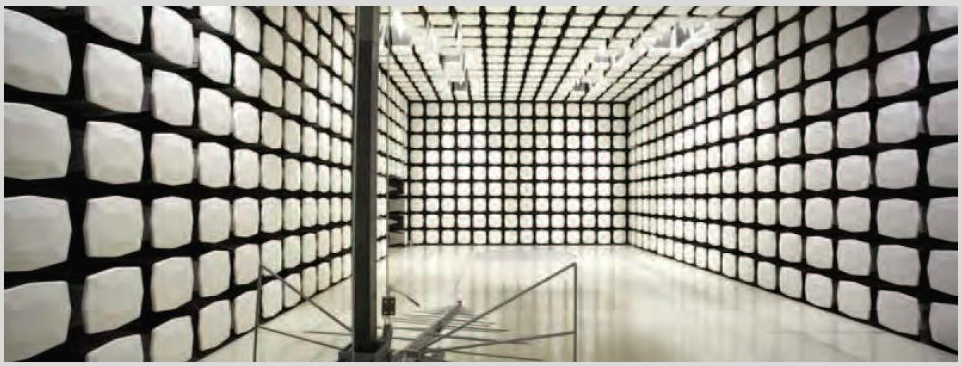
Nelson Irrigation Corporation

TWIG V – Radio Module

FCC 15.247:2019

902 – 928 MHz Other Wideband DTS Transceiver

Report # NELS0008.1



NVLAP LAB CODE: 200630-0

CERTIFICATE OF TEST

Last Date of Test: September 19, 2019
Nelson Irrigation Corporation
EUT: TWIG V - Radio Module

Radio Equipment Testing

Standards

Specification	Method
FCC 15.207:2019	ANSI C63.10:2013, KDB 558074
FCC 15.247:2019	

Results

Method Clause	Test Description	Applied	Results	Comments
6.2	Powerline Conducted Emissions (Transmitter)	Yes	Pass	
6.5, 6.6, 11.12.1, 11.13.2	Spurious Radiated Emissions	Yes	Pass	
11.6	Duty Cycle	Yes	Pass	
7.8.2	Carrier Frequency Separation	No	N/A	Not required for DTS devices.
7.8.3	Number of Hopping Frequencies	No	N/A	Not required for DTS devices.
7.8.4	Dwell Time	No	N/A	Not required for DTS devices.
11.9.1.1	Output Power	Yes	Pass	
11.9.1.1	Equivalent Isotropic Radiated Power	Yes	Pass	
11.11	Band Edge Compliance	Yes	Pass	
7.8.6	Band Edge Compliance - Hopping Mode	No	N/A	Not required for DTS devices.
11.8.2	Occupied Bandwidth	Yes	Pass	
11.11	Spurious Conducted Emissions	Yes	Pass	
11.10.2	Power Spectral Density	Yes	Pass	

Deviations From Test Standards

None

Approved By:

Kyle Holgate, Operations Manager

Product compliance is the responsibility of the client; therefore, the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test. This report reflects only those tests from the referenced standards shown in the certificate of test. It does not include inspection or verification of labels, identification, marking or user information. As indicated in the Statement of Work sent with the quotation, Element's standard process is to always use the latest published version of the test methods even when earlier versions are cited in the test specification. Issuance of a purchase order was de facto acceptance of this approach. Otherwise, the client would have advised Element in writing of the specific version of the test methods they wanted applied to the subject testing.

REVISION HISTORY

Revision Number	Description	Date (yyyy-mm-dd)	Page Number
00	None		

ACCREDITATIONS AND AUTHORIZATIONS

United States

FCC - Designated by the FCC as a Telecommunications Certification Body (TCB). Certification chambers, Open Area Test Sites, and conducted measurement facilities are listed with the FCC.

A2LA - Accredited by A2LA to ISO / IEC 17065 as a product certifier. This allows Element to certify transmitters to FCC and IC specifications.

NVLAP - Each laboratory is accredited by NVLAP to ISO 17025

Canada

ISED - Recognized by Innovation, Science and Economic Development Canada as a Certification Body (CB) and as a CAB for the acceptance of test data.

European Union

European Commission – Within Element, we have a EU Notified Body validated for the EMCD and RED Directives.

Australia/New Zealand

ACMA - Recognized by ACMA as a CAB for the acceptance of test data.

Korea

MSIT / RRA - Recognized by KCC's RRA as a CAB for the acceptance of test data.

Japan

VCCI - Associate Member of the VCCI. Conducted and radiated measurement facilities are registered.

Taiwan

BSMI – Recognized by BSMI as a CAB for the acceptance of test data.

NCC - Recognized by NCC as a CAB for the acceptance of test data.

Singapore

IDA – Recognized by IDA as a CAB for the acceptance of test data.

Israel

MOC – Recognized by MOC as a CAB for the acceptance of test data.

Hong Kong

OFCA – Recognized by OFCA as a CAB for the acceptance of test data.

Vietnam

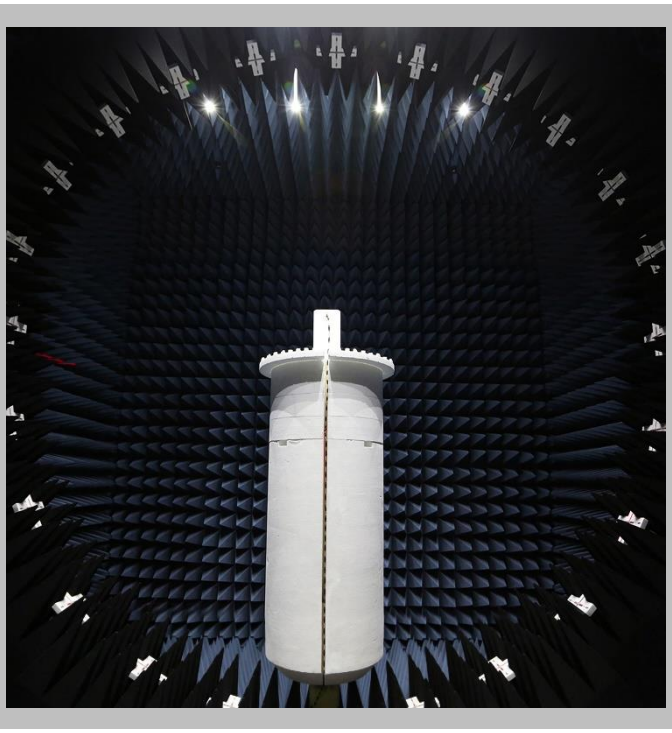
MIC – Recognized by MIC as a CAB for the acceptance of test data.

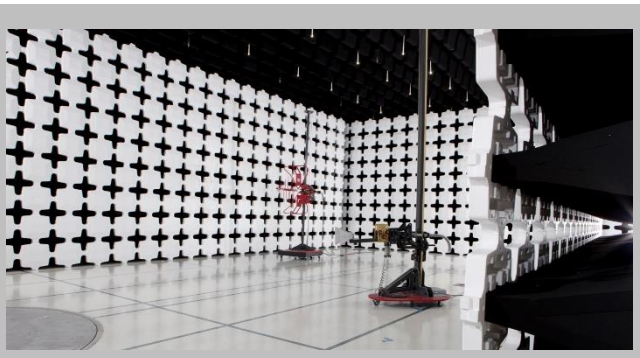
SCOPE

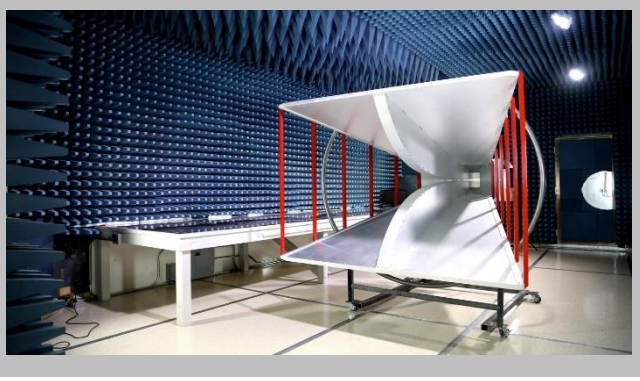
For details on the Scopes of our Accreditations, please visit:
https://www.nwemc.com/emc-testing-accreditations

FACILITIES

California	Minnesota	Oregon	Texas	Washington
Labs OC01-17 41 Tesla Irvine, CA 92618 (949) 861-8918	Labs MN01-10 9349 W Broadway Ave. Brooklyn Park, MN 55445 (612)-638-5136	Labs EV01-12 6775 NE Evergreen Pkwy #400 Hillsboro, OR 97124 (503) 844-4066	Labs TX01-09 3801 E Plano Pkwy Plano, TX 75074 (469) 304-5255	Labs NC01-05 19201 120th Ave NE Bothell, WA 98011 (425)984-6600
NVLAP				
NVLAP Lab Code: 200676-0	NVLAP Lab Code: 200881-0	NVLAP Lab Code: 200630-0	NVLAP Lab Code:201049-0	NVLAP Lab Code: 200629-0
Innovation, Science and Economic Development Canada				
2834B-1, 2834B-3	2834E-1, 2834E-3	2834D-1	2834G-1	2834F-1
BSMI				
SL2-IN-E-1154R	SL2-IN-E-1152R	SL2-IN-E-1017	SL2-IN-E-1158R	SL2-IN-E-1153R
VCCI				
A-0029	A-0109	A-0108	A-0201	A-0110
Recognized Phase I CAB for ISED, ACMA, BSMI, IDA, KCC/RRA, MIC, MOC, NCC, OFCA				
US0158	US0175	US0017	US0191	US0157







MEASUREMENT UNCERTAINTY

element
TMU.2015.07.10

Measurement Uncertainty

When a measurement is made, the result will be different from the true or theoretically correct value. The difference is the result of tolerances in the measurement system that cannot be completely eliminated. To the extent that technology allows us, it has been our aim to minimize this error. Measurement uncertainty is a statistical expression of measurement error qualified by a probability distribution.

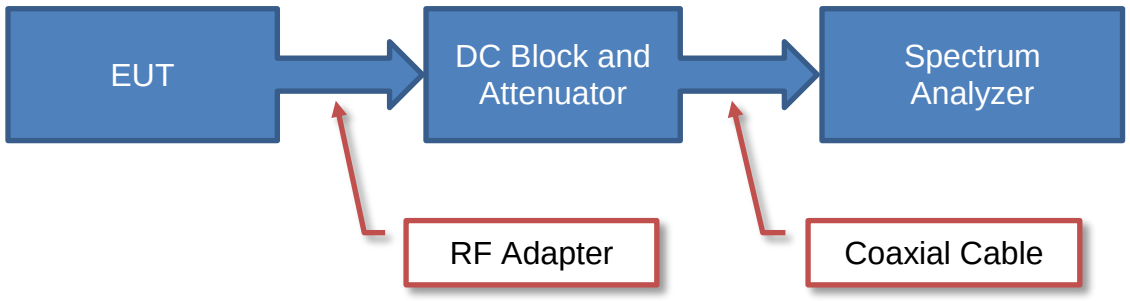
A measurement uncertainty estimation has been performed for each test per our internal quality document QM205.4.6. The estimation is used to compare the measured result with its "true" or theoretically correct value. The expanded measurement uncertainty (K=2) can be found included as part of the applicable test description page. Our measurement data meets or exceeds the measurement uncertainty requirements of the applicable specification; therefore, the test data can be compared directly to the specification limit to determine compliance. The calculations for estimating measurement uncertainty are based upon ETSI TR 100 028 (or CISPR 16-4-2 as applicable), and are available upon request.

The following table represents the Measurement Uncertainty (MU) budgets for each of the tests that may be contained in this report.

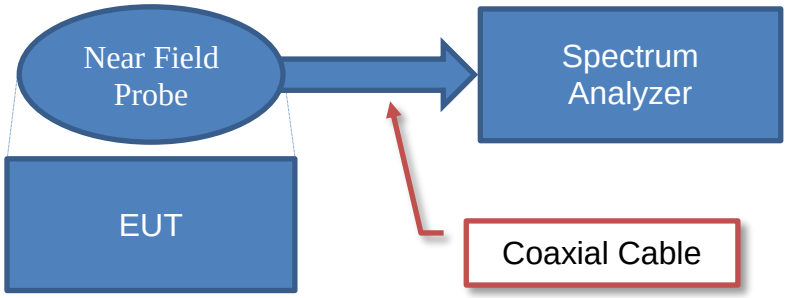
Test	+ MU	- MU
Frequency Accuracy	0.0007%	-0.0007%
Amplitude Accuracy (dB)	1.2 dB	-1.2 dB
Conducted Power (dB)	1.2 dB	-1.2 dB
Radiated Power via Substitution (dB)	0.7 dB	-0.7 dB
Temperature (degrees C)	0.7°C	-0.7°C
Humidity (% RH)	2.5% RH	-2.5% RH
Voltage (AC)	1.0%	-1.0%
Voltage (DC)	0.7%	-0.7%
Field Strength (dB)	5.2 dB	-5.2 dB
AC Powerline Conducted Emissions (dB)	2.4 dB	-2.4 dB

Test Setup Block Diagrams

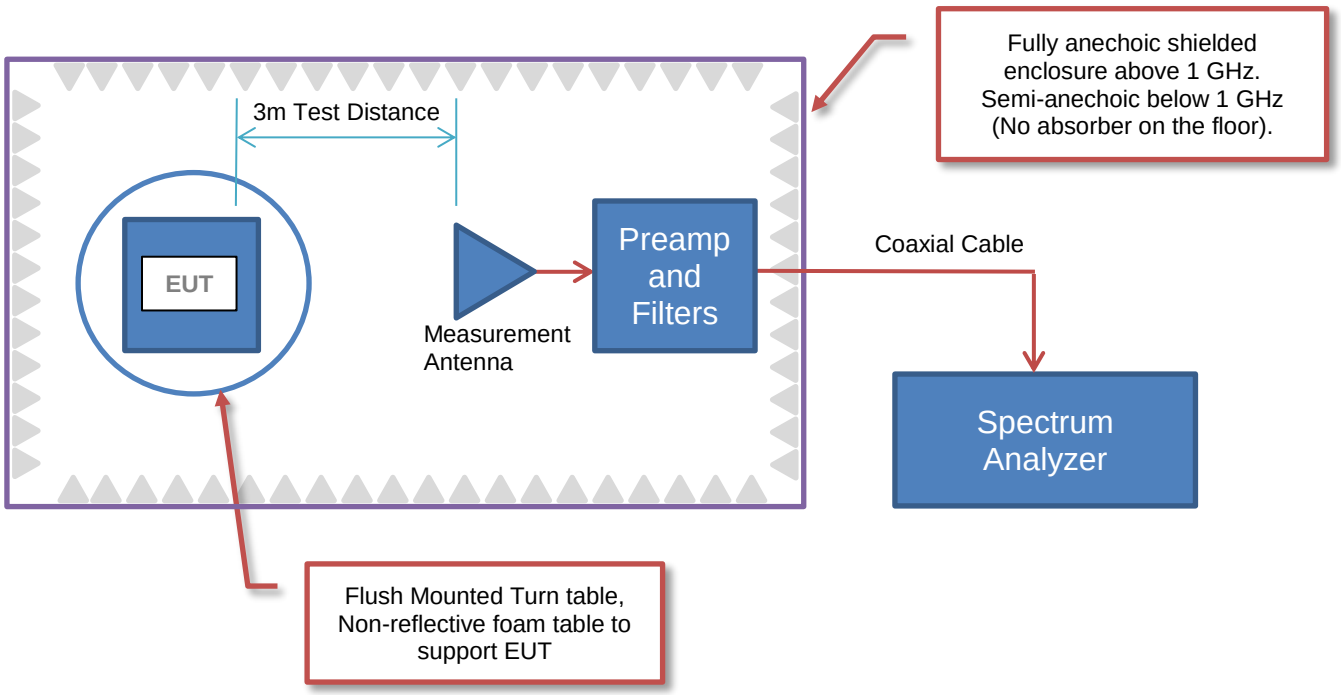
Antenna Port Conducted Measurements



Near Field Test Fixture Measurements



Spurious Radiated Emissions



PRODUCT DESCRIPTION

Client and Equipment Under Test (EUT) Information

Company Name:	Nelson Irrigation Corporation
Address:	848 Airport Road
City, State, Zip:	Walla Walla, WA 99362-2271
Test Requested By:	Mark Bauman
EUT:	TWIG V – Radio Module
First Date of Test:	August 29, 2019
Last Date of Test:	September 19, 2019
Receipt Date of Samples:	August 28, 2019
Equipment Design Stage:	Production
Equipment Condition:	No Damage
Purchase Authorization:	Verified

Information Provided by the Party Requesting the Test

Functional Description of the EUT:
Irrigation Control Network: The End Node product is designed to drive latching solenoids or latching relays in response to LoRa radio packets and provides status information to the network using LoRa radio packets. It is a limited energy device and spends most of its life in a state of sleep. The Command Node product provides network timing information that is encoded into the LoRa packets that coordinates operation. It responds to LoRa packets by providing control data that is utilized by the End Nodes. It is continuously powered and spends most of its time waiting to respond to LoRa packets. The Echo Node product retransmits directed LoRa packets to extend the coverage of the network. It is continuously powered and spends most of its life waiting to receive LoRa packets.

Testing Objective:
Seeking to demonstrate compliance under FCC 15.247:2019 for operation in the 902 - 928 MHz Band.

CONFIGURATIONS

Configuration NELS0008- 8

Software/Firmware Running during test	
Description	**Version**
EMC Test Software	0xAE256A4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
LoRa Radio Module	Nelson Irrigation Corporation	TWIG V	256395-0059

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Omni Antenna	L-com	HG908UP-NF	HG908UP-NFPOLC10063101918
DC Power Supply	TOPWARD	TPS2000	None

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
CA-195R	Yes	3.1 m	No	u.fl to SMA Patch Cable	Antenna
DC Power	No	0.1 m	No	LoRa Radio Module	DC Power
DC Power	No	2.0 m	No	DC Power	DC Power Supply
AC Power	No	1.8 m	No	AC Mains	DC Power Supply
u.fl to SMA Patch Cable	Yes	0.2 m	No	LoRa Radio Module	CA-195R

CONFIGURATIONS

Configuration NELS0008- 9

Software/Firmware Running during test	
Description	**Version**
EMC Test Software	0xAE256A4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
LoRa Radio Module	Nelson Irrigation Corporation	TWIG V	256395-0059

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Yagi Antenna	L-com	HG912YE-NF	HG912YE-NFPO2022821839
DC Power Supply	TOPWARD	TPS2000	None

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
CA-195R	Yes	3.1 m	No	u.fl to SMA Patch Cable	Antenna
DC Power	No	0.1 m	No	LoRa Radio Module	DC Power
DC Power	No	2.0 m	No	DC Power	DC Power Supply
AC Power	No	1.8 m	No	AC Mains	DC Power Supply
u.fl to SMA Patch Cable	Yes	0.2 m	No	LoRa Radio Module	CA-195R

CONFIGURATIONS

Configuration NELS0008- 10

Software/Firmware Running during test	
Description	**Version**
EMC Test Software	0xAE256A4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
LoRa Radio Module	Nelson Irrigation Corporation	TWIG V	256395-0059

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
DC Power Supply	TOPWARD	TPS2000	None

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
DC Power	No	0.1 m	No	LoRa Radio Module	DC Power
DC Power	No	2.0 m	No	DC Power	DC Power Supply
AC Power	No	1.8 m	No	AC Mains	DC Power Supply

CONFIGURATIONS

Configuration NELS0008- 11

Software/Firmware Running during test	
Description	**Version**
EMC Test Software	0xAE256A4

EUT			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
LoRa Radio Module	Nelson Irrigation Corporation	TWIG V	256395-0059

Peripherals in test setup boundary			
Description	**Manufacturer**	**Model/Part Number**	**Serial Number**
Remote Laptop	Panasonic	Toughbook CF30	000634
DC Power Supply	TOPWARD	TPS2000	None

Cables					
Cable Type	**Shield**	**Length (m)**	**Ferrite**	**Connection 1**	**Connection 2**
DC Power	No	0.1 m	No	LoRa Radio Module	DC Power
DC Power	No	2.0 m	No	DC Power	DC Power Supply
AC Power	No	1.8 m	No	AC Mains	DC Power Supply
Serial to USB	Yes	1.5 m	No	Remote Laptop	LoRa Radio Module

MODIFICATIONS

Equipment Modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	2019-08-29	Spurious Radiated Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
2	2019-09-05	Duty Cycle	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
3	2019-09-05	Output Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
4	2019-09-05	Equivalent Isotropic Radiated Power	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
5	2019-09-05	Band Edge Compliance	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
6	2019-09-05	Occupied Bandwidth	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
7	2019-09-05	Spurious Conducted Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
8	2019-09-05	Power Spectral Density	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	EUT remained at Element following the test.
9	2019-09-06	Powerline Conducted Emissions (Transmitter)	Modified from delivered configuration.	Installed Fair-Rite brand ferrite (PN# 0431173951) on the u.fl to SMA adapter/patch cable near the u.fl connection for the external antenna. Modification authorized by Mark Bauman.	EUT remained at Element following the test.
10	2019-09-19	Spurious Radiated Emissions	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

TEST DESCRIPTION

Using the mode of operation and configuration noted within this report, conducted emissions tests were performed. The frequency range investigated (scanned), is also noted in this report. Conducted power line measurements are made, unless otherwise specified, over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from the EUT power-input terminals that are directly (or indirectly via separate transformer or power supplies) connected to a public power network. Per the standard, an insulating material was also added to ground plane between the EUT's power and remote I/O cables. Equipment is tested with power cords that are normally used or that have electrical or shielding characteristics that are the same as those cords normally used. Typically those measurements are made using a LISN (Line Impedance Stabilization Network), the 50ohm measuring port is terminated by a 50ohm EMI meter or a 50ohm resistive load. All 50ohm measuring ports of the LISN are terminated by 50ohm. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Receiver	Rohde & Schwarz	ESCI	ARH	2019-05-02	2020-05-02
Cable - Conducted Cable Assembly	Northwest EMC	EVG, HHD, RKT	EVGA	2019-01-07	2020-01-07
LISN	Solar Electronics	9252-50-R-24-BNC	LIN	2018-12-27	2019-12-27

MEASUREMENT UNCERTAINTY

Description		
Expanded k=2	2.4 dB	-2.4 dB

CONFIGURATIONS INVESTIGATED

NELS0008-10
NELS0008-8
NELS0008-9

MODES INVESTIGATED

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-05
Customer:	Nelson Irrigation Corporation	Temperature:	23.7°C
Attendees:	None	Relative Humidity:	48.7%
Customer Project:	None	Bar. Pressure:	1015 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-10

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	12	Line:	Neutral	Add. Ext. Attenuation (dB):	0

COMMENTS

Measuring AC mains of Linear Lab DC Power Supply.

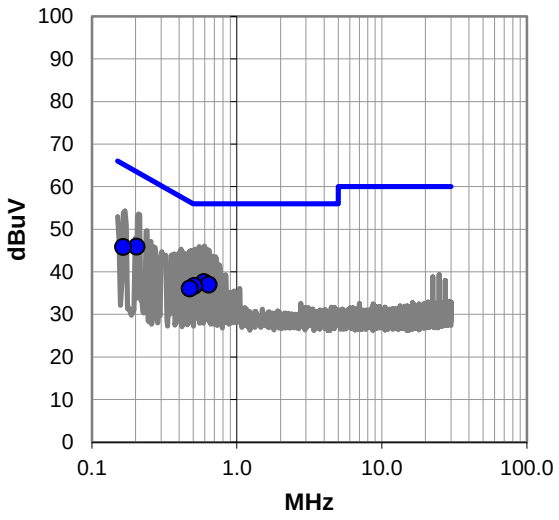
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

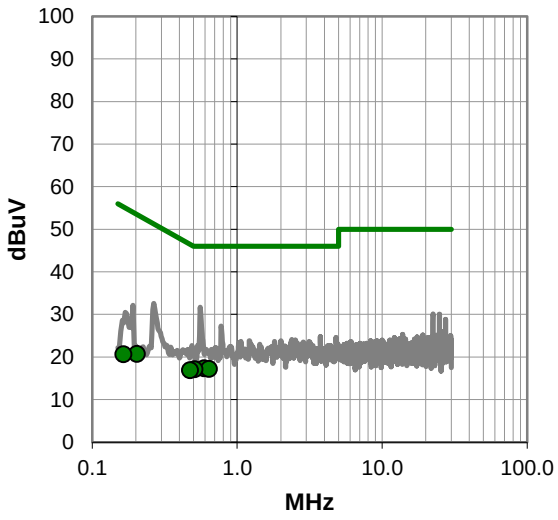
DEVIATIONS FROM TEST STANDARD

None

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #12

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.203	25.9	20.0	45.9	63.5	-17.6
0.594	17.7	19.9	37.6	56.0	-18.4
0.640	17.1	19.9	37.0	56.0	-19.0
0.507	16.9	19.8	36.7	56.0	-19.3
0.164	25.8	20.0	45.8	65.3	-19.5
0.473	16.3	19.8	36.1	56.5	-20.4

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.594	-2.6	19.9	17.3	46.0	-28.7
0.640	-2.7	19.9	17.2	46.0	-28.8
0.507	-2.7	19.8	17.1	46.0	-28.9
0.473	-2.9	19.8	16.9	46.5	-29.6
0.203	0.7	20.0	20.7	53.5	-32.8
0.164	0.6	20.0	20.6	55.3	-34.7

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-05
Customer:	Nelson Irrigation Corporation	Temperature:	23.7°C
Attendees:	None	Relative Humidity:	48.7%
Customer Project:	None	Bar. Pressure:	1015 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-10

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	13	Line:	High Line	Add. Ext. Attenuation (dB):	0

COMMENTS

Measuring AC mains of Linear Lab DC Power Supply.

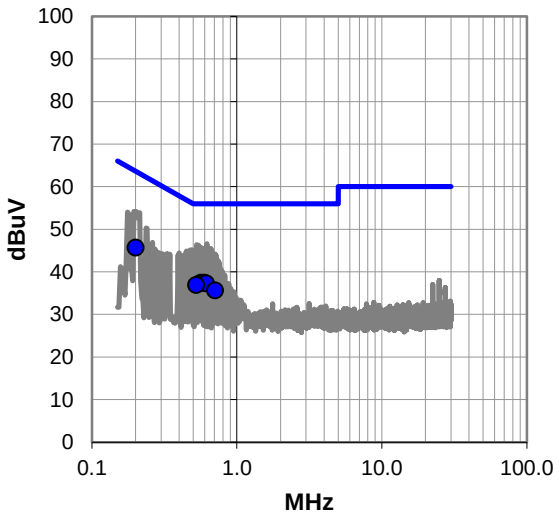
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

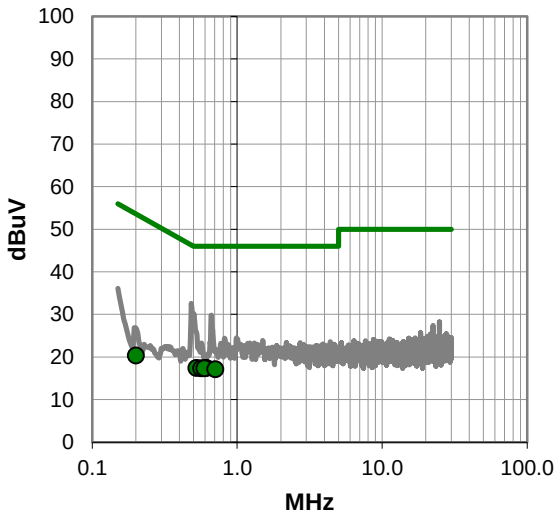
DEVIATIONS FROM TEST STANDARD

None

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #13

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.201	25.7	20.0	45.7	63.6	-17.9
0.565	17.5	19.9	37.4	56.0	-18.6
0.595	17.5	19.9	37.4	56.0	-18.6
0.613	17.4	19.9	37.3	56.0	-18.7
0.525	17.0	19.9	36.9	56.0	-19.1
0.708	15.7	19.9	35.6	56.0	-20.4

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.613	-2.5	19.9	17.4	46.0	-28.6
0.525	-2.5	19.9	17.4	46.0	-28.6
0.565	-2.6	19.9	17.3	46.0	-28.7
0.595	-2.6	19.9	17.3	46.0	-28.7
0.708	-2.8	19.9	17.1	46.0	-28.9
0.201	0.3	20.0	20.3	53.6	-33.3

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-06
Customer:	Nelson Irrigation Corporation	Temperature:	23.2°C
Attendees:	None	Relative Humidity:	48.6%
Customer Project:	None	Bar. Pressure:	1021 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-9

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	18	Line:	Neutral	Add. Ext. Attenuation (dB):	0

COMMENTS

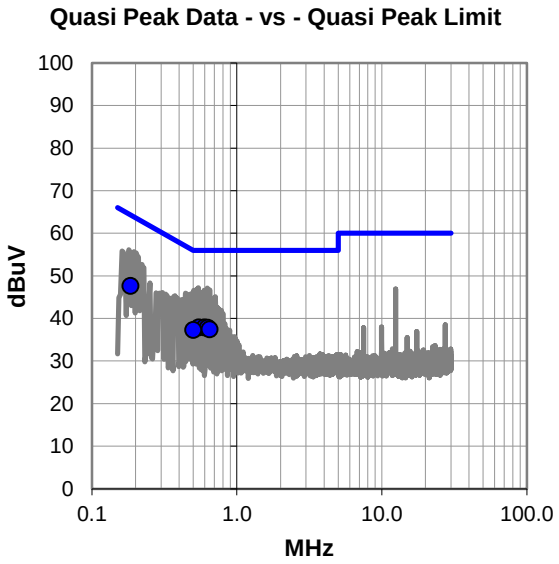
Measuring AC mains of Linear Lab DC Power Supply. Fair-Rite brand ferrite (PN#0431173951) installed on the u.fl to SMA patch cable at the u.fl end of the cable.

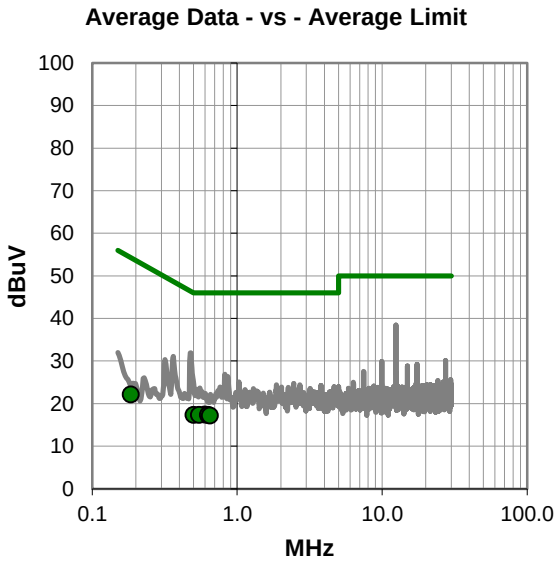
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

DEVIATIONS FROM TEST STANDARD

None





POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #18

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.185	27.6	20.0	47.6	64.3	-16.7
0.547	18.0	19.9	37.9	56.0	-18.1
0.598	18.0	19.9	37.9	56.0	-18.1
0.629	17.9	19.9	37.8	56.0	-18.2
0.650	17.5	19.9	37.4	56.0	-18.6
0.501	17.5	19.8	37.3	56.0	-18.7

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.598	-2.5	19.9	17.4	46.0	-28.6
0.501	-2.5	19.8	17.3	46.0	-28.7
0.547	-2.6	19.9	17.3	46.0	-28.7
0.629	-2.6	19.9	17.3	46.0	-28.7
0.650	-2.7	19.9	17.2	46.0	-28.8
0.185	2.1	20.0	22.1	54.3	-32.2

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-06
Customer:	Nelson Irrigation Corporation	Temperature:	23.2°C
Attendees:	None	Relative Humidity:	48.6%
Customer Project:	None	Bar. Pressure:	1021 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-9

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	19	Line:	High Line	Add. Ext. Attenuation (dB):	0

COMMENTS

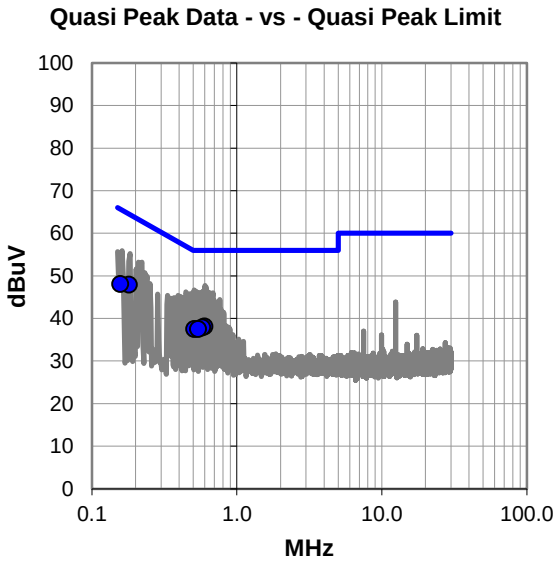
Measuring AC mains of Linear Lab DC Power Supply. Fair-Rite brand ferrite (PN#0431173951) installed on the u.fl to SMA patch cable at the u.fl end of the cable.

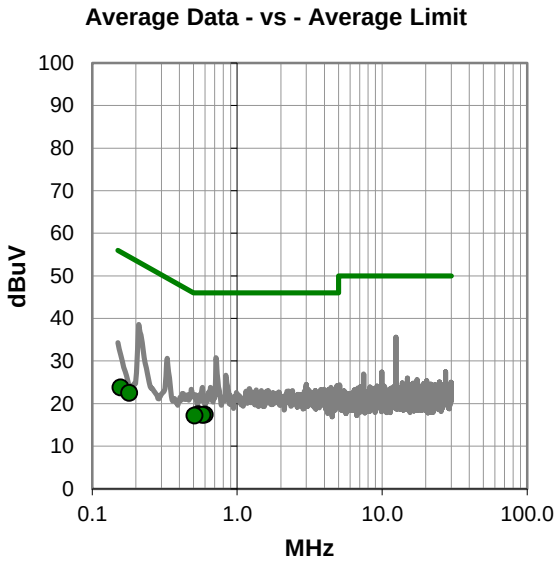
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

DEVIATIONS FROM TEST STANDARD

None





POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #19

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.180	27.9	20.0	47.9	64.5	-16.6
0.157	28.0	20.1	48.1	65.6	-17.5
0.597	18.2	19.9	38.1	56.0	-17.9
0.577	18.0	19.9	37.9	56.0	-18.1
0.509	17.7	19.8	37.5	56.0	-18.5
0.540	17.6	19.9	37.5	56.0	-18.5

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.540	-2.4	19.9	17.5	46.0	-28.5
0.597	-2.5	19.9	17.4	46.0	-28.6
0.577	-2.6	19.9	17.3	46.0	-28.7
0.509	-2.6	19.8	17.2	46.0	-28.8
0.157	3.7	20.1	23.8	55.6	-31.8
0.180	2.5	20.0	22.5	54.5	-32.0

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-06
Customer:	Nelson Irrigation Corporation	Temperature:	23.2°C
Attendees:	None	Relative Humidity:	48.6%
Customer Project:	None	Bar. Pressure:	1021 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-8

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	20	Line:	High Line	Add. Ext. Attenuation (dB):	0

COMMENTS

Measuring AC mains of Linear Lab DC Power Supply. Fair-Rite brand ferrite (PN#0431173951) installed on the u.fl to SMA patch cable at the u.fl end of the cable.

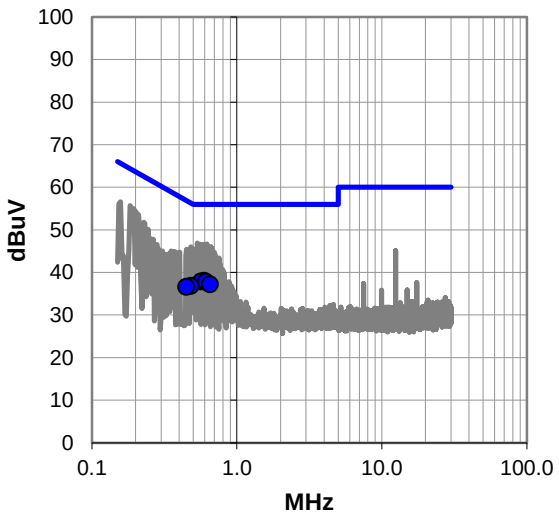
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

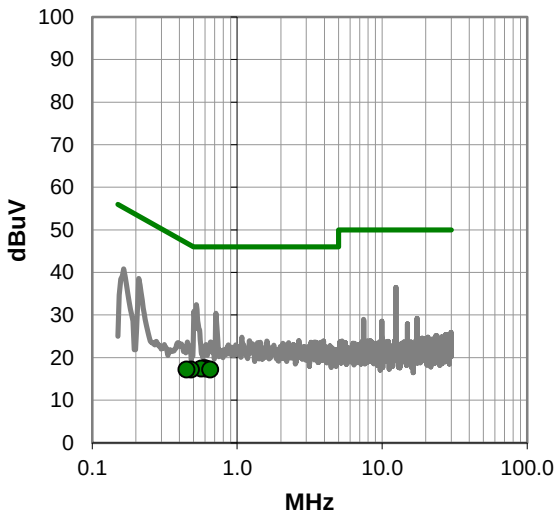
DEVIATIONS FROM TEST STANDARD

None

Quasi Peak Data - vs - Quasi Peak Limit



Average Data - vs - Average Limit



POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #20

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.594	18.1	19.9	38.0	56.0	-18.0
0.565	18.0	19.9	37.9	56.0	-18.1
0.611	17.9	19.9	37.8	56.0	-18.2
0.651	17.3	19.9	37.2	56.0	-18.8
0.481	17.0	19.8	36.8	56.3	-19.5
0.448	16.8	19.8	36.6	56.9	-20.3

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
0.594	-2.4	19.9	17.5	46.0	-28.5
0.611	-2.5	19.9	17.4	46.0	-28.6
0.565	-2.5	19.9	17.4	46.0	-28.6
0.651	-2.7	19.9	17.2	46.0	-28.8
0.481	-2.6	19.8	17.2	46.3	-29.1
0.448	-2.6	19.8	17.2	46.9	-29.7

CONCLUSION

Pass

Tested By

POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

EUT:	TWIG V - Radio Module	Work Order:	NELS0008
Serial Number:	256395-0059	Date:	2019-09-06
Customer:	Nelson Irrigation Corporation	Temperature:	23.2°C
Attendees:	None	Relative Humidity:	48.6%
Customer Project:	None	Bar. Pressure:	1021 mb
Tested By:	Jeff Alcoke	Job Site:	EV07
Power:	5.0 VDC via 110VAC/60Hz	Configuration:	NELS0008-8

TEST SPECIFICATIONS

Specification:	Method:
FCC 15.207:2019	ANSI C63.10:2013

TEST PARAMETERS

Run #:	21	Line:	Neutral	Add. Ext. Attenuation (dB):	0

COMMENTS

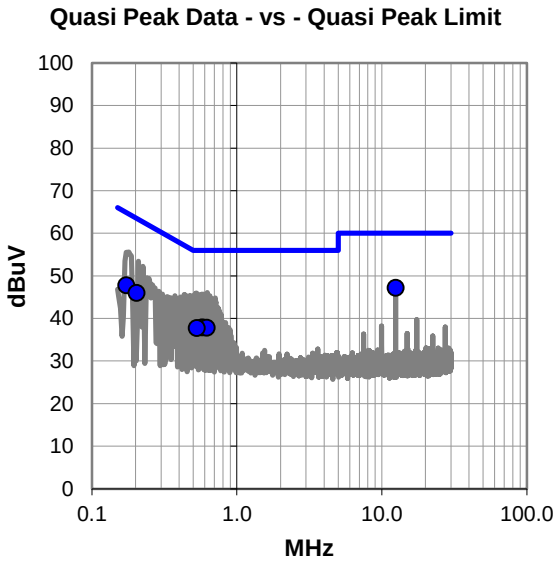
Measuring AC mains of Linear Lab DC Power Supply. Fair-Rite brand ferrite (PN#0431173951) installed on the u.fl to SMA patch cable at the u.fl end of the cable.

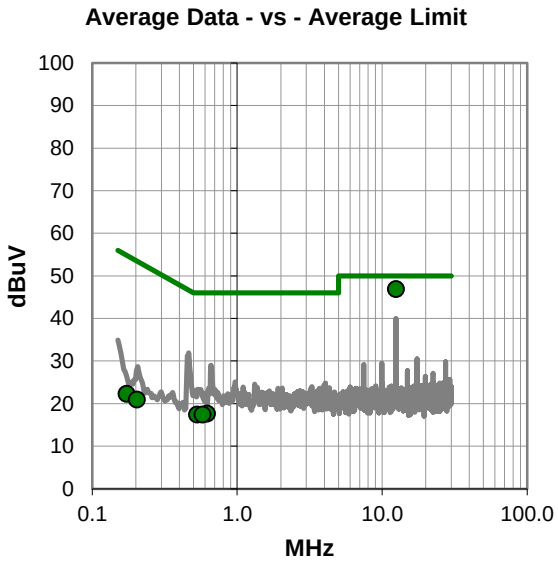
EUT OPERATING MODES

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Mid Ch. = 915 MHz

DEVIATIONS FROM TEST STANDARD

None





POWERLINE CONDUCTED EMISSIONS (Transmitter)

element
WTD.2019.4.24.1

RESULTS - Run #21

Quasi Peak Data - vs - Quasi Peak Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
12.452	26.8	20.4	47.2	60.0	-12.8
0.173	27.8	20.0	47.8	64.8	-17.0
0.204	26.0	20.0	46.0	63.5	-17.5
0.577	18.0	19.9	37.9	56.0	-18.1
0.620	17.9	19.9	37.8	56.0	-18.2
0.529	17.8	19.9	37.7	56.0	-18.3

Average Data - vs - Average Limit

Freq (MHz)	Amp. (dBuV)	Factor (dB)	Adjusted (dBuV)	Spec. Limit (dBuV)	Margin (dB)
12.452	26.5	20.4	46.9	50.0	-3.1
0.620	-2.3	19.9	17.6	46.0	-28.4
0.529	-2.5	19.9	17.4	46.0	-28.6
0.577	-2.5	19.9	17.4	46.0	-28.6
0.173	2.3	20.0	22.3	54.8	-32.5
0.204	0.9	20.0	20.9	53.5	-32.6

CONCLUSION

Pass

Tested By

SPURIOUS RADIATED EMISSIONS

PSA-ESCI 2019.05.10

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data. The test data represents the configuration / operating mode/ model that produced the highest emission levels as compared to the specification limit.

MODES OF OPERATION

Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz, Mid Ch. = 915 MHz, High Ch. = 927 MHz

POWER SETTINGS INVESTIGATED

5.0 VDC

CONFIGURATIONS INVESTIGATED

NELS0008 - 10
NELS0008 - 9
NELS0008 - 8

FREQUENCY RANGE INVESTIGATED

Start Frequency	30 MHz	Stop Frequency	12750 MHz

SAMPLE CALCULATIONS

Radiated Emissions: Field Strength = Measured Level + Antenna Factor + Cable Factor - Amplifier Gain + Distance Adjustment Factor + External Attenuation

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Filter - Band Pass/Notch	K&L Microwave	3TNF-500/1000-N/N	HFT	5-Dec-2018	12 mo
Filter - Low Pass	Micro-Tronics	LPM50003	LFB	15-Feb-2019	12 mo
Attenuator	Coaxicom	3910-10	AWX	15-Feb-2019	12 mo
Attenuator	Coaxicom	3910-20	AXZ	15-Feb-2019	12 mo
Cable	None	Standard Gain Horns Cable	EVF	24-Nov-2018	12 mo
Cable	N/A	Double Ridge Horn Cables	EVB	24-Nov-2018	12 mo
Cable	N/A	Bilog Cables	EVA	24-Nov-2018	12 mo
Amplifier - Pre-Amplifier	Miteq	AMF-6F-12001800-30-10P	AVD	24-Nov-2018	12 mo
Amplifier - Pre-Amplifier	L-3 Narda-MITEQ	AMF-6F-08001200-30-10P	PAO	24-Nov-2018	12 mo
Amplifier - Pre-Amplifier	Miteq	AMF-3D-00100800-32-13P	PAG	24-Nov-2018	12 mo
Amplifier - Pre-Amplifier	Miteq	AM-1616-1000	AOL	24-Nov-2018	12 mo
Antenna - Standard Gain	ETS Lindgren	3160-08	AHV	NCR	0 mo
Antenna - Standard Gain	ETS Lindgren	3160-07	AHU	NCR	0 mo
Antenna - Double Ridge	ETS Lindgren	3115	AIZ	7-Feb-2018	24 mo
Antenna - Biconilog	Teseq	CBL 6141B	AXR	2-Oct-2018	24 mo
Analyzer - Spectrum Analyzer	Agilent	E4446A	AAQ	24-Mar-2019	12 mo

TEST DESCRIPTION

The highest gain antenna of each type to be used with the EUT was tested. The EUT was configured for the required transmit frequencies and the modes as showed in the data sheets.

For each configuration, the spectrum was scanned throughout the specified range as part of the exploratory investigation of the emissions. These “pre-scans” are not included in the report. Final measurements on individual emissions were then made and included in this test report.

The individual emissions from the EUT were maximized by rotating the EUT on a turntable, adjusting the position of the EUT and EUT antenna in three orthogonal axis if required, and adjusting the measurement antenna height and polarization (per ANSI C63.10). A preamp and high pass filter (and notch filter) were used for this test in order to provide sufficient measurement sensitivity.

Measurements were made with the required detectors and annotated on the data for each individual point using the following annotation:

QP = Quasi-Peak Detector
PK = Peak Detector
AV = RMS Detector

Measurements were made to satisfy the specific requirements of the test specification for out of band emissions as well as the restricted band requirements.

If there are no detectable emissions above the noise floor, the data included may show noise floor measurements for reference only.

Measurements at the edges of the allowable band may be presented in an alternative method as provided for in the ANSI C63.10 Marker-Delta method. This method involves performing an in-band fundamental measurement followed by a screen capture of the fundamental and out-of-band emission using reduced measurement instrumentation bandwidths. The amplitude delta measured on this screen capture is applied to the fundamental emission value to show the out-of-band emission level as applied to the limit.

Where the radio test software does not provide for a duty cycle at continuous transmit conditions (> 98%) and the RMS (power average) measurements were made across the on and off times of the EUT transmissions, a duty cycle correction is added to the measurements using the formula of 10*LOG(dc).

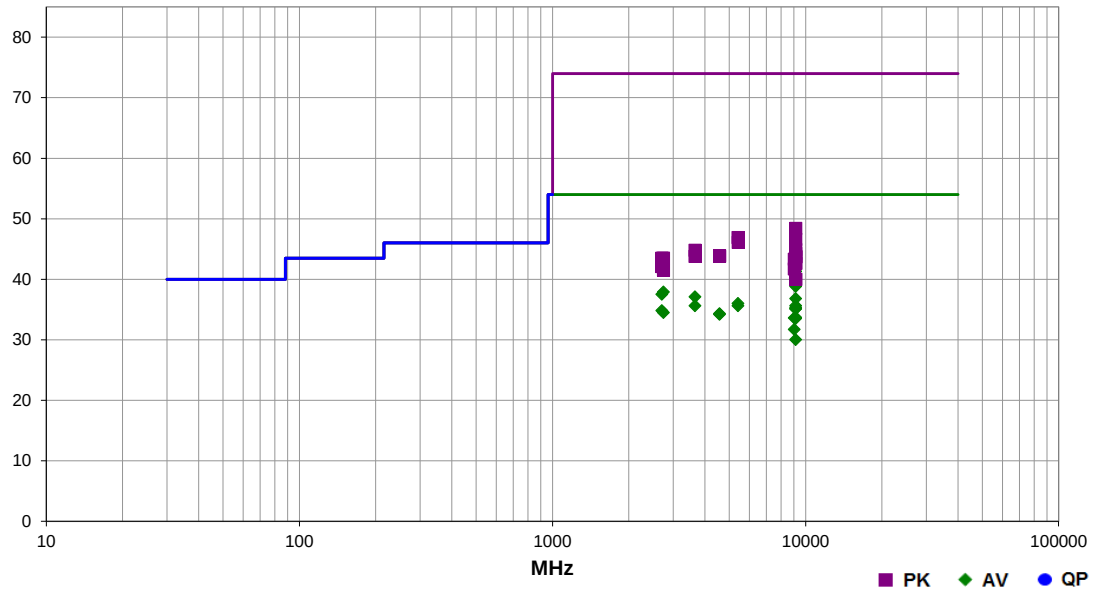
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	NELS0008	**Date:**	29 August 2019		
Project:	None	**Temperature:**	23.2 °C		
Job Site:	EV01	**Humidity:**	46.5% RH		
Serial Number:	256395-0059	**Barometric Pres.:**	1013 mbar	**Tested by:**	Jeff Alcoke
EUT:	TWIG V - Radio Module				
Configuration:	8				
Customer:	Nelson Irrigation Corporation				
Attendees:	None				
EUT Power:	5.0 VDC				
Operating Mode:	Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz and Mid Ch. = 915 MHz				
Deviations:	None				
Comments:	See comments below for Channel, EUT orientation, Antenna Orientation, and Antenna Type. The EUT transmits at a duty cycle of 93.3%, a DCCF of 0.3 dB was added to the RMS AVG measurements {0.3 dB = 10*Log (1/.933) }.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	56	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
9148.450	42.8	-1.8	2.9	131.0	0.3	0.0	Horz	AV	0.0	41.3	54.0	-12.7	Mid Ch, EUT Vert, Ant Vert, Omni
9148.467	40.3	-1.8	2.3	277.0	0.3	0.0	Vert	AV	0.0	38.8	54.0	-15.2	Mid Ch, EUT on Side, Ant Vert, Omni
2745.017	41.0	-3.4	3.8	64.0	0.3	0.0	Horz	AV	0.0	37.9	54.0	-16.1	Mid Ch, EUT Vert, Ant Vert, Omni
2707.633	40.6	-3.4	4.0	129.0	0.3	0.0	Vert	AV	0.0	37.5	54.0	-16.5	Low Ch, EUT Horz, Ant Vert, Omni
3660.300	34.7	2.1	1.0	216.0	0.3	0.0	Horz	AV	0.0	37.1	54.0	-16.9	Mid Ch, EUT Vert, Ant Vert, Omni
9148.367	38.3	-1.8	2.5	144.0	0.3	0.0	Horz	AV	0.0	36.8	54.0	-17.2	Mid Ch, EUT on Side, Ant Horz, Omni
5414.283	29.7	6.0	2.6	119.0	0.3	0.0	Vert	AV	0.0	36.0	54.0	-18.0	Low Ch, EUT Horz, Ant Vert, Omni
9148.600	37.1	-1.8	2.3	314.0	0.3	0.0	Horz	AV	0.0	35.6	54.0	-18.4	Mid Ch, EUT on Side, Ant Vert, Omni
3660.217	33.2	2.1	2.2	136.0	0.3	0.0	Vert	AV	0.0	35.6	54.0	-18.4	Mid Ch, EUT Horz, Ant Vert, Omni
5414.467	29.3	6.0	1.5	169.0	0.3	0.0	Horz	AV	0.0	35.6	54.0	-18.4	Low Ch, EUT Vert, Ant Vert, Omni
9148.433	36.8	-1.8	2.2	79.0	0.3	0.0	Vert	AV	0.0	35.3	54.0	-18.7	Mid Ch, EUT on Side, Ant Horz, Omni
9148.650	36.6	-1.8	3.8	3.0	0.3	0.0	Horz	AV	0.0	35.1	54.0	-18.9	Mid Ch, EUT Horz, Ant Vert, Omni
9148.350	36.6	-1.8	2.1	286.0	0.3	0.0	Vert	AV	0.0	35.1	54.0	-18.9	Mid Ch, EUT Horz, Ant Horz, Omni
2707.683	37.9	-3.4	1.5	250.0	0.3	0.0	Horz	AV	0.0	34.8	54.0	-19.2	Low Ch, EUT Vert, Ant Vert, Omni
2745.167	37.6	-3.4	1.3	59.0	0.3	0.0	Vert	AV	0.0	34.5	54.0	-19.5	Mid Ch, EUT Horz, Ant Vert, Omni
4575.000	30.0	4.0	1.5	289.0	0.3	0.0	Horz	AV	0.0	34.3	54.0	-19.7	Mid Ch, EUT Vert, Ant Vert, Omni
4575.617	30.0	3.9	2.6	35.0	0.3	0.0	Vert	AV	0.0	34.2	54.0	-19.8	Mid Ch, EUT Horz, Ant Vert, Omni
9148.250	35.2	-1.8	1.5	71.0	0.3	0.0	Vert	AV	0.0	33.7	54.0	-20.3	Mid Ch, EUT Vert, Ant Vert, Omni
9024.183	35.4	-2.1	1.8	204.0	0.3	0.0	Horz	AV	0.0	33.6	54.0	-20.4	Low Ch, EUT Vert, Ant Vert, Omni
9148.500	35.0	-1.8	1.6	85.0	0.3	0.0	Vert	AV	0.0	33.5	54.0	-20.5	Mid Ch, EUT Vert, Ant Horz, Omni
9024.500	33.5	-2.1	2.8	121.0	0.3	0.0	Vert	AV	0.0	31.7	54.0	-22.3	Low Ch, EUT Horz, Ant Vert, Omni
9149.000	31.5	-1.8	2.6	196.0	0.3	0.0	Horz	AV	0.0	30.0	54.0	-24.0	Mid Ch, EUT Horz, Ant Horz, Omni
9147.567	50.2	-1.8	2.9	131.0	0.0	0.0	Horz	PK	0.0	48.4	74.0	-25.6	Mid Ch, EUT Vert, Ant Vert, Omni
5413.917	40.9	6.0	2.6	119.0	0.0	0.0	Vert	PK	0.0	46.9	74.0	-27.1	Low Ch, EUT Horz, Ant Vert, Omni
9148.433	48.4	-1.8	2.3	277.0	0.0	0.0	Vert	PK	0.0	46.6	74.0	-27.4	Mid Ch, EUT on Side, Ant Vert, Omni

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
5415.033	40.1	6.0	1.5	169.0	0.0	0.0	Horz	PK	0.0	46.1	74.0	-27.9	Low Ch, EUT Vert, Ant Vert, Omni
9148.050	46.7	-1.8	2.5	144.0	0.0	0.0	Horz	PK	0.0	44.9	74.0	-29.1	Mid Ch, EUT on Side, Ant Horz, Omni
3659.850	42.7	2.1	1.0	216.0	0.0	0.0	Horz	PK	0.0	44.8	74.0	-29.2	Mid Ch, EUT Vert, Ant Vert, Omni
9148.217	46.1	-1.8	2.3	314.0	0.0	0.0	Horz	PK	0.0	44.3	74.0	-29.7	Mid Ch, EUT on Side, Ant Vert, Omni
4574.983	40.0	3.9	2.6	35.0	0.0	0.0	Vert	PK	0.0	43.9	74.0	-30.1	Mid Ch, EUT Horz, Ant Vert, Omni
4574.367	39.9	3.9	1.5	289.0	0.0	0.0	Horz	PK	0.0	43.8	74.0	-30.2	Mid Ch, EUT Vert, Ant Vert, Omni
3659.233	41.7	2.1	2.2	136.0	0.0	0.0	Vert	PK	0.0	43.8	74.0	-30.2	Mid Ch, EUT Horz, Ant Vert, Omni
9149.400	45.6	-1.8	2.1	286.0	0.0	0.0	Vert	PK	0.0	43.8	74.0	-30.2	Mid Ch, EUT Horz, Ant Horz, Omni
9147.933	45.5	-1.8	2.2	79.0	0.0	0.0	Vert	PK	0.0	43.7	74.0	-30.3	Mid Ch, EUT on Side, Ant Horz, Omni
9148.717	45.5	-1.8	3.8	3.0	0.0	0.0	Horz	PK	0.0	43.7	74.0	-30.3	Mid Ch, EUT Horz, Ant Vert, Omni
2745.283	46.9	-3.4	3.8	64.0	0.0	0.0	Horz	PK	0.0	43.5	74.0	-30.5	Mid Ch, EUT Vert, Ant Vert, Omni
2707.967	46.9	-3.4	4.0	129.0	0.0	0.0	Vert	PK	0.0	43.5	74.0	-30.5	Low Ch, EUT Horz, Ant Vert, Omni
9027.183	45.2	-1.9	1.8	204.0	0.0	0.0	Horz	PK	0.0	43.3	74.0	-30.7	Low Ch, EUT Vert, Ant Vert, Omni
9148.433	44.5	-1.8	1.6	85.0	0.0	0.0	Vert	PK	0.0	42.7	74.0	-31.3	Mid Ch, EUT Vert, Ant Horz, Omni
9147.767	44.4	-1.8	1.5	71.0	0.0	0.0	Vert	PK	0.0	42.6	74.0	-31.4	Mid Ch, EUT Vert, Ant Vert, Omni
2707.583	45.5	-3.4	1.5	250.0	0.0	0.0	Horz	PK	0.0	42.1	74.0	-31.9	Low Ch, EUT Vert, Ant Vert, Omni
9023.850	43.8	-2.1	2.8	121.0	0.0	0.0	Vert	PK	0.0	41.7	74.0	-32.3	Low Ch, EUT Horz, Ant Vert, Omni
2744.383	45.0	-3.5	1.3	59.0	0.0	0.0	Vert	PK	0.0	41.5	74.0	-32.5	Mid Ch, EUT Horz, Ant Vert, Omni
9153.200	41.9	-1.9	2.6	196.0	0.0	0.0	Horz	PK	0.0	40.0	74.0	-34.0	Mid Ch, EUT Horz, Ant Horz, Omni

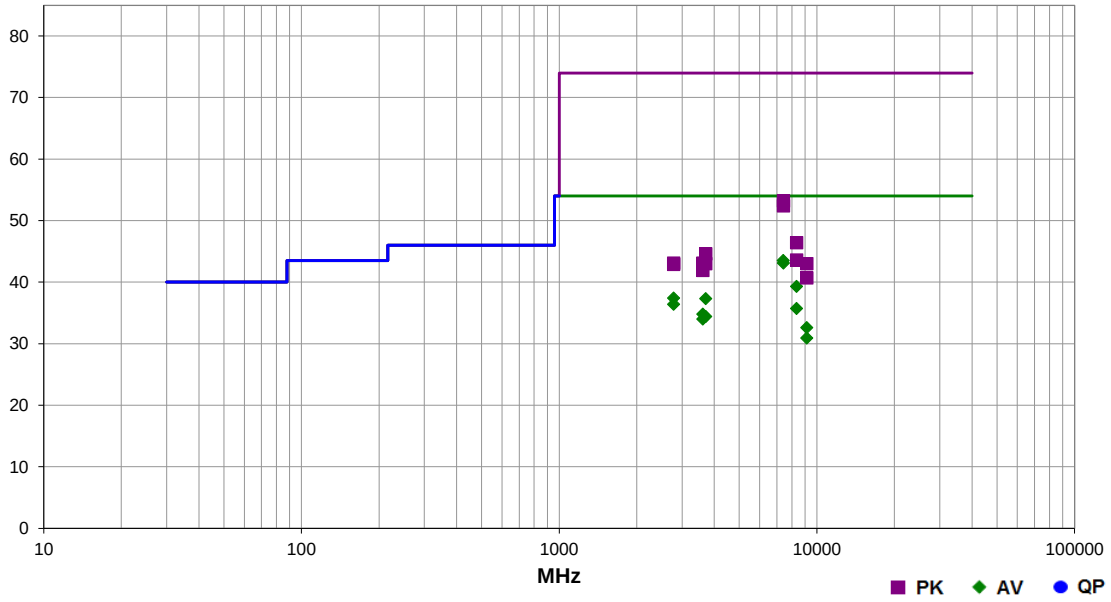
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	NELS0008	**Date:**	19 September 2019		
Project:	None	**Temperature:**	21 °C		
Job Site:	EV01	**Humidity:**	49.7% RH		
Serial Number:	256395-0059	**Barometric Pres.:**	1021 mbar	**Tested by:**	Jeff Alcoke
EUT:	TWIG V - Radio Module				
Configuration:	8				
Customer:	Nelson Irrigation Corporation				
Attendees:	None				
EUT Power:	5.0 VDC				
Operating Mode:	Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz, Mid Ch. = 915 MHz and High Ch. = 927 MHz				
Deviations:	None				
Comments:	Additional measurements were taken on the highest harmonic/emission for the low and mid channels to demonstrate there was no degradation of emissions with the addtion of a ferrite to the u.fl to SMA patch cable. The EUT transmits at a duty cycle of 93.3%, a DCCF of 0.3 dB was added to the RMS AVG measurements {0.3 dB = 10*Log (1/.933) }.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	124	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7415.283	28.9	14.3	1.0	191.0	0.3	0.0	Vert	AV	0.0	43.5	54.0	-10.5	High Ch, EUT Horz, Ant Vert, Omni
7416.925	28.5	14.3	1.0	151.0	0.3	0.0	Horz	AV	0.0	43.1	54.0	-10.9	High Ch, EUT Vert, Ant Vert, Omni
8341.733	43.2	-4.2	2.0	309.0	0.3	0.0	Horz	AV	0.0	39.3	54.0	-14.7	High Ch, EUT Vert, Ant Vert, Omni
2780.900	40.3	-3.2	1.0	218.0	0.3	0.0	Horz	AV	0.0	37.4	54.0	-16.6	High Ch, EUT Vert, Ant Vert, Omni
3708.108	34.8	2.2	1.0	255.0	0.3	0.0	Horz	AV	0.0	37.3	54.0	-16.7	High Ch, EUT Vert, Ant Vert, Omni
2780.775	39.3	-3.2	1.0	1.0	0.3	0.0	Vert	AV	0.0	36.4	54.0	-17.6	High Ch, EUT Horz, Ant Vert, Omni
8341.667	39.6	-4.2	1.0	354.0	0.3	0.0	Vert	AV	0.0	35.7	54.0	-18.3	High Ch, EUT Horz, Ant Vert, Omni
3610.033	32.8	1.7	3.9	243.0	0.3	0.0	Vert	AV	0.0	34.8	54.0	-19.2	Low Ch, EUT Horz, Ant Vert, Omni
3707.717	31.9	2.2	1.0	59.0	0.3	0.0	Vert	AV	0.0	34.4	54.0	-19.6	High Ch, EUT Horz, Ant Vert, Omni
3609.750	32.0	1.7	1.9	246.0	0.3	0.0	Horz	AV	0.0	34.0	54.0	-20.0	Low Ch, EUT Vert, Ant Vert, Omni
7416.883	38.9	14.3	1.0	191.0	0.0	0.0	Vert	PK	0.0	53.2	74.0	-20.8	High Ch, EUT Horz, Ant Vert, Omni
7417.167	38.1	14.3	1.0	151.0	0.0	0.0	Horz	PK	0.0	52.4	74.0	-21.6	High Ch, EUT Vert, Ant Vert, Omni
9150.650	34.2	-1.9	1.8	241.0	0.3	0.0	Horz	AV	0.0	32.6	54.0	-21.4	Mid Ch, EUT Vert, Ant Vert, Omni
9148.450	32.4	-1.8	3.5	326.0	0.3	0.0	Vert	AV	0.0	30.9	54.0	-23.1	Mid Ch, EUT Horz, Ant Vert, Omni
8341.150	50.6	-4.2	2.0	309.0	0.0	0.0	Horz	PK	0.0	46.4	74.0	-27.6	High Ch, EUT Vert, Ant Vert, Omni
3707.967	42.4	2.2	1.0	255.0	0.0	0.0	Horz	PK	0.0	44.6	74.0	-29.4	High Ch, EUT Vert, Ant Vert, Omni
8341.283	47.8	-4.2	1.0	354.0	0.0	0.0	Vert	PK	0.0	43.6	74.0	-30.4	High Ch, EUT Horz, Ant Vert, Omni
2781.717	46.2	-3.1	1.0	218.0	0.0	0.0	Horz	PK	0.0	43.1	74.0	-30.9	High Ch, EUT Vert, Ant Vert, Omni
3610.933	41.4	1.7	3.9	243.0	0.0	0.0	Vert	PK	0.0	43.1	74.0	-30.9	Low Ch, EUT Horz, Ant Vert, Omni
9149.317	44.8	-1.8	1.8	241.0	0.0	0.0	Horz	PK	0.0	43.0	74.0	-31.0	Mid Ch, EUT Vert, Ant Vert, Omni
3708.208	40.8	2.2	1.0	59.0	0.0	0.0	Vert	PK	0.0	43.0	74.0	-31.0	High Ch, EUT Horz, Ant Vert, Omni
2781.400	46.0	-3.1	1.0	1.0	0.0	0.0	Vert	PK	0.0	42.9	74.0	-31.1	High Ch, EUT Horz, Ant Vert, Omni
3609.850	40.2	1.7	1.9	246.0	0.0	0.0	Horz	PK	0.0	41.9	74.0	-32.1	Low Ch, EUT Vert, Ant Vert, Omni

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
9150.900	42.6	-1.9	3.5	326.0	0.0	0.0	Vert	PK	0.0	40.7	74.0	-33.3	Mid Ch, EUT Horz, Ant Vert, Omni

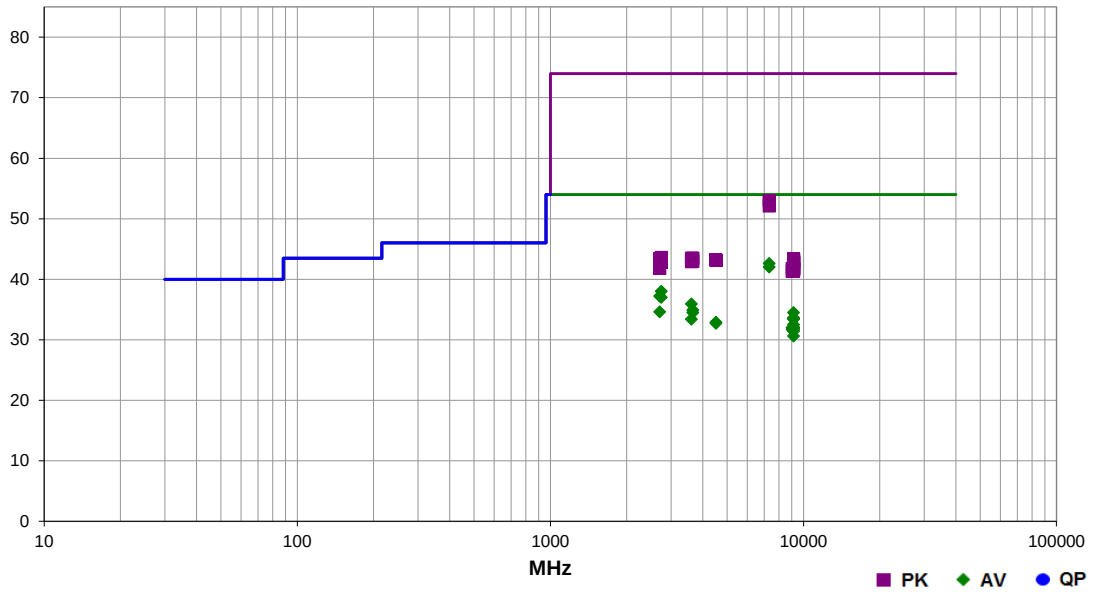
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	NELS0008	**Date:**	29 August 2019		
Project:	None	**Temperature:**	23.2 °C		
Job Site:	EV01	**Humidity:**	46.5% RH		
Serial Number:	256395-0059	**Barometric Pres.:**	1013 mbar	**Tested by:**	Jeff Alcoke
EUT:	TWIG V - Radio Module				
Configuration:	9				
Customer:	Nelson Irrigation Corporation				
Attendees:	None				
EUT Power:	5.0 VDC				
Operating Mode:	Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz, Mid Ch. = 915 MHz				
Deviations:	None				
Comments:	See comments below for Channel, EUT orientation, Antenna Orientation, and Antenna Type. The EUT transmits at a duty cycle of 93.3%, a DCCF of 0.3 dB was added to the RMS AVG measurements {0.3 dB = 10*Log (1/.933) }.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	66	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7320.867	29.2	13.1	1.5	103.0	0.3	0.0	Horz	AV	0.0	42.6	54.0	-11.4	Mid Ch, EUT Vert, Ant Vert, Yagi
7321.883	28.6	13.1	3.2	133.0	0.3	0.0	Vert	AV	0.0	42.0	54.0	-12.0	Mid Ch, EUT Horz, Ant Horz, Yagi
2745.050	41.1	-3.4	3.6	18.0	0.3	0.0	Vert	AV	0.0	38.0	54.0	-16.0	Mid Ch, EUT Horz, Ant Horz, Yagi
2707.650	40.3	-3.4	4.0	23.0	0.3	0.0	Vert	AV	0.0	37.2	54.0	-16.8	Low Ch, EUT Horz, Ant Horz, Yagi
2745.167	40.1	-3.4	1.7	11.0	0.3	0.0	Horz	AV	0.0	37.0	54.0	-17.0	Mid Ch, EUT Vert, Ant Vert, Yagi
3609.767	33.9	1.7	1.0	207.0	0.3	0.0	Horz	AV	0.0	35.9	54.0	-18.1	Low Ch, EUT Vert, Ant Vert, Yagi
3659.717	32.5	2.1	3.4	144.0	0.3	0.0	Horz	AV	0.0	34.9	54.0	-19.1	Mid Ch, EUT Vert, Ant Vert, Yagi
2707.617	37.7	-3.4	2.8	217.0	0.3	0.0	Horz	AV	0.0	34.6	54.0	-19.4	Low Ch, EUT Vert, Ant Vert, Yagi
9148.283	36.0	-1.8	2.3	192.0	0.3	0.0	Vert	AV	0.0	34.5	54.0	-19.5	Mid Ch, EUT Horz, Ant Horz, Yagi
3660.133	32.1	2.1	1.6	89.0	0.3	0.0	Vert	AV	0.0	34.5	54.0	-19.5	Mid Ch, EUT Horz, Ant Horz, Yagi
9148.583	35.1	-1.8	3.3	130.0	0.3	0.0	Horz	AV	0.0	33.6	54.0	-20.4	Mid Ch, EUT Vert, Ant Vert, Yagi
9148.700	35.1	-1.8	1.5	305.0	0.3	0.0	Vert	AV	0.0	33.6	54.0	-20.4	Mid Ch, EUT Horz, Ant Vert, Yagi
9148.417	35.0	-1.8	1.4	207.0	0.3	0.0	Vert	AV	0.0	33.5	54.0	-20.5	Mid Ch, EUT on Side, Ant Vert, Yagi
9148.750	34.9	-1.8	2.5	195.0	0.3	0.0	Vert	AV	0.0	33.4	54.0	-20.6	Mid Ch, EUT on Side, Ant Horz, Yagi
3609.617	31.4	1.7	2.1	71.0	0.3	0.0	Vert	AV	0.0	33.4	54.0	-20.6	Low Ch, EUT Horz, Ant Horz, Yagi
7320.150	39.9	13.1	1.5	103.0	0.0	0.0	Horz	PK	0.0	53.0	74.0	-21.0	Mid Ch, EUT Vert, Ant Vert, Yagi
4512.967	28.6	4.0	1.5	241.0	0.3	0.0	Horz	AV	0.0	32.9	54.0	-21.1	Low Ch, EUT Vert, Ant Vert, Yagi
4516.350	28.5	3.9	1.5	356.0	0.3	0.0	Vert	AV	0.0	32.7	54.0	-21.3	Low Ch, EUT Horz, Ant Horz, Yagi
9148.217	34.0	-1.8	1.4	80.0	0.3	0.0	Horz	AV	0.0	32.5	54.0	-21.5	Mid Ch, EUT Vert, Ant Horz, Yagi
9150.583	33.7	-1.9	3.0	191.0	0.3	0.0	Horz	AV	0.0	32.1	54.0	-21.9	Mid Ch, EUT on Side, Ant Vert, Yagi
7322.650	39.0	13.1	3.2	133.0	0.0	0.0	Vert	PK	0.0	52.1	74.0	-21.9	Mid Ch, EUT Horz, Ant Horz, Yagi
9148.433	33.5	-1.8	1.5	64.0	0.3	0.0	Vert	AV	0.0	32.0	54.0	-22.0	Mid Ch, EUT Vert, Ant Vert, Yagi
9025.033	33.6	-1.9	3.6	178.0	0.3	0.0	Vert	AV	0.0	32.0	54.0	-22.0	Low Ch, EUT Horz, Ant Horz, Yagi
9149.217	33.3	-1.8	1.5	68.0	0.3	0.0	Vert	AV	0.0	31.8	54.0	-22.2	Mid Ch, EUT Vert, Ant Horz, Yagi
9023.483	33.5	-2.1	1.5	14.0	0.3	0.0	Horz	AV	0.0	31.7	54.0	-22.3	Low Ch, EUT Vert, Ant Vert, Yagi

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
9148.900	33.1	-1.8	1.5	142.0	0.3	0.0	Horz	AV	0.0	31.6	54.0	-22.4	Mid Ch, EUT on Side, Ant Horz, Yagi
9148.367	32.9	-1.8	3.3	44.0	0.3	0.0	Horz	AV	0.0	31.4	54.0	-22.6	Mid Ch, EUT Horz, Ant Horz, Yagi
9148.567	32.1	-1.8	2.6	46.0	0.3	0.0	Horz	AV	0.0	30.6	54.0	-23.4	Mid Ch, EUT Horz, Ant Vert, Yagi
2744.200	47.1	-3.5	3.6	18.0	0.0	0.0	Vert	PK	0.0	43.6	74.0	-30.4	Mid Ch, EUT Horz, Ant Horz, Yagi
3661.167	41.4	2.1	1.6	89.0	0.0	0.0	Vert	PK	0.0	43.5	74.0	-30.5	Mid Ch, EUT Horz, Ant Horz, Yagi
3609.483	41.8	1.7	1.0	207.0	0.0	0.0	Horz	PK	0.0	43.5	74.0	-30.5	Low Ch, EUT Vert, Ant Vert, Yagi
9149.000	45.2	-1.8	2.3	192.0	0.0	0.0	Vert	PK	0.0	43.4	74.0	-30.6	Mid Ch, EUT Horz, Ant Horz, Yagi
2707.267	46.8	-3.4	4.0	23.0	0.0	0.0	Vert	PK	0.0	43.4	74.0	-30.6	Low Ch, EUT Horz, Ant Horz, Yagi
4510.033	39.2	4.0	1.5	241.0	0.0	0.0	Horz	PK	0.0	43.2	74.0	-30.8	Low Ch, EUT Vert, Ant Vert, Yagi
9152.317	45.0	-1.9	3.3	130.0	0.0	0.0	Horz	PK	0.0	43.1	74.0	-30.9	Mid Ch, EUT Vert, Ant Vert, Yagi
4512.767	39.1	4.0	1.5	356.0	0.0	0.0	Vert	PK	0.0	43.1	74.0	-30.9	Low Ch, EUT Horz, Ant Horz, Yagi
3659.767	40.9	2.1	3.4	144.0	0.0	0.0	Horz	PK	0.0	43.0	74.0	-31.0	Mid Ch, EUT Vert, Ant Vert, Yagi
9148.100	44.7	-1.8	3.0	191.0	0.0	0.0	Horz	PK	0.0	42.9	74.0	-31.1	Mid Ch, EUT on Side, Ant Vert, Yagi
9151.550	44.8	-1.9	1.5	305.0	0.0	0.0	Vert	PK	0.0	42.9	74.0	-31.1	Mid Ch, EUT Horz, Ant Vert, Yagi
3609.167	41.2	1.7	2.1	71.0	0.0	0.0	Vert	PK	0.0	42.9	74.0	-31.1	Low Ch, EUT Horz, Ant Horz, Yagi
2745.267	46.2	-3.4	1.7	11.0	0.0	0.0	Horz	PK	0.0	42.8	74.0	-31.2	Mid Ch, EUT Vert, Ant Vert, Yagi
9147.867	44.6	-1.8	1.4	207.0	0.0	0.0	Vert	PK	0.0	42.8	74.0	-31.2	Mid Ch, EUT on Side, Ant Vert, Yagi
9148.333	44.5	-1.8	2.5	195.0	0.0	0.0	Vert	PK	0.0	42.7	74.0	-31.3	Mid Ch, EUT on Side, Ant Horz, Yagi
9147.750	43.6	-1.8	1.5	64.0	0.0	0.0	Vert	PK	0.0	41.8	74.0	-32.2	Mid Ch, EUT Vert, Ant Vert, Yagi
9149.000	43.6	-1.8	1.4	80.0	0.0	0.0	Horz	PK	0.0	41.8	74.0	-32.2	Mid Ch, EUT Vert, Ant Horz, Yagi
9148.300	43.6	-1.8	1.5	142.0	0.0	0.0	Horz	PK	0.0	41.8	74.0	-32.2	Mid Ch, EUT on Side, Ant Horz, Yagi
2706.917	45.2	-3.4	2.8	217.0	0.0	0.0	Horz	PK	0.0	41.8	74.0	-32.2	Low Ch, EUT Vert, Ant Vert, Yagi
9025.283	43.7	-1.9	1.5	14.0	0.0	0.0	Horz	PK	0.0	41.8	74.0	-32.2	Low Ch, EUT Vert, Ant Vert, Yagi
9147.517	43.5	-1.8	2.6	46.0	0.0	0.0	Horz	PK	0.0	41.7	74.0	-32.3	Mid Ch, EUT Horz, Ant Vert, Yagi
9149.950	43.4	-1.8	3.3	44.0	0.0	0.0	Horz	PK	0.0	41.6	74.0	-32.4	Mid Ch, EUT Horz, Ant Horz, Yagi
9148.017	43.1	-1.8	1.5	68.0	0.0	0.0	Vert	PK	0.0	41.3	74.0	-32.7	Mid Ch, EUT Vert, Ant Horz, Yagi
9023.533	43.4	-2.1	3.6	178.0	0.0	0.0	Vert	PK	0.0	41.3	74.0	-32.7	Low Ch, EUT Horz, Ant Horz, Yagi

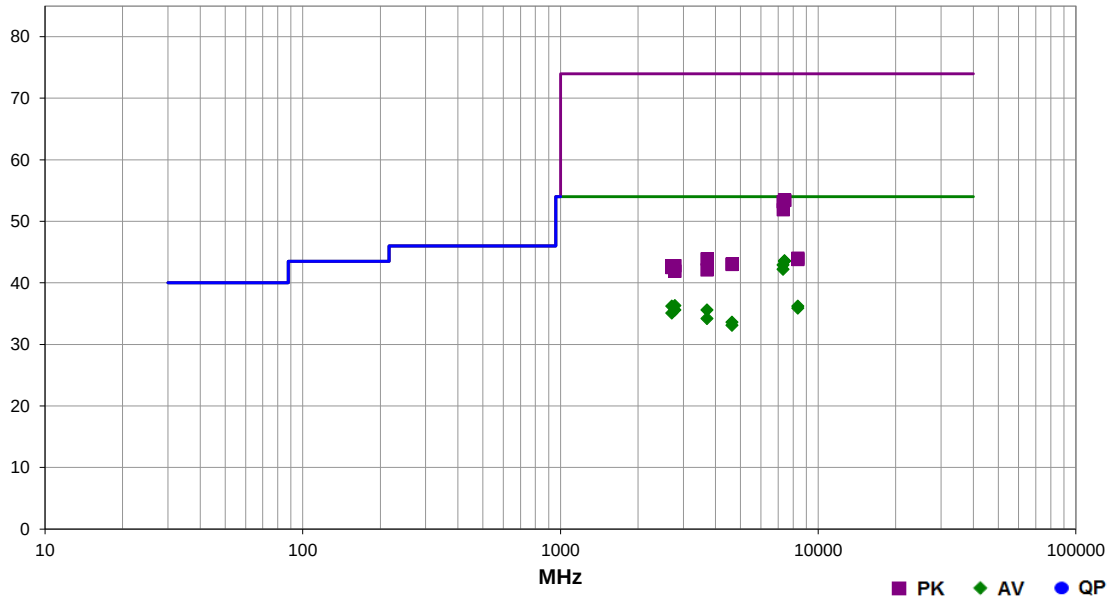
SPURIOUS RADIATED EMISSIONS

EmiRS 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	NELS0008	**Date:**	19 September 2019		
Project:	None	**Temperature:**	21.7 °C		
Job Site:	EV01	**Humidity:**	48.9% RH		
Serial Number:	256395-0059	**Barometric Pres.:**	1022 mbar	**Tested by:**	Jeff Alcoke
EUT:	TWIG V - Radio Module				
Configuration:	9				
Customer:	Nelson Irrigation Corporation				
Attendees:	None				
EUT Power:	5.0 VDC				
Operating Mode:	Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz, Mid Ch. = 915 MHz, High Ch. = 927 MHz				
Deviations:	None				
Comments:	Additional measurements were taken on the highest harmonic/emission for the low and mid channels to demonstrate there was no degradation of emissions with the addtion of a ferrite to the u.fl to SMA patch cable. The EUT transmits at a duty cycle of 93.3%, a DCCF of 0.3 dB was added to the RMS AVG measurements {0.3 dB = 10*Log (1/.933) }.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	127	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
7414.600	29.0	14.3	1.0	181.0	0.3	0.0	Vert	AV	0.0	43.6	54.0	-10.4	High Ch, EUT Horz, Ant Horz, Yagi
7414.817	28.9	14.3	1.0	15.0	0.3	0.0	Horz	AV	0.0	43.5	54.0	-10.5	High Ch, EUT Vert, Ant Vert, Yagi
7319.167	29.5	13.1	3.3	289.0	0.3	0.0	Horz	AV	0.0	42.9	54.0	-11.1	Mid Ch, EUT Vert, Ant Vert, Yagi
7319.117	28.8	13.1	2.6	257.0	0.3	0.0	Vert	AV	0.0	42.2	54.0	-11.8	Mid Ch, EUT Horz, Ant Horz, Yagi
2780.967	39.2	-3.2	1.0	352.0	0.3	0.0	Horz	AV	0.0	36.3	54.0	-17.7	High Ch, EUT Vert, Ant Vert, Yagi
2707.550	39.3	-3.4	2.5	87.0	0.3	0.0	Horz	AV	0.0	36.2	54.0	-17.8	Low Ch, EUT Vert, Ant Vert, Yagi
8341.567	40.1	-4.2	1.0	338.0	0.3	0.0	Vert	AV	0.0	36.2	54.0	-17.8	High Ch, EUT Horz, Ant Horz, Yagi
8341.767	39.8	-4.2	2.2	219.0	0.3	0.0	Horz	AV	0.0	35.9	54.0	-18.1	High Ch, EUT Vert, Ant Vert, Yagi
3707.967	33.1	2.2	1.0	257.0	0.3	0.0	Horz	AV	0.0	35.6	54.0	-18.4	High Ch, EUT Vert, Ant Vert, Yagi
2780.950	38.5	-3.2	1.1	16.0	0.3	0.0	Vert	AV	0.0	35.6	54.0	-18.4	High Ch, EUT Horz, Ant Horz, Yagi
2707.567	38.2	-3.4	3.9	353.0	0.3	0.0	Vert	AV	0.0	35.1	54.0	-18.9	Low Ch, EUT Horz, Ant Horz, Yagi
3707.967	31.7	2.2	3.2	65.0	0.3	0.0	Vert	AV	0.0	34.2	54.0	-19.8	High Ch, EUT Horz, Ant Horz, Yagi
4635.117	29.3	4.0	1.0	218.0	0.3	0.0	Horz	AV	0.0	33.6	54.0	-20.4	High Ch, EUT Vert, Ant Vert, Yagi
7415.367	39.2	14.3	1.0	181.0	0.0	0.0	Vert	PK	0.0	53.5	74.0	-20.5	High Ch, EUT Horz, Ant Horz, Yagi
7420.500	39.2	14.2	1.0	15.0	0.0	0.0	Horz	PK	0.0	53.4	74.0	-20.6	High Ch, EUT Vert, Ant Vert, Yagi
7316.833	40.0	13.2	3.3	289.0	0.0	0.0	Horz	PK	0.0	53.2	74.0	-20.8	Mid Ch, EUT Vert, Ant Vert, Yagi
4634.233	28.8	4.0	1.0	301.0	0.3	0.0	Vert	AV	0.0	33.1	54.0	-20.9	High Ch, EUT Horz, Ant Horz, Yagi
7322.050	38.8	13.1	2.6	257.0	0.0	0.0	Vert	PK	0.0	51.9	74.0	-22.1	Mid Ch, EUT Horz, Ant Horz, Yagi
8342.817	48.2	-4.2	1.0	338.0	0.0	0.0	Vert	PK	0.0	44.0	74.0	-30.0	High Ch, EUT Horz, Ant Horz, Yagi
3707.900	41.7	2.2	1.0	257.0	0.0	0.0	Horz	PK	0.0	43.9	74.0	-30.1	High Ch, EUT Vert, Ant Vert, Yagi
8343.367	48.0	-4.2	2.2	219.0	0.0	0.0	Horz	PK	0.0	43.8	74.0	-30.2	High Ch, EUT Vert, Ant Vert, Yagi
4638.200	39.0	4.1	1.0	301.0	0.0	0.0	Vert	PK	0.0	43.1	74.0	-30.9	High Ch, EUT Horz, Ant Horz, Yagi
4636.083	39.0	4.0	1.0	218.0	0.0	0.0	Horz	PK	0.0	43.0	74.0	-31.0	High Ch, EUT Vert, Ant Vert, Yagi

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
2780.517	46.0	-3.2	1.0	352.0	0.0	0.0	Horz	PK	0.0	42.8	74.0	-31.2	High Ch, EUT Vert, Ant Vert, Yagi
2707.733	46.2	-3.4	2.5	87.0	0.0	0.0	Horz	PK	0.0	42.8	74.0	-31.2	Low Ch, EUT Vert, Ant Vert, Yagi
2707.867	45.9	-3.4	3.9	353.0	0.0	0.0	Vert	PK	0.0	42.5	74.0	-31.5	Low Ch, EUT Horz, Ant Horz, Yagi
3709.483	39.9	2.2	3.2	65.0	0.0	0.0	Vert	PK	0.0	42.1	74.0	-31.9	High Ch, EUT Horz, Ant Horz, Yagi
2780.183	45.1	-3.2	1.1	16.0	0.0	0.0	Vert	PK	0.0	41.9	74.0	-32.1	High Ch, EUT Horz, Ant Horz, Yagi

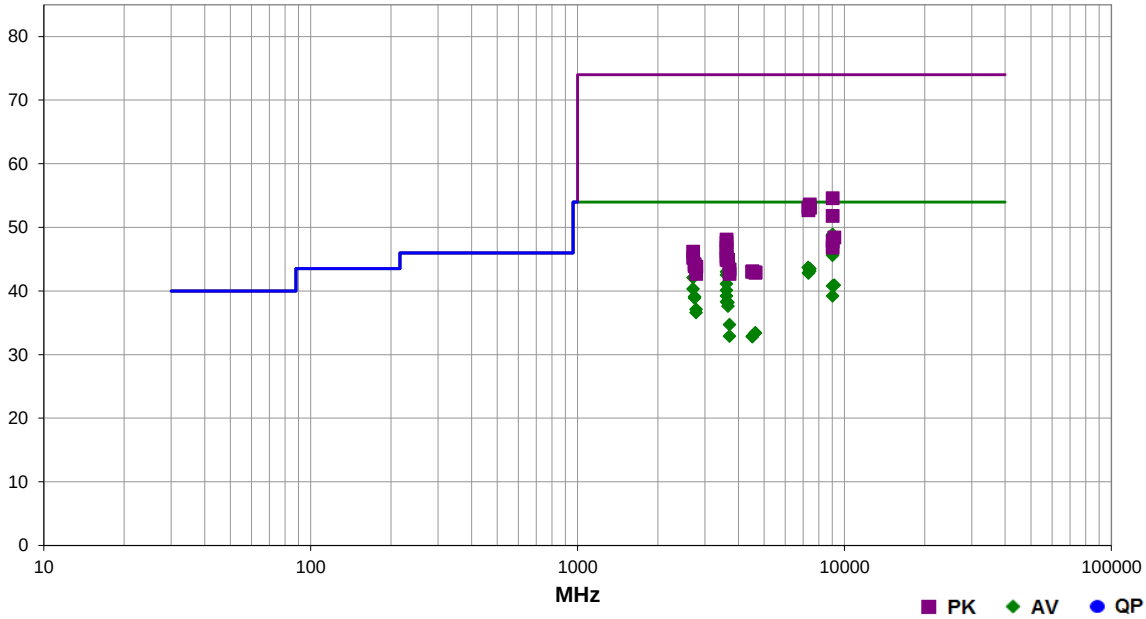
SPURIOUS RADIATED EMISSIONS

EmiR5 2019.08.01 PSA-ESCI 2019.05.10

Work Order:	NELS0008	**Date:**	29 August 2019		
Project:	None	**Temperature:**	23.2 °C		
Job Site:	EV01	**Humidity:**	46.5% RH		
Serial Number:	256395-0059	**Barometric Pres.:**	1013 mbar	**Tested by:**	Jeff Alcoke
EUT:	TWIG V - Radio Module				
Configuration:	10				
Customer:	Nelson Irrigation Corporation				
Attendees:	None				
EUT Power:	5.0 VDC				
Operating Mode:	Transmitting LoRa, SF8, 500 kHz BW, Software power setting = 10. Low Ch. = 902.5 MHz, Mid Ch. = 915 MHz, High Ch. = 927 MHz				
Deviations:	None				
Comments:	See comments below for Channel, EUT orientation, and Antenna Type. The EUT transmits at a duty cycle of 93.3%, a DCCF of 0.3 dB was added to the RMS AVG measurements {0.3 dB = 10*Log (1/.933) }.				

Test Specifications	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

Run #	72	**Test Distance (m)**	3	**Antenna Height(s)**	1 to 4(m)	**Results**	Pass



Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
9026.517	50.5	-1.9	1.0	58.0	0.3	0.0	Horz	AV	0.0	48.9	54.0	-5.1	Low ch, EUT Vert, Dipole
9026.483	47.2	-1.9	3.4	59.0	0.3	0.0	Vert	AV	0.0	45.6	54.0	-8.4	Low ch, EUT Horz, Dipole
7318.733	30.2	13.2	1.6	126.0	0.3	0.0	Vert	AV	0.0	43.7	54.0	-10.3	Mid ch, EUT Vert, Dipole
7416.433	28.9	14.3	1.1	107.0	0.3	0.0	Vert	AV	0.0	43.5	54.0	-10.5	High Ch, EUT Vert, Dipole
7414.500	28.5	14.3	3.1	166.0	0.3	0.0	Horz	AV	0.0	43.1	54.0	-10.9	High Ch, EUT Horz, Dipole
3609.800	41.0	1.7	2.7	33.0	0.3	0.0	Horz	AV	0.0	43.0	54.0	-11.0	Low ch, EUT Horz, Dipole
7319.383	29.4	13.1	1.5	360.0	0.3	0.0	Horz	AV	0.0	42.8	54.0	-11.2	Mid ch, EUT Horz, Dipole
3609.983	40.5	1.7	2.5	118.0	0.3	0.0	Horz	AV	0.0	42.5	54.0	-11.5	Low ch, EUT On Side, Dipole
2707.483	45.2	-3.4	2.6	135.0	0.3	0.0	Horz	AV	0.0	42.1	54.0	-11.9	Low ch, EUT Horz, Dipole
3609.817	39.1	1.7	1.7	207.0	0.3	0.0	Horz	AV	0.0	41.1	54.0	-12.9	Low ch, EUT Vert, Dipole
9151.633	42.5	-1.9	2.2	39.0	0.3	0.0	Vert	AV	0.0	40.9	54.0	-13.1	Mid ch, EUT Horz, Dipole
9026.600	42.4	-1.9	3.6	123.0	0.3	0.0	Horz	AV	0.0	40.8	54.0	-13.2	Low ch, EUT Horz, Dipole
2707.417	43.4	-3.4	1.0	270.0	0.3	0.0	Vert	AV	0.0	40.3	54.0	-13.7	Low ch, EUT Vert, Dipole
3610.283	38.1	1.7	3.5	269.0	0.3	0.0	Vert	AV	0.0	40.1	54.0	-13.9	Low ch, EUT Vert, Dipole
9026.567	40.8	-1.9	1.5	166.0	0.3	0.0	Vert	AV	0.0	39.2	54.0	-14.8	Low ch, EUT Vert, Dipole
3610.117	37.2	1.7	1.5	355.0	0.3	0.0	Vert	AV	0.0	39.2	54.0	-14.8	Low ch, EUT On Side, Dipole
2745.000	42.2	-3.4	2.6	137.0	0.3	0.0	Horz	AV	0.0	39.1	54.0	-14.9	Mid ch, EUT Horz, Dipole
2745.083	42.0	-3.4	3.0	217.0	0.3	0.0	Vert	AV	0.0	38.9	54.0	-15.1	Mid ch, EUT Vert, Dipole
3609.800	36.3	1.7	3.9	148.0	0.3	0.0	Vert	AV	0.0	38.3	54.0	-15.7	Low ch, EUT Horz, Dipole
3660.117	35.8	2.1	1.9	260.0	0.3	0.0	Horz	AV	0.0	38.2	54.0	-15.8	Mid ch, EUT Horz, Dipole

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)	Comments
3660.217	35.2	2.1	3.8	292.0	0.3	0.0	Vert	AV	0.0	37.6	54.0	-16.4	Mid ch, EUT Vert, Dipole
2781.150	40.0	-3.2	1.0	338.0	0.3	0.0	Vert	AV	0.0	37.1	54.0	-16.9	High Ch, EUT Vert, Dipole
2780.900	39.5	-3.2	1.0	328.0	0.3	0.0	Horz	AV	0.0	36.6	54.0	-17.4	High Ch, EUT Horz, Dipole
3708.067	32.2	2.2	3.7	326.0	0.3	0.0	Horz	AV	0.0	34.7	54.0	-19.3	High Ch, EUT Horz, Dipole
9027.100	56.5	-1.9	1.0	58.0	0.0	0.0	Horz	PK	0.0	54.6	74.0	-19.4	Low ch, EUT Vert, Dipole
7414.567	39.3	14.3	3.1	166.0	0.0	0.0	Horz	PK	0.0	53.6	74.0	-20.4	High Ch, EUT Horz, Dipole
4635.367	29.1	4.0	2.6	20.0	0.3	0.0	Horz	AV	0.0	33.4	54.0	-20.6	High Ch, EUT Horz, Dipole
4635.667	29.1	4.0	1.0	338.0	0.3	0.0	Vert	AV	0.0	33.4	54.0	-20.6	High Ch, EUT Vert, Dipole
7321.517	40.0	13.1	1.6	126.0	0.0	0.0	Vert	PK	0.0	53.1	74.0	-20.9	Mid ch, EUT Vert, Dipole
7418.183	38.8	14.3	1.1	107.0	0.0	0.0	Vert	PK	0.0	53.1	74.0	-20.9	High Ch, EUT Vert, Dipole
4513.167	28.6	4.0	1.5	261.0	0.3	0.0	Vert	AV	0.0	32.9	54.0	-21.1	Low ch, EUT Vert, Dipole
3707.633	30.4	2.2	1.0	110.0	0.3	0.0	Vert	AV	0.0	32.9	54.0	-21.1	High Ch, EUT Vert, Dipole
4512.133	28.5	4.0	1.7	153.0	0.3	0.0	Horz	AV	0.0	32.8	54.0	-21.2	Low ch, EUT Horz, Dipole
7323.267	39.6	13.1	1.5	360.0	0.0	0.0	Horz	PK	0.0	52.7	74.0	-21.3	Mid ch, EUT Horz, Dipole
9027.433	53.7	-1.9	3.4	59.0	0.0	0.0	Vert	PK	0.0	51.8	74.0	-22.2	Low ch, EUT Horz, Dipole
9151.883	50.3	-1.9	2.2	39.0	0.0	0.0	Vert	PK	0.0	48.4	74.0	-25.6	Mid ch, EUT Horz, Dipole
3610.650	46.4	1.7	2.7	33.0	0.0	0.0	Horz	PK	0.0	48.1	74.0	-25.9	Low ch, EUT Horz, Dipole
9027.450	49.7	-1.9	3.6	123.0	0.0	0.0	Horz	PK	0.0	47.8	74.0	-26.2	Low ch, EUT Horz, Dipole
3609.883	45.9	1.7	2.5	118.0	0.0	0.0	Horz	PK	0.0	47.6	74.0	-26.4	Low ch, EUT On Side, Dipole
3610.300	45.1	1.7	1.7	207.0	0.0	0.0	Horz	PK	0.0	46.8	74.0	-27.2	Low ch, EUT Vert, Dipole
9026.883	48.7	-1.9	1.5	166.0	0.0	0.0	Vert	PK	0.0	46.8	74.0	-27.2	Low ch, EUT Vert, Dipole
3609.933	44.5	1.7	3.5	269.0	0.0	0.0	Vert	PK	0.0	46.2	74.0	-27.8	Low ch, EUT Vert, Dipole
2708.067	49.6	-3.4	2.6	135.0	0.0	0.0	Horz	PK	0.0	46.2	74.0	-27.8	Low ch, EUT Horz, Dipole
3609.833	43.7	1.7	1.5	355.0	0.0	0.0	Vert	PK	0.0	45.4	74.0	-28.6	Low ch, EUT On Side, Dipole
2707.717	48.6	-3.4	1.0	270.0	0.0	0.0	Vert	PK	0.0	45.2	74.0	-28.8	Low ch, EUT Vert, Dipole
3660.133	42.8	2.1	1.9	260.0	0.0	0.0	Horz	PK	0.0	44.9	74.0	-29.1	Mid ch, EUT Horz, Dipole
3610.283	43.2	1.7	3.9	148.0	0.0	0.0	Vert	PK	0.0	44.9	74.0	-29.1	Low ch, EUT Horz, Dipole
3659.583	42.7	2.1	3.8	292.0	0.0	0.0	Vert	PK	0.0	44.8	74.0	-29.2	Mid ch, EUT Vert, Dipole
2744.783	47.6	-3.4	3.0	217.0	0.0	0.0	Vert	PK	0.0	44.2	74.0	-29.8	Mid ch, EUT Vert, Dipole
2744.283	47.4	-3.5	2.6	137.0	0.0	0.0	Horz	PK	0.0	43.9	74.0	-30.1	Mid ch, EUT Horz, Dipole
2781.300	46.9	-3.1	1.0	328.0	0.0	0.0	Horz	PK	0.0	43.8	74.0	-30.2	High Ch, EUT Horz, Dipole
3708.133	41.2	2.2	3.7	326.0	0.0	0.0	Horz	PK	0.0	43.4	74.0	-30.6	High Ch, EUT Horz, Dipole
4513.683	39.1	4.0	1.5	261.0	0.0	0.0	Vert	PK	0.0	43.1	74.0	-30.9	Low ch, EUT Vert, Dipole
4508.350	39.0	4.0	1.7	153.0	0.0	0.0	Horz	PK	0.0	43.0	74.0	-31.0	Low ch, EUT Horz, Dipole
4633.100	38.9	4.0	2.6	20.0	0.0	0.0	Horz	PK	0.0	42.9	74.0	-31.1	High Ch, EUT Horz, Dipole
4634.517	38.9	4.0	1.0	338.0	0.0	0.0	Vert	PK	0.0	42.9	74.0	-31.1	High Ch, EUT Vert, Dipole
2780.633	45.9	-3.2	1.0	338.0	0.0	0.0	Vert	PK	0.0	42.7	74.0	-31.3	High Ch, EUT Vert, Dipole
3708.350	40.5	2.2	1.0	110.0	0.0	0.0	Vert	PK	0.0	42.7	74.0	-31.3	High Ch, EUT Vert, Dipole

DUTY CYCLE

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The Duty Cycle (x) of the single channel operation of the radio as controlled by the provided test software was measured for each of the EUT operating modes.

There is no compliance requirement to be met by this test, so therefore no Pass / Fail criteria.

The measurements were made using a zero span on the spectrum analyzer to see the pulses in the time domain. The transmit power was set to its default maximum.

The duty cycle was calculated by dividing the transmission pulse duration (T) by the total period of a single on and total off time.

If the transmit duty cycle < 98 percent, burst gating may have been used during some of the other tests in this report to only take the measurement during the burst duration.

DUTY CYCLE

element

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.6% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss). Software power setting = 10.

DEVIATIONS FROM TEST STANDARD

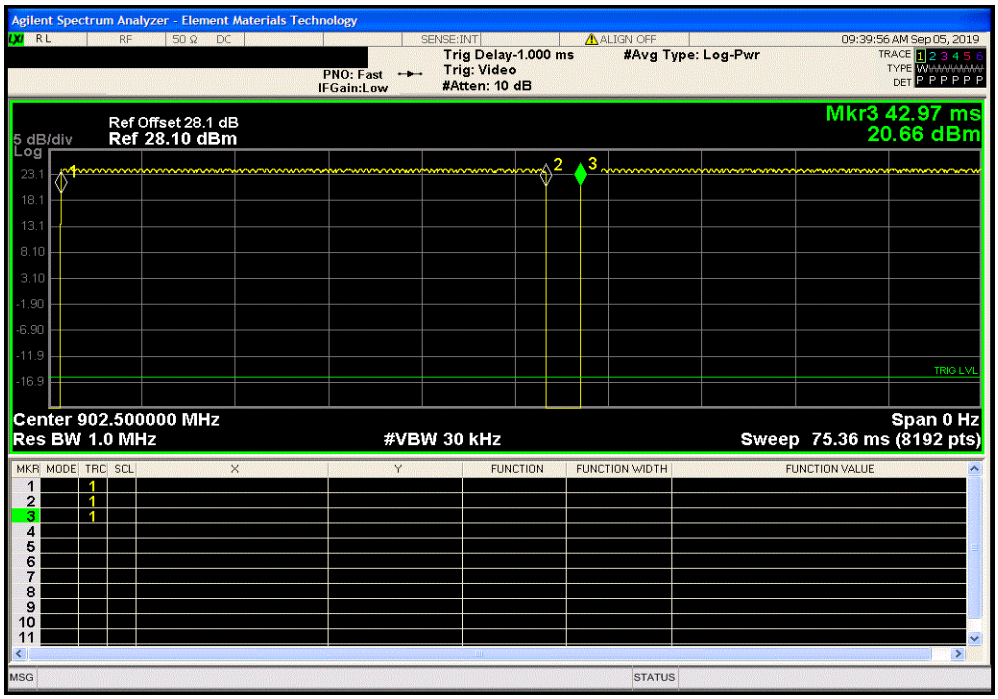
None

Configuration #	**11**	*Signature*

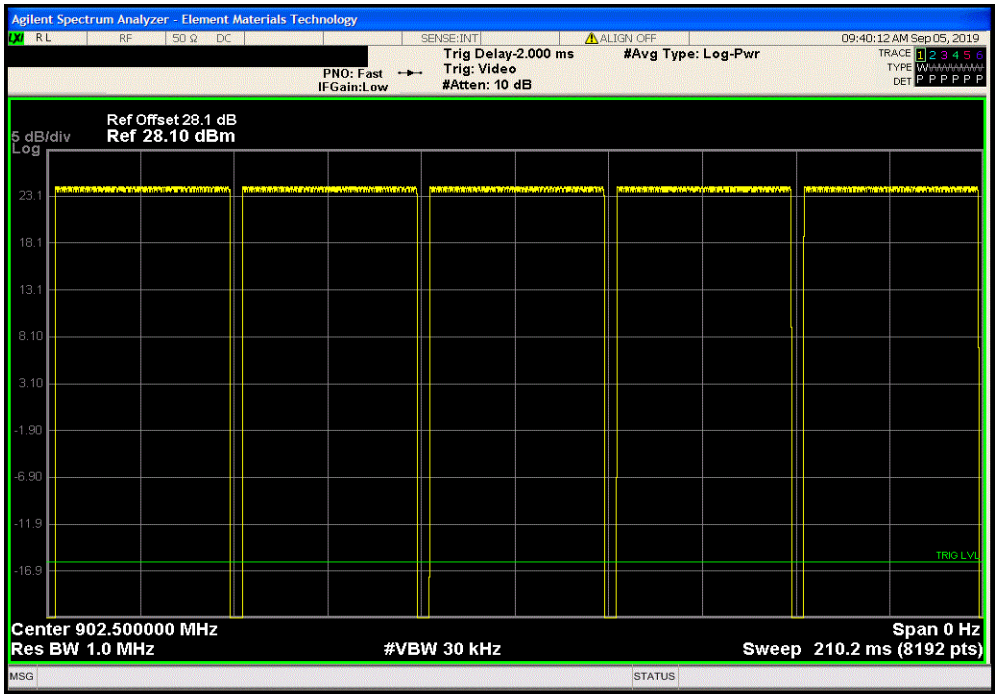
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
LoRa, Spreading Factor = 8						
Low Channel, 902.5 MHz	39.147 ms	41.981 ms	1	93.3	N/A	N/A
Low Channel, 902.5 MHz	N/A	N/A	5	N/A	N/A	N/A
Mid Channel, 915 MHz	39.174 ms	41.981 ms	1	93.3	N/A	N/A
Mid Channel, 915 MHz	N/A	N/A	5	N/A	N/A	N/A
High Channel, 927 MHz	39.157 ms	41.982 ms	1	93.3	N/A	N/A
High Channel, 927 MHz	N/A	N/A	5	N/A	N/A	N/A

DUTY CYCLE

LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	39.147 ms	41.981 ms	1	93.3	N/A	N/A

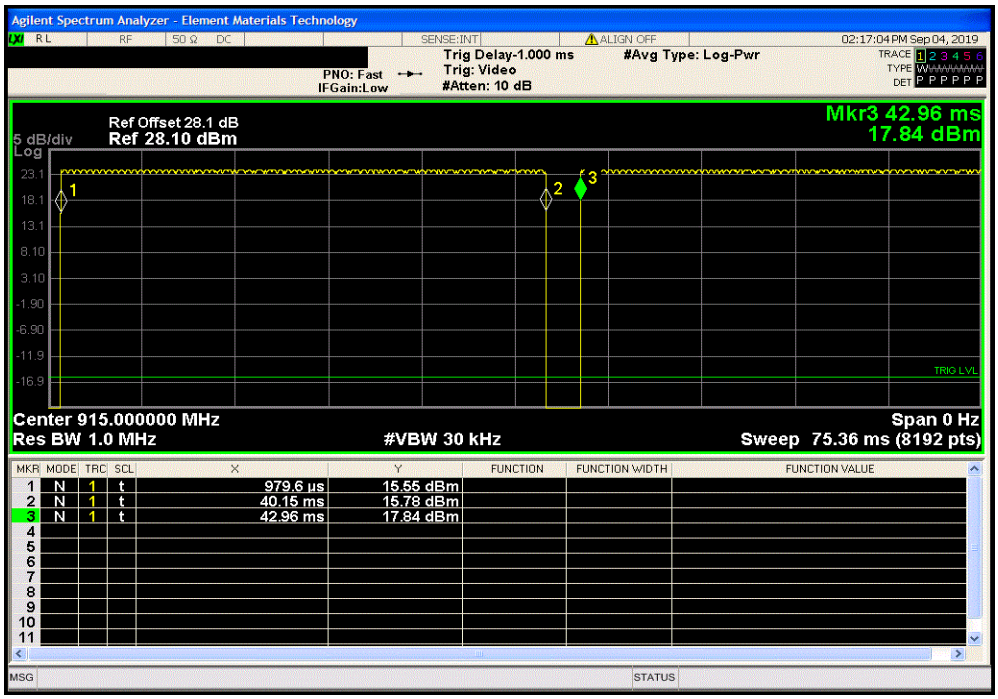


LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

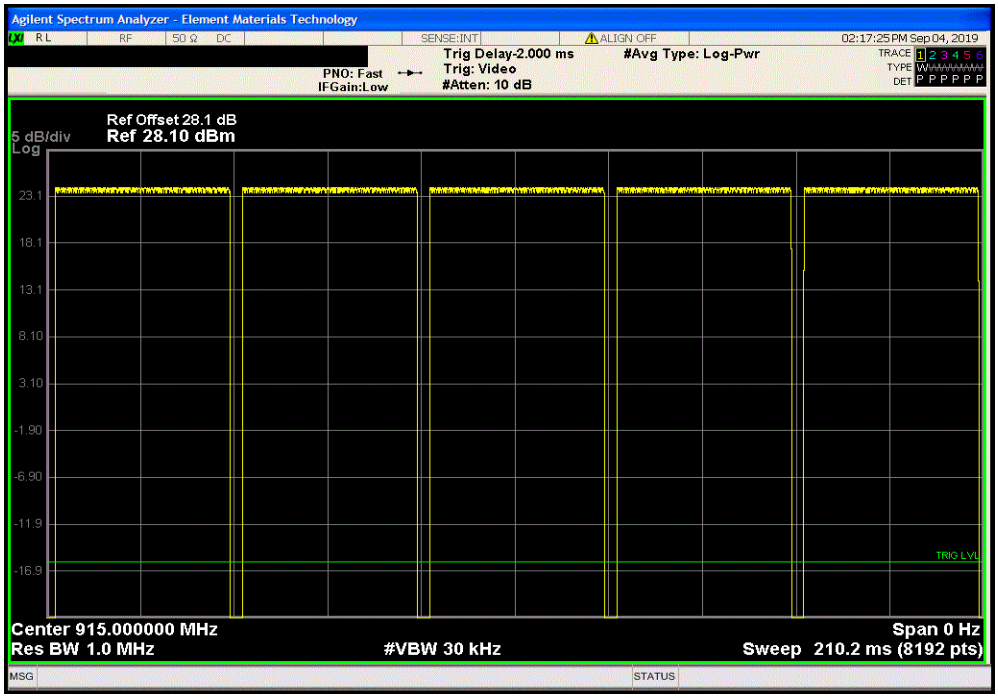


DUTY CYCLE

LoRa, Spreading Factor = 8, Mid Channel, 915 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	39.174 ms	41.981 ms	1	93.3	N/A	N/A

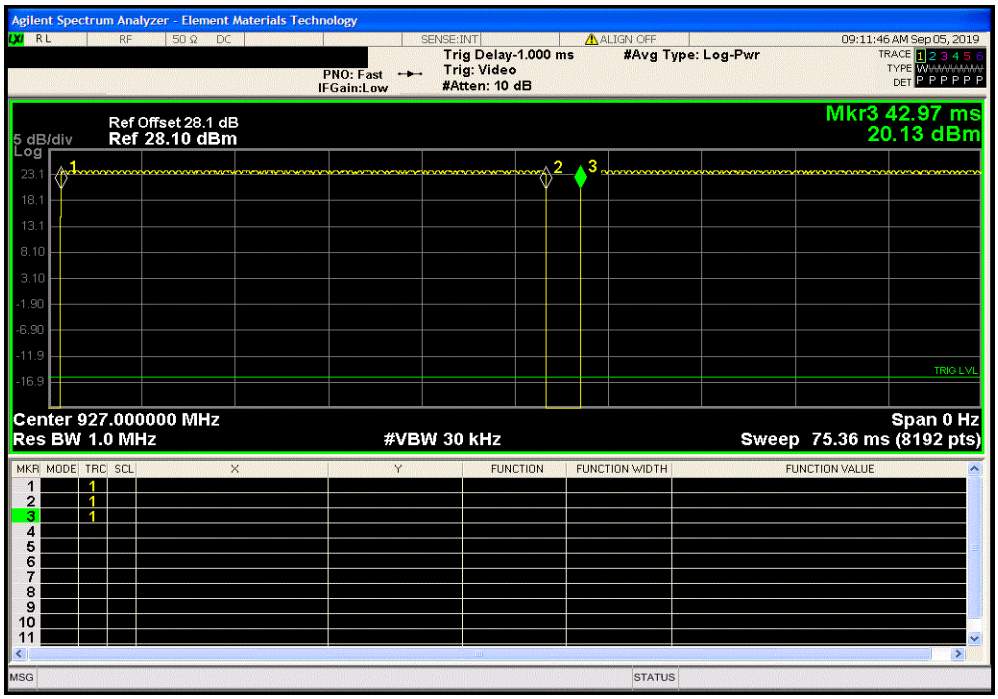


LoRa, Spreading Factor = 8, Mid Channel, 915 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A

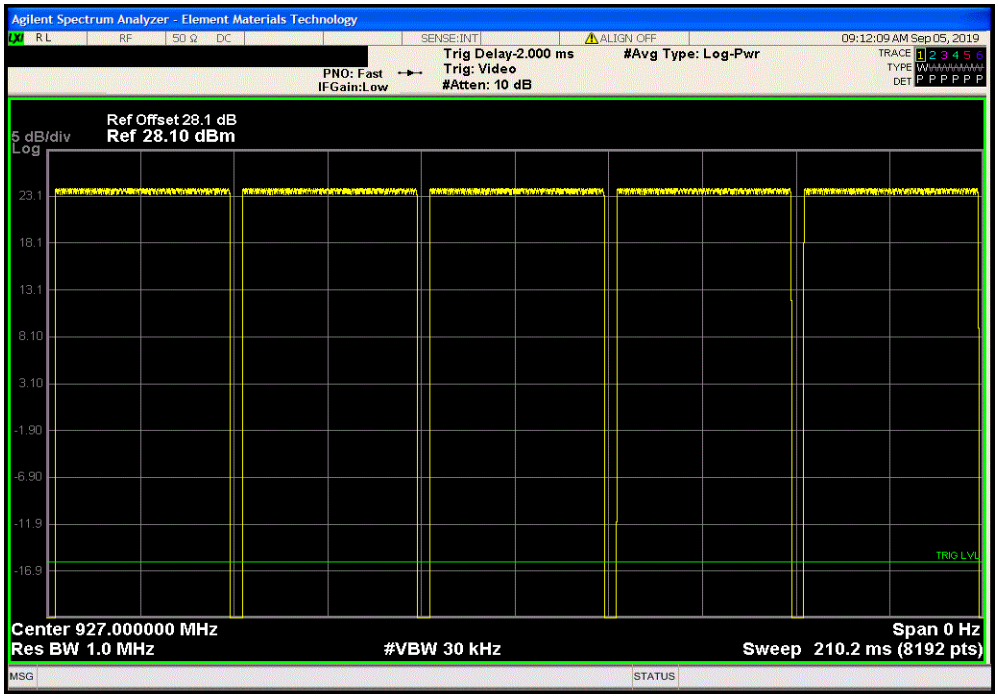


DUTY CYCLE

LoRa, Spreading Factor = 8, High Channel, 927 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	39.157 ms	41.982 ms	1	93.3	N/A	N/A



LoRa, Spreading Factor = 8, High Channel, 927 MHz						
	Pulse Width	Period	Number of Pulses	Value (%)	Limit (%)	Results
	N/A	N/A	5	N/A	N/A	N/A



OUTPUT POWER

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The fundamental emission output power (maximum average conducted output power) was measured using the channels and modes as called out on the following data sheets. The transmit power was set to its default maximum.

Prior to measuring output power; the emission bandwidth (B) and the transmission pulse duration (T) were measured. Both are required to determine the method of measuring Maximum Conducted Output Power. The transmission pulse duration (T) was measured using a zero span on the spectrum analyzer to see the pulses in the time domain.

The method AVGSA-2 in section 11.9.2.2.4 of ANSI C63.10:2013 was used to make the measurement. This method uses trace averaging across ON and OFF times of the EUT using an RMS detector. Following the measurement a duty cycle correction was applied by adding [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times.

OUTPUT POWER

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.6% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss). Software power setting = 10. Maximum antenna assembly gain (Antenna Gain + Cable loss) = 11 dBi. Conducted output power limit adjusted accordingly as per 15.247(b)(4)

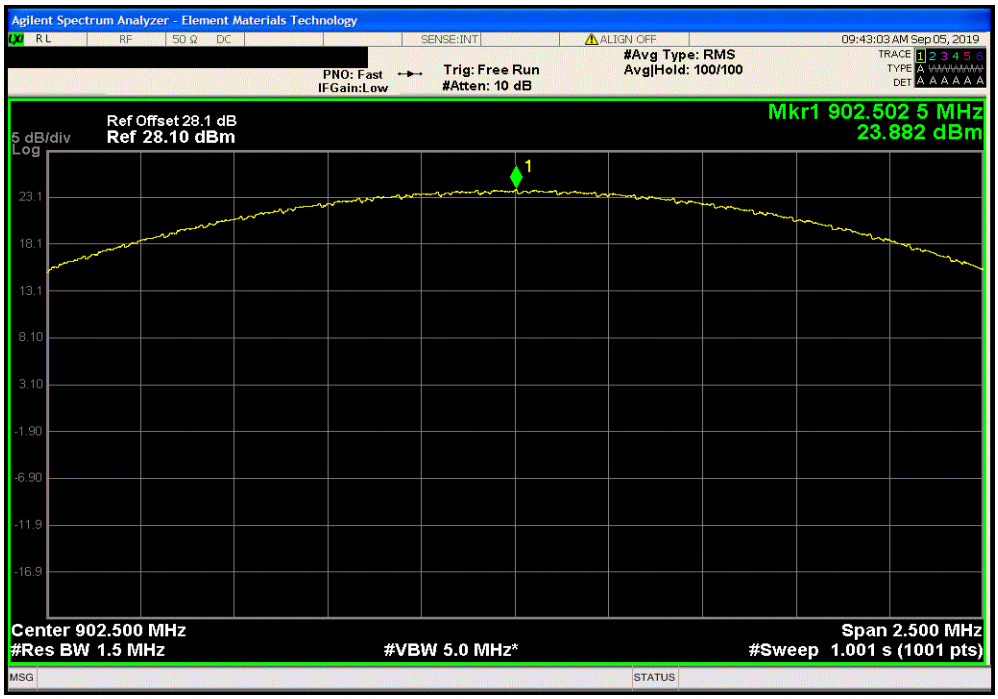
DEVIATIONS FROM TEST STANDARD

None

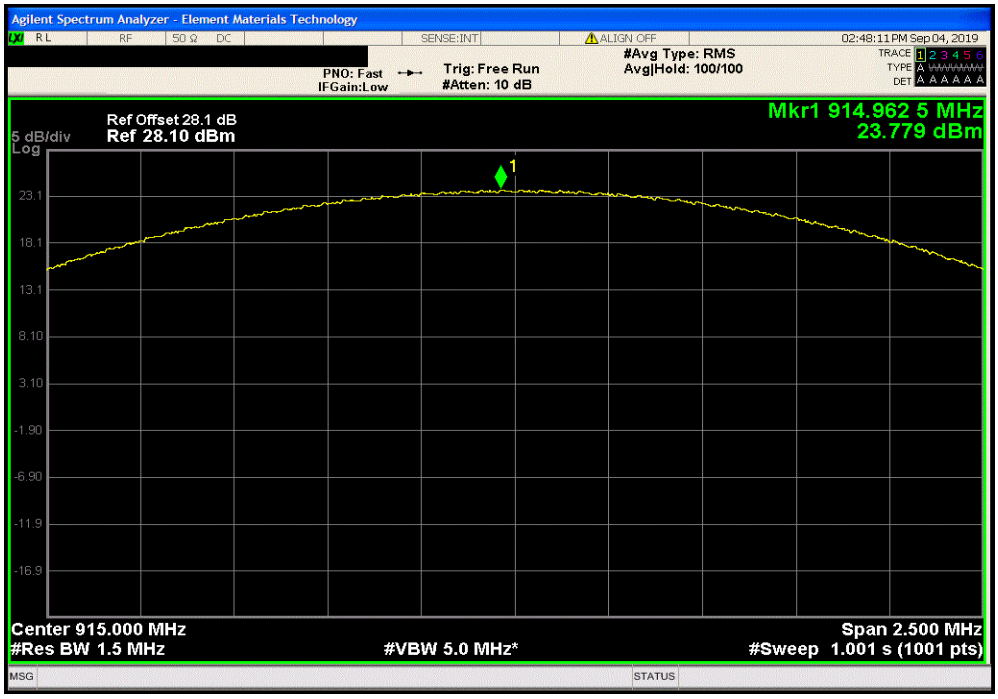
Configuration #	**11**	*Signature*

	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)	Value (dBm)	Limit (dBm)	Results
LoRa, Spreading Factor = 8					
Low Channel, 902.5 MHz	23.882	0.3	24.2	≤ 25	Pass
Mid Channel, 915 MHz	23.779	0.3	24.1	≤ 25	Pass
High Channel, 927 MHz	23.740	0.3	24.0	≤ 25	Pass

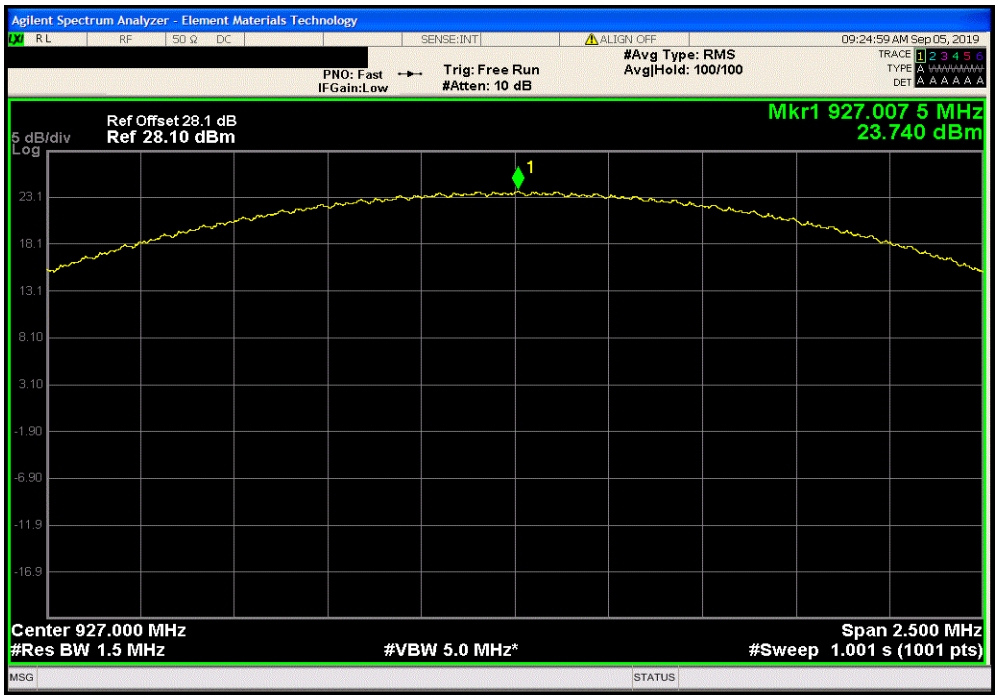
LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.882	0.3		24.2	≤ 25	Pass



LoRa, Spreading Factor = 8, Mid Channel, 915 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.779	0.3		24.1	≤ 25	Pass



LoRa, Spreading Factor = 8, High Channel, 927 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.740	0.3		24.0	≤ 25	Pass



EQUIVALENT ISOTROPIC RADIATED POWER

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The fundamental emission output power (maximum average conducted output power) was measured using the channels and modes as called out on the following data sheets. The transmit power was set to its default maximum.

Prior to measuring output power; the emission bandwidth (B) and the transmission pulse duration (T) were measured. Both are required to determine the method of measuring Maximum Conducted Output Power. The transmission pulse duration (T) was measured using a zero span on the spectrum analyzer to see the pulses in the time domain.

The method AVGSA-2 in section 11.9.2.2.4 of ANSI C63.10:2013 was used to make the measurement. This method uses trace averaging across ON and OFF times of the EUT using an RMS detector. Following the measurement a duty cycle correction was applied by adding [10 log (1 / D)], where D is the duty cycle, to the measured power to compute the average power during the actual transmission times.

The antenna gain/s of the EUT was then added to the conducted output power to derive the EIRP Values

EQUIVALENT ISOTROPIC RADIATED POWER

element

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.6% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufacturers patch cable (0.2 dB stated loss). Software power setting = 10.

Cable loss value was determined from the data sheet for CA-195R cable. The cable loss @ 900 MHz = 0.365 dB/m. The specified cable length used is 3.1 m giving a calculated cable loss of 0.365 dB/m * 3.1 m = 1.1 dB.

DEVIATIONS FROM TEST STANDARD

None

Configuration #	**11**	*Signature*

	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)	Value (dBm)	Limit (dBm)	Results
LoRa, Spreading Factor = 8					
Low Channel, 902.5 MHz	23.882	0.3	24.2	-	-
Mid Channel, 915 MHz	23.779	0.3	24.1	-	-
High Channel, 927 MHz	23.740	0.3	24.0	-	-

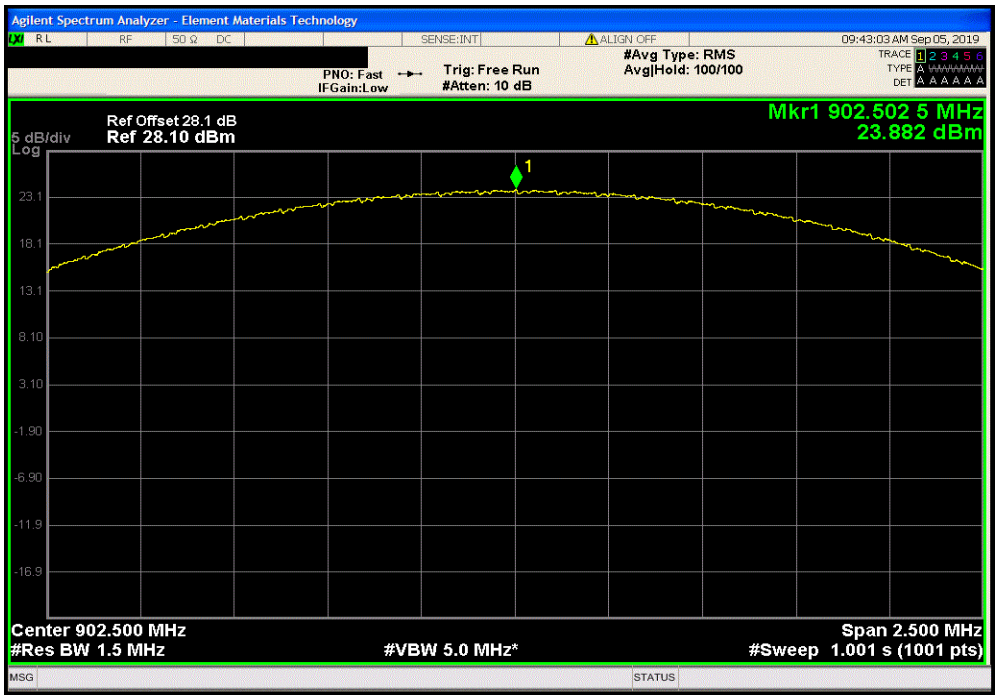
	Value (dBm)	Cable Loss (dB)	Antenna Gain (dBi)	Corrected Value (dBm)	Limit (dBm)	Results
LoRa, Spreading Factor = 8						
Internal Dipole						
Low Channel, 902.5 MHz	24.2	0.0	2	26.2	≤ 36	Pass
Mid Channel, 915 MHz	24.1	0.0	2	26.1	≤ 36	Pass
High Channel, 927 MHz	24.0	0.0	2	26.0	≤ 36	Pass
LoRa, Spreading Factor = 8						
External Yagi Antenna						
Low Channel, 902.5 MHz	24.2	1.1	12	35.1	≤ 36	Pass
Mid Channel, 915 MHz	24.1	1.1	12	35.0	≤ 36	Pass
High Channel, 927 MHz	24.0	1.1	12	34.9	≤ 36	Pass
LoRa, Spreading Factor = 8						
External Omnidirectional Antenna						
Low Channel, 902.5 MHz	24.2	1.1	8	31.1	≤ 36	Pass
Mid Channel, 915 MHz	24.1	1.1	8	31.0	≤ 36	Pass
High Channel, 927 MHz	24.0	1.1	8	30.9	≤ 36	Pass

EQUIVALENT ISOTROPIC RADIATED POWER

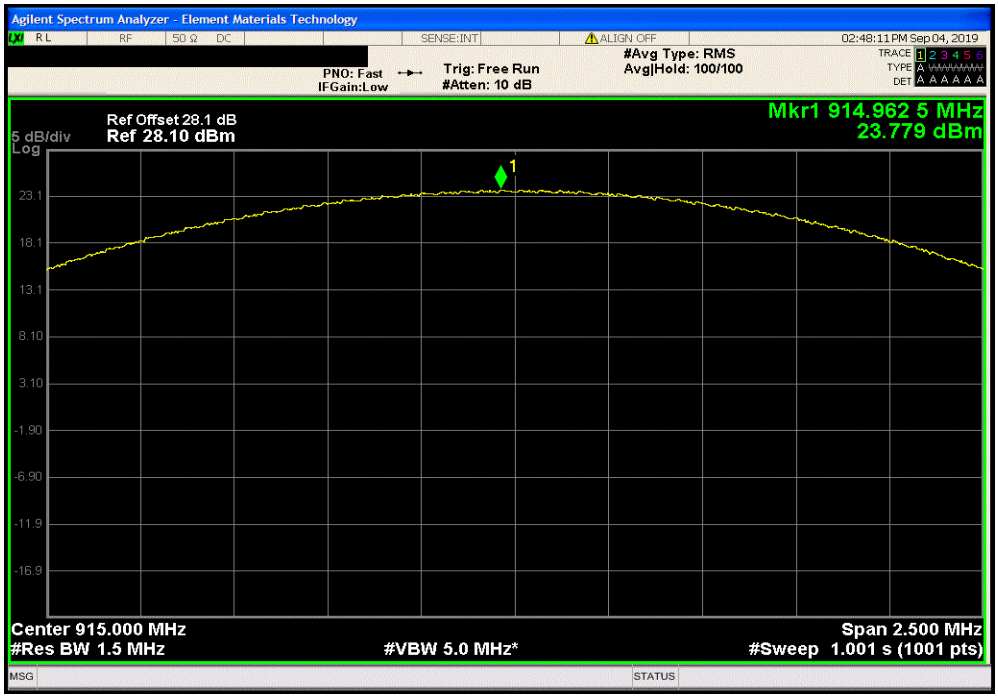
element

TbtTx 2019.08.02 XMit 2019.06.11

LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.882	0.3		24.2	-	-

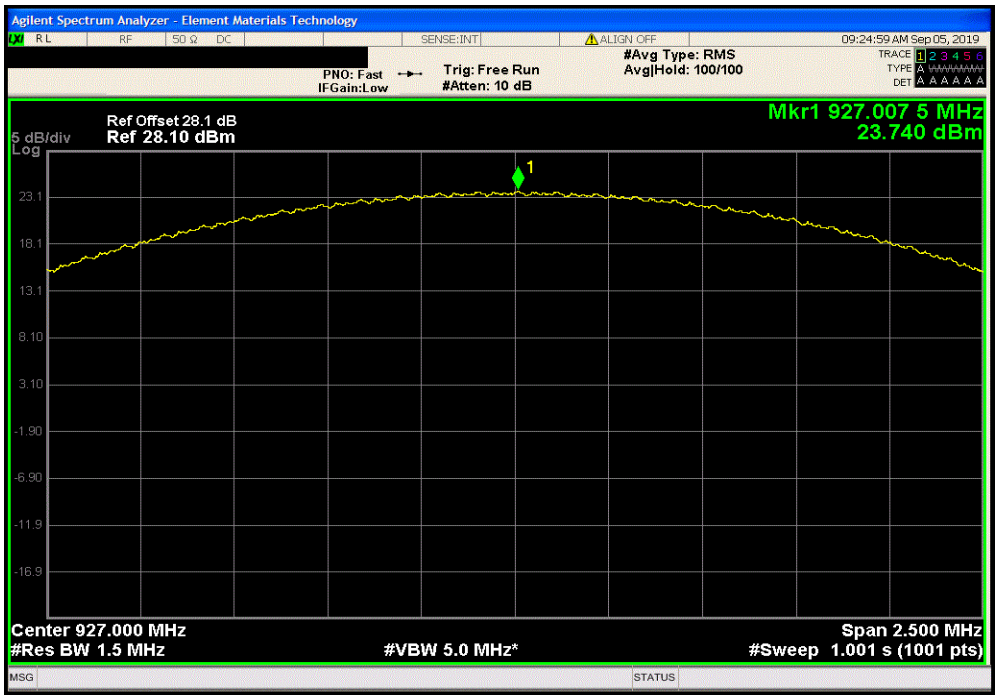


LoRa, Spreading Factor = 8, Mid Channel, 915 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.779	0.3		24.1	-	-



EQUIVALENT ISOTROPIC RADIATED POWER

LoRa, Spreading Factor = 8, High Channel, 927 MHz						
	Avg Cond Pwr (dBm)	Duty Cycle Factor (dB)		Value (dBm)	Limit (dBm)	Results
	23.740	0.3		24.0	-	-



BAND EDGE COMPLIANCE

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The spurious RF conducted emissions at the edges of the authorized bands were measured with the EUT set to low and high transmit frequencies in each available band. The channels closest to the band edges were selected. The EUT was transmitting at the data rate(s) listed in the datasheet.

The spectrum was scanned below the lower band edge and above the higher band edge.

BAND EDGE COMPLIANCE

element

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.5% RH**
Project:	**None**			**Barometric Pres.:**	**1017 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss).

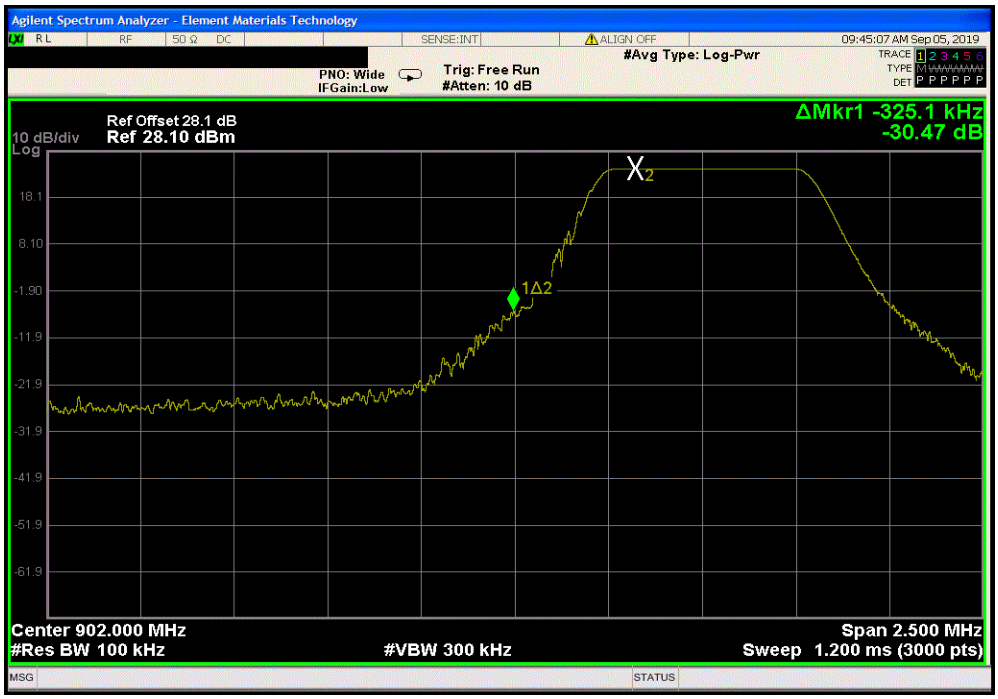
DEVIATIONS FROM TEST STANDARD

None

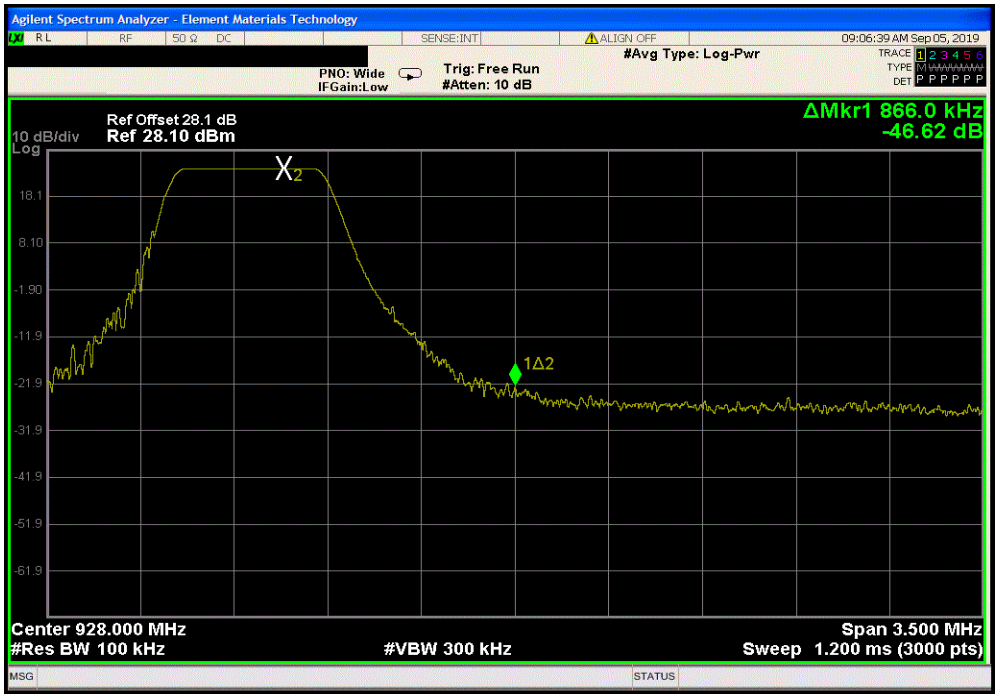
Configuration #	**11**	*Signature*

	Value (dBc)	**Limit ≤ (dBc)**	**Result**
LoRa, Spreading Factor = 8			
Low Channel, 902.5 MHz	-30.47	-30	Pass
High Channel, 927 MHz	-46.63	-30	Pass

LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-30.47	-30	Pass



LoRa, Spreading Factor = 8, High Channel, 927 MHz						
				Value (dBc)	Limit ≤ (dBc)	Result
				-46.63	-30	Pass



OCCUPIED BANDWIDTH

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The EUT was set to the channels and modes listed in the datasheet.

The 6dB occupied bandwidth was measured using 100 kHz resolution bandwidth and 300 kHz video bandwidth. The 99.0% occupied bandwidth was also measured at the same time which can be needed during Output Power depending on the applicable method.

OCCUPIED BANDWIDTH

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.4% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss). Software power setting = 10.

DEVIATIONS FROM TEST STANDARD

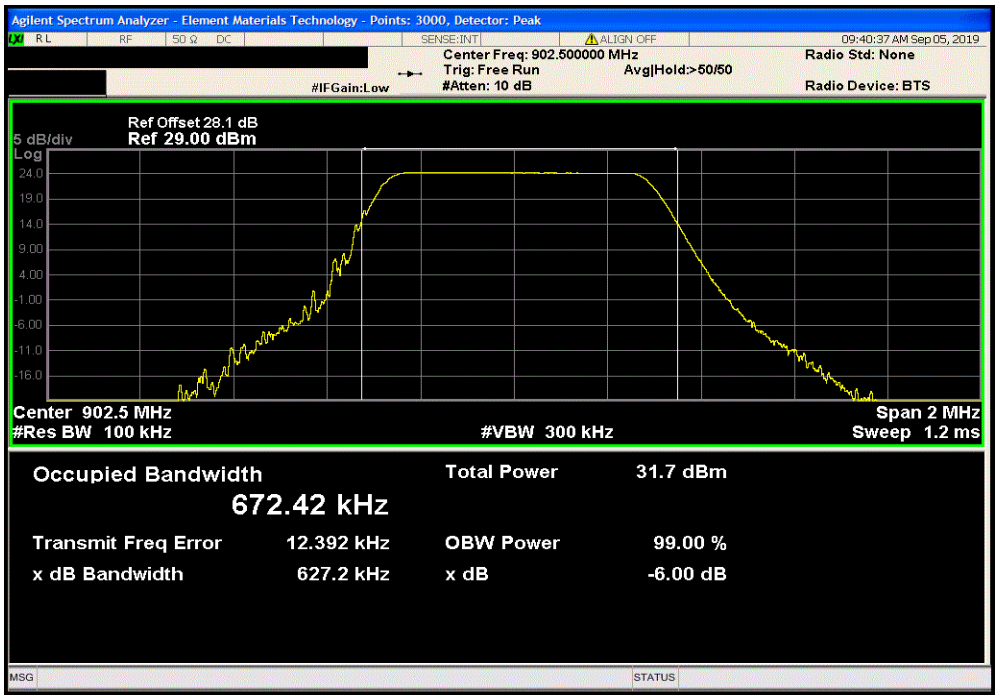
None

Configuration #	**11**	*Signature*

	Value	**Limit (≥)**	**Result**
LoRa, Spreading Factor = 8			
Low Channel, 902.5 MHz	627.218 kHz	500 kHz	Pass
Mid Channel, 915 MHz	631.819 kHz	500 kHz	Pass
High Channel, 927 MHz	632.018 kHz	500 kHz	Pass

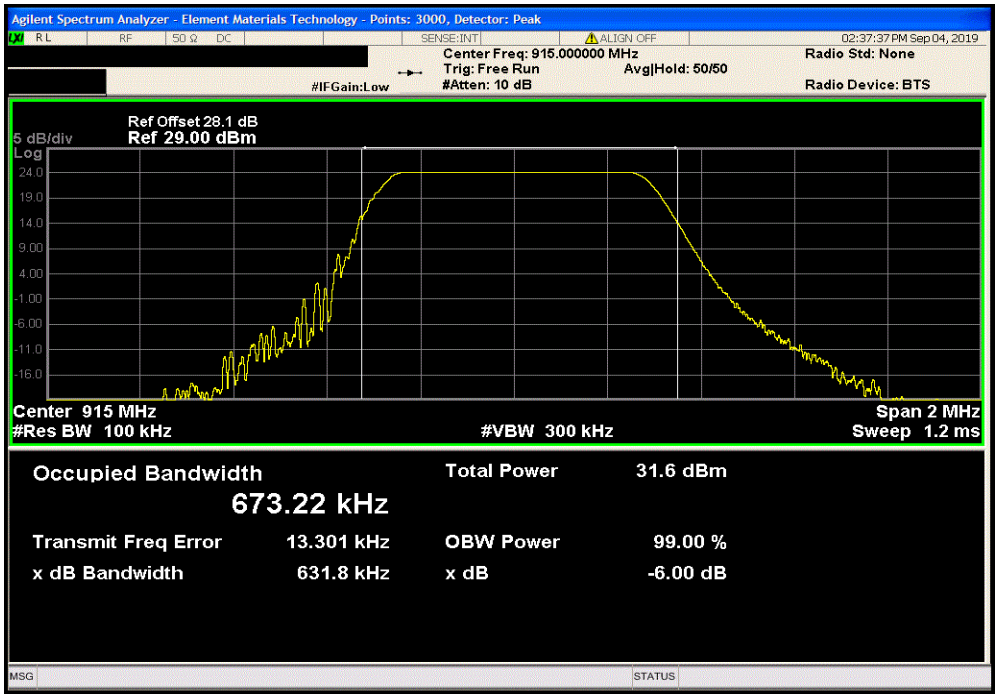
LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz

				Value	Limit (≥)	Result
				627.218 kHz	500 kHz	Pass



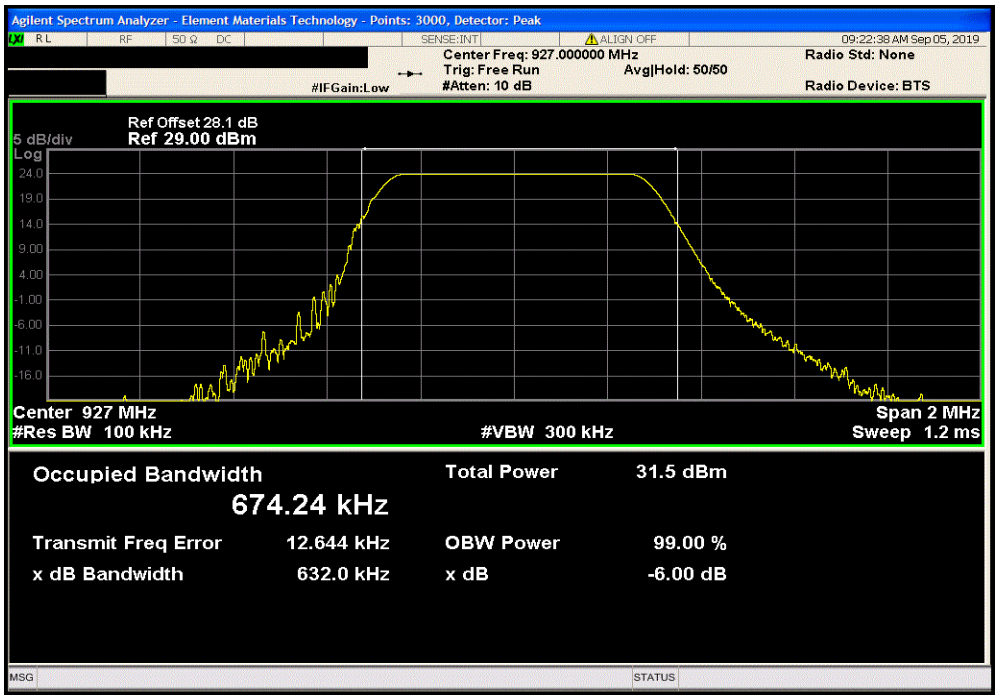
LoRa, Spreading Factor = 8, Mid Channel, 915 MHz

				Value	Limit (≥)	Result
				631.819 kHz	500 kHz	Pass



OCCUPIED BANDWIDTH

LoRa, Spreading Factor = 8, High Channel, 927 MHz						
				Value	Limit (≥)	Result
				632.018 kHz	500 kHz	Pass



SPURIOUS CONDUCTED EMISSIONS

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The spurious RF conducted emissions were measured with the EUT set to low, medium and high transmit frequencies. The EUT was transmitting at the data rate(s) listed in the datasheet. For each transmit frequency, the spectrum was scanned throughout the specified frequency range.

SPURIOUS CONDUCTED EMISSIONS

element

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.6% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss). Software power setting = 10.

DEVIATIONS FROM TEST STANDARD

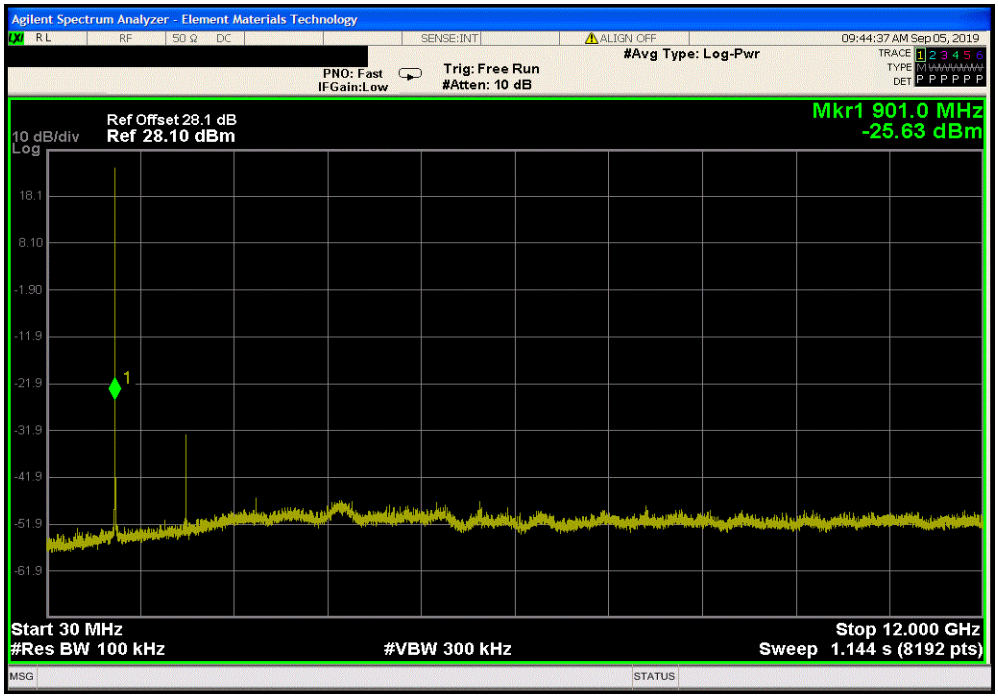
None

Configuration #	**11**	*Signature*

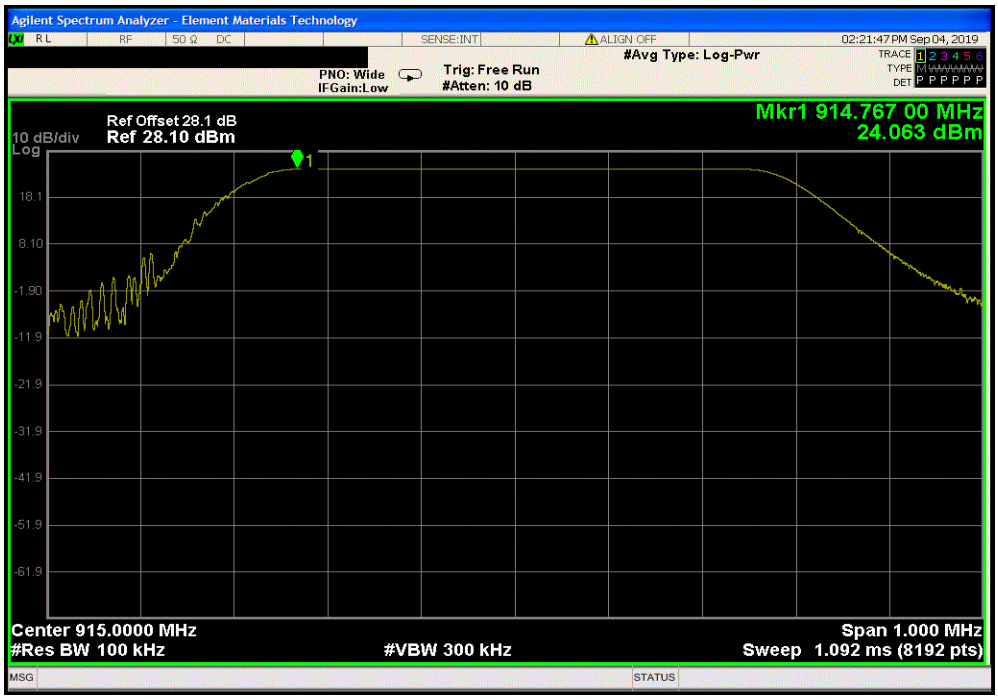
	Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
LoRa, Spreading Factor = 8					
Low Channel, 902.5 MHz	Fundamental	902.28	N/A	N/A	N/A
Low Channel, 902.5 MHz	30 MHz - 12 GHz	900.97	-49.77	-30	Pass
Mid Channel, 915 MHz	Fundamental	914.77	N/A	N/A	N/A
Mid Channel, 915 MHz	30 MHz - 12 GHz	1830.4	-60.06	-30	Pass
High Channel, 927 MHz	Fundamental	927.08	N/A	N/A	N/A
High Channel, 927 MHz	30 MHz - 12 GHz	930.2	-52.84	-30	Pass

LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	902.28	N/A	N/A	N/A

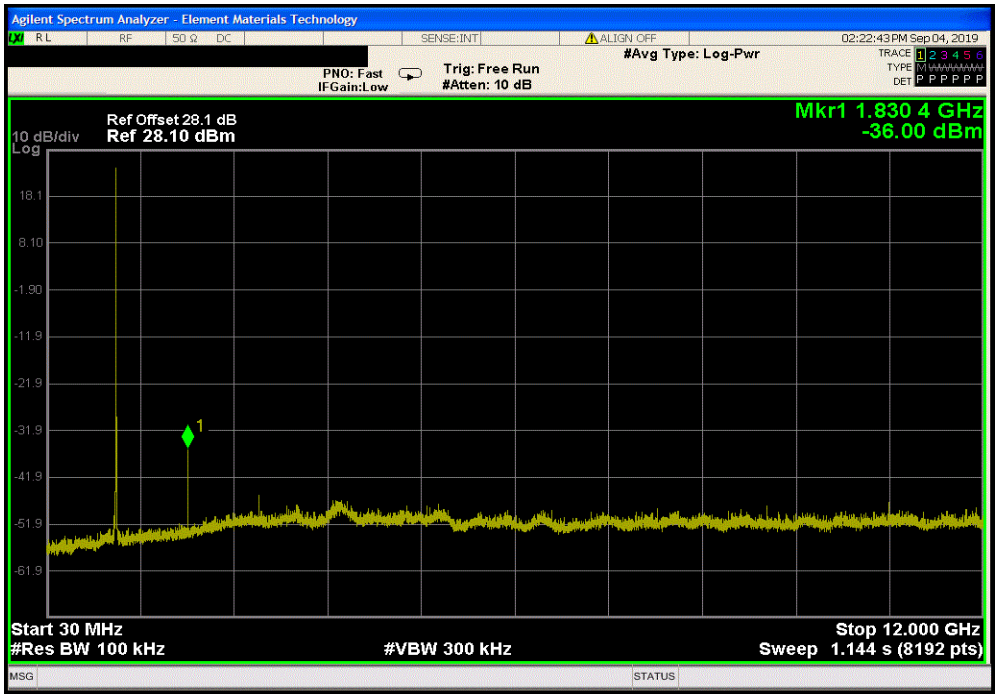
LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12 GHz	900.97	-49.77	-30	Pass



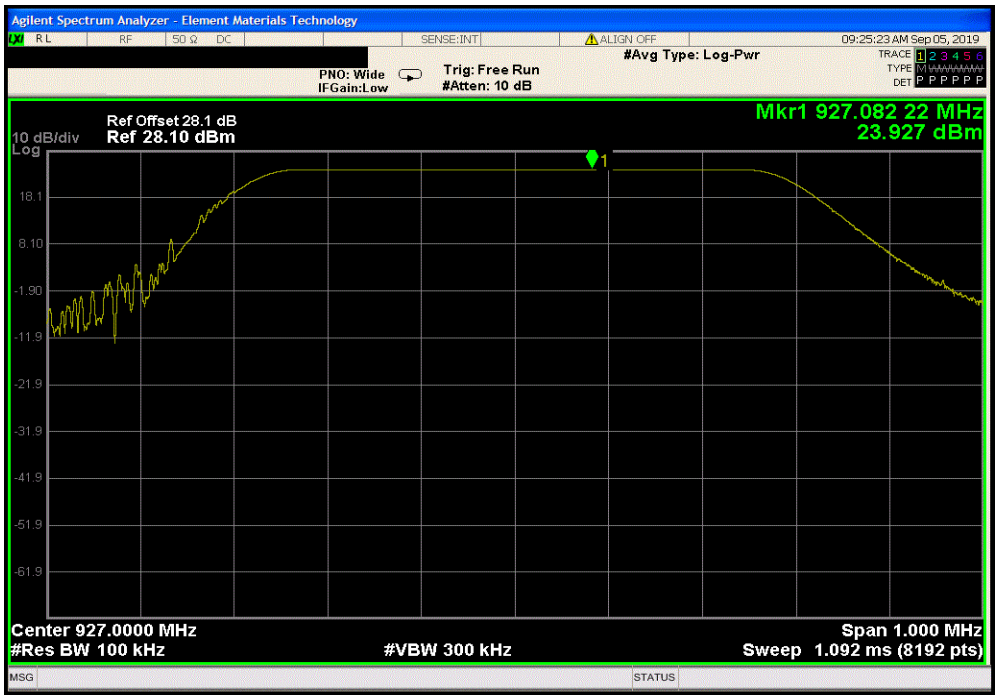
LoRa, Spreading Factor = 8, Mid Channel, 915 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	914.77	N/A	N/A	N/A



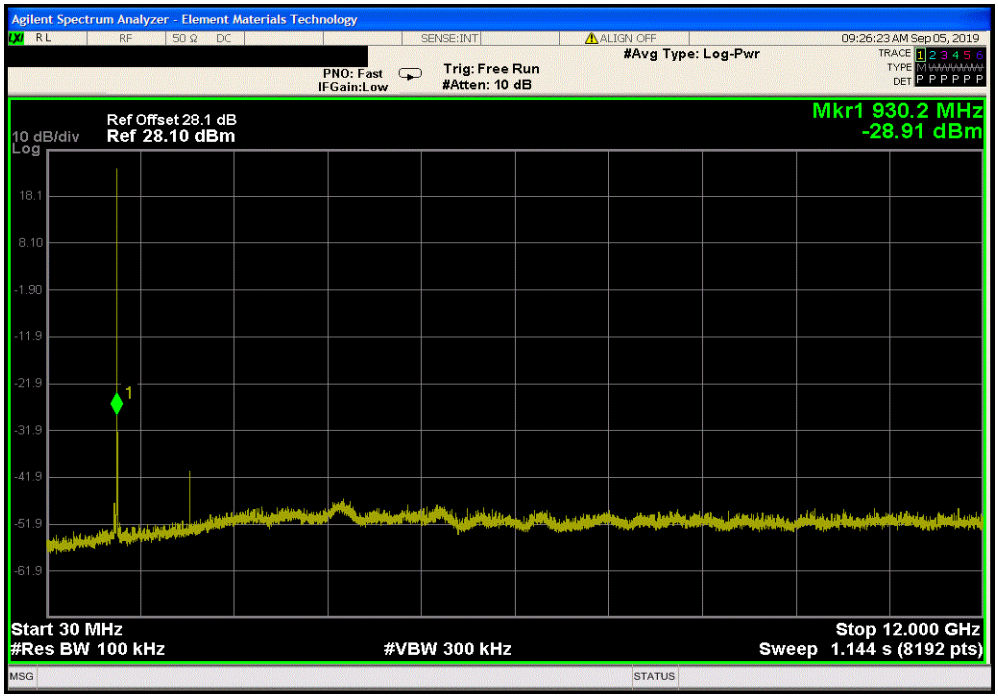
LoRa, Spreading Factor = 8, Mid Channel, 915 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12 GHz	1830.4	-60.06	-30	Pass



LoRa, Spreading Factor = 8, High Channel, 927 MHz					
Frequency Range		Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
	Fundamental	927.08	N/A	N/A	N/A



LoRa, Spreading Factor = 8, High Channel, 927 MHz				
Frequency Range	Measured Freq (MHz)	Max Value (dBc)	Limit ≤ (dBc)	Result
30 MHz - 12 GHz	930.2	-52.84	-30	Pass



POWER SPECTRAL DENSITY

XMit 2019.06.11

Testing was performed using the mode(s) of operation and configuration(s) noted within the report. The individuals and/or the organization requesting the test provided the modes, configurations and settings used to complete the evaluation. The actual test parameters are specified in the test data, this includes items such as investigated frequency range (scanned) and test levels. The testing methods and performance specifications, as well as the test site used for the evaluation are indicated in the test data.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Cal. Due
Cable	Micro-Coax	UFD150A-1-0720-200200	EVH	28-Mar-19	28-Mar-20
Attenuator	Fairview Microwave	18B5W-26	RFZ	23-Jul-19	23-Jul-20
Block - DC	Fairview Microwave	SD3379	AMX	29-Mar-19	29-Mar-20
Generator - Signal	Keysight	N5182B	TFU	5-Nov-18	5-Nov-21
Analyzer - Spectrum Analyzer	Agilent	N9010A	AFI	7-Jun-19	7-Jun-20

TEST DESCRIPTION

The measurement was made using a direct connection between the RF output of the EUT and a spectrum analyzer. The power spectral density was measured using the channels and modes as called out on the following data sheets. The transmit power was set to its default maximum.

The method AVGPSD-2 in section 11.10.5 of ANSI C63.10:2013 was used to make the measurement. This method uses trace averaging and RMS detection across the on and off times of the transmission, followed by a duty cycle correction. This method is allowed as the same method has been used to determine the conducted output power.

POWER SPECTRAL DENSITY

element

TbtTx 2019.08.02 XMit 2019.06.11

EUT:	**TWIG V - Radio Module**			**Work Order:**	**NELS0008**
Serial Number:	**256395-0059**			**Date:**	**5-Sep-19**
Customer:	**Nelson Irrigation Corporation**			**Temperature:**	**23.1 °C**
Attendees:	**None**			**Humidity:**	**48.6% RH**
Project:	**None**			**Barometric Pres.:**	**1018 mbar**
Tested by:	**Jeff Alcoke**	**Power:**	**5.0 VDC**	**Job Site:**	**EV06**

TEST SPECIFICATIONS	**Test Method**
FCC 15.247:2019	ANSI C63.10:2013

COMMENTS

Reference level offset of 28.1 dB includes: DC Block, 26 dB attenuator, measurement cable, and manufactureres patch cable (0.2 dB stated loss). Software power setting = 10.

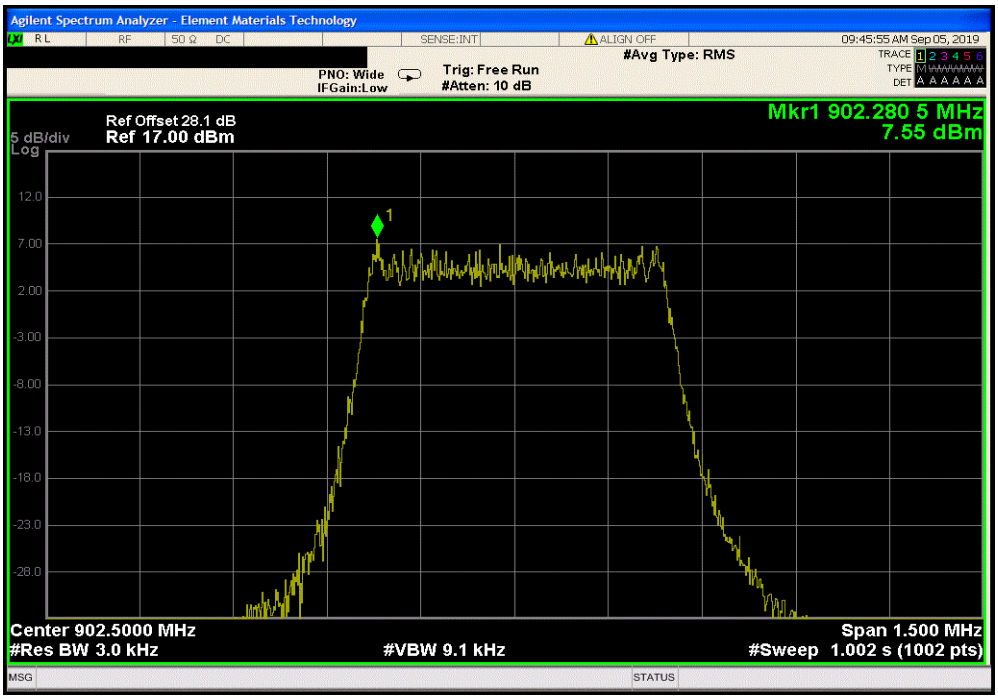
DEVIATIONS FROM TEST STANDARD

None

Configuration #	**11**	*Signature*

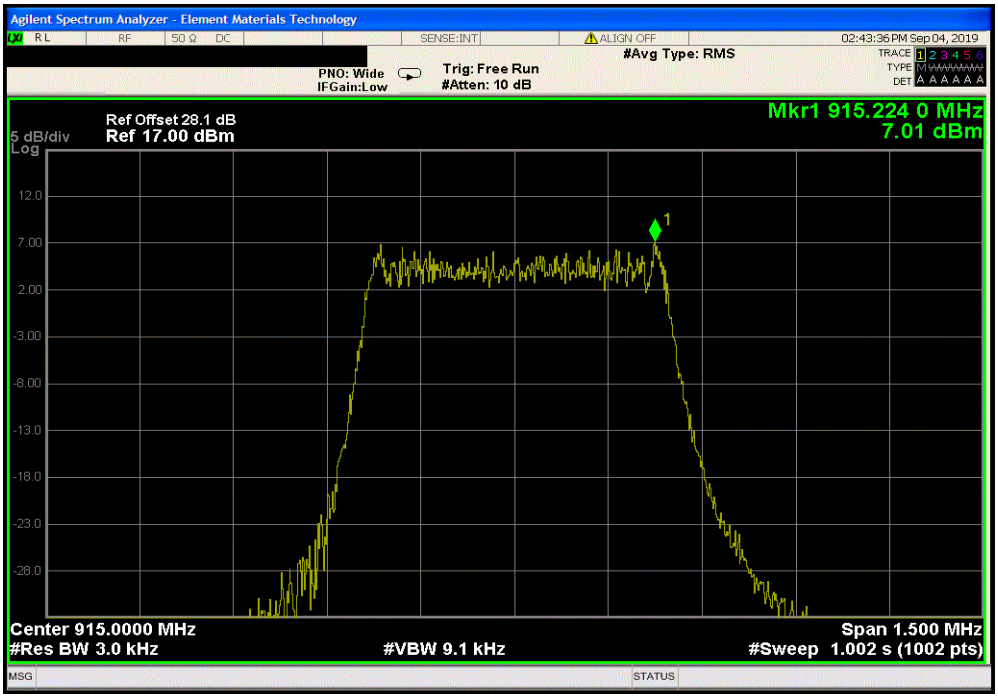
	Value dBm/3kHz	**DCCF (dB)**	**Corrected Value dBm/3kHz**	**Limit ≤ dBm/3kHz**	**Results**
LoRa, Spreading Factor = 8					
Low Channel, 902.5 MHz	7.552	0.3	7.852	8	Pass
Mid Channel, 915 MHz	7.008	0.3	7.308	8	Pass
High Channel, 927 MHz	6.561	0.3	6.861	8	Pass

LoRa, Spreading Factor = 8, Low Channel, 902.5 MHz						
		Value dBm/3kHz	DCCF (dB)	Corrected Value dBm/3kHz	Limit ≤ dBm/3kHz	Results
		7.552	0.3	7.852	8	Pass



LoRa, Spreading Factor = 8, Mid Channel, 915 MHz						
		Value dBm/3kHz	DCCF (dB)	Corrected Value dBm/3kHz	Limit ≤ dBm/3kHz	Results
		7.008	0.3	7.308	8	Pass

0



LoRa, Spreading Factor = 8, High Channel, 927 MHz						
		Value dBm/3kHz	DCCF (dB)	Corrected Value dBm/3kHz	Limit ≤ dBm/3kHz	Results
		6.561	0.3	6.861	8	Pass