Project 19214-15

Hetronic
PA-1
Amplifier Module

410.000 to 475.000 MHz

Wireless Certification Report

FCC Part 90 and IC RSS-119

Prepared for:

Hetronic
3905 NW 36th St.
Oklahoma City, OK 73112
USA

By

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

15 Nov 2017

Reviewed by

Larry Finn
Chief Technical Officer

Written by

Eric Lifsey
EMC Engineer

Revision History

Revision Number	Description	Date
DRAFT 01	Draft for review.	12 Jul 2017
Final 01		15 Nov 2017

Corrections:

None.

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Certificate of Compliance

Applicant	Device & Test Identification	
Hetronic 3905 NW 36th St. Oklahoma City, OK 73112 USA Certificate Date: 15 Nov 2017	FCC ID: IC ID: Model(s): Laboratory Project ID:	LW9-PA1 2119-PA1 PA-1 19214-15

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 IC(Industry Canada)		
Parameter	**FCC**	**IC**
Conducted Output Power	90.210, 2.1046	RSS-119 Issue 12, 5.4
Emission Mask (90.217 power below 120 mW)	90.217, 2.1047	RSS-119 Issue 12, 5.10
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 Fundamental to 5 GHz	90.210, 15.209, 2.1053	RSS-119 Issue 12, 5.8
Transient Frequency Behavior	90.214, ANSI/TIA-603-E	RSS-119 Issue 12, 5.9
Frequency Stability	90.213, 2.1055	RSS-119 Issue 12, 5.3
Occupied Bandwidth, 20 dB, < 11.5 kHz	90.209, 2.1049	RSS-119 Issue 12, 5.5
Radiated Emissions 30 MHz – 5 GHz	15.109	RSS-Gen Issue 4, ICES-003
Zone Enhancer	N/A	RSS-131 Issue 3, 6.4
Operating frequency per licensed channel allocations of:	Part 90	SRSP-510 Issue 5; 410 to 430 MHz and 450 to 460 MHz

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 requirements 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 North America.

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. The methods of TIA/EIA-603 were applied unless specified otherwise in the associated agency rules and procedures.

1.2 EUT Description

The EUT is an amplifier module used in the manufacturer's systems that transmit and receive control codes with associated wireless devices in industrial environments. It receives power from the host system and RF/control from as associated radio module. The EUT supports external antennas, or a cable thereto, attached to the modules SMB connector.

Table 1.2.1 Equipment Under Test

Manufacturer & Description	Model	Serial #
Hetronic Amplifier and Transceiver module for 410 to 475 MHz.	PA-1	none

Table 1.2.2 Options

Manufacturer & Description	Gain	Notes
Hetronic; ¼ wave SMB whip antenna	1 dBi	For use directly on module in RF transparent hosts.
Hetronic; cable extension to TNC-F	NA	Extends modules to external antenna.
Hetronic; ¼ wave TNC-M antenna	4 dBi	External mobile antenna.
RFS 201-7N; fiberglass vertical antenna	7.1 dBi	External fixed-mounted antenna; 450-470 MHz

1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations. It was tested alone with no additional shielding or filtering. It was powered by a linear DC power supply.

These modules are used as a transceiver and optional amplifier pair in portable battery or vehicular powered/fixed applications.

Table 1.3.1 Operating Frequency/Range

Lowest Frequency	Center Frequency	Highest Frequency	Total Frequency Range
410.000 MHz	442.500 MHz	475.000 MHz	65 MHz
The three channels were tested per customary practice for a frequency range exceeding 10 MHz.			

1.4 Modifications to Equipment

No modifications were made to the EUT during the performance of the test program.

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
47 CFR	FCC Part 90
IC RSS-119 Issue 12	Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz
IC RSS-Gen Issue 4	General Requirements for Compliance of Radio Apparatus
IC RSS-131 Issue 3	Zone Enhancers
ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
ANSI/TIA-603-E	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

2.0 Conducted Output Power

2.1 Procedure

The EUT is placed into continuous transmit mode without modulation for peak power measurement.

2.2 Criteria

Parameter	Section Reference	Date
Conducted Output Power	90.210, 2.1046 | RSS-119 Issue 12, 5.4	10 Jul 2017

2.3 Results

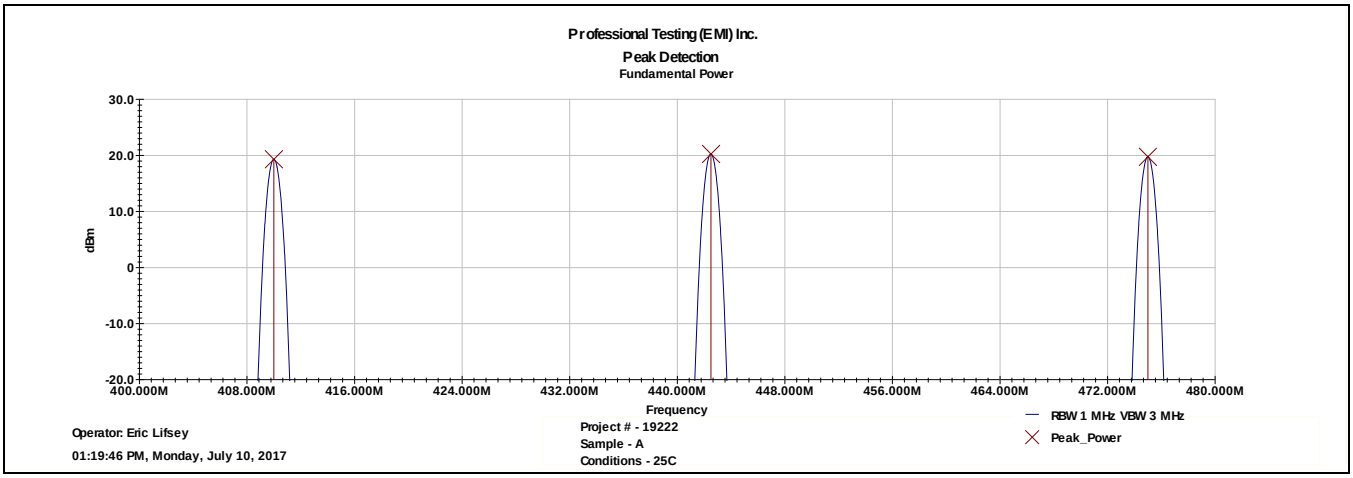
EUT antenna port was directly coupled to the spectrum analyzer without a cable so power was read directly with no factors required.

The EUT satisfied the requirement. Tabular results are presented below.

Table 2.3.1 Power, Peak, Conducted

Frequency (MHz)	Power (dBm)	Power (mW)
410.000	19.3	85.1
442.500	20.3	107.2
475.000	19.7	93.3

The average of power over the channels is approximately 19.8 dBm and serves as the operating specification for other tests.



3.0 Emission Mask

3.1 Procedure

Emissions are measured with peak detector with the mask superimposed on the graph.

3.2 Criteria

Parameter	Section Number	Date
Emissions at Antenna Terminals	90.217(b), 2.1047| RSS-119 Issue 12, 5.10	10 Jul 2017

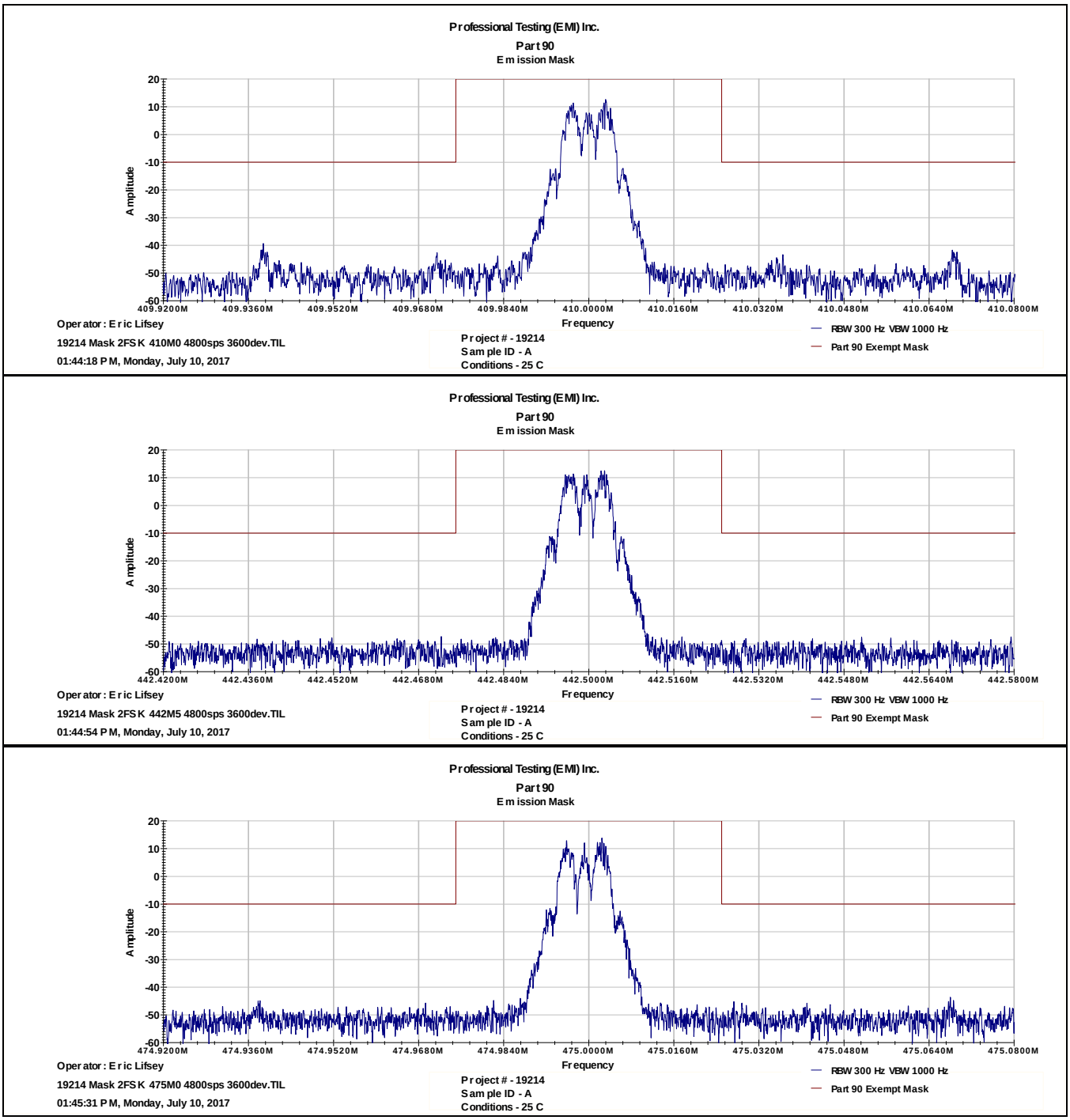
3.3 Results

The emission was measured coupled directly to the analyzer without cabling. The EUT satisfied the requirement.

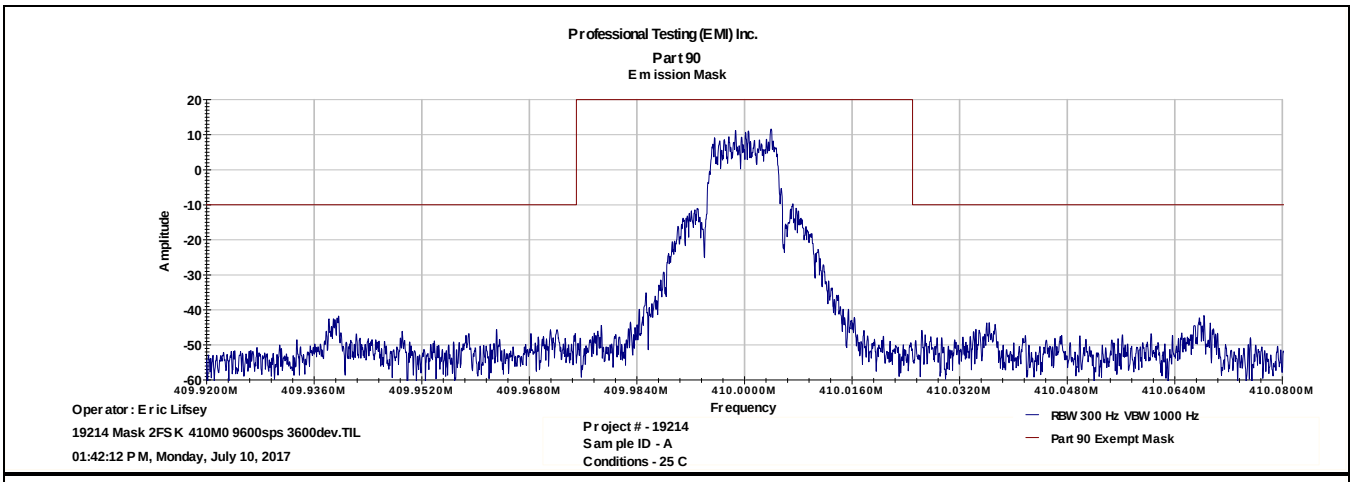
The peak power is below the exemption criteria of 120 mW, therefore the exemption mask of -30 dBc applies in all modulation modes.

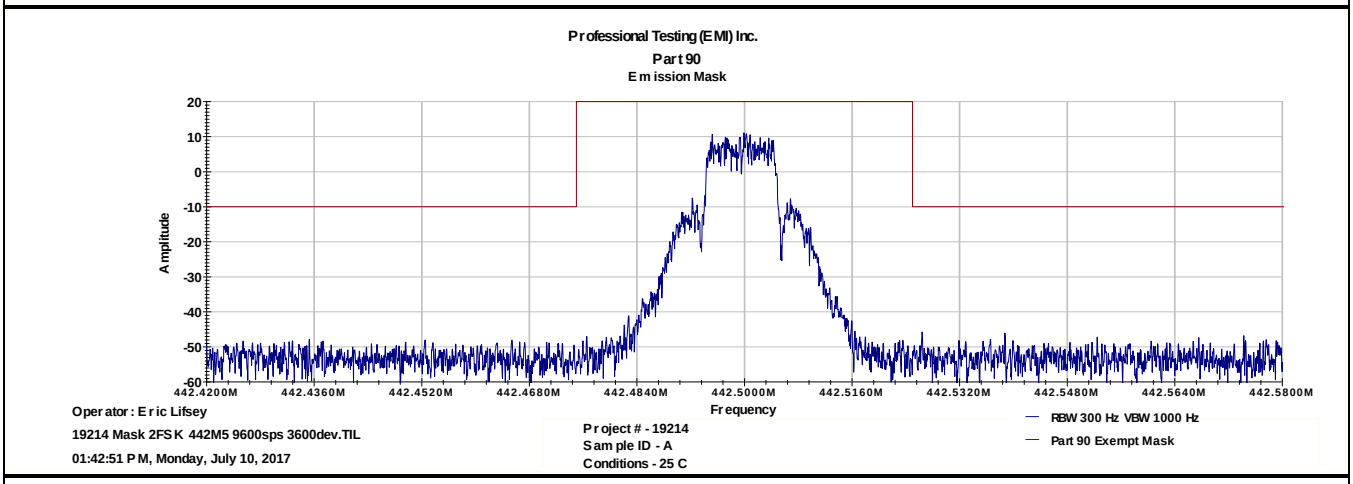
Measurements appear on the following pages.

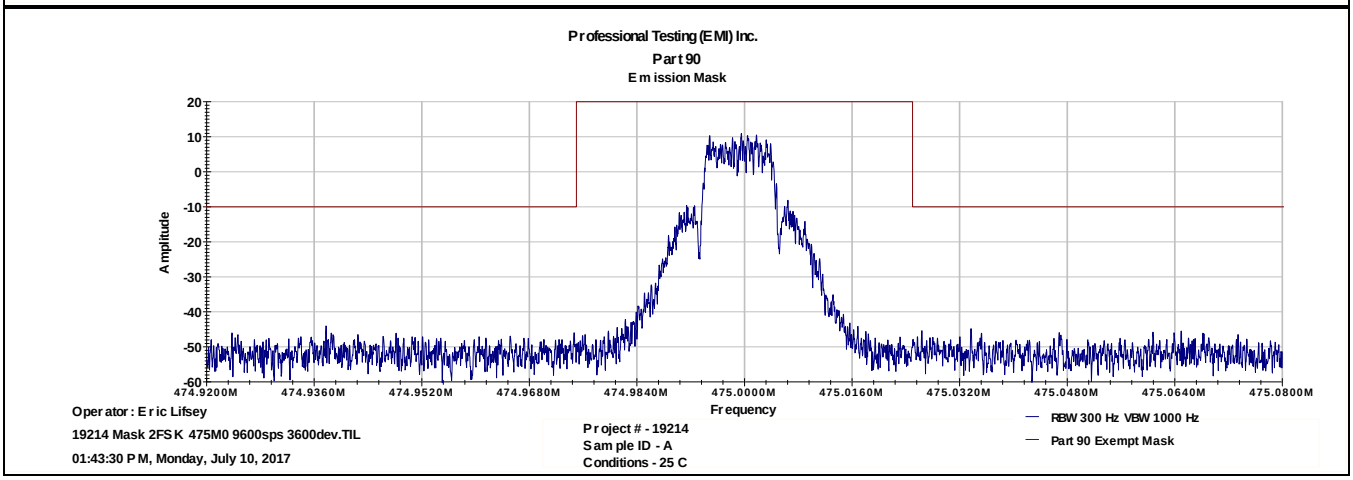
3.3.1 Modulation 2GFSK at 4800 Symbols per Second



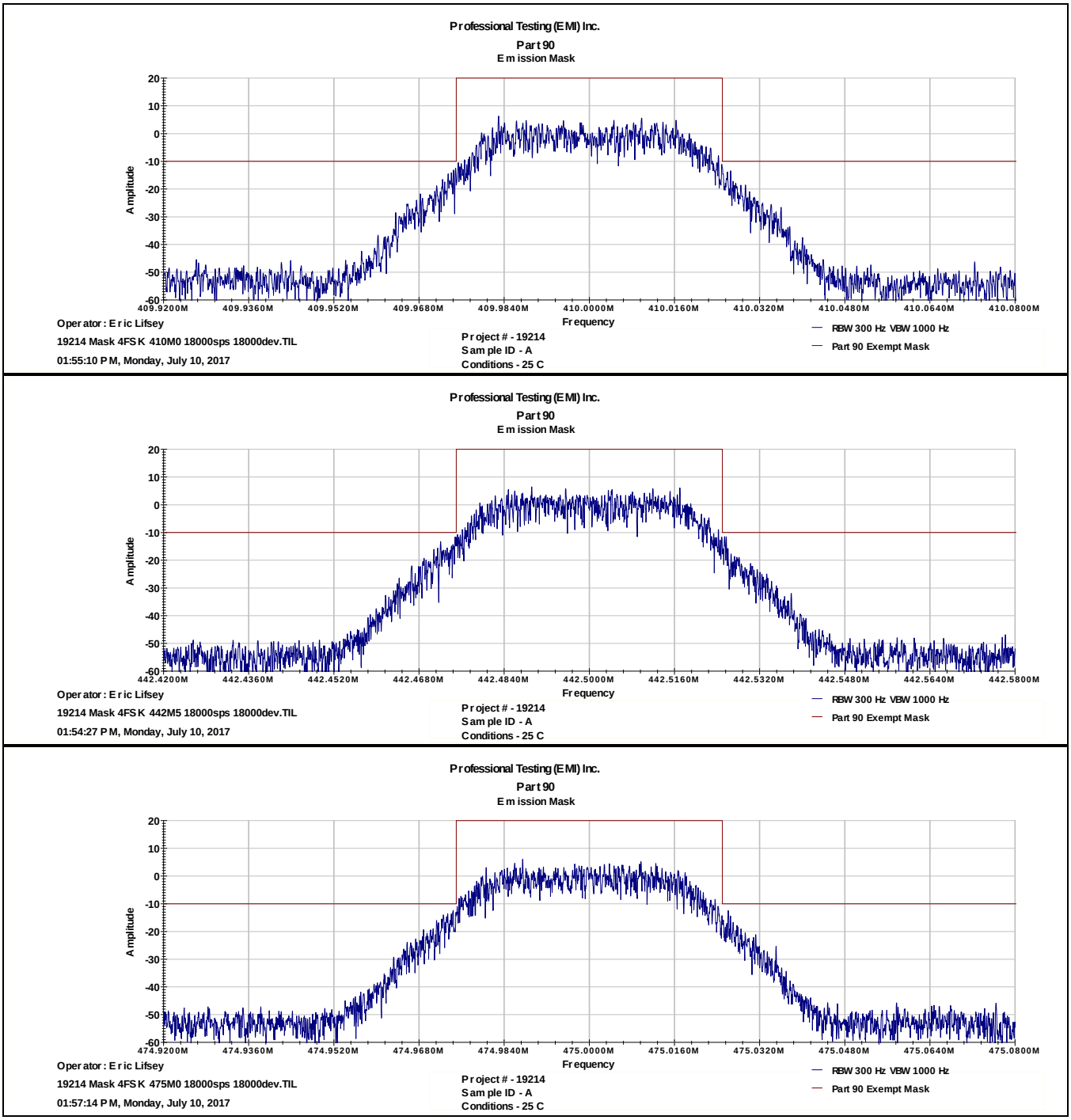
3.3.2 Modulation 2GFSK at 9600 Symbols per Second



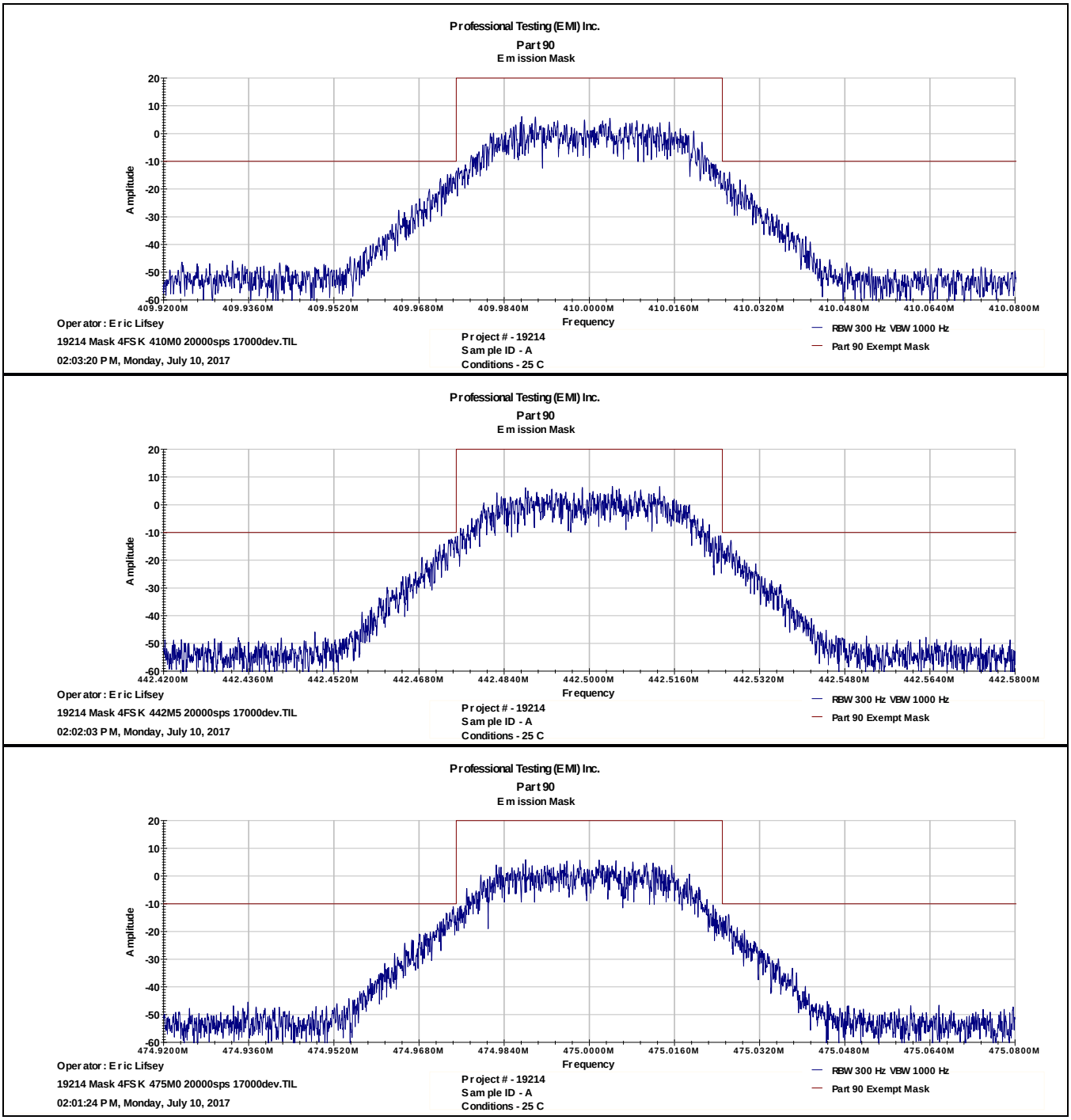




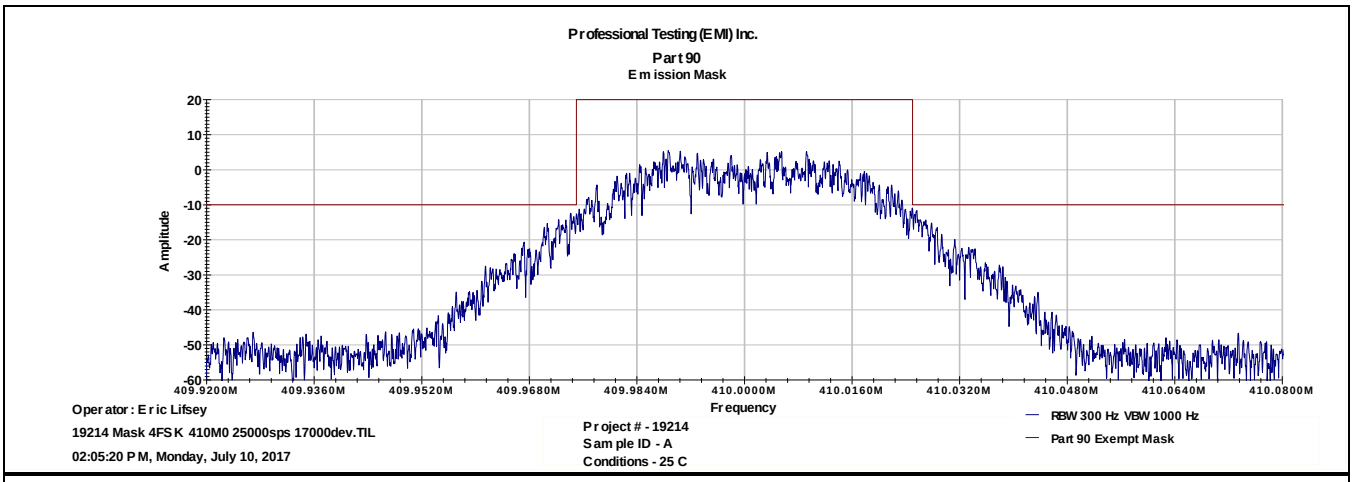
3.3.3 Modulation 4GFSK at 18000 Symbols per Second with 18000 Hz Deviation

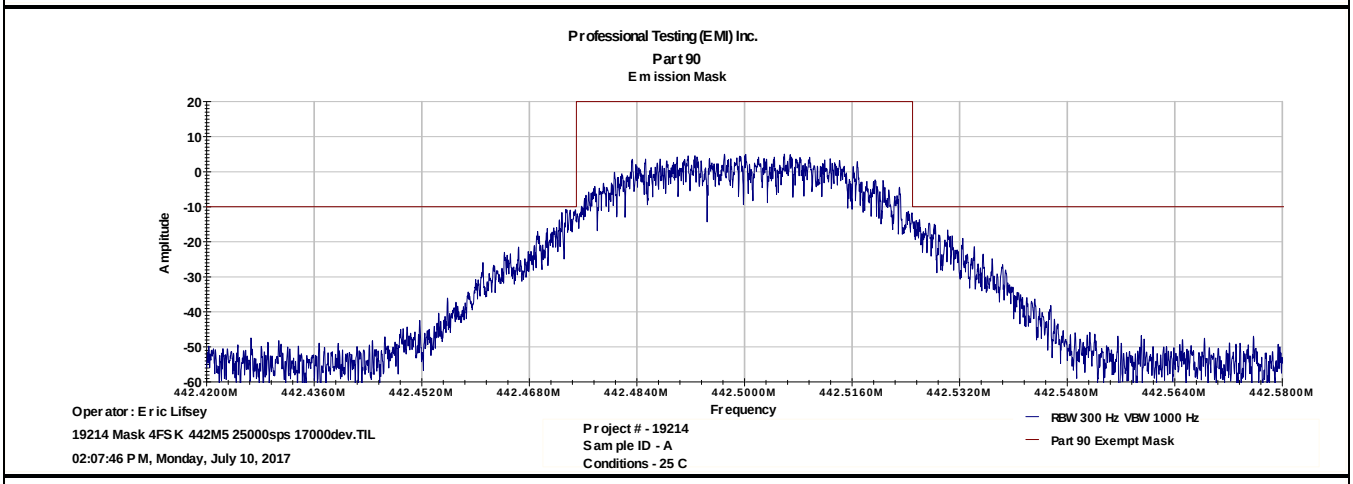


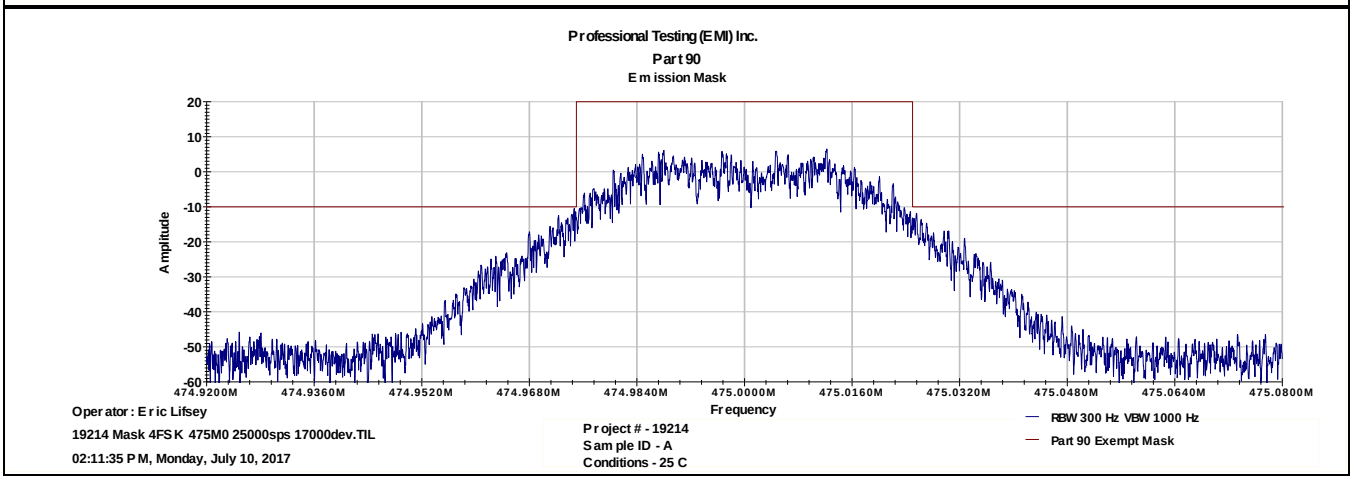
3.3.4 Modulation 4GFSK at 20000 Symbols per Second with 17000 Hz Deviation



3.3.5 Modulation 4GFSK at 25000 Symbols per Second with 17000 Hz Deviation







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. The connection is direct and no cables are used. Spurious signals are then measured directly with no additional calculation required. Emissions are measured with a peak detector function from 9 kHz to 5 GHz to include the tenth harmonic 4.75 GHz.

4.2 Criteria

Parameter	Section Number	Date
Emissions at Antenna Terminals	90.210(b), 2.1047| RSS-119 Issue 12, 5.8	10 Jul 2017

Limit is determined from for emissions beyond 250% of authorized bandwidth.

Per 90.210(c)(3) $\text{Attenuation}_{(dB)} = 43 + 10\ \text{Log}_{10}(0.1072\ \text{W}) = 33.3\ \text{dB}$

$\text{Limit}_{(dBm)} = \text{Fundamental\_Power}_{(dBm)} - \text{Attenuation}_{(dB)} = 20.3\ \text{dBm} - 33.3\ \text{dB} = -13\ \text{dBm}$

4.3 Results

Measurements were performed with a direct connection to the spectrum analyzer such that no external losses or gains would apply. Measurement bandwidth is detailed in the graphs provided.

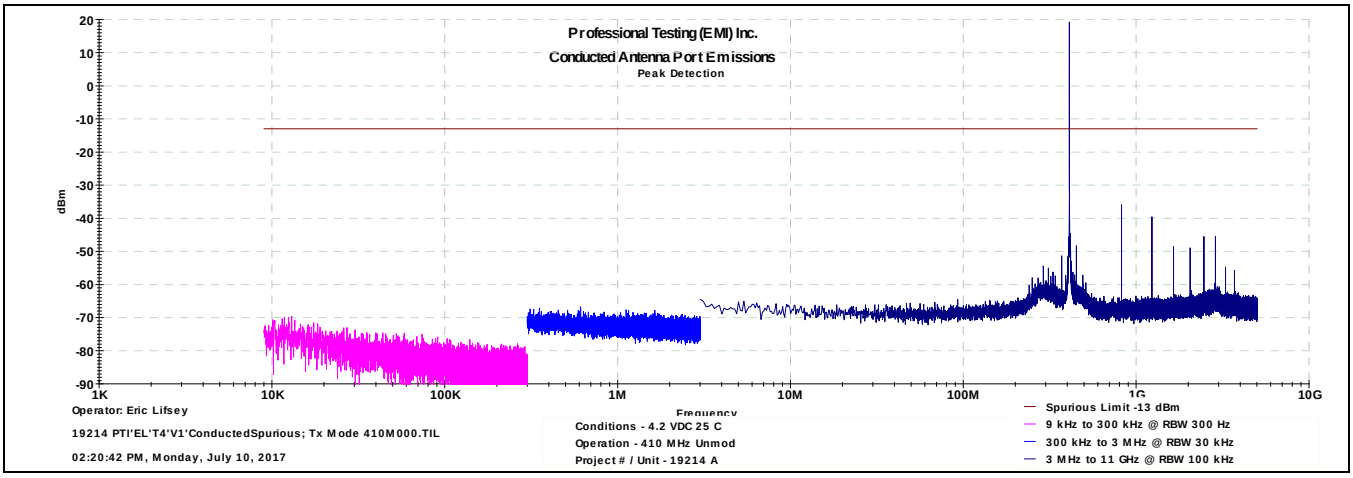
The EUT was found to be in compliance with applicable requirements.

In the plots the licensed emission limit is shown as a solid red line at -13 dBm.

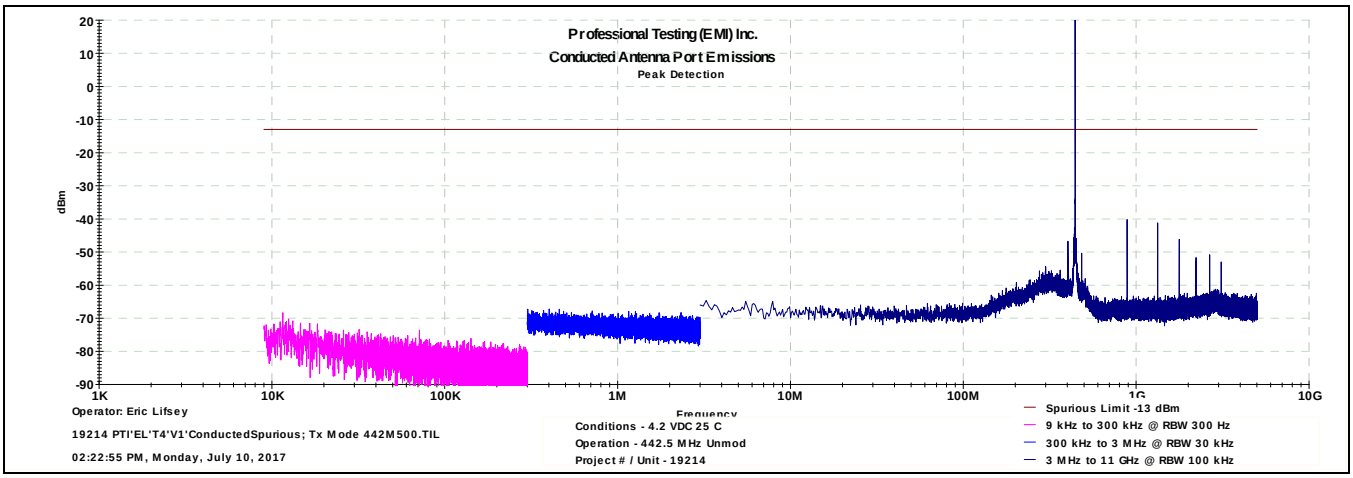
For receive mode the -41 dBm general emission limit is included as a dashed red line.

Measurements appear below.

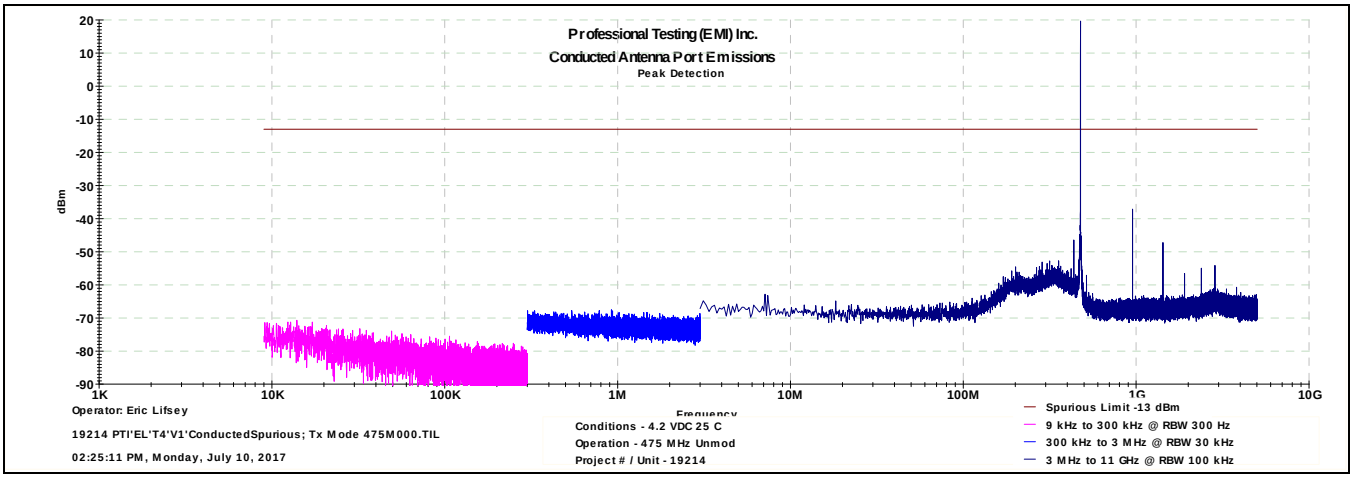
4.3.1 Transmit Mode, Bottom Channel



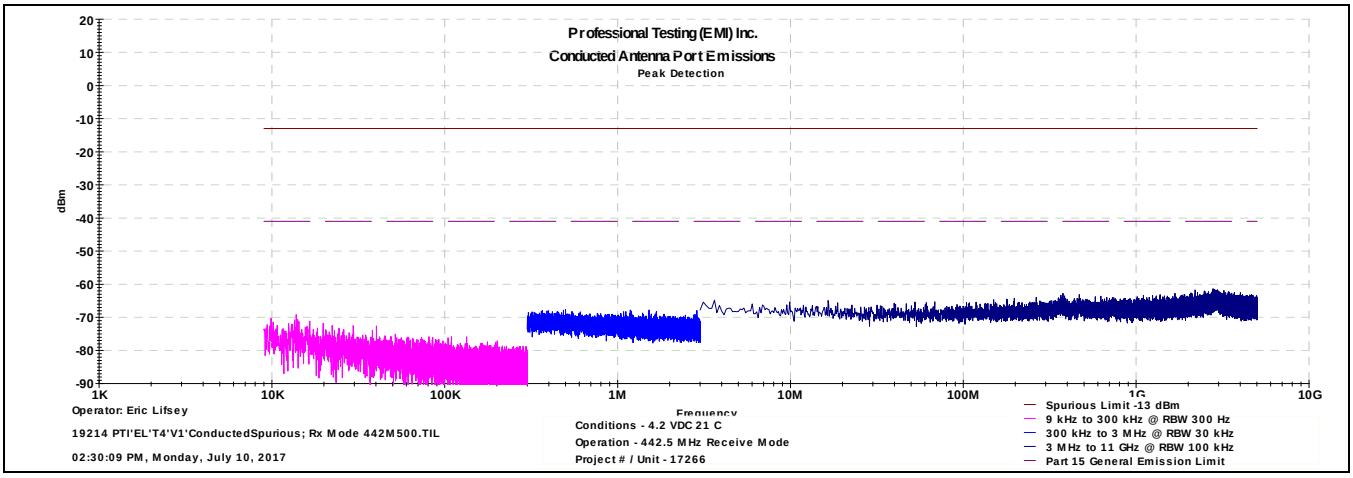
4.3.2 Transmit Mode, Middle Channel



4.3.3 Transmit Mode, Top Channel



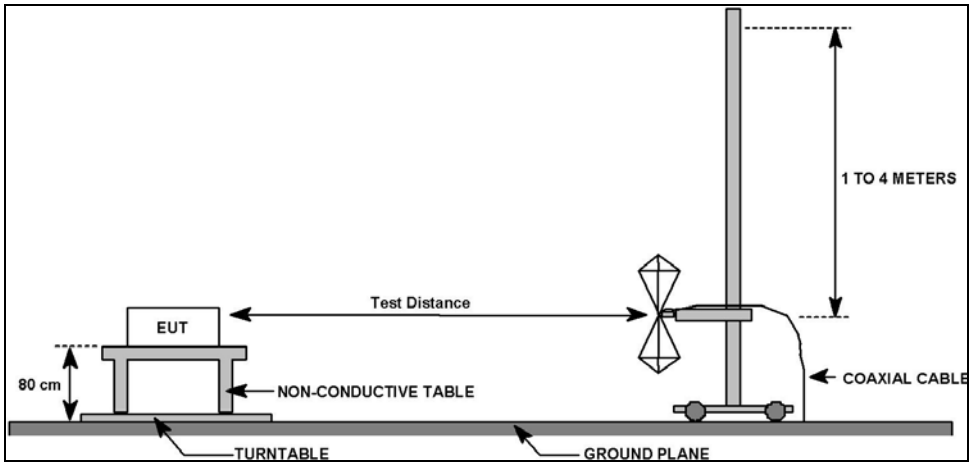
4.3.4 Receive Mode, Middle Channel



5.0 Field Strength of Radiated Spurious Emissions

5.1 Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 10 meters from the measurement antenna. The EUT was placed into transmit mode with the antenna removed and a resistive terminator substituted.



Field Strength of Radiated Emissions Test Setup

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	30 Jun 2017

5.3 Results

The emission limits for the module were determined as follows:

Limit is determined from for emissions beyond 250% of authorized bandwidth.

Per 90.210(c)(3) $Attenuation_{(dB)} = 43 + 10\ Log_{10}(0.1072\ W) = 33.3$ dB

$Limit_{(dBm)} = Fundamental\_Power_{(dBm)} – Attenuation_{(dB)} = 20.3$ dBm – 33.3 dB = -13 dBm

Restated as radiated limits of: 73.9 dBµV/m at 10 meters and 84.4 dBµV/m at 3 meters.

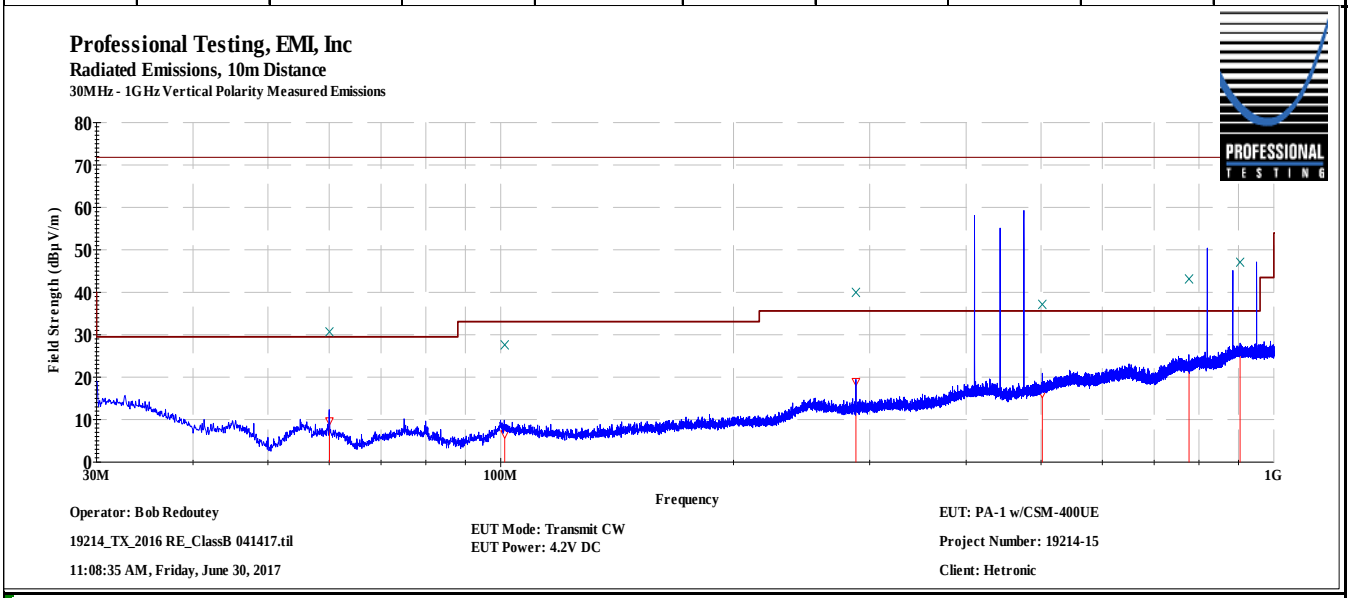
The EUT satisfied the requirement. Measurements appear below.

5.3.1 Transmit Mode, Up to 1 GHz, All Channels

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	19214-15	Test Technician:	Bob Redoutey
Purchase Order #:	N/A	Supervisor:	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	4.2 VDC	EUT Power Frequency:	- N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Transmit CW	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
60.0336	10	161	2.23	Quasi-peak	28	9.683	29.5	-19.8	Pass
101.194	10	258	3.01	Quasi-peak	23.1	6.616	33.1	-26.5	Pass
288.03	10	37	3.76	Quasi-peak	29.5	18.955	35.6	-16.6	Pass
501.762	10	145	2.49	Quasi-peak	22.4	16.134	35.6	-19.5	Pass
776.605	10	122	2.21	Quasi-peak	21.5	22.129	35.6	-13.5	Pass
904.489	10	52	3.31	Quasi-peak	21.2	26.081	35.6	-9.5	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

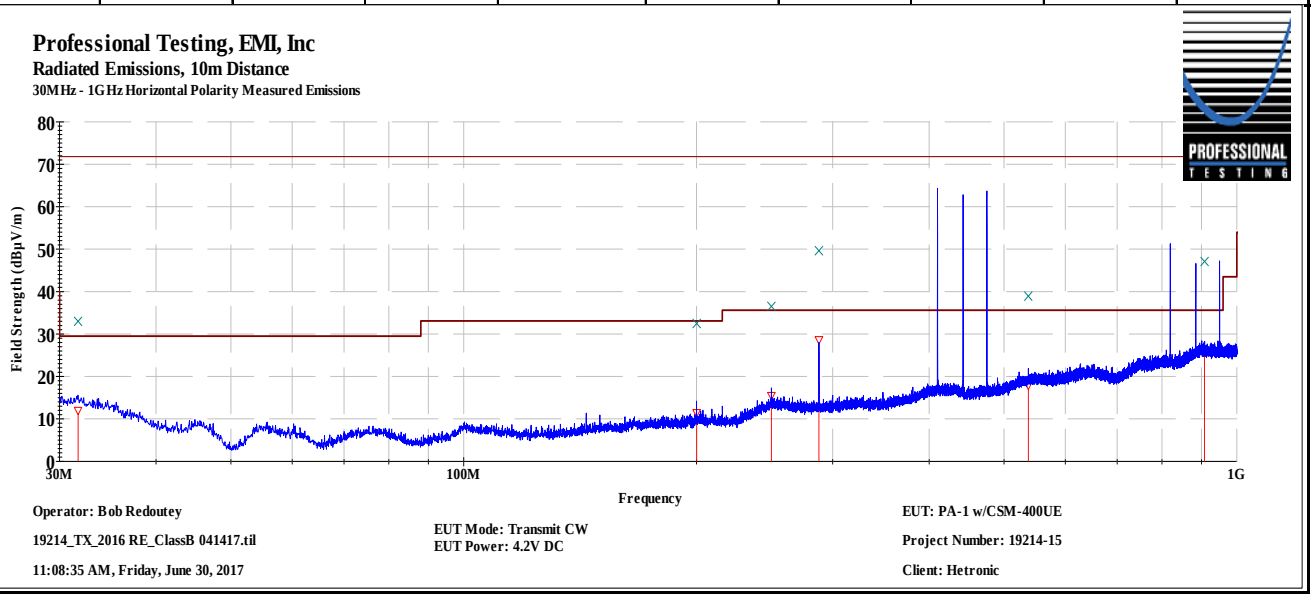
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	19214-15	**Test Technician:**	Bob Redoutey
Purchase Order #:	N/A	**Supervisor:**	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	4.2 VDC	**EUT Power Frequency:**	- N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Transmit CW	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
31.7095	10	41	1.07	Quasi-peak	24	11.984	29.5	-17.5	Pass
200.109	10	323	2.82	Quasi-peak	25.8	11.463	33.1	-21.6	Pass
250.029	10	152	2.66	Quasi-peak	25.5	15.496	35.6	-20.1	Pass
288.034	10	296	2.99	Quasi-peak	39.2	28.631	35.6	-7.0	Pass
537.253	10	250	3.71	Quasi-peak	22.2	17.93	35.6	-17.7	Pass
908.4	10	110	1.46	Quasi-peak	21.2	26.078	35.6	-9.5	Pass



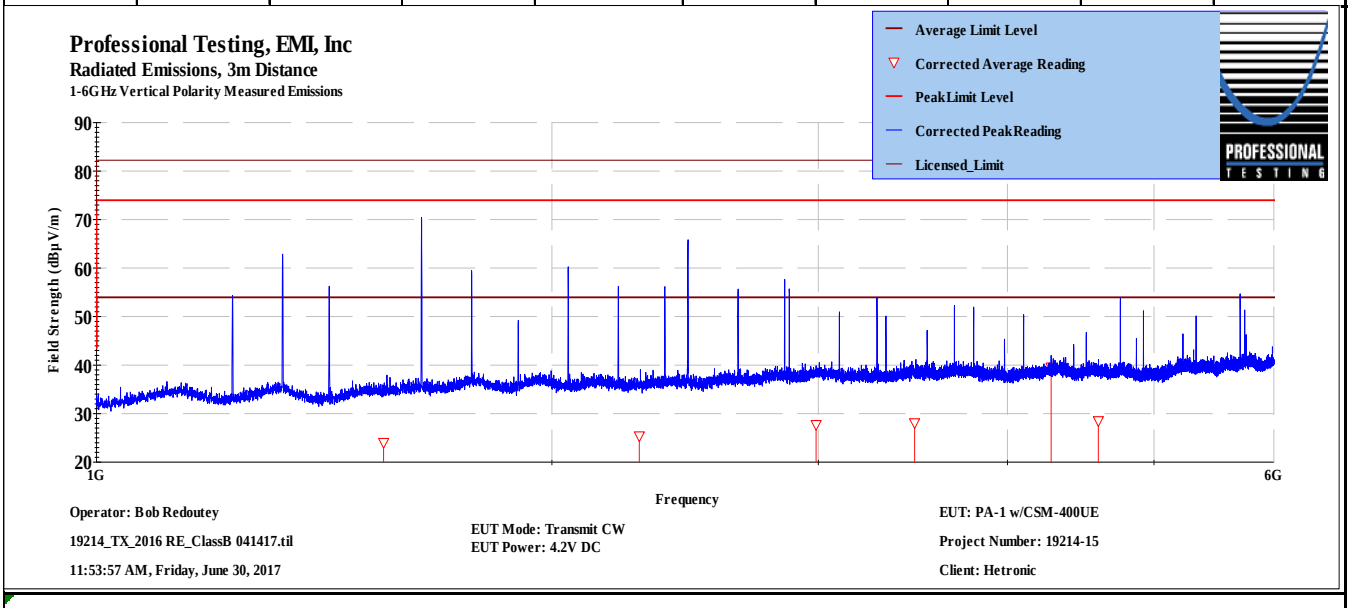
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.2 Transmit Mode, Above 1 GHz, All Channels

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	19214-15	Test Technician:	Bob Redoutey
Purchase Order #:	N/A	Supervisor:	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	4.2 VDC	EUT Power Frequency:	- N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Transmit CW	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1548.09	3	121	2.55	Average	35.7	24.007	54.0	-30.0	Pass
2284.57	3	303	3.19	Average	34.9	25.364	54.0	-28.6	Pass
2989.56	3	33	1.98	Average	34.8	27.713	54.0	-26.2	Pass
3473.01	3	315	1.69	Average	35.2	28.091	54.0	-25.9	Pass
4274.87	3	212	2.14	Average	44.5	39.564	54.0	-14.4	Pass
4593.31	3	258	2.9	Average	32.9	28.514	54.0	-25.4	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

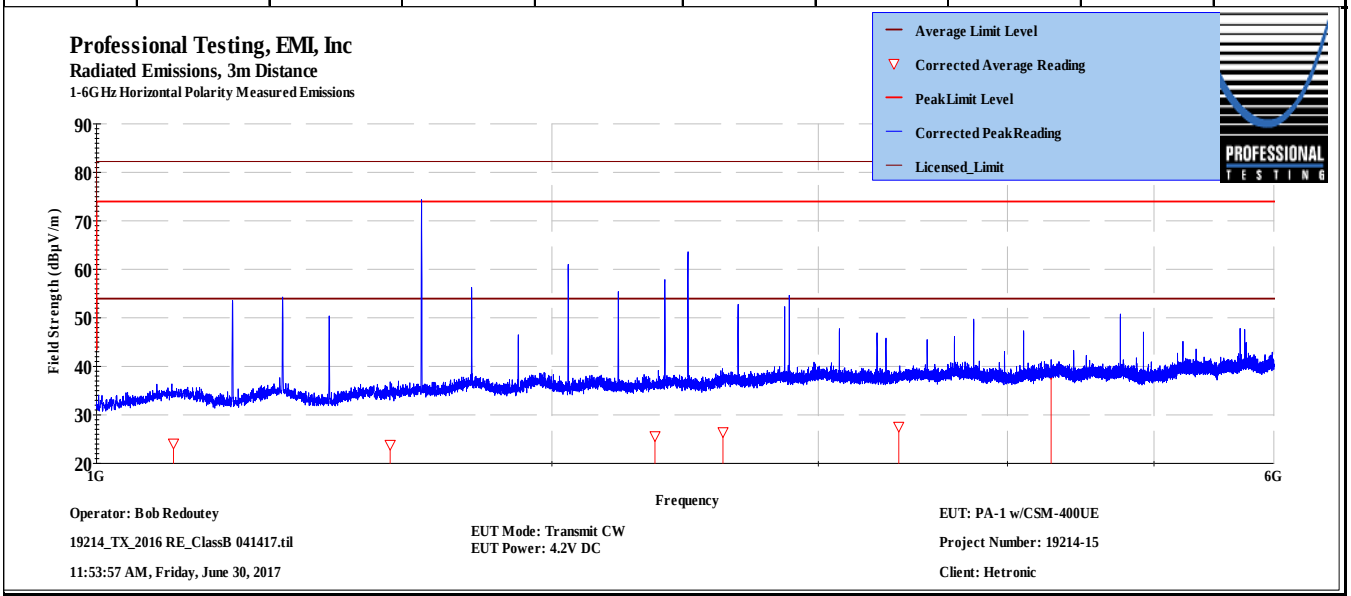
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	19214-15	**Test Technician:**	Bob Redoutey
Purchase Order #:	N/A	**Supervisor:**	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	4.2 VDC	**EUT Power Frequency:**	- N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit CW	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1124.43	3	240	1.82	Average	36.8	24.13	54.0	-29.8	Pass
1563.38	3	212	2.29	Average	35.5	23.901	54.0	-30.1	Pass
2339.38	3	106	3.24	Average	35	25.657	54.0	-28.3	Pass
2594.62	3	284	3.96	Average	35.1	26.49	54.0	-27.5	Pass
3390.42	3	151	3.05	Average	35.1	27.607	54.0	-26.4	Pass
4274.95	3	225	3.41	Average	43.4	38.453	54.0	-15.5	Pass



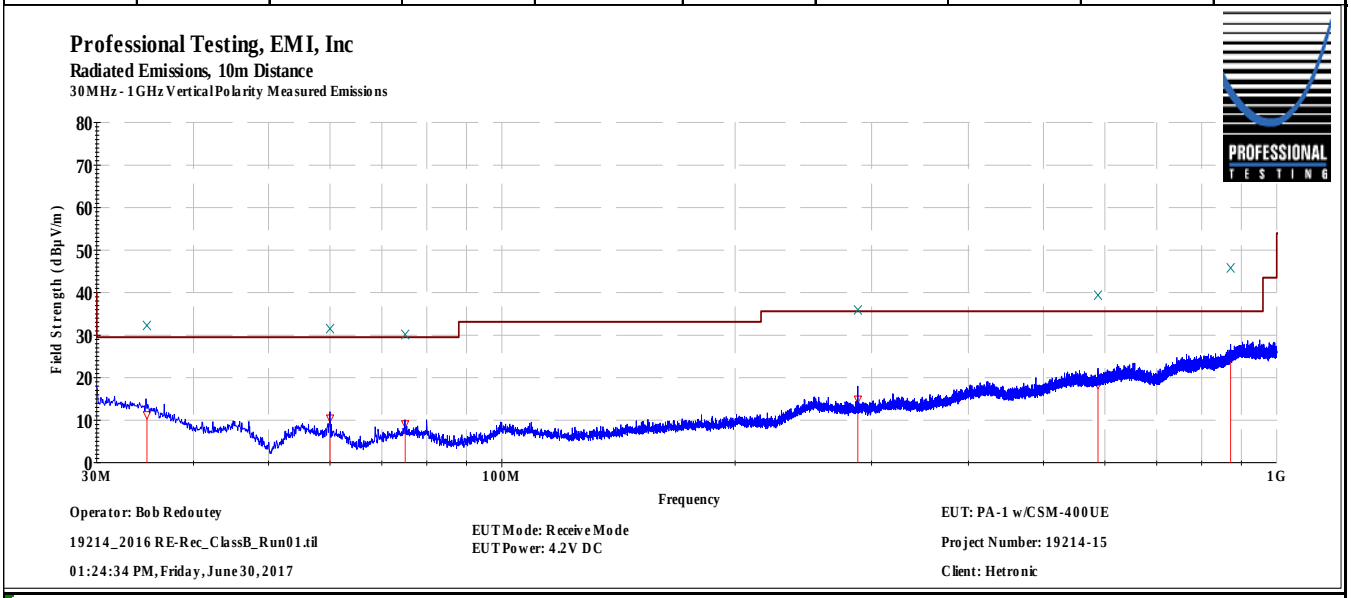
> 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.3 Receive Mode, Up to 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	19214-15	Test Technician:	Bob Redoutey
Purchase Order #:	N/A	Supervisor:	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	4.2 VDC	EUT Power Frequency:	- N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Receive	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
34.8237	10	62	2.03	Quasi-peak	23	11.245	29.5	-18.3	Pass
60.0211	10	84	2.63	Quasi-peak	28.8	10.493	29.5	-19.0	Pass
75.0231	10	255	1.51	Quasi-peak	26.8	9.125	29.5	-20.4	Pass
288.022	10	188	2.96	Quasi-peak	25.5	14.922	35.6	-20.7	Pass
587.912	10	42	1.21	Quasi-peak	22.1	18.382	35.6	-17.2	Pass
871.974	10	80	3.49	Quasi-peak	21.3	24.784	35.6	-10.8	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

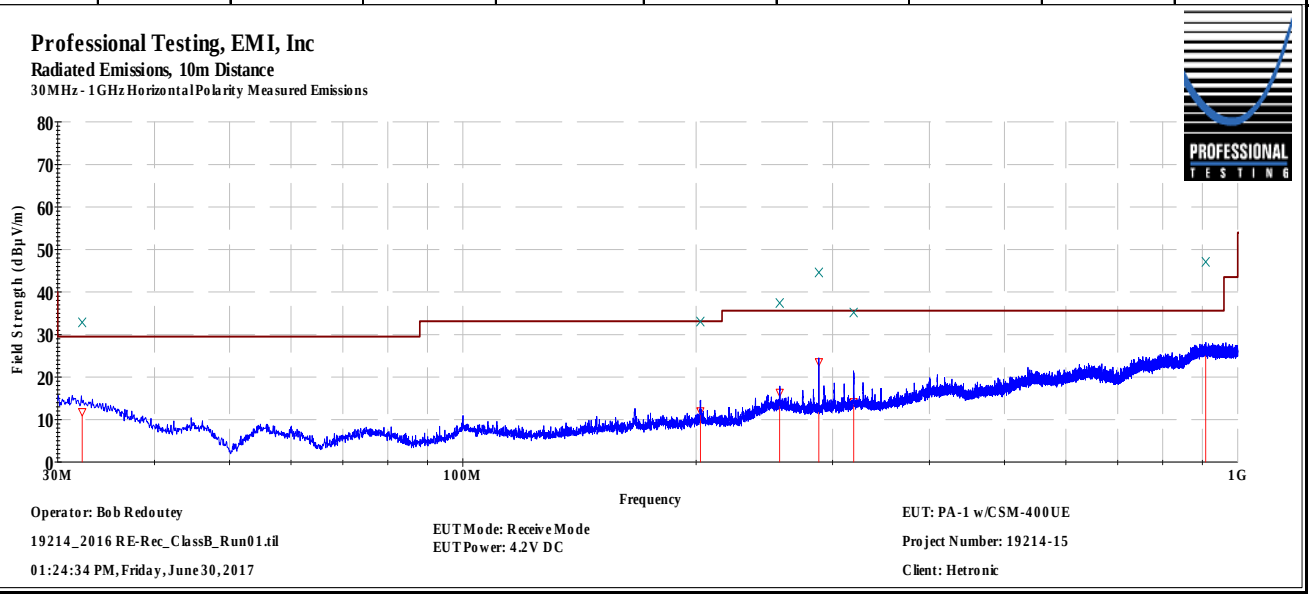
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	19214-15	**Test Technician:**	Bob Redoutey
Purchase Order #:	N/A	**Supervisor:**	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	4.2 VDC	**EUT Power Frequency:**	- N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Receive	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
32.262	10	332	2.93	Quasi-peak	23.8	11.846	29.5	-17.7	Pass
202.554	10	339	3.77	Quasi-peak	26.4	12.048	33.1	-21.1	Pass
256.398	10	5	3.08	Quasi-peak	26.6	16.396	35.6	-19.2	Pass
288.043	10	306	3.53	Quasi-peak	34.1	23.585	35.6	-12.0	Pass
319.43	10	259	3.69	Quasi-peak	23.9	14.155	35.6	-21.4	Pass
909.351	10	54	1.06	Quasi-peak	21.2	26.059	35.6	-9.5	Pass



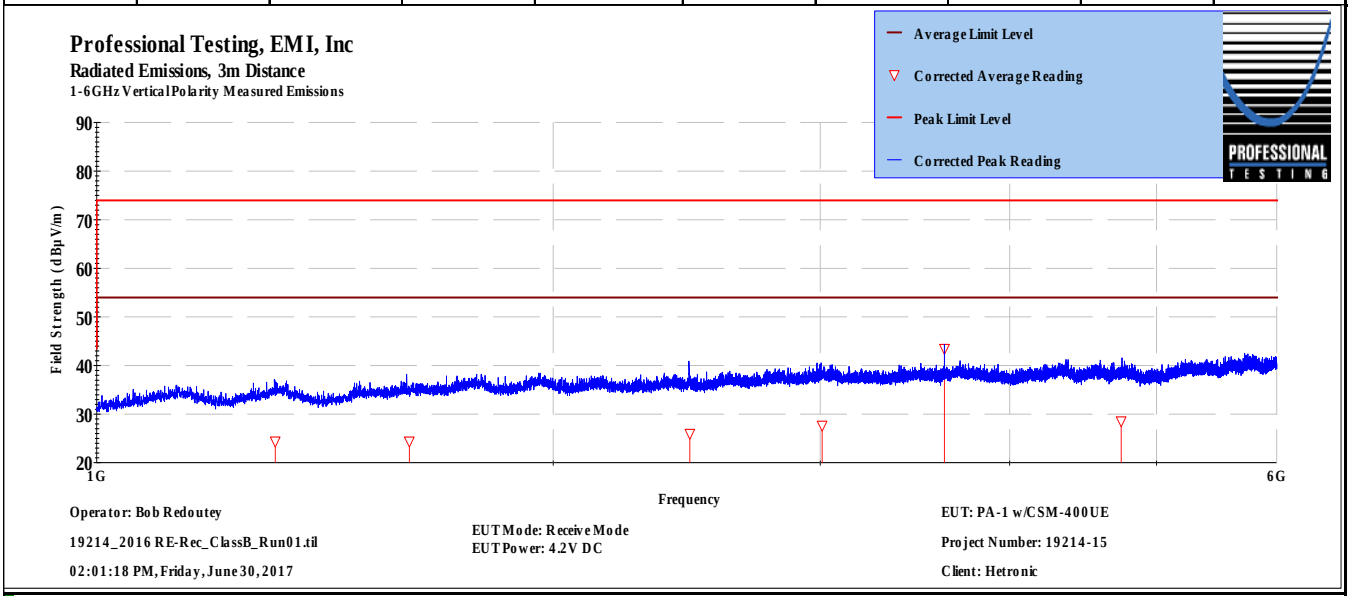
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.4 Receive Mode, Above 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	19214-15	**Test Technician:**	Bob Redoutey
Purchase Order #:	N/A	**Supervisor:**	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	4.2 VDC	**EUT Power Frequency:**	- N/A
Antenna Orientation:	Vertical	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Receive	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1311.36	3	137	1.8	Average	36.3	24.393	54.0	-29.6	Pass
1607.42	3	357	2.9	Average	35.6	24.401	54.0	-29.6	Pass
2461.15	3	154	2.01	Average	35.1	25.992	54.0	-28.0	Pass
3008.34	3	73	1.92	Average	34.7	27.662	54.0	-26.3	Pass
3622.76	3	228	1.94	Average	50.4	43.44	54.0	-10.5	Pass
4737.56	3	137	1.65	Average	32.6	28.558	54.0	-25.4	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

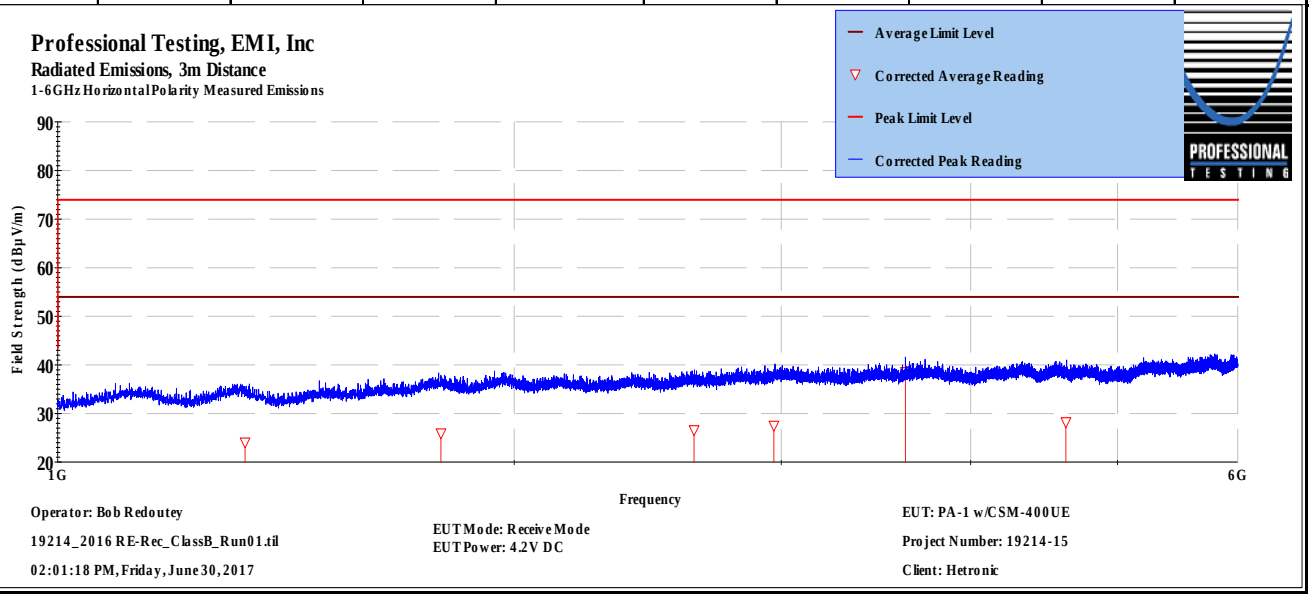
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	6/30/2017	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	19214-15	**Test Technician:**	Bob Redoutey
Purchase Order #:	N/A	**Supervisor:**	Lisa Arndt
Equip. Under Test:	PA-1 with CSM-400UE	**Witness' Name:**	None

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	4.2 VDC	**EUT Power Frequency:**	- N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Receive	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1329.02	3	117	2.79	Average	36	24.073	54.0	-29.9	Pass
1789.47	3	330	3.46	Average	35.8	25.971	54.0	-28.0	Pass
2628.36	3	290	3.79	Average	35	26.61	54.0	-27.3	Pass
2966.99	3	164	3.83	Average	34.7	27.532	54.0	-26.4	Pass
3622.71	3	57	2.24	Average	45.5	38.573	54.0	-15.4	Pass
4622.33	3	290	3.49	Average	32.5	28.248	54.0	-25.7	Pass



> 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	11 Jul 2017

Table 6.2.1 Frequency Tolerance
± 5 ppm or restated as ± 2050 Hz

Table 6.2.2 Operating Voltages (From manufacturer's specifications.)		
Low	**Nominal**	**High**
3.3	**4.2**	**5.1**

The operating frequency shall remain within the required tolerance.

6.3 Results

The highest deviation from frequency observed was -895 Hz. The EUT satisfied the requirement. Measurements appear below.

6.3.1 Bottom Channel, Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	410.000000	409.999917	-83
-20	410.000000	409.999998	-2
-10	410.000000	410.000004	4
0	410.000000	409.999906	-94
10	410.000000	409.999853	-147
20	410.000000	409.999881	-119
30	410.000000	409.999926	-74
40	410.000000	409.999894	-106
50	410.000000	409.999910	-90
Max Deviation (Hz)			4
Min Deviation (Hz)			-147

6.3.2 Bottom Channel, Operating Voltage

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	3.30	410.000000	409.999926	-74
Nominal	4.20	410.000000	409.999923	-77
High	5.10	410.000000	409.999924	-76

6.3.3 Middle Channel, Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	442.500000	442.499557	-443
-20	442.500000	442.499640	-360
-10	442.500000	442.499641	-359
0	442.500000	442.499538	-462
10	442.500000	442.499478	-522
20	442.500000	442.499510	-490
30	442.500000	442.499560	-440
40	442.500000	442.499525	-475
50	442.500000	442.499544	-456
Max Deviation (Hz)			-359
Min Deviation (Hz)			-522

6.3.4 Middle Channel, Operating Voltage

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	3.30	442.500000	442.499562	-438
Nominal	4.20	442.500000	442.499561	-439
High	5.10	442.500000	442.499561	-439

6.3.5 Top Channel, Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	475.000000	474.999190	-810
-20	475.000000	474.999286	-714
-10	475.000000	474.999278	-722
0	475.000000	474.999168	-832
10	475.000000	474.999105	-895
20	475.000000	474.999151	-849
30	475.000000	474.999193	-807
40	475.000000	474.999155	-845
50	475.000000	474.999174	-826
Max Deviation (Hz)			-714
Min Deviation (Hz)			-895

6.3.6 Top Channel, Operating Voltage

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	3.30	475.000000	474.999188	-812
Nominal	4.20	475.000000	474.999188	-812
High	5.10	475.000000	474.999189	-811

7.0 Transient Frequency Behavior

The EUT was tested for transient frequency behavior using the test method outlined in TIA/EIA-603-E paragraph on 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, 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 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 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.

7.1 Criteria

Parameter	Section Reference	Date
Transient Frequency Behavior	90.214 | RSS-119 Issue 12, 5.9 Procedure: TIA-603-E	10 Jul 2017

Table 7.1.1 Transient Frequency Limits

Time intervals[1,2]	Maximum frequency difference[3]	Frequency Range	
		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] t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

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

t_2 is the time period immediately following t_1.

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

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

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

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

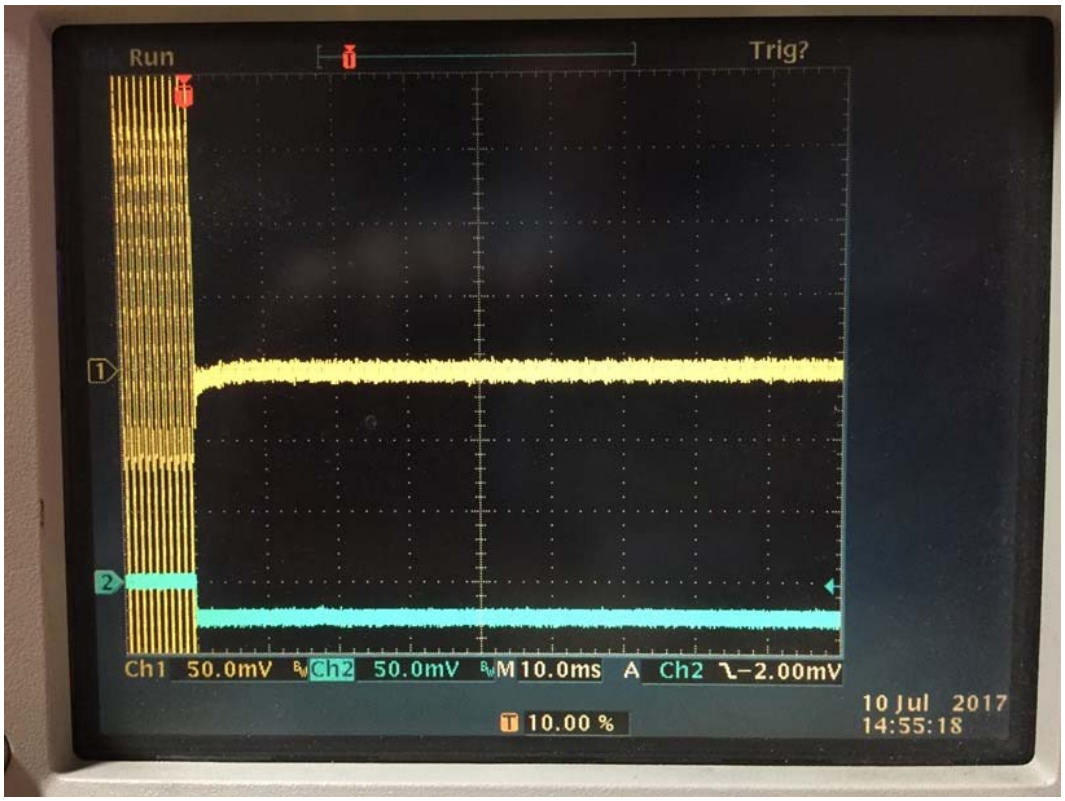
[4]If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

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

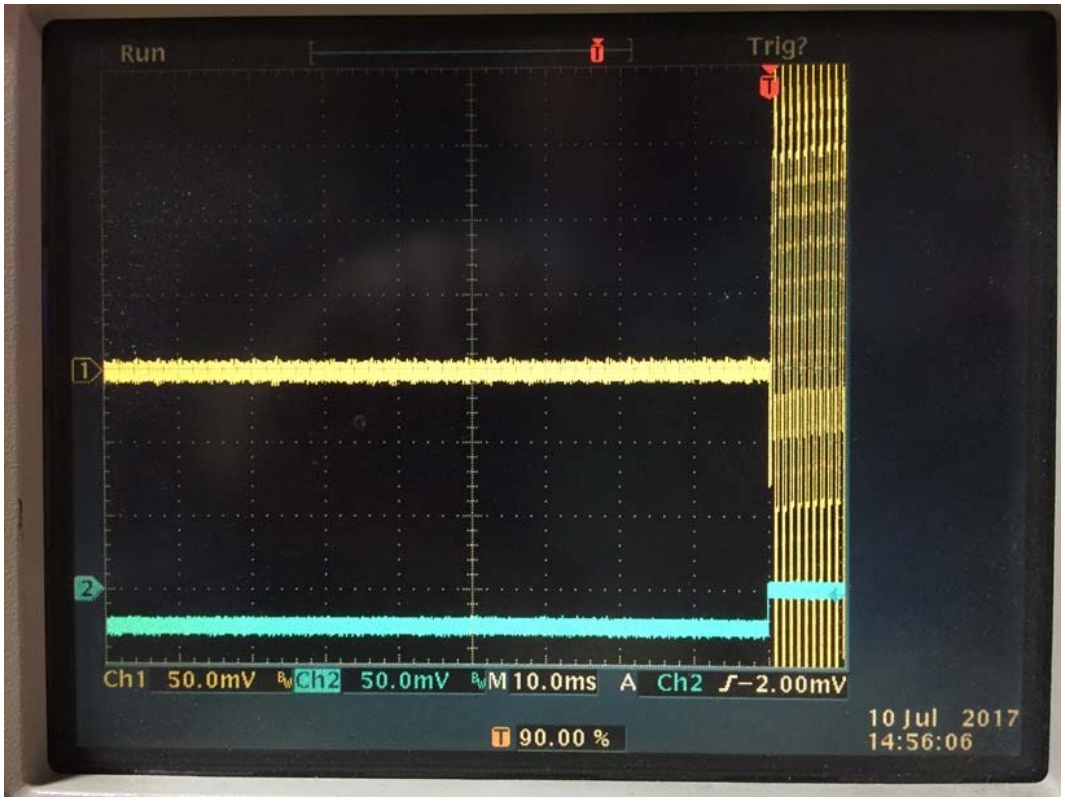
7.2 Results

The EUT satisfied the requirements. Plotted measurements appear on the following pages. The limits were not superimposed on the plots as the transmitter performance was clearly in compliance for any allowed channel scheme.

7.2.1 Bottom Channel

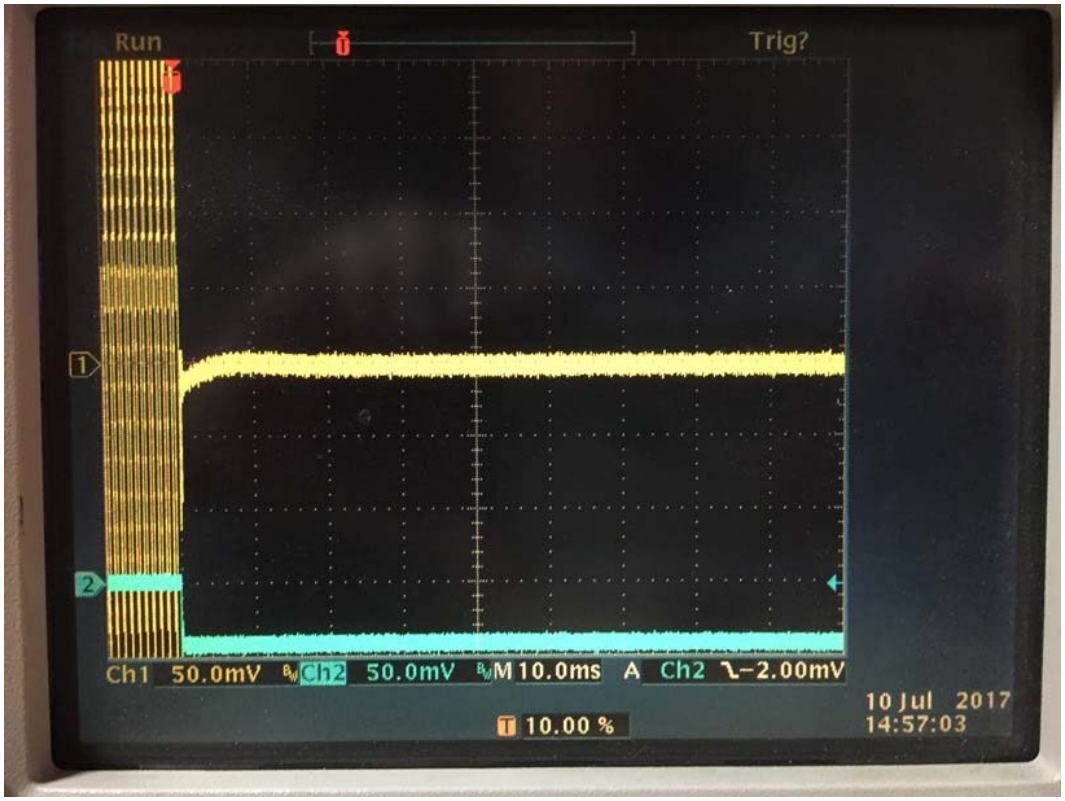


Attack

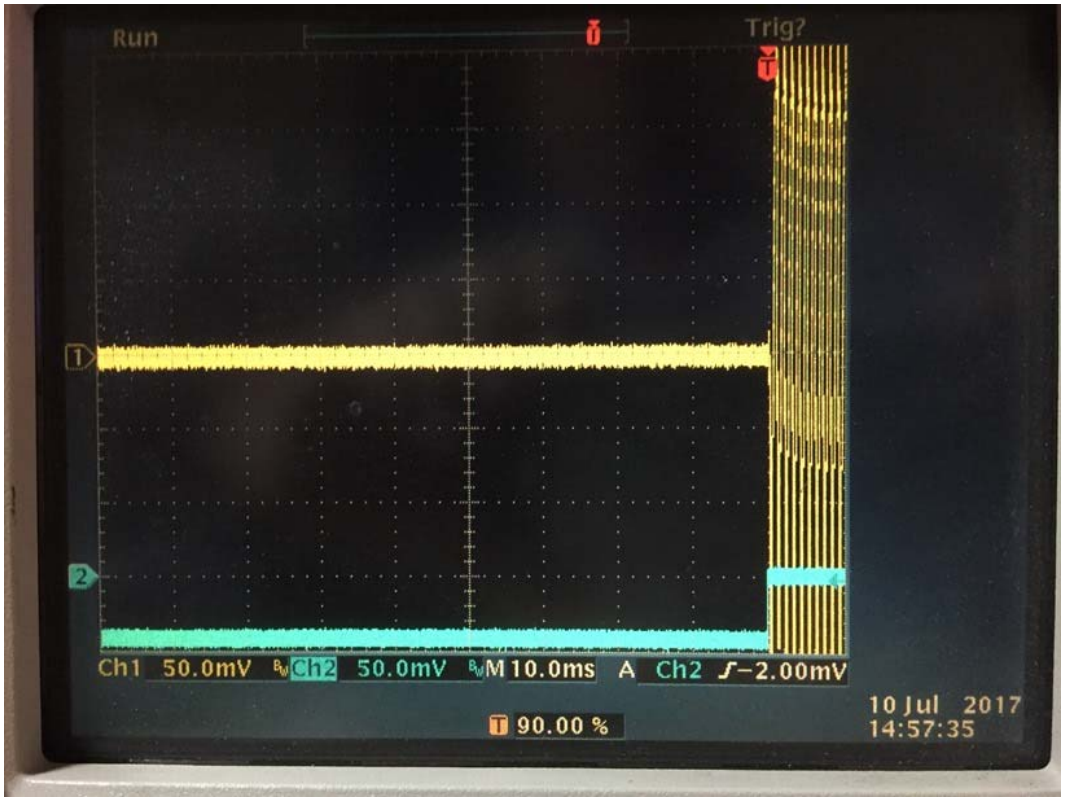


Release

7.2.2 Middle Channel

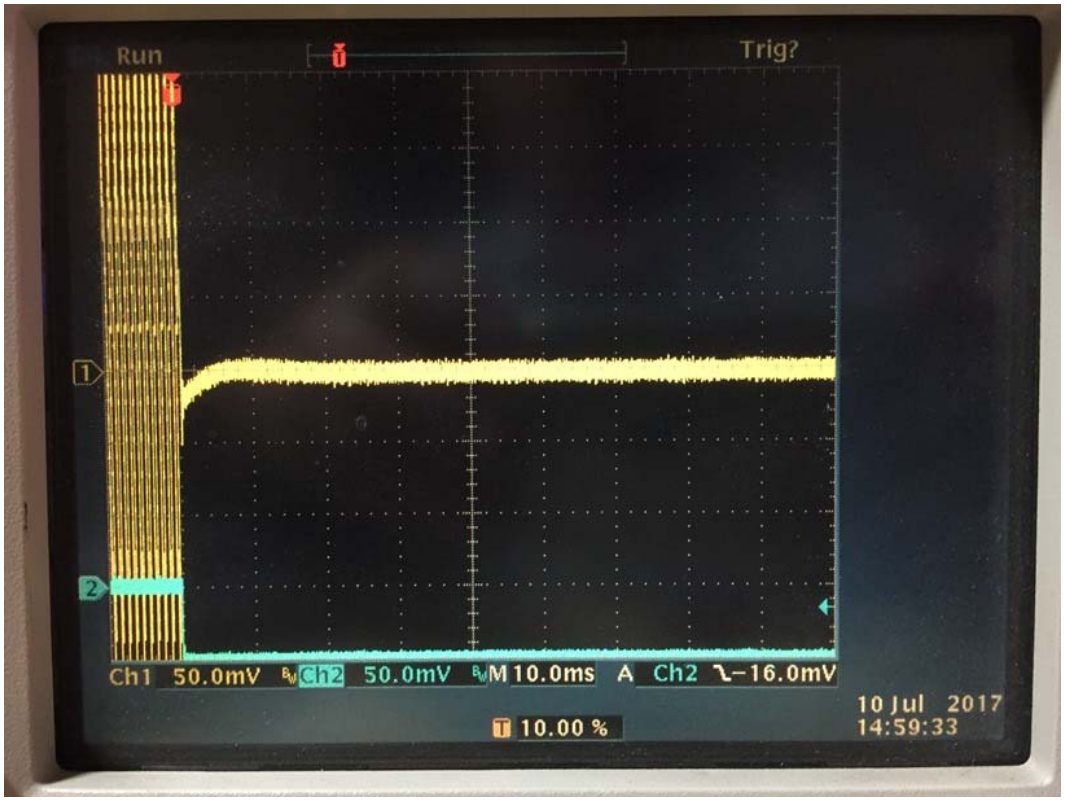


Attack

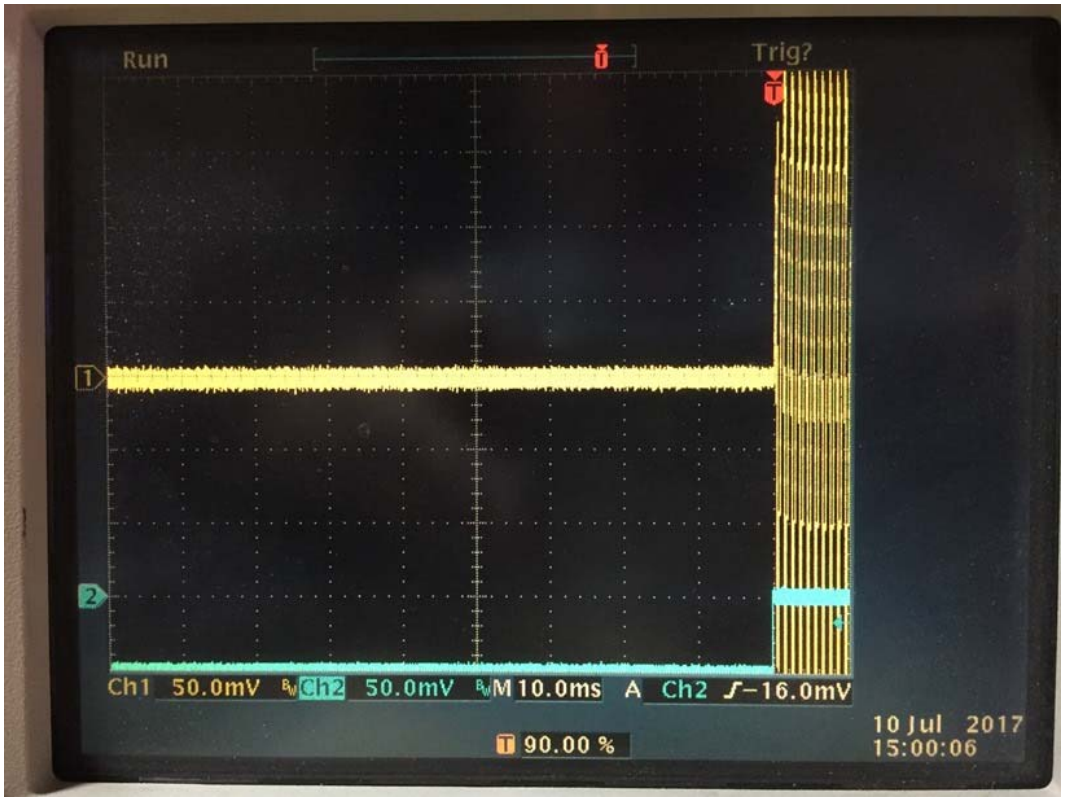


Release

7.2.3 Top Channel



Attack



Release

8.0 Emission Bandwidth

8.1 Procedure

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

8.2 Criteria

Parameter	Section Number	Date
90.210(c) Bandwidth < 12. 5 kHz Or spectrum efficiency minimum 4800 baud per 6.25 kHz bandwidth per 90.203(j)(3).	90.210(c), 90.203(j)(3), 2.1049 | RSS-119 Issue 12, 5.5	10 Jul 2017

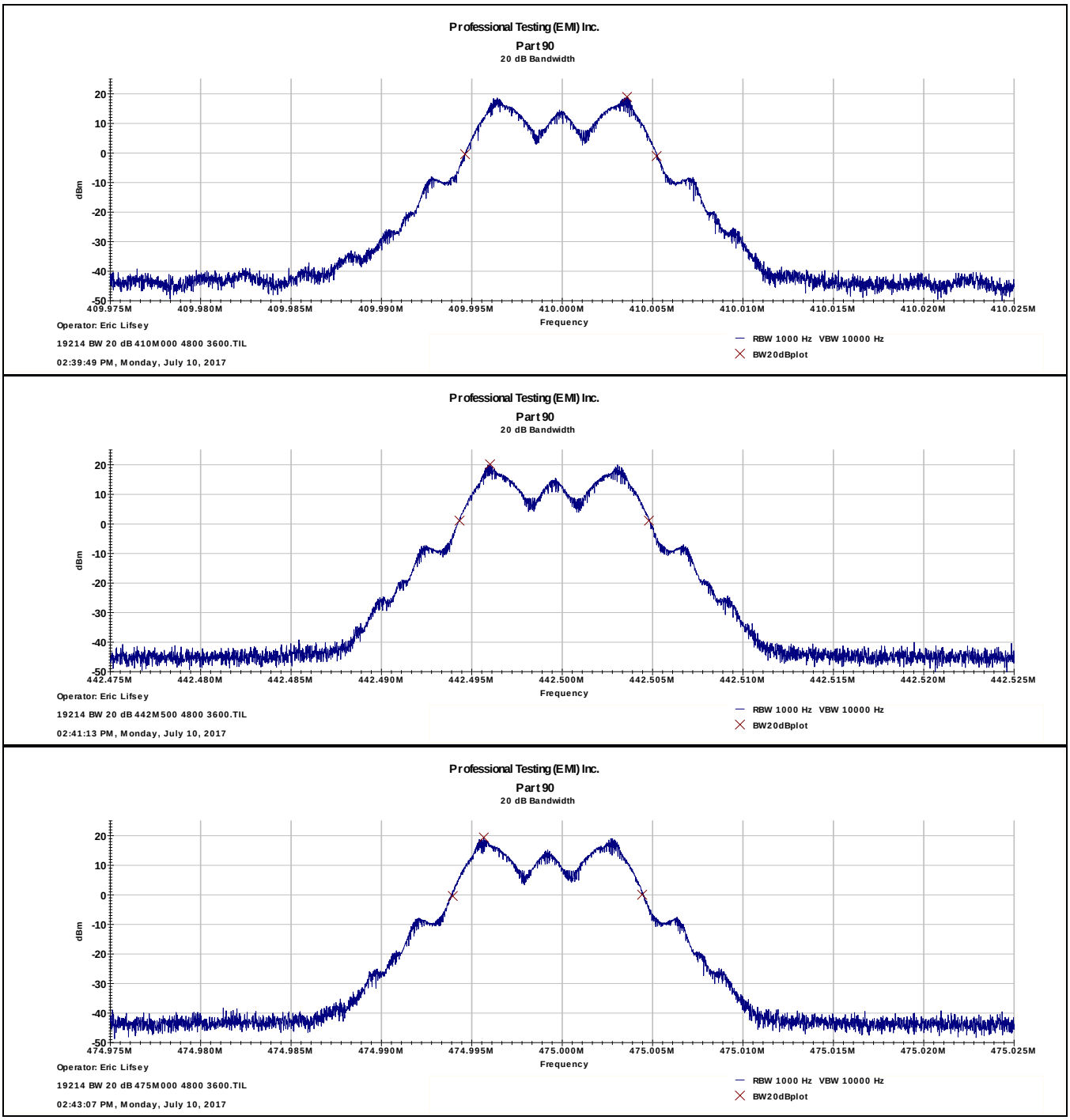
8.3 Results

Table 8.3.1 Bandwidth 20 dB (kHz)

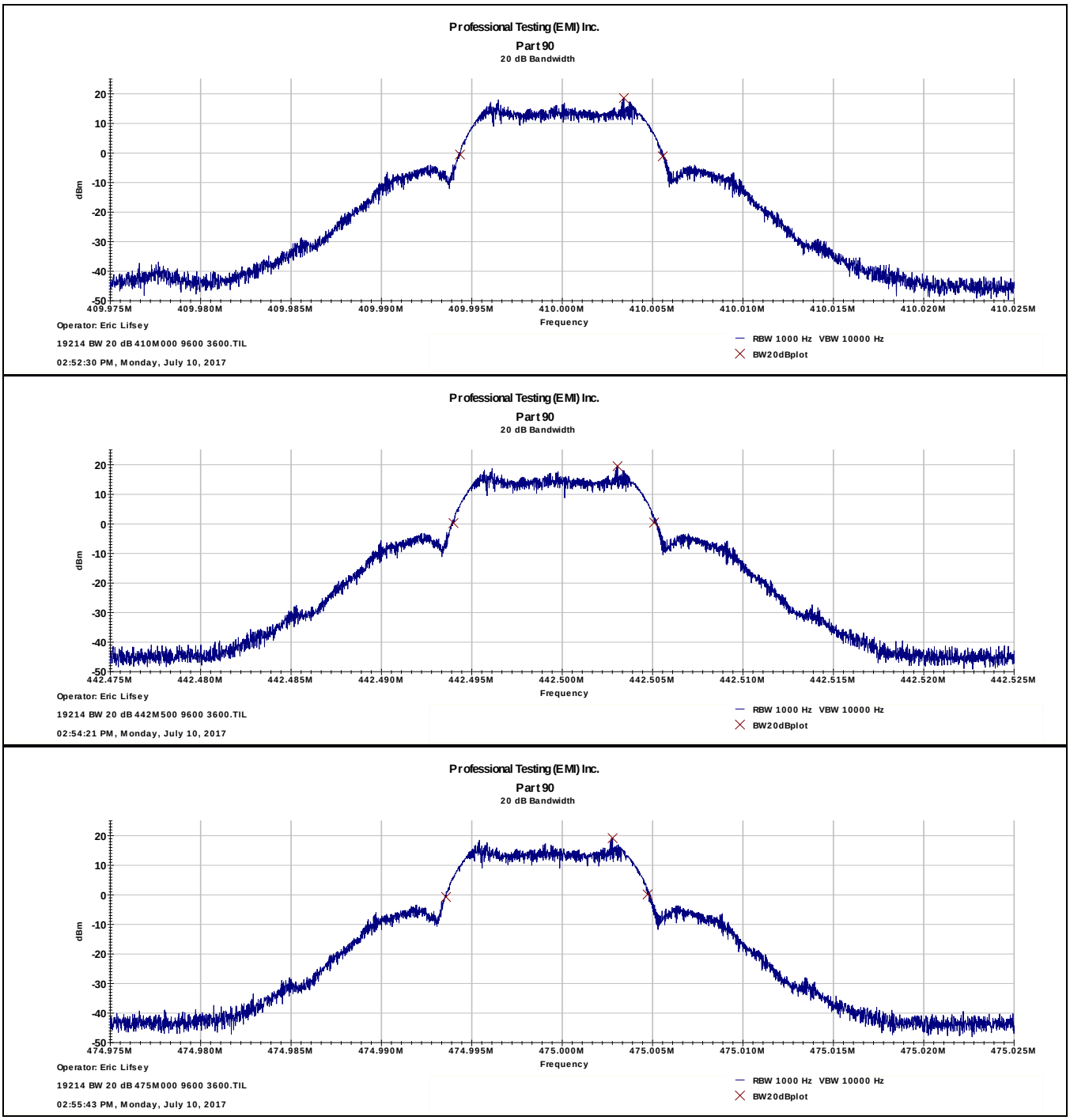
Frequency	2GFSK 4800 sps	2GFSK 9600 sps	4GFSK 18000 sps	4GFSK 20000 sps	4GFSK 25000 sps
410.0 MHz	10.65	11.34	48.54	45.26	50.42
442.5 MHz	10.66	11.29	48.39	46.45	50.14
475.0 MHz	10.66	11.30	48.47	45.33	50.42

The emission satisfies the bandwidth. Plotted results appear on the following pages.

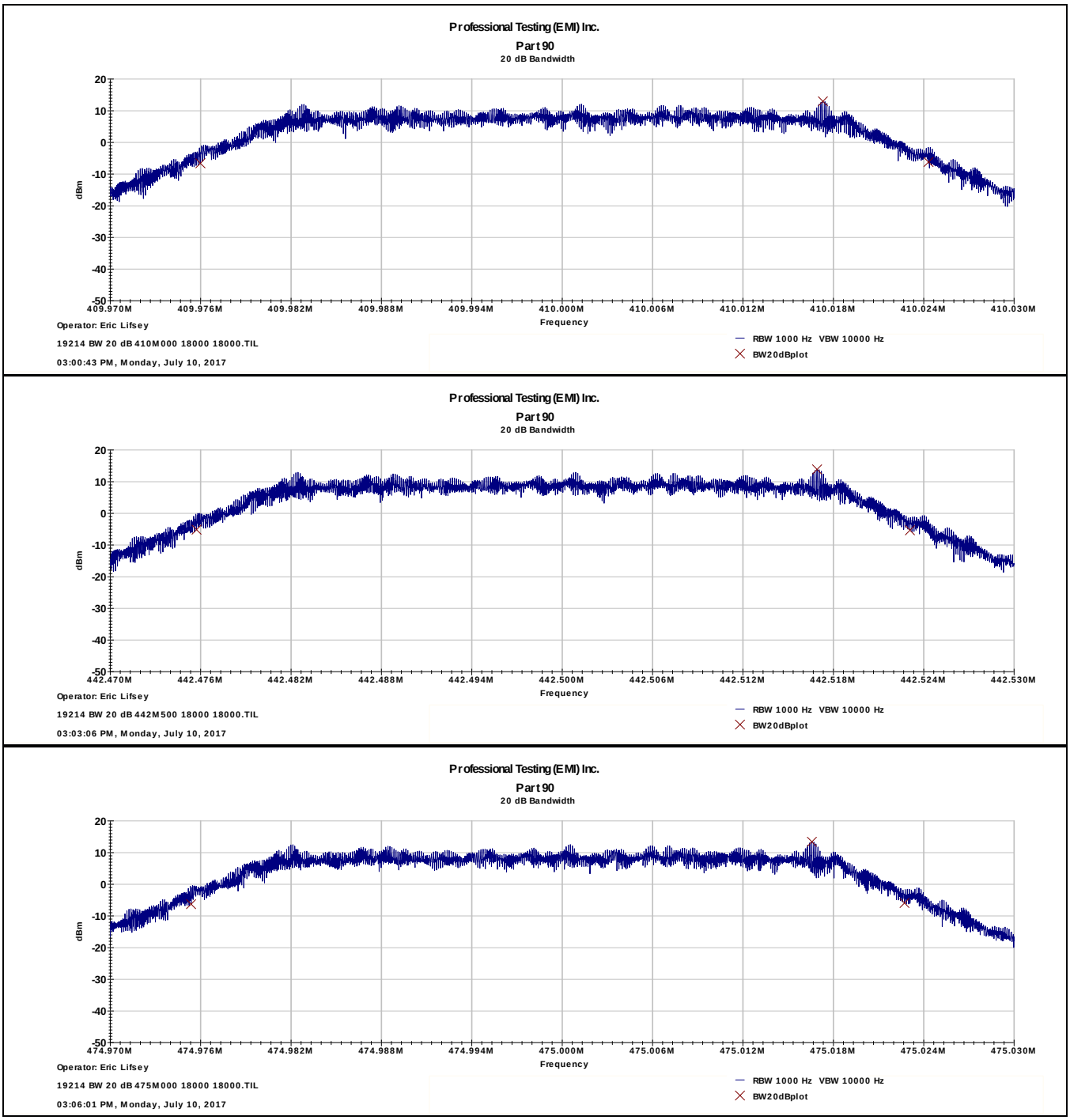
8.3.1 Modulation 2GFSK, 4800 Symbols Per Second



8.3.2 Modulation 2GFSK, 9600 Symbols Per Second

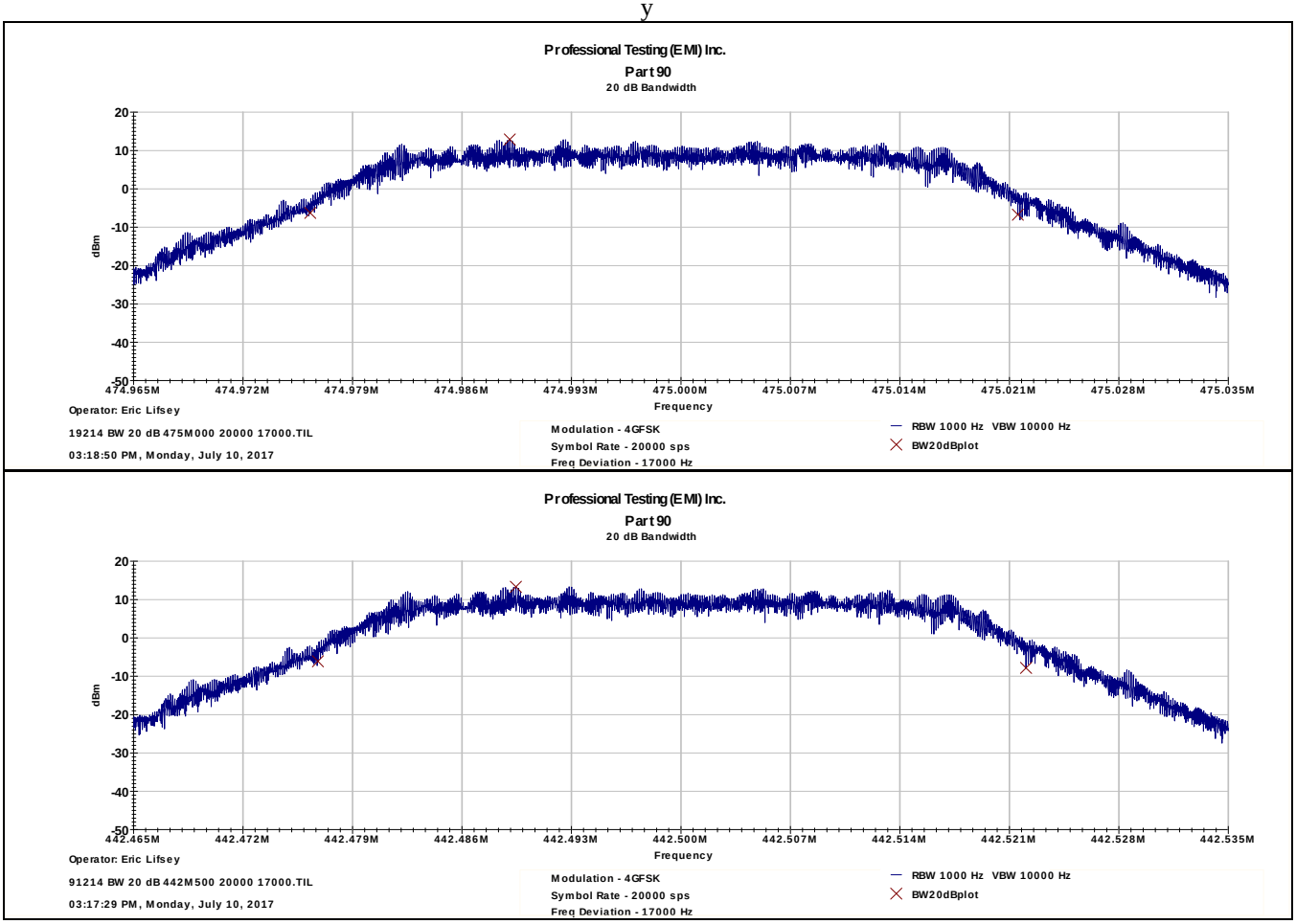


8.3.3 Modulation 4GFSK, 18000 Symbols Per Second

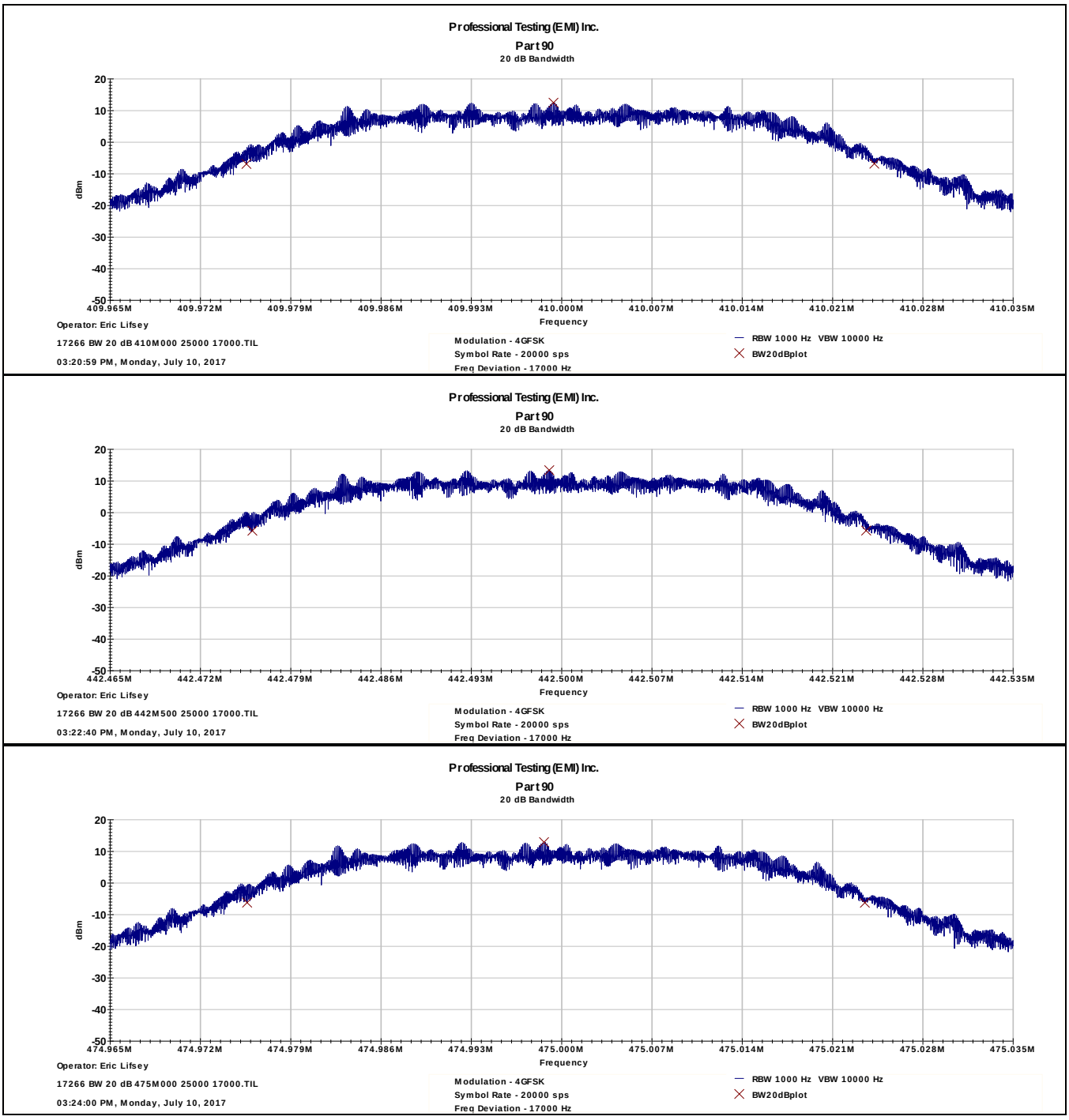


8.3.4 Modulation 4GFSK, 20000 Symbols Per Second

y



8.3.5 Modulation 4GFSK, 25000 Symbols Per Second



9.0 Noise Measurements (RSS-131)

9.1 Procedure

The EUT antenna port is coupled direct to the spectrum analyzer for measurement with input port terminated in the required impedance. This test is recommended though the amplifier is never operated as a zone enhancer for over-the-air signals.

9.2 Criteria

Parameter	Section Number	Date
Power +/- 1 dB of specification. Intermodulation Products -30 dBm / 10 kHz. Spurious emissions -13 dBm / 100 kHz. In Band Emission < -43 dBm / 10 kHz. Out Band Emission < -70 dBm / 10 kHz. Noise figure shall not exceed 9 dB.	RSS-131 Iss. 3 Section 6	11 Jul 2017

9.3 Results

The EUT satisfied the requirements that apply. Results appear on the following pages.

9.3.1 Power

Power varied 0.5 dB maximum from 19.8 dBm. This requirement is satisfied.

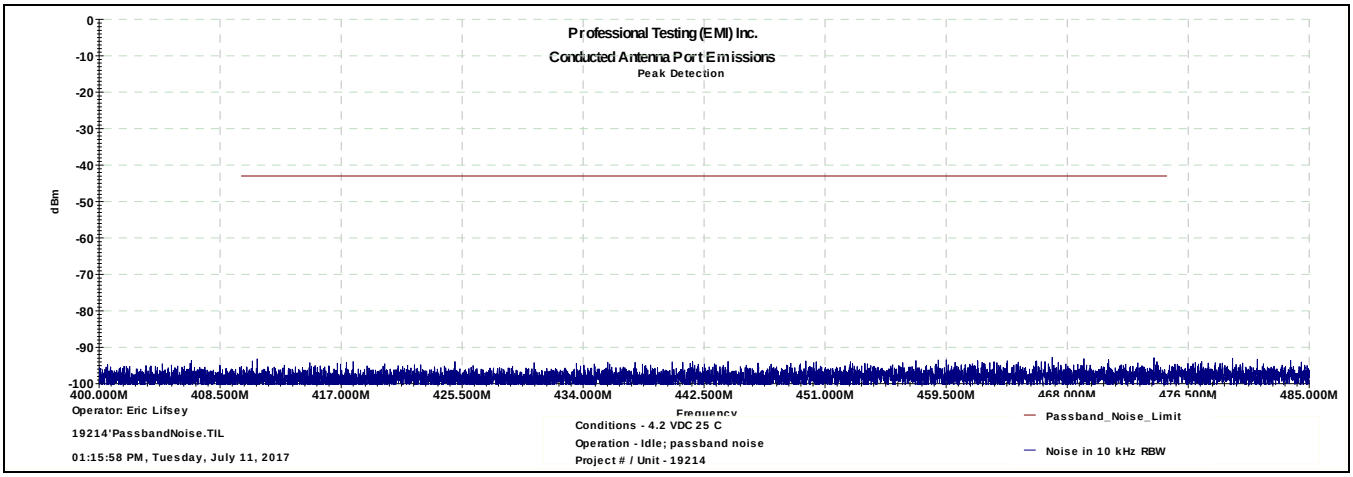
9.3.2 Intermodulation Products

The amplifier is not used with multiple inputs and not used to amplify radiated signals. Only one signal source of one operating frequency is possible by direct connection. This measurement does not apply.

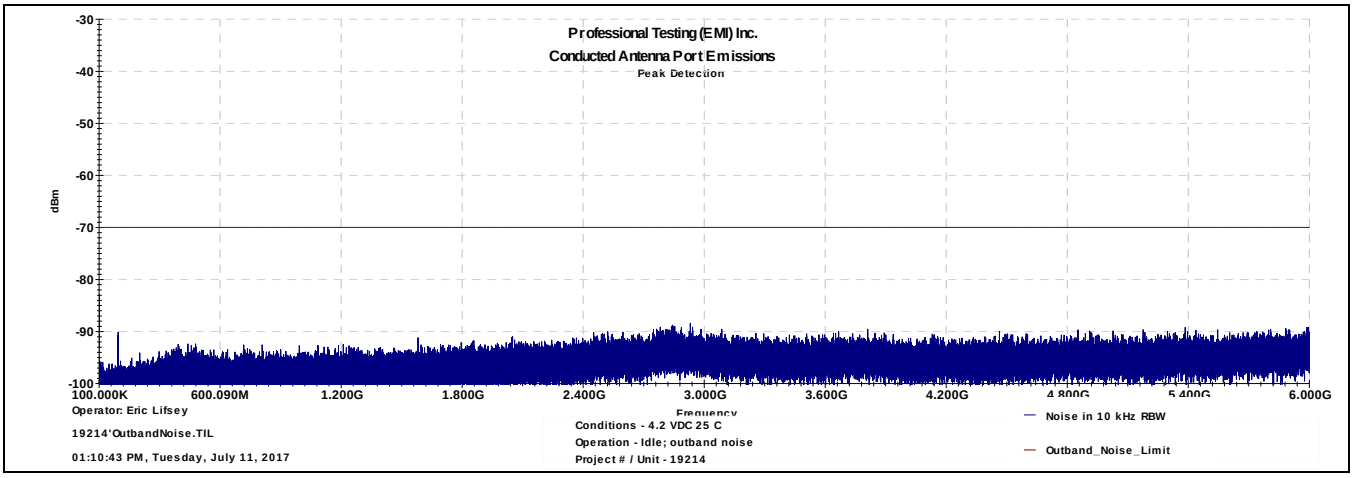
9.3.3 Spurious Emission in 100 kHz

Compliance to this requirement is demonstrated by the conducted spurious measurements in section 4. The requirement is satisfied.

9.3.4 Antenna Port In-band Noise, Transmit Mode



9.3.5 Antenna Port Out-band Noise, Transmit Mode



9.3.6 Noise Figure, Preamplifier

The noise figure of a zone enhancer shall not exceed 9 dB.

Determine or measure amplifier gain:

Preamplifier Gain = 20 dB +/- 10%

Measure noise output power with amplifier input terminated:

EUT powered: -94.0 dBm / MHz
EUT off: -94.0 dBm / MHz

No difference seen in measured noise on or off.

Subtracting worse-case gain 18 dB: -94 - 18 = -112 dBm

Given the thermal noise floor is -114 dBm.

Difference is 2 dB above the thermal noise floor. EUT satisfies the requirement.

9.3.7 Noise Figure, Power Amplifier

The output power amplifier is always driven by the full input power signal of a directly connected single source and completely shut off when receiving. It does not amplify radiated signals from outside the system and the single-channel signal is generated by the attached radio module. Therefore this measurement does not apply.

10.0 Equipment Lists

10.1 Conducted Measurements of: Power, Spurious, Bandwidth, and Noise

Asset #	Manufacturer	Model #	Description	Calibration Due
2295	Agilent	E4440A	Spectrum Analyzer	30 Sep 2017
0472	Tektronix	THS730A	Scope/DMM	7 Dec 2017
2201	Agilent	E3632A	Adjustable DC Power Supply	CIU

10.2 Frequency Stability

Asset #	Manufacturer	Model #	Description	Calibration Due
2295	Agilent	E4440A	Spectrum Analyzer	30 Sep 2017
2134	Tenny	TPS	Temperature Chamber	12 Oct 2017
C247	Pasternack	RG type	Coaxial Cable, double shielded	CNR
0472	Tektronix	THS730A	Scope/DMM	7 Dec 2017
None	B&K	1710	Adjustable DC Power Supply	CIU
2201	Agilent	E3632A	Adjustable DC Power Supply	CIU

10.3 Frequency Transient Behavior

Asset #	Manufacturer	Model #	Description	Calibration Due
0836	Narda	3293-1	Broadband Directional Coupler	CNR
2228	Tektronix	TDS3034	Oscilloscope, Digital	19 Jul 2017
1678	HP	8921A	Cell Site Tester (as signal generator)	CIU
0742	HP	355C	Step Attenuator	CNR
0637	HP	8901A	Modulation Analyzer	10 Nov 2018
None	Mini-Circuits	ZFRSC-43	3 Port Resistive Divider/Combiner SMA	CNR
0835	Narda	3293-1	Forward Power Coupler	CNR
None	Unknown	Unknown	10 dB SMA-SMA attenuator	CNR
A100	Narda	94455-1	Diode Detector	CNR
2201	Agilent	E3632A	Adjustable DC Power Supply	CIU
None	Various	None	RG Type coaxial cables	CNR

10.4 Radiated Spurious Transmit Mode and Receive Mode

Radiated Emissions Test Equipment List					
Tile! Software Version:		**4.2.A, May 23, 2010, 08:38:52 AM**			
Test Profile:		**2016 RE_ClassA - Boresite+Mast_LowPRF_030617.til or 2016 RE_ClassB - Boresite+Mast_LowPRF_030617.til**			
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	7/10/2017
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	2/1/2018
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/15/2017
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/7/2019
C027D	PTI	None	Relay	none	N/A
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	N/A	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	6/23/2019
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2017
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/15/2019

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

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