# INGERSOLL-RAND INDUSTRIAL U.S. INC.

# TEST REPORT

**SCOPE OF WORK**
Emissions Testing on Model QX5PM for Class II Permissive Change

**REPORT NUMBER**
105295733BOX-012

**ISSUE DATE**
03/26/2024

**[REVISED DATE]**
Original issue

**DOCUMENT CONTROL NUMBER**
Non-Specific Radio Report Shell Rev. December 2017


# EMISSIONS TEST REPORT

(FULL COMPLIANCE) – CLASS II PERMISSIVE CHANGE

**Report Number:** 105295733BOX-012
**Project Number:** G105295733

**Report Issue Date:** 03/26/2024

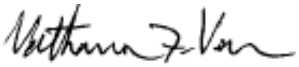
**Model(s) Tested:** QX5PM
**Model(s) Partially Tested:** None
**Model(s) Not Tested but declared equivalent by the client:** None

**Standards:** CFR47 FCC Part 15.247 Subpart C: 03/2024,
CFR47 FCC Part 15 Subpart B: 03/2024,
RSS-247 Issue 3 August 2023,
ISED ICES-003 Issue 7 October 2020,
RSS-Gen Issue 5 April 2018 +Amendment 1 March 2019

Tested by:
Intertek Testing Services NA, Inc.
70 Codman Hill Road
Boxborough, MA 01719
USA

Client:
Ingersoll-Rand Industrial U.S. Inc.
53 Frontage Rd Ste 250
Hampton, NJ 08827
USA

Report prepared by



Vathana Ven / Senior Staff Engineer

Report reviewed by

Kouma Sinn / Senior Staff Engineer

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## 1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

## 2 Test Summary

| Section | Test full name | Result |
|---|---|---|
| 3 | Client Information | -- |
| 4 | Description of Equipment Under Test and Variant Models | -- |
| 5 | System Setup and Method | -- |
| 6 | Maximum Peak Output Power<br>CFR47 FCC Part 15 Subpart C:03/2024, Section 15.247 (b)(3)<br>RSS-247 Issue 3 August 2023 | Pass |
| 7 | Maximum Power Spectral Density<br>CFR47 FCC Part 15 Subpart C: 03/2024, Section 15.247 (e)<br>RSS-247 Issue 3 August 2023 | Pass |
| 8 | Band Edge Compliance<br>CFR47 FCC Part 15 Subpart C: 03/2024, Section 15.247 (d)<br>RSS-247 Issue 3 August 2023 | Pass |
| 9 | Transmitter spurious emissions<br>CFR47 FCC Part 15 Subpart C: 03/2024, Section 15.247 (d)<br>RSS-247 Issue 3 August 2023 | Pass |
| 10 | Digital Device and Receiver Radiated Spurious Emissions<br>CFR47 FCC Part 15 Subpart B 15.109: 03/2024,<br>ISED ICES-003 Issue 7 October 2020 | Pass |
| --- | AC Mains Conducted Emissions<br>FCC 47CFR Part 15.107: 03/2024<br>ISED ICES-003 Issue 7 October 2020 | N/A* |
| 11 | Revision History | -- |

Note: *The device is battery powered.
This is a class II permissive. Only selected tests as listed above were performed.

## 3 Client Information

**This EUT was tested at the request of:**

**Client:** Ingersoll-Rand Industrial U.S. Inc.
53 Frontage Rd Ste 250
Hampton, NJ 08827
USA

**Contact:** Graham Ginder
**Telephone:** Not Provided
**Email:** graham.ginder@irco.com

## 4 Description of Equipment Under Test and Variant Models

**Manufacturer:** Ingersoll-Rand Industrial U.S. Inc.
53 Frontage Rd Ste 250
Hampton, NJ 08827
USA

| Equipment Under Test | | | |
|---|---|---|---|
| Description | Manufacturer | Model Number | Serial Number |
| Pistol Driver | Ingersoll-Rand Industrial U.S. Inc. | QX5PM | SP23B24508 (BLE) |
| Pistol Driver | Ingersoll-Rand Industrial U.S. Inc. | QX5PM | SP23B24505 (802.15.4) |

| | |
|---|---|
| Receive Date: | 03/28/2023 |
| Received Condition: | Good |
| Type: | Production |

| Description of Equipment Under Test (provided by client) |
|---|
| The EUT is a Pistol Angle Wrench. Testing was performed for Class 2 Permissive Change filing. Original FCC ID: 2ATB3-QXXSTM32W, Intertek test report # 104363035BOX-003. |

| Equipment Under Test Power Configuration | | | |
|---|---|---|---|
| Rated Voltage | Rated Current | Rated Frequency | Number of Phases |
| 40 VDC | 2.5 Ah | N/A | N/A |

**Operating modes of the EUT:**

| No. | Descriptions of EUT Exercising |
|---|---|
| 1 | The EUT was set to transmit at Low, Mid, and High channel continuous with modulation at 100 % duty cycle. |
| 2 | The EUT was set to receive mode. |

**Software used by the EUT:**

| No. | Descriptions of EUT Exercising |
|---|---|
| 1 | Clear Terminal version 2.0.0.4 |
| 2 | STM32CubeMonitor_RF version 2.5.0 |

| Radio/Receiver Characteristics BLE Pistol Driver (worst-case) | |
|---|---|
| **Frequency Band(s)** | 2402-2480 MHz |
| **Modulation Type(s)** | GFSK |
| **Maximum Output Power** | 13.69 dBm EIRP (Pistol Angle Wrench) |
| **Test Channels** | Low Channel (2402 MHz)<br>Mid Channel (2442 MHz)<br>High Channel (2480 MHz) |
| **Frequency Hopper: Number of Hopping Channels** | N/A |
| **Frequency Hopper: Channel Dwell Time** | N/A |
| **Frequency Hopper: Max interval between two instances of use of the same channel** | N/A |
| **MIMO Information (# of Transmit and Receive antenna ports)** | 1 |
| **Equipment Type** | Standalone |
| **Antenna Type and Gain** | Integrated, 2 dBi |

| Radio/Receiver Characteristics 802.15.4 Pistol Driver (worst-case) | |
|---|---|
| **Frequency Band(s)** | 2405-2480 MHz |
| **Modulation Type(s)** | QPSK |
| **Maximum Output Power** | 4.82 dBm EIRP (Pistol Angle Wrench) |
| **Test Channels** | Low Channel (2405 MHz)<br>Mid Channel (2440 MHz)<br>High Channel (2480 MHz) |
| **Frequency Hopper: Number of Hopping Channels** | N/A |
| **Frequency Hopper: Channel Dwell Time** | N/A |
| **Frequency Hopper: Max interval between two instances of use of the same channel** | N/A |
| **MIMO Information (# of Transmit and Receive antenna ports)** | 1 |
| **Equipment Type** | Standalone |
| **Antenna Type and Gain** | Integrated, 2 dBi |

**Variant Models:**

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

None

## 5 System Setup and Method

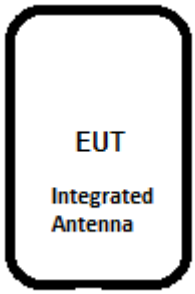
| Cables | | | | | |
|---|---|---|---|---|---|
| ID | Description | Length (m) | Shielding | Ferrites | Termination |
| -- | None | -- | -- | -- | -- |
| | | | | | |

| Support Equipment | | | |
|---|---|---|---|
| Description | Manufacturer | Model Number | Serial Number |
| 40V Lithium Ion battery Pack | INGERSOLL RAND | BL4011 | Not Labelled |
| Li-ion charger | INGERSOLL RAND | BL1121 | P120G0208 |
| Li-ion charger | INGERSOLL RAND | BL1161 | PI19F0280 |
| Laptop | HP | EliteBook 8470p | Not Labelled |

### 5.1 Method:

Configuration as required by Configuration as required by FCC Part 15 Subpart C 15.247: 03/2024, FCC Part 15 Subpart B: 03/2024, RSS 247 Issue 3 August 2023, ISED ICES-003 Issue 7 October 2020, RSS-Gen Issue 5 April 2018 +Amendment 1 March 2019, ANSI C 63.10: 2013, ANSI C 63.4: 2014, and 558074 D0115.247Meas Guidancev05r02.

### 5.2 EUT Block Diagram:



# 6 Maximum Peak Output Power

## 6.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and KDB 558074 D0115.247 Meas Guidancev05r02.

**TEST SITE:** 10m ALSE

The 10m Absorber-lined Shielded Enclosures (ALSE) is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

**Measurement Uncertainty**

| Measurement | Frequency Range | Expanded Uncertainty (k=2) | Ucispr |
|---|---|---|---|
| Radiated Emissions, 10m | 30-1000 MHz | 5.6 dB | 6.3 dB |
| Radiated Emissions, 3m | 30-1000 MHz | 4.9 dB | 6.3 dB |
| Radiated Emissions, 3m | 1-6 GHz | 4.4 dB | 5.2 dB |
| Radiated Emissions, 3m | 6-15 GHz | 4.9 dB | 5.5 dB |
| Radiated Emissions, 3m | 15-18 GHz | 4.6 dB | 5.5 dB |
| Radiated Emissions, 3m | 18-40 GHz | 4.6 dB | 5.5 dB |

As shown in the table above our radiated emissions $U_{lab}$ is less than the corresponding $U_{CISPR}$ reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

**Sample Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

**Example:**

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

## 6.2 Test Equipment Used:

| Asset | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DAV007' | Weather Station Vantage Vue | Davis | 6250 | MS191212003 | 03/15/2023 | 03/15/2024 |
| ETS002' | 1-18GHz DRG Horn Antenna | ETS Lindgren | 3117 | 00143260 | 09/27/2022 | 09/27/2023 |
| 145108' | EMI Test Receiver (20Hz - 40GHz) | Rohde & Schwarz | ESIB40 | 100209 | 06/23/2022 | 06/23/2023 |
| IW001' | 2 meter cable | Insulated Wire | 2801-NPS | 001 | 07/14/2022 | 07/14/2023 |
| 145-420' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| 145-414' | Cable 145-414 | Huber + Suhner | 3m Track A cable | 145-414 | 07/14/2022 | 07/14/2023 |
| IW003' | 8.4 meter cable | Insulated Wire | 2800-NPS | 003 | 11/14/2022 | 11/14/2023 |

**Software Utilized:**

| Name | Manufacturer | Version |
|---|---|---|
| None | --- | --- |

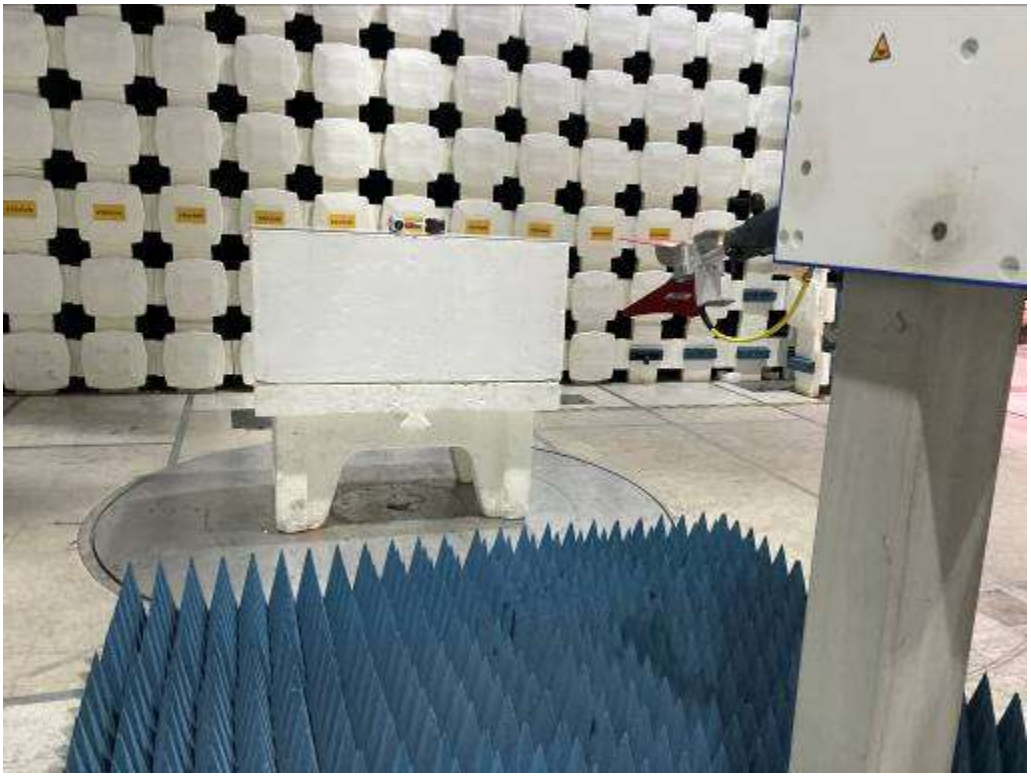
## 6.3 Results:

The sample tested was found to Comply.

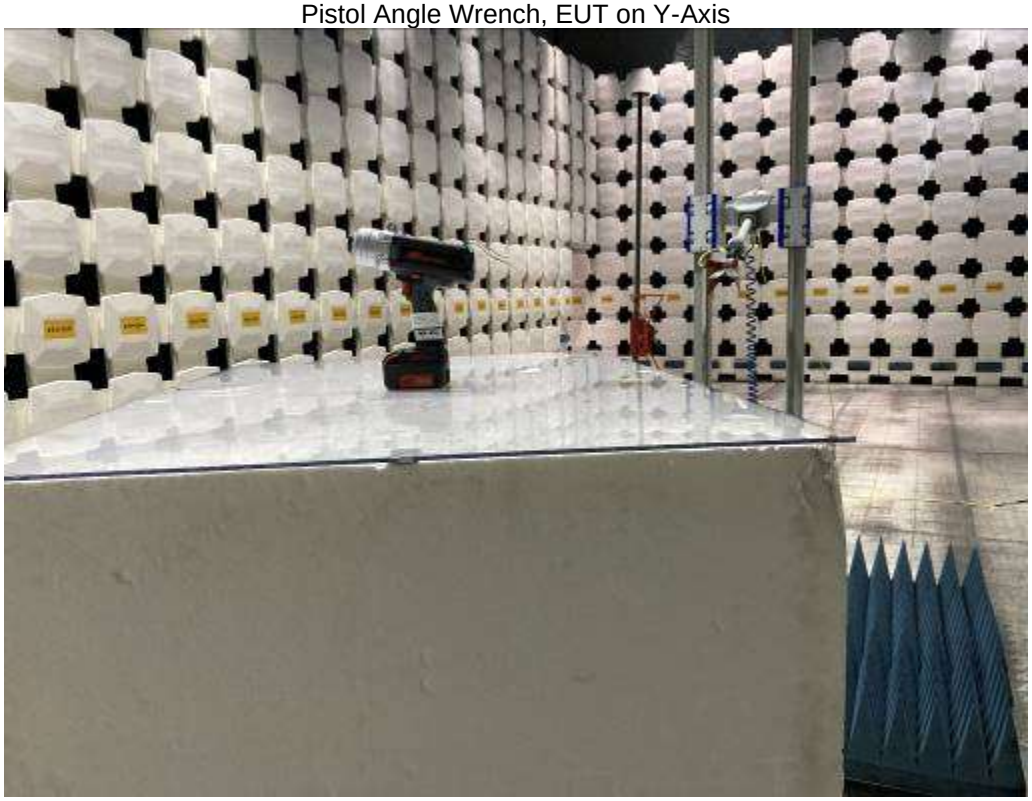
§15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt or 30 dBm or 36 dBm EIRP.

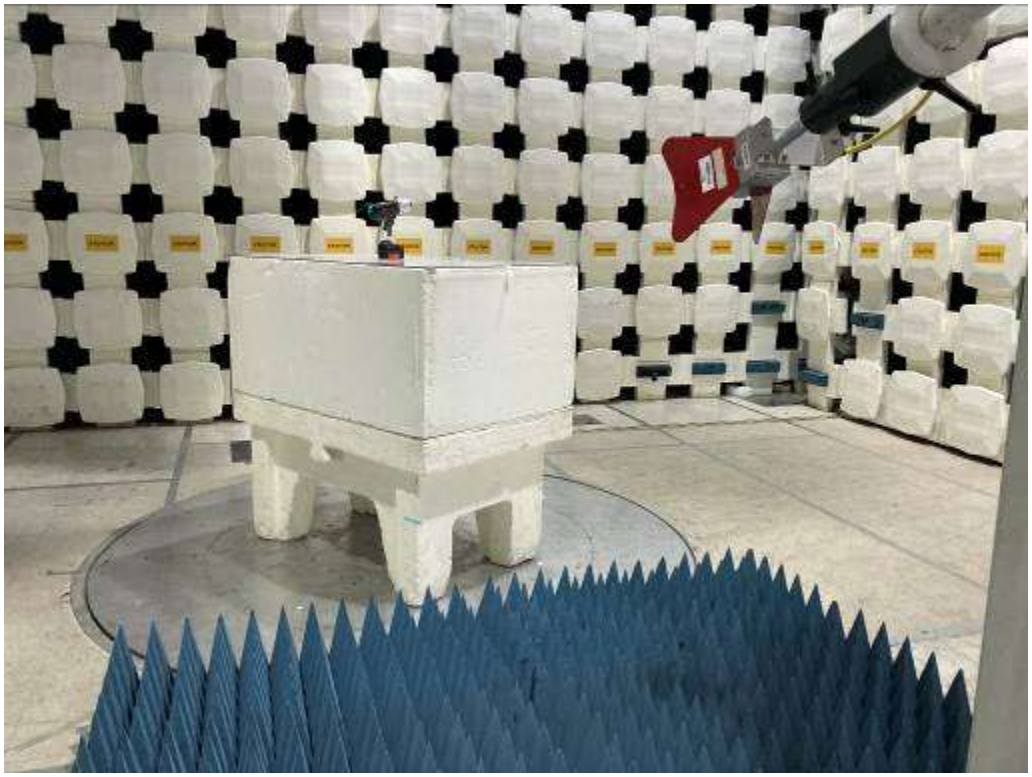
## 6.4 Setup Photograph:

Pistol Angle Wrench, EUT on X-Axis

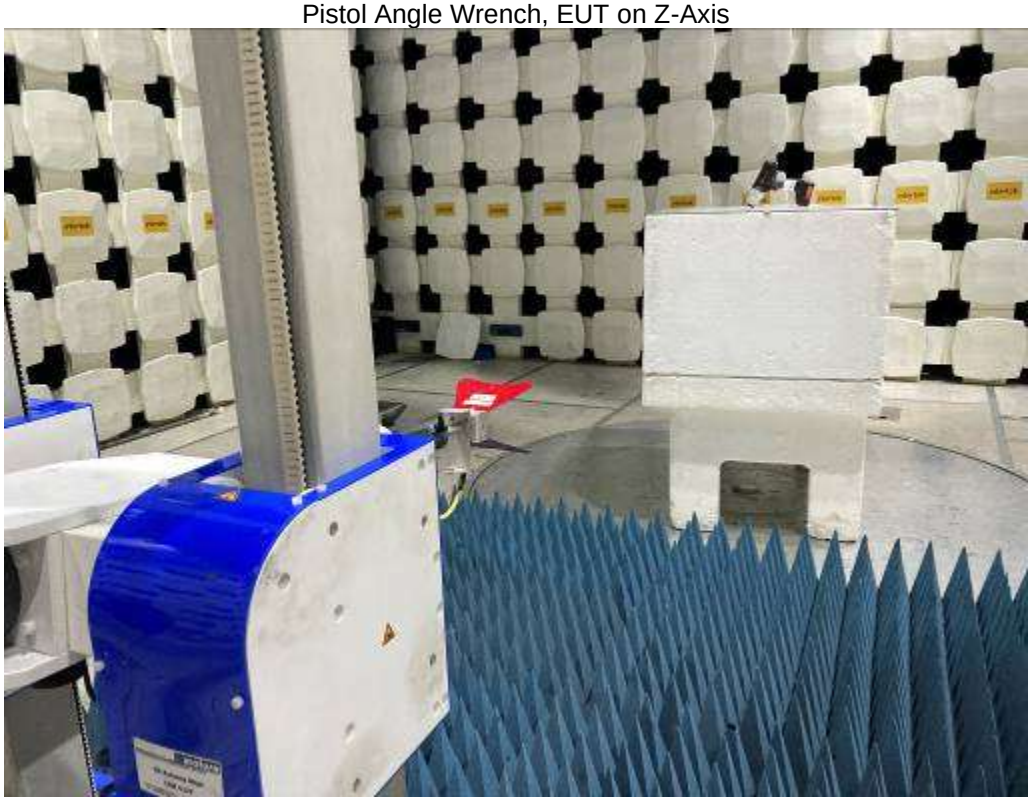


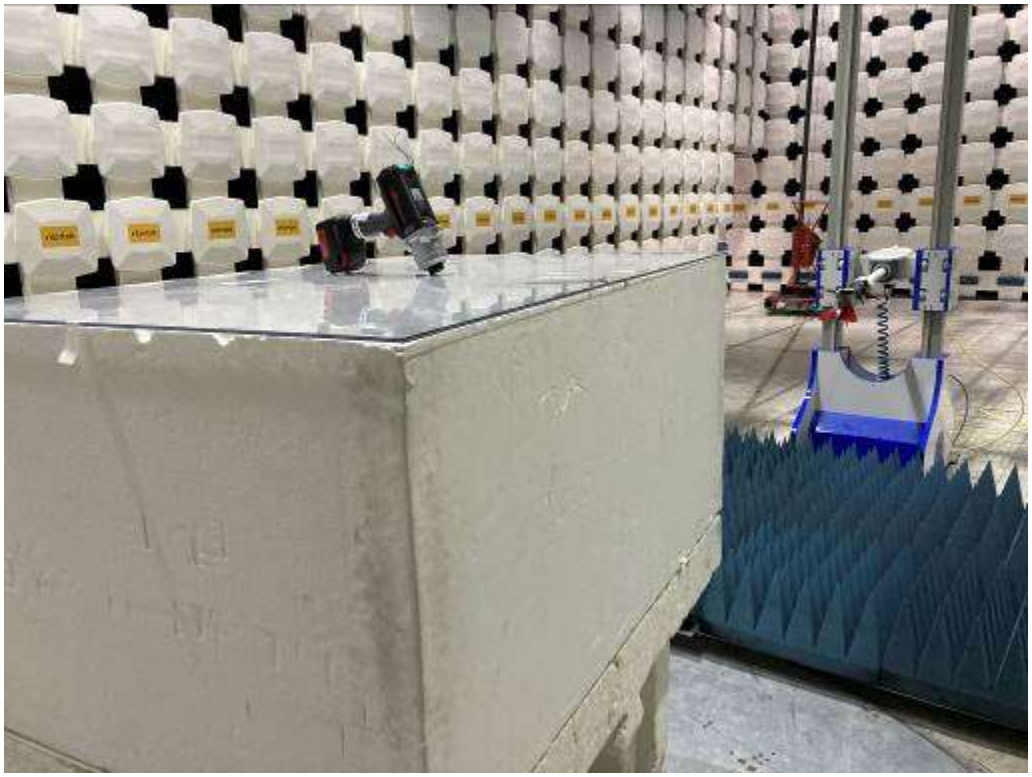
Pistol Angle Wrench, EUT on Y-Axis





Pistol Angle Wrench, EUT on Z-Axis





## 6.5 Test Data:

BLE- Output power, Pistol Angle Wrench

**Radiated Spurious Emissions**

Company: Ingersoll Rand | Antenna & Cables: HF | Bands: N, LF, HF, SHF
Model #: QX5PM (BLE) | Antenna: ETS002 | ETS002
Serial #: SP23B24508 | Cable(s): IW001, IW004, 145-414, 145-420 | IW001, IW004, 145-414, 145-420
Engineers: Vathana Ven | Location: 10m Chamber | Barometer: DAV006 | Filter: NONE
Project #: G105295733 | Date(s): 03/30/23
Standard: FCC Part 15 Subpart C 15.247 | Temp/Humidity/Pressure: 25 deg C | 18% | 1012 mB
Receiver: R&S ESIB40 (145-108) | Limit Distance (m): 3
PreAmp: No | Test Distance (m): 3
PreAmp Used? (Y or N): N | Voltage/Frequency: Battery power | Frequency Range: Frequencies Shown

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)

Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | EIRP Net dBm | EIRP Limit dBm | Margin dB | Bandwidth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: RF Output Power (BLE), Level setting = 25 (0 dBm) - X-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| PK | V | 2402.000 | 63.81 | 31.95 | 5.85 | 0.00 | 0.00 | 6.39 | 36.00 | -29.61 | 5/10 MHz |
| PK | H | 2402.000 | 58.72 | 31.95 | 5.85 | 0.00 | 0.00 | 1.30 | 36.00 | -34.70 | 5/10 MHz |
| PK | V | 2402.000 | 63.46 | 31.95 | 5.85 | 0.00 | 0.00 | 6.04 | 36.00 | -29.96 | 1/3 MHz |
| PK | H | 2402.000 | 58.33 | 31.95 | 5.85 | 0.00 | 0.00 | 0.91 | 36.00 | -35.09 | 1/3 MHz |
| PK | V | 2442.000 | 67.32 | 32.08 | 5.85 | 0.00 | 0.00 | 10.03 | 36.00 | -25.97 | 5/10 MHz |
| PK | H | 2442.000 | 61.76 | 32.08 | 5.85 | 0.00 | 0.00 | 4.47 | 36.00 | -31.53 | 5/10 MHz |
| PK | V | 2442.000 | 66.79 | 32.08 | 5.85 | 0.00 | 0.00 | 9.50 | 36.00 | -26.50 | 1/3 MHz |
| PK | H | 2442.000 | 61.25 | 32.08 | 5.85 | 0.00 | 0.00 | 3.96 | 36.00 | -32.04 | 1/3 MHz |
| PK | V | 2480.000 | 66.51 | 32.43 | 5.85 | 0.00 | 0.00 | 9.57 | 36.00 | -26.43 | 5/10 MHz |
| PK | H | 2480.000 | 65.82 | 32.43 | 5.85 | 0.00 | 0.00 | 8.88 | 36.00 | -27.12 | 5/10 MHz |
| PK | V | 2480.000 | 66.16 | 32.43 | 5.85 | 0.00 | 0.00 | 9.22 | 36.00 | -26.78 | 1/3 MHz |
| PK | H | 2480.000 | 65.54 | 32.43 | 5.85 | 0.00 | 0.00 | 8.60 | 36.00 | -27.40 | 1/3 MHz |
| Note: RF Output Power (BLE), Level setting = 25 (0 dBm) - Y-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| PK | V | 2402.000 | 62.05 | 31.95 | 5.85 | 0.00 | 0.00 | 4.63 | 36.00 | -31.37 | 5/10 MHz |
| PK | H | 2402.000 | 61.76 | 31.95 | 5.85 | 0.00 | 0.00 | 4.34 | 36.00 | -31.66 | 5/10 MHz |
| PK | V | 2402.000 | 61.74 | 31.95 | 5.85 | 0.00 | 0.00 | 4.32 | 36.00 | -31.68 | 1/3 MHz |
| PK | H | 2402.000 | 61.47 | 31.95 | 5.85 | 0.00 | 0.00 | 4.05 | 36.00 | -31.95 | 1/3 MHz |
| PK | V | 2442.000 | 66.23 | 32.08 | 5.85 | 0.00 | 0.00 | 8.94 | 36.00 | -27.06 | 5/10 MHz |
| PK | H | 2442.000 | 68.71 | 32.08 | 5.85 | 0.00 | 0.00 | 11.42 | 36.00 | -24.58 | 5/10 MHz |
| PK | V | 2442.000 | 65.66 | 32.08 | 5.85 | 0.00 | 0.00 | 8.37 | 36.00 | -27.63 | 1/3 MHz |
| PK | H | 2442.000 | 68.35 | 32.08 | 5.85 | 0.00 | 0.00 | 11.06 | 36.00 | -24.94 | 1/3 MHz |
| PK | V | 2480.000 | 67.69 | 32.43 | 5.85 | 0.00 | 0.00 | 10.75 | 36.00 | -25.25 | 5/10 MHz |
| PK | H | 2480.000 | 70.63 | 32.43 | 5.85 | 0.00 | 0.00 | 13.69 | 36.00 | -22.31 | 5/10 MHz |
| PK | V | 2480.000 | 67.18 | 32.43 | 5.85 | 0.00 | 0.00 | 10.24 | 36.00 | -25.76 | 1/3 MHz |
| PK | H | 2480.000 | 70.28 | 32.43 | 5.85 | 0.00 | 0.00 | 13.34 | 36.00 | -22.66 | 1/3 MHz |
| Note: RF Output Power (BLE), Level setting = 25 (0 dBm) - Z-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| PK | V | 2402.000 | 56.22 | 31.95 | 5.85 | 0.00 | 0.00 | -1.20 | 36.00 | -37.20 | 5/10 MHz |
| PK | H | 2402.000 | 66.93 | 31.95 | 5.85 | 0.00 | 0.00 | 9.51 | 36.00 | -26.49 | 5/10 MHz |
| PK | V | 2402.000 | 55.77 | 31.95 | 5.85 | 0.00 | 0.00 | -1.65 | 36.00 | -37.65 | 1/3 MHz |
| PK | H | 2402.000 | 66.30 | 31.95 | 5.85 | 0.00 | 0.00 | 8.88 | 36.00 | -27.12 | 1/3 MHz |
| PK | V | 2442.000 | 61.30 | 32.08 | 5.85 | 0.00 | 0.00 | 4.01 | 36.00 | -31.99 | 5/10 MHz |
| PK | H | 2442.000 | 70.50 | 32.08 | 5.85 | 0.00 | 0.00 | 13.21 | 36.00 | -22.79 | 5/10 MHz |
| PK | V | 2442.000 | 60.88 | 32.08 | 5.85 | 0.00 | 0.00 | 3.59 | 36.00 | -32.41 | 1/3 MHz |
| PK | H | 2442.000 | 70.02 | 32.08 | 5.85 | 0.00 | 0.00 | 12.73 | 36.00 | -23.27 | 1/3 MHz |
| PK | V | 2480.000 | 61.90 | 32.43 | 5.85 | 0.00 | 0.00 | 4.96 | 36.00 | -31.04 | 5/10 MHz |
| PK | H | 2480.000 | 67.84 | 32.43 | 5.85 | 0.00 | 0.00 | 10.90 | 36.00 | -25.10 | 5/10 MHz |
| PK | V | 2480.000 | 61.49 | 32.43 | 5.85 | 0.00 | 0.00 | 4.55 | 36.00 | -31.45 | 1/3 MHz |
| PK | H | 2480.000 | 67.41 | 32.43 | 5.85 | 0.00 | 0.00 | 10.47 | 36.00 | -25.53 | 1/3 MHz |

# 802.15.4 - Output power, Pistol Angle Wrench

**Radiated Emissions**

Company: Ingersoll Rand
Model #: QX5PM (802.15.4)
Serial #: SP23B24505
Engineers: Vathana Ven
Project #: G105295733
Standard: FCC Part 15 Subpart C 15.247
Receiver: R&S ESIB40 (145-108)
PreAmp: No
PreAmp Used? (Y or N): N
Date(s): 03/28/23
Limit Distance (m): 3
Test Distance (m): 3
Location: 10m Chamber
Voltage/Frequency: Battery power
Antenna & Cables: HF
Antenna: ETS002
Cable(s): IW001, IW003, 145-414, 145-420
Barometer: DAV006
Temp/Humidity/Pressure: 23 deg C
Bands: N, LF, HF, SHF
ETS002
IW001, IW003, 145-414, 145-420
Filter: NONE
28%
1007mB
Frequency Range: Frequencies Shown

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)

Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | EIRP Net dBm | EIRP Limit dBm | Margin dB | Bandwidth | FCC | IC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: RF Output Power (802.15.4), PA Level setting = 1, Power Level setting = -3 - X-Axis | | | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | | | |
| PK | V | 2405.000 | 52.16 | 31.95 | 5.85 | 0.00 | 0.00 | -5.26 | 36.00 | -41.26 | 5/10 MHz | | |
| PK | H | 2405.000 | 46.50 | 31.95 | 5.85 | 0.00 | 0.00 | -10.92 | 36.00 | -46.92 | 5/10 MHz | | |
| PK | V | 2405.000 | 50.33 | 31.95 | 5.85 | 0.00 | 0.00 | -7.09 | 36.00 | -43.09 | 1/3 MHz | | |
| PK | H | 2405.000 | 43.13 | 31.95 | 5.85 | 0.00 | 0.00 | -14.29 | 36.00 | -50.29 | 1/3 MHz | | |
| PK | V | 2440.000 | 55.42 | 32.08 | 5.85 | 0.00 | 0.00 | -1.87 | 36.00 | -37.87 | 5/10 MHz | | |
| PK | H | 2440.000 | 51.12 | 32.08 | 5.85 | 0.00 | 0.00 | -6.17 | 36.00 | -42.17 | 5/10 MHz | | |
| PK | V | 2440.000 | 54.55 | 32.08 | 5.85 | 0.00 | 0.00 | -2.74 | 36.00 | -38.74 | 1/3 MHz | | |
| PK | H | 2440.000 | 50.03 | 32.08 | 5.85 | 0.00 | 0.00 | -7.26 | 36.00 | -43.26 | 1/3 MHz | | |
| PK | V | 2480.000 | 60.50 | 32.43 | 5.85 | 0.00 | 0.00 | 3.56 | 36.00 | -32.44 | 5/10 MHz | | |
| PK | H | 2480.000 | 52.87 | 32.43 | 5.85 | 0.00 | 0.00 | -4.07 | 36.00 | -40.07 | 5/10 MHz | | |
| PK | V | 2480.000 | 60.29 | 32.43 | 5.85 | 0.00 | 0.00 | 3.35 | 36.00 | -32.65 | 1/3 MHz | | |
| PK | H | 2480.000 | 52.52 | 32.43 | 5.85 | 0.00 | 0.00 | -4.42 | 36.00 | -40.42 | 1/3 MHz | | |
| Note: RF Output Power (802.15.4), PA Level setting = 1, Power Level setting = -3 - Y-Axis | | | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | | | |
| PK | V | 2405.000 | 47.21 | 31.95 | 5.85 | 0.00 | 0.00 | -10.21 | 36.00 | -46.21 | 5/10 MHz | | |
| PK | H | 2405.000 | 51.30 | 31.95 | 5.85 | 0.00 | 0.00 | -6.12 | 36.00 | -42.12 | 5/10 MHz | | |
| PK | V | 2405.000 | 46.65 | 31.95 | 5.85 | 0.00 | 0.00 | -10.77 | 36.00 | -46.77 | 1/3 MHz | | |
| PK | H | 2405.000 | 51.04 | 31.95 | 5.85 | 0.00 | 0.00 | -6.38 | 36.00 | -42.38 | 1/3 MHz | | |
| PK | V | 2440.000 | 53.17 | 32.08 | 5.85 | 0.00 | 0.00 | -4.12 | 36.00 | -40.12 | 5/10 MHz | | |
| PK | H | 2440.000 | 57.69 | 32.08 | 5.85 | 0.00 | 0.00 | 0.40 | 36.00 | -35.60 | 5/10 MHz | | |
| PK | V | 2440.000 | 52.12 | 32.08 | 5.85 | 0.00 | 0.00 | -5.17 | 36.00 | -41.17 | 1/3 MHz | | |
| PK | H | 2440.000 | 56.77 | 32.08 | 5.85 | 0.00 | 0.00 | -0.52 | 36.00 | -36.52 | 1/3 MHz | | |
| PK | V | 2480.000 | 57.56 | 32.43 | 5.85 | 0.00 | 0.00 | 0.62 | 36.00 | -35.38 | 5/10 MHz | | |
| PK | H | 2480.000 | 61.76 | 32.43 | 5.85 | 0.00 | 0.00 | 4.82 | 36.00 | -31.18 | 5/10 MHz | | |
| PK | V | 2480.000 | 57.41 | 32.43 | 5.85 | 0.00 | 0.00 | 0.47 | 36.00 | -35.53 | 1/3 MHz | | |
| PK | H | 2480.000 | 61.55 | 32.43 | 5.85 | 0.00 | 0.00 | 4.61 | 36.00 | -31.39 | 1/3 MHz | | |
| Note: RF Output Power (802.15.4), PA Level setting = 1, Power Level setting = -3 - Z-Axis | | | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | | | |
| PK | V | 2405.000 | 42.35 | 31.95 | 5.85 | 0.00 | 0.00 | -15.07 | 36.00 | -51.07 | 5/10 MHz | | |
| PK | H | 2405.000 | 50.66 | 31.95 | 5.85 | 0.00 | 0.00 | -6.76 | 36.00 | -42.76 | 5/10 MHz | | |
| PK | V | 2405.000 | 41.76 | 31.95 | 5.85 | 0.00 | 0.00 | -15.66 | 36.00 | -51.66 | 1/3 MHz | | |
| PK | H | 2405.000 | 50.84 | 31.95 | 5.85 | 0.00 | 0.00 | -6.58 | 36.00 | -42.58 | 1/3 MHz | | |
| PK | V | 2440.000 | 50.40 | 32.08 | 5.85 | 0.00 | 0.00 | -6.89 | 36.00 | -42.89 | 5/10 MHz | | |
| PK | H | 2440.000 | 55.96 | 32.08 | 5.85 | 0.00 | 0.00 | -1.33 | 36.00 | -37.33 | 5/10 MHz | | |
| PK | V | 2440.000 | 49.35 | 32.08 | 5.85 | 0.00 | 0.00 | -7.94 | 36.00 | -43.94 | 1/3 MHz | | |
| PK | H | 2440.000 | 54.68 | 32.08 | 5.85 | 0.00 | 0.00 | -2.61 | 36.00 | -38.61 | 1/3 MHz | | |
| PK | V | 2480.000 | 54.62 | 32.43 | 5.85 | 0.00 | 0.00 | -2.32 | 36.00 | -38.32 | 5/10 MHz | | |
| PK | H | 2480.000 | 61.62 | 32.43 | 5.85 | 0.00 | 0.00 | 4.68 | 36.00 | -31.32 | 5/10 MHz | | |
| PK | V | 2480.000 | 54.47 | 32.43 | 5.85 | 0.00 | 0.00 | -2.47 | 36.00 | -38.47 | 1/3 MHz | | |
| PK | H | 2480.000 | 61.13 | 32.43 | 5.85 | 0.00 | 0.00 | 4.19 | 36.00 | -31.81 | 1/3 MHz | | |

| | | | |
|---|---|---|---|
| Test Personnel: | Vathana Ven | Test Date: | 03/28/2023<br>03/30/2023 |
| Supervising/Reviewing Engineer: (Where Applicable) | N/A | | |
| Product Standard: | CFR47 FCC Part 15.247<br>RSS-247 | Limit Applied: | See report section 6.3 |
| Input Voltage: | Battery power | Ambient Temperature: | 25, 23 ºC |
| Pretest Verification w/ Ambient Signals or BB Source: | N/A | Relative Humidity: | 18, 28 % |
| | | Atmospheric Pressure: | 1012, 1007 mbars |

Deviations, Additions, or Exclusions: None

# 7 Maximum Power Spectral Density

## 7.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, and ANSI C63.10, and KDB 558074 D0115.247Meas Guidancev05r02.

**TEST SITE:** EMC Lab

**The EMC Lab** has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

## 7.2 Test Equipment Used:

| Asset | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DAV007' | Weather Station Vantage Vue | Davis | 6250 | MS191212003 | 03/15/2023 | 03/15/2024 |
| ETS002' | 1-18GHz DRG Horn Antenna | ETS Lindgren | 3117 | 00143260 | 09/27/2022 | 09/27/2023 |
| 145108' | EMI Test Receiver (20Hz - 40GHz) | Rohde & Schwarz | ESIB40 | 100209 | 06/23/2022 | 06/23/2023 |
| IW001' | 2 meter cable | Insulated Wire | 2801-NPS | 001 | 07/14/2022 | 07/14/2023 |
| 145-420' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| 145-414' | Cable 145-414 | Huber + Suhner | 3m Track A cable | 145-414 | 07/14/2022 | 07/14/2023 |
| IW003' | 8.4 meter cable | Insulated Wire | 2800-NPS | 003 | 11/14/2022 | 11/14/2023 |

**Software Utilized:**

| Name | Manufacturer | Version |
|---|---|---|
| None | -- | -- |

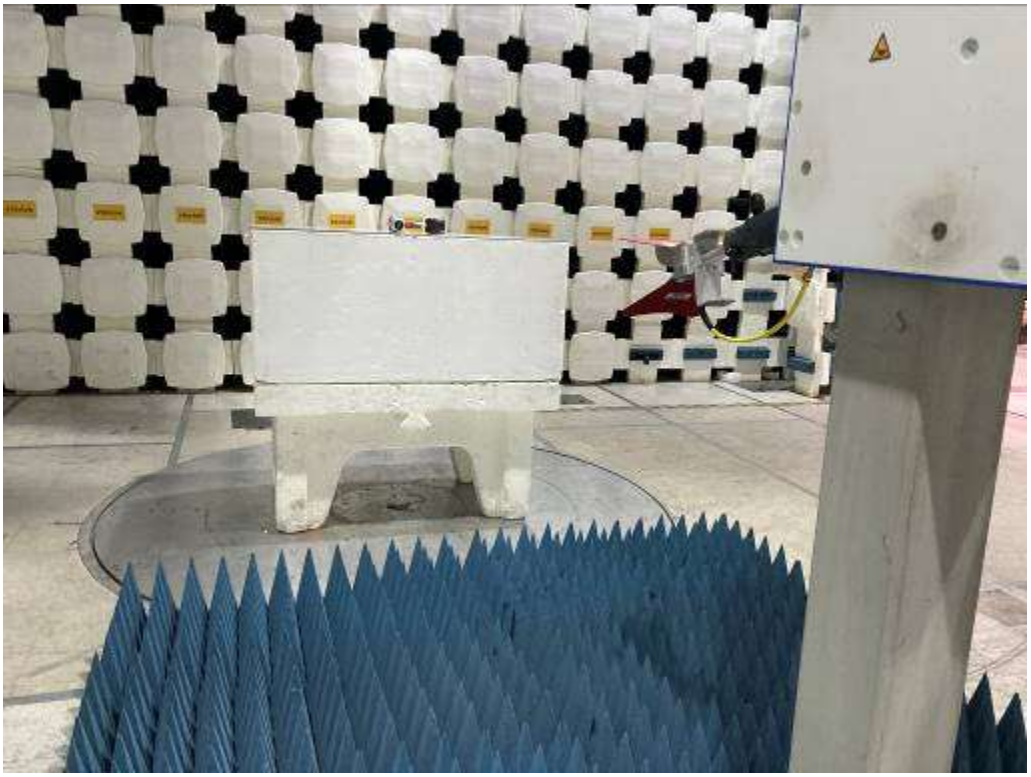
## 7.3 Results:

The sample tested was found to Comply.

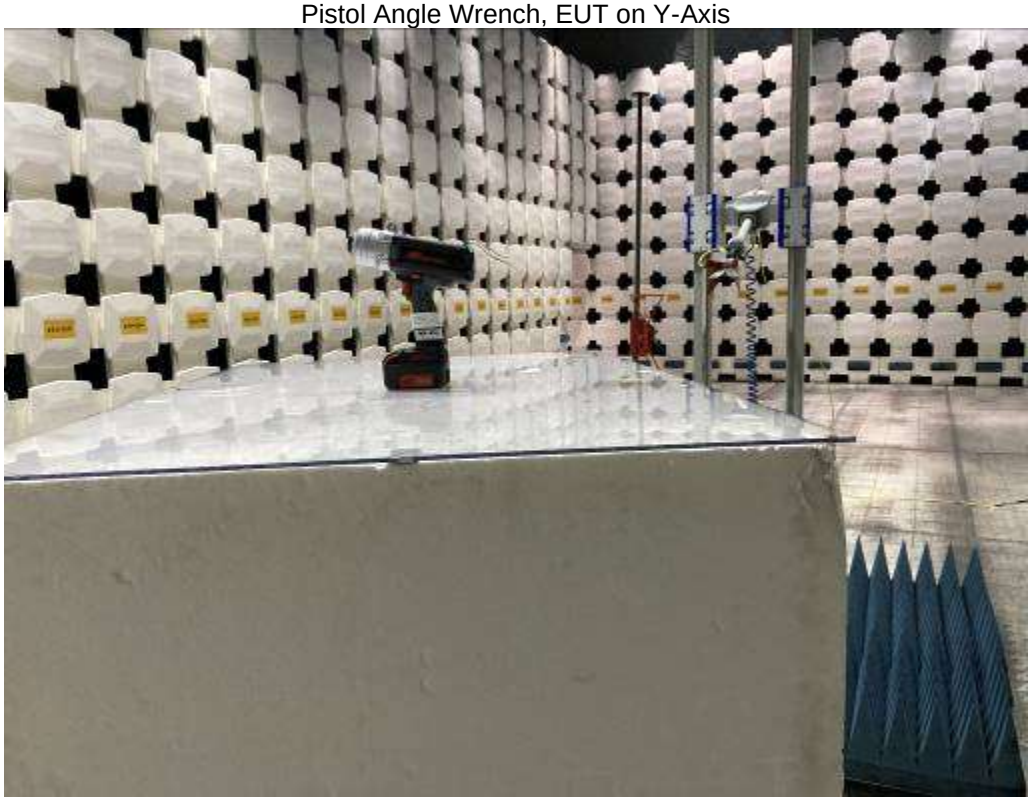
§15.247 (e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

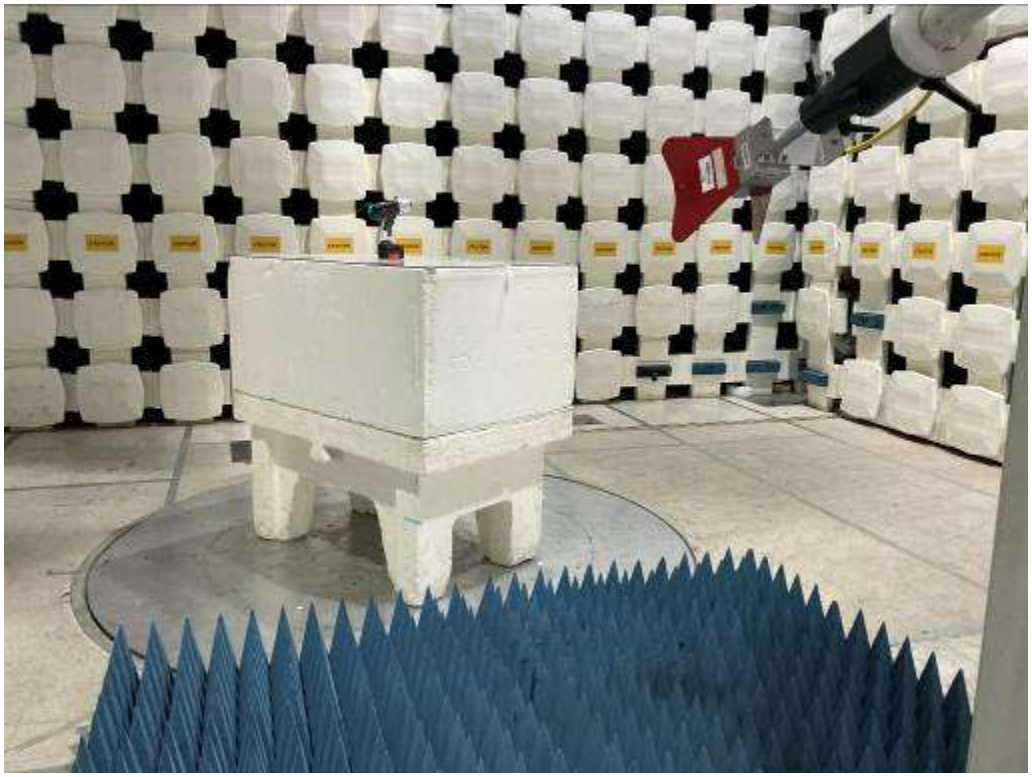
## 7.4 Setup Photographs:

Pistol Angle Wrench, EUT on X-Axis

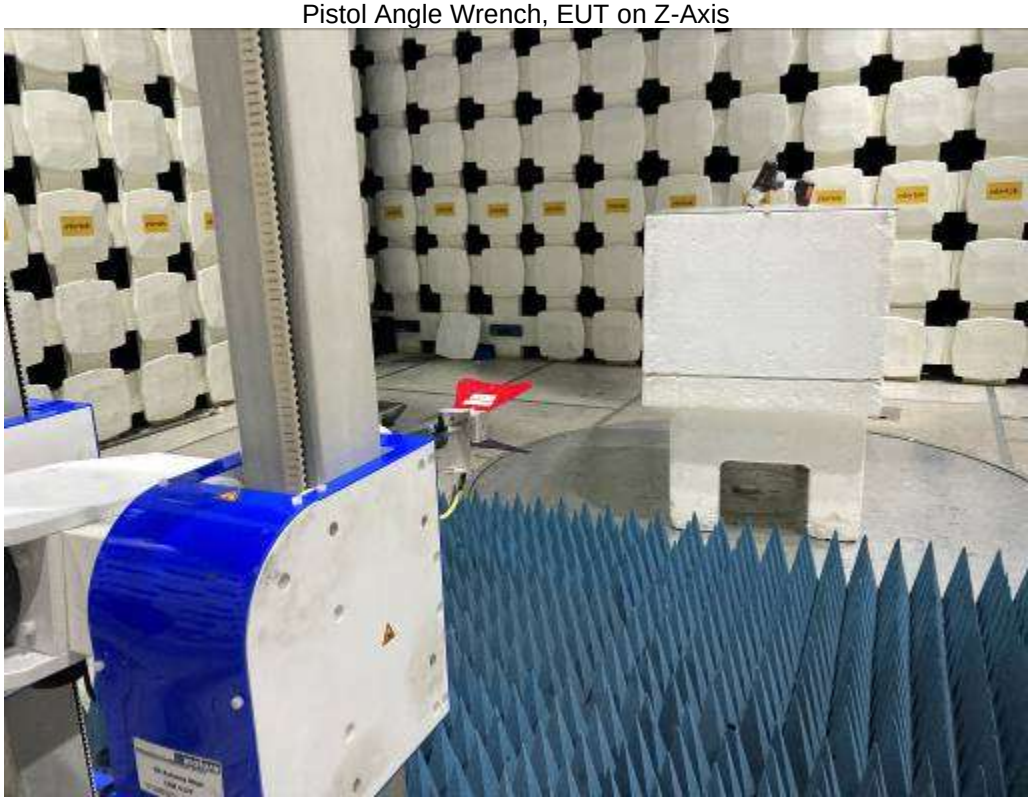


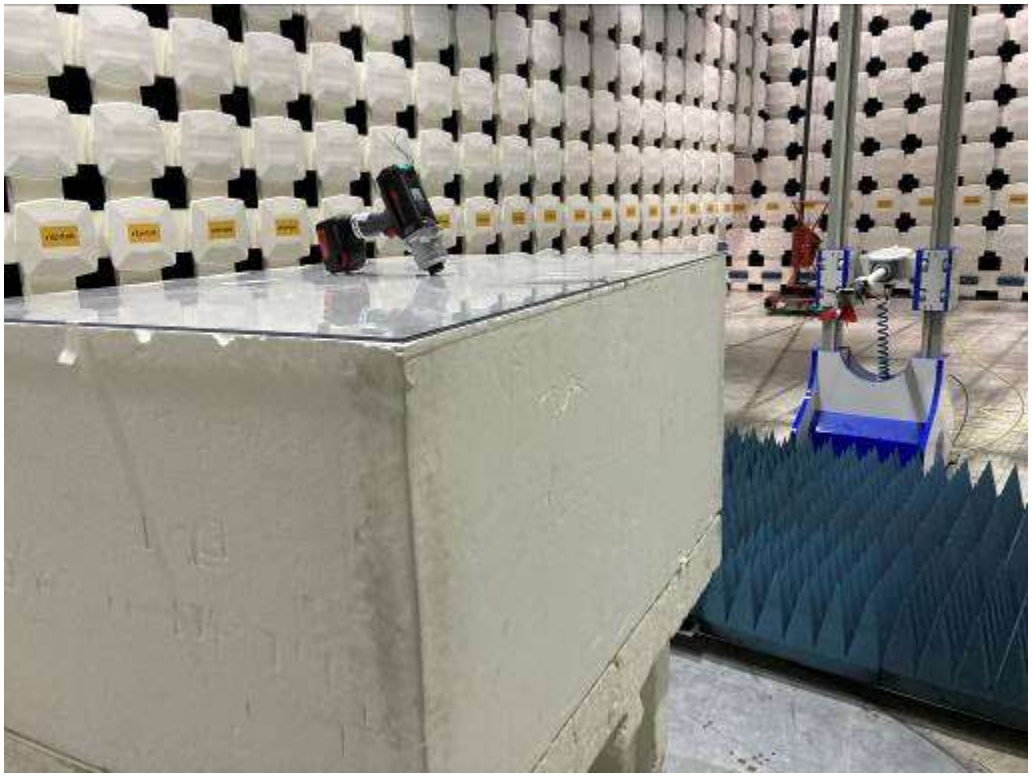
Pistol Angle Wrench, EUT on Y-Axis





Pistol Angle Wrench, EUT on Z-Axis





## 7.5 Test Data:

802.15.4 Power Spectral Density

**Radiated Emissions**

Company: Ingersoll Rand | Antenna & Cables: HF | Bands: N, LF, HF, SHF
Model #: QX5PM (802.15.4) | Antenna: ETS002 | ETS002
Serial #: SP23B24505 | Cable(s): IW001, IW003, 145-414, 145-420 | IW001, IW003, 145-414, 145-420
Engineers: Vathana Ven | Location: 10m Chamber | Barometer: DAV006 | Filter: NONE
Project #: G105295733 | Date(s): 03/28/23
Standard: FCC Part 15 Subpart C 15.247 | Temp/Humidity/Pressure: 23 deg C | 28% | 1007mB
Receiver: R&S ESIB40 (145-108) | Limit Distance (m): 3
PreAmp: No | Test Distance (m): 3
PreAmp Used? (Y or N): N | Voltage/Frequency: Battery power | Frequency Range: Frequencies Shown

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | EIRP Net dBm | EIRP Limit dBm | Margin dB | Bandwidth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: PSD (802.15.4), PA Level setting = 1, Power Level setting = -3 - X-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | V | 2405.000 | 31.44 | 31.95 | 5.85 | 0.00 | 0.00 | -25.98 | 8.00 | -33.98 | 3/10 kHz |
| PK | V | 2440.000 | 37.16 | 32.08 | 5.85 | 0.00 | 0.00 | -20.13 | 8.00 | -28.13 | 3/10 kHz |
| PK | V | 2480.000 | 40.96 | 32.43 | 5.85 | 0.00 | 0.00 | -15.98 | 8.00 | -23.98 | 3/10 kHz |
| Note: PSD (802.15.4), PA Level setting = 1, Power Level setting = -3 - Y-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | H | 2402.000 | 31.49 | 31.95 | 5.85 | 0.00 | 0.00 | -25.93 | 8.00 | -33.93 | 3/10 kHz |
| PK | H | 2440.000 | 38.63 | 32.08 | 5.85 | 0.00 | 0.00 | -18.66 | 8.00 | -26.66 | 3/10 kHz |
| PK | H | 2480.000 | 42.84 | 32.43 | 5.85 | 0.00 | 0.00 | -14.10 | 8.00 | -22.10 | 3/10 kHz |
| Note: PSD (802.15.4), PA Level setting = 1, Power Level setting = -3 - Z-Axis | | | | | | | | | | | |
| Note: EIRP Obtained by applying the path loss correction for a 3m test distance, E(dBuV/m)@3m - 95.22 = dBm EIRP | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | H | 2405.000 | 31.57 | 31.95 | 5.85 | 0.00 | 0.00 | -25.85 | 8.00 | -33.85 | 3/10 kHz |
| PK | H | 2440.000 | 36.23 | 32.08 | 5.85 | 0.00 | 0.00 | -21.06 | 8.00 | -29.06 | 3/10 kHz |
| PK | H | 2480.000 | 43.50 | 32.43 | 5.85 | 0.00 | 0.00 | -13.44 | 8.00 | -21.44 | 3/10 kHz |

# BLE Power Spectral Density

**Radiated Emissions**

Company: Ingersoll Rand
Model #: QX5PM (BLE)
Serial #: SP23B24508
Engineers: Vathana Ven
Project #: G105295733
Standard: FCC Part 15 Subpart C 15.247
Receiver: R&S ESIB40 (145-108)
PreAmp: No
PreAmp Used? (Y or N): N

Antenna & Cables: HF Bands: N, LF, HF, SHF
Antenna: ETS002 ETS002
Cable(s): IW001, IW004, 145-414, 145-420 IW001, IW004, 145-414, 145-420
Location: 10m Chamber Barometer: DAV006 Filter: NONE
Date(s): 03/30/23
Temp/Humidity/Pressure: 25 deg C 18% 1012 mB
Limit Distance (m): 3
Test Distance (m): 3
Voltage/Frequency: Battery power Frequency Range: Frequencies Shown

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | EIRP Net dBm | EIRP Limit dBm | Margin dB | Bandwidth |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: Power Spectral Density (BLE), Level setting = 25 (0 dBm) - X-Axis | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | V | 2402.000 | 47.41 | 31.95 | 5.85 | 0.00 | 0.00 | -10.01 | 8.00 | -18.01 | 3/10 kHz |
| PK | V | 2442.000 | 50.71 | 32.08 | 5.85 | 0.00 | 0.00 | -6.58 | 8.00 | -14.58 | 3/10 kHz |
| PK | V | 2480.000 | 49.73 | 32.43 | 5.85 | 0.00 | 0.00 | -7.21 | 8.00 | -15.21 | 3/10 kHz |
| Note: Power Spectral Density (BLE), Level setting = 25 (0 dBm) - Y-Axis | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | V | 2402.000 | 45.30 | 31.95 | 5.85 | 0.00 | 0.00 | -12.12 | 8.00 | -20.12 | 3/10 kHz |
| PK | H | 2440.000 | 51.82 | 32.08 | 5.85 | 0.00 | 0.00 | -5.47 | 8.00 | -13.47 | 3/10 kHz |
| PK | H | 2480.000 | 52.00 | 32.43 | 5.85 | 0.00 | 0.00 | -4.94 | 8.00 | -12.94 | 3/10 kHz |
| Note: Power Spectral Density (BLE), Level setting = 25 (0 dBm) - Z-Axis | | | | | | | | | | | |
| Note: Power Density measured in a 3 kHz RBW | | | | | | | | | | | |
| PK | H | 2402.000 | 50.50 | 31.95 | 5.85 | 0.00 | 0.00 | -6.92 | 8.00 | -14.92 | 3/10 kHz |
| PK | H | 2442.000 | 53.72 | 32.08 | 5.85 | 0.00 | 0.00 | -3.57 | 8.00 | -11.57 | 3/10 kHz |
| PK | H | 2480.000 | 51.28 | 32.43 | 5.85 | 0.00 | 0.00 | -5.66 | 8.00 | -13.66 | 3/10 kHz |

Test Personnel: Vathana Ven VSV
Test Date: 03/28/2023
03/30/2023
Supervising/Reviewing Engineer: (Where Applicable) N/A
Product Standard: CFR47 FCC Part 15.247 RSS-247
Limit Applied: See report section 7.3
Input Voltage: Battery power
Ambient Temperature: 25, 23 ºC
Pretest Verification w/ Ambient Signals or BB Source: N/A
Relative Humidity: 18, 28 %
Atmospheric Pressure: 1012, 1007 mbars

Deviations, Additions, or Exclusions: None

# 8 Band Edge Compliance

## 8.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247 RSS 247, and ANSI C 63.10.

**TEST SITE:** EMC Lab

**The EMC Lab** has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

## 8.2 Test Equipment Used:

| Asset | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DAV007' | Weather Station Vantage Vue | Davis | 6250 | MS191212003 | 03/15/2023 | 03/15/2024 |
| ETS002' | 1-18GHz DRG Horn Antenna | ETS Lindgren | 3117 | 00143260 | 09/27/2022 | 09/27/2023 |
| 145108' | EMI Test Receiver (20Hz - 40GHz) | Rohde & Schwarz | ESIB40 | 100209 | 06/23/2022 | 06/23/2023 |
| IW001' | 2 meter cable | Insulated Wire | 2801-NPS | 001 | 07/14/2022 | 07/14/2023 |
| 145-420' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| 145-414' | Cable 145-414 | Huber + Suhner | 3m Track A cable | 145-414 | 07/09/2021 | 07/09/2022 |
| IW003' | 8.4 meter cable | Insulated Wire | 2800-NPS | 003 | 11/14/2022 | 11/14/2023 |

**Software Utilized:**

| Name | Manufacturer | Version |
|---|---|---|
| None | -- | -- |

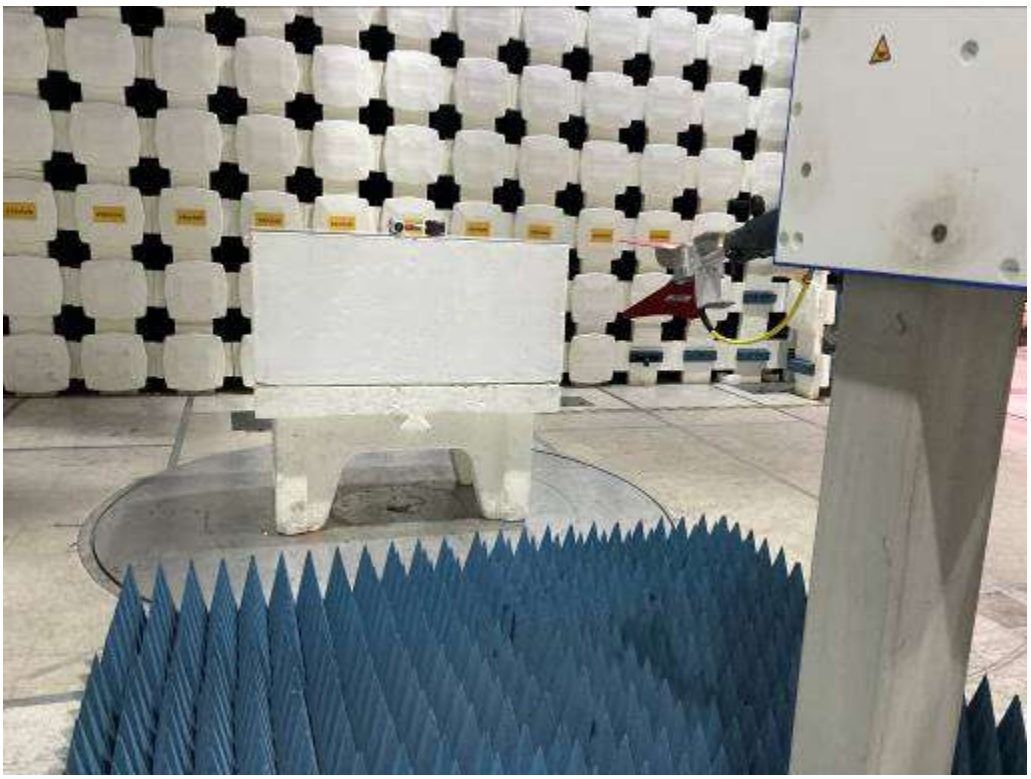
## 8.3 Results:

The sample tested was found to Comply.

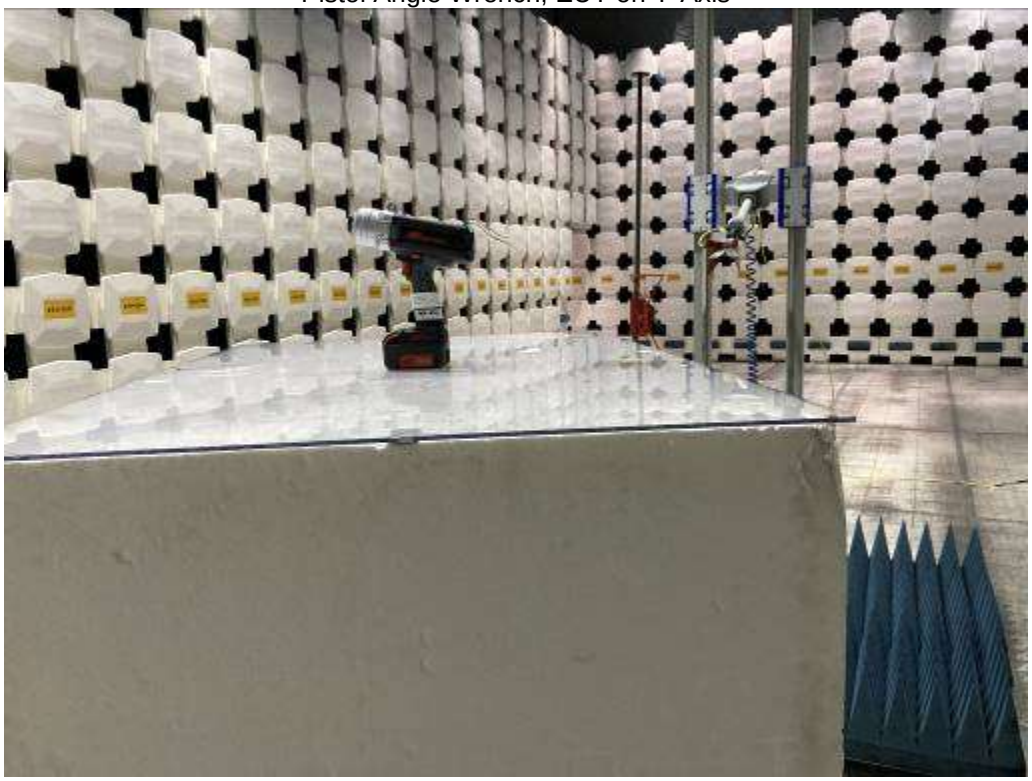
15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

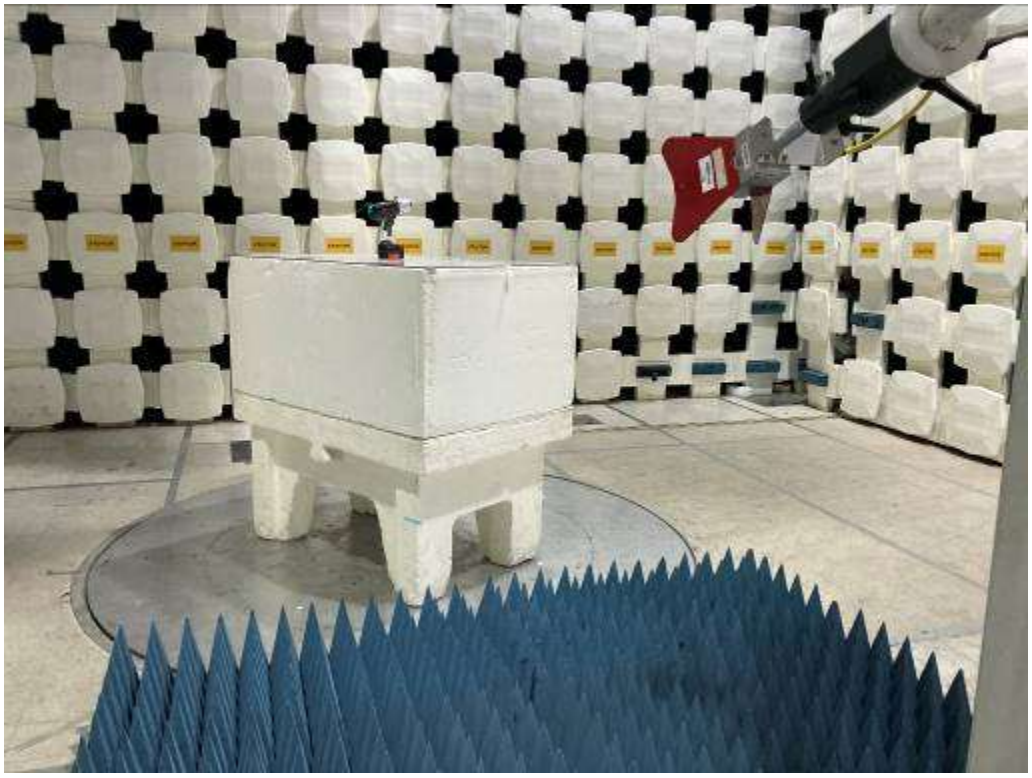
## 8.4 Setup Photographs:

Pistol Angle Wrench, EUT on X-Axis

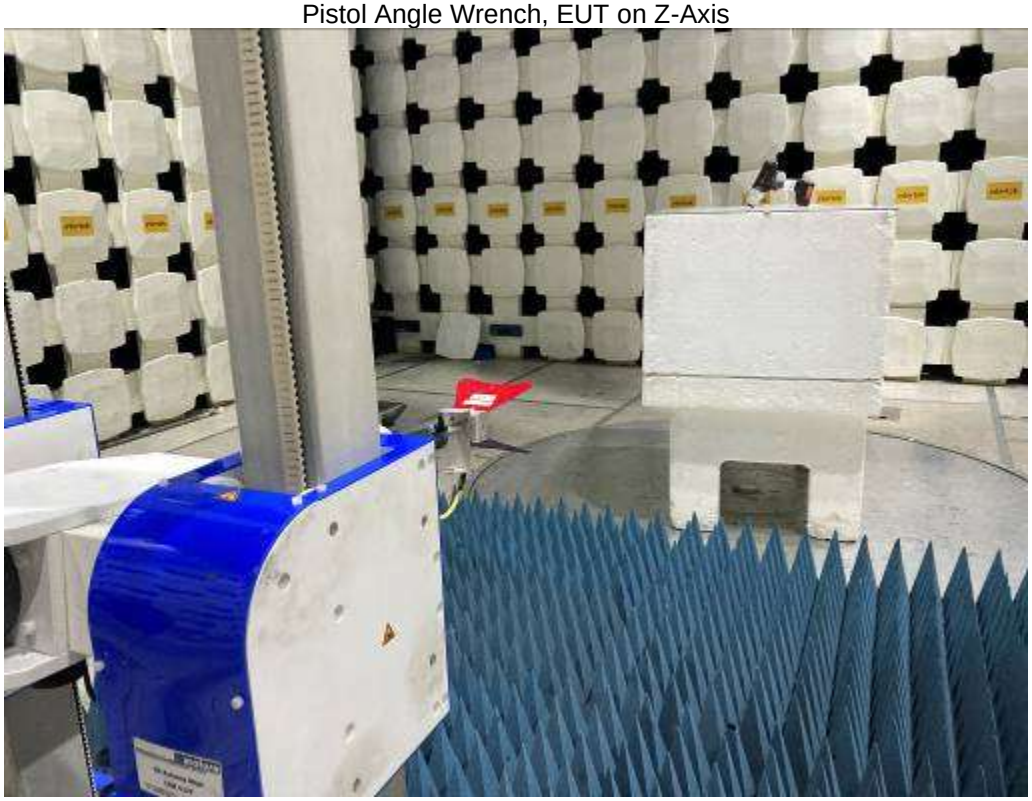


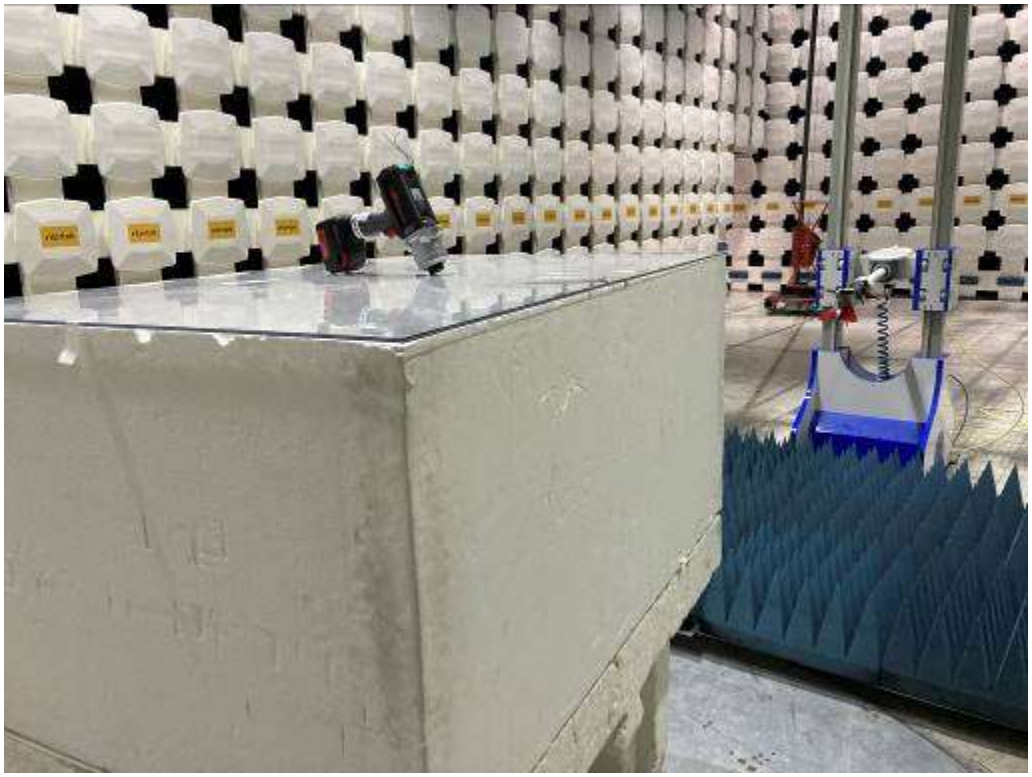
Pistol Angle Wrench, EUT on Y-Axis





Pistol Angle Wrench, EUT on Z-Axis





## 8.5 Test Data:

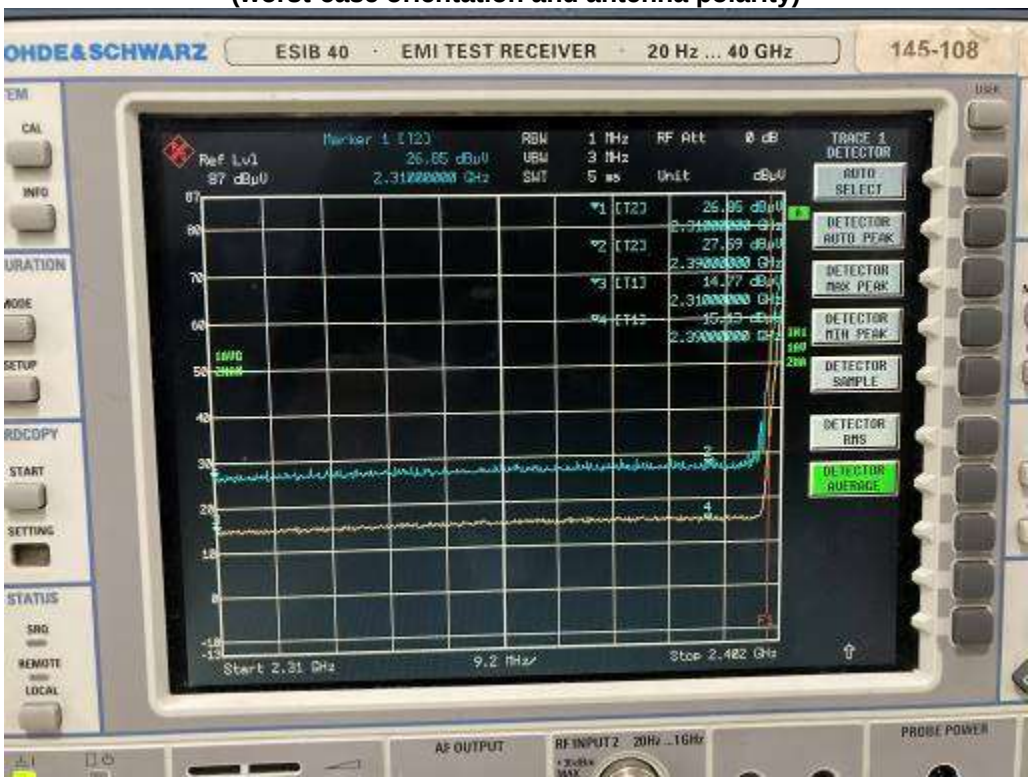
**Upper Band Edge, 1MHz RBW, BLE Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**


Note: Cable losses, antenna factor, and distance factor were not compensated. Final data is shown in the spreadsheet below.

**Upper Band Edge, 100kHz RBW, BLE Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**

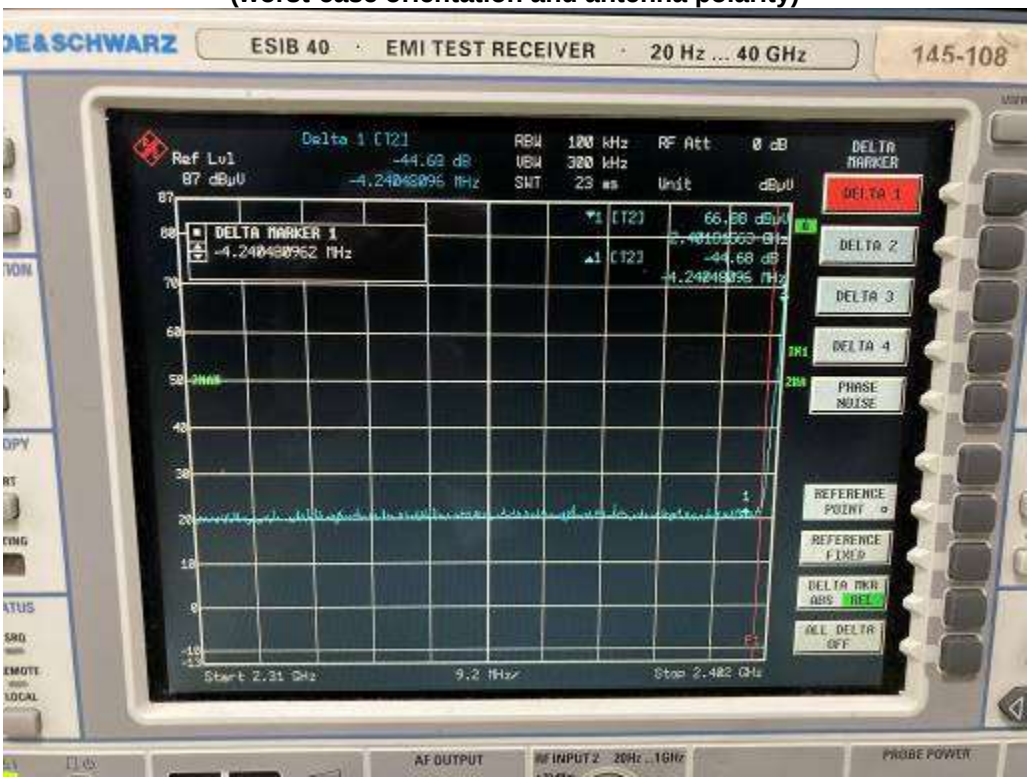

Note: Plot showed 20 dB down from peak level

**Lower Band Edge, 1MHz RBW, BLE Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**




Note: Cable losses, antenna factor, and distance factor were not compensated. Final data is shown in the spreadsheet below.

**Lower Band Edge, 100kHz RBW**
**(worst-case orientation and antenna polarity)**




Note: Plot showed 20 dB down from peak level

**Radiated Emissions**

Company: Ingersoll Rand
Model #: QX5PM (BLE)
Serial #: SP23B24508
Engineers: Vathana Ven
Project #: G105295733
Standard: FCC Part 15 Subpart C 15.247
Receiver: R&S ESIB40 (145-108)
PreAmp: No
Date(s): 04/01/23
Location: 10m Chamber
Limit Distance (m): 3
Test Distance (m): 1.2
Antenna & Cables: HF Bands: N, LF, HF, SHF
Antenna: ETS002 ETS002
Cable(s): IW001, IW004, 145-414, 145-420 IW001, IW004, 145-414, 145-420
Barometer: DAV006 Filter: NONE
Temp/Humidity/Pressure: 27 deg C 20% 1005 mB
PreAmp Used? (Y or N): N Voltage/Frequency: Battery power Frequency Range: Frequencies Shown

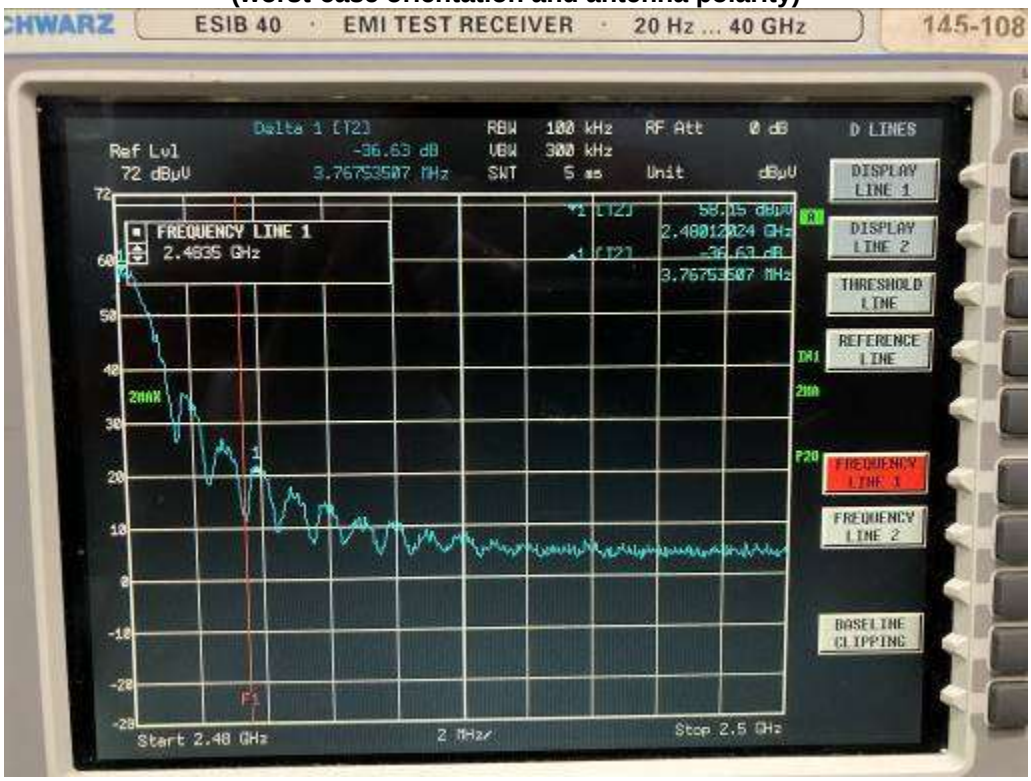
Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB | Bandwidth | FCC | IC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: RF Output Power (BLE), Level setting = 25 (0 dBm) - Y-Axis | | | | | | | | | | | | | |
| PK | H | 2310.000 | 26.85 | 31.71 | 5.85 | 0.00 | 7.96 | 56.45 | 74.00 | -17.55 | 1/3 MHz | Test at 1.2m | |
| AVG | H | 2310.000 | 14.53 | 31.71 | 5.85 | 0.00 | 7.96 | 44.13 | 54.00 | -9.87 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2390.000 | 27.69 | 31.86 | 5.85 | 0.00 | 7.96 | 57.44 | 74.00 | -16.56 | 1/3 MHz | Test at 1.2m | |
| AVG | H | 2390.000 | 15.09 | 31.86 | 5.85 | 0.00 | 7.96 | 44.84 | 54.00 | -9.16 | 1/3 MHz | Test at 1.2m | |
| Note: RF Output Power (BLE), Level setting = 25 (0 dBm) - Y-Axis | | | | | | | | | | | | | |
| PK | H | 2483.500 | 34.42 | 32.43 | 5.85 | 0.00 | 7.96 | 64.74 | 74.00 | -9.26 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2483.500 | 20.17 | 32.43 | 5.85 | 0.00 | 7.96 | 50.49 | 54.00 | -3.51 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2500.000 | 26.08 | 32.66 | 5.85 | 0.00 | 7.96 | 56.63 | 74.00 | -17.37 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2500.000 | 14.93 | 32.66 | 5.85 | 0.00 | 7.96 | 45.48 | 54.00 | -8.52 | 1/3 MHz | Test at 1.2m | |

**Upper Band Edge, 1MHz RBW, 802.15.4 Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**


Note: Cable losses, antenna factor, and distance factors were internally compensated as Offset. Plot shown net readings. Data also shown in the spreadsheet below.

**Upper Band Edge, 100kHz RBW, 802.15.4 Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**

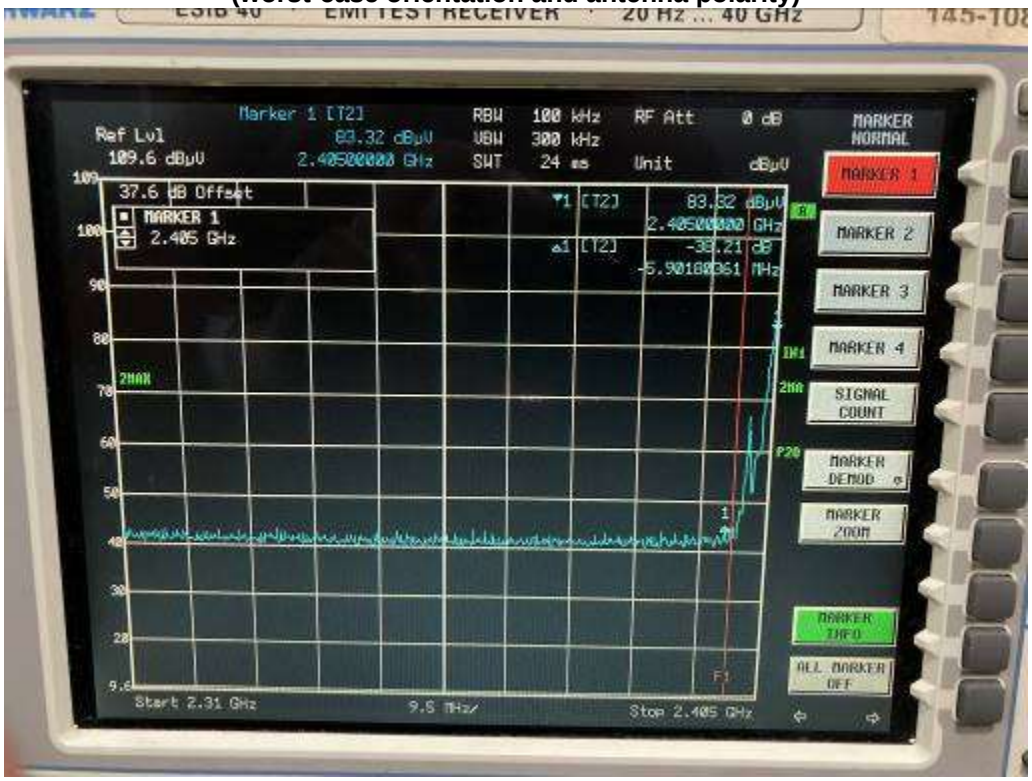



Note: Cable losses, antenna factor, and distance factor were internally compensated as Offset. Plot shown 20dB down from peak level.

**Lower Band Edge, 1MHz RBW, 802.15.4 Pistol Angle Wrench**
**(worst-case orientation and antenna polarity)**


Note: Cable losses, antenna factor, and distance factor were internally compensated as Offset. Plot shown net readings. Data also shown in the spreadsheet below.

**Lower Band Edge, 100kHz RBW, 802.15.4 Pistol Angle Wrench (worst-case orientation and antenna polarity)**




Note: Cable losses, antenna factor, and distance factor were internally compensated as Offset. Plot shown 20dB down from peak level.

**Radiated Emissions**

Company: Ingersoll Rand
Model #: QX5PM (802.15.4)
Serial #: SP23B24505
Engineers: Vathana Ven
Project #: G105295733 Date(s): 03/29/23
Standard: FCC Part 15 Subpart C 15.247
Receiver: R&S ESIB40 (145-108)
PreAmp: No

Antenna & Cables: HF Bands: N, LF, HF, SHF
Antenna: ETS002 ETS002
Cable(s): IW001, IW004, 145-414, 145-420 IW001, IW004, 145-414, 145-420
Location: 10m Chamber Barometer: DAV006 Filter: NONE
Temp/Humidity/Pressure: 27 deg C 20% 1005 mB
Limit Distance (m): 3
Test Distance (m): 1.2
PreAmp Used? (Y or N): N Voltage/Frequency: Battery power Frequency Range: Frequencies Shown

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

| Detector Type | Ant. Pol. (V/H) | Frequency MHz | Reading dB(uV) | Antenna Factor dB(1/m) | Cable Loss dB | Pre-amp Factor dB | Distance Factor dB | Net dB(uV/m) | Limit dB(uV/m) | Margin dB | Bandwidth | FCC | IC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Note: Lower BEC (802.15.4), PA Level setting = 1, Power Level setting = -3 - Y-Axis | | | | | | | | | | | | | |
| PK | H | 2310.000 | 11.55 | 31.71 | 5.85 | 0.00 | 0.00 | 49.11 | 74.00 | -24.89 | 1/3 MHz | Test at 3m | |
| AVG | H | 2310.000 | 0.23 | 31.71 | 5.85 | 0.00 | 0.00 | 37.79 | 54.00 | -16.21 | 1/3 MHz | Test at 3m | |
| PK | H | 2390.000 | 11.78 | 31.86 | 5.85 | 0.00 | 0.00 | 49.49 | 74.00 | -24.51 | 1/3 MHz | Test at 3m | |
| AVG | H | 2390.000 | 0.12 | 31.86 | 5.85 | 0.00 | 0.00 | 37.83 | 54.00 | -16.17 | 1/3 MHz | Test at 3m | |
| Note: Upper BEC (802.15.4), PA Level setting = 1, Power Level setting = -3 - Y-Axis | | | | | | | | | | | | | |
| PK | H | 2483.500 | 30.22 | 32.43 | 5.85 | 0.00 | 7.96 | 60.54 | 74.00 | -13.46 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2483.500 | 20.70 | 32.43 | 5.85 | 0.00 | 7.96 | 51.02 | 54.00 | -2.98 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2500.000 | 11.66 | 32.66 | 5.85 | 0.00 | 7.96 | 42.21 | 74.00 | -31.79 | 1/3 MHz | Test at 1.2m | |
| PK | H | 2500.000 | 0.90 | 32.66 | 5.85 | 0.00 | 7.96 | 31.45 | 54.00 | -22.55 | 1/3 MHz | Test at 1.2m | |

| | | | |
|---|---|---|---|
| Test Personnel: | Vathana Ven | Test Date: | 03/28/2023<br>04/01/2023 |
| Supervising/Reviewing Engineer: (Where Applicable) | N/A | | |
| Product Standard: | CFR47 FCC Part 15.247<br>RSS-247 | Limit Applied: | See report section 8.3 |
| Input Voltage: | Battery power | Ambient Temperature: | 25, 27 ºC |
| Pretest Verification w/ Ambient Signals or BB Source: | N/A | Relative Humidity: | 18, 20 % |
| | | Atmospheric Pressure: | 1012, 1005 mbars |

Deviations, Additions, or Exclusions: None

# 9 Transmitter spurious emissions

## 9.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247, FCC Part 15 Subpart B, RSS 247 ICES 003, ANSI C 63.10, and ANSI C 63.4.

**TEST SITE:** 10m ALSE

**The 10m ALSE** is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

**Measurement Uncertainty**

| Measurement | Frequency Range | Expanded Uncertainty (k=2) | Ucispr |
|---|---|---|---|
| Radiated Emissions, 10m | 30-1000 MHz | 4.6dB | 6.3 dB |
| Radiated Emissions, 3m | 30-1000 MHz | 5.3 dB | 6.3 dB |
| Radiated Emissions, 3m | 1-6 GHz | 4.5 dB | 5.2 dB |
| Radiated Emissions, 3m | 6-15 GHz | 5.2 dB | 5.5 dB |
| Radiated Emissions, 3m | 15-18 GHz | 5.0 dB | 5.5 dB |
| Radiated Emissions, 3m | 18-40 GHz | 5.0 dB | 5.5 dB |

As shown in the table above our radiated emissions $U_{lab}$ is less than the corresponding $U_{CISPR}$ reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

**Sample Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

**Example:**

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the “Level” includes all losses and gains and is compared directly in the “Margin” column to the “Limit”. The “Correction” includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the “Level” column.

**TEST SITE:** EMC Lab

**The EMC Lab** has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

## 9.2 Test Equipment Used:

| Asset | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DAV007' | Weather Station Vantage Vue | Davis | 6250 | MS191212003 | 03/15/2023 | 03/15/2024 |
| 145108' | EMI Test Receiver (20Hz - 40GHz) | Rohde & Schwarz | ESIB40 | 100209 | 06/23/2022 | 06/23/2023 |
| PRE11' | 50dB gain pre-amp | Pasternack | PRE11 | PRE11 | 09/20/2022 | 09/20/2023 |
| 145145' | Broadband Hybrid Antenna 30 MHz - 3 GHz | Sunol Sciences Corp. | JB3 | A122313 | 06/16/2022 | 06/16/2023 |
| IW001' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| 145-420' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| HS001' | DC-18GHz cable 1.5m long | Huber & Suhner | SucoFlex 106A | HS001 | 01/25/2023 | 01/25/2024 |
| IW003' | 8.4 meter cable | Insulated Wire | 2800-NPS | 003 | 11/14/2022 | 11/14/2023 |
| 145-422' | 10Amp Pre-amp to under floor | Utiflex | UFB311A-0-2756-70070 | 145-422 | 02/18/2023 | 02/18/2024 |
| HS003' | 10m under floor cable | Huber-Schuner | 10m-1 | HS003 | 02/18/2023 | 02/18/2024 |
| ETS002' | 1-18GHz DRG Horn Antenna | ETS Lindgren | 3117 | 00143260 | 09/27/2022 | 09/27/2023 |
| CBLSHF205' | Cable, SMA-SMA, 9kHz-40GHz, (Cable Kit5) | Huber + Suhner | Sucoflex 102EA | 234715001 | 02/18/2023 | 02/28/2024 |
| REA004' | 3GHz High Pass Filter | Reactel, Inc | 7HSX-3G/18G-S11 | 06-1 | 02/14/2023 | 02/14/2024 |
| REA006' | 18GHz High Pass Filter | Reactel, Inc | 7HS-18G/40G K11 | (06)1 | 04/28/2022 | 04/28/2023 |
| CBLSHF101' | Cable, SMA - SMA, 9kHz-40GHz, (Cable Kit 6) | Sucoflex (Huber Suhn | 104PE | CBLSHF101 | 04/14/2022 | 04/14/2023 |
| BONN001' | 1-18GHz low noise pre-amp | Bonn | BLMA 0118-M | 1811749 | 07/19/2022 | 07/19/2023 |
| ETS004' | 18-40GHZ horn antenna | ets004 | 3116C | 00218579 | 02/23/2023 | 02/23/2024 |
| PRE9' | 100MHz-40GHz Preamp | MITEQ | NSP4000-NFG | 1260417 | 09/23/2022 | 09/23/2023 |

**Software Utilized:**

| Name | Manufacturer | Version |
|---|---|---|
| EMI Boxborough.xls | Intertek | 08/27/2010 |
| BAT-EMC | Nexio | 3.18.0.16 |

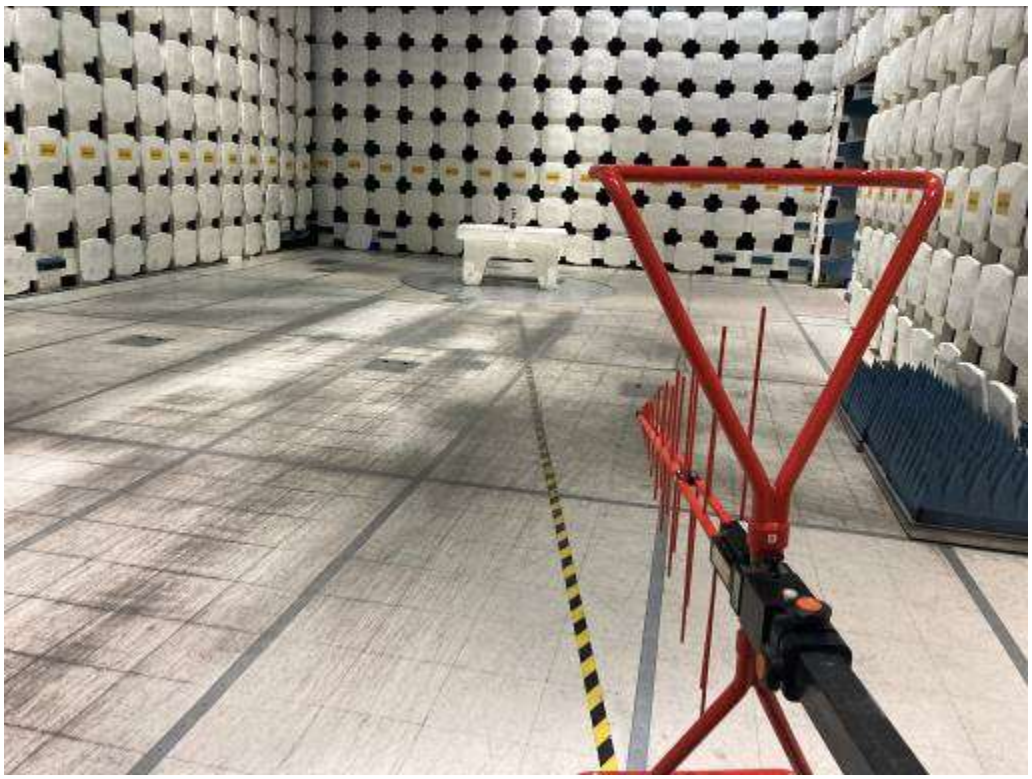
## 9.3 Results:

The sample tested was found to Comply.

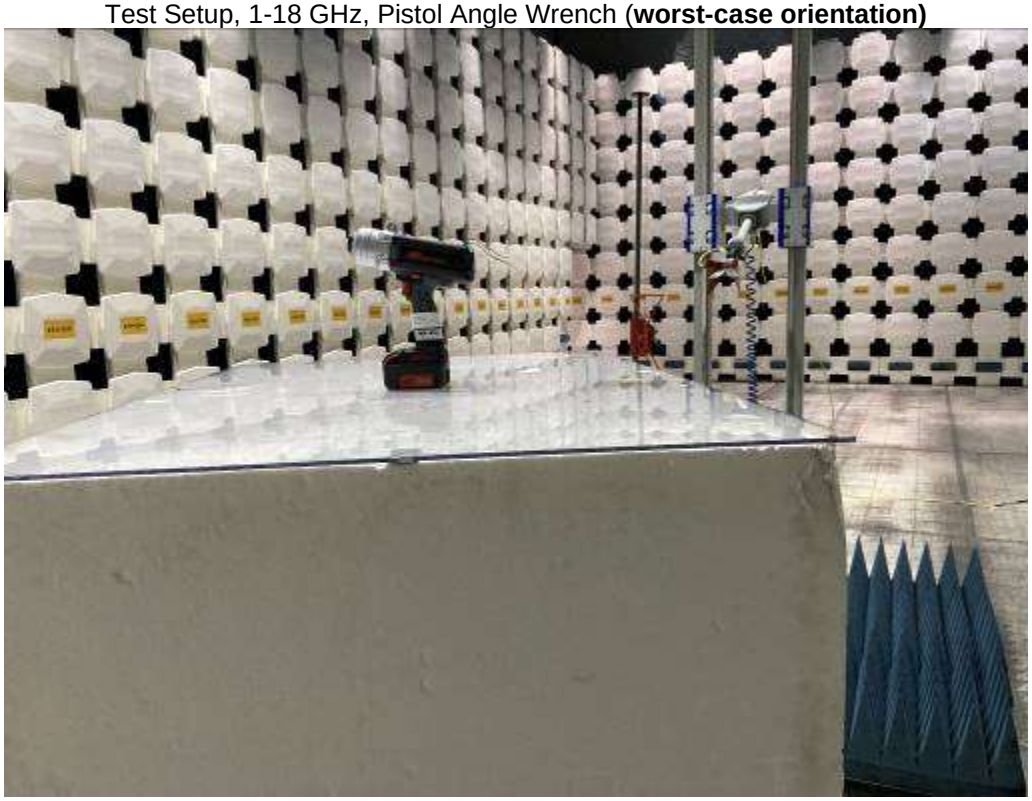
15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

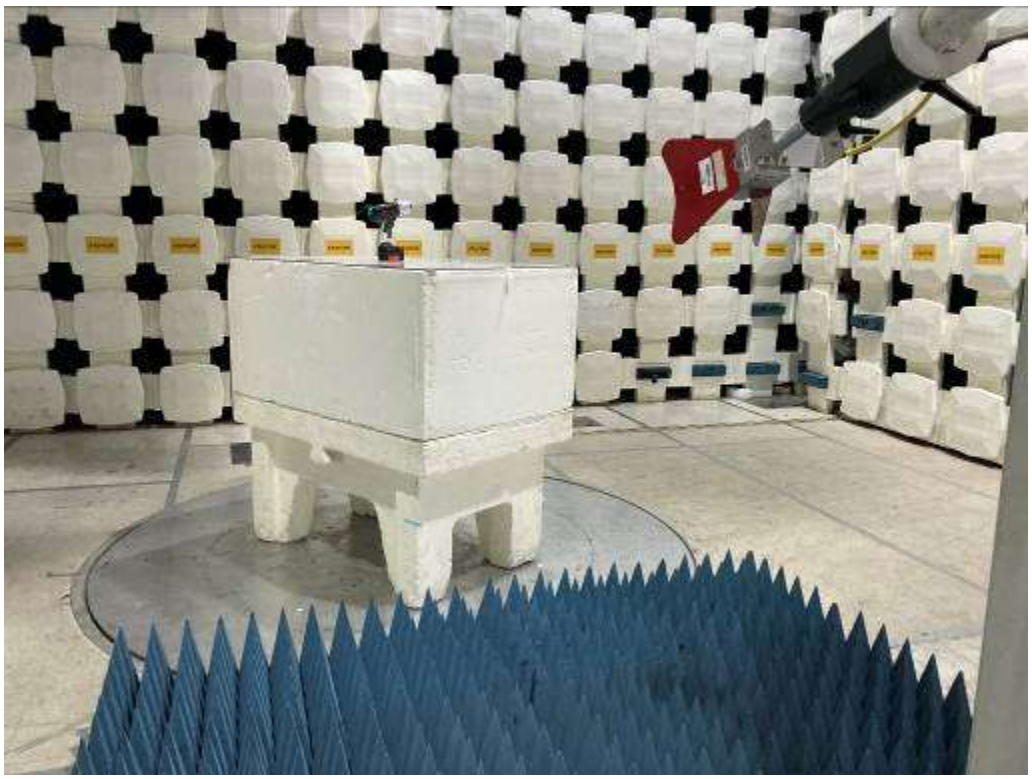
## 9.4 Setup Photographs:

Test Setup, 30-1000 MHz, Pistol Angle Wrench (**worst-case orientation)**

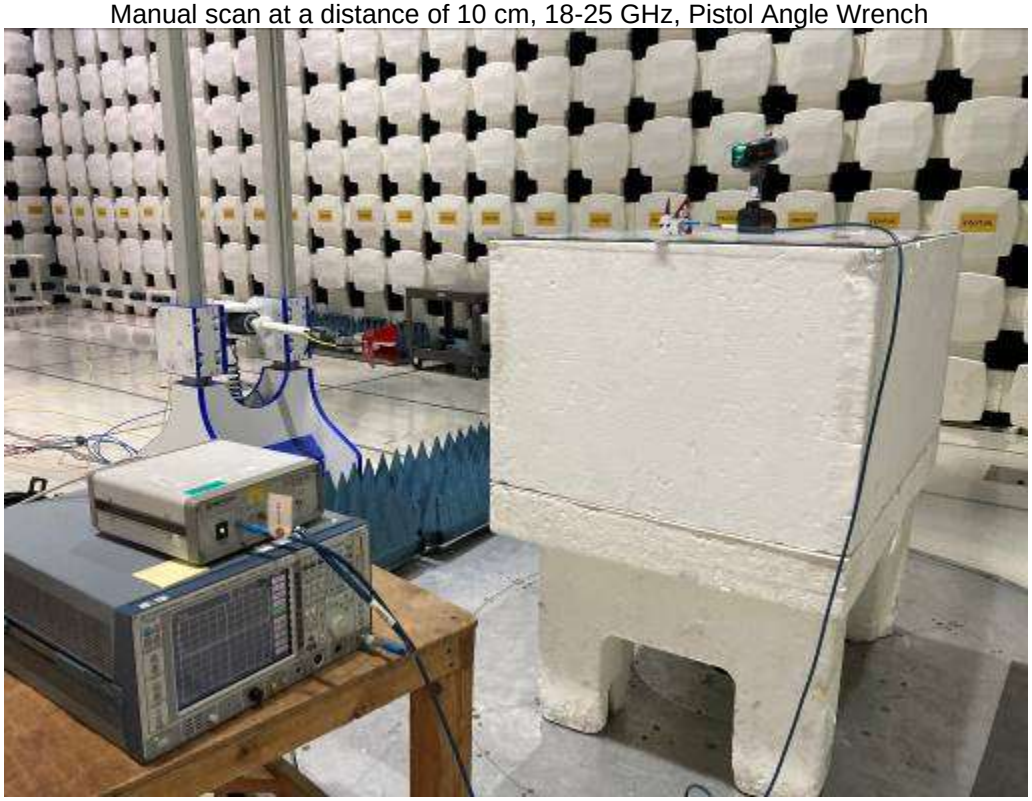


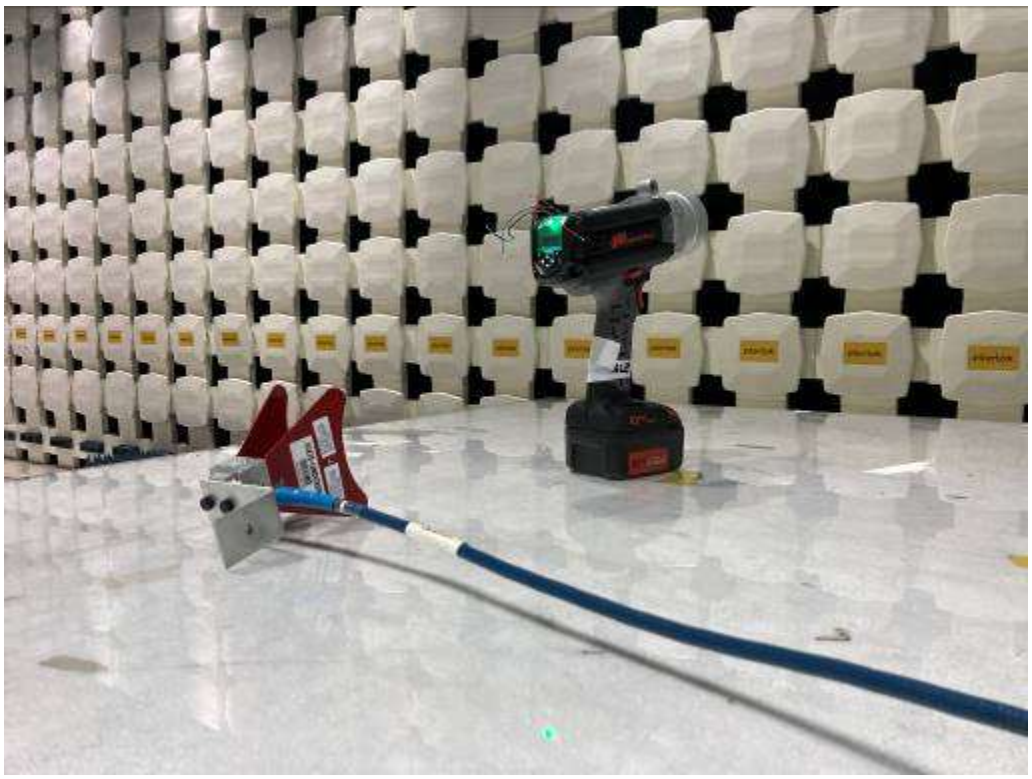
Test Setup, 1-18 GHz, Pistol Angle Wrench (**worst-case orientation)**





Manual scan at a distance of 10 cm, 18-25 GHz, Pistol Angle Wrench





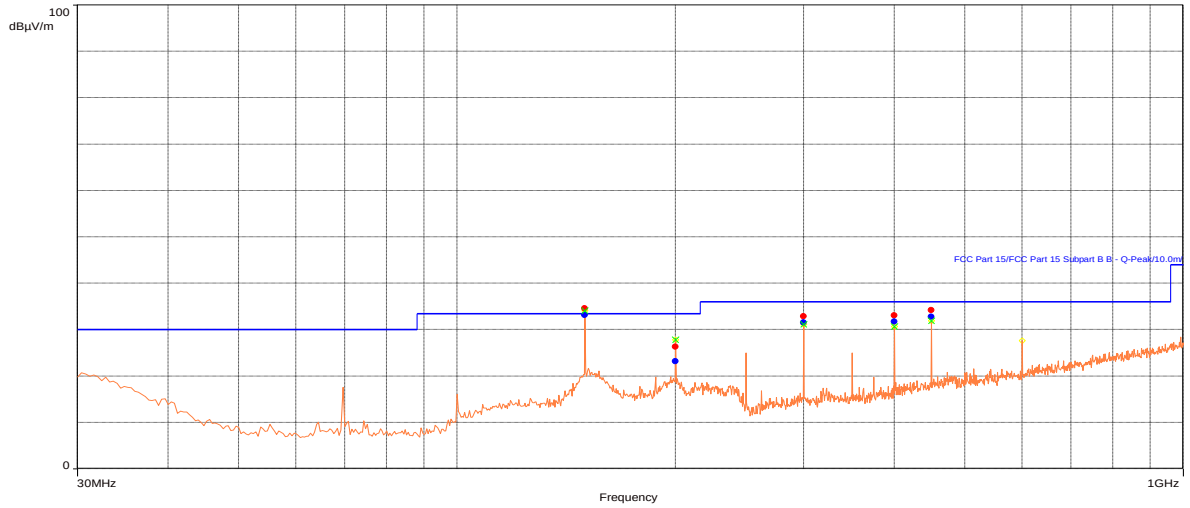
## 9.5 Plots/Data:

### BLE Pistol, Transmit mode (worst-case orientation and channel), 30-1000 MHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/30/2023 10:25:14 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 25 deg C |
| Humidity | 18% |
| Atmospheric Pressure | 1012 mB |
| Comments | RE 30-1000MHz_Battery power_BLE_Tx High CH_PWR setting 25 (0 dBm)_Worst-case orientation and CH |

**Graph:**




**Results:**

QuasiPeak (PASS) (5)

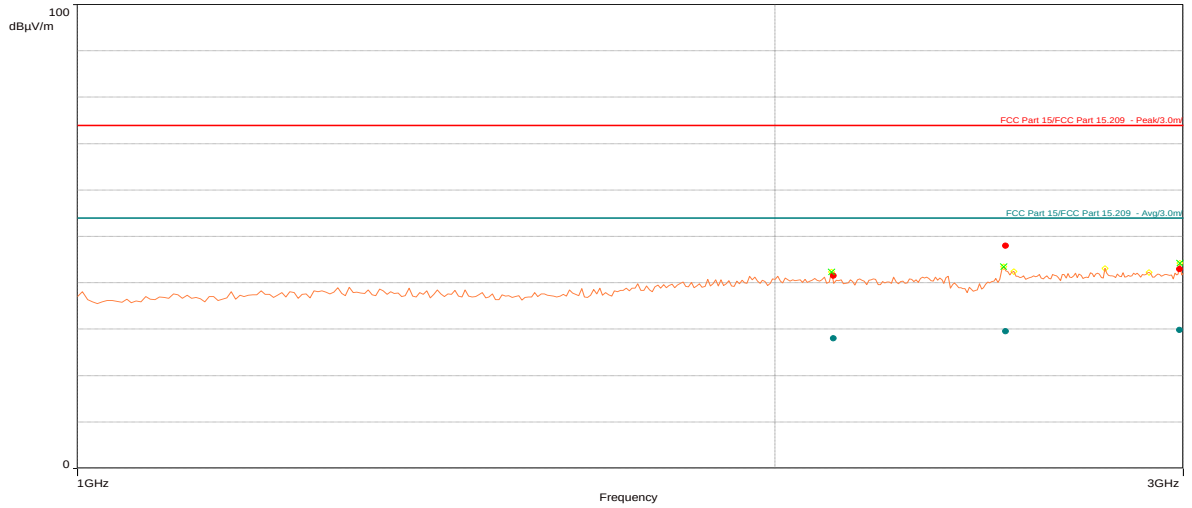
| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 149.9684211 | 33.14 | 33.50 | -0.36 | 275.00 | 3.62 | Horizontal | 120k | -19.80 |
| 200 | 23.16 | 33.50 | -10.34 | 214.00 | 1.62 | Vertical | 120k | -19.39 |
| 299.9684211 | 31.56 | 36.00 | -4.44 | 348.00 | 1.00 | Vertical | 120k | -18.16 |
| 399.9684211 | 31.72 | 36.00 | -4.28 | 283.00 | 1.59 | Horizontal | 120k | -15.49 |
| 449.9684211 | 32.80 | 36.00 | -3.20 | 285.00 | 1.75 | Horizontal | 120k | -13.97 |

## BLE Pistol, Transmit mode (worst-case orientation and channel), 1-3 GHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/30/2023 9:14:46 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 25 deg C |
| Humidity | 18% |
| Atmospheric Pressure | 1012 mB |
| Comments | RE 1 to 3GHz_Battery power_BLE_Tx High CH_PWR setting 25 (0dBm)_Worst-case output power and orientation |

**Graph:**




**Results:**

Peak (PASS) (3)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 2118.684211 | 41.54 | 74.00 | -32.46 | 202.00 | 3.39 | Horizontal | 1M | -16.92 |
| 2513.947368 | 48.02 | 74.00 | -25.98 | 277.00 | 2.22 | Vertical | 1M | -15.31 |
| 2989.473684 | 42.93 | 74.00 | -31.07 | 29.00 | 1.44 | Vertical | 1M | -14.63 |

Average (PASS) (3)

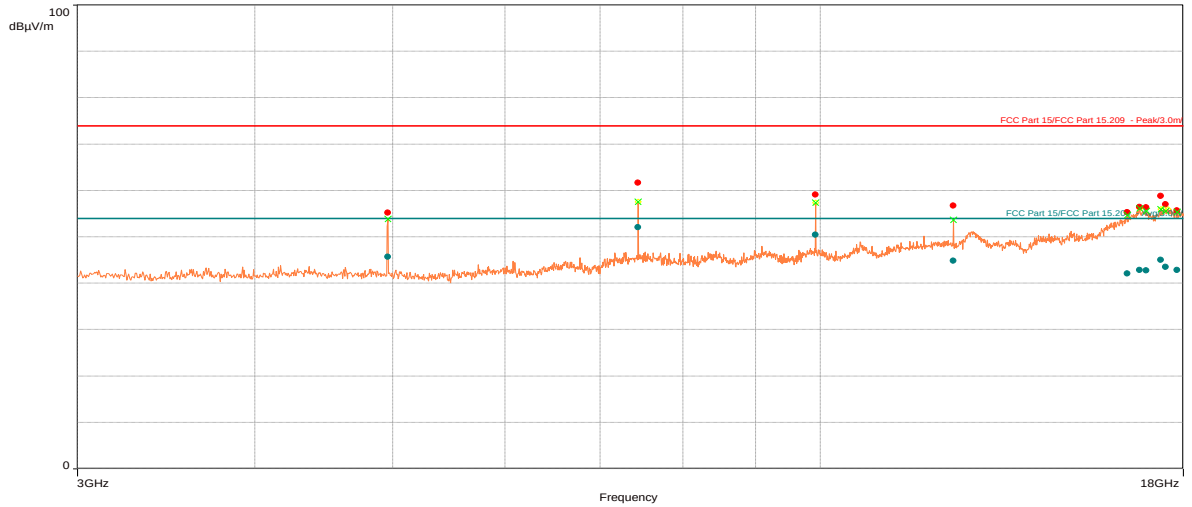
| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 2118.684211 | 28.02 | 54.00 | -25.98 | 202.00 | 3.39 | Horizontal | 1M | -16.92 |
| 2513.947368 | 29.60 | 54.00 | -24.40 | 277.00 | 2.22 | Vertical | 1M | -15.31 |
| 2989.473684 | 29.84 | 54.00 | -24.16 | 29.00 | 1.44 | Vertical | 1M | -14.63 |

## BLE Pistol, Transmit mode (worst-case orientation and channel), 3-25 GHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/30/2023 9:35:42 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 25 deg C |
| Humidity | 18% |
| Atmospheric Pressure | 1012 mB |
| Comments | RE 3 to 18GHz_Battery power_BLE_Tx High CH_PWR setting 25 (0dBm)_Worst-case output power and orientation |

**Graph:**




**Results:**

Peak (PASS) (10)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4960.526316 | 55.25 | 74.00 | -18.75 | 5.00 | 1.34 | Horizontal | 1000000.00 | 1M | -11.65 |
| 7439.210526 | 61.69 | 74.00 | -12.31 | 358.00 | 3.76 | Horizontal | 1000000.00 | 1M | -7.73 |
| 9918.947368 | 59.15 | 74.00 | -14.85 | 0.00 | 1.02 | Horizontal | 1000000.00 | 1M | -4.99 |
| 12398.68421 | 56.80 | 74.00 | -17.20 | 358.00 | 1.00 | Vertical | 1000000.00 | 1M | -0.24 |
| 16445.78947 | 55.29 | 74.00 | -18.71 | 329.00 | 1.11 | Horizontal | 1000000.00 | 1M | 4.42 |
| 16770.78947 | 56.44 | 74.00 | -17.56 | 254.00 | 2.89 | Horizontal | 1000000.00 | 1M | 5.57 |
| 16952.89474 | 56.37 | 74.00 | -17.63 | 139.00 | 1.91 | Vertical | 1000000.00 | 1M | 5.65 |
| 17361.57895 | 58.87 | 74.00 | -15.13 | 0.00 | 4.00 | Vertical | 1000000.00 | 1M | 5.45 |
| 17494.73684 | 57.04 | 74.00 | -16.96 | 179.00 | 3.63 | Horizontal | 1000000.00 | 1M | 5.70 |
| 17821.84211 | 55.71 | 74.00 | -18.29 | 69.00 | 2.25 | Horizontal | 1000000.00 | 1M | 6.09 |

Average (PASS) (10)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 4960.526316 | 45.76 | 54.00 | -8.24 | 5.00 | 1.34 | Horizontal | 1000000.00 | 1M | -11.65 |
| 7439.210526 | 52.08 | 54.00 | -1.92 | 358.00 | 3.76 | Horizontal | 1000000.00 | 1M | -7.73 |
| 9918.947368 | 50.49 | 54.00 | -3.51 | 0.00 | 1.02 | Horizontal | 1000000.00 | 1M | -4.99 |
| 12398.68421 | 44.91 | 54.00 | -9.09 | 358.00 | 1.00 | Vertical | 1000000.00 | 1M | -0.24 |
| 16445.78947 | 42.16 | 54.00 | -11.84 | 329.00 | 1.11 | Horizontal | 1000000.00 | 1M | 4.42 |
| 16770.78947 | 42.85 | 54.00 | -11.15 | 254.00 | 2.89 | Horizontal | 1000000.00 | 1M | 5.57 |
| 16952.89474 | 42.77 | 54.00 | -11.23 | 139.00 | 1.91 | Vertical | 1000000.00 | 1M | 5.65 |
| 17361.57895 | 45.10 | 54.00 | -8.90 | 0.00 | 4.00 | Vertical | 1000000.00 | 1M | 5.45 |
| 17494.73684 | 43.54 | 54.00 | -10.46 | 179.00 | 3.63 | Horizontal | 1000000.00 | 1M | 5.70 |
| 17821.84211 | 42.84 | 54.00 | -11.16 | 69.00 | 2.25 | Horizontal | 1000000.00 | 1M | 6.09 |

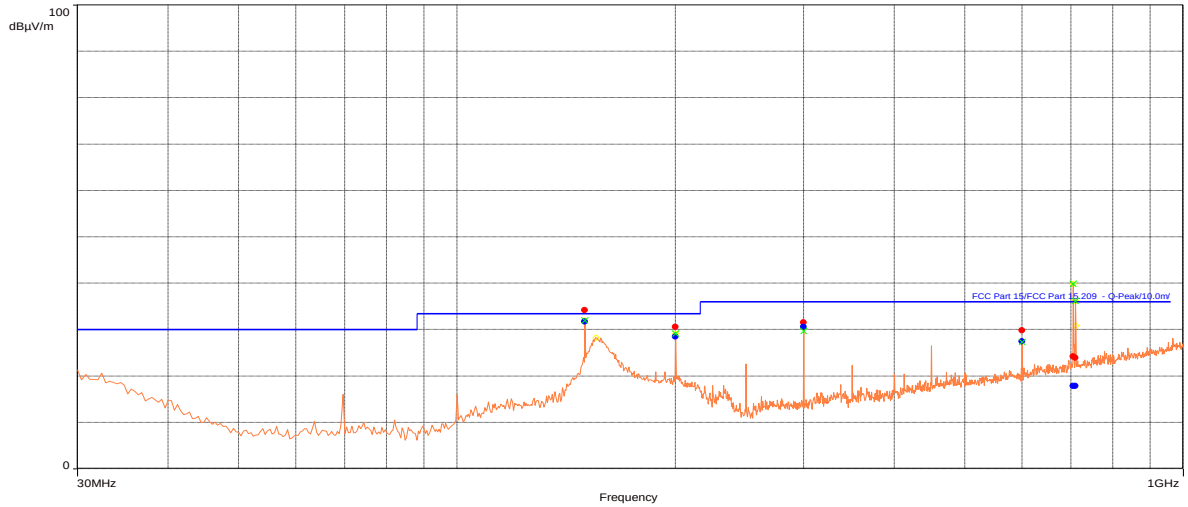
Note: Manual testing was performed from 13-25GHz, no emissions were detected above the measuring equipment noise floor.

## Zigbee Pistol, Transmit mode (worst-case orientation and channel), 30-1000 MHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/29/2023 5:19:36 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 27 deg C |
| Humidity | 31% |
| Atmospheric Pressure | 1005 mB |
| Comments | RE 30-1000MHz_Battery power_Tx mode_High CH_Worst-case output power |

**Graph:**




**Results:**

QuasiPeak (PASS) (6)

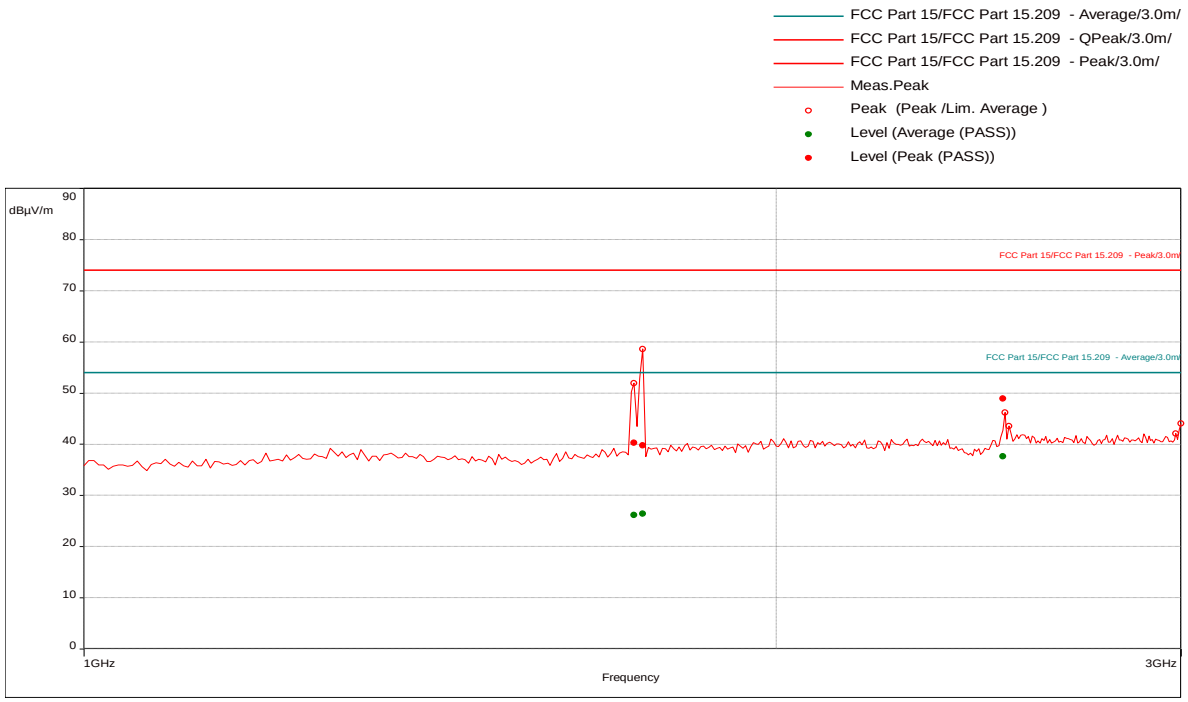
| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 149.9684211 | 31.80 | 33.50 | -1.70 | 165.00 | 1.00 | Vertical | 120k | -19.80 |
| 199.9684211 | 28.57 | 33.50 | -4.93 | 2.00 | 1.00 | Vertical | 120k | -19.40 |
| 299.9684211 | 30.59 | 36.00 | -5.41 | 174.00 | 1.00 | Vertical | 120k | -18.16 |
| 599.9684211 | 27.51 | 36.00 | -8.49 | 244.00 | 3.74 | Horizontal | 120k | -11.70 |
| 705.1578947 | 17.88 | 36.00 | -18.12 | 0.00 | 1.57 | Vertical | 120k | -9.09 |
| 710.1578947 | 17.89 | 36.00 | -18.11 | 105.00 | 2.77 | Vertical | 120k | -8.95 |

## Zigbee Pistol, Transmit mode (worst-case orientation and channel), 1-3 GHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/28/2023 9:24:35 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 23 deg C |
| Humidity | 28% |
| Atmospheric Pressure | 1007 mB |
| Comments | RE 1 to 3 GHz_Battery power_Tx mode_High CH 2480MHz_Worst-case output power |

**Graph:**




**Results:**

Peak (PASS) (3)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW (Hz) | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 1735 | 40.29 | 74.00 | -33.71 | 117.00 | 2.65 | Vertical | 1000000.00 | -19.52 |
| 1748.947368 | 39.82 | 74.00 | -34.18 | 206.00 | 2.60 | Vertical | 1000000.00 | -19.27 |
| 2511.842105 | 48.98 | 74.00 | -25.02 | 282.00 | 1.01 | Vertical | 1000000.00 | -15.30 |

Average (PASS) (3)

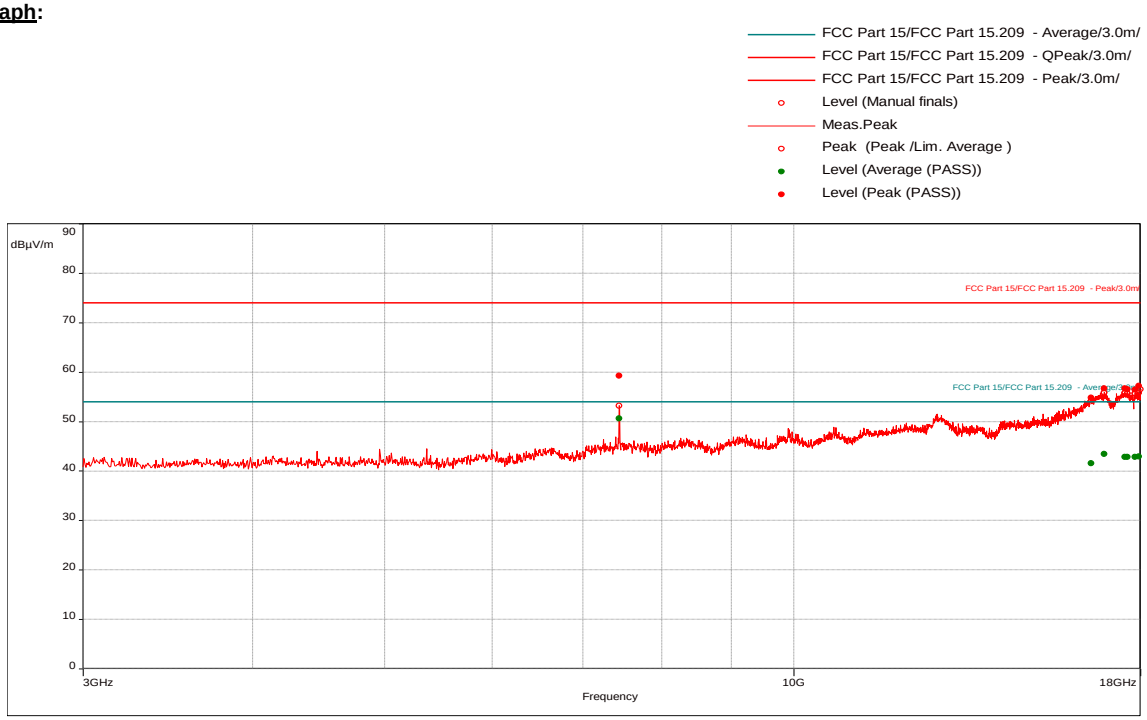
| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW (Hz) | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 1735 | 26.21 | 54.00 | -27.79 | 117.00 | 2.65 | Vertical | 1000000.00 | -19.52 |
| 1748.947368 | 26.44 | 54.00 | -27.56 | 206.00 | 2.60 | Vertical | 1000000.00 | -19.27 |
| 2511.842105 | 37.68 | 54.00 | -16.32 | 282.00 | 1.01 | Vertical | 1000000.00 | -15.30 |

## Zigbee Pistol, Transmit mode (worst-case orientation and channel), 3-25 GHz

**Test Information:**

| | |
|---|---|
| Date and Time | 3/28/2023 9:44:17 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 23 deg C |
| Humidity | 28% |
| Atmospheric Pressure | 1007 mB |
| Comments | RE 3 to 18 GHz_Battery power_Tx mode_High CH 2480MHz_Worst-case output power |

**Graph:**




**Results:**

Peak (PASS) (7)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW (Hz) | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 7438.684211 | 59.29 | 74.00 | -14.71 | 329.00 | 1.40 | Horizontal | 1000000.00 | -7.73 |
| 16559.47368 | 54.82 | 74.00 | -19.18 | 334.00 | 2.40 | Horizontal | 1000000.00 | 4.81 |
| 16928.42105 | 56.69 | 74.00 | -17.31 | 284.00 | 2.90 | Vertical | 1000000.00 | 5.66 |
| 17525 | 56.77 | 74.00 | -17.23 | 79.00 | 2.90 | Horizontal | 1000000.00 | 5.74 |
| 17606.57895 | 56.55 | 74.00 | -17.45 | 289.00 | 2.55 | Vertical | 1000000.00 | 5.82 |
| 17831.84211 | 56.51 | 74.00 | -17.49 | 1.00 | 2.05 | Horizontal | 1000000.00 | 6.09 |
| 17944.47368 | 57.22 | 74.00 | -16.78 | 81.00 | 3.00 | Horizontal | 1000000.00 | 6.04 |

Average (PASS) (7)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW (Hz) | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 7438.684211 | 50.66 | 54.00 | -3.34 | 329.00 | 1.40 | Horizontal | 1000000.00 | -7.73 |
| 16559.47368 | 41.63 | 54.00 | -12.37 | 334.00 | 2.40 | Horizontal | 1000000.00 | 4.81 |
| 16928.42105 | 43.46 | 54.00 | -10.54 | 284.00 | 2.90 | Vertical | 1000000.00 | 5.66 |
| 17525 | 42.90 | 54.00 | -11.10 | 79.00 | 2.90 | Horizontal | 1000000.00 | 5.74 |
| 17606.57895 | 42.91 | 54.00 | -11.09 | 289.00 | 2.55 | Vertical | 1000000.00 | 5.82 |
| 17831.84211 | 42.86 | 54.00 | -11.14 | 1.00 | 2.05 | Horizontal | 1000000.00 | 6.09 |
| 17944.47368 | 42.98 | 54.00 | -11.02 | 81.00 | 3.00 | Horizontal | 1000000.00 | 6.04 |

Note: Manual testing was performed from 13-25GHz, no emissions were detected above the measuring equipment noise floor.

| | | | |
|---|---|---|---|
| Test Personnel: | Vathana Ven | Test Date: | 03/28/2023<br>03/29/2023<br>03/30/2023 |
| Supervising/Reviewing Engineer: (Where Applicable) | N/A | | |
| Product Standard: | CFR47 FCC Part 15.247<br>RSS-247 | Limit Applied: | See report section 9.3 |
| Input Voltage: | Battery power | Ambient Temperature: | 23, 25, 25 ºC |
| Pretest Verification w/ Ambient Signals or BB Source: | N/A | Relative Humidity: | 28, 18, 18 % |
| | | Atmospheric Pressure: | 1007, 1012, 1012 mbars |

Deviations, Additions, or Exclusions: None

# 10 Digital Device and Receiver Radiated Spurious Emissions

## 10.1 Method

Tests are performed in accordance with FCC Part 15 Subpart B, ISED ICES-003, and ANSI C 63.4.

**TEST SITE:** 10m ALSE

**The 10m ALSE** is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

**Measurement Uncertainty**

| Measurement | Frequency Range | Expanded Uncertainty (k=2) | Ucispr |
|---|---|---|---|
| Radiated Emissions, 10m | 30-1000 MHz | 4.6dB | 6.3 dB |
| Radiated Emissions, 3m | 30-1000 MHz | 5.3 dB | 6.3 dB |
| Radiated Emissions, 3m | 1-6 GHz | 4.5 dB | 5.2 dB |
| Radiated Emissions, 3m | 6-15 GHz | 5.2 dB | 5.5 dB |
| Radiated Emissions, 3m | 15-18 GHz | 5.0 dB | 5.5 dB |
| Radiated Emissions, 3m | 18-40 GHz | 5.0 dB | 5.5 dB |

As shown in the table above our radiated emissions $U_{lab}$ is less than the corresponding $U_{CISPR}$ reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

**Sample Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

**Example:**

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the “Level” includes all losses and gains and is compared directly in the “Margin” column to the “Limit”. The “Correction” includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the “Level” column.

## 10.2 Test Equipment Used:

| Asset | Description | Manufacturer | Model | Serial | Cal Date | Cal Due |
|---|---|---|---|---|---|---|
| DAV007' | Weather Station Vantage Vue | Davis | 6250 | MS191212003 | 03/15/2023 | 03/15/2024 |
| 145108' | EMI Test Receiver (20Hz - 40GHz) | Rohde & Schwarz | ESIB40 | 100209 | 06/23/2022 | 06/23/2023 |
| PRE11' | 50dB gain pre-amp | Pasternack | PRE11 | PRE11 | 09/20/2022 | 09/20/2023 |
| 145145' | Broadband Hybrid Antenna 30 MHz - 3 GHz | Sunol Sciences Corp. | JB3 | A122313 | 06/16/2022 | 06/16/2023 |
| IW001' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| 145-420' | Receiver to floor cable | Utiflex | UFB311A-2-0591-70070 | 145-420 | 02/18/2023 | 02/18/2024 |
| HS001' | DC-18GHz cable 1.5m long | Huber & Suhner | SucoFlex 106A | HS001 | 01/25/2023 | 01/25/2024 |
| IW003' | 8.4 meter cable | Insulated Wire | 2800-NPS | 003 | 11/14/2022 | 11/14/2023 |
| 145-422' | 10Amp Pre-amp to under floor | Utiflex | UFB311A-0-2756-70070 | 145-422 | 02/18/2023 | 02/18/2024 |
| HS003' | 10m under floor cable | Huber-Schuner | 10m-1 | HS003 | 02/18/2023 | 02/18/2024 |
| ETS002' | 1-18GHz DRG Horn Antenna | ETS Lindgren | 3117 | 00143260 | 09/27/2022 | 09/27/2023 |
| BONN001' | 1-18GHz low noise pre-amp | Bonn | BLMA 0118-M | 1811749 | 07/19/2022 | 07/19/2023 |

**Software Utilized:**

| Name | Manufacturer | Version |
|---|---|---|
| BAT-EMC | Nexio | 3.18.0.16 |

## 10.3 Results:

The sample tested was found to Comply.

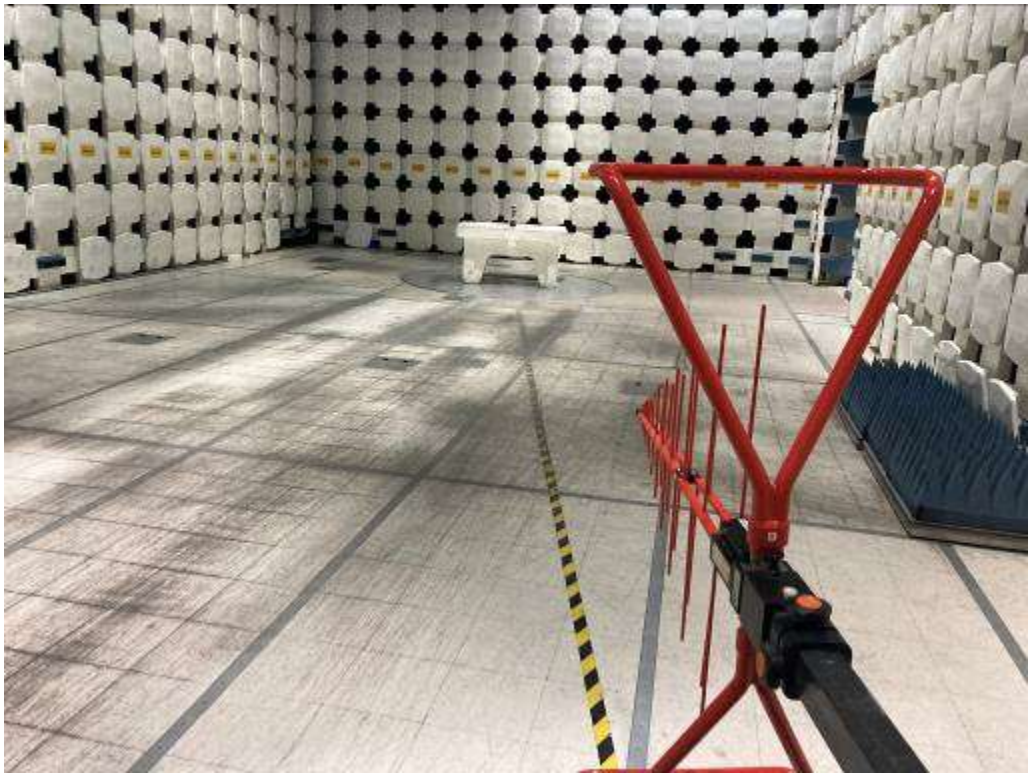
§15.109 Radiated emission limits.

The field strength of radiated emissions form unintentional radiators at a distance of 3 meters shall not exceed the following values.

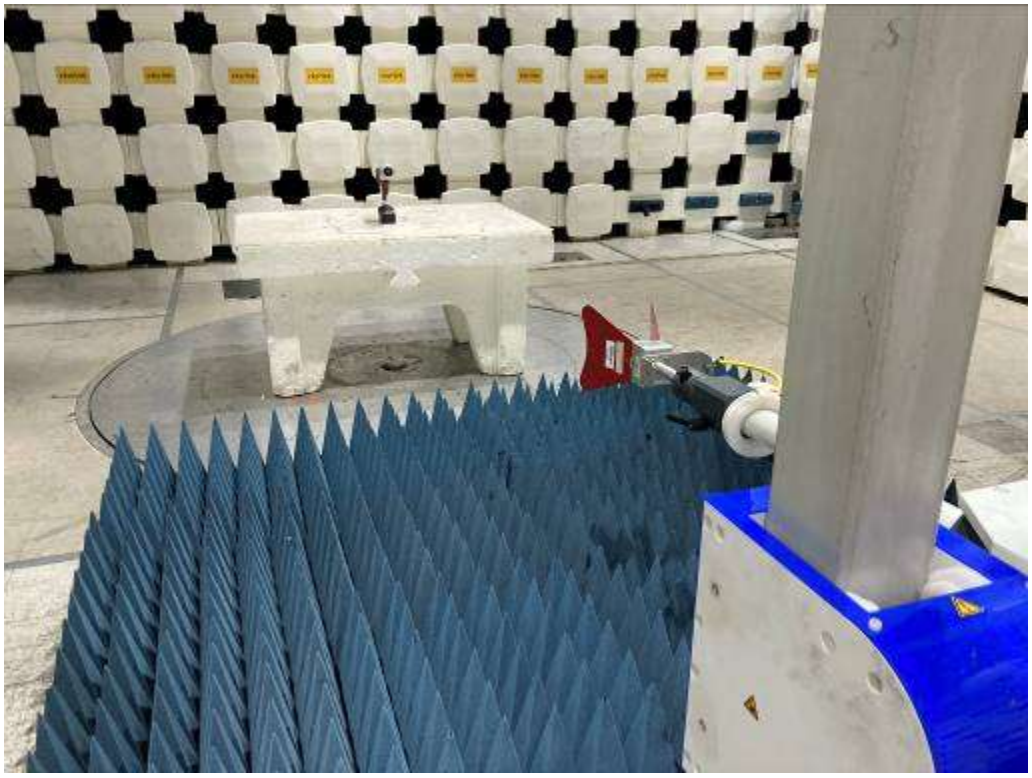
| Frequency of emission (MHz) | Field strength (microvolts/meter) | Field strength (dBµV/m) |
|---|---|---|
| 30-88 | 100 | 40.00 |
| 88-216 | 150 | 43.52 |
| 216-960 | 200 | 46.02 |
| Above 960 | 500 | 54.00 |

## 10.4 Setup Photographs:

Test Setup, 30-1000 MHz, Pistol Angle Wrench



Test Setup, 1-13 GHz, Pistol Angle Wrench



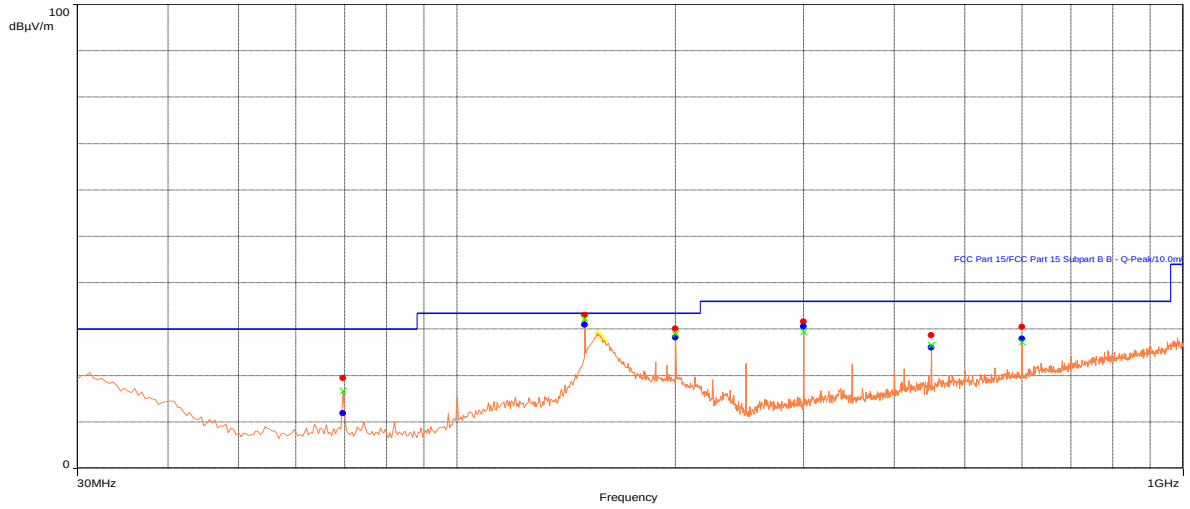
## 10.5 Plots/Data:

**30-1000 MHz, Idle mode**

**Test Information:**

| | |
|---|---|
| Date and Time | 3/29/2023 4:45:38 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 27 deg C |
| Humidity | 31% |
| Atmospheric Pressure | 1005 mB |
| Comments | RE 30-1000MHz_Battery power_Rx mode |

**Graph:**




**Results:**

QuasiPeak (PASS) (6)

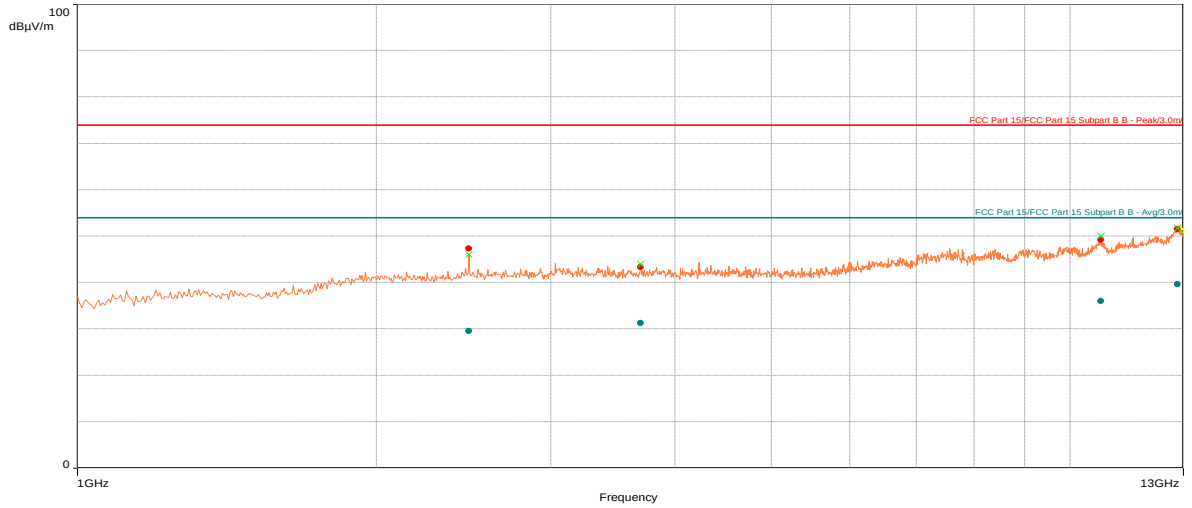
| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 69.50526316 | 11.89 | 30.00 | -18.11 | 228.00 | 2.23 | Vertical | 120k | -24.80 |
| 149.9684211 | 31.03 | 33.50 | -2.47 | 328.00 | 1.37 | Vertical | 120k | -19.80 |
| 199.9684211 | 28.26 | 33.50 | -5.24 | 119.00 | 1.00 | Vertical | 120k | -19.40 |
| 299.9684211 | 30.63 | 36.00 | -5.37 | 298.00 | 1.00 | Vertical | 120k | -18.16 |
| 449.9684211 | 26.03 | 36.00 | -9.97 | 274.00 | 2.15 | Horizontal | 120k | -13.97 |
| 599.9684211 | 27.95 | 36.00 | -8.05 | 299.00 | 1.00 | Horizontal | 120k | -11.70 |

## 1-13 GHz, Idle

**Test Information:**

| | |
|---|---|
| Date and Time | 3/29/2023 10:14:07 PM |
| Client and Project Number | Ingersoll Rand_G105295733 |
| Engineer | Vathana Ven |
| Temperature | 27 deg C |
| Humidity | 31% |
| Atmospheric Pressure | 1005 mB |
| Comments | RE 1 to 13GHz_Battery power_BLE_Rx mode |

**Graph:**




**Results:**

Peak (PASS) (4)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 2479.473684 | 47.34 | 74.00 | -26.66 | 92.00 | 2.28 | Vertical | 1M | -15.59 |
| 3696.052632 | 43.33 | 74.00 | -30.67 | 246.00 | 3.53 | Vertical | 1M | -13.46 |
| 10736.84211 | 49.29 | 74.00 | -24.71 | 173.00 | 2.65 | Horizontal | 1M | -3.25 |
| 12826.84211 | 51.57 | 74.00 | -22.43 | 5.00 | 1.91 | Vertical | 1M | 1.57 |

Average (PASS) (4)

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Azimuth (°) | Height (m) | Pol. | RBW | Correction (dB) |
|---|---|---|---|---|---|---|---|---|
| 2479.473684 | 29.56 | 54.00 | -24.44 | 92.00 | 2.28 | Vertical | 1M | -15.59 |
| 3696.052632 | 31.28 | 54.00 | -22.72 | 246.00 | 3.53 | Vertical | 1M | -13.46 |
| 10736.84211 | 36.06 | 54.00 | -17.94 | 173.00 | 2.65 | Horizontal | 1M | -3.25 |
| 12826.84211 | 39.63 | 54.00 | -14.37 | 5.00 | 1.91 | Vertical | 1M | 1.57 |

| | | | |
|---|---|---|---|
| Test Personnel: | Vathana Ven | Test Date: | 03/30/2023 |
| Supervising/Reviewing Engineer: (Where Applicable) | N/A | | |
| Product Standard: | CFR47 FCC Part 15B ISED ICES-003 | Limit Applied: | See report section 10.3 |
| Input Voltage: | Battery power | Ambient Temperature: | 25 ºC |
| Pretest Verification w/ Ambient Signals or BB Source: | N/A | Relative Humidity: | 18 % |
| | | Atmospheric Pressure: | 1012 mbars |

Deviations, Additions, or Exclusions: None

## 11 Revision History

| Revision Level | Date | Report Number | Prepared By | Reviewed By | Notes |
|---|---|---|---|---|---|
| 0 | 03/26/2024 | 105295733BOX-012 | VFV | KPS | Original Issue |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |