Project 17266-15

Hetronic
CSM-400UE
Transceiver 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

28 Mar 2017

Reviewed by

Larry Finn
Chief Technical Officer

Written by

Eric Lifsey
EMC Engineer

Revision History

Revision Number	Description	Date
03	Last draft for review.	8 Feb 2017
02	Final.	8 Jun 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: 28 Mar 2017	FCC ID: IC ID: Model(s): Laboratory Project ID:	LW9-CSM400UE 2119-CSM400UE CSM-400UE 17266-15

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 C	90.210(c), 2.1047	RSS-119 Issue 12, 5.8.3
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, TIA/EIA-603C	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

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

Table 1.2.1 Equipment Under Test

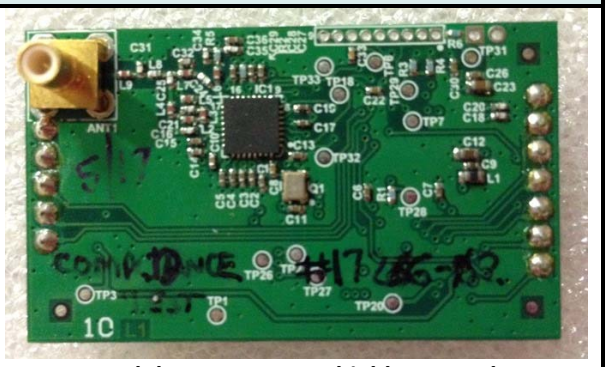
Manufacturer & Description	Model	Serial #	Photo
Hetronic Transceiver module for 410 to 475 MHz.	CSM-400UE	none	 Module appearance, shield removed.

Table 1.2.2 Options

Manufacturer & Description	Gain	Notes
Hetronic; ¼ wave SMB whip antenna	1 dBi	For use directly on module with host.
Hetronic; cable extension to TNC-F	NA	Extends module to external antenna.
Hetronic; ¼ wave TNC-M antenna	4 dBi	External antenna.

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.

The module is normally used as a transmitter in portable battery or vehicular powered applications. The module is normally used as a receiver in vehicular or mains powered applications. The mains powered hosts are tested for emission compliance separately.

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.			

1.3.1 Operation with External Amplifiers under 120 mW

When operated alone or with optional external amplifier with power under 120 mW all symbol rates are supported. In this case the 90.217 exemption (30 dBc mask) applies and the EUT satisfies the spectrum efficiency requirement where power is under 500 mW.

1.3.2 Operation with External Amplifiers above 120 mW

When operating with optional external power amplifier with power above 120 mW the symbol rates above 9600 use a lower deviation setting. In this case Mask C applies.

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**	**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-603D	Land Mobile FM or PM – Communications Equipment – Measurement and Performance Standards	2009

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	25 Oct 2016

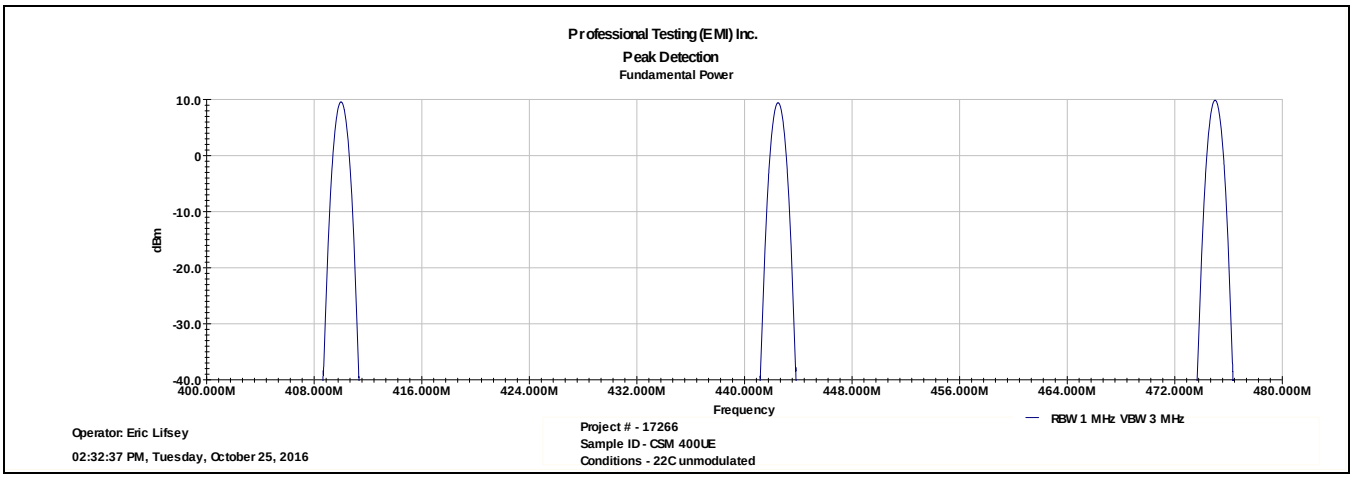
2.3 Results

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	9.6	9.1
442.500	9.4	8.7
475.000	9.9	9.8



3.0 Emission Mask

3.1 Procedure

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

3.2 Criteria

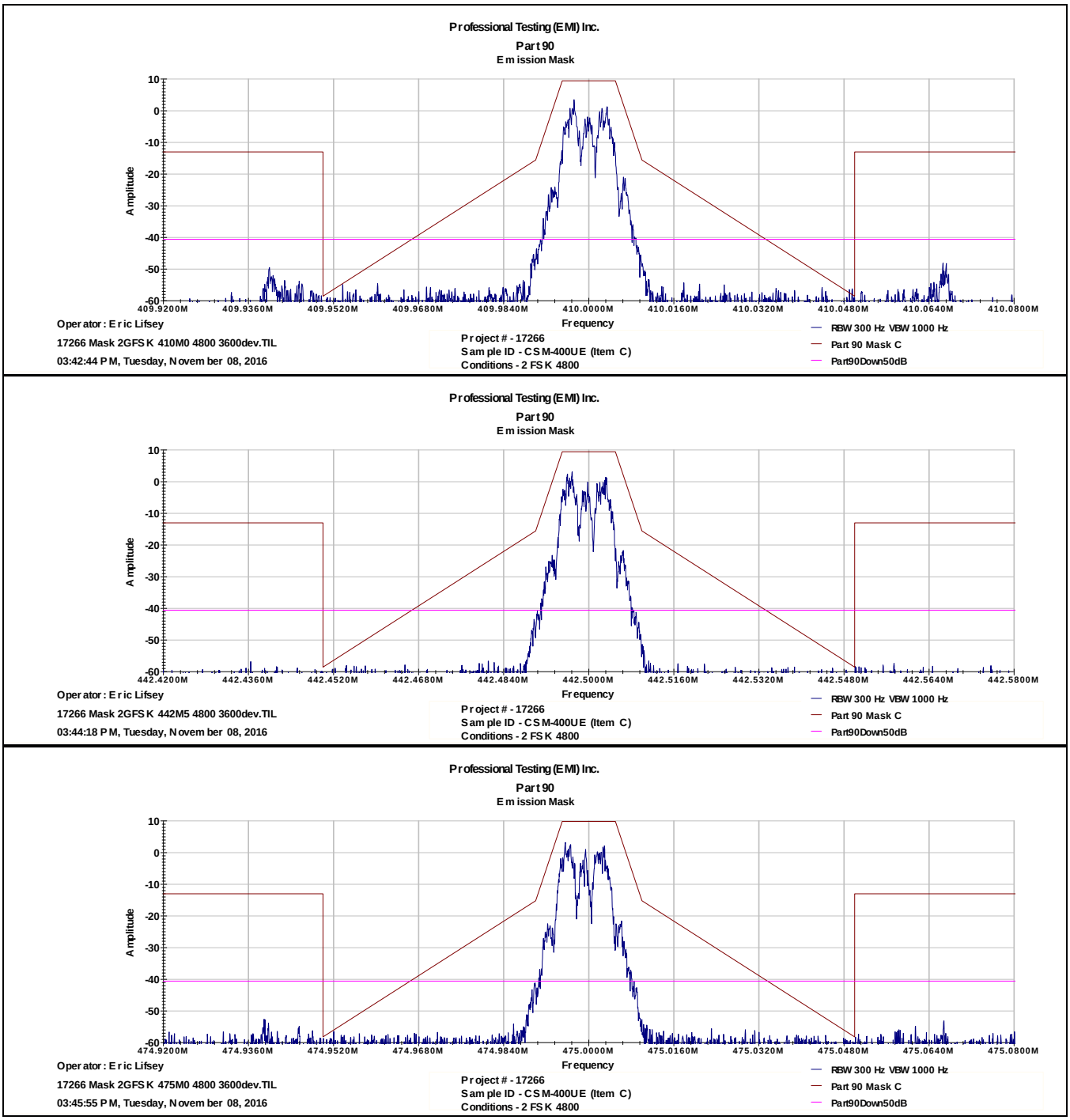
Parameter	Section Number	Date
Emissions at Antenna Terminals	90.210(c), 90.217(b), 2.1047| RSS-119 Issue 12, 5.8.3	8/9 Nov 2016 7 Feb 2017

3.3 Results

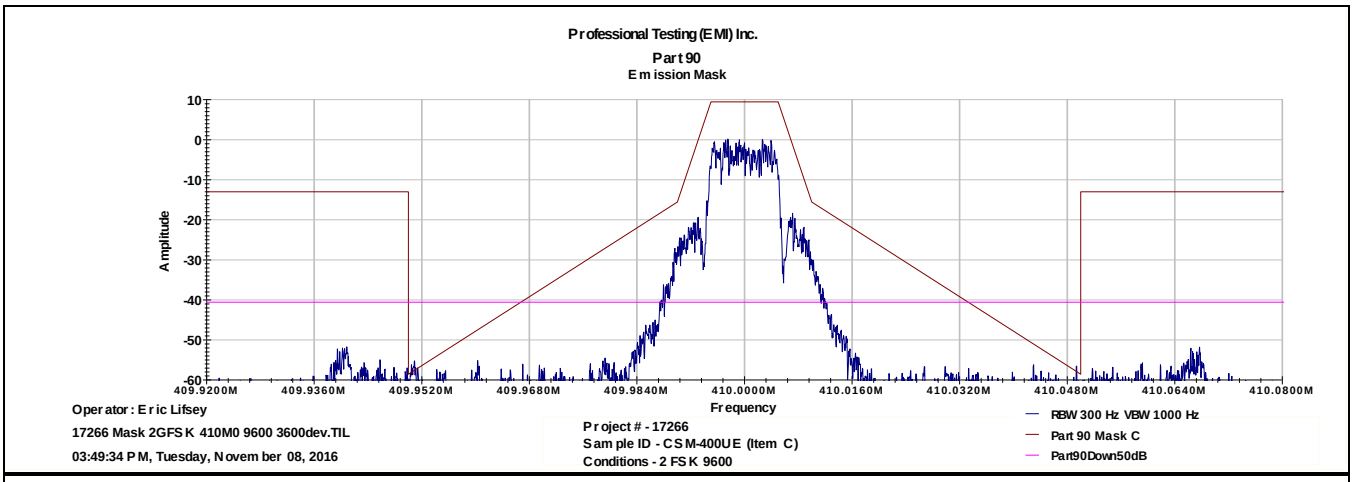
The emission was measured coupled directly to the analyzer without cabling. The EUT satisfied the requirement.

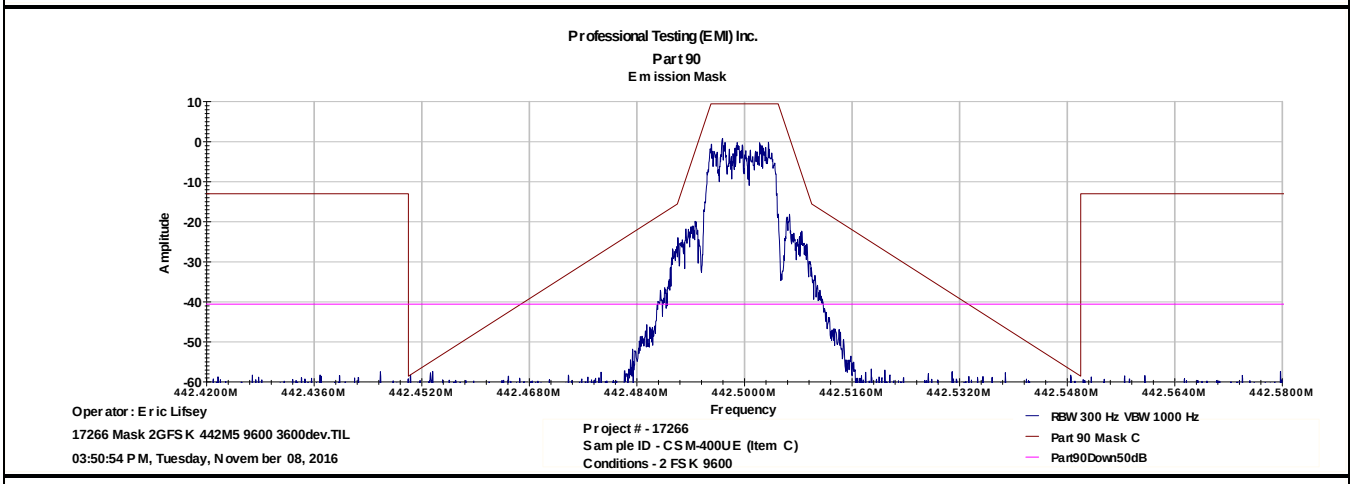
Measurements appear on the following pages.

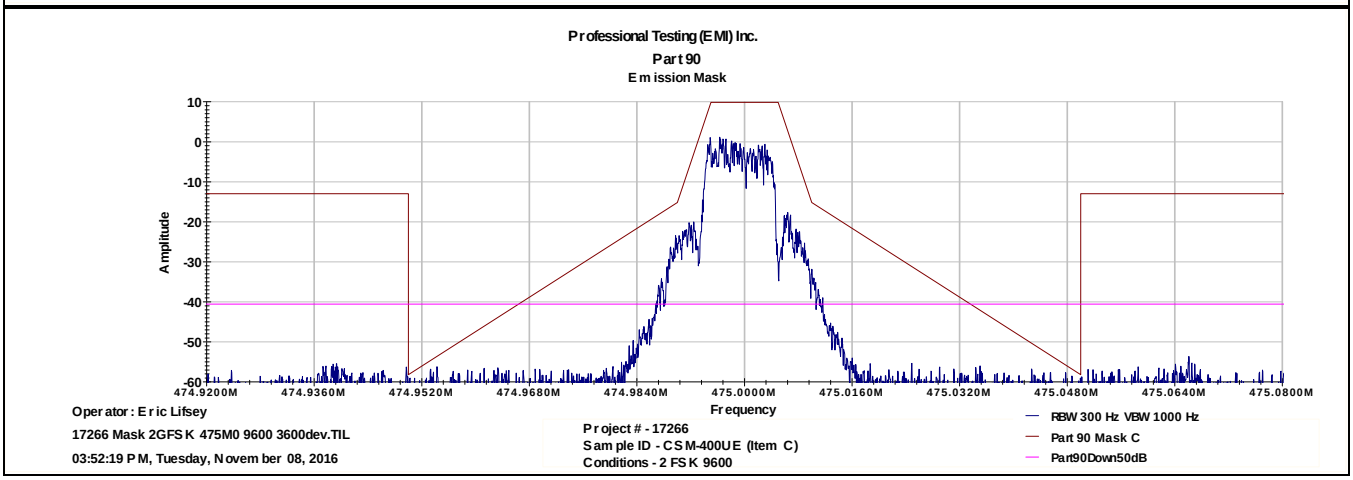
3.3.1 Modulation 2GFSK at 4800 Symbols per Second



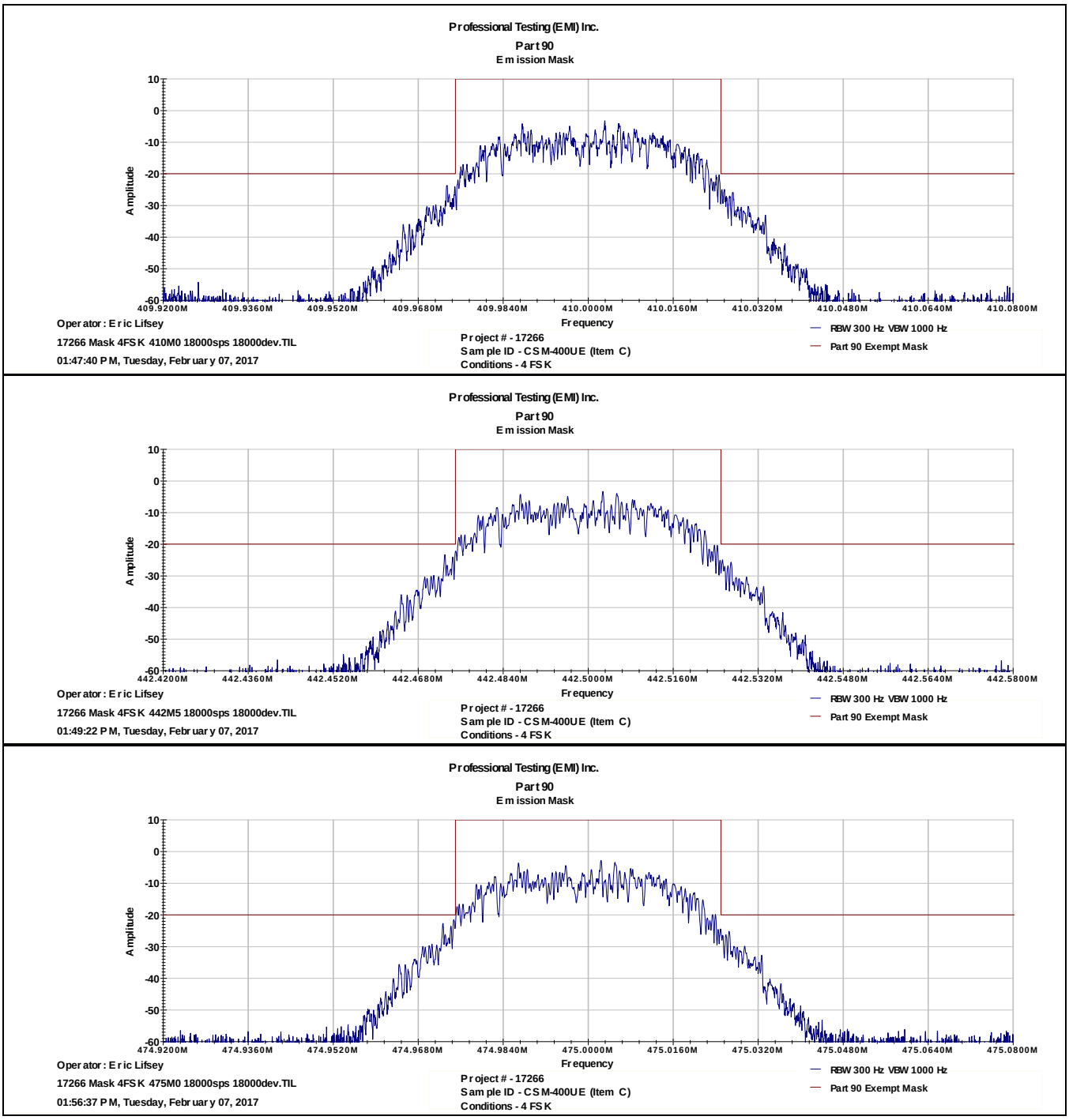
3.3.2 Modulation 2GFSK at 9600 Symbols per Second



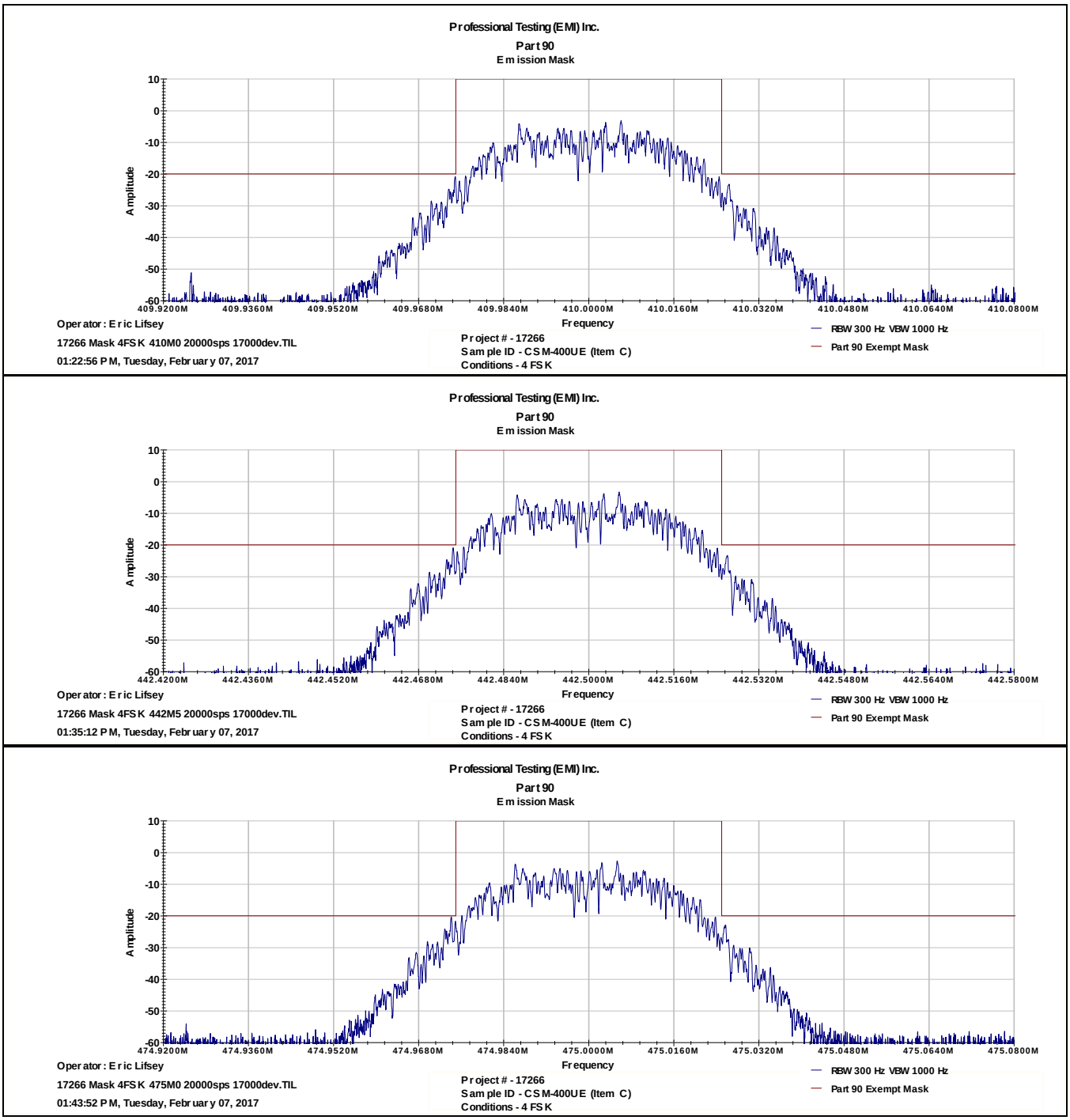




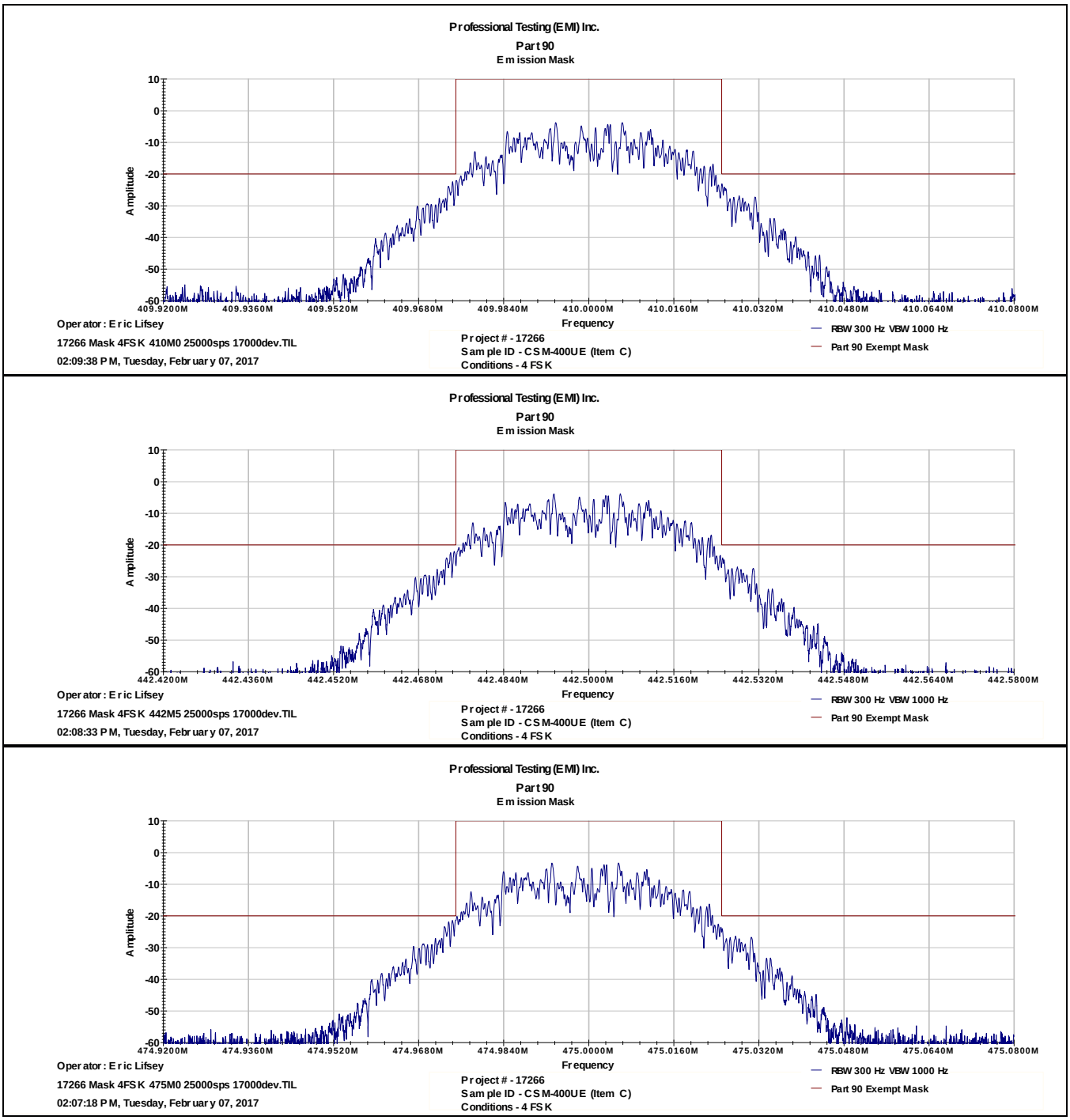
3.3.3 Modulation 4GFSK at 18000 Symbols per Second with 18000 Hz Deviation



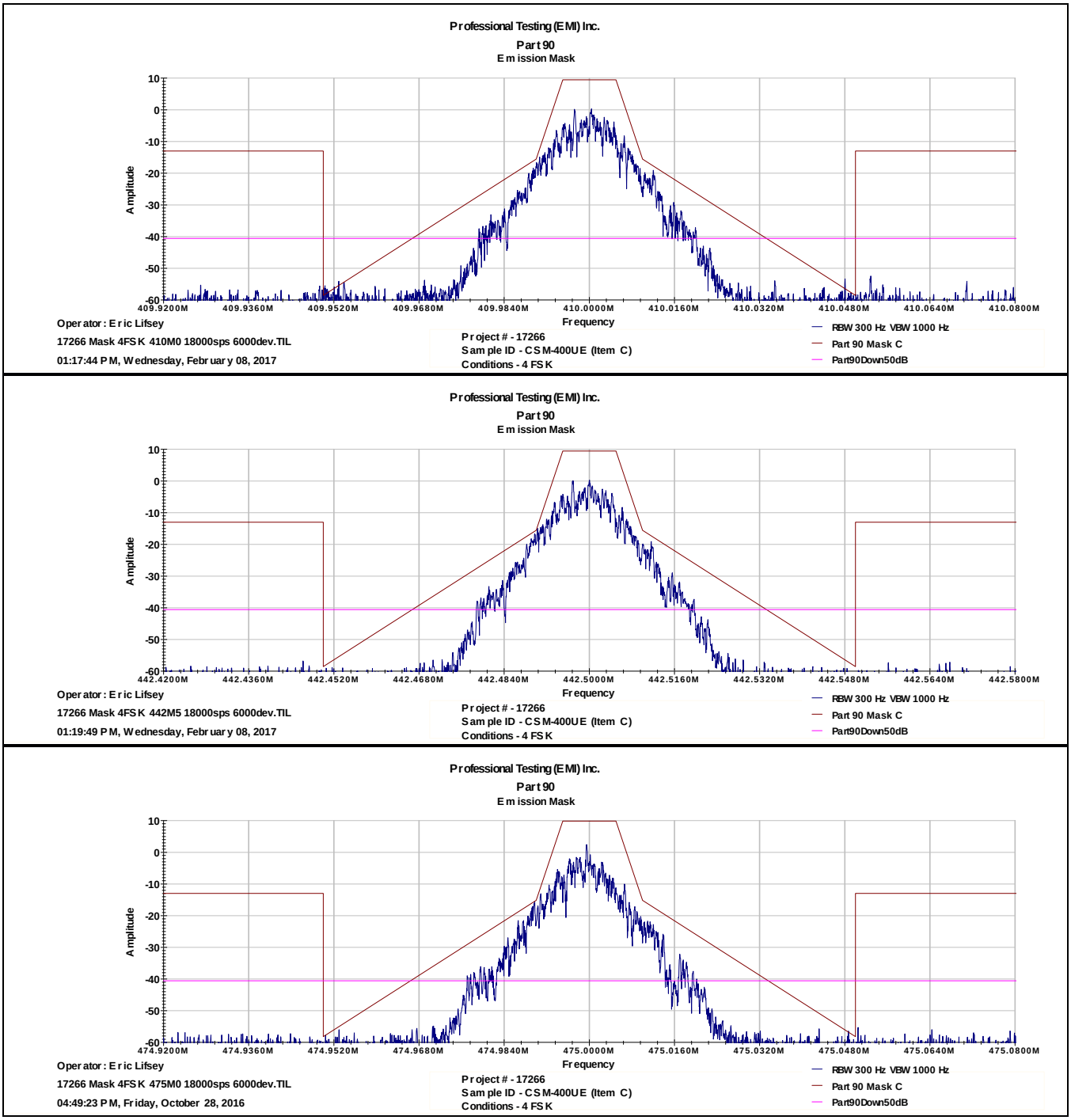
3.3.4 Modulation 4GFSK at 20000 Symbols per Second with 17000 Hz Deviation



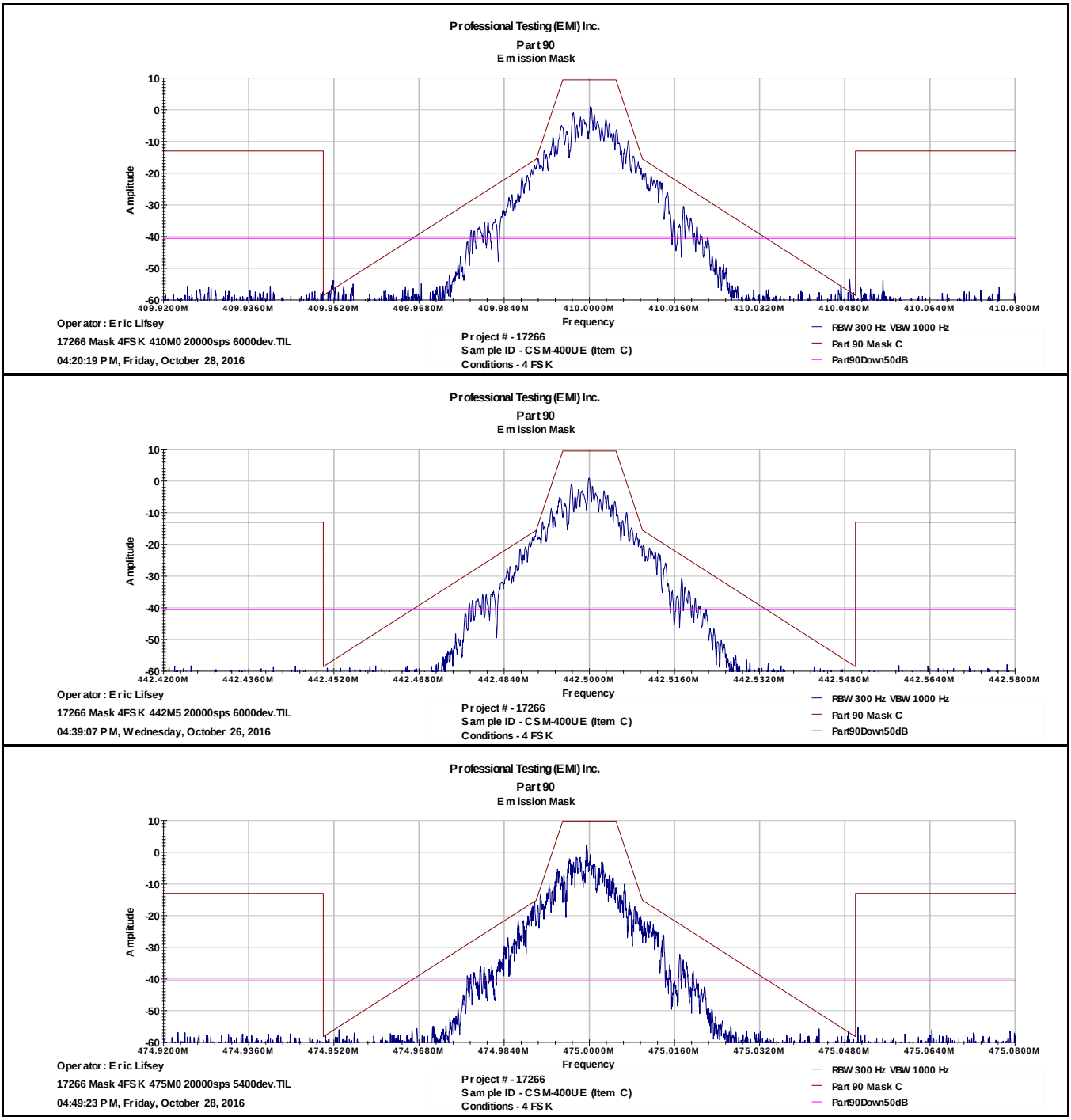
3.3.5 Modulation 4GFSK at 25000 Symbols per Second with 17000 Hz Deviation



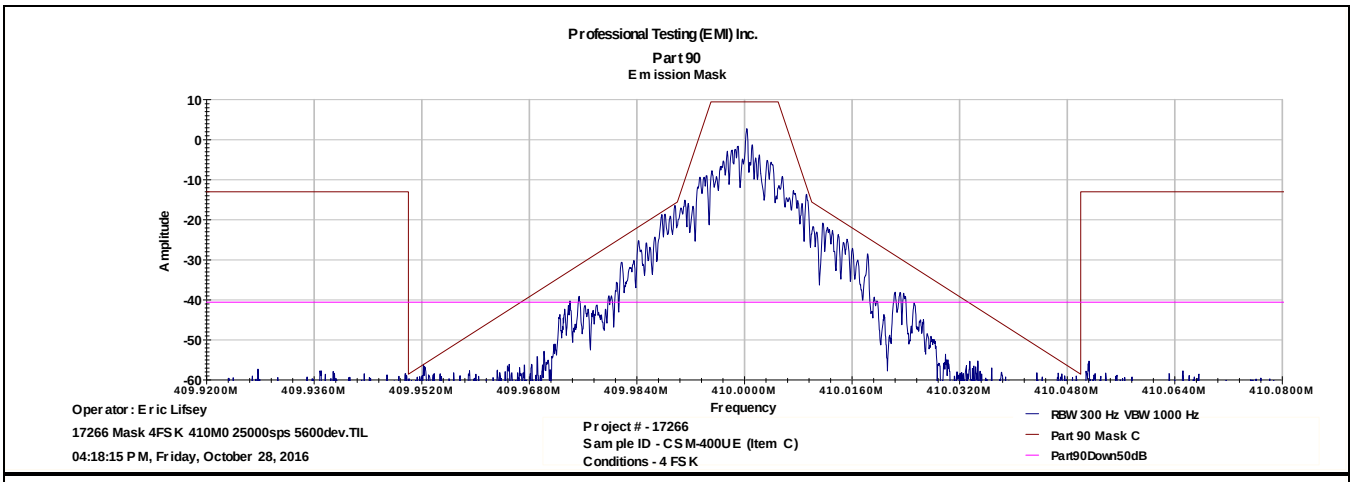
3.3.6 Modulation 4GFSK at 18000 Symbols per Second with 6000 Hz Deviation, Mask C

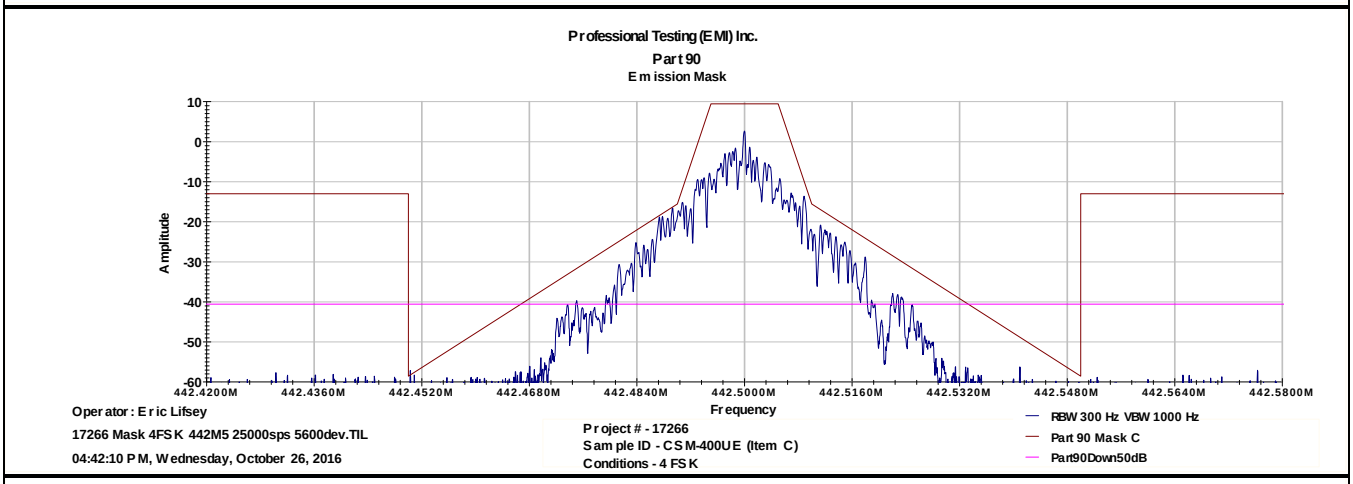


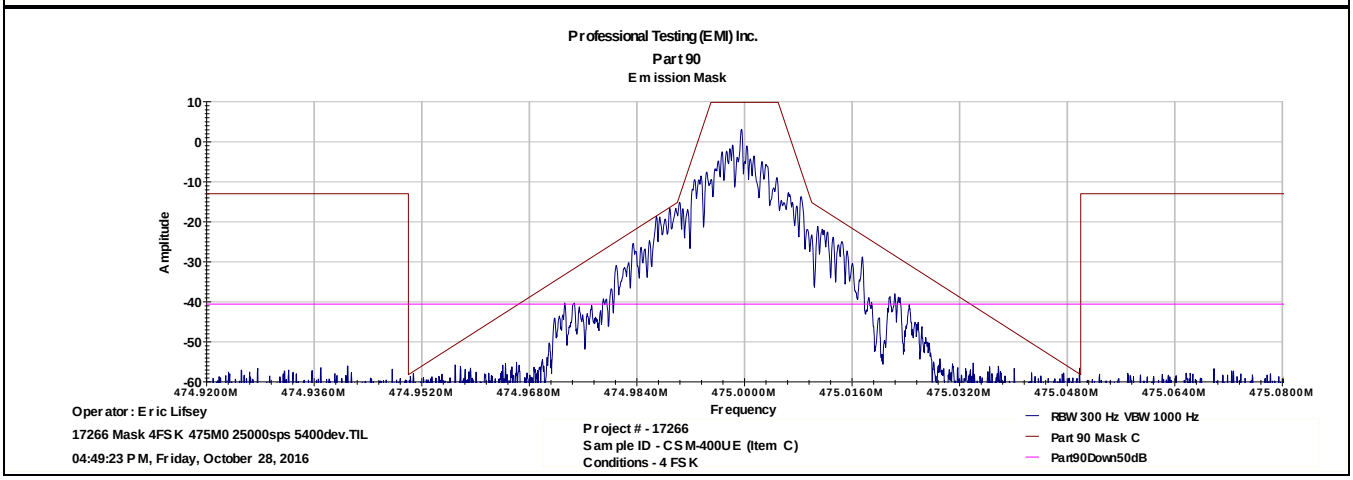
3.3.7 Modulation 4GFSK at 20000 Symbols per Second with 5400 Hz Deviation, Mask C



3.3.8 Modulation 4GFSK at 25000 Symbols per Second with 5400 Hz Deviation, Mask C







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	7 Nov 2016

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

Per 90.210(c)(3) $\text{Attenuation}_{(dB)} = 43 + 10\ \text{Log}_{10}(0.0098\ \text{W}) = 22.9\ \text{dB}$

$\text{Limit}_{(dBm)} = \text{Fundamental\_Power}_{(dBm)} - \text{Attenuation}_{(dB)} = 9.9\ \text{dBm} - 22.9\ \text{dB} = -13\ \text{dBm}$

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.

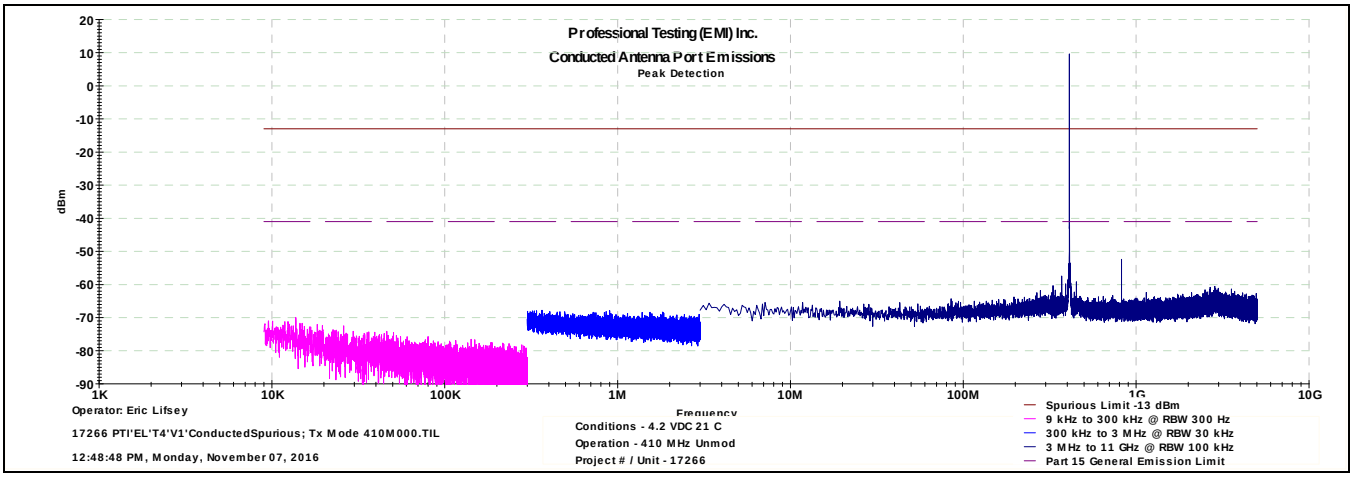
The EUT was found to be in compliance with applicable requirements.

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

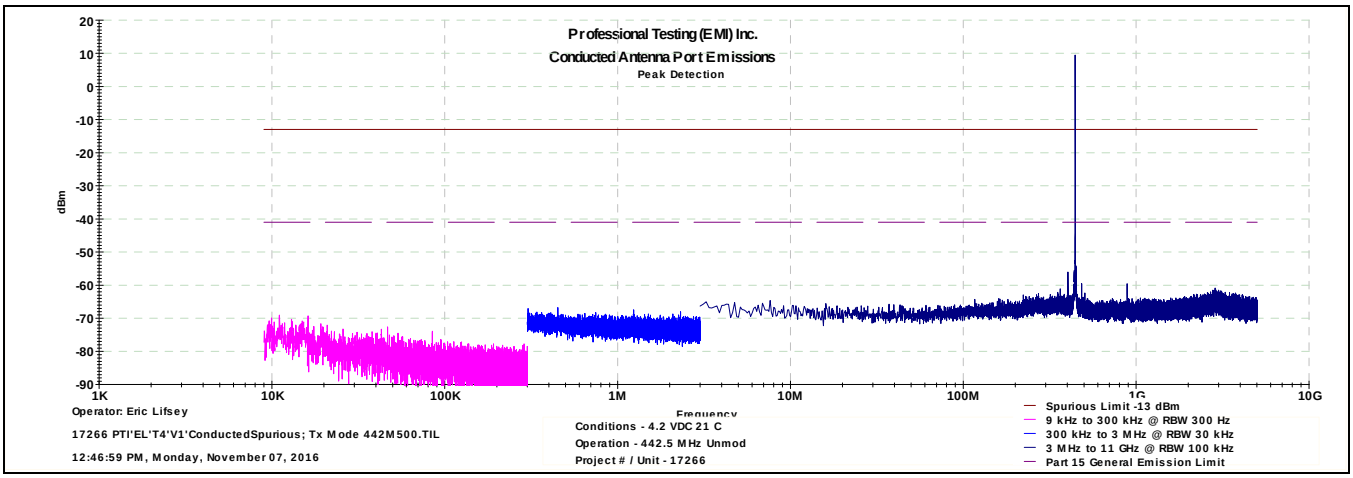
As supplemental information, the -41 dBm general emission limit was included as a dashed red line. It can be seen that both transmit and receive modes satisfy the general emission limit.

Measurements appear below.

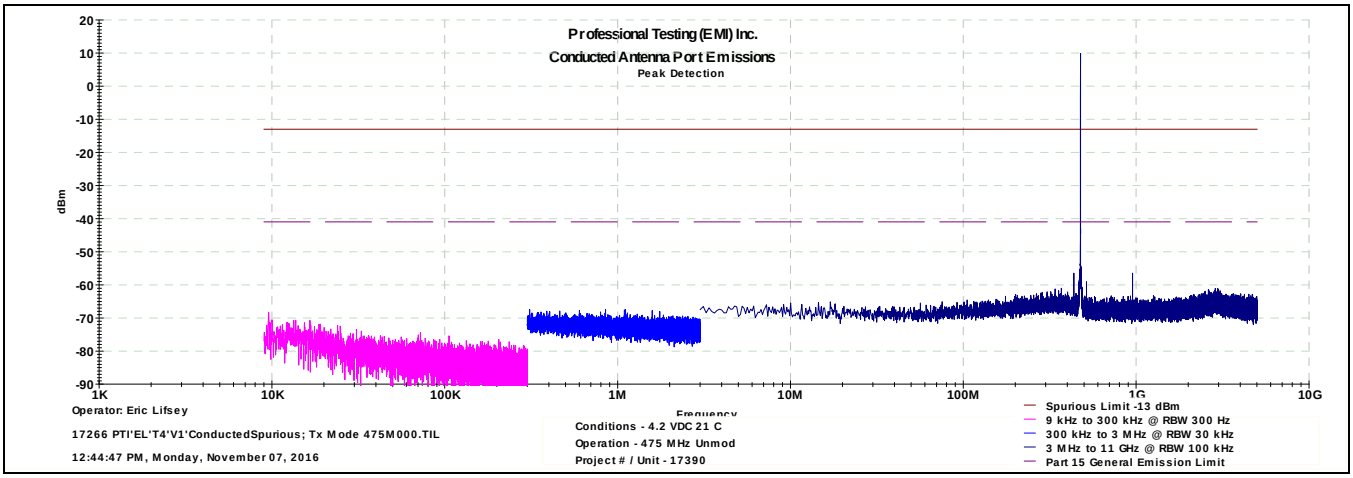
4.3.1 Transmit Mode, Bottom Channel



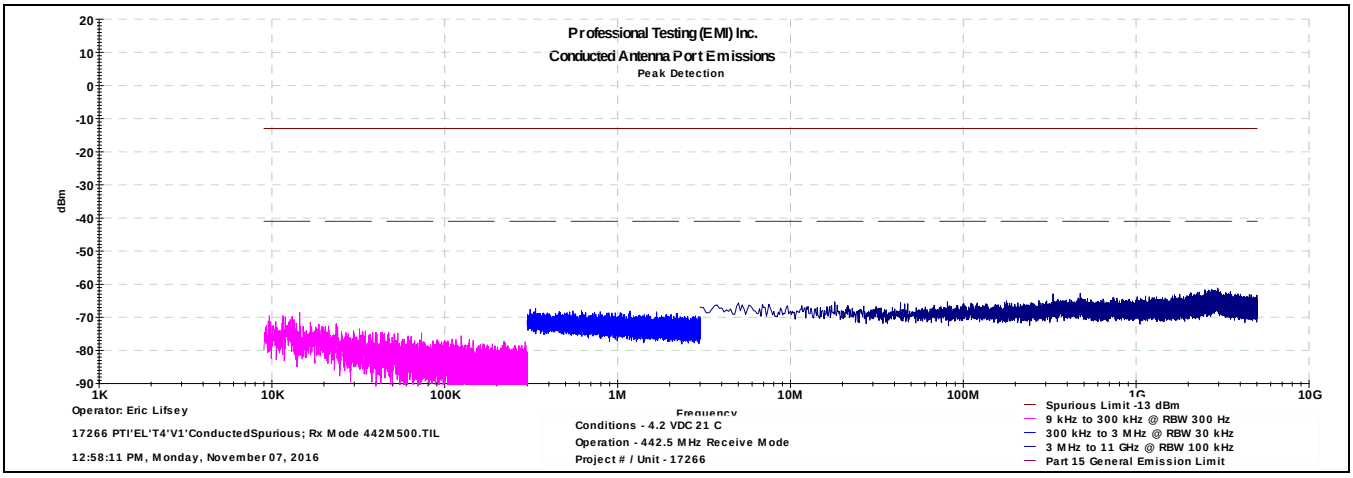
4.3.2 Transmit Mode, Middle Channel



4.3.3 Transmit Mode, Top Channel



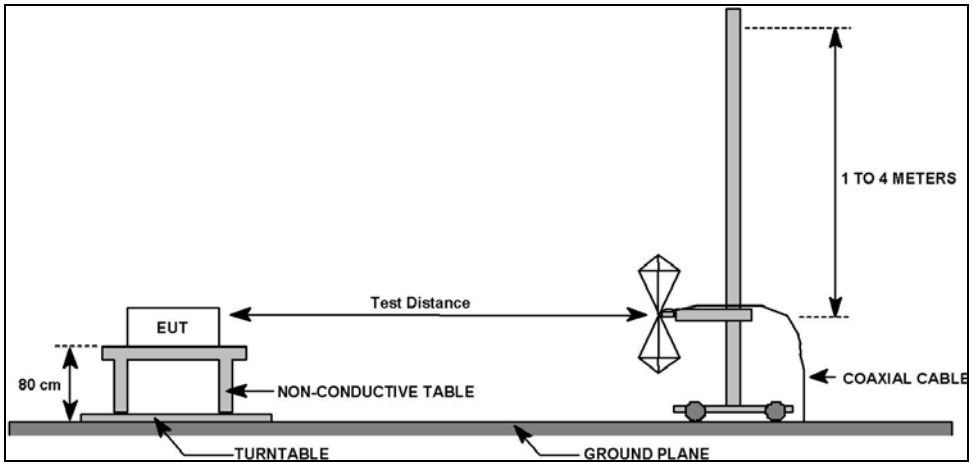
4.3.4 Receive Mode, Middle Channel



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	2016

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) $Attenuation_{(dB)} = 43 + 10\ Log_{10}(0.0098\ W) = 22.9$ dB

$Limit_{(dBm)} = Fundamental\_Power_{(dBm)} – Attenuation_{(dB)} = 9.9$ dBm – 22.9 dB = -13 dBm

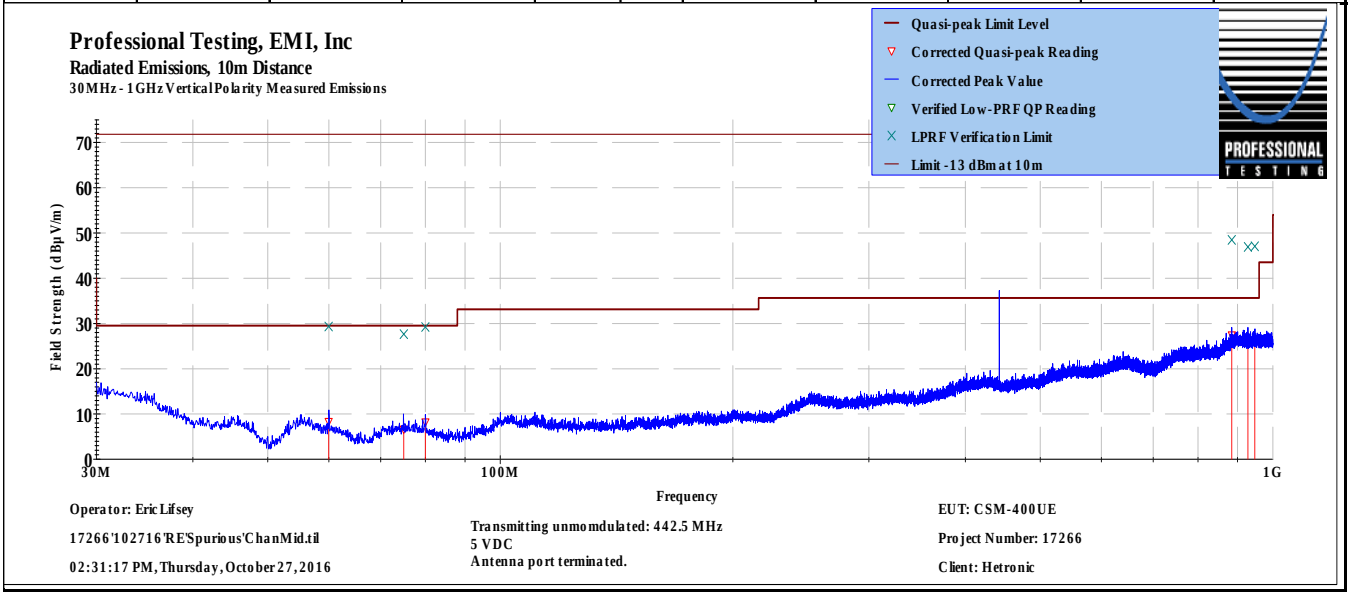
The EUT satisfied the requirement. Measurements appear below.

5.3.1 Transmit Mode, Below 1 GHz, Middle Channel

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	17266	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	5 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Continuous Transmit; middle channel	

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
59.9494	10	298	3.3	Quasi-peak	26.5	8.316	29.5	-21.2	Pass
75.0071	10	143	2.82	Quasi-peak	24.5	6.627	29.5	-22.9	Pass
79.9949	10	66	1.46	Quasi-peak	26.9	8.204	29.5	-21.3	Pass
884.998	10	102	1.91	Quasi-peak	23.1	27.45	35.6	-8.2	Pass
928.787	10	32	2.99	Quasi-peak	21	25.911	35.6	-9.7	Pass
947.9	10	319	3.22	Quasi-peak	20.9	26.044	35.6	-9.6	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

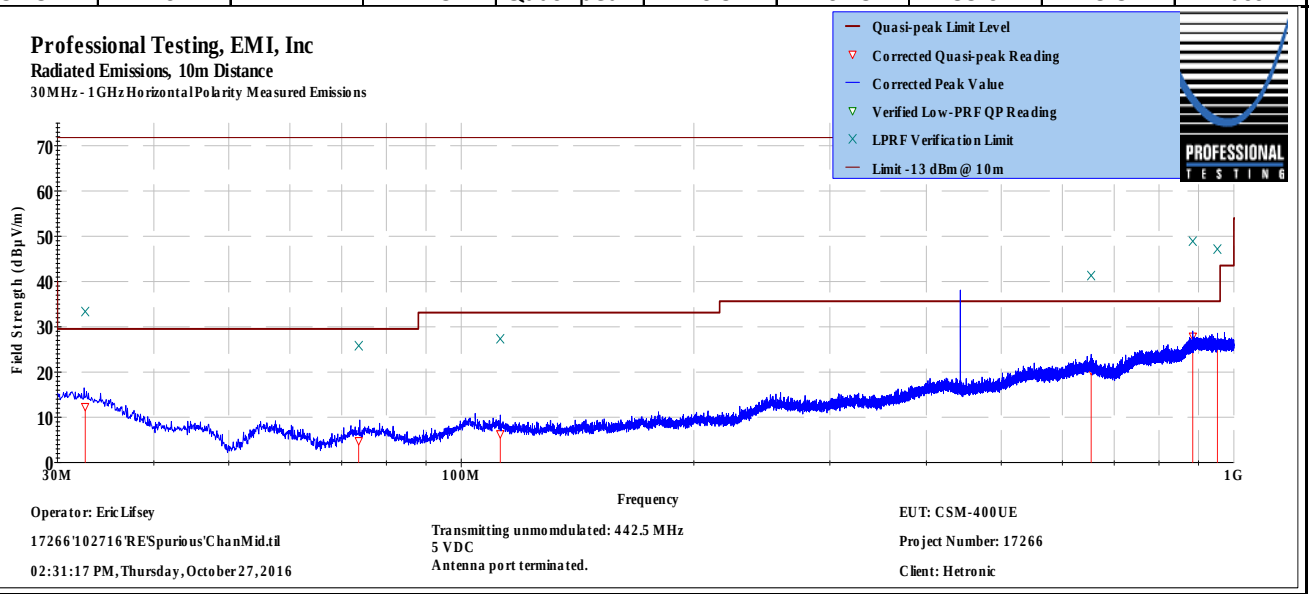
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits
Section:	15.209

Test Date(s):	10/27/2016	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	17266	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	CSM-400UE	**Witness' Name:**	None

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

EUT Line Voltage:	5 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Continuous Transmit; middle channel	

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
32.5943	10	46	1.15	Quasi-peak	23.8	12.352	29.5	-17.1	Pass
73.6668	10	244	3.14	Quasi-peak	23.2	4.815	29.5	-24.7	Pass
112.294	10	97	3.28	Quasi-peak	23.1	6.327	33.1	-26.8	Pass
653.708	10	123	3.97	Quasi-peak	21.8	20.303	35.6	-15.3	Pass
885.03	10	308	1.32	Quasi-peak	23.5	27.906	35.6	-7.7	Pass
952.312	10	224	2.15	Quasi-peak	20.9	26.15	35.6	-9.5	Pass



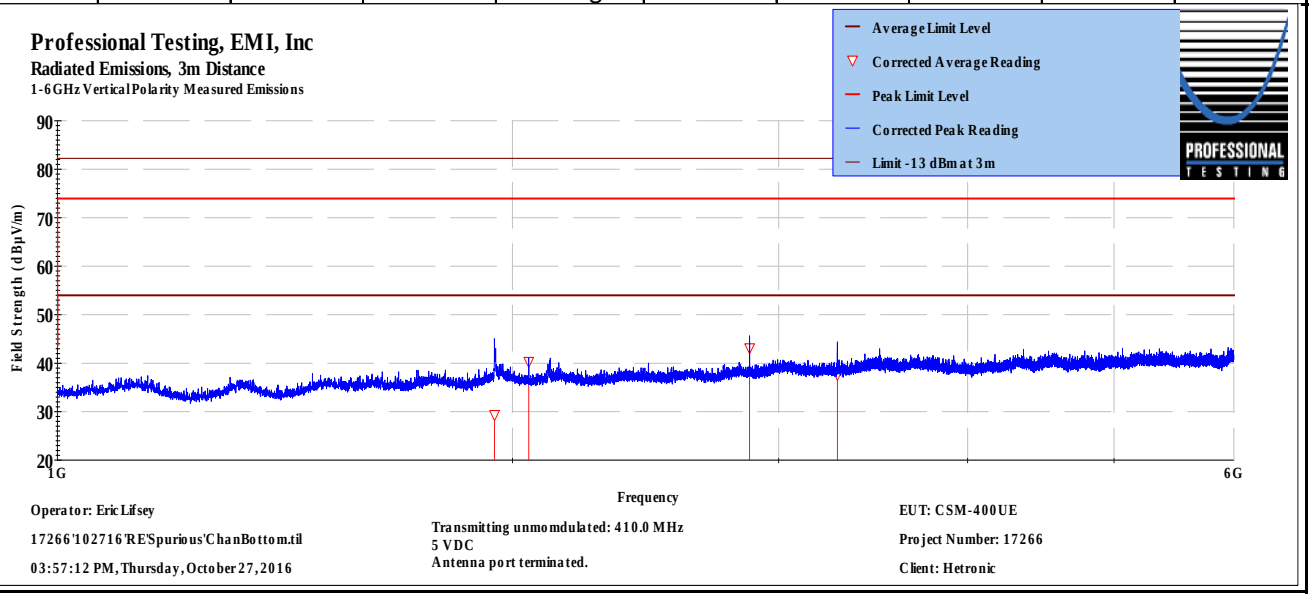
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.2 Transmit Mode, Above 1 GHz, Bottom Channel

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	17266	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			Page:	1	of	1
EUT Line Voltage:	5	VDC	EUT Power Frequency:	0	N/A	
Antenna Orientation:	Vertical		Frequency Range:	Above 1GHz		
EUT Mode of Operation:	Continuous Transmit; bottom channel					

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
1946.15	3	37	3.41	Average	38.2	29.339	54.0	-24.6	Pass
2049.95	3	112	3.22	Average	49	40.305	54.0	-13.7	Pass
2869.89	3	40	2.43	Average	50.3	43.124	54.0	-10.8	Pass
3279.97	3	36	2.33	Average	44.5	37.653	54.0	-16.3	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

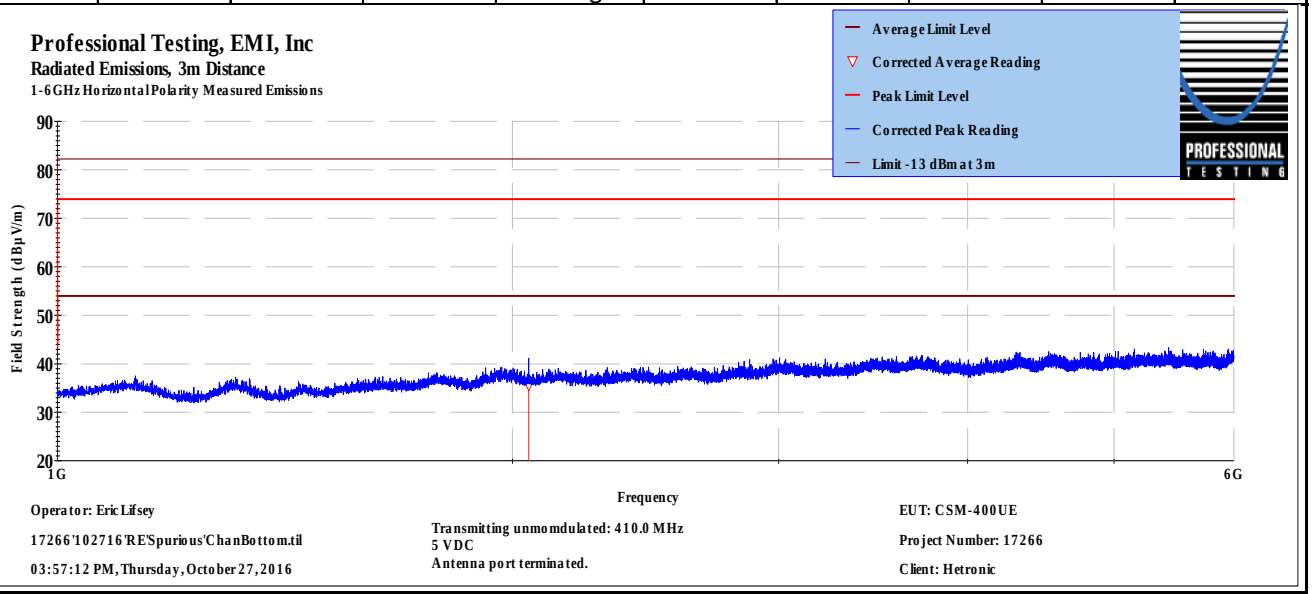
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	17266	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	CSM-400UE	**Witness' Name:**	None

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

EUT Line Voltage:	5 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Continuous Transmit; bottom channel	

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
2050.09	3	154	2.5	Average	44.3	35.583	54.0	-18.4	Pass



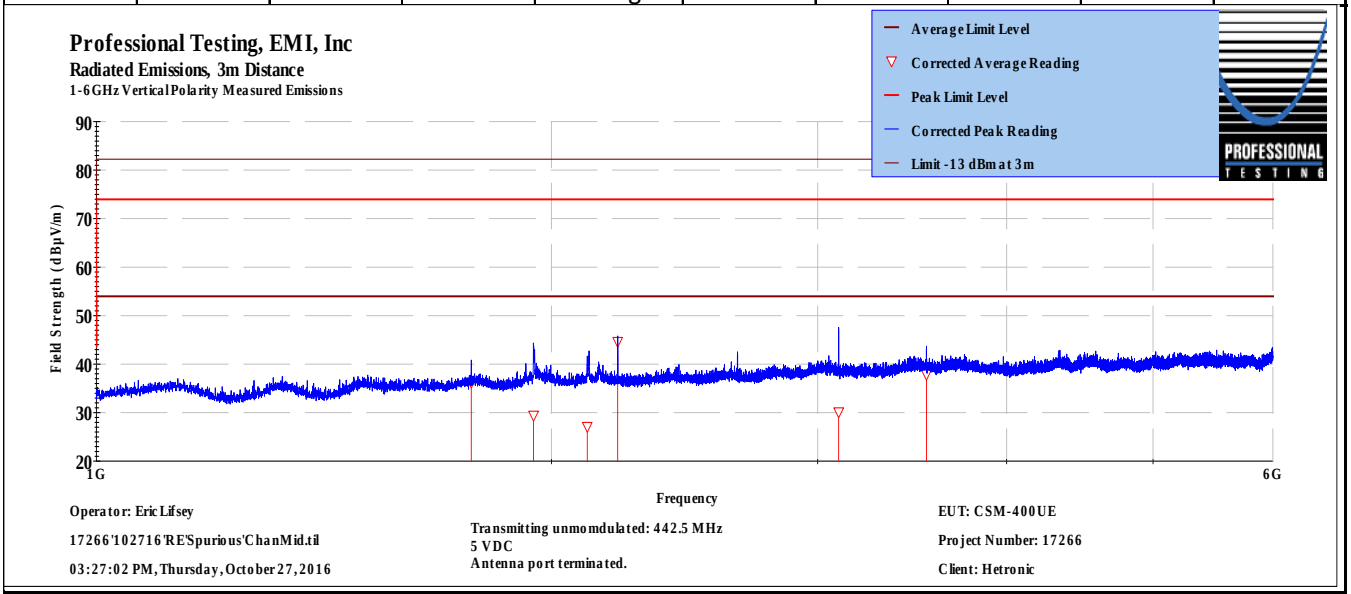
> 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.3 Transmit Mode, Above 1 GHz, Middle Channel

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	17266	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	5 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Continuous Transmit; middle channel	

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
1769.98	3	46	1.19	Average	46.2	36.217	54.0	-17.7	Pass
1946.19	3	28	1.04	Average	38.3	29.429	54.0	-24.5	Pass
2112.08	3	26	1.94	Average	35.8	27.112	54.0	-26.8	Pass
2212.37	3	56	1.86	Average	53.6	44.627	54.0	-9.3	Pass
3097.48	3	280	1.82	Average	36.7	30.096	54.0	-23.9	Pass
3539.97	3	87	1.04	Average	43.6	37.877	54.0	-16.1	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

Professional Testing, EMI, Inc.

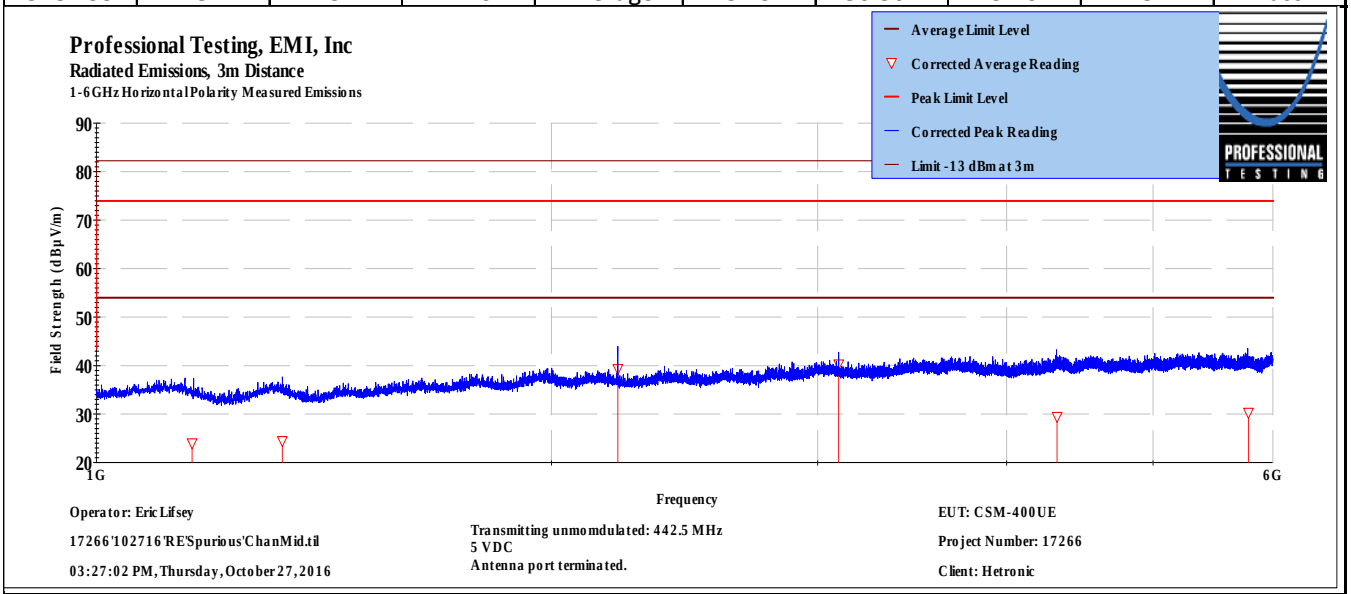
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits
Section:	15.209

Test Date(s):	10/27/2016	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	17266	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	CSM-400UE	**Witness' Name:**	None

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

EUT Line Voltage:	5 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Continuous Transmit; middle channel	

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
1156.97	3	61	3.68	Average	35.8	24.014	54.0	-29.9	Pass
1327.33	3	338	3.59	Average	36.2	24.495	54.0	-29.5	Pass
2212.51	3	81	2.88	Average	48.3	39.303	54.0	-14.7	Pass
3097.43	3	312	3.03	Average	46.9	40.265	54.0	-13.7	Pass
4319.94	3	104	1.56	Average	33.7	29.472	54.0	-24.5	Pass
5781.99	3	137	1.16	Average	31.9	30.307	54.0	-23.7	Pass



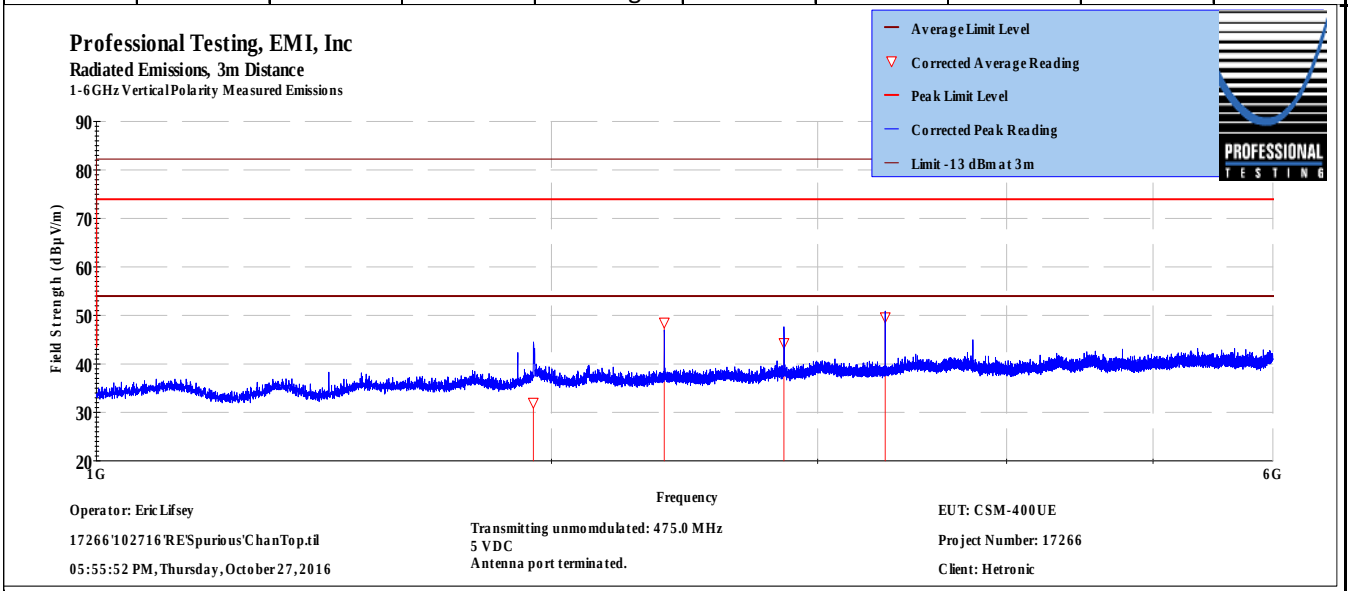
> 1GHz Horizontal Antenna Polarity Measured Emissions

5.3.4 Transmit Mode, Above 1 GHz, Top Channel

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	EUT Serial #:	None
Customer:	Hetronic	EUT Part #:	None
Project Number:	17266	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	CSM-400UE	Witness' Name:	None

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	5 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Continuous Transmit; top channel	

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
1945.41	3	301	1.02	Average	40.9	32.026	54.0	-21.9	Pass
2375.06	3	81	3.08	Average	57.1	48.563	54.0	-5.4	Pass
2849.89	3	64	2.45	Average	51.6	44.325	54.0	-9.6	Pass
3325.06	3	43	2.19	Average	56.3	49.655	54.0	-4.3	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

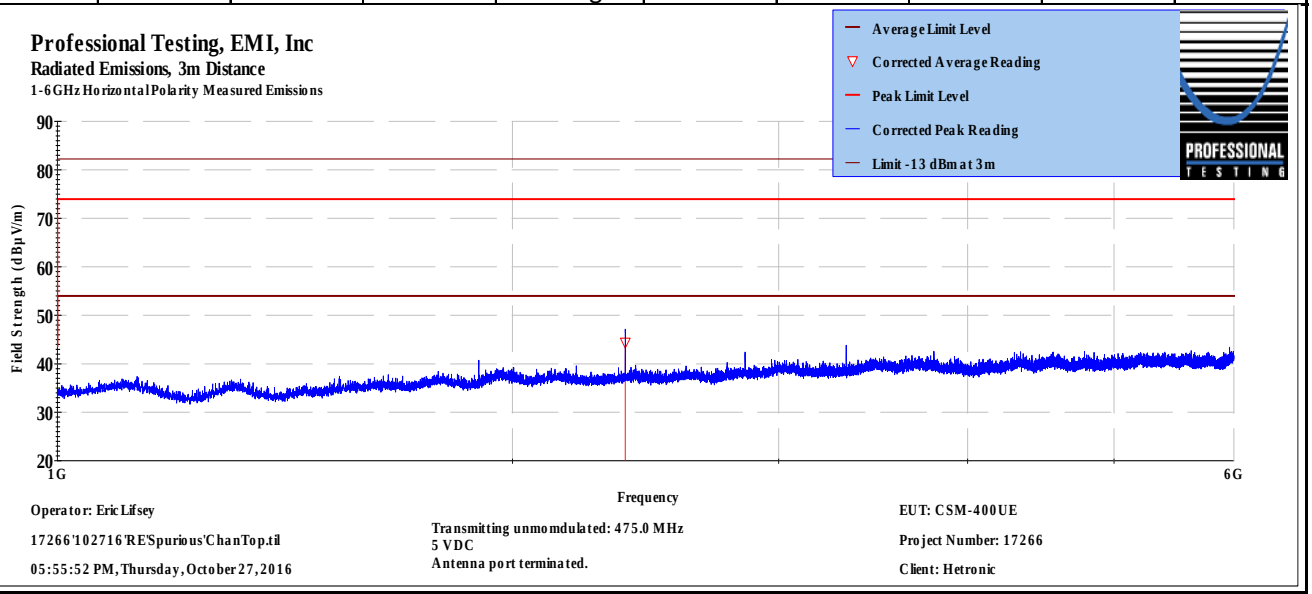
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference, see §15.38).		
In accordance with:	FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits		
Section:	15.209		
Test Date(s):	10/27/2016	**EUT Serial #:**	None
Customer:	Hetronic	**EUT Part #:**	None
Project Number:	17266	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	CSM-400UE	**Witness' Name:**	None

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

EUT Line Voltage:	5 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Continuous Transmit; top channel	

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
2374.9	3	128	1.93	Average	52.9	44.402	54.0	-9.6	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	4 Nov 2016

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 1212 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	409.999632	-368
-20	410.000000	409.999825	-175
-10	410.000000	409.999814	-186
0	410.000000	409.999818	-182
10	410.000000	409.999842	-158
20	410.000000	409.999885	-115
30	410.000000	409.999848	-152
40	410.000000	409.999825	-175
50	410.000000	409.999625	-375
Max Deviation (Hz)			-115
Min Deviation (Hz)			-375

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	409.999893	-107
Nominal	4.20	410.000000	409.999892	-108
High	5.10	410.000000	409.999875	-125

6.3.3 Middle Channel, Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	442.500000	442.499275	-725
-20	442.500000	442.499459	-541
-10	442.500000	442.499455	-545
0	442.500000	442.499453	-547
10	442.500000	442.499479	-521
20	442.500000	442.499532	-468
30	442.500000	442.499949	-51
40	442.500000	442.499448	-552
50	442.500000	442.499249	-751
Max Deviation (Hz)			-51
Min Deviation (Hz)			-751

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	442.499506	-494
Nominal	4.20	442.500000	442.499517	-483
High	5.10	442.500000	442.499514	-486

6.3.5 Top Channel, Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	475.000000	474.998915	-1085
-20	475.000000	474.999082	-918
-10	475.000000	474.999103	-897
0	475.000000	474.999087	-913
10	475.000000	474.999118	-882
20	475.000000	474.999166	-834
30	475.000000	474.999136	-864
40	475.000000	474.998881	-1119
50	475.000000	474.998788	-1212
Max Deviation (Hz)			-834
Min Deviation (Hz)			-1212

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	474.999118	-882
Nominal	4.20	475.000000	474.999122	-878
High	5.10	475.000000	474.999122	-878

7.0 Transient Frequency Behavior

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

Refer to diagram of TIA-603-C page 99 and the procedure of 2.2.19.3.

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-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.

7.1 Criteria

Parameter	Section Reference	Date
Transient Frequency Behavior	90.214 | RSS-119 Issue 12, 5.9 Procedure: TIA-603-C	7 Nov 2016

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.

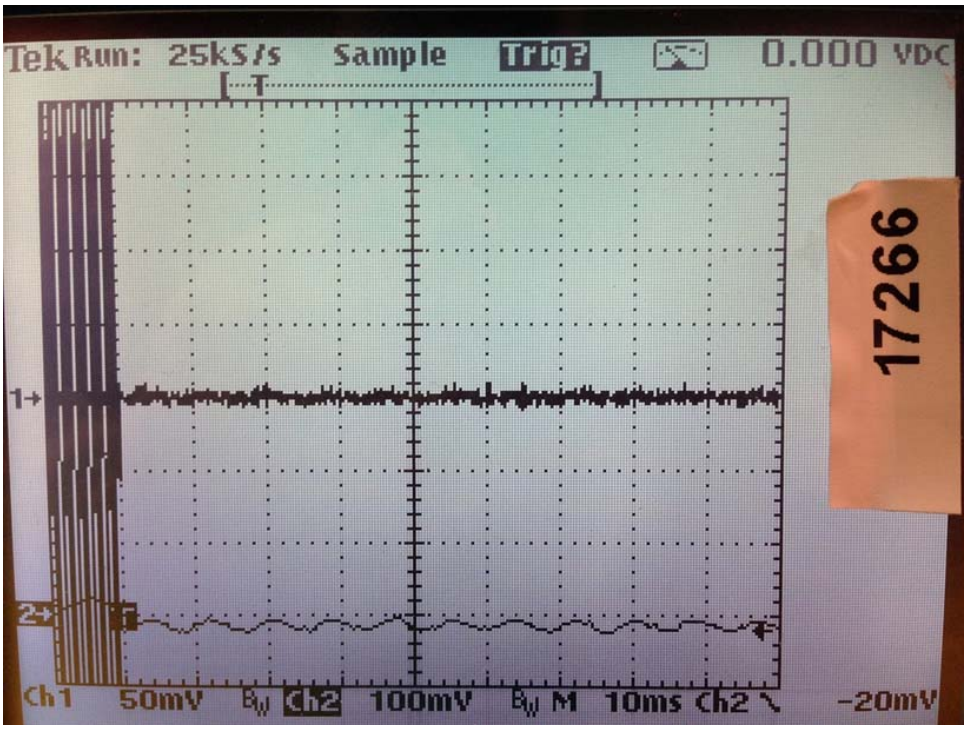
[4] If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

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

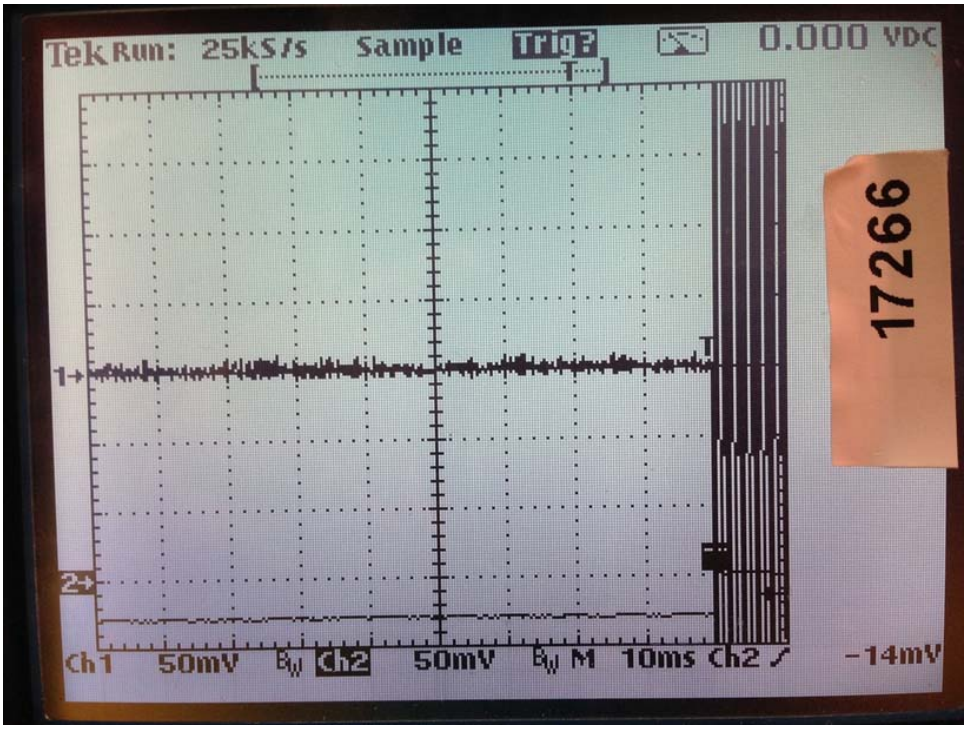
7.2 Results

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

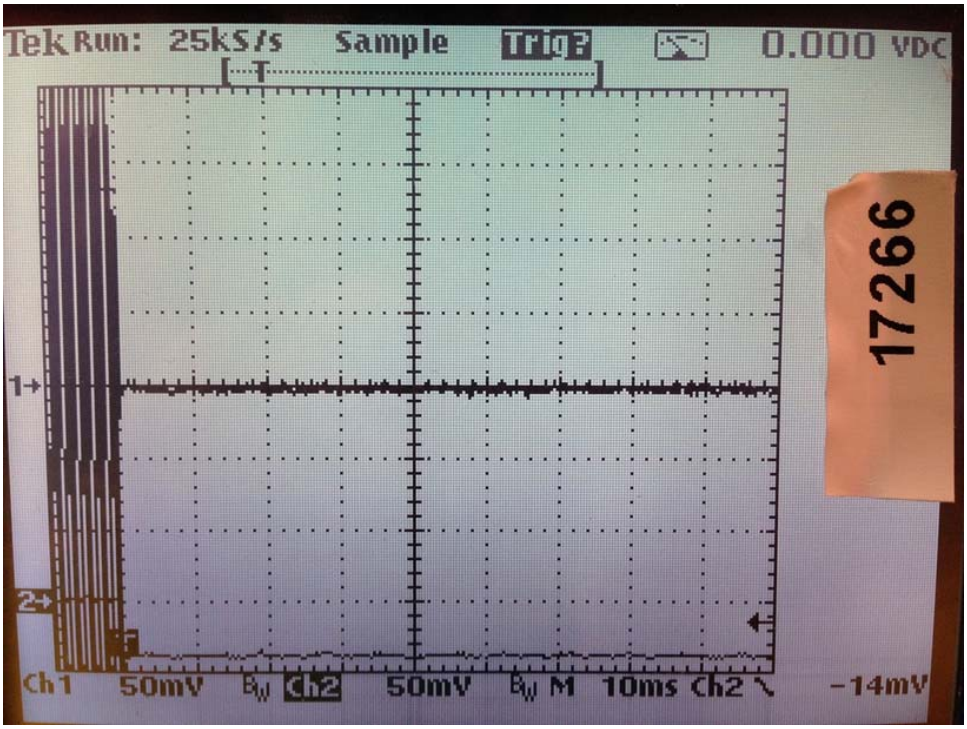


Attack



Release

7.2.2 Middle Channel



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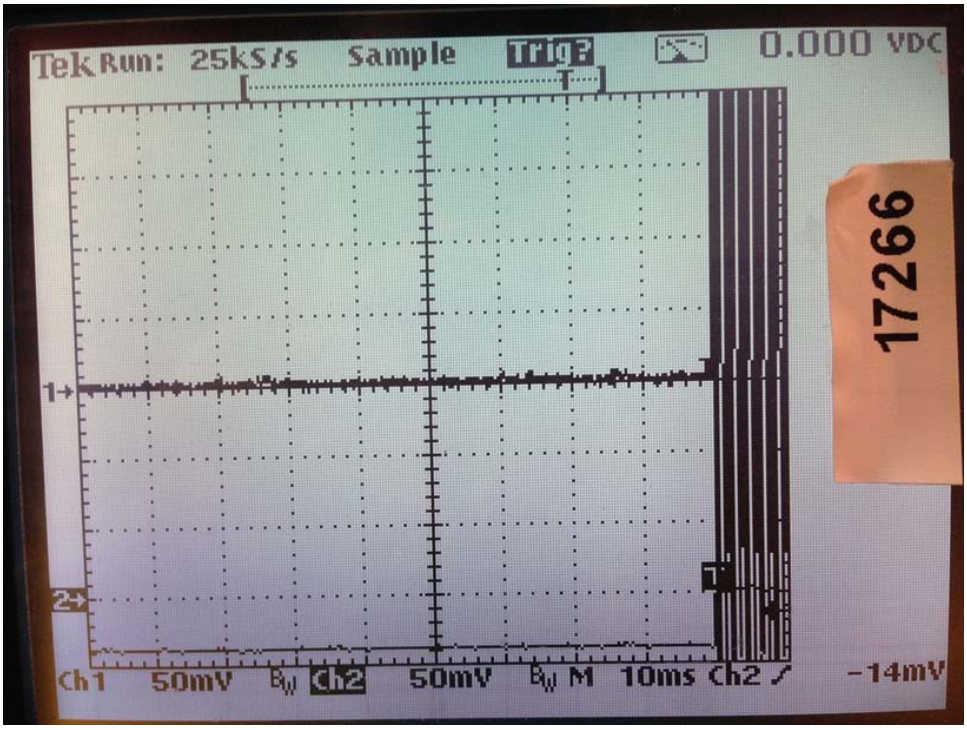
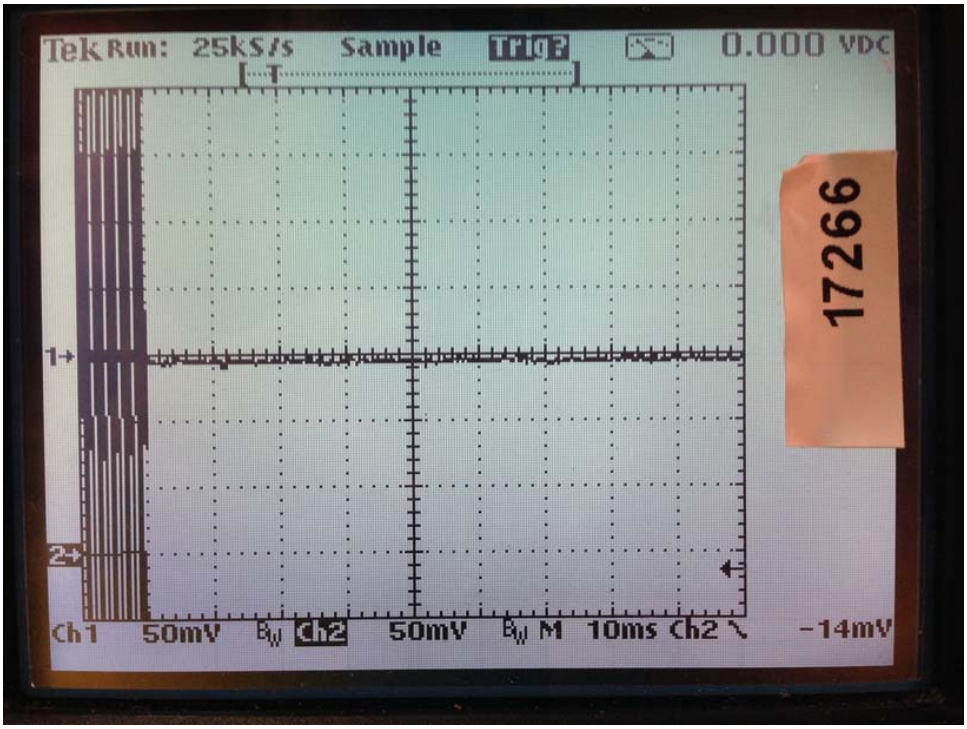
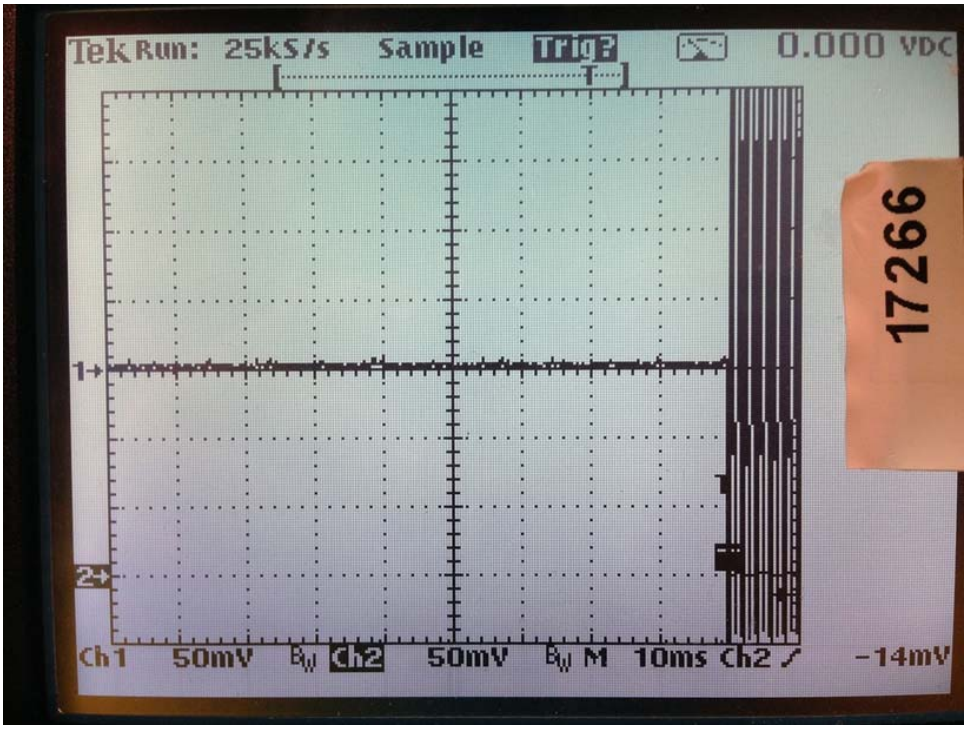


Release

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

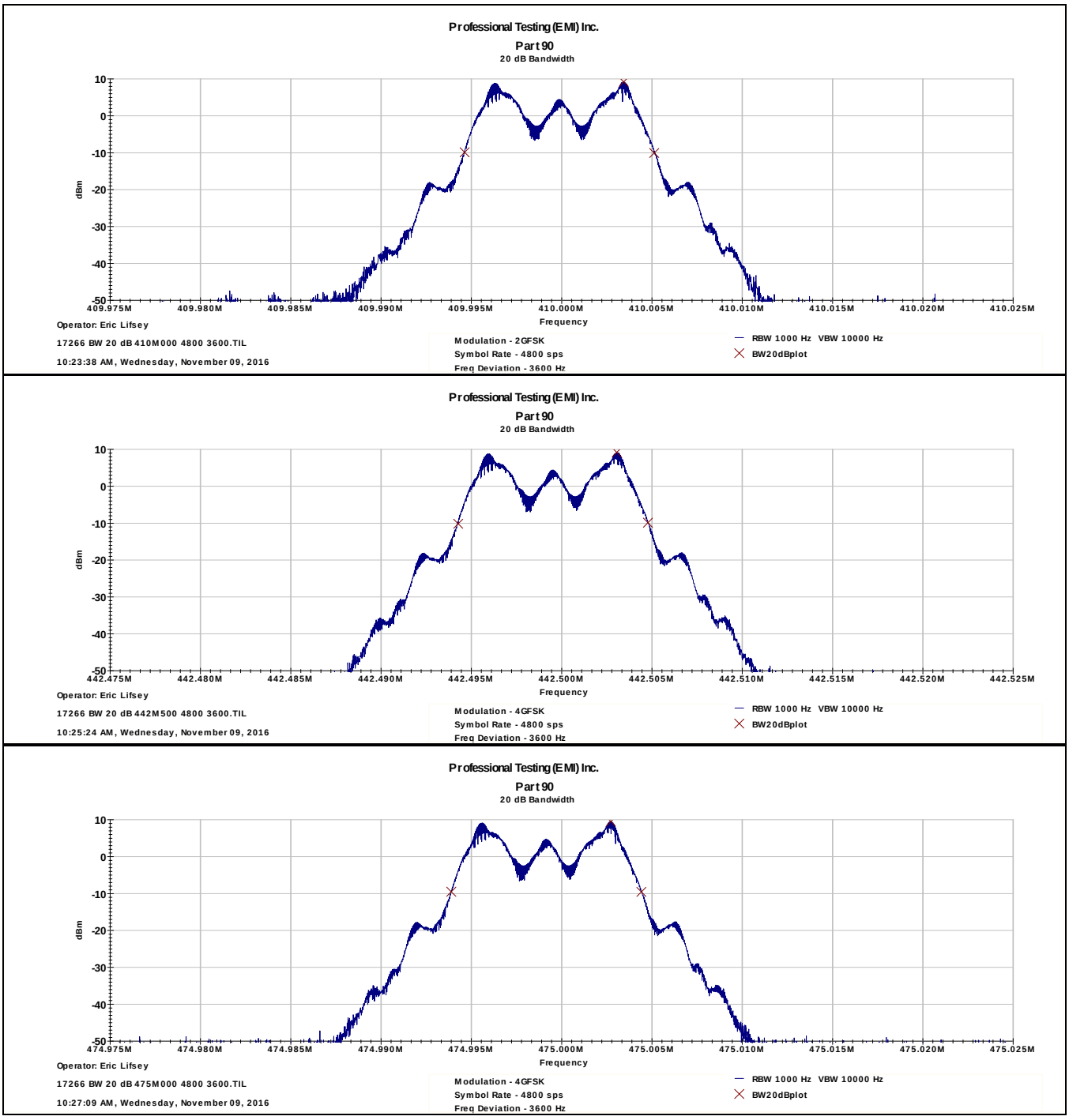
Parameter	Section Number	Date
90.210(c) Bandwidth < 12. 5 kHz Or spectrum efficiency minimum 4800 baud per 6.25 kHz bandwidth per 90.203(j)(3).	90.210(c), 90.203(j)(3), 2.1049 | RSS-119 Issue 12, 5.5	9 Nov 2016

8.3 Results

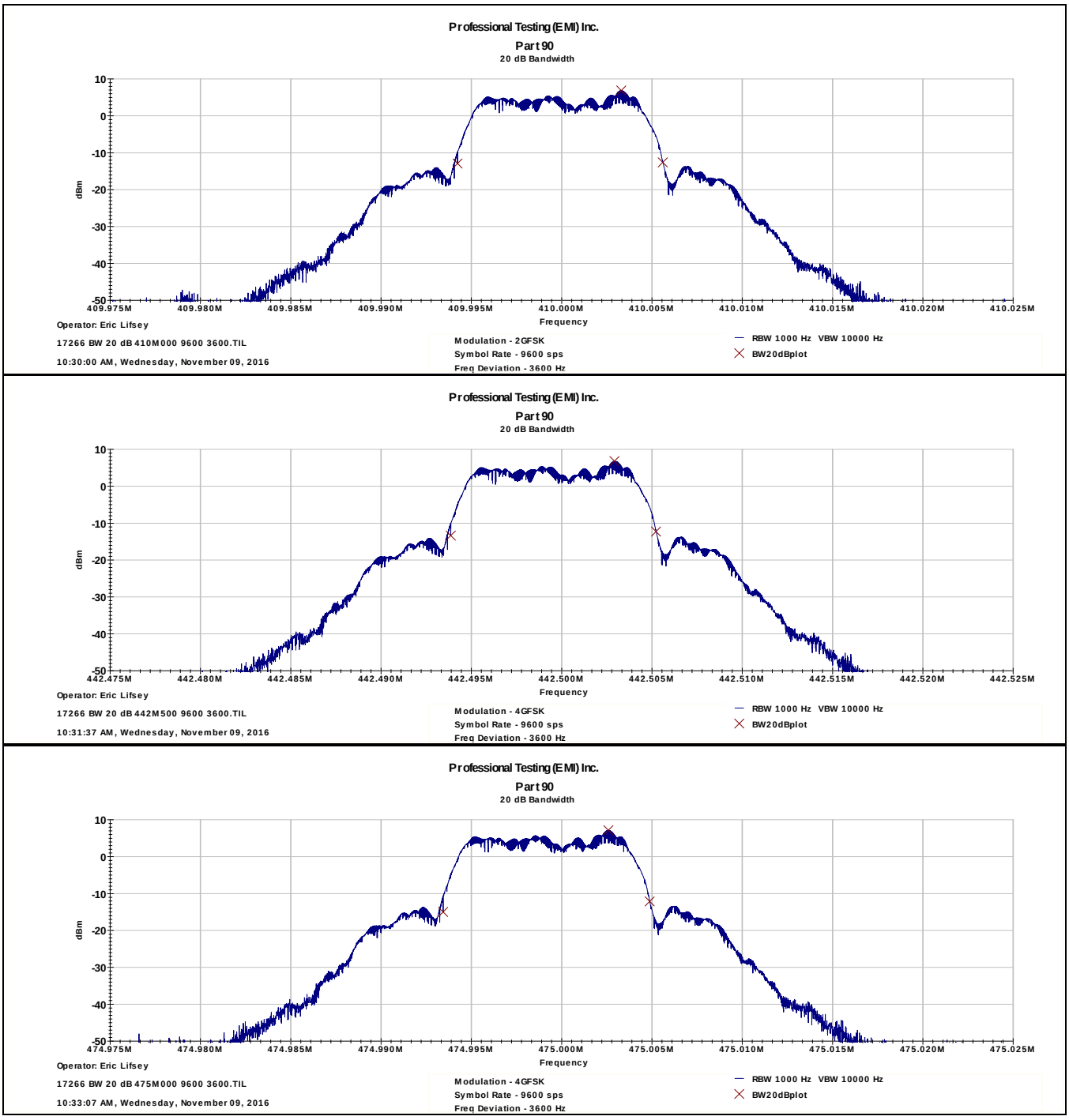
Table 9.3.1 Bandwidth 20 dB (kHz)				
Frequency	**2GFSK 4800 sps**	**2GFSK 9600 sps**	**4GFSK 20000 sps**	**4GFSK 25000 sps**
410.0 MHz	10.663	11.588	21.375	20.012
442.5 MHz	10.675	11.413	21.375	20.025
475.0 MHz	10.675	11.488	21.363	20.025

The emission satisfies the bandwidth criteria including the spectrum efficiency requirement at lower power than the threshold of 500 mW. Plotted results appear on the following pages.

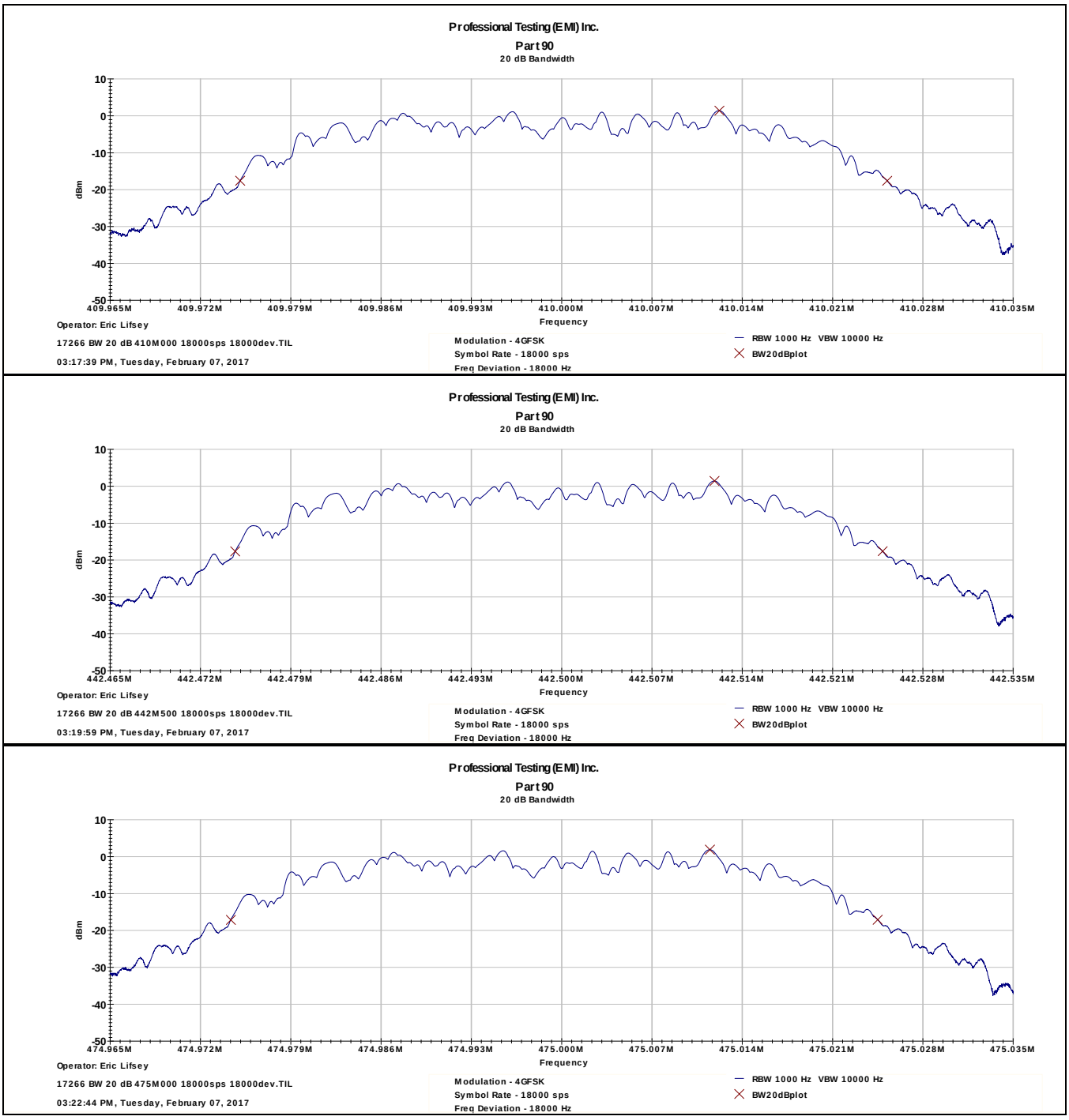
8.3.1 Modulation 2GFSK, 4800 Symbols Per Second



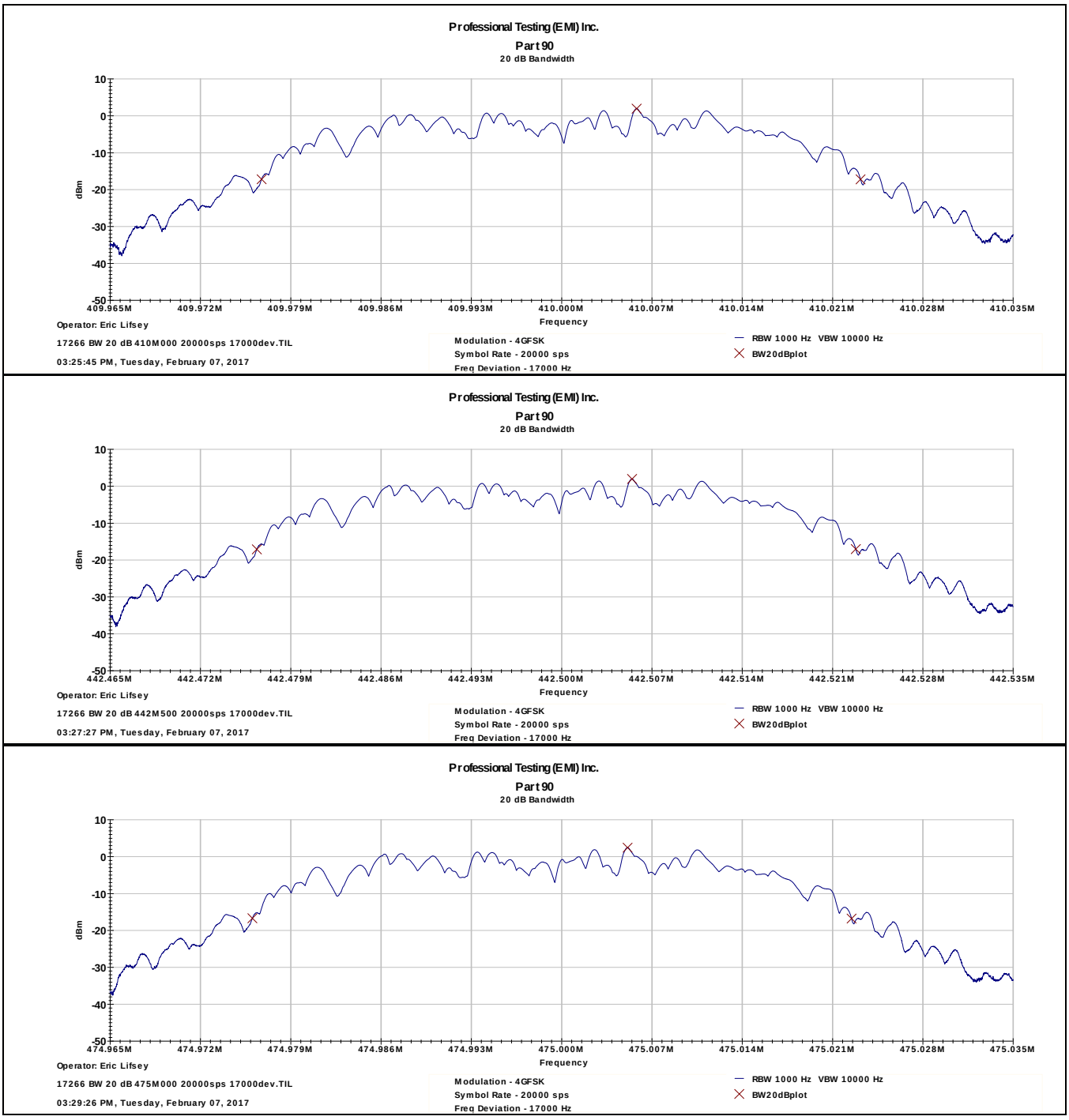
8.3.2 Modulation 2GFSK, 9600 Symbols Per Second



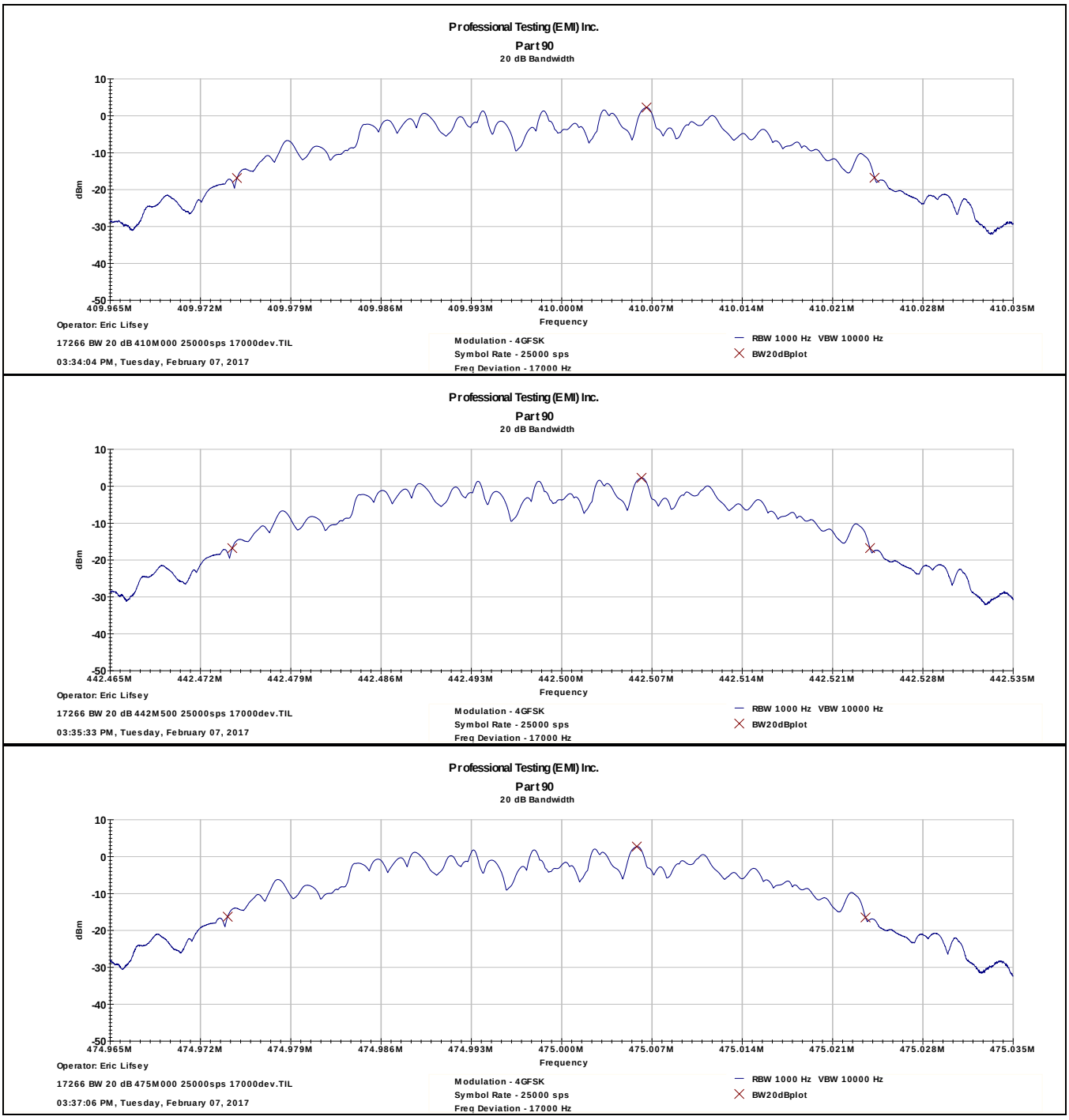
8.3.3 Modulation 4GFSK, 20000 Symbols Per Second



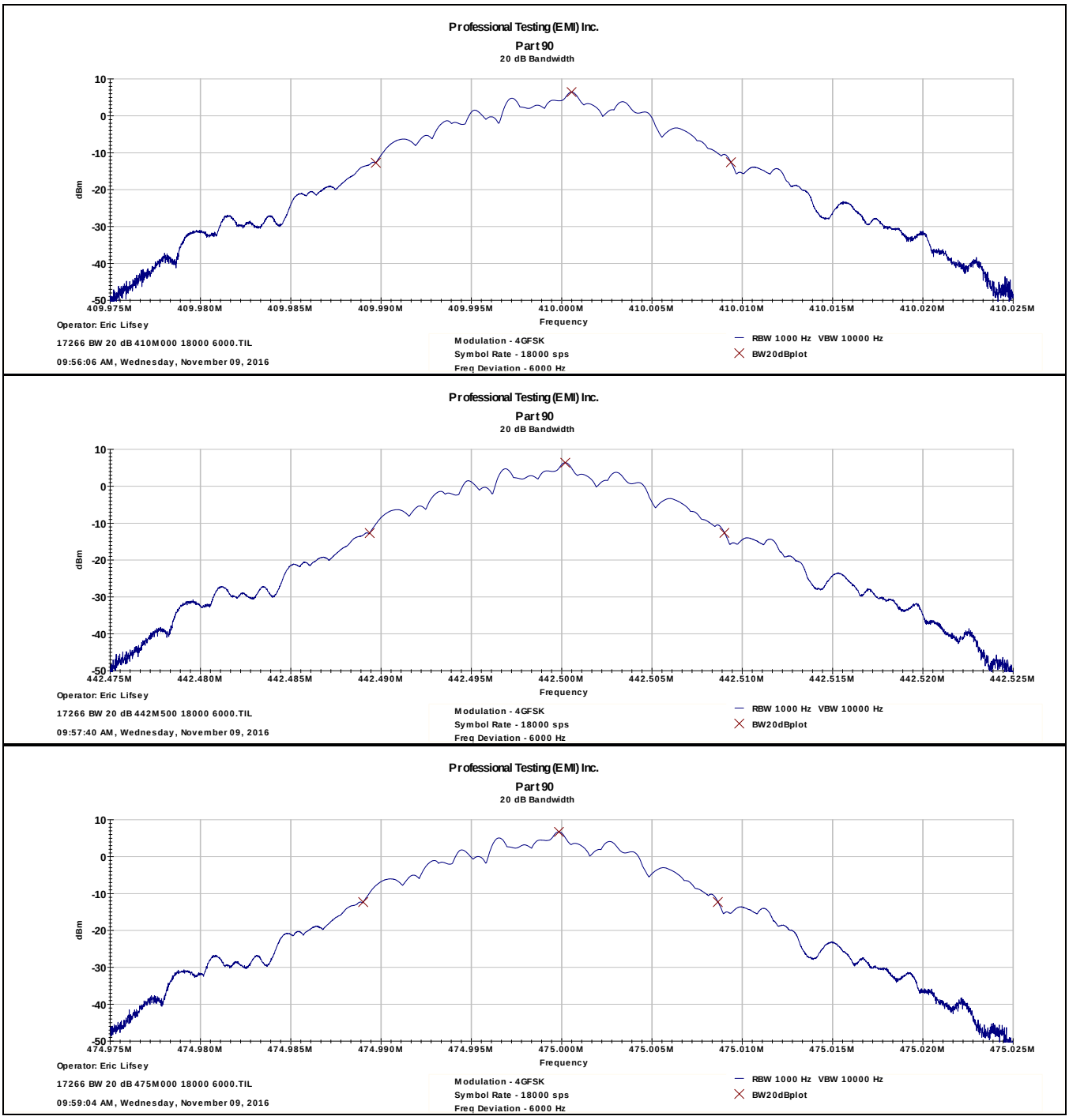
8.3.4 Modulation 4GFSK, 20000 Symbols Per Second



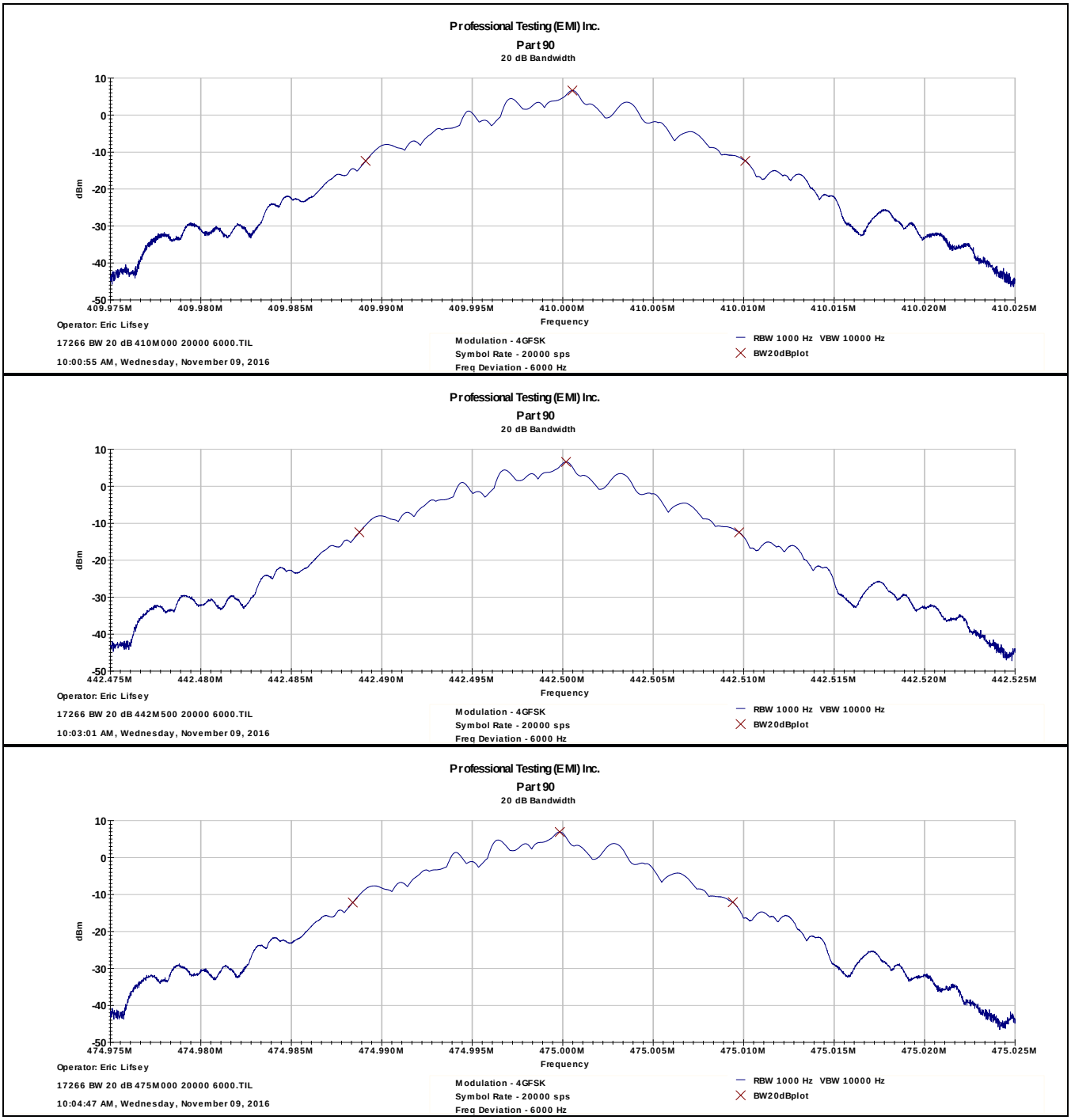
8.3.5 Modulation 4GFSK, 25000 Symbols Per Second



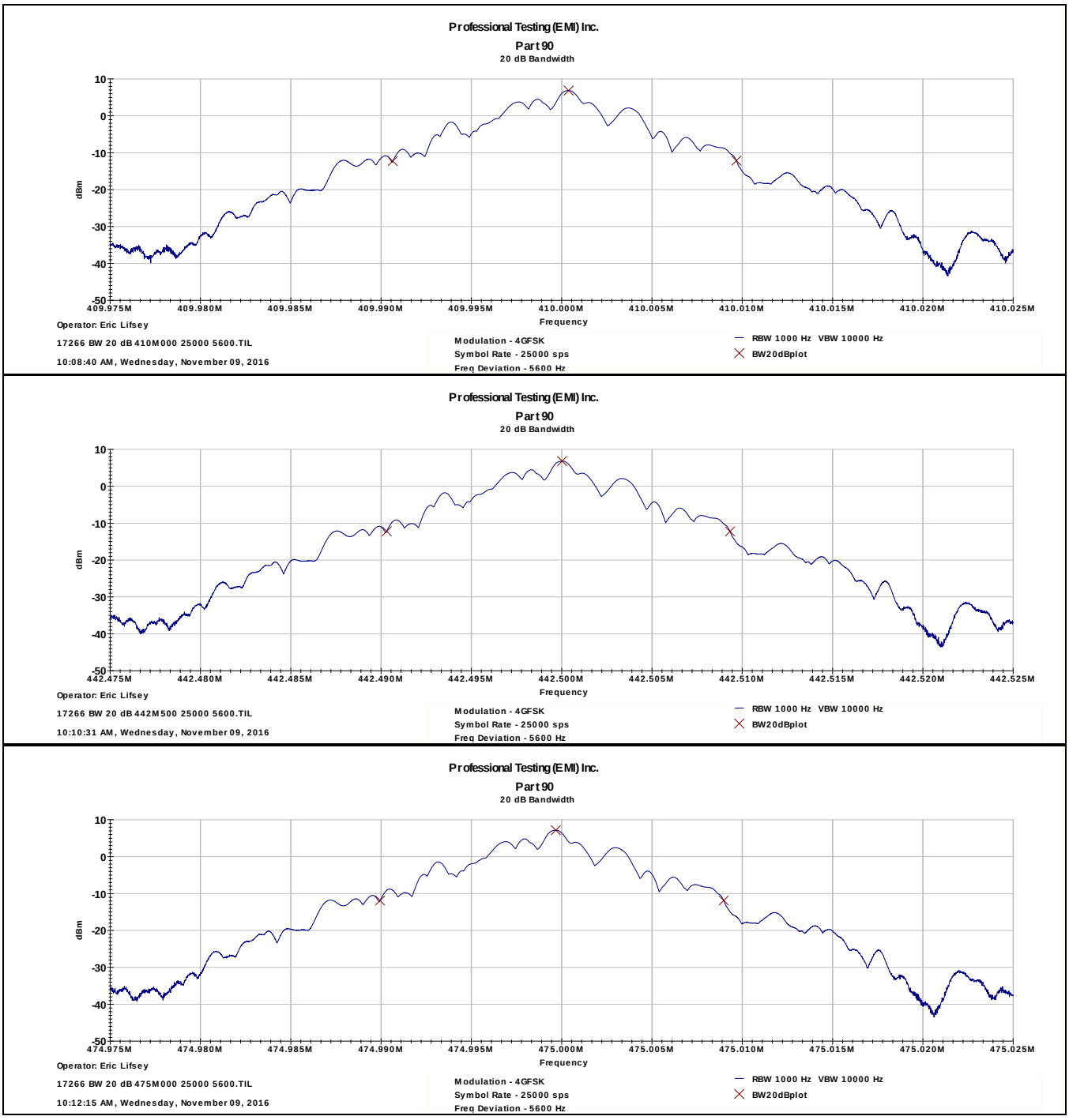
8.3.6 Modulation 4GFSK, 18000 Symbols Per Second, Low Deviation



8.3.7 Modulation 4GFSK, 20000 Symbols Per Second, Low Deviation



8.3.8 Modulation 4GFSK, 25000 Symbols Per Second, Low Deviation



9.0 Equipment Lists

9.1 Conducted Power, Conducted Spurious, and Bandwidth

Asset #	Manufacturer	Model #	Description	Calibration Due
2295	Agilent	E4440A	Spectrum Analyzer	30 Sep 2017
0472	Tektronix	THS730A	Scope/DMM	7 Dec 2016
None	B&K	1710	Adjustable DC Power Supply	CIU
2201	Agilent	E3632A	Adjustable DC Power Supply	CIU

9.2 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 2016
None	B&K	1710	Adjustable DC Power Supply	CIU
2201	Agilent	E3632A	Adjustable DC Power Supply	CIU

9.3 Frequency Transient Behavior

Asset #	Manufacturer	Model #	Description	Calibration Due
0836	Narda	3293-1	Broadband Directional Coupler	CNR
0472	Tektronix	THS730A	Oscilloscope, Digital	7 Dec 2016
1678	HP	8921A	Cell Site Tester (as signal generator)	CIU
0742	HP	355C	Step Attenuator	CNR
0637	HP	8901A	Modulation Analyzer	CNR
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

9.4 Radiated Spurious Transmit Mode and Receive Mode

Professional Testing, EMI, Inc.			
Test Method:	**ANSI C63.4–2003: "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" (incorporated by reference,**		
In accordance with:	**FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, Radiated Emissions Limits**		
Section:	**15.209**		
Test Date(s):	**10/27/2016**	**EUT Serial #:**	**None**
Customer:	**Hetronic**	**EUT Part #:**	**None**
Project Number:	**17266**	**Test Technician:**	**Eric Lifsey**
Purchase Order #:	**0**	**Supervisor:**	**Lisa Arndt**
Equip. Under Test:	**CSM-400UE**	**Witness' Name:**	**None**

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_072616.til or 2016 RE_Class**B **- Boresite+Mast_LowPRF_072616.til**

Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	2/5/2017
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	12/15/2016
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	1/25/2017
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	3/14/2017
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	2/25/2017

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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