INGERSOLL-RAND INDUSTRIAL U.S., INC.

EMISSIONS TEST REPORT

SCOPE OF WORK
EMISSIONS TESTING – MODEL QCXD21 (Zigbee – IEEE 802.15.4 USB Dongle)

REPORT NUMBER
105001833BOX-006

ISSUE DATE	**[REVISED DATE]**
June 2, 2022	Original Issue

DOCUMENT CONTROL NUMBER
Non-Specific Radio Report Shell Rev. August 2020

EMISSIONS TEST REPORT

(FULL COMPLIANCE FOR LIMITED SINGLE-MODULAR TRANSMITTER)

Report Number: 105001833BOX-006
Project Number: G105001833

Report Issue Date: June 2, 2022

Model(s) Tested:	QCXD21 (Zigbee – IEEE 802.15.4 USB Dongle)
Model(s) Partially Tested:	None
Model(s) Not Tested but declared equivalent by the client:	None

Standards: CFR47 FCC Part 15.247 Subpart C: 05/2022,
CFR47 FCC Part 15 Subpart B: 05/2022,
RSS-247 Issue 2 February 2017,
ISED ICES-003 Issue 7 October 2020,
RSS-Gen Issue 5 April 2018,
KDB 558074 D01 15.247 Meas Guidance v05r02: 04/2019

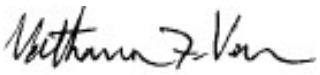
Tested by:
Intertek Testing Services NA, Inc.
70 Codman Hill Road
Boxborough, MA 01719
USA

Client:
Rand Industrial U.S., Inc.
800-E Beaty Street
Davidson, NC 28036
USA

Report prepared by

Kouma Sinn / EMC Engineering Supervisor

Report reviewed by



Vathana Ven / EMC Engineering Supervisor

Table of Contents

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 and Human RF exposure CFR47 FCC Part 15 Subpart C: 05/2022, Section 15.247 (b)(3) RSS-247 Issue 2 February 2017	Pass
7	6 dB Bandwidth and Occupied Bandwidth CFR47 FCC Part 15 Subpart C: 05/2022, Section 15.247 (a)(2) RSS-247 Issue 2 February 2017	Pass
8	Maximum Power Spectral Density CFR47 FCC Part 15 Subpart C: 05/2022, Section 15.247 (e) RSS-247 Issue 2 February 2017	Pass
9	Band Edge Compliance CFR47 FCC Part 15 Subpart C: 05/2022, Section 15.247 (d) RSS-247 Issue 2: 02/2017)	Pass
10	Transmitter spurious emissions CFR47 FCC Part 15 Subpart C: 05/2022, Section 15.247 (d) RSS-247 Issue 2 February 2017	Pass
11	Digital Device and Receiver Radiated Spurious Emissions (CFR47 FCC Part 15 Subpart B 15.109: 05/2022 ISED ICES-003 Issue 7 October 2020	Pass
12	AC Mains Conducted Emissions FCC 47CFR Part 15.107:2019 ISED ICES-003 Issue 7 October 2020	Pass
13	Revision History	--

3 Client Information

This EUT was tested at the request of:

Client: Ingersoll-Rand Industrial U.S., Inc.
800-E Beaty Street
Davidson, NC 28036
USA

Contact: John Linehan
Telephone: Not provided
Fax: Not provided
Email: john_linehan@irco.com

4 Description of Equipment Under Test and Variant Models

Manufacturer: Ingersoll-Rand Industrial U.S., Inc.
800-E Beaty Street
Davidson, NC 28036
USA

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Zigbee (IEEE 802.15.4) USB Dongle	Ingersoll-Rand Company	QCXD21 (USB Dongle)	*BOX220506946-002

*Shipping track number issued by Intertek.

Receive Date:	05/06/2022
Received Condition:	Good
Type:	Production

Description of Equipment Under Test (provided by client)
The equipment under test is Zigbee (IEEE 802.15.4) USB Dongle that use with the INSIGHTqcx Wireless Tool Controller

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
USB Powered	N/A	DC	N/A

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	The transmitter was programmed to transmit at low, mid, and high channels
2	The transmitter was programmed to receive at mid channel

Software used by the EUT:

No.	Descriptions of EUT Exercising
1	The Command Script using ClearTerminal was provided by the client

Radio/Receiver Characteristics	
Frequency Band(s)	2405-2475 MHz
Modulation Type(s)	O-QPSK
Maximum Output Power	Low Channel (2405 MHz): +3.93 dBm Mid Channel (2440 MHz): +4.47 dBm High Channel (2475 MHz): +5.42 dBm
Test Channels	Low Channel (2405 MHz) Mid Channel (2440 MHz) High Channel (2475 MHz)
Occupied Bandwidth	Low Channel (2405 MHz): 2.417 MHz Mid Channel (2440 MHz): 2.439 MHz High Channel (2475 MHz): 2.438 MHz
6 dB Bandwidth	Low Channel (2405 MHz): 1.470 MHz Mid Channel (2440 MHz): 1.480 MHz High Channel (2475 MHz): 1.450 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, +2.0 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	--	--	--	--

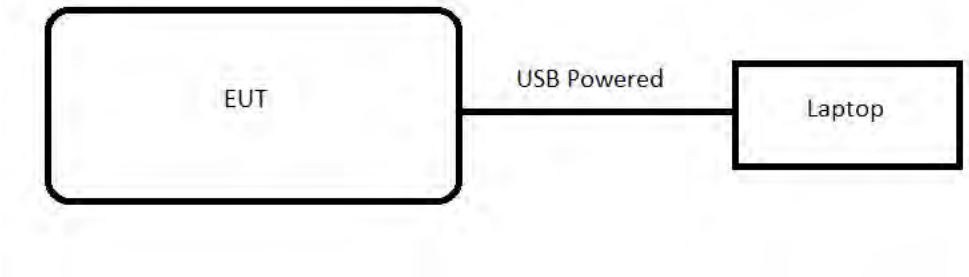
Support Equipment			
Description	Manufacturer	Model Number	Serial Number
Laptop	HP	EliteBook 8470p	Not labeled
*Cordless Tool Controller	Ingersoll-Rand Industrial U.S., Inc.	QCXD11	K20M02100

*Used for line conducted emissions test.

5.1 Method:

Configuration as required by Configuration as required by CFR47 FCC Part 15.247 Subpart C: 05/2022, CFR47 FCC Part 15 Subpart B: 05/2022, RSS-247 Issue 2 February 2017, ICES-003 Issue 7 October 2020, RSS-Gen Issue 5 April 2018, ANSI C 63.10: 2013, ANSI C 63.4: 2014, and 558074 D01 15.247 Meas Guidance v05r02: 04/2019.

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 D01.

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.

6.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV005'	Weather Station	Davis	6250	MS191218083	02/11/2022	02/11/2023
CEN001'	DC-40GHz attenuator 20dB	Centric RF	C411-20	CEN001	01/26/2022	01/26/2023
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	11/02/2021	11/02/2022
CBLHF2012-2M-2'	2m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252675002	02/10/2023	02/10/2023

Software Utilized:

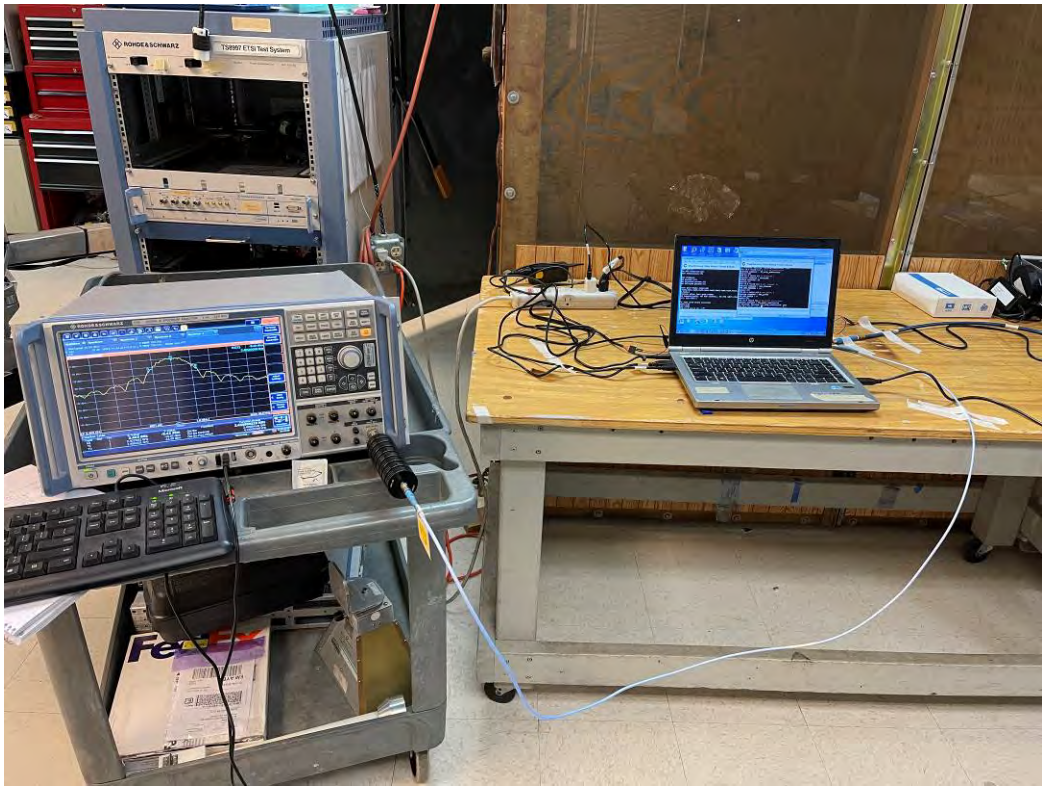
Name	Manufacturer	Version
None	--	--

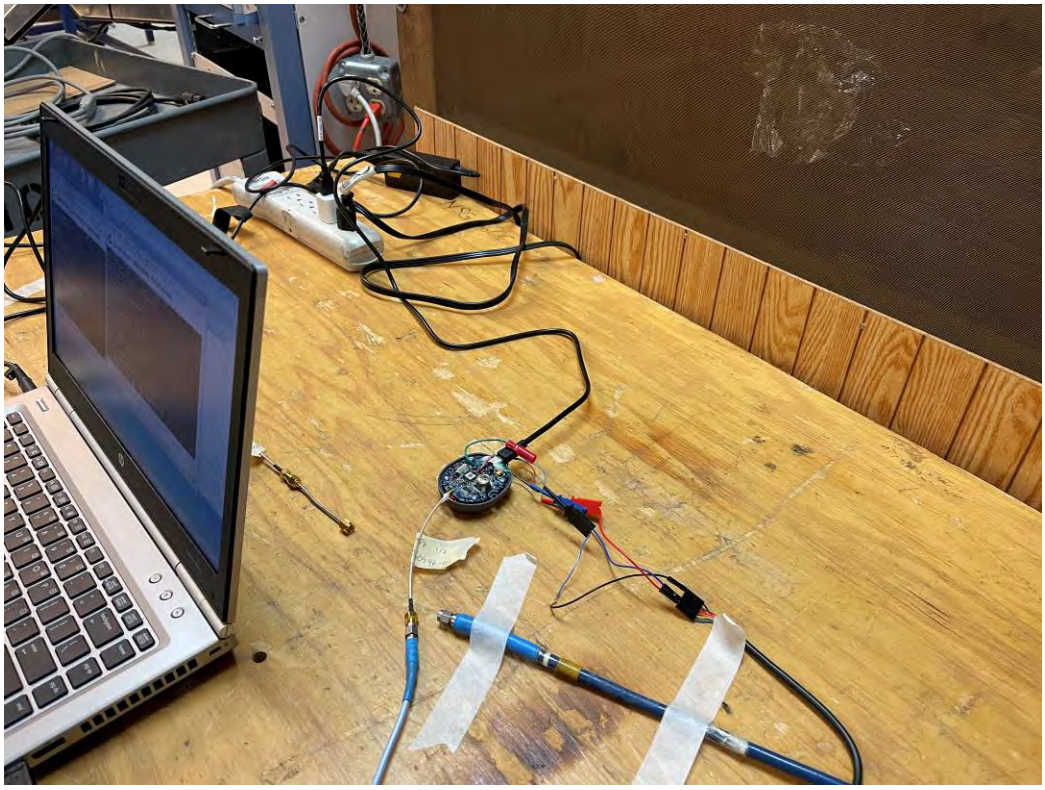
6.3 Results:

The sample tested was found to Comply.

Limits – FCC Part §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.

6.4 Setup Photographs:





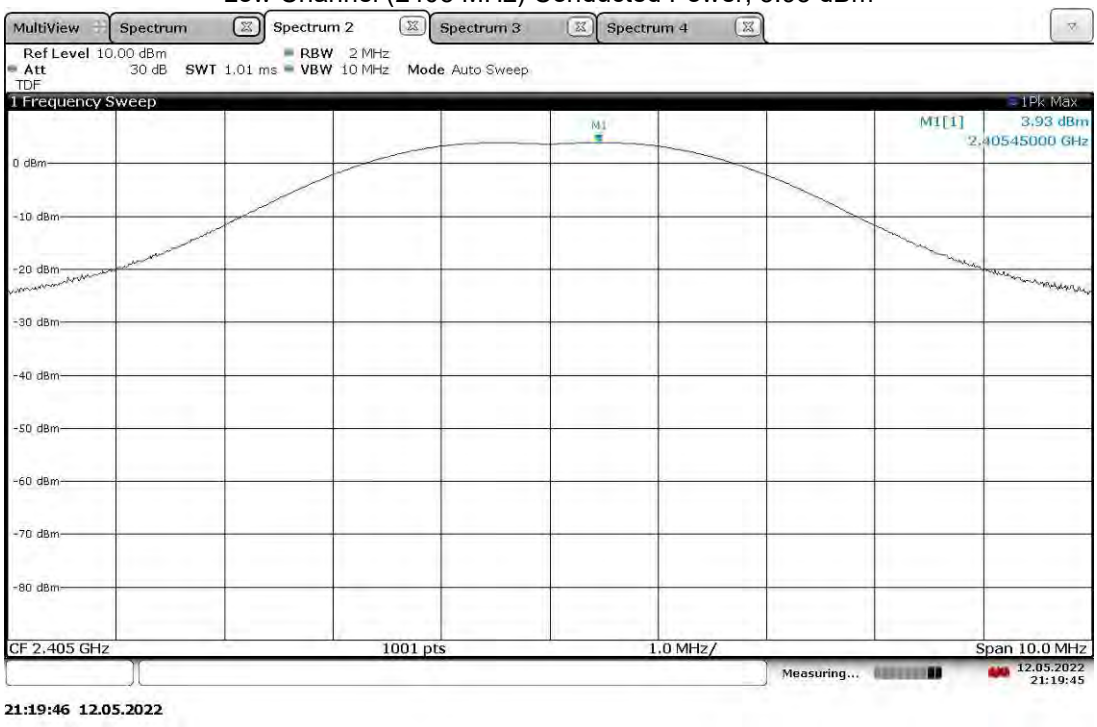
6.5 Plots/Data:

Output Power

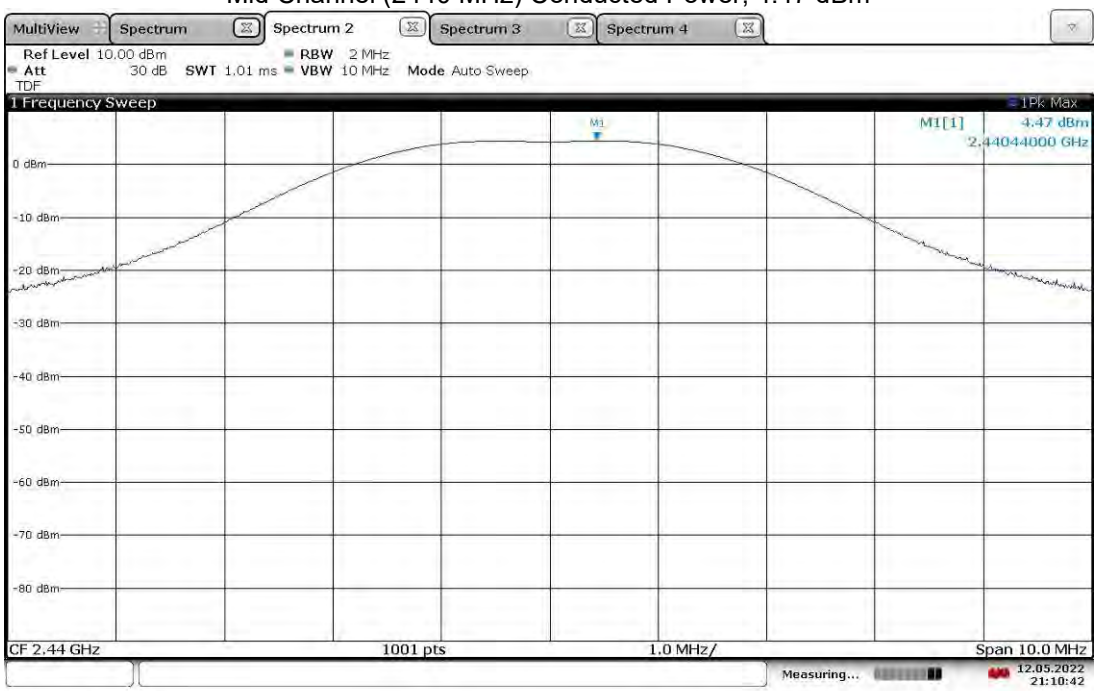
Frequency (MHz)	Conducted Output power (dBm)	Antenna gain (dBi)	EIRP (dBm)	Conducted Output Power Limit (dBm)	Conducted Output Power Margin (dB)
2405	3.93	2	5.93	30	-26.07
2440	4.47	2	6.47	30	-24.53
2475	5.42	2	7.42	30	-24.58

Note: See plots below. All cable and attenuation factors were internally compensated as TDF.

Low Channel (2405 MHz) Conducted Power, 3.93 dBm

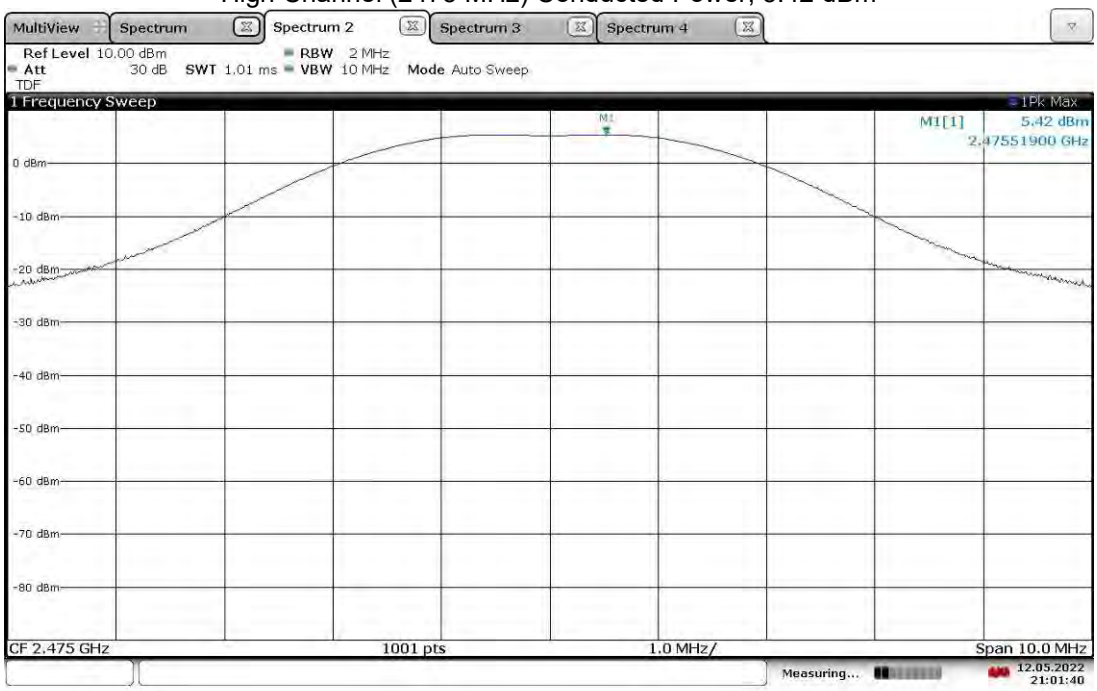


Mid Channel (2440 MHz) Conducted Power, 4.47 dBm



21:10:42 12.05.2022

High Channel (2475 MHz) Conducted Power, 5.42 dBm



21:01:40 12.05.2022

Test Personnel:	Kouma Sinn KPS	Test Date:	05/12/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	CFR47 FCC Part 15.247 RSS-247	Limit Applied:	See report section 6.3
Input Voltage:	USB Powered		
		Ambient Temperature:	22 ºC
Pretest Verification BB Source:	N/A	Relative Humidity:	48 %
		Atmospheric Pressure:	1017 mbars

Deviations, Additions, or Exclusions: None

7 6 dB Bandwidth and Occupied Bandwidth

7.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and KDB 558074 D01.

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
DAV005'	Weather Station	Davis	6250	MS191218083	02/11/2022	02/11/2023
CEN001'	DC-40GHz attenuator 20dB	Centric RF	C411-20	CEN001	01/26/2022	01/26/2023
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	11/02/2021	11/02/2022
CBLHF2012-2M-2'	2m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252675002	02/10/2023	02/10/2023

Software Utilized:

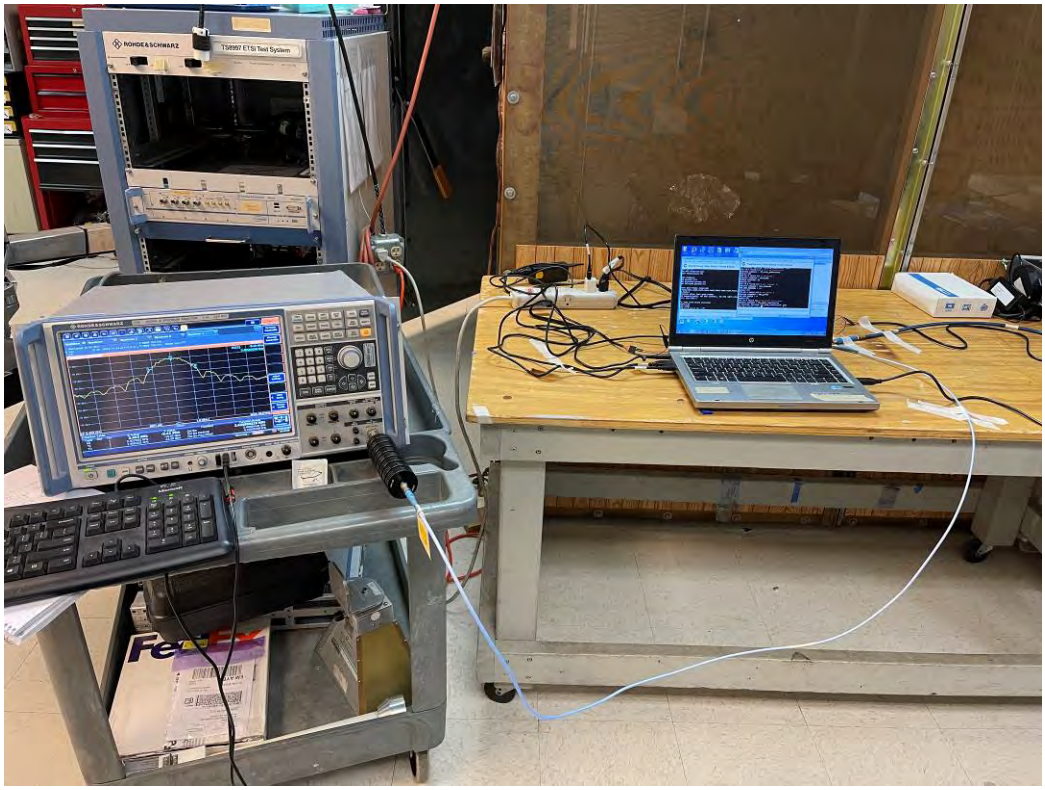
Name	Manufacturer	Version
None	--	--

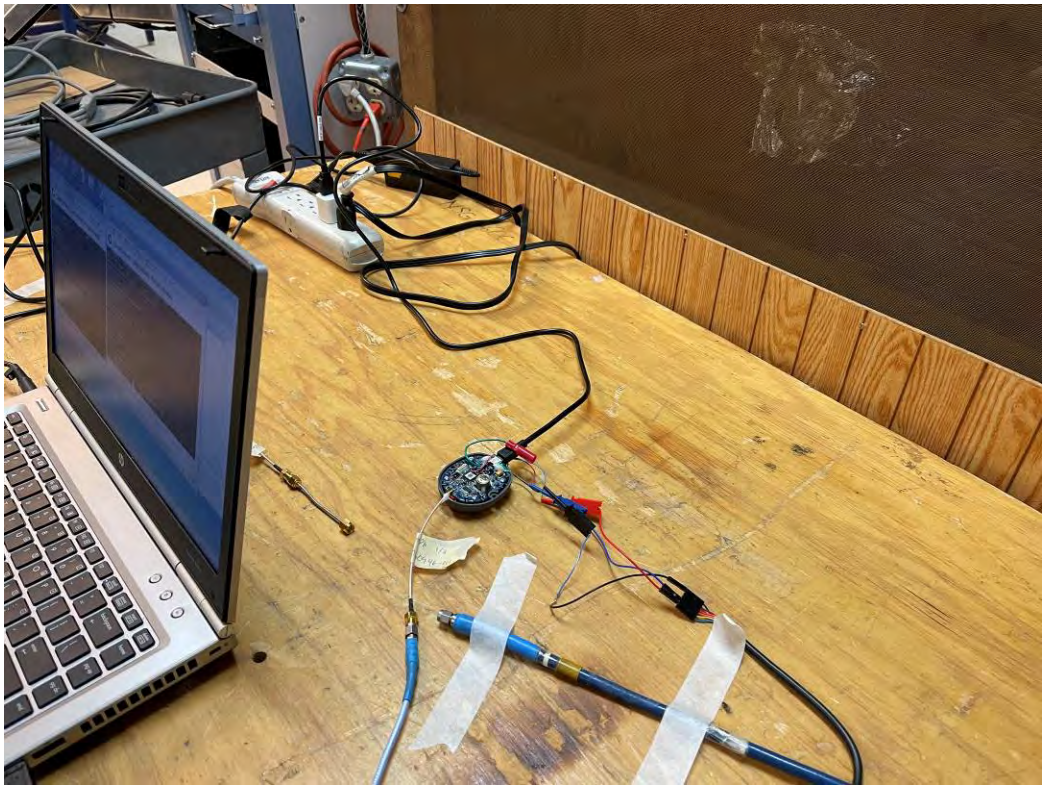
7.3 Results:

The sample tested was found to Comply.

Limits – FCC Part §15.247 (a) (2) Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

7.4 Setup Photographs:





7.5 Plots / Data:

DTS Bandwidth

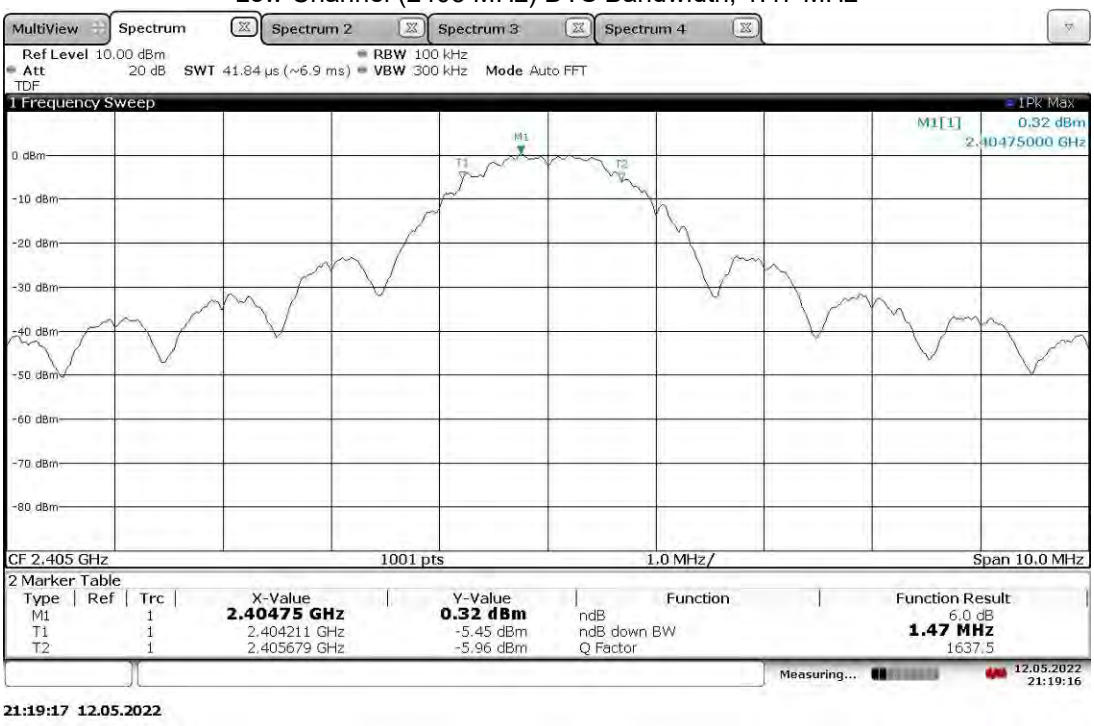
Frequency (MHz)	DTS Bandwidth (6 dB Bandwidth) (MHz)	DTS Bandwidth Limit (kHz)	Results
2405	1.470	≥ 500	Compliance
2440	1.480	≥ 500	Compliance
2475	1.450	≥ 500	Compliance

Occupied Bandwidth (OBW)

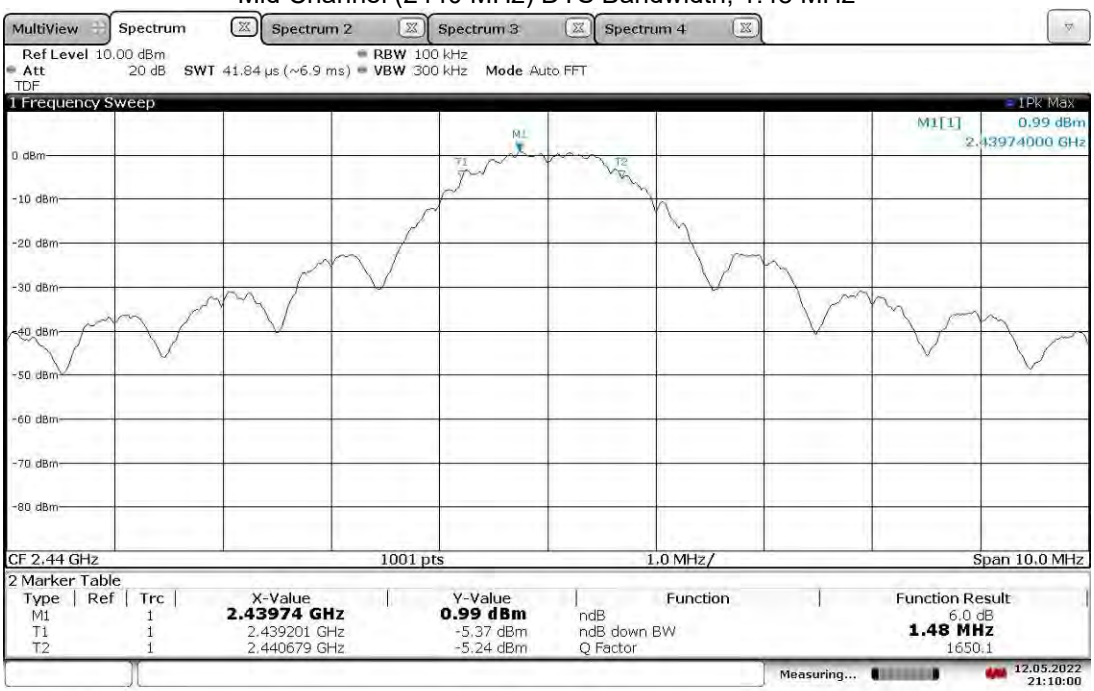
Frequency (MHz)	Occupied Bandwidth (MHz)	Occupied Bandwidth Limit	Results
2405	2.417	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Compliance
2440	2.439	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Compliance
2475	2.438	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Compliance

Note: See plots below. All cable and attenuation factors were internally compensated as TDF.

Low Channel (2405 MHz) DTS Bandwidth, 1.47 MHz

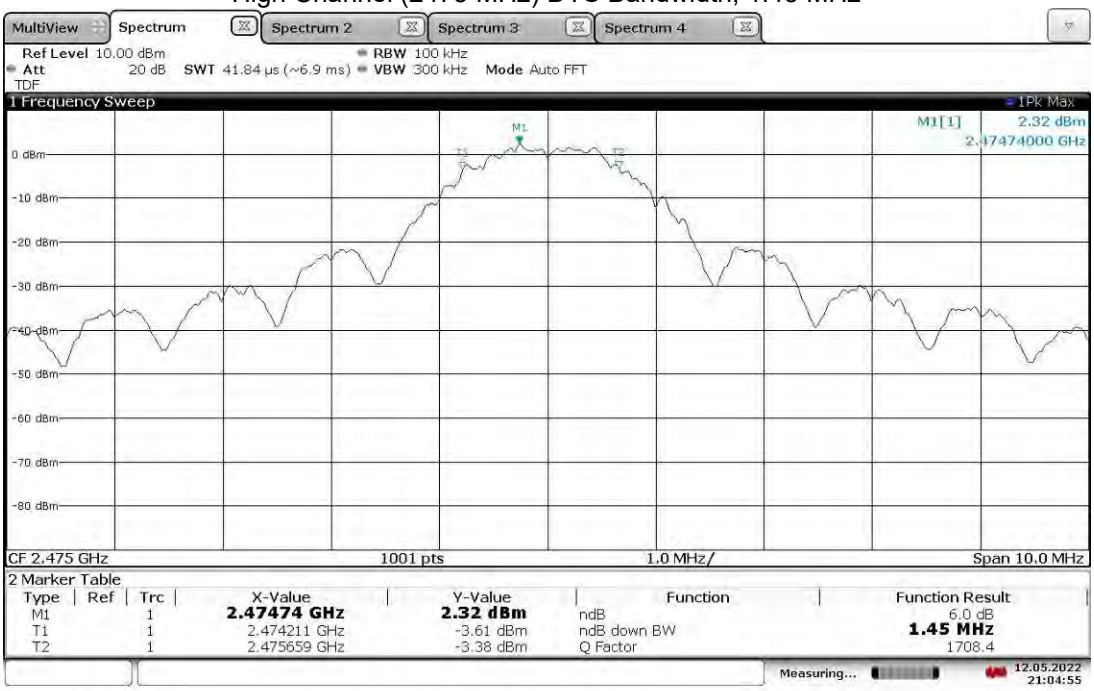


Mid Channel (2440 MHz) DTS Bandwidth, 1.48 MHz



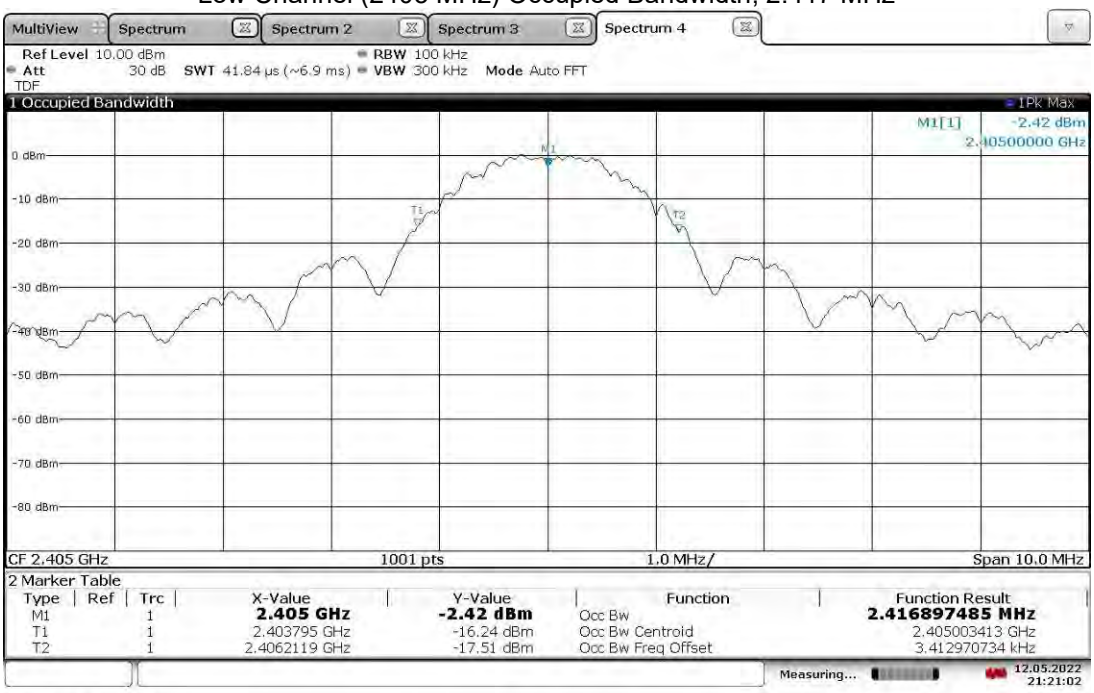
21:10:00 12.05.2022

High Channel (2475 MHz) DTS Bandwidth, 1.45 MHz



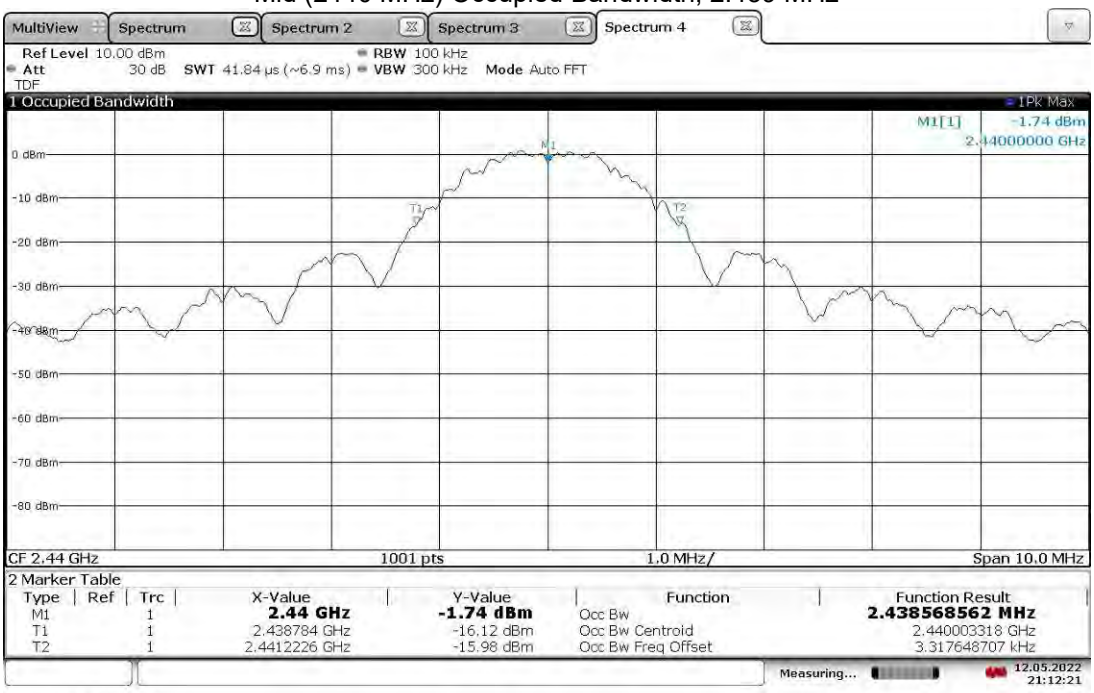
21:04:56 12.05.2022

Low Channel (2405 MHz) Occupied Bandwidth, 2.417 MHz



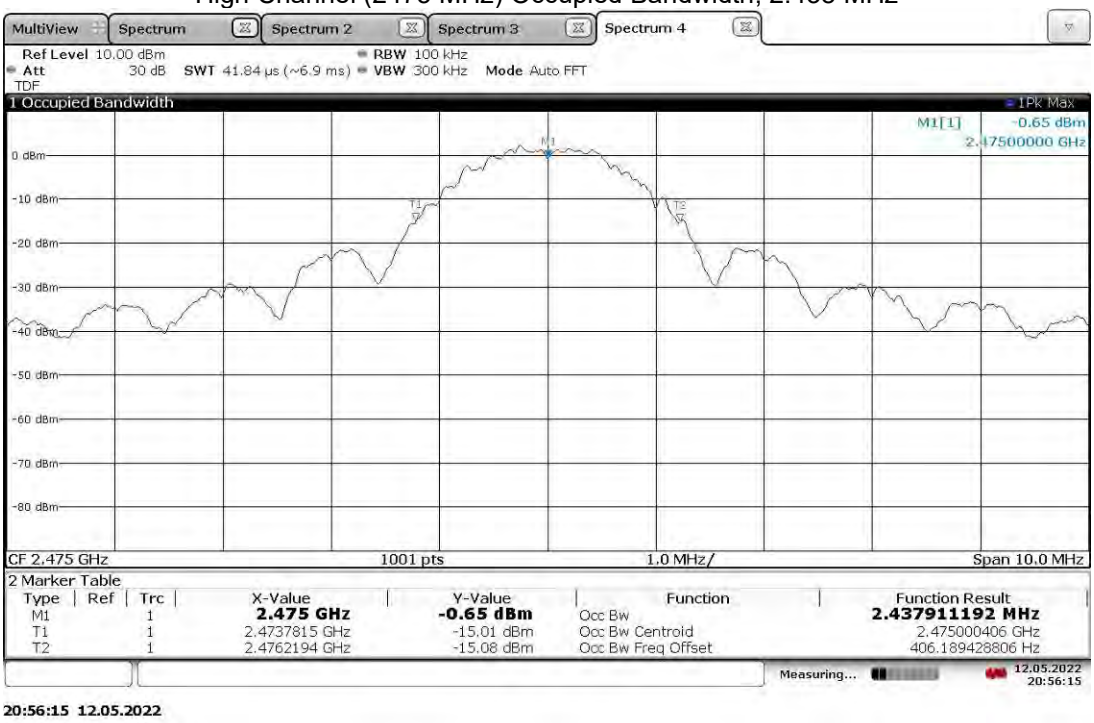
21:21:03 12.05.2022

Mid (2440 MHz) Occupied Bandwidth, 2.439 MHz



21:12:21 12.05.2022

High Channel (2475 MHz) Occupied Bandwidth, 2.438 MHz



Test Personnel:	Kouma Sinn KPS	Test Date:	05/12/2022
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:	USB Powered		
		Ambient Temperature:	22 ºC
Pretest Verification BB Source:	N/A	Relative Humidity:	48 %
		Atmospheric Pressure:	1017 mbars

Deviations, Additions, or Exclusions: None

8 Maximum Power Spectral Density

8.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02: 04/2019.

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
DAV005'	Weather Station	Davis	6250	MS191218083	02/11/2022	02/11/2023
CEN001'	DC-40GHz attenuator 20dB	Centric RF	C411-20	CEN001	01/26/2022	01/26/2023
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	11/02/2021	11/02/2022
CBLHF2012-2M-2'	2m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252675002	02/10/2023	02/10/2023

Software Utilized:

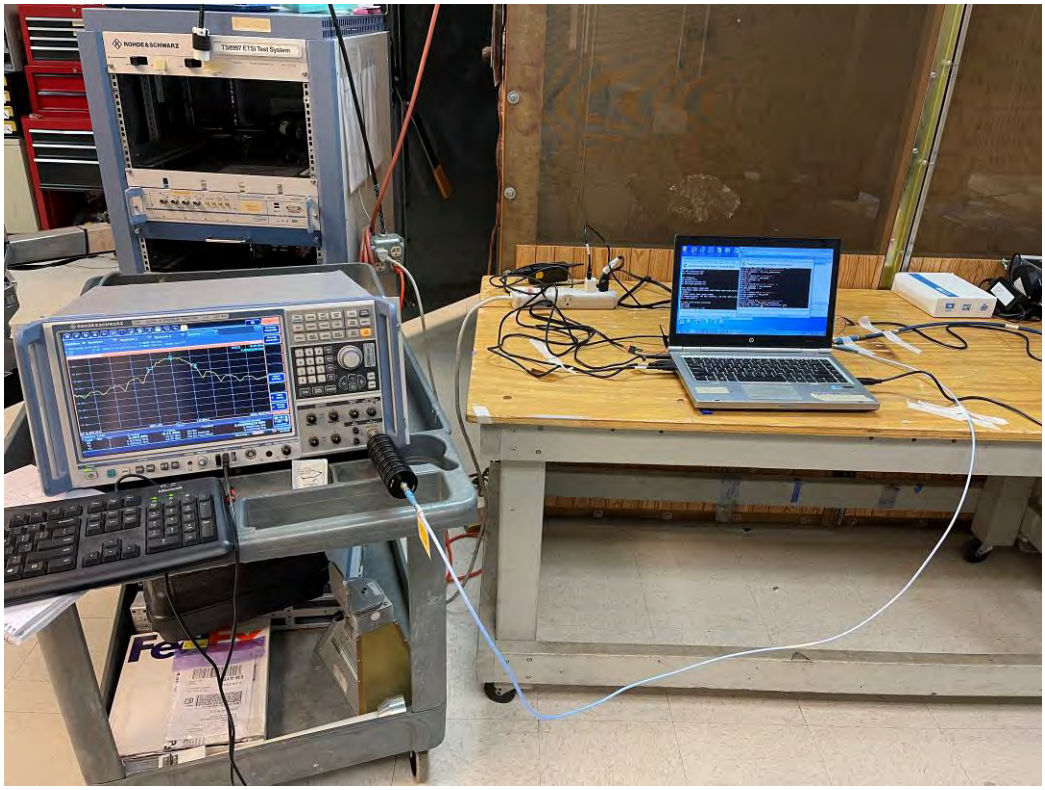
Name	Manufacturer	Version
None	--	--

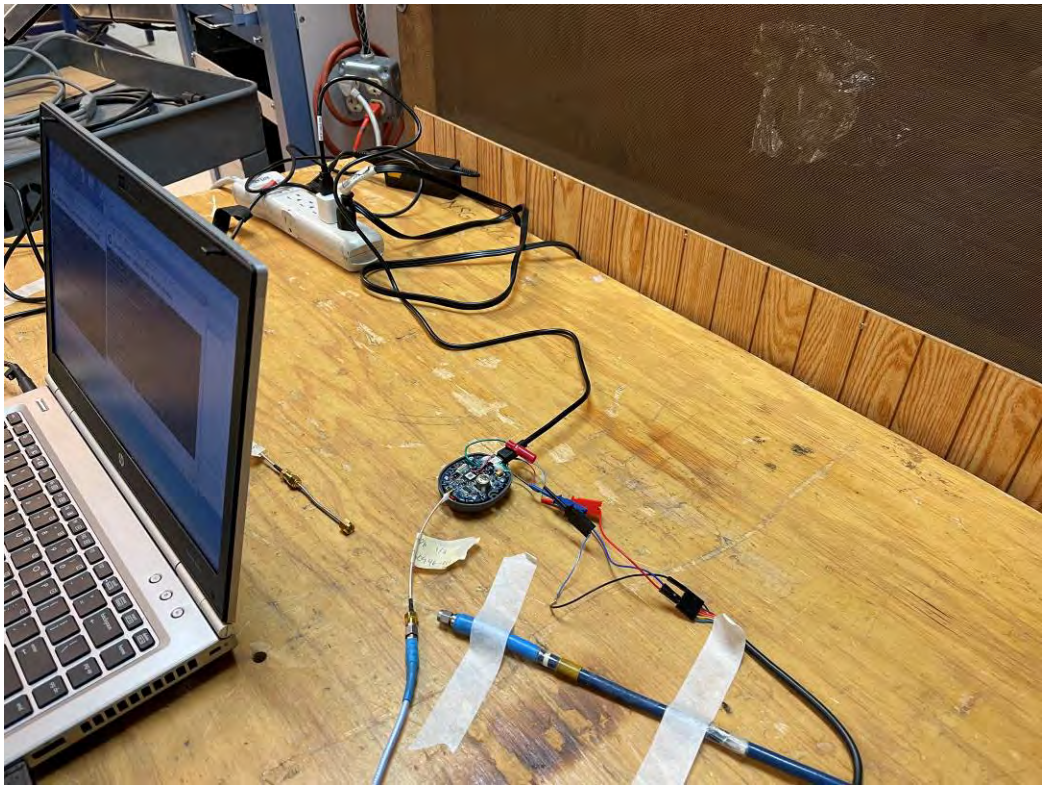
8.3 Results:

The sample tested was found to Comply.

Limits – FCC Part §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.

8.4 Setup Photographs:

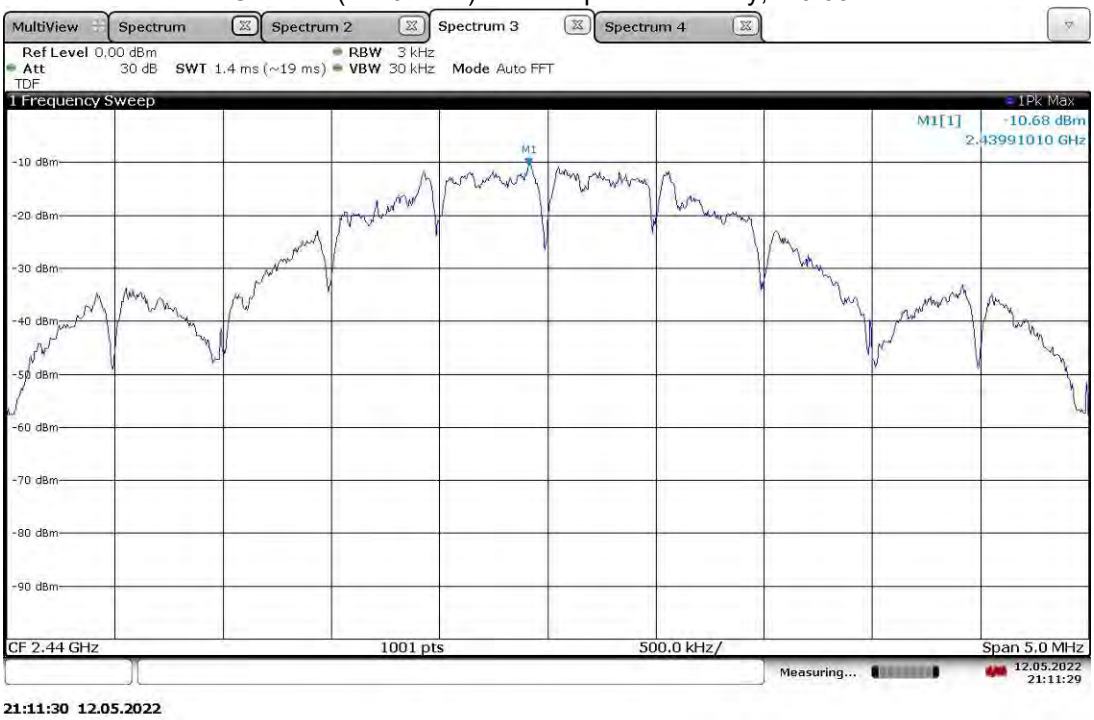




8.5 Plots / Data:

Low Channel (2405 MHz) Power Spectral Density, -11.30 dBm

Mid Channel (2440 MHz) Power Spectral Density, -10.68 dBm



High Channel (2475 MHz) Power Spectral Density, -9.26 dBm

Test Personnel:	Kouma Sinn KPS	Test Date:	05/12/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	CFR47 FCC Part 15.247 RSS-247	Limit Applied:	See report section 8.3
Input Voltage:	USB Powered		
		Ambient Temperature:	22 ºC
Pretest Verification BB Source:	N/A	Relative Humidity:	48 %
		Atmospheric Pressure:	1017 mbars

Deviations, Additions, or Exclusions: None

9 Band Edge Compliance

9.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247, RSS 247, 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	5.0 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.9 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.1 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7 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.

9.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145-414'	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
IW002'	2 meter Armored cable	Insulated Wire	2800-NPS	002	09/23/2021	09/23/2022
IW003'	8.4 meter cable	Insulated Wire	2800-NPS	003	10/15/2022	10/15/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022

Software Utilized:

Name	Manufacturer	Version
None	--	--

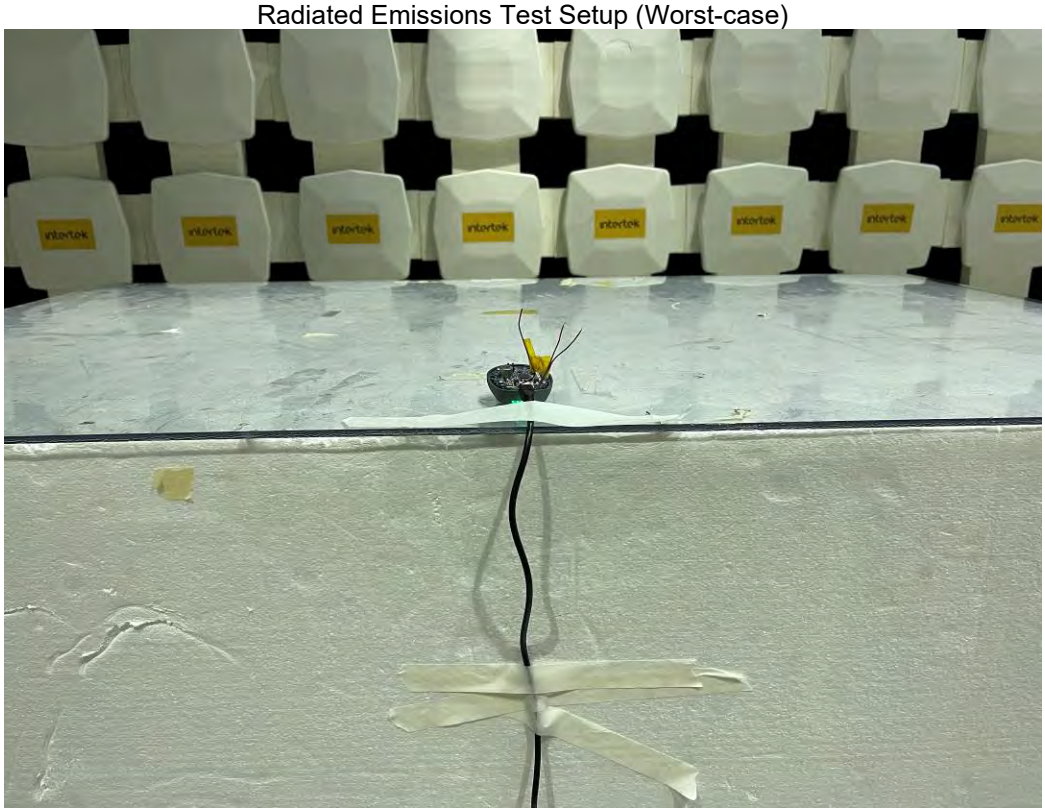
9.3 Results:

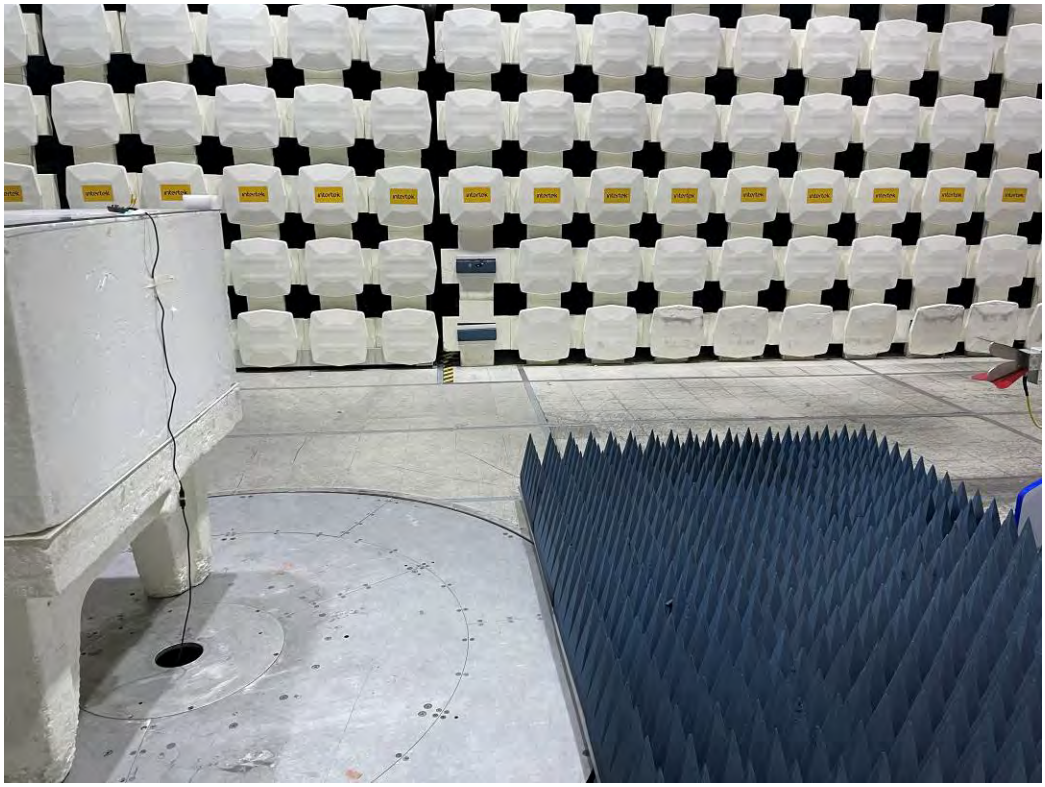
The sample tested was found to Comply.

Limits – FCC Part §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))

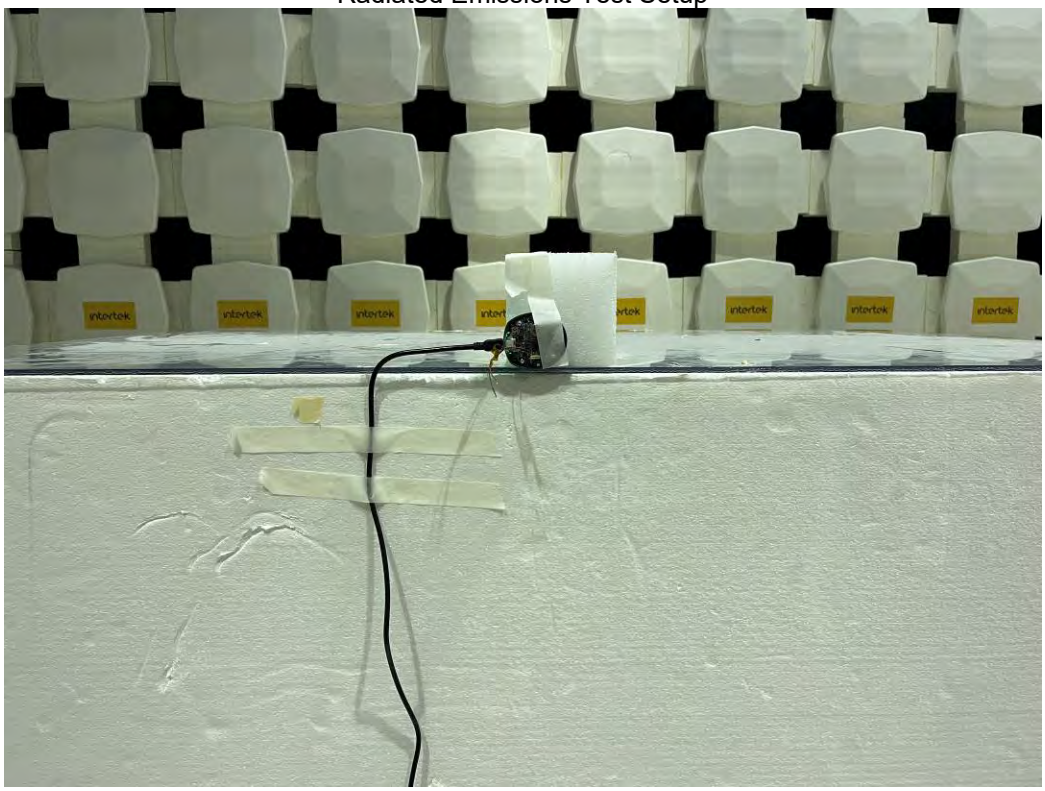
9.4 Setup Photographs:

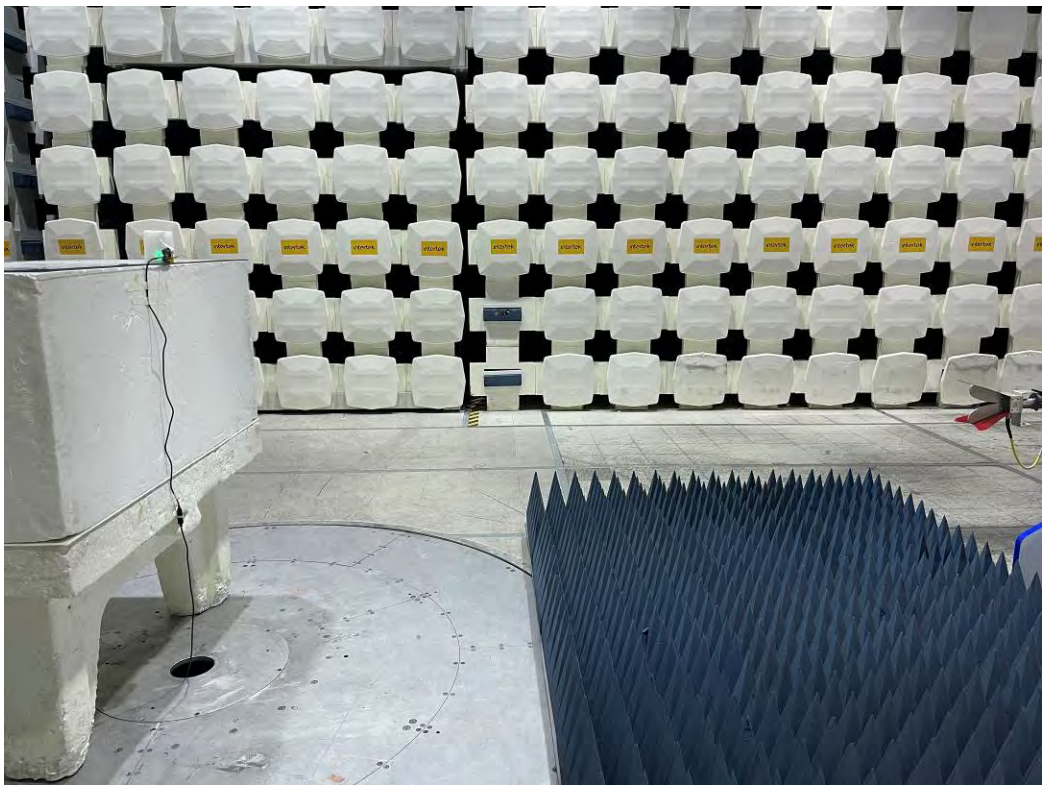
Radiated Emissions Test Setup (Worst-case)



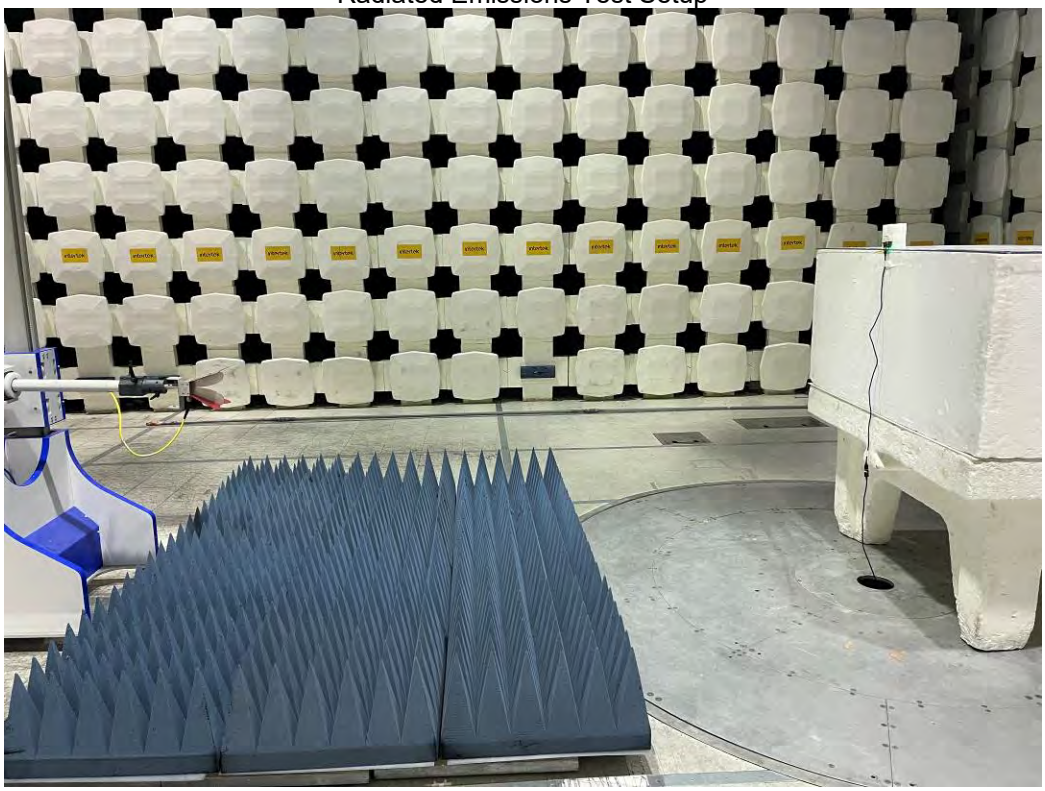


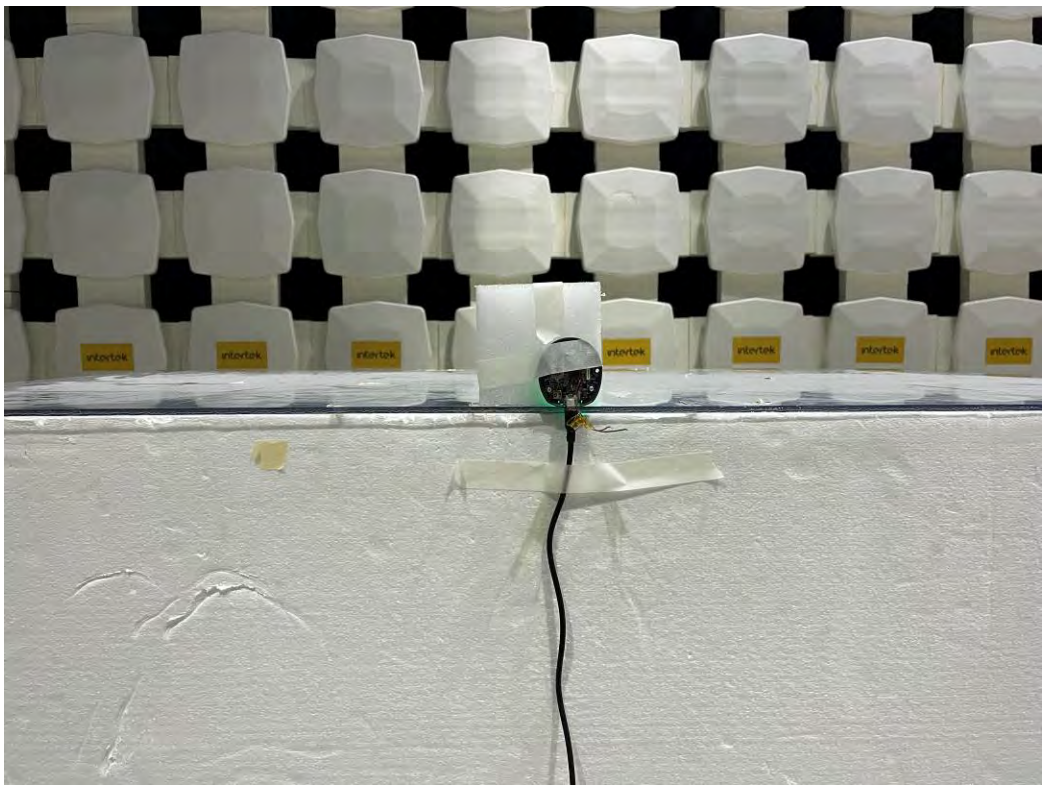
Radiated Emissions Test Setup





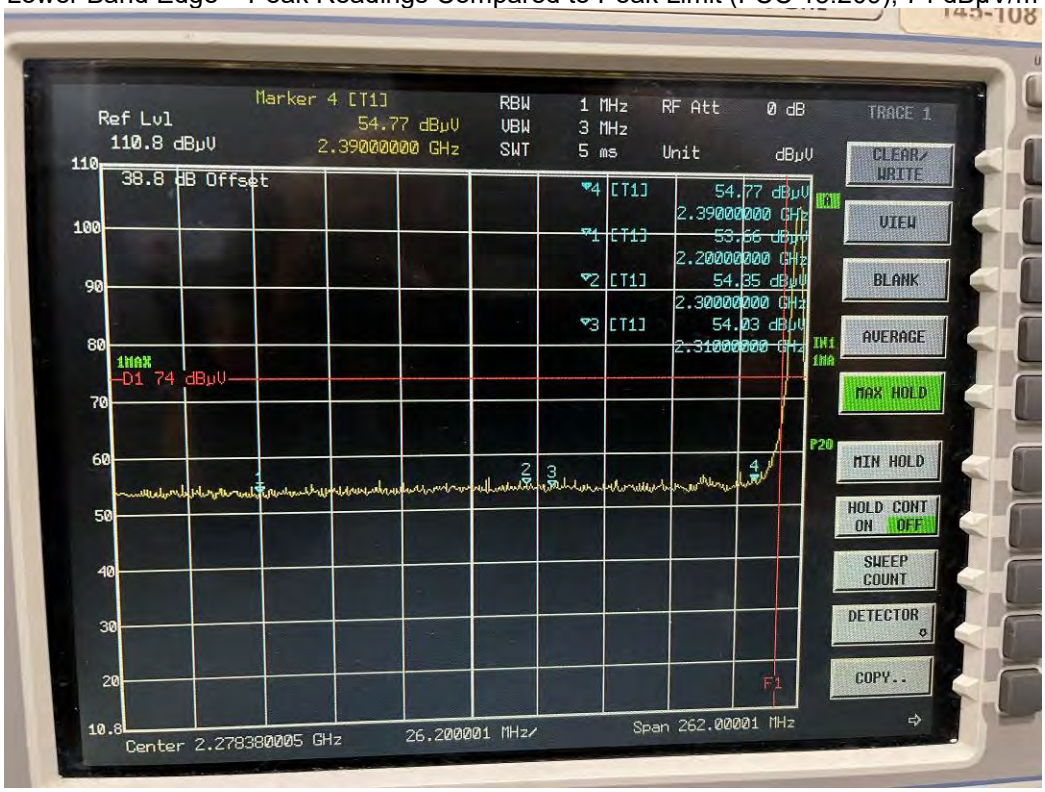
Radiated Emissions Test Setup



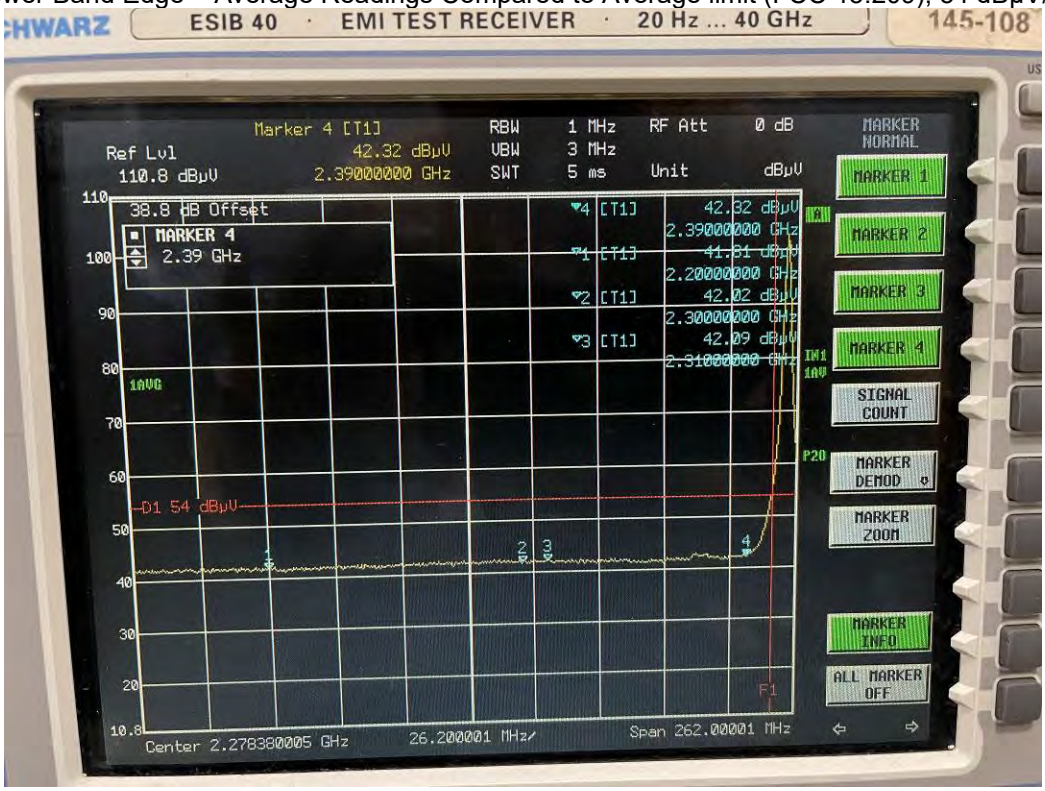


9.5 Plots / Data:

Lower Band Edge – Peak Readings Compared to Peak Limit (FCC 15.209), 74 dBµV/m

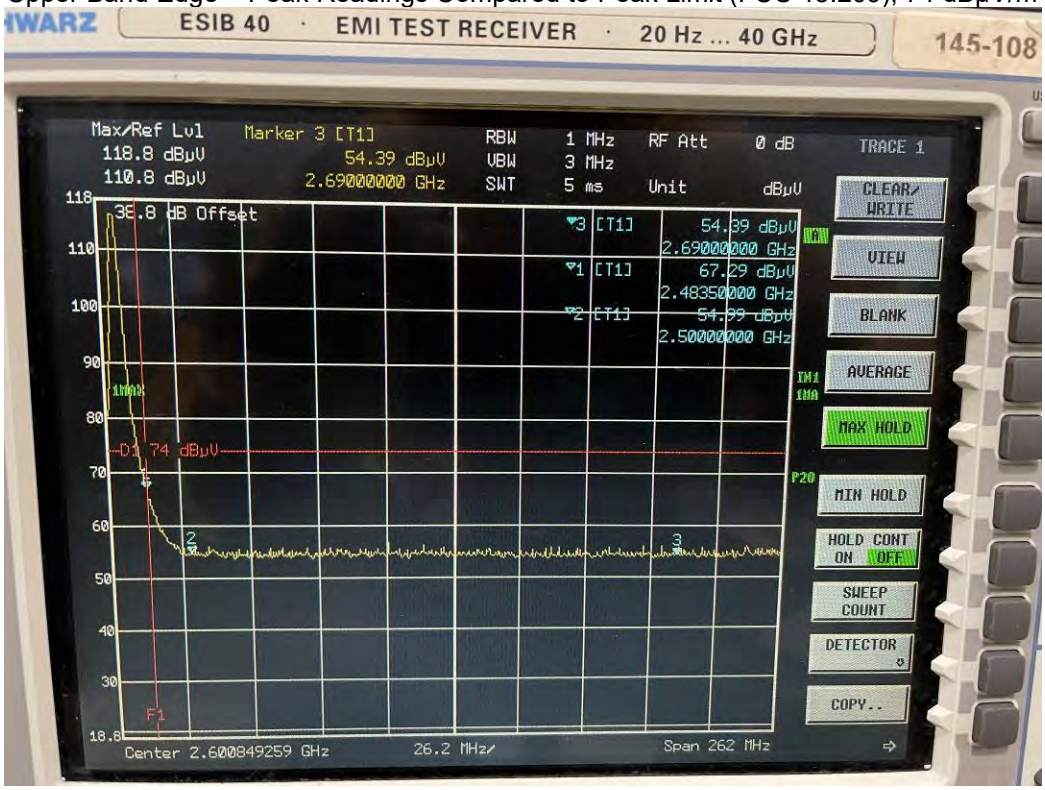


Lower Band Edge – Average Readings Compared to Average limit (FCC 15.209), 54 dBµV/m

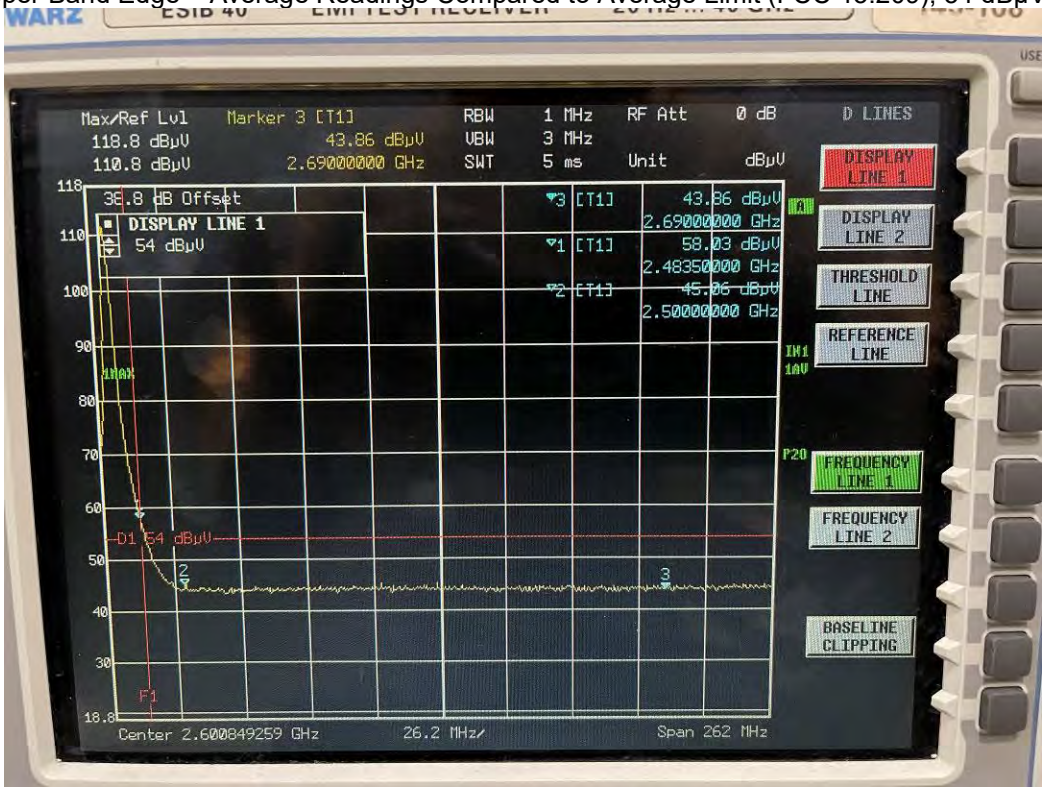


Lower Band Edge – Peak Readings Compared to 20 dBc limit (FCC 15.247 (d))

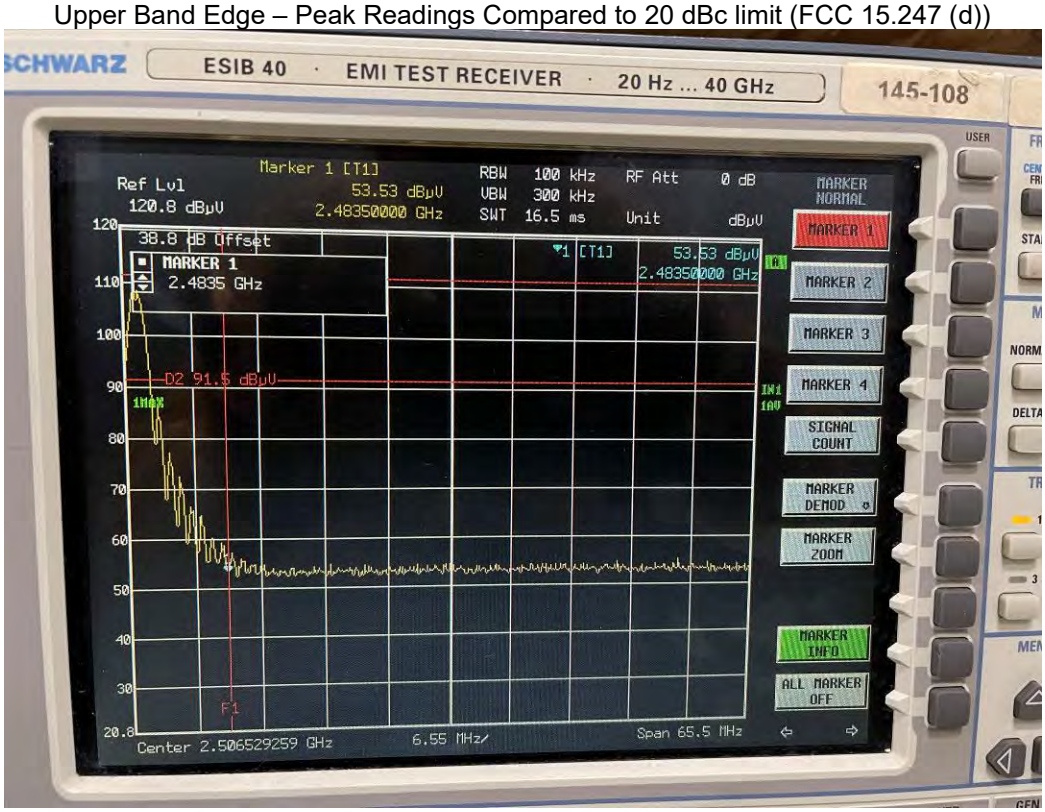
Upper Band Edge – Peak Readings Compared to Peak Limit (FCC 15.209), 74 dBµV/m



Upper Band Edge – Average Readings Compared to Average Limit (FCC 15.209), 54 dBµV/m



Upper Band Edge – Peak Readings Compared to 20 dBc limit (FCC 15.247 (d))



Test Personnel:	Kouma Sinn KPS	Test Date:	05/07/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	CFR47 FCC Part 15.247 RSS-247	Limit Applied:	See report section 9.3
Input Voltage:	USB Powered		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	23 ºC
		Relative Humidity:	26 %
		Atmospheric Pressure:	1005 mbars

Notes: The worst-case axis was used for the final measurements. All cable and attenuation factors were internally compensated as dB offset.

Deviations, Additions, or Exclusions: None

10 Transmitter spurious emissions

10.1 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	5.0 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.9 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.1 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7 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:

Test equipment used for radiated emissions from 9 kHz-30 MHz

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145-414'	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
IW002'	2 meter Armored cable	Insulated Wire	2800-NPS	002	09/23/2021	09/23/2022
IW003'	8.4 meter cable	Insulated Wire	2800-NPS	003	10/15/2022	10/15/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
ETS003'	9kHz-30MHz Active Loop Antenna	ETS Lindgren	6502	00143396	08/26/2021	08/26/2022

Test equipment used for radiated emissions from 30-1000 MHz

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
145106'	Bilog Antenna (30MHz - 5GHz)	Sunol Sciences	JB5	A111003	07/15/2021	07/15/2022
HS002'	DC-18GHz cable 1.5M long	Huber & Suhner	SucoFlex 106A	HS002	12/06/2021	12/06/2022
IW006'	DC-18GHz cable 8.4m long	Insulated Wire	2800-NPS	IW006	07/22/2021	07/22/2022
PRE11'	50dB gain pre-amp	Pasternack	PRE11	PRE11	09/02/2021	09/02/2022
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	06/09/2021	06/09/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022

Test equipment used for radiated emissions from 1-13

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145-414'	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
IW002'	2 meter Armored cable	Insulated Wire	2800-NPS	002	09/23/2021	09/23/2022
IW003'	8.4 meter cable	Insulated Wire	2800-NPS	003	10/15/2022	10/15/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
PRE12'	Pre-amplifier	Com Power	PAM-118A	18040117	12/06/2021	12/06/2022
REA008'	band reject filter 2.4GHz	Reactel, Inc	12RX7-2441.75-x140 S	17-01	07/28/2021	07/28/2022
REA004'	3GHz High Pass Filter	Reactel, Inc	7HSX-3G/18G-S11	06-1	02/09/2022	02/09/2023

Test equipment used for radiated emissions from 13-25

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
PRE8'	PREAMPLFIER 1- 40 GHz	MITEQ	NSP4000-NF	507145	12/27/2021	12/27/2022
REA004'	3GHz High Pass Filter	Reactel, Inc	7HSX-3G/18G-S11	06-1	02/09/2022	02/09/2023
CBLHF2012-5M-2'	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/16/2022	02/16/2023
CBLSHF202'	Cable, SMA - SMA, 9kHz-40GHz	Sucoflex (Huber Suhn	104PE	CBLSHF202	01/21/2022	02/21/2023
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
ETS004'	18-40GHZ horn antenna	ets004	3116C	00218579	03/11/2022	03/11/2023
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	11/02/2021	11/02/2022

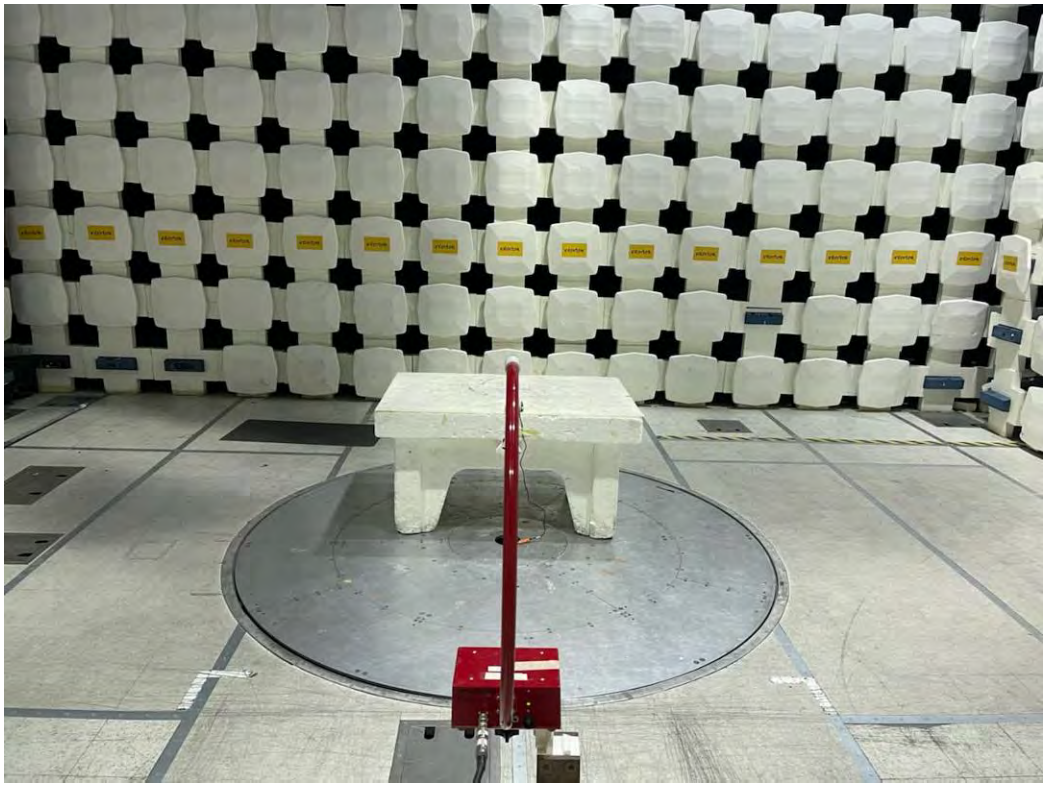
10.3 Results:

The sample tested was found to Comply.

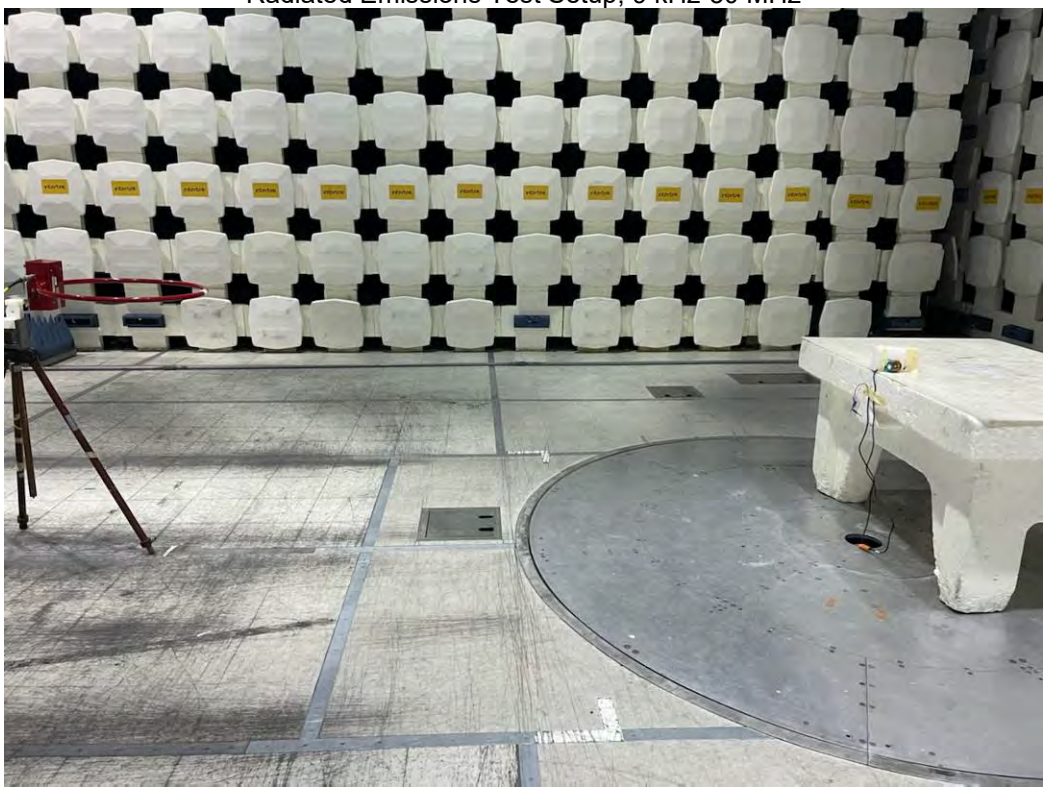
Limits – FCC Part §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within 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))

10.4 Setup Photographs:

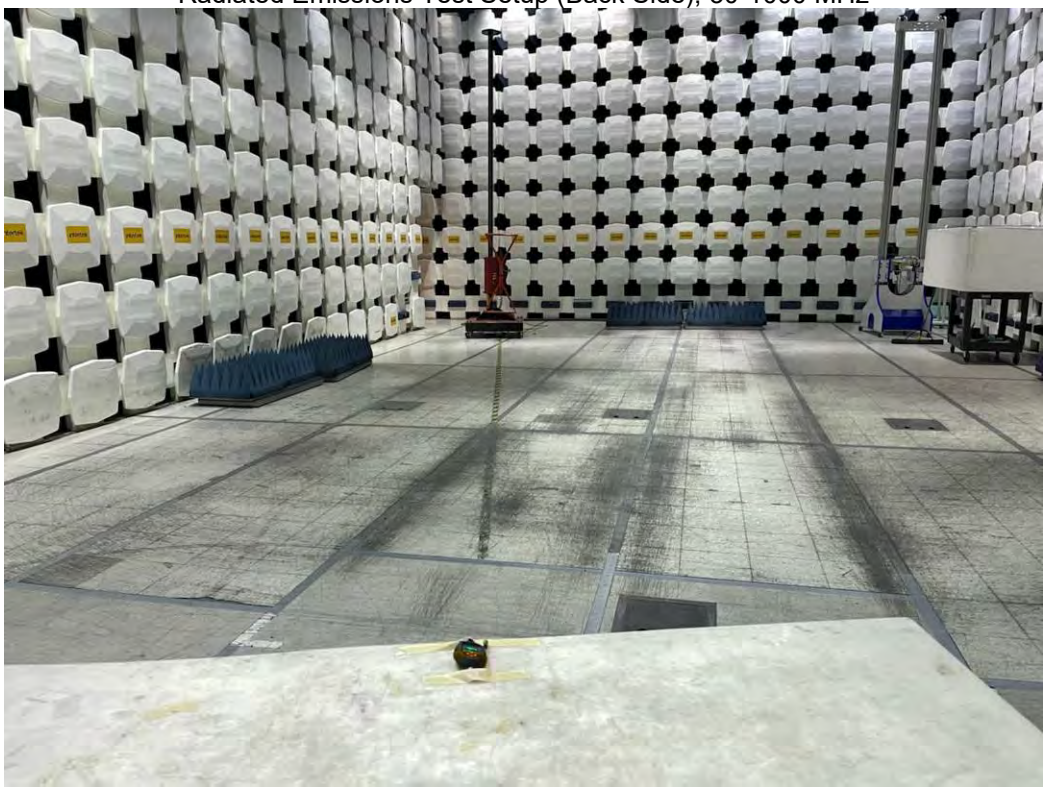
Radiated Emissions Test Setup, 9 kHz-30 MHz



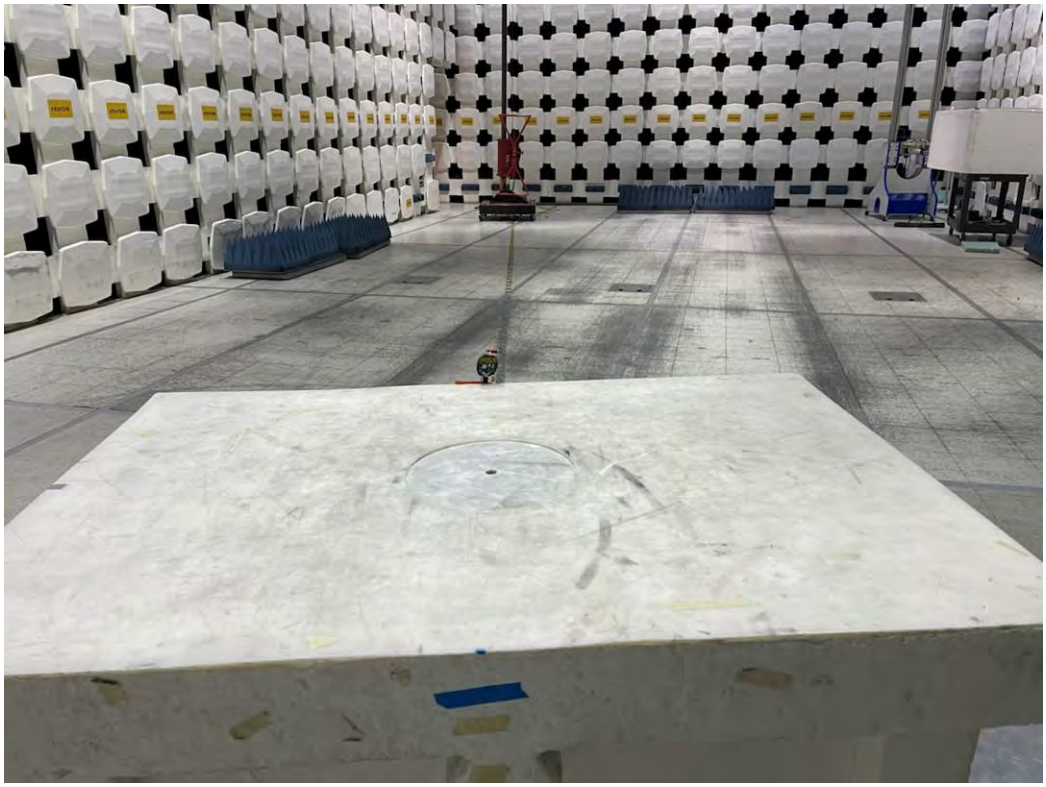
Radiated Emissions Test Setup, 9 kHz-30 MHz



Radiated Emissions Test Setup (Back Side), 30-1000 MHz

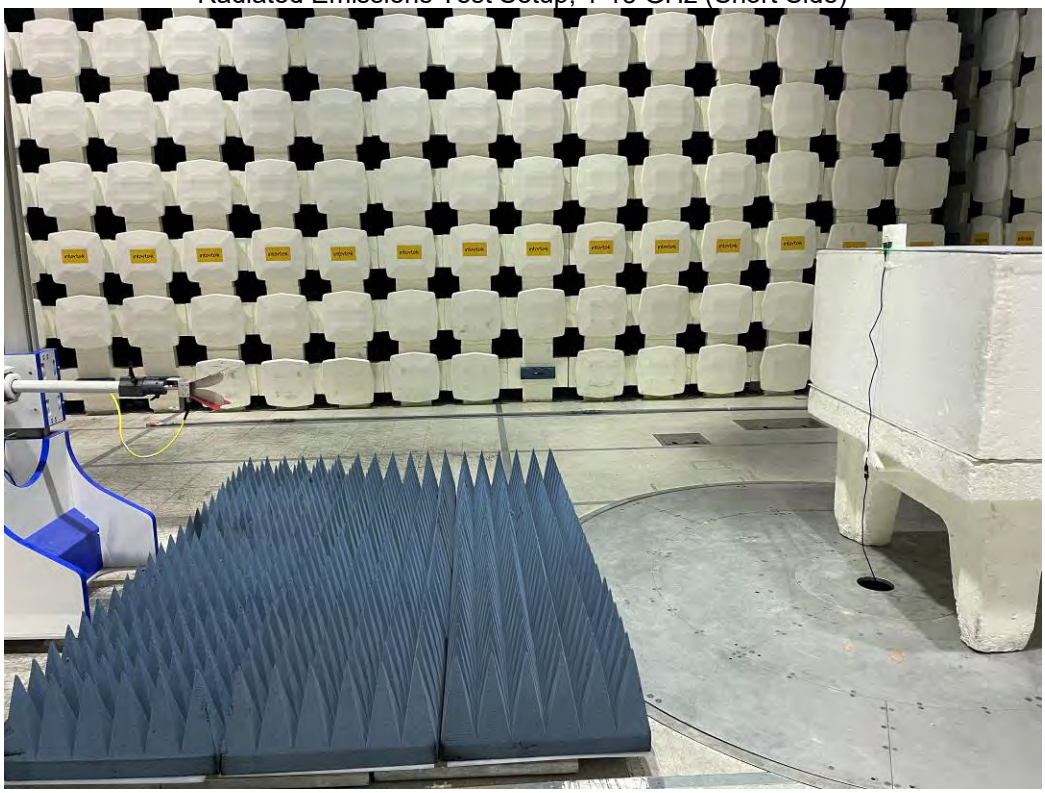


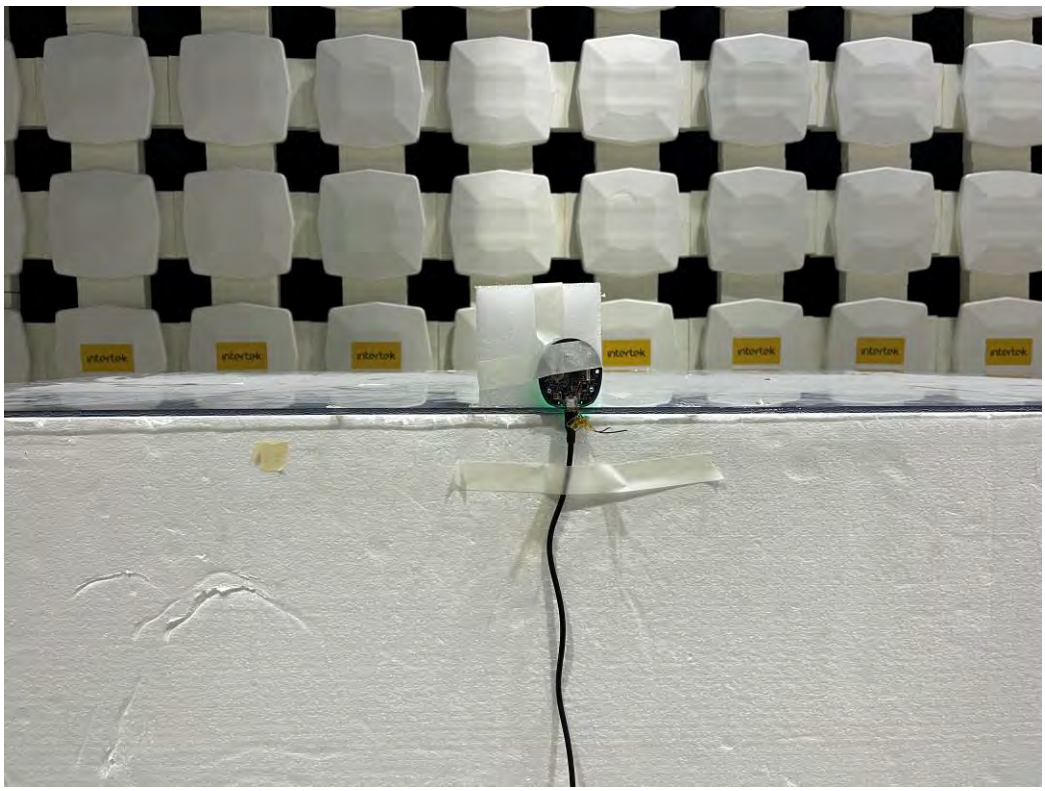
Radiated Emissions Test Setup (Short Side), 30-1000 MHz



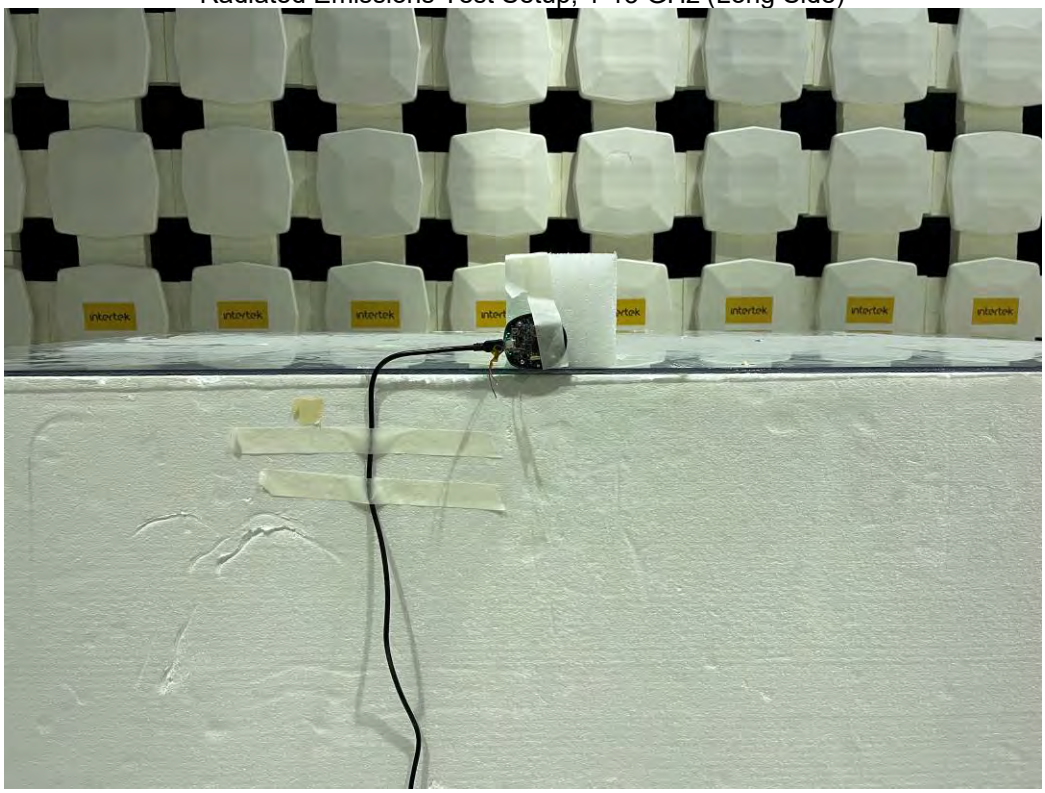
Radiated Emissions Test Setup (Long Side), 30-1000 MHz

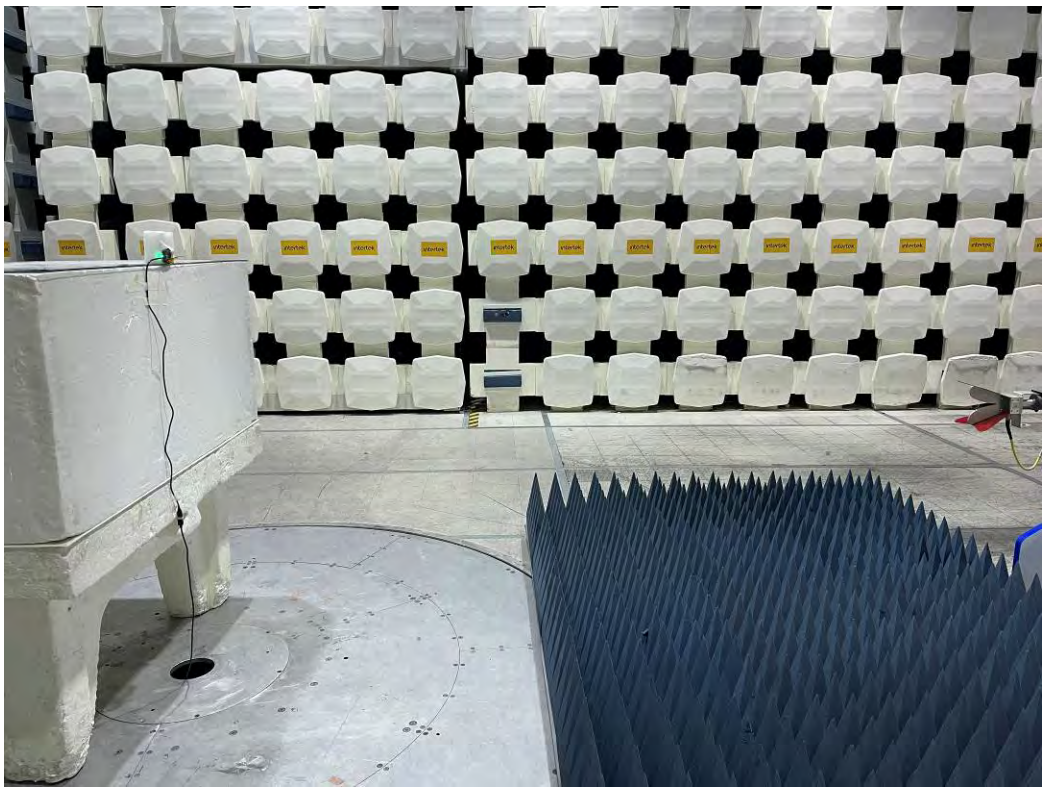
Radiated Emissions Test Setup, 1-13 GHz (Short Side)



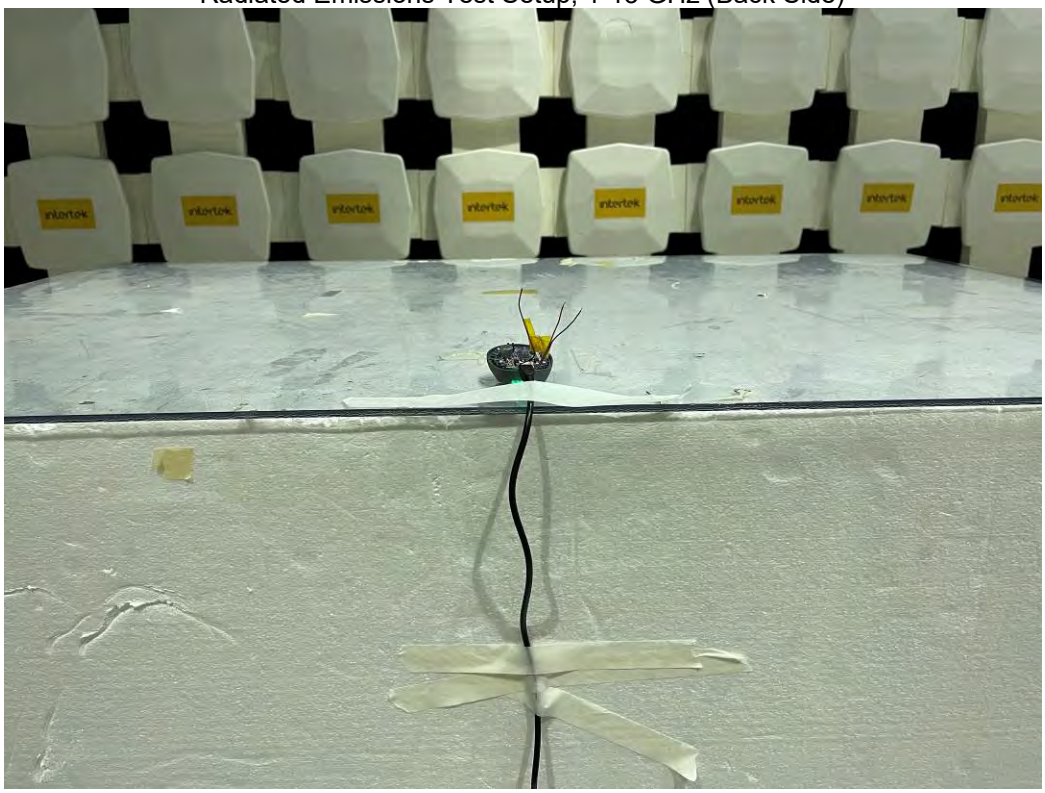


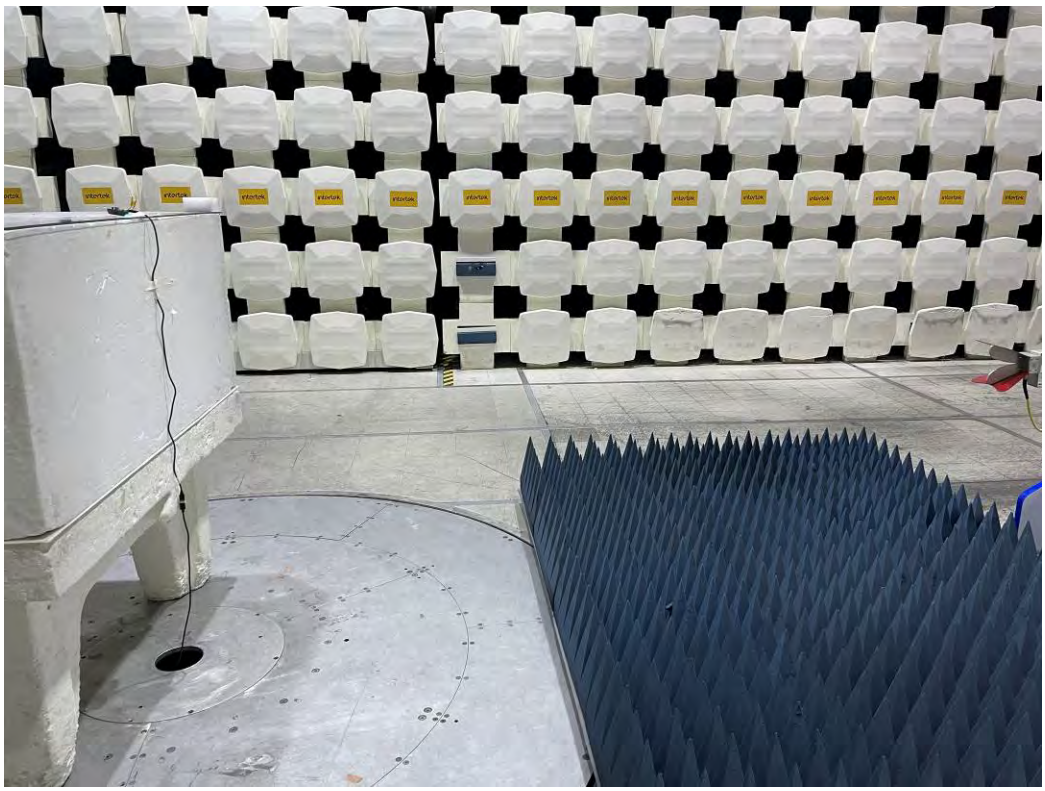
Radiated Emissions Test Setup, 1-13 GHz (Long Side)





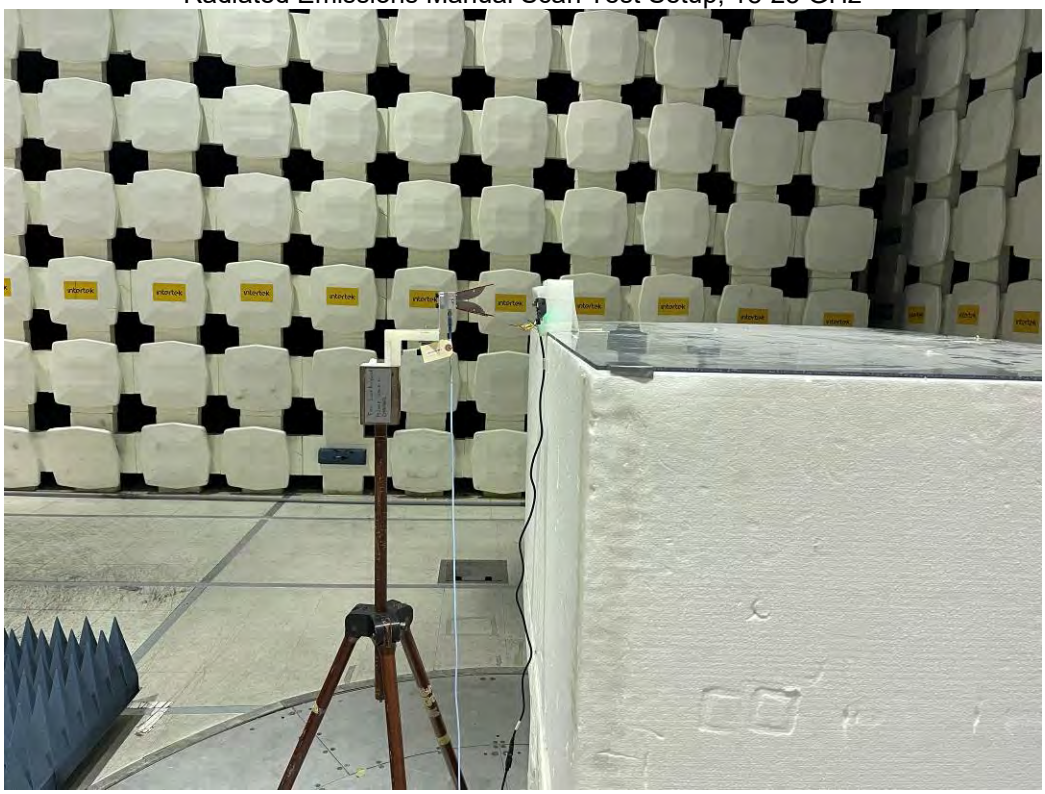
Radiated Emissions Test Setup, 1-13 GHz (Back Side)





Radiated Emissions Manual Scan Test Setup, 13-18 GHz

Radiated Emissions Manual Scan Test Setup, 18-25 GHz



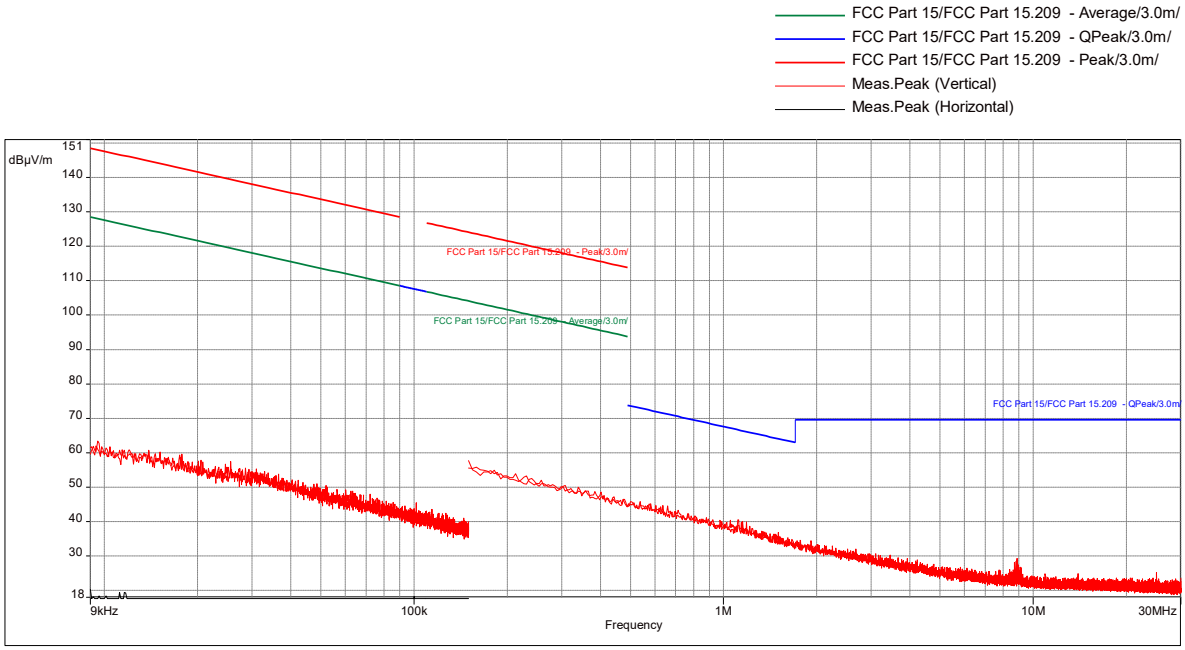
10.5 Plots / Data:

Transmit at high channel (worst-case channel), 2405 MHz, 9 kHz-30 MHz

Test Information:

Date and Time	4/27/2022 12:23:06 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	24 C
Humidity	38 %
Atmospheric Pressure	1000 mbar
Comments	Scan 15: Tx High, RE 9kHz-30MHz Loop antenna, Electric Field, 3M Location (FCC 15.209)

Graph:



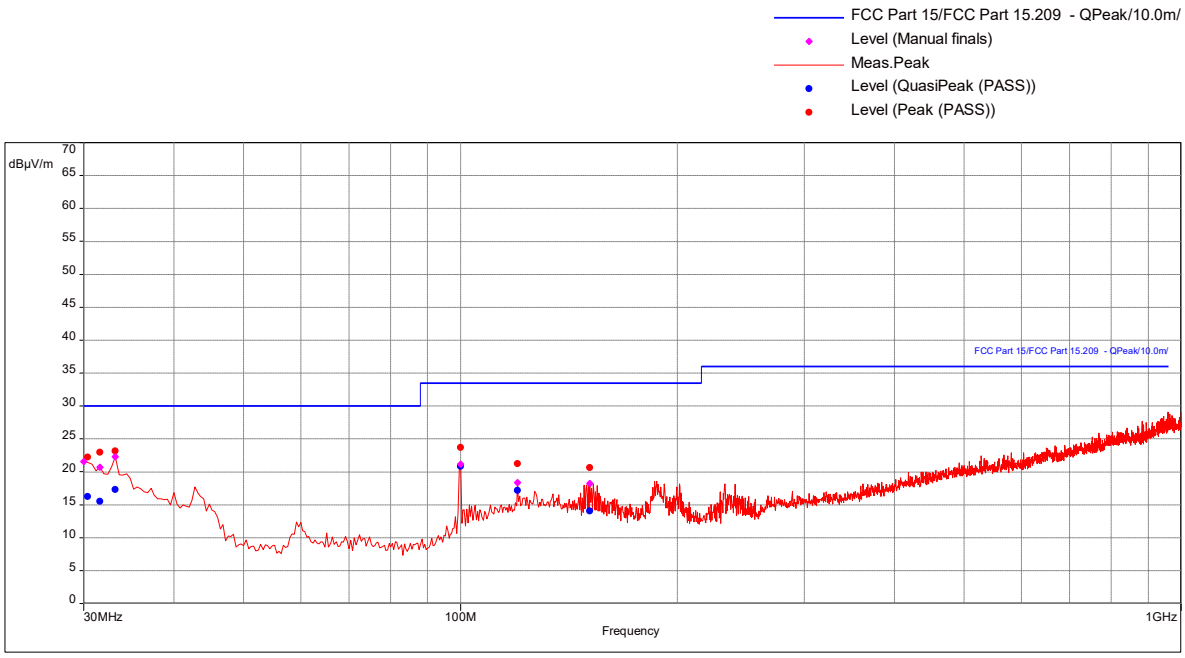
Results: Only worst-case channel was selected for testing in this frequency range. No emission was detected.

Transmit at low channel (EUT sits on its short side), 2405 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 1:38:02 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 6: Tx Low, EUT on its short side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.52105263	30.00	-13.76	358.00	1.74	Vertical	120000.00	-13.01
31.75789474	30.00	-14.50	126.00	2.90	Horizontal	120000.00	-13.80
33.2	30.00	-12.67	272.00	2.01	Vertical	120000.00	-14.67
99.93684211	33.50	-12.67	192.00	1.41	Vertical	120000.00	-22.66
120	33.50	-16.30	278.00	2.19	Vertical	120000.00	-18.92
151.2	33.50	-19.48	228.00	1.64	Vertical	120000.00	-19.99

Transmit at low channel (EUT sits on its short side), 2405 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 9:35:56 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Low CH_X-Axis

Graph:

Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2446.315789	38.45	74.00	-35.55	326.00	1.55	Vertical	1000000.00	-3.44
2827.894737	40.80	74.00	-33.20	118.00	3.00	Horizontal	1000000.00	-2.82

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2446.315789	26.80	54.00	-27.20	326.00	1.55	Vertical	1000000.00	-3.44
2827.894737	27.81	54.00	-26.19	118.00	3.00	Horizontal	1000000.00	-2.82

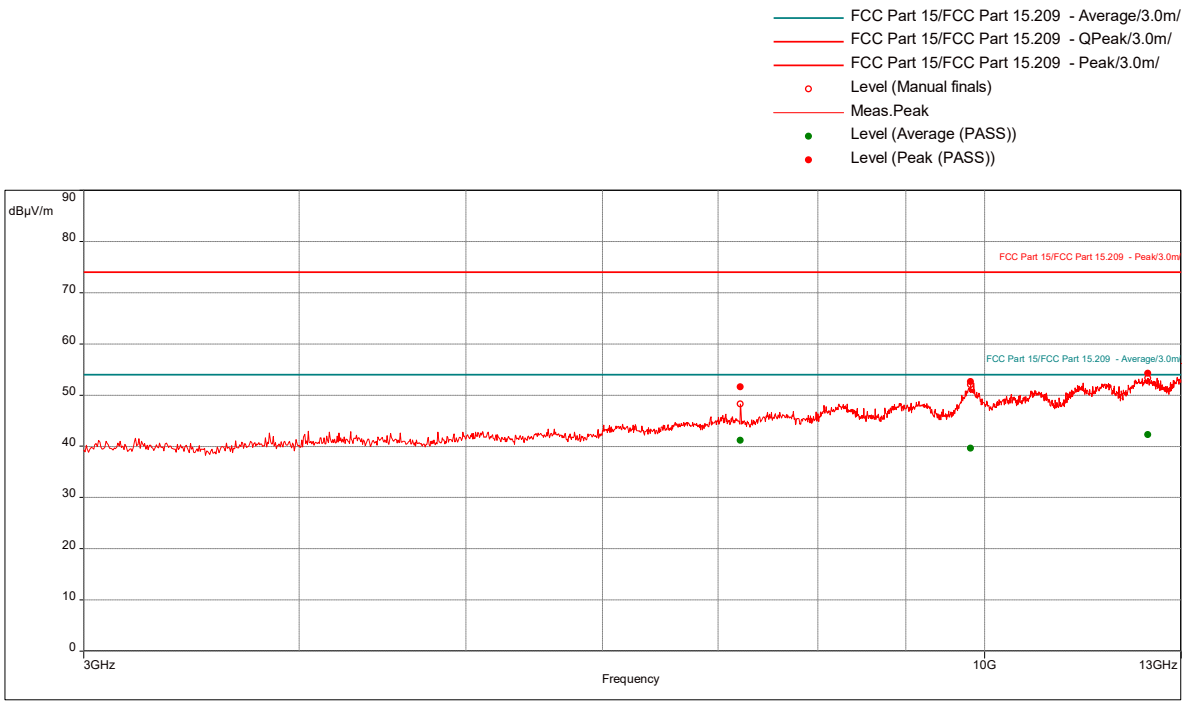
Note: Big peak was the ambient.

Transmit at low channel (EUT sits on its short side), 2405 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 4:43:40 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Low CH 2405 MHz_X-Axis

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7213.684211	51.61	74.00	-22.39	24.00	1.75	Vertical	1000000.00	5.15
9816.052632	52.61	74.00	-21.39	10.00	1.80	Horizontal	1000000.00	9.92
12436.05263	54.25	74.00	-19.75	125.00	1.70	Horizontal	1000000.00	13.51

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7213.684211	41.16	54.00	-12.84	24.00	1.75	Vertical	1000000.00	5.15
9816.052632	39.65	54.00	-14.35	10.00	1.80	Horizontal	1000000.00	9.92
12436.05263	42.30	54.00	-11.70	125.00	1.70	Horizontal	1000000.00	13.51

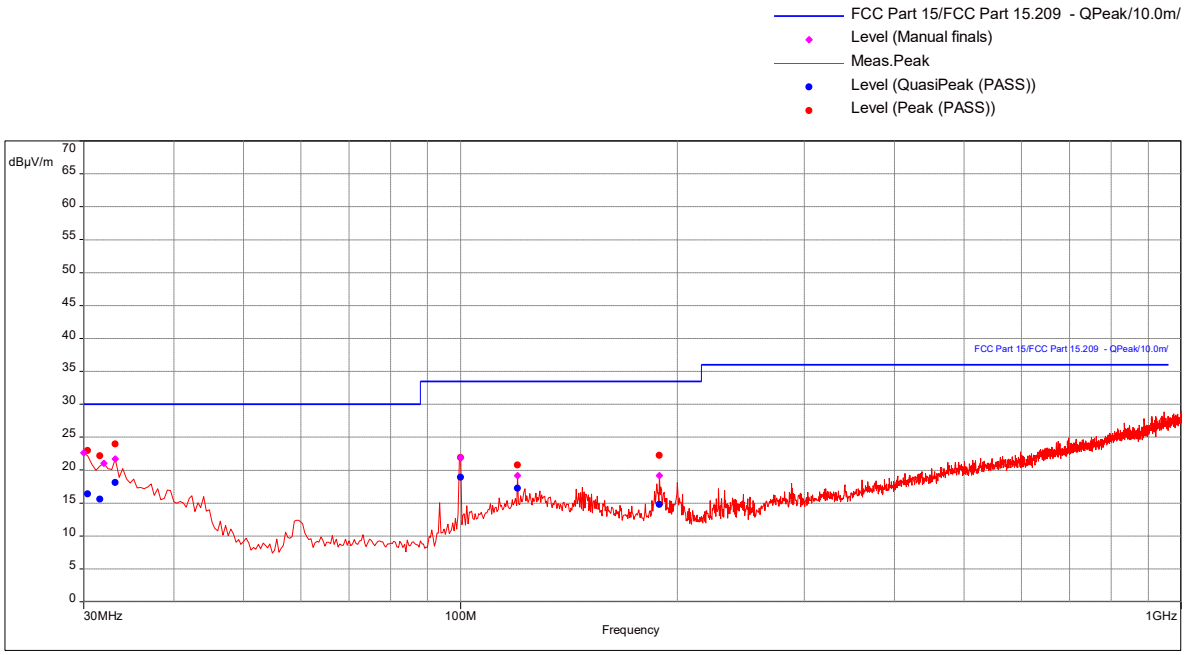
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at low channel (EUT sits on its long side), 2405 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 12:41:16 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 4: Tx Low, EUT on its long side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

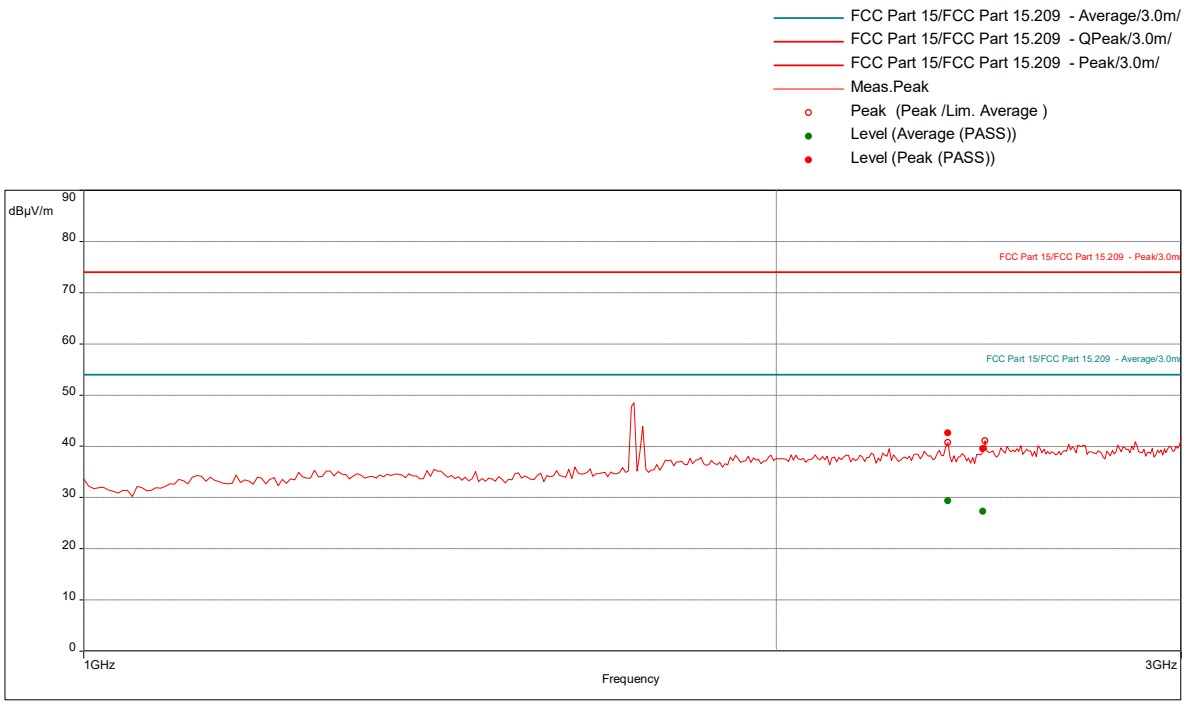
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.28421053	30.00	-13.62	171.00	2.23	Horizontal	120000.00	-12.87
31.65263158	30.00	-14.43	191.00	3.45	Vertical	120000.00	-13.72
33.2	30.00	-11.87	199.00	2.07	Vertical	120000.00	-14.67
99.93684211	33.50	-14.58	68.00	2.47	Vertical	120000.00	-22.66
120	33.50	-16.23	279.00	2.36	Vertical	120000.00	-18.92
188.7052632	33.50	-18.71	338.00	1.00	Vertical	120000.00	-20.96

Transmit at low channel (EUT sits on its long side), 2405 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 9:48:34 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Low CH_Y-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2372.631579	42.64	74.00	-31.36	153.00	2.05	Vertical	1000000.00	-3.81
2462.368421	39.57	74.00	-34.43	177.00	1.00	Horizontal	1000000.00	-3.25

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2372.631579	29.38	54.00	-24.62	153.00	2.05	Vertical	1000000.00	-3.81
2462.368421	27.29	54.00	-26.71	177.00	1.00	Horizontal	1000000.00	-3.25

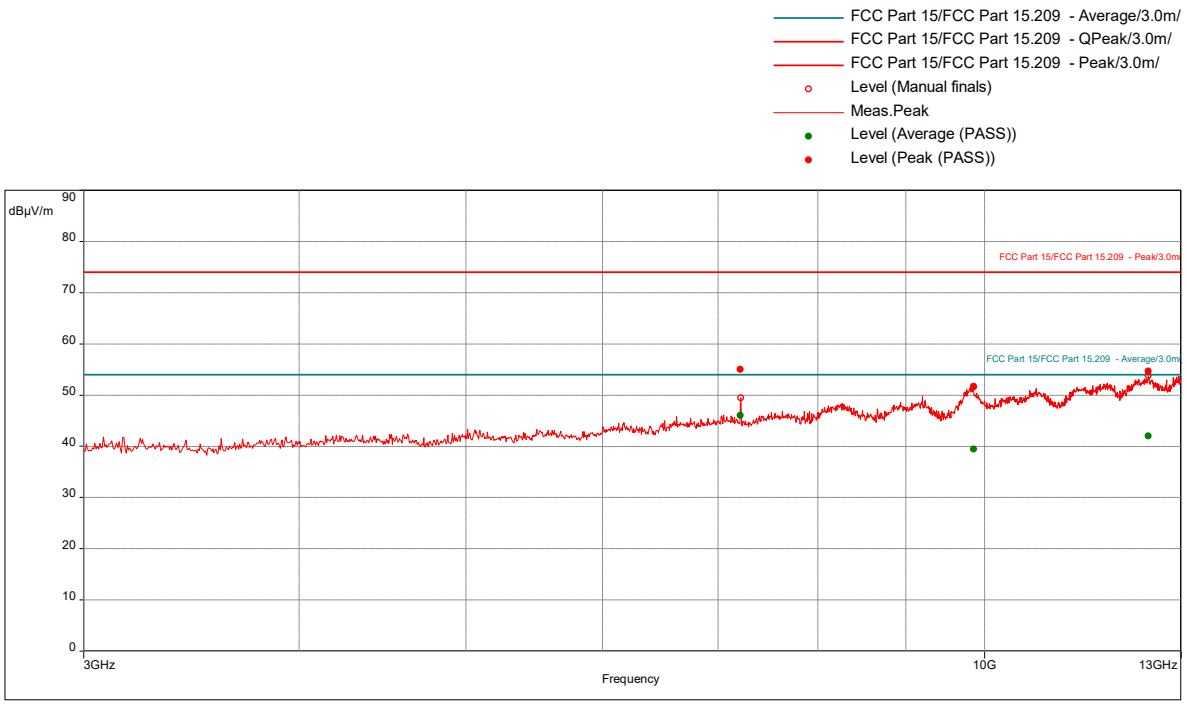
Note: Big peak was the ambient.

Transmit at low channel (EUT sits on its long side), 2405 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 5:13:39 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Low CH 2405 MHz_Y-Axis

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7216.315789	55.03	74.00	-18.97	357.00	3.98	Vertical	1000000.00	5.15
9849.473684	51.56	74.00	-22.44	212.00	2.45	Vertical	1000000.00	9.79
12441.57895	54.67	74.00	-19.33	300.00	1.30	Horizontal	1000000.00	13.53

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7216.315789	46.07	54.00	-7.93	357.00	3.98	Vertical	1000000.00	5.15
9849.473684	39.48	54.00	-14.52	212.00	2.45	Vertical	1000000.00	9.79
12441.57895	42.05	54.00	-11.95	300.00	1.30	Horizontal	1000000.00	13.53

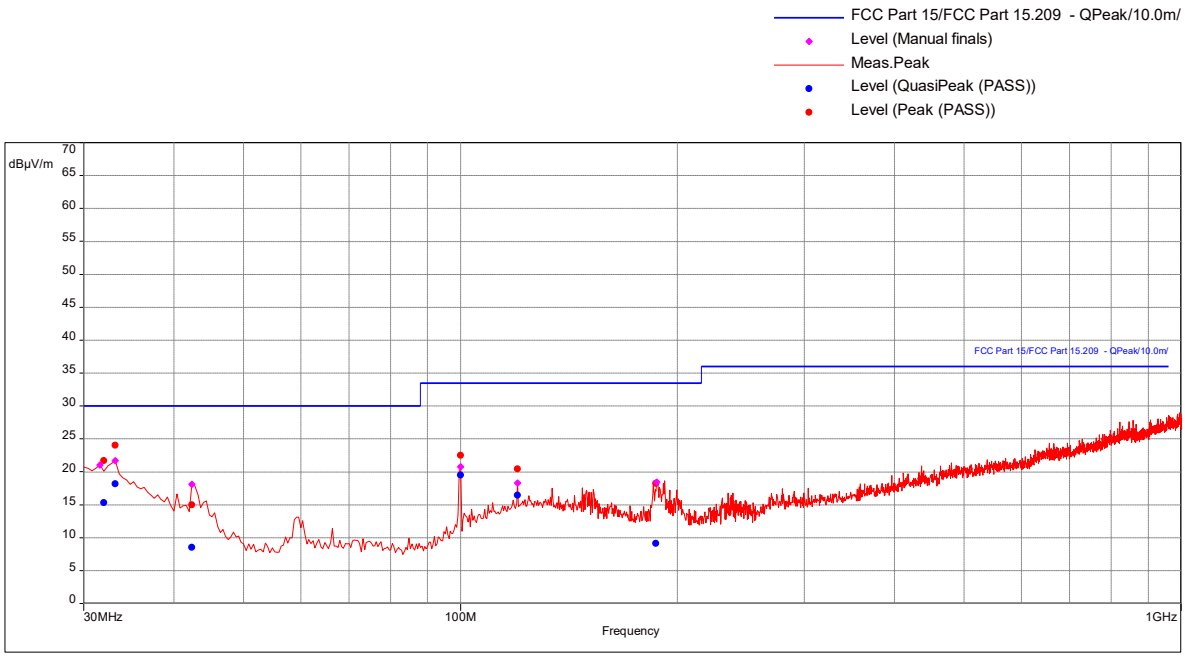
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at low channel (EUT sits on its back side), 2405 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 1:34:33 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 5: Tx Low, EUT on its back, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
32.04210526	30.00	-14.69	76.00	1.41	Vertical	120000.00	-13.99
33.23157895	30.00	-11.86	292.00	1.35	Vertical	120000.00	-14.69
42.27368421	30.00	-21.51	11.00	1.40	Vertical	120000.00	-20.90
99.93684211	33.50	-13.98	176.00	2.58	Vertical	120000.00	-22.66
120	33.50	-17.06	352.00	3.00	Vertical	120000.00	-18.92
186.7894737	33.50	-24.38	75.00	1.51	Vertical	120000.00	-21.07

Transmit at low channel (EUT sits on its back side), 2405 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 10:00:06 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Low CH_Z-Axis

Graph:

Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2369.473684	46.66	74.00	-27.34	184.00	1.55	Horizontal	1000000.00	-3.83
2543.684211	40.80	74.00	-33.20	177.00	2.90	Vertical	1000000.00	-3.20

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2369.473684	33.53	54.00	-20.47	184.00	1.55	Horizontal	1000000.00	-3.83
2543.684211	27.72	54.00	-26.28	177.00	2.90	Vertical	1000000.00	-3.20

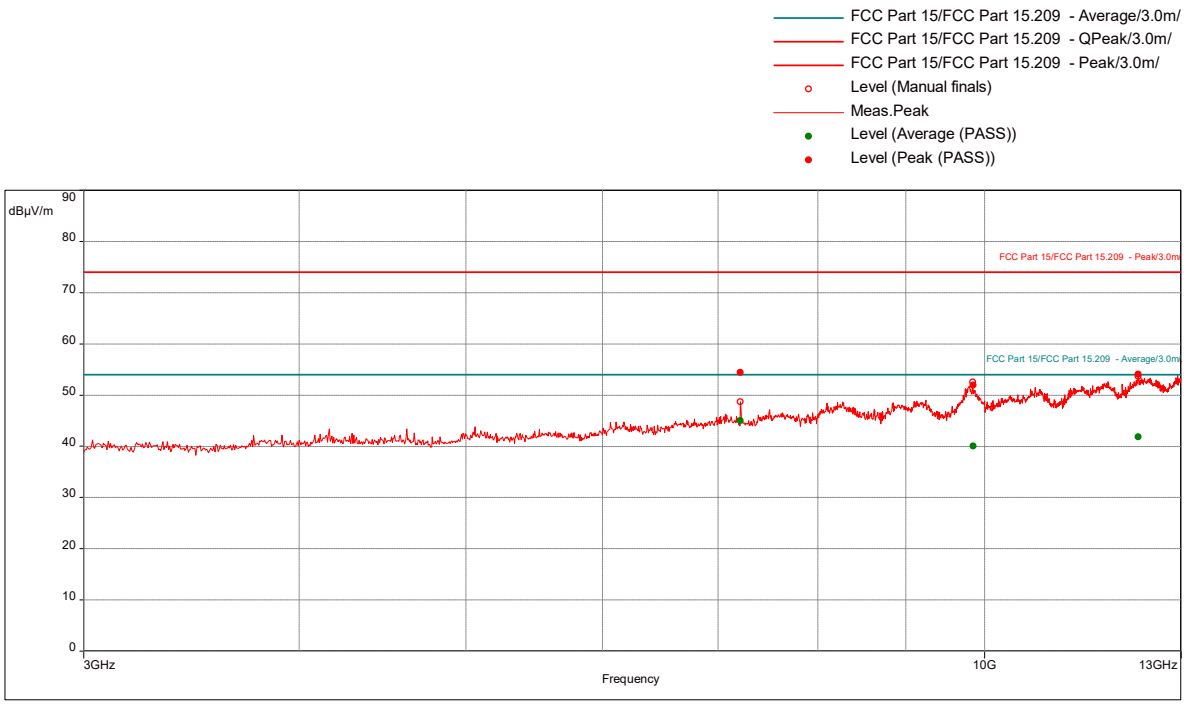
Note: Big peak was the ambient.

Transmit at low channel (EUT sits on its back side), 2405 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 5:32:59 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Low CH 2405 MHz_Z-Axis

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7213.684211	54.39	74.00	-19.61	10.00	3.79	Horizontal	1000000.00	5.15
9843.421053	51.97	74.00	-22.03	132.00	1.15	Vertical	1000000.00	9.81
12272.63158	54.11	74.00	-19.89	322.00	3.44	Vertical	1000000.00	13.25

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7213.684211	45.00	54.00	-9.00	10.00	3.79	Horizontal	1000000.00	5.15
9843.421053	40.00	54.00	-14.00	132.00	1.15	Vertical	1000000.00	9.81
12272.63158	41.87	54.00	-12.13	322.00	3.44	Vertical	1000000.00	13.25

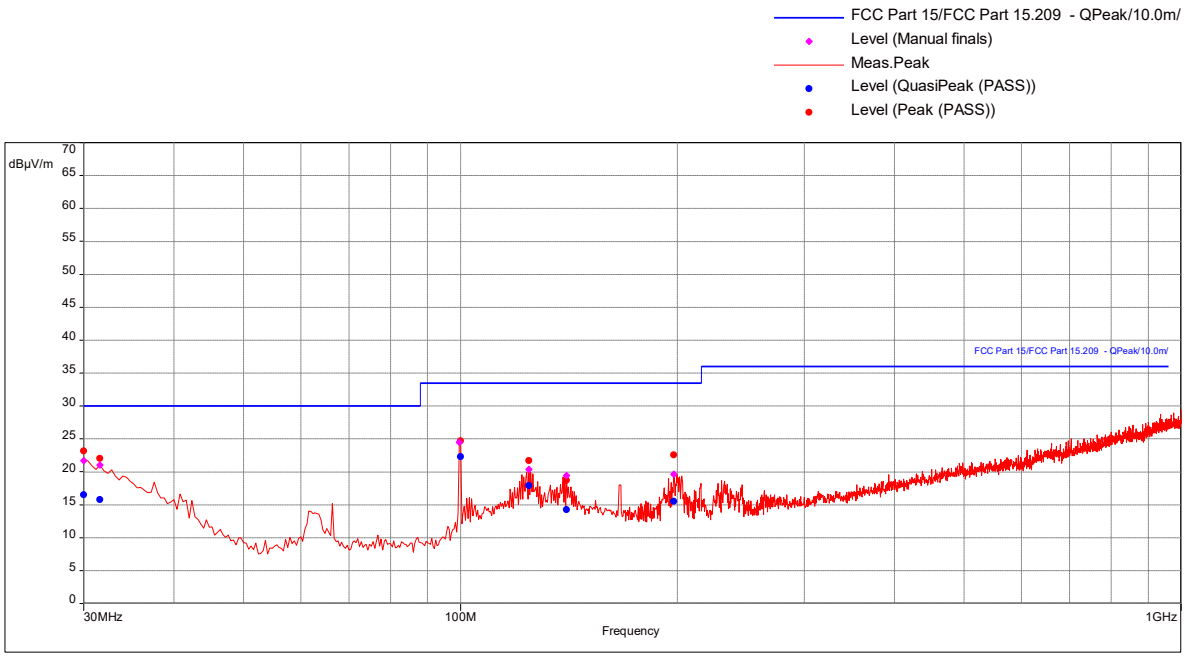
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at Mid channel (EUT sits on its short side), 2440 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 11:35:20 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 2: Tx Mid 2440 MHz, EUT on its short side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

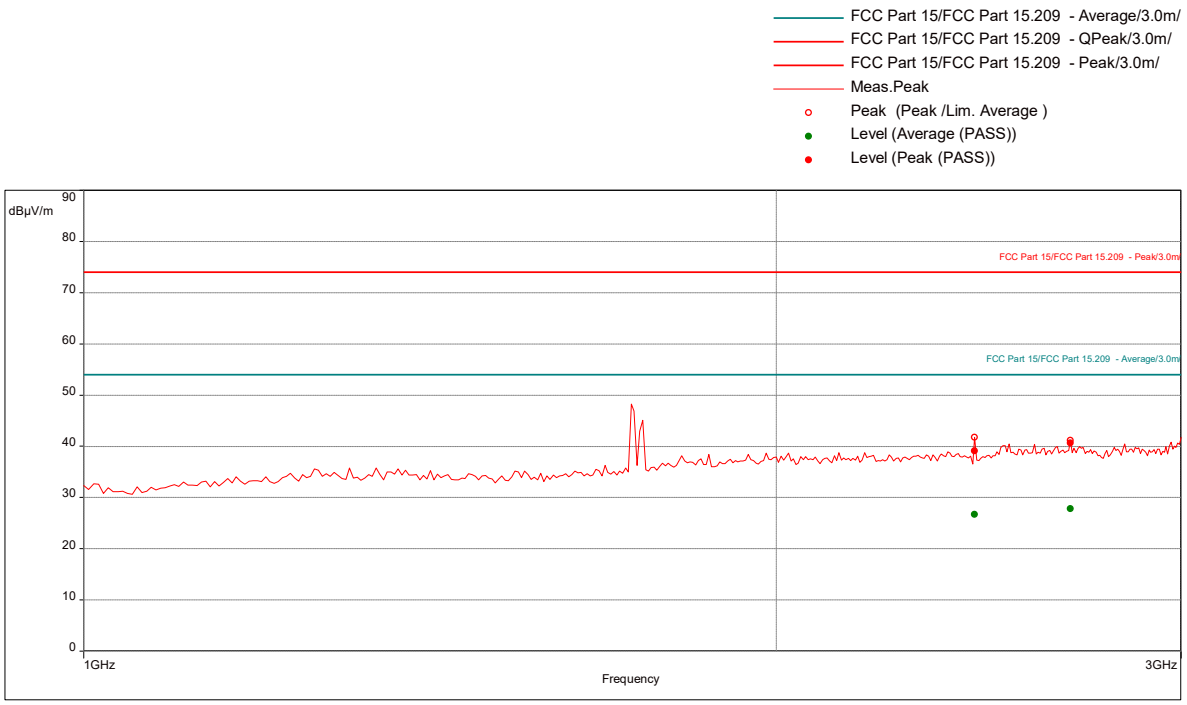
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.03157895	30.00	-13.48	126.00	2.71	Vertical	120000.00	-12.73
31.41052632	30.00	-14.21	323.00	2.53	Horizontal	120000.00	-13.56
99.91578947	33.50	-11.21	249.00	1.30	Vertical	120000.00	-22.67
124.3368421	33.50	-15.62	0.00	1.79	Vertical	120000.00	-18.79
140.4	33.50	-19.25	10.00	2.63	Vertical	120000.00	-19.28
197.6	33.50	-17.98	350.00	1.30	Vertical	120000.00	-19.75

Transmit at Mid channel (EUT sits on its short side), 2440 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 9:15:24 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Mid CH_X-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2440.789474	39.11	74.00	-34.89	9.00	1.15	Horizontal	1000000.00	-3.45
2685.526316	40.65	74.00	-33.35	233.00	3.05	Horizontal	1000000.00	-2.97

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2440.789474	26.74	54.00	-27.26	9.00	1.15	Horizontal	1000000.00	-3.45
2685.526316	27.79	54.00	-26.21	233.00	3.05	Horizontal	1000000.00	-2.97

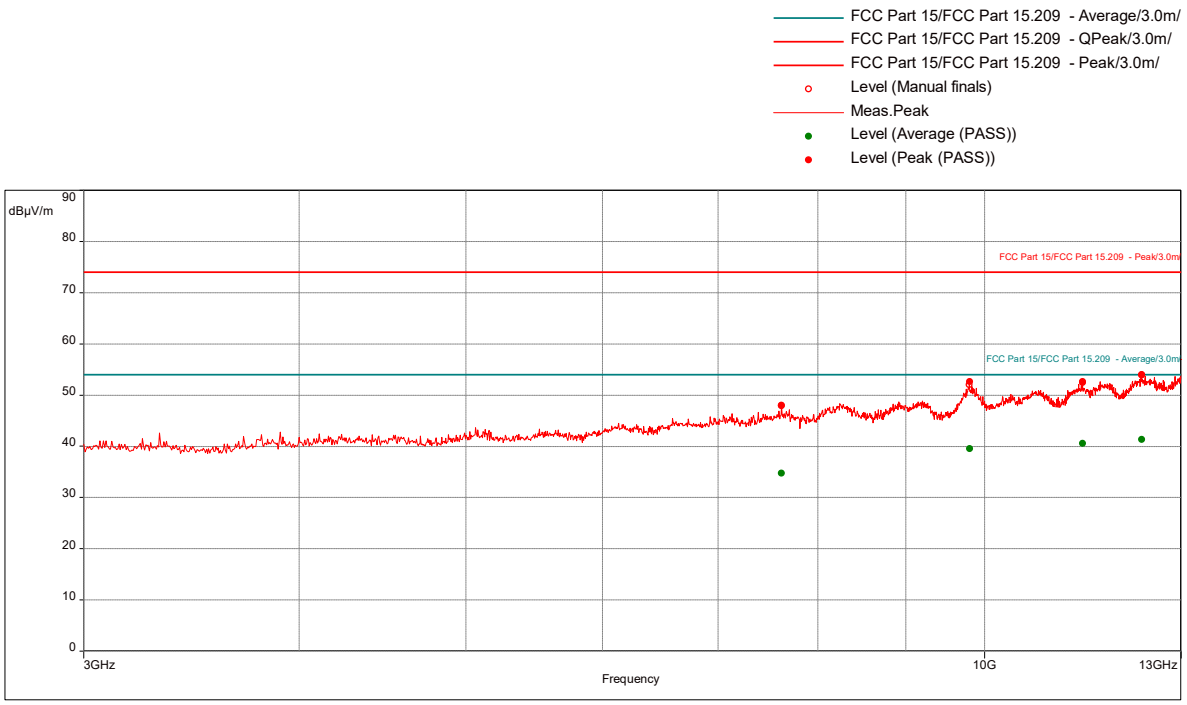
Note: Big peak was the ambient.

Transmit at Mid channel (EUT sits on its short side), 2440 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 6:38:12 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Mid CH_X-Axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7619.473684	47.93	74.00	-26.07	75.00	1.30	Horizontal	1000000.00	6.04
9798.947368	52.66	74.00	-21.34	358.00	1.85	Horizontal	1000000.00	9.97
11395.52632	52.47	74.00	-21.53	212.00	3.84	Horizontal	1000000.00	11.48
12327.89474	54.02	74.00	-19.98	127.00	1.90	Vertical	1000000.00	13.29

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7619.473684	34.77	54.00	-19.23	75.00	1.30	Horizontal	1000000.00	6.04
9798.947368	39.56	54.00	-14.44	358.00	1.85	Horizontal	1000000.00	9.97
11395.52632	40.57	54.00	-13.43	212.00	3.84	Horizontal	1000000.00	11.48
12327.89474	41.30	54.00	-12.70	127.00	1.90	Vertical	1000000.00	13.29

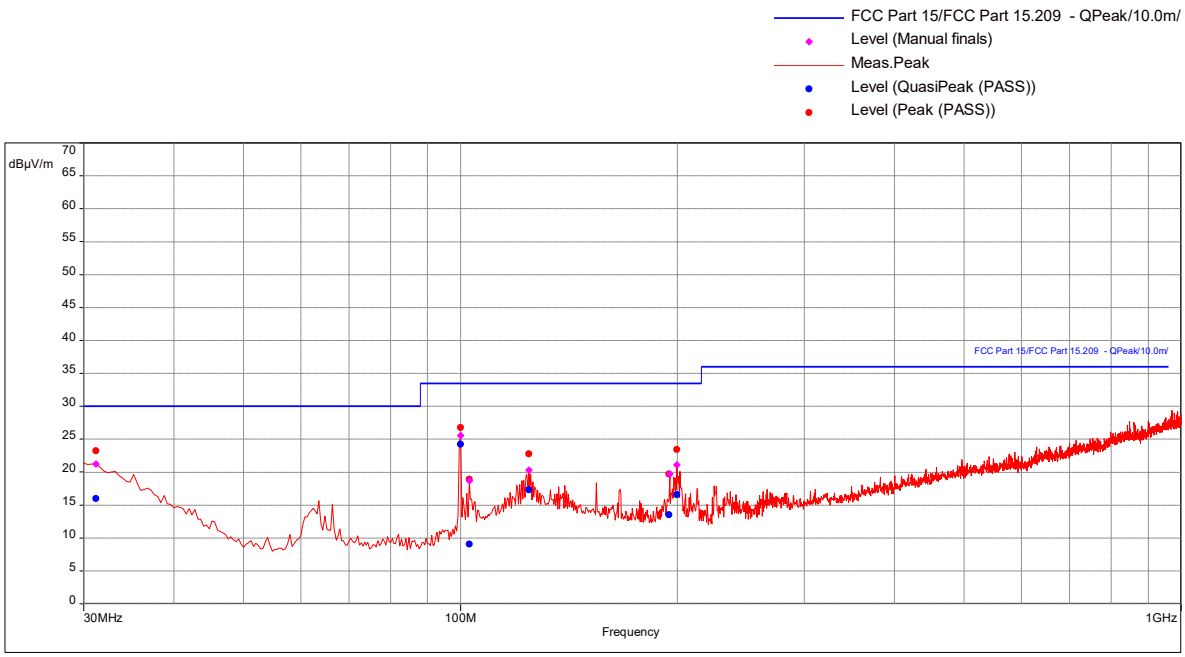
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at Mid channel (EUT sits on its long side), 2440MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 12:04:50 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 3: Tx Mid 2440 MHz, EUT on its long side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

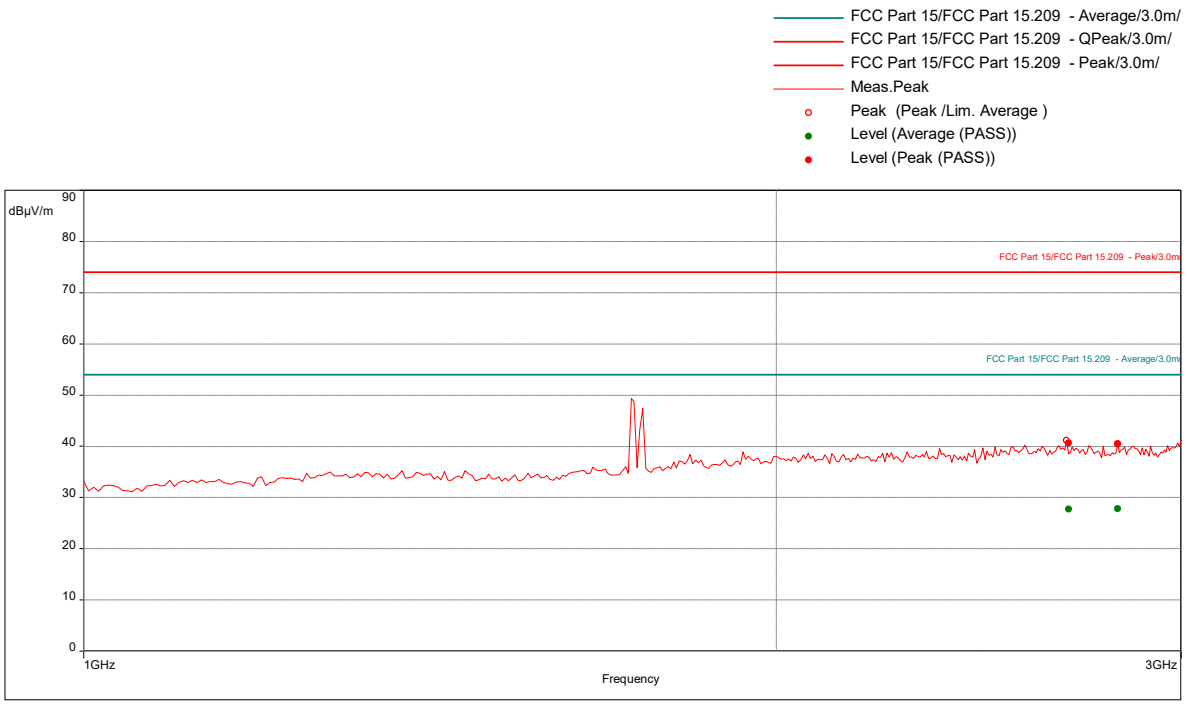
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
31.01052632	30.00	-14.00	307.00	1.58	Vertical	120000.00	-13.29
99.93684211	33.50	-9.26	74.00	1.53	Vertical	120000.00	-22.66
102.7052632	33.50	-24.42	11.00	3.01	Vertical	120000.00	-21.92
124.3052632	33.50	-16.17	242.00	1.68	Vertical	120000.00	-18.79
194.9789474	33.50	-19.98	300.00	2.35	Vertical	120000.00	-20.19
199.4421053	33.50	-16.92	358.00	1.00	Vertical	120000.00	-19.45

Transmit at Mid channel (EUT sits on its long side), 2440 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 8:58:21 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Mid CH_Y-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2678.157895	40.64	74.00	-33.36	24.00	3.89	Horizontal	1000000.00	-2.97
2817.105263	40.43	74.00	-33.57	314.00	1.55	Vertical	1000000.00	-2.79

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2678.157895	27.70	54.00	-26.30	24.00	3.89	Horizontal	1000000.00	-2.97
2817.105263	27.79	54.00	-26.21	314.00	1.55	Vertical	1000000.00	-2.79

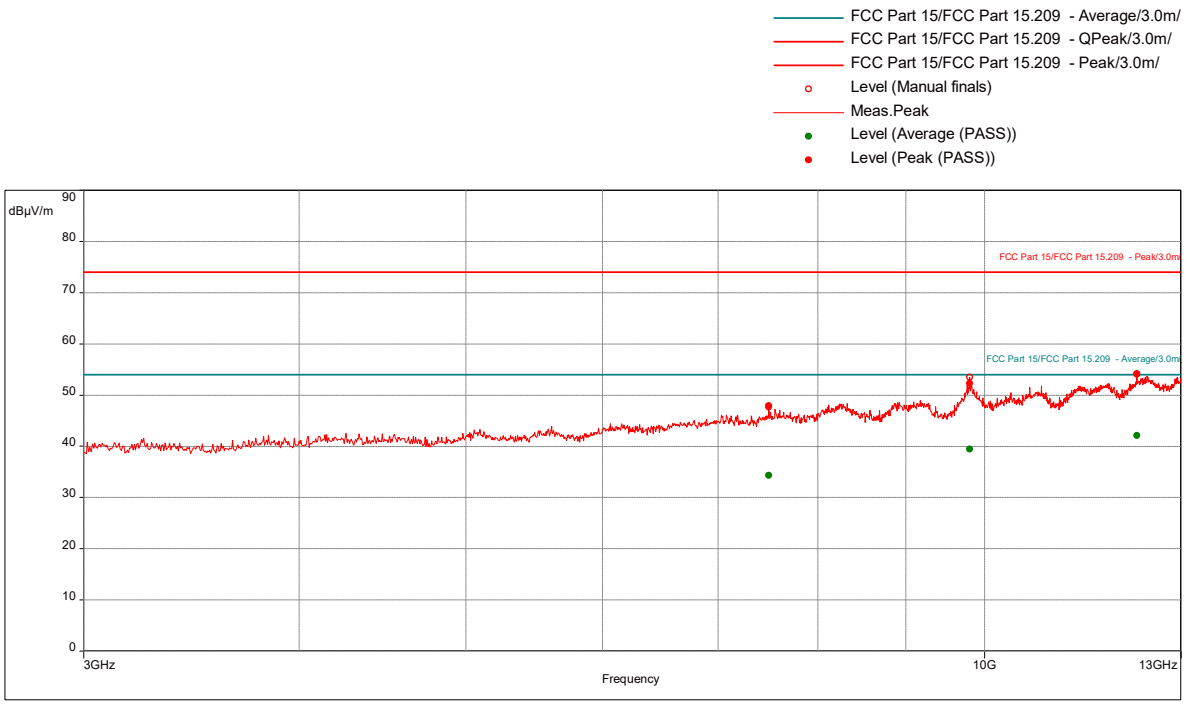
Note: Big peak was the ambient.

Transmit at Mid channel (EUT sits on its long side), 2440 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 6:17:41 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Mid CH_Y-Axis

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7493.157895	47.94	74.00	-26.06	104.00	1.60	Horizontal	1000000.00	5.92
9800	52.26	74.00	-21.74	337.00	3.44	Horizontal	1000000.00	9.98
12254.73684	54.11	74.00	-19.89	25.00	1.35	Horizontal	1000000.00	13.24

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
7493.157895	34.28	54.00	-19.72	104.00	1.60	Horizontal	1000000.00	5.92
9800	39.42	54.00	-14.58	337.00	3.44	Horizontal	1000000.00	9.98
12254.73684	42.13	54.00	-11.87	25.00	1.35	Horizontal	1000000.00	13.24

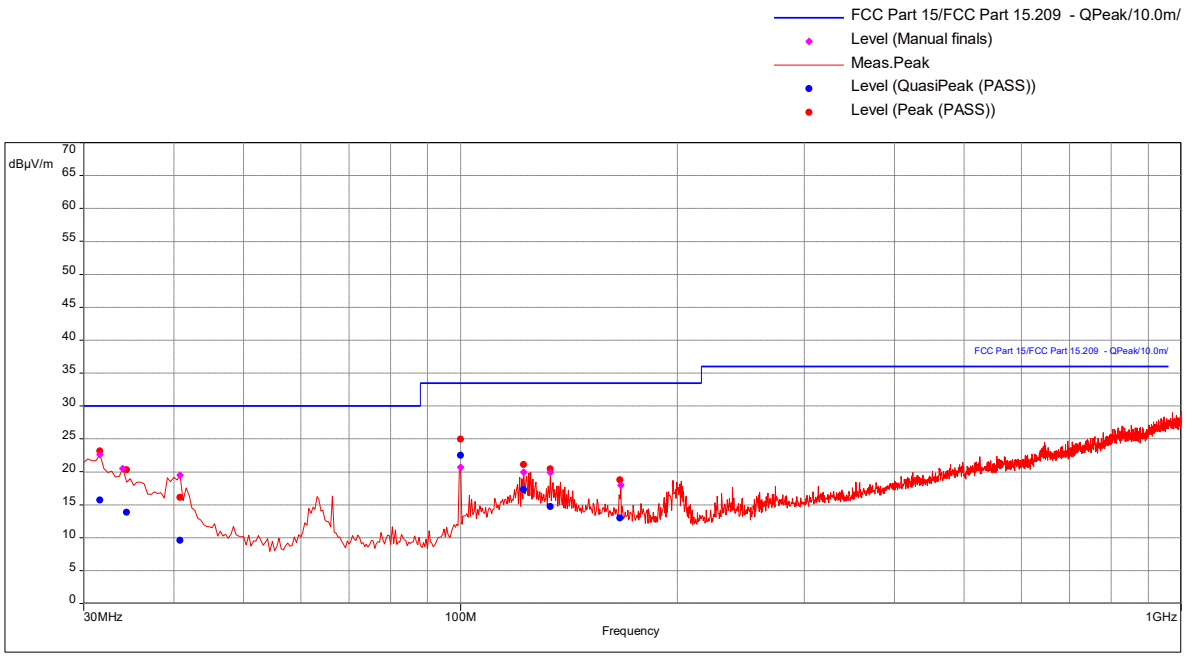
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at Mid channel (EUT sits on its back side), 2440 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 11:30:52 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 1: Tx Mid 2440 MHz, EUT on its back, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (7)

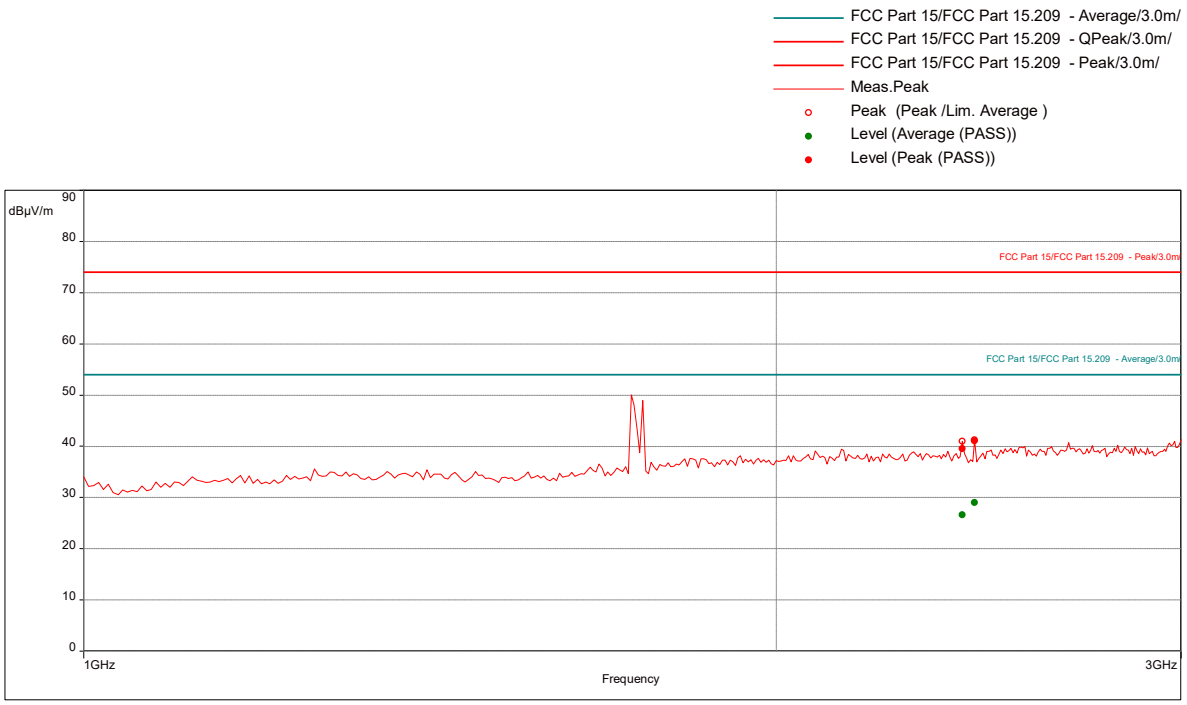
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
31.56842105	30.00	-14.32	280.00	3.12	Vertical	120000.00	-13.67
34.34736842	30.00	-16.17	343.00	3.64	Horizontal	120000.00	-15.42
40.67368421	30.00	-20.40	133.00	1.36	Vertical	120000.00	-19.79
99.93684211	33.50	-11.01	176.00	2.68	Vertical	120000.00	-22.66
122.5578947	33.50	-16.23	291.00	2.30	Vertical	120000.00	-18.80
133.2315789	33.50	-18.81	164.00	2.01	Vertical	120000.00	-18.84
166.3578947	33.50	-20.50	147.00	1.30	Vertical	120000.00	-20.47

Transmit at Mid channel (EUT sits on its back side), 2440 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 8:47:29 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode Mid CH_Z-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2408.947368	39.52	74.00	-34.48	189.00	2.95	Vertical	1000000.00	-3.71
2438.947368	41.08	74.00	-32.92	40.00	1.00	Vertical	1000000.00	-3.46

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2408.947368	26.57	54.00	-27.43	189.00	2.95	Vertical	1000000.00	-3.71
2438.947368	29.03	54.00	-24.97	40.00	1.00	Vertical	1000000.00	-3.46

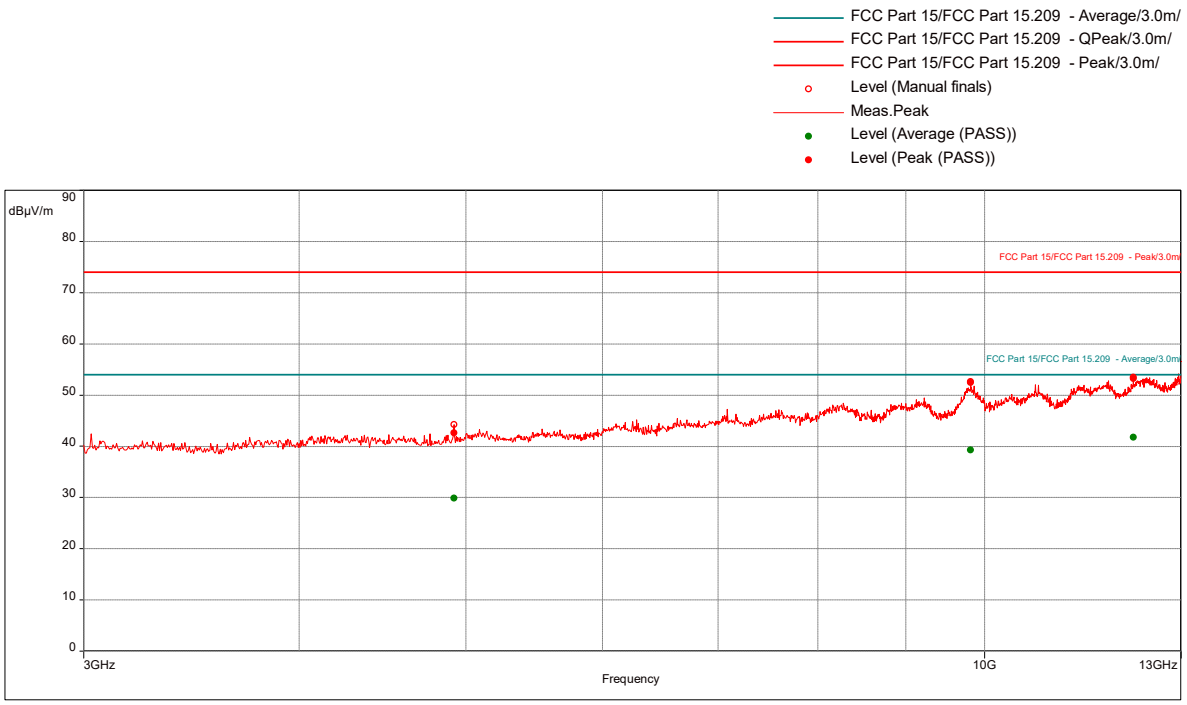
Note: Big peak was the ambient.

Transmit at Mid channel (EUT sits on its back side), 2440 MHz, 3-25 GHz

Test Information:

Date and Time	5/3/2022 5:58:18 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_USB power_Tx mode Mid CH_Z-Axis

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4921.842105	42.65	74.00	-31.35	359.00	2.95	Vertical	1000000.00	1.01
9813.947368	52.48	74.00	-21.52	222.00	3.64	Horizontal	1000000.00	9.92
12193.94737	53.24	74.00	-20.76	295.00	3.74	Vertical	1000000.00	13.05

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4921.842105	29.84	54.00	-24.16	359.00	2.95	Vertical	1000000.00	1.01
9813.947368	39.32	54.00	-14.68	222.00	3.64	Horizontal	1000000.00	9.92
12193.94737	41.73	54.00	-12.27	295.00	3.74	Vertical	1000000.00	13.05

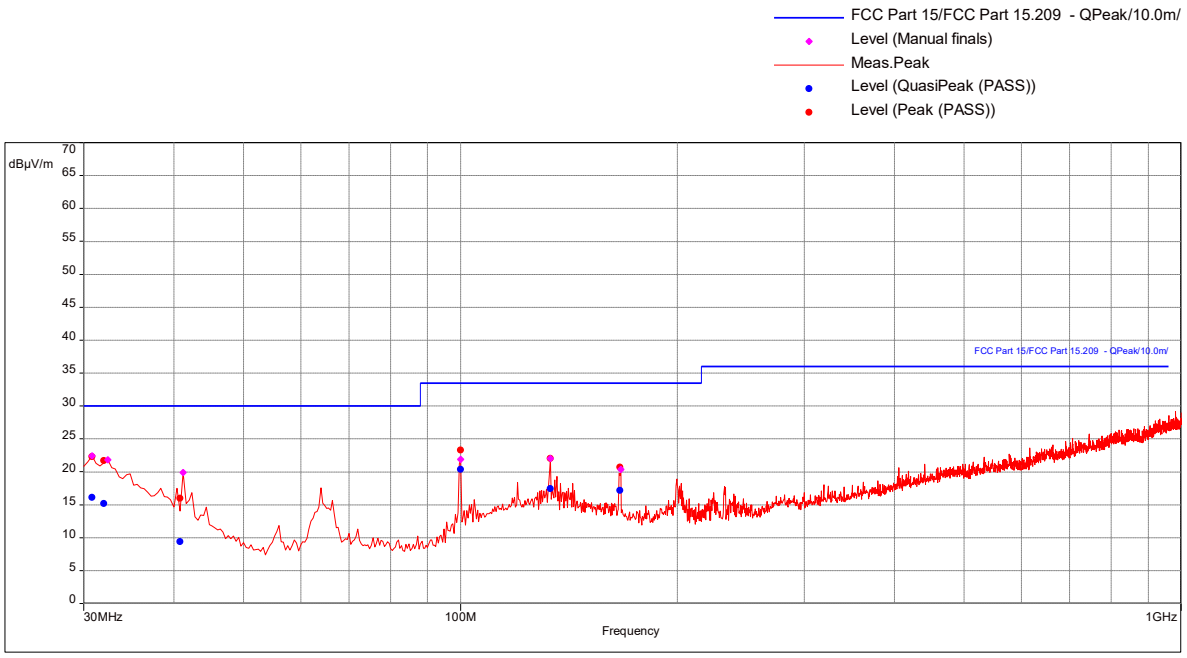
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at High channel (EUT sits on its short side), 2475 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 2:14:09 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 7: Tx High, EUT on its short side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

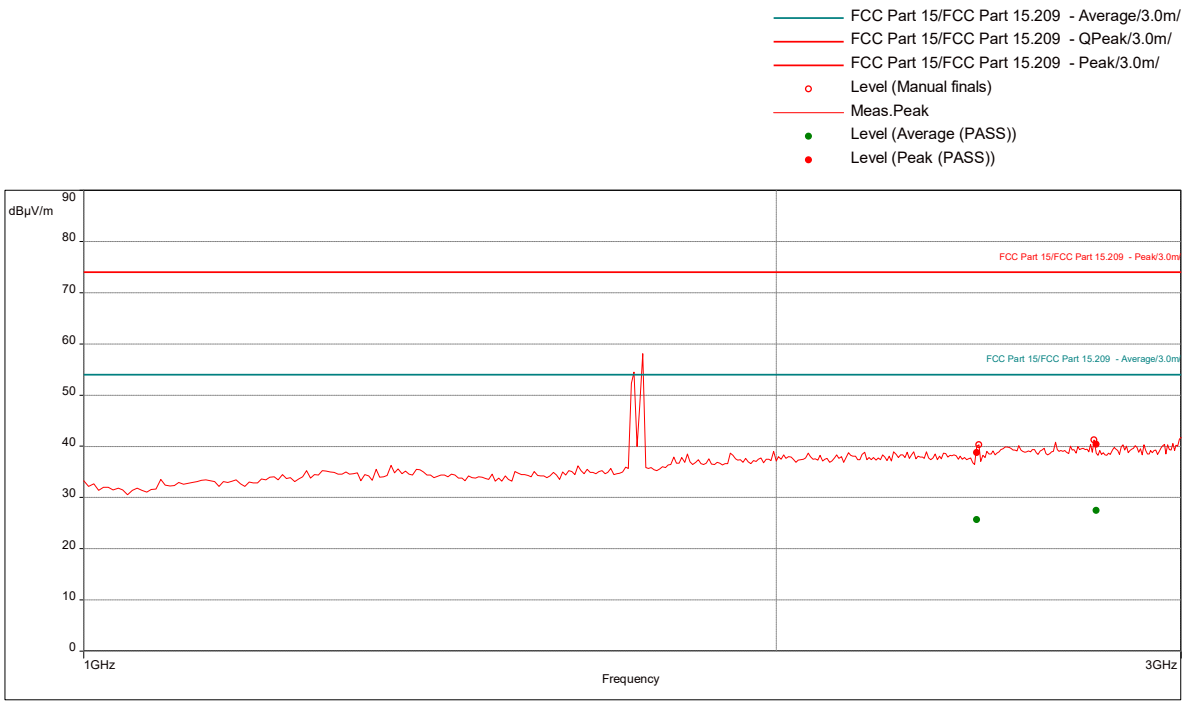
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.8	30.00	-13.87	186.00	1.52	Horizontal	120000.00	-13.17
32.14736842	30.00	-14.80	222.00	1.40	Horizontal	120000.00	-14.05
40.85263158	30.00	-20.62	74.00	3.74	Vertical	120000.00	-19.92
99.93684211	33.50	-13.16	69.00	1.47	Vertical	120000.00	-22.66
133.2631579	33.50	-16.09	171.00	1.68	Vertical	120000.00	-18.84
166.5789474	33.50	-16.30	359.00	1.00	Vertical	120000.00	-20.47

Transmit at High channel (EUT sits on its short side), 2475 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 8:08:52 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode High CH_X-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2447.368421	38.72	74.00	-35.28	314.00	1.65	Vertical	1000000.00	-3.43
2753.684211	40.35	74.00	-33.65	109.00	2.55	Vertical	1000000.00	-2.88

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2447.368421	25.71	54.00	-28.29	314.00	1.65	Vertical	1000000.00	-3.43
2753.684211	27.45	54.00	-26.55	109.00	2.55	Vertical	1000000.00	-2.88

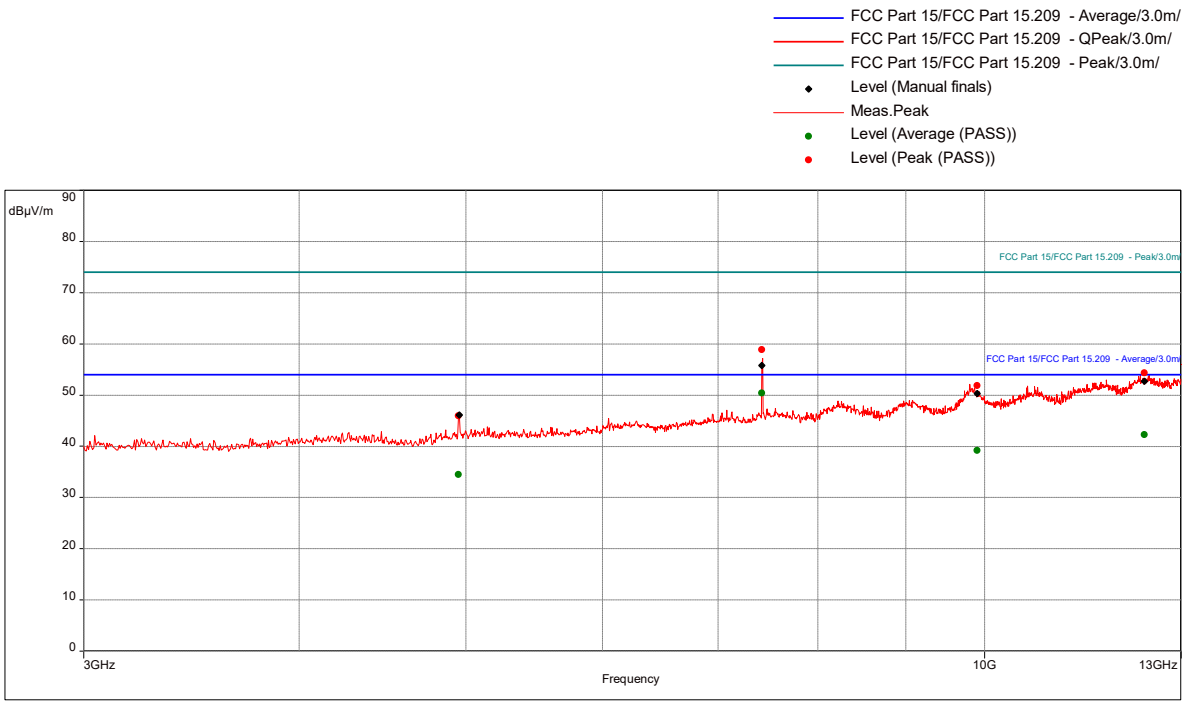
Note: Big peak was the ambient.

Transmit at High channel (EUT sits on its short side), 2475 MHz, 3-25 GHz

Test Information:

Date and Time	5/7/2022 8:50:46 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	23 C
Humidity	26 %
Atmospheric Pressure	1005 mbar
Comments	Scan 1: Tx High CH_X-Axis (short side), RE 3 to 13 GHz SA mode

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4950.789474	45.93	74.00	-28.07	254.00	2.45	Vertical	1000000.00	1.11
7426.315789	58.86	74.00	-15.14	322.00	1.65	Horizontal	1000000.00	5.72
9898.157895	51.88	74.00	-22.12	253.00	3.34	Horizontal	1000000.00	9.59
12373.15789	54.35	74.00	-19.65	80.00	2.55	Vertical	1000000.00	13.35

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4950.789474	34.49	54.00	-19.51	254.00	2.45	Vertical	1000000.00	1.11
7426.315789	50.38	54.00	-3.62	322.00	1.65	Horizontal	1000000.00	5.72
9898.157895	39.23	54.00	-14.77	253.00	3.34	Horizontal	1000000.00	9.59
12373.15789	42.24	54.00	-11.76	80.00	2.55	Vertical	1000000.00	13.35

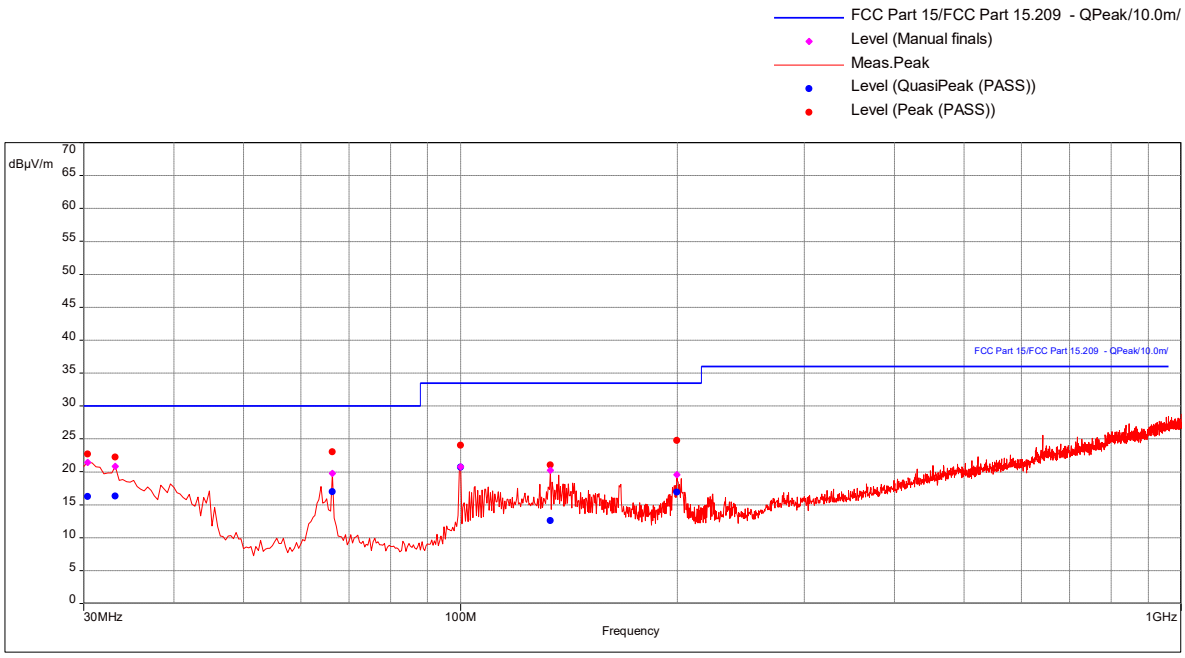
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at High channel (EUT sits on its long side), 2475 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 3:35:14 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 9 Tx High, EUT on its long side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

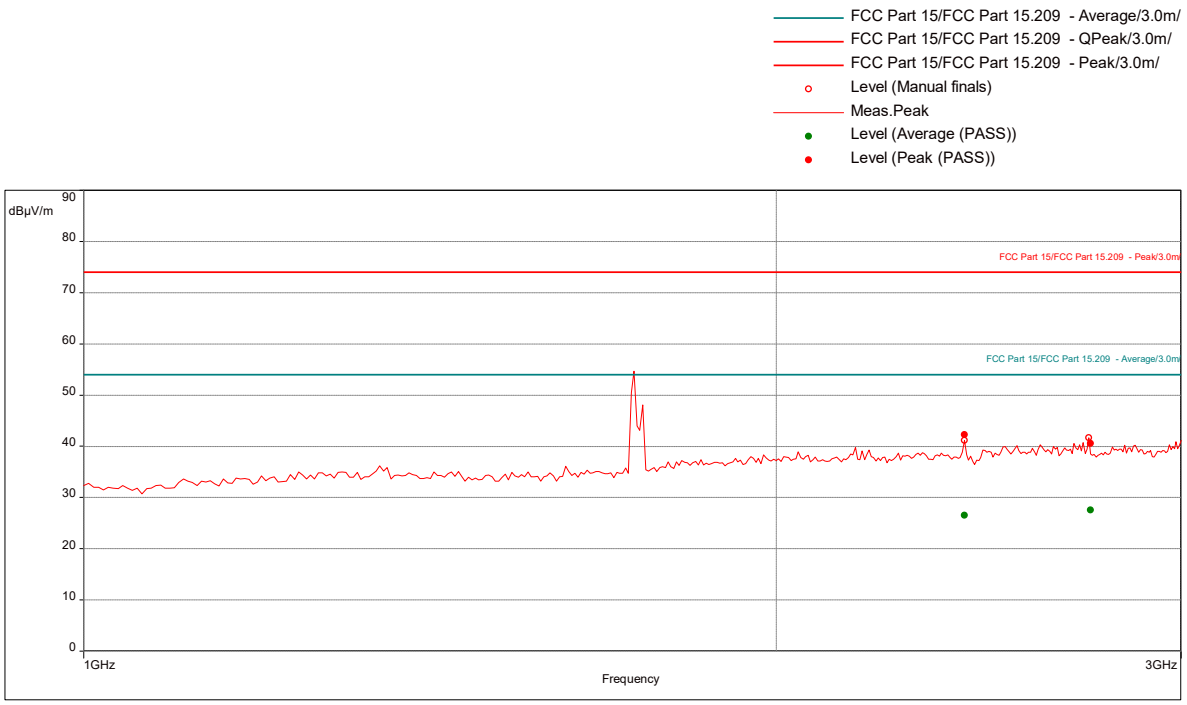
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.56842105	30.00	-13.79	33.00	2.58	Horizontal	120000.00	-13.03
33.26315789	30.00	-13.67	287.00	3.24	Vertical	120000.00	-14.71
66.4	30.00	-13.02	171.00	1.63	Vertical	120000.00	-25.24
99.93684211	33.50	-12.80	104.00	2.90	Vertical	120000.00	-22.66
133.0736842	33.50	-20.89	31.00	2.84	Vertical	120000.00	-18.83
199.4105263	33.50	-16.61	9.00	1.30	Vertical	120000.00	-19.45

Transmit at High channel (EUT sits on its long side), 2475 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 8:21:34 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode High CH_Y-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2414.210526	42.24	74.00	-31.76	357.00	2.25	Vertical	1000000.00	-3.67
2738.421053	40.60	74.00	-33.40	257.00	2.05	Vertical	1000000.00	-2.89

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2414.210526	26.52	54.00	-27.48	357.00	2.25	Vertical	1000000.00	-3.67
2738.421053	27.52	54.00	-26.48	257.00	2.05	Vertical	1000000.00	-2.89

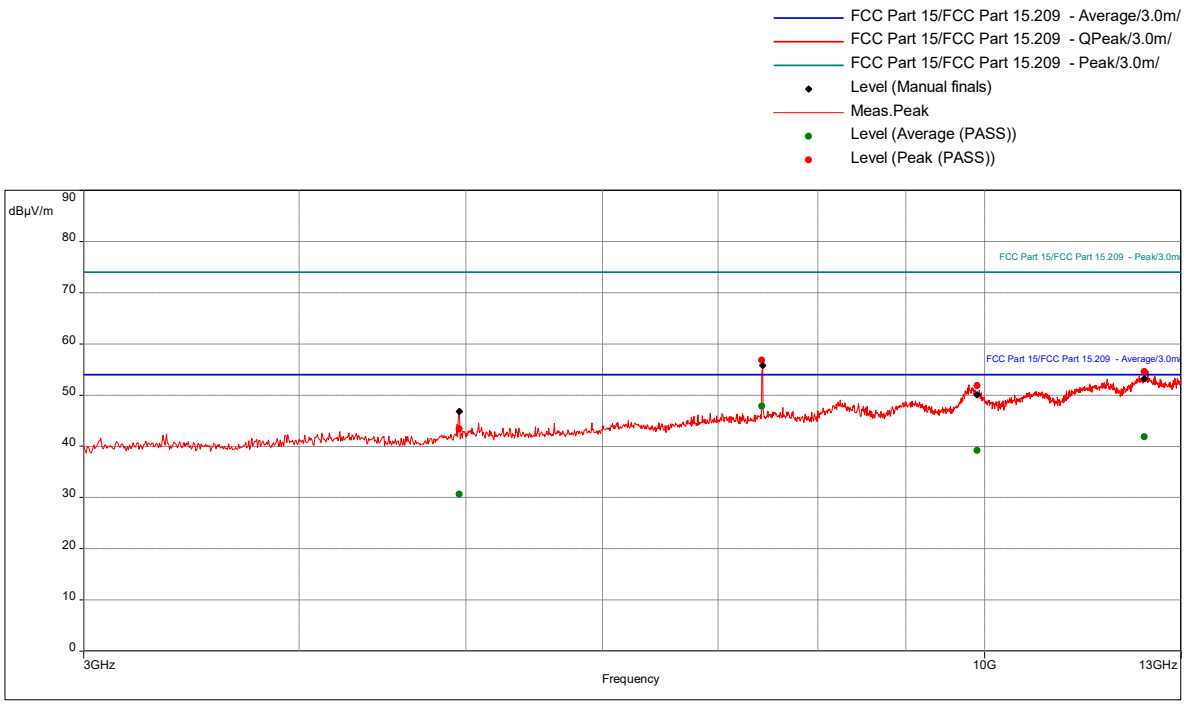
Note: Big peak was the ambient.

Transmit at High channel (EUT sits on its long side), 2475 MHz, 3-25 GHz

Test Information:

Date and Time	5/7/2022 9:19:21 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	23 C
Humidity	26 %
Atmospheric Pressure	1005 mbar
Comments	Scan 2: Tx High CH_Y-Axis (long side), RE 3 to 13 GHz SA mode

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4956.578947	43.42	74.00	-30.58	10.00	3.59	Horizontal	1000000.00	1.13
7426.315789	56.79	74.00	-17.21	359.00	1.60	Vertical	1000000.00	5.72
9897.894737	51.88	74.00	-22.12	125.00	2.80	Vertical	1000000.00	9.59
12377.36842	54.62	74.00	-19.38	228.00	3.05	Vertical	1000000.00	13.36

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
4956.578947	30.62	54.00	-23.38	10.00	3.59	Horizontal	1000000.00	1.13
7426.315789	47.86	54.00	-6.14	359.00	1.60	Vertical	1000000.00	5.72
9897.894737	39.23	54.00	-14.77	125.00	2.80	Vertical	1000000.00	9.59
12377.36842	41.82	54.00	-12.18	228.00	3.05	Vertical	1000000.00	13.36

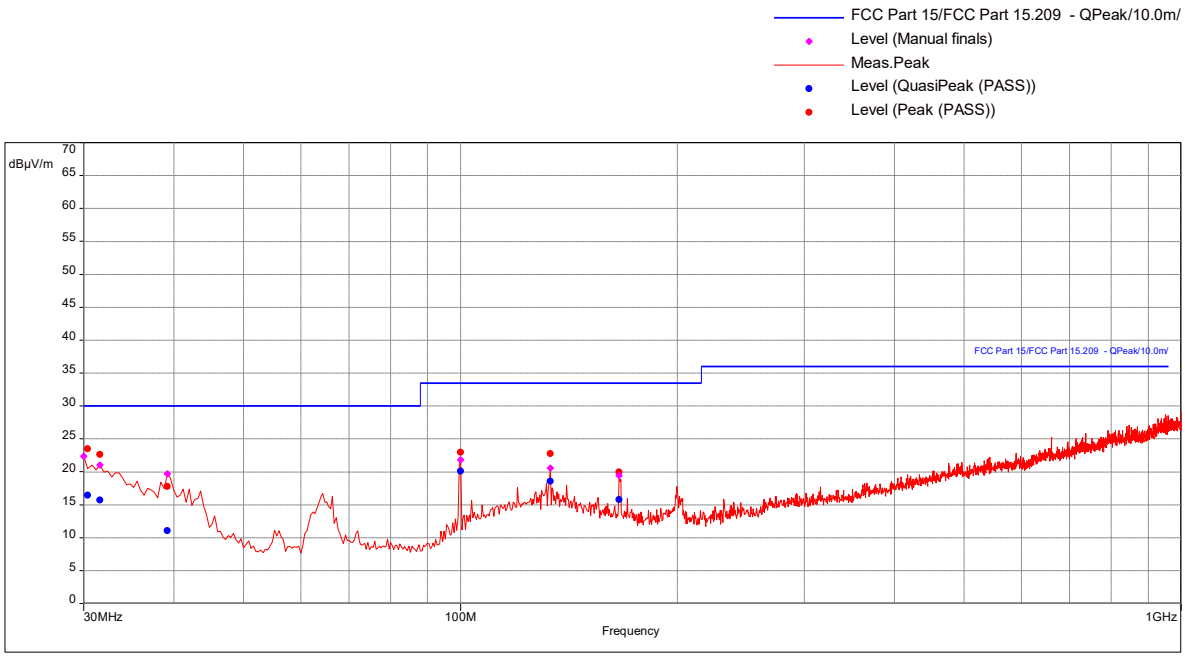
Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Transmit at High channel (EUT sits on its back side), 2475 MHz, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 2:43:51 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 8: Tx High, EUT on its back side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

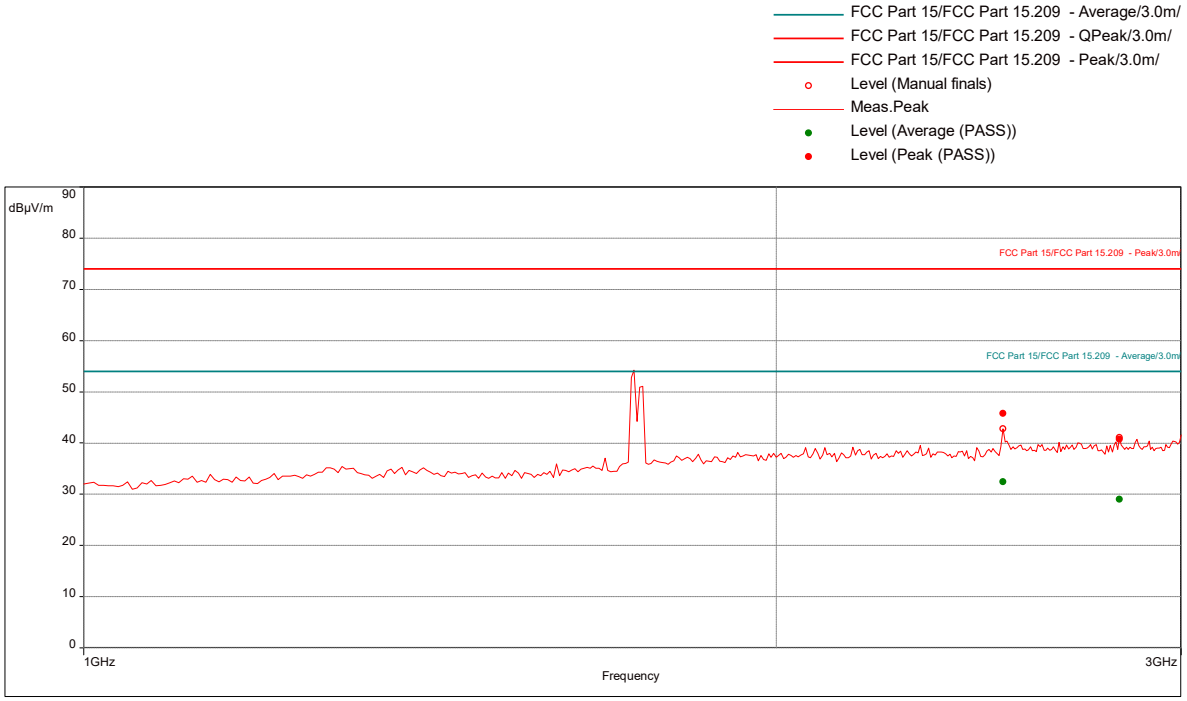
Frequency (MHz)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.26842105	30.00	-13.56	157.00	3.70	Vertical	120000.00	-12.86
31.50526316	30.00	-14.28	280.00	1.57	Vertical	120000.00	-13.62
39.01052632	30.00	-18.96	4.00	3.45	Vertical	120000.00	-18.55
99.93684211	33.50	-13.42	191.00	2.28	Vertical	120000.00	-22.66
133.2315789	33.50	-14.94	331.00	1.00	Vertical	120000.00	-18.84
165.9684211	33.50	-17.74	301.00	2.30	Vertical	120000.00	-20.47

Transmit at High channel (EUT sits on its back side), 2475 MHz, 1-3 GHz

Test Information:

Date and Time	5/3/2022 8:32:43 PM
Client and Project Number	Ingersoll-Rand_G105001833
Engineer	Vathana Ven
Temperature	25 deg C
Humidity	34%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 3 GHz_USB power_Tx mode High CH_Z-Axis

Graph:



Results:

Peak (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2510.526316	45.77	74.00	-28.23	178.00	1.20	Horizontal	1000000.00	-3.01
2820.526316	40.70	74.00	-33.30	75.00	2.20	Horizontal	1000000.00	-2.79

Average (PASS) (2)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
2510.526316	32.40	54.00	-21.60	178.00	1.20	Horizontal	1000000.00	-3.01
2820.526316	28.99	54.00	-25.01	75.00	2.20	Horizontal	1000000.00	-2.79

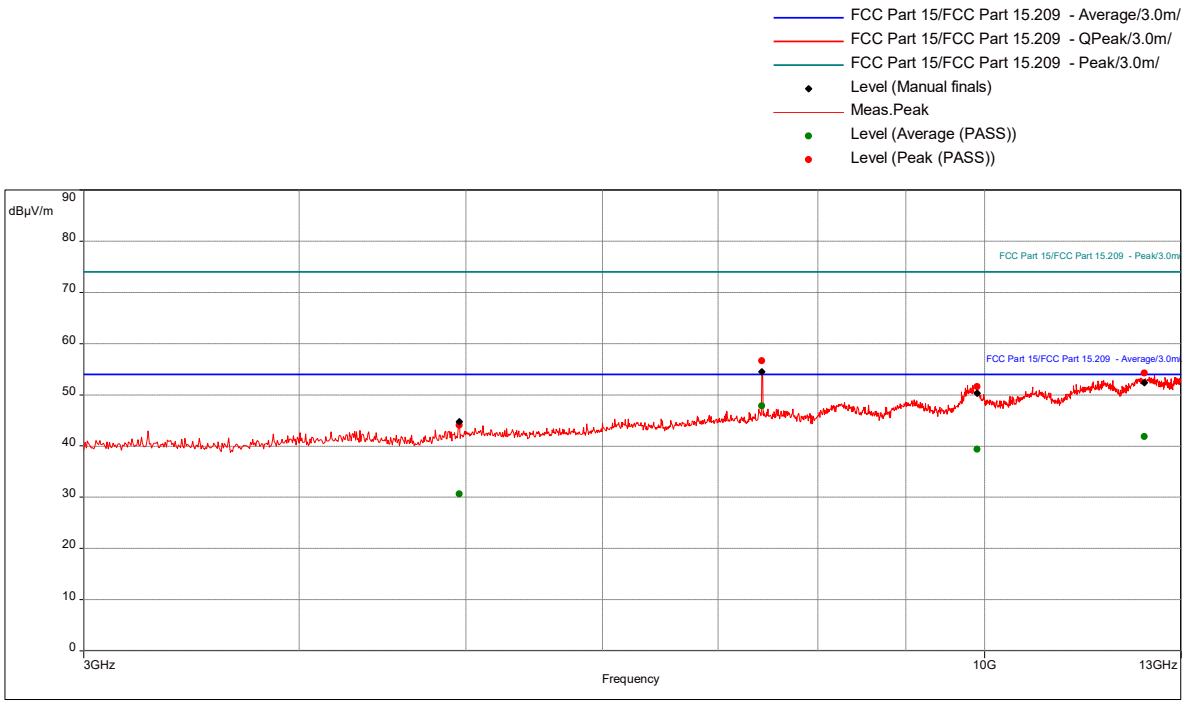
Note: Big peak was the ambient.

Transmit at High channel (EUT sits on its back side), 2475 MHz, 3-25 GHz

Test Information:

Date and Time	5/7/2022 9:44:19 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	23 C
Humidity	26 %
Atmospheric Pressure	1005 mbar
Comments	Scan 3: Tx High CH_Z-Axis (back side), RE 3 to 13 GHz SA mode

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°) (dB)	Height (m) (dB)	Pol. (dB)	RBW (dB)	Correction (dB)
4957.105263	44.10	74.00	-29.90	119.00	2.70	Horizontal	1000000.00	1.13
7423.684211	56.64	74.00	-17.36	118.00	1.01	Vertical	1000000.00	5.71
9898.947368	51.60	74.00	-22.40	206.00	3.35	Vertical	1000000.00	9.59
12378.15789	54.23	74.00	-19.77	53.00	2.00	Horizontal	1000000.00	13.36

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°) (dB)	Height (m) (dB)	Pol. (dB)	RBW (dB)	Correction (dB)
4957.105263	30.62	54.00	-23.38	119.00	2.70	Horizontal	1000000.00	1.13
7423.684211	47.80	54.00	-6.20	118.00	1.01	Vertical	1000000.00	5.71
9898.947368	39.36	54.00	-14.64	206.00	3.35	Vertical	1000000.00	9.59
12378.15789	41.88	54.00	-12.12	53.00	2.00	Horizontal	1000000.00	13.36

Notes: From 13-25 GHz, manual scan was performed at 10 cm from the EUT with no emission was detected above the measuring instrument noise floor.

Test Personnel:	Kouma Sinn KPS	Test Date:	04/26/2022, 04/27/2022, 05/07/2022
	Vathana Ven VSV		05/03/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	CFR47 FCC Part 15.247 RSS-247	Limit Applied:	See report section 10.3
Input Voltage:	USB Powered		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	25, 24, 25, 23 ºC
		Relative Humidity:	25, 38, 34, 26 %
		Atmospheric Pressure:	1010,1000, 1011, 1005 mbars

Deviations, Additions, or Exclusions: None

11 Digital Device and Receiver Radiated Spurious Emissions

11.1 Method

Tests are performed in accordance with FCC Part 15 Subpart B, 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.

11.2 Test Equipment Used:

Equipment used for radiated emission measurement from 30-1000 MHz

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
145106'	Bilog Antenna (30MHz - 5GHz)	Sunol Sciences	JB5	A111003	07/15/2021	07/15/2022
HS002'	DC-18GHz cable 1.5M long	Huber & Suhner	SucoFlex 106A	HS002	12/06/2021	12/06/2022
IW006'	DC-18GHz cable 8.4m long	Insulated Wire	2800-NPS	IW006	07/22/2021	07/22/2022
PRE11'	50dB gain pre-amp	Pasternack	PRE11	PRE11	09/02/2021	09/02/2022
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	06/09/2021	06/09/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022

Equipment used for radiated emission measurement from 1-13 GHz

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007	Weather Station Vantage Vue	Davis	6250	MS191212003	03/08/2022	03/08/2023
145-414	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
IW001	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
IW002	2 meter Armored cable	Insulated Wire	2800-NPS	002	09/23/2021	09/23/2022
IW003	8.4 meter cable	Insulated Wire	2800-NPS	003	10/15/2022	10/15/2022
145108	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
ETS002	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
PRE12	Pre-amplifier	Com Power	PAM-118A	18040117	12/06/2021	12/06/2022

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.17.0.3

11.3 Results:

The sample tested was found to Comply.

Limits – FCC Part §15.109 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

11.4 Setup Photographs:

Radiated Emissions Test Setup, 30-1000 MHz

Radiated Emissions Test Setup, 1-13 GHz

Photos not available

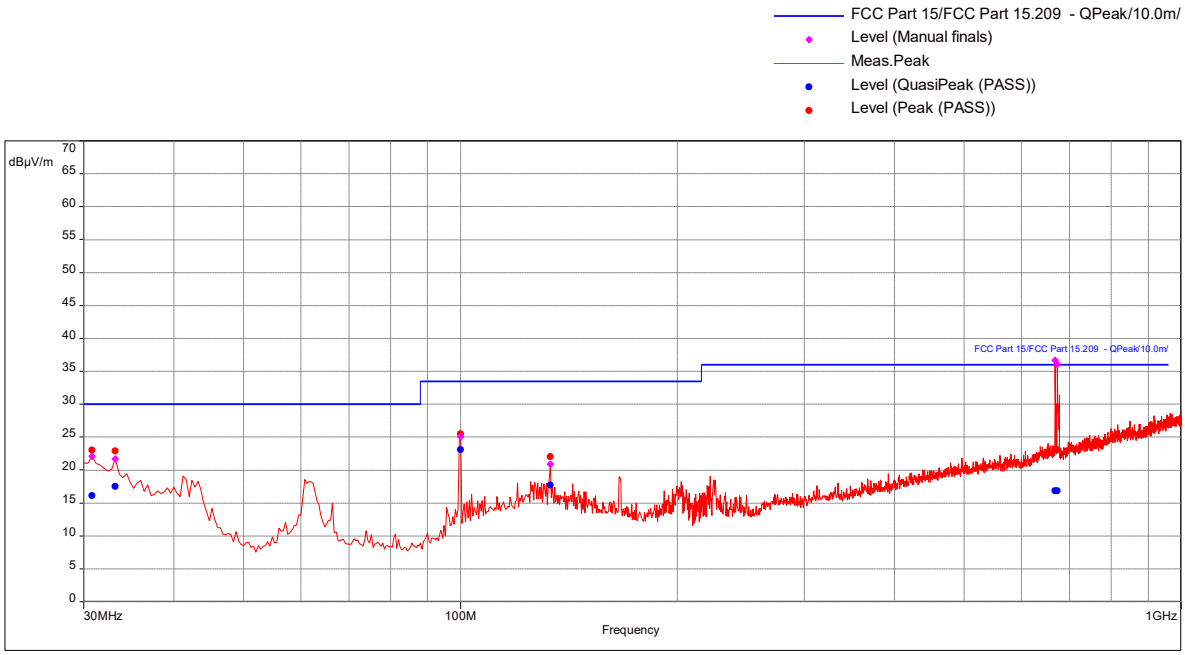
11.5 Plots/Data:

Radiated Emissions, 30-1000 MHz

Test Information:

Date and Time	4/26/2022 3:40:54 PM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	25 C
Humidity	25 %
Atmospheric Pressure	1010 mbar
Comments	Scan 10: Rx Mid, EUT on its long side, RE 30-1000MHz SA mode

Graph:



Results:

QuasiPeak (PASS) (6)

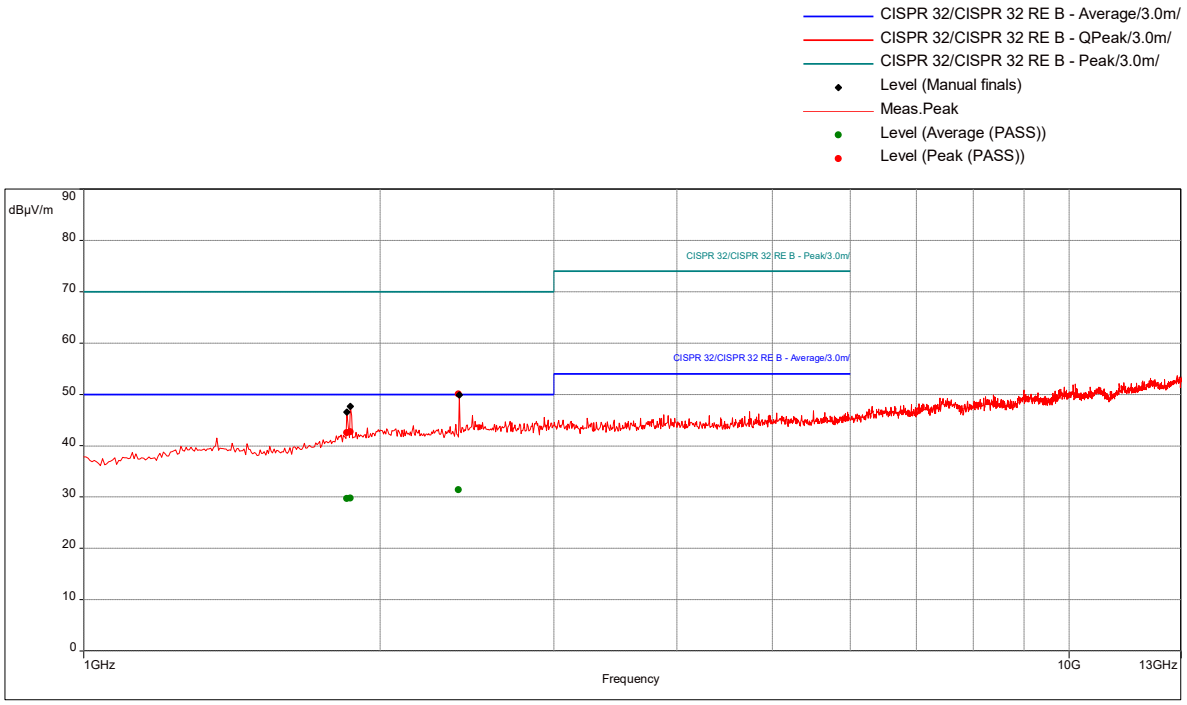
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
30.86315789	16.09	30.00	-13.91	323.00	3.01	Horizontal	120000.00	-13.21
33.2	17.47	30.00	-12.53	4.00	2.72	Vertical	120000.00	-14.67
99.93684211	23.09	33.50	-10.41	336.00	1.30	Vertical	120000.00	-22.66
133.2315789	17.72	33.50	-15.78	127.00	1.86	Vertical	120000.00	-18.84
668.4631579	16.82	36.00	-19.18	359.00	3.35	Horizontal	120000.00	-10.41
673.5368421	16.86	36.00	-19.14	205.00	1.46	Horizontal	120000.00	-10.31

Radiated Emissions, 1-13 GHz

Test Information:

Date and Time	5/7/2022 11:07:16 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	23 C
Humidity	26 %
Atmospheric Pressure	1005 mbar
Comments	Scan 4: Rx High CH_Y-Axis (short side), used BONN001 Pre-amp, RE 1 to 13 GHz SA mode

Graph:



Results:

Peak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1851.052632	42.55	70.00	-27.45	214.00	3.50	Horizontal	1000000.00	-17.10
1862.894737	42.67	70.00	-27.33	170.00	1.35	Horizontal	1000000.00	-16.98
2402.105263	50.02	70.00	-19.98	295.00	1.65	Vertical	1000000.00	-15.19

Average (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1851.052632	29.72	50.00	-20.28	214.00	3.50	Horizontal	1000000.00	-17.10
1862.894737	29.75	50.00	-20.25	170.00	1.35	Horizontal	1000000.00	-16.98
2402.105263	31.42	50.00	-18.58	295.00	1.65	Vertical	1000000.00	-15.19

Test Personnel:	Kouma Sinn KPS	Test Date:	04/26/2022, 05/07/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart B, ISED ICES-003	Limit Applied:	See report section 11.3
Input Voltage:	USB Powered	Ambient Temperature:	25, 23 ºC
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Relative Humidity:	25, 26 %
		Atmospheric Pressure:	1010, 1005 mbars

Deviations, Additions, or Exclusions: None

12 AC Mains Conducted Emissions

12.1 Method

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

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.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
AC Line Conducted Emissions	150 kHz - 30 MHz	1.2 dB	3.4dB
Telco Port Emissions	150 kHz - 30 MHz	2.8 dB	5.0dB
AC Line Conducted Emissions	9 kHz - 150 MHz	2.2 dB	3.4 dB

As shown in the table above our conducted 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 Calculations

The following is how net line-conducted readings were determined:

NF = RF + LF + CF + AF
Where NF = Net Reading in dBμV
RF = Reading from receiver in dBμV
LF = LISN or ISN Correction Factor in dB
CF = Cable Correction Factor in dB
AF = Attenuator Loss Factor in dB

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:

NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 dBμV
$UF = 10^{(49.1\ dB\mu V / 20)}$ = 285.1 μV/m

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 LISN Factor, Attenuator, and Cable Loss. These are already accounted for in the “Level” column.

12.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV005'	Weather Station	Davis	6250	MS191218083	02/11/2022	02/11/2023
ROS002'	9kHz to 3GHz EMI Test Receiver	Rohde & Schwartz	ESCI 1166.5950K03	100067	06/24/2021	06/24/2022
LISN33'	LISN - CISPR16 Compliant 9kHz-30MHz	Com-Power	LI-215A	191953	08/26/2021	08/26/2022
CBL044'	15 ft BNC cable	Pomona	RG58	CBL044	07/02/2021	07/02/2022
WEI26'	Attenuator 20dB 2 Watts	Weinschel	WA18-20	1001015N0010004	05/18/2021	05/18/2022

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.18.0.16

12.3 Results:

The sample tested was found to Comply.

Limits – FCC § 15.107 (a)

Frequency (MHz)	Conducted Limit (dBµV)	
	Quasi-peak	Average
0.150-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

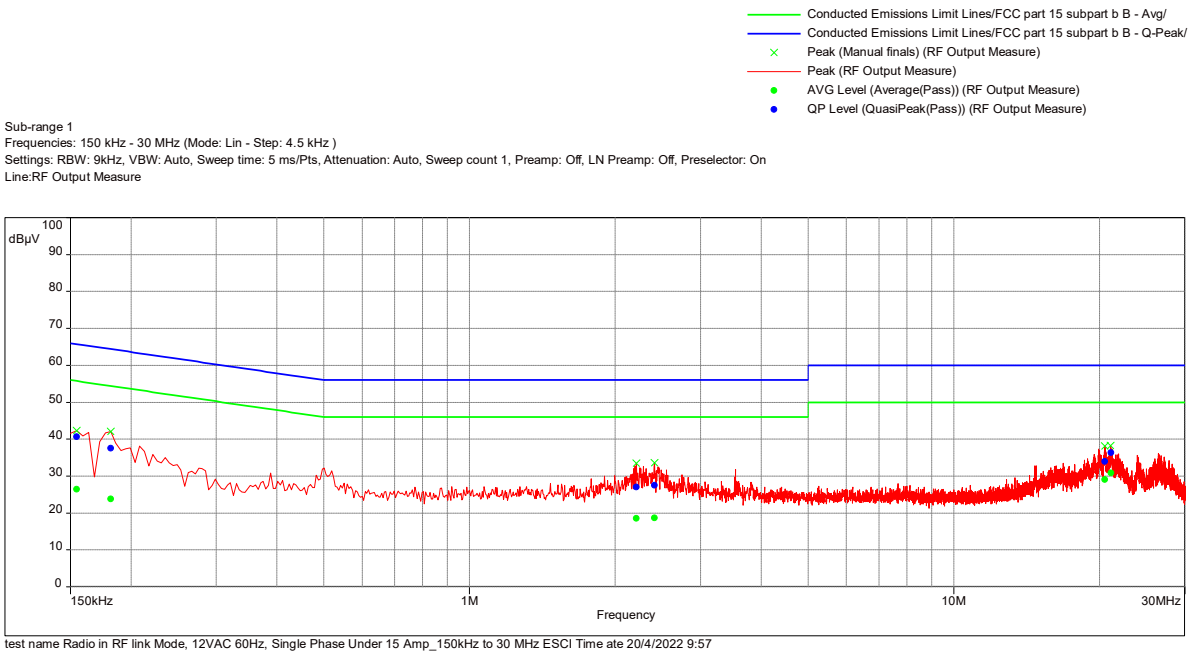
12.4 Setup Photographs:

12.5 Plots/Data:

Test Information:

Date and Time	4/20/2022 9:48:32 AM
Client and Project Number	Ingersoll Rand
Engineer	Kouma Sinn
Temperature	24 deg C
Humidity	21 %
Atmospheric Pressure	1011 mbars
Comments	Radio in RF link Mode, 120VAC 60Hz, Single Phase Under 15 Amp_150kHz to 30 MHz ESCI

Graph:



Results:

QuasiPeak(Pass) (6)

Frequency (MHz)	QP Level (dBµV)	QP Limit (dBuV)	QP Margin (dB)	Line	RBW	Meas.Time	Correction (dB)
0.155	40.59	65.75	-25.16	Neutral	9k	0.01	20.17
0.18	37.51	64.42	-26.91	Phase 1	9k	0.01	19.78
2.2115	26.98	56.00	-29.02	Phase 1	9k	0.01	19.87
2.407	27.52	56.00	-28.48	Neutral	9k	0.01	19.91
20.491	33.98	60.00	-26.02	Phase 1	9k	0.01	20.09
21.088	36.31	60.00	-23.69	Phase 1	9k	0.01	20.10

Average(Pass) (6)

Frequency (MHz)	AVG Level (dBµV)	AVG Limit (dBuV)	AVG Margin (dB)	Line	RBW	Meas.Time	Correction (dB)
0.155	26.35	55.75	-29.40	Neutral	9k	0.01	20.17
0.18	23.83	54.42	-30.58	Phase 1	9k	0.01	19.78
2.2115	18.50	46.00	-27.50	Phase 1	9k	0.01	19.87
2.407	18.61	46.00	-27.39	Neutral	9k	0.01	19.91
20.491	29.07	50.00	-20.93	Phase 1	9k	0.01	20.09
21.088	30.89	50.00	-19.11	Phase 1	9k	0.01	20.10

Test Personnel:	Kouma Sinn KPS	Test Date:	04/20/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart B, ISED ICES-003	Limit Applied:	All Class B
Input Voltage:	USB Powered		
		Ambient Temperature:	24 ºC
Pretest Verification w/ Signal generator:	**Yes**	Relative Humidity:	21 %
		Atmospheric Pressure:	1011 mbars

Deviations, Additions, or Exclusions: None

13 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	06/02/2022	105001833BOX-006	KPS	VFV	Original Issue