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Test Report

Prepared for: Wilson Electronics, LLC

Model: Pro 140i

Description: Band 14 Industrial Signal Booster

Serial Number: 8000385 T

FCC ID: PWO074
ISED ID: 4762A-074

To

FCC Part 90
RSS-131 Issue 4 (December 16, 2022)

Date of Issue: 5/3/2023

On the behalf of the applicant:	**Wilson Electronics, LLC** **3301 E Deseret Drive** **St. George, UT 84790**
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Greg Corbin
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	5/5/2023	Greg Corbin	Original Document
2.0	6/6/2023	Greg Corbin	Updated antenna gain to include antenna cable loss on page 7 and 12 Updated AGC measurement using AWGN signal

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Test Result Summary

Specification		Test Name	Pass, Fail, N/A	Comments
FCC	ISED			
KDB 935210 D05 (4.2)	N/A	AGC Threshold	Pass	
KDB 935210-D05 (4.3)	RSS-131 (9.1)	Out of Band Rejection	Pass	
KDB 935210 D05 (4.5) 2.1046	RSS-131 (9.3)	Output Power (Conducted)	Pass	
KDB 935210 D05 (4.4) 90.210 2.1049	RSS-131 (9.2)	Input vs Output_ Occupied Bandwidth (Emission Masks)	Pass	
KDB 935210 D05 (4.7.3) 90.543(e)(f) 2.1051	RSS-140 (4.4)	Spurious Emissions (Transmitter Conducted)	Pass	
2.1053	N/A	Radiated Spurious Emissions	Pass	
KDB 935210-D05	N/A	Intermodulation	Pass	
90.219(e)(2)	N/A	Noise Figure	Pass	
90.213	RSS-131 (9.4)	Frequency Stability (Temperature Variation)	N/A	This EUT does not perform any frequency translation
90.213	RSS-131 (9.4)	Frequency Stability (Voltage Variation)	N/A	This EUT does not perform any frequency translation

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

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 Part 90.219, Part 2,ANSI C63.26-2015, KDB 935210 D05, RSS-131, RSS-140, RSS-GEN where appropriate.

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 specify 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 – 28.0	21.8 – 26.1	959.2 – 970.4

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

EUT Description
Model: Pro 140i
Description: Band 14 Industrial Signal Booster
Software: 4.8.1.12
Serial Number: 8000385 T
FVIN: 4600074
HVIN: 074
Host Marketing Name: 074

Additional Information:

The EUT is a single-band bi-directional amplifier for enhancing the range of cell phones and data communication devices (computers, PDAs, etc.) in in-building applications. The amplifier is connected to an external antenna mounted outside the building. An inside antenna is positioned within the building and connected to the amplifier. The inside antenna enables a wireless connection to host devices located inside the building.

The frequency band, modulation, emission designator and antenna gain is listed in the following table.

Per the user manual both the indoor and outdoor antenna have a 75 ft. LMR 400 Cable to be used for installation.

The cable loss has been included in calculating the antenna gain.

LMR 400 cable loss = 3.5 dB / 100 ft.

	Frequency (MHz)	Modulation	Emission Designators	Antenna Gain (dB)	75' Cable Loss (dB)	Net antenna gain (dB)
Downlink	788 - 798	LTE (FirstNet)	G7D	7.0	2.6	4.4
Uplink	758 - 768	LTE (FirstNet)	G7D	6.3	2.6	3.7

EUT Operation during Tests

The EUT was tested under normal operating conditions and was powered by a 120 VAC to DC power supply.

Accessories:

Qty	Description	Manufacturer	Model	S/N
1	AC adapter	EDAC Power	EA1024P2-120	N/A

Cables: None

Modifications: None

AGC Threshold

Engineer: Greg Corbin

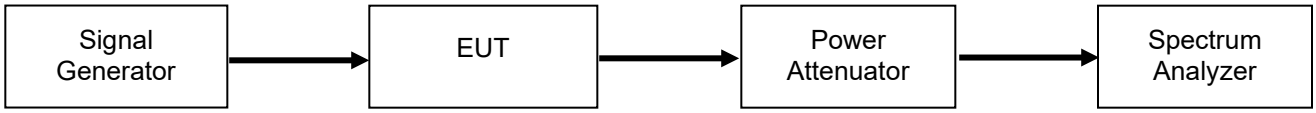
Test Date: 4/28/2023

Test Procedure

A signal generator producing a AWGN signal was connected to the input of the EUT. A spectrum analyzer was connected to the EUT in order to monitor the output power levels. The input power level was increased in 1 dB increments until the power no longer increased. The input levels were recorded in the table below.

Spectrum Analyzer settings
RBW = 1-5% of EBW
Video BW = 3x RBW

Test Setup



Mobile to Base

Tuned Frequency (MHz)	AGC Threshold (dBm)
793	-63

Base to Mobile

Tuned Frequency (MHz)	AGC Threshold (dBm)
763	-65

Out of Band Rejection

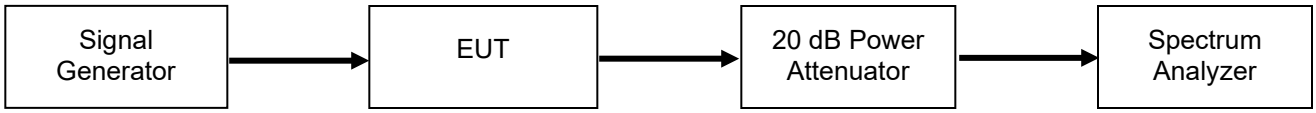
Engineer: Greg Corbin

Test Date: 4/28/2023

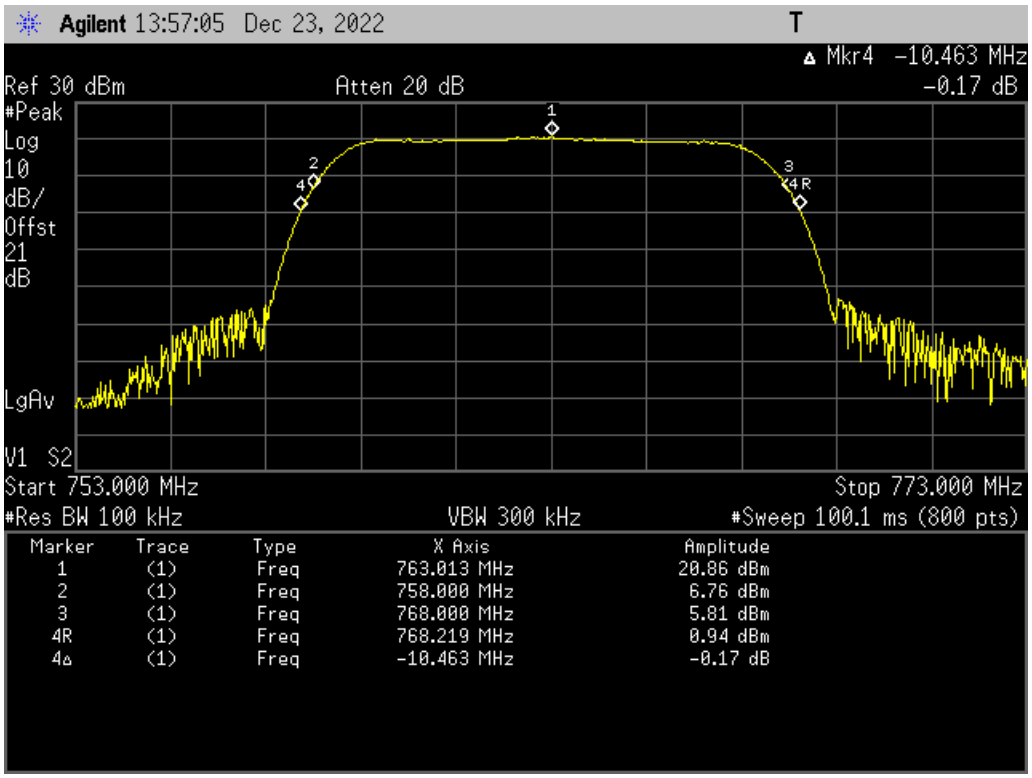
Test Procedure

The EUT was connected to a spectrum analyzer through a 20 dB power attenuator. A signal generator was utilized to produce a swept CW signal with the RF input level set to 3 dB below the AGC Threshold level. The Uplink and Downlink filter response and the -20 dB bandwidth were measured. The marker table function of the spectrum analyzer was used to show the peak amplitude in the passband and the -20 dB bandwidth of the pass band filter.
RBW = 100 KHz
Video BW = 3x RBW

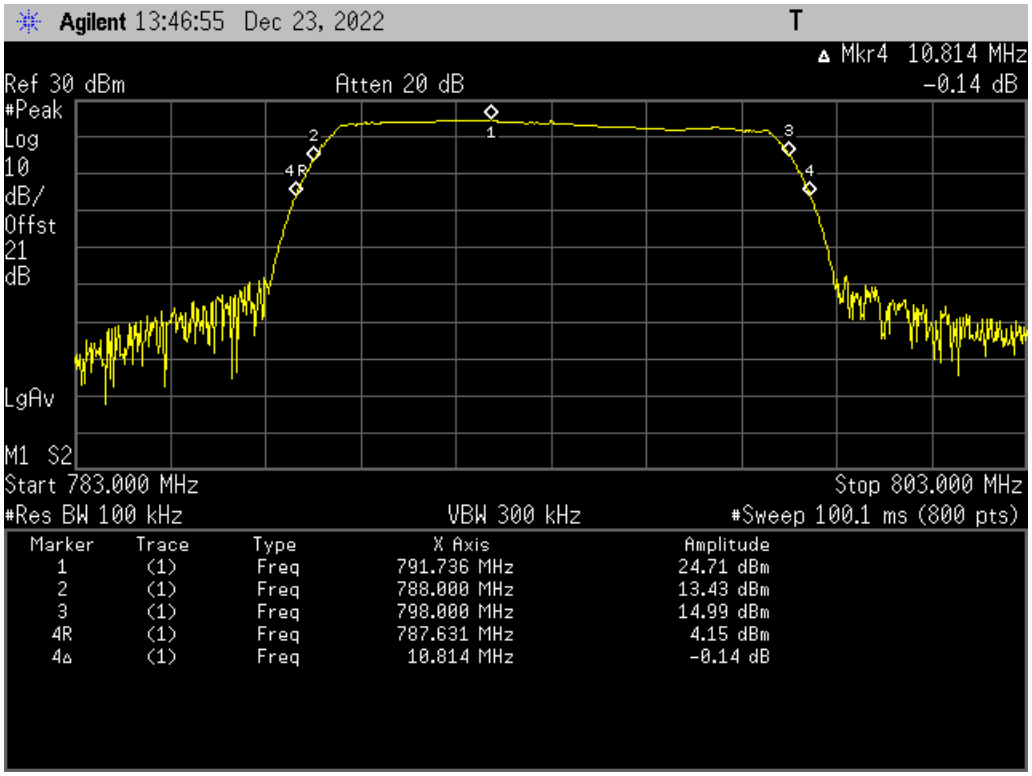
Test Setup



Out of Band Rejection_758 - 768 MHz



Out of Band Rejection_788 - 798 MHz



Conducted Output Power and Amplifier Gain

Engineer: Greg Corbin

Test Date: 4/28/2023

Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer through a 20 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.

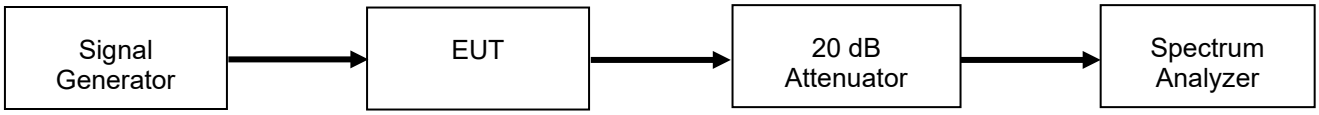
Since the signal booster is designed to pass broadband signals and the AGC circuitry responds better to a broadband signal, a 4.1 MHz wide AWGN test signal was used to measure the output power
The spectrum analyzer channel power tool was used to accurately measure the output power.

The test signal was set to the frequency of the peak amplitude measured in the Out of Band Rejection test.
The RF input signal level was set to 0.2 dB below the AGC Threshold.

The Input and Output power levels were recorded and the gain was calculated using the following formula:

Gain (dB) = Output Power (dBm) – Input Power (dBm)

Test Setup



Output Power and Gain Test Results

Tuned Frequency	Input Power (dBm)	Output Power (dBm)	Gain (dB)	Antenna Gain (dB)	EIRP	
MH	dBm	dBm	dB	dB	dBm	Watts
763.013	-64.9	25.7	90.6	3.7	29.4	0.871
791.736	-64.0	26.1	90.1	4.4	30.5	1.122

Conducted Spurious Emissions

Engineer: Greg Corbin

Test Date: 5/1/2023

Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer through a 20 dB Power attenuator. All cable and attenuator losses were input into the spectrum analyzer as a combination of reference level offset and correction factor as needed to ensure accurate readings were obtained.
A CW signal was utilized, set to the center frequency of the passband.
The RF input signal level was set to 0.2 dB below the AGC Threshold.

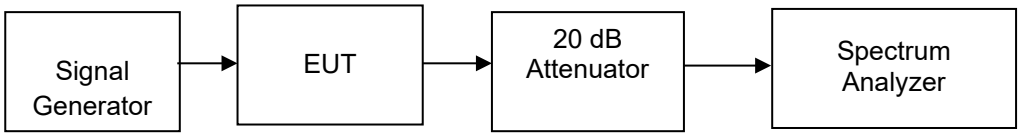
For the frequency ranges of 769 – 775 MHz, 775 – 788 MHz, 799 – 805 MHz the RBW was set to 6.25 kHz.
Outside of the frequency ranges listed above the RBW was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz
The VBW was set to 3 times the RBW.
The test was performed at the low, mid, high frequency of the passband.
The frequency range from 30 MHz to the 10th harmonic of the passband frequency was observed and plotted.

Signal Boosters using the 758 – 768 MHz, 788 – 798 MHz Bands need to meet the spurious emission requirements of FCC Part 90.543 (e)(f).

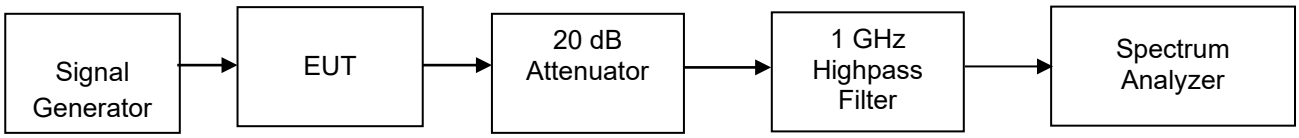
90.543
Transmitters operating in 758-768 MHz and 788-798 MHz bands must meet the emission limitations in (e) of this section.
90.543(e)
For operations in the 758-768 MHz and the 788-798 MHz bands, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following:
(1) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 76 + 10 log (P) dB in a 6.25 kHz band segment, for base and fixed stations.
(2) On all frequencies between 769-775 MHz and 799-805 MHz, by a factor not less than 65 + 10 log (P) dB in a 6.25 kHz band segment, for mobile and portable stations.
(3) On any frequency between 775-788 MHz, above 805 MHz, and below 758 MHz, by at least 43 + 10 log (P) dB.
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. For the purpose of equipment authorization, a transmitter shall be tested with an antenna that is representative of the type that will be used with the equipment in normal operation.

Conducted Spurious Emissions Limit
90.543(e)(1) = P1 – (76+ 10Log(P2)) = -46 dBm
90.543(e)(3) = P1 – (43+ 10Log(P2)) = -13 dBm
P1 = power in dBm
P2 = power in Watts

90.543(e) Test Setup



90.543(f) Test Setup



Conducted Spurious Emissions Test Results

90.543(e)(3)_30 MHz – 8 GHz

FCC Rule Section	Test Freq	Spurious Frequency	Spurious Level	Limit	Margin
	MHz	MHz	dBm	dBm	dB
90.543(e)(3)	758.5	7215.9	-35.4	-13	-22.4
90.543(e)(3)	763	7744.5	-34.4	-13	-21.4
90.543(e)(3)	767.5	7657	-35.2	-13	-22.2
90.543(e)(3)	788.5	7024.3	-34.5	-13	-21.5
90.543(e)(3)	793	7693	-35.1	-13	-22.1
90.543(e)(3)	797.5	7711	-35.3	-13	-22.3

90.543(e)(3)_ 775 – 788 MHz

Freq span	Test Freq	Spurious Frequency	Spurious Level	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
775 - 788	758.5	779.463	-73.6	-13	-60.6
775 - 788	763	775.286	-71.9	-13	-58.9
775 - 788	767.5	775.033	-67	-13	-54
775 - 788	788.5	787.987	-29.5	-13	-16.5
775 - 788	793	787.662	-51.6	-13	-38.6
775 - 788	797.5	787.971	-51.7	-13	-38.7

FCC 90.543(e)(1)_ 769 – 775 MHz and 799 – 805 MHz

Freq span	Test Freq	Spurious Frequency	Spurious Level	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
769 - 775	758.5	769.049	-66.6	-46	-20.6
769 - 775	763	769.115	-60.9	-46	-14.9
769 - 775	767.5	769.048	-51.6	-46	-5.6
769 - 775	788.5	773.850	-73.8	-46	-27.8
769 - 775	793	774.961	-73.9	-46	-27.9
769 - 775	797.5	772.092	-73.7	-46	-27.7
799 - 805	758.5	804.333	-73.9	-46	-27.9
799 - 805	763	804.713	-73.7	-46	-27.7
799 - 805	767.5	799.813	-73.5	-46	-27.5
799 - 805	788.5	801.993	-58.8	-46	-12.8
799 - 805	793	799.148	-58.4	-46	-12.4
799 - 805	797.5	799.018	-48.9	-46	-2.9

FCC 90.543(f)_ 1559 – 1610 MHz

RBW	Test Freq	Spurious Frequency	Spurious Level	Antenna Gain	EIRP Spurious Level	EIRP Limit	Margin
	MHz	MHz	dBm	dB	dBm	dBm	dB
1 MHz	758.5	1591.045	-79.8	7	-72.8	-40	-32.8
1 MHz	763	1587.73	-78.8	7	-71.8	-40	-31.8
1 MHz	767.5	1586.2	-79.7	7	-72.7	-40	-32.7
1 MHz	788.5	1583.055	-78.9	6.3	-72.6	-40	-32.6
1 MHz	793	1581.1	-78.8	6.3	-72.5	-40	-32.5
1 MHz	797.5	1607.195	-79.6	6.3	-73.3	-40	-33.3
700 Hz	758.5	1609.405	-111	7	-104	-50	-54
700 Hz	763	1601.84	-111.9	7	-104.9	-50	-54.9
700 Hz	767.5	1599.97	-111.6	7	-104.6	-50	-54.6
700 Hz	788.5	1595.32	-111.7	6.3	-105.4	-50	-55.4
700 Hz	793	1586.03	-104.2	6.3	-97.9	-50	-47.9
700 Hz	797.5	1593.685	-110.9	6.3	-104.6	-50	-54.6

Annex A Conducted Spurious Emissions

Refer to Annex A for Conducted Spurious Emissions Plots

Radiated Spurious Emissions

Engineer: Greg Corbin

Test Date: 5/1/2023

Test Procedure

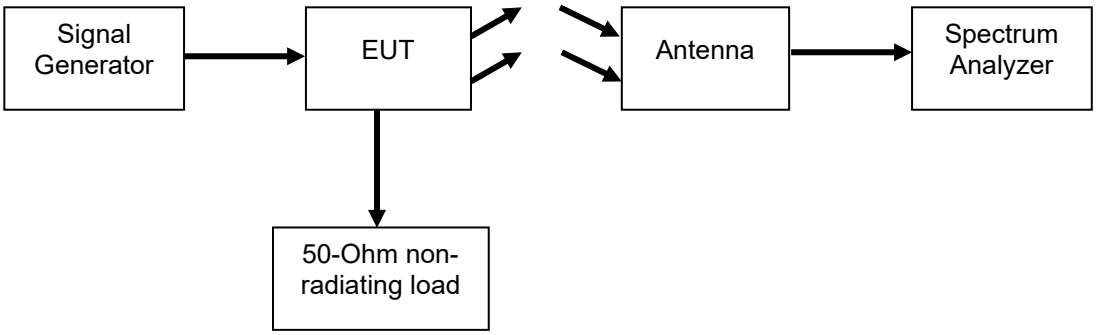
The EUT was tested in a semi-anechoic chamber with the turntable set 3m from the receiving antenna. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360 degrees with the antenna in both the vertical and horizontal orientation 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. A signal generator was used to provide a CW signal. 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 = P1 – (43+ 10Log(P2)) = -13dBm
P1 = power in dBm
P2 = power in Watts

Test Setup



Test Results

Test Freq	Spurious Frequency	Spurious Level	Limit	Margin
MHz	MHz	dBm	dBm	dB
758	7261.8	-49.9	-13	-36.9
763	7144.6	-49.3	-13	-36.3
768	7762.7	-49.4	-13	-36.4
788	7372.8	-49.9	-13	-36.9
793	7477.4	-49.2	-13	-36.2
798	6963.9	-49.7	-13	-36.7

Annex B Radiated Spurious Emissions

Refer to Annex B for the Radiated Spurious Emissions Plots

Input vs Output, Occupied Bandwidth (Emission Masks)

Engineer: Greg Corbin

Test Date: 5/2/2023

Test Procedure

Due to the broadband nature of the signals used the emission mask per 90.210 does not apply. The emission requirements are listed in FCC 90.543(e)(f). Refer to the Conducted Emissions section of this report for 90.543(e)(f) test results.
This section lists the Occupied Bandwidth test results.

This test was performed at the center frequency of the band.
A 4.1 MHz AWGN signal was used for the Input vs Output test.
The input signal 26 dB BW was recorded and compared to the output signal 26 dB BW.
The input and output was tested at 0.2 dB below the AGC Threshold and +3 dB above the AGC Threshold.

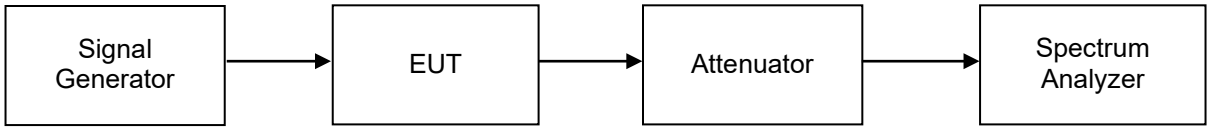
The Output Signal BW = 26 dB BW

The specification is that the Occupied BW cannot vary by more than 5% when compared to the input.

% change =100 – ((Input BW x 100)/Output BW))

Limit = < 5%

Test Setup



Input vs Output at 0.2 dB below AGC Threshold

Test Freq	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz	MHz	%	%	
763	4.864	4.837	0.56	< 5	Pass
793	4.901	4.868	0.68	< 5	Pass

Input vs Output at +3.0 dB above AGC Threshold

Test Freq	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz	MHz	%	%	
763	4.864	4.856	0.16	< 5	Pass
793	4.901	4.862	0.80	< 5	Pass

Annex C Input vs Output

Refer to Annex C for Input vs Output plots

Intermodulation

Engineer: Greg Corbin

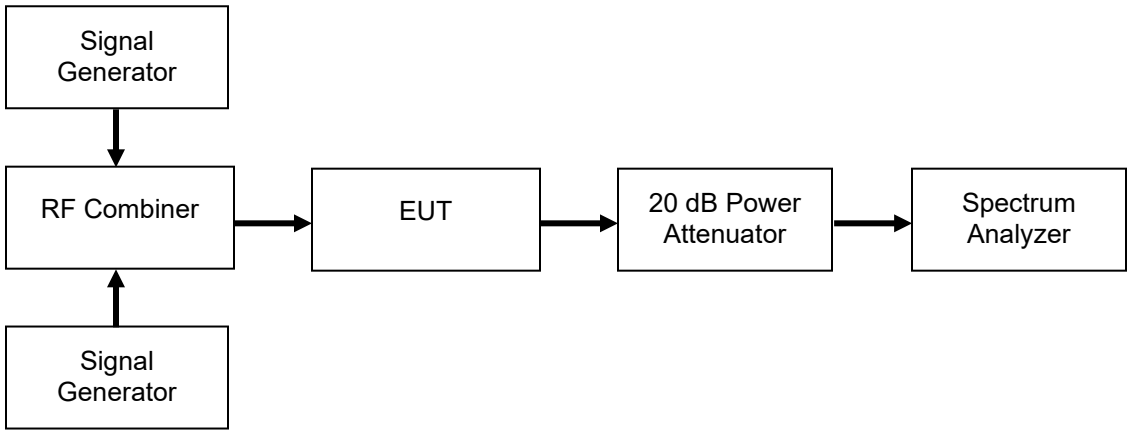
Test Date: 5/2/2023

Test Procedure

This booster is exempt from the intermodulation test.
It uses a 10 MHz wide LTE signal.
Per KDB 935210 D05,
4.7 Measuring out-of-band/out-of-block (including intermodulation) and spurious emissions
4.7.1 General
NOTE—Intermodulation-product spurious emission measurements are not required for single-channel boosters that cannot accommodate two simultaneous signals within the passband.

The Booster is designed to pass 10 MHz wide broadband signals, testing intermodulation using CW signals is not appropriate.
Intermodulation was performed using 2 each, 4.1 MHz WCDMA test signals to simulate 2 broadband signals within the 10 MHz passband.
RBW was set to 100 kHz in order to view the signals properly.
VBW = 300 kHz
The input power level of each signal was set so the output was within 0.2 dB of the AGC threshold using the channel power tool on the spectrum analyzer.
The test was repeated with the input power increased 3 dB above the previous setting.

Test Setup



Input vs Output at 0.2 dB below AGC Threshold

Band	Test Frequencies		Intermodulation Frequency	Intermodulation Amplitude	Limit	Margin
MHz	MHz	MHz	MHz	dBm	dBm`	dB
758 - 768	760	766	772	-41.0	-13	- 28
788 - 798	790	796	772	-40.3	-13	-27.3

Input vs Output at +3.0 dB above AGC Threshold

Band	Test Frequencies		Intermodulation Frequency	Intermodulation Amplitude	Limit	Margin
MHz	MHz	MHz	MHz	dBm	dBm`	dB
758 - 768	760	766	802.0	-36.6	-13	-23.6
788 - 798	790	796	801.487	-26.2	-13	-13.2

Annex D Intermodulation

Refer to Annex D for Intermodulation plots

Noise Figure Test

Engineer: Greg Corbin

Test Date: 5/2/2023

Test Procedure

The test equipment was connected as shown in the test setup.

THe AGC circuitry was dis-abled for the noise figure test.

The noise figure was measured at the passband center frequency.

Frequency (MHz)	Noise Figure (dB)	Limit (dB)	Margin (dB)
763	2.5	9	- 6.5
793	2.4	9	-6.6

Measurement Uncertainty

Measurement Uncertainty (U_{lab}) for Compliance Testing is listed in the table below.

Measurement	U_{lab}
Radio Frequency	± 3.3 x 10^{-8}
RF Power, conducted	± 1.5 dB
RF Power Density, conducted	± 1.0 dB
Conducted Emissions	± 1.8 dB
Radiated Emissions	± 4.5 dB
Temperature	± 1.5 deg C
Humidity	± 4.3 %
DC voltage	± 0.20 VDC
AC Voltage	± 1.2 VAC

The reported expanded uncertainty +/- U_{lab}(dB) has been estimated at a 95% confidence level (k=2)

U_{lab} is less than or equal to U_{ETSI} therefore

- Compliance is deemed to occur if no measured disturbance exceeds the disturbance limit
- Non-Compliance is deemed to occur if any measured disturbance exceeds the disturbance limit

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Bi-Log Antenna	Chase	CBL6111C	i00267	8/10/22	8/10/24
Horn Antenna	ARA	DRG-118/A	i00271	8/11/22	8/11/24
Vector Signal Generator	Agilent	E4438C	i00348	6/14/22	6/14/23
Signal Generator	Rohde & Schwarz	SMU200A	i00405	1/25/23	1/025/24
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	7/17/20	7/17/23
Highpass Filter (1 GHz)	K&L	7IH40-980/T6000-O/O	i00432	Verified on: 4/28/23	
Noise Figure Meter	Hewlett Packard	8970B	i00444	3/3/22	3/3/24
Noise Source	Hewlett Packard	346A	i00445	3/2/22	3/2/24
PSA Spectrum Analyzer	Agilent	E4445A	i00471	12/29/22	12/29/23
Voltmeter	Fluke	179	i00488	6/8/22	6/8/23
MXE EMI receiver	Keysight	N9038A	i00552	2/23/23	2/23/24
Attenuator, 20 dB, 5W	Mini-Circuits	BW- S20W5+	N/A	Verified on: 4/28/23	
Preamplifier	Eravant	SBB-0115034018-2F2F-E3	i00650	Verified on: 5/1/23	

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