H.B. Compliance Solutions

Intentional Radiator Test Report

For the

Schweizer Electronic AG

LC100 Transmitter (Mobile Unit)

Tested under

The FCC Rules contained in Title 47 of the CFR, Part 90 for

Private Land Mobile Radio Services

November 14, 2019

Prepared for:

Schweizer Electronic AG

Industriestrasse 3,

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Prepared By:

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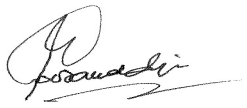
Reviewed By:



Hoosamuddin Bandukwala

Cert # ATL-0062-E

Engineering Statement: The measurements shown in this report were made in accordance with the procedure indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurement made, the equipment tested is capable of operation in accordance with the requirements of Part 90 of the FCC Rules under normal use and maintenance. All results contained herein relate only to the sample tested.

Report Status Sheet

Revision #	Report Date	Reason for Revision
Ø	November 14, 2019	Initial Issue
1	June 22, 2020	TCB Comments

Table of Contents

EXECUTIVE SUMMARY

1. Testing Summary

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 90. All tests were conducted using measurement procedure from ANSI TIA/EIA-603-D-2010 as appropriate.

Test Name	Test Method/Standard	Result	Comments
RF Output Power	2.1046; 90.205	Pass	
Modulation Characteristics	2.1047(a)	Pass	The EUT does not transmit voice. The device transmits data signal only
Occupied Bandwidth	2.1049; 90.210	Pass	EUT Meets Mask D
Spurious Emissions at Antenna Terminals	2.1051; 90.210	Pass	
Radiated Spurious Emissions	2.1053; 90.210	Pass	
Frequency Stability over Temperature Variations	2.1055(a)(1); 90.213	Pass	
Frequency Stability over Voltage Variations	2.1055(d)	Pass	
Transient Frequency Behavior	90.214	Pass	

EQUIPMENT CONFIGURATION

1. Overview

H.B Compliance Solutions was contracted by Schweizer Electronic to perform testing on the LocControl 100 Radio remote control system under the quotation number Q17031006.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Schweizer Electronic, LocControl 100 Radio remote control system.

The tests were based on FCC Part 90 Rules. The tests described in this document were formal tests as described with the objective of the testing was to evaluate compliance of the Equipment Under Test (EUT) to the requirements of the aforementioned specifications. Schweizer Electronic should retain a copy of this document and it should be kept on file for at least five years after the manufacturing of the EUT has been permanently discontinued. The results obtained relate only to the item(s) tested.

Product Name:	LC100-Transmitter (Mobile Unit)
Model(s) Tested:	LC100
FCC ID:	2AQQU-01LC100M0
Supply Voltage Input:	Primary Power: 7.2 Vdc
Frequency Range:	450MHz to 470MHz
No. of Channels:	Single Channel
Necessary Bandwidth	7 kHz
Type(s) of Modulation:	GFSK, **Coding** = MFM, **Bit Rate** = 4.166bit/s, **Symbol Rate**= 2.083symbol/s
Range of Operation Power:	0.5W
Voltage into final Transistor	6 volts
Current into final Transistor	2.5 amps
Emission Designator:	7K00F1D
Channel Spacing(s)	12.5 kHz
Test Item:	Pre-Production
Type of Equipment:	Fixed
Antenna:	50-ohm Miniflex TNC- type connector (0dBi Gain)
Environmental Test Conditions:	Temperature: 15-35°C Humidity: 30-60% Barometric Pressure: 860-1060 mbar
Modification to the EUT:	None
Evaluated By:	Staff at H.B. Compliance Solutions
Test Date(s):	04/23/2018 till 06/19/2018

2. Test Facility

All testing was performed at H.B. Compliance Solutions. This facility is located at 5005 S. Ash Avenue, Suite # A-10, Tempe AZ-85282. All equipment used in making physical determination is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements from 30MHz to 1GHz were performed in a GTEM chamber (equivalent to an Open Area Test Site). Radiated Emission above 1GHz were performed on an Open Area Test Site (OATS). In accordance with §2.948(a)(3), a complete site description is contained at H.B. Compliance Solutions.

Test facility H.B. Compliance Solutions is an ANAB accredited test site. The ANAB certificate number is L2458. The scope of accreditation can be found on ANAB website www.anab.org

3. Description of Test Sample

The Schweizer Electronic, LocControl 100 is used for railway operations. Typical application is shunting, flow and crossing operation, during distance trips, or for special vehicles. The Firmware # is KP=SW/Version 4.08

4. Equipment Configuration

Ref. ID	Name / Description	Model Number	Serial Number
# 1	Radio Remote Control System	LocControl 100	N/A

Table 1. Equipment Configuration

5. Support Equipment

All support equipment supplied is listed in the following Support Equipment List.

Ref ID	Name / Description	Manufacturer	Model #	Serial #
#2	DC Power Supply	Lambda	LA-200	LA2-AA20-1433535
#3	Laptop	Dell	Inspiron 1545	17934612445

Table 2. Support Equipment

6. Ports and Cabling Information

Ref ID	Port name on the EUT	Cable Description	Qty.	Length (m)	Shielded? (Y/N)	Termination Box ID & Port ID
#4	Power	2 wire	1	2	N	DC Power Supply

Table 3. Ports and Cabling Information

7. Method of Monitoring EUT Operation

A test receiver will be used to monitor the data transmission from the EUT.

8. Mode of Operation

The EUT will be configured to transmit at maximum power level. Test mode was provided to select the lower, middle and upper band of the transmitter by customer provided software which is a standard Windows terminal tool with the commands necessary to connect to the device. This software programmed the transmitter from three frequencies modulated and the other three in CW mode. These settings were created for testing purpose only.

9. Modifications

9.1 Modifications to EUT

No modifications were made to the EUT

9.2 Modifications to Test Standard

No Modifications were made to the test standard.

10. Disposition of EUT

The test sample including all support equipment submitted to H.B Compliance Solutions for testing will be returned to Schweizer Electronic upon completion of testing & certification.

1. RF Power Output

Test Requirement(s):	§2.1046 and §90.215	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/04/2018

Test Procedures: As required by 47 CFR 2.1046, RF Power output measurements were made at the RF output terminals of the EUT.

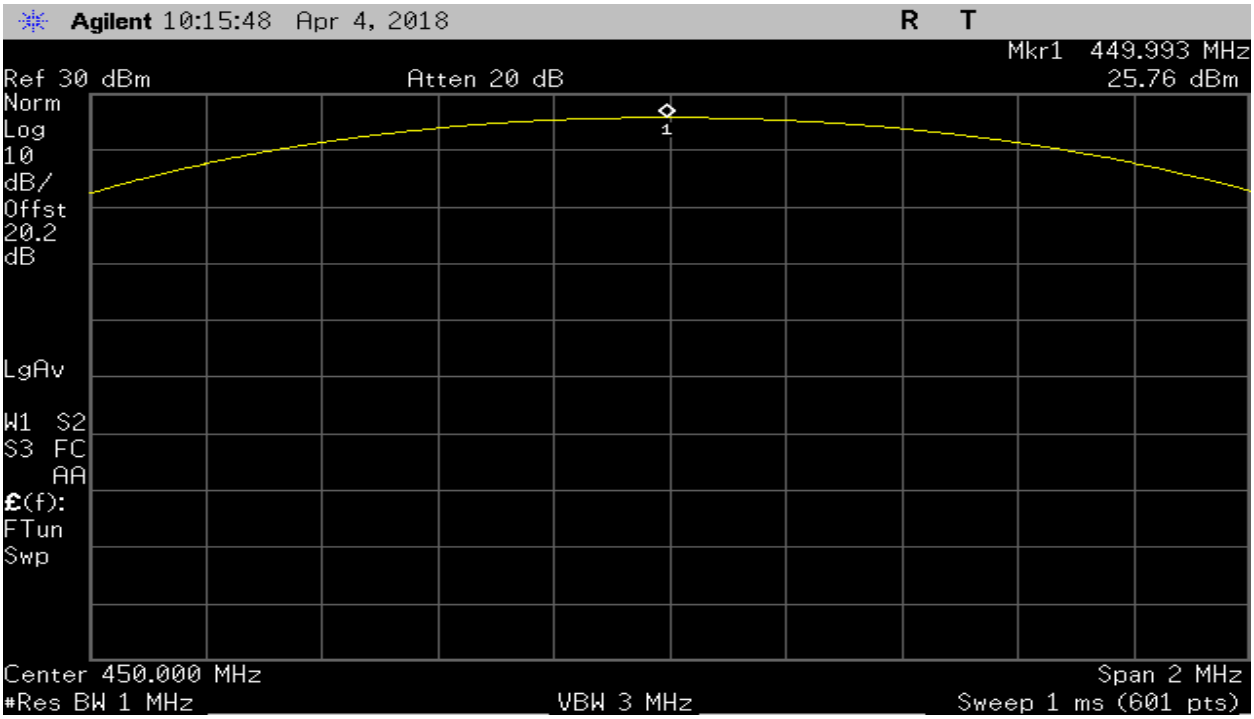
Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer capable of making power measurements. Measurements were made at the low, mid, and high channels of the entire frequency band.

Frequency (MHz)	Conducted Power (dBm)	Conducted Power (W)
450	25.76	0.38
460	26.68	0.5
470	25.69	0.37

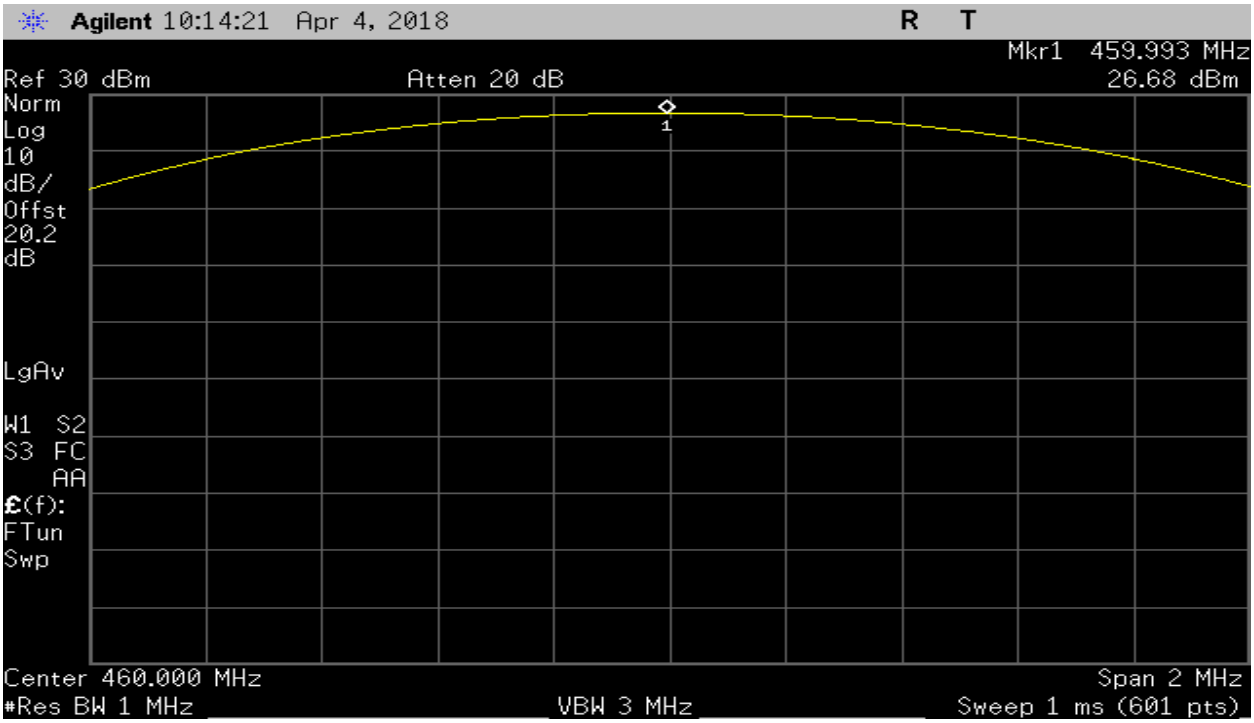
Table 4. RF Power Output, Test Results

Test Setup:

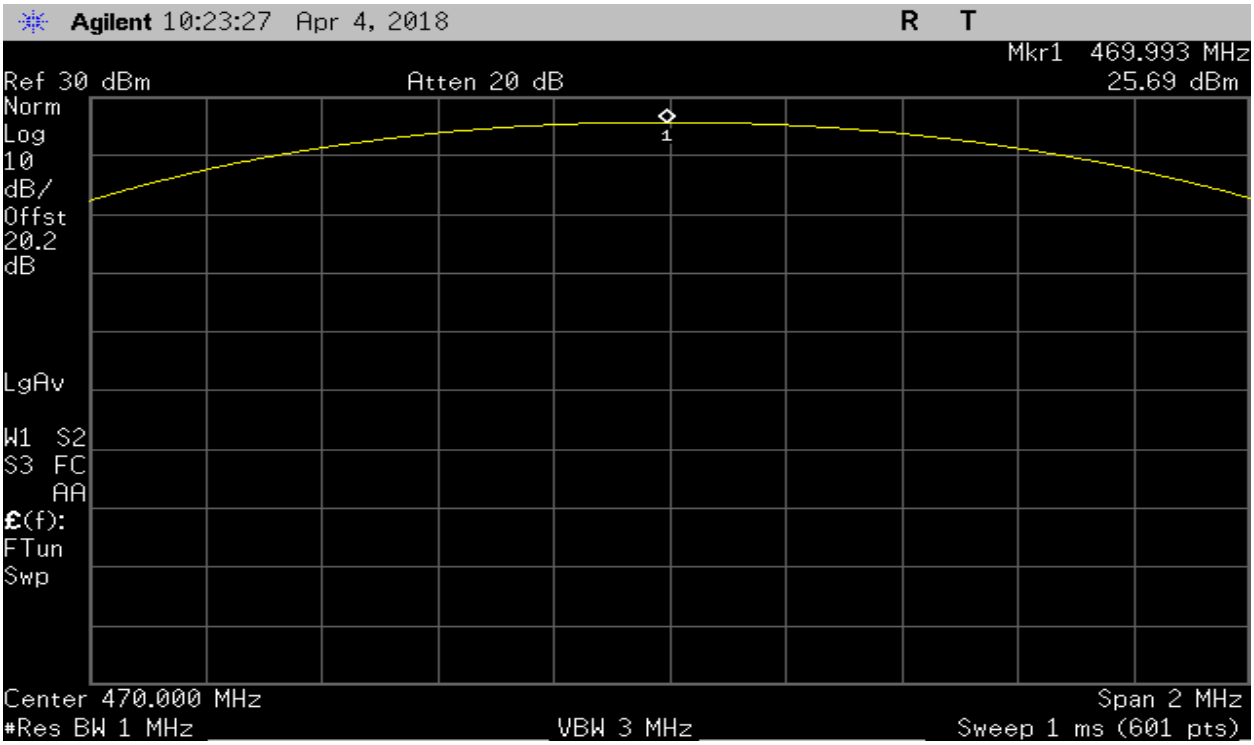
Figure 1 Output RF power Test Setup



Plot 1 – Output Power – Low



Plot 2 – Output Power – Mid



Plot 3 – Output Power – High

2. Modulation Characteristics

Test Requirement(s):	2.1047 and §90.207	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/04/2018

Test Procedure:

As required by 47 CFR 2.1047, Modulation characteristics measurements were made at the RF output terminals of the EUT.

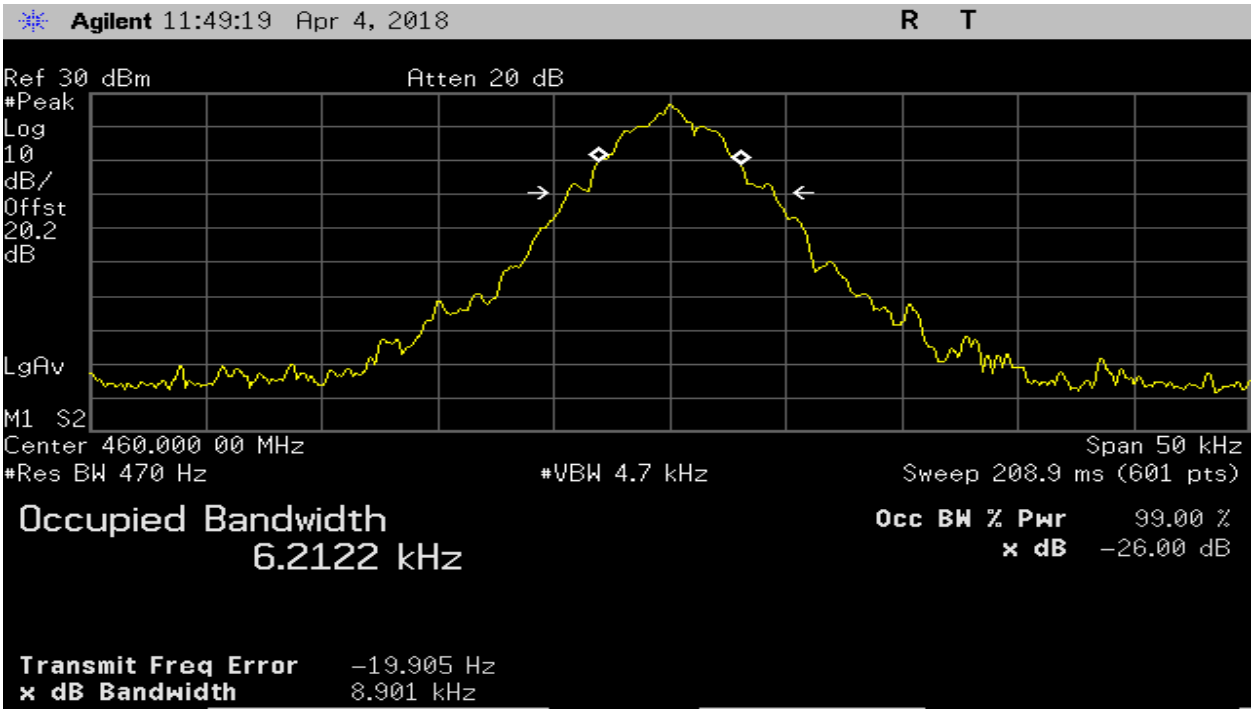
Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer.

As per standard a curve or equivalent data of the EUT is shown

The plot(s) of the modulation characteristic is presented hereinafter as reference.

Test Setup:

Figure 2: Modulation Characteristics Bandwidth Test Setup



Plot 4 – Narrow Band

3. Occupied Bandwidth (Emission Mask)

Test Requirement(s):	2.1049 and §90.210 with FCC (Emission Mask D)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/04/2018

Test Procedure: As required by 47 CFR 2.1049, occupied bandwidth measurements were made at the output terminals of the EUT.

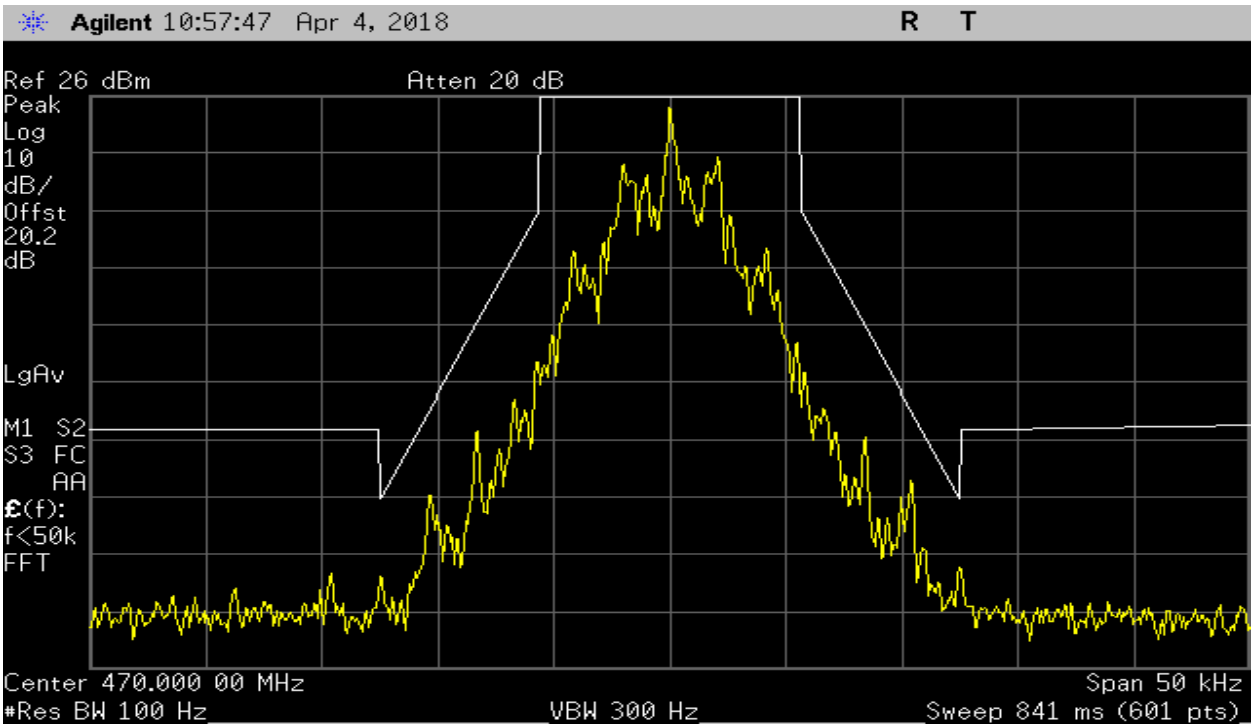
Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer. The measured highest peak power was set relative to zero dB reference. The RBW of the Spectrum Analyzer was set to at least 1% of the channel bandwidth. Measurements were carried out at the low, mid and high channels of the TX band.

Test Setup:

Figure 3: Occupied Bandwidth Test Setup

The following pages show measurements of Emission Mask plots:

Plot 5 – Low Chanel 12.5 kHz Spacing – Mask D



Plot 6 – Mid Chanel 12.5 kHz Spacing – Mask D

Plot 7 – High Chanel 12.5 kHz Spacing – Mask D

4. Spurious Emissions at Antenna Terminals

Test Requirement(s):	§2.1051 and 90.210(m)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/04/2018

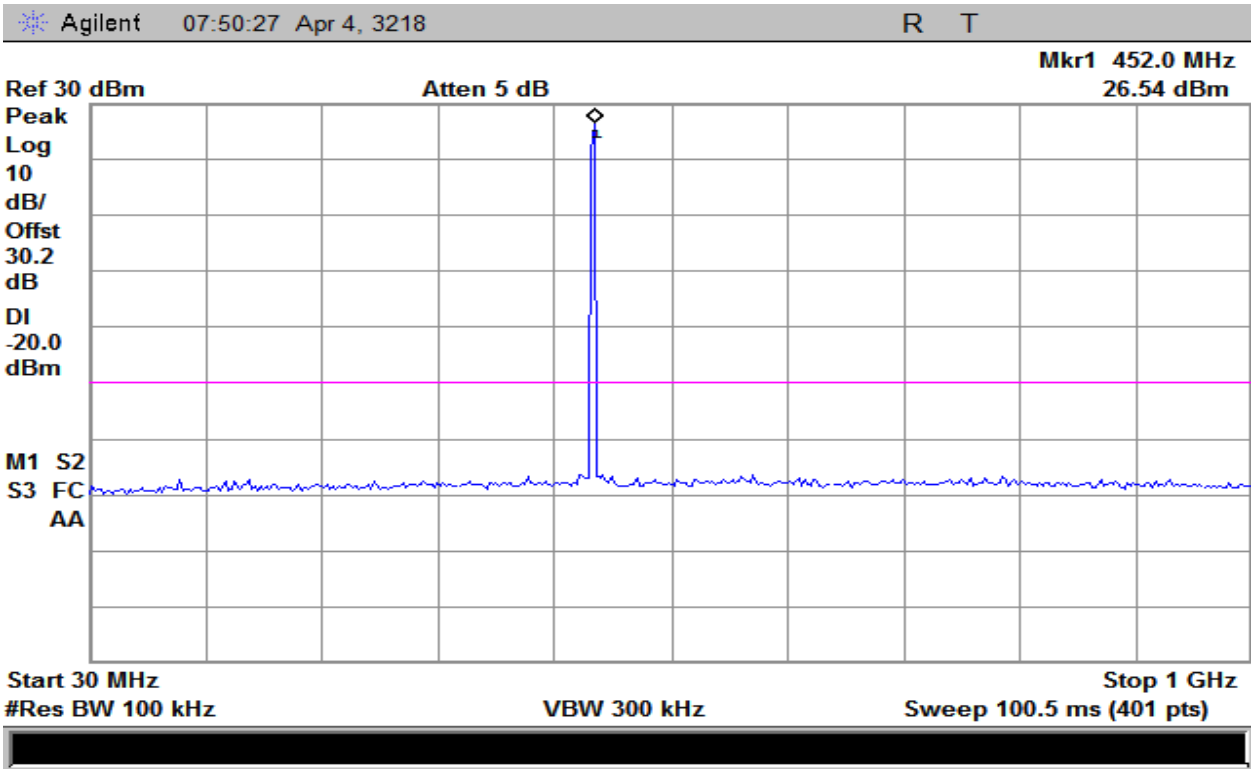
Test Procedures:

As required by 47 CFR 2.1051, spurious emissions at antenna terminal measurements were made at the RF output antenna terminal of the EUT.

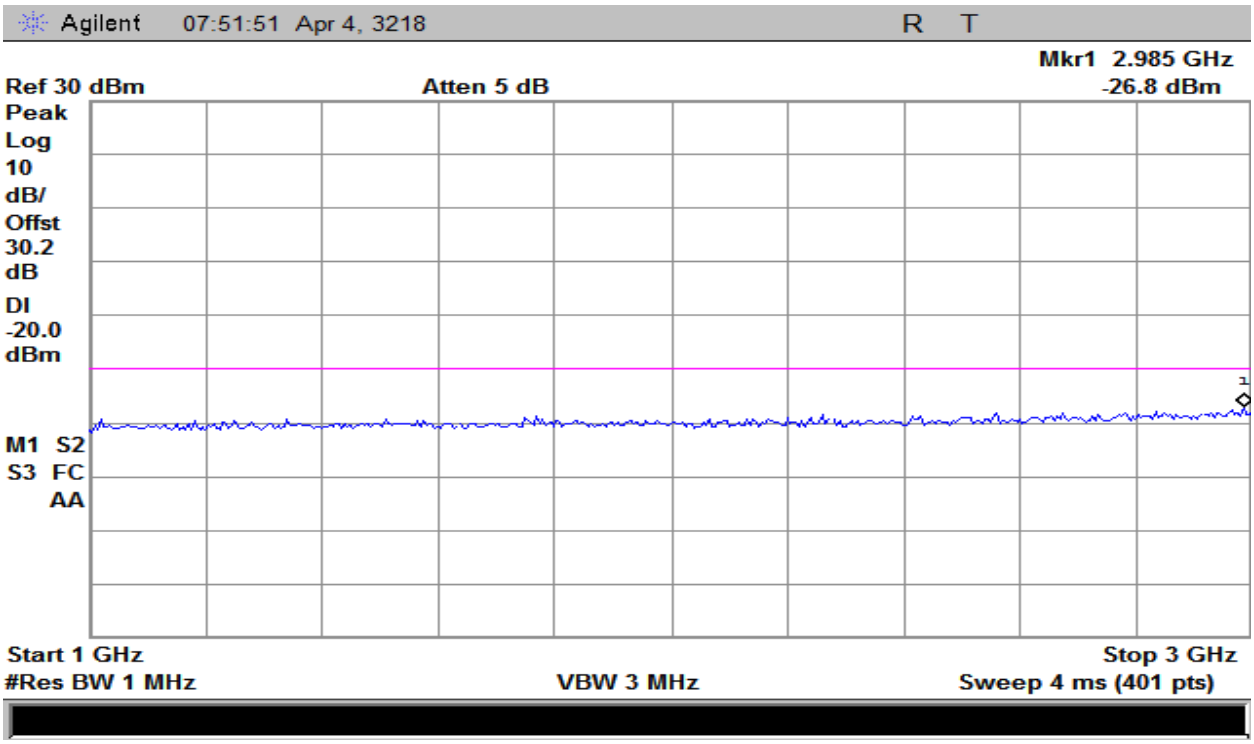
Customer provided a test mode internal to the EUT to control the RF modulation, and frequency channel. The EUT was connected through an attenuator to a Spectrum Analyzer. The Spectrum Analyzer was set to sweep from 30MHz up to 10th harmonic of the fundamental or 40GHz whichever is the lesser. Measurements were made at the low, mid and high frequency of the transmit band.

Test Setup:

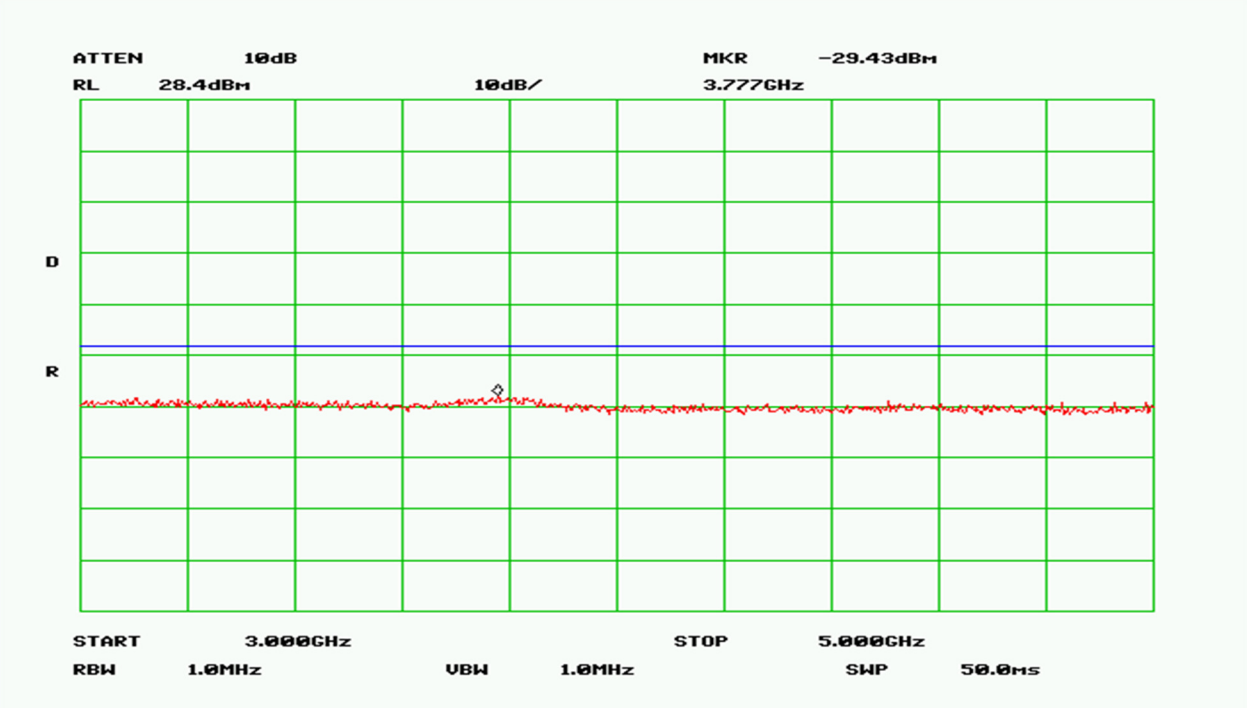
Figure 4: Spurious Emission at Antenna Terminal Test setup



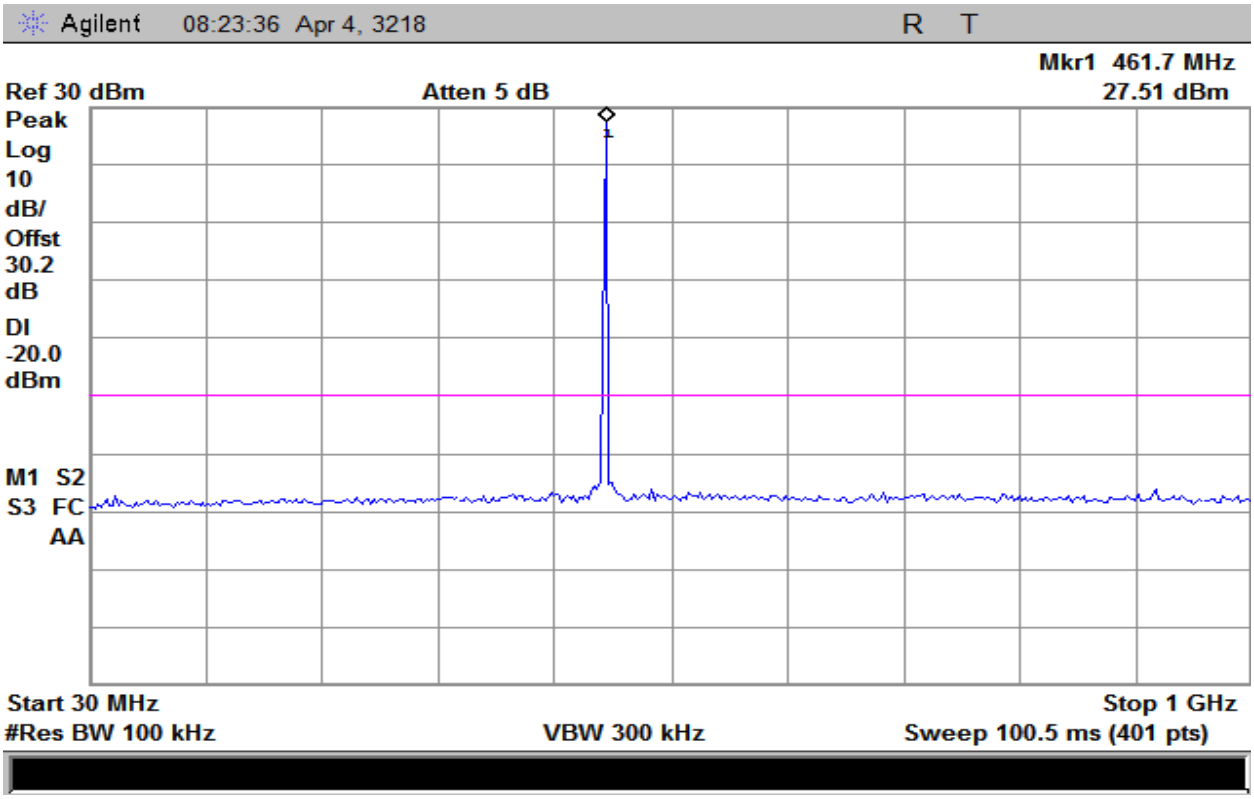
Plot 8 – Low Band



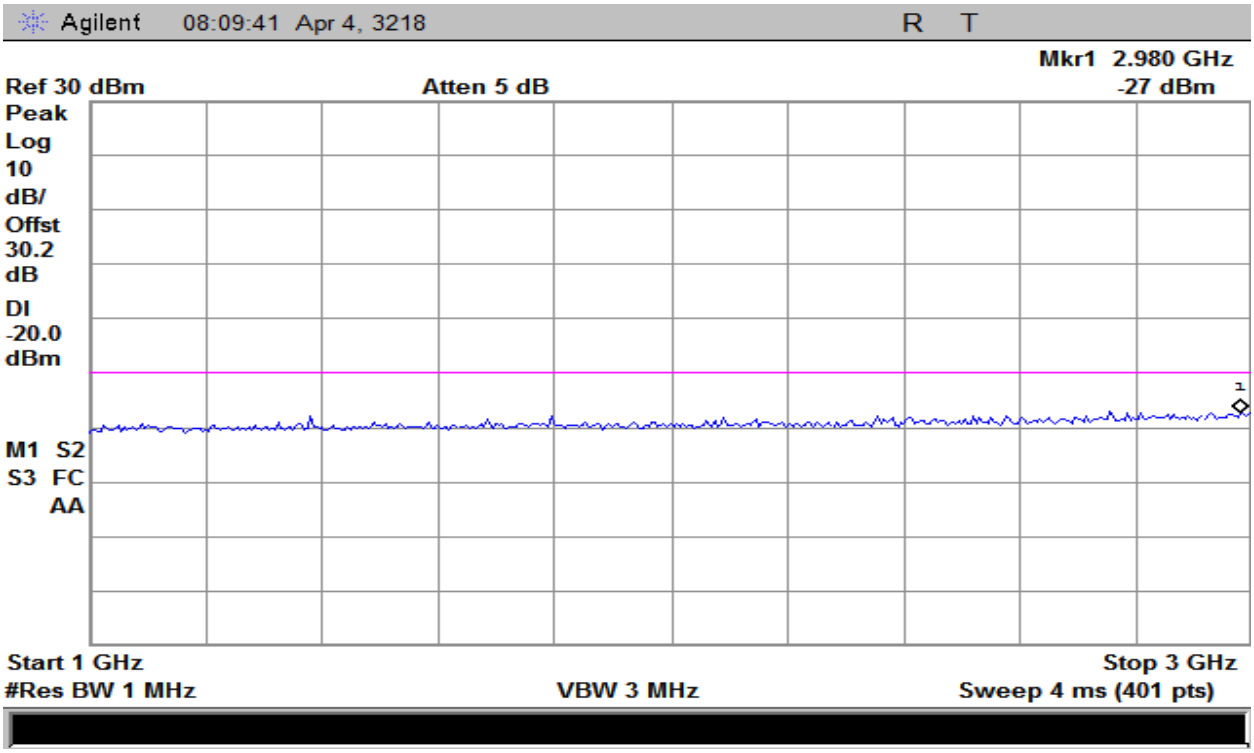
Plot 9 – Low Band



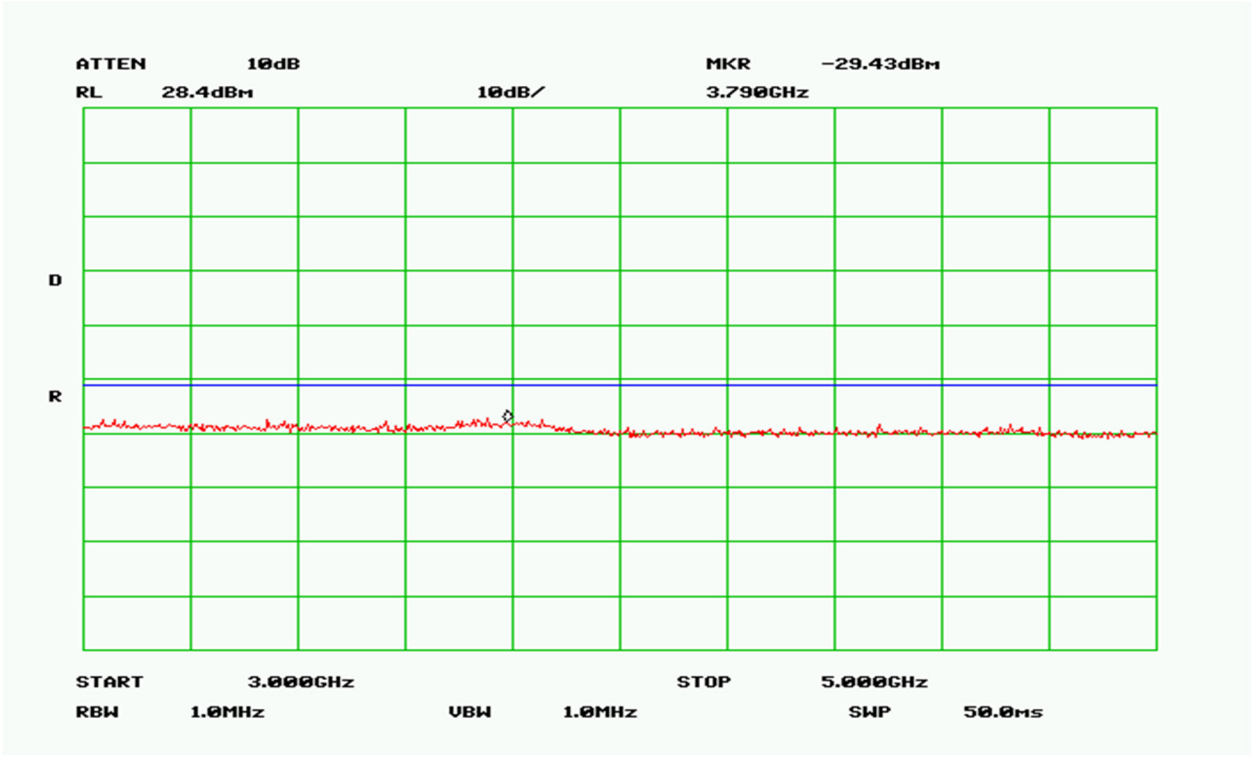
Plot 10 – Low Band



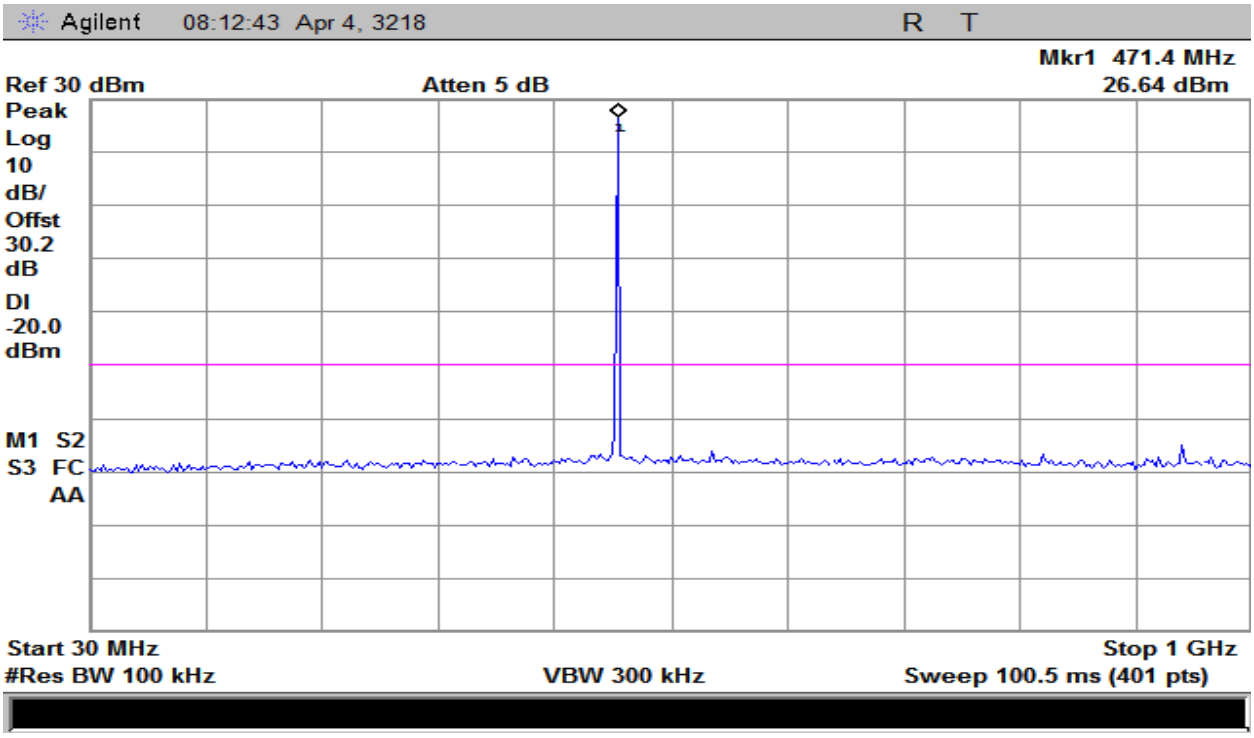
Plot 11 – Mid Band



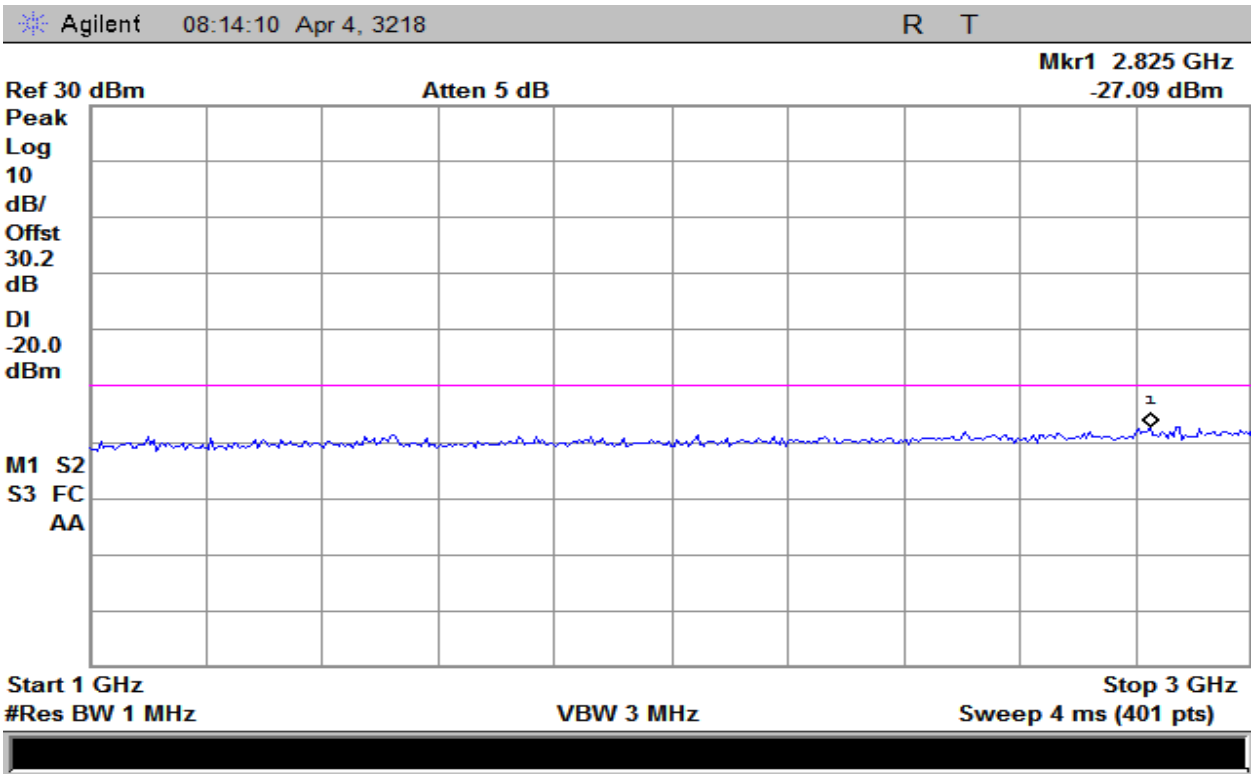
Plot 12 – Mid Band



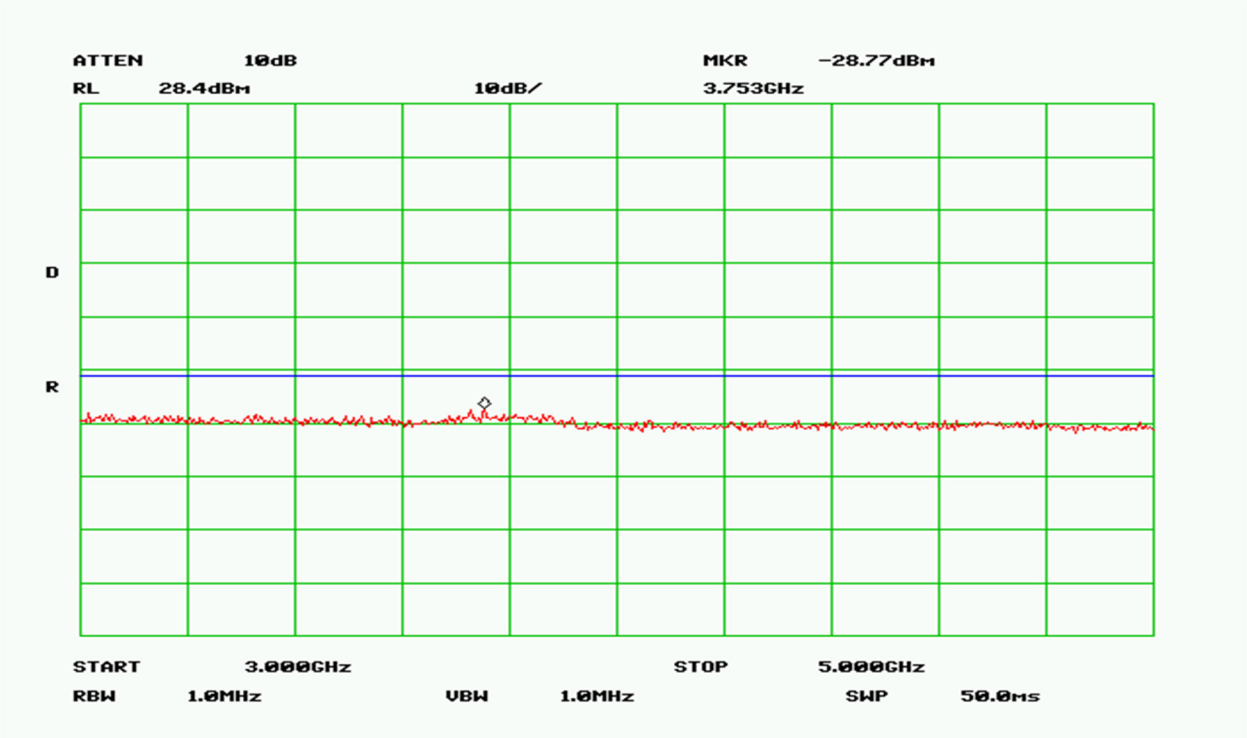
Plot 13 – Mid Band



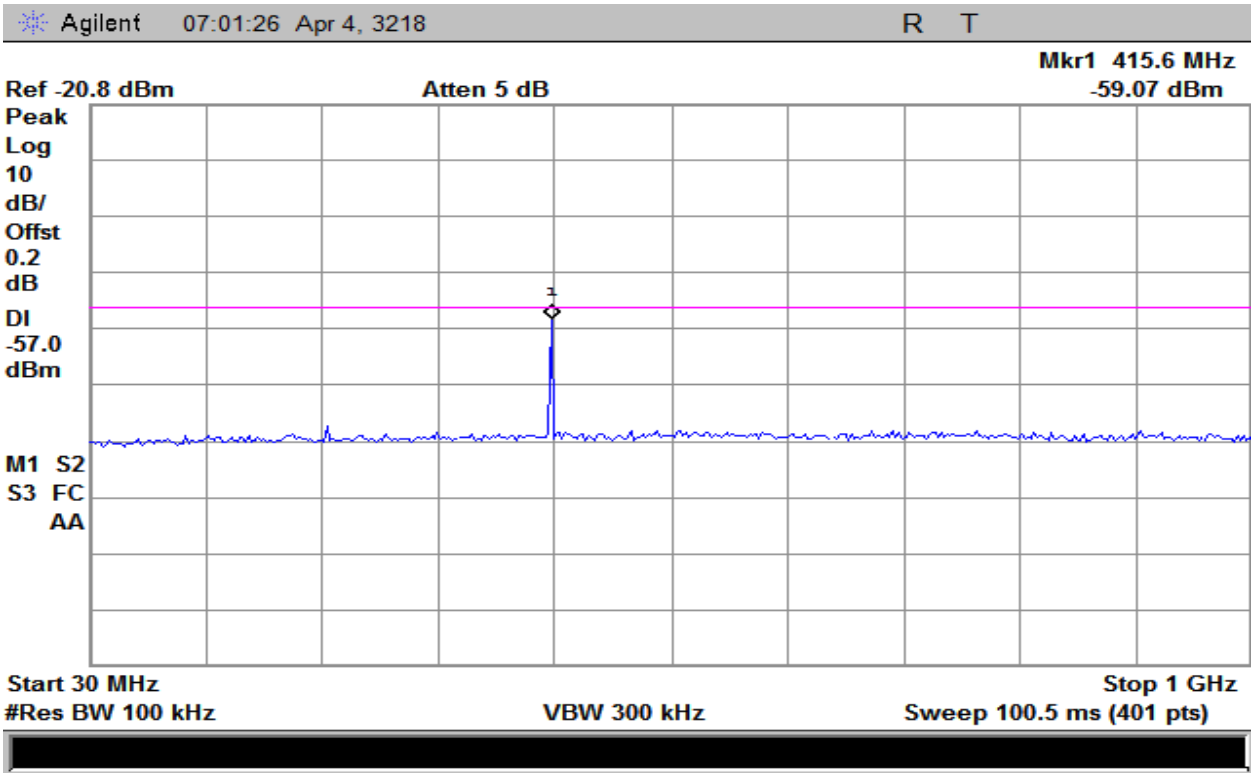
Plot 14 – High Band



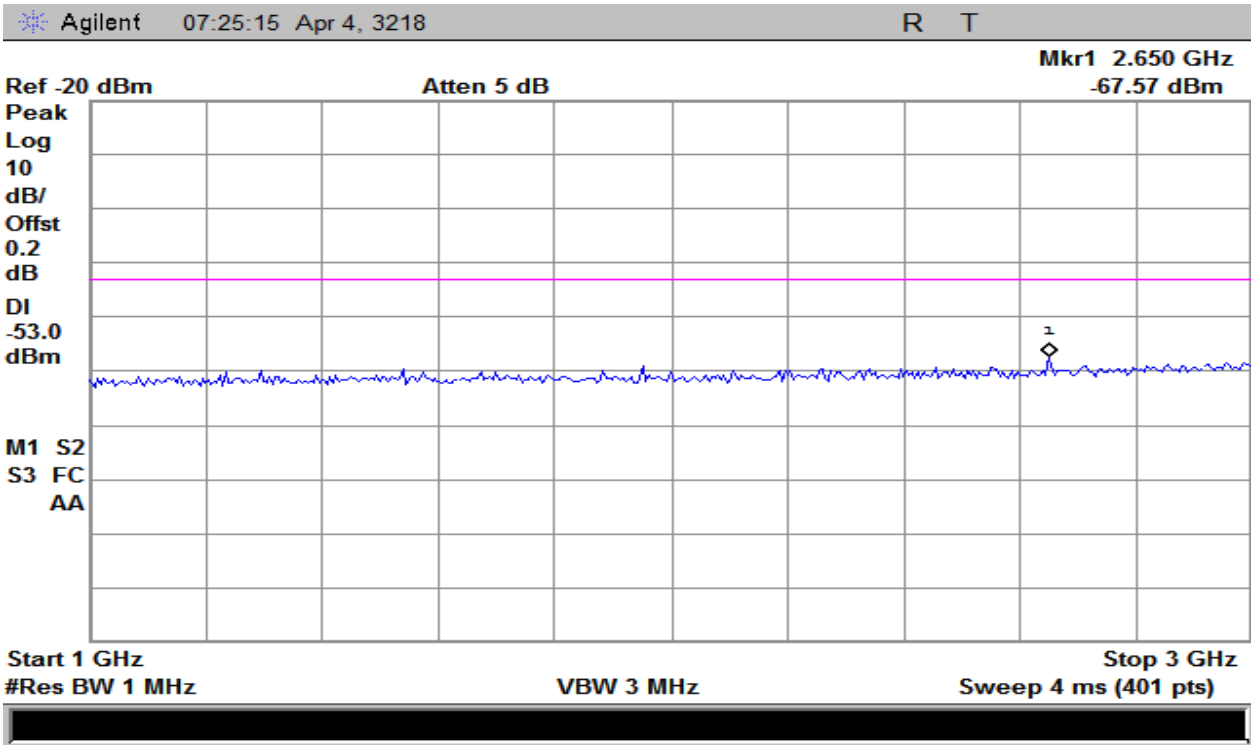
Plot 15 – High Band



Plot 16 – High Band



Plot 17 – Receiver Emission – For Industry Canada Only (RSS-GEN)



Plot 18 – Receiver Emission – For Industry Canada Only (RSS-GEN)

5. Radiated Spurious Emissions

Test Requirement(s):	§2.1053 and 90.210(j)	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/16/2018

Test Procedures:

As required by 47 CFR 2.1053, field strength of radiated spurious measurements were made in accordance with the procedures of the TIA/EIA-603-D-2010.

The EUT was placed on a wooden table inside a 3 meter semi-anechoic chamber. The EUT was transmitting into a non-radiating load which was directly connected to the EUT antenna port.

The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT. The test was performed by placing the EUT on 3 orthogonal axis. The frequency range up to the 10^{th} harmonic was investigated.

The EUT is removed and replaced with a substitution antenna. A signal generator was connected to the substitution antenna by a non-radiating cable. The absolute levels of the spurious emissions were measured by the substitution.

Spurious emissions in dB = 10 log (Txpwr in Watts/0.001)-the absolute level

Spurious attenuation limit in dB = 50 + 10 $\log_{10}$ (P) dB or 70dB whichever is the lesser attenuation

Test Setup:

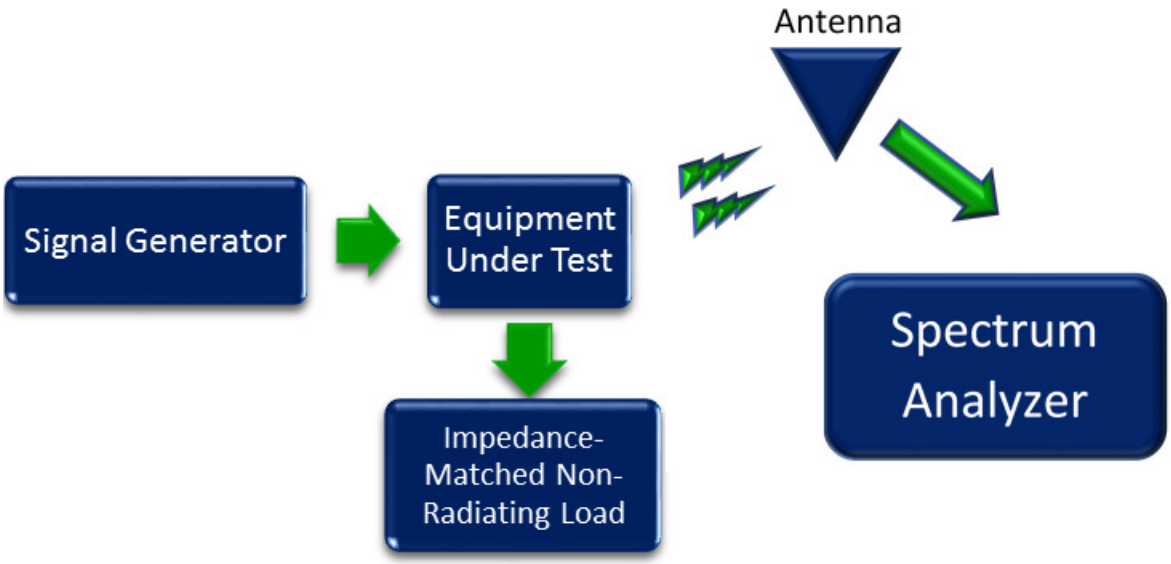


Figure 5 – Radiated Spurious Emissions

Frequency (MHZ)	Amplitude (dbuV)	Antenna Polarity	Cable Loss	Substitution Generator Level (dbm)	Transmit Antenna Gain	Corrected Amplitude (dBm)	Limit (dBm)
900	52.3	Vert	0.3	-43	6.6	-36.4	-20
1800	42.2	Vert	0.35	-55	6.5	-48.5	-20

Table 5 - Spurious Radiated Emission Data – Low Band

Frequency	Amplitude (dbuV)	Antenna Polarity	Cable Loss	Substitution Generator Level (dbm)	Transmit Antenna Gain	Corrected Amplitude (dBm)	Limit (dBm)
920	51.8	Vert	0.3	-48	6.6	-41.4	-20
1380	N.F.	Vert	0.35	-	-	-	-20
1840	42	Horz	0.45	-55	7.3	-47.7	-20
2300	35.5	Horz	0.8	-55	7.6	-47.4	-20

Table 6 – Spurious Radiated Emission Data – Mid Band

Frequency	Amplitude (dbuV)	Antenna Polarity	Cable Loss	Substitution Generator Level (dbm)	Transmit Antenna Gain	Corrected Amplitude (dBm)	Limit (dBm)
940	47.2	Vert	0.3	-59	6.6	-52.4	-20
1410	32.5	Horz	0.35	-60	6.5	-53.5	-20
1850	39.8	Horz	0.45	-55	7.3	-47.7	-20

Table 7 – Spurious Radiated Emission Data – High Band

6. Frequency Stability vs Temperature

Test Requirement(s):	§2.1055 and 90.213	**Test Engineer(s):**	Jerry M.
Test Results:	Pass	**Test Date(s):**	04/20/2018

Test Procedures: As required by 47 CFR 2.0155, Frequency Stability measurements were made at the RF antenna output terminals of the EUT.

The EUT was placed in an Environmental Chamber with all the support equipment outside the chamber. The EUT was set to transmit a modulated carrier. The reference frequency at 20°C was observed and noted down. The frequency drift was investigated for every 10°C increment until the unit was stabilized then recorded the reading in tabular format with the temperature range of -30°C to 50°C.

Test Setup:

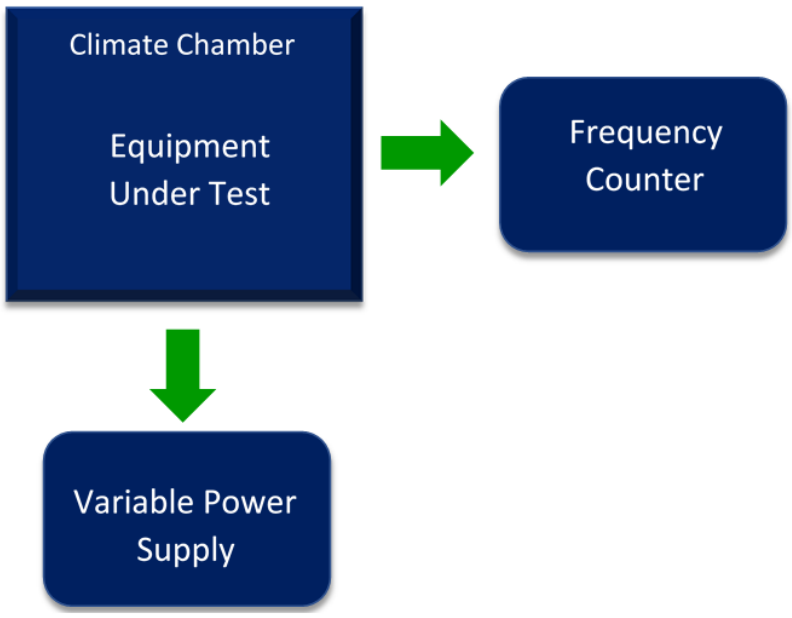
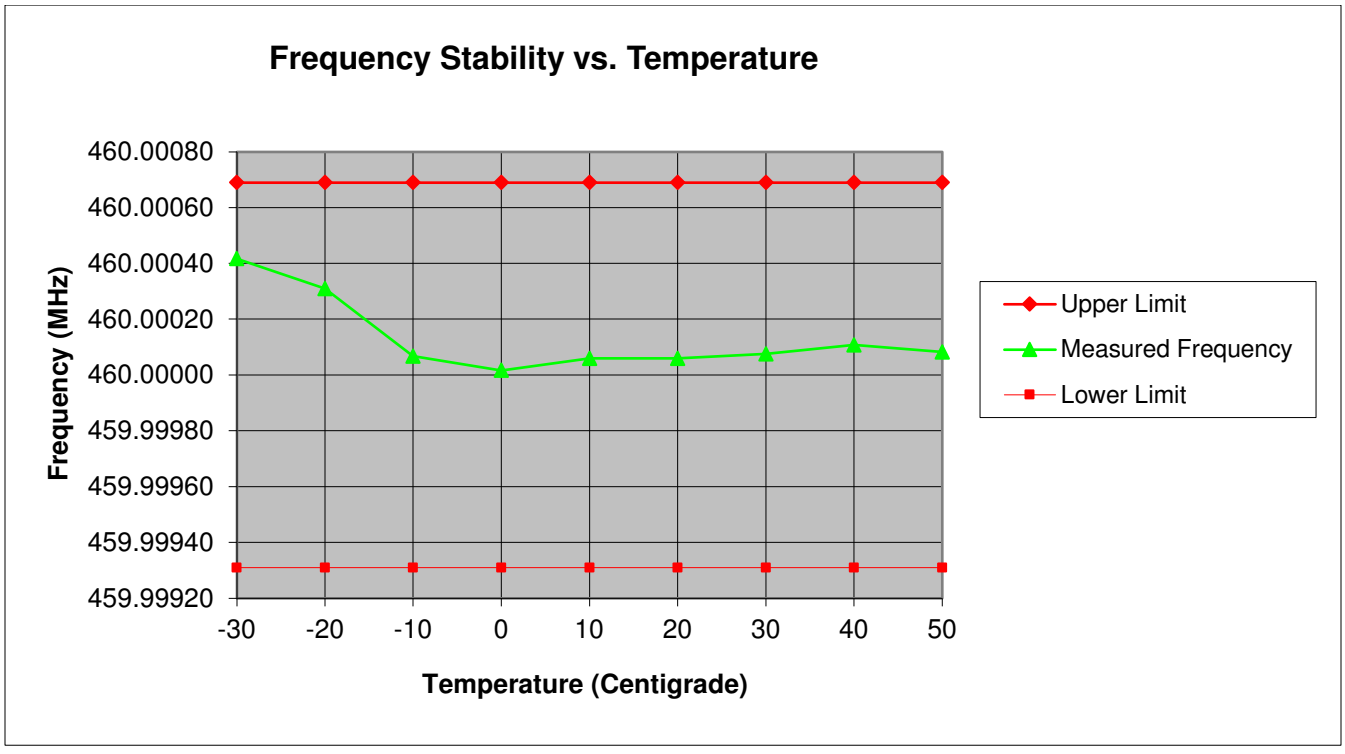


Figure 6 – Frequency Stability Test Setup

Temperature centigrade	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
-30	460.000417	-0.00027	0.00111
-20	460.000309	-0.00038	0.00100
-10	460.000067	-0.00062	0.00076
0	460.000017	-0.00067	0.00071
10	460.000059	-0.00063	0.00075
20	460.000059	-0.00063	0.00075
30	460.000075	-0.00062	0.00077
40	460.000108	-0.00058	0.00080
50	460.000083	-0.00061	0.00077

Table 8 – Temperature vs Frequency Test Result



Plot 19 – Temperature vs Frequency

7. Frequency Stability vs Voltage

Test Requirement(s):	§2.1055	**Test Engineer(s):**	Jerry Mejak
Test Results:	Pass	**Test Date(s):**	04/20/2018

Test Procedures: As required by 47 CFR 2.0155, Frequency Stability measurements were made at the RF antenna output terminals of the EUT.

The EUT was connected to a variable DC source. The frequency was measured at both the nominal 7.2 Vdc of the EUT and at the extreme lower and upper voltages.

With the voltage set to a measurement point, the transmitted signal was captured by the spectrum analyzer and the frequency value determined. The frequencies are compared to the tuned frequency. All data for these measurements are found in the table 9.

Reference Frequency: 460MHz at 7.2VdC at 20°C

Test Setup:

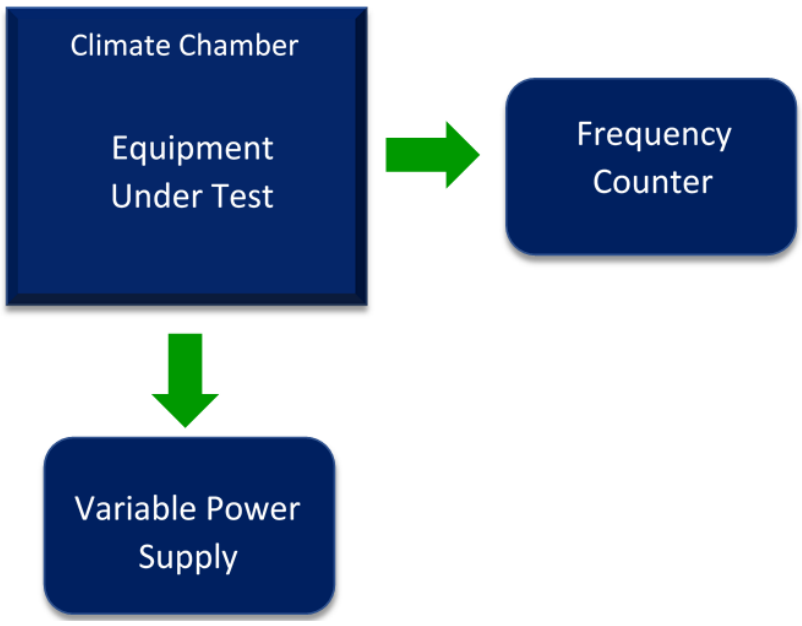
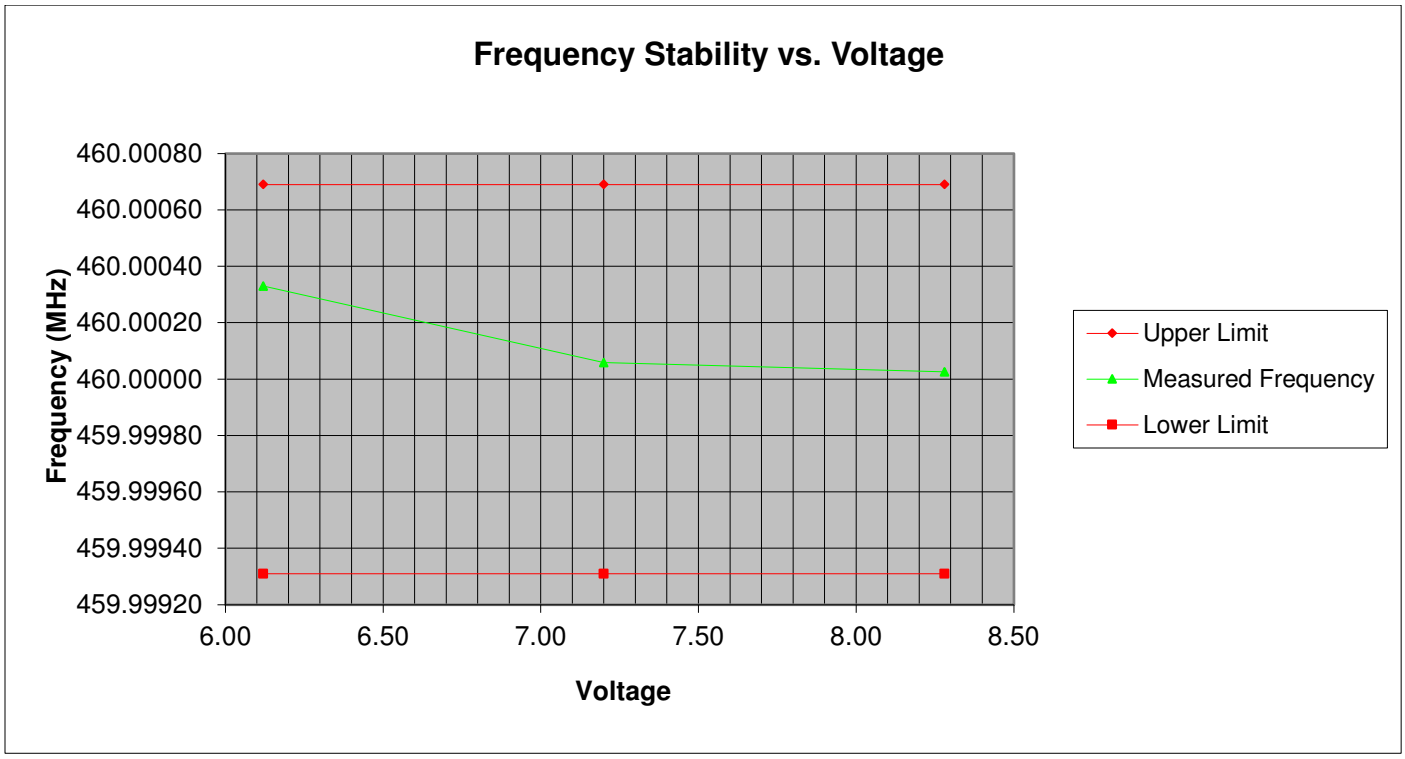


Figure 7 – Frequency Stability Test Setup

Input Voltage (Vdc)	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
6.12	460.00033	-0.00036	0.00102
7.20	460.000059	-0.00063	0.00075
8.28	460.000026	-0.00066	0.00072

Table 9. Temperature vs. Voltage Test Result



Plot 20 – Temperature vs Voltage

8. Transient Frequency Behavior

Test Requirement(s):	§90.214	**Test Engineer(s):**	Keith T.
Test Results:	Pass	**Test Date(s):**	04/10/2018

Test Procedures: The EUT was tested for transient frequency behavior using the test method of TIA/EIA 603.

RF Frequency	Channel Bandwidth	Transient Period	Transient Behavior	Result
460MHz	12.5KHz	t1= 10ms	<±12.5kHz	Pass
		t2= 25ms	<±6.25kHz	Pass
		t3= 10ms	<±12.5kHz	Pass

Table 10. Transient Frequency – Test Requirement

The following pages show measurements of Transient Frequency Behavior plots:

Test Setup:

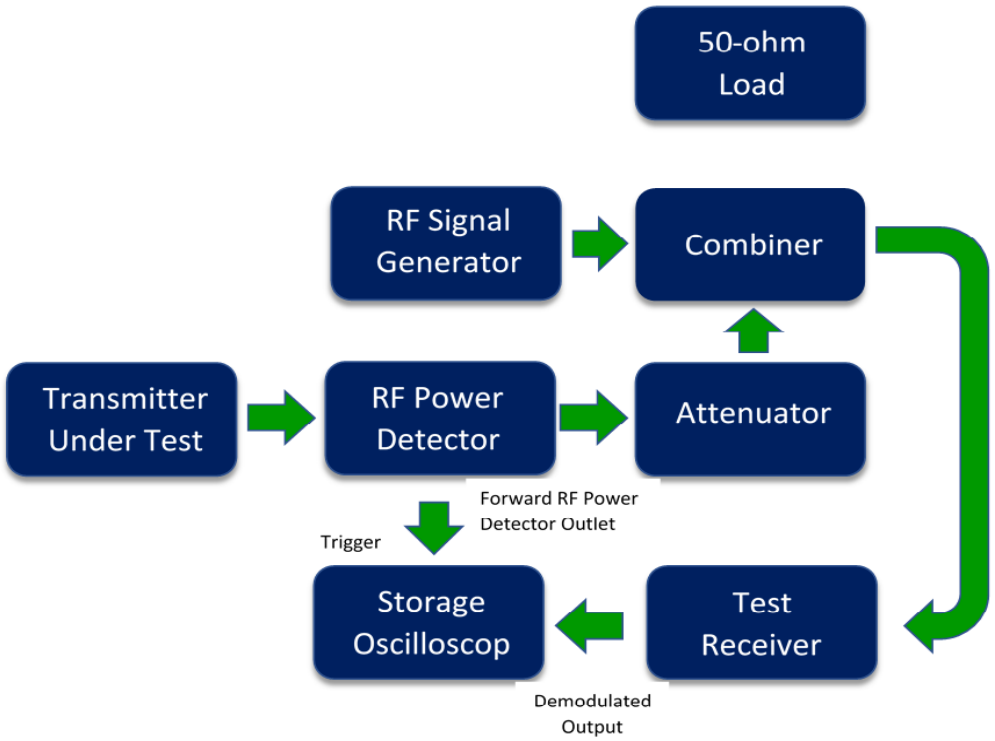
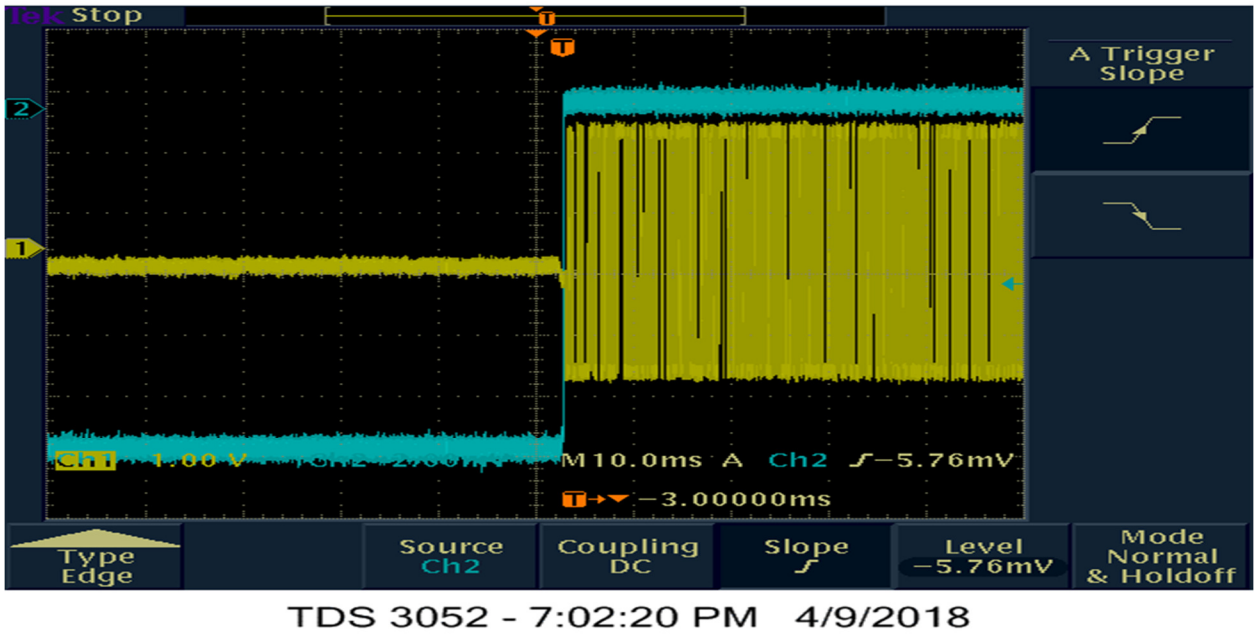
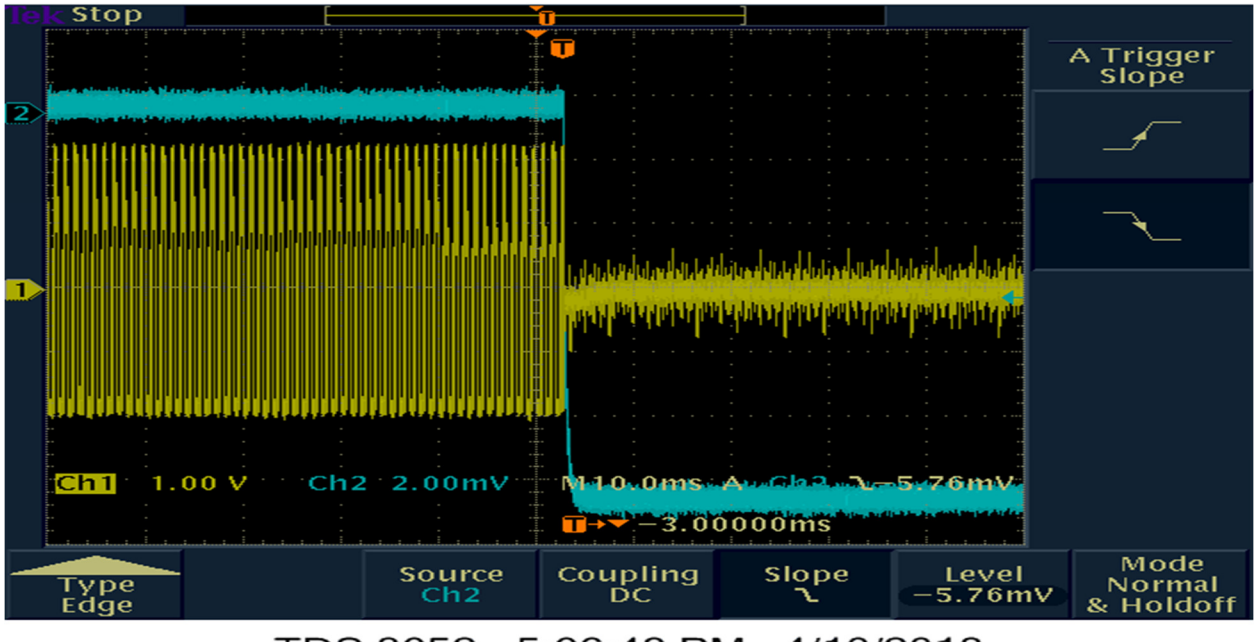


Figure 8 – Transient Frequency Behavior Test Setup



Plot 21 – On Time



Plot 22 – Off Time

9. Necessary Bandwidth

Referencing Part 2.202 of the FCC Rules and Regulation and using the following formula for calculating the Necessary Bandwidth

B = 2M + 2DK

Where M = Baud Rate, D = Deviation and K= Constant

Digital Data: TDMA; 4800 bps; Narrow Band; 12.5 KHz Channel Spacing

Calculation

Data Rate in bps (R) = 4800

Peak Deviation of Carrier (D) = +-1.5KHz

Number of States in Each Symbol = 2

Bn = 3.86 + 0.27R

BN = [3.86*(1500) + 0.27*4800] =7.08 KHz

Emission Designator: 7K00F1D

10. Test Equipment

Equipment	Manufacturer	Model	Serial #	Last Cal Date	Cal Due Date
Power Supply	Lambda	LA-200	LA2AA201433535	Verified	
Digital Multimeter	Fluke	77 III	72550270	Jan/30/18	Jan/30/20
Spectrum Analyzer	Agilent	E4402B	US41192757	Mar/19/18	Mar/19/19
Temperature Chamber	Thermotron	SM-3.5S	12817	Oct/17/17	Oct/17/18
Spectrum Analyzer	Hewlett Packard	8563E	3821A09316	Jan/30/18	Jan/30/19
Attenuator 10dB	Huber+Suhner	6810.17.A	757300	Verified	
High Pass Filter	Mini-Circuits	VHF-3100+	1023	Verified	
Variable Attenuator	H.P.	None	None	NCR	None
EMI Receiver	Hewlett Packard	8568B	2314A02642	Jul/11/17	Jul/11/18
Signal Generator	Agilent	E4432B	US38220446	NCR	None
Attenuator 20dB	Weinschel	41-20-12	86332	Verified	
Horn Antenna	Com-Power	AHA-118	711150	May/10/16	May/10/19
Horn Antenna	Com-Power	AH-118	71350	Verified	
Diode/Crystal Detector	H.P.	8470B	None	Verified	
Combiner/Splitter	MiniCircuits	ZFSC-2-2	None	Verified	
Oscilloscope	Tektronix	TDS 3052	B013389	Aug/18/17	Aug/18/18

Table 11 – Test Equipment List

***Statement of Traceability:** Test equipment is maintained and calibrated on a regular basis. All calibrations have been performed by a 17025 accredited test facility, traceable to National Institute of Standards and Technology (NIST)

11. Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. These measurements figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2. Instrumentation measurement uncertainty has **not** been taken into account to determine compliance.

The following measurement uncertainty values have been calculated as show in the table below:

Measured Parameter	Measurement Unit	Frequency Range	Expanded Uncertainty
Conducted Emissions (AC Power)	dBuV or dBuA	150kHz – 30MHz	± 4.3dB
Radiated Emissions below 1GHz	dBuV/m	30 – 1000MHz	± 5.6dB
Radiated Emissions above 1GHz	dBuV/m	1 – 26.5GHz	± 4.1dB

The reported expanded uncertainty has been estimated at a 95% confidence level (k=2)

END OF TEST REPORT