

Prüfbericht-Nr.: <i>Test report no.:</i>	CN222KWR (P15C-BT) 001	Auftrags-Nr.: <i>Order no.:</i>	238549206	Seite 1 von 26 Page 1 of 26
Kunden-Referenz-Nr.: <i>Client reference no.:</i>	N/A	Auftragsdatum: <i>Order date:</i>	2022-10-24	
Auftraggeber: <i>Client:</i>	Caterpillar, Inc. 100, North East Adams Street, Peoria, Illinois, 61629, United States			
Prüfgegenstand: <i>Test item:</i>	RADIO BOX			
Bezeichnung / Typ-Nr.: <i>Identification / Type no.:</i>	621-8167 / 621-8168			
Auftrags-Inhalt: <i>Order content:</i>	FCC Part 15C Test report (BT)			
Prüfgrundlage: <i>Test specification:</i>	FCC 47CFR Part 15: Subpart C Section 15.247			
Wareneingangsdatum: <i>Date of sample receipt:</i>	2022-10-18			
Prüfmuster-Nr.: <i>Test sample no.:</i>	A003355537-025 A003355537-021			
Prüfzeitraum: <i>Testing period:</i>	2022-10-29 - 2022-11-11			
Ort der Prüfung: <i>Place of testing:</i>	EMC/RF Taipei Testing Site			
Prüflaboratorium: <i>Testing laboratory:</i>	Taipei Testing Laboratories			
Prüfergebnis*: <i>Test result*:</i>	Pass			
überprüft von: <i>compiled by:</i>		genehmigt von: <i>authorized by:</i>		
Datum: <i>Date:</i>	2022-11-15	Ausstellungsdatum: <i>Issue date:</i>	2022-11-15	
Stellung / Position:	Senior Project Manager	Stellung / Position:	Senior Project Manager	
Sonstiges / Other:				
Zustand des Prüfgegenstandes bei Anlieferung: <i>Condition of the test item at delivery:</i>		Prüfmuster vollständig und unbeschädigt <i>Test item complete and undamaged</i>		
* Legende:	1 = sehr gut P(ass) = entspricht o.g. Prüfgrundlage(n)	2 = gut F(ail) = entspricht nicht o.g. Prüfgrundlage(n)	3 = befriedigend N/A = nicht anwendbar	4 = ausreichend N/T = nicht getestet
* Legend:	1 = very good P(ass) = passed a.m. test specification(s)	2 = good F(ail) = failed a.m. test specification(s)	3 = satisfactory N/A = not applicable	4 = sufficient N/T = not tested
<p>Dieser Prüfbericht bezieht sich nur auf das o.g. Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. <i>This test report only relates to the a. m. test sample. Without permission of the test center this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any test mark.</i></p>				

TEST SUMMARY

Report Section	FCC Clause	Test Item	Result
5.1.1	15.247(b) & 15.203	Antenna Requirement	Pass
5.1.2	15.247(b)(1)	Peak Output Power	Pass
5.1.3	15.247(a)(1)	20 dB Bandwidth	Pass
5.1.3	2.1049	99% Occupied Bandwidth	Pass
5.1.4	15.247(d)	Conducted Spurious Emission and Band Edges	Pass
5.1.5	15.247(d) & 15.205 & 15.209	Radiated Spurious Emissions and Band Edges	Pass
5.1.6	15.247(a)(1)	Hopping Channel Separation	Pass
5.1.7	15.247(a)(1) (iii)	Number of Hopping Frequency Used	Pass
5.1.8	15.247(a)(1) (iii)	Dwell Time on Each Channel	Pass
-	15.207	Mains Conducted Emission	N/A

Note:

1. If the Frequency Hopping Systems operating in 2400-2483.5 MHz band and the output power less than 125 mW. The hopping channel carrier frequencies separated by a minimum of 25 kHz or two-thirds of the 20 dB bandwidth of hopping channel whichever is greater.
2. Determining compliance based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty.

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APPENDIX A - TEST RESULT OF CONDUCTED

APPENDIX B - TEST RESULT OF RADIATED EMISSIONS

APPENDIX SP - PHOTOGRAPHS TEST SETUP

APPENDIX EP - PHOTOGRAPHS OF EUT

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HISTORY OF THIS TEST REPORT

Report No.	Description	Date Issued
CN222KWR (P15C-BT) 001	Original Release	2022-11-15

1. General Remarks

1.1 Complementary Materials

All attachments are integral parts of this test report. This applies especially to the following appendix:

Appendix A - Test Result of Conducted

Appendix B - Test Result of Radiated Emissions

Appendix SP - Photographs Test Setup

Appendix EP - Photographs of EUT

Applied Standard and Test Levels

Radio
FCC 47CFR Part 15: Subpart C Section 15.247
FCC 47CFR Part 2: Subpart J Section 2.1049
ANSI C63.10:2013
KDB 558074 D01 15.247 Meas Guidance v05r02

1.2 Decision Rule of Conformity

The decision rule of conformity of this test report is following the requirements of the requested standard in the quotation, and agreed among testing laboratory and manufacturer (applicant) to exclude the consideration of Measurement Uncertainty, unless it is required by the specific standard.

2. Test Sites

2.1 Test Laboratory

Taipei Testing Laboratories

11F. No.758, Sec. 4, Bade Rd., Songshan Dist.
Taipei City 105
Taiwan (R.O.C.)

2.2 Test Facility

Taipei Testing Laboratories

No.458-18, Sec. 2, Fenliao Rd., Linkou Dist.,
New Taipei City 244
Taiwan (R.O.C.)
FCC Registration No.: 180491
ISED Registration No.: 25563

2.3 Traceability

All measurement equipment calibrations are traceable to NML(Taiwan)/NIST(USA) or where calibration is performed outside Taiwan, to equivalent nationally recognized standards organizations.

2.4 Calibration

Equipment requiring calibration is calibrated periodically in a suitably accredited Calibration Lab. Additionally all equipment is verified for proper performance on a regular basis using in house standards or comparisons.

2.5 Measurement Uncertainty

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicate a 95% level of confidence.

Emission Measurement Uncertainty

Parameter	Uncertainty
Radiated Emission (9 kHz ~ 30 MHz)	± 1.15 dB
Radiated Emission (30 MHz ~ 200 MHz)	± 1.30 dB
Radiated Emission (200 MHz ~ 1 GHz)	± 1.30 dB
Radiated Emission (1 GHz ~ 18 GHz)	± 1.54 dB
Radiated Emission (18 GHz ~ 40 GHz)	± 2.52 dB
Mains Conducted Emission	± 1.65 dB

3. General Product Information

3.1 Product Function and Intended Use

The EUT is a RADIO BOX. It contains a Bluetooth compatible module enabling the user to communicate data through a Wireless interface.

For details refer to the User Guide, Data Sheet and Circuit Diagram.

3.2 System Details and Ratings

Basic Information of EUT

Item	EUT information
Kind of Equipment/Test Item	RADIO BOX
Type Identification	621-8167 / 621-8168
FCC ID	PQMCRM02

Technical Specification of EUT

Item	EUT information
Operating Frequency	2402 MHz ~ 2480 MHz
Channel Number	79
Operation Voltage	12 Vdc / 24 Vdc (Tested at 3.3 Vdc from USB converter)
Modulation	GFSK, $\pi/4$ -DQPSK, 8DPSK
Maximum Output Power (mW)	8.453
Antenna Information	Refer to 5.1.1
Accessory Device	Refer to 4.4

Note:

- All models are listed as below.

	Type Identification	Difference
Main Model	621-8168	The difference between these 2 models are 621-8168 with DAB tuner and 621-8167 without DAB tuner, all other are electrically identical, the worst model 621-8168 has been evaluated.
Series Model	621-8167	

3.3 Noise Generating and Noise Suppressing Parts

Refer to the Circuit Diagram.

3.4 Submitted Documents

- Circuit Diagram
- Instruction Manual
- Rating Label
- Technical Description

4. Test Set-up and Operation Modes

4.1 Principle of Configuration Selection

The test modes were adapted accordingly in reference to the instructions for use.

During testing, Channel and Power Controlling Software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output expected by the customer and is going to be fixed on the firmware of the final end product.

Table for Parameters of Test Software Setting

Frequency (MHz)	Power Setting		
	GFSK	$\pi/4$ -DQPSK	8DPSK
2402	Default	Default	Default
2441	Default	Default	Default
2480	Default	Default	Default

4.2 Carrier Frequency and Channel

Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
0	2402	20	2422	40	2442	60	2462
1	2403	21	2423	41	2443	61	2463
2	2404	22	2424	42	2444	62	2464
3	2405	23	2425	43	2445	63	2465
4	2406	24	2426	44	2446	64	2466
5	2407	25	2427	45	2447	65	2467
6	2408	26	2428	46	2448	66	2468
7	2409	27	2429	47	2449	67	2469
8	2410	28	2430	48	2450	68	2470
9	2411	29	2431	49	2451	69	2471
10	2412	30	2432	50	2452	70	2472
11	2413	31	2433	51	2453	71	2473
12	2414	32	2434	52	2454	72	2474
13	2415	33	2435	53	2455	73	2475
14	2416	34	2436	54	2456	74	2476
15	2417	35	2437	55	2457	75	2477
16	2418	36	2438	56	2458	76	2478
17	2419	37	2439	57	2459	77	2479
18	2420	38	2440	58	2460	78	2480
19	2421	39	2441	59	2461		

4.3 Test Operation and Test Software

Setup for testing: Test samples are provided with a USB interface which makes it possible to control them through a test software installed on a notebook computer.

This software was running on the laptop computer connected to the EUT. It was used to enable the operation modes listed as below.

Test Software	Cypress Blutool V1.9.8.6
---------------	--------------------------

The samples were used as follows:

A00335537-025

A00335537-021

Full test was applied on all test modes, but only worst case was shown.

EUT Configure Mode	Applicable To				Description
	Antenna Port Conducted Measurement	Radiated Spurious Emissions above 1 GHz	Radiated Spurious Emissions below 1 GHz	Mains Conducted Emission	
-	√	√	√	-	-

Note:

1. The EUT had been pre-tested on the positioned of each 3 axis. The worst case was found when position on **Z-plane**.
2. "-" means no effect.

Antenna Port Conducted Measurement

Pre-Scan full test was applied on all test modes, but only worst case was shown.

Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Frequency (MHz)	Tested Frequency (MHz)	Modulation Type	Packet Type
-	2402 to 2480	2402, 2441, 2480	GFSK	1DH5
-	2402 to 2480	2402, 2441, 2480	$\pi/4$ -DQPSK	2DH5
-	2402 to 2480	2402, 2441, 2480	8DPSK	3DH5

Radiated Spurious Emissions (Above 1 GHz)

Pre-Scan full test was applied on all test modes, but only worst case was shown.

Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Frequency (MHz)	Tested Frequency (MHz)	Modulation Type	Packet Type
-	2402 to 2480	2402, 2441, 2480	GFSK	1DH5
-	2402 to 2480	2402, 2441, 2480	8DPSK	3DH5

Radiated Spurious Emissions (Below 1 GHz)

Pre-Scan full test was applied on all test modes, but only worst case was shown.

Following channel(s) was (were) selected for the final test as listed below.

EUT Configure Mode	Available Frequency (MHz)	Tested Frequency (MHz)	Modulation Type	Packet Type
-	2402 to 2480	2480	GFSK	1DH5

Test Condition

Test Item	Ambient Temperature	Relative Humidity	Tested by
Conducted Measurement	18-23 °C	58-69 %	Nick Hsu
Radiated Spurious Emissions above 1 GHz	19.8-20.9 °C	52-57 %	Ray Huang
Radiated Spurious Emissions below 1 GHz	19.8-20.9 °C	52-57 %	Ray Huang

4.4 Special Accessories and Auxiliary Equipment

The product has been tested together with the following additional accessories:

Accessory of EUT

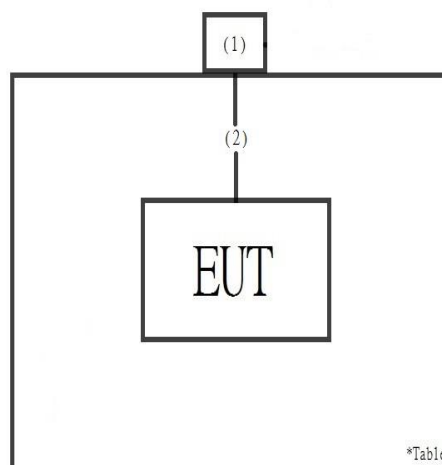
None

Support Unit

Support Unit								
No	Description	Brand	Model	S/N	Shielded	Ferrite Core (Qty)	Length (cm)	Remark
1	Notebook	HP	9470M	00-24-69	NO	NO	N/A	--
2	USB Cable	TUV	NA	NO	NO	NO	200	--

4.5 Test Setup Diagram

<Radiated Spurious Emissions mode>



5. Test Results

5.1 Transmitter Requirement & Test Suites

5.1.1 Antenna Requirement

Requirement Use of approved antennas only

According to the manufacturer declaration, the EUT has an antenna with a directional gain of 2 dBi. The antenna is Multilayer Ceramic antenna with no possibility of replacement with a non-approved antenna by the end-user. Therefore, the EUT is considered to comply with this provision.

Refer to EUT photo for details.

5.1.2 Peak Output Power

Limit

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. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

Kind of Test Site Shielded room

Test Setup



Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Power Meter	Anritsu	ML2495A	1901008	2022/3/15	2023/3/14	2022/10/29	2022/11/11
Power Sensor	Anritsu	MA2411B	1725269	2022/3/15	2023/3/14	2022/10/29	2022/11/11

Test Procedures

A peak power sensor was used on the output port of the EUT. A power meter was used to read the response of the peak power sensor. Record the power level.

Average power sensor was used to perform output power measurement, trigger and gating function of wide band power meter is enabled to measure max output power of TX on burst. Duty factor is not added to measured value.

Test Result
Peak Output Power
<GFSK>

Channel	Channel Frequency	Peak Output Power		Limit
	(MHz)	(dBm)	(mW)	(mW)
Low Channel	2402	7.69	5.875	125
Middle Channel	2441	9.24	8.395	125
High Channel	2480	9.27	8.453	125

<8DPSK>

Channel	Channel Frequency	Peak Output Power		Limit
	(MHz)	(dBm)	(mW)	(mW)
Low Channel	2402	7.54	5.675	125
Middle Channel	2441	9.18	8.279	125
High Channel	2480	9.24	8.395	125

Average Power
<GFSK>

Channel	Channel Frequency	Average Power	
	(MHz)	(dBm)	(mW)
Low Channel	2402	7.61	5.768
Middle Channel	2441	9.16	8.241
High Channel	2480	9.18	8.279

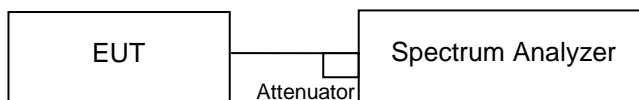
<8DPSK>

Channel	Channel Frequency	Average Power	
	(MHz)	(dBm)	(mW)
Low Channel	2402	4.91	3.097
Middle Channel	2441	6.74	4.721
High Channel	2480	6.94	4.943

5.1.3 20 dB Bandwidth and 99% Occupied Bandwidth

Kind of Test Site Shielded room

Test Setup



Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Spectrum Analyzer	Agilent	N9010A	MY53470241	2022/6/15	2023/6/14	2022/10/29	2022/11/11

Test Procedure

- a. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
- c. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
- d. Repeat above procedures until all frequencies measured were complete.
- e. The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with resolution bandwidth in the range of 1 % to 5 % of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth and set the detector to PEAK. The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage 0.5 % of the total mean power of a given emission.

Test Results

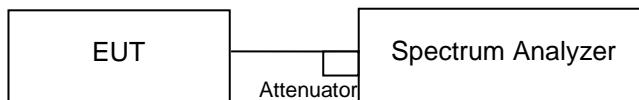
Please refer to Appendix A.

5.1.4 Conducted Spurious Emissions and Frequency Band Edges Measured in 100kHz Bandwidth

Limit

20dB (below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.)

Kind of Test Site Shielded room

Test Setup

Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Spectrum Analyzer	Agilent	N9010A	MY53470241	2022/6/15	2023/6/14	2022/10/29	2022/11/11

Test Procedure

The transmitter output was connected to the spectrum analyzer via a low lose cable. Set both RBW and VBW of spectrum analyzer to 100 kHz and 300 kHz with suitable frequency span including 100 MHz bandwidth from band edge. The band edges was measured and recorded.

Test Results

Please refer to Appendix A.

5.1.5 Radiated Spurious Emissions and Band Edges

Limit

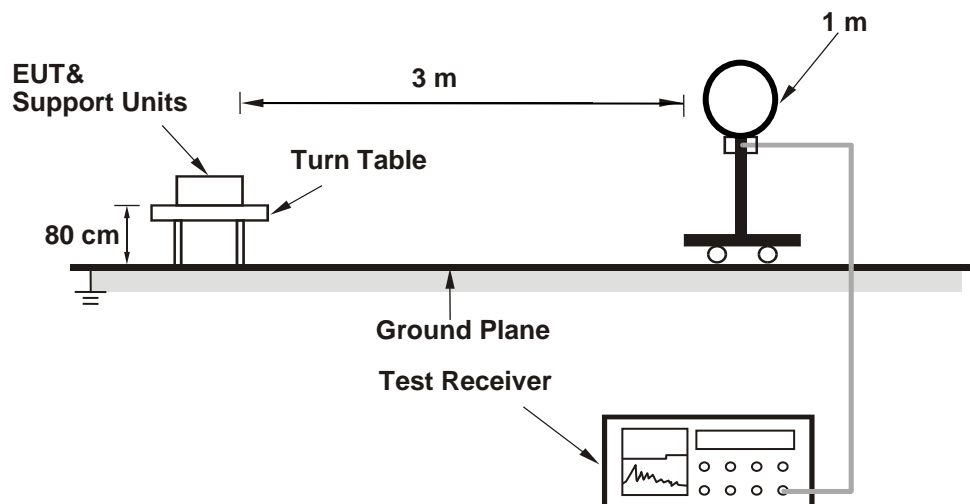
Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must comply with the radiated emission limits specified in §15.209(a).

Emissions radiated outside the restricted and authorized frequency bands must either comply with the radiated emission limits specified for the restricted bands or in §15.247(d).

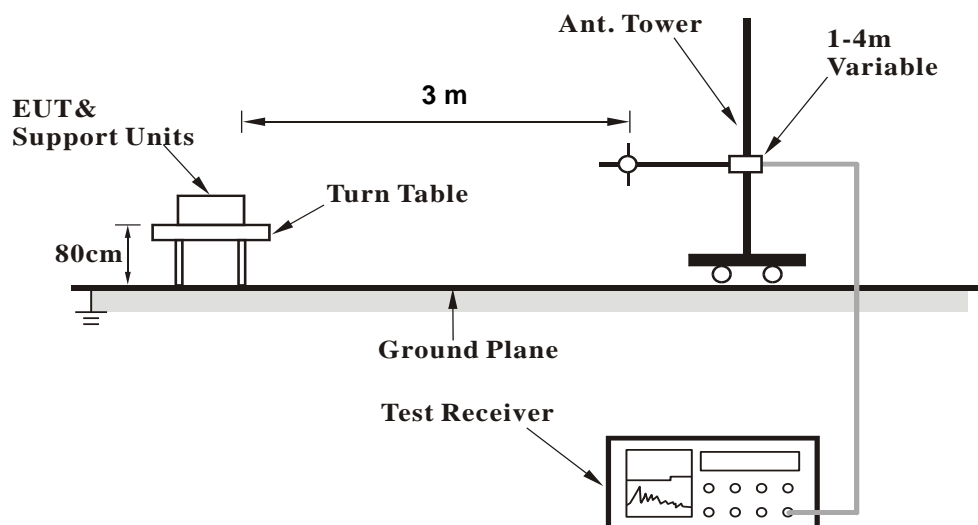
Kind of Test Site 3m Semi-Anechoic Chamber

Test Setup

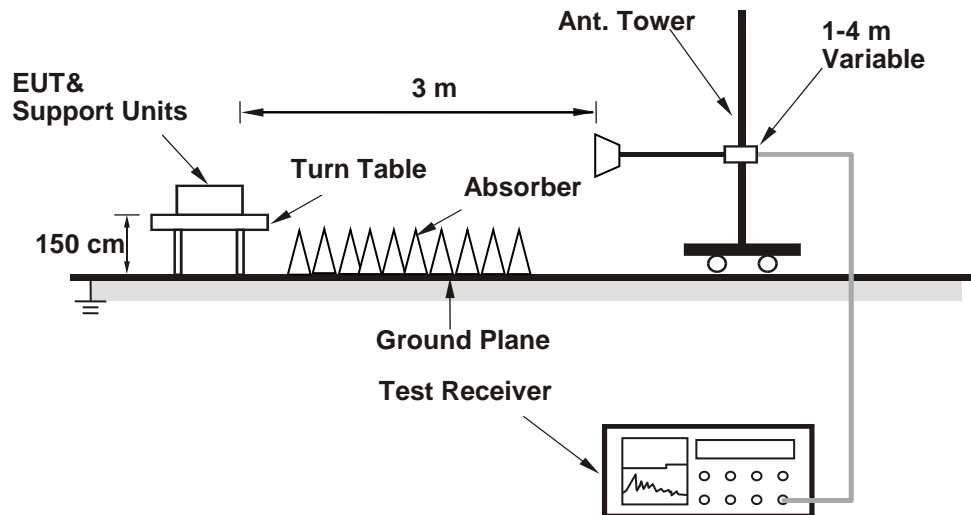
<Radiated Emissions below 30 MHz>



<Radiated Emissions 30 MHz to 1 GHz>



<Radiated Emissions above 1 GHz>



For the actual test configuration, please refer to the attached file (Test Setup Photo).

Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date
Above 1 GHz					
Signal Analyzer	R&S	FSV40	101508	2022/4/13	2023/4/12
Horn Antenna	ETS-Lindgren	3117	00218929	2021/11/25	2022/11/24
HF-AMP + AC source	EMCI	EMC051845SE	980635	2022/1/20	2023/1/19
HF-AMP + AC source	EMCI	EMC184045SE	980656	2022/1/20	2023/1/19
Horn Antenna	SCHWARZBECK	BBHA 9170	00887	2022/3/29	2023/3/28
Test Software	Audix E3	15914a_20191106 tuv	PK-001087	N/A	N/A
30 MHz ~ 1 GHz					
Receiver	R&S	ESR7	102108	2022/4/28	2023/4/27
Bilog Antenna	SCHWARZBECK	VULB-9168	00950	2022/4/6	2023/4/5
LF-AMP	Agilent	8447D	2944A107722	2022/3/22	2023/3/21
Test Software	Audix E3	15914a_20191106 tuv	PK-001087	N/A	N/A
Below 30 MHz					
Receiver	R&S	ESR7	102108	2022/4/28	2023/4/27
Loop Antenna	SCHWARZBECK	FMZB 1519B	00215	2021/12/8	2022/12/7
Test Software	Audix E3	15914a_20191106 tuv	PK-001087	N/A	N/A

Test Procedures**For Radiated Emissions below 30 MHz**

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter chamber room. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. Parallel (OPEN), perpendicular (CLOSE), and ground-parallel (GROUND) orientations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to Quasi-Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 9 kHz at frequency below 30 MHz.
2. All modes of operation were investigated and the worst-case emissions are reported.

For Radiated Emissions above 30 MHz

- a. The EUT was placed on the top of a rotating table 0.8 meters (for 30 MHz ~ 1 GHz) / 1.5 meters (for above 1 GHz) above the ground at 3 meter chamber room for test. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to quasi-peak detect function and specified bandwidth with maximum hold mode when the test frequency is below 1 GHz.
- f. The test-receiver system was set to peak and average detected function and specified bandwidth with maximum hold mode when the test frequency is above 1 GHz. If the peak reading value also meets average limit, measurement with the average detector is unnecessary.

Note:

1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) or Peak detection (PK) at frequency below 1 GHz.
2. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 MHz for Peak detection (PK) at frequency above 1 GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is $\geq 1/T$ (Duty cycle < 98 %) or 10 Hz (Duty cycle ≥ 98 %) for Average detection (AV) at frequency above 1 GHz.
4. For fundamental frequency: The average value is "Average = Peak value + 20log(Duty cycle)
Where the duty factor is calculated from following formula for DH5 packet type which has worst duty factor:
 $20\log(\text{Duty cycle}) = 20\log(\text{dwell time} / 100\text{ms}) = 20\log(3.125 / 100) = -30.1 \text{ dB}$
5. All modes of operation were investigated and the worst-case emissions are reported.

6. The Radiated Emissions testing was performed in the X(E1), Y(H) and Z(E2) axis orientation. The worst-case Axis orientation is recorded in this test report.

Test Results

Factor (dB/m) = Antenna Factor (dB/m) + Cable Loss (dB)

Level (dBuV/m) = Reading (dBuV) + Factor (dB/m)

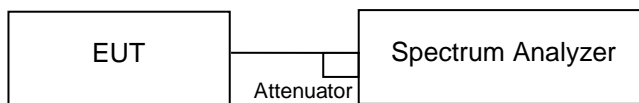
Please refer to Appendix B.

5.1.6 Hopping Channel Separation

Limit ≥ 25 kHz or 2/3 of 20 dB bandwidth, whichever is greater

Kind of Test Site Shielded room

Test Setup



Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Spectrum Analyzer	Agilent	N9010A	MY53470241	2022/6/15	2023/6/14	2022/10/29	2022/11/11

Test Procedure

Measurement Procedure REF

- Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range.
- By using the MaxHold function record the separation of two adjacent channels.
- Measure the frequency difference of these two adjacent channels by SA MARK function. And then plot the result on SA screen.
- Repeat above procedures until all frequencies measured were complete.

Test Results

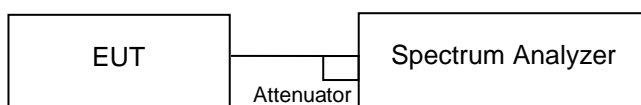
Please refer to Appendix A.

5.1.7 Number of Hopping Frequency

Limit ≥ 15 non-overlapping channels

Kind of Test Site Shielded room

Test Setup



Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Spectrum Analyzer	Agilent	N9010A	MY53470241	2022/6/15	2023/6/14	2022/10/29	2022/11/11

Test Procedure

- a. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
- b. Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
- c. Set the SA on MaxHold Mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.
- d. Set the SA on View mode and then plot the result on SA screen.
- e. Repeat above procedures until all frequencies measured were complete.

Test Results

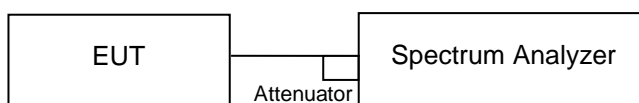
Please refer to Appendix A.

5.1.8 Dwell Time

Limit 0.4s

Kind of Test Site Shielded room

Test Setup



Test Instruments

Kind of Equipment	Manufacturer	Type	S/N	Calibration Date	Calibration Due Date	Test Date	
						From	Until
Spectrum Analyzer	Agilent	N9010A	MY53470241	2022/6/15	2023/6/14	2022/10/29	2022/11/11

Test Procedures

- Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
- Turn on the EUT and connect its antenna terminal to measurement via a low loss cable. Then set it to any one measured frequency within its operating range and make sure the instrument is operated in its linear range.
- Adjust the center frequency of SA on any frequency be measured and set SA to zero span mode. And then, set RBW and VBW of spectrum analyzer to proper value.
- Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
- Repeat above procedures until all different time-slot modes have been completed.

Test Results

Please refer to Appendix A.

Appendix A: Test Results of Conducted Test

Test Result of 20 dB Bandwidth

GFSK

Channel	Channel Frequency (MHz)	20 dB Bandwidth (kHz)	Result
Low Channel	2402	999.00	Pass
Middle Channel	2441	996.00	Pass
High Channel	2480	960.00	Pass

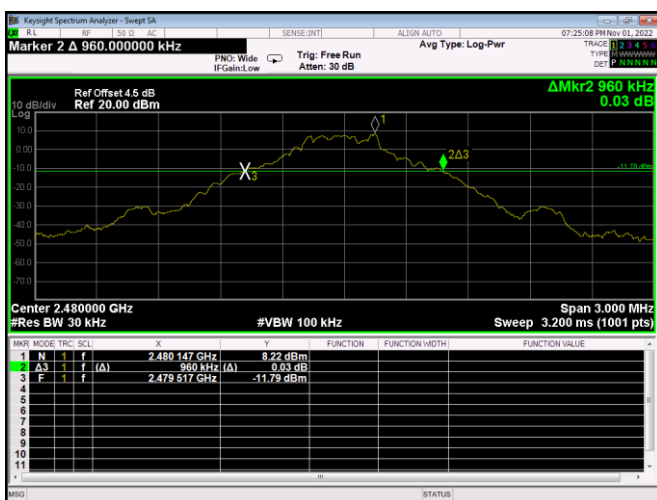
Low Channel



Middle Channel



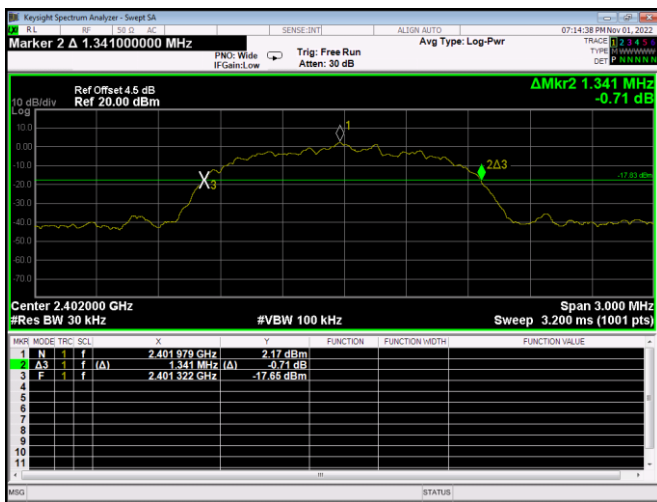
High Channel



8DPSK

Channel	Channel Frequency (MHz)	20 dB Bandwidth (kHz)	Result
Low Channel	2402	1341.00	Pass
Middle Channel	2441	1344.00	Pass
High Channel	2480	1338.00	Pass

Low Channel



Middle Channel



High Channel

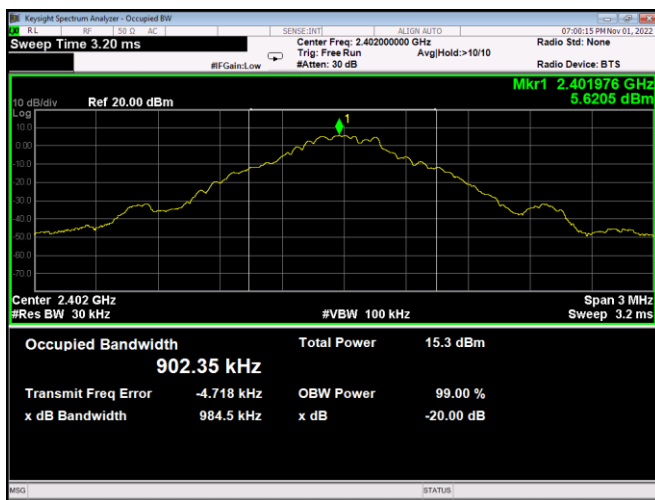


Test Result of 99% Occupied Bandwidth

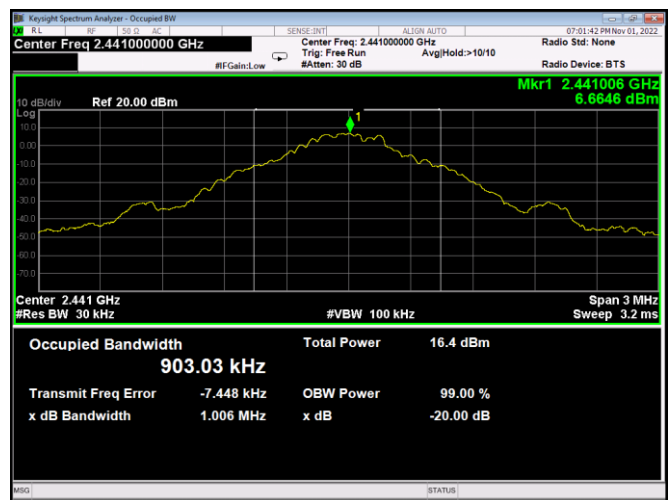
GFSK

Channel	Channel Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	2402	902.35
Middle Channel	2441	903.03
High Channel	2480	904.63

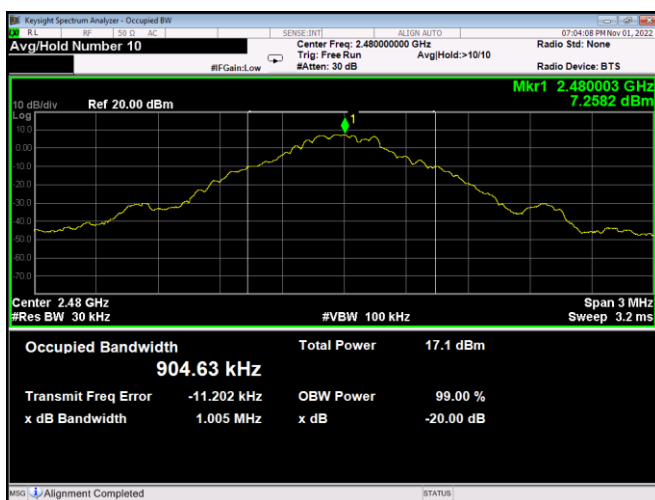
Low Channel



Middle Channel

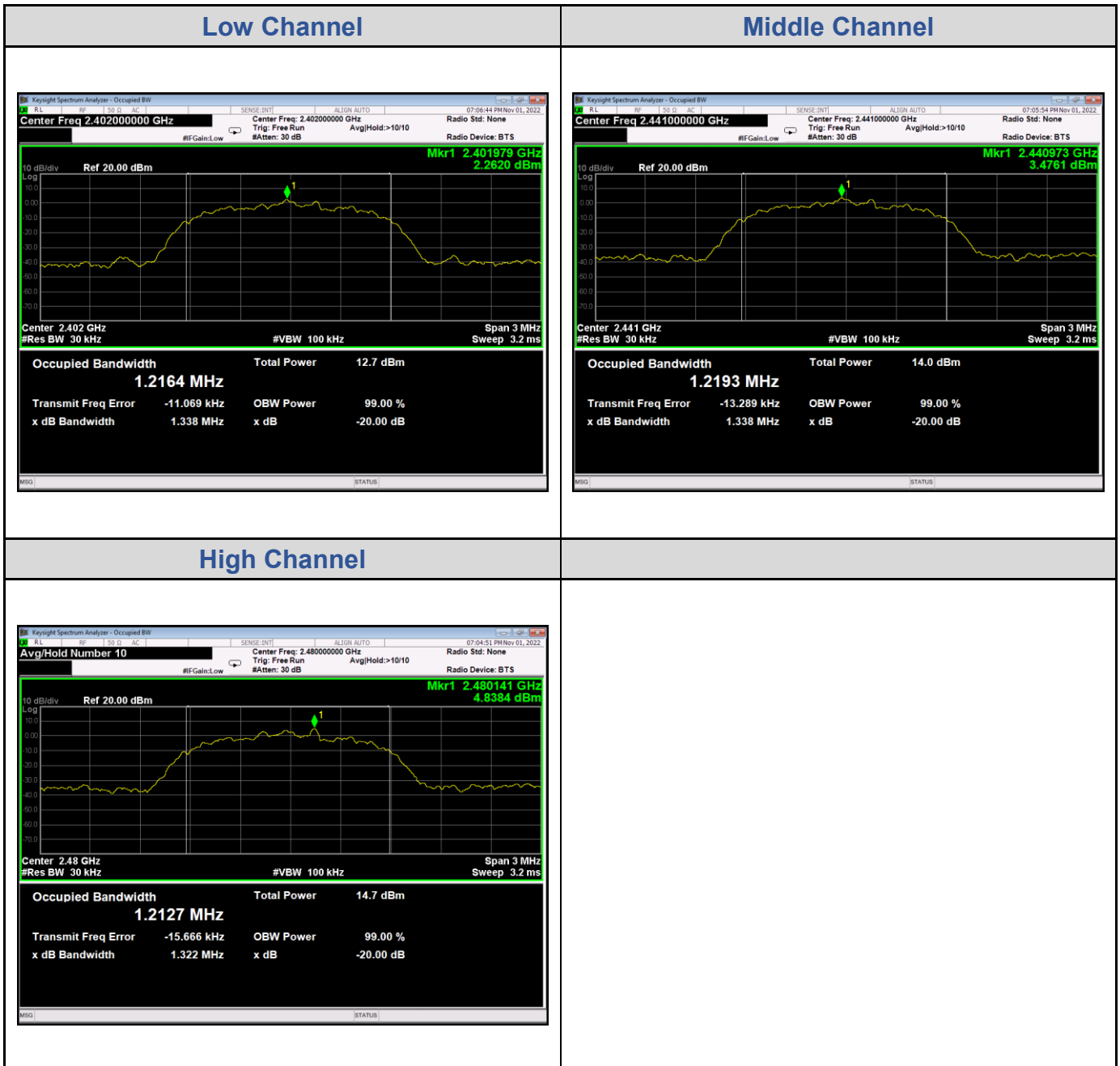


High Channel



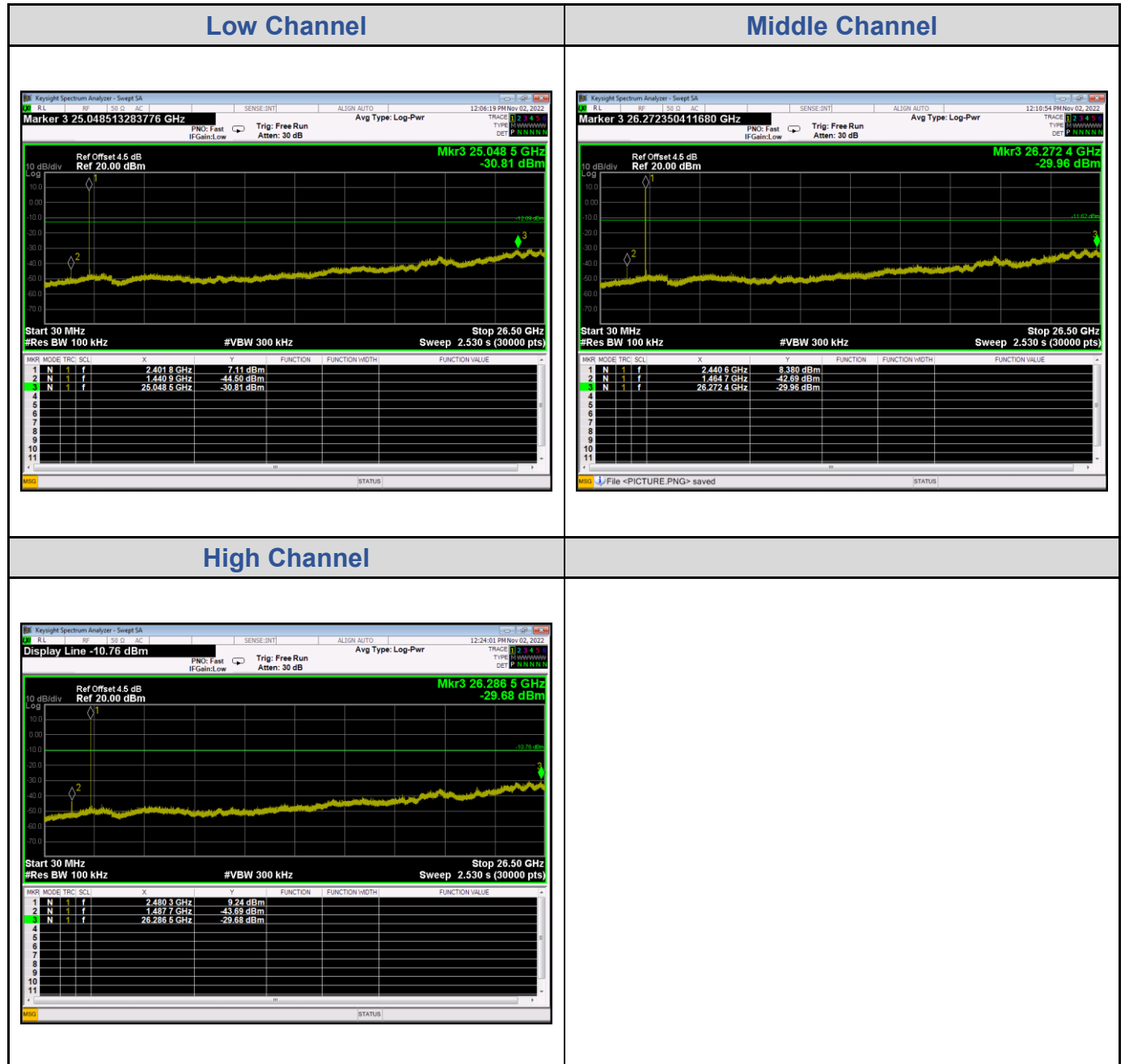
8DPSK

Channel	Channel Frequency (MHz)	99% Bandwidth (kHz)
Low Channel	2402	1216.40
Middle Channel	2441	1219.30
High Channel	2480	1212.70



Test Result of Conducted Spurious Emissions, Tx Mode

GFSK

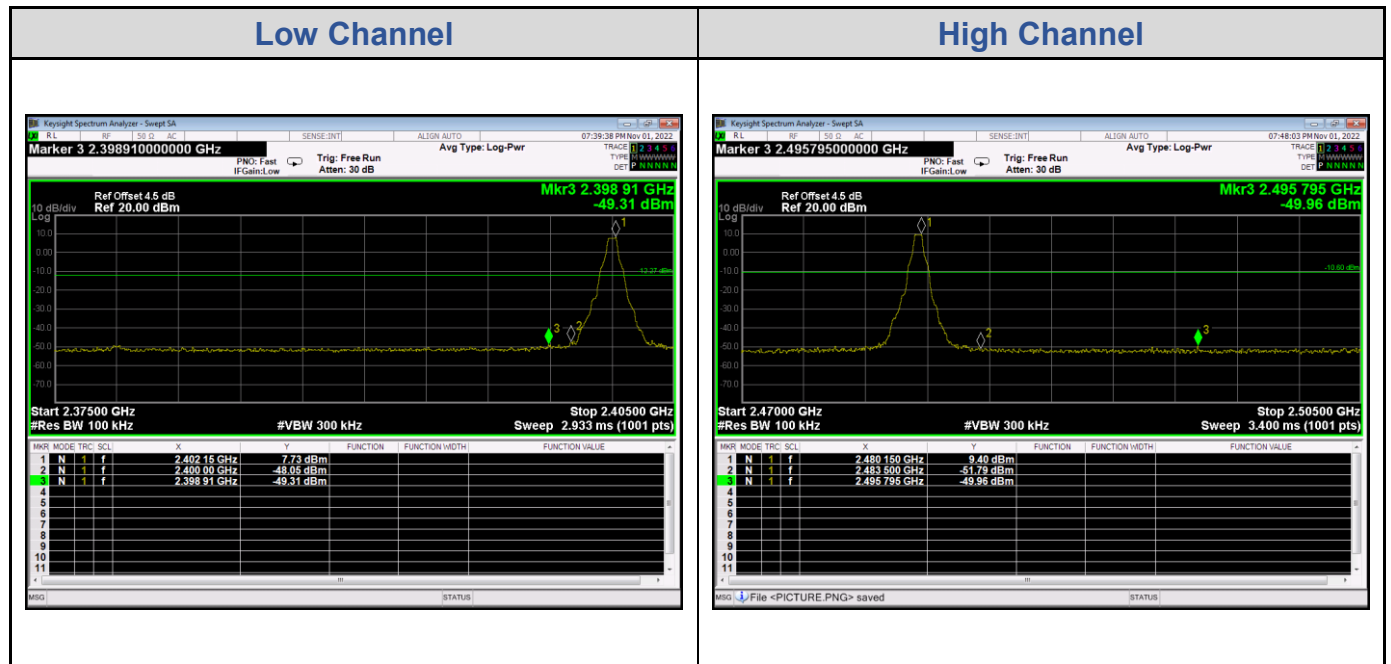


8DPSK

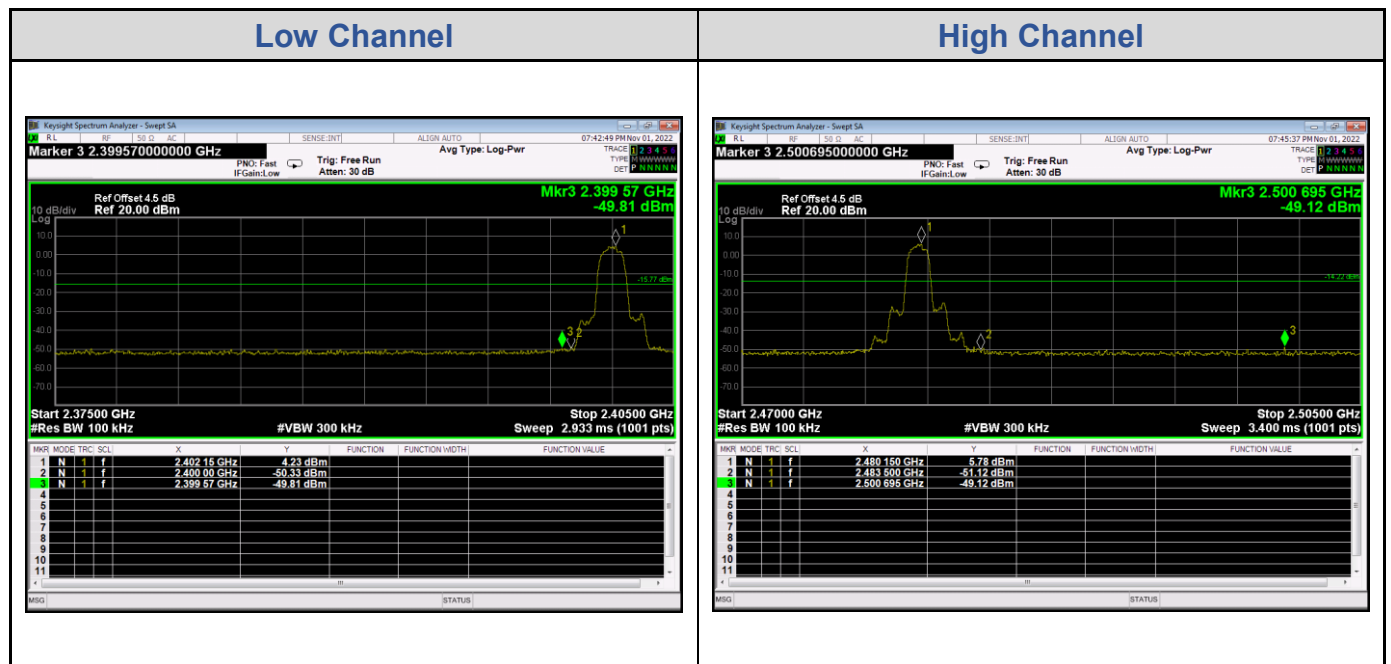


Test Result of Conducted Band Edge, Tx Mode

GFSK

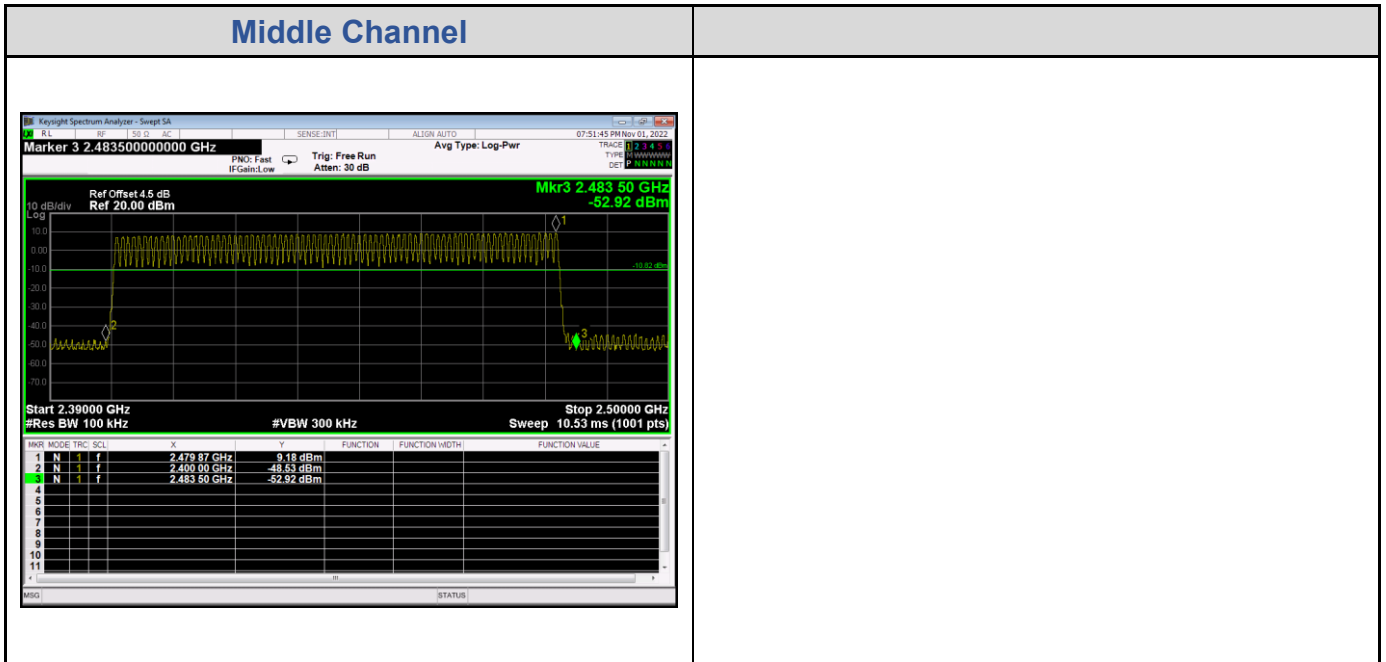


8DPSK

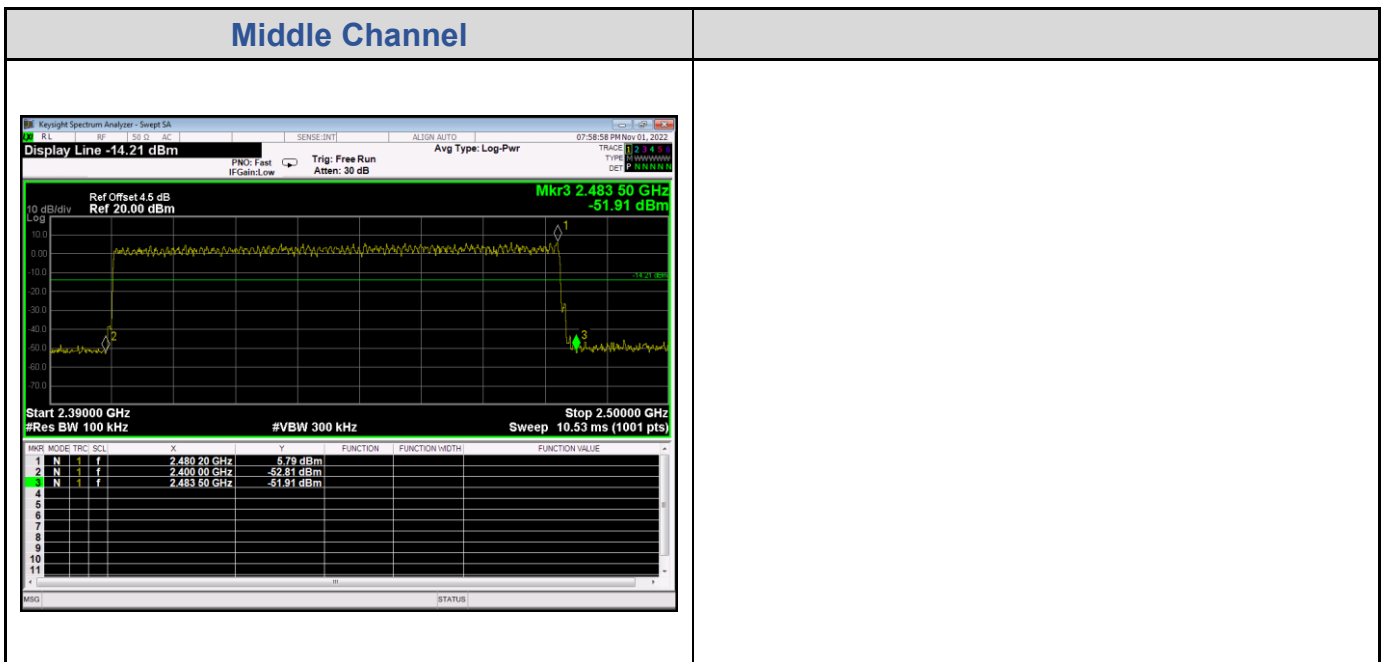


Test Result of Hopping Band Edge

GFSK



8DPSK

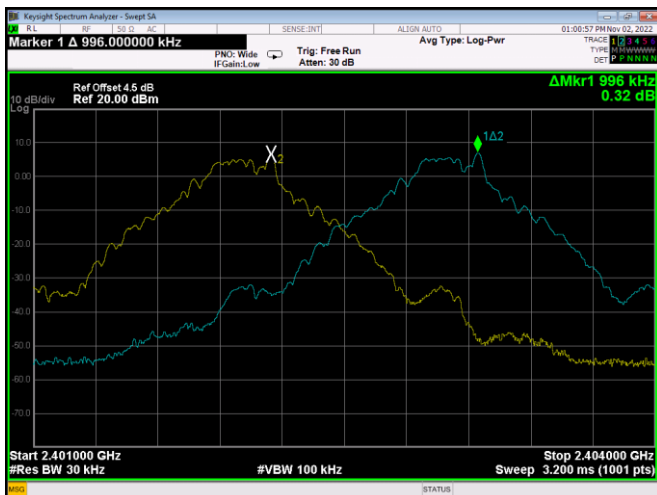


Test Result of Hopping Channel Separation

GFSK

Channel	Channel Frequency (MHz)	Adjacent Channel Separation (MHz)	20 dB Bandwidth (kHz)	Minimum Limit (MHz)	Result
0	2402	996.00	999.00	0.666	Pass
39	2441	996.00	996.00	0.664	Pass
78	2480	996.00	960.00	0.640	Pass

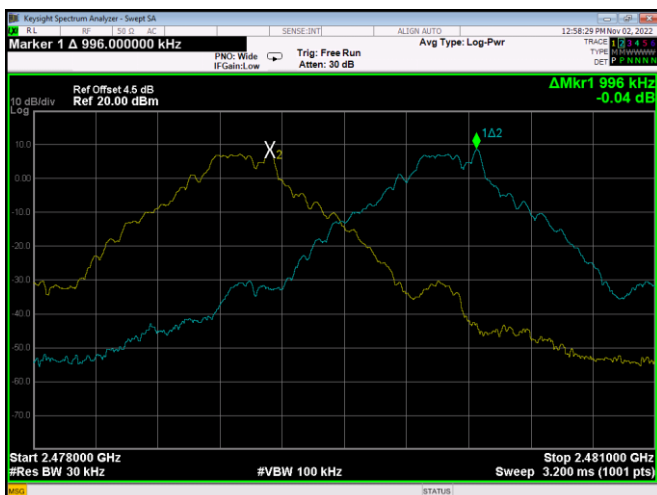
Low Channel



Middle Channel

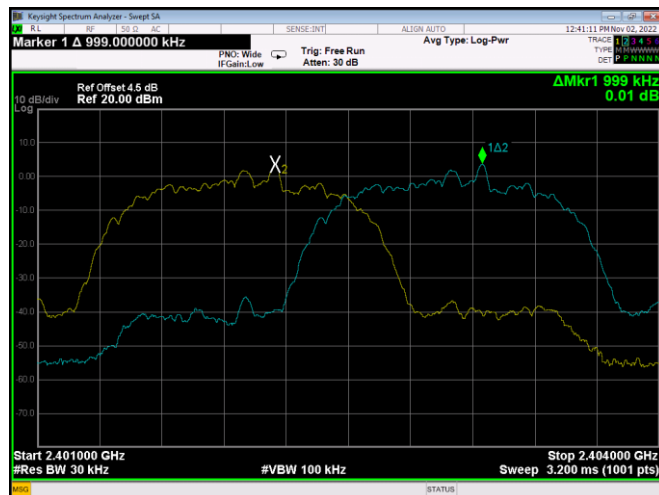
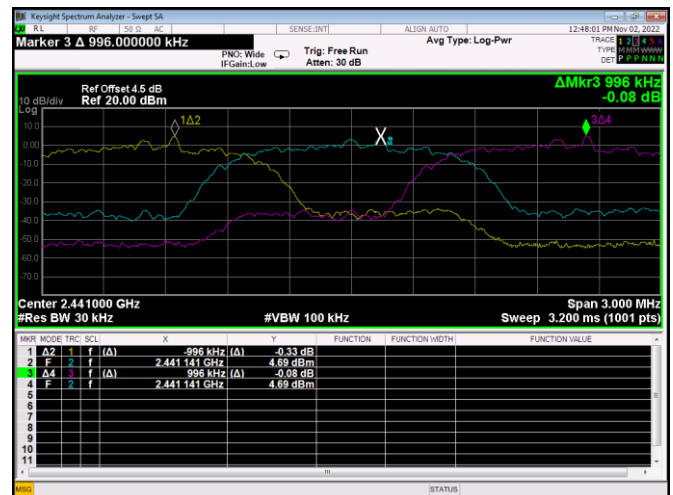
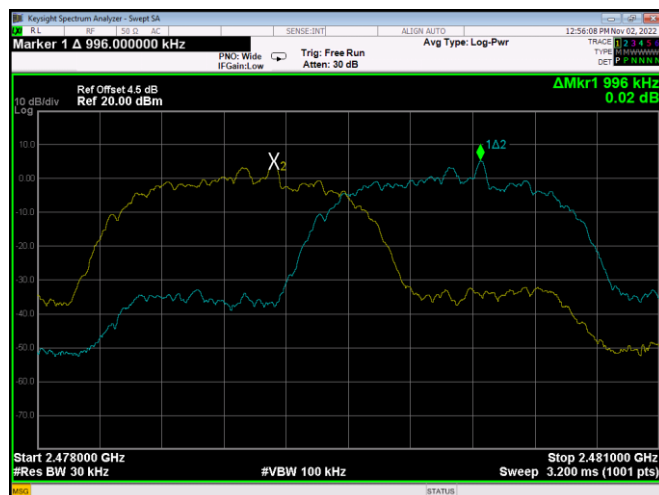


High Channel



8DPSK

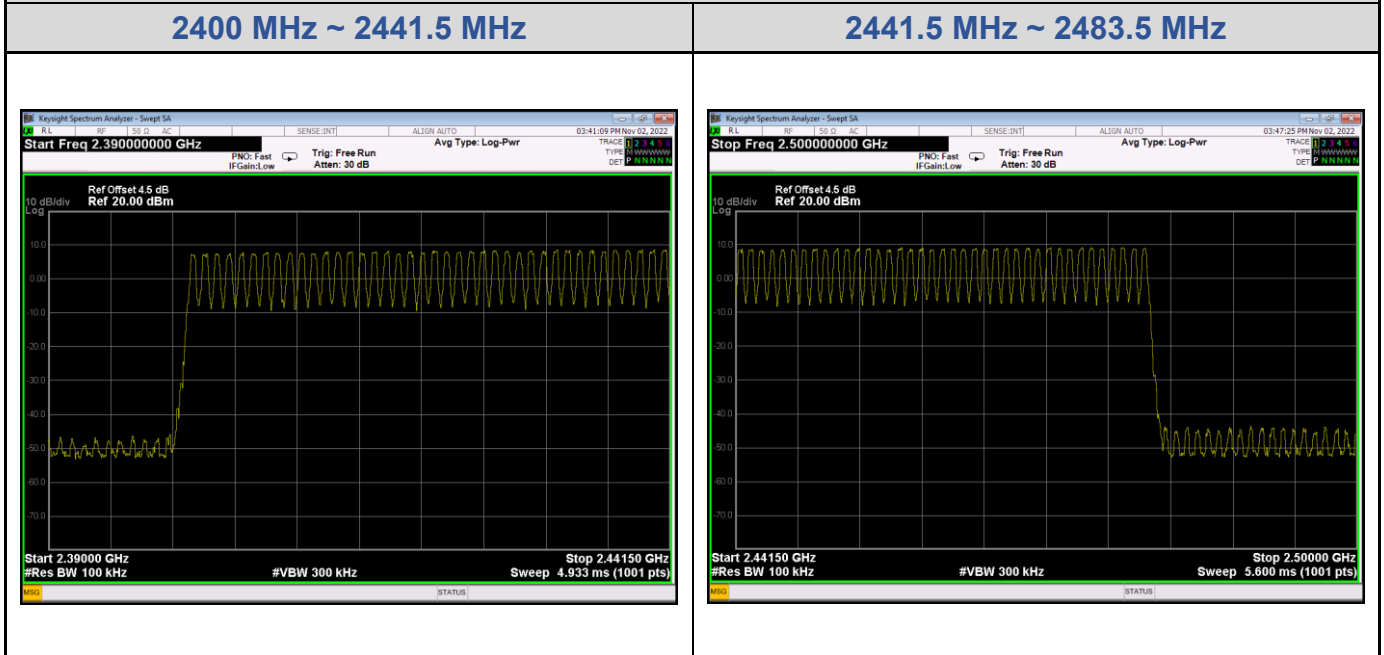
Channel	Channel Frequency (MHz)	Adjacent Channel Separation (MHz)	20 dB Bandwidth (kHz)	Minimum Limit (MHz)	Result
0	2402	999.00	1341.00	0.894	Pass
39	2441	996.00	1344.00	0.896	Pass
78	2480	996.00	1338.00	0.892	Pass

Low Channel

Middle Channel

High Channel


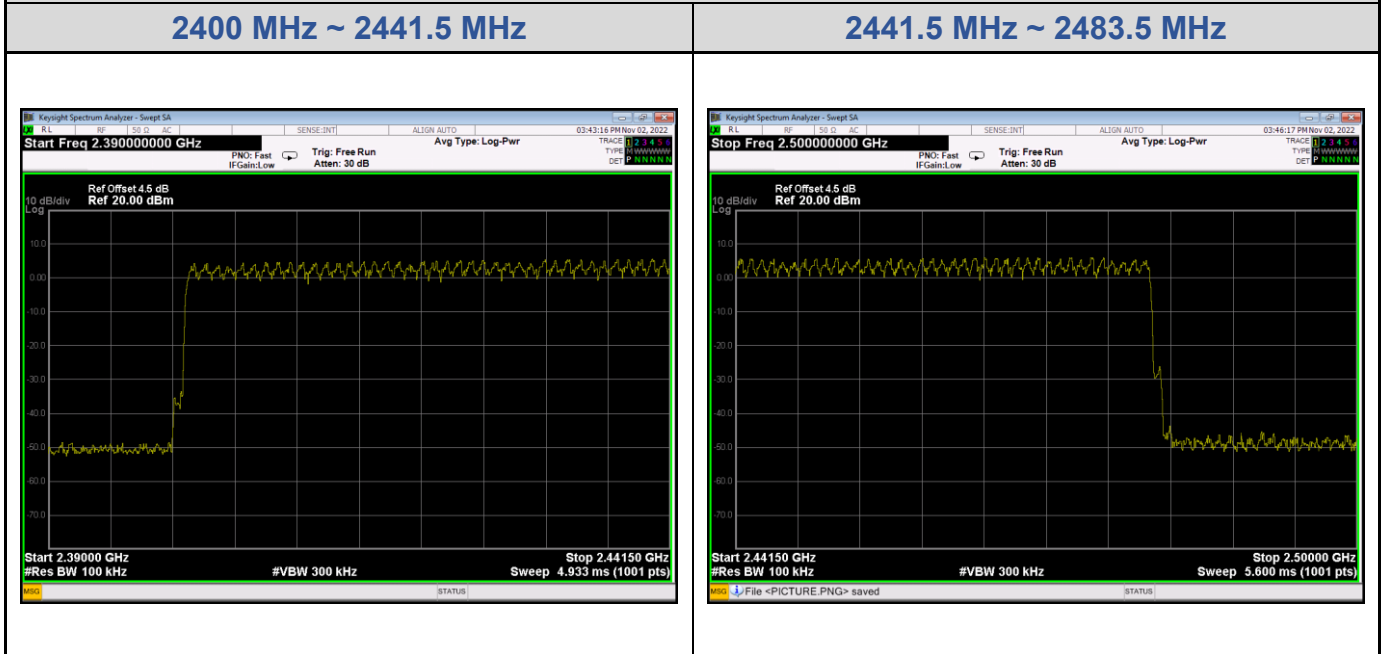
Test Result of Number of Hopping Frequency

Frequency Range	Measured Quantity of Hopping Channel	Limit	Result
2400 to 2483.5 MHz	79	≥15	Pass

GFSK



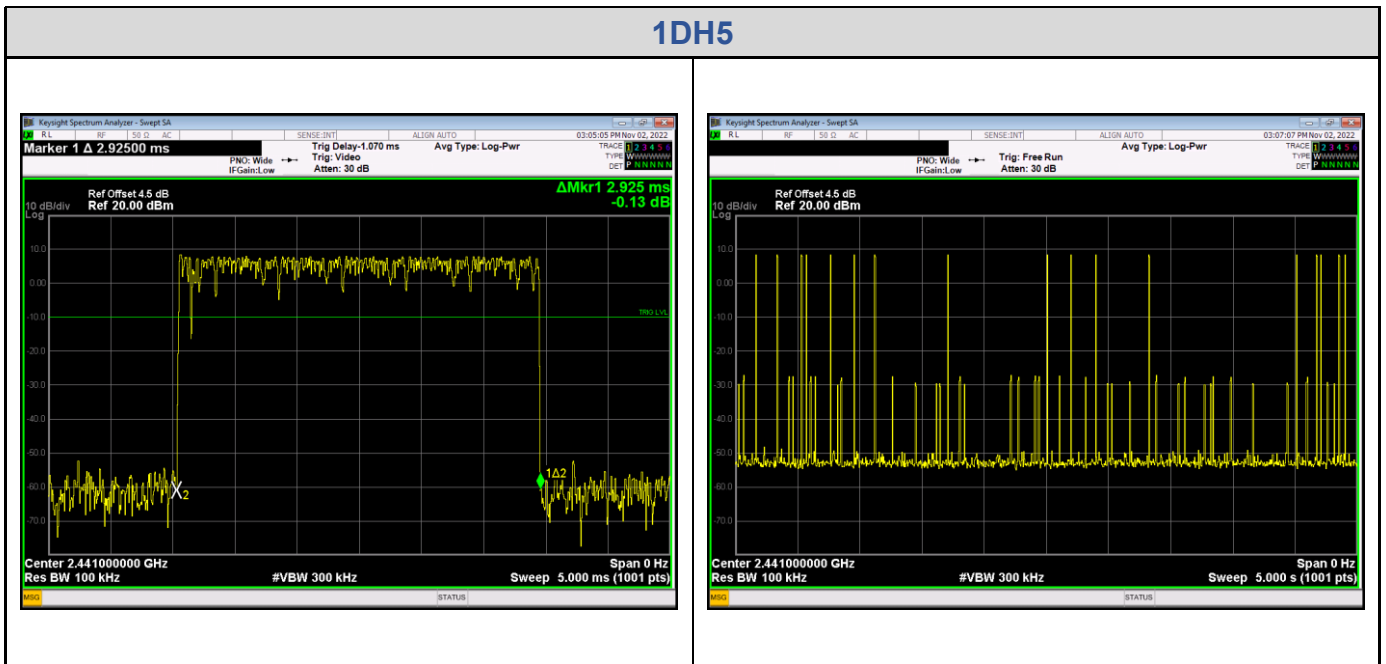
8DPSK



Test Result of Dwell Time

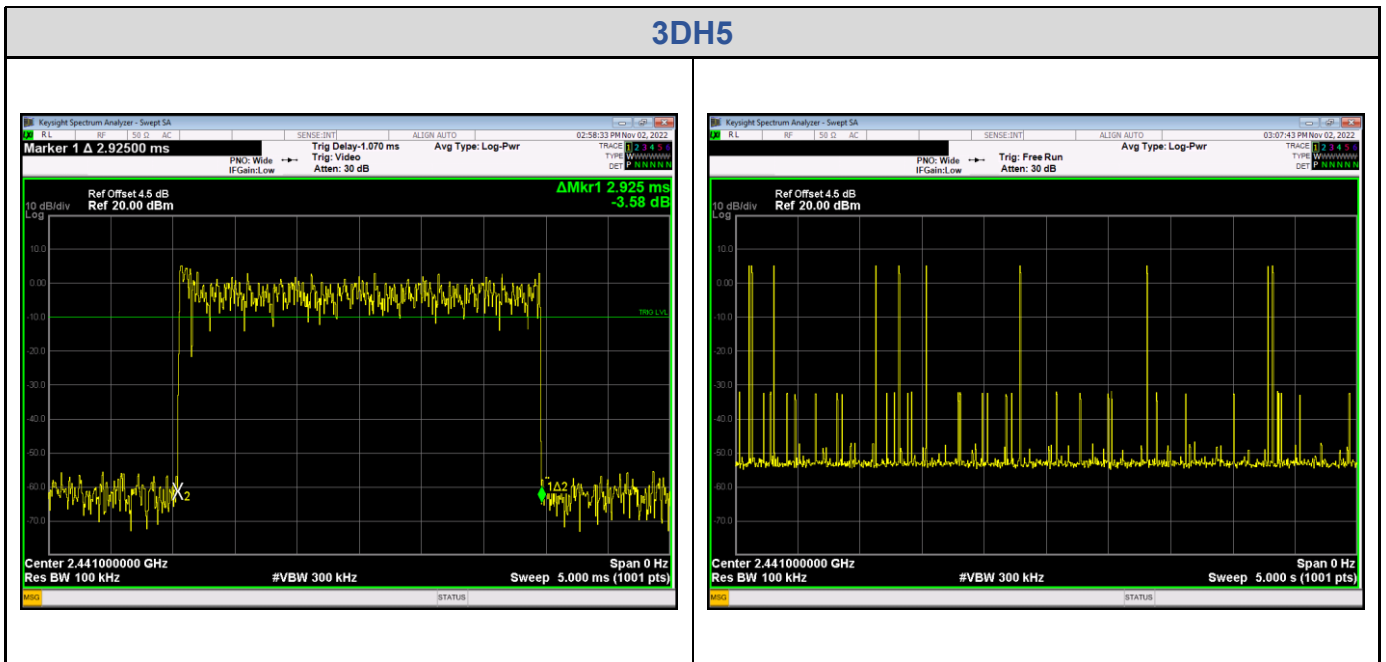
GFSK

Data Mode	Number of transfer in a 31.6 (79Hopping*0.4s)	Package transfer time (msec)	Dwell time (s)	Limit (s)	Result
1DH5	17 (times / 5 sec) * 6.32 = 107.44 times	2.925	0.314262	0.4	Pass



8DPSK

Data Mode	Number of transfer in a 31.6 (79Hopping*0.4s)	Package transfer time (msec)	Dwell time (s)	Limit (s)	Result
3DH5	10 (times / 5 sec) * 6.32 = 63.2 times	2.925	0.18486	0.4	Pass



Appendix B: Test Results of Radiated Spurious Emissions

Band Edges, 2.31GHz ~ 2.9GHz

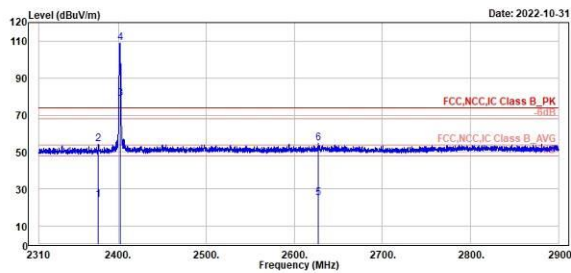
GFSK

Low Channel (Horizontal)

Low Channel (Vertical)



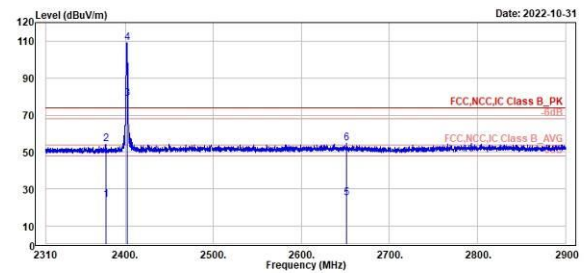
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1	2	3 *	4 *	5	6
2377.73	2377.73	2482.00	2482.00	2627.54	2627.54
MHz	Level	Read	Level	Factor	Limit
dBuV/m	dBuV	dB/m	dBuV	dB/m	dBuV/m
24.29	54.39	78.74	108.83	24.87	54.97
-13.23	16.87	41.11	71.20	-13.13	16.97
37.52	37.52	37.63	37.63	38.00	38.00
54.00	74.00	54.00	74.00	54.00	74.00
-29.71	-19.61	24.74	34.83	-29.13	-19.83
272	272	272	272	272	272
290	290	290	290	290	290
Average	Peak	Average	Peak	Average	Peak
Horizontal	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal
CF	CF	CF	CF	CF	CF



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1	2	3 *	4 *	5	6
2377.97	2377.97	2482.00	2482.00	2651.61	2651.61
MHz	Level	Read	Level	Factor	Limit
dBuV/m	dBuV	dB/m	dBuV	dB/m	dBuV/m
23.98	54.08	78.83	108.93	24.87	54.97
-13.54	16.56	41.20	71.30	-13.15	16.95
37.52	37.52	37.63	37.63	38.02	38.02
54.00	74.00	54.00	74.00	54.00	74.00
-30.82	-19.92	24.83	34.93	-29.13	-19.83
269	269	269	269	269	269
289	289	289	289	289	289
Average	Peak	Average	Peak	Average	Peak
Vertical	Vertical	Vertical	Vertical	Vertical	Vertical
CF	CF	CF	CF	CF	CF

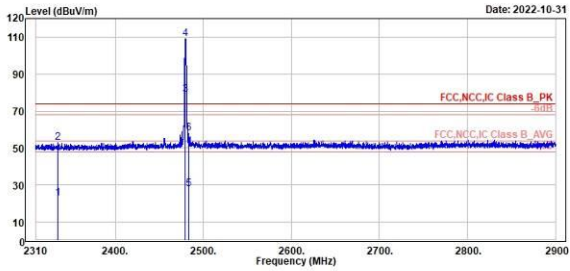
GFSK

High Channel (Horizontal)

High Channel (Vertical)



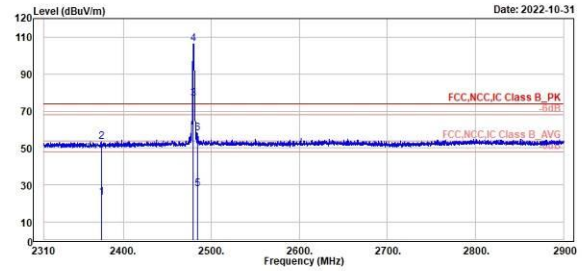
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Freq	Level	Read	Level	Factor	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	dB	cm	deg			
1	2335.82	22.64	-14.69	37.33	54.00	-31.36	151	300	Average	Horizontal	CF
2	2335.82	52.74	15.41	37.33	74.00	-21.26	151	300	Peak	Horizontal	
3	2480.00	78.98	41.19	37.79	54.00	24.98	151	300	Average	Horizontal	CF
4	2480.00	109.08	71.29	37.79	74.00	35.08	151	300	Peak	Horizontal	
5	2483.70	27.85	-9.95	37.80	54.00	-26.15	151	300	Average	Horizontal	CF
6	2483.70	57.95	20.15	37.80	74.00	-16.05	151	300	Peak	Horizontal	

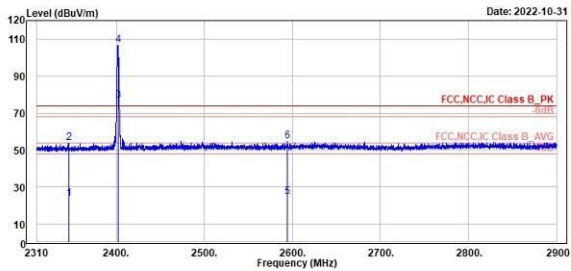


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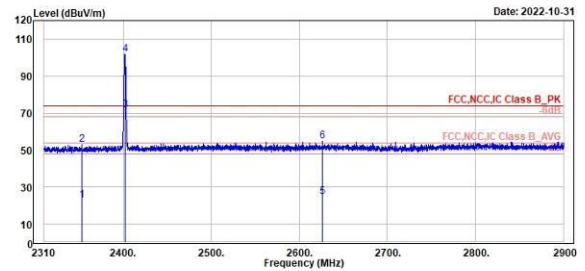


Freq	Level	Read	Level	Factor	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	dB	cm	deg			
1	2375.61	23.23	-14.27	37.50	54.00	-30.77	321	262	Average	Vertical	CF
2	2375.61	53.33	15.83	37.50	74.00	-20.67	321	262	Peak	Vertical	
3	2480.00	76.44	38.65	37.79	54.00	22.44	321	262	Average	Vertical	CF
4	2480.00	106.54	68.75	37.79	74.00	32.54	321	262	Peak	Vertical	
5	2484.05	28.01	-9.79	37.80	54.00	-25.99	321	262	Average	Vertical	CF
6	2484.05	58.11	20.31	37.80	74.00	-15.89	321	262	Peak	Vertical	

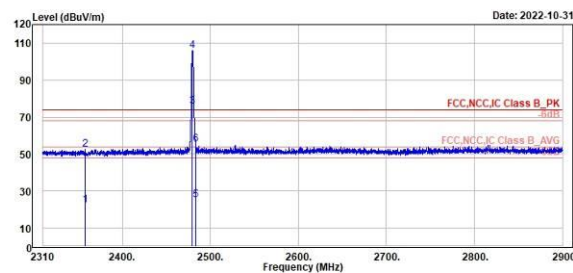
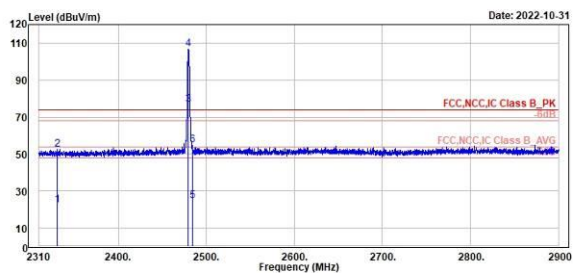
8DPSK
Low Channel (Horizontal)
Low Channel (Vertical)

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Freq	Level	Read	Limit	Over	Apos	Tpos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	2346.58	23.61	-13.75	37.36	54.00	-38.39	267	288 Average	Horizontal CF
2	2346.58	53.71	16.35	37.36	74.00	-20.29	267	288 Peak	Horizontal
3	2482.00	76.69	39.06	37.63	54.00	22.69	267	288 Average	Horizontal CF
4	2482.00	106.79	69.16	37.63	74.00	32.79	267	288 Peak	Horizontal
5	2594.38	24.67	-13.29	37.96	54.00	-29.33	267	288 Average	Horizontal CF
6	2594.38	54.77	16.81	37.96	74.00	-19.23	267	288 Peak	Horizontal


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Freq	Level	Read	Limit	Over	Apos	Tpos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	2352.83	22.70	-14.69	37.39	54.00	-31.30	392	184 Average	Vertical CF
2	2352.83	52.80	15.41	37.39	74.00	-21.29	392	184 Peak	Vertical
3	2482.00	71.69	34.06	37.63	54.00	17.69	392	184 Average	Vertical CF
4	2482.00	101.79	64.16	37.63	74.00	27.79	392	184 Peak	Vertical
5	2625.89	24.43	-13.57	38.00	54.00	-29.57	392	184 Average	Vertical CF
6	2625.89	54.53	16.53	38.00	74.00	-19.47	392	184 Peak	Vertical

8DPSK
High Channel (Horizontal)
High Channel (Vertical)


Freq	Level	Read	Level	Limit	Over	Apos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	2331.48	22.29	-15.02	37.31	54.00	-31.71	254	301 Average	Horizontal	CF
2	2331.48	52.39	15.08	37.31	74.00	-21.61	254	301 Peak	Horizontal	
3	2480.00	76.63	38.84	37.79	54.00	22.63	254	301 Average	Horizontal	CF
4	2480.00	106.73	68.94	37.79	74.00	32.73	254	301 Peak	Horizontal	
5	2484.64	24.61	-13.19	37.80	54.00	-29.39	254	301 Average	Horizontal	CF
6	2484.64	54.71	16.91	37.80	74.00	-19.29	254	301 Peak	Horizontal	

Freq	Level	Read	Level	Limit	Over	Apos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	2358.14	22.55	-14.06	37.41	54.00	-31.45	359	266 Average	Vertical	CF
2	2358.14	52.65	15.24	37.41	74.00	-21.35	359	266 Peak	Vertical	
3	2480.00	75.71	37.92	37.79	54.00	21.71	359	266 Average	Vertical	CF
4	2480.00	105.81	68.02	37.79	74.00	31.81	359	266 Peak	Vertical	
5	2483.58	25.12	-12.68	37.80	54.00	-28.88	359	266 Average	Vertical	CF
6	2483.58	55.22	17.42	37.80	74.00	-18.78	359	266 Peak	Vertical	

Spurious Emissions, Tx Mode, 9kHz ~ 30MHz

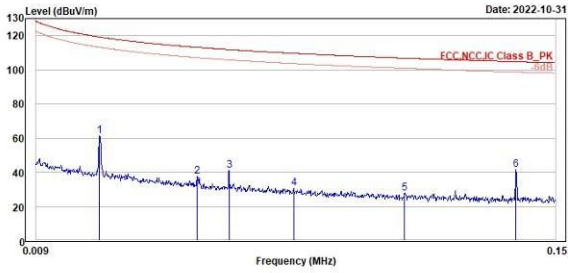
GFSK

High Channel (Open) 9kHz~150kHz

High Channel (Open) 150kHz~30MHz



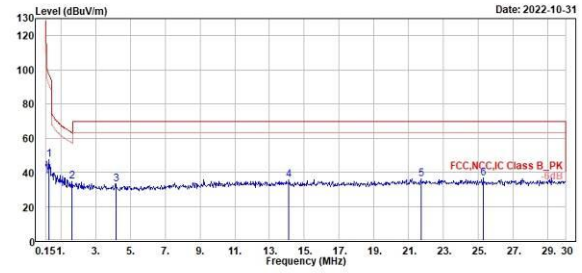
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Freq	Level	Read	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	0.03	61.53	42.35	19.18	119.18	-57.65	100	65 QP	Open
2	0.05	37.57	18.32	19.25	113.13	-75.56	100	281 QP	Open
3	0.06	40.83	21.77	19.06	111.82	-70.99	100	286 QP	Open
4	0.08	30.45	11.78	18.67	109.65	-79.20	100	27 QP	Open
5	0.11	27.88	9.63	18.25	106.84	-78.96	100	360 QP	Open
6	0.14	41.66	23.30	18.36	104.72	-63.06	100	212 QP	Open



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Freq	Level	Read	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	0.33	47.34	28.40	18.94	97.26	-49.92	100	188 QP	Open
2	1.64	34.53	15.17	19.36	63.29	-28.76	100	234 QP	Open
3	4.18	33.22	13.79	19.43	69.50	-36.28	100	215 QP	Open
4	14.12	35.50	13.71	21.79	69.50	-34.00	100	360 QP	Open
5	21.70	36.09	13.81	22.28	69.50	-33.41	100	63 QP	Open
6	25.28	36.56	14.12	22.44	69.50	-32.94	100	74 QP	Open

Spurious Emissions, Tx Mode, 30MHz ~ 1GHz

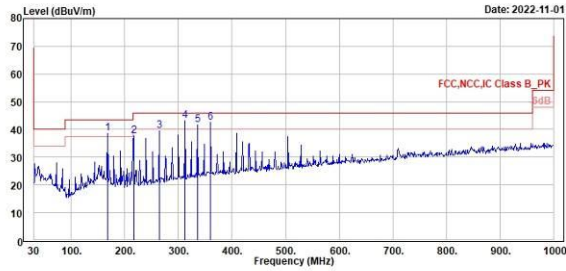
GFSK

High Channel (Horizontal)

High Channel (Vertical)



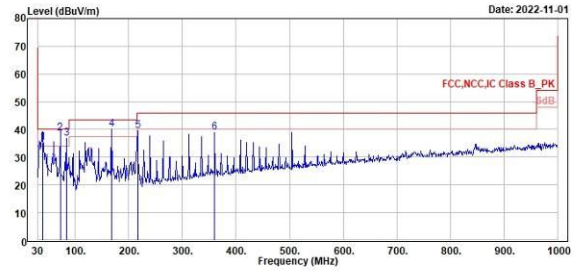
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Freq	Level	Read	Limit	Over	Apos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	167.74	38.61	44.60	-5.99	43.50	-4.89	200	91 QP	Horizontal
2	216.24	37.62	45.75	-8.13	46.00	-8.38	100	100 QP	Horizontal
3	263.77	39.67	45.83	-6.16	46.00	-6.33	100	143 QP	Horizontal
4	312.27	43.09	47.73	-4.64	46.00	-2.91	100	283 QP	Horizontal
5	335.55	41.78	45.69	-3.91	46.00	-4.22	100	135 QP	Horizontal
6	359.80	42.61	46.36	-3.75	46.00	-3.39	100	295 QP	Horizontal



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Freq	Level	Read	Limit	Over	Apos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	38.73	35.18	41.53	-6.35	40.00	-4.82	100	179 QP	Vertical
2	71.71	38.54	47.45	-8.91	40.00	-1.46	100	204 QP	Vertical
3	83.35	36.85	48.09	-11.24	40.00	-3.15	100	231 QP	Vertical
4	167.74	40.17	46.16	-5.99	43.50	-3.33	100	80 QP	Vertical
5	216.24	39.41	47.54	-8.13	46.00	-6.59	100	160 QP	Vertical
6	359.80	38.99	42.74	-3.75	46.00	-7.01	200	267 QP	Vertical

Spurious Emissions, Tx Mode, 1GHz ~ 26.5GHz

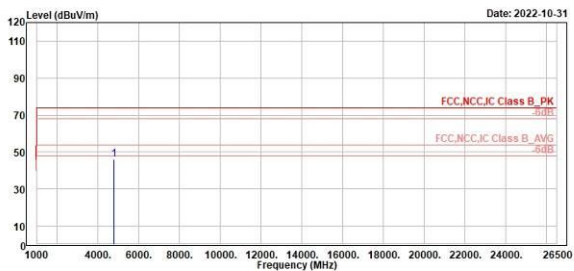
GFSK

Low Channel (Horizontal)

Low Channel (Vertical)



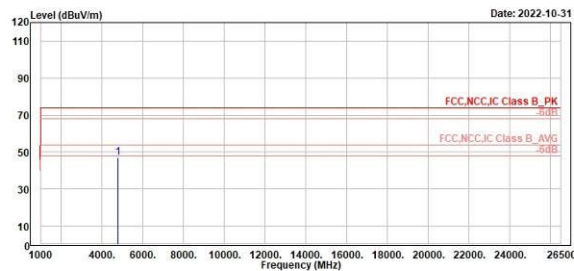
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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4884.00	46.03	55.90	-9.87	74.00	-27.97	100	131 Peak	Horizontal	



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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4884.00	46.88	56.75	-9.87	74.00	-27.12	300	82 Peak	Vertical	

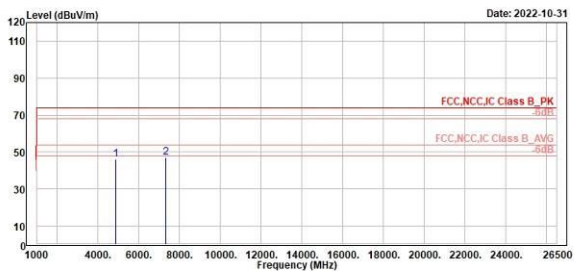
GFSK

Middle Channel (Horizontal)

Middle Channel (Vertical)



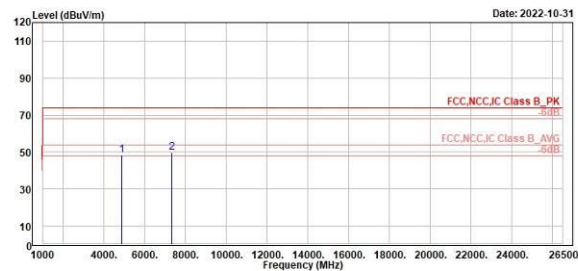
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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4882.00	45.91	55.69	-9.78	74.00	-28.09	100	126 Peak	Horizontal	
2	7324.00	47.07	54.55	-7.48	74.00	-26.93	100	123 Peak	Horizontal	



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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4882.00	48.27	58.05	-9.78	74.00	-25.73	300	117 Peak	Vertical	
2	7324.00	49.61	57.09	-7.48	74.00	-24.39	300	347 Peak	Vertical	

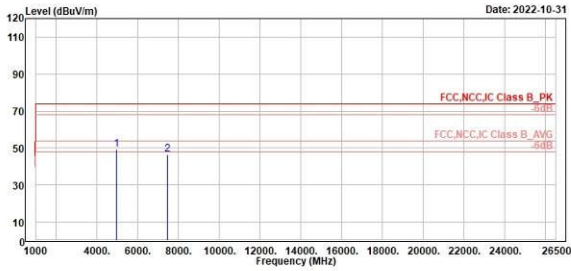
GFSK

High Channel (Horizontal)

High Channel (Vertical)



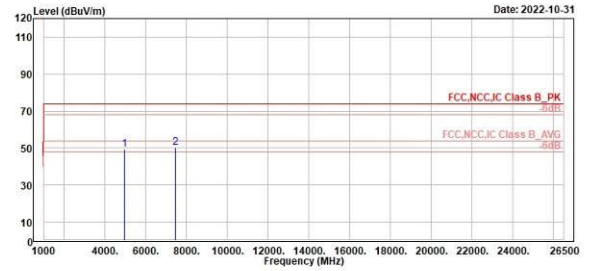
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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4969.00	49.12	58.66	-9.54	74.00	-24.88	100	129 Peak	Horizontal	
2	7440.00	46.62	53.97	-7.35	74.00	-27.38	400	256 Peak	Horizontal	



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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4969.00	49.09	58.63	-9.54	74.00	-24.91	100	41 Peak	Vertical	
2	7440.00	50.33	57.68	-7.35	74.00	-23.67	382	42 Peak	Vertical	

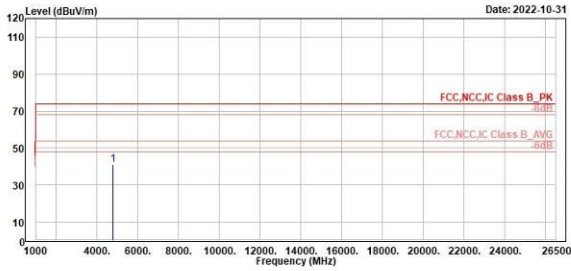
8DPSK

Low Channel (Horizontal)

Low Channel (Vertical)



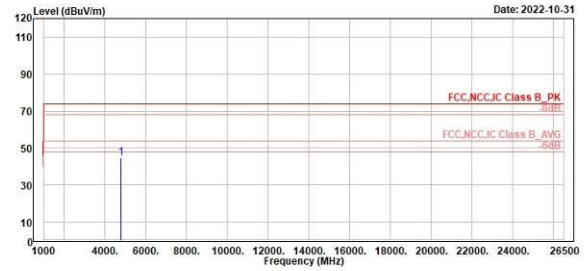
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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4884.00	41.24	51.11	-9.87	74.00	-32.76	100	133 Peak	Horizontal	



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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4884.00	44.61	54.48	-9.87	74.00	-29.39	100	59 Peak	Vertical	

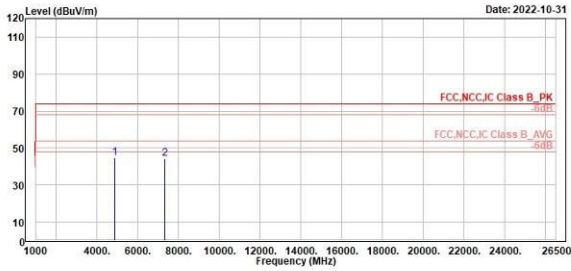
8DPSK

Middle Channel (Horizontal)

Middle Channel (Vertical)



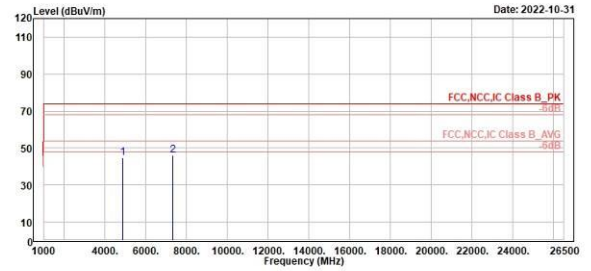
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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4882.00	44.62	54.60	-9.78	74.00	-29.18	100	111 Peak	Horizontal	
2	7323.00	44.19	51.67	-7.48	74.00	-29.81	400	327 Peak	Horizontal	



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Freq	Level	Read Level	Factor	Limit Line	Over Limit	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg			
1	4882.00	44.64	54.42	-9.78	74.00	-29.36	100	54 Peak	Vertical	
2	7323.00	46.09	53.57	-7.48	74.00	-27.91	364	10 Peak	Vertical	

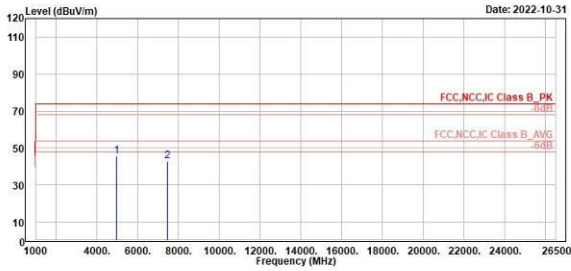
8DPSK

High Channel (Horizontal)

High Channel (Vertical)



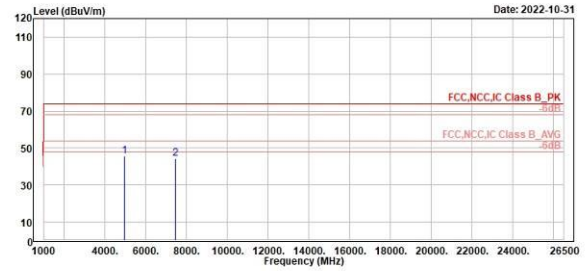
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Freq	Level	Read	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	4969.00	45.74	55.28	-9.54	74.00	-28.26	100	131 Peak	Horizontal
2	7440.00	43.01	50.36	-7.35	74.00	-30.99	100	114 Peak	Horizontal



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Freq	Level	Read	Limit	Over	APos	TPos	Remark	Pol/Phase	Note
MHz	dBuV/m	dBuV	dB/m	dBuV/m	dB	cm	deg		
1	4969.00	45.85	55.39	-9.54	74.00	-28.15	308	114 Peak	Vertical
2	7440.00	44.44	51.79	-7.35	74.00	-29.56	100	128 Peak	Vertical