FCC / IC Test Report

FOR:
Virscient Limited

Model Name:
Trimble Comm board Tornado

Product Description:
WIFI/BT Module

FCC ID: YK5-73350047
IC ID: ----------

Applied Rules and Standards:
47 CFR Part 15.247 (DSS)
RSS-247 Issue 2 (FHSs) & RSS-Gen Issue 4

REPORT #: EMC_VIRSC-001-17001_15.247_BT_DSS

DATE: 2019-02-08

A2LA Accredited

IC recognized #
3462B-2

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Virscient Limited	WIFI/BT Module	V0009F

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2019-02-08	Compliance	Cindy Li (EMC Lab Manager)	Cindy Li Digitally signed by Cindy Li DN: cn=Cindy Li, o=Cetecom Inc., ou=EMC, email=cindy.li@cetecom.com, c=US Date: 2019.02.08 16:00:25 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2019-02-08	Compliance	Kevin Wang (Senior EMC Engineer)	kevin.wang@cetecom.com Digitally signed by: kevin.wang@cetecom.com DN: CN = kevin.wang@cetecom.com Date: 2019.02.08 15:33:53 -08'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Cindy Li
Responsible Project Leader:	Rami Saman

2.2 Identification of the Client

Applicant's Name:	Virscient Limited
Street Address:	Ruakura Research Centre, 10 Bisley Road
City/Zip Code	Hamilton/3214
Country	New Zealand

2.3 Identification of the Manufacturer

Manufacturer's Name:	Trimble Jena GmbH
Manufacturers Address:	Carl-Zeiss-Promenade 10
City/Zip Code	Jena/07745
Country	Germany

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	Trimble Comm board Tornado
HW Version :	F
SW Version :	v4.5.10.016.DFS
FCC-ID:	YK5-73350047
IC-ID:	--------
HVIN:	--------
PMN:	--------
Product Description:	WIFI/BT Module
Frequency Range / number of channels:	Nominal band: 2400 MHz – 2483.5 MHz Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 78), 79 Channels
Type(s) of Modulation:	Bluetooth BR/EDR: GFSK, π /4 DQPSK, 8DPSK
Modes of Operation:	Hopping
Antenna Information as declared:	Pulse W3334B0150, 2.4G 4dBi 5G 5.5dBi
Max. declared output Powers:	Conducted Power 7.19dBm
Power Supply/ Rated Operating Voltage Range:	USB / Vmin: 4.75 VDC/ Vnom: 5 VDC / Vmax: 5.5 VDC
Operating Temperature Range	-20 ºC to +70 ºC
Other Radios included in the device:	Bluetooth 4.2 Low Energy (BT LE) WIFI 802.11a/b/g/n/ac
Sample Revision	☐Prototype Unit; ■Production Unit; ☐Pre-Production

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	311	F	V4.5.10.016.DFS	Radiated Emissions
2	351	F	V4.5.10.016.DFS	Conducted RF

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Laptop	Dell	Latitude E6440	00186-242-768-970
2	Laptop	Dell	Latitude E6430s	00186-210-105-587

3.4 Test Sample Configuration

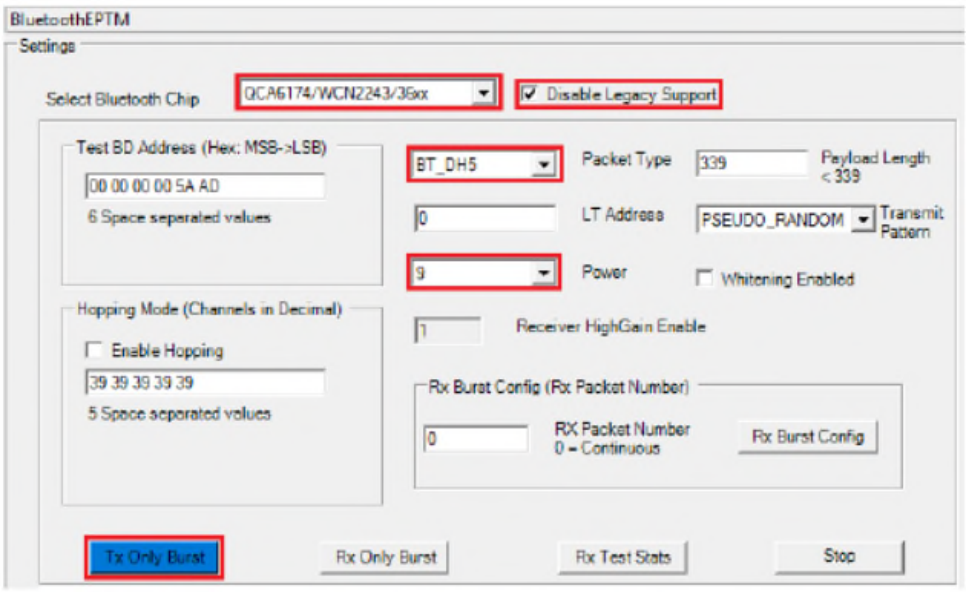
EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#2 + AE#1 + AE#2	The radio of the EUT was configured to a fixed channel transmission with highest possible duty cycle using software “QRCT” provided by client that is not available to the end user. The measurement equipment was connected to the 50 ohm RF port of the EUT.
2	EUT#1 + AE#1 + AE#2	The radio of the EUT was configured to a fixed channel with highest possible duty cycle using software “QRCT” provided by client that is not available to the end user. The external antenna “Pulse W3334B0150” provided by client was used for radiated testing.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels with the highest possible duty cycle.

The EUT were configured by "QRCT" provided by client (not available to the end user), target power level index "9" was used for testing.

QRCT Tool:



For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

For conducted measurements, the highest power mode of operation (2DH5), was used to evaluate the worst case performance of the EUT, including the band edge compliance and TX radiated spurious emissions testing. Maximum peak conducted output power and spectrum bandwidth, were measured in all supported modulation modes for the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 Issue1 of ISED Canada.

Testing procedures are based on ANSI C63.10:2013 including section 7.8 for FHSS systems.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(b)(1) RSS-247 5.4(2)	Maximum Peak Conducted Output Power	Nominal	GFSK DH5 DQPSK DH5 8DPSK DH5	■	☐	☐	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	π/4-DQPSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(1)	Spectrum Bandwidth	Nominal	GFSK DH5 DQPSK DH5 8DPSK DH5	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(1)	Carrier Frequency Separation	Nominal	π/4-DQPSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(4)	Number of Hopping Channels	Nominal	π/4-DQPSK	■	☐	☐	Complies
§15.247(a)(1)(iii) RSS-247 5.1(4)	Time of occupancy	Nominal	8DPSK max duty cycle	■	☐	☐	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	π/4-DQPSK	■	☐	☐	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	N/A[2]	☐	■	☐	N/A[2]

Note1: NA= Not Applicable; NP= Not Performed.
Note2: EUT is powered by USB

6 Measurements

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

Conducted measurement

150 kHz to 30 MHz	±0.7 dB (LISN)
RF conducted measurement	±0.5 dB

6.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6.3 Dates of Testing:

07/17/2018 - 07/20/2018

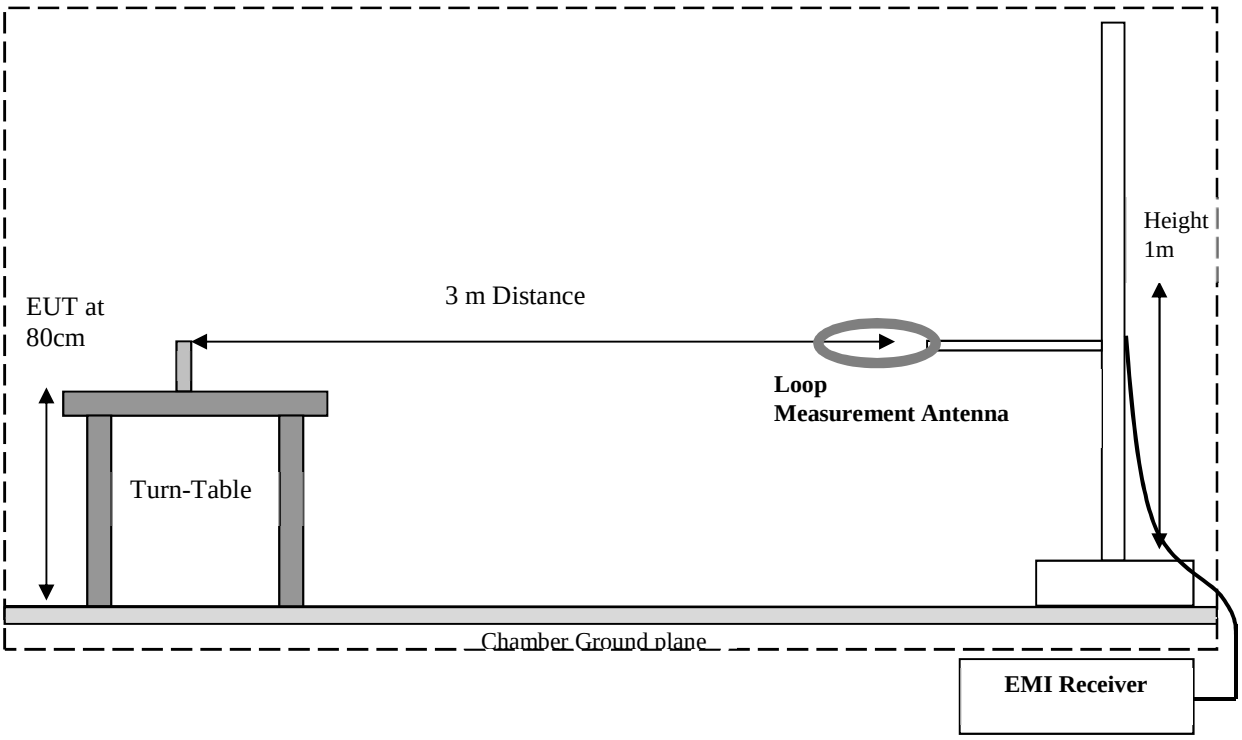
7 Measurement Procedures

7.1 Radiated Measurement

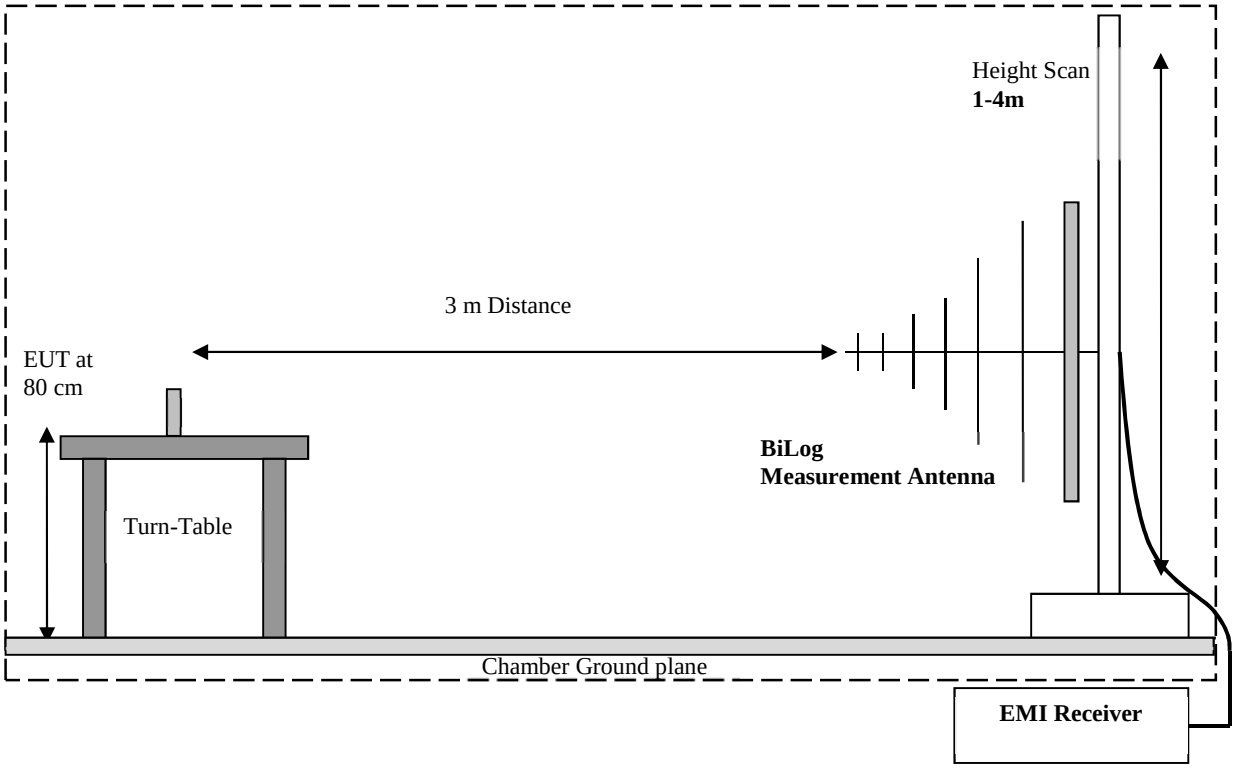
The radiated measurement is performed according to: ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

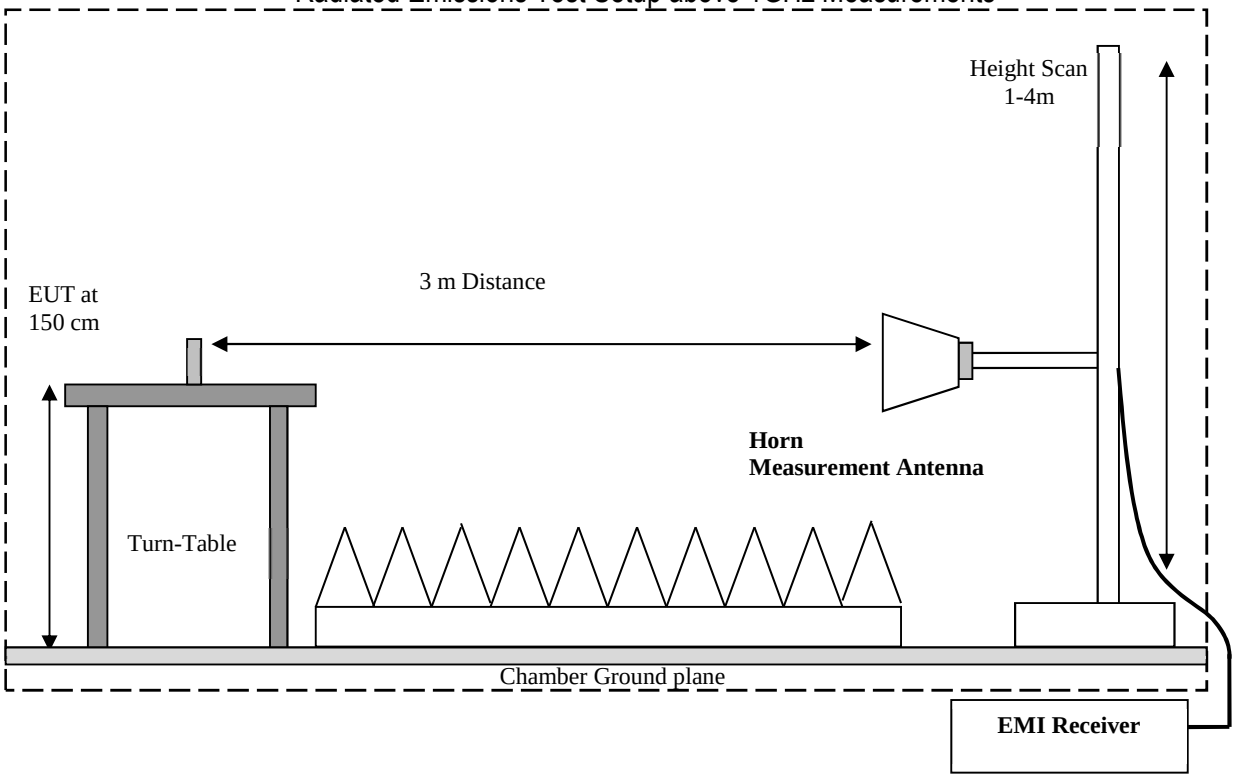
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 RF Conducted Measurement Procedure

Reference: ANSI C63.10 (2013) Section 6.9, 6.10, and 7.8

- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to ANSI C63.10 Section 7.8

Spectrum Analyzer settings:

- Span = approximately 5 times the 20 dB bandwidth
- RBW > the 20 dB bandwidth of the emission being measured
- VBW ≥ RBW
- Sweep = Auto Couple
- Detector function = Peak
- Trace = Max hold
- Use the marker-peak function to set the marker to the peak of the emission.

8.1.2 Limits:

Maximum Peak Output Power:
FCC 15.247 (b)(1): 1 W
IC RSS-247: 1 W

8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	1	GFSK, π /4 DQPSK, 8DPSK	USB 5 VDC	4dBi

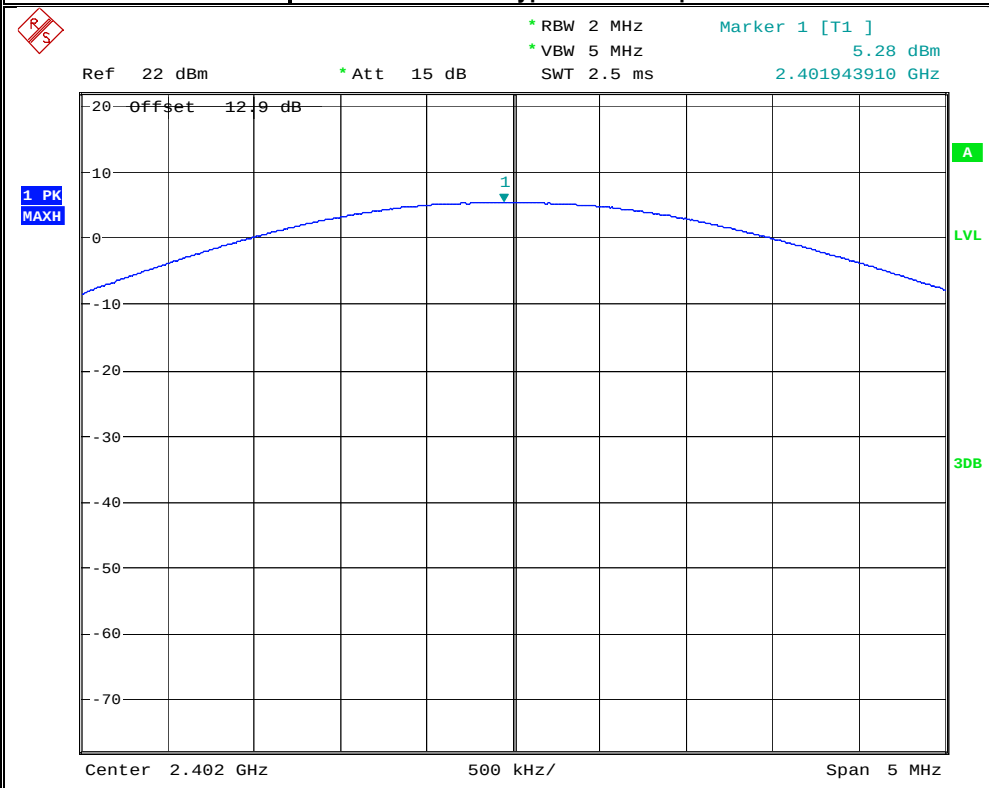
8.1.4 Measurement result:

Plot #	Frequency (MHz)	EUT operating mode	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	2402	GFSK 1Mbps	5.28	9.28	30(Pk) / 36(EIRP)	Pass
2	2402	π /4 DQPSK 2Mbps	6.25	10.25	30(Pk) / 36(EIRP)	Pass
3	2402	8DPSK 3Mbps	5.89	9.89	30(Pk) / 36(EIRP)	Pass
4	2441	GFSK 1Mbps	5.9	9.9	30(Pk) / 36(EIRP)	Pass
5	2441	π /4 DQPSK 2Mbps	6.88	10.88	30(Pk) / 36(EIRP)	Pass
6	2441	8DPSK 3Mbps	6.5	10.5	30(Pk) / 36(EIRP)	Pass
7	2480	GFSK 1Mbps	6.16	10.16	30(Pk) / 36(EIRP)	Pass
8	2480	π /4 DQPSK 2Mbps	7.19	11.19	30(Pk) / 36(EIRP)	Pass
9	2480	8DPSK 3Mbps	6.8	10.8	30(Pk) / 36(EIRP)	Pass

8.1.5 Measurement Plots:

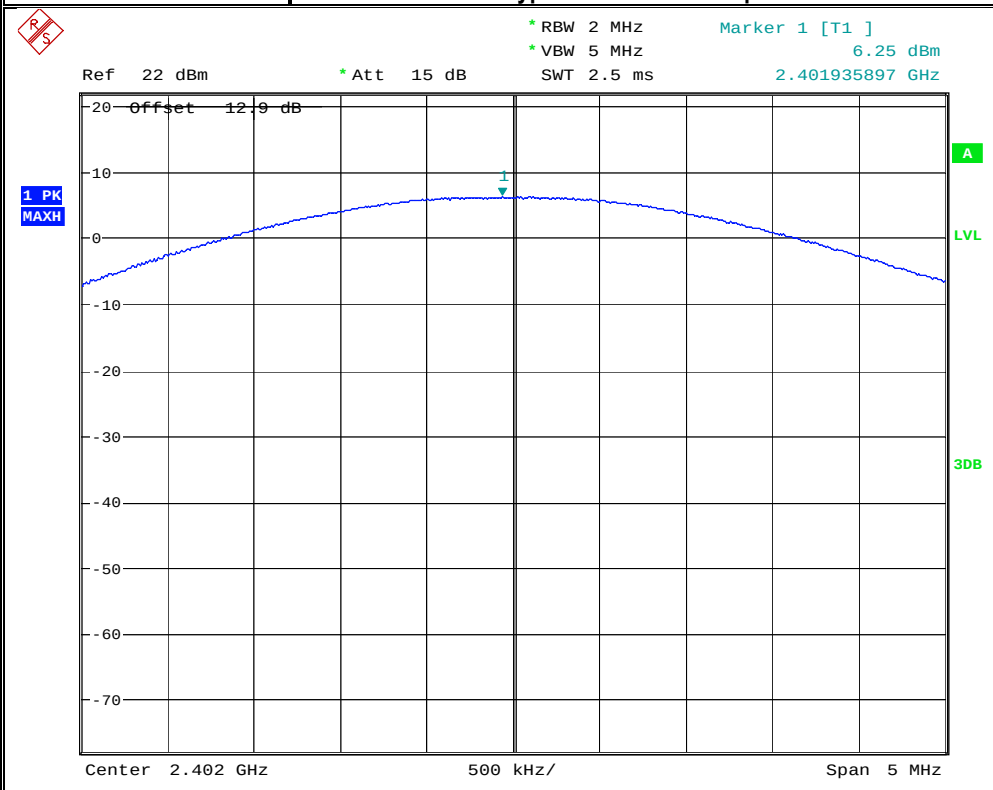
Plot #1

2402 MHz | **Modulation/Packet Type: GFSK 1Mbps**



Plot #2

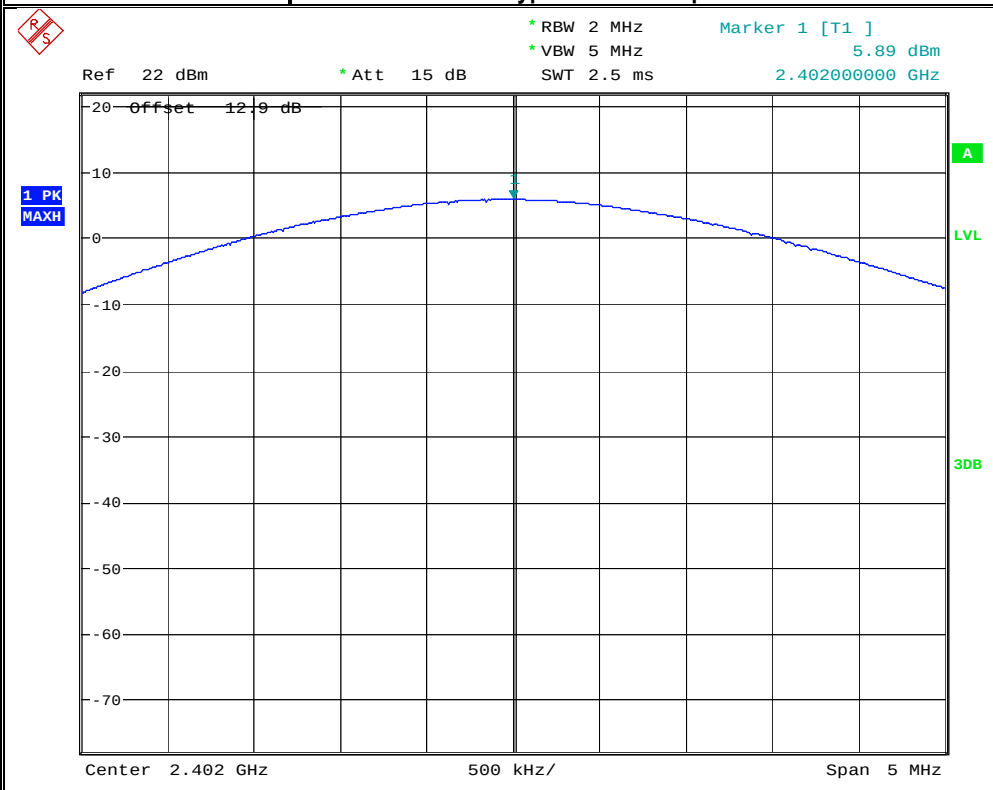
2402 MHz | **Modulation/Packet Type: π /4 DQPSK 2Mbps**



Date: 10.JUL.2018 16:36:40

Plot #3

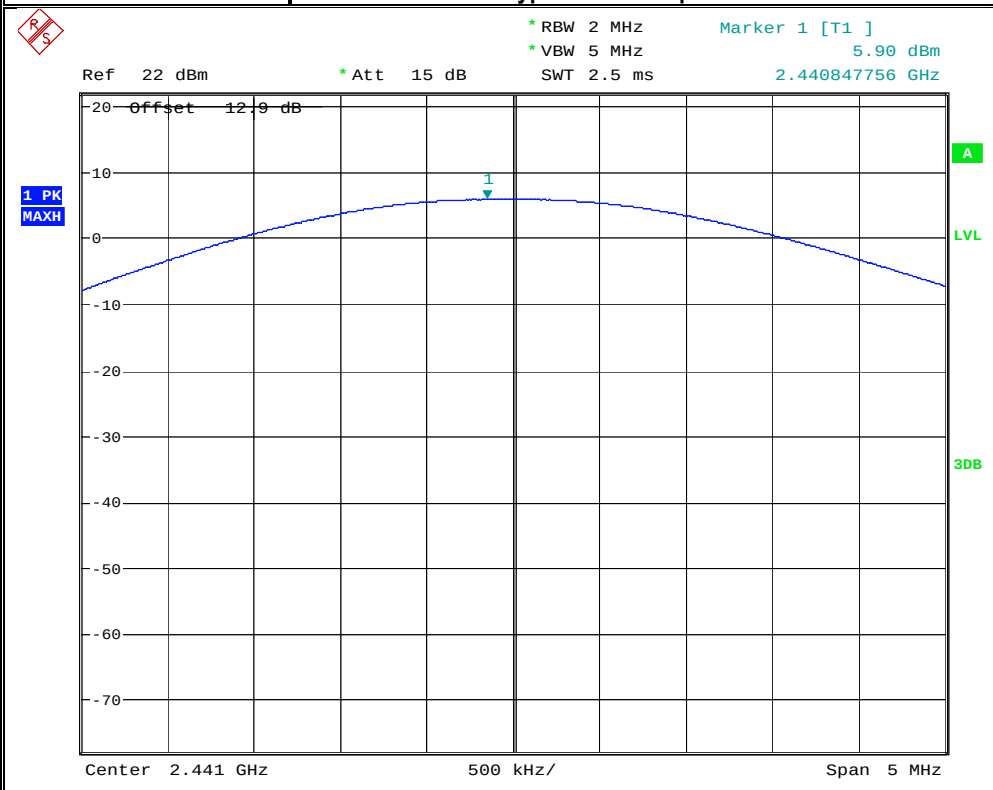
2402 MHz | **Modulation/Packet Type: 8DPSK 3Mbps**



Date: 10.JUL.2018 16:37:55

Plot #4

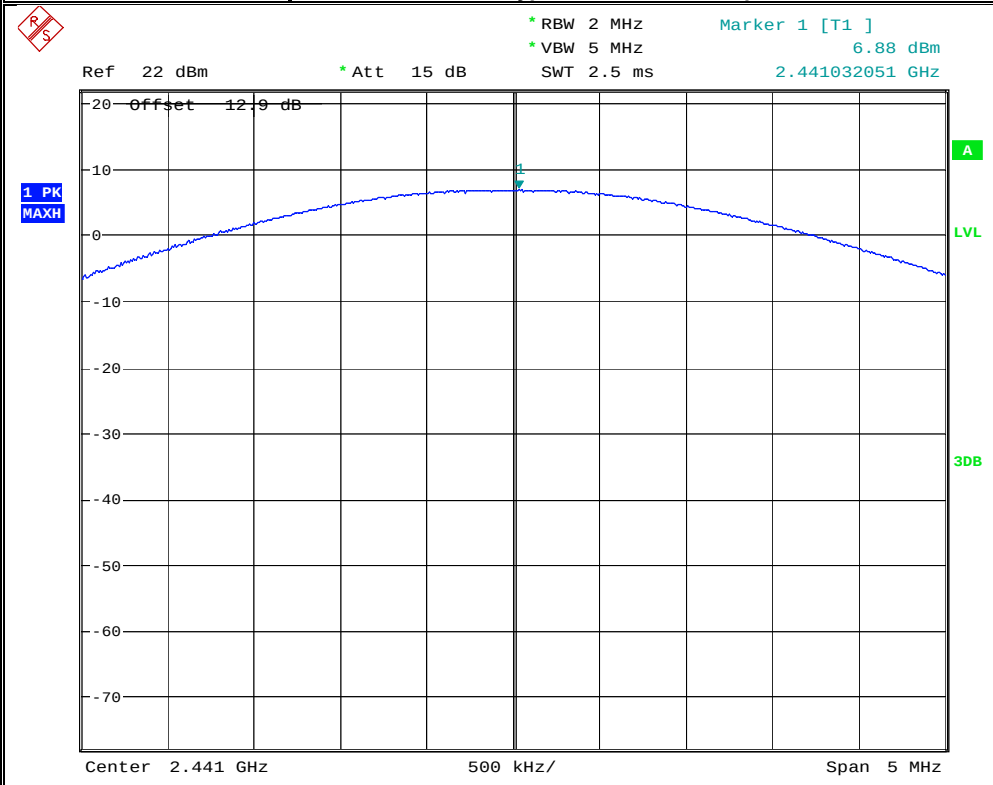
2441 MHz | **Modulation/Packet Type: GFSK 1Mbps**



Date: 10.JUL.2018 16:39:58

Plot #5

2441 MHz | **Modulation/Packet Type: π /4 DQPSK 2Mbps**



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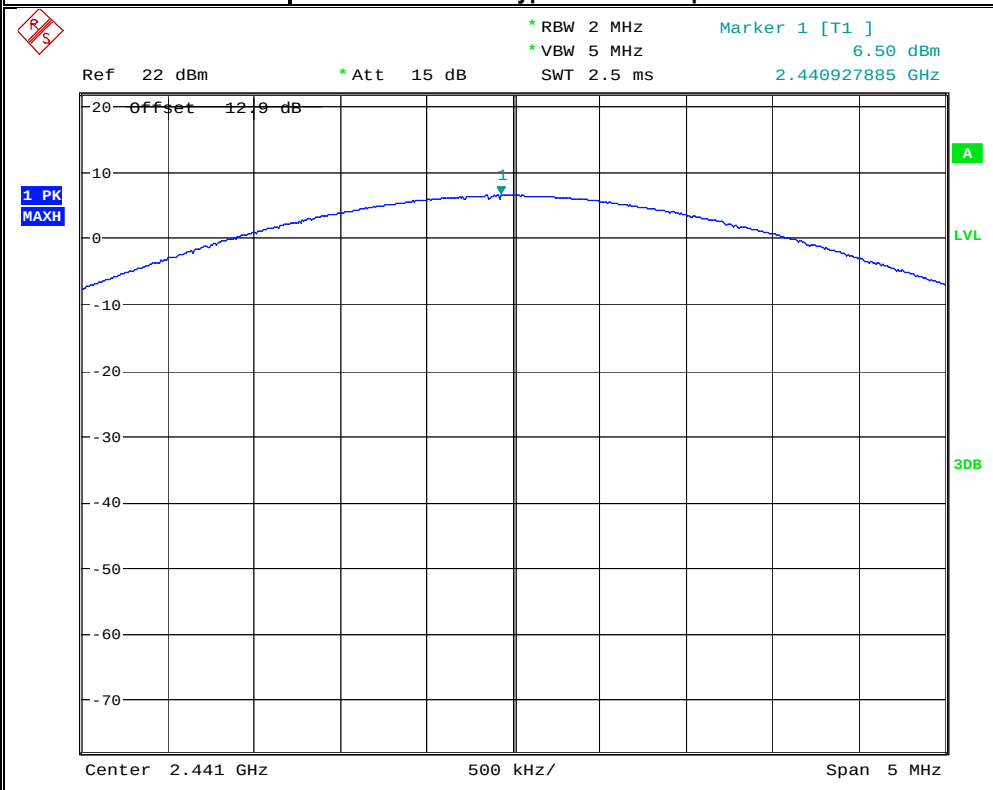
Plot #6

2441 MHz	Modulation/Packet Type: 8DPSK 3Mbps



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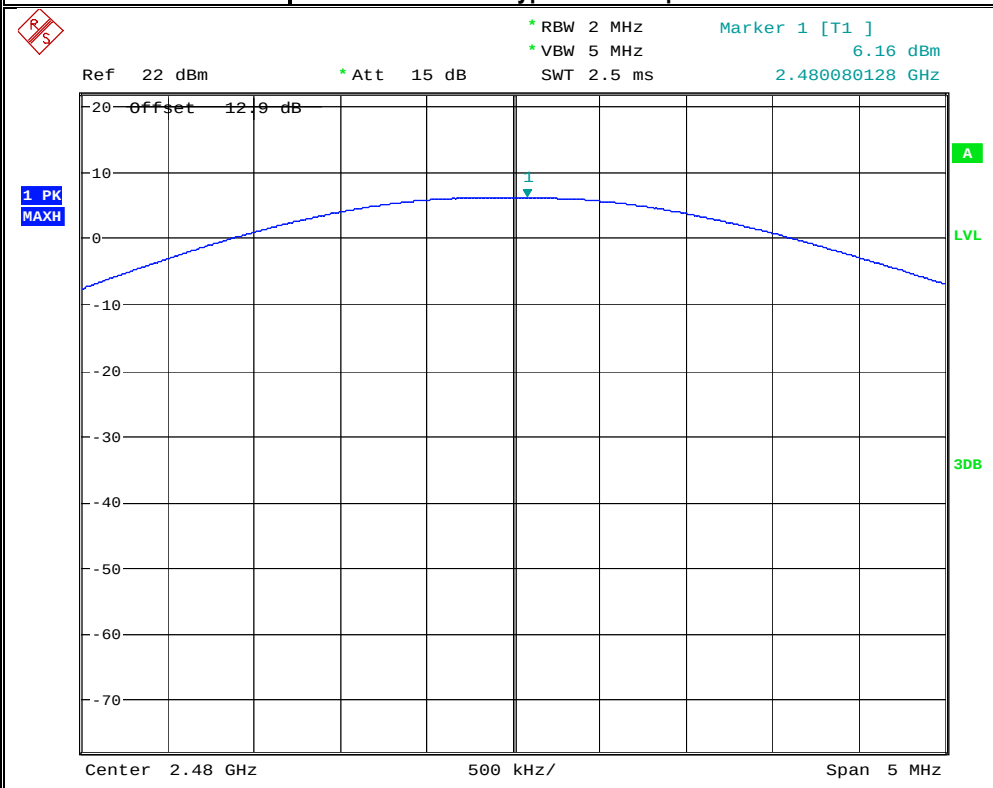
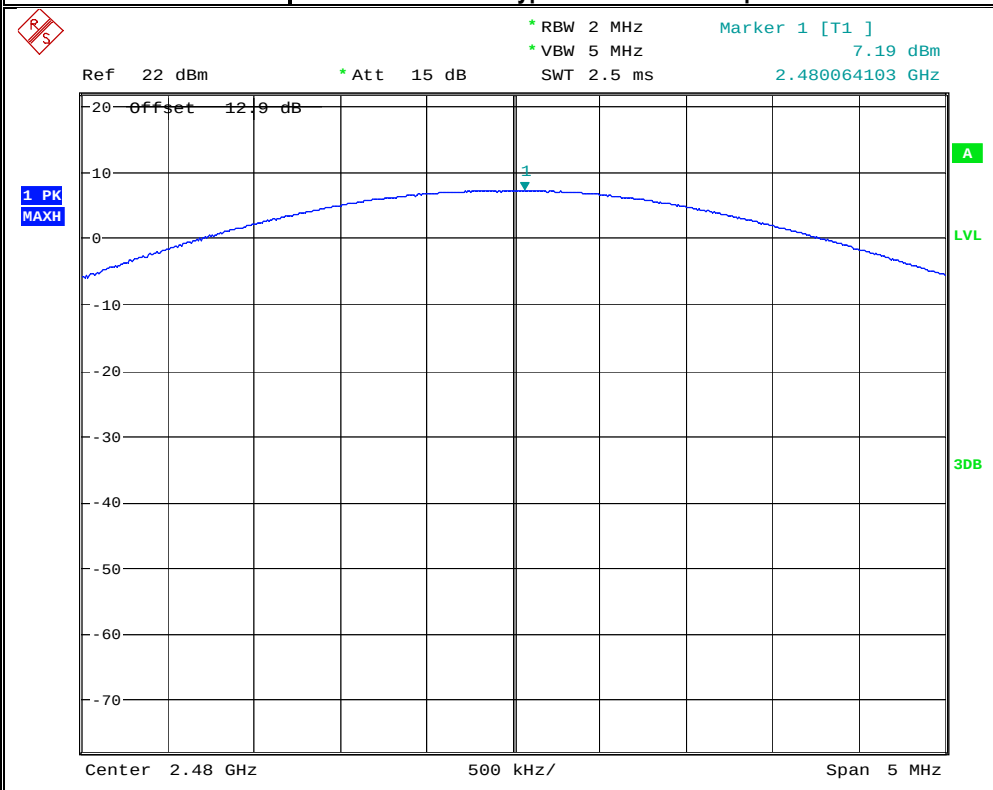
Plot #7

2480 MHz	Modulation/Packet Type: GFSK 1Mpbs



Plot #8

2480 MHz | **Modulation/Packet Type: π /4 DQPSK 2Mbps**



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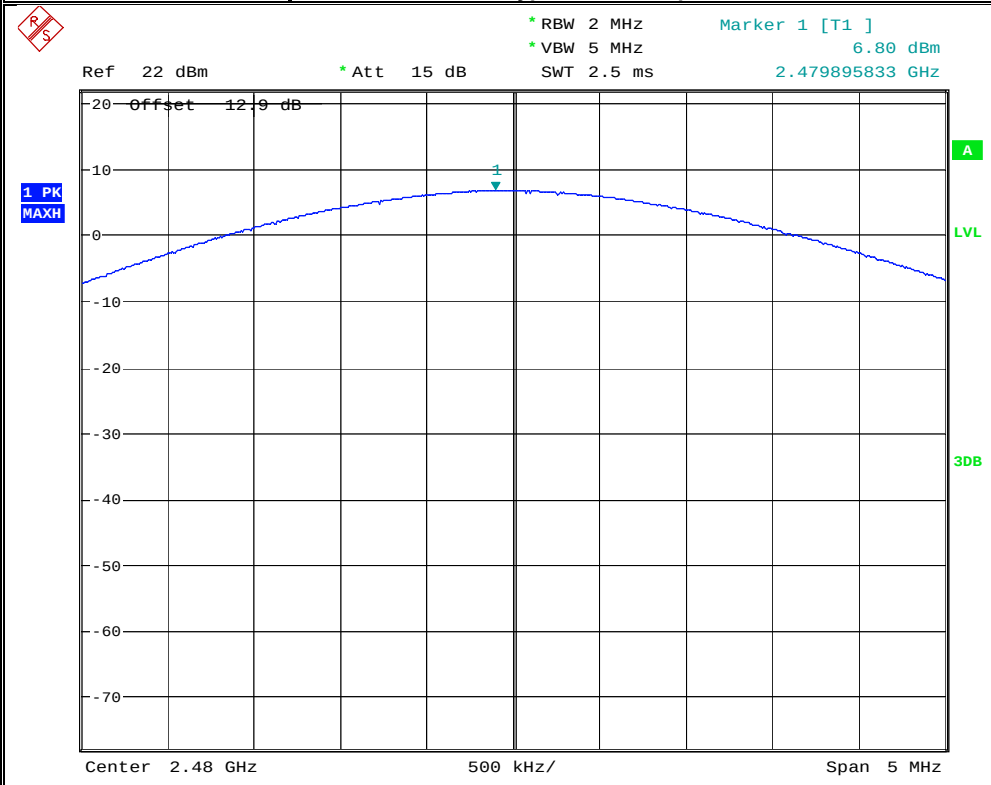
Plot #9

2480 MHz	Modulation/Packet Type: 8DPSK 3Mpbs



8.2 Duty cycle

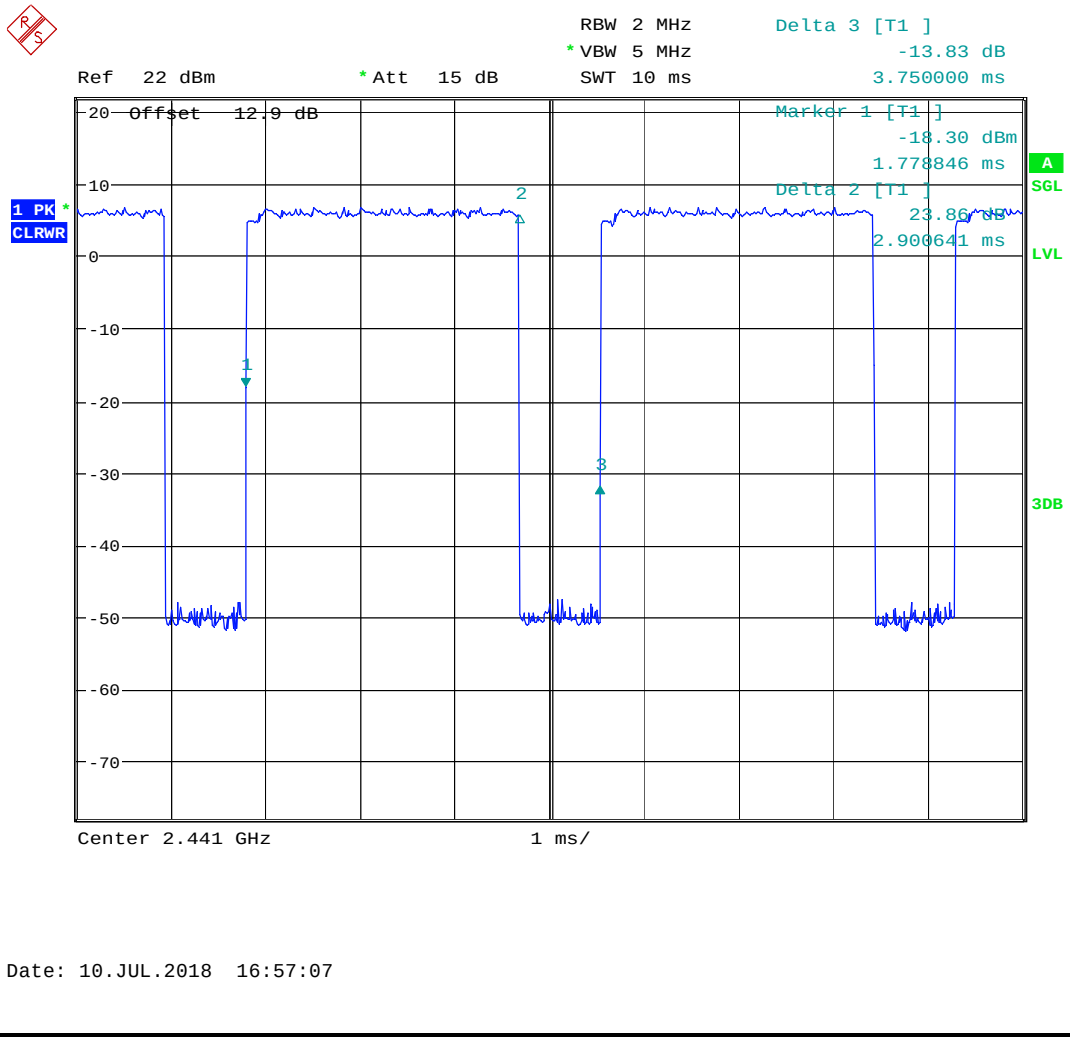
8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- Set the center frequency of the instrument to the center frequency of the transmission
- Zero span
- Set RBW >=OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.2.2 Measurement result

Duty cycle measurement	
Mid channel / 2441 MHz	**Modulation/Packet Type: 2DH5**



Duty cycle =77.3%
Duty cycle correction factor =10*log (0.773) = 1.12 dB

8.3 Band Edge Compliance

8.3.1 Measurement according to ANSI C63.10 Section 6.10

Spectrum Analyzer settings for non-restricted band edge:

- Span: wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
- RBW ≥ 1% of the span
- VBW ≥ RBW
- Sweep Time: Auto couple
- Detector = Peak/RMS
- Trace = Max hold
- Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge.
- Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
- Now, using the same instrument settings, enable the hopping function of the EUT.
- Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.3.2 Limits: Restricted Band FCC 15.209 and RSS-Gen 8.10

- PEAK LIMIT= 74 dBµV/m @3 m =-21.23 dBm
- AVG. LIMIT= 54 dBµV/m @3 m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205

Restricted bands of operation:

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

8.3.3 Limits: Non-restricted Band §15.247 and RSS-247 5.5

FCC15.247 (d)

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

RSS-247 5/5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

8.3.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna gain
22° C	1	2DH5 - fixed channel 2DH5 - hopping	USB 5 VDC	4dBi

8.3.5 Measurement result:

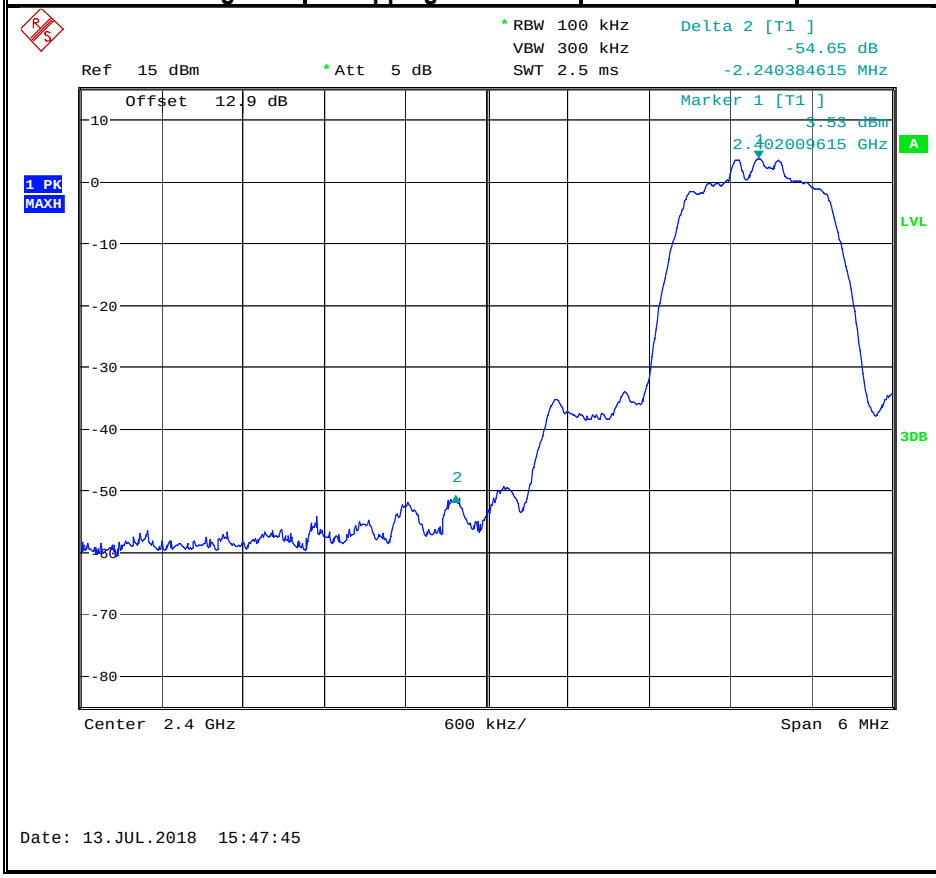
Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	2DH5 fixed channel	Lower, non-restricted	54.65	> 20	Pass
2	3DH5 hopping	Lower, non-restricted	52.63	> 20	Pass

Plot #	EUT operating mode	Band Edge	Measured value	Corrected by duty cycle	Corrected by gain	Limit (dBm)	Result
3	2DH5 fixed channel	Upper restricted peak	-35.52	NA	-31.52	-21.23 Peak	Pass
4	2DH5 hopping	Upper restricted peak	-37.32	NA	-33.32	-21.23 Peak	Pass
5	2DH5 fixed channel	Upper restricted average	-58	-56.88	-52.88	-41.23 AVG	Pass
6	2DH5 hopping	Upper restricted average	-58.9	-57.78	-53.78	-41.23 AVG	Pass

8.3.6 Measurement Plots:

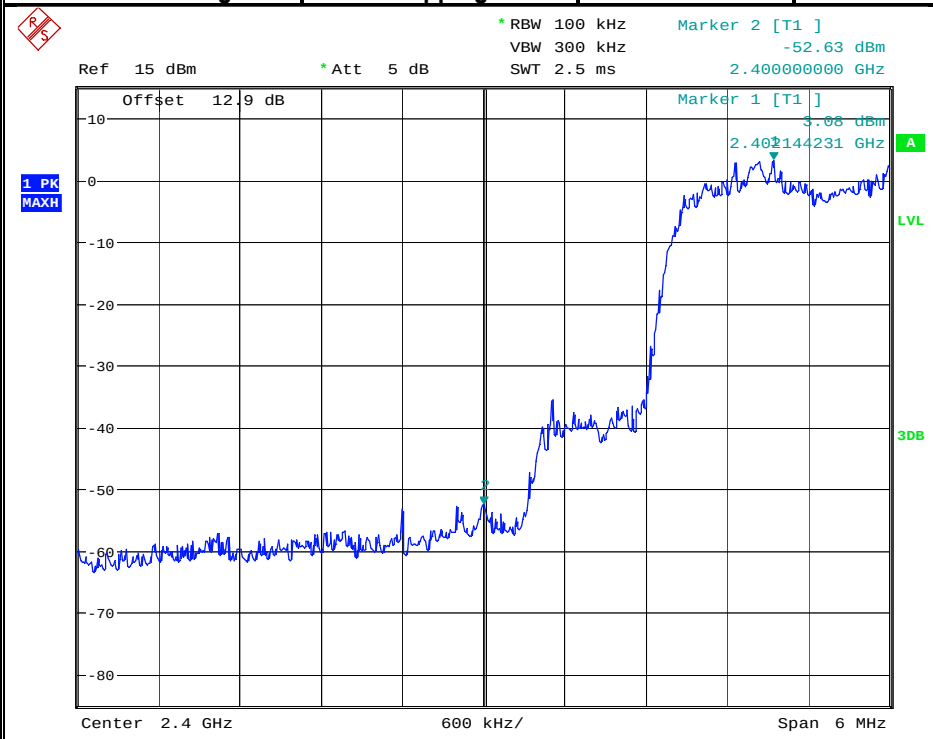
Plot #1 Lower Band Edge

Low Band-edge	Hopping Disabled	Peak	2DH5



Plot #2 Lower Band Edge

Low Band-edge	Hopping	Peak	2DH5



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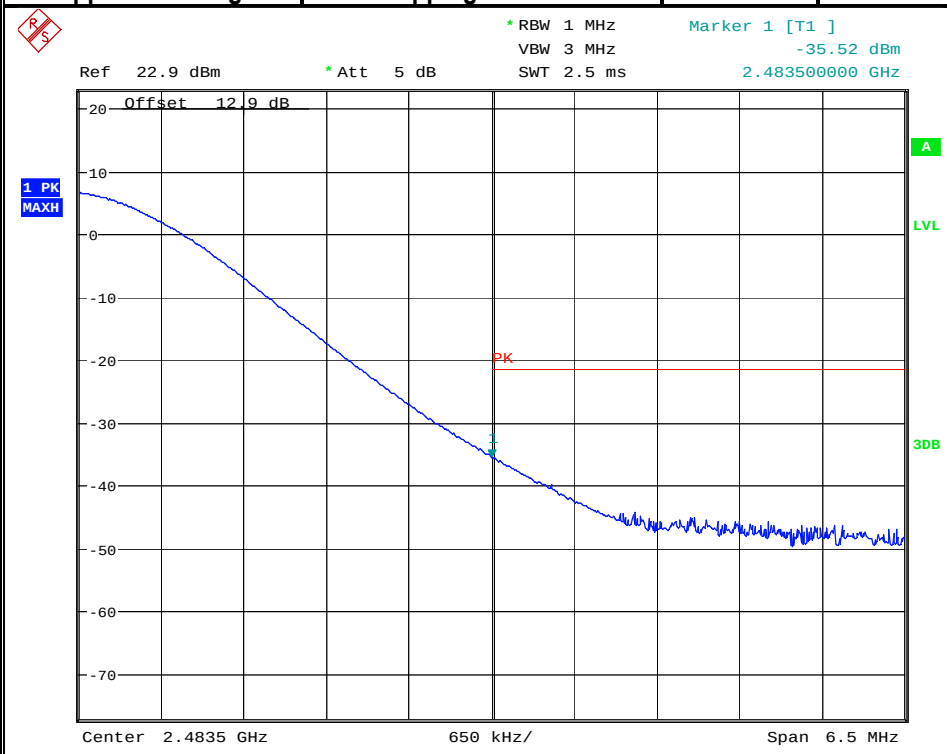
Plot #3 Upper Band Edge

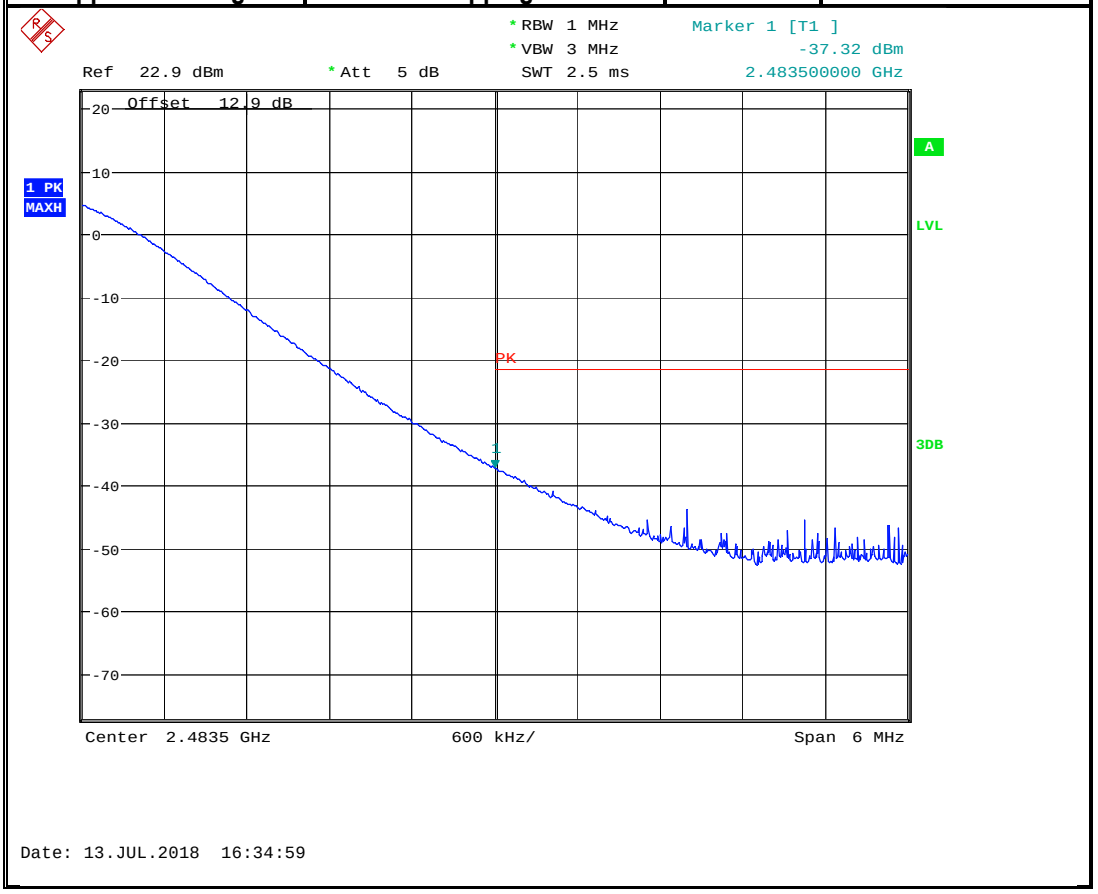
Upper Band-edge	Hopping Disabled	Peak	2DH5



Date: 13.JUL.2018 15:56:28

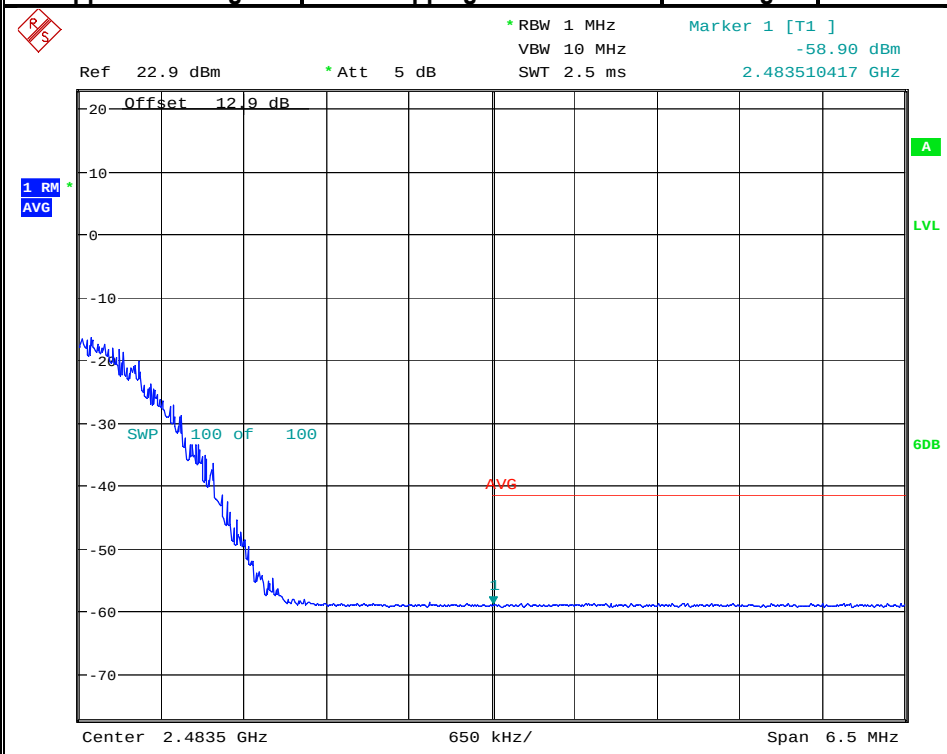
Plot #4 Upper Band Edge

Upper Band-edge	Hopping	Peak	2DH5



Plot #4 Upper Band Edge

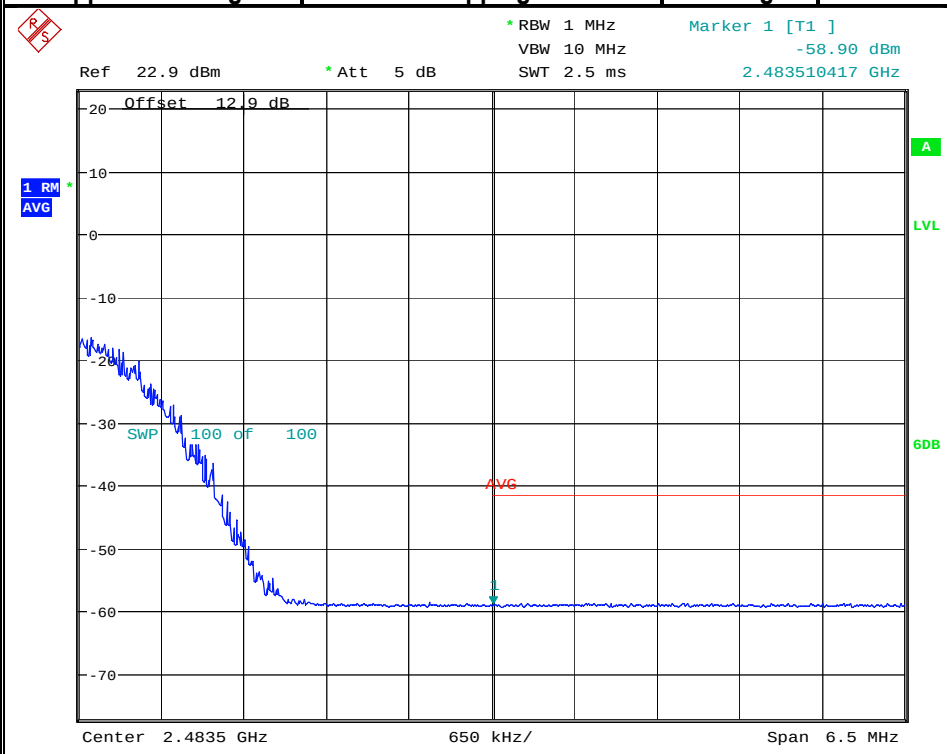
Upper Band-edge	Hopping Disabled	Average	2DH5



Date: 13.JUL.2018 16:10:17

Plot #4 Upper Band Edge

Upper Band-edge	Hopping	Average	2DH5



Date: 13.JUL.2018 16:10:17

8.4 20dB Bandwidth

8.4.1 Measurement according to ANSI C63.10 Section 6.9

Spectrum Analyzer settings:

- Span: approximately 2 to 3 times the 20 dB bandwidth, centered on the hopping channel
- RBW ≥ 1% of the 20 dB bandwidth
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max hold

8.4.2 Limits: FCC 15.247 (a) (1), RSS-227

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

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	1	GFSK, DQPSK, 8PSK	USB 5VDC

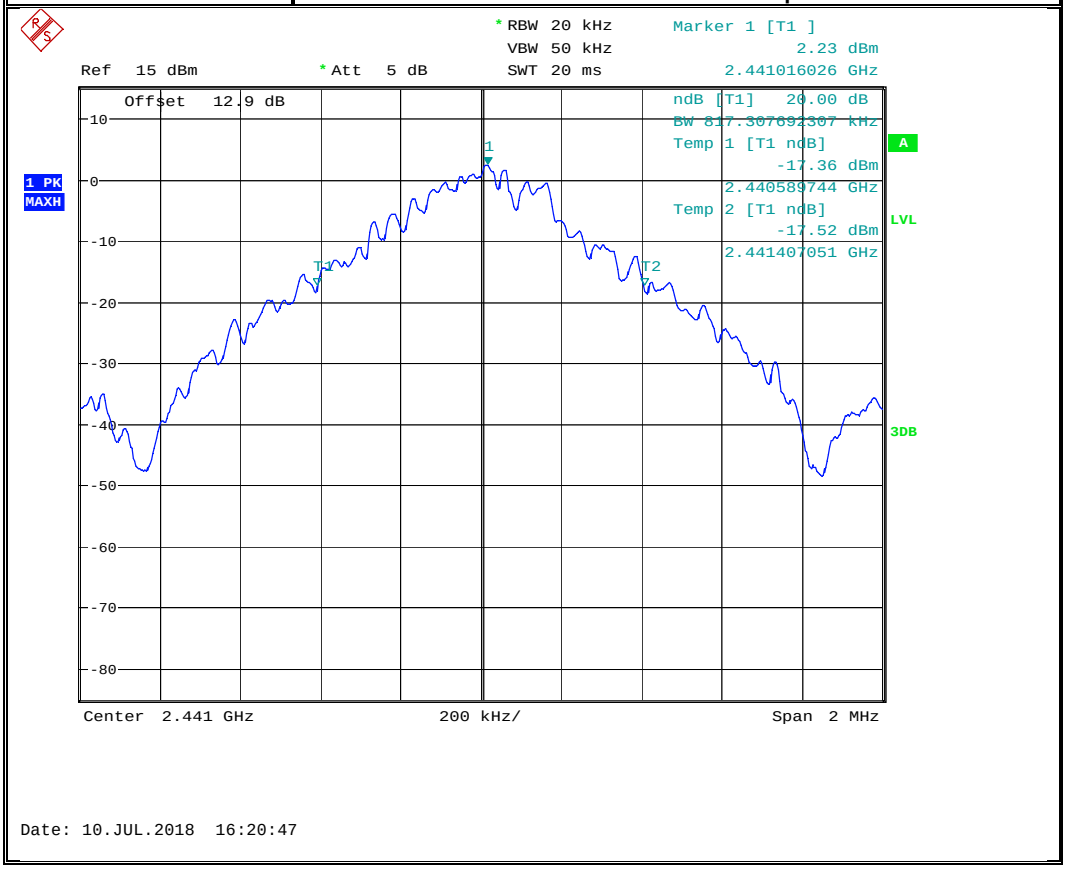
8.4.4 Measurement result:

Plot #	EUT operating mode	20 dB Bandwidth (MHz)
1	GFSK 1Mbps ch39	0.817
2	DQPSK 2Mbps ch39	1.26
3	8PSK 3Mbps ch39	1.26

8.4.5 Measurement Plots:

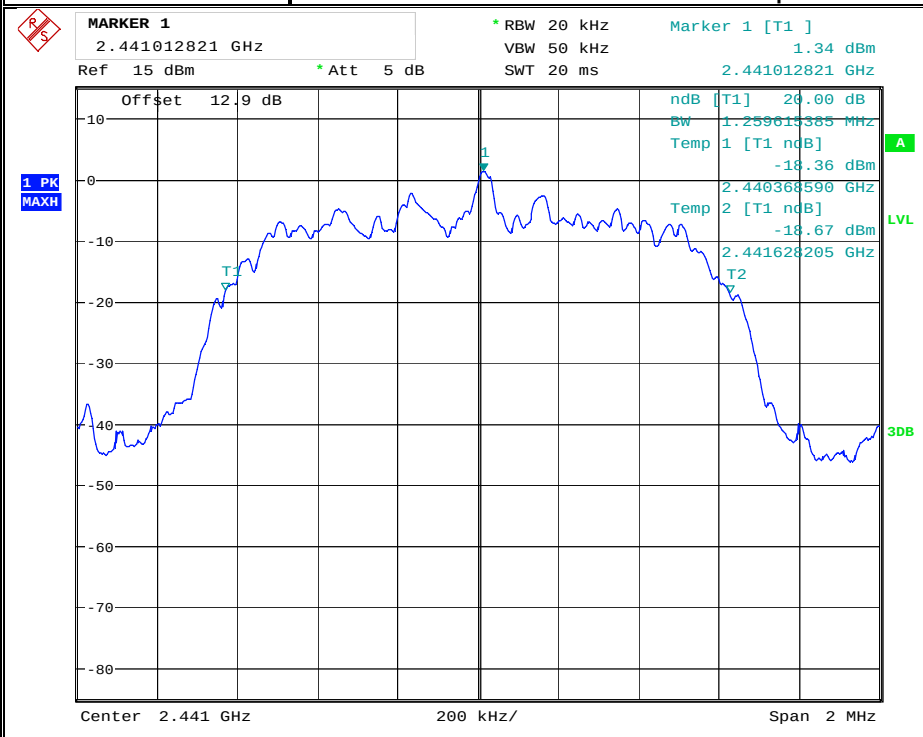
Plot #1 20dB Bandwidth

Ch Mid / 2441 MHz | **Modulation: GFSK 1Mbps**



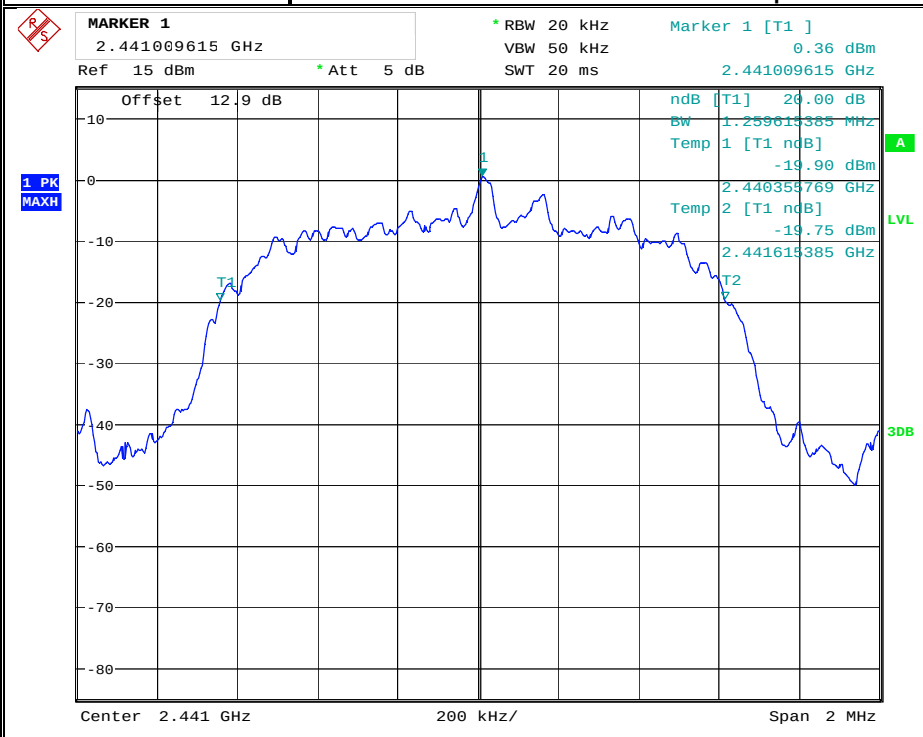
Plot #2 20dB Bandwidth

Ch Mid / 2441 MHz | **Modulation: DQPSK 2Mpbs**



Plot #3 20dB Bandwidth

Ch Mid / 2441 MHz | **Modulation: 8DPSK 3Mpbs**



8.5 Carrier Frequency Separation

8.5.1 Measurement according to ANSI C63.10 Section 7.8

Spectrum Analyzer settings:

- Span = Wide enough to capture the peaks of the two adjacent channels
- RBW ≥ 1% of the span
- VBW ≥ RBW or 3 x
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use marker-delta function to determine the separation between the peaks of the two adjacent channels.

8.5.2 Limits: FCC 15.247 (a) (1) & RSS-247

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

8.5.3 Test conditions and setup:

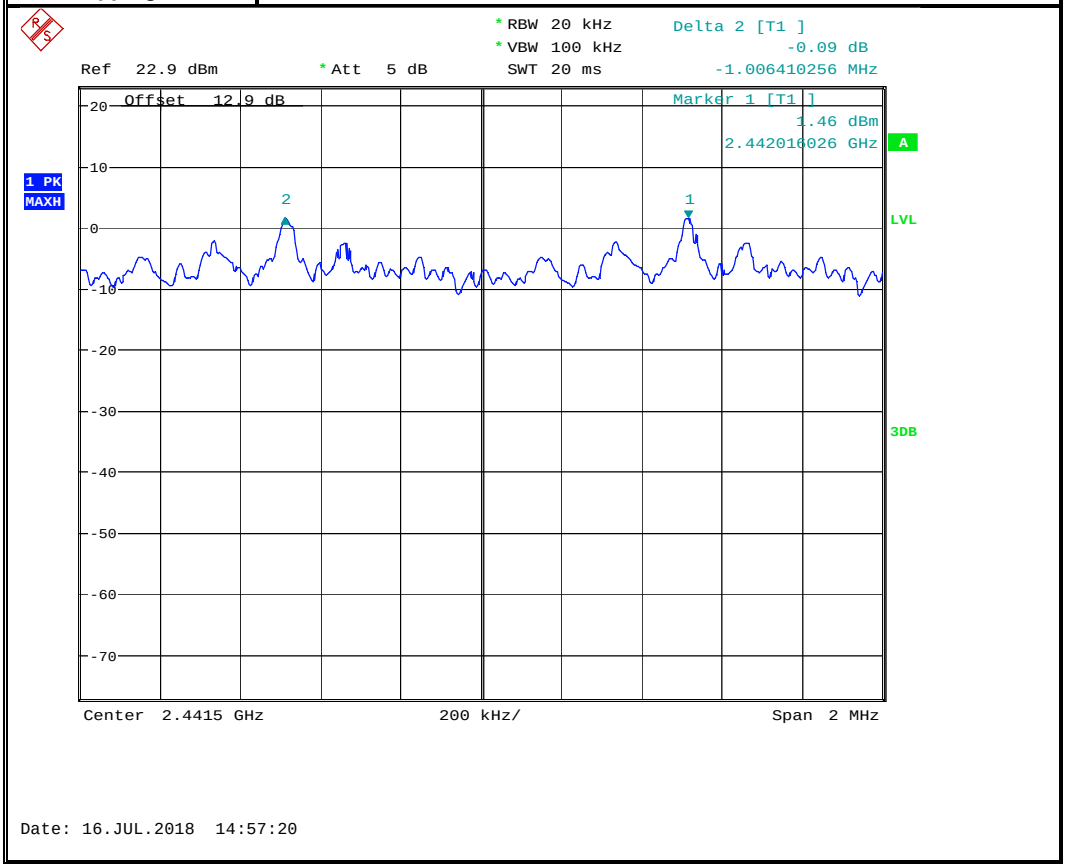
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	2DH5 Hopping	USB 5VDC

8.5.4 Measurement result:

Plot #	Carrier Frequency Separation (MHz)	Limit (MHz)	Result
1	1.0064	> 2/3 * OBW = 0.84	Pass

8.5.5 Measurement Plots:

Plot # 1 Carrier Frequency Separation	
Packet Type: DH5	Modulation: π/4-DQPSK
Hopping On	Channel 39 & Channel 40



8.6 Number of hopping channels

8.6.1 Measurement according to ANSI C63.10 Section 7.8

Spectrum Analyzer settings:

- Span = the entire frequency band of operation
- RBW ≥ 50 KHz
- VBW ≥ RBW or 3X
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold

8.6.2 Limits: FCC 15.247 (a) (1) (ii) (iii) & RSS-227

At least 15 non-overlapping channels

8.6.3 Test conditions and setup:

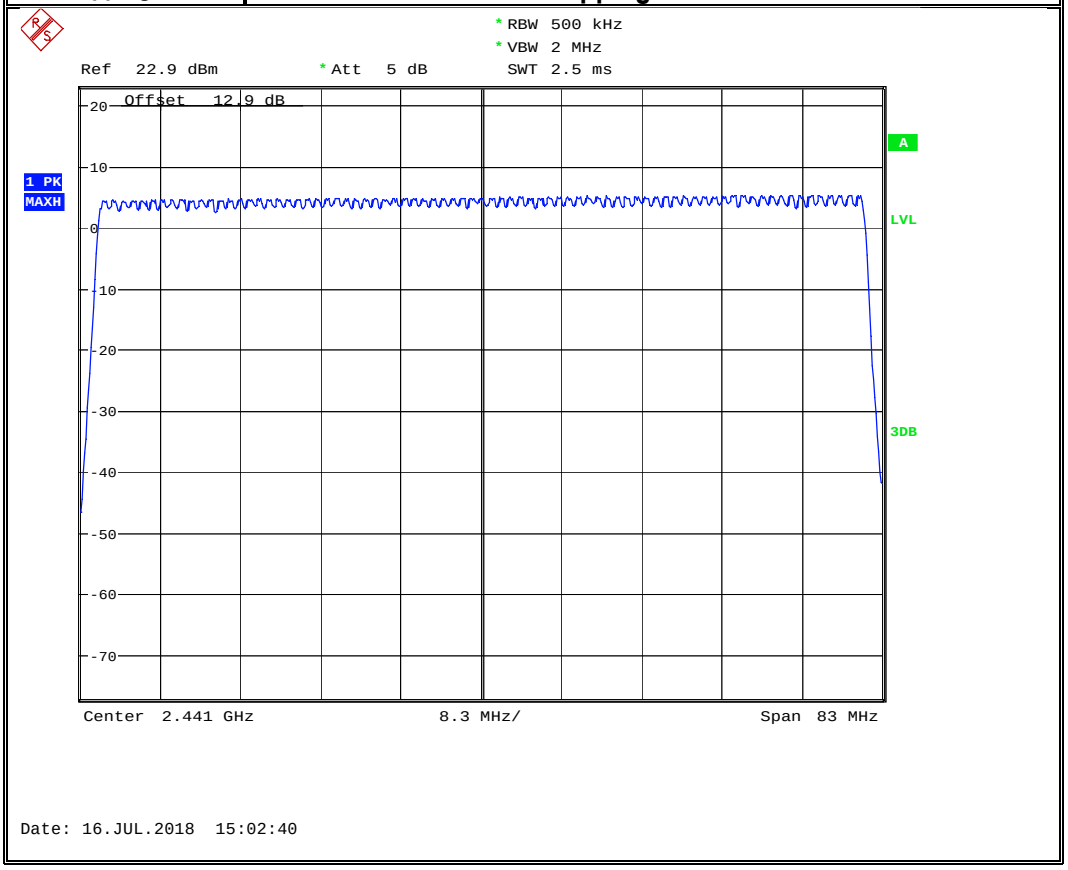
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	2DH5 hopping	USB 5VDC

8.6.4 Measurement result:

Plot #	Number of Hopping Frequencies	Limit	Result
1	79	15 non-overlapping channels	Pass

8.6.5 Measurement Plots:

Plot # 1 Number of Hopping Frequencies	
Packet Type: DH5	Modulation: π/4-DQPSK
Hopping On	Total Hopping channels = 79



8.7 Time of Occupancy (Dwell Time)

8.7.1 Measurement according to ANSI C63.10 Section 7.8

Spectrum Analyzer settings:

Duration of Pulse Measurement

- RBW = 1 MHz
- VBW = 3 MHz
- Span = 0
- Sweep Time = 10 ms
- Sweep Mode = Single
- Detector =Peak
- Trigger = Video

Observation Period

- RBW = 1 MHz
- VBW = 3 MHz
- Span = 0
- Sweep Time = 31.6 s
- Sweep Mode = Single
- Detector = Peak
- Trigger = Free Run

Observation Period = 0.4s x No. of hopping channels = 0.4 x 79 = 31.6 s

8.7.2 Limits: FCC 15.247 (a) (1) (iii) & RSS-247

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

8.7.3 Test conditions and setup:

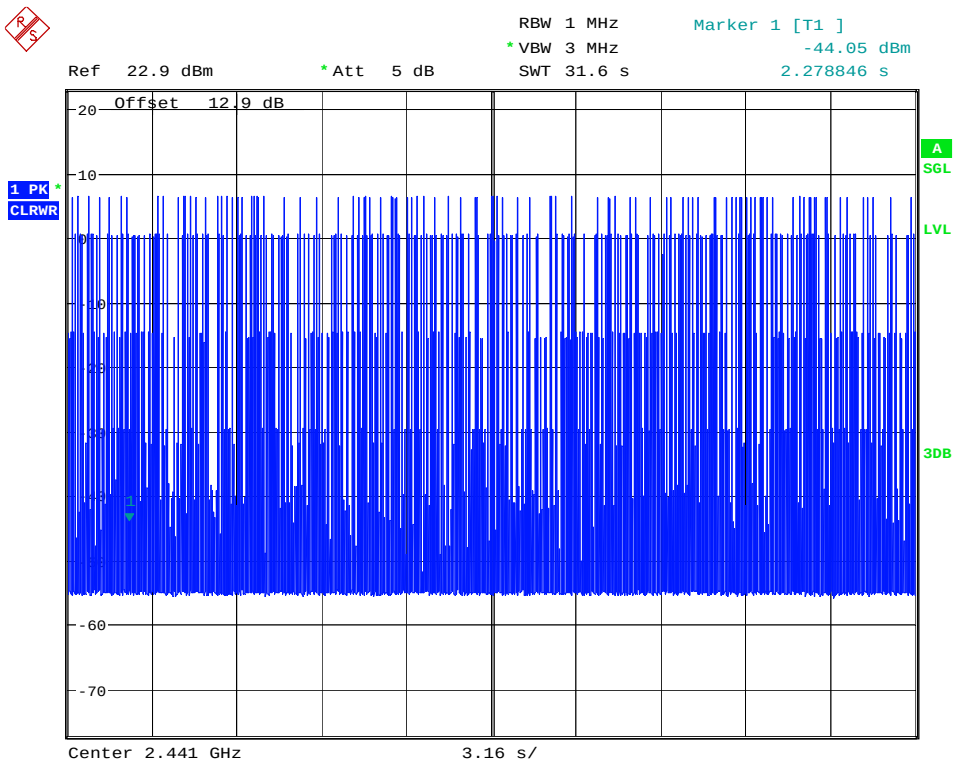
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	2DH5 hopping	USB 5VDC

8.7.4 Measurement result:

Plot #	Modulation	Timing	Number of hops 31.6s	Pulse Width (ms)	Total Dwell Time in 31.6s (ms)	Limit (ms)	Result
1	π/4-DQPSK	DH5	104	2.9	301.6	< 400 in 31.6s	Pass

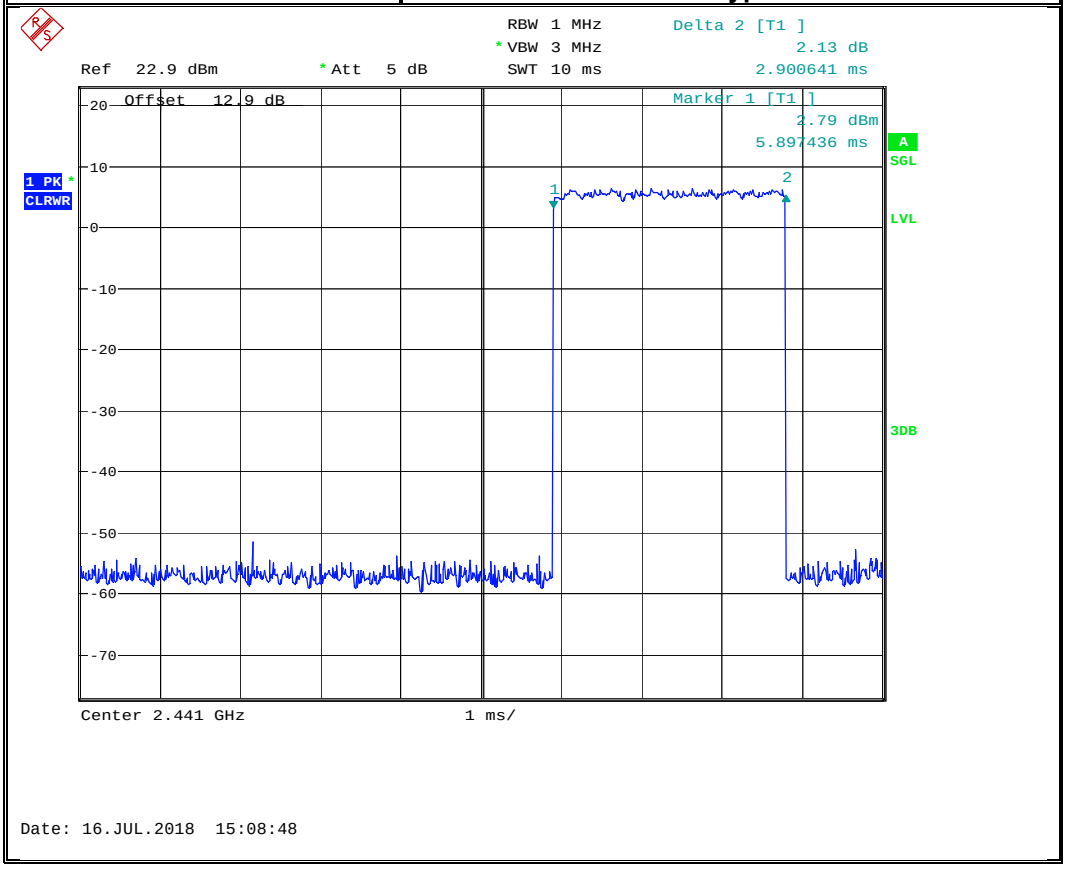
8.7.5 Measurement Plots:

Plot #1 Transmission on Time in Observation Period > (31.6 s)	
Modulation: π/4-DQPSK	Packet Type: DH5



Pulse Duration

Modulation: π/4-DQPSK | Packet Type: DH5



8.8 Transmitter Spurious Emissions and Restricted Bands

8.8.1 Measurement according to ANSI C63.10

Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector = Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW = 120 KHz (<1 GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1MHz

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

8.8.2 Limits: FCC 15.247(d)/15.209(a)

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

- Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).
- PEAK LIMIT= 74dBµV/m
- AVG. LIMIT= 54dBµV/m

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 spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements described in 5.4.
The highest (or worst-case) data rate shall be recorded for each measurement.

For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation as follow:

Conversion factor (CF) = 40 log (D/d) = 40 log (300 m / 3 m) = 80 dB

8.8.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	2DH5 fixed channel	USB 5VDC

8.8.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.8.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.8.2	Pass
9-12	High	30 MHz – 18 GHz	See section 8.8.2	Pass

8.8.5 Measurement Plots:

Plot # 1 Radiated Emissions: 30MHz -1GHz

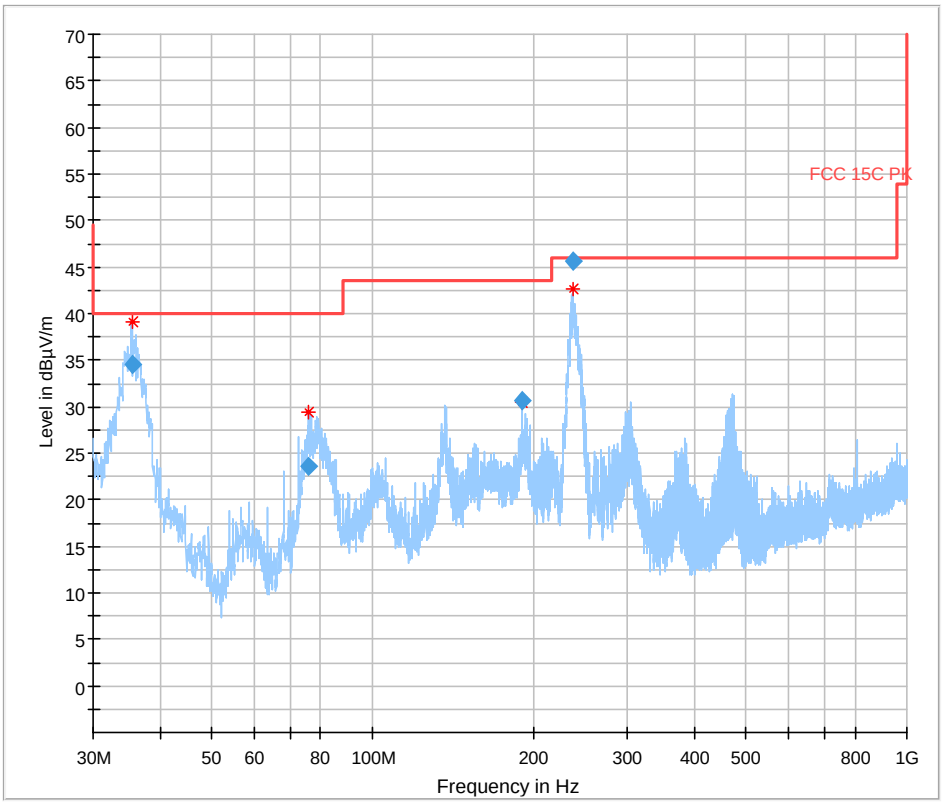
Modulation: π/4-DQPSK	Channel: Low	77.3% Duty Cycle

Final_Result

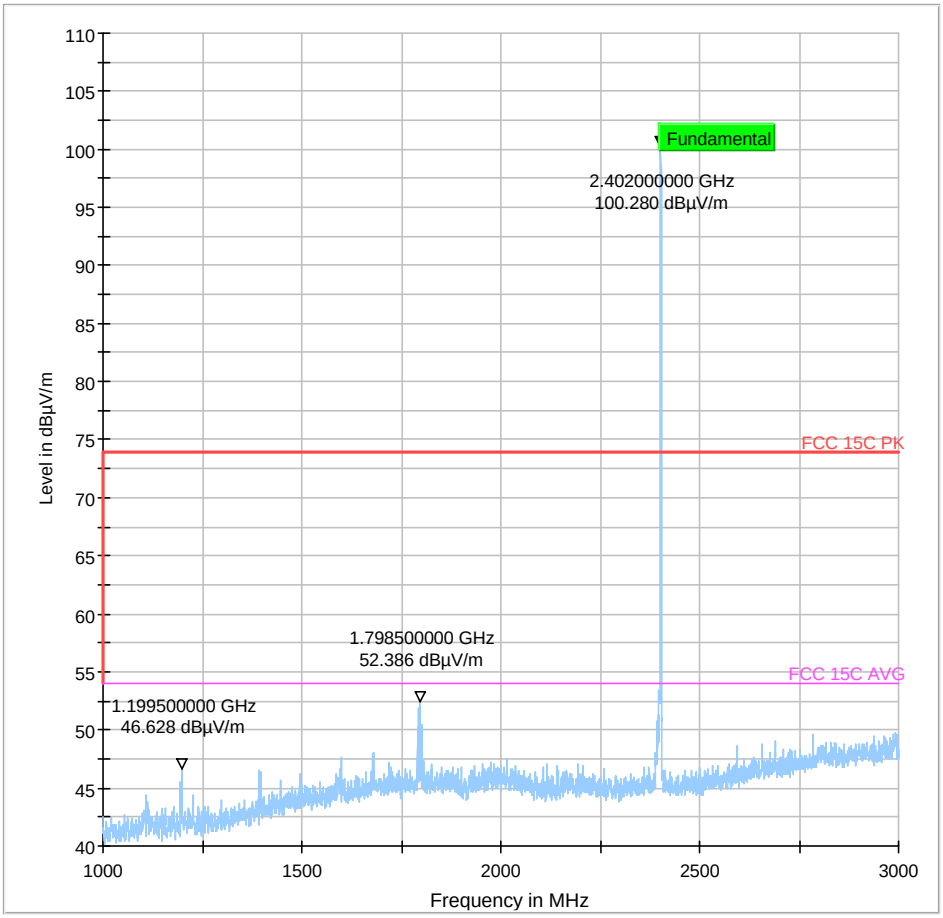
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.504225	34.51	40.00	5.49	500.0	100.000	100.0	V	338.0	-12.8
76.103220	23.64	40.00	16.36	500.0	100.000	153.0	V	264.0	-24.9
190.578205	30.70	43.50	12.80	500.0	100.000	108.0	V	178.0	-21.4
237.466980	45.60	46.00	0.40	500.0	100.000	141.0	H	150.0	-18.8

(continuation of the "Final_Result" table from column 16 ...)

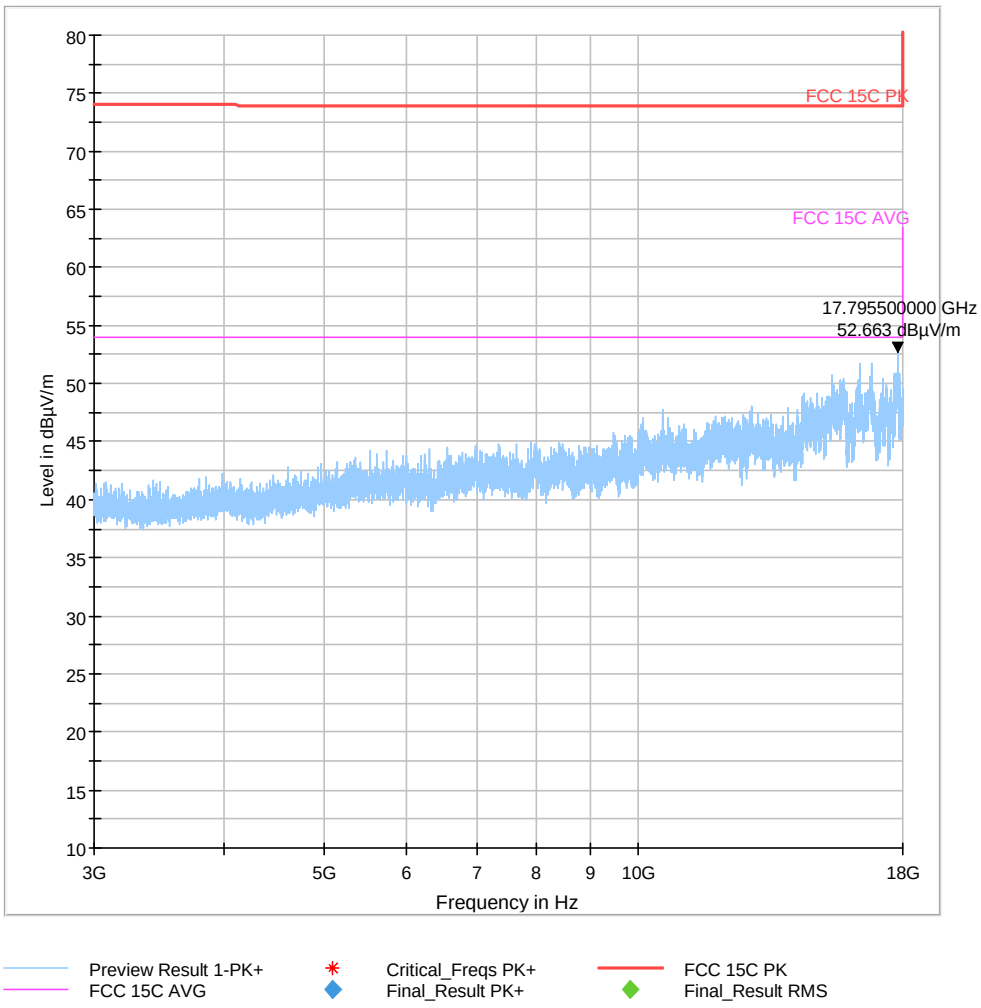
Frequency (MHz)	Comment
35.504225	5:00:35 PM - 7/18/2018
76.103220	4:58:03 PM - 7/18/2018
190.578205	4:55:23 PM - 7/18/2018
237.466980	4:52:50 PM - 7/18/2018



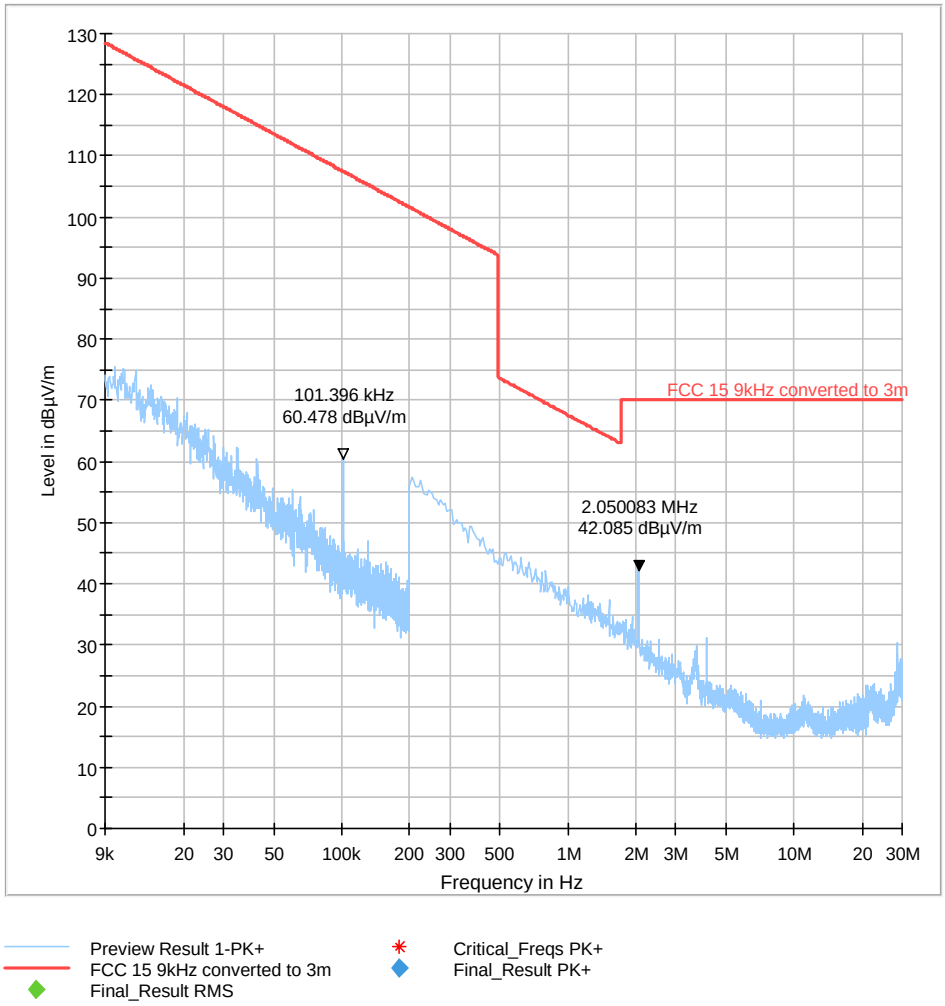
Plot # 2 Radiated Emissions: 1-3 GHz		
Modulation: π/4-DQPSK	**Channel: Low**	**77.3% Duty Cycle**



Plot # 3 Radiated Emissions: 3-18 GHz		
Modulation: π/4-DQPSK	**Channel: Low**	**77.3% Duty Cycle**



Plot # 4 Radiated Emissions: 9 KHz - 30 MHz		
Modulation: π/4-DQPSK	**Channel: Mid**	**77.3% Duty Cycle**



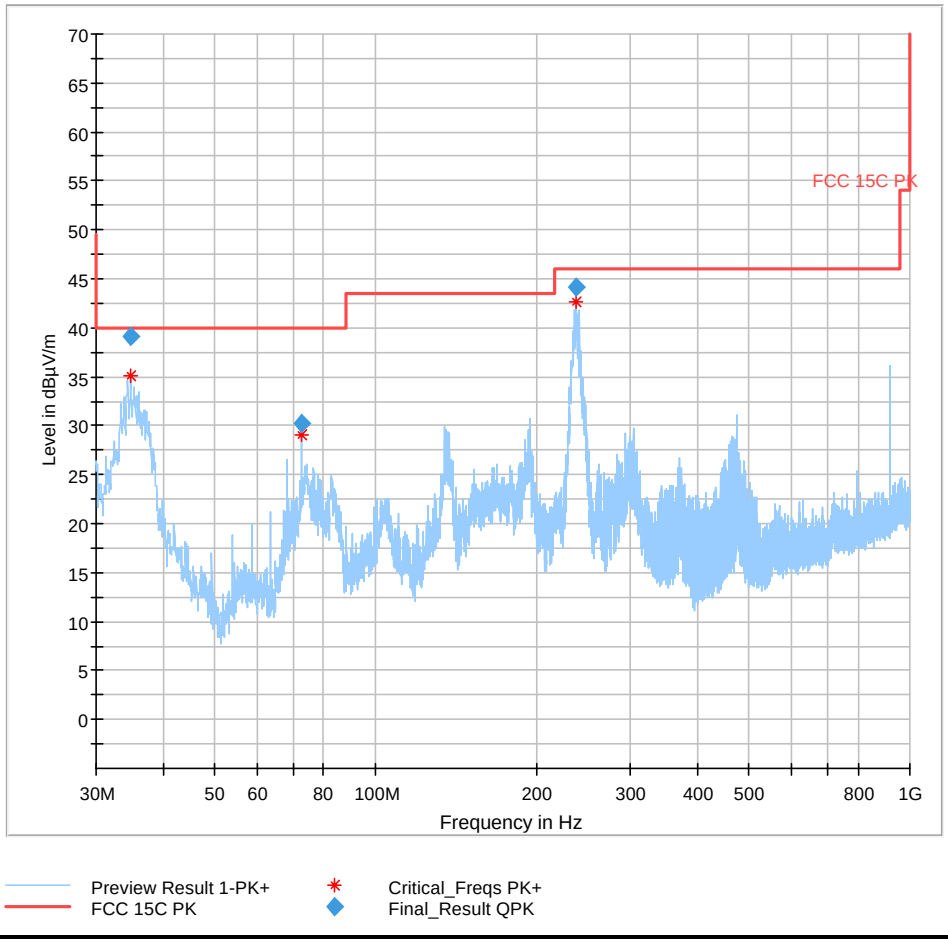
Plot #5 Radiated Emissions: 30 MHz – 1GHz		
Modulation: π/4-DQPSK	**Channel: Mid**	**77.3% Duty Cycle**

Final_Result

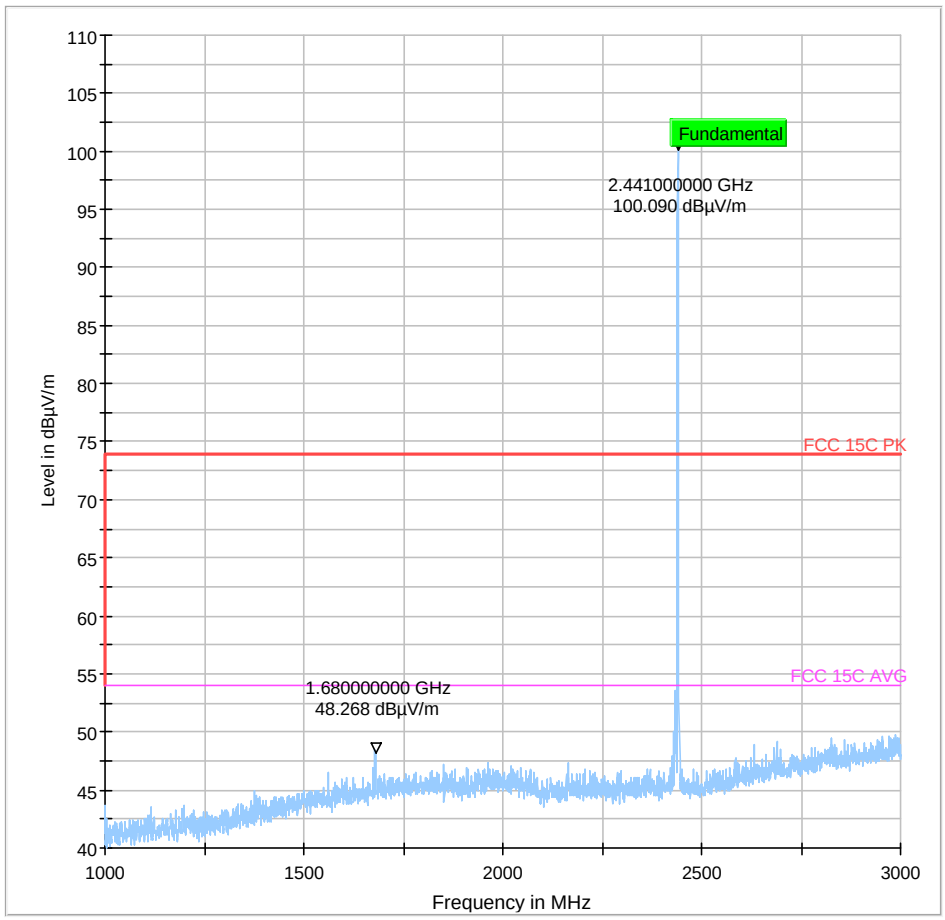
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.829105	39.17	40.00	0.83	500.0	100.000	108.0	V	294.0	-12.5
72.901725	30.17	40.00	9.83	500.0	100.000	255.0	V	174.0	-25.2
237.024200	44.22	46.00	1.78	500.0	100.000	142.0	H	149.0	-18.8

(continuation of the "Final_Result" table from column 16 ...)

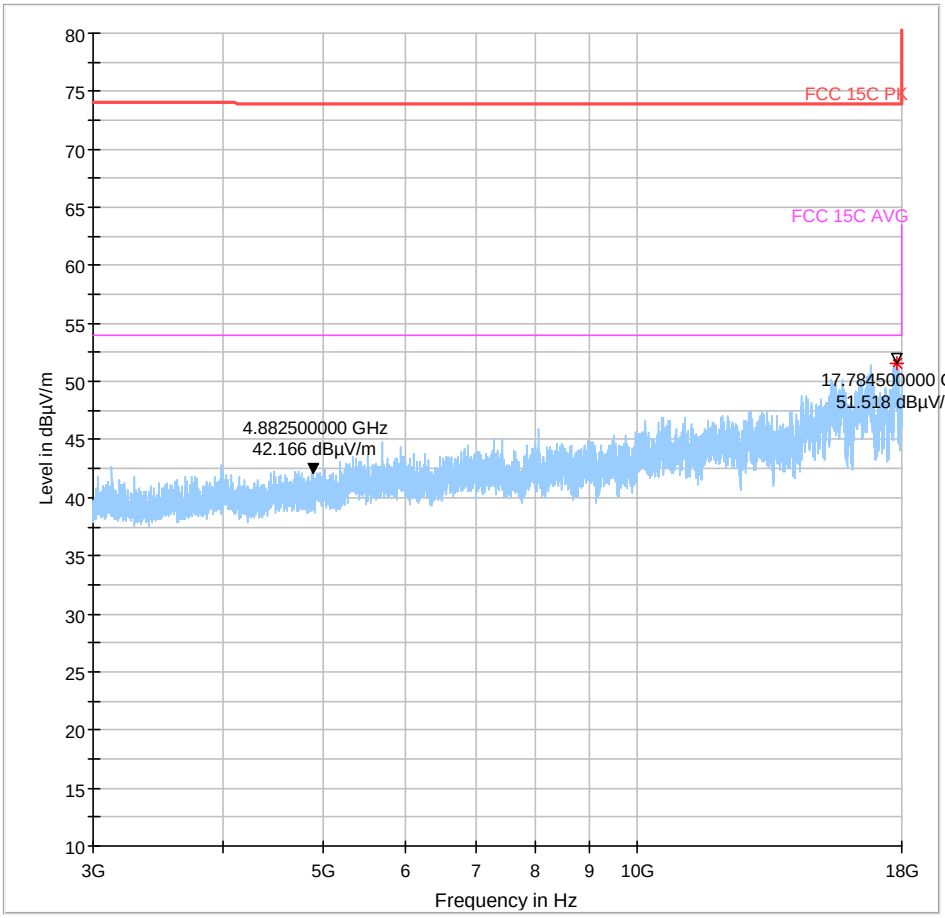
Frequency (MHz)	Comment
34.829105	5:23:26 PM - 7/18/2018
72.901725	5:21:01 PM - 7/18/2018
237.024200	5:18:24 PM - 7/18/2018



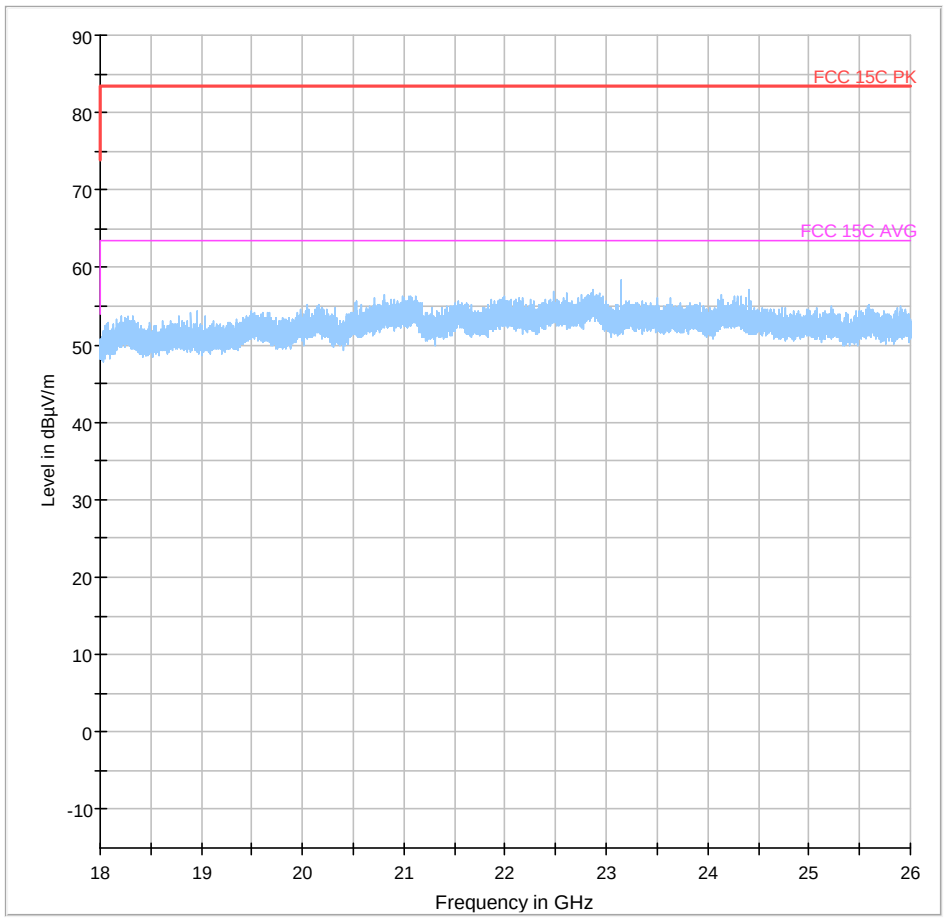
Plot #6 Radiated Emissions: 1-3 GHz		
Modulation: π/4-DQPSK	**Channel: Mid**	**77.3% Duty Cycle**



Plot #7 Radiated Emissions: 3-18 GHz		
Modulation: π/4-DQPSK	**Channel: Mid**	**77.3% Duty Cycle**



Plot #8 Radiated Emissions: 18-26 GHz		
Modulation: π/4-DQPSK	**Channel: Mid**	**77.3% Duty Cycle**



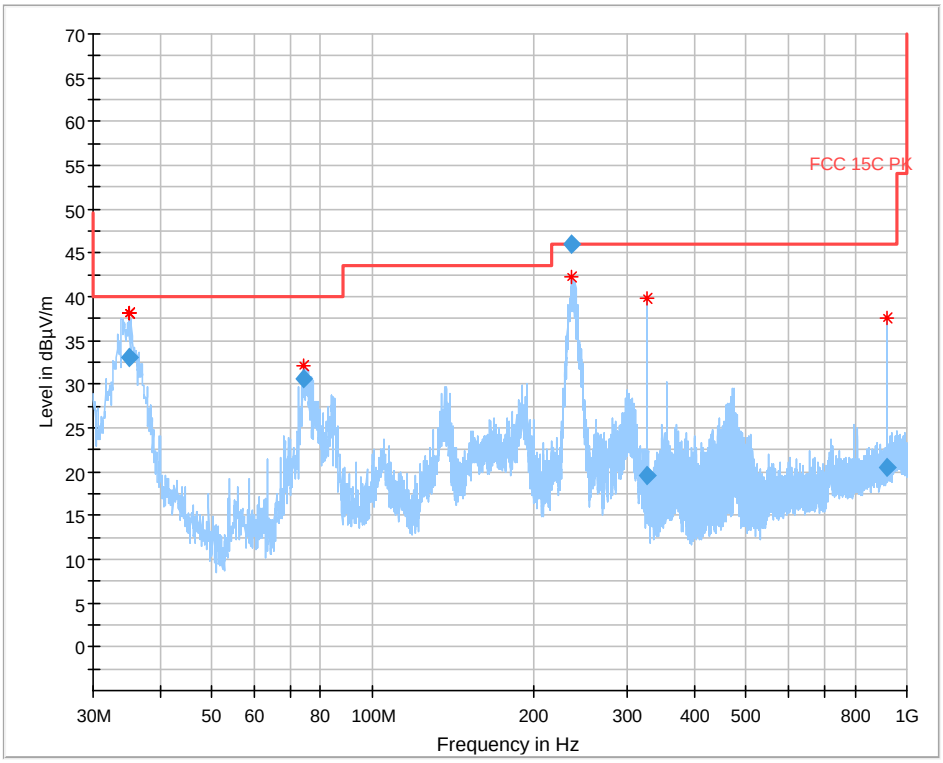
Plot #9 Radiated Emissions: 30 MHz – 1GHz		
Modulation: π/4-DQPSK	**Channel: High**	**77.3% Duty Cycle**

Final_Result

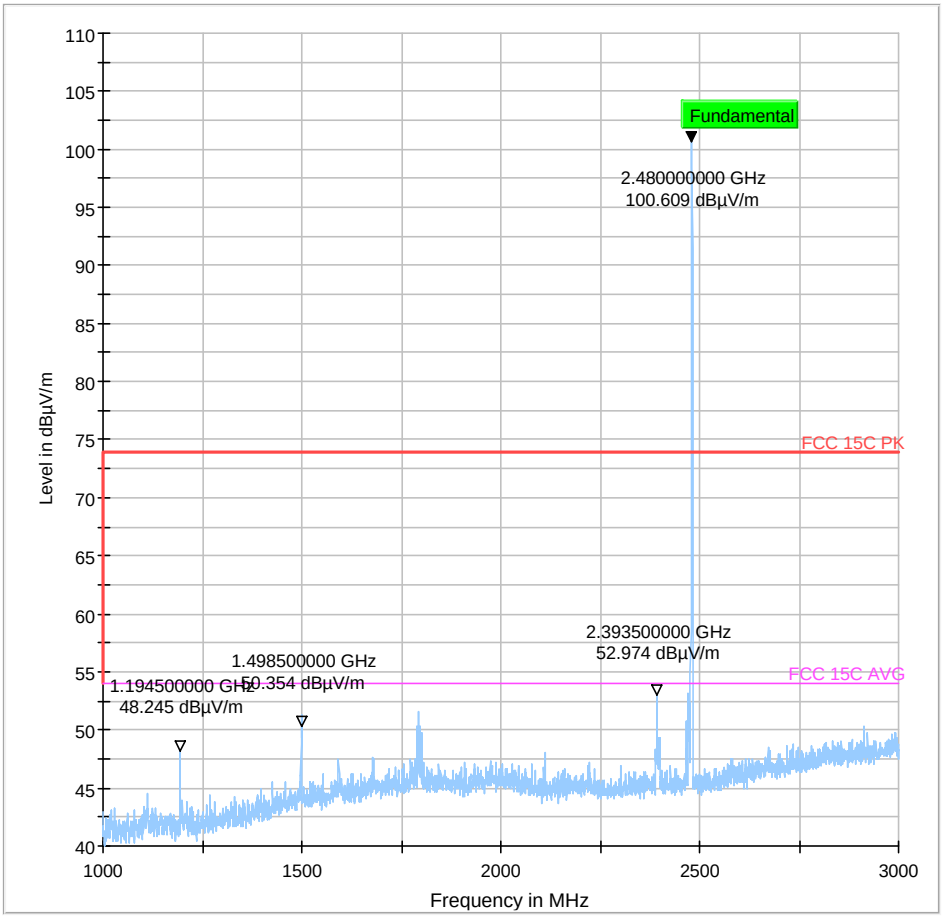
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.029815	33.13	40.00	6.87	500.0	100.000	108.0	V	26.0	-12.6
74.322530	30.61	40.00	9.39	500.0	100.000	142.0	V	-80.0	-25.0
235.772060	45.94	46.00	0.06	500.0	100.000	132.0	H	152.0	-18.8
326.954490	19.49	46.00	26.51	500.0	100.000	132.0	V	262.0	-17.2
920.596600	20.45	46.00	25.55	500.0	100.000	143.0	V	286.0	-5.8

(continuation of the "Final_Result" table from column 16 ...)

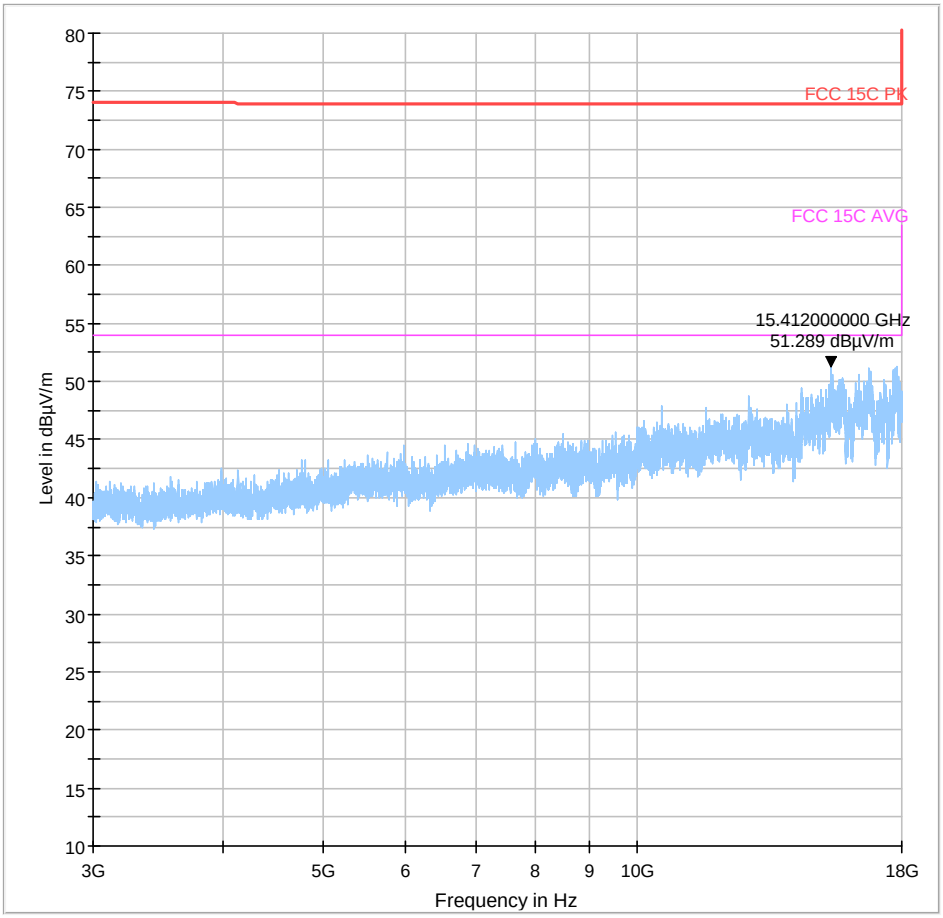
Frequency (MHz)	Comment
35.029815	5:50:42 PM - 7/18/2018
74.322530	5:37:31 PM - 7/18/2018
235.772060	5:34:36 PM - 7/18/2018
326.954490	5:43:35 PM - 7/18/2018
920.596600	5:46:08 PM - 7/18/2018



Plot # 10 Radiated Emissions: 1-3 GHz and Restricted Bands		
Modulation: π/4-DQPSK	**Channel: High**	**77.3% Duty Cycle**



Plot #11 Radiated Emissions: 3-18 GHz		
Modulation: π/4-DQPSK	**Channel: High**	**77.3% Duty Cycle**



9 Test setup photos

Setup photos are included in supporting file name: “EMC_VIRSC-001-17001_15.247_BT_Setup_Photos.pdf”

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Biconlog Antenna	EMCO	3142E	166067	3 years	6/28/2017
Loop Antenna	ETS Lindgren	6507	161344	3 years	10/26/2017
Horn Antenna	EMCO	3115	35111	3 years	11/17/2015
Horn Antenna	ETS Lindgren	3117 PA	169547	3 years	8/8/2017
Compact Digital Barometer	Control Company	35519-055	91119547	2 Years	6/20/2017
Spectrum Analyzer	R&S	FSU26	200065	3 years	7/3/2017
Spectrum Analyzer	R&S	FSV40	101022	3 years	7/5/2017
Thermometer Humidity	Dickson	TM320	5280063	1 Year	11/2/2017

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated “N/A” for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

Date	Report Name	Changes to report	Report prepared by
2019-02-05	EMC_VIRSC-001-17001_15.247_BT_DSS	Initial Version	Kevin Wang