



Bluetooth (Basic rate/EDR)

FCC / IC Test Report

FOR:

Apple Inc.

Model Name: A1644

Product Description:

Bluetooth Device with BDR, EDR and LE Support

FCC ID: BCGA1644

IC ID: 579C-A1644

47 CFR Part 15.247 [DSS]

RSS-247 Issue 1 [FHS] & RSS-Gen Issue 4

TEST REPORT #: EMC_APPLE-166-15001_15.247_BT_rev2

DATE: 2015-08-13



A2LA Accredited

**IC recognized #
3462B**

CETECOM Inc.

411 Dixon Landing Road ♦ Milpitas, CA 95035 ♦ U.S.A.

Phone: + 1 (408) 586 6200 ♦ Fax: + 1 (408) 586 6299 ♦ E-mail: info@cetecom.com ♦ <http://www.cetecom.com>

CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

TABLE OF CONTENTS

1	Assessment	4
2	Administrative Data.....	5
2.1	Identification of the Testing Laboratory Issuing the Test Report	5
2.2	Identification of the Client	5
2.3	Identification of the Manufacturer	5
3	Equipment under Test (EUT)	6
3.1	Specification of the Equipment under Test.....	6
3.2	Identification of the Equipment Under Test (EUT)	7
3.3	Identification of Ancillary equipment	7
3.4	Environmental conditions during Test:	7
3.5	Dates of Testing:	7
3.6	Test mode of operation with multiple modulations:	8
4	Subject of Investigation	9
5	Summary of Measurement Results	10
6	Measurements.....	11
6.1	Radiated Measurement Procedure.....	11
6.2	Sample Calculations for Radiated Measurements.....	12
6.2.1	Field Strength Measurements:	12
6.3	Conducted Emissions Measurement Procedure (AC Power Line)	13
6.4	RF Conducted Measurement Procedure.....	14
7	Technical Specifications Requirements	15
7.1	Maximum Peak Conducted Output Power.....	15
7.1.1	Limits:	15
7.1.2	Test Conditions	15
7.1.3	Test Procedure.....	15
7.1.4	Test Data:	16
7.1.5	Measurement Result.....	16
7.1.6	Measurement Plots:	17
7.2	Band Edge Compliance & Restricted and Non-restricted Band Edge	26
7.2.1	Limits: §15.247/15.205 & RSS-247 Section 5.5/RSS-Gen Section 8.10	26
7.2.2	Test Conditions	27
7.2.3	Test Procedure.....	28
7.2.4	Measurement Result.....	28
7.2.5	Measurement Plots:	29
7.3	20dB Bandwidth / 99% Bandwidth.....	37

7.3.1	Limits:	37
7.3.2	Test Conditions:	37
7.3.3	Test Procedure.....	37
7.3.4	Test Data:	38
7.3.5	Measurement Result.....	38
7.3.6	Test Data/plots:	39
7.4	Carrier Frequency Separation	48
7.4.1	Limits:	48
7.4.2	Test Conditions:	48
7.4.3	Test Procedure:	48
7.4.4	Measurement result:	48
7.4.5	Measurement plots:	49
7.5	Number of hopping channels	51
7.5.1	Limits:	51
7.5.2	Test Conditions:	51
7.5.3	Test Procedure:	51
7.5.4	Measurement Result:	51
7.5.5	Measurement Plots:	51
7.6	Time of occupancy / Dwell time	54
7.6.1	Limits:	54
7.6.2	Test Conditions	54
7.6.3	Test Procedure:	54
7.6.4	Measurement Result:	55
7.6.5	Test Data/Plots:	56
7.7	Transmitter Spurious Emissions & Restricted Bands- Radiated.....	66
7.7.1	Limits:	66
7.7.2	Test Conditions	67
7.7.3	Test Procedure.....	68
7.7.4	Measurement Result:	68
7.7.5	Measurement plots:	69
7.8	AC Power Line Conducted Emissions.....	91
7.8.1	Limits:	91
7.8.2	Test Conditions:	91
7.8.3	Test Procedure.....	91
7.8.4	Measurement Result:	92
7.8.5	Measurement Plots:	92
8	Test Equipment and Ancillaries used for tests.....	94
9	Test Setup Diagram:	95
10	Revision History	97

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 IC standard RSS-247 issue 1, Section 5. No deviations were ascertained.

Company	Description	Model #
Apple Inc.	Bluetooth Device with BDR, EDR and LE Support	A1644

Responsible for Testing Laboratory:

Franz Engert

2015-08-13 Compliance (Compliance Manager)



Digitally signed by
Franz Engert
DN: cn=Franz Engert,
c=US, o=CETECOM,
ou=Compliance,
email=franz.
engert@cetecom.com

Date	Section	Name	Signature
------	---------	------	-----------

Responsible for the Report:Douglas Antioco
(EMC Engineer)

2015-08-13 Compliance

Douglas Antioco
2015.08.13
11:44:13 -07'00'

Date	Section	Name	Signature
------	---------	------	-----------

The test results of this test report relate exclusively to the test item specified in Section 3.

CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Address:	411 Dixon Landing Road Milpitas, CA 95035 U.S.A.
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Compliance Manager:	Franz Engert
Responsible Project Leader:	Douglas Antioco

2.2 Identification of the Client

Applicant's Name:	Apple Inc.
Street Address:	1 Infinite Loop
City/Zip Code	Cupertino, CA 95014
Country	USA
Contact Person:	Jacqueline Zhai
Phone No.	(408) 620-0616
Fax:	-----
e-mail:	jacqueline_zhai@apple.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Applicant
Manufacturers Address:	---
City/Zip Code	---
Country	---

3 Equipment under Test (EUT)

3.1 Specification of the Equipment under Test

Model No:	A1644
HW Version :	Rev 1.0
SW Version :	STFW 0x0781 (BTFW 0x0048)
FCC-ID :	BCGA1644
IC-ID:	579C-A1644
HVIN:	A1644
PMN:	A1644
Product Description:	Bluetooth Device with BDR, EDR and LE Support
Frequency Range / number of channels:	Nominal band: 2400 – 2483.5; Center to center: 2402(ch 0) – 2480(ch 78), 79 channels
Type(s) of Modulation:	Bluetooth Basic/EDR: GFSK, $\pi/4$ DQPSK, 8DPSK
Modes of Operation:	Hopping
Antenna Information as declared:	Slot Antenna: Documented max antenna gain (2.4GHz) = 6 dBi
Max. Output Powers:	Conducted Peak Power: 7.57 dBm (5.71 mW) with 8-DPSK
Power Supply/ Rated Operating Voltage Range:	lithium battery pack (dedicated) Vmin: 3.0V dc/ Vnom: 3.8V dc / Vmax: 4.3V dc
operating temperature range	0 °C to 35 °C
Other Radios included in the device:	1. Bluetooth 4.2 Low Energy (BT LE)
Prototype / Production unit	Pre-Production

3.2 Identification of the Equipment Under Test (EUT)

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	F0T5172006BGJYP18	Rev 1.0	STFW 0x0781 BTFW 0x0048	Radiated and Conducted Emissions (AC power line) Sample
2	F0T5172001ZGJYL14	Rev 1.0	STFW 0x0781 BTFW 0x0048	Conducted RF Sample

3.3 Identification of Ancillary equipment

STE #	Type	Manufacturer	Model	Serial Number	Notes/Comments
1	USB Power Adapter	Phihong	PSAI05R-050Q	P142302633A1	Conducted Emissions
2	USB Power Adapter	Apple	A1357	W010A051	Radiated Emissions

3.4 Environmental conditions during Test:

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

Ambient Temperature: 20-25°C

Relative humidity: 40-60%

3.5 Dates of Testing:

6/3/2015-6/8/2015

3.6 Test mode of operation with multiple modulations:

1. The channels and modulation schemes of the EUT was set with a 100% Duty Cycle using special software that is not available to the end user.
2. According to RMS measurements using a fast power sensor, the GFSK modulation scheme has the highest output power.

- a. RMS Power Measurements (used for reference)

Modulation	100% duty cycle
GFSK	6.86
8PSK	4.71
QPSK	4.71

3. According to peak power measurements, the 8-DPSK modulation scheme was found to have the highest value (Section 7).
4. The GFSK and 8-DPSK modulation schemes were used in all test cases as they are considered the worst case with respect to output power (RMS and Peak).
5. During tests which require Frequency Hopping, the packet length is DH5 unless otherwise noted. This value was selected by measuring the RMS Power of the different timing schemes of GFSK modulation, although the deviation in the timing schemes is within the conducted RF measurement uncertainty (Section 6.4).

- a. RMS power of timing schemes.

Timing	Ch 39 (2441MHz) GFSK (dBm)
DH1/ 2-DH1	6.54
DH3/ 3-DH3	6.55
DH5/ 3-DH5	6.74

4 Subject of Investigation

The objective of the evaluation documented in this report was to assess if the performance of the EUT meets 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 Issue 1, Section 5 of Industry Canada.

This test report is to support a request for new equipment authorization under the FCC ID: BCGA1644 and IC: 579C-A1644

All testing was performed on the product referred to in Section 3 as the EUT.

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

Testing procedures are based on Public Notice “DA 00-705: March 30, 2000” and ANSI C63.10:2013 for FHSS systems.

A worst case evaluation for the highest power modulation has been carried out for GFSK and 8-DPSK modulation with 100% Duty Cycle.

For Bandwidth and timing measurements packet types and modulations have been tested according to DA 00-705: March 30, 2000.

5 Summary of Measurement Results

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§15.247(b)(1) RSS-247 5.4 (2)	Maximum Peak Conducted Output Power	Nominal	GFSK QPSK 8DPSK	■	□	□	□	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	GFSK 8DPSK	■	□	□	□	Complies
§15.247(a)(1) RSS-247 5.1 (1)	Spectrum Bandwidth	Nominal	GFSK QPSK 8DPSK	■	□	□	□	Complies
§15.247(a)(1) RSS-247 5.1 (1)	Carrier Frequency Separation	Nominal	GFSK 8DPSK	■	□	□	□	Complies
§15.247(a)(1) RSS-247 5.1 (4)	Number of Hopping Channels	Nominal	GFSK 8DPSK	■	□	□	□	Complies
§15.247(a)(1)(iii) RSS-247 5.1 (4)	Time of occupancy	Nominal	GFSK QPSK 8DPSK	■	□	□	□	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions- Radiated	Nominal	GFSK 8DPSK	■	□	□	□	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions <30MHz	Nominal	GFSK 8DPSK	■	□	□	□	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurements

6.1 Radiated Measurement Procedure

**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 9kHz to 30MHz, a Biconlog antenna is used from 30MHz to 1GHz, two different horn antennas are used to cover frequencies up to 40GHz.

Radiated Measurement Uncertainty:

	Uncertainty in dB Radiated <30MHz	Uncertainty in dB Radiated 30MHz - 1GHz	Uncertainty in dB Radiated > 1GHz
Standard Deviation k=1	2.48	1.94	2.16
95% Confidence Interval in dB	4.86	3.79	4.24
95% Confidence Interval in dB in Delta to Result	+/-2.5 dB	+/-2.0 dB	+/- 2.3dB

6.2 Sample Calculations for Radiated Measurements

6.2.1 Field Strength Measurements:

Measurements from the Spectrum Analyzer/ Receiver are used to calculate the Field Strength, taking into account the following parameters:

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

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

Eg:

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

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

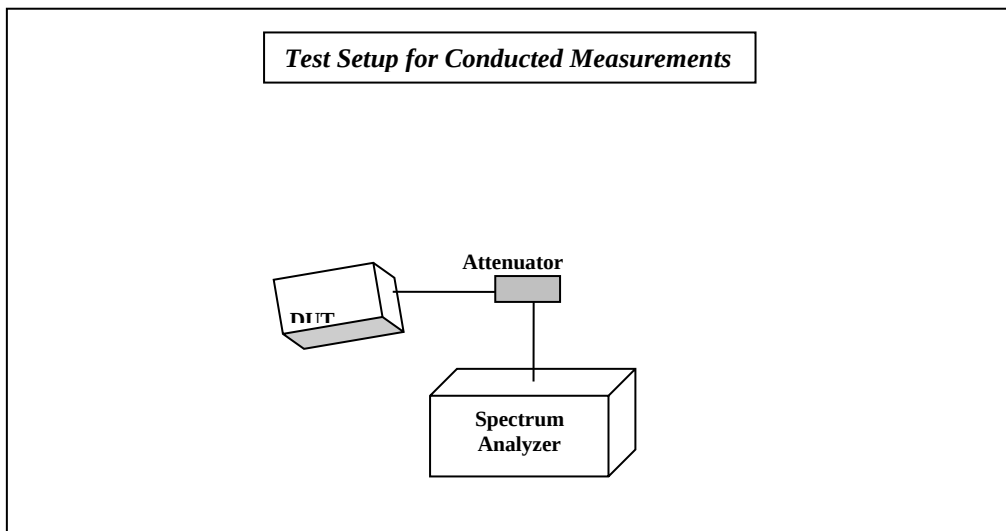
6.3 Conducted Emissions Measurement Procedure (AC Power Line)

Conducted Emissions measurements done according to:

ANSI C63.10 (2013)

6.4 RF Conducted Measurement Procedure

Reference: FCC Public Notice DA 00-705:2000 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems).



1. Connect the equipment as shown in the above diagram.
2. Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
3. Measurements are to be performed with the EUT set to the low, middle and high channels and for GFSK, $\pi/4$ DQPSK and 8-DPSK modulation schemes.

Measurement Uncertainty:

	Uncertainty in dB Conducted measurement
standard deviation k=1	0.63
95% confidence interval in dB	1.24
95% confidence interval in dB in delta to Result	+/-0.7dB

7 Technical Specifications Requirements

7.1 Maximum Peak Conducted Output Power

7.1.1 Limits:

Maximum Peak Output Power:

FCC §15.247 (b)(1): 1W

IC RSS-247 issue 1, Section 5.4(2): 1W

7.1.2 Test Conditions

Tnom: 20°C; Vnom: 3.8V

7.1.3 Test Procedure

Refer to DA 00-705:2000

Hopping OFF

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

Detector function = peak

Trace = max hold

Use the marker-peak function to set the marker to the peak of the emission.

Specified Antenna Gain (dBi):

2.400 – 2.48GHz: +6 dBi

7.1.4 Test Data:

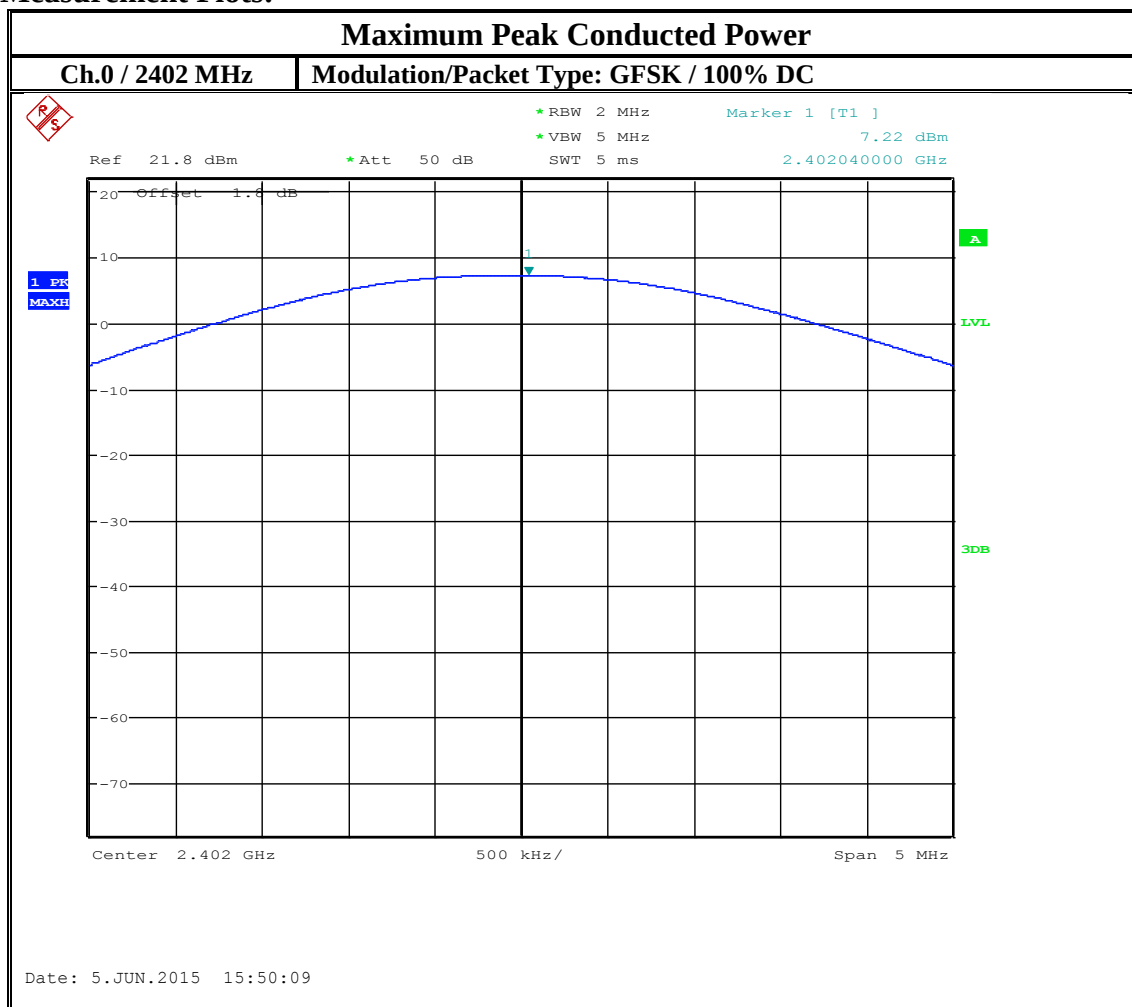
Maximum Peak Conducted Output Power (dBm)			
Modulation	Frequency (MHz)		
	2402	2441	2480
GFSK	7.22	7.18	7.21
8-DPSK	7.52	7.53	7.57
$\pi/4$ DQPSK	7.09	7.15	7.08

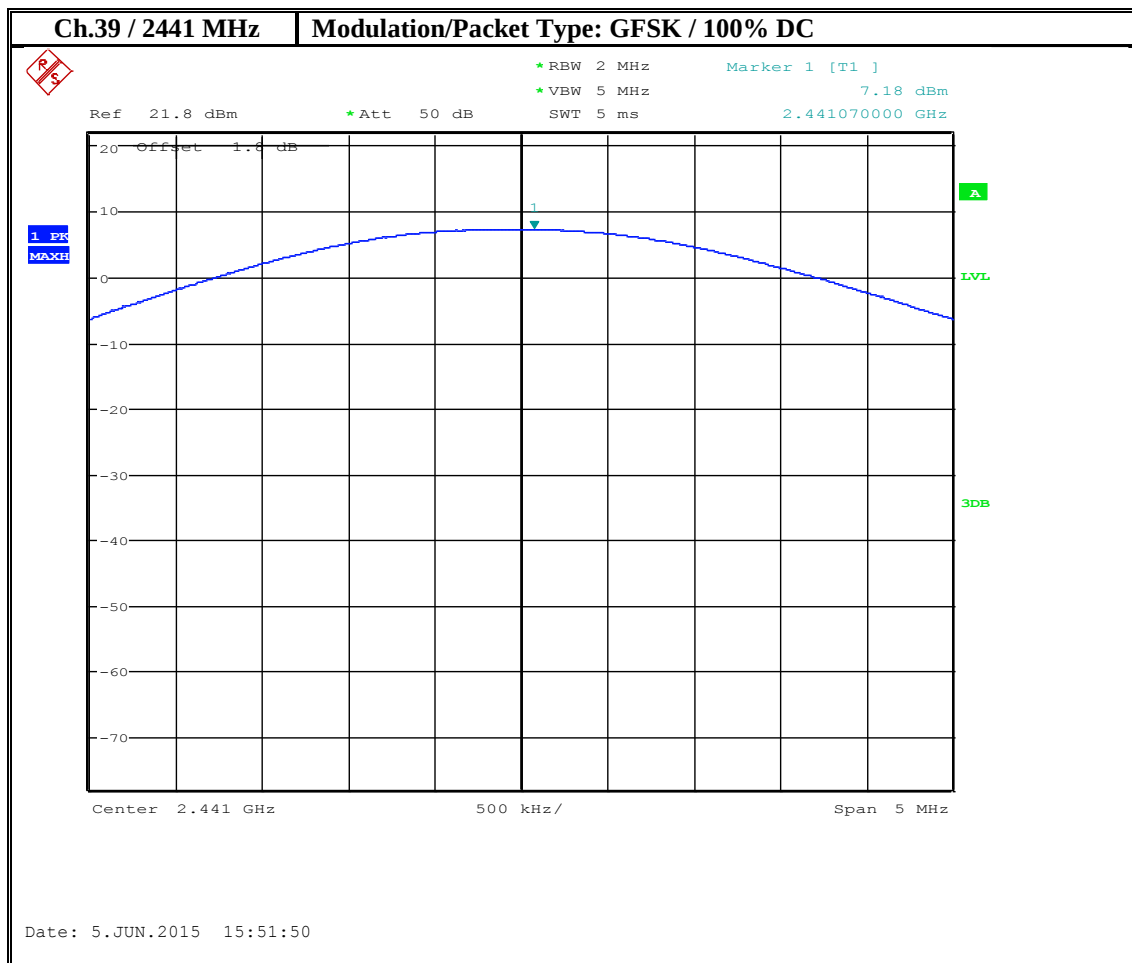
Limit: 30 dBm

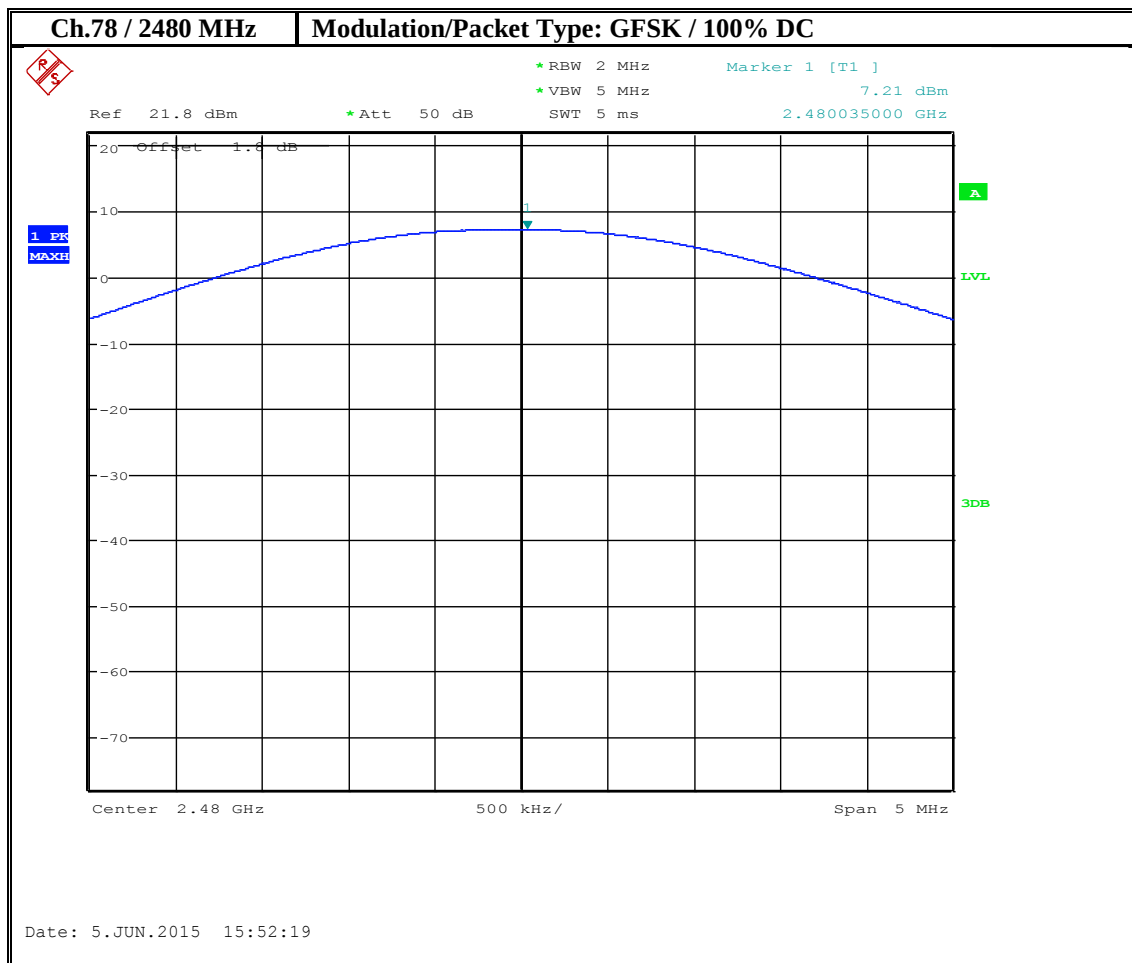
7.1.5 Measurement Result

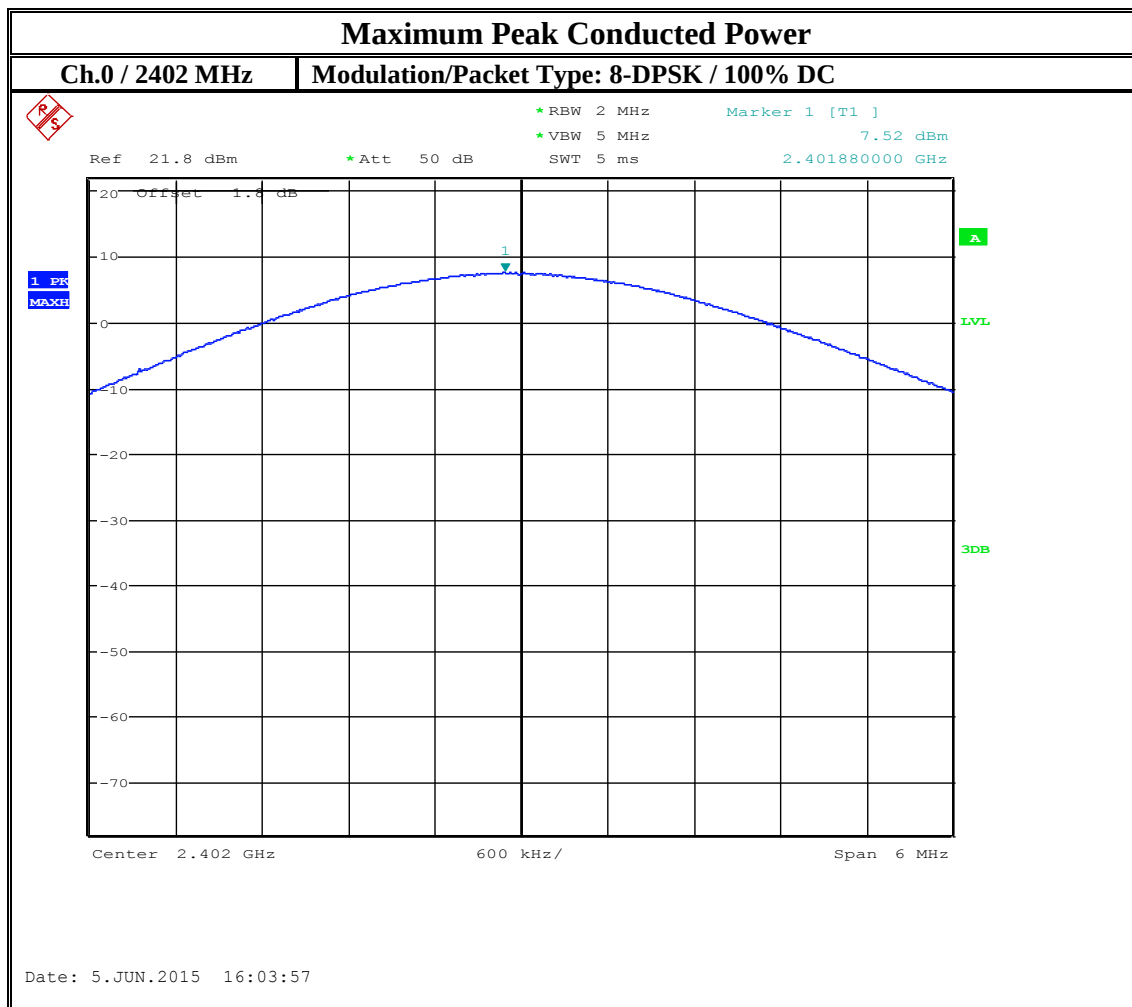
Pass.

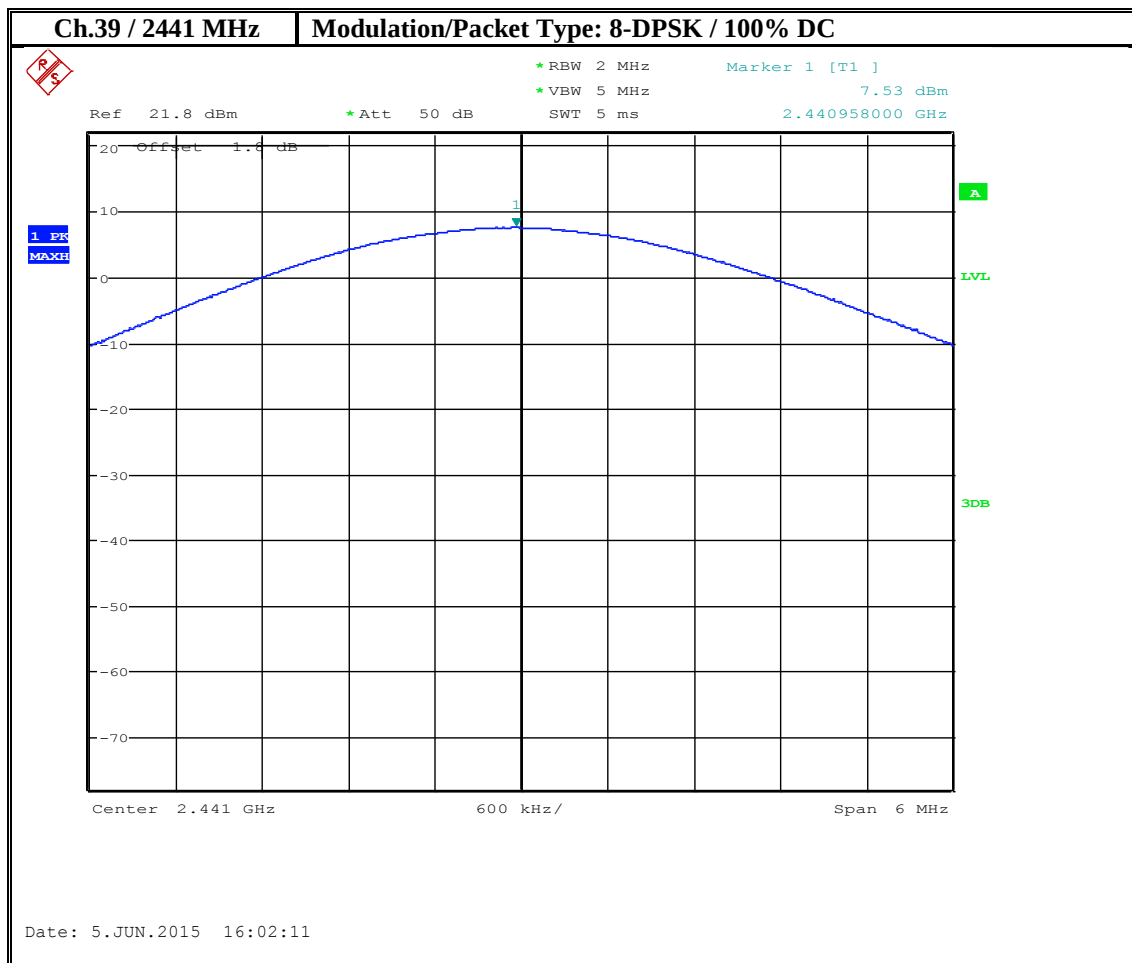
7.1.6 Measurement Plots:

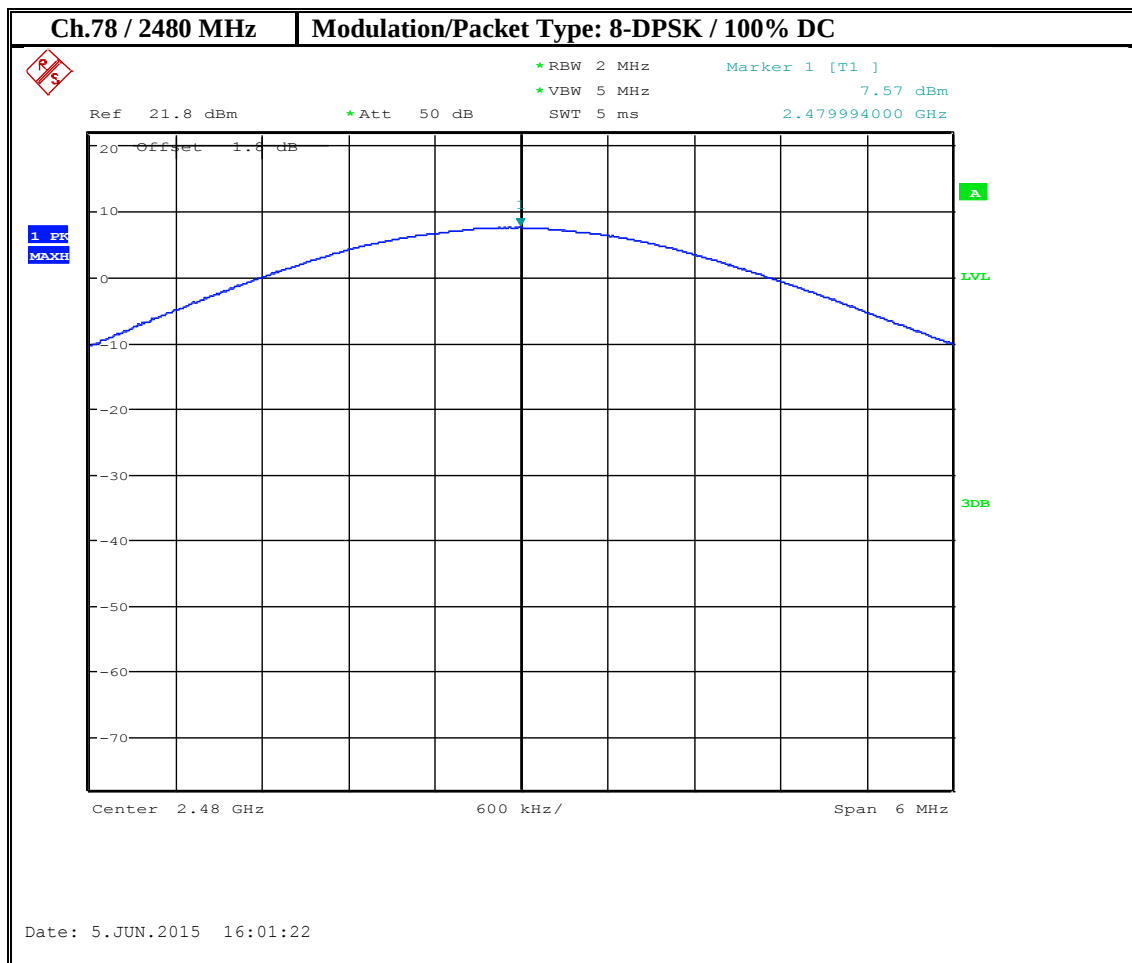


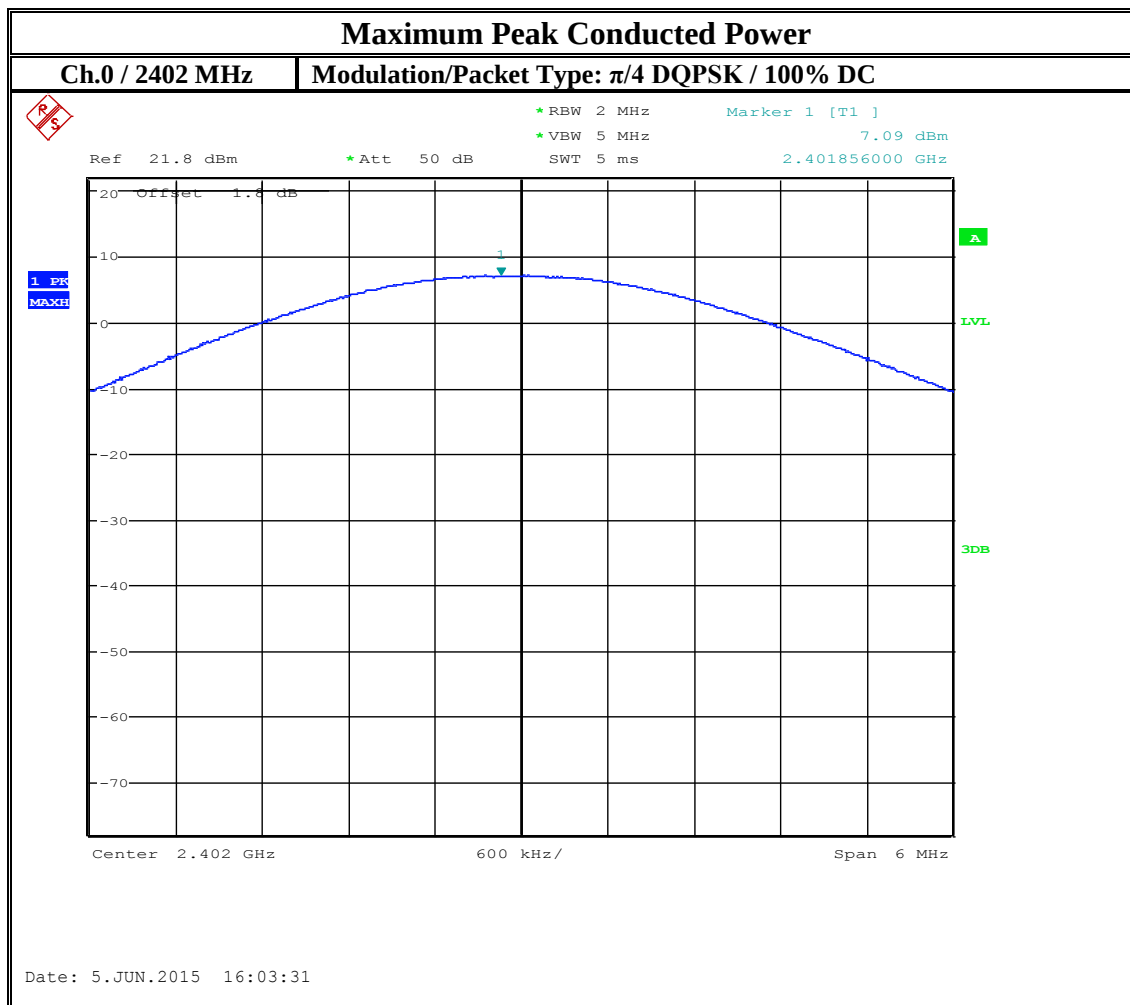


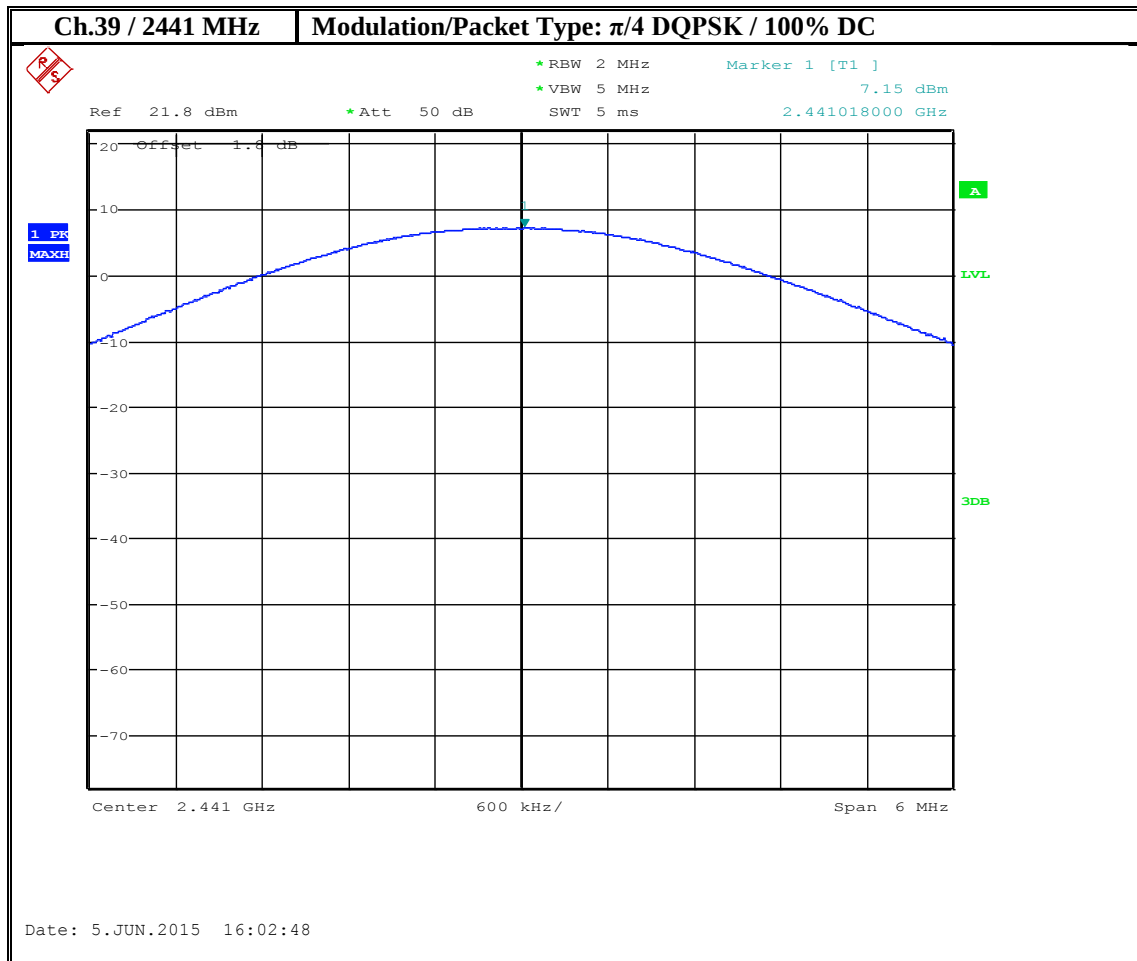


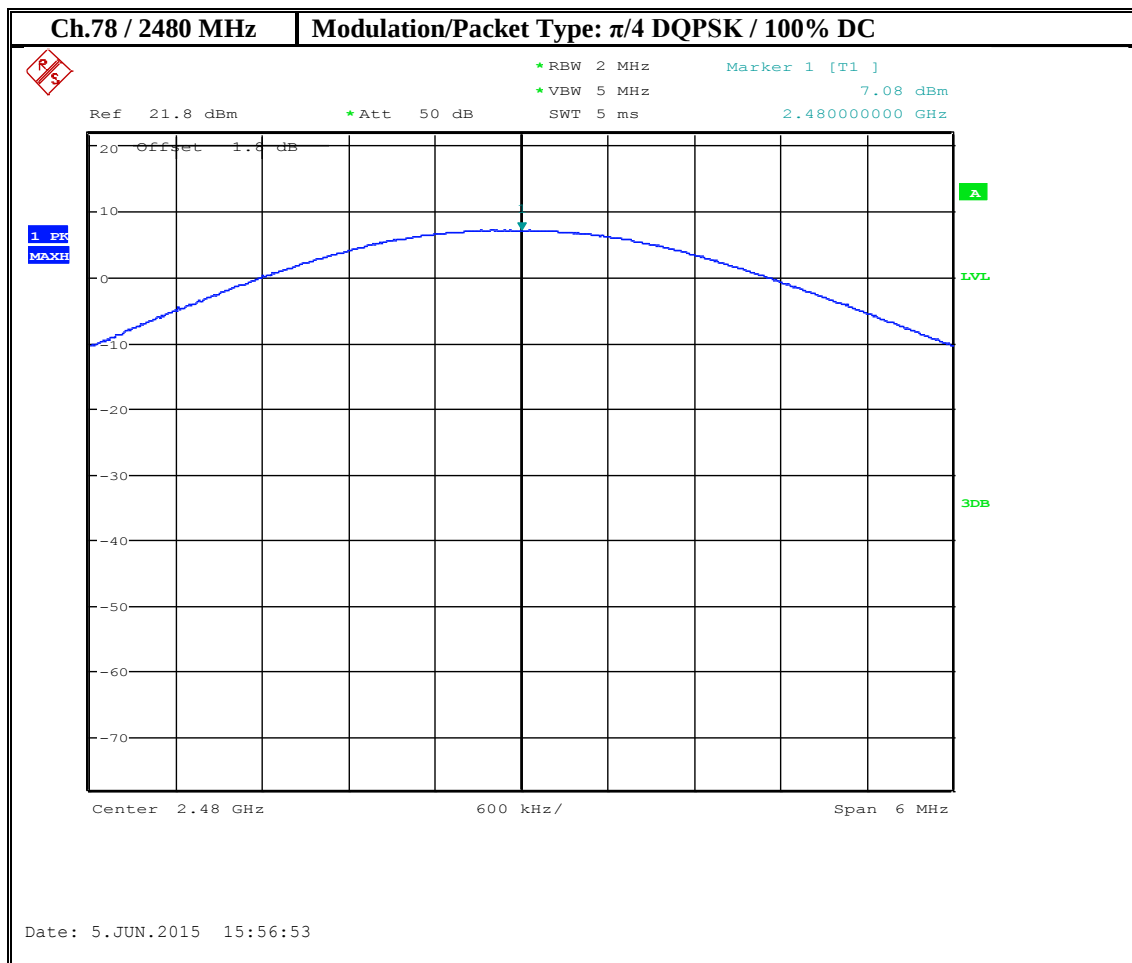












7.2 Band Edge Compliance & Restricted and Non-restricted Band Edge**7.2.1 Limits: §15.247/15.205 & RSS-247 Section 5.5/RSS-Gen Section 8.10****§15.205**

(a) Except as shown in paragraph (d) of this section, 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	(²)
13.36 - 13.41			

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 device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

7.2.2 Test Conditions

Tnom: 20°C; Vnom: 3.8V

7.2.3 Test Procedure

Refer to DA 00-705:2000

Spectrum Analyzer settings for band edge:

Span: wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation.

RBW $\geq$ 1% of the spanVBW $\geq$ RBW

Sweep Time: Auto

Detector = peak

Trace = max. hold

Allow the trace to stabilize. Set the marker on the emission at the bandedge, or on the highest modulation product outside of the band, if this level is greater than that at the bandedge.

Spectrum Analyzer settings for restricted band:Peak measurements are made using a peak detector and RBW=1 MHz, VBW $\geq$ RBW

At 3 meter distance radiated limits are:

*PEAK LIMIT= 74dB μ V/m*AVG. LIMIT= 54dB μ V/m

For conducted measurements at the antenna port:

*PEAK LIMIT= -21.2 dBm EIRP

*AVG. LIMIT= -41.2 dBm EIRP

Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10

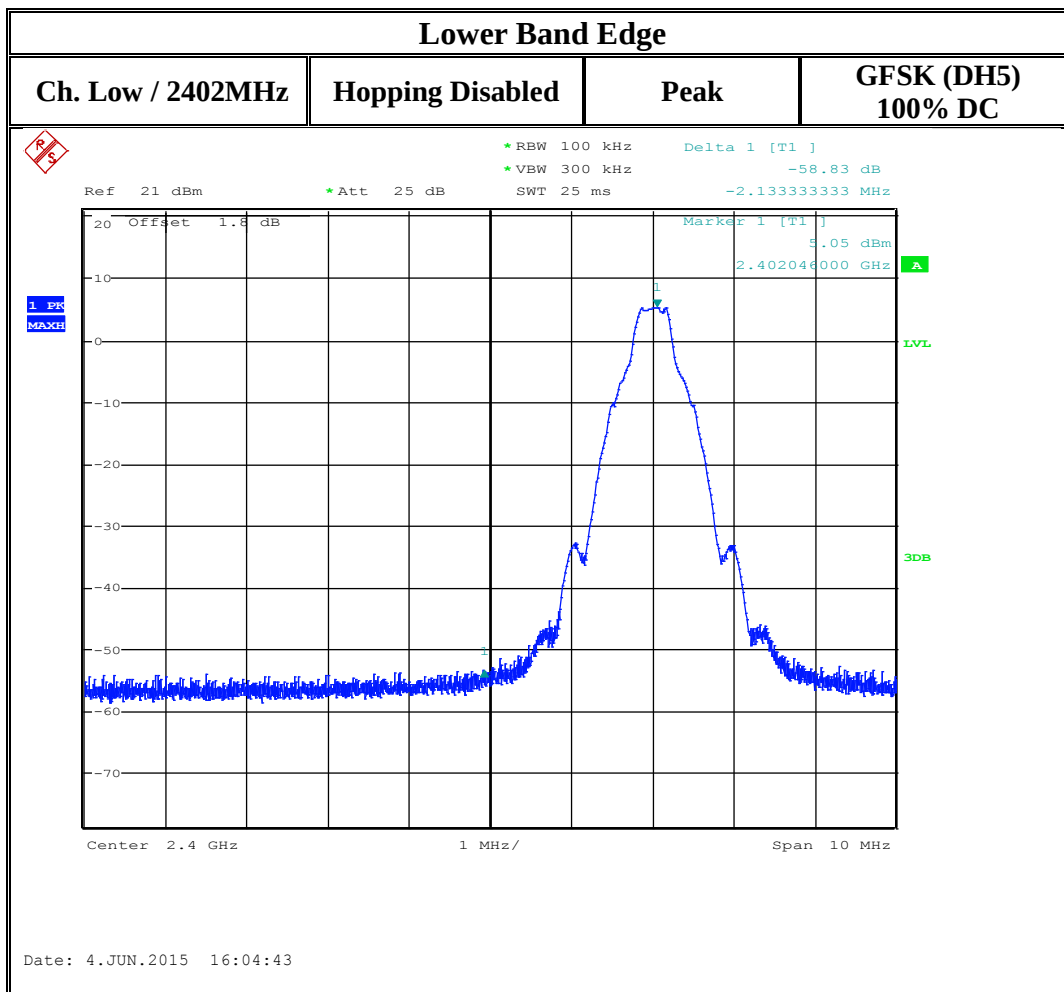
Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.

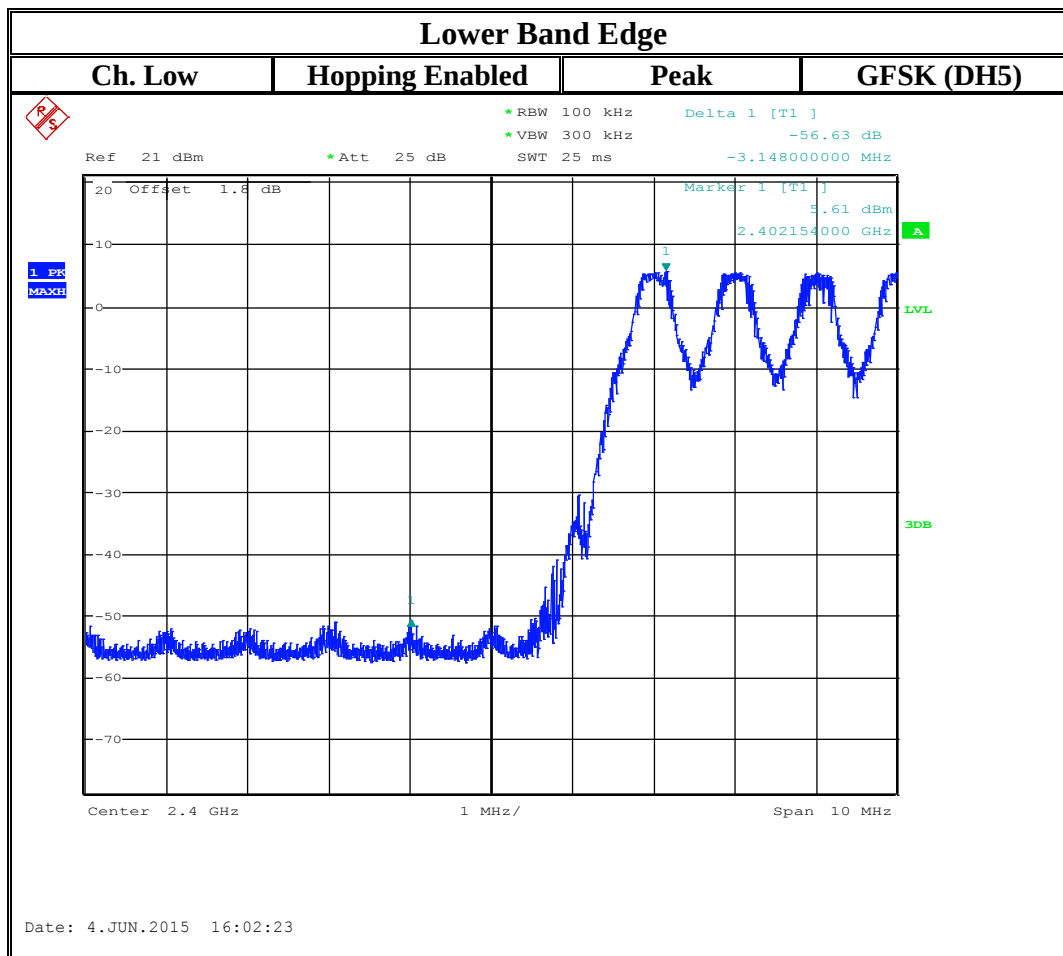
7.2.4 Measurement Result

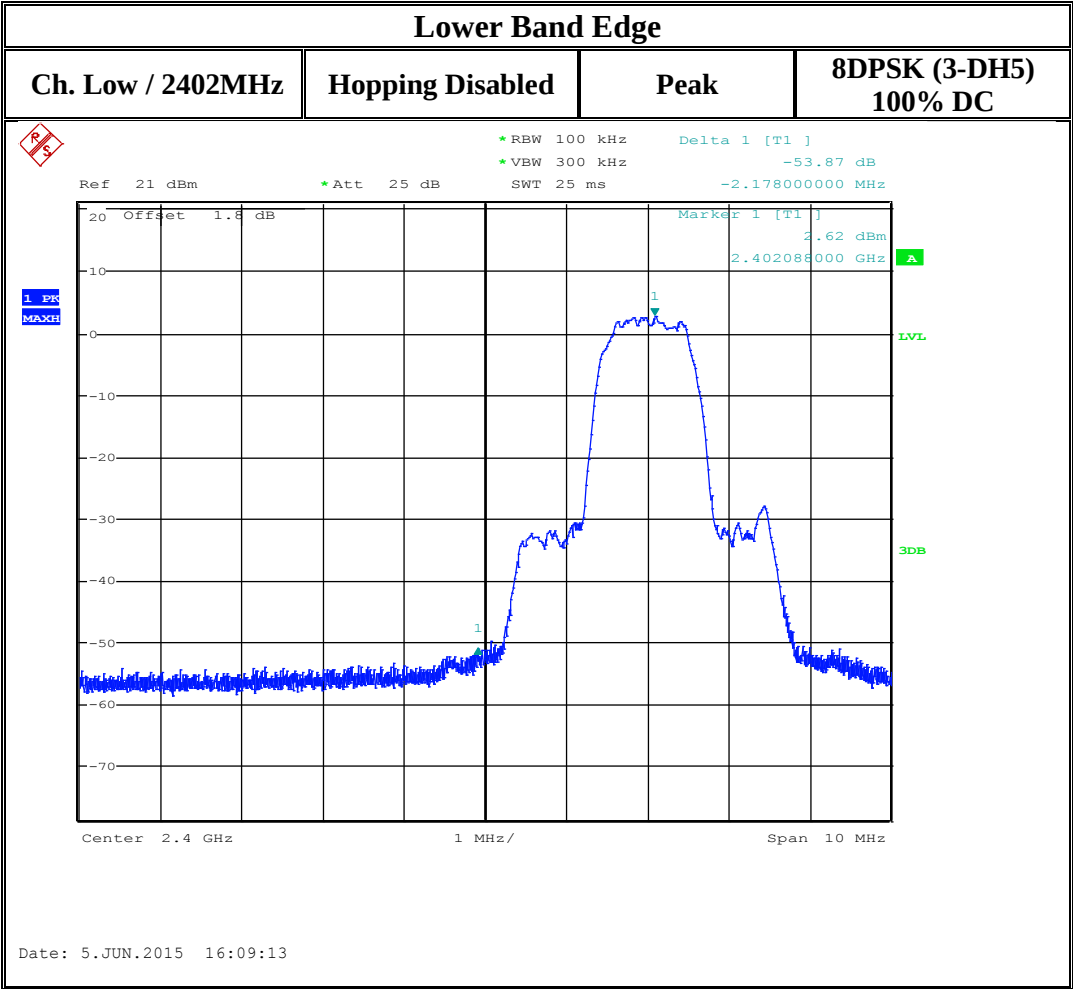
Pass.

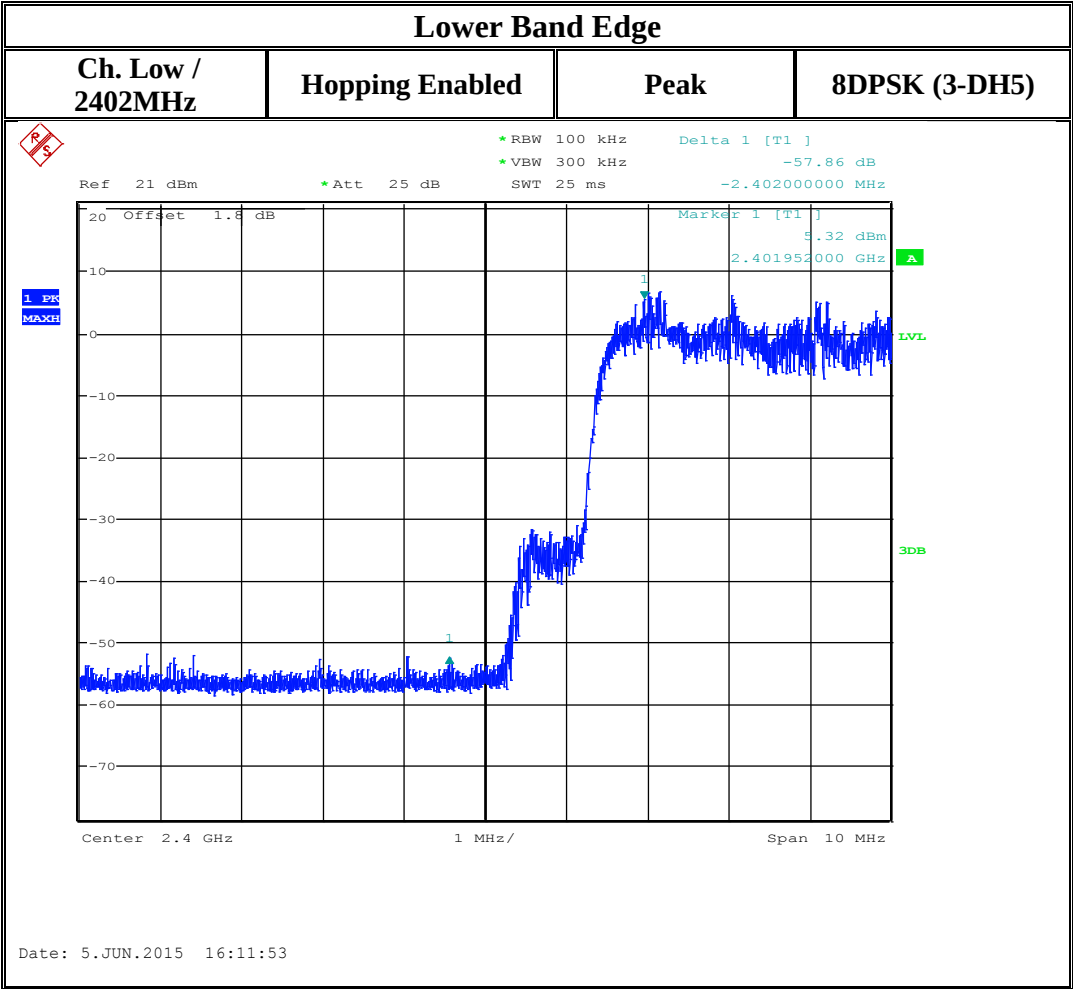
7.2.5 Measurement Plots:

7.2.5.1 Non Restricted Band edge

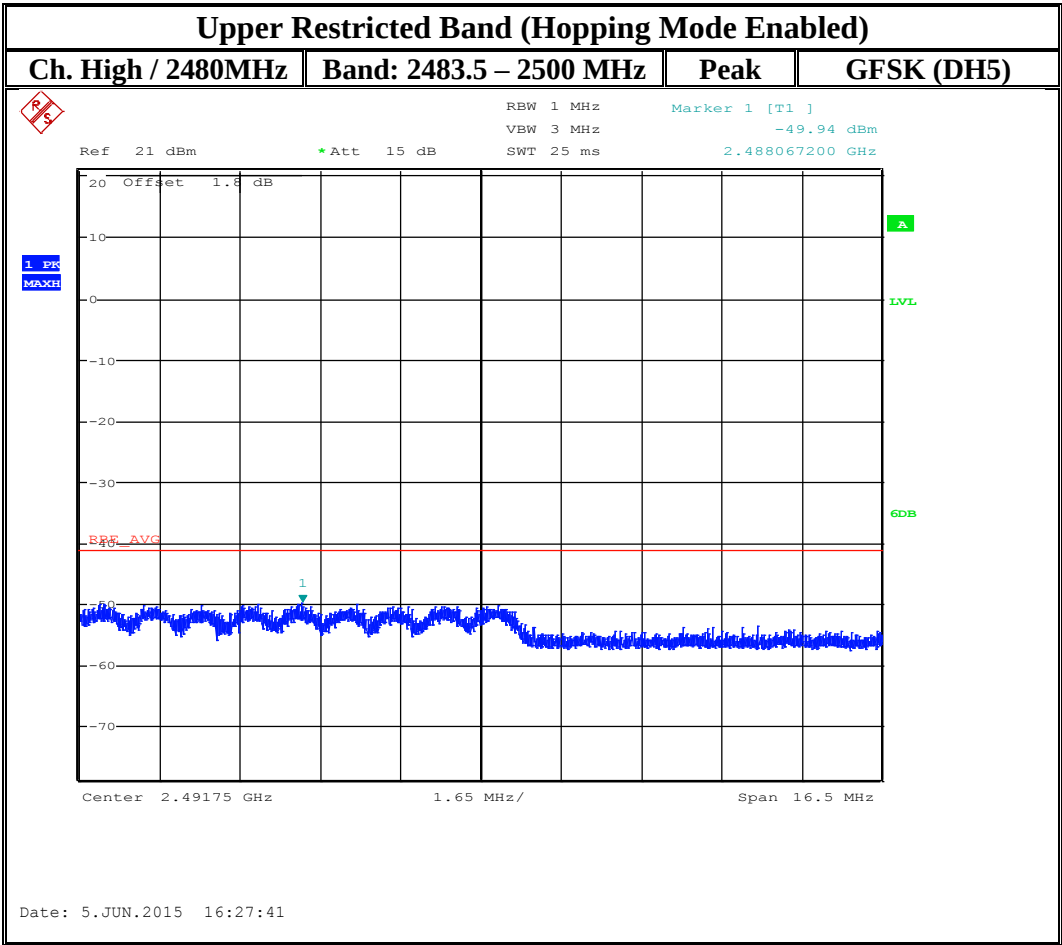






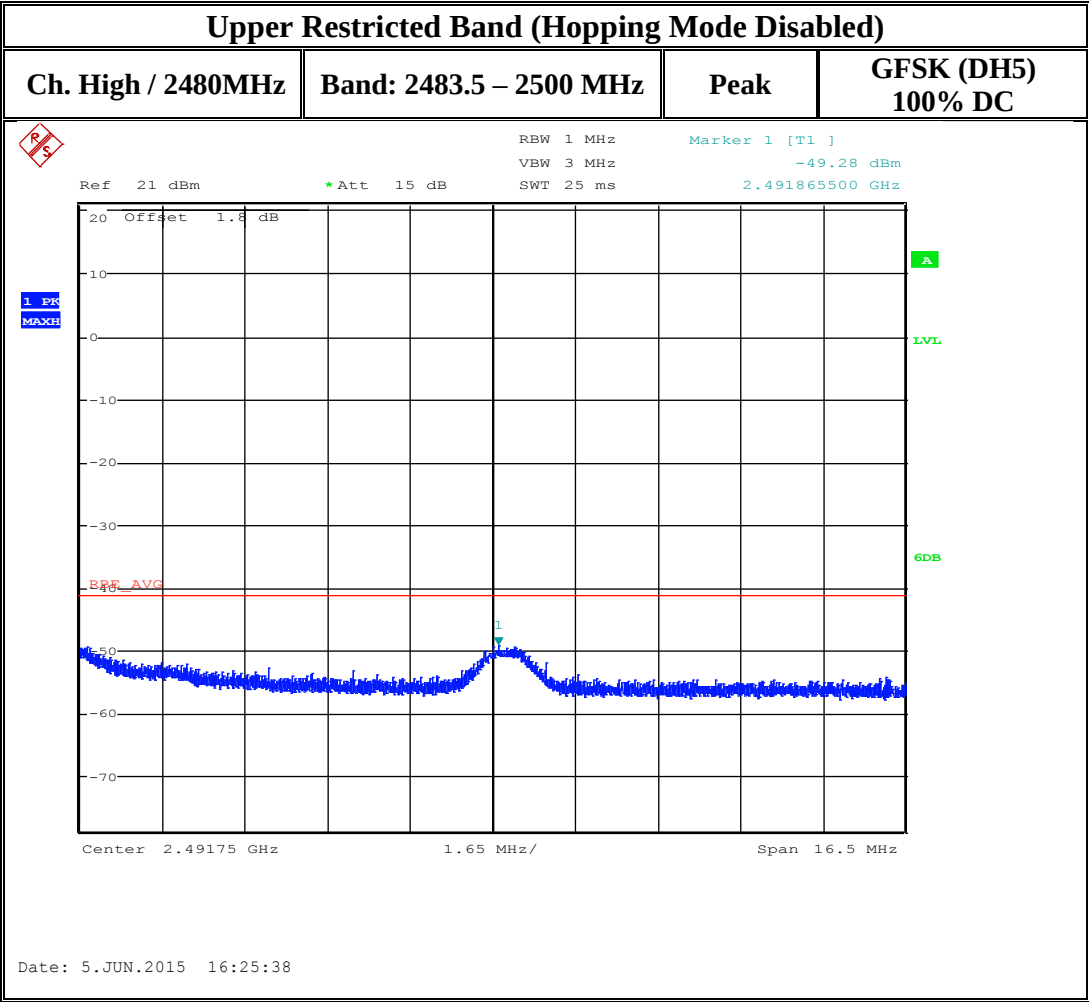


7.2.5.2 Restricted Band

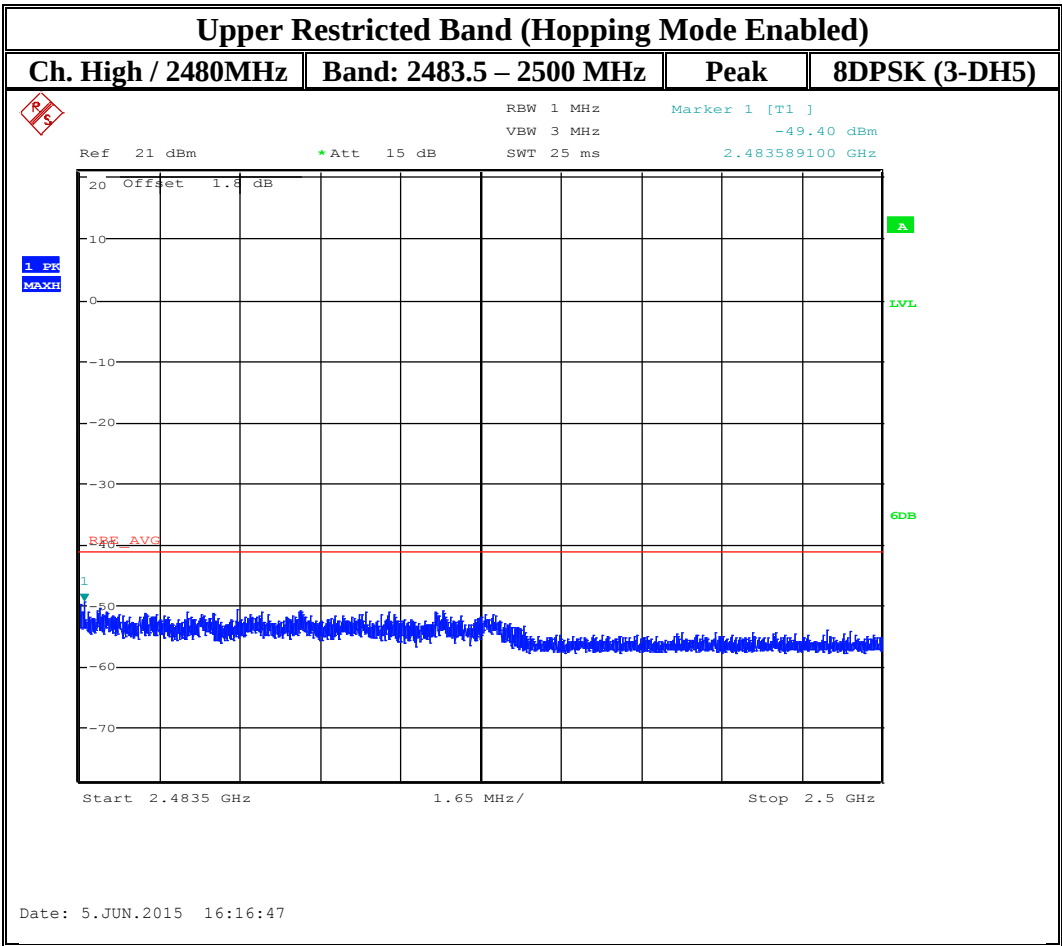


Note: Antenna gain is not in the offset.

Note 1: The Peak detector measurement is passing the average limit of -41.2 dBm with a margin greater than the antenna gain (6 dBi) that is not included in the offset or limit.

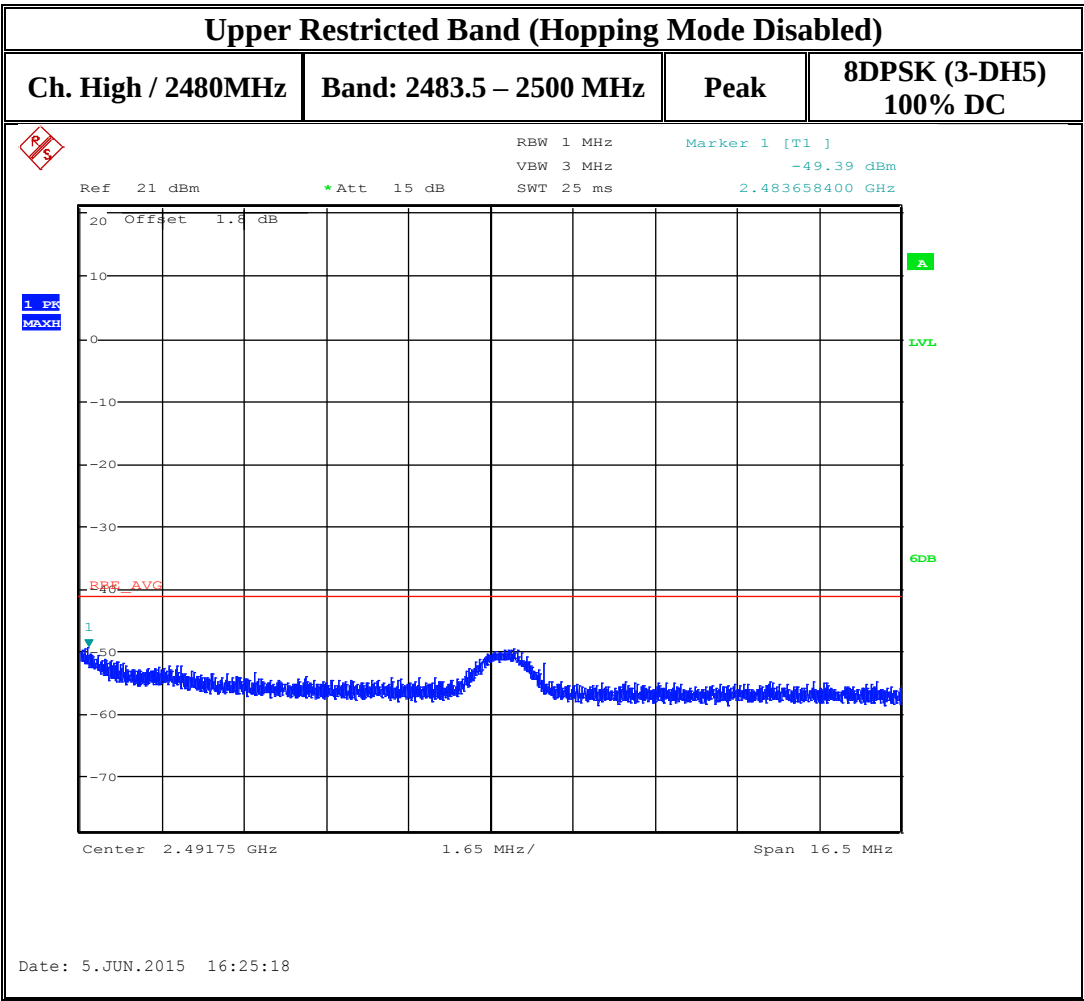


Note: Antenna gain is not in the offset.
Note 1: The Peak detector measurement is passing the average limit of -41.2 dBm with a margin greater than the antenna gain (6 dBi) that is not included in the offset or limit.



Note: Antenna gain is not in the offset.

Note 1: The Peak detector measurement is passing the average limit of -41.2 dBm with a margin greater than the antenna gain (6 dBi) that is not included in the offset or limit.



Note: Antenna gain is not in the offset.

Note 1: The Peak detector measurement is passing the average limit of -41.2 dBm with a margin greater than the antenna gain (6 dBi) that is not included in the offset or limit.

7.3 20dB Bandwidth / 99% Bandwidth

7.3.1 Limits:

For Reference only.

7.3.2 Test Conditions:

Tnom: 21°C; Vnom: 3.8 V
Hopping OFF

Testing was done on all 3 modulations with 100% duty cycle.

7.3.3 Test Procedure

Measurement according to DA 00-705:2000

Spectrum Analyzer settings:

Span: approximately 2 to 3 times the 20 dB bandwidth, centered on the hopping channel

RBW $\geq$ 1% of the 20 dB bandwidth

Sweep Time: Auto

Detector = peak

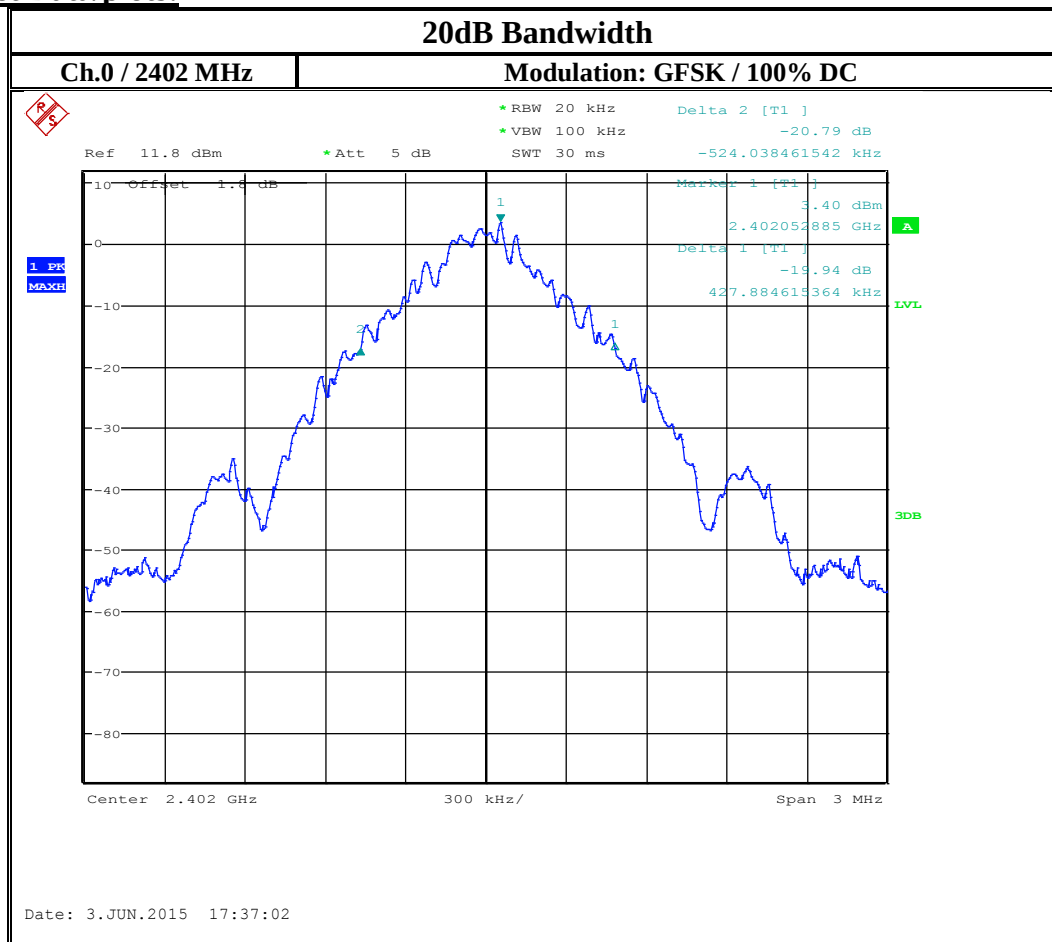
Trace = max. hold

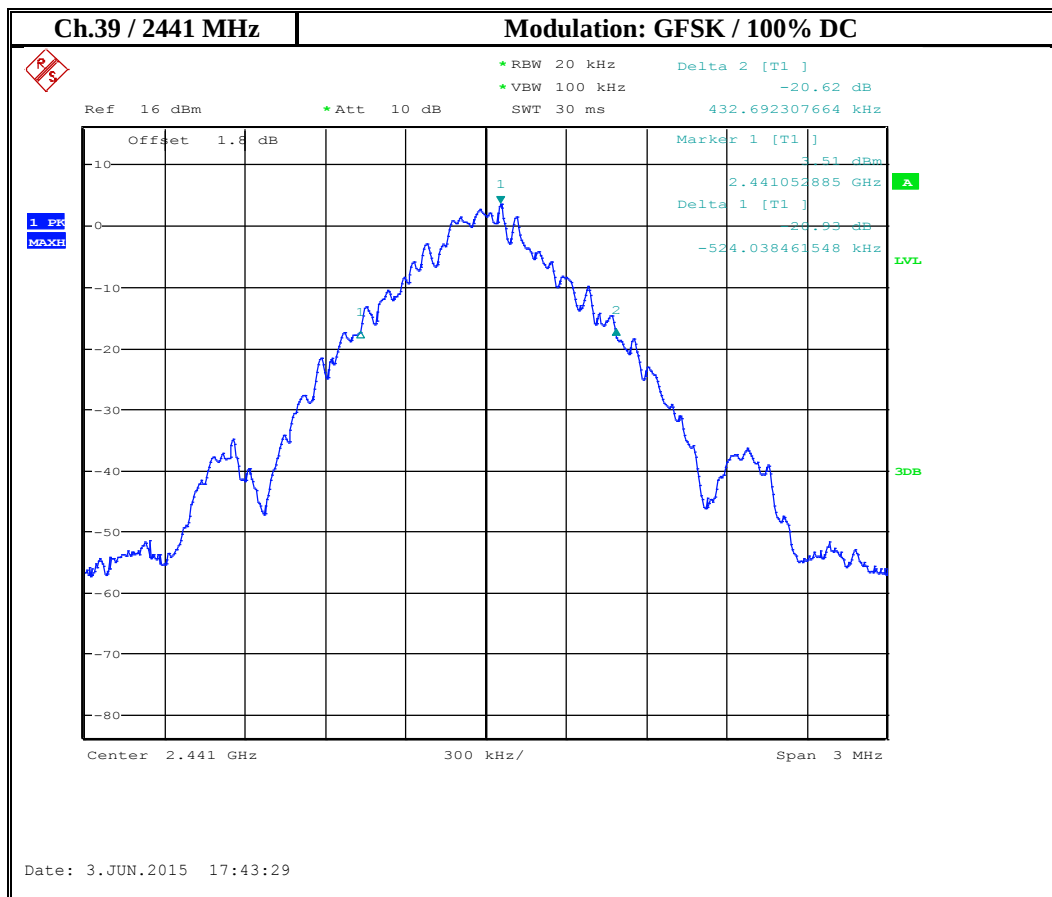
7.3.4 Test Data:

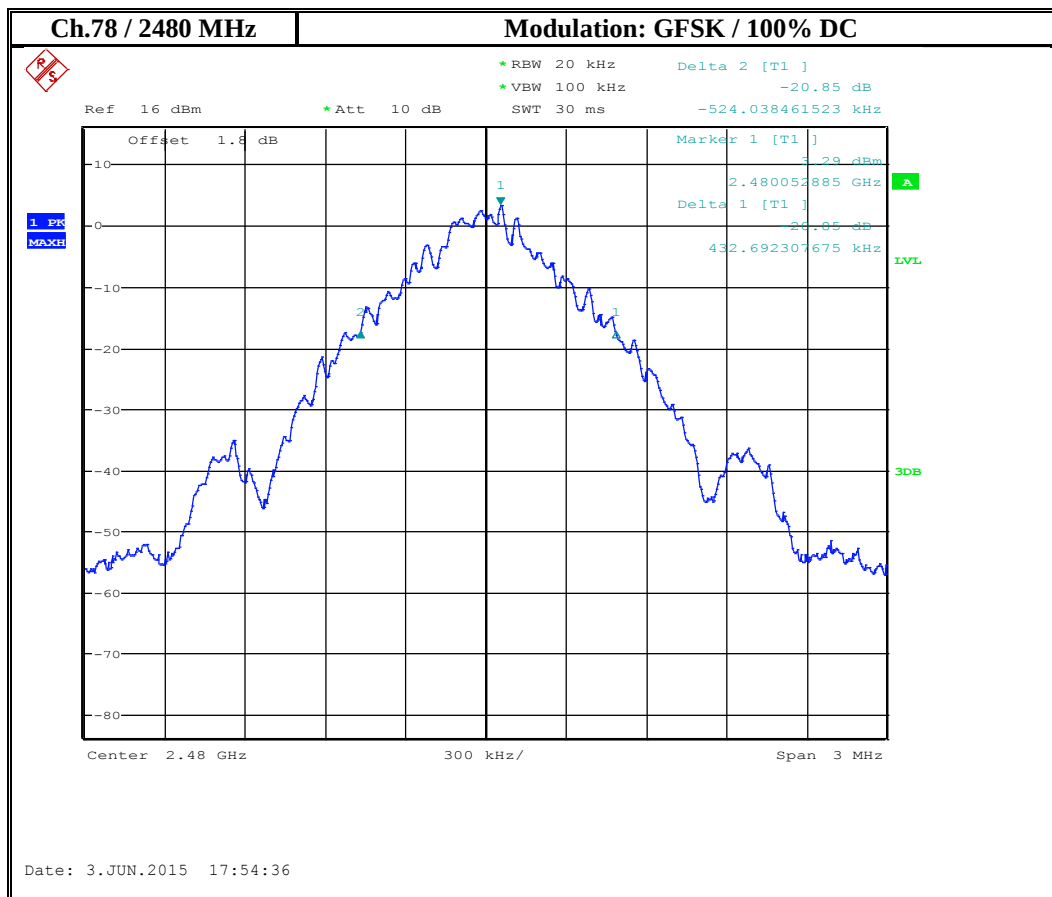
20dB Bandwidth / 99% Bandwidth			
Modulation	Frequency (MHz)		
	2402	2441	2480
GFSK	0.952	0.957	0.957
8-DPSK	1.351	1.351	1.356
$\pi/4$ DQPSK	1.365	1.361	1.361

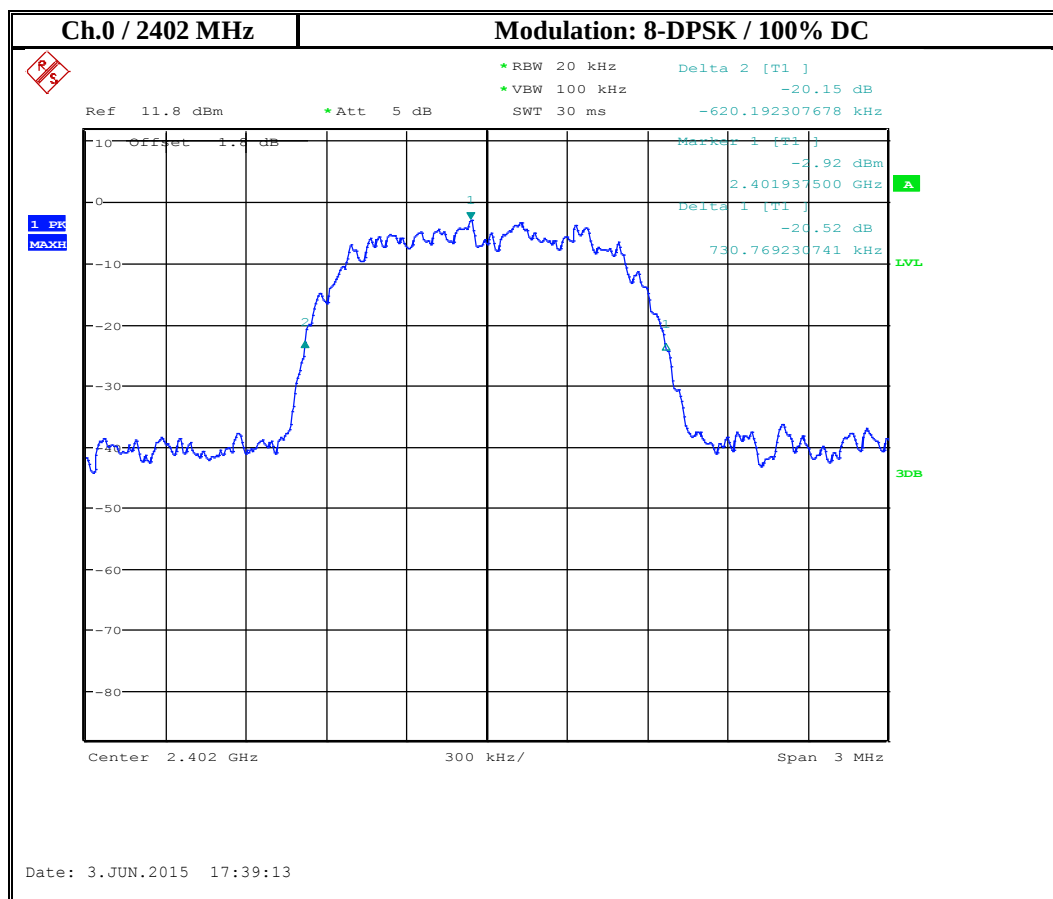
7.3.5 Measurement Result

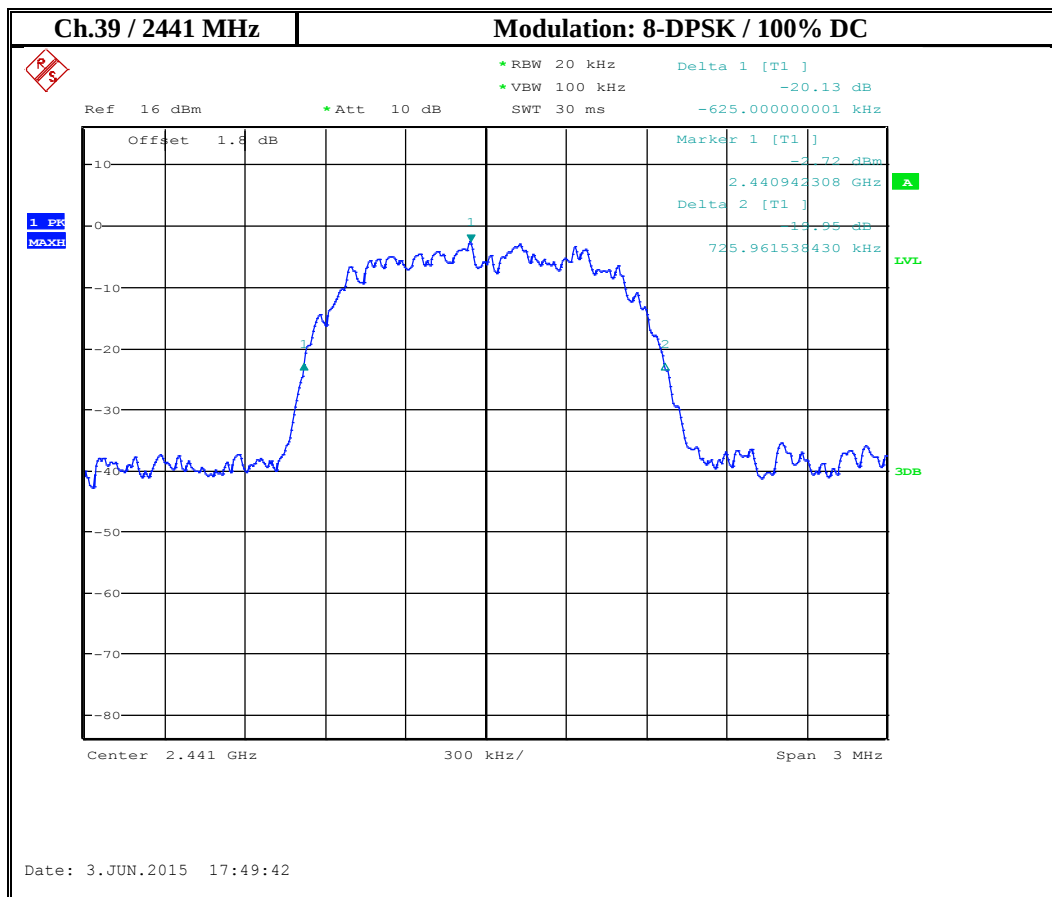
Not Applicable (for reference only)

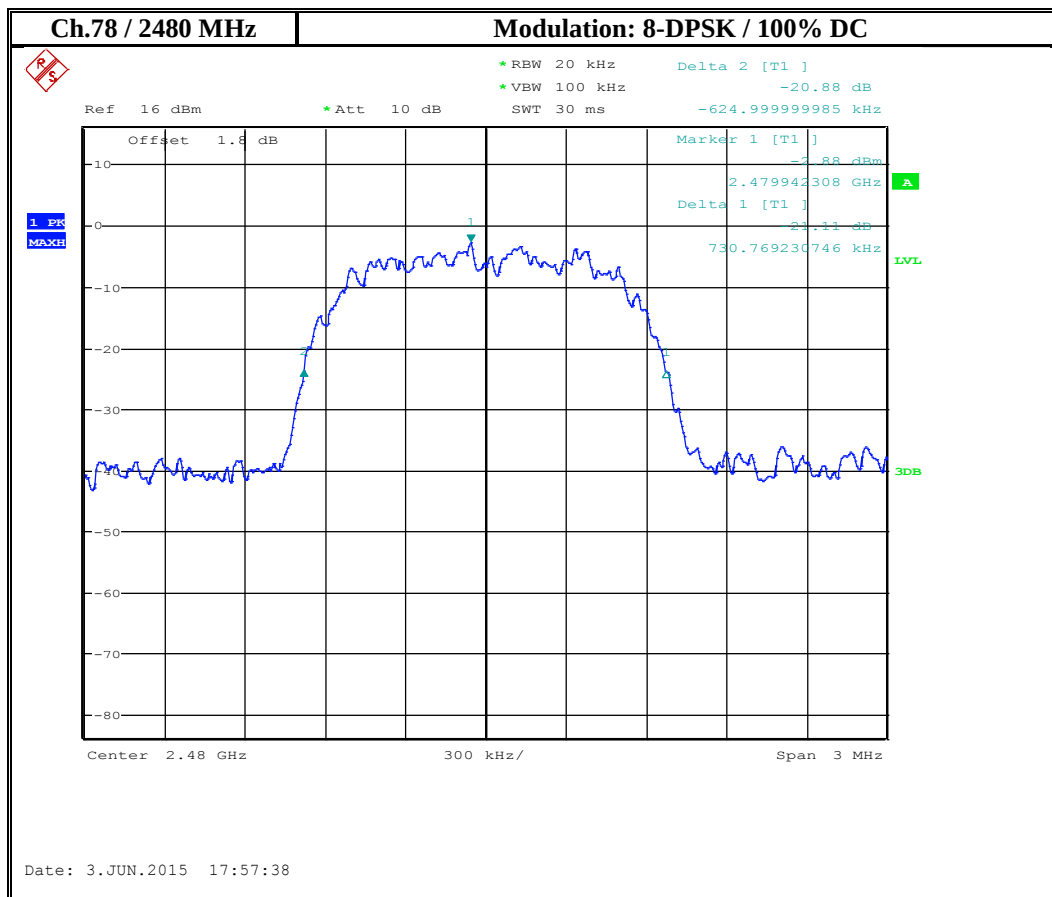
7.3.6 Test Data/plots:

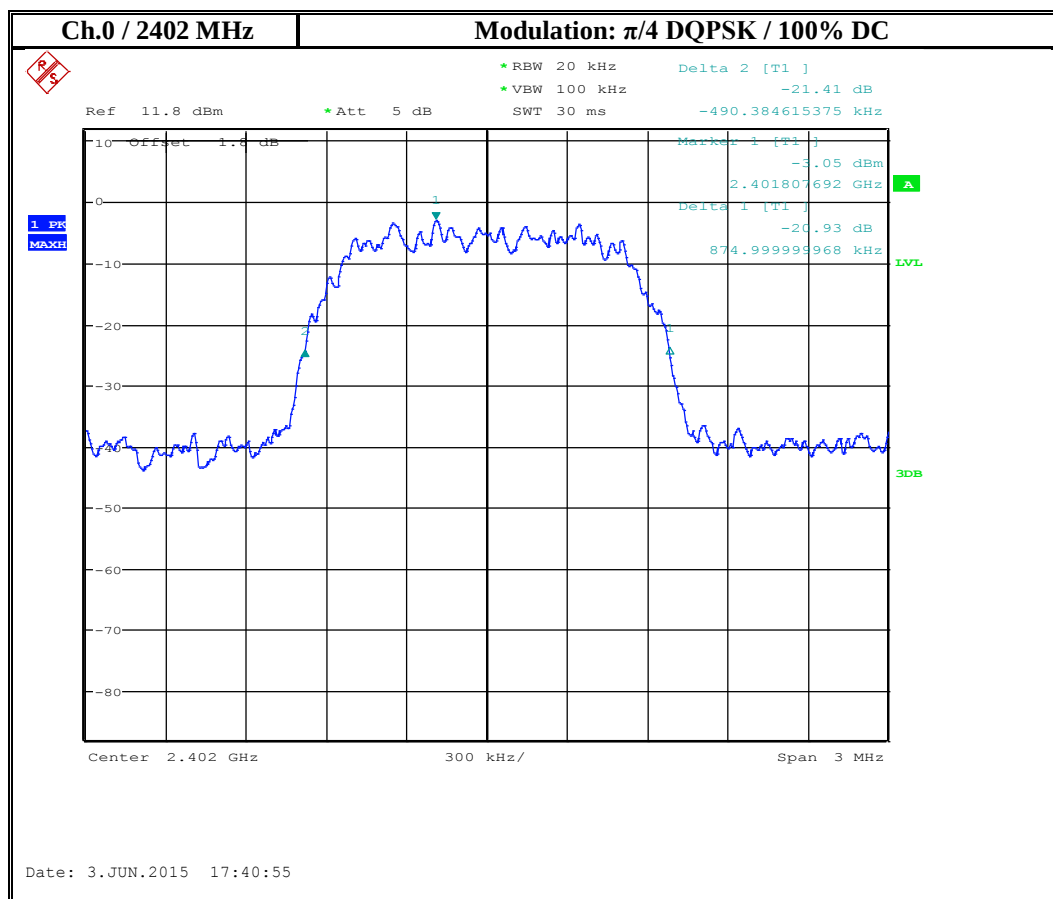


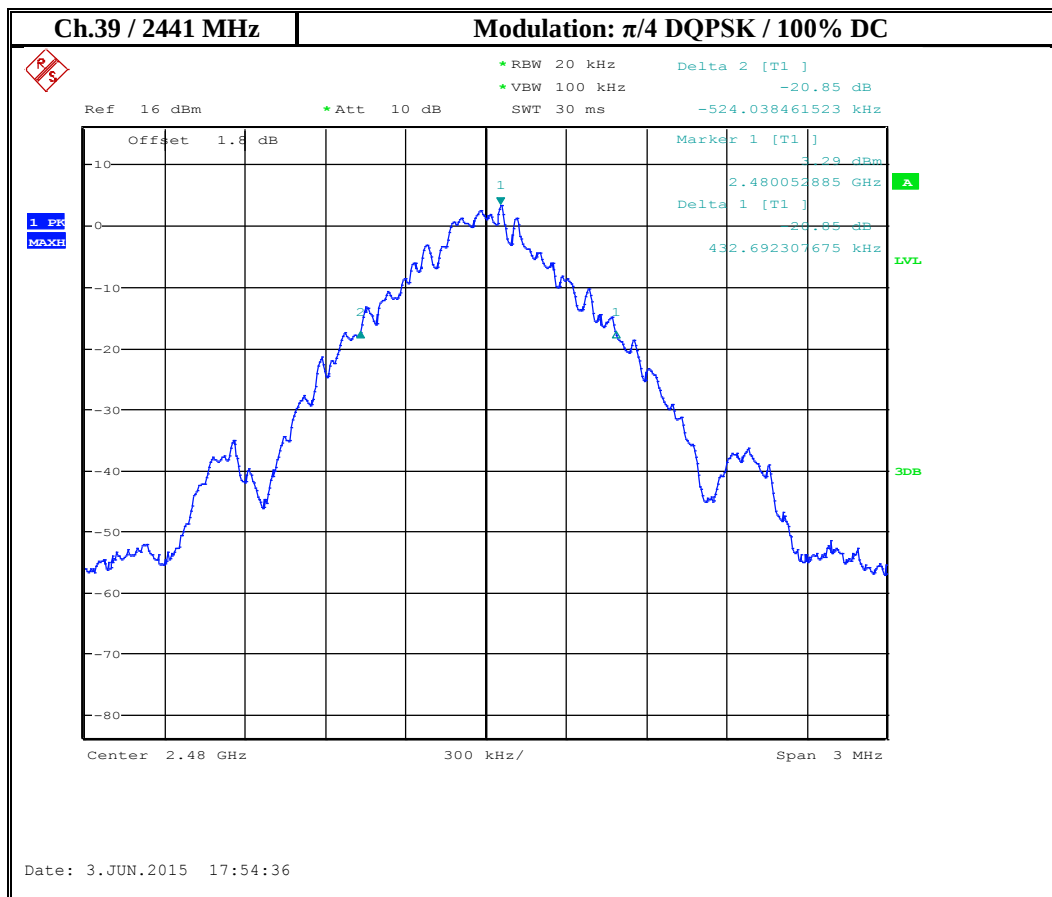


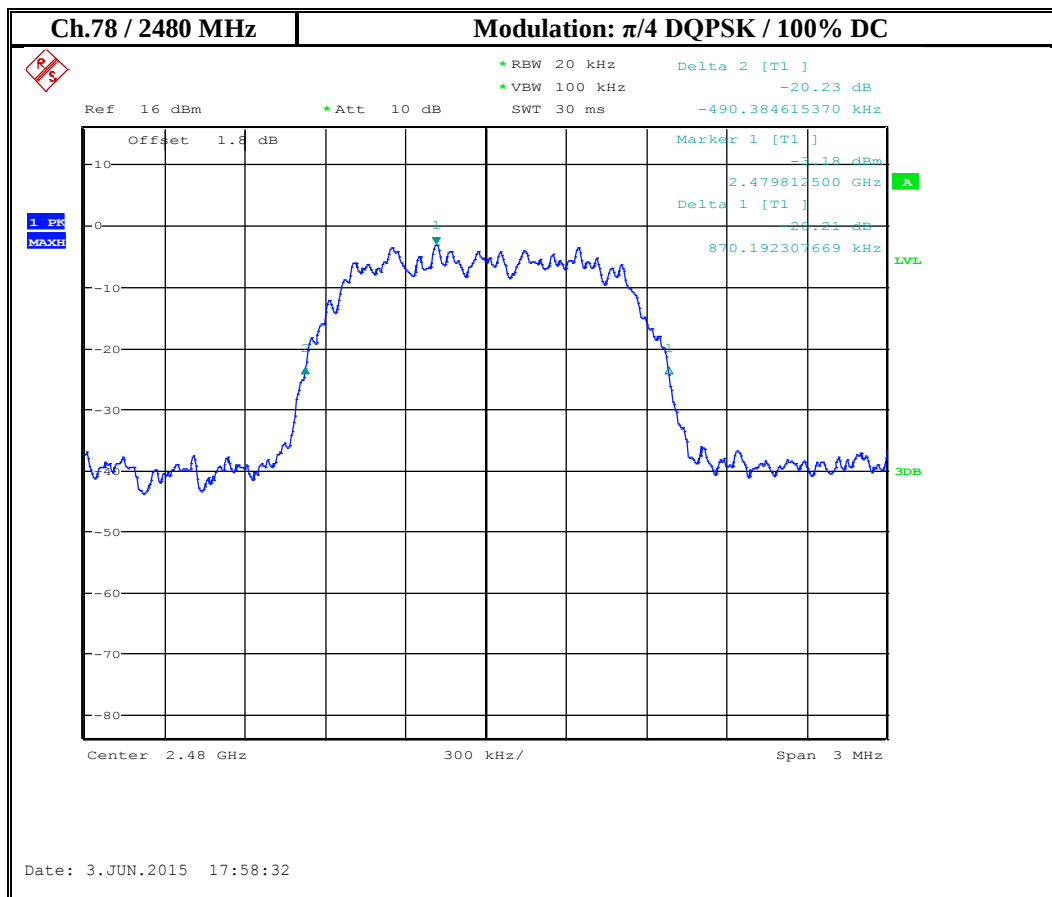












7.4 Carrier Frequency Separation

7.4.1 Limits:

§ 15.247 (a) (1) & RSS-247 Section 5.1 (2)

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.

Considering the maximum 20 dB bandwidth measured of each modulation, the minimum carrier frequency separation is:

GFSK

$$\frac{2}{3} (20 \text{ dB Bandwidth}) = 0.638 \text{ MHz}$$

For 8PSK:

$$\frac{2}{3} (20 \text{ dB Bandwidth}) = 0.904 \text{ MHz}$$

7.4.2 Test Conditions:

Tnom: 22°C; Vnom: 3.8 V

7.4.3 Test Procedure:

Measurement according to DA 00-705:2000

Hopping function: enabled

Spectrum Analyzer settings:

Span = Wide enough to capture the peaks of the two adjacent channels

RBW ≥ 1% of the span

VBW ≥ RBW or 3X

Sweep = auto

Detector function = peak

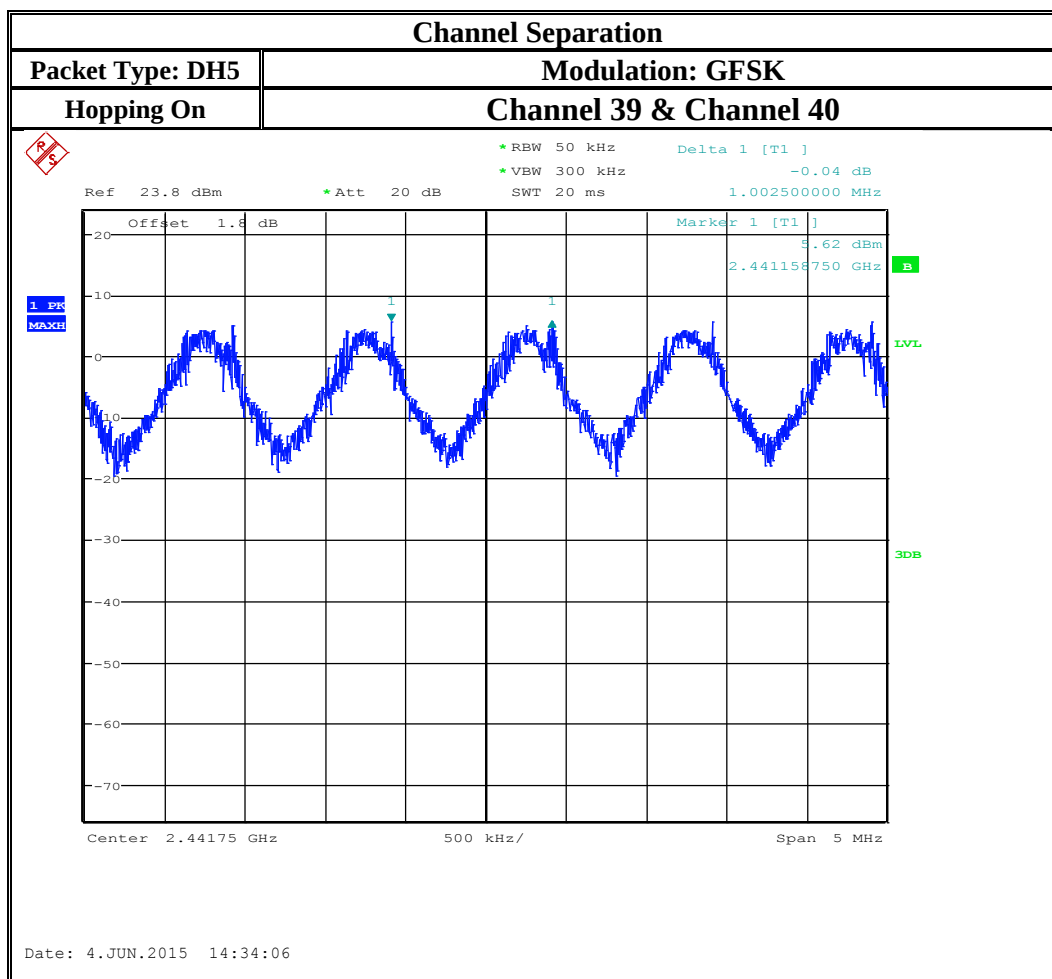
Trace = max hold

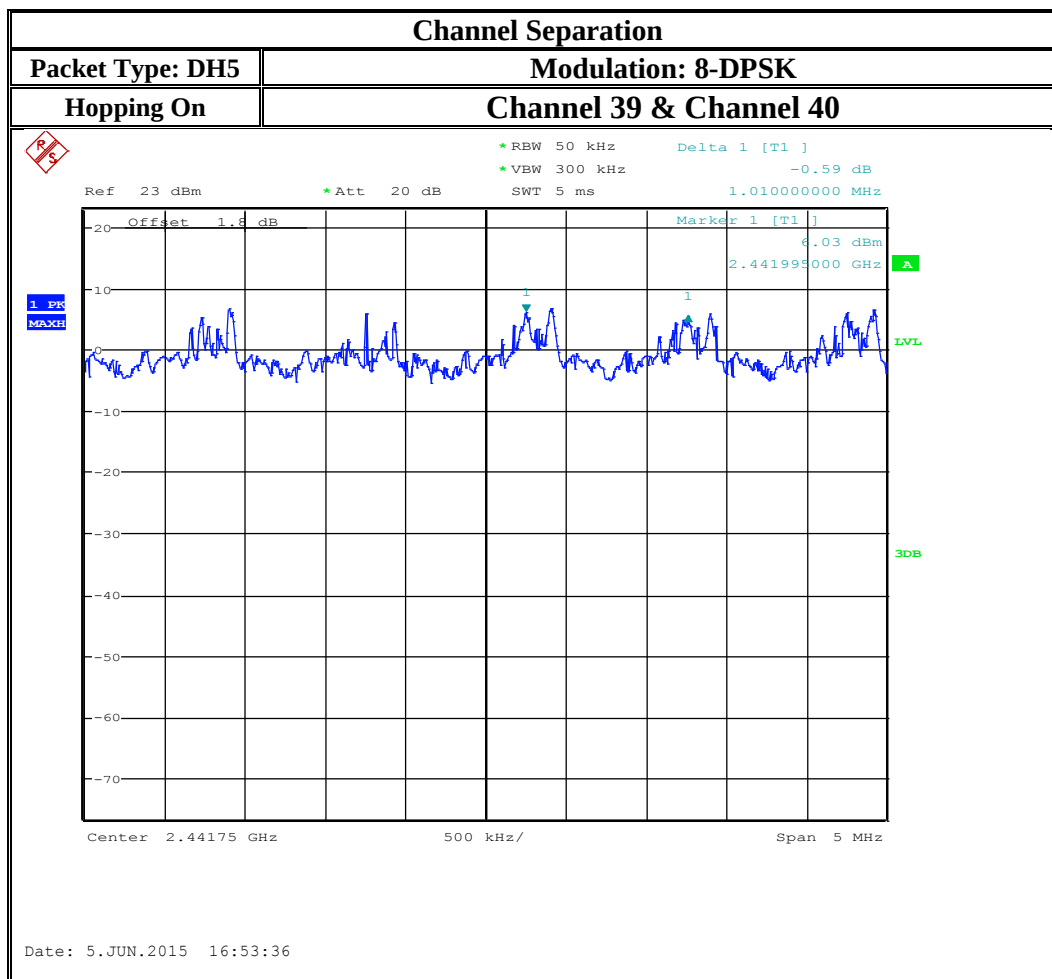
Use marker-delta function to determine the separation between the peak of the two adjacent channels.

7.4.4 Measurement result:

Channel Separation: GFSK: 1.010 MHz
 8-DPSK: 1.003 MHz

Pass





7.5 Number of hopping channels

7.5.1 Limits:

§ 15.247 (a) (1) (ii) (iii) & RSS-247 5.1 (4)

At least 15 non-overlapping channels

7.5.2 Test Conditions:

Tnom: 22°C; Vnom: 3.8 V

7.5.3 Test Procedure:

Measurement according to DA 00-705:2000

Hopping function: enabled

Spectrum Analyzer settings:

Span = the entire frequency band of operation

RBW $\geq$ 50 KHz

VBW $\geq$ RBW or 3X

Sweep = auto

Detector function = peak

Trace = max hold

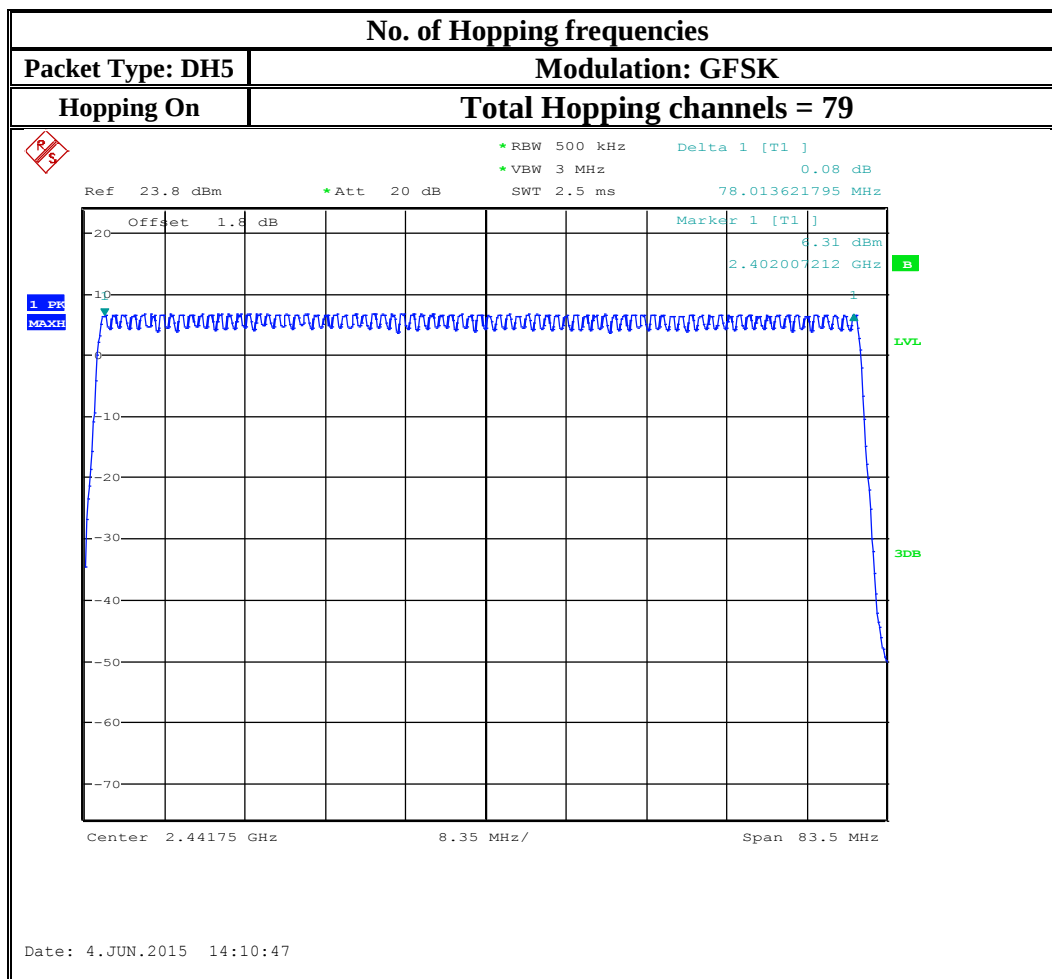
The EUT must have its hopping function enabled during the test.

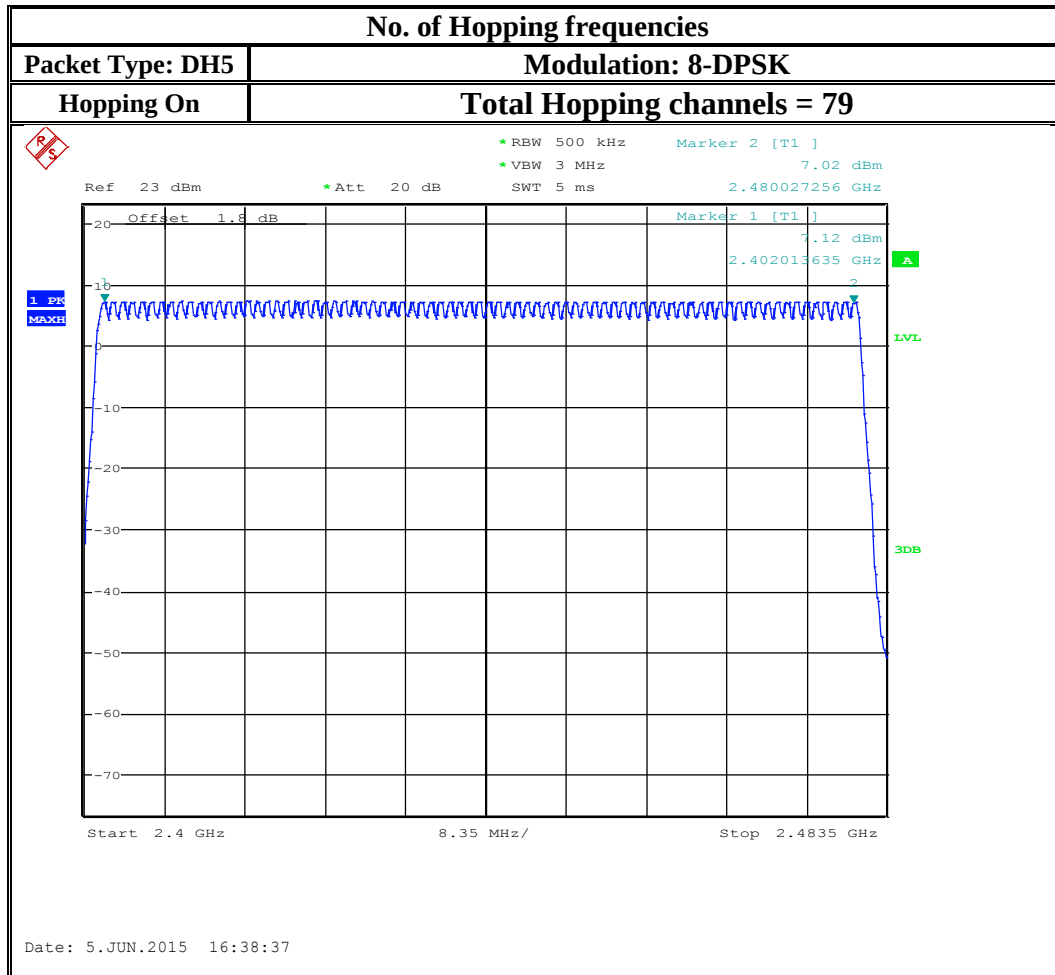
7.5.4 Measurement Result:

Number of hopping channels: 79

Pass

7.5.5 Measurement Plots:





7.6 Time of occupancy / Dwell time**7.6.1 Limits:****§ 15.247 (a) (1) (iii) & RSS-247 Section 5.1 (4)**

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.

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

7.6.2 Test Conditions

Tnom: 23°C; Vnom: 3.8V

7.6.3 Test Procedure:**Duration of Pulse Measurement**

Spectrum Analyser Settings:

RBW= 1MHz

VBW= 3MHz

Sweep Time= 10 ms

Sweep Mode= Single

Detector=Peak

Trigger= Video

Observation Period

Spectrum Analyser Settings:

RBW= 1MHz

VBW= 3MHz

Sweep Time= 31.6 s

Sweep Mode= Single

Detector=Peak

Trigger= Free Run

A 31.6 second sweep was performed for each test case. The trace data was saved and the number of Tx pulses were computed by applying a threshold. The time of occupancy was calculated by multiplying the number of Tx pulses by the duration of the pulse.

7.6.4 Measurement Result:

Channel	Timing	Modulation	Pulse Duration (ms)	# hops 31.6s	total dwell time in 31.6s (ms)	Limit	Result
39	DH1	GFSK	0.383	312	120.12	< 400 in 31.6s	Pass
39	DH3	GFSK	1.64	155	254.2	< 400 in 31.6s	Pass
39	DH5	GFSK	2.89	95	274.55	< 400 in 31.6s	Pass
39	DH5	$\pi/4$ DQPSK	3.03	105	318.15	< 400 in 31.6s	Pass
39	DH5	8-DPSK	2.89	113	326.57	< 400 in 31.6s	Pass

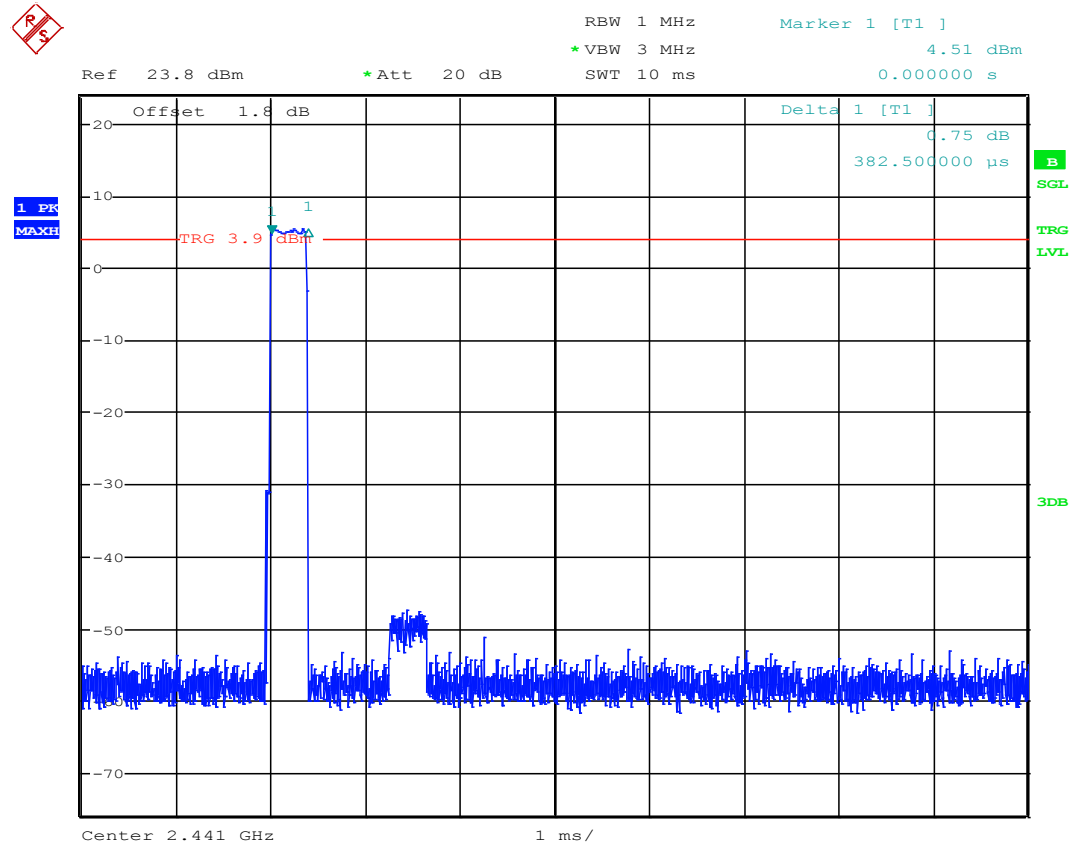
Date of Report : 2015-08-03

Page 56 of 97

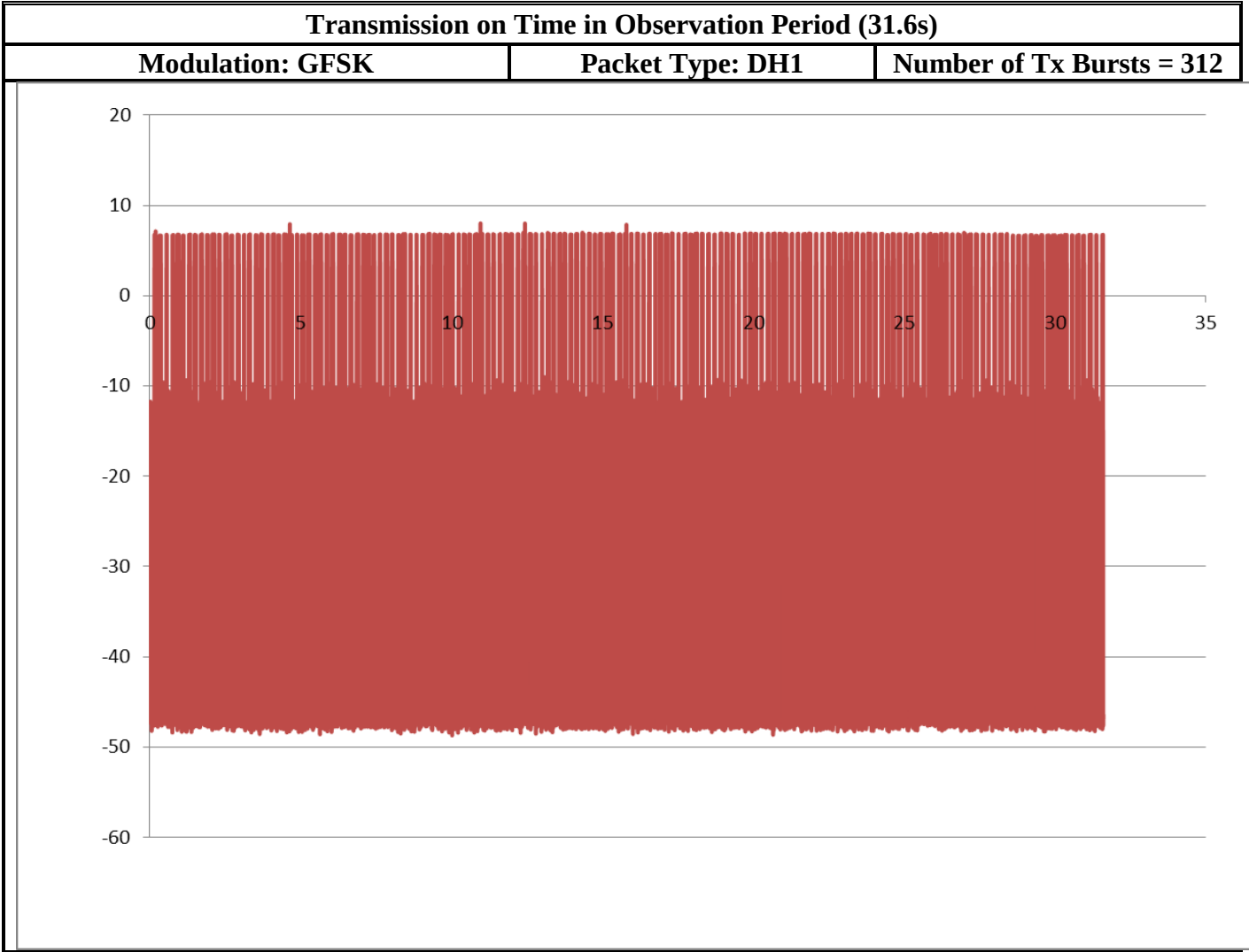
7.6.5 Test Data/Plots:

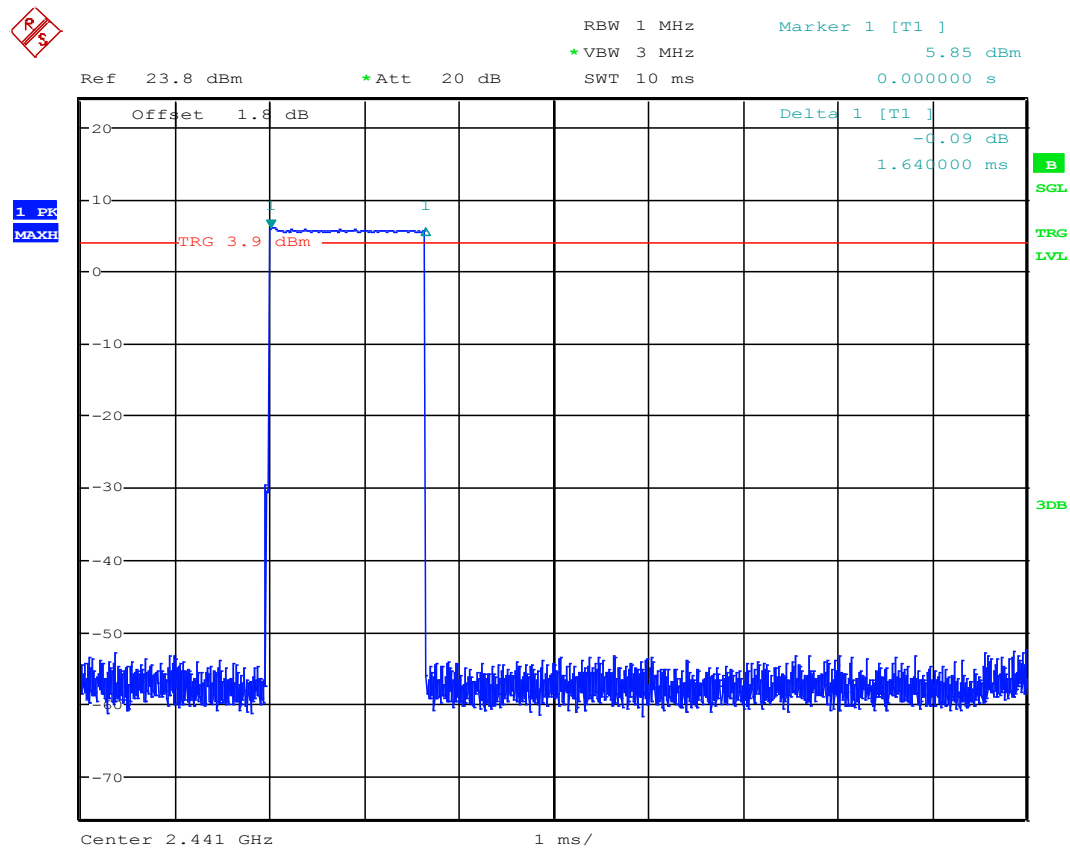
7.6.5.1 GFSK DH1

Duration of Pulse

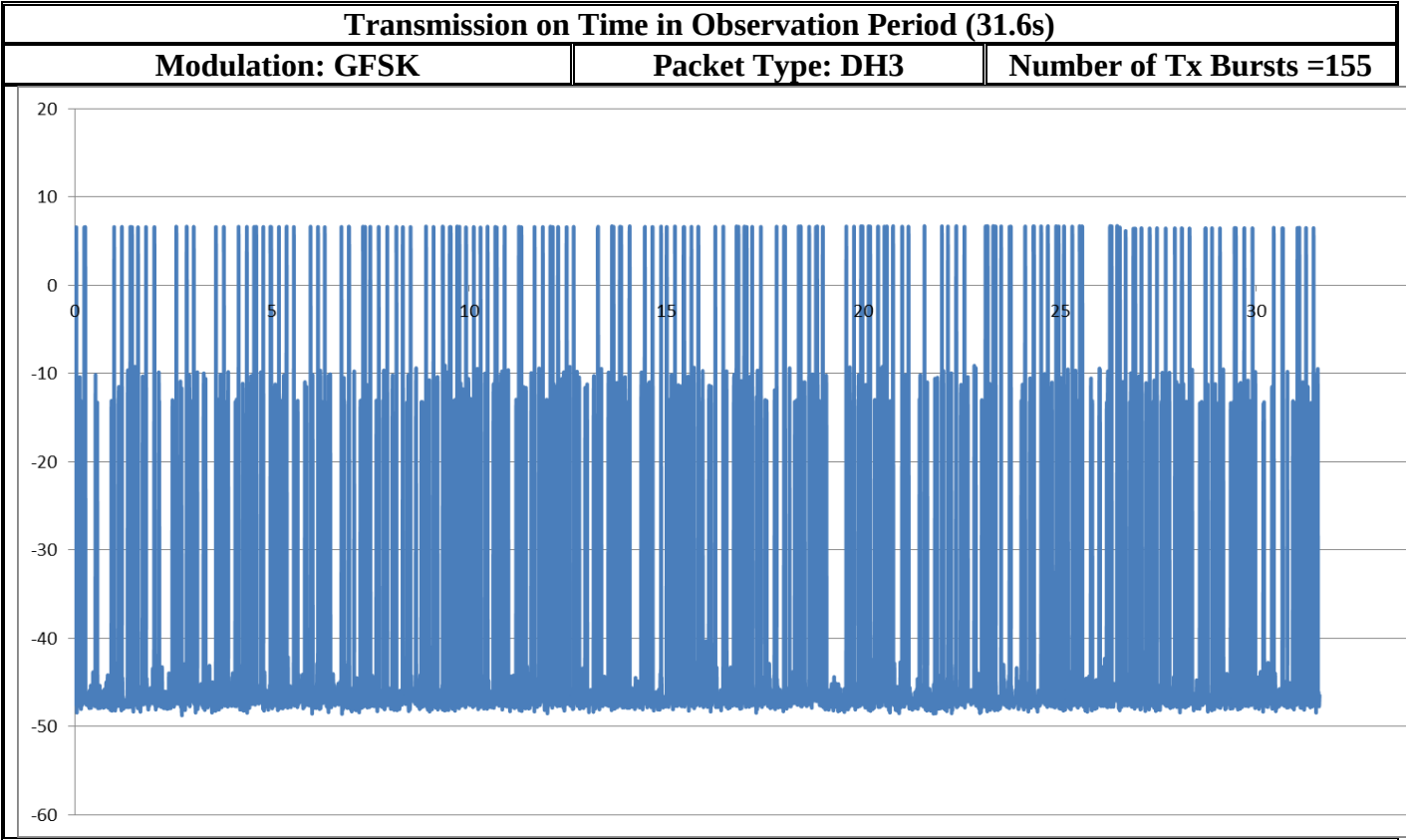


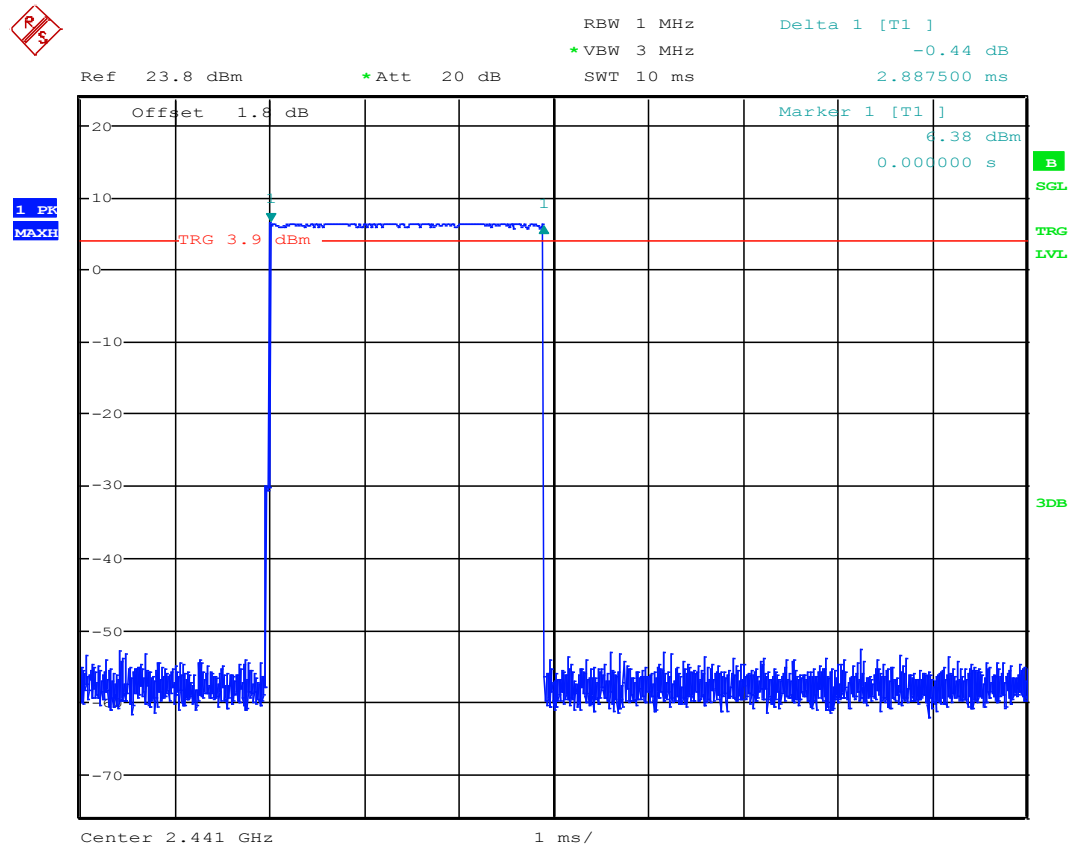
Date: 4.JUN.2015 15:28:49



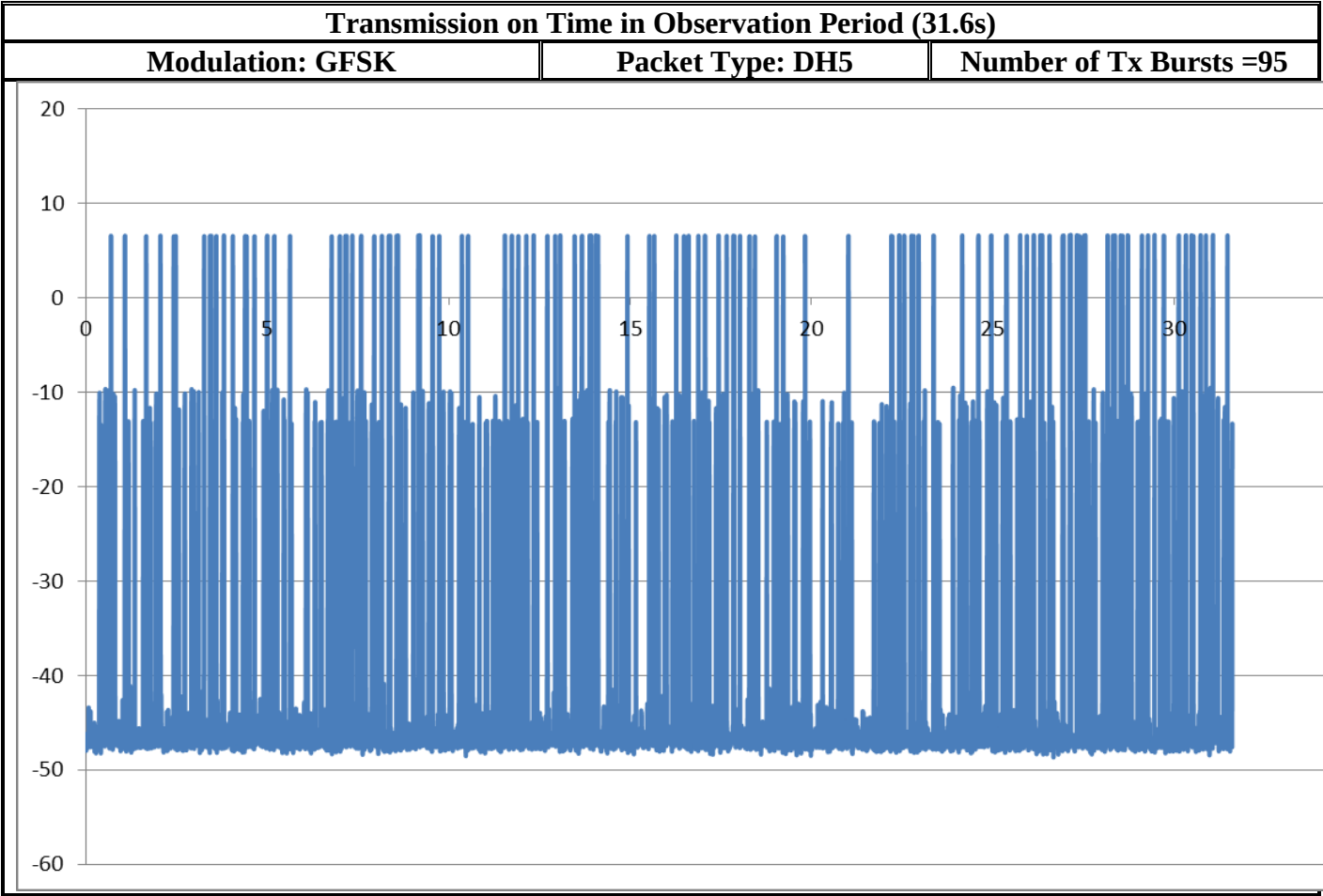
7.6.5.2 GFSK DH3**Duration of Pulse**

Date: 4.JUN.2015 15:16:39



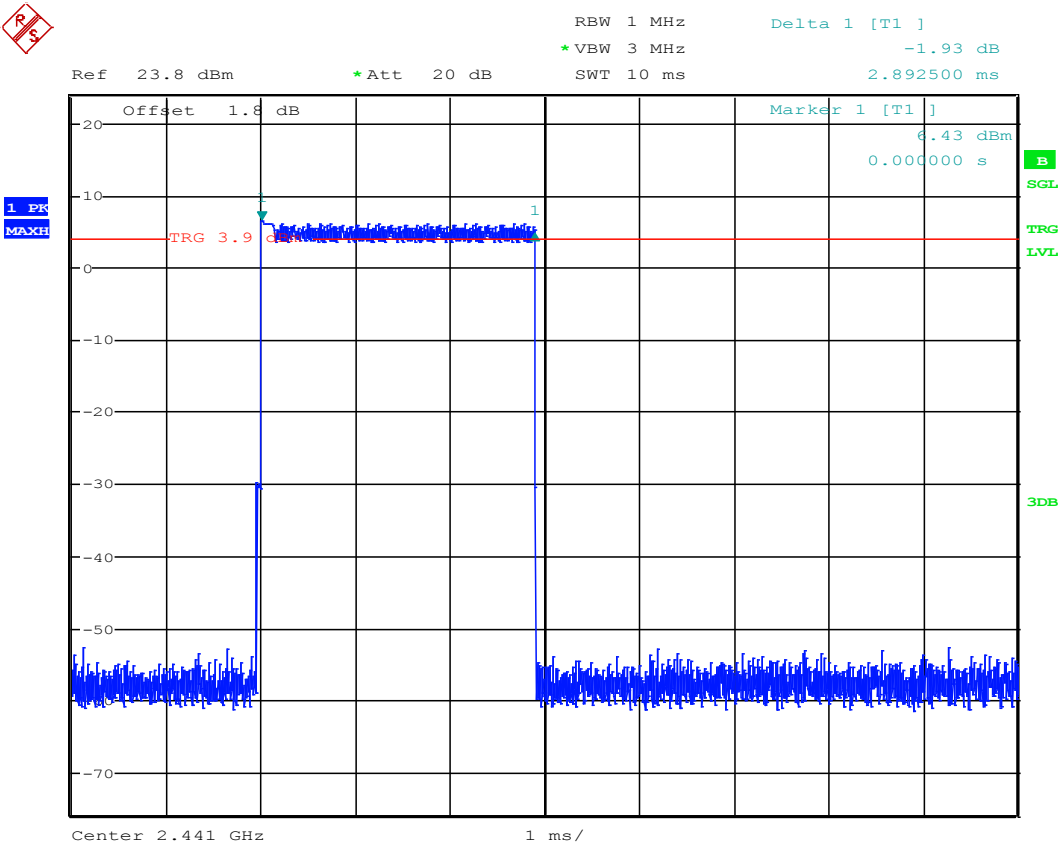
7.6.5.3 GFSK DH5**Duration of Pulse**

Date: 4.JUN.2015 15:06:04

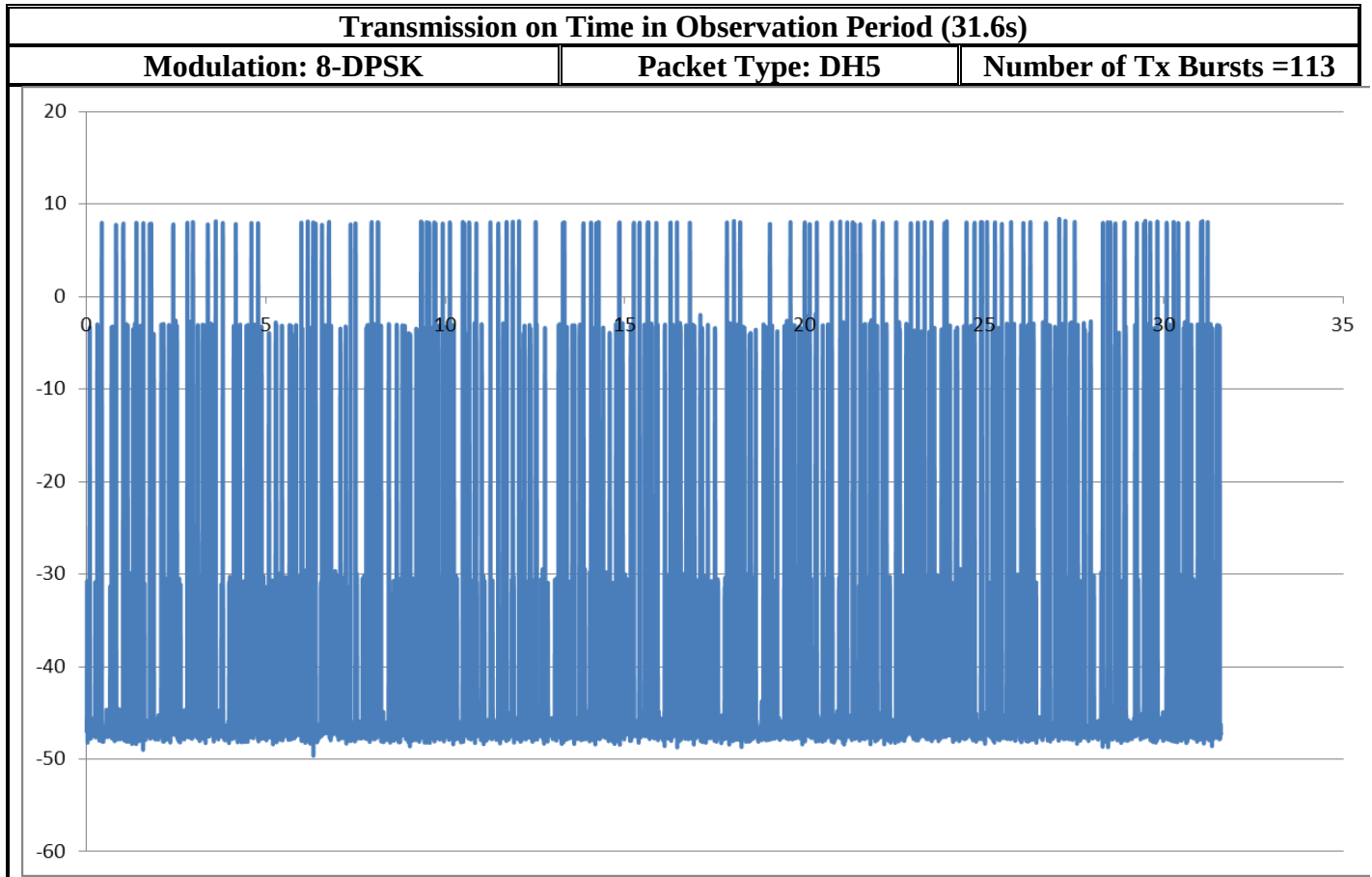


7.6.5.4 8-DPSK DH5

Duration of Pulse

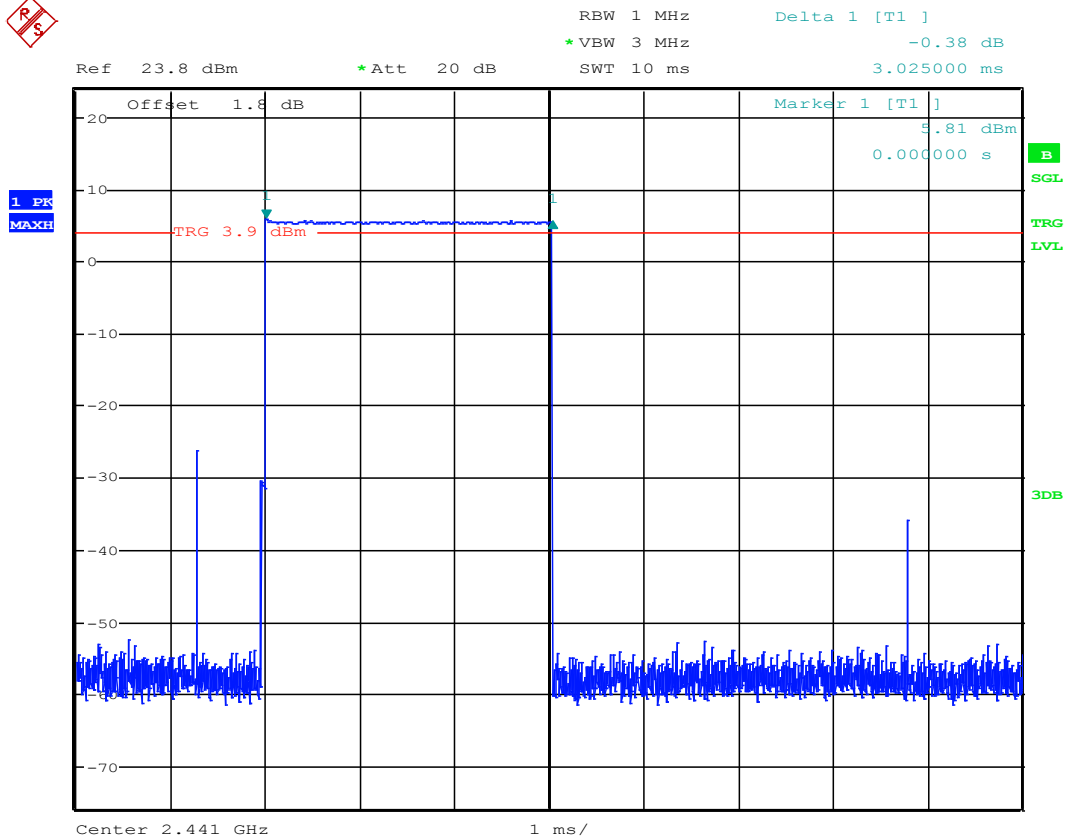


Date: 4.JUN.2015 15:53:02

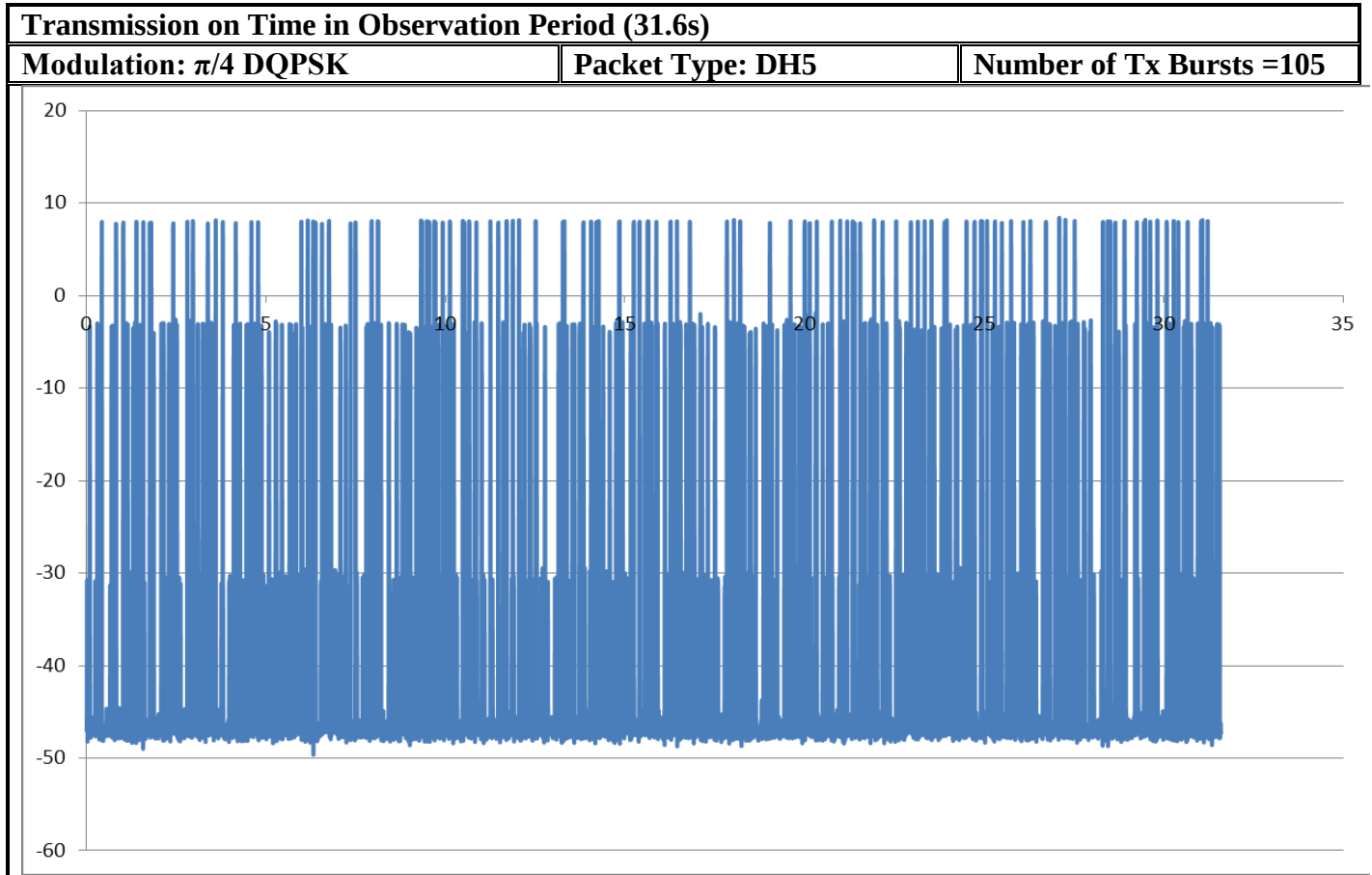


7.6.5.5 $\pi/4$ DQPSK DH5

Duration of Pulse



Date: 4.JUN.2015 15:30:19



7.7 Transmitter Spurious Emissions & Restricted Bands- Radiated**7.7.1 Limits:****§15.247/15.205/15.209 & RSS-Gen 8.9/ 8.10 (restricted bands)**

(a) Except as shown in paragraph (d) of this section, 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	(²)
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= 74dB μ V/m

*AVG. LIMIT= 54dB μ V/m

Table 1:

Frequency of emission (MHz)	Field strength @ 3m (μ V/m)	Field strength @ 3m (dB μ V/m)
30–88	100	40dB μ V/m
88–216	150	43.5 dB μ V/m
216–960	200	46 dB μ V/m
Above 960	500	54 dB μ V/m

Table 2:

Frequency of emission (MHz)	Field strength (μV/m) / (dBuV/m)	Measurement Distance (m)
0.009–0.490	2400/F(kHz) / -----	300
0.490–1.705	24000/F(kHz) / -----	30
1.705–30.0	30 / (29.5)	30

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.

When testing at other than specified distance in the standard, the approach calculation by using 40 dB/decade extrapolation factor equation (4) as follow:

Conversion factor (CF) = $40 \log (D/d) = 40 \log (300\text{m} / 3\text{m}) = 80\text{dB}$

7.7.2 Test Conditions

Tnom: 23°C; Vnom: 3.8V

7.7.3 Test Procedure

Measurement according to:
ANSI C63.10 (2013)

Analyzer Settings:

From 9 KHz – 30 MHz

RBW = 9 KHz

Detector: Peak

From 30 MHz – 1 GHz

Detector = Peak / Quasi-Peak

RBW=120 KHz (<1GHz)

Above 1 GHz

Detector = Peak / Average

RBW= 1MHz

Test mode: *Modulation:* GFSK and 8-DPSK- the highest conducted output power from the peak and average measurements

Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

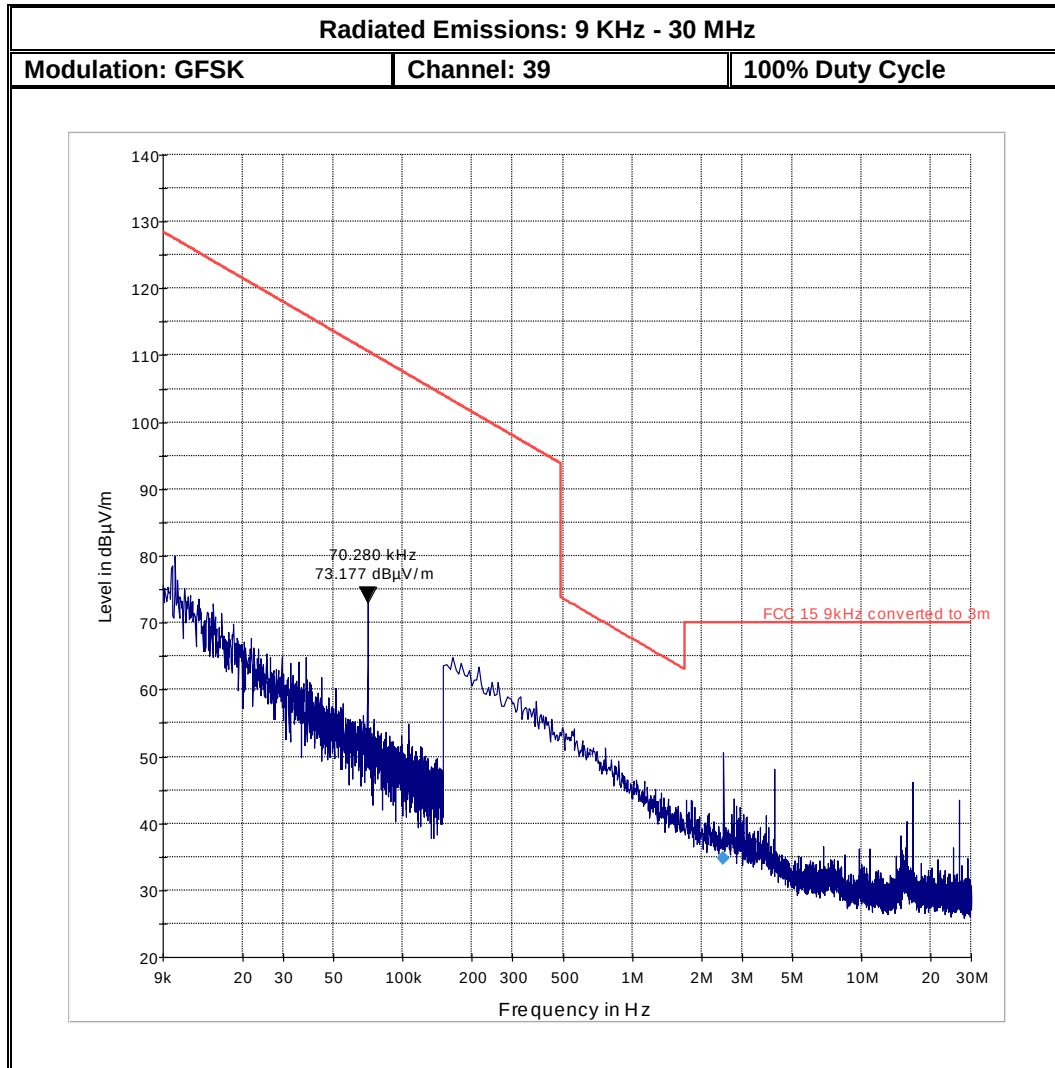
Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

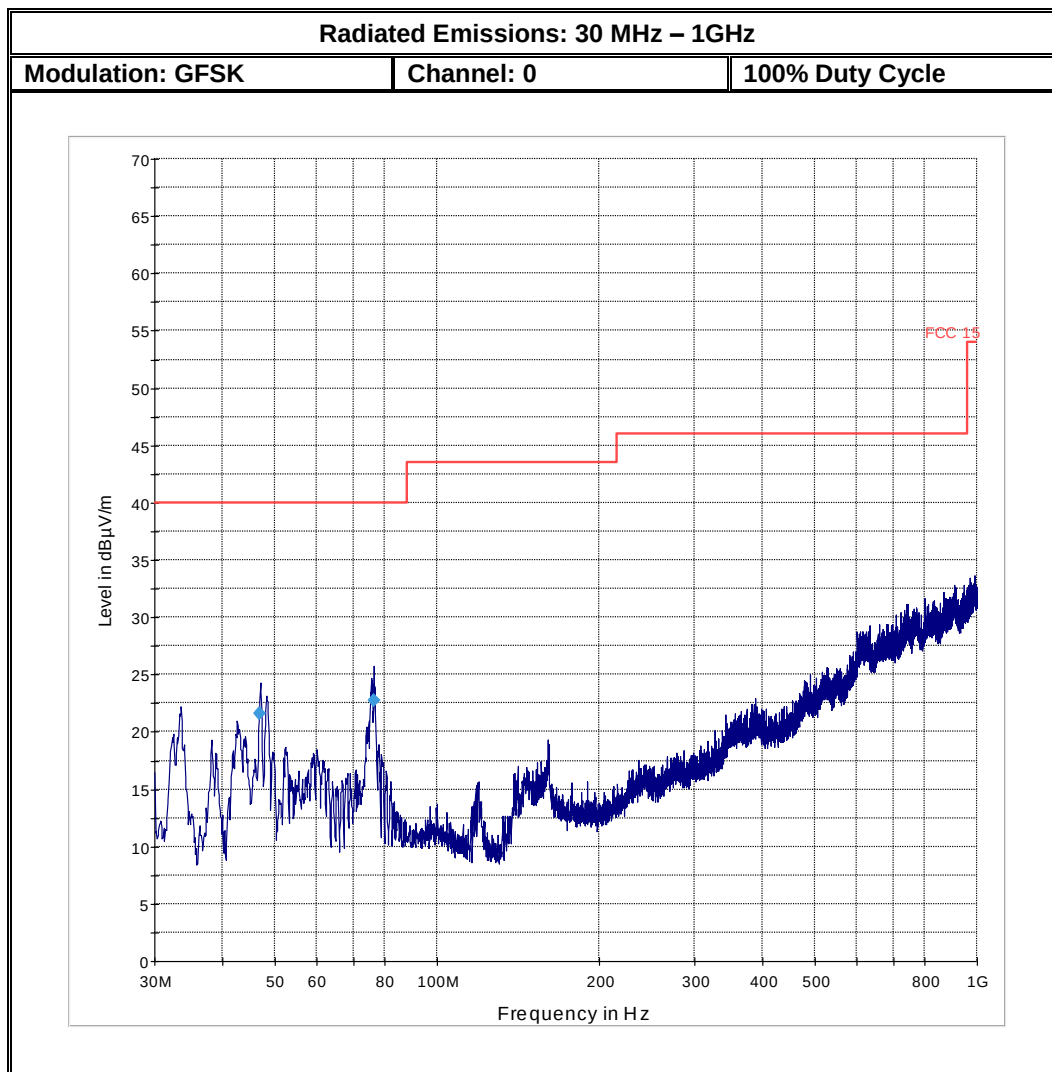
7.7.4 Measurement Result:

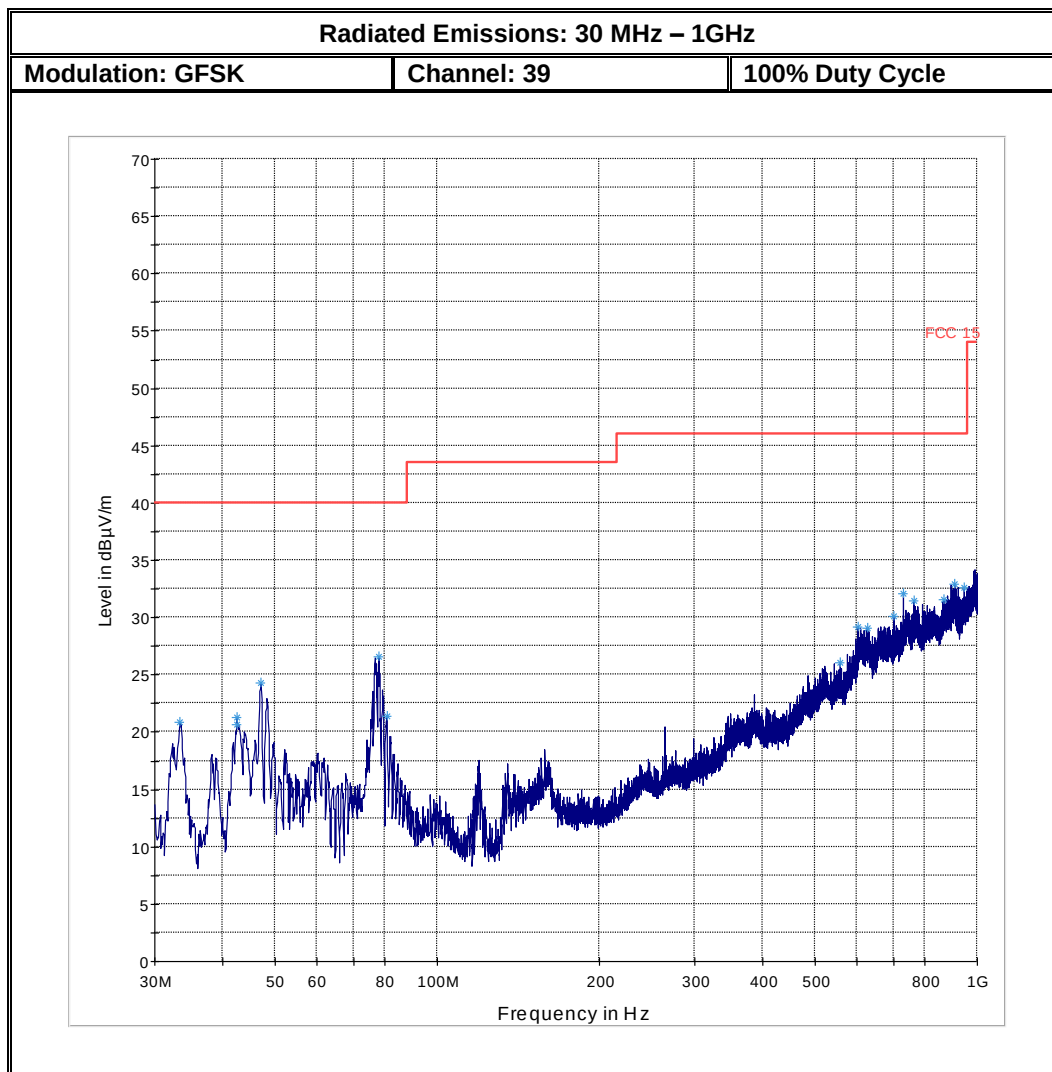
Pass.

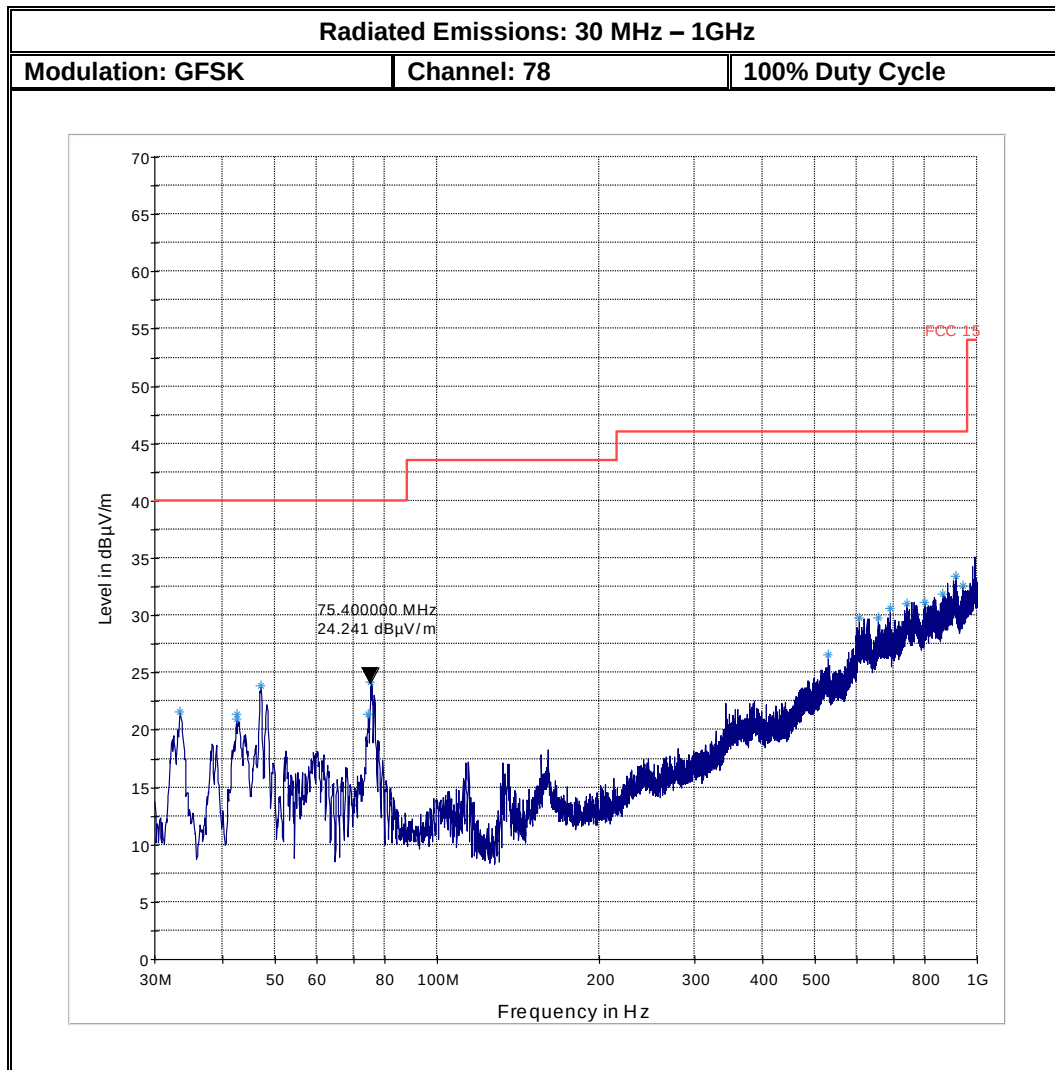
7.7.5 Measurement plots:

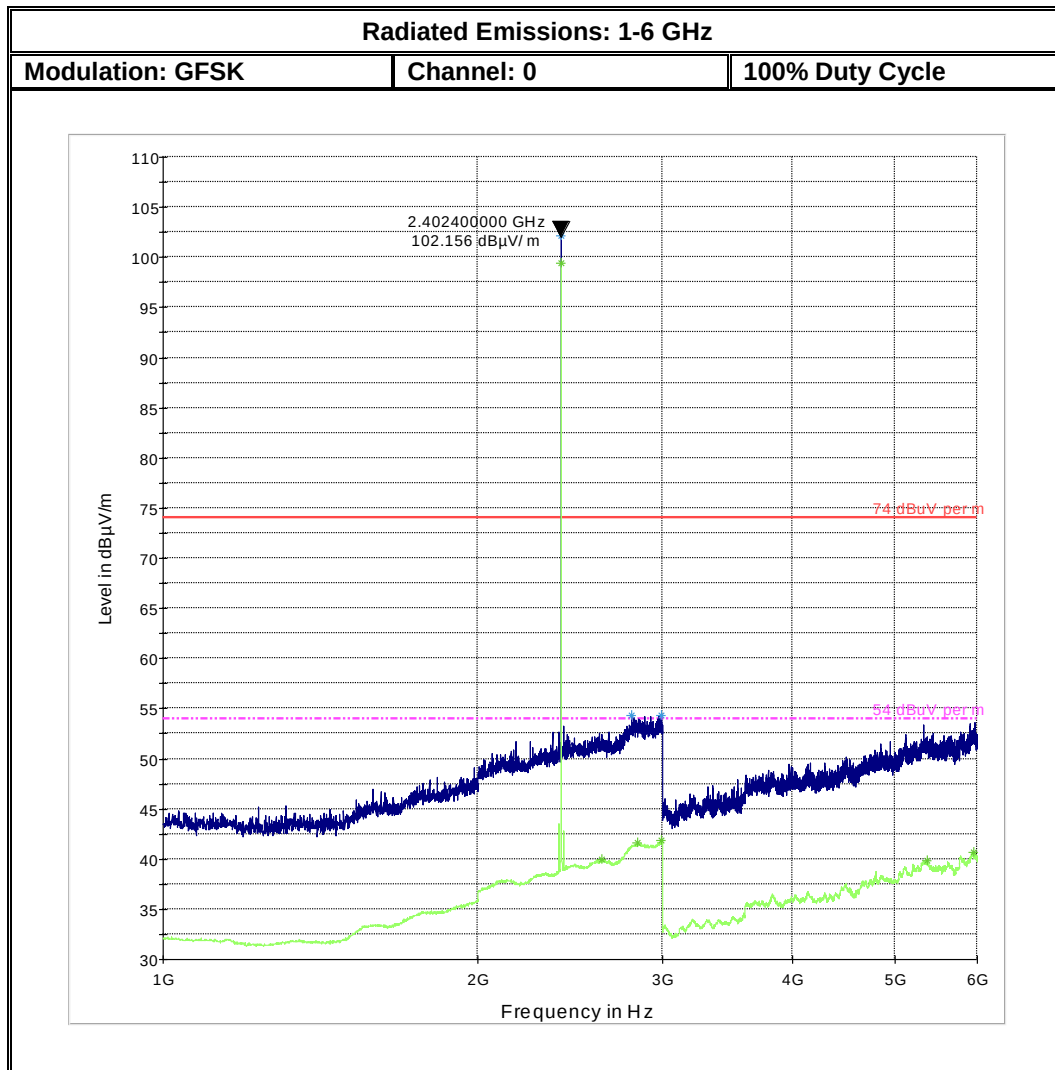
**Note: Worst case representation for all modes of operation in this frequency range.
Limits adjusted for 3m measurement.**

7.7.5.1 GFSK

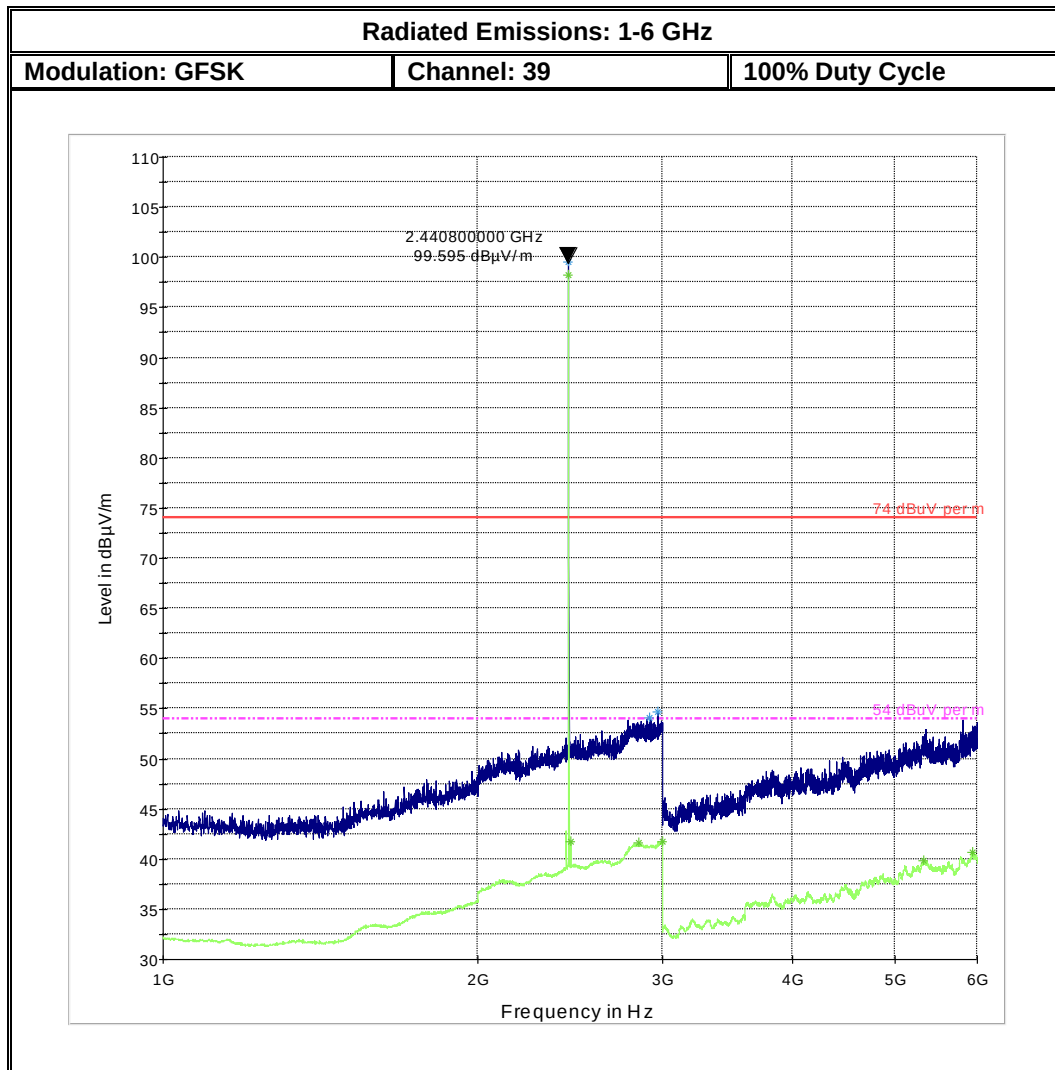




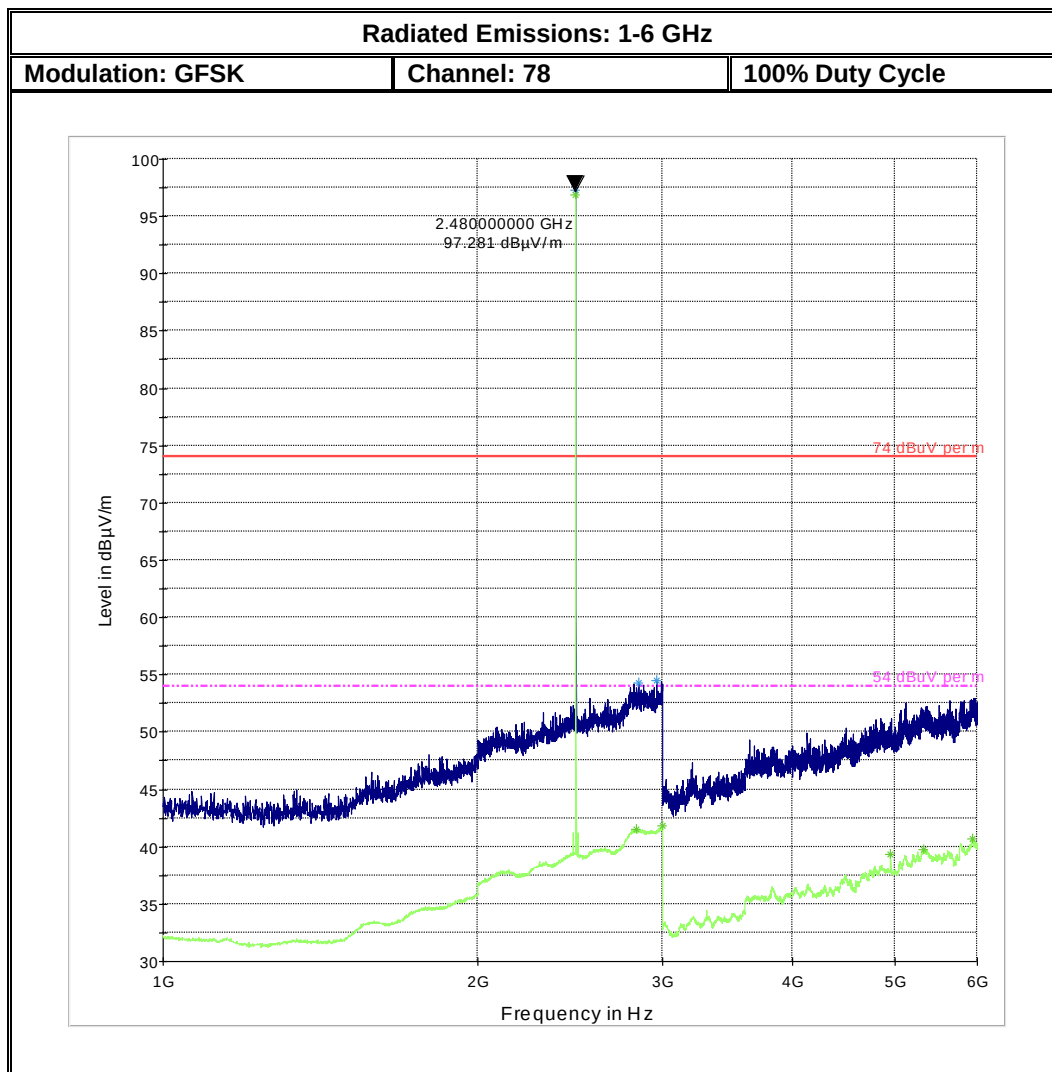




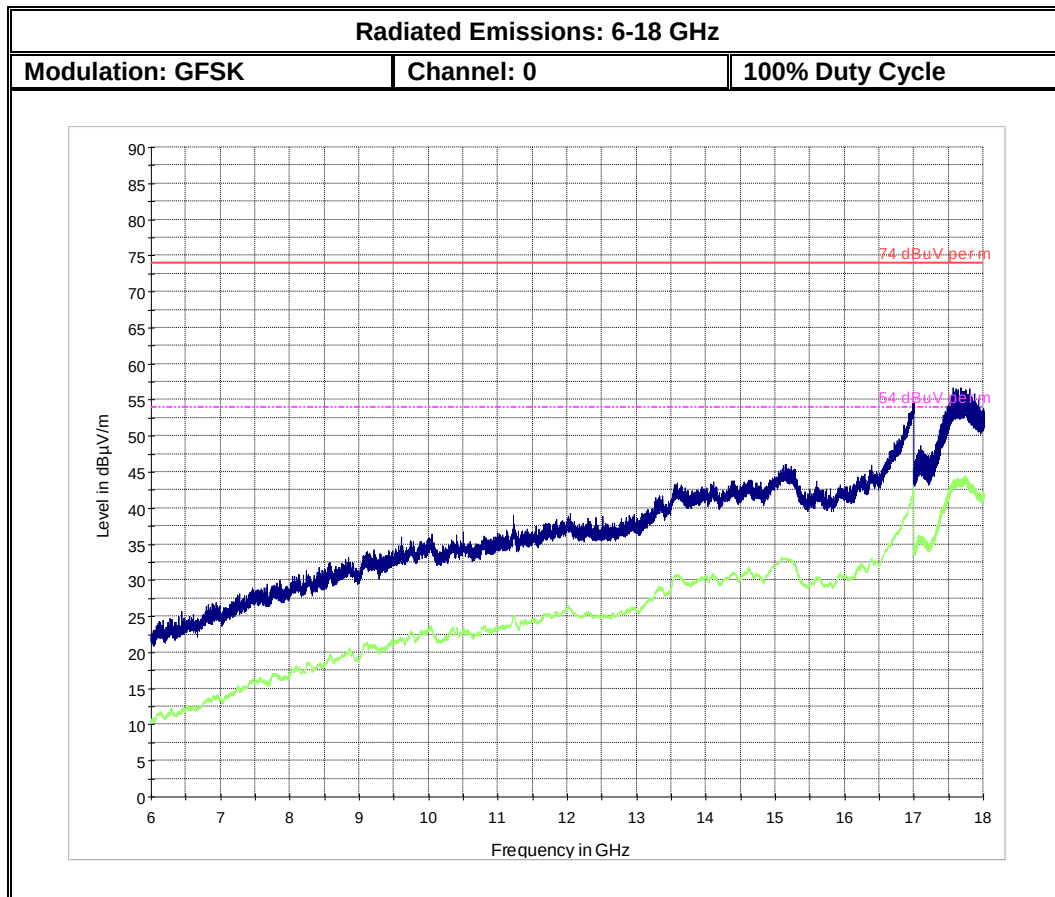
Note: Emission above limit is the Tx Signal

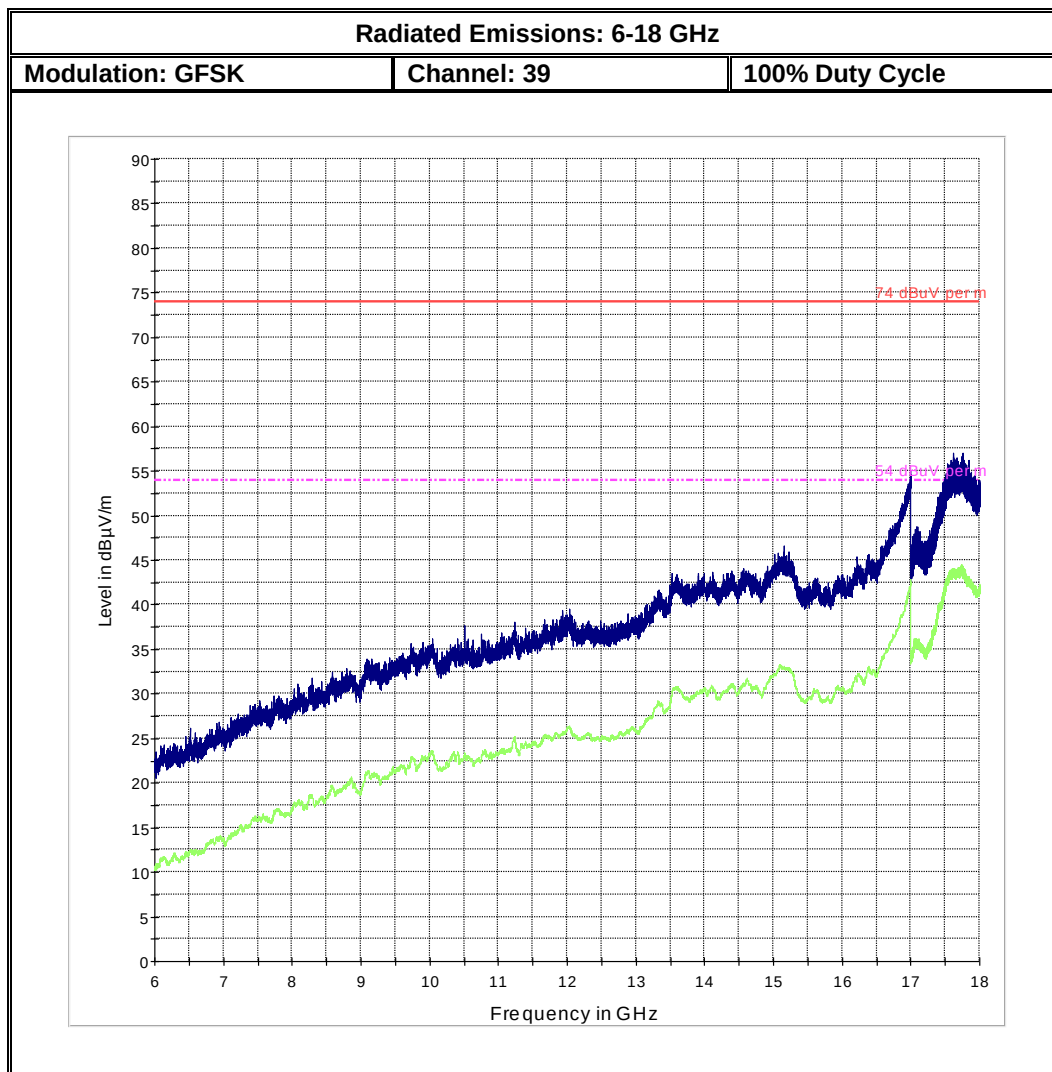


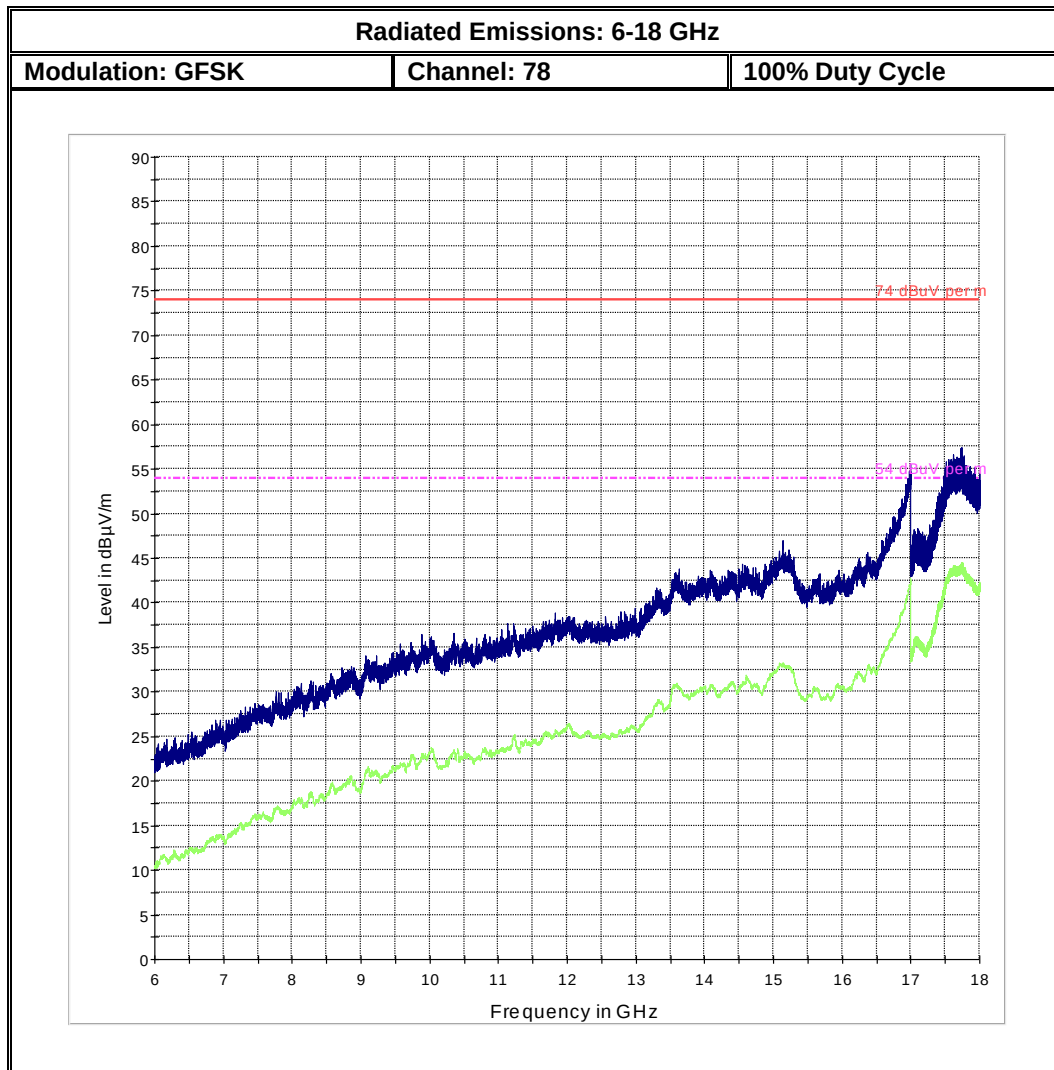
Note: Emission above limit is the Tx Signal

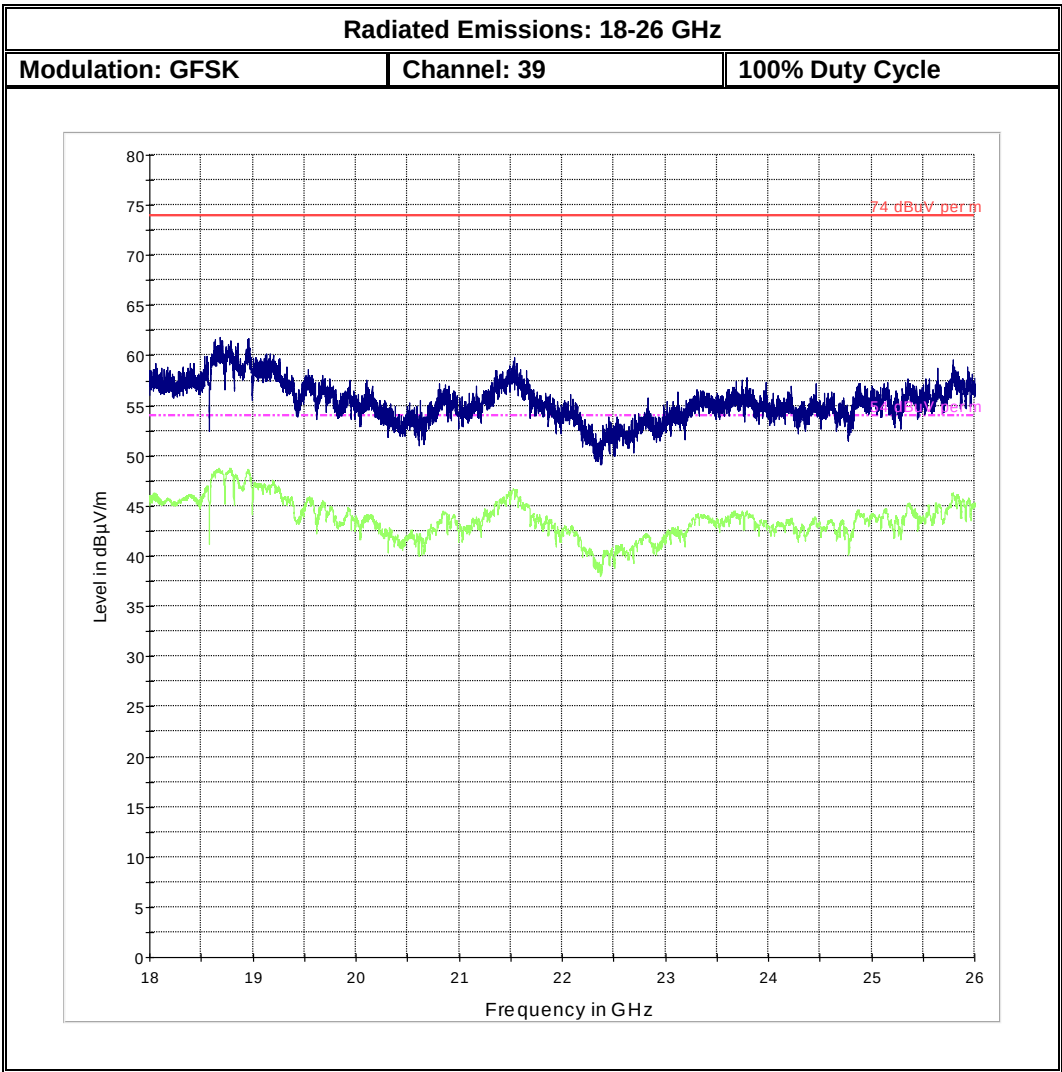


Note: Emission above limit is the Tx Signal

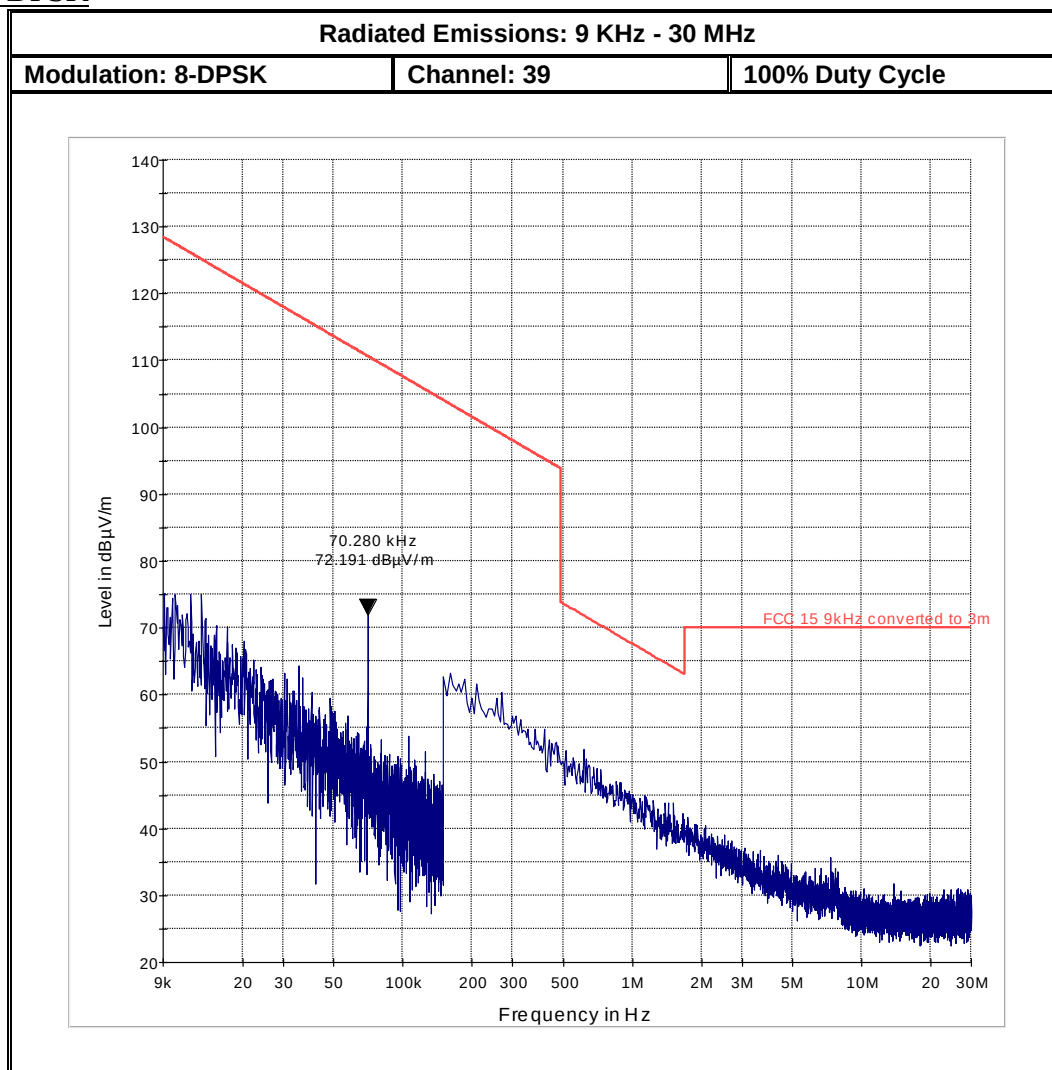


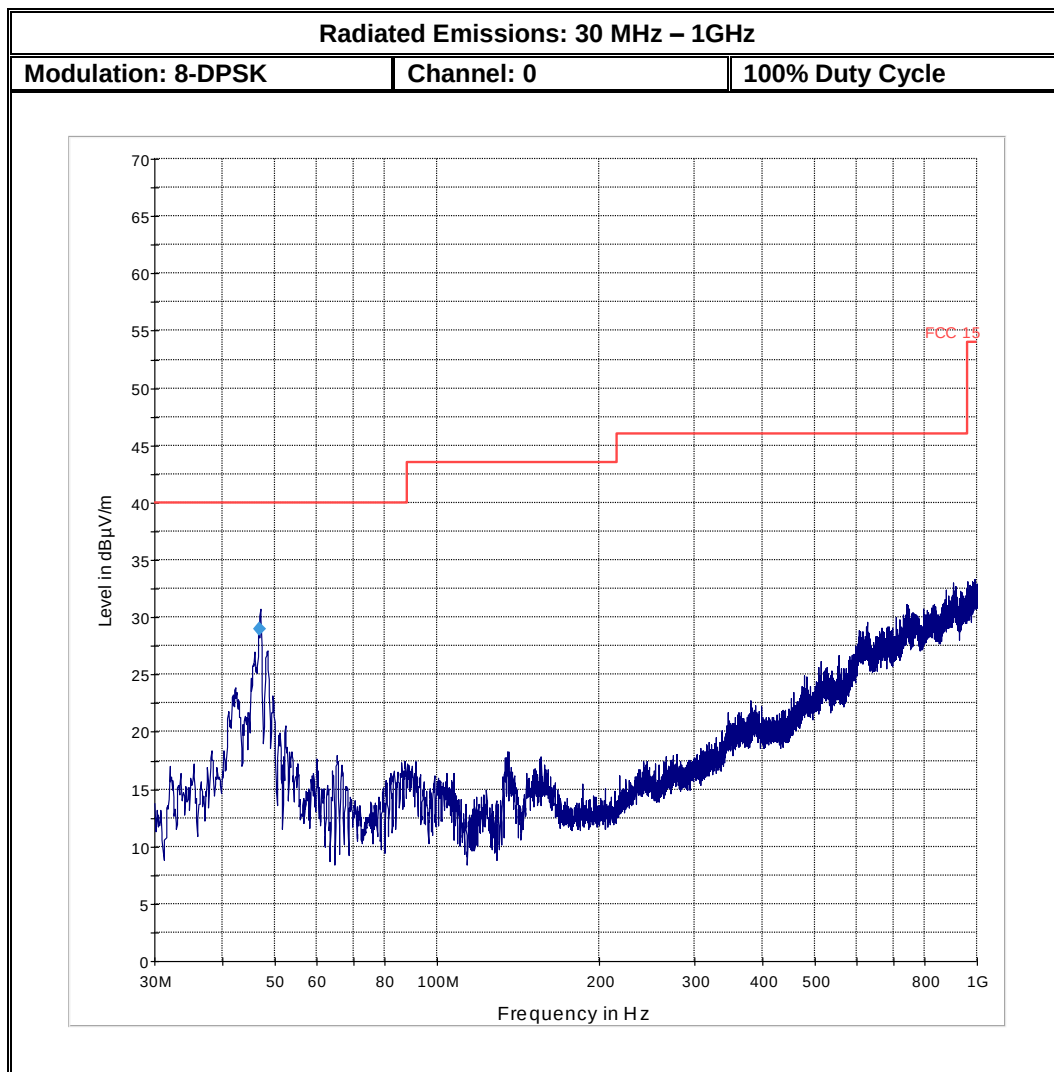


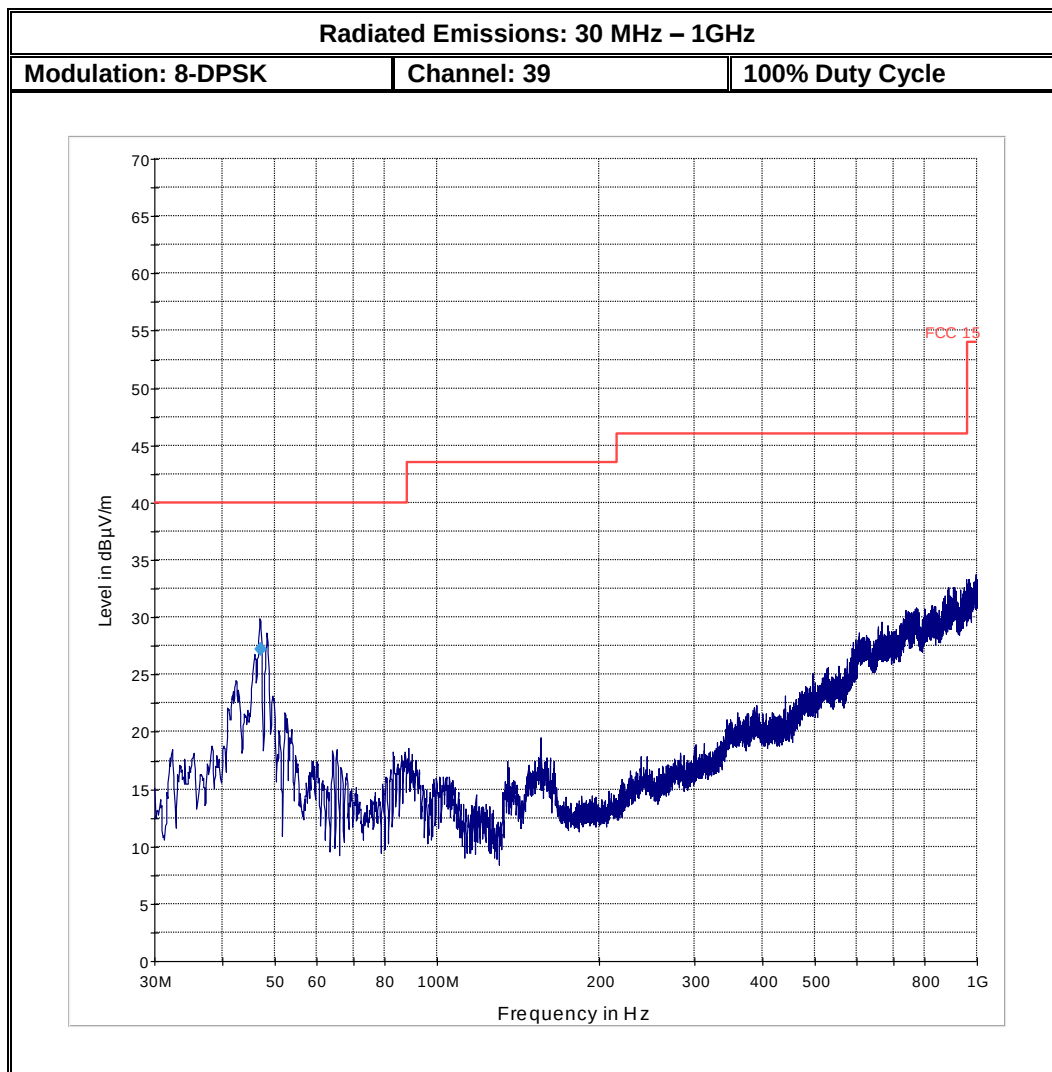


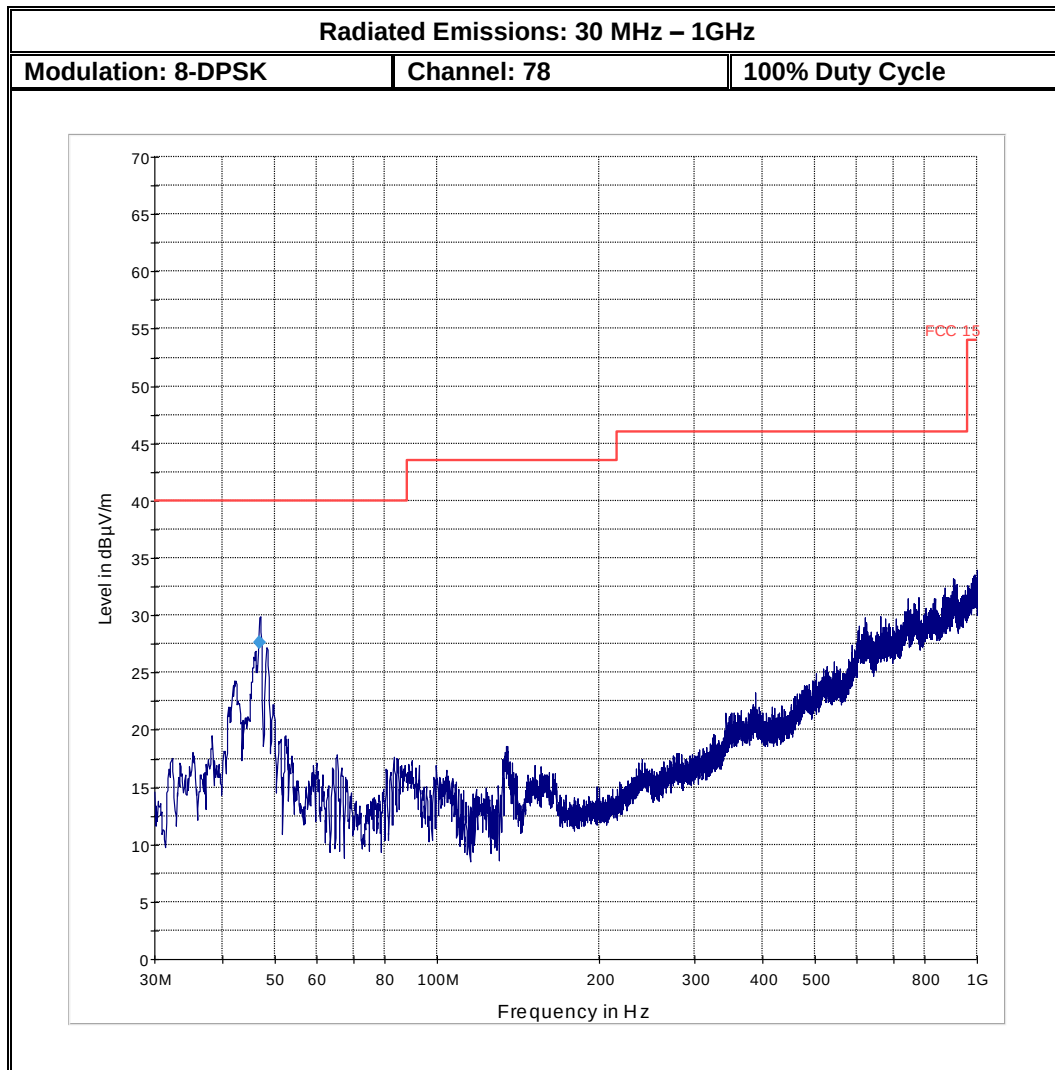


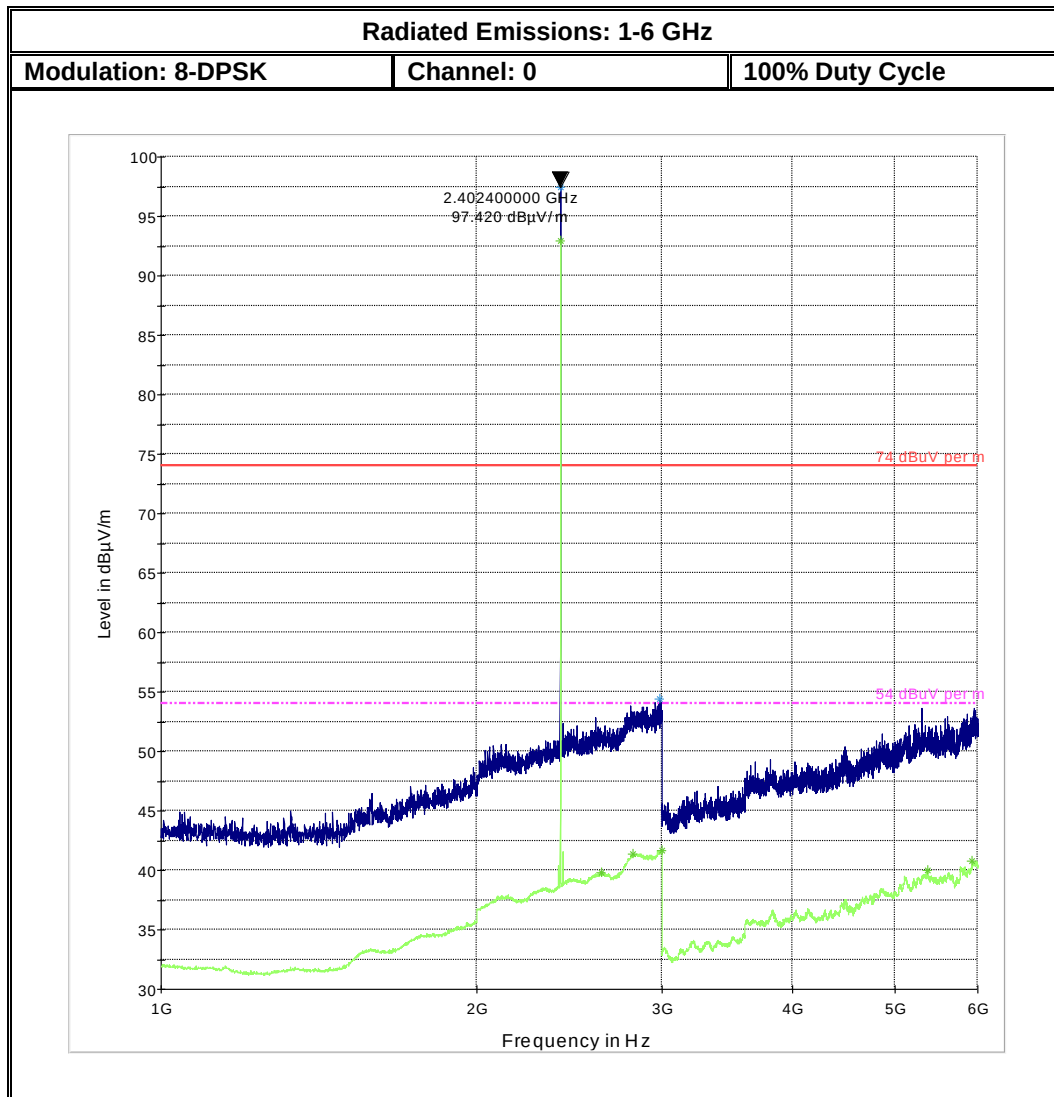
7.7.5.2 8-DPSK



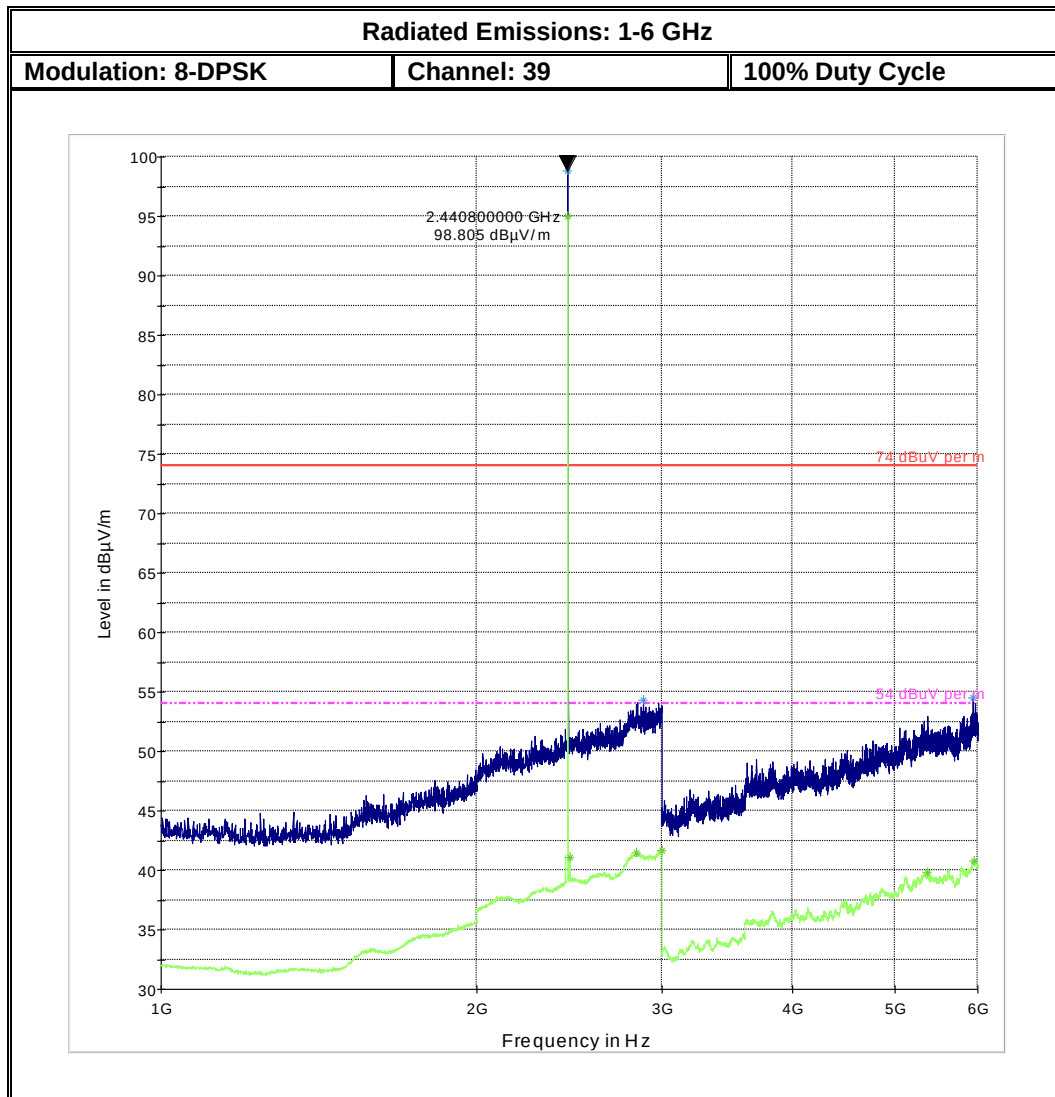




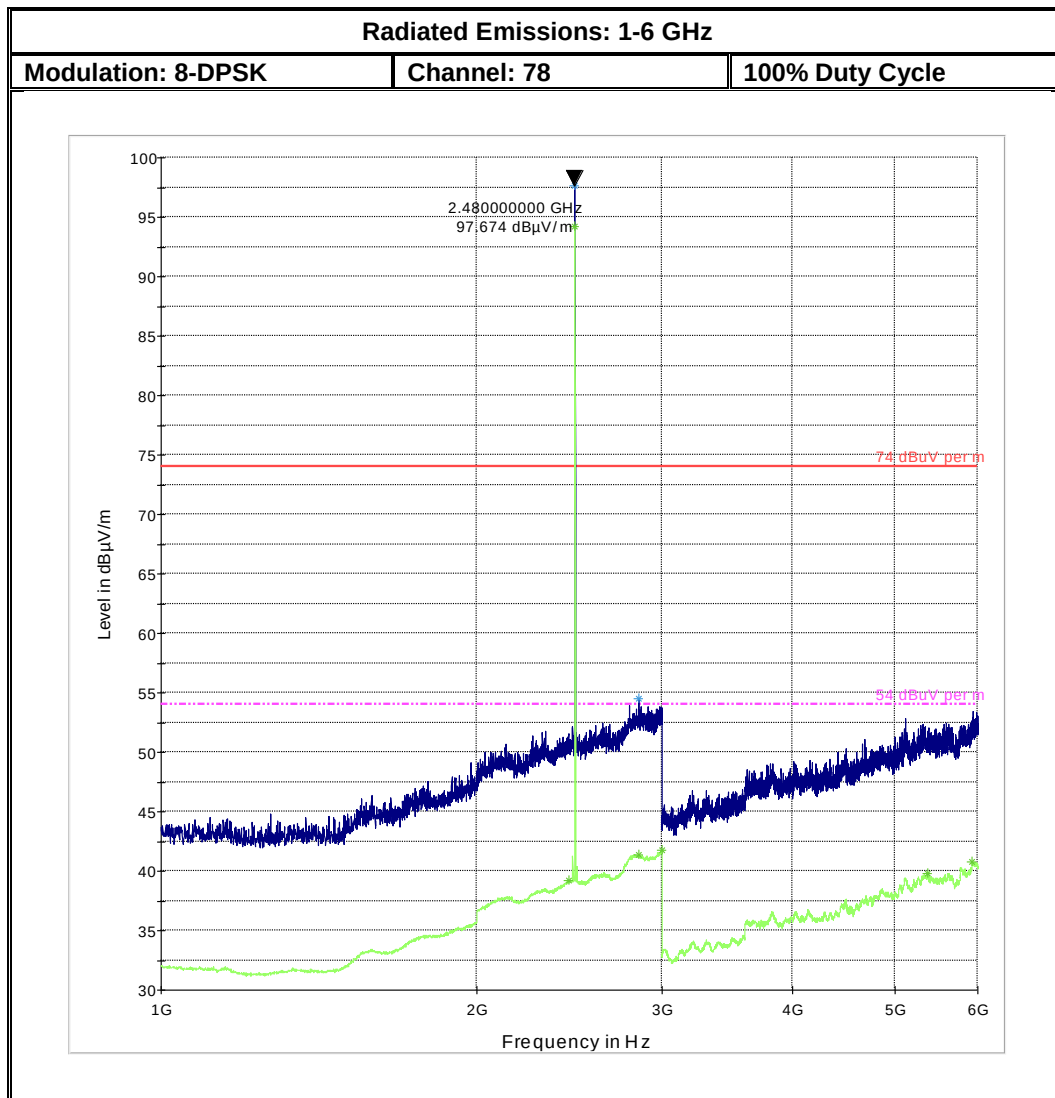




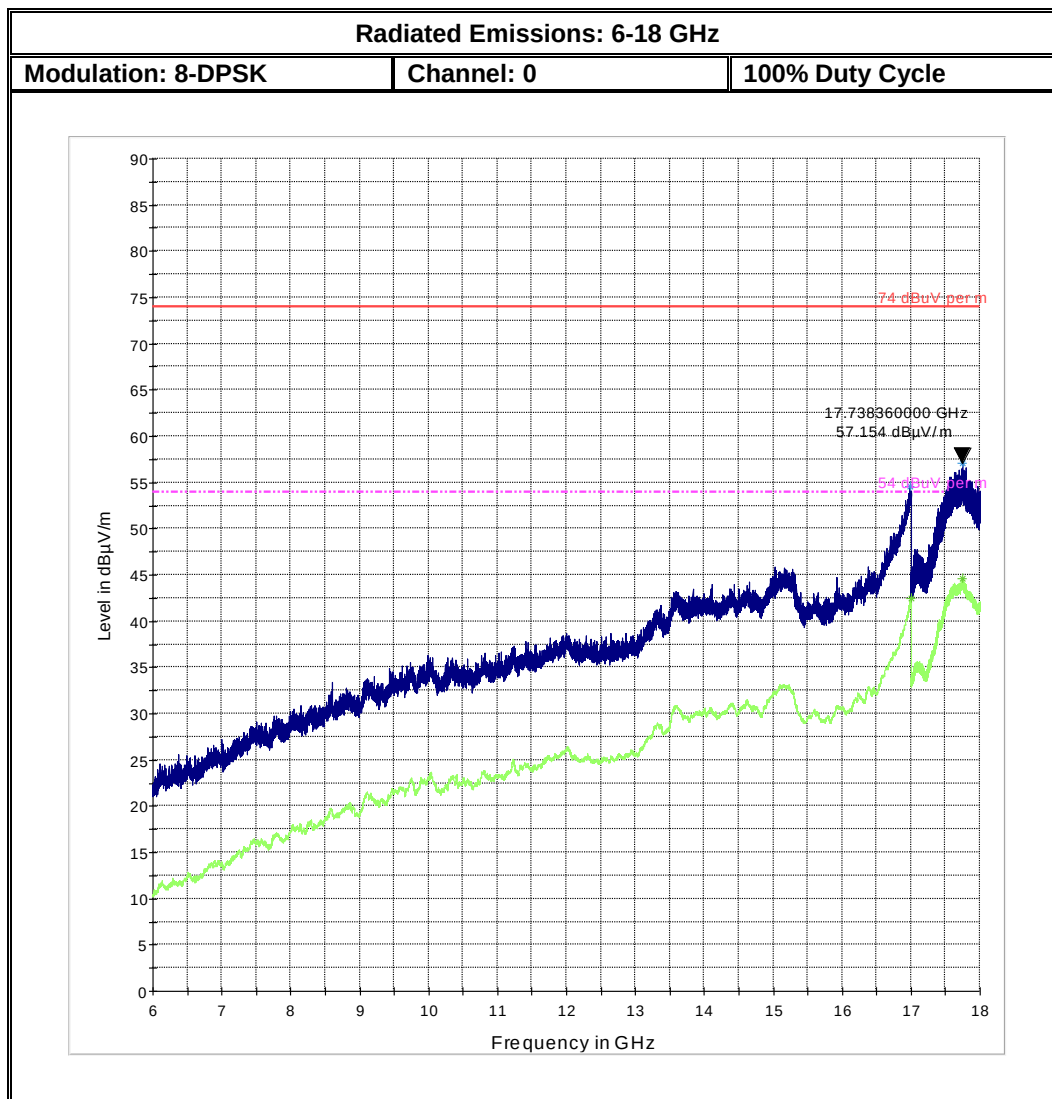
Note: Emission above limit is the Tx Signal

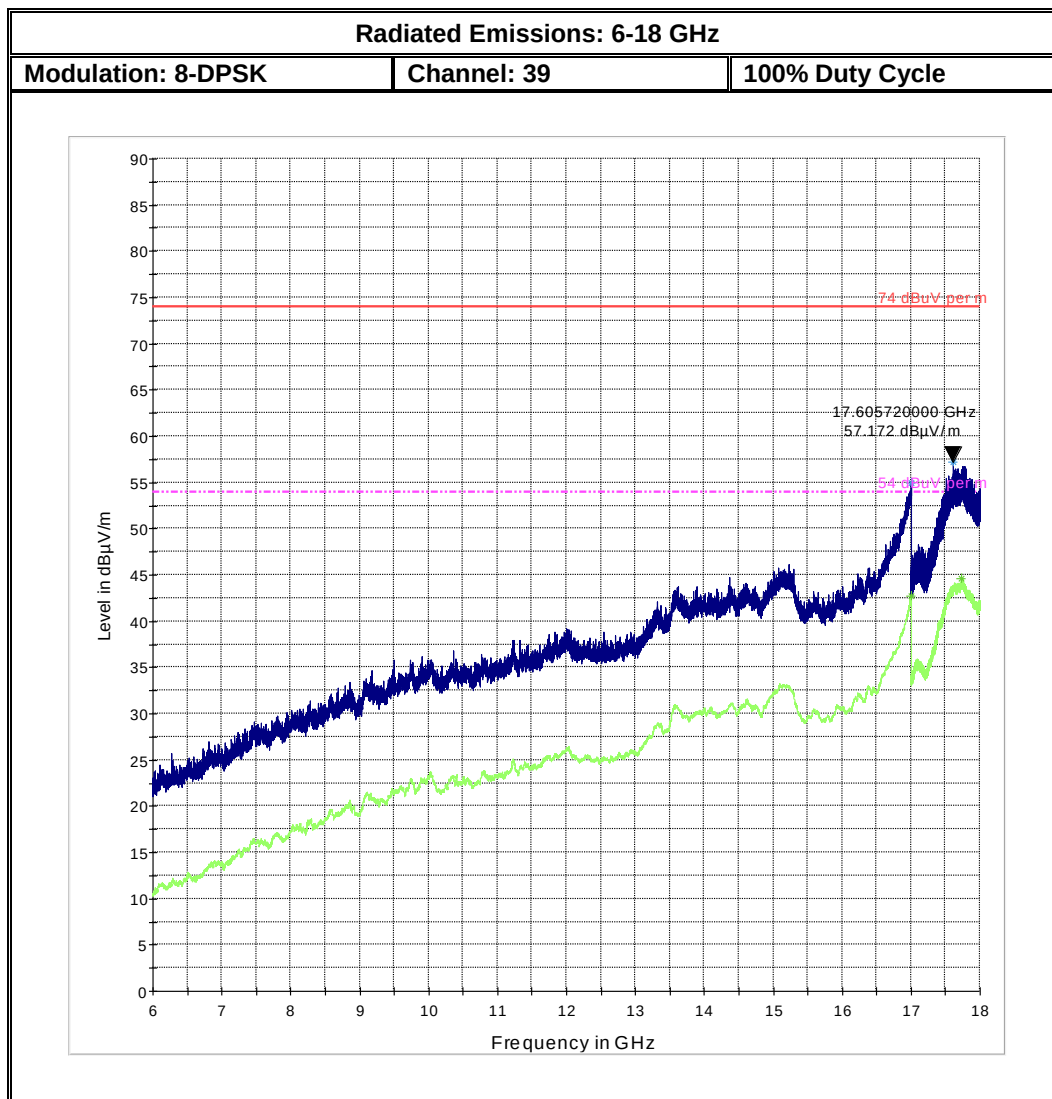


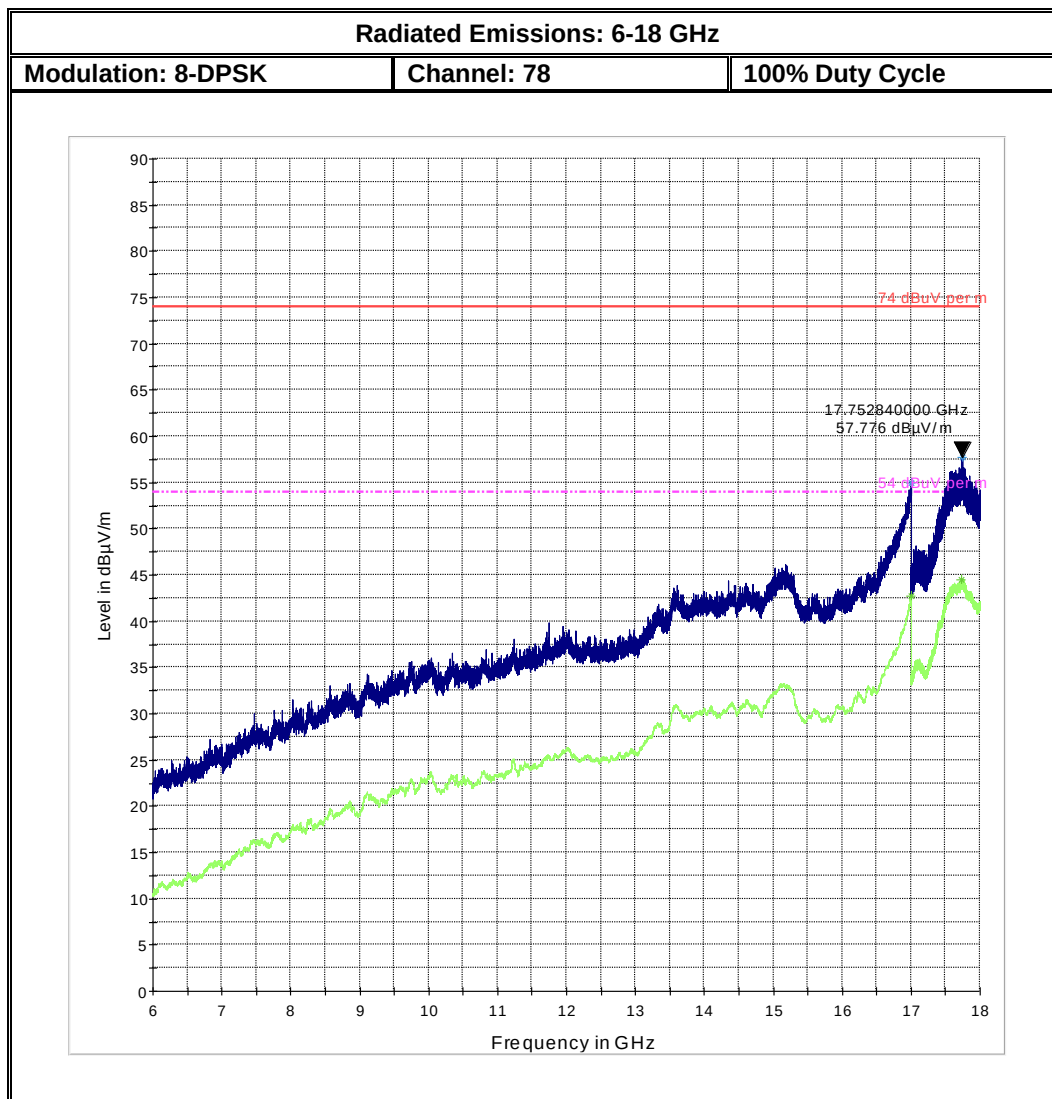
Note: Emission above limit is the Tx Signal

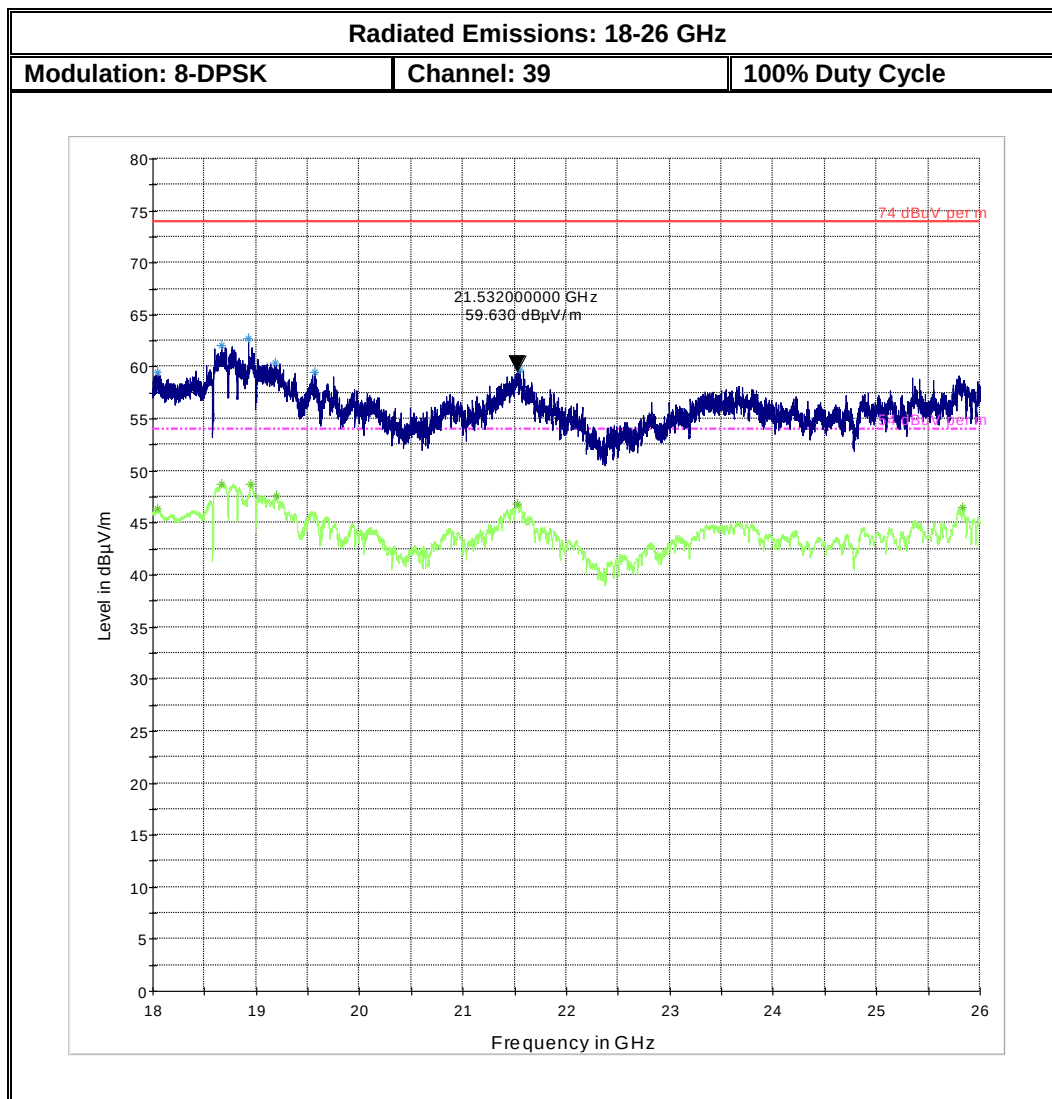


Note: Emission above limit is the Tx Signal









7.8 AC Power Line Conducted Emissions

The purpose of this test is to measure unwanted radio frequency currents induced in any AC conductor external to the equipment which could conduct interference to other equipment via the AC electrical network.

7.8.1 Limits:

§15.207 & RSS-Gen 8.8

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Table 1:

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

7.8.2 Test Conditions:

Modulation: GFSK and 8-DPSK modulation - Transmit modes of operation with 100% Duty Cycle

Tnom: 20°C; Vnom: 3.8V

7.8.3 Test Procedure

Measurement according to

ANSI C63.10 (2013)

Analyzer Settings:

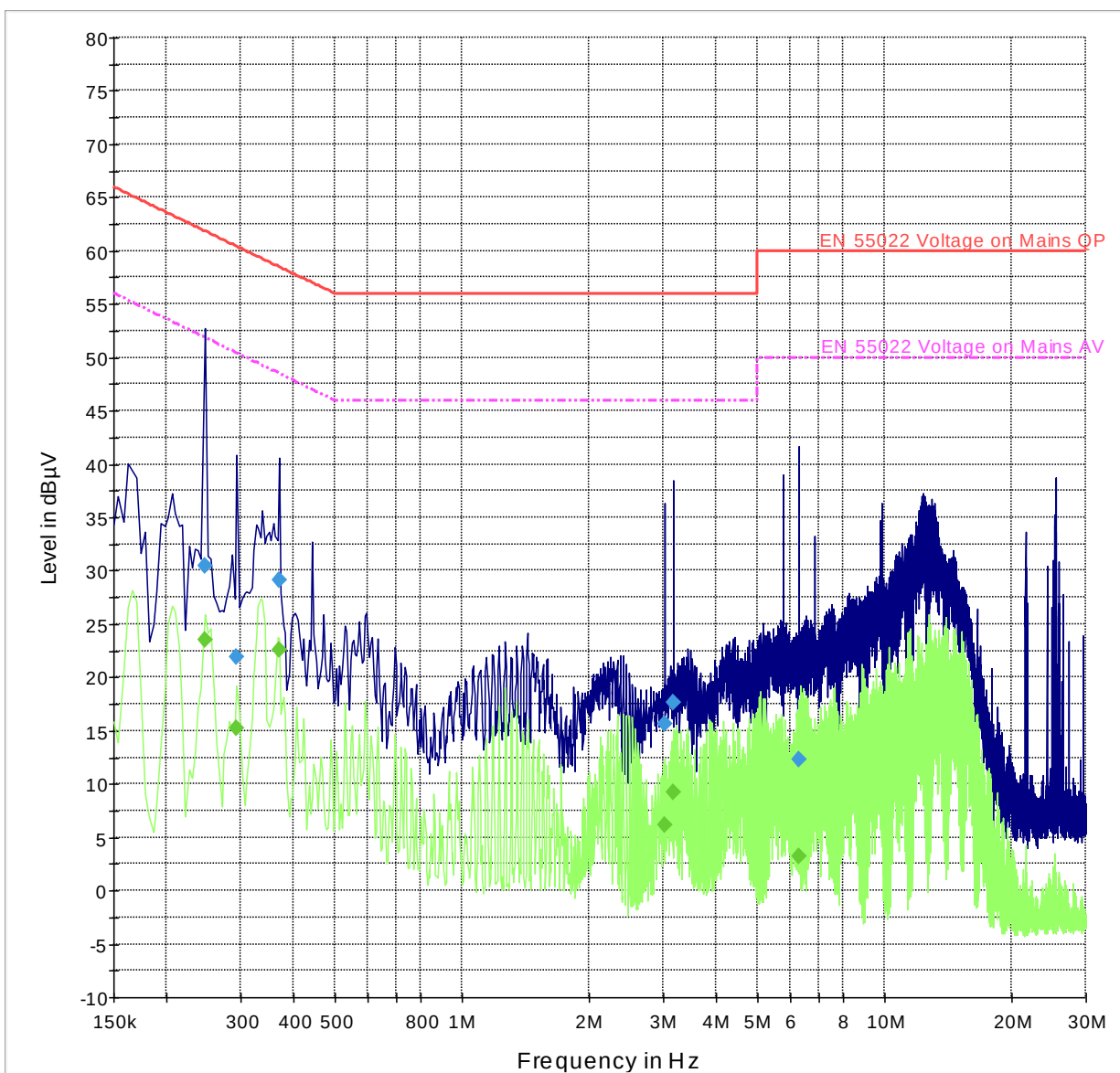
RBW = 9 KHz (CISPR Bandwidth)

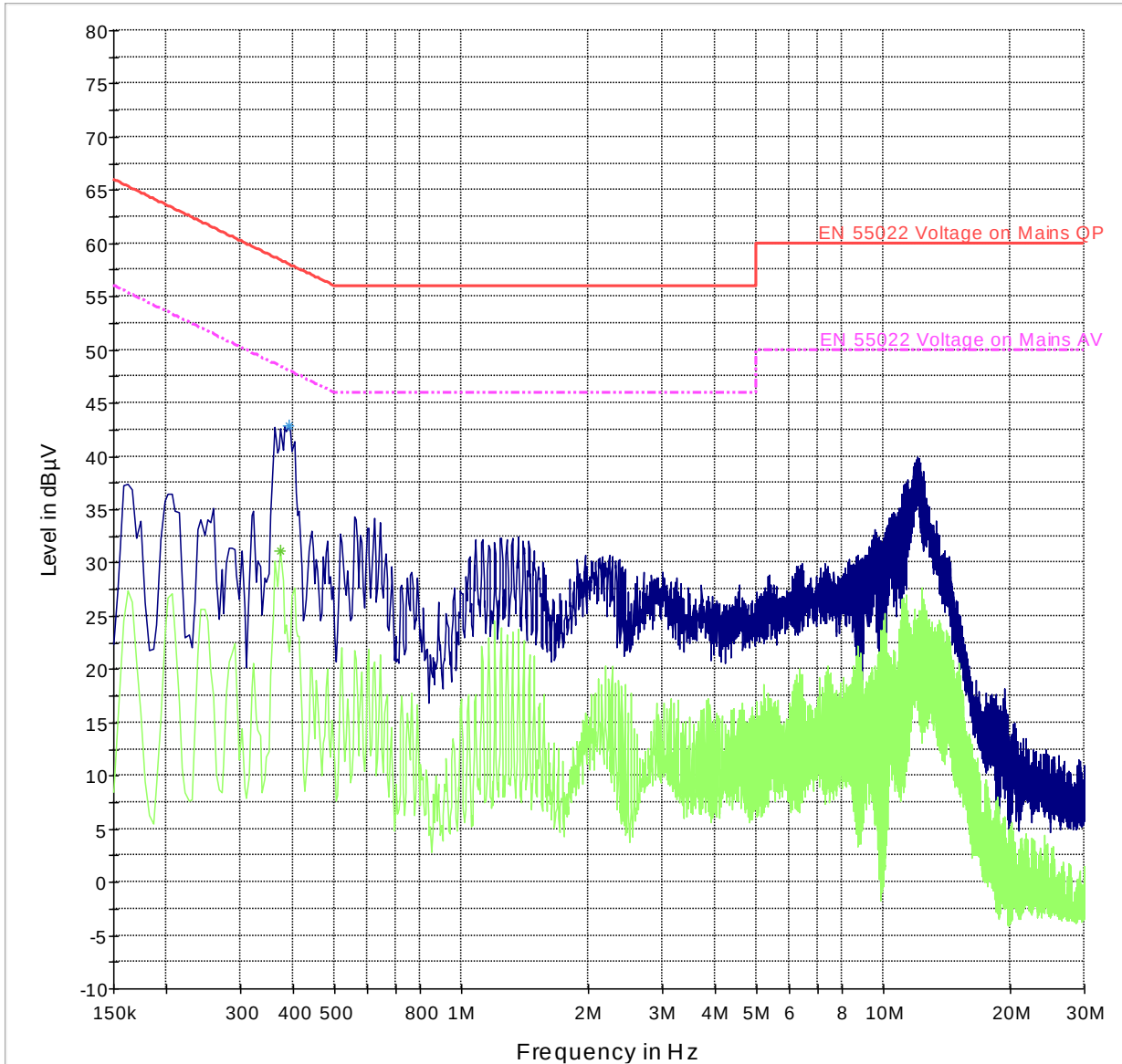
Detector: Peak / Average for Pre-scan

Quasi-Peak/Average for Final Measurements

7.8.4 Measurement Result:

Pass. No emissions measured within 6 dB of limit.

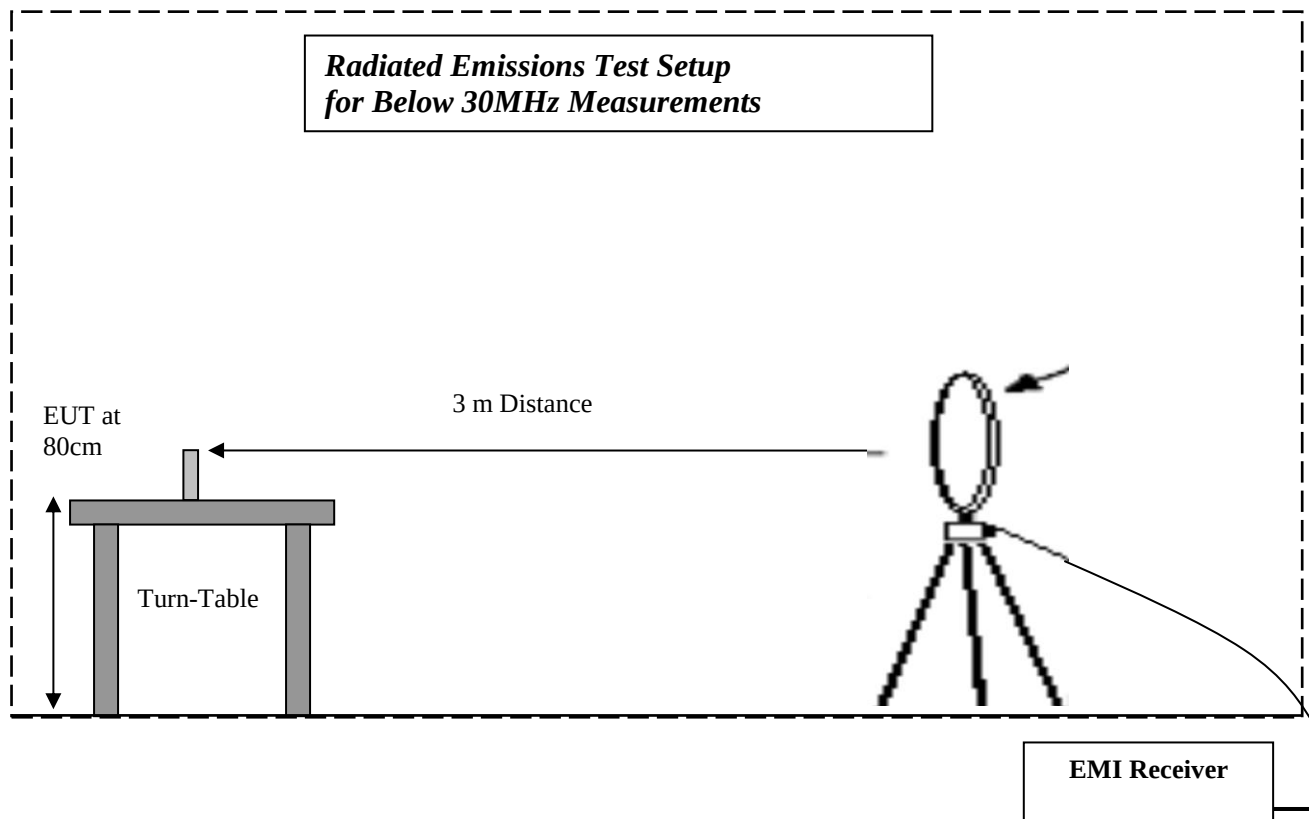
7.8.5 Measurement Plots:**7.8.5.1 Conducted Emissions: 150 KHz – 30 MHz — GFSK modulation**

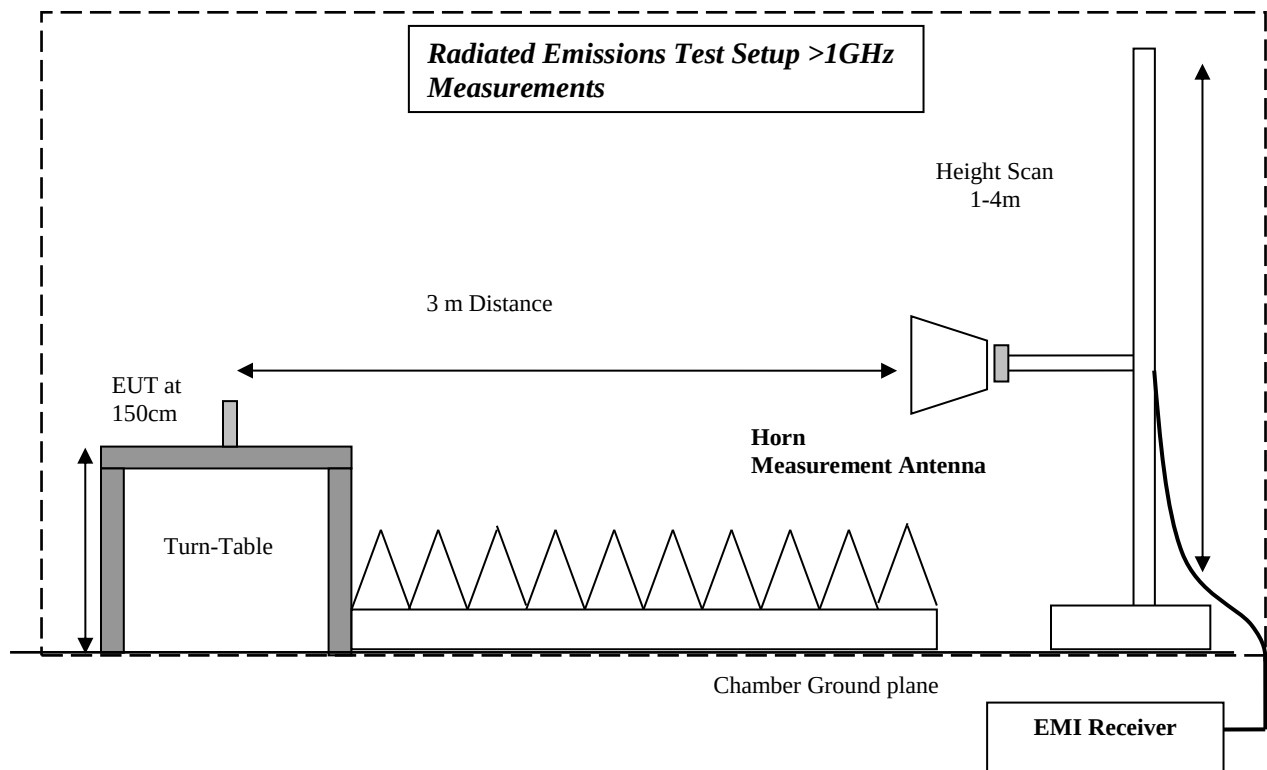
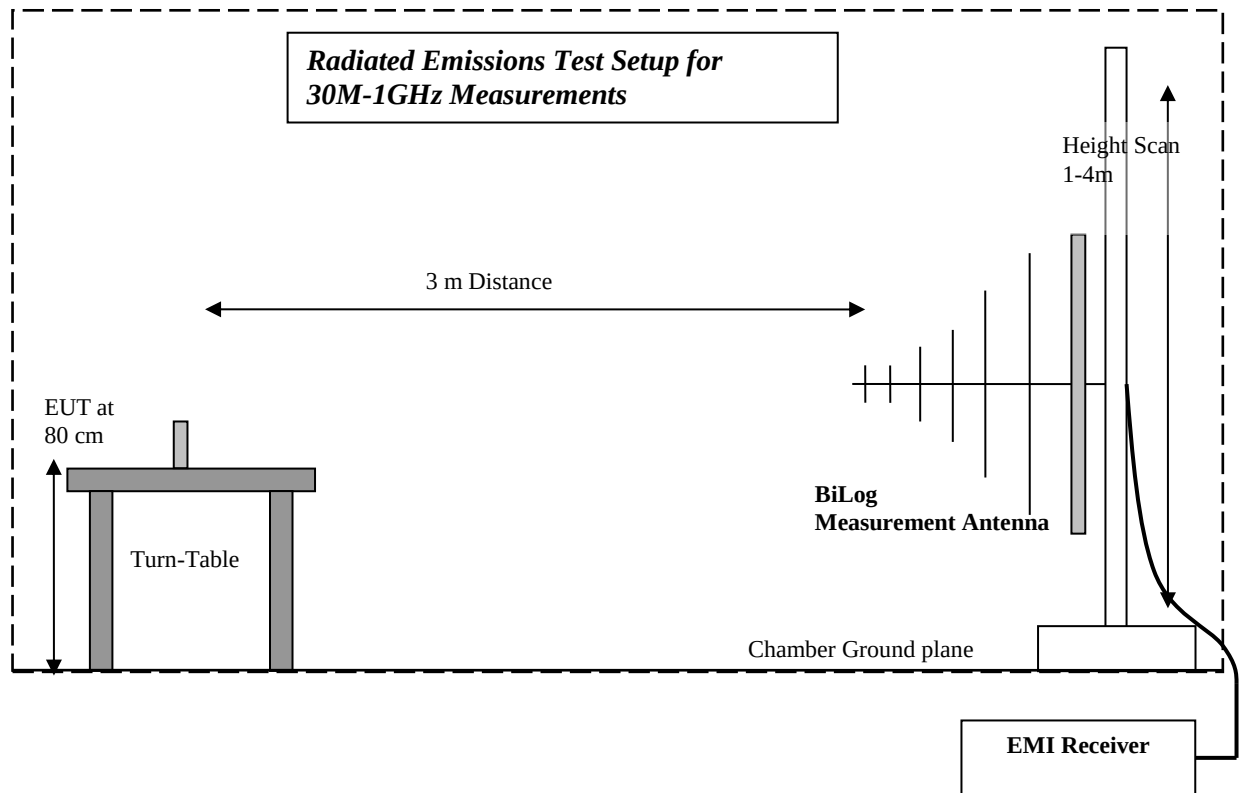
7.8.5.2 Conducted Emissions: 150 KHz – 30 MHz — 8-DPSK modulation

8 Test Equipment and Ancillaries used for tests

No.	Equipment Name	Manufacturer	Type/model	Serial No.	Cal Date	Cal Interval
	Turn table	EMCO	2075	N/A	N/A	N/A
	MAPS Position Controller	ETS Lindgren	2092	0004-1510	N/A	N/A
	Antenna Mast	EMCO	2075	N/A	N/A	N/A
	High Pass Filter	5HC2700	Trilithic Inc.	9926013	Part of system calibration	
	High Pass Filter	4HC1600	Trilithic Inc.	9922307	Part of system calibration	
	6GHz High Pass Filter	HPM50106	Microtronics	001	Part of system calibration	
	Pre-Amplifier	JS4-00102600	Miteq	00616	Part of system calibration	
	Relay Switch Unit	Rohde&Schwarz	RSU	338964/001	N/A	N/A
	EMI Receiver/Analyzer	Rohde&Schwarz	ESU 40	100251	Sept 2013	2 Year
	Spectrum Analyzer	Rohde&Schwarz	FSU	200302	Jun 2013	2 Years
	1500MHz HP Filter	Filtek	HP12/1700	14c48	N/A	N/A
	2800 MHZ HP Filter	Filtek	HP12/2800	14C47	N/A	N/A
	Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
	Binconilog Antenna	EMCO	3141	0005-1186	Apr 2012	3.5 Years
	Binconilog Antenna	ETS	3149	J000123908	Feb 2012	3.5 years
	Horn Antenna	EMCO	3115	35114	Mar 2012	3.5 Years
	Loop Antenna	EMCO	6512	00049838	Apr 2012	3 years
	LISN	R&S	ESH3-Z5	836679/003	Jun 2013	3 Years
	Fast Power Detector 5Ms/s	ETS Lindgren	7002-006	00160034	Sep 2014	2 Years

9 Test Setup Diagram:





10 Revision History

Date	Report Name	Changes to report	Report prepared by
2015-06-15	EMC_APPLE-166-15001_Z11_15.247_BT	First Version	Douglas Antioco
2015-08-03	EMC_APPLE-166-15001_15.247_BT_rev1	Replaces previous test report number. Replaced relevant references of RSS-210 to relevant references of RSS-247. Model number changed to "A1644." Product Description Changed to "Bluetooth Device. with BDR, EDR and LE support." EUT Status in Section 3.1 changed to "Pre-Production." Measurement Uncertainty in Section 6.4 updated.	Douglas Antioco
2015-08-13	EMC_APPLE-166-15001_15.247_BT_rev2	Replaces previous test report number. Added HVIN and PMN in section 3.1. Removed EIRP limit in section 7.1.1. Specified limits in section 7.2.3 with regards to conducted and radiated measurements. Clarified limit in section 7.4.1. Removed measurement uncertainty in section 7.7.3.	