TEST REPORT # 316398 BLE
LSR Job #: C-2664

Compliance Testing of:

Carrier Infinity System Control Thermostat

Test Date(s):

2/8/17 – 3/24/17 & 5/25/17 – 6/9/17

Prepared For:

Attn: Gregg Householder
United Technologies Electronic Controls Inc.
3650 W 200 N
Huntington, IN 46750

This Test Report is issued under the Authority of: Coty Hammerer, EMC Engineer Signature: Coty Hammerer Date: 7/11/17	
Test Report Reviewed by: Adam Alger, Quality Systems Engineer Signature: Adam O Alger Date: 7/11/17	**Project Engineer:** Coty Hammerer, EMC Engineer Signature: Coty Hammerer Date: 7/5/17

TABLE OF CONTENTS

EXHIBIT 1. INTRODUCTION

1.1 - Scope

References:	FCC Part 15, Subpart C, Section 15.247 RSS 247
Title:	FCC : Telecommunication – Code of Federal Regulations, CFR 47, Part 15
Purpose of Test:	FCC and IC Certification Authorization for Low-Power License-Exempt Transmitters.
Test Procedures:	FCC KDB 558074 D01 DTS Measurement Guidance v04 ANSI C63.10 RSS 247 RSS GEN
Environmental Classification:	Residential

1.2 – Normative References

Publication	Year	Title
FCC CFR Parts 0-15	2017	Code of Federal Regulations – Telecommunications
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
RSS-247 Issue 2	2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN Issue 4	2014	General Requirements and Information for the Certification of Radio Apparatus
ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
FCC KDB 558074 D01 DTS Measurement Guidance v04	2017	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.3 -Laird Technologies, Inc. Test Lab in Review

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of two 3 Meter Semi-Anechoic Chambers based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industrie Canada Industry Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

1.4 – Location of Testing

All testing was performed at the following location utilizing the facilities listed below, unless otherwise noted.

Laird Technologies Inc.
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA,

List of Facilities Located at Laird Technologies, Inc.:

Semi-Anechoic Chamber

1.5 – Test Equipment Utilized

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated by a calibration laboratory accredited to the requirements of ISO/IEC 17025, and traceable to the SI standard.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	United Technology Electronic Controls Inc.
Address:	3650 W 200 N Huntington, IN 46750
Contact Name:	Gregg Householder

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Carrier Infinity System Control Thermostat
Model Number:	SYSTXCCITC01-B
Serial Number:	Engineering Samples #42 and #79

2.3 - Associated Antenna Description

The associated antenna is a chip antenna, a WiLink 8 CC1835 with a part # of ANT162442DT-2001A2. The peak antenna gain of this chip antenna is +2.1 dBi.

2.4 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2402 – 2480 MHz
Type of Modulation	Gaussian Frequency Shift Keying
Transmitter Spurious (worst case) at 3 meters	54.84 dBuV/m (Peak) at 4880 MHz, 50.82 dBuV/m (Average) at 4880 MHz
Frequency Tolerance %, Hz, ppm	Better than 100 ppm
Microprocessor Model # (if applicable)	N/A
Antenna Information	
Detachable/non-detachable	Non-Detachable
Type	Chip
Gain	2.1 dBi
EUT will be operated under FCC Rule Part(s)	Title 47 part 15.247
Modular Filing	☐ Yes ☒ No

Radio Characteristics

	BLE
Maximum Peak conducted Output Power (dBm)	5.70
Maximum Peak conducted Output Power (Watts)	0.0037
Minimum Peak Conducted Output Power (dBm)	4.58
Minimum Peak Conducted Output Power (Watts)	0.0029
99% BW (MHz)	1.04
6 dB BW (kHz)	705.8

2.5 - Product Description

Product Description for Carrier Infinity System Control (BING)

The new Infinity System Control (SYSTXCCITC01-B) and Bryant Connex Control (SYSTXBBECC01-B) is the user interface and control for Infinity or Bryant system. The Infinity System Control communicates to other intelligent devices in the system, such as Furnace, fan coil, air conditioner and heat pump using a 4 wire digital communication interface (ABCD) bus.

The Infinity System Control offers the following hardware features:

1. A sleek, new flat glass design
2. 5” WQVGA landscape display at 480x272 resolution
3. An integrated capacitive touch interface with smart phone like response
4. On board flat lens infrared motion detector to support occupancy sensing
5. New Temperature / Humidity sensor for better performance
6. MicroSD card interface for flexible, concealed, mass storage area for pictures for wall control
7. WiFi (w/MIMO) and Bluetooth Low Energy (BLE) radio to support internet connection and wireless sensors for zone control

The Infinity System Control has a rich graphical menu system which offers the following application features.

1. 4 Programmable Comfort profiles – Home/Away/Sleep/Wake
2. Programmable schedule and Vacation menus
3. Energy Tracking information
4. Photo Upload capability to display
5. Zoning definition capability
6. Intelligent WiFi and BLE interface
7. Real time weather icon per zip code
8. Reminders for filter and accessories

There is an “i” button on each screen to help define what every button is for.

Note: Only the BLE functionality of the Radio was testing during the specified test dates. No aspect of Classic Bluetooth was tested at any time.

Note: The AC Adapter/Transformer used to power the EUT throughout testing is not supplied with the unit. This power supply was for testing purposes only.

EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	70 -74° F
Humidity:	30-48%
Pressure:	728-741mmHg

3.2 - Applicability & Summary of EMC Emission Test Results

FCC and IC Paragraph	Test Requirements	Compliance (Yes/No)
FCC: 15.207 IC: RSS-GEN 8.8	Power Line Conducted Emissions Measurements	Yes
FCC : 2.1049 IC: RSS-GEN 6.6	99% Bandwidth	Yes
FCC: 15.247 (b)(3) IC: RSS-247 5.4 (4)	Maximum Output Power	Yes
FCC: 2.1055 (d) IC: RSS-GEN 6.11	Frequency Stability	Yes
FCC: 15.247(d) IC: RSS-247 5.5	RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
FCC: 15.247 (a)(2) IC: RSS-247 5.2 (1)	6 dB Bandwidth of a Digital Modulation System	Yes
FCC : 15.247 (e) IC : RSS-247 5.2 (2)	Power Spectral Density of a Digital Modulation System	Yes
FCC: 15.247(d), 15.209 & 15.205 IC: RSS-GEN 8.10	Spurious Radiated Emissions in Restricted Bands	Yes

3.3 - Modifications Incorporated In The EUT For Compliance Purposes

☒ None ☐ Yes (explain below)

3.4 - Deviations & Exclusions From Test Specifications

☒ None ☐ Yes (explain below)

EXHIBIT 4. CONFORMANCE SUMMARY

When tested between February 8th to March 24th of 2017 and May 25th to June 9th of 2017, it was determined that the EUT, BING, was compliant to the requirements of:

FCC Title 47 CFR Part 15.247
RSS 247 Issue 2

Using the methods of ANSI C63.10-2013, RSS GEN, and KDB 558074 D01 DTS Measurement Guidance v04.

Any modifications made to the EUT after the specified test date(s) will invalidate the data herein.

If some emissions measurements are seen to be within the uncertainty value, as listed in Appendix C there is a possibility that this unit may not meet the required limit specification if subsequently tested.

EXHIBIT 5. UNWANTED EMISSIONS INTO THE RESTRICTED FREQUENCY BANDS.

5.1 - Test Setup

The test setup was assembled in accordance with Title 47, CFR FCC Part 15 and ANSI C63.10-2013. The EUT was placed on a 150 cm high non-conductive pedestal (80 cm for measurements under 1 GHz), centered on a flush mounted turntable inside a 3 meter Semi-Anechoic Chamber. The EUT was operated in continuous transmit mode. The unit was tested on the low, middle and high channels, controllable via proprietary software provided by the manufacturer.

The applicable limits apply at a 3 meter distance. The calculations to determine these limits are detailed in the following pages. Please refer to Appendix A for a complete list of test equipment. The test sample was operated on one of three (3) standard channels to comply with FCC Part 15.31(m).

5.2 - Test Procedure

Radiated RF measurements were performed on the EUT in a 3 meter Semi-Anechoic, FCC listed Chamber. The frequency range from 30 MHz to 25000 MHz was scanned and investigated. The radiated RF emission levels were manually noted at the various fixed degree settings of azimuth on the turntable and antenna height. The EUT was placed on a non-conductive pedestal in the 3 meter Semi-Anechoic Chamber, with the antenna mast placed such that the antenna was 3 meters from the EUT. A Biconical Antenna was used to measure emissions from 30 MHz to 200 MHz, and a Log Periodic Antenna was used to measure emissions from 200 MHz to 1000 MHz. A Double-Ridged Waveguide Horn Antenna was used from 1 GHz to 18 GHz while a standard gain horn antenna was used in the 18 GHz to 25 GHz range. The maximum radiated RF emissions between 30MHz to 25 GHz were found by raising and lowering the sense antenna between 1 and 4 meters in height, using both horizontal and vertical antenna polarities. A tilt gear was utilized to keep the EUT within the cone of radiation for measurements above 1 GHz. Attenuating foam lined the chamber floor between the EUT and Mast for measurements above 1 GHz.

The EUT was positioned in a single orientation in which it is intended to be installed.

5.3 - Test Equipment Utilized

A list of the test equipment and antennas utilized for the Radiated Emissions test can be found in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. All calibrations of the antennas used were performed at a calibration laboratory accredited to ISO 17025, and are traceable to the SI standard. The resulting correction factors and the cable loss factors from these calibrations were entered into the EMI Receiver database. As a result, the data taken from the EMI Receiver accounts for the antenna correction factor as well as cable loss or other corrections, and can therefore be entered into the database as a corrected meter reading. The EMI Receiver was operated with a resolution bandwidth of 120 kHz for measurements below 1 GHz (video bandwidth of at least 300 kHz), and a resolution bandwidth of 1 MHz for measurements above 1 GHz (video bandwidth of at least 3 MHz). For some plots, a reduced video bandwidth was used in order to identify spurious emissions (The relevant plots are labeled as such). In these cases, the standard video bandwidth was used with the appropriate detectors for measurement.

5.4 - Test Results

The EUT was found to **MEET** the Radiated Emissions requirements of Title 47 CFR, FCC Part 15.247 and RSS 247 for a DTS transmitter. The frequencies with significant RF signal strength were recorded and plotted as shown in the Data Charts and Graphs.

5.5 - Calculation of Radiated Emissions Limits and reported data.

Reported data:

For both fundamental and spurious emissions measurement, the data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBµV) + Antenna correction Factor + Cable factor (dB) + Miscellaneous factors when applicable (dB) – amplification factor when applicable (dB).

Generic example of reported data at 200 MHz:

Reported Measurement data = 18.2 (raw receiver measurement) + 15.8 (antenna factor) + 1.45 (cable factor) = 35.45 (dBµV/m).

As specified in 15.247 (d), radiated emissions that fall within the restricted band described in 15.205(c) for FCC must comply with the general emissions limit.

The following table depicts the general radiated emission limits above 30 MHz. These limits are obtained from Title 47 CFR, Part 15.209, for radiated emissions measurements. These limits were applied to any signals found in the 15.205 restricted bands. The mentioned limits correspond to those limits listed in RSS GEN.

Frequency (MHz)	3 m Limit µV/m	3 m Limit (dBµV/m)	1 m Limit (dBµV/m)
30-88	100	40.0	-
88-216	150	43.5	-
216-960	200	46.0	-
960-40,000	500	54.0	63.5

Sample conversion of field strength (µV/m to dBµV/m):
$dB\mu V/m = 20 \log_{10} (100) = 40$ dBµV/m (from 30-88 MHz)

5.6 - Data

Manufacturer:	United Technology Electronic Controls					
Date(s) of Test:	2/8/17 to 3/2/17 and 5/25/17 to 6/9/17					
Project Engineer(s):	Coty Hammerer					
Test Engineer(s):	Coty Hammerer & Shane Dock					
Voltage:	120VAC/60 Hz to 24VAC (AC Adaptor/Transformer)					
Operation Mode:	Continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 70-74° F Relative Humidity: 30-42%					
EUT Power:		Single Phase 120VAC		3 Phase ___VAC		
	X	24VAC		Other: 3V		
EUT Placement:	X	150 cm non-conductive pedestal (80 cm for <1 GHz)		10cm Spacers		
EUT Test Location:	X	3 Meter Semi-Anechoic Chamber		3/10m OATS		
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:	X	Peak	X	Quasi-Peak	X	Average

Measurements above 1 GHz:

Note: Emissions below were maximized between the three channels tested in the standard EUT orientation. The worst-case emissions are reported

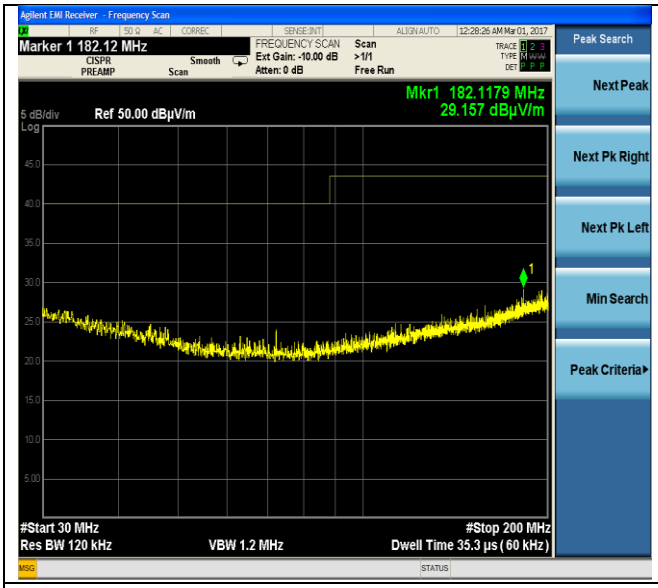
Frequency (MHz)	Height (m)	Azimuth (degree)	Peak Reading A (dBµV/m)	Average Reading B (dBµV/m)	Peak Limit A (dBµV/m)	Average Limit B (dBµV/m)	Peak Margin A (dB)	Average Margin B (dB)	Antenna Polarity	EUT orientation	Notes
3452.18	1.50	0.00	49.5	37.1	74.0	54.0	24.55	16.89	V	V	Noise Floor
3558.24	1.50	0.00	49.9	37.6	74.0	54.0	24.09	16.37	H	V	Noise Floor
2196.99	1.50	0.00	44.3	32.2	74.0	54.0	29.72	21.76	V	V	Noise Floor
2309.56	1.50	0.00	45.5	32.4	74.0	54.0	28.49	21.59	H	V	Noise Floor
4804	1.53	2.79	51.45	46.71	74.0	54.0	22.55	7.29	H	V	-
4804	2.81	74	48.86	43.1	74.0	54.0	25.14	10.90	V	V	-
7320	1.77	110.8	48.34	39.35	74.0	54.0	25.66	14.65	H	V	-
7440	1.67	107.8	48.92	39.85	74.0	54.0	25.08	14.15	H	V	-
4880	1.78	288.75	54.84	50.82	74.0	54.0	19.16	3.18	H	V	-
4880	2.2	261	53	48.16	74.0	54.0	21.00	5.84	V	V	-
7320	1.48	135	50.26	41.35	74.0	54.0	23.74	12.65	H	V	-
4960	1.29	151	49.87	44.51	74.0	54.0	24.13	9.49	H	V	-
4960	2.37	45	46.13	41.35	74.0	54.0	27.87	12.65	V	V	-

Note: No measurements were recorded for <1 GHz, mostly noise floor or extremely low emissions were seen <1 GHz.

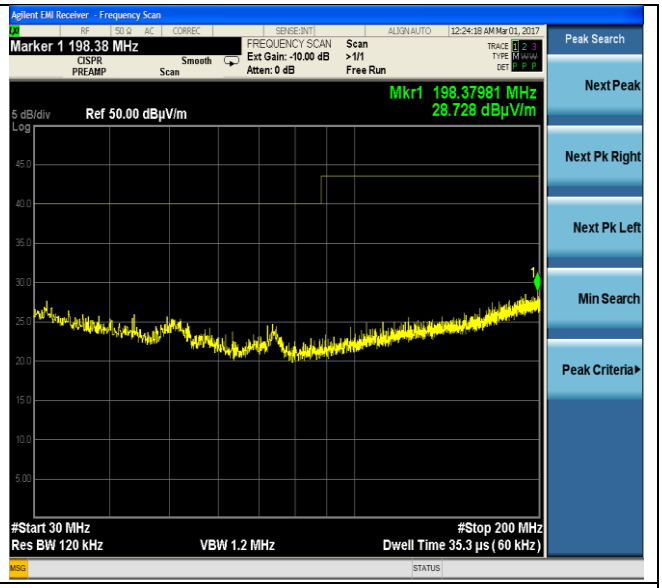
5.7 – Screen Captures.

The screen captures below are those using the Peak detector of the analyzer. The worst case plots are displayed.

30 to 200 MHz, 3m distance

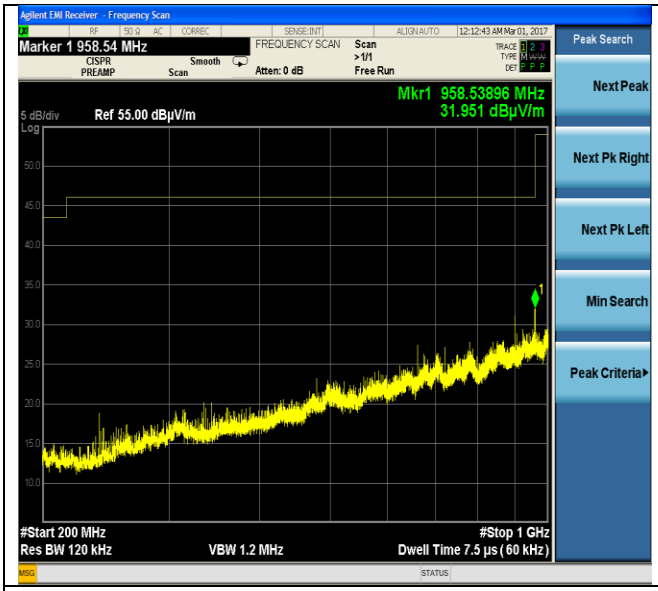


Horizontal Antenna (High Channel)

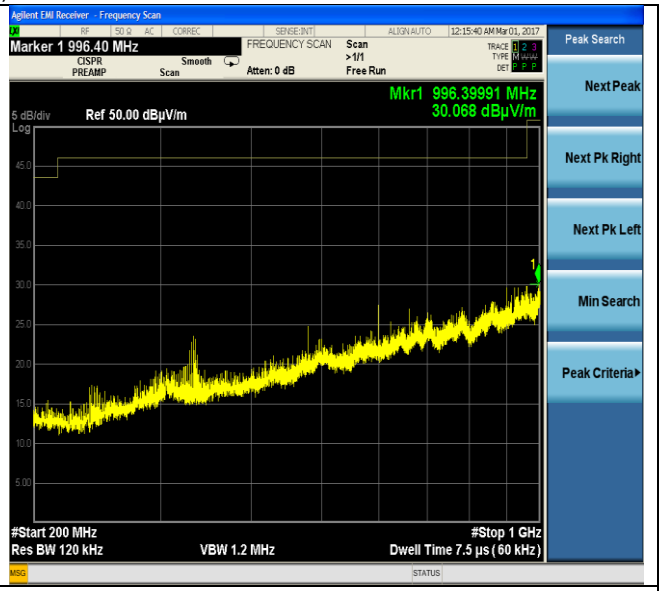


Vertical Antenna (High Channel)

200 to 1000 MHz, 3m distance.

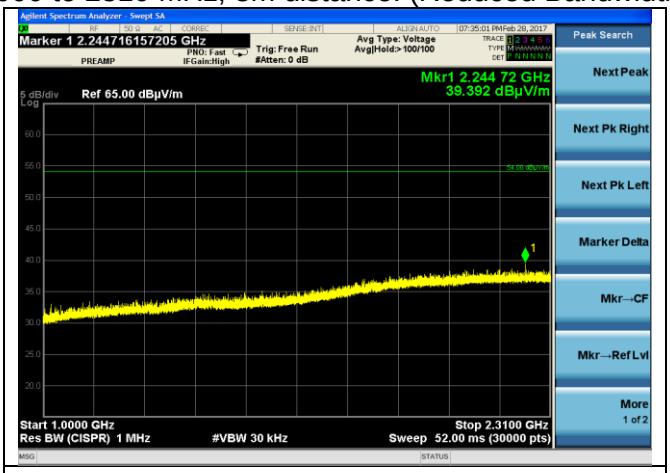


Horizontal Antenna (High Channel)



Vertical Antenna (High Channel)

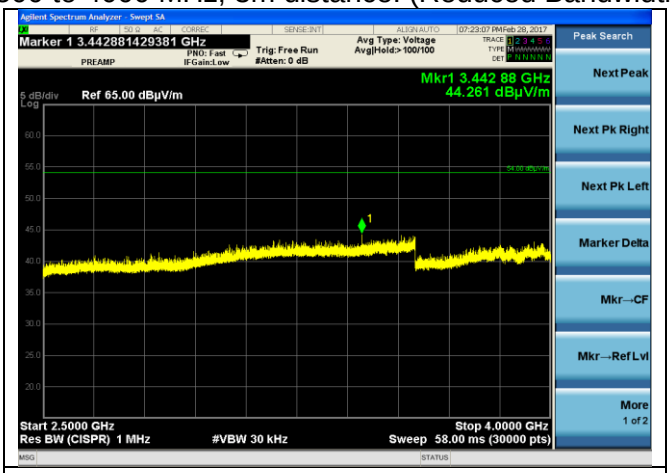
1000 to 2310 MHz, 3m distance. (Reduced Bandwidth)



Low Channel

Note: The ranges 2310 to 2390 and 2483.5 to 2500 MHz are in section 8 of this report (Band-edges).

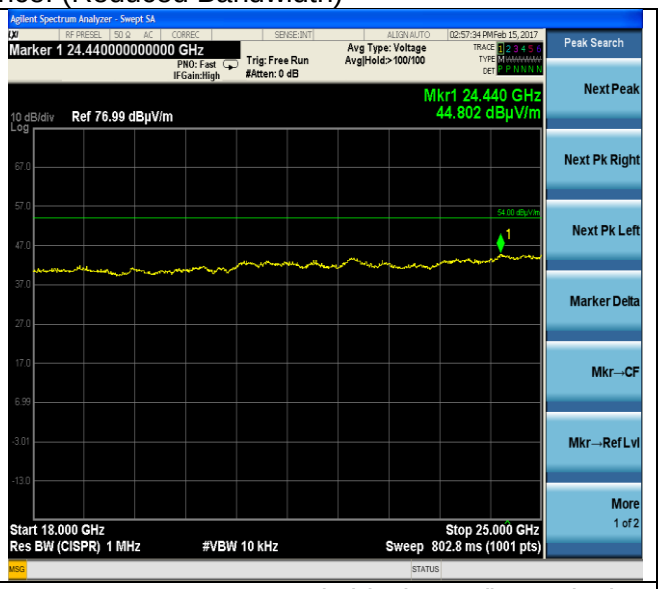
2500 to 4000 MHz, 3m distance. (Reduced Bandwidth)



High Channel

4000 to 25000 MHz, 3m distance. (Reduced Bandwidth)

4000 to 18000 MHz (Mid Channel), Horizontal Antenna Polarization



18000 to 25000 MHz (Mid Channel), Vertical Antenna Polarization , Noise Floor

EXHIBIT 6. CONDUCTED EMISSIONS TEST, AC POWER LINE

6.1 Test Setup

The test area and setup are in accordance with ANSI C63.10and with Title 47 CFR, FCC Part 15/ The EUT was placed on a non-conductive wooden table, with a height of 80 cm above the reference ground plane. The power supply was then plugged into a 50Ω (ohm) Line Impedance Stabilization Network (LISN). The AC power supply was provided via an appropriate broadband EMI Filter, and then to the LISN line input. Final readings were then taken and recorded. After the EUT was setup and connected to the LISN, the RF Sampling Port of the LISN was connected to an EMI receiver System. The LISN used has the ability to be switched between either L1 (line) or L2 (neutral).

6.2 Test Procedure

The EUT was investigated in continuous modulated transmit mode for this portion of the testing. The appropriate frequency range and bandwidths were selected on the EMI Receiver, and measurements were made. The bandwidth used for these measurements is 9 kHz, for Quasi-Peak and Average detectors in the frequency range of 150 kHz to 30 MHz. Final readings were then taken and recorded.

6.3 Test Equipment Utilized

A list of the test equipment and accessories utilized for the Conducted Emissions test is provided in Appendix A. This list includes calibration information and equipment descriptions. All equipment is calibrated and used according to the operation manuals supplied by the manufacturers. The emissions are measured on the EMI System, which contains correction factors to account for the equipment used in measurements.

6.4 Test Results

The EUT was found to **MEET** the Conducted Emission requirements of FCC Part 15.207 for Conducted Emissions for an Intentional Radiator. See the Data Charts and Graphs for more details of the test results.

6.5 FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBµV)	
	Quasi-Peak	Average
0.150 -0.50 *	66-56	56-46
0.5 – 5.0	56	46
5.0 – 30	60	50
* The limit decreases linearly with the Logarithm of the frequency in this range.		

6.6 Conducted Emissions Test Data Chart

Frequency Range inspected: 150 KHz to 30 MHz

Manufacturer:	United Technology Electronic Controls					
Date(s) of Test:	3/22/17					
Project Engineer:	Coty Hammerer					
Test Engineer:	Khairul Aidi Zainal					
Voltage:	24VAC via a (120VAC/60 Hz AC Adapter/ step-down transformer)					
Operation Mode:	Continuous transmit, modulated					
Environmental Conditions in the Lab:	Temperature: 71° F Relative Humidity: 42%					
Test Location:	X	AC Mains Test area				Chamber
EUT Placed On:	X	40cm from Vertical Ground Plane				10cm Spacers
	X	80cm above Ground Plane				Other:
Measurements:		Pre-Compliance		Preliminary	X	Final
Detectors Used:		Peak	X	Quasi-Peak	X	Average

Data Table

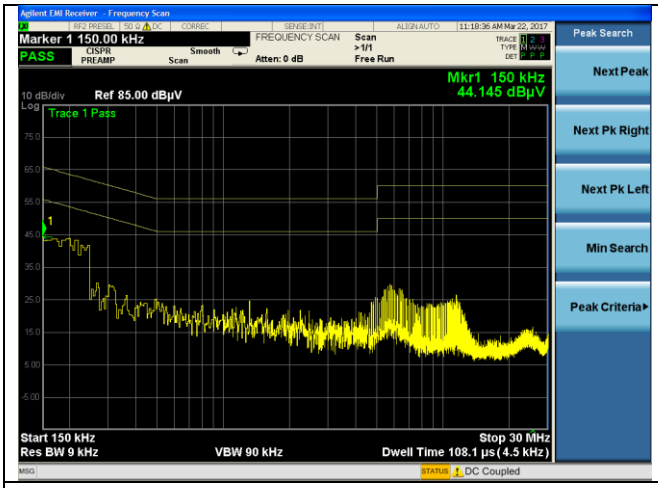
Frequency (MHz)	Line	Q-Peak Reading (dBµV)	Q-Peak Limit (dBµV)	Quasi-Peak Margin (dB)	Average Reading (dBµV)	Average Limit (dBµV)	Average Margin (dB)
0.150	1	42.3	66.0	23.7	32.3	56.0	23.7
1.314	1	20.1	56.0	35.9	13.3	46.0	32.7
5.792	1	26.5	60.0	33.5	15.1	50.0	34.9
11.385	1	22.8	60.0	37.2	12.0	50.0	38.0
11.475	2	23.6	60.0	36.4	13.3	50.0	36.7
6.467	2	17.9	60.0	42.1	11.2	50.0	38.8
1.964	2	18.9	56.0	37.1	12.0	46.0	34.0

Note: The following data is representative of the worst case emissions. Data represents the middle channel. Changing between low, mid, and high channels showed no difference in the emissions signature or amplitude.

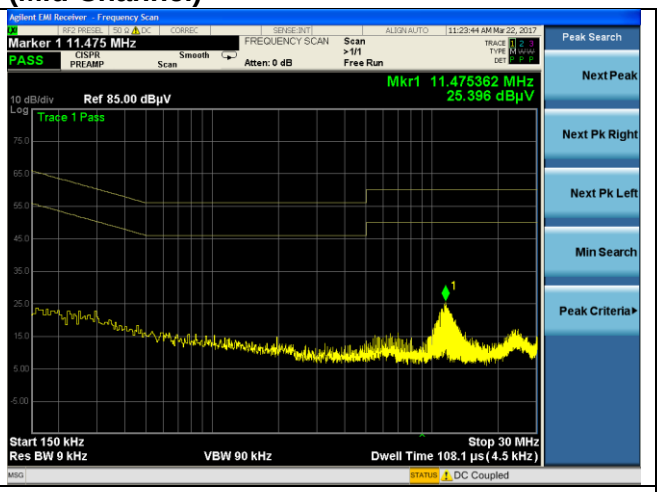
6.8 Screen Captures – Conducted Emissions Test

These screen captures represent the worst-case Peak Emissions. For conducted emission measurements, both a Quasi-Peak detector function and an Average detector function are utilized.

Transmit Mode, (Mid Channel)



Line 1



Line 2

EXHIBIT 7. OCCUPIED BANDWIDTH

Test Engineer(s): Coty Hammerer

7.1 - Limits

For a DTS system operating in the 2400 to 2483.5 MHz band, the minimum 6dB emission bandwidth limit is 500 kHz.

7.2 - Method of Measurements

For this portion of the tests, a direct measurement of the transmitted signal was performed at the antenna port of the EUT, via a cable connection to a spectrum analyzer. An attenuator was placed in series with the cable to protect the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings thereby allowing direct measurements, without the need for any further corrections. The EUT was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. A bandwidth measurement function that is built into the spectrum analyzer was used to measure the 20dB/emission bandwidth while the 6dB bandwidth was measured in accordance **FCC OET KDB 558074 section 8.**

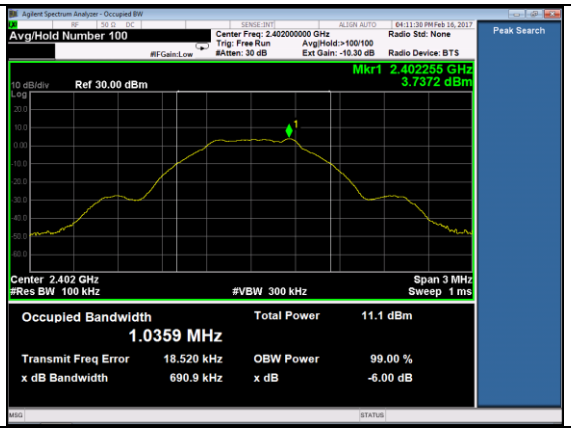
7.3 - Test Data

Data Rate (Mbps)	Channel (MHz)	6 dB BW (kHz)	99% BW (MHz)	6 dB BW Minimum Limit(kHz)	6 dB BW Margin (kHz)
1	2402	690.90	1.03	500.00	190.90
	2440	682.30	1.03	500.00	182.30
	2480	705.80	1.04	500.00	205.80

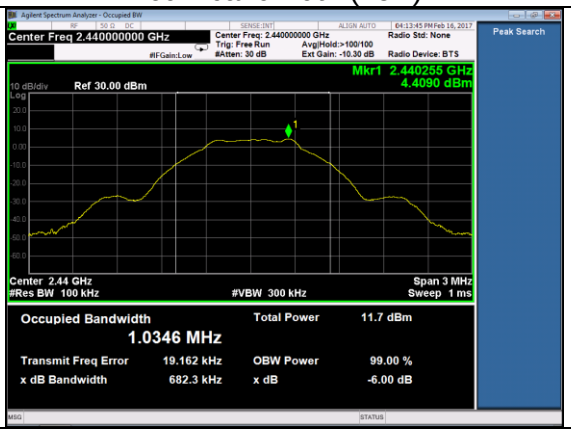
7.4 – Screen Captures

Examples of bandwidth measurements:

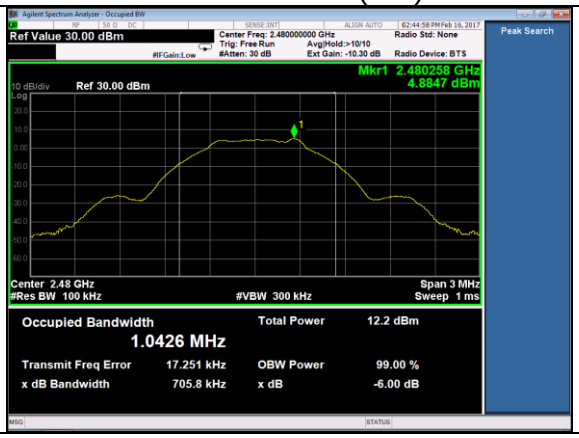
6 dB Bandwidth



6dB bandwidth (Low)

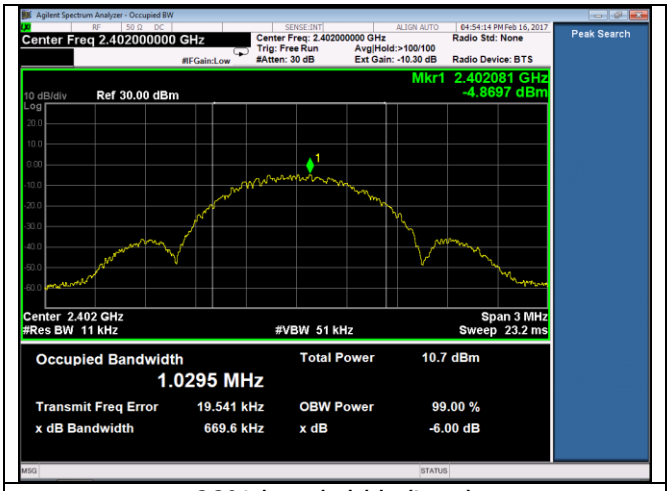


6dB bandwidth (Mid)

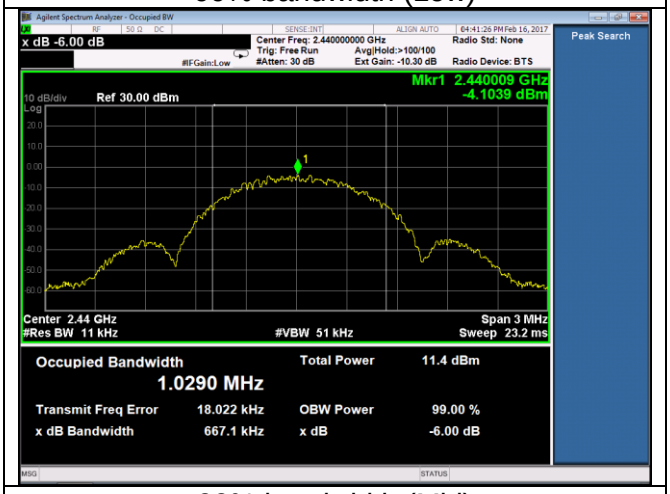


6dB bandwidth (High)

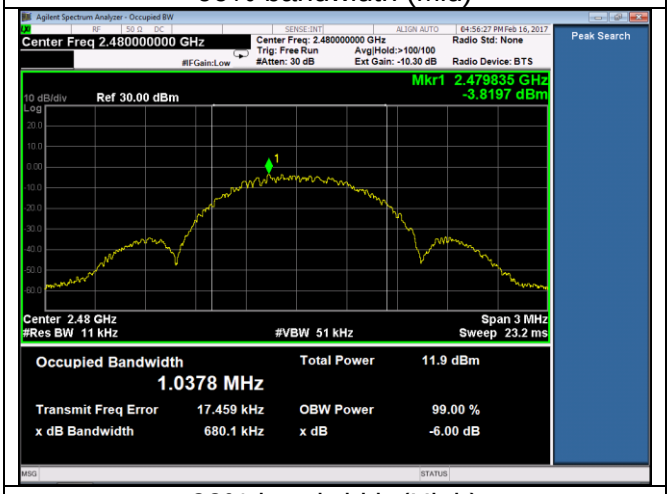
99% Bandwidth



99% bandwidth (Low)



99% bandwidth (Mid)



99% bandwidth (High)

EXHIBIT 8. BAND EDGE MEASUREMENTS

Test Engineer(s): Coty Hammerer

8.1 - Method of Measurements

FCC 15.247 requires a measurement of spurious emission levels at the restricted band to be compliant to the general emissions limit, in particular at the Band-Edges where the intentional radiator operates. The EUT was operated in continuous transmit mode (100% Duty Cycle) with continuous modulation.

The Band-edge measurements were performed conducted (100 kHz bandwidth) and radiated. The measurement of band-edge was performed to satisfy FCC 15.247(d).

Per FCC KDB 558074 D01 Measurement Guidance v04 (section 11), conducted measurements were performed with 100 kHz bandwidth for all emissions outside of the band of operation. For measuring radiated emissions in the restricted band, a bandwidth of 120 kHz (below 1000MHz) or 1MHz (above 1000MHz) was used in accordance with C63.4.

For both conducted and radiated measurements, correction factors and the cable loss factors were entered into the EMI Receiver database. **As a result, the plots taken from the EMI Receiver accounts for all applicable correction factor as well as cable loss, and can therefore be entered into the database as a corrected meter reading.**

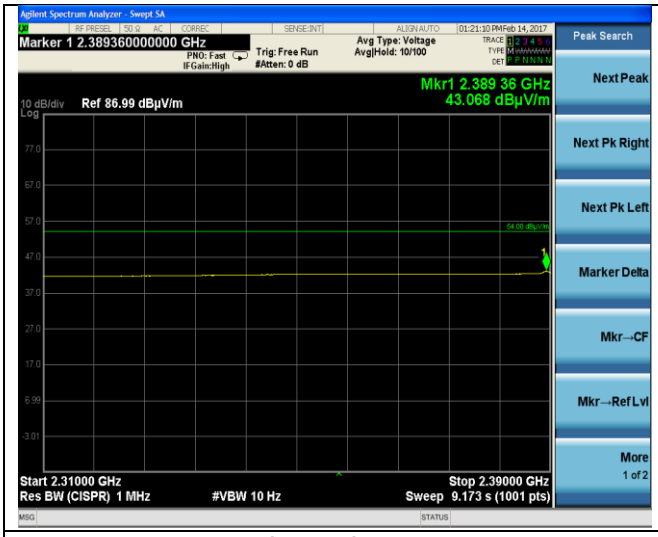
8.2. Band Edge Screen Captures

The data presented below are samples selected from the various data rates and channels tested.

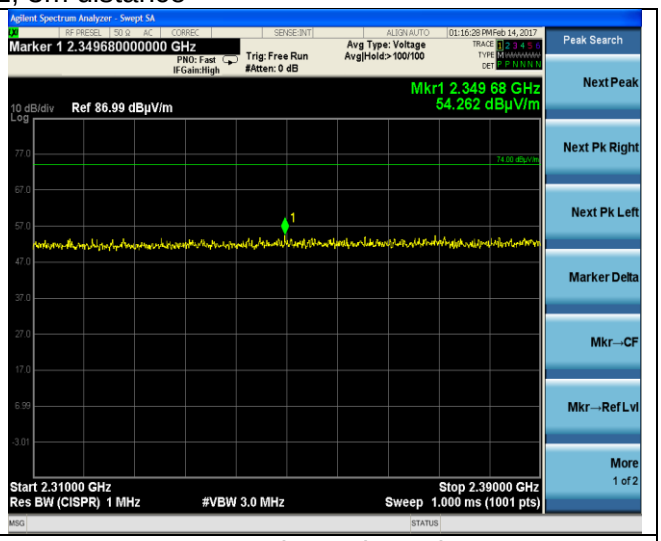
Band-edge in Restricted Band

Radiated Band-edge in Restricted Band:

2310 to 2390 MHz, 3m distance



Low Channel, Average

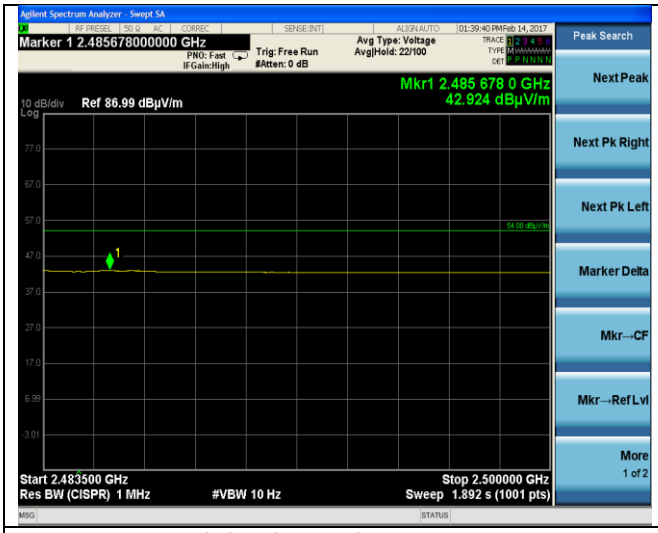


Low Channel, Peak

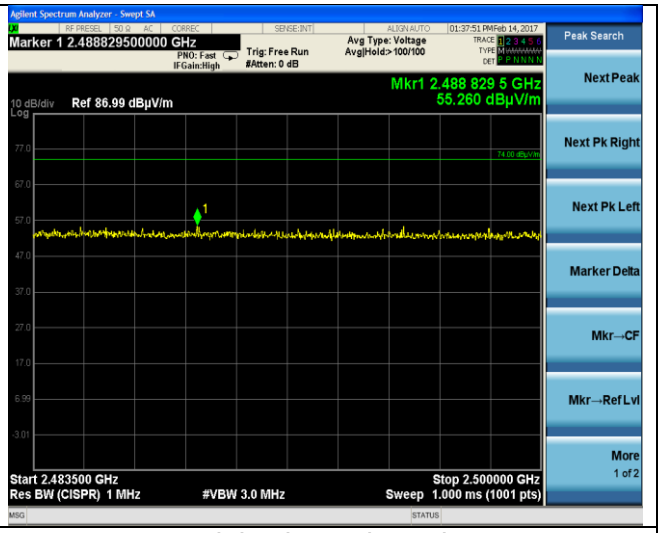
Data: Lower Band-Edge

Peak Frequency (MHz)	Peak Measurement (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Frequency (MHz)	Average Measurement (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
2349.68	54.26	74.00	19.74	2389.36	43.07	54.00	10.93

2483.5 to 2500 MHz Restricted band



High Channel, Average



High Channel, Peak

Data: Upper Band-Edge

Peak Frequency (MHz)	Peak Measurement (dBµV/m)	Peak Limit (dBµV/m)	Peak Margin (dB)	Average Frequency (MHz)	Average Measurement (dBµV/m)	Average Limit (dBµV/m)	Average Margin (dB)
2488.83	55.26	74.00	18.74	2485.68	42.92	54.00	11.08

Conducted Band Edge Reference Pictures

Refer to Section 10 for reference levels.

Band-edge in 100 kHz bandwidth (Conducted Band Edge)

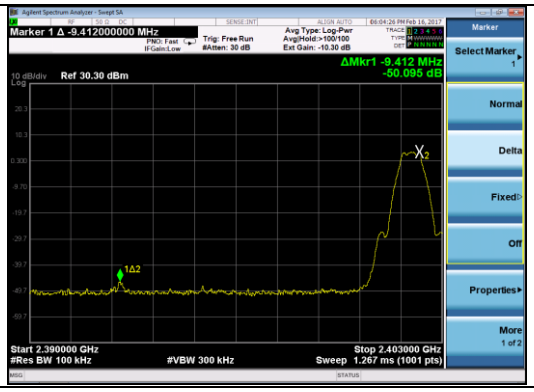
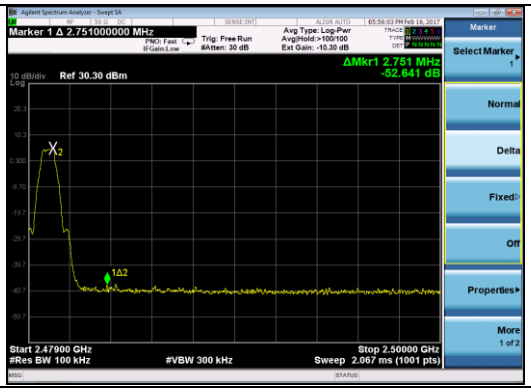
	
Lower Band-Edge	Upper Band-Edge

EXHIBIT 9. POWER OUTPUT (CONDUCTED): 15.247(b)

Test Engineer(s): Coty Hammerer

9.1 - Method of Measurements

The conducted RF output power of the EUT was measured at the antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings thereby allowing direct measurements without the need for any further corrections. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v04section 9.1.1.

Peak Conducted Output Power Limit = 1 Watt (30 dBm).

9.2 - Test Data

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

Generic example of reported data at 2440 MHz:

Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

9.2.1. Maximum conducted peak power:

Data

Frequency (MHz)	Peak Cond. Power (dBm)	Antenna Gain (dBi)	Peak. Cond. Power E.I.R.P (dBm)
2402	4.58	2.10	6.68
2440	5.20	2.10	7.30
2480	5.70	2.10	7.80

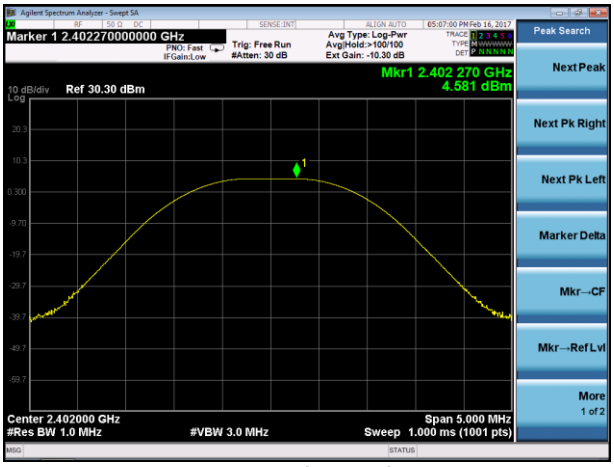
9.2.1.1 Duty cycle:

Measurement procedure: **FCC OET KDB 558074 D01 Measurement Guidance v04.**

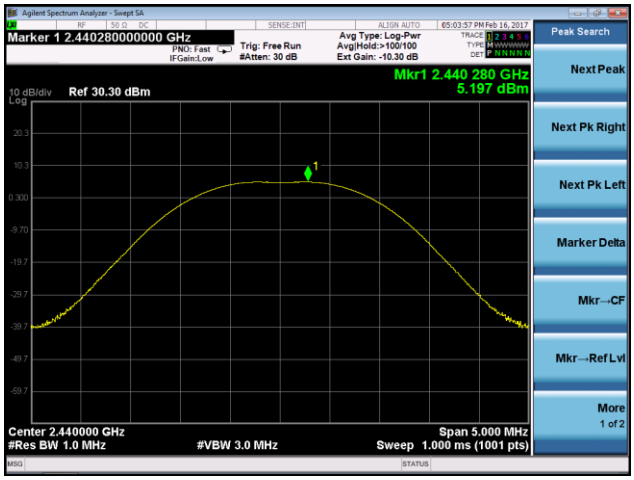
Screen captures:

Duty Cycle is 100%, for all 3 channels.

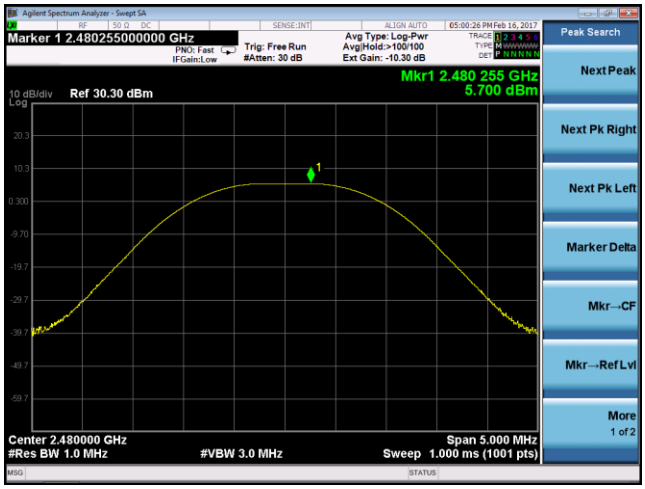
9.2.1.2 Maximum conducted (peak) output power:



Low Channel



Mid Channel



High Channel

EXHIBIT 10. CONDUCTED SPURIOUS EMISSIONS: 15.247(d)

Test Engineer(s): Coty Hammerer

10.1 - Limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

10.2 – Conducted Harmonic and Spurious RF Measurements

FCC Part 15.247(d) and IC RSS 247 both require a measurement of conducted harmonic and spurious RF emission levels, as reference to the carrier level when measured in a 100 kHz bandwidth. For this test, the spurious and harmonic RF emissions from the EUT were measured at the EUT antenna port using a short RF cable along with an attenuator as protection for the spectrum analyzer. The loss from the cable and the attenuator were added on the analyzer as gain offset settings, thereby allowing direct readings of the measurements made without the need for any further corrections. A spectrum analyzer was used with the resolution bandwidth set to 100 kHz for this portion of the tests. The unit was configured to run in a continuous transmit mode, while being supplied with typical data as a modulation source. The spectrum analyzer was used with measurements from a peak detector presented in the chart below. Screen captures were acquired and any noticeable spurious and harmonic signals were identified and measured.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v04 section 11.

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

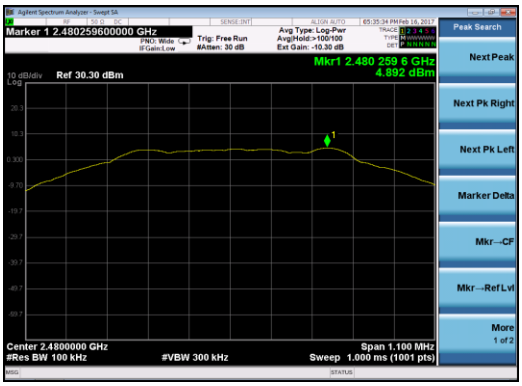
Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

Generic example of reported data at 2440 MHz:

Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

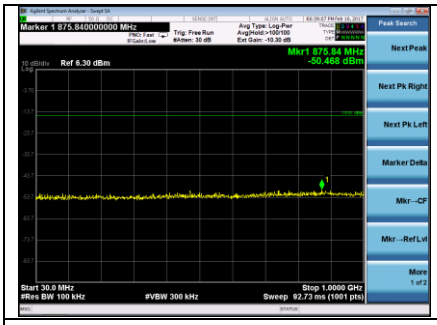
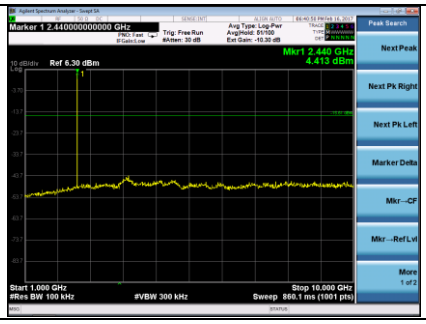
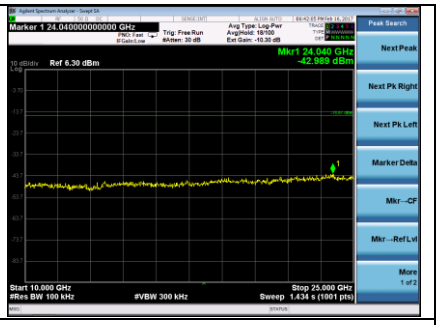
10.3 - Test Data

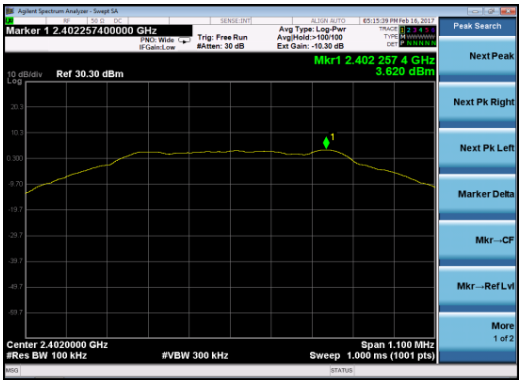
The data presented below are samples selected from the various data rates and channels tested. Display lines on captures do not represent limit lines, so refer to the fundamental picture for limits. Pictures below are samples. All emissions are more than 20 dB below the limit.



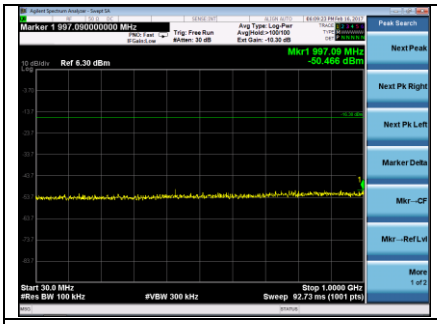
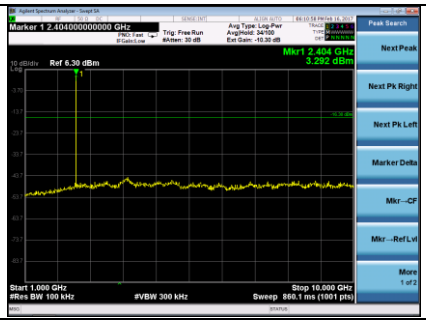
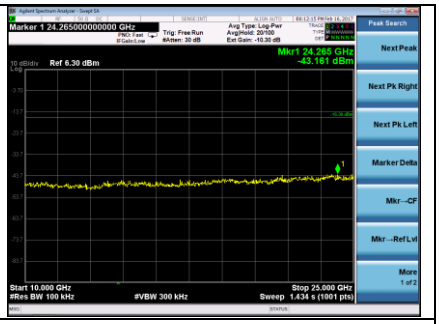
Note: Refer to PSD screenshots in Section 11.3 for limits

Example: Mid Channel. Reference Level = 4.39 dBm – 20 dB = -15.61dB

		
30 to 1000 MHz	1000 to 10000 MHz	10000 to 25000 MHz



Low Channel. Reference Level = 3.62 dBm – 20 dB = -16.38dB

		
30 to 1000 MHz	1000 to 10000 MHz	10000 to 25000 MHz

High Channel. Reference Level = 4.89 – 20 dB = -15.11

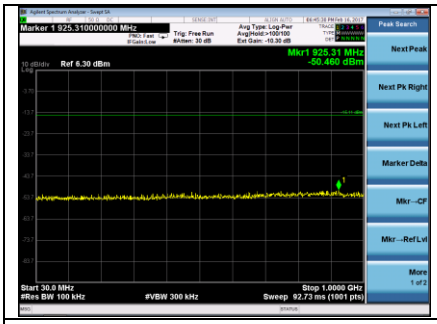
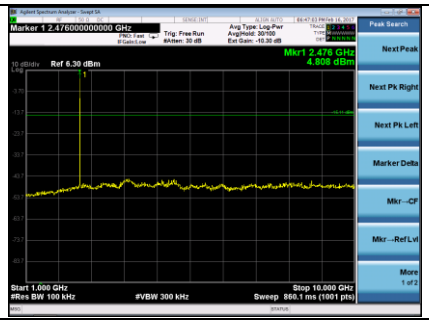
		
30 to 1000 MHz	1000 to 10000 MHz	10000 to 25000 MHz

EXHIBIT 11. POWER SPECTRAL DENSITIES: 15.247(e)

11.1 Limits

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

In accordance with FCC Part 15.247(e) and RSS 247, the peak power spectral density should not exceed +8 dBm in any 3 kHz band. This measurement was performed along with the conducted power output readings as described in previous sections. The peak output frequency for each representative frequency was scanned, with a narrow bandwidth, and reduced sweep, and a power density measurement was performed.

Measurement procedure used was FCC OET KDB 558074 D01 Measurement Guidance v04 section 10.2.

The data reported includes all necessary correction factors. These correction factors are loaded onto the EMI receiver when measurements are performed.

Reported Measurement data = Raw receiver measurement (dBm) + Cable factor (dB) + Miscellaneous factors when applicable (dB).

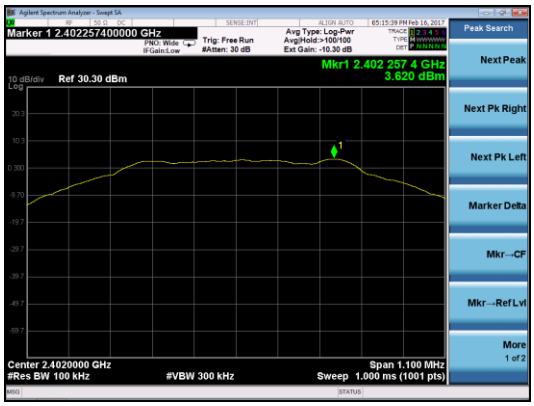
Generic example of reported data at 2440 MHz:

Reported Measurement data = 8.55 (raw receiver measurement in dBm) + 0.85 (cable factor in dB) = 9.4 (dBm).

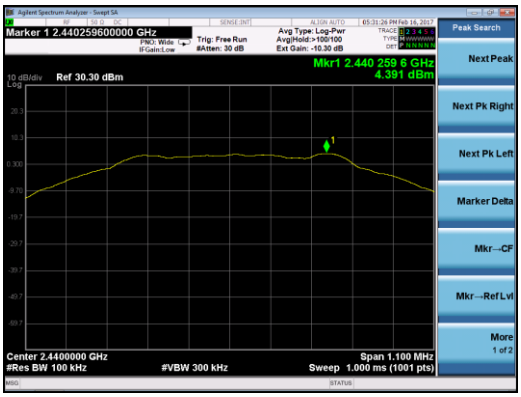
11.2 Test Data

Channel (MHz)	PSD Measurement in 100kHz Bw (dBm)	PSD Limit (dBm)	PSD Margin (dB)
2402	3.62	8	4.38
2440	4.39	8	3.61
2480	4.89	8	3.11

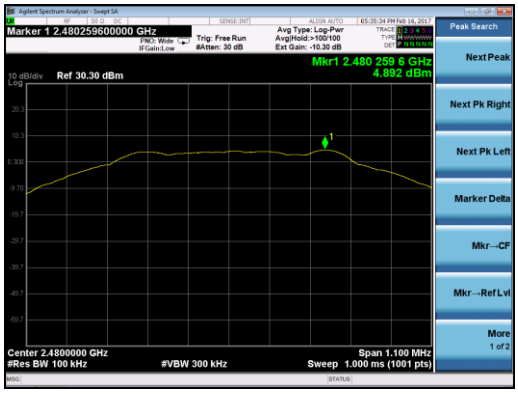
11.3 Screen Captures – Power Spectral Density



Low Channel



Mid Channel



High Channel

EXHIBIT 12. FREQUENCY STABILITY OVER VOLTAGE VARIATIONS

Test Engineer(s): Coty Hammerer

The frequency stability of the device was examined as a function of the input voltage available to the EUT. A Spectrum Analyzer was used to measure the RF output power and frequency at the appropriate frequency markers. Power was supplied by a variable voltage supply. The nominal test voltage was varied ±15% from the nominal value. If the unit could not be changed by ±15% it was instead changed to its minimum or maximum value.

The power was then cycled On/Off to observe system response. No unusual response was observed, the emission characteristics were well behaved, and the system returned to the same state of operation as before the power cycle. The EUT was found to be better than 100 ppm.

Data

	21.4VAC	24VAC	27.6VAC	
Channel	Frequency (Hz)	Frequency (Hz)	Frequency (Hz)	Frequency Drift (Hz)
2402	2402016767	2402016446	2402017973	1526.737
2440	2440017613	2440016555	2440017541	1057.213
2480	2480017990	2480016868	2480017095	1121.983

APPENDIX A – Test Equipment List

Laird
Smart Technology. Delivered.

Date: 8-Feb-2017 Test: Radiated Measurements Job #: C-2664

PE: Coty Hammerer Customer: United Technology Electronic Controls Quote #: 316398

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	AA 960171	Cable - low loss 6m	A.H. Systems, Inc.	SAC-26G-6	386	3/31/2016	9/13/2017	Active Verification
2	EE 960085	EMI Receiver	Agilent	N9038A	MY51210148	5/12/2017	5/12/2018	Active Calibration
3	AA 960007	Double Ridge Horn Antenna	EMCO	3115	9311-4138	7/22/2016	7/22/2017	Active Calibration
4	AA 960154	High Pass Filter 2.4 GHz	KWM	HPF-L-14186	7272-02	7/25/2016	7/25/2017	Active Calibration
5	AA 960158	Double Ridge Horn Antenna	ETS Lindgren	3117	109300	10/13/2016	10/13/2017	Active Calibration
6	EE 960159	Low Noise Amplifier	Mini-Circuits	ZVA-213X-S+	462101702	4/12/2017	4/12/2018	Active Calibration
7	AA 960174	Small Horn Antenna	ETS Lindgren	3116C-PA	00206880	5/1/2017	5/1/2018	Active Calibration
8	AA 960176	Cable - low loss 6m	A.H. Systems, Inc.	SAC-26G-6	395	5/15/2017	5/15/2018	Active Verification
9	AA 960128	Biconical Antenna	ETS Lindgren	3110B	00062899	4/13/2017	4/13/2018	Active Calibration
10	AA 960078	Log Periodic Antenna	EMCO	93146	9701-4855	4/17/2017	4/17/2018	Active Calibration
11	AA 960153	High Pass Filter 2.4 GHz	KWM	HPF-L-14186	7272-04	5/2/2017	5/2/2018	Active Calibration
12	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration
13	EE 960088	EMI Receiver	Agilent	N9038A	MY51210138	3/2/2017	3/2/2018	Active Calibration

Tested By: Coty Hammerer Quality Assurance: Khairul Aidi Zainal

Laird
Smart Technology. Delivered.

Date: 16-Feb-2017 Test: Conducted Measurements Job #: C-2664

PE: Coty Hammerer Customer: United Technology Electronic Controls Quote #: 316398

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960001	Multimeter	HP	971A	JP36004055	5/2/2017	5/2/2018	Active Calibration
2	EE 960088	EMI Receiver	Agilent	N9038A	MY51210138	3/2/2017	3/2/2018	Active Calibration
3	EE 960087	Spectrum Analyzer	Agilent	N9010A	MY53400296	12/22/2016	12/22/2017	Active Calibration

Tested By: Shane Dock Quality Assurance: Coty Hammerer

Laird
Smart Technology. Delivered.

Date: 22-Mar-2017 Test: AC mains Emissions Job #: C-2664

PE: Coty Hammerer Customer: United Technology Electronic Controls Quote #: 316398

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960088	EMI Receiver	Agilent	N9038A	MY51210138	3/2/2017	3/2/2018	Active Calibration
2	EE 960089	LISN	COM-POWER	LI-215A	191943	3/13/2017	3/13/2018	Active Calibration

Tested By: Khairul Aidi Zainal Quality Assurance: Adam Alger

APPENDIX B – Test Standards: CURRENT PUBLICATION DATES RADIO

STANDARD #	DATE	Am. 1	Am. 2
ANSI C63.4	2014		
ANSI C63.10	2013		
FCC 47 CFR, Parts 0-15, 18, 90, 95	2017		
RSS GEN	2014		
RSS 247	2017		

APPENDIX C - Uncertainty Summary

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %