RF TEST REPORT

FCC / ISED

APPLICANT

Treadly Inc

MODEL NAME

TRB200

FCC ID

2AYVR-TRB200

REPORT NUMBER

HA210106-ESM-001-R02

TEST REPORT

Date of Issue
February 25, 2021

Test Site
Hyundai C-Tech, Inc. dba HCT America, Inc.
1726 Ringwood Ave, San Jose, CA 95131, USA

Applicant	Treadly Inc
Applicant Address	530 Secaucus Rd, Secaucus, NJ 07094, U.S.A.
FCC ID	2AYVR-TRB200
Model Name	TRB200
EUT Type	Wi-Fi/BLE Module
Modulation Type	GFSK, π/4-DPSK, 8DPSK
FCC Classification	Spread Spectrum Transmitter (DSS)
FCC Rule Part(s)	Part 15.247
Test Procedure	ANSI C63.10-2013, KDB 558074 D01 v05r02

The device bearing the trade name and model specified above, has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures required. The results of testing in this report apply only to the product which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Hyundai C-Tech, Inc. dba HCT America, Inc. certifies that no party to application has been denied the FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C 862

Tested By	**Reviewed By**
Yongsoo Park	Sunwoo Kim
Test Engineer	Technical Manager

REVISION HISTORY

The revision history for this document is shown in table.

TEST REPORT NO.	DATE	DESCRIPTION
HA210106-ESM-001-R02	2/17/2021	Initial Issue
HA210106-ESM-001-R02	02/25/2021	Added Test Configuration Setup on page 12.

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1. GENERAL INFORMATION

EUT DESCRIPTION

Model	TRB200
EUT Type	Wi-Fi/BLE Module
Power Supply	3.0 – 3.6 VDC
RF Specification	WIFI 2.4 GHz : IEEE 802.11b/g, 802.11n HT20, 802.11n HT40 (SISO) Bluetooth LE (1Mbps) Bluetooth BDR/EDR
Operating Environment	Indoor and outdoor
Operating Temperature	-40 °C ~ +85 °C

RF SPECIFICATION SUBJECT TO THE REPORT

RF Specification	Bluetooth BDR/EDR
Transmitter Chain	1
Frequency Range	2402 MHz – 2480 MHz
Max. RF Output Power	Peak : 4.924 dBm (3.107 mW)
Modulation Type	GFSK, π/4-DQPSK, 8DPSK
Number of Channels	79 Channels
Antenna Specification [1)]	Antenna Type : Chip Antenna Peak Gain : 1.5 dBi
Firmware Version [2)]	3.70.0
Hardware Version [2)]	v1.1
Date(s) of Tests	January 28, 2021 ~ February 5, 2021

Note :
1. Antenna information is based on the document provided.
2. Firmware and Hardware Versions are provided by the client.

OPERATING FREQUENCY CHANNELS

Bluetooth (BDR/EDR)							
Channel	**Frequency (MHz)**	**Channel**	**Frequency (MHz)**	**Channel**	**Frequency (MHz)**	**Channel**	**Frequency (MHz)**
00	2 402	**20**	2 422	**40**	2 442	**60**	2 462
01	2 403	**21**	2 423	**41**	2 443	**61**	2 463
02	2 404	**22**	2 424	**42**	2 444	**62**	2 464
03	2 405	**23**	2 425	**43**	2 445	**63**	2 465
04	2 406	**24**	2 426	**44**	2 446	**64**	2 466
05	2 407	**25**	2 427	**45**	2 447	**65**	2 467
06	2 408	**26**	2 428	**46**	2 448	**66**	2 468
07	2 409	**27**	2 429	**47**	2 449	**67**	2 469
08	2 410	**28**	2 430	**48**	2 450	**68**	2 470
09	2 411	**29**	2 431	**49**	2 451	**69**	2 471
10	2 412	**30**	2 432	**50**	2 452	**70**	2 472
11	2 413	**31**	2 433	**51**	2 453	**71**	2 473
12	2 414	**32**	2 434	**52**	2 454	**72**	2 474
13	2 415	**33**	2 435	**53**	2 455	**73**	2 475
14	2 416	**34**	2 436	**54**	2 456	**74**	2 476
15	2 417	**35**	2 437	**55**	2 457	**75**	2 477
16	2 418	**36**	2 438	**56**	2 458	**76**	2 478
17	2 419	**37**	2 439	**57**	2 459	**77**	2 479
18	2 420	**38**	2 440	**58**	2 460	**78**	2 480
19	2 421	**39**	2 441	**59**	2 461	-	-

2. METHODOLOGY

FCC KDB 558074 D01 Measurement Guidance v05r02 dated April 2nd, 2019 entitled “Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) and Frequency Hopping Spread Spectrum System (FHSS) and the measurement procedure described in ANSI C63.10(Version : 2013) ‘the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices’.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C / the RSS-GEN issue 5, RSS-247 issue 2.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. Also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 8 of ANSI C63.10. (Version: 2013)

Conducted Antenna Terminal

KDB 558074 D01 v05r02

DESCRIPTION OF TEST MODES

The EUT has been tested at continuous UHF RFID operating mode. Universal Assistant software was used to control the channels, power setting, continuous TX mode.

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment’s, which is traceable to recognized national standards. Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

4. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC (Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at 1726 Ringwood Avenue, San Jose, California 95131, USA.
The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements.

Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, “Radio Interference Measuring Apparatus and Measurement Methods.”

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR §15.203 :
"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

(1) The antenna of this E.U.T is permanently attached and there is no provision for connection to an external antenna.
(2) The E.U.T Complies with the requirement of §15.203

According to RSS-Gen Issue 5 (Section 6.8) :
The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded Uncertainty (±dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	2.55
Radiated Disturbance (9 kHz ~ 30 MHz)	3.20
Radiated Disturbance (30 MHz ~ 1 GHz)	4.73
Radiated Disturbance (1 GHz ~ 18 GHz)	5.21
Radiated Disturbance (18 GHz ~ 40 GHz)	5.18

7. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	IC Part Section(s)	Test Limit	Test Result
20 dB Bandwidth	§15.247(a)(1)(i)	RSS-247, 5.1(c)	≤ 500 kHz	N/A [1)]
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A	N/A [1)]
Conducted Maximum Peak Output Power	§15.247(b)(2)	RSS-247, 5.4(a)	≤ 1 W (channels ≥ 50)	N/A [1)]
Maximum e.i.r.p.	N/A	RSS-247, 5.4(a)	≤ 4 W e.i.r.p. (channels ≥ 50)	N/A [1)]
Number of Channels	§15.247(a)(1)(i)	RSS-247, 5.1(c)	≤ 8 dBm / 3 kHz	N/A [1)]
Carrier Frequency Separation	§15.247(a)(1)	RSS-247, 5.1	≥ 25 kHz or 20dB BW Whichever is greater	N/A [1)]
Time of Occupancy	§15.247(a)(1)(i)	RSS-247, 5.1(c)	≤ 0.4 s (within 10s period)	N/A [1)]
Conducted Band Edge Conducted Spurious Emission	§15.247(d)	RSS-247, 5.5	≥ 20 dBc	N/A [1)]
AC Power line Conducted Emissions	§15.207	RSS-GEN, 8.8	cf. Section 8.8	PASS
Radiated Spurious Emissions	§15.247(d) §15.209	RSS-GEN, 8.9	cf. Section 8.7	PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7.3	cf. Section 8.7	N/A [1)]

Note :

1. Not applicable since the radio module contained in the EUT was fully modular approved

WORST CASE CONFIGURATION

Radiated test

1. EUT Axis

All X, Y, and Z positions for horizontal / vertical antenna polarization were investigated to find the worst-case position.
Y position was selected as the worst-case for full evaluation.

The following modes were selected for the final evaluation of radiated spurious emission.

BDR : 1-DH5
EDR : 3-DH5

Conducted test

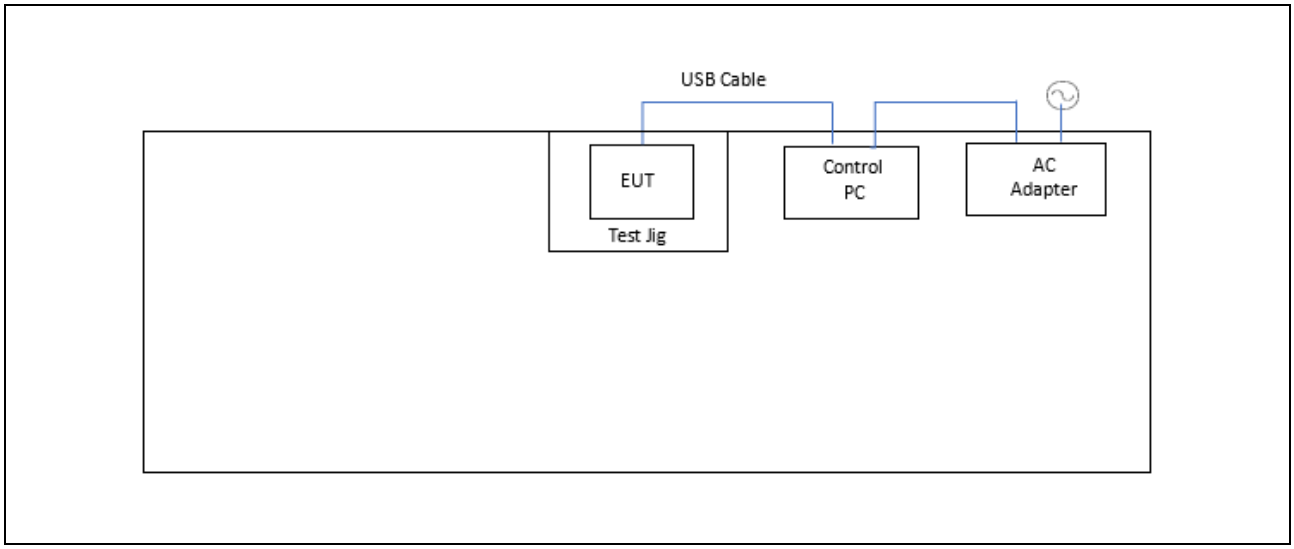
1. AC Line Conducted Emission test was performed at BLE continuous Tx mode.
2. Channel separation and number of hopping channels were measured only at the middle channels.
3. Conducted output power and spurious emission / bandedge test were performed at 1-DH5 / 2-DH5 / 3-DH5.

OUTPUT POWER SETTING

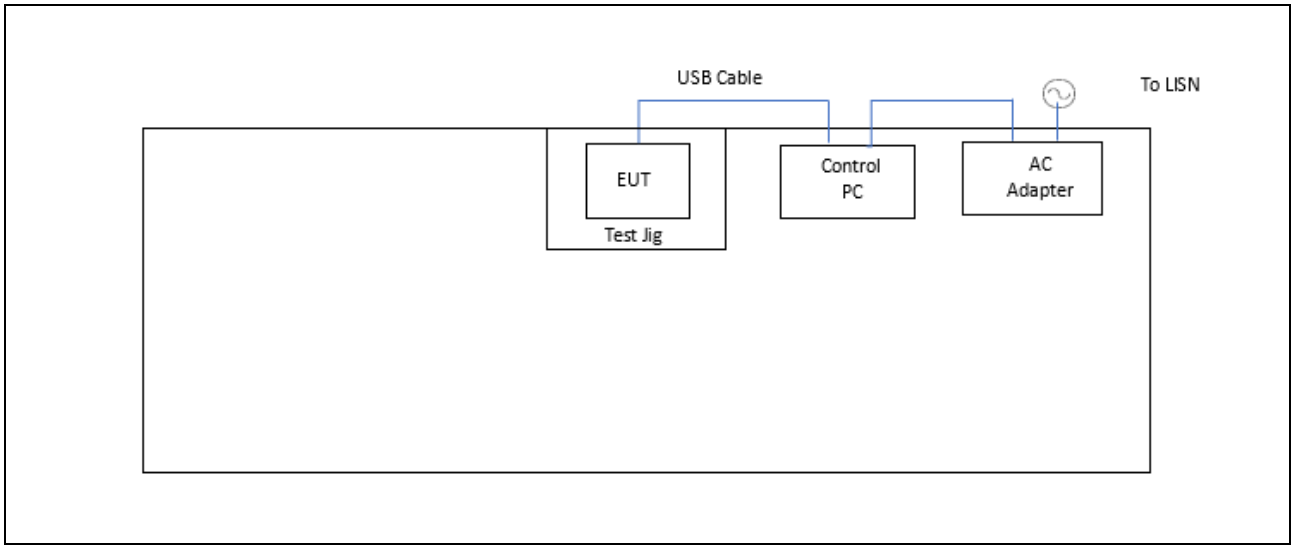
PLS is set to 8 for all the channels.

TEST CONFIGURATION

Radiated Emission



Conducted Emission



LIST OF SUPPORT EQUIPMENT

Equipment Type	Model No.	Serial Number	Manufacturer	Qty	Note
Laptop	T450	TA181240	Lenovo	1	-
AC Adapter	ADLX65SDC2A	36200350	Delta	1	100-240 VAC, 1.5A 50-60Hz (20 VDC)
USB Cable (mini)	-	-	-	1	0.5 m length
Test Jig Board	FTDI TOOL (w/ F232RL)	-	Crius	1	FTDI board USB-TTL 3.3V 5V

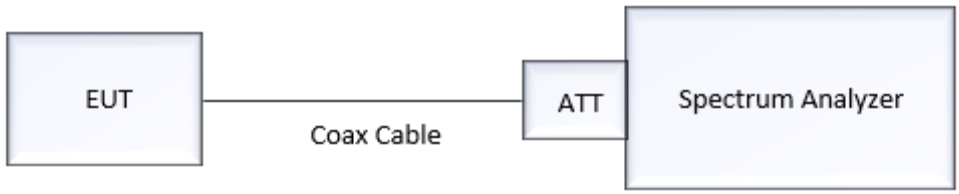
8. DESCRIPTION OF TESTS

8.1. 20 dB BANDWIDTH / 99% OCCUPIED BANDWIDTH

Limit

§15.247(a)(1)(i) / RSS-247 Issue 2, Section 5.1(c)
The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Configuration



Test Procedure (20 dB Bandwidth)

ANSI C63.10-2013, Section 6.9.2

The transmitter output is connected to the Spectrum Analyzer.
The Spectrum Analyzer Setting :

- RBW = 1% ~ 5% of 20 dB bandwidth
- VBW ≒ 3 x RBW
- Span : 2-5 times the 20 dB bandwidth, centered on the hopping channel
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Used the automatic bandwidth measurement capability of a spectrum analyzer, setting X dB as 20 dB.

Test Procedure (99% Bandwidth)

The transmitter output is connected to the spectrum analyzer.

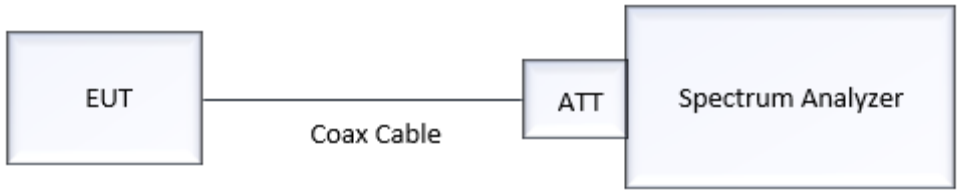
- RBW = 1% ~ 5% of the occupied bandwidth
- VBW ≒ 3 x RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- Used the automatic bandwidth measurement capability of a spectrum analyzer.

8.2. OUTPUT POWER

Limit

§15.247(b)(2) / RSS-247 Issue2, Section 5.4 (a)
For frequency hopping systems operating in the 902-928 MHz band: 1 watt (not exceeding 4.0 W e.i.r.p.) for systems employing at least 50 hopping channels; and, 0.25 watts (not exceeding 1.0 W e.i.r.p.) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i)

Test Configuration



Test Procedure

ANSI C63.10-2013, Section 7.8.5

The EUT is connected to the Spectrum Analyzer. Hopping mode shall be disabled.
Use the following Spectrum Analyzer setting :

- RBW ≥ 20 dB Bandwidth
- VBW ≥ RBW
- SPAN : Approximately 5 x RBW
- Detector Mode : Peak
- Sweep : Auto couple
- Trace Mode : Max hold
- Allow trace to fully stabilize.
- Use marker-to-peak function to determine the peak emission level

Sample Calculation

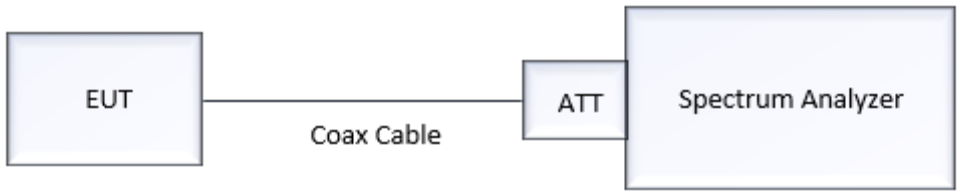
- Conducted Output Power (Peak) = Reading Value + ATT loss + Cable loss

8.3. NUMBER OF HOPPING CHANNELS

Limit

§15.247(a)(1)(i) / RSS-247 Issue 2, Section 5.1 (c)
The system shall use at least 50 hopping channels if the 20 dB bandwidth of the hopping channel is less than 250 kHz.
The system shall use at least 25 hopping channels if the 20 dB bandwidth of the hopping channel is 250 kHz or greater.

Test Configuration



Test Procedure

ANSI C63.10-2013, Section 7.8.3
The transmitter output is connected to the Spectrum Analyzer.

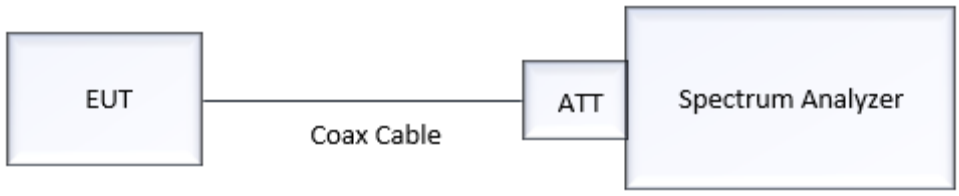
- RBW ≤ 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller
- VBW = 8 MHz (≥ RBW)
- SPAN = Frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans to allow the individual channels to be clearly seen.
- Sweep : Auto.
- Detector = Peak.
- Trace mode = Max hold.
- Allow the trace to stabilize.

8.4. CARRIER FREQUENCY SEPARATION

Limit

§15.247(a)(1) / RSS-247 Issue2, Section 5.1
The system shall have hopping channel carrier frequencies separated by a minimum 25 kHz or the 20 dB bandwidth, whichever is greater.

Test Configuration



Test Procedure

ANSI C63.10-2013 Section 7.8.2

The EUT output shall be in the hopping mode and connected to the Spectrum Analyzer.
Use the following spectrum analyzer setting :

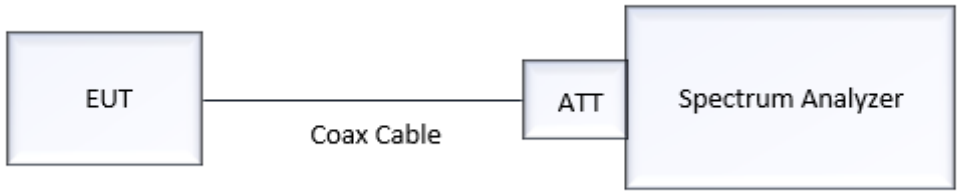
- RBW = Start with approximately 30% of the channel spacing; Then adjust as needed to best identify of each individual channel.
- VBW ≥ RBW.
- SPAN = Wide enough to capture two adjacent peaks.
- Sweep : Auto coupled.
- Detector = Peak.
- Trace mode = Max hold.
- Allow the trace to stabilize.

8.5. TIME OF OCCUPANCY (DWELL TIME)

Limit

§15.247(a)(1)(i) / RSS-247 Issue 2 Section 5.1 (c)
The average time of occupancy shall not be greater than 0.4s over 20s period if the 20 dB bandwidth of the hopping channel is less than 250 kHz.
The average time of occupancy shall not be greater than 0.4s over 10s period if the 20 dB bandwidth of the hopping channel is 250 kHz or greater.

Test Configuration



Test Procedure

ANSI C63.10-2013 Section 7.8.4

The EUT output shall be in the hopping mode and connected to the Spectrum Analyzer.
Use the following spectrum analyzer setting :

- RBW ≤ Channel spacing and where possible, RBW should be set >> 1/T, where T is the expected dwell time per channel.
- VBW ≥ RBW.
- Span : Zero span, centered on a hopping channel.
- Sweep : As needed to capture entire dwell time per hopping channel (Use video trigger and trigger delay for the transmitted signal to better show the plot little after start). Second plot might be needed with longer sweep time to show two successive hops on a channel
- Detector = Peak.
- Trace mode = Max hold.

Use the marker-delta function to determine transmit time per hop. Repeat the test for each different mode of operation.

Sample Calculation

No of hops specified in the requirement
= No of hops on spectrum analyzer x (period specified in the requirement / sweep time on SA)

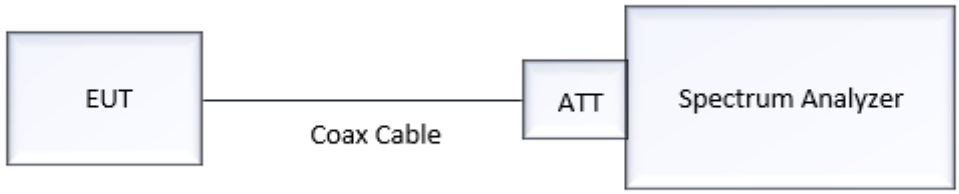
Dwell Time (s)
= Transmit time per hops x No of hops specified in the requirement

8.6. CONDUCTED BAND EDGE / CONDUCTED SPURIOUS EMISSIONS

Limit

§15.247(d) / RSS-247 Issue 2, Section 5.5.
The maximum conducted (peak) output power was used to demonstrate compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz.
[Conducted > 20 dBc]

Test Configuration



Test Procedure

ANSI C63.10-2013, Section 7.8.6 and 7.8.8

The transmitter output port is connected to the spectrum analyzer.

- RBW = 100 kHz
- VBW = 300 kHz
- Set span to encompass the spectrum to be examined
- Detector = Peak
- Trace Mode = max hold
- Sweep time = auto couple
- Ensure that the number of measurement points ≥ 2*Span/RBW
- Allow trace to fully stabilize.
- Use peak marker function to determine the maximum amplitude level.

Measurements are made from 30 MHz to ten times operating frequency in GHz for the lowest, middle, and highest channels.

8.7. RADIATED EMISSIONS

Radiated Emission Limits

FCC : 47 CFR § 15.209		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

ISED : RSS-GEN Section 8.9		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Receiver Radiated Emission Limits

ISED : RSS-GEN Section 7.3		
Frequency (MHz)	**Field Strength (uV/m)**	**Measurement Distance (m)**
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

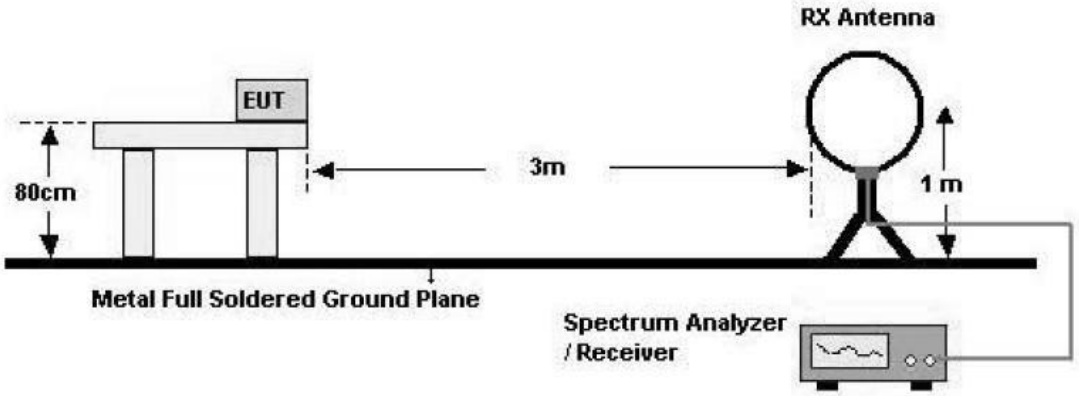
Restricted Bands of Operation

FCC : 47 CFR § 15.205(a)				
Frequency (MHz)	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**
0.090 – 0.110	12.29-12.293	149.9 - 150.05	1660.0 - 1710.0	8025 – 8500
0.495 - 0.505	12.51975-12.52025	156.52475 - 156.52525	1718.8 - 1722.2	9000 – 9200
2.1735 – 2.1905	12.57675-12.57725	156.7 - 156.9	2200.0 - 2300.0	9300 – 9500
4.125 - 4.128	13.36-13.41	162.0125 - 167.17	2310.0 - 2390.0	10600 - 12700
4.17725-4.17775	16.42-16.423	167.72 - 173.2	2483.5 – 2500.0	13250 – 13400
4.20725-4.20775	16.69475-16.69525	240.0 - 285.0	2690.0 - 2900.0	14470 – 14500
6.215-6.218	16.80425-16.80475	322.0 - 335.4	3260.0 – 3267.0	15350 – 16200
6.26775-6.26825	25.5-25.67	399.9 - 410.0	3332.0 – 3339.0	17700 – 21400
6.31175-6.31225	37.5-38.25	608.0 - 614.0	3345.8 – 3358.0	22010 – 23120
8.291-8.294	73 - 74.6	960.0 - 1240.0	3600.0 – 4400.0	23600 – 24000
8.362-8.366	74.8 - 75.2	1300.0 - 1427.0	4500.0 – 5150.0	31200 – 31800
8.37625-8.38675	108 - 121.94	1435.0 - 1626.5	5350.0 – 5460.0	36430 – 36500
8.41425-8.41475	123 - 138	1645.5 - 1646.5	7250.0 – 7750.0	Above 38600

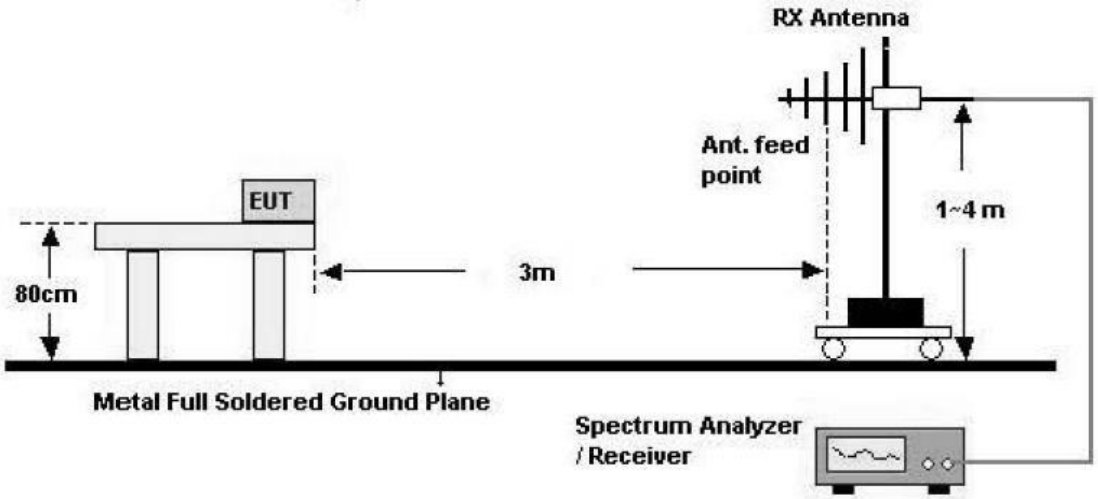
ISED : RSS-GEN Section 8.10				
Frequency (MHz)	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**	**Frequency (MHz)**
0.090 - 0.110	8.37625 - 8.38675	108 – 138	1660 - 1710	8025 – 8500
0.495 - 0.505	8.41425 - 8.41475	149.9 - 150.05	1718.8 - 1722.2	9000 - 9200
2.1735 - 2.1905	12.29 - 12.293	156.52475 - 156.52525	2200 - 2300	9300 - 9500
3.020 - 3.026	12.51975 - 12.52025	156.7 - 156.9	2310 - 2390	10600 - 12700
4.125 - 4.128	12.57675 - 12.57725	162.0125 - 167.17	2483.5 - 2500	13250 – 13400
4.17725 - 4.17775	13.36 - 13.41	167.72 - 173.2	2655 - 2900	14470 – 14500
4.20725 - 4.20775	16.42 - 16.423	240 – 285	3260 – 3267	15350 – 16200
5.677 - 5.683	16.69475 - 16.69525	322 - 335.4	3332 - 3339	17700 – 21400
6.215 - 6.218	16.80425 - 16.80475	399.9 - 410	3345.8 - 3358	22010 – 23120
6.26775 - 6.26825	25.5 - 25.67	608 - 614	3500 - 4400	23600 – 24000
6.31175 - 6.31225	37.5 - 38.25	960 - 1427	4500 - 5150	31200 – 31800
8.291 - 8.294	73 - 74.6	1435 - 1626.5	5350 - 5460	36430 – 36500
8.362 - 8.366	74.8 - 75.2	1645.5 - 1646.5	7250 - 7750	Above 38600

Test Configuration

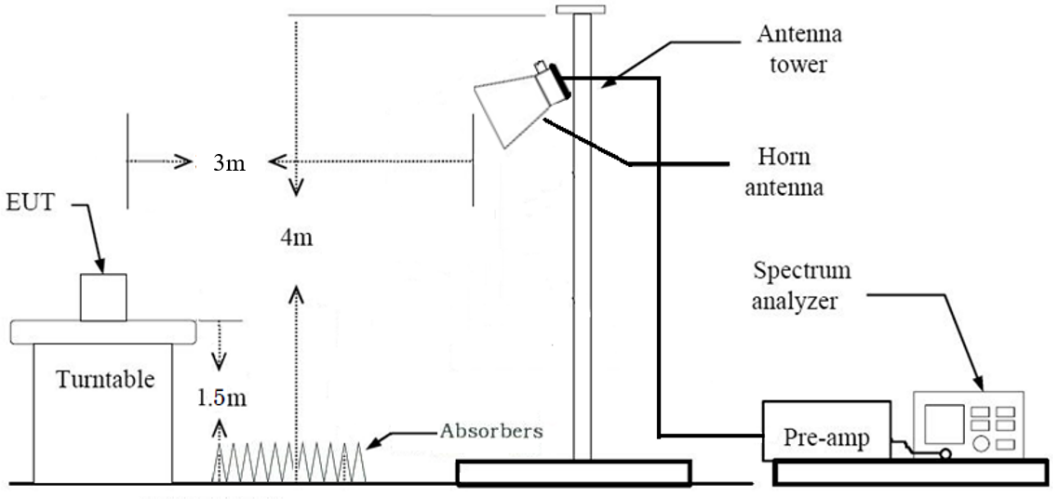
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions (Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3m from the EUT
3. The EUT is placed on a turntable, which is 0.8m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor (0.009 MHz – 0.490 MHz) = 40*log(3 m/300 m) = - 80 dB
   Measurement Distance: 3 m
7. Distance Correction Factor (0.490 MHz – 30 MHz) = 40*log(3 m/30 m) = - 40 dB
   Measurement Distance: 3 m
8. Spectrum Setting

   - Frequency Range = 9 kHz ~ 30 MHz
   - Detector = Peak
   - Trace = Max hold
   - RBW = 9 kHz
   - VBW ≥ 3*RBW

9. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L)
10. There is a comparison data both open-field test site and alternative test site – semi-Anechoic chamber according to 414788 D01. And the results are properly calibrated.

Test Procedure of Radiated spurious emissions (Below 1GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8 m above ground plane.
3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
5. Spectrum Setting

   (1) Measurement Type (Peak):
   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Peak
   - Trace = Max hold
   - RBW = 100 kHz
   - VBW ≥ 3*RBW

   (2) Measurement Type(Quasi-peak):
   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Quasi-Peak
   - RBW = 120 kHz

   Method (2) has been applied

6. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L)

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. Use the following Spectrum Analyzer setting :

   (1) Measurement Type(Peak):
   - Measured Frequency Range : Upto 10^{th} harmonics
   - Detector = Peak
   - Trace = Max hold
   - RBW = 1 MHz
   - VBW ≥ 3*RBW

   (2) Measurement Type(Average):
   - Duty Cycle Correction Factor (DCCF) was applied to derive the average field strength from the peak field strength according to the rule part 15.35(c).
   - Duty Cycle = T_{ON} / 100 ms (or T_{ON} / One complete pulse train), whichever comes shorter.
   - TON = No (Pulse1) x Length (Pulse1) + No (Pulse2) x Length (Pulse2) + …
   - Average Emission Level = Peak Emission Level + 20 log(Duty Cycle)

8. Measurement value only up to 6 maximum emissions noted or would be lesser if no specific emissions from the EUT are recorded (i.e.: margin > 20 dB from the applicable limit) and considered that is already beyond the background noise floor.

9. Sample Calculation

   (1) Total (Peak) = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)
   (2) Total (Average) = Total (Peak) + 20 log(Duty Cycle)

8.8. AC POWER LINE CONDUCTED EMISSIONS

Limit

47 CFR § 15.207, RSS-GEN Section 8.8

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency.
voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.

According to FCC KDB 174176 D01 Line Conducted FAQ v01r01 :

Devices Operating Above 30 MHz

For a device with a permanent or detachable antenna operating above 30 MHz, measurements must be performed with the antenna connected as specified in clause 6.2 of ANSI C63.10-2013.

Devices Operating Below 30 MHz

For a device with a permanent or detachable antenna operating at or below 30 MHz, the FCC will accept measurements performed with a suitable dummy load in lieu of the antenna under the following conditions:

(1) Perform the AC power-line conducted tests with the antenna connected to determine compliance with Section 15.207 limits outside the transmitter's fundamental emission band;

(2) Retest with a dummy load in lieu of the antenna to determine compliance with Section 15.207 limits within the transmitter's fundamental emission band. For a detachable antenna, remove the antenna and connect a suitable dummy load to the antenna connector. For a permanent antenna, remove the antenna and terminate the RF output with a dummy load or network which simulates the antenna in the fundamental frequency band. All measurements must be performed as specified in clause 6.2 of ANSI C63.10-2013.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

9. TEST RESULT

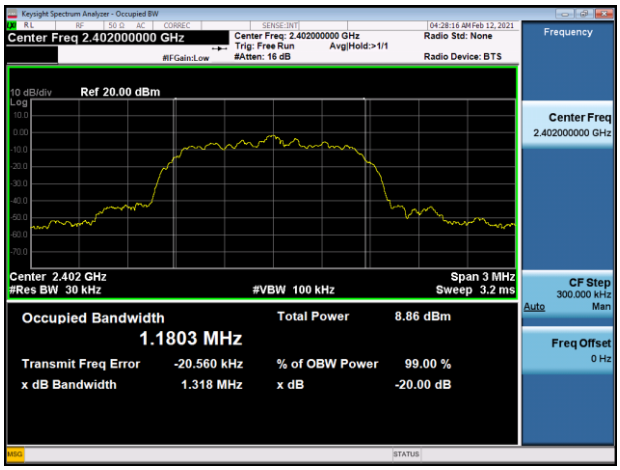
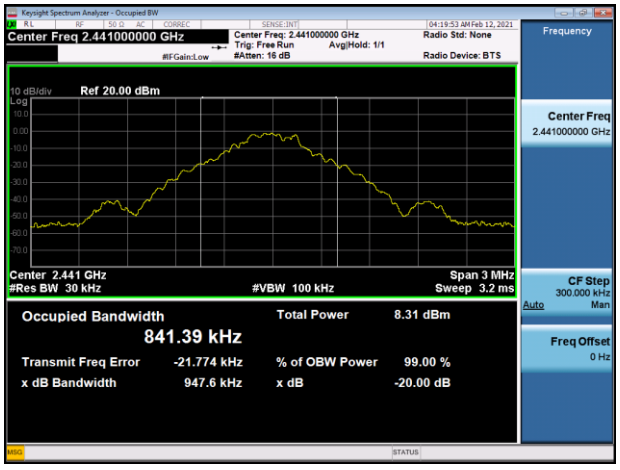
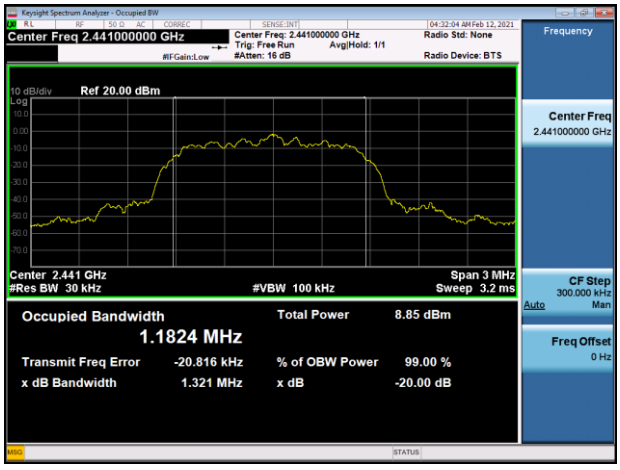
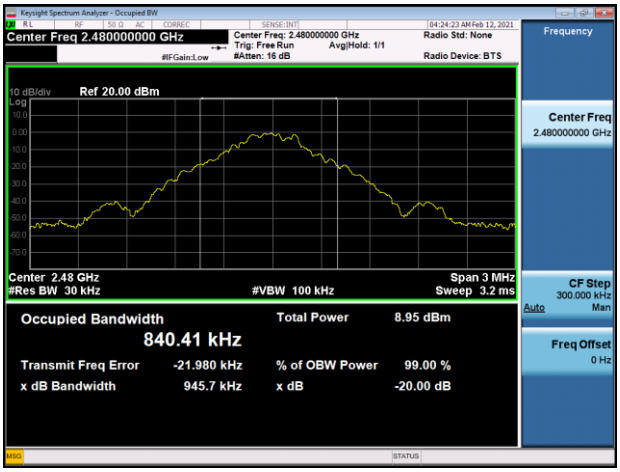
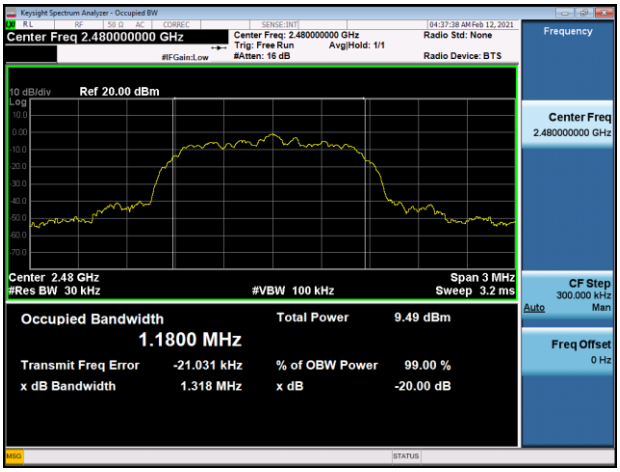
9.1. 20 dB BANDWIDTH / 99% BANDWIDTH MEASUREMENT

BDR (GFSK)		99% Bandwidth (kHz)	20 dB Bandwidth (kHz)	
Frequency (MHz)	Channel	Result	Result	Limit
2402	0	841.63	948.96	≤ 500
2441	39	841.39	947.61	
2480	78	840.41	945.71	

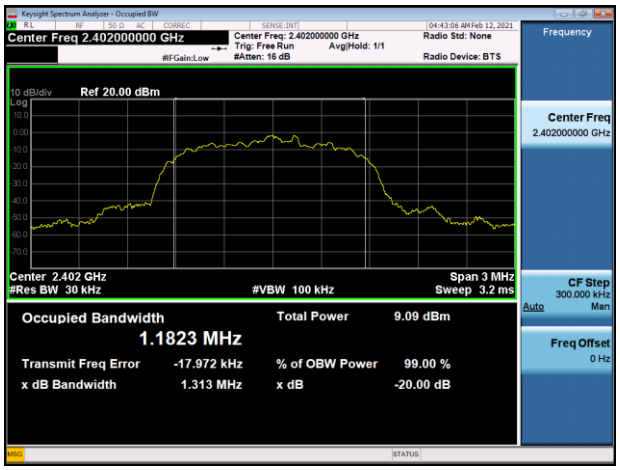
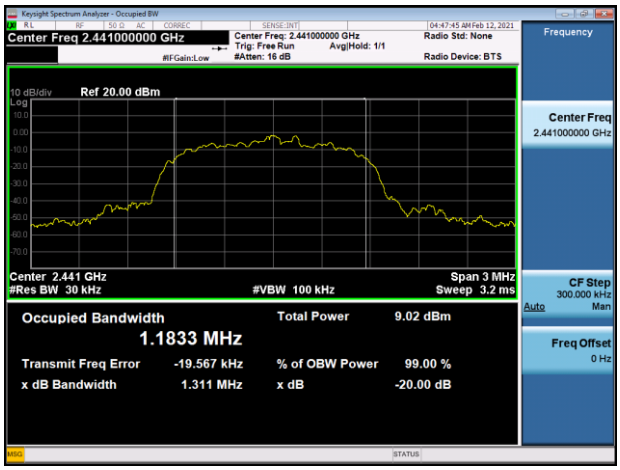
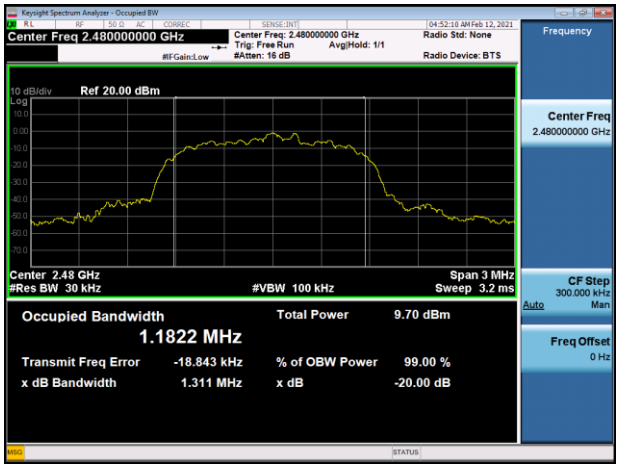
EDR (π/4-DQPSK)		99% Bandwidth (kHz)	20 dB Bandwidth (kHz)	
Frequency (MHz)	Channel	Result	Result	Limit
2402	0	1180.35	1317.84	≤ 500
2441	39	1182.41	1321.11	
2480	78	1180.00	1318.22	

EDR (8DPSK)		99% Bandwidth (kHz)	20 dB Bandwidth (kHz)	
Frequency (MHz)	Channel	Result	Result	Limit
2402	0	1182.32	1313.23	≤ 500
2441	39	1183.34	1311.30	
2480	78	1182.25	1310.95	

▣ TEST PLOTS

BDR (GFSK) : 20dB BW / OBW (CH0)	EDR (π/4-DQPSK) : 20dB BW / OBW (CH0)
	
BDR (GFSK) : 20dB BW / OBW (CH39)	**EDR (π/4-DQPSK) : 20dB BW / OBW (CH39)**
	
BDR (GFSK) : 20dB BW / OBW (CH78)	**EDR (π/4-DQPSK) : 20dB BW / OBW (CH78)**
	

▣ TEST PLOTS

EDR (8DPSK) : 20dB BW / OBW (CH0)	EDR (8DPSK) : 20dB BW / OBW (CH39)
	
EDR (8DPSK) : 20dB BW / OBW (CH78)	
	

9.2. OUTPUT POWER

Peak Power

BDR (GFSK)		Test Result		
Frequency (MHz)	Channel No.	Measured Power (dBm)	Limit (dBm)	Result
2402	0	1.493	30	Compliant
2441	39	1.447	30	Compliant
2480	78	2.209	30	Compliant

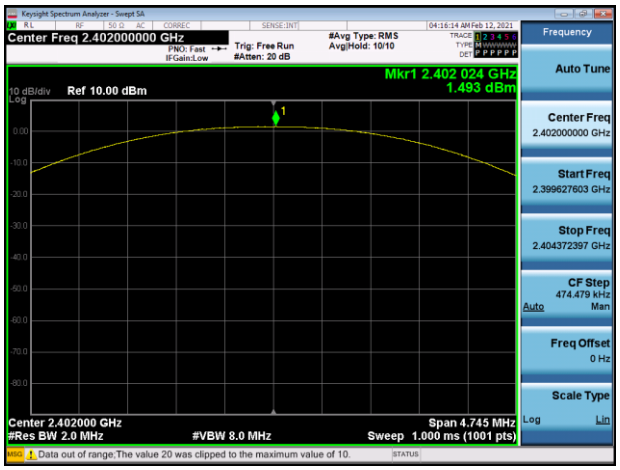
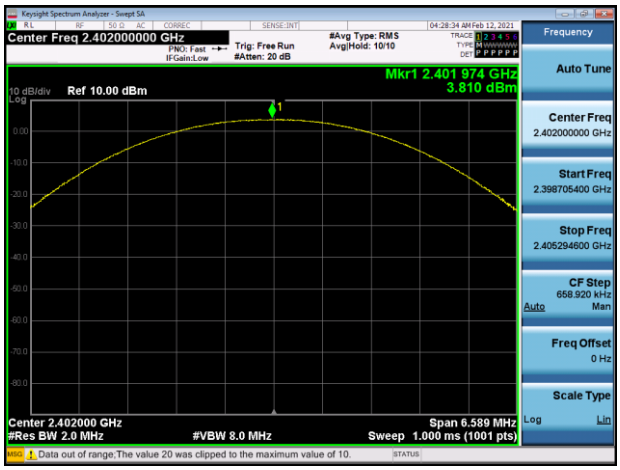
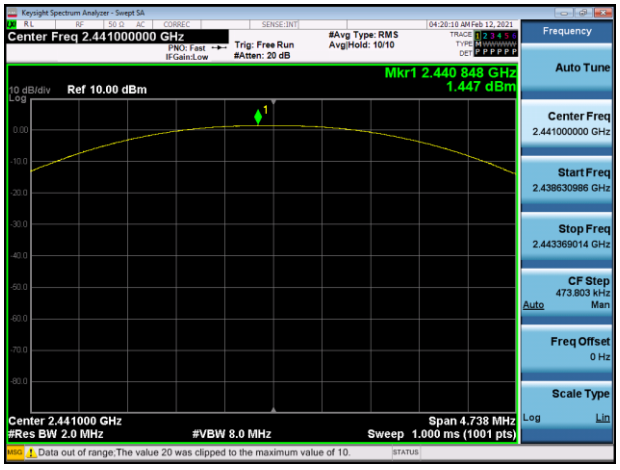
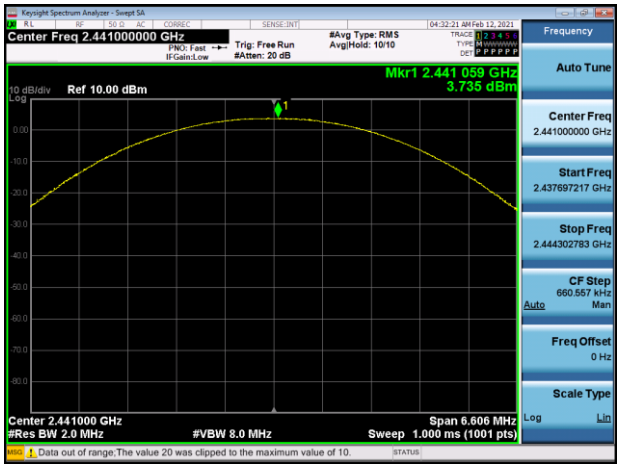
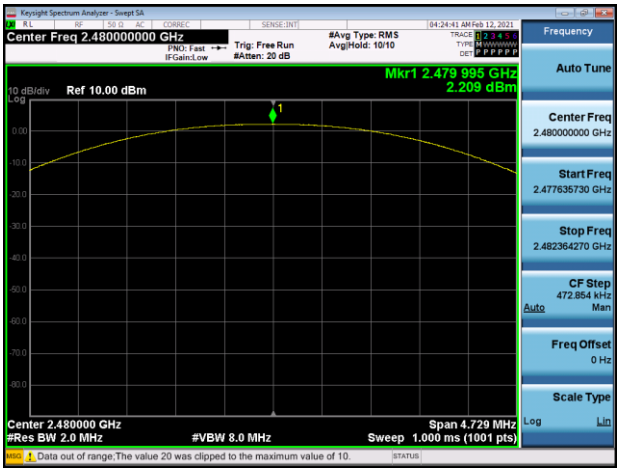
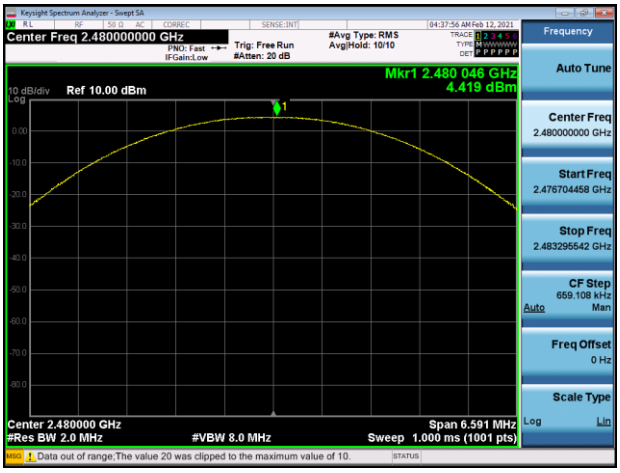
EDR (π/4-DQPSK)		Test Result		
Frequency (MHz)	Channel No.	Measured Power (dBm)	Limit (dBm)	Result
2402	0	3.810	30	Compliant
2441	39	3.735	30	Compliant
2480	78	4.419	30	Compliant

EDR (8DPSK)		Test Result		
Frequency (MHz)	Channel No.	Measured Power (dBm)	Limit (dBm)	Result
2402	0	4.261	30	Compliant
2441	39	4.193	30	Compliant
2480	78	4.924	30	Compliant

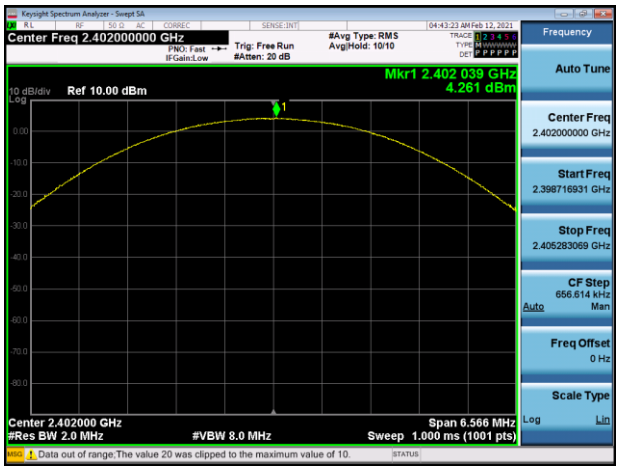
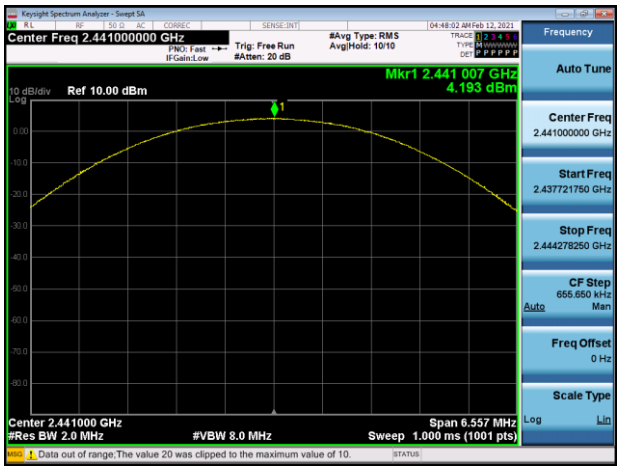
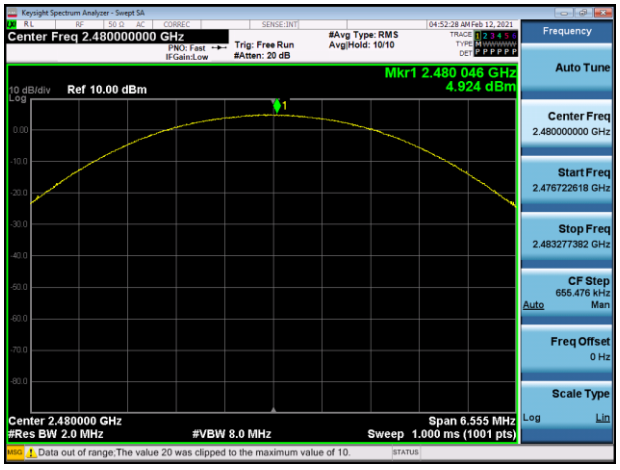
Note :

1. The output power results in plot include the spectrum offset, which is a combination loss of the attenuator and the cable used for testing

▣ TEST PLOTS

BDR (GFSK) : Output Power (CH0)	EDR (π/4-DQPSK) : Output Power (CH0)
	
BDR (GFSK) : Output Power (CH39)	**EDR (π/4-DQPSK) : Output Power (CH39)**
	
BDR (GFSK) : Output Power (CH78)	**EDR (π/4-DQPSK) : Output Power (CH78)**
	

▣ TEST PLOTS

EDR (8DPSK) : Output Power (CH0)	EDR (8DPSK) : Output Power (CH39)
	
EDR (8DPSK) : Output Power (CH78)	
	

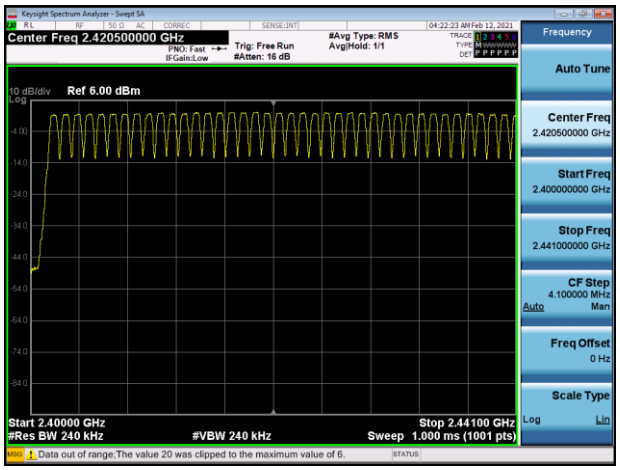
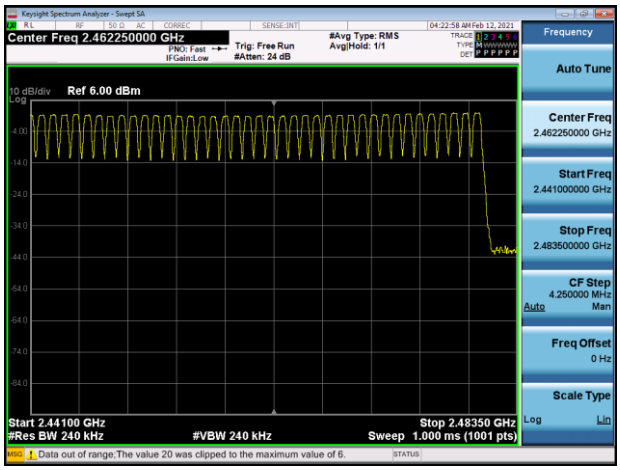
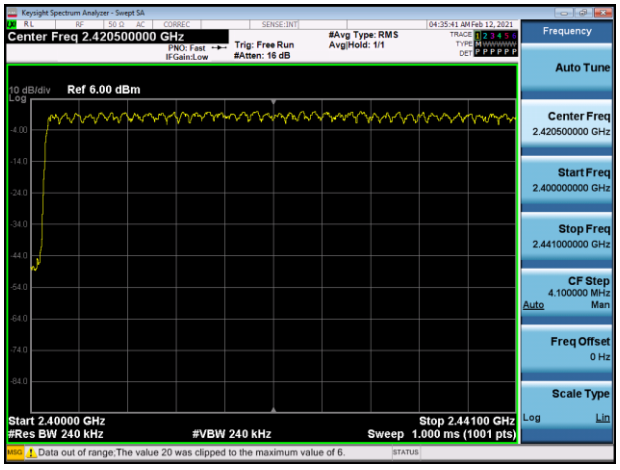
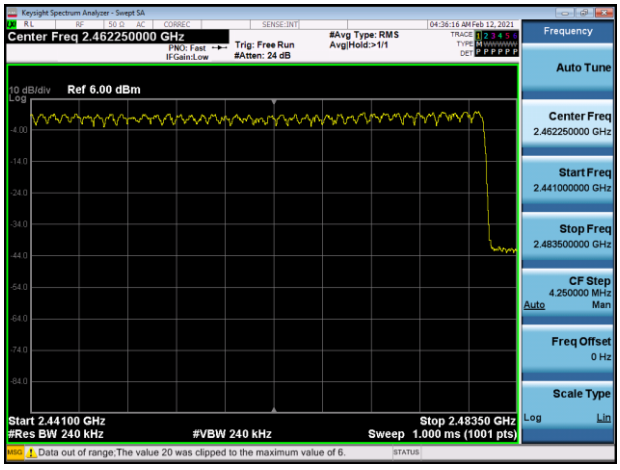
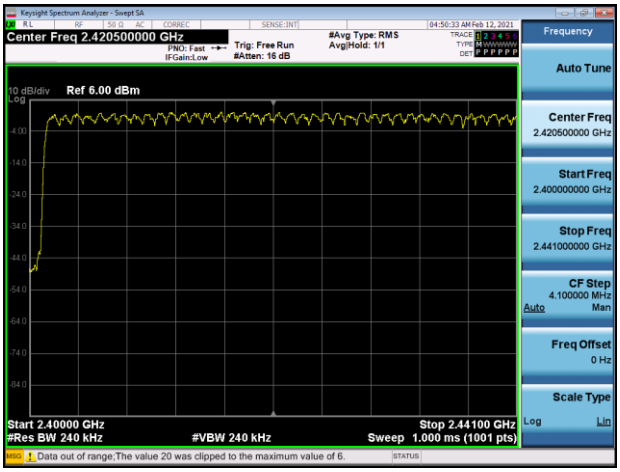
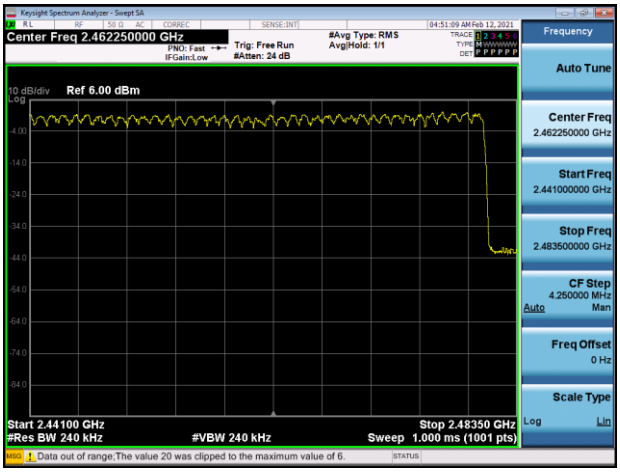
9.3. NUMBER OF HOPPING CHANNELS

BDR (GFSK)	Test Result		
Frequency Range (MHz)	No. of Channels	Limit	Result
2402 – 2480	79	≥ 50	Compliant

EDR (π/4-DQPSK)	Test Result		
Frequency Range (MHz)	No. of Channels	Limit	Result
2402 – 2480	79	≥ 50	Compliant

EDR (8DPSK)	Test Result		
Frequency Range (MHz)	No. of Channels	Limit	Result
2402 – 2480	79	≥ 50	Compliant

▣ TEST PLOTS

BDR (GFSK) : Number of Hopping Channels	
	
EDR (π/4-DQPSK) : Number of Hopping Channels	
	
EDR (8DPSK) : Number of Hopping Channels	
	

9.4. CARRIER FREQUENCY SEPARATION

Mode	Test Result		
	Separation (kHz)	Limit (kHz) [1)]	Result
BRD (GFSK)	997.78	≥ 632.64	Compliant
EDR (π/4-DQPSK)	977.75	≥ 880.74	Compliant
EDR (8DPSK)	977.75	≥ 875.48	Compliant

Note :
1. 2/3 of 20 dB BW was used as the limit since it is greater than 25 kHz.

▣ TEST PLOTS

BDR (GFSK)	EDR (π/4-DQPSK)
	
EDR (8DPSK)	
	

9.5. TIME OF OCCUPANCY

Mode	Data Rate	Frequency (MHz)	Pulse Time (ms)	No of Hops	Dwell Time (ms)	Limit (ms)	Result
BDR (GFSK)	1-DH1	2441	0.374	320	119.81	≤ 400	Compliant
	1-DH3	2441	1.630	160	260.80		Compliant
	1-DH5	2441	2.878	106.6	306.99		Compliant
EDR (π/4-DQPSK)	2-DH1	2441	0.390	320	124.80	≤ 400	Compliant
	2-DH3	2441	1.638	160	262.08		Compliant
	2-DH5	2441	2.894	106.6	308.69		Compliant
EDR (8DPSK)	3-DH1	2441	0.382	320	122.30	≤ 400	Compliant
	3-DH3	2441	1.638	160	262.08		Compliant
	3-DH5	2441	2.894	106.6	308.69		Compliant

Note :
Max permitted DH1 packet : 1600 / 79 / 2 = 10.12 hops/sec in each channel.
Number of hops within 31.6 seconds = 10.12 hops/sec x 31.6 sec = 320 hops

Max permitted DH3 packet : 1600 / 79 / 4 = 5.06 hops/sec in each channel.
Number of hops within 31.6 seconds = 5.06 hops/sec x 31.6 sec = 160 hops

Max permitted DH5 packet : 1600 / 79 / 6 = 3.37 hops/sec in each channel.
Number of hops within 31.6 seconds = 3.37 hops/sec x 31.6 sec = 106.6 hops

Time of Occupancy (Dwell Time) = Pulse Time x Number of Hops within 31.6 seconds.