



TEST REPORT

Test Report No. : UL-RPT-RP-13795303-116-FCC

Applicant : NBB Controls + Components GmbH
Model No. : TM2400A
FCC ID : SJ7TM2400A
Technology : ZigBee (IEEE 802.15.4)
Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.247

For details of applied tests refer to test result summary

1. This test report shall not be reproduced in full or partial, without the written approval of UL International Germany GmbH.
2. The results in this report apply only to the sample tested.
3. The test results in this report are traceable to the national or international standards.
4. **Test Report Version 1.2 supersede Version 1.1 with immediate effect**
Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.2, Issue Date 03 MARCH 2022 replaces
Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.1, Issue Date 25 FEBRUARY 2022, which is no longer valid.
5. Result of the tested sample: **PASS**

Prepared by: Muhammad Faiq, Khan
Title: Laboratory Engineer
Date: 03 March 2022

Approved by: Ajit, Phadtare
Title: Lead Test Engineer
Date: 03 March 2022



Deutsche
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This laboratory is accredited by DAkkS.
The tests reported herein have been performed in
accordance with its' terms of accreditation.

UL INTERNATIONAL GERMANY GMBH

Hedelfinger Str. 61
70327 Stuttgart, Germany
STU.CTECHLab@ul.com

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Table of Contents

1. Customer Information.....	4
1.1. Applicant Information	4
1.2. Manufacturer Information	4
2. Summary of Testing.....	5
2.1. General Information	5
Applied Standards	5
Location	5
Date information	5
2.2. Summary of Test Results	6
2.3. Methods and Procedures	6
2.4. Deviations from the Test Specification	6
3. Equipment Under Test (EUT)	7
3.1. Identification of Equipment Under Test (EUT)	7
3.2. Description of EUT	7
3.3. Modifications Incorporated in the EUT	7
3.4. Additional Information Related to Testing	8
3.5. Support Equipment	9
A. Support Equipment (In-house)	9
B. Support Equipment (Manufacturer supplied)	9
4. Operation and Monitoring of the EUT during Testing	10
4.1. Operating Modes	10
4.2. Configuration and Peripherals	10
5. Measurements, Examinations and Derived Results	12
5.1. General Comments	12
5.2. Test Results	13
5.2.1. Transmitter AC Conducted Spurious Emissions	13
5.2.2. Transmitter Maximum (Peak) Output Power	23
5.2.3. Transmitter Duty Cycle	28
5.2.4. Transmitter Minimum 6 dB Bandwidth	30
5.2.5. Transmitter Power Spectral Density	32
5.2.6. Transmitter Radiated Emissions	34
5.2.7. Transmitter Band Edge Radiated Emissions	51
6. Measurement Uncertainty	57
7. Used equipment	58
8. Report Revision History	59

1. Customer Information

1.1.Applicant Information

Company Name:	NBB Controls + Components GmbH
Company Address:	Otto-Hahn-Straße 3-5, 75248 Ölbronn-Dürrn, GERMANY
Company Phone No.:	+49 7237 9990
Company E-Mail:	info@nbb.de
Contact Person:	Mr. Alex Gorynin
Contact E-Mail Address:	Alex.Gorynin@nbb.de
Contact Phone No.:	+49 7237 999537

1.2.Manufacturer Information

Company Name:	NBB Controls + Components GmbH
Company Address:	Otto-Hahn-Straße 3-5, 75248 Ölbronn-Dürrn, GERMANY
Company Phone No.:	+49 7237 9990
Company E-Mail:	info@nbb.de
Contact Person:	Mr. Alex Gorynin
Contact E-Mail Address:	Alex.Gorynin@nbb.de
Contact Phone No.:	+49 7237 999537

2. Summary of Testing

2.1. General Information

Specification Reference:	47CFR15.247
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247
Specification Reference:	47CFR15.207 and 47CFR15.209
Specification Title:	Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209

Applied Standards

Location

Location of Testing:	UL International Germany GmbH Hedelfinger Str. 61 70327 Stuttgart Germany
Test Firm Registration:	399704

Date information

Order Date:	21 April 2021
EUT arrived:	08 June 2021
Test Dates:	11 November 2021 to 23 February 2022
EUT returned:	-/-

2.2. Summary of Test Results

Clause	Measurement	Complied	Did not comply	Not performed	Not applicable
Part 15.207	Transmitter AC Conducted Emissions	☒	☐	☐	☐
Part 15.247(a)(2)	Transmitter Minimum 6 dB Bandwidth	☒	☐	☐	☐
Part 15.35(c)	Transmitter Duty Cycle ⁽¹⁾	☒	☐	☐	☐
Part 15.247(e)	Transmitter Power Spectral Density	☒	☐	☐	☐
Part 15.247(b)(3)	Transmitter Maximum (Peak) Output Power	☒	☐	☐	☐
Part 15.247(d) & 15.209(a)	Transmitter Radiated Emissions	☒	☐	☐	☐
Part 15.247(d) & 15.209(a)	Transmitter Band Edge Radiated Emissions	☒	☐	☐	☐

Note(s):

1. The measurement was performed to assist in the calculation of the average measurements.

2.3. Methods and Procedures

Reference:	ANSI C63.10-2013
Title:	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Reference:	KDB 558074 D01 DTS Meas Guidance v05r02 April 2, 2019
Title:	Guidance for compliance measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 of the FCC rules
Reference:	FCC KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
Title:	AC Power-Line Conducted Emissions Frequently Asked Questions

2.4. Deviations from the Test Specification

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

3. Equipment Under Test (EUT)

3.1. Identification of Equipment Under Test (EUT)

Brand Name:	NBB
Model Name or Number:	TM2400A
Serial Number:	1116050024 (RF Sample with U.FL Connector)
Hardware Version:	2.100.1584_V011
Software Version:	FWTM2400A

3.2. Description of EUT

The equipment under test was a radio module Model No. TM2400A supporting ZigBee (IEEE 802.15.4) operations in 2.4 - 2.4835 GHz ISM band.

3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

3.4. Additional Information Related to Testing

Technology Tested:	ZigBee (IEEE 802.15.4) / (Digital Transmission System)		
Type of Unit:	Transceiver		
Channel Spacing:	5 MHz		
Modulation:	O-QPSK		
Data Rate:	250 Kbit/s		
Power Supply Requirement(s): (rated input supply voltage & upper & lower limit of the particular fluctuation range as specified in the construction design)	V _{nom}	5.0 V DC	
	V _{min}	3.5 V DC	
	V _{max}	5.5 V DC	
Declared Conducted Output Power: (Note 1)	12.0 dBm		
Number of Antenna Port(s): (Note 1)	2 (Port X11 & Port X14)		
Number of Antenna Type(s): (Note 1)	2 (Refer below details of Antenna 1 & Antenna 2)		
Antenna 1 Gain: (Note 1)	3.7 dBi (Max. Peak Gain) @ 2.4 GHz		
Antenna 1 Type: (Note 1)	2.4GHz SMD MID Chip Antenna		
Antenna 1 Connector: (Note 1)	U.FL (female socket)		
Antenna 1 Details: (Note 1)	Part No.: 0479480001 Molex		
Antenna 2 Gain: (Note 1)	3.2 dBi (Max. Peak Gain) @ 2.4 GHz		
Antenna 2 Type: (Note 1)	2.4 GHz Connectorized Dipole Antenna (Rod)		
Antenna 2 Connector: (Note 1)	RP-SMA Connector (female socket)		
Antenna 2 Details: (Note 1)	Part No. ANT-2.4-CW-HW-T Linx Technologies		
Transceiver Frequency Range:	2415 MHz to 2475 MHz		
Transceiver Channels Tested:	Channel ID	RF Channel Number	Channel Frequency (MHz)
	Bottom	13	2415
	Middle	18	2440
	Top	25	2475
(Note 1) As per the applicant's declaration & supplied document 'Description Radio Module TM2400A' the RF output signal is fed to Rf switcher in front of the antenna connections. This Rf switcher is part of the EUT and has two RF ports (type : U.FL) for antenna connections. The intended use of these port is as follows : Port X 11 : the antenna connection, which is intended for antenna diversity reception purposes. Port X14 : the antenna connection, which is intended for antenna diversity reception purposes.			
(Note 2) As per the applicant's declaration the Channel numbers 11, 12 and 26 will not be implemented in operation of the device. Therefore, the compliance testing have been performed with Channel 13 as the Bottom channel and Channel 25 as the Top channel.			

3.5. Support Equipment

The following support equipment was used to exercise the EUT during testing:

A. Support Equipment (In-house)

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Laboratory DC Power Supply	Elektro - Automatik	PS 2342-10 B	2814040002
2	Laboratory DC Power Supply	Good Will Instrument	GPC-1850D	7662217

B. Support Equipment (Manufacturer supplied)

Item	Description	Brand Name	Model Name or Number	Serial Number
1	Test Evaluation Board Housing	NBB	2.250.1655	N/A
2	Test Evaluation Board	NBB	2.101.1426	N/A
3	Battery Pack (7.2 V DC)	NBB	2.260.1022	N/A

4. Operation and Monitoring of the EUT during Testing

4.1. Operating Modes

The EUT was tested in the following operating mode(s):

- Continuous Transmissions Mode with Modulated Carrier
- Output Power Settings: 12.0 dBm (Declared Conducted Output Power)

4.2. Configuration and Peripherals

The EUT was tested in the following configuration(s):

- In accordance with FCC rule section(s) 15.212(a)(1)(v), the EUT being a modular transmitter was tested in a stand-alone configuration.
 - The EUT was not placed inside another device during testing for compliance requirements.
 - The EUT was mounted on Test Evaluation Board (a stand-alone PCB) with voltage supply & RF control settings connections made directly to the module.
 - The length of power voltage supply lines was at least 10 centimeters to insure that there is no coupling between the case of the EUT and Test Evaluation Board.

EUT Power Supply:

- The EUT was powered with a 5 V DC via this Test Evaluation Board which in turn was powered via Battery Pack (7.2 V DC) enclosed in the Test Evaluation Board Housing supplied by customer.

Test Mode Activation:

- The EUT transmitter power was configured to minimum possible power settings +12 dBm using X16 8-bit Dip Switch. The configurations used for actual testing are highlighted in below summary.

Model: TM2400A									
X16 Dip Switch Bit Configurations									TX Output Power Details
	1	2	3	4	5	6	7	8	
	0	0	0						Power Settings: +4dBm (Min.)
	0	0	1						
	0	1	0						
	0	1	1						
	1	0	0						
	1	0	1						Power Settings: +12 dBm
	1	1	0						
	1	1	1						Power Settings: +19 dBm (Max.)

- The EUT was configured into required ZigBee TX test modes using X12 8-bit Dip Switch configurations supplied by customer. The configurations used for actual testing are highlighted in below summary.

Model: TM2400A									
X12 Dip Switch Bit Configurations								Test Mode Details	
1	2	3	4	5	6	7	8		
0	0							5 ms Normal Mode	
0	1							43 ms Normal Mode	
1	0							Continuous Modulated Signal	
1	1							Continuous Unmodulated Signal	
		0						Transmit Mode	
		1						Receive Mode / RESET	
			0					Port X14	
			1					Port X11	
								Test Channel	Frequency (MHz)
				0	0	0	0	11	2405
				0	0	0	1	12	2410
				0	0	1	0	13	2415
				0	0	1	1	14	2420
				0	1	0	0	15	2425
				0	1	0	1	16	2430
				0	1	1	0	17	2435
				0	1	1	1	18	2440
				1	0	0	0	19	2445
				1	0	0	1	20	2450
				1	0	1	0	21	2455
				1	0	1	1	22	2460
				1	1	0	0	23	2465
				1	1	0	1	24	2470
				1	1	1	0	25	2475
				1	1	1	1	26	2480

- The EUT has two RF ports X11 and X14 respectively. During the measurement on one port the other unused port was terminated with a 50 Ω termination.
- As the EUT continuous transmission of the EUT ($D \geq 98\%$) can be achieved and EUT was transmitting continuously with a constant Duty Cycle of 100 % (duty cycle variations are less than $\pm 2\%$). Therefore, a Duty Cycle Correction Factor isn't applicable to the measured average values of the emissions.

AC Conducted Emissions Measurements:

- The EUT RF sample with U.FL connector was used for AC conducted emissions measurements.
- For AC conducted line emissions measurement the EUT was powered via AC/DC power supply. The measurements were carried out with 120 VAC / 60 Hz & 240 VAC / 60 Hz.
- The Toyo EMI Software EP5/CE Ver 4.0.1. was used for these measurements.

Conducted Measurements:

- All conducted measurements were carried out by using the EUT RF sample with U.FL connector and U.FL to SMA (Female) RF Cable supplied by the customer. The SMA RF cable's attenuation (maximum 0.5 dB@2.4GHz) was added to as a reference level offset to each of the conducted plots.

Radiated Measurements:

- All radiated measurements were carried out by using the EUT RF sample with U.FL connector.
- All the radiated test were performed with listed antenna types connected to Port X14 as it was found to be the worst-case port with respect to output power.
- During the radiated measurements the other unused port Port X14 was terminated with a 50 Ω termination.
- Before starting final radiated spurious emission measurements "worst case verification" with the EUT + Antenna in Standing &/ Laying-position was performed by Lab.
- Following combinations of positions found to be the worst case that tend to produce maximum emissions
 - EUT + SMD Antenna : EUT in Laying Position & Antenna in Laying Position (i.e. 0° to the EUT)
 - EUT + Rod Antenna : EUT in Laying Position & Antenna in Standing Position (i.e. 90° to the EUT)
- Therefore, this report includes relevant test results.
- The radiated measurements below 30 MHz were performed with the EUT positioned on the turn table and rotating 360 degrees while the loop antenna height was set to 80 cm.
- The radiated measurements above 30 MHz were performed with the EUT positioned on the turn table and rotating 360 degrees while the antenna height varies from 1 to 4 m over the measurement frequency range.
- R&S® EMC32 V10.60.10 Software was used for the Radiated spurious emission measurements.

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to Section 6 *Measurement Uncertainty* for details.

In accordance with DAkkS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

5.2. Test Results

5.2.1. Transmitter AC Conducted Spurious Emissions

Test Summary:

Test Engineer:	Muhammad Faiq Khan	Test Date:	23 February 2022
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 7/8		

FCC Reference:	Part 15.207
Test Method Used:	ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below

Environmental Conditions:

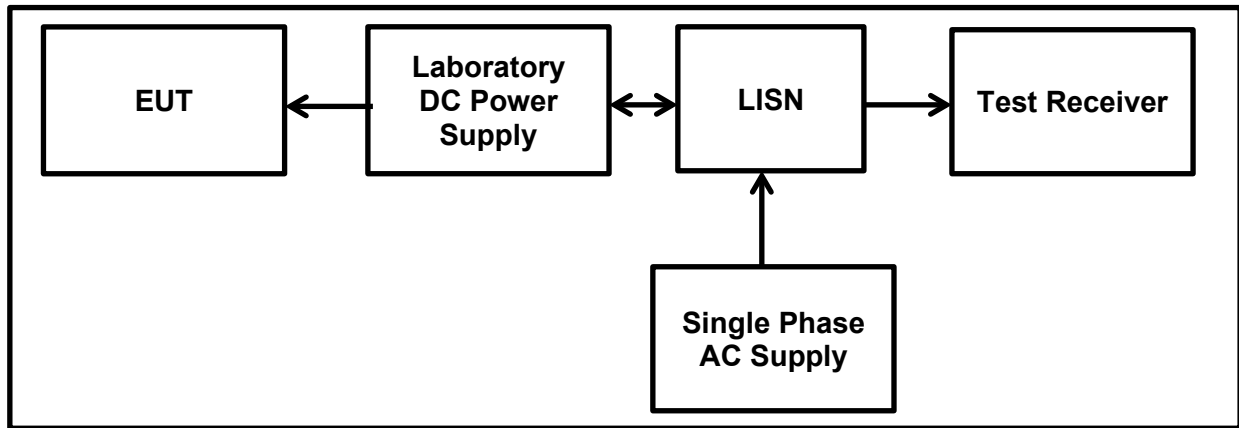
Temperature (°C):	23.6
Relative Humidity (%):	42.8

Settings of the Instrument

Detector	Quasi Peak/ Average Peak
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Note(s):

1. The EUT RF sample with U.FL connector was used for AC conducted emissions measurements with both the Rod and SMD antennas.
2. In accordance with FCC KDB 174176 Q4, tests were also performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the 100-240 VAC~50/60 Hz power supply.
3. The tests were performed only on port X14 as it was found to be the worst-case port with respect to conducted output power. During the measurements the other unused port X11 was terminated with a 50 Ω termination.
4. The EUT was configured with the following modes:
 - ZigBee | Port X14 | PWR 12 dBm | Channel :Top | Rod Antenna
 - ZigBee | Port X14 | PWR 12 dBm | Channel :Top | SMD Antenna
5. Pre-scans were performed, and markers placed on the highest live and neutral measured levels. Final measurements were performed on the marker frequencies and the results entered into the tables below.
6. The final measured value, for the given emission, in the table below incorporates the cable loss.
7. All other emissions shown on the pre-scan plot were investigated. Only the highest 6 emissions have been reported in the tables below in accordance with ANSI C63.10 section 6.2.5.
8. Measurements were performed in shielded room (SR7/ 8 Asset Number 1603671). The EUT was placed at a height of 80 cm above the reference ground plane and in a distance of 40 cm from the vertical ground plane at the edge of the table.
9. Measurement software used: Toyo EMI Software; CE measurement software EP5/CE Ver 4.0.1.

Transmitter AC Conducted Spurious Emissions (continued)**Test Setup:**

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / Rod Antenna****Results: Live / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1783	Live	16.60	64.60	48.00	Complied
0.2721	Live	15.10	61.10	46.00	Complied
0.4855	Live	7.90	56.20	48.30	Complied
0.9039	Live	6.70	56.00	49.30	Complied
1.7548	Live	6.60	56.00	49.40	Complied
23.6035	Live	19.90	60.00	40.10	Complied

Results: Live / Average / 120 VAC 60 Hz

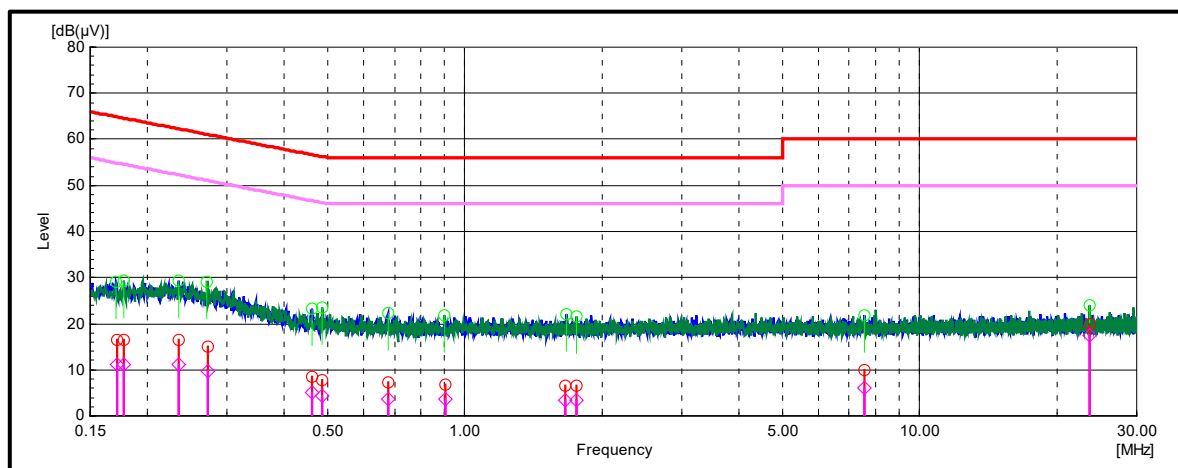
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1783	Live	11.20	54.60	43.40	Complied
0.2721	Live	9.80	51.10	41.30	Complied
0.4855	Live	4.30	46.20	41.90	Complied
0.9039	Live	3.50	46.00	42.50	Complied
1.7548	Live	3.40	46.00	42.60	Complied
23.6035	Live	17.50	50.00	32.50	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1719	Live	16.60	64.90	48.30	Complied
0.2343	Live	16.40	62.30	45.90	Complied
0.4622	Live	8.40	56.70	48.30	Complied
0.6780	Live	7.40	56.00	48.60	Complied
1.6667	Live	6.60	56.00	49.40	Complied
7.5530	Live	10.00	60.00	50.00	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / Rod Antenna****Results: Neutral / Average / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.1719	Neutral	11.20	54.90	43.70	Complied
0.2343	Neutral	11.20	52.30	41.10	Complied
0.4622	Neutral	5.20	46.70	41.50	Complied
0.6780	Neutral	3.50	46.00	42.50	Complied
1.6667	Neutral	3.40	46.00	42.60	Complied
7.5530	Neutral	6.00	50.00	44.00	Complied

Result: Pass**Plot: Live and Neutral Line / 120 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / Rod Antenna****Results: Live / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.2132	Live	16.60	63.10	46.50	Complied
0.3025	Live	14.10	60.20	46.10	Complied
0.4031	Live	16.40	57.80	41.40	Complied
0.7058	Live	7.40	56.00	48.60	Complied
6.8951	Live	10.00	60.00	50.00	Complied
23.5992	Live	23.90	60.00	36.10	Complied

Results: Live / Average / 240 VAC 60 Hz

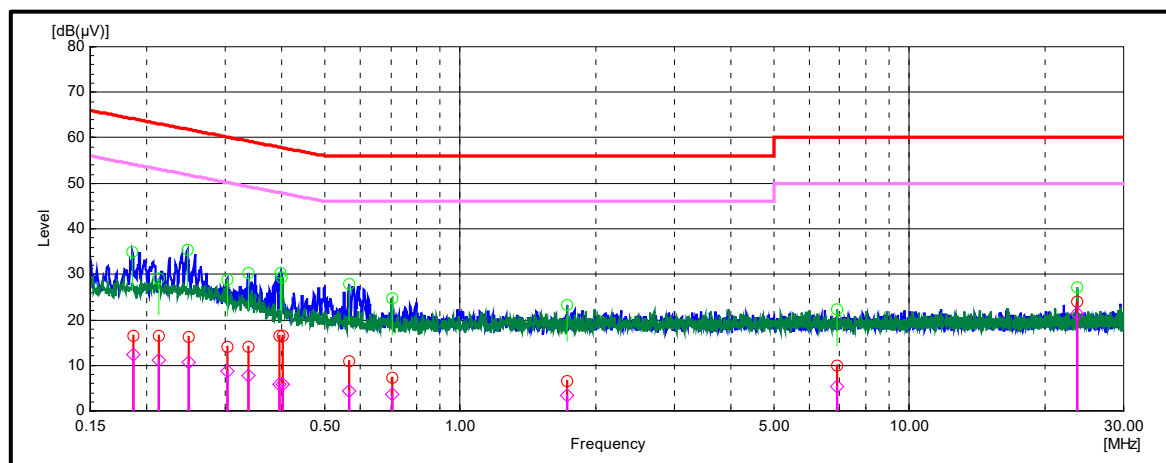
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.2132	Live	11.20	53.10	41.90	Complied
0.3026	Live	8.80	50.20	41.40	Complied
0.4032	Live	5.90	47.80	41.90	Complied
0.7058	Live	3.50	46.00	42.50	Complied
6.8951	Live	5.30	50.00	44.70	Complied
23.5992	Live	21.30	50.00	28.70	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1868	Neutral	16.60	64.20	47.60	Complied
0.2479	Neutral	16.30	61.80	45.50	Complied
0.3376	Neutral	14.10	59.30	45.20	Complied
0.3958	Neutral	16.60	57.90	41.30	Complied
0.5655	Neutral	10.90	56.00	45.10	Complied
1.7300	Neutral	6.60	56.00	49.40	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / Rod Antenna****Results: Neutral / Average / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.1868	Neutral	12.30	54.20	41.90	Complied
0.2479	Neutral	10.70	51.80	41.10	Complied
0.3376	Neutral	7.80	49.30	41.50	Complied
0.3958	Neutral	5.90	47.90	42.00	Complied
0.5655	Neutral	4.40	46.00	41.60	Complied
1.7300	Neutral	3.40	46.00	42.60	Complied

Result: Pass**Plot: Live and Neutral Line / 240 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / SMD Antenna****Results: Live / Quasi Peak / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.1718	Live	16.60	64.90	48.30	Complied
0.2548	Live	16.10	61.60	45.50	Complied
0.4111	Live	9.40	57.60	48.20	Complied
2.8604	Live	7.90	56.00	48.10	Complied
9.7064	Live	8.50	60.00	51.50	Complied
29.4892	Live	17.90	60.00	42.10	Complied

Results: Live / Average / 120 VAC 60 Hz

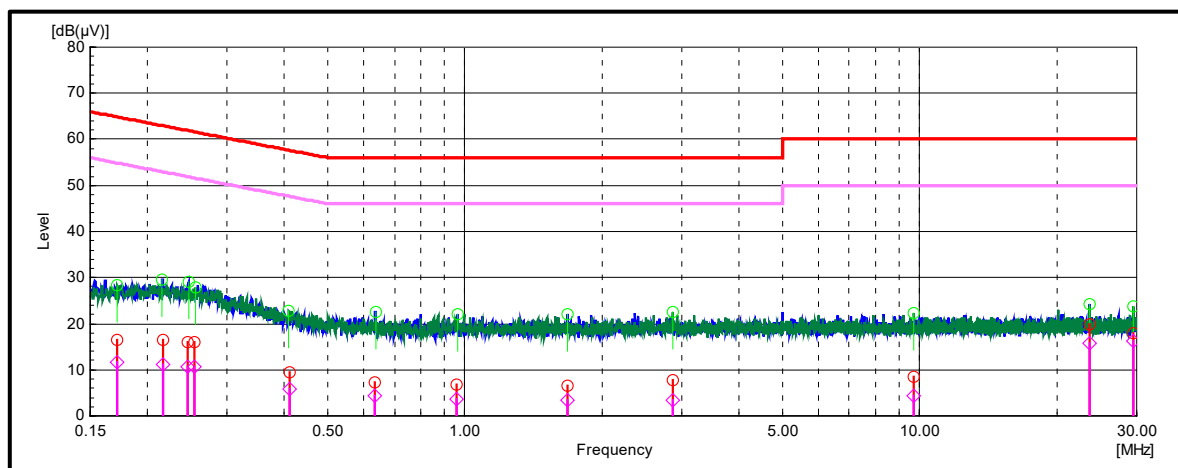
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.1718	Live	11.60	54.90	43.30	Complied
0.2548	Live	10.70	51.60	40.90	Complied
0.4111	Live	5.90	47.60	41.70	Complied
2.8604	Live	3.40	46.00	42.60	Complied
9.7064	Live	4.40	50.00	45.60	Complied
29.4892	Live	16.20	50.00	33.80	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.2172	Live	16.60	62.90	46.30	Complied
0.2463	Live	16.10	61.90	45.80	Complied
0.6352	Live	7.40	56.00	48.60	Complied
0.9573	Live	6.70	56.00	49.30	Complied
1.6819	Live	6.60	56.00	49.40	Complied
23.5936	Live	19.90	60.00	40.10	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / SMD Antenna****Results: Neutral / Average / 120 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.2172	Neutral	11.20	52.90	41.70	Complied
0.2463	Neutral	10.70	51.90	41.20	Complied
0.6352	Neutral	4.40	46.00	41.60	Complied
0.9573	Neutral	3.50	46.00	42.50	Complied
1.6819	Neutral	3.40	46.00	42.60	Complied
23.5936	Neutral	15.80	50.00	34.20	Complied

Result: Pass**Plot: Live and Neutral Line / 120 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / SMD Antenna****Results: Live / Quasi Peak / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1878	Live	16.60	64.10	47.50	Complied
0.4002	Live	16.40	57.90	41.50	Complied
0.4583	Live	15.00	56.70	41.70	Complied
0.7031	Live	8.00	56.00	48.00	Complied
1.8472	Live	6.60	56.00	49.40	Complied
23.5918	Live	24.00	60.00	36.00	Complied

Results: Live / Average / 240 VAC 60 Hz

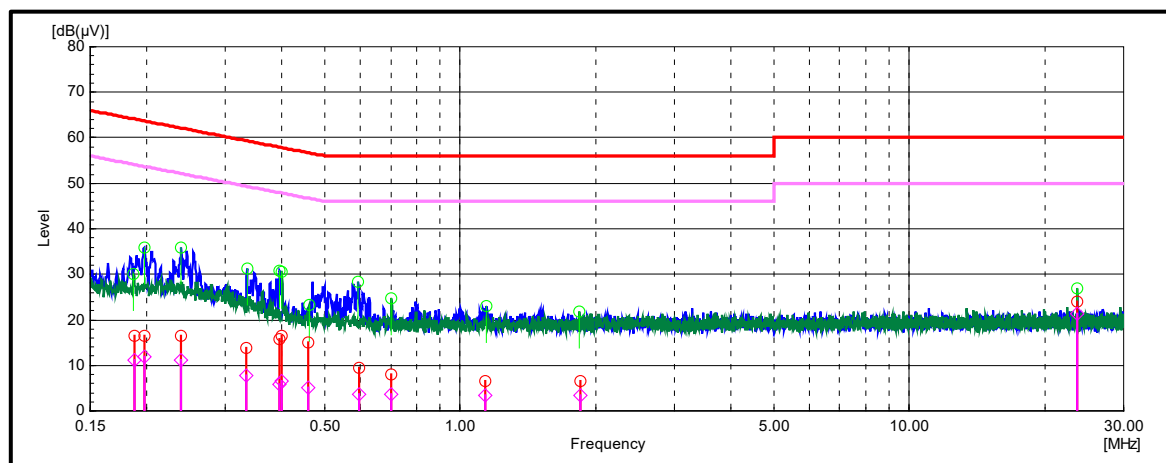
Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1878	Live	11.20	54.10	42.90	Complied
0.4002	Live	6.60	47.90	41.30	Complied
0.4583	Live	5.20	46.70	41.50	Complied
0.7031	Live	3.50	46.00	42.50	Complied
1.8472	Live	3.40	46.00	42.60	Complied
23.5918	Live	21.30	50.00	28.70	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

Frequency (MHz)	Line	Level (dBμV)	Limit (dBμV)	Margin (dB)	Result
0.1981	Neutral	16.60	63.70	47.10	Complied
0.2387	Neutral	16.40	62.10	45.70	Complied
0.3339	Neutral	13.80	59.40	45.60	Complied
0.3968	Neutral	15.70	57.90	42.20	Complied
0.5953	Neutral	9.50	56.00	46.50	Complied
1.1384	Neutral	6.60	56.00	49.40	Complied

Transmitter AC Conducted Spurious Emissions (continued)**Results : ZigBee / Port X14 / PWR 12 dBm / Channel Top / SMD Antenna****Results: Neutral / Average / 240 VAC 60 Hz**

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.1981	Neutral	11.90	53.70	41.80	Complied
0.2387	Neutral	11.20	52.10	40.90	Complied
0.3339	Neutral	7.80	49.40	41.60	Complied
0.3968	Neutral	5.90	47.90	42.00	Complied
0.5953	Neutral	3.50	46.00	42.50	Complied
1.1384	Neutral	3.40	46.00	42.60	Complied

Result: Pass**Plot: Live and Neutral Line / 240 VAC 60 Hz**

Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.

5.2.2. Transmitter Maximum (Peak) Output Power**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	16 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(b)(3)
Test Method Used:	FCC KDB 558074 Section 8.3.1.3 referencing ANSI C63.10 Sections 11.9.1.3

Environmental Conditions:

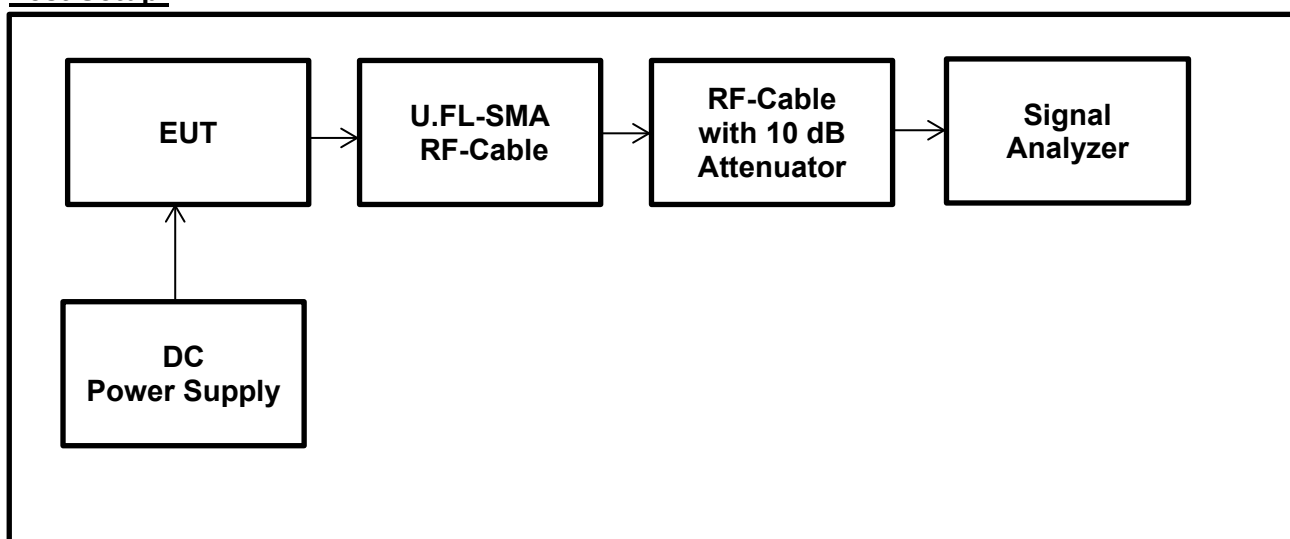
Temperature (°C):	24.3
Relative Humidity (%):	35.3

Notes:

1. The conducted power tests were performed using a spectrum analyser in accordance with FCC KDB 558074 Section 8.3.1.1 with the RBW $\geq$ DTS bandwidth referencing ANSI C63.10 Section 11.9.1.1.
2. The signal analyser resolution bandwidth was set to 3 MHz and video bandwidth of 10 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 10 MHz. A marker was placed at the peak of the signal and the results recorded in the table below.
3. The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values take into consideration the external attenuation correction factors.
 - The U.FL to SMA (Female) RF Cable connected to the EUT's U.FL port with maximum attenuation of 0.5 dB at the tested frequencies.
 - The RF cable from the EUT to Analyzer with maximum attenuation of 0.5 dB at the tested frequencies including the 10 dB attenuator at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.0 dB was added to each of the at the tested frequencies conducted plots.

4. The declared antenna gain was added to conducted power to obtain the EIRP.

Test Setup:

Transmitter Maximum (Peak) Output Power (continued)**Results: ZigBee / Port X11 / PWR 12 dBm**

Channel	Conducted Peak Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	11.58	30.00	18.42	Complied
Middle	11.08	30.00	18.92	Complied
Top	10.36	30.00	19.64	Complied

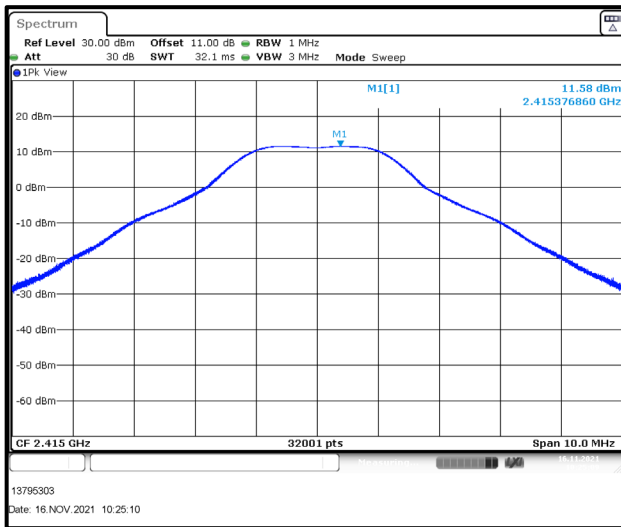
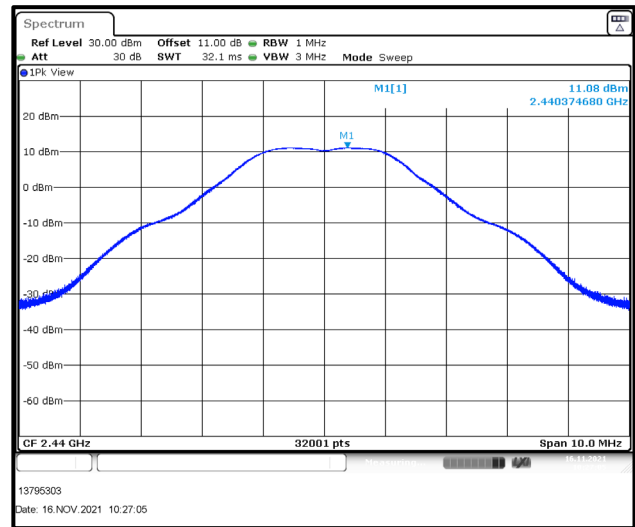
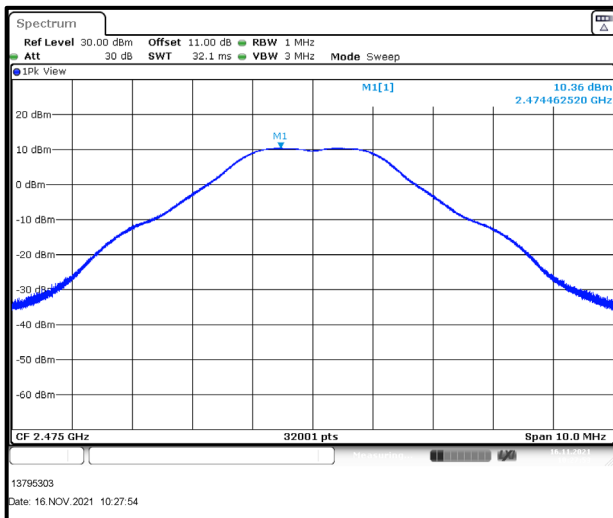
Results: ZigBee / Port X11 / PWR 12 dBm / SMD Antenna

Channel	Conducted Peak Power (dBm)	Declared SMD Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.58	3.70	15.28	36.00	20.72	Complied
Middle	11.08	3.70	14.78	36.00	15.10	Complied
Top	10.36	3.70	14.06	36.00	14.99	Complied

Results: ZigBee / Port X11 / PWR 12 dBm / Rod Antenna

Channel	Conducted Peak Power (dBm)	Declared Rod Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.58	3.20	14.78	36.00	-21.22	Complied
Middle	11.08	3.20	14.28	36.00	-21.72	Complied
Top	10.36	3.20	13.56	36.00	-22.44	Complied

Result: Pass

Transmitter Maximum (Peak) Output Power (continued)**Plots: ZigBee / Port X11 / PWR 12 dBm****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum (Peak) Output Power (continued)**Results: ZigBee / Port X14 / PWR 12 dBm**

Channel	Conducted Peak Power (dBm)	Conducted Power Limit (dBm)	Margin (dB)	Result
Bottom	11.62	30.00	18.38	Complied
Middle	11.21	30.00	18.79	Complied
Top	10.66	30.00	19.34	Complied

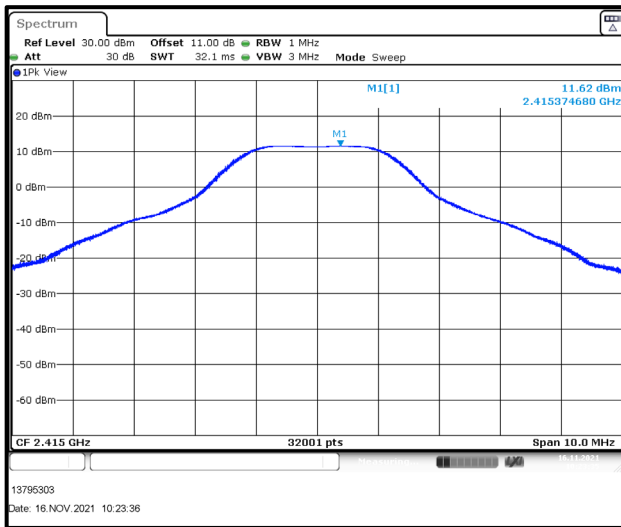
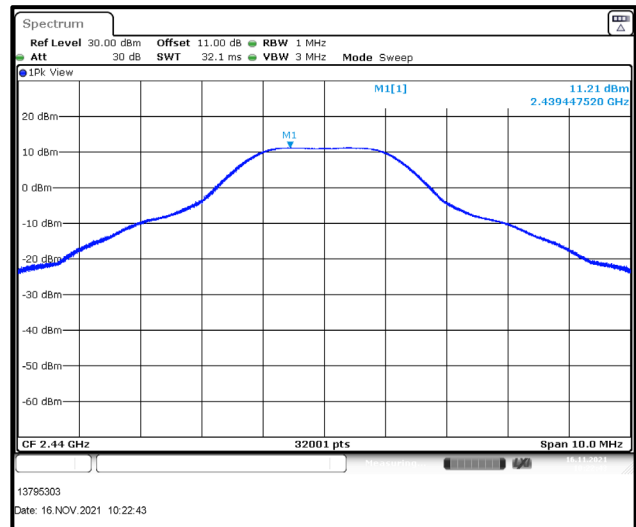
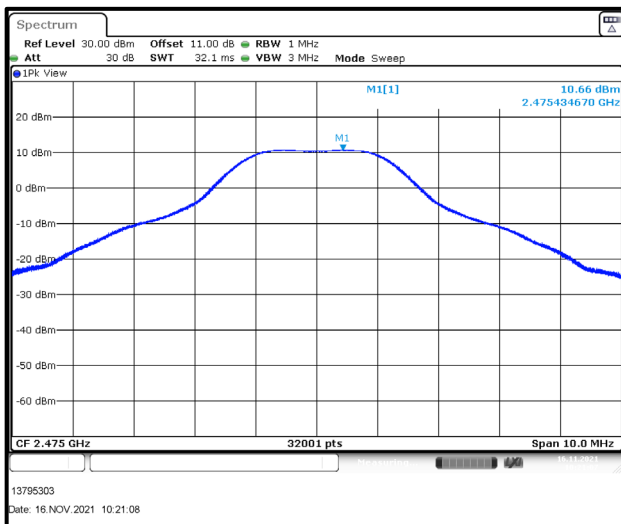
Results: ZigBee / Port X14 / PWR 12 dBm / SMD Antenna

Channel	Conducted Peak Power (dBm)	Declared SMD Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.62	3.70	15.32	36.00	20.68	Complied
Middle	11.21	3.70	14.91	36.00	15.10	Complied
Top	10.66	3.70	14.36	36.00	14.99	Complied

Results: ZigBee / Port X14 / PWR 12 dBm / Rod Antenna

Channel	Conducted Peak Power (dBm)	Declared Rod Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)	Result
Bottom	11.62	3.20	14.82	36.00	-21.18	Complied
Middle	11.21	3.20	14.41	36.00	-21.59	Complied
Top	10.66	3.20	13.86	36.00	-22.14	Complied

Result: Pass

Transmitter Maximum (Peak) Output Power (continued)**Plots: ZigBee / Port X14 / PWR 12 dBm****Bottom Channel****Middle Channel****Top Channel**

5.2.3. Transmitter Duty Cycle**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	22 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.35(c)
Test Method Used:	FCC KDB 558074 Section 6.0 referencing ANSI C63.10 Section 11.6

Environmental Conditions:

Temperature (°C):	25.7
Relative Humidity (%):	36.9

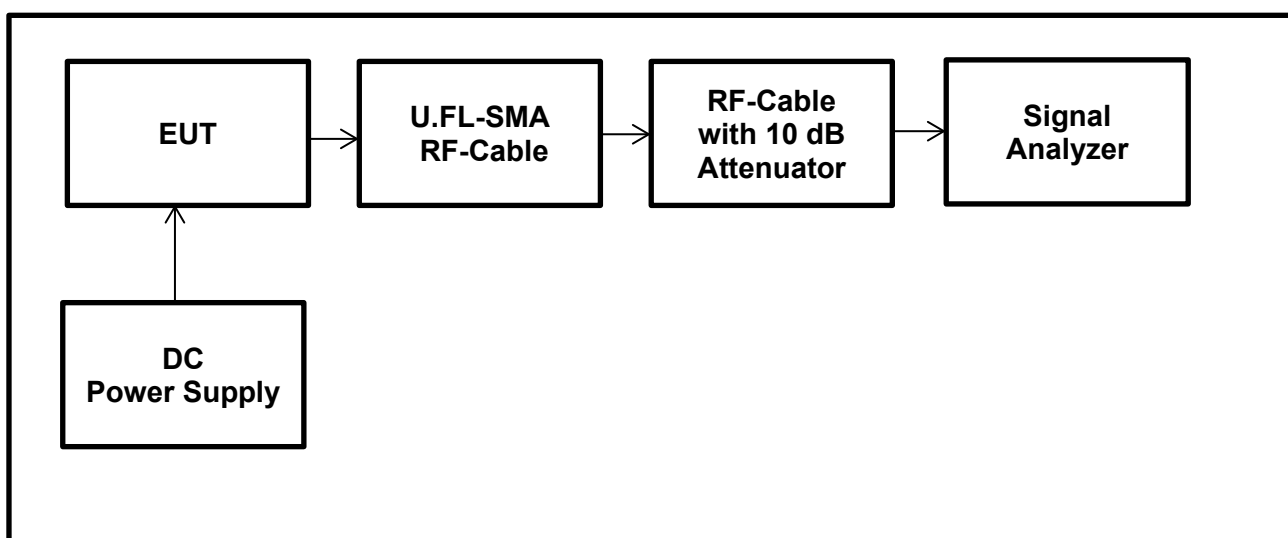
Notes:

- The transmitter duty cycle was measured using a spectrum analyser in the time domain and calculated by using the following calculation:

$$\text{Duty Cycle (\%)} = 100 \times [\text{On Time } (T_{ON})] / [\text{Period}(T_{ON} + T_{OFF}) \text{ or } 100\text{ms whichever is the lesser}]$$

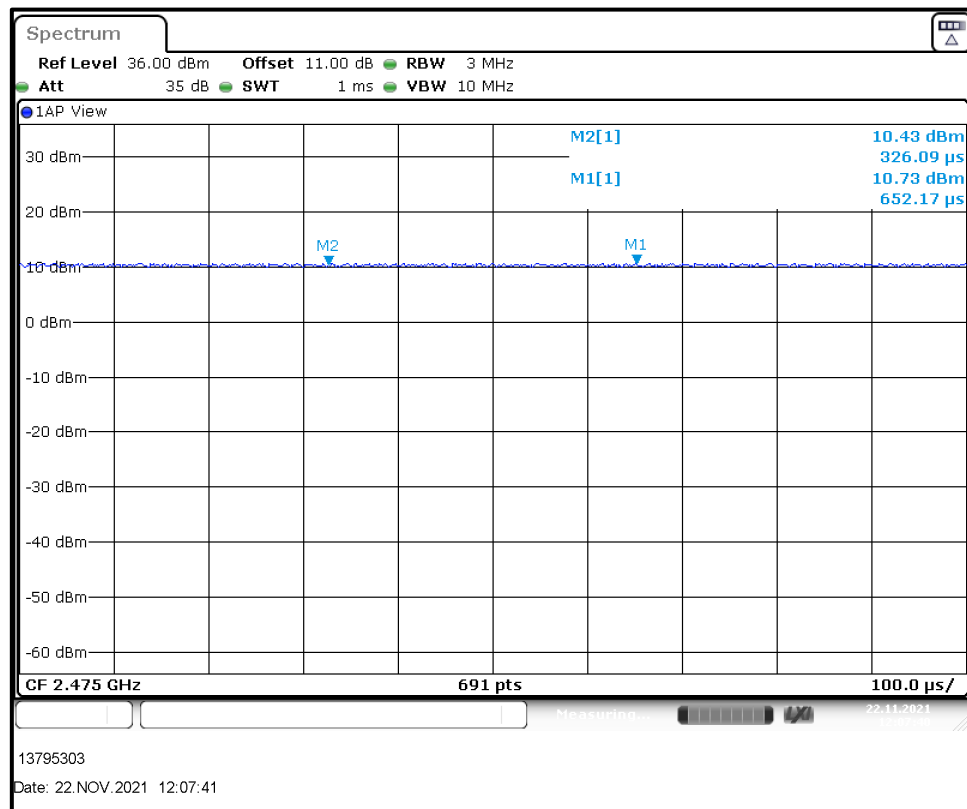
$$\text{Duty Cycle Correction Factor} = 10 \log 1 / [\text{On Time } (T_{ON})] / [\text{Period}(T_{ON} + T_{OFF}) \text{ or } 100\text{ms whichever is the lesser}]$$
- The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values take into consideration the external attenuation correction factors.
 - The U.FL to SMA (Female) RF Cable connected to the EUT's U.FL port with maximum attenuation of 0.5 dB at the tested frequencies.
 - The RF cable from the EUT to Analyzer with maximum attenuation of 0.5 dB at the tested frequencies including the 10 dB attenuator at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.0 dB was added to each of the at the tested frequencies conducted plots.

Test Setup:

Transmitter Duty Cycle (continued)**Results: ZigBee / Port X11 / PWR 12 dBm / Channel Top**

Pulse On Time (T _{ON}) (ms)	Pulse Period (T _{ON} + T _{OFF}) (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
--	--	> 98	0.00

**Result: Pass**

5.2.4. Transmitter Minimum 6 dB Bandwidth**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	22 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(a)(2)
Test Method Used:	FCC KDB 558074 Section 8.2 referencing ANSI C63.10:2013 Section 11.8.1 Option 1

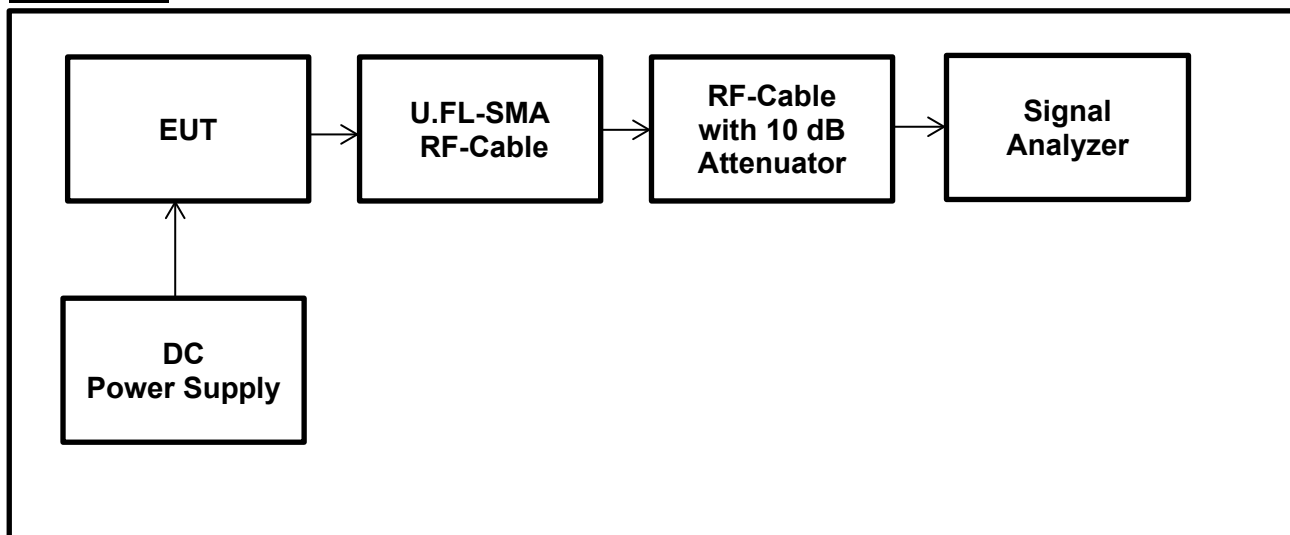
Environmental Conditions:

Temperature (°C):	25.7
Relative Humidity (%):	36.9

Notes:

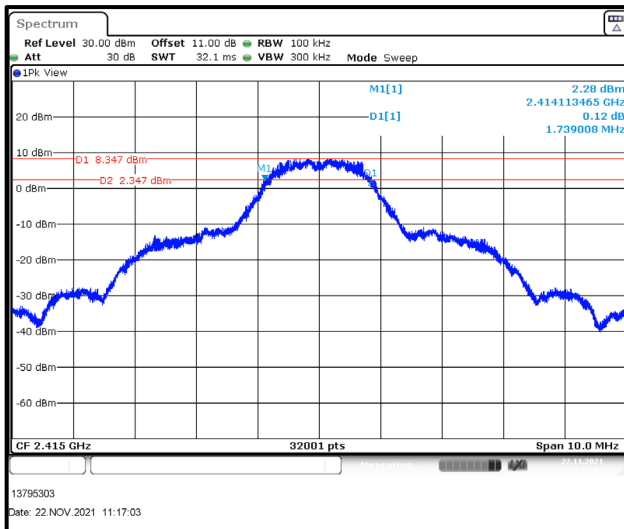
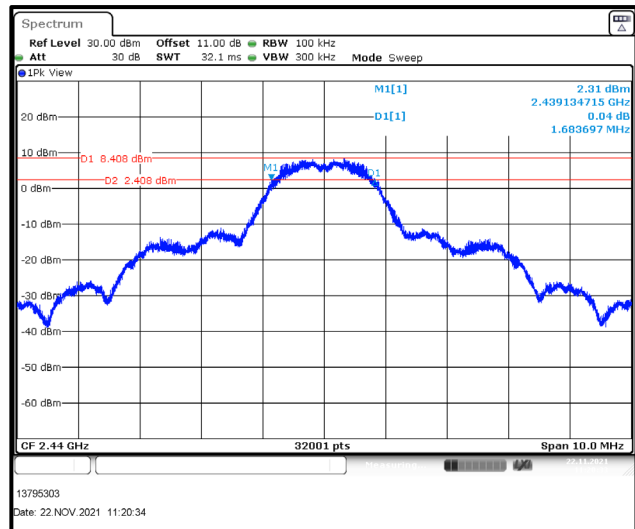
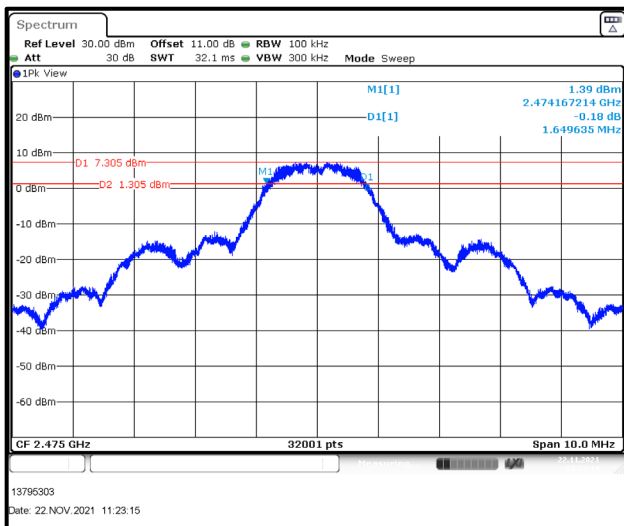
1. The measurements were performed using the above configurations on the bottom, middle and top channels in accordance FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8 (11.8.1 Option 1 measurement procedure).
2. The spectrum analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
3. The test was performed only on port X14 as it was found to be the worst-case port with respect to conducted output power. During the measurements the other unused port X11 was terminated with a 50 Ω termination.
4. The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values take into consideration the external attenuation correction factors.
 - The U.FL to SMA (Female) RF Cable connected to the EUT's U.FL port with maximum attenuation of 0.5 dB at the tested frequencies.
 - The RF cable from the EUT to Analyzer with maximum attenuation of 0.5 dB at the tested frequencies including the 10 dB attenuator at the input of Spectrum Analyzer

Therefore, total a reference level offset 11.0 dB was added to each of the at the tested frequencies conducted plots.

Test Setup:

Transmitter Minimum 6 dB Bandwidth (continued)**Results: ZigBee / Port X14 / PWR 12 dBm**

Channel	6 dB Bandwidth (kHz)	Limit (kHz)	Margin (kHz)	Result
Bottom	1739.008	≥ 500	1239.008	Complied
Middle	1683.697	≥ 500	1183.697	Complied
Top	9561.260	≥ 500	9061.260	Complied

**Bottom Channel****Middle Channel****Top Channel****Result: Pass**

5.2.5. Transmitter Power Spectral Density**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	22 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 9		

FCC Reference:	Part 15.247(e)
Test Method Used:	FCC KDB 558074 Section 8.4 referencing ANSI C63.10 Sections 11.10.2

Environmental Conditions:

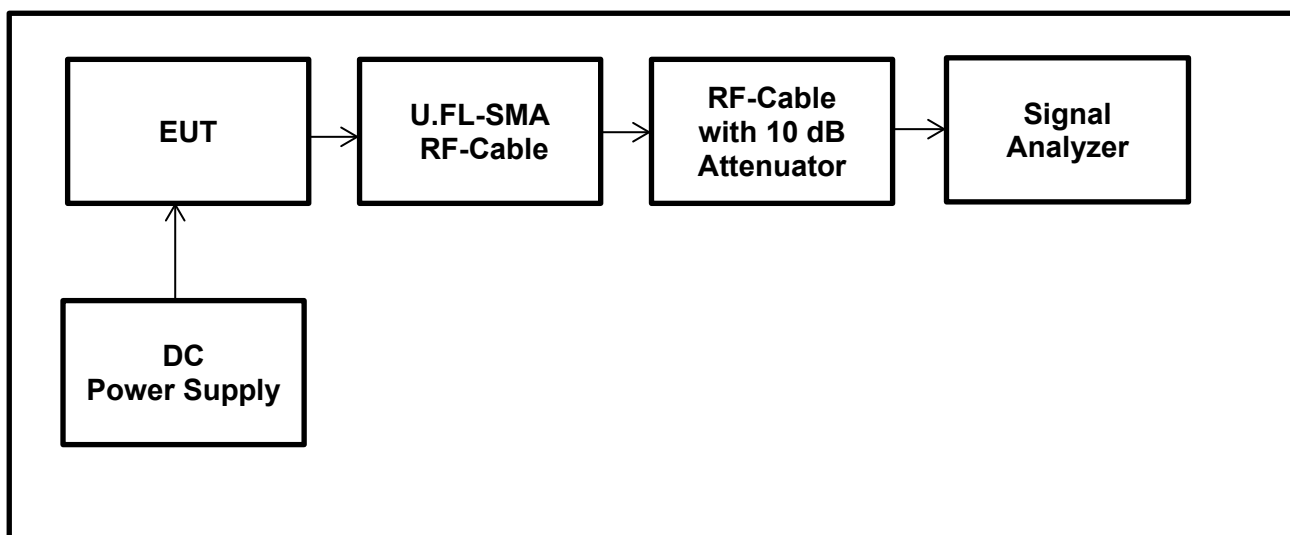
Temperature (°C):	25.7
Relative Humidity (%):	36.9

Notes:

- Final measurements were performed using the below configurations on the bottom, middle and top channels.
- The test was performed only on port X14 as it was found to be the worst-case port with respect to conducted output power. During the measurements the other unused port X11 was terminated with a 50 Ω termination.
- The RF port on the EUT was connected to the spectrum analyser using suitable attenuation and RF cable. The measured values take into consideration the external attenuation correction factors.
 - The U.FL to SMA (Female) RF Cable connected to the EUT's U.FL port with maximum attenuation of 0.5 dB at the tested frequencies.
 - The RF cable from the EUT to Analyzer with maximum attenuation of 0.5 dB at the tested frequencies including the 10 dB attenuator at the input of Spectrum Analyzer

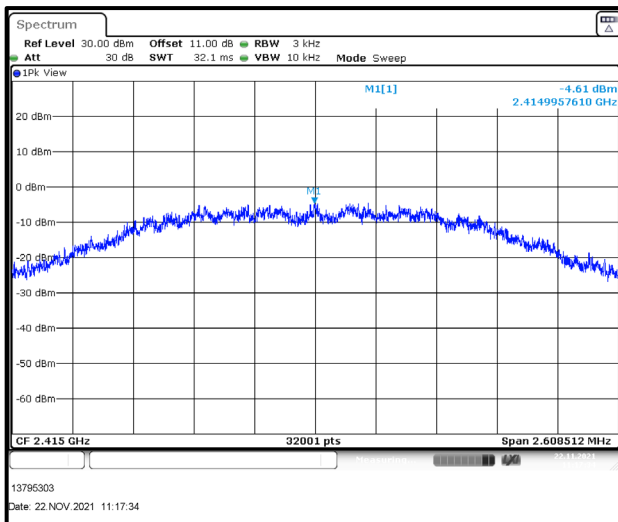
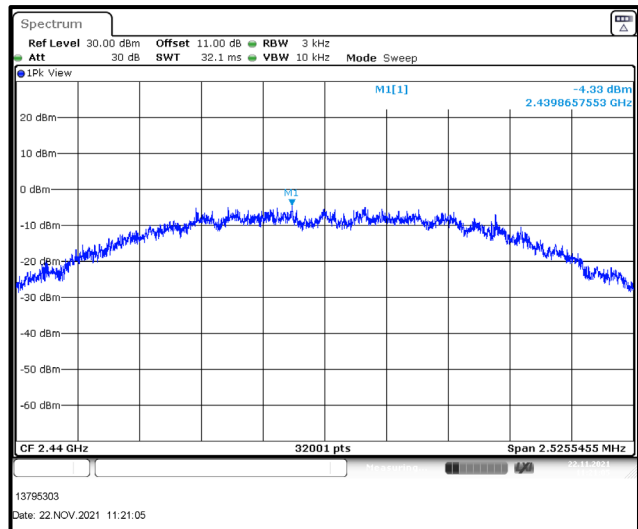
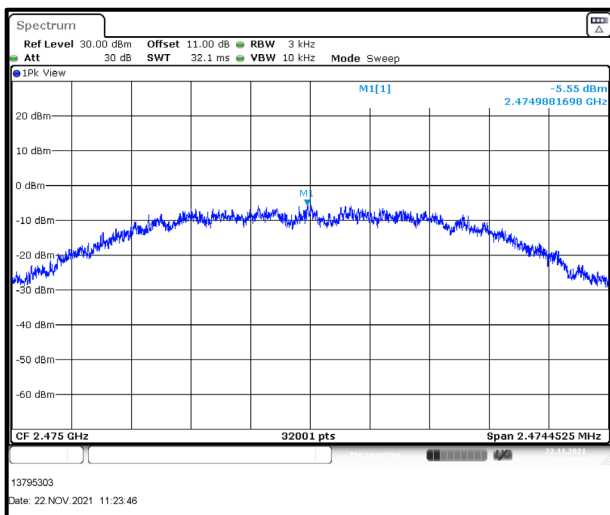
Therefore, total a reference level offset 11.0 dB was added to each of the at the tested frequencies conducted plots.

- The signal analyser resolution bandwidth was set to 3 kHz and video bandwidth 10 kHz. A Peak detector was used and sweep time was set to Auto. The span was set to 1.5 times the DTS bandwidth. The highest peak of the measured signal was recorded..

Test Setup:

Transmitter Power Spectral Density (continued)**Results: ZigBee / Port X14 / PWR 12 dBm**

Channel	Output Power (dBm/3 kHz)	Limit (dBm/3 kHz)	Margin (dB)	Result
Bottom	-4.61	8.00	12.61	Complied
Middle	-4.33	8.00	12.33	Complied
Top	-5.55	8.00	13.55	Complied

**Bottom Channel****Middle Channel****Top Channel****Result: Pass**

5.2.6. Transmitter Radiated Emissions**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	16 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.4
Frequency Range	9 kHz to 30 MHz

Environmental Conditions:

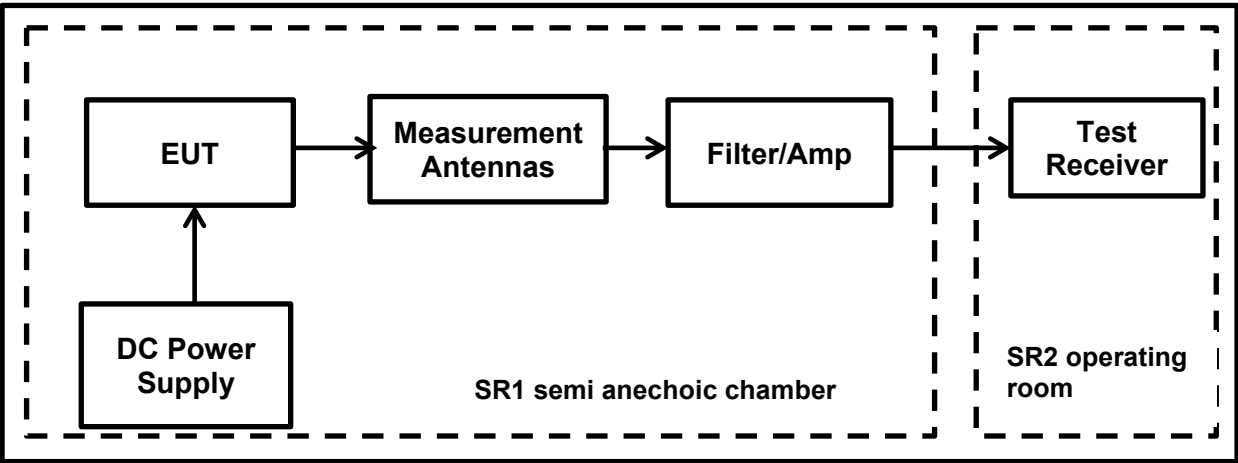
Temperature (°C):	23.1
Relative Humidity (%):	34.6

Note(s):

- In accordance with FCC KDB 414788 D01 Radiated Test Site & ANSI C63.10 clause 5.2 an alternative test site that can demonstrate equivalence to a open area test site may be used. Therefore, the measurement was performed in a Semi Anechoic Chamber. (The OATS / SAC comparison data is available upon request).
- The limits are specified at a test distances of 30 and 300 metres. However, as specified in FCC Section 15.31 (f)(2) & ANSI C63.10 clause 6.4.3, measurements may be performed at a closer distance and the measured level extrapolated to the specified measurement distance using the method described in clauses 6.4.4, specifically sub-clause 6.4.4.1 which specifies that the measured level shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade.
Therefore, measurements were performed at a measurement distance of 3 m.
- Therefore, the limit values are extrapolated to a measurement distance of 3 m.
 - 9 kHz- 490 kHz: limits extrapolated from 300 m to 3 m by adding 80 dB at 40 dB /decade.
 - 490 kHz-1705 kHz: limits extrapolated from 30 m to 3 m by adding 40 dB at 40 dB /decade.
- The preliminary scans showed similar emission levels below 30 MHz, for each channel & modes of operation. Therefore final radiated emissions measurements were performed with the EUT set to the top channel only.
- Measurements below 30 MHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. The measurement loop antenna height was 80 cm.
- All emissions shown on the pre-scan plots were investigated and found to be below system noise floor.
- Pre-scans were performed and markers placed on the highest measured levels. The test receiver was set to:
 - Frequency range: 9 kHz-150 kHz : RBW: 1 kHz /VBW: 3 kHz
 - Frequency range: 150 kHz – 30 MHz: RBW: 10 kHz /VBW: 30 kHz
 - Detector: Max-Peak detector
 - Trace Mode: Max Hold

Transmitter Radiated Emissions (continued)

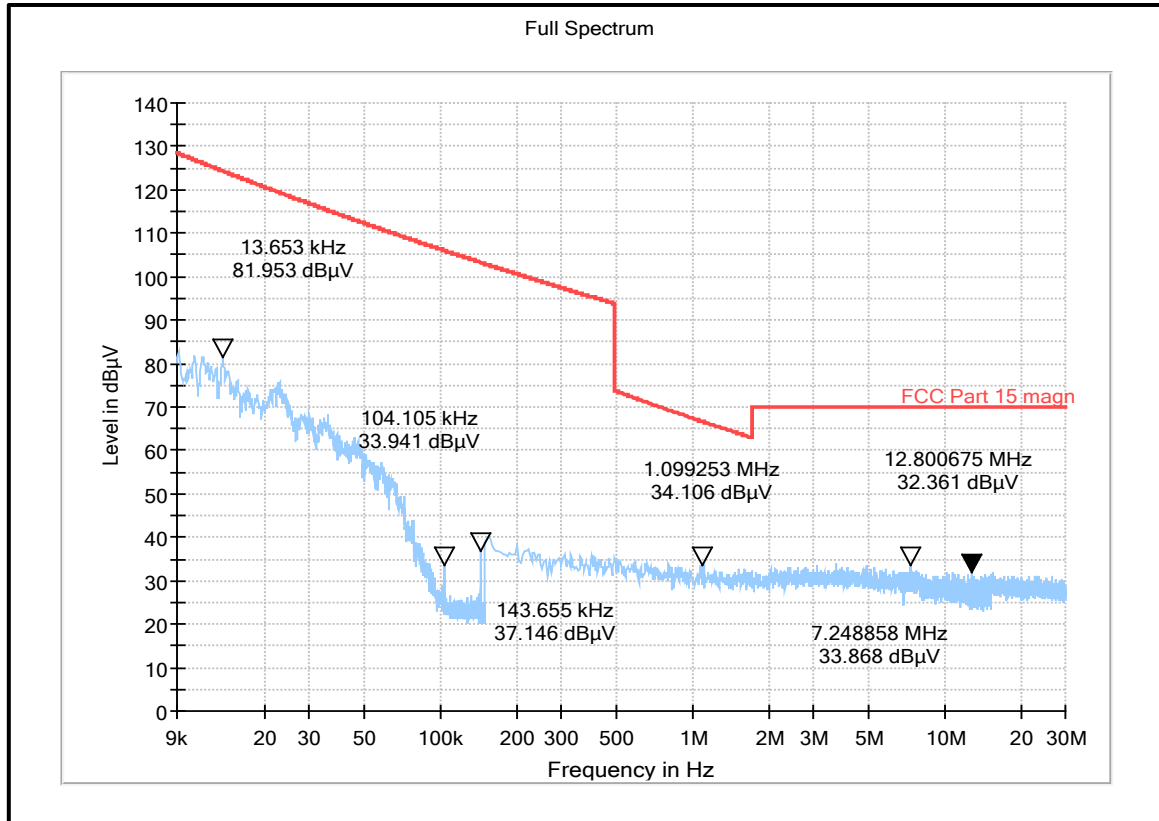
Test Setup:



Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna**

Frequency (MHz)	Loop Antenna Orientation	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 9 kHz – 30 MHz



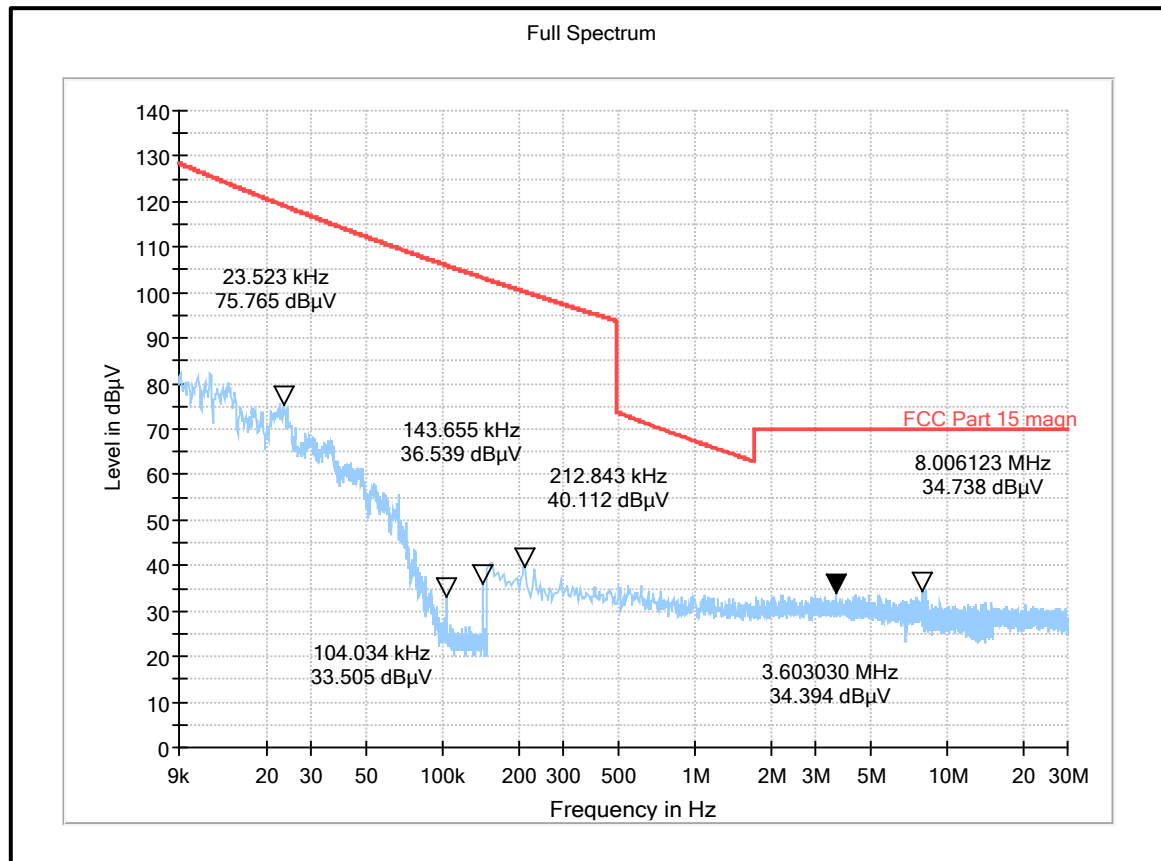
ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna**

Frequency (MHz)	Loop Antenna Orientation	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 9 kHz – 30 MHz



ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	16 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 1/2		

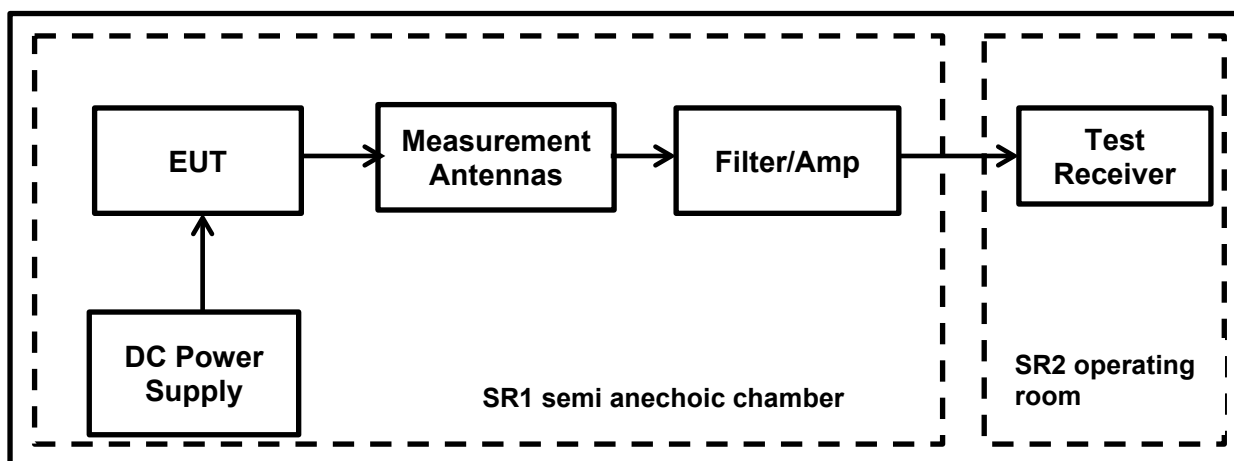
FCC Reference:	Parts 15.247(d) & 15.209(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.5
Frequency Range	30 MHz to 1000 MHz

Environmental Conditions:

Temperature (°C):	23.1
Relative Humidity (%):	34.6

Note(s):

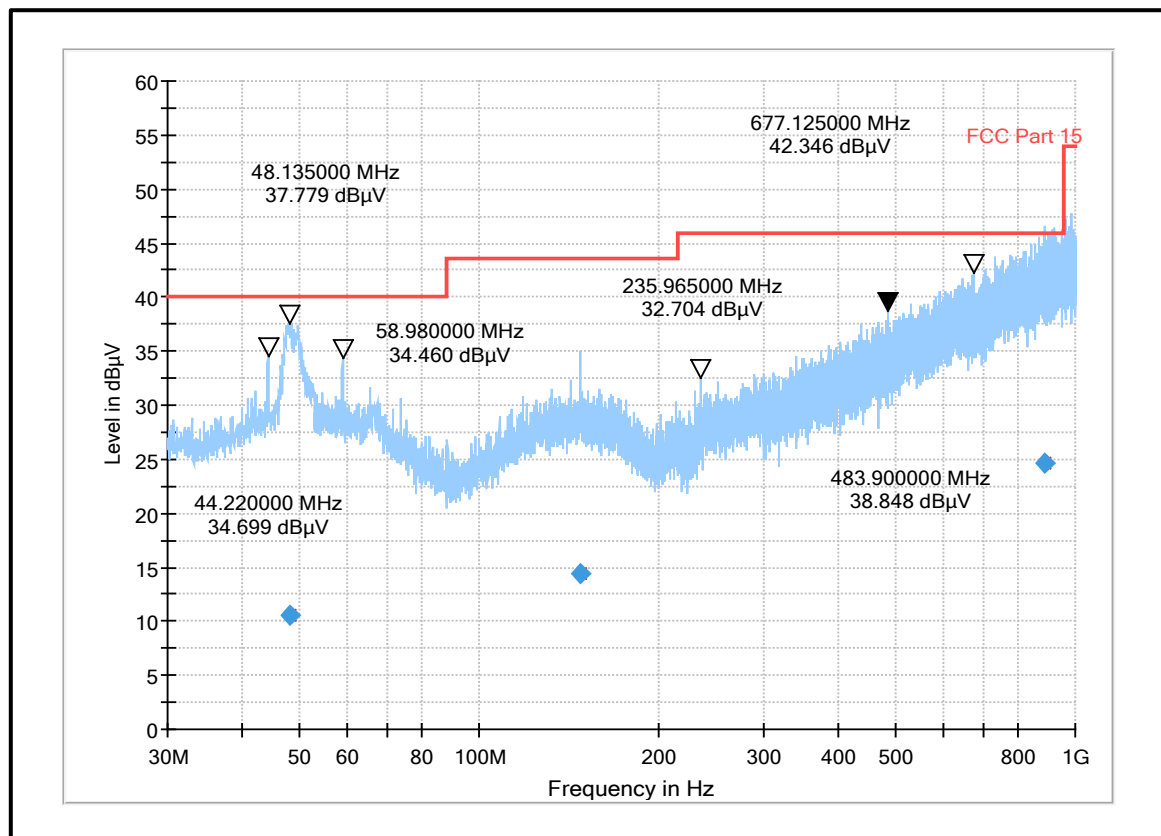
1. Measurements below 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) at a distance of 3 m. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m.
2. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
3. The preliminary scans showed similar emission levels below 1 GHz, for each channel & modes of operation. Therefore final radiated emissions measurements were performed with the EUT set to the top channel only.
4. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
5. All other emissions shown on the pre-scan plots were investigated and found to be below system noise floor.

Test Setup:

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna**

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
48.1350	Horizontal	10.64	40.00	29.36	Complied
147.4950	Horizontal	14.36	43.50	29.14	Complied
888.5416	Horizontal	24.69	46.00	21.31	Complied

Plot: Radiated Transmitter spurious emission from 30 MHz – 1 GHz



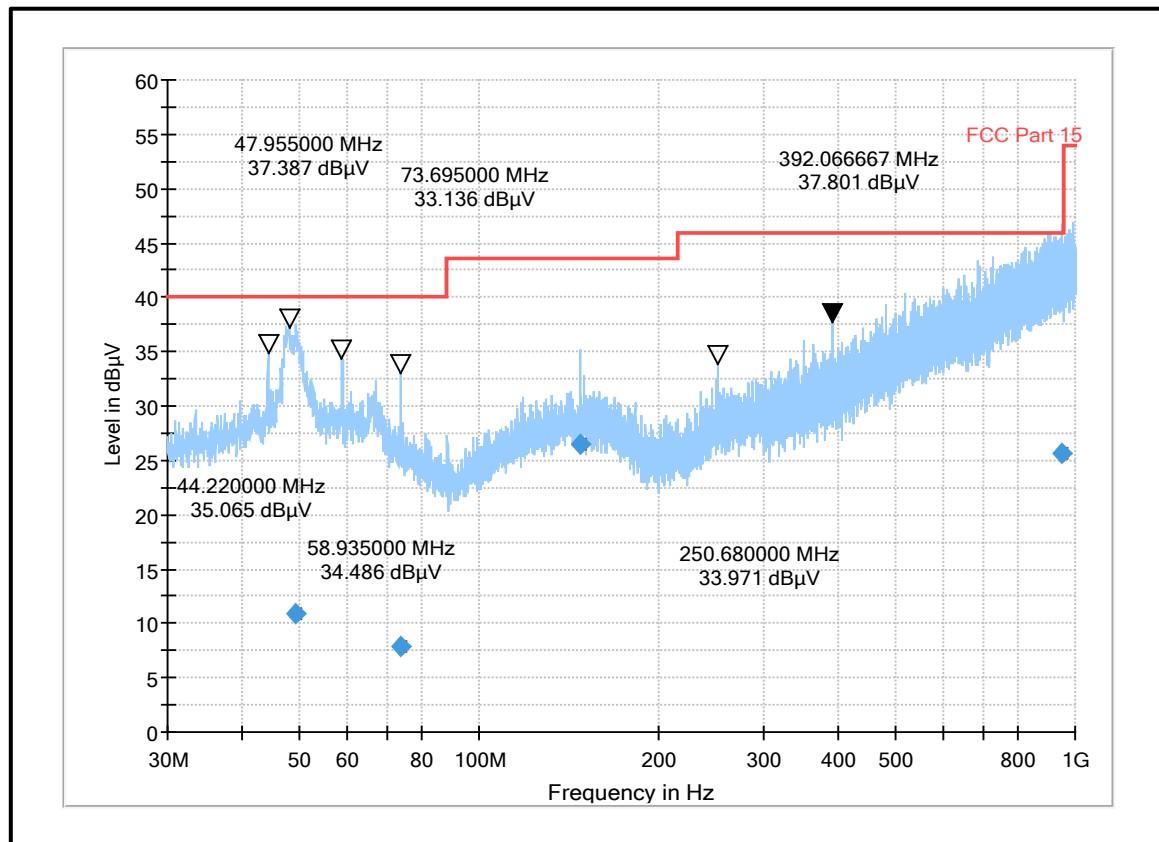
ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna**

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
49.2600	Horizontal	10.87	40.00	29.13	Complied
73.6950	Vertical	7.95	40.00	32.05	Complied
147.4500	Horizontal	26.46	43.50	17.04	Complied
948.7083	Horizontal	25.64	46.00	20.36	Complied

Plot: Radiated Transmitter spurious emission from 30 MHz – 1 GHz



ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	16 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d), 15.209(a) & 15.205(a)
Test Method Used:	FCC KDB 558074 Sections 8.5 & 8.6 referencing ANSI C63.10 Sections 11.11 and 11.12 ANSI C63.10:2013 Sections 6.3 and 6.6
Frequency Range	1 GHz to 25 GHz

Environmental Conditions:

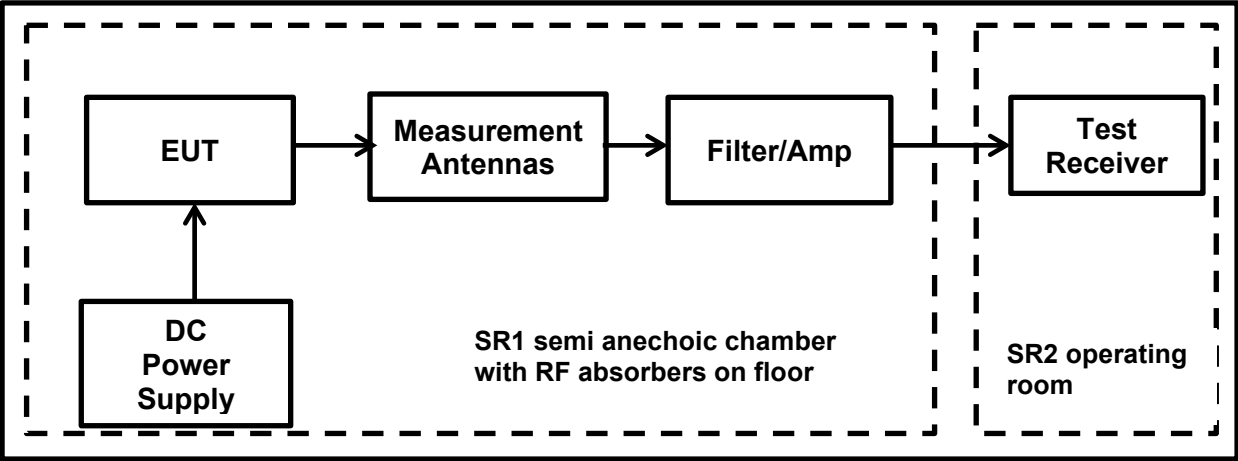
Temperature (°C):	23.1
Relative Humidity (%):	34.6

Note(s):

1. Pre-scans above 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with RF absorbers on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 m above the test chamber floor, in line with the EUT. Final measurements above 1 GHz were performed in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with absorber on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m.
2. Pre-scans were performed and a marker placed on the highest measured level of the appropriate plot. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. The sweep time was set to auto.
3. The emissions shown at frequencies approximately 2.4 GHz to 2.4835 GHz on the 1 GHz to 18 GHz plots are the EUT fundamental for the tested channel.
4. All emissions shown on the pre-scans were investigated and found to be below the noise floor of the measurement system.
5. In accordance with ANSI C63.10-2013 Section 5.3.3 & 6.5.3 measurements above 18 GHz were performed at closer distance (1 m); because at specified measurement distance (3m) for compliance the instrumentation noise floor was typically close to the radiated emission limit.
6. The preliminary scans showed similar emission levels above 18 GHz, for each channel & modes of operation. Therefore final radiated emissions measurements were performed with the EUT set to the top channel only.
7. The preliminary scans showed similar emission levels above 18 GHz, for each channel & modes of operation. Therefore final radiated emissions measurements were performed with the EUT set to the top channel only.

Transmitter Radiated Emissions (continued)

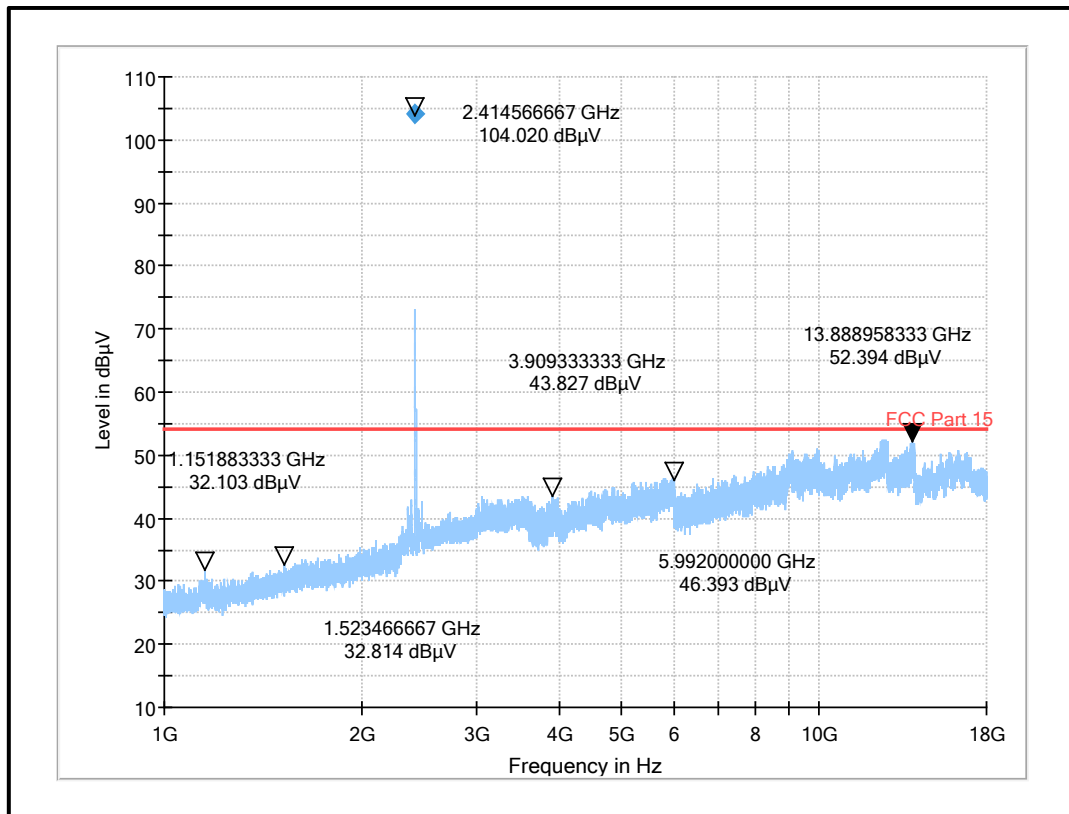
Test Setup:



Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Bottom Channel / Rod Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



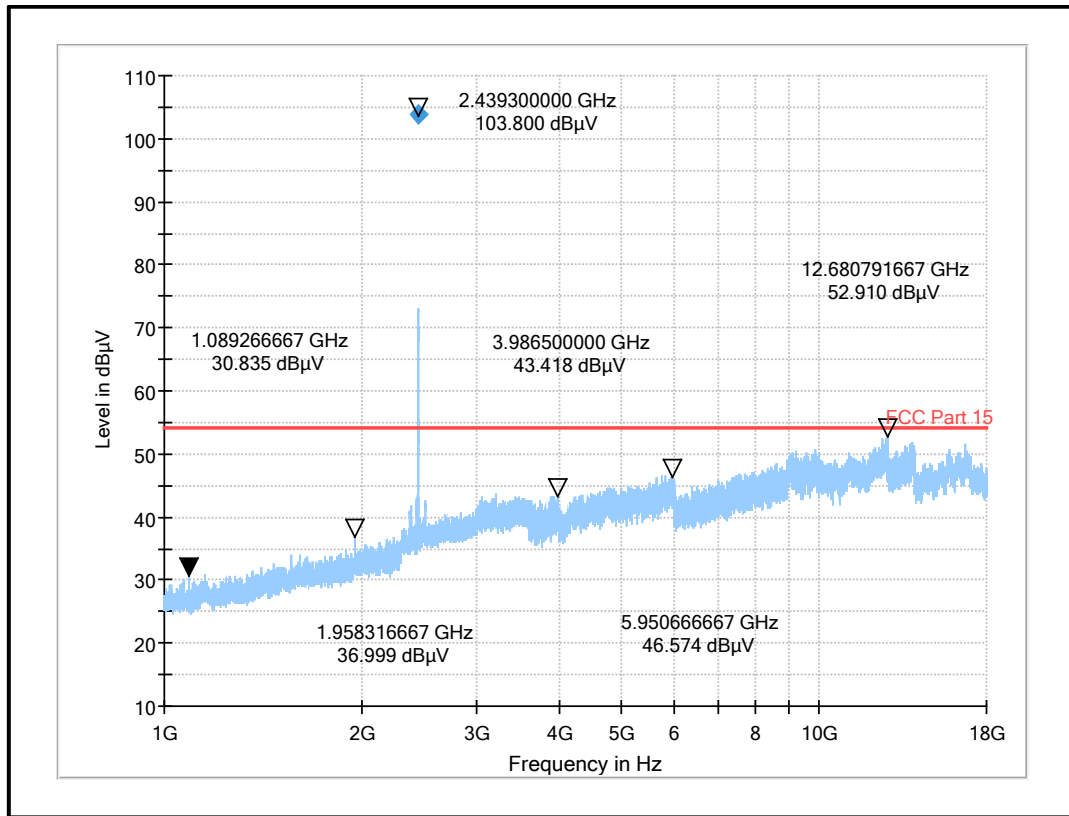
ZigBee / Port X14 / PWR 12 dBm / Bottom Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Middle Channel / Rod Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



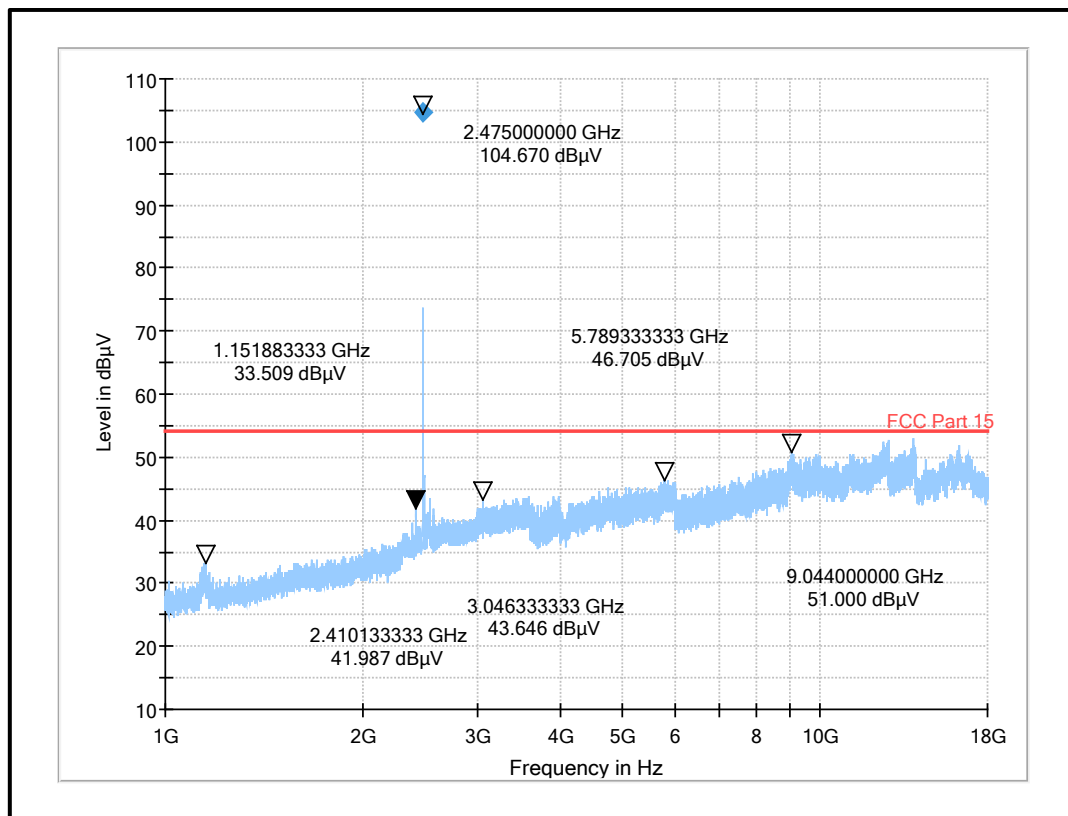
ZigBee / Port X14 / PWR 12 dBm / Middle Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



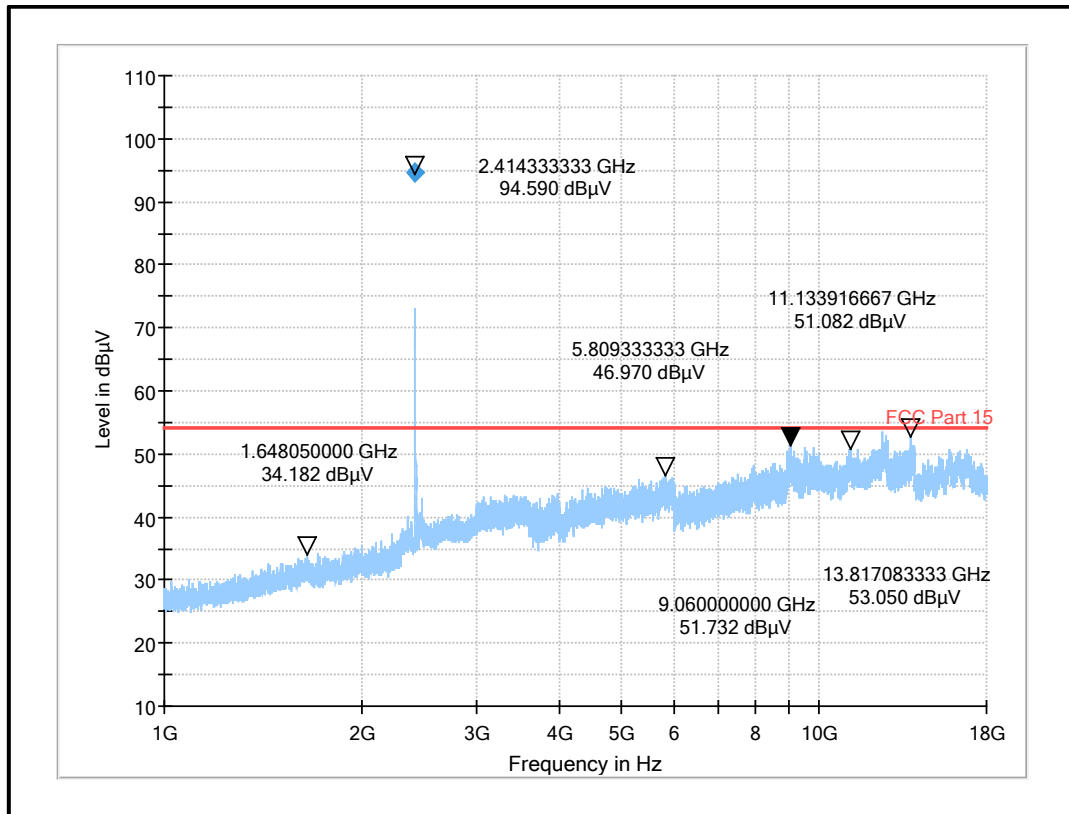
ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Bottom Channel / SMD Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



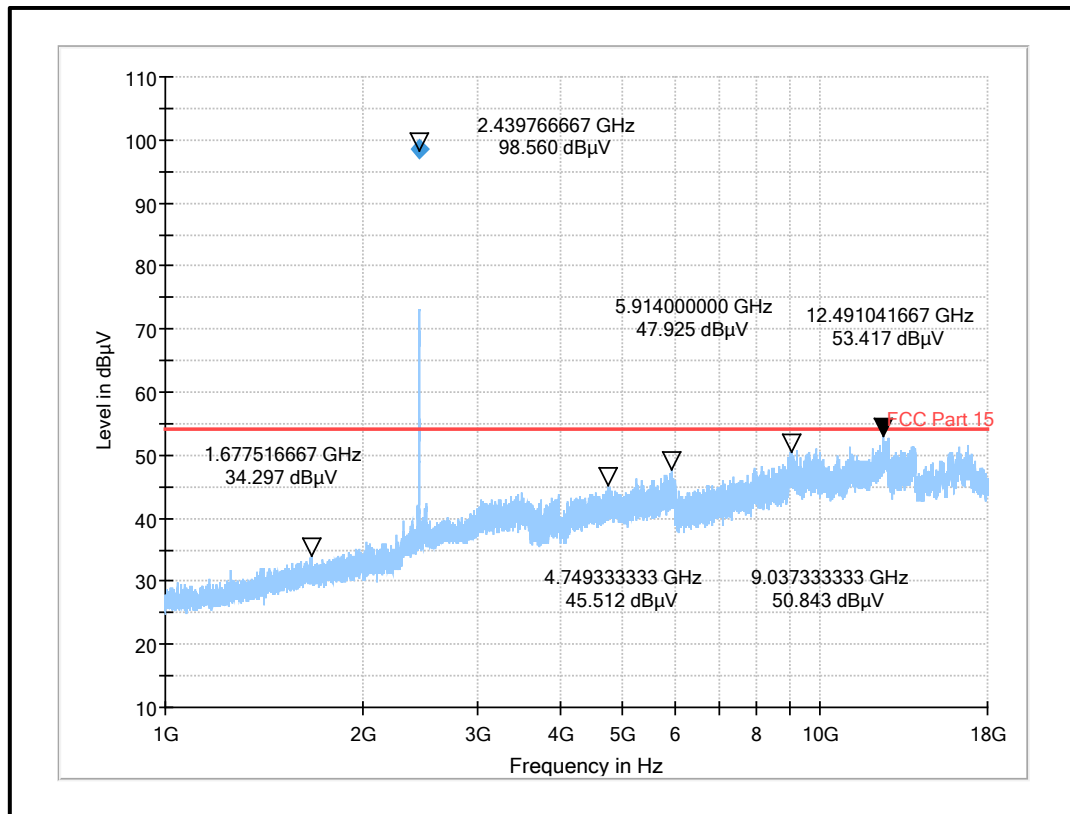
ZigBee / Port X14 / PWR 12 dBm / Bottom Channel / SMD Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Middle Channel / SMD Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



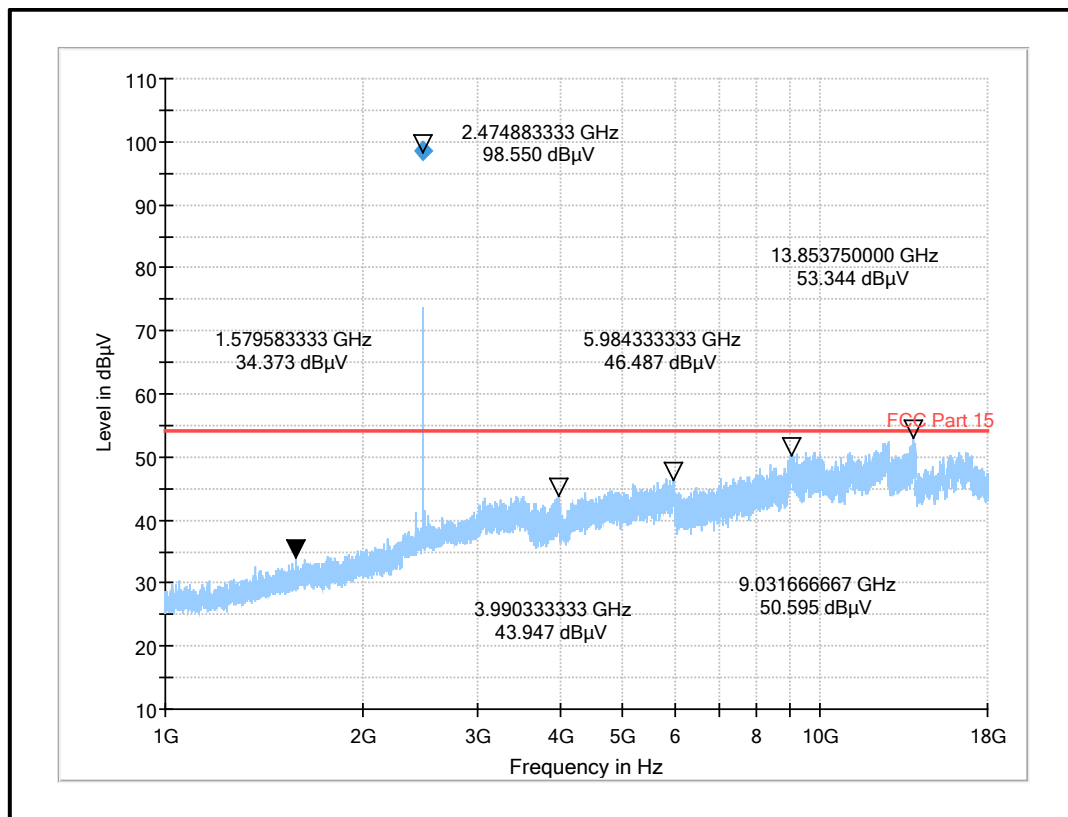
ZigBee / Port X14 / PWR 12 dBm / Middle Channel / SMD Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna**

Frequency (MHz)	Antenna Polarization	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were detected					

Plot: Radiated Transmitter spurious emission from 1 GHz – 18 GHz



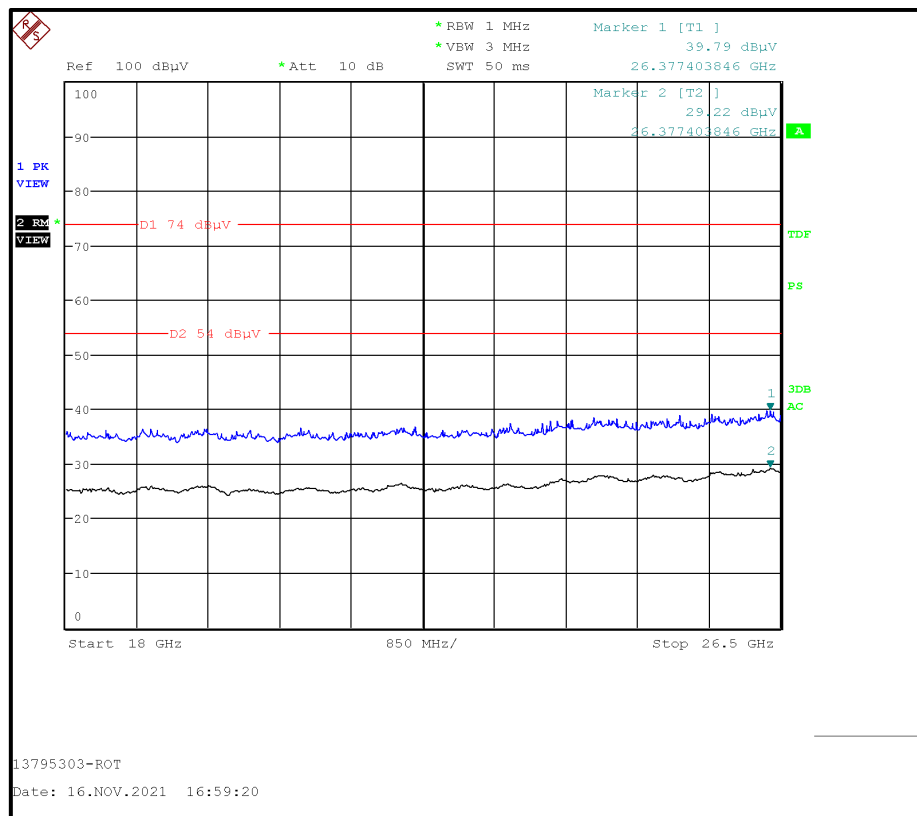
ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna**

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 18 GHz – 26.5 GHz



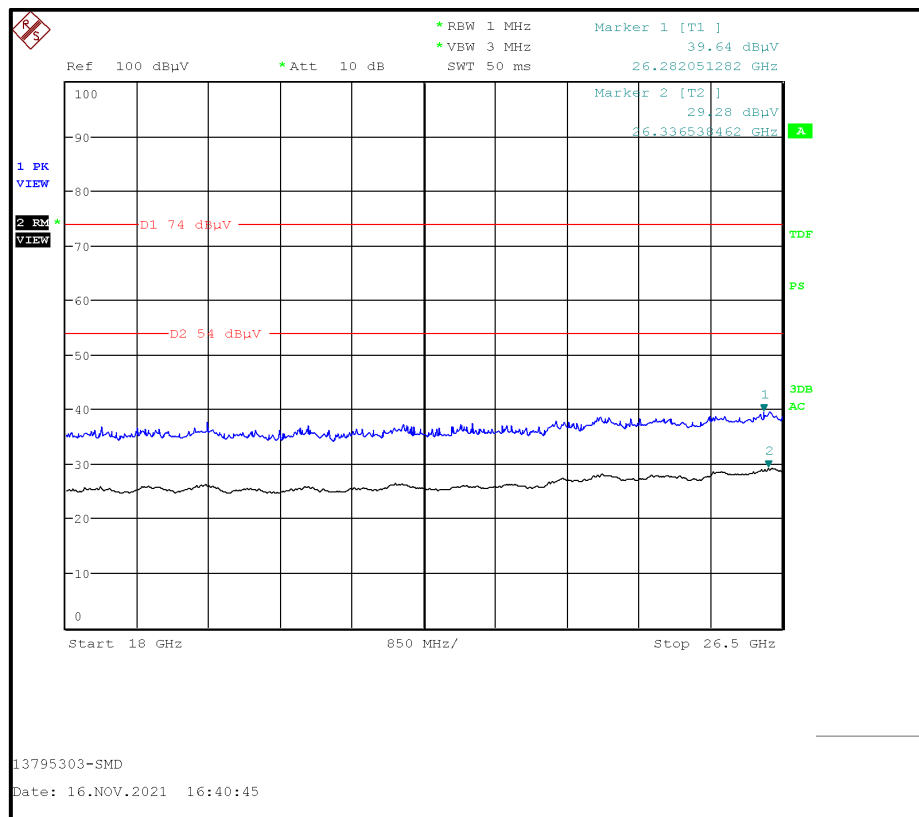
ZigBee / Port X14 / PWR 12 dBm / Top Channel / Rod Antenna

Result: Pass

Transmitter Radiated Emissions (continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna**

Frequency (MHz)	Antenna Polarization	MaxPeak Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
No critical spurious emissions were found					

Plot: Radiated Transmitter spurious emission from 18 GHz – 26.5 GHz



ZigBee / Port X14 / PWR 12 dBm / Top Channel / SMD Antenna

Result: Pass

5.2.7. Transmitter Band Edge Radiated Emissions**Test Summary:**

Test Engineer:	Muhammad Faiq Khan	Test Date:	11 November 2021
Test Sample Serial Number:	1116050024 (RF Sample with U.FL Connector)		
Test Site Identification	SR 1/2		

FCC Reference:	Parts 15.247(d), 15.209(a) & 15.205(a)
Test Method Used:	DTS emissions in non-restricted frequency bands: FCC KDB 558074 Section 8.5 referencing ANSI C63.10:2013 Sections 11.11
	DTS emissions in restricted frequency bands: FCC KDB 558074 Section 8.6 referencing ANSI C63.10:2013 Sections 11.12
	ANSI C63.10:2013 Sections 6.10.4, 6.10.5

Environmental Conditions:

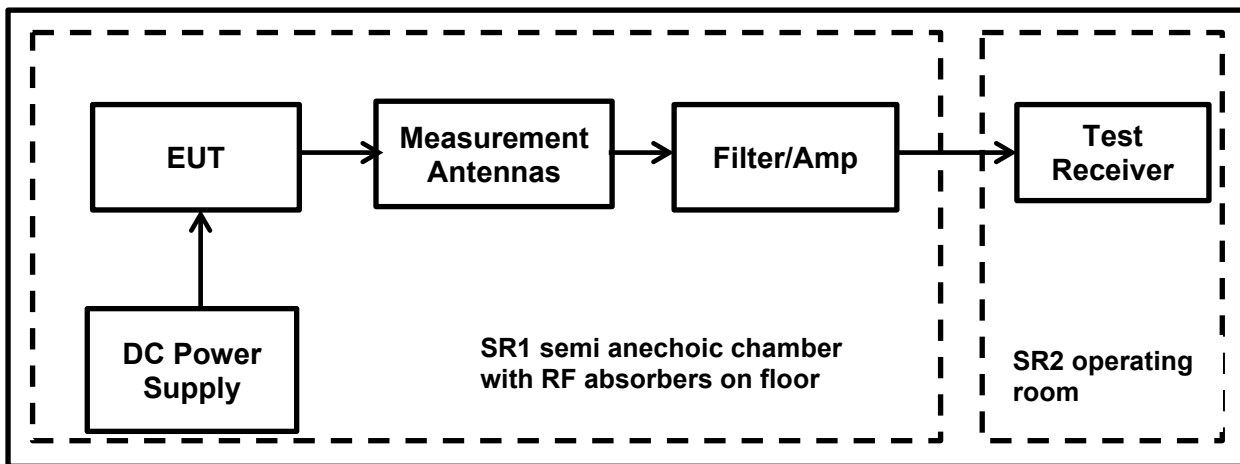
Temperature (°C):	23.5
Relative Humidity (%):	35.6

Note(s):

1. The measurements were in a semi-anechoic chamber SR1/ 2 (Asset Number 1603665) with RF absorbers on the floor at a distance of 3 m. The EUT was placed at a height of 1.5 m above the test chamber floor in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 m to 4 m
2. As the lower band edge falls within a non-restricted band, measurements were performed in accordance with FCC KDB 558074 Section 8.5 referencing ANSI C63.10 Section 11.11.
As the maximum peak conducted output power was previously measured, in accordance with ANSI C63.10 Section 11.11.1(a) lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge falls within a non-restricted band, only peak measurements are required. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. Marker frequencies and levels were recorded.
4. The restricted band peak measurements were performed in accordance with ANSI C63.10 Section 11.12.2.4.
5. As the upper band edge falls within a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz and RMS detector in linear power averaging mode was used. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher-level emission was present). Marker frequencies and levels were recorded.

Transmitter Band Edge Radiated Emissions (continued)**Note(s): (continued)**

6. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.
7. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
8. As the EUT continuous transmission of the EUT ($D \geq 98\%$) can be achieved and EUT was transmitting continuously with a constant Duty Cycle of 100 % (duty cycle variations are less than $\pm 2\%$). Therefore, a Duty Cycle Correction Factor isn't applicable to the measured average values of the emissions.

Test Setup:

Transmitter Band Edge Radiated Emissions (Continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Rod Antenna****Results: Lower Band Edge / Peak**

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
2380.85	44.81	72.018	27.208	Complied
2400.00	41.04	72.018	30.978	Complied

Results: 2310 to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2350.64	54.93	74.00	19.07	Complied

Results: 2310 to 2390 MHz Restricted Band / Average

Frequency (MHz)	Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2351.02	47.15	54.00	6.85	Complied

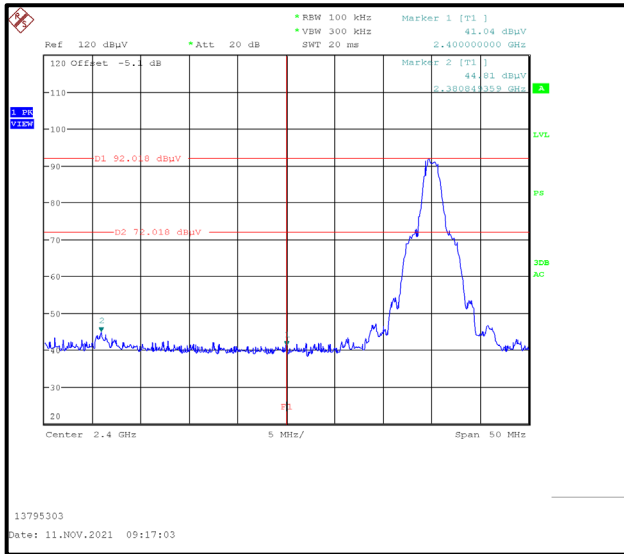
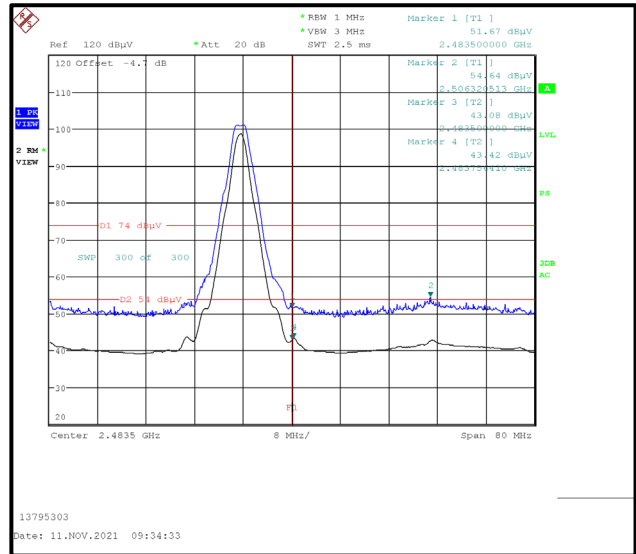
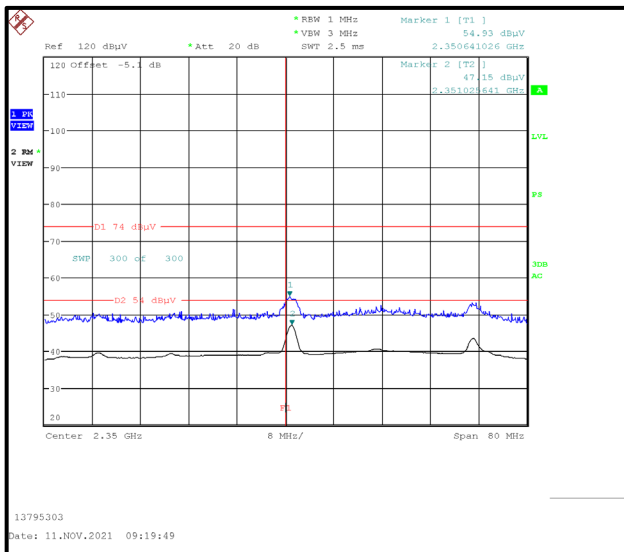
Results: Upper Band Edge / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2483.50	51.67	74.00	22.33	Complied
2506.32	54.64	74.00	19.36	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2483.50	43.08	54.00	10.92	Complied
2483.75	43.42	54.00	10.58	Complied

Result: Pass

Transmitter Band Edge Radiated Emissions (Continued)**Results: ZigBee / Port X14 / PWR 12 dBm / Rod Antenna****Lower Band Edge Peak Measurement****Upper Band Edge Measurement****Restricted Band Edge Measurement****Result: Pass**

Transmitter Band Edge Radiated Emissions (Continued)**Results: ZigBee / Port X14 / PWR 12 dBm / SMD Antenna****Results: Lower Band Edge / Peak**

Frequency (MHz)	Peak Level (dB μ V/m)	-20 dBc Limit (dB μ V/m)	Margin (dB)	Result
2380.92	44.98	74.31	29.33	Complied
2400.00	40.55	74.31	33.76	Complied

Results: 2310 to 2390 MHz Restricted Band / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2351.15	53.64	74.00	20.36	Complied

Results: 2310 to 2390 MHz Restricted Band / Average

Frequency (MHz)	Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2351.02	44.71	54.00	9.29	Complied

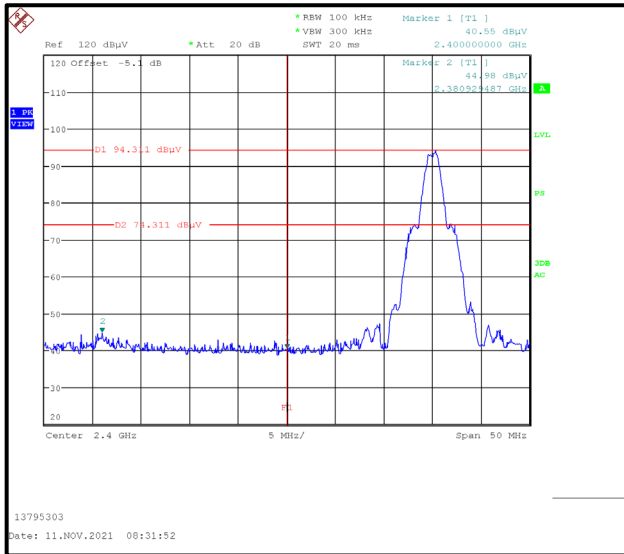
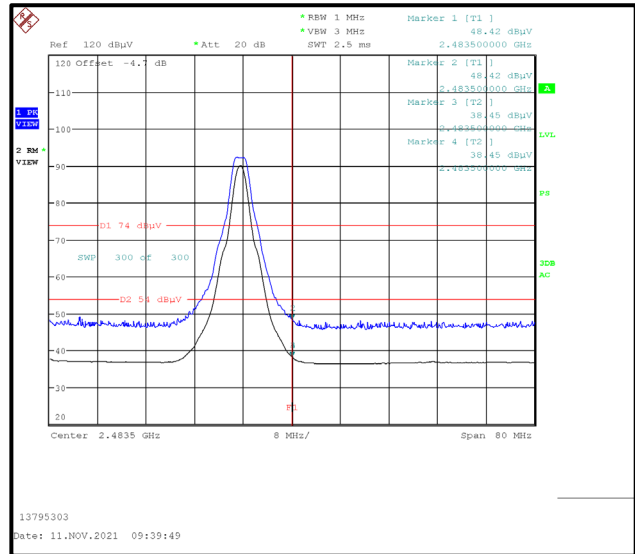
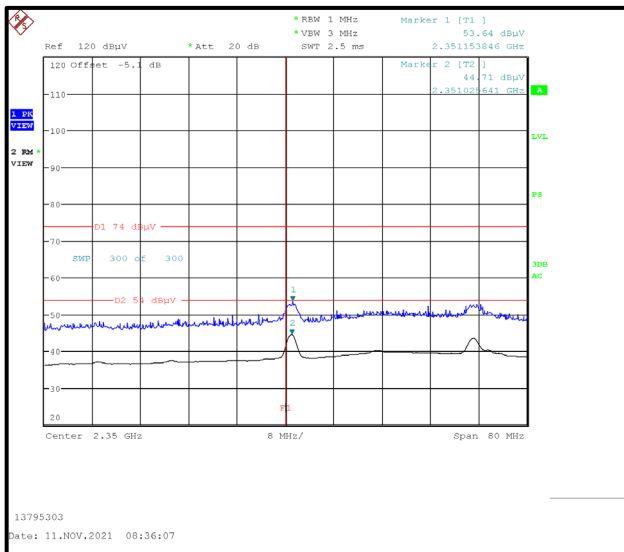
Results: Upper Band Edge / Peak

Frequency (MHz)	Peak Level (dB μ V/m)	Peak Limit (dB μ V/m)	Margin (dB)	Result
2483.50	48.42	74.00	25.58	Complied

Results: Upper Band Edge / Average

Frequency (MHz)	Average Level (dB μ V/m)	Average Limit (dB μ V/m)	Margin (dB)	Result
2483.50	38.45	54.00	15.55	Complied

Result: Pass

Transmitter Band Edge Radiated Emissions (Continued)**Results: ZigBee / Port X14 / PWR 12 dBm / SMD Antenna****Lower Band Edge Peak Measurement****Upper Band Edge Measurement****Restricted Band Edge Measurement****Result: Pass**

6. Measurement Uncertainty

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

Measurement Type	Confidence Level (%)	Calculated Uncertainty
Conducted Maximum Peak Output Power	95%	±0.59 dB
Radiated Spurious Emissions	95%	±3.10 dB
Band Edge Radiated Emissions	95%	±3.10 dB
Transmitter Duty Cycle	95%	±3.4%
Minimum 6 dB Bandwidth	95%	±0.87 %
Spectral Power Density	95%	±0.59 dB

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

7. Used equipment

Test site: SR 1/2

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
1	Rohde & Schwarz	Antenna, Loop	HFH2-Z2	831247/012	10/07/2020	36
377	BONN Elektronik	Amplifier, Low Noise Pre	BLMA 0118-1A	025294B	14/07/2021	12
423	Bonn Elektronik	Amplifier, Low Noise Pre	BLMA 1840-1A	55929	16/07/2021	12
460	Deisel	Turntable	DT 4250 S	n/a	n/a	n/a
452	Schwarzbeck	Antenna, Trilog Broadband	VULB 9168	9168-240	02/09/2020	24
496	Rohde & Schwarz	Antenna, log. - periodical	HL050	100297	05/08/2020	36
607	Schwarzbeck	Antenna broadband horn antenna	BBHA 9170	9170-561	15/10/2019	36
587	Maturo	antenna mast, tilting	TAM 4.0-E	011/7180311	n/a	n/a
588	Maturo	Controller	NCD	029/7180311	n/a	n/a
591	Rohde & Schwarz	Receiver	ESU 40	100244/040	28/06/2021	12
608	Rohde & Schwarz	Switch Matrix	OSP 120	101227	lab verification	n/a
628	Maturo	Antenna mast	CAM 4.0-P	224/19590716	n/a	n/a
629	Maturo	Kippeinrichtung	KE 2.5-R-M	MAT002	n/a	n/a
-/-	Testo	Thermo-Hygrometer	608-H1	01	lab verification	n/a
328	SPS	AC/DC power distribution system	PAS 5000	A2464 00/2 0200	lab verification	n/a
1603665	Siemens Matsushita Components	semi-anechoic chamber SR1/ 2	-/-	B83117-A1421-T161	n/a	n/a

Test site: SR 9

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
445	Huber & Suhner	RF Attenuator (10 dB)	6810.17.AC	--	lab verification	12
637	Rohde & Schwarz	Spectrum Analyzer	FSV40	101587	14/07/2021	12
-/-	Testo	Thermo-Hygrometer	608-H1	07	lab verification	n/a
1603668	Siemens Matsushita Components	shielded room		B83117-B1422-T161	n/a	n/a

Test site: SR 7/8

ID	Manufacturer	Type	Model	Serial	Calibration Date	Cal. Cycle (months)
23	Rohde & Schwarz	Artificial Mains	ESH3-Z5	831767/013	14/07/2021	12
28	Rohde & Schwarz	Passive Probe	ESH2-Z3	none	11/07/2019	36
349	Rohde & Schwarz	Receiver, EMI Test	ESIB7	836697/009	13/07/2021	12
351	Rohde & Schwarz	network, Artificial Mains	ESH3-Z5	862770/018	14/07/2021	12
564	Teseq	Impedance stabilisation network (ISN)	ISN T800	26076	14/07/2021	24
616	Rohde & Schwarz	ISN	ENY81-CA6	101656	07/07/2020	36
-/-	Testo	Thermo-Hygrometer	608-H1	08	lab verification	n/a
327	SPS	AC/DC power distribution system	PAS 5000	A2464 00/1 0200	lab verification	n/a

8. Report Revision History

Version Number	Revision Details		
	Page No(s)	Clause	Details
1.0	-	-	Initial Version
Test Report Version 1.1 supersede Version 1.0 with immediate effect Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.1, Issue Date 25 FEBRUARY 2022 replaces Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.0, Issue Date 08 DECEMBER 2021, which is no longer valid.			
1.1	as below	as below	Intermediate Version
	5	2.1	Test dates updated
	7	3.2	EUT decription updated
	8	3.4	Transceiver Frequency Range updated & intended use of each port was included
	9	3.5.B	Support Equipment Description corrected
	10-11	4.2	Details of stand-alone configuration added & Radiated Measurements section updated
	13-22	5.2.1	Transmitter AC Conducted Spurious Emissions results added
	25 & 27	5.2.2	Conducted ouput power plots included
	34,38 & 41	5.2.6	Test Site Identification corrected & Note section updated
	51	5.2.7	Test Site Identification corrected & Note section updated
Test Report Version 1.2 supersede Version 1.1 with immediate effect Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.2, Issue Date 03 MARCH 2022 replaces Test Report No. UL-RPT-RP-13795303-116-FCC Version 1.1, Issue Date 25 FEBRUARY 2022, which is no longer valid.			
1.2	as below	as below	Current Version
	6	2.2	Part 15.207 'Not applicable' box corrected

--- END OF REPORT ---