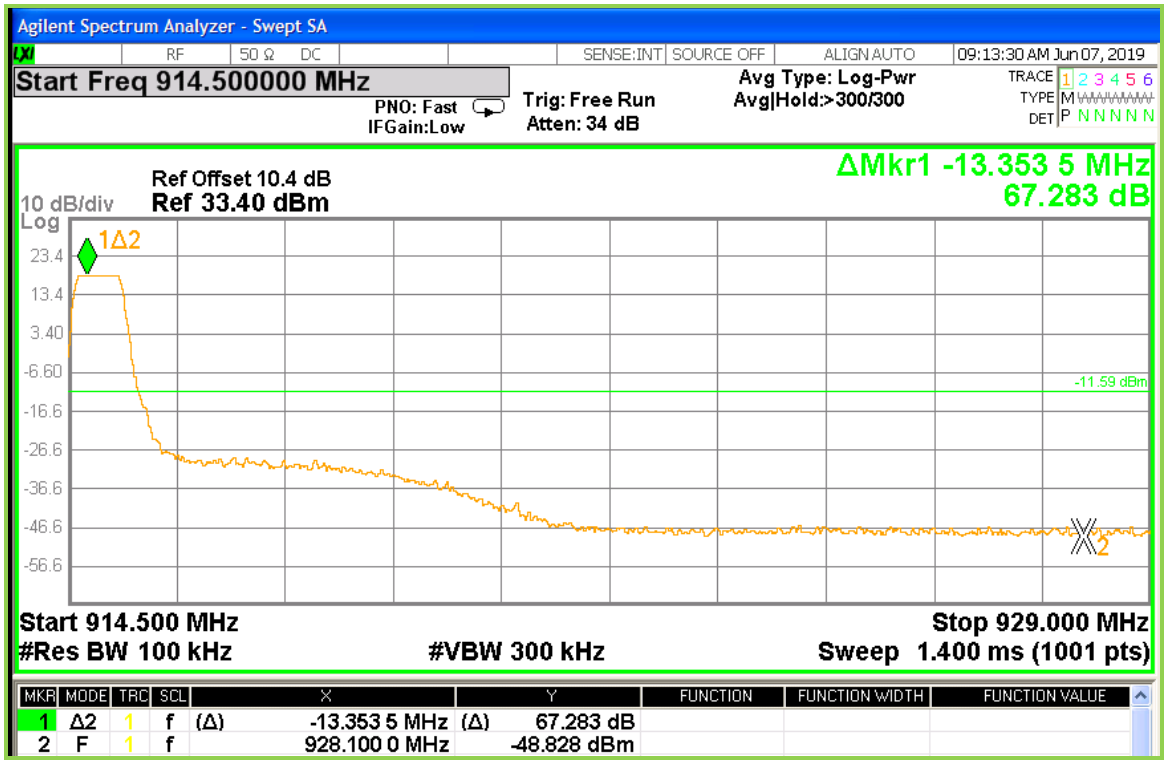
2.5.5 Band Edge Data (DTS MODE)

Modulation	Channel	Attenuation at Band Edge	Attenuation Limit at Band Edge
Lora 500KHz Channels	903	50.948 dBc	30 dBc
	914.9	67.283 dBc	30 dBc

Screen Capture from the spectrum analyzer: Lower Band Edge (500 KHz DTS Mode)



Screen Capture from the spectrum analyzer: Upper Band Edge (500 KHz DTS Mode)



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

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-(06/07) (20.7°C,11.8 % RH)	**Basic Standard: ANSI C63.4-2014** **FCC OET KDB 558470 v04 DTS**

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 11.11, FCC KDB 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:

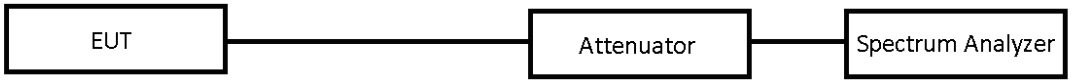
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
Signal Analyzer	Agilent	N9010A	6678	2018-07-16	2019-07-16
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2018-11-23	2019-11-23
DC Blocker	MCL	BLK-89-S+	-	2019-01-15	2020-01-15
CE Cable (50cm length)	Huber+Suhner	Enviroflex 400	-	2019-01-15	2020-01-15

2.6.4 Test Sample Verification, Configuration & Modifications

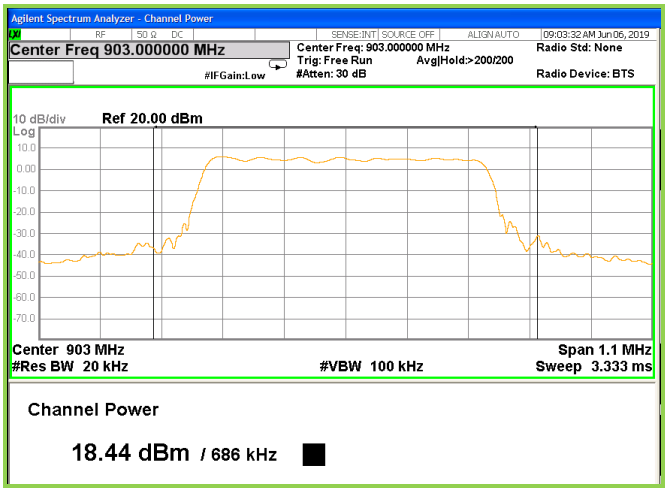
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation. The EUT met the requirements without modification.

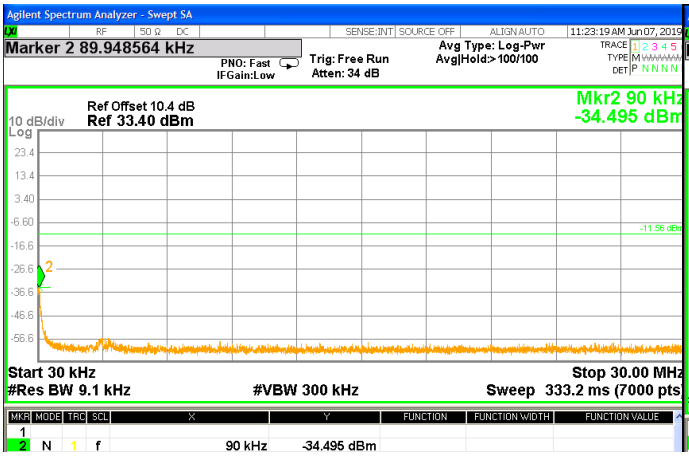
The EUT modified to provide the direct access to antenna trace for conducted measurements.

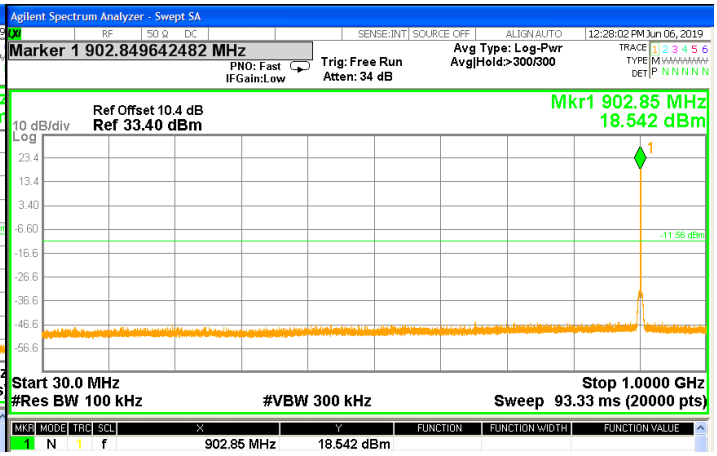
Test setup diagram for Conducted Spurious Emissions testing:

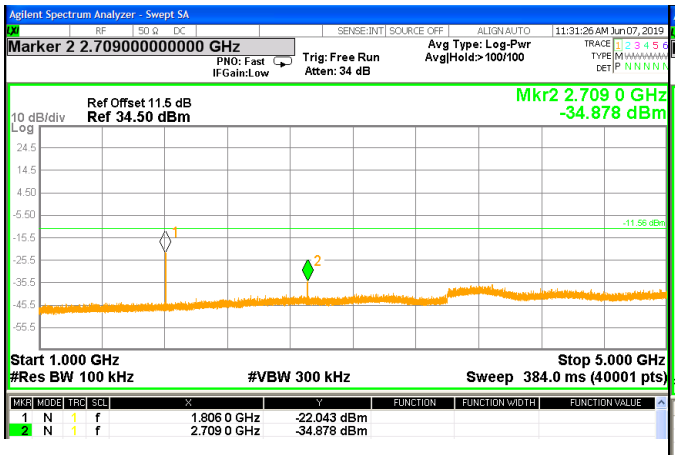


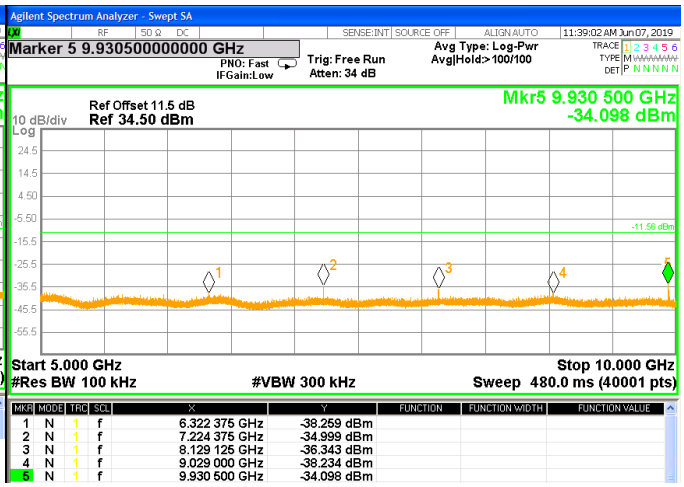
2.6.5 Conducted Emissions Data:



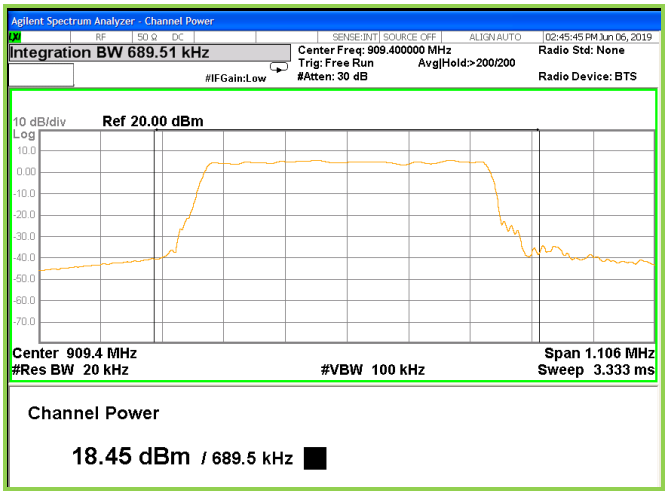


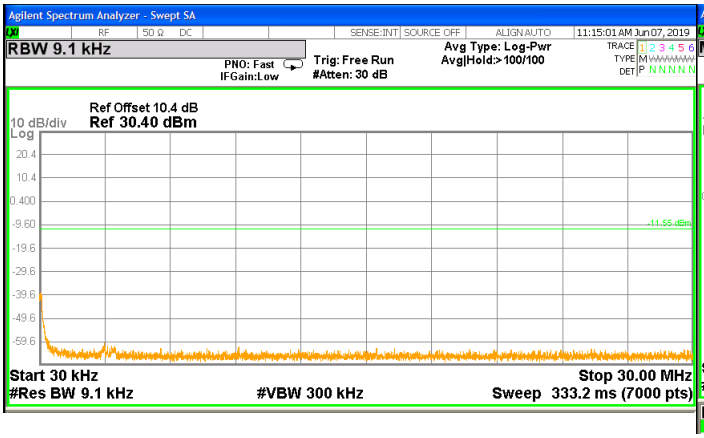


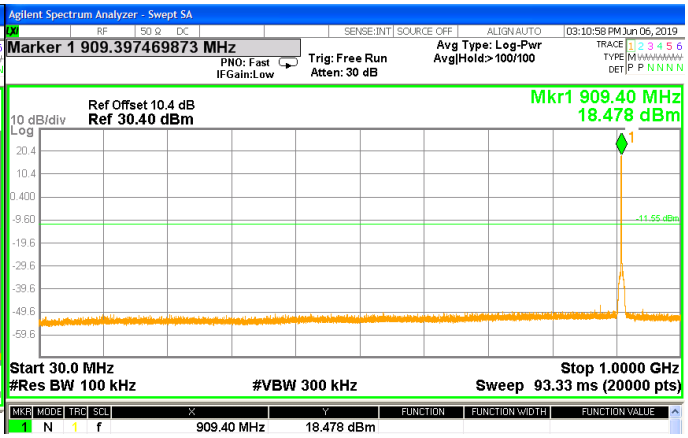


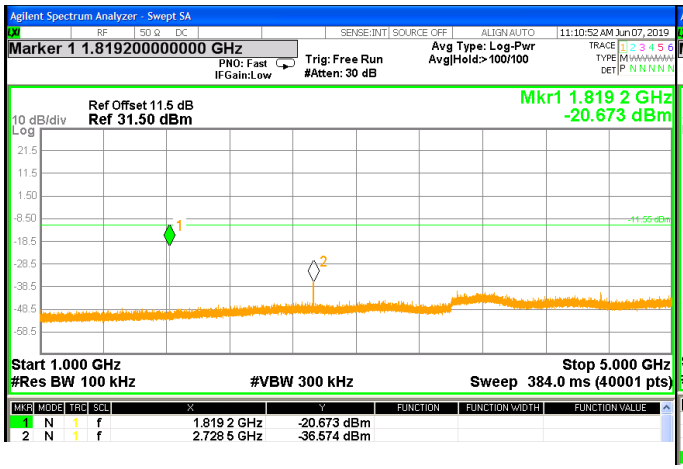


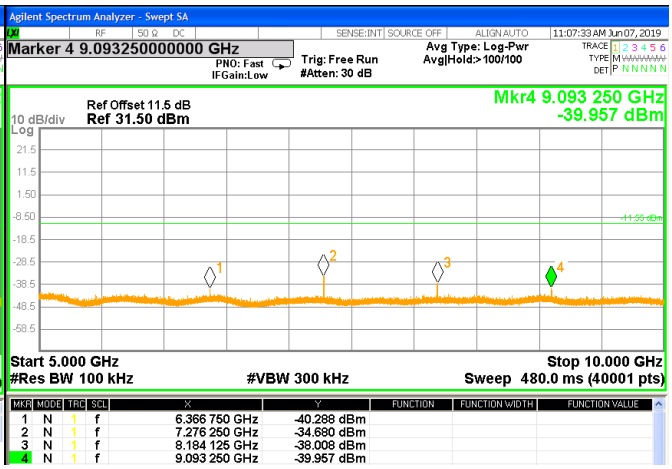
500 KHz MID Channel



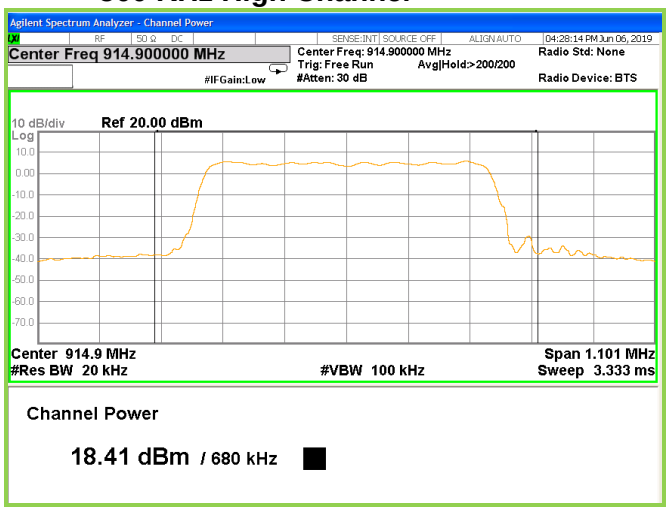


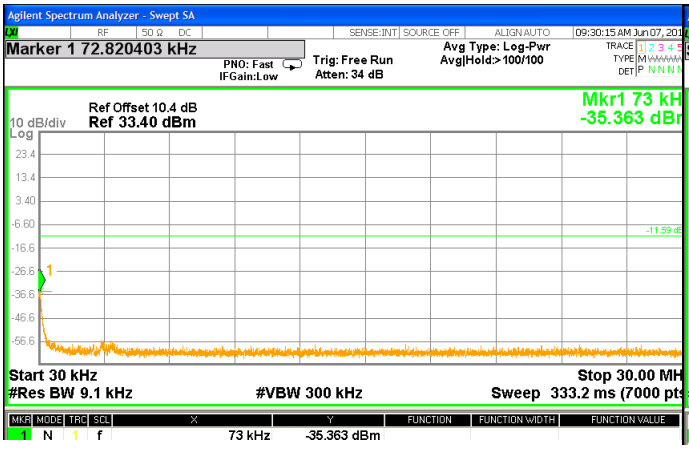


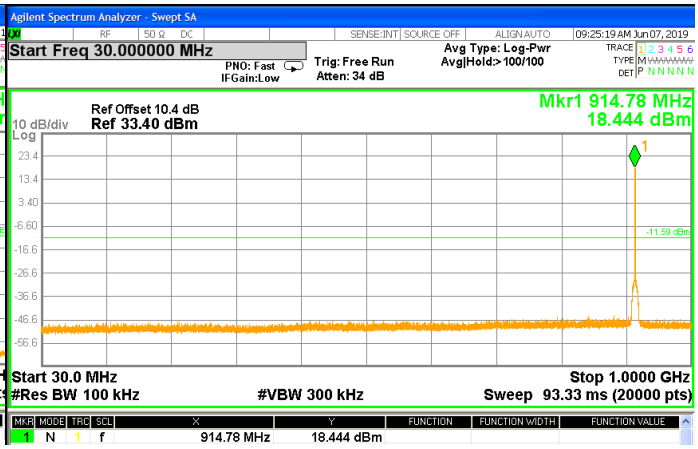


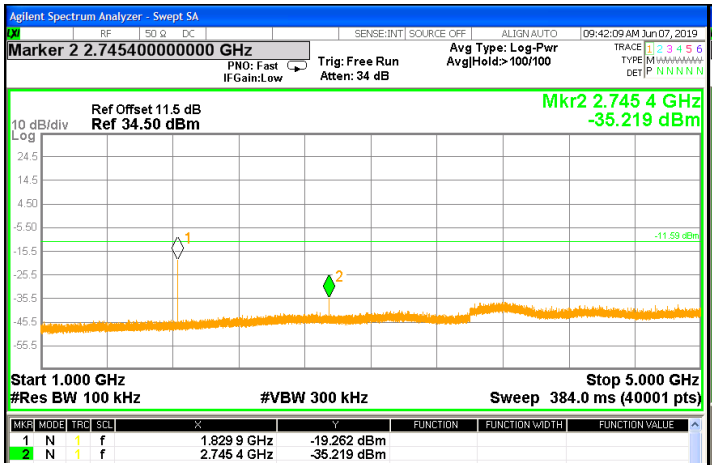


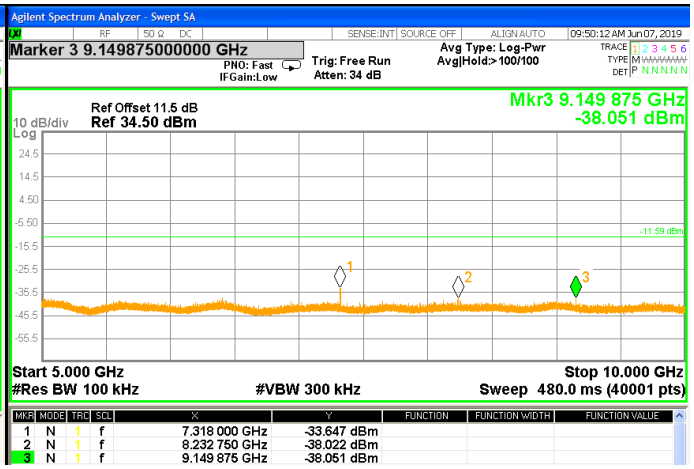
500 KHz High Channel











2.7 EUT Positioning Assessment

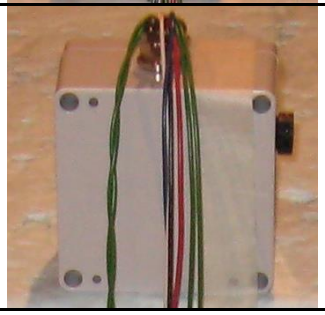
Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-04(23.6°C,28.0% RH)	**Basic Standard: ANSI C63.4-2014**

3rd Axis Found worse

Comments: EUT oriented in three axis's and 3rd 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.

1st Axis	
2nd Axis	
3rd Axis	

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

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
Test Personnel: Bushra Muharram	**Standard: FCC PART 15.247**
Date: 2019-06-06/07 (26.4°C,21.7 % 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)).

2.8.1 Test Guidance: ANSI C63.10-2013, Clause 11.12 / 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.

2.8.4 Test Equipment

Testing was performed with the following equipment:

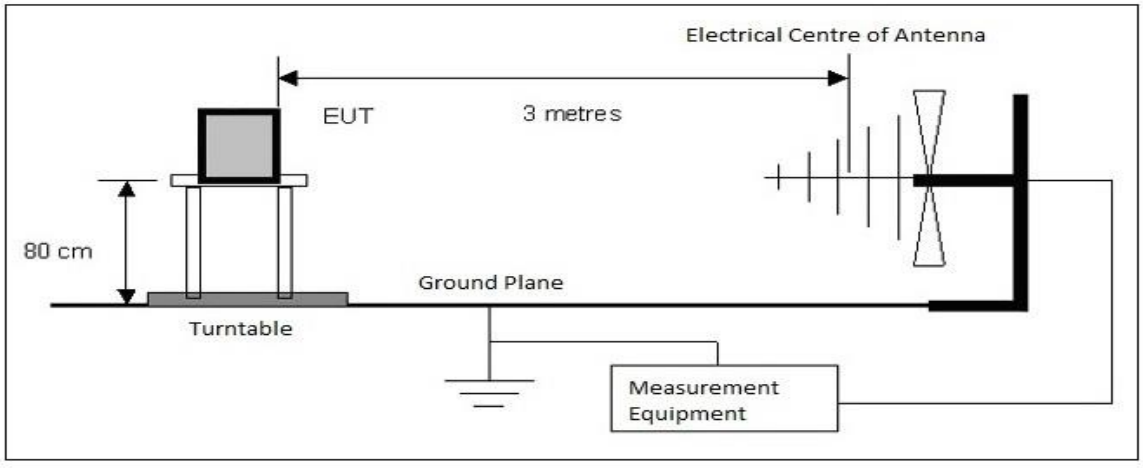
Equipment	Manufacturer	Model #	Asset #	Calibration Date	Calibration Due
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A	6130	2019-05-10	2020-05-10
Loop Antenna	EMCO	6502	10868	2019-04-11	2020-04-11
Biconilog Antenna	ARA	LPB-2520/A	4318	2018-09-19	2020-09-19
DRG Horn	EMCO	3115	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	2019-01-03	2020-01-03
Pre-Amplifier (30 – 1300 MHz)	hp	8447D	9291	2019-01-03	2020-01-03
RE Cable below 1GHz	Insulated Wire Inc.	KPS-1501A-3600-KPA-01102006	4419	2019-01-03	2020-01-03
Re Cable Above 1 GHz	A.H. System Inc.	SAC-26G-8.23	6187	2019-01-03	2020-01-03

2.8.5 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 (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

2.8.6 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.

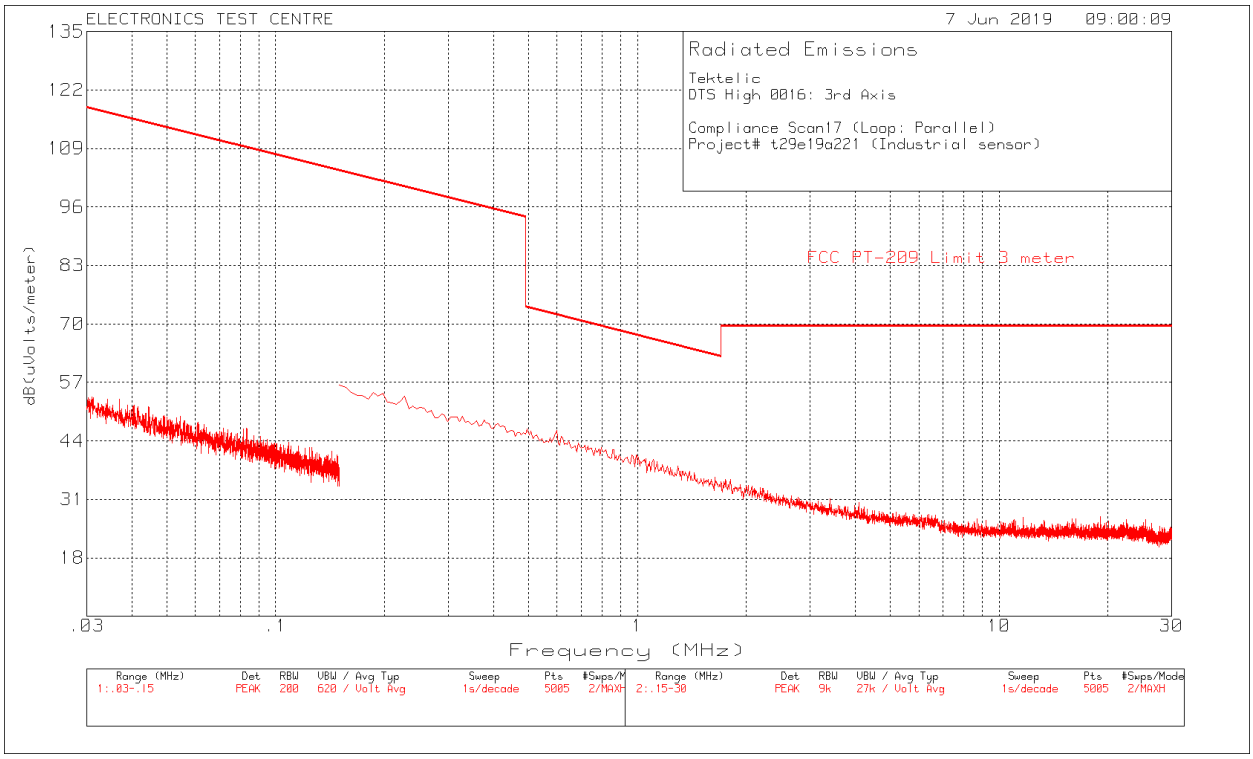
- Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum EUT emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discrete increments of height and azimuth, while the reported measurement 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 High band channel 914.9 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.

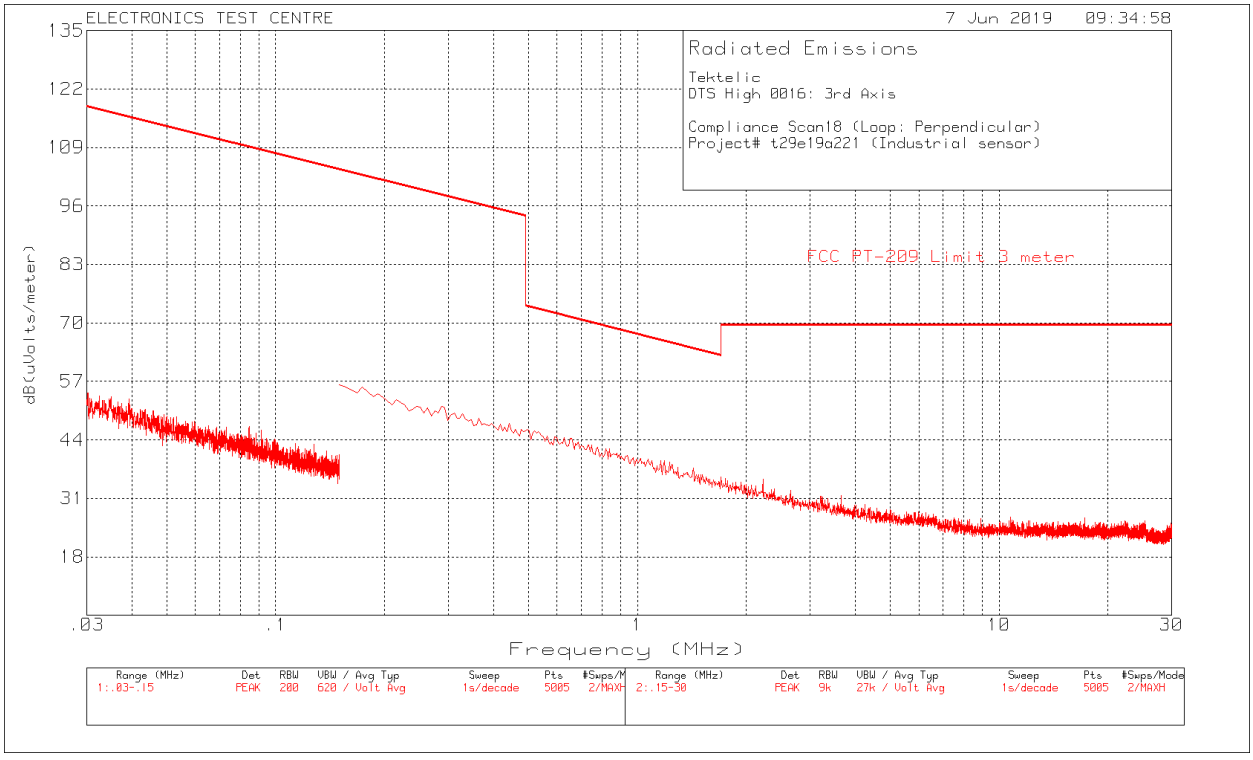
Freq. Marker	Freq. [MHz]	Raw reading [dBμv]	Det	Antenna Factor [dB/m]	Pre amp Gain [dB]	Corrected Reading [dBμv/m]	FCC 15.209 Limit [dBμv/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
Frequency Range 30 – 1000 MHz											
1	892.3908	3.3	QP	25.6	7.2	36.1	46.02	-9.92	277	237	Horizontal
2	941.5436	2.59	QP	26.3	7.3	36.19	46.02	-9.83	100	206	Horizontal
3	882.0673	12.48	QP	25.5	7.1	45.08	46.02	-0.94	350	123	Vertical
4	946.3187	7.2	QP	26.3	7.3	40.8	46.02	-5.22	0	107	Vertical
Frequency Range 1 – 3.6 GHz											
1	1090	28.97	AV	24.6	-19.1	34.47	54	-19.53	328	110	Vertical
2	*2742.8	51.23	AV	29.9	-33.4	47.73	54	-5.27	339	161	Horizontal
2	*2742.8	56.5	PK	29.9	-33.4	53	74	-21.0	339	161	Horizontal
3	*2742.3	50.02	AV	29.9	-33.4	46.52	54	-7.48	103	228	Vertical
3	*2742.3	56.16	PK	29.9	-33.4	52.66	74	-21.34	103	228	Vertical
Frequency Range 3.6 – 10 GHz											
1	*3657.4	37.88	AV	31.7	-32.6	36.98	54	-17.02	276	114	Horizontal
1	*3657.4	53.81	PK	31.7	-32.6	52.91	74	-21.09	276	114	Horizontal
2	*4572.0	43.99	AV	32.6	-31.3	45.29	54	-8.71	244	233	Horizontal
2	*4572.0	47.89	PK	32.6	-31.3	49.19	74	-24.81	244	233	Horizontal
3	*7311.9	24.39	AV	36.5	-27.2	33.69	54	-20.31	224	104	Horizontal
3	*7311.9	35.58	PK	36.5	-27.2	44.88	74	-29.12	224	104	Horizontal
4	*8226.1	32.03	AV	36.6	-26.9	41.73	54	-12.27	290	235	Horizontal
4	*8226.1	38.71	PK	36.6	-26.9	48.41	74	-25.59	290	235	Horizontal
1	*3657.3	35.62	AV	31.7	-32.6	34.72	54	-19.28	315	182	Vertical
1	*3657.3	47.14	PK	31.7	-32.6	46.24	74	-27.59	315	182	Vertical
2	*4569.9	39.82	AV	32.5	-31.3	41.02	54	-12.98	188	255	Vertical
2	*4569.9	45.6	PK	32.5	-31.3	46.8	74	-27.2	188	255	Vertical
3	*7312.0	24.71	AV	36.5	-27.2	34.01	54	-19.99	10	143	Vertical
3	*7312.0	35.41	PK	36.5	-27.2	44.71	74	-29.29	10	143	Vertical
4	*8226.9	33.55	AV	36.6	-26.9	43.25	54	-10.75	259	103	Vertical
4	*8226.9	40.748	PK	36.6	-26.9	50.18	74	-23.82	259	103	Vertical

*** Restricted Band**

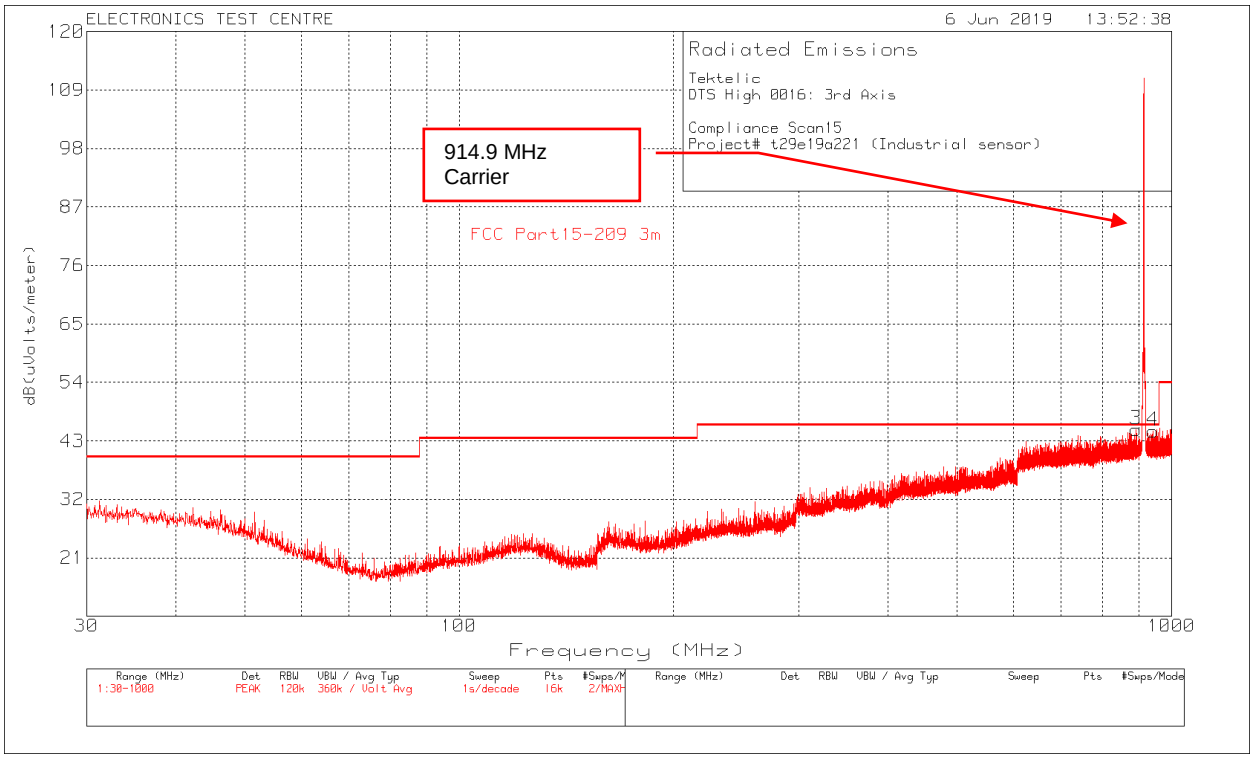
Plot of Radiated Emissions: Measuring Antenna Parallel



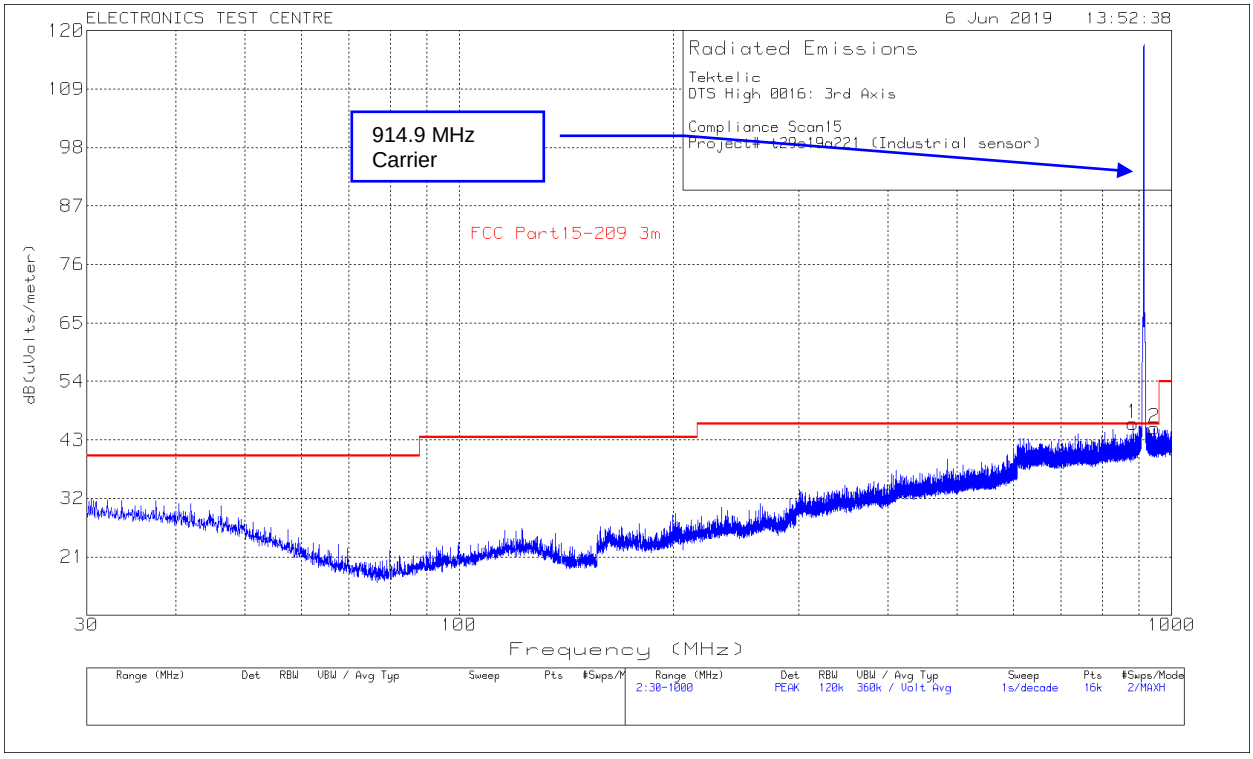
Plot of Radiated Emissions: Measuring Antenna Perpendicular



Plot of Radiated Emissions: Horizontal polarization

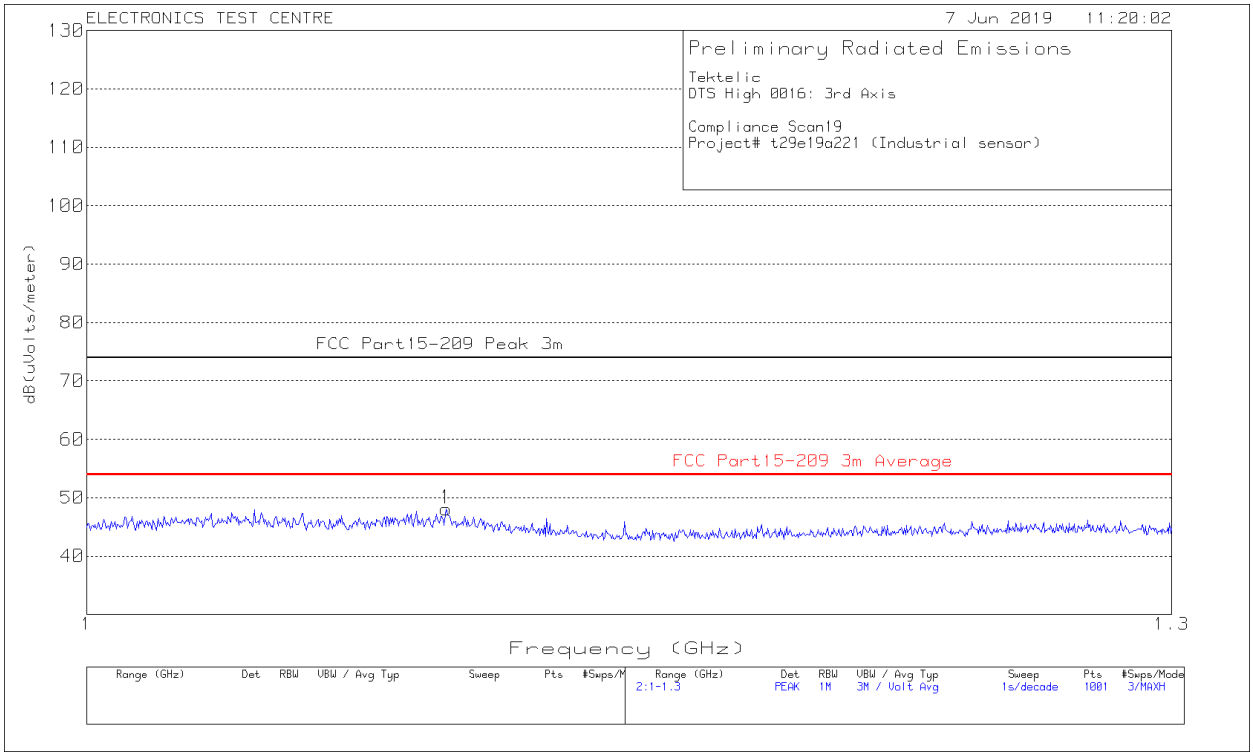


Plot of Radiated Emissions: Vertical polarization

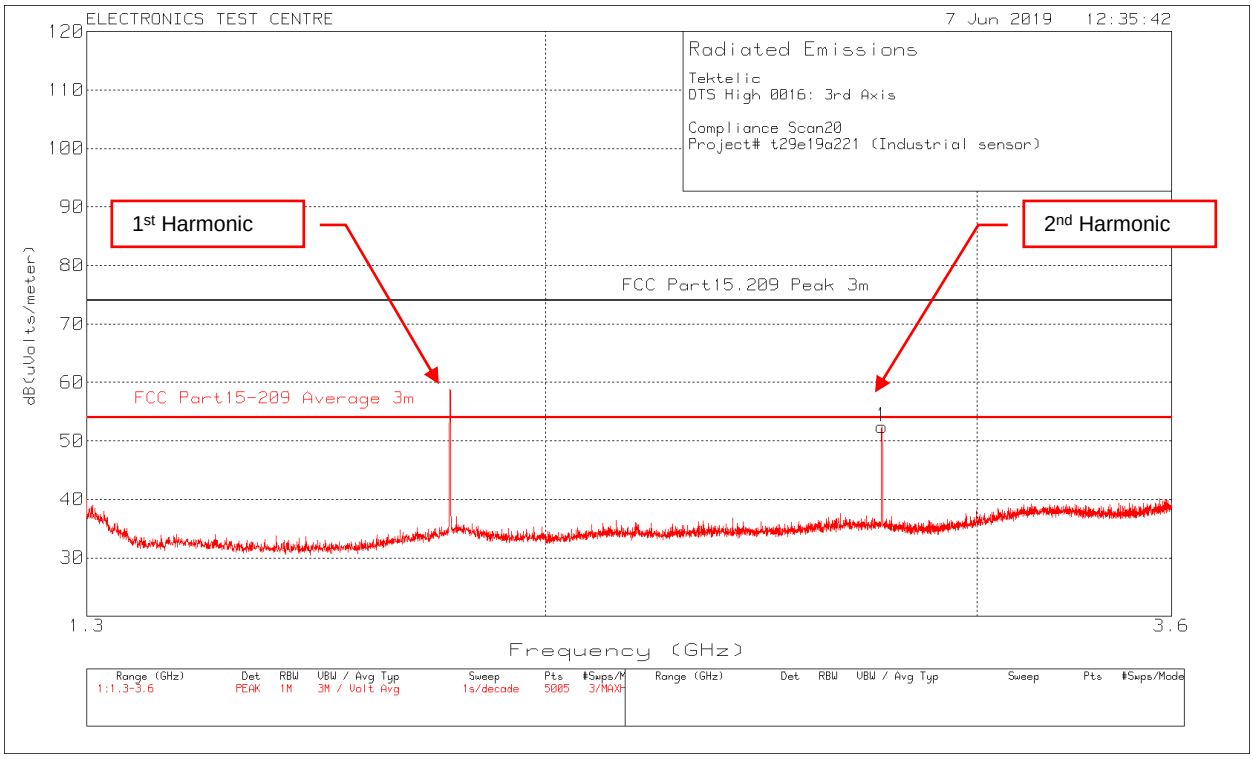


Plot of Radiated Emissions: Horizontal polarization

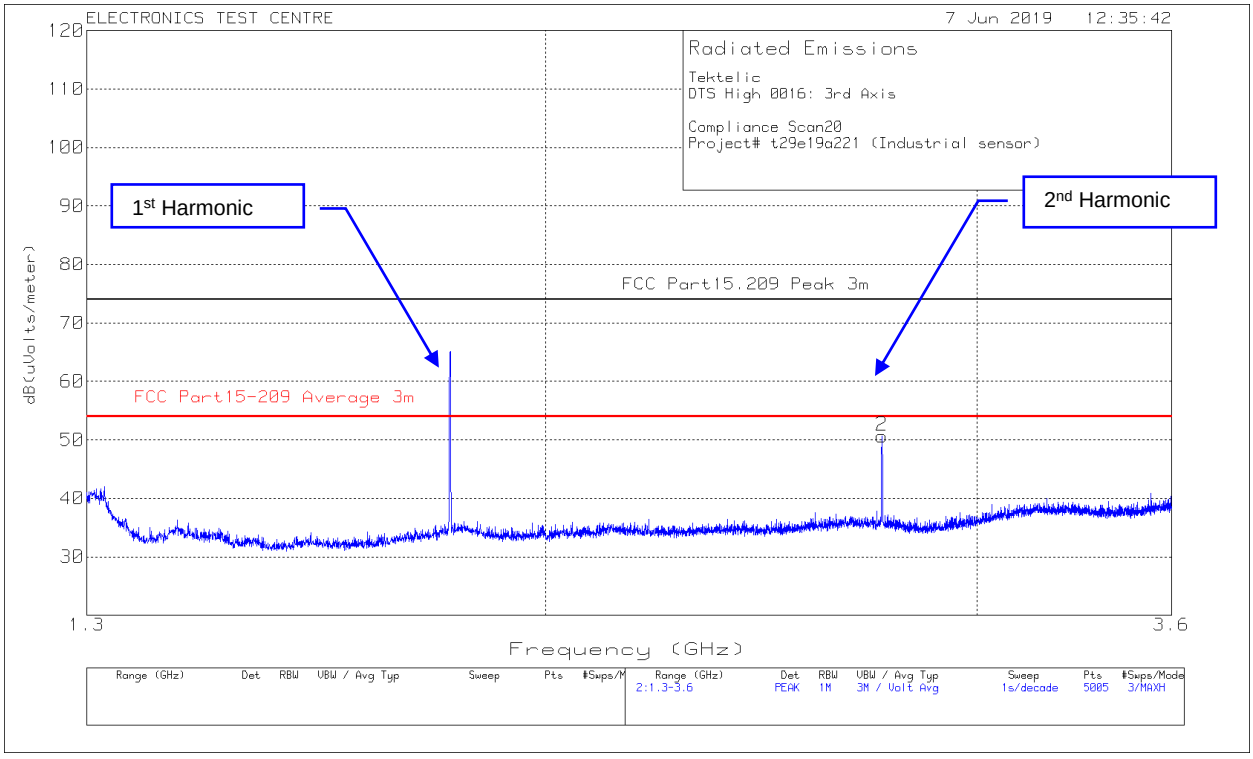
Plot of Radiated Emissions: Vertical polarization



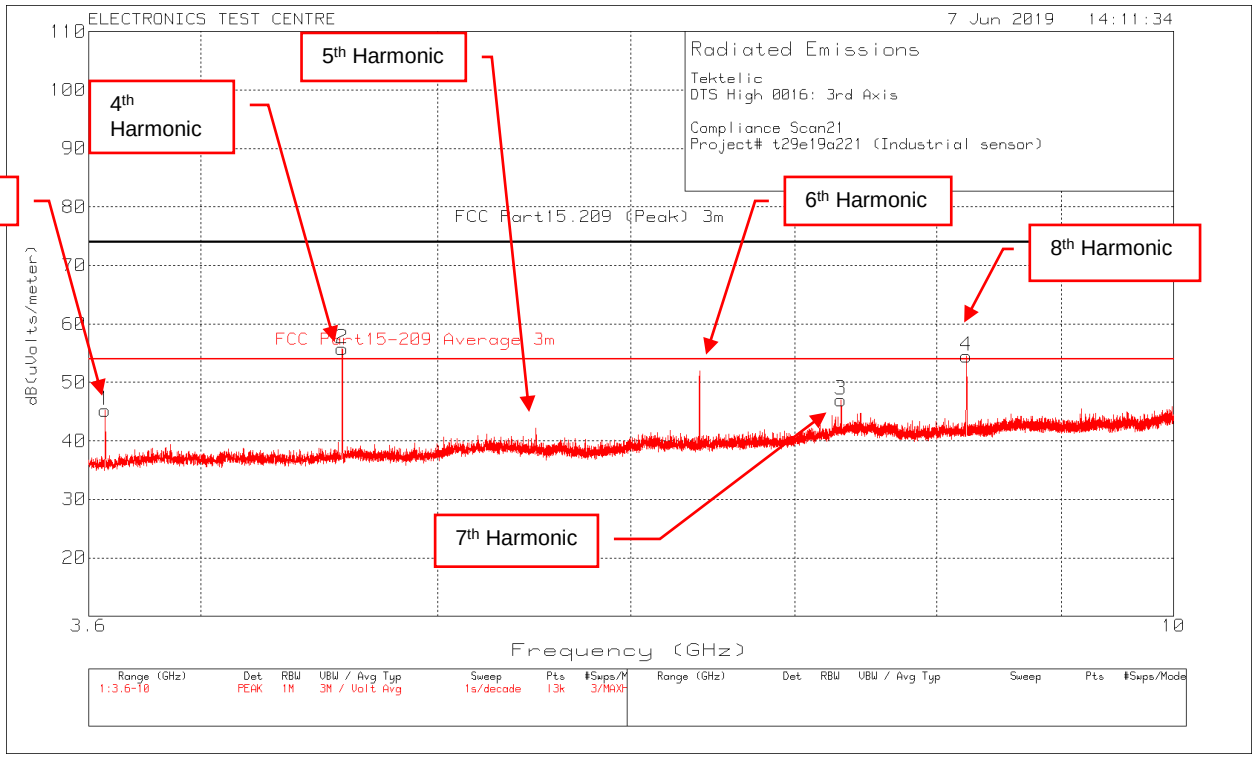
Plot of Radiated Emissions: Horizontal polarization



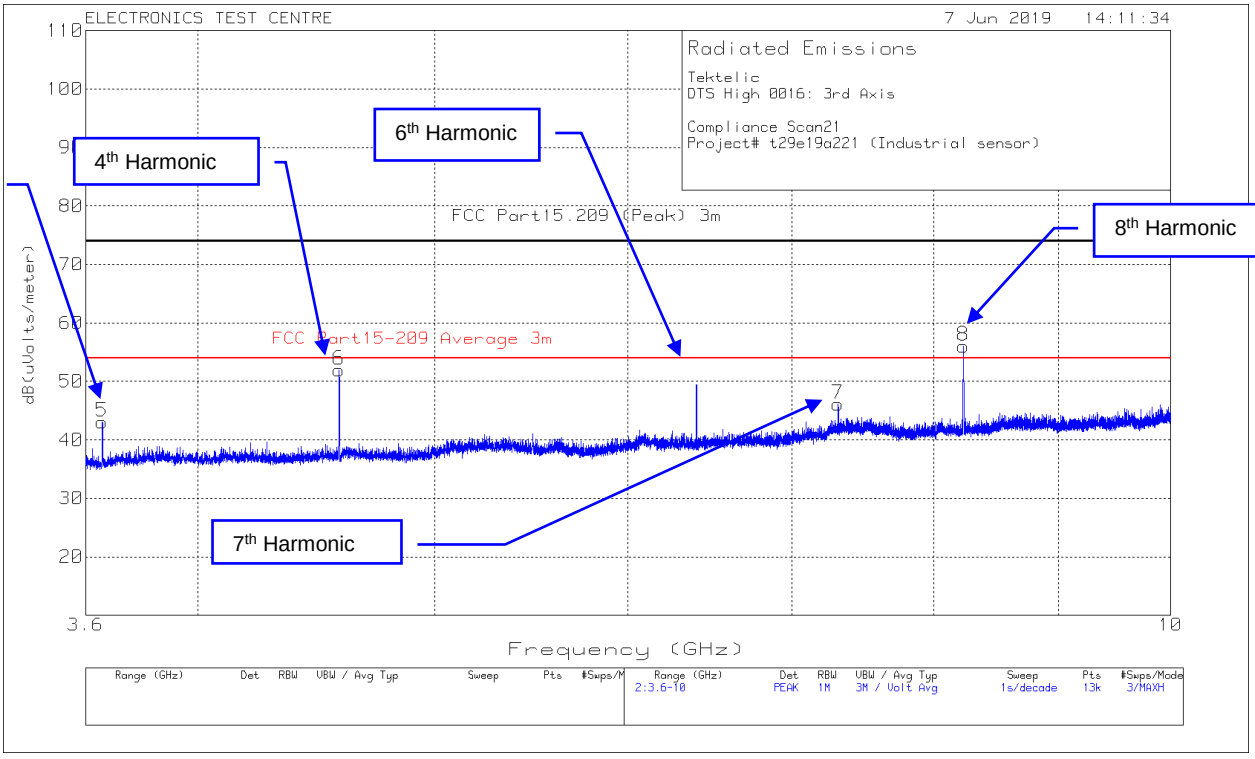
Plot of Radiated Emissions: Vertical polarization



Plot of Radiated Emissions: Horizontal polarization



Plot of Radiated Emissions: Vertical polarization



2.9 RF Exposure

Test Lab: Electronics Test Centre, Airdrie	**EUT: Kona Industrial Sensor**
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 Kona Industrial Sensor 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 Kona Industrial Sensor was placed at the centre of the test chamber turntable on top of an 80-cm high polystyrene foam table. The EUT was grounded according to Tektelic Communication Inc. specifications.

3.3 Power Supply

All EUT power was supplied by an internal rechargeable battery. There is no EUT function while the battery is charging.

Appendix A – Antenna

Pulse | LARSEN Antennas
A YAGEO Company

TECHNICAL DATA SHEET

Description: LTE 698-3600MHz FPC Antenna

Series: Gemini

PART NUMBER: W3907XXXX

Features:

- 2G / 3G / 4G Div Ant for MiMo
- Used as pair for W3906B0100
- Can be used as Primary antenna
- 698-3600MHz
- Global LTE Bands:
  - B1-B23, B25-B29, B33-B42
  - N.A.; Europe, Asia (incl. Jap.)
- Foldable for tight spaces

Applications:

- Challenging RF Environments Demanding:
  - Highest Peak Gain
  - Lowest ECC (Envelope Correlation Coeff.).
- Matched to Radio Modules from:
  - Sierra Wireless, Quectel, Telit, Huawei, Gemalto, uBlox, ZTE, and others.
- Security, Video, Graphics
- IoT, SmartGrid, Meters, Remote Monitoring, Sensor Networks

All dimensions are in mm / inches

Issue: 1907

RoHS COMPLIANT

In the effort to improve our products, we reserve the right to make changes judged to be necessary.

For more information:

Pulse Worldwide Headquarters
15255 Innovation Drive #100
San Diego, CA 92128
USA
Tel:1-858-674-8100

Pulse/Larsen Antennas
18110 SE 34th St Bldg 2 Suite 250
Vancouver, WA 98683
USA
Tel: 1-360-944-7551

Europe Headquarters
Pulse GmbH & Do, KG
Zeppelinstrasse 15
Herrenberg, Germany
Tel: 49 7032 7806 0

Pulse (Suzhou) Wireless Products Co, Inc.
99 Huo Ju Road(#29 Bldg,4th Phase
Suzhou New District
Jiangsu Province, Suzhou 215009 PR China
Tel: 86 512 6807 9998

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Pulse | LARSEN Antennas
A YAGEO Company

TECHNICAL DATA SHEET

Description: LTE 698-3600MHz FPC Antenna

Series: Gemini

PART NUMBER: W3907XXXX

ELECTRICAL SPECIFICATIONS

P/N	W3907B0100/ W3907B0127/ W3907BD0100	W3907BD0350
Frequency	698-960/1427.9-1510.9/1559-1610/1695-2200/2300-2700/3400-3600MHz	698-960/1427.9-1510.9/1559-1610/1695-2200/2300-2700/3400-3600MHz
Return Loss(698-960MHz)	-6dB	-6dB
Return Loss(1427.9-1510.9/1559-1610/1695-2200/2300-2700/3400-3600MHz)	-7.5dB	-7.5dB
Average Total Efficiency(698-960MHz)	55%	49%
Average Total Efficiency(1427.9-1510.9MHz)	60%	48%
Average Total Efficiency(1559-1610MHz)	60%	52%
Average Total Efficiency(1695-2200MHz)	65%	48%
Average Total Efficiency(2300-2700MHz)	70%	48%
Average Total Efficiency(3400-3600MHz)	65%	40%

Issue: 1907

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Pulse | LARSEN Antennas
A YAGEO Company

TECHNICAL DATA SHEET

Description: LTE 698-3600MHz FPC Antenna

Series: Gemini

PART NUMBER: W3907XXXX

ELECTRICAL SPECIFICATIONS		
P/N	**W3907B0100/ W3907B0127/ W3907BD0100**	**W3907BD0350**
Peak Gain(698-960MHz)	2.9dBi	1.0dBi
Peak Gain(1427.9-1510.9MHz)	1.7dBi	1.1dBi
Peak Gain(1559-1610MHz)	1.8dBi	1.4dBi
Peak Gain(1695-2200MHz)	3.4dBi	2.2dBi
Peak Gain(2300-2700MHz)	3.8dBi	2.0dBi
Peak Gain(3400-3600MHz)	4.2dBi	1.4dBi
Polarization	Linear	Linear
Nominal Impedance	50ohm	50ohm
Power Standing	3W	3W

Typical free space performance measured on 2mm thickness PC plate

Issue: 1907

RoHS COMPLIANT

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Pulse | LARSEN Antennas
A YAGEO Company

TECHNICAL DATA SHEET

Description: LTE 698-3600MHz FPC Antenna

Series: Gemini

PART NUMBER: W3907XXXX

MECHANICAL SPECIFICATIONS

Overall Length	110.7X20.4mm
Antenna Color / Material	BLACK FPC
Cable type	See table detail
Cable length	See table detaill

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature	-40~+85° C
Storage Temperature	-40~+85° C
RoHS Compliant	Yes

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End of Document