Test Report

Prepared for: RF Industries Pty Ltd

Model: DSPbR Edge

Description: Channelized Bidirectional Repeater

FCC ID: YK7040004901CXXXM
ISED ID:31365-DEDGE400490

To

FCC Part 90
FCC Part 22
RSS-131 Issue 4 (December 16, 2022)

Date of Issue: October 27, 2023

On the behalf of the applicant:	**RF Industries Pty Ltd** **99 Station Road** **Seven Hills, New South Wales 2147** **Australia**
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Project No: p2380005

Greg Corbin
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	10/27/2023	Greg Corbin	Original Document
2.0	1/4/2024	Greg Corbin	Corrected low band duplexer freq, page 8 table 4. Changed Part 22 test frequency and updated test data for Part 22 throughout the report. Added C63.26 test method references to test summary table Updated Annex A, C, E with part 22 test data Added the ISED ID for the cellular module to page 6

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Table of Annexes

Test Result Summary

Specification		Test Name	Pass, Fail, N/A	Comments
FCC	ISED			
KDB 935210 D05 (4.2) C63.26 (7.2.3.1 a)	N/A	AGC Threshold	Pass	
KDB 935210-D05 (4.3) C63.26 (7.2.3.2)	RSS-131 (9.1)	Out of Band Rejection	Pass	
90.219 (e)(1) 2.1046 KDB 935210 D05 (4.5) C63.26 (7.2.3.4)	RSS-131 (9.3, 10.2)	Output Power (Conducted)	Pass	
90.219 (e)(4)(ii) 90.210 2.1049 KDB 935210 D05 (4.4) C63.26 (7.2.3.3)	RSS-131 (9.2)	Input vs Output_ Occupied Bandwidth (Emission Masks)	Pass	
90.219 (e)(3) 90.219 (e)(4)(iii) 2.1051 KDB 935210 D05 (4.7.3) C63.26 (7.2.3.7)	RSS-131 (10.5)	Spurious Emissions (Transmitter Conducted)	Pass	
2.1053 KDB 935210 D05 (4.9) C63.26 (7.2.3.9)	N/A	Radiated Spurious Emissions	Pass	
90.219 (e)(3) KDB 935210-D05 (4.7) C63.26 (7.2.3.6)	RSS-131 (10.3)	Intermodulation	Pass	
90.219(e)(2) KDB 935210-D05 (4.6) C63.26 (7.2.3.5)	RSS-131 (10.4)	Noise Figure	Pass	
N/A	RSS-131 (10.4)	Noise Limits	Pass	
90.219 (e)(4)(i) 90.213 KDB 935210-D05 (4.8) C63.26 (7.2.3.8)	RSS-131 (9.4)	Frequency Stability (Temperature Variation)	Pass	
90.219 (e)(4)(i) 90.213 KDB 935210-D05 (4.8) C63.26 (7.2.3.8)	RSS-131 (9.4)	Frequency Stability (Voltage Variation)	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 Part 90.219, Part 2, ANSI C63.26-2015, KDB 935210 D05, RSS-131, 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 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)**
24.9 – 31.0	25.9 – 43.0	961.7 – 974.6

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

EUT Description
Model: DSPbR Edge
Description: Channelized Bidirectional Repeater
Serial Number: ESY23089108, ESY23079202
Software:4.9.4
HVIN: DEDGE400490
PMN: DSPbR EDGE
UPN: DEDGE400490

Additional Information:

The EUT is a channelized bidirectional industrial signal booster / repeater.
The EUT is controlled by a webserver GUI.
The EUT has a pre-certified cellular modem installed for remote access.
The cellular modem FCC ID is XPYTOBYL280.
The cellular modem ISED ID is 8595A-TOBYL280.
The modem has singular module approval for Bands 2,5,7.
The modem was connected over the air to a basestation simulator during the radiated emissions testing. See the radiated emissions section of this report for more details.
The EUT can provide up to 8 channels with the output power limited to +36 dBm composite output power. The output power is limited in software per the number of channels selected as shown in Table 1.
Since the EUT can perform frequency translation in repeater mode, Frequency Stability was recorded.
The EUT ports are labeled Service and Donor are referred to as Server and Donor throughout this report.
The EUT was powered by 120 vac 60 Hz for all tests.

Table 1 - # of Channels and Maximum Output Power

# of channels	Maximum Power dBm
1	+36
2	+33
4	+30
8	+27

Table 2 - EUT frequency range and emission designators

Regulation	Frequency Range MHz	Modulation	Emission Designators
FCC Part 90	450 – 490	FM, C4FM, TDMA H-CPM, TDMA H-DQPSK	F1D, F1E, F3E, FXE, F1W, G1E, G1D, D7E, D7W, D7D, D1E, D1W, F9W
FCC Part 22.561 (repeater mode)	Base - 454.025 – 454.650 Mobile – 459.025 – 459.650	FM, C4FM, TDMA H-CPM, TDMA H-DQPSK	
ISED	450 – 470	FM, C4FM, TDMA H-CPM, TDMA H-DQPSK	

For tests using TDMA modulations, for Server to Donor port testing TDMA H-CPM modulation was used. For Donor to Server port testing, TDMA H-DQPSK was used.

Internal passive duplexers limit frequencies to within the 450-470MHz and 470-490 MHz frequency ranges, which is the only difference in the EUT P/N.
1. EUT # 1 – P/N: DE-4547-0001-AC, 450-470MHz
2. EUT # 2 – P/N: DE-4749-0001-AC, 470-490 MHz

The EUT incorporates 2 types of filtering (Duplexers and DSP filtering) to limit the passband response and provide out of band rejection.
The EUT incorporates duplexers to limit the frequency range to a small section of the passband.
Refer to the Out of Band section of this report for duplexer test data.
The EUT DSP configurable filters limit the signal to a configured channel bandwidth.
For all tests except noise figure, the DSP filter was set to P25P1_12K5 (12.5 kHz BW).
For the noise figure test the filter bandwidth needed to be increased from 12.5 kHz to 25 kHz.
The DSP filter used for noise figure was P25P1_25K.

Since the duplexers limit the passband to a subset of the full band, testing was performed with the duplexers removed and then repeated with the duplexers installed.
The exact configuration used for each test is described in each test section in this report.
2 sets of duplexers were provided for testing. 1 set for the low band (450 – 470 MHz) and 1 set for the high band (470 – 490 MHz).
The manufacturer lists 2 bands to cover the frequency range of 450 – 490 MHz.
For FCC Part 90 testing the frequency range was treated as 1 band, 450 – 490 MHz.
For FCC Part 22 testing, the frequency range was limited to the frequency range listed in Table 2.
For ISED the frequency range is limited to 450 - 470 MHz.

Most tests require the signal to be measured at center frequency (Fc) or the peak of the passband determined by the out of band test.
The out of band test cannot be performed due to the DSP filtering limiting the passband to 1 channel width.
For this reason, all tests were performed at Fc for Booster mode and the following selected frequencies for Repeater mode.
For Part 22,the duplexer passband frequency was outside the frequency range allowed for Part 22, so the tests for Part 22 were performed without the duplexers installed
For the 470 – 490 MHz test data, the testing was only performed with the duplexers installed.
The test data recorded at 459.975 without the duplexer meets the requirements for testing at center frequency for the 450 – 470 MHz band for ISED.
The test data recorded at 469.975 without the duplexer meets the requirements for testing at center frequency for the 450 – 490 MHz band for the FCC.
If the test requirements are different for the FCC and ISED, the test data is marked “for FCC and ISED” or “FCC only).

Table 3 - Test Frequencies without duplexer

Agency	Freq Band MHz	Booster mode		Repeater Mode			
		Server	Donor	Server to Donor		Donor to Server	
				Server	Donor	Donor	Server
ISED	450 – 470	459.975	459.975	450.025	459.975	450.025	459.975
FCC Part 90	450 – 490	469.975	469.975	450.025	469.975	450.025	469.975
FCC Part 22	Base - 454.025 – 454.650 Mobile – 459.025 – 459.650	N/A	N/A	459.350	454.350	454.350	459.350

Table 4 - Test Frequencies with duplexer

Agency	Duplexer	Specified Duplexer BW MHz	Measured Duplexer 1 dB BW MHz	Booster mode		Repeater Mode			
				Server	Donor	Server to Donor		Donor to Server	
						Server	Donor	Donor	Server
FCC and ISED	Low Band Duplexer	(Low) 449 - 454	448.25 – 454.81	451.5	451.5	450.025	453.975	457.025	461.975
		(High) 457 – 462	456.625 – 462.562	459.975	459.975				
FCC Only	High Band Duplexer	(Low) 474 – 479	471.906 – 479.781	476.5	476.5	474.025	478.975	483.5	487.5
		(High) 483 – 488	482.513 – 488.437	485.5	485.5				
Note: Duplexers passbands were measured, and test frequencies were selected for operation within the measured passbands. Filter responses are included in this test report.									

Accessories: None

Cables:

Qty	Description	Length (m)	From	To
1	AC Power Cable	2	TECRA A40-J	A6M1HVF8D515
1	Ethernet cable_ P25 CC to PC	2	N/A	N/A
1	Alarm cable, multi-pin	>3	EUT	Client equipment

Modifications: None

AGC Threshold

Engineer: Greg Corbin

Test Date: 9/18/2023

Test Procedure

A signal generator producing a CW signal was connected to the input of the EUT.
A spectrum analyzer was connected to the EUT 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.
Per KDB 935210 D05 section 4.2, the AGC threshold was repeated for each type of modulation (C4FM, TDMA).
The AGC level was recorded with and without the duplexers installed for CW, C4FM, TDMA modulations.

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

Test Setup

450 – 470 MHz (FCC and ISED)
Booster without Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
459.975	459.975	CW	-64.0	459.975	459.975	CW	-64.1
459.975	459.975	C4FM	-64.0	459.975	459.975	C4FM	-64.5
459.975	459.975	TDMA	-64.5	459.975	459.975	TDMA	-64.5
469.975	469.975	CW	-64.1	469.975	469.975	CW	-64.2
469.975	469.975	C4FM	-63.5	469.975	469.975	C4FM	-64.0
469.975	469.975	TDMA	-63	469.975	469.975	TDMA	-64.0

Repeater without Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
450.025	459.975	CW	-63.7	450.025	459.975	CW	-63.7
450.025	459.975	C4FM	-63.5	450.025	459.975	C4FM	-63.5
450.025	459.975	TDMA	-64.0	450.025	459.975	TDMA	-64.0
450.025	469.975	CW	-63.5	450.025	469.975	CW	-63.6
450.025	469.975	C4FM	-63.0	450.025	469.975	C4FM	-64.0
450.025	469.975	TDMA	-64.0	450.025	469.975	TDMA	-63.0

Part 22 Repeater without Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
459.350	454.350	CW	-63.4	454.350	459.350	CW	-63.5
459.350	454.350	C4FM	-64	454.350	459.350	C4FM	-64
459.350	454.350	TDMA	-64	454.350	459.350	TDMA	-64.5

Booster with Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
451.5	451.5	CW	-63.3	459.975	459.975	CW	-63.3
451.5	451.5	C4FM	-63.0	459.975	459.975	C4FM	-63.0
451.5	451.5	TDMA	-63.0	459.975	459.975	TDMA	-63.0

Repeater with Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
450.025	453.975	CW	-63.3	457.025	461.975	CW	-62.7
450.025	453.975	C4FM	-62.5	457.025	461.975	C4FM	-63.0
450.025	453.975	TDMA	-63.0	457.025	461.975	TDMA	-62.8

470 – 490 MHz (FCC only)

Booster with Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
476.5	476.5	CW	-63.6	485.5	485.5	CW	-63.8
476.5	476.5	C4FM	-64.0	485.5	485.5	C4FM	-64
476.5	476.5	TDMA	-64.0	485.5	485.5	TDMA	-64.5

Repeater with Duplexer

Server to Donor				Donor to Server			
Server	Donor	Signal Type	AGC Threshold	Donor	Server	Signal Type	AGC Threshold
MHz	MHz		dBm	MHz	MHz		dBm
474.025	478.975	CW	-64.1	483.5	487.5	CW	-64.1
474.025	478.975	C4FM	-64.5	483.5	487.5	C4FM	-64.5
474.025	478.975	TDMA	-64	483.5	487.5	TDMA	-64.5

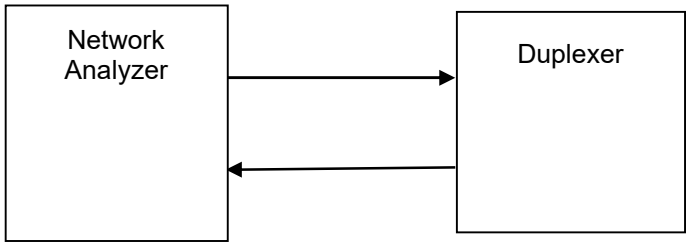
Out of Band Rejection
Engineer: Greg Corbin
Test Date: 9/13/2023

Test Procedure

Out of Band rejection could not be measured across the entire passbands due to the EUT filter implementation.
The EUT incorporates 2 types of filtering (Duplexers and DSP filtering) to limit the passband response and provide out of band rejection.
The EUT incorporates duplexers to limit the frequency range to ~6 - 10 MHz section of the passband.
The EUT DSP configurable filters limit the signal to a configured channel bandwidth.
For all tests except noise figure, the DSP filter was set to P25P1_12K5 (12.5 kHz BW).
For the noise figure test the filter bandwidth needed to be increased from 12.5 kHz to 25 kHz.
The DSP filter used for noise figure was P25P1_25K.

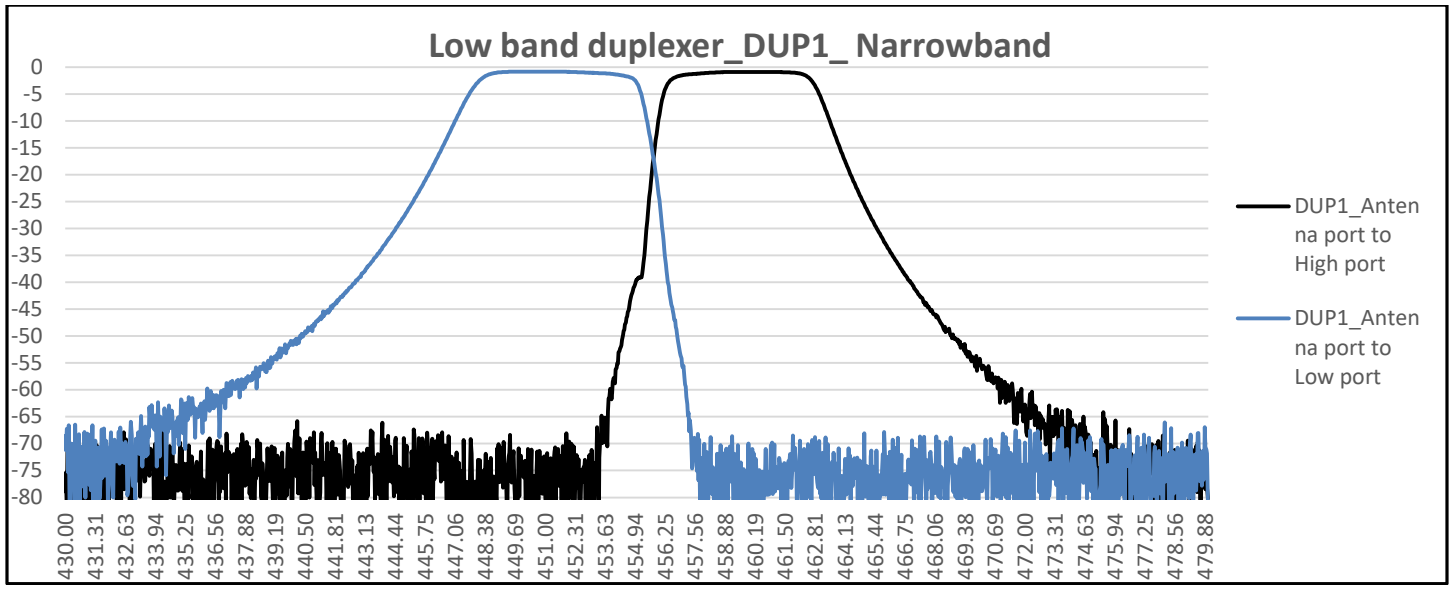
The duplexer frequency response was recorded using a network analyzer.
The 1 dB and 20 dB points were recorded.
A swept frequency response was recorded for each duplexer port.

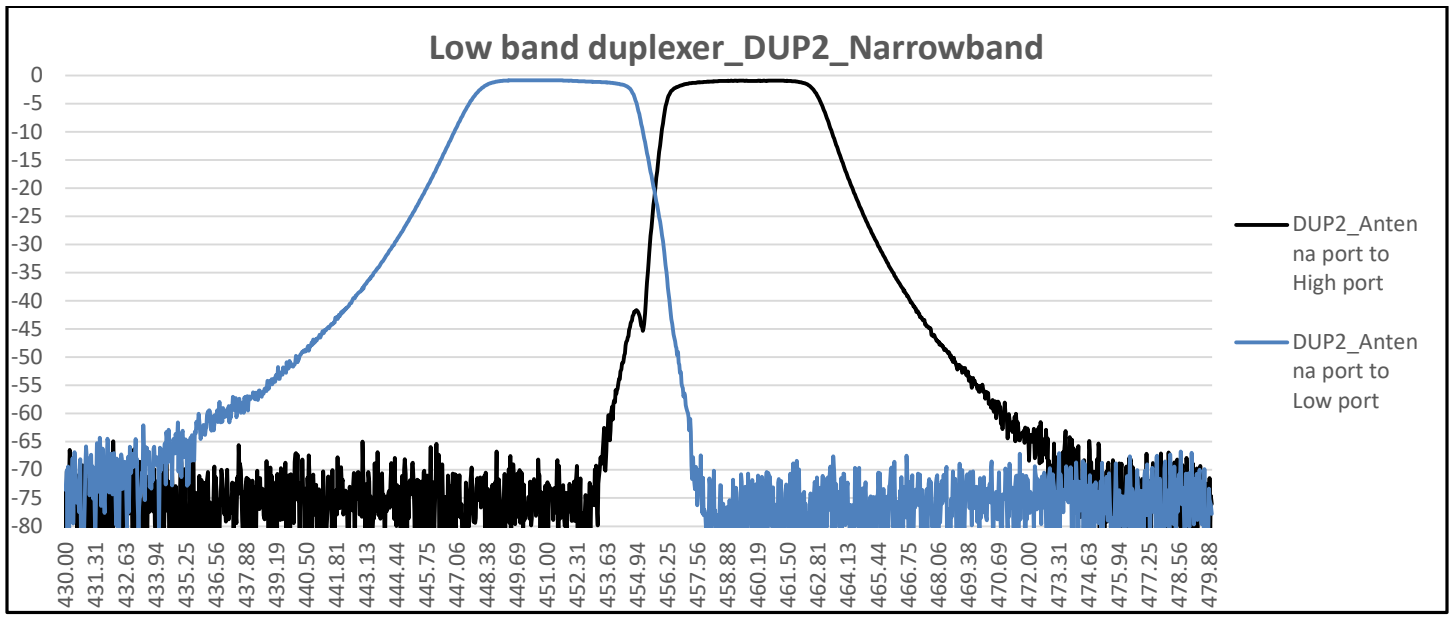
Test Setup



Low Band Duplexer_ -1 dB and -20 dB points

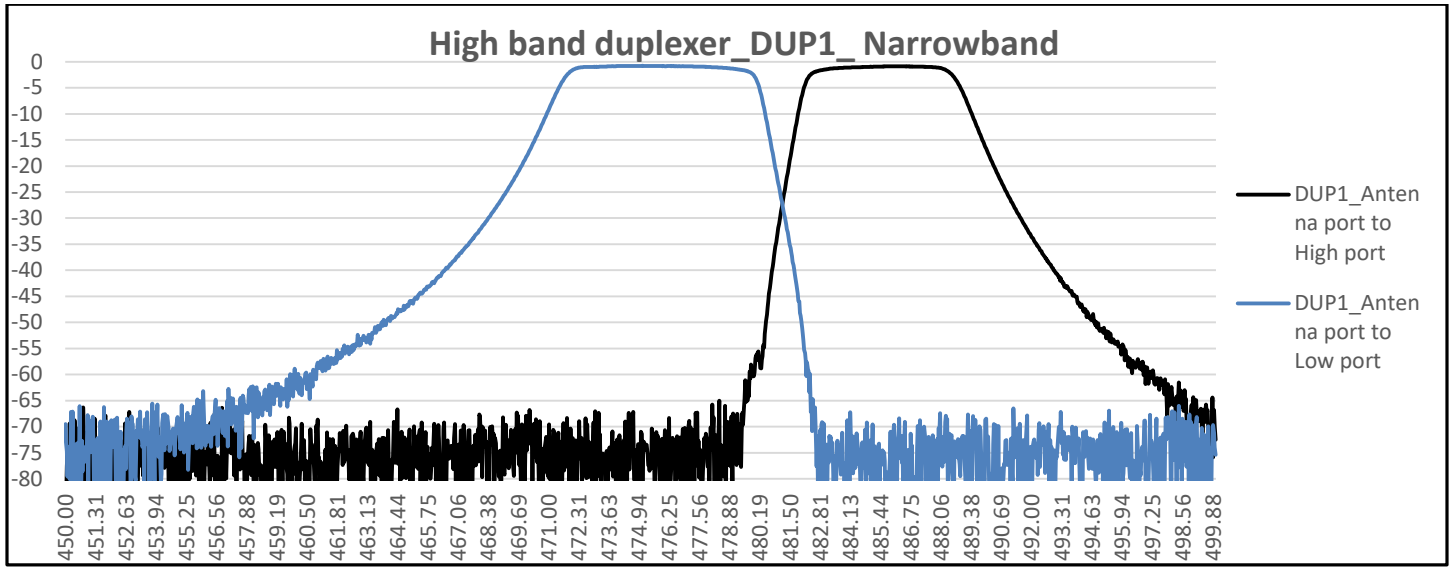
Low Band Duplexer	Low to Antenna port			High to antenna port		
	Frequency MHz		Bandwidth	Frequency MHz		Bandwidth
	Start	Start	MHz	Start	Stop	MHz
Duplexer 1						
Label	449	454	5	457	462	5
Measured -1 dB points	448.25	454.8125	6.5625	456.625	462.5625	5.9375
Measured -20 dB points	445.75	455.875	10.125	455.625	464.4687	8.8437
Duplexer 2						
Label	449	454	5	457	462	5
Measured -1 dB points	448.25	454.5312	6.2812	456.6875	462.5	5.8125
Measured -20 dB points	445.625	455.7187	10.0937	455.7187	464.4062	8.6875

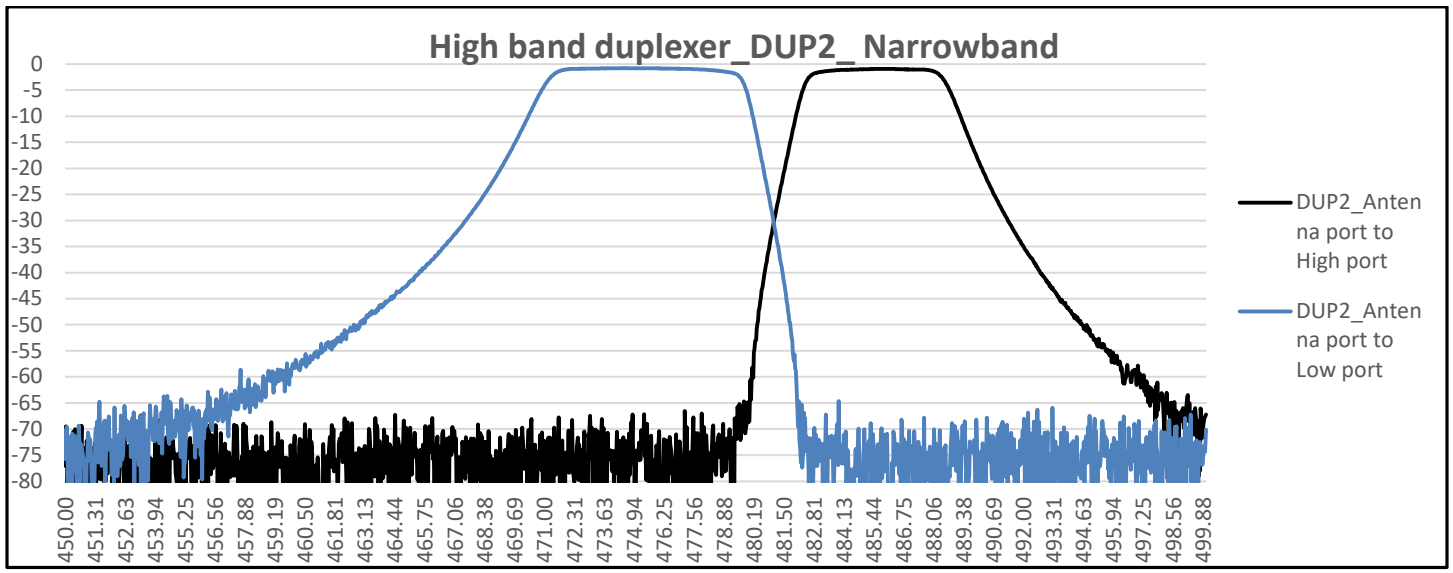




High Band Duplexer_ -1 dB and -20 dB points

High Band Duplexer	Low to Antenna port			High to antenna port		
	Frequency MHz		Bandwidth	Frequency MHz		Bandwidth
	Start	Start	MHz	Start	Stop	MHz
Duplexer 1						
Label	474	479	5	483	488	5
Measured -1 dB points	471.9062	479.7812	7.875	482.5132	488.4375	5.9243
Measured -20 dB points	469.6875	480.9062	11.2187	481.4062	490.4687	9.0625
Duplexer 2						
Label	474	479	5	483	488	5
Measured -1 dB points	471.4062	479.4687	8.0625	482.75	488.3125	5.5625
Measured -20 dB points	468.9687	480.6562	11.6875	481.5	490.2812	8.7812





Conducted Output Power and Amplifier Gain
Engineer: Greg Corbin
Test Date: 9/26/2023

Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer as shown in the test set-up diagram.
All cable and attenuator losses were input into the spectrum analyzer as a reference level offset to ensure accurate readings were obtained.

The output power was recorded with and without the duplexers installed for CW, C4FM, and TDMA modulations.
The input power was set so that the output power was 0.2 dB below the AGC threshold.
The spectrum analyzer channel power tool was used to measure the output power for the digital modulations.
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
Output Power Limit = 5 watts.

Test Setup

ERP Limit:
The EUT has a configurable output power level, which allows the user to lower the power level per channel in 1dB increments.

The EUT is capable of 36dBm composite power, based on the antenna gain and feeder loss and the FCC ERP limit of 37dBm, the power levels per channel must be set appropriately by the end user to ensure the ERP limit of 37dBm is not exceeded.

Output Power and Gain Test Results

450 – 470 MHz (FCC and ISED)
Booster without Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
459.975	459.975	CW	-63.4	35.53	98.9
459.975	459.975	C4FM	-63.5	35.32	98.8
459.975	459.975	TDMA	-63.5	35.36	98.9
469.975	469.975	CW	-63.4	35.62	99
469.975	469.975	C4FM	-63.5	35.53	99
469.975	469.975	TDMA	-63.5	35.54	99

450 – 470 MHz (FCC and ISED)
Booster without Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
459.975	459.975	CW	-63.6	35.87	99.5
459.975	459.975	C4FM	-63.5	35.81	99.3
459.975	459.975	TDMA	-63.5	35.01	98.5
469.975	469.975	CW	-63.7	35.81	99.7
469.975	469.975	C4FM	-64	35.64	100.1
469.975	469.975	TDMA	-64	35.22	99.6

450 – 470 MHz (FCC and ISED)
Booster with Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
451.5	451.5	CW	-63.4	35.73	99.1
451.5	451.5	C4FM	-63.5	35.50	99.0
451.5	451.5	TDMA	-63.5	35.65	99.2

450 – 470 MHz (FCC and ISED)
Booster with Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
459.975	459.975	CW	-63.3	35.74	99.0
459.975	459.975	C4FM	-63.3	35.65	99.0
459.975	459.975	TDMA	-63.3	35.05	98.4

450 – 470 MHz (FCC and ISED)
Repeater without Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
450.025	459.975	CW	-63.4	35.55	99.0
450.025	459.975	C4FM	-63.5	35.32	98.8
450.025	459.975	TDMA	-63.5	35.31	98.8
450.025	469.975	CW	-63.4	35.61	99.0
450.025	469.975	C4FM	-63.3	35.27	98.6
450.025	469.975	TDMA	-63.5	35.43	98.9

450 – 470 MHz (FCC and ISED)
Repeater without Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
450.025	459.975	CW	-63.7	35.81	99.5
450.025	459.975	C4FM	-64	35.64	99.6
450.025	459.975	TDMA	-64	35.22	99.2
450.025	469.975	CW	-63.6	36.02	99.6
450.025	469.975	C4FM	-64	35.98	100.0
450.025	469.975	TDMA	-64	35.33	99.3

Part 22 Repeater without Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
459.350	454.350	CW	-63.4	35.71	99.11
459.350	454.350	C4FM	-64	35.21	99.21
459.350	454.350	TDMA	-64	35.28	99.28

Part 22 Repeater without Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
454.350	459.350	CW	-63.5	35.77	99.27
454.350	459.350	C4FM	-64	35.14	99.14
454.350	459.350	TDMA	-64.5	34.95	99.45

450 – 470 MHz (FCC and ISED)
Repeater with Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
450.025	453.975	CW	-63.4	35.42	98.8
450.025	453.975	C4FM	-62.9	35.44	98.3
450.025	453.975	TDMA	-63.0	35.58	98.6

450 – 470 MHz (FCC and ISED)
Repeater with Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
457.025	461.975	CW	-62.8	35.53	98.33
457.025	461.975	C4FM	-62.8	35.27	98.07
457.025	461.975	TDMA	-62.8	34.95	97.75

470 - 490 MHz (FCC only)
Booster with Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
476.5	476.5	CW	-63.6	35.67	99.27
476.5	476.5	C4FM	-64	35.47	99.47
476.5	476.5	TDMA	-63.5	35.66	99.16

470 - 490 MHz (FCC only)
Booster with Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
485.5	485.5	CW	-63.9	35.24	99.14
485.5	485.5	C4FM	-64.5	34.77	99.27
485.5	485.5	TDMA	-64.5	34.58	99.08

470 - 490 MHz (FCC only)
Repeater with Duplexer

Server to Donor					
Server	Donor	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
474.025	478.975	CW	-63.8	35.22	99.0
474.025	478.975	C4FM	-64	35.33	99.3
474.025	478.975	TDMA	-64	35.18	99.2

470 - 490 MHz (FCC only)
Repeater with Duplexer

Donor to Server					
Donor	Server	Signal Type	Input Power	Output Power	Gain
MHz	MHz		dBm	dBm	dB
483.5	487.5	CW	-63.8	35.26	99.1
483.5	487.5	C4FM	-64	35.28	99.3
483.5	487.5	TDMA	-64	34.88	98.9

Conducted Spurious Emissions
Engineer: Greg Corbin
Test Date: 9/27/2023

Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer as shown in the test set-up diagram.
All cable and attenuator losses were input into the spectrum analyzer as a reference level offset to ensure accurate readings were obtained.
A CW signal was utilized, set to the frequencies listed in the test summary tables.
The RF input signal level was set to 0.2 dB below the AGC Threshold.
Conducted spurious emissions were recorded from 30 MHz to 5 GHz.
Spectrum analyzer plots were recorded, and the highest spurious level was recorded in the test summary tables.
Only test data with the duplexers installed was recorded.
Test data was provided for both the low band duplexers and high band duplexers in Booster and Repeater mode of operation.
For Part 22, the test was performed without the duplexers installed.

Spectrum analyzer settings:
Detector: Peak, max hold
RBW = 100 kHz from 30 – 1000 MHz
RBW = 1 MHz from 1 – 5 GHz.
VBW = 3 x RBW

In the tables below, the frequency in the first column is the input frequency, the second frequency is the output frequency.

Test Setup

Conducted Spurious Emissions Test Results

Booster with Low Band Duplexer (FCC and ISED)

Server to Donor					
Server	**Donor**	**Spurious Frequency**	**Spurious Amplitude**	**Limit**	**Margin**
MHz	**MHz**	**MHz**	**dBm**	**dBm**	**dB**
451.5	451.5	3690.3	-29.5	-20	-9.5
Donor to Server					
Donor	**Server**	**Spurious Frequency**	**Spurious Amplitude**	**Limit**	**Margin**
MHz	**MHz**	**MHz**	**dBm**	**dBm**	**dB**
459.975	459.975	3132.3	-29.4	-20	-9.4

Repeater with Low Band Duplexer (FCC and ISED)

Server to Donor					
Server	Donor	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
450.025	453.975	3294.3	-29.9	-20	-9.9
Donor to Server					
Donor	Server	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
457.025	461.975	3166.8	-29.7	-20	-9.7

Part 22 Repeater without Duplexer

Server to Donor					
Server	Donor	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
459.35	454.35	909.5	-23.1	-20	-3.1
Donor to Server					
Donor	Server	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
454.35	459.35	919.2	-22.1	-20	-2.1

Booster with High Band Duplexer (FCC only)

Server to Donor					
Server	Donor	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
485.5	485.5	3088.8	-29.2	-20	-9.2
Donor to Server					
Donor	Server	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
476.5	476.5	3933.4	-29.4	-20	-9.4

Repeater with High Band Duplexer (FCC only)

Server to Donor					
Server	Donor	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
474.025	478.975	3149.8	-29.4	-20	-9.4
Donor to Server					
Donor	Server	Spurious Frequency	Spurious Amplitude	Limit	Margin
MHz	MHz	MHz	dBm	dBm	dB
483.5	487.5	3702.8	-29.6	-20	-9.6

Annex A Conducted Spurious Emissions
Refer to Annex A for Conducted Spurious Emissions Plots

Radiated Spurious Emissions
Engineer: Greg Corbin
Test Date: 10/14/2023

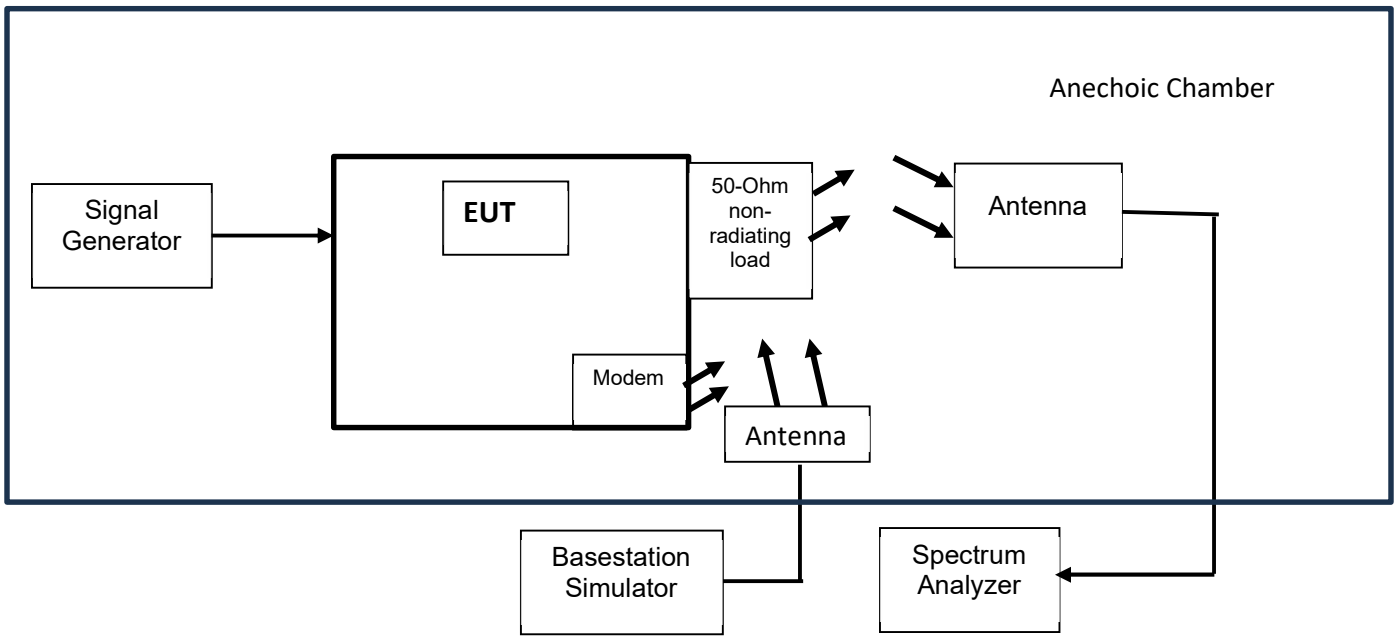
Test Procedure

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.
Radiated emissions was recorded with the low band duplexer installed.
The EUT incorporates a cellular modem for remote access, control, and monitoring functions.
The cellular module is pre-certified with singular module approval for cellular bands 3, 5, 7.
Radiated emissions were recorded with the cellular modem antennas installed and the modem connected and controlled over the air to a basestation simulator.
The frequency range of 30 MHz to 13 GHz was recorded, to accommodate testing to the 5th harmonic of the highest frequency produced by the cellular modem.
A combination of notch filters and highpass filters were used to keep the modem frequencies from overloading the receive pre-amplifier.
From 30 – 1000 MHz the following filter combinations were used.,
For Band 5, a notch filter tuned to 836.5 MHz was used to filter the basestation uplink signal.
For band 3 and 7, a 1.1 GHz low pass filter was used to filter the basestation uplink signal to keep from overdriving the pre-amplifier.
From 1 - 13 GHz, the test frequency range was split into 2 ranges 1 – 3.2 GHz and 3.2 GHz to 13 GHz and the following filter combinations were used.,
For Band 7, a notch filter tuned to 2535 MHz, was used to filter the basestation uplink signal to keep from overdriving the pre-amplifier. The sweep range was limited to 1 - 3.2 GHz. From 3.2 GHz to 13 GHz a 3.2 GHz Highpass filter was used.
For Band 3 a notch filter tuned to 1747.5 MHz, was used to filter the basestation uplink signal to keep from overdriving the pre-amplifier. The sweep range was limited to 1 - 3.2 GHz. From 3.2 GHz to 13 GHz a 3.2 GHz Highpass filter was used.
For B5, a 1 - 10 GHz HP filter was used. The highest freq to test is ~ 5 GHz. The sweep range was 1 - 10 GHz.

Spectrum analyzer settings:
Detector: Peak, max hold
RBW = 100 kHz from 30 – 1000 MHz
RBW = 1 MHz from 1 – 5 GHz.
VBW = 3 x RBW
The following formula was used for calculating the limits:

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

Test Setup



Radiated Spurious Emissions Test Results

Server to Donor							
Server	Donor	Cellular Modem		Spurious Frequency	Spurious Amplitude	Limit	Margin
		Band	Frequency				
MHz	MHz		MHz	MHz	dBm	dBm	dB
451.5	451.5	3	1747.5	12089.0	-37.2	-20	-17.2
451.5	451.5	5	836.5	99.9	-48.1	-20	-28.1
451.5	451.5	7	2535	12091.3	-34.5	-20	-14.5

Donor to Server							
Donor	Server	Cellular Modem		Spurious Frequency	Spurious Amplitude	Limit	Margin
		Band	Frequency				
MHz	MHz		MHz	MHz	dBm	dBm	dB
459.5	459.5	3	1747.5	12084.3	-36.5	-20	-16.5
459.5	459.5	5	836.5	5600.6	-47.3	-20	-27.3
459.5	459.5	7	2535	12050.5	-36.1	-20	-16.1

Note: in the spectrum analyzer plots, there are markers for the cellular modem fundamental frequencies that are exempt from the spurious limits.
The highest spurious frequency is marked and included in the test summary tables above.
The individual graph titles describe what filtering (notch, lowpass, or highpass) was used between the receive antenna and pre-amplifier.

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: 9/18/2023

Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer as shown in the test set-up diagram.
All cable and attenuator losses were input into the spectrum analyzer as a reference level offset to ensure accurate readings were obtained.
The test was performed at center frequency without the duplexers installed for 450 – 470 MHz.
The test was repeated with the high band duplexers installed.
This testing shows the emission mask and occupied bandwidth are not impacted due to the addition of duplexers in the circuit.
Emission mask D and occupied bandwidth was recorded using FM, C4FM, TDMA modulations.
For TDMA, TDMA H-CPM was used for the Server to Donor path, and TDMA H-DPQSK was used for Donor to Server path.

The input signal -26 dB BW was recorded and compared to the output signal -26 dB BW.
The emission mask and occupied bandwidth were tested at 0.2 dB below the AGC Threshold and +3 dB above the AGC Threshold.

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

Booster Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.975	459.975	FM	8.324	8.260	-0.77	+5	Pass
459.975	459.975	C4FM	10.721	9.103	-17.77	+5	Pass
459.975	459.975	TDMA_H-CPM	10.888	7.319	-48.76	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.975	459.975	FM	8.324	8.260	-0.77	+5	Pass
459.975	459.975	C4FM	10.721	9.439	-13.58	+5	Pass
459.975	459.975	TDMA_H-DQPSK	12.310	10.417	-18.17	+5	Pass

Booster Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.975	459.975	FM	8.324	8.260	0.31	+5	Pass
459.975	459.975	C4FM	10.721	9.469	-13.22	+5	Pass
459.975	459.975	TDMA_H-CPM	10.888	9.481	-14.84	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.975	459.975	FM	8.324	8.260	0.31	+5	Pass
459.975	459.975	C4FM	10.721	9.206	-16.46	+5	Pass
459.975	459.975	TDMA_H-DQPSK	12.310	10.288	-5.83	+5	Pass

Booster Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
469.975	469.975	FM	8.325	8.259	-0.80	+5	Pass
469.975	469.975	C4FM	10.884	9.164	-18.77	+5	Pass
469.975	469.975	TDMA_H-CPM	10.877	9.473	-14.82	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
469.975	469.975	FM	8.325	8.260	-0.79	+5	Pass
469.975	469.975	C4FM	10.884	9.399	-15.80	+5	Pass
469.975	469.975	TDMA_H-DQPSK	12.276	10.392	-18.13	+5	Pass

Booster Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
469.975	469.975	FM	8.325	8.259	-0.80	+5	Pass
469.975	469.975	C4FM	10.884	9.454	-15.13	+5	Pass
469.975	469.975	TDMA_H-CPM	10.877	9.397	-15.75	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
469.975	469.975	FM	8.325	8.259	-0.80	+5	Pass
469.975	469.975	C4FM	10.884	9.529	-14.22	+5	Pass
469.975	469.975	TDMA_H-DQPSK	12.276	10.406	-17.97	+5	Pass

Repeater Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	459.975	FM	8.325	8.267	-0.70	+5	Pass
450.025	459.975	C4FM	11.186	9.226	-21.24	+5	Pass
450.025	459.975	TDMA_H-CPM	10.610	9.439	-12.41	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	459.975	FM	8.325	8.266	-0.71	+5	Pass
450.025	459.975	C4FM	11.186	9.147	-22.29	+5	Pass
450.025	459.975	TDMA_H-DQPSK	10.610	10.381	-2.21	+5	Pass

Repeater Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	459.975	FM	8.325	8.266	-0.71	+5	Pass
450.025	459.975	C4FM	11.186	9.433	-18.58	+5	Pass
450.025	459.975	TDMA_H-CPM	10.610	9.456	-12.20	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	459.975	FM	8.325	8.266	-0.71	+5	Pass
450.025	459.975	C4FM	11.186	9.388	-19.15	+5	Pass
450.025	459.975	TDMA_H-DQPSK	10.610	10.258	-3.43	+5	Pass

Repeater Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	469.975	FM	8.325	8.332	0.08	+5	Pass
450.025	469.975	C4FM	11.186	9.481	-17.98	+5	Pass
450.025	469.975	TDMA_H-CPM	10.610	9.447	-12.31	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	469.975	FM	8.325	8.330	0.06	+5	Pass
450.025	469.975	C4FM	11.186	7.140	-56.67	+5	Pass
450.025	469.975	TDMA_H-DQPSK	10.610	10.259	-3.42	+5	Pass

Repeater Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	469.975	FM	8.325	7.250	-14.83	+5	Pass
450.025	469.975	C4FM	11.186	9.473	-18.08	+5	Pass
450.025	469.975	TDMA_H-CPM	10.610	9.429	-12.53	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
450.025	469.975	FM	8.325	8.330	0.06	+5	Pass
450.025	469.975	C4FM	11.186	9.357	-19.55	+5	Pass
450.025	469.975	TDMA_H-DQPSK	10.610	10.417	-1.85	+5	Pass

Part 22 Repeater Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.35	454.35	FM	8.27	8.272	0.02	+5	Pass
459.35	454.35	C4FM	11.1	9.404	-18.03	+5	Pass
459.35	454.35	TDMA_H-CPM	12.1	9.253	-30.77	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
454.35	459.35	FM	8.27	8.270	0.00	+5	Pass
454.35	459.35	C4FM	11.1	9.395	-18.15	+5	Pass
454.35	459.35	TDMA_H-DQPSK	12.1	10.270	-17.82	+5	Pass

Part 22 Repeater Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
459.35	454.35	FM	8.27	8.273	0.04	+5	Pass
459.35	454.35	C4FM	11.1	9.006	-23.25	+5	Pass
459.35	454.35	TDMA_H-CPM	12.1	9.474	-27.72	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
454.35	459.35	FM	8.27	8.269	-0.01	+5	Pass
454.35	459.35	C4FM	11.1	9.382	-18.31	+5	Pass
454.35	459.35	TDMA_H-DQPSK	12.1	10.330	-17.13	+5	Pass

Booster Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
476.5	476.5	FM	8.334	8.268	-0.80	+5	Pass
476.5	476.5	C4FM	10.420	8.810	-18.27	+5	Pass
476.5	476.5	TDMA_H-CPM	10.881	9.362	-16.23	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
485	485	FM	8.335	8.267	-0.82	+5	Pass
485	485	C4FM	10.898	9.586	-13.69	+5	Pass
485	485	TDMA_H-DQPSK	12.054	10.306	-16.96	+5	Pass

Booster Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
476.5	476.5	FM	8.334	8.267	-0.81	+5	Pass
476.5	476.5	C4FM	10.420	9.380	-11.09	+5	Pass
476.5	476.5	TDMA_H-CPM	10.881	9.228	-17.91	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
485	485	FM	8.335	8.267	-0.82	+5	Pass
485	485	C4FM	10.898	9.405	-15.87	+5	Pass
485	485	TDMA_H-DQPSK	12.054	10.421	-15.67	+5	Pass

Repeater Input vs Output at 0.2 dB below AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
474.025	478.975	FM	8.333	8.247	-1.04	+5	Pass
474.025	478.975	C4FM	10.570	9.399	-12.46	+5	Pass
474.025	478.975	TDMA_H-CPM	10.525	9.416	-11.78	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
483.5	487.5	FM	8.333	8.266	-0.81	+5	Pass
483.5	487.5	C4FM	10.885	8.834	-23.22	+5	Pass
483.5	487.5	TDMA_H-DQPSK	12.347	10.371	-19.05	+5	Pass

Repeater Input vs Output at +3.0 dB above AGC Threshold

Server to Donor							
Server	Donor	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
474.025	478.975	FM	8.333	8.247	-1.04	+5	Pass
474.025	478.975	C4FM	10.570	9.026	-17.11	+5	Pass
474.025	478.975	TDMA_H-CPM	10.525	9.361	-12.43	+5	Pass
Donor to Server							
Donor	Server	Modulation	Input Signal BW	Output Signal BW	% change	Limit (%)	Pass / Fail
MHz	MHz		kHz	kHz	%	%	
483.5	**487.5**	**FM**	8.333	8.266	-0.81	**+5**	**Pass**
483.5	**487.5**	**C4FM**	10.885	9.515	-14.40	**+5**	**Pass**
483.5	**487.5**	**TDMA_H-DQPSK**	12.347	10.316	-19.69	**+5**	**Pass**

Annex C Input vs Output

Refer to Annex C for Input vs Output plots.

Annex D Emission Mask

Refer to Annex D for Emission Mask plots.

Intermodulation
Engineer: Greg Corbin
Test Date: 10/11/2023

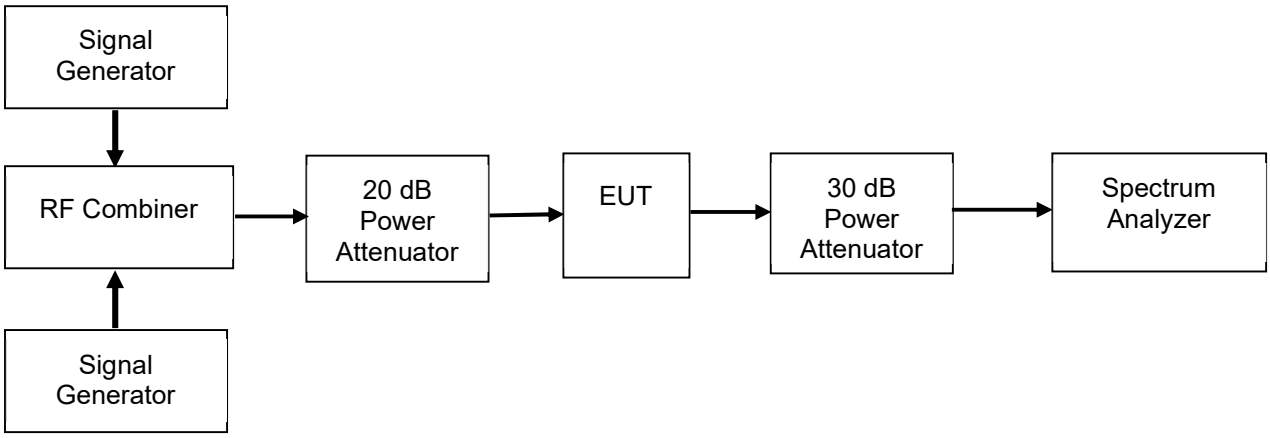
Test Procedure

The Equipment Under Test (EUT) was connected to a spectrum analyzer as shown in the test set-up diagram.
All cable and attenuator losses were input into the spectrum analyzer as a reference level offset to ensure accurate readings were obtained.
2 frequencies for Booster mode and 2 sets of frequencies in Repeater mode were used to show compliance to the intermodulation limit.

For ISED, the RBW = 10 kHz. The signals needed to be set to a 50 kHz channel spacing to get the required resolution on the spectrum analyzer.
For the FCC, the RBW is set to 300 Hz, the channel spacing was set to 12.5 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 Set-up



Booster Intermodulation at 0.2 dB below AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
451.4875	451.5125	451.5375	-29.2	-13	Pass
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
459.9625	459.9875	460.0125	-28.4	-13	Pass

Booster Intermodulation at +3.0 dB above AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
451.4875	451.5125	451.4625	-30.1	-13	Pass
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
459.9625	459.9875	460.0125	-28.8	-13	Pass

Part 22 Repeater Intermodulation at 0.2 dB below AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
459.3375	454.3375	454.3875	-29.1	-13	Pass
459.3625	454.3625				
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
454.3375	459.3375	459.3875	-24.6	-13	Pass
454.3625	459.3625				

Part 22 Repeater Intermodulation at +3.0 dB above AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
459.3375	454.3375	454.3875	-29.2	-13	Pass
459.3625	454.3625				
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
454.3375	459.3375	459.3875	-24.7	-13	Pass
454.3625	459.3625				

Repeater Intermodulation at 0.2 dB below AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
450.0125	453.9625	454.0125	-25.8	-13	Pass
450.0375	453.9875				
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
457.0125	461.9625	462.0125	-30.4	-13	Pass
457.0375	461.9875				

Repeater Intermodulation at +3.0 dB above AGC Threshold (FCC only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
450.0125	453.9625	454.0125	-25.7	-13	Pass
450.0375	453.9875				
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
457.0125	461.9625	462.0125	-25.8	-13	Pass
457.0375	461.9875				

Booster Intermodulation (ISED only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
451.475	451.525	451.4247	-33.0	-30	Pass
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
459.95	459.60	460.04998	-31.3	-30	Pass

Repeater Intermodulation (ISED only)

Server to Donor					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Server	Donor				
MHz	MHz	MHz	dBm	dBm	
450.0	453.95	453.92519	-47.0	-30	Pass
450.05	454.0				
Donor to Server					
Test Frequency		Intermodulation Frequency	Intermodulation Amplitude	Limit	Pass / Fail
Donor	Server				
MHz	MHz	MHz	dBm	dBm	
457.0	461.95	462.04999	-32.2	-30	Pass
457.05	462.0				

Annex E Intermodulation

Refer to Annex E for Intermodulation plots.

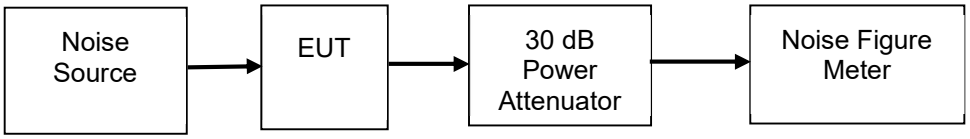
Noise Figure

Engineer: Greg Corbin

Test Date: 10/12/2023

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 EUT was set to the frequencies in the noise figure test summary tables below.
The test was performed with the low band duplexers installed.
For Part 22, the duplexers were bypassed.



Booster Noise Figure

Server to Donor				
Test Frequency		Noise Figure	Limit	Pass / Fail
Server	Donor			
MHz	MHz	dB	dB	
451.5	451.5	7.2	9	Pass
Donor to Server				
Test Frequency		Noise Figure	Limit	Pass / Fail
Donor	Server			
MHz	MHz	dB	dB	
459.975	459.975	7.2	9	Pass

Repeater Noise Figure

Server to Donor				
Test Frequency		Noise Figure	Limit	Pass / Fail
Server	Donor			
MHz	MHz	dB	dB	
450.025	453.975	7.0	9	Pass
Donor to Server				
Test Frequency		Noise Figure	Limit	Pass / Fail
Donor	Server			
MHz	MHz	dB	dB	
459.025	461.975	6.7	9	Pass

Part 22 Repeater Noise Figure

Server to Donor				
Test Frequency		Noise Figure	Limit	Pass / Fail
Server	Donor			
MHz	MHz	dB	dB	
459	454	6.5	9	Pass
Donor to Server				
Test Frequency		Noise Figure	Limit	Pass / Fail
Donor	Server			
MHz	MHz	dB	dB	
454	459	6.3	9	Pass

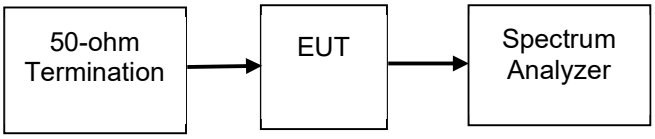
Noise Power

Engineer: Greg Corbin

Test Date: 10/12/2023

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 EUT was tuned to the frequencies in the noise power test summary tables with the input port terminated in 50 ohms.
The In-band and out of band noise power was recorded.
The test was performed with the low band duplexers installed.
RBW = 10 kHz



In-Band Noise Power (ISED only)

Server Port					
Tuned Frequency		Noise Power		Limit	Pass / Fail
Server	Donor	Frequency	Level		
MHz	MHz	MHz	dBm	dBm	
459.975	459.975	449.9986	-51.1	-43	Pass
Donor Port					
Tuned Frequency		Noise Power		Limit	Pass / Fail
Donor	Server	Frequency	Level		
MHz	MHz	MHz	dBm	dBm	
451.5	451.5	462.4491	-66.6	-43	Pass

Out of Band Noise Power (ISED only)

Server Port					
Tuned Frequency		Noise Power		Limit	Pass / Fail
Server	Donor	Frequency	Level		
MHz	MHz	MHz	dBm	dBm	
459.975	459.975	3095.7	-100.6	-43	Pass
Donor Port					
Tuned Frequency		Noise Power		Limit	Pass / Fail
Donor	Server	Frequency	Level		
MHz	MHz	MHz	dBm	dBm	
451.5	451.5	3062.0	-100.7	-43	Pass

Annex F Noise Power

Refer to Annex F for Noise Power

Frequency Stability (Temperature Variation)

Engineer: Greg Corbin

Test Date:9/29/2023

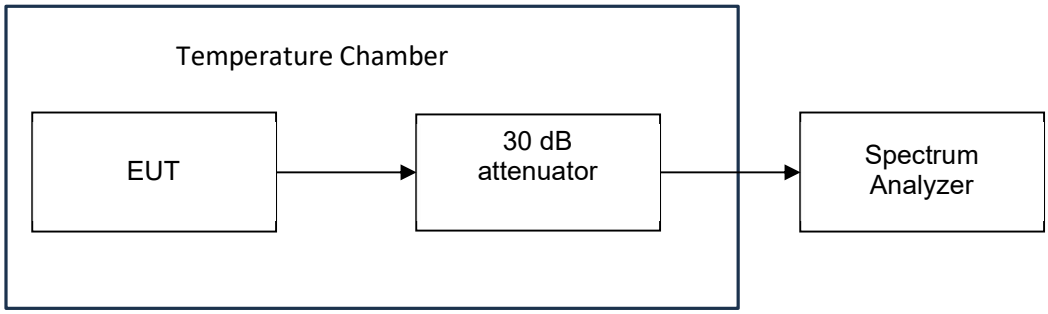
Measurement Procedure

The EUT can function as a repeater and can perform frequency translation, so Frequency Stability testing is required. 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.

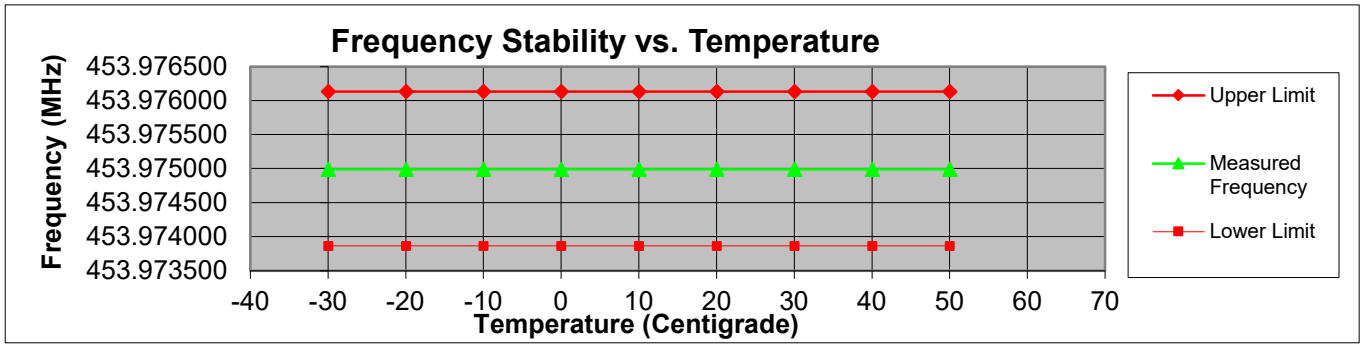
At 20°C the power supply voltage to the EUT was varied from 85% to 115% of the nominal value and the RF output was measured.

Measurement Setup



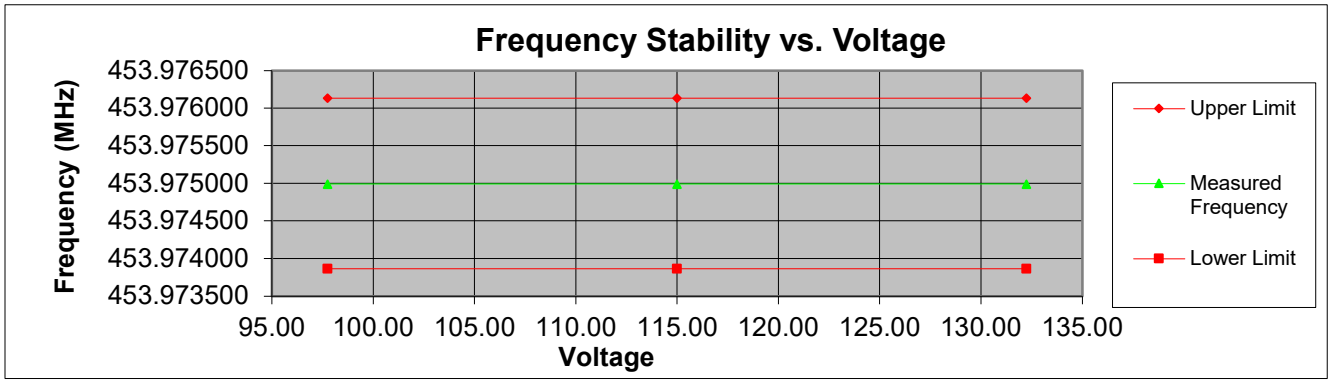
Frequency Stability vs Temperature

Tuned Frequency	Temperature	Tolerance	Measured Frequency	Upper Limit	Lower Limit	Upper Margin	Lower Margin
(MHz)	(deg C)	(PPM)	(MHz)	(MHz)	(MHz)	(MHz)	(MHz)
453.975	-30	2.5	453.974991	453.976135	453.973865	-0.001144	0.001126
453.975	-20	2.5	453.974991	453.976135	453.973865	-0.001144	0.001126
453.975	-10	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	0	2.5	453.974991	453.976135	453.973865	-0.001144	0.001126
453.975	10	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	20	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	30	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	40	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	50	2.5	453.974992	453.976135	453.973865	-0.001143	0.001127



Frequency Stability vs Voltage @ 20 dec C

Tuned Frequency	Tolerance	Voltage	Measured Frequency	Upper Limit	Lower Limit	Upper Margin	Lower Margin
(MHz)	(PPM)	VAC	(MHz)	(MHz)	(MHz)	(MHz)	(MHz)
453.975	2.5	97.75	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	2.5	115.00	453.974992	453.976135	453.973865	-0.001143	0.001127
453.975	2.5	132.25	453.974992	453.976135	453.973865	-0.001143	0.001127



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
Tunable Notch Filter	Eagle	TNF-1-(250-850MHz)	i00124	Verified on: 10/14/23	
High Pass Filter (3.4 GHz)	Trilithic	4HX3400-3-XX	i00177	Verified on: 10/14/23	
Horn Antenna	ARA	DRG-118/A	i00271	8/11/22	8/11/24
Bi-Log Antenna	Schaffner	CBL 6111D	i00349	2/7/23	2/7/25
Signal Generator	Rohde & Schwarz	SMU200A	i00405	1/25/23	1/025/24
Tunable Notch Filter	Trilithic	3VNF1500/25090-50-KK	i00410	Verified on: 10/14/23	
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: 10/14/23	
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
Attenuator, 30 dB, 50W	Mini-Circuits	BW- N30W50+	I00459	Verified on: 9/18/23	
PSA Spectrum Analyzer	Agilent	E4445A	i00471	12/29/22	12/29/23
Attenuator, 30 dB, 50W	Mini-Circuits	BW- N30W50+	I00459	Verified on: 9/18/23	
Voltmeter	Fluke	179	i00488	6/19/23	6/19/24
MXE EMI receiver	Keysight	N9038A	i00552	2/23/23	2/23/24
Preamplifier	Eravant	SBB-0115034018-2F2F-E3	i00646	Verified on: 7/27/23	
Lowpass Filter (1.1 GHz)	Reactel	TB5L-5-1200-M/M	i00700	Verified on: 10/14/23	

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