Nemko Korea Co., Ltd.

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FCC and IC EVALUATION REPORT FOR CERTIFICATION

Applicant :
Harman International Industries, Inc.
8500 Balboa Blvd, Northridge, CA
91329, USA
Attn. : Nicholas Clarke

Dates of Issue : Sep 20, 2019
Test Report No. : NK-19-R-173
Test Site : Nemko Korea Co., Ltd.

FCC ID	**APILUXABT01**
IC	**6132A-LUXABT01**
Brand Name	**HARMAN**
Contact Person	**Harman International Industries, Inc.** **8500 Balboa Blvd, Northridge, CA,** **91329, USA** **Nicholas Clarke** **Telephone No. : +44 1223 203270**

Applied Standard:	FCC 47 CFR Part 15.247 IC RSS-247 Issue 2 and IC RSS-GEN Issue 5
Classification:	FCC Part 15 Spread Spectrum Transmitter (DSS)
EUT Type:	Bluetooth Module

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.

Sep. 20. 2019

Tested By : Wonjae Song
Engineer

Sep. 20. 2019

Reviewed By : Seungyong Shin
Technical Manager

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1. SCOPE

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 Issue2.

Responsible Party :	Harman International Industries, Inc. 8500 Balboa Blvd, Northidge, CA, 91329, USA
Contact Person :	Nicholas Clarke
Manufacturer :	Anam Electronics Co., Ltd. 27, Digital-ro 27ga-gil, Guro-gu, Seoul, 08375, Republic of Korea

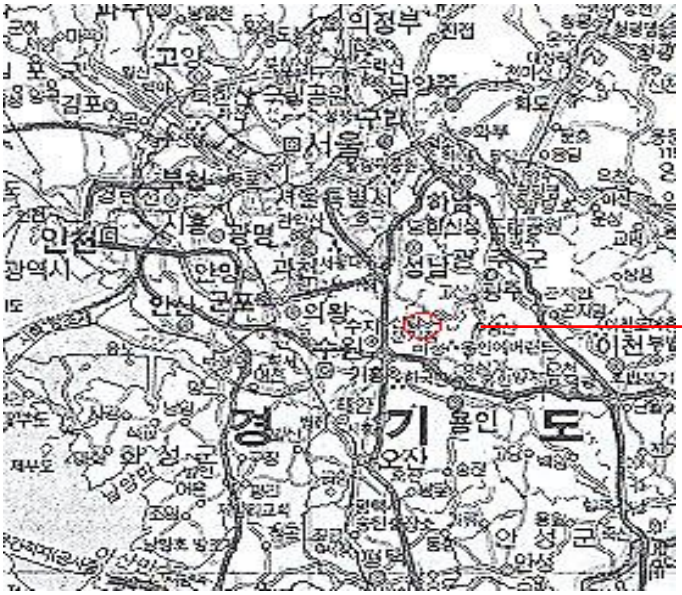
- FCC ID: APILUXABT01
- IC: 6132A-LUXABT01
- Model: LUXABT01
- Variant Models -
- HVIN: LUXABT01
- Brand Name: HARMAN
- EUT Type: Bluetooth Module
- Classification: Part 15 Spread Spectrum Transmitter (DSS)
- Applied Standard: FCC 47 CFR Part 15.247
  IC RSS-247 Issue 2 and IC RSS-GEN Issue 5
- Test Procedure(s): ANSI C63.10-2013
- Dates of Test: Aug 8, 2019 ~ Sep 3, 2019
- Place of Test: Nemko Korea Co., Ltd.

2. INTRODUCTION

2.1 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 from **Harman International Industries, Inc. FCC ID : APILUXABT01** and **IC : 6132A-LUXABT01.**

These measurement tests were conducted at ***Nemko Korea Co., Ltd. EMC Laboratory*** .
The site address 155 & 159, Osan-Ro, Mohyeon-Eup, Cheoin-Gu, Yongin-Si, Gyeonggi-Do 16885 KOREA, REPULIC OF.
The area of Nemko Korea Corporation Ltd. EMC Test Site is located in a mountain area at 80 km (48 miles) southeast and Incheon International Airport (Incheon Airport), 30 km (18miles) south-southeast from central Seoul.
It is located in the valley surrounded by mountains in all directions where ambient radio signal conditions are quiet and a favorable area to measure the radio frequency interference on open field test site for the computing and ISM devices manufactures.
The detailed description of the measurement facility was found to be in compliance with the requirements of ANSI C63.4-2014 according to §2.948.



Nemko Korea Co., Ltd.
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Fig. 1. The map above shows the Seoul in Korea vicinity area.
The map also shows Nemko Korea Corporation Ltd. EMC Lab. and Incheon Airport.

2.2 Accreditation and listing

Accreditation type		Accreditation number
	CAB Accreditation for DOC	Designation No. KR0026
	KOLAS Accredited Lab. (Korea Laboratory Accreditation Scheme)	Registration No. 155
Industry Canada	Canada IC Registered site	Site No. 2040E
	VCCI registration site(RE/CE/Telecom CE)	Member No. 2118
	EMC CBTL	-
	KCC(RRL)Designated Lab.	Registration No. KR0026

3. TEST CONDITIONS & EUT INFORMATION

3.1 Operation During Test

The EUT is the transceiver which is Bluetooth 4.2 module 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 (Bluetest) supported by manufacturer.
The operating voltage of EUT was 5.0 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.

3.1.1 Table of Test power setting

Frequency	Mode	Modulation	Power setting Level
2402 MHz ~ 2480 MHz	BDR	GFSK	Default
2402 MHz ~ 2480 MHz	EDR	π/4DQPSK	Default
2402 MHz ~ 2480 MHz	EDR	8DPSK	Default

3.1.2 Table of Test channels

Frequency band	Modulation	Test Channel (CH)	Frequency (MHz)
2.4 GHz	GFSK, π/4DQPSK, 8DPSK	0	2402
		39	2441
		78	2480

3.1.3 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

3.1.4 Additional Information Related to Testing

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

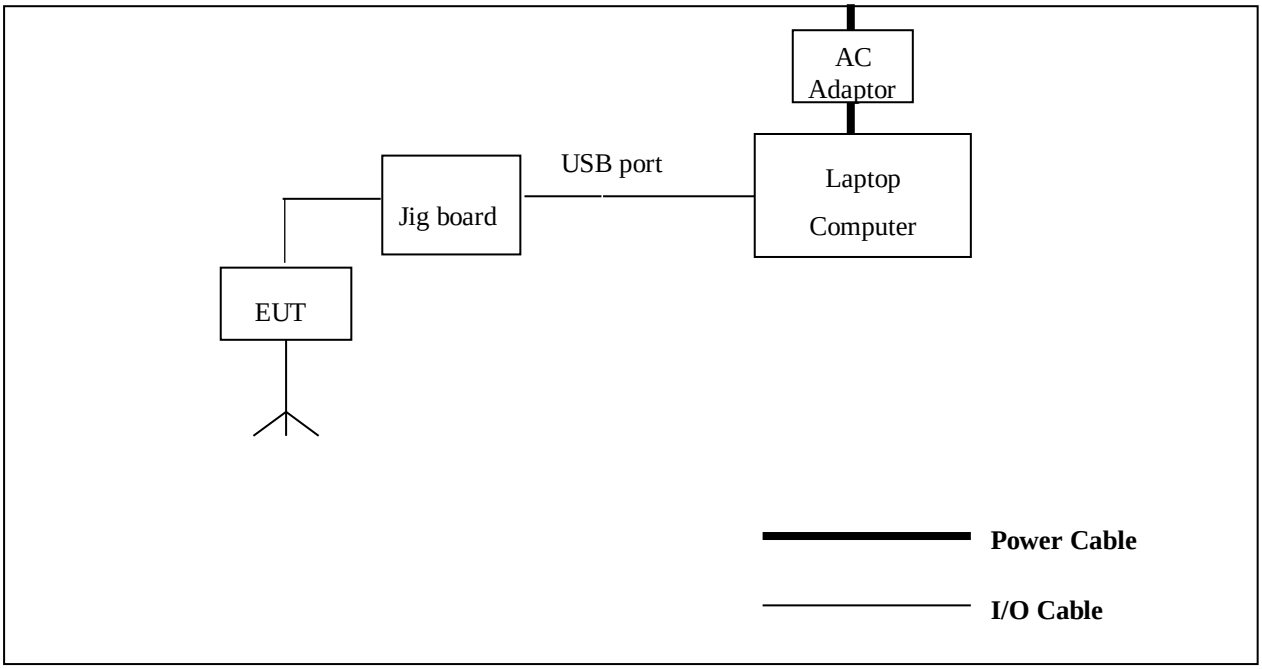
3.1.5 Table of Test modes

Test Items	Modulation	Test Channel (CH)
Conducted Emissions	GFSK	39
Radiated Emissions	GFSK	0/39/78
20 dB Bandwidth	GFSK, π/4DQPSK, 8DPSK	0/39/78
Carrier Frequency Separation	GFSK, π/4DQPSK, 8DPSK	0/39/78
Transmitter Average Time of Occupancy	GFSK, π/4DQPSK, 8DPSK	0/39/78
Number of Hopping Channels	GFSK, π/4DQPSK, 8DPSK	0/39/78
Peak Output Power and E.I.R.P	GFSK, π/4DQPSK, 8DPSK	0/39/78
Conducted Spurious Emission, Radiated Spurious Emission, Band edge Emission	GFSK, π/4DQPSK, 8DPSK	0/39/78

3.2 Support Equipment

EUT	Harman International Industries, Inc. Model : LUXABT01	S/N: N/A
Laptop Computer	HP Model : G62-355TU	FCC DOC S/N : CNF0489WDT
AC/DC Adapter	HP Model : PPP009D 1.5 m unshielded power cable	FCC DOC S/N : WBGSV0ACXZH162

3.3 Setup Drawing



3.4 EUT Information

The EUT is the **Harman International Industries, Inc. Bluetooth Module FCC ID: APILUXABT01, IC: 6132A-LUXABT01.**

Specifications:

EUT Type	Bluetooth Module
Model Name	LUXABT01
Variant Model Name	-
Brand Name	HARMAN
Frequency of Operation	2402 MHz ~ 2480 MHz
Peak Output Power (Conducted)	5.93 dBm
FCC Classification	FCC Part 15 Spread Spectrum Transmitter (DSS)
Spreading Method	Frequency Hopping Spread Spectrum (FHSS)
Number of Channels	79 CH
Modulations	GFSK, π/4DQPSK, 8DPSK
Antenna Gain (peak)	1.83 dBi
Antenna Setup	1TX / 1RX
Voltage	5.0 Vdc
Temperature Range	-10 ℃ ~ +70 ℃
Size (W x H x D)	About 62.5 mm x 26 mm x 97.3 mm
Weight	About 36 g
HVIN (Hardware Version Number)	LUXABT01
FVIN (Firmware Version Identification Number)	-
Remarks	-

4. SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specification:

Name of Test	FCC Paragraph No.	IC Paragraph No.	Result	Remark
Conducted Emission	15.207	RSS-GEN Issue 5 8.8	Complies	
Radiated Emission	15.209	RSS-GEN Issue 5 8.9	Complies	
20dB Bandwidth	15.247(a)(1)	RSS-247 Issue 2 5.1	Complies	
Carrier Frequency Separation	15.247(a)(1)	RSS-247 Issue 2 5.1	Complies	
Transmitter Average Time of Occupancy	15.247(a)(1)(iii)	RSS-247 Issue 2 5.1	Complies	
Peak Output Power and E.I.R.P	15.247(b)(1)	RSS-247 Issue 2 5.4	Complies	
Conducted Spurious Emission	15.247(d)	RSS-247 Issue 2 5.5	Complies	
Radiated Spurious Emission	15.247(d)	RSS-247 Issue 2 5.5	Complies	
Number of Hopping channels	15.247(a)(1)(iii)	RSS-247 Issue 2 5.1	Complies	

5. RECOMMENDATION/CONCLUSION

The data collected shows that the **Harman International Industries, Inc. Bluetooth Module FCC ID: APILUXABT01, IC: 6132A-LUXABT01** is in compliance with Part 15.247 of the FCC Rule and RSS-247 Issue 2 of the IC Specification.

6. ANTENNA REQUIREMENTS

§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 **Harman International Industries, Inc. Bluetooth Module FCC ID: APILUXABT01, IC: 6132A-LUXABT01** is **permanently attached** and there are no provisions for connection to an external antenna. It complies with the requirement of §15.203.

Used Antenna		
Model name	Max. gain (dBi)	
	2.4GHz	5GHz
CSA3A020Z	1.83	2.79

7. DESCRIPTION OF TESTS

7.1 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 (ESH3-Z5) and (ESH2-Z5) 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 (ESH3-Z5) and the support equipment is powered from the Rohde & Schwarz LISN (ESH2-Z5). 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 (serpentinefashion) 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 ESCS30). 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.

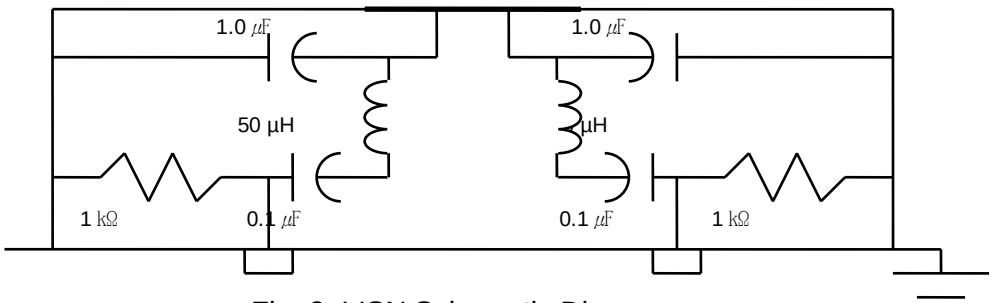


Fig. 2. LISN Schematic Diagram

7.2 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(Rohde&Schwarz, HFH2-Z2) and 30 to 1000 MHz using Trilog broadband test antenna(Schwarzbeck, VULB 9163). Above 1 GHz, Horn antenna (Schwarzbeck BBHA 9120D: up to 18 GHz, Q-par Angus QSH20S20 : 18 to 26.5 GHz) 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.

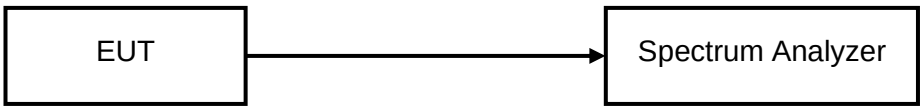
At frequencies below 1000 MHz, measurements performed using the CISPR quasi-peak detection. At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in ANSI 63.10-2013 section 11.12. Peak emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Trace mode = max hold. Average emission levels were measured by setting the analyzer RBW = 1 MHz, VBW = 10kHz, 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

7.3 20 dB Bandwidth

Test Setup

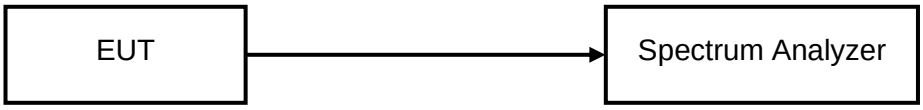


Test Procedure

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

7.4 Carrier Frequency Separation

Test Setup

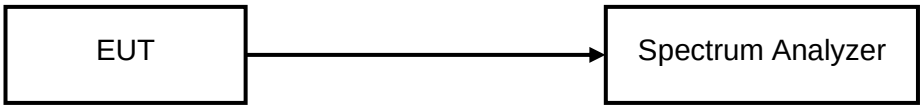


Test Procedure

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.

7.5 Transmitter Average Time of Occupancy

Test Setup

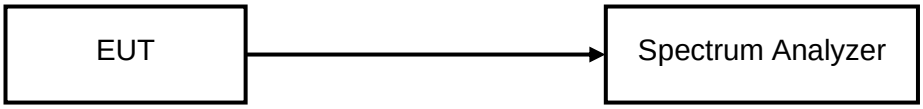


Test Procedure

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

7.6 Number of Hopping Channels

Test Setup

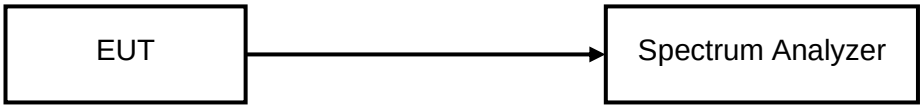


Test Procedure

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

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

Test Setup

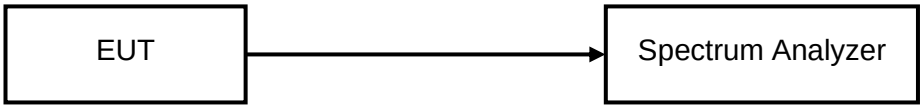


Test Procedure

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

7.8 Conducted Spurious Emission

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

8. TEST DATA

8.1 Conducted Emissions

FCC §15.207

Result

Frequency	Level (dBμV)		*) Factor	**) Line	Limit (dBμV)		Margin (dB)	
(MHz)	Q-Peak	Average	(dB)		Q-Peak	Average	Q-Peak	Average
0.15	44.6	21.2	10.50	L	65.8	55.8	21.2	34.6
0.19	49.9	44.7	10.40	N	64.0	54.0	14.1	9.3
0.25	42.5	35.8	10.40	L	61.9	51.9	19.4	16.1
3.25	35.9	23.1	10.60	L	56.0	46.0	20.1	22.9
3.27	36.0	23.2	10.60	L	56.0	46.0	20.0	22.8
19.33	33.7	25.6	11.40	L	60.0	50.0	26.3	24.4

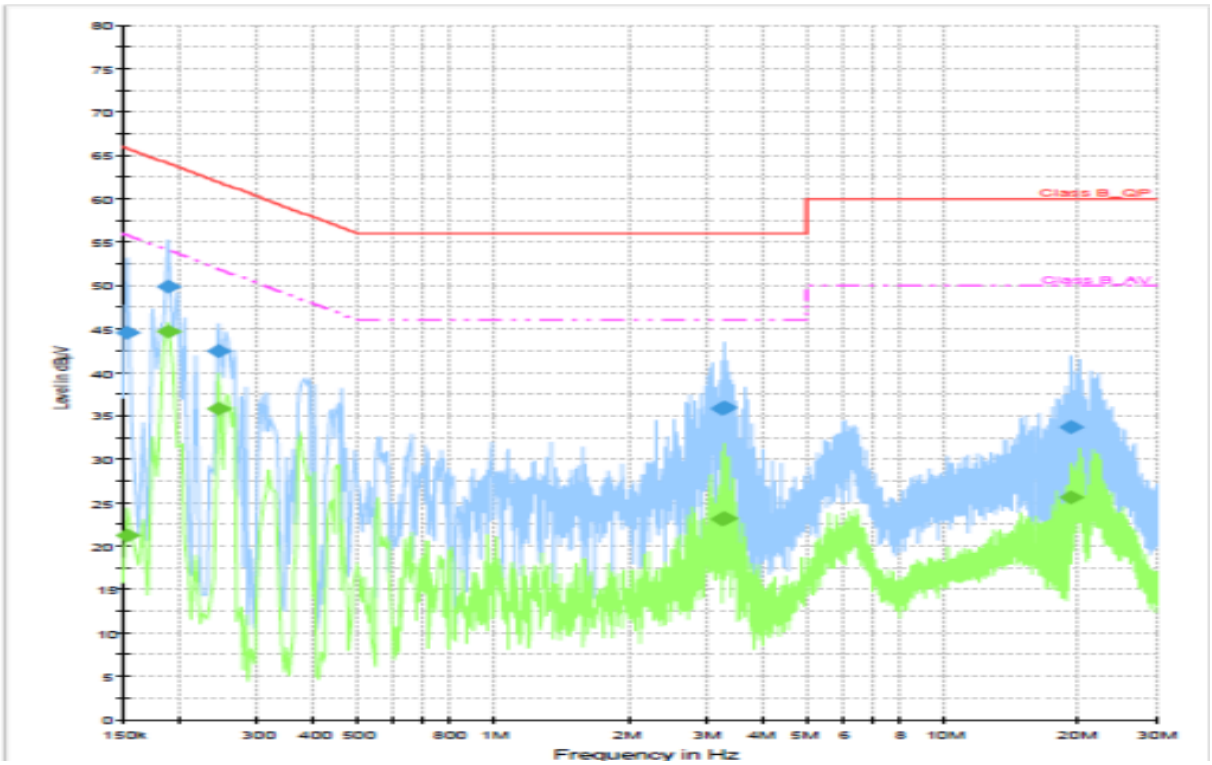
Line Conducted Emissions Tabulated Data

Notes:

1. Measurements using CISPR quasi-peak mode & average mode.
2. All modes of operation were investigated and the worst -case emission are reported. See attached Plots.
*3. *) Factor = LISN + Cable Loss*
*4. **) LINE : L = Line , N = Neutral*
5. The limit is on FCC §15.207(a)

PLOTS OF EMISSIONS

Conducted Emission at the Mains port (Line + Neutral)



8.2 Radiated Emissions

FCC §15.209, IC RSS-Gen Issue 5 8.9

Result

Frequency	Reading	Pol*	Antenna Heights	Turntable	AF+CL+Amp	Result	Limit	Margin
(MHz)	(dBµV/m)	(H/V)	(cm)	Angles (°)	(dB)**	(dBµV/m)	(dBµV/m)	(dB)
67.67	34.78	H	300	358	-25.9	8.9	40.0	31.1
86.96	42.02	H	300	338	-27.2	14.8	40.0	25.2
96.45	42.70	H	200	328	-24.8	17.9	43.5	25.6
97.47	39.50	H	100	0	-24.6	14.9	43.5	28.6
126.41	46.93	H	400	8	-27.1	19.8	43.5	23.7
129.53	43.38	H	100	328	-27.3	16.1	43.5	27.4
143.98	64.48	H	200	129	-27.9	36.6	43.5	6.9

Radiated Measurements at 3meters

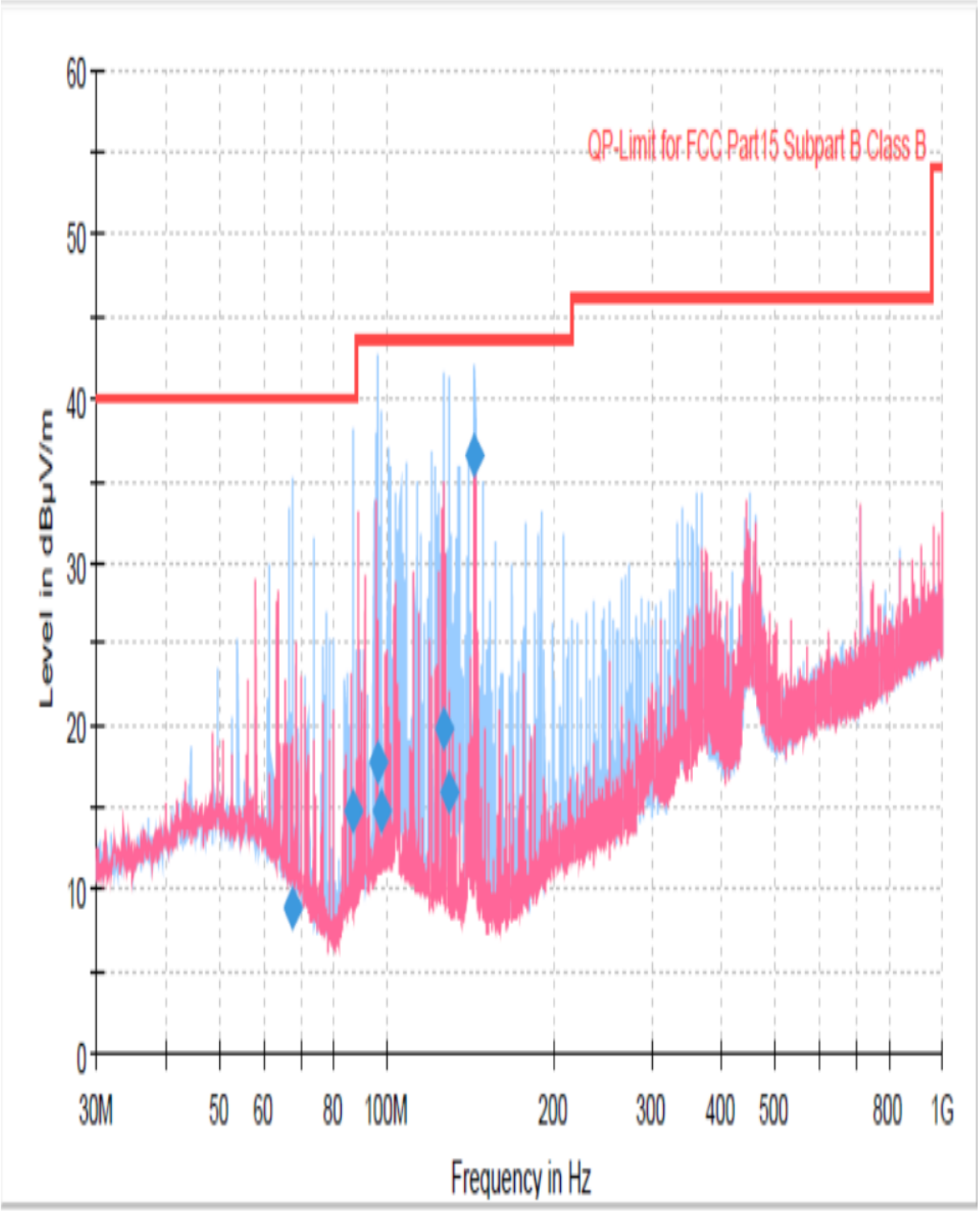
Notes:

1. *All modes were measured and 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. *Lowest channel (2402MHz) in GFSK modulation is the worst case.*
7. *No emission found between lowest internal used/generated frequency to 30MHz (9kHz~30MHz).*
8. *The limit is on the FCC §15.209 and RSS-Gen Issue 5 8.9.*

PLOTS OF EMISSIONS

Worst Case

Radiated emission below 1GHz_2402 MHz_GFSK modulation



8.3 20 dB Bandwidth

FCC §15.247(a)(2), IC RSS-247 Issue 2 5.2

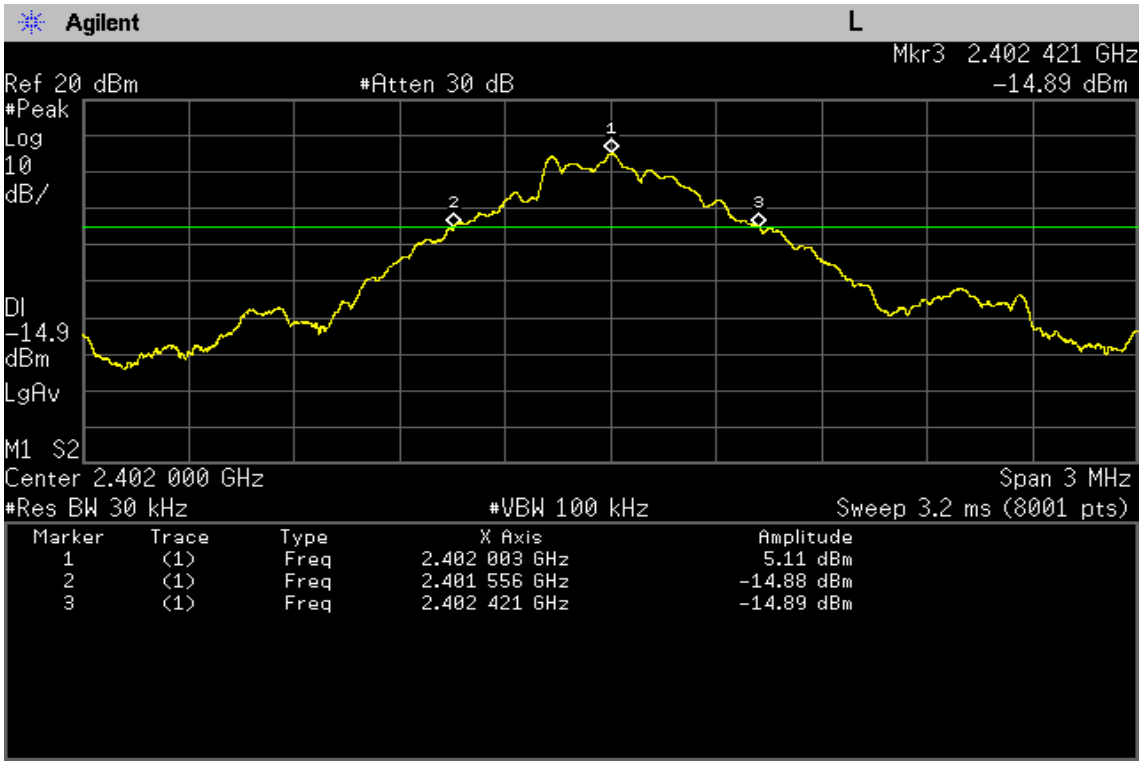
Test Mode : Set to Lowest channel, Middle channel and Highest channel,

Result

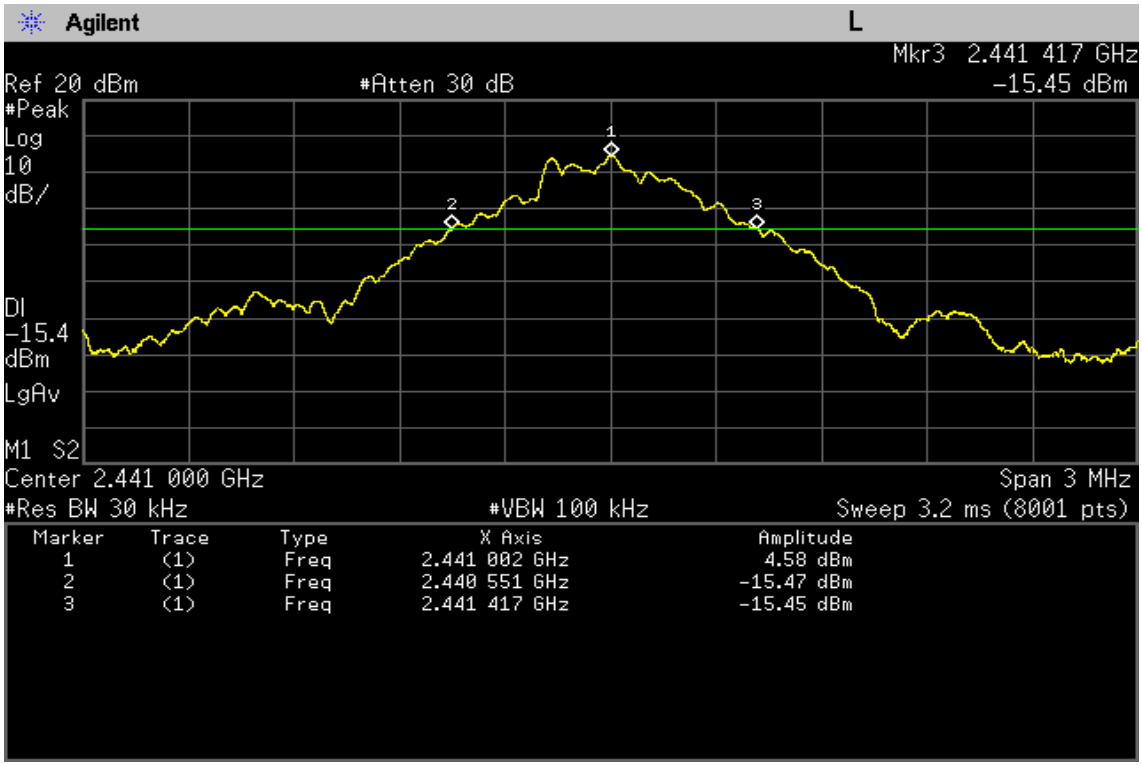
Modulation	Channel	Frequency (MHz)	20 dB Bandwidth (MHz)	Limit (MHz)	99% emission bandwidth (MHz)
GFSK	Lowest	2402	0.87	Non Specified	0.84
GFSK	Middle	2441	0.87	Non Specified	0.84
GFSK	Highest	2480	0.87	Non Specified	0.84
π/4DQPSK	Lowest	2402	1.23	Non Specified	1.18
π/4DQPSK	Middle	2441	1.24	Non Specified	1.17
π/4DQPSK	Highest	2480	1.23	Non Specified	1.17
8DPSK	Lowest	2402	1.27	Non Specified	1.17
8DPSK	Middle	2441	1.26	Non Specified	1.17
8DPSK	Highest	2480	1.26	Non Specified	1.17

PLOTS OF EMISSIONS

20 dB Bandwidth, GFSK modulation, Lowest Channel (2402 MHz)

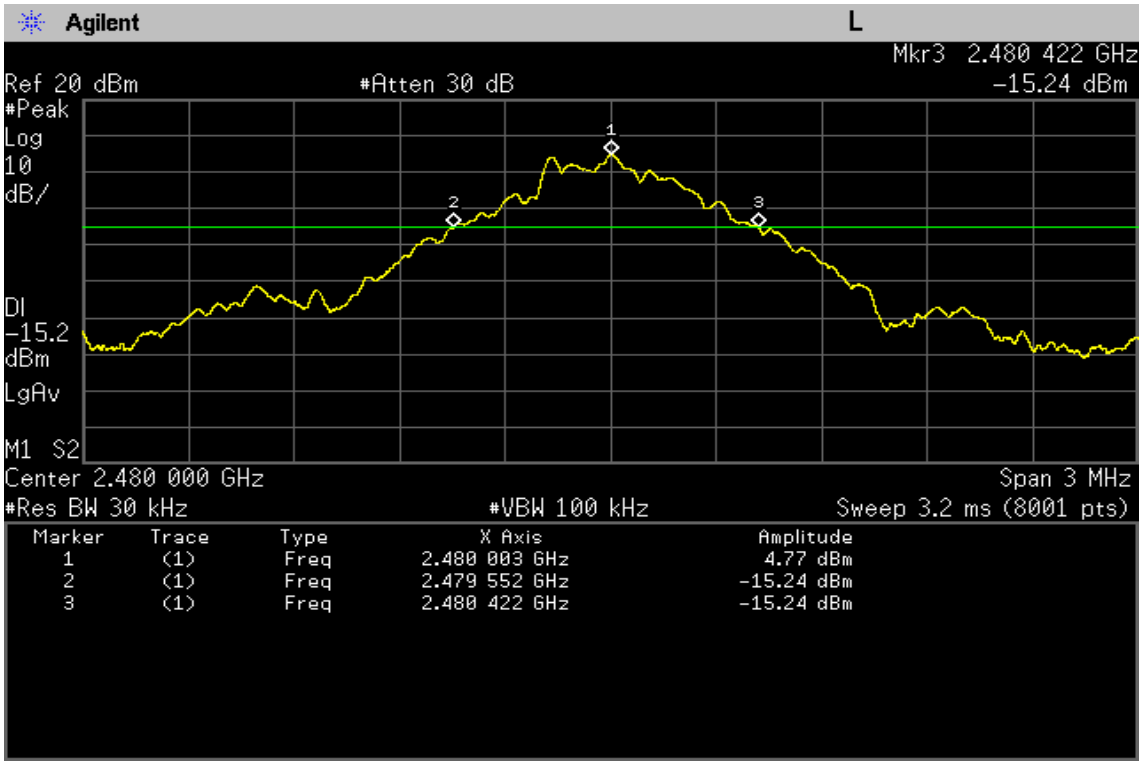


20 dB Bandwidth, GFSK modulation, Middle Channel (2441 MHz)

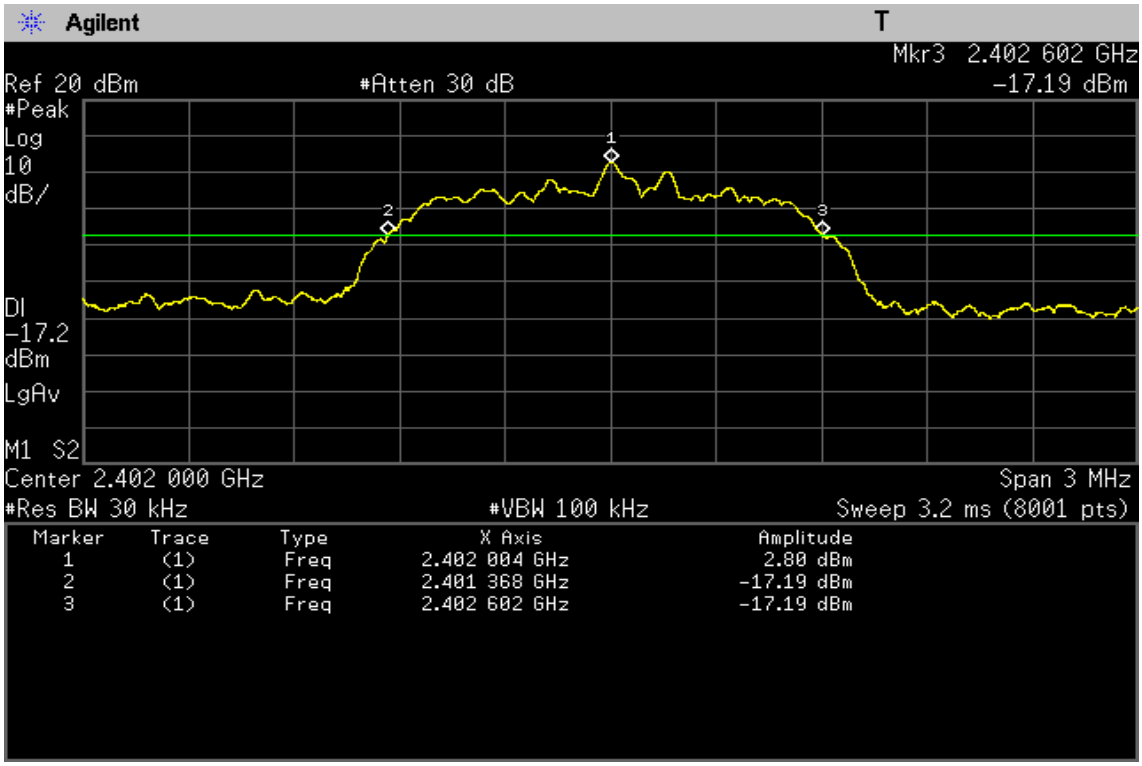


PLOTS OF EMISSIONS

20 dB Bandwidth, GFSK modulation, Highest Channel (2480 MHz)

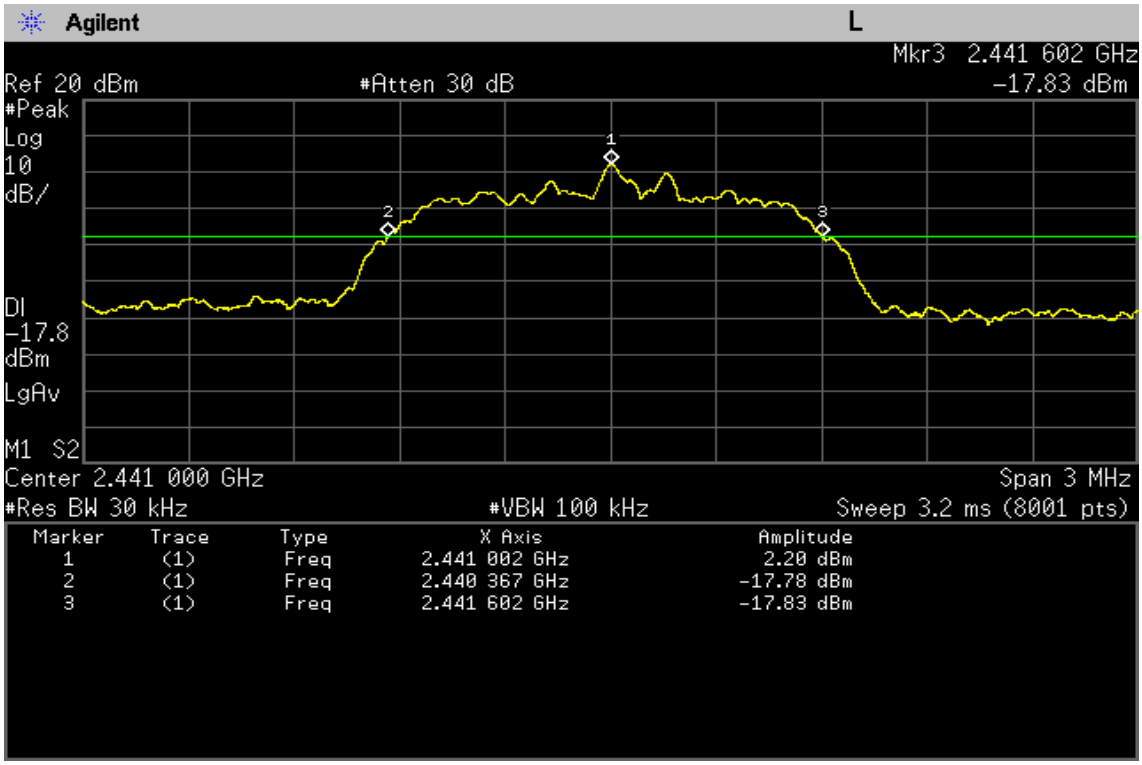


20 dB Bandwidth, π/4DQPSK modulation, Lowest Channel (2402 MHz)

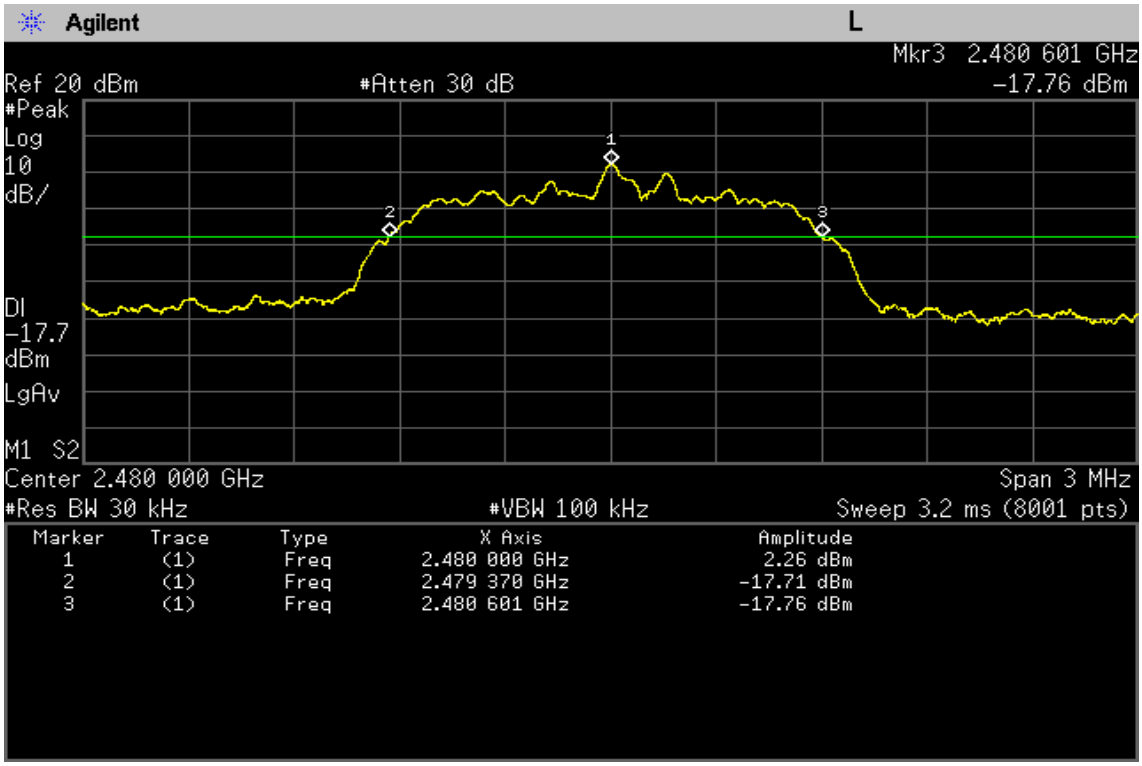


PLOTS OF EMISSIONS

20 dB Bandwidth, π/4DQPSK modulation, Middle Channel (2441 MHz)

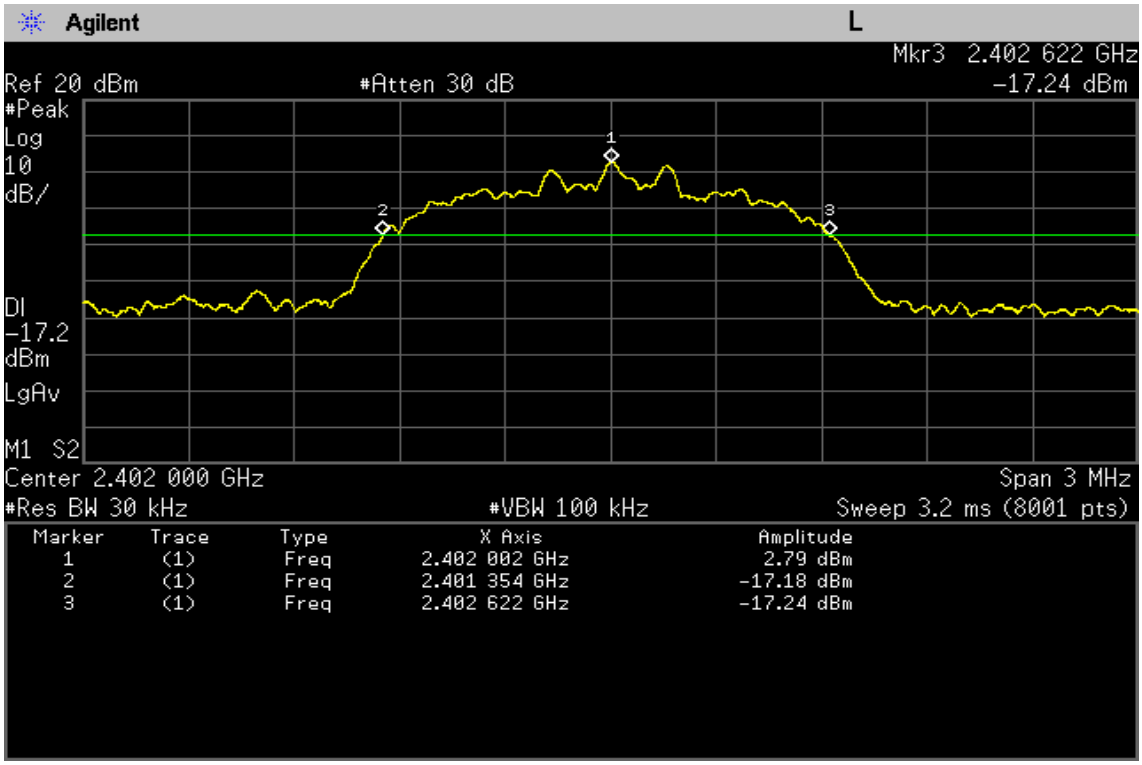


20 dB Bandwidth, π/4DQPSK modulation, Highest Channel (2480 MHz)

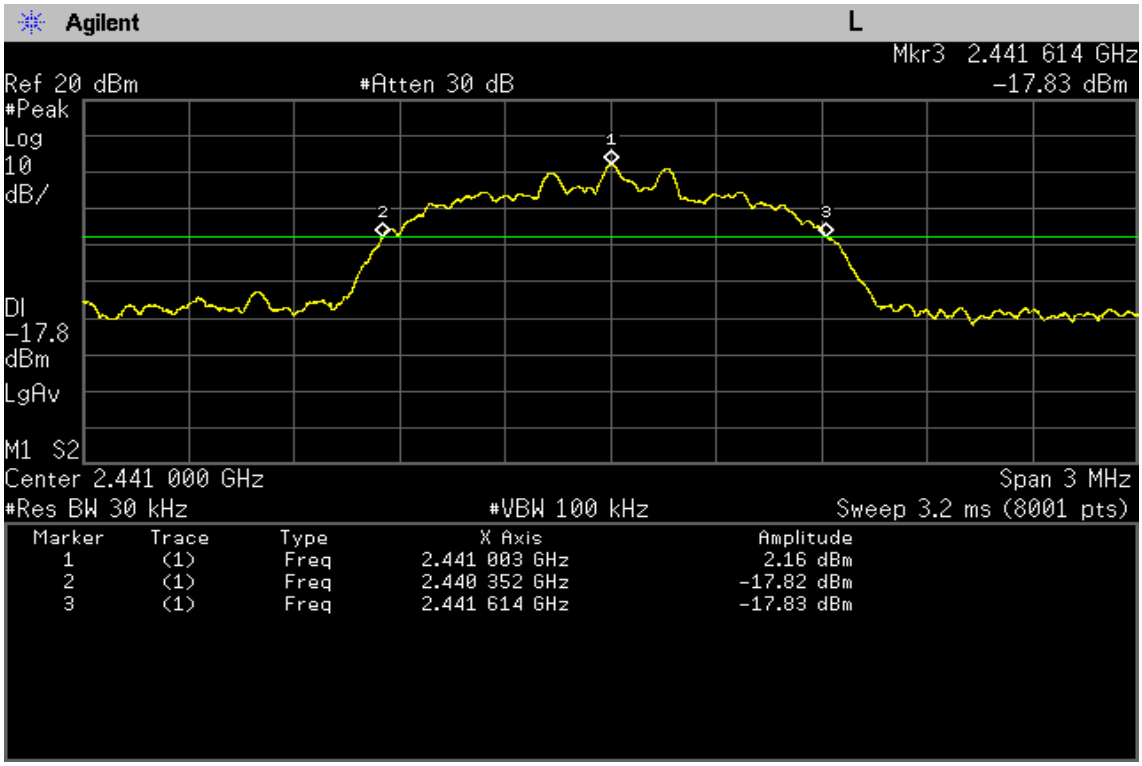


PLOTS OF EMISSIONS

20 dB Bandwidth, 8DPSK modulation, Lowest Channel (2402 MHz)

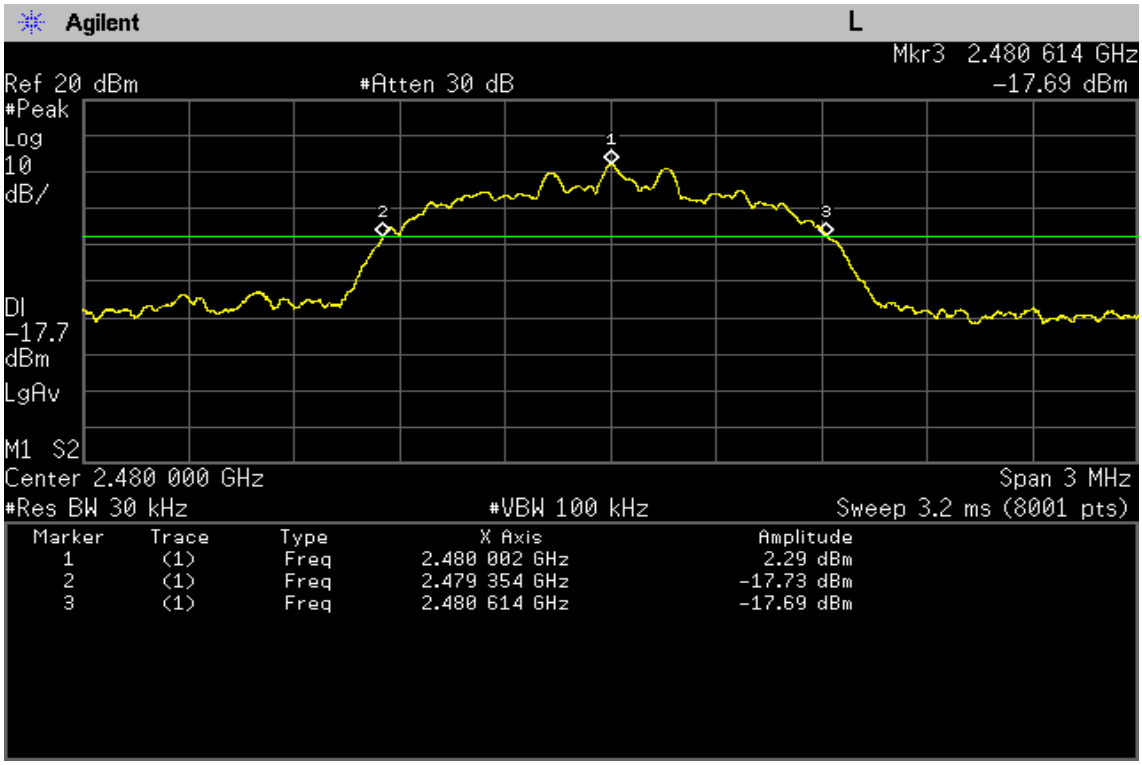


20 dB Bandwidth, 8DPSK modulation, Middle Channel (2441 MHz)



PLOTS OF EMISSIONS

20 dB Bandwidth, 8DPSK modulation, Highest Channel (2480 MHz)



8.4 Carrier Frequency Separation

FCC §15.247(a)(1), IC RSS-247 Issue 2, 5.1

Test Mode : Set to Hopping mode

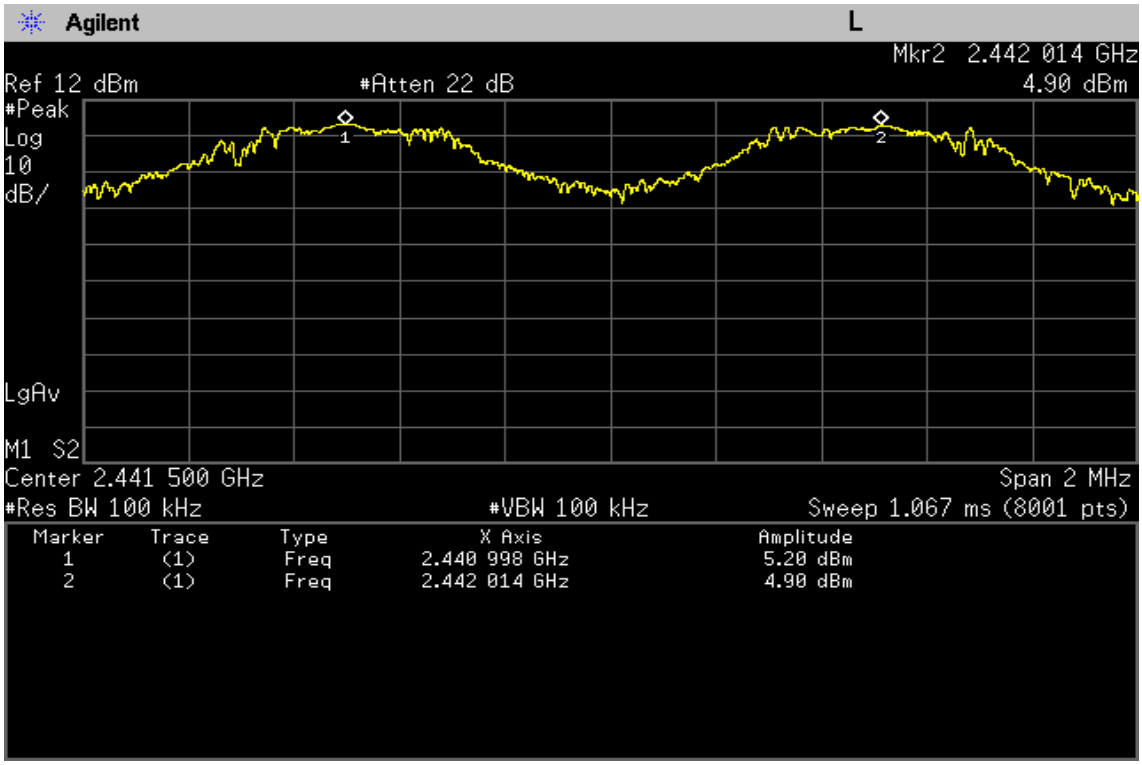
Result

Modulation	Carrier Frequency Separation (kHz)	Limit (2/3 of 20dB Bandwidth) (kHz)
GFSK	1.02	0.68
π/4DQPSK	1.01	0.67
8DPSK	0.98	0.66

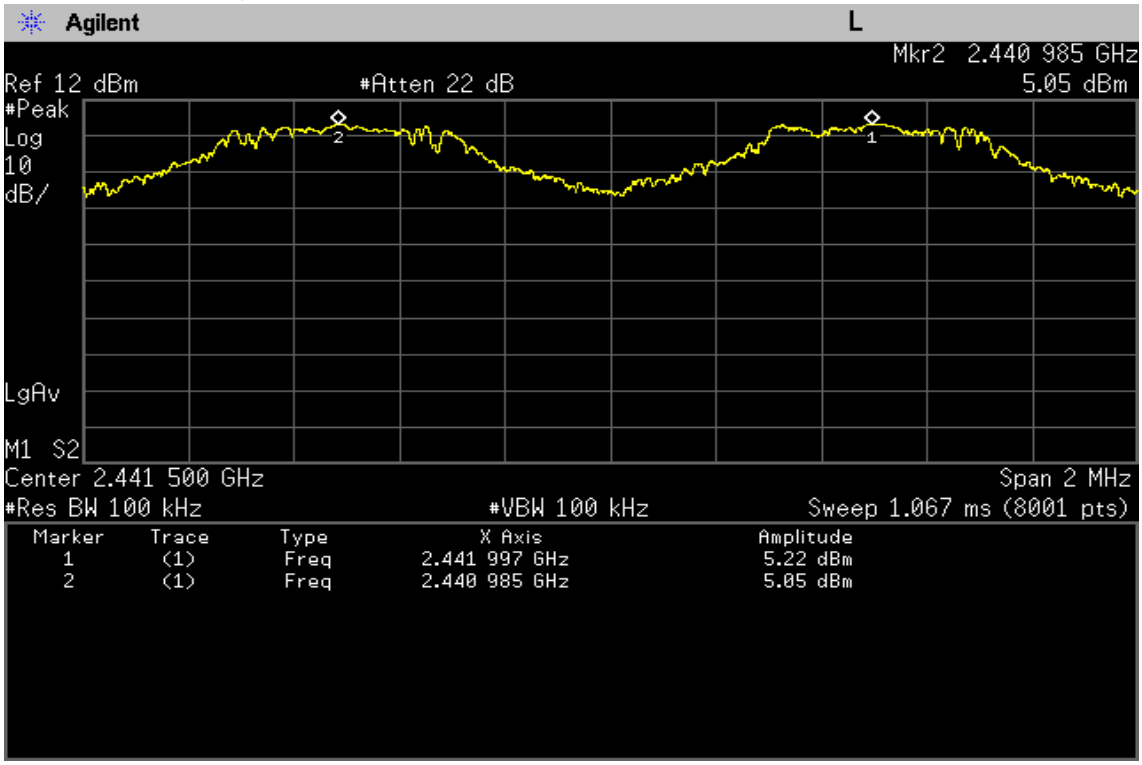
Note:
*The EUT complies with the minimum channel separation requirement when it is operating **1x/EDR mode using 79 channels** and when operating in **AFH mode using 20 channels**.*

PLOTS OF EMISSIONS

Carrier Frequency Separation, GFSK modulation

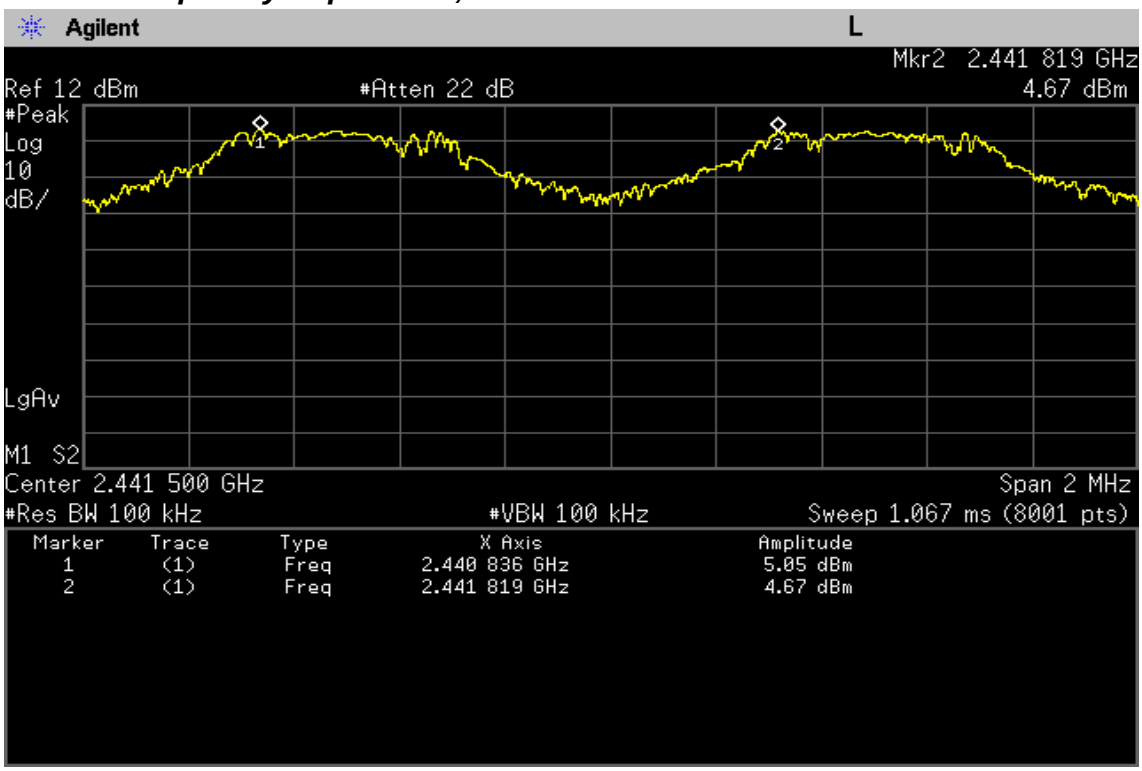


Carrier Frequency Separation, π/4DQPSK modulation



PLOTS OF EMISSIONS

Carrier Frequency Separation, 8DPSK modulation



8.5 Transmitter Average Time of Occupancy

FCC §15.247(a)(1), IC RSS-247 Issue 2, 5.1

Test mode : Set to Hopping mode

Result

Mode	Pulse width (ms)	*)Numbers of slots	**) Average time of Occupancy (ms)	Limit (ms)	Margin (ms)
1x/EDR	2.88	106.67	307.52	400	92.48
AFH	2.88	53.33	153.60	400	246.40

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 1600 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 = (1600 / 6) / 79 x 31.6
5) **) Average time of Occupancy = 2.88 ms x 106.67 = 307.52 ms

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
5) **) Average time of Occupancy = 2.88 ms x 53.33 = 153.60 ms

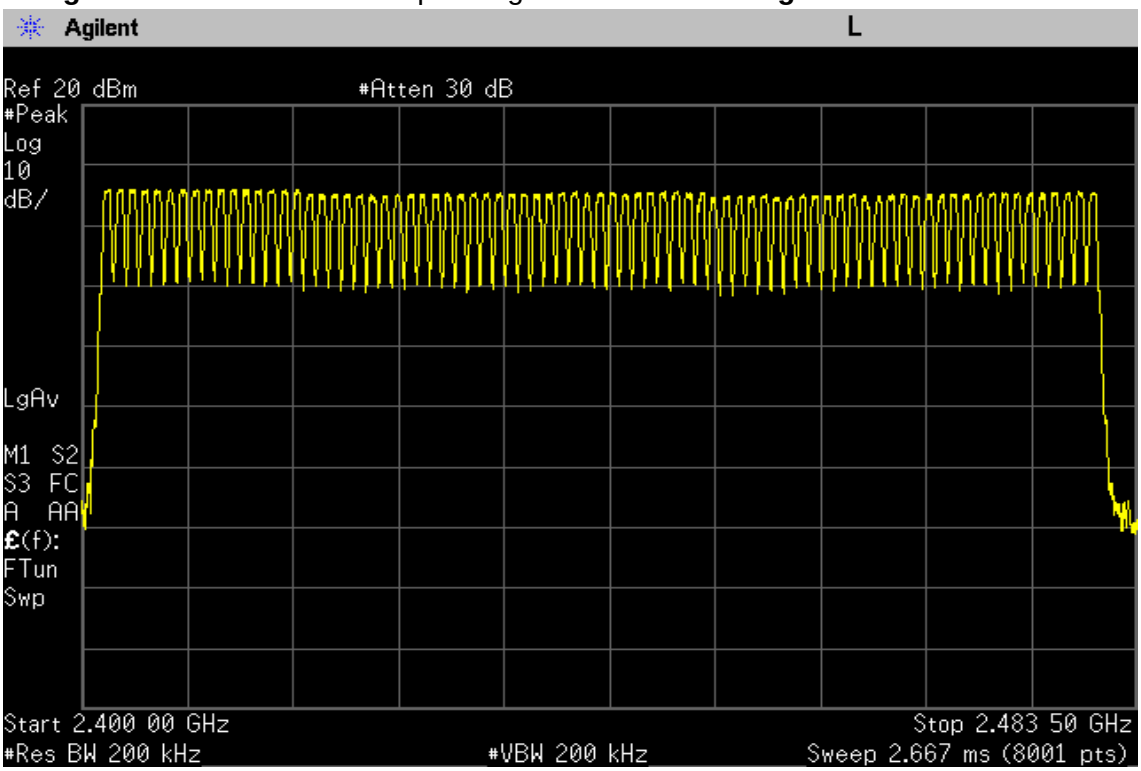
8.6 Number of Hopping Channels

FCC §15.247(a)(1)(iii), IC RSS-247 Issue 2, 5.1

Test mode : Set to Hopping mode

Result

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



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

FCC §15.247(b)(3), IC RSS-247 Issue 2 5.4

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

Result

Modulation	Channel	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)	E.I.R.P (dBm)	E.I.R.P Limit (dBm)
GFSK	Lowest	2402	5.93	30.00	7.76	36.00
GFSK	Middle	2441	5.47	30.00	7.30	36.00
GFSK	Highest	2480	5.61	30.00	7.44	36.00
π/4DQPSK	Lowest	2402	4.48	30.00	6.31	36.00
π/4DQPSK	Middle	2441	3.90	30.00	5.73	36.00
π/4DQPSK	Highest	2480	3.97	30.00	5.80	36.00
8DPSK	Lowest	2402	4.84	30.00	6.67	36.00
8DPSK	Middle	2441	4.27	30.00	6.10	36.00
8DPSK	Highest	2480	4.38	30.00	6.21	36.00

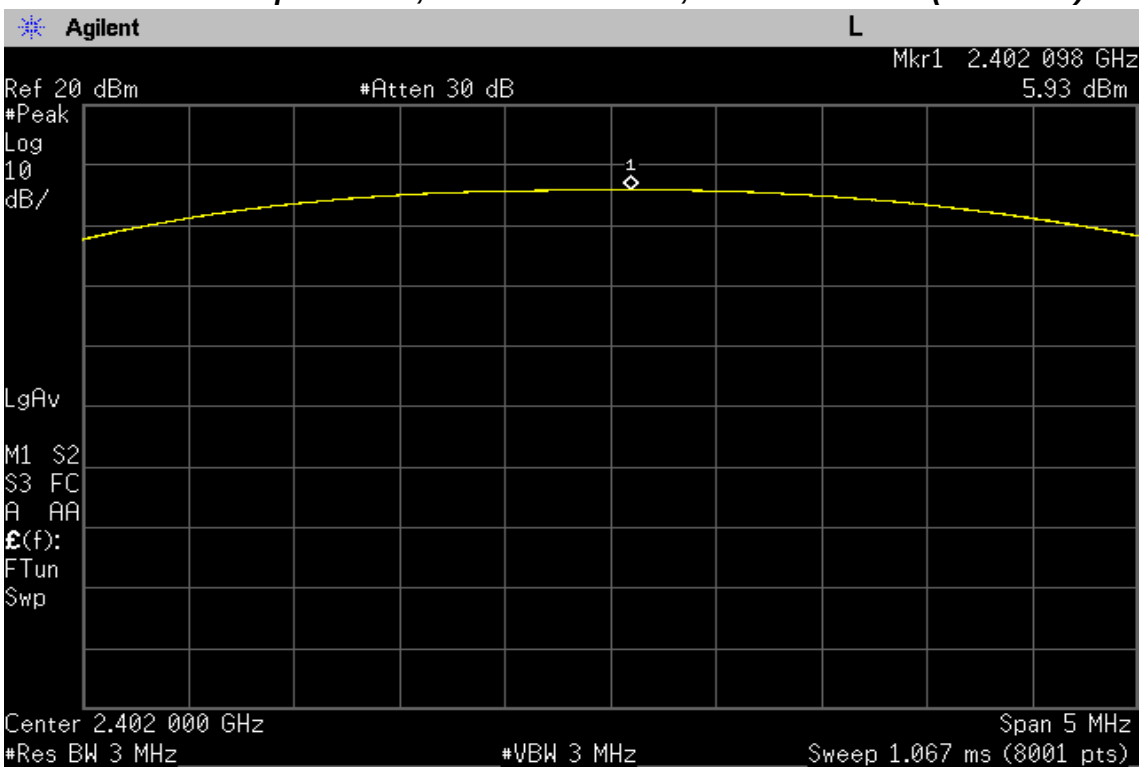
TEST DATA

Note:

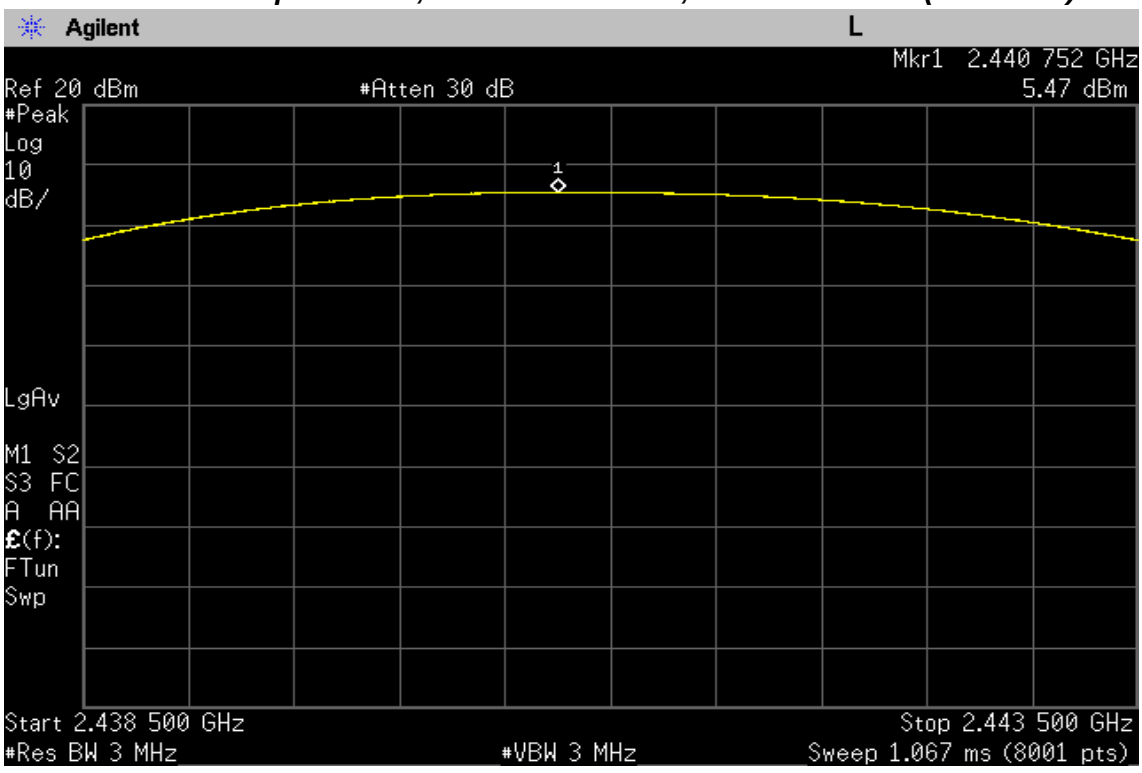
1. *E.I.R.P was calculated by following equation according to KDB412172 D01 Determining ERP and EIRP v01r01.*
   E.I.R.P = P_T + G_T – Lc
   P_T = Peak output power (dBm)
   *G_T = Gain of the transmitting antenna in dBi, Directional antenna gain is **1.83 dBi.***
   L_C = Signal attenuation in the connecting cable between the transmitter and antenna in dB. This factor of an integral antenna is negligible.
2. *The following equation was used for spectrum offset:*
   Spectrum offset (dB) = Attenuator (dB) + Cable Loss (dB) + SMA Type Connector Loss (dB)

PLOTS OF EMISSIONS

Maximum Peak Output Power, GFSK modulation, Lowest Channel (2402 MHz)

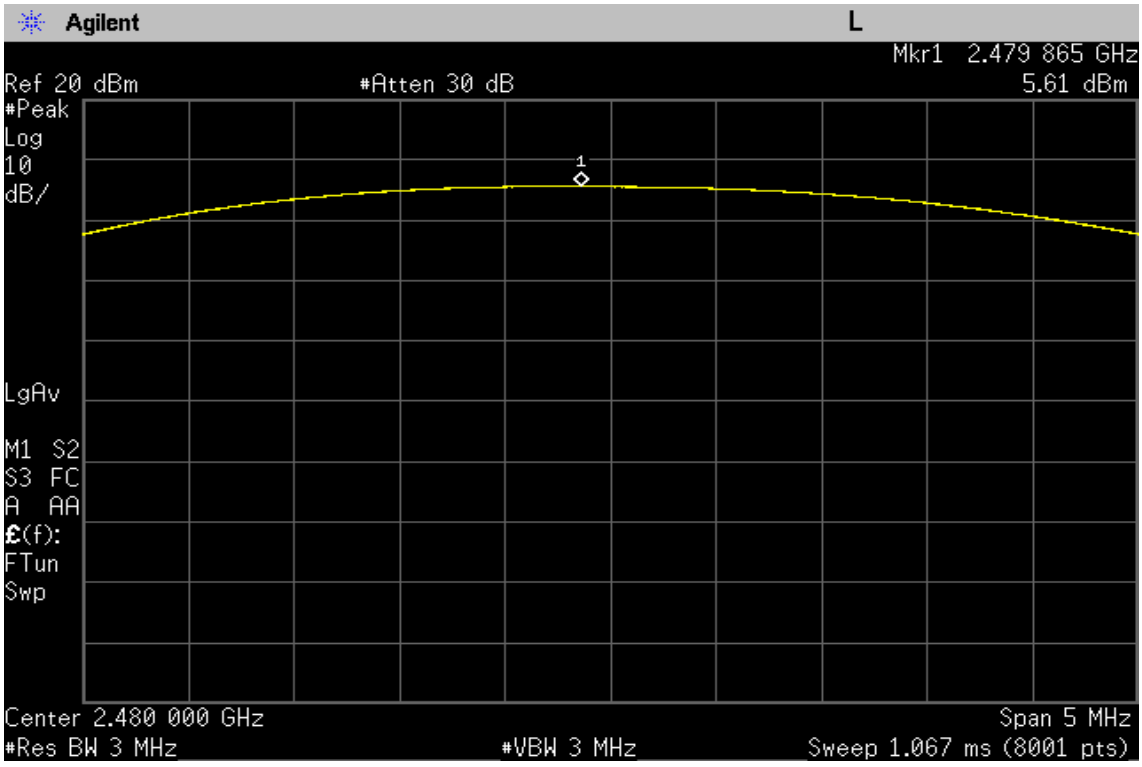


Maximum Peak Output Power, GFSK modulation, Middle Channel (2441 MHz)

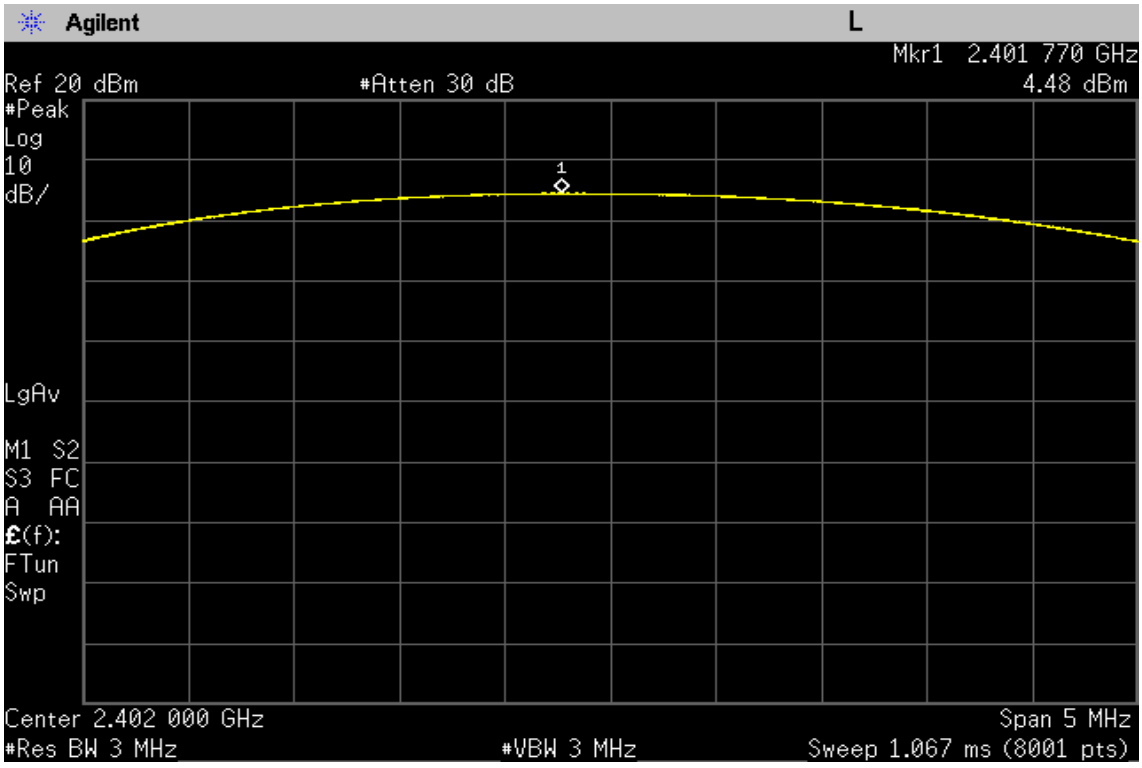


PLOTS OF EMISSIONS

Maximum Peak Output Power, GFSK modulation, Highest Channel (2480 MHz)

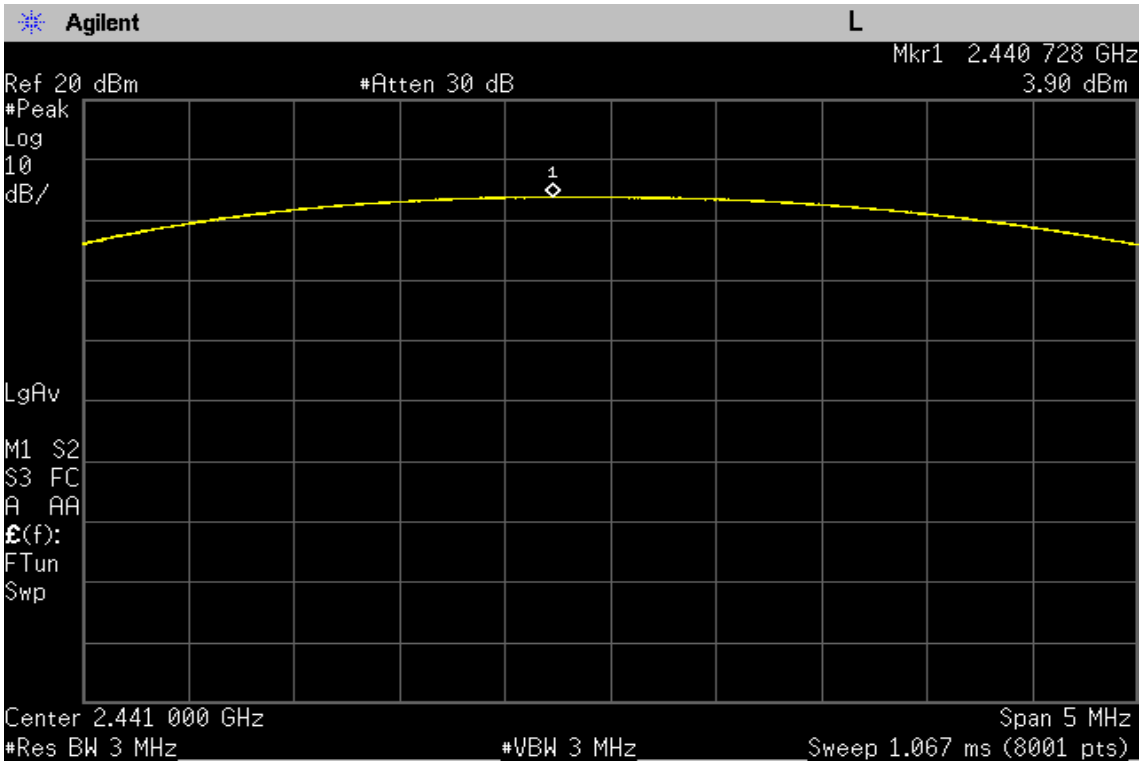


Maximum Peak Output Power, π/4DQPSK modulation, Highest Channel (2402 MHz)

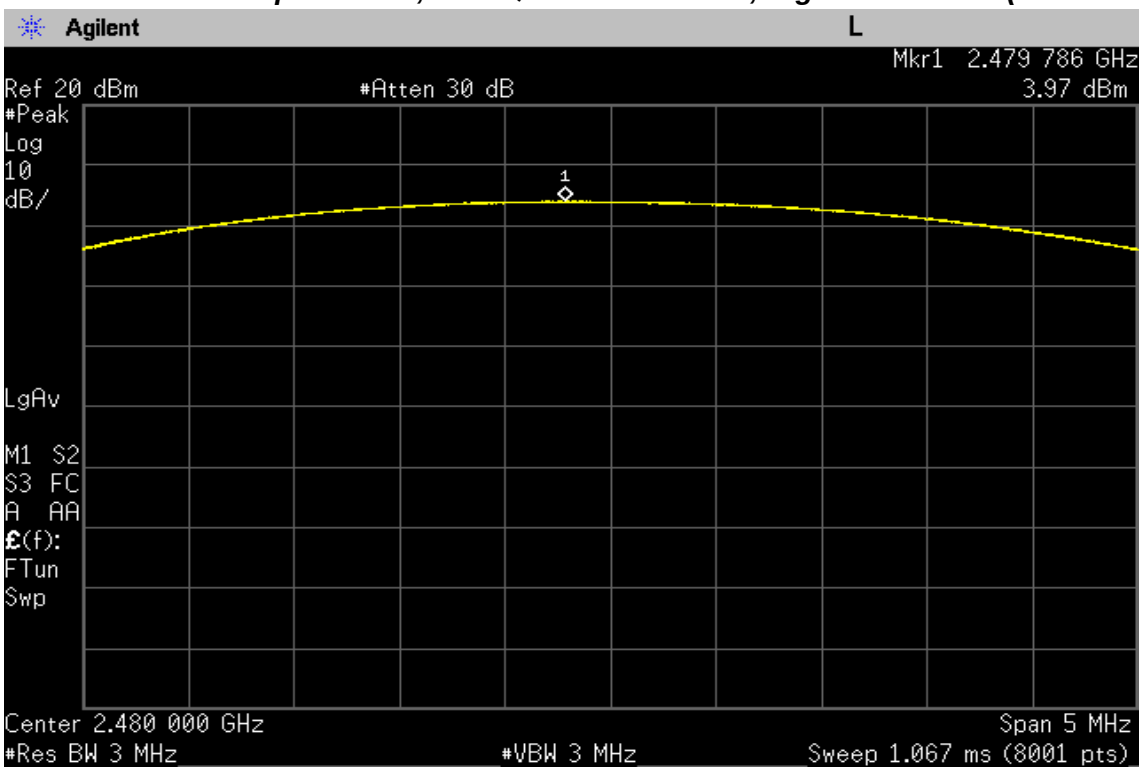


PLOTS OF EMISSIONS

Maximum Peak Output Power, π/4DQPSK modulation, Highest Channel (2441 MHz)

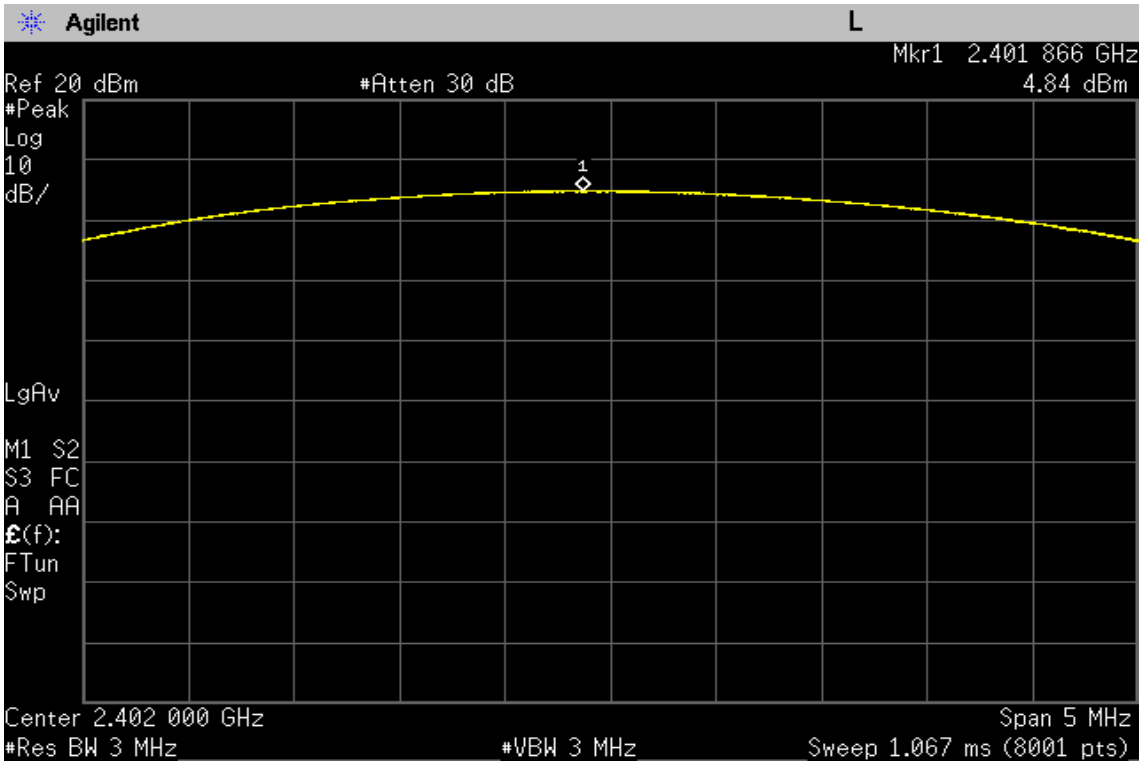


Maximum Peak Output Power, π/4DQPSK modulation, Highest Channel (2480 MHz)

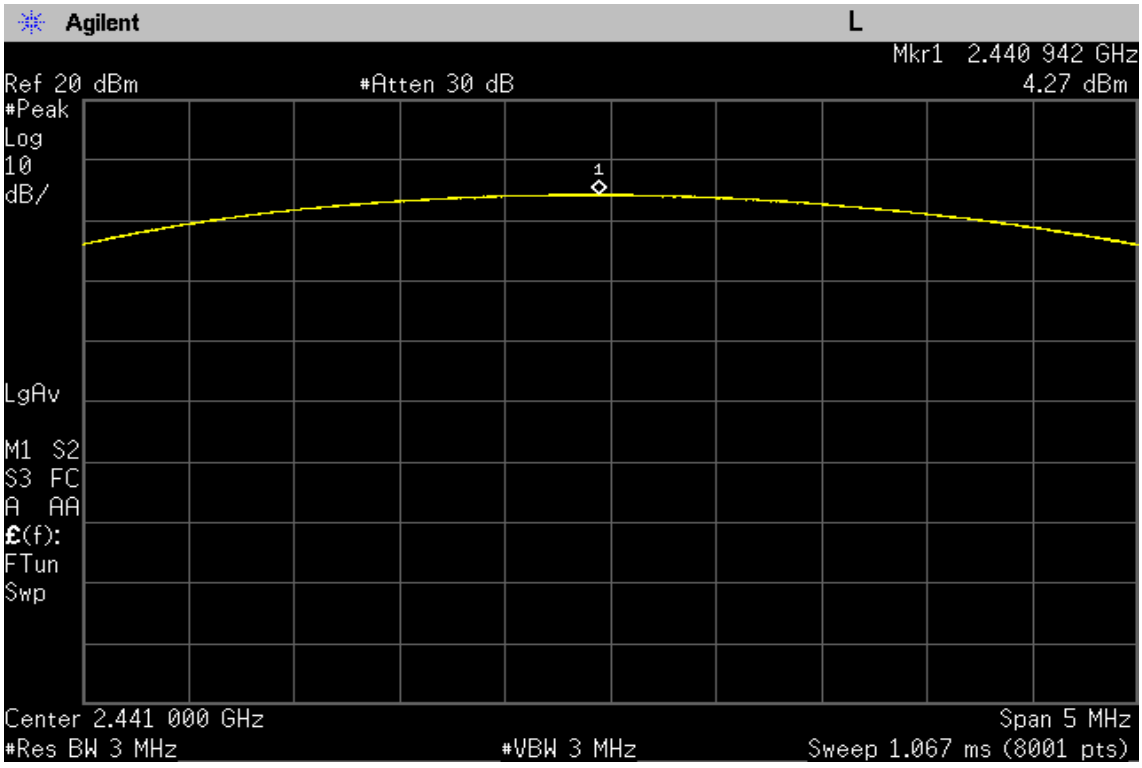


PLOTS OF EMISSIONS

Maximum Peak Output Power, 8DPSK modulation, Highest Channel (2402 MHz)

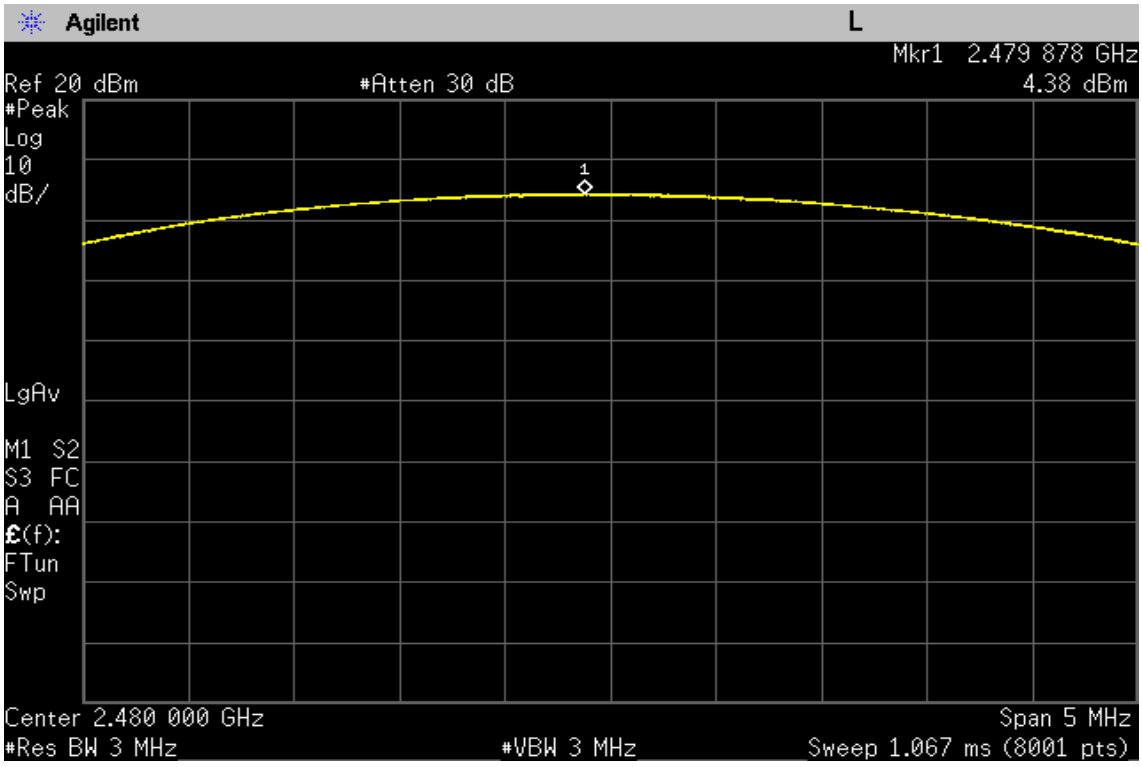


Maximum Peak Output Power, 8DPSK modulation, Highest Channel (2441 MHz)



PLOTS OF EMISSIONS

Maximum Peak Output Power, 8DPSK modulation, Highest Channel (2480 MHz)



8.8 Conducted Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 2 5.5

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

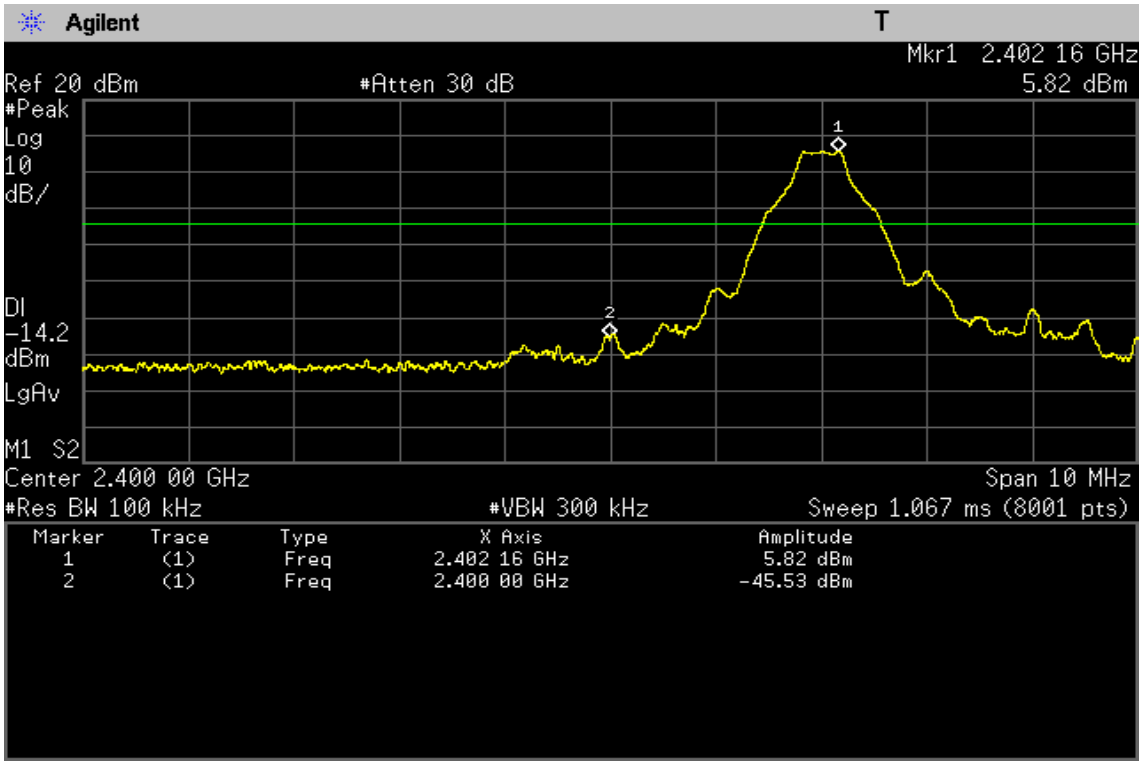
Result

Modulation	Channel	Frequency (MHz)	Conducted Spurious Emissions (dBc)	Limit (dBc)
GFSK	Lowest	2402	More than 20 dBc	20
GFSK	Middle	2441	More than 20 dBc	20
GFSK	Highest	2480	More than 20 dBc	20
π/4DQPSK	Lowest	2402	More than 20 dBc	20
π/4DQPSK	Middle	2441	More than 20 dBc	20
π/4DQPSK	Highest	2480	More than 20 dBc	20
8DPSK	Lowest	2402	More than 20 dBc	20
8DPSK	Middle	2441	More than 20 dBc	20
8DPSK	Highest	2480	More than 20 dBc	20

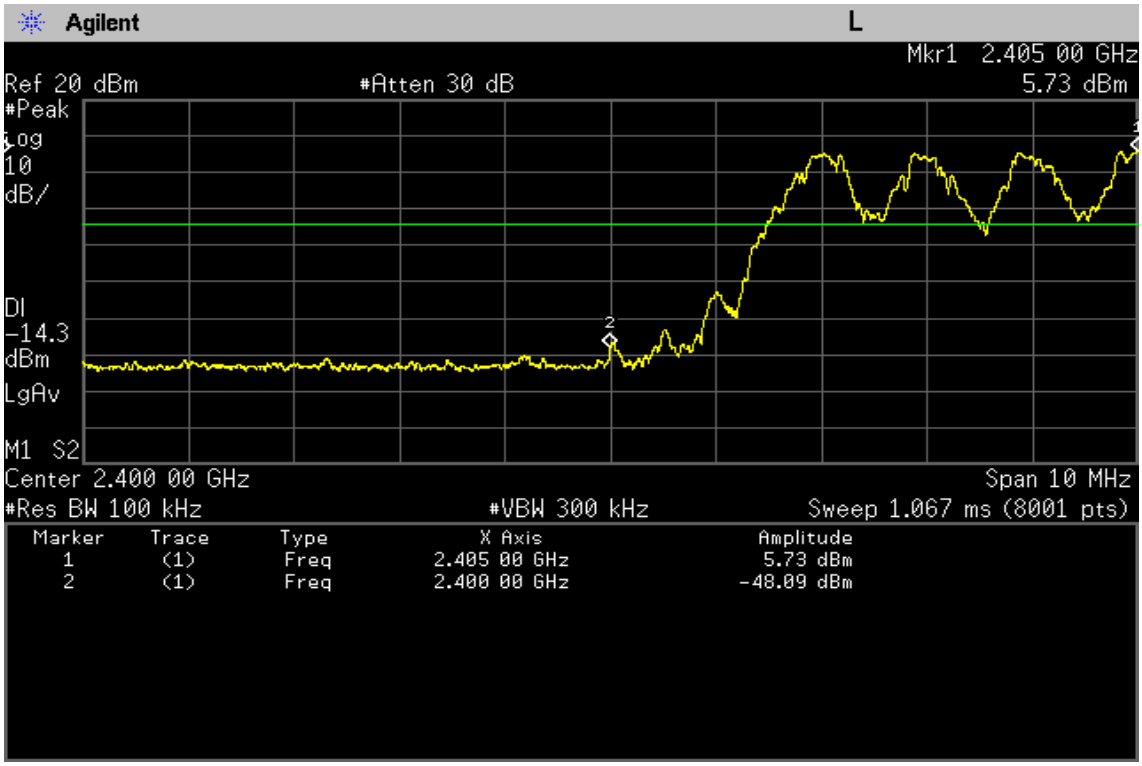
Notes:
The cable and attenuator loss from 30 MHz to 26.5 GHz was reflected in spectrum analyzer with correction factor for the spurious emissions test.

PLOTS OF EMISSIONS

Band Edge, Single channel mode, GFSK modulation, Lowest Channel (2402 MHz)

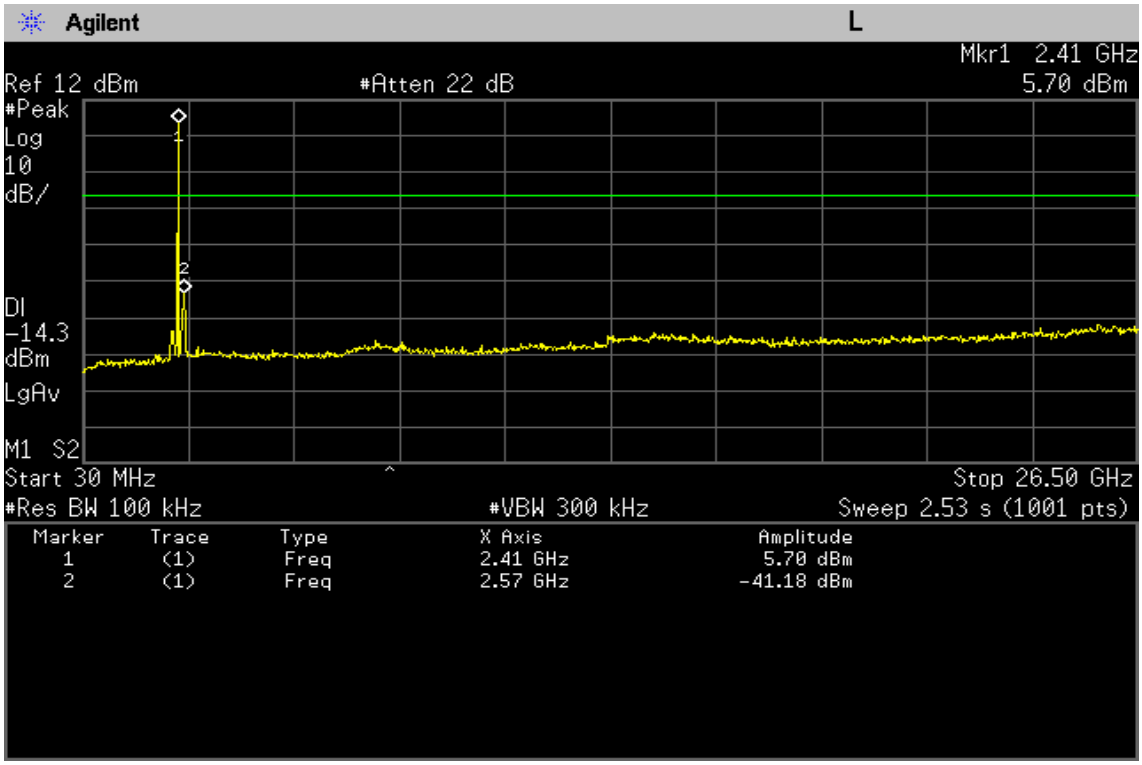


Band Edge, Hopping mode, GFSK modulation, Lowest Channel (2402 MHz)

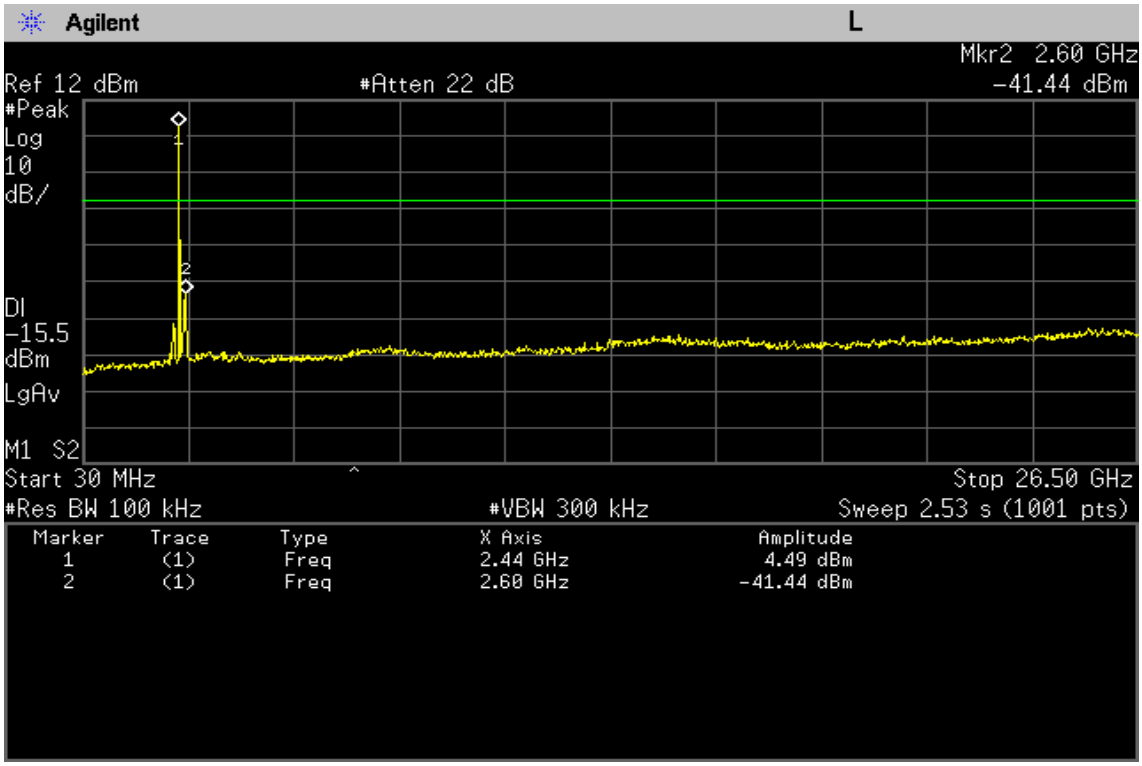


PLOTS OF EMISSIONS

Conducted Spurious Emissions, GFSK modulation, Lowest channel (2402MHz)

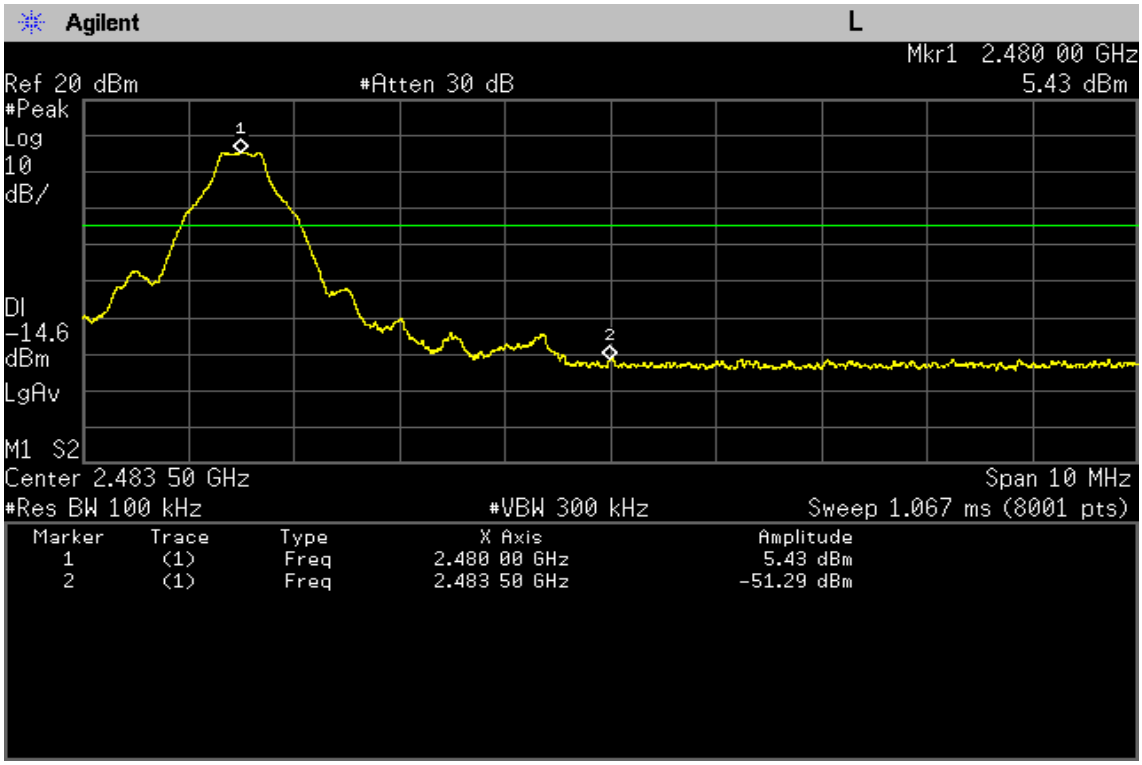


Conducted Spurious Emissions, GFSK modulation, Middle channel (2441MHz)

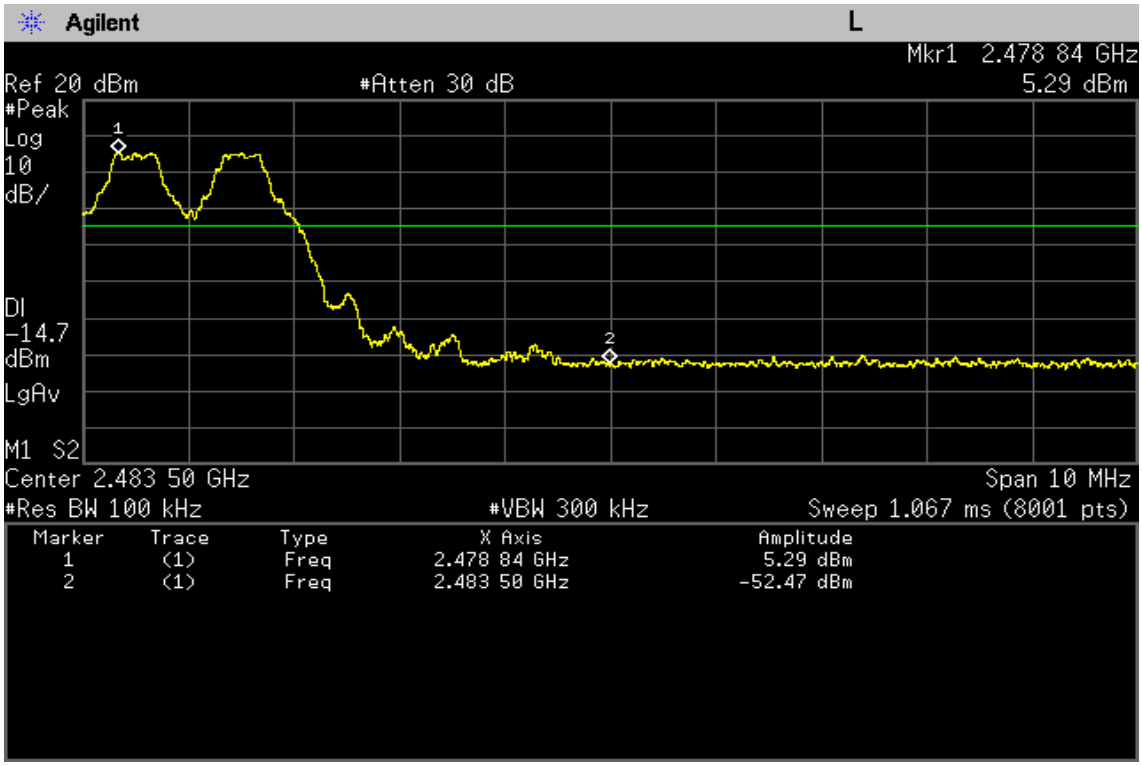


PLOTS OF EMISSIONS

Band Edge, Single channel mode, GFSK modulation, Highest Channel (2480 MHz)

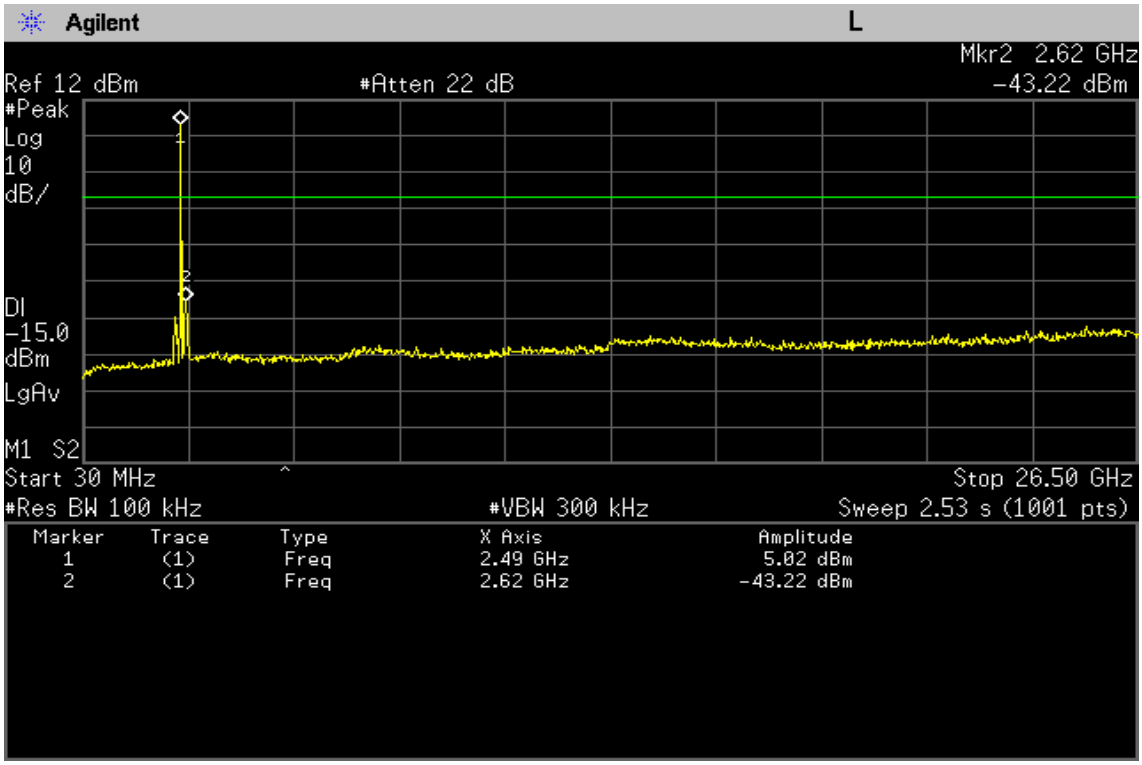


Band Edge, Hopping mode, GFSK modulation, Highest Channel (2480 MHz)

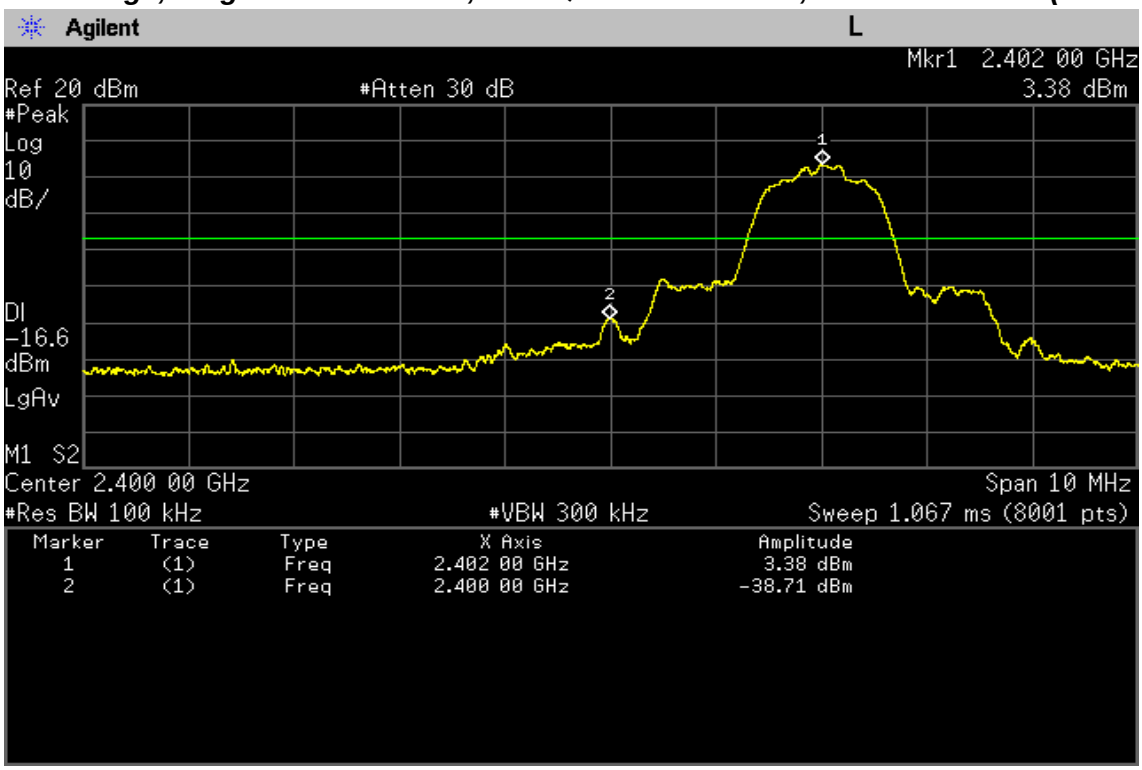


PLOTS OF EMISSIONS

Conducted Spurious Emissions, GFSK modulation, Highest channel (2480MHz)

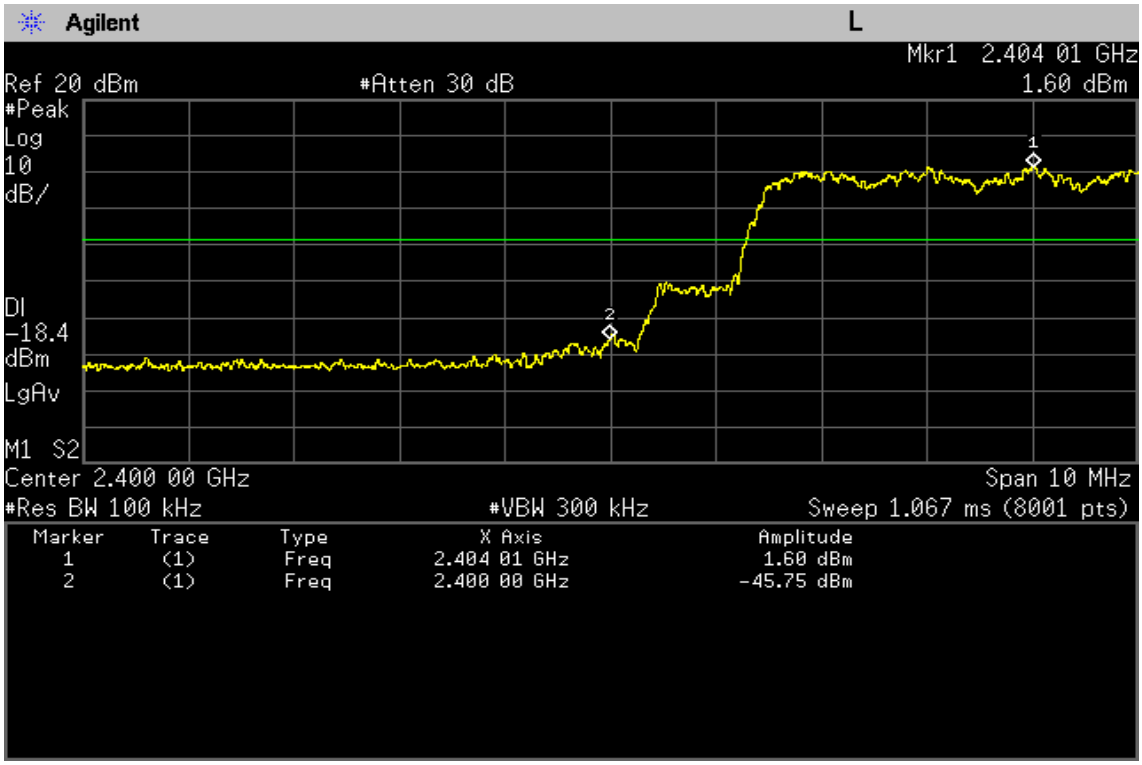


Band Edge, Single channel mode, π/4DQPSK modulation, Lowest Channel (2402 MHz)

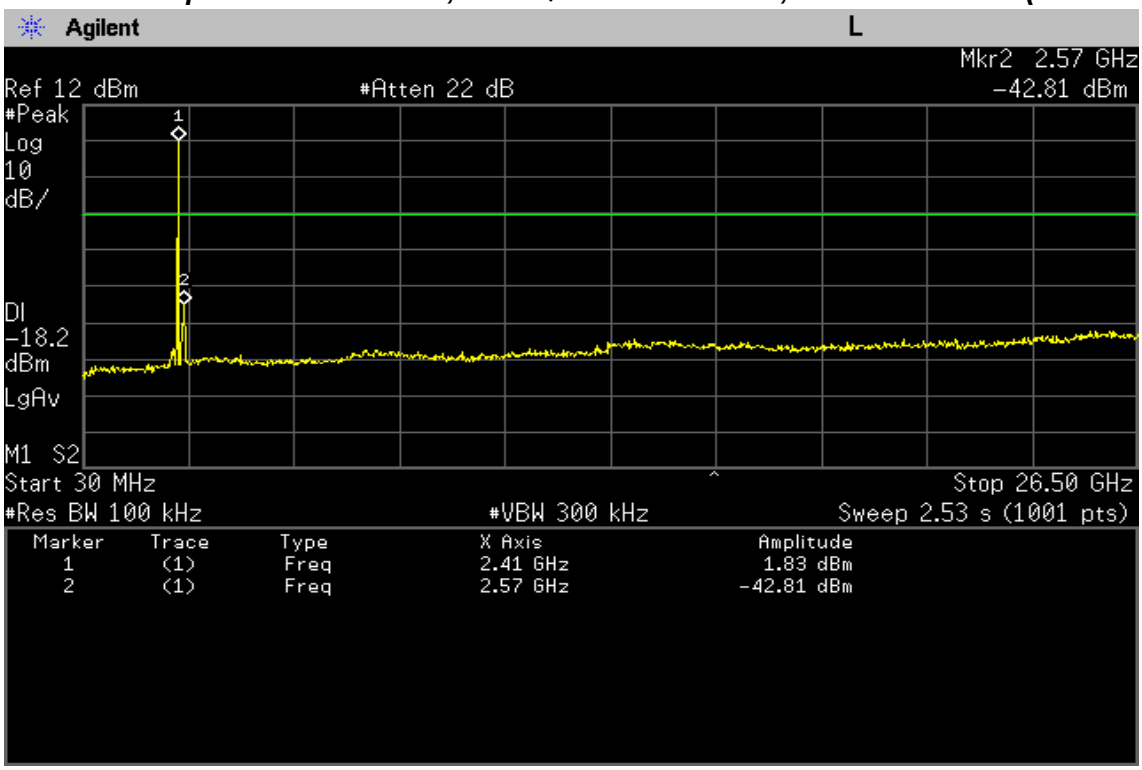


PLOTS OF EMISSIONS

Band Edge, Hopping mode, π/4DQPSK modulation, Lowest Channel (2402 MHz)

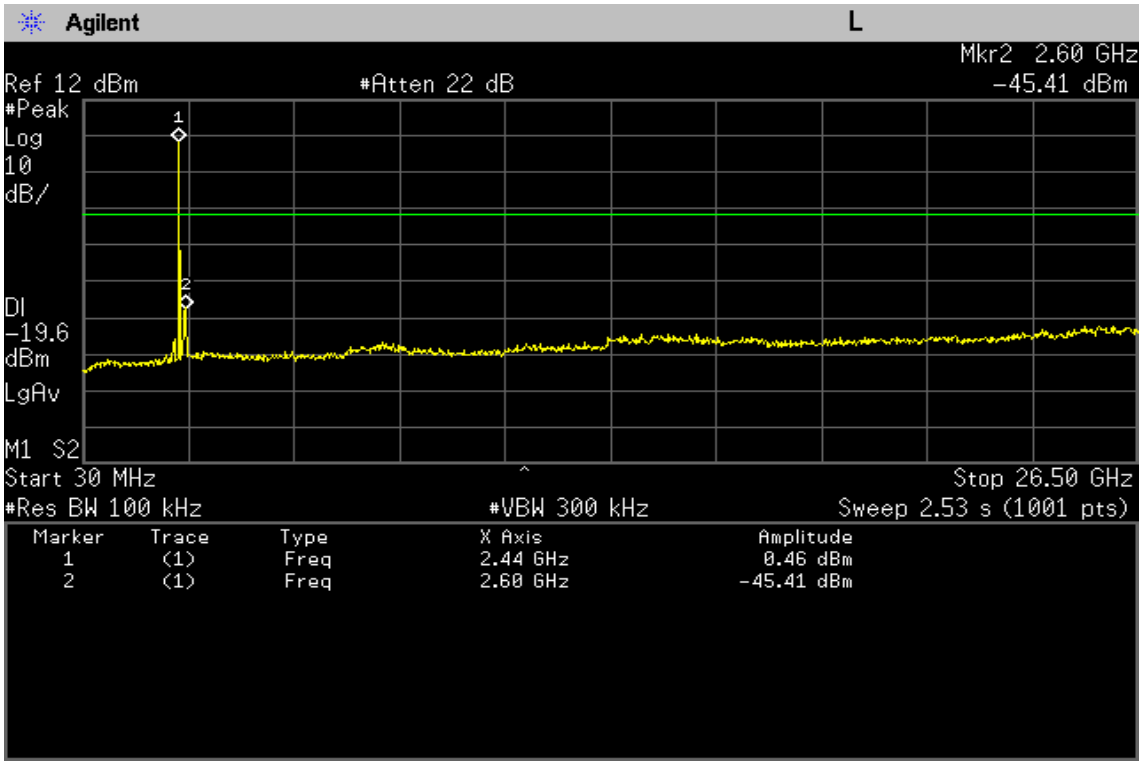


Conducted Spurious Emissions, π/4DQPSK modulation, Lowest channel (2402MHz)

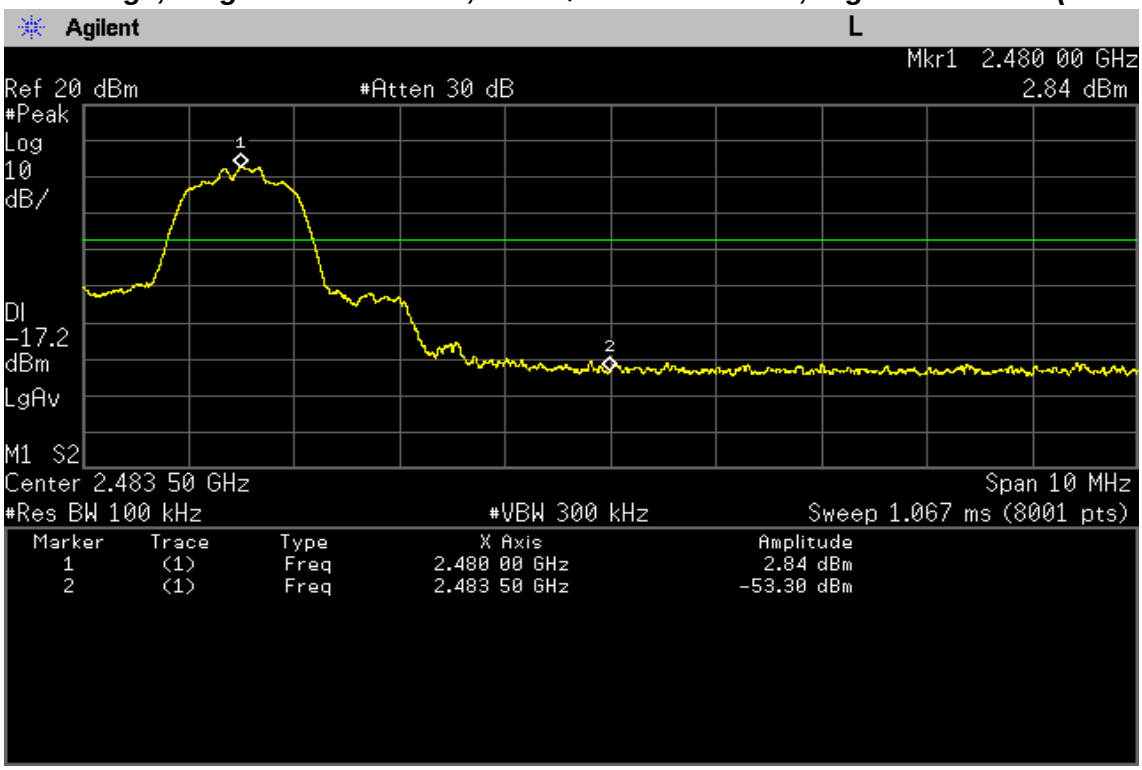


PLOTS OF EMISSIONS

Conducted Spurious Emissions, π/4DQPSK modulation, Middle channel (2441MHz)

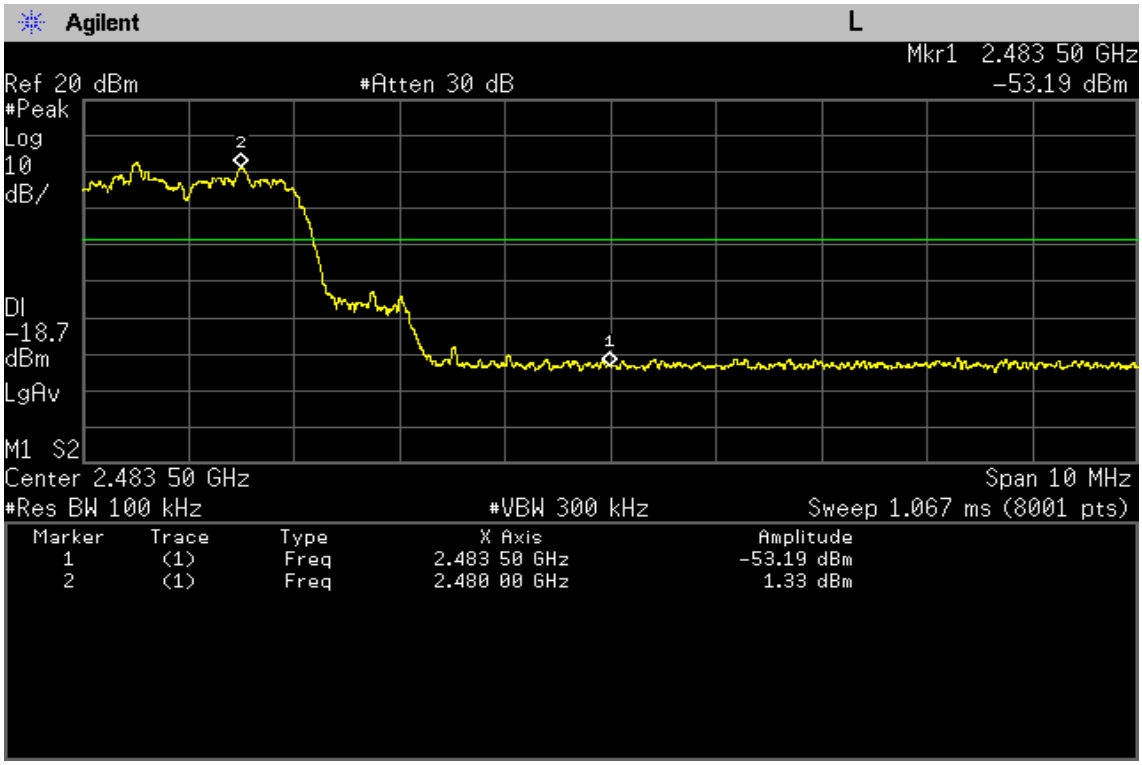


Band Edge, Single channel mode, π/4DQPSK modulation, Highest Channel (2480 MHz)

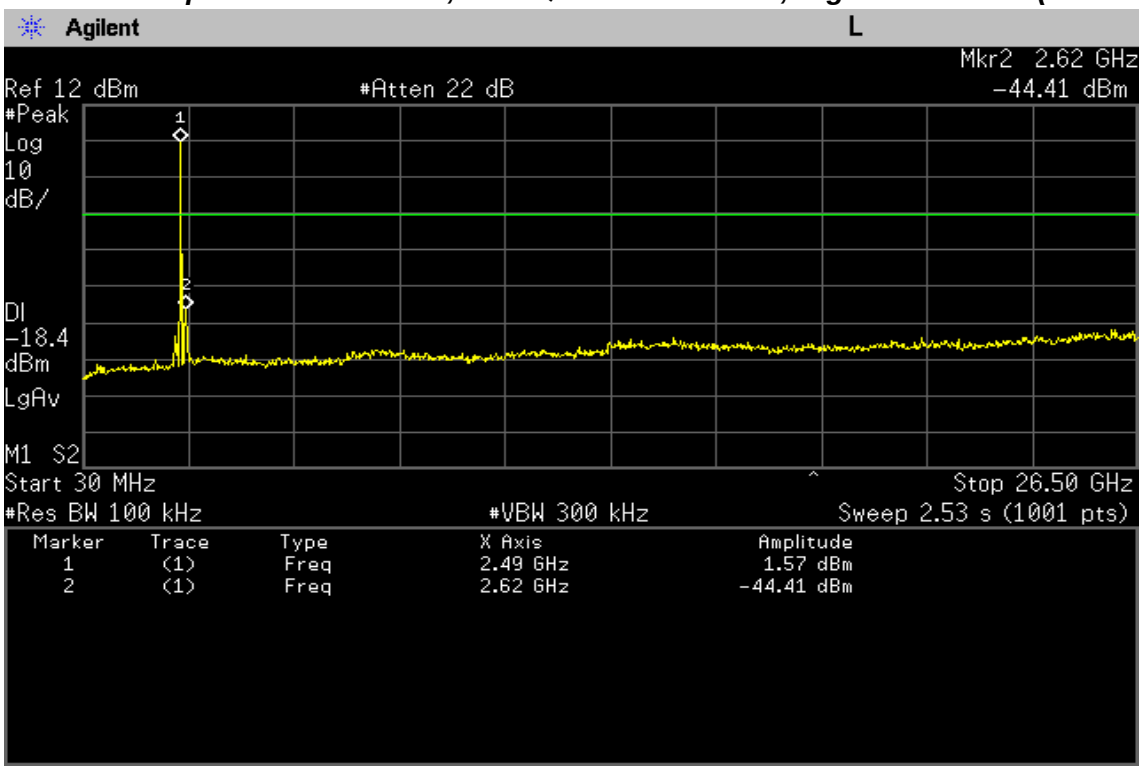


PLOTS OF EMISSIONS

Band Edge, Hopping mode, π/4DQPSK modulation, Highest Channel (2480 MHz)

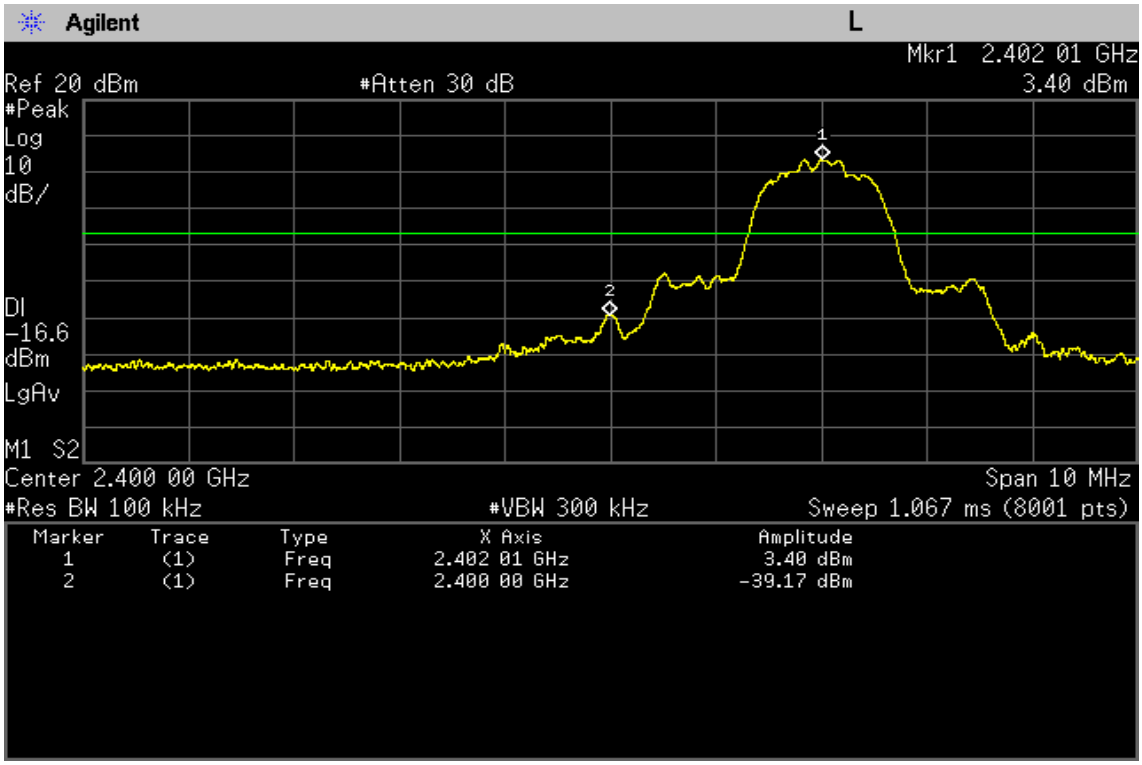


Conducted Spurious Emissions, π/4DQPSK modulation, Highest Channel (2480 MHz)

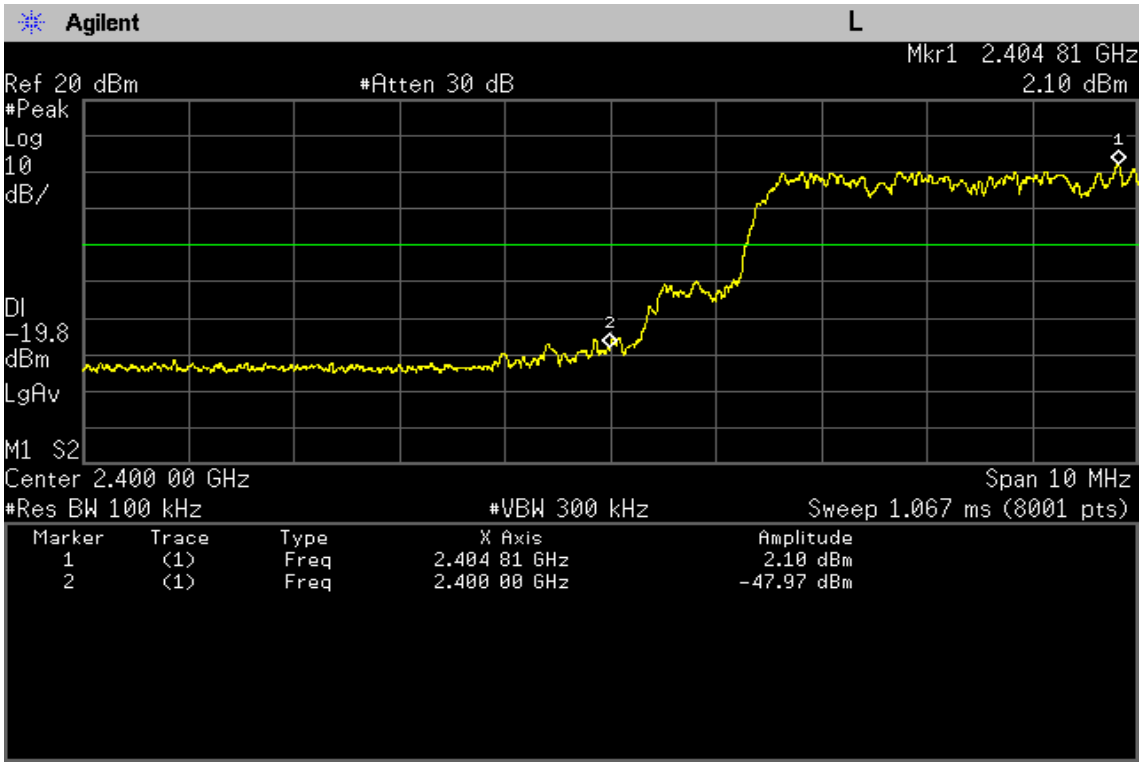


PLOTS OF EMISSIONS

Band Edge, Single channel mode, 8DPSK modulation, Lowest Channel (2402 MHz)

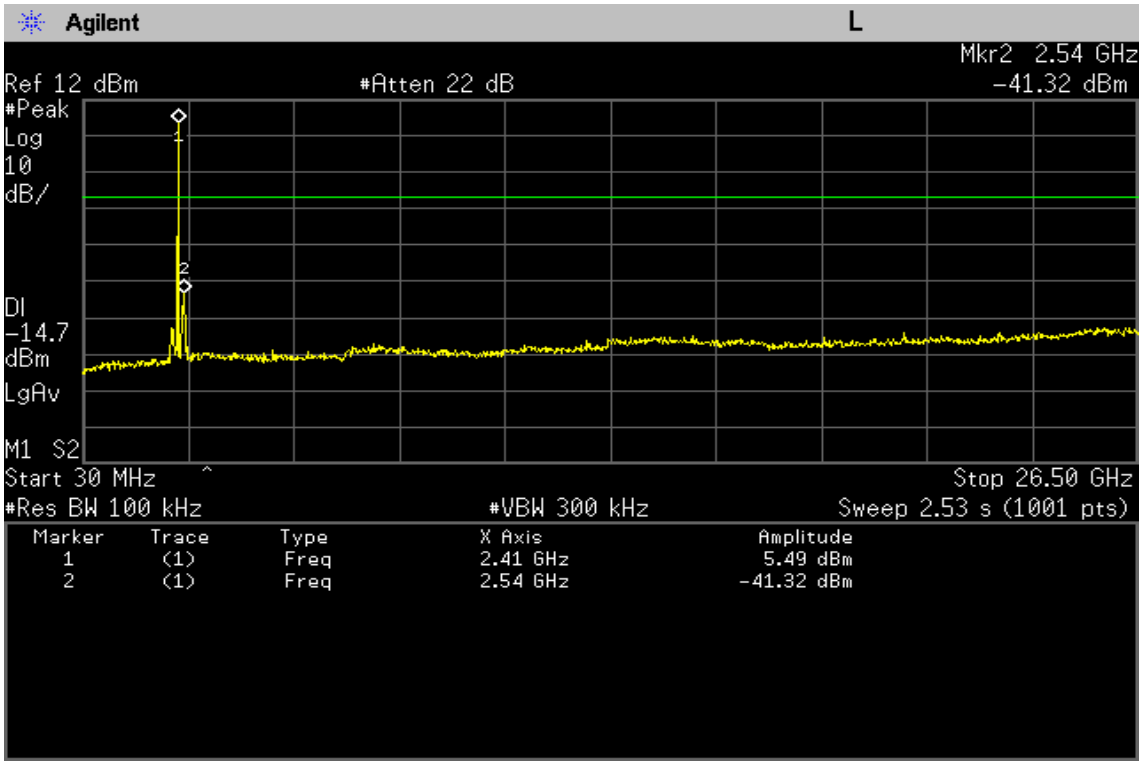


Band Edge, Hopping mode, 8DPSK modulation, Lowest Channel (2402 MHz)

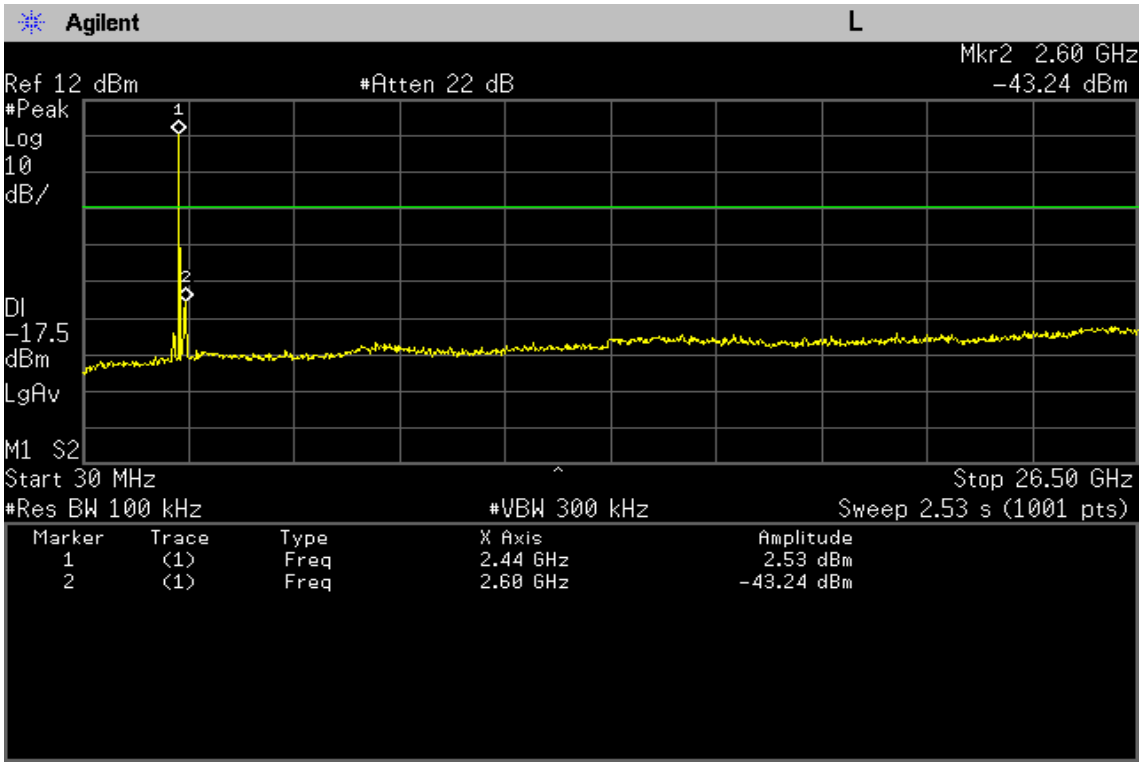


PLOTS OF EMISSIONS

Conducted Spurious Emissions, 8DPSK modulation, Lowest channel (2402MHz)

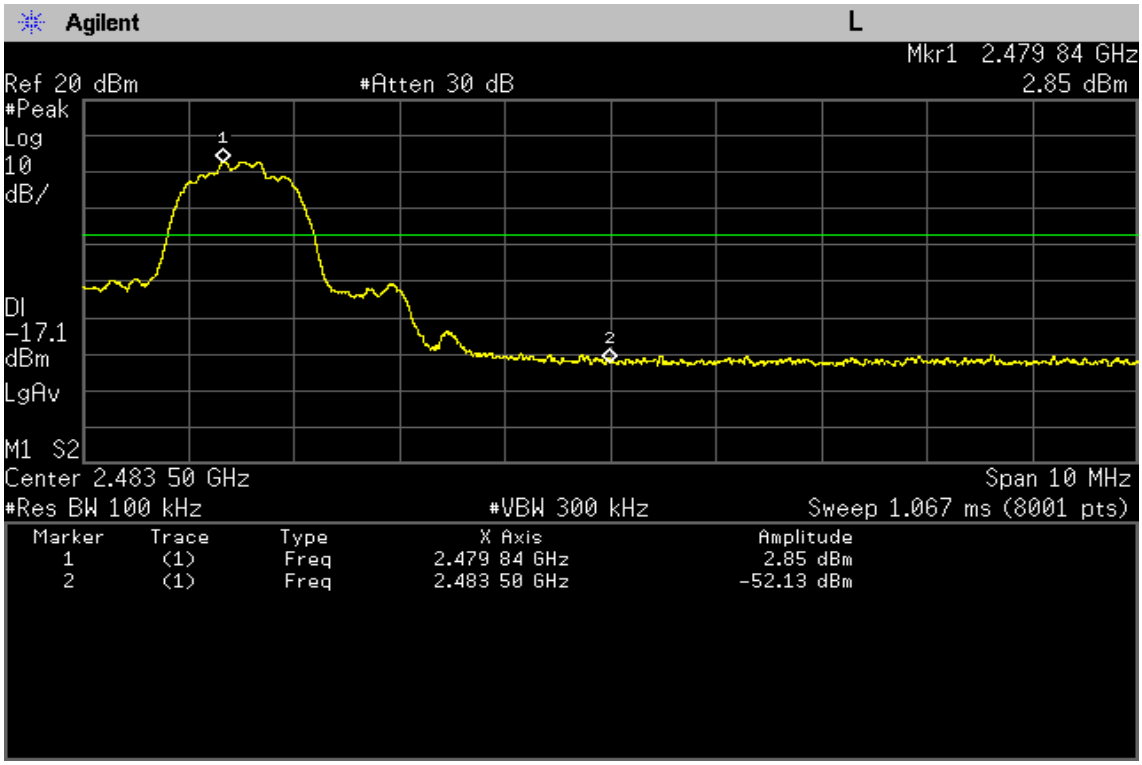


Conducted Spurious Emissions, 8DPSK modulation, Middle channel (2441MHz)

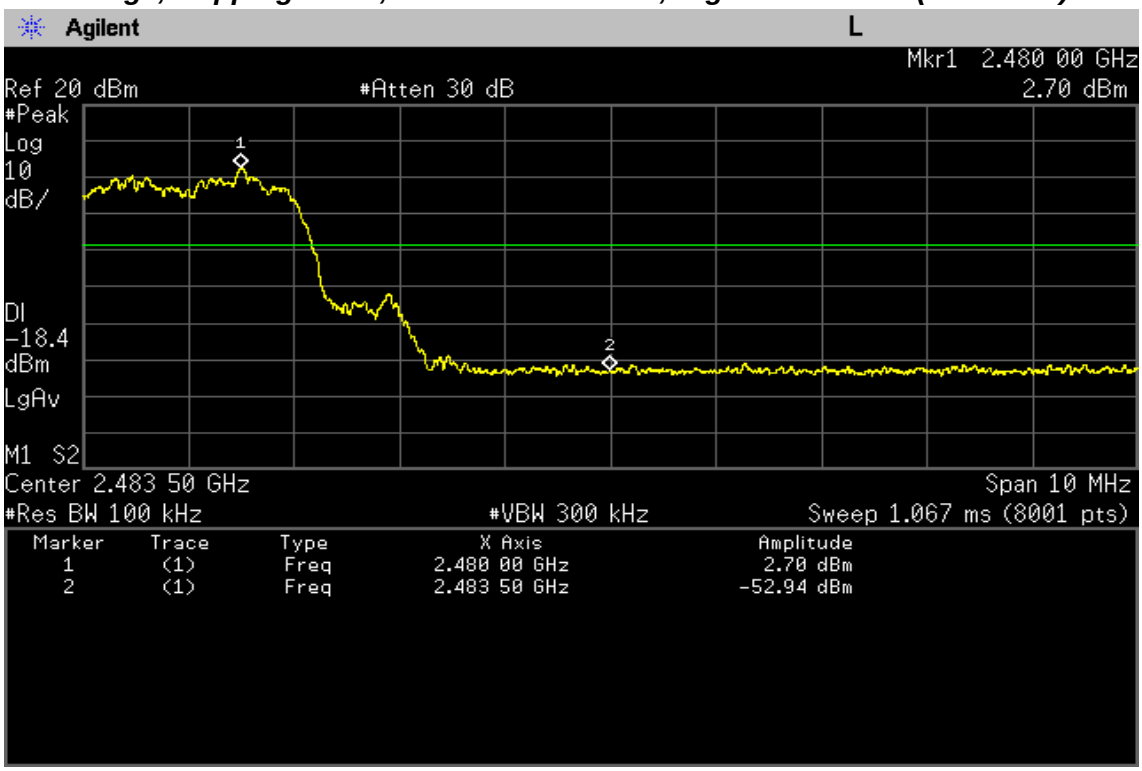


PLOTS OF EMISSIONS

Band Edge, Single channel mode, 8DPSK modulation, Highest Channel (2480 MHz)

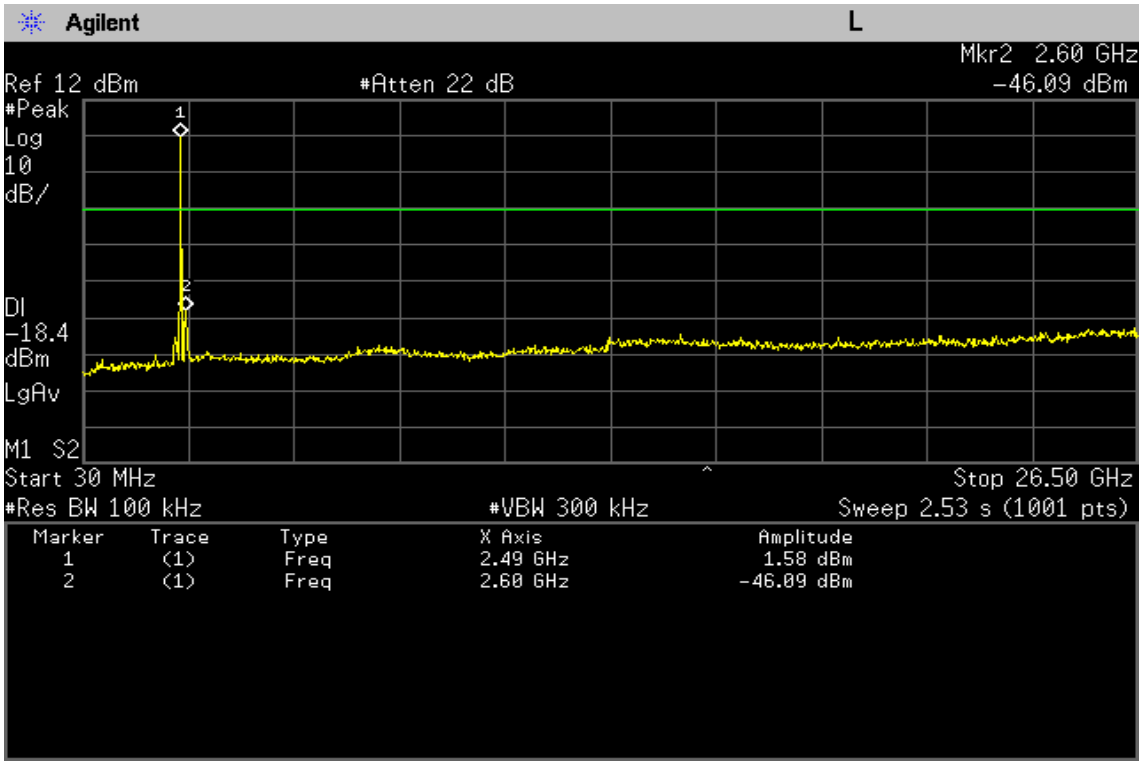


Band Edge, Hopping mode, 8DPSK modulation, Highest Channel (2480 MHz)



PLOTS OF EMISSIONS

Conducted Spurious Emissions, 8DPSK modulation, Highest channel (2480MHz)



TEST DATA

8.9 Radiated Spurious Emissions

FCC §15.247(d), IC RSS-247 Issue 2 5.5

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

Result

8DPSK modulation_Lowest Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2245.80	50.9	V	peak	-8.7	42.2	74.0	31.8
4804.17	46.2	H	peak	0.9	47.1	74.0	27.0

8DPSK modulation_Middle Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2284.53	54.2	V	peak	-8.6	45.6	74.0	28.4
2311.00	53.8	V	peak	-8.4	45.4	74.0	28.6
4882.50	47.1	V	peak	1.1	48.2	74.0	25.8

8DPSK modulation_Highest Channel

Frequency (MHz)	Reading (dBμV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2324.00	56.1	V	peak	-8.3	47.8	74.0	26.3
4959.50	46.1	H	peak	1.5	47.6	74.0	26.4

TEST DATA

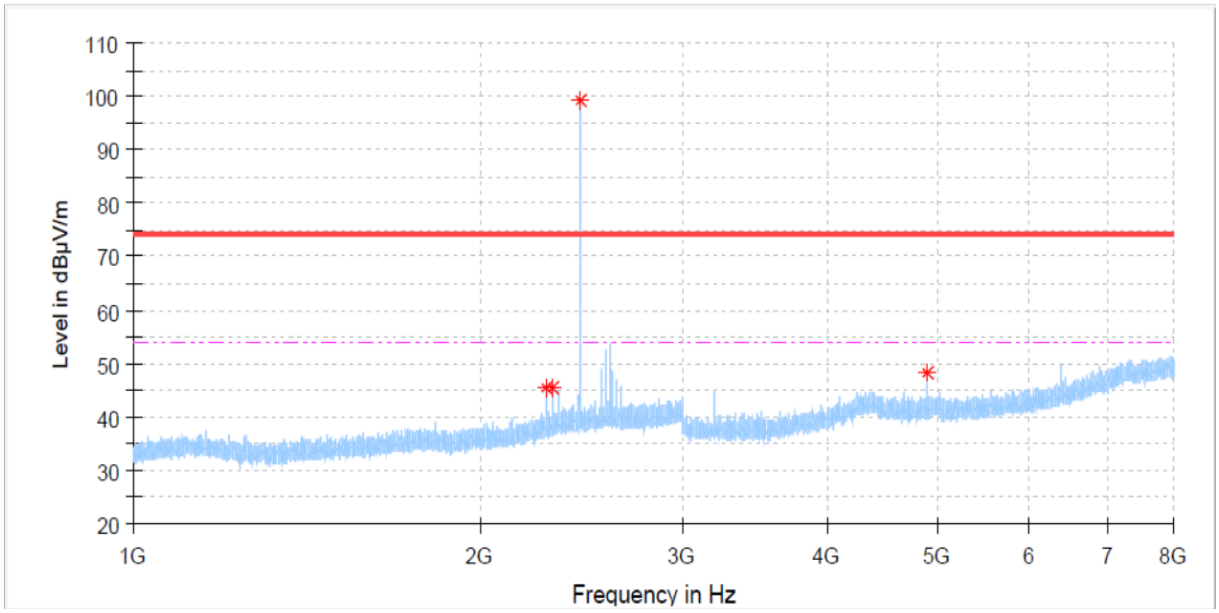
Note:

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. Middle channel (2441 MHz) in GFSK modulation was the worst condition. For other modes, peak-detected emissions have enough margin more than 20dBc, therefore the results were not recorded in this report
6. 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.
7. Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.
9. Average emissions were measured using RBW = 1 MHz, VBW = 1 kHz, Detector = Peak.
8. The spectrum was measured from 9 kHz to 10^{th} harmonic and the worst-case emissions were reported. No significant emissions were found beyond the 2nd harmonic for this device.

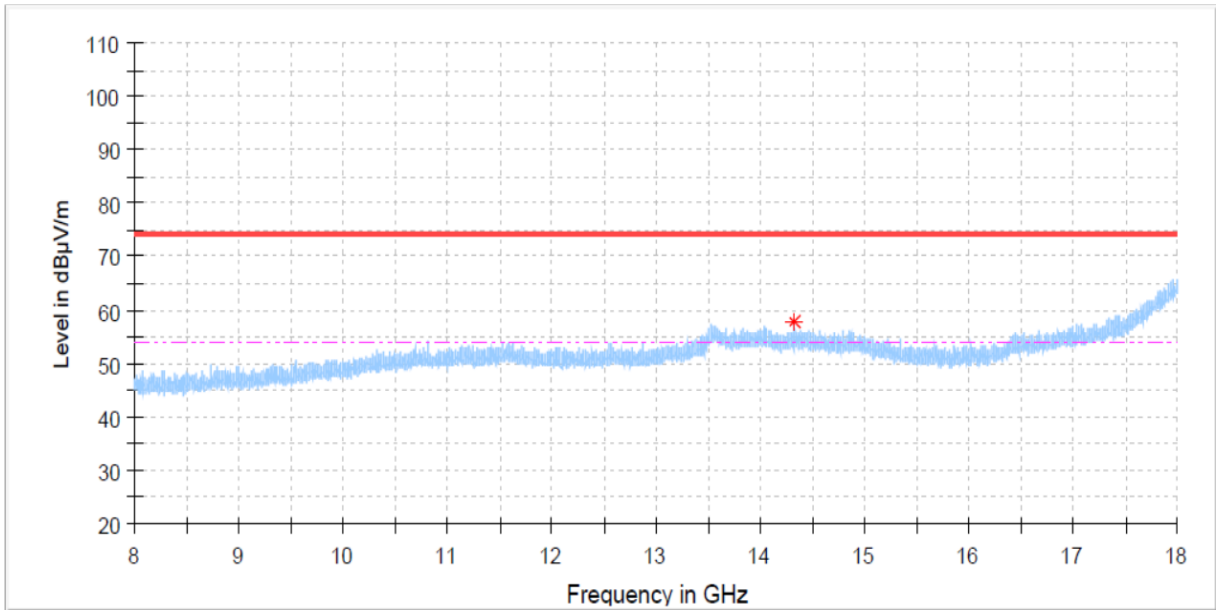
PLOTS OF EMISSIONS

Worst Case

Lowest channel : 1 GHz to 8 GHz_Peak

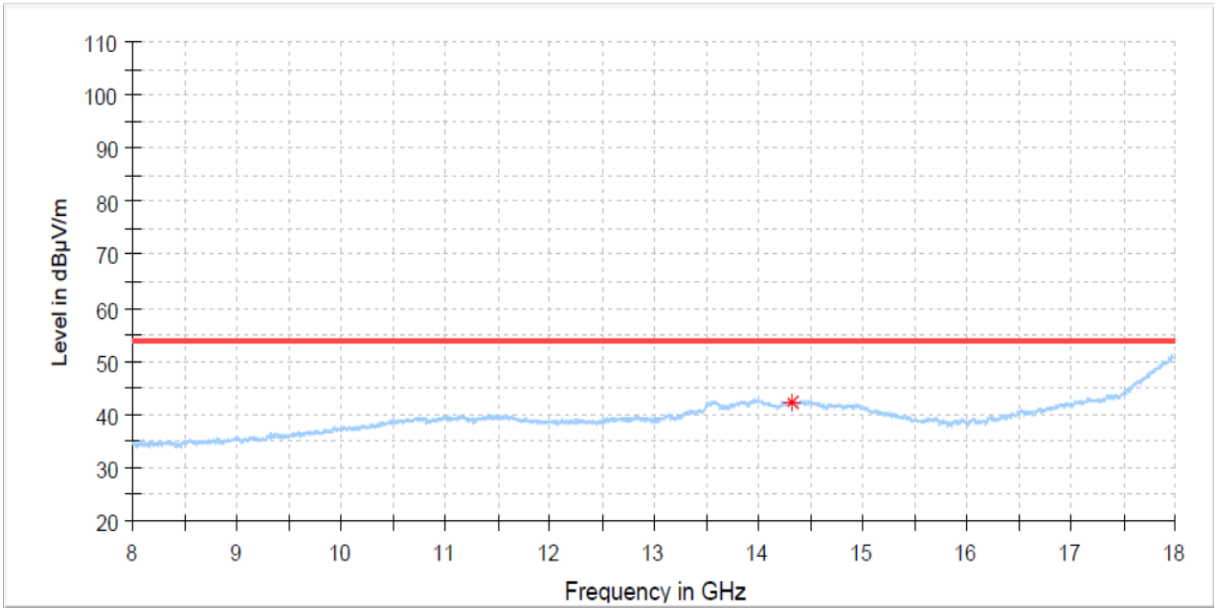


Lowest channel : 8 GHz to 18 GHz_Peak

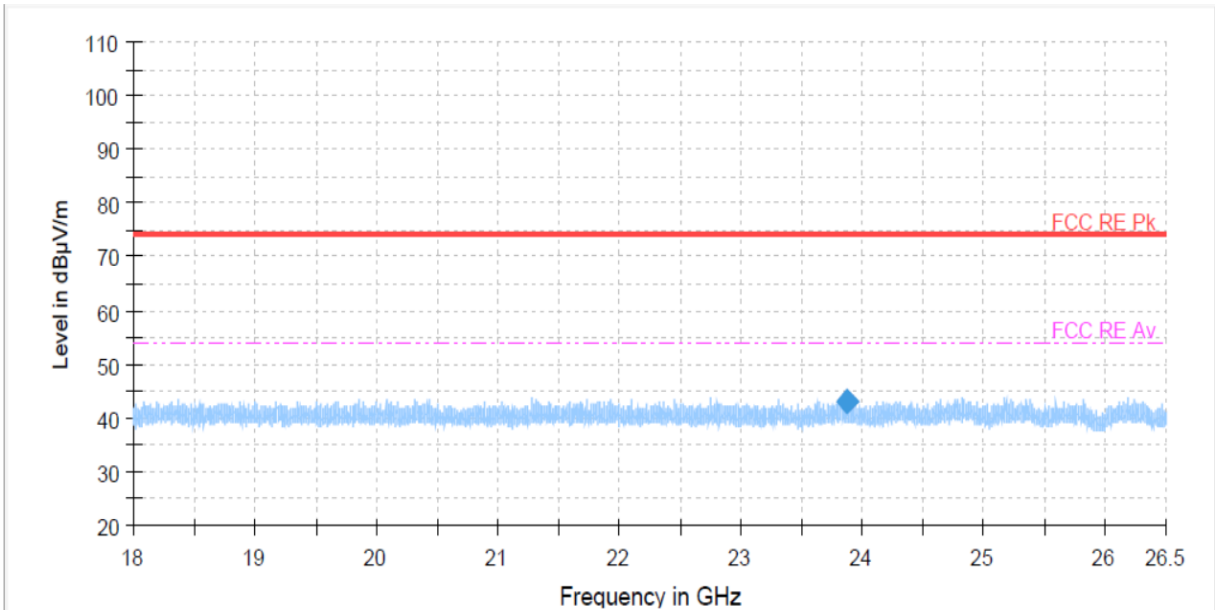


PLOTS OF EMISSIONS

Lowest channel : 8 GHz to 18 GHz_Average



Lowest channel : 18 GHz to 26.5 GHz_Peak



8.10 Radiated Band Edge

FCC §15.247(d), IC RSS-247 Issue 2 5.5

Test Mode : Set to Lowest channel and Highest channel

Result

GFSK modulation_Lowest Channel

Frequency (MHz)	Reading (dBµV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2375.93	50.2	V	peak	-7.9	42.3	74.0	31.7
2390.00	46.1	H	peak	-7.8	38.3	74.0	35.7

GFSK modulation_Highest Channel

Frequency (MHz)	Reading (dBµV)	Pol* (H/V)	mode	AF+CL+Amp (dB)**	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2483.50	53.4	V	peak	-7.6	45.8	74.0	28.2
2483.51	54.3	V	peak	-7.6	46.7	74.0	27.3

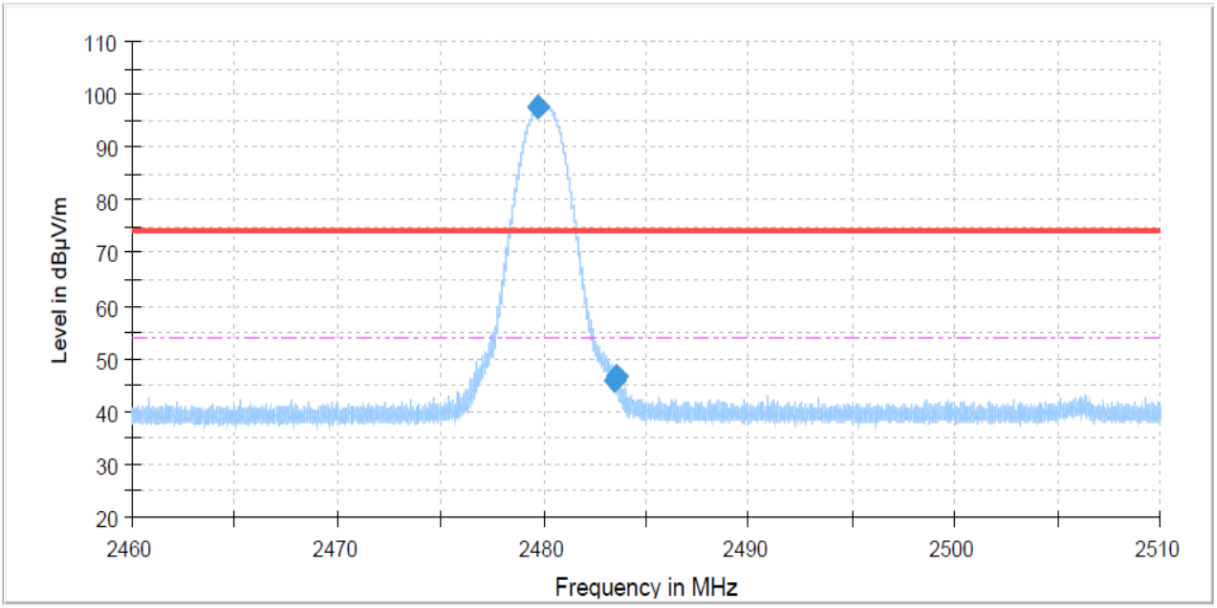
Note:

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. *Highest channel (2480MHz) mode in GFSK modulation was the worst condition. For other modes, peak-detected emissions have enough margin more than 20dBc, therefore the results were not recorded in this report*
6. *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.*
7. *Peak emissions were measured using RBW = 1 MHz, VBW = 3 MHz, Detector = Peak.*

PLOT OF TEST DATA

Worst Case

Highest Channel_Peak



9. TEST EQUIPMENT

No.	Instrument	Manufacturer	Model	Serial No.	Calibration Date	Calibration Interval
1	*Test Receiver	R & S	ESU 40	100202	Apr. 02 2019	1 year
2	*Test Receiver	R & S	ESCS30	100302	Oct. 11 2018	1 year
3	*Attenuator	PASTERNACK	PE7395-10	1441-1	Jul. 11 2019	1 year
4	*Attenuator	FAIRVIEW	SA3N5W-06	N/A	Apr. 03 2019	1 year
5	*Attenuator	FAIRVIEW	SA3N5W-10	N/A	Apr. 03 2019	1 year
6	Attenuator	WEINSCHEL	56-10	58765	Oct. 12 2018	1 year
7	*Amplifier	R & S	SCU 01	10029	Apr. 02 2019	1 year
8	*Amplifier	R & S	SCU18F	180025	Apr. 02 2019	1 year
9	*Amplifier	R & S	SCU26	10011	Jul. 15 2019	1 year
10	Amplifier	R & S	SCU40	100380	Jul. 15 2019	1 year
11	Spectrum Analyzer	R & S	FSW43	100732	Apr. 02 2019	1 year
12	*Spectrum Analyzer	Agilent	E4440A	MY44022567	Oct. 11 2018	1 year
13	*Spectrum Analyzer	R & S	FSW43	104084	Apr. 02 2019	1 year
14	*Loop Antenna	R & S	HFH2-Z2	100279	Feb. 13 2019	2 year
15	*Horn Antenna	SCHWARZBECK	BBHA9120D	9120D-508	Mar. 26 2019	2 year
16	*Horn Antenna	Q-par Angus	QSH20S20	8179	Jul. 15 2019	2 year
17	Horn Antenna	Q-par Angus	QSH22K20	8180	Jul. 15 2019	2 year
18	*Trilog-Broadband Antenna	SCHWARZBECK	VULB 9163	946	May. 18 2019	2 year
19	*LISN	R & S	ESH3-Z5	833874/006	Oct. 12 2018	1 year
20	*Position Controller	INNCO	CO2000	12480406/L	N/A	N/A
21	*Controller	INNCO	CO3000	CO3000/937/38330516/L	N/A	N/A
22	*Turn Table	INNCO	DS1200S	N/A	N/A	N/A
23	*Turn Table	INNCO	DT2000-2t	N/A	N/A	N/A
24	*Antenna Mast	INNCO	MA4000	N/A	N/A	N/A
25	*TILT Antenna Mast	INNCO	MA4640-XP-EP	N/A	N/A	N/A
26	*Open Switch And Control Unit	R & S	OSP-120	100081	N/A	N/A
27	*Open Switch And Control Unit	R & S	OSP-120	101766	N/A	N/A
28	*Shielded Room	Seo-Young EMC	N/A	N/A	N/A	N/A
29	*Anechoic Chamber	Seo-Young EMC	N/A	N/A	N/A	N/A
30	WiFi Filter Bank	R & S	U083	N/A	N/A	N/A
31	*WiFi Filter Bank	R & S	U082	N/A	N/A	N/A

*) Test equipment used during the test

10. ACCURACY OF MEASUREMENT

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%

1. Conducted Uncertainty Calculation

Source of Uncertainty	Xi	Uncertainty of Xi		Coverage factor k	u(Xi) (dB)	Ci	Ci u(Xi) (dB)
		Value (dB)	Probability Distribution				
Receiver reading	RI	± 0.1	normal 1	1.000	0.1	1	0.1
Attenuation AMN-Receiver	LC	± 0.08	normal 2	2.000	0.04	1	0.04
AMN Voltage division factor	LAMN	± 0.8	normal 2	2.000	0.4	1	0.4
Sine wave voltage	dVSW	± 2.00	normal 2	2.000	1.00	1	1.00
Pulse amplitude response	dVPA	± 1.50	rectangular	1.732	0.87	1	0.87
Pulse repetition rate response	dVPR	± 1.50	rectangular	1.732	0.87	1	0.87
Noise floor proximity	dVNF	± 0.00	-	-	0.00	1	0.00
AMN Impedance	dZ	± 1.80	triangular	2.449	0.73	1	0.73
ⓐ Mismatch	M	+ 0.70	U-Shaped	1.414	0.49	1	0.49
ⓑ Mismatch	M	- 0.80	U-Shaped	1.414	- 0.56	1	- 0.56
Measurement System Repeatability	RS	0.05	normal 1	1.000	0.05	1	0.05
Remark	ⓐ: AMN-Receiver Mismatch : + ⓑ: AMN-Receiver Mismatch : -						
Combined Standard Uncertainty	Normal			± 1.88			
Expended Uncertainty U	Normal (k = 2)			± 3.76			

2. Radiation Uncertainty Calculation

Source of Uncertainty	Xi	Uncertainty of Xi		Coverage factor k	u(Xi) (dB)	Ci	Ci u(Xi) (dB)
		Value (dB)	Probability Distribution				
Measurement System Repeatability	**RS**	0.34	normal 1	1.00	0.34	1	0.34
Receiver reading	**Ri**	± 0.02	normal 2	2.00	0.01	1	0.01
Sine wave voltage	**dVsw**	± 0.17	normal 2	2.00	0.09	1	0.09
Pulse amplitude response	**dVpa**	± 0.92	normal 2	2.00	0.46	1	0.46
Pulse repetition rate response	**dVpr**	± 0.35	normal 2	2.00	0.18	1	0.18
Noise floor proximity	**dVnf**	± 0.50	normal 2	2.00	0.25	1	0.25
Antenna Factor Calibration	**AF**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Cable Loss	**CL**	± 1.00	normal 2	2.00	0.50	1	0.50
Antenna Directivity	**AD**	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.00
Antenna Factor Height Dependence	**AH**	± 2.00	rectangular	$\sqrt{3}$	1.15	1	1.15
Antenna Phase Centre Variation	**AP**	± 0.20	rectangular	$\sqrt{3}$	0.12	1	0.12
Antenna Factor Frequency Interpolation	**Ai**	± 0.25	rectangular	$\sqrt{3}$	0.14	1	0.14
Site Imperfections	**Si**	± 4.00	triangular	$\sqrt{6}$	1.63	1	1.63
Measurement Distance Variation	**DV**	± 0.60	rectangular	$\sqrt{3}$	0.35	1	0.35
Antenna Balance	**Dbal**	± 0.90	rectangular	$\sqrt{3}$	0.52	1	0.52
Cross Polarisation	**DCross**	± 0.00	rectangular	$\sqrt{3}$	0.00	1	0.18
Mismatch	**M**	+ 0.98 - 1.11	U-Shaped	$\sqrt{2}$	0.74	1	0.74
EUT Volume Diameter	**Vd**	0.33	normal 1	1.00	0.33	1	0.11
Remark							
Combined Standard Uncertainty	Normal						
Expended Uncertainty U	Normal (k = 2)						