FCC Testing of the DAQRI International Ltd Model: DAQRI Smart Helmet In accordance with FCC 47 CFR Part 15C

Prepared for: DAQRI LLC
1201 W. 5th St. Suite T-800
Los Angeles
California
90017
United States

FCC ID: 2AEWMDQR001001

Product Service

Choose certainty.
Add value.

COMMERCIAL-IN-CONFIDENCE

Date: March 2017
Document Number: 75937080-01 | Issue: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Steven White	24 March 2017	
Authorised Signatory	Matthew Russell	24 March 2017	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

ENGINEERING STATEMENT
The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 15C. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Neil Rousell	24 March 2017	
Testing	Graeme Lawler	24 March 2017	
Testing	Mehadi Choudhury	24 March 2017	

FCC Accreditation
90987 Octagon House, Fareham Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be in compliance with FCC 47 CFR Part 15C: (2015)

DISCLAIMER AND COPYRIGHT
This non-binding report has been prepared by TÜV SÜD Product Service with all reasonable skill and care. The document is confidential to the potential Client and TÜV SÜD Product Service. No part of this document may be reproduced without the prior written approval of TÜV SÜD Product Service. © 2017 TÜV SÜD Product Service.

ACCREDITATION
Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation. Results of tests not covered by our UKAS Accreditation Schedule are marked NUA (Not UKAS Accredited).

TÜV SÜD Product Service
is a trading name of TUV SUD Ltd
Registered in Scotland at East Kilbride,
Glasgow G75 0QF, United Kingdom
Registered number: SC215164

TUV SUD Ltd is a
TÜV SÜD Group Company

Phone: +44 (0) 1489 558100
Fax: +44 (0) 1489 558101
www.tuv-sud.co.uk

TÜV SÜD Product Service
Octagon House
Concorde Way
Fareham
Hampshire PO15 5RL
United Kingdom

Contents

1 Report Summary 2

1.1 Report Modification Record 2
1.2 Introduction 2
1.3 Brief Summary of Results 3
1.4 Application Form 4
1.5 Product Information 10
1.6 Deviations from the Standard 10
1.7 EUT Modification Record 10
1.8 Test Location 11

2 Test Details 12

2.1 Maximum Conducted Output Power 12
2.2 Frequency Hopping Systems - Average Time of Occupancy 14
2.3 Frequency Hopping Systems - Channel Separation 19
2.4 Frequency Hopping Systems - Number of Hopping Channels 22
2.5 Frequency Hopping Systems - 20 dB Bandwidth 24
2.6 Spurious Radiated Emissions 30
2.7 Restricted Band Edges 42
2.8 Authorised Band Edges 57

3 Measurement Uncertainty 66

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Issue	Description of Change	Date of Issue
1	First Issue	24 March 2017

Table 1

1.2 Introduction

Applicant	DAQRI LLC
Manufacturer	DAQRI International Ltd
Model Number(s)	DAQRI Smart Helmet
Serial Number(s)	1) 106 2) 1829C-DC8-6UPN9XJWJW
Hardware Version(s)	DAQRI Thor DE
Software Version(s)	V16
Number of Samples Tested	2
Test Specification/Issue/Date	FCC 47 CFR Part 15C: (2015)
Order Number Date	107133 25-November-2016
Date of Receipt of EUT	28-November-2016
Start of Test	28-November-2016
Finish of Test	13-March-2017
Name of Engineer(s)	Mehadi Choudhury, Neil Russell and Graeme Lawler
Related Document(s)	ANSI C63.10 (2013)

1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15C, Industry Canada RSS-247 and Industry Canada RSS-GEN is shown below.

Section	Specification Clause	Test Description	Result	Comments/Base Standard
Configuration: Bluetooth				
2.1	15.247 (b)(3)	Maximum Conducted Output Power	Pass	ANSI C63.10
2.2	15.247 (a)(1)(iii)	Frequency Hopping Systems - Average Time of Occupancy	Pass	ANSI C63.10
2.3	15.247 (a)(1)	Frequency Hopping Systems - Channel Separation	Pass	ANSI C63.10
2.4	15.247 (a)(1)(iii)	Frequency Hopping Systems - Number of Hopping Channels	Pass	ANSI C63.10
2.5	15.247 (a)(1)	Frequency Hopping Systems - 20 dB Bandwidth	Pass	ANSI C63.10
2.6	15.247 (d) and 15.205	Spurious Radiated Emissions	Pass	ANSI C63.10
2.7	15.205	Restricted Band Edges	Pass	ANSI C63.10
2.8	15.247 (d)	Authorised Band Edges	Pass	ANSI C63.10

Table 2

1.4 Application Form

EQUIPMENT DESCRIPTION	
Model Name/Number	DAQRI Smart Helmet
Part Number	THR5002101
Hardware Version	DAQRI Thor DE
Software Version	V16
FCC ID (if applicable)	2AEWMDQR001001
Industry Canada ID (if applicable)	N/A
Technical Description (Please provide a brief description of the intended use of the equipment)	DAQRI Smart Helmet is a wearable human-machine interface that connects workers in a variety of industries and environments to real time information and augmented work instructions.

Types of Modulations used by the Equipment	
☒	FHSS
☒	Other forms of modulation
In case of FHSS Modulation	
In case of non-Adaptive Frequency Hopping equipment:	
	Number of Hopping Frequencies:
In case of Adaptive Frequency Hopping Equipment:	
	Maximum number of Hopping Frequencies: 79
	Minimum number of Hopping Frequencies: 20
Dwell Time: Up to 3.2 ms for Bluetooth	
Adaptive / non-adaptive equipment:	
☐	non-adaptive Equipment
☒	adaptive Equipment without the possibility to switch to a non-adaptive mode
☐	adaptive Equipment which can also operate in a non-adaptive mode
In case of adaptive equipment:	
The maximum Channel Occupancy Time implemented by the equipment: 13 ms	
☐	The equipment has implemented an LBT based DAA mechanism
In case of equipment using modulation different from FHSS:	
☐	The equipment is Frame Based equipment
☒	The equipment is Load Based equipment
☐	The equipment can switch dynamically between Frame Based and Load Based equipment
The CCA time implemented by the equipment: 18 µs	
☒	The equipment has implemented an non-LBT based DAA mechanism
☐	The equipment can operate in more than one adaptive mode

In case of non-adaptive Equipment:		
The maximum RF Output Power (e.i.r.p.): 19 dBm		
The maximum (corresponding) Duty Cycle: 100 %		
Equipment with dynamic behaviour, that behaviour is described here. (e.g. the different combinations of duty cycle and corresponding power levels to be declared):		
The worst case operational mode for each of the following tests:		
RF Output Power: Determined by test lab		
Power Spectral Density: Determined by test lab		
Duty cycle, Tx-Sequence, Tx-gap: Determined by test lab		
Accumulated Transmit Time, Frequency Occupation & Hopping Sequence (only for FHSS equipment): Determined by test lab		
Hopping Frequency Separation (only for FHSS equipment): Determined by test lab		
Medium Utilisation: N/A		
Adaptivity & Receiver Blocking: Determined by test lab		
Nominal Channel Bandwidth: Determined by test lab		
Transmitter unwanted emissions in the OOB domain: Determined by test lab		
Transmitter unwanted emissions in the spurious domain: Determined by test lab		
Receiver spurious emissions: Determined by test lab		
The different transmit operating modes (tick all that apply):		
☒	Operating mode 1: Single Antenna Equipment	
	☒	Equipment with only 1 antenna
	☒	Equipment with 2 diversity antennas but only 1 antenna active at any moment in time
	☐	Smart Antenna Systems with 2 or more antennas, but operating in a (legacy) mode where only 1 antenna is used. (e.g. IEEE 802.11™ [i.3] legacy mode in smart antenna systems)
☒	Operating mode 2: Smart Antenna Systems - Multiple Antennas without beam forming	
	☒	Single spatial stream / Standard throughput / (e.g. IEEE 802.11™ [i.3] legacy mode)
	☒	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1
	☒	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 3
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 4
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 5
NOTE: Add more lines if more channel bandwidths are supported.		
☐	Operating mode 3: Smart Antenna Systems - Multiple Antennas with beam forming	
	☐	Single spatial stream / Standard throughput (e.g. IEEE 802.11™ [i.3] legacy mode)
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 1
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 2
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 3
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 4
	☐	High Throughput (> 1 spatial stream) using Nominal Channel Bandwidth 5
NOTE: Add more lines if more channel bandwidths are supported.		

In case of Smart Antenna Systems:
The number of Receive chains: 2
The number of Transmit chains: 2
☒ symmetrical power distribution
☐ asymmetrical power distribution
In case of beam forming, the maximum (additional) beam forming gain: dB
NOTE: The additional beam forming gain does not include the basic gain of a single antenna.
Operating Frequency Range(s) of the equipment:
Operating Frequency Range 1: 2400 MHz to 2483.5 MHz
Operating Frequency Range 2: MHz to MHz
Operating Frequency Range 3: MHz to MHz
NOTE: Add more lines if more Frequency Ranges are supported.
Nominal Channel Bandwidth(s):
Nominal Channel Bandwidth1: 20 MHz
Nominal Channel Bandwidth2: 40 MHz
Nominal Channel Bandwidth3: 1 MHz (Bluetooth)
Nominal Channel Bandwidth4: 2 MHz MHz (BLE)
Nominal Channel Bandwidth5: MHz
NOTE: Add more lines if more channel bandwidths are supported.
Type of Equipment (stand-alone, combined, plug-in radio device, etc.):
☒ Stand-alone
☐ Combined Equipment (Equipment where the radio part is fully integrated within another type of equipment)
☐ Plug-in radio device (Equipment intended for a variety of host systems)
☐ Other
The normal and extreme operating conditions that apply to the equipment:
Normal operating conditions (if applicable):
Operating temperature: °C
Other (please specify if applicable):
Extreme operating conditions:
Operating temperature range: Minimum 0 °C to Maximum 37 °C
Other (please specify if applicable): Minimum °C to Maximum °C
Details provided are for the:
☒ stand-alone equipment
☐ combined (or host) equipment
☐ test jig

The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels:			
Antenna Type:			
☒ Integral Antenna (information to be provided in case of conducted measurements)			
Antenna Gain: 2 dBi			
If applicable, additional beamforming gain (excluding basic antenna gain): dB			
☒ Temporary RF connector provided			
☐ No temporary RF connector provided			
☐ Dedicated Antennas (equipment with antenna connector)			
☐ Single power level with corresponding antenna(s)			
☐ Multiple power settings and corresponding antenna(s)			
Number of different Power Levels:			
Power Level 1: dBm			
Power Level 2: dBm			
Power Level 3: dBm			
NOTE 1: Add more lines in case the equipment has more power levels.			
NOTE 2: These power levels are conducted power levels (at antenna connector).			
For each of the Power Levels, provide the intended antenna assemblies, their corresponding gains (G) and the resulting e.i.r.p. levels also taking into account the beamforming gain (Y) if applicable			
Power Level 1: 19 dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1	2.0	19.0	Taoglas FXP840
2	2.0	19.0	Taoglas FXP840
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			
Power Level 2: dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1			
2			
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			
Power Level 3: dBm			
Number of antenna assemblies provided for this power level:			
Assembly #	**Gain (dBi)**	**e.i.r.p (dBm)**	**Part number or model number**
1			
2			
3			
4			
NOTE: Add more rows in case more antenna assemblies are supported for this power level.			

The nominal voltages of the stand-alone radio equipment or the nominal voltages of the combined (host) equipment or test jig in case of plug-in devices:	
Details provided are for the:	
☒ stand-alone equipment	
☐ combined (or host) equipment	
☐ test jig	
Supply Voltage ☐ AC mains State AC voltage V	
☐ DC State DC voltage V	
In case of DC, indicate the type of power source	
☐ Internal Power Supply	
☐ External Power Supply or AC/DC adapter	
☐ Battery	
☒ Other: Li-ion	
Describe the test modes available which can facilitate testing:	
The equipment type (e.g. Bluetooth®, IEEE 802.11™ [i.3] IEEE 802.15.4™ [i.4], proprietary, etc.):	
If applicable, the statistical analysis referred in clause 5.4.1 q)	
To be provided as separate attachment	
If applicable, the statistical analysis referred in clause 5.4.1 r)	
To be provided as separate attachment	
Geo-location capability supported by the equipment:	
☒ Yes	
☒ The geographical location determined by the equipment as defined in clause 4.3.1.13.2 or clause 4.3.2.12.2 is not accessible to the user.	
☐ No	
Describe the minimum performance criteria that apply to the equipment (see clause 4.3.1.12.3 or 4.3.2.11.3)	
Get this from 328 blocking test section.	
Combination for testing (see clause 5.3.2.3 of EN 300 328 V21.1)	
From all combinations of conducted power settings and intended antenna assembly(ies) specified in clause 5.4.1 m), specify the combination resulting in the highest e.i.r.p. for the radio equipment. Unless otherwise specified in ETSI EN 300 328, this power setting is to be used for testing against the requirements of ETSI EN 300 328. In case there is more than one such conducted power setting resulting in the same (highest) e.i.r.p. level, the highest power setting is to be used for testing. See also ETS EN 300 328, clause 5.3.2.3	
Highest overall e.i.r.p. value: 19 dBm	
Corresponding Antenna assembly gain: 2.0 dBi	Antenna Assembly #:
Corresponding conducted power setting: dBm (also the power level to be used for testing)	Listed as Power Setting #:
Additional information provided by the applicant	
Modulation	
ITU Class(es) of emission: 20M0 G1D, 40M0 G1D, 2M00 G1D, 1M00 G1D	
Can the transmitter operate unmodulated? ☐ Yes ☒ No	

Duty Cycle	
The transmitter is intended for:	
☒	Continuous duty
☐	Intermittent duty
☐	Continuous operation possible for testing purposes
About the UUT	
☐	The equipment submitted are representative production models
☐	If not, the equipment submitted are pre-production models?
☒	If pre-production equipment are submitted, the final production equipment will be identical in all respects with the equipment tested
☐	If not, supply full details
☐	The equipment submitted is CE marked
Additional items and/or supporting equipment provided	
☒	Spare batteries (e.g. for portable equipment)
☒	Battery charging device
☒	External Power Supply or AC/DC adapter
☐	Test Jig or interface box
☐	RF test fixture (for equipment with integrated antennas)
☐	Host System
	Manufacturer
	Model
	Model Name
☐	Combined equipment
	Manufacturer
	Model
	Model Name
☒	User Manual
☐	Technical documentation (Handbook and circuit diagrams)

I hereby declare that that the information supplied is correct and complete.

Name: Dave Williams Position held: Certification Test Manager
Date: 1st March 2017

1.5 Product Information

1.5.1 Technical Description

DAQRI Smart Helmet is a wearable human-machine interface that connects workers in a variety of industries and environments to real time information and augmented work instructions.

1.6 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
Serial Number: 106			
0	As supplied by the customer	Not Applicable	Not Applicable
Serial Number: 1829C-DC8-6UPN9XJWJW			
0	As supplied by the customer	Not Applicable	Not Applicable

Table 3

1.8 Test Location

TÜV SÜD Product Service conducted the following tests at our Fareham Test Laboratory.

Test Name	Name of Engineer(s)	Accreditation
Configuration: Bluetooth		
Maximum Conducted Output Power	Neil Rousell	UKAS
Frequency Hopping Systems - Average Time of Occupancy	Neil Rousell	UKAS
Frequency Hopping Systems - Channel Separation	Neil Rousell	UKAS
Frequency Hopping Systems - Number of Hopping Channels	Neil Rousell	UKAS
Frequency Hopping Systems - 20 dB Bandwidth	Neil Rousell	UKAS
Spurious Radiated Emissions	Graeme Lawler	UKAS
Restricted Band Edges	Graeme Lawler	UKAS
Authorised Band Edges	Graeme Lawler	UKAS

Table 4

Office Address:

Octagon House
Concorde Way
Segensworth North
Fareham
Hampshire
PO15 5RL
United Kingdom

2 Test Details

2.1 Maximum Conducted Output Power

2.1.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (b)(3)

2.1.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 106 - Modification State 0

2.1.3 Date of Test

13-March-2017

2.1.4 Test Method

This test was performed in accordance with ANSI C63.10, Clause 7.8.5.

2.1.5 Environmental Conditions

Ambient Temperature 23.6 °C
Relative Humidity 31.4 %

2.1.6 Test Results

Bluetooth

Testing was performed on the modulation/packet type with the highest conducted output power. This modulation/packet type was GFSK/DH5.

Frequency (MHz)	Output Power	
	dBm	mW
2402	4.71	2.96
2441	5.15	3.27
2480	4.41	2.76

Table 5

FCC 47 CFR Part 15, Limit Clause 15.247 (b)

The maximum peak conducted output power of the intentional radiator shall not exceed the following:

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non overlapping hopping channels, and all frequency hopping systems in the 5725-5850MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

2.1.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	5-Mar-2017
Attenuator (20dB, 1W)	Sealectro	60-674-1020-89	1520	12	30-Jun-2017
Multimeter	Iso-tech	IDM101	2419	12	14-Nov-2017
Hygrometer	Rotronic	I-1000	3220	12	23-Aug-2017
Signal Analyser	Rohde & Schwarz	FSQ 26	3545	12	9-Sep-2017
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	15-Sep-2017
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	8-Sep-2017
Frequency Standard	Spectracom	Secure Sync 1200-0408-0601	4393	6	5-Mar-2017
4 Channel PSU	Rohde & Schwarz	HMP4040	4736	-	TU

Table 6

2.2 Frequency Hopping Systems - Average Time of Occupancy

2.2.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)(iii)

2.2.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 106 - Modification State 0

2.2.3 Date of Test

29-November-2016

2.2.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 7.8.4.

2.2.5 Environmental Conditions

Ambient Temperature 21.3 °C
Relative Humidity 23.7 %

2.2.6 Test Results

Bluetooth

Packet Type	Dwell Time (ms)	Number of Transmissions	Average Occupancy Time (ms)
DH1	0.378	108	40.824
DH3	1.632	111	181.152
DH5	2.880	108	311.040

Table 7

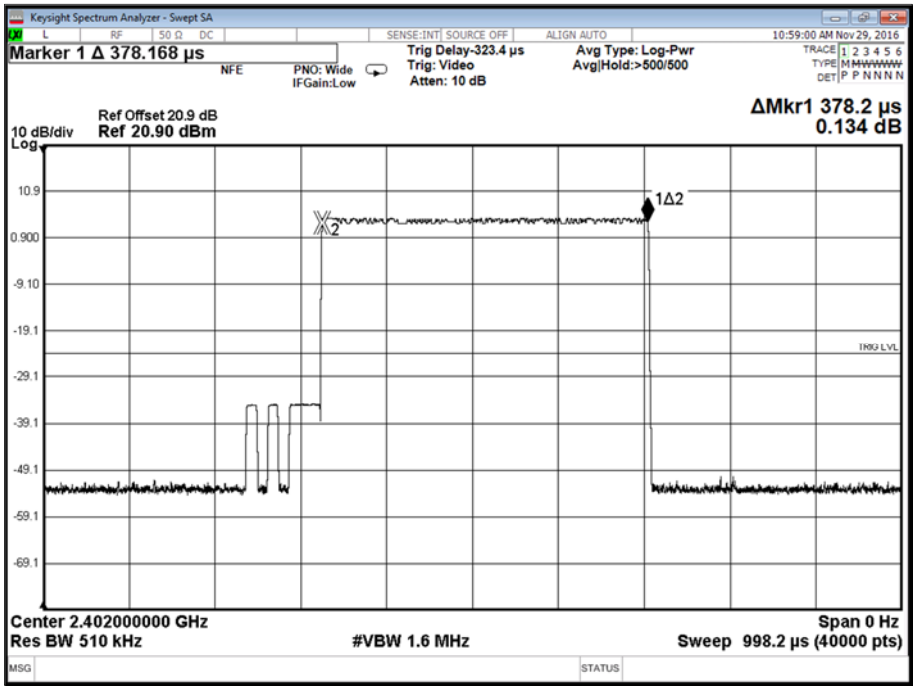

Figure 1 - DH1, Dwell Time

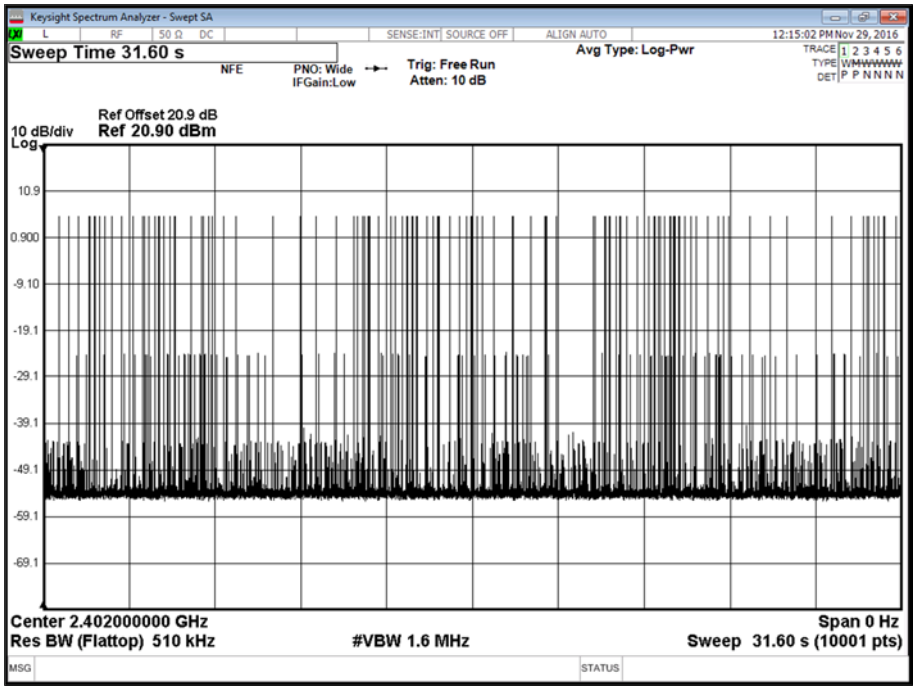

Figure 2 - DH1, Total Average Time of Occupancy

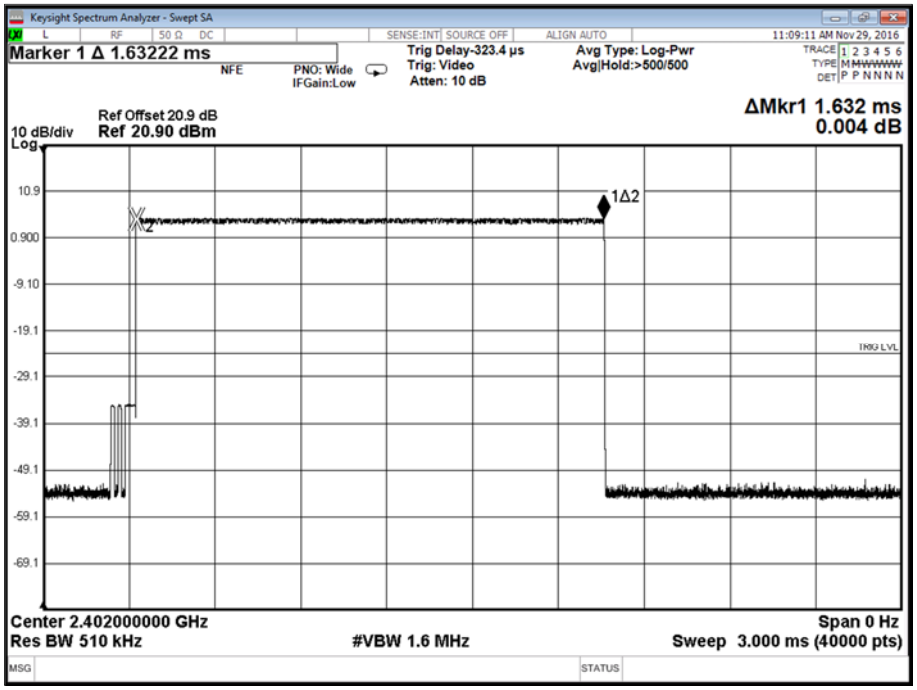

Figure 3 - DH3, Dwell Time

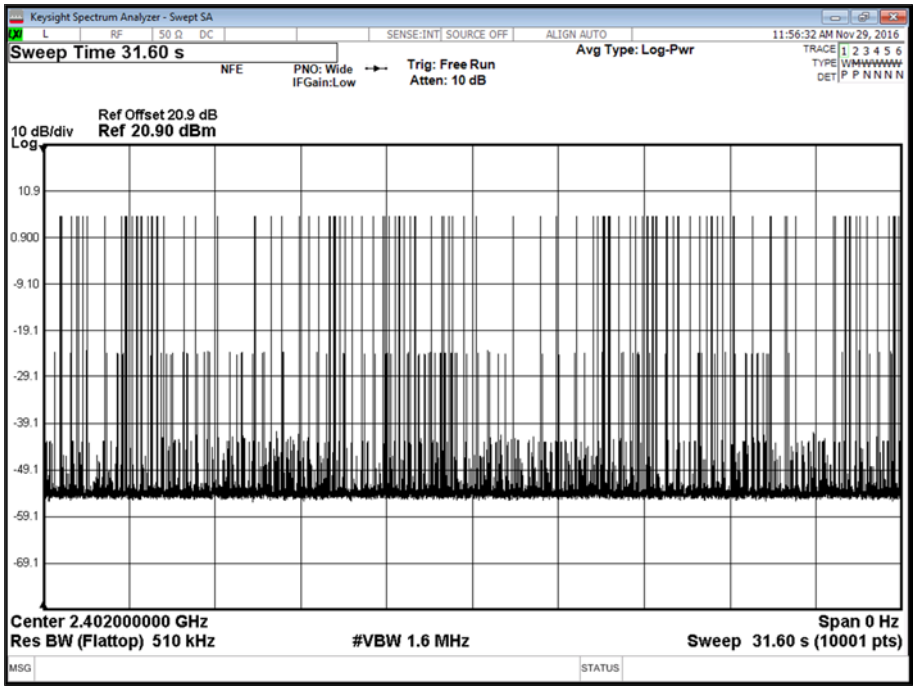

Figure 4 - DH3, Total Average Time of Occupancy

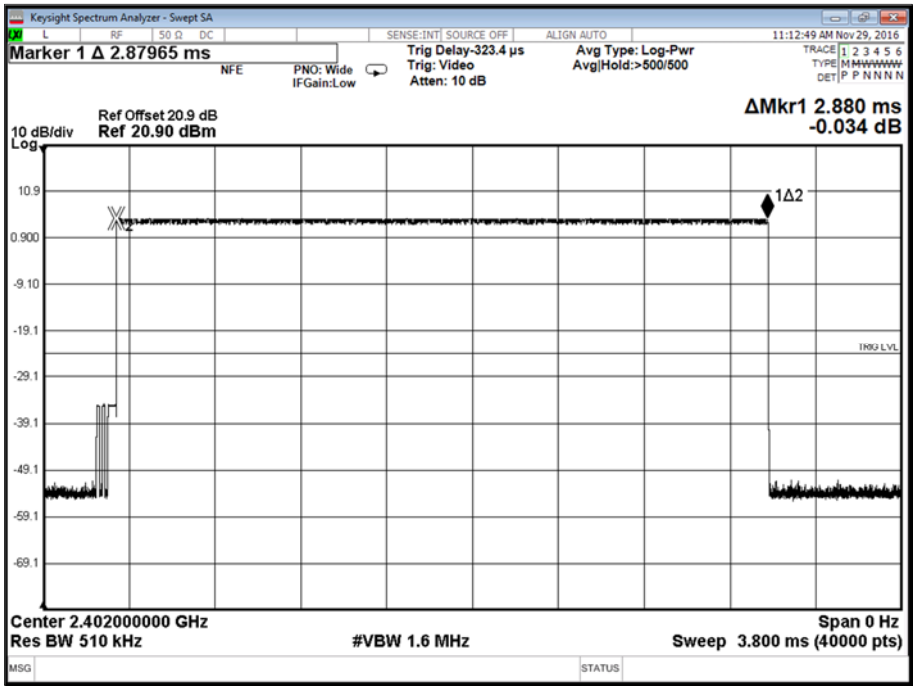

Figure 5 - DH5, Dwell Time

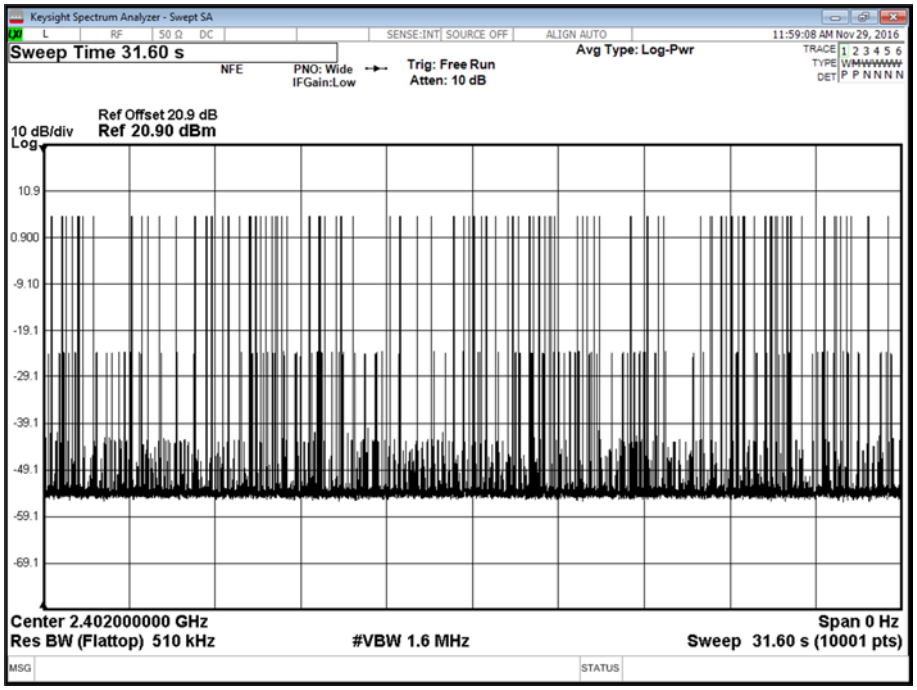

Figure 6 - DH5, Total Average Time of Occupancy

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

Frequency hopping systems operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that a minimum of 15 hopping channels are used.

2.2.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	05-Mar-2017
Hygrometer	Rotronic	I-1000	3220	12	23-Aug-2017
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	15-Sep-2017
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	08-Sep-2017
Frequency Standard	Spectracom	Secure Sync 1200-0408-0601	4393	6	05-Mar-2017
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2017

Table 8

2.3 Frequency Hopping Systems - Channel Separation

2.3.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)

2.3.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 106 - Modification State 0

2.3.3 Date of Test

28-November-2016

2.3.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 7.8.2.

2.3.5 Environmental Conditions

Ambient Temperature 22.2 °C
Relative Humidity 21.6 %

2.3.6 Test Results

Bluetooth

Modulation	Channel Separation (MHz)
GFSK	0.999
π/4 DQPSK	1.011
8-DPSK	0.993

Table 9

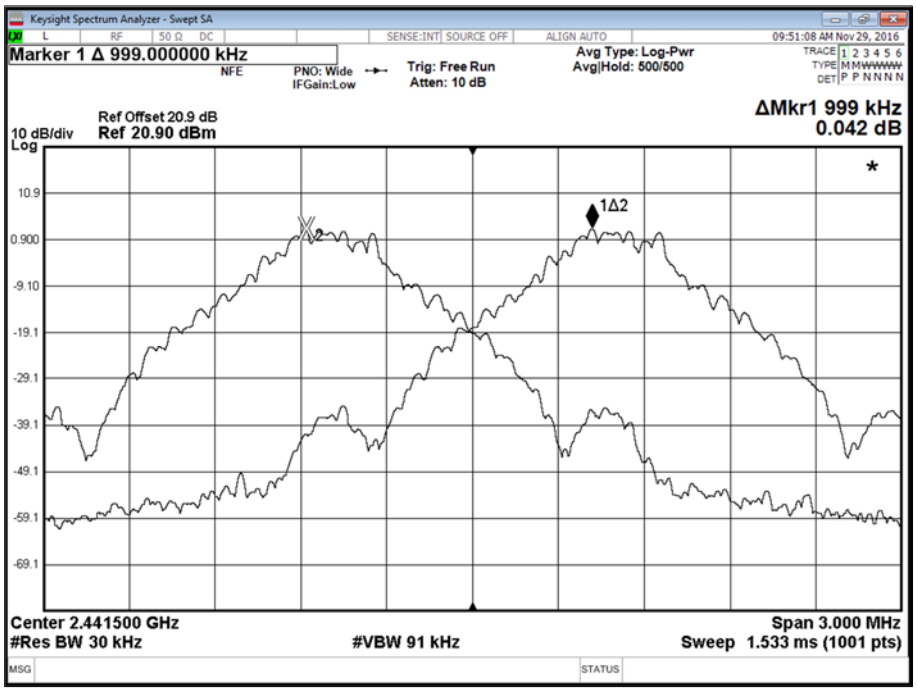

Figure 7 - GFSK

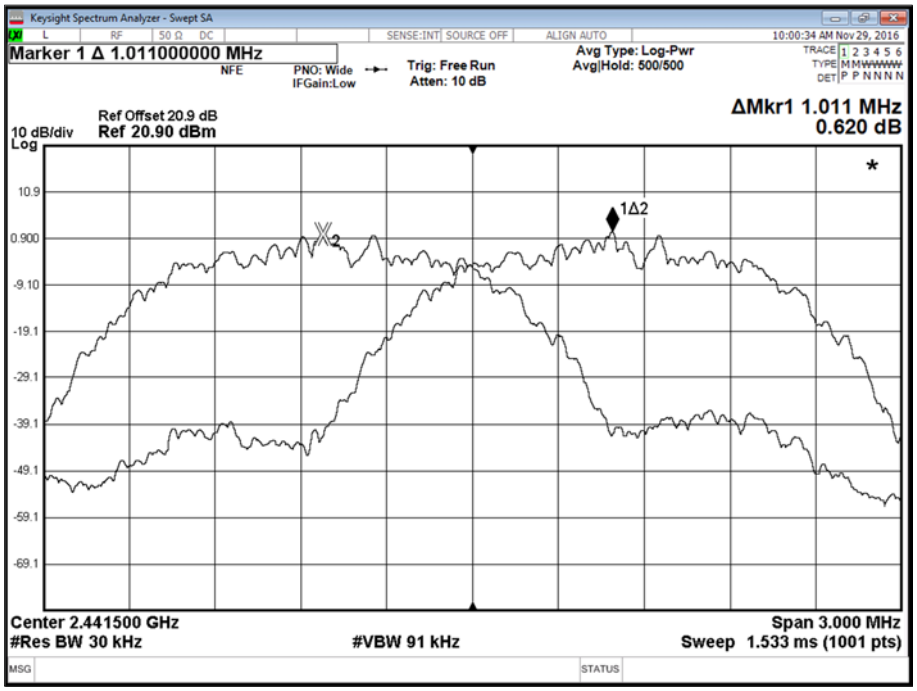

Figure 8 - π/4 DQPSK

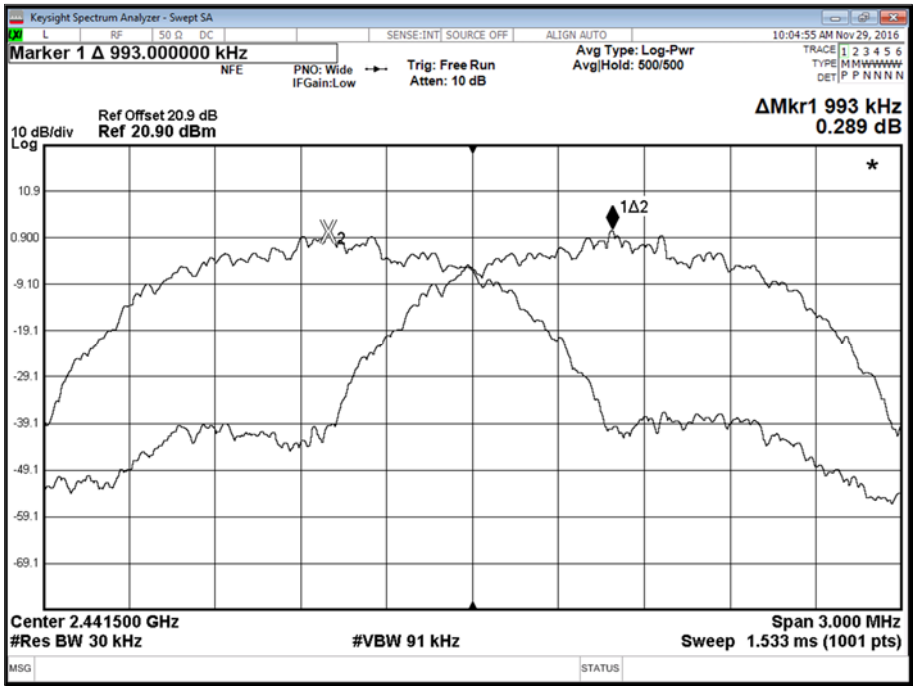

Figure 9 - 8-DPSK

<u>FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)</u>

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 band 2400-2483.5 MHz 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 0.125 W.

2.3.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	05-Mar-2017
Hygrometer	Rotronic	I-1000	3220	12	23-Aug-2017
Frequency Standard	Spectracom	Secure Sync 1200-0408-0601	4393	6	05-Mar-2017
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2017

Table 10

2.4 Frequency Hopping Systems - Number of Hopping Channels

2.4.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)(iii)

2.4.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 106 - Modification State 0

2.4.3 Date of Test

28-November-2016

2.4.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 7.8.3.

2.4.5 Environmental Conditions

Ambient Temperature	22.2 °C
Relative Humidity	21.6 %

2.4.6 Test Results

Bluetooth

Number of Hopping Channels: 79

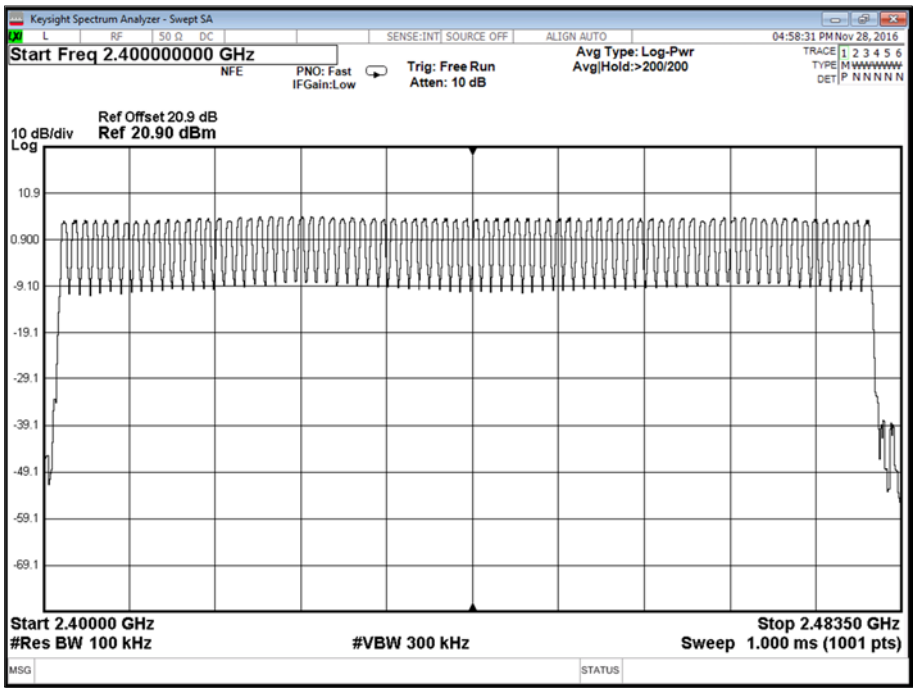

Figure 10 - Measurement Frequency Range: 2400 MHz to 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (a)(1)(iii)

≥ 15 channels

2.4.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	05-Mar-2017
Hygrometer	Rotronic	I-1000	3220	12	23-Aug-2017
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	15-Sep-2017
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	08-Sep-2017
Frequency Standard	Spectracom	Secure Sync 1200-0408-0601	4393	6	05-Mar-2017
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2017

Table 11

2.5 Frequency Hopping Systems - 20 dB Bandwidth

2.5.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (a)(1)

2.5.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 106 - Modification State 0

2.5.3 Date of Test

24-February-2017

2.5.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 6.9.2.

2.5.5 Environmental Conditions

Ambient Temperature 22.2 °C
Relative Humidity 21.6 %

2.5.6 Test Results

Bluetooth

Frequency (MHz)	20 dB Bandwidth (kHz)		
	GFSK	π/4 DQPSK	8-DPSK
2402	958.3	1587.0	1587.0
2441	955.7	1626.0	1586.0
2480	962.3	1567.0	1595.0

Table 12

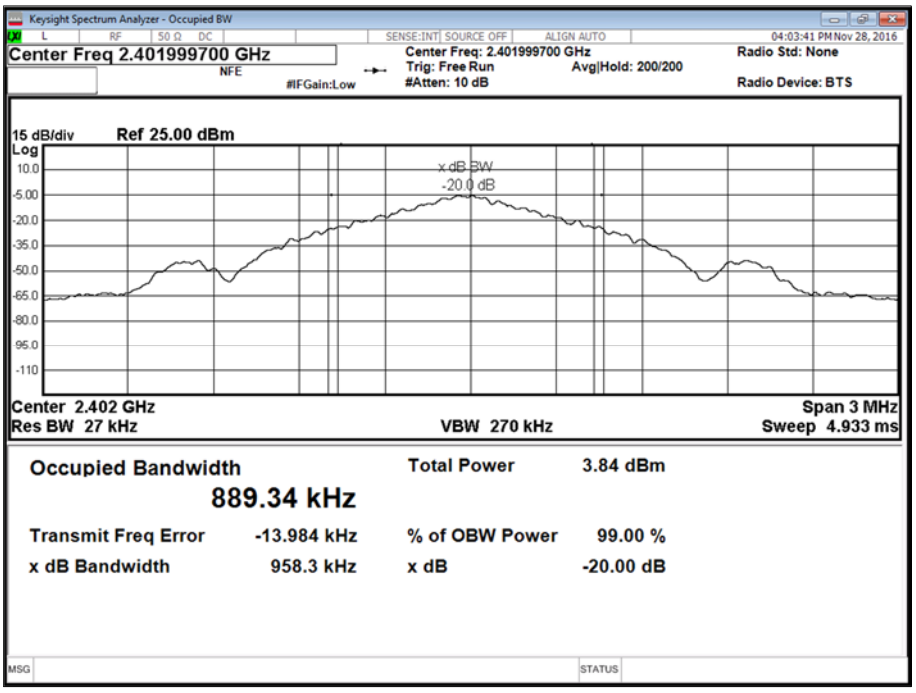

Figure 11 - 2402 MHz - GFSK

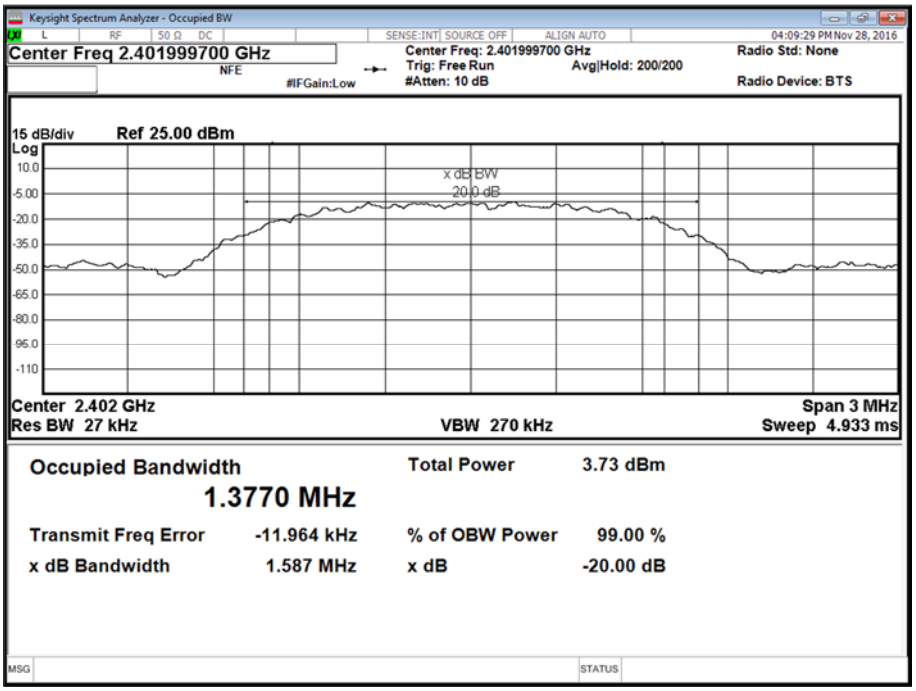

Figure 12 - 2402 MHz - π/4 DQPSK

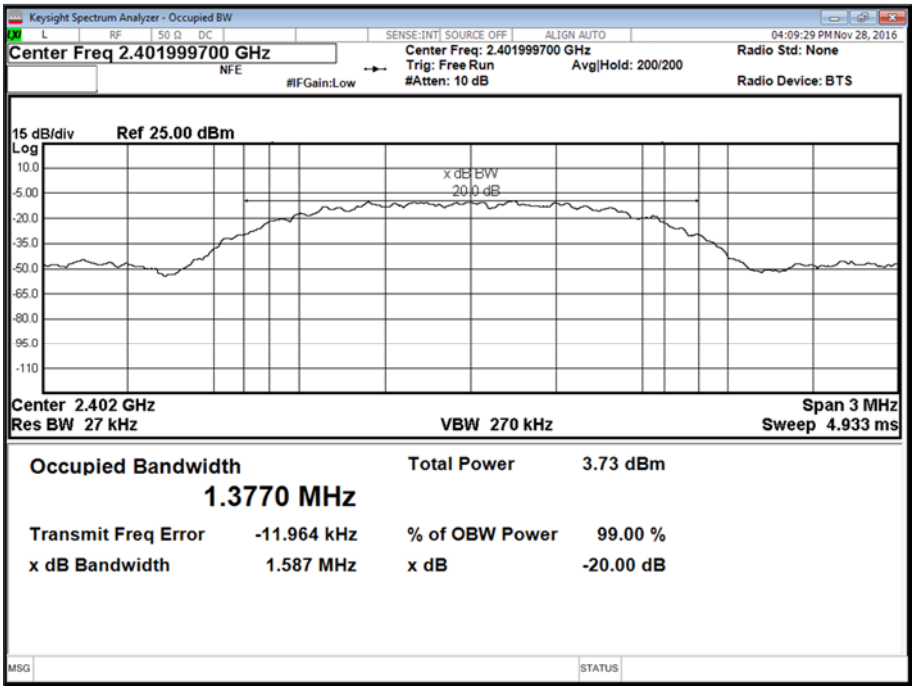

Figure 13 - 2402 MHz - 8-DPSK

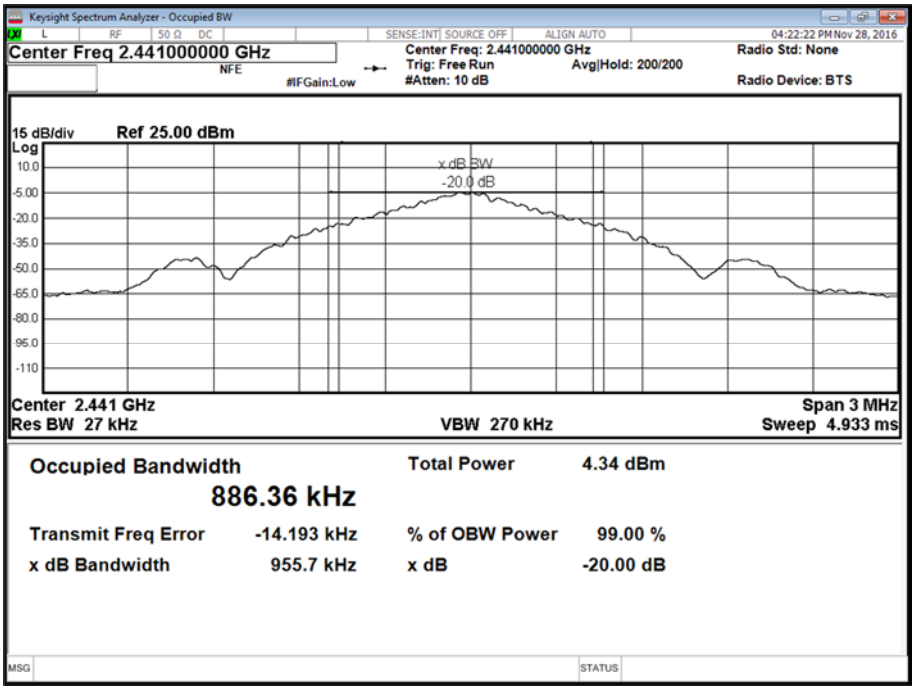

Figure 14 - 2441 MHz - GFSK

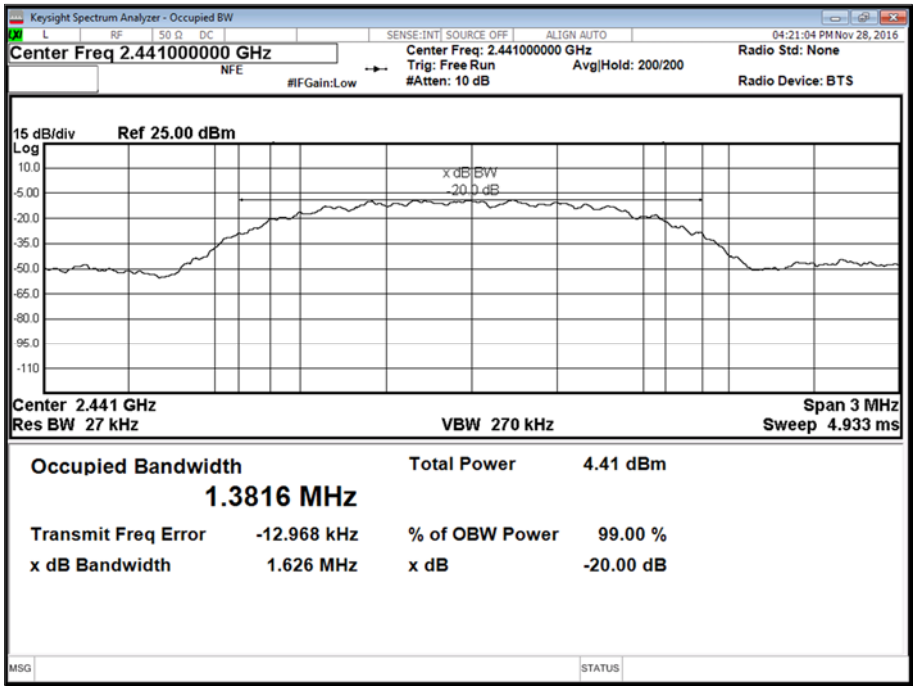

Figure 15 - 2441 MHz - π/4 DQPSK

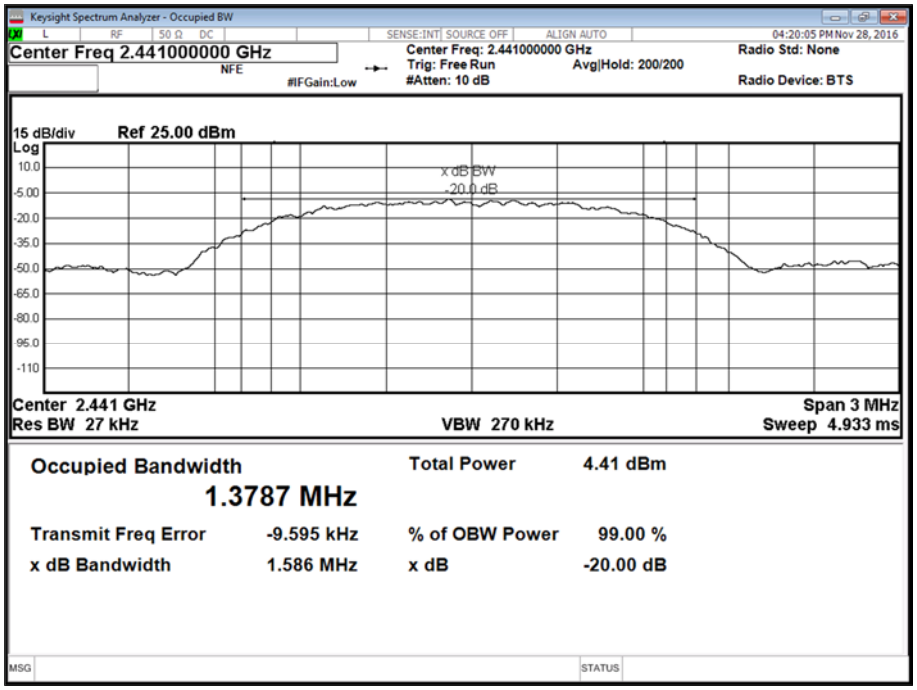

Figure 16 - 2441 MHz - 8-DPSK

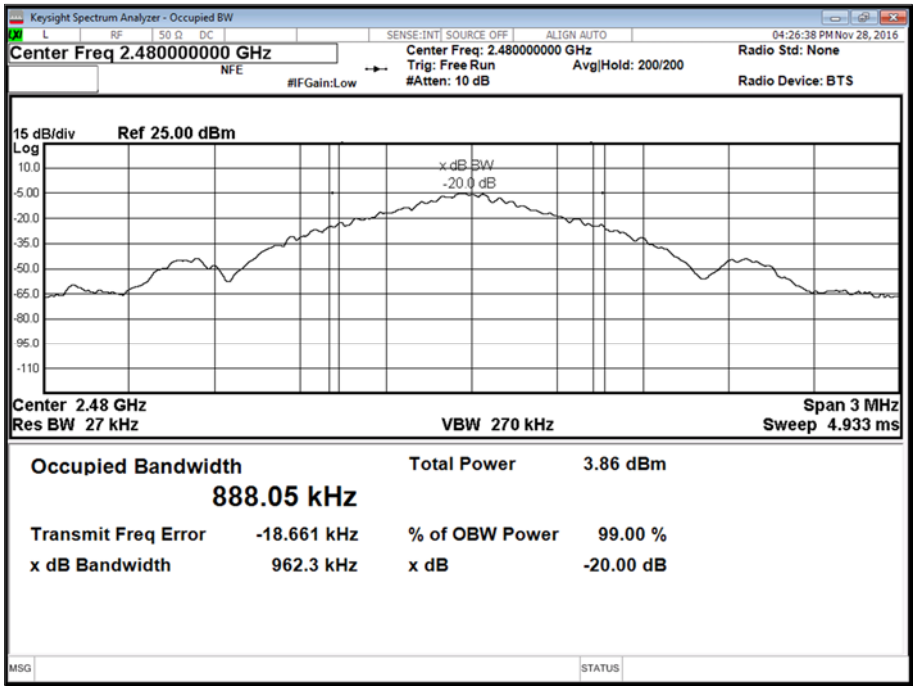

Figure 17 - 2480 MHz - GFSK

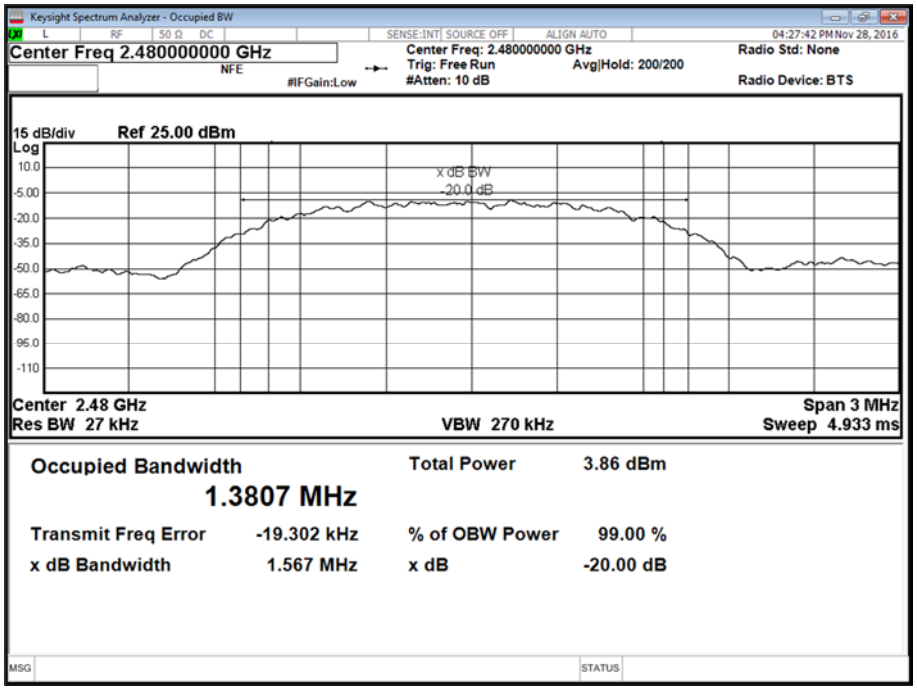

Figure 18 - 2480 MHz - π/4 DQPSK

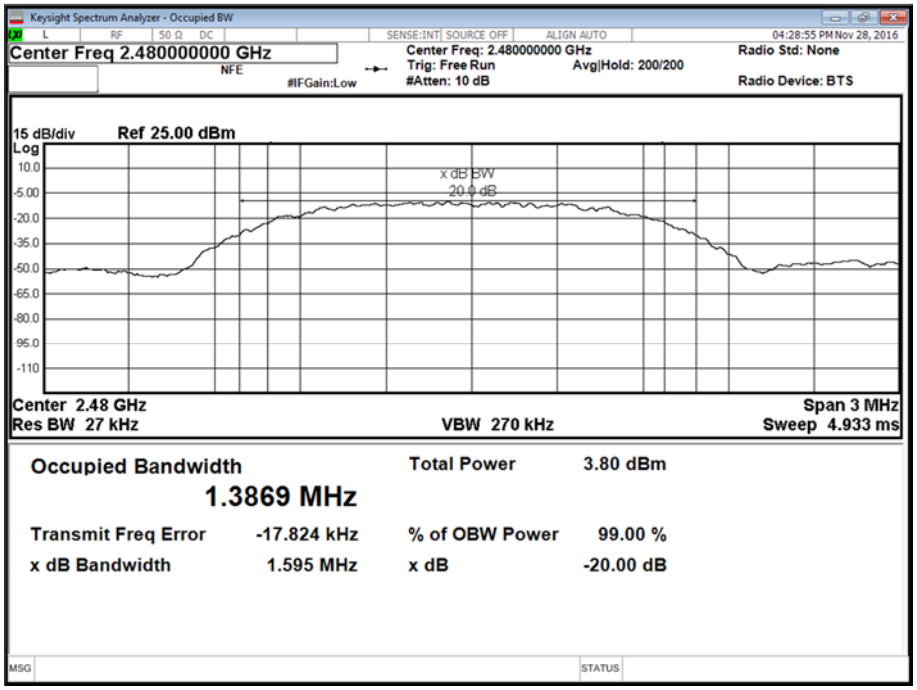

Figure 19 - 2480 MHz - 8-DPSK

2.5.7 Test Location and Test Equipment Used

This test was carried out in RF Laboratory 1.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Rubidium Standard	Rohde & Schwarz	XSRM	1316	6	05-Mar-2017
Attenuator (20dB, 1W)	Sealectro	60-674-1020-89	1506	-	O/P Mon
Hygrometer	Rotronic	I-1000	3220	12	23-Aug-2017
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	15-Sep-2017
Calibration Unit	Rohde & Schwarz	ZV-Z54	4368	12	08-Sep-2017
Frequency Standard	Spectracom	Secure Sync 1200-0408-0601	4393	6	05-Mar-2017
PXA Signal Analyser	Keysight Technologies	N9030A	4654	12	06-Oct-2017

Table 13

O/P Mon – Output Monitored

2.6 Spurious Radiated Emissions

2.6.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d) and 15.205

2.6.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 1829C-DC8-6UPN9XJWJW - Modification State 0

2.6.3 Date of Test

28-February-2017 to 06-March-2017

2.6.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 6.3, 6.5 and 6.6.

Plots for average measurements were taken in accordance with ANSI C63.10, Clause 4.1.4.2.3.

Final average measurements were taken in accordance with ANSI C63.10, Clause 4.1.4.2.2.

2.6.5 Environmental Conditions

Ambient Temperature	15.0 - 19.3 °C
Relative Humidity	33.0 - 44.0 %

2.6.6 Test Results

Bluetooth

Testing was performed on the modulation and packet type which resulted in the highest conducted output power. The Modulation/Packet type was GFSK/DH5.

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
37.901	32.6	40.0	-7.4	184	1.00	Vertical
47.345	34.3	40.0	-5.7	267	1.00	Vertical
52.796	32.5	40.0	-7.5	231	1.00	Vertical
79.207	37.2	40.0	-2.8	67	1.56	Vertical
224.999	36.1	46.0	-9.9	52	1.08	Horizontal
226.498	35.4	46.0	-10.6	360	1.00	Vertical

Table 14 - 2402 MHz - 30 MHz to 1 GHz Emissions Results

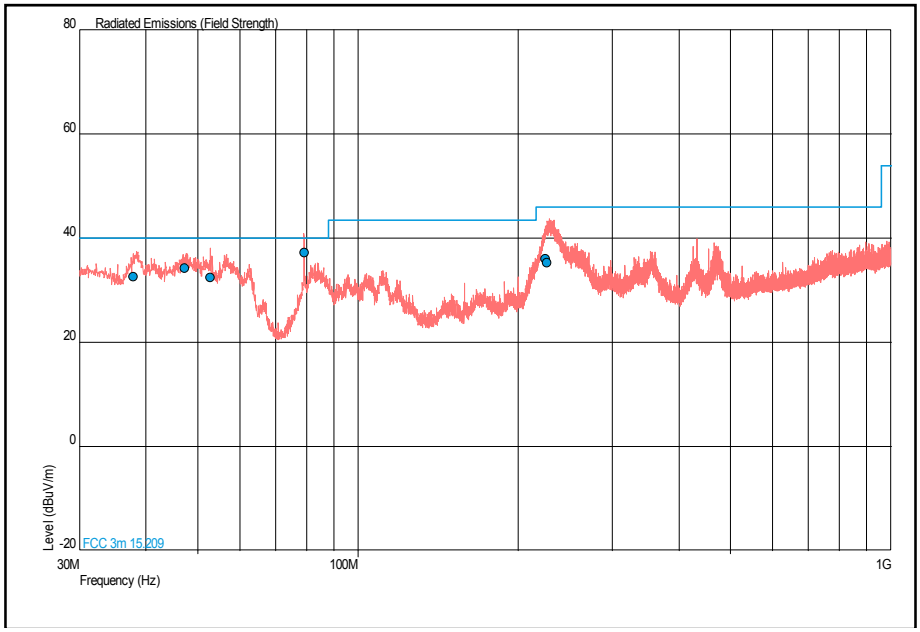

Figure 20 - 2402 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (MHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 15 - 2402 MHz - 1 GHz to 25 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

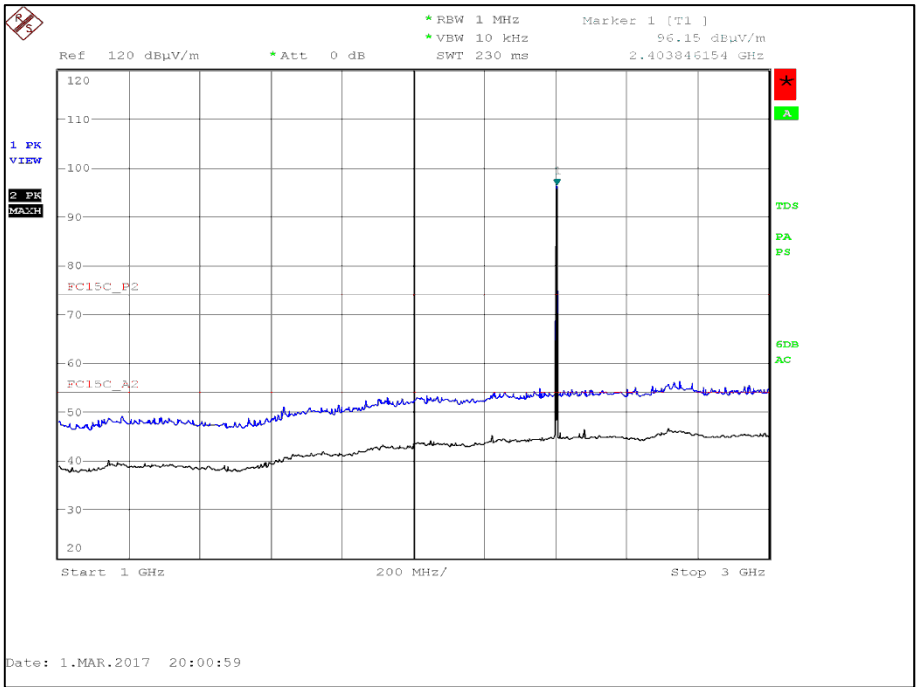

Figure 21 - 2402 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

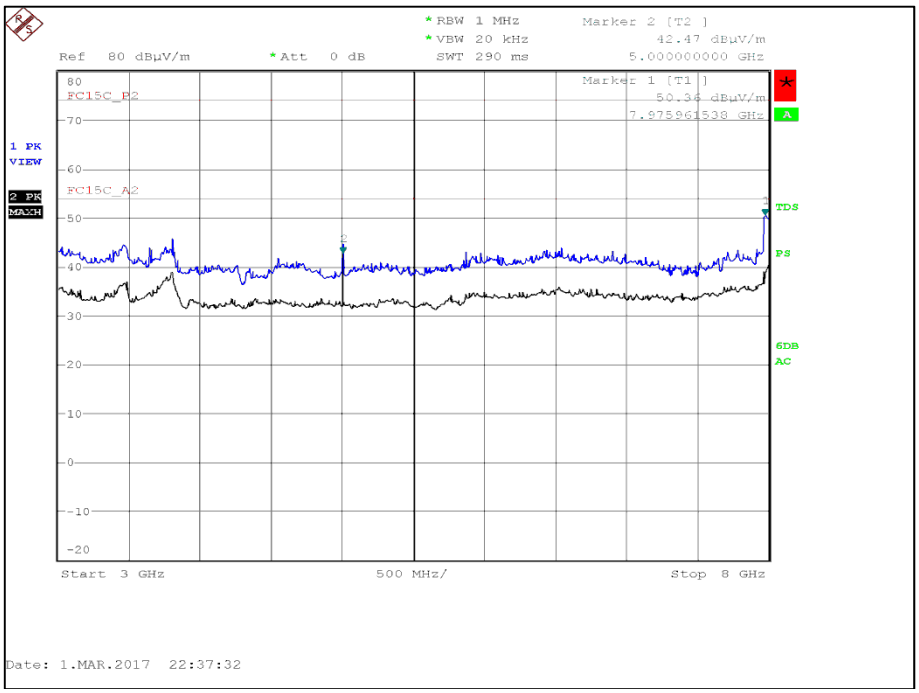

Figure 22 - 2402 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

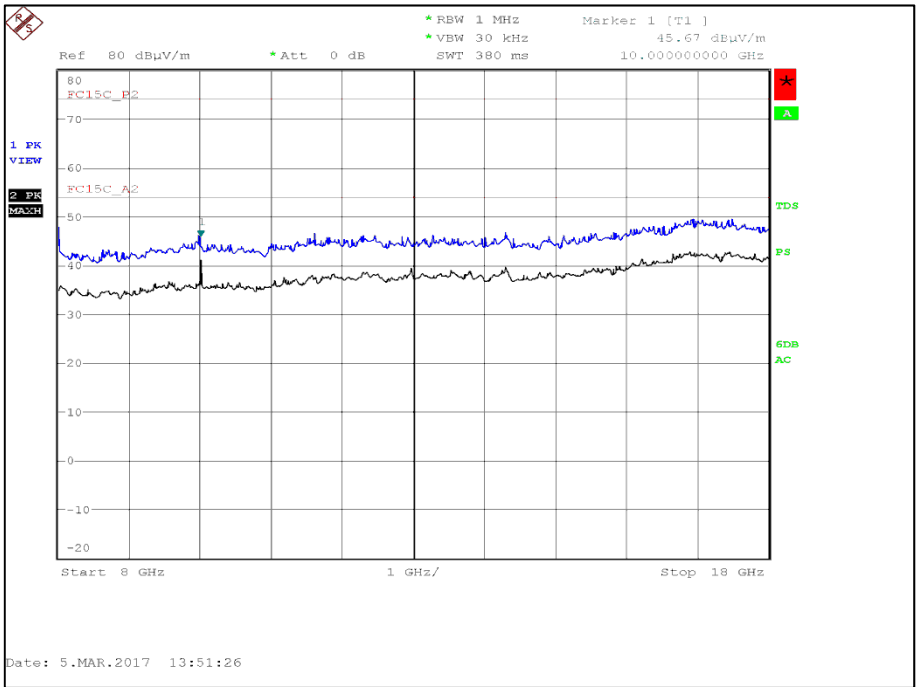

Figure 23 - 2402 MHz - 8 GHz to 18 GHz - Horizontal and Vertical

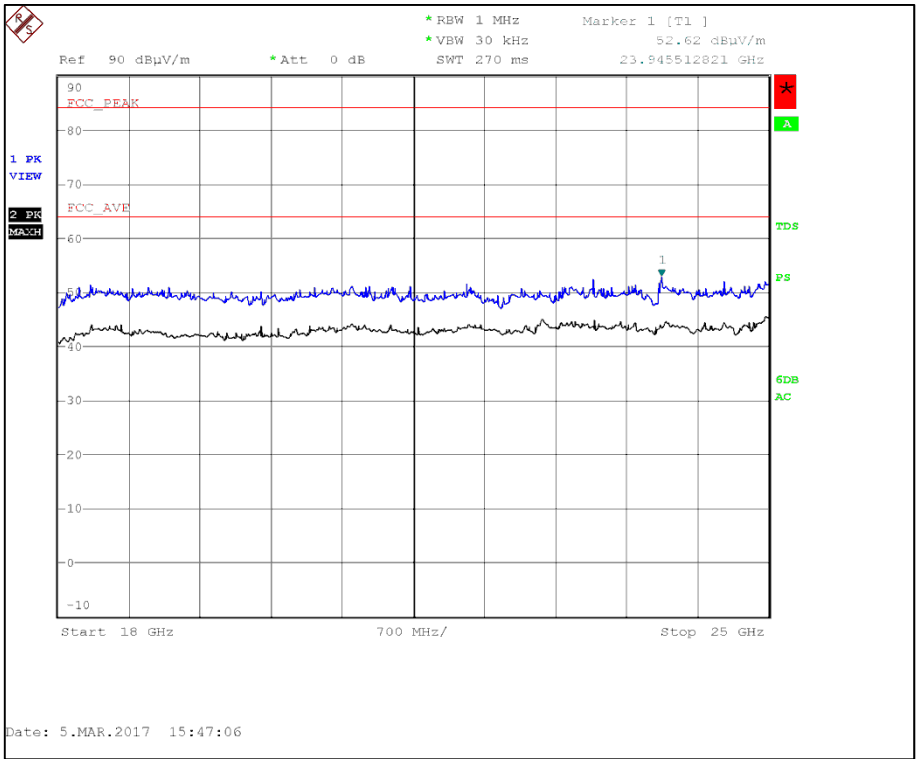

Figure 24 - 2402 MHz - 18 GHz to 25 GHz - Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
38.149	32.1	40.0	-7.9	60	1.00	Vertical
41.651	33.9	40.0	-6.1	301	1.00	Vertical
46.531	35.1	40.0	-4.9	182	1.00	Vertical
79.191	38.2	40.0	-1.8	69	1.00	Vertical
224.622	36.4	46.0	-9.6	350	1.00	Vertical
224.974	37.0	46.0	-9.0	69	1.00	Horizontal

Table 16 - 2441 MHz - 30 MHz to 1 GHz Emissions Results

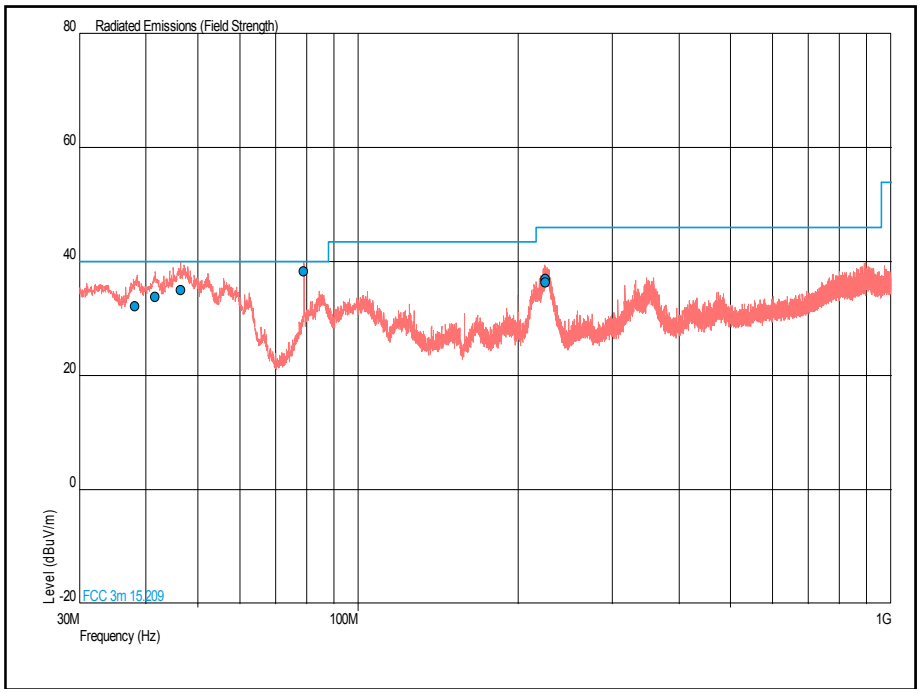

Figure 25 - 2441 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (MHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 17 - 2441 MHz - 1 GHz to 25 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

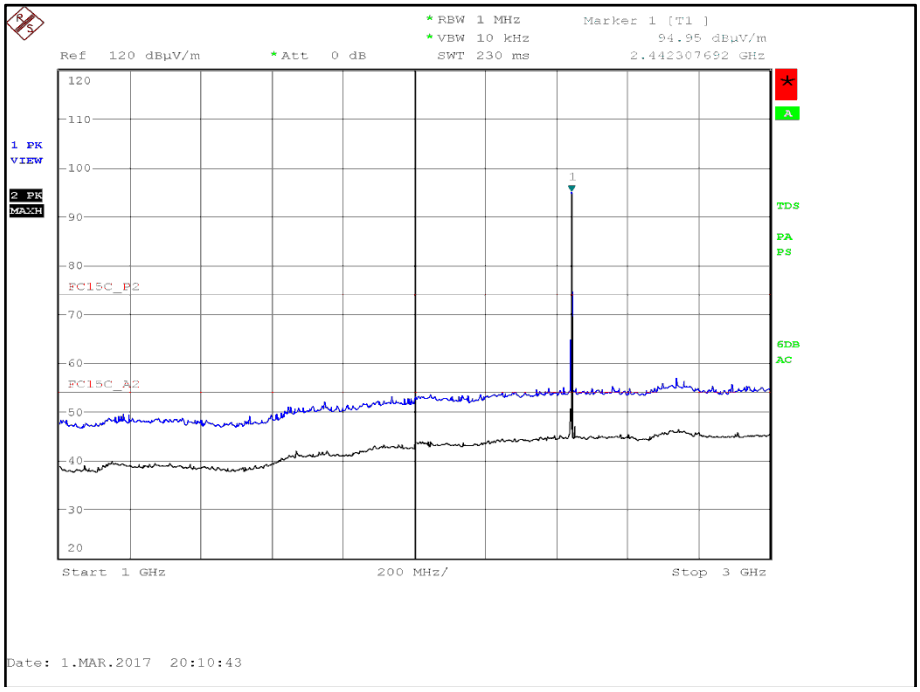

Figure 26 - 2441 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

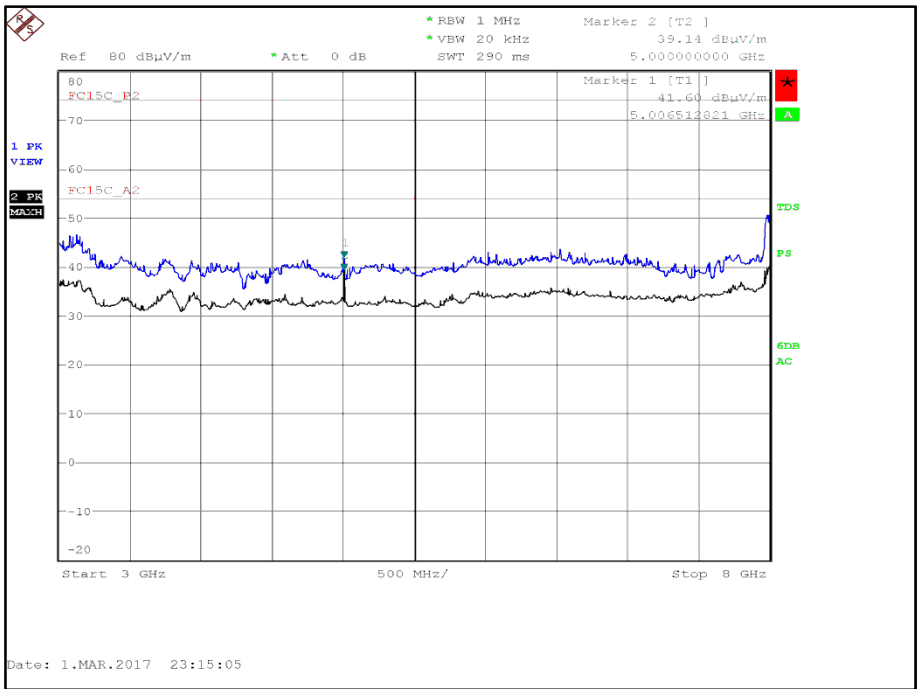

Figure 27 - 2441 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

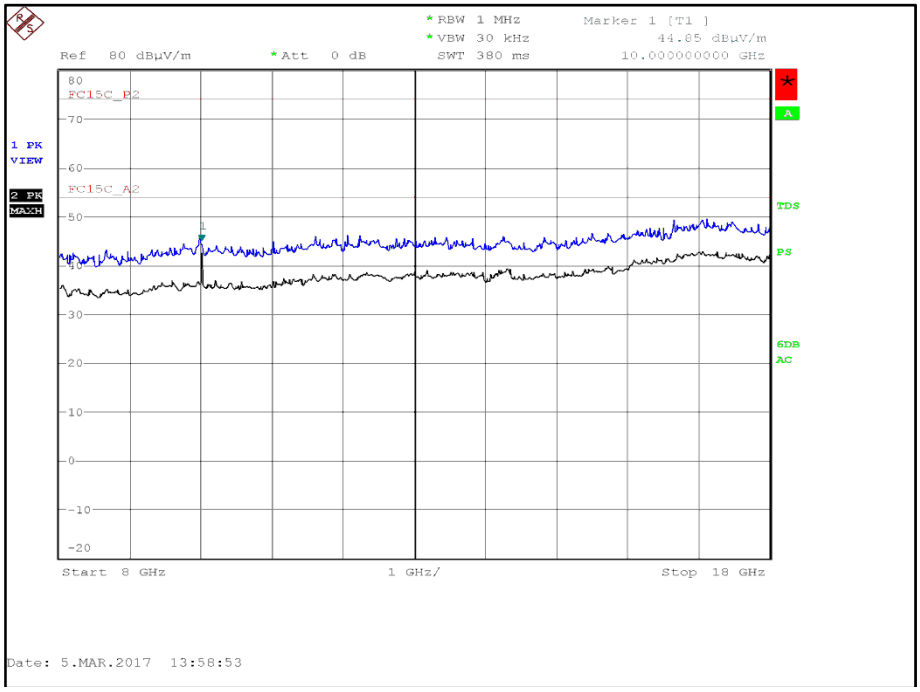

Figure 28 - 2441 MHz - 8 GHz to 18 GHz - Horizontal and Vertical

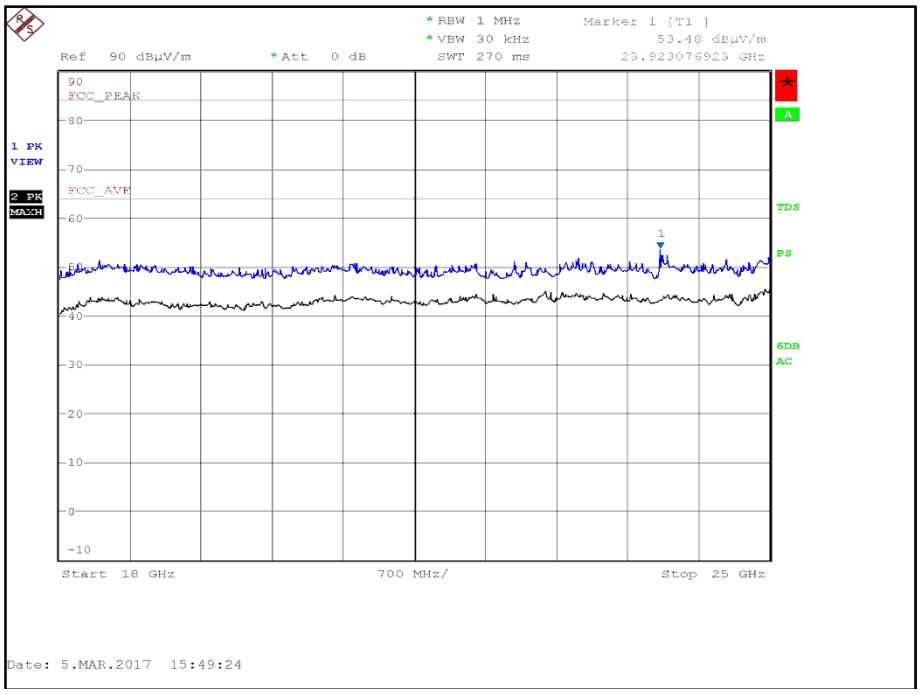

Figure 29 - 2441 MHz - 18 GHz to 25 GHz - Horizontal and Vertical

Frequency (MHz)	QP Level (dBuV/m)	QP Limit (dBuV/m)	QP Margin (dBuV/m)	Angle(Deg)	Height(m)	Polarity
37.799	29.5	40.0	-10.5	360	1.00	Vertical
41.563	32.7	40.0	-7.3	297	1.00	Vertical
46.447	32.0	40.0	-8.0	257	1.00	Vertical
79.177	31.4	40.0	-8.6	183	1.00	Vertical
226.137	29.2	46.0	-16.8	135	1.00	Vertical
229.126	38.8	46.0	-7.2	208	1.00	Horizontal

Table 18 - 2480 MHz - 30 MHz to 1 GHz Emissions Results

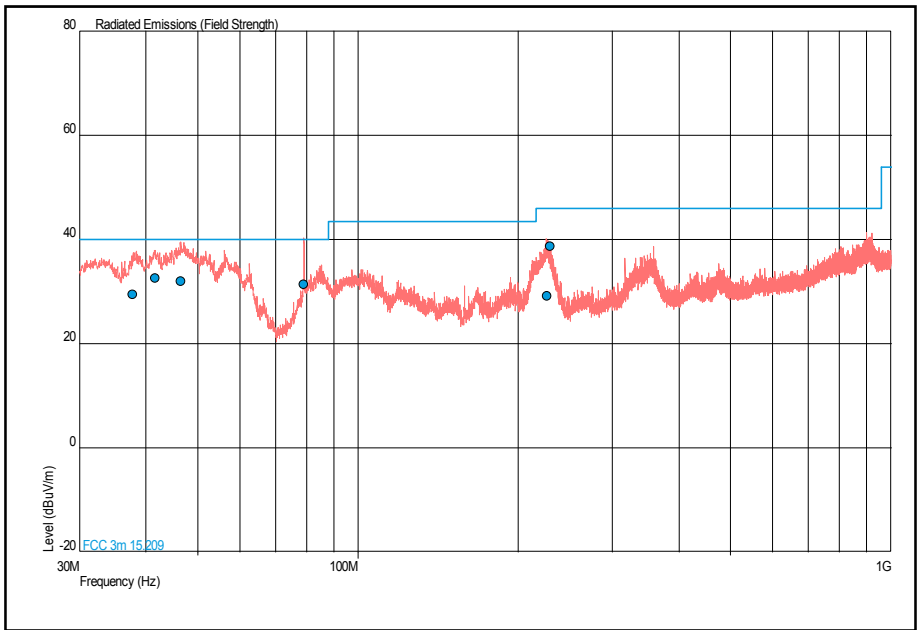

Figure 30 - 2480 MHz - 30 MHz to 1 GHz - Horizontal and Vertical

Frequency (MHz)	Result (µV/m)		Limit (µV/m)		Margin (µV/m)	
	Peak	Average	Peak	Average	Peak	Average
*						

Table 19 - 2480 MHz – 1 GHz to 25 GHz Emissions Results

*No emissions were detected within 10 dB of the limit.

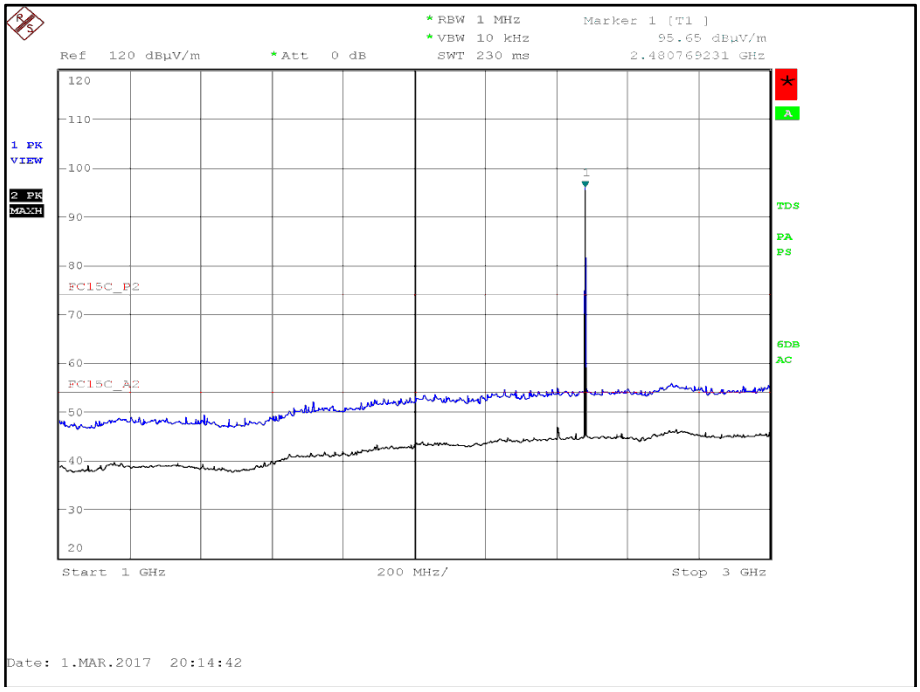

Figure 31 - 2480 MHz - 1 GHz to 3 GHz - Horizontal and Vertical

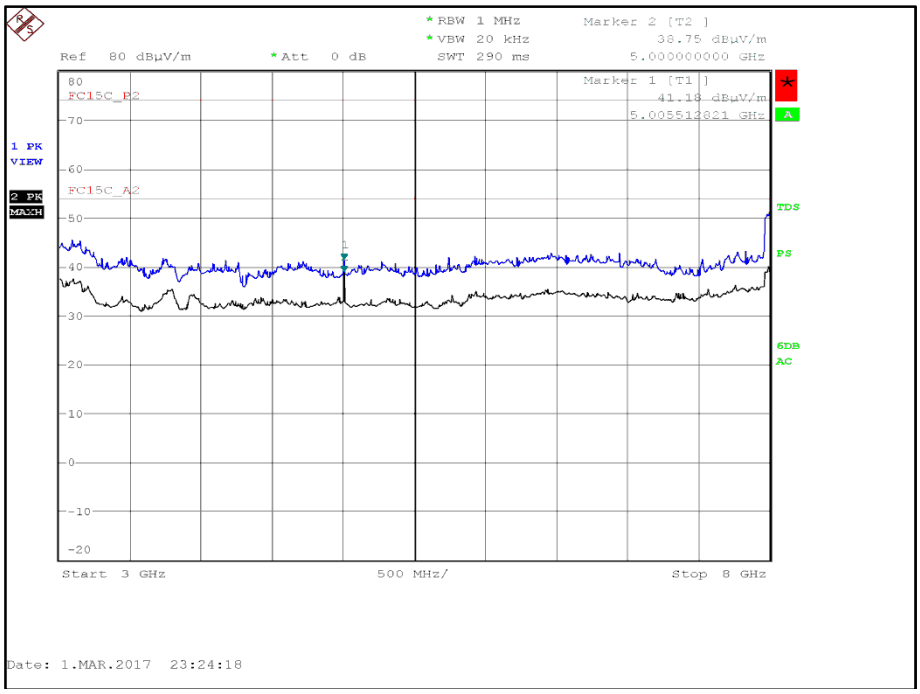

Figure 32 – 2480 MHz - 3 GHz to 8 GHz - Horizontal and Vertical

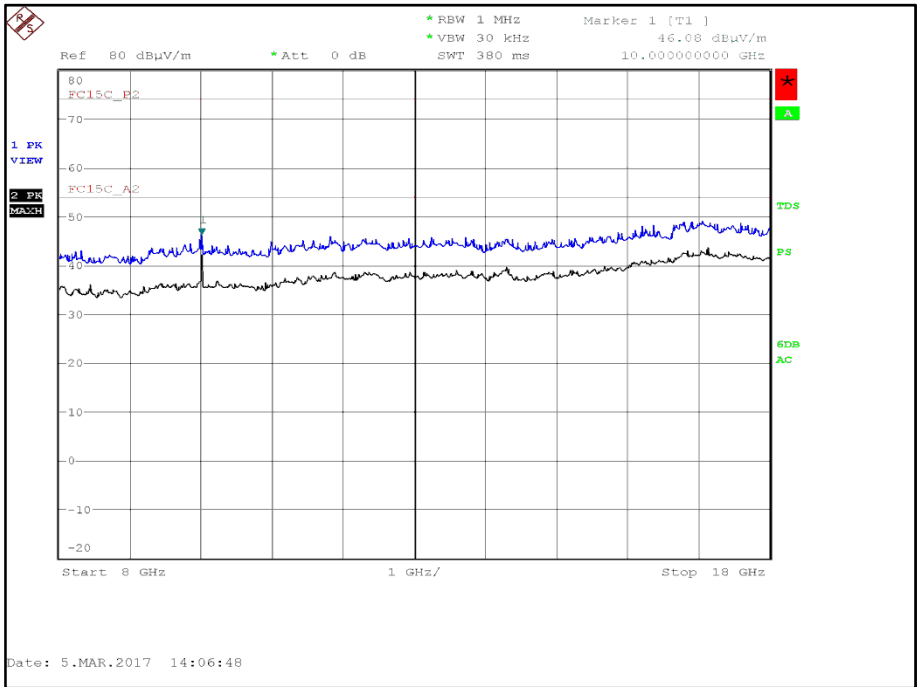

Figure 33 - 2480 MHz - 8 GHz to 18 GHz - Horizontal and Vertical

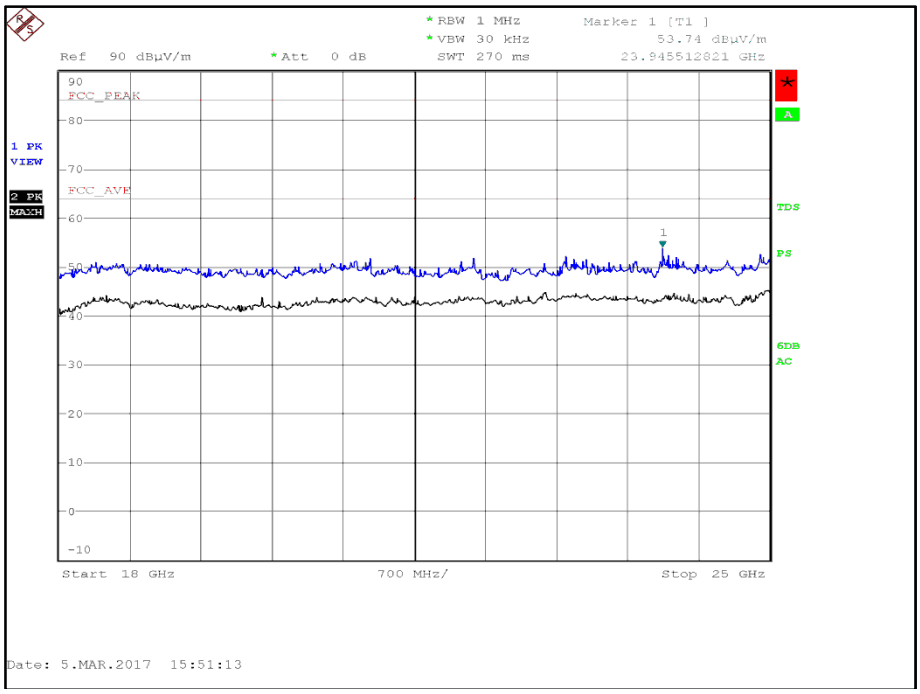

Figure 34 - 2480 MHz - 18 GHz to 25 GHz - Horizontal and Vertical

FCC 47 CFR Part 15, Limit Clause 15.247 (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)

2.6.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Antenna 18-40GHz (Double Ridge Guide)	Link Microtek Ltd	AM180HA-K-TU2	230	24	12-Feb-2018
Pre-Amplifier	Phase One	PS04-0086	1533	12	29-Jul-2017
18GHz - 40GHz Pre-Amplifier	Phase One	PSO4-0087	1534	12	23-Jan-2018
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Hygrometer	Rotronic	HYGROPALM 1	2338	12	21-Sep-2017
Multimeter	Iso-tech	IDM101	2417	12	30-Sep-2017
Antenna (Bilog)	Chase	CBL6143	2904	24	11-Jun-2017
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
1GHz to 8GHz Low Noise Amplifier	Wright Technologies	APS04-0085	4365	12	17-Oct-2017

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Suspended Substrate Highpass Filter	Advance Power Components	11SH10-3000/X18000-O/O	4411	12	23-Mar-2017
Suspended Substrate Highpass Filter	Advance Power Components	11SH10-3000/X18000-O/O	4412	12	23-Mar-2017
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	29-Jul-2015
Cable (Rx, SMAm-SMAm 0.5m)	Scott Cables	SLSLL18-SMSM-00.50M	4528	6	03-Feb-2017
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	17-Feb-2018

Table 20

TU - Traceability Unscheduled

2.7 Restricted Band Edges

2.7.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.205

2.7.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 1829C-DC8-6UPN9XJWJW - Modification State 0

2.7.3 Date of Test

01-March-2017

2.7.4 Test Method

This test was performed in accordance with ANSI C63.10, Clause 6.10.5.

Plots for average measurements were taken in accordance with ANSI C63.10, Clause 4.1.4.2.3.

Final average measurements were taken in accordance with ANSI C63.10, Clause 4.1.4.2.2.

2.7.5 Environmental Conditions

Ambient Temperature 18.9 °C
Relative Humidity 35.0 %

2.7.6 Test Results

Bluetooth

Mode	Modulation	Measured Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	2390.0	62.92	46.14
Static	π/4 DQPSK	2390.0	62.32	46.15
Static	8-DPSK	2390.0	63.22	46.15
Hopping	GFSK	2390.0	63.89	46.15
Hopping	π/4 DQPSK	2390.0	64.41	46.16
Hopping	8-DPSK	2390.0	63.47	46.17

Table 21 - 2402 MHz

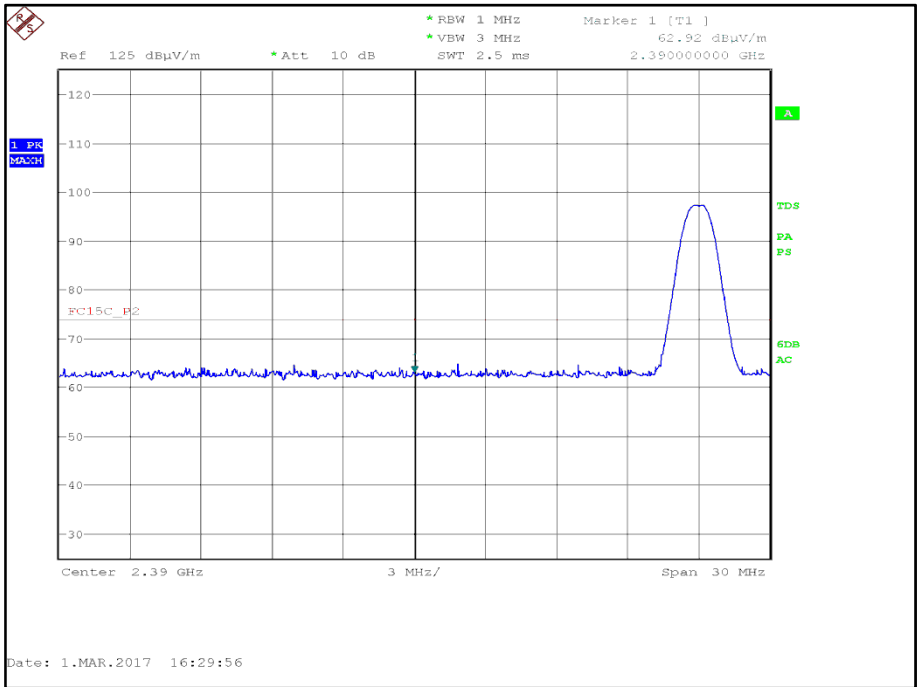

Figure 35 - 2402 MHz, Static, GFSK, Measured Frequency 2390.0 MHz, Peak

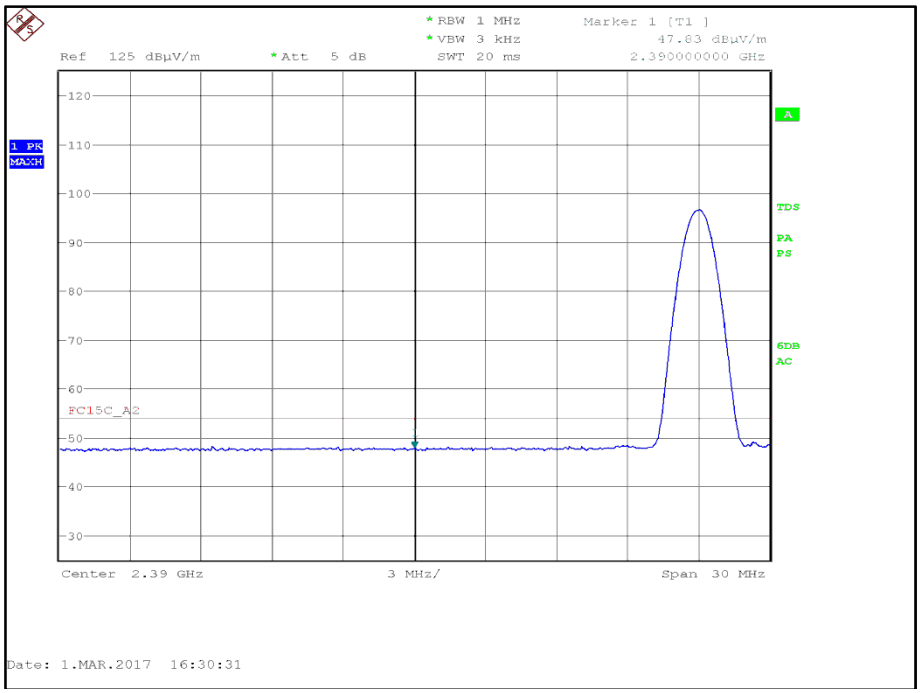

Figure 36 - 2402 MHz, Static, GFSK, Measured Frequency 2390.0 MHz, Average

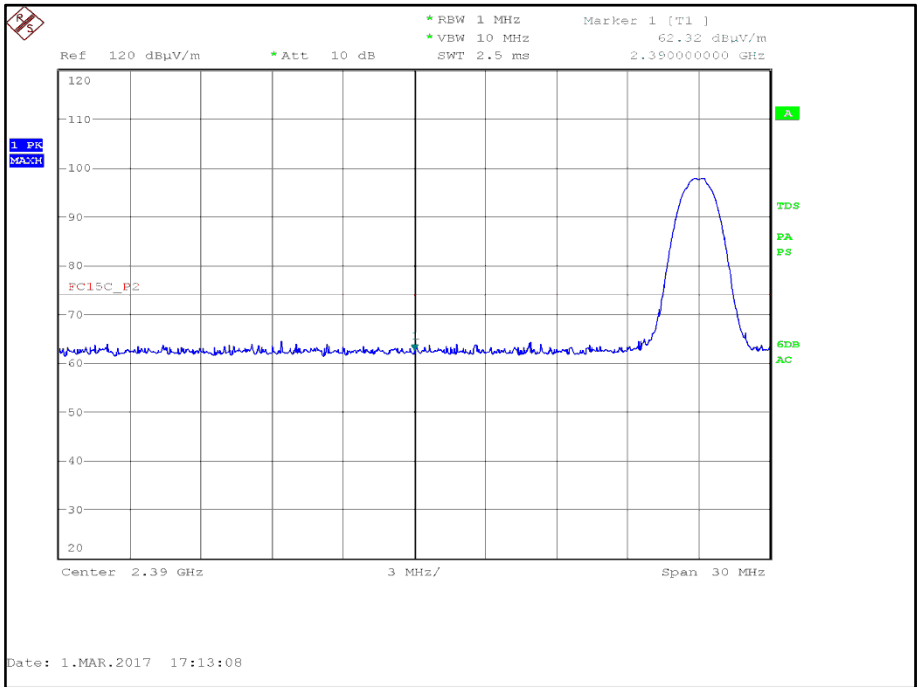

Figure 37 - 2402 MHz, Static, π/4 DQPSK, Measured Frequency 2390.0 MHz, Peak

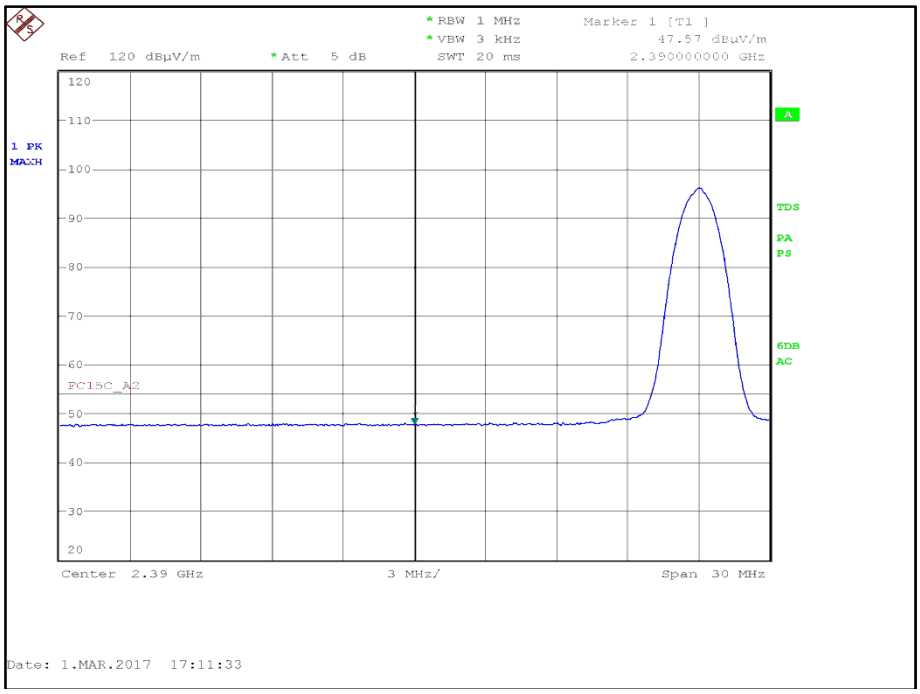

Figure 38 - 2402 MHz, Static, π/4 DQPSK, Measured Frequency 2390.0 MHz, Average

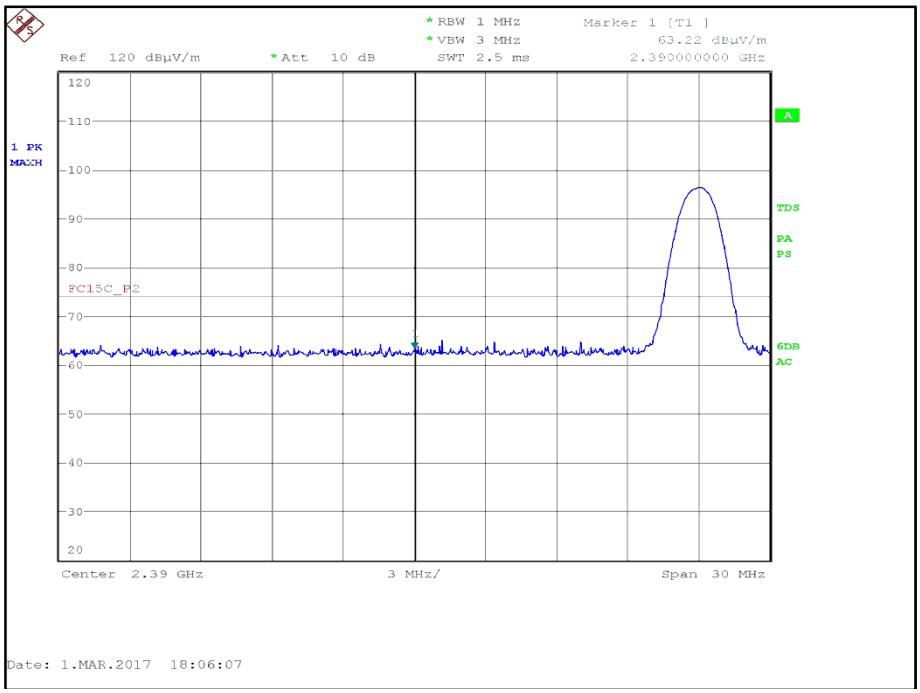

Figure 39 - 2402 MHz, Static, 8-DPSK, Measured Frequency 2390.0 MHz, Peak

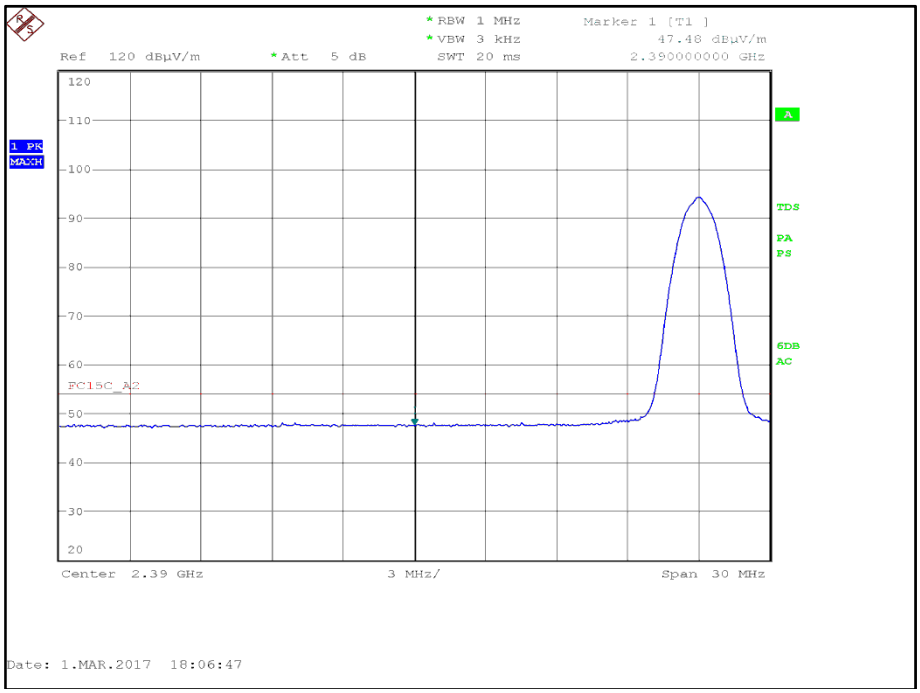

Figure 40 - 2402 MHz, Static, 8-DPSK, Measured Frequency 2390.0 MHz, Average

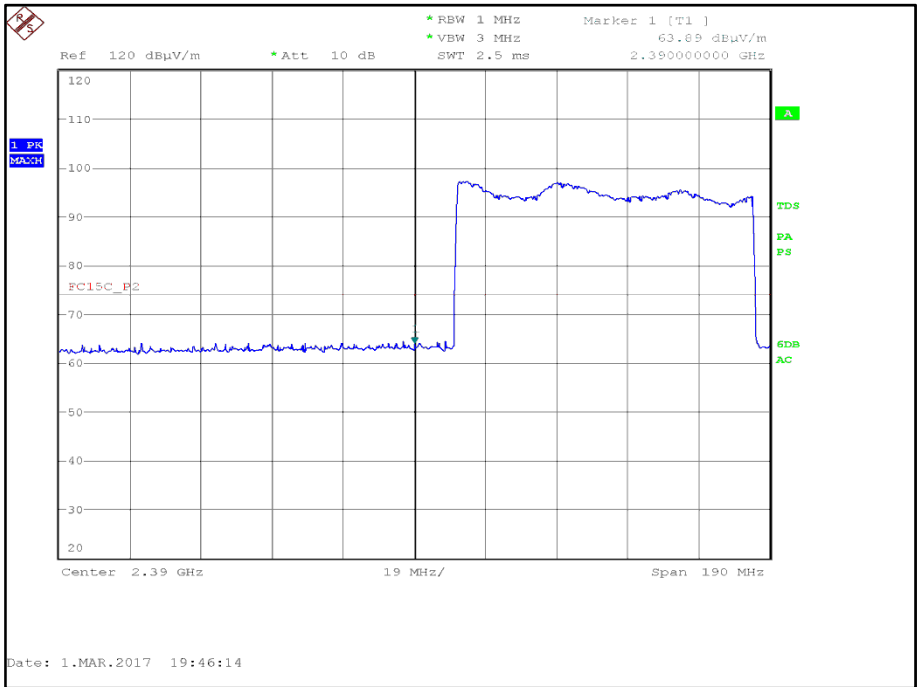

Figure 41 - 2402 MHz, Hopping, GFSK, Measured Frequency 2390.0 MHz, Peak

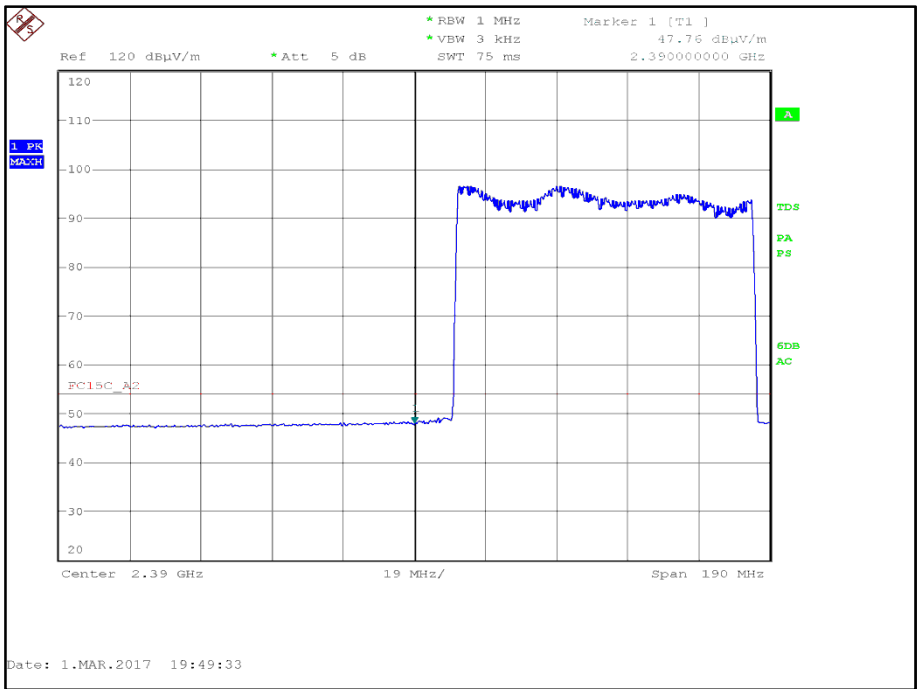

Figure 42 - 2402 MHz, Hopping, GFSK, Measured Frequency 2390.0 MHz, Average

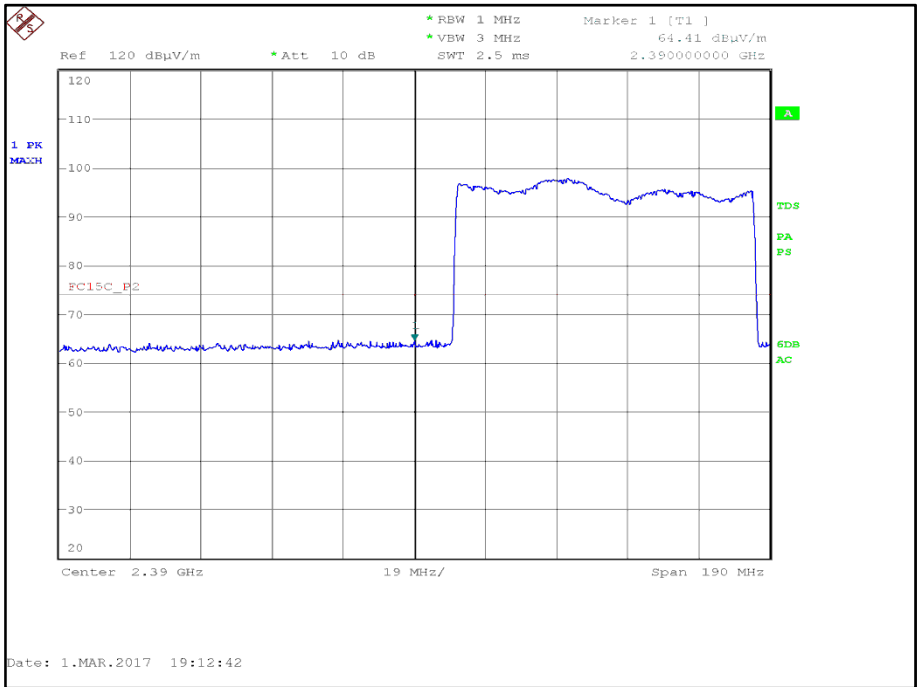

Figure 43 - 2402 MHz, Hopping, π/4 DQPSK, Measured Frequency 2390.0 MHz, Peak

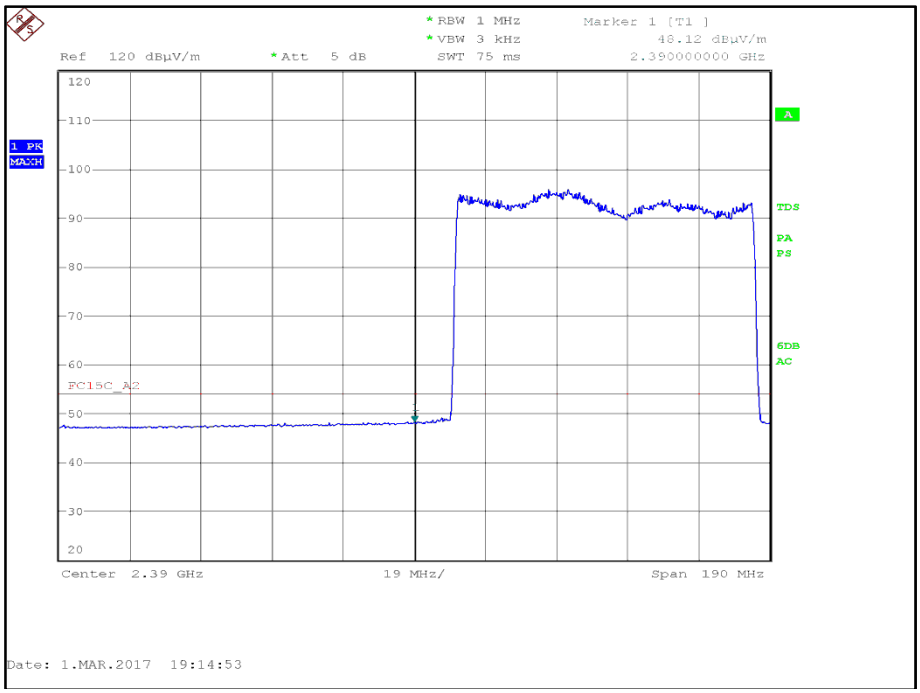

Figure 44 - 2402 MHz, Hopping, π/4 DQPSK, Measured Frequency 2390.0 MHz, Average

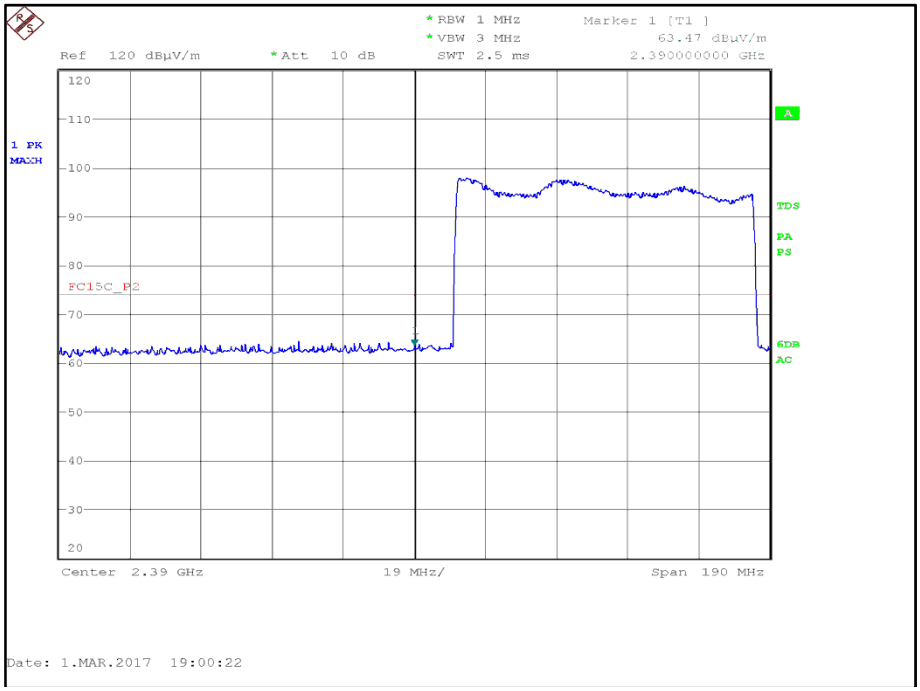

Figure 45 - 2402 MHz, Hopping, 8-DPSK, Measured Frequency 2390.0 MHz, Peak

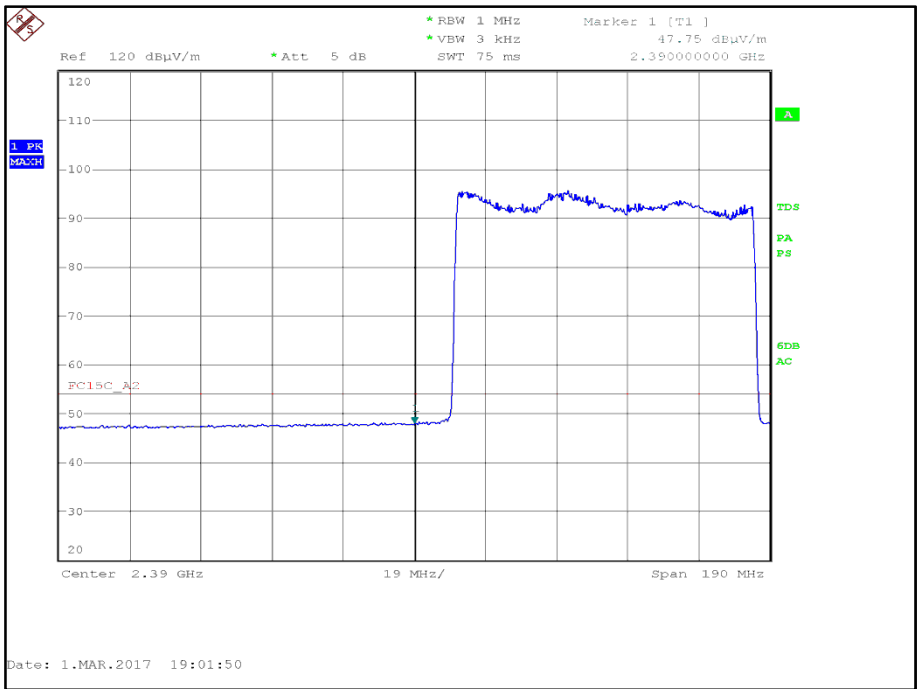

Figure 46 - 2402 MHz, Hopping, 8-DPSK, Measured Frequency 2390.0 MHz, Average

Mode	Modulation	Measured Frequency (MHz)	Peak Level (dBµV/m)	Average Level (dBµV/m)
Static	GFSK	2483.5	62.98	46.49
Static	π/4 DQPSK	2483.5	62.88	46.66
Static	8-DPSK	2483.5	62.12	46.79
Hopping	GFSK	2483.5	62.63	46.31
Hopping	π/4 DQPSK	2483.5	63.77	46.29
Hopping	8-DPSK	2483.5	62.82	46.81

Table 22 - 2480 MHz

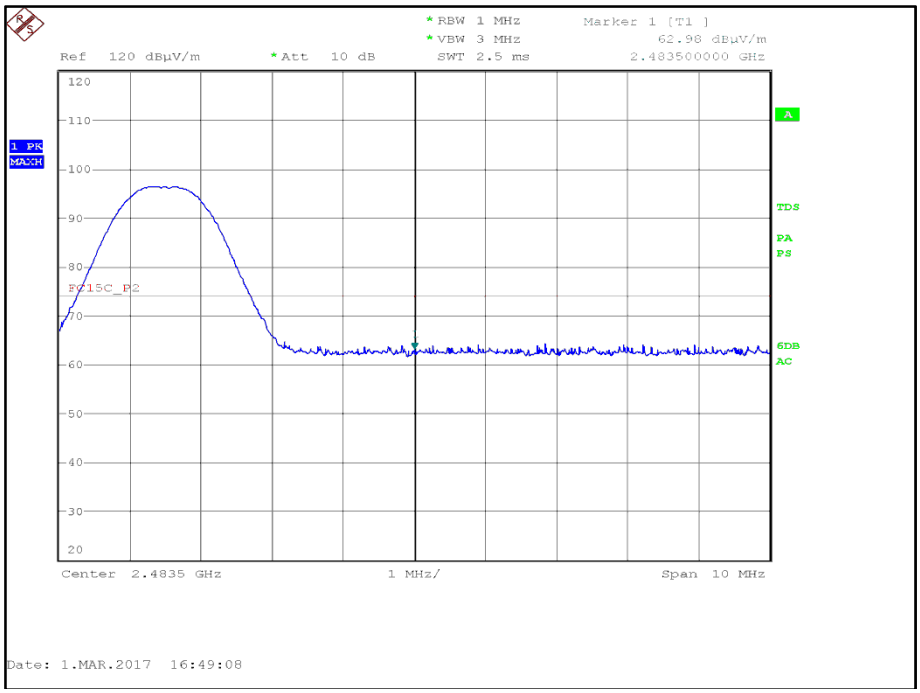

Figure 47 - 2480 MHz, Static, GFSK, Measured Frequency 2483.5 MHz, Peak

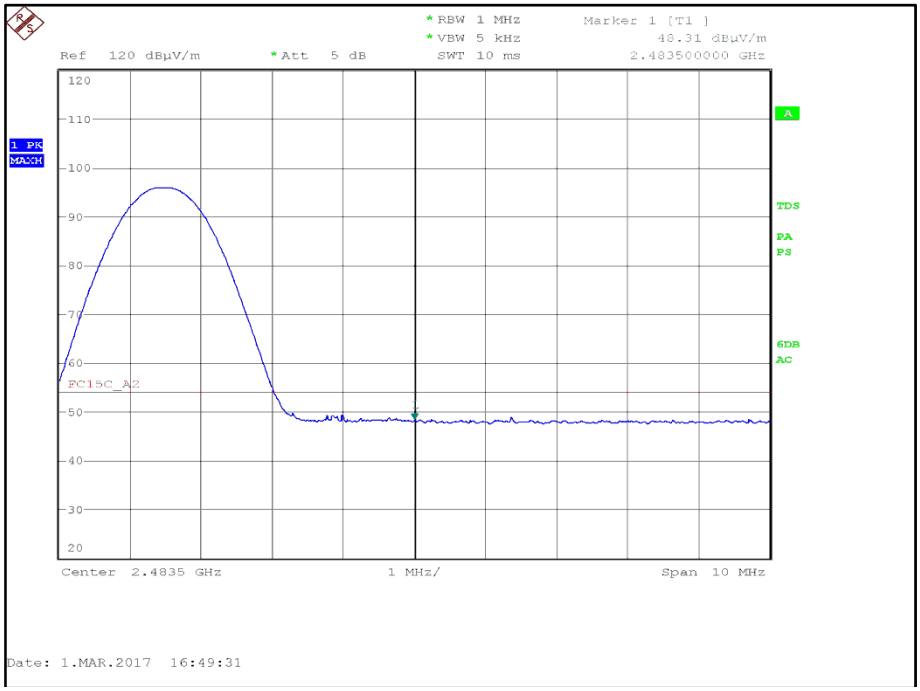

Figure 48 - 2480 MHz, Static, GFSK, Measured Frequency 2483.5 MHz, Average

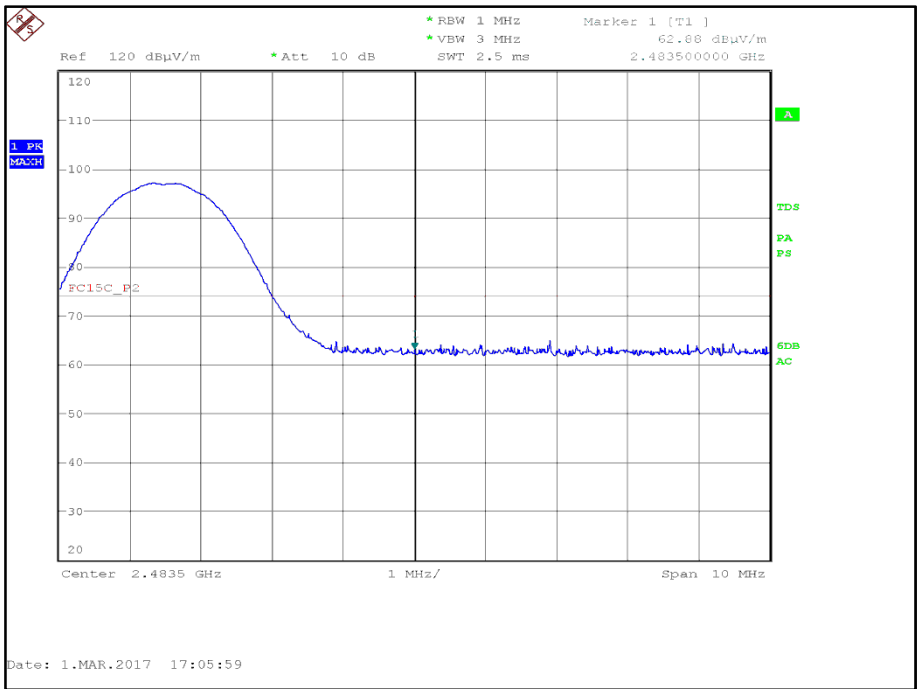

Figure 49 - 2480 MHz, Static, π/4 DQPSK, Measured Frequency 2483.5 MHz, Peak

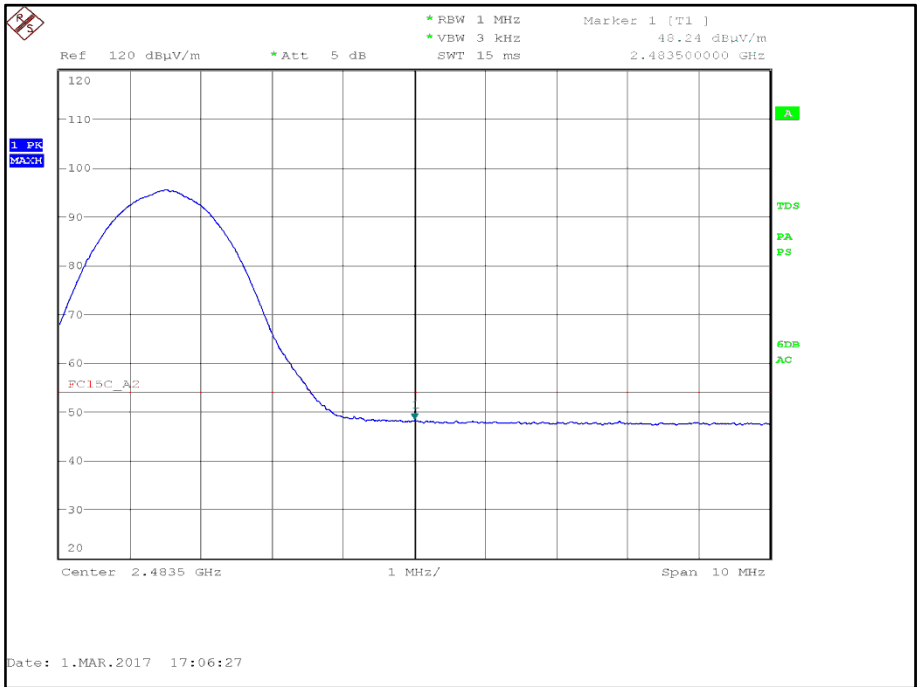

Figure 50 - 2480 MHz, Static, π/4 DQPSK, Measured Frequency 2483.5 MHz, Average

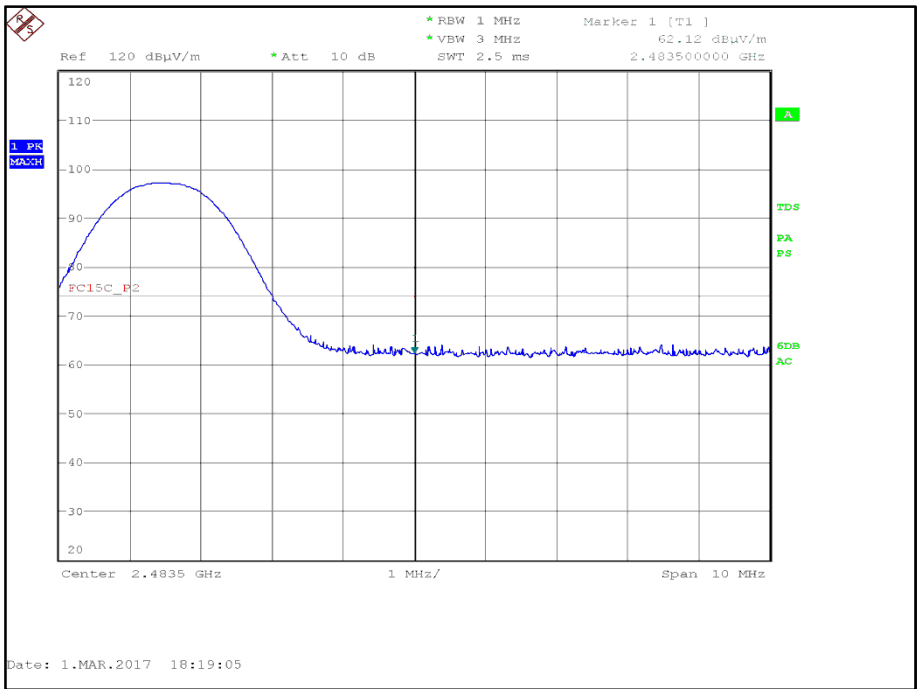

Figure 51 - 2480 MHz, Static, 8-DPSK, Measured Frequency 2483.5 MHz, Peak

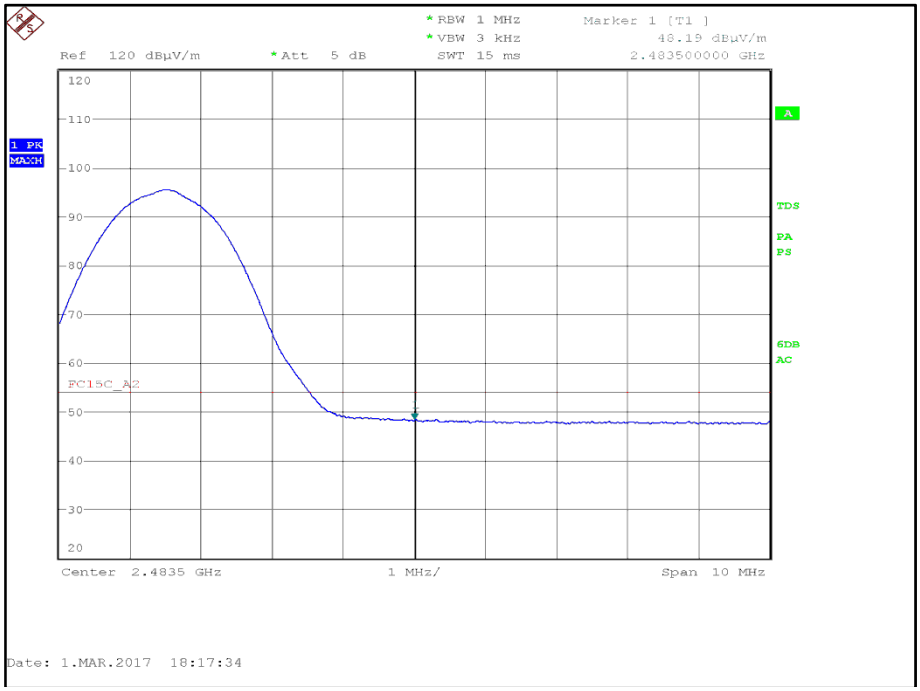

Figure 52 - 2480 MHz, Static, 8-DPSK, Measured Frequency 2483.5 MHz, Average

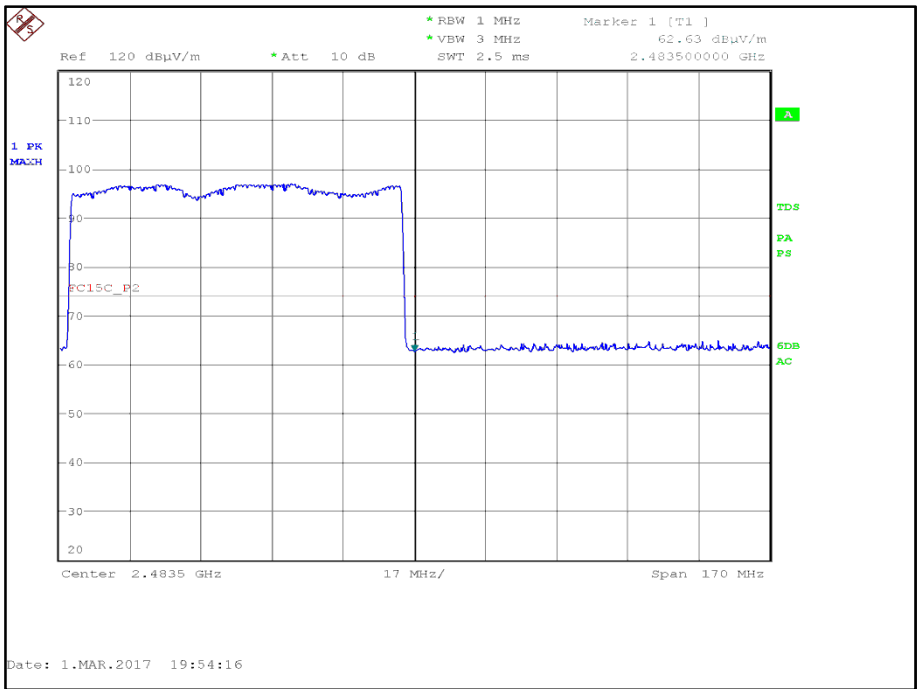

Figure 53 - 2480 MHz, Hopping, GFSK, Measured Frequency 2483.5 MHz, Peak

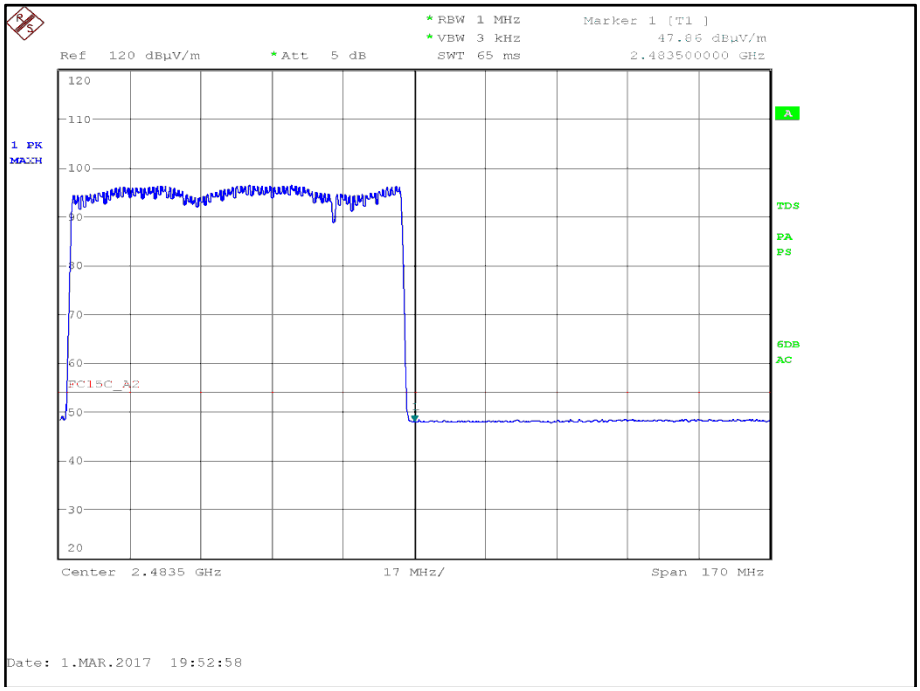

Figure 54 - 2480 MHz, Hopping, GFSK, Measured Frequency 2483.5 MHz, Average

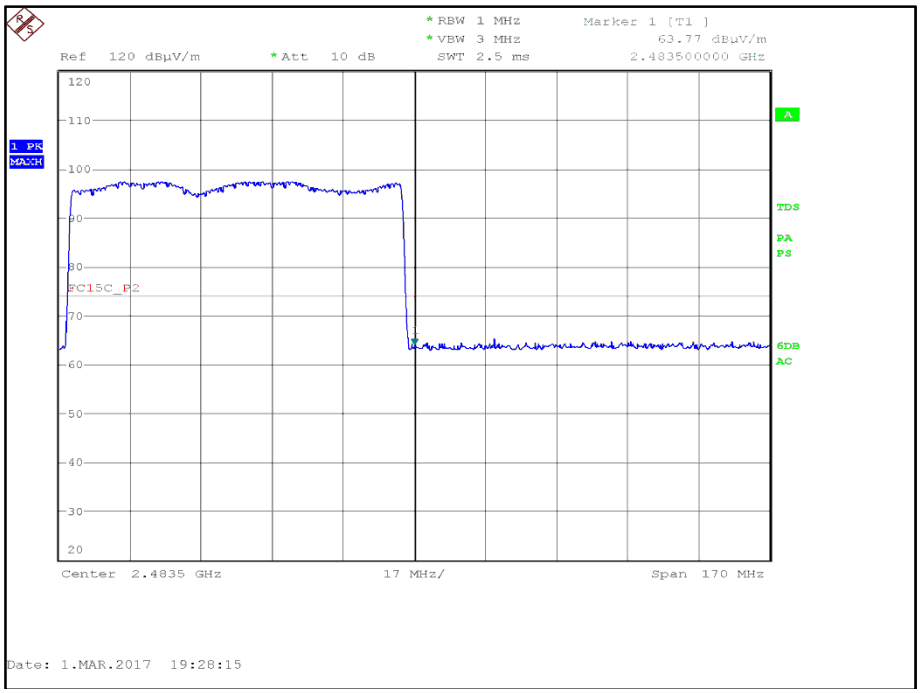

Figure 55 - 2480 MHz, Hopping, π/4 DQPSK, Measured Frequency 2483.5 MHz, Peak

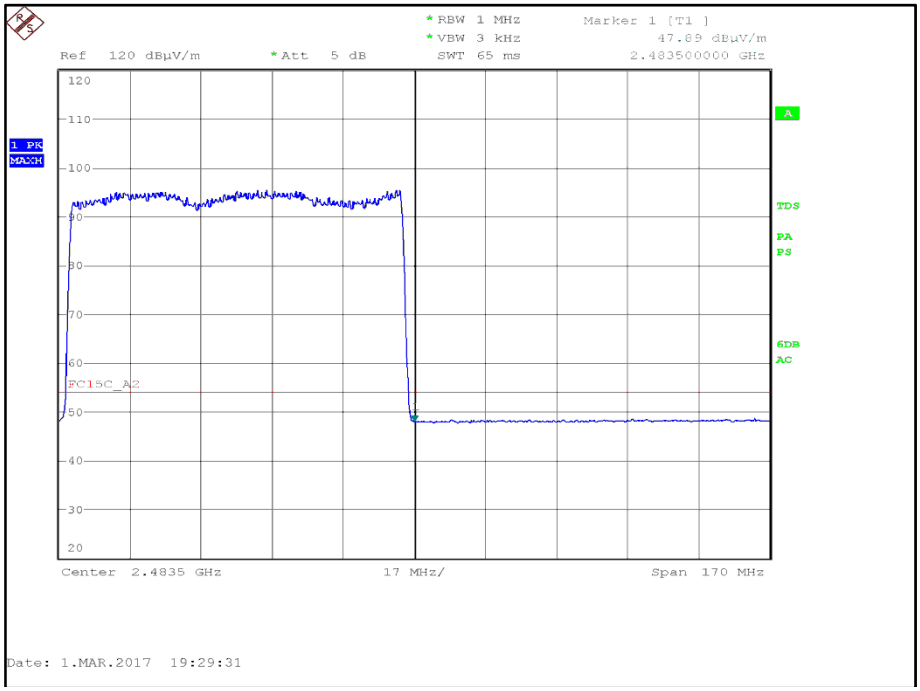

Figure 56 - 2480 MHz, Hopping, π/4 DQPSK, Measured Frequency 2483.5 MHz, Average

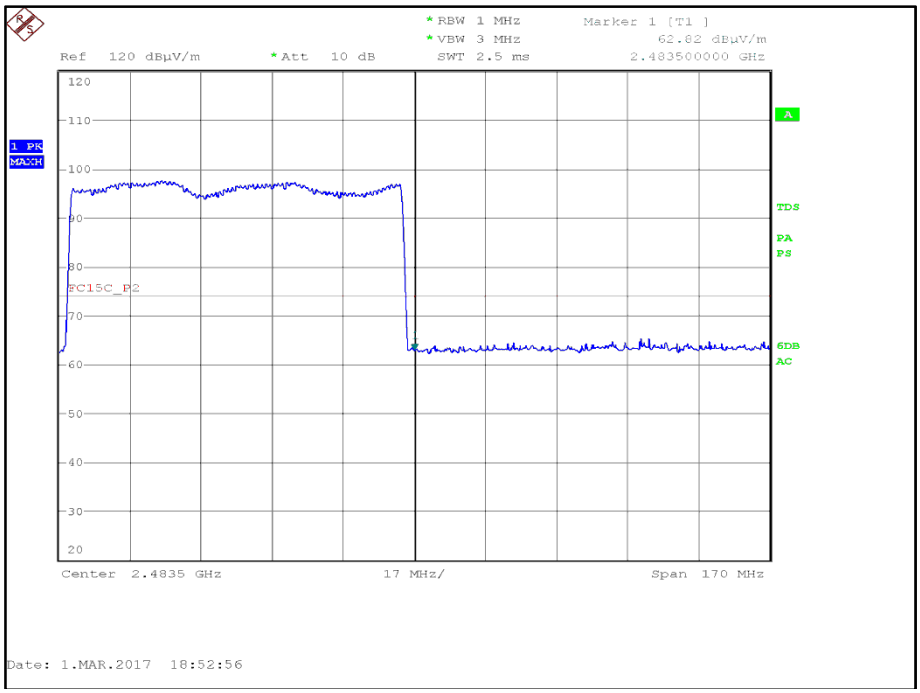

Figure 57 - 2480 MHz, Hopping, 8-DPSK, Measured Frequency 2483.5 MHz, Peak

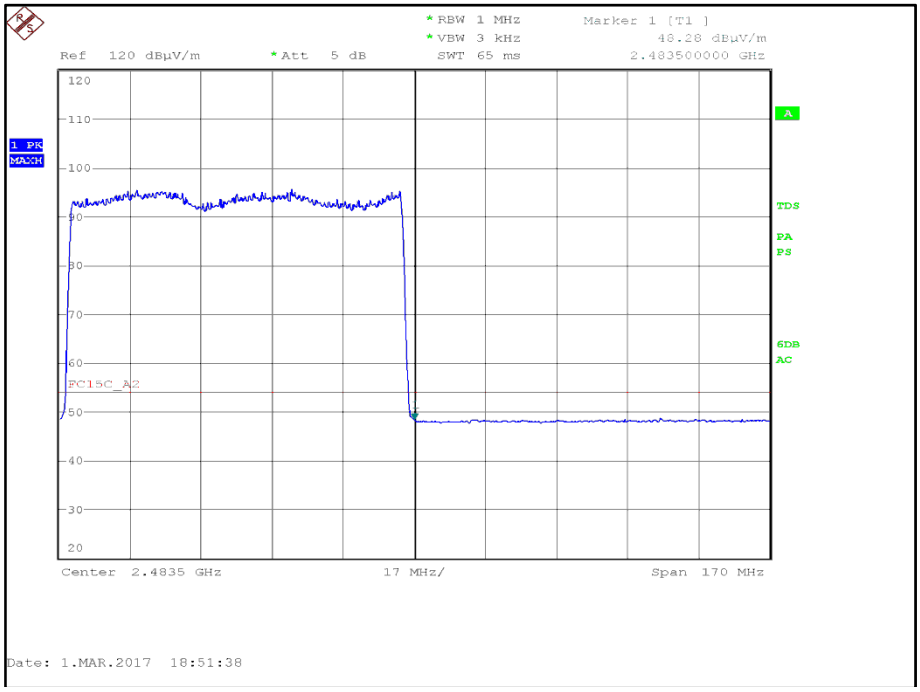

Figure 58 - 2480 MHz, Hopping, 8-DPSK, Measured Frequency 2483.5 MHz, Average

FCC 47 CFR Part 15, Limit Clause 15.205

	Peak (dBµV/m)	Average (dBµV/m)
Restricted Bands of Operation	74	54

Table 23

2.7.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Hygrometer	Rotronic	HYGROPALM 1	2338	12	21-Sep-2017
Multimeter	Iso-tech	IDM101	2417	12	30-Sep-2017
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	29-Jul-2015
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	29-Dec-2016
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	17-Feb-2018

Table 24

TU - Traceability Unscheduled

2.8 Authorised Band Edges

2.8.1 Specification Reference

FCC 47 CFR Part 15C, Clause 15.247 (d)

2.8.2 Equipment Under Test and Modification State

DAQRI Smart Helmet, S/N: 1829C-DC8-6UPN9XJWJW - Modification State 0

2.8.3 Date of Test

01-March-2017

2.8.4 Test Method

The test was performed in accordance with ANSI C63.10, Clause 6.10.4.

2.8.5 Environmental Conditions

Ambient Temperature 18.9 °C
Relative Humidity 35.0 %

2.8.6 Test Results

Bluetooth

Mode	Modulation	Measured Frequency (MHz)	Peak Level (dBµV/m)
Static	GFSK	2400.0	52.15
Static	π/4 DQPSK	2400.0	53.86
Static	8-DPSK	2400.0	52.88
Hopping	GFSK	2400.0	52.40
Hopping	π/4 DQPSK	2400.0	51.79
Hopping	8-DPSK	2400.0	53.26

Table 25 - 2402 MHz

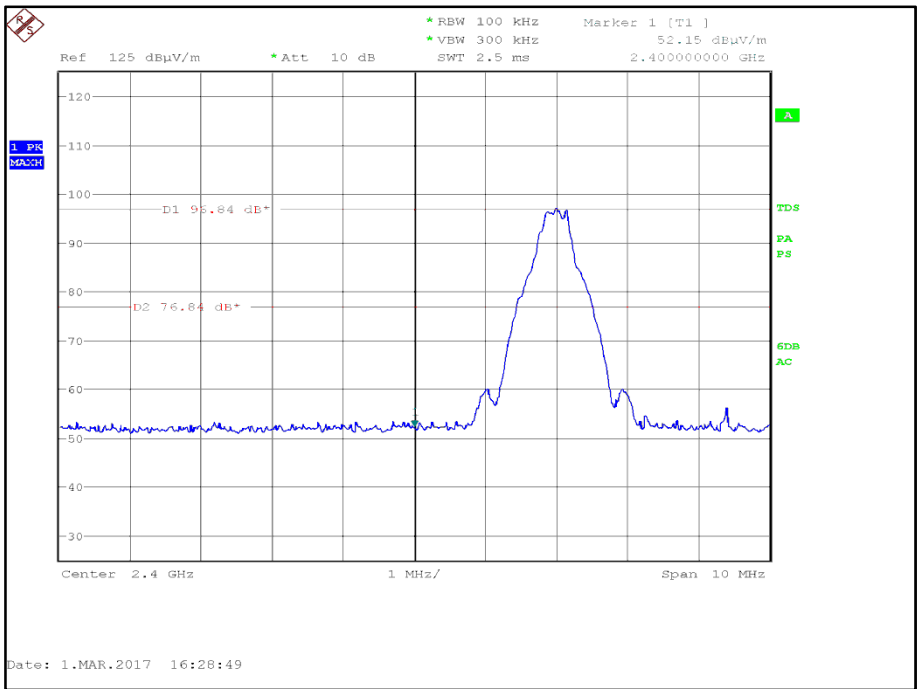

Figure 59 - 2402 MHz, Static, GFSK, Measured Frequency 2400.0 MHz

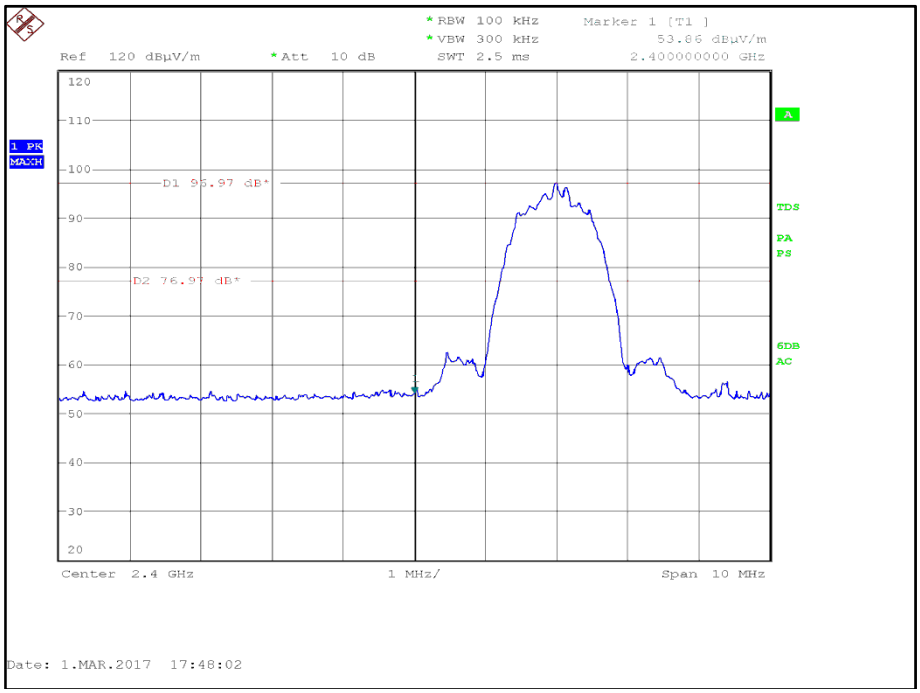

Figure 60 - 2402 MHz, Static, π/4 DQPSK, Measured Frequency 2400.0 MHz

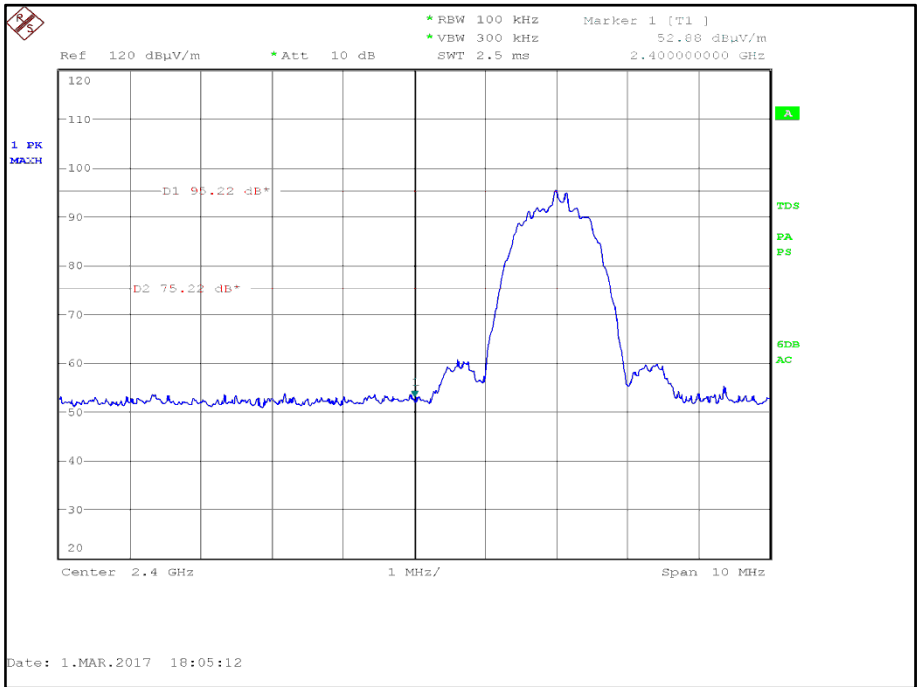

Figure 61 - 2402 MHz, Static, 8-DPSK, Measured Frequency 2400.0 MHz

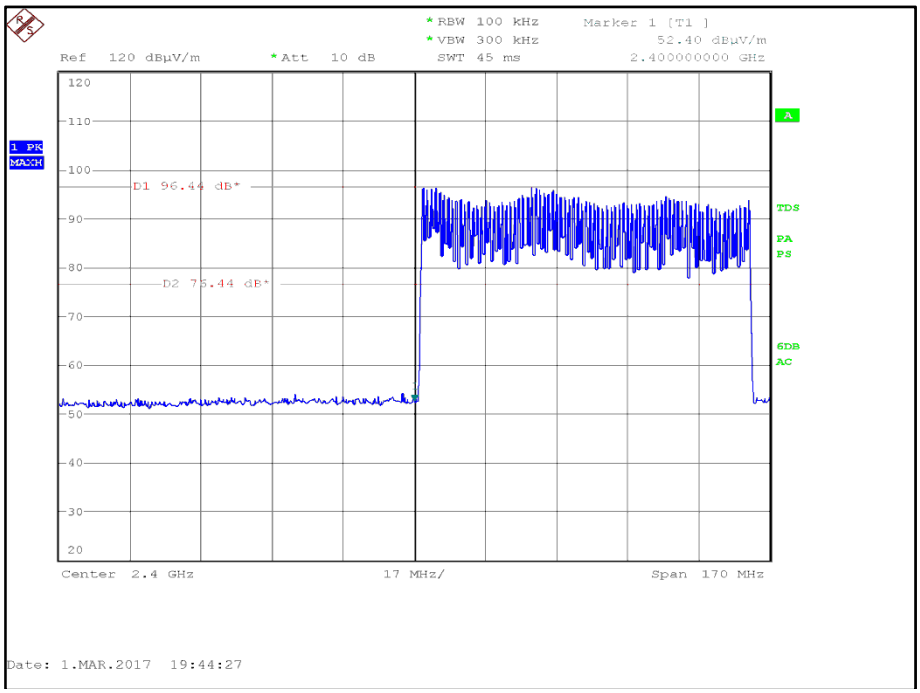

Figure 62 - 2402 MHz, Hopping, GFSK, Measured Frequency 2400.0 MHz

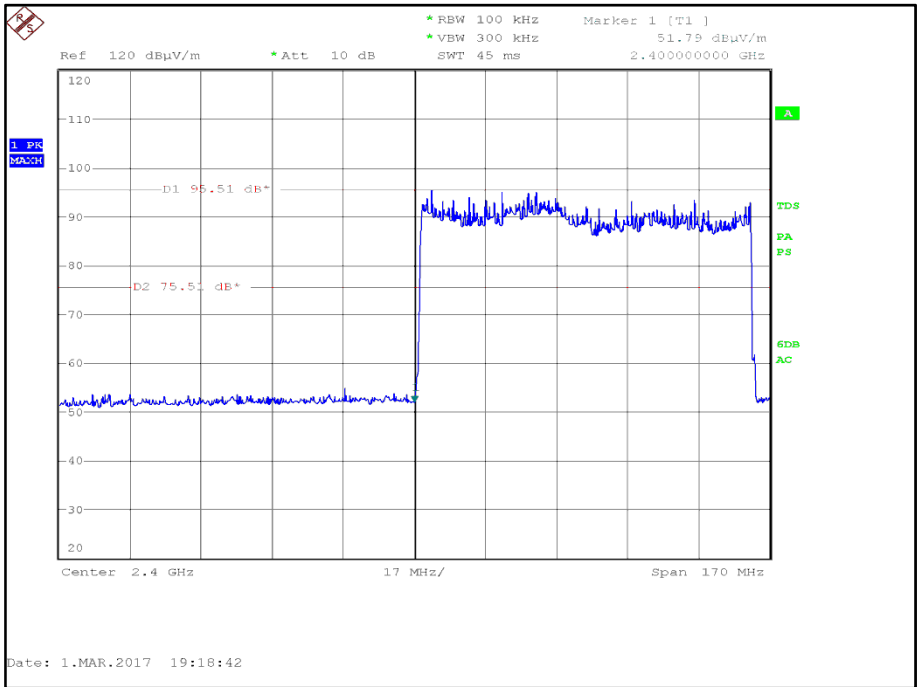

Figure 63 - 2402 MHz, Hopping, π/4 DQPSK, Measured Frequency 2400.0 MHz

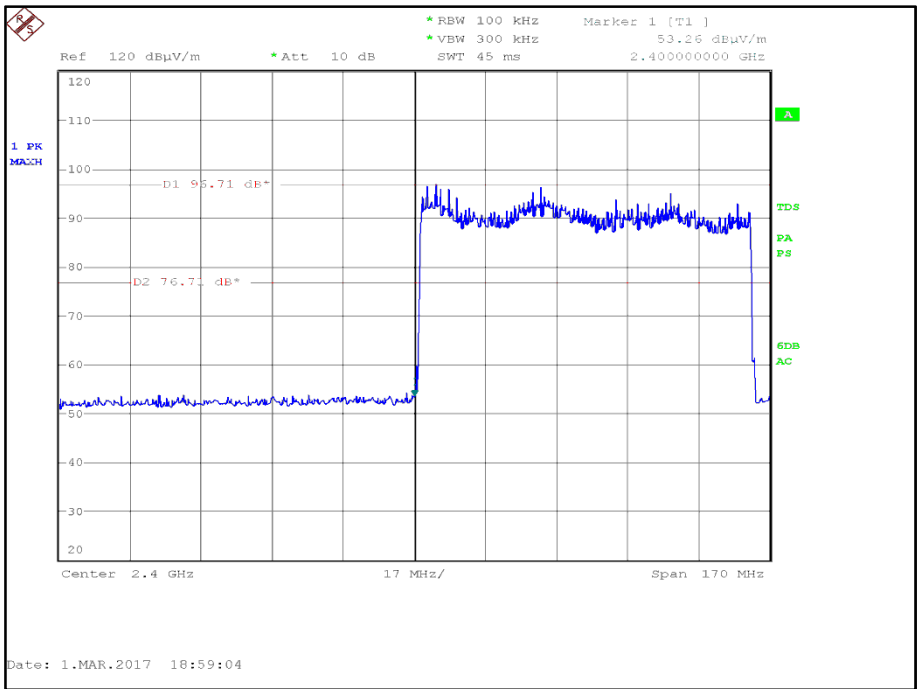

Figure 64 - 2402 MHz, Hopping, 8-DPSK, Measured Frequency 2400.0 MHz

Mode	Modulation	Measured Frequency (MHz)	Peak Level (dBµV/m)
Static	GFSK	2483.5	52.72
Static	π/4 DQPSK	2483.5	52.22
Static	8-DPSK	2483.5	52.90
Hopping	GFSK	2483.5	52.21
Hopping	π/4 DQPSK	2483.5	52.28
Hopping	8-DPSK	2483.5	52.15

Table 26 - 2480 MHz

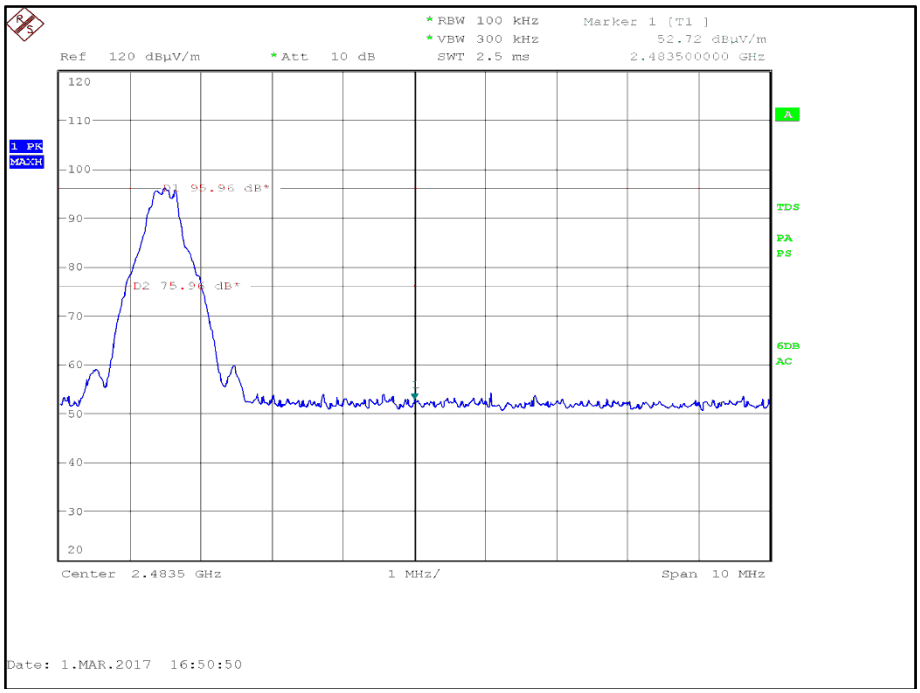

Figure 65 - 2480 MHz, Static, GFSK, Measured Frequency 2483.5 MHz

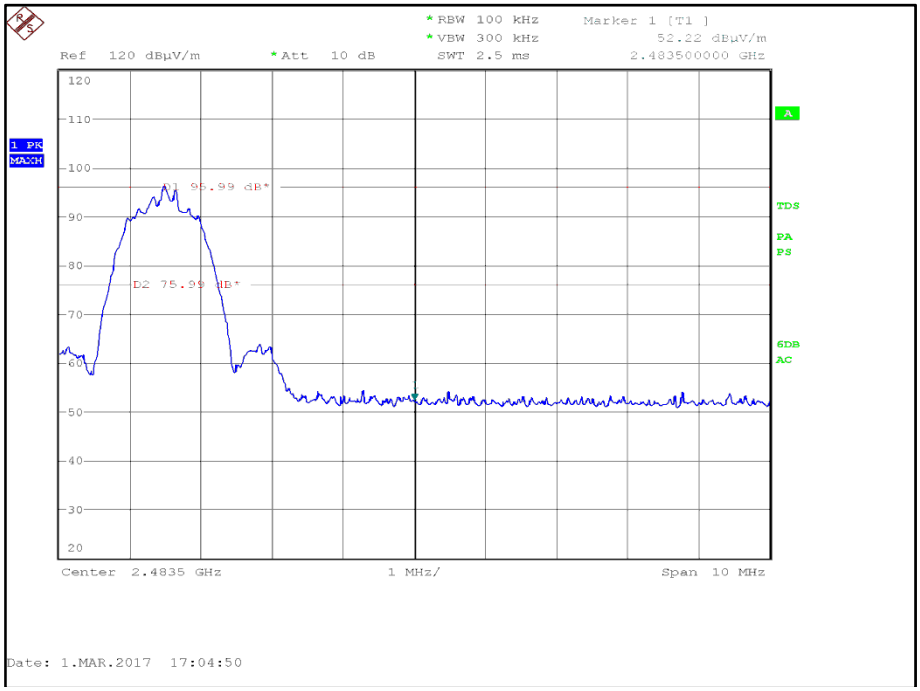

Figure 66 - 2480 MHz, Static, π/4 DQPSK, Measured Frequency 2483.5 MHz

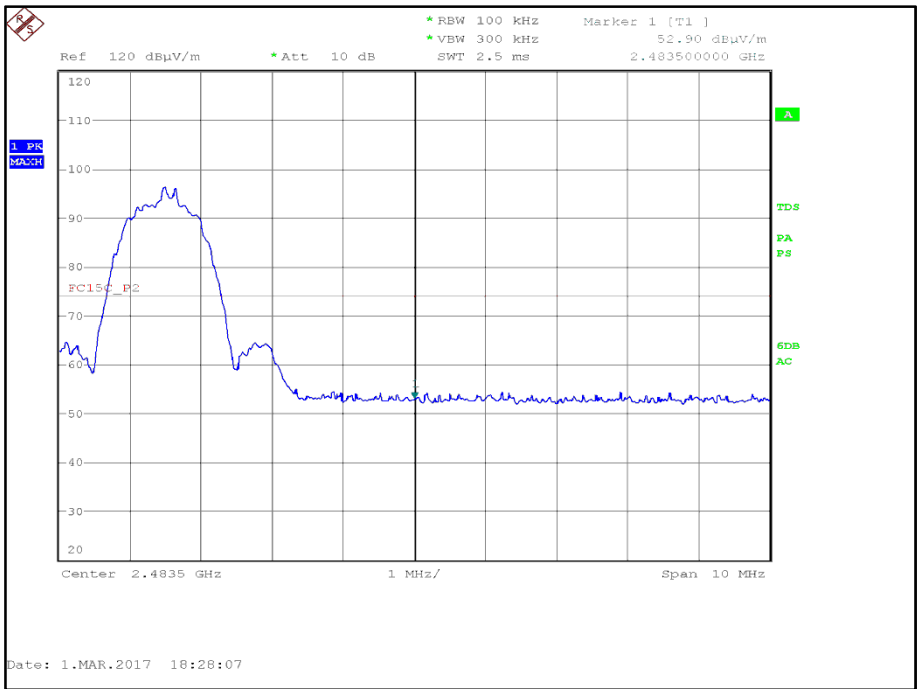

Figure 67 - 2480 MHz, Static, 8-DPSK, Measured Frequency 2483.5 MHz

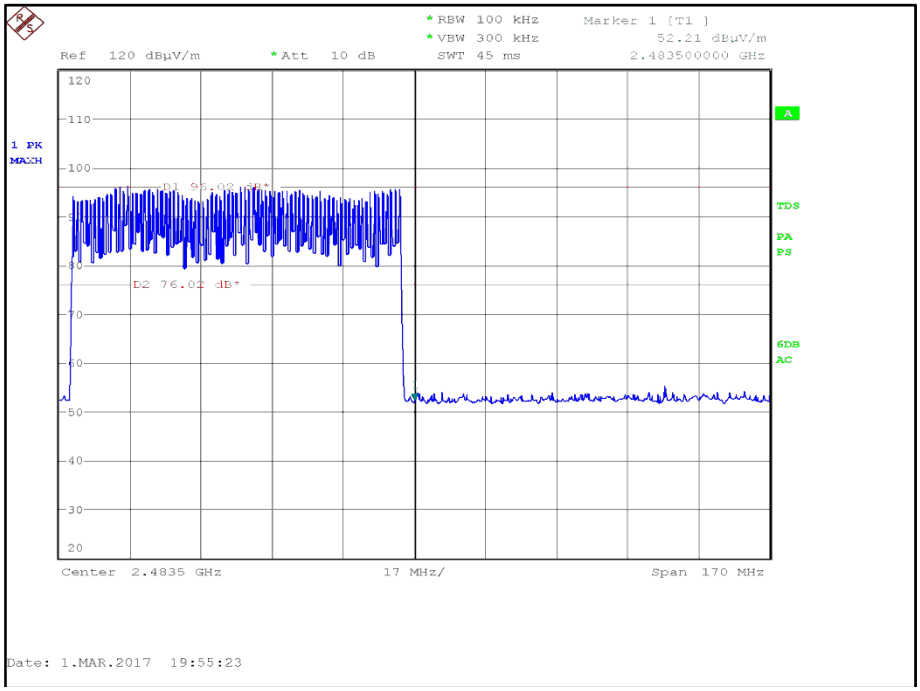

Figure 68 - 2480 MHz, Hopping, GFSK, Measured Frequency 2483.5 MHz

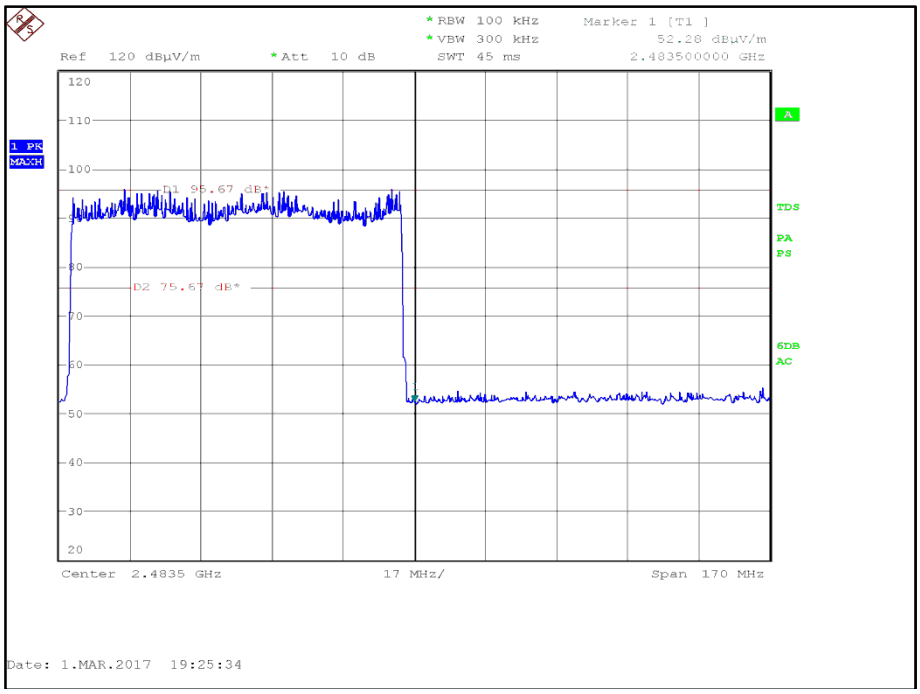

Figure 69 - 2480 MHz, Hopping, π/4 DQPSK, Measured Frequency 2483.5 MHz

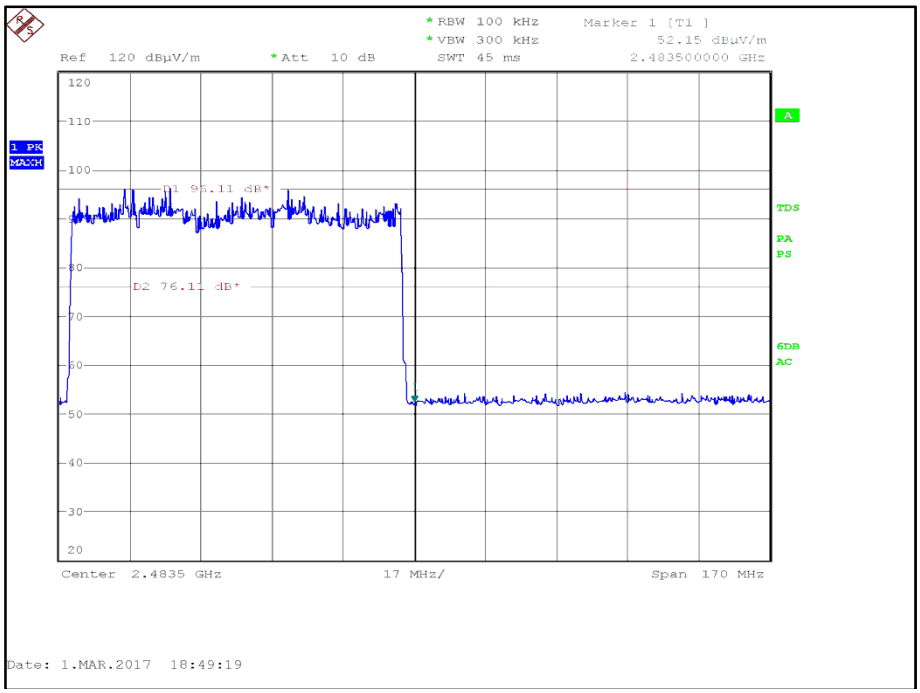

Figure 70 - 2480 MHz, Hopping, 8-DPSK, Measured Frequency 2483.5 MHz

FCC 47 CFR Part 15, Limit Clause 15.247 (d)

20 dB below the fundamental measured in a 100 kHz bandwidth using a peak detector. If the transmitter complies with the conducted power limits, based on the use of RMS averaging over a time interval, the attenuation required shall be 30 dB below the fundamental instead of 20 dB.

2.8.7 Test Location and Test Equipment Used

This test was carried out in EMC Chamber 5.

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
Screened Room (5)	Rainford	Rainford	1545	36	20-Dec-2017
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Hygrometer	Rotronic	HYGROPALM 1	2338	12	21-Sep-2017
Multimeter	Iso-tech	IDM101	2417	12	30-Sep-2017
Cable (N-N, 8m)	Rhophase	NPS-2302-8000-NPS	3248	-	TU
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	12-Nov-2017
Tilt Antenna Mast	maturo Gmbh	TAM 4.0-P	3916	-	TU
Mast Controller	maturo Gmbh	NCD	3917	-	TU
Cable (Yellow, Rx, Km-Km 2m)	Scott Cables	KPS-1501-2000-KPS	4527	6	29-Jul-2015
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	29-Dec-2016
Double Ridged Waveguide Horn Antenna	ETS-Lindgren	3117	4722	12	17-Feb-2018

Table 27

TU - Traceability Unscheduled

3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

Test Name	Measurement Uncertainty
Maximum Conducted Output Power	± 0.70 dB
Frequency Hopping Systems - Average Time of Occupancy	-
Frequency Hopping Systems - Channel Separation	± 16.74 kHz
Frequency Hopping Systems - Number of Hopping Channels	-
Frequency Hopping Systems - 20 dB Bandwidth	± 16.74 kHz
Spurious Radiated Emissions	Radiated: 30 MHz to 1 GHz: ± 5.1 dB Radiated: 1 GHz to 40 GHz: ± 6.3 dB
Restricted Band Edges	Radiated: 30 MHz to 1 GHz: ± 5.1 dB Radiated: 1 GHz to 40 GHz: ± 6.3 dB
Authorised Band Edges	Radiated: 30 MHz to 1 GHz: ± 5.1 dB Radiated: 1 GHz to 40 GHz: ± 6.3 dB