FCC PART 15.247

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TEST REPORT

For

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FCC ID: 2AXUU-IR5000
IC: 26584-IR5000

Report Type:	**Product Type:**
Original Report	Bluetooth Speaker

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Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

Shenzhen Accurate Technology Co., Ltd. is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk '*'. Customer model name, addresses, names, trademarks etc. are not considered data.

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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	Bluetooth Speaker
Tested Model	iR5000
Frequency Range	Bluetooth: 2402~2480MHz
Transmit Power	Bluetooth: 0.41dBm
Modulation Technique	Bluetooth: GFSK, π/4-DQPSK, 8DPSK
Antenna Specification	PCB Antenna: -0.68dBi
Voltage Range	DC 3.7 V from battery or DC 5.0V from adapter(provided by laboratory)
Date of Test	2020-10-22 to 2020-11-03
Sample serial number	RSZ201014801-RF-S1
Received date	2020-10-14
Sample/EUT Status	Good condition

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions rules and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, March 2019 Amendment 1 of the Innovation, Science and Economic Development Canada rules.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, March 2019 Amendment 1 of the Innovation, Science and Economic Development Canada rules.

For Radiated Emissions testing, please refer to DA 00-705 Released March 30, 2000, Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Parameter		Uncertainty
AC Power Lines Conducted Emissions		±2.72dB
Emissions, Radiated	30MHz - 1GHz	±4.28dB
	1GHz- 18GHz	±4.98dB
	18GHz- 26.5GHz	±5.06dB

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the 1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0016.

Listed by Innovation, Science and Economic Development Canada (ISEDC)
The Registration Number is 5077A-2

Accredited by American Association for Laboratory Accreditation (A2LA)
The Certificate Number is 4297.01

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

EUT Exercise Software

“BT_Tool”* exercise software was made to the EUT tested and the power level is 3*. The software and power level was provided by the applicant.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

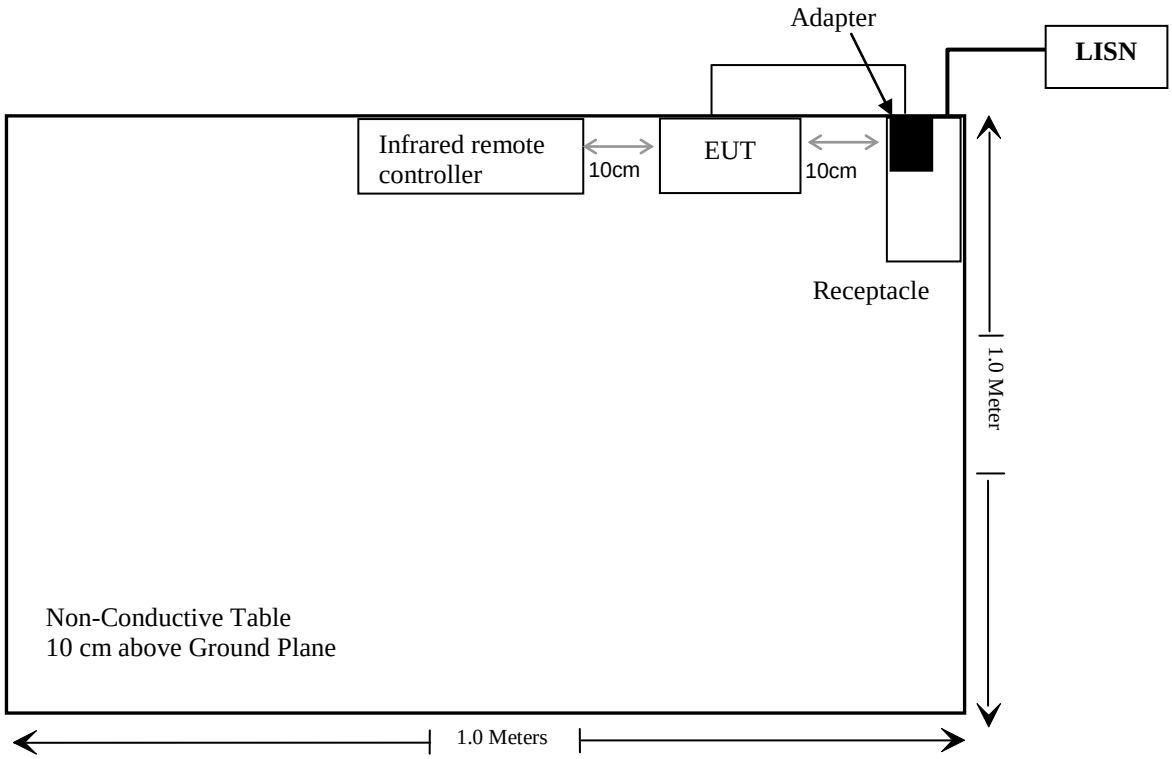
Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
Xiaomi	Adapter	CH-P002	14052760469

External I/O Cable

Cable Description	Length (m)	From/Port	To
Un-shielding Detachable USB Cable	0.4	EUT	Adapter

Block Diagram of Test Setup



SUMMARY OF TEST RESULTS

Rules	Description of Test	Result
FCC §15.247 (i), §2.1091	Maximum Permissible Exposure(MPE)	Compliance
RSS-102 § 2.5.2	Exemption Limits for Routine Evaluation – SAR Evaluation	Compliance
FCC §15.203 RSS-Gen §6.8	Antenna Requirement	Compliance
FCC §15.207(a) RSS-Gen §8.8	AC Line Conducted Emissions	Compliance
FCC §15.205, §15.209, §15.247(d) RSS-247 § 5.5, RSS-GEN § 8.10	Radiated Emissions	Compliance
FCC §15.247(a)(1) RSS-247 § 5.1(a), RSS-GEN § 6.7	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliance
FCC §15.247(a)(1) RSS-247 § 5.1 (b)	Channel Separation Test	Compliance
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Time of Occupancy (Dwell Time)	Compliance
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Quantity of hopping channel Test	Compliance
FCC §15.247(b)(1) RSS-247 § 5.1(b) &§ 5.4(b)	Peak Output Power Measurement	Compliance
FCC §15.247(d) RSS-247 § 5.5	Band edges	Compliance

TEST EQUIPMENT LIST

Conducted Emissions Test/ RF Conducted Test

Item	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
1.	Test Receiver	Rohde & Schwarz	ESCS30	100307	Jan. 04, 2020	1 Year
2.	L.I.S.N.	Schwarzbeck	NLSK8126	8126431	Jan. 04, 2020	1 Year
3.	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100305	Jan. 04, 2020	1 Year
4.	50Ω Coaxial Switch	Anritsu Corp	MP59B	6100237248	Jan. 04, 2020	1 Year
5.	Spectrum Analyzer	Rohde & Schwarz	FSV-40	101495	Jan. 04, 2020	1 Year
6.	Open Switch and Control Unit	Rohde & Schwarz	OSP120 + OSP-B157	101244 + 100866	Jan. 04, 2020	1 Year
Conducted Emission Measurement Software: ES-K1 V1.71						

Radiated Emissions Test

Kind of equipment	Manufacturer	Type	S/N	Calibrated dates	Calibrated until
Test Receiver	Rohde&Schwarz	ESR	101817	Jan. 04, 2020	Jan. 03, 2021
Spectrum Analyzer	Rohde & Schwarz	FSV-40	101495	Jan. 04, 2020	Jan. 03, 2021
Pre-Amplifier	Compliance Direction	RSU-M2	38322	Jan. 04, 2020	Jan. 03, 2021
Pre-Amplifier	Agilent	8447D	294A10619	Jan. 04, 2020	Jan. 03, 2021
Bilog Antenna	Schwarzbeck	VULB9163	9163-323	Jan. 05, 2020	Jan. 04, 2021
Bilog Antenna	Schwarzbeck	VULB9163	9163-194	Jan. 05, 2020	Jan. 04, 2021
Horn Antenna	Schwarzbeck	BBHA9120D	9120D-655	Jan. 05, 2020	Jan. 04, 2021
Horn Antenna	Schwarzbeck	BBHA9120D	9120D-1067	Jan. 05, 2020	Jan. 04, 2021
Quinstar	Amplifier	QLW-18405536-J0	15964001002	Nov. 29, 2017	Nov. 28, 2020
Ducommun Technolagies	Horn antenna	ARH-4223-02	1007726-021304	Dec. 06, 2017	Dec. 05, 2020
Ducommun Technolagies	Horn antenna	ARH-4223-02	1007726-011304	Dec. 06, 2017	Dec. 05, 2020
Ducommun Technolagies	Horn antenna	ARH-2823-02	1007726-021302	Dec. 06, 2017	Dec. 05, 2020
Ducommun Technolagies	Horn antenna	ARH-2823-02	1007726-011302	Dec. 06, 2017	Dec. 05, 2020
Radiated Test Software: EZ_EMC V1.1.4.2					

*** Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (Minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

Frequency (MHz)	**Antenna Gain**		**Tune up conducted power**		**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**MPE Limit (mW/cm^2)**
	(dBi)	**(numeric)**	**(dBm)**	**(mW)**			
2402-2480	-0.68	0.86	1.0	1.26	20	0.0002	1

Note: To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Pass

RSS-102 § 2.5.2 –EXEMPTION LIMITS FOR ROUTINE EVALUATION-RF EXPOSURE EVALUATION

Applicable Standard

According to RSS-102 § (2.5.2):

2.5.2 Exemption Limits for Routine Evaluation — RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz[6] and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $22.48/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2}\ f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

Calculated Data:

The maximum tune-up conducted output power is 1dBm.

And the maximum antenna gain is -0.68dBi.

So the maximum tune-up conducted power is 1dBm=1.26mW<2.68W.

f = 2402 MHz:
The limit is $1.31*10^{-2}*2402^{0.6834}$=2.68W

So the RF Exposure evaluation can be exempted.

FCC §15.203 & RSS-GEN §6.8 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

According to FCC § 15.203, 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.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device. Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

Antenna Connector Construction

The EUT has one internal PCB antenna arrangement which was permanently attached and the maximum antenna gain is -0.68dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Antenna Type	Antenna Gain	Impedance	Frequency Range
PCB	-0.68dBi	50 Ω	2.4~2.5GHz

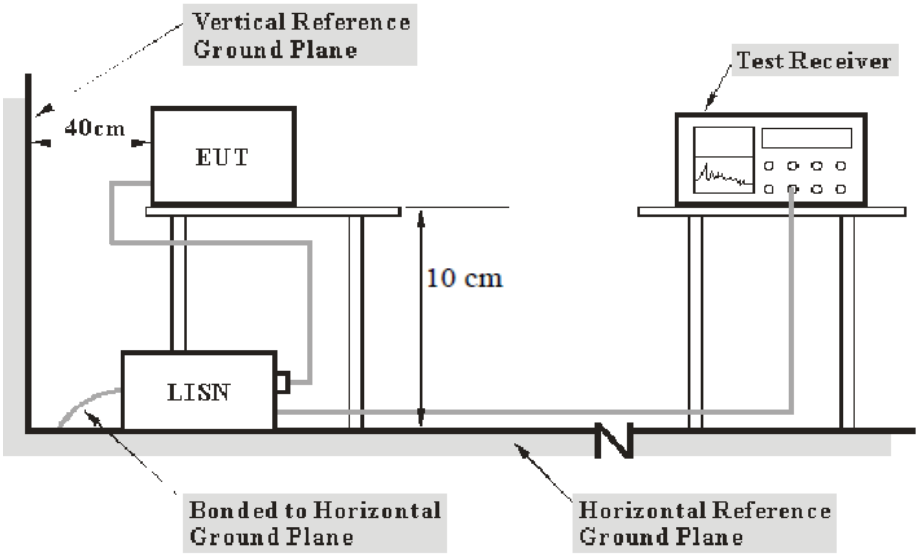
Result: Compliance

FCC §15.207 (a) & RSS-GEN § 8.8 – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a), RSS-GEN § 8.8

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 10 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207 & RSS-Gen.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Data

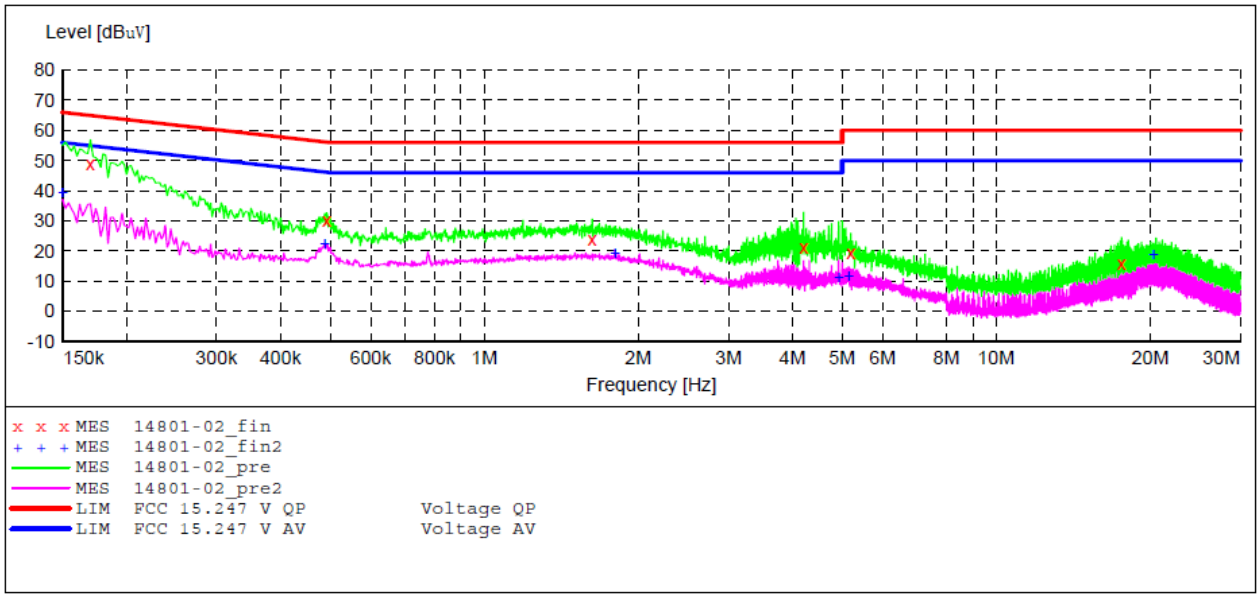
Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	50 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-11-03

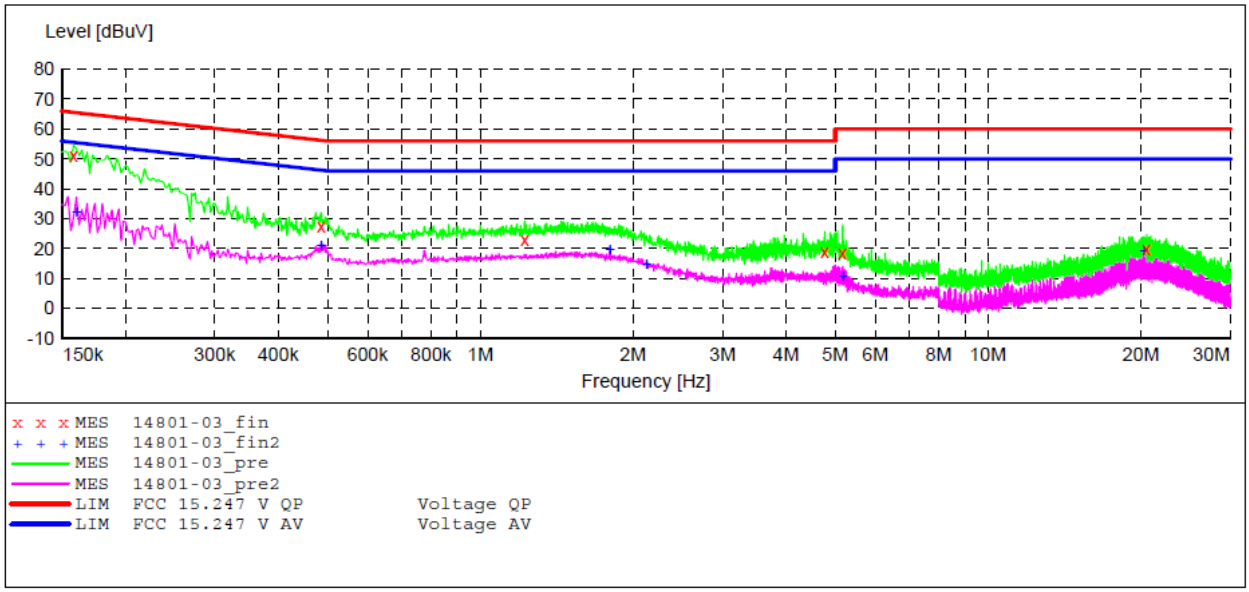
EUT operation mode: Transmitting & charging (the worst case is GFSK Mode, High channel)

AC 120V/60 Hz, Line



Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.170000	49.00	10.8	65.0	16.0	QP
0.492000	30.00	11.0	56.0	26.0	QP
1.624000	23.90	11.2	56.0	32.1	QP
4.205000	21.40	11.4	56.0	34.6	QP
5.200000	19.40	11.4	60.0	40.6	QP
17.580000	15.90	11.7	60.0	44.1	QP
0.150000	39.60	10.8	56.0	16.4	Ave.
0.488000	22.50	11.0	46.0	23.5	Ave.
1.800000	19.60	11.2	46.0	26.4	Ave.
4.925000	11.20	11.4	46.0	34.8	Ave.
5.145000	12.00	11.4	50.0	38.0	Ave.
20.325000	19.10	11.7	50.0	30.9	Ave.

AC 120V/60 Hz, Neutral



Frequency (MHz)	Corrected Amplitude (dBμV)	Correction Factor (dB)	Limit (dBμV)	Margin (dB)	Detector (PK/Ave./QP)
0.158000	51.30	10.8	66.0	14.7	QP
0.486000	27.50	11.0	56.0	28.5	QP
1.224000	22.80	11.2	56.0	33.2	QP
4.770000	19.00	11.4	56.0	37.0	QP
5.175000	18.60	11.4	60.0	41.4	QP
20.555000	20.00	11.7	60.0	40.0	QP
0.160000	32.60	10.8	56.0	23.4	Ave.
0.486000	21.30	11.0	46.0	24.7	Ave.
1.800000	19.70	11.2	46.0	26.3	Ave.
2.125000	14.90	11.3	46.0	31.1	Ave.
5.175000	11.90	11.4	50.0	38.1	Ave.
20.325000	19.60	11.7	50.0	30.4	Ave.

Note:

1) Corrected Amplitude = Reading + Correction Factor
2) Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation
3) Margin = Limit – Corrected Amplitude

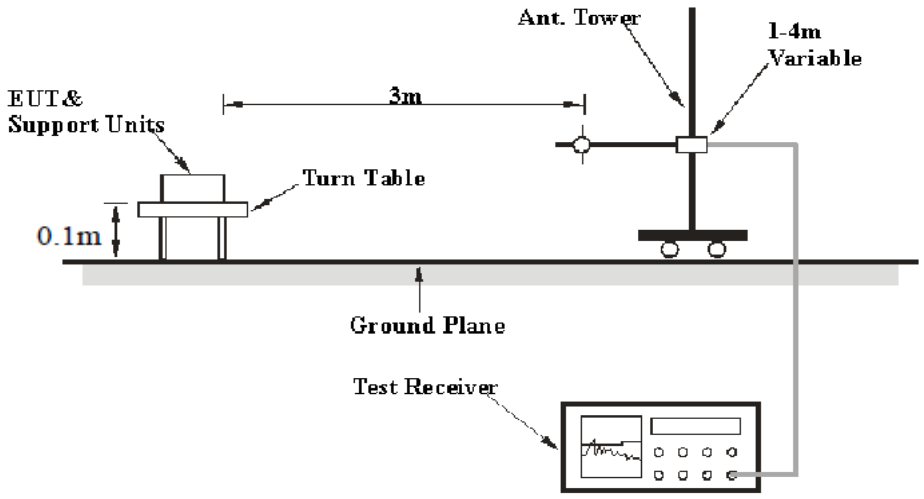
FCC §15.209, §15.205 & §15.247(d) & RSS-247§ 5.5 - SPURIOUS EMISSIONS

Applicable Standard

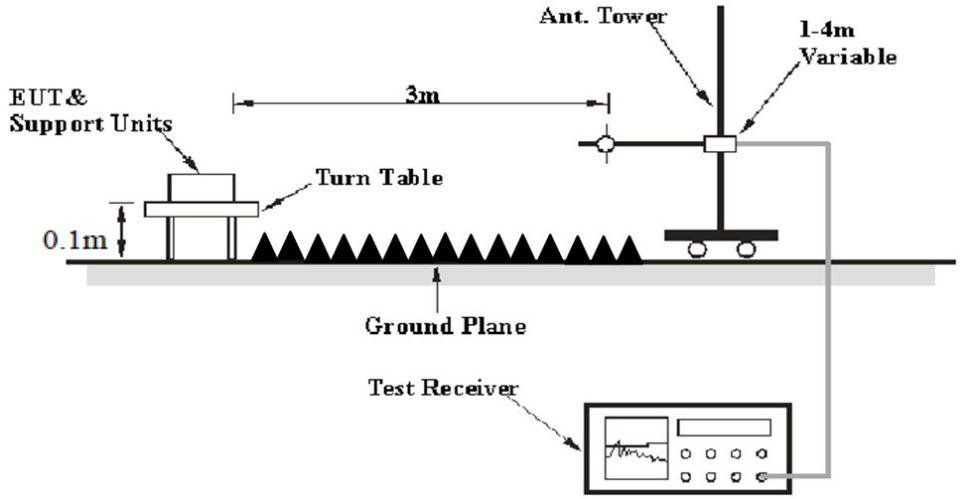
FCC §15.205; §15.209; §15.247(d); RSS-247§ 5.5; RSS-GEN § 8.10

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209, FCC 15.247, RSS-247, RSS-Gen limits.

EMI Test Receiver & Spectrum Analyzer Setup

During the radiated emission test, according to the DA 00-705 Released March 30, 2000, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK
	1 MHz	10 Hz	/	Average

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Data

Environmental Conditions

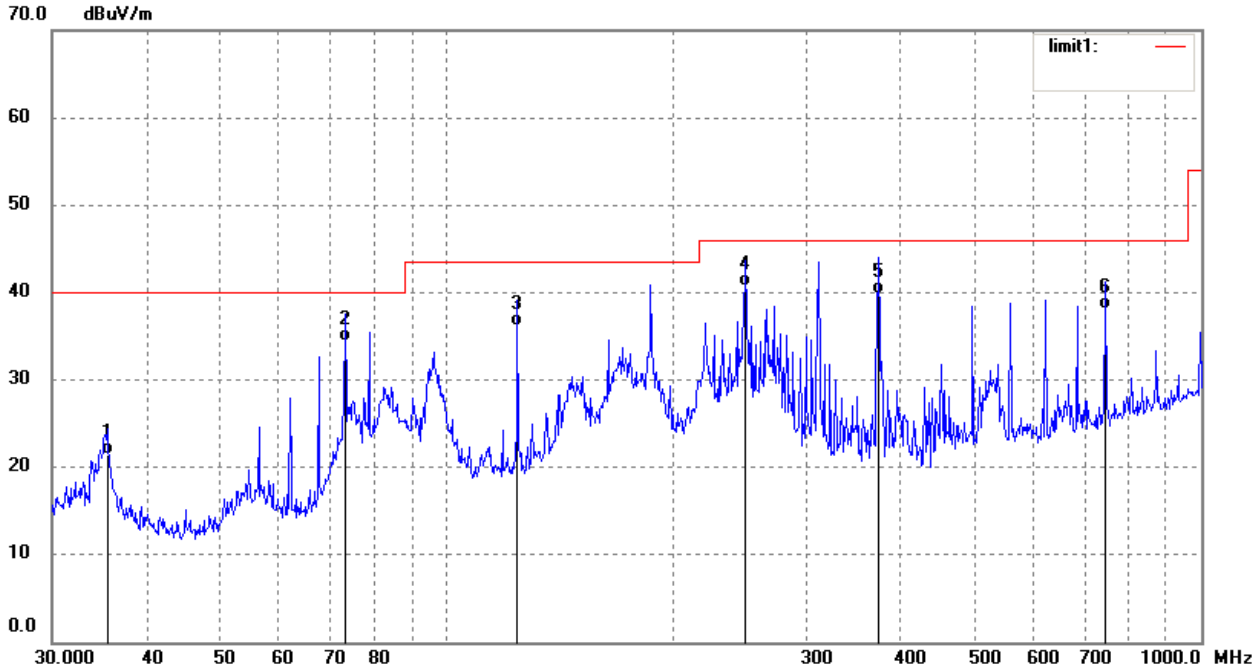
Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-10-22

EUT operation mode: Transmitting (*Scan with GFSK, π/4-DQPSK, 8DPSK mode, the worst case is GFSK Mode*)

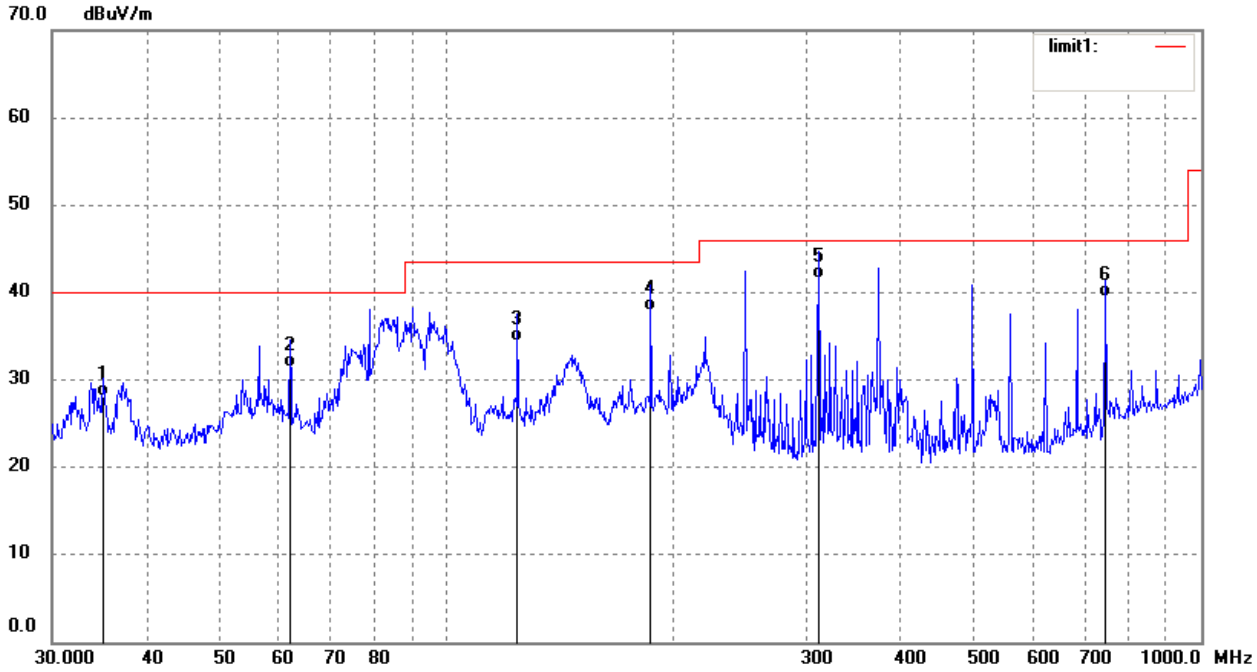
30 MHz~1 GHz: *(the worst case is GFSK Mode, High channel)*

Horizontal



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	35.4992	32.98	-11.53	21.45	40.00	18.55	QP	100	234	
2	73.3593	52.02	-17.55	34.47	40.00	5.53	QP	100	51	
3	124.1329	50.74	-14.64	36.10	43.50	7.40	QP	100	117	
4	248.5518	52.48	-11.78	40.70	46.00	5.30	QP	100	153	
5	373.3110	48.20	-8.46	39.74	46.00	6.26	QP	100	276	
6	747.4825	40.20	-2.07	38.13	46.00	7.87	QP	200	310	

Vertical



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	35.1278	39.56	-11.45	28.11	40.00	11.89	QP	100	336	
2	61.9951	47.15	-15.65	31.50	40.00	8.50	QP	100	5	
3	124.1330	49.10	-14.64	34.46	43.50	9.04	QP	100	103	
4	186.4409	51.60	-13.69	37.91	43.50	5.59	QP	100	75	
5	311.0867	51.64	-9.99	41.65	46.00	4.35	QP	100	231	
6	747.4825	41.50	-2.07	39.43	46.00	6.57	QP	100	154	

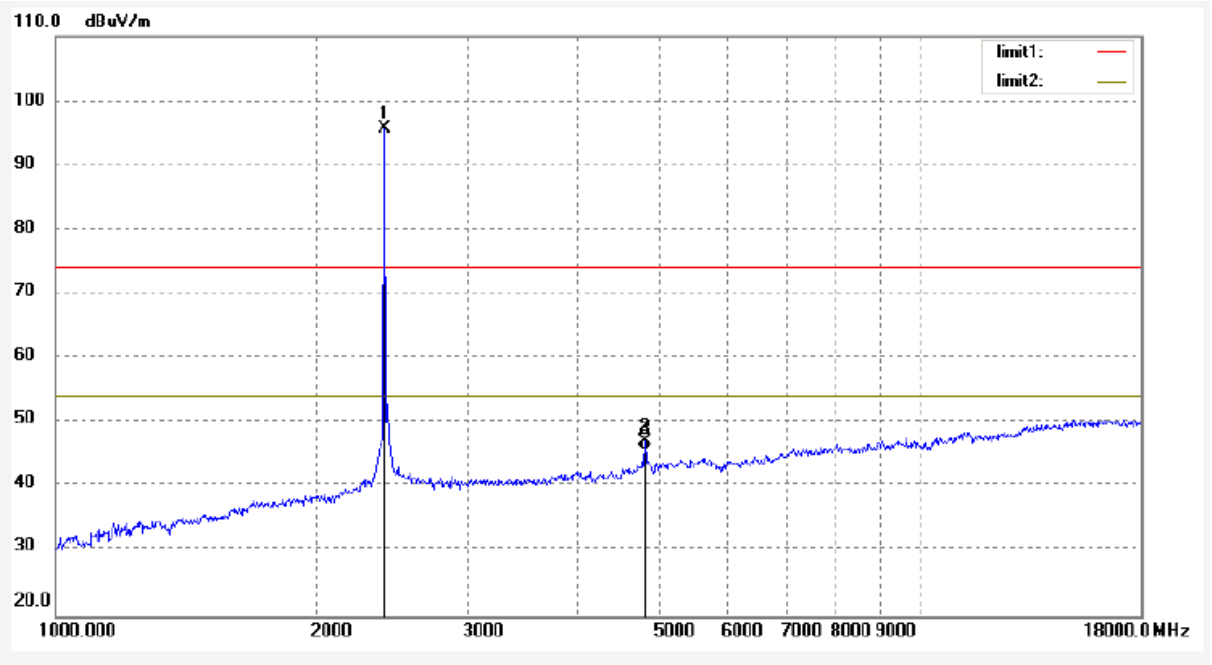
1 GHz - 25 GHz: (*Scan with GFSK, π/4-DQPSK, 8DPSK mode, the worst case is in GFSK Mode*)

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	FCC 15.209/RSS-247	
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)			Limit (dBμV/m)	Margin (dB)
Low Channel (2402 MHz)									
2375.92	45.67	PK	229	1.5	H	1.10	43.60	74	25.40
2375.92	35.01	Ave.	229	1.5	H	1.10	38.83	54	15.17
2390.00	41.06	PK	302	1.5	H	1.10	43.89	74	30.11
2390.00	31.23	Ave.	302	1.5	H	1.10	34.35	54	19.65
4804.00	39.65	PK	216	1.5	H	7.40	47.05	74	26.95
4804.00	38.41	Ave.	216	1.5	H	7.40	45.81	54	8.19
Middle Channel (2441 MHz)									
4882.00	38.80	PK	13	1.5	H	7.61	46.41	74	27.59
4882.00	37.29	Ave.	13	1.5	H	7.61	44.90	54	9.10
High Channel (2480 MHz)									
2483.50	50.41	PK	77	1.5	H	1.60	52.01	74	21.99
2483.50	41.04	Ave.	77	1.5	H	1.60	42.64	54	11.36
2500.00	42.52	PK	125	1.5	H	1.60	44.12	74	29.88
2500.00	32.63	Ave.	125	1.5	H	1.60	34.23	54	19.77
4960.00	38.11	PK	147	1.5	H	8.10	46.21	74	27.79
4960.00	36.60	Ave.	147	1.5	H	8.10	44.70	54	9.30

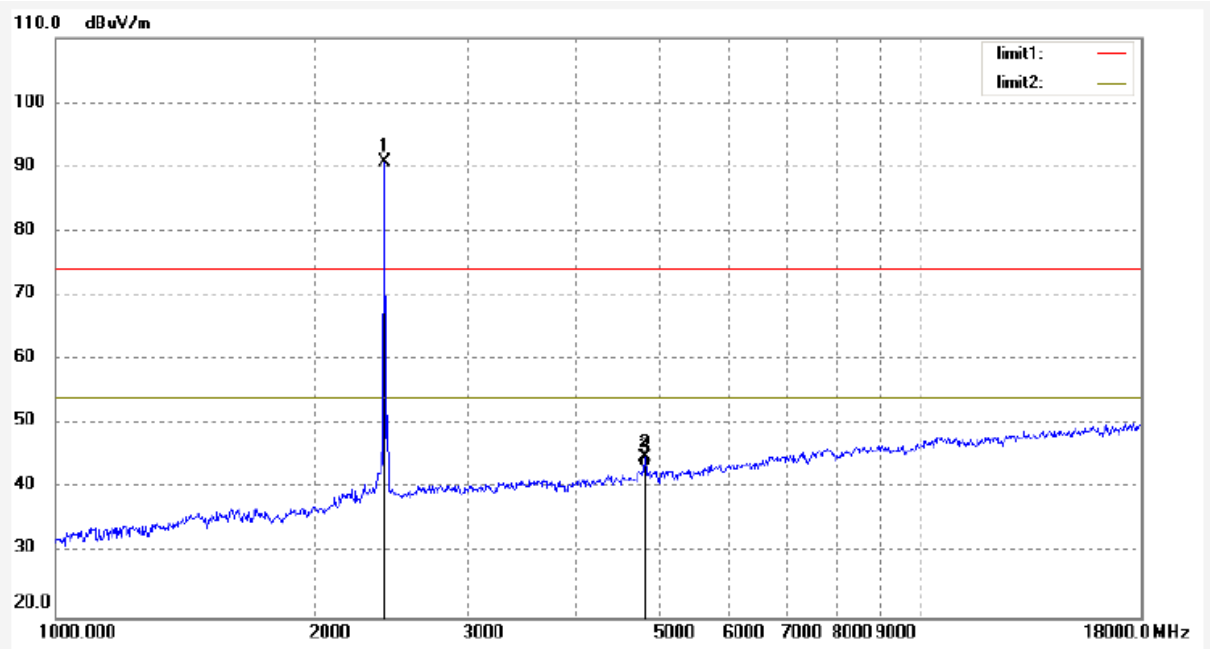
Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude
The other spurious emission which is 20dB to the limit was not recorded.

Test plots for Pre-scan:

Horizontal



Vertical



FCC §15.247(a) (1) & RSS-247 § 5.1 (b) -CHANNEL SEPARATION TEST

Applicable Standard

According to FCC §15.247(a) (1):

Frequency hopping systems shall have hoping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

According to RSS-247 § 5.1 (b):

Frequency hopping systems (FHSs) shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Test Procedure

1. Set the EUT in transmitting mode, max hold the channel.
2. Set the adjacent channel of the EUT and max hold another trace.
3. Measure the channel separation.

Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-10-31.

EUT operation mode: Transmitting

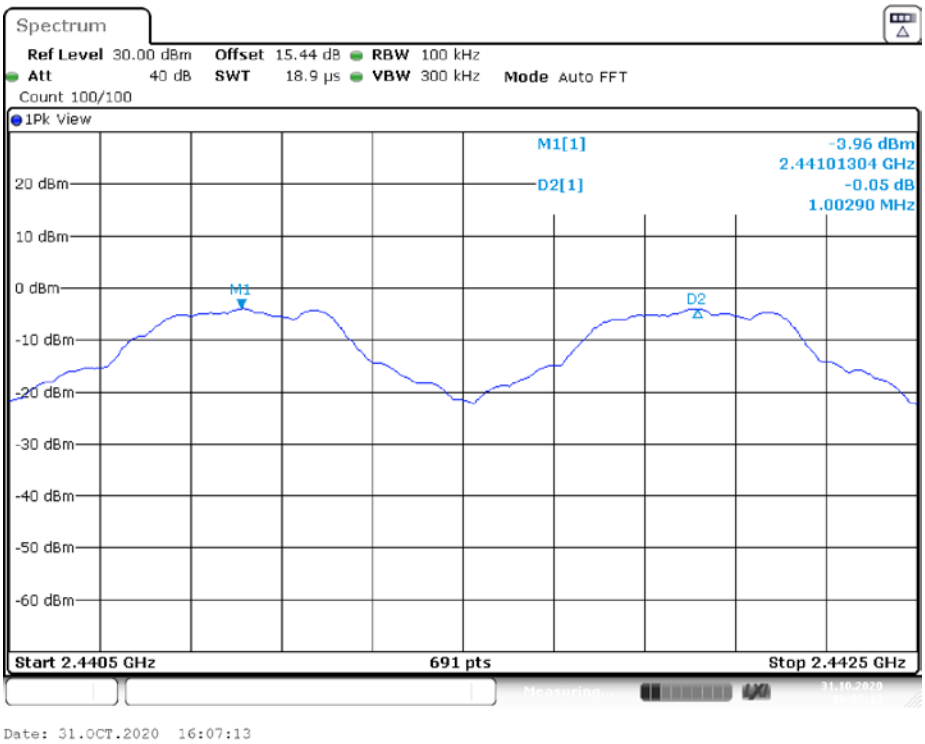
Test Result: Pass

Please refer to following table and plots.

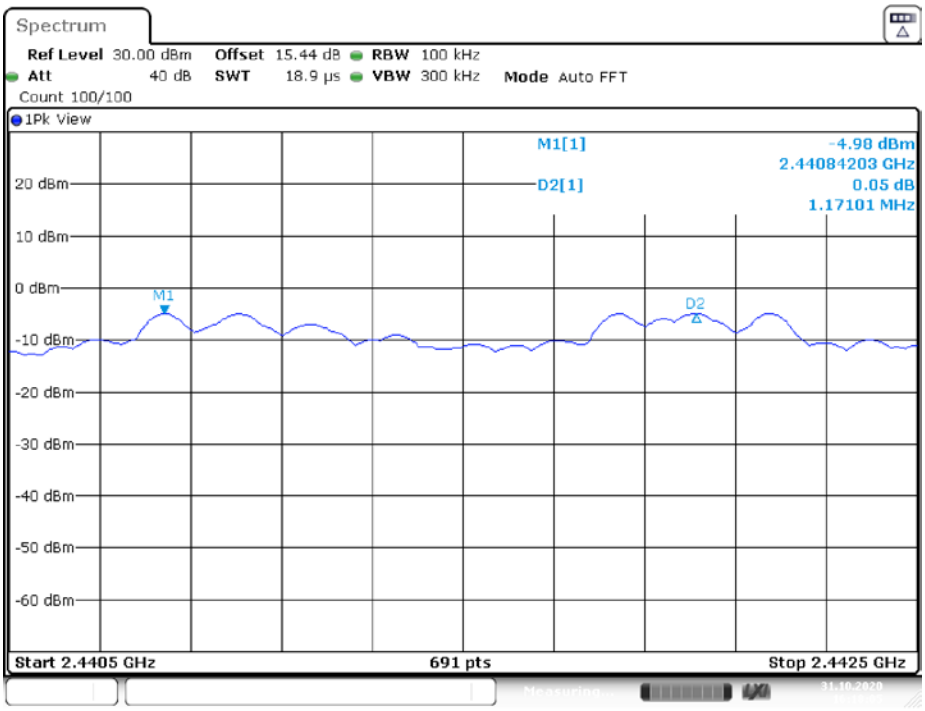
Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	≥Limit (MHz)	Result
BDR (GFSK)	Middle	2441	1.003	0.704	Pass
	Adjacent	2442			
EDR (π/4-DQPSK)	Middle	2441	1.17	0.928	Pass
	Adjacent	2442			
EDR (8DPSK)	Middle	2441	1.003	0.922	Pass
	Adjacent	2442			

Note: the limit = (2/3) * 20dB bandwidth

BDR (GFSK): Middle Channel

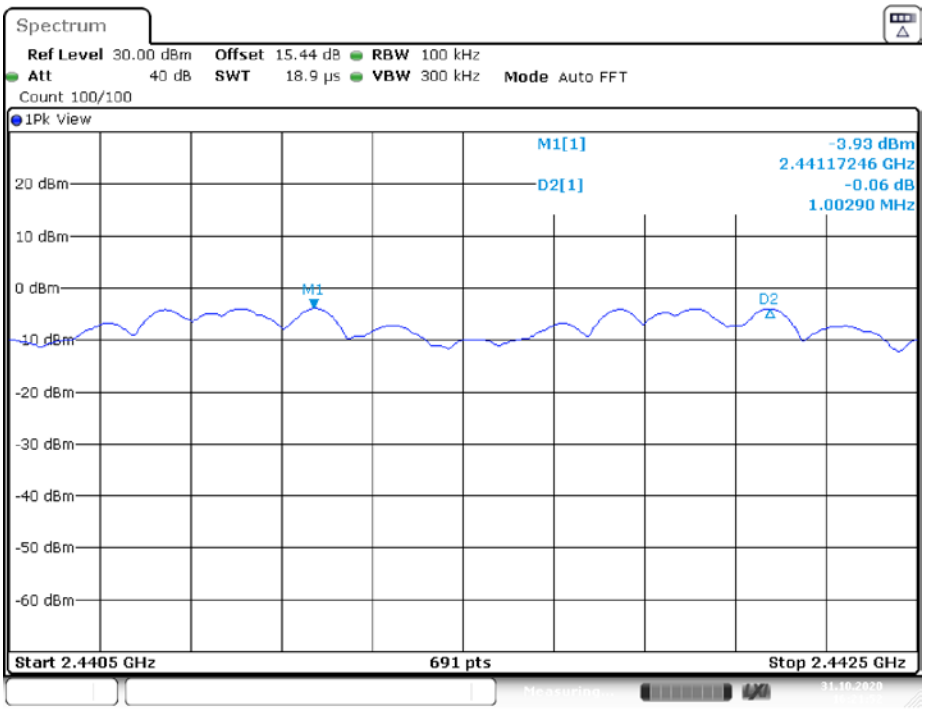


EDR (π/4-DQPSK): Middle Channel



Date: 31.OCT.2020 16:18:05

EDR (8DPSK): Middle Channel



Date: 31.OCT.2020 16:21:52

FCC §15.247(a) (1) & RSS-247 § 5.1 (a), RSS-GEN § 6.7 – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

According to FCC §15.247(a) (1):

Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

According to RSS-247 § 5.1 (a), RSS-GEN § 6.7:

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the "20 dB bandwidth" is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 20 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

Test Procedure

The following conditions shall be observed for measuring the occupied bandwidth and 20 dB bandwidth:
• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / 20 dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 20 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.
For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-10-31

EUT operation mode: Transmitting

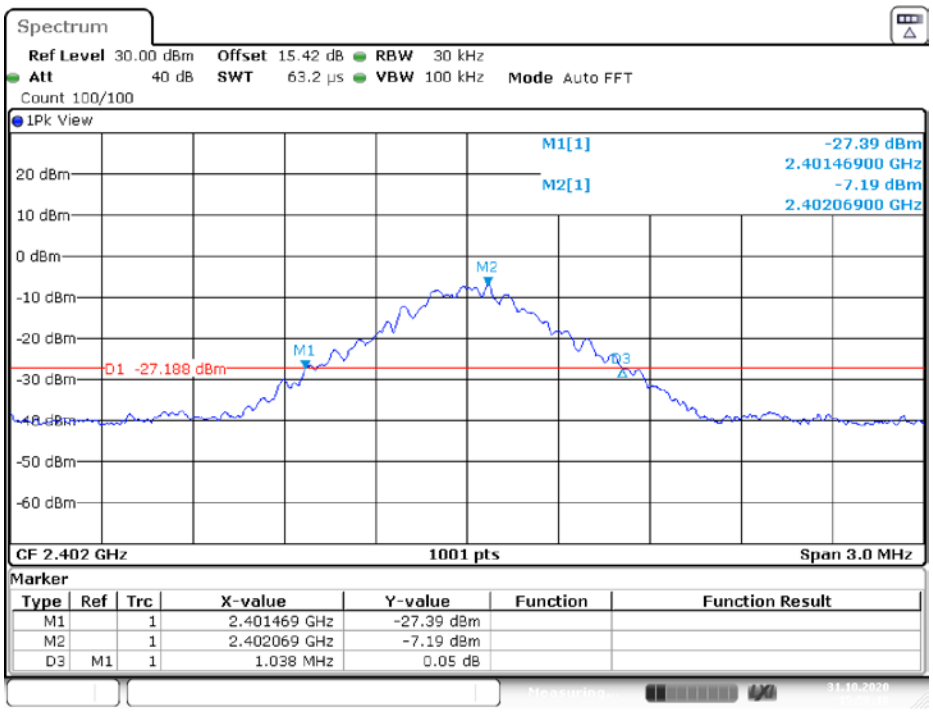
Test Result: Pass

Please refer to following table and plots.

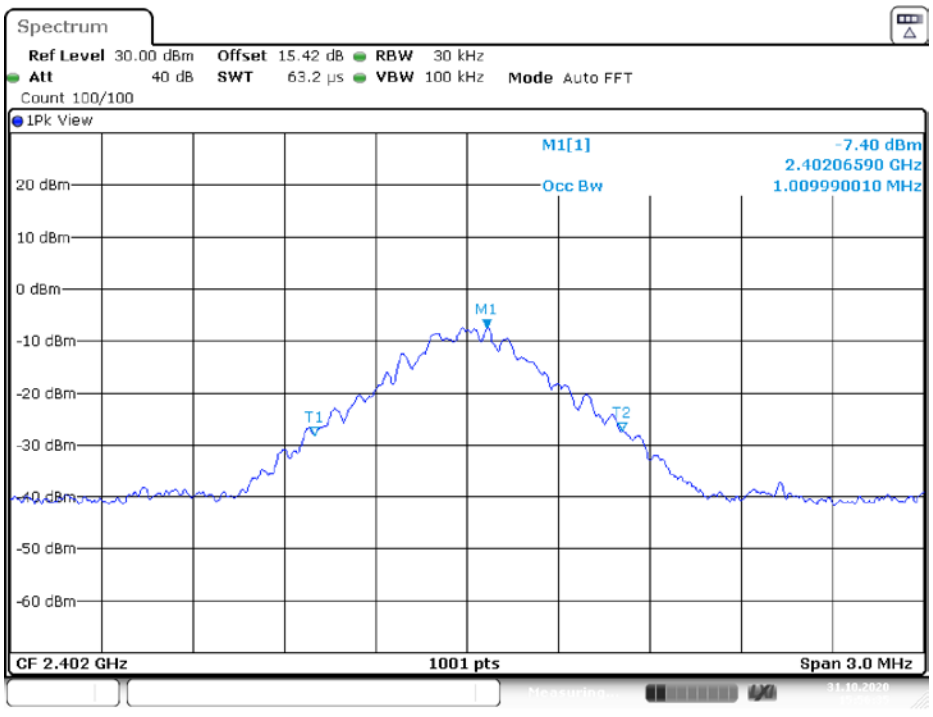
Mode	Frequency (MHz)	99% Occupied Bandwidth (MHz)	20 dB Emission Bandwidth (MHz)
BDR (GFSK)	2402	1.01	1.038
	2441	1.001	1.038
	2480	1.043	1.056
EDR (π/4-DQPSK)	2402	1.256	1.386
	2441	1.262	1.392
	2480	1.283	1.395
EDR (8DPSK)	2402	1.259	1.380
	2441	1.265	1.383
	2480	1.268	1.377

BDR (GFSK):

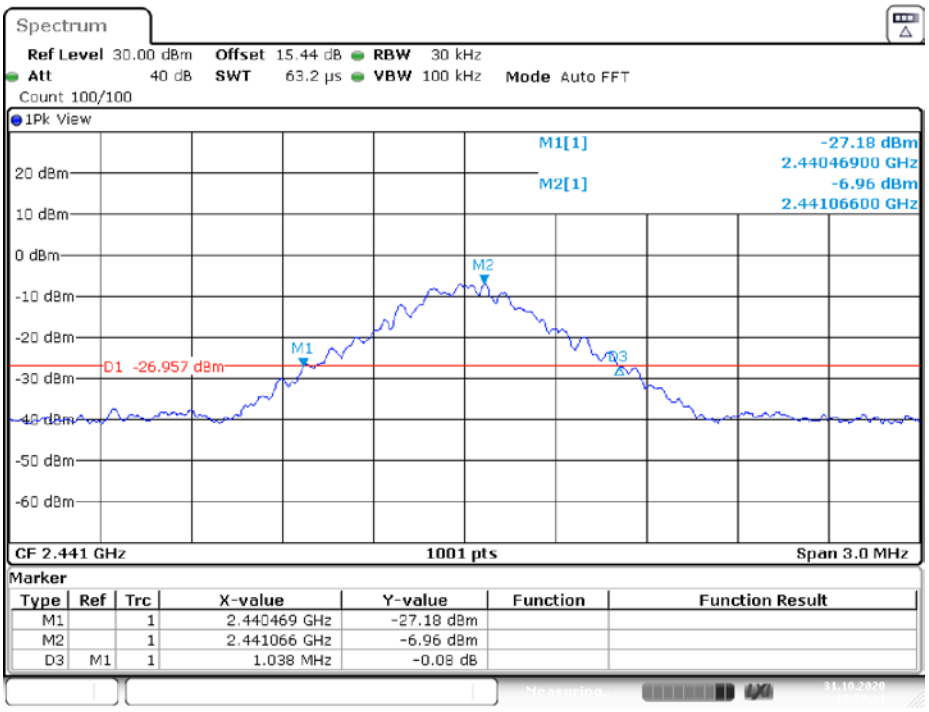
20dB Emission Bandwidth, Low Channel



99% Occupied Bandwidth, Low Channel

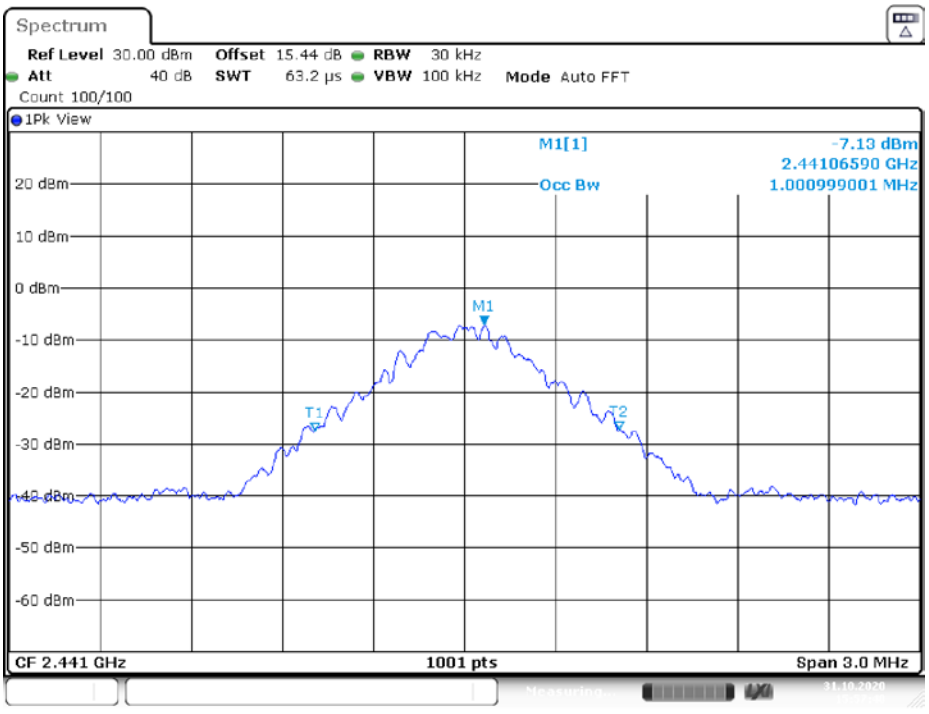


20dB Emission Bandwidth, Middle Channel



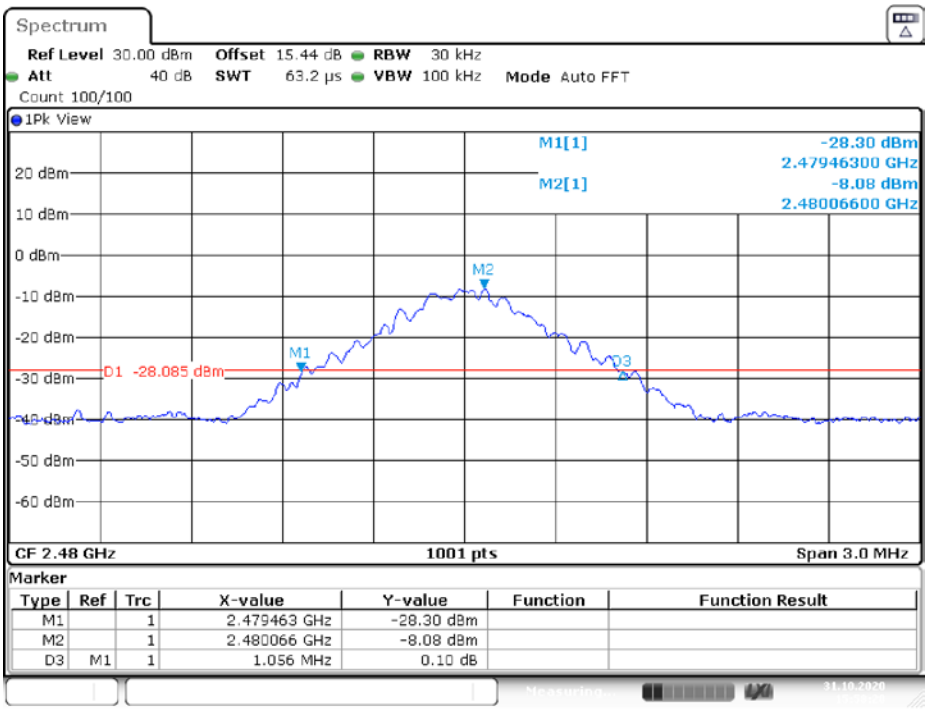
Date: 31.OCT.2020 15:57:32

99% Occupied Bandwidth, Middle Channel

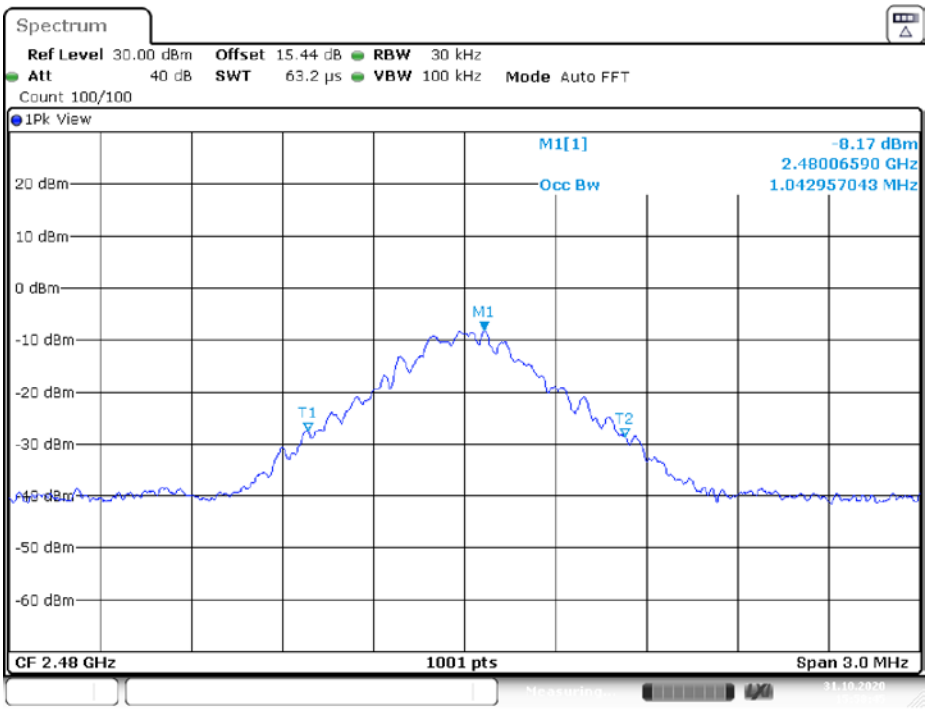


Date: 31.OCT.2020 15:57:49

20dB Emission Bandwidth, High Channel



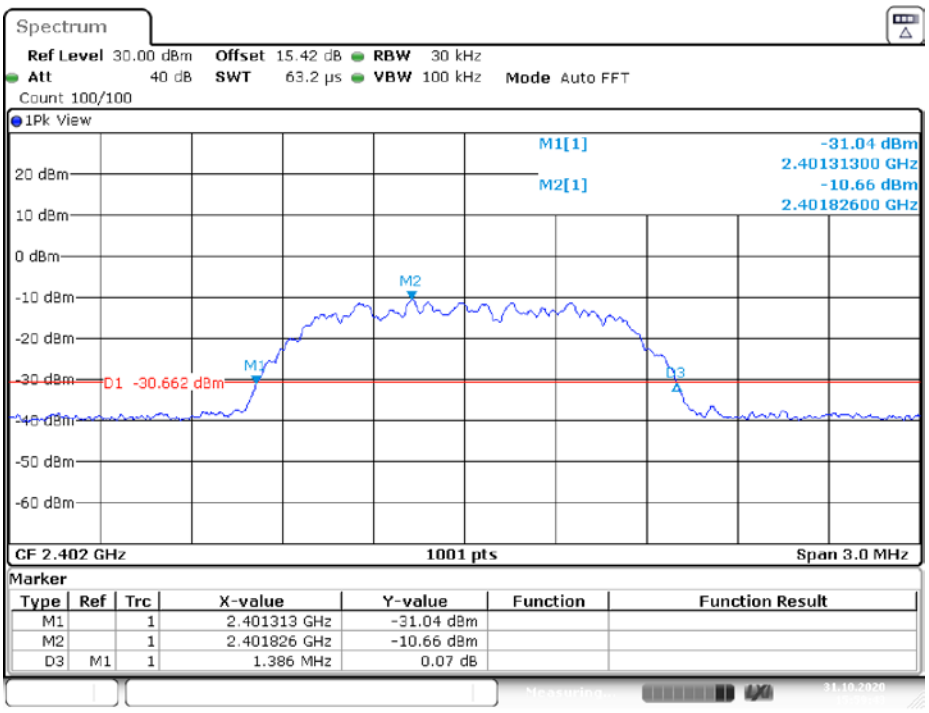
99% Occupied Bandwidth, High Channel



Date: 31.OCT.2020 15:58:45

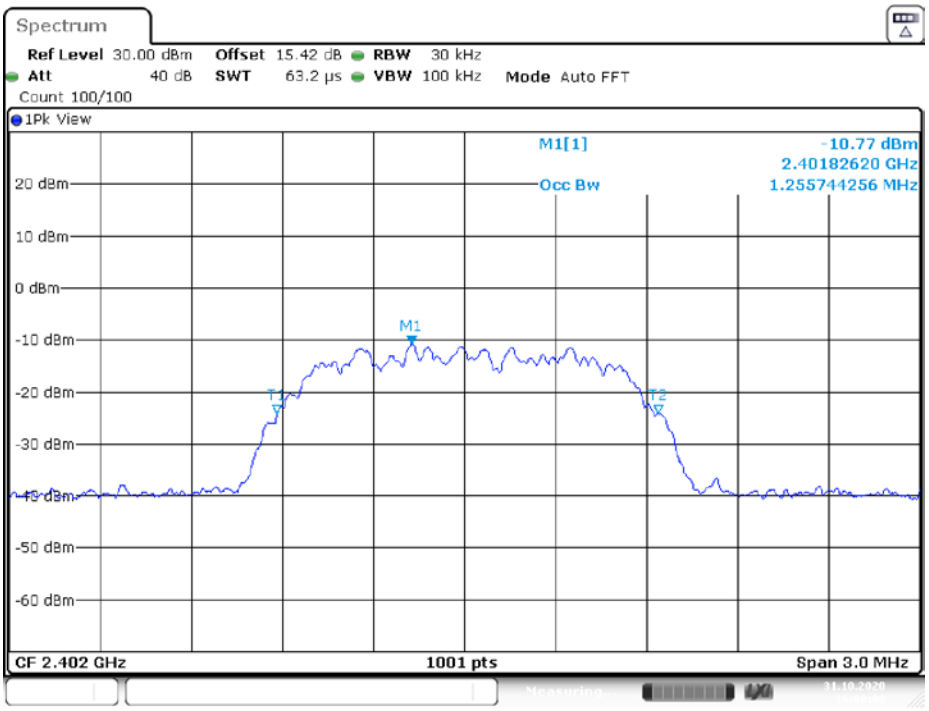
EDR (π/4-DQPSK):

20dB Emission Bandwidth, Low Channel



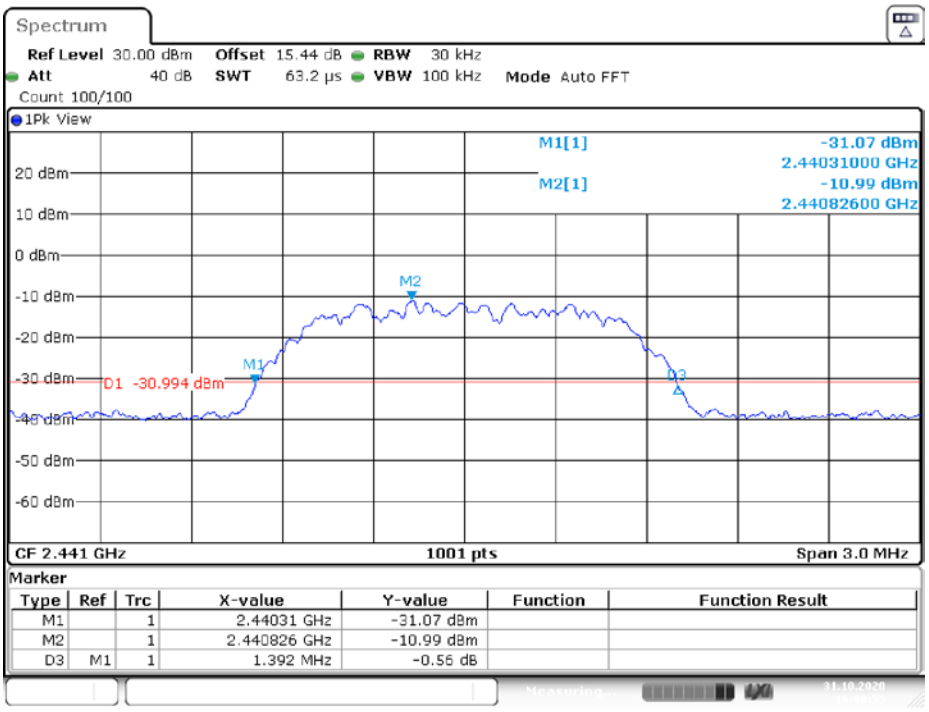
Date: 31.OCT.2020 15:59:44

99% Occupied Bandwidth, Low Channel



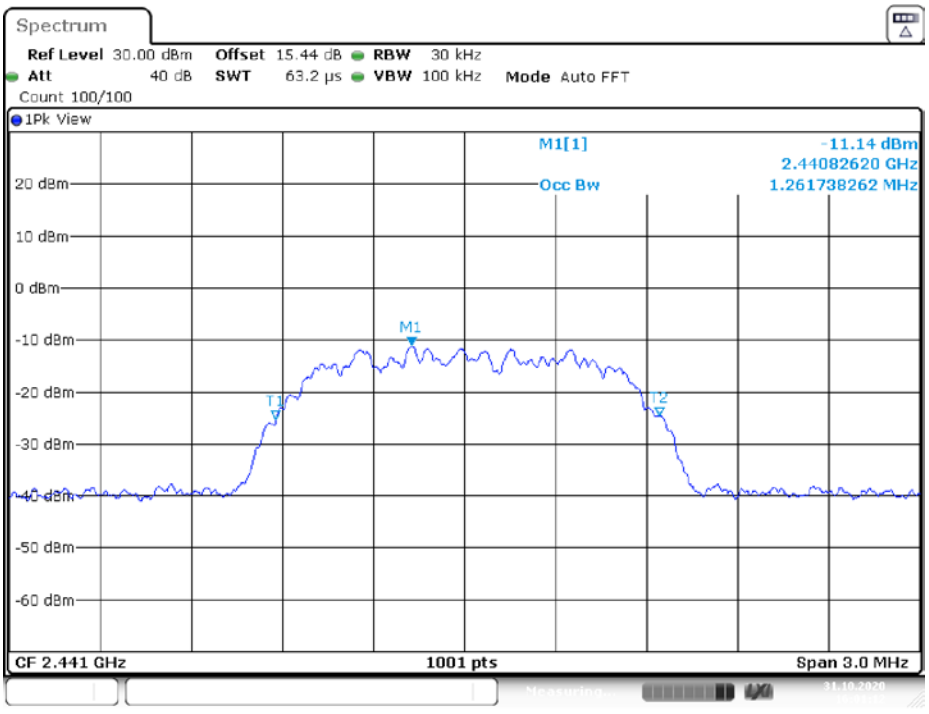
Date: 31.OCT.2020 16:00:00

20dB Emission Bandwidth, Middle Channel



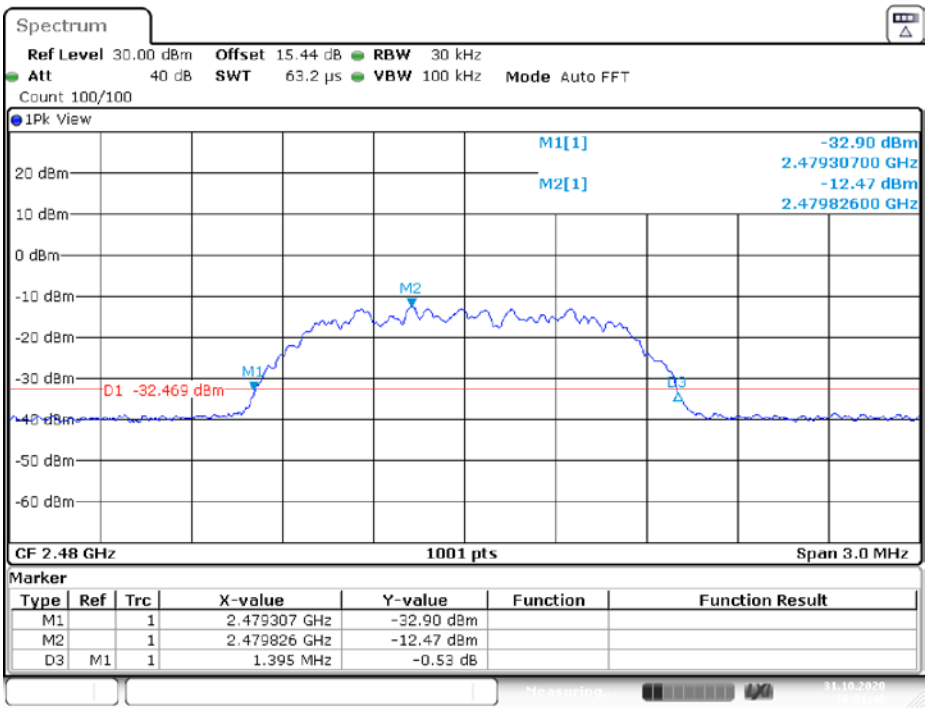
Date: 31.OCT.2020 16:00:56

99% Occupied Bandwidth, Middle Channel



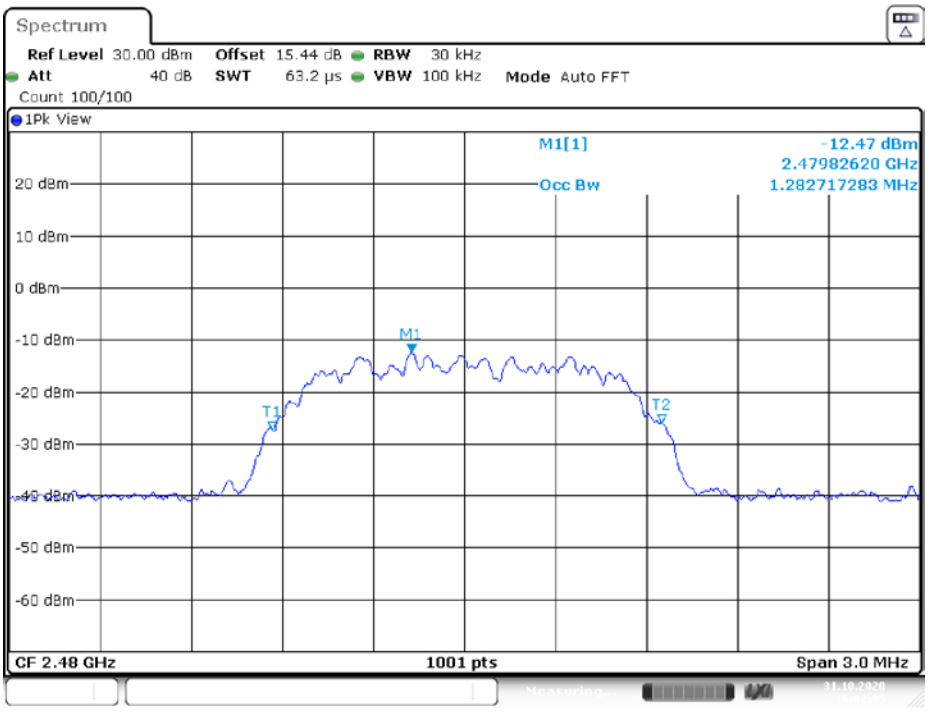
Date: 31.OCT.2020 16:01:13

20dB Emission Bandwidth, High Channel



Date: 31.OCT.2020 16:01:49

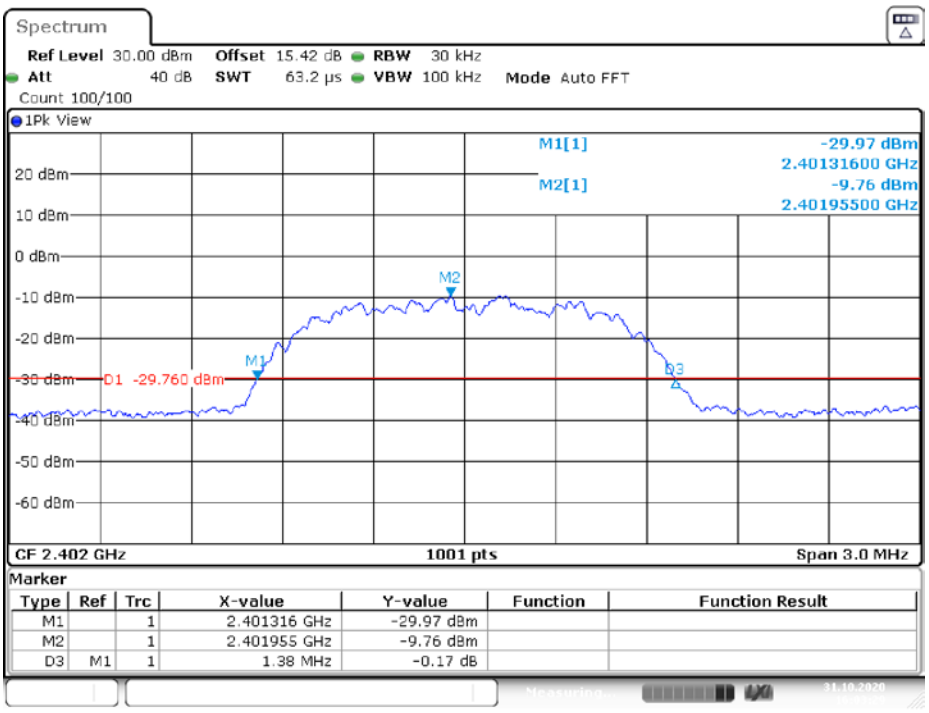
99% Occupied Bandwidth, High Channel



Date: 31.OCT.2020 16:02:06

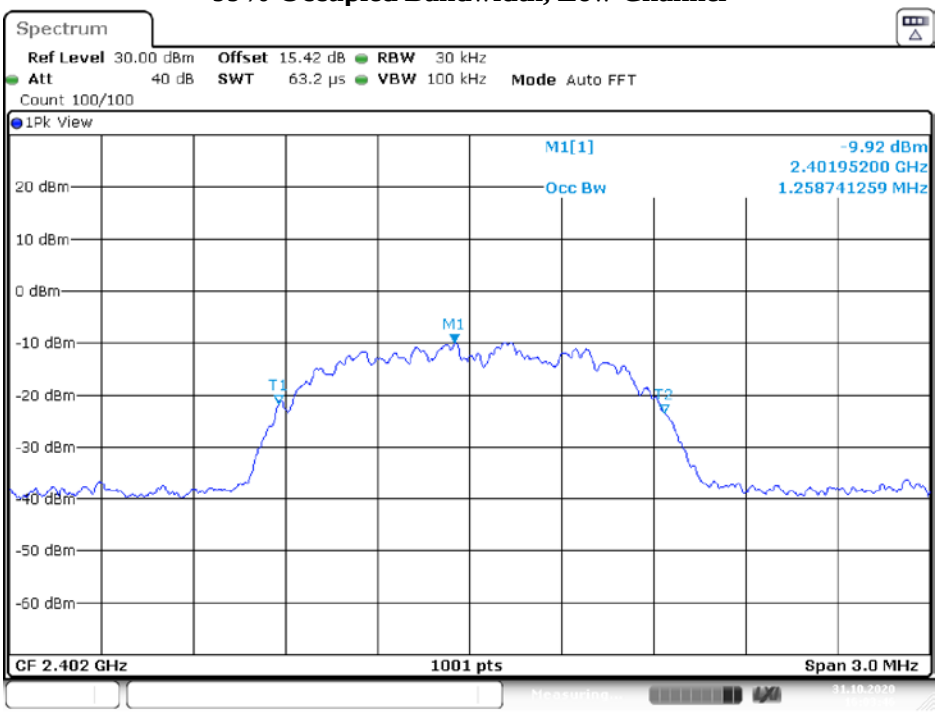
EDR (8DPSK):

20dB Emission Bandwidth, Low Channel



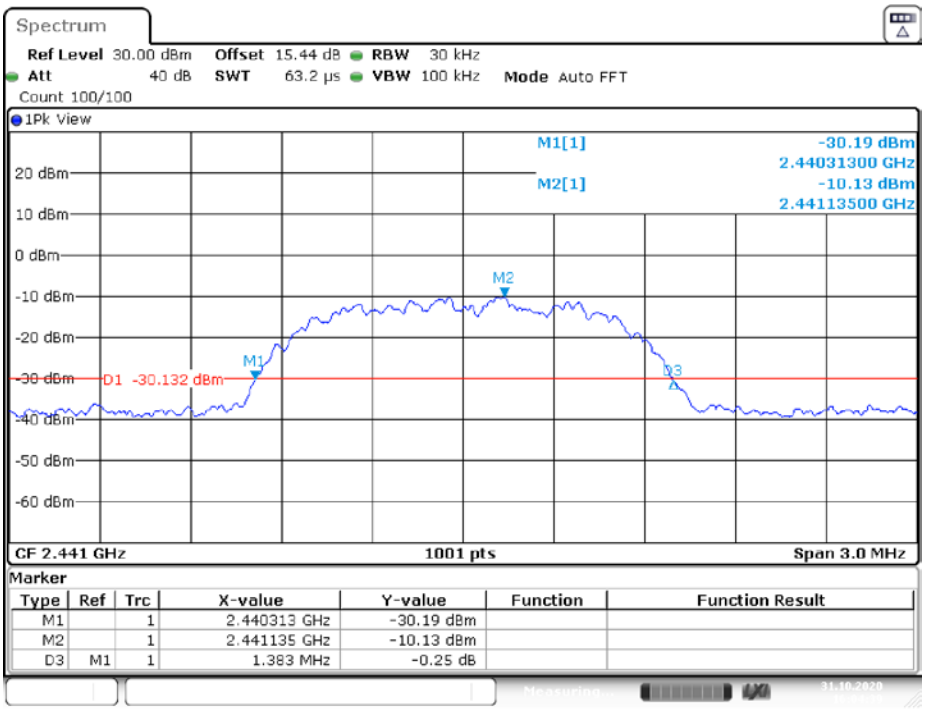
Date: 31.OCT.2020 16:03:30

99% Occupied Bandwidth, Low Channel



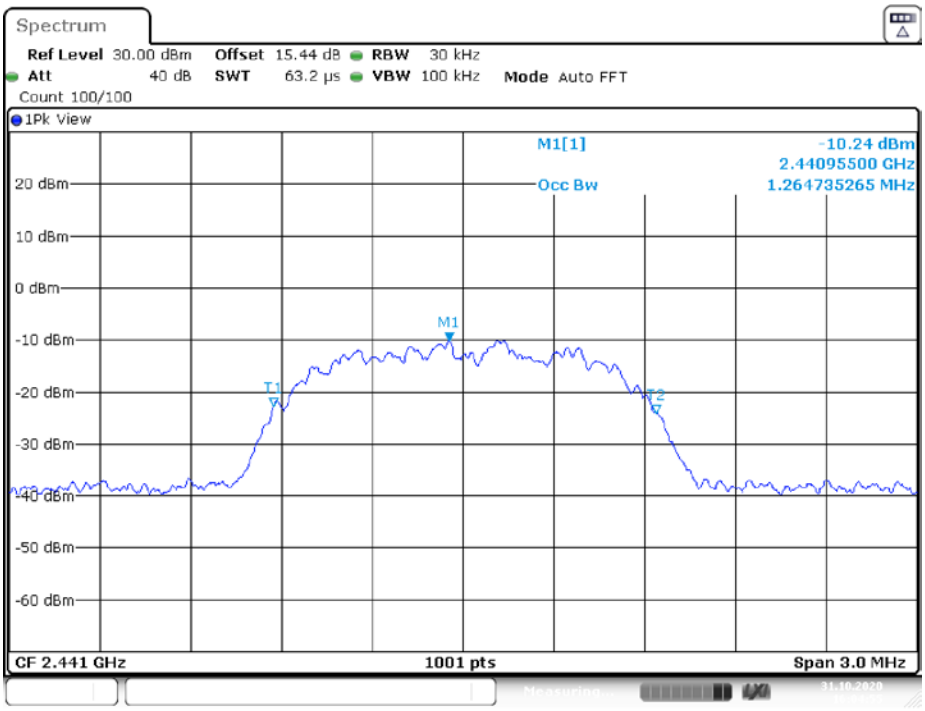
Date: 31.OCT.2020 16:03:47

20dB Emission Bandwidth, Middle Channel

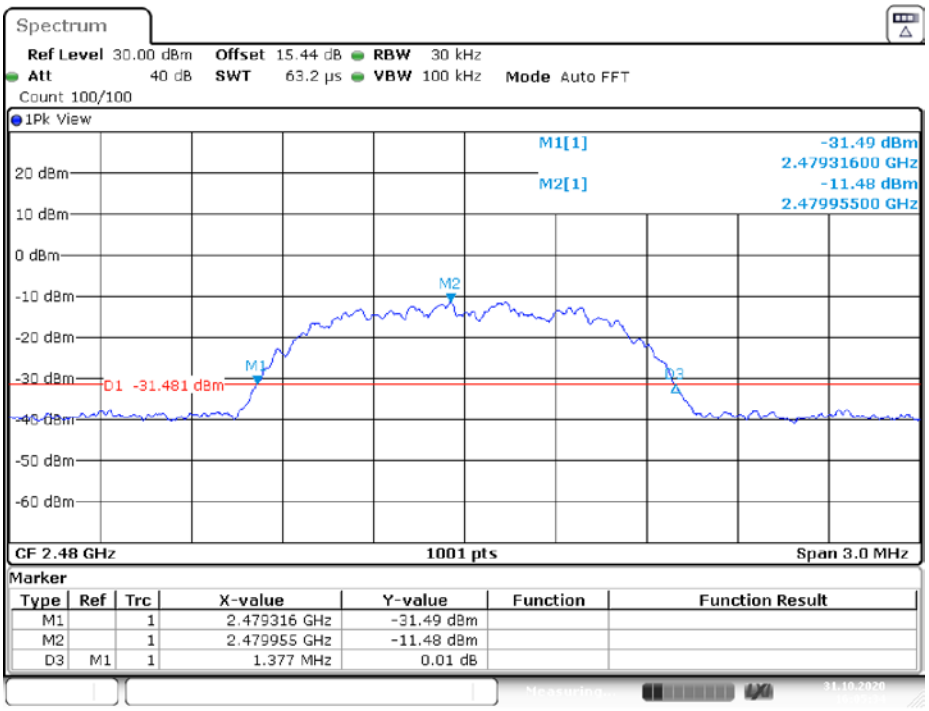


Date: 31.OCT.2020 16:04:39

99% Occupied Bandwidth, Middle Channel

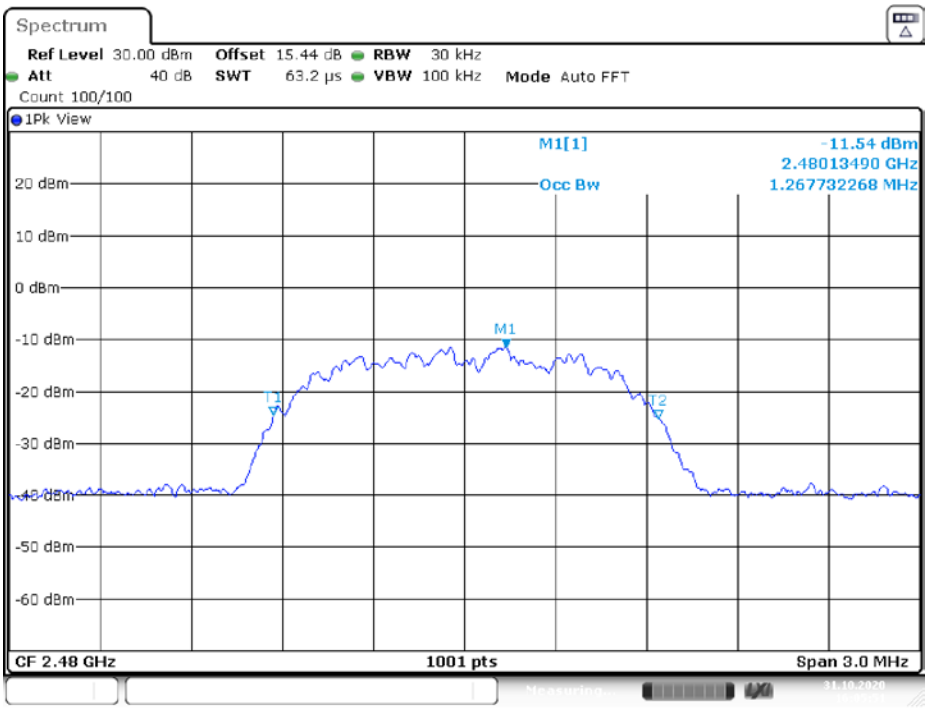


20dB Emission Bandwidth, High Channel



Date: 31.OCT.2020 16:05:35

99% Occupied Bandwidth, High Channel



Date: 31.OCT.2020 16:05:52

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

According to FCC §15.247(a) (1) (iii):

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

2. Set the EUT in hopping mode from first channel to last.

3. By using the max-hold function record the quantity of the channel.

Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-10-31

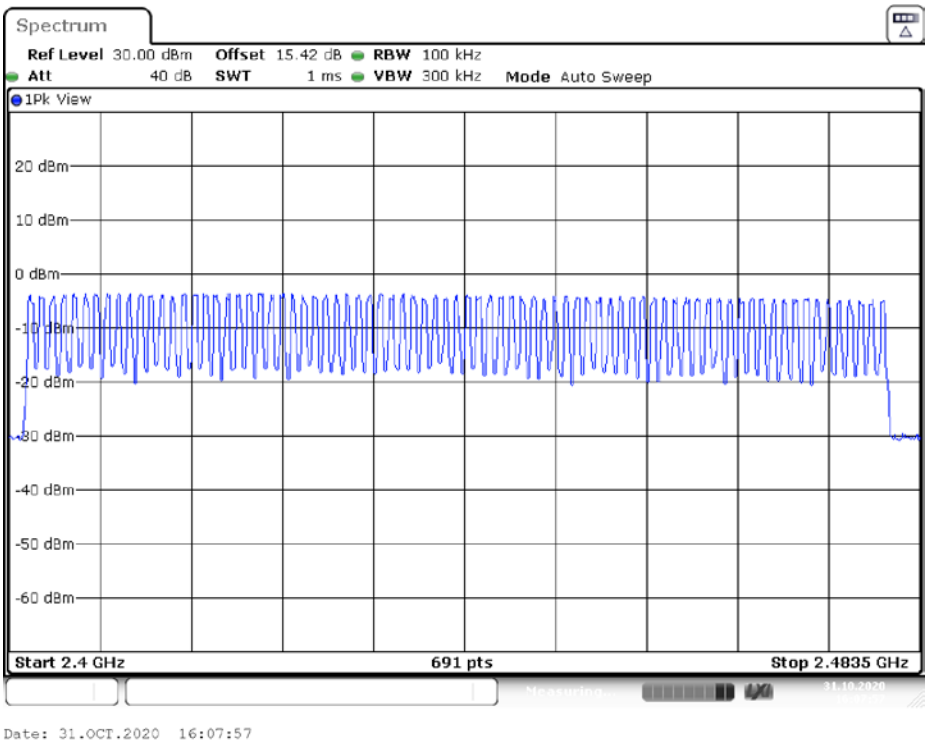
EUT operation mode: Transmitting

Test Result: Pass

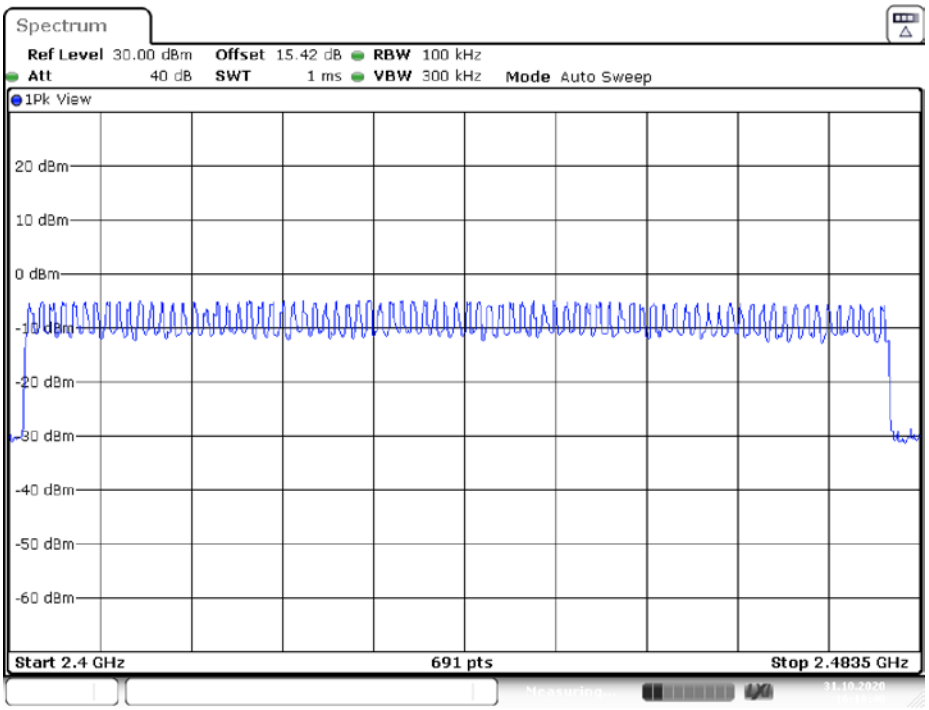
Please refer to following table and plots.

Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
BDR (GFSK)	2400-2483.5	79	⩾15
EDR (π/4-DQPSK)	2400-2483.5	79	⩾15
EDR (8DPSK)	2400-2483.5	79	⩾15

BDR (GFSK): Number of Hopping Channels

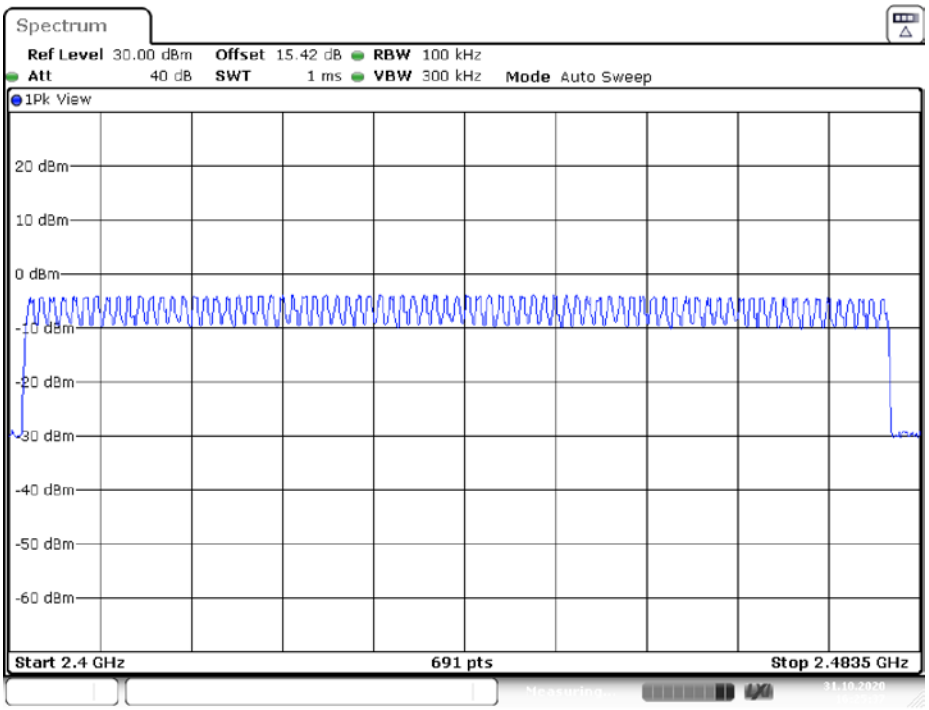


EDR (π/4-DQPSK): Number of Hopping Channels



Date: 31.OCT.2020 16:18:41

EDR (8DPSK): Number of Hopping Channels



Date: 31.OCT.2020 16:25:38

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

According to FCC §15.247(a) (1) (iii):

Frequency hopping systems in the 2400-2483.5 MHz shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses

Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-11-01.

EUT operation mode: Transmitting

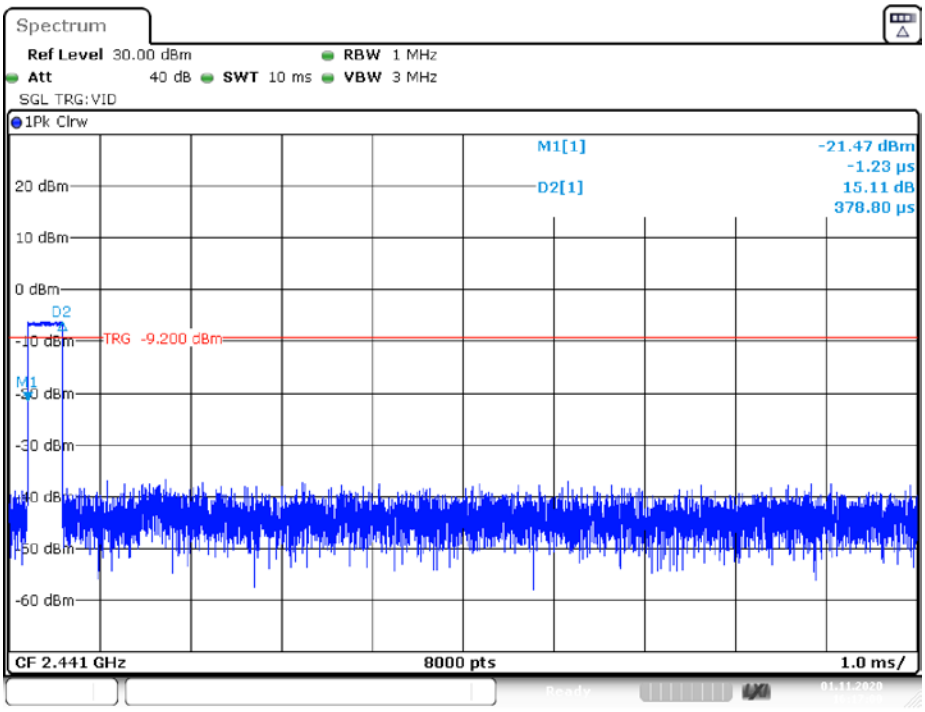
Test Result: Pass

Please refer to following table and plots

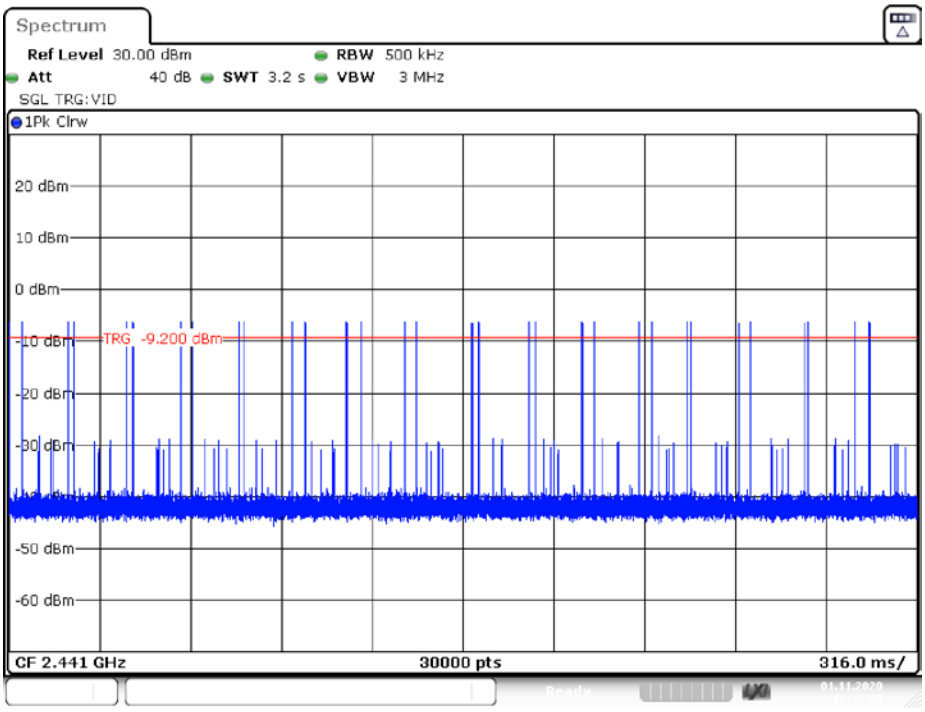
Test Mode	Channel	Burst Width [ms]	Total Hops [Num]	Result[s]	Limit[s]	Verdict
DH1	Hop	0.38	320	0.122	<=0.4	PASS
DH3	Hop	1.63	170	0.277	<=0.4	PASS
DH5	Hop	2.87	100	0.287	<=0.4	PASS
2DH1	Hop	0.39	320	0.125	<=0.4	PASS
2DH3	Hop	1.63	140	0.228	<=0.4	PASS
2DH5	Hop	2.87	130	0.373	<=0.4	PASS
3DH1	Hop	0.39	330	0.129	<=0.4	PASS
3DH3	Hop	1.63	170	0.277	<=0.4	PASS
3DH5	Hop	2.87	110	0.316	<=0.4	PASS

Note 1: A period time=0.4*79=31.6(S), Result=Burst Width*Total Hops
Note 2: Total Hops =Hopping Number in 3.16s*10
Note 3: Hoping Number in 3.16s=Total of highest signals in 3.16s (Second high signals were other channel)

BDR (GFSK):
DH1

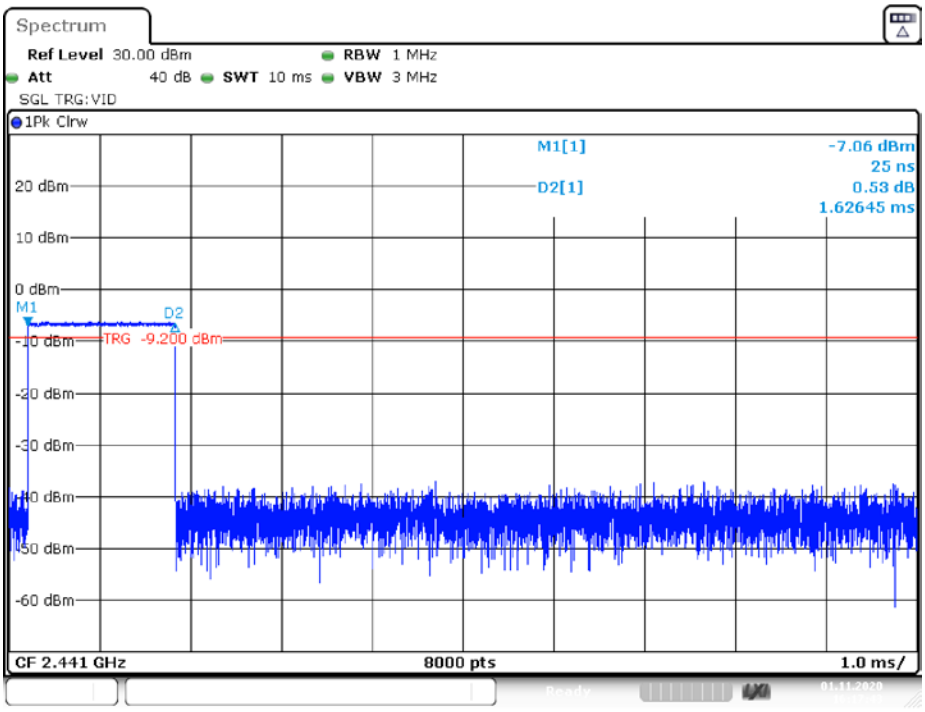


Date: 1.NOV.2020 16:17:00



Date: 1.NOV.2020 16:17:06

DH3



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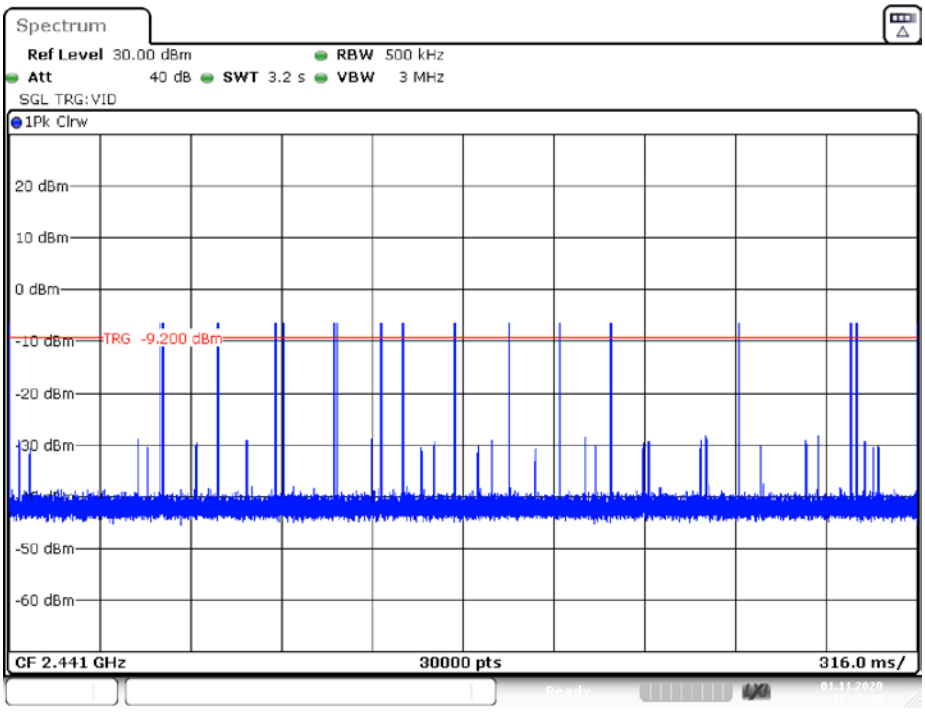
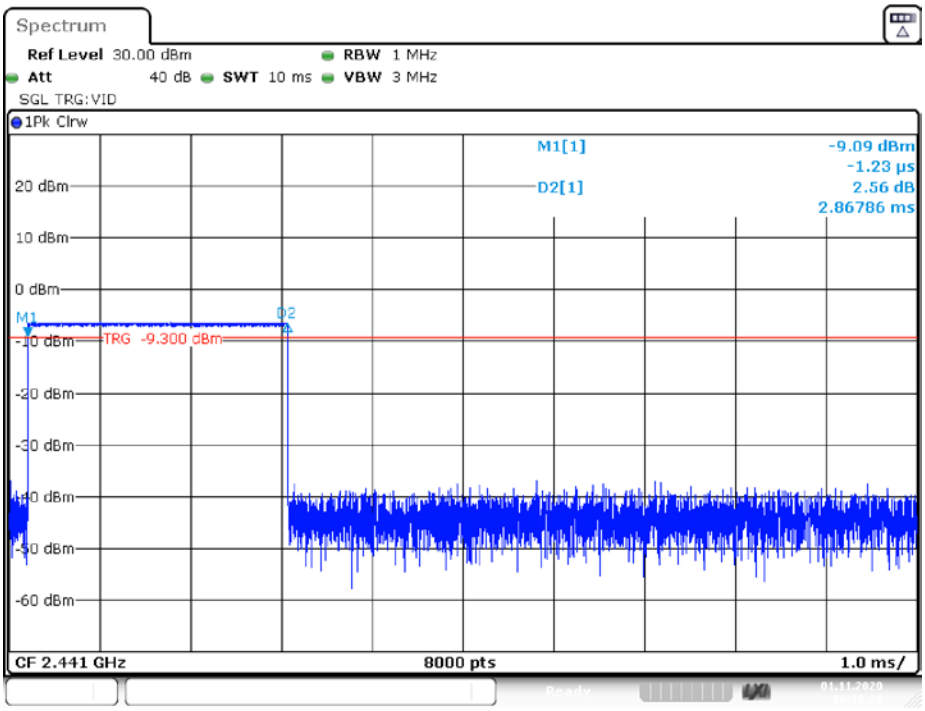
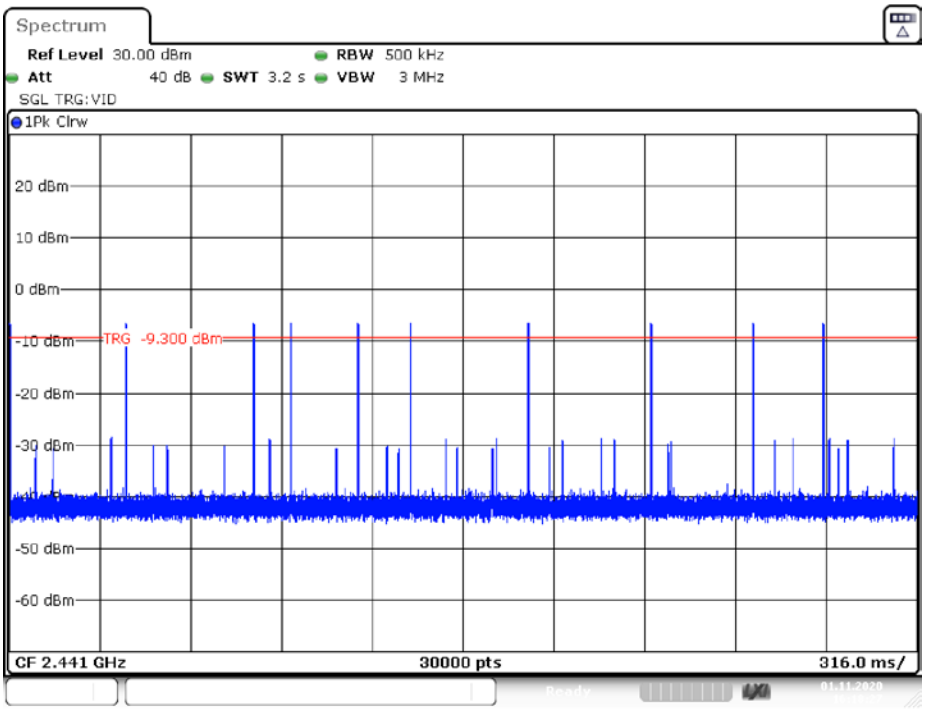


Date: 1.NOV.2020 16:17:48

DH5



Date: 1.NOV.2020 16:18:22



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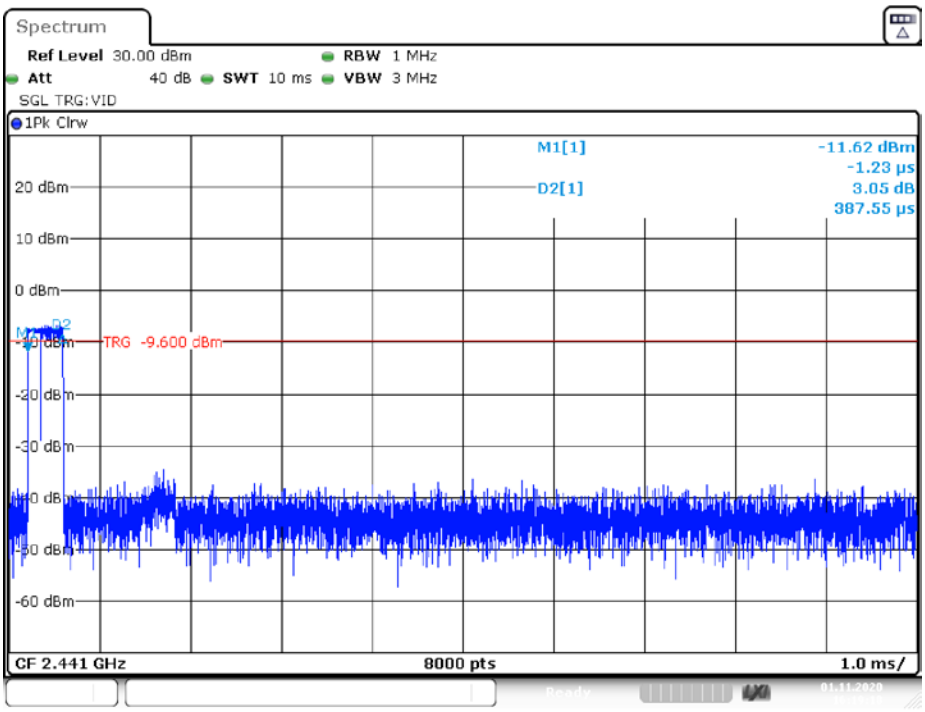
EDR(π/4-DQPSK):
2DH1



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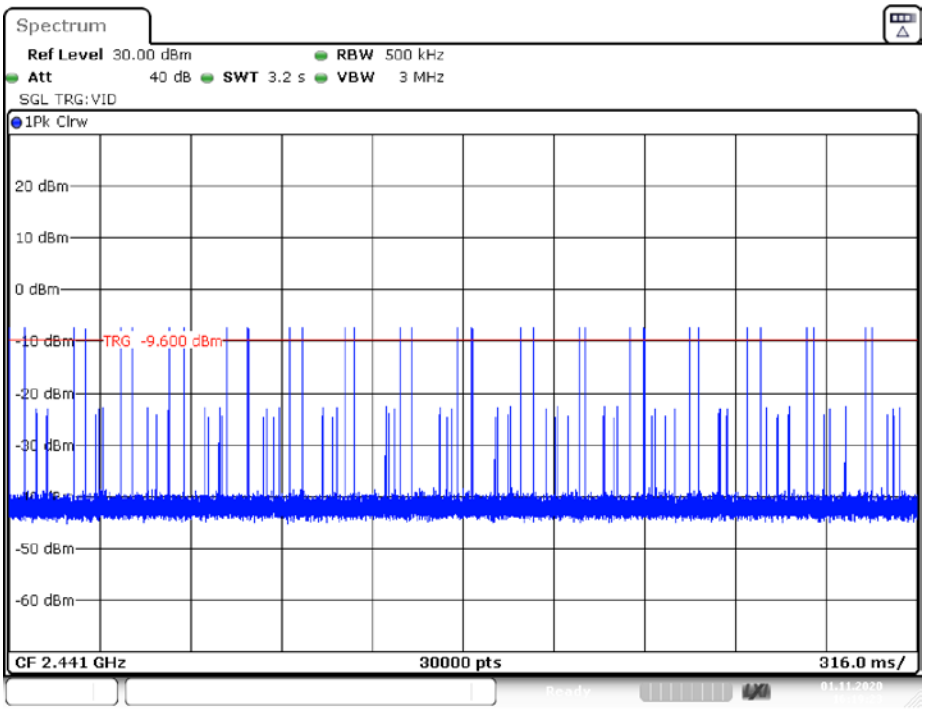
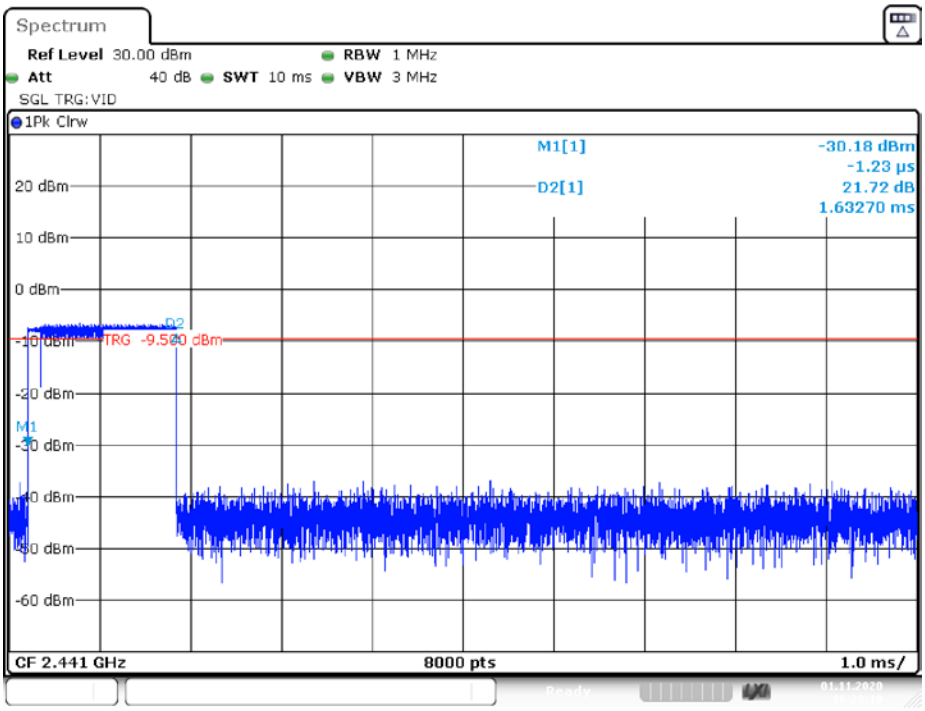


Date: 1.NOV.2020 16:19:23

2DH3



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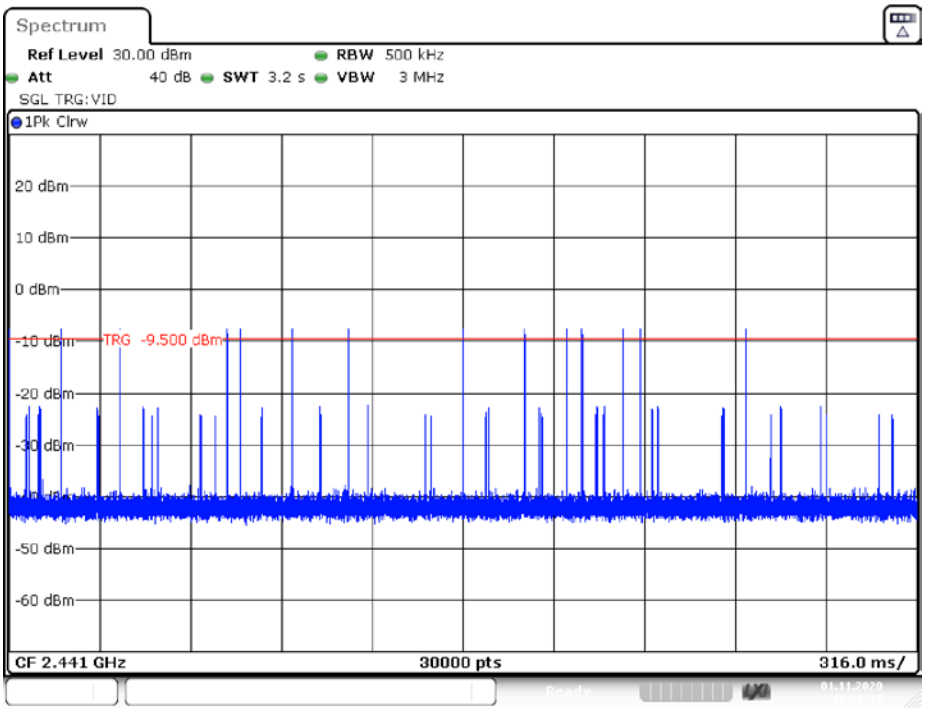

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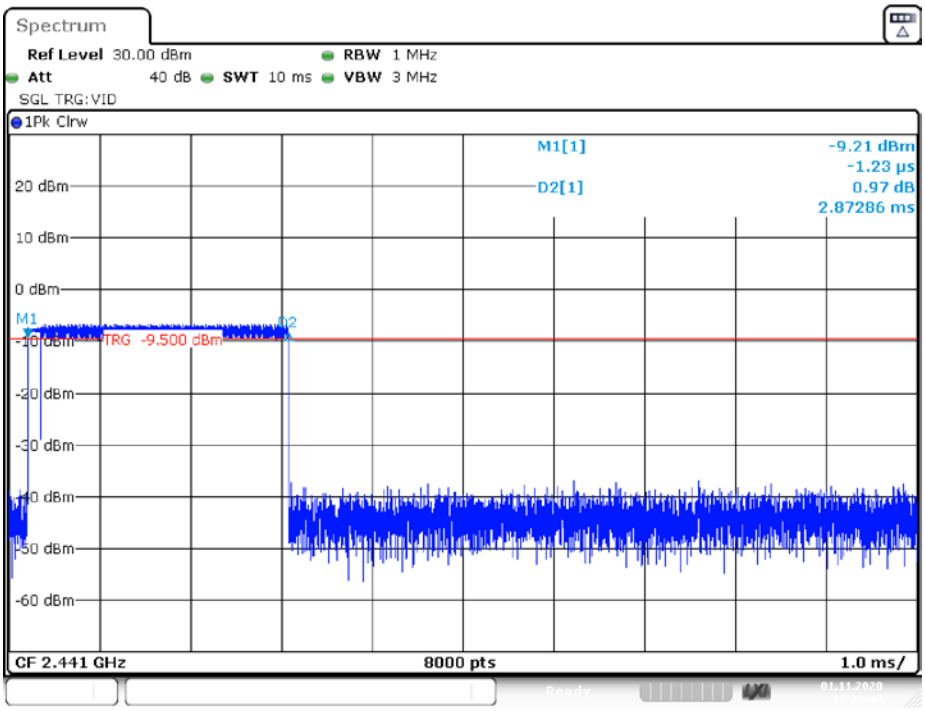
2DH5



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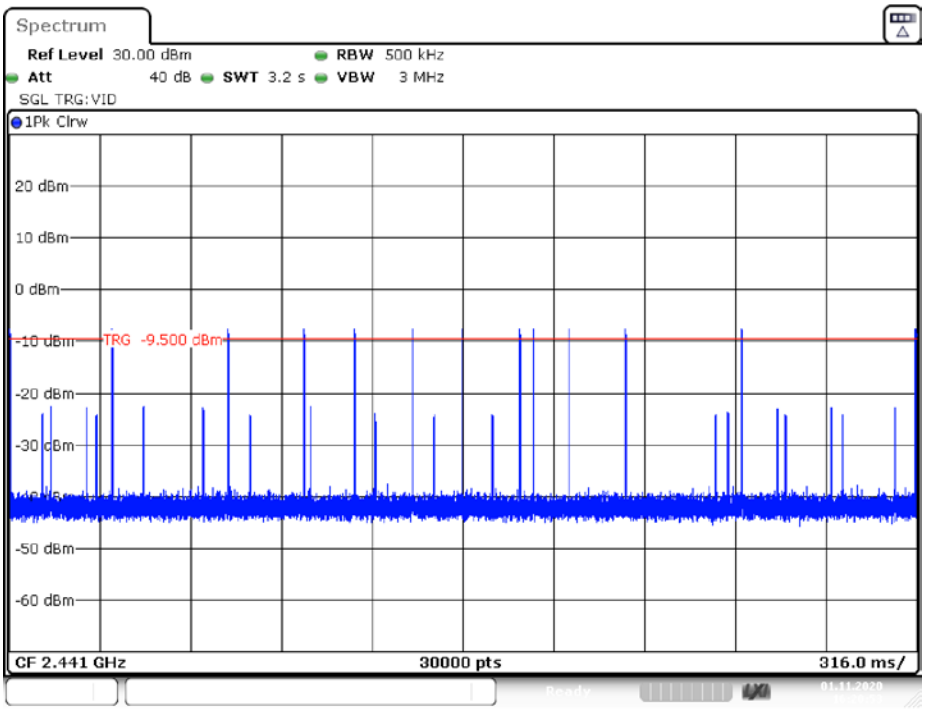
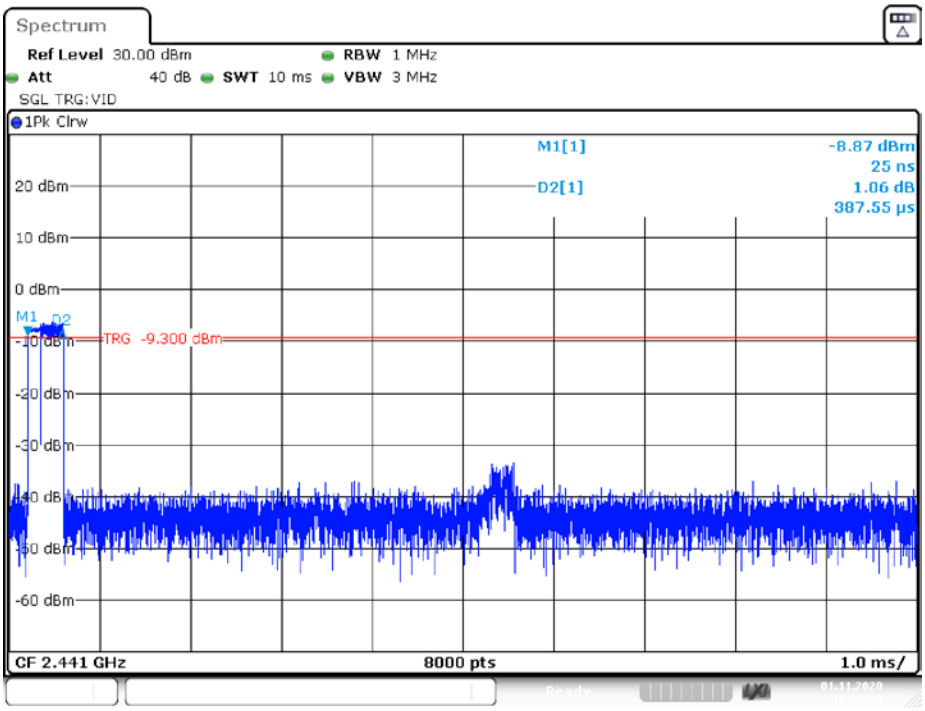
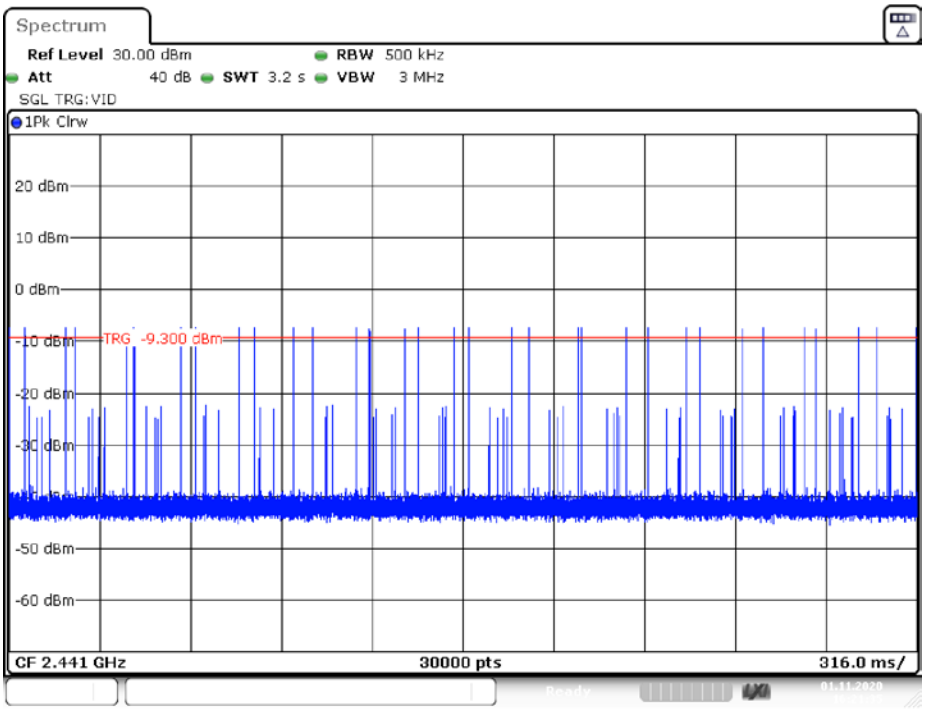


Date: 1.NOV.2020 16:20:53

EDR (8DPSK):
3DH1



Date: 1.NOV.2020 16:21:30



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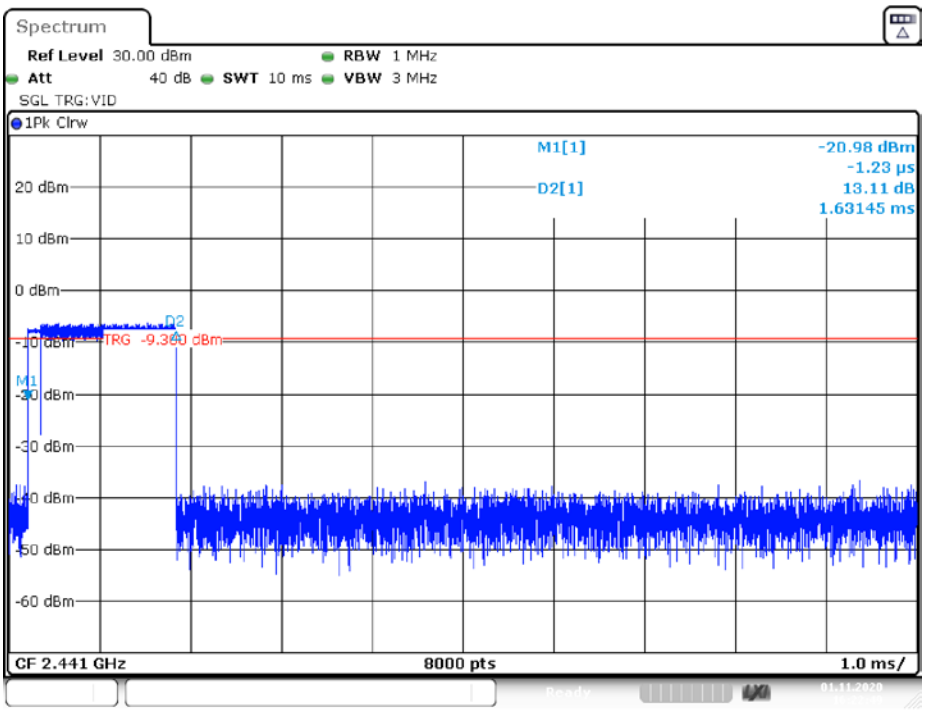
3DH3



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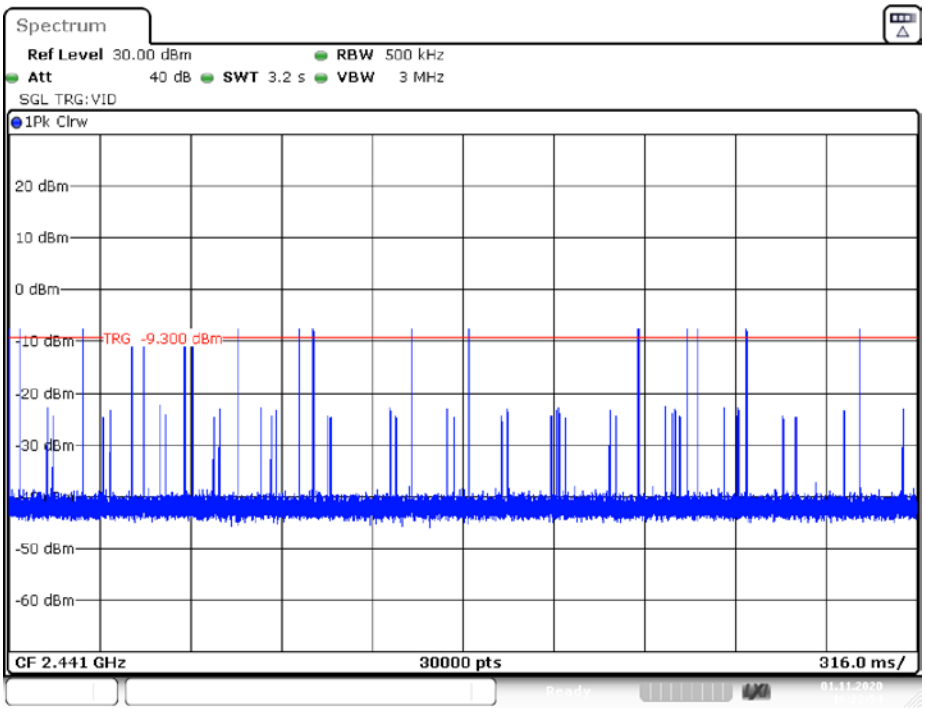

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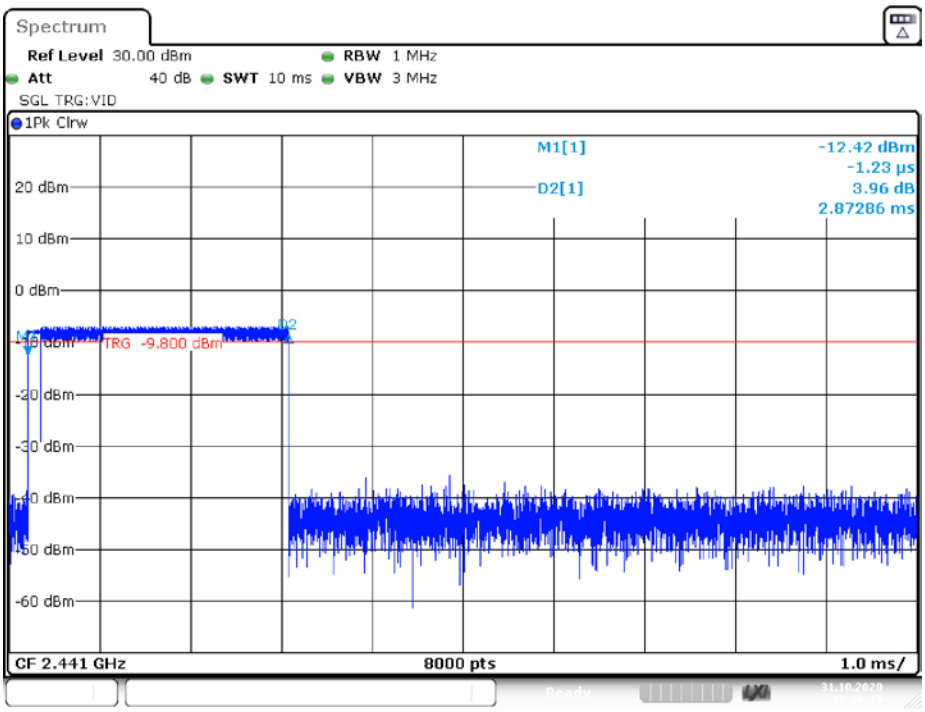
3DH5



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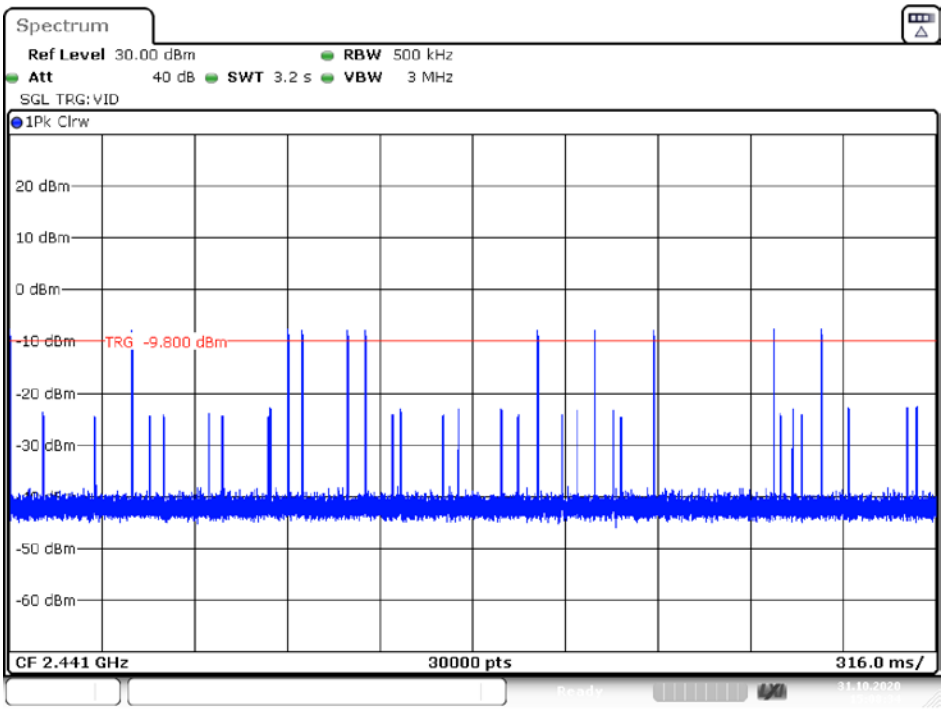


Date: 31.OCT.2020 15:08:35

FCC §15.247(b) (1) & RSS-247§ 5.1(b) &§ 5.4(b) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to FCC §15.247(b) (1):

For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

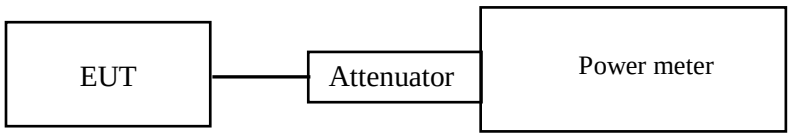
According to RSS-247§ 5.1(b) &§ 5.4(b):

For frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (see Section 5.4(e) for exceptions).

Frequency hopping systems (FHSs) shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

Test Procedure

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Black Ding on 2020-10-31

EUT operation mode: Transmitting

Test Result: Pass

Please refer to following table.

Test Mode	Channel	Result [dBm]	Limit [dBm]	Verdict
BDR (GFSK)	2402	0.24	<=20.97	PASS
	2441	0.41	<=20.97	PASS
	2480	-0.26	<=20.97	PASS
EDR (π/4-DQPSK)	2402	0.05	<=20.97	PASS
	2441	0.37	<=20.97	PASS
	2480	-0.17	<=20.97	PASS
EDR (8DPSK)	2402	0.07	<=20.97	PASS
	2441	0.32	<=20.97	PASS
	2480	-0.2	<=20.97	PASS

Note 1: The data above was tested in conducted mode.
Note 2: The maximum EIRP is 0.41dBm-0.68dBi=-0.27dBm<36dBm, so it can meet the EIRP limit of ISEDC.

FCC §15.247(d) & RSS-247 § 5.5 - BAND EDGES TESTING

Applicable Standard

According to FCC §15.247(d).

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

According to RSS-247 § 5.5.

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(e), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

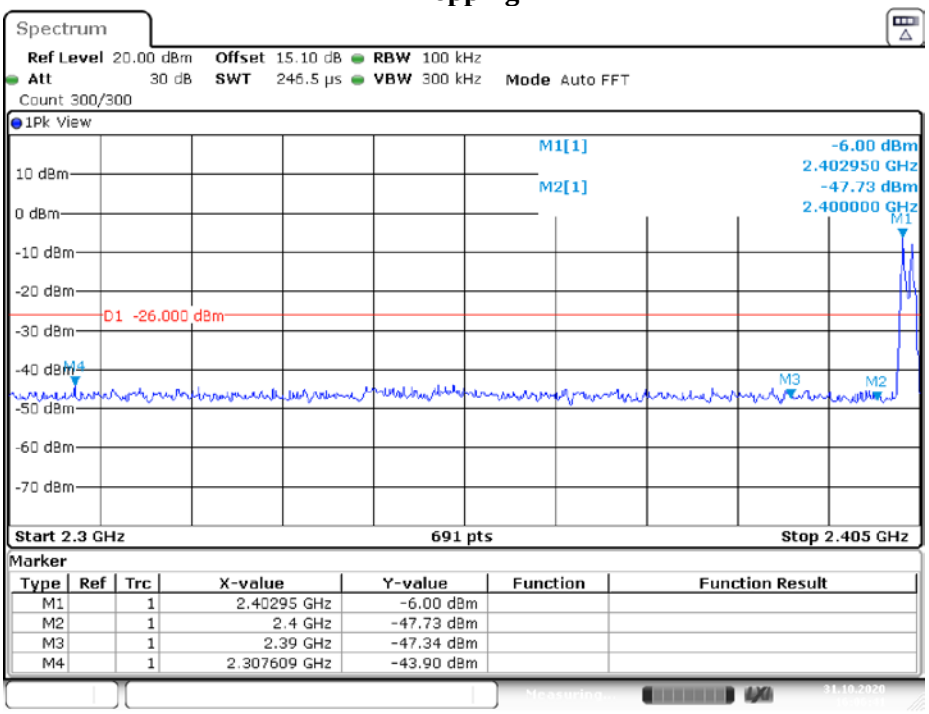
The testing was performed by Black Ding on 2020-10-31.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to following table and plots

BDR (GFSK): Band Edge-Left Side
Hopping



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.40295 GHz	-6.00 dBm		
M2		1	2.4 GHz	-47.73 dBm		
M3		1	2.39 GHz	-47.34 dBm		
M4		1	2.307609 GHz	-43.90 dBm		

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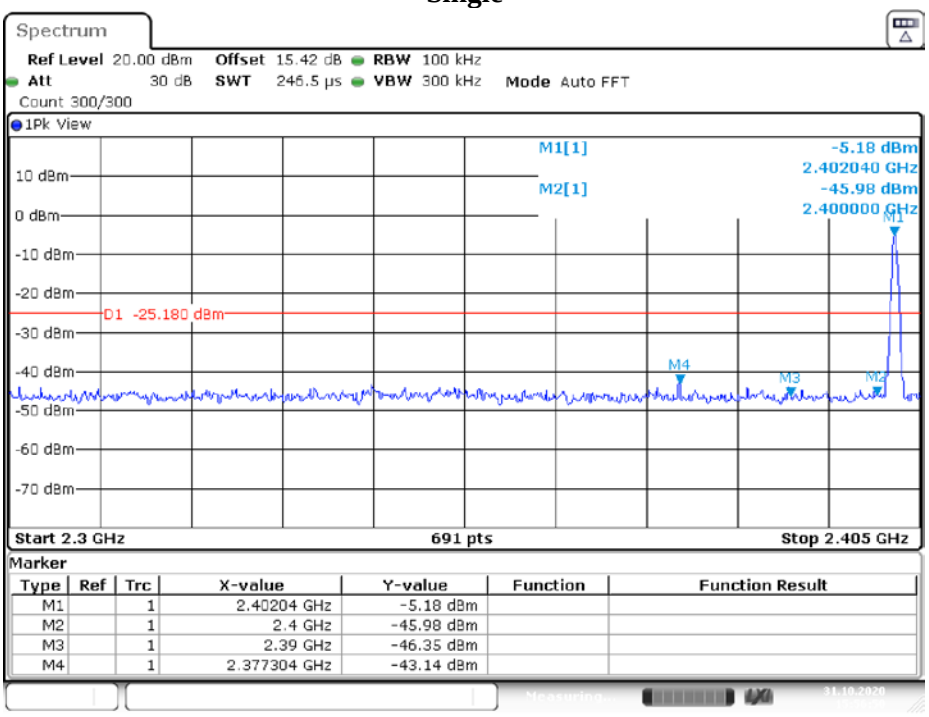
Single



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.40204 GHz	-5.18 dBm		
M2		1	2.4 GHz	-45.98 dBm		
M3		1	2.39 GHz	-46.35 dBm		
M4		1	2.377304 GHz	-43.14 dBm		

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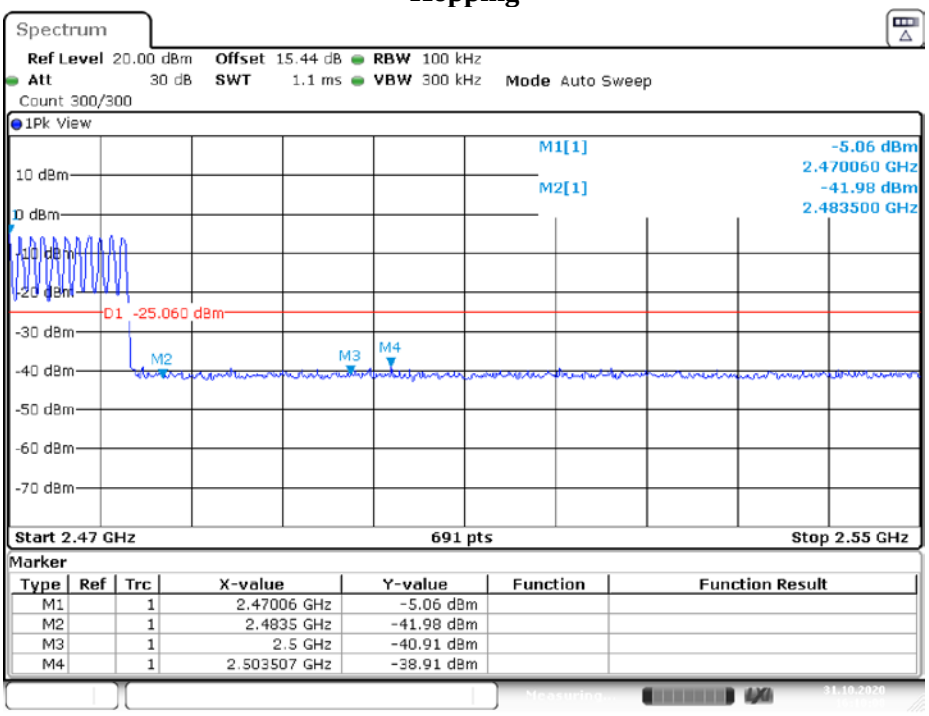
BDR (GFSK): Band Edge-Right Side Hopping



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.47006 GHz	-5.06 dBm		
M2		1	2.4835 GHz	-41.98 dBm		
M3		1	2.5 GHz	-40.91 dBm		
M4		1	2.503507 GHz	-38.91 dBm		

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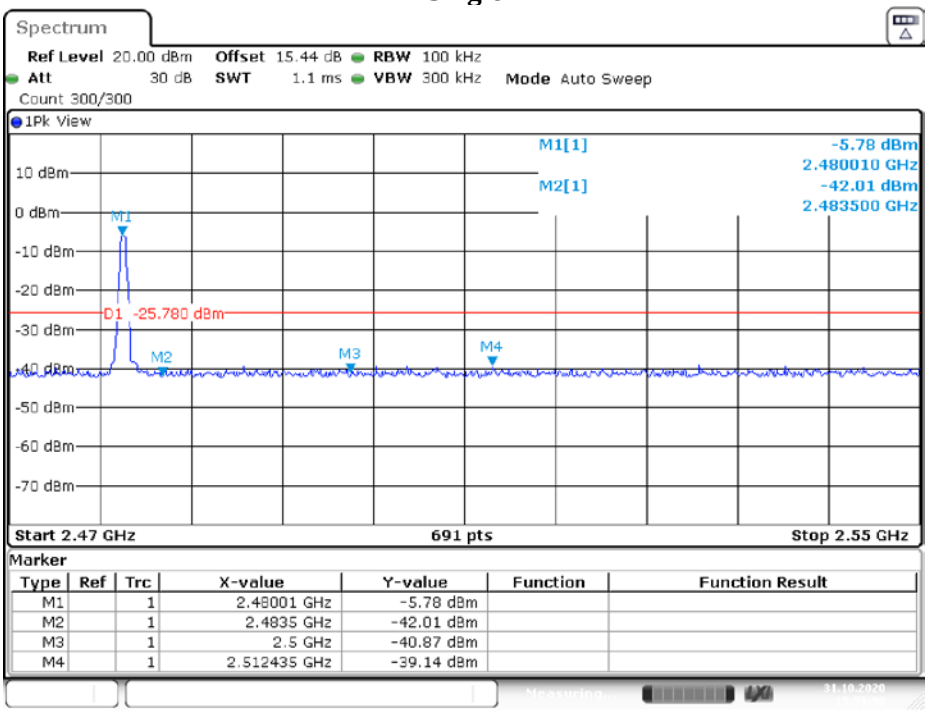
Single



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.48001 GHz	-5.78 dBm		
M2		1	2.4835 GHz	-42.01 dBm		
M3		1	2.5 GHz	-40.87 dBm		
M4		1	2.512435 GHz	-39.14 dBm		

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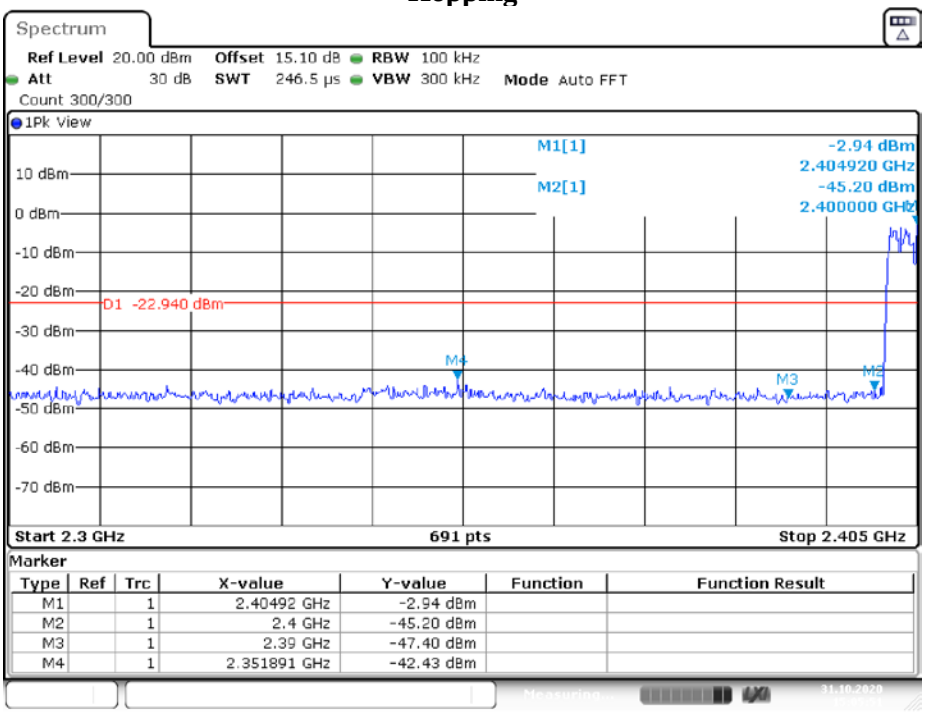
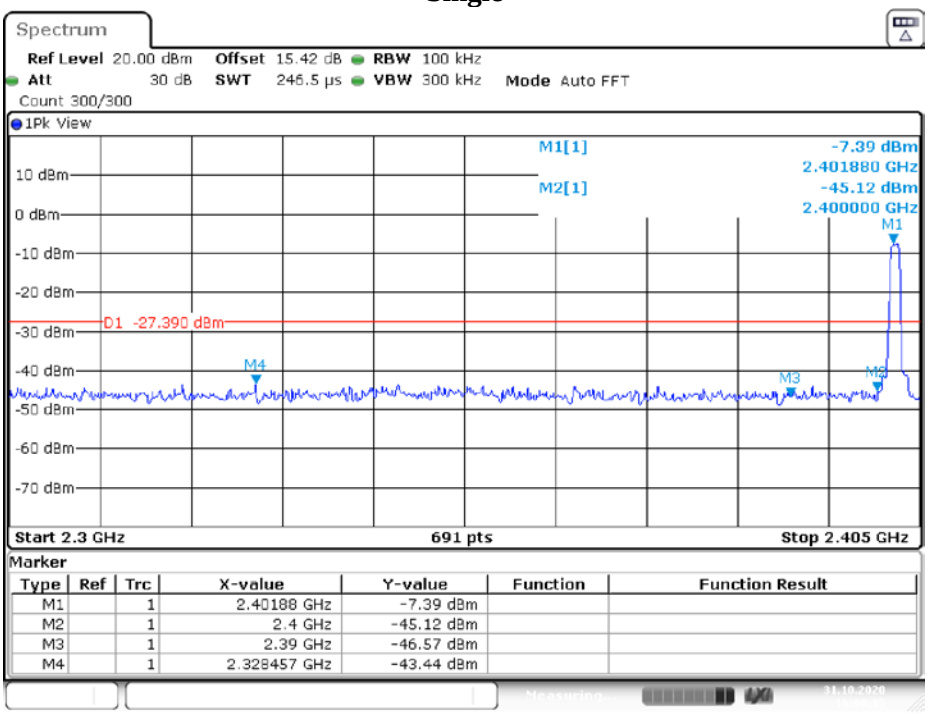
EDR (π/4-DQPSK): Band Edge-Left Side
Hopping



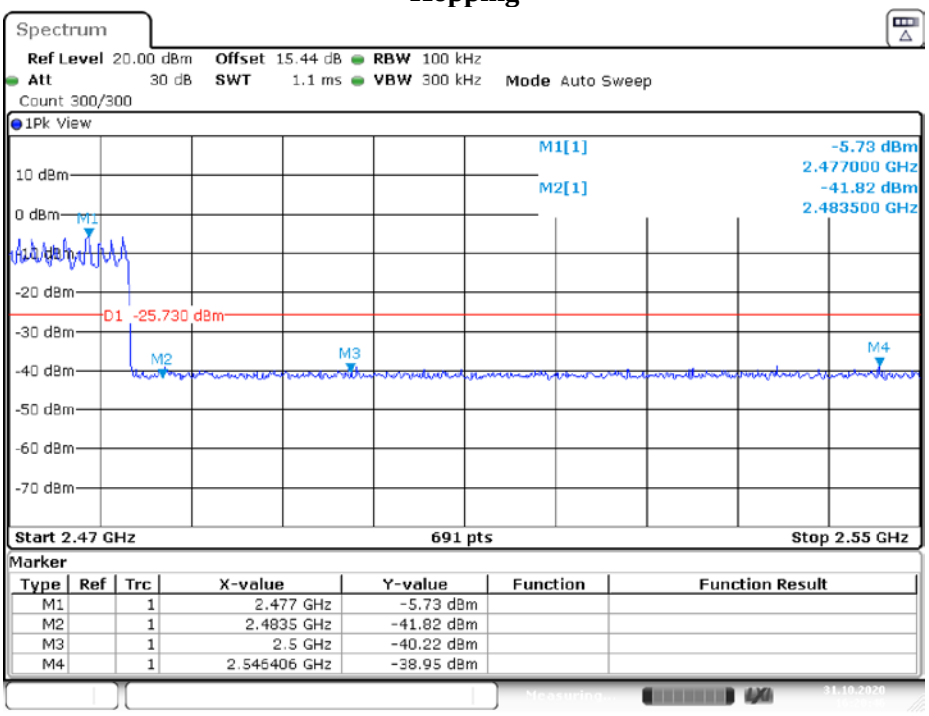
Date: 31.OCT.2020 15:05:51

Single



Date: 31.OCT.2020 16:00:15

EDR (π/4-DQPSK): Band Edge-Right Side
Hopping



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.477 GHz	-5.73 dBm		
M2		1	2.4835 GHz	-41.82 dBm		
M3		1	2.5 GHz	-40.22 dBm		
M4		1	2.546406 GHz	-38.95 dBm		

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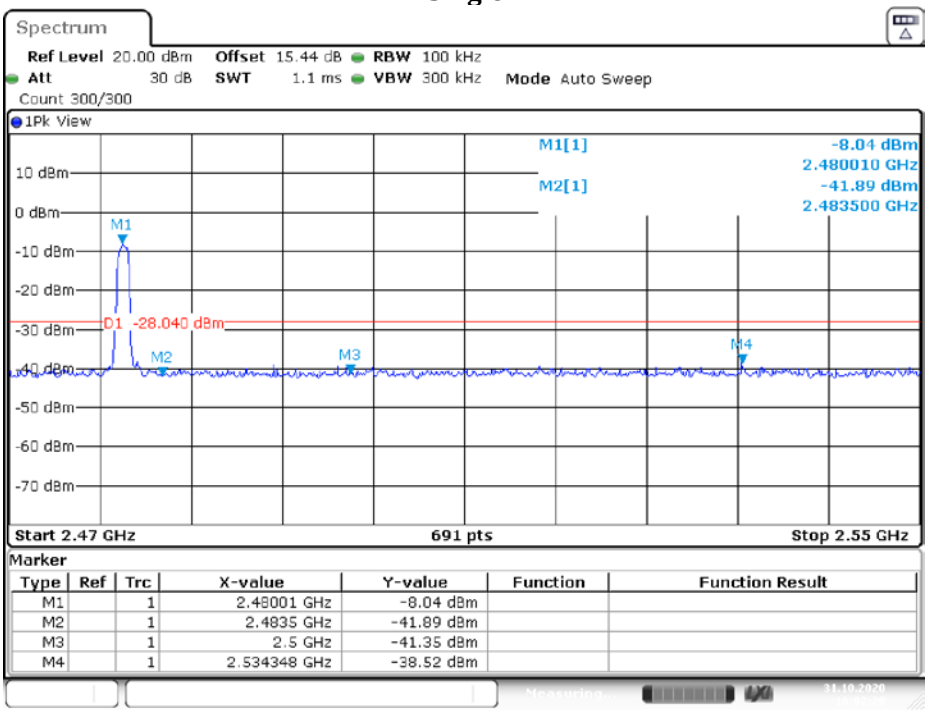
Single



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.48001 GHz	-8.04 dBm		
M2		1	2.4835 GHz	-41.89 dBm		
M3		1	2.5 GHz	-41.35 dBm		
M4		1	2.534348 GHz	-38.52 dBm		

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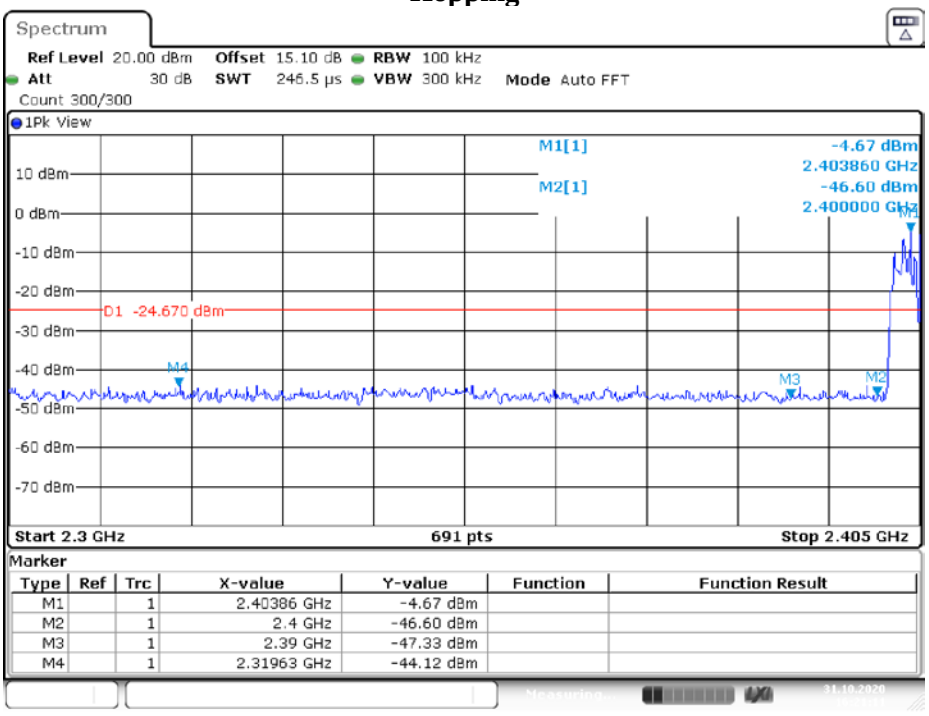
EDR (8DPSK): Band Edge-Left Side
Hopping



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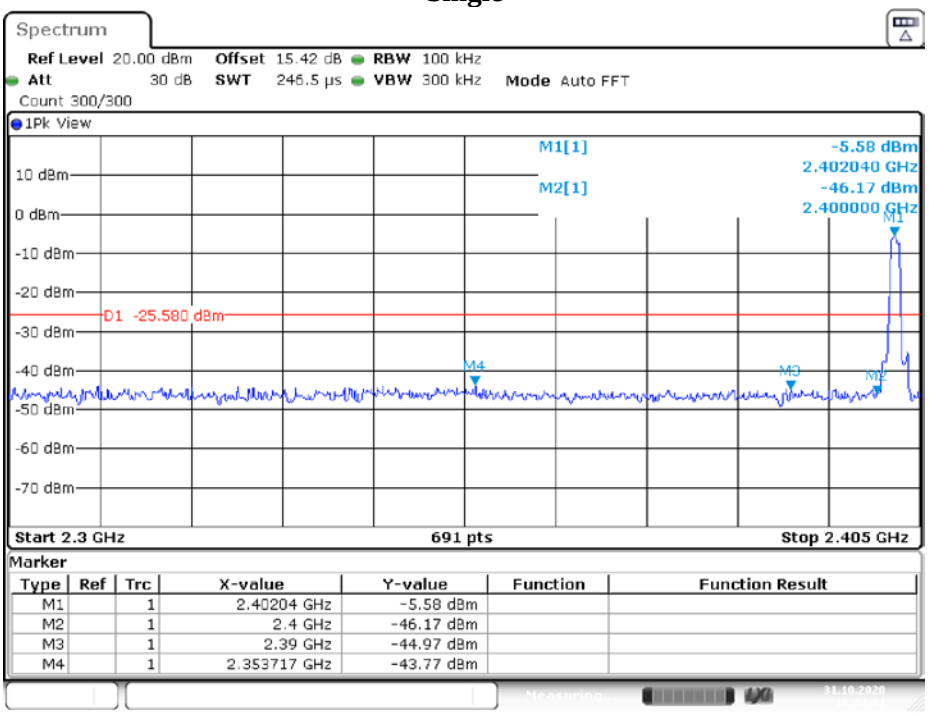
Single



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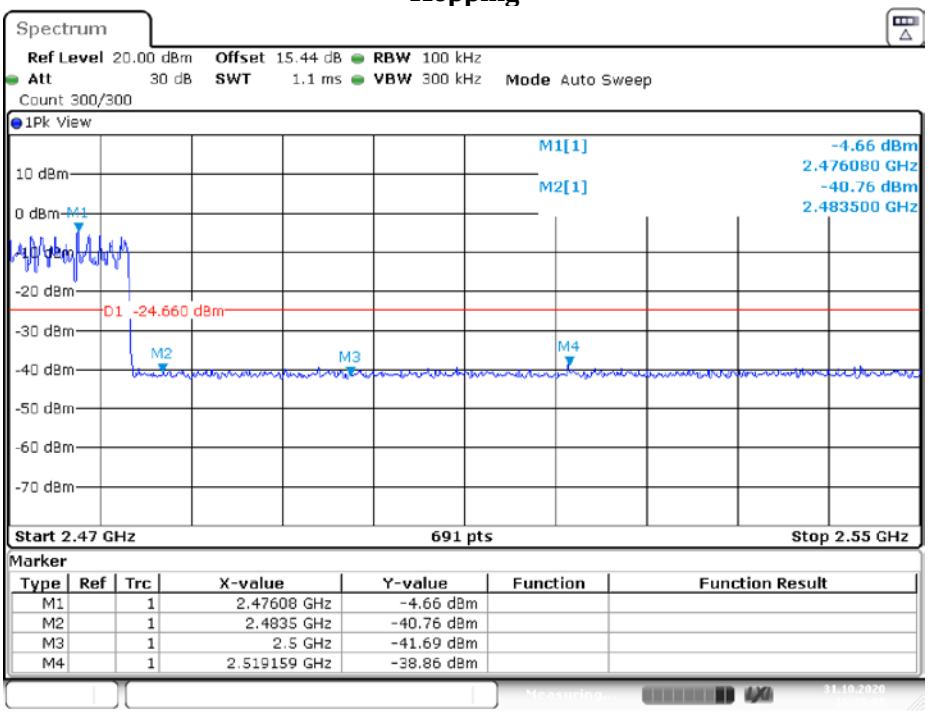
EDR (8DPSK): Band Edge-Right Side
Hopping



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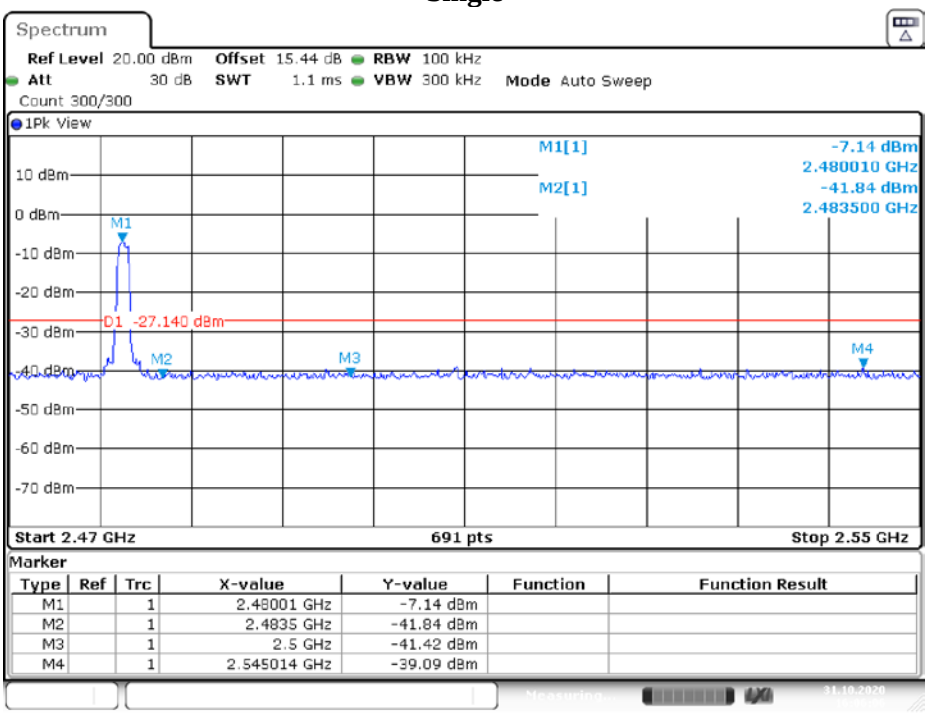
Single



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******* END OF REPORT *******