



Test Report Prepared By:

Electronics Test Centre 27 East Lake Hill Airdrie, Alberta Canada T4A 2K3

sales@etc-mpbtech.com http://www.etc-mpb.com

Telephone: 1-403-912-0037

ETC Report #: t29e20a151-DSS\_FCC Release 1

Report date: March 23, 2020

Test Dates: March 03, 04 and 06, 2020

EMC testing of the Tektelic Communication Inc. Agriculture Sensor 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: 2ALEPT0005978

Tested by: Bushra Muharram / Imran Akram

Prepared for:

Tektelic Communication Inc.

7657 10<sup>th</sup> Street NE Calgary, Alberta Canada T2E 8X2

Telephone: 1-403-338-6910

Bushra Muharram <u>bmuharram@etc-mpbtech.com</u> EMC Technologist Electronics Test Centre (Airdrie)

Marc Rousseau <u>marc.rousseau@mpbc.ca</u> QA Manager Electronics Test Centre (Airdrie)

# **REVISION RECORD**

ISSUE	DATE	AUTHOR	REVISIONS
DRAFT 1	2020-03-19	I. Akram	Initial draft submitted for review.
Release 1	2020-03-23	M. Rousseau	Sign off

# TABLE OF CONTENTS

1.0	INTR	ODUCTION	5
	1.1	Scope 1.2 Applicant	
	1.3	Test Sample Description	.5
	1.4	General Test Conditions and Assumptions	.6
	1.5	Scope of Testing1.5.1Test Methodology1.5.2Variations in Test Methodology1.5.3Test Sample Verification, Configuration & Modifications1.5.4Uncertainty of Measurement:	.6 .6 .6
2.0	TEST	T CONCLUSION	7
	2.1	AC Power Line Conducted Emissions – Not Applicable	.8
	2.2	Channel Occupied Bandwidth (Hybrid Mode)2.2.1Test Guidance: ANSI C63.10-2013, Clause 6.9.2, 6.9.3 &7.8.7 / KDB558074 D01 15.247 Measurement Guidance v05r022.2.2Deviations From The Standard:2.2.3Test Equipment2.2.4Test Sample Verification, Configuration & Modifications2.2.5Channel Occupied Bandwidth Data: (Hybrid Mode)	.9 .9 .9 10
	2.3	Max Average Output Power (Hybrid Mode)12.3.1Test Guidance: ANSI C63.10-2013, Clause 11.9.2.2.2, Clause 7.8.5 /558074 D01 15.247 Measurement Guidance v05r0212.3.2Deviations From The Standard:12.3.3Test Equipment12.3.4Test Sample Verification, Configuration & Modifications12.3.5Peak Output Power Data (Hybrid Mode)1	12 13 13 13
	2.4	Power Spectral Density (Hybrid Mode)	16 16 17 17
	2.5	Band Edge Attenuation (Hybrid Mode)22.5.1Test Guidance: ANSI C63.10-2013 Clause 6.10.4, 6.10.6 & 7.8.6 / 558074D01 15.247 Measurement Guidance v05r0222.5.2Deviations From The Standard:2.5.3Test Equipment2.5.4Test Sample Verification, Configuration & Modifications2.5.5Band Edge Data (Hybrid Mode)	4 20 21 21 21
	2.6	Conducted Spurious Emissions in non-restricted frequency bands (Hybrid Mode) 22.6.1Test Guidance: ANSI C63.10-2013, Clause 6.7, 7.8.8 / 558074 D01 15.24Measurement Guidance v05r0222.6.2Deviations From The Standard:2.6.3Test Equipment2.6.4Test Sample Verification, Configuration & Modifications2.6.5Conducted Emissions Data: (Hybrid Mode)	7 24 24 25 25 25 26
	2.7	Channel Separation (Hybrid Mode)	29

		2.7.1 Measur 2.7.2 2.7.3 2.7.4 2.7.5	Test Guidance: ANSI 63.10 Clause 7.8.2 / 558074 D01 15.247 ement Guidance v05r02 Deviations From The Standard: Test Equipment Test Sample Verification, Configuration & Modifications Channel Separation Data:	29 29 29
	2.8	2.8.1	Occupancy (Hybrid Mode) Test Guidance: ANSI 63.10 Clause 7.8.4 / 558074 D01 15.247 ement Guidance v05r02 Deviations From The Standard: Test Equipment. Test Sample Verification, Configuration & Modifications. Dwell Time Data:	31 31 31 32
	2.9	EUT Po	sitioning Assessment	
	2.10	2.10.1 2.10.2 2.10.3 2.10.4	d Spurious Emissions in restricted frequency bands (TX Mode) Test Guidance: ANSI C63.10-2013, Clause 13.4.2 Deviations From The Standard: Test Equipment Test Sample Verification, Configuration & Modifications Radiated Emissions Data:	35 35 36 36
	2.11	RF Exp	osure	45
3.0	TEST	FACILI	TY	46
	3.1	Locatio	n	46
	3.2	Ground	ing Plan	46
	3.3	Power	Supply	46
Append	lix A (V	Vorse E	mission variant test setup Block Diagram)	47
End of I	Docum	nent		48

# 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. Agriculture Sensor 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 N	Name:	Agriculture Sensor	
	Frequency Band	902 – 928 MHz	
	Type of Modulation	Chirp Spread Spectrum	
LoRa	BW/Frequency Range	Hybrid 125kHz, 902.3 – 914.9 MHz	
Radio	Associated Antenna	Omnidirectional antenna 1.6 dBi gain	
	Detachable/Non Detachable	Internal, Non Detachable	
Model# / Serial#		T0005982 / 1949A0019	
Power supply:		Internal Battery	

<u>Note:</u> All three channels for T0005982 variant and all three channels / axis for T0005986/Sr#1949A0045 variant in hybrid mode were evaluated. Variant with worse emission profile and worse channel / axes were selected for detail analysis for radiated emission.

The EUT variant T0005982 is comprised of two PCBAs which provides all the functionality required by the product. The main PCBA provides the majority of the functionality including the internal LoRa radio antenna, while the second PCBA forms the basis for an external moisture sensing probe.

The EUT variant T0005986 is intended to allow external moisture probes to be connected, rather than the integrated probe of the first variant. The supported external probes are:

1) the watermark probe by Irrometer, and

2) a Tektelic remote moisture that uses the same PCBA as the first variant, but in this case it is separately housed and connected to the Agricultural sensor via a cable.

# 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 125 kHz Hybrid transmission mode. Test results regarding DTS 500 kHz transmission mode is provided in the separate report.

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

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 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 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."

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 %

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

# 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 = 902.3 – 914.9 MHz 125 KHz Hybrid Mode Max. Conducted Tx Power=20.0dBm (0.1) Watt							
2.1	AC Conducted Emissions (Tx)	15.207	Agriculture Sensor	none	see § 2.1	n/a		
2.2	Occupied Bandwidth	15.247(a)(1) 15.247(2)(2)	Agriculture Sensor	none	see § 2.2	Compliant		
2.3	Max Output average Power Conducted	15.247(b)	Agriculture Sensor	none	see § 2.3	Compliant		
2.4	Power Spectral Density	15.247(e) 15.247(f)	Agriculture Sensor	none	see § 2.4	Compliant		
2.5	Band Edge	15.247(d)	Agriculture Sensor	none	see § 2.5	Compliant		
2.6	Conducted Spurious Emission (Non-Restricted Band Operation)	15.247(d)	Agriculture Sensor	none	see § 2.6	Compliant		
2.7	Minimum channel separation	15.247(a)(1)	Agriculture Sensor	none	see § 2.7	Compliant		
2.8	Average time of Occupancy for hybrid System	15.247(f)	Agriculture Sensor	none	see § 2.8	Compliant		
2.9	EUT Position	ANSI C63.4	Agriculture Sensor	none	see § 2.9	Assessed		
2.10	Radiated Spurious Emission (Restricted Band Operation) (Tx Mode)	15.205, 15.209 15.247(d)	Agriculture Sensor	none	see § 2.10	Compliant		
2.11	RF Exposure	15.247(i)	Agriculture Sensor	none	see § 2.11	Exempt		

Refer to the test data for applicable test conditions.

# 2.1 AC Power Line Conducted Emissions – Not Applicable

Test Lab: Electronics Test Centre, Airdrie

Test Personnel:

EUT: Agriculture Sensor Standard: FCC Part 15.207 Basic Standard: ANSI C63.10: 2013

Date:

# EUT status: n/a

**Comments:** EUT powered up by Internal Battery. There is no connection to main during operation.

# 2.2 Channel Occupied Bandwidth (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	EUT: Agriculture Sensor
Test Personnel: Bushra Muharram/I.	Standard: FCC PART 15.247
Date: 2020-03-06(21.1°C,13.2% 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 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

## 2.2.4 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.

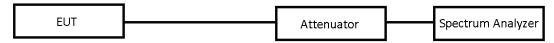
The EUT modified to provide the direct access to antenna port for conducted measurements.

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:**



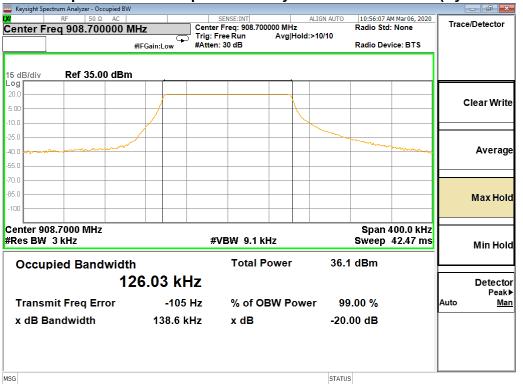
## 2.2.5 Channel Occupied Bandwidth Data: (Hybrid Mode) LoRa 125 KHz Channels

Channel	Freq. [MHz]	20 dB OBW [kHz]	99% OBW [KHz]
Low	902.3	137.9	125.87
Mid	908.7	138.6	126.03
High	914.9	138.0	125.85

# Screen

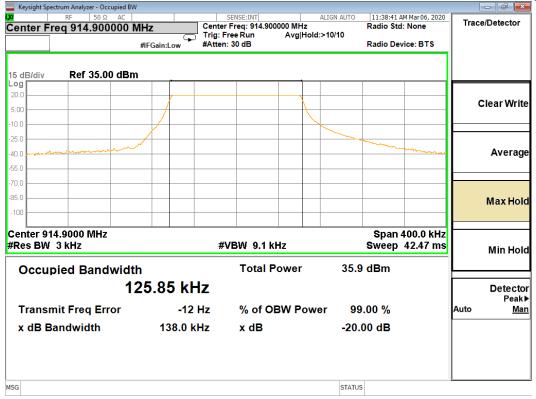
### captures from the spectrum analyzer 125 KHz Channel (Hybrid Mode)

RF 50 Ω AC <b>dB -20.00 dB</b>		SENSE:INT er Freq: 902.300000 Free Run Av	ALIGN AUT MHz /g Hold:>10/10	0 09:52:28 Radio Sto	AM Mar 06, 2020 d: None	Trace	/Detector
	#IFGain:Low #Atte	n: 30 dB		Radio De	vice: BTS		
5 dB/div Ref 35.00 dBm			_				
20.0			_				lear Writ
5.00						Ĭ	
25.0							
0.0 man					mm		Avera
5.0							
0.0							
15.0							Max Ho
100							
enter 902.3000 MHz Res BW 3 kHz	ŧ	≇VBW 9.1 kHz			400.0 kHz 42.47 ms		Min Ho
Occupied Bandwidth	n	Total Pow	er 36	5.3 dBm			
12	25.87 kHz						Detect
Transmit Freq Error	-18 Hz	% of OBW	Power	99.00 %		Auto	Peal <u>M</u> a
x dB Bandwidth	137.9 kHz	x dB	-2	0.00 dB			
G			STA	TUS			



#### Screen captures from the spectrum analyzer 125 KHz Channel (Hybrid Mode)

Screen captures from the spectrum analyzer 125 KHz Channel (Hybrid Mode)



# 2.3 Max Average Output Power (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	EUT: Agriculture Sensor
Test Personnel: Bushra Muharram	Standard: FCC PART 15.247
Date: 2020-03-06(21.1°C,13.2% 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.

Outp	ut Power Method AVGSA-1
Span	≥ 1.5 times the OBW
RBW	$1 - 5$ % of the OBW, $\leq 1$ 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 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

## 2.3.4 Test Sample Verification, Configuration & Modifications

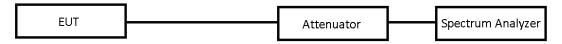
The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation.

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:

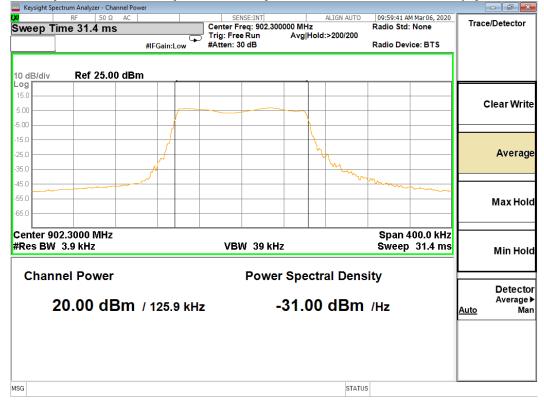


## 2.3.5 Peak Output Power Data (Hybrid Mode)

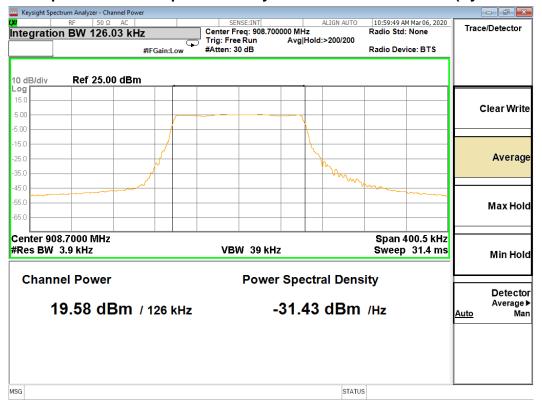
## Lora 125 KHz

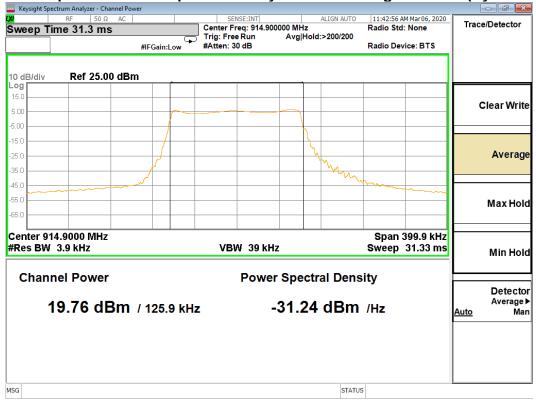
Channel	Freq. [MHz]	Out Put Power (dBm)	Out Put Power Limit (dBm	Margin (dB)
Low	902.3	20	30	10
Mid	908.7	19.58	30	10.42
High	914.9	19.76	30	10.24

Screen Captures from the spectrum analyzer: 125 KHz Low Channel (Hybrid Mode)



Screen Captures from the spectrum analyzer: 125 KHz MID Channel (Hybrid Mode)





#### Screen Captures from the spectrum analyzer: 125 KHz High Channel (Hybrid Mode)

# 2.4 Power Spectral Density (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: Bushra Muharram

Date: 2020-03-06(21.1°C,13.2% RH)

EUT: Agriculture Sensor Standard: FCC PART 15.247 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 s	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 nu	imber of measurement points in the sweep $\geq [2 \times \text{span} / \text{RBW}]$ . 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

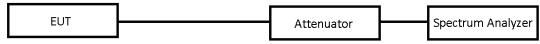
Testing was performed with this equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc			2019-10-29	2020-10-29
Temp/Humidity	Extech	42270		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

# 2.4.4 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	5.682	8
Mid	908.7	5.292	8
High	914.9	5.346	8

#### Screen Capture from Spectrum Analyzer: 125 KHz Channel LOW (Hybrid Mode)



#### Screen Capture from Spectrum Analyzer: 125 KHz Channel MID (Hybrid Mode)



This report shall not be reproduced, except in full, without prior written approval of Page 18 of 48 MPB Technologies

# Screen Capture from Spectrum Analyzer: 125 KHz Channel High (Hybrid Mode)

Keysight Spectrum Analyzer - Swept SA					
α RF 50 Ω AC Marker 1 914.943600000	MHz	SENSE:INT	ALIGN AUTO Avg Type: RMS	11:46:44 AM Mar 06, 2020 TRACE 1 2 3 4 5 6	Peak Search
Ref Offset 10.5 dB	PNO: Close 😱 IFGain:Low	Trig: Free Run #Atten: 30 dB	Avg Hold:>300/300	1914.943 6 MHz	NextPea
0 dB/div Ref 28.50 dBm				5.346 dBm	Next Pk Righ
1.50		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~		[	Next Pk Le
21.5					Marker Delt
11.5			how		Mkr→C
51.5				When when a second	Mkr→RefL
Center 914.9000 MHz	#VB1A/	100 kHz*	Sween	Span 400.0 kHz 52.80 ms (1001 pts)	Mor 1 of
SG			STATU		

# 2.5 Band Edge Attenuation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	EUT: Agriculture Sensor
Test Personnel: Imran Akram/B. Muharram	Standard: FCC PART 15.247
Date: 2020-03-06(21.1°C,13.2% 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 §15.209(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:

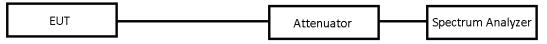
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
MXE EMI Receiver	Keysight Technologies Inc	N9038A FW A 22.08	6906	2019-10-29	2020-10-29
Temp/Humidity	Extech	42270	5892	2019-04-05	2020-04-05
Attenuator	FairView Microwave	SA18N5WA-10	6886	2020-02-01	2021-02-01
DC Blocker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

# 2.5.4 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	902.3	52.031 dBc	30 dBc
Channels	914.9	70.540 dBc	30 dBc
Lora 125KHz	902.3	54.430 dBc	30 dBc
Channels (Hopping)	914.9	71.945 dBc	30 dBc

## Screen Capture from the spectrum analyzer: Lower Band Edge (125 KHz)

								Analyzer -	· · · · · · · · · · · · · · · · · · ·	eysight	📕 Ke
Trace/Detector	10:22:59 AM Mar 06, 2020 TRACE 1 2 3 4 5 6	ALIGN AUTO		NSE:INT		-17	0Ω AC 00000 kH		RF 1 Δ 4	rker	<mark>u</mark> Mar
Select Trace	DET P NNNN	>300/300	Avg Hold		Trig: Free #Atten: 3	PNO: Wide C IFGain:Low					
1	Vkr1 408.0 kHz 52.031 dB	Δ					: 10.5 dB 0 dBm			B/div	0 d
	<u>1∆2</u>										og 20.5
Clear Writ	· · · · · · · · · · · · · · · · · · ·										:0.5
											500
	DL1 -10.00 dBm									1	.50
Trace Averag		/								1	9.5
-		(	VI							1	9.5
			2×2	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	m	mm				1	9.5
Max Ho											9.5
											9.5
Min Hol	top 902.5000 MHz .000 ms (1001 pts)			:	/ 300 kHz	#VB	!	0 MHz kHz	1.000 V 100		
		ICTION WIDTH	CTION FU		Y		Х		TRC SCI		
View Blenk					52.031 -31.909 dE	408.0 kHz (Δ 900 0 MHz		(Δ)	1 f 1 f	Δ2 F	2
View Blank Trace On											3 4
hace on											5
Мо											7 8
1 of											9 0
10	~										1
	>	STATUS									G
		STATUS									1

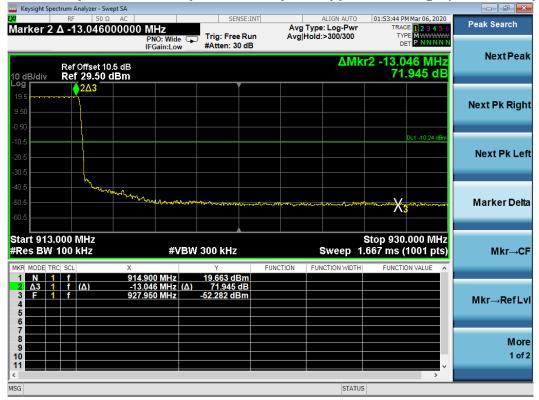
## Screen Capture from the spectrum analyzer: Upper Band Edge (125 KHz)

Keysight Spectrum Analyzer - Swept SA					
RF 50 Ω AC Marker 1 Δ -13.197000000	MHz PNO: Wide	SENSE:INT	ALIGN AUTO Avg Type: Log-Pwr Avg Hold:>300/300	11:57:47 AM Mar 06, 2020 TRACE 1 2 3 4 5 6 TYPE M WWWW	Trace/Detector
Ref Offset 10.5 dB 0 dB/div Ref 30.50 dBm	IFGain:Low	#Atten: 30 dB	ΔMkr1	-13.197 0 MHz 70.540 dB	Select Trace
20.5 10.5 .500					Clear Write
9.50				DL1 -10.24 dBm	Trace Averag
39.5	Sunday and	and the second of the second s		······································	Max Hol
tart 914.500 MHz Res BW 100 kHz	#VBW :			Stop 930.000 MHz 533 ms (1001 pts)	Min Hol
	97 0 MHz (Δ) 100 0 MHz -	70.540 dB 50.862 dBm			View Blank Trace On
7 8 9 10 11					Mor 1 of
SG			STATUS	>	

#### Screen Capture from the spectrum analyzer: Lower Band Edge (125 KHz Hopping)



### Screen Capture from the spectrum analyzer: Upper Band Edge (125 KHz Hopping)



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

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: Bushra Muharram Date: 2020-03-06(21.1°C,13.2% RH) EUT: Agriculture Sensor Standard: FCC PART 15.247 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 s	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 trees to	stabilize. Use the peak marker function to determine the maximum amplitude

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 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

## 2.6.4 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

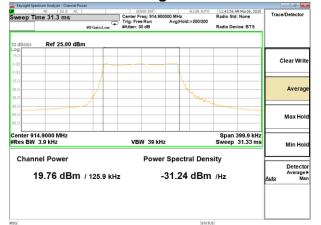
🔤 Keysight Spec		Spurious Emissions					- # ×		Keysight Spe		- Spurious Emissions							
风 Start Limi		0Ω AC dBm		q: 901.750000 MHz	Radio S	2 AM Mar 06, 2020 td: None	Range Table	Sta	art Lim	RF 5				q: 901.750000 MHz	Radio S	9 AM Mar 06, 2020 Std: None	Ra	nge Table
FAIL		IFGain	Low Trig: Free I #Atten: 30	Run Avg Hold:>50/ dB	Radio D	evice: BTS	Range	PA	SS		IFGair	:Low 두	Trig: Free F #Atten: 30		Radio I	Device: BTS		Range
15 dB/div		set 11.5 dB I <b>.00 dB</b> m			90 21.	2.38 MHz 097 dBm	<u>On</u> Off		dB/div	Ref Off Ref 3	set 10.5 dB 0.00 dBm				6 -54	4.256 kHz .520 dBm	<u>On</u>	Off
46.0 31.0 16.0	¢ <sup>1</sup>						Start Freq 30.000000 MHz		0									Start Freq 30.000 kHz
1.00 -14.0 -29.0							Stop Freq 10.000000000 GHz	-30.1 -45.1 -60.1	• <mark>1</mark> —								30	Stop Freq 0.000000 MHz
-44.0 -59.0 -74.0							Res BW 100.00 kHz Auto <u>Man</u>	-75.) -90.) -10	1								Auto	Res BW 10.000 kHz <u>Man</u>
Start 30 N	IHz				S	top 10 GHz	Video BW 300.00 kHz	Sta	art 30 k	Hz			<b>k</b>		S	top 30 MHz FFT		Video BW 30.000 kHz
Spur	Range	Frequency	Amplitude	Limit	∆ Limit		Auto <u>Man</u>		Spur	Range	Frequency	An	nplitude	Limit	∆ Limit		Auto	<u>Man</u>
1				F -10.00 dBm		^	Filter Type Gaussian									î	ſ	ilter Type Gaussian
						~	More 1 of 3									Ŷ		More 1 of 3
MSG					STATUS			MSG							STATUS 1 DC	Coupled		

### 125 KHz MID Channel



L <mark>XI</mark>	.imit -10.42		Trig: Free Run	08.700000 MHz n Avg Hold:>50/50	Radio Std: None	Range Table	LXI			Trig: Free F	1: 908.700000 MHz Run Avg Hold:>50		Range Table
15 dB/d		IFGain ffset 10.5 dB 16.00 dBm	:Low #Atten: 30 dB		Radio Device: BTS	Range 1 <u>On</u> Off	15 dB/div		IFGain: ffset 11.5 dB 52.00 dBm	Low #Atten: 30 d	18	Radio Device: BTS	Range 2 <u>On</u> Off
Log 1.00 -14.0						Start Freq 30.000 kHz	47.0 32.0 17.0						Start Freq 30.000000 MHz
-44.0 -59.0 -74.0						Stop Freq 30.000000 MHz	2.00 -13.0 -28.0						Stop Freq 10.000000000 GHz
-89.0 -104 -119						Res BW 10.000 kHz Auto <u>Man</u>	-43.0 -58.0 -73.0						Res BW 100.00 kHz Auto <u>Man</u>
Start					Stop 30 MH; FFT		Start 30	MHz				Stop 10 GHz	Video BW 300.00 kHz Auto Man
Spi	ir Range		Amplitude	Limit	∆ Limit	Mato <u>man</u>	Spur	Range	Frequency	Amplitude	Limit	∆ Limit	Muto <u>muti</u>
1	1	72.82 kHz 227.0 kHz	-52.98 dBm -57.23 dBm		-42.56 dB ^	Filter Type	1	2 2	908.9 MHz 1.817 GHz	20.82 dBm	F -10.42 dBm -10.42 dBm	31.24 dB ^	Filter Type
2	1	5.100 MHz	-57.23 dBm -57.95 dBm		-46.81 dB -47.53 dB	Gaussian	23	2	3.628 GHz	-29.85 dBm -46.41 dBm	-10.42 dBm -10.42 dBm	-19.43 dB -35.99 dB	Gaussian
4	1	175.6 kHz	-58.62 dBm		-48.20 dB		4	2	2.927 GHz	-47.17 dBm	-10.42 dBm	-36.75 dB	
5	1	342.6 kHz	-61.41 dBm		-50.99 dB	More	5	2	3.116 GHz	-47.37 dBm	-10.42 dBm	-36.95 dB	More
6	1	261.2 kHz	-62.66 dBm		-52.24 dB	1 of 3	6	2	2.631 GHz	-47.39 dBm	-10.42 dBm	-36.97 dB	1 of 3
· ·	1	616.6 kHz	-63.24 dBm	-10.42 dBm	-52.82 dB 🔍		· ·	2	3.175 GHz	-47.45 dBm	-10.42 dBm	-37.03 dB 🔍	
MSG				ST	ATUS 1 DC Coupled	_	MSG					STATUS	

# 125 KHz High Channel



🔤 Keysight							👝 🚱 🚾 Keysight Spectrum Analyzer - Spurious Emissions						
💴 Start Li	<sup>RF</sup> mit -10.24	50 Ω <u>A</u> DC dBm		14.900000 MHz	Radio Std: None	Range Table	X Start L	r⊧ imit -10.24	50 Ω AC	Center Fr	eq: 914.900000 MHz	IGN AUTO 12:07:10 PM Mar 06, 202 Radio Std: None	Range Table
PASS		IFGain	Low Trig: Free Run #Atten: 30 dB	Avg Hold:>50/5	0 Radio Device: BTS	Range	FAIL		IFGain	:Low Trig: Free #Atten: 30		50/50 Radio Device: BTS	Range
15 dB/div		fset 10.5 dB 7.00 dBm				On Off	15 dB/di		ffset 11.5 dB 8.00 dBm				<u>On</u> Off
Log 2.00 -13.0 -28.0						Start Freq 30.000 kHz	Log 33.0 18.0 3.00						Start Freq 30.000000 MHz
-43.0 -58.0 -73.0						Stop Freq 30.000000 MHz	-12.0 -27.0 -42.0						Stop Freq 10.000000000 GHz
-88.0 -103 -118						Res BW 10.000 kHz Auto <u>Man</u>	-57.0 -72.0 -87.0						Res BW 100.00 kHz Auto <u>Man</u>
Start 3	0 kHz				Stop 30 MHz FFT	30.000 kHz	Start 3	0 MHz				Stop 10 GH	300.00 kHz
Spur	Range	Frequency	Amplitude	Limit	Δ Limit	Auto <u>Man</u>	Spu	r Range	Frequency	Amplitude	Limit	∆ Limit	Auto <u>Man</u>
1 2 3	1 1 1	98.51 kHz 158.5 kHz 201.3 kHz 5.100 MHz	-52.46 dBm -54.06 dBm -56.91 dBm -57.24 dBm	-10.24 dBm -10.24 dBm -10.24 dBm -10.24 dBm	-42.22 dB ^ -43.82 dB -46.67 dB -47.00 dB	Filter Type Gaussian	1 2 3	2 2 2	914.8 MHz 1.830 GHz 3.163 GHz 3.715 GHz	20.69 dBm -28.79 dBm -47.27 dBm -47.31 dBm	F -10.24 dBm -10.24 dBm -10.24 dBm -10.24 dBm	30.93 dB ^ -18.55 dB -37.03 dB -37.07 dB	Filter Type Gaussian
4 5 6 7	1 1 1	5.100 MHz 291.2 kHz 381.1 kHz 231.3 kHz	-57.24 dBm -62.14 dBm -62.18 dBm -64.18 dBm	-10.24 dBm -10.24 dBm -10.24 dBm -10.24 dBm	-47.00 dB -51.90 dB -51.94 dB -53.94 dB	More 1 of 3	4 5 6 7	2 2 2 2	3.715 GHZ 3.063 GHZ 2.484 GHZ 3.157 GHZ	-47.31 dBm -47.35 dBm -47.55 dBm -47.66 dBm	-10.24 dBm -10.24 dBm -10.24 dBm -10.24 dBm	-37.07 dB -37.11 dB -37.31 dB -37.42 dB	More 1 of 3
MSG					STATUS 1 DC Coupled		MSG					STATUS	

## 2.7 Channel Separation (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: Imran Akram

EUT: Agriculture Sensor

Standard: FCC Part 15.247

Date: 2020-03-06(21.1°C,13.2% 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.

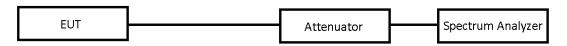
## 2.7.3 Test Equipment

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

	ectrum Analyzer - Swept SA						
<mark>x</mark> Marker 1	RF 50 Ω AC   200.0000000 kHz	PNO: Wide	SENSE:IN	Avg Typ	ALIGN AUTO e: Log-Pwr d:>300/300	02:16:11 PM Mar 06, 20 TRACE 1 2 3 4 TYPE MWWW	5 6 Peak Search
10 dB/div	Ref Offset 10.5 dB Ref 29.50 dBm	IFGain:Low	#Atten: 30 dB			ΔMkr1 200 kH -0.012 d	z NextPeak
19.5			×2	1∆2			Next Pk Right
9.50							Next Pk Left
-10.5							Marker Delta
-20.5							
-40.5							
-60.5							More 1 of 2
Center 90 #Res BW	8.0000 MHz 100 kHz	#VBW	/ 300 kHz		Sweep	Span 1.000 M 1.000 ms (1001 p	Hz

## 2.8 Time of Occupancy (Hybrid Mode)

Test Lab: Electronics Test Centre, Airdrie	EUT: Agriculture Sensor
Test Personnel: Imran Akram	Standard: FCC PART 15.247
Date: 2020-03-06(21.1°C,13.2% 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  $\leq$  Channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel. VBW  $\geq$  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.

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

## 2.8.3 Test Equipment

Testing was performed with the following equipment:

## 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:

EUT	Attenuator	Spectrum Analyzer
-----	------------	-------------------

## 2.8.5 Dwell Time Data:

Measured Dwell time = 370.2 ms

Window of measurement is equal to number of hopping channels multiple by  $400ms = 0.4 \times 64 = 25.6Sec$ 

Number of events in 25.6Sec = 1

Margin = 400 - 370.2 = 29.8ms

#### Screen Capture from the spectrum analyzer: Dwell time in 600ms

Keysight Spectrum Analyzer - Swept SA					
4 RF 50 Ω AC Marker 1 370.200 ms	PNO: Fast ↔	SENSE:INT Trig Delay-100.0 ms Trig: Video	ALIGN AUTO Avg Type: Log-Pwr	02:23:29 PM Mar 06, 2020 TRACE 1 2 3 4 5 6 TYPE WWWWWW	Peak Search
Ref Offset 10.5 dB 0 dB/div Ref 29.50 dBm	IFGain:Low	#Atten: 30 dB	Ĺ	Mkr1 370.2 ms 0.34 dB	NextPeak
19.5 Xum	mm	๛๛๛๛๛๛๛๛๛		1Δ2	Next Pk Righ
9.50				TRIG LVL	
0.50					Next Pk Lef
10.5					Marker Delta
20.5					
30.5					Mkr→Cl
40.5					
50.5				a tatin o kunik na kunik in tatin.	Mkr→RefLv
60.5					
Center 908.000000 MHz				Snon 0 U	More 1 of 2
Res BW 1.0 MHz	#VBW :	3.0 MHz	Sweep 6	Span 0 Hz 000.0 ms (1001 pts)	
ISG			STATUS	5	

- F						•	n Analyzer - Swe	· ·	
Marker	02:30:55 PM Mar 06, 2020	ALIGN AUTO	ISE:INT	SEN		AC	VF 50 Ω		
SelectMarke	TRACE 1 2 3 4 5 6 TYPE WWWWW DET P NNNNN	Avg Type: Log-Pwr		Trig: Vide #Atten: 30	lO: Wide Bain:Low	PN	384.000 r	ker 1Δ.	lark
1	Mkr1 384.0 ms dB	Δ					ef Offset 10. ef 29.50 d		) dB
Norm								1Δ2	9.5
	TRIG LVL								.50
Del									50 -
Fixed									).5 -
									).5
c									).5
	<b>r</b> q				-				).5
Properties	And propagation	hin . historian	ydd Llwollingryflyndyyd	hlungarh hu	uly July many	former by more that	nd Ni wheelmatters	R-hap-lath-half	).5 -
									.5 -
Мо 1 о						-			
	Span 0 Hz 25.60 s (1001 pts)	Sweep		300 kHz	#VBW	IZ	00000 MH kHz	er 908.0 BW 100	
		STATUS							G

## Screen Capture from the spectrum analyzer: Dwell Time in 25.6 Sec

Note: The time reported for the duration of the transmit occurrence has a sampling period of 25.6ms, which makes its accuracy  $\pm/-25.6$ ms.

## 2.9 EUT Positioning Assessment

Test Lab: Electronics Test Centre, Airdrie

Test Personnel: I. Akram

Date: 2020-03-02 (19.5°C,13.5 % RH)

EUT: Agriculture Sensor Standard: FCC PART 15.247 Basic Standard: ANSI C63.4-2014

# X-Axis Found worse

**Comments:** T0005986 variant oriented in three axis's and X- axis found to be worse emission axis.

T0005982 variant has only one possible application orientation 'X' and was found with emission similar to T0005986 X-axis but showed more spurious emission. The radiated spurious testing was performed with this unit.

## 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: Agriculture Sensor
Test Personnel: Bushra Muharram	Standard: FCC PART 15.247
Date: 2020-03-(03/04) (20.7°C,15.6 % 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:

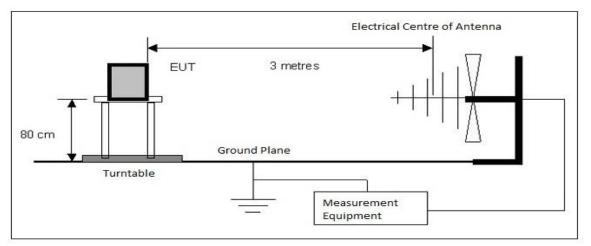
Equipment	Manufacturer	Model #	Asset #	Cal. Date (yyyy-mm-dd)	Cal. Due (yyyy-mm-dd)
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2019-05-10	2020-05-10
Loop Antenna	EMCO	6502	10868	2019-04-11	2021-04-11
Biconilog Antenna	ARA	LPB-2520/A	4318	2018-09-19	2020-09-19
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.

MHz	MHz	MHz	GHz	
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15	
<sup>1</sup> 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				

#### FCC Part 15.205 Restricted Bands of Operation:

<sup>1</sup> Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz, <sup>2</sup> 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 dB $\mu$ V + Antenna Factor in dB/m + Gain/Loss Factor in dB = Corrected Field Strength in db $\mu$ V/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.

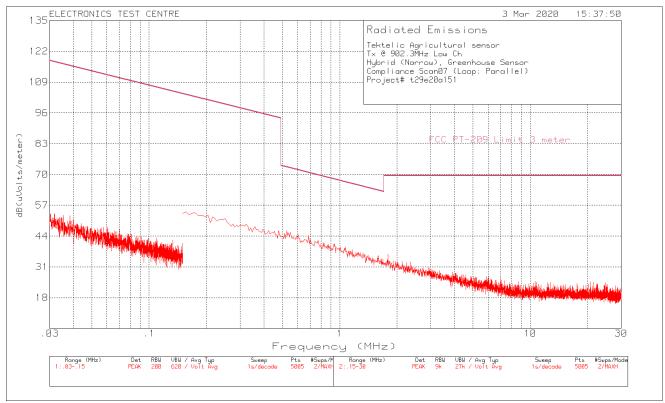
#### Negative values for Delta indicate compliance.

						Pre amp						
			Raw		Antenna	Gain	Corrected	FCC 15.209				
	Freq.	Freq.	reading		Factor	/Cable	Reading	Limit	Delta	Azimuth	Height	
Band	Marker	[MHz]	[dBµv]	Det	[dB/m]	Loss [dB]	[dBµv/m]	[dBµv/m]	[dB]	[Deg]	[cm]	Polarization
	Frequency Range 30 – 1000 MHz											
RB	7	111.424	13.65	QP	14.5	2.8	30.95	43.5	-12.55	79	108	Vertical
NRB	10	519.2311	13.2	QP	21.8	5.8	40.8	46.02	-5.22	93	103	Verical
	Frequency Range 1000 – 1400 MHz											
RB	1	1070.0	27.04	AV	24.5	-18.7	32.84	54	-21.16	89	215	Horizontal
RB	1	1070.0	39.31	PK	24.5	-18.7	45.11	74	-28.89	89	215	Horizontal
RB	2	1123.7	19.07	AV	24.6	-18.9	24.77	54	-29.23	276	379	Horizontal
RB	2	1123.7	32.6	PK	24.6	-18.9	38.36	74	-35.64	276	379	Horizontal
RB	3	1337.0	18.47	AV	25.2	-18.8	24.87	54	-29.13	335	202	Vertical
RB	3	1337.0	52.29	PK	25.2	-18.8	58.69	74	-15.31	335	202	Vertical
RB	4	1348.0	30.69	AV	25.2	-18.8	37.09	54	-16.91	302	154	Vertical
RB	4	1348.0	57.53	PK	25.2	-18.8	63.93	74	-10.07	302	154	Vertical
						Frequency R	ange 1400 -	- 3600 MHz				
RB	1	1448.8	26.55	AV	25.3	-29	22.85	54	-31.15	300	345	Horizontal
RB	1	1448.8	41.03	PK	25.3	-29	37.33	74	-36.67	300	345	Horizontal
RB	2	1682.3	40.67	AV	26	-34.5	32.17	54	-21.83	343	145	Horizontal
RB	2	1682.3	41.15	PK	26	-34.5	32.65	74	-41.35	343	145	Horizontal
RB	3	2239.3	27.09	AV	28	-34.4	20.69	54	-33.31	284	152	Horizontal
RB	3	2239.3	40.46	PK	28	-34.4	34.06	74	-39.94	284	152	Horizontal
RB	4	1448.8	26.54	AV	25.3	-29	22.84	54	-31.16	263	178	Vertical
RB	4	1448.8	58.71	PK	25.3	-29	55.01	74	-18.99	263	178	Vertical
RB	5	1571	27.88	AV	25.5	-33.4	19.98	54	-34.02	92	133	Vertical
RB	5	1571	40.24	PK	25.5	-33.4	32.34	74	-41.66	92	133	Vertical
RB	6	1682.3	27.7	AV	26	-34.5	19.2	54	-34.8	123	102	Vertical
RB	6	1682.3	40.55	PK	26	-34.5	32.05	74	-41.95	123	102	Vertical
RB	7	2239.3	27.09	AV	28	-34.4	20.69	54	-33.31	146	382	Vertical
RB	7	2239.3	38.9	PK	28	-34.4	32.5	74	-41.5	146	382	Vertical
RB	8	3354.2	27.85	AV	31.1	-32.9	26.05	54	-27.95	147	158	Vertical
RB	8	3354.2	45.07	PK	31.1	-32.9	43.27	74	-30.73	147	158	Vertical

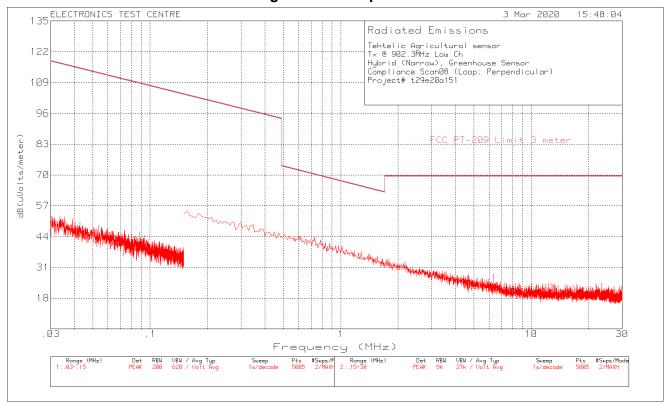
			-						-	-		
			Raw		Antenna	Pre amp	Corrected	FCC 15.209				
	Freq.	Freq.	reading		Factor	Gain	Reading	Limit	Delta	Azimuth	Height	
Band	Marker	[MHz]	[dBµv]	Det	[dB/m]	[dB]	[dBµv/m]	[dBµv/m]	[dB]	[Deg]	[cm]	Polarization
					Fr	equency F	Range 3600	– 10000 MHz				
RB	1	3609.3	45.19	AV	31.5	-32.8	43.89	54	-10.11	203	103	Horizontal
RB	1	3609.3	48.34	PK	31.5	-32.8	47.04	74	-26.96	203	103	Horizontal
RB	2	4511.4	39.75	AV	32.4	-32.4	39.75	54	-14.25	306	287	Horizontal
RB	2	4511.4	44.61	PK	32.4	-32.4	44.61	74	-29.39	306	287	Horizontal
RB	3	5413.5	40.91	AV	34	-30.6	44.31	54	-9.69	211	290	Horizontal
RB	3	5413.5	46.92	PK	34	-30.6	50.32	74	-23.68	211	290	Horizontal
RB	4	8121.1	31.12	AV	36.7	-26.1	41.72	54	-12.28	105	343	Horizontal
RB	4	8121.1	39.3	PK	36.7	-26.1	49.9	74	-24.1	105	343	Horizontal
RB	5	3609.3	48.26	AV	31.5	-32.8	46.96	54	-7.04	247	286	Vertical
RB	5	3609.3	50.96	PK	31.5	-32.8	49.66	74	-24.34	247	286	Vertical
RB	6	4510.9	35.62	AV	32.4	-32.4	35.62	54	-18.38	274	270	Vertical
RB	6	4510.9	45.08	PK	32.4	-32.4	45.08	74	-28.92	274	270	Vertical
RB	7	5413.5	41.26	AV	34	-30.6	44.66	54	-9.34	299	261	Vertical
RB	7	5413.5	46.76	PK	34	-30.6	50.16	74	-23.84	299	261	Vertical
RB	8	8120.6	39.77	AV	36.7	-26.1	50.37	54	-3.63	247	197	Vertical
RB	8	8120.6	44.28	PK	36.7	-26.1	54.88	74	-19.12	247	197	Vertical
RB	9	9022.7	29.23	AV	37.5	-26.5	40.23	54	-13.77	254	235	Vertical
RB	9	9022.7	37.86	PK	37.5	-26.5	48.86	74	-25.14	254	235	Vertical

Restricted Band (RB) Non Restricted Band (NRB)

# Plot of Radiated Emissions: Measuring Antenna Parallel

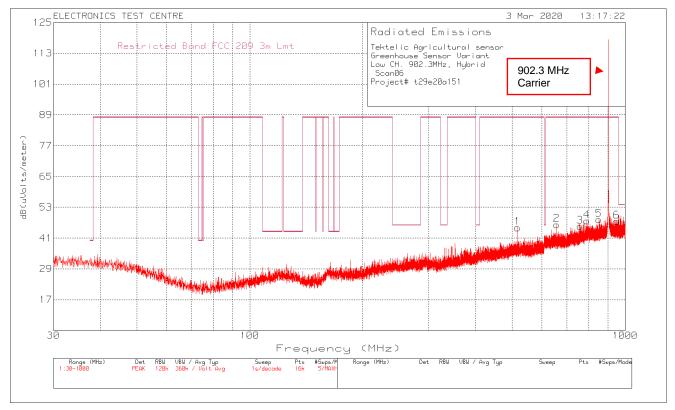


#### Plot of Radiated Emissions: Measuring Antenna Perpendicular

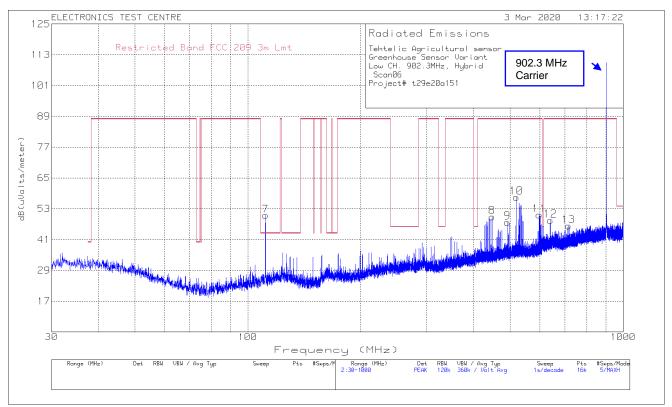


This report shall not be reproduced, except in full, without prior written approval of Page 40 of 48 **MPB Technologies** 



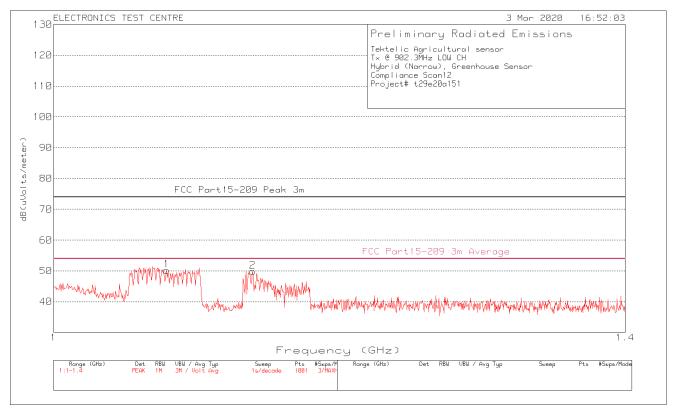


#### Plot of Radiated Emissions: Vertical polarization

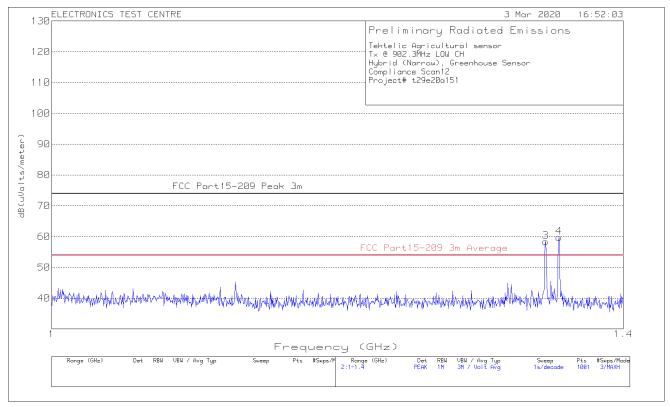


This report shall not be reproduced, except in full, without prior written approval of Page 41 of 48 **MPB Technologies** 

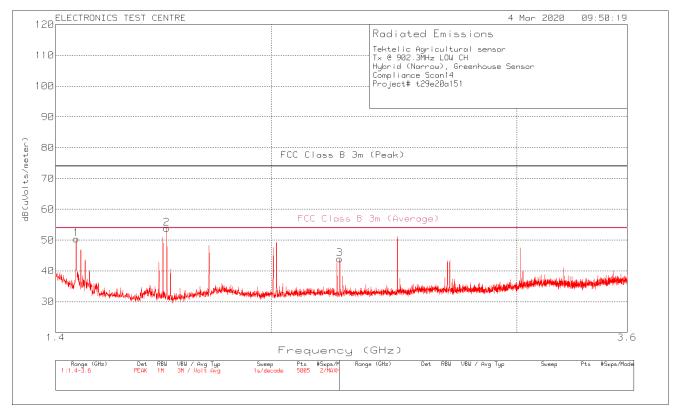
#### Plot of Radiated Emissions: Horizontal polarization



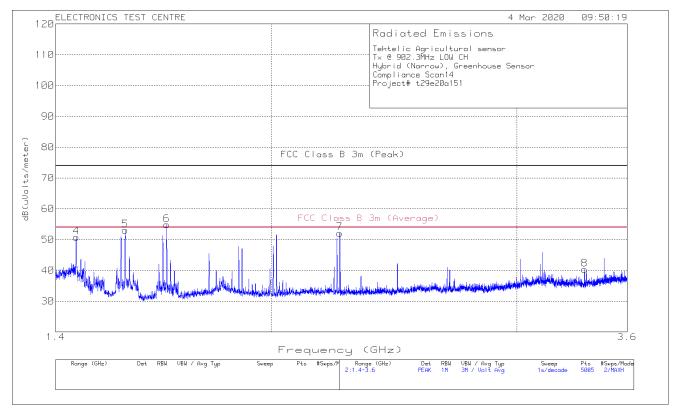
#### Plot of Radiated Emissions: Vertical polarization



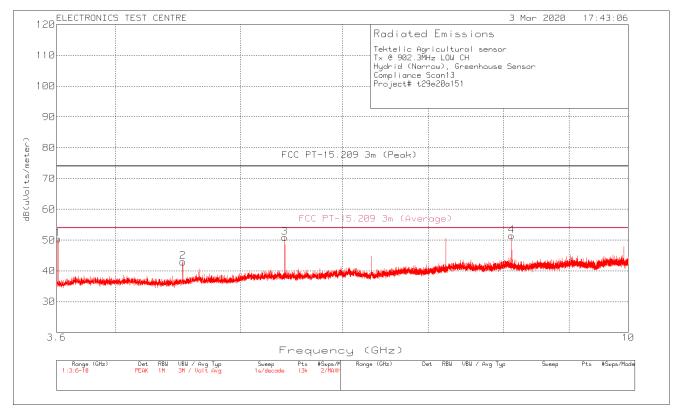
#### Plot of Radiated Emissions: Horizontal polarization



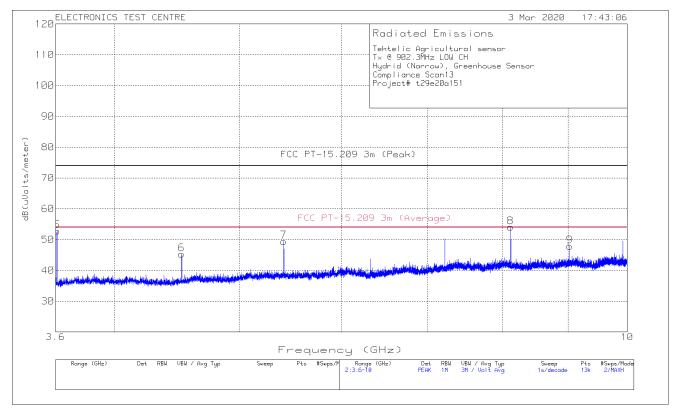
#### Plot of Radiated Emissions: Vertical polarization



#### Plot of Radiated Emissions: Horizontal polarization



# Plot of Radiated Emissions: Vertical polarization



# 2.11 RF Exposure

Test Lab: Electronics Test Centre, Airdrie Test Personnel:	EUT: Agriculture Sensor 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 Agriculture 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.

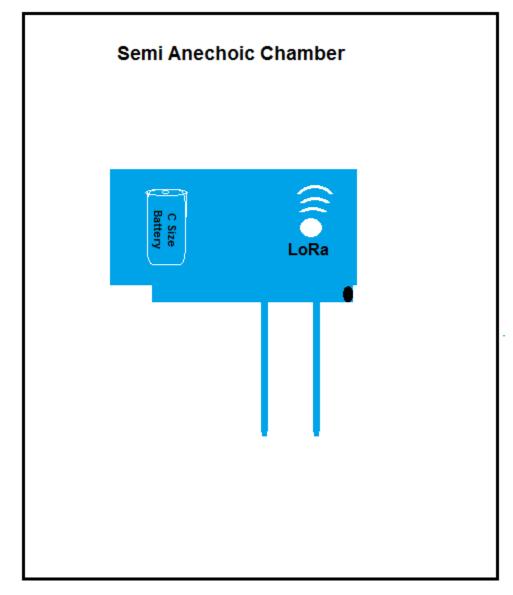
#### 3.2 Grounding Plan

The Agriculture Sensor was placed at the center of the test chamber turntable on top of polystyrene foam table. It is enclosed in a non-conductive plastic case and has no earth ground provisioning.

#### 3.3 Power Supply

The Agricultural Sensor is powered from a Lithium Thionyl Chloride (LTC), C-size, bobbin cell.

# Appendix A (Worse Emission variant test setup Block Diagram)



# **End of Document**