# 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<br>Number | Description            | Date       |
|--------------------|------------------------|------------|
| 03                 | Last draft for review. | 8 Feb 2017 |
| 02                 | Final.                 | 8 Jun 2017 |
|                    |                        |            |
|                    |                        |            |

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None.

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#### NOTICE:

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

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

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



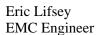
# **Certificate of Compliance**

| Applicant                     | Device & Test Identification |               |
|-------------------------------|------------------------------|---------------|
| Hetronic                      | FCC ID:                      | LW9-CSM400UE  |
| 3905 NW 36th St.              | IC ID:                       | 2119-CSM400UE |
| Oklahoma City, OK 73112 USA   | Model(s):                    | CSM-400UE     |
| Certificate Date: 28 Mar 2017 | Laboratory Project ID:       | 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<br>Issue 4 |  |  |  |
| Field Strength of Radiated Spurious/Harmonic<br>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.



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<br>Transceiver module for<br>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      |   |      |  |  |
| 47 CFR                            | FCC Part 90   |      |  |  |
| IC RSS-119<br>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

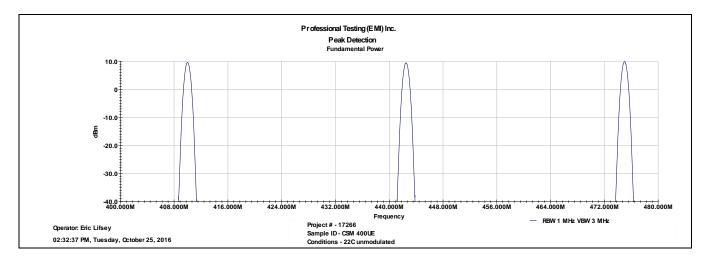
| Parameter              | Section Reference                      | Date        |
|------------------------|--|-------------|
| Conducted Output Power | 90.210, 2.1046   RSS-119 Issue 12, 5.4 | 25 Oct 2016 |

### 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

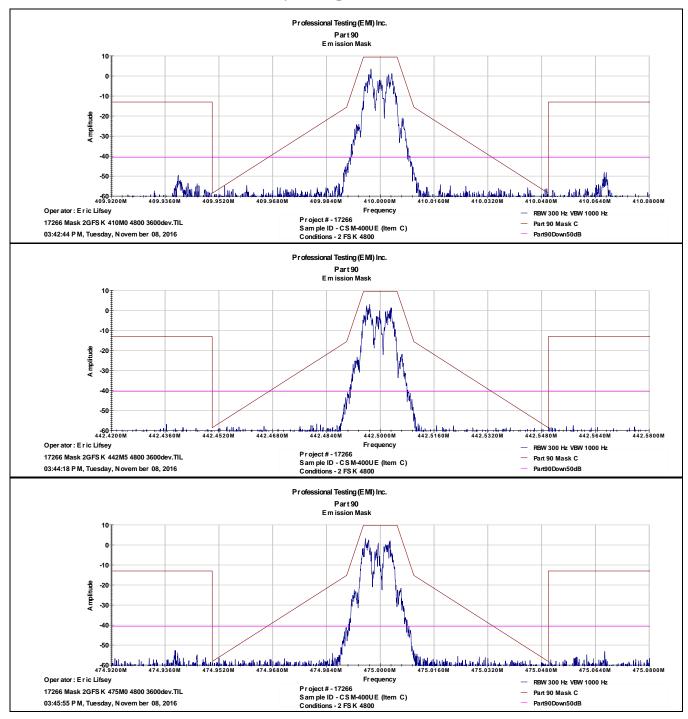
| Parameter                        | Section Number                         | Date         |
|----------------------------------|--|--------------|
| Emissions at Antenna Terminals   | 90.210(c), 90.217(b), 2.1047   RSS-119 | 8/9 Nov 2016 |
| Ellissions at Affelina Terminals | Issue 12, 5.8.3       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

# 3.3 Results

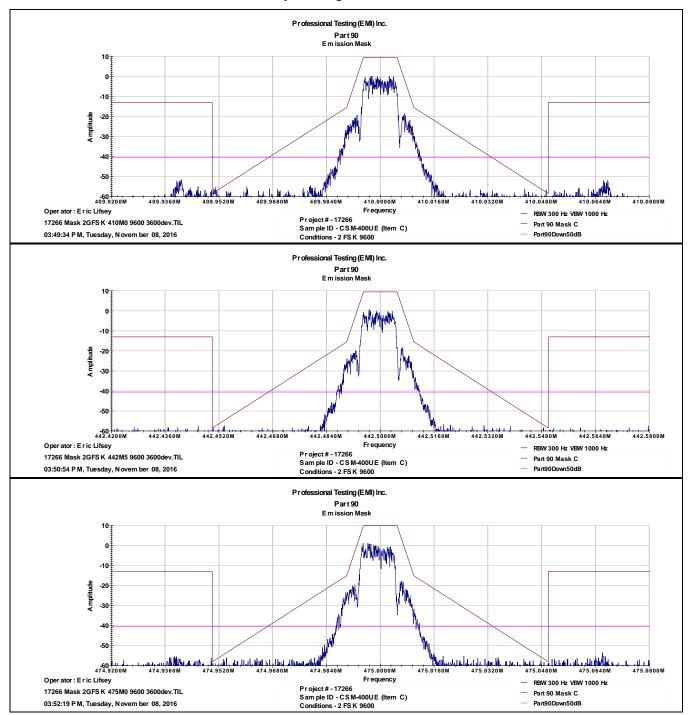
The emission was measured coupled directly to the analyzer without cabling. The EUT satisfied the requirement.

Measurements appear on the following pages.

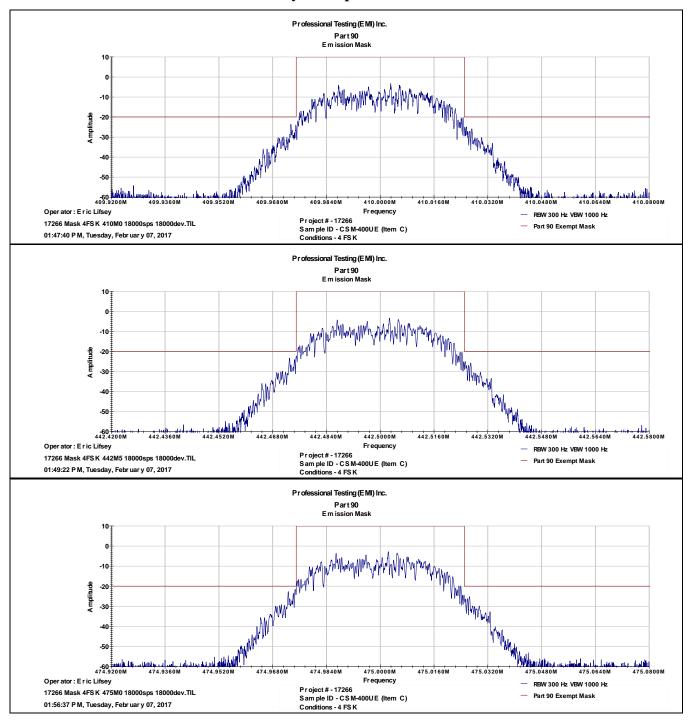
# 3.3.1 Modulation 2GFSK at 4800 Symbols per Second



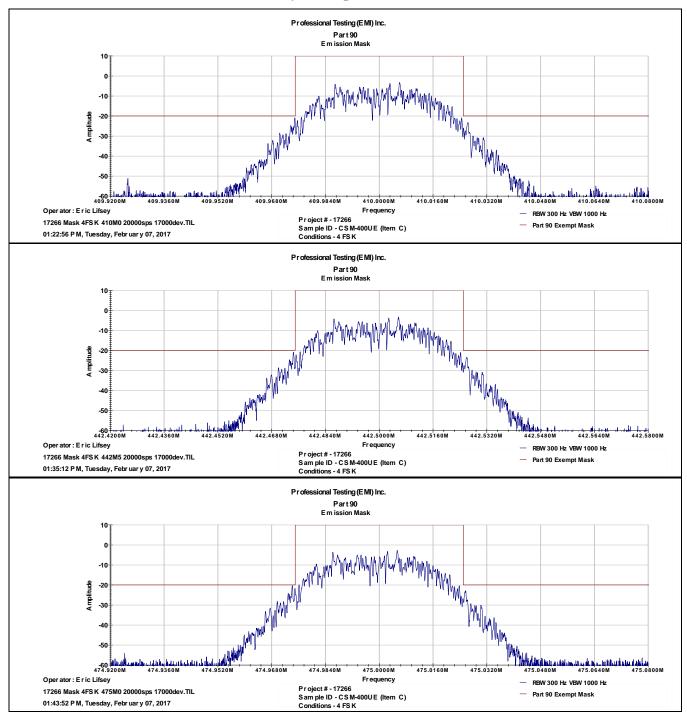
# 3.3.2 Modulation 2GFSK at 9600 Symbols per Second



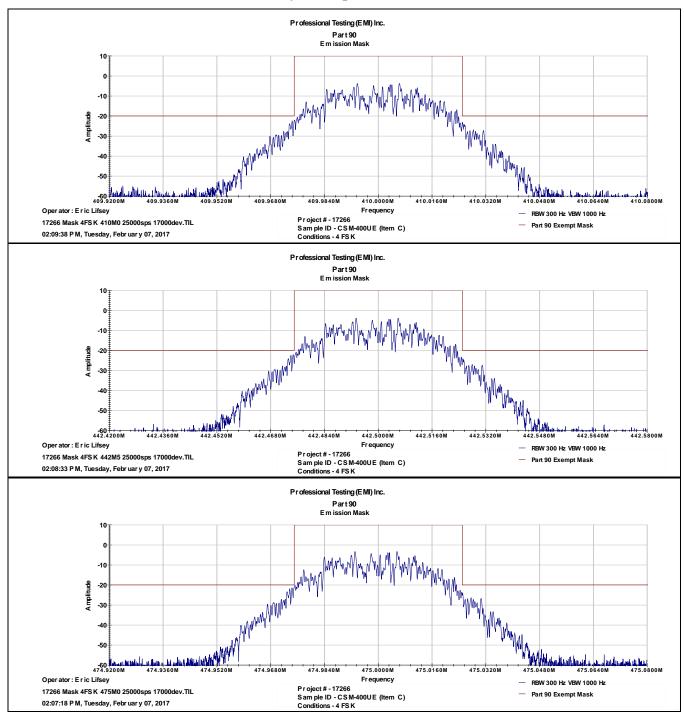
### 3.3.3 Modulation 4GFSK at 18000 Symbols per Second with 18000 Hz Deviation



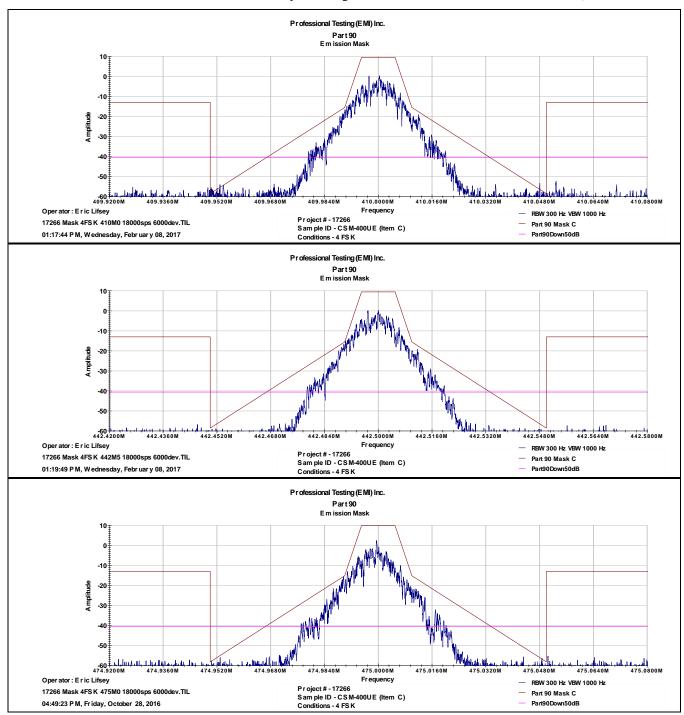
### 3.3.4 Modulation 4GFSK at 20000 Symbols per Second with 17000 Hz Deviation



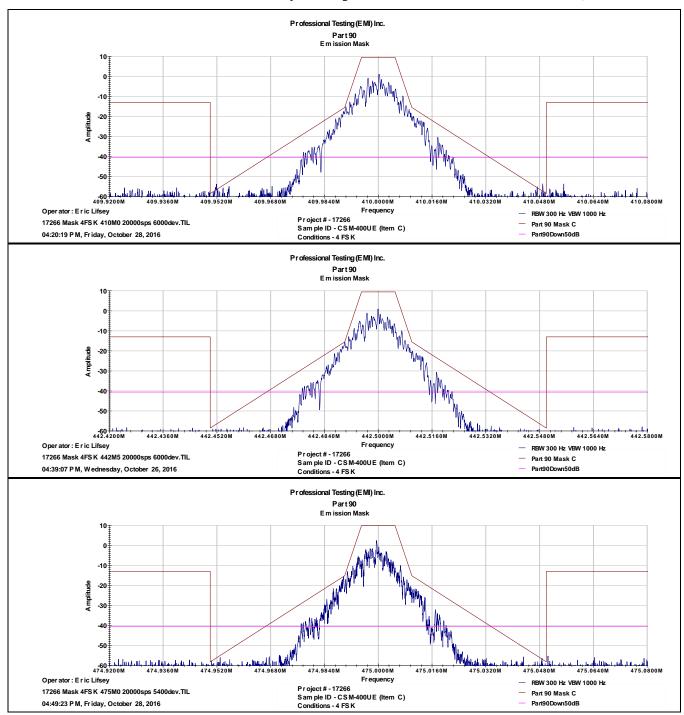
### 3.3.5 Modulation 4GFSK at 25000 Symbols per Second with 17000 Hz Deviation



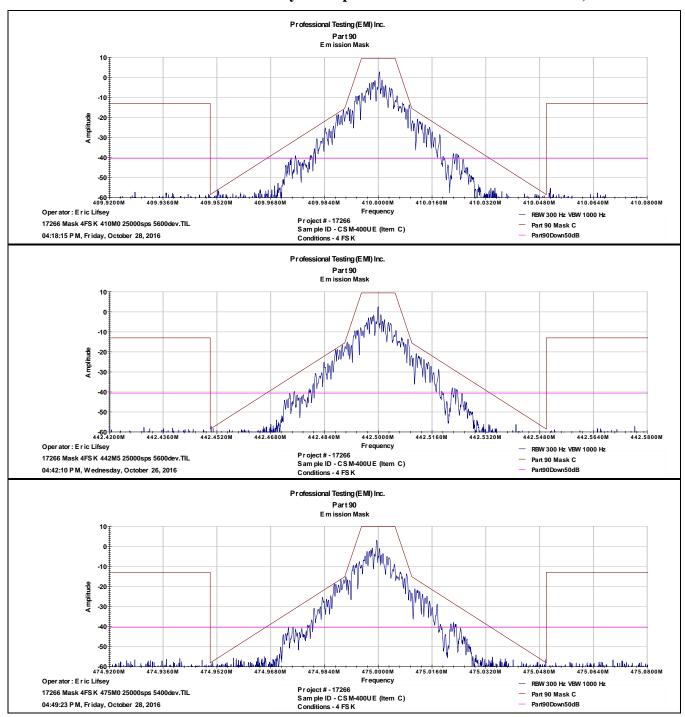
# 3.3.6 Modulation 4GFSK at 18000 Symbols per Second with 6000 Hz Deviation, Mask C



# 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) Attenuation<sub>(dB)</sub> =  $43 + 10 \text{ Log}_{10}(0.0098 \text{ W}) = 22.9 \text{ dB}$ 

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

#### 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.

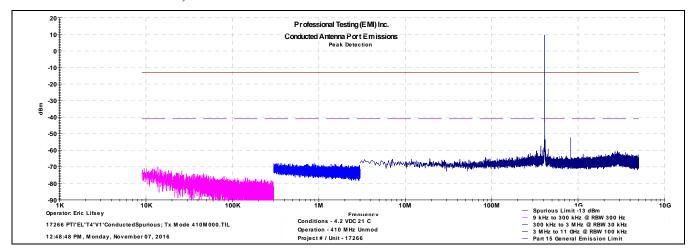
The EUT was found to be in compliance with applicable requirements.

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

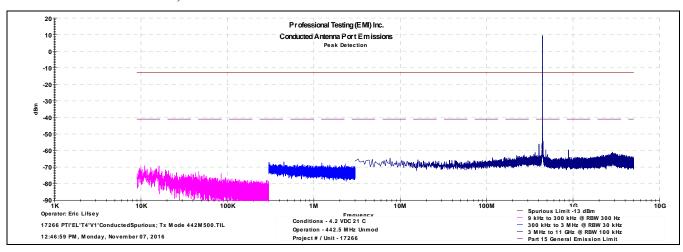
As supplemental information, the -41 dBm general emission limit was included as a dashed red line. It can be seen that both transmit and receive modes satisfy the general emission limit.

Measurements appear below.

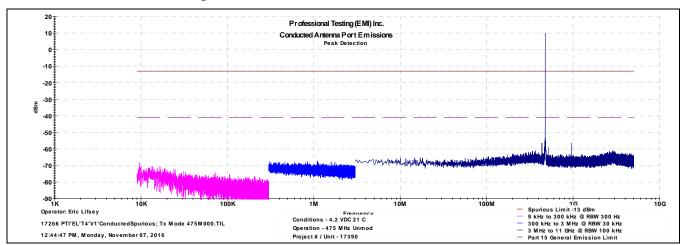
#### 4.3.1 Transmit Mode, Bottom Channel



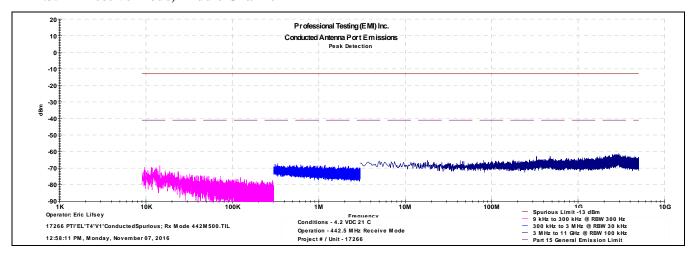
### 4.3.2 Transmit Mode, Middle Channel



### 4.3.3 Transmit Mode, Top Channel



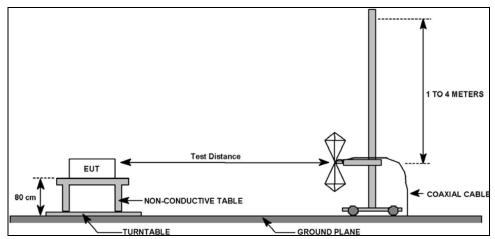
### 4.3.4 Receive Mode, Middle Channel



### **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 | 90.210, 15.209, 2.1053   RSS-119 Issue 12, | 2016 |
| 30 MHz to 5 GHz                      | 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<sub>(dB)</sub> =  $43 + 10 \text{ Log}_{10}(0.0098 \text{ W}) = 22.9 \text{ dB}$ 

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

The EUT satisfied the requirement. Measurements appear below.

# 5.3.1 Transmit Mode, Below 1 GHz, Middle Channel

|  |  |  | Profes   | sional Te  | sting, El                       | MI, Inc.   |   |                       |              |  |
|--|--|--|--|--|---------------------------------|--|---|-----------------------|--------------|--|
| Test Metho   | od:  |  |  | ods of Measurer<br>e Range of 9 kH   |                                 |  |   | •                     |              |  |
| n accordar   | nce with:  | Limits   | .209 - Code of   | Federal Regulat  | ions Part 47,                   | Subpart C - Int  | entional Radi   | ators, Radiate        | ed Emissions |  |
| Section:   |  | 15.209   | _  |  | I                               |  | <b>K</b> .,   |                       |              |  |
| est Date(s   | s):  | 10/27/201  | 16   |  | EUT Serial                      |  | None  |                       |              |  |
| Customer:  |  | Hetronic   |  |  | EUT Part #:                     |  | None  |                       |              |  |
| Project Nui  |  | 17266  |  |  | Test Techn                      |  | Eric Lifsey   |                       |              |  |
| Purchase O   |  | 0  |  |  | Supervisor                      |  | Lisa Arndt  |                       |              |  |
| Equip. Und   | er Test:   | CSM-400U   | IE .   |  | Witness' N                      | ame:   | None  |                       |              |  |
|  | F  | Radiated Er  | missions Tes   | t Results Data   | Sheet                           |  | Pa  | ge: 1                 | of 1         |  |
| EUT Li   | ine Voltage  |  | 5 VDC  |  | EUT Pov                         | ver Frequen  | cy: (   | N/A                   |              |  |
| Antenna  | a Orientatio   | on:  | Vertic   | cal  | Frequ                           | ency Range   | 1   | 30MHz to              | 1GHz         |  |
|  | EUT N  | /lode of Op  | eration:   |  | C                               | ontinuous 1  | ransmit; m  | nsmit; middle channel |              |  |
| Frequency<br>Measured<br>(MHz)                                   | Test<br>Distance<br>(Meters)   | EUT<br>Direction<br>(Degrees)  | Antenna<br>Height<br>(Meters)  | Detector<br>Function   | Recorded<br>Amplitude<br>(dBµV) | Corrected<br>Level<br>(dBµV/m)   | Level (dRuV/m)  |                       | 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         |  |
| Radiated   | sional Testing,<br>Emissions, 10m Di<br>GHz Vertical Polarity  | stance   | _  |  |                                 | ∨ Corre  Corre  ∨ Verifi  × LPRE   | i-peak Limit Level<br>ected Quasi-peak Read<br>ected Peak Value<br>ed Low-PRF QP Read<br>Verification Limit |                       | PROFESSIONAL |  |
| 70 Field Strength (dBpVm) 60 60 60 60 60 60 60 60 60 60 60 60 60 |  |  |  |  |                                 | — Limit  | -13 dBm at 10 m   |                       | TESTING  XXX |  |
| 30 Stree   | Jaku   |  | ×  |  |                                 | The same of the sa |   |                       |              |  |
| lynn   | Control Control  |  | And the later when the same of the later to  | Andreite de la contra del la contra del la contra del la contra de la contra del la contra de la contra de la contra del la contra de la contra del la contra del la contra de la contra del  |                                 |  |   |                       |              |  |
| 10 -   | The state of the s | March Millians Commenced Conference  | And the last of th | and and the second and and are   |                                 |  |   |                       |              |  |
| lynn   | The state of the s | and the same of th | 100M   | Company of the Compan |                                 |  |   |                       | 1G           |  |
| 10   | Eric Lifsey  | and the same of th | 100M   | Freq<br>ing unmomdulated: 442.   | quency                          | F  | EUT: CSM-400UE  |                       | 1G           |  |

|                                |   |  |  |                                    |  |          |   |                         |  | CSM-400U      | IE by Hetron            |
|--------------------------------|---|--|--|------------------------------------|--|----------|---|-------------------------|--|---------------|-------------------------|
|                                |   |  | Profes   | sional Te                          | sting, El  | ΜI, I    | Inc.  |                         |  |               |                         |
| Test Metho                     | d:  |  |  | ods of Measurer<br>e Range of 9 kH |  |          |   |                         |  | •             |                         |
| In accordan                    | ce with:  | FCC Part 15<br>Limits  | 5.209 - Code of  | Federal Regulat                    | ions Part 47,  | Subpar   | rt C - Int  | entio                   | nal Radia  | ators, Radiat | ed Emissions            |
| Section:                       |   | 15.209   |  |                                    |  |          |   |                         |  |               |                         |
| Test Date(s                    | ):  | 10/27/20   | 16   |                                    | EUT Serial   | #:       |   | Non                     | е  |               |                         |
| Customer:                      |   | Hetronic   |  |                                    | EUT Part #:  |          |   | Non                     |  |               |                         |
| Project Nur                    | nber:   | 17266  |  |                                    | Test Techn   | ician:   |   |                         | Lifsey   |               |                         |
| Purchase O                     | rder #:   | 0  |  |                                    | Supervisor   | ;        |   | _                       | Arndt  |               |                         |
| Equip. Und                     | er Test:  | CSM-400  | JE   |                                    | Witness' N   | ame:     |   | Non                     | е  |               |                         |
|                                | F   | Radiated E   | missions Test  | t Results Data                     | Sheet  |          |   |                         | Pa   | ge: 1         | of 1                    |
| EUT Li                         | ne Voltage:   |  | 5 VDC  |                                    | EUT Pov  | ver Fr   | equen   | су:                     | C  | N/A           | ı                       |
| Antenna                        | Orientatio  | n:   | Horizor  | ntal                               | Frequ  | ency     | Range:  | !                       |  | 30MHz to      | 1GHz                    |
|                                | EUT N   | /lode of O   | peration:  |                                    | C  | ontin    | uous T  | ransı                   | mit; mi  | ddle chan     | nel                     |
| Frequency<br>Measured<br>(MHz) | Test<br>Distance<br>(Meters)                                | EUT<br>Direction<br>(Degrees   |  | Detector<br>Function               | Recorded<br>Amplitude<br>(dBµV)  | Le       | ected<br>evel<br>iV/m)                                      |                         | Limit Level Margin<br>(dBμV/m) (dB)  |               | Test Result             |
| 32.5943                        | 10  | 46   | 1.15   | Quasi-peak                         | 23.8   | 12.      | .352  | 2                       | 9.5  | -17.1         | Pass                    |
| 73.6668                        | 10  | 244  | 3.14   | Quasi-peak                         | 23.2   | 4.       | 815   | 2                       | 9.5  | -24.7         | Pass                    |
| 112.294                        | 10  | 97   | 3.28   | Quasi-peak                         | 23.1   | 6.       | 327   | 7 33.1 -26.8            |  | Pass          |                         |
| 653.708                        | 10  | 123  | 3.97   | Quasi-peak                         | 21.8   | 20.      | .303  | 3                       | 5.6  | -15.3         | Pass                    |
| 885.03                         | 10  | 308  | 1.32   | Quasi-peak                         | 23.5   | 27.      | .906  | 3                       | 5.6  | -7.7          | Pass                    |
| 952.312                        | 10  | 224  | 2.15   | Quasi-peak                         | 20.9   | 26       | 5.15  | 3                       | 5.6  | -9.5          | Pass                    |
| Radiated 1                     | ional Testing,<br>Emissions, 10m Di<br>GHz Horizontal Polar | istance  | io ns  |                                    |  |          | <ul><li>∇ Correct</li><li>Correct</li><li>Verifie</li></ul> | cted Peak               | si-peak Read<br>Value<br>RF QP Readi   |               |                         |
| 60 -                           |   |  |  |                                    |  |          |   | 13 dBm @                |  |               | PROFESSIONAL<br>TESTING |
| Field Strength                 | What.   |  | X  | ×                                  |  | National |   |                         | Carles de la Carle |               |                         |
| 10                             | - Marie franchischer franchischer                           | A CONTRACTOR OF THE PARTY OF TH | And the Samuel State of the Sta |                                    | A STATE OF THE STA |          |   |                         |  | - '''         |                         |
| 0<br>30 M                      |   | <u> </u>   | 100M   |                                    |  |          |   | +                       | -  |               | 1G                      |
| Operator: I                    | Eric Lifsey   |  | m  |                                    | luency   |          | E   | UT: CSM                 | -400UE   |               |                         |
|                                | 716 'RE'Spurious'Cha<br>M, Thursday, Octobe                 |  | 5 VDC  | ing unmomdulated: 442.             | 5 MHz  |          |   | roject Nu<br>lient: Het | mber: 17266<br>ronic   | <u> </u>      |                         |
|                                |   | ≤ 1  | GHz Horizont   | tal Antenna P                      | olarity Mea  | sure     | d Emiss   | sions                   |  |               |                         |

# 5.3.2 Transmit Mode, Above 1 GHz, Bottom Channel

|                                |  |                             | P                          | rofess                       | sional Te                         | sting, EN                       | VII, Ι   | Inc.   |   |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
|--------------------------------|--|-----------------------------|----------------------------|------------------------------|-----------------------------------|---------------------------------|--|--|---|---------------------|----------------|---------|---------|----|------|--|------|--|------|--|-------|----|-----|
| Test Metho                     | od:  |                             |                            |                              | ds of Measuren<br>e Range of 9 kH |                                 |  |  |   |                     | _              |         | nd      |    |      |  |      |  |      |  |       |    |     |
| In accordar                    | nce with:  | Limits                      | 15.209                     | - Code of F                  | ederal Regulat                    | ions Part 47, S                 | Subpar   | rt C - Int   | entiona   | al Radia            | ors, Radiat    | ed Emis | ssions  |    |      |  |      |  |      |  |       |    |     |
| Section:                       |  | 15.209                      |                            |                              |                                   |                                 |  |  | ,   |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Test Date(s                    | s <b>)</b> :   | 10/27/2                     |                            |                              |                                   | EUT Serial #                    |  |  | None  |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Customer:                      |  | Hetroni                     | ic                         |                              |                                   | EUT Part #:                     | -  |  | None  |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Project Nur                    |  | 17266                       |                            |                              |                                   | Test Techni                     |  |  | Eric Li   | •                   |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Purchase O                     |  | 0                           | 21.15                      |                              |                                   | Supervisor:                     |  |  | Lisa A  |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Equip. Und                     | er Test:   | CSM-40                      | OUE                        |                              |                                   | Witness' Na                     | ame:   |  | None  |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
|                                | P  | Radiated                    | Emissi                     | ions Test                    | Results Data                      | 3 Sheet                         |  |  |   | Pag                 | e: 1           | of      | 1       |    |      |  |      |  |      |  |       |    |     |
| EUT Li                         | ine Voltage:   | :                           | 5                          | VDC                          |                                   | EUT Pow                         | ver Fr   | equen  | су:   | 0                   | N/A            |         |         |    |      |  |      |  |      |  |       |    |     |
| Antenna                        | a Orientatio   | n:                          |                            | Vertica                      | al                                | Freque                          | ency l   | Range:   | Above   |                     |                | GHz     |         |    |      |  |      |  |      |  |       |    |     |
|                                | EUT N  | /lode of                    | Operat                     | tion:                        |                                   | Cc                              | Continuous Transmit; bottom chan   |  | ansmit; bottom channel  |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |
| Frequency<br>Measured<br>(MHz) | Test<br>Distance<br>(Meters)                                     | EUT<br>Direction<br>(Degree | on                         | Antenna<br>Height<br>Meters) | Detector<br>Function              | Recorded<br>Amplitude<br>(dBµV) | Le   | ected<br>evel<br>iV/m)                                     | Limit I   |                     | Margin<br>(dB) | Test I  | Results |    |      |  |      |  |      |  |       |    |     |
| 1946.15                        | 3  | 37                          |                            | 3.41                         | Average                           | 38.2                            | 29.  | .339   | 54.0  |                     | 54.0           |         | 54.0    |    | 54.0 |  | 54.0 |  | 54.0 |  | -24.6 | Pi | ass |
| 2049.95                        | 3  | 112                         |                            | 3.22                         | Average                           | 49                              | 40.  | .305   | 5 54.0  |                     | 54.0           |         | -13.7   | Pa | ass  |  |      |  |      |  |       |    |     |
| 2869.89                        | 3  | 40                          |                            | 2.43                         | Average                           | 50.3                            | 43.  | .124   | 54  | 54.0 -10.8          |                | Pa      | ass     |    |      |  |      |  |      |  |       |    |     |
| 3279.97                        | 3  | 36                          |                            | 2.33                         | Average                           | 44.5                            | 37.  | .653   | 54  | 54.0 -16.3          |                | Pa      | ass     |    |      |  |      |  |      |  |       |    |     |
| Radiated                       | sional Testing,<br>Emissions, 3m Dist<br>ertical Polarity Measur | tance                       |                            |                              |                                   |                                 |  | <ul><li>∇ Corre</li><li>— Peak I</li><li>— Corre</li></ul> | ge Limit Lev<br>cted A vera g<br>.imit Level<br>cted Peak R<br>113 dBm at 3 | e Reading<br>eading |                | PROFES  | SSIONAL |    |      |  |      |  |      |  |       |    |     |
| 30 - 20 G                      | Eric Lif sey   | hamban banda da             | hana di paga di didukta di | handan laya kalab            |                                   | quency                          | The state of the s | E  | UT: CSM-4   | OOUE                |                | 6       | G G     |    |      |  |      |  |      |  |       |    |     |
| Operator: 1                    |  |                             |                            |                              | ng unmomdulated: 410.             |                                 |  |  |   |                     |                |         |         |    |      |  |      |  |      |  |       |    |     |

|   |   |                            |         |                               |   |                                 |              |  |   |                      | CSM-4      | 100UI                     | by He     | etroni          |  |  |  |
|---|---|----------------------------|---------|-------------------------------|---|---------------------------------|--------------|--|---|----------------------|------------|---------------------------|-----------|-----------------|--|--|--|
|   |   |                            |         | Profess                       | sional Te                               | sting, El                       | ΜI, I        | Inc.   |   |                      |            |                           |           |                 |  |  |  |
| Test Metho  | od:   |                            |         |                               |   | ment of Radio<br>Hz to 40 GHz"  |              |  |   |                      | _          |                           | rical and | d               |  |  |  |
| n accordai  | nce with:   | FCC Par<br>Limits          | rt 15.2 | 209 - Code of F               | ederal Regula                           | tions Part 47, S                | Subpar       | rt C - Int   | entiona   | al Radia             | ators, R   | adiate                    | d Emis    | sions           |  |  |  |
| Section:  |   | 15.209                     | 1       |                               |   |                                 |              |  |   |                      |            |                           |           |                 |  |  |  |
| Test Date(s   | s):   | 10/27                      | /2016   | 5                             |   | EUT Serial                      | #:           |  | None  |                      |            |                           |           |                 |  |  |  |
| Customer:   |   | Hetro                      | nic     |                               |   | EUT Part #:                     |              |  | None  |                      |            |                           |           |                 |  |  |  |
| Project Nu  | mber:   | 17266                      | i       |                               |   | Test Techn                      | ician:       |  | Eric Li   | ifsey                |            |                           |           |                 |  |  |  |
| Purchase C  | order #:  | 0                          |         |                               |   | Supervisor:                     | :            |  | Lisa A  | rndt                 |            |                           |           |                 |  |  |  |
| Equip. Und  | ler Test:   | CSM-4                      | 100UE   |                               |   | Witness' N                      | ame:         |  | None  |                      |            |                           |           |                 |  |  |  |
|   | F   | Radiate                    | d Em    | issions Test                  | Results Dat                             | a Sheet                         |              |  |   | Pa                   | ge:        | 1                         | of        | 1               |  |  |  |
| EUT L   | ine Voltage   | :                          | 5       | VDC                           |   | EUT Pow                         | ver Fr       | equen  | су:   | C                    | )          | N/A                       |           |                 |  |  |  |
| Antenn  | a Orientatio  | n:                         |         | Horizon                       | tal                                     | Frequ                           | ency         | Range:   |   |                      | Abo        | ve 1                      | GHz       |                 |  |  |  |
|   | EUT N   | /lode o                    | f Ope   | eration:                      |   | Co                              | ontin        | uous T   | ransm   | it; bo               | ttom o     | hanr                      | innel     |                 |  |  |  |
| Frequency<br>Measured<br>(MHz)                                      | Test<br>Distance<br>(Meters)                                  | EU<br>Direc<br>(Degr       | tion    | Antenna<br>Height<br>(Meters) | Detector<br>Function                    | Recorded<br>Amplitude<br>(dBμV) | Le           | rected<br>evel<br>uV/m)                                    | Limit (dBµ\   |                      | Mar<br>(dE | _                         | Test Resu |                 |  |  |  |
| 2050.09   | 3   | 15                         | 4       | 2.5                           | Average                                 | 44.3                            | 35.          | 35.583 54.0 -18.4  |   | Pa                   | ss         |                           |           |                 |  |  |  |
| Radiated<br>1-6GHzH<br>90   | sional Testing,<br>Emissions, 3m Dis<br>orizontalPolarity Mea | tance                      |         |                               |   |                                 |              | <ul><li>∇ Corre</li><li>— Peak I</li><li>— Corre</li></ul> | ge Limit Lev<br>cted A verag<br>Limit Level<br>cted Peak R<br>13 dBm at 3 | ge Reading<br>eading |            |                           | PROFESS   | SIONAL<br>I N 6 |  |  |  |
| Field Strength (d Bp Vm) (m) 40 40 40 40 40 40 40 40 40 40 40 40 40 | Frie I Foor   | erit taligen de actions de |         |                               | Fre                                     | quency                          | Lever trains | E  | UT: CSM-4   | LIGOTIE              |            | ll <sub>n</sub> ederte po | 66        | G               |  |  |  |
|   | 2716 'RE'Spurious'Cha   | a nBotto m.til             |         | 5 VDC                         | ng unmomdulated: 410<br>ort terminated. | 0.0 MHz                         |              | P  | roject Numl<br>lient: Hetro   | ber: 17266           |            |                           |           |                 |  |  |  |

# 5.3.3 Transmit Mode, Above 1 GHz, Middle Channel

|   |  |                                      | Profess                       | sional Te                         | sting, El                       | ΜI, I  | lnc.   |   |                   |            |            |                     |               |      |  |     |    |
|---|--|--------------------------------------|-------------------------------|-----------------------------------|---------------------------------|--------|--|---|-------------------|------------|------------|---------------------|---------------|------|--|-----|----|
| Test Metho  | od:  |                                      |                               | ds of Measurer<br>e Range of 9 kH |                                 |        |  |   |                   | _          |            | cal and             |               |      |  |     |    |
| n accordai  | nce with:  | FCC Part 15.<br>Limits               | 209 - Code of I               | ederal Regulat                    | tions Part 47, S                | Subpar | t C - Int  | entiona   | l Radia           | tors, Radi | ated       | l Emissi            | ions          |      |  |     |    |
| Section:  |  | 15.209                               |                               |                                   |                                 |        |  |   |                   |            |            |                     |               |      |  |     |    |
| Test Date(s   | <u>s):</u>   | 10/27/201                            | .6                            |                                   | EUT Serial                      |        |  | None  |                   |            |            |                     |               |      |  |     |    |
| Customer:   |  | Hetronic                             |                               |                                   | EUT Part #:                     |        |  | None  |                   |            |            |                     |               |      |  |     |    |
| Project Nu  |  | 17266                                |                               |                                   | Test Techn                      |        |  | Eric Li   |                   |            |            |                     |               |      |  |     |    |
| Purchase C  |  | 0                                    |                               |                                   | Supervisor:                     |        |  | Lisa A  | rndt              |            |            |                     |               |      |  |     |    |
| quip. Und   | er Test:   | CSM-400U                             | E                             |                                   | Witness' N                      | ame:   |  | None  |                   |            |            |                     |               |      |  |     |    |
|   | F  | Radiated Er                          | nissions Test                 | Results Data                      | a Sheet                         |        |  |   | Pag               | ge: 1      |            | of                  | 1             |      |  |     |    |
| EUT L   | ine Voltage:   | :                                    | 5 VDC                         |                                   | EUT Pow                         | ver Fr | equen  | су:   | 0                 | N/         | Α          |                     |               |      |  |     |    |
| Antenn  | a Orientatio   | n:                                   | Vertic                        | al                                | Frequ                           | ency   | Range:   |   |                   | Above      | 1 <b>G</b> | Hz                  |               |      |  |     |    |
|   | EUT N  | Node of Op                           | eration:                      |                                   | C                               | ontin  | uous T   | ransm   | it; mi            | ddle cha   | nne        | el                  |               |      |  |     |    |
| Frequency<br>Measured<br>(MHz)  | Test<br>Distance<br>(Meters)                                   | EUT<br>Direction<br>(Degrees)        | Antenna<br>Height<br>(Meters) | Detector<br>Function              | Recorded<br>Amplitude<br>(dBµV) | Le     | ected<br>evel<br>iV/m)                                     | Limit Level Margin (dBµV/m) (dB)                              |                   | 7          | Test Re    | esults              |               |      |  |     |    |
| 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      |            | Pas                 | SS            |      |  |     |    |
| 2212.37   | 3  | 56                                   | 1.86                          | Average                           | 53.6                            | 44.    | .627 54  | .627 5  |                   | 527 54.    |            | 54.0                |               | -9.3 |  | Pas | SS |
| 3097.48   | 3  | 280                                  | 1.82                          | Average                           | 36.7                            | 30     | .096   | 54.   | 0                 | -23.9      |            | Pas                 | SS            |      |  |     |    |
| 3539.97   | 3  | 87                                   | 1.04                          | Average                           | 43.6                            | 37.    | .877   | 54.   | 0                 | -16.1      |            | Pas                 | SS            |      |  |     |    |
| Radiated<br>1-6GHzV<br>90   | sional Testing,<br>Emissions, 3m Dis<br>ertical Polarity Measu | tance                                |                               |                                   |                                 |        | <ul><li>∇ Corre</li><li>— Peak I</li><li>— Corre</li></ul> | ge Limit Leve<br>cted A verage<br>Limit Level<br>cted Peak Re | e Reading         |            |            | PROFESSI<br>T E S T | ONAL<br>I N 6 |      |  |     |    |
| 30 Special Control of | Eric Lifsey<br>27.16 'R ES purious' Cha                        | all desired the second of the second | Transmitti                    | Free ng unmomdulated: 442         | quency<br>5 MHz                 | Y      | E  | UT: CSM-40  | 00UE<br>er: 17266 |            |            | 6G                  |               |      |  |     |    |

|                                |  |                               |                               |                                  |                                 | -  |  |   | (           | CSM-40         | 0UE        | by He              | troni  |
|--------------------------------|--|-------------------------------|-------------------------------|----------------------------------|---------------------------------|--|--|---|-------------|----------------|------------|--------------------|--------|
|                                |  |                               | Profess                       | sional Te                        | sting, El                       | MI,  | Inc.   |   |             |                |            |                    |        |
| Test Metho                     | d:   |                               |                               | ds of Measure<br>e Range of 9 kH |                                 |  |  |   |             | _              |            | rical and          | l      |
| In accordan                    | ce with:   | FCC Part 15<br>Limits         | 209 - Code of I               | Federal Regulat                  | tions Part 47,                  | Subpar   | rt C - Int   | tentional   | Radiat      | ors, Rad       | liate      | d Emiss            | ions   |
| Section:                       |  | 15.209                        |                               |                                  |                                 |  |  |   |             |                |            |                    |        |
| Test Date(s                    | ):   | 10/27/20:                     | .6                            |                                  | EUT Serial                      | #:   |  | None  |             |                |            |                    |        |
| Customer:                      |  | Hetronic                      |                               |                                  | EUT Part #                      |  |  | None  |             |                |            |                    |        |
| Project Nun                    |  | 17266                         |                               |                                  | Test Techn                      |  |  | Eric Life   |             |                |            |                    |        |
| Purchase O                     |  | 0                             |                               |                                  | Supervisor                      |  |  | Lisa Ar   | ndt         |                |            |                    |        |
| Equip. Und                     | er Test:   | CSM-400L                      | E                             |                                  | Witness' N                      | ame:   |  | None  |             |                |            |                    |        |
|                                | R  | Radiated E                    | nissions Test                 | Results Dat                      | a Sheet                         |  |  |   | Page        | e:             | 1          | of                 | 1      |
| EUT Li                         | ne Voltage:  | :                             | 5 VDC                         |                                  | EUT Pov                         | ver Fr   | equen  | су:   | 0           | N,             | <b>/</b> A |                    |        |
| Antenna                        | Orientatio   | n:                            | Horizor                       | ntal                             | Frequ                           | ency   | Range  | :   |             | Above          | e 10       | 3Hz                |        |
|                                | EUT N  | lode of Op                    | eration:                      |                                  | С                               | ontin  | uous 1   | ransmi  | dle channel |                |            |                    |        |
| Frequency<br>Measured<br>(MHz) | Test<br>Distance<br>(Meters)   | EUT<br>Direction<br>(Degrees) | Antenna<br>Height<br>(Meters) | Detector<br>Function             | Recorded<br>Amplitude<br>(dBμV) | Le   | rected<br>evel<br>uV/m)  | Limit Le  |             | Margii<br>(dB) | n          | Test Re            | esults |
| 1156.97                        | 3  | 61                            | 3.68                          | Average                          | 35.8                            | 24.  | .014   | 54.0  | )           | -29.9          | )          | Pas                | SS     |
| 1327.33                        | 3  | 338                           | 3.59                          | Average                          | 36.2                            | 24.495   |  | 54.0  |             | -29.5          |            | Pa:                | ss     |
| 2212.51                        | 3  | 81                            | 2.88                          | Average                          | 48.3                            | 39.  | .303   | 54.0  | )           | -14.7          | '          | Pas                | SS     |
| 3097.43                        | 3  | 312                           | 3.03                          | Average                          | 46.9                            | 40.  | .265   | 54.0  | )           | -13.7          | '          | Pas                | SS     |
| 4319.94                        | 3  | 104                           | 1.56                          | Average                          | 33.7                            | 29.472   |  | 54.0  |             | -24.5          | ,          | Pas                | SS     |
| 5781.99                        | 3  | 137                           | 1.16                          | Average                          | 31.9                            | 30   | .307   | 54.0  | )           | -23.7          | <u> </u>   | Pas                | SS     |
| Radiated 1                     | ional Testing,<br>Emissions, 3m Distrizontal Polarity Mea  | tance                         |                               | ·                                |                                 |  | <ul><li>∇ Corre</li><li>Peak</li></ul>   | age Limit Level<br>ected Average l<br>Limit Level<br>ected Peak Rea | Reading     |                |            |                    |        |
| 80                             |  |                               |                               |                                  |                                 |  | — Limit  | -13 dBm at 3 m  | 1           |                |            | PROFESS<br>T E S T |        |
| Field Strength (d B µ Vm)  90  | halla head and the same and the | Mindala Milanda               |                               |                                  |                                 | Total Automotive Control of the Cont | and the state of t |   |             |                |            | Millia Laboura     |        |
| 30<br>20<br>G                  | Y  | 7                             |                               |                                  |                                 |  |  |   | 7           |                |            |                    |        |
| Operator: F<br>17266'1027      | Cric Lifsey<br>716 'R E'S purio us'C ha<br>M , Thursday , Octobe   |                               | 5 VDC                         | Freing unmomdulated: 442         | quency<br>.5 MHz                |  | P  | EUT: CSM-400<br>Project Number<br>Client: Hetronic                  | r: 17266    |                |            | 6G                 |        |

> 1GHz Horizontal Antenna Polarity Measured Emissions

# 5.3.4 Transmit Mode, Above 1 GHz, Top Channel

|  |  |  | Profess   | sional Te                                       | sting, El                       | MI, I         | lnc.   |   |                         |                          |                    |         |             |
|--|--|--|---|---|---------------------------------|---------------|--|---|-------------------------|--------------------------|--------------------|---------|-------------|
| Test Metho   | d:   |  | -2003: "Metho<br>quipment in the  |   |                                 |               |  |   |                         | •                        |                    | l and   |             |
| In accordar  | ce with:   | FCC Part 15<br>Limits  | .209 - Code of I  | ederal Regulat                                  | tions Part 47, S                | Subpar        | t C - Int  | entiona   | al Radiat               | ors, Radia               | ited E             | missi   | ions        |
| Section:   |  | 15.209   |   |   | •                               |               |  | ,   |                         |                          |                    |         |             |
| Test Date(s  | ):   | 10/27/20   | 16  |   | EUT Serial                      |               |  | None  |                         |                          |                    |         |             |
| Customer:  |  | Hetronic   |   |   | EUT Part #:                     |               |  | None  |                         |                          |                    |         |             |
| Project Nur  |  | 17266  |   |   | Test Techn                      |               |  | Eric Li   | •                       |                          |                    |         |             |
| Purchase O   |  | 0  |   |   | Supervisor:                     |               |  | Lisa A  | rndt                    |                          |                    |         |             |
| Equip. Und   | er Test:   | CSM-400L   | IE  |   | Witness' N                      | ame:          |  | None  |                         |                          |                    |         |             |
|  | F  | Radiated E   | missions Test   | Results Data                                    | a Sheet                         |               |  |   | Page                    | e: 1                     | (                  | of      | 1           |
| EUT Li   | ne Voltage:  | :  | 5 VDC   |   | EUT Pow                         | ver Fr        | equen  | су:   | 0                       | N/A                      | 4                  |         |             |
| Antenna  | Orientatio   | n:   | Vertic  | al  | Frequ                           | ency l        | Range:   |   |                         | Above                    | 1GH                | z       |             |
|  | EUT N  | lode of Op   | eration:  |   |                                 | Conti         | Continuous Transmit; top channel                               |   | s Transmit; top channel |                          |                    |         |             |
| Frequency<br>Measured<br>(MHz)                                       | Test<br>Distance<br>(Meters)   | EUT<br>Direction<br>(Degrees)  | Antenna<br>Height<br>(Meters)   | Detector<br>Function                            | Recorded<br>Amplitude<br>(dBµV) | Le            | ected<br>vel<br>V/m)   | Limit I   |                         | Margin<br>(dB)           | Te                 | est Re  | esults      |
| 1945.41  | 3  | 301  | 1.02  | Average   | 40.9                            | 32.           | 026  | 54  | .0                      | -21.9                    |                    | Pas     | SS          |
| 2375.06  | 3  | 81   | 3.08  | Average   | 57.1                            | 48.           | 563  | 54  | .0                      | -5.4                     | 4 Pass             |         | SS          |
| 2849.89  | 3  | 64   | 2.45  | Average   | 51.6                            | 44.           | 325  | 54  | .0                      | -9.6                     |                    | Pas     | SS          |
| 3325.06  | 3  | 43   | 2.19  | Average   | 56.3                            | 49.           | 655  | 54  | .0                      | -4.3                     |                    | Pas     | SS          |
| Radiated<br>1-6GHz Ve<br>90  | ional Testing,<br>Emissions, 3m Dis<br>rticalPolarity Measur   | tance  |   |   |                                 |               | <ul> <li>∇ Corre</li> <li>— Peak I</li> <li>— Corre</li> </ul> | ge Limit Lev<br>cted A verag<br>Limit Level<br>cted Peak Ro | e Reading<br>eading     |                          | PR                 | OFESSII | ONAL<br>N 6 |
| Field Strength (d Bp V/m)  100 40 40 40 40 40 40 40 40 40 40 40 40 4 | de la constitución de la constit | and the second s | Long to Markey and a | 7   | <b>V</b>                        | Market partie |  |   |                         | h had a selection of the | Indiana di Indiana |         |             |
|  | Eric Lifsey<br>716 'R E'S purious'C ha<br>'M , Thursday , Octo be  | •  | 5 VDC   | Free<br>ng unmomdulated: 475<br>ort terminated. | quency<br>.0 MHz                |               | P  | UT: CSM-4<br>roject Numb                                    | oer: 17266              |                          |                    | 6G      |             |

|                 |   |                        |                               |                      |                                   |  |   | CSM-400U                                | E by Hetroi  |
|-----------------|---|------------------------|-------------------------------|----------------------|-----------------------------------|--|---|---|--|
|                 |   |                        | Profess                       | ional Te             | sting, EN                         | VII, Inc.  |   |   |  |
| Test Method:    |   |                        |                               |                      | ment of Radio-<br>Iz to 40 GHz" ( |  |   | •                                       |  |
| In accordance v | vith: FCC P   |                        | 09 - Code of F                | ederal Regulat       | tions Part 47, S                  | Subpart C - In   | tentional Radi  | ators, Radiat                           | ed Emissions   |
| Section:        | 15.20   | 19                     |                               |                      |                                   |  |   |   |  |
| Test Date(s):   | 10/2  | 7/2016                 | j                             |                      | EUT Serial                        | #:   | None  |   |  |
| Customer:       | Hetr  |                        |                               |                      | EUT Part #:                       |  | None  |   |  |
| Project Numbe   |   | 6                      |                               |                      | Test Techni                       | ician:   | Eric Lifsey   |   |  |
| Purchase Orde   |   |                        |                               |                      | Supervisor:                       |  | Lisa Arndt  |   |  |
| Equip. Under T  | est: CSM  | -400UE                 |                               |                      | Witness' Na                       | ame:   | None  |   |  |
|                 | Radia   | ted Em                 | issions Test                  | Results Dat          | a Sheet                           |  | Ра  | ge: 1                                   | of 1   |
| EUT Line \      | /oltage:  | 5                      | VDC                           |                      | EUT Pow                           | er Frequen   | icy:  | N/A                                     |  |
| Antenna Or      | ientation:  |                        | Horizon                       | tal                  | Freque                            | ency Range   | :   | Above 1                                 | GHz  |
|                 | EUT Mode  | of Ope                 | ration:                       |                      |                                   | Continuous   | Transmit;   | top channe                              | !  |
| Measured Di     | stance Dire   | UT<br>ection<br>grees) | Antenna<br>Height<br>(Meters) | Detector<br>Function | Recorded<br>Amplitude<br>(dBµV)   | Corrected<br>Level<br>(dBµV/m)                         | /el Limit Level Margi   |   | Test Resul   |
| 2374.9          | 3 1   | 28                     | 1.93                          | Average              | 52.9                              | 44.402   | 54.0  | -9.6                                    | Pass   |
| Radiated Emissi | Testing, EMI, 1<br>ons, 3m Distance<br>1Polarity Measured Emi |                        |                               |                      |                                   | <ul><li>✓ Corr</li><li>— Peak</li><li>— Corr</li></ul> | age Limit Level ected A verage Reading Limit Level ected Peak Reading -13 dBm at 3m |   | PROFESSIONAL   |
| ≣ 50 -          |   |                        |                               | <b>*</b>             |                                   |  | مرافات منافعات  | ing diagraph of the last discrete field | ter et la constitue de la cons |

# 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<br>(C)    | Reference<br>Center<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>Deviation<br>(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         | -115                                      |                                |                                 |  |
| Min Deviation (Hz) -3 |   |                                |                                 |  |

# **6.3.2** Bottom Channel, Operating Voltage

| Condition          | Voltage           | Frequency                       |                                |                              |
|--------------------|-------------------|---------------------------------|--------------------------------|------------------------------|
| Voltage<br>Extreme | Voltage<br>(V DC) | Reference<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>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               | Freq                                      | Deviation                      |                                 |  |
|-------------------------|---|--------------------------------|---------------------------------|--|
| Temperature<br>(C)      | Reference<br>Center<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>Deviation<br>(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) -5:  |   |                                |                                 |  |
| Min Deviation (Hz) -751 |   |                                |                                 |  |

# **6.3.4** Middle Channel, Operating Voltage

| Condition          | Voltage           | Frequency                       |                                |                              |
|--------------------|-------------------|---------------------------------|--------------------------------|------------------------------|
| Voltage<br>Extreme | Voltage<br>(V DC) | Reference<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>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                | Freq                                      | Deviation                      |                                 |  |
|--------------------------|---|--------------------------------|---------------------------------|--|
| Temperature<br>(C)       | Reference<br>Center<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>Deviation<br>(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) -83   |   |                                |                                 |  |
| Min Deviation (Hz) -1212 |   |                                |                                 |  |

# 6.3.6 Top Channel, Operating Voltage

| Condition          | Voltage           | Frequency                       |                                |                              |
|--------------------|-------------------|---------------------------------|--------------------------------|------------------------------|
| Voltage<br>Extreme | Voltage<br>(V DC) | Reference<br>Frequency<br>(MHz) | Measured<br>Frequency<br>(MHz) | Calculated<br>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                    | Parameter Section Reference                            |            |
|------------------------------|--|------------|
| Transient Frequency Behavior | 90.214   RSS-119 Issue 12, 5.9<br>Procedure: TIA-603-C | 7 Nov 2016 |

| Table 7.1.1 Transient Frequency Limits |   |                                  |                |  |  |  |
|--|---|----------------------------------|----------------|--|--|--|
|  | Maximum   | Frequency Range                  |                |  |  |  |
| Time intervals <sup>1,2</sup>          | frequency<br>difference <sup>3</sup>  | 150 to 174 MHz                   | 421 to 512 MHz |  |  |  |
| Transient Frequ                        | ency Behavior for Equip   | ment Designed to Operate on 25   | kHz Channels   |  |  |  |
| t <sub>1</sub> 4                       | ±25.0 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |
| t <sub>2</sub>                         | ±12.5 kHz   | 20.0 ms                          | 25.0 ms        |  |  |  |
| t <sub>3</sub> <sup>4</sup>            | ±25.0 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |
| Transient Freque                       | ency Behavior for Equipn  | nent Designed to Operate on 12.5 | 5 kHz Channels |  |  |  |
| t <sub>1</sub> 4                       | ±12.5 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |
| t <sub>2</sub>                         | ±6.25 kHz   | 20.0 ms                          | 25.0 ms        |  |  |  |
| t <sub>3</sub> 4                       | ±12.5 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |
| Transient Freque                       | Transient Frequency Behavior for Equipment Designed to Operate on 6.25 kHz Channels |                                  |                |  |  |  |
| t <sub>1</sub> 4                       | ±6.25 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |
| t <sub>2</sub>                         | ±3.125 kHz  | 20.0 ms                          | 25.0 ms        |  |  |  |
| t <sub>3</sub> 4                       | ±6.25 kHz   | 5.0 ms                           | 10.0 ms        |  |  |  |

 $\frac{1}{2}$  on is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

t<sub>1</sub> is the time period immediately following t<sub>on</sub>.

 $t_2$  is the time period immediately following  $t_1$ .

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

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

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.

<sup>3</sup>Difference between the actual transmitter frequency and the assigned transmitter frequency.

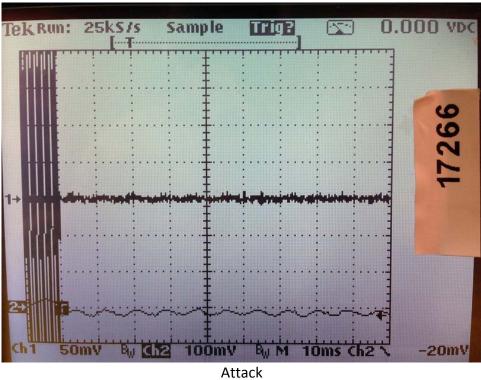
fif the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

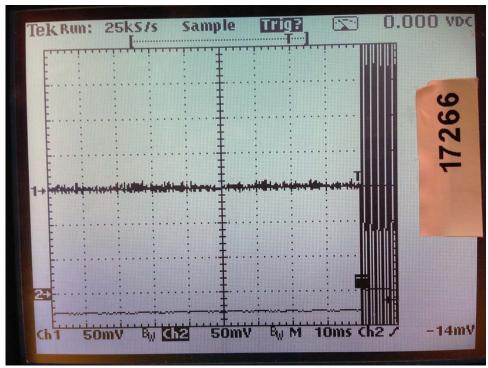
The measurement is performed for the lowest, middle, and highest operating frequency.

#### 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.

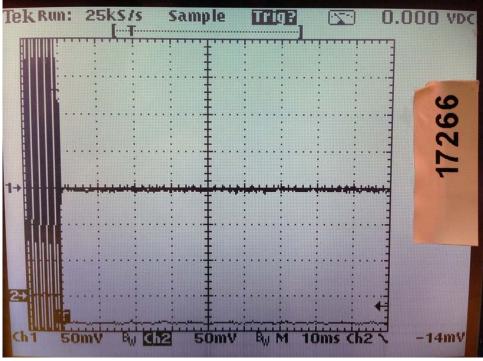
# **7.2.1** Bottom Channel



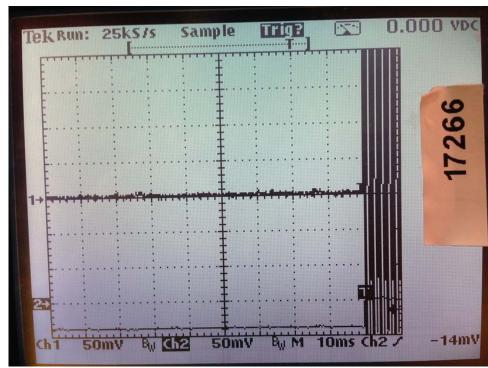


Release

#### 7.2.2 Middle Channel

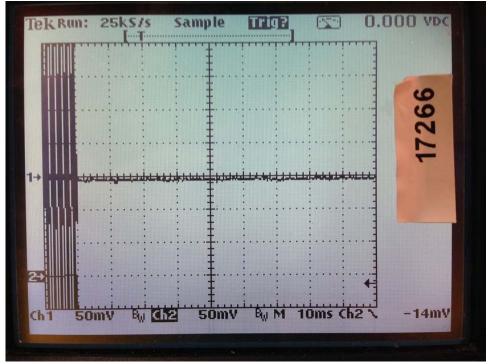


Attack

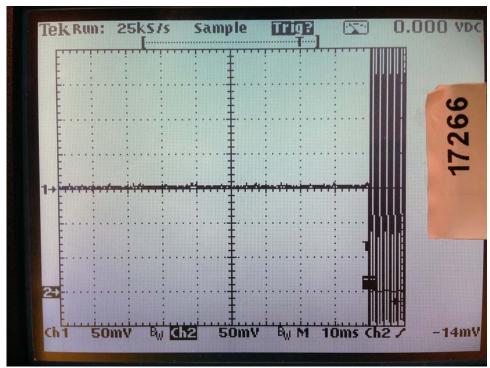


Release

# 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

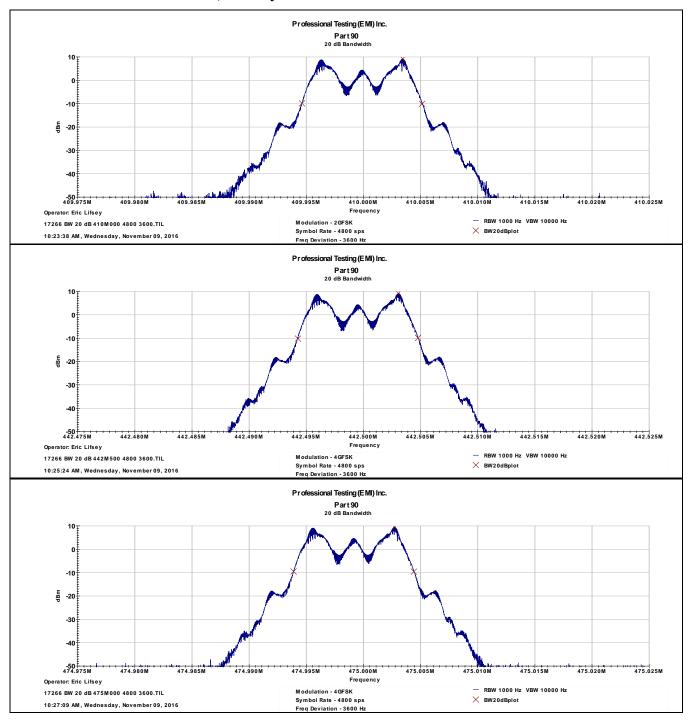
| Parameter                           | Section Number                         | Date       |
|-------------------------------------|--|------------|
| 90.210(c) Bandwidth < 12. 5 kHz     |  |            |
| Or spectrum efficiency minimum 4800 | 90.210(c), 90.203(j)(3), 2.1049   RSS- | 9 Nov 2016 |
| baud per 6.25 kHz bandwidth per     | 119 Issue 12, 5.5                      | 9 NOV 2010 |
| 90.203(j)(3).                       |  |            |

#### 8.3 Results

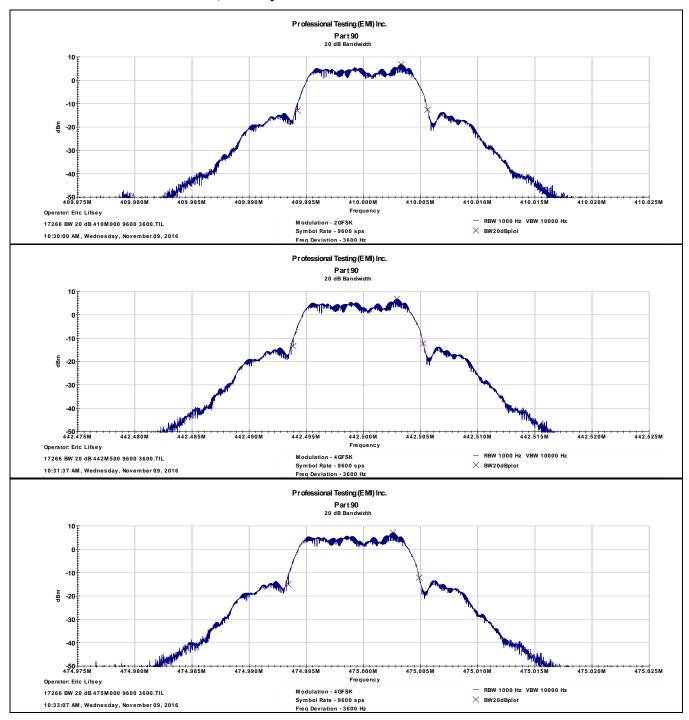
| Table 9.3.1 Bandwidth 20 dB (kHz) |                   |                   |                    |                    |  |
|-----------------------------------|-------------------|-------------------|--------------------|--------------------|--|
| Frequency                         | 2GFSK<br>4800 sps | 2GFSK<br>9600 sps | 4GFSK<br>20000 sps | 4GFSK<br>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.

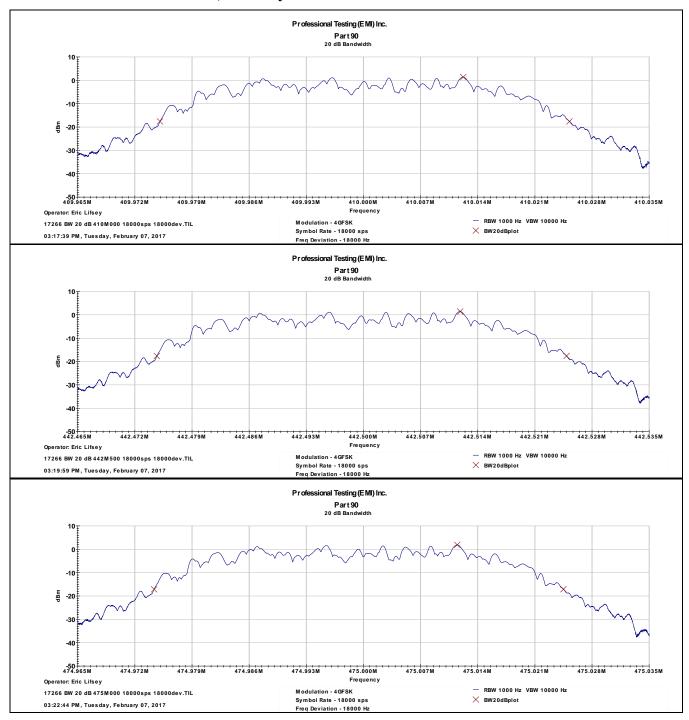
# 8.3.1 Modulation 2GFSK, 4800 Symbols Per Second



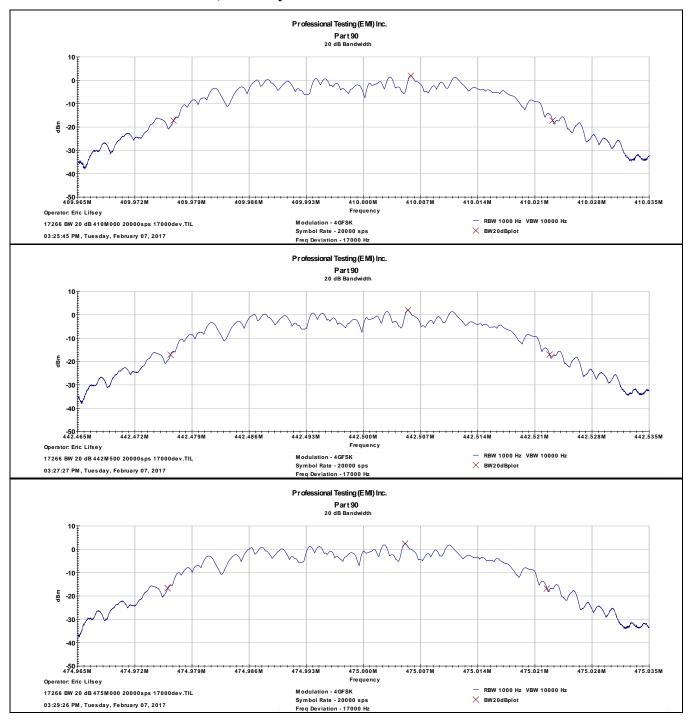
# 8.3.2 Modulation 2GFSK, 9600 Symbols Per Second



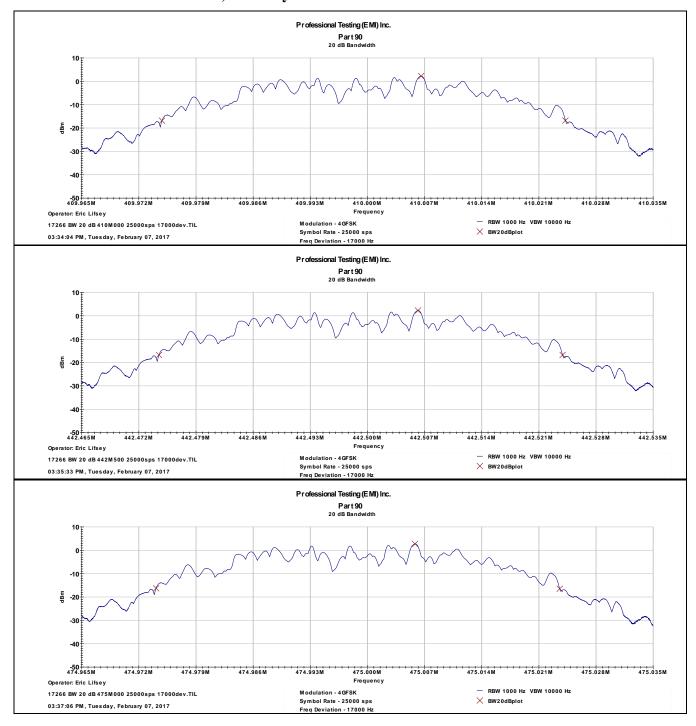
### 8.3.3 Modulation 4GFSK, 20000 Symbols Per Second



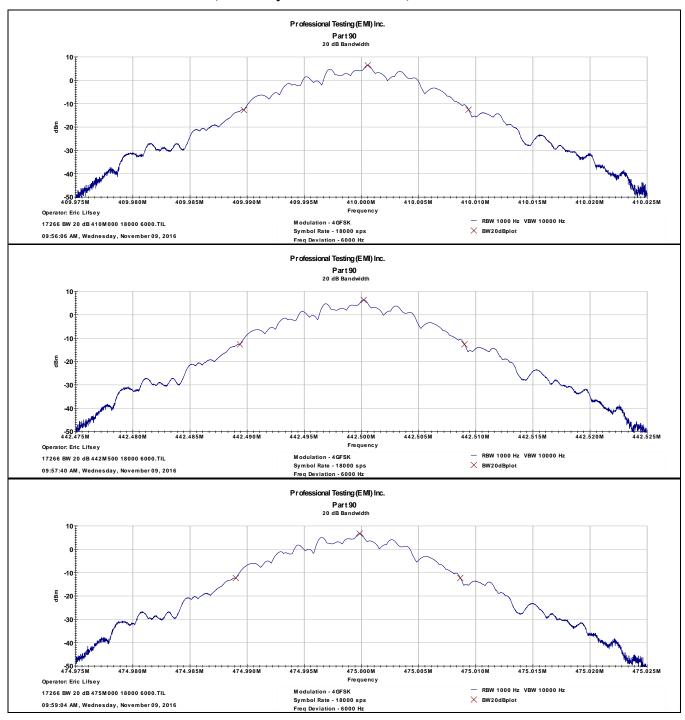
### 8.3.4 Modulation 4GFSK, 20000 Symbols Per Second



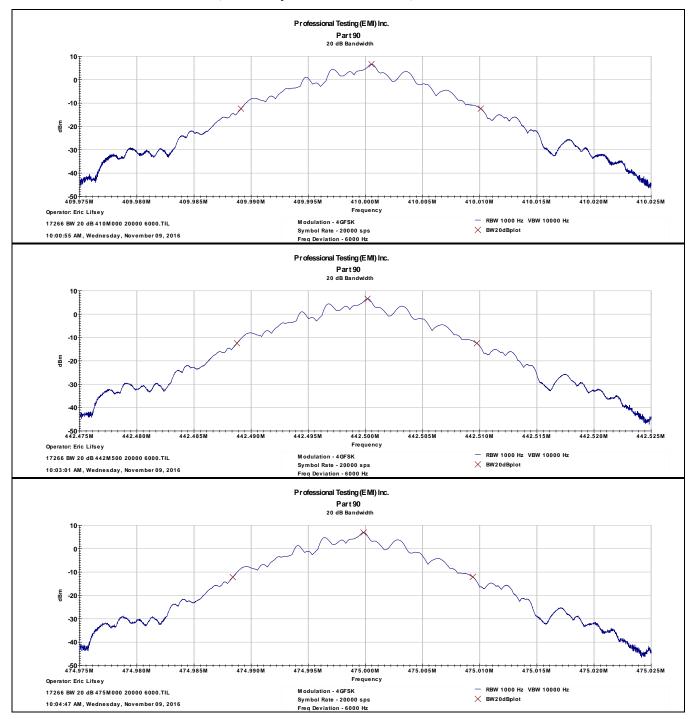
#### 8.3.5 Modulation 4GFSK, 25000 Symbols Per Second



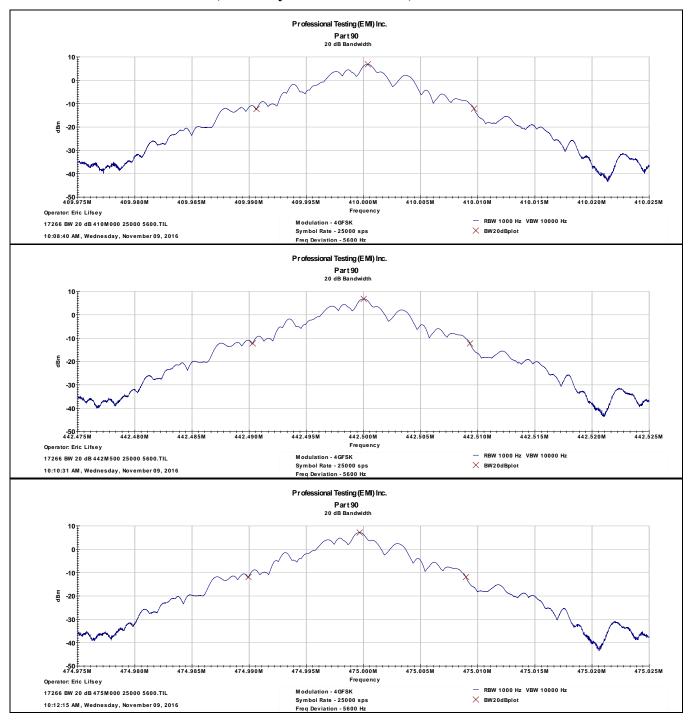
### 8.3.6 Modulation 4GFSK, 18000 Symbols Per Second, Low Deviation



### 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<br>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<br>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<br>Due |
|---------|---------------|----------|--|--------------------|
| 0836    | Narda         | 3293-1   | Broadband Directional Coupler          | CNR                |
| 0472    | Tektronix     | THS730A  | Oscilloscope, Digital                  | 7 Dec 2016         |
| 1678    | НР            | 8921A    | Cell Site Tester (as signal generator) | CIU                |
| 0742    | НР            | 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 Me   | asurement of Radio-Noi    | se Emissions from Low-Voltage          |  |
| rest Method.                    | <b>Electrical and Electronic Equipmen</b>   | t in the Range of 9 kHz t | to 40 GHz" (incorporated by reference, |  |
|                                 | FCC Part 15.209 - Code of Federal Regulations Part 47, Subpart C - Intentional Radiators, |                           |  |  |
| In accordance with:             | 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\_ClassB - 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    | НР           | 8447F                        | Preamp/Amp, 9kHz-1300MHz,<br>28/25dB             | 3313A05298     | 2/1/2018             |
| 1937    | Agilent      | E4440A                       | Spectrum Analyzer, 3 Hz - 26.5 GHz,<br>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    | НР           | 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-<br>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<br>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.<br>Dist. | Expanded<br>Uncertainty<br>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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