TÜVRheinland®
Precisely Right.

Emissions
Test Report

EUT Name (PMN): Blade

Model No. (HVIN): 477
CFR 47 Part 15.247: 2018, RSS 247 Issue 2, 2017

Prepared for:

Vuzix Corporation
25 Hendrix Rd
West Henrietta, NY 14586

Prepared by:

TUV Rheinland of North America, Inc.
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Revisions

Revision No.	Date MM/DD/YYYY	Reason for Change	Author
1	4/26/2018	Initial	N/A
2	06/27/2018	TCB review changes	D. Foster
3	07/01/2018	TCB review changes	D. Foster

Note: Latest revision report will replace all previous reports.

Statement of Compliance

Manufacturer:	Vuzix Corporation 25 Hendrix Rd West Henrietta, NY 14586
Name of Equipment:	Blade
Model No.	447
Type of Equipment:	Intentional Radiator
Test Dates:	20 April 2018 to 1 May 2018

Guidance Documents:

Emissions: ANSI C63.10-2013, KDB 55074 D01 DTS Measurment Guidance v04

Test Methods:

Emissions: CFR47 part15.247 2018

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that the equipment described above has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by A2LA or any agency of the U.S. Government. This report shall not be reproduced except in full, without the written authorization of TUV Rheinland of North America.

Josie Sabado	July 2, 2018	Isaac Aguilar	July 2, 2018
Test Engineer	Date	Laboratory Signature	Date

INDUSTRY CANADA

Testing Cert #3331.02 US1131 2932M-1

1 Executive Summary

1.1 Scope

The purpose of the following report is to demonstrate compliance of the Vuzix Blade head worn glasses to the various regulatory requirements further listed in this Report.

It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Summary of Test Results

Table 1: Summary of Test Results

Test	Test Method	Result
DTS		
DTS Bandwidth	ANSI C63.10:2013 section 11.8.2	**Complies**
Output Power (Peak)	ANSI C63.10:2013 section 11.9.1.2/11.9.1.3	**Complies**
Power Spectral Density	ANSI C63.10:2013 section 11.10.2	**Complies**
Emission (Non-Restricted Band)	ANSI C63.10:2013 section 11.11	**Complies**
Emissions (Restricted Band)	ANSI C63.10:2013 section 11.12	**Complies**
Band-edge	ANSI C63.10:2013 section 11.13.2	**Complies**
AC Power Conducted Emissions	ANSI C63.4:2014 section 7	**Complies**
DSS		
20 dB Bandwidth	ANSI C63.10:2013 section 6.9.2	**Complies**
Output Power	ANSI C63.10:2013 section 7.8.5	**Complies**
Number Hopping Frequencies	ANSI C63.10:2013 section 7.8.3	**Complies**
Carrier Separation	ANSI C63.10:2013 section 7.8.2	**Complies**
Dwell Time	ANSI C63.10:2013 section 7.8.4	**Complies**
Emissions (Non-Restricted Band)	ANSI C63.10:2013 section 7.8.8	**Complies**
Emissions (Restricted Band)	ANSI C63.10:2013 section 7.8.8	**Complies**
Band-edge	ANSI C63.10:2013 section 7.8.8	**Complies**
AC Power Conducted Emissions	ANSI C63.4:2014 section 7	**Complies**

Note:

1.4 Test Software

Proprietary test software was used to enable a test mode. The test software forced the radio to transmit at maximum power. The test software was used to change the channel and modulations.

1.5 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.6 Equipment Modifications

None

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 is recognized by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US1131). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / A2LA

TUV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2005 and ISO 9002 (Lab Code 3331.02). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures.

VCCI Registration No. for Pleasanton: A-0268

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / A2LA accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 and 5 meters. The site is listed with the FCC and accredited by A2LA (Lab Code 3331.02). The 3/5-meter semi-anechoic chamber used to collect the radiated data has been verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4-2014, at a test distance of 3 meter and 5 meters. A report detailing this site can be obtained from TUV Rheinland of North America.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.
The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBµV/m) = RAW - AMP + CBL + ACF
Where: RAW = Measured level before correction (dBµV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz
Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)
25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.3.2 Measurement Uncertainty Emissions

Per CISPR 16-4-2	**U_{lab}**	**U_{cispr}**
Radiated Disturbance @ 10 meters		
30 – 1,000 MHz	2.25 dB	4.51 dB
Radiated Disturbance @ 3 meters		
30 – 1,000 MHz	2.26 dB	4.52 dB
1 – 6 GHz	2.12 dB	4.25 dB
6 – 18 GHz	2.47 dB	4.93 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.09 dB	2.18 dB
Disturbance Power		
30 MHz– 300 MHz	3.92 dB	4.3 dB

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005.

2.5 Equipment Configuration

A description of the equipment configuration is given in the Test Plan Section. The EUT was tested as called for in the test standard and was configured and operated in a manner consistent with its intended use. The EUT was charged from the support laptop used to configure the various modes of operation. The placement of the EUT system components was guided by the test standard and selected to represent typical installation conditions.
In the case of a EUT that can operate in more than one configuration, preliminary testing was performed to determine the configuration that produced maximum radiation.

2.6 Operating Mode

A description of the operation mode is given in the Test Plan Section. In the case of a EUT that can operate in more than one state, preliminary testing was performed to determine the operating mode that produced maximum radiation.
The final operating mode was selected to produce the worst case radiation for emissions testing and to place the EUT in the most susceptible. Please see Table 9 for operational mode details.

2.7 Unique Antenna Connector

The Vuzix Blade has an internal fixed antenna which is not removable.

3 Product Information

3.1 Introduction

This section provides a description of the Equipment Under Test (EUT), configurations, operating conditions, and performance acceptance criteria. It is an overview of information provided by the manufacturer so that the test laboratory may perform the requested testing.

3.2 Customer

Table 2: Customer Information

Company Name	Vuzix Corporation
Address	25 Hendrix Road
City, State, Zip	West Henrietta, NY 14586
Country	USA

Table 3: Technical Contact Information

Name	Devrin Talen
E-mail	devrin_talen@vuzix.com
Phone	585-359-5921

3.3 Equipment Under Test (EUT)

Table 4: EUT Specifications

EUT Specifications	
Dimensions	H4.6cm W16.2cm L18.7cm
DC Input	Battery
Environment	Indoor /Outdoor
Operating Temperature Range:	-20 / 60C
Multiple Feeds:	☐ Yes and how many ☒ No
Product Marketing Name (PMN)	Blade
Hardware Version Identification Number (HVIN)	447
Firmware Version Identification Number (FVIN)	n/a
Bluetooth Radio	
Operating Mode	BDR, EDR, and BLE
Transmitter Frequency Band	2402 MHz to 2480 MHz
Operating Bandwidth	1, 2 MHz
Max. Power Output	8.16 dBm
Power Setting @ Operating Channel	Fixed
Antenna Type	1 integrated PCB antenna
Antenna Gain	1.6 dBi
Modulation Type	GFSK, pi/4DQPSK, 8DPSK
Data Rate	1 Mbps, 2 Mbps and 3 Mbps

Table 5: Antenna Information

Number	Antenna Type	Description	Max Gain (dBi)
Antenna 1	Integrated PCB	Max. peak gain at 2.4 GHz	+1.6

Table 6: Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
USB	USB to micro USB	☒ Yes	☒ Metric: 40cm	☒ M

Table 7: Supported Equipment

Equipment	Manufacturer	Model	Serial	Used for
Laptop	Lenovo	80LY	P200PR56	Laptop
USB cable	(generic)	A to Micro-B	n/a	USB cable
Laptop AC adapter	Lenovo	ADLX45 DLC3A	17748-17J91667	Laptop AC adapter
Note: None.				

Table 8: Description of Sample used for Testing

Device	Serial	RF Connection	CFR47 Part 15.247 2018
Blade	M004SW 00110	Integrated Antenna	TX Emissions.
	M004SW 00012	Direct via SMA Connection	Transmit Power, Occupied Bandwidth, Out of Band Emission, Hopping Requirement

Table 9: Test specifications and mode of operation

Test	Mode
Bandwidth CFR 47 15.247 2018(a1), RSS-247 Sect 5.1, RSS-247 Sect 5.2.	2402, 2442, 2480 MHz at BDR, EDR, and BLE
Output Power CFR47 15.247 2018 (b1), RSS-247 Sect. 5.4	2402, 2442, 2480 MHz at BDR, EDR, and BLE
Out of Band Emission CFR47 15.247 2018 (d), RSS-247 Sect. 5.5	2402, 2442, 2480 MHz at BDR and BLE
Power Spectral Density CDR47 15.247 2018 (e), RSS-247 Sect. 5.2 (b)	2402, 2442, 2480 MHz at BLE
Hopping Channel CFR47 15.247 2018 (a1), RSS-247 Sect. 5.1	2402, 2442, 2480 MHz at BDR and EDR
Carrier Separation CFR:15.247 1018 (a1), RSS-247 Sect 5.1	2402, 2442, 2480 MHz at BDR and EDR
Dwell Time CFR:15.247 2018 (a1)(iii), RSS-247 Sect 5.1	2402, 2442, 2480 MHz at BDR and EDR
Band-Edge (Radiated) FCC Part 15.205, 15.209, 15.247(d), RSS-247 Sect.5.5	2402, 2480 MHz at BDR, EDR and BLE
Transmitted Spurious Emission (30 MHz – 1GHz) FCC Part 15.205, 15.209, RSS-Gen 8.9	2402 MHz at DH1 (Worst Case)
Transmitted Spurious Emission (Above 1GHz) FCC Part 15.205, 15.209, RSS-Gen 8.9	2402 MHz at DH1 (Worst Case)
AC Conducted Emission FCC Part 15.207, RSS-Gen Sect 8.8	The unit will be tested in the charging state with a USB adapter.
Note: 1. The EUT supports DSS and DTS modulation schemes. Complaince will be show for both modulation independently. 2. Pretest showed DH1 was the worst case configuration producing the highest emission. 3. All tests were pre-scanned for worst case configuration before final testing.	

4 Measurement Results

4.1 Output Power – 2400 MHz to 2483.5 MHz Band

Testing was performed in accordance with CFR 47 part 15.209 and CFR47 Part 15.247 2018. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

4.1.1.1 Test Method

Conducted method was used to measure the channel power output. The preliminary investigation was performed at different data rate to determine the highest power output for each mode. This test was conducted on 3 channels. The worst mode result indicated in the tables below.

For BDR, EDR, ANSI C63.10-2013 Section 7.8.5 was used. For BLE, ANSI C63.10-2013 section 11.9.1.1 was used.

4.1.1.2 Test Setup

A diagram of the configuration of this test is found in the test plan, please see Table 9.

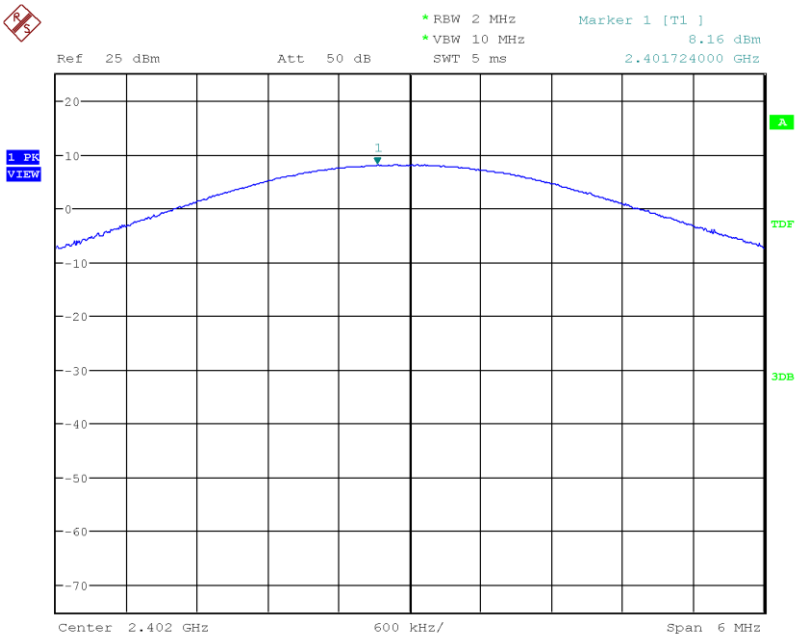
4.1.1.3 Results

Table 10: RF Output Power at the Antenna Port – Test Results

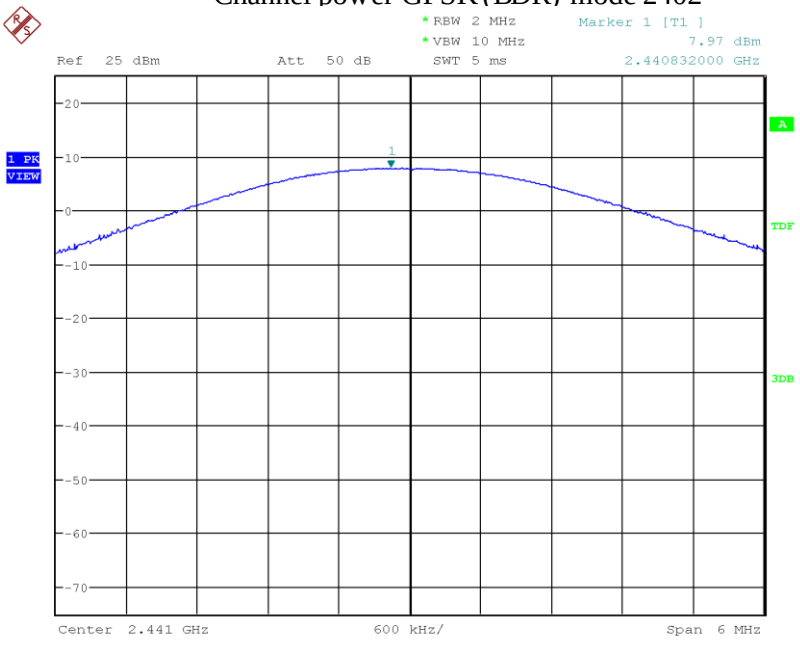
Test Conditions: Conducted Measurement, Normal Temperature	**Date**: 4/25/2018
Antenna Type: Integrated Antenna	**Power Setting:** Maximum
Max. Antenna Gain: 1.6 dBi	**Signal State:** Modulated
Duty Cycle: 100%	**Data Rate:** BDR,EDR and BLE
Ambient Temp.: 23º C	**Relative Humidity:** 38 %RH

Results				
Mode	**Operating Channel**	**Limit [dBm]**	**Power [dBm]**	**Comments**
GFSK (BDR) / DH5	2402 MHz	+30.00	8.16	
	2441 MHz	+30.00	7.97	
	2480 MHz	+30.00	6.83	
π/4 DQPSK / DH5	2402 MHz	+30.00	6.87	
	2441 MHz	+30.00	6.75	
	2480 MHz	+30.00	6.40	
8DPSK / DH5	2402 MHz	+30.00	6.86	
	2441 MHz	+30.00	6.27	
	2480 MHz	+30.00	6.65	
BLE	2402 MHz	+30.00	7.42	
	2442 MHz	+30.00	7.24	
	2480 MHz	+30.00	6.83	

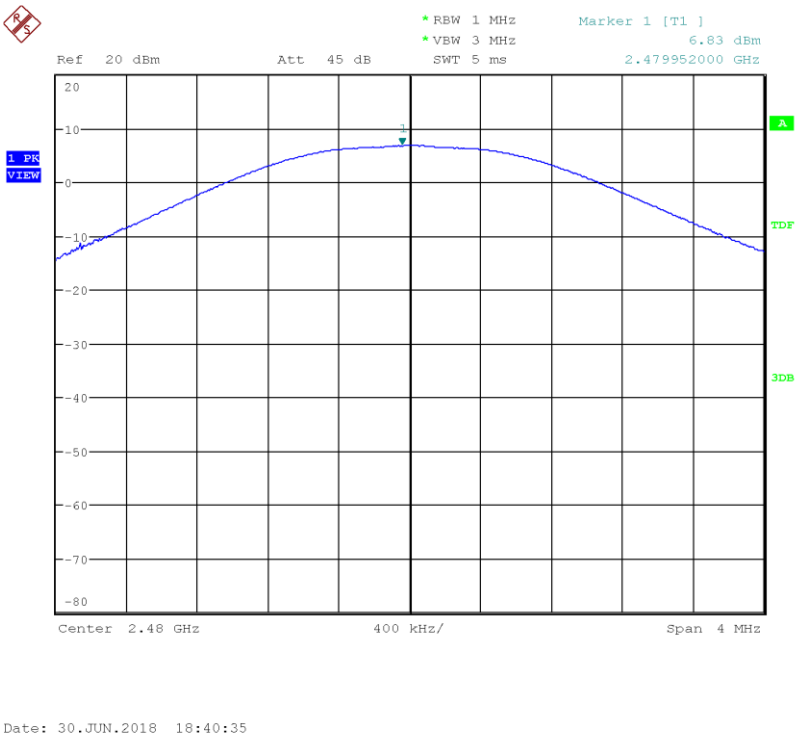
4.1.1.3.1 GFSK (BDR) Test Plots



Channel power GFSK (BDR) mode 2402

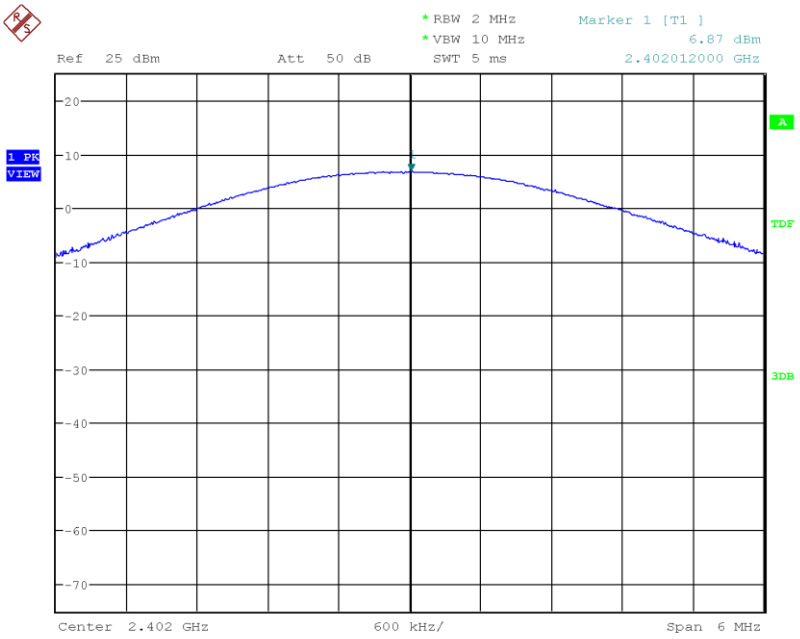


Channel power GFSK (BDR) mode 2441

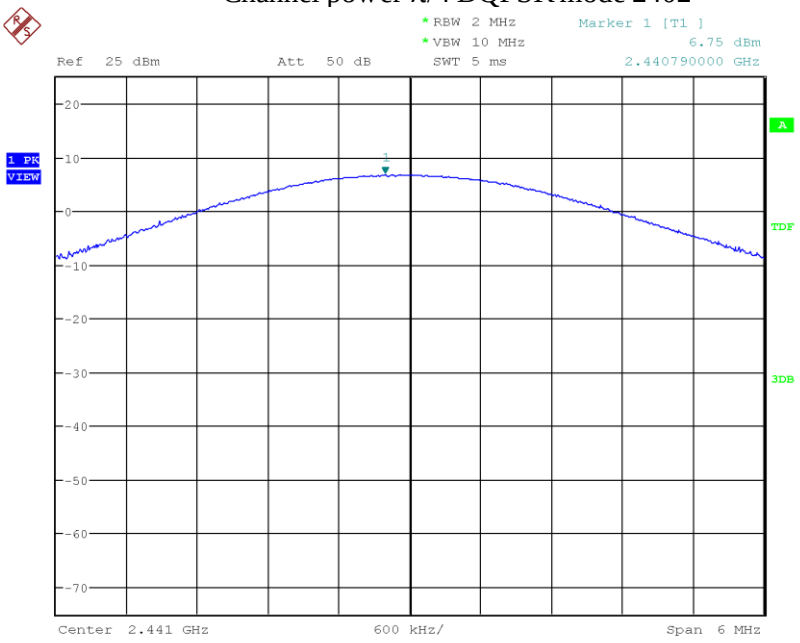


Channel power GFSK (BDR) mode 2480

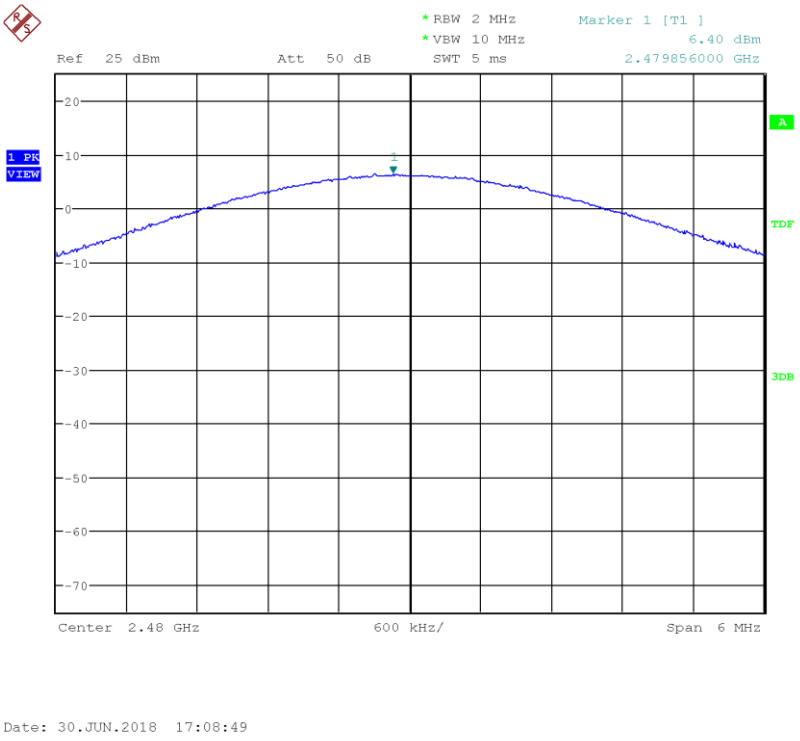
4.1.1.3.2 π/4 DQPSK Test Plots



Channel power π/4 DQPSK mode 2402

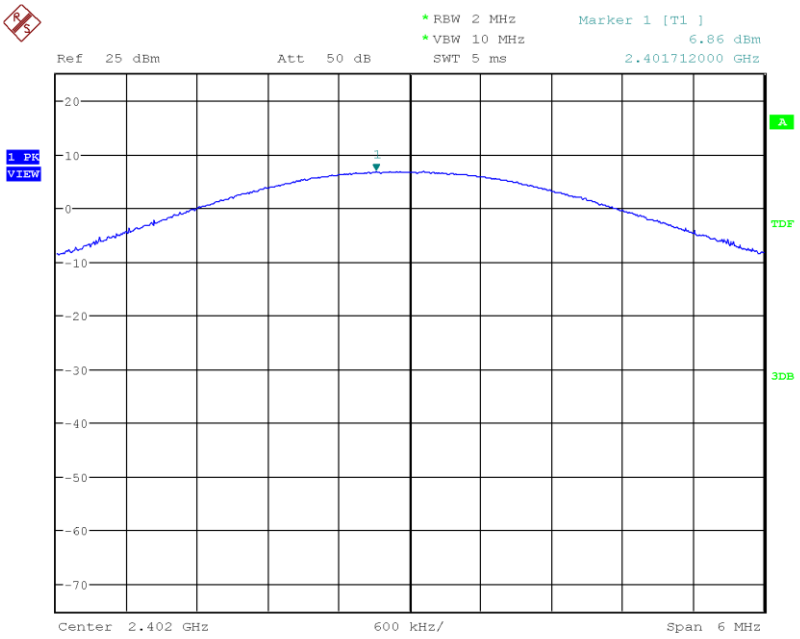


Channel power π/4 DQPSK mode 2441

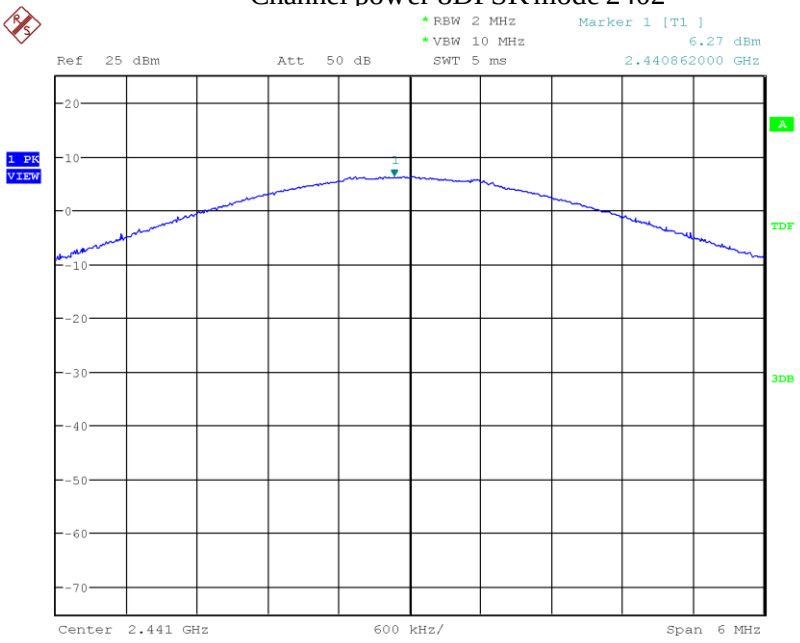


Channel power π/4 DQPSK mode 2480

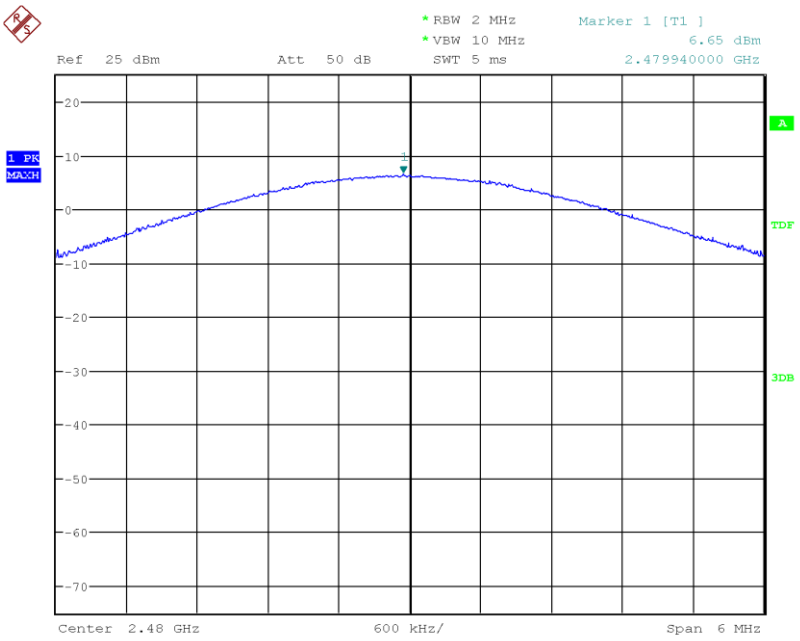
4.1.1.3.3 8DPSK Test Plots



Channel power 8DPSK mode 2402

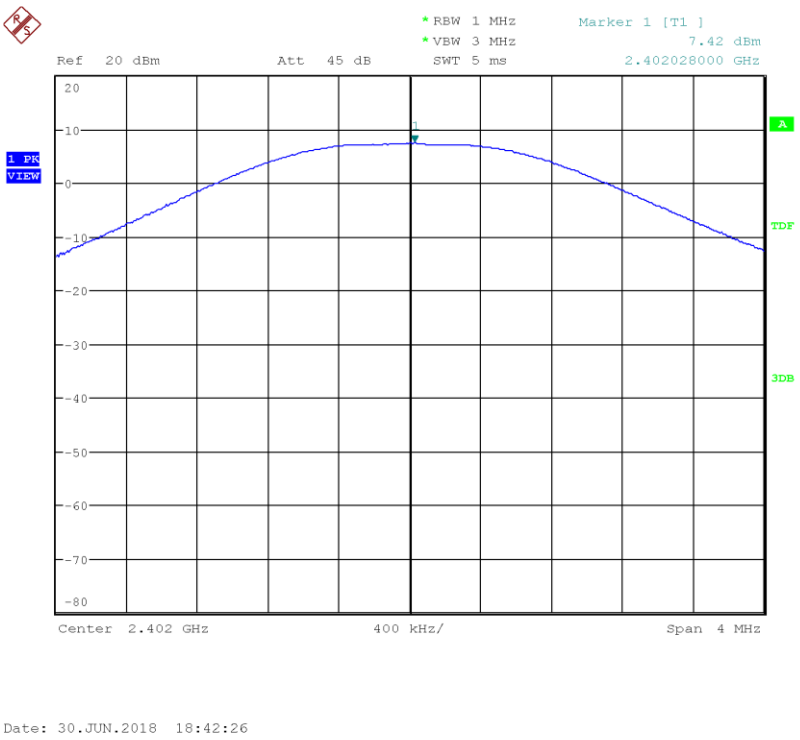


Channel power 8DPSK mode 2441

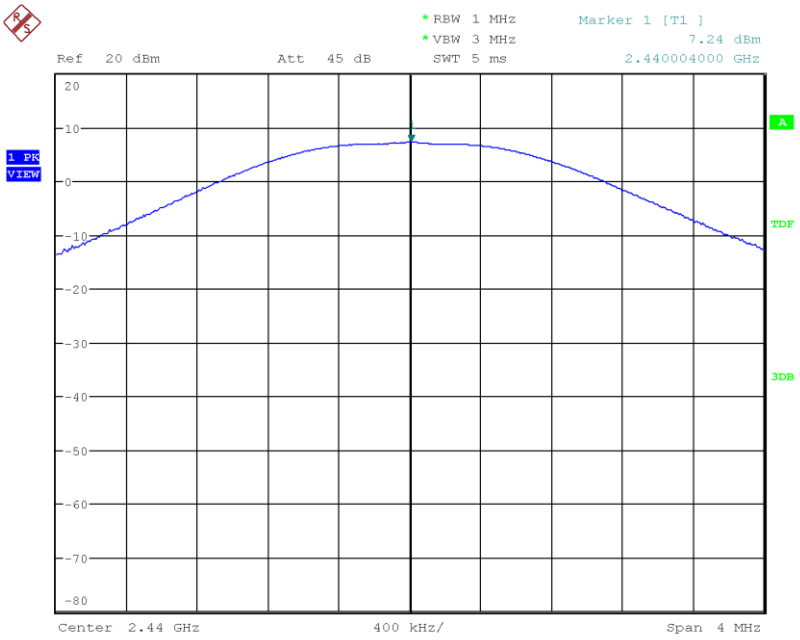


Channel power 8DPSK mode 2480

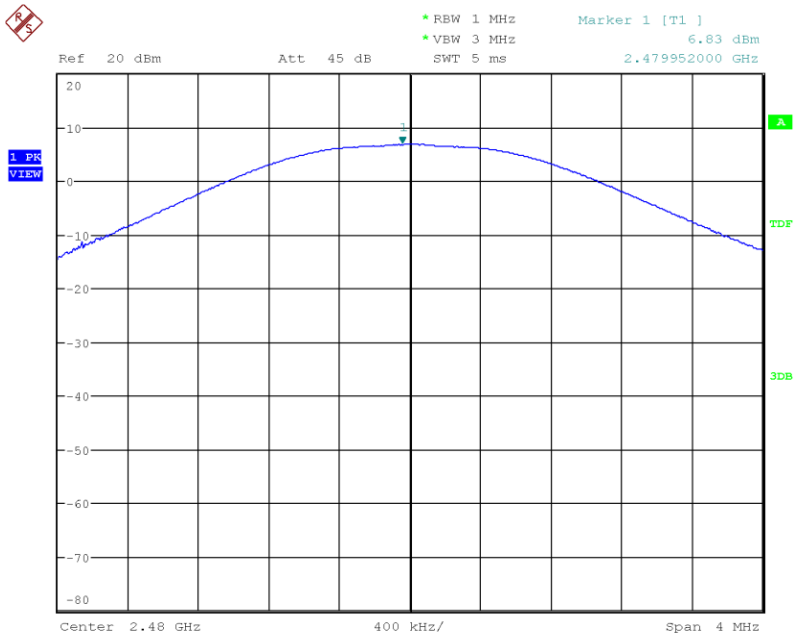
4.1.1.3.4 BLE Test Plots



Channel power BLE mode 2402



Channel power BLE mode 2440



Channel power BLE mode 2480

4.2 Bandwidth

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

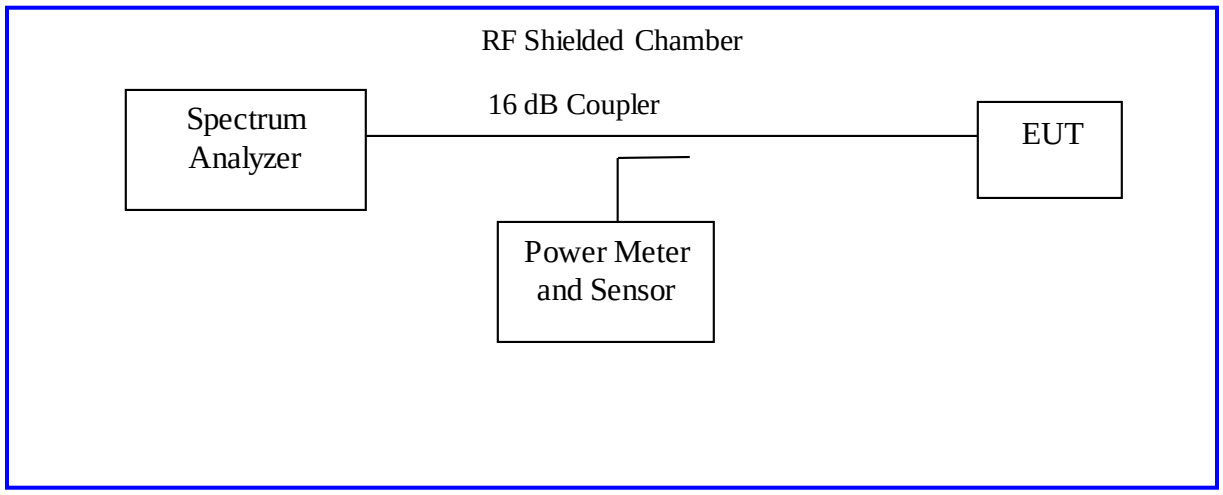
The 20db bandwidth is the bandwidth 20db below the peak of the fundamental. The 6dB bandwidth is defined as the bandwidth of 6dB from highest transmitted level of the fundamental frequency.

The minimum 6 dB bandwidth shall be at least 500 kHz per Section CFR47 15.247 2018(a2) 2017 and RSS-247 Sect. 5.3(a) Issue 2, 2017.

4.2.1 Test Method

The conducted method was used to measure the occupied bandwidth according to ANSI C63.10:2013 Section 6.9.2 (DSS) and Section 11.8.1 (DTS). The measurement was performed with modulation per CFR47 15.247 2018 (a) (2) 2016 and RSS Gen Sect. 6.6 2014. This test was conducted on 3 channels. The worst sample result indicated below.

Test Setup:



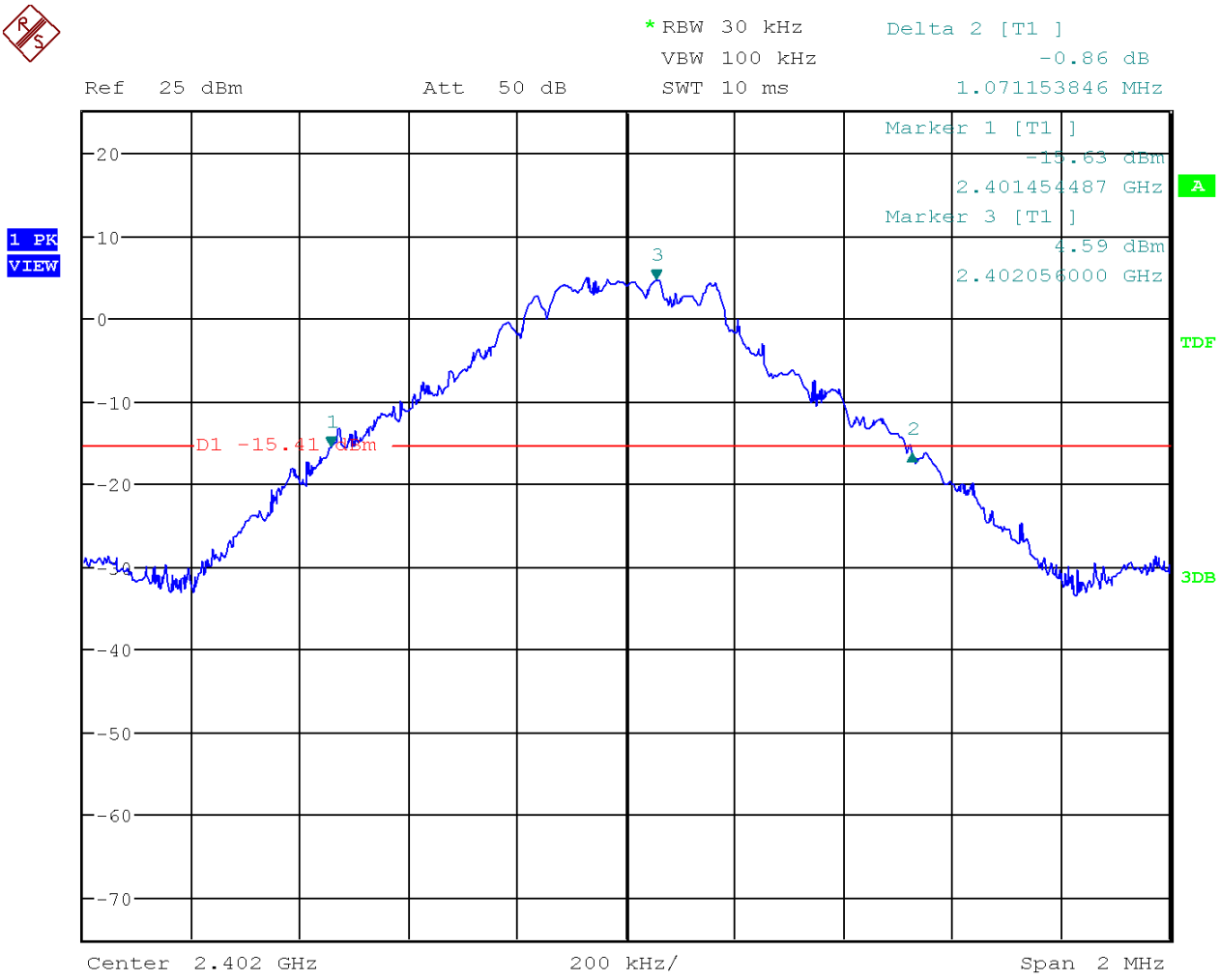
4.2.2 Results

Test Conditions: Conducted Measurement, Normal Temperature	**Date**: 05/22/2018
Antenna Type: Integrated Antenna	**Power Setting:** Maximum
Max. Antenna Gain: 1.6 dBi	**Signal State:** Modulated
Duty Cycle: 100%	**Data Rate:** BDR,EDR and BLE
Ambient Temp.: 23º C	**Relative Humidity:** 38 %RH

Results

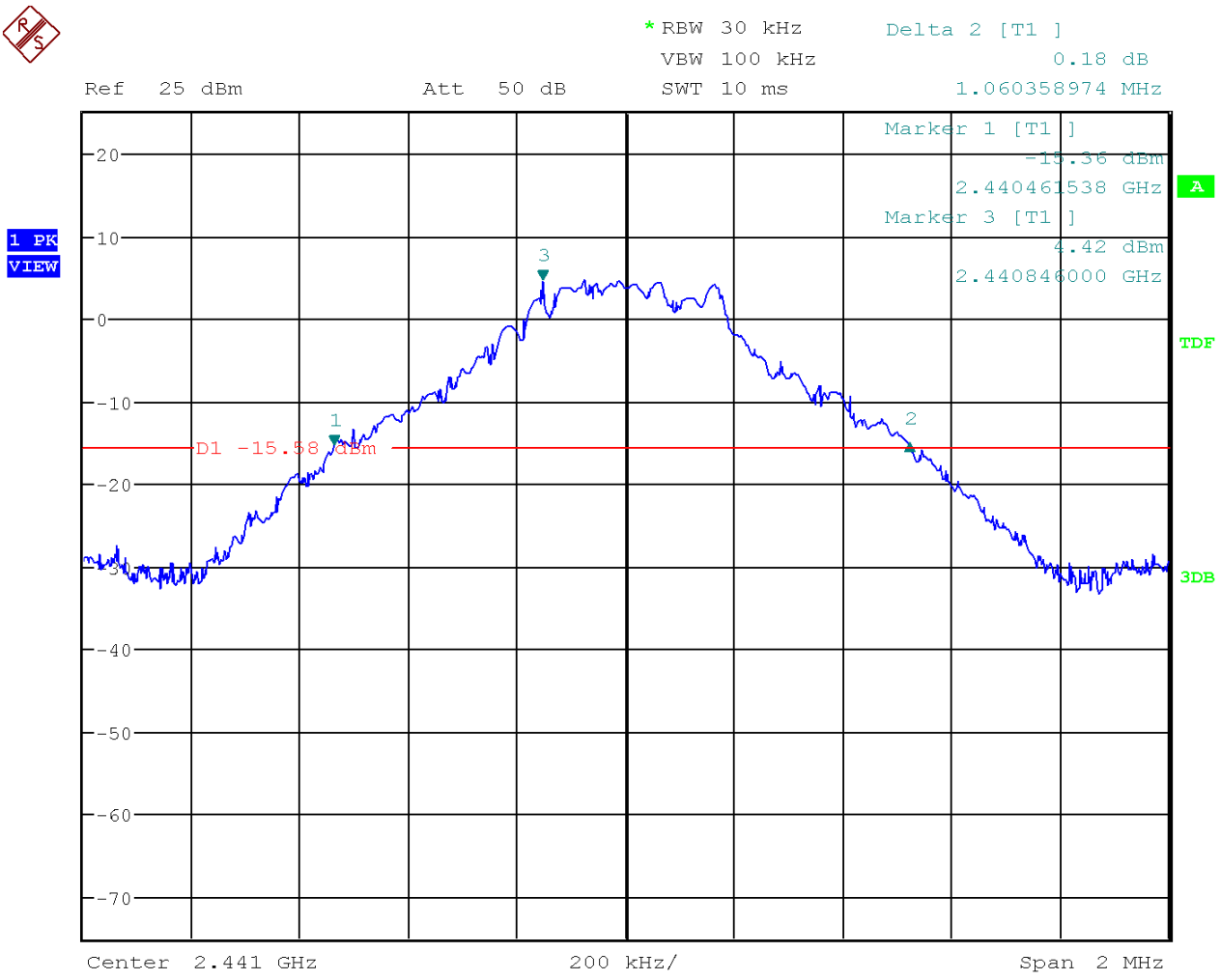
Mode	Operating Channel	Limit [dBm]	Bandwidth [MHz]	Comments
GFSK (BDR) / DH5	2402 MHz	none	1.07	20dB BW
	2441 MHz	none	1.06	20dB BW
	2480 MHz	none	1.07	20dB BW
π/4 DQPSK / DH5	2402 MHz	none	1.34	20dB BW
	2441 MHz	none	1.31	20dB BW
	2480 MHz	none	1.36	20dB BW
8DPSK / DH5	2402 MHz	none	1.35	20dB BW
	2441 MHz	none	1.31	20dB BW
	2480 MHz	none	1.35	20dB BW
BLE	2402 MHz	none	0.724	6dB BW
	2442 MHz	none	0.722	6dB BW
	2480 MHz	none	0.722	6dB BW

4.2.1.1.1 GFSK (BDR) Test Plots (20 dB Bandwidth)



Date: 30.JUN.2018 16:32:04

20db BW GFSK (BDR) mode 2402



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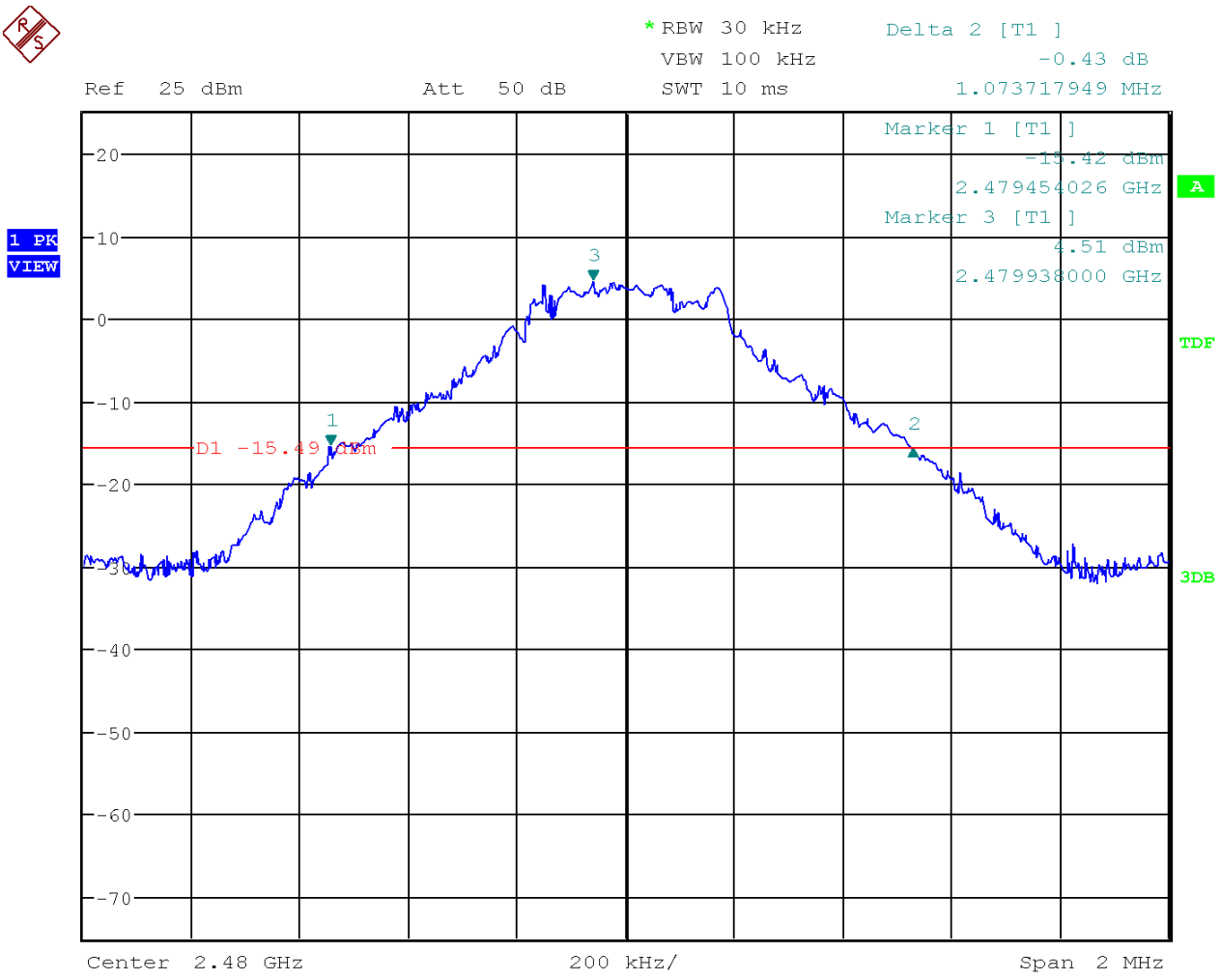
20db BW GFSK (BDR) mode 2441



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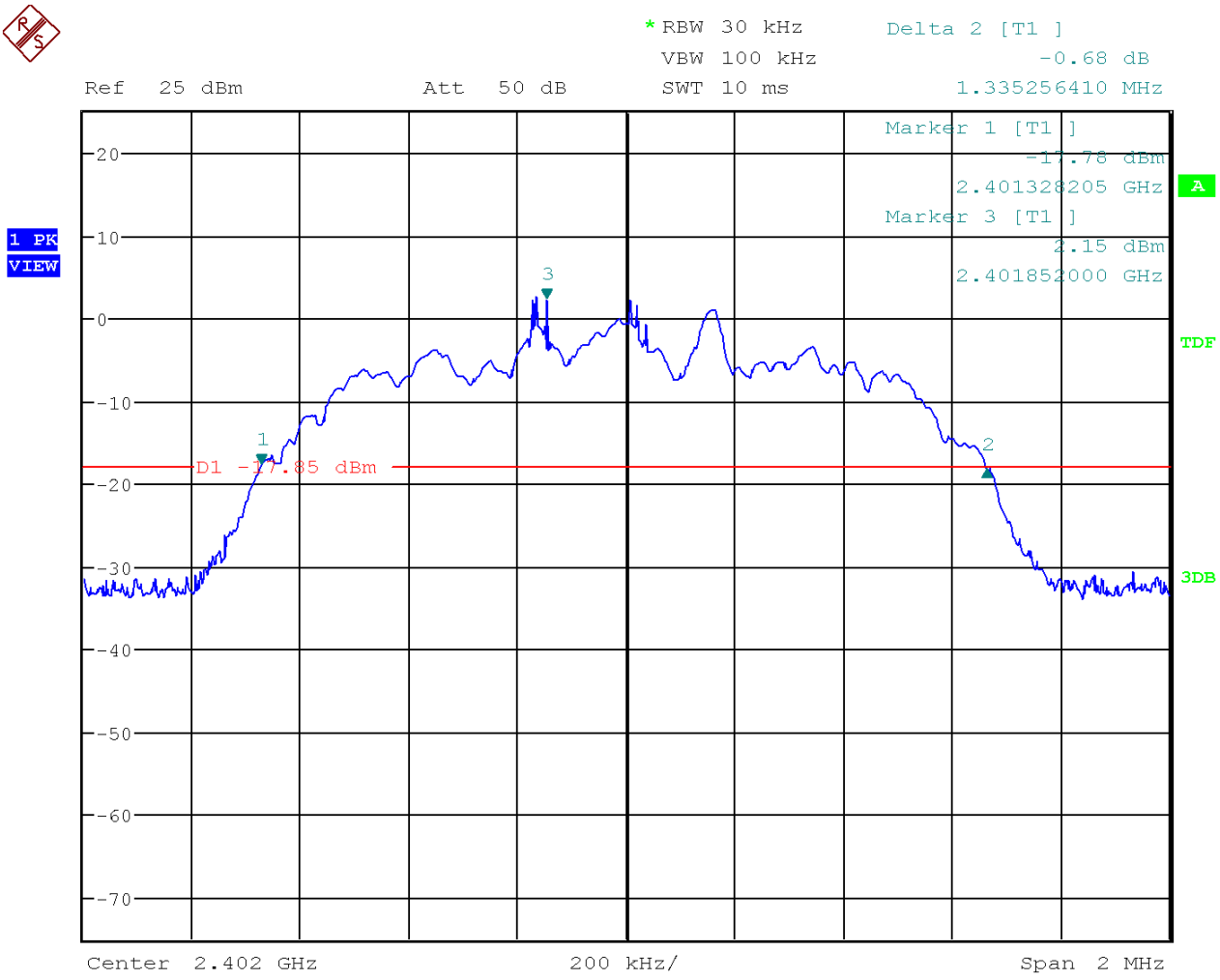
20db BW GFSK (BDR) mode 2480

4.2.1.1.2 π/4 DQPSK Test Plots (20 dB Bandwidth)



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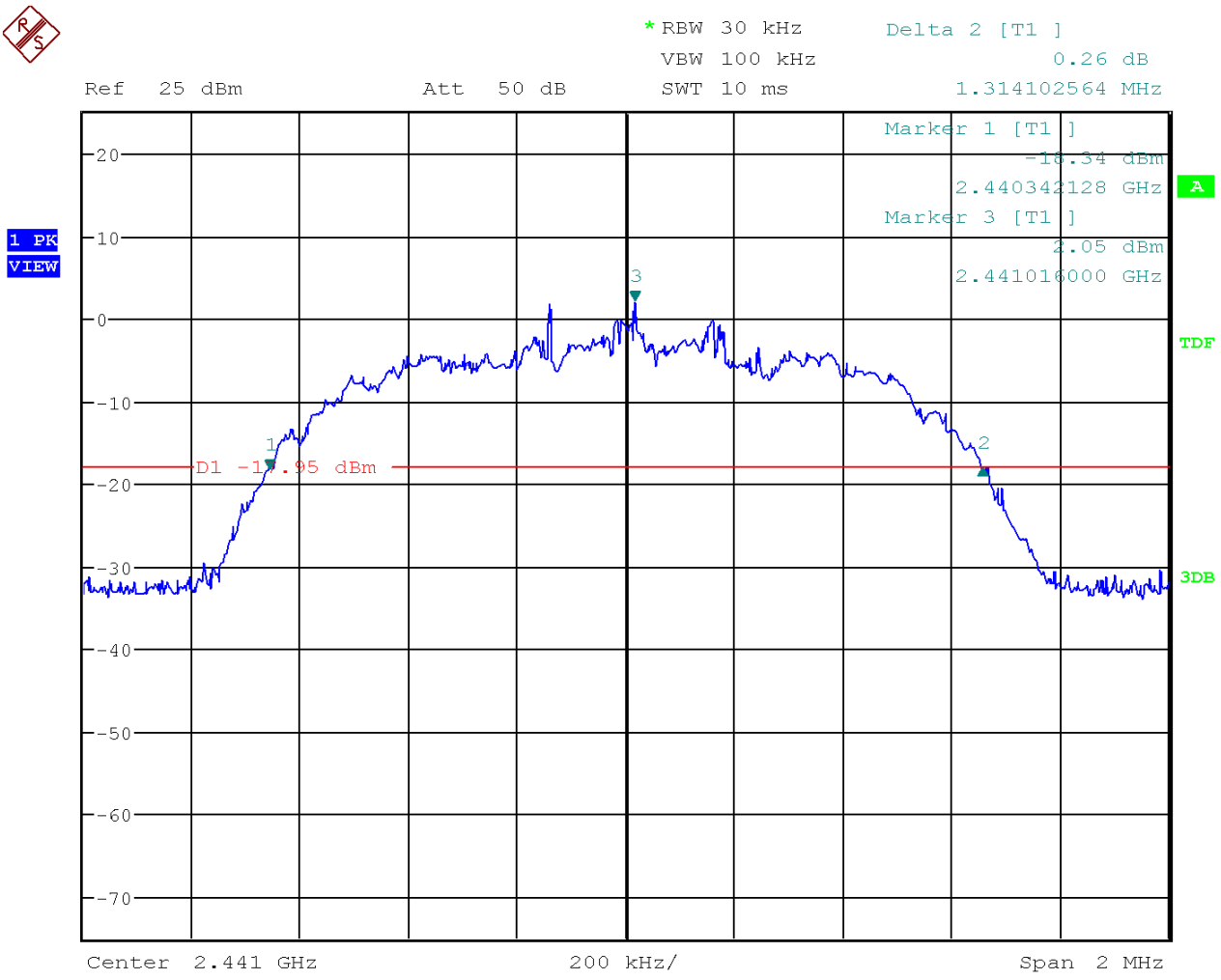
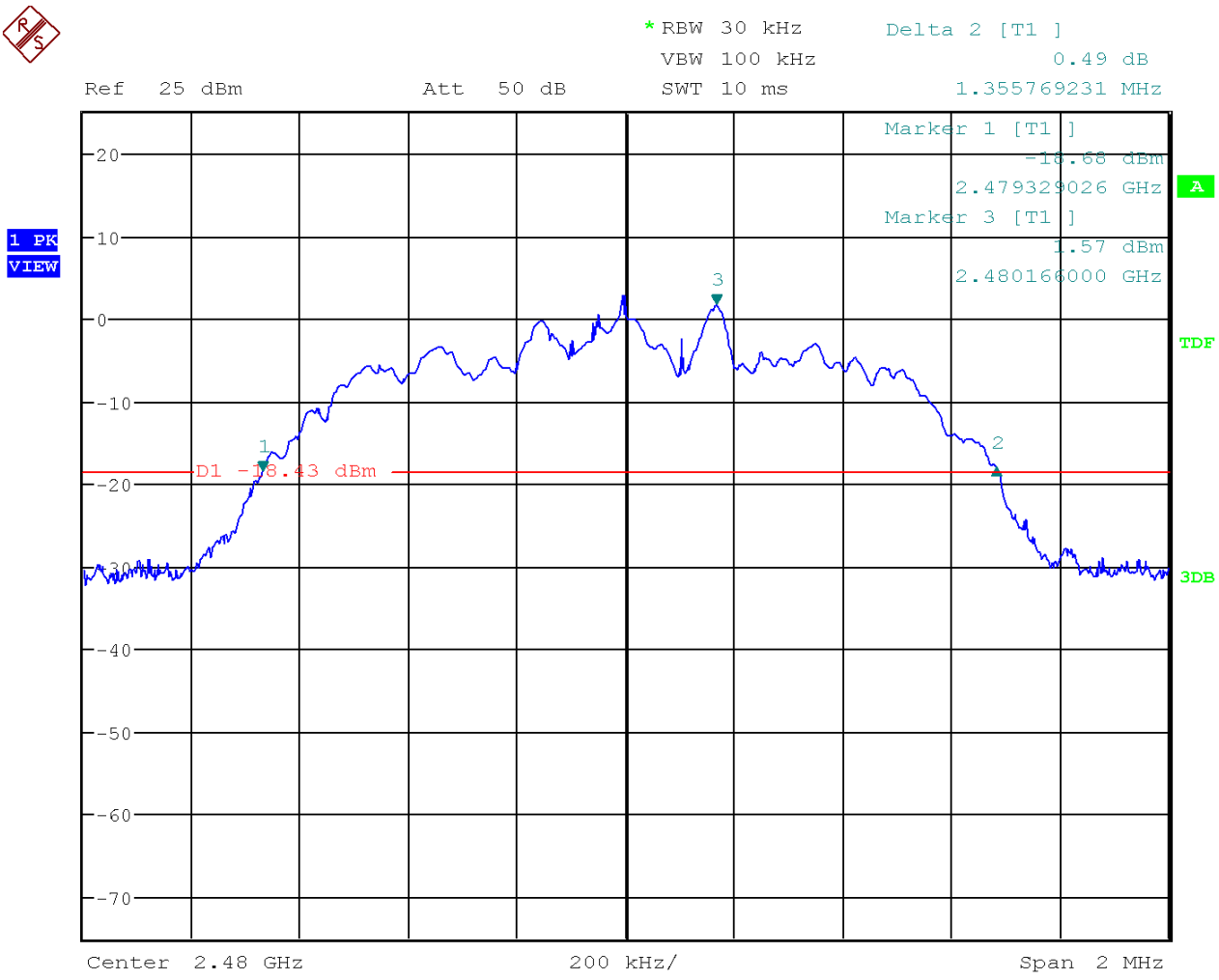
20db BW π/4 DQPSK mode 2402



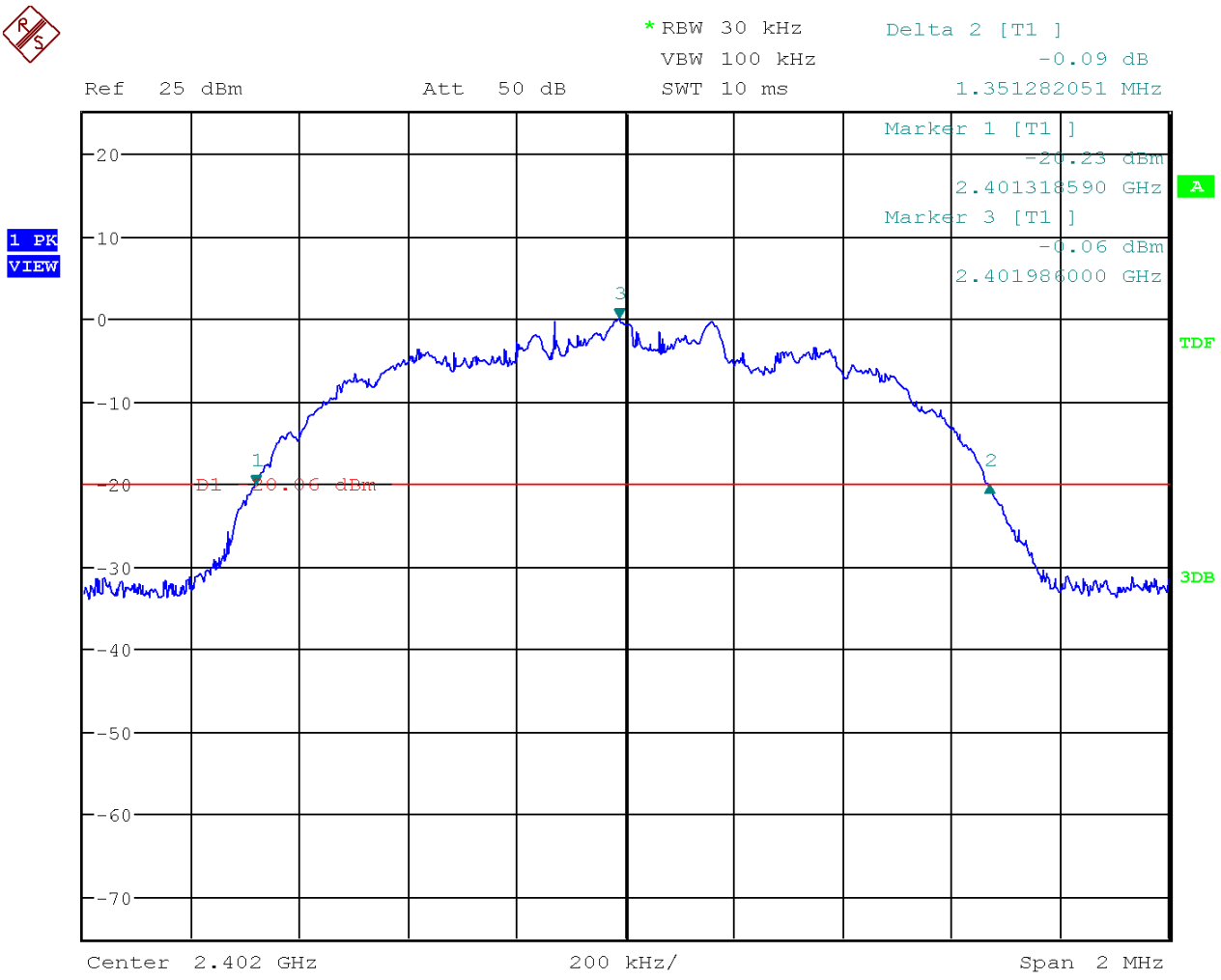
Date: 30.JUN.2018 16:58:06

20db BW π/4 DQPSK mode 2441



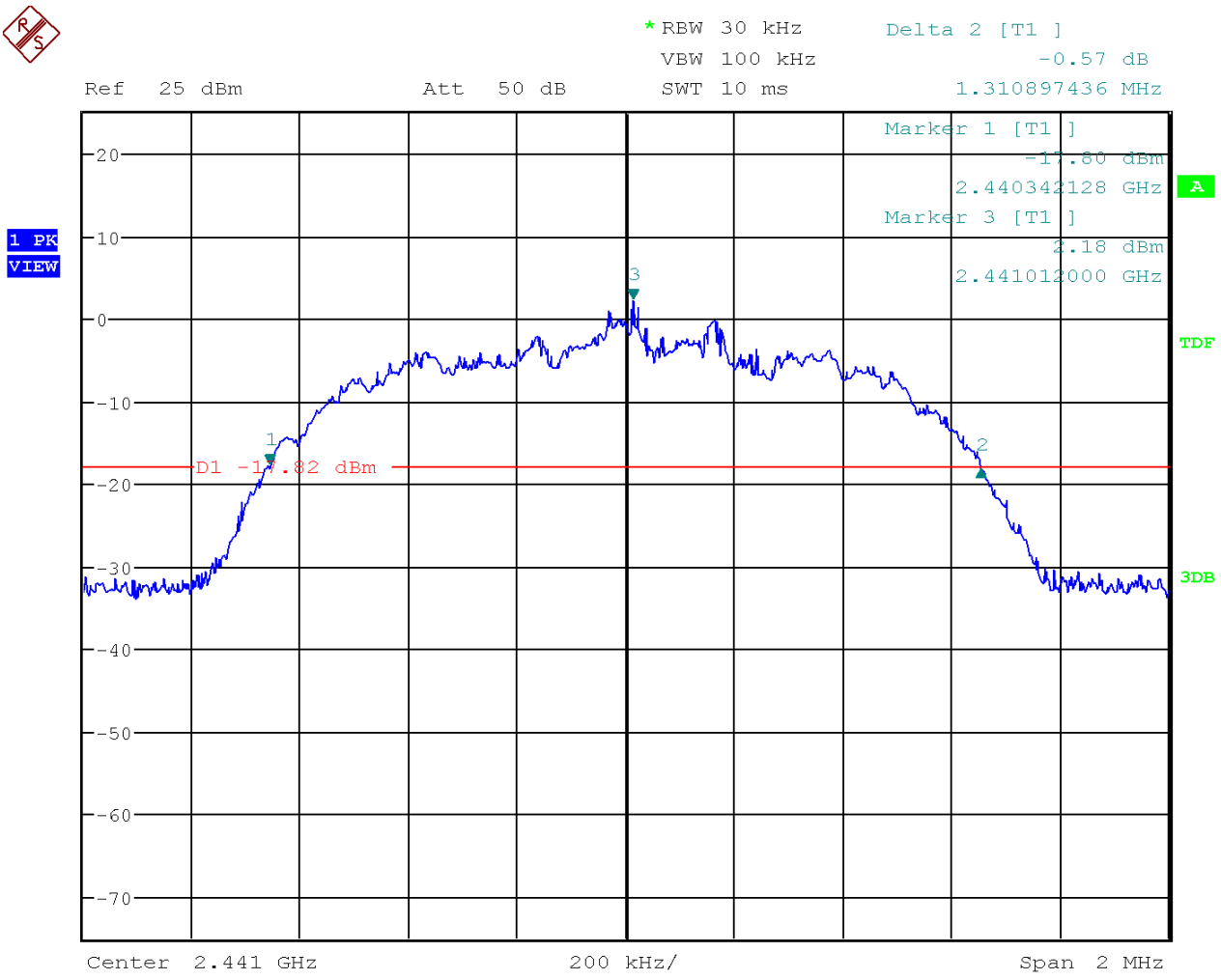
20db BW π/4 DQPSK mode 2480

4.2.1.1.3 8DPSK Test Plots (20 dB Bandwidth)



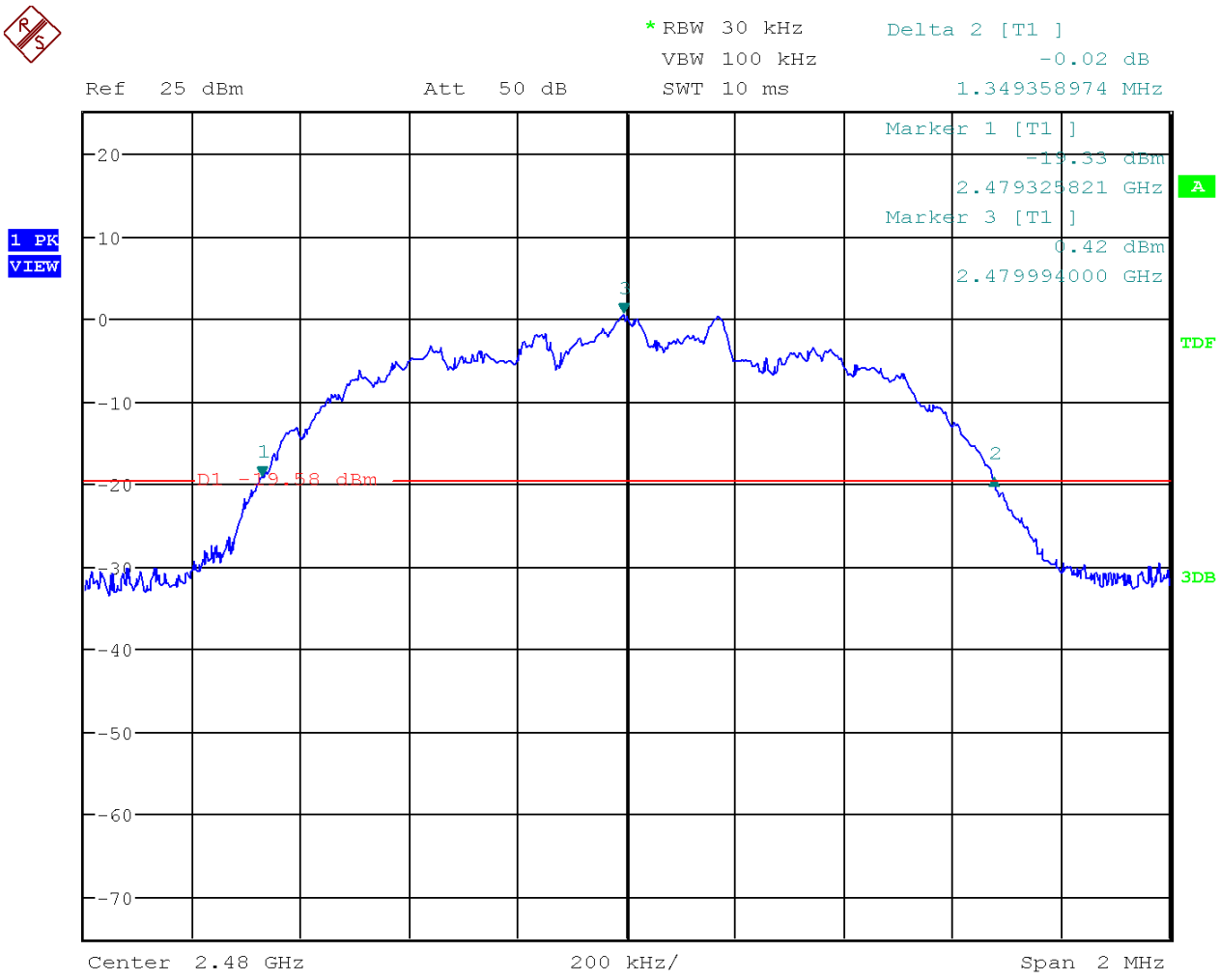
Date: 30.JUN.2018 17:02:48

20db BW π/4 DQPSK mode 2402



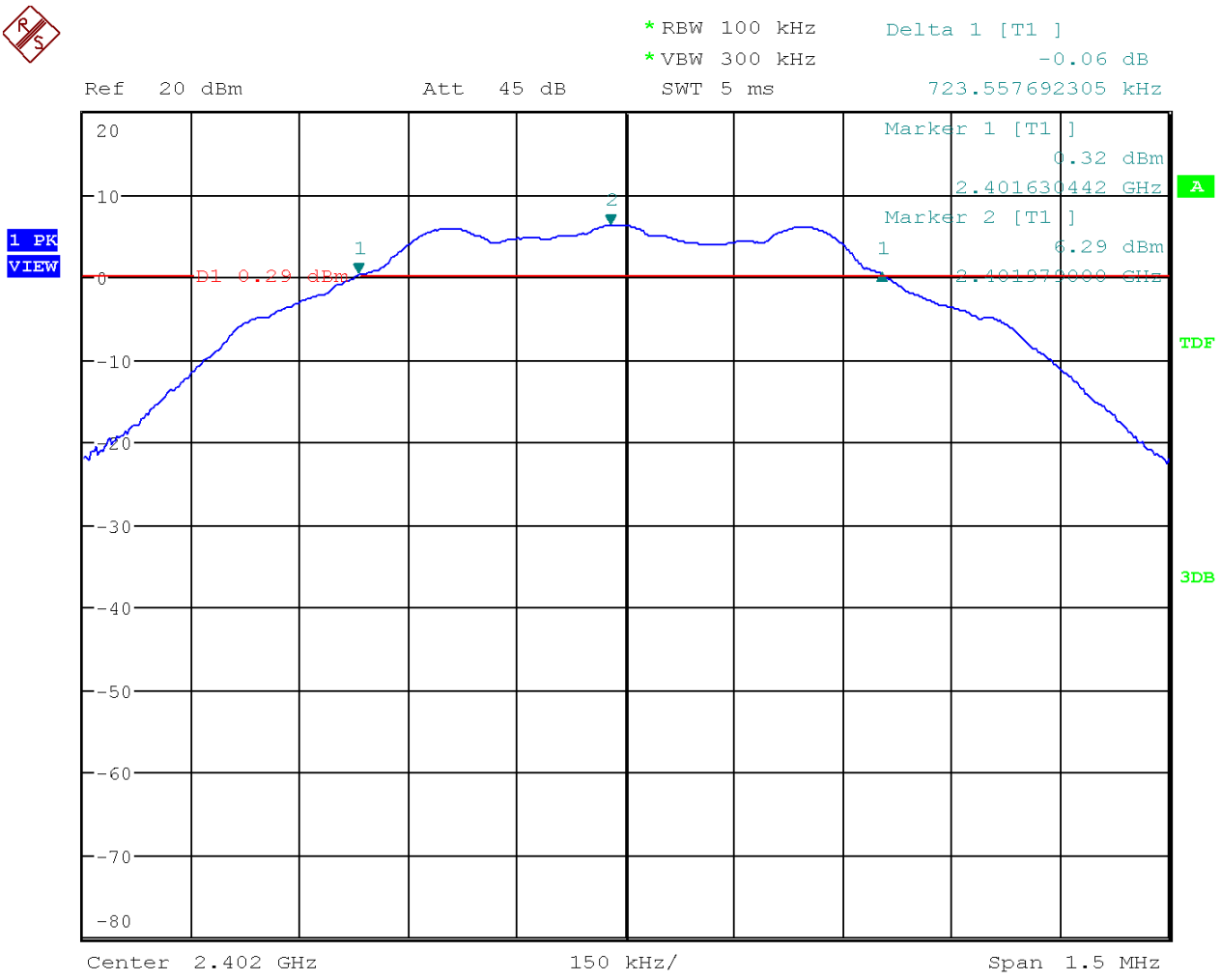
Date: 30.JUN.2018 16:55:25

20db BW π/4 DQPSK mode 2441



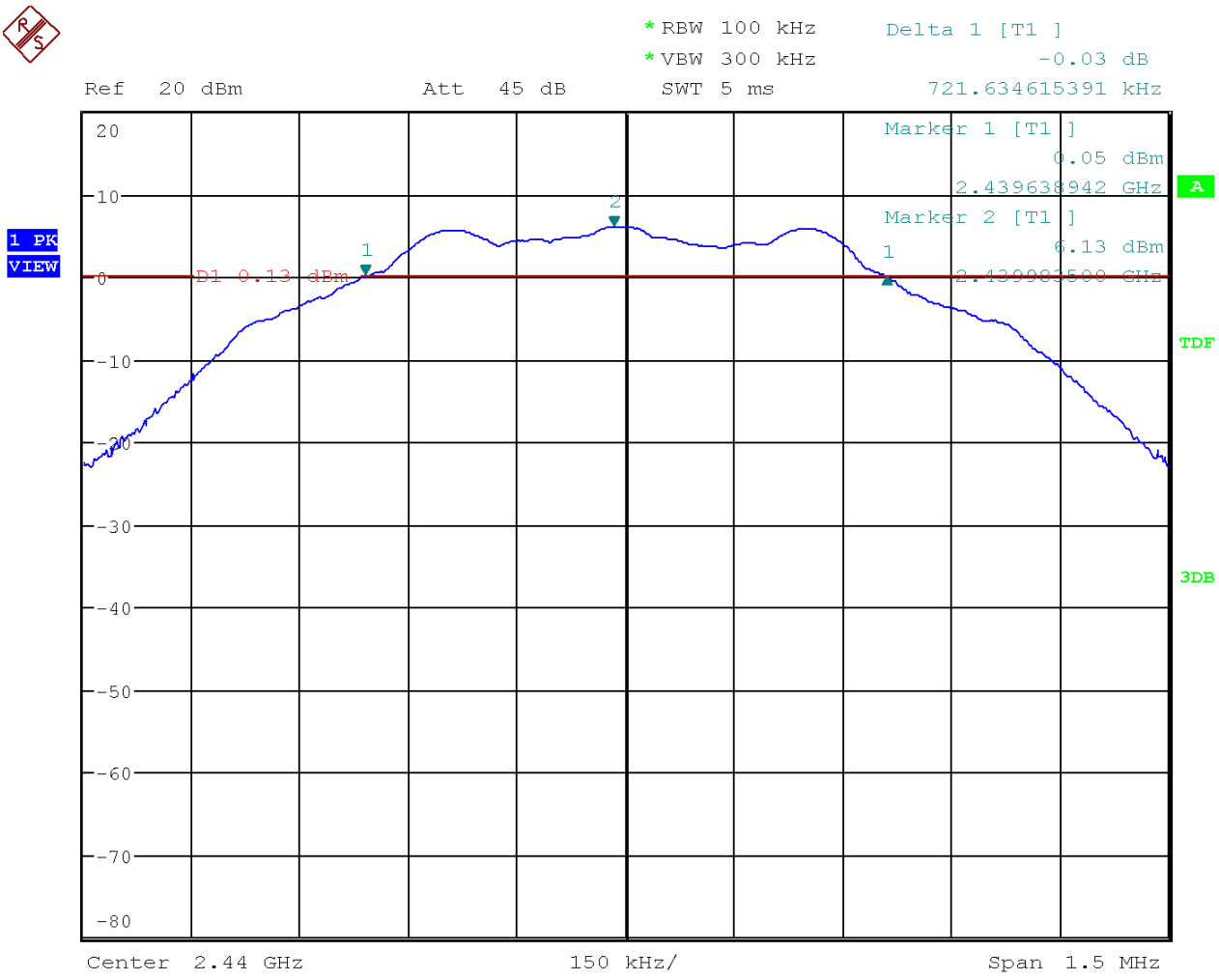
20db BW π/4 DQPSK mode 2480

4.2.1.1.4 BLE Test Plots (6 dB Bandwidths)



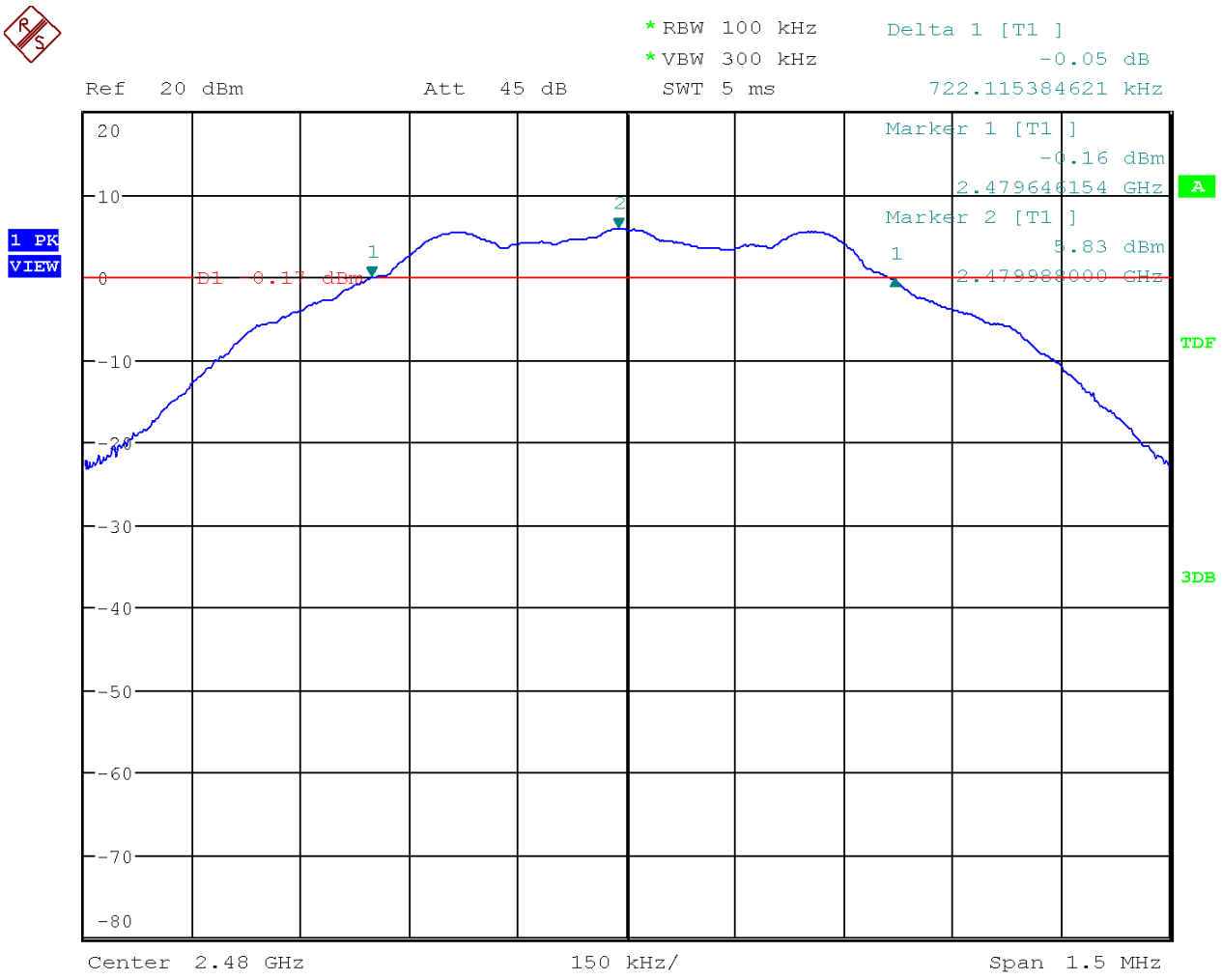
Date: 30.JUN.2018 18:32:20

6 dB BW BLE mode 2402



Date: 30.JUN.2018 18:35:35

6 dB BW BLE mode 2442



Date: 30.JUN.2018 18:37:54

6 dB BW BLE mode 2480

4.3 Peak Power Spectral Density

According to the CFR47 Part 15.247 2018 2018 (e) and RSS 247 Sect.5.2 (b), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

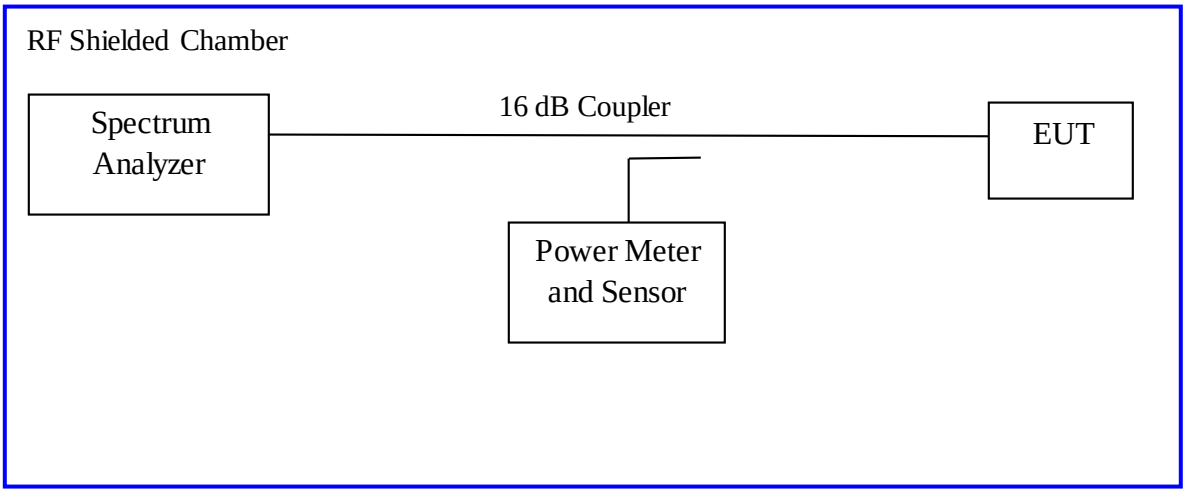
Power spectral density is only required for DTS devices.

4.3.1 Test Method

The conducted method was used to measure the channel power output per ANSI C63.10-2013 Section 11.10.2. The measurement was performed with modulation per CFR47 Part 15.247 2018 (e) and RSS 247 Sect.5.2 (b).

Only BLE is tested because it is a DTS system. BDR and EDR is not required.

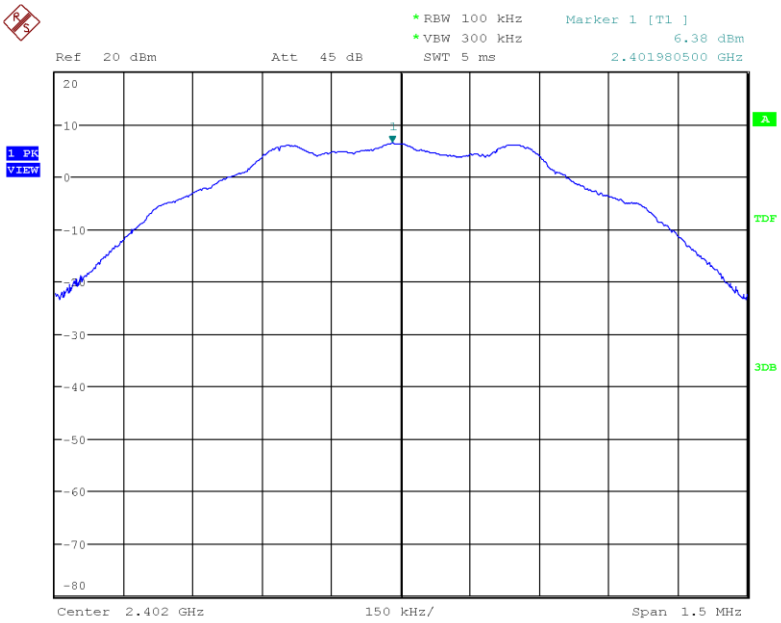
4.3.1 Test Setup:



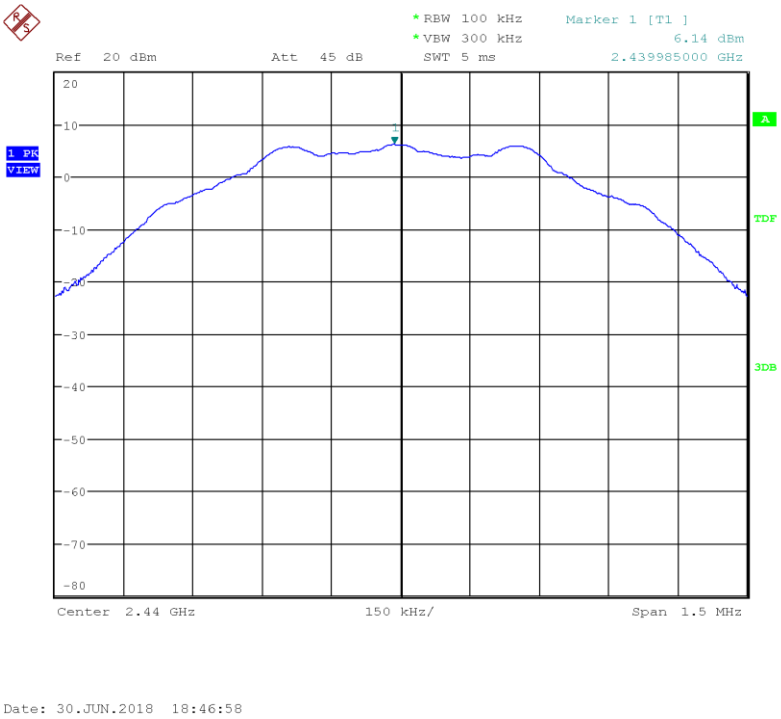
4.3.2 Results

Test Conditions: Conducted Measurement, Normal Temperature			**Date**: 04/25/2018	
Antenna Type: Integrated Antenna			**Power Setting:** Maximum	
Max. Antenna Gain: 1.6 dBi			**Signal State:** Modulated	
Duty Cycle: 100%			**Data Rate:** BLE	
Ambient Temp.: 23º C			**Relative Humidity:** 38 %RH	
Results				
Mode	**Operating Channel**	**Limit [dBm/3kHz]**	**PPSD [dBm/100kHz]**	**Comments**
BLE	2402 MHz	8	6.38	--
	2442 MHz	8	6.14	--
	2480 MHz	8	5.69	--

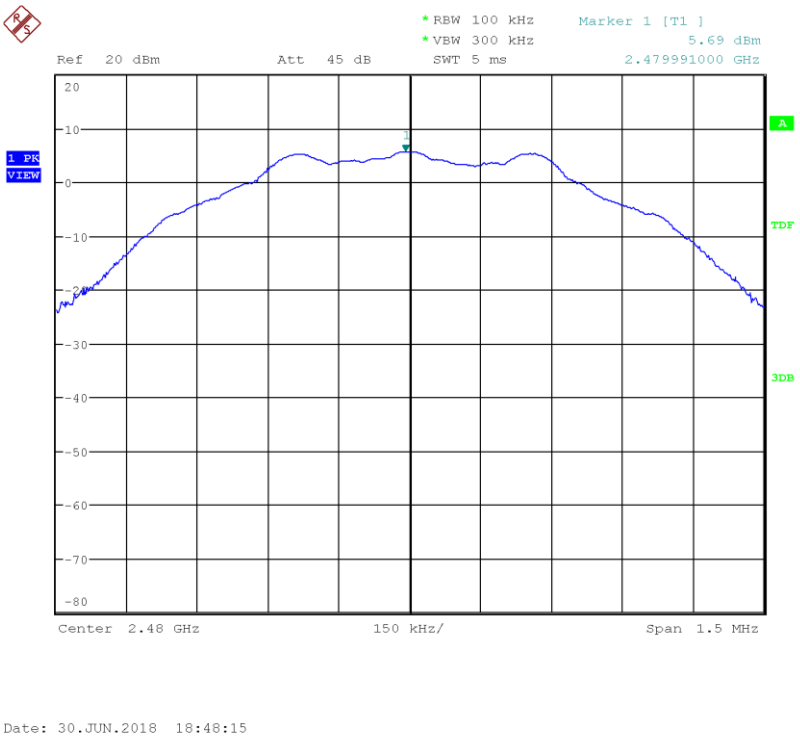
4.3.2.1.1 BLE Test Plots (Power Spectral Density)



Power Spectral Density BLE mode 2402



Power Spectral Density BLE mode 2442



Power Spectral Density BLE mode 2480

4.4 Out of Band Emission requirements

The setup was identical to RF output power measurement. Intentional radiators operating under the alternative provisions to the general emission limits, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If the frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Any frequency outside the band of 2400 MHz to 2483.5 MHz, the power output level must be below 20 dB from the in-band transmitting signal; CFR 47 Part 15.215, 15.247 2018 2018(d) and RSS 247 Sect.5.5.

Only BDR and BLE is reported because these modes represent the worst case operation modes.

4.4.1 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.4.2 Out of band emissions

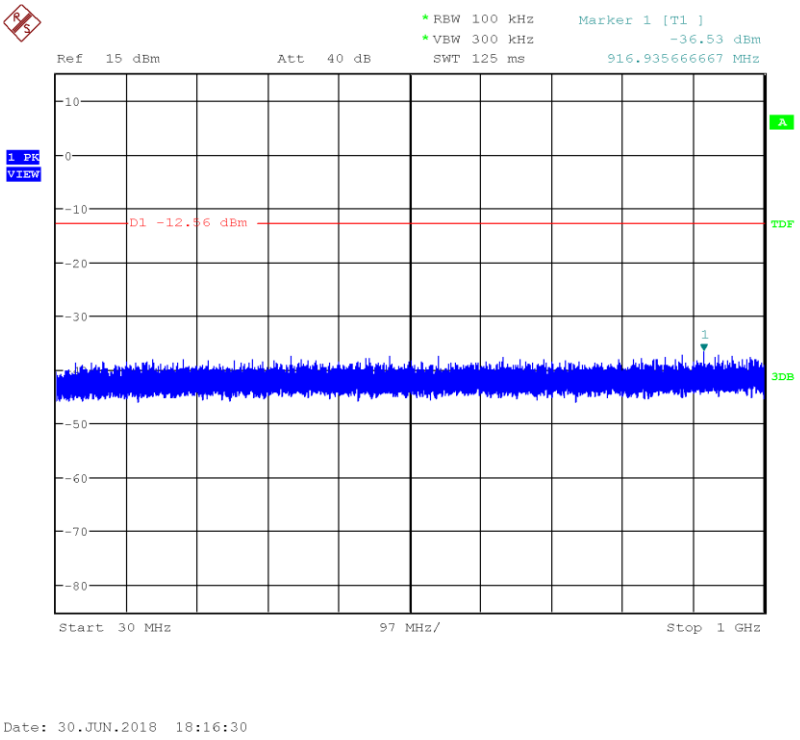
Test Conditions: Conducted Measurement, Normal Temperature	**Date**: 04/27/2018
Antenna Type: Integrated Antenna	**Power Setting:** Maximum
Max. Antenna Gain: 1.6 dBi	**Signal State:** Modulated
Duty Cycle: 100%	**Data Rate:** BDR,EDR and BLE
Ambient Temp.: 23º C	**Relative Humidity:** 38 %RH

Results

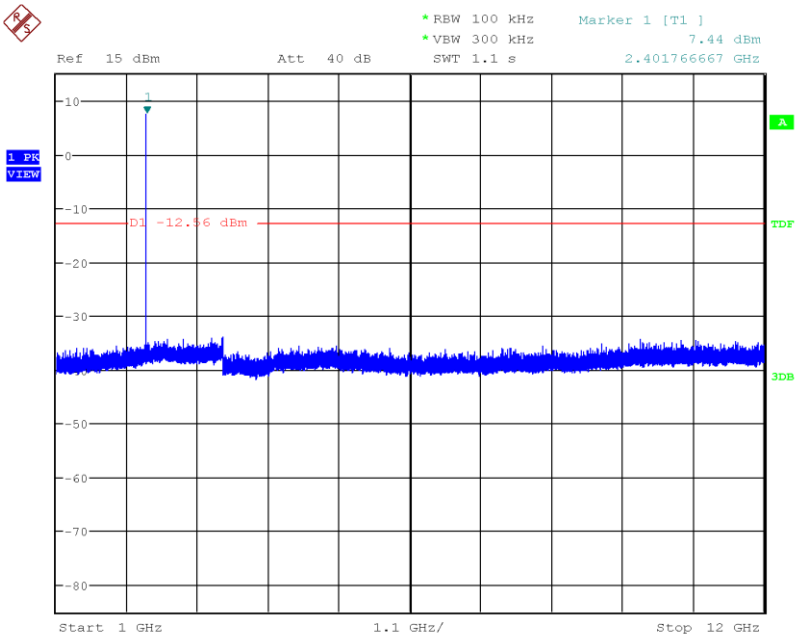
Mode	Operating Channel	Limit [dBm]	Max Emission [dBm]	Comments
GFSK (BDR) / DH5	2402 MHz	-12.56	See plot marker tables	
	2441 MHz	-12.77	See plot marker tables	
	2480 MHz	-13.36	See plot marker tables	
	Hopping	-12.84	See plot marker tables	
BLE	2402 MHz	-13.62	See plot marker tables	
	2442 MHz	-13.86	See plot marker tables	
	2480 MHz	-14.31	See plot marker tables	

4.4.3 Non-Restricted Band Emissions

4.4.3.1 GFSK (BDR)

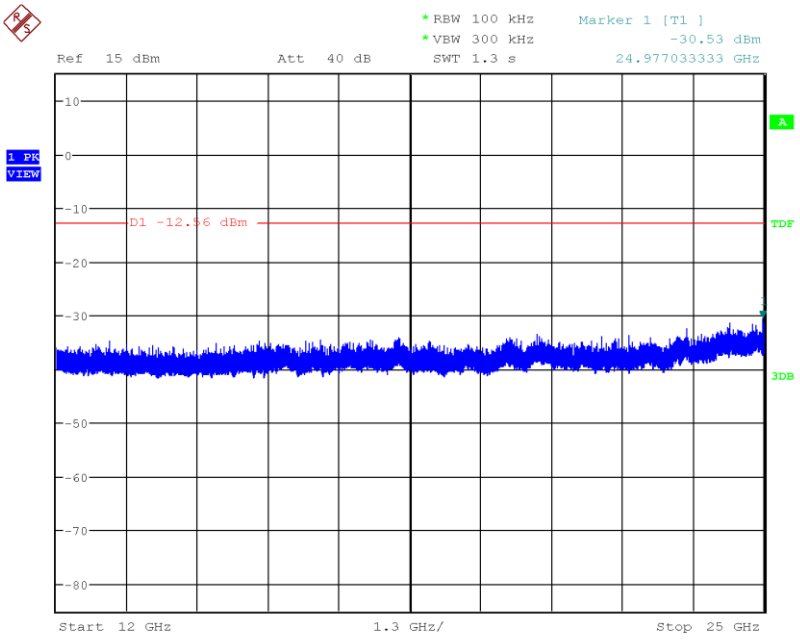


Non-Restricted Band Emissions 30MHz – 1 GHz GFSK mode 2402



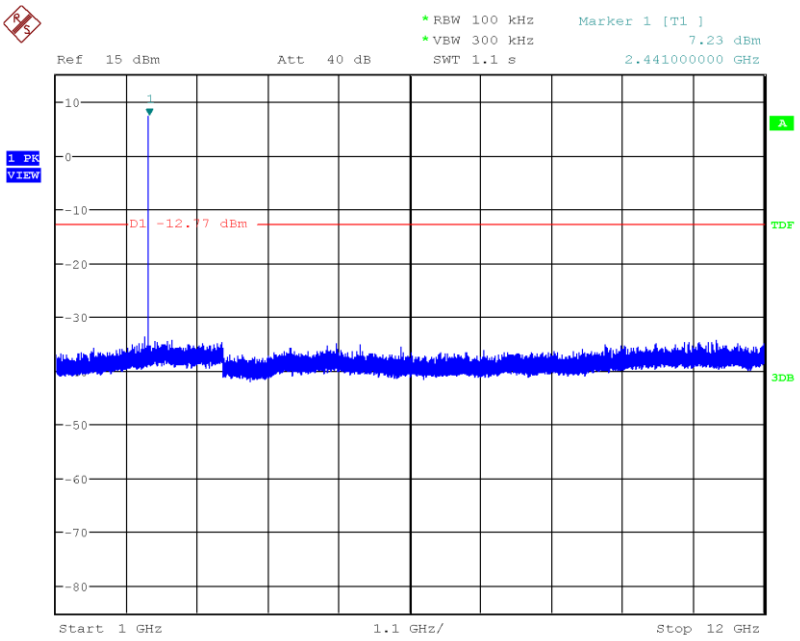
Date: 30.JUN.2018 18:14:38

Non-Restricted Band Emissions 1 GHz – 12 GHz GFSK mode 2402

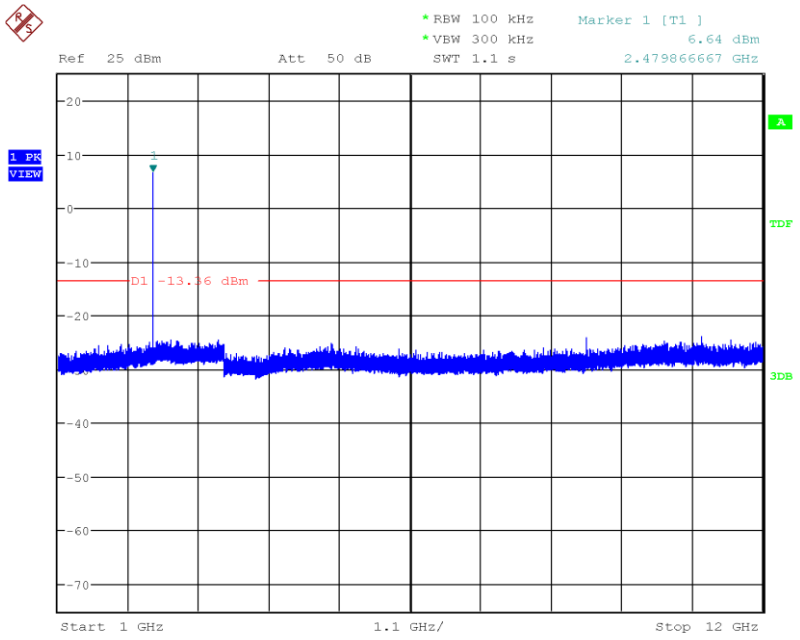


Date: 30.JUN.2018 18:15:26

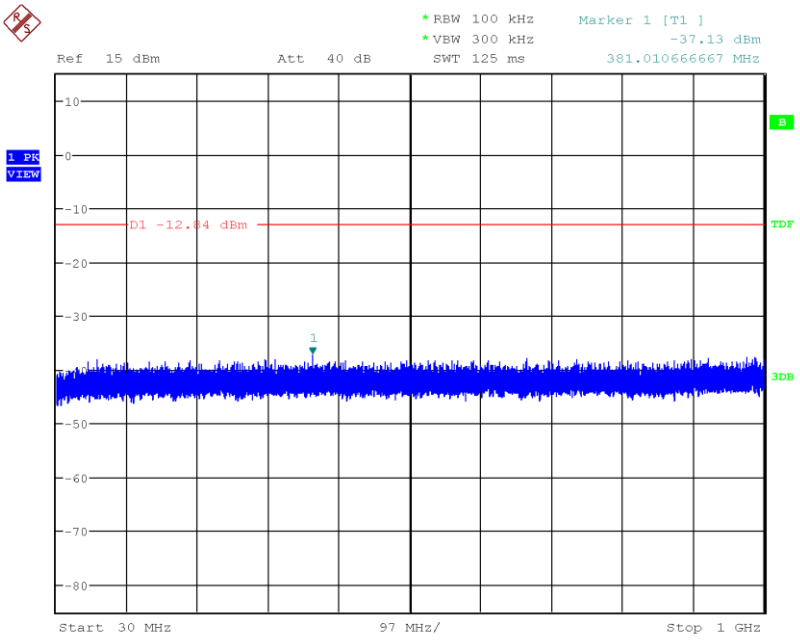
Non-Restricted Band Emissions 12 GHz – 25 GHz GFSK mode 2402



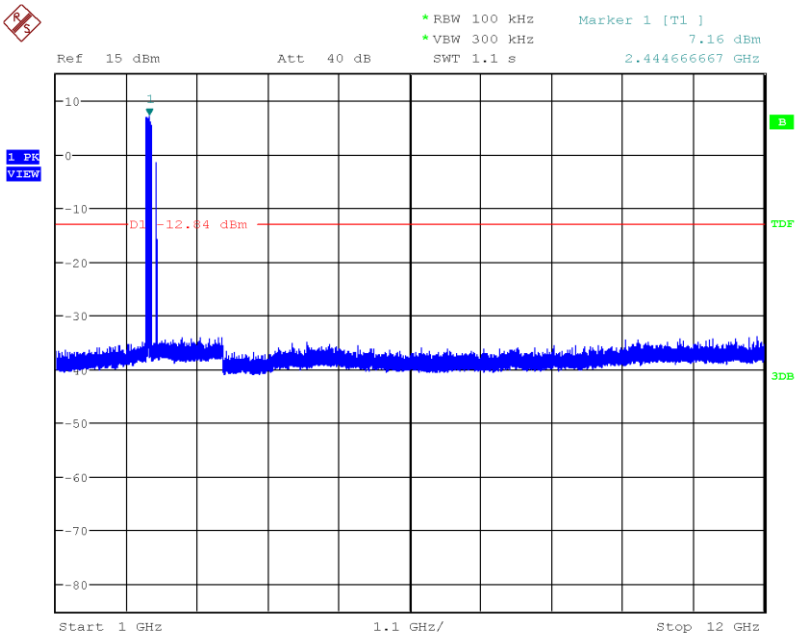
Non-Restricted Band Emissions 1 GHz – 12 GHz GFSK mode 2441



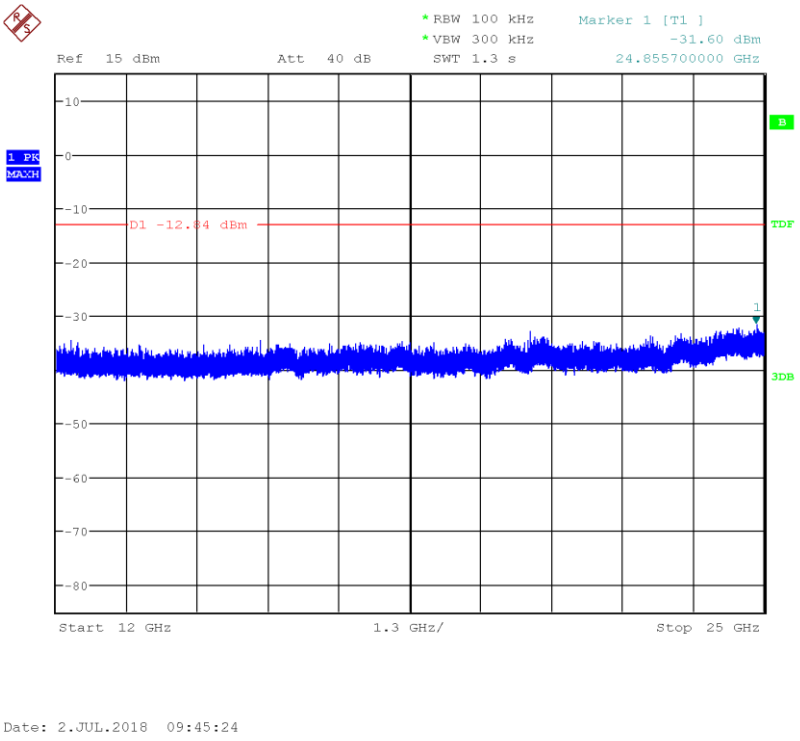
Non-Restricted Band Emissions 1 GHz – 12 GHz GFSK mode 2480



Non-Restricted Band Emissions 30 MHz – 1 GHz GFSK mode Hopping

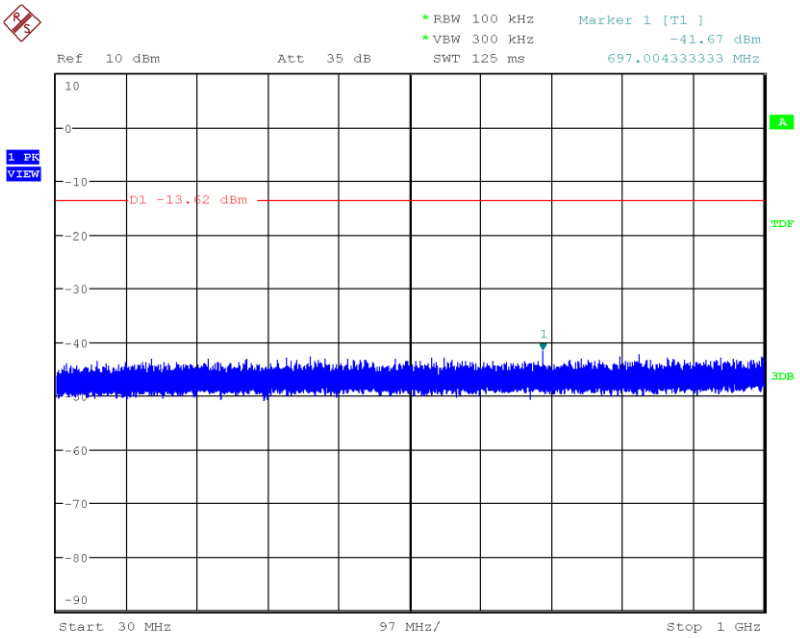


Non-Restricted Band Emissions 1 GHz – 12 GHz GFSK mode Hopping

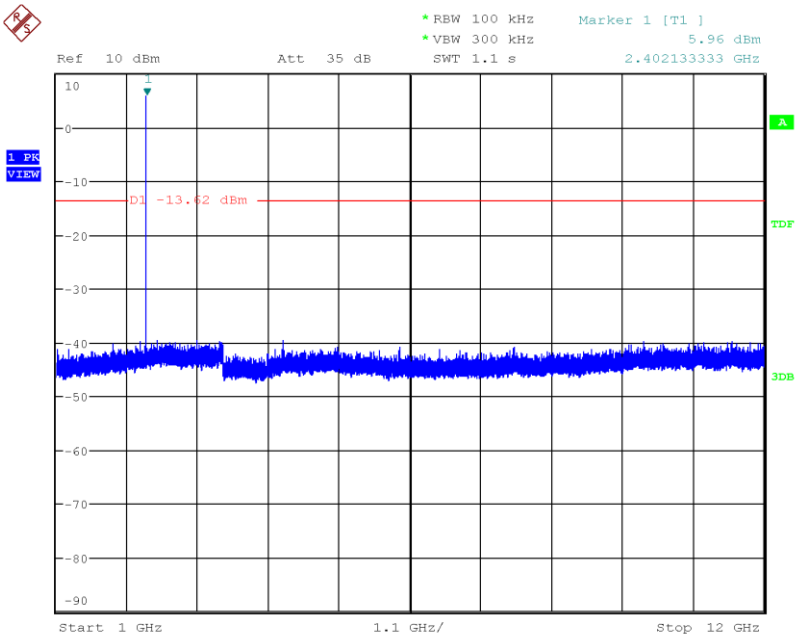


Non-Restricted Band Emissions 12 GHz – 25 GHz GFSK mode Hopping

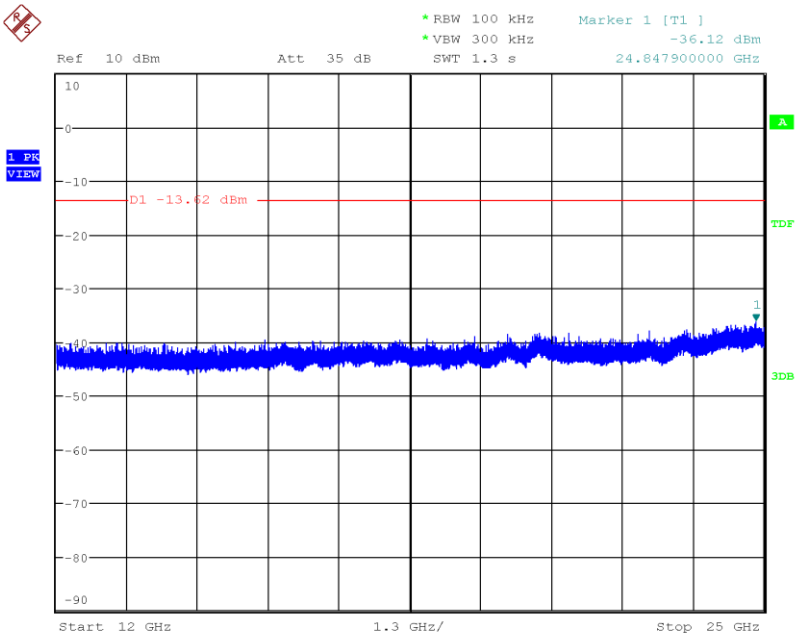
4.4.3.2 BLE



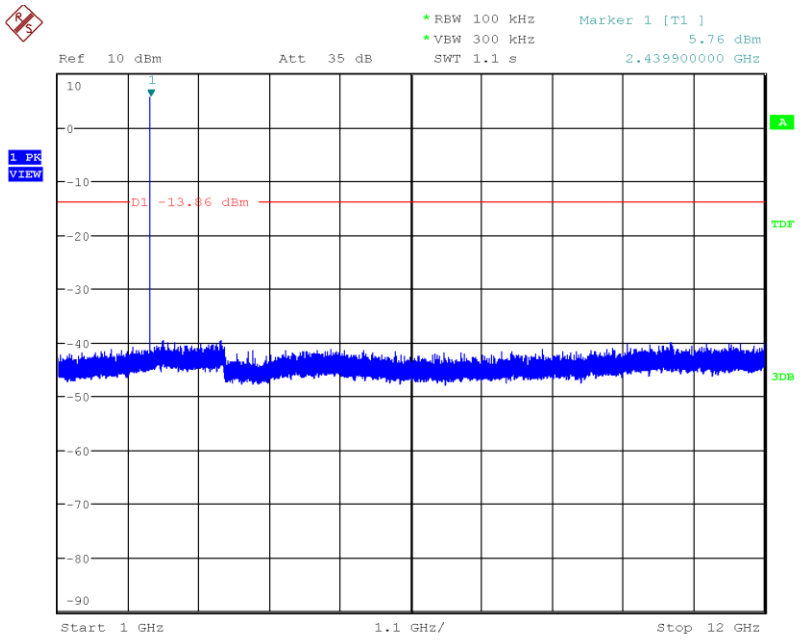
Non-Restricted Band Emissions 30MHz – 1 GHz BLE mode 2402



Non-Restricted Band Emissions 1 GHz – 12 GHz BLE mode 2402

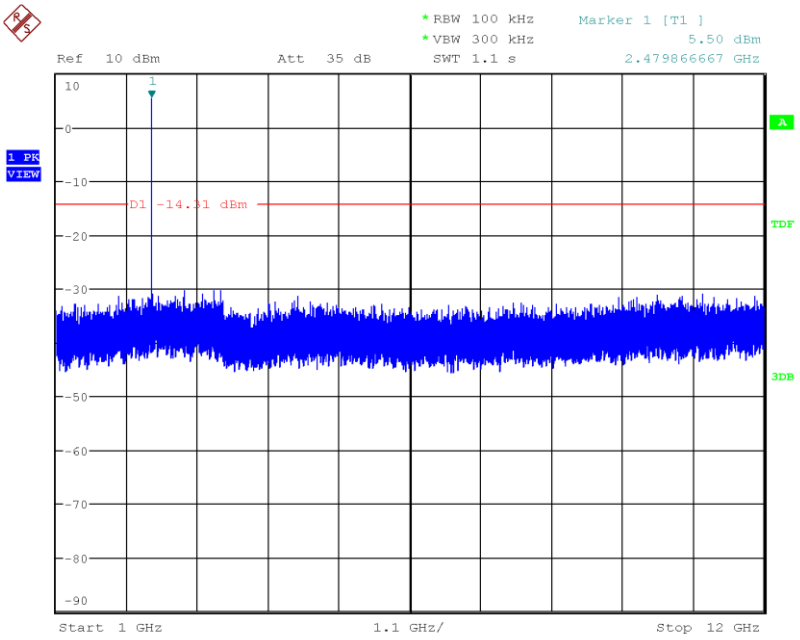


Non-Restricted Band Emissions 12 GHz – 25 GHz BLE mode 2402



Date: 30.JUN.2018 18:57:47

Non-Restricted Band Emissions 1 GHz – 12 GHz BLE mode 2440



Date: 30.JUN.2018 18:52:25

Non-Restricted Band Emissions 1 GHz – 12 GHz BLE mode 2480

4.4.3.3 AC Conducted Emissions

Testing was performed in accordance with ANSI C63.10: 2013. These test methods are listed under the laboratory's A2LA Scope of Accreditation.
This test measures the levels emanating from the EUT's AC input port, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.
The AC conducted emissions of equipment under test shall not exceed the values in CFR47 Part 15.207 and RSS-GEN. Sect. 8.8.

4.4.4 Test Methodology

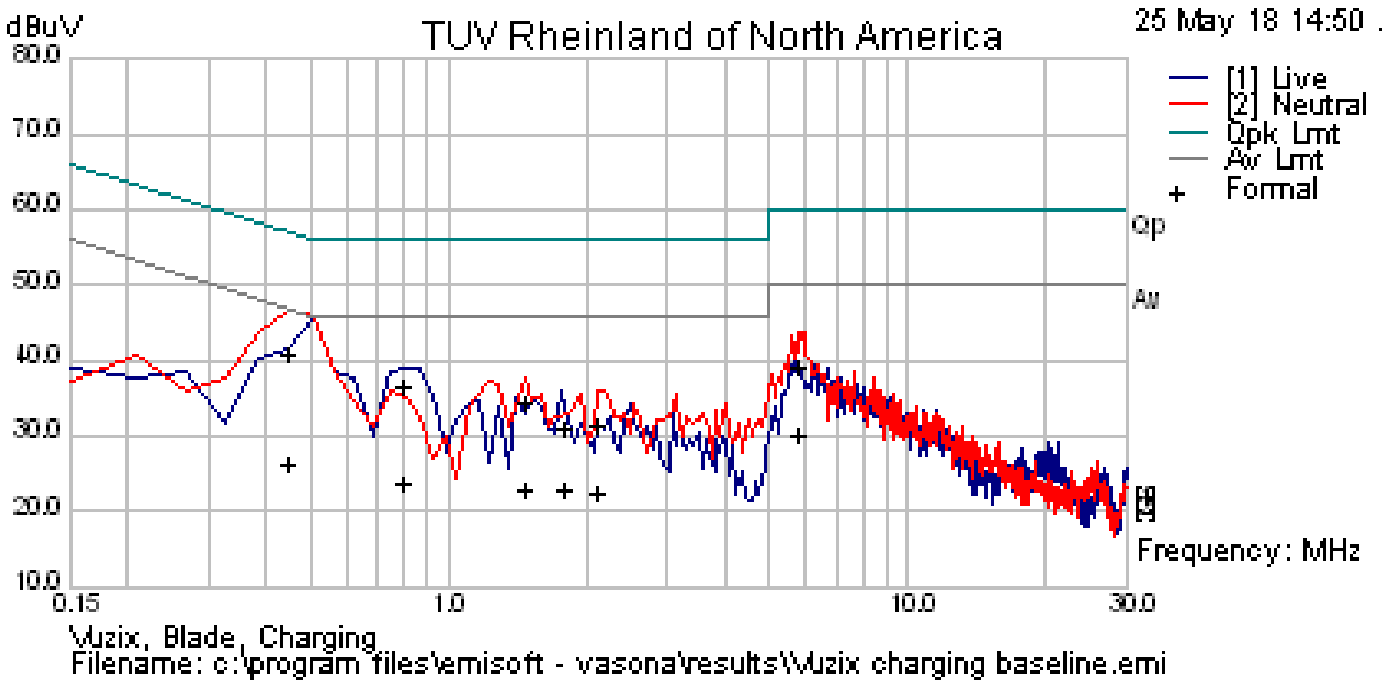
A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. Each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50µH / 50Ω LISNs.
Testing is performed in Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel, and it is bonded to the horizontal ground plane. In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs.
Preliminary test performed on all modes to show the highest emission. The worst case observed at DH1.

4.4.4.1 Deviations

The unit in charging mode was unable to be placed

4.4.5 Test Results

Vasona Data : Formally Assessed Peaks										
No	Frequency	Raw dBu\	Cable Los	Factors d	Level dBu	Measurem	Line	Limit dBu\	Margin dE	Pass /Fail
1 (1)	0.447259	31.1	9.84	0.03	40.97	Quasi Pea	Neutral	56.93	-15.95	Pass
2 (3)	0.79622	26.56	9.87	0.03	36.46	Quasi Pea	Live	56	-19.54	Pass
3 (2)	5.78412	20.05	9.93	0.03	30.01	Average	Neutral	50	-19.99	Pass
4 (1)	0.447259	16.54	9.84	0.03	26.41	Average	Neutral	46.93	-20.52	Pass
5 (2)	5.78412	29.33	9.93	0.03	39.29	Quasi Pea	Neutral	60	-20.71	Pass
6 (4)	1.470253	24.4	9.88	0.03	34.3	Quasi Pea	Neutral	56	-21.7	Pass
7 (3)	0.79622	13.99	9.87	0.03	23.89	Average	Live	46	-22.11	Pass
8 (4)	1.470253	13.02	9.88	0.03	22.92	Average	Neutral	46	-23.08	Pass
9 (5)	1.768846	12.81	9.88	0.03	22.72	Average	Live	46	-23.28	Pass
10 (6)	2.117663	12.48	9.88	0.03	22.4	Average	Neutral	46	-23.6	Pass
11 (6)	2.117663	21.69	9.88	0.03	31.61	Quasi Pea	Neutral	56	-24.39	Pass
12 (5)	1.768846	20.95	9.88	0.03	30.86	Quasi Pea	Live	56	-25.14	Pass



AC conducted emissions

4.5 Hopping Channels/Carrier Separation/Dwell Time

As per FCC 15.247 and RSS-247 requires a system which operates in the 2.4-2483.5 GHz band may have a 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 operating power is no greater than 125 mW.

Frequency hopping systems in the 2.4-2483.5 GHz band shall us at least 15 hopping channels.

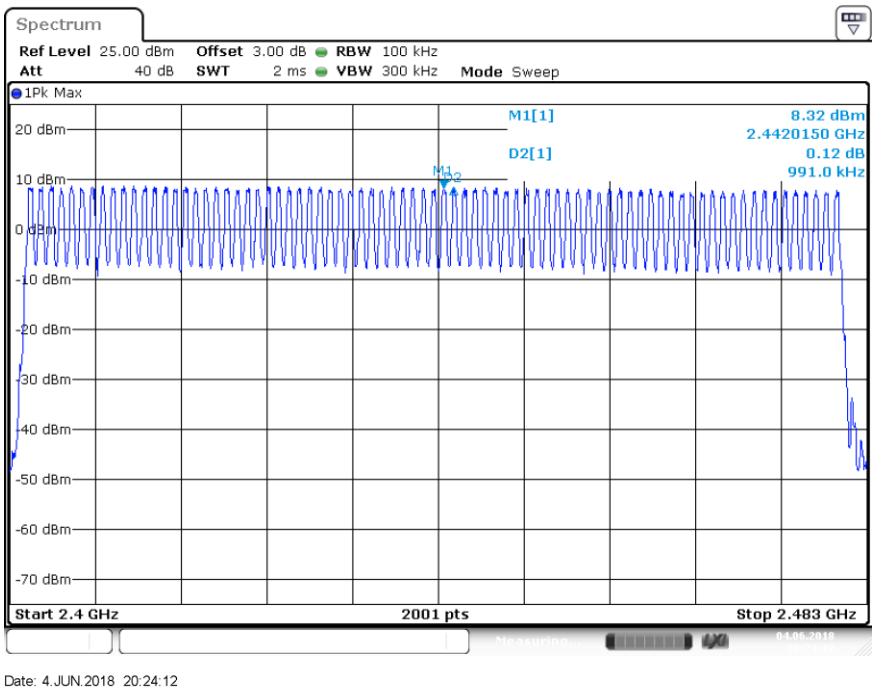
The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels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

4.5.1 Testing methodology

The EUT was connected to spectrum analyzer and was set to hopping mode. Section 7.8 Evaluation of frequency-hopping device parameters was used to test the device.

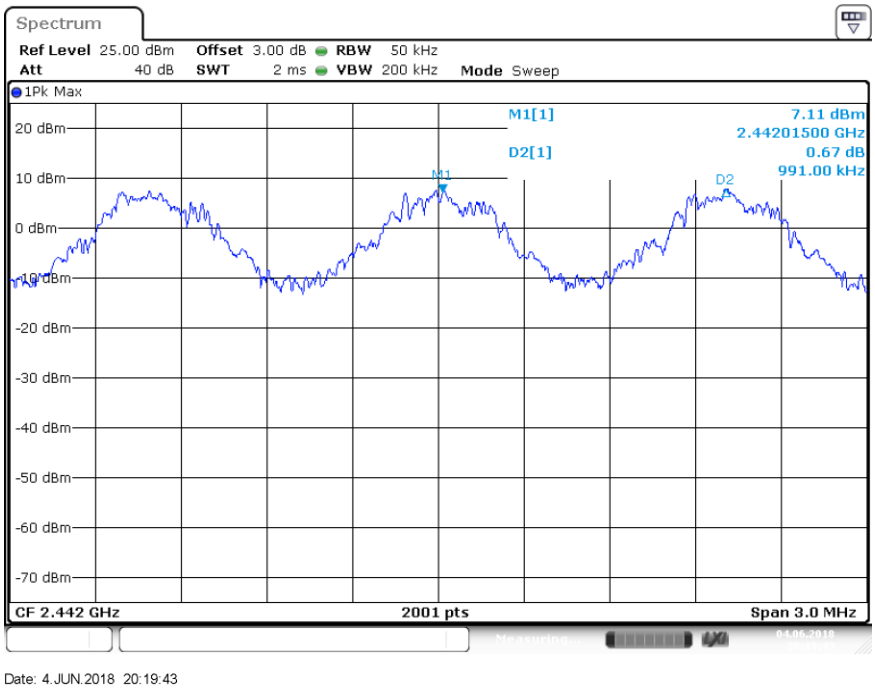
4.5.2 Test Results

4.5.2.1 Number of hopping frequencies



79 Hopping channels

4.5.2.2 Carrier Separation

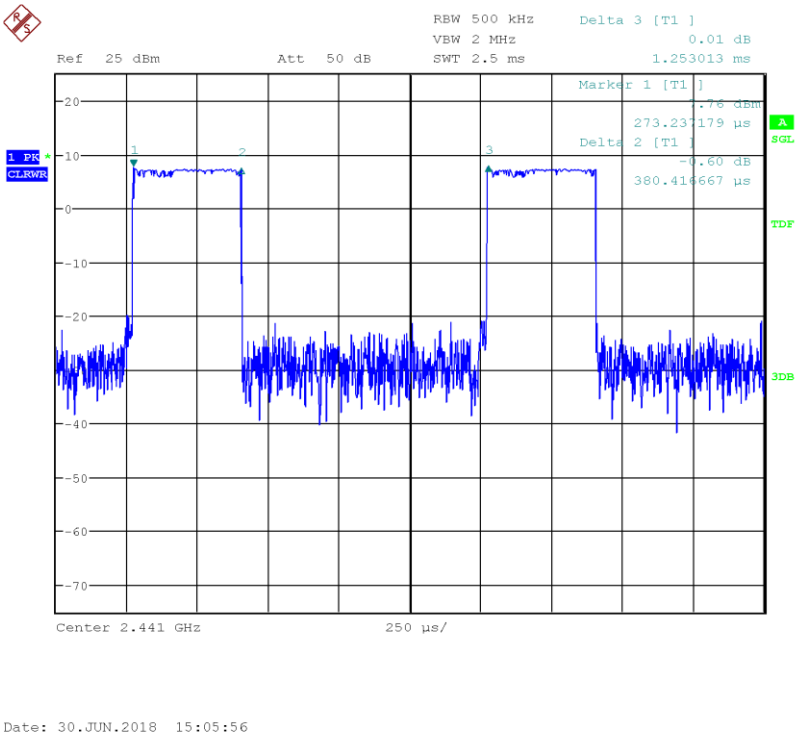


Carrier Separation 991kHz

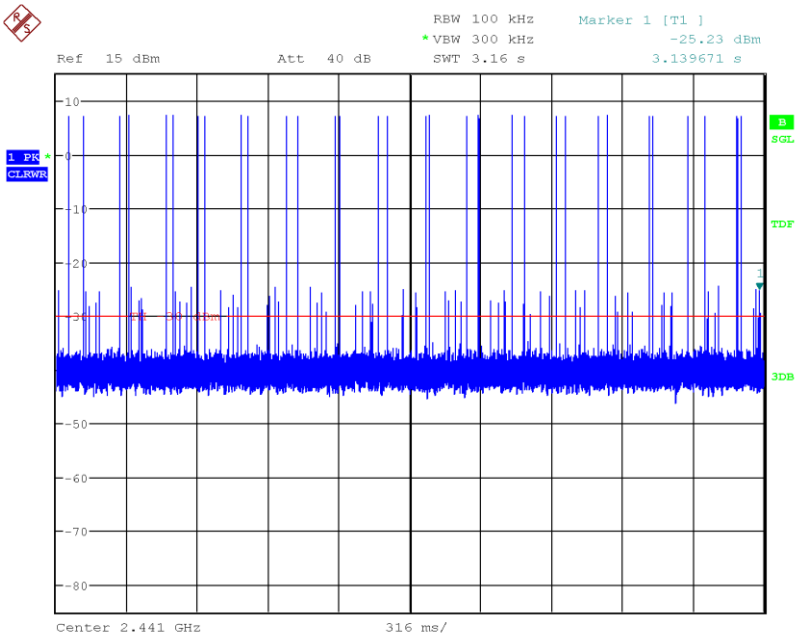
4.5.2.3 Time of Occupancy

4.5.2.3.1 DH1 Packet Type

Dwell time: 380.4 µs
Number of Hops in 3.16 s: 32 Hops
Observation Period: 31.6 s
Time of Occupancy in 31.6s: 380.4 µs x (31.6 s / 3.16 s) * 32 Hops = 121.7 ms



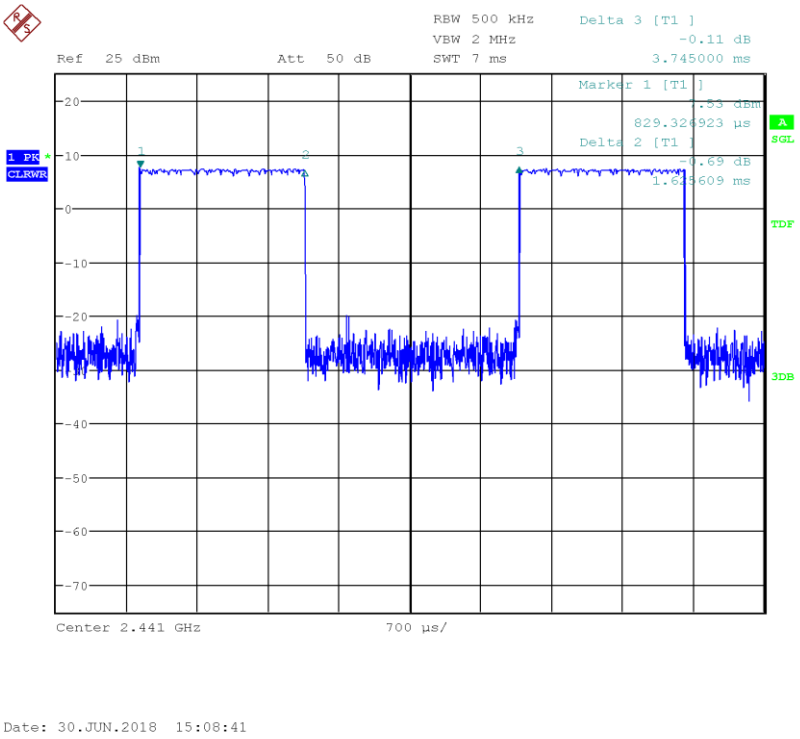
Dwell Time DH1



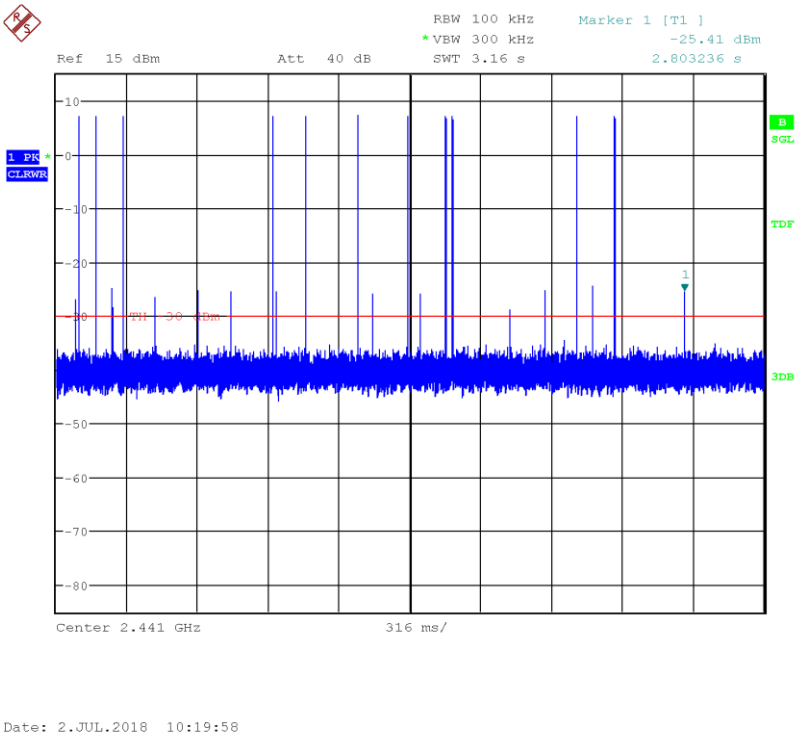
Number of Hops DH1

4.5.2.3.2 DH3 Packet Type

Dwell time: 1.63 ms
Number of Hops in 3.16 s: 11 Hops
Observation Period: 31.6 s
Time of Occupancy in 31.6s: 1.63 ms x (31.6 s / 3.16 s) * 11 Hops = 179.3 ms



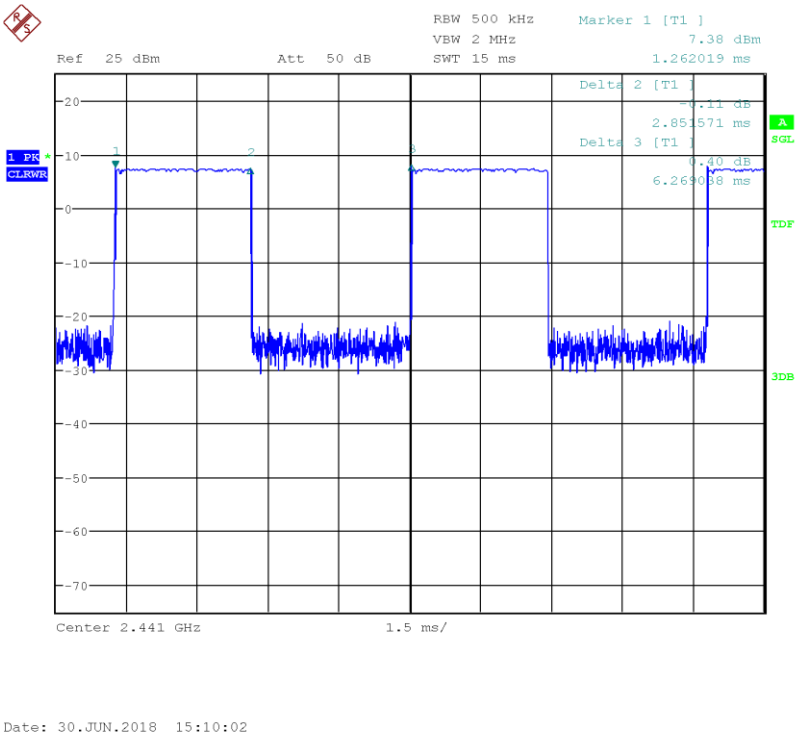
Dwell time DH3



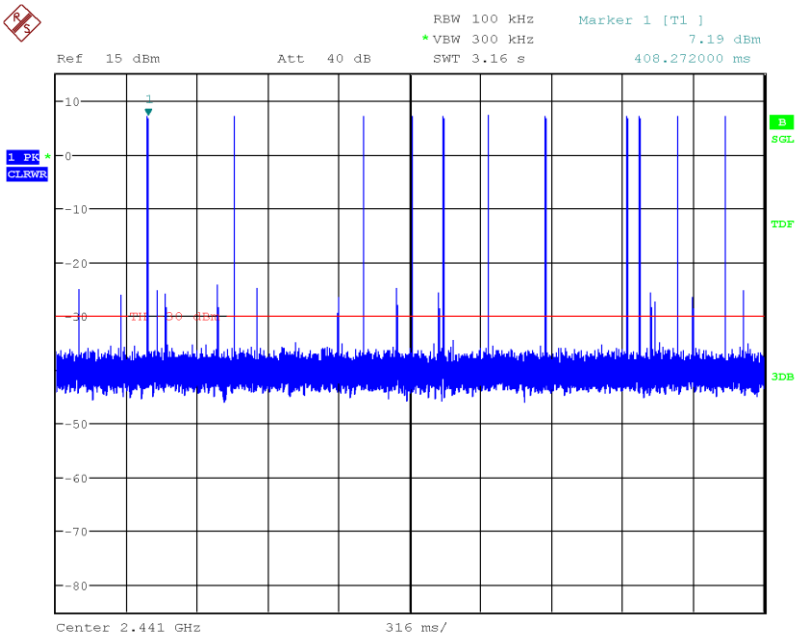
Number of Hops DH3

4.5.2.3.3 DH5 Packet Type

Dwell time: 2.85 ms
Number of Hops in 3.16 s: 11 Hops
Observation Period: 31.6 s
Time of Occupancy in 31.6s: 2.85 ms x (31.6 s / 3.16 s) * 11 Hops = 313.5 ms



Dwell Time DH5



Number of Hops DH5

4.6 Restricted Band Spurious Emissions

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmitting mode; per requirement of CFR47 15.205, 15.209, 15.247 2018(d), RSS-Gen Sect. 6.13

4.6.1 Test Methodology

Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table, 80cm above the floor for 30 MHz to 1 GHz and 150cm above the floor for 1 GHz to 26 GHz. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

A peak detector was used to search for emissions in the range.

Final Test

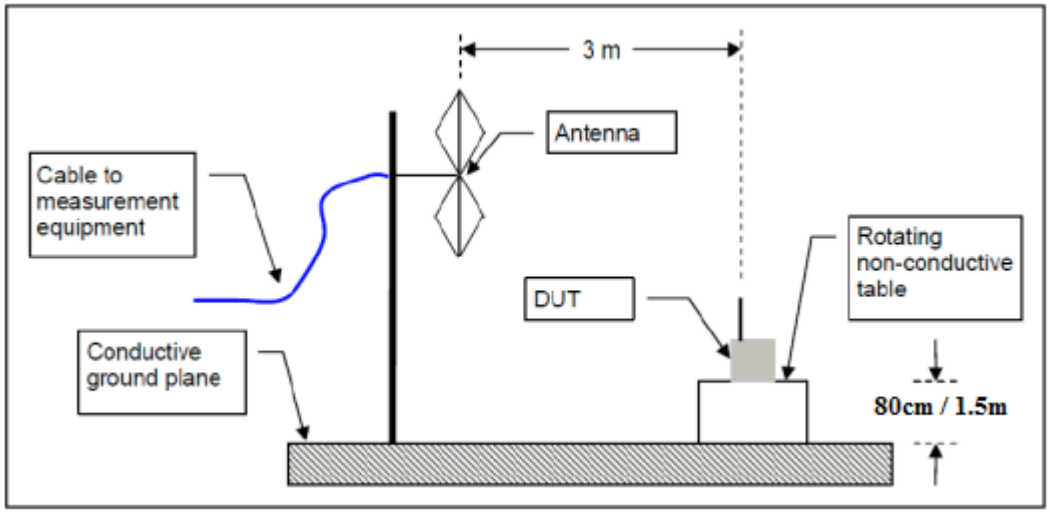
For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table, 80cm above the floor for 30 MHz to 1 GHz and 150cm above the floor for 1 GHz to 26 GHz. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The band edge final scans were not performed when the peak emissions were greater than 10 dB below the average limit

The radiated emissions final scans performed on the worst axis, Y-Axis, for three operating channels: 2402 MHz, 2442 MHz and 2480 MHz at 3DH1.

4.6.2 Test Setup



Deviations

None.

Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2017 and RSS –Gen Sect.6.13: 2014.

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

All harmonics and spurious emission which are outside of the restricted band shall be 20 dB below the in-band emission.

4.6.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and Test Plan.
As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.6.4 Sample Calculation

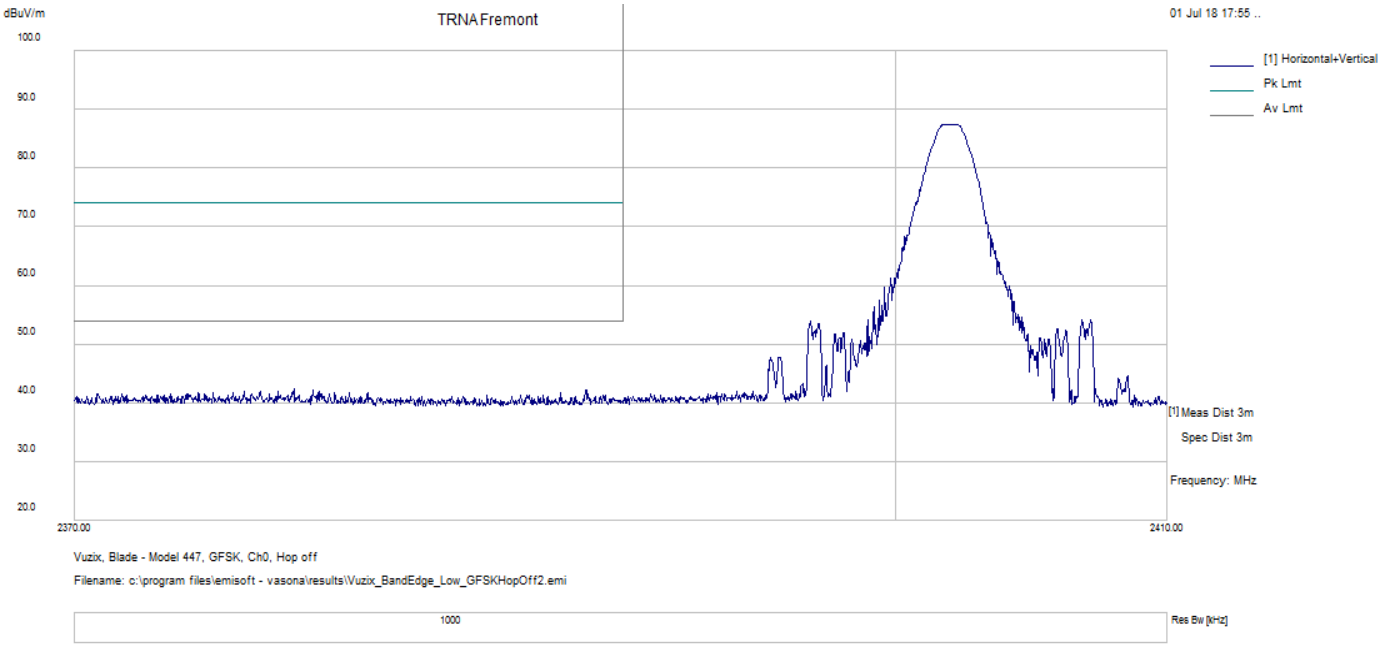
The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBµV/m) = FIM - AMP + CBL + ACF

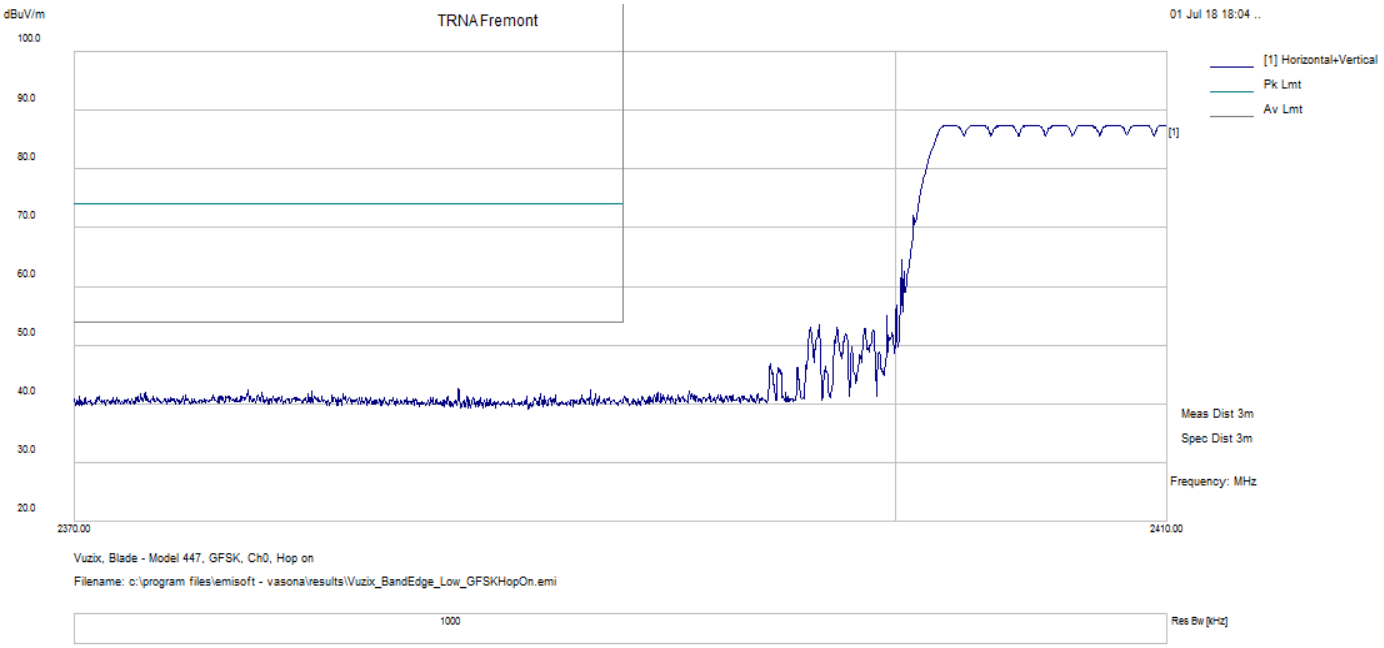
Where:
FIM = Field Intensity Meter (dBµV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

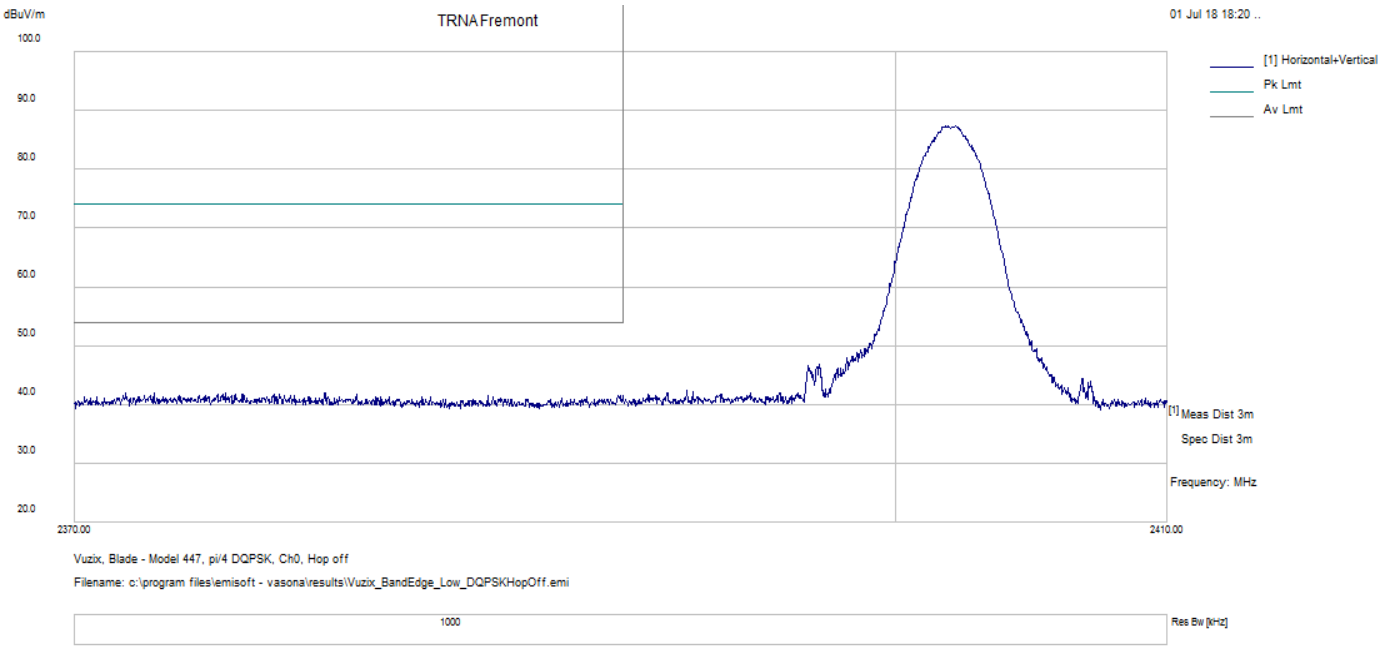
4.6.5 Band Edge



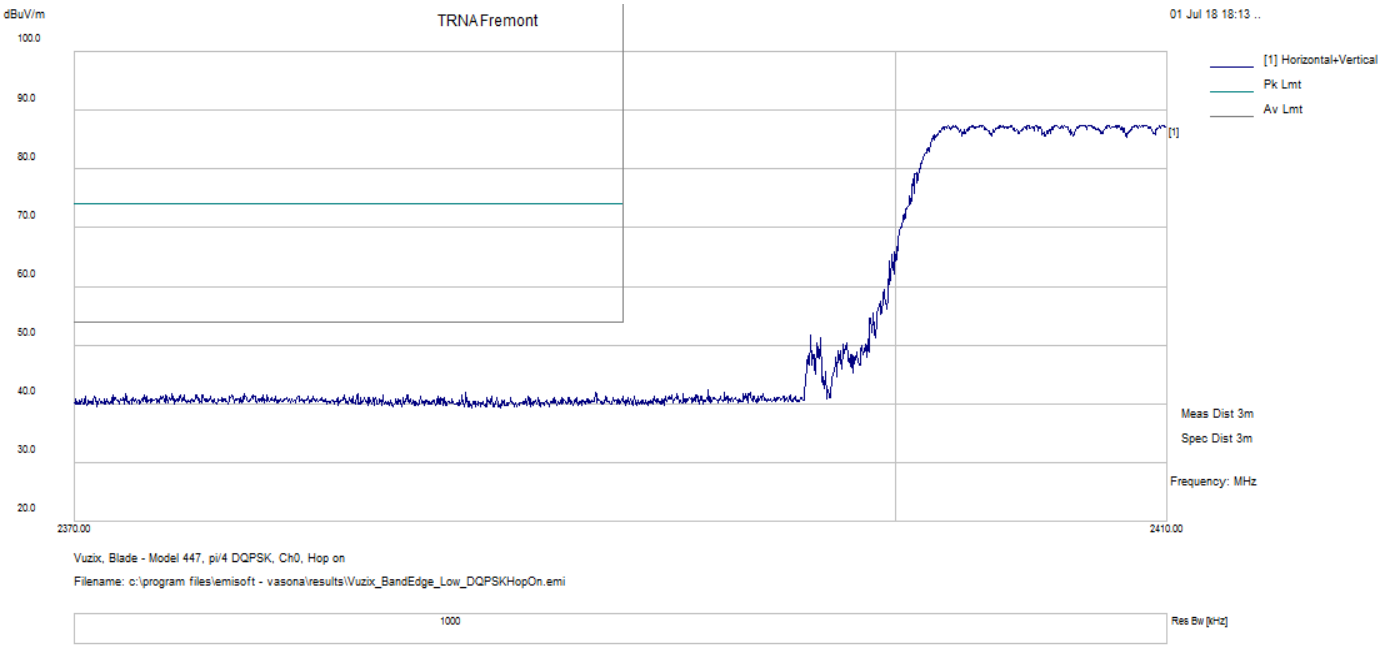
Low Band Edge GFSK Hopping Off



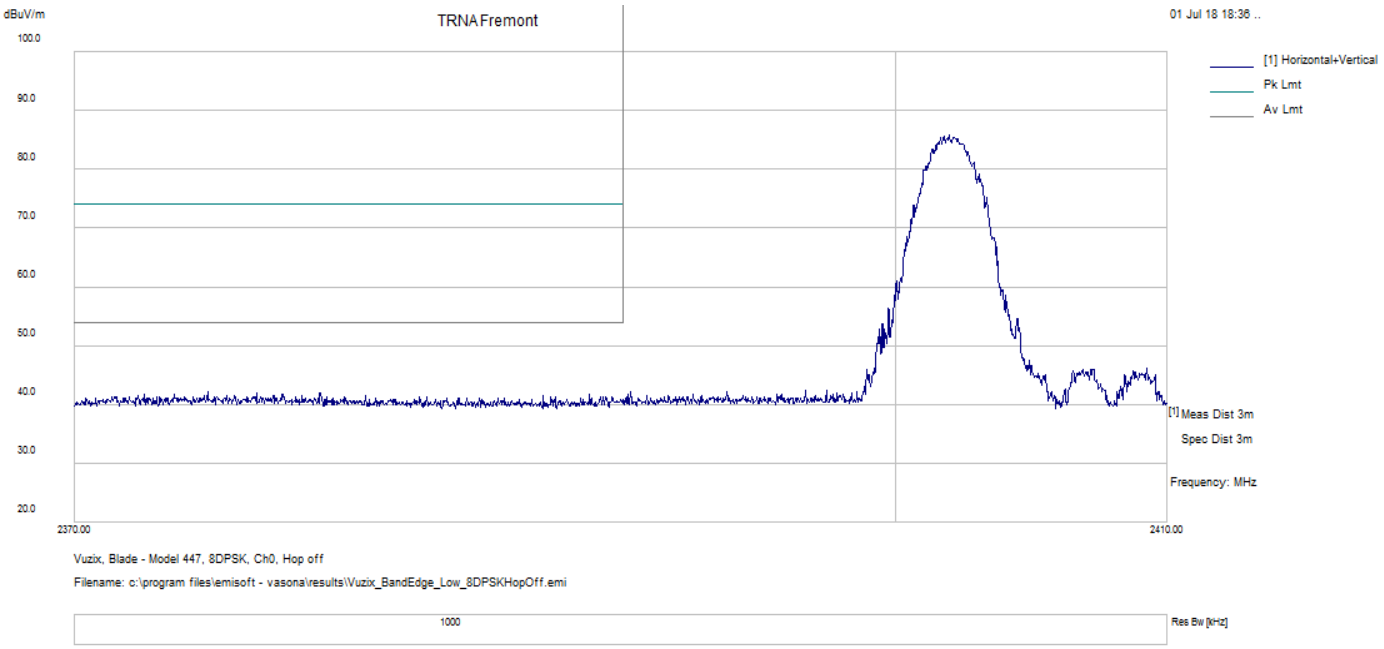
Low Band Edge GFSK Hopping On



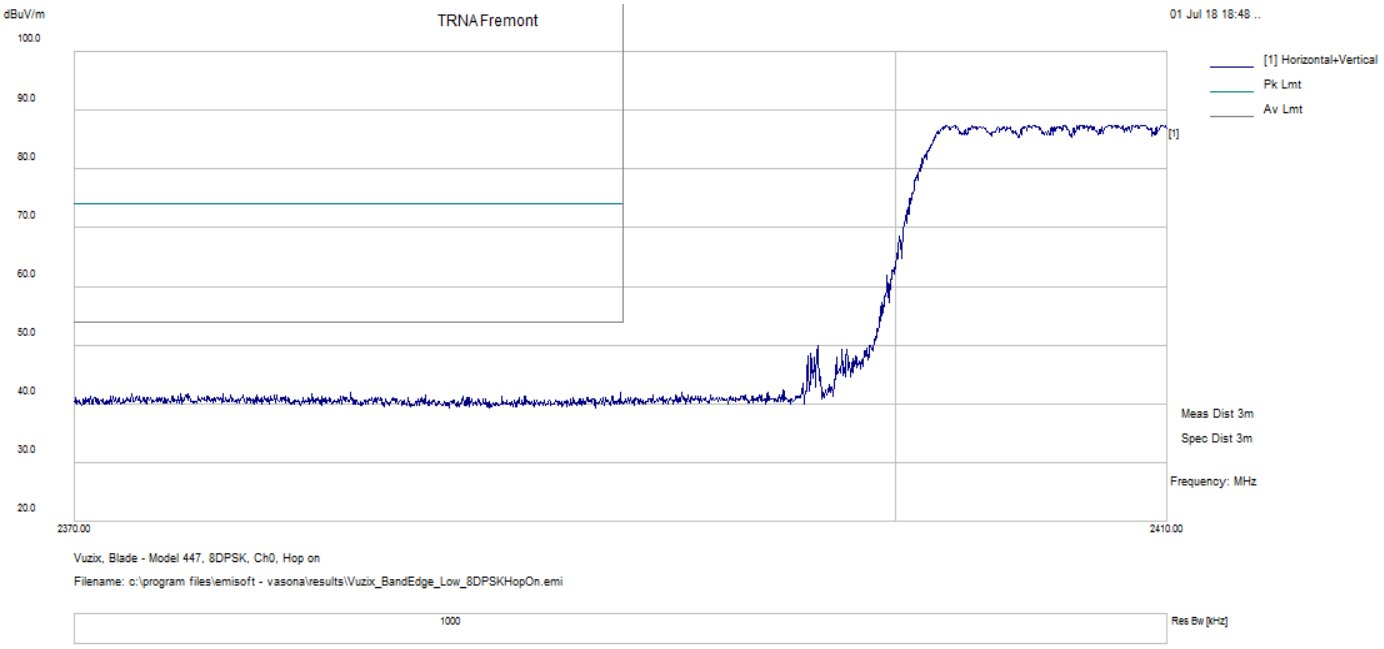
Low Band Edge π/4 DQPSK Hopping Off



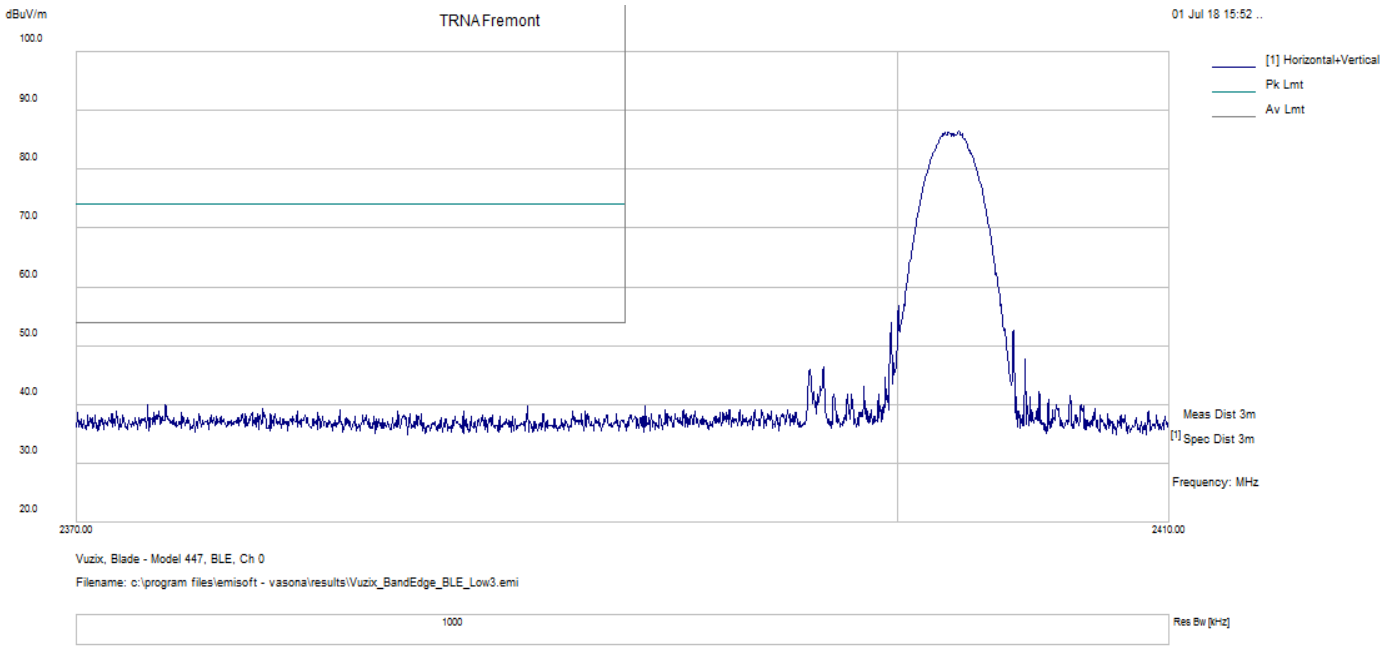
Low Band Edge π/4 DQPSK Hopping On



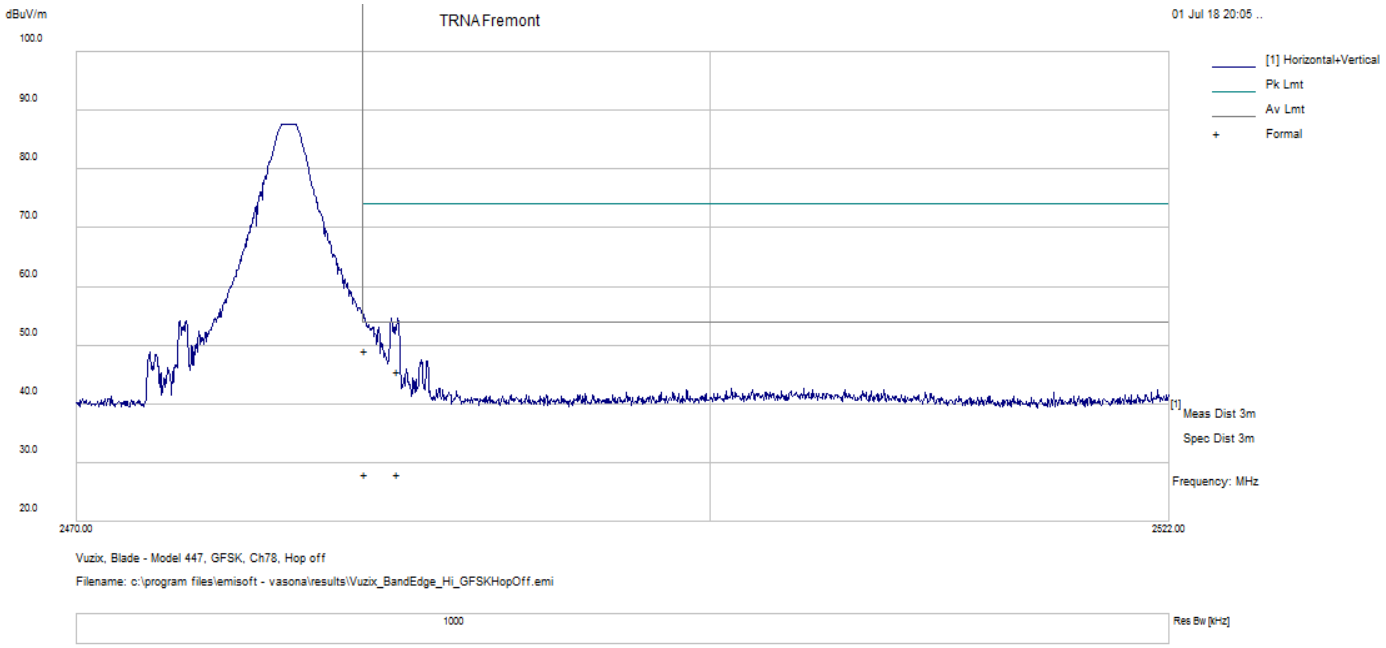
Low Band Edge 8DPSK Hopping Off



Low Band Edge 8DPSK Hopping On

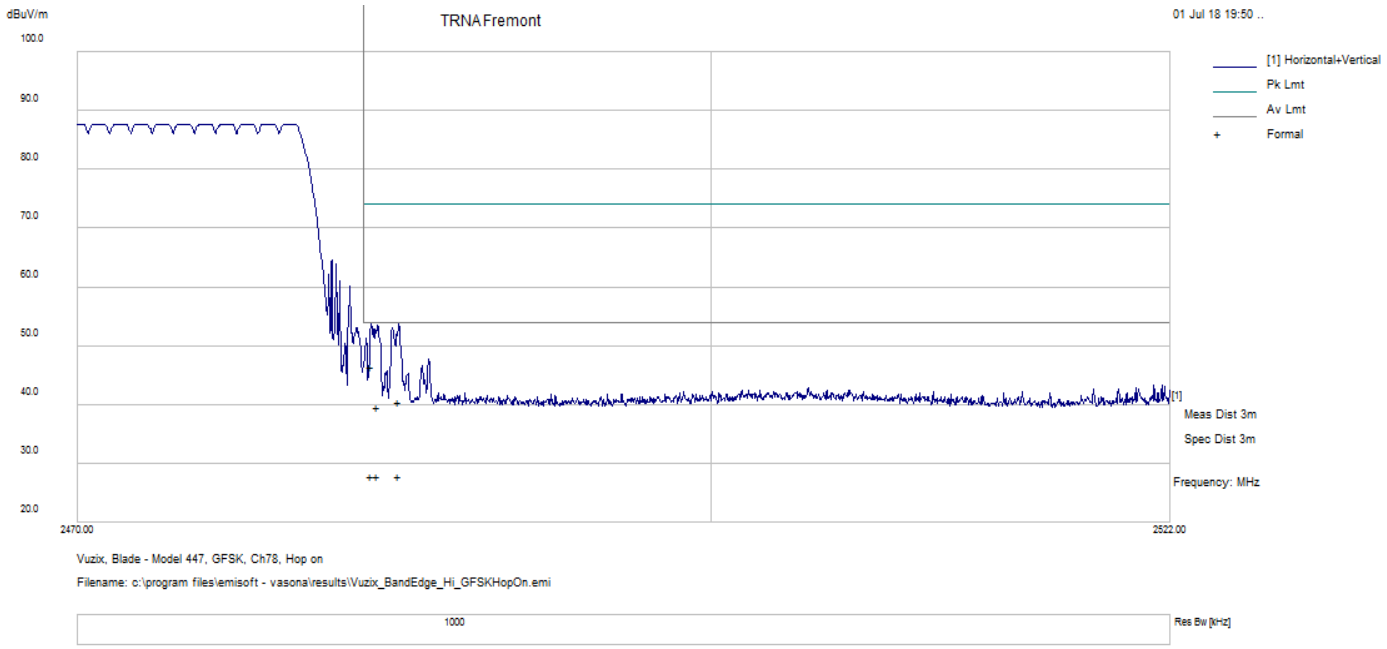


Low Band Edge BLE



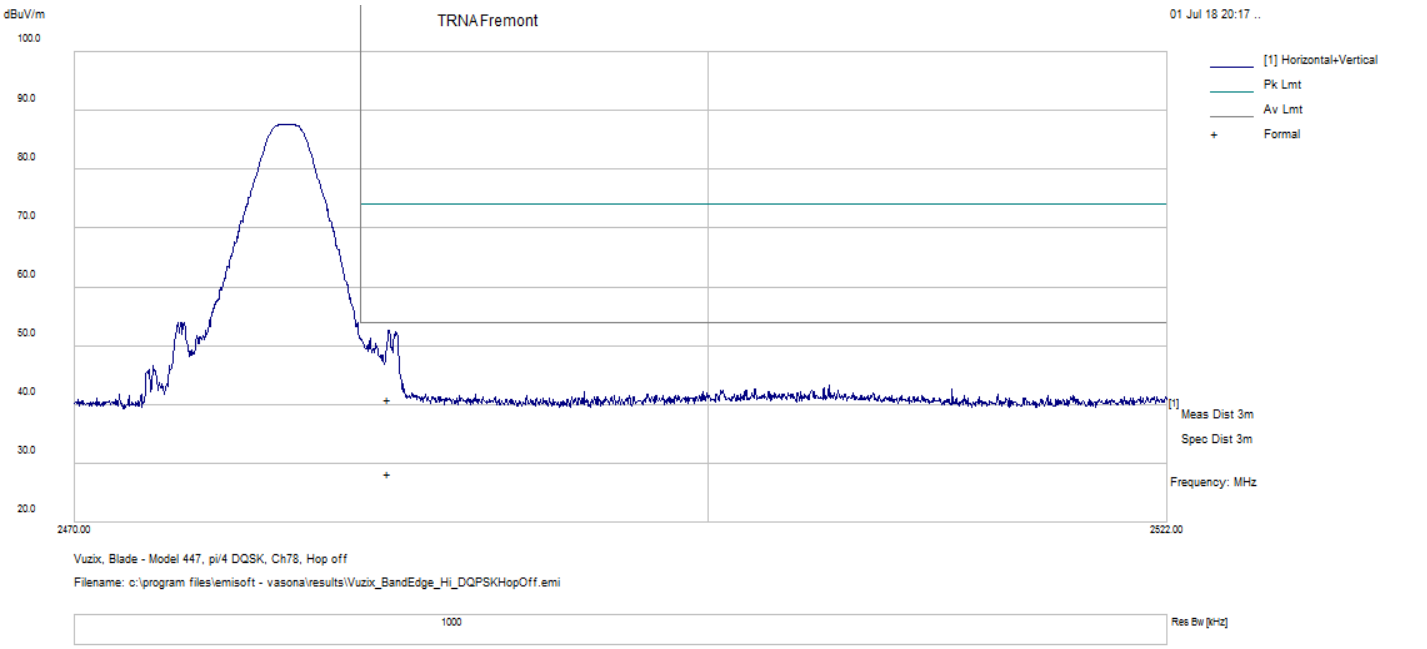
Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBu	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2483.65	54.35	2.43	-7.6	49.18	Peak Max	V	152	4	74	-24.82
2485.1775	50.71	2.43	-7.59	45.54	Peak Max	H	164	4	74	-28.46
2483.65	33.33	2.43	-7.6	28.15	Average Max	V	152	4	54	-25.85
2485.1775	33.34	2.43	-7.59	28.17	Average Max	H	164	4	54	-25.83

High Band Edge GFSK Hopping Off



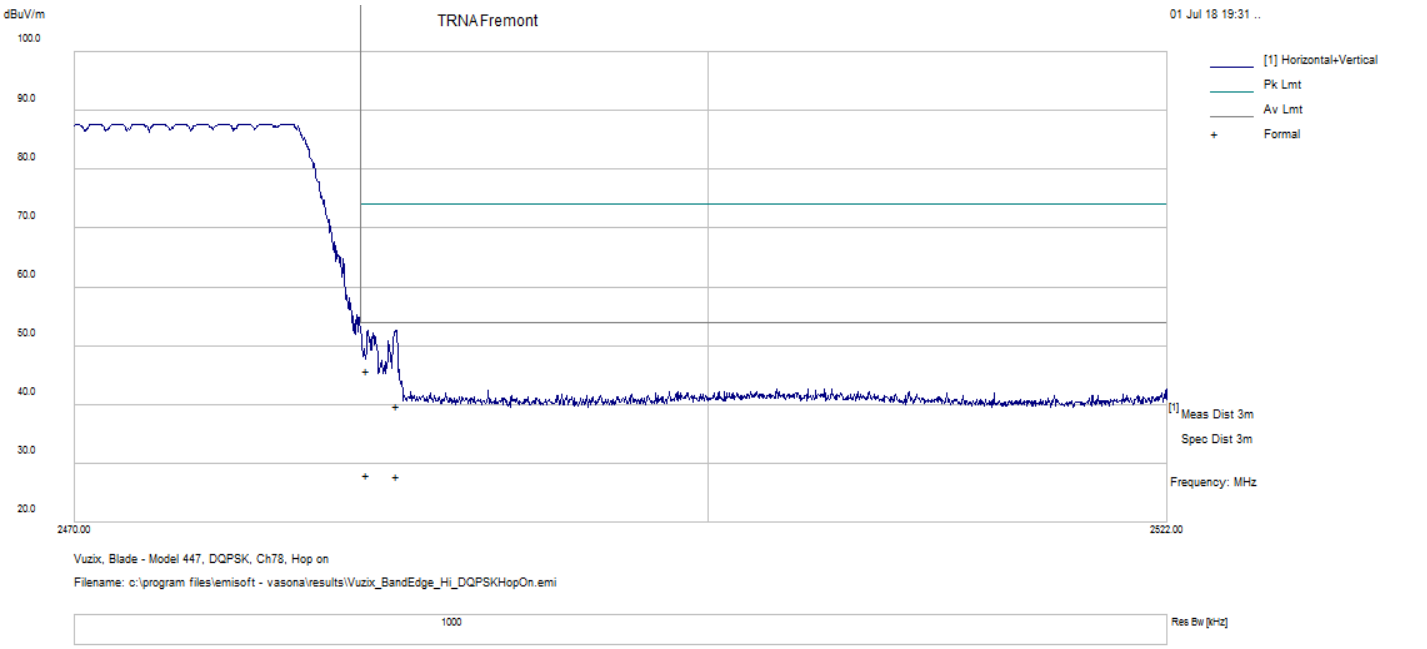
Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB
2483.8775	51.71	2.43	-7.6	46.54	Peak Max	H	106	4	74	-27.46
2485.1775	45.7	2.43	-7.59	40.54	Peak Max	H	101	4	74	-33.47
2484.17	44.73	2.43	-7.6	39.56	Peak Max	H	185	4	74	-34.44
2483.8775	33.18	2.43	-7.6	28.01	Average Max	H	106	4	54	-25.99
2485.1775	33.06	2.43	-7.59	27.9	Average Max	H	101	4	54	-26.1
2484.17	33.14	2.43	-7.6	27.98	Average Max	H	185	4	54	-26.02

High Band Edge GFSK Hopping On



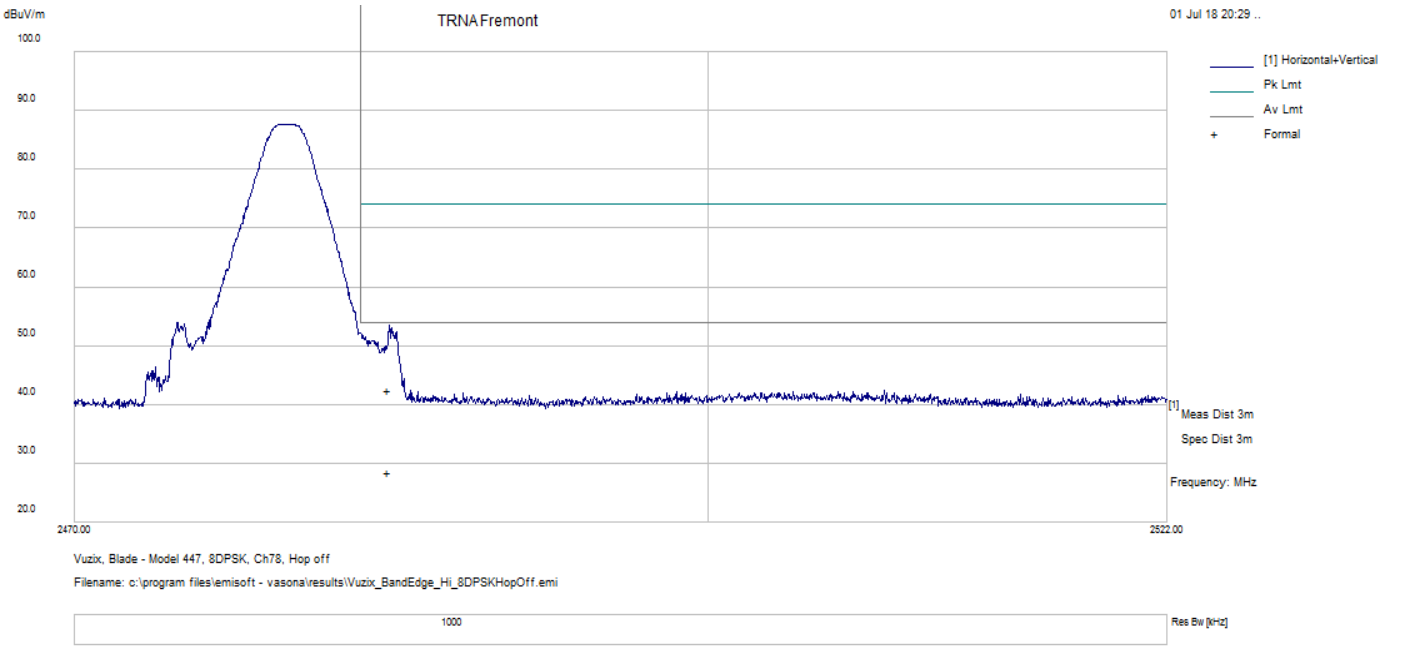
Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2484.82	46.12	2.43	-7.59	40.95	Peak Max	H	222	4	74	-33.05
2484.82	33.52	2.43	-7.59	28.35	Average M	H	222	4	54	-25.65

High Band Edge π/4 DQPSK Hopping Off



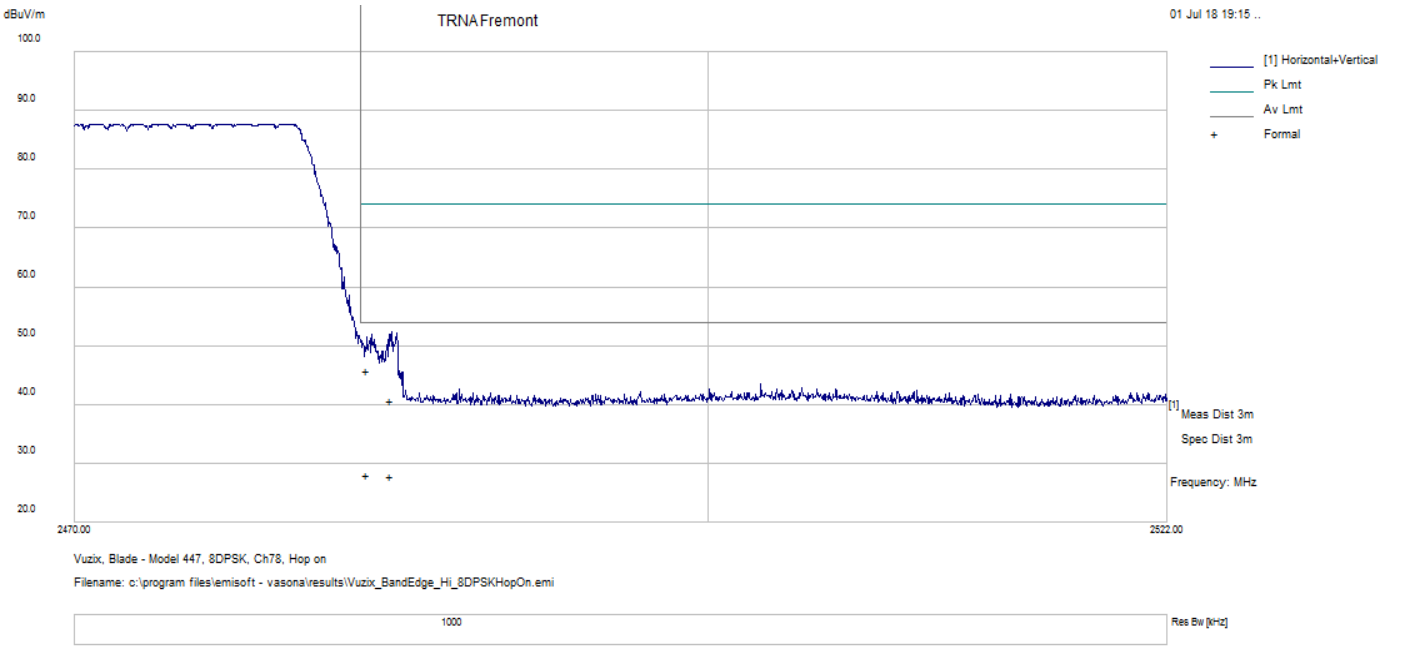
Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2483.845	51.05	2.43	-7.6	45.88	Peak Max	H	180	4	74	-28.12
2485.243	45.01	2.43	-7.59	39.85	Peak Max	H	148	4	74	-34.15
2483.845	33.31	2.43	-7.6	28.14	Average M	H	180	4	54	-25.86
2485.243	33.06	2.43	-7.59	27.9	Average M	H	148	4	54	-26.1

High Band Edge π/4 DQPSK Hopping On



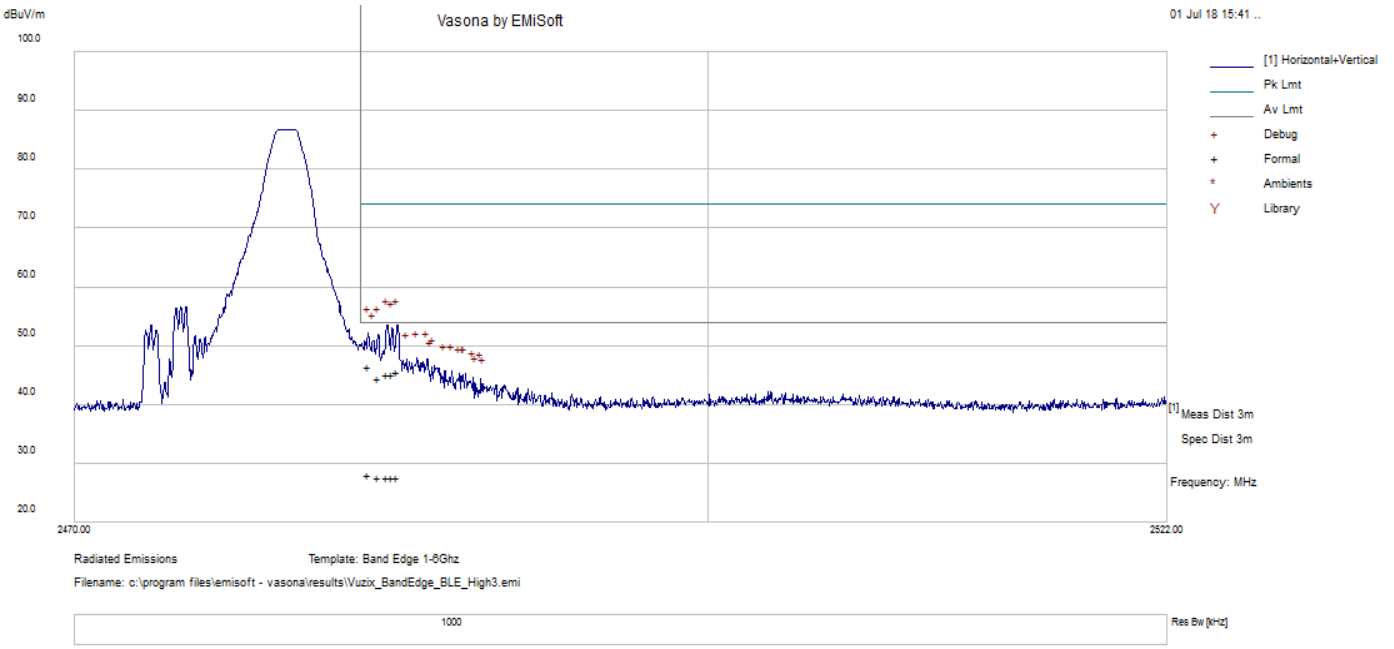
Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2484.853	47.75	2.43	-7.59	42.59	Peak Max	H	189	5	74	-31.41
2484.853	33.64	2.43	-7.59	28.48	Average M	H	189	5	54	-25.52

High Band Edge 8DPSK Hopping Off



Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2484.983	45.83	2.43	-7.59	40.66	Peak Max	H	148	4	74	-33.34
2483.813	51	2.43	-7.6	45.83	Peak Max	H	232	4	74	-28.17
2484.983	33.11	2.43	-7.59	27.94	Average M	H	148	4	54	-26.06
2483.813	33.29	2.43	-7.6	28.12	Average M	H	232	4	54	-25.88

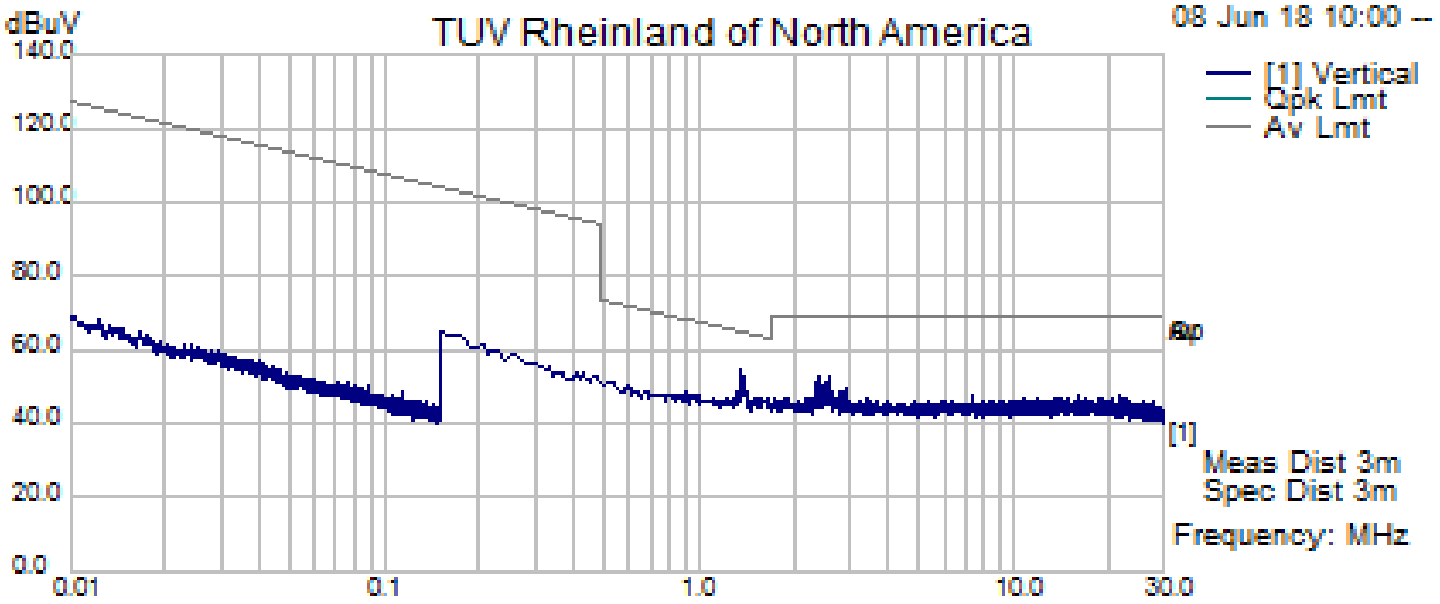
High Band Edge 8DPSK Hopping On



Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB
2485.275	50.84	2.43	-7.59	45.68	Peak Max	H	159	4	74	-28.32
2484.788	50.35	2.43	-7.59	45.19	Peak Max	H	198	4	74	-28.81
2485.015	50.45	2.43	-7.59	45.29	Peak Max	H	189	4	74	-28.71
2483.878	51.59	2.43	-7.6	46.42	Peak Max	H	193	4	74	-27.58
2484.365	49.71	2.43	-7.6	44.55	Peak Max	H	127	4	74	-29.45
2485.275	32.85	2.43	-7.59	27.68	Average M	H	159	4	54	-26.32
2484.788	32.96	2.43	-7.59	27.79	Average M	H	198	4	54	-26.21
2485.015	32.89	2.43	-7.59	27.73	Average M	H	189	4	54	-26.27
2483.878	33.36	2.43	-7.6	28.19	Average M	H	193	4	54	-25.82
2484.365	32.88	2.43	-7.6	27.71	Average M	H	127	4	54	-26.29

High Band Edge BLE

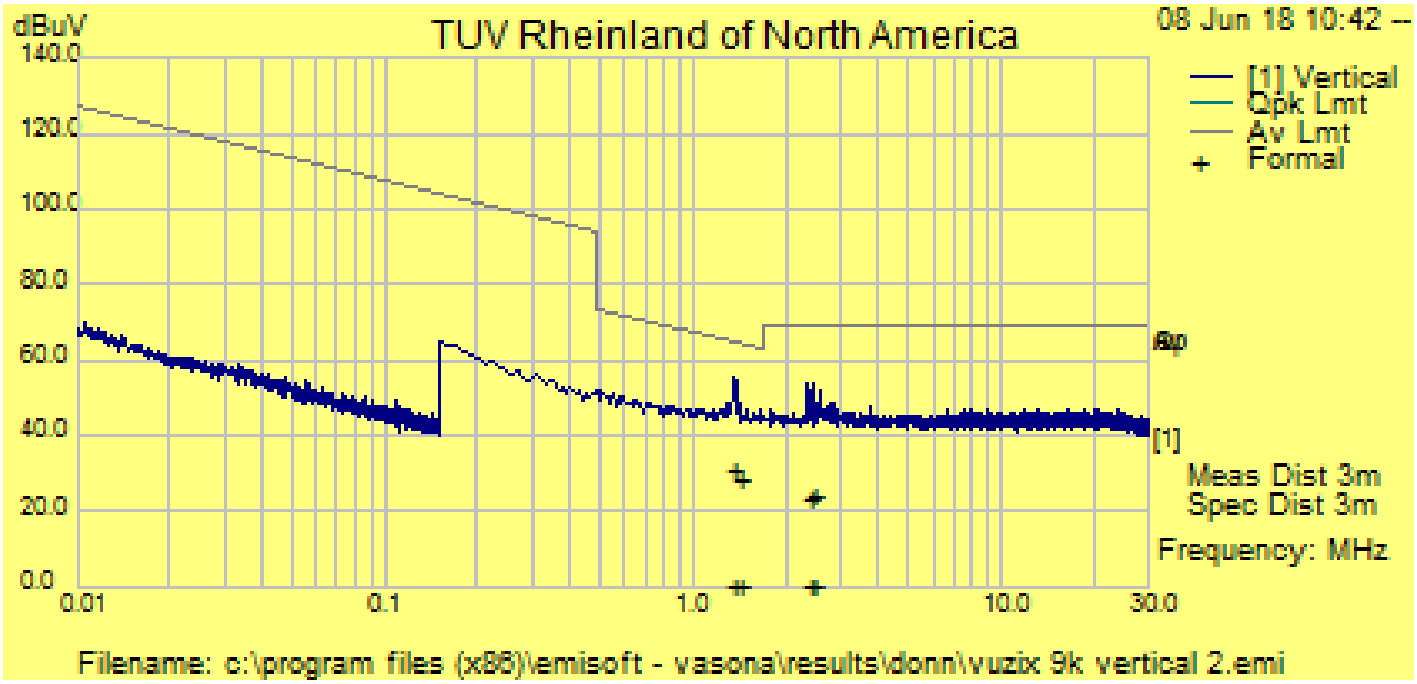
4.6.6 Radiated Spurious Emissions



Filename: c:\program files (x86)\emisoft - vasona\results\donn\vuzix 9k horiz 2.emi

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB	
Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV	Margin dB	Pass /Fail
1.35	40.67	3.13	10.60	54.40	Pk	H	100	62	65.01	-10.61	Pass
1.38	38.95	3.13	10.60	52.68	Pk	H	100	50	64.84	-12.16	Pass
1.43	34.74	3.13	10.60	48.48	Pk	H	100	254	64.49	-16.02	Pass
2.34	37.00	3.17	10.56	50.74	Pk	H	100	314	69.50	-18.76	Pass
2.43	39.20	3.17	10.55	52.93	Pk	H	100	50	69.50	-16.57	Pass
2.57	38.78	3.18	10.54	52.49	Pk	H	100	349	69.50	-17.01	Pass

Radiated Emissions 9kHz-30 MHz. Horizontal

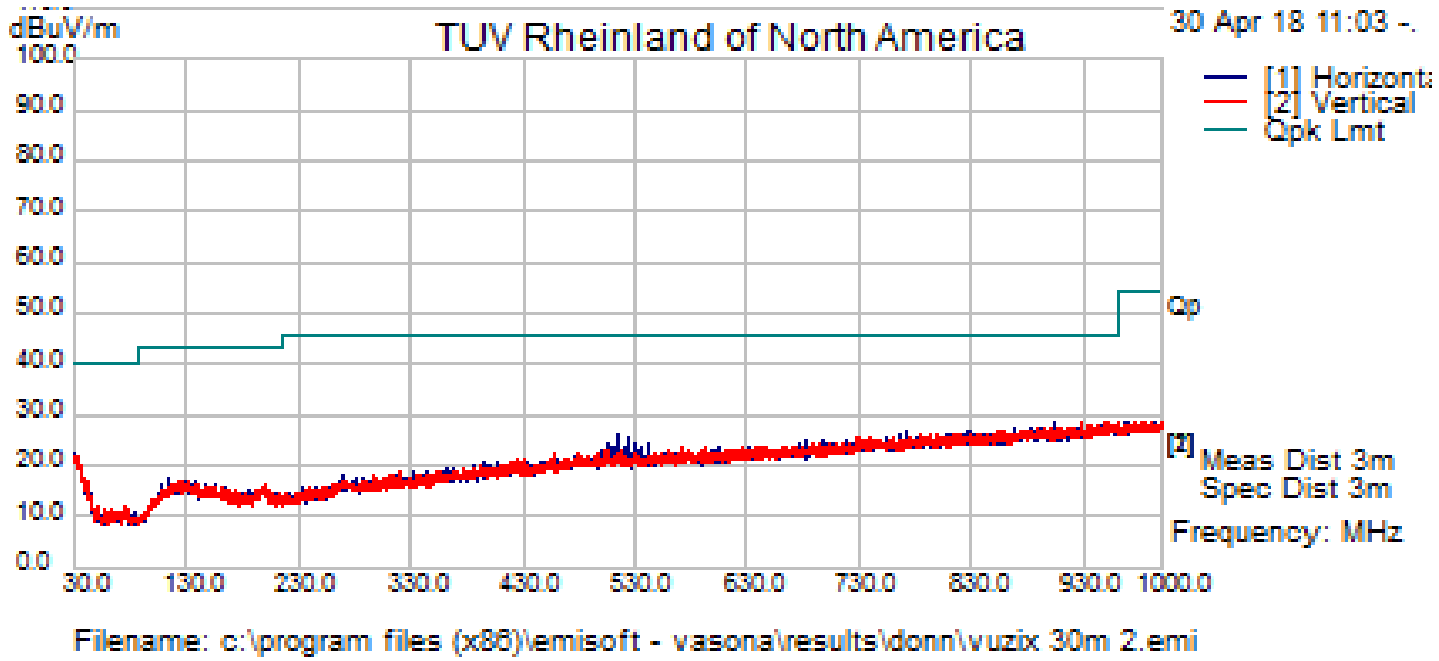


Radiated Emissions 9kHz-30 MHz. Vertical

Vasona Data : List of Debug Frequencies												
No	Frequency	Raw dBuV	Cable Los	AF dB	Level dBu	Measuren	Pol	Hgt cm	Azt Deg	Limit dBu	Margin dB	Pass /Fail
1 (44)	1.347684	40.91	3.13	10.6	54.64	Peak [Scar	V	100	149	65.01	-10.38	Pass
2 (45)	1.421959	35.22	3.13	10.6	48.95	Peak [Scar	V	100	242	64.55	-15.59	Pass
3 (46)	2.368966	40.05	3.17	10.56	53.79	Peak [Scar	V	100	213	69.5	-15.72	Pass
4 (47)	2.461809	39.93	3.18	10.55	53.66	Peak [Scar	V	100	202	69.5	-15.84	Pass
5 (48)	2.573222	38.31	3.18	10.54	52.02	Peak [Scar	V	100	312	69.5	-17.48	Pass
6 (49)	2.424672	37.23	3.17	10.55	50.96	Peak [Scar	V	100	340	69.5	-18.54	Pass
7 (50)	2.786763	35.26	3.18	10.52	48.96	Peak [Scar	V	100	166	69.5	-20.54	Pass

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result	Comments
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB		
No	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass /Fail
1 (28)	30.00	27.33	2.28	-7.48	22.13	Peak [Scan]	H	400	178.00	40.00	-17.87	Pass
2 (29)	41.52	29.36	2.34	-15.05	16.65	Peak [Scan]	V	400	138.00	40.00	-23.35	Pass
3 (30)	970.60	28.33	3.75	-3.24	28.84	Peak [Scan]	H	300	311.00	54.00	-25.16	Pass

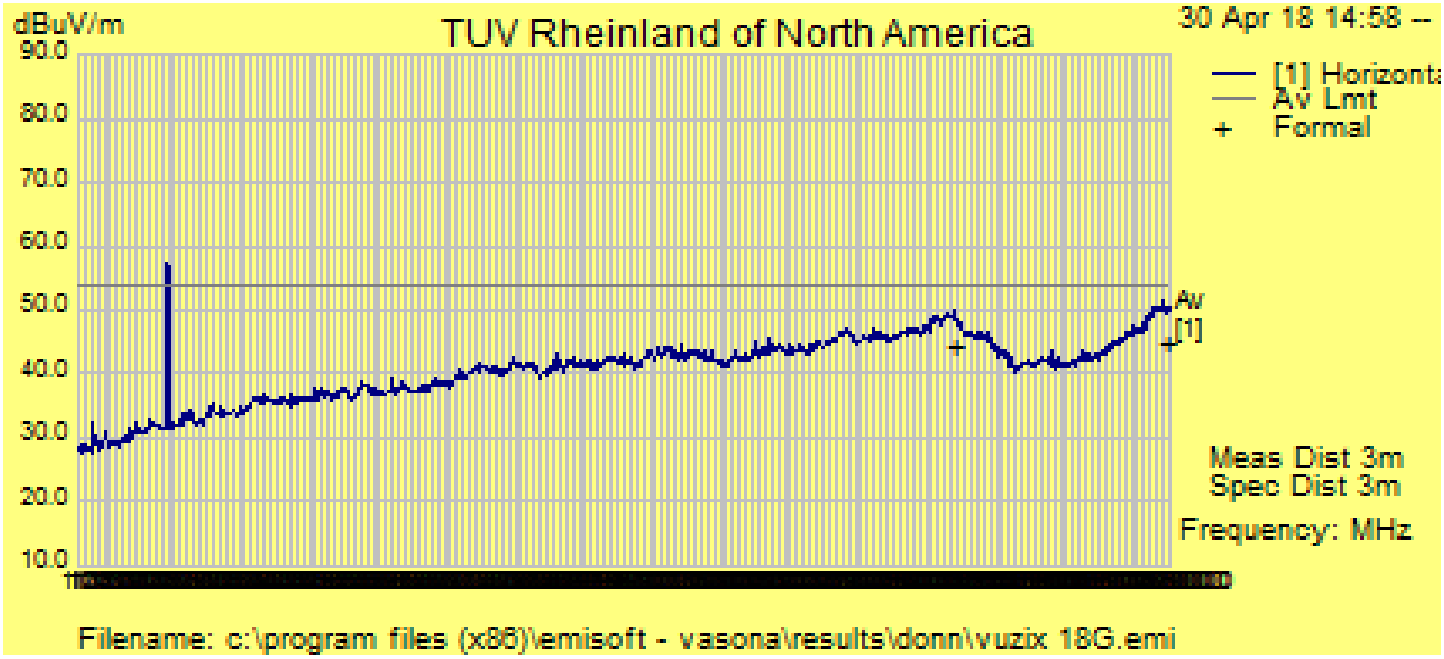
Note: Since there were no emissions that were measurable in all the bands tested only one channel was tested.



Radiated Emissions 30-1000 MHz.

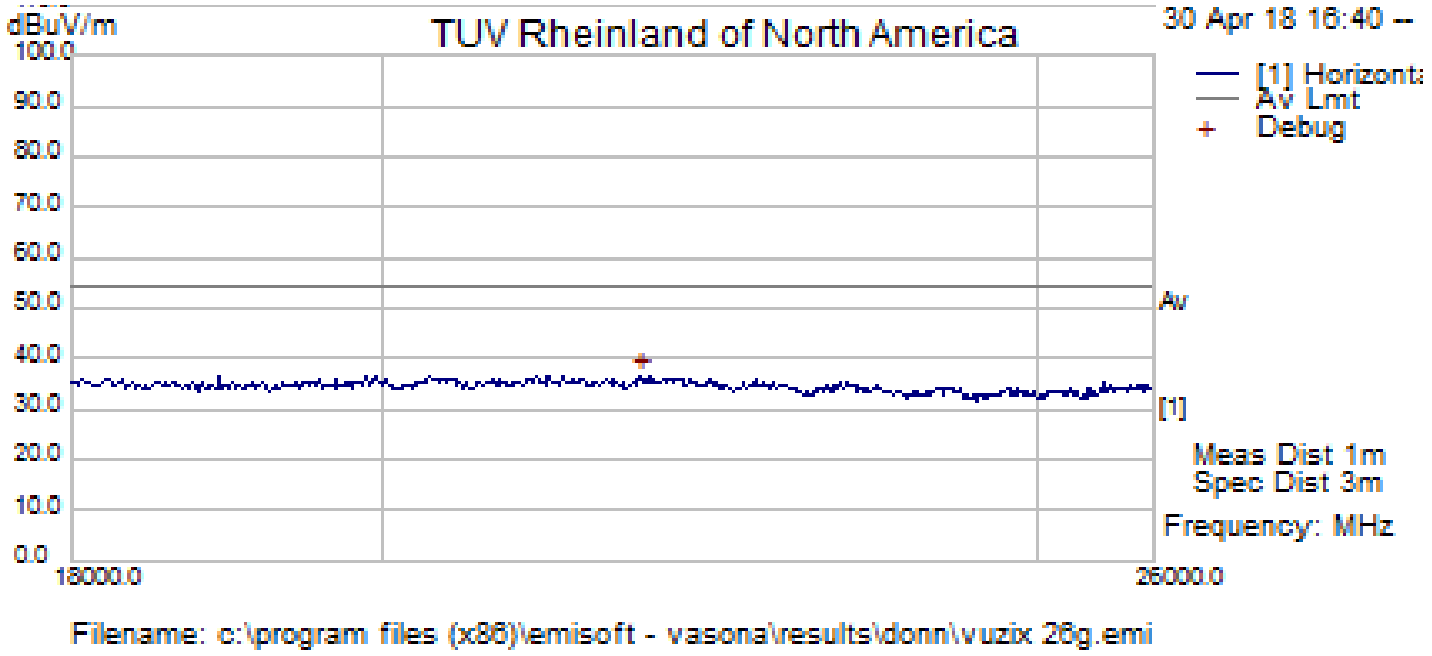
Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB	
2402.36	62.20	1.30	-6.24	57.26	Pk	H	200	0	54.00	3.26	Pass
14644.65	29.24	3.53	11.45	44.21	Average Max	H	197	92	54.00	-9.79	Pass
17913.27	25.66	4.20	15.20	45.06	Average Max	V	127	132	54.00	-8.94	Pass

Note: The signal at 2402 MHz. is the Bluetooth transmit channel.



Radiated Emissions 1-18 GHz.

Frequency	Raw	Cable Loss	AF	Level	Detector	Polarity	Height	Azimuth	Limit	Margin	Result	Comments
MHz	dBuV/m	dB	dB	dBuV/m		H/V	cm	deg	dBuV/m	dB		
21831.66	39.09	7.64	-9.97	36.75	Pk	H	100	0	54.00	-17.25	Pass	



Radiated Emissions 18-26 GHz

6 Test Equipment Use List

Pleasanton Facility

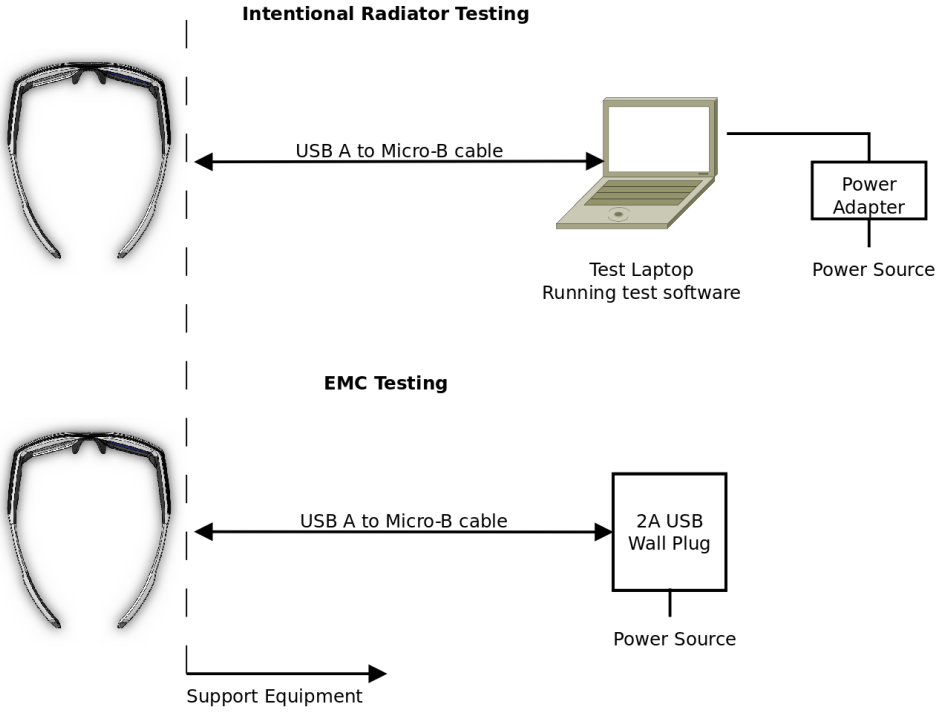
Equipment	Manufacturer	Model#	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Bilog Antenna	Sunol Sciences	JB3	A102606	06/15/2016	06/15/2018
Horn Antenna	Sunol Science	DRH118	A040806	11/11/2016	11/11/2018
Horn Antenna	Com-Power	AHA-840	105005	05/26/2017	05/26/2019
Amplifier	Sonoma Instruments	310	165516	01/23/2018	01/23/2019
Spectrum Analyzer	Rohde & Schwarz	ESI	832340/001	01/22/2018	01/22/2019
Spectrum Analyzer	Agilent	MXE	52260210	1/22/2018	1/22/2019
Amplifier	AR	80S1G3	27207	----	-----
Power Sensor	Hewlett Packard	8482A	1925A04647	01/24/2018	01/24/2019
Power Meter	Agilent	E4418B	MY45103902	1/24/2018	1/24/2019
Amplifier	IFI	ST181-20	K334-1206	-----	-----
Amplifier	IFI	SMX5005	K332-1106	-----	-----
Amplifier	Rohde & Schwarz	TS-PR40	100012	08/02/2017	08/02/2018
Horn Antenna	DRG	SAS571	none	-----	-----
LISN	Com-Power	LI-215	12100	01/24/2018	01/24/2019

* Calibration of equipment past due for re-calibration will be performed expeditiously. If any equipment is found to be out of tolerance at that time, affected customers will be notified accordingly.

Fremont Facility

Equipment	Manufacturer	Model#	Serial/Inst #	Last Cal mm/dd/yyyy	Next Cal mm/dd/yyyy
Horn Antenna	EMCO	3115	9710-5301	11/15/2016	11/15/2018
Amplifier	HP	8449B	3008A01842	01/23/2018	01/23/2019
Spectrum Analyzer	Rohde & Schwarz	FSU26	200050	10/24/2017	10/24/2018
Spectrum Analyzer	Agilent	MXE	MY52260210	1/22/2018	1/22/2019
Bluetooth Tester	Rohde & Schwarz	CMW500	164957	1/23/2018	1/23/2019

6.1 Block Diagram



End of Report