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

For the

Controlant EHF

Model: CO 15.01

FCC ID: 2AD9R-CO1501

UST Project: 15-0029
Issue Date: February 13, 2015

Total Pages in This Report: 69

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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 February 13, 2015

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Controlant EHF

MODEL: CO 15.01

FCC ID: 2AD9R-CO1501

DATE: February 13, 2015

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

Equipment Type: 903-927 MHz Transmitter

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:

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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.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on February 2, 2015 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Controlant EHF Model CO 15.01. The CO 15.01 is a wireless logger with a built in ambient temperature sensor. The logger transmits its data to a local transceiver which then collects the data to an online central database. The CO 15.01 is a hybrid system where both Frequency Hopping and Digital Modulation occur and is a wireless transmitter operating in the 900 MHz band. When trying to synch with a gateway/receiver the EUT will send a single packet out every 20 or more seconds. If the EUT receives an ACK, then EUT goes into frequency hopping mode, i.e. normal operation mode.

Antenna: Monopole (-1 dBi Gain)
Modulation: GFSK (FHSS) and 2-FSK (DTS)
Maximum Output Power: 11 dBm (FHSS)
Symbol rate: 4.75 kbps (FHSS) and 475 bps (DTS)
Bit Rate: 38 kbps (FHSS) and 4 kbps (DTS)

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2009, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2009)* 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 DA00-705 were 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

1.6.1 The EUT is subject to the following FCC authorizations:

a) Certification under section 15.247 as a transmitter.
b) Verification under 15.101 as a digital device and receiver.

1.6.2 Verification of the Digital apparatus

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 (part 15.107 and 15.109) for the EUT is included herein.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
EUT Controlant EHF	CO 15.01	Engineering Sample	2AD9R-CO1501 (Pending)	None
Receiver Controlant EHF	CO 13.01	Engineering Sample	2AD9R-CO1301 (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	2/03/2014 Extended 90 days
SPECTRUM ANALYZER	E4407B	Agilent	US41442935	1/28/2015
PREAMP	8449B	HEWLETT-PACKARD	3008A00480	12/05/2014
PREAMP	8447D	HEWLETT-PACKARD	1145A00307	11/21/2014
PREAMP	8447D	HEWLETT-PACKARD	1937A02980	12/04/2014
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/12/2013 2 yr
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr
BICONICAL ANTENNA	3110B	EMCO	9307-1431	2/11/2014 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	7/11/2014 2 yr
HORN ANTENNA	SAS-571	A. H. Systems	605	7/23/2013 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 MHz to 927 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 10th 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:

2.5.1 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.

2.5.2 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.

2.5.3 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	Linx	Monopole	ANT-868-JJB-RA	-1	Direct Solder connection

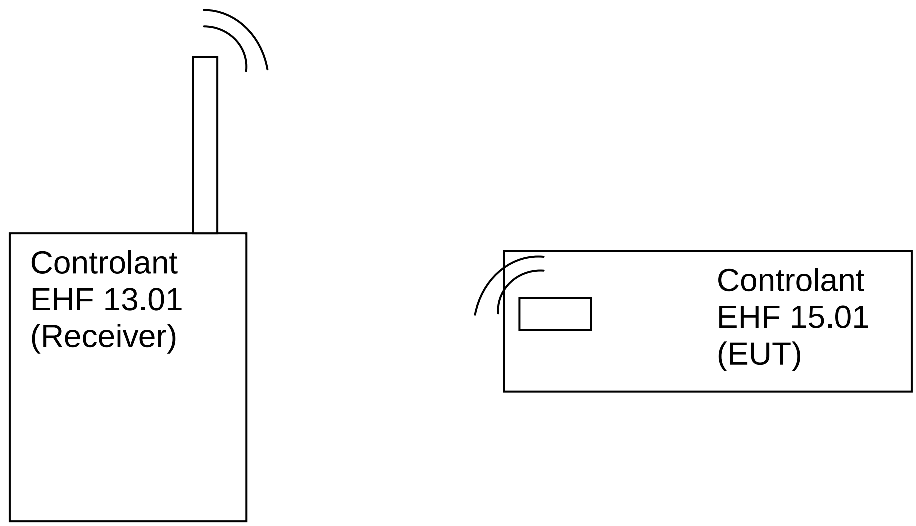

Figure 1. Test Configuration for Normal Use Mode (Frequency Hopping Mode)

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 2.1

2.8 Transmitter Duty Cycle (CFR 35 (c))

Measurements of the duty cycle and transmission duration were performed using the zero span method per KDB 558074. The spectrum analyzer was set to the center frequency of the transmission. The RBW and VBW were set to the largest available value. The method was used because the RBW and VBW were > 50/T.

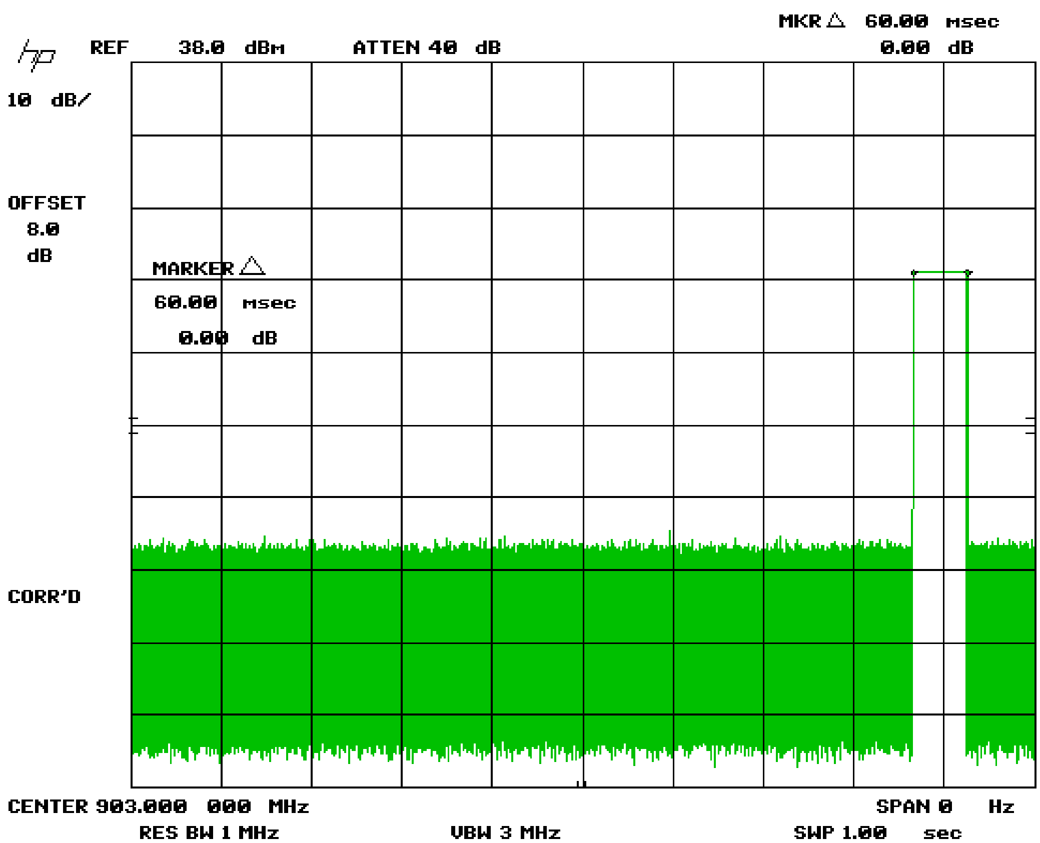

Figure 2. Transmitter Pulse Width

Total Time On from Figure 2 = 60.0 ms (Transmitter Pulse Width)

(0.06 s Total Time On)/(0.100 s Time period) = 0.60 Numeric Duty Cycle
Duty Cycle = 20 Log (0.60) = -4.4 dB

Duty Cycle applied in this test report is -4.4 dB.

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

Manufacturer's note regarding EUT standard operation:

Synching with gateway/receiver: Once every period (>20 sec) it transmits a single package and the transmit duration is less than 40 msec. The package includes at what channel it will start listening on. After transmitting package it goes into Rx mode and waits for ack.

If no answer it will wait for more than 20 sec to transmit another package on the same channel. The waiting period has some random effect, i.e.

$T_{waiting}$ = 20 + random(>0) [seconds]

If the logger gets an ACK from a gateway it goes into frequency hopping mode and starts communicating in a periodic manner. The ACK includes clock information from the gateway, and when the logger can transmit again and at what channel. The gateway uses a pseudo random ordered channel list.

Periodic transmission: Logger wakes up at a time decided by the gateway and transmits a package on the channel indicated by the gateway and waits for an ACK. If ACK is received the periodic transmissions continues. If no ACK is received the logger can try to resend the package or retry synching with a gateway.

Burst transmission (log dump): Logger can log measurements into memory and send up to 40 packages in a burst mode. When logger sends burst transmission it uses the appropriate channel in the pseudo random sequence controlled by the gateway.

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 applied.

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 FCC Public Notice DA 00-705 and 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 was placed in the FHSS modulation because the output power of the FHSS modulation was larger than the DTS modulation output power and the normal mode of operation is when the EUT is frequency hopping.

Radiated measurements were then conducted between the frequency range of 9 kHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no 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 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 to 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 from 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 the FHSS modulation because the output power of the FHSS modulation was larger than the DTS modulation output power and the normal mode of operation is when the EUT is frequency hopping.

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

9 kHz to 30 MHz							
Test: Radiated Emissions				**Client:** Controlant EHF			
Project: 15-0029				**Model:** CO 15.01			
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 form the limit.							

Tested from 9 kHz to 30 MHz

SAMPLE CALCULATION: N/A

Test Date: February 11, 2015
Tested By
Signature: ____________ Name: Carrie Fincannon

Table 6. Average Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Controlant EHF			
Project: 15-0029				**Model:** CO 15.01			
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	76.97	24.86	101.86		3 m/HORZ		**AVG**
1806	52.92	-6.97	37.45	81.8	1 m/HORZ	44.4	**AVG**
Mid Channel – AVERAGE							
915	71.18	24.96	96.14		3m /HORZ		**AVG**
1830	47.75	-6.72	32.53	76.1	1 m/HORZ	43.6	**AVG**
High Channel – AVERAGE							
927	68.43	25.09	93.52		3 m/HORZ		**AVG**
1854	52.74	-6.66	37.58	73.5	1 m/HORZ	35.9	**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 meter 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 MHz:

Magnitude of Measured Frequency	76.97	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty cycle	24.86	dB/m
Corrected Result	101.86	dBuV/m

Test Date: February 4, 2015
Tested By
Signature: ________________ Name: Carrie Fincannon

Table 7. Peak Radiated Fundamental & Harmonic Emissions

Test: FCC Part 15, Para 15.209, 15.247(d)				**Client:** Controlant EHF			
Project: 15-0029				**Model:** CO 15.01			
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	77.25	24.86	102.11		3 m/HORZ		**PK**
1806	55.06	-6.97	39.59	82.1	1 m/HORZ	42.5	**PK**
Mid Channel – AVERAGE							
915	71.95	24.96	96.91		3 m/HORZ		**PK**
1830	53.87	-6.72	38.65	76.9	1 m/HORZ	38.3	**PK**
High Channel - AVERAGE							
927	68.89	25.09	93.98		3m /HORZ		**PK**
1854	56.82	-6.66	41.66	74.0	1 m/HORZ	32.3	**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 meter using a factor of (-9.5 dB).
4. All measurements are corrected with a -18.13 dB duty. See section 2.8
5. 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 MHz:

Magnitude of Measured Frequency	77.25	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	24.86	dB/m
Corrected Result	102.11	dBuV/m

Test Date: February 4, 2015
Tested By
Signature: ________________ Name: Carrie Fincannon

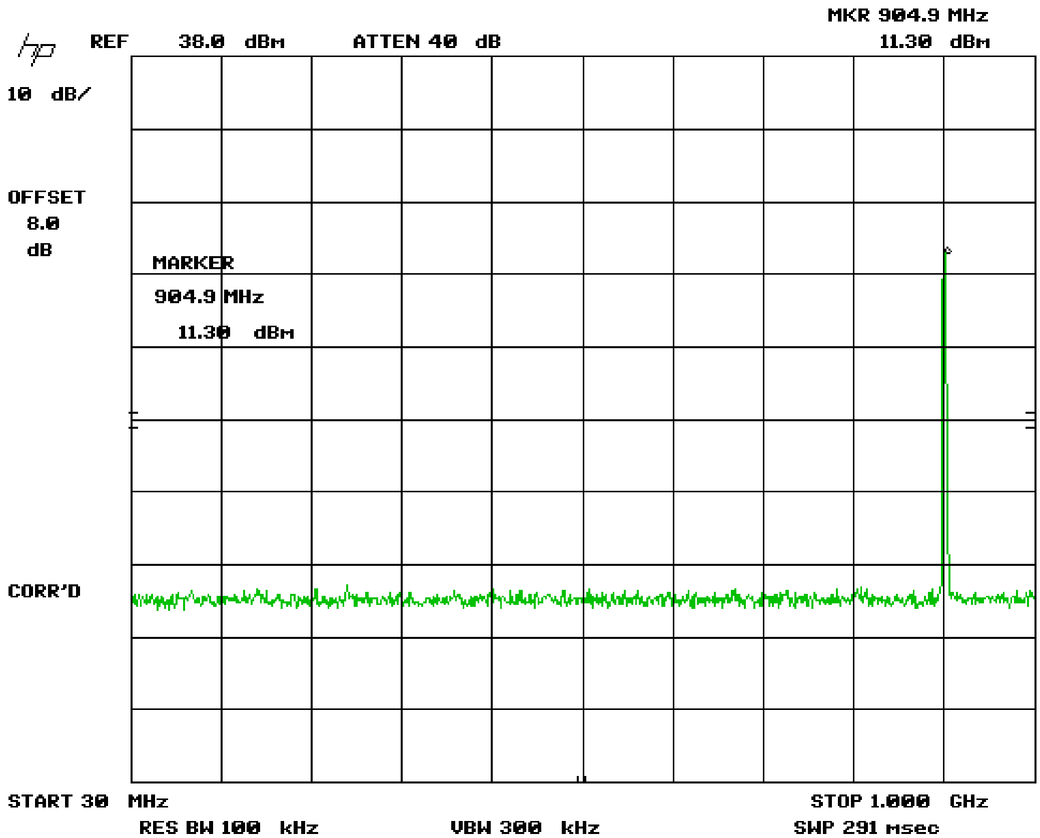

Figure 3. Antenna Conducted Emissions Low, Part 1 GFSK Modulation

Note: Large emission seen is the fundamental emission.

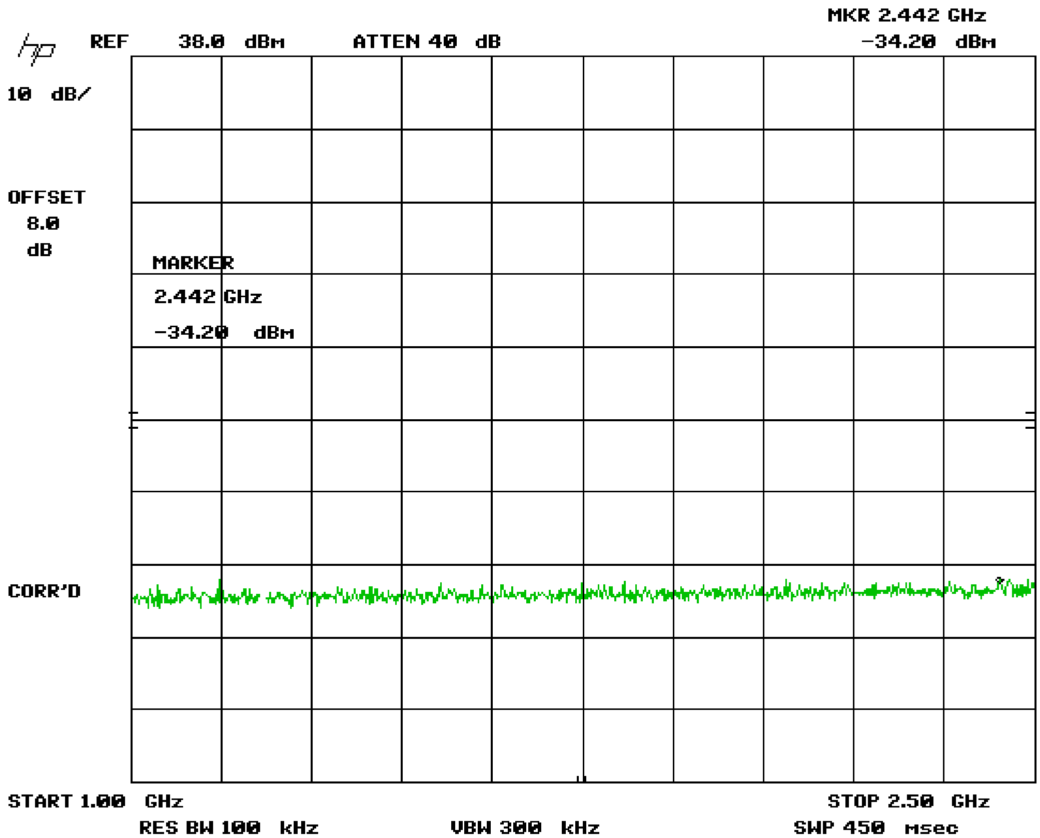

Figure 4. Antenna Conducted Emissions Low, Part 2 GFSK modulation

Fundamental (from Figure 3)	11.30	dBm
Peak Spurious (from figure 4)	(-34.20)	dBm
Difference	45.50	dBm
Difference from Fundamental	45.50	dBm
Limit	20.00	dBm
Margin	25.50	dB

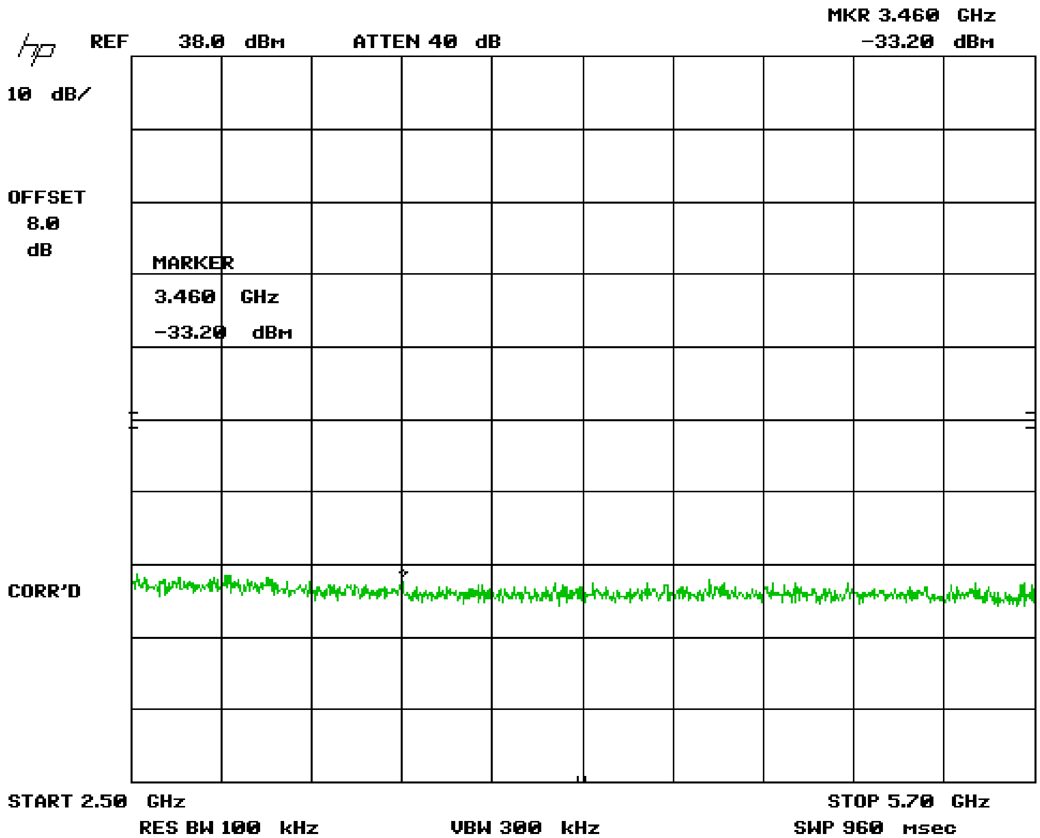

Figure 5. Antenna Conducted Emissions Low, Part 3 GFSK modulation

Fundamental (from Figure 3)	10.43	dBm
Peak Spurious (from figure 5)	(-33.20)	dBm
Difference	43.63	dBm
Difference from Fundamental	43.63	dBm
Limit	20.00	dBm
Margin	23.63	dB

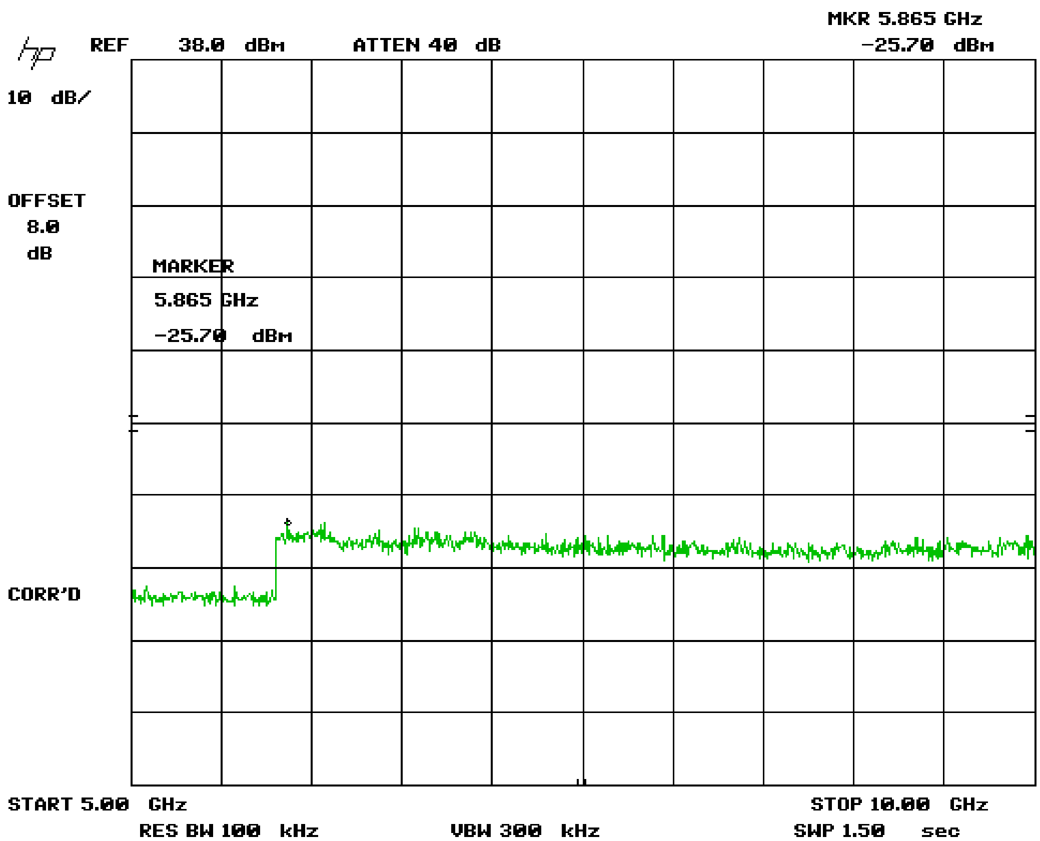

Figure 6. Antenna Conducted Emissions Low, Part 4 GFSK modulation

Fundamental (from Figure 3)	10.43	dBm
Peak Spurious (from figure 6)	(-25.70)	dBm
Difference	36.13	dBm
Difference from Fundamental	36.13	dBm
Limit	20.00	dBm
Margin	36.13	dB

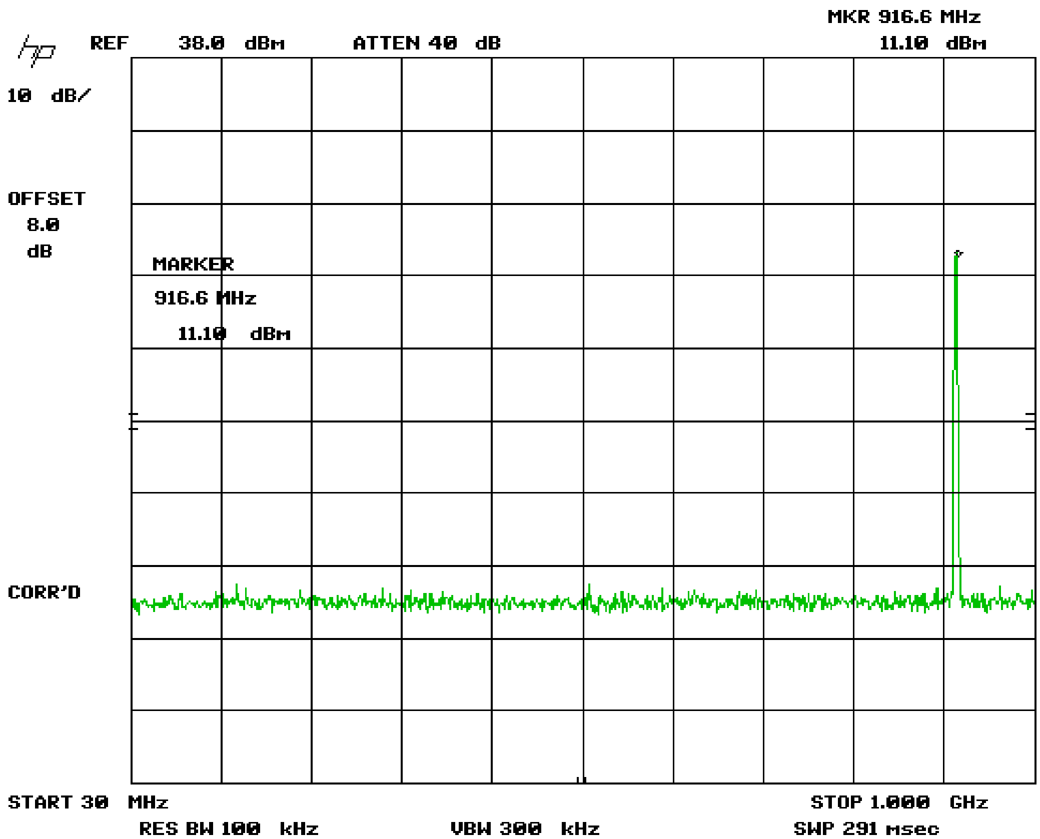

Figure 7. Antenna Conducted Emissions Mid, Part 1 GFSK Modulation

Note: Large emission seen is the fundamental emission.

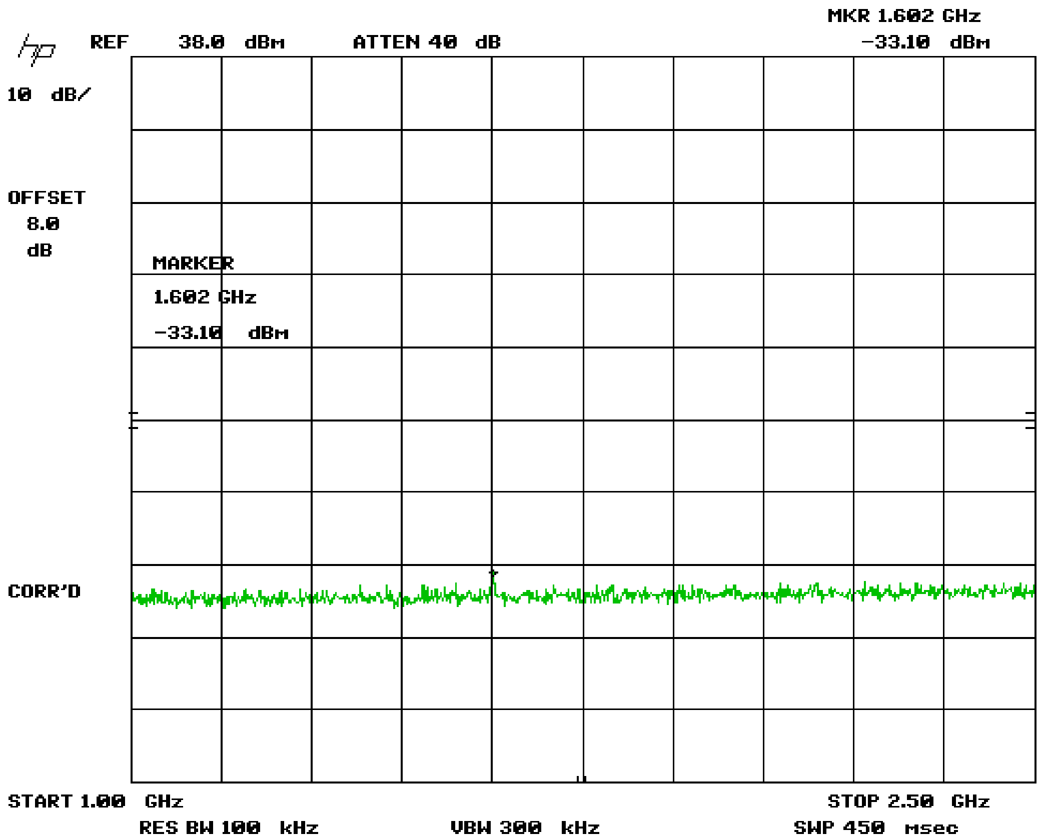

Figure 8. Antenna Conducted Emissions Mid, Part 2 GFSK Modulation

Fundamental (from Figure 7)	11.10	dBm
Peak Spurious (from Figure 8)	(-33.10)	dBm
Difference	44.20	dBm
Difference from Fundamental	44.20	dBm
Limit	20.00	dBm
Margin	24.20	dB

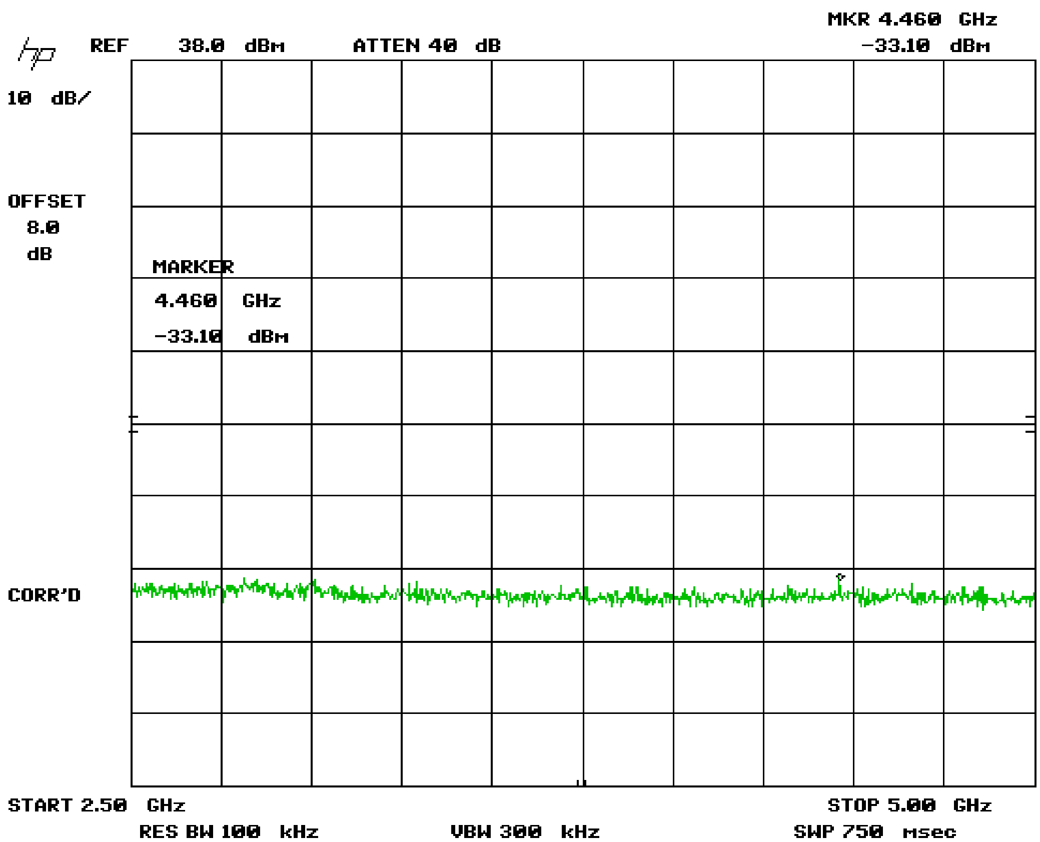

Figure 9. Antenna Conducted Emissions Mid, Part 3 GFSK Modulation

Fundamental (from Figure 7)	11.10	dBm
Peak Spurious (from figure 9)	(-33.10)	dBm
Difference	44.20	dBm
Difference from Fundamental	44.20	dBm
Limit	20.00	dBm
Margin	24.20	dB

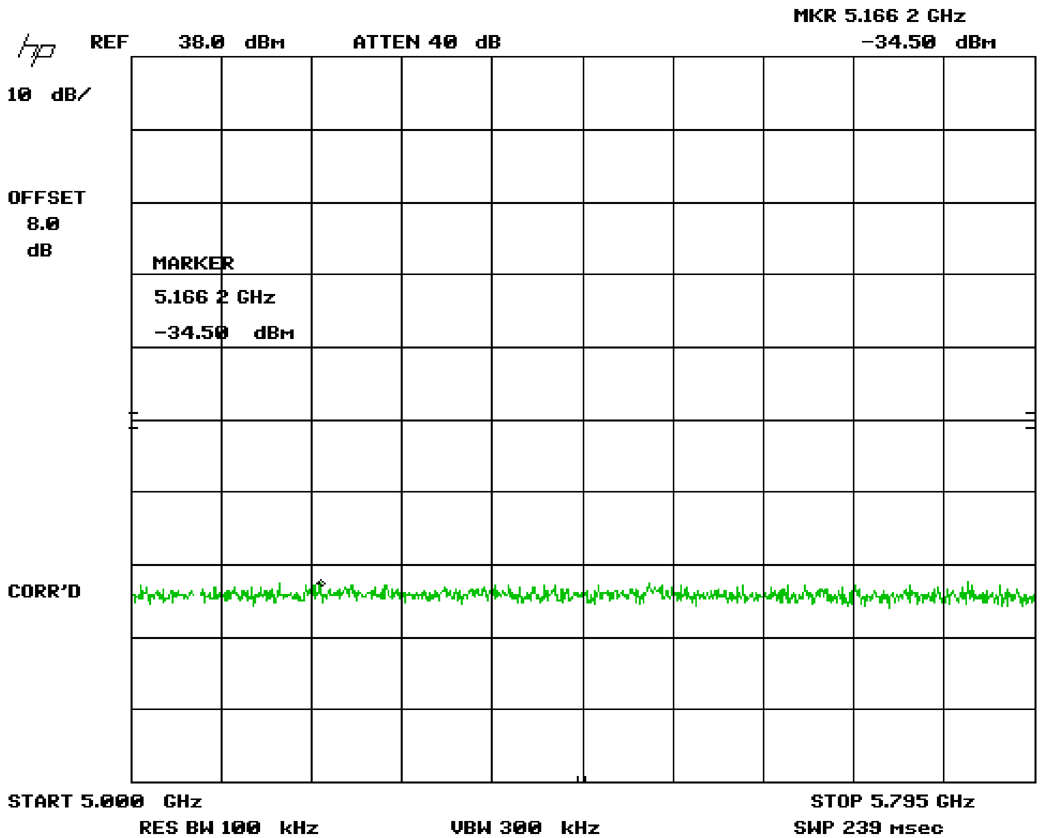

Figure 10. Antenna Conducted Emissions Mid, Part 4 GFSK Modulation

Fundamental (from Figure 7)	11.10	dBm
Peak Spurious (from figure 10)	(-34.50)	dBm
Difference	45.60	dBm
Difference from Fundamental	45.60	dBm
Limit	20.00	dBm
Margin	25.60	dB

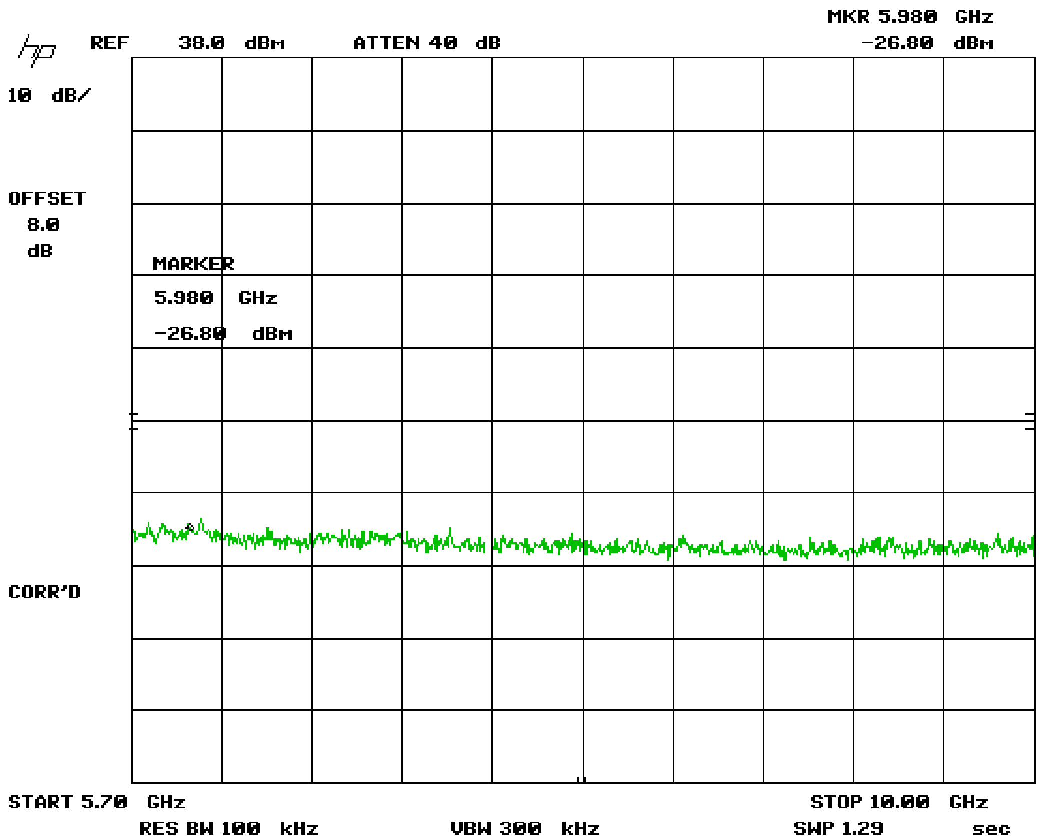

Figure 11. Antenna Conducted Emissions Mid, Part 5 GFSK Modulation

Fundamental (from Figure 7)	11.10	dBm
Peak Spurious (from figure 11)	(-26.80)	dBm
Difference	37.90	dBm
Difference from Fundamental	37.90	dBm
Limit	20.00	dBm
Margin	17.90	dB

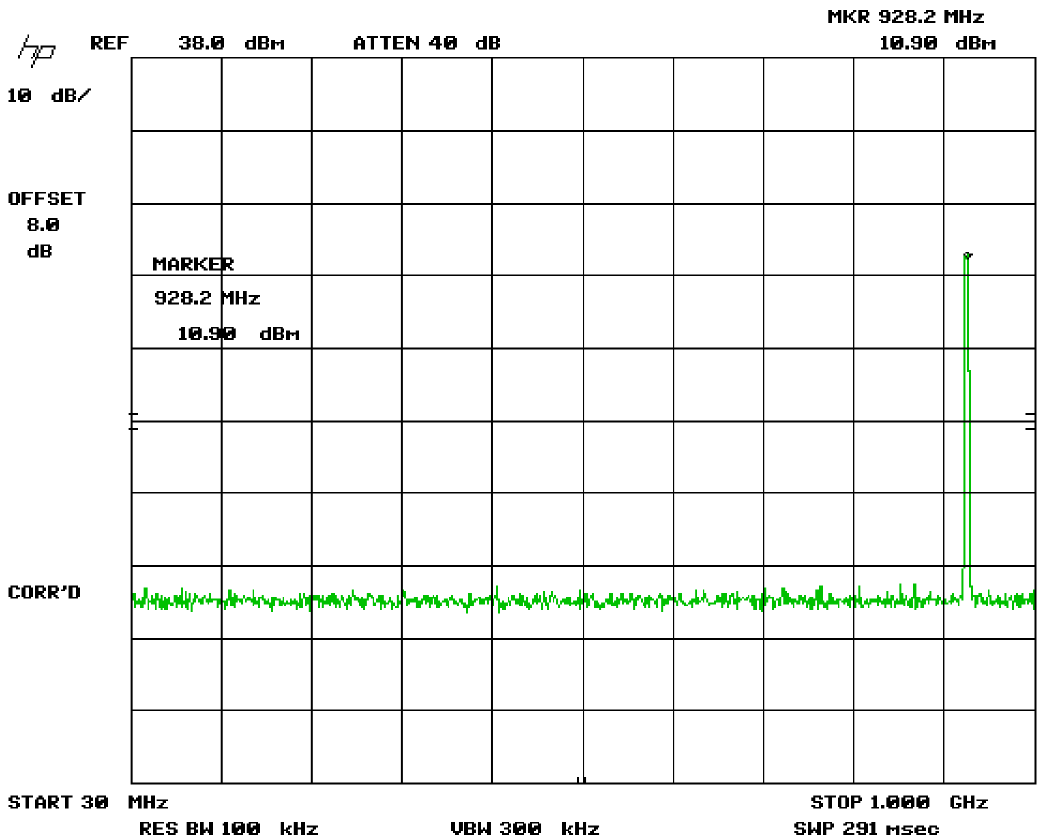

Figure 12. Antenna Conducted Emissions High, Part 1 GFSK Modulation

Note: Large emission seen is the fundamental emission.

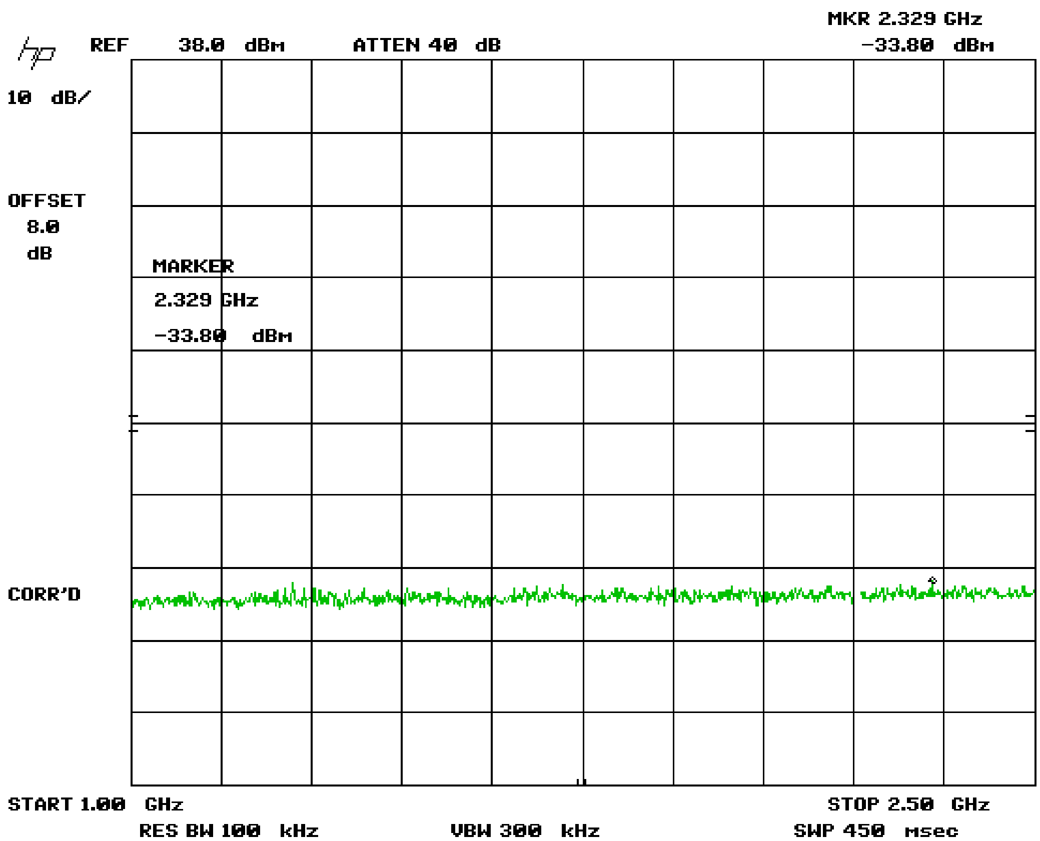

Figure 13. Antenna Conducted Emissions High, Part 2 GFSK Modulation

Fundamental (from Figure 12)	10.90	dBm
Peak Spurious (from Figure 13)	(-33.80)	dBm
Difference	44.70	dBm
Difference from Fundamental	44.70	dBm
Limit	20.00	dBm
Margin	24.70	dB

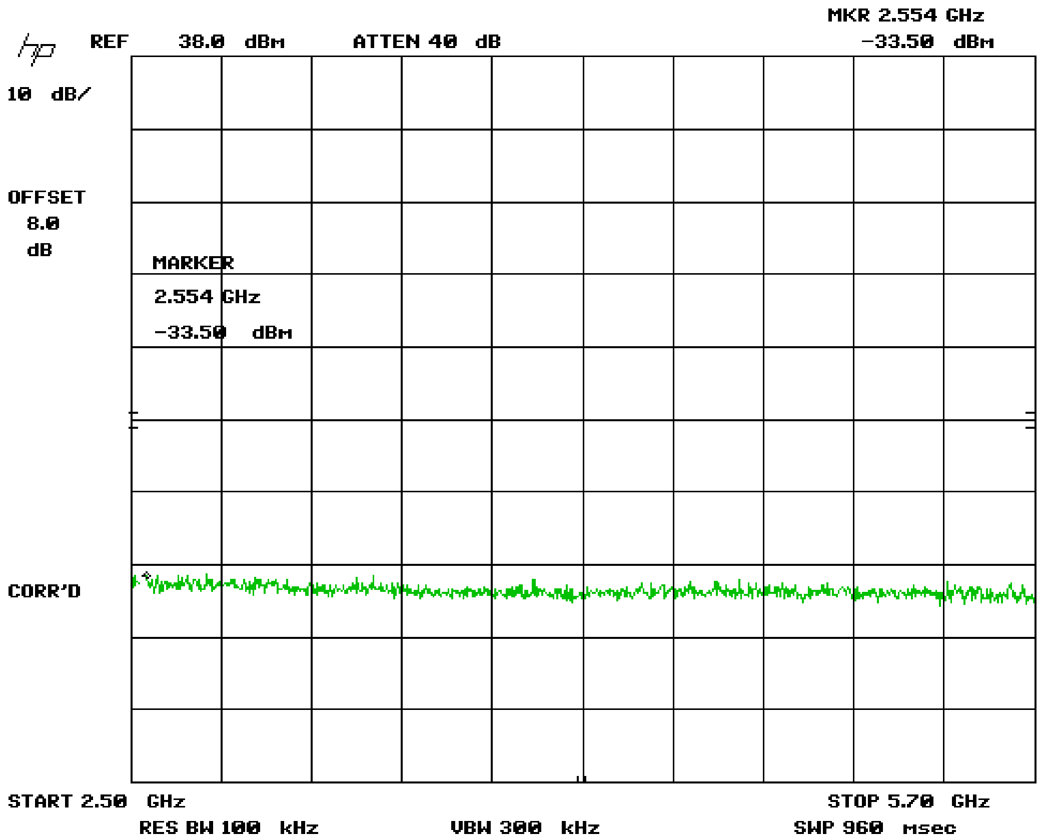

Figure 14. Antenna Conducted Emissions High, Part 3 GFSK Modulation

Fundamental (from Figure 12)	10.90	dBm
Peak Spurious (from Figure 14)	(-33.50)	dBm
Difference	44.50	dBm
Difference from Fundamental	44.50	dBm
Limit	20.00	dBm
Margin	24.50	dB

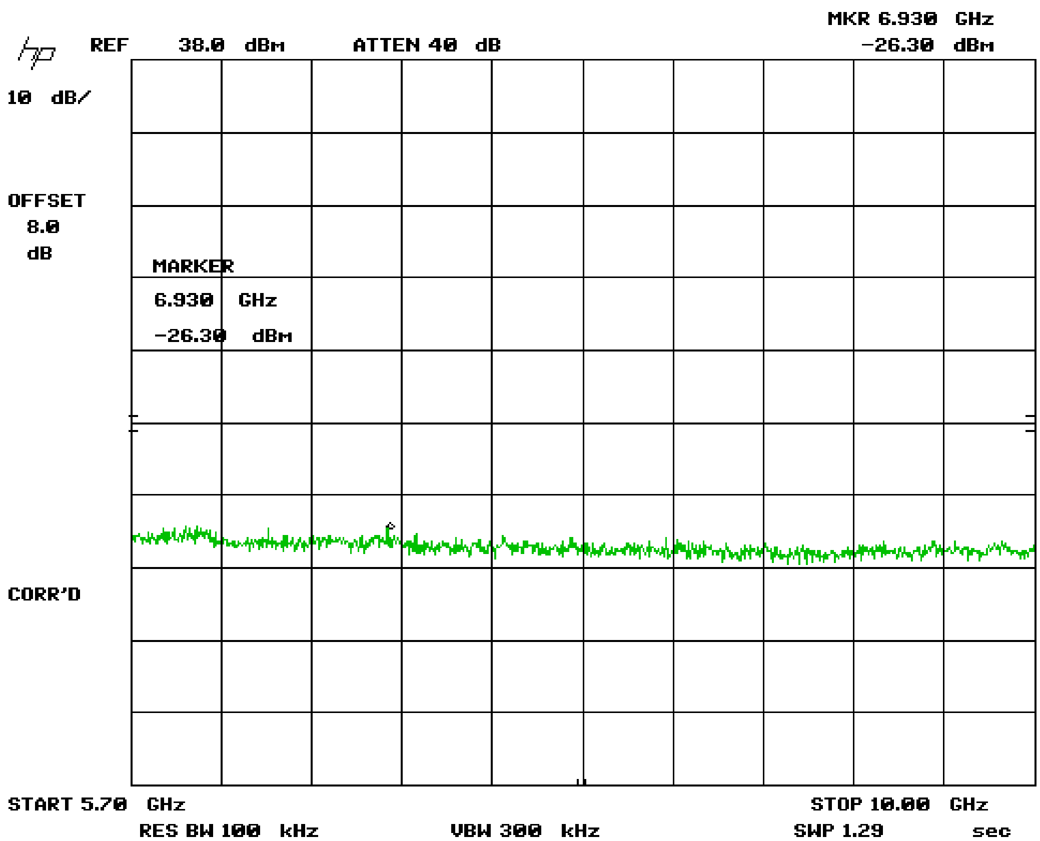

Figure 15. Antenna Conducted Emissions High, Part 4 GFSK Modulation

Fundamental (from Figure 12)	10.90	dBm
Peak Spurious (from Figure 15)	(-26.30)	dBm
Difference	37.20	dBm
Difference from Fundamental	37.20	dBm
Limit	20.00	dBm
Margin	17.20	dB

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 00-75 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 GFSK Modulation

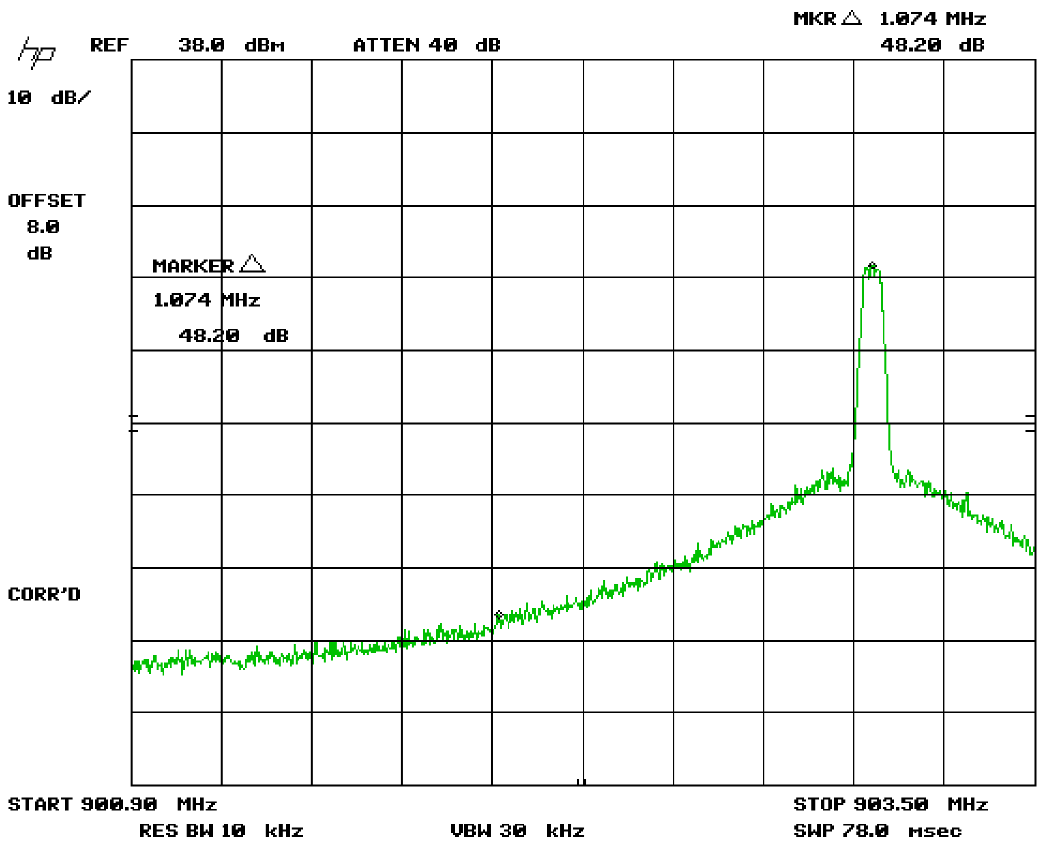

Figure 16. Band Edge Compliance, Low Channel Delta – Continuous Transmission GFSK Modulation

Measured Delta (from Figure 27)	48.20	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	28.20	dB

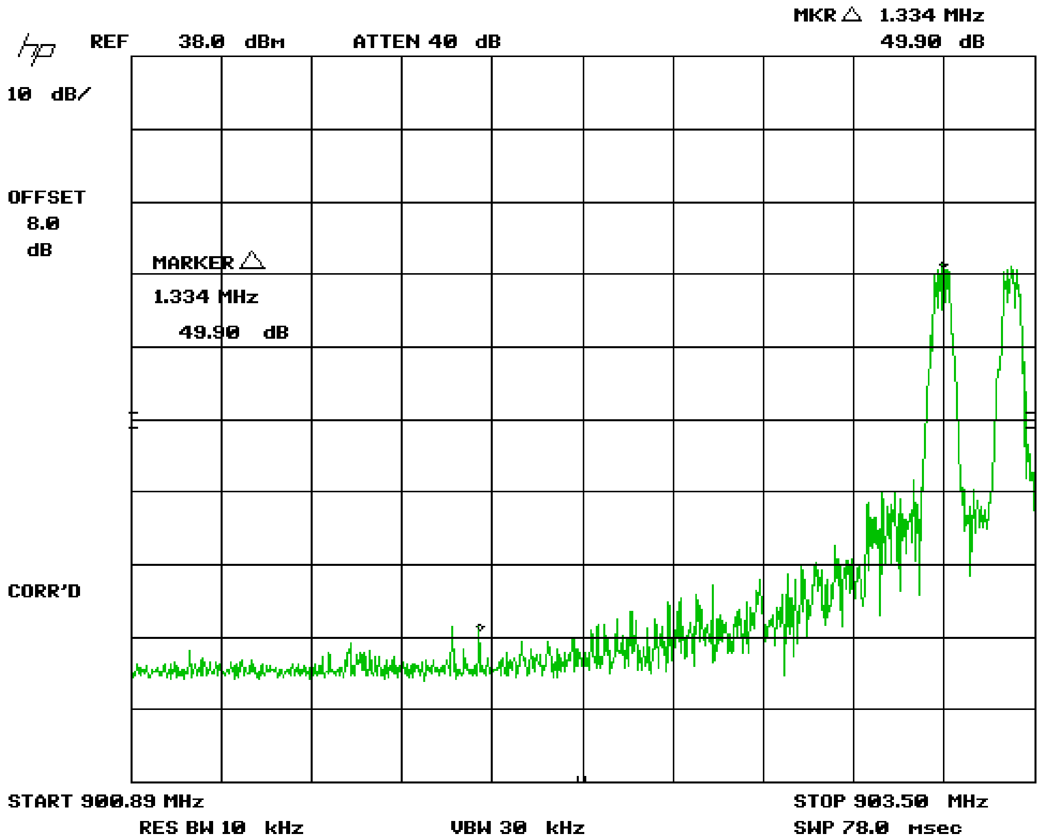

Figure 17. Band Edge Compliance, Low Channel Delta – Channel Hopping GFSK Modulation

Measured Delta (from Figure 28)	49.90	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	29.90	dB

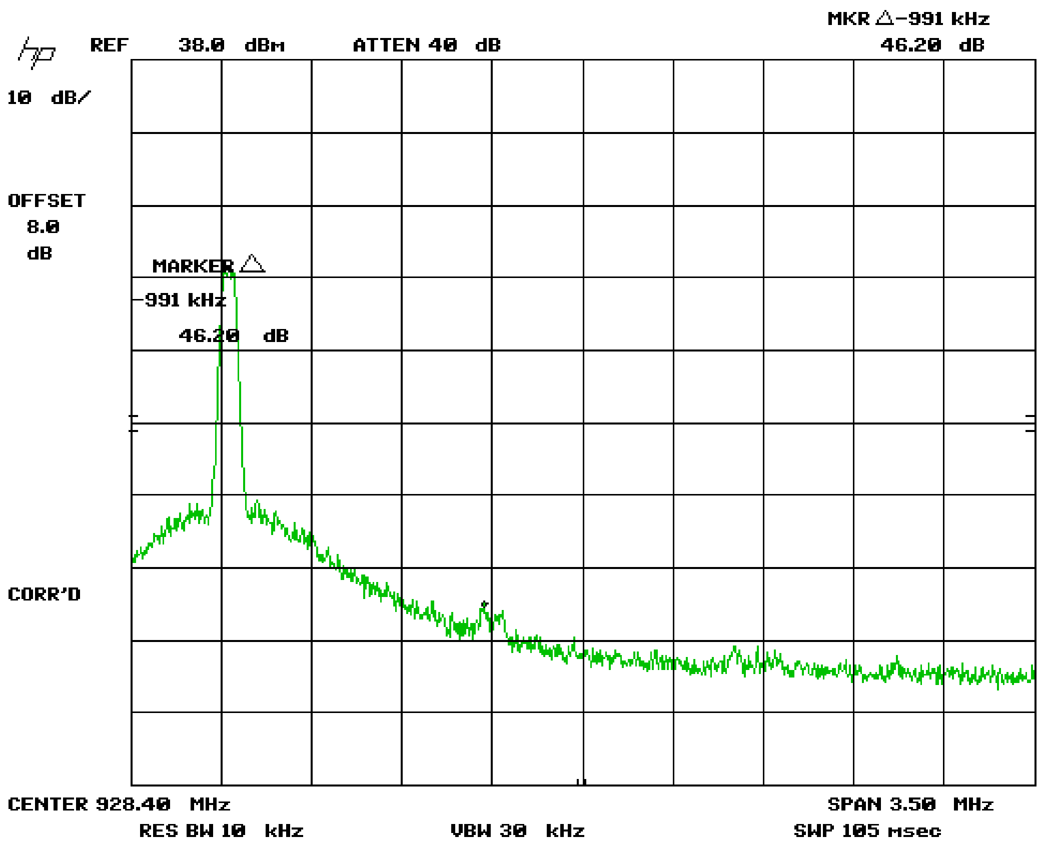

Figure 18. Band Edge Compliance, High Channel Delta – Continuous Transmission GFSK Modulation

Measured Delta (from Figure 29)	46.20	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	26.20	dB

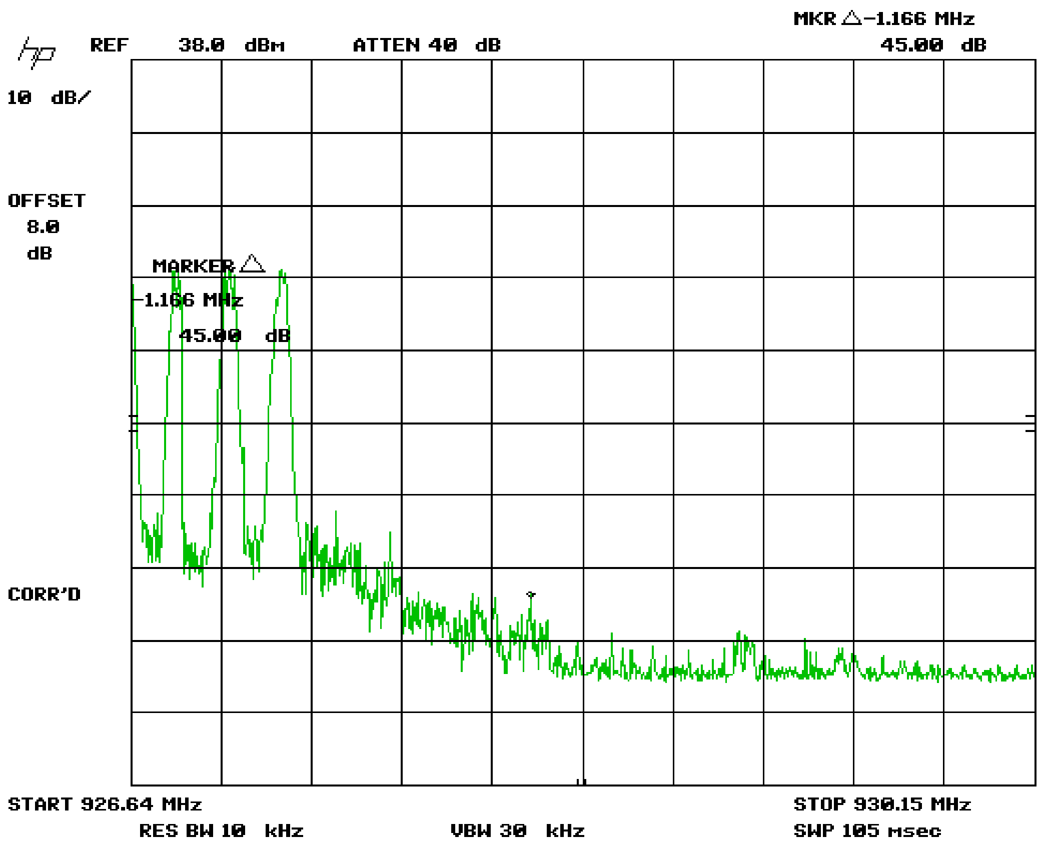

Figure 19. Band Edge Compliance, High Channel Delta – Channel Hopping GFSK Modulation

Measured Delta (from Figure 30)	45.00	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	25.00	dB

2.11.2 2-FSK Modulation

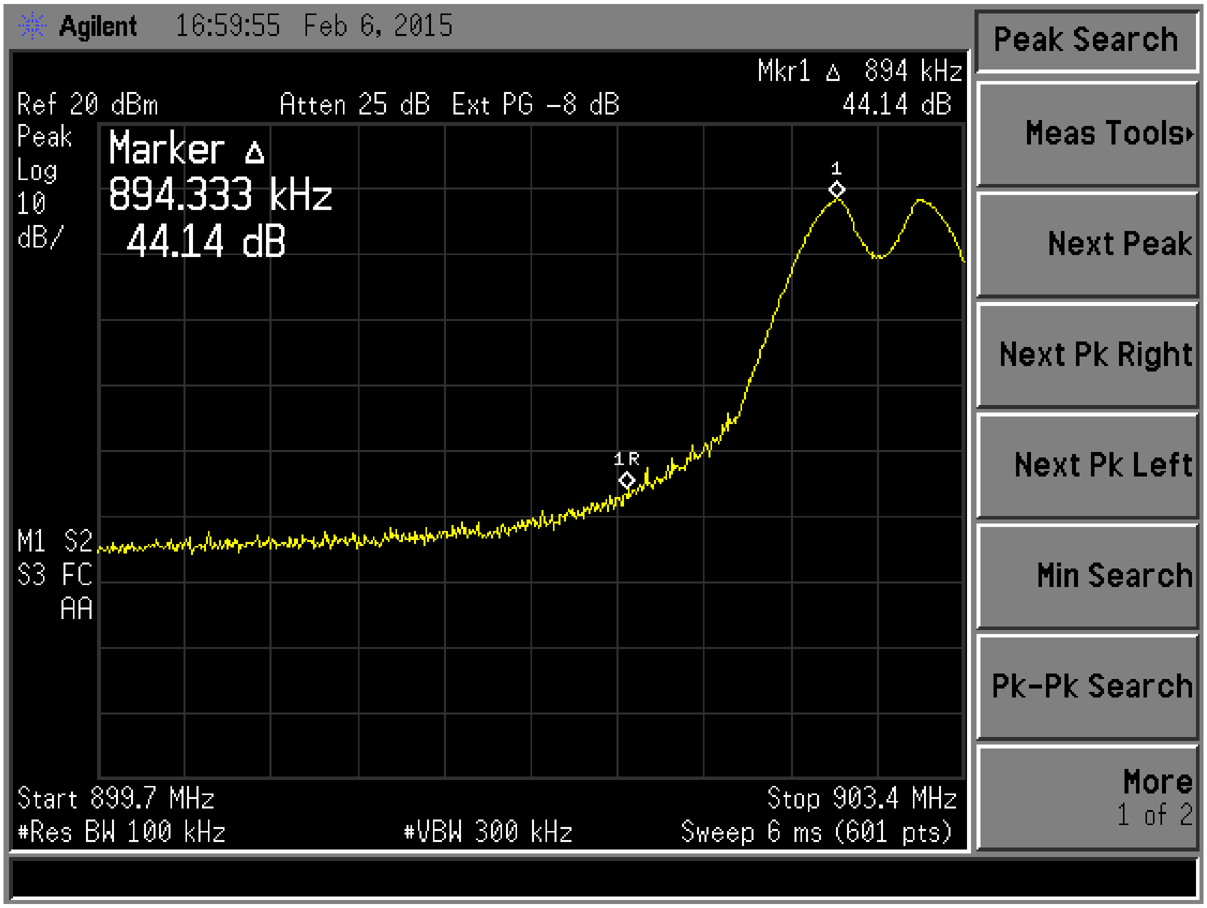

Figure 20. Band Edge Compliance, Low Channel Delta – Peak 2-FSK Modulation

Measured Delta (from Figure 31)	44.14	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	24.14	dB

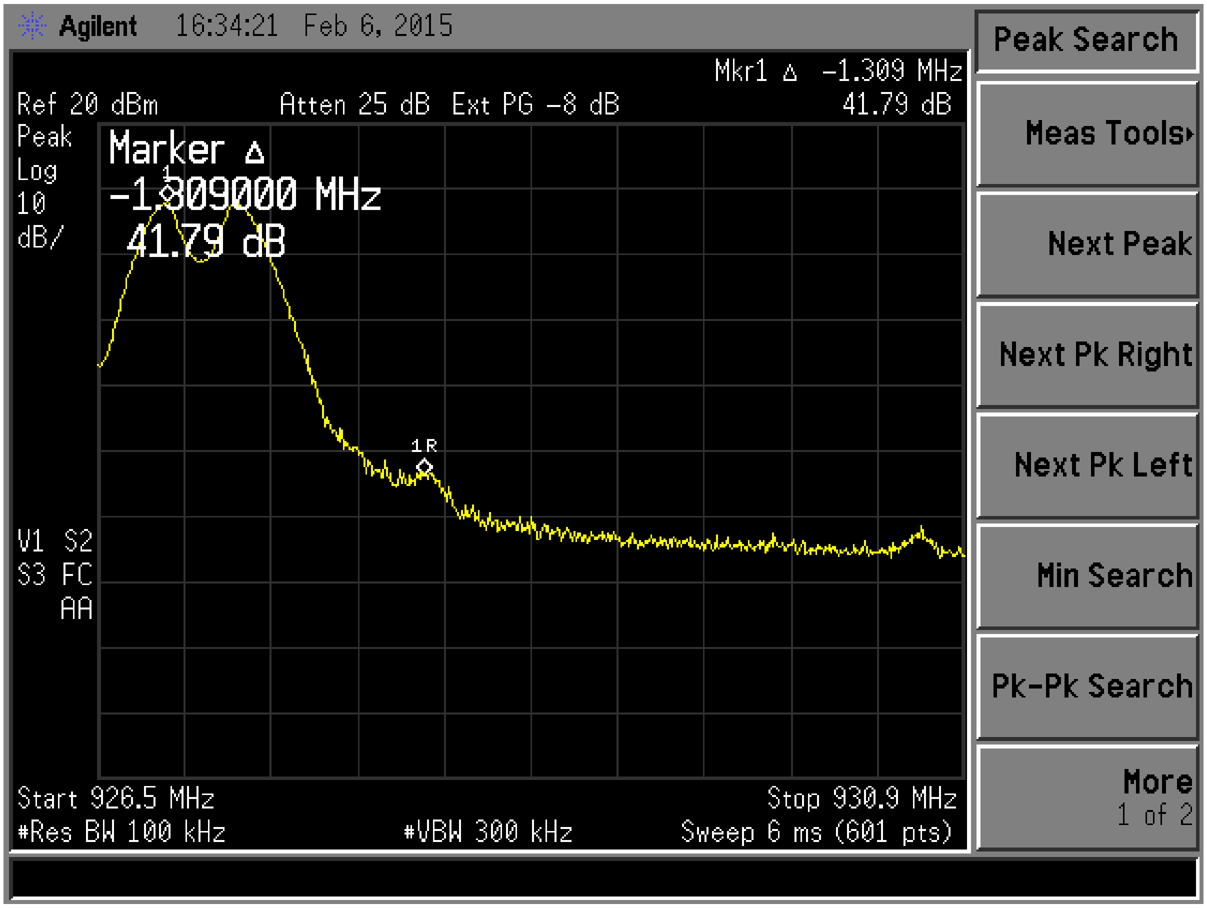

Figure 21. Band Edge Compliance, High Channel Delta – Peak 2-FSK Modulation

Measured Delta (from Figure 32)	41.79	dBm
Limit (20 dB from fundamental)	20.00	dBm
Band Edge Margin	21.79	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 8. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
903	.631	0.500
915	.626	0.500
927	.620	0.500

Test Date: February 5, 2015
Tested By
Signature: ________________ Name: Carrie Fincannon

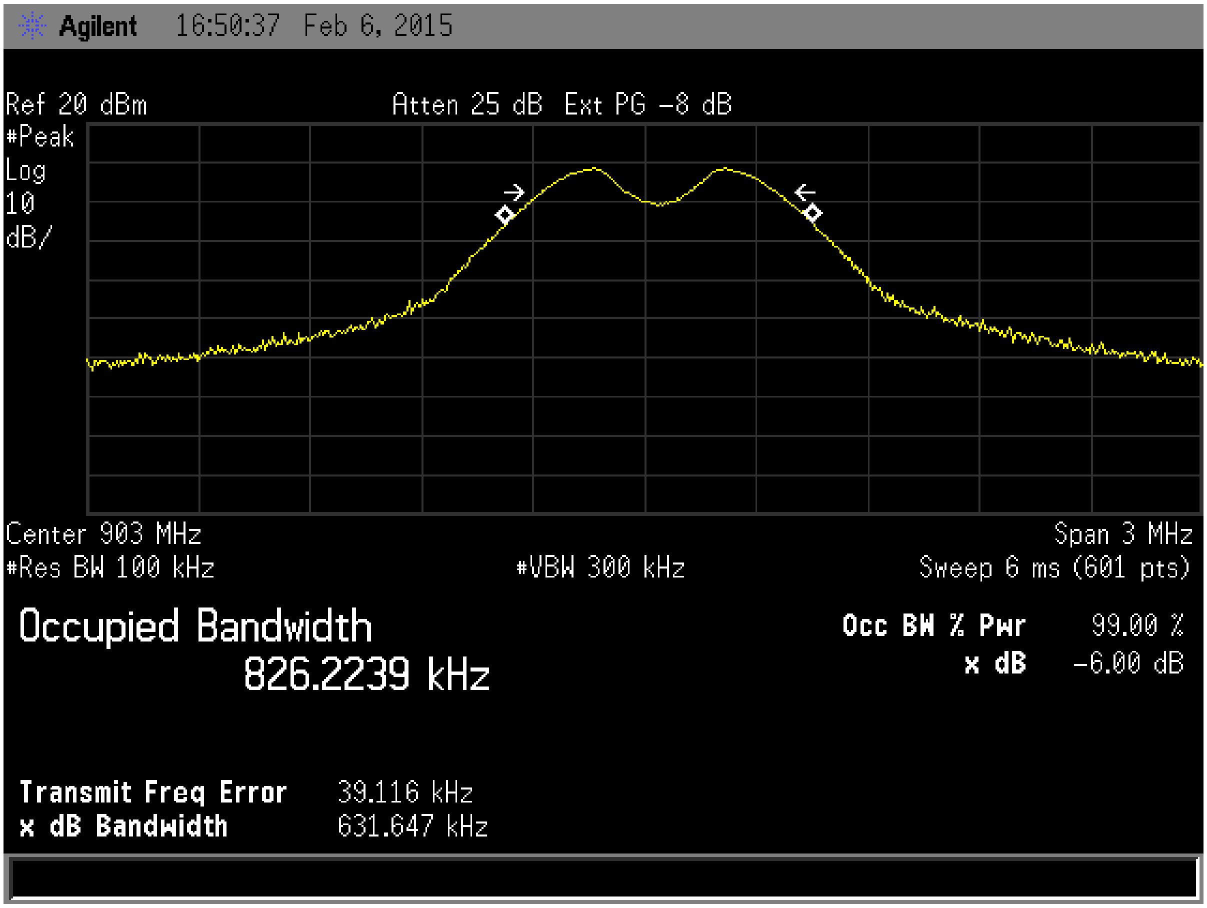

Figure 22. Six dB Bandwidth - 15.247 - Low Channel

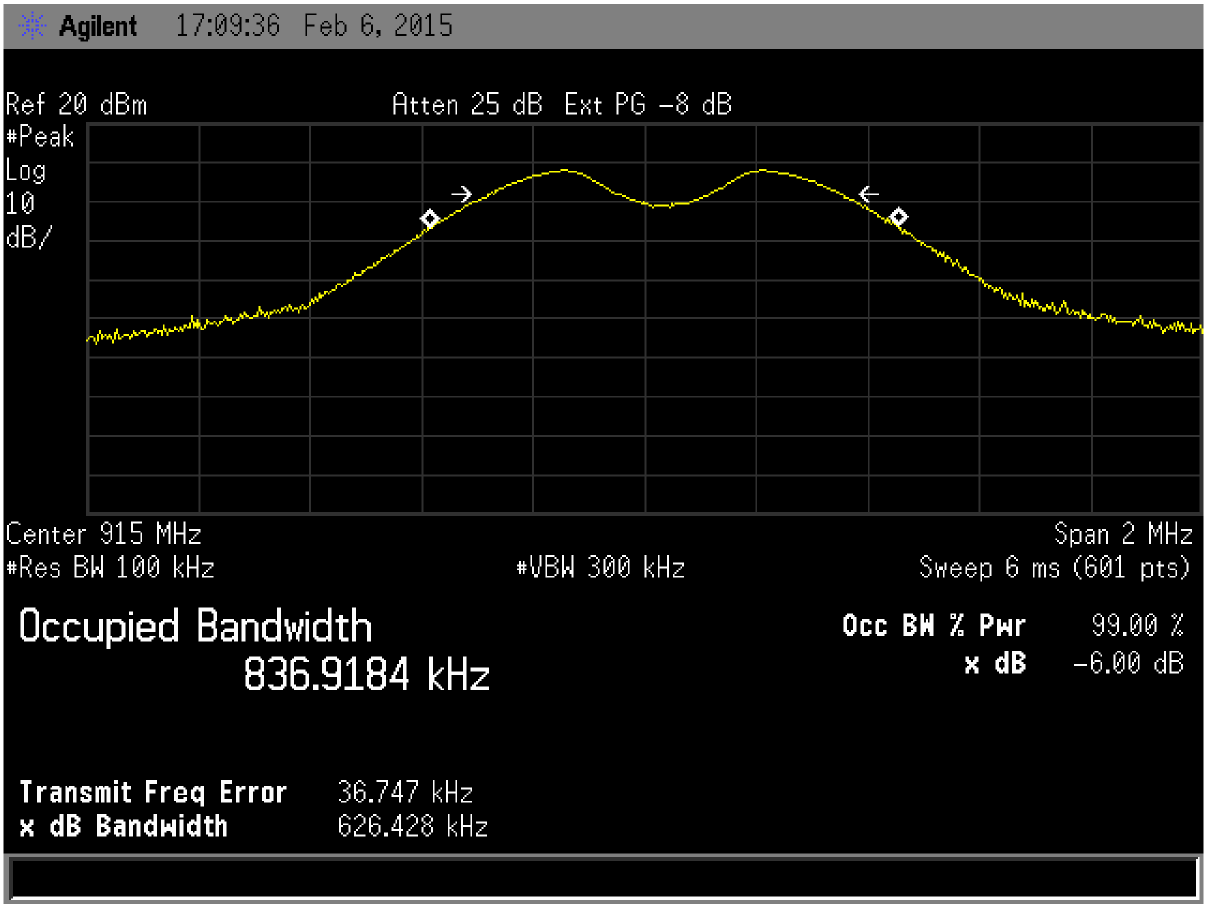

Figure 23. Six dB Bandwidth - 15.247 - Mid Channel

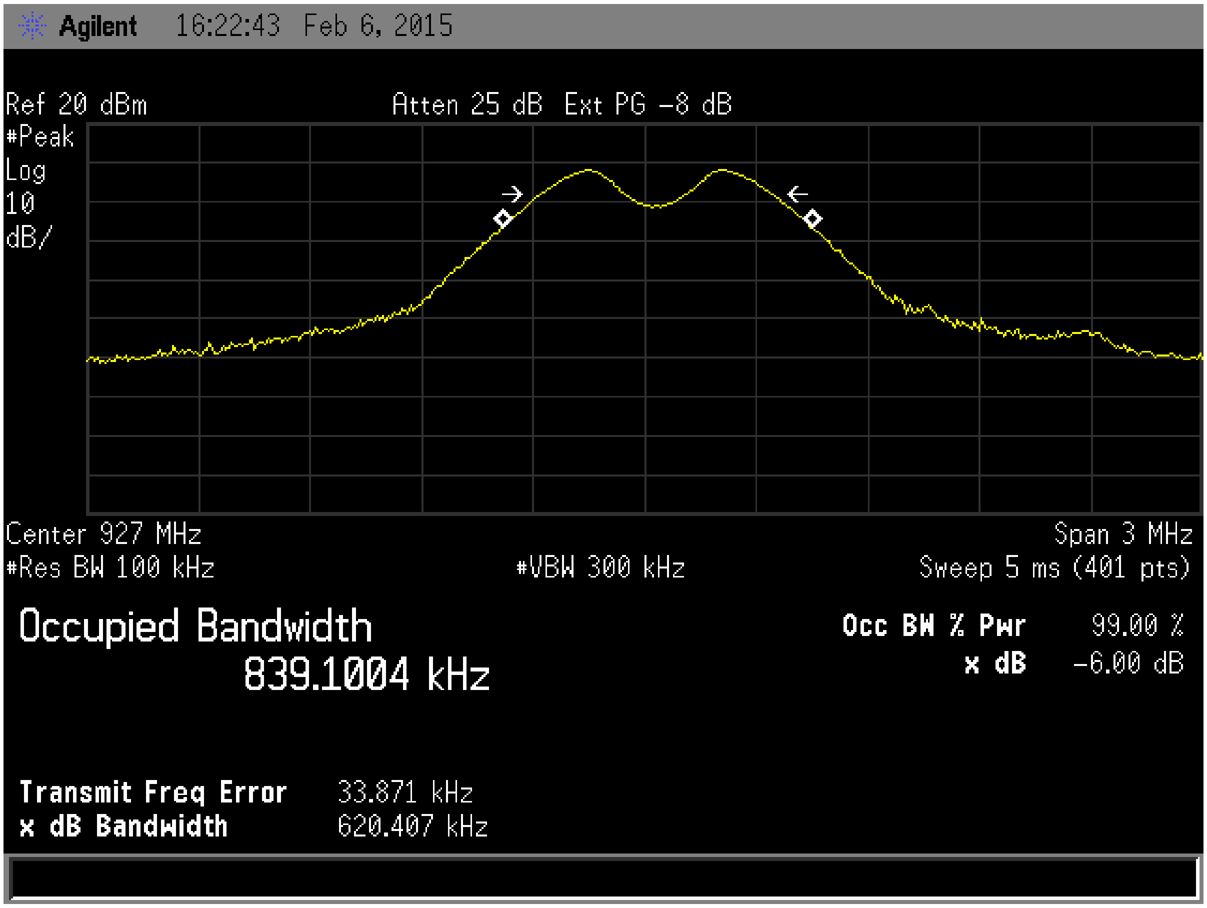

Figure 24. Six dB Bandwidth - 15.247 - High Channel

2.13 20 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 shown in the following tables and figures.

Table 9. 20 dB Bandwidth

Frequency (MHz)	20 dB Bandwidth (kHz)	Limit (kHz)
903	76.0	500
915	75.6	500
927	76.5	500

Test Date: February 5, 2015
Tested By
Signature: ____________ Name: Carrie Fincannon

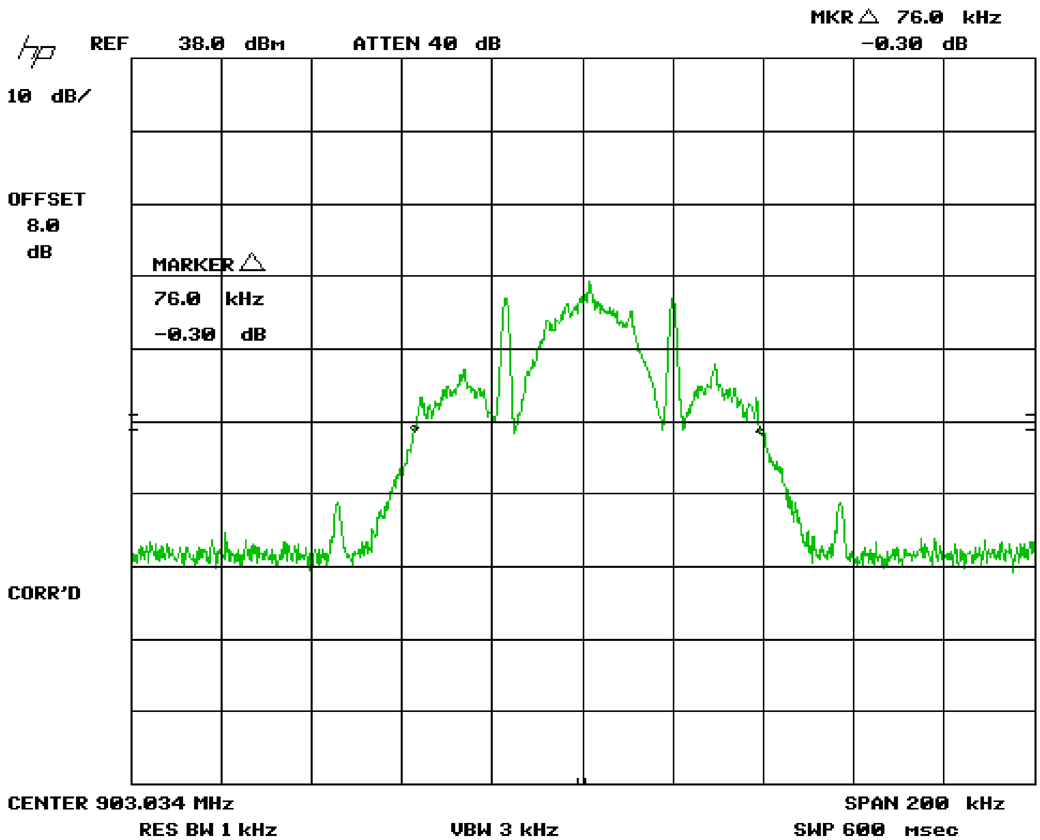

Figure 25. Twenty dB Bandwidth – Low Channel

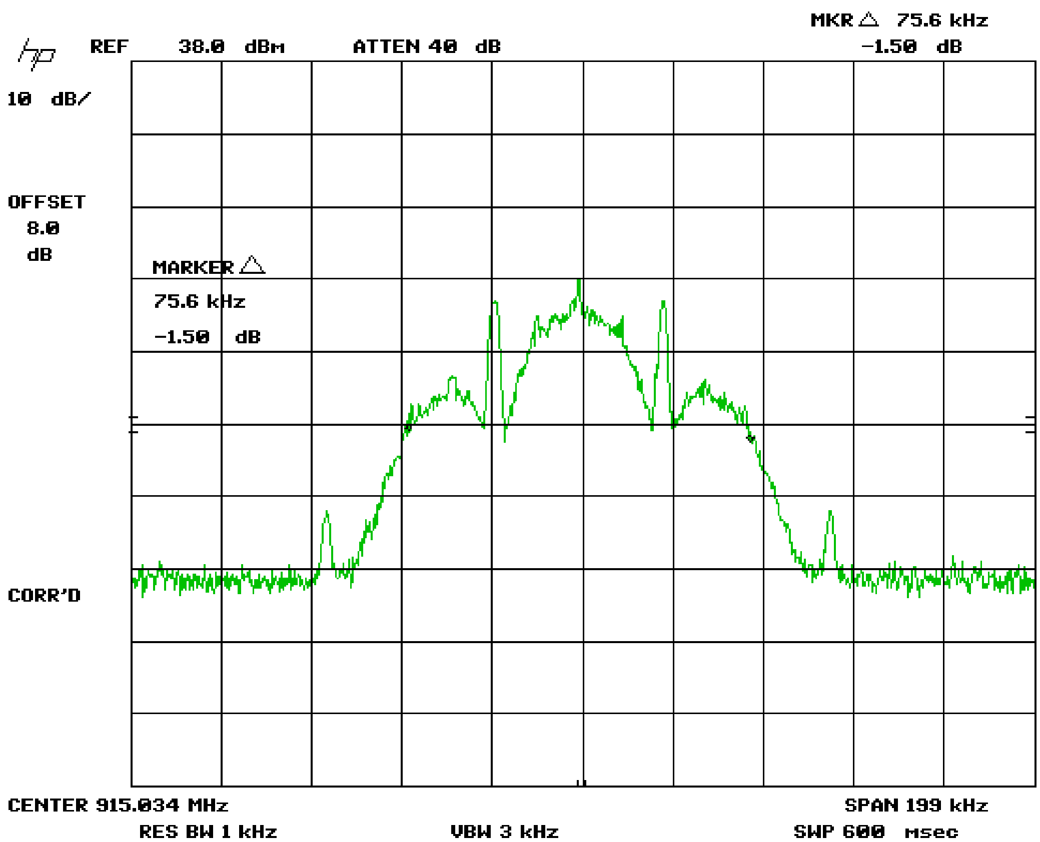

Figure 26. Twenty dB Bandwidth – Mid Channel

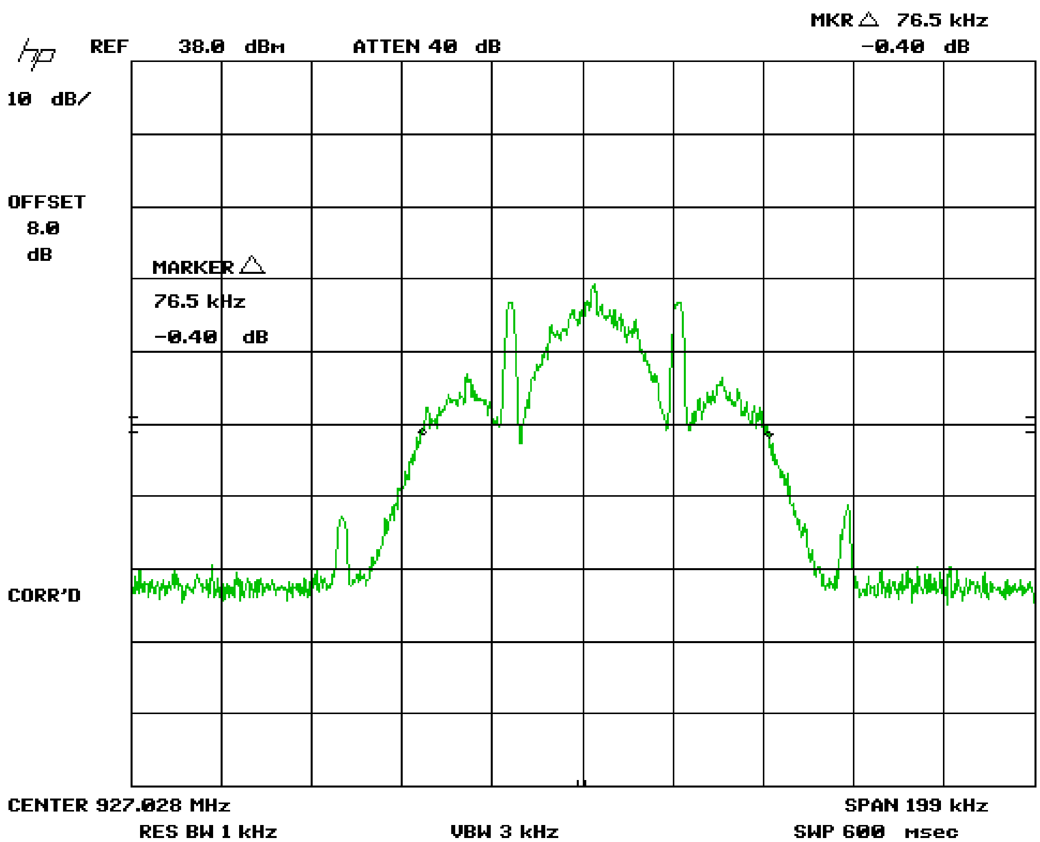

Figure 27. Twenty dB Bandwidth – High Channel

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

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. For 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 902 MHz to 927 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 shown below.

Table 10. 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)
903	11.70	14.79	1000
915	11.40	13.80	1000
927	11.20	13.18	1000

Test Date: February 5, 2015
Tested By
Signature: ______________ Name: Carrie Fincannon

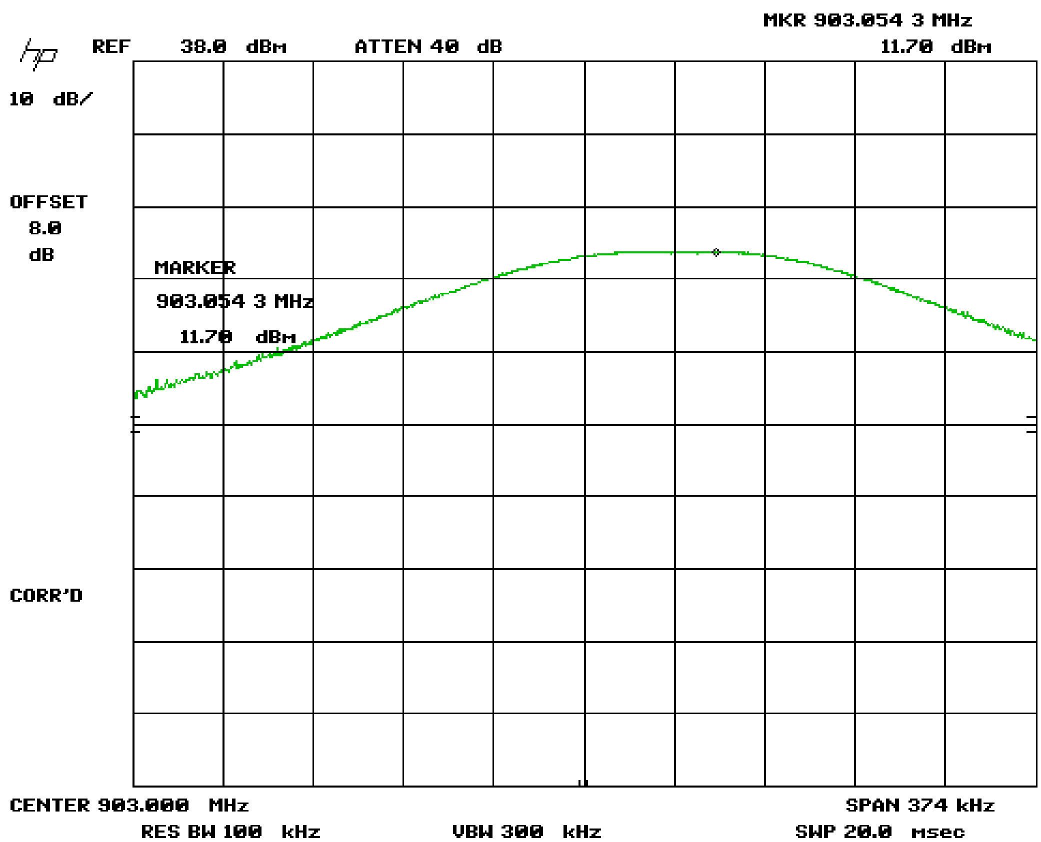

Figure 28. Peak Antenna Conducted Output Power, Low Channel

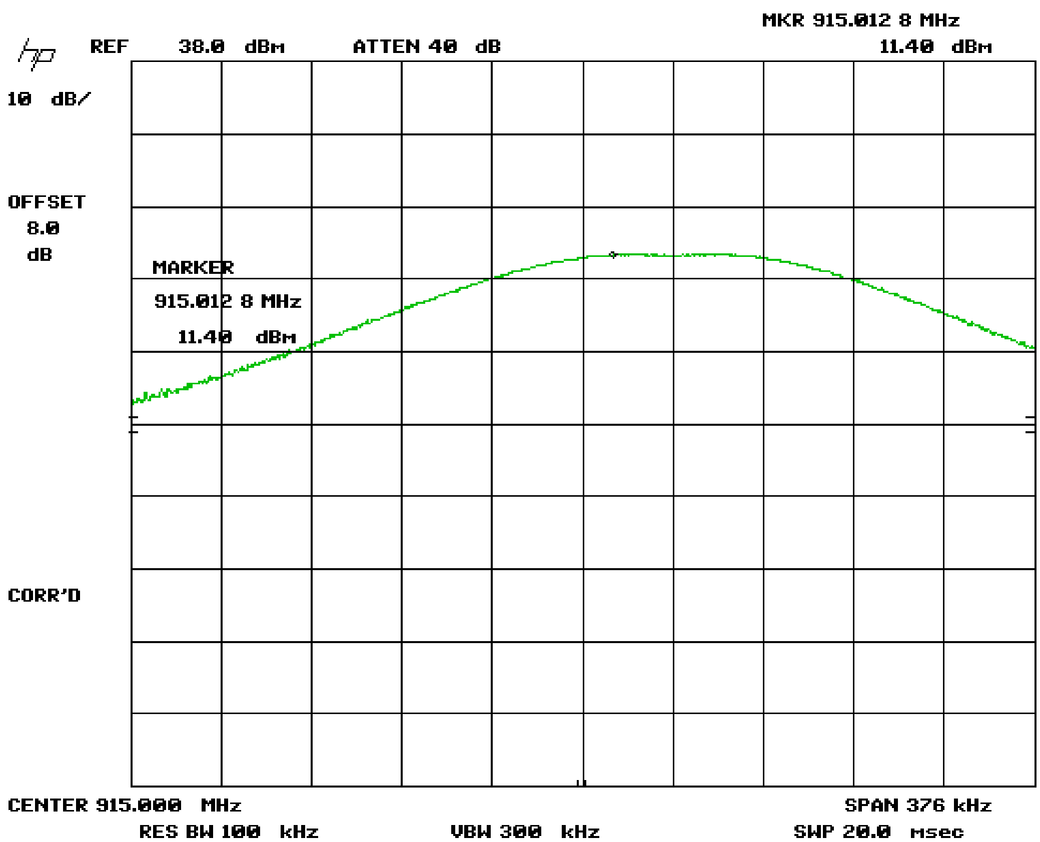

Figure 29. Peak Antenna Conducted Output Power, Mid Channel

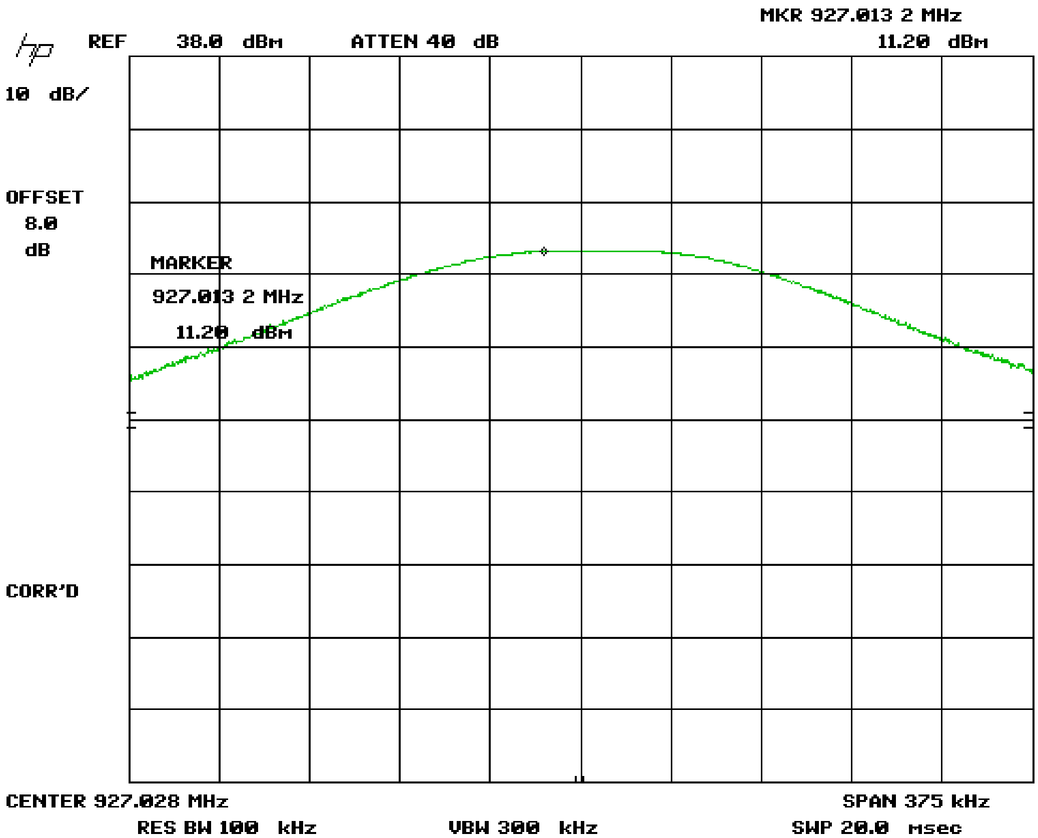

Figure 30. Peak Antenna Conducted Output Power, High Channel

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 11. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Test Data (dBm/3 KHz)	FCC Limit (dBm/3 kHz)
903	-0.79	+8.0
915	-0.72	+8.0
927	-0.73	+8.0

Test Date: February 5, 2015
Tested By
Signature: ________________ Name: Carrie Fincannon

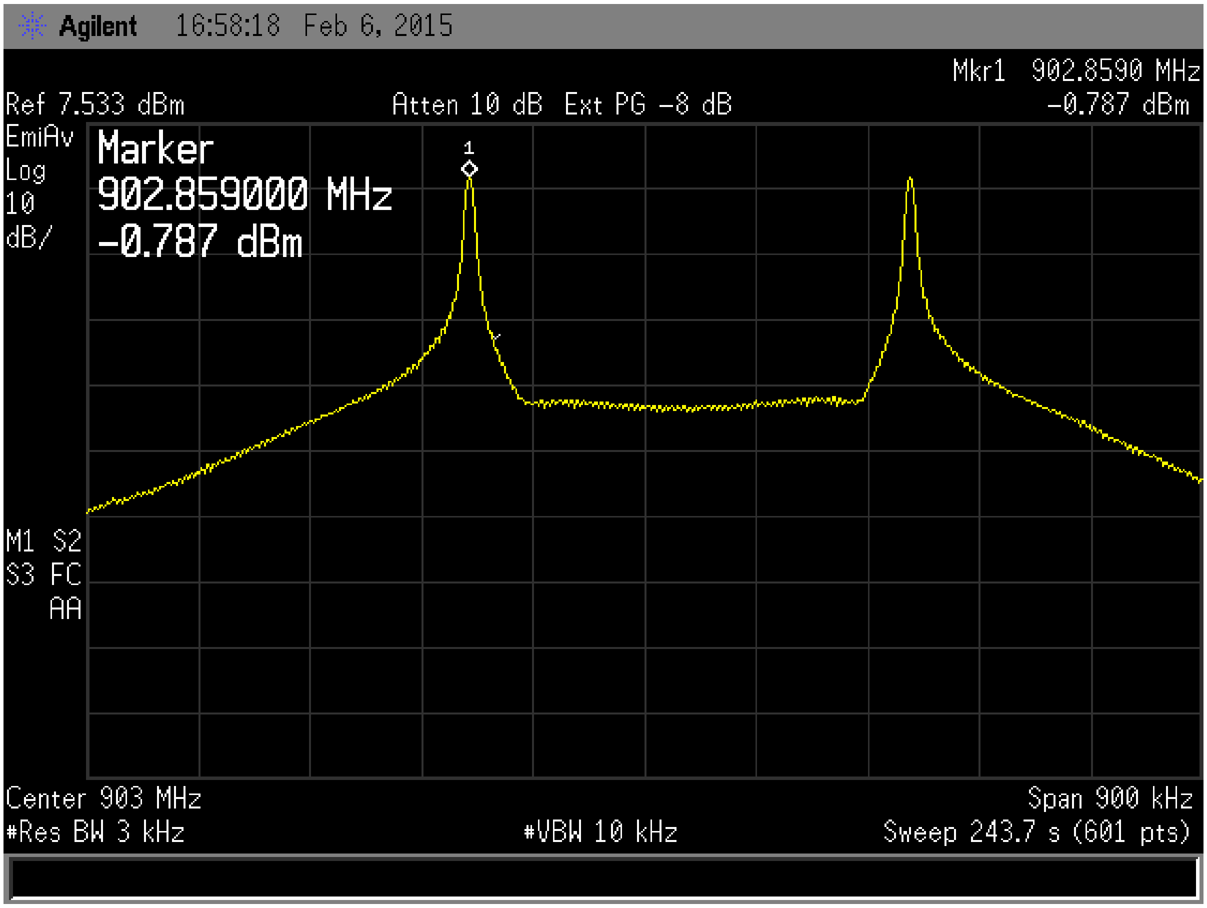

Figure 31. Peak Power Spectral Density, Low Channel

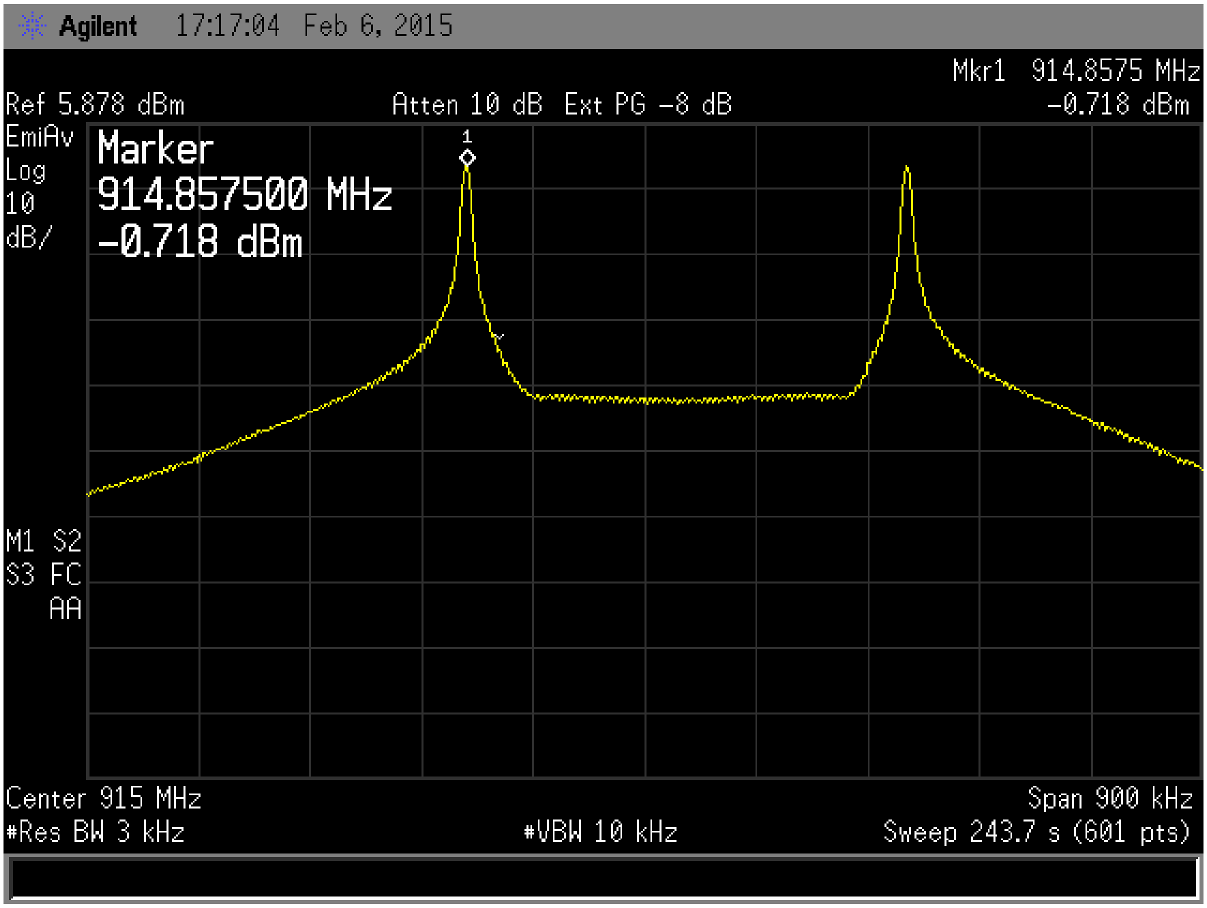

Figure 32. Peak Power Spectral Density, Mid Channel

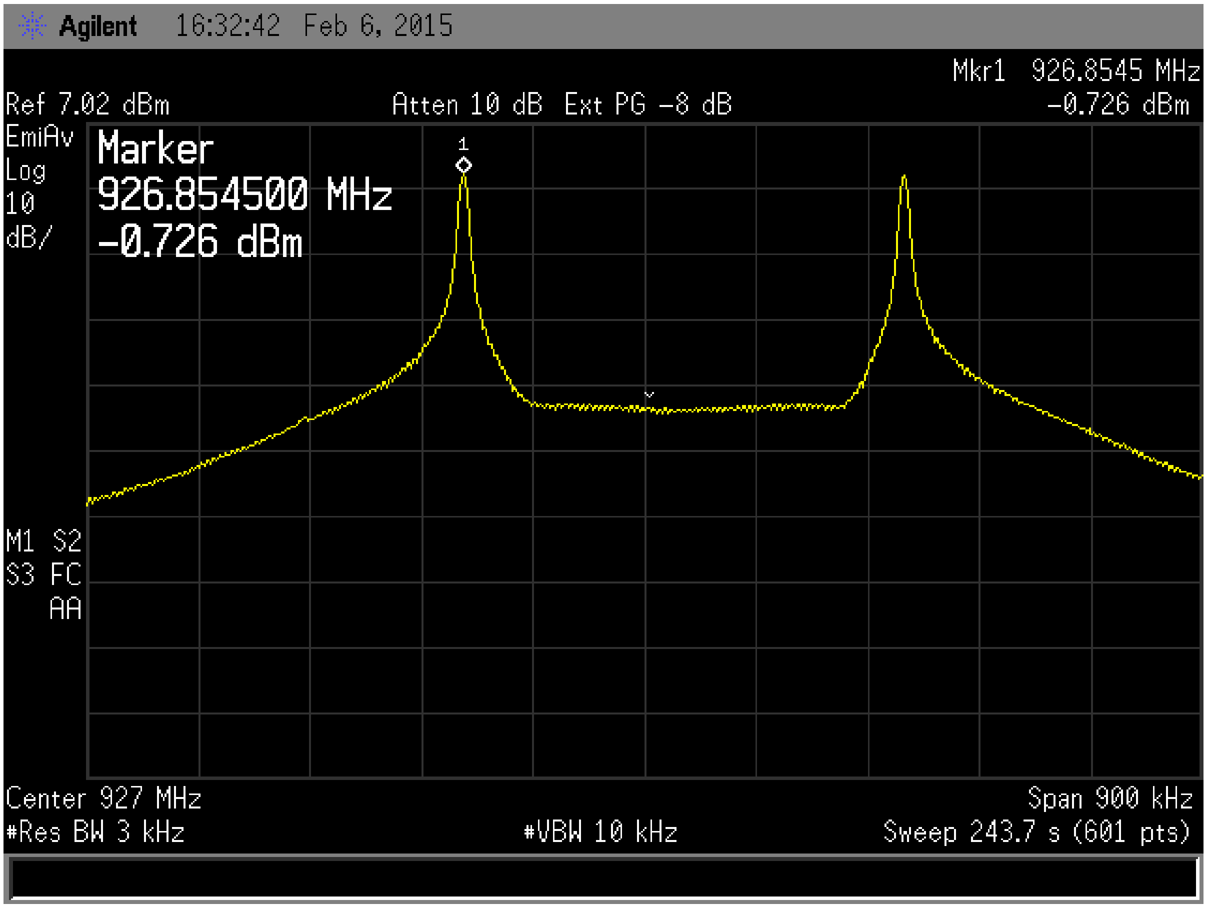

Figure 33. Peak Power Spectral Density, High Channel

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 25 hopping frequencies shall be used.

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

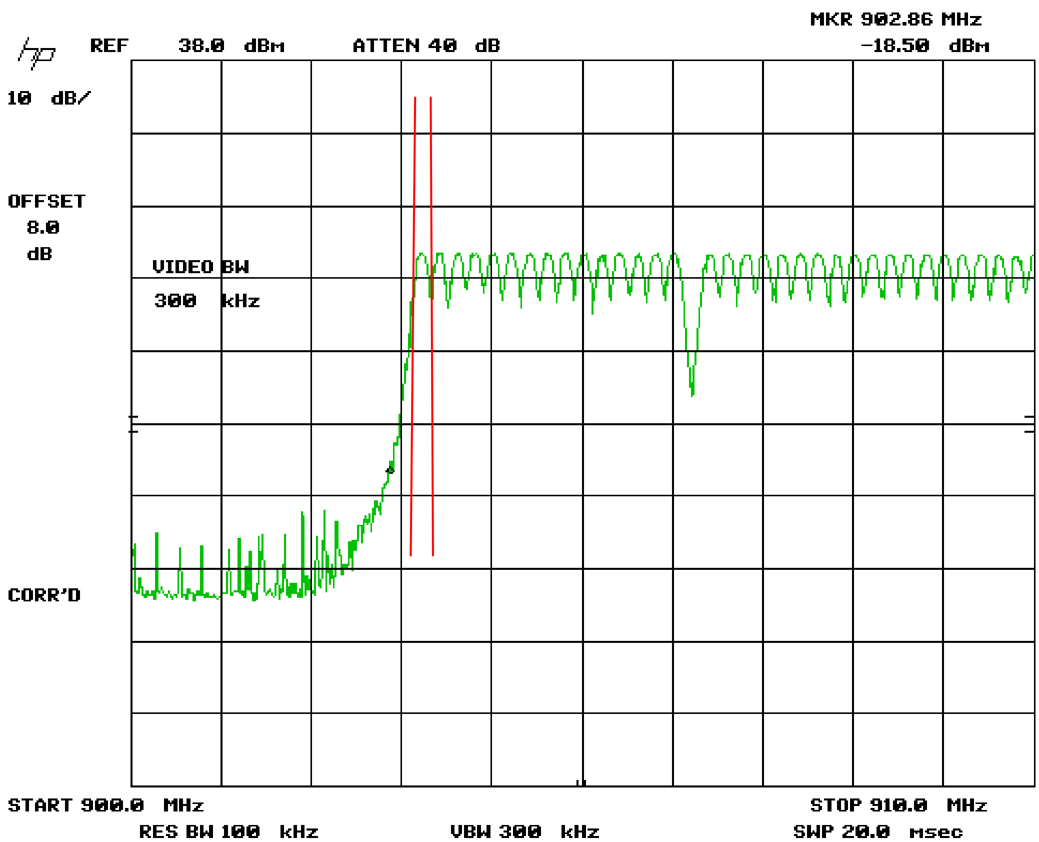

Figure 34. Hopping Channels 0 through 32

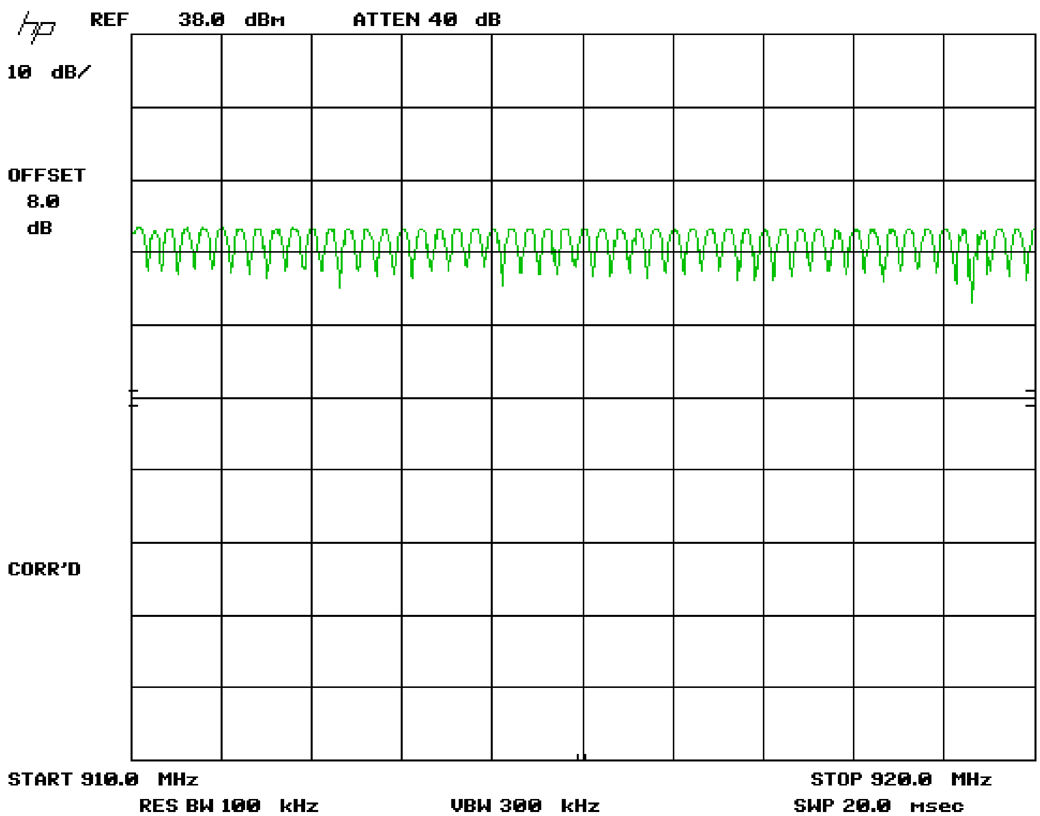

Figure 35. Hopping Channels 33 through 82

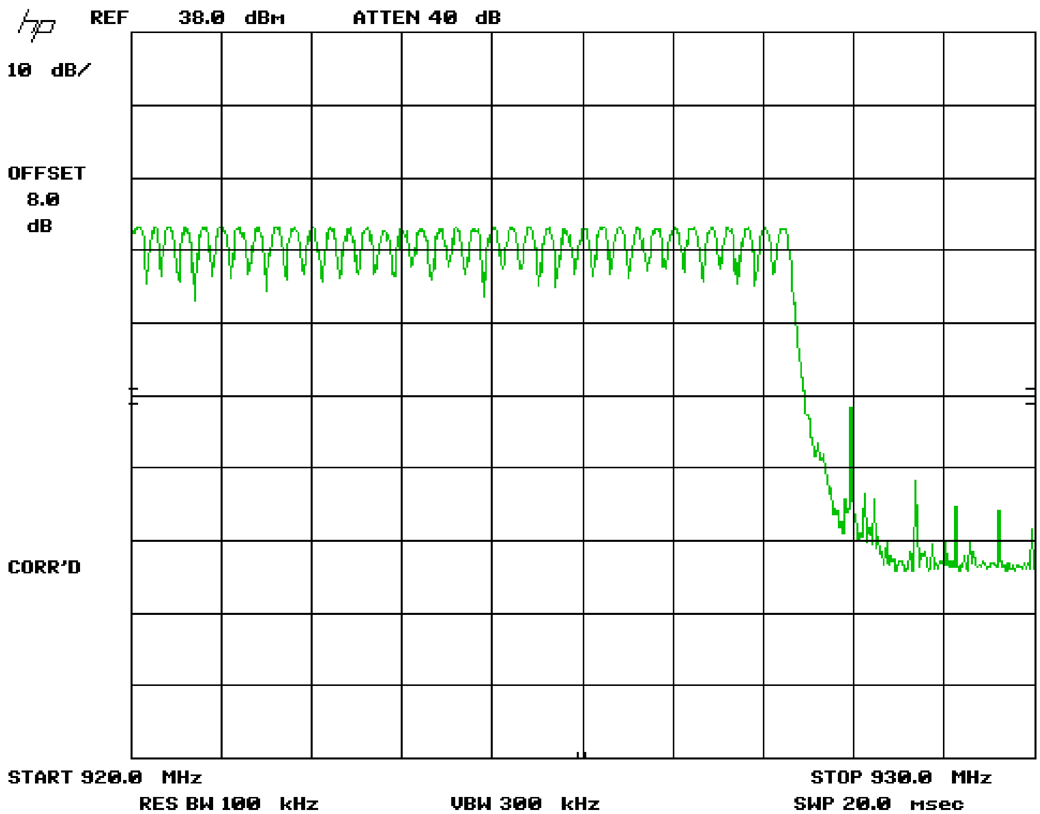

Figure 36. Hopping Channels 83 through 120

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 76 kHz. Therefore the frequency separation must be greater than 76 kHz.

The EUT met the frequency separation requirement.

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

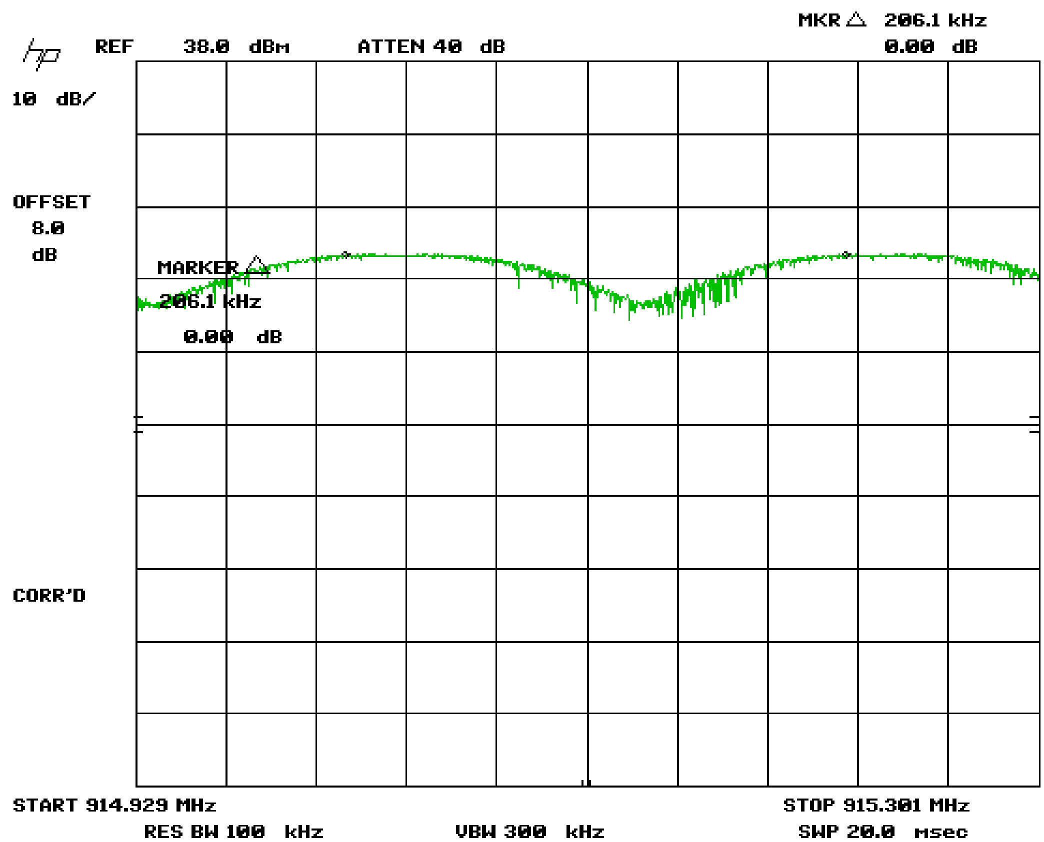

Figure 37. Channel Separation

Measured Delta (Figure 37)	286.1 kHz
-Limit (20 dB Bandwidth)	77.00 kHz
Margin	209.1 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 121 channels in the frequency hopping mode, the average time on shall not exceed 0.4 s within 48.4 s.

The test procedures outline in the FCC Public Notice DA 00-705 were used to conduct measurements. The EUT was set to normal use mode, i.e. frequency hopping mode.

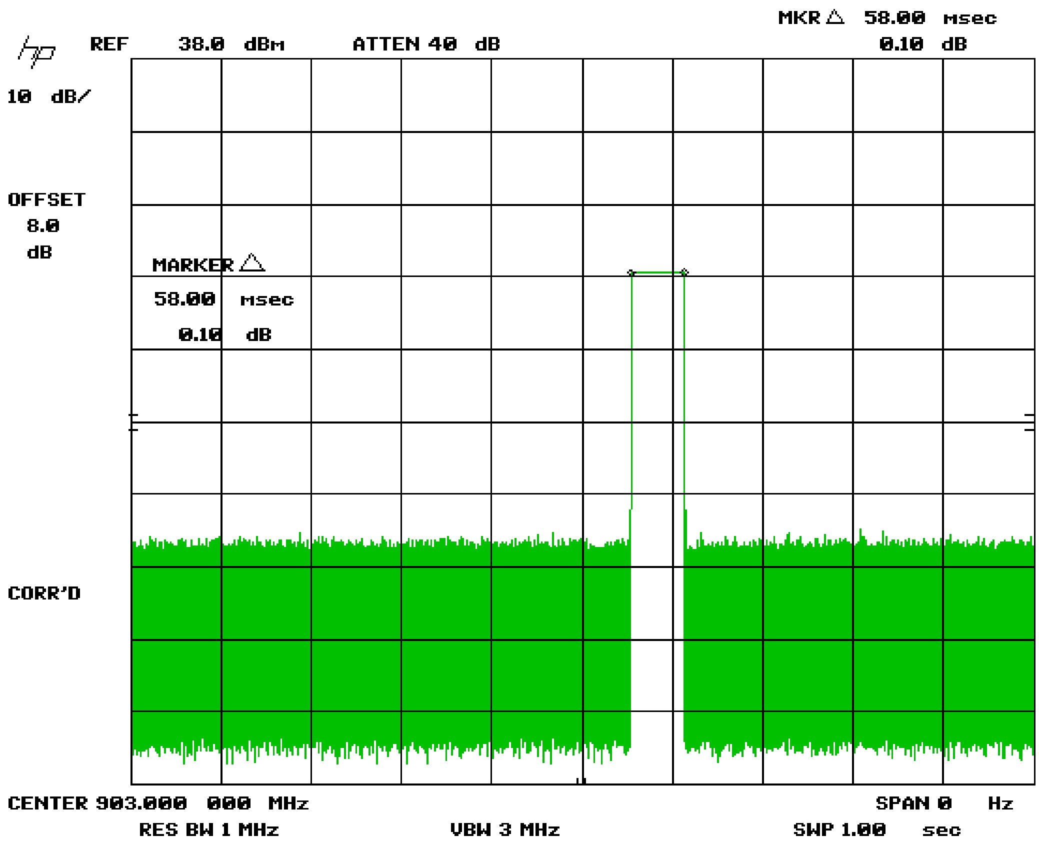

Figure 38. Time On

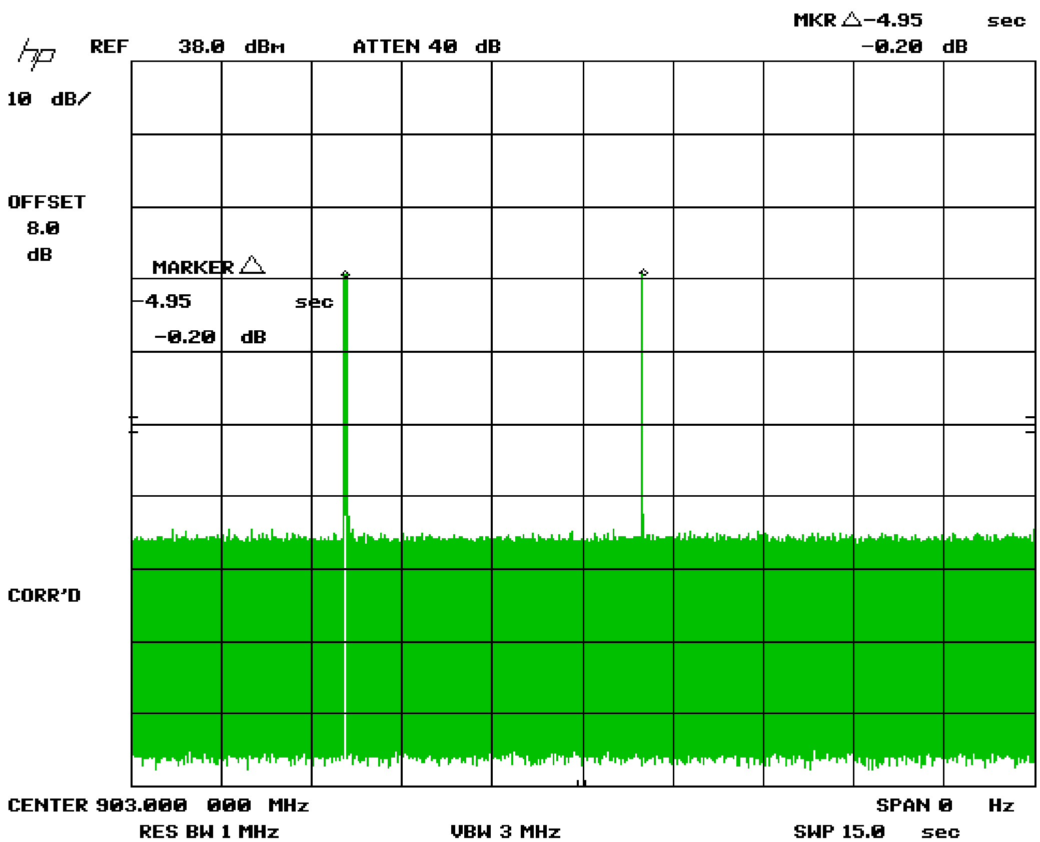

Figure 39. Time between Occupancy

Limit = 0.400 s within 48.4 s

Average time of Occupancy = 0.348 s = 0.058 s x 2 x 3 (2 pulses per 15 secs)

Limit	400	ms
-Average Time of Occupancy	348	ms
Margin	52	ms

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

The power line conducted emissions measurements have been carried out in accordance with CFR 15.107, per ANSI C63.4:2009, 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 OFF and then 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 applied.

Table 12. 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:** Controlant EHF		
Project: 15-0029				**Model:** CO 15.01		
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 deemed not applicable.						

SAMPLE CALCULATION: N/A

Test Date: February 5, 2015
Tested By
Signature: ____________ Name: Carrie Fincannon

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 1 GHz was 6.4 dB below the limit at 668.32 MHz. This signal is found in Table 13. All other radiated emissions were 6.5 dB or more below the limit.

The radiated emissions in the range of 1GHz to 6 GHz were 20 dB or more from the limit.

Table 13. 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:** Controlant EHF			
Project: 15-0029				**Model:** CO 15.01			
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**
71.74	51.74	-18.20	33.54	40.0	3m /VERT	6.5	**PK**
388.30	44.26	-8.37	35.89	46.0	3m /VERT	10.1	**PK**
566.30	39.05	-3.86	35.19	46.0	3m /VERT	10.8	**QP**
587.02	39.46	-3.26	36.20	46.0	3m /VERT	9.8	**QP**
668.32	40.95	-1.35	39.60	46.0	3m /VERT	6.4	**QP**
569.65	42.30	-3.24	39.06	46.0	3m /HORZ	6.9	**QP**

Tested from 30 MHz to 1 GHz

SAMPLE CALCULATION at 71.74 MHz:

Magnitude of Measured Frequency	51.74	dBuV
+ Cable Loss+Antenna Factor-Amp Gain	-18.20	dB
=Corrected Result	33.54	dBuV
Limit	40.00	dBuV
-Corrected Result	33.54	dBuV
Margin	6.50	dB

Test Date: February 11, 2015
Tested By
Signature: ______ Name: Carrie Fincannon

Table 14 . 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:** Controlant EHF			
Project: 15-0029				**Model:** CO 15.01			
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**
All emissions seen were 20 dB or more from the limit.							

Tested from 1 GHz to 6 GHz

SAMPLE CALCULATION: N/A

Test Date: February 11, 2015
Tested By
Signature: ______________ Name: Carrie Fincannon

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%.

2.21.1 Conducted Emissions Measurement Uncertainty

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

The data listed in this test report does have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.

2.21.2 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 have sufficient margin to negate the effects of uncertainty. Therefore, the EUT unconditionally meets this requirement.