Test Report

Prepared for: Etherstack

Model: Model: SFFR-6

Description: Small Form Factor Repeater

Serial Number: 17050004

FCC ID: 2ADAKSFFR6UL2
IC: 9487A-SFFR6UL2

To

FCC Part 22, 74, 80, 90

and

IC RSS-119 (Issue 12)

Date of Issue: January 24, 2019

On the behalf of the applicant:	**Etherstack Inc. 1115 Broadway Suite 1276 New York, NY 10010**
Attention of:	**Doug Chapman, V.P. Business Development N.A. Ph: (917)661-4110 E-Mail: doug.chapman@etherstack.com**

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Greg Corbin

Greg Corbin
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	October 16, 2017	Greg Corbin	Original Document
2.0	November 28, 2017	Greg Corbin	Corrected attenuator value on page 13. Added Table 2 on page 7 listing FCC test frequencies used. Added power limits to page 9. Added ppm specification to page 21. Added ANSI C63.26 reference to page 6.
3.0	December 17,2017	Greg Corbin	Updated Model and Description, manufacturer address. Added emission designators 8K10F7D, 8K10F7E, 8K10F1W, 8K10F7W. Removed emission designator 20k0F3E. Updated test modulation description on pages 11,13,14,16,18,20. Updated the following test data, emission masks, occupied bandwidth, audio low pass filter, audio frequency response, modulation limiting, updated frequency stability limit and added frequency stability for DC voltage
4.0	June 8, 2018	Greg Corbin	Updated FCC and IC IDs, Removed all references to internal duplexer and associated losses, Updated Output power tables
5.0	June 21, 2018	Greg Corbin	Added 8K10F1E to page 6. Updated notes on pages 11, 12. Corrected label for graph on page 8 in Annex B. Updated cannel bandwidth for C4FM in table on page 13. Updated FM narrowband and FM wideband plots in Annex D Removed 8K10F1E from necessary BW calculation page 24 Added 8K10F1E,8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W to necessary BW calculations Added audio source to test setup on page 11 and 14. Replaced repeater with basestation Replaced channel spacing with channel bandwidth
6.0	August 13, 2018	Greg Corbin	Added technical requirements and test results summary table to page 16
7.0	October 15, 2018	Greg Corbin	Changed description back to Small Form Factor Repeater
8.0	October 25, 2018	Greg Corbin	Added emission designators to table 1 on page 7.
9.0	January 18, 2019	Greg Corbin	Updated extended frequencies in Table 1.

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ILAC / A2LA

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

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

Testing Certificate Number: **2152.01**

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FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The Applicant has been cautioned as to the following:

15.21: **Information to the User**

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

15.27(a): **Special Accessories**

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

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

Test and Measurement Data

All tests and measurement data shown were performed in accordance with FCC Rules and Regulations, Volume II, Part 2, Subpart J, Sections 2.947, 2.1033(c), 2.1041, 2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055, 2.1057, the following individual Parts: FCC Part 22, 74, 80, 90 and ANSI C63.26.

Standard Test Conditions and Engineering Practices

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

In accordance with ANSI/TIA 603E, and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Environmental Conditions		
Temp (ºC)	**Humidity (%)**	**Pressure (mbar)**
26.3 – 30.0	33.6 – 46.2	963.8 – 965.3

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

EUT Description
Model: SFFR-6
Description: Small Form Factor Repeater
Firmware: 2.04.000
Software: N/A
Serial Number: 17060004
Additional Information: The EUT is a UHF small form factor repeater operating from 380 - 470 MHz per Table 1 below. The EUT is AC or DC powered, with 2 battery packs for battery power.

EUT Operation during Tests
Throughout the test report, there are references to narrowband, wideband, and digital signals.
Narrowband (NB) utilizes analog FM test signals with 12.5 kHz cannel bandwidth.
Wideband (WB) utilizes analog FM test signals with 25 kHz cannel bandwidth.
Digital utilizes C4FM test signals.

Table 1 Frequency Allocation

Frequency Range (380 - 470 MHz)							
Rule Part	**Frequency Range (MHz)**	**Sub-Bands (MHz)**			**Extended Frequency**		**Emission Designator**
FCC Part 90	406.1 - 470	406.1 - 420	421 - 430	440 - 470	380 - 406	430 - 440	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 11K0F3E
FCC Part 90	N/A	N/A	N/A	N/A	380 - 406	430 - 450	16K0F3E
FCC Part 22	454 - 460	454 - 455	456 - 460	N/A	N/A	N/A	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 11K0F3E, 16K0F3E
FCC Part 74	450 - 456	450 - 454	455 - 456	N/A	N/A	N/A	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 11K0F3E, 16K0F3E
FCC Part 80	454 - 470	454 - 455	456 - 460	462.7375 - 470	N/A	N/A	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 11K0F3E, 16K0F3E
RSS 119	406.1 - 470	406.1 - 430	450 - 470	N/A	N/A	N/A	8K10F1D, 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 11K0F3E, 16K0F3E

Table 2 - FCC Test Frequencies

Test Frequency (MHz)	FCC Rule Part
406.1	90
418	90
429	90
450.0125	74, 90
459.9875	22, 80, 90
469.9875	80, 90

Accessories:

Qty	Description	Manufacturer	Model	S/N
1	Audio breakout box	Etherstack	N/A	N/A

Cables:

Qty	Description	Length (M)	Shielding Y/N	Shielded Hood Y/N	Termination
1	AC Power cord	1	N	N	N/A
1	DC Power cord	1	N	N	N/A

Modifications: None

Test Result Summary

Specification	Test Name	Pass, Fail, N/A	Comments
2.1046 RSS-119 (5.4) 22.565 (a) 80.215 (f)(g) 74.461	Conducted Output Power	Pass	
2.1051 RSS-119 (5.8) 22.359 (a) 80.211 (f) 74.462(C)	Conducted Spurious Emissions	Pass	
2.1053 Rss-119 (5.8) 22.359 (a) 80.211 (f) 74.462(C)	Radiated Spurious Emissions	Pass	
90.210 2.1049 RSS-119 (5.5) 80.211 (f)	Emission Masks	Pass	
2.1049	Occupied Bandwidth	Pass	
2.1047	Audio Low Pass Filter (Voice Input)	Pass	
2.1047	Audio Frequency Response	Pass	
2.1047(a)	Modulation Limiting	Pass	
90.213 RSS-119 (5.3) 22.355 80.209 (a)(7) 74.464	Frequency Stability (Temperature Variation)	Pass	
90.213 RSS-119 (5.3) 22.355 80.209 (a)(7) 74.464	Frequency Stability (Voltage Variation)	Pass	
90.214 RSS-119 (5.9)	Transient Frequency Behavior	Pass	
2.202 (g)	Necessary Bandwidth Calculation	Pass	

Conducted Output Power

Engineer: Greg Corbin

Test Date: 8/28/17

Measurement Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer through a 30 dB Power attenuator. All cable and attenuator losses were input into the spectrum analyzer as a reference level offset to ensure accurate readings were obtained.
For narrowband and wideband signals, a CW signal and peak detector was used for performing output power measurements.
For digital signals a C4FM signal and average detector was used for performing output power measurements

Output power was recorded for both the lowest and highest power setting

The output power limits are as follows for each FCC rule part.

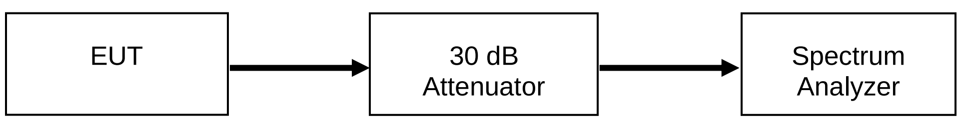
Part 22: 22.565(a)_150 watts

Part 74: 74.461_100 watts

Part 80: 80.215(l)_For operational fixed stations using frequencies in the 72-76 MHz band and for other classes of stations operating above 162.025 MHz, the transmitter power must be specified in the station authorization.

Part 90: 90.205(h)_450-470 MHz. (1) The maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna HAAT and required service area and will be authorized in accordance with table 2 in part 90.205(h).

Test Setup



Peak Output Power – Narrowband - Low Power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	32.5	1.778	Pass
418.0125	32.5	1.778	Pass
429.9875	32.6	1.820	Pass
450.1025	32.6	1.820	Pass
459.9875	32.6	1.820	Pass
469.9875	32.6	1.820	Pass

Peak Output Power – Narrowband - High power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	44.3	26.915	Pass
418.0125	44.3	26.915	Pass
429.9875	44.4	27.542	Pass
450.1025	44.4	27.542	Pass
459.9875	44.4	27.542	Pass
469.9875	44.4	27.542	Pass

Peak Output Power – Wideband - Low Power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	32.5	1.778	Pass
418.0125	32.5	1.778	Pass
429.9875	32.6	1.820	Pass
450.1025	32.6	1.820	Pass
459.9875	32.6	1.820	Pass
469.9875	32.6	1.820	Pass

Peak Output Power – Wideband - High power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	44.3	26.915	Pass
418.0125	44.3	26.915	Pass
429.9875	44.4	27.542	Pass
450.1025	44.4	27.542	Pass
459.9875	44.4	27.542	Pass
469.9875	44.4	27.542	Pass

Peak Output Power – Digital - Low Power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	32.5	1.778	Pass
418.0125	32.5	1.820	Pass
429.9875	32.5	1.820	Pass
450.1025	32.5	1.820	Pass
459.9875	32.6	1.820	Pass
469.9875	32.6	1.820	Pass

Peak Output Power – Digital - High power setting

Tuned Frequency (MHz)	Measured Output Power		Result
	(dBm)	(watts)	
406.1	44.3	26.915	Pass
418.0125	44.3	26.915	Pass
429.9875	44.3	26.915	Pass
450.1025	44.3	26.915	Pass
459.9875	44.4	27.542	Pass
469.9875	44.4	27.542	Pass

Conducted Spurious Emissions

Engineer: Greg Corbin

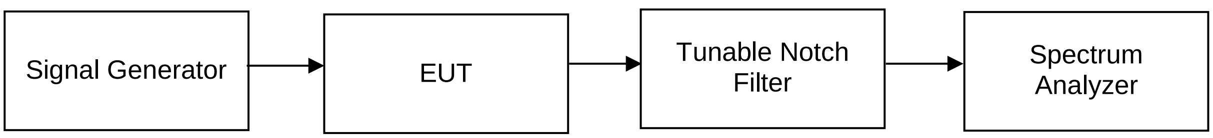
Test Date: 9/5/17

Test Procedure

The EUT was connected directly to a spectrum analyzer to verify that the UUT met the requirements for spurious emissions. A tunable notch filter was utilized to ensure the fundamental did not put the spectrum analyzer into compression. The resolution bandwidth set for 100 kHz and the reference level was adjusted to ensure the system had sufficient dynamic range to measure spurious emissions. The frequency range from 30 MHz to the 10th harmonic of the fundamental transmitter was observed and plotted

The EUT was tested in 3 modes of operation, Wideband (WB), Narrowband (NB), and Digital.
The high power output was used for all conducted spurious tests.
For analog modulation, a 2.5 kHz tone was used, set to 50% modulation (NB 50% of 2.5 kHz = 1.125 kHz, WB 50% of 5 kHz is 2.5 kHz).
The input level was then set to 16 dB above the level used for 50 % modulation.
For digital modulation, the EUT internal C4FM modulation was used.

Test Setup



Refer to Annex A for Conducted Spurious Emission test data.

Notes:
The limit line on the graphs is set to -13dBm.
The test limit for 25 kHz channels is -13dBm.
The test limit is for 12.5 kHz channels is -20dBm.
All spurious measurements were below -20 dBm.

Radiated Spurious Emissions
Engineer: Greg Corbin
Test Date: 9/6/2017

Test Procedure

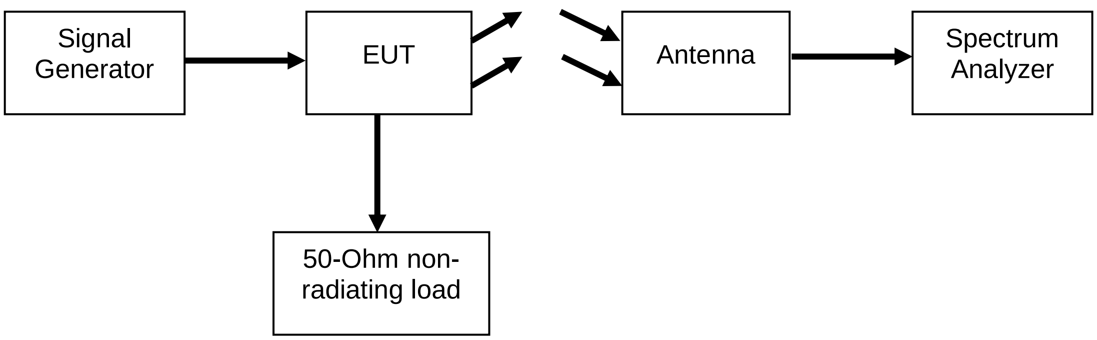
The EUT was tested in a semi-anechoic chamber with the turntable set 3m from the receiving antenna. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360 degrees with the antenna in both the vertical and horizontal orientation while raised from 1 to 4 meters to ensure that the signal levels were maximized. All cable and antenna correction factors were input into the spectrum analyzer ensuring an accurate measurement in ERP/EIRP with the resultant power in dBm. A signal generator was used to provide a modulated signal as required. The EUT output was terminated into a 50 Ohm non-radiating load.

The RBW was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz.
The VBW was set to 3 times the RBW.

The following formula was used for calculating the limits:

Radiated Spurious Emissions Limit
Wideband = P1 – (43+ 10Log(P2)) = -13dBm
Narrowband = P1 – (50+ 10Log(P2)) = -20dBm
P1 = power in dBm
P2 = power in Watts

Test Setup



Refer to Annex B for the Radiated Spurious Emissions test data.

Notes:
The limit line on the graphs is set to -13dBm.
The test limit for 25 kHz channels is -13dBm.
The test limit is for 12.5 kHz channels is -20dBm.
All spurious measurements were below -20 dBm.
No other emissions were detected.

Emission Masks

Engineer: Greg Corbin

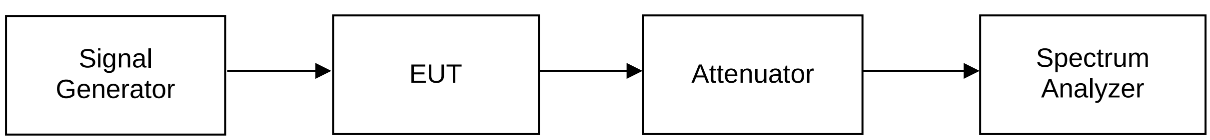
Test Date: 8/29/2017

Test Procedure

The EUT was connected directly to a spectrum analyzer to verify that the EUT meets the required emissions mask.
A reference level plot is provided to verify that the peak power was established prior to testing the mask.
The modulation settings are listed in the table below.
For analog modulation, a 2.5 kHz tone was used, set to 50% modulation (NB 50% of 2.5 kHz = 1.125 kHz, WB 50% of 5 kHz is 2.5 kHz).
The input level was then set to 16 dB above the level used for 50 % modulation.
For digital modulation, the EUT internal C4FM modulation was used.

Cannel bandwidth (kHz)	Emission Mask	Emission Bandwidth	Type of Modulation	Audio Frequency (kHz)	Deviation (kHz)	RBW (Hz)
25	B	16k0	FM	2.5	50%	300
12.5	D	11k0	FM	2.5	50%	100
12.5	D	8k10	C4FM	N/A	N/A	100

Test Setup



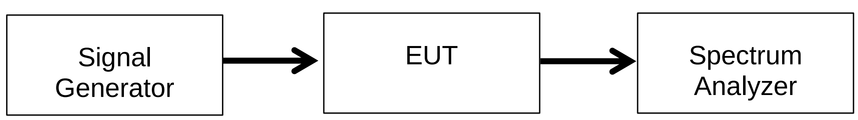
Refer to Annex C for Emission Mask test data.

Occupied Bandwidth
Engineer: Greg Corbin
Test Date: 8/28/17

Test Procedure

The EUT was connected directly to a spectrum analyzer. The Span was set wide enough to capture the entire transmit spectrum and the resolution bandwidth was set to at least 1% of the span. The Occupied Bandwidth tool on the spectrum analyzer was used to measure the -26 dB (99%) occupied bandwidth.
For analog modulation, a 2.5 kHz tone was used, set to 50% modulation (NB 50% of 2.5 kHz = 1.125 kHz, WB 50% of 5 kHz is 2.5 kHz).
The input level was then set to 16 dB above the level used for 50 % modulation.
For digital modulation, the EUT internal C4FM modulation was used.

Test Setup



Refer to Annex D for Occupied Bandwidth test data.

Transient Frequency Behavior
Engineer: Greg Corbin
Test Date: 10/9/2017

Measurement Procedure

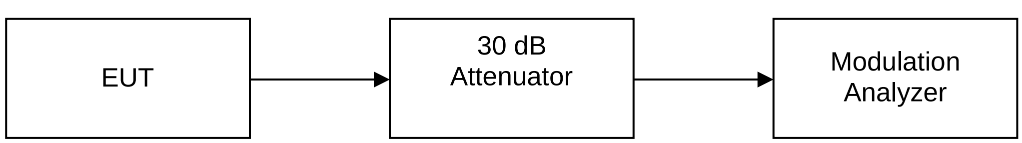
The EUT was connected directly to a modulation analyzer through a 30 dB attenuator to verify that the EUT meets the required Transient Frequency Behavior response per the specification. The modulation analyzer is a real time spectrum analyzer with integrated demodulation, audio measurement capabilities, and timing analysis.
The turn on and turn off transient timing was measured and recorded.

Part 90.214 transient frequency behavior requirements.

Time Intervals [1,2]	Maximum Frequency Difference[3]	All Equipment	
		150 – 174 MHz	421 – 512 MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels			
t_1[4]	±25.0 kHz	5.0 ms	10.0 ms
t_2	±12.5 kHz	20.0 ms	25.0 ms
t_3[4]	±25.0 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels			
t_1[4]	±12.5 kHz	5.0 ms	10.0 ms
t_2	±6.25 kHz	20.0 ms	25.0 ms
t_3[4]	±12.5 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels			
t_1[4]	±6.25 kHz	5.0 ms	10.0 ms
t_2	±3.125 kHz	20.0 ms	25.0 ms
t_3[4]	±6.25 kHz	5.0 ms	10.0 ms

[1]t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.
t_1 is the time period immediately following t_{on}.
t_2 is the time period immediately following t_1.
t_3 is the time period from the instant when the transmitter is turned off until t_{off}.
t_{off} is the instant when the 1 kHz test signal starts to rise.
[2] During the time from the end of t_2 to the beginning of t_3, the frequency difference must not exceed the limits specified in §90.213.
[3] Difference between the actual transmitter frequency and the assigned transmitter frequency.
[4] If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

Test Setup



Transient Frequency Test Results

12.5 kHz Ch spacing				
	Time (ms)	**Measured Value (kHz)**	**Limit (kHz)**	**Margin (kHz)**
t_1	10	0.024	± 25	24.976
t_2	25	1.166	± 12.5	11.334
t_3	10	1.043	± 25	23.957

25 kHz Ch spacing				
	Time – Referenced from Ton (ms)	**Measured Value (kHz)**	**Limit (kHz)**	**Margin (kHz)**
t_1	10	0.156	± 25	24.844
t_2	25	1	± 12.5	11.5
t_3	10	0.791	± 25	24.209

Refer to Annex E for Transient Frequency Behavior plots.

Audio Low Pass Filter (Voice Input)

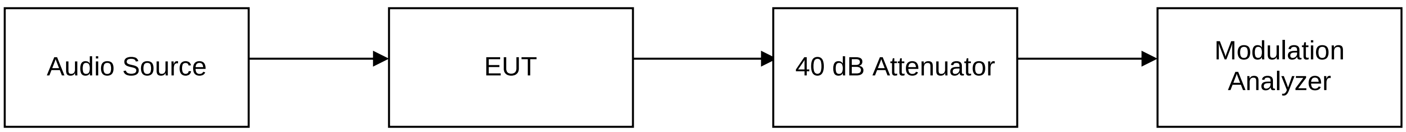
Engineer: Greg Corbin

Test Date: 12/11/2017

Measurement Procedure

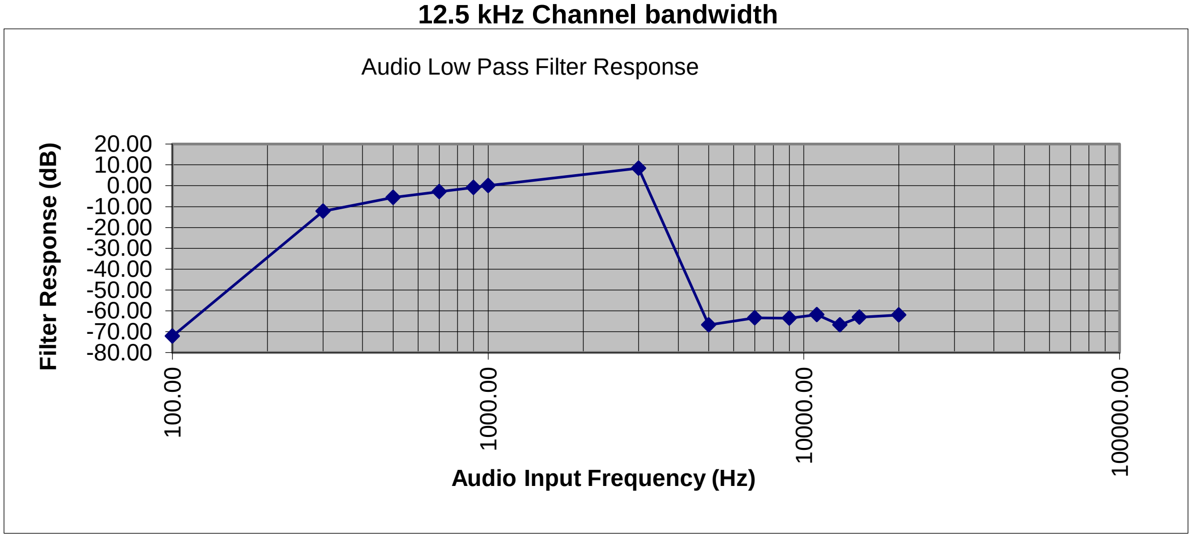
The EUT was connected directly to a modulation analyzer through an attenuator.
Set the audio frequency generator to 1 kHz and adjust the level per manufacturer's specifications.
The audio source was tuned from 100 Hz to 20 kHz and the audio frequency response was measured and plotted.
The modulation analyzer is a real time spectrum analyzer with integrated demodulation, audio measurement capabilities, and timing analysis.
The Audio Low Pass Filter test data was recorded for 12.5 kHz and 25 kHz cannel bandwidth.

Test Setup

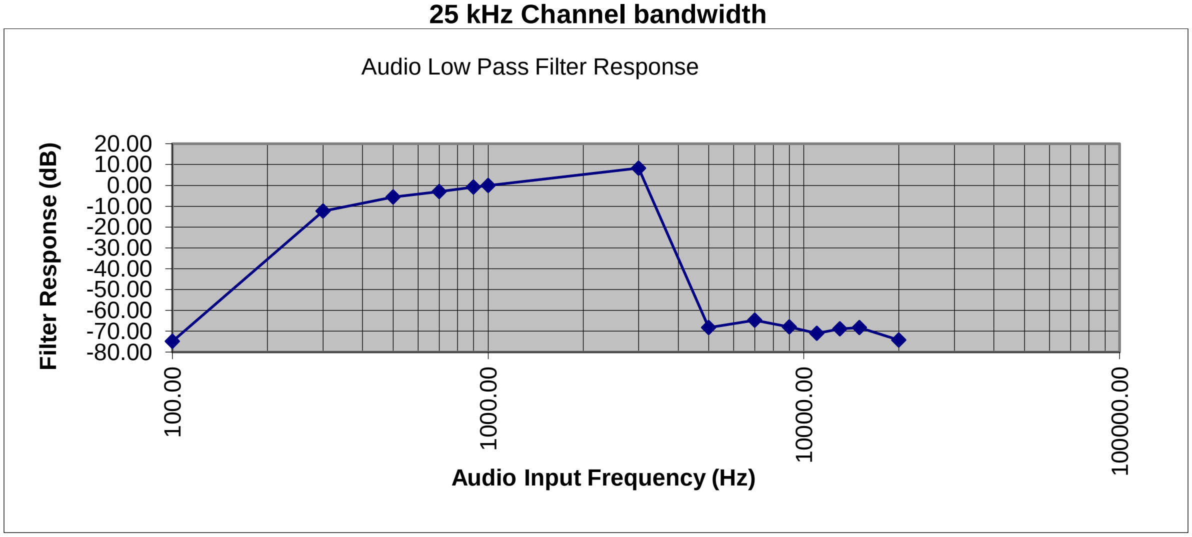


Test Results

12.5 kHz Channel bandwidth



25 kHz Channel bandwidth



Audio Frequency Response

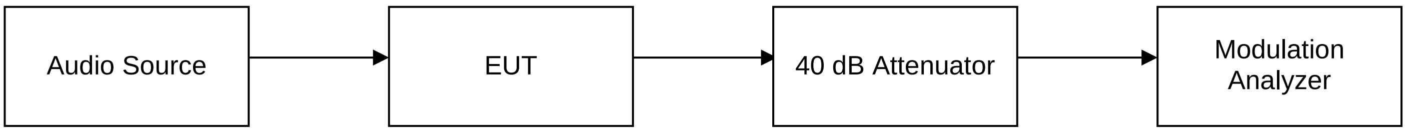
Engineer: Greg Corbin

Test Date: 12/11/2017

Measurement Procedure

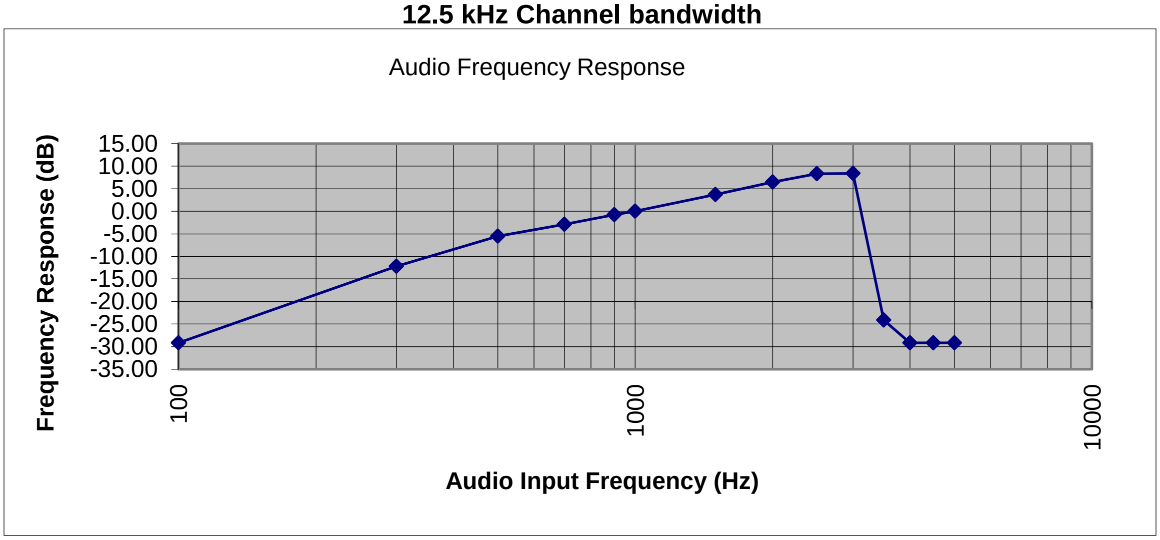
The EUT was connected directly to a modulation analyzer through an attenuator.
The audio frequency was set to 1 kHz and the level was adjusted for 20% deviation according to the manufacturer's instructions.
The audio source was tuned from 100 Hz to 5000 Hz and the audio frequency response was measured and plotted.
The modulation analyzer is a real time spectrum analyzer with integrated demodulation, audio measurement capabilities, and timing analysis.
The Audio Frequency Response test data was recorded for 12.5 kHz and 25 kHz cannel bandwidth.

Test Setup

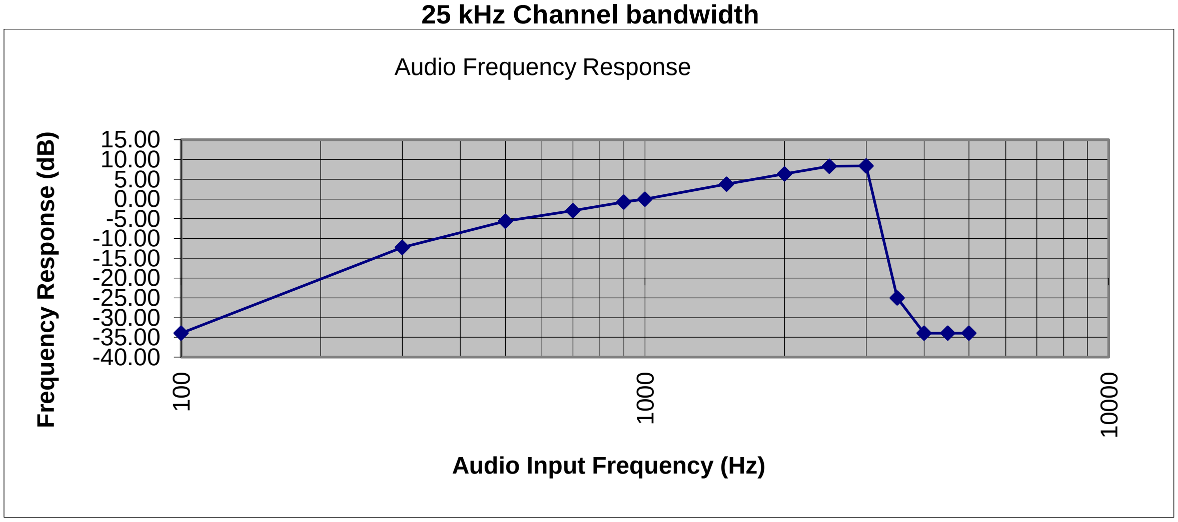


Test Results

12.5 kHz Channel bandwidth



25 kHz Channel bandwidth



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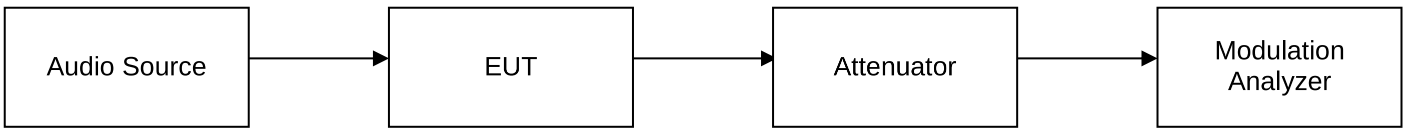
Modulation Limiting
Engineer: Greg Corbin
Test Date: 12/11/2017

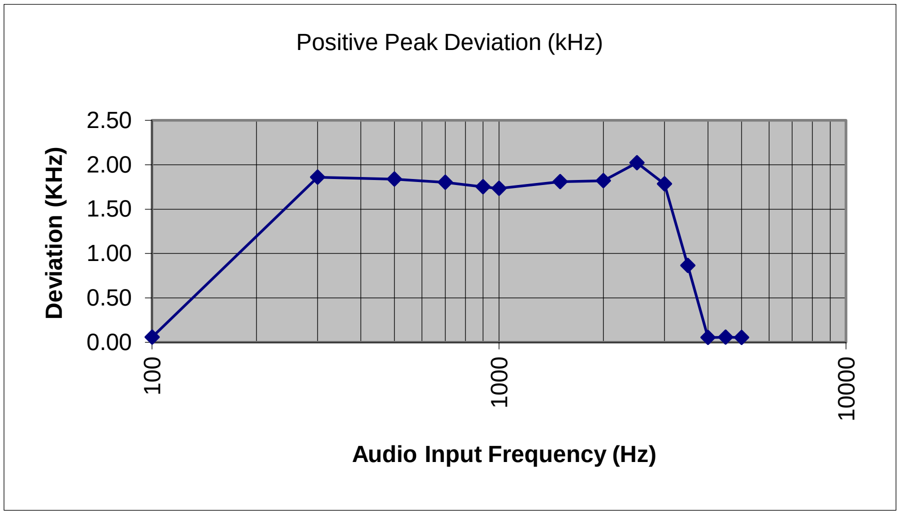
Measurement Procedure

The EUT was connected directly to a modulation analyzer through an attenuator.
The audio frequency was set to 1 kHz and the level was adjusted for 60% deviation according to the manufacturer's instructions. The input level was then set to 16 dB above the level used for 50 % modulation.
The audio source was tuned from 100 Hz to 5000 Hz and the audio frequency response was measured and plotted.
The modulation analyzer is a real time spectrum analyzer with integrated demodulation, audio measurement capabilities, and timing analysis.
The Modulation Limiting test data was recorded for 12.5 kHz and 25 kHz cannel bandwidth.

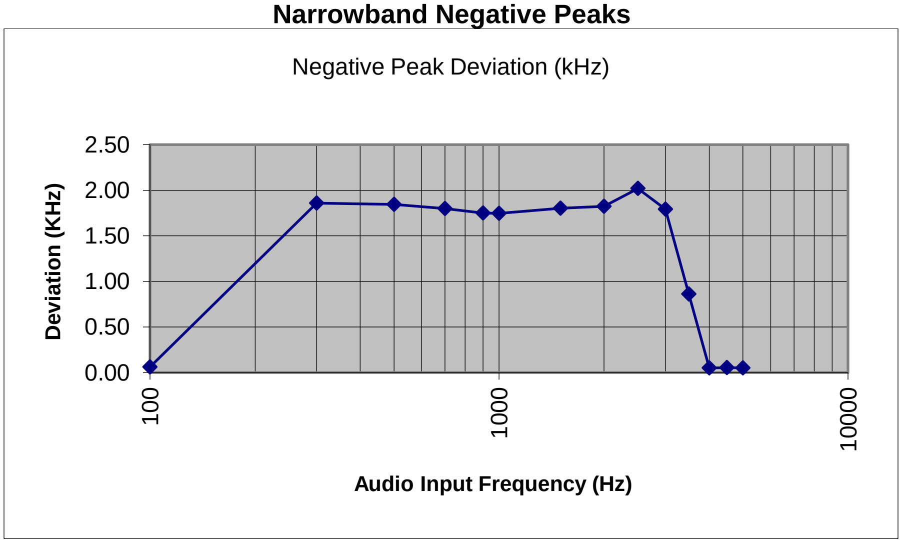
Test Setup



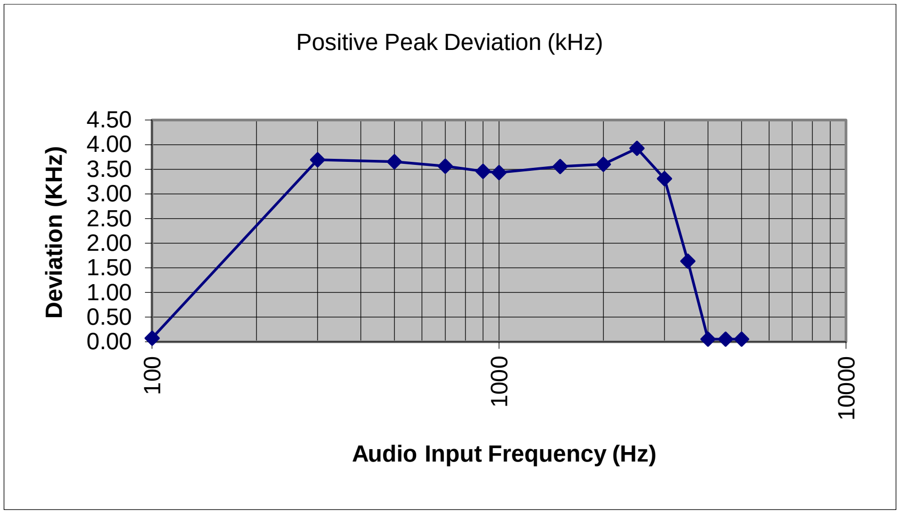
Narrowband Positive Peaks



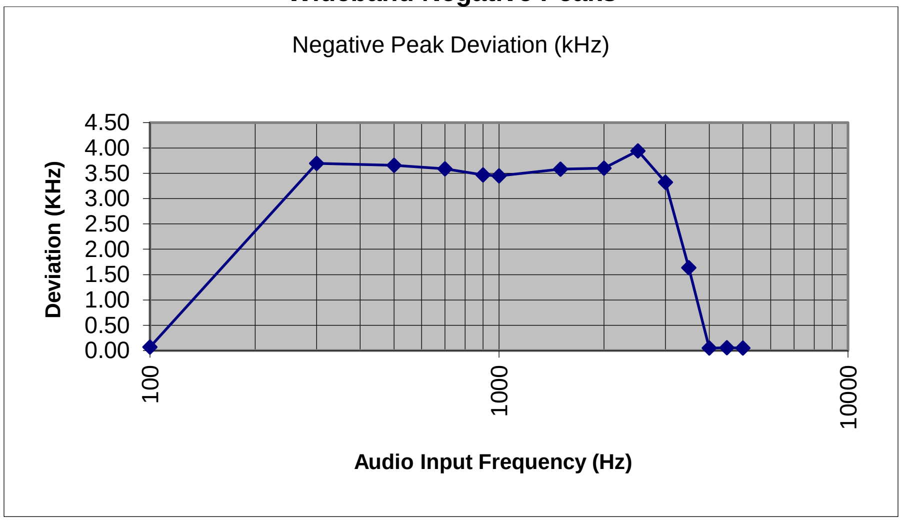
Narrowband Negative Peaks



Wideband Positive Peaks



Wideband Negative Peaks



Frequency Stability (Temperature Variation)

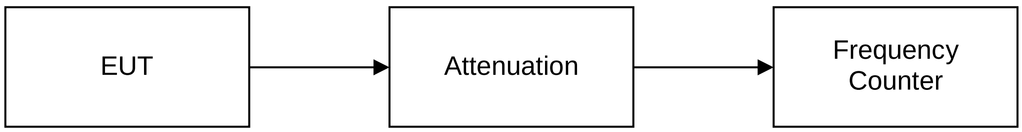
Engineer: Greg Corbin

Test Date: 9/12/2017

Measurement Procedure

The EUT was placed in an environmental test chamber and the RF output was connected directly to a spectrum analyzer. The temperature was varied from -30°C to 50°C in 10°C increments. After a sufficient time for temperature stabilization the RF output frequency was measured. At 20°C the power supply voltage to the EUT was varied from 85% to 115% of the nominal value and the RF output was measured.

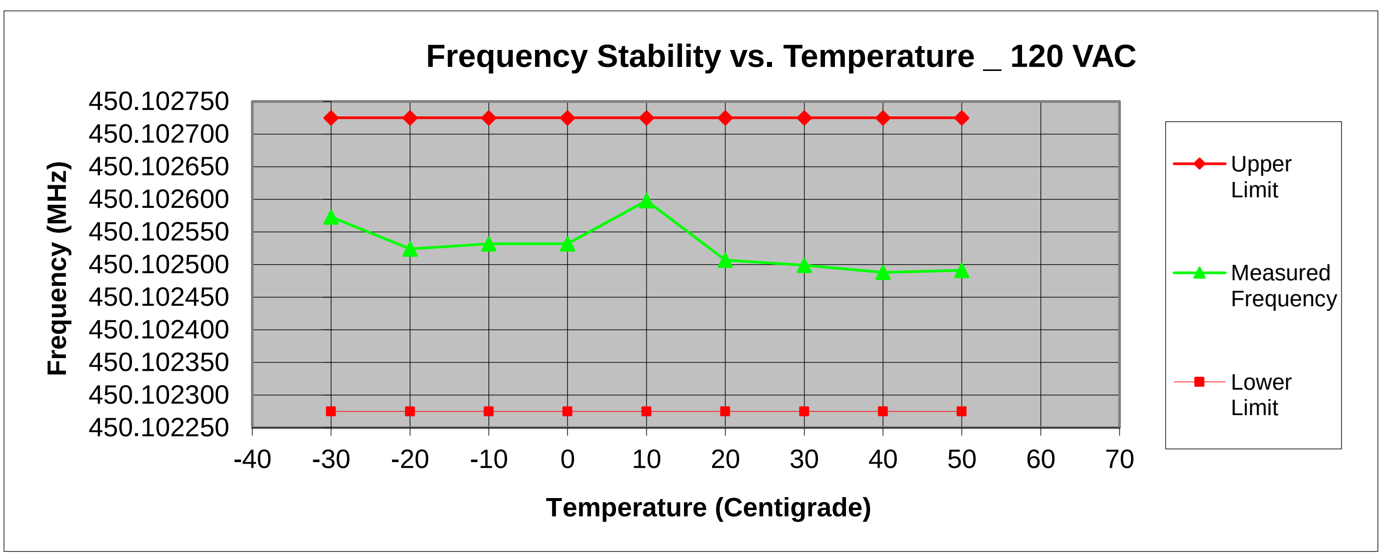
Measurement Setup



Measurement Results

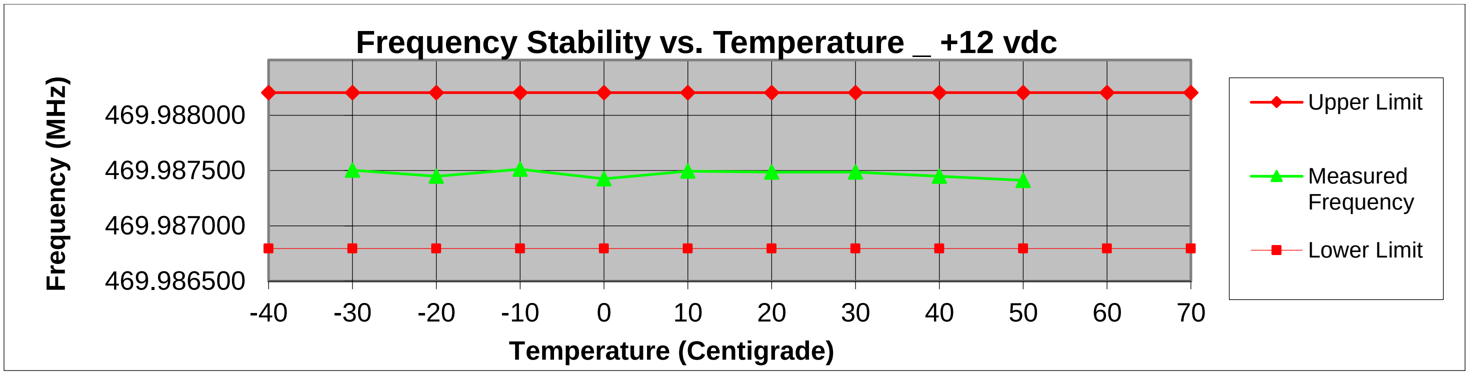
Frequency Stability vs. Temperature _120 VAC

Tuned Frequency (MHz)	Frequency Tolerance (PPM)	Temperature centigrade	Measured Frequency (MHz)	Upper Limit (MHz)	Lower Limit (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
450.1025	1.5	-30	450.102573	450.103175	450.101825	-0.000602	0.000748
450.1025	1.5	-20	450.102524	450.103175	450.101825	-0.000651	0.000699
450.1025	1.5	-10	450.102532	450.103175	450.101825	-0.000643	0.000707
450.1025	1.5	0	450.102532	450.103175	450.101825	-0.000643	0.000707
450.1025	1.5	10	450.102598	450.103175	450.101825	-0.000577	0.000773
450.1025	1.5	20	450.102507	450.103175	450.101825	-0.000668	0.000682
450.1025	1.5	30	450.102499	450.103175	450.101825	-0.000676	0.000674
450.1025	1.5	40	450.102488	450.103175	450.101825	-0.000687	0.000663
450.1025	1.5	50	450.102491	450.103175	450.101825	-0.000684	0.000666



Frequency Stability vs. Temperature_+ 12 VDC

Tuned Frequency (MHz)	Frequency Tolerance (PPM)	Temperature centigrade	Measured Frequency (MHz)	Upper Limit (MHz)	Lower Limit (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
469.9875	1.5	-30	469.987504	469.988205	469.986795	-0.000701	0.000709
469.9875	1.5	-20	469.987449	469.988205	469.986795	-0.000756	0.000654
469.9875	1.5	-10	469.987512	469.988205	469.986795	-0.000693	0.000717
469.9875	1.5	0	469.987425	469.988205	469.986795	-0.000780	0.000630
469.9875	1.5	10	469.987495	469.988205	469.986795	-0.000710	0.000700
469.9875	1.5	20	469.987487	469.988205	469.986795	-0.000718	0.000692
469.9875	1.5	30	469.987487	469.988205	469.986795	-0.000718	0.000692
469.9875	1.5	40	469.987450	469.988205	469.986795	-0.000755	0.000655
469.9875	1.5	50	469.987412	469.988205	469.986795	-0.000793	0.000617



Frequency Stability (Voltage Variation)

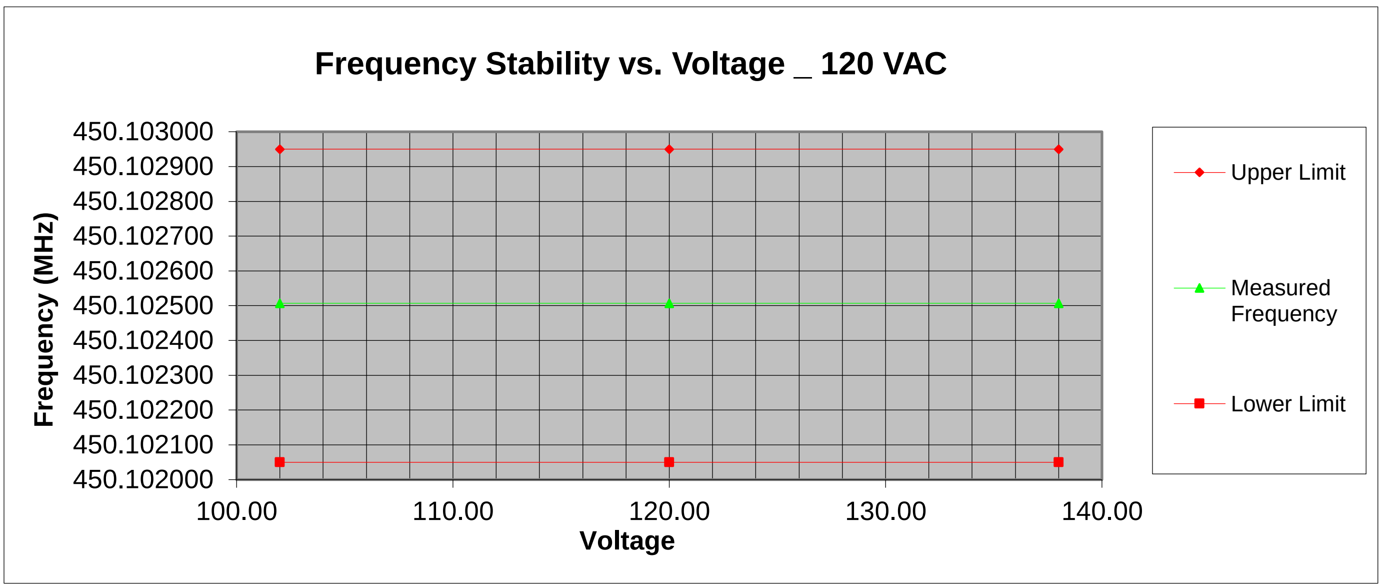
Engineer: Greg Corbin

Test Date: 12/17/2017

The EUT was placed in an environmental test chamber and the RF output was connected directly to a spectrum analyzer. At 20°C the power supply voltage to the EUT was varied from 85% to 115% of the nominal value and the RF output was measured.
Tests were performed for both 120 VAC and +12 VDC supply voltages.

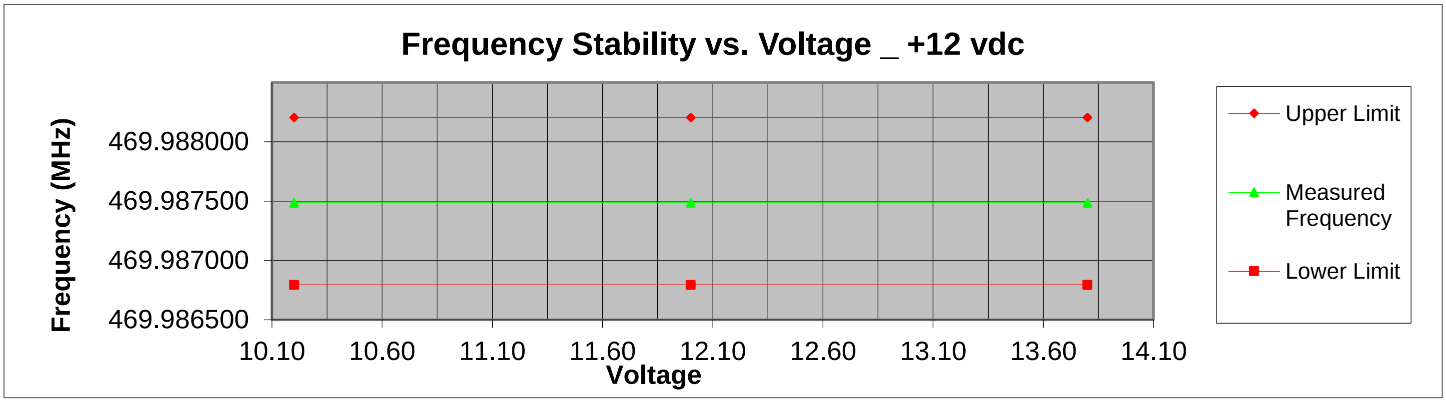
Frequency Stability vs. Voltage_120 VAC

Tuned Frequency (MHz)	Frequency Tolerance (PPM)	Upper Limit (MHz)	Lower Limit (MHz)	Nominal Voltage	Measured Voltage	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
450.1025	1.5	450.103175	450.101825	120.00	102.00	450.102507	-0.000668	0.000682
450.1025	1.5	450.103175	450.101825	120.00	120.00	450.102507	-0.000668	0.000682
450.1025	1.5	450.103175	450.101825	120.00	138.00	450.102507	-0.000668	0.000682



Frequency Stability vs. Voltage_+12 VDC

Tuned Frequency (MHz)	Frequency Tolerance (PPM)	Upper Limit (MHz)	Lower Limit (MHz)	Nominal Voltage	Measured Voltage	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
469.9875	1.5	469.988205	469.986795	12.00	10.20	469.987487	-0.000718	0.000692
469.9875	1.5	469.988205	469.986795	12.00	12.00	469.987487	-0.000718	0.000692
469.9875	1.5	469.988205	469.986795	12.00	13.80	469.987487	-0.000718	0.000692



Necessary Bandwidth Calculations
Engineer: Greg Corbin
Test Date: 10/10/2017

Modulation = 11K0F3E		
Necessary Bandwidth Calculation:		
Maximum Modulation (M), kHz	=	3
Maximum Deviation (D), kHz	=	2.5
Constant Factor (K)	=	1
Necessary Bandwidth (B_N), kHz	=	(2xM)+(2xDxK)
	=	11.0

Modulation = 16K0F3E		
Necessary Bandwidth Calculation:		
Maximum Modulation (M) kHz	=	3
Maximum Deviation (D), kHz	=	5
Constant Factor (K)	=	1
Necessary Bandwidth (B_N), kHz	=	(2xM)+(2xDxK)
	=	16.0

Modulation = 8K10F1E, 8K10F1W, 8K10F7D, 8K10F7E, 8K10F7W, 8K10F1D		
Necessary Bandwidth Calculation:		
Data Rate (R) Kbps	=	9.6
Maximum Deviation (D), kHz	=	3.111
Signaling States	=	4
Constant Factor (K)	=	0.531
Necessary Bandwidth (B_N), kHz	=	($R/\log_2 S$)+2DK
	=	8.1

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Horn Antenna	ARA	DRG-118/A	i00271	6/16/16	6/16/18
Humidity / Temp Meter	Newport	IBTHX-W-5	i00282	6/9/17	6/9/18
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	8/3/16	8/3/18
EMI Analyzer	Agilent	E7405A	i00379	2/22/17	2/22/18
Signal Generator	Rohde & Schwarz	SMU200A	i00405	5/5/17	5/5/18
Spectrum Analyzer	Textronix	RSA5126A	i00424	5/3/17	5/3/18
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	8/15/16	8/15/19
Signal Generator	Agilent	E4438C	i00457	10/19/16	10/19/18
Preamplifier for 1-18GHz horn antenna	Miteq	AFS44 00101 400 23-10P-44	i00509	N/A	N/A

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

END OF TEST REPORT