Test Report

Prepared for: Etherstack, Inc

Model: XBR5100T5V

Description: XBR Digital Base Station/Repeater P25 Phase 1

FCC ID:2ADAKXBR5100T5V

To

FCC_ Part 90

Date of Issue: October 5, 2023

On the behalf of the applicant:	**Etherstack Inc** **16 Madison Square W. FL12 Suite 1200** **New York, NY 10010**
Attention of:	**Doug Chapman** **Ph: (917) 258-6601** **E-Mail: dougc@etherstack.com**

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Project No: p2380009

Greg Corbin
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	10/5/2023	Greg Corbin	Original Document

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Table of Annexes

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Test Result Summary

FCC Specification	Test Name	Pass, Fail, N/A	Comments
2.1046 90.205(s)	Carrier Output Power (Conducted)	Pass	
2.1051 90.210 90.543(f)	Unwanted Emissions (Transmitter Conducted)	Pass	
2.1051 90.210	Field Strength of Spurious Radiation	Pass	
2.1049 90.210(b)(d)	Emission Masks	Pass	
2.1049(c)(1)	Occupied Bandwidth	Pass	
90.543(a)	Adjacent Channel Power	Pass	
2.1047(a)	Audio Low Pass Filter (Voice Input)	N/A	No analog modulation
2.1047(a)	Audio Frequency Response	N/A	No analog modulation
2.1047(a)	Modulation Limiting	N/A	No analog modulation
2.1055 90.213 90.539(c)	Frequency Stability (Temperature Variation)	Pass	
2.1055 90.213 90.539(c)	Frequency Stability (Voltage Variation)	Pass	
2.202	Necessary Bandwidth Calculation	Pass	

Statements of conformity are reported as:

- Pass - the measured value is below the acceptance limit, *acceptance limit = test limit*.
- Fail - the measured value is above the acceptance limit, *acceptance limit = test limit*.

ANAB

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to the joint ISO-ILAC-IAF Communiqué dated January 2009).

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

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

FCC Site Reg. #349717

IC Site Reg. #2044A-2

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, ANSI C63.26-2015, Part 90.

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 603C, 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)**
25.2 – 30.6	25.1 – 33.2	961.7 – 971.7

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

EUT Description
Model: XBR5100T5V
Description: XBR Digital Base Station / Repeater, P25 Phase 1
Firmware: 0.2.01_7
Serial Number: 230700002

Additional Information:
The EUT is a 100-watt digital base station / repeater transmitter using C4FM modulation operating in the 700, 800 MHz bands as noted in Table 1.
The transmitter consists of 2 units, a P25 channel controller (Model: P25CC) and a transmitter (model: XBR5100T5V). Both units are required for operation and are marketed as a single system.

Table 1 – Frequency Range, Modulation Type and Emission Designators

Frequency Range (MHz)	Test Frequency (MHz)	Modulation	Emission Designator
769 - 775	769.025 774.975	C4FM	8K10F1D 8K10F1E 8K10F1W
851 - 869	851.025 859.975 868.975	C4FM	8K10F1D 8K10F1E 8K10F1W

EUT Operation during Tests
The EUT requires 3 power supplies for operation.
The channel controller requires a 12.0 vdc.
The transmitter requires 13.8 vdc and 28 vdc.
The P25 channel Controller was used to set the transmitter parameters.
The output power was set to the maximum (100 watts) for all tests.

Accessories:				
Qty	**Description**	**Length**	**Model**	**S/N**
1	Dynabook MJ54/HV Laptop PC with P25CC controller software	N/A	TECRA A40-J	A6M1HVF8D515
1	Ethernet cable_ P25 CC to PC	3m	N/A	N/A
1	USB cable_ transmitter to PC	1m	N/A	N/A
1	Multi-pin cable_ P25 CC to transmitter	1m	N/A	N/A

Modifications: None

Carrier Output Power (Conducted)

Engineer: Greg Corbin

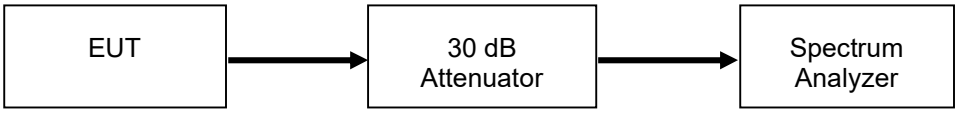
Test Date: 9/21/2023

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.
Output power was recorded in CW, C4FM modes of operation.
CW was measured with peak detector with max hold.
C4FM was measured using the Channel Power integration tool in the spectrum analyzer.

Manufacturer Rated Power = 100 watts (50 dBm)
FCC Output Power Limit = 120 w (20% of manufacturer rated power)

Test Setup



Transmitter Peak Output Power_ CW

Tuned Frequency	Output Power	Output Power	Result
MHz	(dBm)	(watts)	
769.025	50.50	112.2	Pass
774.975	50.54	113.2	Pass
851.025	50.64	115.9	Pass
859.975	50.66	116.4	Pass
868.975	50.61	115.1	Pass

Transmitter Peak Output Power_ C4FM

Tuned Frequency	Output Power	Output Power	Result
MHz	(dBm)	(watts)	
769.025	50.33	107.9	Pass
774.975	50.38	109.1	Pass
851.025	50.51	112.5	Pass
859.975	50.32	107.6	Pass
868.975	50.22	105.2	Pass

Conducted Spurious Emissions

Engineer: Greg Corbin

Test Date: 10/2/2023

Test Procedure

The EUT was connected directly to a spectrum analyzer to verify that the EUT met the requirements for spurious emissions. The resolution bandwidth was set for 100 kHz or 1 MHz as required per the rule section and the reference level was adjusted to ensure the system had sufficient dynamic range to measure spurious emissions.

A tunable notch filter was utilized for 30 MHz to 1 GHz to ensure the fundamental did not put the spectrum analyzer into compression.
The notch filter was replaced with a 1 GHz highpass filter that was used for measurements above 1 GHz.

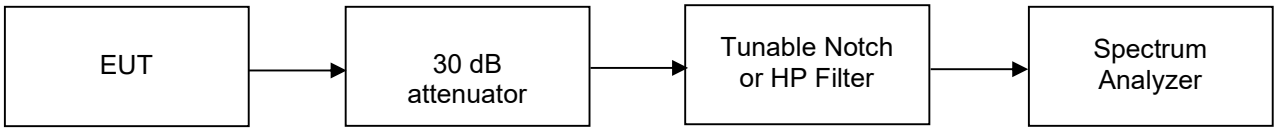
The frequency range from 30 MHz to the 10th harmonic of the fundamental transmitter was observed and plotted.

The conducted spurious emissions were recorded using C4FM modulation.

The specification limit was set for -20 dBm for comparison to the emission mask “D” limit.

Note: A marker was placed on the fundamental frequency and the highest spurious emission. Only the fundamental TX signal exceeded the limit as shown in the spectrum analyzer screenshots.

Test Setup



Conducted Spurious Emissions Summary Test Table_ C4FM

Tuned Frequency (MHz)	Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Specification Limit (dBm)	Result
769.025	3844.4	-33.4	-13	Pass
774.975	3875.4	-27.6	-13	Pass
851.025	774.67	-33.7	-20	Pass
859.975	7236.8	-35.8	-20	Pass
868.975	3476.3	-32.1	-20	Pass

Annex A Conducted Spurious Emission

Refer to Annex A for Conducted Spurious Emission plots.

Conducted Spurious Emissions (1559 – 1610 MHz)

Engineer: Greg Corbin

Test Date: 9/11/2023

Test Procedure

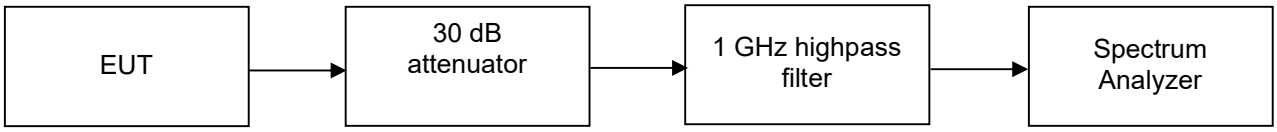
Conducted spurious test data was recorded for FCC part 90.543 (f) requirements.

90.543(f)_
For operations in the 758-775 MHz and 788-805 MHz bands, all emissions including harmonics in the band 1559-1610 MHz shall be limited to −70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and −80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth.

The EUT was connected directly to a spectrum analyzer to verify that the EUT met the requirements for spurious emissions.
A 1 GHz highpass filter was utilized as required to ensure the fundamental did not put the spectrum analyzer into compression.
The resolution bandwidth set for 700 Hz or 1 MHz as required per the rule section and the reference level was adjusted to ensure the system had sufficient dynamic range to measure spurious emissions.

The manufacturer does not provide an antenna.
The antenna gain of 0 dBi was used in the EIRP calculation for the Final value listed in the test results table.

Test Setup



768 - 776 MHz Band_ Narrowband Test Results

Spurious Frequency Range (MHz)	Tuned Frequency (MHz)	Modulation	Measured Frequency (MHz)	Measured Value (dBm)	Gain/Loss from Antenna Kitting Information (dBi)	Final Value EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)
1559 – 1610 (NB)	769.025	C4FM	1607.8	-83.9	0	-83.9	-50	-33.9
1559 – 1610 (NB)	774.975	C4FM	1588.0	-84.8	0	-84.8	-50	-34.8

768 - 776 MHz Band_ Wideband Test Results

Spurious Frequency Range (MHz)	Tuned Frequency (MHz)	Modulation	Measured Frequency (MHz)	Measured Value (dBm)	Gain/Loss from Antenna Kitting Information (dBi)	Final Value EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)
1559 – 1610 (WB)	769.025	C4FM	1576.8	-52.6	0	-52.6	-40	-12.6
1559 – 1610 (WB)	774.975	C4FM	1564.2	-52.7	0	-52.7	-40	-12.7

Annex A Conducted Spurious Emission

Refer to Annex A for Conducted Spurious Emission (1559 – 1610 MHz) plots.

Note: Conducted Spurious Emission (1559 – 1610 MHz) plots are included with Annex A.

Field Strength of Spurious Radiation

Engineer: Greg Corbin

Test Date: 10/2/2023

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.

The EUT was set to transmit at maximum power with the RF output terminated with a 200-watt 50 ohm load.

Radiated spurious emissions were recorded with the EUT using C4FM modulation.

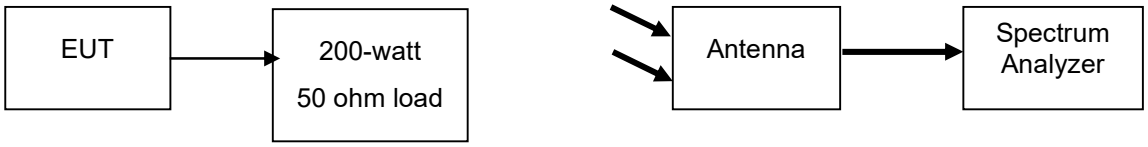
The RBW was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz.
The VBW was set to 3 times the RBW.

The following formula was used for calculating the limits:

For the 700 band the radiated spurious limit = P1 – (43+ 10Log(P2)) = -13dBm

For the 800 MHz band the radiated spurious limit = P1 – (50+ 10Log(P2)) = -20dBm

Test Setup



Radiated Spurious Emissions Summary Test Table_ C4FM

Tuned Frequency (MHz)	Spurious Frequency (MHz)	Measured Spurious Level (dBm)	Specification Limit (dBm)	Result
769.0250	3076.8	-35.5	-20	Pass
774.9750	3100.8	-35.2	-20	Pass
851.0250	1702.4	-30.0	-20	Pass
859.9750	4300.0	-41.7	-20	Pass
868.9750	1738.4	-24.7	-20	Pass

Annex B Radiated Spurious Emission

Refer to Annex B for Radiated Spurious Emission plots with C4FM modulation.

Emission Masks (Occupied Bandwidth)

Engineer: Greg Corbin

Test Date: 9/20/2023

Measurement 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.

For C4FM modulation the internal C4FM standard test pattern was used.

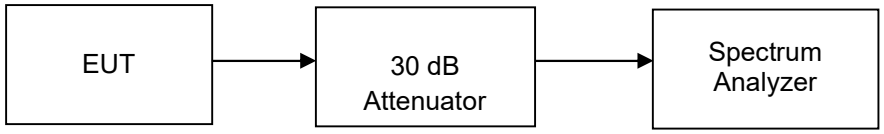
The -26 dB Occupied Bandwidth was recorded for each frequency with C4FM modulation.

Mask D and H was used for the 800 band.

Mask per FCC Part 90.691 was also recorded for the 800 band.

For the 700 band, the adjacent channel power was recorded. Refer to a separate section of the test report for Adjacent Channel Power data.

Test Setup



Annex C Emission Mask and Occupied Bandwidth

Refer to Annex C for Emission Mask and Occupied Bandwidth plots.

Adjacent Channel power

Engineer: Greg Corbin

Test Date: 9/21/2023

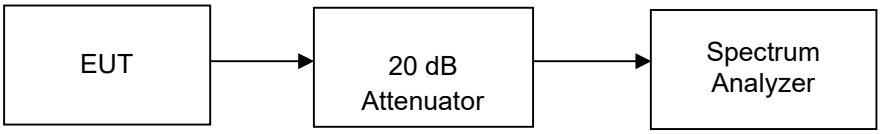
Measurement Procedure

The EUT was connected directly to a spectrum analyzer to verify that the EUT meets the required Adjacent Channel Power requirements for FCC Part 90.543.

For C4FM modulation the internal C4FM standard test pattern was used.

For the portion of the test (In the paired receive band) , a notch filter was used in order to achieve the 100 dB dynamic range required in the paired receive band.

Test Setup



Annex D Adjacent Channel Power

Refer to Annex D for Adjacent Channel Power plots with C4FM modulation.

Frequency Stability (Temperature Variation)

Engineer: Greg Corbin

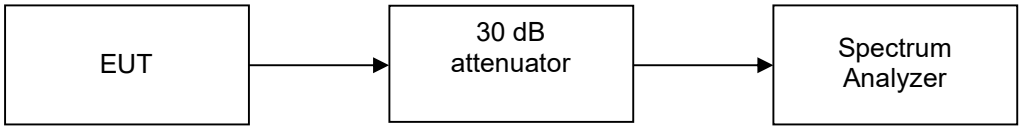
Test Date:9/15/2023

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.
The transmitter has 2 DC inputs, 13.8 vdc and 28 vdc. Both inputs were varied at the same time for the frequency stability vs voltage measured at 20 deg C.

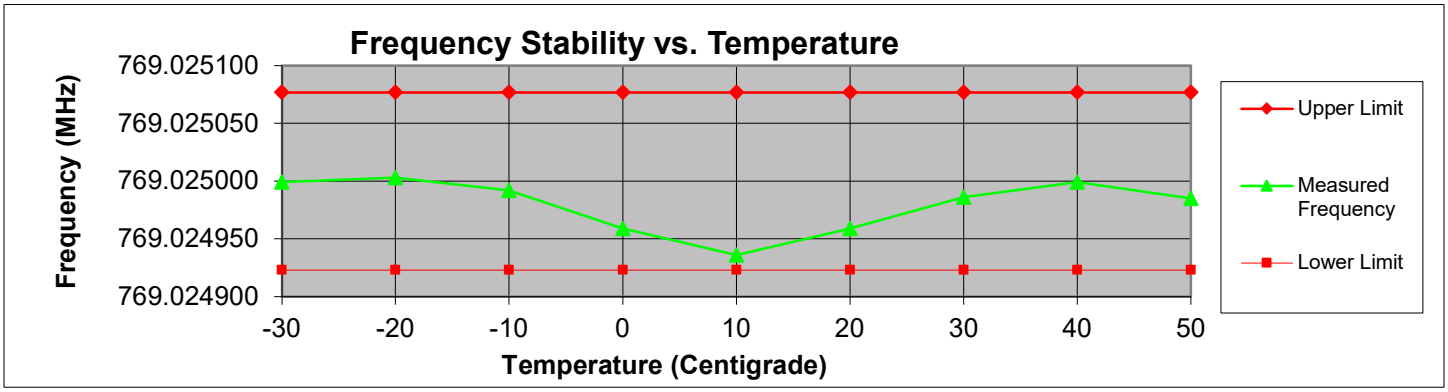
Frequency stability was recorded for the 700 MHz band and the 800 MHz band.

Measurement Setup



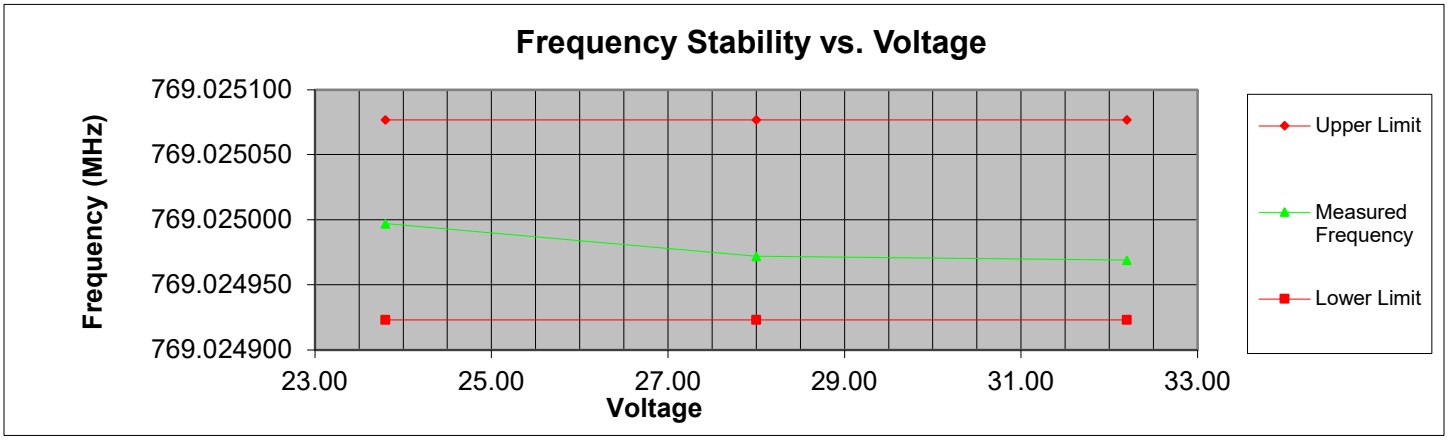
Frequency Stability vs Temperature _700 band

Tuned (MHz)	Temperature (deg C)	Tolerance (PPM)	Measured (MHz)	Upper (MHz)	Lower (MHz)	Upper (MHz)	Lower (MHz)
769.025	-30	0.1	769.025077	769.024923	769.024231	-0.000078	0.000076
769.025	-20	0.1	769.025077	769.024923	769.024231	-0.000074	0.000080
769.025	-10	0.1	769.025077	769.024923	769.024231	-0.000085	0.000069
769.025	0	0.1	769.025077	769.024923	769.024231	-0.000118	0.000036
769.025	10	0.1	769.025077	769.024923	769.024231	-0.000141	0.000013
769.025	20	0.1	769.025077	769.024923	769.024231	-0.000118	0.000036
769.025	30	0.1	769.025077	769.024923	769.024231	-0.000091	0.000063
769.025	40	0.1	769.025077	769.024923	769.024231	-0.000078	0.000076
769.025	50	0.1	769.025077	769.024923	769.024231	-0.000092	0.000062



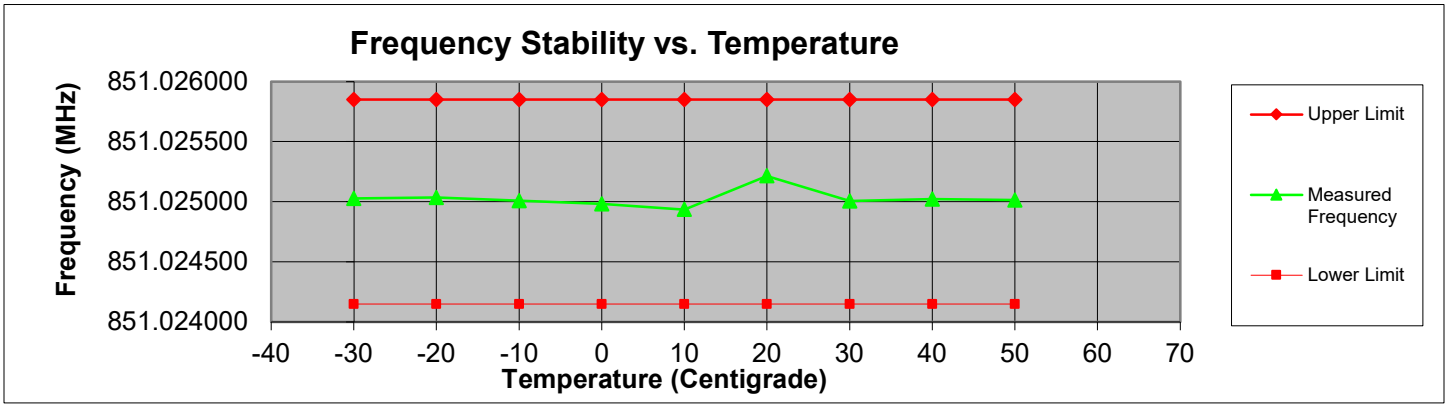
Frequency Stability vs Voltage_ 700 band

Tuned Frequency (MHz)	Tolerance (PPM)	Voltage (PPM)	Measured Frequency (MHz)	Upper Limit (MHz)	Lower Limit (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
769.025	0.1	23.80	769.024997	769.025077	769.024923	-0.000080	0.000074
769.025	0.1	28.00	769.024972	769.025077	769.024923	-0.000105	0.000049
769.025	0.1	32.20	769.024969	769.025077	769.024923	-0.000108	0.000046



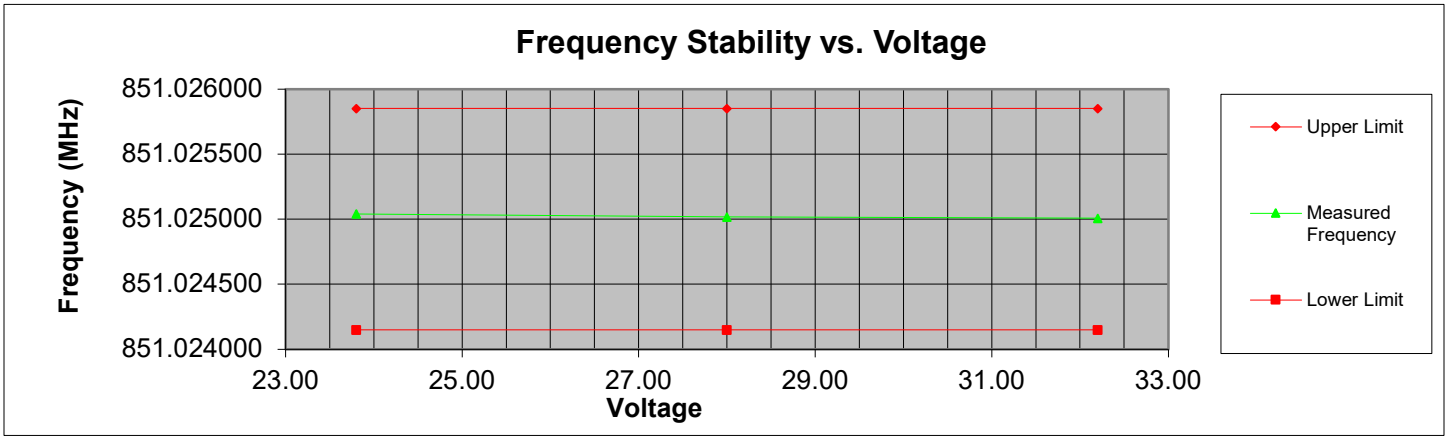
Frequency Stability vs Temperature _800 band

Tuned (MHz)	Temperature (deg C)	Tolerance (PPM)	Measured (MHz)	Upper (MHz)	Lower (MHz)	Upper (MHz)	Lower (MHz)
851.025	-30	1.0	851.025028	851.025851	851.024149	-0.000823	0.000879
851.025	-20	1.0	851.025035	851.025851	851.024149	-0.000816	0.000886
851.025	-10	1.0	851.025009	851.025851	851.024149	-0.000842	0.000860
851.025	0	1.0	851.024981	851.025851	851.024149	-0.000870	0.000832
851.025	10	1.0	851.024936	851.025851	851.024149	-0.000915	0.000787
851.025	20	1.0	851.025216	851.025851	851.024149	-0.000635	0.001067
851.025	30	1.0	851.025007	851.025851	851.024149	-0.000844	0.000858
851.025	40	1.0	851.025023	851.025851	851.024149	-0.000828	0.000874
851.025	50	1.0	851.025028	851.025851	851.024149	-0.000836	0.000866



Frequency Stability vs Voltage_ 800 band

Tuned Frequency (MHz)	Tolerance (PPM)	Voltage (PPM)	Measured Frequency (MHz)	Upper Limit (MHz)	Lower Limit (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
851.025	1.0	23.80	851.025041	851.025851	851.024149	-0.000810	0.000892
851.025	1.0	28.00	851.025016	851.025851	851.024149	-0.000835	0.000867
851.025	1.0	32.20	851.025008	851.025851	851.024149	-0.000843	0.000859



Necessary Bandwidth Calculations

Engineer: Greg Corbin

Test Date: 10/5/2023

Modulation = 8K10F1E		
Necessary Bandwidth Calculation:		
Maximum Modulation (M), kHz	=	1.55
Maximum Deviation (D), kHz	=	2.5
Constant Factor (K)	=	1
Necessary Bandwidth (B_N), kHz	=	(2xM)+(2xDxK)
	=	8.3

Modulation = 8K10F1D / 8K10F1W		
Necessary Bandwidth Calculation:		
Data Rate (R) Kbps	=	2.35
Maximum Deviation (D), kHz	=	2.5
Necessary Bandwidth (B_N), kHz	=	2.4D+1.0R
	=	8.3

Measurement Uncertainty

Measurement Uncertainty for Compliance Testing is listed in the table below.

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

Measurement Type	Expanded Uncertainty
Conducted Emissions, AC Powerline	± 3.28 dB
Radiated Emissions_30 – 1000 MHz	± 4.82 dB
Radiated Emissions_1 – 18 GHz	± 5.73 dB
Frequency Error	± 22 Hz
Conducted RF Power	± 0.98 dB
Conducted Spurious Emission	± 2.49 dB
AC Voltage	± 2.3 %
DC Voltage	± 0.12 %
Temperature	± 1.0 deg C
Humidity	± 4.32 %

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Tunable Notch Filter	Eagle	TNF-1-(250-850MHz)	i00124	Verified on: 10/2/23	
Horn Antenna	ARA	DRG-118/A	i00271	8/11/22	8/11/24
Temp./humidity/pressure monitor	Omega Engineering	iBTHX-W-5	i00686	1/5/23	1/5/24
Data Logger	Fluke	Hydra Data Bucket	i00343	6/28/23	6/28/24
Attenuator, 30 dB, 150W	Narda	769-30	i00347	Verified on: 9/21/23	
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	2/7/23	2/7/25
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	6/27/23	6/27/24
Highpass Filter (1 GHz)	K&L	7IH40-980/T6000-O/O	i00432	Verified on: 10/2/23	
Voltmeter	Fluke	179	i00488	6/19/23	6/19/24
MXE EMI receiver	Keysight	N9038A	i00552	2/23/23	2/23/24
Temperature Chamber	Thermotron	SE-1000-3-3	I00557	Verified on:9/15/23	
Attenuator, 20 dB, 50W	Mini-Circuits	BW- N20W50+	i00611	Verified on: 9/21/23	
Preamplifier	Eravant	SBB-0115034018-2F2F-E3	i00646	Verified on: 7/27/23	
Spectrum Analyzer	Agilent	PSA E4448A	i00688	11/9/22	11/9/23

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