Engineering Test Report No. 2001156-01	
Report Date	April 28, 2020
Manufacturer Name	Johnson Controls Inc
Manufacturer Address	507 E Michigan Street Milwaukee, WI 53202
Product Name Brand/Model No.	ZFR Pro 2.0
Date Received	February 24, 2020
Test Dates	February 24, 2020 to April 24, 2020
Specifications	FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 Innovation, Science, and Economic Development Canada, RSS-247 and RSS-GEN
Test Facility	Elite Electronic Engineering, Inc. 1516 Centre Circle, Downers Grove, IL 60515
Signature	Javier Cardenas
Tested by	Javier Cardenas
Signature	Raymond J Klouda
Approved by	Raymond J. Klouda, Registered Professional Engineer of Illinois – 44894

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1. Report Revision History

Revision	Date	Description
–	28 APR 2020	Initial Release of Engineering Test Report No. 2001156-01

2. Introduction

This document presents the results of a series of electromagnetic compatibility (EMC) tests that were performed on one (1) ZFR Pro 2.0 (hereinafter referred to as the Equipment Under Test (EUT)). The EUT was identified as follows:

EUT Identification	
Description	ZFR Pro 2.0
Model/Part No.	ZFR-1831
S/N	Antenna Unit or Conducted Unit
Size of EUT	13.5cm (Length) x 8.5cm (Width) x 2.6cm (Depth)
Number of Interconnection Wires	N/A
Type of Interconnection Wires	N/A
Highest Internal Frequency of the EUT:	2.4GHz ZigBee and Bluetooth

The EUT listed above was used throughout the test series.

The EUT was submitted for testing along with the following support equipment:

Description	Model #	S/N
Transformer	024-1000	A24-1A
FEC	-	MS-FEC2610-0

3. Test Specification(s)

The tests were performed to selected portions of, and in accordance with the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 test specification(s).

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subparts B and C

- 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"

- ANSI C63.10-2013, "American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices"

- Federal Communications Commission Office of Engineering and Technology Laboratory Division, Guidance For Performing Compliance Measurements On Digital Transmissions Systems (DTS) Operating Under §15.247
  April 2, 2019

- Industry Canada RSS-247, Issue 2, February 2017, "Spectrum Management and Telecommunications Radio Standards Specification, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs), and License-Exempt Local Area Network (LE-LAN) Devices"

- Industry Canada RSS-GEN, Issue 5, March 2019, "Spectrum Management and Telecommunications Radio Standards Specification, General Requirements for Compliance of Radio Apparatus"

4. Laboratory Conditions

The temperature at the time of the test was 21°C and the relative humidity was 18%.

5. Summary

The following EMC tests were performed and the results are shown below:

Test Description	Test Methods	Equipment Class	S/N	Results
RF Conducted Emissions Test (AC Mains)	FCC 15.207(a)	B	Antenna Unit	Conforms
Duty Cycle	FCC 15.247 ISED RSS-247	---	Conducted Unit	N/A
6dB Bandwidth	FCC 15.247 ISED RSS-247	---	Conducted Unit	Conforms
99% Bandwidth	FCC 15.247 ISED RSS-247	---	Conducted Unit	Conforms
Output Power	FCC 15.247 ISED RSS-247	---	Antenna Unit	Conforms
Radiated Spurious Emissions	FCC 15.247 ISED RSS-247	---	Antenna Unit	Conforms
Band Edge Compliance	FCC 15.247 ISED RSS-247	---	Antenna Unit	Conforms
Power Spectral Density	FCC 15.247 ISED RSS-247	---	Conducted Unit	Conforms

6. Test Plan

No test plan was provided. Instructions were provided by personnel from Johnson Controls Inc and used in conjunction with the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 and RSS-GEN specifications.

7. Grounding

The EUT was not grounded.

8. Modifications Made to EUT

No modifications were made to the EUT during the testing.

9. Deviations from Specification(s)

No deviations from the specification(s) were made during the testing.

10. Modes of Operation

The EMC tests were performed with the EUT operating in one or more of the test modes described below. See the specific test section for the applicable test modes.

10.1. Transmitting

This mode was achieved by applying power to the device. The EUT was configured to transmit in the following modes:

- ZigBee - 2405, 2440, and 2480MHz
- Bluetooth – 2402, 2440, and 2480MHz

11. Test Method

The tests were performed using the referenced methods described in the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 and RSS-GEN test specifications. The specific test sections and

specification references are called out in the individual test sections.

12. Sample Calculations

For Powerline Conducted Emissions:

The resultant voltage level (VL) is a summation in decibels (dB) of the receiver meter reading (MTR) and the cable loss factor (CF).

Formula 1: VL (dBuV) = MTR (dBuV) + CF (dB).

For Radiated Emissions:

The resultant field strength (FS) is a summation in decibels (dB) of the receiver meter reading (MTR), the antenna correction factor (AF), and the cable loss factor (CF). If an external preamplifier is used, the total is reduced by its gain (-PA). If a distance correction (DC) is required, it is added to the total.

Formula 1: FS (dBuV/m) = MTR (dBuV) + AF (dB/m) + CF (dB) + (- PA (dB)) + DC (dB)

To convert the Field Strength dBuV/m term to uV/m, the dBuV/m is first divided by 20. The Base 10 AntiLog is taken of this quotient. The result is the Field Strength value in uV/m terms.

Formula 2: FS (uV/m) = AntiLog [(FS (dBuV/m))/20]

13. Statement of Conformity

The Johnson Controls Inc ZFR Pro 2.0, Model No. ZFR-1831 did fully conform to the selected requirements of FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 and RSS-GEN.

14. Certification

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections 15.207 and 15.247 and Innovation, Science, and Economic Development Canada, RSS-247 and RSS-GEN test specifications. The data presented in this test report pertains to the EUT on the test date specified. Any electrical or mechanical modifications made to the EUT subsequent to the specified test date will serve to invalidate the data and void this certification.

15. Photographs of EUT

16. Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW0	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-30-20G20R6G	PL2926/0646	20GHZ-26.5GHZ	10/2/2019	10/2/2020
APW11	PREAMPLIFIER	PMI	PE2-35-120-5R0-10-12-SFF	PL11685/1241	1GHZ-20GHZ	4/8/2019	4/8/2020
APW3	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10-12	PL2924	1GHZ-20GHZ	3/23/2020	3/23/2021
CDU2	LAPTOP COMPUTER	DELL	PRECISION	---	---	N/A	
CDX6	COMPUTER	ELITE	WORKSTATION			N/A	
CDX8	COMPUTER	ELITE	WORKSTATION			N/A	
GRB0	1MHZ, LISN SIGNAL CHECKER	ELITE	LISNCHKR1M	1	1MHZ	1/9/2019	1/9/2021
GRE2	SIGNAL GENERATOR	AGILENT	E4438C	MY42081749	250KHZ-6GHZ	3/20/2020	3/20/2021
MDC26	MULTIMETER (JAVIER)	FLUKE	179	34720014	I;VDC;VAC;R	8/15/2019	8/15/2020
MEA0	MICRO-OHM METER	KEITHLEY	580	674866	10UOHM-200KOHM	7/13/2019	7/13/2020
NTA4	BILOG ANTENNA	TESEQ	6112D	46660	20-2000GHZ	9/23/2019	9/23/2020
NWQ0	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS LINDGREN	3117	66657	1GHZ-18GHZ	5/31/2018	5/31/2020
NWQ1	DOUBLE RIDGED WAVEGUIDE ANTENNA	ETS-LINDGREN	3117	66655	1GHZ-18GHZ	4/10/2018	4/10/2020
PLF1	CISPR16 50UH LISN	ELITE	CISPR16/70A	001	.15-30MHz	4/24/2019	4/24/2020
PLF3	CISPR16 50UH LISN	ELITE	CISPER16/70A	003	.15-30MHz	4/24/2019	4/24/2020
RBG0	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101533	10HZ-44GHZ	2/19/2020	2/19/2021
RBG2	EMI ANALYZER	ROHDE & SCHWARZ	ESW44	101591	2HZ-44GHZ	3/23/2020	3/23/2021
SHC2	Power Supplies	HENGFU	HF60W-SL-24	A11372702	24V	NOTE 1	
VBR8	CISPR EN FCC CE VOLTAGE.exe					N/A	
WOJ0	SOFTWARE, BSI61000-4-3 RS	ELITE	BSI_610004_3_RS	1	80-2000MHZ	I/O	
XLT37	5W, 50 OHM TERMINATION	JFW INDUSTRIES	50T-199 N M	---	DC-18 GHZ	12/13/2019	12/13/2021
XPR0	HIGH PASS FILTER	K&L MICROWAVE	11SH10-4800/X20000	001	4.8-20GHZ	9/6/2019	9/6/2021

N/A: Not Applicable I/O: Initial Only CNR: Calibration Not Required

NOTE 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

17. RF Conducted Emissions Test (AC Mains)

Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Antenna Unit
Mode	Transmitting

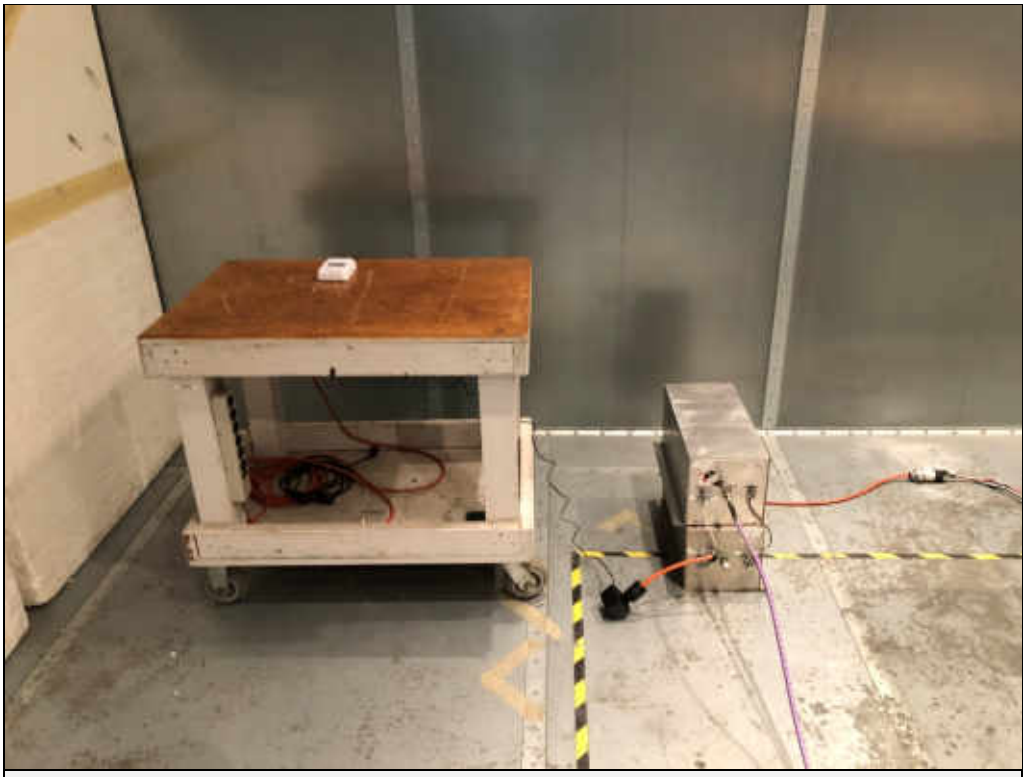
Information	
Setup Format	Tabletop
Height of Support	N/A
Type of Test Site	Reverberation Chamber
Note	

Measurement Uncertainty	
Measurement Type	Expanded Measurement Uncertainty
Conducted disturbance (mains port) (150 kHz – 30 MHz)	2.7

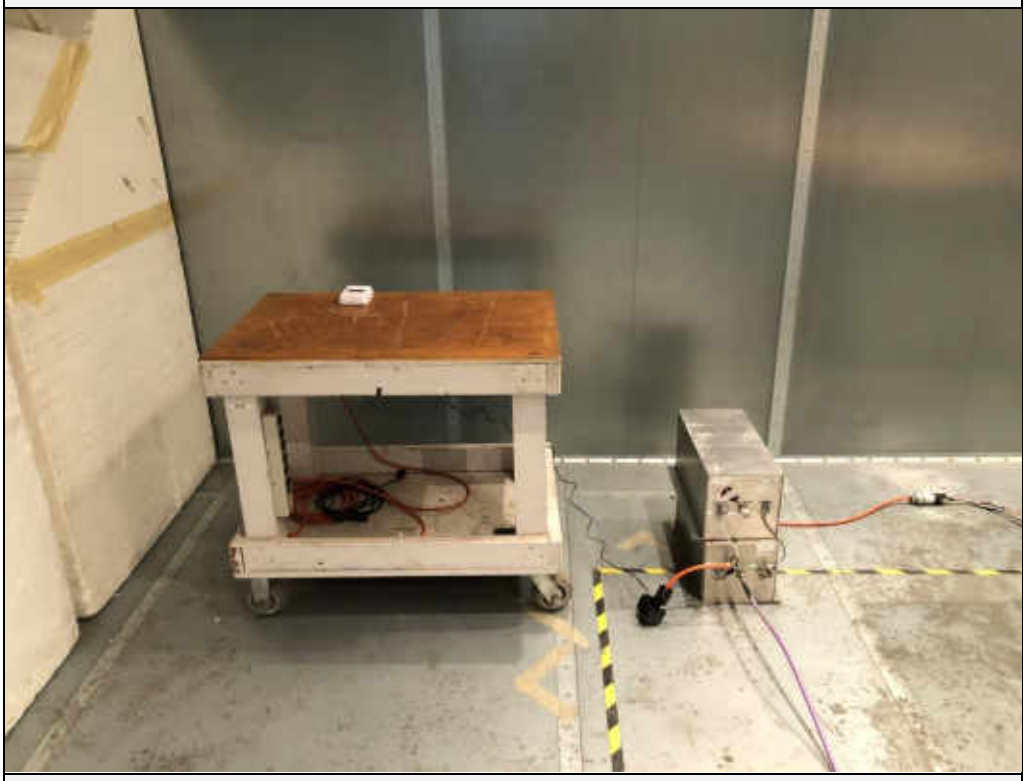
Procedures

The interference on each power lead of the EUT was measured by connecting the measuring equipment to the appropriate meter terminal of the Line Impedance Stabilization Network (LISN). The meter terminal of the LISN not under test was terminated with 50 ohms.

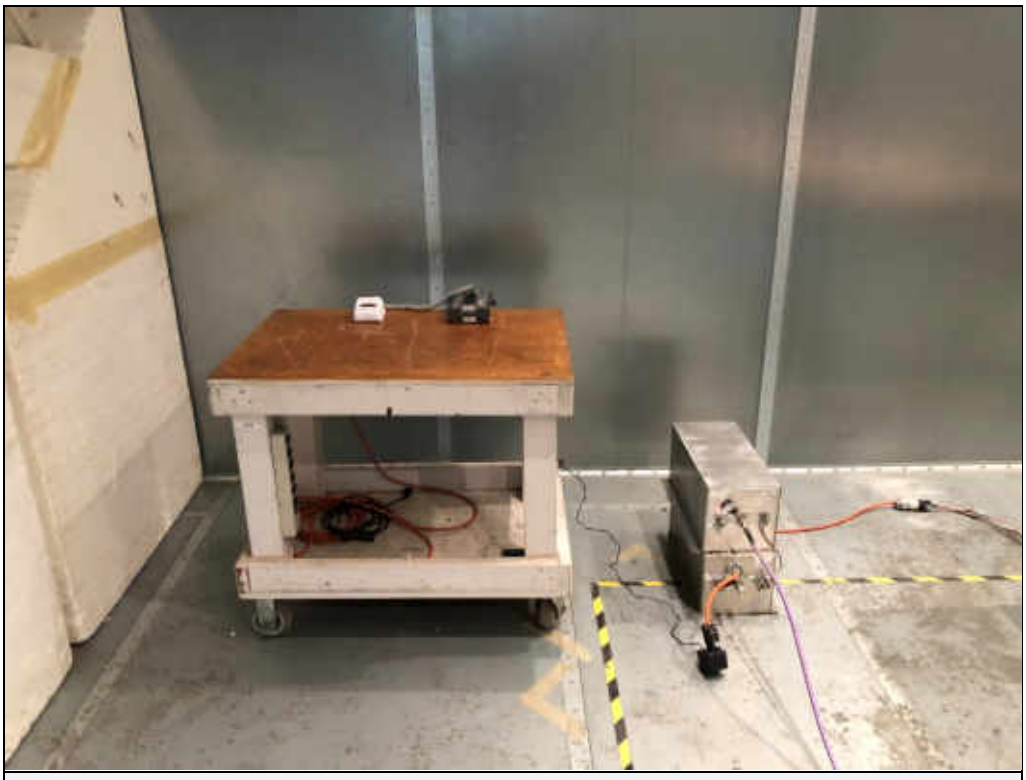
1) The EUT was operated in the Transmitting mode.
2) Measurements were first made on the Voltage high line.
3) The frequency range from 150 kHz to 30 MHz was broken up into smaller frequency sub-bands.
4) Conducted emissions measurements were taken on the first frequency sub-band using a peak detector.
5) The data thus obtained was then searched by the computer for the highest levels. Any emissions levels that were within 10dB of the average limit were then measured again using both a quasi-peak detector and an average detector. (If no peak readings were within 10dB of the average limit, quasi-peak and average readings were taken on the highest emissions levels measured during the peak detector scan.)
6) Steps (4) and (5) were repeated for the remainder of the frequency sub-bands until the entire frequency range from 150kHz to 30MHz was investigated. The peak trace was automatically plotted. The plot also shows quasi-peak and average readings that were taken on discrete frequencies. A table showing the quasi-peak and average readings was also generated. This tabular data compares the quasi-peak and average conducted emissions to the applicable conducted emissions limits.
7) Steps (3) through (6) were repeated on the Voltage return line.
8) Steps (2) through (7) were repeated with the EUT receiving power from the FEC listed in the support equipment in section 2.



Test Setup for RF Conducted Emissions (AC Mains)



Test Setup for RF Conducted Emissions (AC Mains)



Test Setup for RF Conducted Emissions (AC Mains) – Using the FEC

Test Setup for RF Conducted Emissions (AC Mains) – Using the FEC

FCC Part 15 Subpart B Conducted Emissions Test

Significant Emissions Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 09:28:49 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 10 dB margin below limit

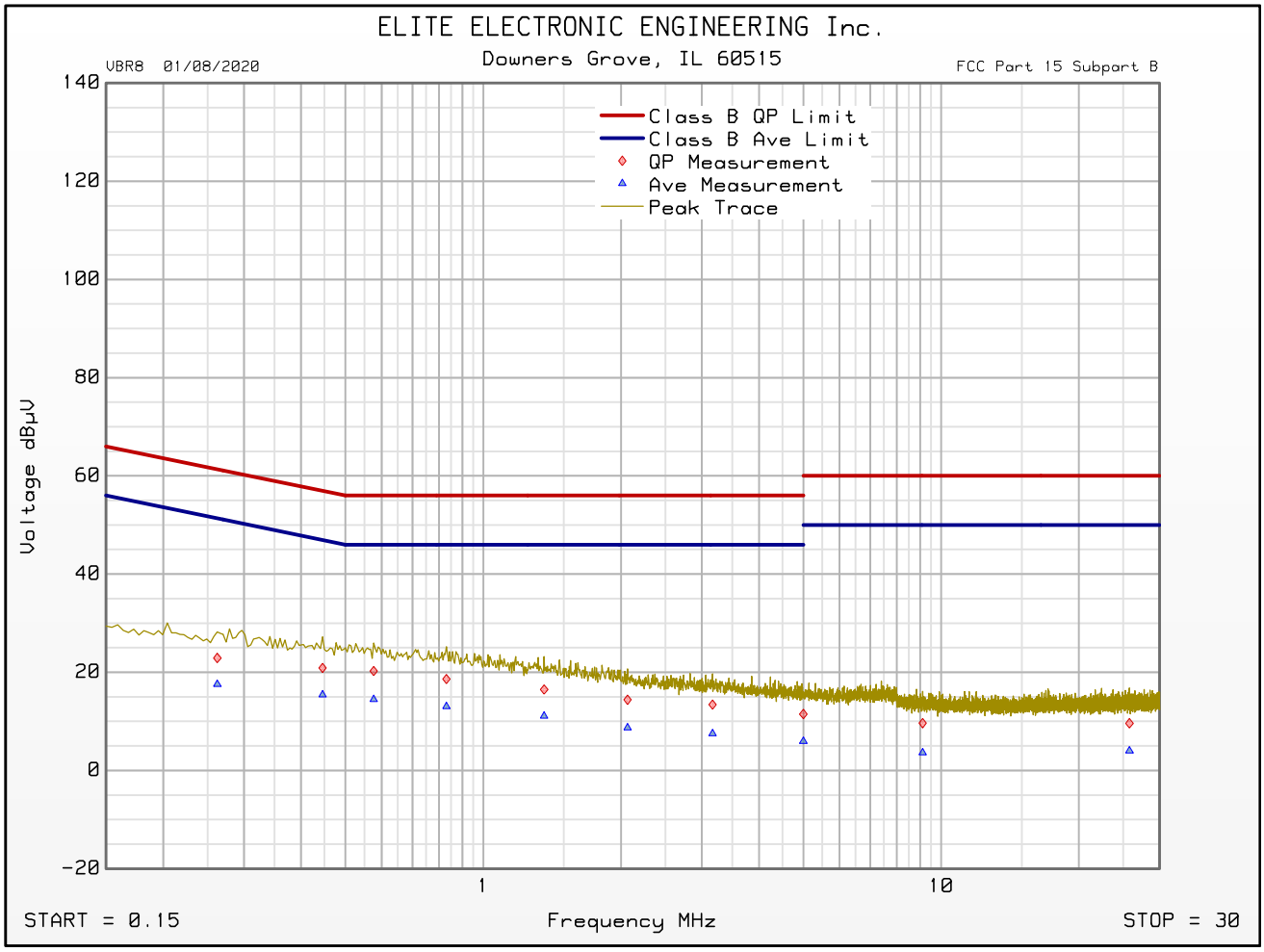
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.263	22.9	61.4		17.6	51.4	
0.446	20.9	57.0		15.4	47.0	
0.577	20.2	56.0		14.5	46.0	
0.831	18.6	56.0		13.1	46.0	
1.358	16.5	56.0		11.1	46.0	
2.066	14.4	56.0		8.7	46.0	
3.167	13.4	56.0		7.5	46.0	
5.000	11.5	56.0		6.0	46.0	
9.113	9.6	60.0		3.6	50.0	
25.790	9.6	60.0		4.0	50.0	

FCC Part 15 Subpart B Conducted Emissions Test

Cumulative Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 09:28:49 AM



Emissions Meet QP Limit
Emissions Meet Ave Limit

FCC Part 15 Subpart B Conducted Emissions Test

Significant Emissions Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 09:22:13 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 10 dB margin below limit

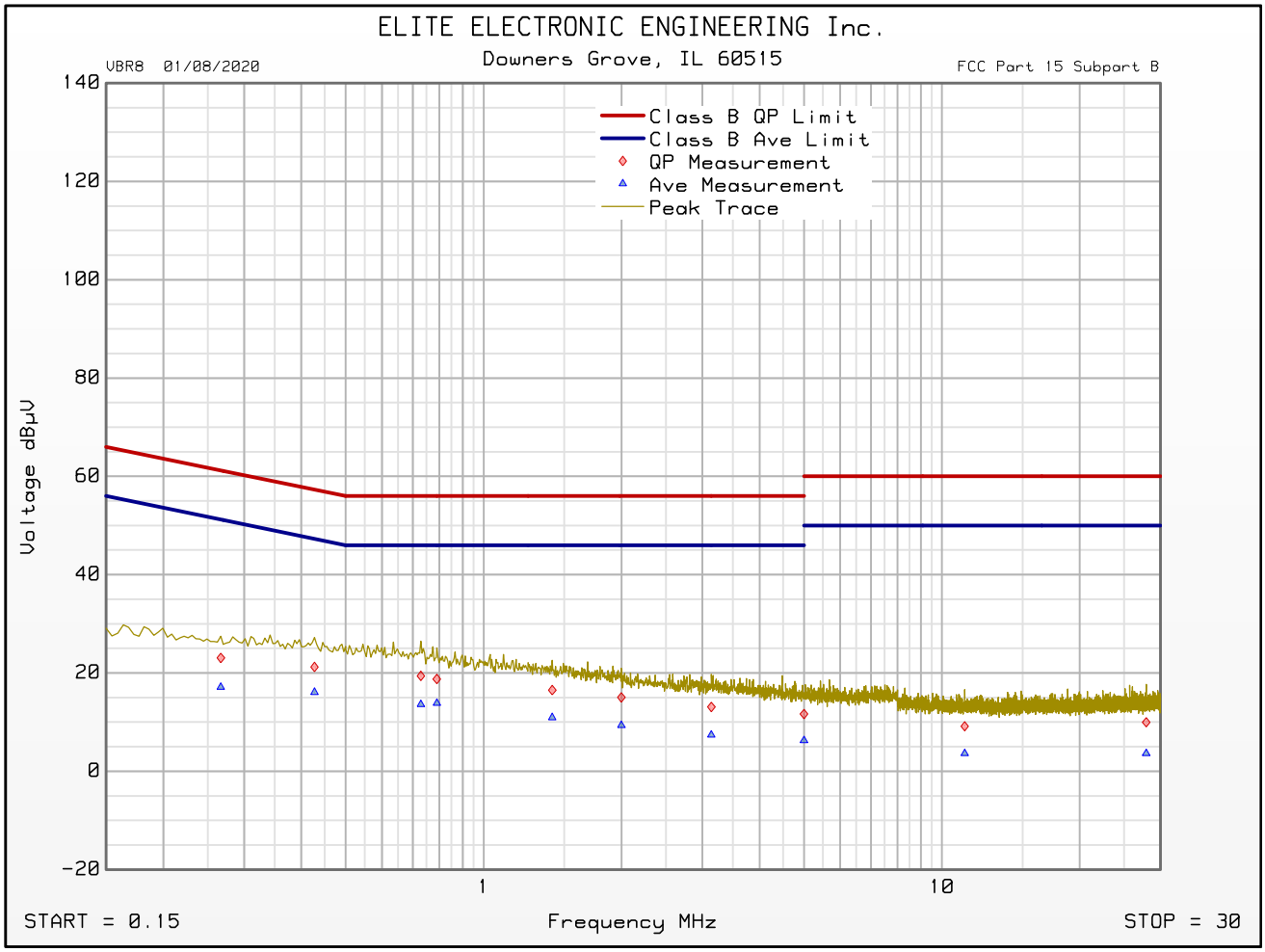
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.267	23.1	61.2		17.1	51.2	
0.428	21.2	57.3		16.1	47.3	
0.730	19.4	56.0		13.6	46.0	
0.790	18.8	56.0		13.9	46.0	
1.412	16.5	56.0		10.9	46.0	
1.998	15.0	56.0		9.3	46.0	
3.140	13.1	56.0		7.4	46.0	
5.000	11.6	56.0		6.2	46.0	
11.219	9.2	60.0		3.6	50.0	
27.914	10.0	60.0		3.6	50.0	

FCC Part 15 Subpart B Conducted Emissions Test

Cumulative Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 09:22:13 AM



Emissions Meet QP Limit
Emissions Meet Ave Limit

FCC Part 15 Subpart B Conducted Emissions Test

Significant Emissions Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	w/ FEC and 24VAC Transformer, Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 10:10:57 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 1 dB margin below limit

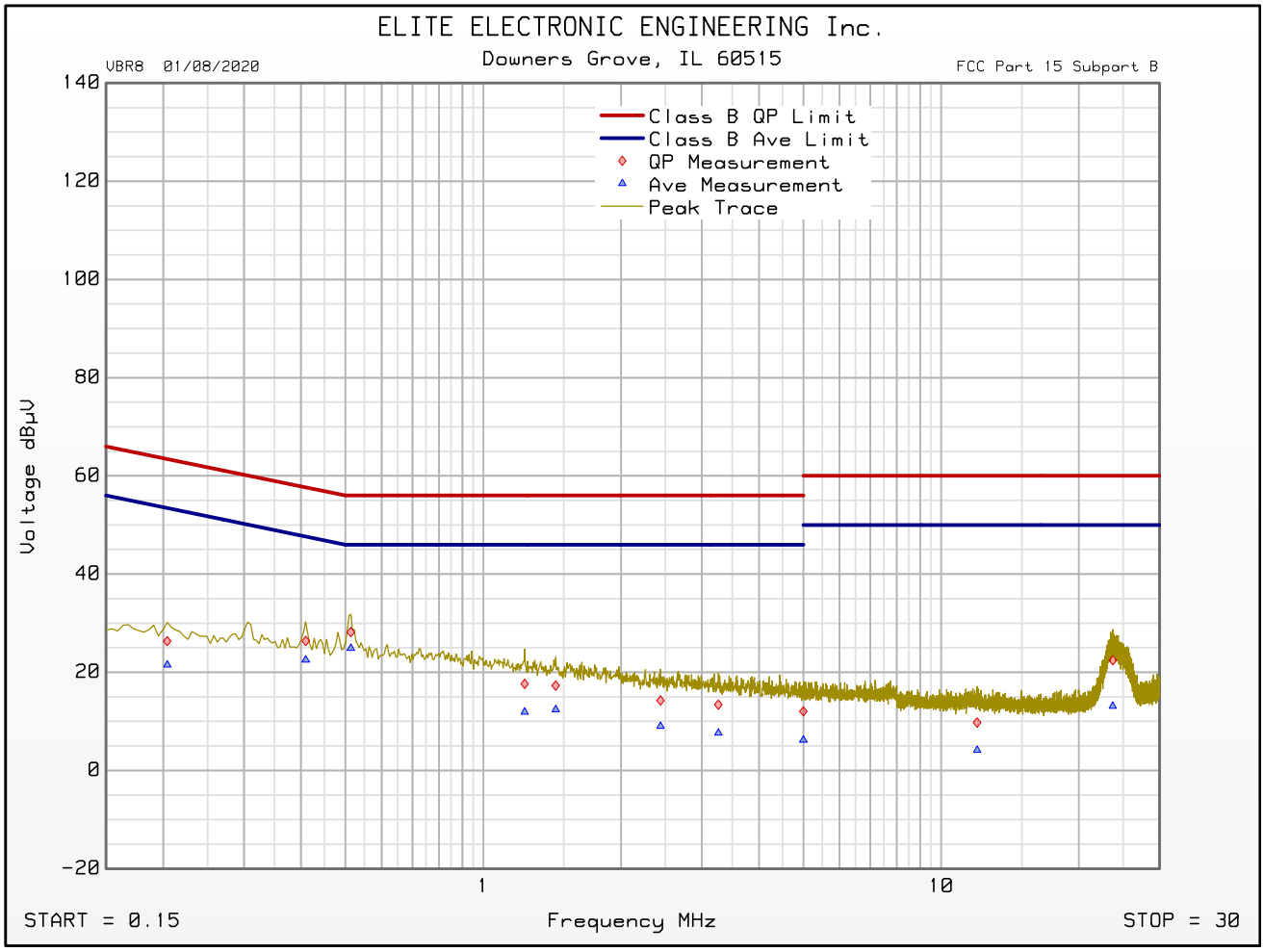
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.204	26.3	63.4		21.5	53.4	
0.410	26.4	57.7		22.5	47.7	
0.514	28.2	56.0		24.9	46.0	
1.231	17.6	56.0		11.9	46.0	
1.439	17.3	56.0		12.4	46.0	
2.439	14.2	56.0		9.0	46.0	
3.262	13.4	56.0		7.6	46.0	
5.000	12.0	56.0		6.2	46.0	
11.984	9.7	60.0		4.1	50.0	
23.720	22.4	60.0		13.1	50.0	

FCC Part 15 Subpart B Conducted Emissions Test

Cumulative Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	High
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	w/ FEC and 24VAC Transformer, Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 10:10:57 AM



Emissions Meet QP Limit
Emissions Meet Ave Limit

FCC Part 15 Subpart B Conducted Emissions Test

Significant Emissions Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	w/ FEC and 24VAC Transformer, Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 10:15:57 AM
Data Filter	:	Up to 80 maximum levels detected with 6 dB level excursion threshold over 1 dB margin below limit

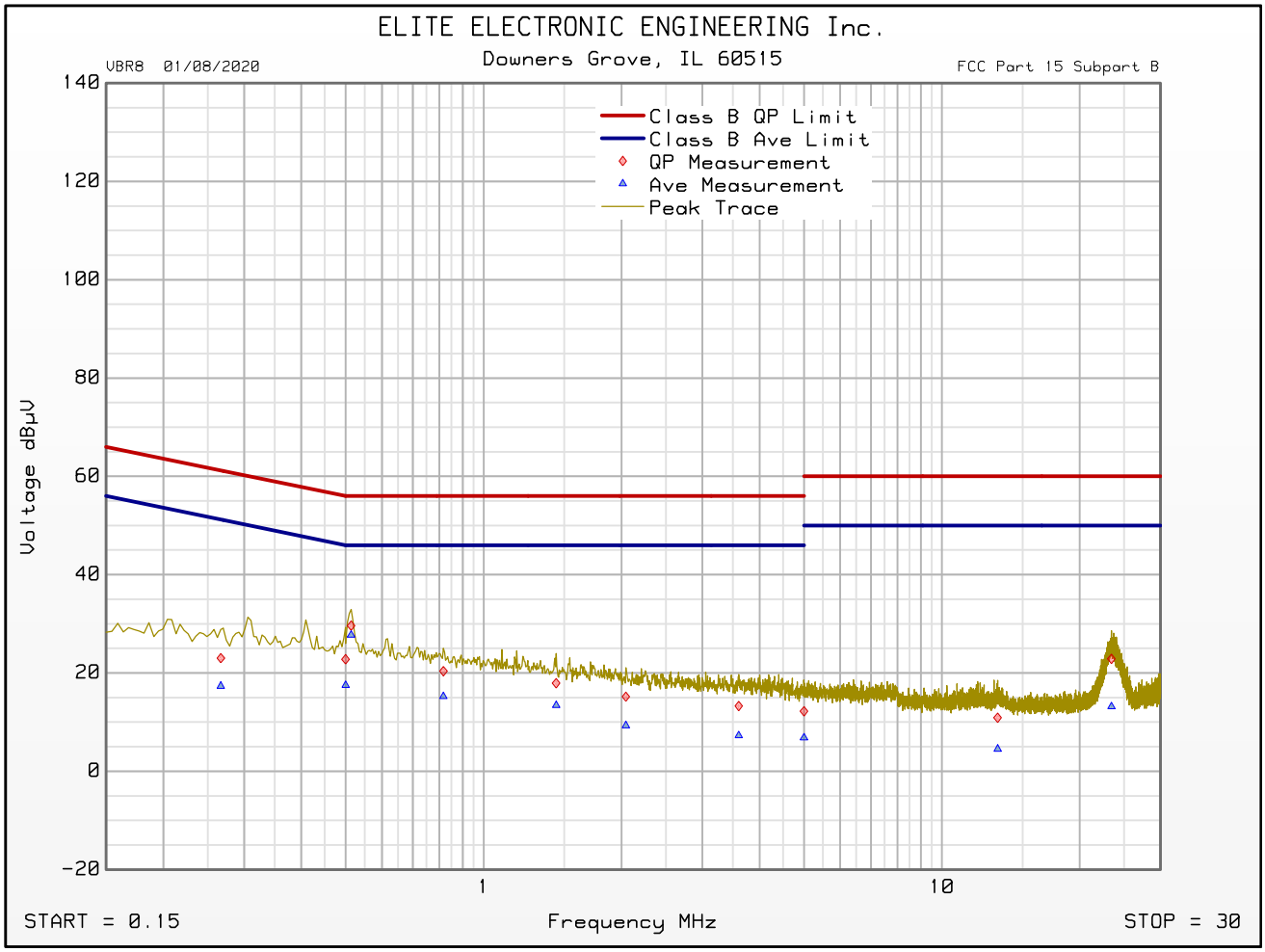
Freq MHz	Quasi-peak Level dBµV	Quasi-peak Limit dBµV	Excessive Quasi-peak Emissions	Average Level dBµV	Average Limit dBµV	Excessive Average Emissions
0.267	23.0	61.2		17.3	51.2	
0.500	22.8	56.0		17.5	46.0	
0.514	29.6	56.0		27.7	46.0	
0.817	20.4	56.0		15.2	46.0	
1.439	17.9	56.0		13.4	46.0	
2.043	15.2	56.0		9.3	46.0	
3.604	13.3	56.0		7.2	46.0	
5.000	12.2	56.0		6.8	46.0	
13.230	10.9	60.0		4.5	50.0	
23.437	22.9	60.0		13.2	50.0	

FCC Part 15 Subpart B Conducted Emissions Test

Cumulative Data

VBR8 01/08/2020

Manufacturer	:	Johnson Controls Inc
Model	:	ZFR-1831
DUT Revision	:	N/A
Serial Number	:	Antenna Unit
DUT Mode	:	Transmitting
Line Tested	:	Neutral
Scan Step Time [ms]	:	30
Meas. Threshold [dB]	:	-10
Notes	:	w/ FEC and 24VAC Transformer, Tx ZigBee
Test Engineer	:	J. Cardenas
Limit	:	Class B
Test Date	:	Feb 24, 2020 10:15:57 AM



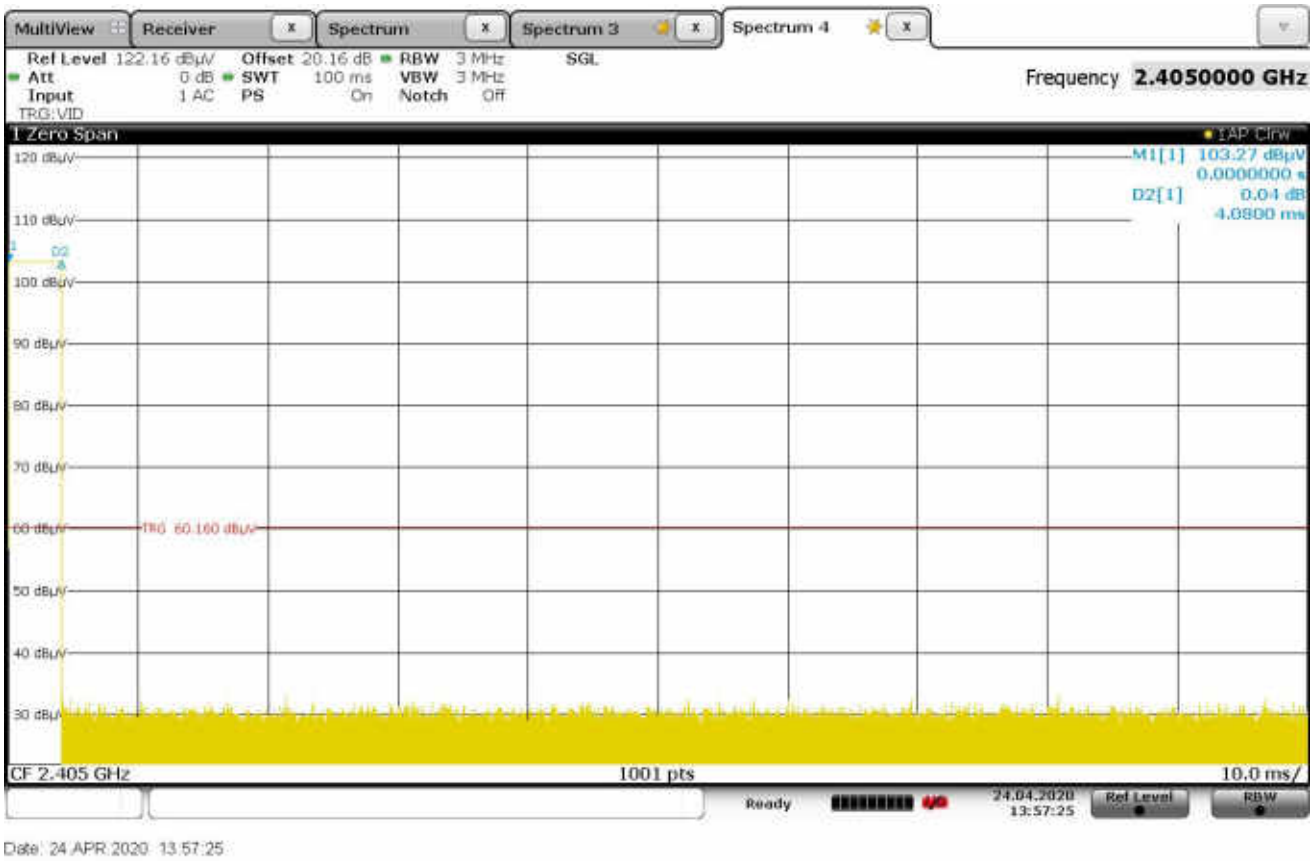
Emissions Meet QP Limit
Emissions Meet Ave Limit

18. Duty Cycle

Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
The EUT was allowed to transmit continuously. The output of the EUT was connected to the spectrum analyzer via a coaxial cable and 20dB RF attenuator. The spectrum analyzer center frequency is set to the transmitter frequency with a zero span width and 10msec/div. The analyzer's display was plotted using a 'screen dump' utility.

Mode	Transmitting – ZigBee
Parameters	Duty Cycle = 4.08%
Test Date	April 24,2020
Notes	The Duty Cycle Factor calculated below is lower than the factor used in Section 22 of this report. The recorded duty cycle below is typical of the device, as stated by Johnson Controls Inc personnel. Per Johnson Controls Inc personnel, the “worst case” duty cycle would be 15% with a factor of -16.5dB. The “worst case” factor was used for the results in Section 22.



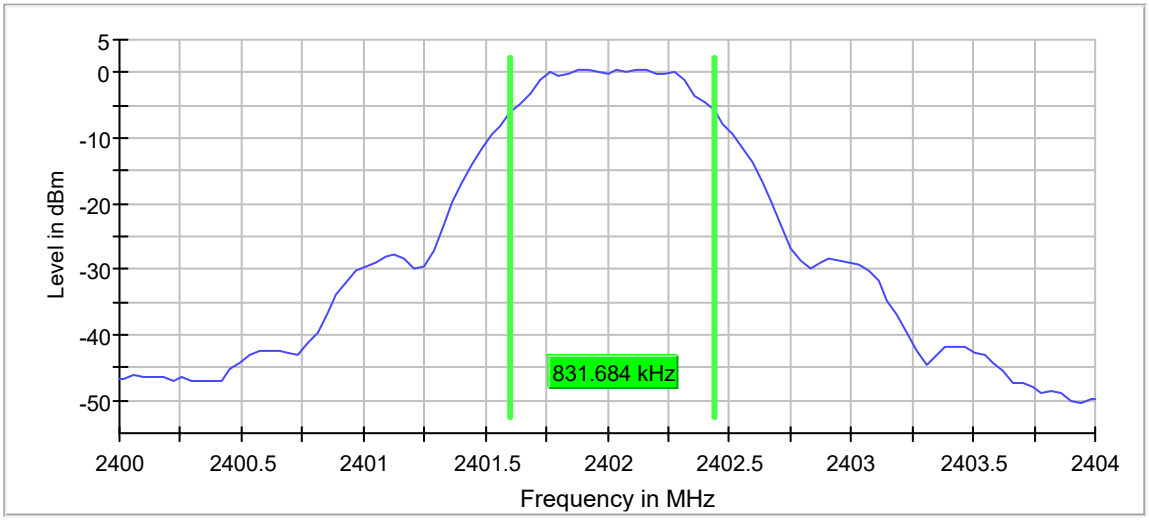
$$\text{Duty Cycle Factor} = 20\log\left(\frac{3.8\text{msec}}{100\text{msec}}\right) = -27.79\text{dB}$$

19. 6dB Bandwidth

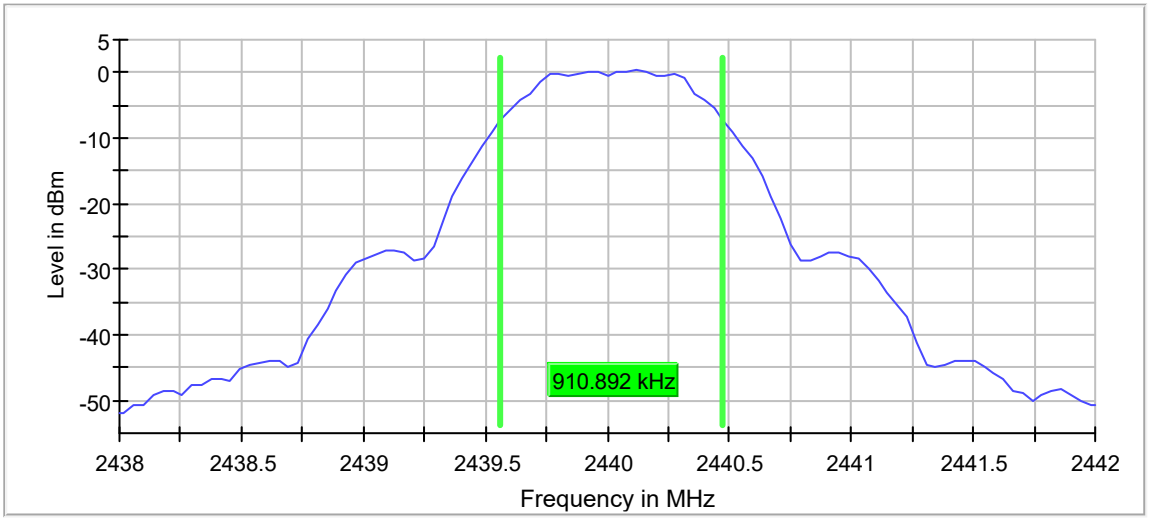
Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
The output of the EUT was connected to the spectrum analyzer through the DUT 1 port of a Rohde & Schwarz OSP 120/OSP-B157 system via a coaxial cable and RF attenuator. The EUT was allowed to transmit continuously. The transmit channel was set separately to low, middle, and high channels. The resolution bandwidth (RBW) was set to 100kHz and the span was set to greater than the RBW. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

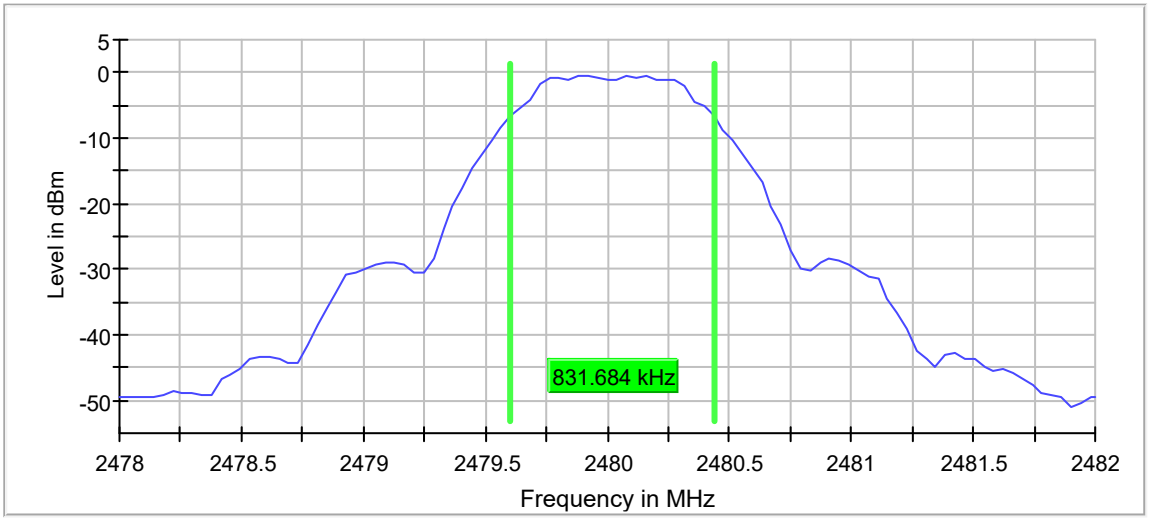
Mode	Transmitting – Bluetooth: 2402MHz
Parameters	6dB Bandwidth = 831.684kHz
Test Date	February 25,2020
Notes	N/A



Mode	Transmitting – Bluetooth: 2440MHz
Parameters	6dB Bandwidth = 910.892kHz
Test Date	February 25,2020
Notes	N/A

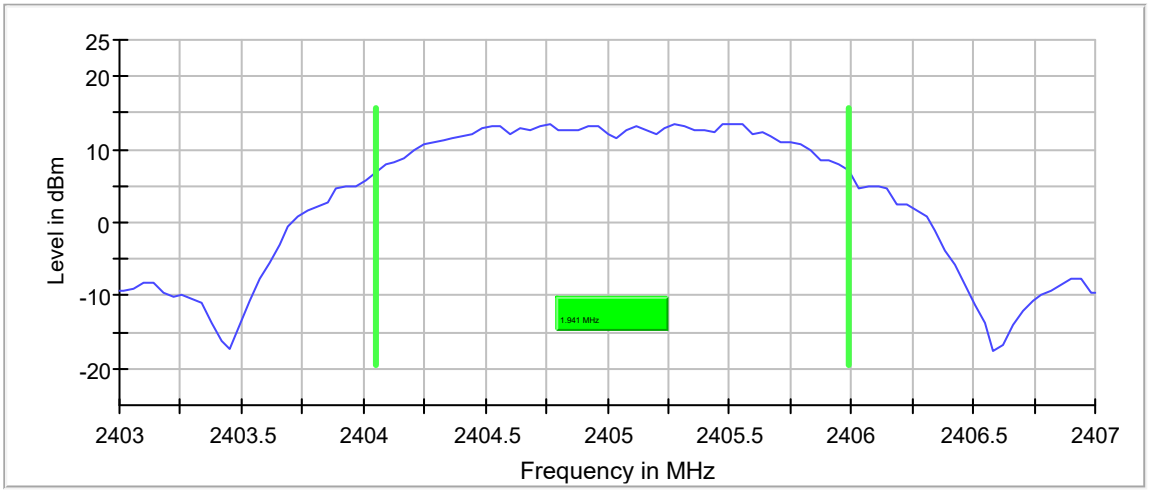


Mode	Transmitting – Bluetooth: 2480MHz
Parameters	6dB Bandwidth = 831.684kHz
Test Date	February 25,2020
Notes	N/A



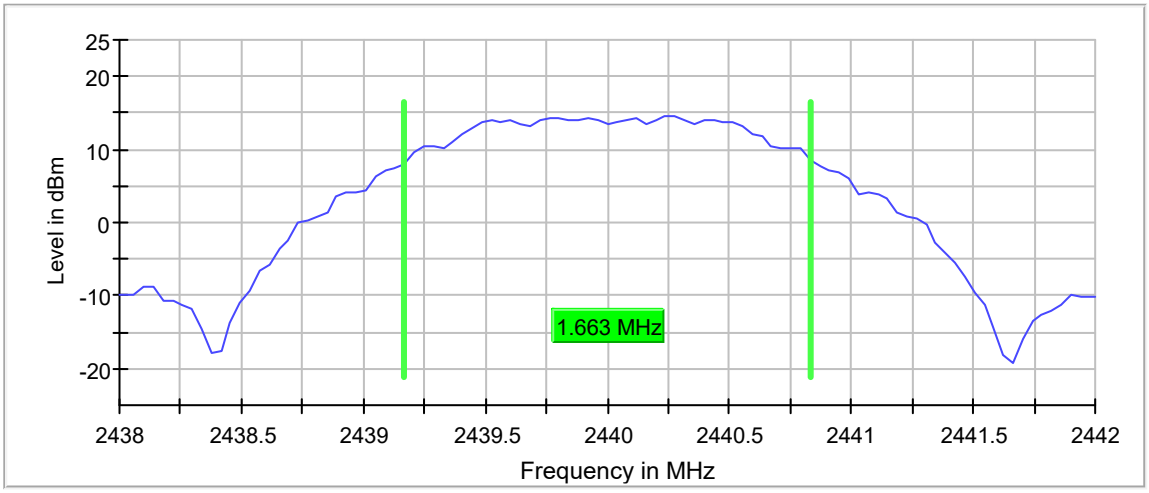
Mode	Transmitting – ZigBee: 2405MHz
Parameters	6dB Bandwidth = 1.94MHz
Test Date	February 25,2020
Notes	N/A

6 dB Bandwidth



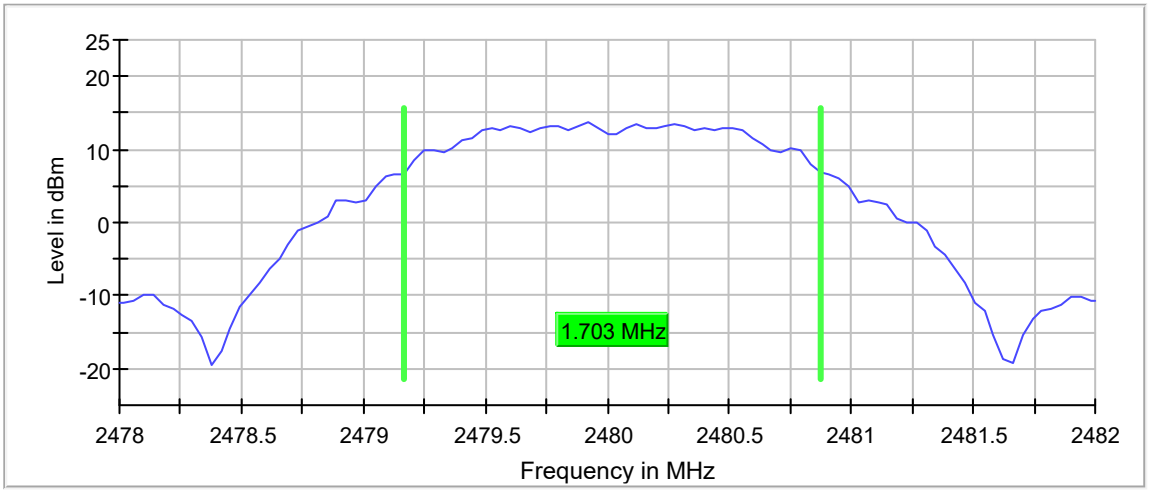
Mode	Transmitting – ZigBee: 2440MHz
Parameters	6dB Bandwidth = 1.66MHz
Test Date	February 25,2020
Notes	N/A

6 dB Bandwidth



Mode	Transmitting – ZigBee: 2480MHz
Parameters	6dB Bandwidth = 1.70MHz
Test Date	February 25,2020
Notes	N/A

6 dB Bandwidth

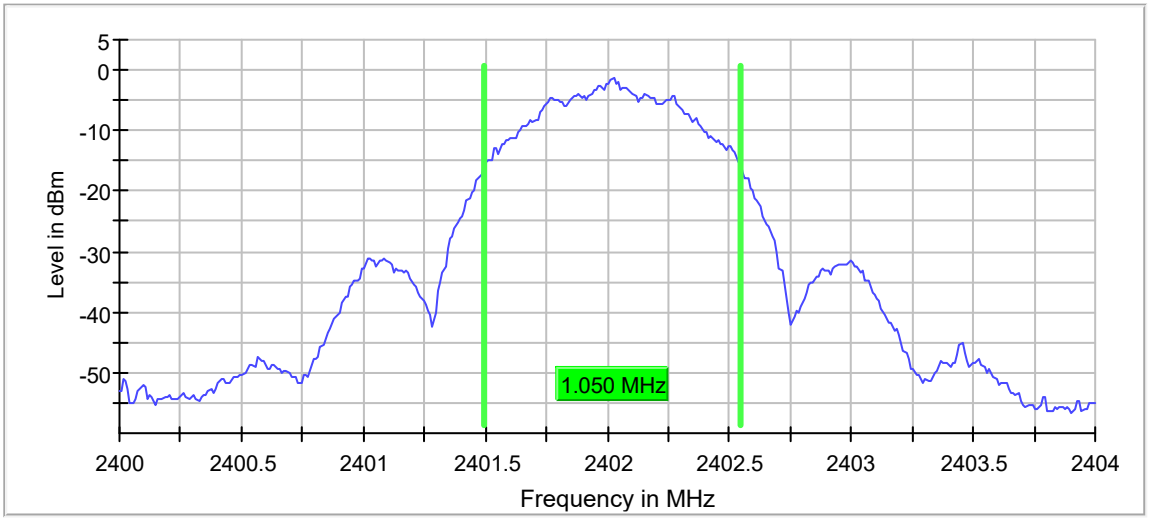


20. 99% Bandwidth

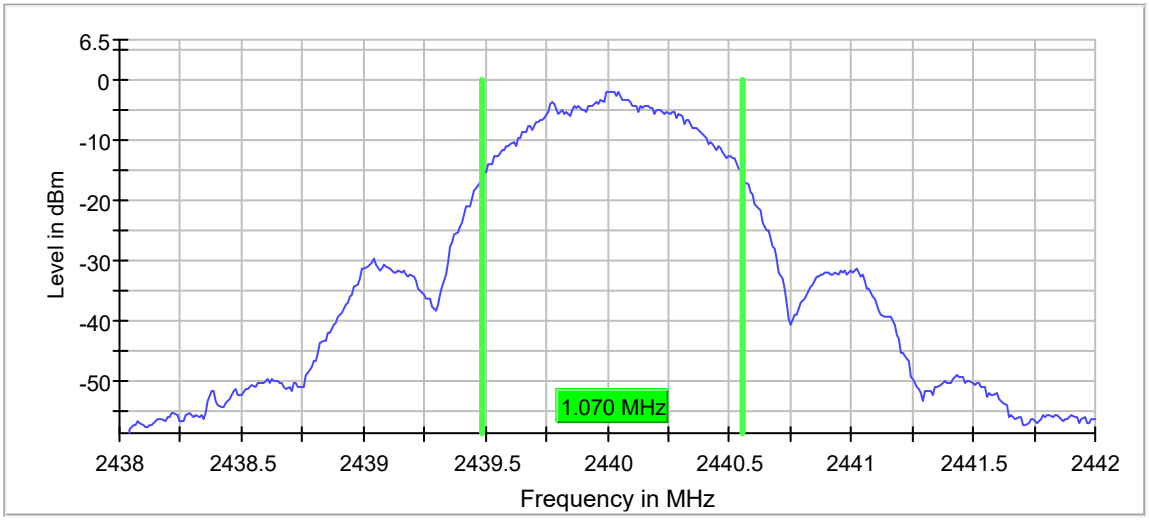
Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
The output of the EUT was connected to the spectrum analyzer through the DUT 1 port of a Rohde & Schwarz OSP 120/OSP-B157 system via a coaxial cable and RF attenuator. The EUT was allowed to transmit continuously. The transmit channel was set separately to low, middle, and high channels. The resolution bandwidth (RBW) was set to 1-5%≤OBW and the span was set to greater than the RBW. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

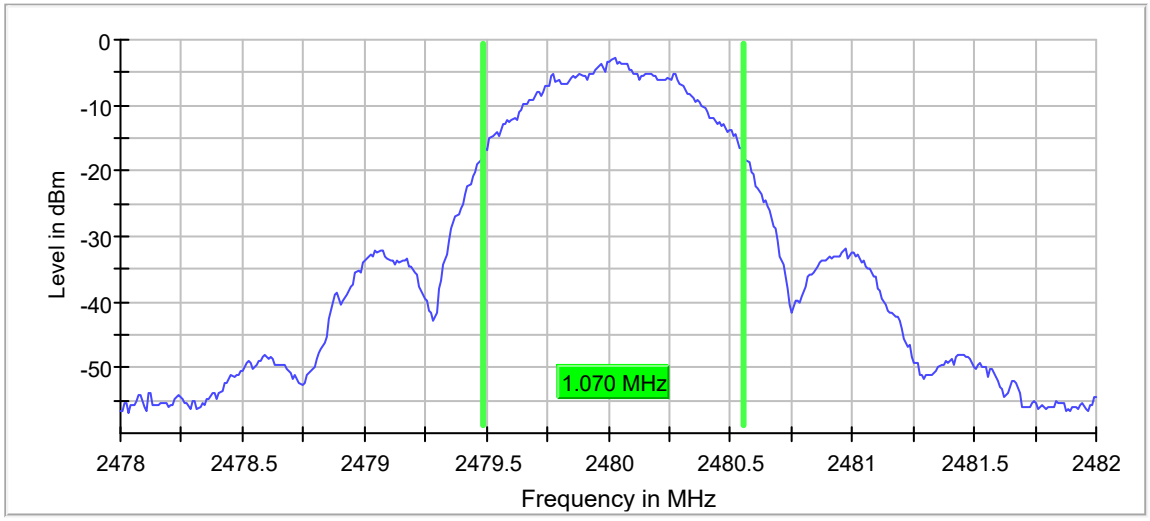
Mode	Transmitting – Bluetooth: 2402MHz
Parameters	99% Bandwidth = 1.05MHz
Test Date	February 25,2020
Notes	N/A



Mode	Transmitting – Bluetooth: 2440MHz
Parameters	99% Bandwidth = 1.07MHz
Test Date	February 25,2020
Notes	N/A

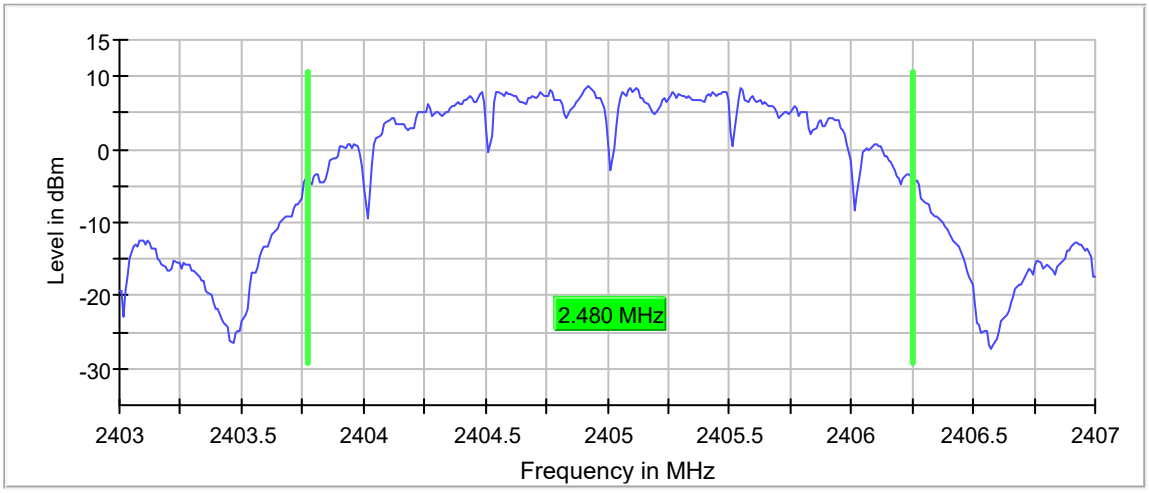


Mode	Transmitting – Bluetooth: 2480MHz
Parameters	99% Bandwidth = 1.07MHz
Test Date	February 25,2020
Notes	N/A



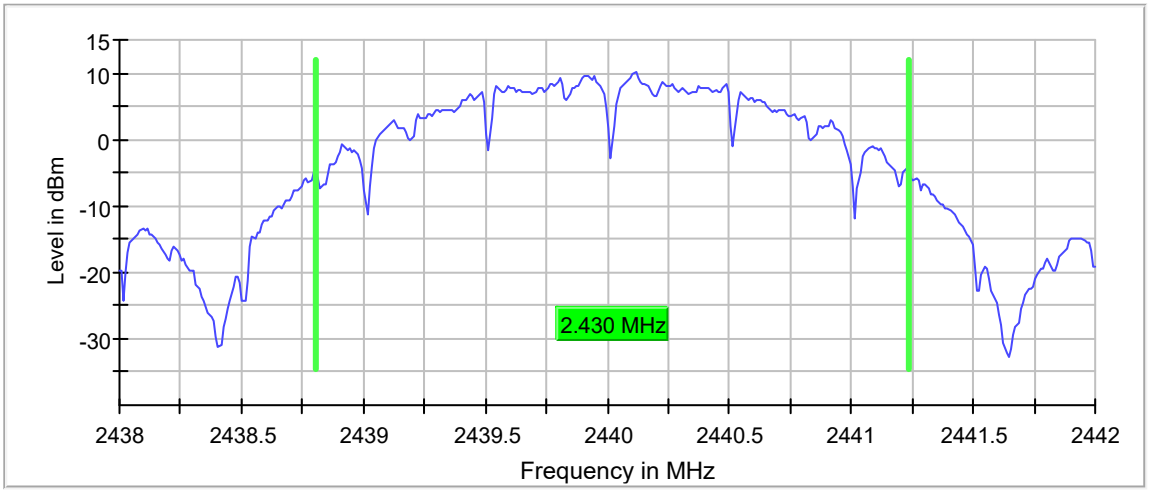
Mode	Transmitting – ZigBee: 2405MHz
Parameters	99% Bandwidth = 2.48MHz
Test Date	February 25,2020
Notes	N/A

99 % Bandwidth



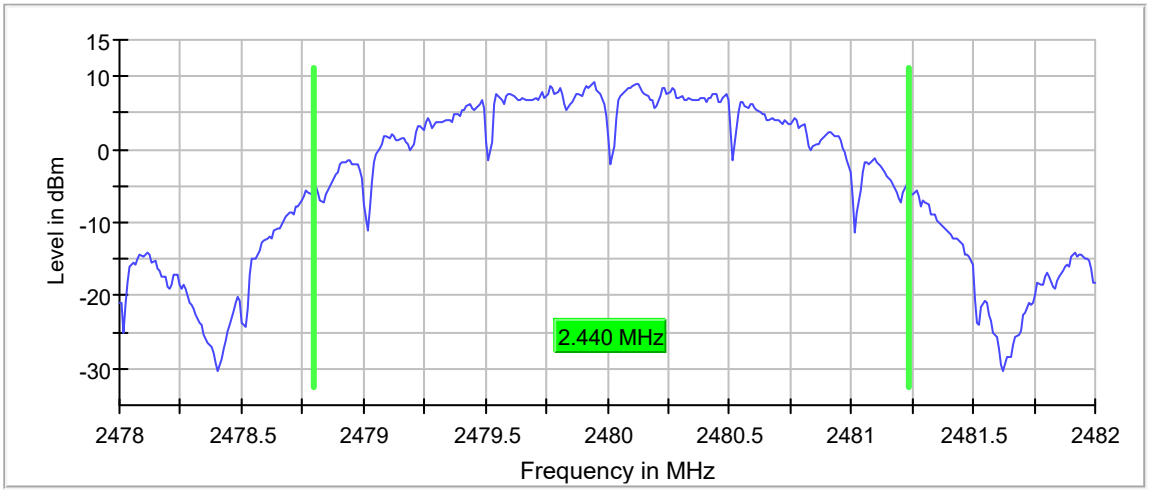
Mode	Transmitting – ZigBee: 2440MHz
Parameters	99% Bandwidth = 2.43MHz
Test Date	February 25,2020
Notes	N/A

99 % Bandwidth



Mode	Transmitting – ZigBee: 2480MHz
Parameters	99% Bandwidth = 2.44MHz
Test Date	February 25,2020
Notes	N/A

99 % Bandwidth



21. Output Power

Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
The output of the EUT was connected to the spectrum analyzer through the DUT 1 port of a Rohde & Schwarz OSP 120/OSP-B157 system via a coaxial cable and RF attenuator. The EUT was allowed to transmit continuously. The transmit channel was set separately to low, middle, and high channels. The resolution bandwidth (RBW) was set to 1MHz and the span was set to greater than the RBW. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The analyzer's display was plotted using a 'screen dump' utility.

Mode	Transmitting – Bluetooth: 2402MHz
Parameters	Peak Output Power = 3.4dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2402.00	H	64.3	2.6	4.2	3.4	3.4	36.0	-32.6
2402.00	V	58.3	-4.4	4.2	3.4	-3.6	36.0	-39.6

Mode	Transmitting – Bluetooth: 2440MHz
Parameters	Peak Output Power = 2.3dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2440.00	H	63.3	1.4	4.4	3.5	2.3	36.0	-33.7
2440.00	V	61.3	-0.3	4.4	3.5	0.6	36.0	-35.4

Mode	Transmitting – Bluetooth: 2480MHz
Parameters	Peak Output Power = 1.1dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2480.00	H	62.5	0.1	4.5	3.5	1.1	36.0	-34.9
2480.00	V	59.4	-5.6	4.5	3.5	-4.7	36.0	-40.7

Mode	Transmitting – ZigBee: 2405MHz
Parameters	Peak Output Power = 17.8dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2405.00	H	79.1	17.1	4.2	3.4	17.8	36.0	-18.2
2405.00	V	73.6	11.0	4.2	3.4	11.8	36.0	-24.2

Mode	Transmitting – ZigBee: 2440MHz
Parameters	Peak Output Power = 18.7dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2440.00	H	79.7	17.8	4.4	3.5	18.7	36.0	-17.3
2440.00	V	78.5	14.9	4.4	3.5	15.8	36.0	-20.2

Mode	Transmitting – ZigBee: 2480MHz
Parameters	Peak Output Power = 18.0dBm
Test Date	March 10,2020
Notes	N/A

Freq. (MHz)	Ant Pol	Wide BW Meter Reading (dBuV)	Matched Sig. Gen. Reading (dBm)	Equivalent Antenna Gain (dB)	Cable Loss (dB)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2480.00	H	79.4	17.0	4.5	3.5	18.0	36.0	-18.0
2480.00	V	74.9	12.3	4.5	3.5	13.3	36.0	-22.7

22. Radiated Spurious Emissions

Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2014 for site attenuation. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads. Preliminary radiated emissions tests were performed to determine the emission characteristics of the EUT. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the EUT. The entire frequency range from 30MHz to 25GHz was investigated using a peak detector function. The final open field emission tests were then manually performed over the frequency range of 30MHz to 25GHz. 1) For all harmonics not in the restricted bands, the following procedure was used: a) The field strength of the fundamental was measured using a double ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. An average detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer. b) The field strengths of all of the harmonics not in the restricted band were then measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. An average detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer. c) To ensure that maximum or worst case emission levels at the fundamental and harmonics were measured, the following steps were taken when measuring the fundamental emissions and the spurious emissions: i) The EUT was rotated so that all of its sides were exposed to the receiving antenna. ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured. iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings. iv) In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer, the measuring antenna was not raised or lowered to ensure maximized readings. Instead the EUT was rotated through all axes to ensure the maximum readings were recorded for the EUT. d) All harmonics not in the restricted bands must be at least 30 dB below levels measured at the fundamental. However, attenuation below the general limits specified in §15.209(a) is not required. 2) For all emissions in the restricted bands, the following procedure was used: a) The field strengths of all emissions below 1 GHz were measured using a bilog antenna. The bi-log antenna was positioned at a 3 meter distance from the EUT. A peak detector with a resolution bandwidth of 100 kHz was used on the spectrum analyzer. b) The field strengths of all emissions above 1 GHz were measured using a double-ridged waveguide antenna. The waveguide antenna was positioned at a 3 meter distance from the EUT. A peak detector with a resolution bandwidth of 1 MHz was used on the spectrum analyzer. c) To ensure that maximum or worst case emission levels were measured, the following steps were

taken when taking all measurements:

i) The EUT was rotated so that all of its sides were exposed to the receiving antenna.
ii) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
iii) The measuring antenna was raised and lowered for each antenna polarization to maximize the readings.
iv) In instances where it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer, the measuring antenna was not raised or lowered to ensure maximized readings. Instead the EUT was rotated through all axes to ensure the maximum readings were recorded for the EUT.

d) For all radiated emissions measurements below 1 GHz, if the peak reading is below the limits listed in 15.209(a), no further measurements are required. If however, the peak readings exceed the limits listed in 15.209(a), then the emissions are remeasured using a quasi-peak detector.
e) For all radiated emissions measurements above 1 GHz, the peak readings must comply with the 15.35(b) limits. 15.35(b) states that when average radiated emissions measurements are specified, there also is a limit on the peak level of the radiated emissions. The limit on the peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. Therefore, all peak readings above 1 GHz must be no greater than 20 dB above the limits specified in 15.209(a).

Next, for all radiated emissions measurements above 1GHz, the resolution bandwidth was set to 1MHz. The analyzer was set to linear mode with a 10Hz video bandwidth in order to simulate an average detector. An average reading was taken.

Mode	Transmitting – Bluetooth: 2402MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4804.00	H	50.1		3.7	34.5	-39.3	49.0	280.4	5000.0	-25.0
4804.00	V	49.6		3.7	34.5	-39.3	48.4	264.4	5000.0	-25.5
12010.00	H	49.3		6.1	38.5	-39.2	54.8	548.2	5000.0	-19.2
12010.00	V	49.0		6.1	38.5	-39.2	54.4	527.2	5000.0	-19.5
19216.00	H	37.0	*	2.2	40.4	-28.8	50.8	344.9	5000.0	-23.2
19216.00	V	36.4	*	2.2	40.4	-28.8	50.2	321.9	5000.0	-23.8

Mode	Transmitting – Bluetooth: 2440MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4880.00	H	49.4		3.7	34.4	-39.3	48.2	257.7	5000.0	-25.8
4880.00	V	50.0		3.7	34.4	-39.3	48.8	275.5	5000.0	-25.2
7320.00	H	49.1		4.7	35.6	-39.4	50.0	316.3	5000.0	-24.0
7320.00	V	48.8		4.7	35.6	-39.4	49.7	304.8	5000.0	-24.3
12200.00	H	48.2		6.1	38.7	-39.1	53.9	493.5	5000.0	-20.1
12200.00	V	48.4		6.1	38.7	-39.1	54.0	503.3	5000.0	-19.9
19520.00	H	36.3	*	2.2	40.4	-28.7	50.2	323.7	5000.0	-23.8
19520.00	V	37.1	*	2.2	40.4	-28.7	50.9	352.1	5000.0	-23.0

Mode	Transmitting – Bluetooth: 2480MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4960.00	H	50.1		3.7	34.3	-39.3	48.9	277.1	5000.0	-25.1
4960.00	V	52.4		3.7	34.3	-39.3	51.1	360.2	5000.0	-22.8
7440.00	H	48.7		4.7	35.7	-39.4	49.7	304.4	5000.0	-24.3
7440.00	V	48.8		4.7	35.7	-39.4	49.8	308.3	5000.0	-24.2
12400.00	H	48.2		6.1	38.8	-39.0	54.0	499.8	5000.0	-20.0
12400.00	V	48.0		6.1	38.8	-39.0	53.9	493.5	5000.0	-20.1
19840.00	H	37.5	*	2.2	40.4	-28.4	51.7	386.5	5000.0	-22.2
19840.00	V	37.6	*	2.2	40.4	-28.4	51.8	389.2	5000.0	-22.2
22320.00	H	36.7	*	2.2	40.6	-29.3	50.2	324.3	5000.0	-23.8
22320.00	V	36.6	*	2.2	40.6	-29.3	50.1	318.7	5000.0	-23.9

Mode	Transmitting – Bluetooth: 2402MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4804.00	H	35.3		3.7	34.5	-39.3	0.0	34.2	51.0	500.0	-19.8
4804.00	V	34.9		3.7	34.5	-39.3	0.0	33.8	48.8	500.0	-20.2
12010.00	H	33.6		6.1	38.5	-39.2	0.0	39.1	89.8	500.0	-14.9
12010.00	V	33.9		6.1	38.5	-39.2	0.0	39.3	92.7	500.0	-14.6
19216.00	H	21.3	*	2.2	40.4	-28.8	0.0	35.1	57.2	500.0	-18.8
19216.00	V	21.1	*	2.2	40.4	-28.8	0.0	34.9	55.9	500.0	-19.0

Mode	Transmitting – Bluetooth: 2440MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4880.00	H	35.5		3.7	34.4	-39.3	0.0	34.3	52.0	500.0	-19.7
4880.00	V	35.2		3.7	34.4	-39.3	0.0	34.0	50.0	500.0	-20.0
7320.00	H	33.78		4.7	35.6	-39.4	0.0	34.7	54.3	500.0	-19.3
7320.00	V	33.7		4.7	35.6	-39.4	0.0	34.6	53.8	500.0	-19.4
12200.00	H	33.6		6.1	38.7	-39.1	0.0	39.3	92.0	500.0	-14.7
12200.00	V	33.6		6.1	38.7	-39.1	0.0	39.3	92.3	500.0	-14.7
19520.00	H	21.1	*	2.2	40.4	-28.7	0.0	35.0	56.3	500.0	-19.0
19520.00	V	20.8	*	2.2	40.4	-28.7	0.0	34.6	54.0	500.0	-19.3

Mode	Transmitting – Bluetooth: 2480MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4960.00	H	37.5		3.7	34.3	-39.3	0.0	36.2	64.5	500.0	-17.8
4960.00	V	41.4		3.7	34.3	-39.3	0.0	40.1	100.7	500.0	-13.9
7440.00	H	34.37		4.7	35.7	-39.4	0.0	35.3	58.4	500.0	-18.6
7440.00	V	34.4		4.7	35.7	-39.4	0.0	35.4	58.7	500.0	-18.6
12400.00	H	33.3		6.1	38.8	-39.0	0.0	39.1	90.1	500.0	-14.9
12400.00	V	33.3		6.1	38.8	-39.0	0.0	39.1	90.0	500.0	-14.9
19840.00	H	21.0	*	2.2	40.4	-28.4	0.0	35.2	57.6	500.0	-18.8
19840.00	V	21.1	*	2.2	40.4	-28.4	0.0	35.4	58.7	500.0	-18.6
22320.00	H	21.4	*	2.2	40.6	-29.3	0.0	34.9	55.8	500.0	-19.1
22320.00	V	21.2	*	2.2	40.6	-29.3	0.0	34.7	54.2	500.0	-19.3

Mode	Transmitting – Bluetooth: 2402MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2402.00	H	64.0		2.6	32.2	0.0	98.7	86388.7		
2402.00	V	58.0		2.6	32.2	0.0	92.7	43396.7		
7206.00	H	39.4		4.6	35.6	-39.4	40.1	101.7	8638.9	-38.6
7206.00	V	40.5		4.6	35.6	-39.4	41.3	115.9	8638.9	-37.4
9608.00	H	39.9		5.2	36.5	-39.3	42.3	130.8	8638.9	-36.4
9608.00	V	40.1		5.2	36.5	-39.3	42.5	133.5	8638.9	-36.2
14412.00	H	38.2	*	6.6	39.4	-38.3	45.9	198.1	8638.9	-32.8
14412.00	V	38.1	*	6.6	39.4	-38.3	45.8	194.7	8638.9	-32.9
16814.00	H	38.5		7.2	42.1	-37.5	50.3	326.2	8638.9	-28.5
16814.00	V	38.2		7.2	42.1	-37.5	50.0	316.2	8638.9	-28.7
21618.00	H	25.9	*	2.2	40.6	-28.9	39.8	97.7	8638.9	-38.9
21618.00	V	26.0	*	2.2	40.6	-28.9	39.9	99.4	8638.9	-38.8
24020.00	H	27.8	*	2.2	40.6	-30.2	40.4	104.9	8638.9	-38.3
24020.00	V	27.0	*	2.2	40.6	-30.2	39.6	95.7	8638.9	-39.1

Mode	Transmitting – Bluetooth: 2440MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2440.00	H	63.2		2.6	32.4	0.0	98.2	81688.7		
2440.00	V	61.3		2.6	32.4	0.0	96.4	65866.1		
9760.00	H	43.0		5.2	36.7	-39.3	45.7	192.9	8168.9	-32.5
9760.00	V	42.7		5.2	36.7	-39.3	45.4	185.5	8168.9	-32.9
14640.00	H	38.5	*	6.7	39.6	-38.2	46.5	211.1	8168.9	-31.8
14640.00	V	38.3	*	6.7	39.6	-38.2	46.3	207.0	8168.9	-31.9
17080.00	H	40.7		7.3	41.6	-37.6	51.9	394.4	8168.9	-26.3
17080.00	V	37.9		7.3	41.6	-37.6	49.2	287.7	8168.9	-29.1
21960.00	H	26.0	*	2.2	40.6	-29.4	39.4	92.9	8168.9	-38.9
21960.00	V	27.0	*	2.2	40.6	-29.4	40.4	104.4	8168.9	-37.9
24400.00	H	26.4	*	2.2	40.6	-30.4	38.8	87.3	8168.9	-39.4
24400.00	V	26.4	*	2.2	40.6	-30.4	38.8	87.0	8168.9	-39.5

Mode	Transmitting – Bluetooth: 2480MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2480.00	H	62.3		2.7	32.5	0.0	97.5	74920.7		
2480.00	V	59.1		2.7	32.5	0.0	94.2	51475.6		
9920.00	H	40.0		5.3	36.7	-39.2	42.8	138.2	7492.1	-34.7
9920.00	V	39.2		5.3	36.7	-39.2	41.9	125.1	7492.1	-35.5
14880.00	H	37.6	*	6.8	39.7	-38.2	45.9	197.6	7492.1	-31.6
14880.00	V	38.0	*	6.8	39.7	-38.2	46.3	207.0	7492.1	-31.2
17360.00	H	39.2	*	7.4	41.1	-37.7	49.9	311.4	7492.1	-27.6
17360.00	V	39.0	*	7.4	41.1	-37.7	49.6	303.6	7492.1	-27.8
24800.00	H	26.7	*	2.2	40.6	-31.2	38.4	83.0	7492.1	-39.1
24800.00	V	26.1	*	2.2	40.6	-31.2	37.8	77.4	7492.1	-39.7

Mode	Transmitting – ZigBee: 2405MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4810.00	H	72.5		3.7	34.5	-39.3	71.4	3719.5	5000.0	-2.6
4810.00	V	72.1		3.7	34.5	-39.3	71.0	3552.1	5000.0	-3.0
12025.00	H	48.7		6.1	38.5	-39.2	54.2	512.8	5000.0	-19.8
12025.00	V	48.8		6.1	38.5	-39.2	54.3	516.9	5000.0	-19.7
19240.00	H	36.4	*	2.2	40.4	-28.7	50.3	328.1	5000.0	-23.7
19240.00	V	36.5	*	2.2	40.4	-28.7	50.3	328.5	5000.0	-23.6

Mode	Transmitting – ZigBee: 2440MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4880.00	H	71.0		3.7	34.4	-39.3	69.9	3109.2	5000.0	-4.1
4880.00	V	70.2		3.7	34.4	-39.3	69.0	2816.1	5000.0	-5.0
7320.00	H	56.4		4.7	35.6	-39.4	57.3	731.3	5000.0	-16.7
7320.00	V	56.8		4.7	35.6	-39.4	57.7	764.0	5000.0	-16.3
12200.00	H	48.7		6.1	38.7	-39.1	54.4	524.0	5000.0	-19.6
12200.00	V	48.4		6.1	38.7	-39.1	54.1	504.4	5000.0	-19.9
19520.00	H	36.0	*	2.2	40.4	-28.7	49.9	312.0	5000.0	-24.1
19520.00	V	36.2	*	2.2	40.4	-28.7	50.1	319.6	5000.0	-23.9

Mode	Transmitting – ZigBee: 2480MHz
Test	Spurious Emissions – Peak Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
4960.00	H	71.7		3.7	34.3	-39.3	70.4	3300.6	5000.0	-3.6
4960.00	V	70.4		3.7	34.3	-39.3	69.1	2838.5	5000.0	-4.9
7440.00	H	58.9		4.7	35.7	-39.4	59.8	980.6	5000.0	-14.1
7440.00	V	57.8		4.7	35.7	-39.4	58.7	863.9	5000.0	-15.2
12400.00	H	49.4		6.1	38.8	-39.0	55.2	575.2	5000.0	-18.8
12400.00	V	48.4		6.1	38.8	-39.0	54.3	516.2	5000.0	-19.7
19840.00	H	36.6	*	2.2	40.4	-28.4	50.8	346.9	5000.0	-23.2
19840.00	V	36.2	*	2.2	40.4	-28.4	50.5	333.9	5000.0	-23.5
22320.00	H	36.7	*	2.2	40.6	-29.3	50.2	322.4	5000.0	-23.8
22320.00	V	36.2	*	2.2	40.6	-29.3	49.7	305.4	5000.0	-24.3

Mode	Transmitting – ZigBee: 2405MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4810.00	H	71.4		3.7	34.5	-39.3	-16.5	53.8	490.9	500.0	-0.2
4810.00	V	70.9		3.7	34.5	-39.3	-16.5	53.3	464.5	500.0	-0.6
12025.00	H	34.0		6.1	38.5	-39.2	-16.5	23.0	14.1	500.0	-31.0
12025.00	V	34.0		6.1	38.5	-39.2	-16.5	23.0	14.1	500.0	-31.0
19240.00	H	21.0	*	2.2	40.4	-28.7	-16.5	18.4	8.3	500.0	-35.6
19240.00	V	20.9	*	2.2	40.4	-28.7	-16.5	18.3	8.2	500.0	-35.7

Mode	Transmitting – ZigBee: 2440MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4880.00	H	70.4		3.7	34.4	-39.3	-16.5	52.7	433.7	500.0	-1.2
4880.00	V	68.6		3.7	34.4	-39.3	-16.5	50.9	352.1	500.0	-3.0
7320.00	H	51.81		4.7	35.6	-39.4	-16.5	36.2	64.9	500.0	-17.7
7320.00	V	52.6		4.7	35.6	-39.4	-16.5	37.1	71.2	500.0	-16.9
12200.00	H	35.0		6.1	38.7	-39.1	-16.5	24.2	16.2	500.0	-29.8
12200.00	V	33.6		6.1	38.7	-39.1	-16.5	22.8	13.8	500.0	-31.2
19520.00	H	20.2	*	2.2	40.4	-28.7	-16.5	17.6	7.6	500.0	-36.4
19520.00	V	20.7	*	2.2	40.4	-28.7	-16.5	18.0	8.0	500.0	-35.9

Mode	Transmitting – ZigBee: 2480MHz
Test	Spurious Emissions – Average Measurements – In the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
4960.00	H	70.8		3.7	34.3	-39.3	-16.5	53.0	448.8	500.0	-0.9
4960.00	V	69.5		3.7	34.3	-39.3	-16.5	51.7	384.7	500.0	-2.3
7440.00	H	56.03		4.7	35.7	-39.4	-16.5	40.5	106.0	500.0	-13.5
7440.00	V	54.7		4.7	35.7	-39.4	-16.5	39.2	91.2	500.0	-14.8
12400.00	H	34.7		6.1	38.8	-39.0	-16.5	24.0	15.8	500.0	-30.0
12400.00	V	33.4		6.1	38.8	-39.0	-16.5	22.7	13.7	500.0	-31.2
19840.00	H	20.6	*	2.2	40.4	-28.4	-16.5	18.4	8.3	500.0	-35.6
19840.00	V	20.9	*	2.2	40.4	-28.4	-16.5	18.6	8.5	500.0	-35.3
22320.00	H	20.9	*	2.2	40.6	-29.3	-16.5	18.0	7.9	500.0	-36.0
22320.00	V	21.0	*	2.2	40.6	-29.3	-16.5	18.0	8.0	500.0	-36.0

Mode	Transmitting – ZigBee: 2405MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2405.00	H	79.0		2.6	32.2	0.0	113.8	488142.5		
2405.00	V	73.2		2.6	32.2	0.0	108.0	249773.6		
7215.00	H	56.5		4.6	35.6	-39.4	57.3	731.3	48814.2	-36.5
7215.00	V	59.6		4.6	35.6	-39.4	60.3	1040.2	48814.2	-33.4
9620.00	H	56.1		5.2	36.6	-39.3	58.5	844.9	48814.2	-35.2
9620.00	V	51.7		5.2	36.6	-39.3	54.2	513.2	48814.2	-39.6
14430.00	H	39.7	*	6.6	39.4	-38.3	47.4	235.6	48814.2	-46.3
14430.00	V	40.1	*	6.6	39.4	-38.3	47.8	245.8	48814.2	-46.0
16835.00	H	37.9	*	7.2	42.1	-37.5	49.7	303.8	48814.2	-44.1
16835.00	V	37.7	*	7.2	42.1	-37.5	49.4	295.9	48814.2	-44.3
21645.00	H	26.1	*	2.2	40.6	-28.9	40.0	100.2	48814.2	-53.8
21645.00	V	26.1	*	2.2	40.6	-28.9	40.1	100.6	48814.2	-53.7
24050.00	H	26.2	*	2.2	40.6	-30.3	38.8	87.0	48814.2	-55.0
24050.00	V	25.6	*	2.2	40.6	-30.3	38.2	80.9	48814.2	-55.6

Mode	Transmitting – ZigBee: 2440MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2440.00	H	79.3		2.6	32.4	0.0	114.4	522590.9		
2440.00	V	78.5		2.6	32.4	0.0	113.5	473872.8		
9760.00	H	57.6		5.2	36.7	-39.3	60.3	1032.4	52259.1	-34.1
9760.00	V	53.0		5.2	36.7	-39.3	55.7	609.3	52259.1	-38.7
14640.00	H	41.1		6.7	39.6	-38.2	49.1	286.1	52259.1	-45.2
14640.00	V	48.1		6.7	39.6	-38.2	56.1	640.6	52259.1	-38.2
17080.00	H	38.7		7.3	41.6	-37.6	49.9	312.9	52259.1	-44.5
17080.00	V	38.4		7.3	41.6	-37.6	49.7	304.4	52259.1	-44.7
21960.00	H	26.6	*	2.2	40.6	-29.4	40.0	99.7	52259.1	-54.4
21960.00	V	26.6	*	2.2	40.6	-29.4	40.0	99.9	52259.1	-54.4
24400.00	H	26.4	*	2.2	40.6	-30.4	38.8	87.5	52259.1	-55.5
24400.00	V	26.2	*	2.2	40.6	-30.4	38.6	84.9	52259.1	-55.8

Mode	Transmitting – ZigBee: 2480MHz
Test	Spurious Emissions – Peak Measurements – Not in the restricted bands
Test Date	March 4-11-2020
Notes	N/A

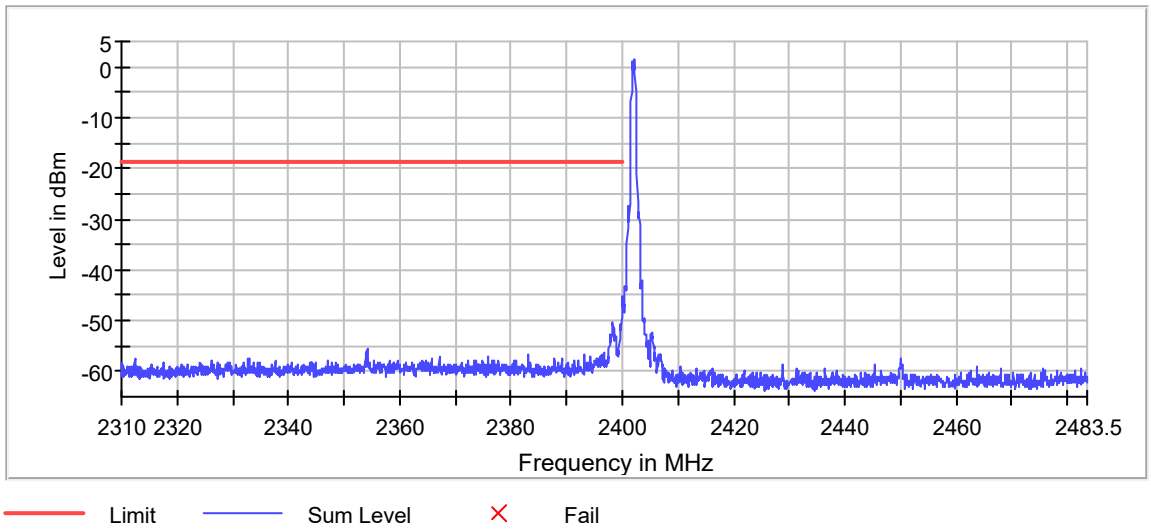
Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2480.00	H	79.3		2.7	32.5	0.0	114.5	530397.9		
2480.00	V	74.5		2.7	32.5	0.0	109.7	304159.8		
9920.00	H	56.2		5.3	36.7	-39.2	59.0	892.1	53039.8	-35.5
9920.00	V	54.2		5.3	36.7	-39.2	56.9	702.1	53039.8	-37.6
14880.00	H	42.6		6.8	39.7	-38.2	50.9	351.5	53039.8	-43.6
14880.00	V	41.4		6.8	39.7	-38.2	49.6	303.7	53039.8	-44.8
17360.00	H	38.4		7.4	41.1	-37.7	49.1	285.0	53039.8	-45.4
17360.00	V	37.7		7.4	41.1	-37.7	48.4	262.0	53039.8	-46.1
24800.00	H	26.3	*	2.2	40.6	-31.2	38.0	79.6	53039.8	-56.5
24800.00	V	26.5	*	2.2	40.6	-31.2	38.2	80.9	53039.8	-56.3

23. Band Edge Compliance

Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
Low Band Edge 1) The output of the EUT was connected to the spectrum analyzer through 40dB of attenuation. 2) The EUT was set to transmit continuously at the channel closest to the low band edge. 3) To determine the band edge compliance, the following spectrum analyzer settings were used: a) Center frequency = low band edge frequency. b) Span = Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation. c) Resolution bandwidth (RBW) ≥ 1% of the span. d) The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. e) The marker was set on the peak of the in-band emissions. A display line was placed 30dB down from the peak of the in-band emissions. All emissions which fall outside of the authorized band of operation must be below the 30dB down display line. (All emissions to the left of the center frequency (band edge) must be below the display line.) f) The analyzer's display was plotted using a 'screen dump' utility. High Band Edge 1) The EUT was set up inside the test chamber on a non-conductive stand. 2) A broadband measuring antenna was placed at a test distance of 3 meters from the EUT. 3) The EUT was maximized for worst case emissions at the measuring antenna. A peak reading was taken with a resolution bandwidth of 1MHz and a video bandwidth of 1MHz or greater. An average reading was then taken with receiver set to an average detector. The maximum peak and average meter readings were recorded.

Mode	Transmitting – Bluetooth: 2402MHz
Parameters	Low Band-Edge
Test Date	February 25,2020
Notes	N/A



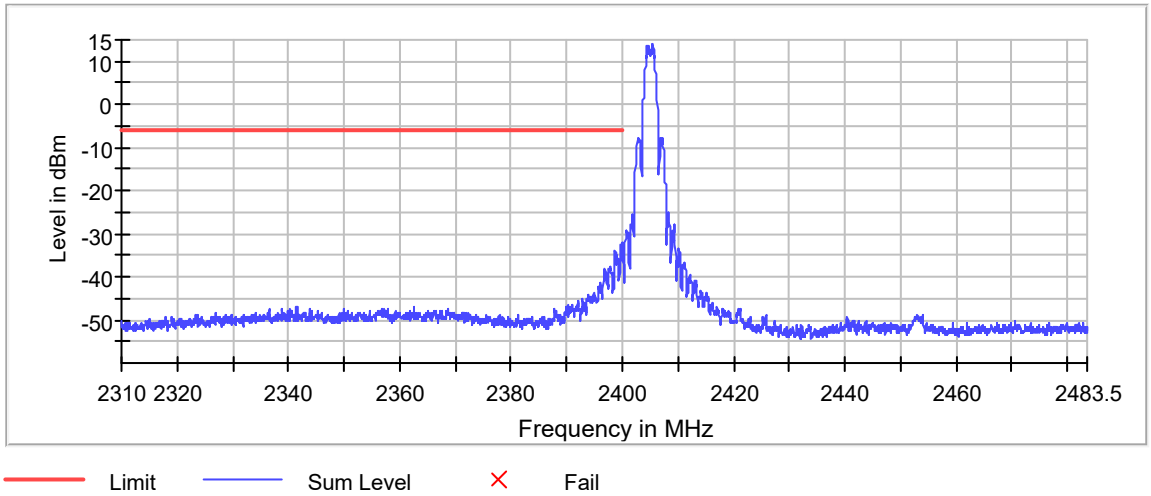
Mode	Transmitting – Bluetooth: 2480MHz
Parameters	High Band-Edge
Test Date	March 4,2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2483.50	H	38.2		2.7	32.5	0.0	73.4	4653.9	5000.0	-0.6
2483.50	V	36.1		2.7	32.5	0.0	71.3	3654.4	5000.0	-2.7

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
2483.50	H	32.9		2.7	32.5	0.0	-16.5	51.5	377.0	500.0	-2.5
2483.50	V	27.2		2.7	32.5	0.0	-16.5	45.9	196.5	500.0	-8.1

Mode	Transmitting – ZigBee: 2405MHz
Parameters	Low Band-Edge
Test Date	February 25,2020
Notes	N/A

Band Edge



Mode	Transmitting – ZigBee: 2480MHz
Parameters	High Band-Edge
Test Date	March 4,2020
Notes	N/A

Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Peak Total dBuV/m at 3m	Peak Total uV/m at 3 m	Peak Limit uV/m at 3 m	Margin (dB)
2483.50	H	26.2	*	2.7	32.5	0.0	61.4	1169.0	5000.0	-12.6
2483.50	V	26.2	*	2.7	32.5	0.0	61.3	1167.7	5000.0	-12.6

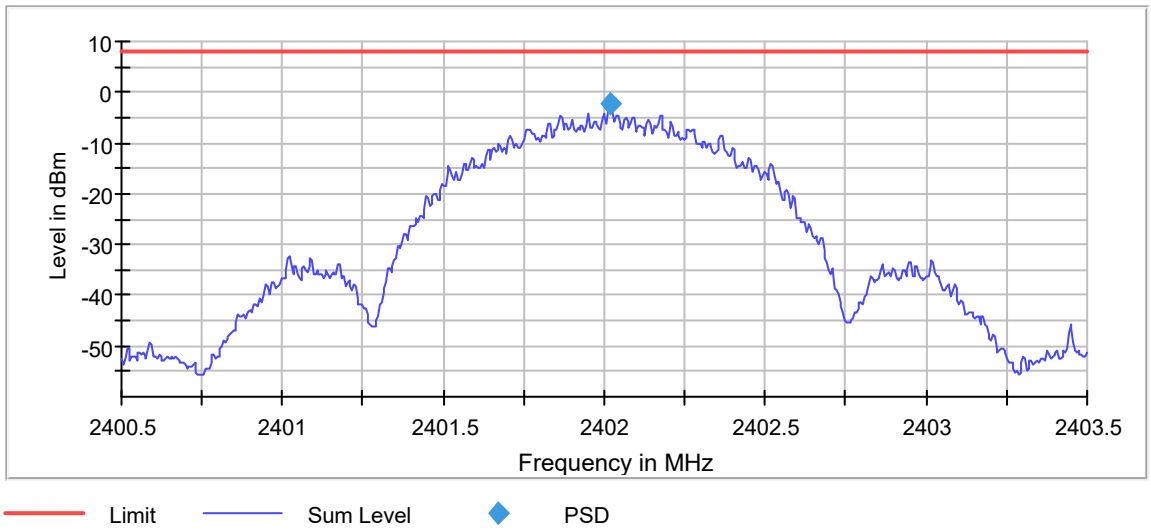
Freq. MHz	Ant Pol	Meter Reading (dBuV)	Ambient	CBL Fac (dB)	Ant Fac (dB/m)	Pre Amp (dB)	Duty Cycle (dB)	Average Total dBuV/m at 3m	Average Total uV/m at 3 m	Average Limit uV/m at 3 m	Margin (dB)
2483.50	H	7.7	*	2.7	32.5	0.0	-16.5	26.4	20.8	500.0	-27.6
2483.50	V	7.5	*	2.7	32.5	0.0	-16.5	26.2	20.4	500.0	-27.8

24. Power Spectral Density

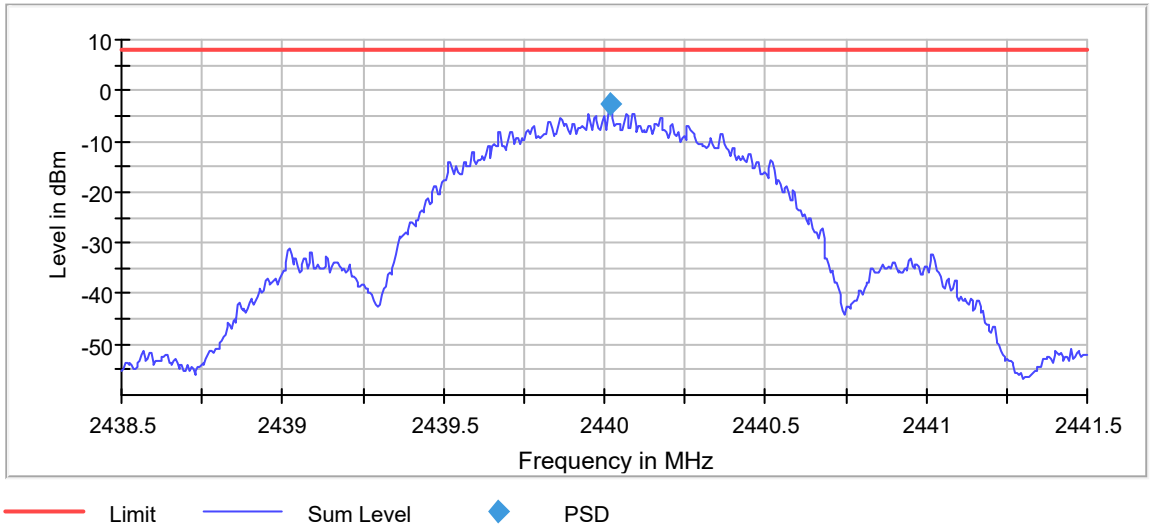
Manufacturer	Johnson Controls Inc
Product	ZFR Pro 2.0
Model	ZFR-1831
Serial No	Conducted Unit
Mode	Transmitting

Procedures
1) The output of the EUT was connected to the spectrum analyzer through the DUT 1 port of a Rohde & Schwarz OSP 120/OSP-B157 system via a coaxial cable and RF attenuator. 2) The EUT was set to transmit at a mid-channel. 3) To determine the power spectral density, the following spectrum analyzer settings were used: a) Center frequency = transmit frequency b) Resolution bandwidth (RBW) ≥ 20dB bandwidth. c) Sweep time = auto d) The average detector and 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. e) The analyzer's display was plotted using a 'screen dump' utility. 4) This reading corresponds to the average EIRP measured for the mid channel. 5) Turn on Display Line 1 and place it at the peak of the measured level. Turn on Display Line 2 and place it at the corresponding +8dBm level (e.g. if the average output power is +18dBm then the +8dBm level will be 10dB down from the radiated level and if the average output power is +6dBm then the +8dBm level will be 2dB above the radiated level.) 6) The EUT was then placed in the normal operation mode. 7) To determine the power spectral density, the following spectrum analyzer settings were used: a) Center frequency = transmit frequency b) Span = 1.5x the channel bandwidth c) Resolution bandwidth (RBW) ≥ 3kHz d) Video bandwidth (VBW) ≥ 3 x RBW e) Sweep time = auto couple f) The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined. The peak detector and 'Max-Hold' function was engaged. g) The analyzer's display was plotted using a 'screen dump' utility. h) If the measured value exceeds the +8dBm limit, reduce the RBW (no less than 3kHz) and repeat step (7).

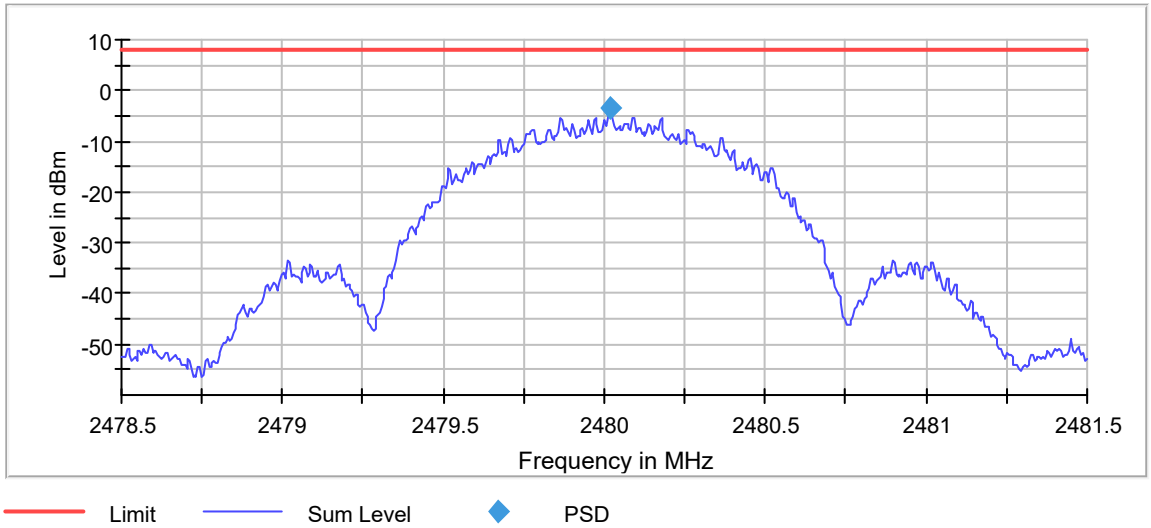
Mode	Transmitting – Bluetooth: 2402MHz
Parameters	Peak Power Spectral Density = -2.377
Test Date	February 25,2020
Notes	N/A



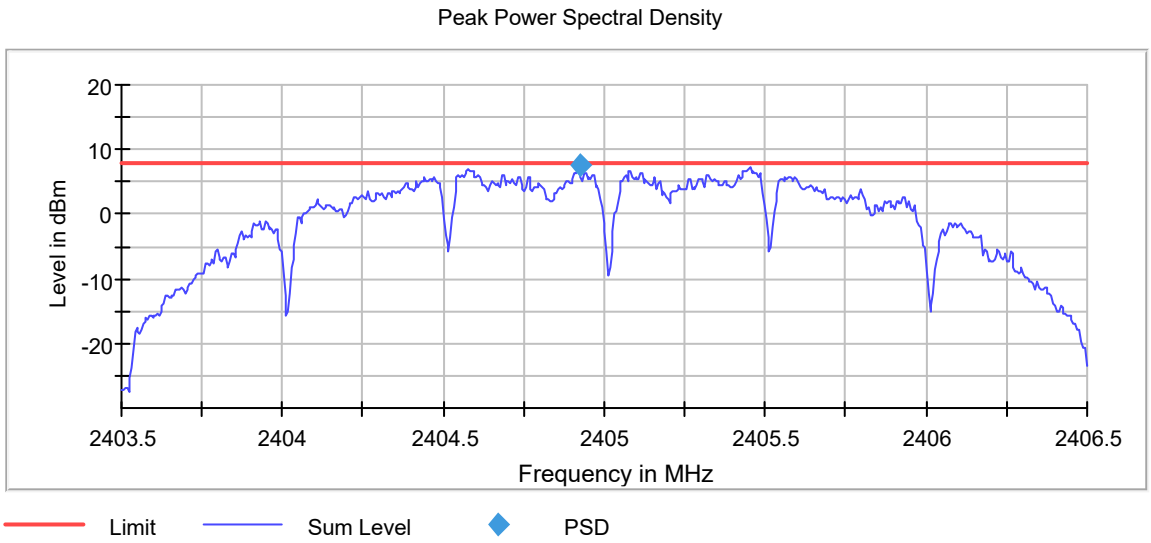
Mode	Transmitting – Bluetooth: 2440MHz
Parameters	Peak Power Spectral Density = -2.617
Test Date	February 25,2020
Notes	N/A



Mode	Transmitting – Bluetooth: 2480MHz
Parameters	Peak Power Spectral Density = -3.513
Test Date	February 25,2020
Notes	N/A

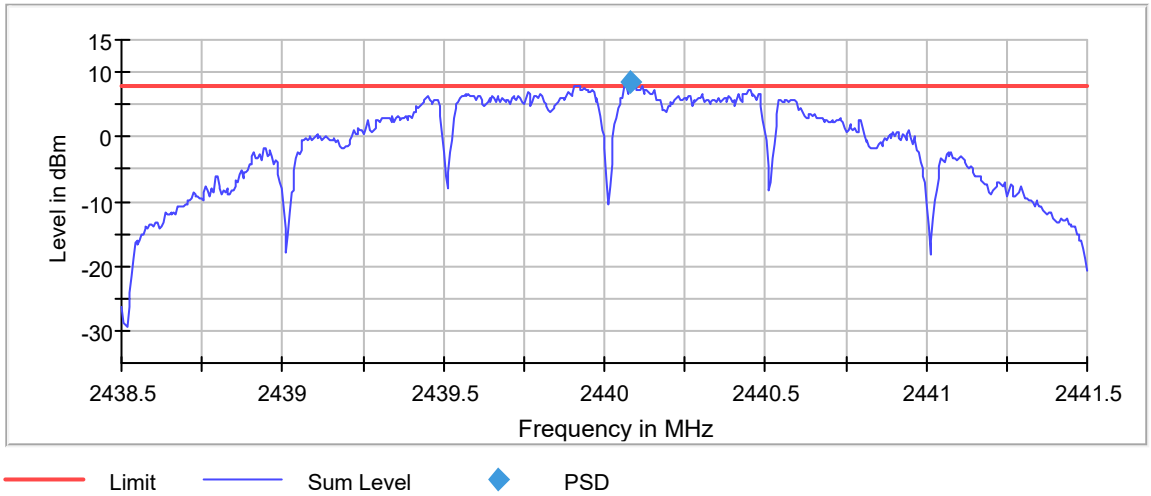


Mode	Transmitting – ZigBee: 2405MHz
Parameters	Peak Power Spectral Density = 7.481
Test Date	February 25,2020
Notes	N/A



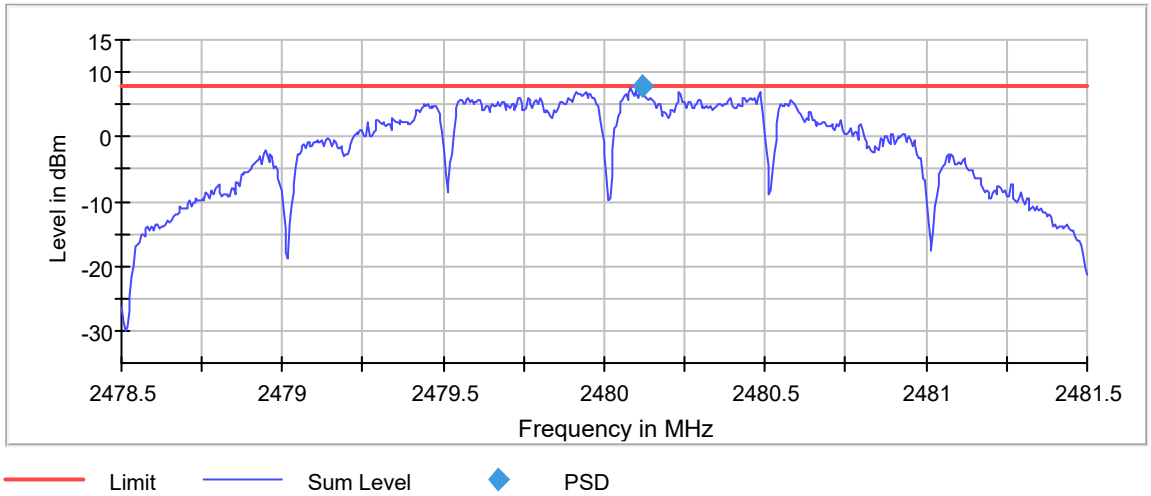
Mode	Transmitting – ZigBee: 2440MHz
Parameters	Peak Power Spectral Density = 5.254
Test Date	February 25,2020
Notes	N/A

Peak Power Spectral Density



Mode	Transmitting – ZigBee: 2480MHz
Parameters	Peak Power Spectral Density = 7.798
Test Date	February 25,2020
Notes	N/A

Peak Power Spectral Density



25. Scope of Accreditation

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

ELITE ELECTRONIC ENGINEERING, INC.
1516 Centre Circle
Downers Grove, IL 60515
Robert Bugielski (QA Manager) Phone: 630 495 9770 ext. 168
Email: rbugielski@elitetest.com
Craig Fanning (EMC Lab Manager) Phone: 630 495 9770 ext. 112
Email: cfanning@elitetest.com
Stanley Dolecki (Automotive Team Leader) Phone: 630 495 9770 ext. 103
Email: sdolecki@elitetest.com
Website: www.elitetest.com

ELECTRICAL

Valid to: June 30, 2021 Certificate Number: 1786.01

In recognition of the successful completion of the A2LA Accreditation Program evaluation process, accreditation is granted to this laboratory to perform the following automotive electromagnetic compatibility and other electrical tests:

Test Technology:	Test Method(s) [1]:
Transient Immunity	ISO 7637-2 (including emissions); ISO 7637-3; ISO 16750-2:2012, Sections 4.6.3 and 4.6.4; CS-11979, Section 6.4; CS.00054, Section 5.9; EMC-CS-2009.1 (CI220); FMC1278 (CI220, CI221, CI222); GMW 3097, Section 3.5; SAE J1113-11; SAE J1113-12
Electrostatic Discharge (ESD)	ISO 10605 (2001, 2008); CS-11979 Section 7.0; CS.00054, Section 5.10; EMC-CS-2009.1 (CI 280); FMC1278 (CI280); SAE J1113-13; GMW 3097 Section 3.6
Conducted Emissions	CISPR 25 (2002, 2008), Sections 6.2 and 6.3; CISPR 25 (2016), Sections 6.3 and 6.4; CS-11979, Section 5.1; CS.00054, Sections 5.6.1 and 5.6.2; GMW 3097, Section 3.3.2; EMC-CS-2009.1 (CE 420); FMC1278 (CE420, CE421)
Radiated Emissions Anechoic	CISPR 25 (2002, 2008), Section 6.4; CISPR 25 (2016), Section 6.5; CS-11979, Section 5.3; CS.00054, Section 5.6.3; GMW 3097, Section 3.3.1; EMC-CS-2009.1 (RE 310); FMC1278 (RE310)
Vehicle Radiated Emissions	CISPR 12; ICES-002

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5202 Presidents Court, Suite 220 | Frederick, MD 21703-8515 | Phone: 301 644 3248 | Fax: 240 454 9449 | www.A2LA.org

Test Technology:	Test Method(s)[1]:
Bulk Current Injection (BCI)	ISO 11452-4; CS-11979, Section 6.1; CS.00054, Section 5.8.1; GMW 3097, Section 3.4.1; SAE J1113-4; EMC-CS-2009.1 (RI112); FMC1278 (RI112)
Bulk Current Injections (BCI) *(Closed Loop Method)*	ISO 11452-4; SAE J1113-4
Radiated Immunity Anechoic *(Including Radar Pulse)*	ISO 11452-2; ISO 11452-5; CS-11979, Section 6.2; CS.00054, Section 5.8.2; GMW 3097, Section 3.4.2; EMC-CS-2009.1 (RI114); FMC1278 (RI114); SAE J1113-21
Radiated Immunity Magnetic Field	ISO 11452-8
Radiated Immunity Reverb	ISO/IEC 61000-4-21; GMW 3097, Section 3.4.3; EMC-CS-2009.1 (RI114); FMC1278 (RI114); ISO 11452-11
Radiated Immunity *(Portable Transmitters)*	ISO 11452-9; EMC-CS-2009.1 (RI115); FMC1278 (RI115)
Vehicle Radiated Immunity (ALSE)	ISO 11451-2
Electrical Loads	ISO 16750-2, Sections 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.11, and 4.12
Dielectric Withstand Voltage	MIL-STD-202, Method 301; EIA-364-20D
Insulation Resistance	MIL-STD-202, Method 302; SAE/USCAR-2, Revision 6, Section 5.5.1; EIA-364-21D
Contact Resistance	MIL-STD-202, Method 307; SAE/USCAR-2, Revision 6, Section 5.3.1; EIA/ECA-364-23C; USCAR21-3 Section 4.5.3
DC Resistance	MIL-STD-202, Method 303
Contact Chatter	MIL-STD-202, Method 310; SAE/USCAR-2, Revision 6, Section 5.1.9
Voltage Drop	SAE/USCAR-2, Revision 6, Section 5.3.2; USCAR21-3 Section 4.5.6

Test Technology:	Test Method(s) [1]:
Emissions	
Radiated and Conducted (3m Semi-anechoic chamber, up to 40 GHz)	47 CFR, FCC Part 15 B (using ANSI C63.4:2014); 47 CFR, FCC Part 18 (using FCC MP-5:1986); ICES-001; ICES-003; ICES-005; IEC/CISPR 11, Ed. 4.1 (2004-06); AS/NZS CISPR 11 (2004); IEC/CISPR 11 Ed 5 (2009-05) + A1 (2010); KN 11 (2008-5) with RRL Notice No. 2008-3 (May 20, 2008); CISPR 11; EN 55011; KN 11; CNS 13803 (1997, 2003); CISPR 14-1; EN 55014-1; AS/NZS CISPR 14.1; KN 14-1; IEC/CISPR 22 (1997); EN 55022 (1998) + A1(2000); EN 55022 (1998) + A1(2000) + A2(2003); EN 55022 (2006); IEC/CISPR 22 (2008-09); AS/NZS CISPR 22 (2004); AS/NZS CISPR 22, 3rd Edition (2006); KN 22 (up to 6 GHz); CNS 13438 (up to 6 GHz); VCCI V-3 (up to 6 GHz); CISPR 32; EN 55032; KN 32
Current Harmonics	IEC 61000-3-2; EN 61000-3-2; KN 61000-3-2
Flicker and Fluctuations	IEC 61000-3-3; EN 61000-3-3; KN 61000-3-3
Immunity	
Electrostatic Discharge	IEC 61000-4-2, Ed. 1.2 (2001); IEC 61000-4-2 (1995) + A1(1998) + A2(2000); EN 61000-4-2 (1995); EN 61000-4-2 (2009-05); KN 61000-4-2 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); IEC 61000-4-2; EN 61000-4-2; KN 61000-4-2; IEEE C37.90.3 2001
Radiated Immunity	IEC 61000-4-3 (1995) + A1(1998) + A2(2000); IEC 61000-4-3, Ed. 3.0 (2006-02); IEC 61000-4-3, Ed. 3.2 (2010); KN 61000-4-3 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); IEC 61000-4-3; EN 61000-4-3; KN 61000-4-3; IEEE C37.90.2 2004
Electrical Fast Transient/Burst	IEC 61000-4-4, Ed. 2.0 (2004-07); IEC 61000-4-4, Ed. 2.1 (2011); IEC 61000-4-4 (1995) + A1(2000) + A2(2001); KN 61000-4-4 (2008-5); RRL Notice No. 2008-5 (May 20, 2008); IEC 61000-4-4; EN 61000-4-4; KN 61000-4-4
Surge	IEC 61000-4-5 (1995) + A1(2000); IEC 61000-4-5, Ed 1.1 (2005-11); EN 61000-4-5 (1995) + A1(2001); KN 61000-4-5 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); IEC 61000-4-5; EN 61000-4-5; KN 61000-4-5; IEEE C37.90.1 2012

Test Technology:	Test Method(s)[1]:
Immunity (cont'd)	
Conducted Immunity	IEC 61000-4-6 (1996) + A1(2000); IEC 61000-4-6, Ed 2.0 (2006-05); IEC 61000-4-6 Ed. 3.0 (2008); KN 61000-4-6 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); EN 61000-4-6 (1996) + A1(2001); IEC 61000-4-6; EN 61000-4-6; KN 61000-4-6
Power Frequency Magnetic Field Immunity	IEC 61000-4-8 (1993) + A1(2000); IEC 61000-4-8 (2009); EN 61000-4-8 (1994) + A1(2000); KN 61000-4-8 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); IEC 61000-4-8; EN 61000-4-8; KN 61000-4-8
Voltage Dips, Short Interrupts, and Line Voltage Variations	IEC 61000-4-11, Ed. 2 (2004-03); KN 61000-4-11 (2008-5); RRL Notice No. 2008-4 (May 20, 2008); IEC 61000-4-11; EN 61000-4-11; KN 61000-4-11
Ring Wave	IEC 61000-4-12, Ed. 2 (2006-09); EN 61000-4-12:2006; IEC 61000-4-12; EN 61000-4-12; KN 61000-4-12
Generic and Product Specific EMC Standards	IEC/EN 61000-6-1; AS/NZS 61000-6-1; KN 61000-6-1; IEC/EN 61000-6-2; AS/NZS 61000-6-2; KN 61000-6-2; IEC/EN 61000-6-3; AS/NZS 61000-6-3; KN 61000-6-3; IEC/EN 61000-6-4; AS/NZS 61000-6-4; KN 61000-6-4; EN 50130-4; IEC 61326-1; IEC/CISPR 14-2; EN 55014-2; AS/NZS CISPR 14.2; KN 14-2; IEC/CISPR 24; AS/NZS CISPR 24; EN 55024; KN 24; IEC 60601-1-2; JIS T0601-1-2
TxRx EMC Requirements	EN 301 489-1; EN 301 489-3; EN 301 489-9; EN 301 489-17; EN 301 489-19; EN 301 489-52;
European Radio Test Standards	ETSI EN 300 086-1; ETSI EN 300 086-2; ETSI EN 300 113-1; ETSI EN 300 113-2; ETSI EN 300 220-1; ETSI EN 300 220-2; ETSI EN 300 330-1; ETSI EN 300 330-2; ETSI EN 300 440-1; ETSI EN 300 440-2; ETSI EN 300 422-1; ETSI EN 300 422-2; ETSI EN 300 328; ETSI EN 301 893; ETSI EN 301 511; ETSI EN 301 908-1; ETSI EN 908-2; ETSI EN 908-13; ETSI EN 301 413; ETSI EN 302 502

Test Technology:	Test Method(s)[1]:
Canadian Radio Tests	RSS-102 (RF Exposure Evaluation only); RSS-111; RSS-112; RSS-117; RSS-119; RSS-123; RSS-125; RSS-127; RSS-130; RSS-131; RSS-132; RSS-133; RSS-134; RSS-135; RSS-137; RSS-139; RSS-140; RSS-141; RSS-142; RSS-170; RSS-181; RSS-182; RSS-191; RSS-192; RSS-194; RSS-195; RSS-196; RSS-197; RSS-199; RSS-210; RSS-211; RSS-213; RSS-215; RSS-216; RSS-220; RSS-222; RSS-236; RSS-238; RSS-243; RSS-244; RSS-246; RSS-247; RSS-251; RSS-252; RSS-287; RSS-288; RSS-310; RSS-GEN
Mexico Radio Tests	IFT-008; NOM-208-SCFI
Japan Radio Tests	Radio Law No. 131, Ordinance of MPT No. 37, 1981, MIC Notification No. 88:2004, Table No. 22-11; ARIB STD-T66, Regulation 18
Taiwan Radio Tests	LP-0002
Australia/New Zealand Radio Tests	AS/NZS 4268; Radiocommunications (Short Range Devices) Standard (2014)
Hong Kong Radio Tests	HKCA 1039 Issue 6; HKCA 1042; HKCA 1033 Issue 7; HKCA 1061; HKCA 1008; HKCA 1043; HKCA 1057; HKCA 1073
Korean Radio Test Standards	KN 301 489-1; KN 301 489-3; KN 301 489-9; KN 301 489-17; KN 301 489-52
Unlicensed Radio Frequency Devices *(3 Meter Semi-Anechoic Room)*	47 CFR FCC Part 15C, 15D, 15E, 15F, 15G, 15H (using ANSI C63.10:2013, ANSI C63.17:2013 and FCC KDB 905462 D02 (v02))
Licensed Radio Service Equipment	47 CFR FCC Parts 20, 22, 24, 25, 27, 30, 73, 74, 80, 87, 90, 95, 96, 97, 101; ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015;
OTA (Over the Air) Performance GSM, GPRS, EGPRS UMTS (W-CDMA) LTE including CAT M1 A-GPS for UMTS/GSM LTS A-GPS, A-GLONASS, SIB8/SIB16 Large Device/Laptop/Tablet Testing Integrated Device Testing WiFi 802.11 a/b/g/n/ac	CTIA Test Plan for Wireless Device Over-the-Air Performance (Method for Measurement for Radiated Power and Receiver Performance) V3.8.2; CTIA Test Plan for RF Performance Evaluation of WiFi Mobile Converged Devices V2.1.0

Test Technology:	Test Method(s)[1]:
Electrical Measurements and Simulation	
AC Voltage / Current	FAA AC 150/5345-10H
(1mV to 5kV) 60 Hz	FAA AC 150/5345-43J
(0.1V to 250V) up to 500 MHz	FAA AC 150/5345-44K
(1µA to 150A) 60 Hz	FAA AC 150/5345-46E
DC Voltage / Current	FAA AC 150/5345-47C
(1mV to 15-kV) / (1µA to 10A)	FAA EB 67D
Power Factor / Efficiency / Crest Factor	
(Power to 30kW)	
Resistance	
(1mΩ to 4000MΩ)	
Surge	
(Up to 10 kV / 5 kA) (Combination Wave and Ring Wave)	

On the following products and materials:
Telecommunications Terminal Equipment (TTE), Radio Equipment, Network Equipment, Information Technology Equipment (ITE), Automotive Electronic Equipment, Automotive Hybrid Electronic Devices, Maritime Navigation and Radio Communication Equipment and Systems, Vehicles, Boats and Internal Combustion Engine Driven Devices, Automotive, Aviation, and General Lighting Products, Medical Electrical Equipment, Motors, Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment, Household Appliances, Electric Tools, Low-voltage Switchgear and Control gear, Programmable Controllers, Electrical Equipment for Measurement, Control and Laboratory Use, Base Materials, Power and Data Transmission Cables and Connectors

[1] When the date, revision or edition of a test method standard is not identified on the scope of accreditation, the laboratory is expected to be using the current version within one year of the date of publication, per part C., Section 1 of A2LA *R101 - General Requirements - Accreditation of ISO-IEC 17025 Laboratories*.

Testing Activities Performed in Support of FCC Declaration of Conformity and Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
Unintentional Radiators Part 15B	ANSI C63.4:2014	40000
Industrial, Scientific, and Medical Equipment Part 18	FCC MP-5 (February 1986)	40000
Intentional Radiators Part 15C	ANSI C63.10:2013	40000
Unlicensed Personal Communication Systems Devices Part 15D	ANSI C63.17:2013	40000

Testing Activities Performed in Support of FCC Declaration of Conformity and Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
U-NII without DFS Intentional Radiators Part 15E	ANSI C63.10:2013	40000
U-NII with DFS Intentional Radiators Part 15E	FCC KDB 905462 D02 (v02)	40000
UWB Intentional Radiators Part 15F	ANSI C63.10:2013	40000
BPL Intentional Radiators Part 15G	ANSI C63.10:2013	40000
White Space Device Intentional Radiators Part 15H	ANSI C63.10:2013	40000
Commercial Mobile Services (FCC Licensed Radio Service Equipment) Parts 22 (cellular), 24, 25 (below 3 GHz), and 27	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
General Mobile Radio Services (FCC Licensed Radio Service Equipment) Parts 22 (non-cellular), 90 (below 3 GHz), 95, 97, and 101 (below 3 GHz)	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
Citizens Broadband Radio Services (FCC Licensed Radio Service Equipment) Part 96	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
Maritime and Aviation Radio Services Parts 80 and 87	ANSI/TIA-603-E; ANSI C63.26:2015	40000
Microwave and Millimeter Bands Radio Services Parts 25, 30, 74, 90 (above 3 GHz), 97 (above 3 GHz), and 101	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000
Broadcast Radio Services Parts 73 and 74 (below 3 GHz)	ANSI/TIA-603-E; TIA-102.CAAA-E; ANSI C63.26:2015	40000

Testing Activities Performed in Support of FCC Declaration of Conformity and Certification in Accordance with 47 Code of Federal Regulations and FCC KDB 974614, Appendix A, Table A.1[2]

Rule Subpart/Technology	Test Method	Maximum Frequency (MHz)
Signal Boosters Part 20 (Wideband Consumer Signal Boosters, Provider-specific signal boosters, and Industrial Signal Boosters) Section 90.219	ANSI C63.26:2015	40000

[2]Accreditation does not imply acceptance to the FCC equipment authorization program. Please see the FCC website (https://apps.fcc.gov/oetcf/eas/) for a listing of FCC approved laboratories.

Accredited Laboratory

A2LA has accredited

ELITE ELECTRONIC ENGINEERING INC.

Downers Grove, IL

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system *(refer to joint ISO-ILAC-IAF Communiqué dated April 2017)*.

Presented this 8th day of August 2019.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 1786.01
Valid to June 30, 2021

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.