
Project 21168-15

TX-7471
LRS Paging Transmitter

Wireless Certification Report
Full Band Coverage

Prepared for:

Long Range Systems, LLC

By

Professional Testing (EMI), Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

19 Feb 2020

Reviewed by

A blue ink signature of Shakil Murad, featuring a stylized 'S' and 'M'.

Shakil Murad
Lead EMC Engineer

Written by

A blue ink signature of Eric Lifsey, featuring a stylized 'E' and 'L'.

Eric Lifsey
EMC Engineer

Revision History

Revision Number	Description	Date
Draft 02	Draft for review.	21 Feb 2020
Final 01		24 Feb 2020
Final 02	Reconcile rated power with measurement and ISED tolerance.	10 Mar 2020

Errata:

None.

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NOTICE:

(1) This Report must not be used to claim product endorsement, by NVLAP, NIST, the FCC or any other Agency. This report also does not warrant certification by NVLAP or NIST.

(2) This report shall not be reproduced except in full, without the written approval of Professional Testing (EMI), Inc.

(3) The significance of this report is dependent on the representative character of the test sample submitted for evaluation and the results apply only in reference to the sample tested. The manufacturer must continuously implement the changes shown herein to attain and maintain the required degree of compliance.



Certificate of Compliance

FCC MRA Designation Number: US5270
NVLAP Accreditation Number: 200062-0

Applicant	Device & Test Identification
Long Range Systems LLC 4550 Excel Parkway Suite 200 Addison TX 75001 Certificate Date: 19 Feb 2020	FCC ID: 2AB6OTX7471 Industry Canada ID: 5501A-TX7471 Model(s): TX-7471, TX-7471-C232 Laboratory Project ID: 21168-15

The device model(s) listed above were tested utilizing the following documents and found to be in compliance with the required criteria.

47 CFR (USA) FCC, RSS ISCED (Canada)		
Parameter	FCC: Licensed to 434.00-469.15 MHz	IC: Licensed to 450.00-469.15 MHz
Conducted Output Power (Rated 1 Watt)	90.210, 2.1046	RSS-119 Issue 12, 5.4
Emission Mask (D)	90.210, 2.1047	RSS-119 Issue 12, 5.8
Conducted Spurious/Harmonic Emissions at Antenna Terminals	90.210, 2.1051	RSS-119 Issue 12, 5.8; RSS-Gen Issue 4
Field Strength of Radiated Spurious/Harmonic Emissions to 5 GHz	90.210, 15.209, 2.1053	RSS-119 Issue 12, 5.8
Transient Frequency Behavior	90.214, TIA/EIA-603-E	RSS-119 Issue 12, 5.9
Frequency Stability	90.213, 2.1055	RSS-119 Issue 12, 5.3
Modulation; Frequency Response & Limiting	2.1047(a), (b)	
Occupied Bandwidth, 99%	90.209, 2.1049	RSS-119 Issue 12, 5.5
Radiated Emissions 30 MHz – 5 GHz	15.109	RSS-Gen Issue 4, ICES-003

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above rules and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Eric Lifsey
EMC Engineer

This report has been reviewed and accepted by the Applicant. The undersigned is responsible for ensuring that this device will continue to comply with the rules listed above.

Representative of Applicant

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States and Canada.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

1.2 EUT Description

The EUT transmits alert codes to receivers held by patrons at restaurants to page them to host for seating or similar purposes in the establishment.

The EUT is housed in a plastic enclosure with optional LCD display and integral keypad. It receives external power from an AC to DC adapter. The EUT employs a BNC connector where a quarter-wave antenna is attached and positioned vertically.

Table 1.2.1 Equipment Under Test		
Manufacturer & Description	Model	Serial #
Long Range Systems, LLC Paging transmitter	TX-7471	T7470-37681 & 33261

Table 1.2.2 Other Model(s) Represented by EUT		
Manufacturer & Description	Model	Serial #
Long Range Systems, LLC Paging transmitter*	TX-7471-C232	N/A

*This is a sub-equipped model with same RF characteristics, same printed circuit board as the EUT but is solely controlled by a serial port. The EUT LCD display and keypad assemblies are not included in this model.

Table 1.2.2: EUT RF Specifications	
Power Output to Antenna (Rated)	+30 dBm or 1 Watt FCC +30.8 dBm or 1.2 Watt ISM
Frequency Range	434.000 to 469.150 MHz (Licensed channels only.)
Channel Bandwidths Supported (kHz)	12.5
Emission Designator	9K7G1D
Data Rate Supported (baud)	1200
Modulation Methods Supported	2GFSK (Data only.)
Declaration of Minimum Baud Rate for Spectrum Efficiency	Not applicable to a 12.5 kHz bandwidth.

Table 1.2.3 Antenna Description

Antenna is a shortened helical monopole included with the EUT as delivered to the final user.

Table 1.2.4 Test Frequency/Range* (Only for licensed frequencies per localized regulations.)

Lowest Frequency	Center Frequency	Highest Frequency	Total Frequency Range
434.000 MHz	450.575 MHz	469.150 MHz	35.15 MHz
The three channels were tested per customary practice for a frequency range exceeding 10 MHz.			

*All references to bottom/low, middle/center/nominal, and top/high channels are from this table unless otherwise specified.

1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations.

Built-in diagnostic firmware was employed to place the EUT into operating modes needed for measurements.

The EUT does not transmit nor receive speech or other audio content. Therefore, measurements of frequency response and limiting do not apply.

1.4 Modifications to Equipment

The transmit output filter section was modified to enhance harmonic suppression.

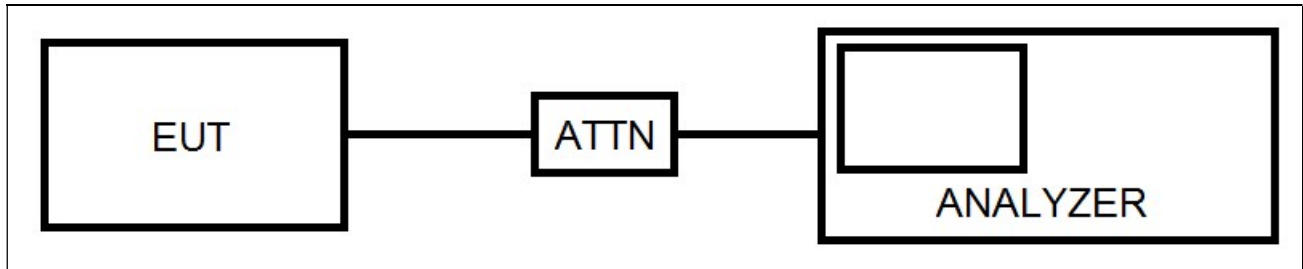
1.5 Test Site

Measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RSS-Gen and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

1.6 Applicable Documents

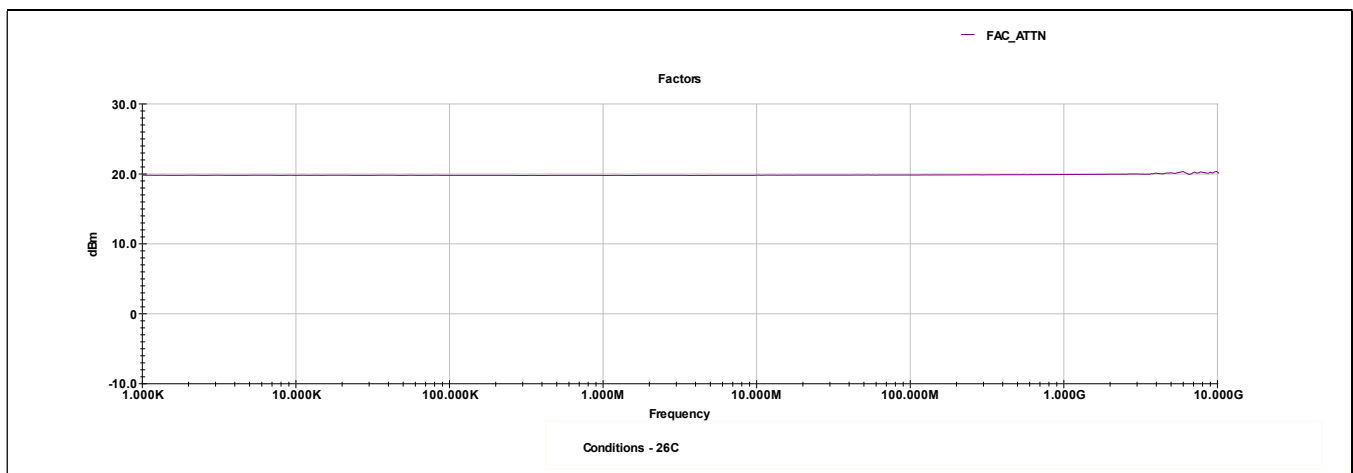
Table 1.6.1: Applicable Documents		
Document #	Title/Description	Date
47 CFR	FCC Part 90	
IC RSS-119 Issue 12	Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz	2015
IC RSS-Gen Issue 4	General Requirements for Compliance of Radio Apparatus	2014
TIA/EIA-603-E	Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards	2016
ANSI C63.26	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;	2015

1.7 Test Setup Diagram



Setup for Conducted Port Measurements

External fixed attenuation is employed to protect the spectrum analyzer from overload damage. The attenuation factor is applied automatically in software and is graphically represented by that software below.



Attenuator Factor vs Frequency
Asset Number A105
20 dB 20 W Narda Attenuator

2.0 Conducted Output Power

2.1 Procedure

The EUT antenna port is coupled through a power attenuator to a spectrum analyzer and then is placed into continuous transmit mode without modulation. The measurement is captured with software and correction factors for attenuator loss etc. are added. Peak detection is used. Power is then measured directly with no additional calculation required.

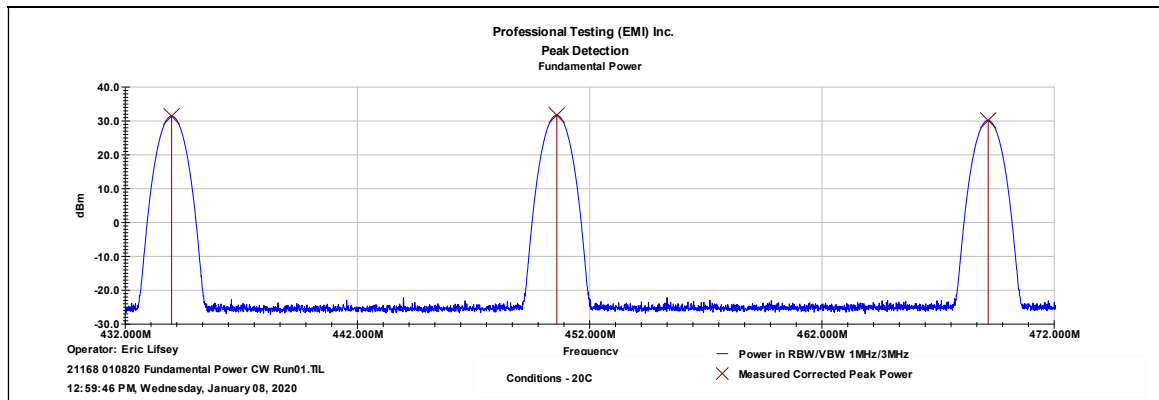
2.2 Criteria

Parameter	Section Reference	Date(s)
Emissions at Antenna Terminals	90.210, 2.1047 RSS-119 Issue 12, 5.8	8 Jan 2020

2.3 Results

The EUT satisfied the requirement. Plotted and tabular results are presented below.

Table 2.3.1 Power, Conducted Manufacturer power specification: 1 Watt FCC; 1.2 Watt ISD	
Frequency (MHz)	Measured Level
434.000	31.4 dBm (1380 mW)
450.575	31.7 dBm (1479 mW)
469.150	30.1 dBm (1024 mW)



Measured & Corrected Peak Power, Conducted

2.4 Calculated Attenuation and Spurious Limits Beyond Authorized Bandwidth

Table 2.4.1 Attenuation and Limits Beyond Authorized Bandwidth Limit(dBm) = Fundamental_Power(dBm) – Attenuation(dB) Fundamental Power = 1 W		
Paragraph/Mask & BW Reference	Calculated Attenuation dB	Calculated Spurious Limit dBm
90.210(d) 12.5 kHz	$50 + 10 \log_{10}(1 W_{\text{power}}) = 50 \text{ dB}_{\text{attenuation}}$	$30 \text{ dBm}_{\text{power}} - 50 \text{ dB}_{\text{attenuation}} = -20 \text{ dBm}$

3.0 Emission Mask

3.1 Procedure

The EUT antenna port is coupled through a power attenuator to a spectrum analyzer and then is placed into continuous transmit mode with modulation. The measurement is captured with software and correction factors for attenuator loss etc. are added. Peak detection is used. The mask was selected to match the rule requirement for the emission bandwidth in use.

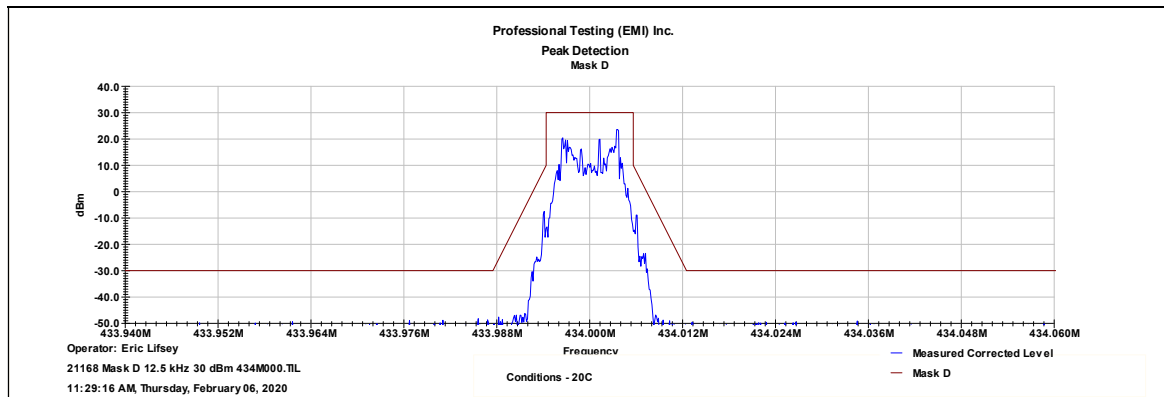
3.2 Criteria

Guideline	Section Number	Date
Emissions at Antenna Terminals	90.210(d), 2.1047 RSS 119 Issue 11, 5.8.3	6 Feb 2020

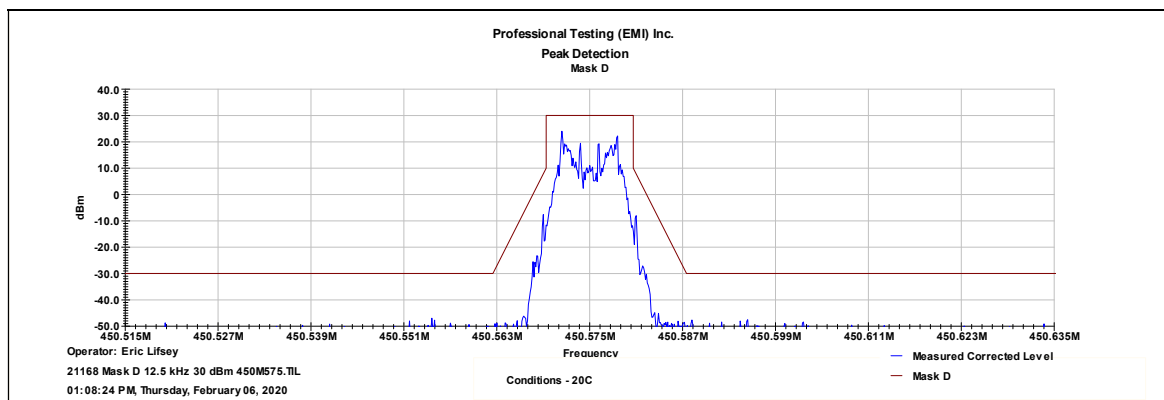
3.3 Results

Measured with resolution bandwidth of 100 Hz per 90.210(d)(4). Video bandwidth set to 300 Hz.

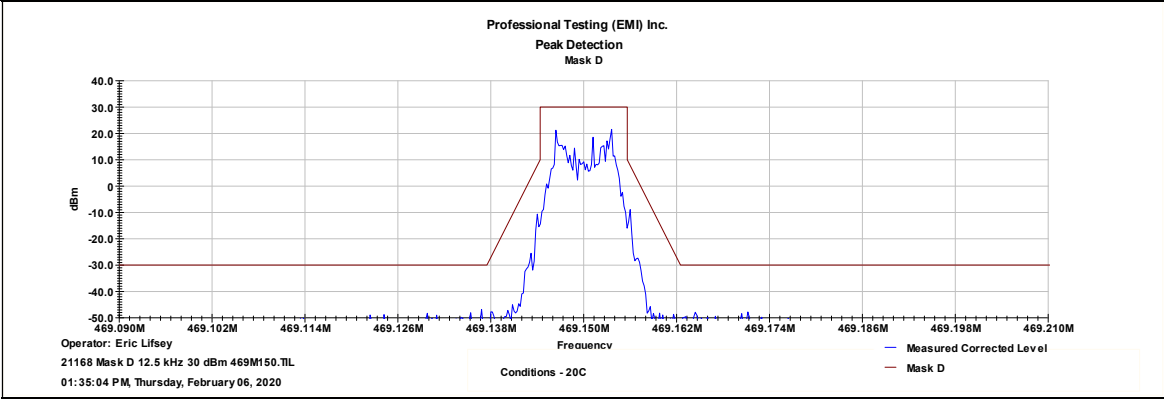
The EUT satisfied the requirement.



Low Channel



Middle Channel



High Channel

4.0 Spurious Emissions at Antenna Terminals

4.1 Procedure

The EUT antenna port is coupled through a power attenuator to a spectrum analyzer and then is placed into continuous transmit mode without modulation on each of the low, middle, and high channels. The measurement is captured with software and correction factors for attenuator loss etc. are added. Peak detection is used. The measurement is then repeated in the receive mode on the middle channel.

4.2 Criteria

Guideline	Section Number	Date
Emissions at Antenna Terminals	90.210, 2.1047 RSS-119 Issue 12, 5.8, RSS-Gen	8 Jan 2020

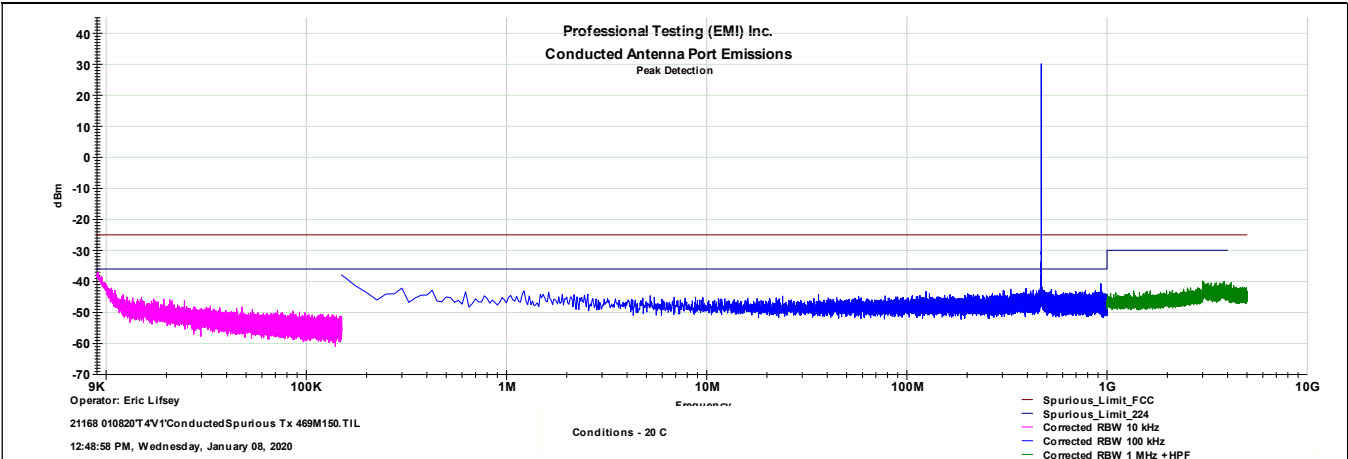
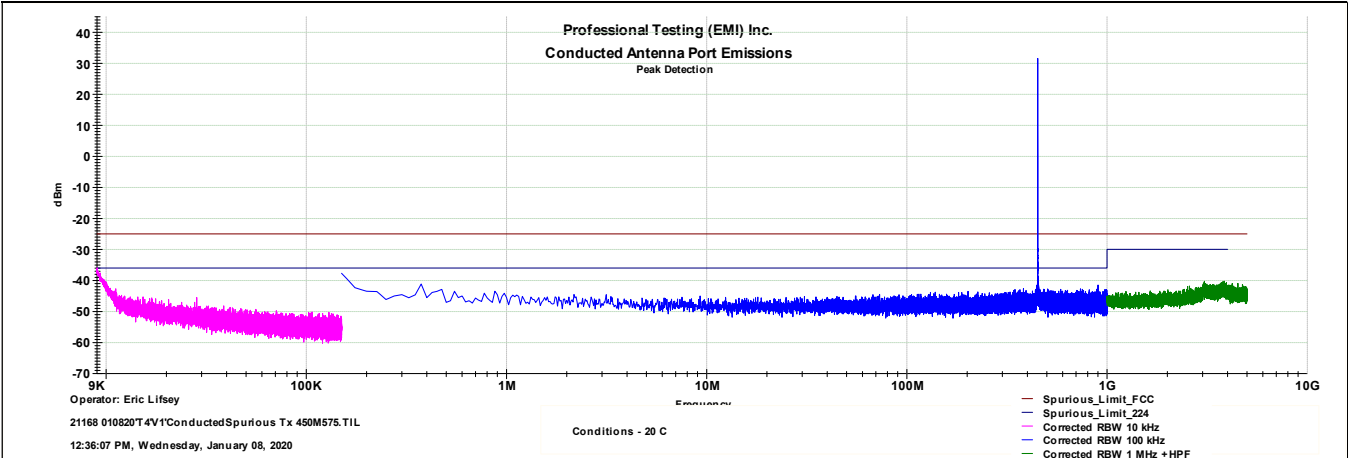
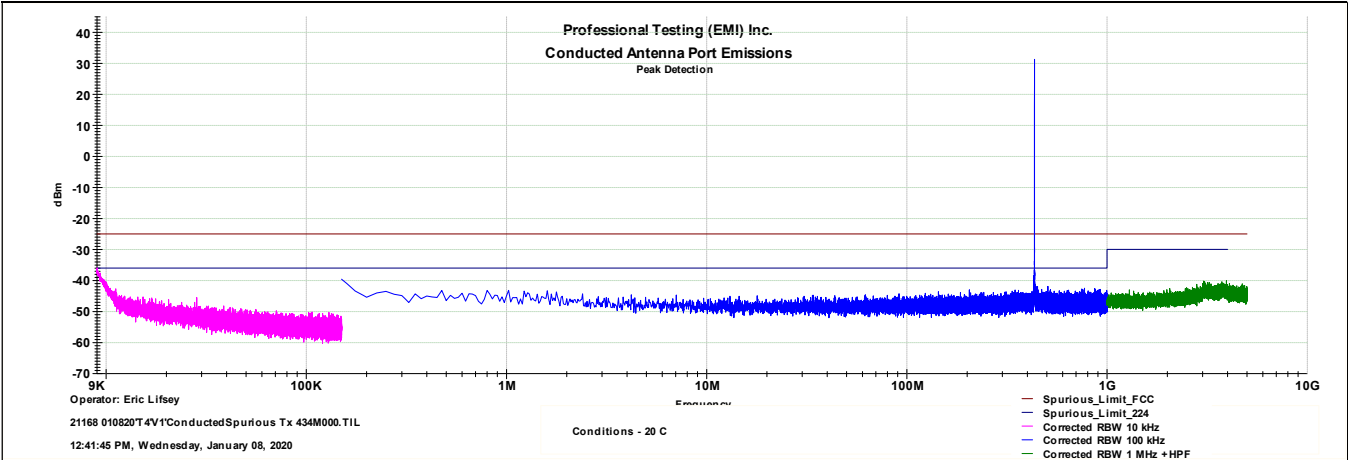
4.3 Results

Setup per section 1.7.

Highest recorded spurious emission: -41.7 dBm at 931.5353 MHz; top channel.

The EUT satisfied the requirement.

4.3.1 Transmit Mode



4.3.2 Receive Mode

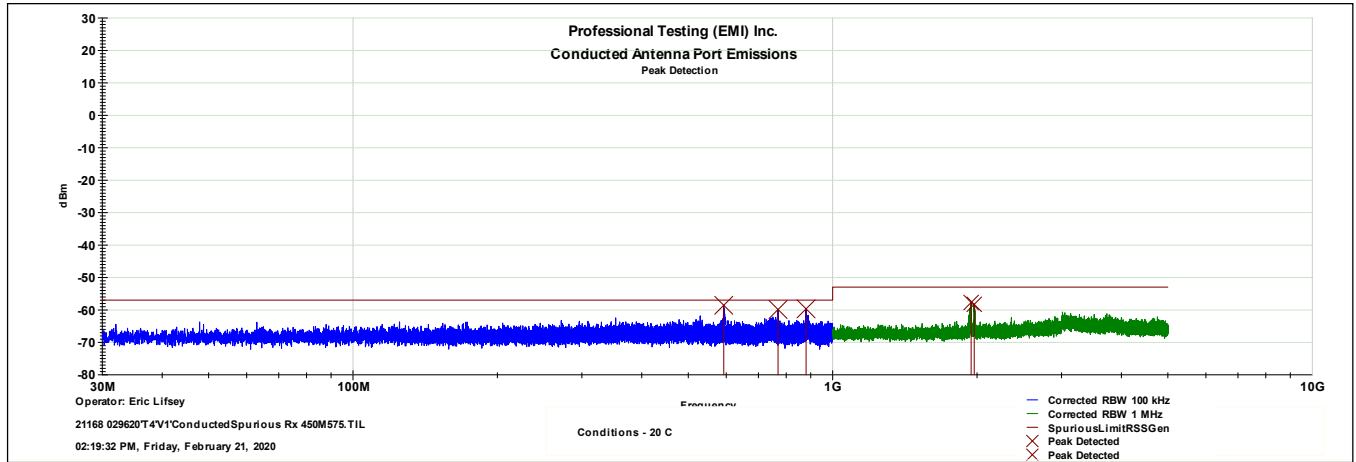


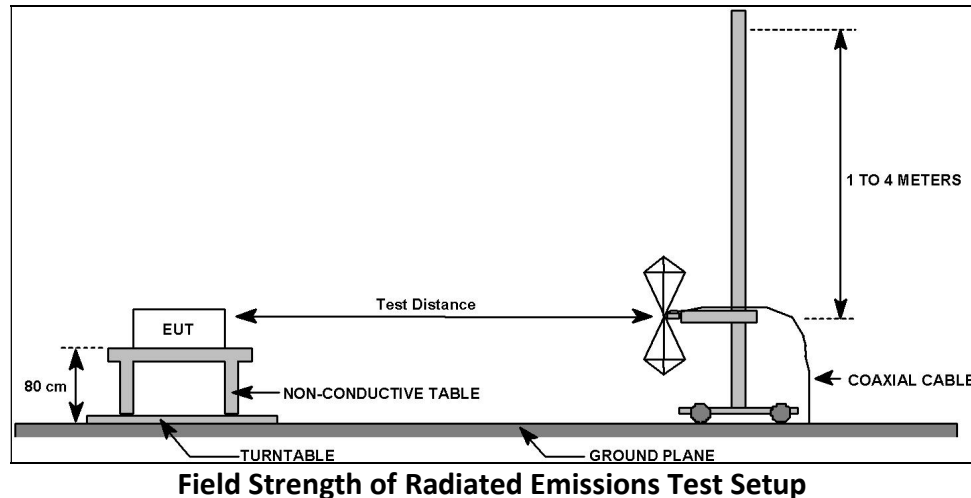
Table 4.3.2.1 Receive Mode, Tabular Results

Frequency MHz	Corrected Level dBm	Limit dBm
592.812	-58.6	-57
769.443	-59.9	-57
880.084	-59.7	-57
1944.000	-57.7	-53
1973.000	-58.3	-53

5.0 Field Strength of Radiated Spurious Emissions

5.1 Procedure

The EUT was placed on a non-conductive table above the ground plane. The table was centered on a rotating turntable. Measurement antennas were placed at 10 and 3 meters respectively for below 1 GHz and above 1 GHz measurements. EUT height above ground was 80 cm and 150 cm respectively for below 1 GHz and above 1 GHz measurements. The EUT was placed into transmit mode with the antenna removed and a resistive terminator substituted.



5.2 Criteria

Parameter	Section Number	Date
Field Strength of Radiated Emissions 30 MHz to 5 GHz	90.210, 15.209, 2.1053 RSS-119 Issue 12, 5.8; RSS-Gen Issue 4	17 Jan 2020

5.3 Results

Conducted limit for Part 90.210(d) is -20 dBm.

Highest recorded spurious emission: 58.118 dB μ V/m @ 3 m on 3284.01 MHz.

The EUT satisfied the requirement.

5.3.1 Transmit Mode, Below 1 GHz, Bottom Channel

Professional Testing, EMI, Inc.								
Test Method:		ANSI C63.26 2015						
In accordance with:		ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;						
Section:		Spurious Emissions						
Test Date(s):		2/17/2020			EUT Serial #:		0	
Customer:		LRS			EUT Part #:		None	
Project Number:		21168			Test Technician:		Eric Lifsey	
Purchase Order #:		0			Supervisor:		Shakil Murad	
Equip. Under Test:		TX-7471			Witness' Name:		N/A	
Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		120 VAC			EUT Power Frequency:		60 Hz	
Antenna Orientation:		Vertical			Frequency Range:		30MHz to 1GHz	
EUT Mode of Operation:					Transmit 434 MHz			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
868.019	10	259	2.07	Quasi-peak	35.856	67.0	-31.1	Pass
Professional Testing, EMI, Inc Radiated Emissions 30MHz - 1GHz Vertical Polarity Measured Emissions Legend: — FCC Peak Limit — FCC Quasi-peak Limit — Ambient Scan — Pre-scan Emissions — Peak Reading — Quasi-peak Reading — LPRF Verification Limit — Verified LPRF QP Reading — ETSI 224 TX Spurious Operator: Eric Lifsey Current Time -11:33:51 AM, Friday, January 17, 2020 Mode: TX 434M000 Pwr 38 (filter mod) Power: 120/60 Height(GHz): 1.5m Notes: Modulation 2GFSK, Mask D limit 67dBμV/m@10m EUT: TX-7471 Project Number: 21168 Client: LRS								
≤ 1GHz Vertical Antenna Polarity Measured Emissions								

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 0

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Eric Lifsey

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: 30MHz to 1GHz

EUT Mode of Operation:

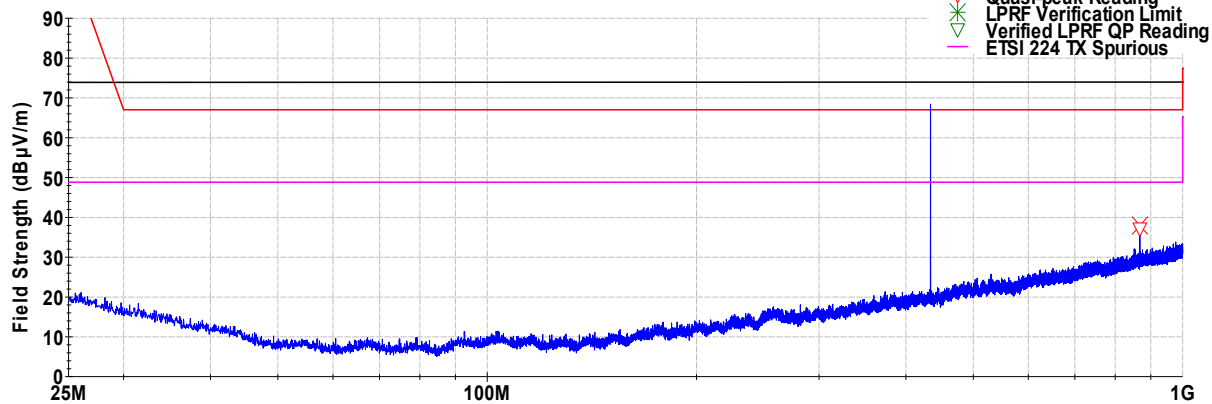
Transmit 434 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
867.998	10	93	1.35	Quasi-peak	37.159	67.0	-29.8	Pass

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Current Time -11:37:21 AM, Friday, January 17, 2020

Mode: TX 434M000 Pwr 38 (filter mod)

Power: 120/60 Height(GHz): 1.5m

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

EUT: TX-7471

Project Number: 21168

Client: LRS

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.2 Transmit Mode, Above 1 GHz, Bottom Channel

Professional Testing, EMI, Inc.								
Test Method:		ANSI C63.26 2015						
In accordance with:		ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;						
Section:		Spurious Emissions						
Test Date(s):		2/17/2020			EUT Serial #:		0	
Customer:		LRS			EUT Part #:		None	
Project Number:		21168			Test Technician:		Eric Lifsey	
Purchase Order #:		0			Supervisor:		Shakil Murad	
Equip. Under Test:		TX-7471			Witness' Name:		N/A	
Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		120 VAC			EUT Power Frequency:		60 Hz	
Antenna Orientation:		Vertical			Frequency Range:		Above 1GHz	
EUT Mode of Operation:					Transmit 434 MHz			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3905.86	3	338	1.63	Peak	49.529	74.0	-24.5	Pass
Professional Testing, EMI, Inc Radiated Emissions 1-18GHz Vertical Polarity Measured Emissions — FCC Peak Limit — ETSI Peak Limit — Ambient Scan — Pre-scan Emissions △ Peak Reading ▽ Average Reading — ETSI 224 TX Spurious Operator: Eric Lifsey Current Time -04:29:36 PM, Friday, January 17, 2020 Mode: TX 434M000 Pwr 38 (filter mod) Power: 120/60 Height(GHz): 1.5m Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m EUT: TX-7471 Project Number: 21168 Client: LRS								
> 1GHz Vertical Antenna Polarity Measured Emissions								

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 0

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Eric Lifsey

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: Above 1GHz

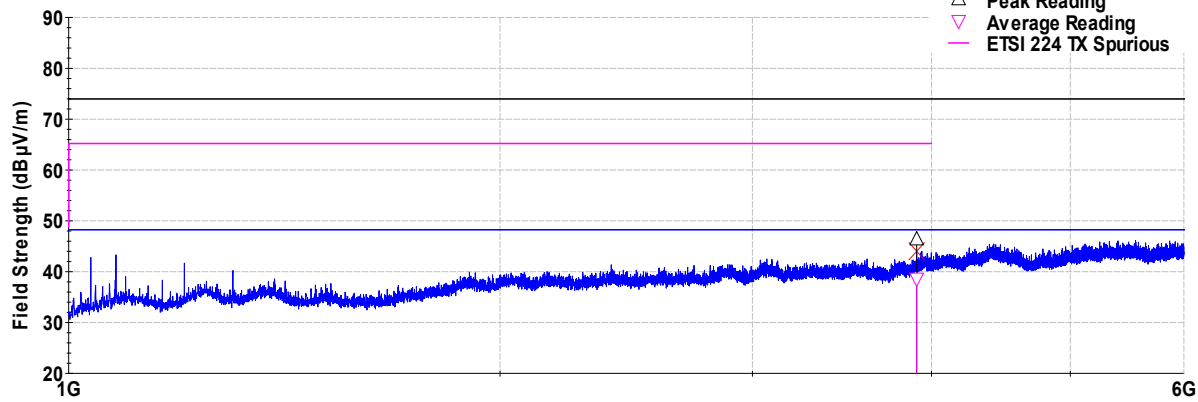
EUT Mode of Operation:
Transmit 434 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3905.89	3	64	1.02	Peak	46.372	74.0	-27.6	Pass

Professional Testing, EMI, Inc

Radiated Emissions

1-18GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 434M000 Pwr 38 (filter mod)

EUT: TX-7471

Current Time -04:32:17 PM, Friday, January 17, 2020

Power: 120/60 Height(GHz): 1.5m

Project Number: 21168

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

Client: LRS

> 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.3 Transmit Mode, Below 1 GHz, Middle Channel

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 1901665415

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Sergio Gutierrez

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power: 60 Hz

Antenna Orientation: Vertical

Frequency Range: 30MHz to 1GHz

EUT Mode of Operation:

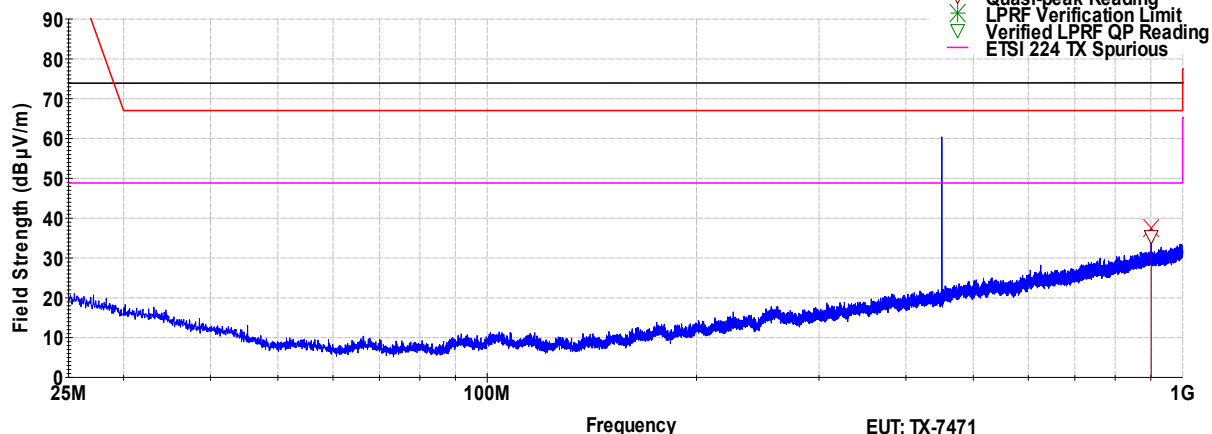
Transmit 450.575 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
901.152	10	340	3.91	Quasi-peak	35.43	67.0	-31.6	Pass

Professional Testing, EMI, Inc.

Radiated Emissions

30MHz - 1GHz Vertical Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 450M575 Pwr 38 (filter mod)

EUT: TX-7471

Power: 120/60 Height: 1.5m

Project Number: 21168

Current Time -02:13:49 PM, Friday, January 17, 2020

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

Client: LRS

≤ 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 1901665415

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Sergio Gutierrez

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: 30MHz to 1GHz

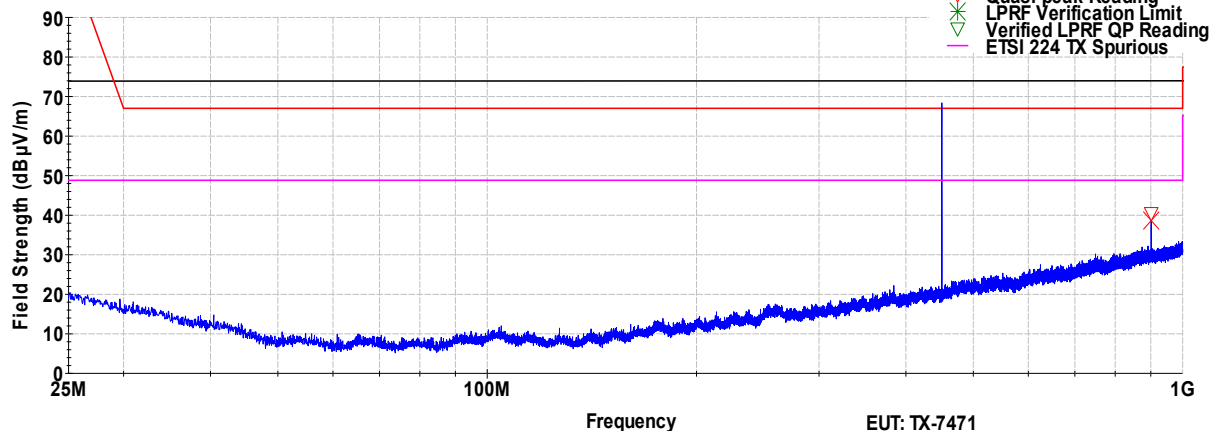
EUT Mode of Operation:
Transmit 450.575 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
901.131	10	33	1.02	Quasi-peak	40.493	67.0	-26.5	Pass

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 450M575 Pwr 38 (filter mod)

EUT: TX-7471

Project Number: 21168

Current Time -01:53:15 PM, Friday, January 17, 2020

Power: 120/60 HeightGHz: 1.5m

Client: LRS

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.4 Transmit Mode, Above 1 GHz, Middle Channel

Test Method:		ANSI C63.26 2015						
In accordance with:		ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;						
Section:		Spurious Emissions						
Test Date(s):		2/17/2020			EUT Serial #:		1901665415	
Customer:		LRS			EUT Part #:		None	
Project Number:		21168			Test Technician:		Sergio Gutierrez	
Purchase Order #:		0			Supervisor:		Shakil Murad	
Equip. Under Test:		TX-7471			Witness' Name:		N/A	

Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		120 VAC		EUT Power		60 Hz		
Antenna Orientation:		Vertical		Frequency Range:		Above 1GHz		
EUT Mode of Operation:				Transmit 450.575 MHz				
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3153.92	3	152	2.54	Peak	57.162	74.0	-16.8	Pass

Professional Testing, EMI, Inc
Radiated Emissions
1-18GHz Vertical Polarity Measured Emissions

— FCC Peak Limit
— ETSI Peak Limit
— Ambient Scan
— Pre-scan Emissions
△ Peak Reading
▽ Average Reading
— ETSI 224 TX Spurious

Field Strength (dBμV/m)

Frequency

EUT: TX-7471

Operator: Eric Lifsey

Mode: TX 450M575 Pwr 38 (filter mod)

Project Number: 21168

Power: 120/60 HeightGHz: 1.5m

Current Time -04:15:24 PM, Friday, January 17, 2020

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

Client: LRS

> 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 1901665415

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Sergio Gutierrez

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: Above 1GHz

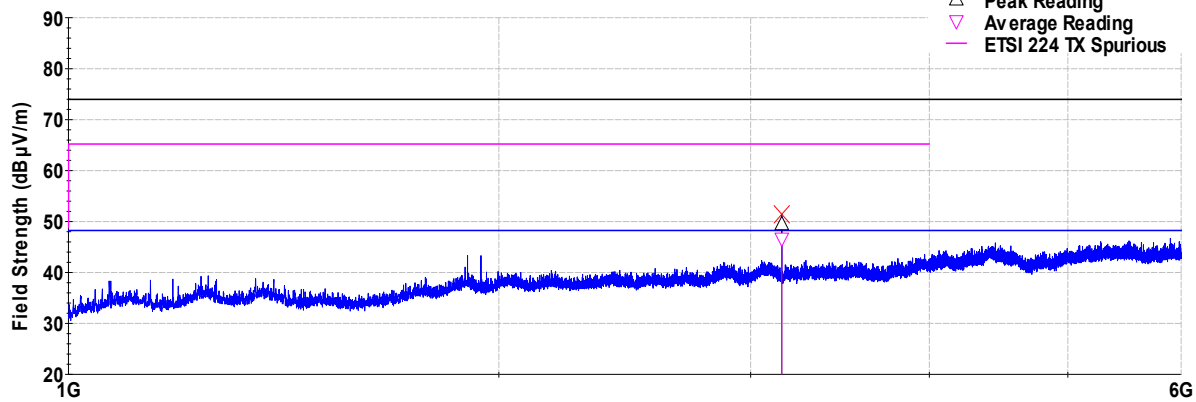
EUT Mode of Operation:
Transmit 450.575 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3154.19	3	140	1.26	Peak	49.491	74.0	-24.5	Pass

Professional Testing, EMI, Inc

Radiated Emissions

1-18GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 450M575 Pwr 38 (filter mod)

EUT: TX-7471

Current Time -04:18:45 PM, Friday, January 17, 2020

Power: 120/60 HeightGHz: 1.5m

Project Number: 21168

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

Client: LRS

> 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.5 Transmit Mode, Below 1 GHz, Top Channel

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 0

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Eric Lifsey

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power: 60 Hz

Antenna Orientation: Vertical

Frequency Range: 30MHz to 1GHz

EUT Mode of Operation:

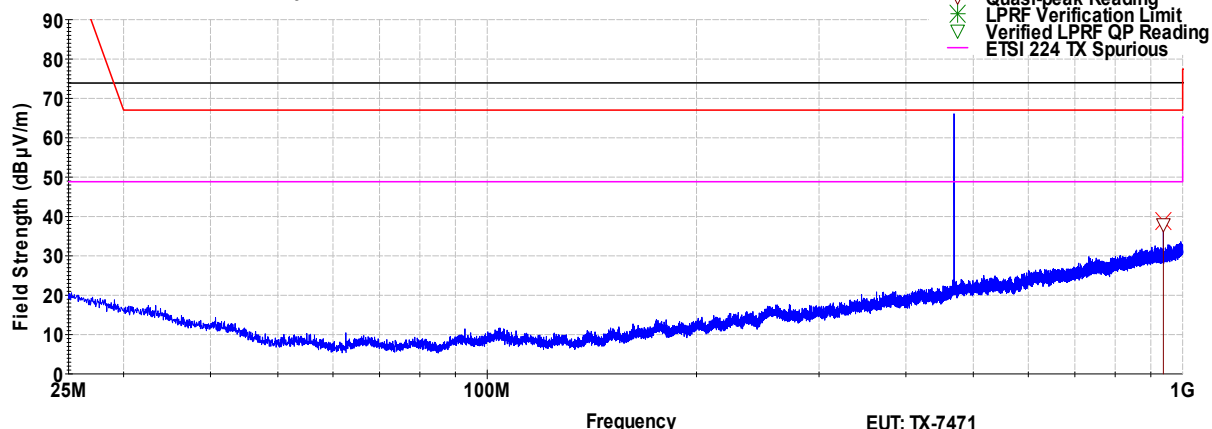
Transmit 469.150 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
938.3	10	59	1.86	Quasi-peak	37.987	67.0	-29.0	Pass

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Vertical Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 469M150 Pwr 38 (filter mod)

EUT: TX-7471

Current Time -02:59:57 PM, Friday, January 17, 2020

Power: 120/60 Heigh(GHz): 1.5m

Project Number: 21168

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m@10m

Client: LRS

≤ 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 0

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Eric Lifsey

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: 30MHz to 1GHz

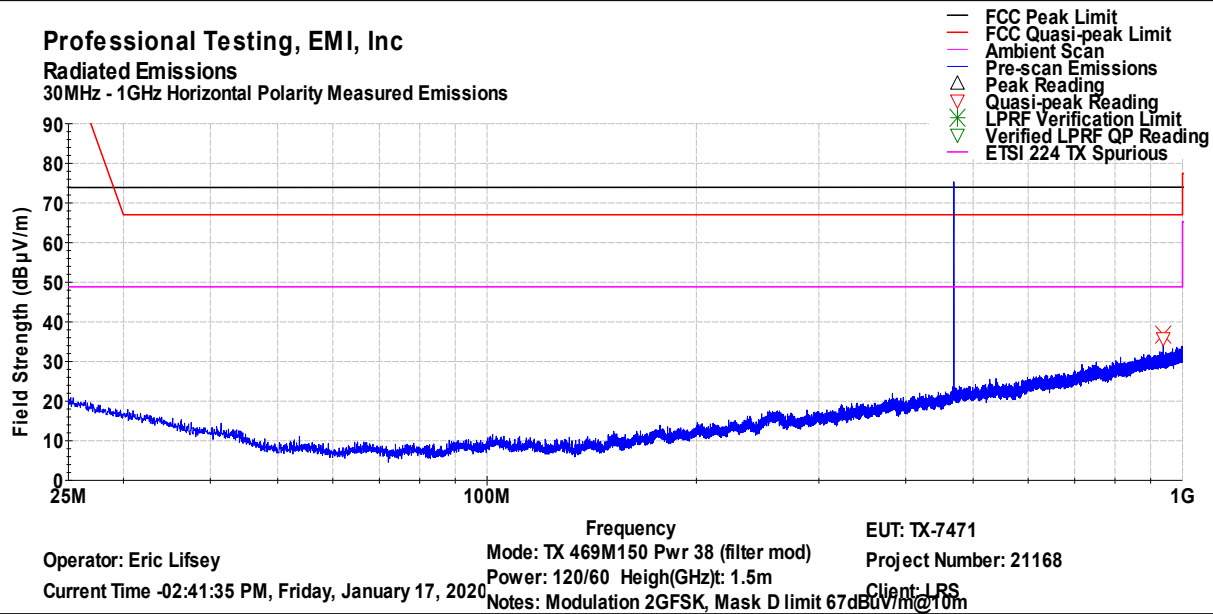
EUT Mode of Operation:
Transmit 469.150 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
938.298	10	97	1.02	Quasi-peak	35.823	67.0	-31.2	Pass

Professional Testing, EMI, Inc

Radiated Emissions

30MHz - 1GHz Horizontal Polarity Measured Emissions



≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.6 Transmit Mode, Above 1 GHz, Top Channel

Professional Testing, EMI, Inc.								
Test Method:		ANSI C63.26 2015						
In accordance with:		ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;						
Section:		Spurious Emissions						
Test Date(s):		2/17/2020			EUT Serial #:		0	
Customer:		LRS			EUT Part #:		None	
Project Number:		21168			Test Technician:		Eric Lifsey	
Purchase Order #:		0			Supervisor:		Shakil Murad	
Equip. Under Test:		TX-7471			Witness' Name:		N/A	
Radiated Emissions Test Results Data Sheet								
EUT Line Voltage:		120 VAC			EUT Power Frequency:		60 Hz	
Antenna Orientation:		Vertical			Frequency Range:		Above 1GHz	
EUT Mode of Operation:					Transmit 469.150 MHz			
Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3284.01	3	162	2.38	Peak	58.118	74.0	-15.9	Pass
Professional Testing, EMI, Inc Radiated Emissions 1-18GHz Vertical Polarity Measured Emissions — FCC Peak Limit — ETSI Peak Limit — Ambient Scan — Pre-scan Emissions △ Peak Reading ▽ Average Reading — ETSI 224 TX Spurious Operator: Eric Lifsey Current Time -03:48:05 PM, Friday, January 17, 2020 Mode: TX 469M150 Pwr 38 (filter mod) Power: 120/60 Heigh(GHz): 1.5m Notes: Modulation 2GFSK, Mask D limit 67dBμV/m@10m EUT: TX-7471 Project Number: 21168 Client: LRS								
> 1GHz Vertical Antenna Polarity Measured Emissions								

Professional Testing, EMI, Inc.

Test Method: ANSI C63.26 2015

In accordance with: ANSI C63.26 American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services;

Section: Spurious Emissions

Test Date(s): 2/17/2020

EUT Serial #: 0

Customer: LRS

EUT Part #: None

Project Number: 21168

Test Technician: Eric Lifsey

Purchase Order #: 0

Supervisor: Shakil Murad

Equip. Under Test: TX-7471

Witness' Name: N/A

Radiated Emissions Test Results Data Sheet

EUT Line Voltage: 120 VAC

EUT Power Frequency: 60 Hz

Antenna Orientation: Horizontal

Frequency Range: Above 1GHz

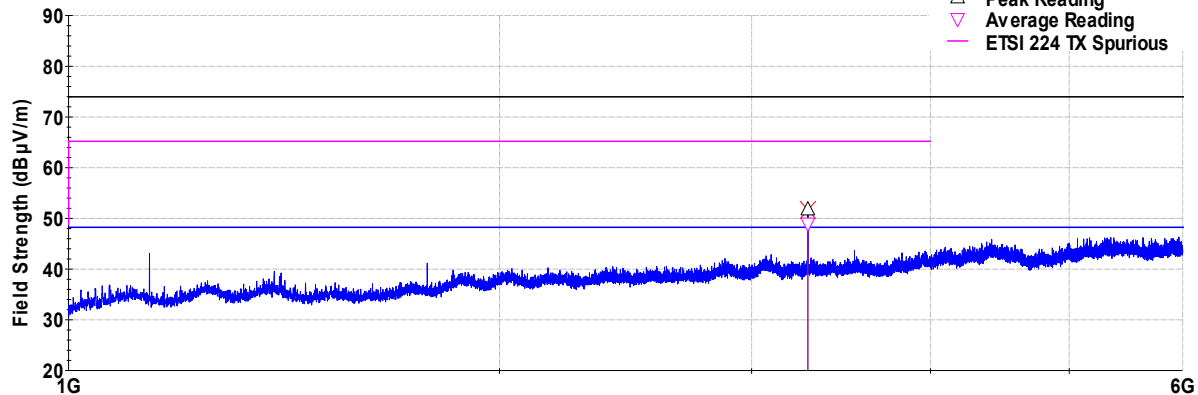
EUT Mode of Operation:
Transmit 469.150 MHz

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Corrected Level (dBμV/m)	Limit Level (dBμV/m)	Margin (dB)	Test Results
3283.95	3	140	1.02	Peak	51.777	74.0	-22.2	Pass

Professional Testing, EMI, Inc

Radiated Emissions

1-18GHz Horizontal Polarity Measured Emissions



Operator: Eric Lifsey

Mode: TX 469M150 Pwr 38 (filter mod)

EUT: TX-7471

Current Time -03:51:27 PM, Friday, January 17, 2020

Power: 120/60 Heigh(GHz)t: 1.5m

Project Number: 21168

Notes: Modulation 2GFSK, Mask D limit 67dBμV/m @ 10m

Client: LRS

> 1GHz Horizontal Antenna Polarity Measured Emissions

6.0 Frequency Stability

6.1 Procedure

The EUT is placed into a temperature chamber with a cable coupling the transmitted signal to a spectrum analyzer. On reaching each set point temperature, the EUT is allowed to soak at least 10 minutes without power applied. After soak time was satisfied, the EUT is powered on in transmit mode and the frequency is observed until it becomes stable; then the measurement of frequency is taken.

6.2 Criteria

Parameter	Section Number	Date
Frequency Stability	90.213 RSS-119 Issue 12, 5.3	6 Feb 2020

Table 6.2.1 Frequency Tolerance

1.5 ppm

Base station 421-512 MHz per 90.213 footnote 7 for 12.5 kHz spacing.:

434.000 MHz * 1.5 = +/- 651.0 Hz

469.150 MHz * 1.5 = +/- 703.7 Hz

Table 6.2.2 Operating Voltages VAC

Low	Nominal	High
102	120	138

Table 6.2.3 Operating Temperatures C

Low	Nominal	High
-30	20	50

6.3 Results

The EUT satisfied the requirement.

6.3.1 Bottom Channel

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	434.000000	434.000188	188
-20	434.000000	434.000156	156
-10	434.000000	434.000048	48
0	434.000000	433.999950	-50
10	434.000000	433.999967	-33
20	434.000000	434.000018	18
30	434.000000	434.000011	11
40	434.000000	433.999971	-29
50	434.000000	433.999786	-214

Max Deviation (Hz)	188
Min Deviation (Hz)	-214

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	102	434.000000	434.000059	59
Nominal	120	434.000000	434.000051	51
High	138	434.000000	434.000071	71

6.3.2 Middle Channel

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	450.575000	450.575218	218
-20	450.575000	450.575164	164
-10	450.575000	450.575143	143
0	450.575000	450.575049	49
10	450.575000	450.575031	31
20	450.575000	450.575106	106
30	450.575000	450.575067	67
40	450.575000	450.575007	7
50	450.575000	450.574870	-130

Max Deviation (Hz)	218
Min Deviation (Hz)	-130

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	102	450.575000	450.575089	89
Nominal	120	450.575000	450.575091	91
High	138	450.575000	450.575088	88

6.3.3 Top Channel

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	469.150000	469.150190	190
-20	469.150000	469.150217	217
-10	469.150000	469.150141	141
0	469.150000	469.150088	88
10	469.150000	469.150023	23
20	469.150000	469.150124	124
30	469.150000	469.150087	87
40	469.150000	469.150033	33
50	469.150000	469.149962	-38

Max Deviation (Hz)	217
Min Deviation (Hz)	-38

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V AC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	102	469.150000	469.150081	81
Nominal	120	469.150000	469.150061	61
High	138	469.150000	469.150072	72

7.0 Transmit Frequency Behavior

7.1 Procedure

The EUT was tested for transient frequency behavior using the test method outlined in TIA/EIA-603-E paragraph 2.2.19.3 Alternate Method of Measurement (Using a Test Receiver).

The EUT is terminated with a suitable resistive attenuator with the output connected to a forward power coupler. The coupler forward output (-10 dB) is run through a detector diode then to the trigger input port of a digital oscilloscope. The RF pass-through output of the coupler is then run to a 3 port resistive power combining network; the #2 port of the combiner is connected to the output of a RF signal generator, the #3 port is used as output and connected to a test receiver (modulation analyzer). The detected output of the modulation analyzer is connected to the vertical input of the digital oscilloscope.

The RF generator is set to the fundamental operating frequency, set to modulate with a 1 kHz tone at +/- 25 kHz FM deviation (or other standard channel deviation), and at a relatively low but usable level where the modulation analyzer is able to demodulate the signal. The modulation analyzer is configured to use the high and low pass filter settings as called out in the TIA-603-C procedure. The modulation analyzer is then dialed via front panel keypad to the fundamental operating frequency for best sensitivity.

The transmitter is keyed as needed and adjustments are made to the instruments to trigger appropriately and render the measurement as required by the TIA-603-C standard. The essential technique is the signal generator provides a reference frequency captured by the modulation analyzer. When the EUT is keyed, at many dB above the signal generator level, the modulation analyzer locks to the EUT signal and deviation from center frequency can be observed and recorded on the digital oscilloscope.

7.2 Criteria

Parameter	Section Reference	Date
Transient Frequency Behavior	90.214 RSS-119 Issue 12, 5.9 Procedure: TIA-603-E	18 Feb 2020

Transmitters for the applicable frequency bands must confine transient frequencies to limits shown:

Time intervals ^{1,2}	Maximum frequency difference ³	All equipment	
		150 to 174 MHz	421 to 512 MHz
Transient Frequency Behavior for Equipment Designed to Operate on 25 kHz Channels			
t ₁ ⁴	±25.0 kHz	5.0 ms	10.0 ms
t ₂	±12.5 kHz	20.0 ms	25.0 ms
t ₃ ⁴	±25.0 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 12.5 kHz Channels			
t ₁ ⁴	±12.5 kHz	5.0 ms	10.0 ms
t ₂	±6.25 kHz	20.0 ms	25.0 ms
t ₃ ⁴	±12.5 kHz	5.0 ms	10.0 ms
Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels			

t_1^4	± 6.25 kHz	5.0 ms	10.0 ms
t_2	± 3.125 kHz	20.0 ms	25.0 ms
t_3^4	± 6.25 kHz	5.0 ms	10.0 ms

¹_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

t_1 is the time period immediately following t_{on} .

t_2 is the time period immediately following t_1 .

t_3 is the time period from the instant when the transmitter is turned off until t_{off} .

t_{off} is the instant when the 1 kHz test signal starts to rise.

²During the time from the end of t_2 to the beginning of t_3 , the frequency difference must not exceed the limits specified in §90.213.

³Difference between the actual transmitter frequency and the assigned transmitter frequency.

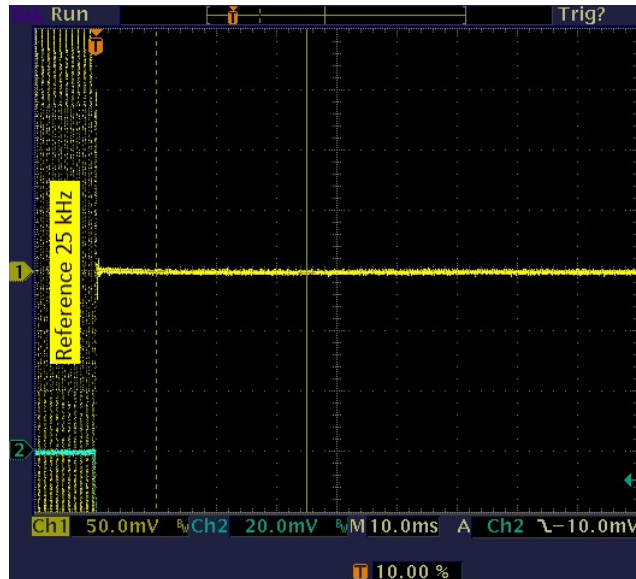
⁴If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

The measurement is performed for the lowest, middle, and highest operating frequency.

7.3 Results

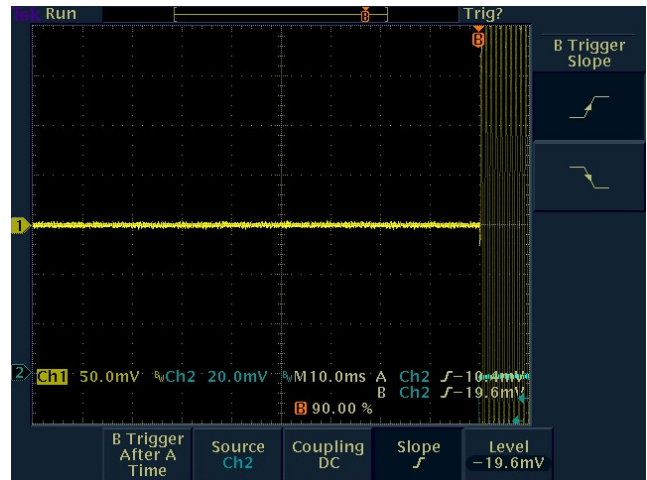
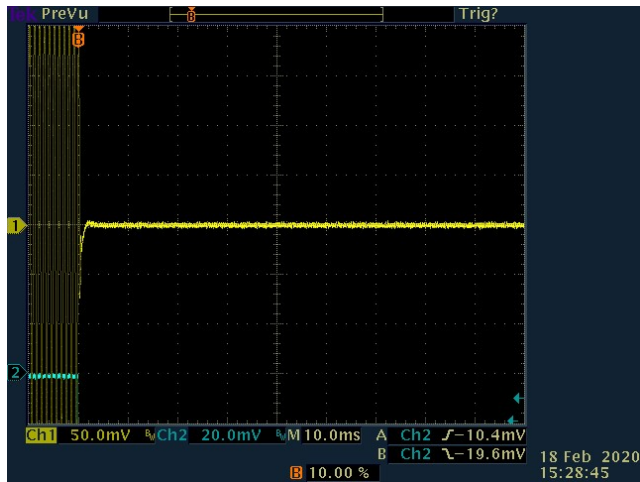
The EUT satisfied the requirement.

The limits were not superimposed on the plots as the transmitter performance was clearly in compliance.

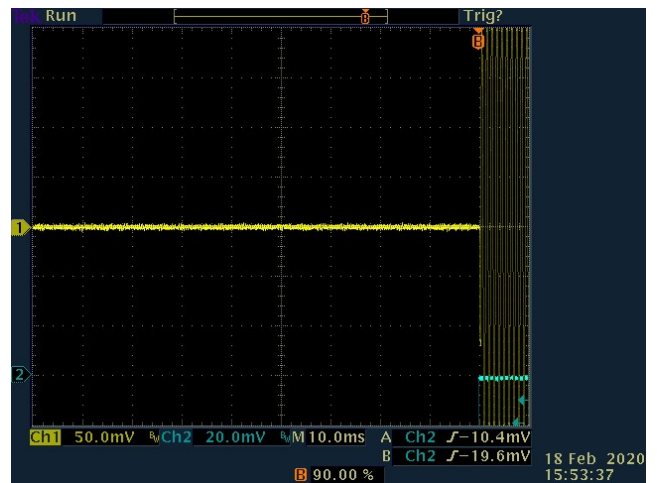
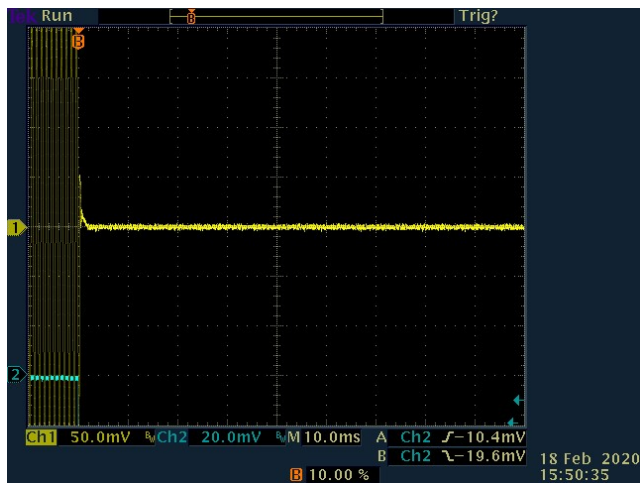


Example Annotated Calibration
(In this case full scale was set using 12.5 kHz deviation.)

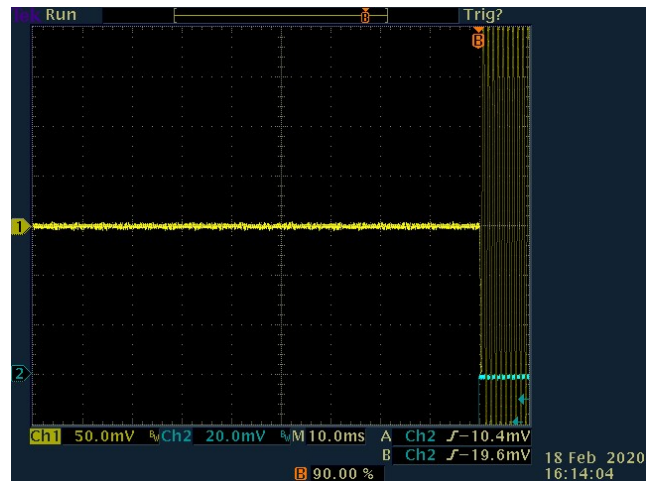
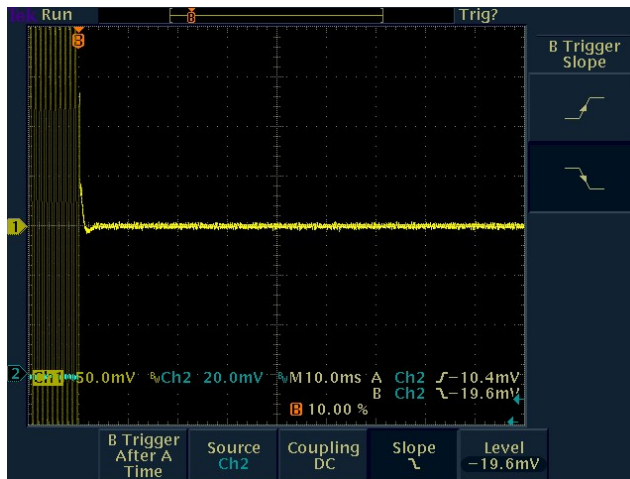
7.3.1 Bottom Channel, Start and Stop



7.3.2 Middle Channel, Start and Stop



7.3.3 Top Channel, Start and Stop



8.0 Emission Bandwidth

8.1 Procedure

The EUT antenna port is coupled to a spectrum analyzer for measurement.

8.2 Criteria

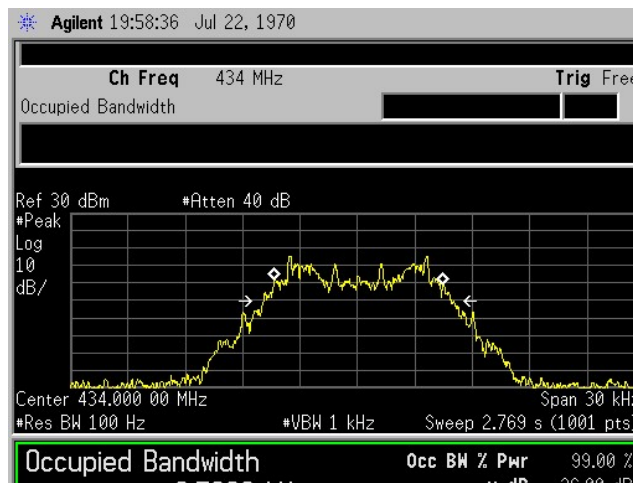
Clause Requirement	Section Number	Date
99% Bandwidth for Reporting	90.210, 90.203(j)(3), 2.1049 RSS-119 Issue 12, 5.5	6 Feb 2020

8.3 Results

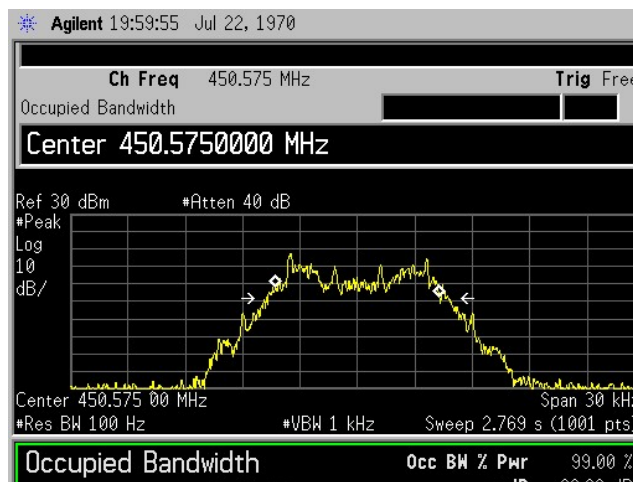
Table 8.3.1 Bandwidth Measurement, 12.5 kHz using 300 Hz RBW		
Channel Frequency MHz	Modulation Method	Measured OBW 99% kHz
434.000	2GFSK	8.79
450.575	2GFSK	8.56
469.150	2GFSK	8.65

Setup is per section 1.7.

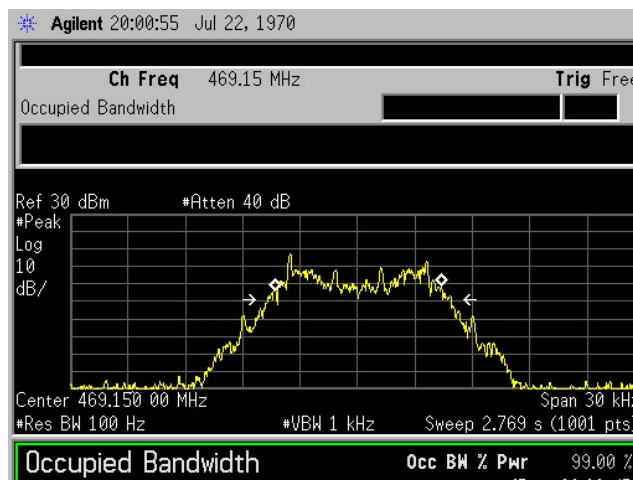
Measurement rounded to 3 significant digits in table above.



Low Channel



Mid Channel



High Channel

9.0 Equipment Lists

9.1 Conducted Power, Conducted Spurious, Mask, and Bandwidth

Asset #	Manufacturer	Model #	Description	Calibration Due
1937	Agilent	E4440A	Spectrum Analyzer	11 Nov 2020
A105	Narda	768A-20	20 dB Attenuator, 20 Watt	23 Mar 2020
C355	Pasternack	RG type	Coaxial Cable, Low Loss, ~5m	30 May 2020
0467	Fluke	077A	DMM	10 Nov 2020

9.2 Frequency Stability

Asset #	Manufacturer	Model #	Description	Calibration Due
1937	Agilent	E4440A	Spectrum Analyzer	11 Nov 2020
A105	Narda	768A-20	20 dB Attenuator, 20 Watt	23 Mar 2020
2134	Tenny	TPS T2C	Temperature Chamber	8 Oct 2020
C355	Pasternack	RG type	Coaxial Cable, double shielded	CNR
0467	Fluke	077A	DMM	10 Nov 2020
1831	HP	6622A	DC Power Supply	CIU
2205	Elgar	5100	AC Power Generator	CIU
2174	Superior Electric	Powerstat	AC Voltage Variable Transformer	CIU

9.3 Transient Frequency Behavior

Asset #	Manufacturer	Model #	Description	Calibration Due
0836	Narda	3293-1	Broadband Directional Coupler	CNR
2228	Tektronix	TDS3034	Oscilloscope, Digital	10 Jul 2020
1816	Agilent	N5181A	Signal Generator	8 Nov 2020
0742	HP	355C	Step Attenuator	CNR
2351	HP	8901B	Modulation Analyzer	CIU
None	Mini-Circuits	ZFRSC-43	3 Port Resistive Divider/Combiner SMA	CNR
A100	Narda	94455-1	Diode Detector	CNR
None	Various	None	RG Type coaxial cables	CNR
None	Various	Unknown	SMA-SMA attenuators, 1 each of: 10 dB	CNR

9.4 Radiated Emissions

Radiated Emissions Test Equipment List					
Tile! Software Version:		Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM			
Test Profile:		2019_May_Unintentional RE_TILE7_v2.5.til			
Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	9/17/2021
1890	HP	8447F-H64	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	1/9/2022
1937	Agilent	E4440A - AYZ	PSA , 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/8/2020
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/11/2021
C027	none	RG214	Cable Coax, N-N, 25m, 25MHz - 1GHz	None	9/9/2020
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	TDK 10M	TDK 10M Chamber,sVSWR > 1 GHz	DAC-012915-005	9/21/2021
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, 100MHz-18GHz	None	1/9/2022
C030	none	none	Cable Coax, N-N, 30m, 1 - 18GHz	None	9/9/2020
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/11/2021

9.5 Measurement Software

Measurement software (TILE V4 or later) as commonly used for power, mask, and conducted measurements is configured at the time of test. The software operation is verified for correct operation by observing the spectrum analyzer screen during operation. The software with its embedded measurement data is archived in the laboratory project folder. The software file name is prefixed by the laboratory project number as referenced in this report. Therefore, the software can be identified unambiguously in the future. This file name appears on the plots presented in this report.

Software for radiated spurious/unintentional measurements is versioned as recorded in the radiated emissions equipment list. This software and its embedded data is also archived in the laboratory project folder.

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

End of Report