Testing Tomorrow's Technology

Application

For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247

And

Part 2, Subpart J, Section 2.902, Verification **Per** **Part 15, Subpart B, for Unintentional Radiators, section 15.101, 15.107 and 15.109**

And

Industry Canada RSS-Gen, Issue 4 and RSS-247, Issue 1

For the

Mueller Systems, LLC

Model: DCOM4-LP

FCC ID: SM6-MINODE-M
IC: 9235A-MINODEM

UST Project: 16-0118
Issue Date: July 22, 2016

Total Pages in This Report: 70

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Testing Tomorrow's Technology

I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: Alan Ghasiani

Title: Compliance Engineer – President

Date July 22, 2016

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Mueller Systems, LLC

MODEL: DCOM4-LP

FCC ID: SM6-MINODE-M

IC: 9235A-MINODE

DATE: July 22, 2016

This report concerns (check one): Original grant X
Class II change

Equipment type: 903.65-927.70 MHz Transmitter Module

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? yes_____ No X

If yes, defer until: N/A
date

agrees to notify the Commission by N/A
date

of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
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1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 247 and Industry Canada RSS-247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on May 9, 2016 in good operating condition.

1.3 Product Description

The Equipment Under Test (EUT) is the Mueller Systems, LLC Model DCOM4-LP. The DCOM4-LP is a transmitter module with:

Antenna: Dipole (2 dBi Gain)
Modulation: FHSS (912.31 – 927.70 Mhz) and DTS (903.65 – 920.60 Mhz)
Maximum Output Power: 13 dBm (TXM 1) and 20 dBm (TXM 2)
Maximum Data rate: 4557.3 bps (FHSS) and 10416.7 bps (DTS)

The module was tested with the host device which is a wireless data logger used by utility companies, such as water utilities.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for FCC subpart A Digital equipment Verification requirements and per FCC KDB Publication number 558074 for Digital Transmission Systems Operating Under section 15.247. Also, FCC, KDB Publication No. 558074 and FCC Public Notice DA 00-705 was used as a test procedure guide.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs are provided in separate Appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

The Equipment Under Test (EUT) is subject to the following FCC/IC authorizations:

a) Certification under section 15.247/IC RSS-247 as a transmitter.
b) Verification under 15.101/ICES-003 as a digital device and receiver.

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report for the EUT is included herein.

1.7 Test Results

In our opinion, and as indicated by the test results documented following, when tested in the configuration as described in this report, the EUT meets the applicable requirements of FCC and IC, including: FCC Parts 2.902, 15.101, 15.107, 15.109, 15.207, 15.209, 15.247, RSS GEN, and RSS-247.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
EUT Mueller Systems, LLC	DCOM4-LP	Engineering Sample	SM6-MINODE-M (Pending)	None
Antenna See antenna details	--	--	--	--

U= Unshielded
S= Shielded
P= Power
D= Data

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2410A00109	05/07/2015 Extended 90 days
SPECTRUM ANALYZER	E4407B	Agilent	US41442935	2/11/2016
PREAMP	8449B	HEWLETT-PACKARD	3008A00480	12/01/2015
PREAMP	8447D	HEWLETT-PACKARD	1145A00307	12/03/2015
PREAMP	8447D	HEWLETT-PACKARD	1937A02980	03/27/15 Ext. 90 days
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/28/2015 2 yr
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2015 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	7/01/2014 2 yr
HORN ANTENNA	SAS-571	A. H. Systems	605	8/25/2015 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	7/8/2014 2 yr

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 below.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the device operates	Number of Frequencies	Location in the Range of operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates at 903.65 MHz to 927.70 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10^{th} harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

2.6 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Antenna 1	Economy Spring and Stamping	Monopole	145-0029-001	2.0	Soldered

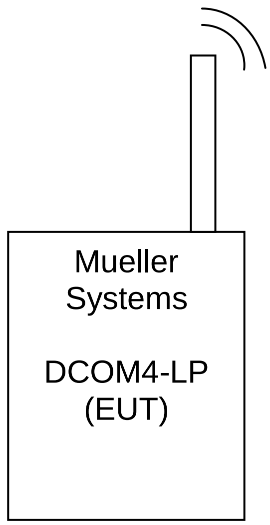

Figure 1. Block Diagram of Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other Spurious are examined for this requirement see paragraph 2.10 of the test report.

2.8 Transmitter Duty Cycle (CFR 15.35 (c))

When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification.

In this case the EUT operates for longer than 0.1 seconds therefore the AVG absolute method was use for all AVG measurements.

2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The EUT is powered by a 3.6 VDC Lithium battery**.** Since the EUT is battery powered, this test was not applicable.

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

Radiated Spurious measurements: The EUT was placed into a continuous transmit mode of operation (>98%) duty cycle) and tested per ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the device. A preliminary scan was performed on the EUT to find the worse case results the EUT was tested in X, Y, and Z axes or in the orientation of normal operation if the device is designed to operate in a fixed position. The EUT has two possible modes for transmitting. The first is “TXM 1” which has a maximum rated output level of +13.0 dBm the second is “TXM 2” which has a maximum rated output level of +20.0 dBm.

Radiated measurements were conducted between the frequency range of 9 kHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (not greater than 40 GHz). In the band below 30 MHz, a resolution bandwidth (RBW) of 9 kHz was used; emissions below 1 GHz were tested with a RBW of 100/120 kHz and emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value.

The EUT was investigated per CFR 15.209, General requirements for unwanted spurious emissions. The conducted spurious method as described below was used to investigate all other emissions emanating from the antenna port.

Conducted Spurious measurements: The EUT was put into a continuous-transmit mode of operation (>98% duty cycle) and tested per FCC Public Notice DA 00-705 for conducted out of band emissions emanating form the antenna port over the frequency range of 30 MHz to 25 GHz. A conducted scan was performed on the EUT to identify and record the spurious signals that were related to the transmitter. The EUT was placed in “TXM 2” mode because the output power was larger than the “TXM 1” mode output power.

Table 5. Intentional Radiator, Spurious Radiated Emissions (CFR 15.209), 9 kHz to 30 MHz

9 kHz to 30 MHz							
Test: Radiated Emissions				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
All emissions seen were 20 dB or more below the limit.							

Tested from 9 kHz to 30 MHz

SAMPLE CALCULATION: N/A

Test Date: May 16, 2016
Tested By
Signature: ____________ Name: Robert Nevels

Table 6. Average Radiated Fundamental & Harmonic Emissions (“TXM 1”)

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – AVERAGE							
903.65	88.90	23.96	112.86	--	3m./VERT	--	AVG
1807.30	44.89	-6.35	38.54	72.9	3.0m./VERT	34.36	AVG
Mid Channel – AVERAGE							
915.00	89.40	23.96	113.36	--	3m./VERT	--	AVG
1830.00	38.91	-6.49	32.42	73.4	3.0m./VERT	40.98	AVG
High Channel – AVERAGE							
927.70	90.10	23.90	114.00	--	3m./VERT	--	AVG
1854.00	41.88	-4.07	37.81	74.0	3.0m./VERT	36.19	AVG

-

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. (~) Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 1807.30 MHz:

Magnitude of Measured Frequency	44.89	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-6.35	dB/m
Corrected Result	38.54	dBuV/m

Test Date: May 18, 2016
Tested By
Signature: Name: Robert Nevels

Table 7. Peak Radiated Fundamental & Harmonic Emissions ("TXM 1")

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – PK							
903.65	88.80	23.96	112.76		3m./VERT		PK
1807.30	52.48	-6.35	46.13	92.7	3.0m./VERT	46.57	PK
Mid Channel – PK							
915.00	89.45	23.96	113.41		3m./VERT		PK
1830.00	49.26	-6.49	42.77	93.4	3.0m./VERT	50.63	PK
High Channel – PK							
927.00	90.05	23.90	113.95		3m./VERT		PK
1854.00	51.69	-4.07	47.62	93.9	3.0m./VERT	46.28	PK

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for **peak** measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10^{th} harmonic
3. (~) Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 1807.30 MHz:

Magnitude of Measured Frequency	52.48	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-6.35	dB/m
Corrected Result	46.13	dBuV/m

Test Date: May 18, 2016
Tested By
Signature: Robert S. Nevels Name: Robert Nevels

Table 8. Average Radiated Fundamental & Harmonic Emissions "TXM 2"

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – AVERAGE							
903.65	95.88	23.96	119.84		3m./VERT	23.96	AVG
1807.40	57.89	-6.35	51.54	79.8	3.0m./VERT	28.2	AVG
2710.80	44.37	-2.85	41.52	54.0	3.0m./VERT	12.5	AVG
3614.50	40.32	-0.32	40.00	54.0	3.0m./VERT	14.0	AVG
Mid Channel – AVERAGE							
915.00	95.99	23.96	119.95		3m./VERT	23.96	AVG
1830.00	54.95	-6.49	48.46	79.9	3.0m./VERT	31.4	AVG
2744.90	46.22	-2.77	43.45	54.0	3.0m./VERT	10.6	AVG
3660.00	40.21	-0.19	40.02	54.0	3.0m./VERT	14.0	AVG
High Channel – AVERAGE							
927.00	96.21	23.90	120.11		3m./VERT	23.90	AVG
1854.05	52.58	-4.07	48.51	80.1	3.0m./VERT	31.5	AVG
2781.00	47.77	-2.75	45.02	54.0	3.0m./VERT	9.0	AVG
3708.00	38.96	0.22	39.18	54.0	3.0m./VERT	14.8	AVG

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10^{th} harmonic
3. (~) Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 903.65 MHz:

Magnitude of Measured Frequency	95.88	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	23.96	dB/m
Corrected Result	119.84	dBuV/m

Test Date: May 18, 2016
Tested By
Signature: Robert S. Nevels   Name: Robert Nevels

Table 9. Peak Radiated Fundamental & Harmonic Emissions “TXM 2”

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Low Channel – PK							
903.65	95.66	23.96	119.62		3m./VERT		PK
1807.40	60.40	-6.35	54.05	99.6	3.0m./VERT	45.5	PK
2710.80	51.97	-2.85	49.12	74.0	3.0m./VERT	24.9	PK
3614.50	51.16	-0.32	50.84	74.0	3.0m./VERT	23.2	PK
Mid Channel – PK							
915.00	96.07	23.96	120.03		3m./VERT		PK
1830.00	58.68	-6.49	52.19	100.0	3.0m./VERT	48.8	PK
2744.90	52.86	-2.77	50.09	74.0	3.0m./VERT	23.9	PK
3660.00	48.93	-0.19	48.74	74.0	3.0m./VERT	25.3	PK
High Channel – PK							
927.00	96.06	23.90	119.96		3m./VERT		PK
1854.05	57.81	-4.07	53.74	99.9	3.0m./VERT	46.2	PK
2781.00	54.17	-2.75	51.42	74.0	3.0m./VERT	22.6	PK
3708.00	48.68	0.22	48.90	74.0	3.0m./VERT	25.1	PK

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for **peak** measurements of CFR 15.35.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10^{th} harmonic
3. (~)Measurements taken at 1 meter were extrapolated to 3 meters using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 1807.40 MHz:

Magnitude of Measured Frequency	60.40	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-6.35	dB/m
Corrected Result	54.05	dBuV/m

Test Date: May 18, 2016
Tested By
Signature: Robert S. Nevels Name: Robert Nevels

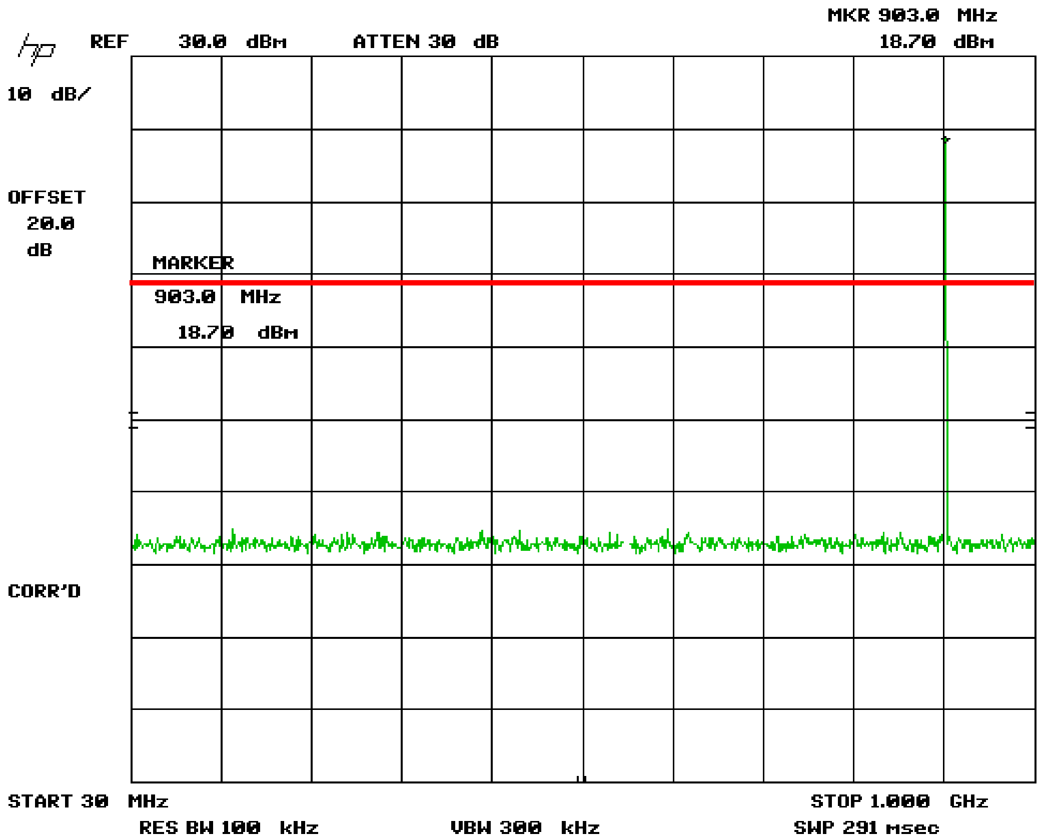

Figure 2. Antenna Conducted Emissions Low, Part 1 “TXM 2”

Note: Large emission seen is the fundamental emission.

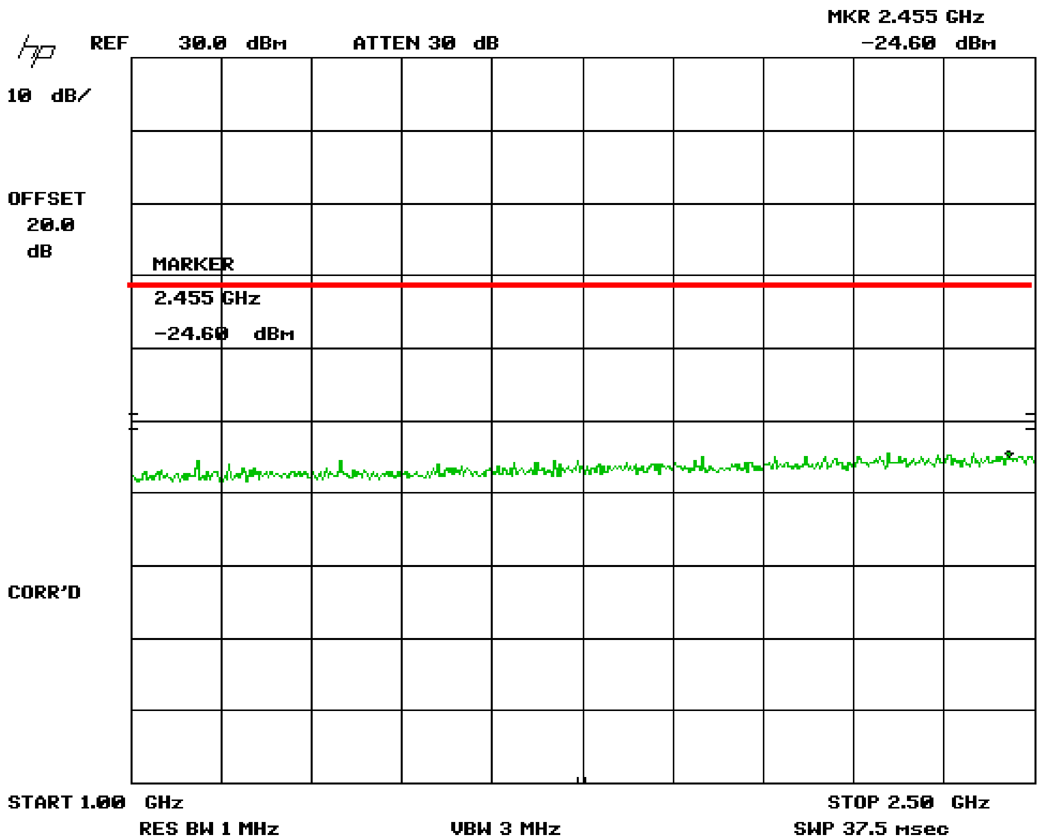

Figure 3. Antenna Conducted Emissions Low, Part 2 “TXM 2”

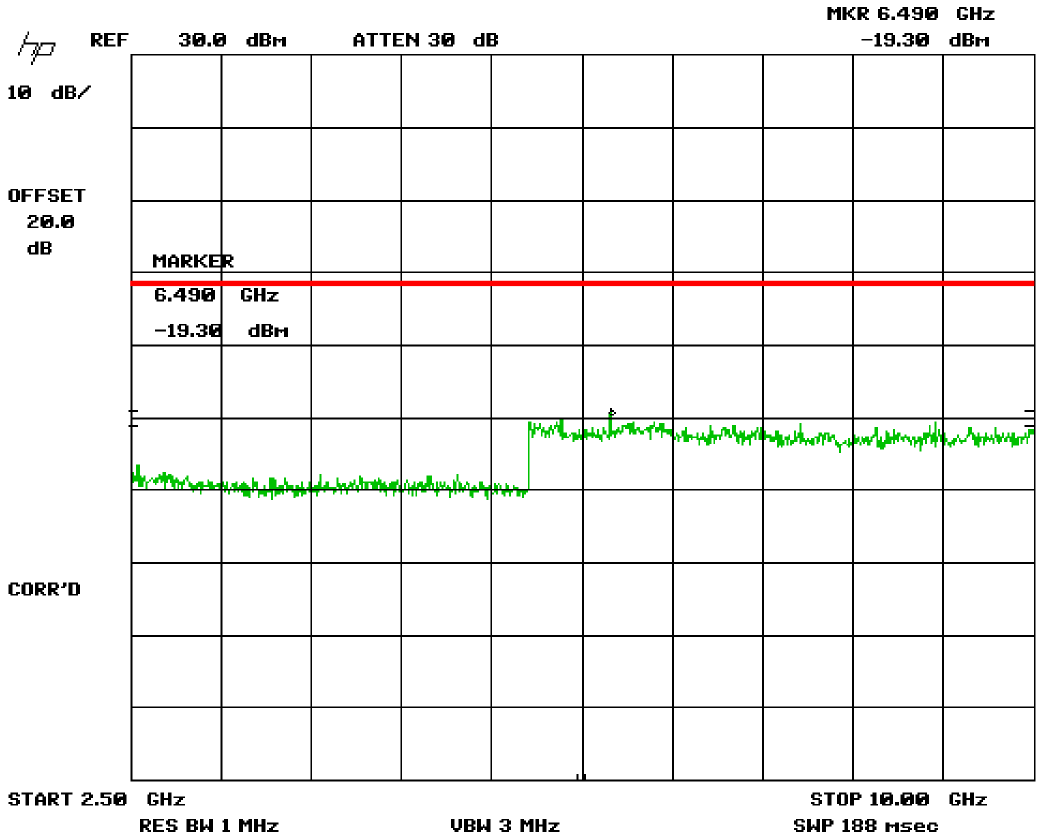

Figure 4. Antenna Conducted Emissions Low, Part 3 "TXM 2"

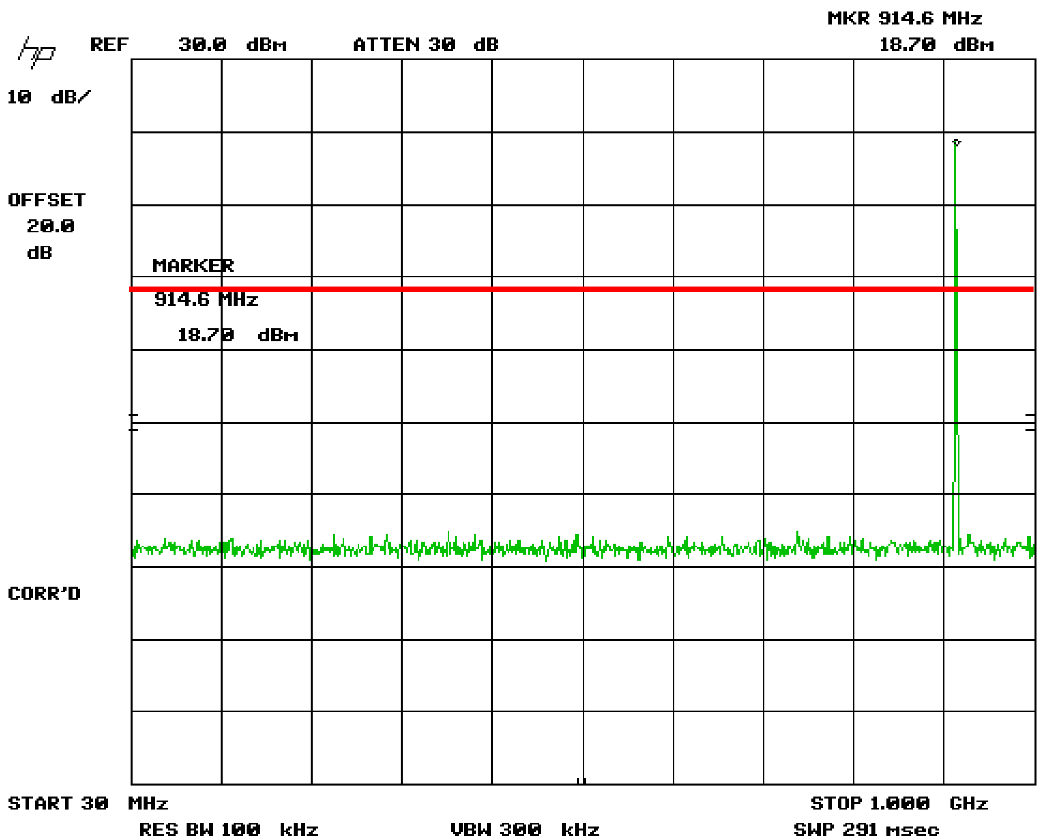

Figure 5. Antenna Conducted Emissions Mid, Part 1 "TXM 2"

Note: Large emission seen is the fundamental emission.

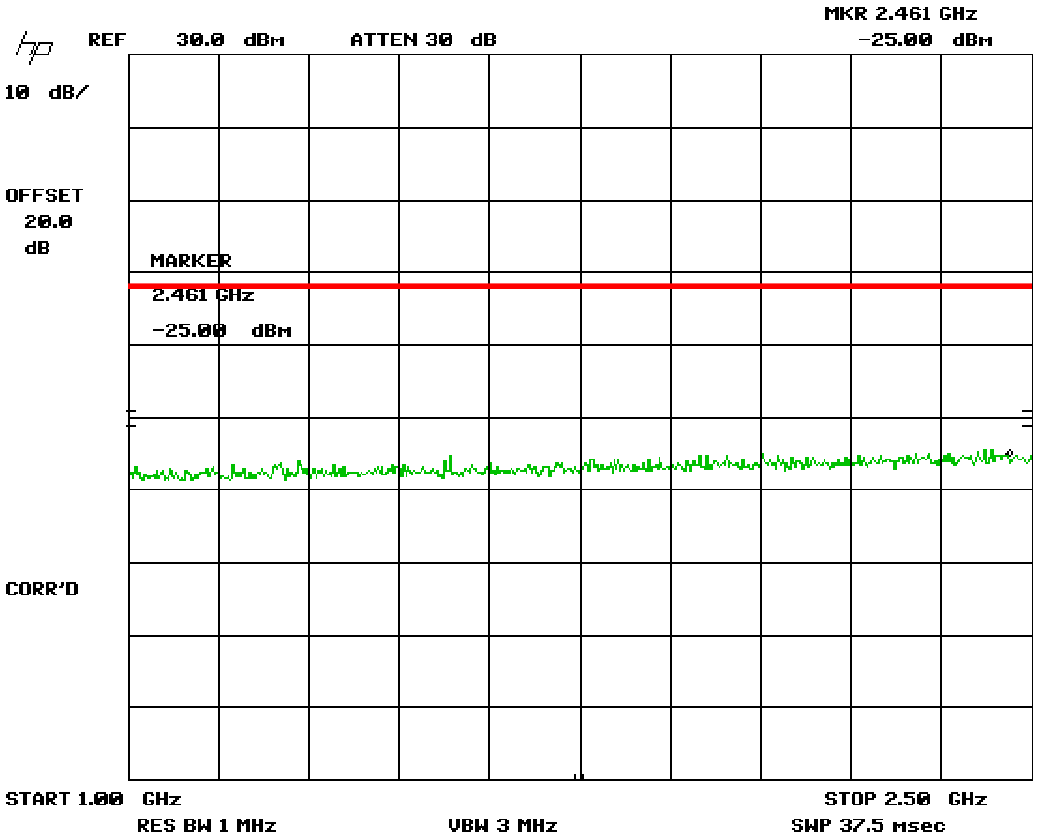

Figure 6. Antenna Conducted Emissions Mid, Part 2 "TXM 2"

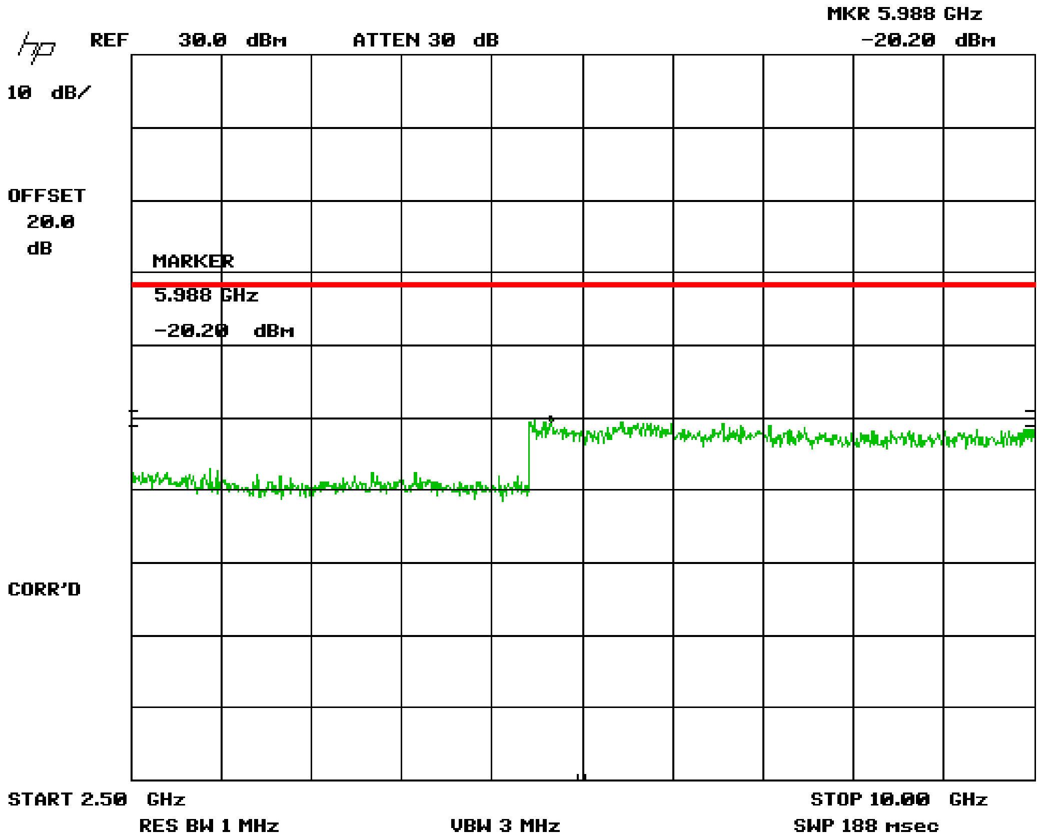

Figure 7. Antenna Conducted Emissions Mid, Part 3 "TXM 2"

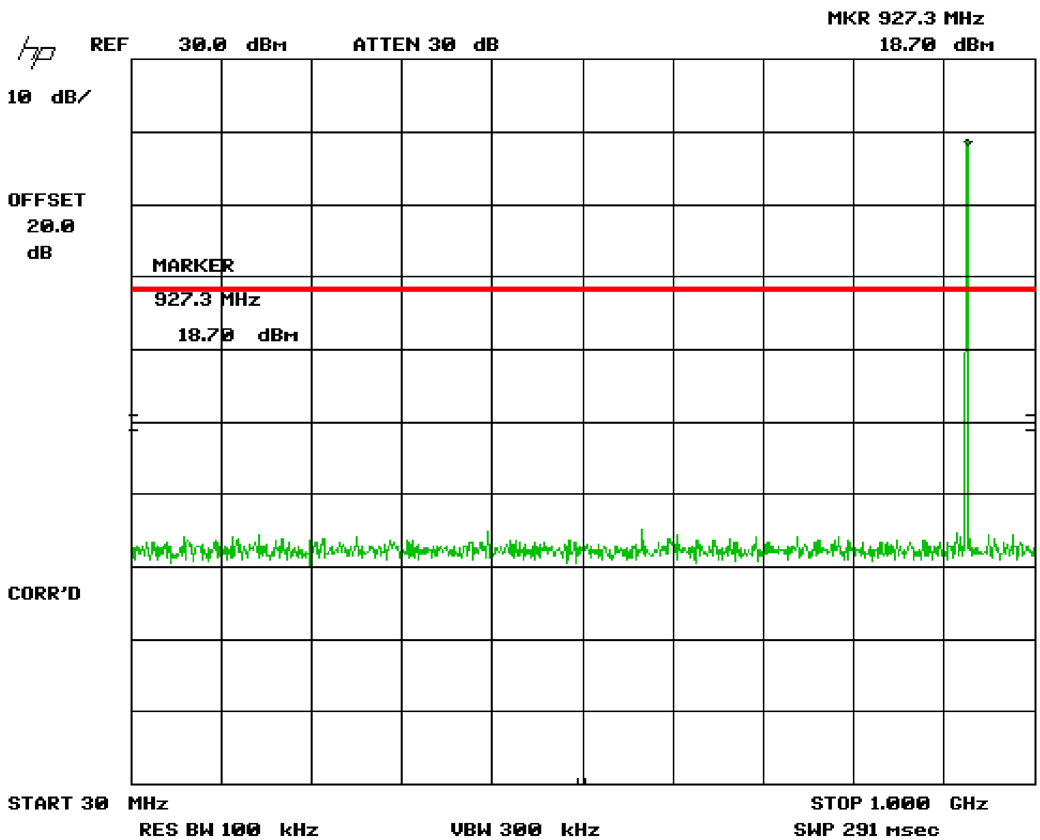

Figure 8. Antenna Conducted Emissions High, Part 1 “TXM 2”

Note: Large emission seen is the fundamental emission.

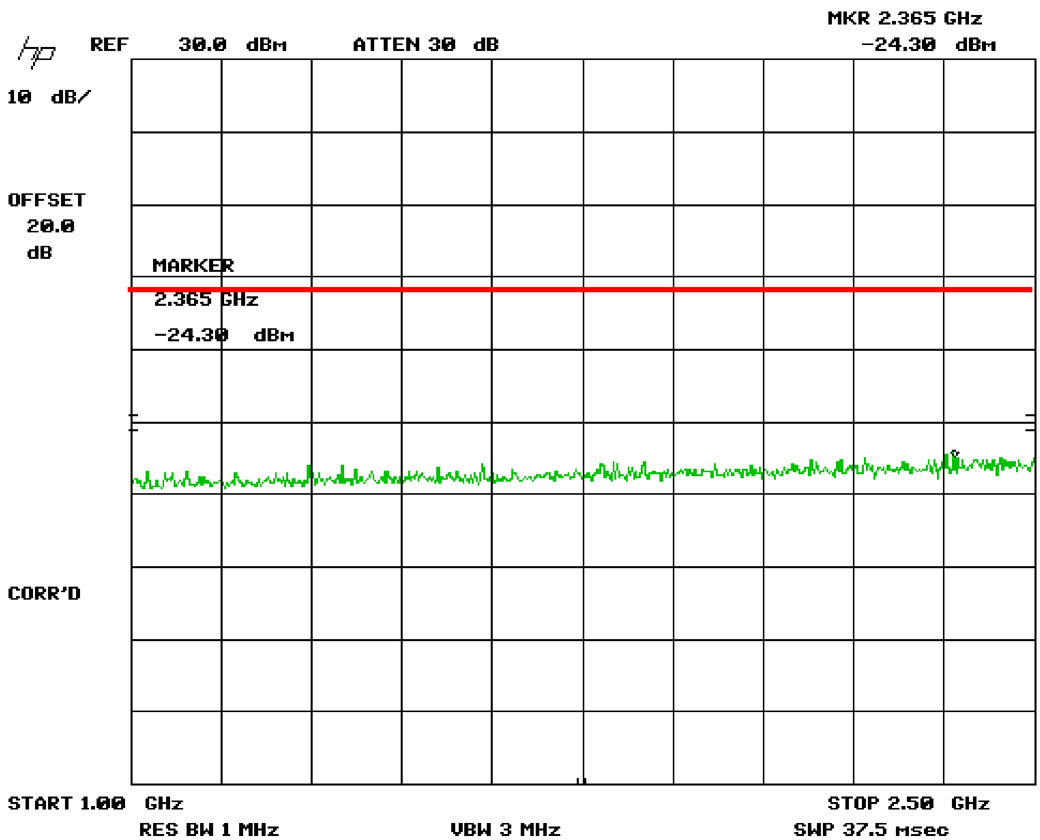

Figure 9. Antenna Conducted Emissions High, Part 2 "TXM 2"

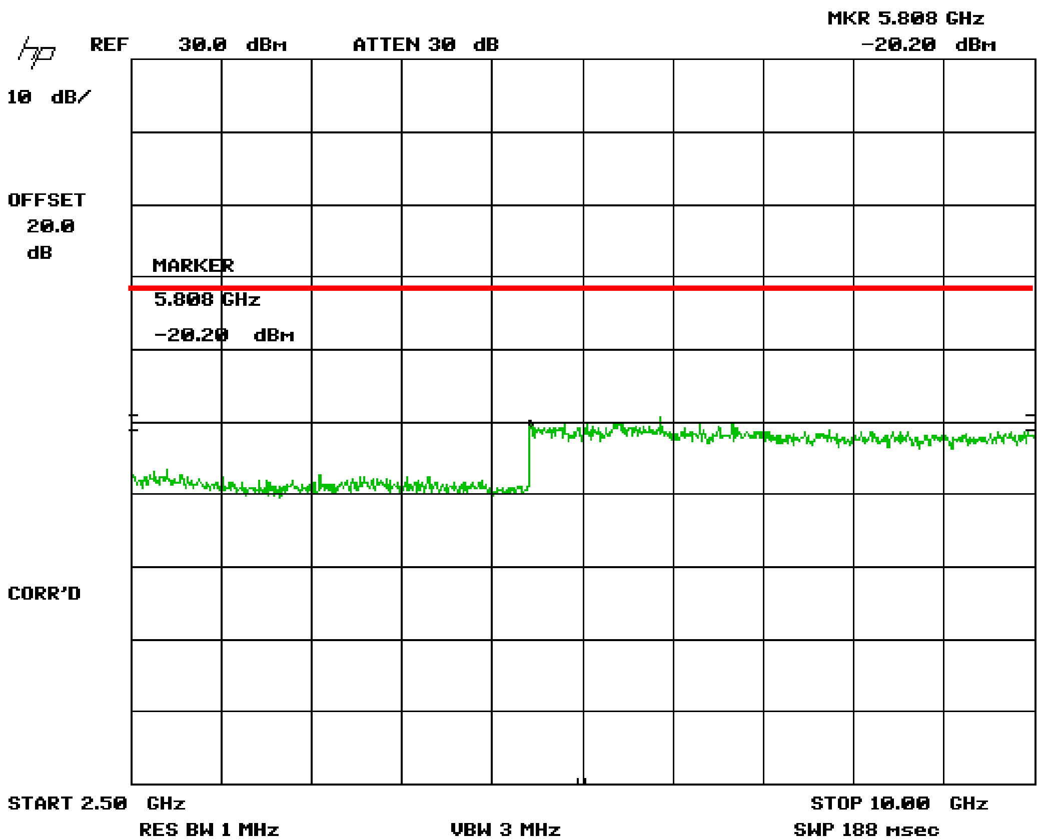

Figure 10. Antenna Conducted Emissions High, Part 3 "TXM 2"

2.11 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made, following the guidelines in FCC KDB Publication No. 558074 for the DTS modulation and FCC Publication DA 00-705 for the FHSS modulation, with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band).

To capture the band edge, set the Spectrum Analyzer frequency span large enough (usually around 2 MHz) to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW= 100kHz for measurements of the DTS modulation and with RBW ≥ 1% of the span for measurements of the FHSS modulation. In all cases, the VBW is set ≥ RBW. See figure and calculations below for more detail.

2.11.1 FHSS Modulation Band Edge

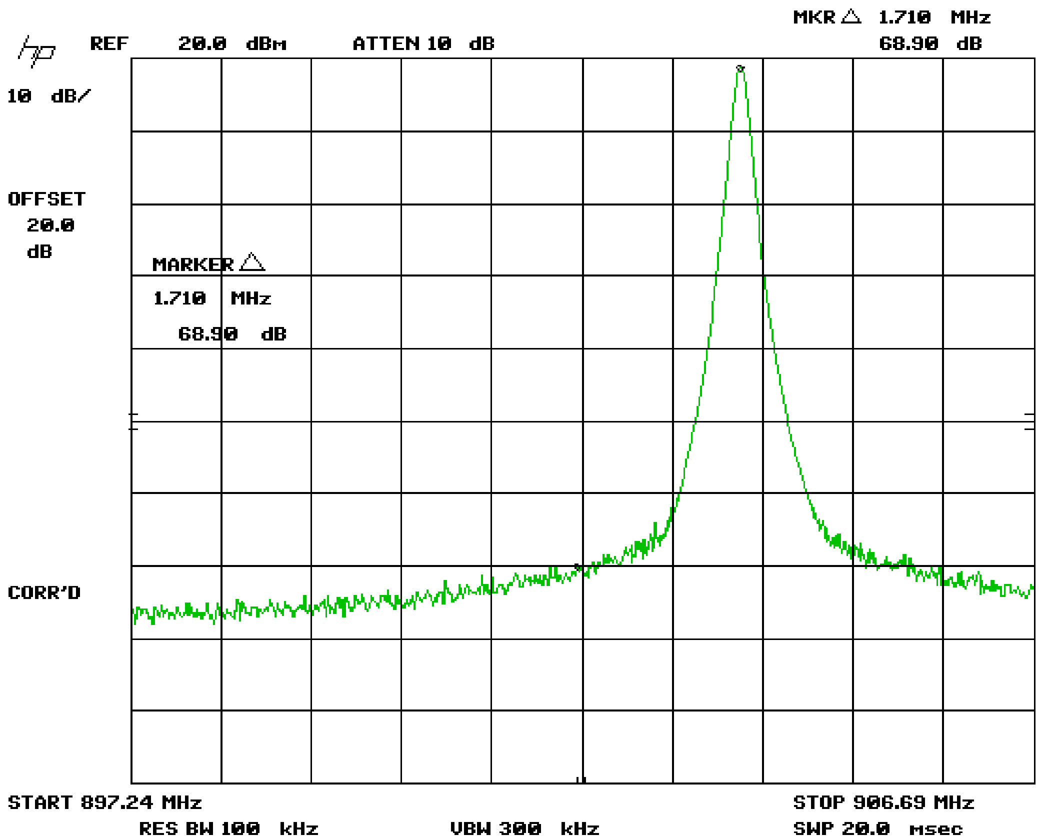

Figure 11. Band Edge Compliance, Low Channel Delta – Continuous Transmission FHSS modulation

Measured Delta (from Figure 11)	68.90	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	48.90	dB

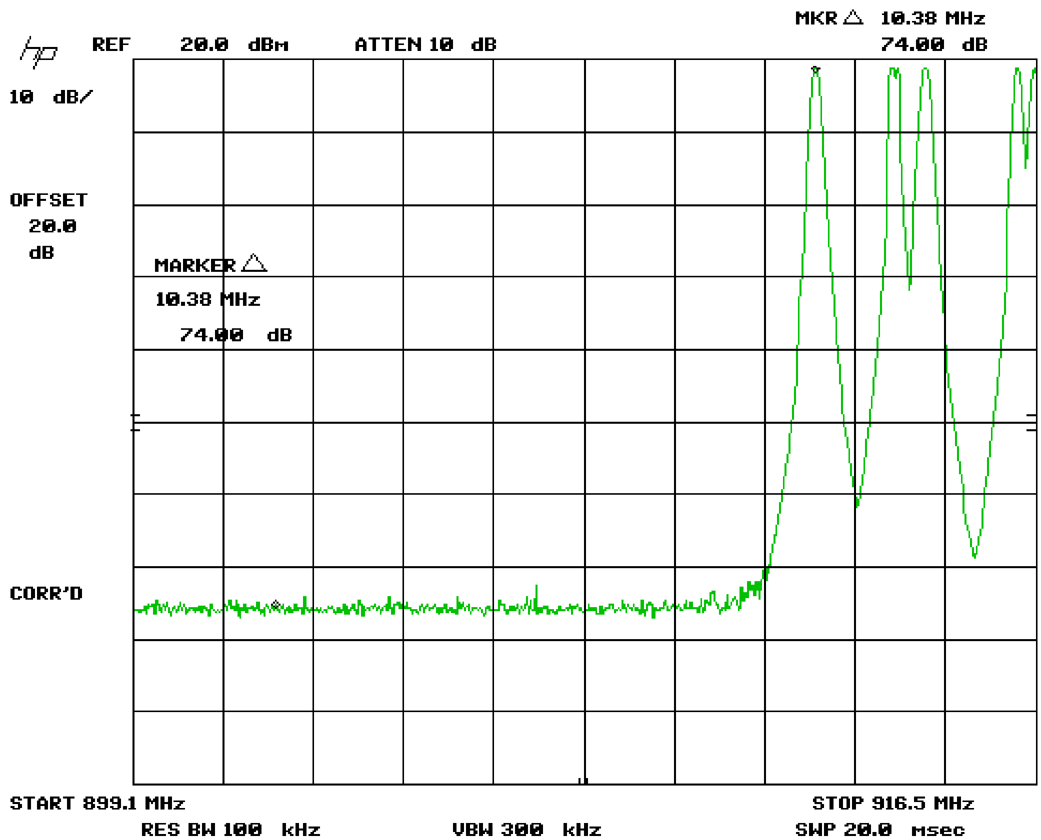

Figure 12. Band Edge Compliance, Low Channel Delta – Channel Hopping FHSS Modulation

Measured Delta (from Figure 12)	74.00	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	54.00	dB

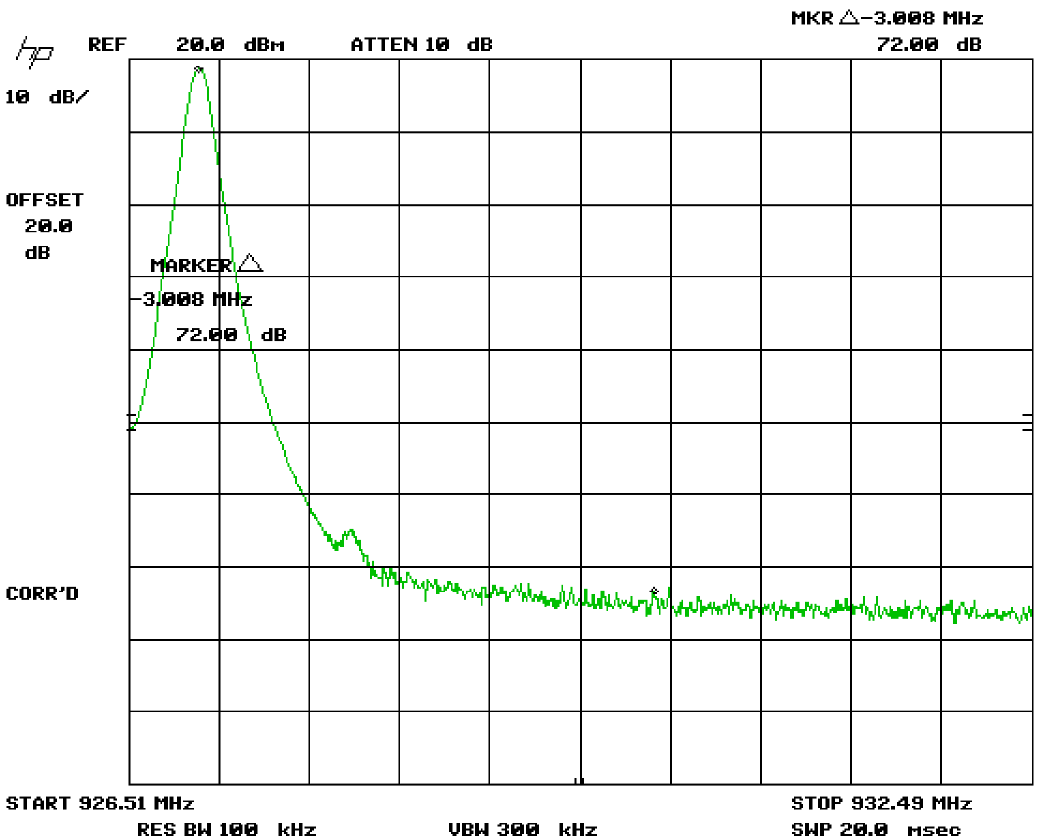

Figure 13. Band Edge Compliance, High Channel Delta – Continuous Transmission FHSS Modulation

Measured Delta (from Figure 13)	72.00	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	52.00	dB

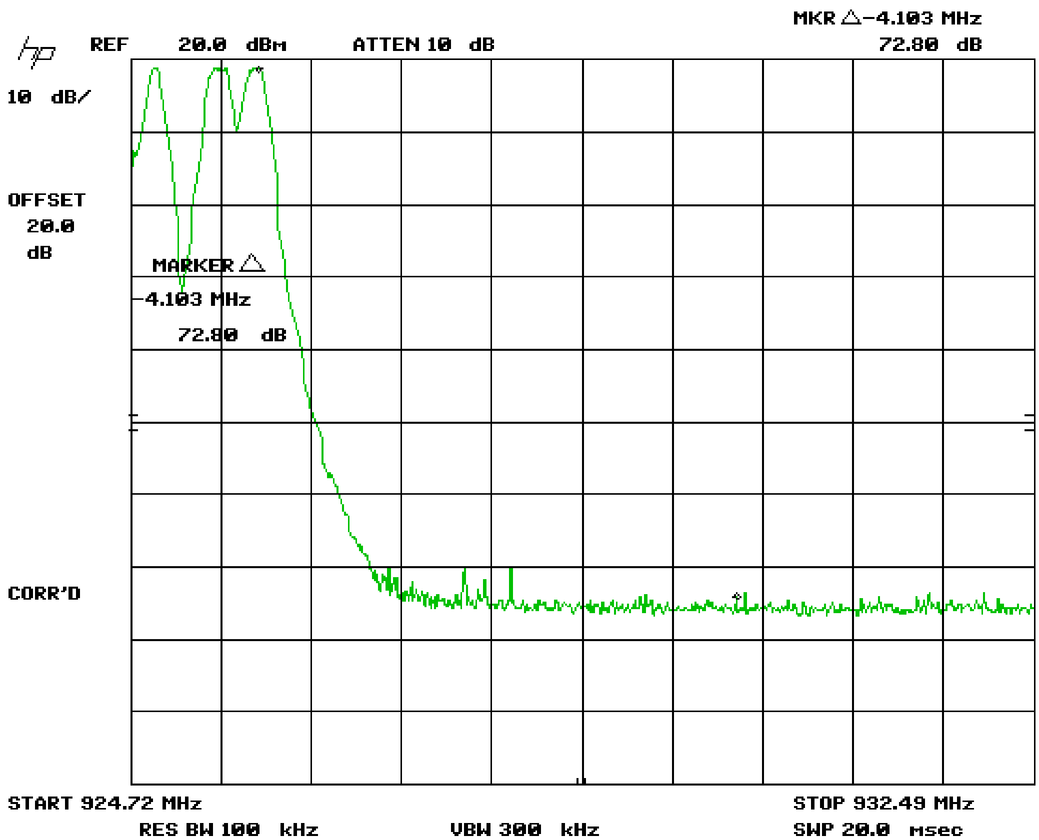

Figure 14. Band Edge Compliance, High Channel Delta – Channel Hopping GFSK Modulation

Measured Delta (from Figure 14)	72.80	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	52.80	dB

2.11.2 DTS Modulation

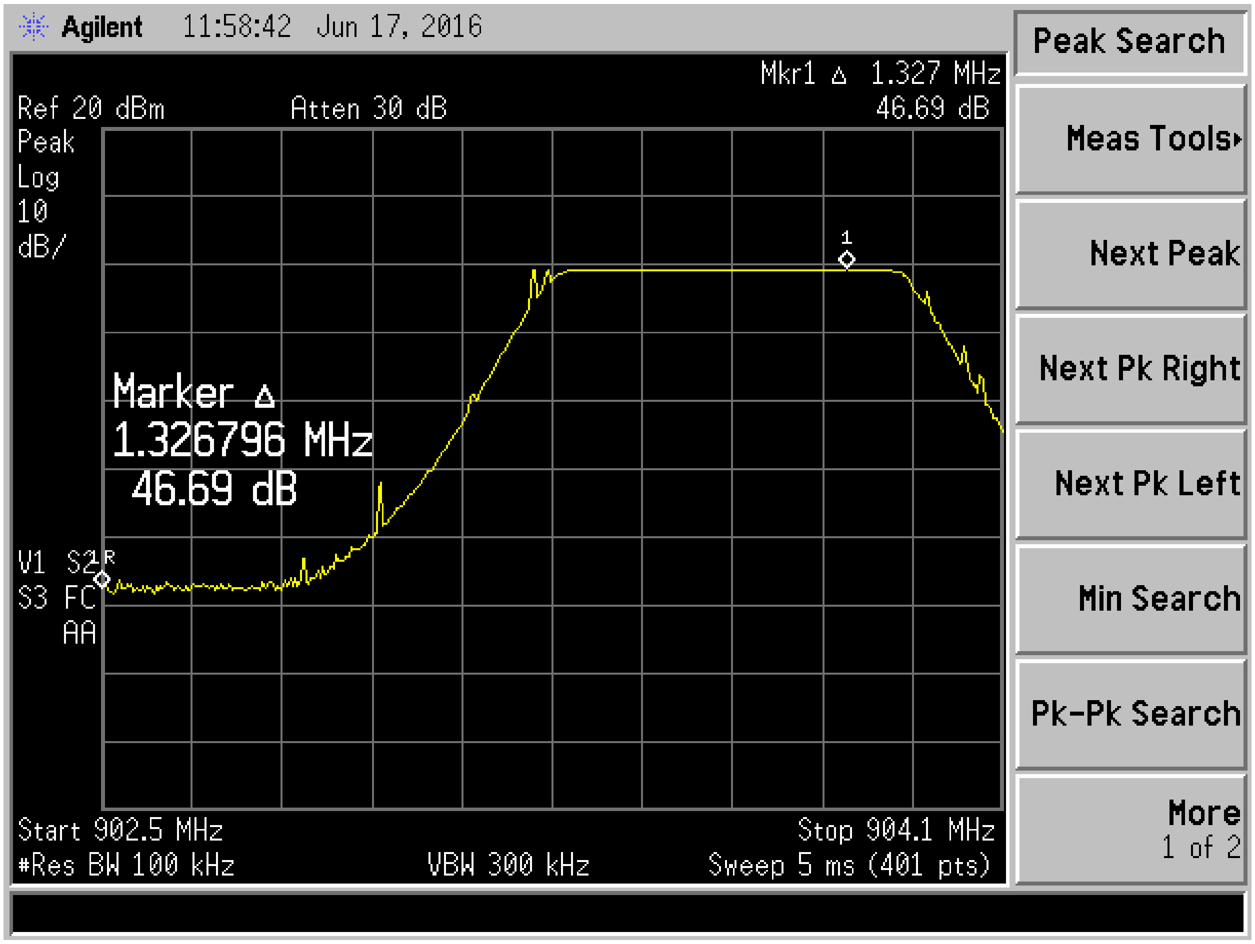

Figure 15. Band Edge Compliance, Low Channel Delta – Peak DTS Modulation

Measured Delta (from Figure 15)	46.69	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	26.69	dB

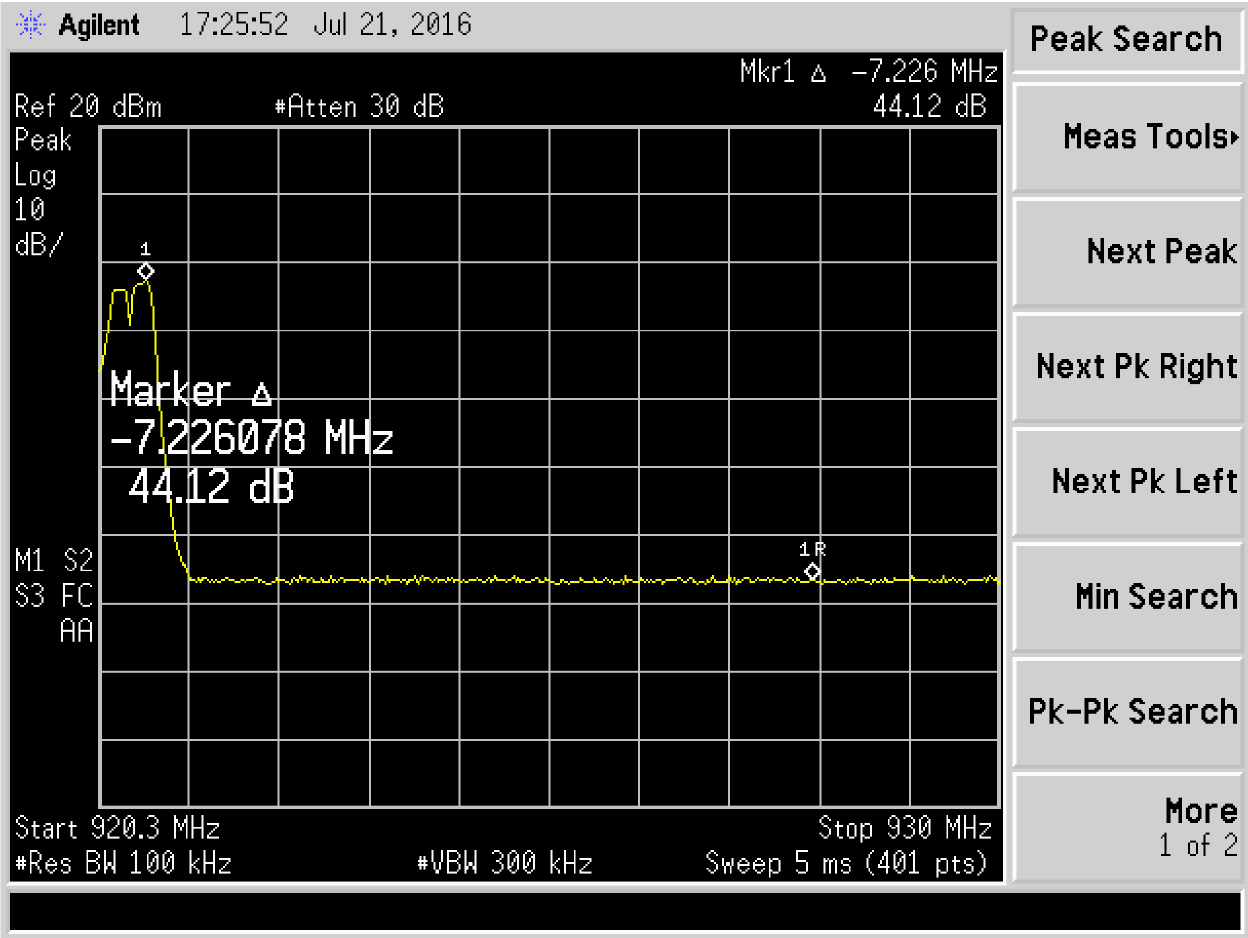

Figure 16. Band Edge Compliance, High Channel Delta – DTS Modulation

Measured Delta (from Figure 16)	44.12	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	24.12	dB

2.12 Six (6) dB Bandwidth per CFR 15.247(a)(2)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 for a bandwidth of 6 dB. The RBW was set to 100 kHz and with the VBW ≥ RBW. The results of this test are given in the table below and Figures below.

Table 10. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)	99 % Occupied Bandwidth (MHz)
903.65	0.706	0.500	0.729
915.01	0.673	0.500	0.737
927.70	0.670	0.500	0.735

Test Date: June 2, 2016
Tested By
Signature: ________ Name: George Yang

NOTE: EUT placed into DTS mode of operation

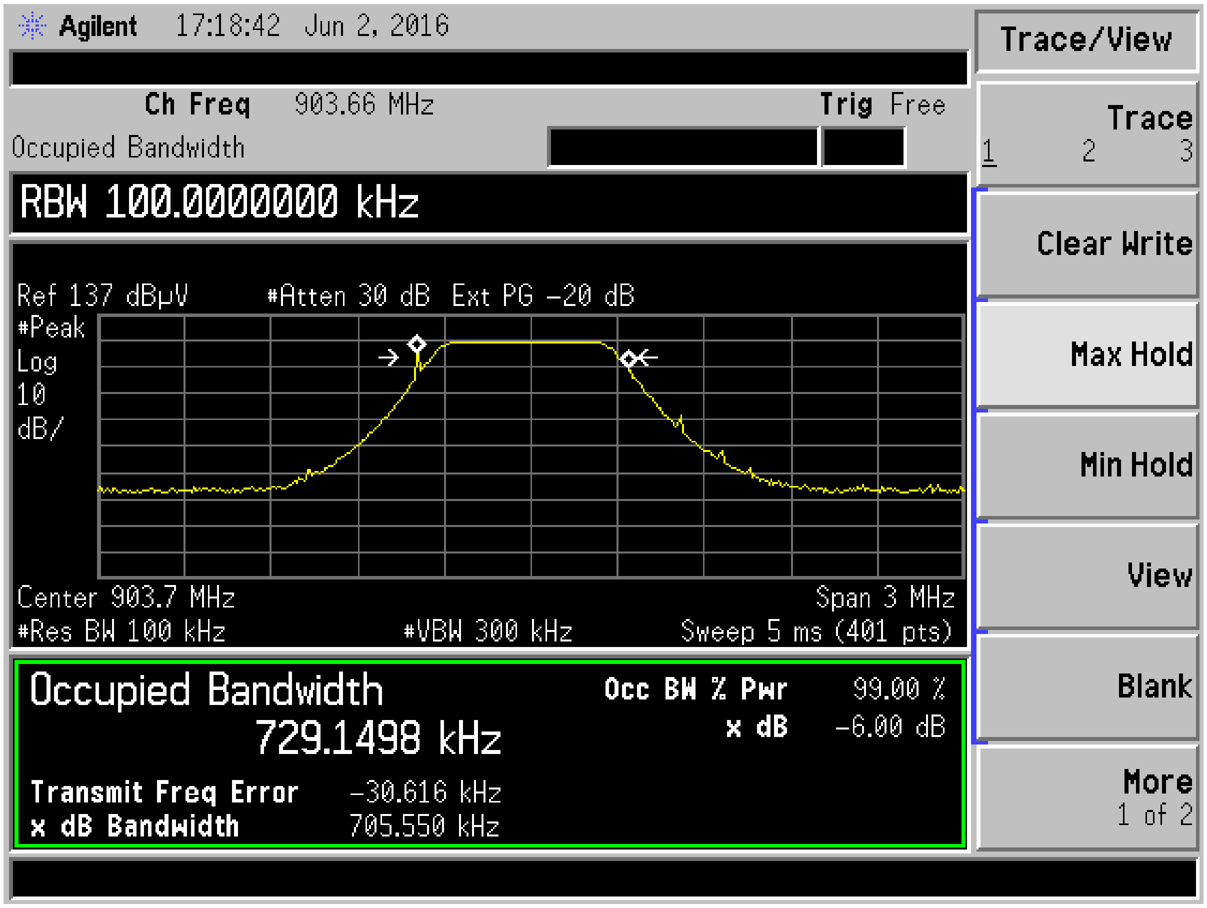

Figure 17. Six dB Bandwidth - 15.247 - Low Channel

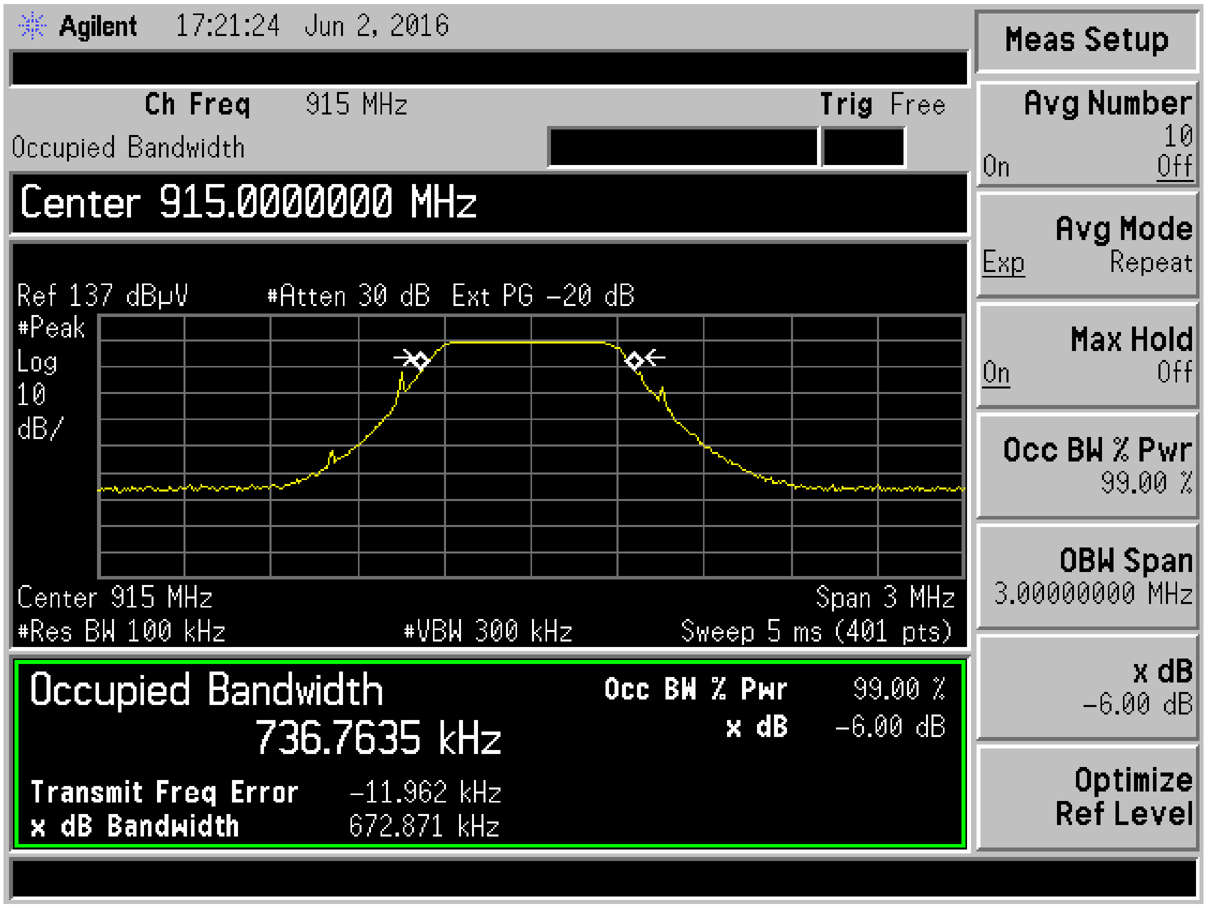

Figure 18. Six dB Bandwidth - 15.247 - Mid Channel

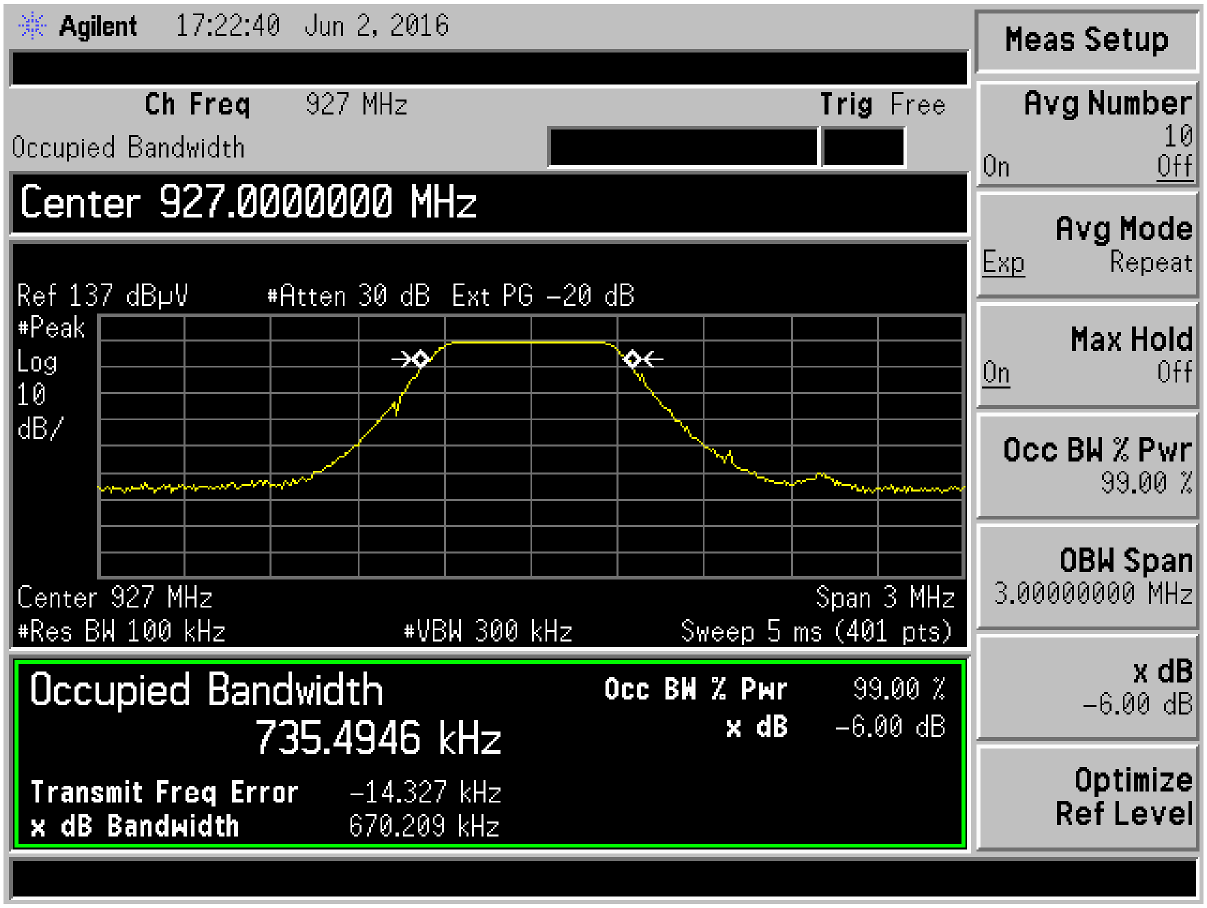

Figure 19. Six dB Bandwidth - 15.247 - High Channel

2.13 Twenty dB Bandwidth (CFR 15.247 (a) (1))

For frequency hopping systems operating in the 902-928 MHz band the maximum allowed 20 dB bandwidth is 500 kHz.

These measurements were performed while the EUT was in a constant transmit mode. A method similar to the marker delta method was used to capture the points. The RBW was set to approximately 1 % of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table and Figures following.

Table 11. Twenty (20) dB Bandwidth

Frequency (MHz)	20 dB Bandwidth (kHz)	Maximum Limit (kHz)	99% Occupied Bandwidth (kHz)
903.65	170.6	500	145.4
915.01	169.9	500	144.7
927.70	166.7	500	141.3

Test Date: June 17, 2016
Tested By
Signature: ____________ Name: George Yang

NOTE: EUT placed into FHSS mode of operation

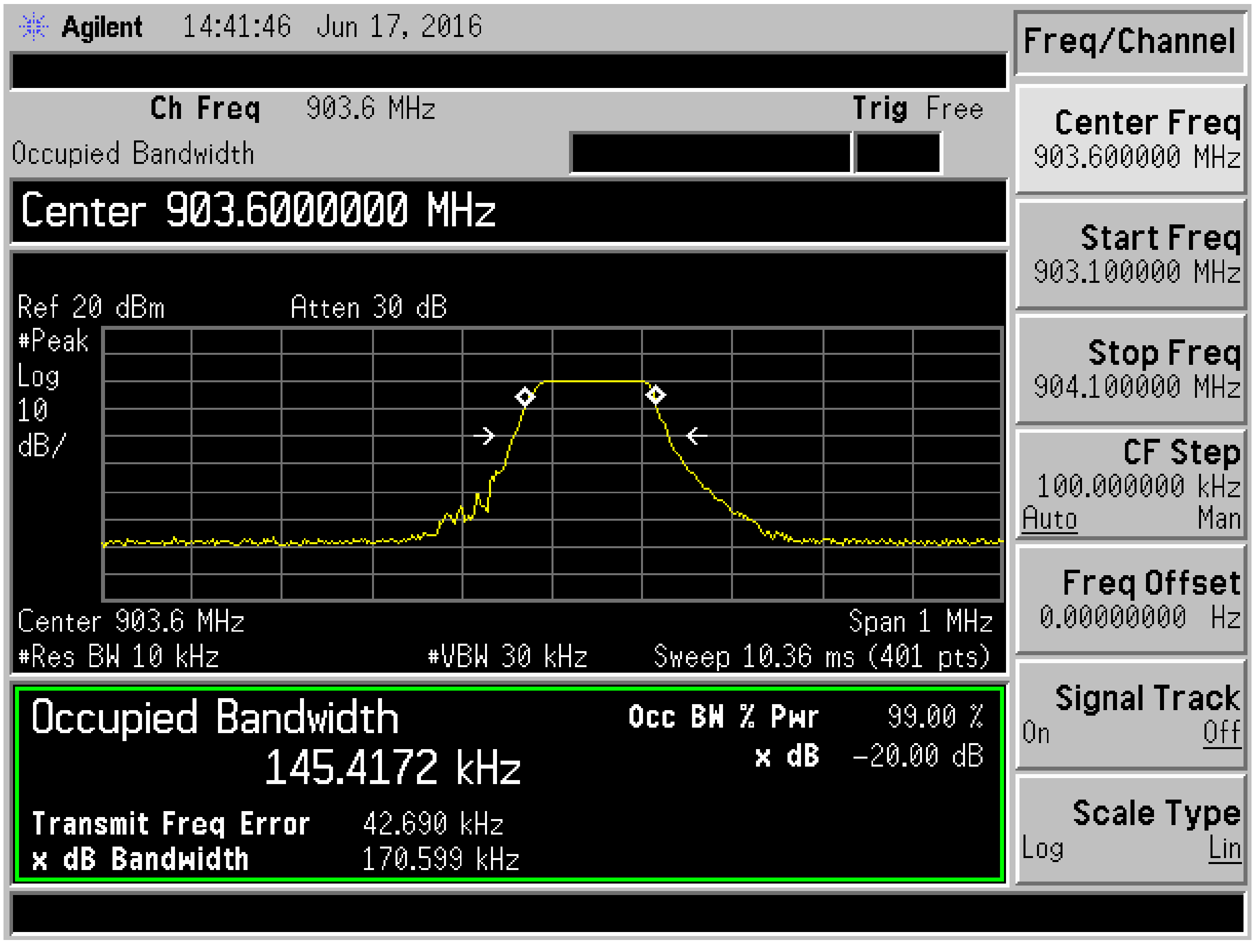

Figure 20. Twenty dB Bandwidth – Low Channel

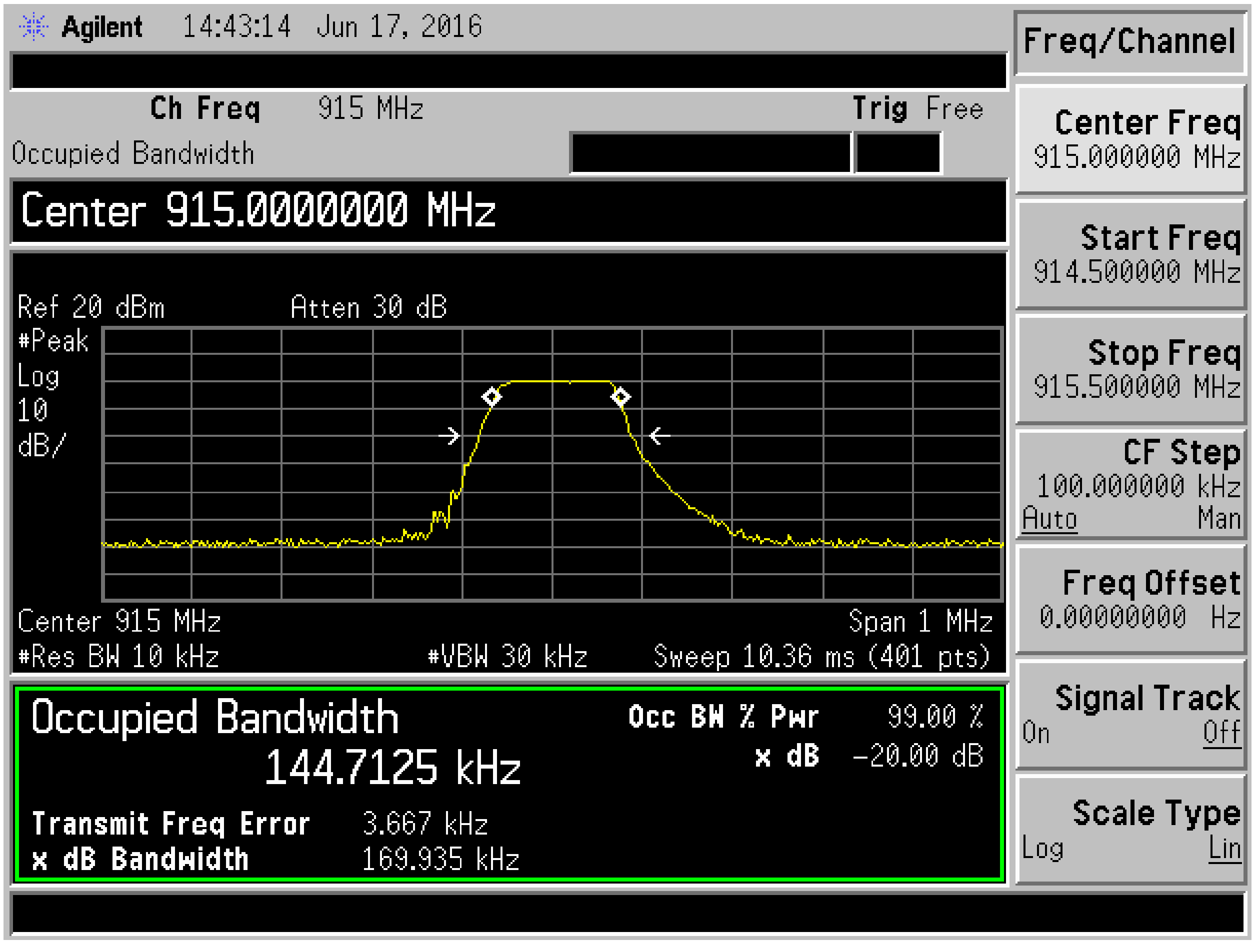

Figure 21. Twenty dB Bandwidth – Mid Channel

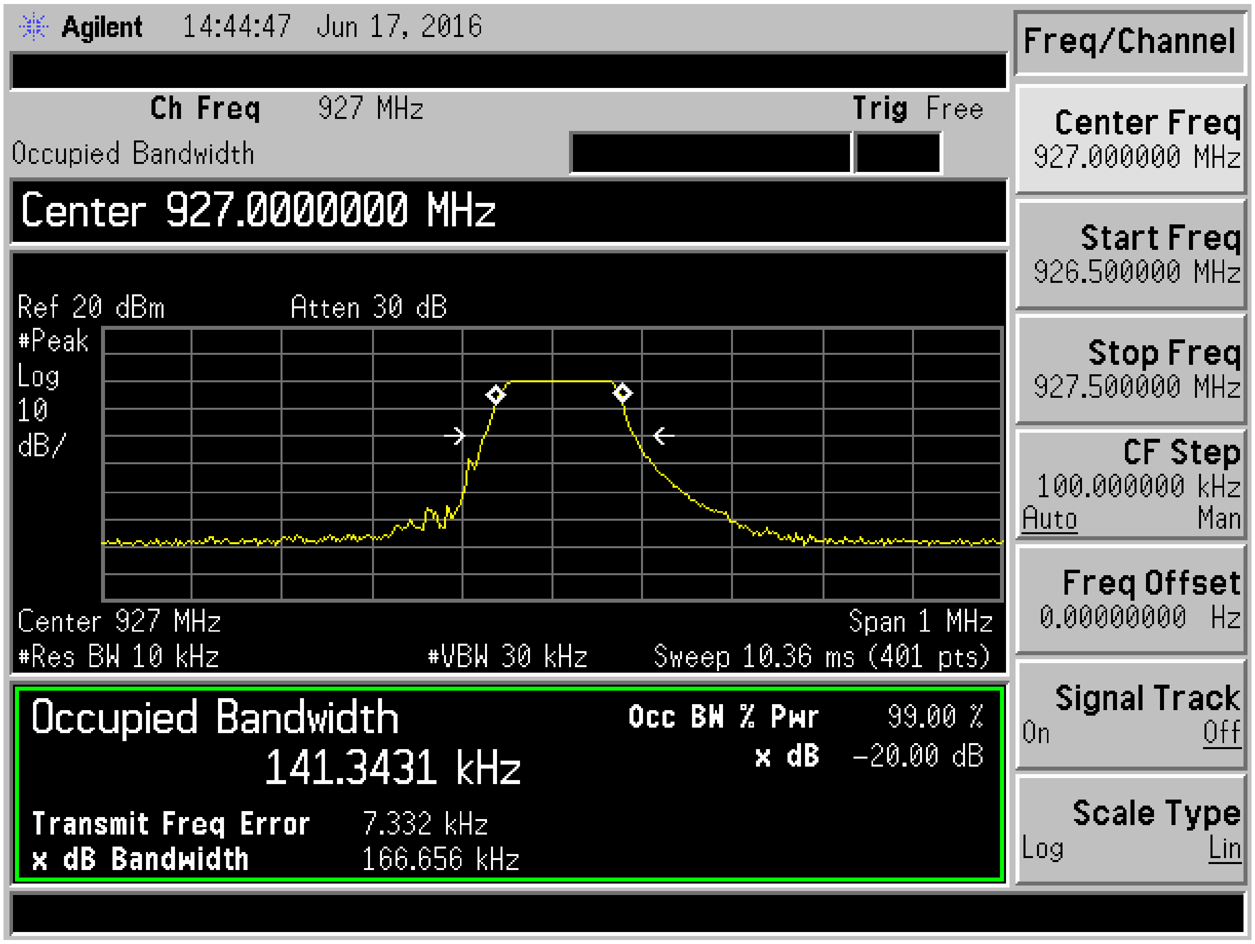

Figure 22. Twenty dB Bandwidth – High Channel

2.14 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

For frequency hopping systems in the 902-928 MHz band with at least 50 hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed 1 watt. Systems with less than 50 hopping channels, but at least 25 hopping channels, the maximum peak conducted output power of the intentional radiator shall not exceed .25 watts. Since the EUT has 121 hopping channels, the maximum peak conducted output power shall not exceed 1 watt.

Peak power within the band 903.65 MHz to 927.70 MHz was measured per FCC KDB Publication DA 00-705 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set greater than the 6 dB bandwidth of the EUT, and the VBW ≥ RBW. Peak antenna conducted output power is tabulated in the table below.

Table 12. Peak Antenna Conducted Output Power per Part 15.247 (b) (3)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
DTS Mode			
903.65	19.60	91.20	1000
909.50	19.60	91.20	1000
915.72	19.62	91.62	1000
FHSS Mode			
912.31	19.60	91.20	1000
919.51	19.58	90.78	1000
927.70	19.55	90.16	1000

Test Date: July 18, 2016
Tested By
Signature: ____________ Name: George Yang

NOTE: EUT placed into "TXM 2" mode of operation for all measurements presented.

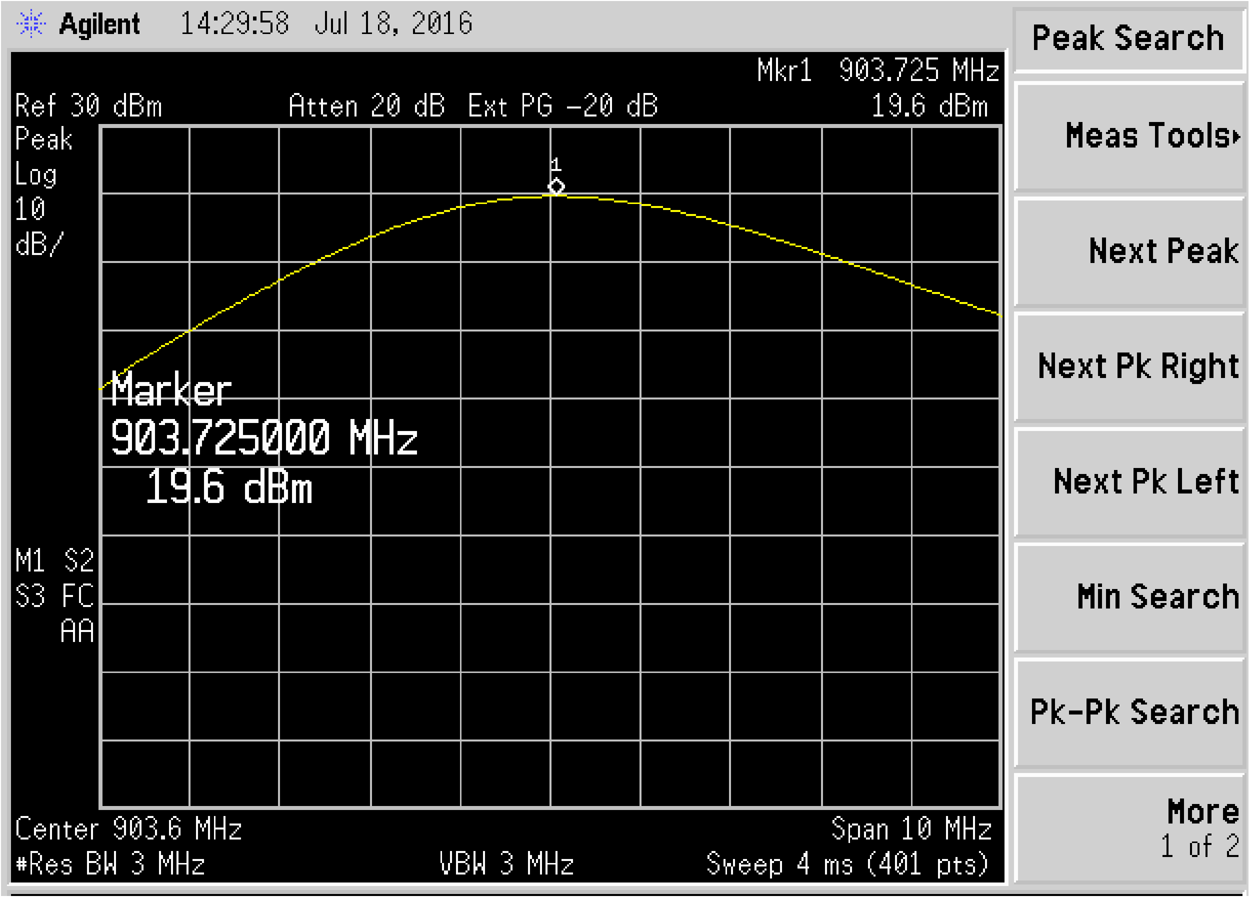

Figure 23. Peak Antenna Conducted Output Power, Low Channel (DTS Mode)

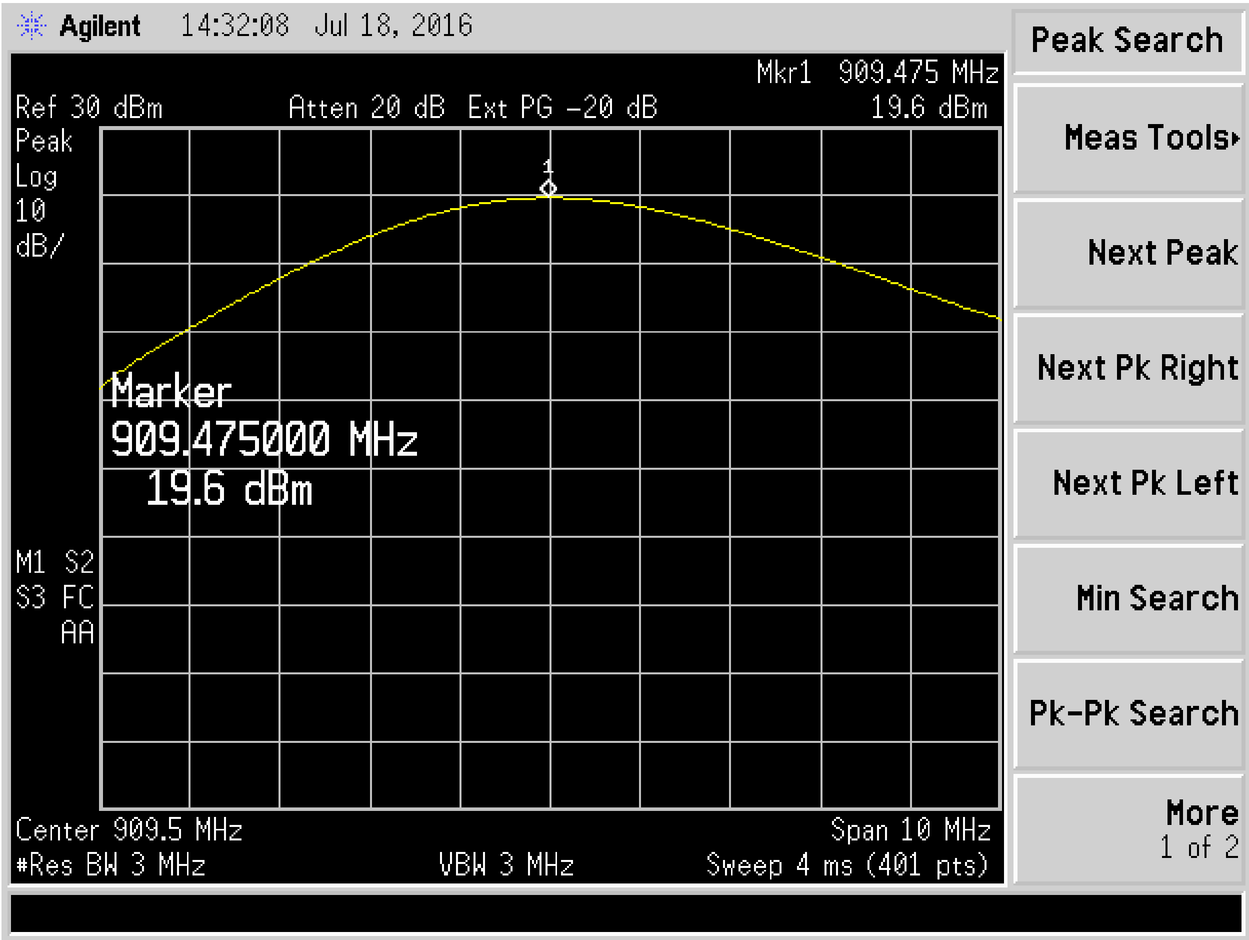

Figure 24. Peak Antenna Conducted Output Power, Mid Channel (DTS Mode)

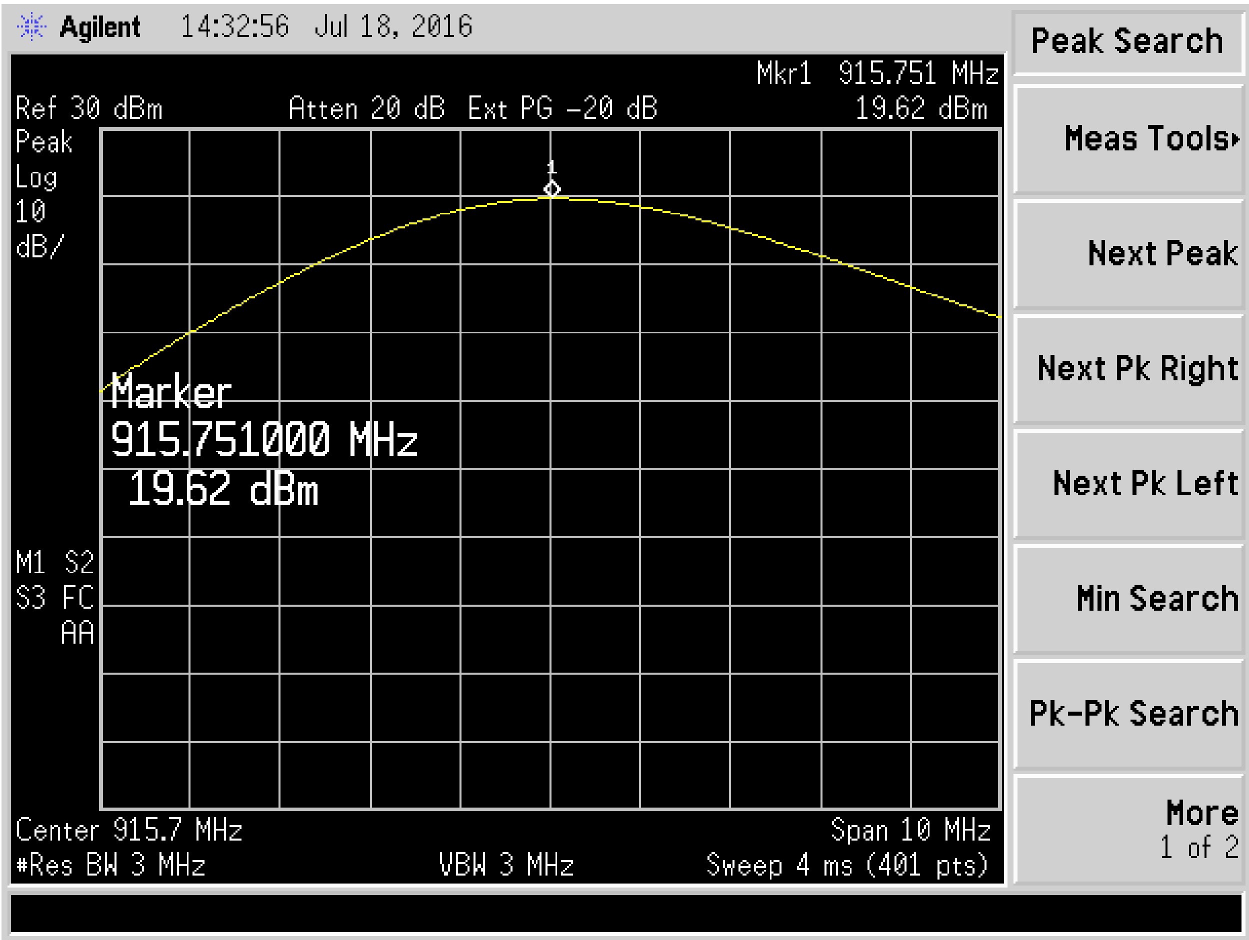

Figure 25. Peak Antenna Conducted Output Power, High Channel (DTS Mode)

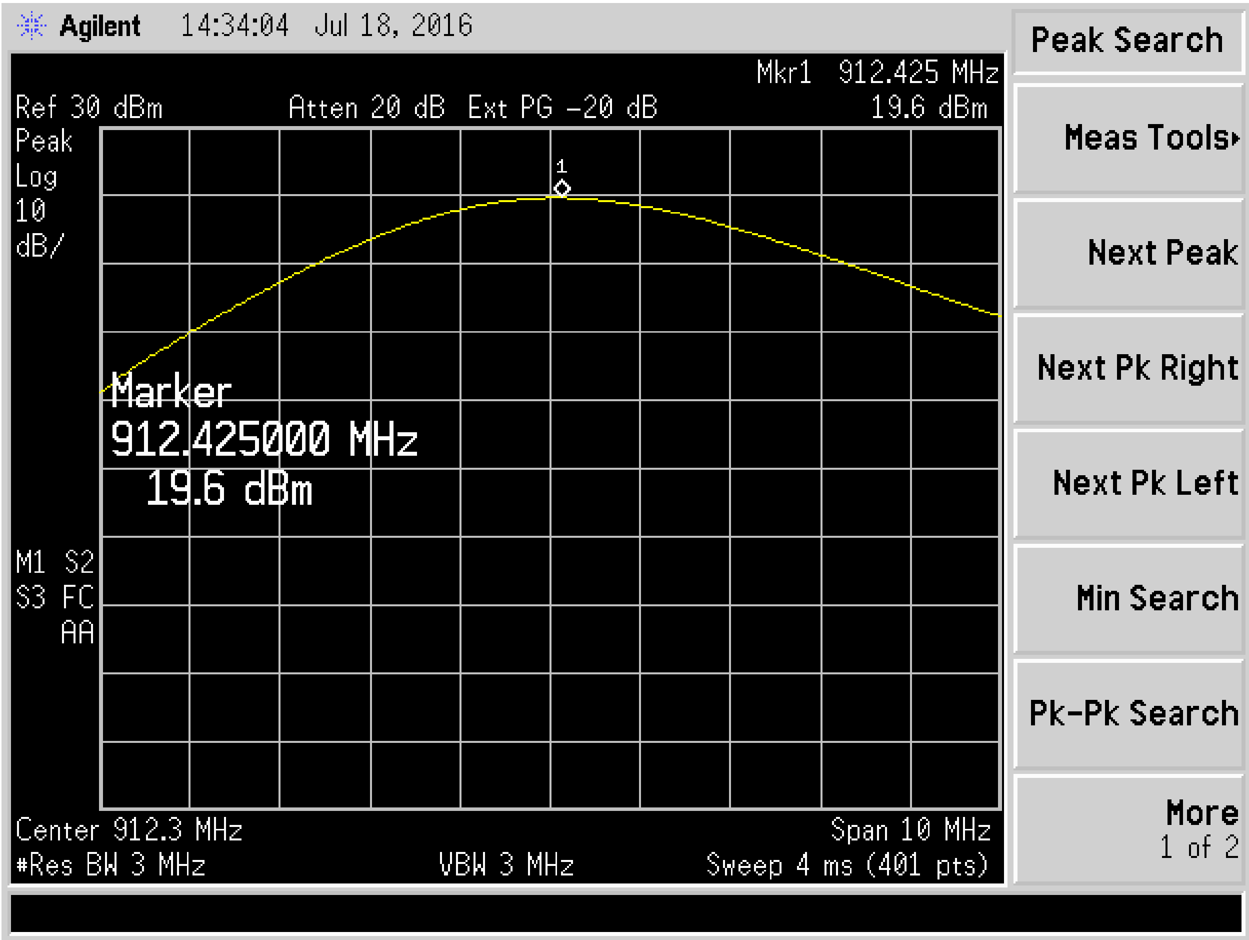

Figure 26. Peak Antenna Conducted Output Power, Low Channel (FHSS Mode)

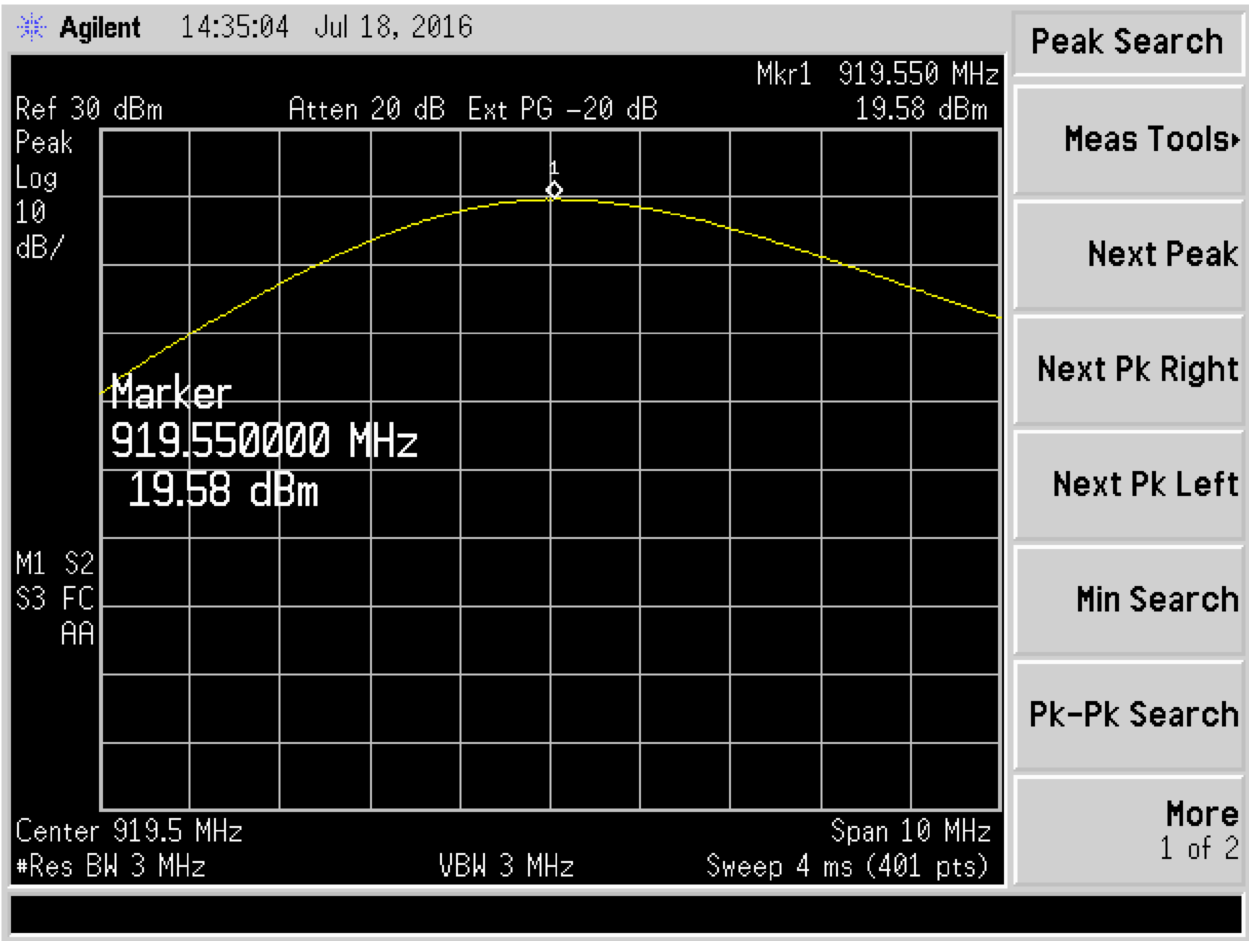

Figure 27. Peak Antenna Conducted Output Power, Mid Channel (FHSS Mode)

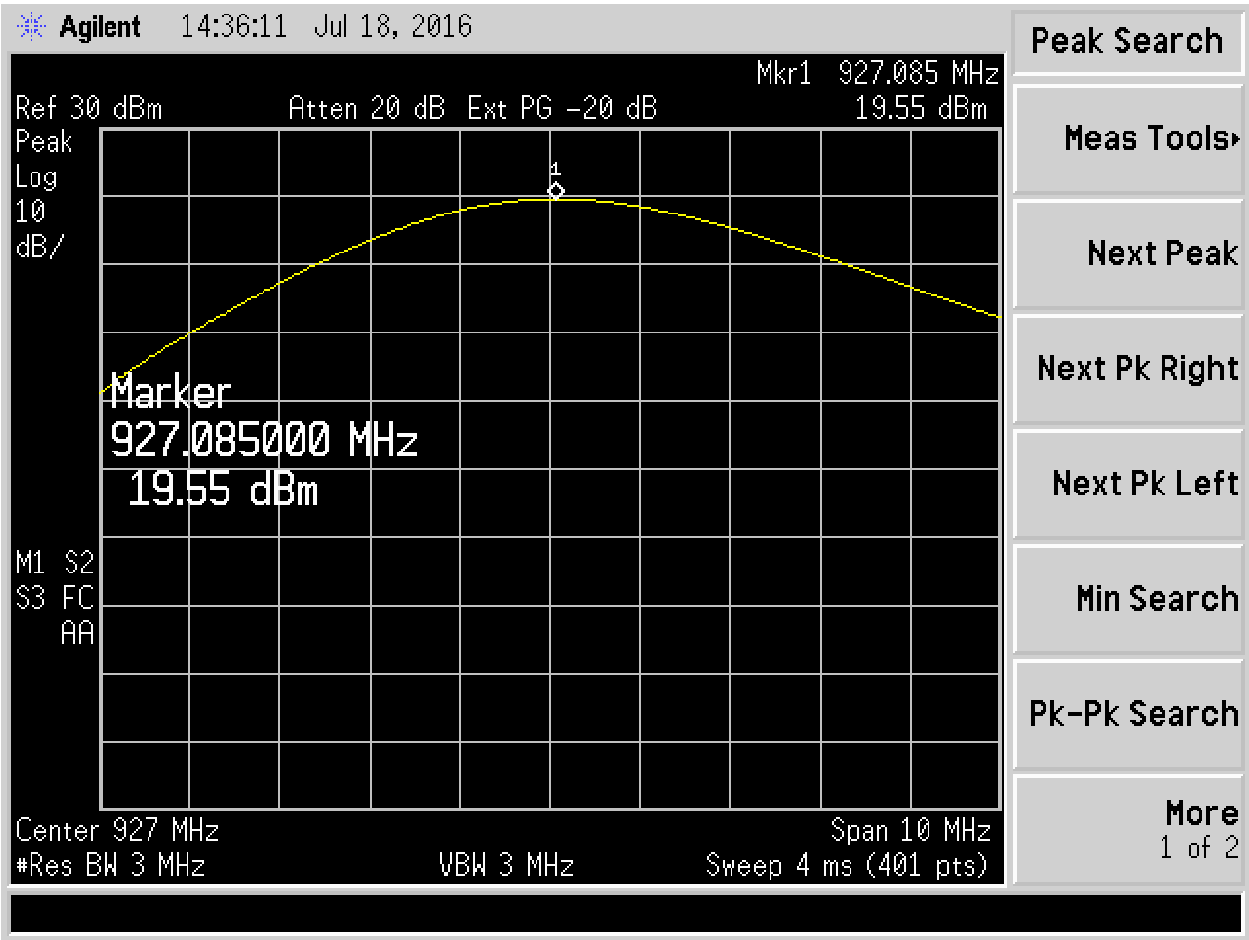

Figure 28. Peak Antenna Conducted Output Power, High Channel (FHSS Mode)

2.15 Power Spectral Density (CFR 15.247(f))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 558074. The RBW was set to 3 kHz and the Video Bandwidth was set to ≥ RBW. The span was set to 1.5 times the OBW.

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

The following results show that all are less than +8 dBm per 3 kHz band.

Table 13. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Test Data (dBm/3 KHz)	FCC Limit (dBm/3 kHz)
903.65	7.756	+8.0
915.01	7.715	+8.0
927.70	7.388	+8.0

Test Date: June 2, 2016
Tested By
Signature: ________________ Name: George Yang

NOTE: EUT placed into DTS mode of operation

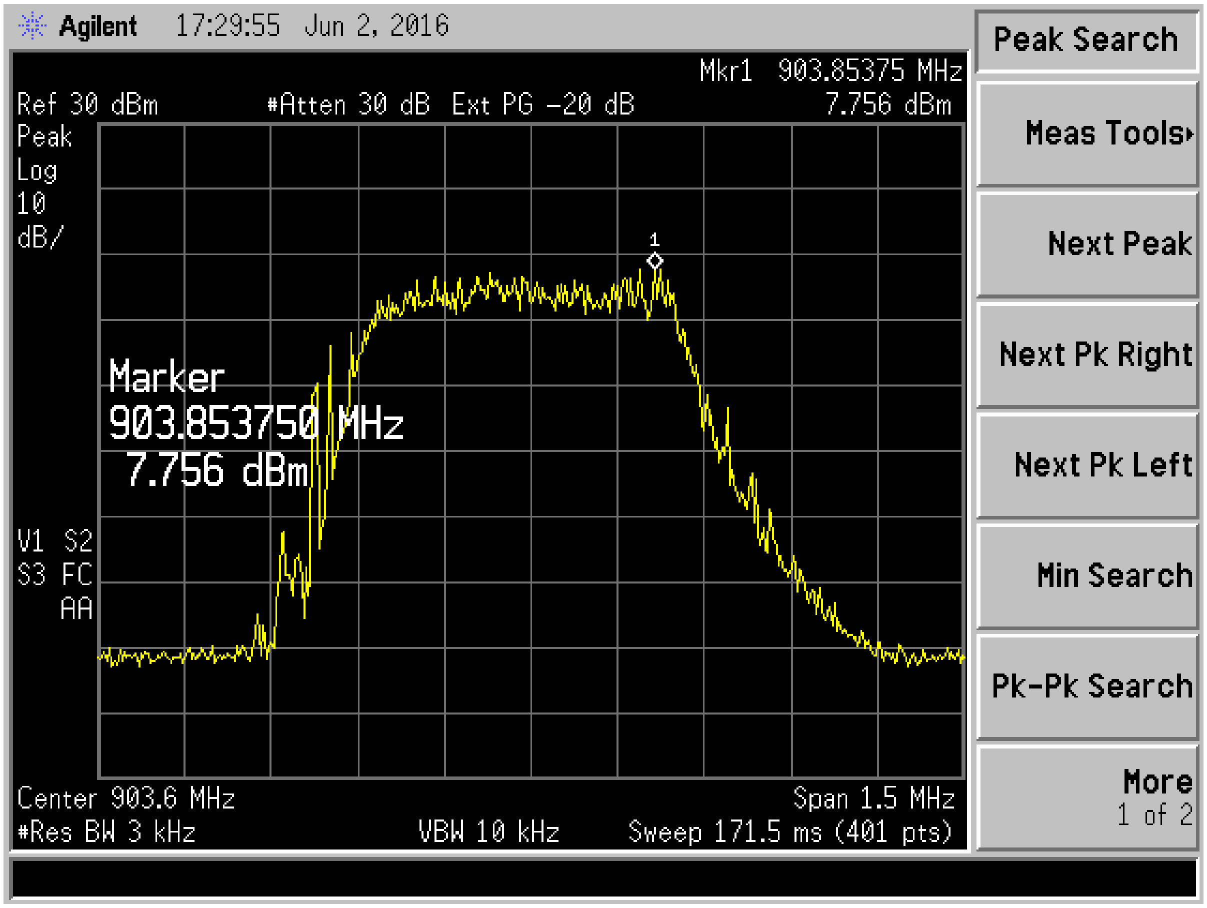

Figure 29. Peak Power Spectral Density, Low Channel

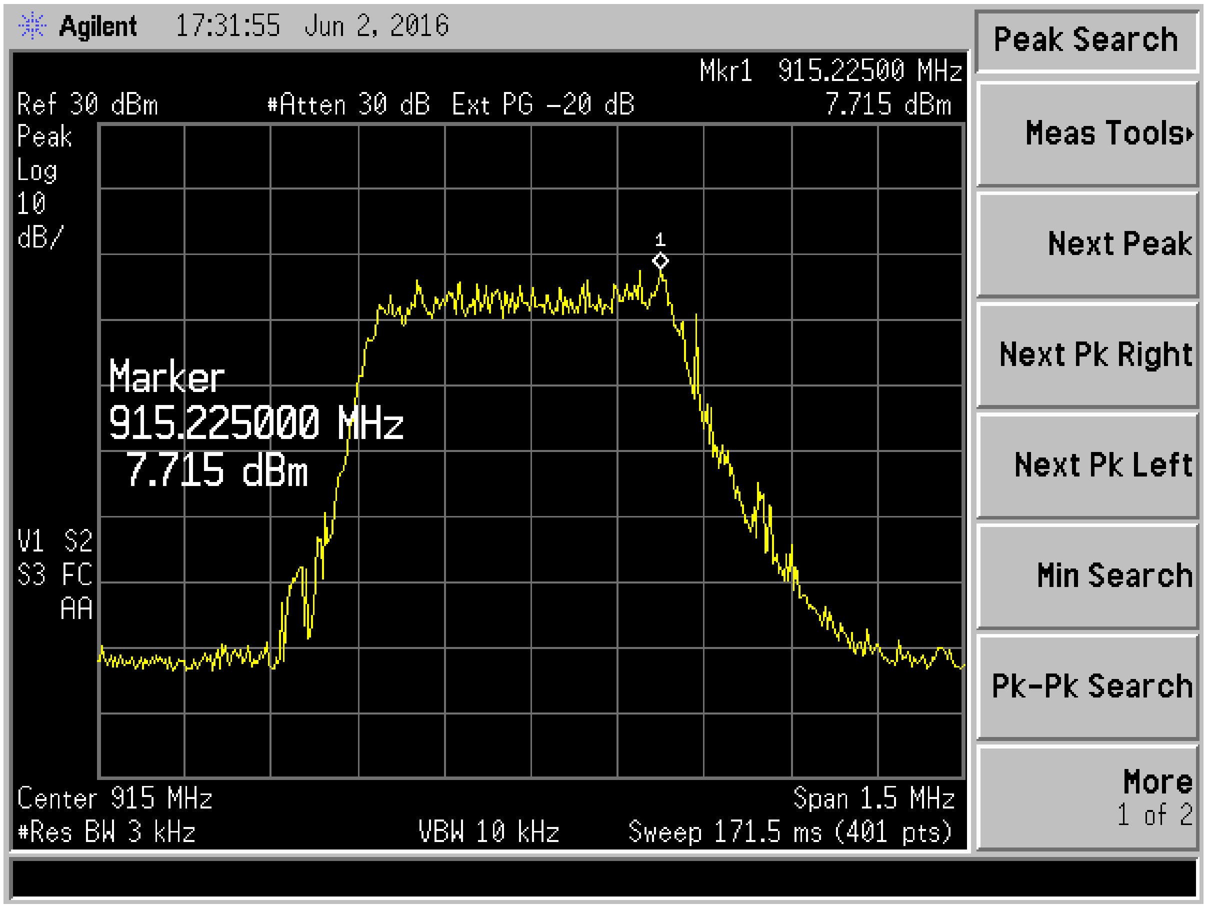

Figure 30. Peak Power Spectral Density, Mid Channel

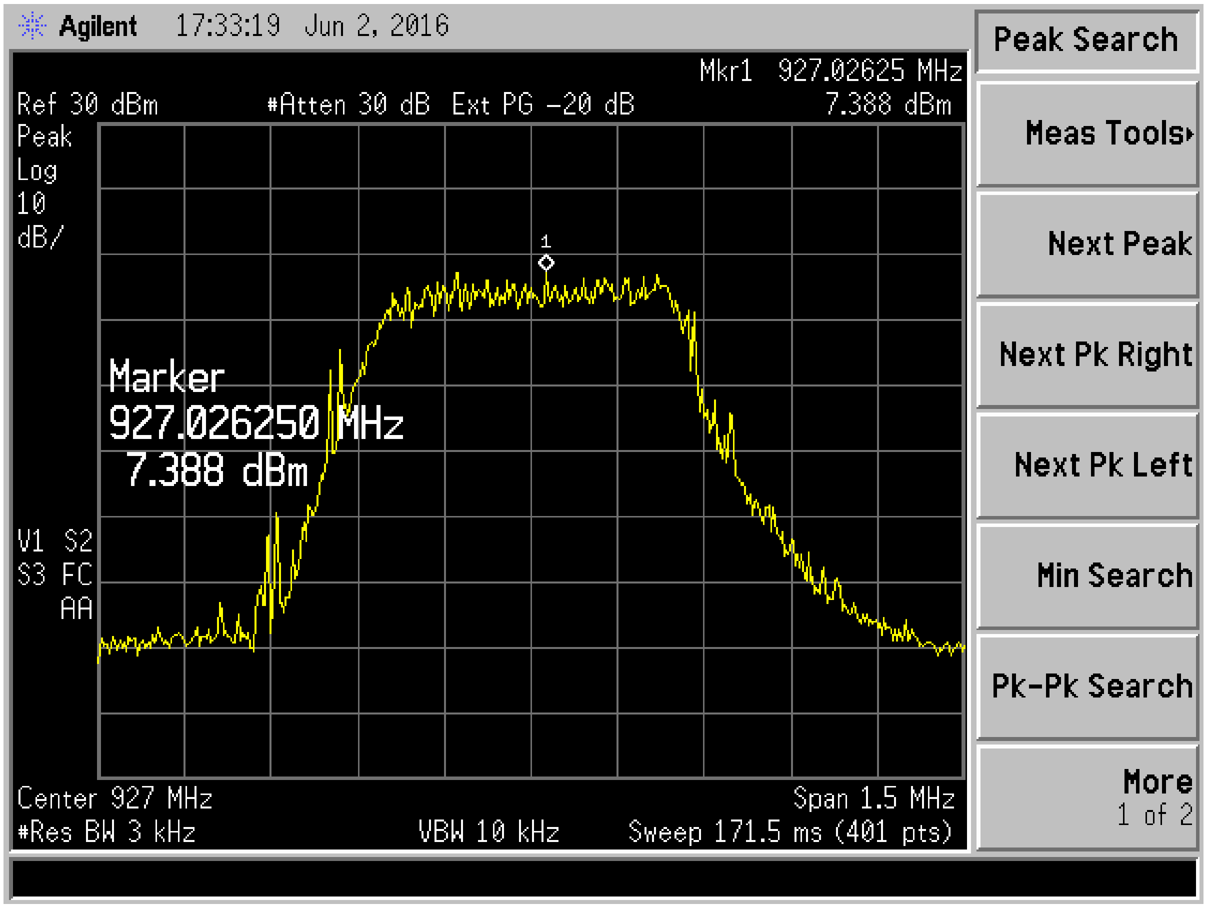

Figure 31. Peak Power Spectral Density, High Channel

2.16 Number of Hopping Frequencies (CFR 15.247 (a)(1)) (CRF 15.247(b)(1))

Frequency hopping systems in the 902-928 MHz band shall have at least 50 hopping frequencies if the 20 dB bandwidth is less than 250 kHz. If the 20 dB bandwidth is 250 kHz or greater, then the system shall have at least 25 hopping frequencies. Since the EUT has a 20 dB bandwidth less than 250 kHz, then at least 50 hopping frequencies shall be used.

The test procedures outlined in FCC Public Notice DA 00-705 were used to conduct measurements.

The table below lists all available channels. The ones marked with “FHSS” are the channels used during FHSS modulation. There are a total of 50 channels.

Channels

CH	Frequency	Mode/BW
102	915.010498	FHSS, 125KHz
103	921.011475	FHSS, 125KHz
104	924.011963	FHSS, 125KHz
105	926.712402	FHSS, 125KHz
106	912.910156	FHSS, 125KHz
107	917.110840	FHSS, 125KHz
108	919.211182	FHSS, 125KHz
109	925.812256	FHSS, 125KHz
110	915.910645	FHSS, 125KHz
111	912.610107	FHSS, 125KHz
112	918.911133	FHSS, 125KHz
113	919.811279	FHSS, 125KHz
114	917.410889	FHSS, 125KHz
115	913.510254	FHSS, 125KHz
116	922.811768	FHSS, 125KHz
117	914.110352	FHSS, 125KHz
118	915.310547	FHSS, 125KHz
119	922.211670	FHSS, 125KHz
120	918.010986	FHSS, 125KHz
121	923.711914	FHSS, 125KHz
122	912.310059	FHSS, 125KHz
123	924.912109	FHSS, 125KHz
124	916.210693	FHSS, 125KHz
125	921.911621	FHSS, 125KHz
126	916.510742	FHSS, 125KHz
127	925.512207	FHSS, 125KHz
128	920.411377	FHSS, 125KHz
129	918.311035	FHSS, 125KHz
130	919.511230	FHSS, 125KHz
131	914.410400	FHSS, 125KHz
132	923.411865	FHSS, 125KHz
133	916.810791	FHSS, 125KHz
134	913.810303	FHSS, 125KHz
135	924.612061	FHSS, 125KHz
136	926.112305	FHSS, 125KHz
137	922.511719	FHSS, 125KHz
138	921.611572	FHSS, 125KHz
139	920.711426	FHSS, 125KHz
140	921.311523	FHSS, 125KHz
141	923.111816	FHSS, 125KHz
142	913.210205	FHSS, 125KHz
143	924.312012	FHSS, 125KHz
144	920.111328	FHSS, 125KHz
145	927.012451	FHSS, 125KHz
146	925.212158	FHSS, 125KHz
147	915.610596	FHSS, 125KHz
148	926.412354	FHSS, 125KHz
149	917.710938	FHSS, 125KHz
150	914.710449	FHSS, 125KHz

151	918.611084	FHSS, 125KHz
152	908.900208	DTS, 500KHz
153	904.174988	DTS, 500KHz
154	913.100403	DTS, 500KHz
155	903.649963	DTS, 500KHz
156	907.850159	DTS, 500KHz
157	904.700012	DTS, 500KHz
158	908.375183	DTS, 500KHz
159	915.725525	DTS, 500KHz
160	913.625427	DTS, 500KHz
161	911.000305	DTS, 500KHz
162	906.800110	DTS, 500KHz
163	909.950256	DTS, 500KHz

164	911.525330	DTS, 500KHz
165	914.150452	DTS, 500KHz
166	912.575378	DTS, 500KHz
167	915.200500	DTS, 500KHz
168	906.275085	DTS, 500KHz
169	907.325134	DTS, 500KHz
170	909.425232	DTS, 500KHz
171	912.050354	DTS, 500KHz
172	905.225037	DTS, 500KHz
173	910.475281	DTS, 500KHz
174	914.675476	DTS, 500KHz
175	905.750061	DTS, 500KHz

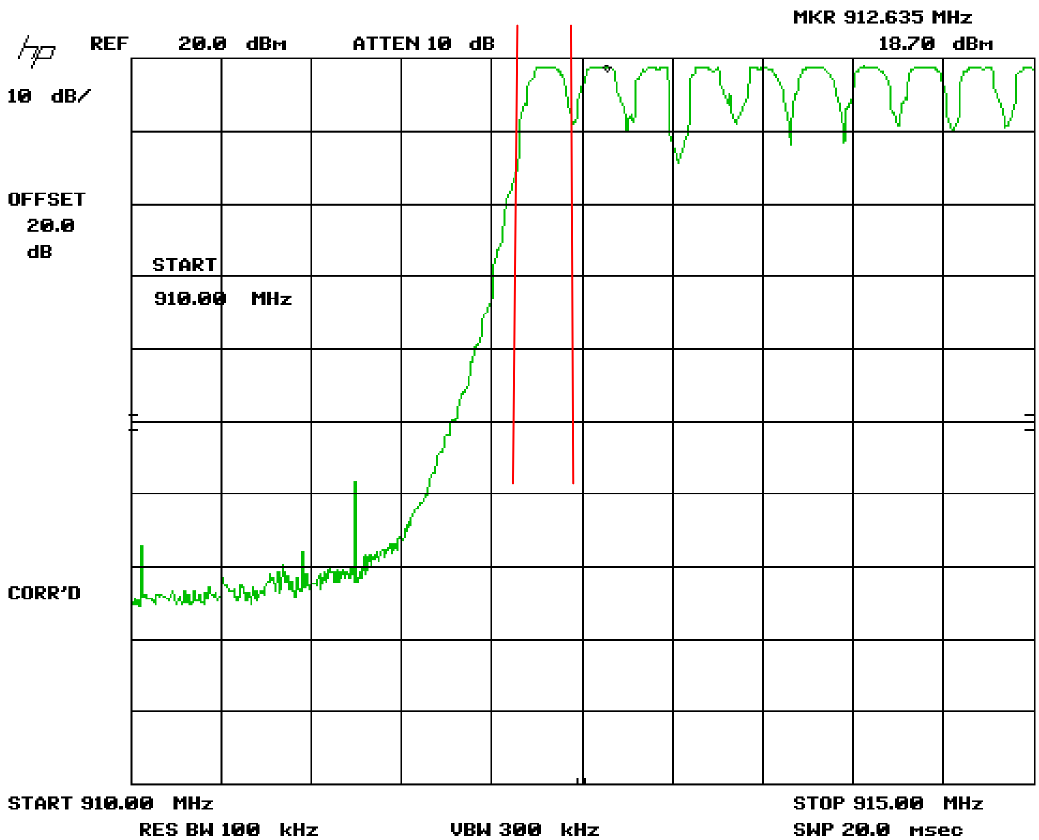

Figure 32. Hopping Channels 0 through 9

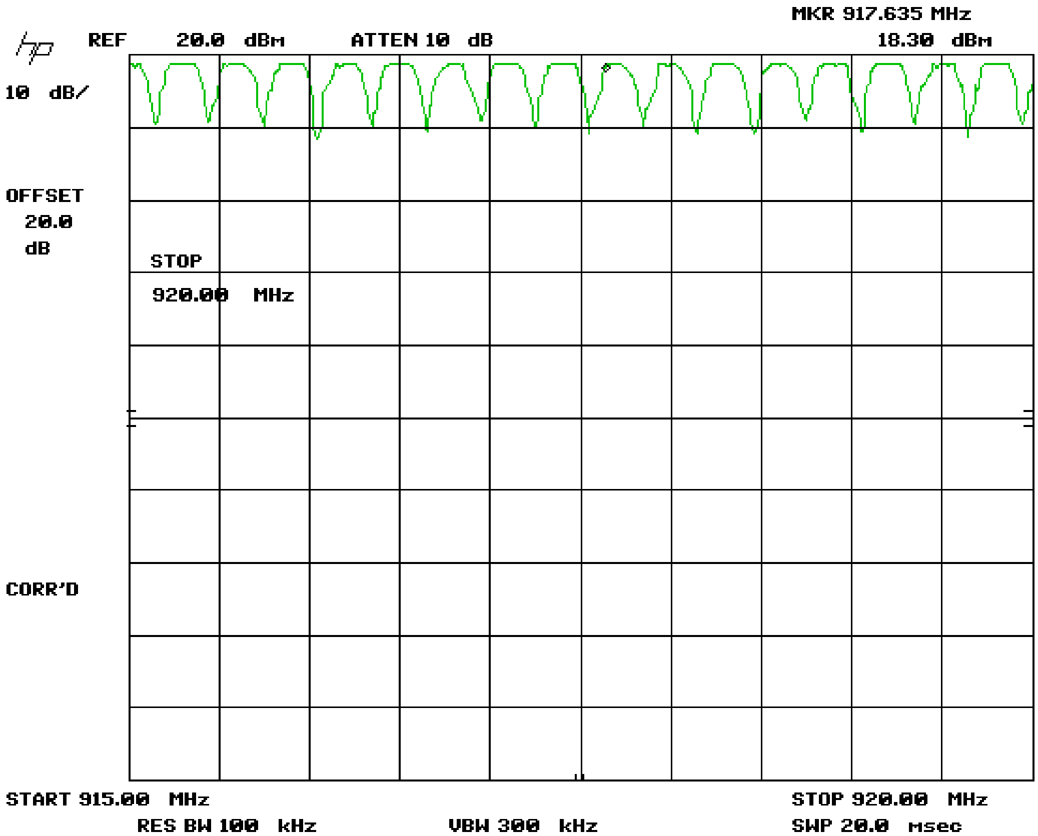

Figure 33. Hopping Channels 10 - 26

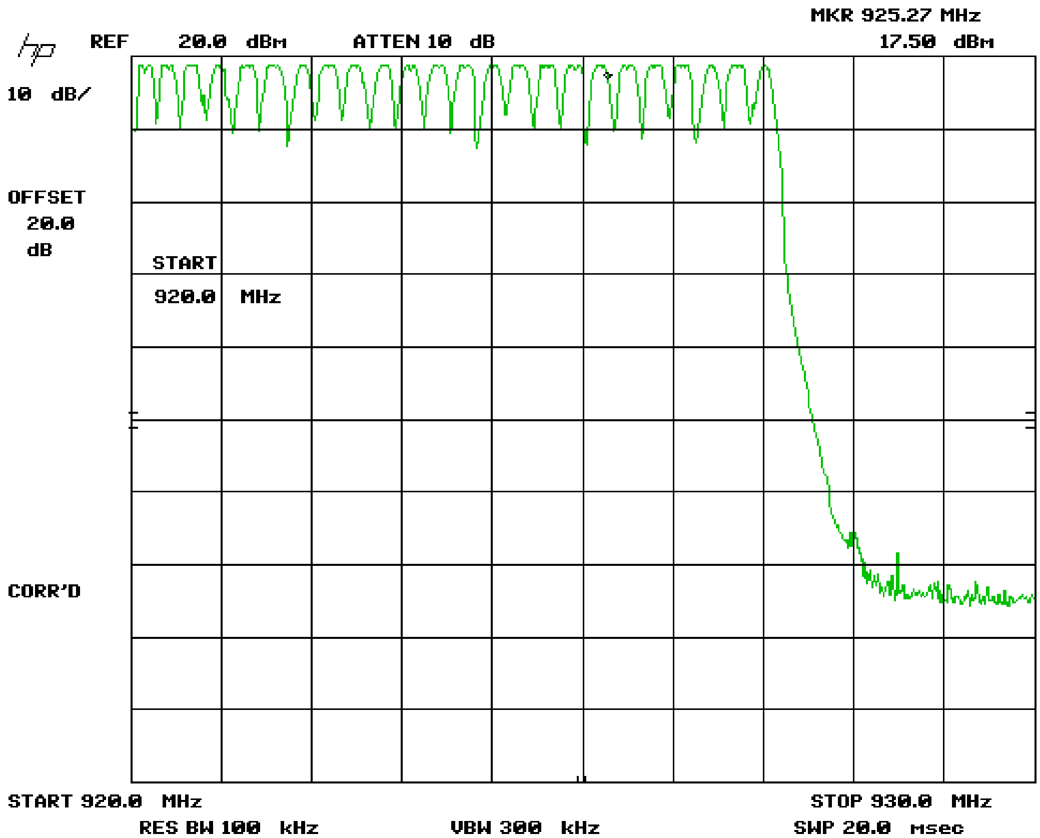

Figure 34. Hopping Channels 27- 49

2.17 Frequency Separation (CRF 15.247(a)(1))

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. In this case, the 20 dB bandwidth of the Frequency hopping system is greater than 25 kHz, so the minimum requirement used was the 20 dB bandwidth, 170.6 kHz. Therefore the frequency separation must be greater than 170.6 kHz.

The EUT does meet the frequency separation requirement.

The test procedures outlined in FCC Public Notice DA 00-705 and ANSI C63.10-2013 were used to conduct measurements. The EUT hopping function was enabled during the testing.

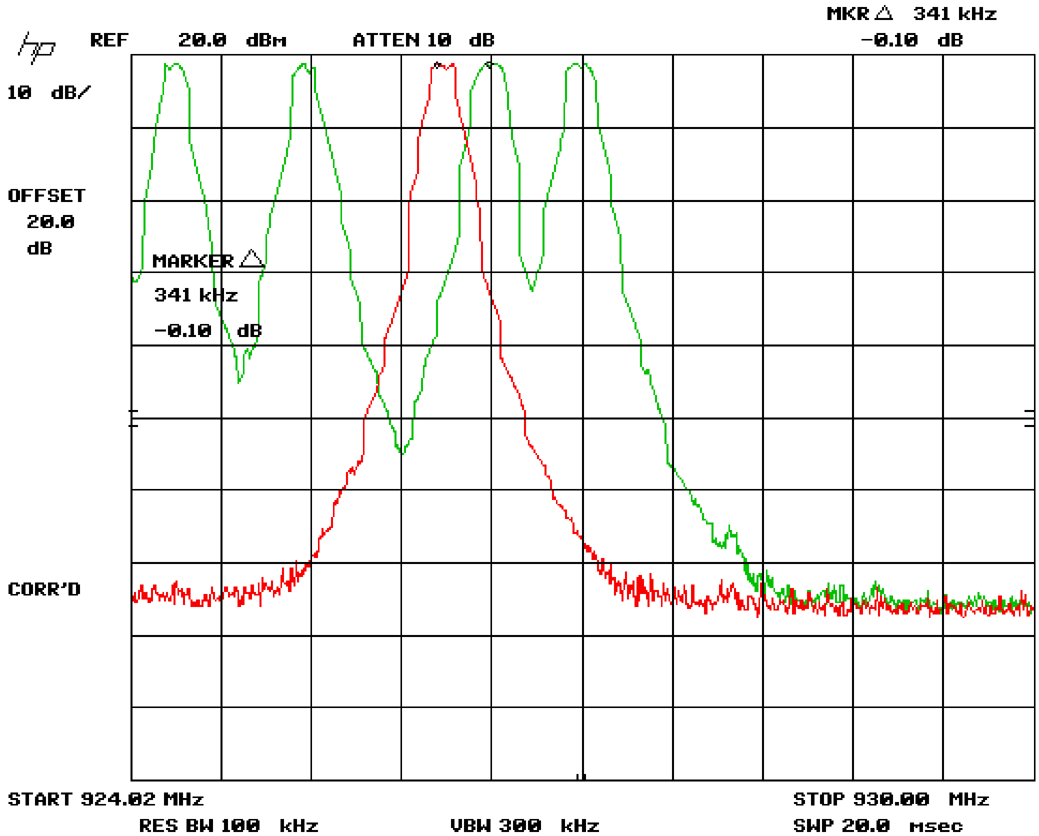

Figure 35. Channel Separation

Measured Delta (Figure 33 above)	341.0 kHz
-Limit (20 dB Bandwidth)	169.0 kHz
Margin	172.0 kHz

2.18 Average Time of Occupancy (CFR 15.247(f))

The frequency hopping operation of the hybrid system shall have an average time on any frequency not exceeding 0.4 s within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. Since the EUT employs 50 channels in the frequency hopping mode, the average time on shall not exceed 0.4 s within 20 s

The test procedures outlined in the FCC Public Notice DA 00-705 and ANSI C63.10-2013 was used to conduct measurements. The EUT was set to normal use, i.e. frequency hopping, mode.

The maximum time of occupancy on any channel is measured to be 383.8mS. The system will cycle through all 50 channels before returning to the measured channel in 20.0 seconds as detailed in the theory of operation. The EUT meets this requirement.

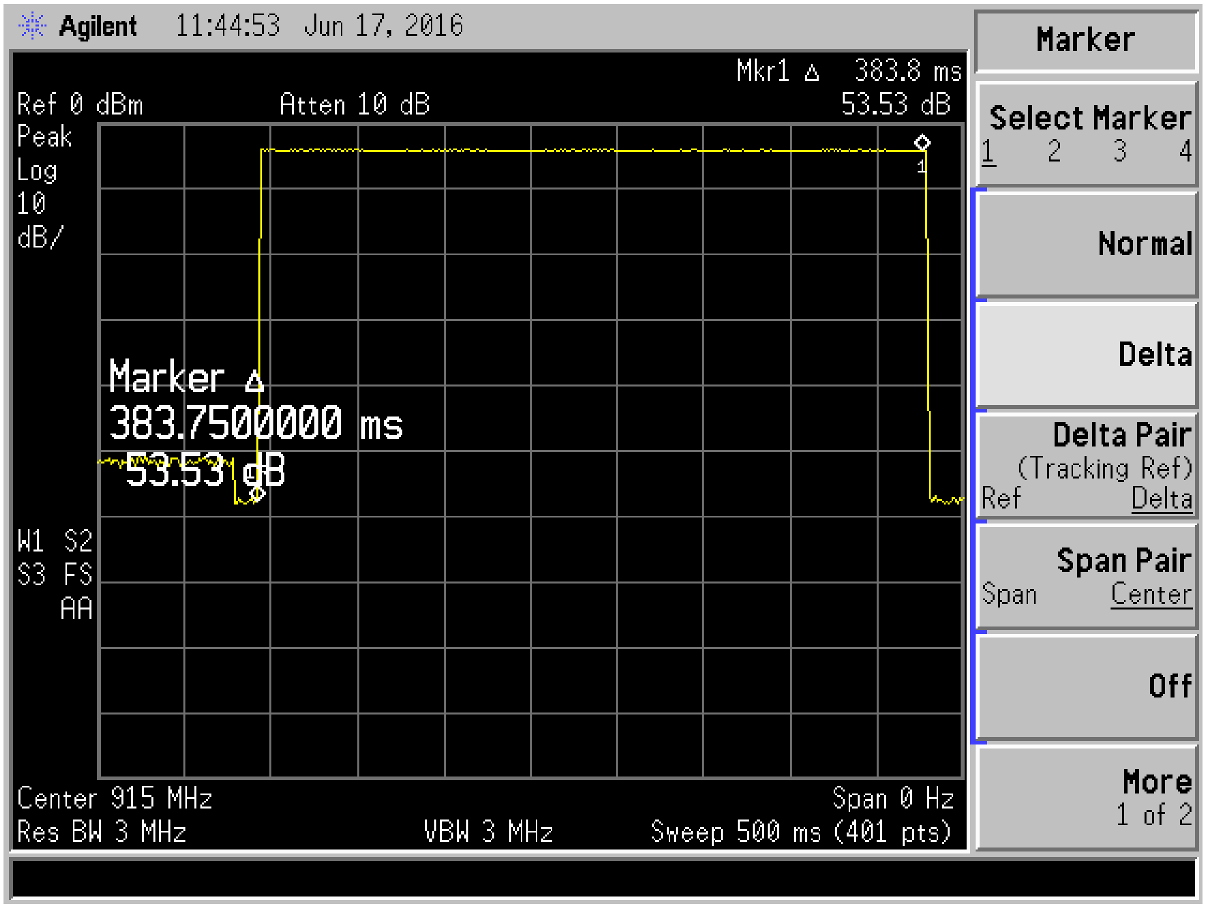

Figure 36. Time On

Limit = 0.400 s within 20 s

Average time of Occupancy = 0.240 sec x 2 (2 pulses per 10 seconds)

Limit	400.0 ms
-Average Time of Occupancy	383.8 ms
Margin	16.2 ms

2.19 Unintentional and Intentional Radiator, Powerline Emissions (CFR 15.107/15.207)

The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.107, per ANSI C63.4:2014, Paragraph 7, with a spectrum analyzer connected to a LISN and the EUT placed into a continuous mode of transmission. Additionally the transmitter was turned ON and the test was repeated with the intentional transmitter circuit ON. The worst case mode of operation is with the transmitter circuit ON. That test data is presented below to show compliance to both parts.

The EUT was battery powered; therefore this test was not applicable.

Table 14. Power Line Conducted Emissions Test Data, Part 15.107, 15.207

150KHz to 30 MHz with Class B Limits						
Test: Power Line Conducted Emissions				**Client:** Mueller Systems, LLC		
Project: 16-0118				**Model:** DCOM4-LP		
Frequency (MHz)	**Test Data (dBuv)**	**LISN+CL-PA (dB)**	**Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector PK, QP, or AVG**
The EUT is battery powered; therefore this test was not applicable.						

SAMPLE CALCULATION: N/A

Test Date: July 7, 2016
Tested By
Signature: ____________ Name: Robert Nevels

2.20 Unintentional and Intentional Radiator, Radiated Emissions (CFR 15.109, 15.209)

Radiated emissions disturbance measurements were performed with the transmitter turned OFF and the test was repeated with the intentional transmitter circuit ON. The worst case mode of operation is with the transmitter circuit ON. That test data is presented below to show compliance to both parts.

An instrument having both peak and quasi-peak detectors was used to perform the test over the frequency range of 30 MHz to five times the highest clock frequency. Measurements of the radiated emissions were made with the receiver antenna at a distance of 3 m from the boundary of the test unit.

The test antenna was varied from 1 m to 4 m in height while watching the analyzers' display for the maximum magnitude of the signal at the test frequency. The antenna polarization (horizontal or vertical) and test sample azimuth were varied during the measurements to find the maximum field strength readings to record.

The worst-case radiated emission in the range of 30 MHz to 6 GHz was 5.1 dB below the limit at 70.66 MHz. This signal is found in Table 15. All other radiated emissions were 6.6 dB or more below the limit.

Table 15. Unintentional and Intentional Radiator, Spurious Radiated Emissions (CFR 15.109, 15.209) 30 MHz to 1000 MHz

30 MHz to 1000 MHz with Class B Limits							
Test: Radiated Emissions				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**QP Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or QP**
129.45	40.61	-13.63	26.98	43.5	3m./HORZ	16.5	**PK**
70.66	52.83	-17.93	34.90	40.0	3m./VERT	5.1	**PK**
602.39	41.95	-2.59	39.36	46.0	3m./VERT	6.6	**PK**
580.03	41.98	-2.67	39.31	46.0	3m./HORZ	6.7	**PK**
110.33	40.89	-15.34	25.55	43.5	3m./HORZ	18.0	**PK**
133.42	38.75	-13.60	25.15	43.5	3m./HORZ	18.3	**PK**
134.00	39.07	-12.91	26.16	43.5	3m./VERT	17.3	**PK**
35.00	42.20	-13.79	28.41	40.0	3m./VERT	11.6	**PK**
290.41	40.76	-10.07	30.69	46.0	3m./VERT	15.3	**PK**
606.98	40.12	-2.69	37.43	46.0	3m./VERT	8.6	**PK**
606.98	40.59	-2.09	38.50	46.0	3m./HORZ	7.5	**PK**
290.41	40.44	-9.77	30.67	46.0	3m./HORZ	15.3	**PK**

Tested from 30 MHz to 1 GHz

SAMPLE CALCULATION at 129.45 MHz:

Magnitude of Measured Frequency	40.61	dBuV
+ Cable Loss+Antenna Factor-Amp Gain	-13.63	dB
=Corrected Result	26.98	dBuV
Limit	43.50	dBuV
-Corrected Result	26.98	dBuV
Margin	16.50	dB

Test Date: May 16, 2016
Tested By
Signature: Robt S. Nevels Name: Robert Nevels

Table 16. Unintentional and Intentional Radiator, Spurious Radiated Emissions (CFR 15.109, 15.209) 1 GHz to 6 GHz

1 GHz to 6 GHz with Class B Limits							
Test: Radiated Emissions				**Client:** Mueller Systems, LLC			
Project: 16-0118				**Model:** DCOM4-LP			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
No emissions seen greater than 6 dB from the noise floor.							

Tested from 1 GHz to 6 GHz

SAMPLE CALCULATION: N/A

Test Date: May 16, 2016
Tested By
Signature: ____________ Name: Robert Nevels

2.21 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB.

This test was not performed. The EUT is battery operated.

Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.

The data listed in this test report does not have sufficient margin to negate the effects of uncertainty. Therefore, the EUT conditionally meets this requirement.