**Compliance Testing, LLC**
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# Test Report

**Prepared for: Sensys Networks, Inc.**

**Model: FLEX-RAD-CM**

**Description: FLEXRADIO Cabinet**

**Serial Number: NA**

**FCC ID: TDB-FLEXRAD**
**IC: 9498A-FLEXRAD**

**To**

**FCC Part 15.247**

**And**

**IC RSS-247**

**Date of Issue: July 7, 2017**

| | |
|---|---|
| **On the behalf of the applicant:** | **Sensys Networks, Inc.**<br>**2560 Ninth St.**<br>**Suite 219**<br>**Berkeley, CA 94710** |
| **Attention of:** | **Sebastian Lodahl, Hardware Engineer**<br>**Ph: (510)847-6189**<br>**E-Mail: slodahl@sensysnetworks.com** |

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**Project No: p1760011**

**Poona Saber**
**Project Test Engineer**

**Test Report Revision History**

| Revision | Date | Revised By | Reason for Revision |
|---|---|---|---|
| 1.0 | June 27, 2017 | Poona Saber | Original Document |
| 2.0 | June 5, 2017 | Poona Saber | On page 12 removed the summary table wording, Revised annex A and added a note on conducted spurious emissions |
| 3.0 | June 7, 2017 | Poona Saber | Updated Annex A, 30MHz-1GHz 209 plots |
| | | | |

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## ILAC / A2LA

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The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

Please refer to http://www.compliancetesting.com/labscope.html for current scope of accreditation.

Testing Certificate Number: **2152.01**

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#2152.01

**FCC Site Reg. #349717**

**IC Site Reg. #2044A-2**

**Non-accredited tests contained in this report:**

**N/A**

**The applicant has been cautioned as to the following**

15.21 - Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a) - Special Accessories

Equipment marked to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator, the responsible party may employ other methods of ensuring that the special accessories are provided to the consumer without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

**Standard Test Conditions Engineering Practices**

Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10-2013 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

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

| Environmental Conditions | | |
|---|---|---|
| **Temperature (ºC)** | **Humidity (%)** | **Pressure (mbar)** |
| 23.3 | 28.9 | 967 |

**EUT Description**
**Model:** FLEX-RAD-CM
**Description:** FLEXRADIO Cabinet
**Firmware:** N/A
**Software:** TrafficDOT2
**Serial Number:** N/A
**Additional Information:**
The FlexRadio Cabinet is the communications edge gateway for the Sensys Networks VDS240 Wireless Vehicle Detection System. The FlexRadio Cabinet uses its DSSS ISM band radio to communicate to battery operated sensors and then relay the information over RS-422 on Cat5 cables to either an APCC or FlexControl to process the data and provide vehicle detection information to a traffic signal controller or remote traffic management center.
The EUT operates in the 2406 – 2480MHz band and incorporates DSSS O-QPSK modulation in an 802.15.4 PHY protocol.
The EUT incorporates a 4.5 dBi antenna and can you up to 6 dBi Antenna.

**EUT Operation during Tests**
The manufacturer supplied software which enabled the EUT to be placed in to a test mode which transmitted high, mid and low channels with a continuous CW tone or a modulated signal.

**Accessories:**

| Qty | Description | Manufacturer | Model | S/N |
|---|---|---|---|---|
| 1 | Laptop | Lenovo | T420 | N/A |
| 1 | Magnetometer Interface Card | Sensys Network | APCC-M-E | 558 |

**Cables:**

| Qty | Description | Length (M) | Shielding Y/N | Shielded Hood Y/N | Ferrite Y/N |
|---|---|---|---|---|---|
| 2 | Ethernet | <3m | N | N | N |

**Modifications:** None

**15.203: Antenna Requirement:**

| | |
|---|---|
| | The antenna is permanently attached to the EUT |
| | The antenna uses a unique coupling |
| **X** | The EUT must be professionally installed |
| | The antenna requirement does not apply |

**Test Summary**

| FCC 15.247 Specification | RSS-247 Specification | Test Name | Pass, Fail, N/A | Comments |
|---|---|---|---|---|
| 15.247(b) | 5.4 | Peak Output Power | Pass | |
| 15.247(d) | 5.5 | Conducted Spurious Emissions | Pass | |
| 15.247(d), 15.209(a), 15.205 | 5.5 | Radiated Spurious Emissions | Pass | |
| 15.247(d), 15.209(a), 15.205 | 5.5 | Emissions at Band Edges | Pass | |
| 15.247(a)(2) | RSS-GEN | Occupied Bandwidth | Pass | |
| 15.247(e) | 5.4 | Transmitter Power Spectral Density | Pass | |
| 15.207 | RSS-GEN | A/C Powerline Conducted Emissions | Pass | |

| References | Description |
|---|---|
| CFR47, Part 15, Subpart B | Unintentional Radiators |
| CFR47, Part 15, Subpart C | Intentional Radiators |
| ANSI C63.10-2013 | American National standard for testing Unlicensed Wireless Devices |
| ANSI C63.4-2014 | Method and Measurements of Radio-Noise Emissions from low-Voltage Electrical and Electronic Equipment in the range 9kHz to 40GHz. |
| ISO/IEC 17025:2005 | General requirements for the Competence of Testing and Calibrations Laboratories |
| KDB 558074 D01 v04 | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating under §15.247 |

**Output Power**

**Engineer:** Poona Saber
**Test Date:** 6/21/2017

## Test Procedure

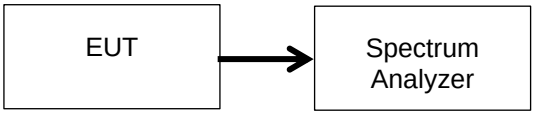
The EUT was connected to Spectrum analyzer through the antenna port and procedures of KDB 558074 D01 v04 was followed to measure the Peak conducted power.

The Spectrum Analyzer was set to the following:

RBW = ≥ DTS bandwidth
VBW ≥ 3 x RBW
Peak Detector
Trace mode = max hold
Sweep = auto
Span ≥ 3 x RBW

The EUT was set to continuous transmit on the lowest, middle and highest frequencies at the maximum power level. The RF output power was measured using the spectrum analyzer's channel power function

## Test Setup




## Transmitter Output Power

| Tuned Frequency (MHz) | Measured Value (dBm) | Specification Limit | Result |
|---|---|---|---|
| 2406 | 4.83 | 1 W (30 dBm) | Pass |
| 2440 | 5.90 | 1 W (30 dBm) | Pass |
| 2480 | -13.5 | 1 W (30 dBm) | Pass |

**Radiated Spurious Emissions**

**Engineer:** Poona Saber

**Test Date:** 6/26/2017

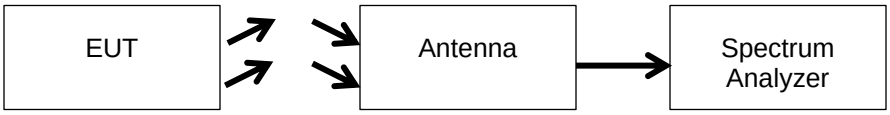
**Test Procedure**
**Radiated Spurious Emissions: 30 – 1000 MHz**

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The Antenna port on EUT got terminated into a 50 Ohms Load. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.

All emissions from 30 MHz to 1 GHz were examined.
Measured Level includes antenna and receiver cable correction factors.
Correction factors were input into the spectrum analyzer before recording “Measured Level”.

RBW = 100 KHz
VBW = 300 KHz
Detector – Quasi Peak

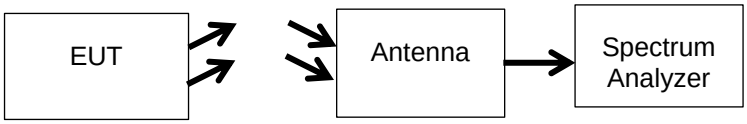
**Test Setup**



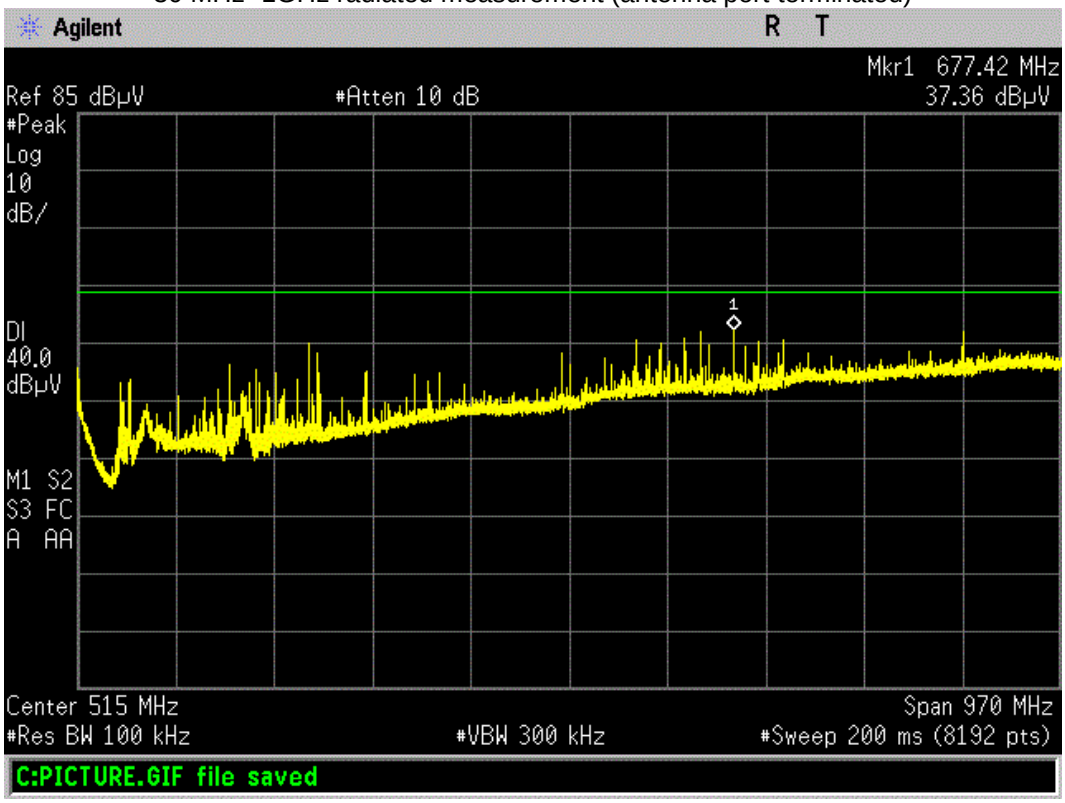

**Test Procedure for**
**Radiated Spurious Emissions above 1 GHz**

The EUT was setup in a semi-anechoic test chamber set 3m from the receiving antenna. The EUT was set to transmit on the lowest, middle and highest frequencies at the maximum power level. A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions. The EUT was tested by rotating it 360° with the antennas in both the vertical and horizontal orientation and was raised from 1 to 4 meters to ensure the TX signal levels were maximized.
Emissions were investigated up to the 10$^{th}$ harmonic. Only noise floor was observed past 10 GHz.

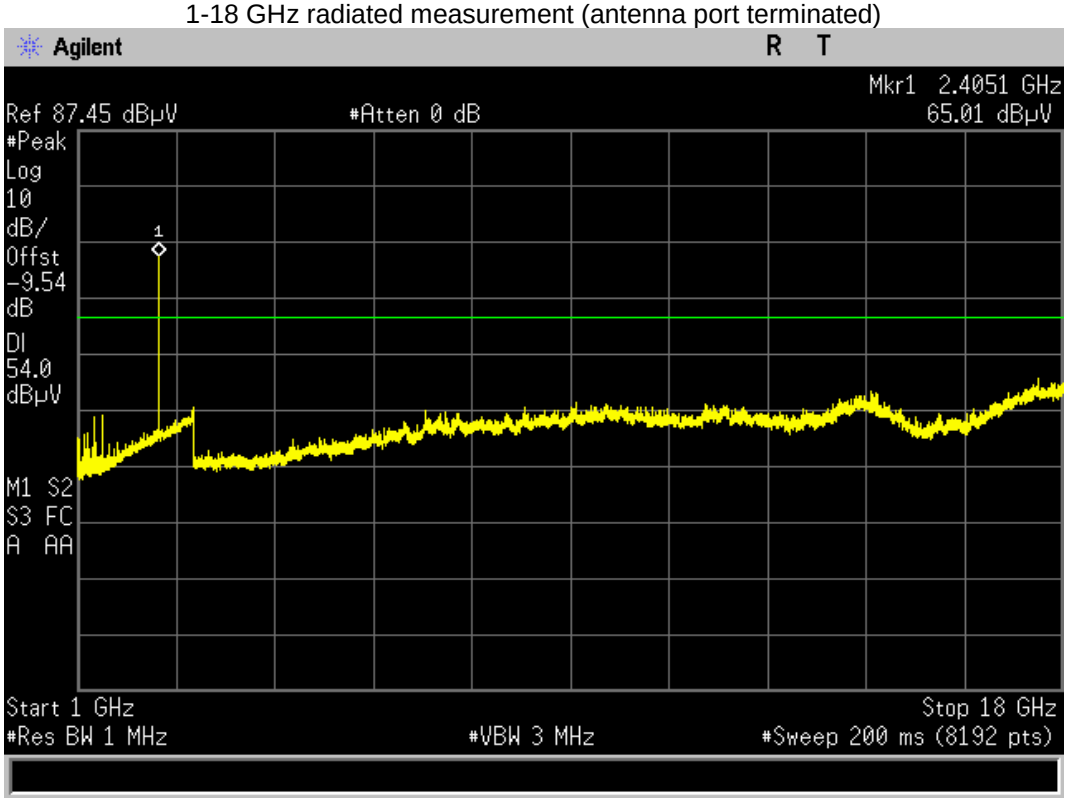
**Test Setup**



30 MHz- 1GHz radiated measurement (antenna port terminated)




1-18 GHz radiated measurement (antenna port terminated)



**Conducted Spurious Emission**

**Engineer: Poona Saber**

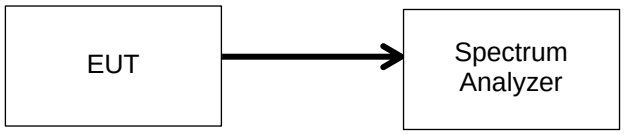
**Test Date:** 6/21/2017

**Test Procedure**

The EUT was connected to a spectrum analyzer to verify that the EUT met the requirements for spurious emissions of part 15.247 (d) and 15.209 for restricted band emissions. The frequency range from 30 MHz to the 10th harmonic of the fundamental transmitter was observed. Only detectable spurious emissions were recorded and plotted. The peak output power is added to the recorded measurement to provide the corrected spurious level dBc.

Only the worst case is recorded in the Conducted Spurious Emissions Summary Test Table.

**Test Setup**




Note: For conducted measurements in restricted bands per KDB 558074 a maximum ground reflection factor of 4.7 dB is added to EIRP level for frequencies between 30 MHz and 1000 MHz.

**See Annex A for test results**

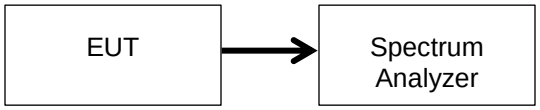
**DTS Bandwidth**

**Engineer:** Poona Saber
**Test Date:** 6/21/2017

## Test Procedure

The EUT was connected directly to a spectrum analyzer. The Span was set wide enough to capture the entire transmit spectrum and the resolution bandwidth was set to at least 1% of the span. The analyzer was set to max hold and when the entire spectrum was captured the 6dB and 99% bandwidths were measured to verify the bandwidth met the specification.

## Test Setup



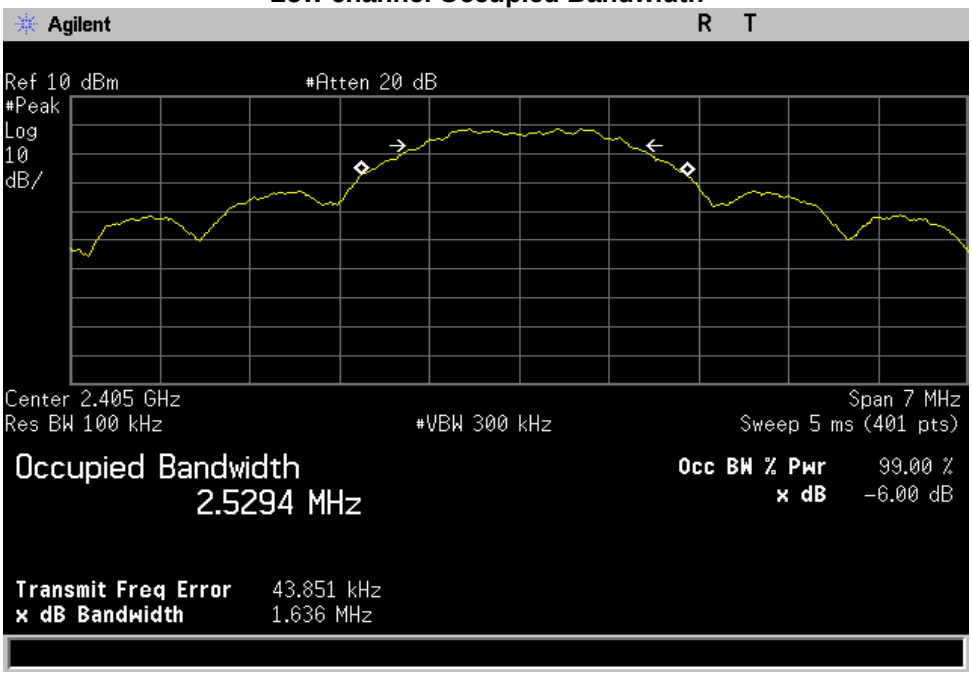

### 6 dB Occupied Bandwidth Summary

| Frequency (MHz) | Measured Bandwidth (MHz) | Specification Limit (kHz) | Result |
|---|---|---|---|
| 2406 | 1.63 | ≥ 500 | Pass |
| 2440 | 1.54 | ≥ 500 | Pass |
| 2480 | 1.53 | ≥ 500 | Pass |

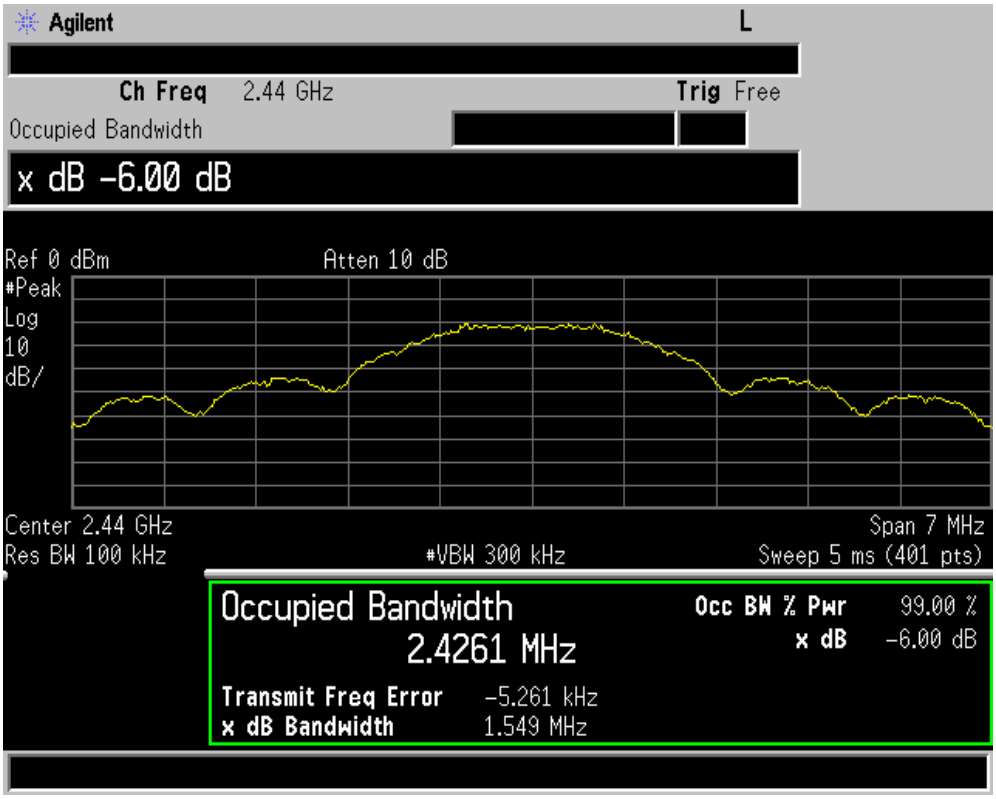
### 99% Bandwidth Summary

| Frequency (MHz) | Measured Bandwidth (MHz) | Result |
|---|---|---|
| 2406 | 2.52 | Pass |
| 2440 | 2.44 | Pass |
| 2480 | 2.50 | Pass |

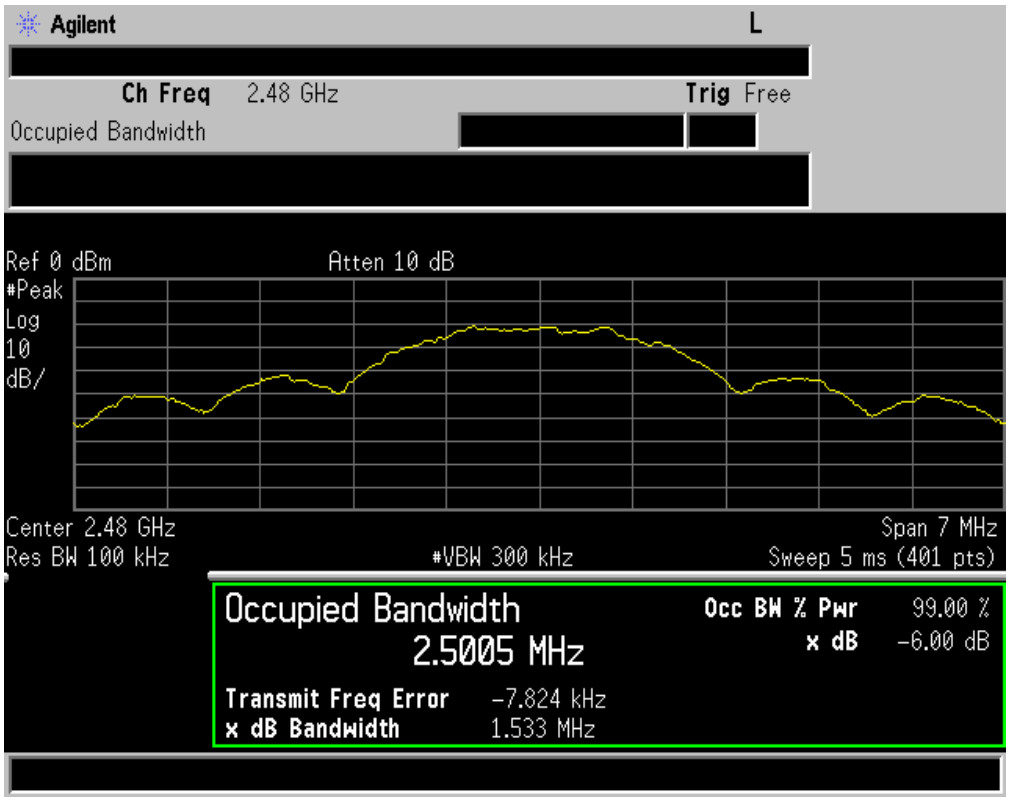
**Low channel Occupied Bandwidth**




**Mid channel Occupied Bandwidth**



**High channel Occupied Bandwidth**



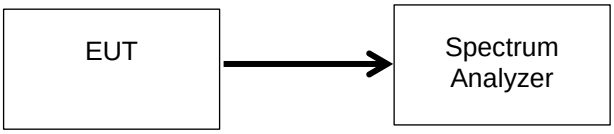
**Transmitter Power Spectral Density (PSD)**

**Engineer:** Poona Saber
**Test Date:** 6/21/2017

**Test Procedure**

The EUT was connected directly to a spectrum analyzer. The test was performed per section 11.10 of C63.10:2013 “Procedure for determining PSD for DTS devices”.

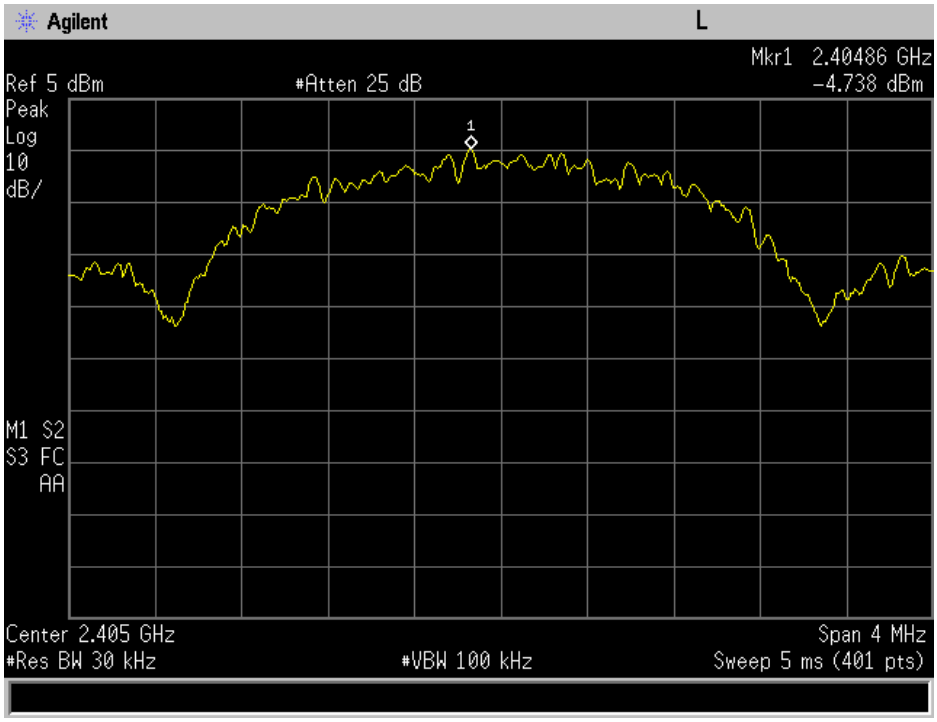
**Test Setup**



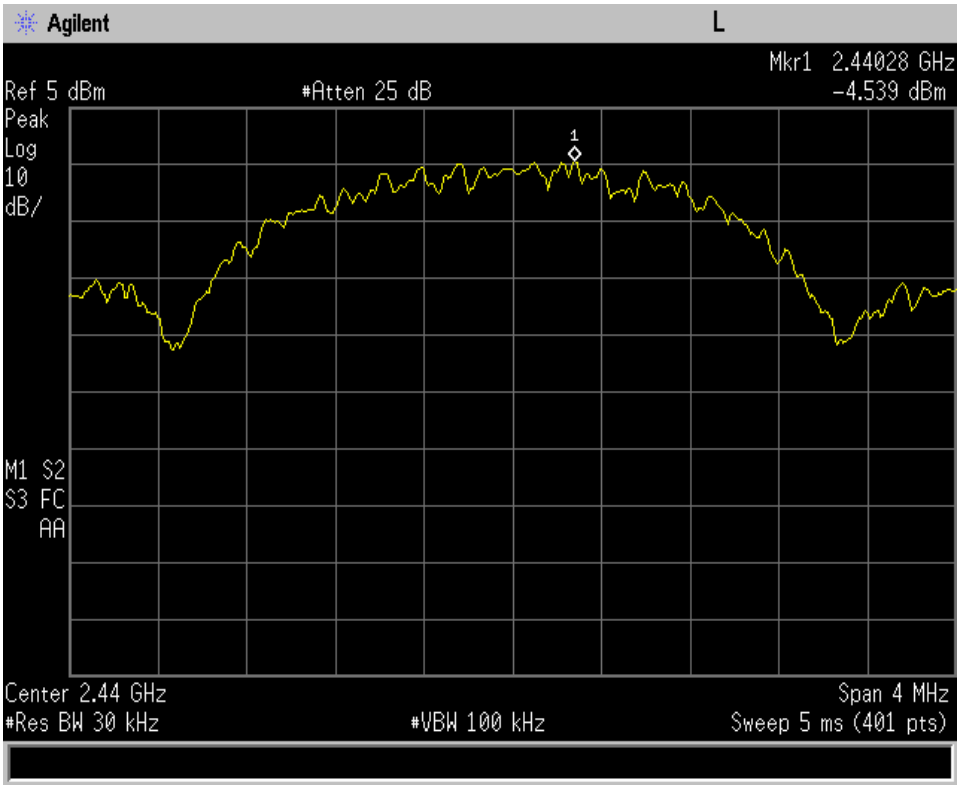

**PSD Summary**

| Frequency (MHz) | Measured Data (dBm) | Specification Limit (dBm) | Result |
|---|---|---|---|
| 2405 | -4.73 | 8 | Pass |
| 2440 | -4.53 | 8 | Pass |
| 2480 | -25.02 | 8 | Pass |

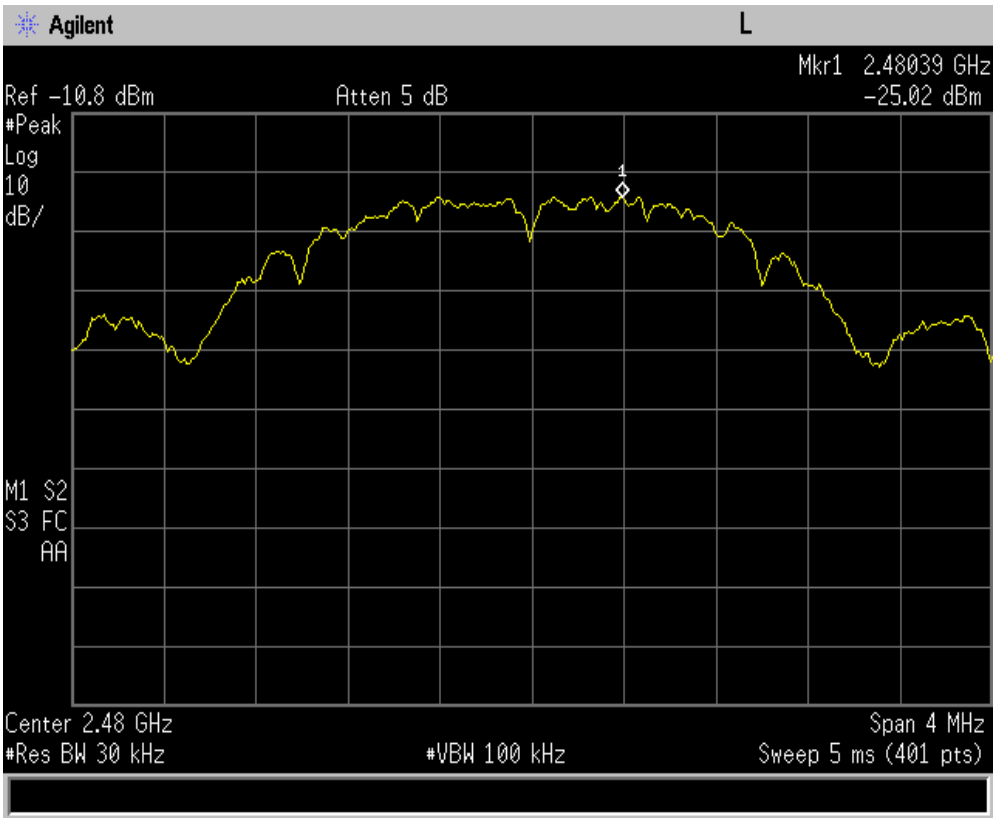
**Low Channel PSD**




**Mid Channel PSD**



**High Channel PSD**



**A/C Powerline Conducted Emission**

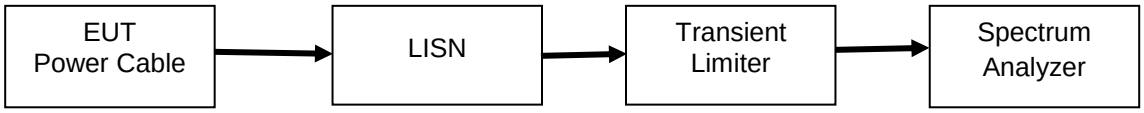
**Engineer:** Poona Saber

**Test Date:** 6/26/2017

## Test Procedure

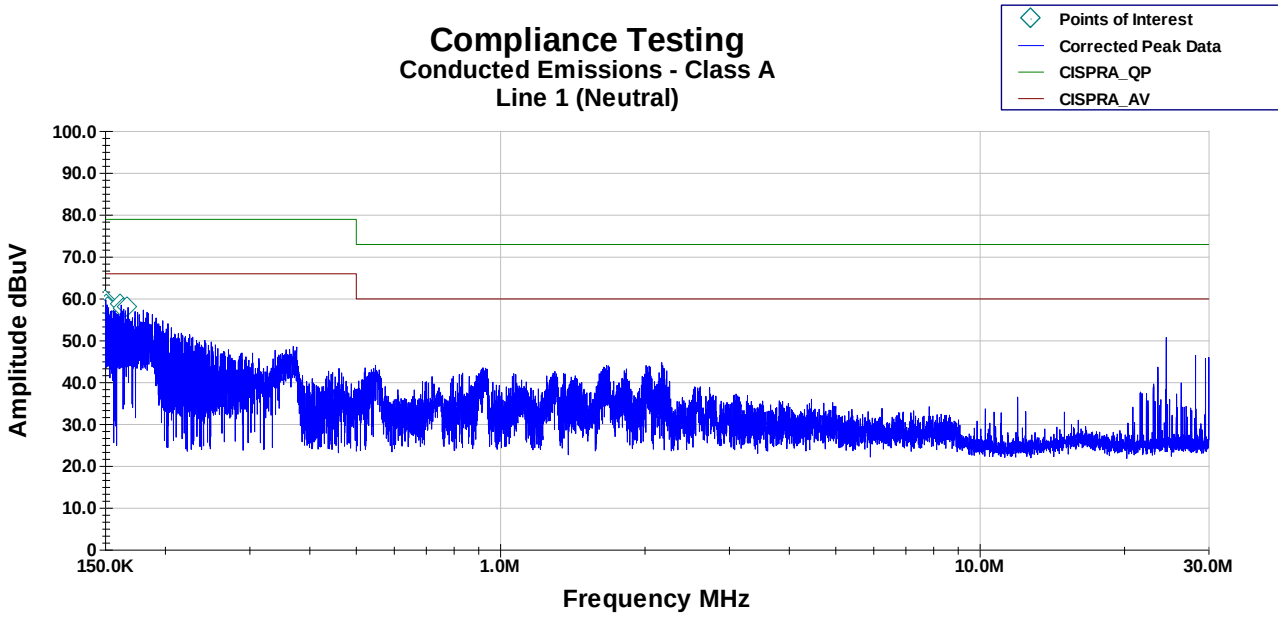
The EUT power cable was connected to a LISN and the monitored output of the LISN was connected to a transient limiter, which then connected directly to a spectrum analyzer. The conducted emissions from 150 kHz to 30 MHz were measured and compared to the specification limits.

## Test Setup



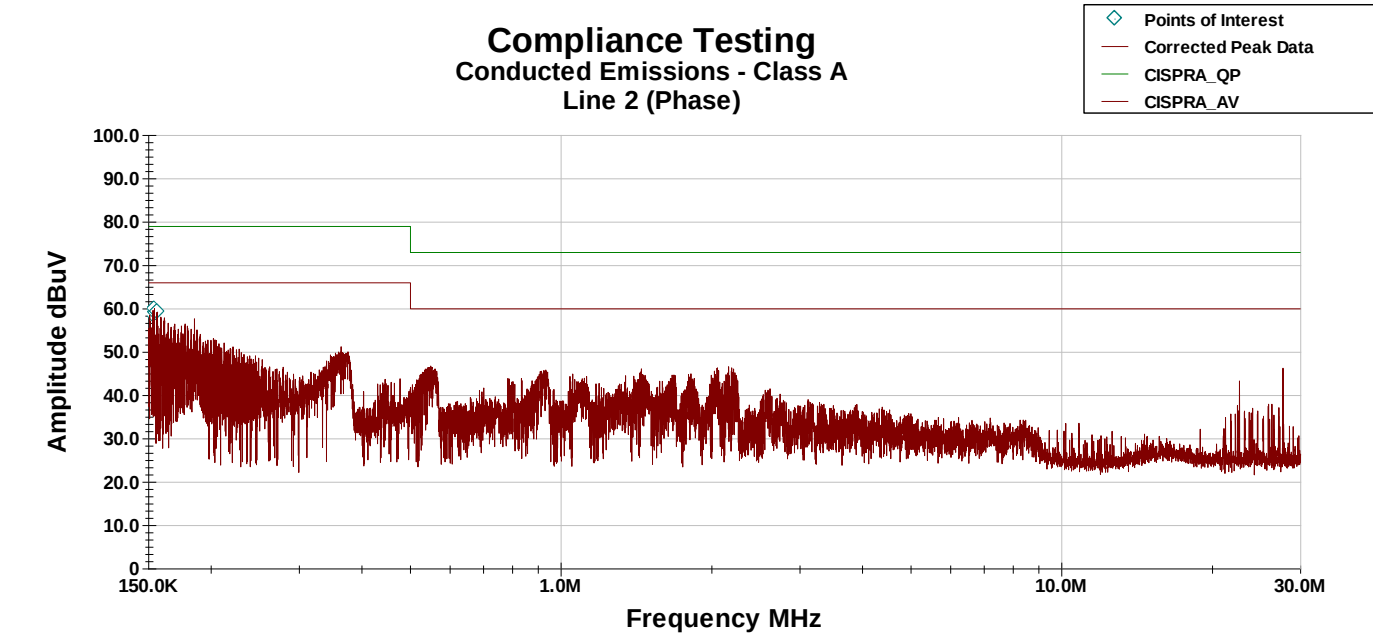
## Conducted Emission Test Results

### Line 1 Peak Plot




**Operator: PS**
**EN55022 Class A.til** **Job #:**

### Line 2 Peak Plot




**Operator: PS**
**EN55022 Class A.til** **Job #:**

**Line 1 Neutral Avg Detector**

| Frequency | Measured Value (dBuV) | LISN Correction Factor (dB) | Cable Loss (dB) | Transient Limiter (dB) | Final Data (dBuV) | Limit (dBuV) | Avg Margin (dB) |
|---|---|---|---|---|---|---|---|
| 150.25 KHz | 14.473 | 0.298 | 0.02 | 10.2 | 24.991 | 66 | -41.009 |
| 150.63 KHz | 14.78 | 0.294 | 0.02 | 10.2 | 25.294 | 66 | -40.706 |
| 154.13 KHz | 14.53 | 0.259 | 0.02 | 10.2 | 25.009 | 66 | -40.991 |
| 155.73 KHz | 14.32 | 0.243 | 0.02 | 10.2 | 24.783 | 66 | -41.217 |
| 156.01 KHz | 14.39 | 0.24 | 0.02 | 10.2 | 24.85 | 66 | -41.15 |
| 159.55 KHz | 14.617 | 0.205 | 0.02 | 10.2 | 25.041 | 66 | -40.959 |

**Line 2 Phase Avg Detector**

| Frequency | Measured Value (dBuV) | LISN Correction Factor (dB) | Cable Loss (dB) | Transient Limiter (dB) | Final Data (dBuV) | Limit (dBuV) | Avg Margin (dB) |
|---|---|---|---|---|---|---|---|
| 150.93 KHz | 13.19 | 0.29 | 0.02 | 10.2 | 23.704 | 66 | -42.296 |
| 152.43 KHz | 13.5 | 0.28 | 0.02 | 10.2 | 23.996 | 66 | -42.004 |
| 152.63 KHz | 13.42 | 0.27 | 0.02 | 10.2 | 23.91 | 66 | -42.09 |
| 154.2 KHz | 13.67 | 0.26 | 0.02 | 10.2 | 24.151 | 66 | -41.849 |
| 154.3 KHz | 13.33 | 0.26 | 0.02 | 10.2 | 23.807 | 66 | -42.193 |
| 157.45 KHz | 13.5 | 0.23 | 0.02 | 10.2 | 23.949 | 66 | -42.051 |

**Line 1 Neutral QP Detector**

| Frequency | Measured Value (dBuV) | LISN Correction Factor (dB) | Cable Loss (dB) | Transient Limiter (dB) | Final Data (dBuV) | Limit (dBuV) | QP Margin (dB) |
|---|---|---|---|---|---|---|---|
| 150.25 KHz | 38.68 | 0.298 | 0.02 | 10.2 | 49.197 | 79 | -29.803 |
| 150.63 KHz | 38.65 | 0.294 | 0.02 | 10.2 | 49.164 | 79 | -29.836 |
| 154.13 KHz | 38.73 | 0.259 | 0.02 | 10.2 | 49.209 | 79 | -29.791 |
| 155.73 KHz | 38.92 | 0.243 | 0.02 | 10.2 | 49.383 | 79 | -29.617 |
| 156.01 KHz | 38.92 | 0.24 | 0.02 | 10.2 | 49.38 | 79 | -29.62 |
| 159.55 KHz | 38.69 | 0.205 | 0.02 | 10.2 | 49.114 | 79 | -29.886 |

**Line 2 Phase QP Detector**

| Frequency | Measured Value (dBuV) | LISN Correction Factor (dB) | Cable Loss (dB) | Transient Limiter (dB) | Final Data (dBuV) | Limit (dBuV) | QP Margin (dB) |
|---|---|---|---|---|---|---|---|
| 150.93 KHz | 38.65 | 0.29 | 0.02 | 10.2 | 49.161 | 79 | -29.839 |
| 152.43 KHz | 38.91 | 0.28 | 0.02 | 10.2 | 49.406 | 79 | -29.594 |
| 152.63 KHz | 39.06 | 0.27 | 0.02 | 10.2 | 49.554 | 79 | -29.446 |
| 154.2 KHz | 38.95 | 0.26 | 0.02 | 10.2 | 49.428 | 79 | -29.572 |
| 154.3 KHz | 38.82 | 0.26 | 0.02 | 10.2 | 49.297 | 79 | -29.703 |
| 157.45 KHz | 39.08 | 0.23 | 0.02 | 10.2 | 49.525 | 79 | -29.475 |

**Test Equipment Utilized**

| Description | Manufacturer | Model # | CT Asset # | Last Cal Date | Cal Due Date |
|---|---|---|---|---|---|
| Horn Antenna | ARA | DRG-118/A | i00271 | 6/16/16 | 6/16/18 |
| Horn Antenna, Amplified | ARA | MWH-1826/B | i00273 | 4/22/15 | 4/22/18 |
| Humidity / Temp Meter | Newport | IBTHX-W-5 | i00282 | 6/9/17 | 6/9/18 |
| Spectrum Analyzer | Agilent | E4407B | i00331 | 10/19/16 | 10/19/17 |
| Bi-Log Antenna | Schaffner | CBL 6111D | i00349 | 8/3/16 | 8/3/18 |
| EMI Analyzer | Agilent | E7405A | i00379 | 2/22/17 | 2/22/18 |
| 3 Meter Semi-Anechoic Chamber | Panashield | 3 Meter Semi-Anechoic Chamber | i00428 | 8/15/16 | 8/15/19 |
| PSA Spectrum Analyzer | Agilent | E4445A | i00471 | 8/30/16 | 8/30/17 |
| Preamplifier | Miteq | AFS44 00101 400 23-10P-44 | i00509 | N/A | N/A |

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT