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165-51, Yurim-ro, Cheoin-gu, Yongin-si,Gyeonggi-do,17042, Republic of Korea
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FCC EVALUATION REPORT FOR CERTIFICATION

Applicant :

Olive Union inc

5F, 24, Banpo-daero 28-gil, Seocho-gu, Seoul, Republic of Korea

Dates of Issue :

January 18, 2023

Test Site :

Nemko Korea Co., Ltd.

FCC ID:	**2AOLH-OU1P0102**
Applicant :	**Olive Union inc**
Brand Name :	Olive

Model:	OU1P0102
Additional Model(s):	
EUT Type:	Olive Max Earbuds
Classification:	FCC Part 15 Spread Spectrum Transmitter (DSS)
Date of Test:	November 02, 2022 ~ December 26, 2022
Applied Standard:	FCC 47 CFR Part 15.247

The device bearing the brand name and model specified above has been shown to comply with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in ANSI C63.10-2013. The client should not use it to claim product endorsement by TAF or any government agencies. The test results in the report only apply to the tested sample.

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

Tested By : Jaehyong Lee
Test Engineer

Reviewed By : Hoonpyo Lee
Technical Manager

Revision History

Rev.	Issue Date	Revisions	Revised By
00	December 27, 2022	Initial issue	Jaehyong Lee
01	January 18, 2023	Updated to address TCB's question	Jaehyong Lee

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1. INTRODUCTION

1.1 Test facility

The measurement procedure described in American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (ANSI C63.4-2014), the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013) was used in determining radiated and conducted emissions emanating.

These measurement tests were conducted at **Nemko Korea Co., Ltd..**
The site address 165-51, Yurim-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, 17042, Rep. of Korea and 155, Osan-ro, Mohyeon-eup, Cheoin-gu, Yongin-si, Gyeonggi-do 16885 Rep. of Korea.

2.2 Accreditation and listing

Accreditation type		Accreditation number
FC	CAB Accreditation for DOC	Designation No. KR0026
KOLAS	KOLAS Accredited Lab. (Korea Laboratory Accreditation Scheme)	Registration No. KT155
Industry Canada	Canada IC Registered site	Site No. 29506 Site No. 2040E
VCCI	VCCI registration site(RE/CE/Telecom CE)	Member No. 2118
IECEE CB SCHEME	EMC CBTL	TL124
KC	KCC(RRL)Designated Lab.	Registration No. KR0026

2. EUT INFORMATION & TEST CONDITIONS

2.1 EUT Information

Specifications:

EUT Type	Olive Max Earbuds
Model Name	OU1P0102
Brand Name	Olive Union
Frequency of Operation	2 402 MHz ~ 2 480 MHz
Peak Output Power (Conducted)	Left : 11.17 dBm Right : 10.62 dBm
Number of Channels	79 CH
Modulations	GFSK, π/4DQPSK, 8DPSK
Antenna Gain (peak)	Left : 2.23 dBi Right : 2.21 dBi
Antenna Setup	1TX / 1RX
EUT Rated Voltage	3.7 Vdc
EUT Test Voltage	3.7 Vdc
Remarks	-

2.2 Operation During Test

The EUT is the transceiver which is Bluetooth v5.1 supporting BDR/EDR/LE mode.
The Laptop was used to control the EUT to transmit the wanted TX channel continuously (duty cycle< 98%) by the testing program (RTLBTAPP) supported by manufacturer.
The operating voltage of EUT was 3.7 Vdc supplied from jig board connected to USB port on Laptop PC.

The EUT was tested at the lowest, middle and the highest channels with the maximum output power in accordance with the manufacturer's specifications. The worst data were recorded in the report.

2.2.1 Table of Test power setting

Frequency	Mode	Modulation	Power setting Level
2 402 MHz ~ 2 480 MHz	BDR	GFSK	Default
2 402 MHz ~ 2 480 MHz	EDR	π/4DQPSK	Default
2 402 MHz ~ 2 480 MHz	EDR	8DPSK	Default

2.2.2 Table of Test frequency

Frequency band	Modulation	Test Channel (CH)	Frequency (MHz)
2.4 GHz	GFSK, π/4DQPSK, 8DPSK	0	2 402
		39	2 441
		78	2 480

2.2.3 Antenna Information

Frequency band	Modulation	Antenna TX mode	Support CDD	Support MIMO
2.4 GHz	GFSK, π/4DQPSK, 8DPSK	■ 1TX, □ 2TX	□ Yes, ■ No	□ Yes, ■ No

2.2.4 Additional Information Related to Testing

The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for all conducted testing.

2.2.5 Worst-case Configuration and Mode

Radiated emission below 1GHz was performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Radiated emission above 1GHz was performed with the EUT set to transmit low/mid/high channels.

The emissions (Band-edge & spurious emissions) were investigated in three orthogonal orientations X, Y and Z.
Accordingly, the orientation was determined and tested as shown in the table below:

- **Left**

Test Items	X	Y	Z
Band-edge	O	-	-
Spurious emissions	O	-	-

- **Right**

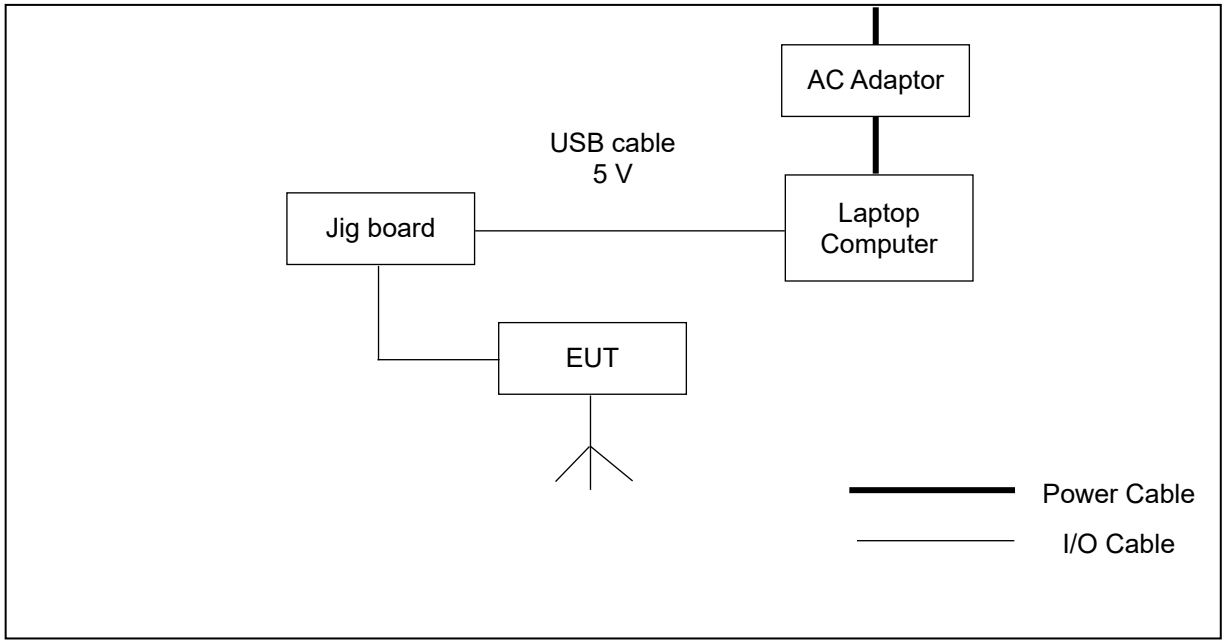
Test Items	X	Y	Z
Band-edge	-	O	-
Spurious emissions	-	O	-

GFSK, π/4DQPSK, 8DPSK peak power were all investigated, GFSK and π/4DQPSK power are the worst case. Radiated emission and conducted test plots were based on this mode to showing compliance.

2.3 Support Equipment

EUT	Olive Union inc Model : OU1P0102	S/N: N/A Identical Proto-type
Laptop Computer	LG Model : 14Z970	FCC DOC S/N : 701NZRP065862
AC/DC Adapter	LG Model : LCAP48-WK	FCC DOC S/N : EGDNV634687019352

2.4 Setup Drawing



3. ANTENNA REQUIREMENTS

Measurement and determination of electromagnetic emissions (EME) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission under FCC part 15 and IC RSS-247 Issue 2.

§15.203 of the FCC Rules part 15 Subpart C
: 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 antenna of the EUT and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

Used Antenna	
Model name	2 402 MHz ~ 2 480 MHz
	Max. peak gain (dBi)
Olive Max Earbuds FPCB Antenna Left	2.23
Olive Max Earbuds FPCB Antenna Right	2.21

4. SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

Name of Test	FCC Paragraph No.	Result	Remark
Conducted Emission	15.207	N/P	
Radiated Emission	15.209	Complies	
20dB Bandwidth	15.247(a)(1)	Complies	
Carrier Frequency Separation	15.247(a)(1)	Complies	
Transmitter Average Time of Occupancy	15.247(a)(1)(iii)	Complies	
Peak Output Power and E.I.R.P.	15.247(b)(1)	Complies	
Conducted Spurious Emission	15.247(d)	Complies	
Radiated Spurious Emission	15.247(d)	Complies	
Number of Hopping channels	15.247(a)(1)(iii)	Complies	
Maximum Permissible Exposure	1.1307(b)	Complies	

5. TEST METHODOLOGY

1. FCC CFR 47 Part 2.
2. FCC CFR 47 Part 15.
3. KDB 558074 D01 15.247 Meas Guidance v05r02.
4. ANSI C63.10-2013.

6. DESCRIPTION OF TESTS

6.1 Duty Cycle

Test Setup

Test Procedure

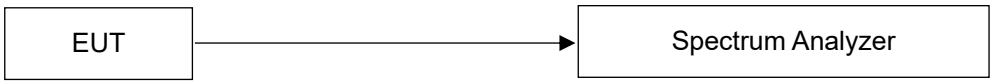
EUTs Duty Cycle is measured at middle channel with a spectrum analyzer connected to the antenna terminal while the EUTs operating at its maximum power control level.
The spectrum analyzer setting is as follows.

RBW ≥ OBW

RBW ≥ VBW
Span = zero span
Detector = Peak
The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100.

6.2 20 dB Bandwidth

Test Setup



Test Procedure

The transmitter is set to the Low, Middle, High channels is connected to the spectrum analyzer.
Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel
RBW = 1% to 5% of the OBW
VBW = approximately 3 x RBW
Sweep = auto
Detector function = peak
Trace = max hold

6.3 Carrier Frequency Separation

Test Setup

Test Procedure

The EUT must have its hopping function enabled. The following spectrum analyzer setting is used.
Span = wide enough to capture the peaks of two adjacent channels
RBW ≥ approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

6.4 Transmitter Average Time of Occupancy

Test Setup

Test Procedure

The transmitter output is connected to a spectrum analyzer. The following spectrum analyzer setting is used.
Span = Zero span, centered on a hopping channel
RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
VBW ≥ RBW
Sweep = as necessary to capture the entire dwell time per hopping channel
Detector function = Peak
Trace = Single sweep
Use the marker-delta function to determine the width of pulse

6.5 Number of Hopping Channels

Test Setup

Test Procedure

Span = The frequency band of operation.
RBW = less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
VBW ≥ RBW
Sweep = Auto
Detector function = Peak
Trace = Max hold

6.6 Peak Output Power and E.I.R.P.

Test Setup

Test Procedure

The transmitter is set to the Low, Middle, High channels is connected to the spectrum analyzer.
Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
RBW > 20 dB bandwidth of the emission being measured
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
E.I.R.P. is calculated according to KDB412172 D01 Determining ERP and EIRP v01r01

6.7 Conducted Spurious Emissions

Test Setup

Test Procedure

Measurements are made over the 30 MHz to 26.5 GHz range with the transmitter set to the Lowest, middle and highest channels.
RBW = 100kHz
VBW = 300kHz
Sweep = auto
Detector function = peak
Trace = max hold

6.6 Radiated Emissions

The measurement was performed at the test site that is specified in accordance with ANSI C63.10-2013.
The spurious emission was scanned from 9 kHz to 30 MHz using Loop Antenna and 30 to 1000 MHz using Trilog broadband test antenna. Above 1 GHz, Horn antenna was used.
For emissions testing at below 1GHz, The test equipment was placed on turntable with 0.8 m above ground. For emission measurements above 1 GHz, The test equipment was placed on turntable with 1.5 m above ground. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The EUT, cable, wire arrangement and mode of operation that has the highest amplitude relative to the limit was selected. Then, the turn table was rotated from 0˚ to 360˚ and an antenna mast was moved from 1 m to 4 m height to maximize the suspected highest amplitude signal. The final maximized level was recorded.

At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in ANSI 63.10-2013 section 11.12. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 10 kHz, Detector = Peak, Trace mode = max hold. Allow max hold to run for at least 50 times (1/duty cycle) traces.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100	3
88–216	150	3
216–960	200	3
Above 960	500	3

Radiated Emissions Limits per 47 CFR 15.209(a) and RSS-GEN Issue 5 8.9

6.7 Conducted Emissions

The Line conducted emission test facility is located inside a 4 x 7 x 2.5 meter shielded enclosure.

It is manufactured by EM engineering. The shielding effectiveness of the shielded room is in accordance with MIL-STD-285 or NSA 65-6. A 1 m x 1.5 m wooden table 0.8 m height is placed 0.4 m away from the vertical wall and 1.5 m away from the side of wall of the shielded room. Rohde & Schwarz (ENV216) of the 50 ohm/50 μH Line Impedance Stabilization Network (LISN) are bonded to the shielded room. The EUT is powered from the Rohde & Schwarz LISN. Power to the LISNs are filtered by high-current high insertion loss Power line filters. The purpose of filter is to attenuate ambient signal interference and this filter is also bonded to shielded enclosure. All electrical cables are shielded by tinned copper zipper tubing with inner diameter of 1 / 2 ”. If DC power device, power will be derived from the source power supply it normally will be powered from and this supply lines will be connected to the LISNs, All interconnecting cables more than 1 meter were shortened by non-inductive bundling (serpentine fashion) to a 1 meter length. Sufficient time for EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the spectrum analyzer to determine the frequency producing the maximum EME from the EUT. The spectrum was scanned from 150 kHz to 30 MHz with 200 msec sweep time. The frequency producing the maximum level was re-examined using the EMI test receiver. (Rohde & Schwarz ESCI). The detector functions were set to CISPR quasi-peak mode & average mode. The bandwidth of receiver was set to 9 kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each EME emission. Each emission was maximized by; switching power lines; varying the mode of operation or resolution; clock or data exchange speed; scrolling H pattern to the EUT and of support equipment, and powering the monitor from the floor mounted outlet box and computer aux AC outlet, if applicable; whichever determined the worst case emission.

Each EME reported was calibrated using the R&S signal generator.

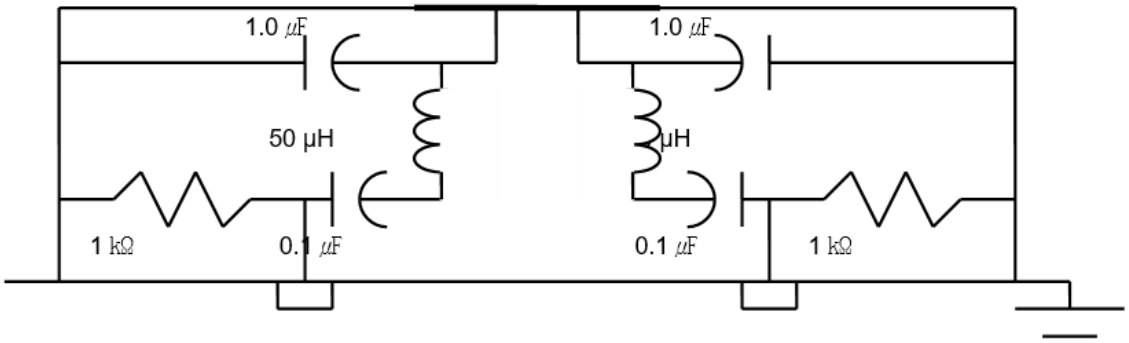


Fig. 2. LISN Schematic Diagram

7. TEST DATA

7.1 Duty Cycle

For reporting purposes only.

Result

- **Left**

Mode	On time [msec]	Period [msec]	Duty cycle x [Linear]	Duty Cycle [%]	Duty Cycle Correction Factor [dB]	1/T Minimum CBW [kHz]
BDR	2.880	3.730	0.772	77.21	1.12	0.35
EDR	2.890	3.730	0.775	77.48	1.11	0.35

- **Right**

Mode	On time [msec]	Period [msec]	Duty cycle x [Linear]	Duty Cycle [%]	Duty Cycle Correction Factor [dB]	1/T Minimum CBW [kHz]
BDR	2.883	3.730	0.773	77.29	1.12	0.35
EDR	2.895	3.734	0.773	77.26	1.12	0.35

PLOTS OF EMISSIONS

Left, Duty Cycle, BDR, Middle Channel (2 441 MHz)

Left, Duty Cycle, EDR, Middle Channel (2 441 MHz)

Right, Duty Cycle, BDR, Middle Channel (2 441 MHz)

Right, Duty Cycle, EDR, Middle Channel (2 441 MHz)

7.2 20 dB Bandwidth

FCC §15.247(a)(2)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- **Left**

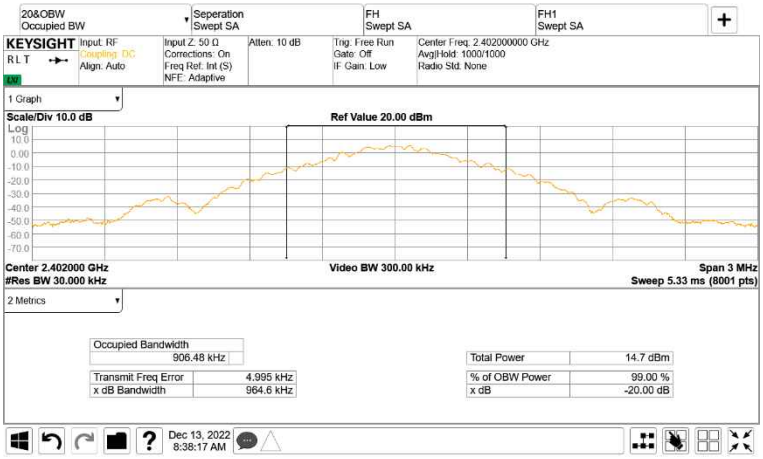
Modulation	Channel	Frequency (MHz)	20 dB Bandwidth (MHz)
GFSK	Lowest	2 402	0.96
	Middle	2 441	0.97
	Highest	2 480	0.97
π/4DQPSK	Lowest	2 402	1.37
	Middle	2 441	1.36
	Highest	2 480	1.36
8DPSK	Lowest	2 402	1.35
	Middle	2 441	1.35
	Highest	2 480	1.35

- **Right**

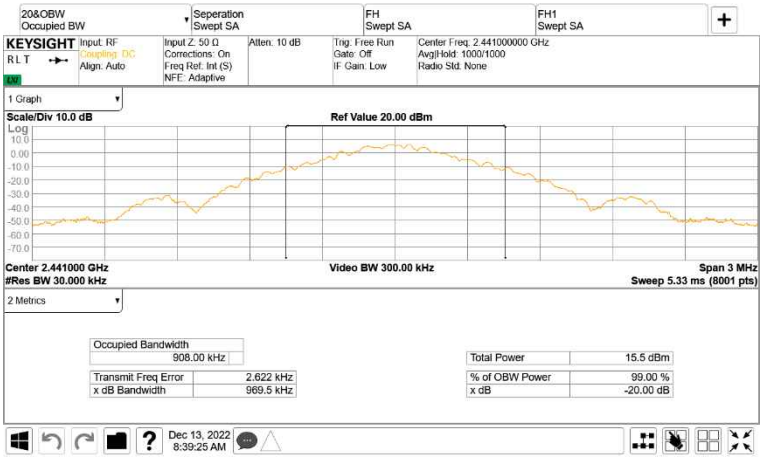
Modulation	Channel	Frequency (MHz)	20 dB Bandwidth (MHz)
GFSK	Lowest	2 402	0.95
	Middle	2 441	0.95
	Highest	2 480	0.95
π/4DQPSK	Lowest	2 402	1.28
	Middle	2 441	1.28
	Highest	2 480	1.28
8DPSK	Lowest	2 402	1.29
	Middle	2 441	1.29
	Highest	2 480	1.29

PLOTS OF EMISSIONS

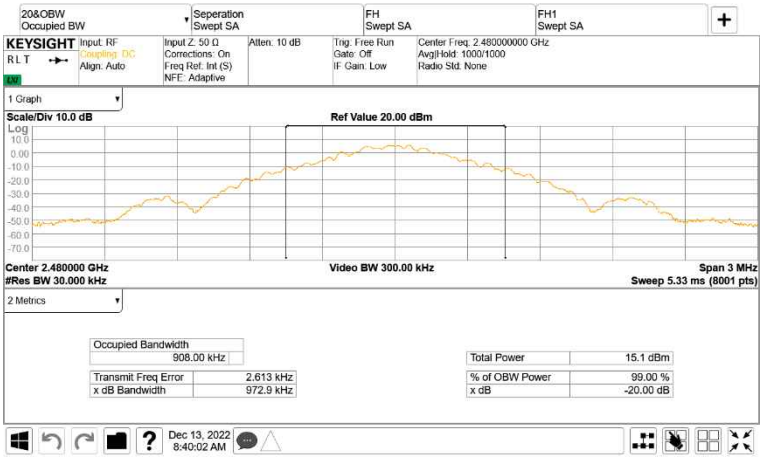
Left, GFSK, 20 dB Bandwidth, Lowest Channel (2 402 MHz)



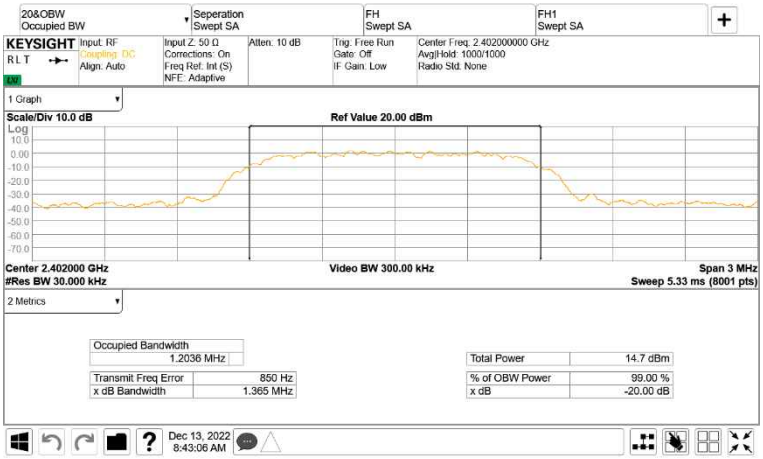
Left, GFSK, 20 dB Bandwidth, Middle Channel (2 441 MHz)



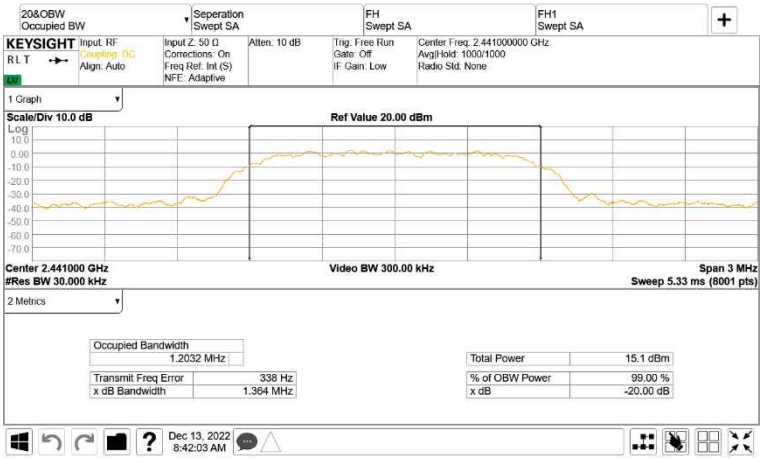
Left, GFSK, 20 dB Bandwidth, Highest Channel (2 480 MHz)



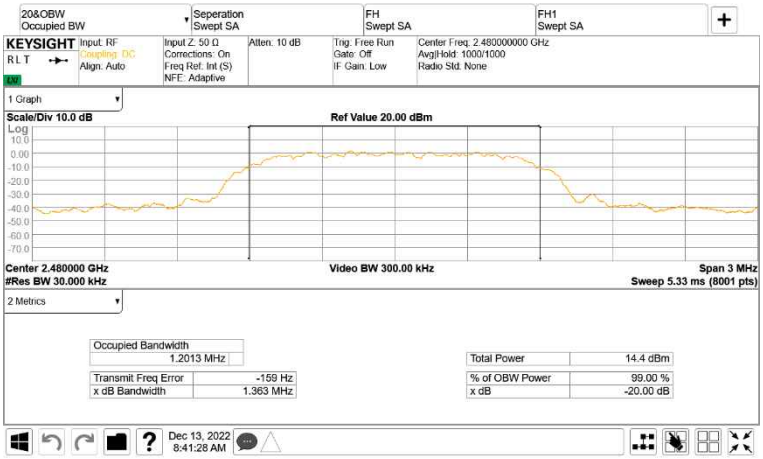
Left, π/4DQPSK, 20 dB Bandwidth, Lowest Channel (2 402 MHz)



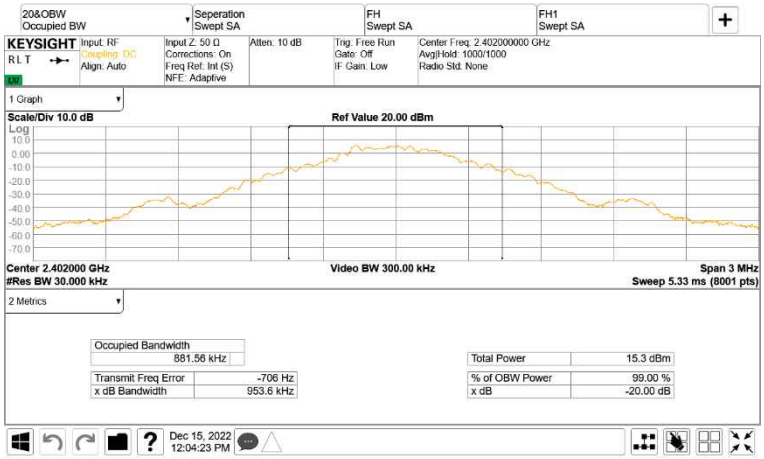
Left, π/4DQPSK, 20 dB Bandwidth, Middle Channel (2 441 MHz)



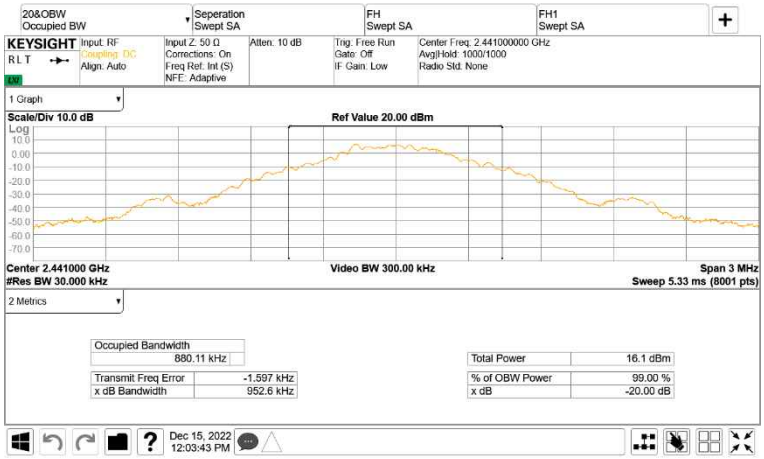
Left, π/4DQPSK, 20 dB Bandwidth, Highest Channel (2 480 MHz)



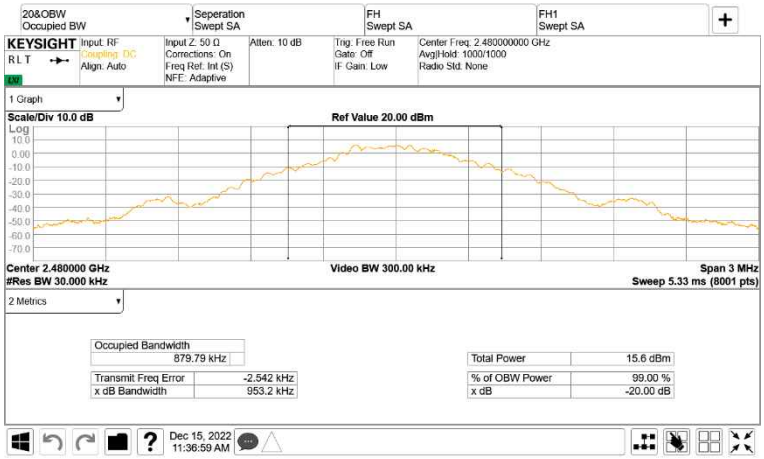
Right, GFSK, 20 dB Bandwidth, Lowest Channel (2 402 MHz)



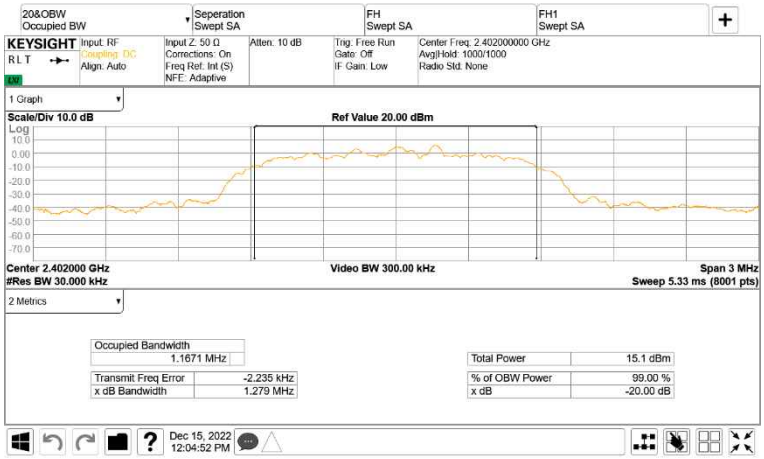
Right, GFSK, 20 dB Bandwidth, Middle Channel (2 441 MHz)



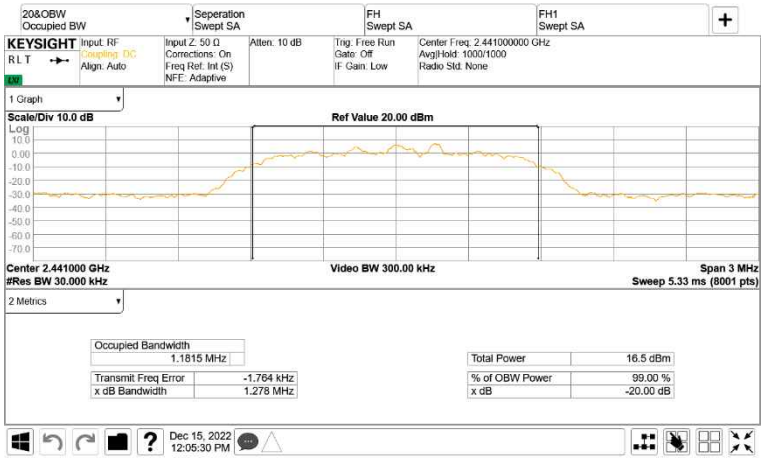
Right, GFSK, 20 dB Bandwidth, Highest Channel (2 480 MHz)



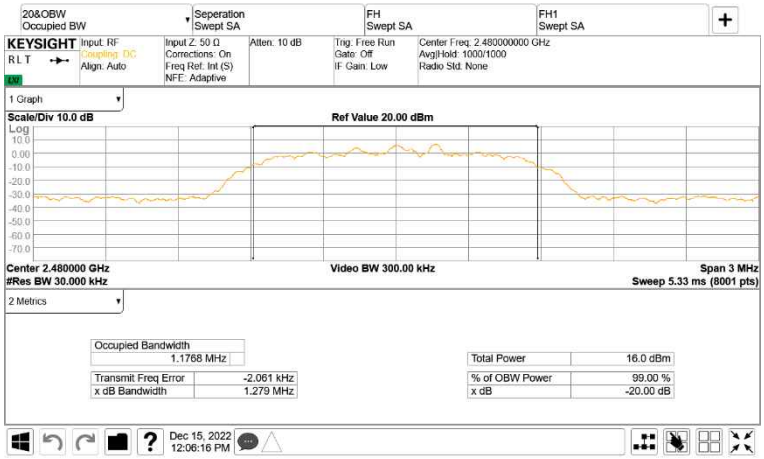
Right, π/4DQPSK, 20 dB Bandwidth, Lowest Channel (2 402 MHz)



Right, π/4DQPSK, 20 dB Bandwidth, Middle Channel (2 441 MHz)



Right, π/4DQPSK, 20 dB Bandwidth, Highest Channel (2 480 MHz)



7.3 Carrier Frequency Separation

FCC §15.247(a)(1)

Test Mode : Set to Hopping mode

Result

- **Left**

Modulation	Carrier Frequency Separation (MHz)	Limit (2/3 of 20dB Bandwidth) (MHz)
GFSK	1.00	0.65
π/4DQPSK	1.00	0.91
8DPSK	1.00	0.90

- **Right**

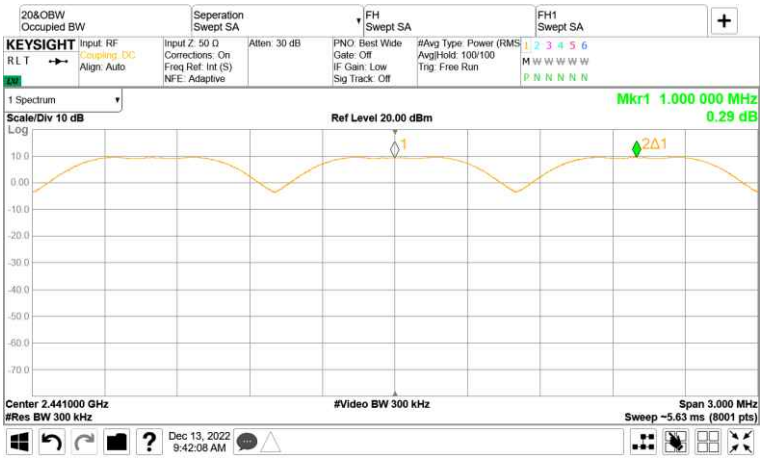
Modulation	Carrier Frequency Separation (MHz)	Limit (2/3 of 20dB Bandwidth) (MHz)
GFSK	1.00	0.63
π/4DQPSK	1.00	0.85
8DPSK	1.00	0.86

Note:

*The EUT complies with the minimum channel separation requirement when it is operating **1x/EDR mode using 79 channels** and when operating in **AFH mode using 20 channels**.*

PLOTS OF EMISSIONS

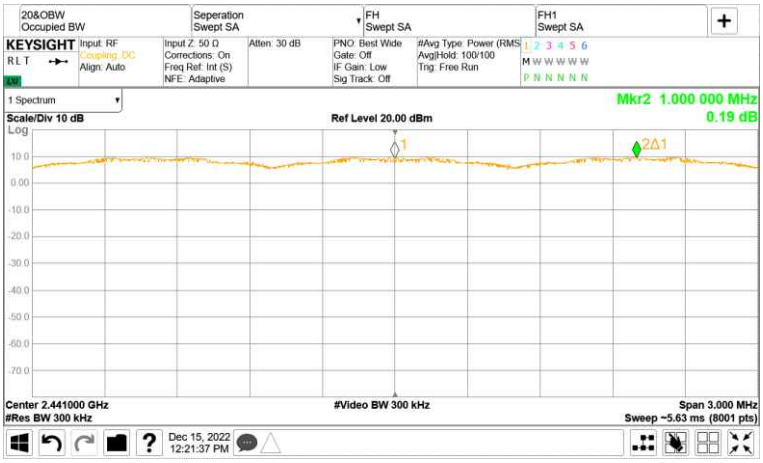
Left, Carrier Frequency Separation, GFSK modulation



Left, Carrier Frequency Separation, π/4DQPSK modulation

Right, Carrier Frequency Separation, GFSK modulation

Right, Carrier Frequency Separation, π/4DQPSK modulation



7.4 Transmitter Average Time of Occupancy

FCC §15.247(a)(1)

Test Mode : Set to Hopping mode

Result

- **Left**

Mode	Pulse width (ms)	*)Numbers of slots	**) Average time of Occupancy (ms)	Limit (ms)	Margin (ms)
1x/EDR	2.88	106.67	307.21	400	92.79
AFH	2.88	53.33	153.59	400	246.41

- **Right**

Mode	Pulse width (ms)	*)Numbers of slots	**) Average time of Occupancy (ms)	Limit (ms)	Margin (ms)
1x/EDR	2.88	106.67	307.21	400	92.79
AFH	2.88	53.33	153.59	400	246.41

1x/EDR mode

1) This result was measured at DH5 mode in **1x/EDR mode**, which has longest time in one transmission burst.

2) Bluetooth 1x/EDR mode has a channel hopping rate of 1 600 hops/s and 79 hopping channels.

3) The average time of occupancy in the specified 31.6 second period (79 channels x 0.4 s) is equal to pulse width x (hopping rate / 6) / 79 x (0.4 x hopping channels).

4) *) Numbers of slots in 31.6 sec = (1 600 / 6) / 79 x 31.6 = 106.67

5) **) Average time of Occupancy = Pulse width x 106.67

AFH mode

1) This result was measured at DH5 mode in **AFH mode**, which has longest time in one transmission burst.

2) Bluetooth AFH mode has a channel hopping rate of 800 hops/s and 20 hopping channels.

3) The average time of occupancy in the specified 8 second period (20 channels x 0.4 s) is equal to pulse width x (hopping rate / 6) / 20 x (0.4 x hopping channels).

4) *) Numbers of slots in 20 sec = (800 / 6) / 20 x 8 = 53.33

5) **) Average time of Occupancy = Pulse width x 53.33.

PLOTS OF EMISSIONS

Left, Pules width, DH5

Right, Pules width, DH5

7.5 Number of Hopping Channels

FCC §15.247(a)(1)(iii)

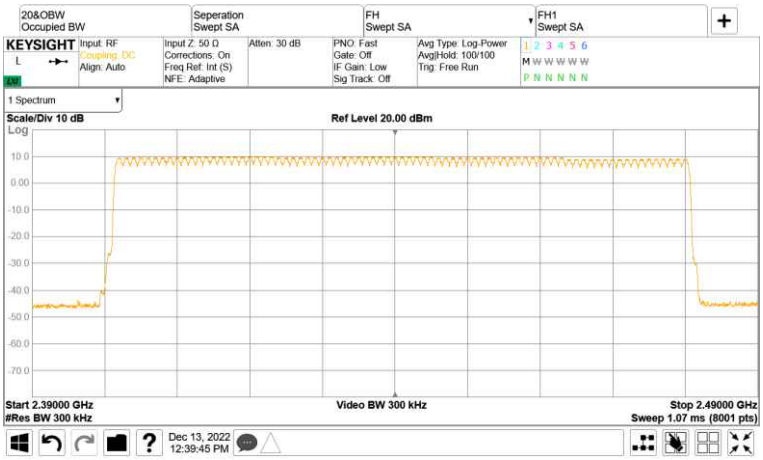
Test Mode : Set to Hopping mode

Result

The EUT complies with the minimum of 15 hopping channels when it is operating **1x/EDR mode using 79 channels** and when operating in **AFH mode using 20 channels**

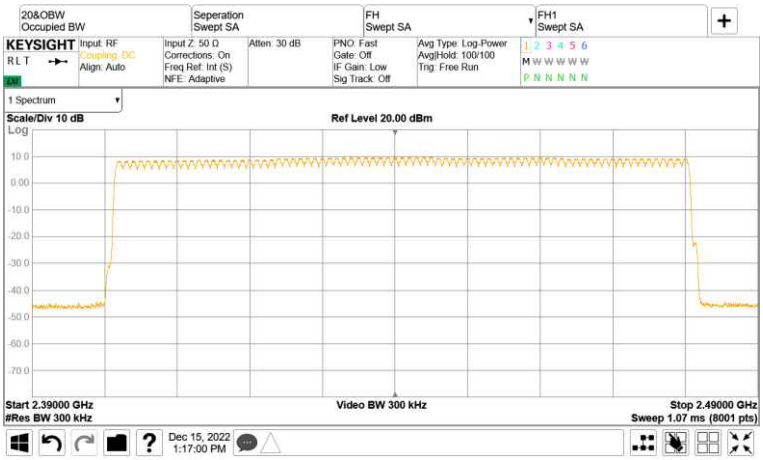
Left, Number of hopping channels, DH5

Left, Number of hopping channels, 2-DH5



Right, Number of hopping channels, DH5

Right, Number of hopping channels, 2-DH5



7.6 Peak Output Power

FCC §15.247(b)(3)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- **Left**

Modulation	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
GFSK	Lowest	2 402	8.32	20.97
	Middle	2 441	9.48	20.97
	Highest	2 480	9.10	20.97
π/4DQPSK	Lowest	2 402	10.74	20.97
	Middle	2 441	11.17	20.97
	Highest	2 480	10.69	20.97
8DPSK	Lowest	2 402	9.47	20.97
	Middle	2 441	10.32	20.97
	Highest	2 480	9.99	20.97

Notes:
1. The following equation was used for spectrum offset:
Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

- **Right**

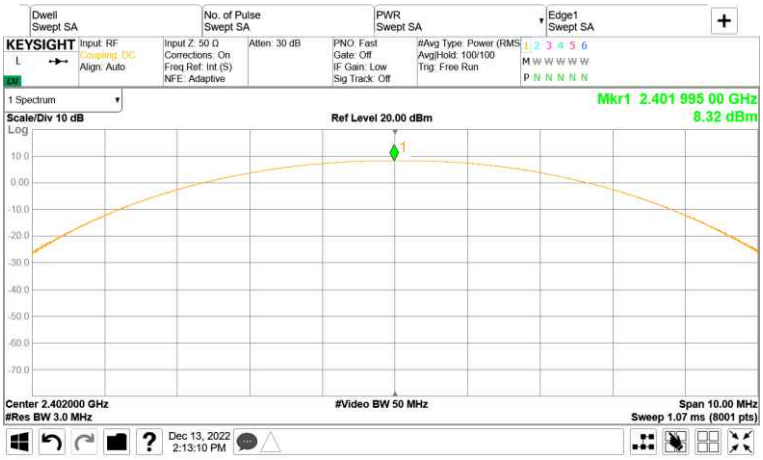
Modulation	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)
GFSK	Lowest	2 402	8.80	20.97
	Middle	2 441	9.27	20.97
	Highest	2 480	8.94	20.97
π/4DQPSK	Lowest	2 402	9.77	20.97
	Middle	2 441	10.62	20.97
	Highest	2 480	10.36	20.97
8DPSK	Lowest	2 402	9.46	20.97
	Middle	2 441	10.02	20.97
	Highest	2 480	9.77	20.97

Notes:

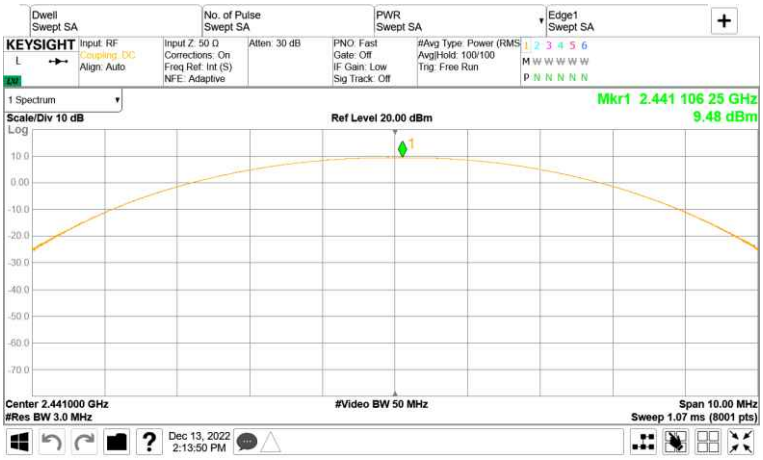
1. The following equation was used for spectrum offset:
   Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

PLOTS OF EMISSIONS

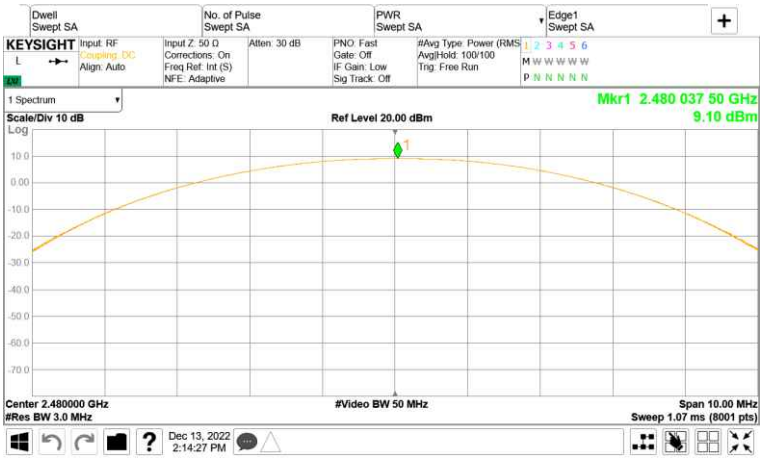
Left, Maximum Peak Output Power, GFSK, Lowest Channel



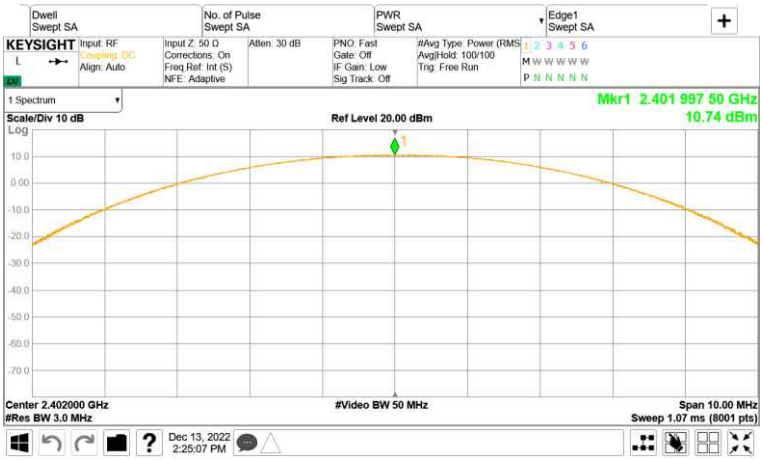
Left, Maximum Peak Output Power, GFSK, Middle Channel



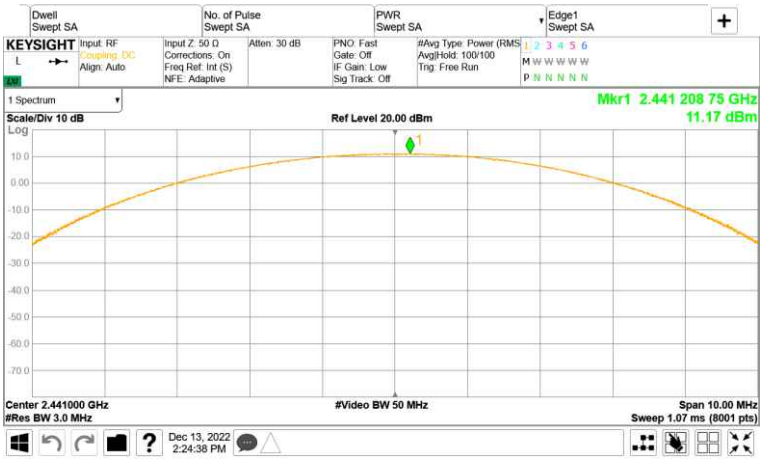
Left, Maximum Peak Output Power, GFSK, Highest Channel



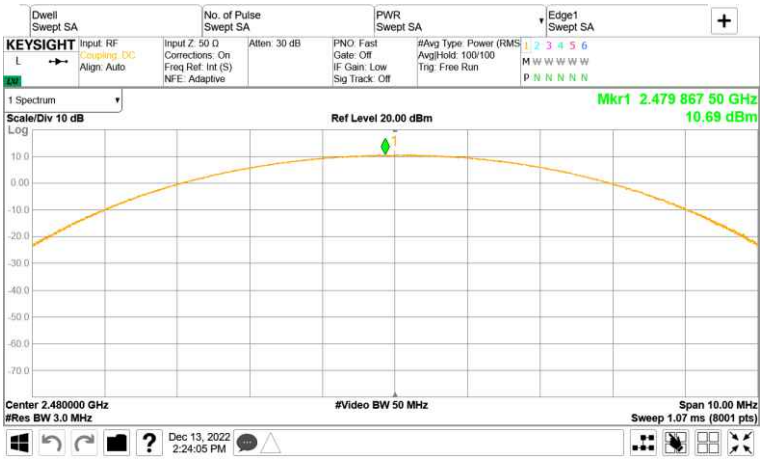
Left, Maximum Peak Output Power, π/4DQPSK, Lowest Channel



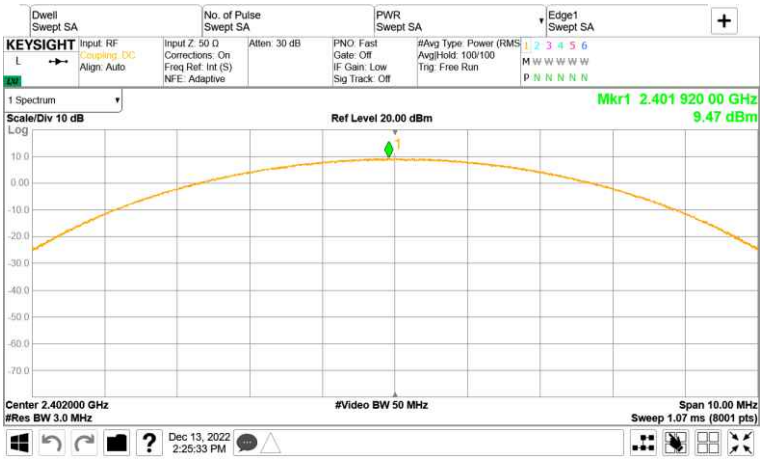
Left, Maximum Peak Output Power, π/4DQPSK, Middle Channel



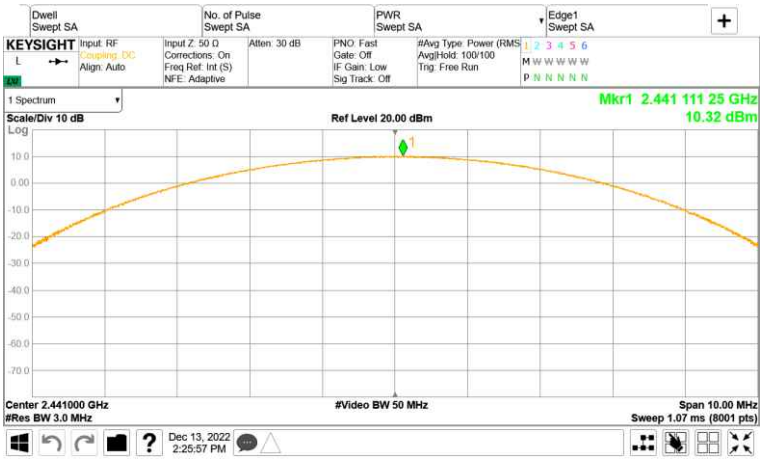
Left, Maximum Peak Output Power, π/4DQPSK, Highest Channel



Right, Maximum Peak Output Power, 8DPSK, Lowest Channel



Right, Maximum Peak Output Power, 8DPSK, Middle Channel



Right, Maximum Peak Output Power, 8DPSK, Highest Channel

Right, Maximum Peak Output Power, GFSK, Lowest Channel

Right, Maximum Peak Output Power, GFSK, Middle Channel

Right, Maximum Peak Output Power, GFSK, Highest Channel

Right, Maximum Peak Output Power, π/4DQPSK, Lowest Channel

Right, Maximum Peak Output Power, π/4DQPSK, Middle Channel

Right, Maximum Peak Output Power, π/4DQPSK, Highest Channel

Right, Maximum Peak Output Power, 8DPSK, Lowest Channel

Right, Maximum Peak Output Power, 8DPSK, Middle Channel

Right, Maximum Peak Output Power, 8DPSK, Highest Channel

7.7 Conducted Spurious Emissions

FCC §15.247(e)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

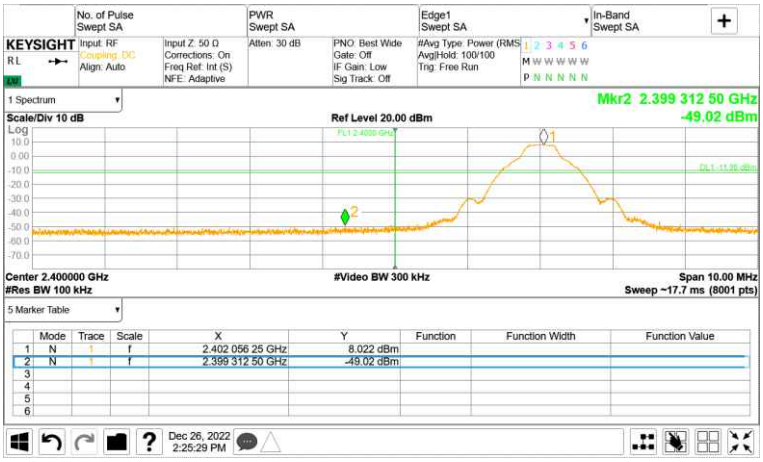
Result

Modulation	Channel	Frequency (MHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
GFSK	Lowest	2 402	More than 20 dBc	20
	Middle	2 441	More than 20 dBc	20
	Highest	2 480	More than 20 dBc	20
π/4DQPSK	Lowest	2 402	More than 20 dBc	20
	Middle	2 441	More than 20 dBc	20
	Highest	2 480	More than 20 dBc	20
8DPSK	Lowest	2 402	More than 20 dBc	20
	Middle	2 441	More than 20 dBc	20
	Highest	2 480	More than 20 dBc	20

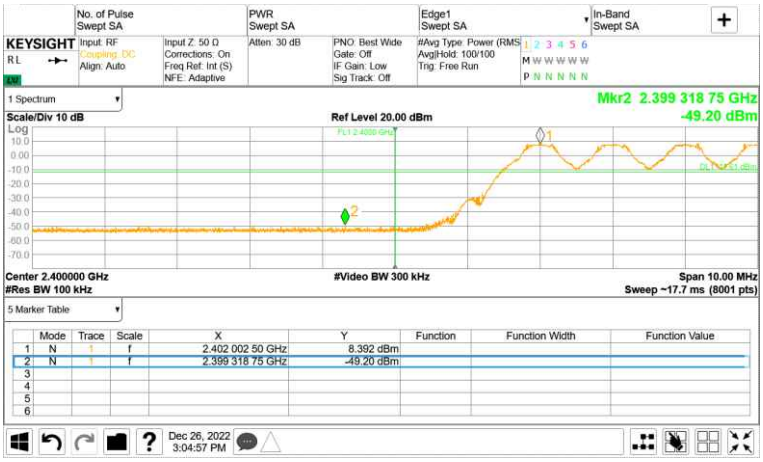
Notes:
The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.

PLOTS OF EMISSIONS

Left, Band Edge, GFSK, Lowest Channel (2 402 MHz)

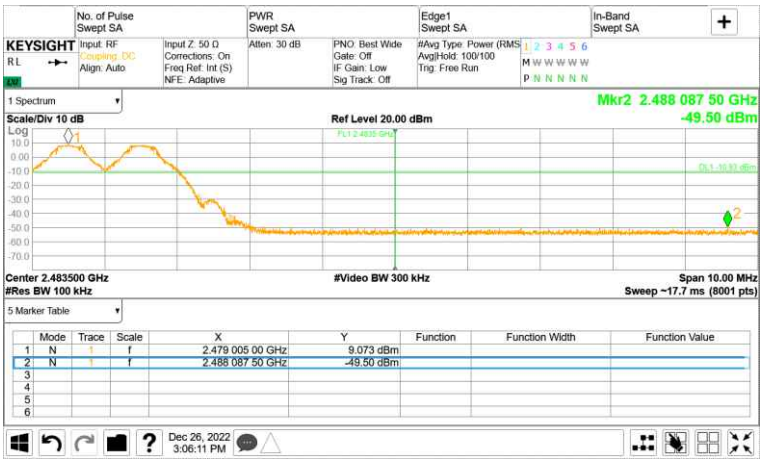


Left, Band Edge, Hopping mode, GFSK, Lowest Channel (2 402 MHz)

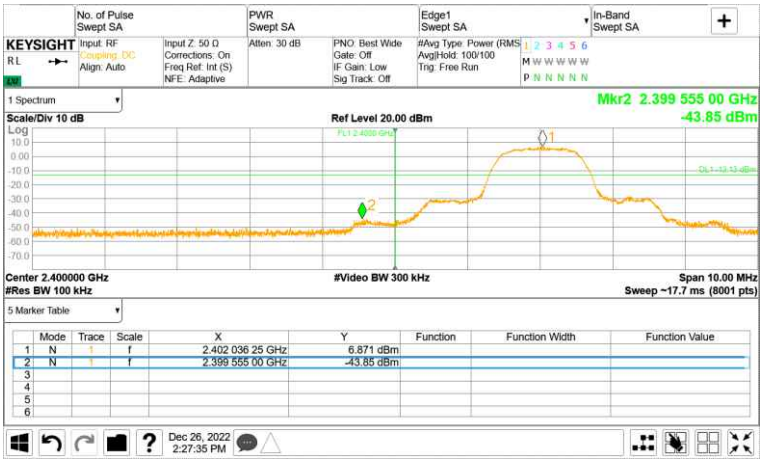


Left, Band Edge, GFSK, Highest Channel (2 480 MHz)

Left, Band Edge, Hopping mode, GFSK, Highest Channel (2 480 MHz)



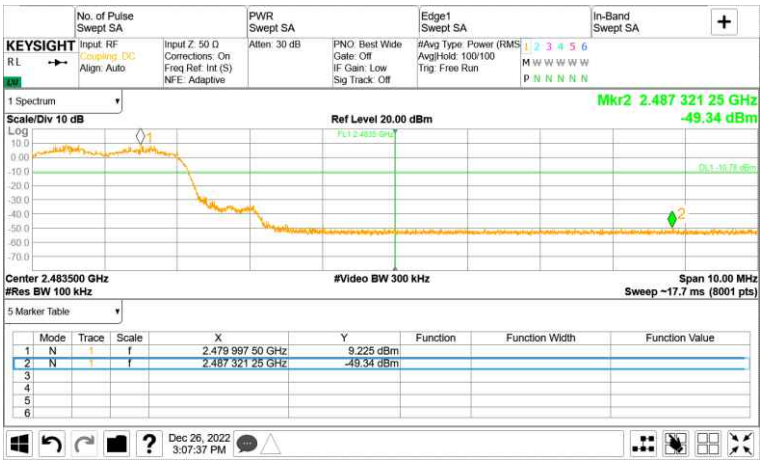
Left, Band Edge, π/4DQPSK, Lowest Channel (2 402 MHz)



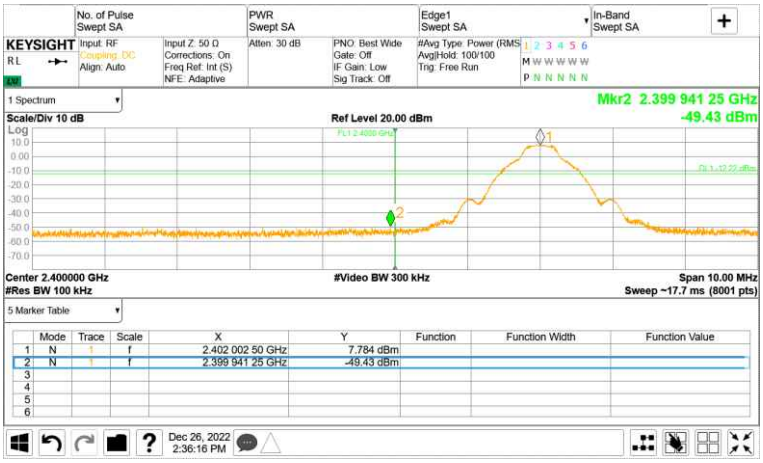
Left, Band Edge, Hopping mode, π/4DQPSK, Lowest Channel (2 402 MHz)

Left, Band Edge, π/4DQPSK, Highest Channel (2 480 MHz)

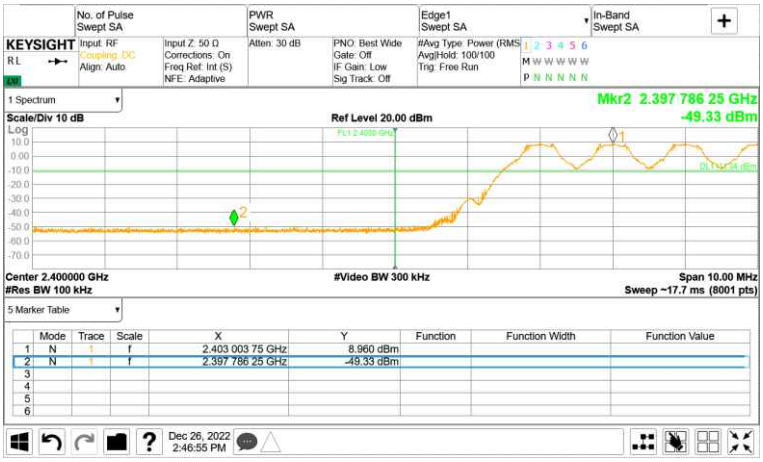
Left, Band Edge, Hopping mode, π/4DQPSK, Highest Channel (2 480 MHz)



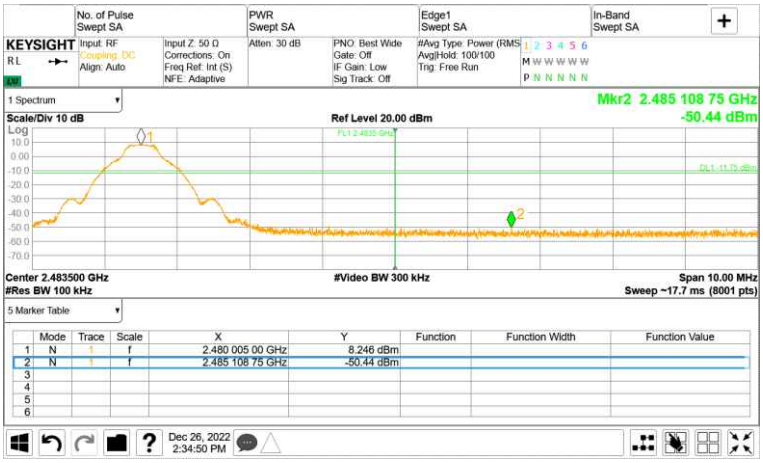
Right, Band Edge, GFSK, Lowest Channel (2 402 MHz)



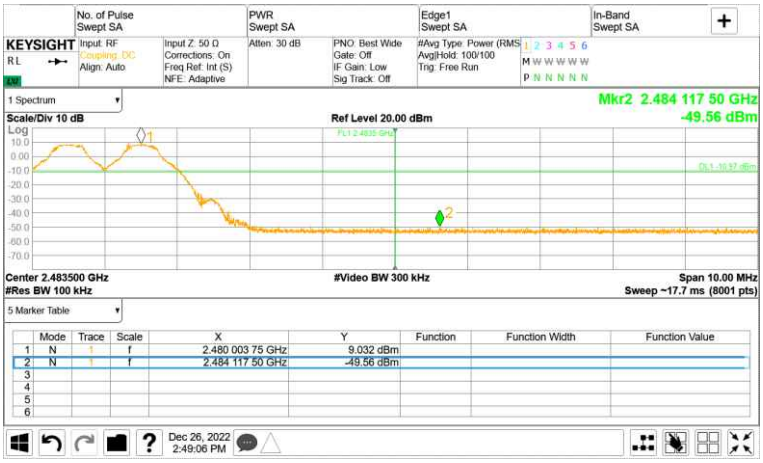
Right, Band Edge, Hopping mode, GFSK, Lowest Channel (2 402 MHz)



Right, Band Edge, GFSK, Highest Channel (2 480 MHz)

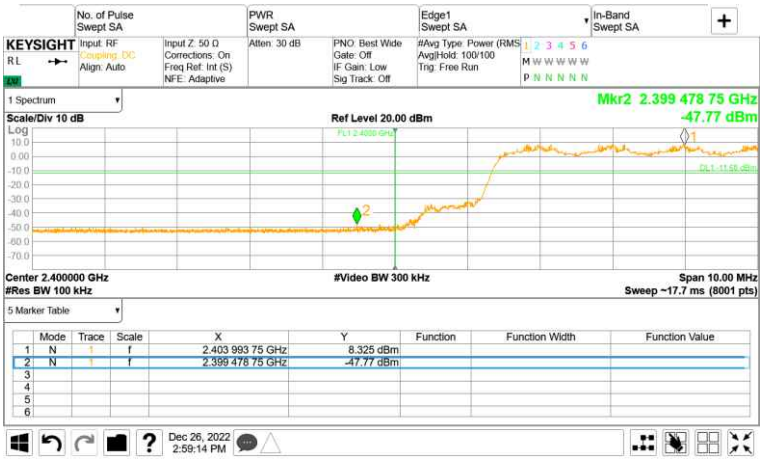


Right, Band Edge, Hopping mode, GFSK, Highest Channel (2 480 MHz)



Right, Band Edge, π/4DQPSK, Lowest Channel (2 402 MHz)

Right, Band Edge, Hopping mode, π/4DQPSK, Lowest Channel (2 402 MHz)

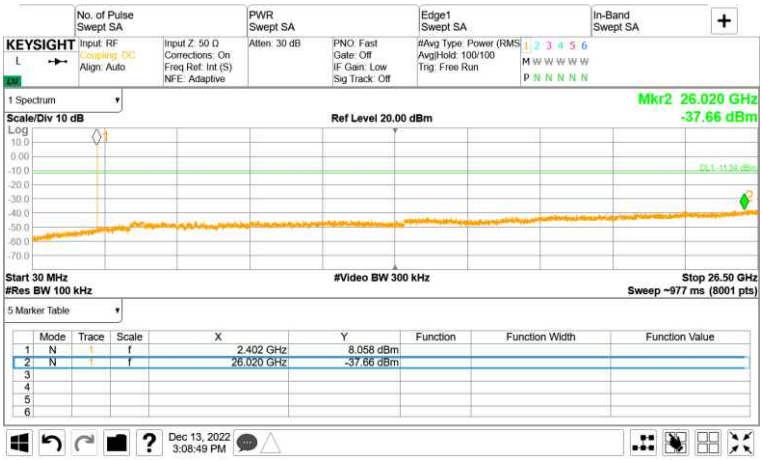


Right, Band Edge, π/4DQPSK, Highest Channel (2 480 MHz)

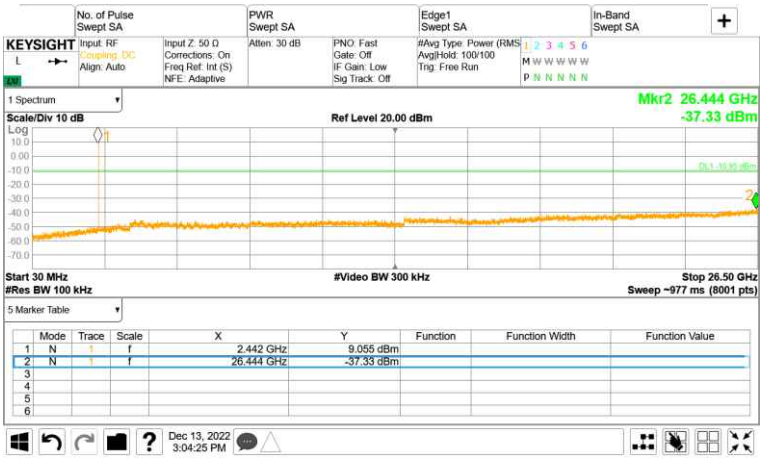
Right, Band Edge, Hopping mode, π/4DQPSK, Highest Channel (2 480 MHz)

PLOTS OF EMISSIONS

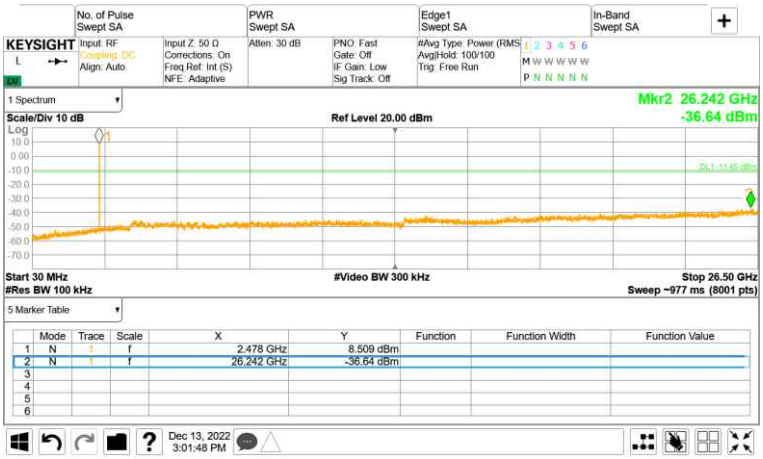
Left, Conducted Spurious Emissions, GFSK, Lowest Channel (2 402 MHz)



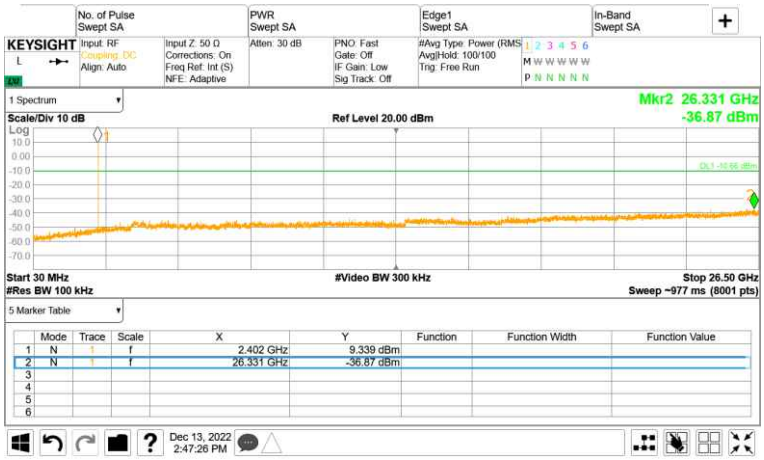
Left, Conducted Spurious Emissions, GFSK, Middle Channel (2 440 MHz)



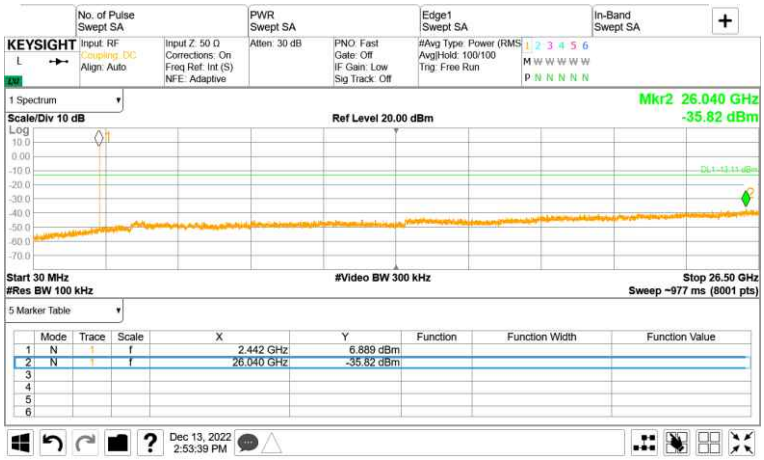
Left, Conducted Spurious Emissions, GFSK, Highest Channel (2 480 MHz)



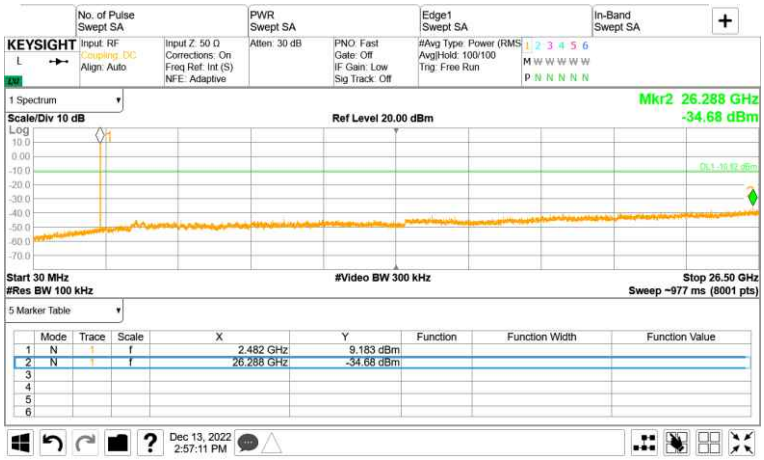
Left, Conducted Spurious Emissions, π/4DQPSK, Lowest Channel (2 402 MHz)



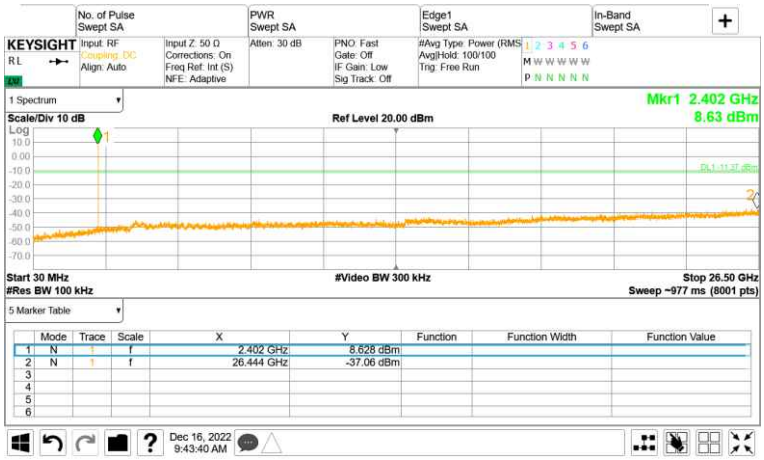
Left, Conducted Spurious Emissions, π/4DQPSK, Middle Channel (2 440 MHz)



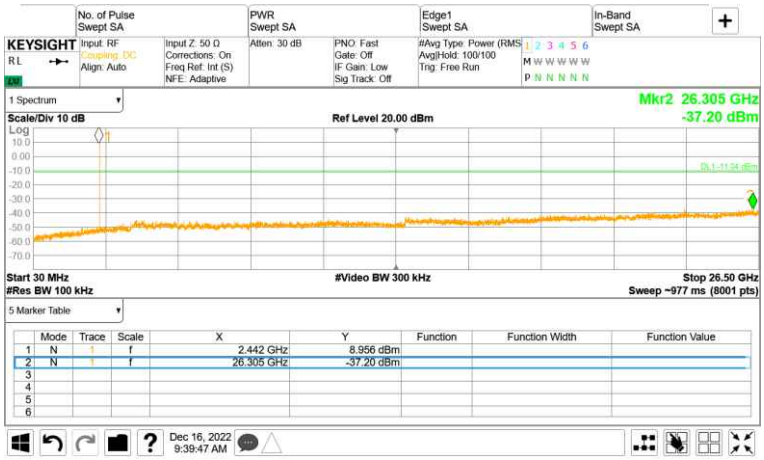
Left, Conducted Spurious Emissions, π/4DQPSK, Highest Channel (2 480 MHz)



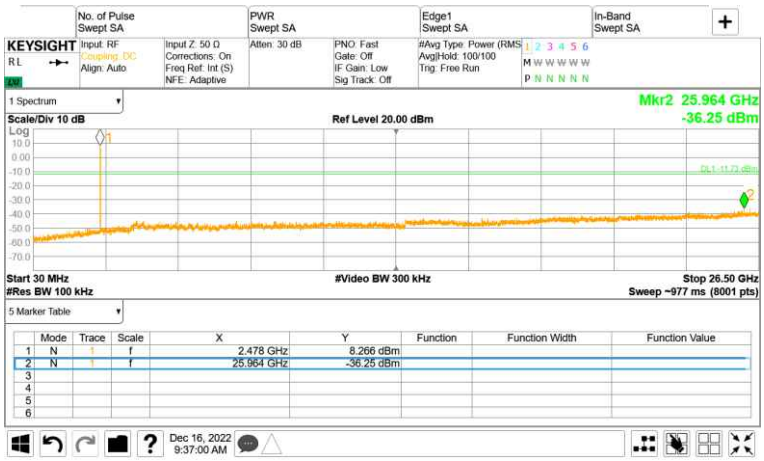
Right, Conducted Spurious Emissions, GFSK, Lowest Channel (2 402 MHz)



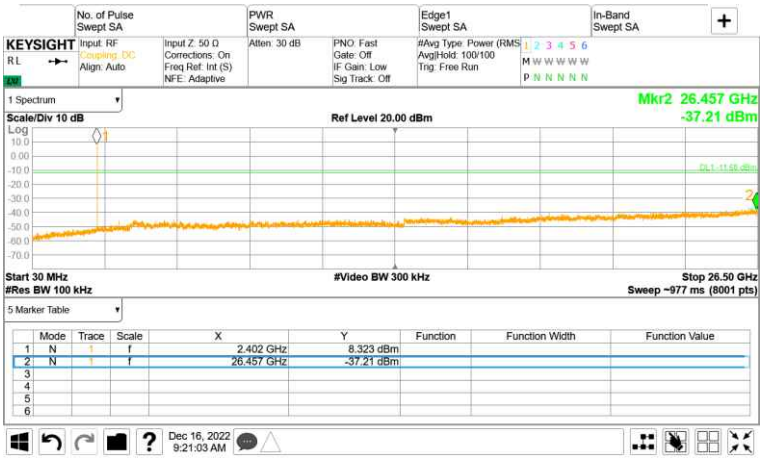
Right, Conducted Spurious Emissions, GFSK, Middle Channel (2 440 MHz)



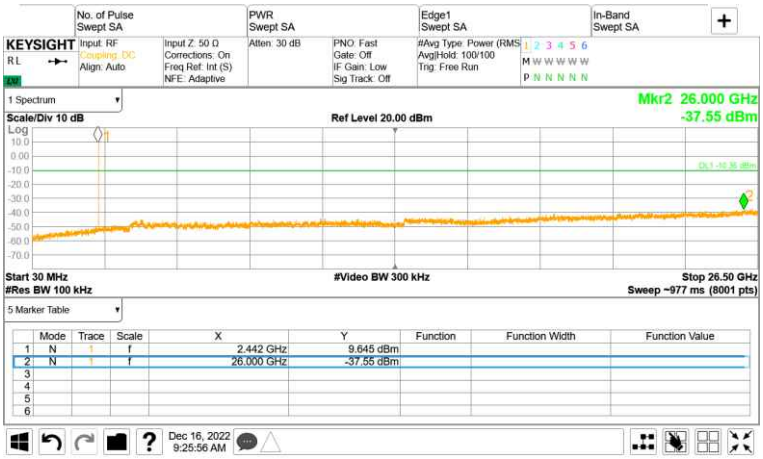
Right, Conducted Spurious Emissions, GFSK, Highest Channel (2 480 MHz)



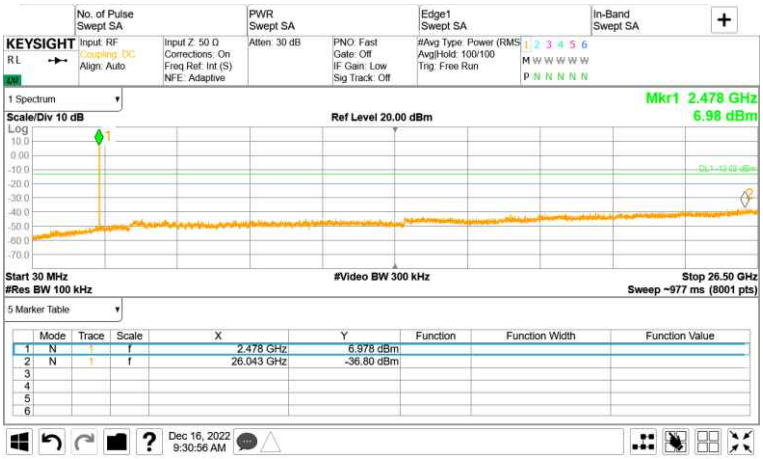
Right, Conducted Spurious Emissions, π/4DQPSK, Lowest Channel (2 402 MHz)



Right, Conducted Spurious Emissions, π/4DQPSK, Middle Channel (2 440 MHz)



Right, Conducted Spurious Emissions, π/4DQPSK, Highest Channel (2 480 MHz)



7.8 Radiated Spurious Emissions

FCC §15.247(d)

Test Mode : Set to Lowest channel, Middle channel and Highest channel

Result

- **Left**

GFSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 803.75	44.04	V	Peak	1.6	45.64	74.00	28.36
7 204.38	40.44	H	Peak	5.8	46.24	74.00	27.76

GFSK modulation_Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 856.25	44.74	H	Peak	2.0	46.74	74.00	27.26
7 338.13	41.22	H	Peak	6.0	47.22	74.00	26.78

GFSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 941.25	43.88	V	Peak	2.3	46.18	74.00	27.82
7 496.25	40.14	V	Peak	6.6	46.74	74.00	27.26

π/4DQPSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 813.13	44.91	H	Peak	3.5	48.41	74.00	25.59
7 202.50	40.86	V	Peak	7.7	48.56	74.00	25.44

π/4DQPSK modulation_Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 884.38	45.17	V	Peak	3.9	49.07	74.00	24.93
7 323.13	40.29	V	Peak	7.8	48.09	74.00	25.91

π/4DQPSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 960.00	44.34	V	Peak	4.0	48.34	74.00	25.66
7 440.63	40.06	H	Peak	8.4	48.46	74.00	25.54

Notes:

1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 20 dB below Fundamental.
5. π/4DQPSK, Middle channel (2 441 MHz) was the worst condition.
6. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
8. Average emissions were measured using RBW = 1 MHz, VBW = 3 kHz, Detector = Peak.
9. The spectrum was measured from 1 GHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 3rd harmonic for this device.

- **Right**

GFSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 805.63	43.65	V	Peak	3.4	47.05	74.00	26.95
7 206.88	39.23	H	Peak	7.7	46.93	74.00	27.07

GFSK modulation_Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 882.50	44.60	V	Peak	3.9	48.50	74.00	25.50
7 323.13	40.49	H	Peak	7.8	48.29	74.00	25.71

GFSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 960.63	43.50	H	Peak	4.0	47.50	74.00	26.50
7 440.00	39.61	V	Peak	8.4	48.01	74.00	25.99

π/4DQPSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 804.38	43.30	V	Peak	3.4	46.70	74.00	27.30
7 206.25	39.79	V	Peak	7.7	47.49	74.00	26.51

π/4DQPSK modulation_Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 882.50	44.17	H	Peak	3.9	48.07	74.00	25.93
7 323.75	38.93	V	Peak	7.9	46.83	74.00	27.17

π/4DQPSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
4 960.63	43.54	V	Peak	4.0	47.54	74.00	26.46
7 440.63	40.87	H	Peak	8.4	49.27	74.00	24.73

Notes:

1. *Pol. H = Horizontal V = Vertical

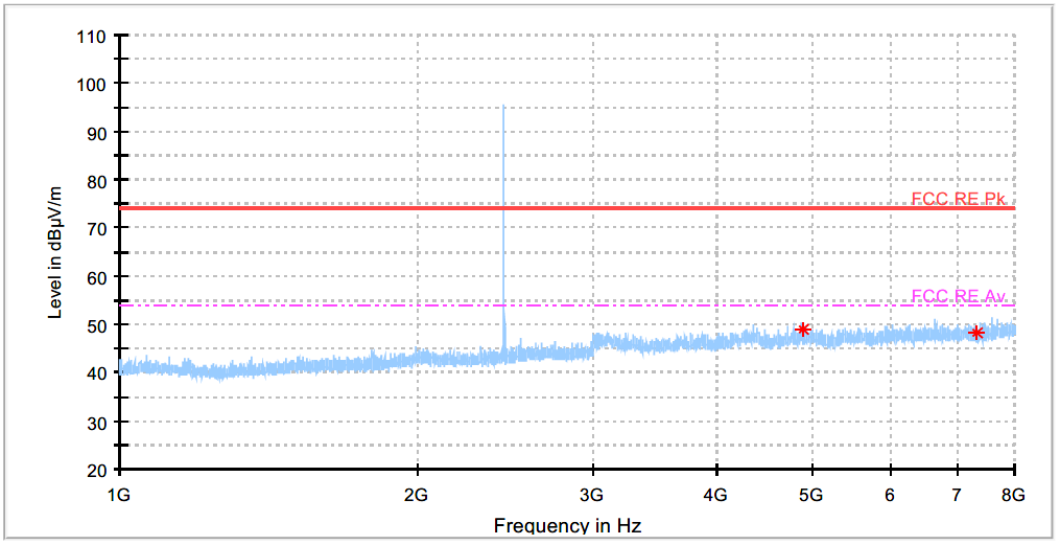
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 20 dB below Fundamental.
5. π/4DQPSK, Highest channel (2 480 MHz) was the worst condition.
6. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
8. Average emissions were measured using RBW = 1 MHz, VBW = 3 kHz, Detector = Peak.
9. The spectrum was measured from 1 GHz to 10th harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 3rd harmonic for this device.

PLOTS OF EMISSIONS

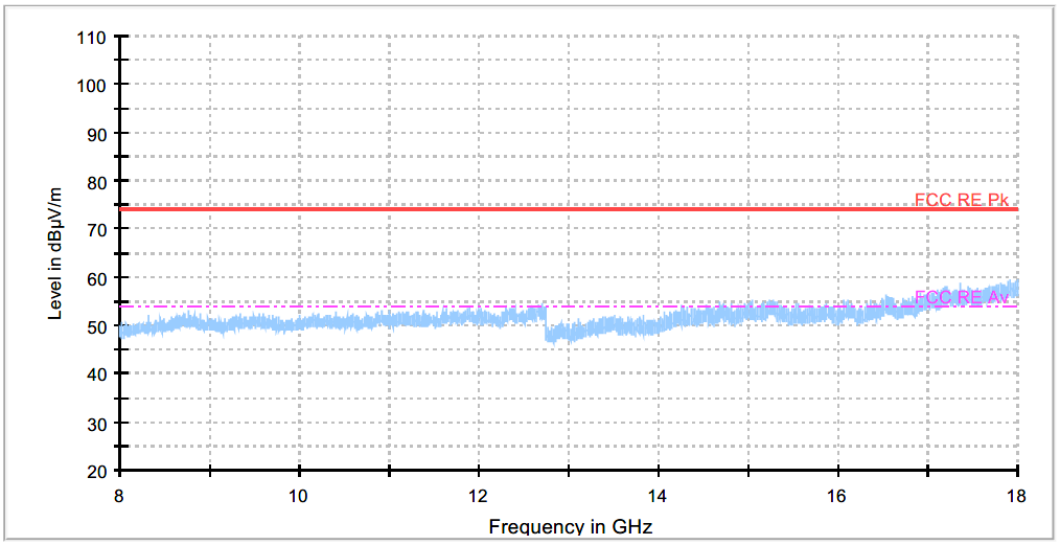
Worst Case

- **Left**

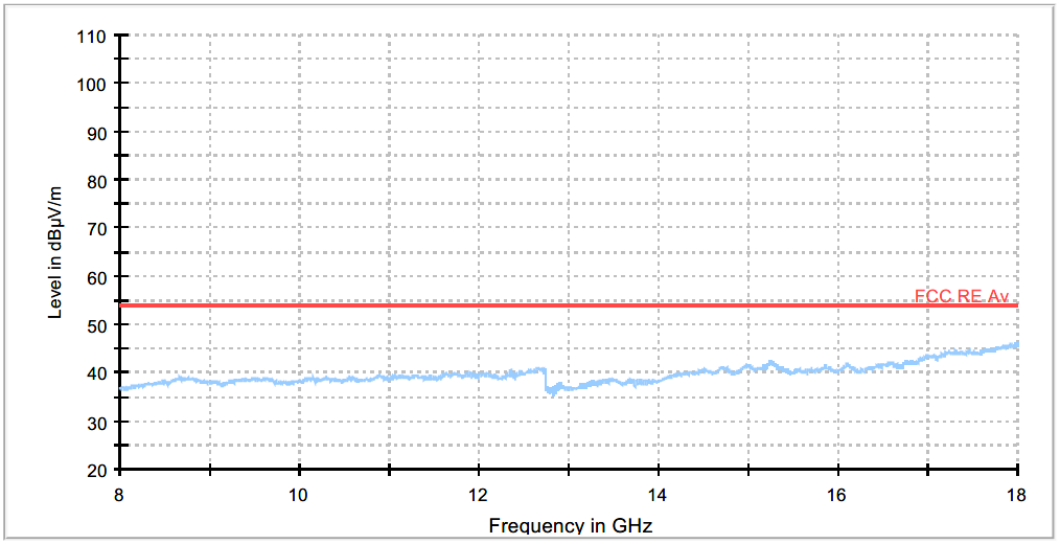
π/4DQPSK, Middle Channel : 1 GHz to 8 GHz_Peak



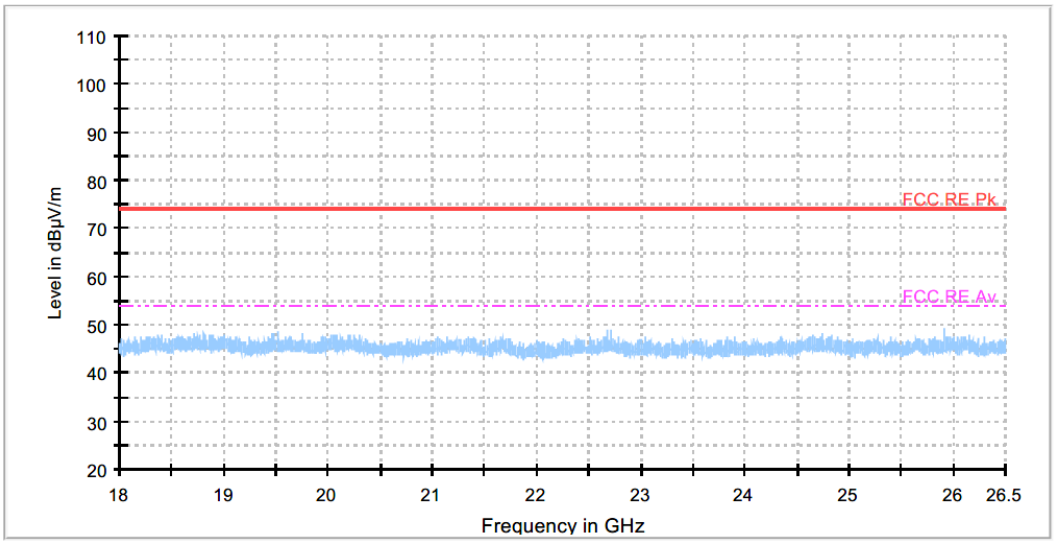
π/4DQPSK, Middle Channel : 8 GHz to 18 GHz_Peak



π/4DQPSK, Middle Channel : 8 GHz to 18 GHz_ Average



π/4DQPSK, Middle Channel : 18 GHz to 26.5 GHz_Peak

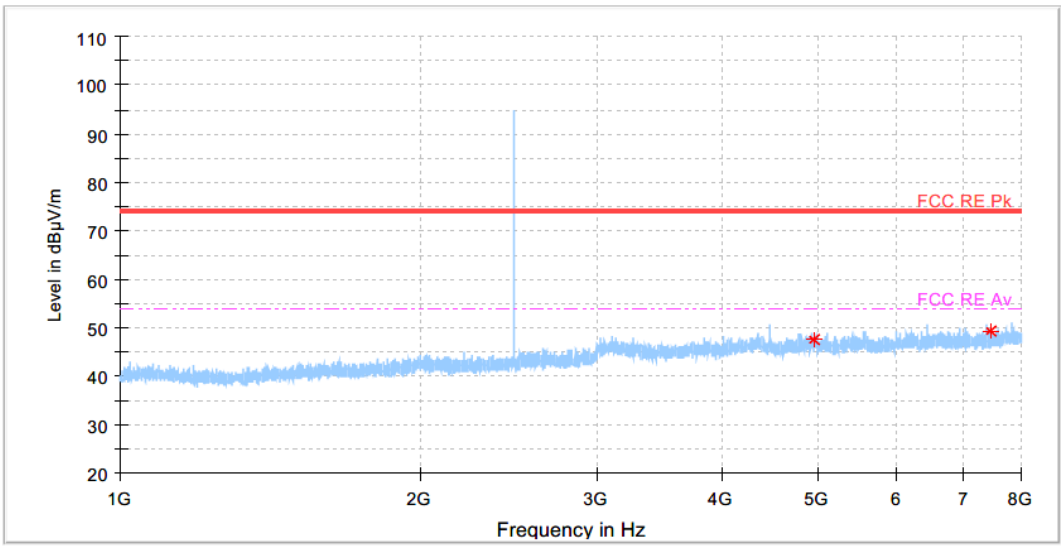


PLOTS OF EMISSIONS

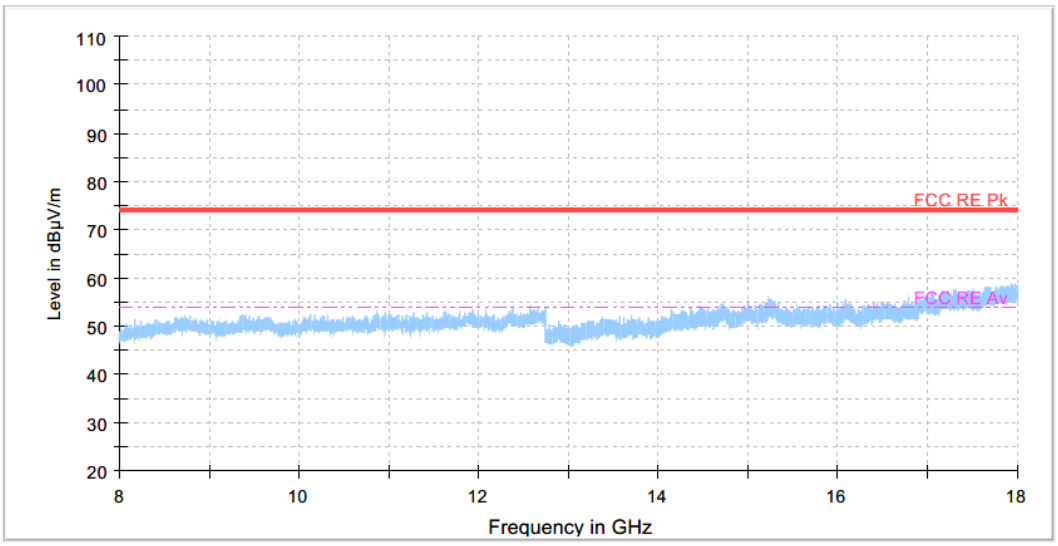
Worst Case

- **Right**

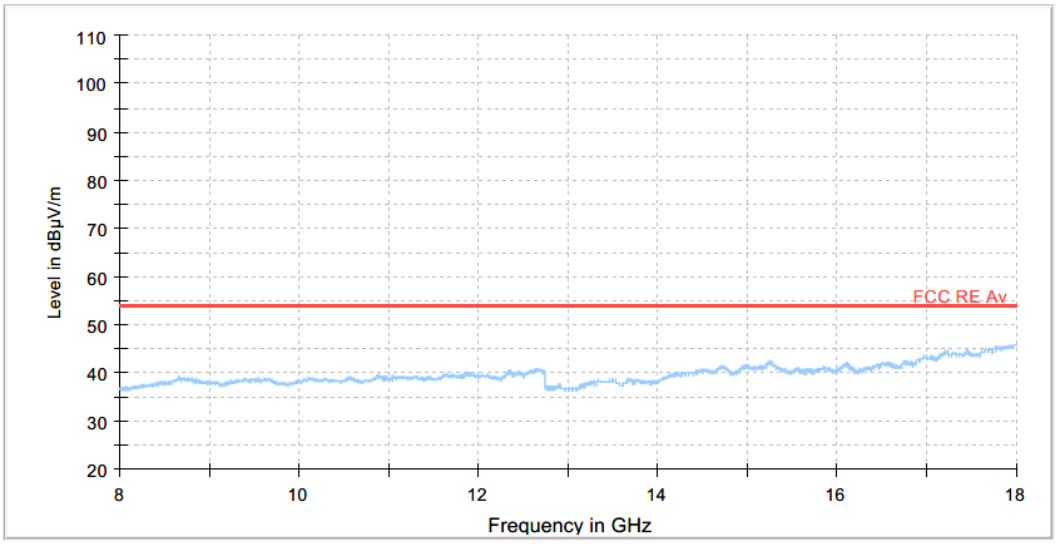
π/4DQPSK, Highest Channel : 1 GHz to 8 GHz_Peak



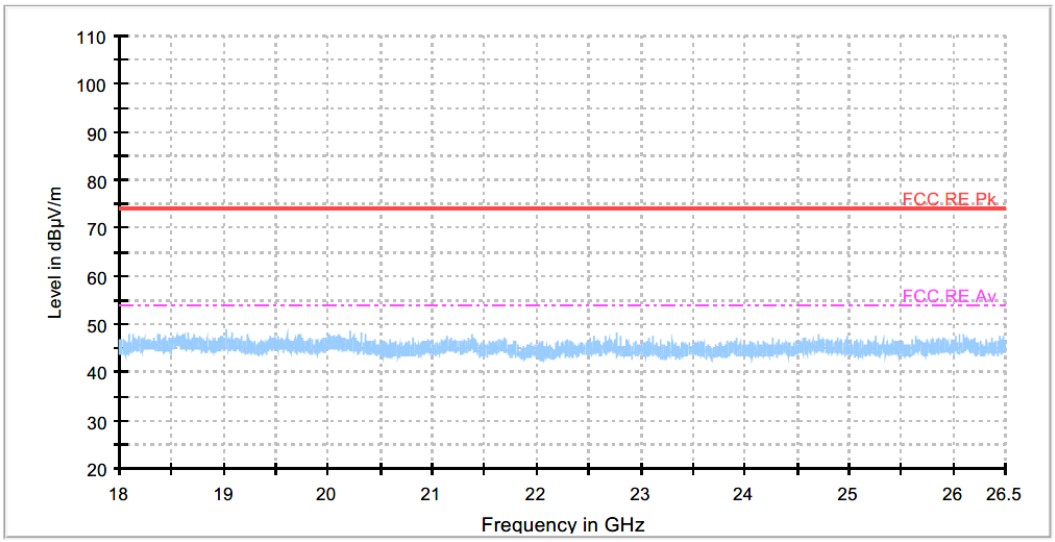
π/4DQPSK, Highest Channel : 8 GHz to 18 GHz_Peak



π/4DQPSK, Highest Channel : 8 GHz to 18 GHz_ Average



π/4DQPSK, Highest Channel : 18 GHz to 26.5 GHz_Peak



7.7 Radiated Band Edge

FCC §15.247(d)

Test Mode : Set to Lowest channel and Highest channel

Result

- **Left**

GFSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 364.80	51.15	V	Peak	-8.0	43.15	74.00	30.85

GFSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 485.92	49.14	H	Peak	-7.2	41.94	74.00	32.06

π/4DQPSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 384.25	51.29	V	Peak	-7.9	43.39	74.00	30.61

π/4DQPSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 497.08	49.03	H	Peak	-7.0	42.03	74.00	31.97

Notes:

1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 20 dB below Fundamental.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
6. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.

- **Right**

GFSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 364.69	51.87	H	Peak	-6.2	45.67	74.00	28.33

GFSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 487.91	49.48	V	Peak	-5.5	43.98	74.00	30.02

π/4DQPSK modulation_Lowest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 360.15	52.31	V	Peak	-6.2	46.11	74.00	27.89

π/4DQPSK modulation_Highest channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2 499.66	49.85	H	Peak	-5.5	44.35	74.00	29.65

Notes:

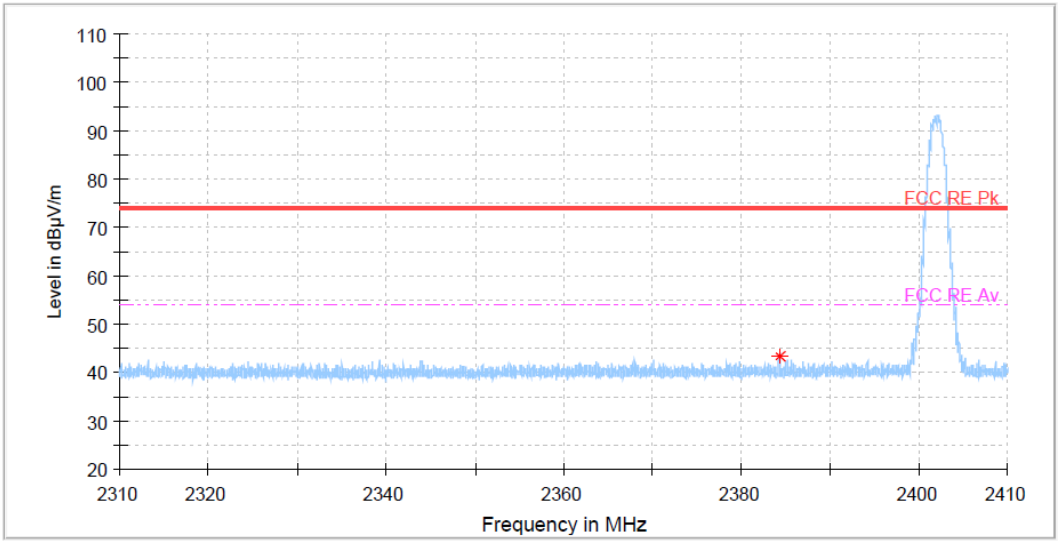
1. *Pol. H = Horizontal V = Vertical
2. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
3. Average measurement was not performed when peak-detected emission complies with the average limit.
4. Other spurious was under 20 dB below Fundamental.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization.
6. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.

PLOTS OF EMISSIONS

Worst Case

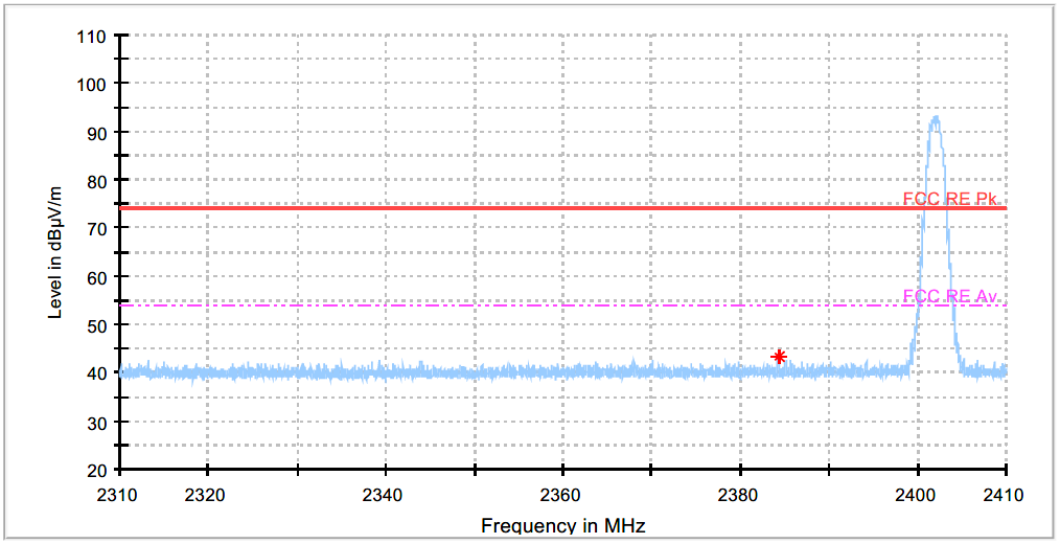
- **Left**

π/4DQPSK modulation, Lowest Channel_Peak



- **Right**

π/4DQPSK modulation, Lowest Channel_Peak



7.8 Radiated Emissions_Below 1GHz

FCC §15.209

Result

- **Left**

π/4DQPSK, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
33.99	57.39	V	QP	-26.3	31.09	40.00	8.91
59.91	51.40	V	QP	-23.6	27.80	40.00	12.20
100.06	40.24	V	QP	-24.3	15.94	43.50	27.56
156.42	51.66	H	QP	-27.3	24.36	43.50	19.14
193.34	49.87	H	QP	-24.5	25.37	43.50	18.13
214.79	48.58	H	QP	-24.3	24.28	43.50	19.22

Radiated Measurements at 3meters

- **Right**

π/4DQPSK, Middle channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	Mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
36.63	58.10	V	QP	-25.3	32.80	40.00	7.20
59.85	52.94	V	QP	-23.6	29.34	40.00	10.66
61.31	52.50	V	QP	-23.9	28.60	40.00	11.40
102.70	45.36	V	QP	-24.1	21.26	43.50	22.24
103.29	50.70	V	QP	-24.1	26.60	43.50	16.90
104.58	50.12	V	QP	-24.0	26.12	43.50	17.38

Radiated Measurements at 3meters

Notes:

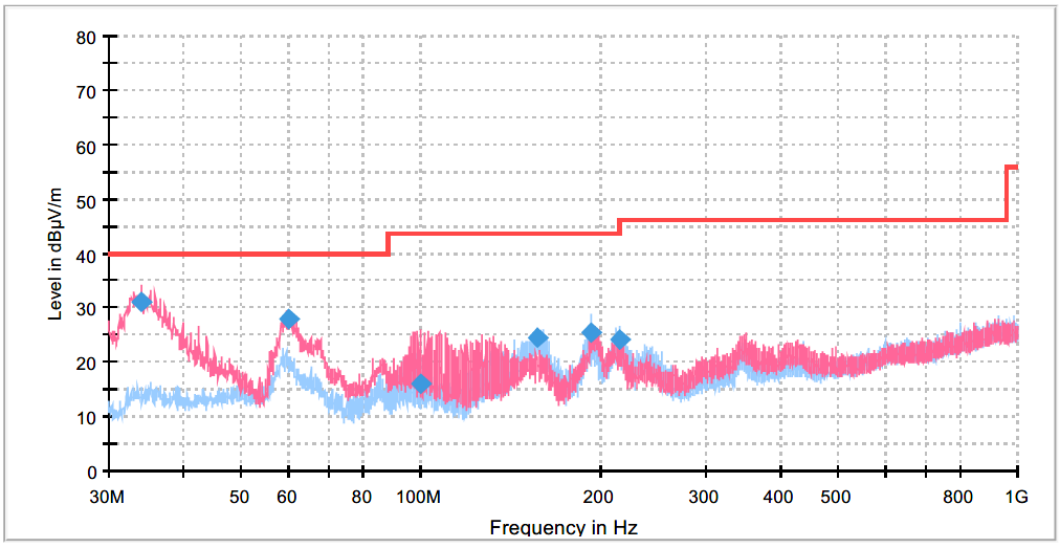
1. The worst-case emission was reported.
2. *Pol. H = Horizontal, V = Vertical
3. **AF + CL + Amp. = Antenna Factor + Cable Loss + Amplifier.
4. Measurements using CISPR quasi-peak mode below 1 GHz.
5. The radiated emissions testing were made by rotating EUT through three orthogonal axes and rotating the receive antenna with horizontal, Vertical polarization. The worst data was recorded.
6. No emission found between lowest internal used/generated frequency to 30MHz (9kHz~30MHz). Per FCC part 15.31(o), test results were not reported.
   Although these tests were performed other than open field test site, adequate comparison measurements were confirmed against 30 m open are test site.
   Therefore, sufficient tests were made to demonstrate that the alternative site produces results that correlate with the one of tests made in an open field based on KDB 414788.
7. The limit is on the FCC §15.209.
8. Emission was pre-scanned from 9kHz to 30MHz; No emissions were detected which was at least 20dB below the specification limit (consider distance correction factor).

PLOTS OF EMISSIONS

Worst Case

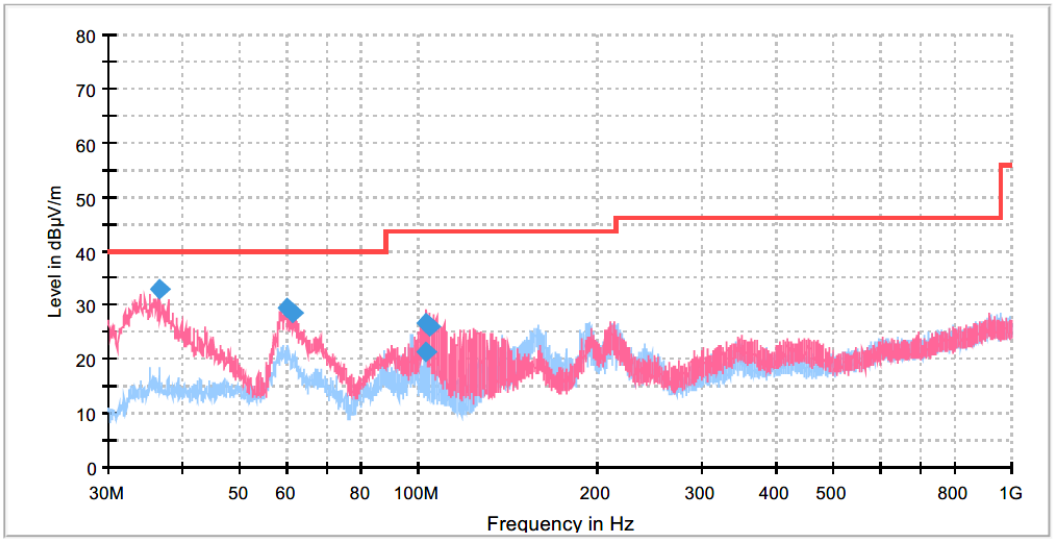
- **Left**

Radiated emission below 1GHz, π/4DQPSK, Middle Channel



- **Right**

Radiated emission below 1GHz, π/4DQPSK, Middle Channel



TEST DATA

7.9 Conducted

FCC §15.207, RSS-GEN Issue 5 8.8

Result : N/P

Note : The AC power line test was not performed because the EUT does not operate Bluetooth mode while charging.

8. TEST EQUIPMENT

No.	Instrument	Manufacture	Model	Serial No.	Calibration Data	Calibration Interval
1	Double Ridged Broadband Horn Antenna	Schwarzbeck	BBHA 9120 D	01615	2022-09-13	2023-09-13
2	SWITCH AND EXTENSION UNIT CAN-BUS	R&S	OSP150	100929	N/A	N/A
3	WiFi Filter Bank	R&S	U082	N/A	N/A	N/A
4	TRILOG Broadband Test Antenna	Schwarzbeck	VULB 9163	01431	2022-11-16	2024-11-16
5	Signal Conditioning Unit	ROHDE & SCHWARZ	SCU 01	10029	2022-04-05	2023-04-05
6	DOUBLE RIDGED HORN ANTENNA	ROHDE & SCHWARZ	HF907	100197	2022-01-28	2023-01-28
7	Signal Conditioning Unit	ROHDE & SCHWARZ	SCU 18	10065	2022-04-05	2023-04-05
8	Horn Antenna	Q-par Angus	QMS-00225	17637	2022-09-13	2023-09-13
9	Signal Conditioning Unit	R&S	SCU-26D	1984522	2022-04-06	2023-04-06
10	LOOP ANTENNA	R&S	HFH2-Z2	100279	2021-03-14	2023-03-14
11	EMI TEST RECEIVER	R&S	ESW44	103091	2022-05-16	2023-05-16
12	DIGITAL MULTIMETER	EZ DIGITAL	DM-334	2111395	2022-10-13	2023-10-13
13	DC POWER SUPPLY	KEYSIGHT	N6953A	MY59130146	2022-07-07	2023-07-07
14	Vector Signal Generator	R&S	SMW200A	105755	2022-04-06	2023-04-06
15	Signal & Spectrum Analyzer	KEYSIGHT	N9030B	MY57144327	2022-04-06	2023-04-06
16	10 dB Attenuator	API technologies corp	40A2W-10	1914	2022-07-06	2023-07-06

*) Test equipment used during the test

9. ACCURACY OF MEASUREMENT & DECISION RULE

9.1 Uncertainty Calculation

The Measurement Uncertainties stated were calculated in accordance with the requirements of measurement uncertainty contained in CISPR 16-4-2 with the confidence level of 95%

PARAMETER	UNCERTAINTY
Conducted Disturbance, 0.15 to 30 MHz	2.44 dB
Radiated Disturbance, 30 MHz to 1 GHz	5.68 dB
Radiated Disturbance, Above 1 GHz	5.06 dB

9.2 Decision rule

Decision rule for statement(s) of conformity is based on Procedure 2, Clause 4.4.3 in IEC Guide 115:2021.

- END REPORT -