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Test Report

Prepared for: Tehama Wireless Design Group Inc.

Model: TW-112

Description: DC Powered Meter Data Transceiver

Serial Numbers: 81C00133 (FSK Unit) and 81C00139 (LORA Unit)

FCC ID: TS4-TW112
IC: 6214A-TW112

To

FCC Part 15.247
And
IC RSS-247

Date of Issue: August 17, 2017

On the behalf of the applicant:	**Tehama Wireless Design Group Inc.** **423 Tehama Sreet** **San Francisco, CA 94103**
Attention of:	**James Orton, Hardware Engineer** **Ph: (415)495-7344** **E-Mail: jorton@tehamawireless.com**

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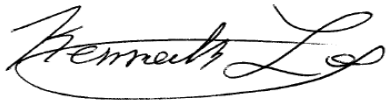
Project No: p1740020



Kenneth Lee
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	August 2, 2017	Kenneth Lee	Original Document
2.0	August 17, 2017	Kenneth Lee	Updated Occupied Bandwidth Tables and Plots

Table of Contents

ILAC / A2LA

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to the joint ISO-ILAC-IAF Communiqué dated January 2009).

The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

Please refer to http://www.compliancetesting.com/labscope.html for current scope of accreditation.

Testing Certificate Number: **2152.01**

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FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10-2013 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
18-26	31-42	962-971

EUT Description
Model: TW-112
Description: DC Powered Meter Data Transceiver
Firmware: N/A
Software: N/A
Serial Numbers: 81C00133 (FSK Unit) and 81C00139 (LORA Unit)
Additional Information: The EUT implements FSK, LORA (DTS) and LORA (FHSS) modulations. The EUT has 2 different options for RF shielding based on the modulation used. Both possible housing was fully tested with their respective modulation set. The radiated spurious emissions testing was done twice, once with the FSK modulation in the non-shielded housing, and again with the LORA modulation in the shielded housing. The worst-case PSD and output power were determined to be the LORA DTS, so the radiated spurious emissions were done on that modulation.

EUT Operation during Tests
The EUT was put into a test mode and set to the high, middle and low channel of operation at the maximum available output power. The EUT was controlled via a laptop computer with TeraTerm software.

Accessories: None

Cables: None

Modifications: None

15.203: Antenna Requirement:

X	The antenna is permanently attached to the EUT
	The antenna uses a unique coupling
	The EUT must be professionally installed
	The antenna requirement does not apply

Test Summary

FCC 15.247 Specification	RSS-247 Specification	Test Name	Pass, Fail, N/A	Comments
15.247(b)	Section 5.4(d)	Output Power	Pass	
15.247(d)	Section 5.5	Conducted Spurious Emissions	N/A	EUT has no Antenna Connector
15.247(d), 15.209(a), 15.205	Section 5.5	Radiated Spurious Emissions	Pass	
15.247(d), 15.209(a), 15.205	Section 5.5	Emissions At Band Edges	Pass	
15.247(a)(2)	Sections 5.1(a) and 5.2(a)	Occupied Bandwidth	Pass	
15.247(e)	Section 5.2(b)	Transmitter Power Spectral Density	Pass	Only for LORA (DTS) modulation
15.247(a)	Section 5.1 (c)	Dwell Time	Pass	Only for LORA(FHSS) and FSK modulations
15.247(a)	Section 5.1 (c)	Number of Hopping Channels	Pass	Only for LORA(FHSS) and FSK modulations
15.247(a)	Section 5.1 (b)	Channel Separation	Pass	Only for LORA(FHSS) and FSK modulations
15.207	RSS-GEN Section 8.8	A/C Powerline Conducted Emissions	N/A	EUT is Battery Powered

References	Description
CFR47, Part 15, Subpart B	Unintentional Radiators
CFR47, Part 15, Subpart C	Intentional Radiators
ANSI C63.10-2013	American National standard for testing Unlicensed Wireless Devices
ANSI C63.4-2014	Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz.
ISO/IEC 17025:2005	General requirements for the Competence of Testing and Calibrations Laboratories
KDB 558074 D01 v03r03	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating under §15.247

Output Power
Engineer: Kenneth Lee
Test Date: 8/1/2017

Test Procedure

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

For the FSK and LORA (FHSS) testing the Spectrum Analyzer was set to the following:

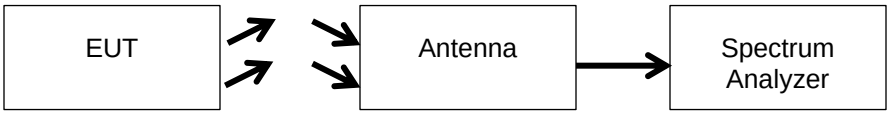
RBW ≥ DTS Bandwidth
VBW ≥ 3 x RBW
Span ≥ 3 x RBW
Sweep time = auto couple
Detector = peak
Trace Mode = max hold

For the LORA (DTS) testing the Spectrum Analyzer was set to the following:

RBW = 1-5% of the OBW, not to exceed 1MHz
VBW ≥ 3 x RBW
RMS Detector
Number of points in sweep ≥ 2 x span / RBW
Trace average at least 100 traces in power averaging mode
Sweep = auto
Span = 1.5 x EBW

For the LORA (DTS) testing the RF output power was measured using the spectrum analyzer's channel power function

Test Setup



Transmitter Output Power

FSK

Tuned Frequency (MHz)	Measured EIRP (dBm)	ERP Conversion (dBm)	Corrected Reading (dBm)	Specification Limit	Result
906	23.92	-2.15	21.77	1 W (30 dBm)	Pass
915	23.93	-2.15	21.78	1 W (30 dBm)	Pass
924	23.98	-2.15	21.83	1 W (30 dBm)	Pass

LORA (FHSS)

Tuned Frequency (MHz)	Measured EIRP (dBm)	ERP Conversion (dBm)	Corrected Reading (dBm)	Specification Limit	Result
906	23.72	-2.15	21.57	1 W (30 dBm)	Pass
915	23.80	-2.15	21.65	1 W (30 dBm)	Pass
924	23.81	-2.15	21.66	1 W (30 dBm)	Pass

LORA (DTS)

Tuned Frequency (MHz)	Measured EIRP (dBm)	ERP Conversion (dBm)	Corrected Reading (dBm)	Specification Limit	Result
906	24.80	-2.15	22.65	1 W (30 dBm)	Pass
915	24.74	-2.15	22.59	1 W (30 dBm)	Pass
924	24.50	-2.15	22.35	1 W (30 dBm)	Pass

Radiated Spurious Emissions

Engineer: Kenneth Lee

Test Date: 8/1/2017

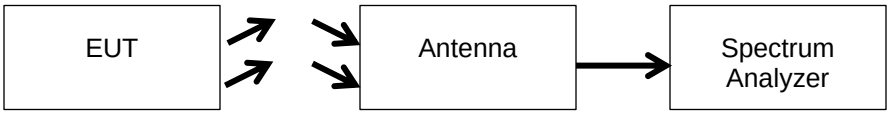
Test Procedure
Radiated Spurious Emissions: 30 – 1000 MHz

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Spurious Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

All emissions from 30 MHz to 1 GHz were examined.
Measured Level includes antenna and receiver cable correction factors.
Correction factors were input into the spectrum analyzer before recording “Measured Level”.

RBW = 100 KHz
VBW = 300 KHz
Detector – Quasi Peak

Test Setup

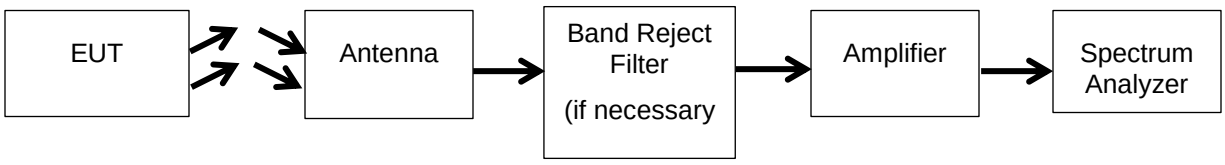


Test Procedure for
Radiated Spurious Emissions above 1 GHz

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

RBW = 100 KHz and 1 MHz
VBW = 300 KHz and 3 MHz
Detector – Peak

Test Setup



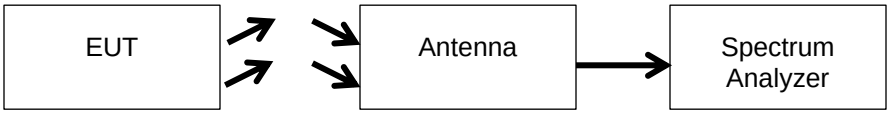
See Annex A for test data

Emissions at Band Edges
Engineer: Kenneth Lee
Test Date: 8/1/2017

Test Procedure

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized. The spectrum analyzer was used to verify that the EUT met the requirements for band edges.

Test Setup



Band Edge Emissions Summary – LORA (DTS)

Tuned Frequency (MHz)	Emission Frequency (MHz)	Monitored Level	Detector	Limit	Result
906	902	-47.28	Peak	-30 dBc	Pass
924	928	-47.39	Peak	-30 dBc	Pass

Band Edge Emissions Summary – FSK

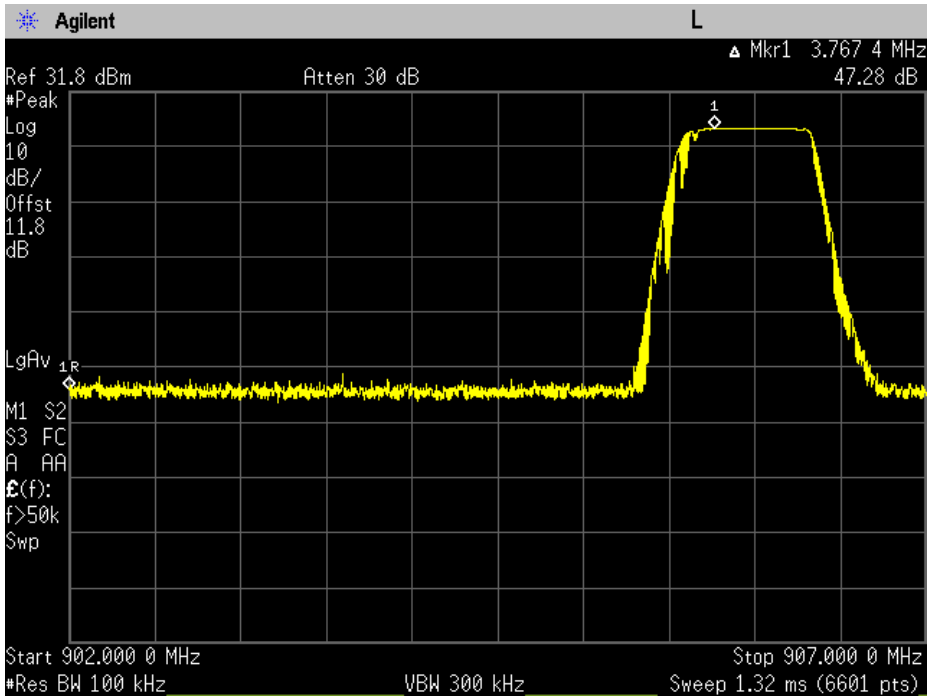
Tuned Frequency (MHz)	Emission Frequency (MHz)	Monitored Level	Detector	Limit	Result
906	902	-72.89	Peak	-20 dBc	Pass
924	928	-70.47	Peak	-20 dBc	Pass

Band Edge Emissions Summary – LORA (FHSS)

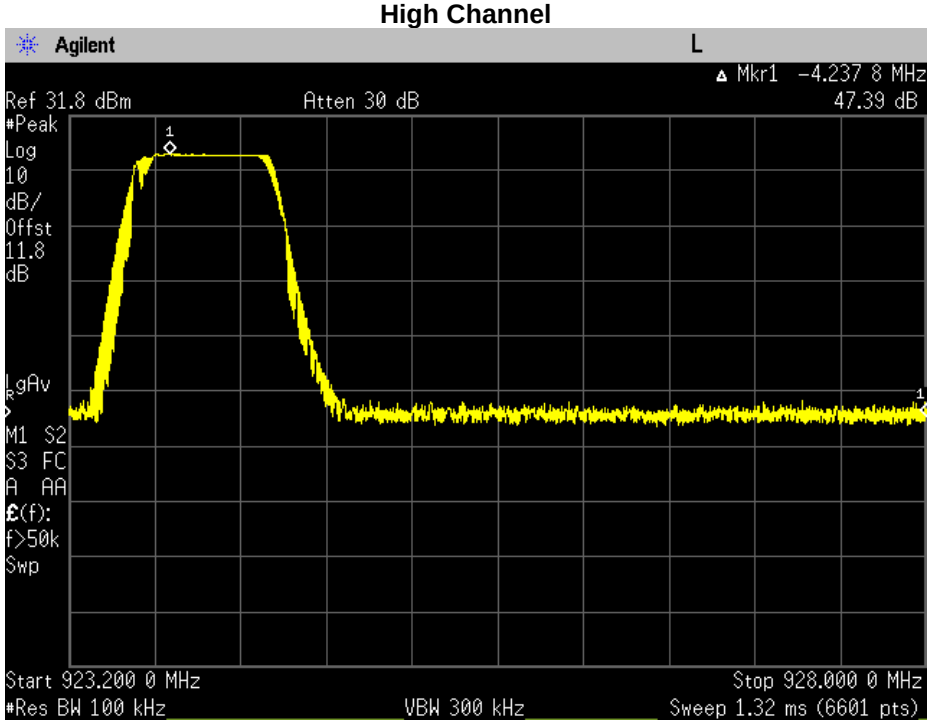
Tuned Frequency (MHz)	Emission Frequency (MHz)	Monitored Level	Detector	Limit	Result
906	902	-71.12	Peak	-20 dBc	Pass
924	928	-71.74	Peak	-20 dBc	Pass

Band Edge Plots

LORA (DTS)
Low Channel

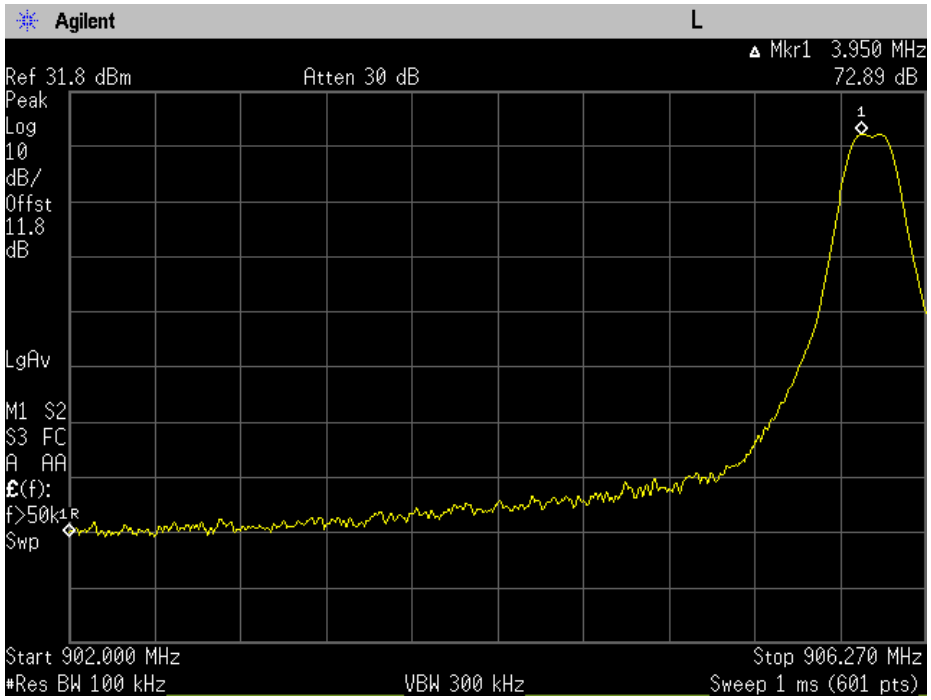


High Channel

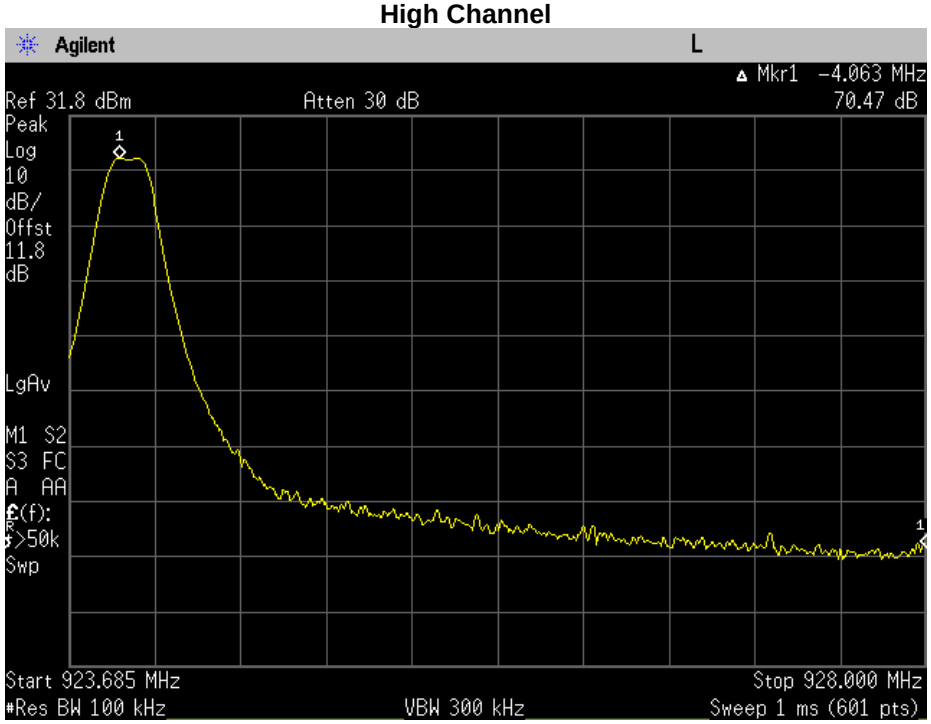


FSK

Low Channel

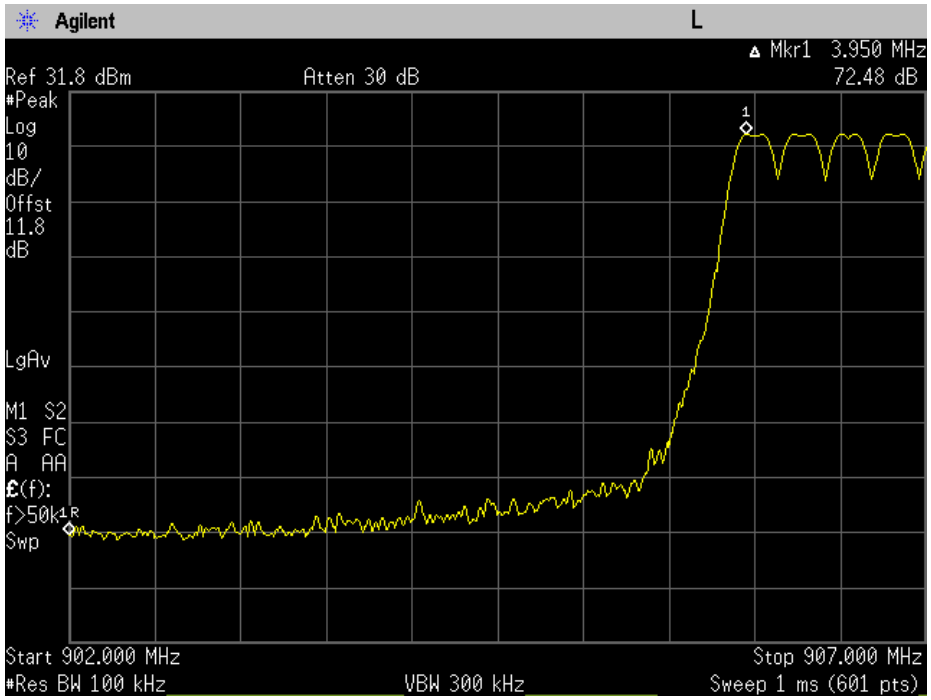


High Channel



FKS (Hopping)

Low Channel



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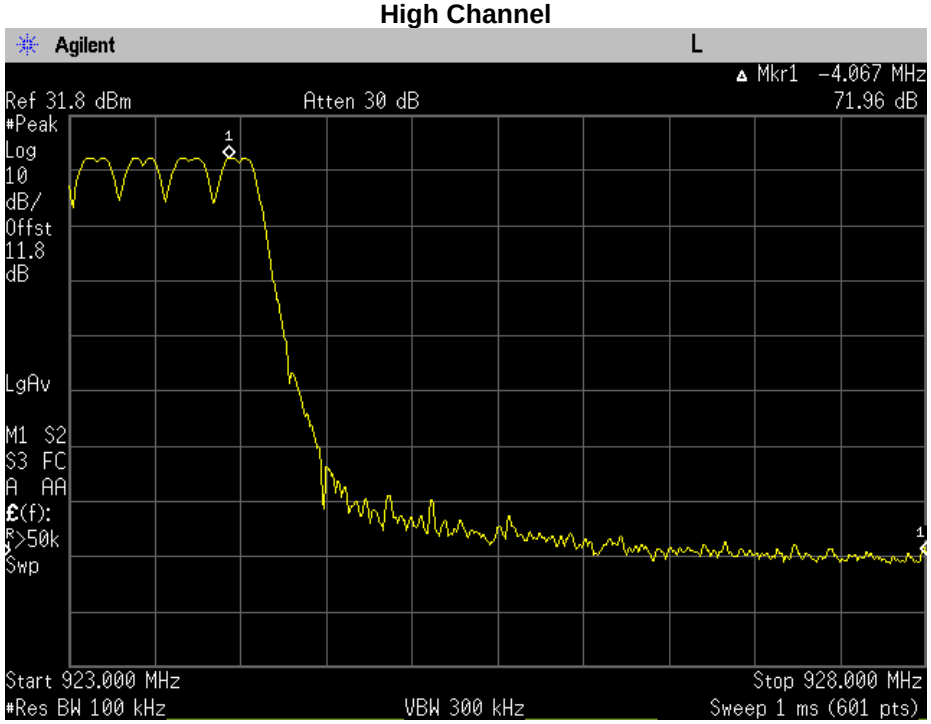
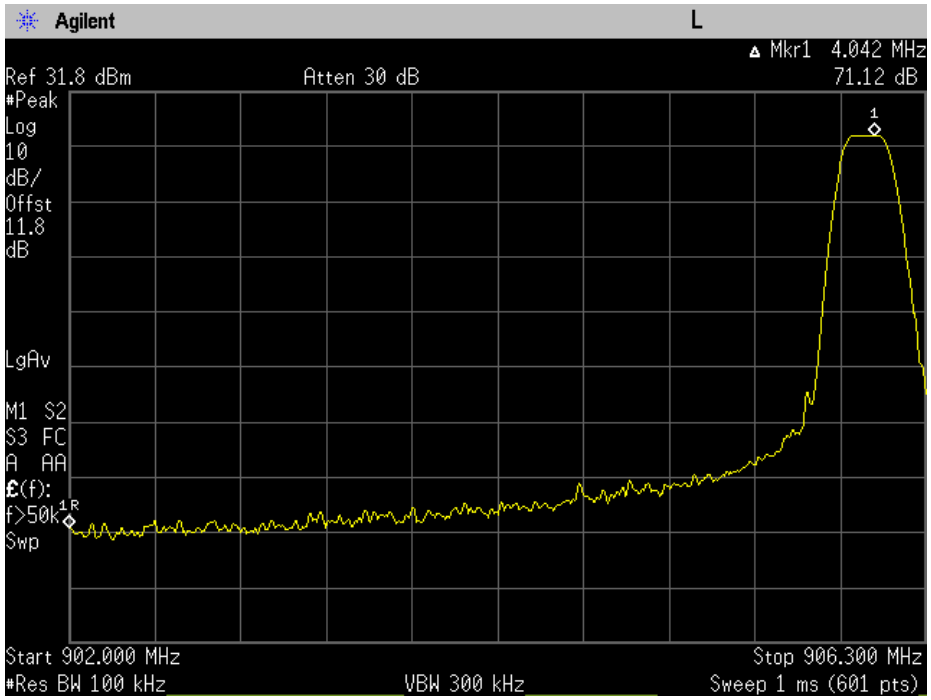
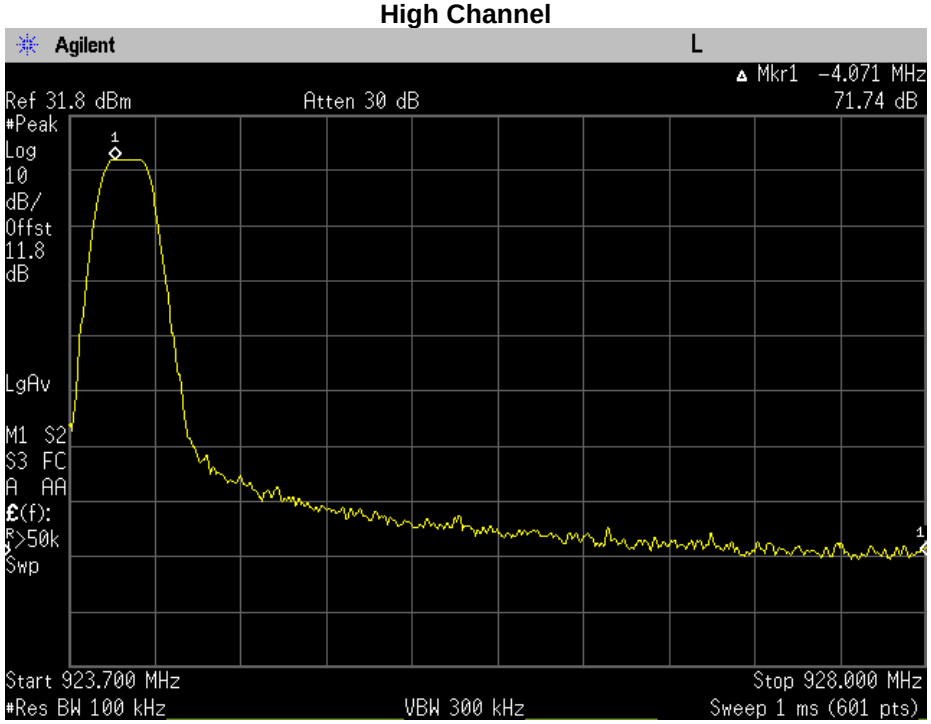


LORA (FHSS)

Low Channel

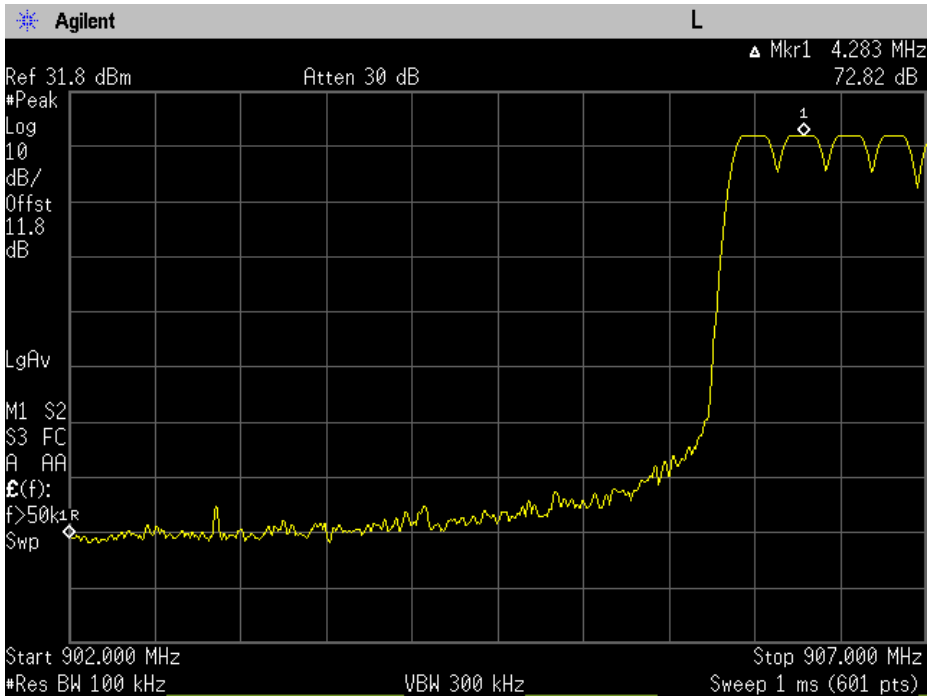


High Channel

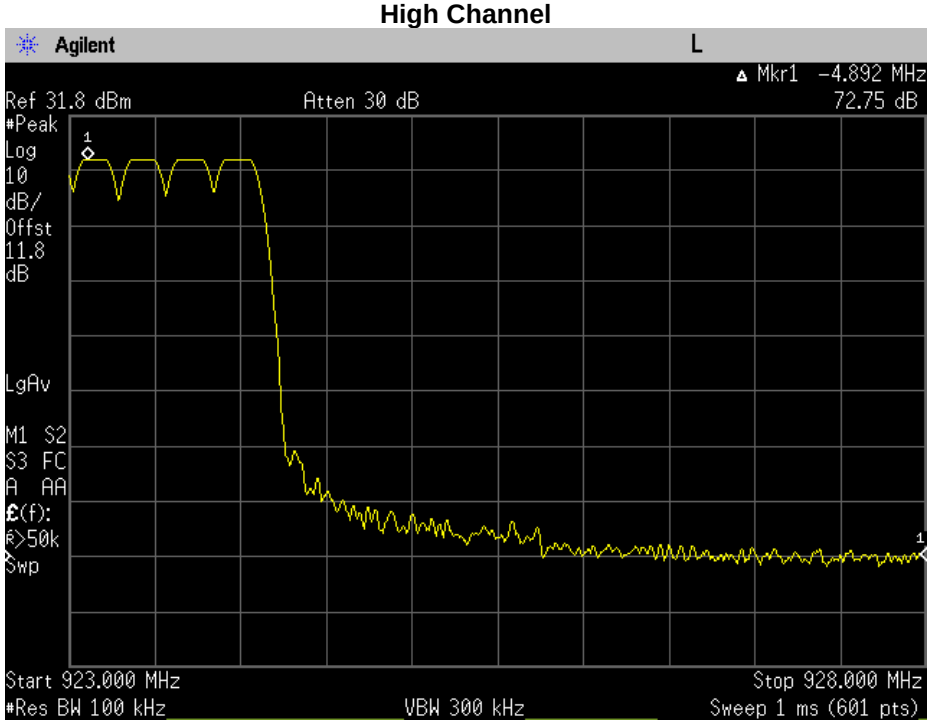


LORA (FHSS) Hopping

Low Channel



High Channel



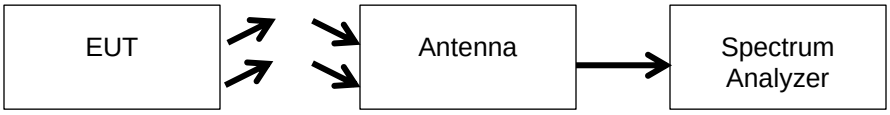
DTS Bandwidth
Engineer: Kenneth Lee
Test Date: 8/1/2017

Test Procedure

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.
The Spectrum Analyzer was set to the following:

RBW = 100 kHz
VBW ≥ 3 x RBW
Peak Detector
Trace mode = max hold
Sweep = auto couple
Span = 1.5 x EBW

Test Setup



6 dB Occupied Bandwidth Summary – LORA (DTS)

Frequency (MHz)	Measured Bandwidth (kHz)	Specification Limit (kHz)	Result
906	840.110	≥ 500	Pass
915	837.651	≥ 500	Pass
924	831.711	≥ 500	Pass

99% Bandwidth Summary – LORA (DTS)

Frequency (MHz)	Measured Bandwidth (kHz)	Result
906	877.381	Pass
915	873.848	Pass
924	866.405	Pass

-20 dB Occupied Bandwidth Summary – FSK

Frequency (MHz)	Measured Bandwidth (kHz)	Specification Limit (kHz)	Result
906	390.277	< 500	Pass
915	390.941	< 500	Pass
924	388.562	< 500	Pass

99% Bandwidth Summary – FSK

Frequency (MHz)	Measured Bandwidth (kHz)	Result
906	323.681	Pass
915	324.546	Pass
924	322.105	Pass

-20 dB Occupied Bandwidth Summary – LORA (FHSS)

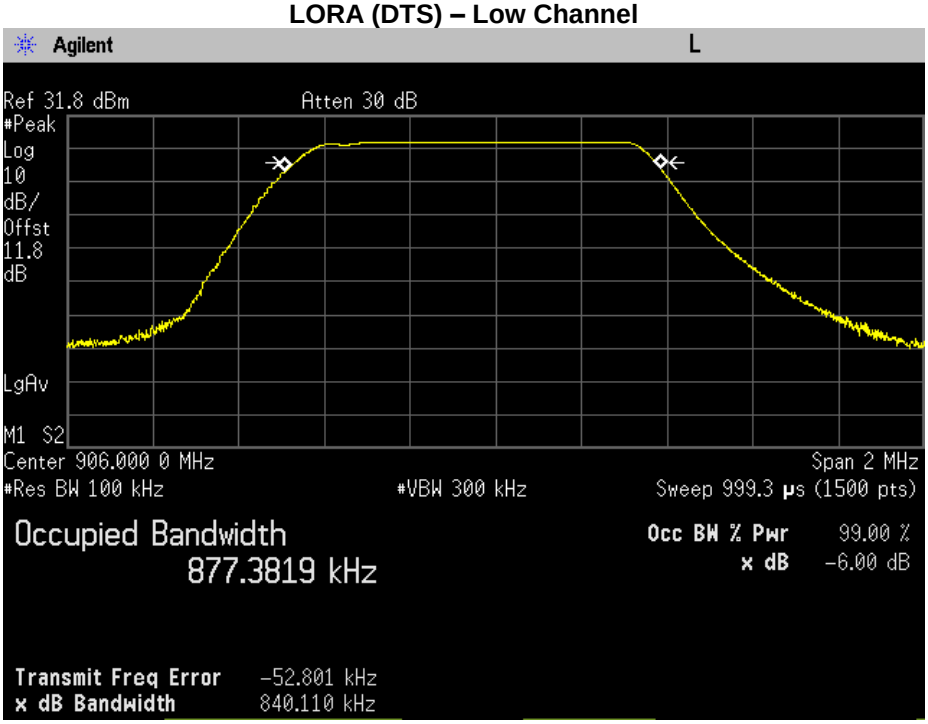
Frequency (MHz)	Measured Bandwidth (kHz)	Specification Limit (kHz)	Result
906	383.144	< 500	Pass
915	383.333	< 500	Pass
924	381.942	< 500	Pass

99% Bandwidth Summary – LORA (FHSS)

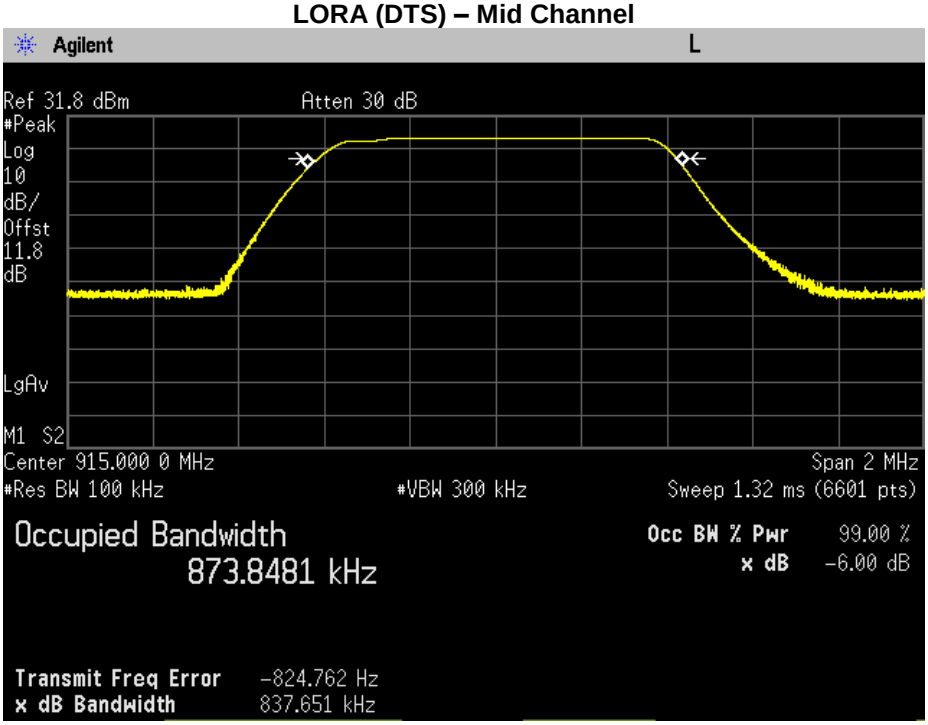
Frequency (MHz)	Measured Bandwidth (kHz)	Result
906	319.063	Pass
915	317.958	Pass
924	317.351	Pass

6 dB and 99% Bandwidth Plots

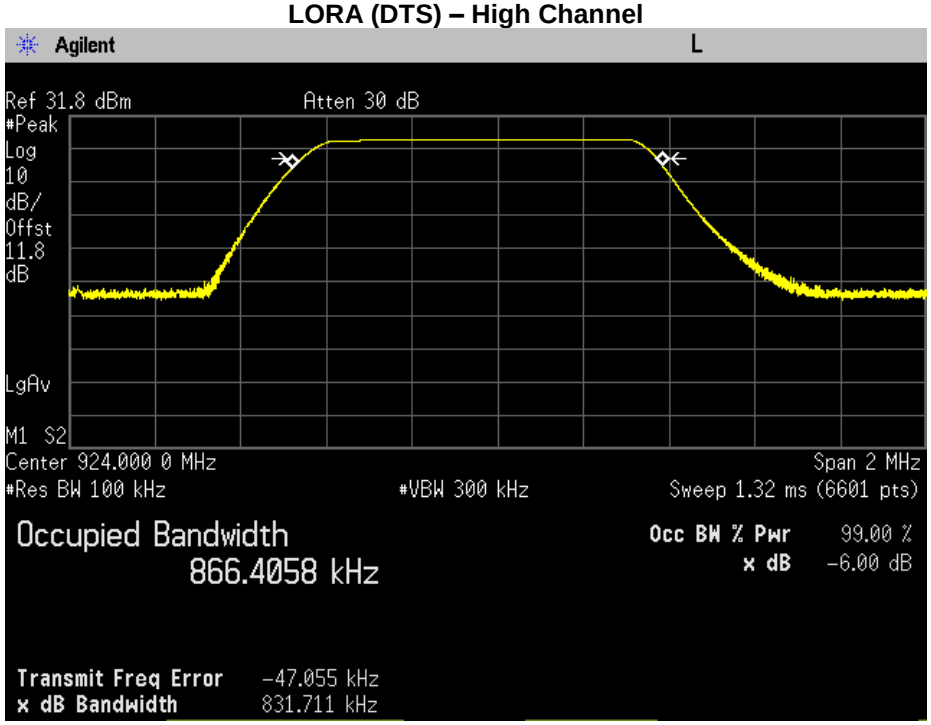
LORA (DTS) – Low Channel



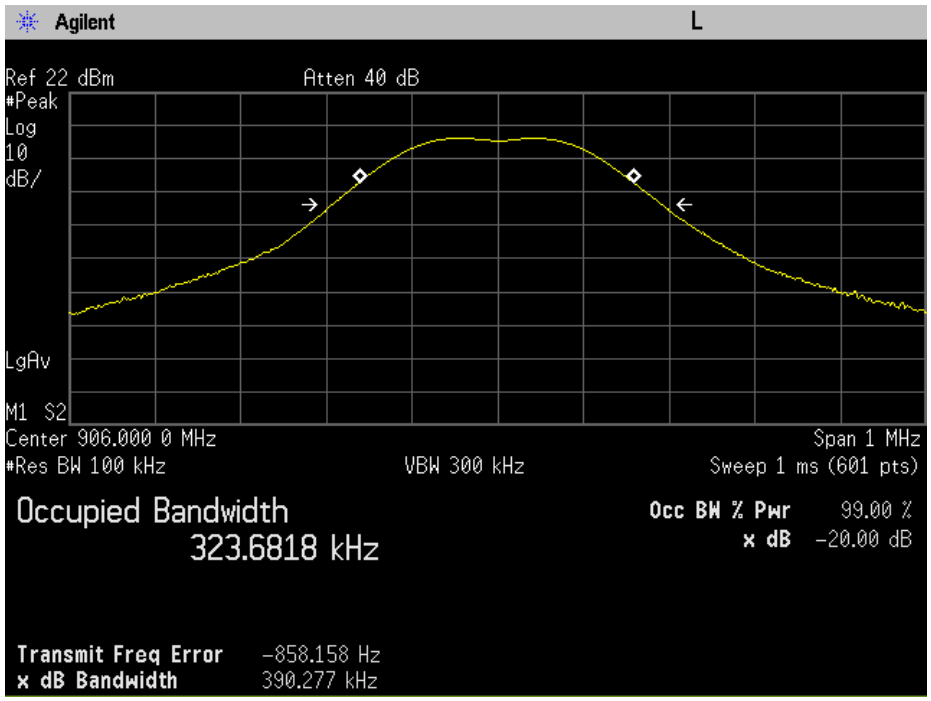
LORA (DTS) – Mid Channel



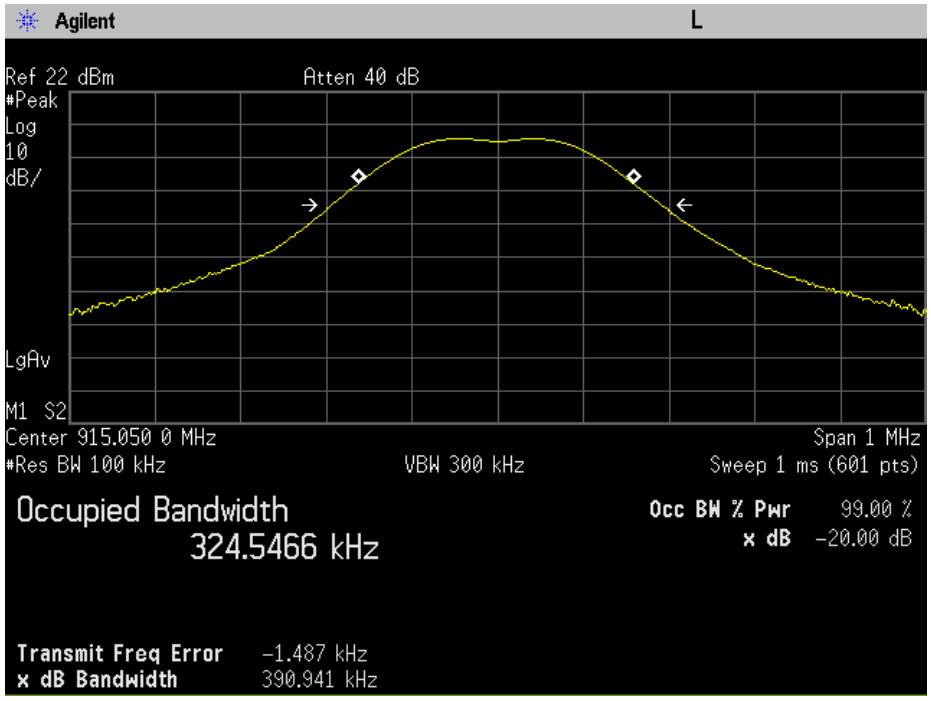
LORA (DTS) – High Channel



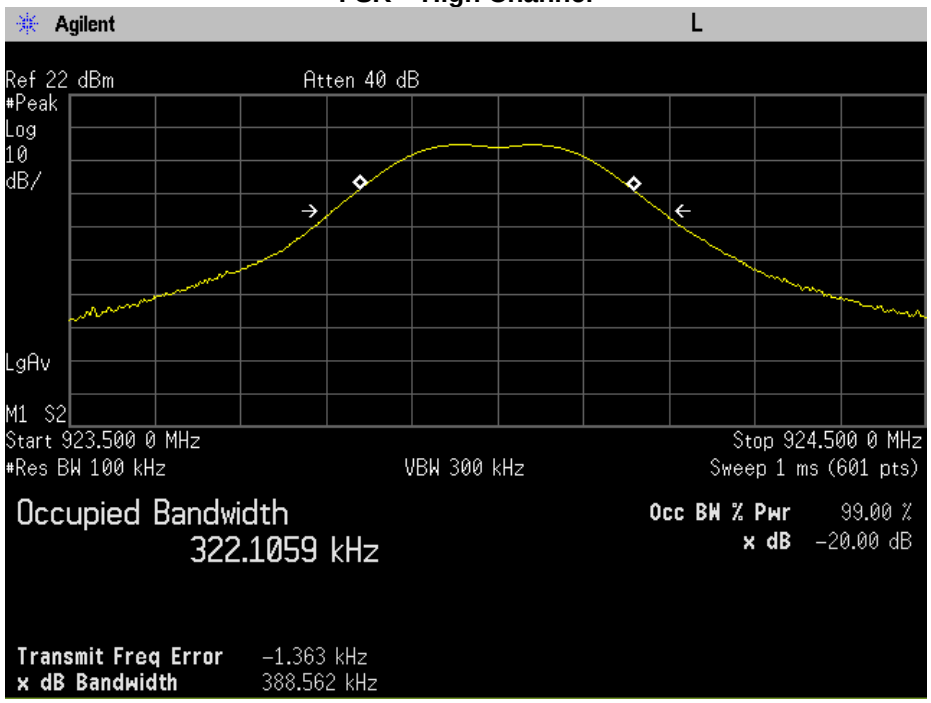
FSK – Low Channel



FSK – Mid Channel

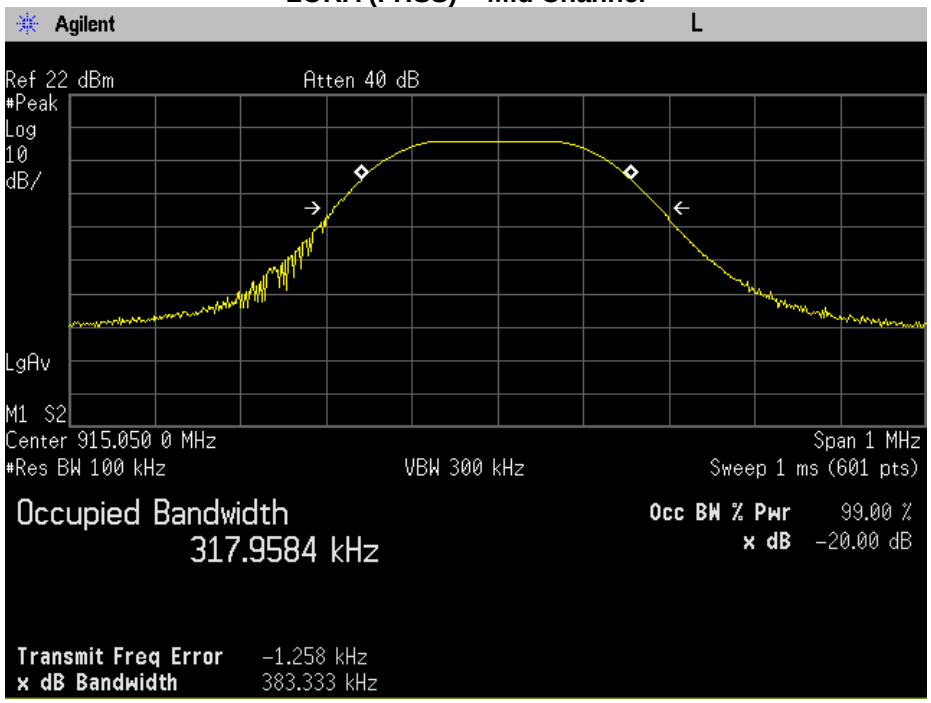


FSK – High Channel

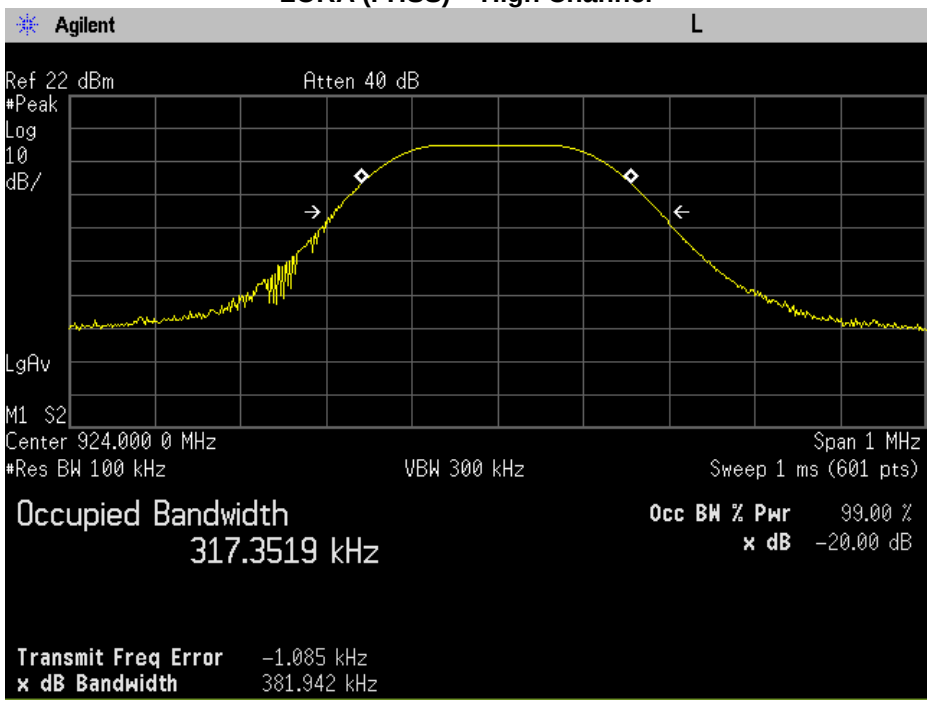


LORA (FHSS) – Low Channel

LORA (FHSS) – Mid Channel



LORA (FHSS) – High Channel



Transmitter Power Spectral Density (PSD)

Engineer: Kenneth Lee

Test Date: 8/1/2017

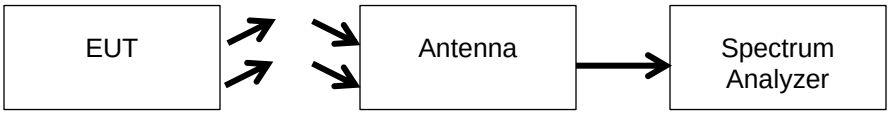
Test Procedure

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.
The Spectrum Analyzer was set to the following:

DTS channel center frequency
Span 1.5 x OBW bandwidth
RBW =3 kHz ≤ RBW ≤ 100 kHz
VBW ≥ 3 x RBW
RMS Detector
Number of points in sweep ≥ 2 x span / RBW
Trace average at least 100 traces in power averaging mode
Sweep time = auto couple

The EUT was set to transmit at the lowest, middle and highest channels of the band at the maximum power levels. Once the trace has stabilized the peak marker was used to determine the power spectral density.

Test Setup

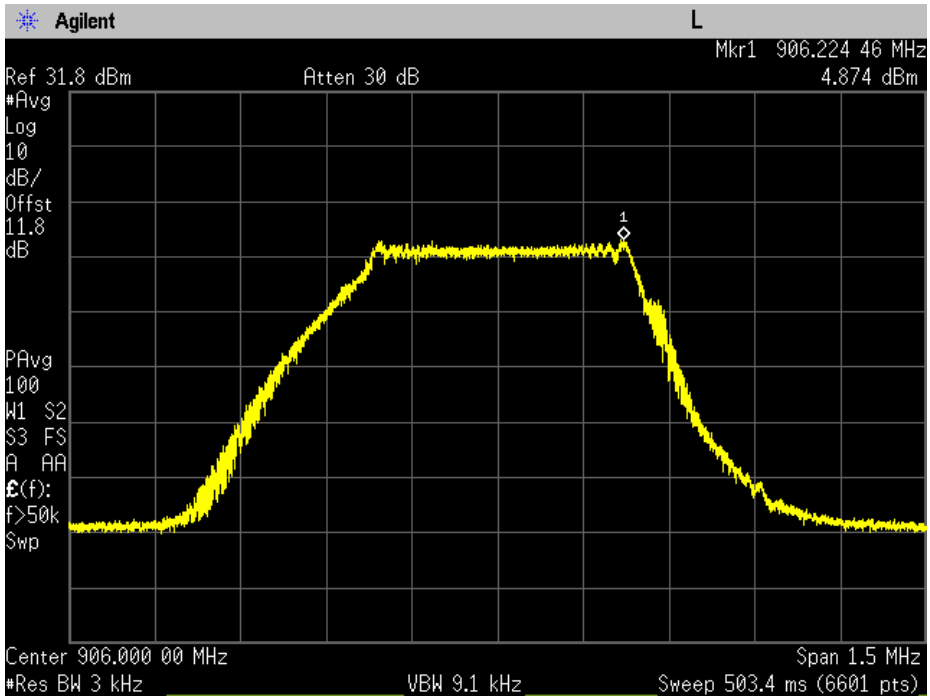


PSD Summary

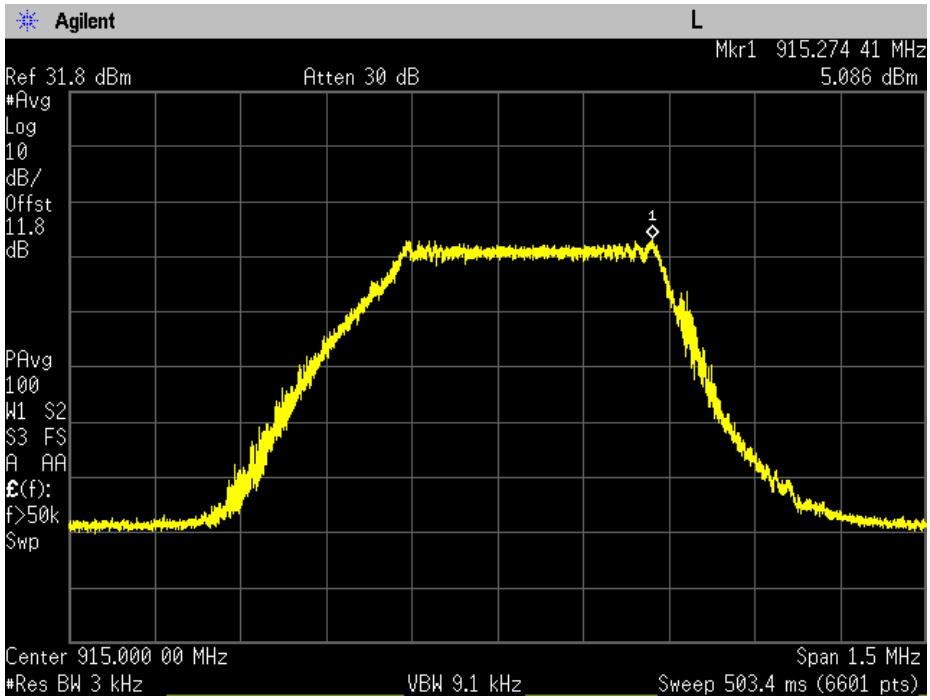
Frequency (MHz)	Measured Data (dBm)	Specification Limit (dBm)	Result
906	4.874	8	Pass
915	5.086	8	Pass
924	5.107	8	Pass

PSD Plots

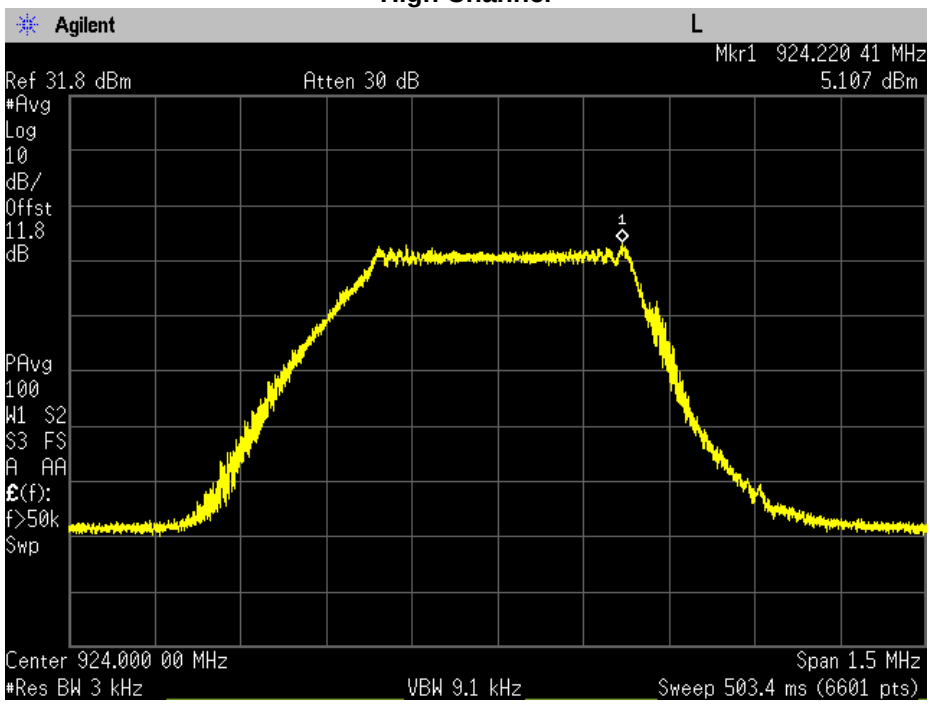
Low Channel



Mid Channel



High Channel



Dwell Time

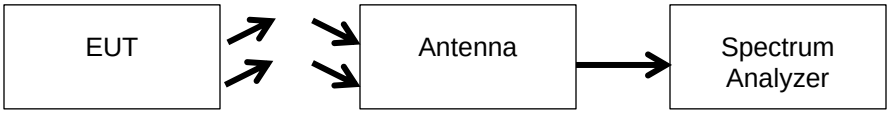
Engineer: Kenneth Lee

Test Date: 8/1/2017

Test Procedure

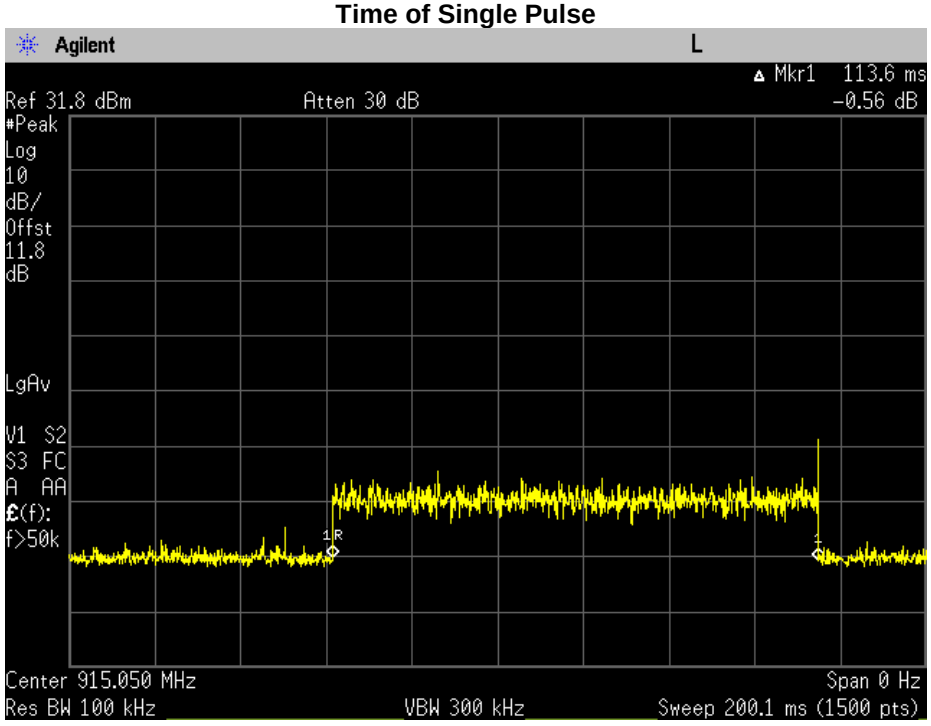
The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized. The EUT was set to hopping mode with the spectrum analyzer set to a 0 Hz span. A single transmission was captured and the dwell time was recorded.

Test Setup

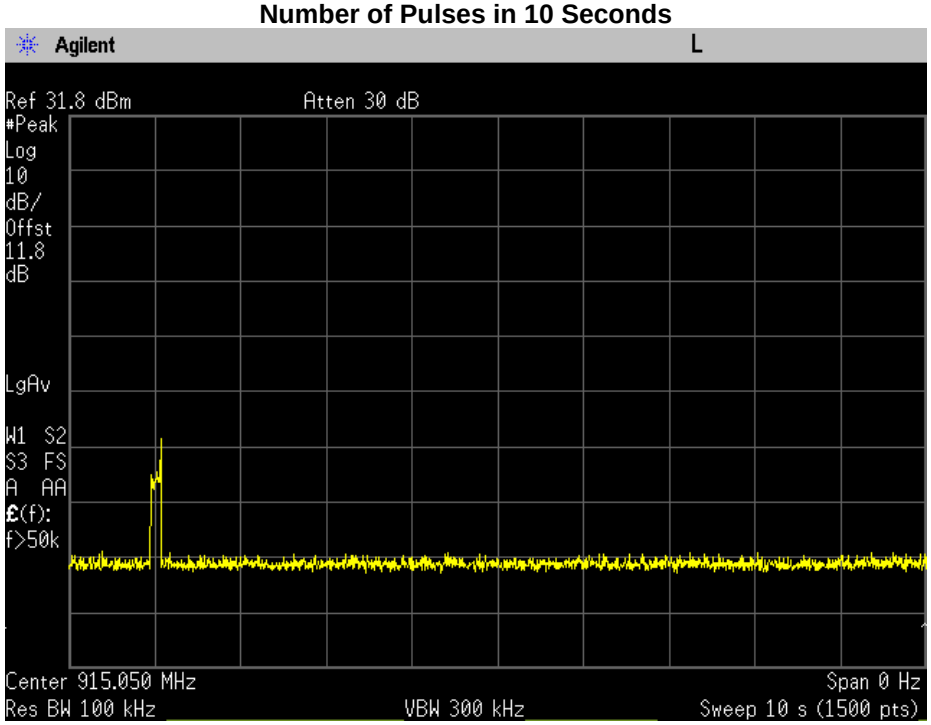


LORA (FHSS)

Time of Single Pulse



Number of Pulses in 10 Seconds

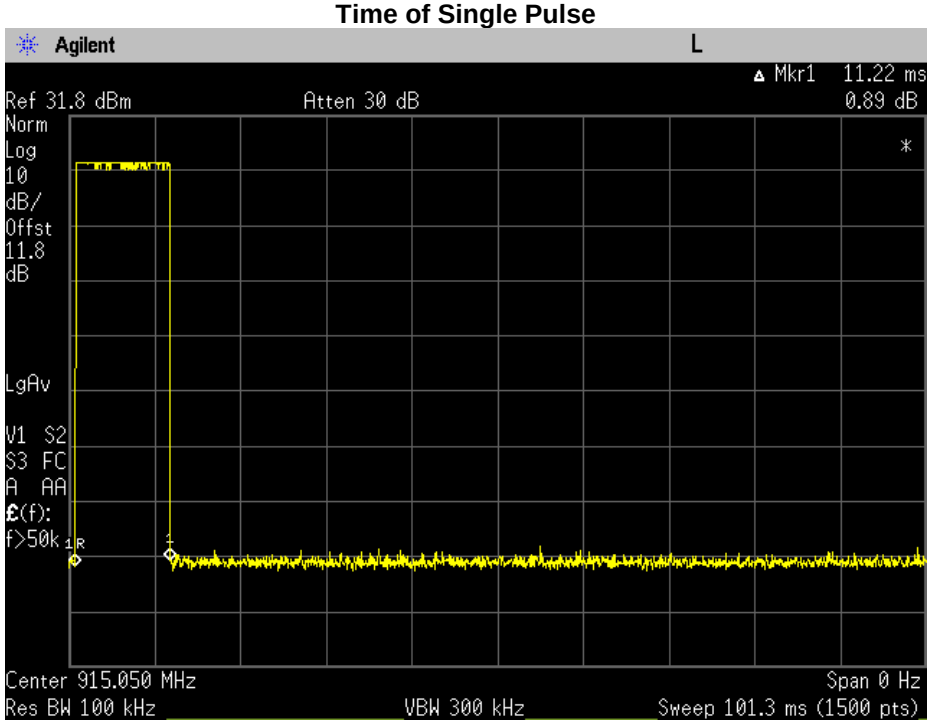


Dwell Time Limit is 400 ms within 10 seconds

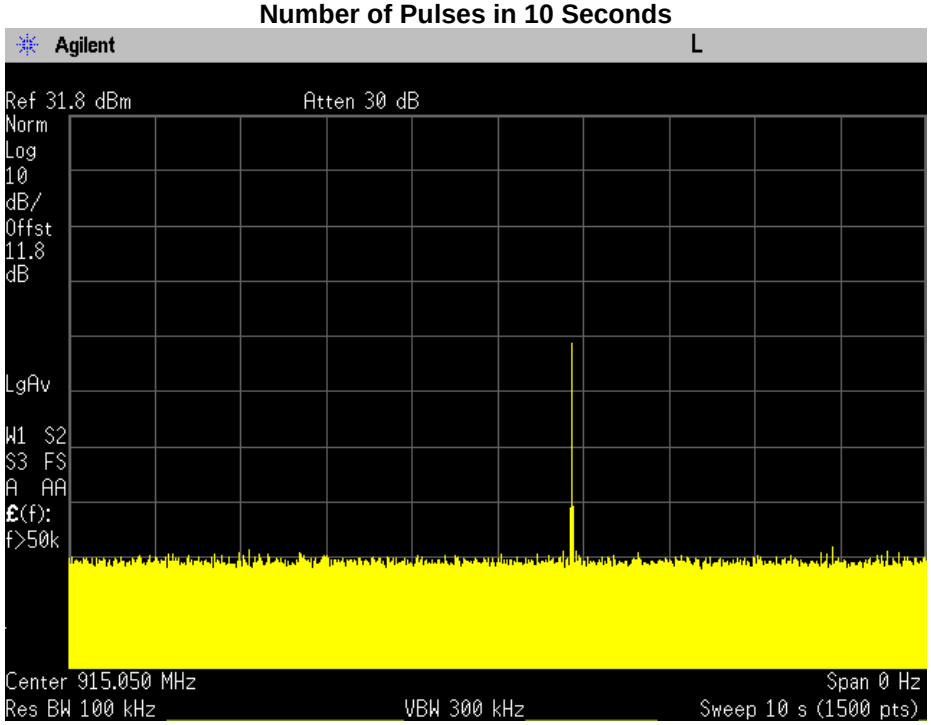
Time of One Pulse = 113.6 ms
Number of Pulses in 10 Seconds = 1

FSK

Time of Single Pulse



Number of Pulses in 10 Seconds



Dwell Time Limit is 400 ms within 10 seconds

Time of One Pulse = 25 ms
Number of Pulses in 10 Seconds = 1

Note: The Manufacturer claims the worst-case dwell time is 25 ms so this will be used as the worst case.

Number of Hopping Channels

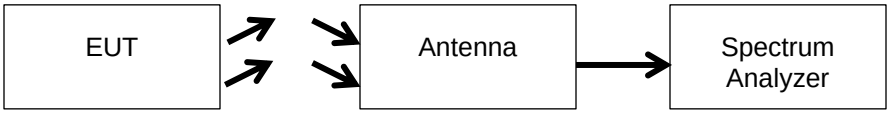
Engineer: Kenneth Lee

Test Date: 8/1/2017

Test Procedure

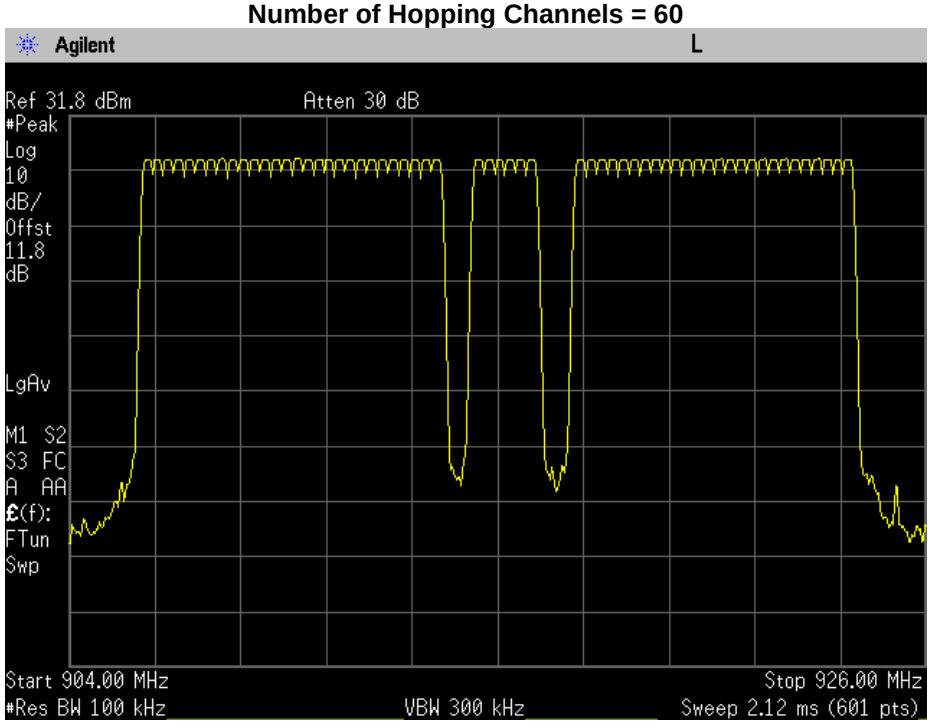
The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized. The Span was set to the specified band end points. The EUT was then set to operate in hopping mode. The MAX HOLD function of the spectrum analyzer was utilized to verify the number of hopping cannels.

Test Setup



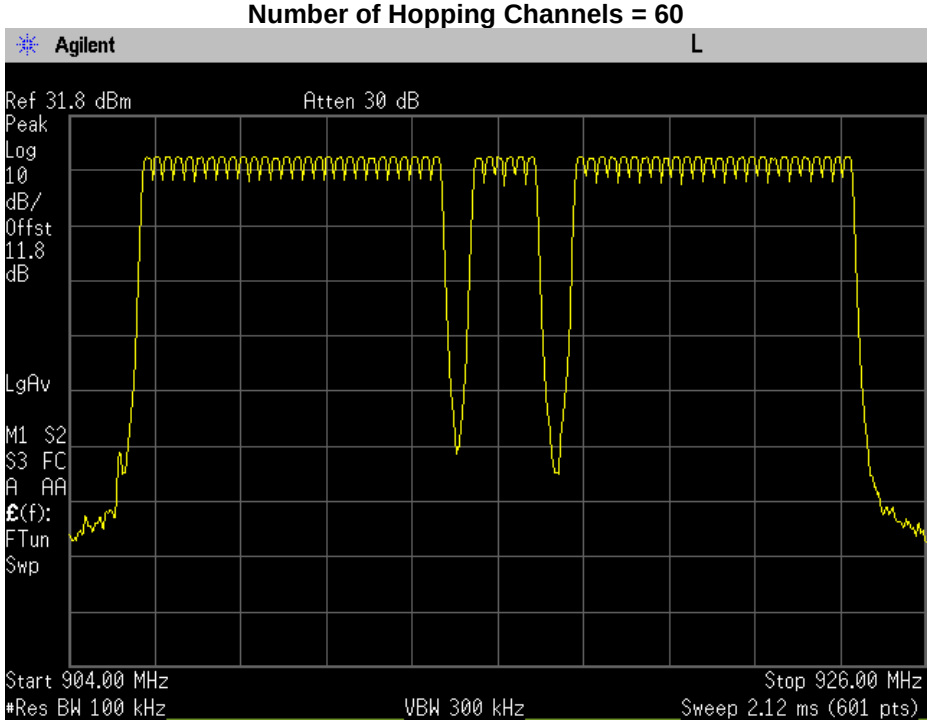
LORA (FHSS)

Number of Hopping Channels = 60



FSK

Number of Hopping Channels = 60



Channel Frequency Separation

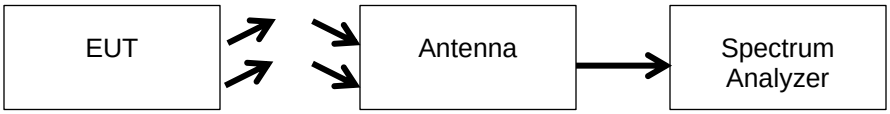
Engineer: Kenneth Lee

Test Date: 8/1/2017

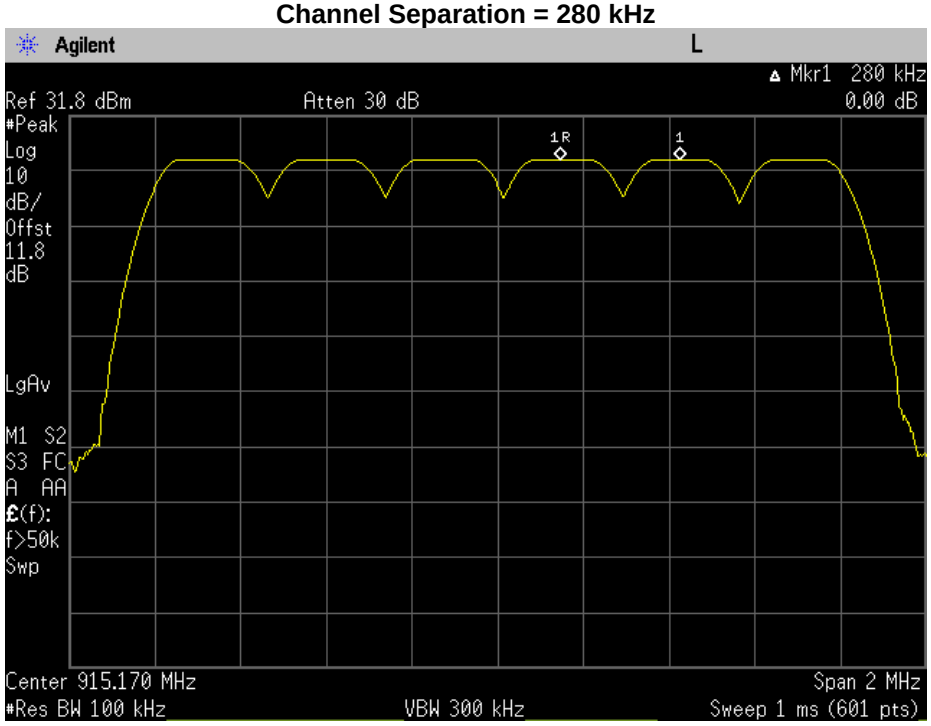
Test Procedure

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was tested by rotating it 360° with the antenna in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized. The Span was set to encompass a minimum of two hopping channels. The EUT was then set to operate in hopping mode. The MAX HOLD and Marker Delta functions of the spectrum analyzer were utilized to verify the channel separation.

Test Setup

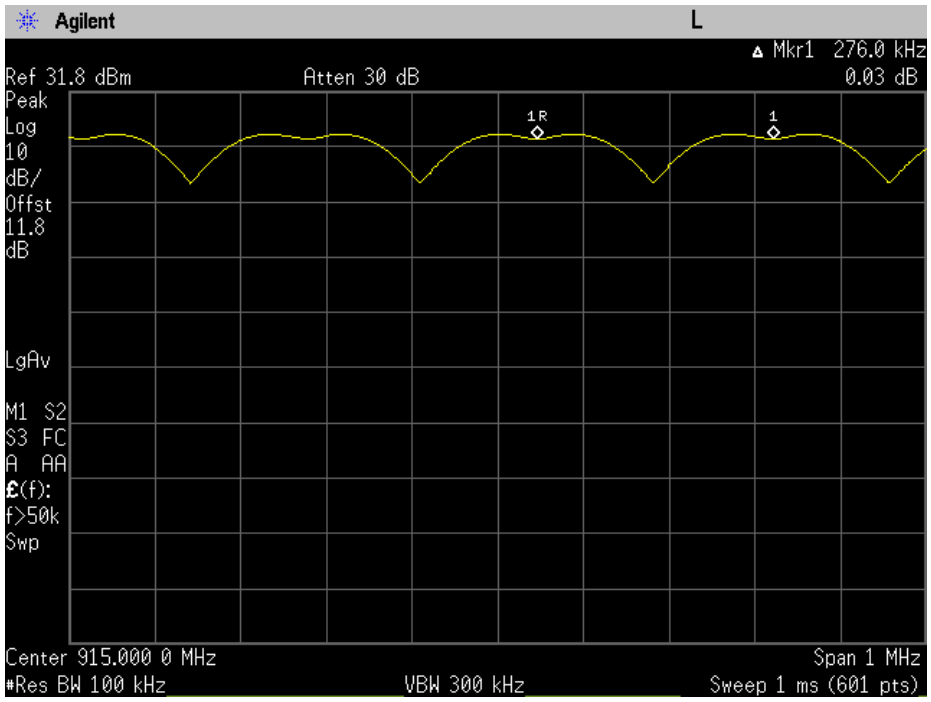


LORA (FHSS)
Channel Separation = 280 kHz



FKS

Channel Separation = 276 kHz



Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Horn Antenna	ARA	DRG-118/A	i00271	6/16/16	6/16/18
Humidity / Temp Meter	Newport	IBTHX-W-5	i00282	6/9/17	6/9/18
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	8/3/16	8/3/18
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	8/15/16	8/15/19
PSA Spectrum Analyzer	Agilent	E4445A	i00471	8/30/16	8/30/17
Preamplifier for 1-18GHz horn antenna	Miteq	AFS44 00101 400 23-10P-44	i00509	N/A	N/A

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT