

# Test Report

|                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Product</b>                                                                                                                                                                                                                                                                                                                                                                                    | Bluetooth Transceiver                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Name and address of the applicant</b>                                                                                                                                                                                                                                                                                                                                                          | LEGO System A/S<br>Aastvej 1,<br>7190 Billund, Denmark                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Name and address of the manufacturer</b>                                                                                                                                                                                                                                                                                                                                                       | LEGO System A/S<br>Aastvej 1,<br>7190 Billund, Denmark                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Model</b>                                                                                                                                                                                                                                                                                                                                                                                      | HUB NO.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Rating</b>                                                                                                                                                                                                                                                                                                                                                                                     | 7.3Vdc (Secondary Batteries)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Trademark</b>                                                                                                                                                                                                                                                                                                                                                                                  | LEGO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Serial number</b>                                                                                                                                                                                                                                                                                                                                                                              | Radiated sample: Marked as "FEP-1_135"                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Additional information</b>                                                                                                                                                                                                                                                                                                                                                                     | This tested device can be operated either with BLE or classic Bluetooth.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Tested according to</b>                                                                                                                                                                                                                                                                                                                                                                        | <b>FCC Part 15.247</b><br>Frequency Hopping Transmitters / Digital Transmission Systems<br><b>Industry Canada RSS-247, Issue 2</b><br>Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs)<br>and Licence-Exempt Local Area Network (LE-LAN) Devices                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Order number</b>                                                                                                                                                                                                                                                                                                                                                                               | 370465                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Tested in period</b>                                                                                                                                                                                                                                                                                                                                                                           | 2019.04.15 – 2019.06.05                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Issue date</b>                                                                                                                                                                                                                                                                                                                                                                                 | 2019.06.17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Name and address of the testing laboratory</b>                                                                                                                                                                                                                                                                                                                                                 | <div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="text-align: center;"> <br/> Instituttveien 6<br/>Kjeller, Norway </div> <div style="text-align: center;"> CAB Number:<br/>FCC: NO0001<br/>ISED: NO0470<br/><br/> TEL: +47 22 96 03 30<br/>FAX: +47 22 96 05 50 </div> <div style="text-align: center;"> <br/>  </div> </div> <p style="text-align: center; color: red;">An accredited technical test executed under the Norwegian accreditation scheme</p> |
| <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <br/> Prepared by [G.Suhanthakumar] </div> <div style="text-align: center;"> <br/> Approved by [Frode Sveisen] </div> </div> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| This report shall not be reproduced except in full without the written approval of Nemko. Opinions and interpretations expressed within this report are not part of the current accreditation. This report was originally distributed electronically with digital signatures. For more information contact Nemko.                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## CONTENTS

|          |                                                          |            |
|----------|----------------------------------------------------------|------------|
| <b>1</b> | <b>INFORMATION .....</b>                                 | <b>3</b>   |
| 1.1      | Test Item.....                                           | 3          |
| 1.2      | Normal test condition .....                              | 4          |
| 1.3      | Test Engineer(s) .....                                   | 4          |
| 1.4      | Description of modification for Modification Filing..... | 4          |
| 1.5      | Family List Rational .....                               | 4          |
| 1.6      | Antenna Requirement.....                                 | 4          |
| 1.7      | Worst-Case Configuration and Mode.....                   | 4          |
| 1.8      | Comments .....                                           | 4          |
| <b>2</b> | <b>TEST REPORT SUMMARY .....</b>                         | <b>5</b>   |
| 2.1      | General.....                                             | 5          |
| 2.2      | Test Summary .....                                       | 6          |
| <b>3</b> | <b>TEST RESULTS.....</b>                                 | <b>7</b>   |
| 3.1      | Number of Frequencies .....                              | 7          |
| 3.2      | Power Line Conducted Emissions .....                     | 8          |
| 3.3      | Channel Separation.....                                  | 9          |
| 3.4      | Pseudorandom Hopping Algorithm .....                     | 11         |
| 3.5      | Occupancy Time.....                                      | 12         |
| 3.6      | Occupied Bandwidth.....                                  | 16         |
| 3.7      | Peak Power Output.....                                   | 25         |
| 3.8      | Conducted Emissions at Antenna Connector .....           | 44         |
| 3.9      | Spurious Emissions (Radiated).....                       | 51         |
| <b>4</b> | <b>Measurement Uncertainty.....</b>                      | <b>190</b> |
| <b>5</b> | <b>LIST OF TEST EQUIPMENT.....</b>                       | <b>191</b> |
| <b>6</b> | <b>BLOCK DIAGRAM.....</b>                                | <b>192</b> |
| 6.1      | Power Line Conducted Emission .....                      | 192        |
| 6.2      | Test Site Radiated Emission.....                         | 192        |

## 1 INFORMATION

### 1.1 Test Item

|                                  |                                                                                      |
|----------------------------------|--------------------------------------------------------------------------------------|
| Name                             | LEGO                                                                                 |
| FCC ID                           | NPI35803                                                                             |
| ISED ID                          | 3072A-35803                                                                          |
| Model/version                    | HUB NO.6                                                                             |
| Serial number                    | Radiated sample : Marked as "FEP-1_135"<br>Conducted sample: Marked as "FEP→EP5 019" |
| Hardware identity and/or version | 10035801-E                                                                           |
| Software identity and/or version | 1.0.00.0000                                                                          |
| Frequency Range                  | 2400 – 2483.5 MHz                                                                    |
| Tunable Bands                    | None                                                                                 |
| Number of Channels               | 79                                                                                   |
| Operating Modes                  | TX and RX                                                                            |
| Measured BW (99%)                | 1.03 MHz                                                                             |
| Emission classification          | F1D                                                                                  |
| Transmitter spurious, dBμV/m@3m  | 61.96 (7.32GHz) PK and 41.96 AV(7.32GHz)                                             |
| Type of Modulation               | GFSK, 8DPSK and 4πDPSK                                                               |
| Data rate                        | 3Mbit/s                                                                              |
| User Frequency Adjustment        | None                                                                                 |
| Conducted Output Power,Max       | 0.00158 W (1.99dBm)                                                                  |
| Type of Power Supply             | 7.3Vdc, Rechargeble Lithium ion battery                                              |
| Antenna Connector                | Only integral antenna                                                                |
| Number of Antennas               | 1                                                                                    |
| Diversity or Smart Antennas      | None                                                                                 |
| Desktop Charger                  | N/A                                                                                  |

### Description of Test Item

The device tested is a toy which controls dedicated motors, sensors and remotely control via BLE or Bluetooth classic with remote device such as iOS, Android or similar.

## 1.2 Normal test condition

Temperature: 20 - 24 °C  
Relative humidity: 20 - 50 %  
Normal test voltage: 7.3Vdc

The values are the limit registered during the test period.

## 1.3 Test Engineer(s)

G.Suwanthakumar

## 1.4 Description of modification for Modification Filing

Not applicable.

## 1.5 Family List Rational

Not Applicable.

## 1.6 Antenna Requirement

Is the antenna detachable?

☐ Yes ☒ No

If detachable, is the antenna connector non-standard?

☐ Yes ☐ No

Type of antenna connector: N/A

Ref. FCC §15.203

## 1.7 Worst-Case Configuration and Mode

Radiated Emissions were performed with the EUT set to transmit at the channel with the highest output power as worst-case scenario.

## 1.8 Comments

All measurements were done with the EUT powered by a fully charged battery.

All ports were populated during spurious emission measurements.

## 2 TEST REPORT SUMMARY

### 2.1 General

All measurements are traceable to national standards.

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and Industry Canada RSS-247 Issue 2 and RSS-GEN Issue 5.

Tests were performed in accordance with ANSI C63.4-2014 and ANSI C63.10-2013.

Radiated tests were made in a semi-anechoic chamber at measuring distances of 1m, 3m and 10m.

A description of the test facility is on file with FCC and ISED.

☒ New Submission

☒ Production Unit

☐ Class II Permissive Change

☐ Pre-production Unit

**DSS** Equipment Code

☐ Family Listing



#### **THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.**

Deviations from, additions to, or exclusions from the test specifications are described in "Summary of Test Data".

Nemko Group authorizes the above named company to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any reproduction of parts of this report requires approval in writing from Nemko Group.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Nemko Group accepts no responsibility for damages suffered by any third party as a result of decisions made or actions based on this report.

## 2.2 Test Summary

| Name of test                           | FCC Part 15 reference               | RSS-247 Issue 2, RSS-GEN Issue 5 reference       | Result                |
|----------------------------------------|-------------------------------------|--------------------------------------------------|-----------------------|
| Supply Voltage Variations              | 15.31(e)                            | 6.11 (RSS-GEN)                                   | N/A <sup>1</sup>      |
| Number of Operating Frequencies        | 15.31(m)                            | 5.1 (d) (RSS-247)                                | Complies              |
| Antenna Requirement                    | 15.203                              | 8.3 (RSS-GEN)                                    | N/A <sup>2</sup>      |
| Power Line Conducted Emission          | 15.107(a)<br>15.207(a)              | 8.8 (RSS-GEN)                                    | Complies <sup>3</sup> |
| Channel Separation                     | 15.247(a)(1)                        | 5.1 (b) (RSS-247)                                | Complies              |
| Pseudorandom Hopping Algorithm         | 15.247(a)(1)                        | 5.1 (a) (RSS-247)                                | Complies              |
| Time of Occupancy                      | 15.247(a)(1)(iii)                   | 5.1 (d) (RSS-247)                                | Complies              |
| Occupied Bandwidth                     | 15.247(a)(1)                        | 5.1 (a) (RSS-247)                                | Complies              |
| Occupied Bandwidth                     | N/A                                 | 6.6 (RSS-GEN)                                    | N/A <sup>4</sup>      |
| Minimum 6 dB Bandwidth                 | 15.247(a)(2)                        | 5.2 (a) (RSS-247)                                | N/A <sup>4</sup>      |
| Peak Power Output                      | 15.247(b)                           | 5.4(b) (RSS-247)                                 | Complies              |
| Power Spectral Density                 | 15.247(d)                           | 5.2 (b) (RSS-247)                                | N/A <sup>4</sup>      |
| Spurious Emissions (Antenna Conducted) | 15.247(c)                           | 5.5 (RSS-247)                                    | Complies              |
| Spurious Emissions (Radiated)          | 15.247(c)<br>15.109(a)<br>15.209(a) | 5.5 (RSS-247)<br>6.13 (RSS-GEN)<br>8.9 (RSS-GEN) | Complies              |

N/A<sup>1</sup>: The tested equipment only operates with rechargeable battery. And recharged with USB power.

N/A<sup>2</sup>: Integral antenna

3 : For rechargeable battery.

N/A<sup>3</sup>: FHSS

### 3 TEST RESULTS

#### 3.1 Number of Frequencies

FCC Part 15.31 (m)

RSS-Gen 6.8

|                       |                   |
|-----------------------|-------------------|
| Authorized Band:      | 2400 - 2483.5 MHz |
| Frequency band width: | 83.5MHz           |
| Low Channel:          | 2402MHz           |
| Mid channel:          | 2441MHz           |
| High Channel:         | 2480MHz           |

## 3.2 Power Line Conducted Emissions

FCC Part 15.207

ISED RSS-GEN Issue 5, Clause 7.2 / 8.8

Measurement procedure: ANSI C63.4-2014 using 50  $\mu$ H/50 ohms LISN

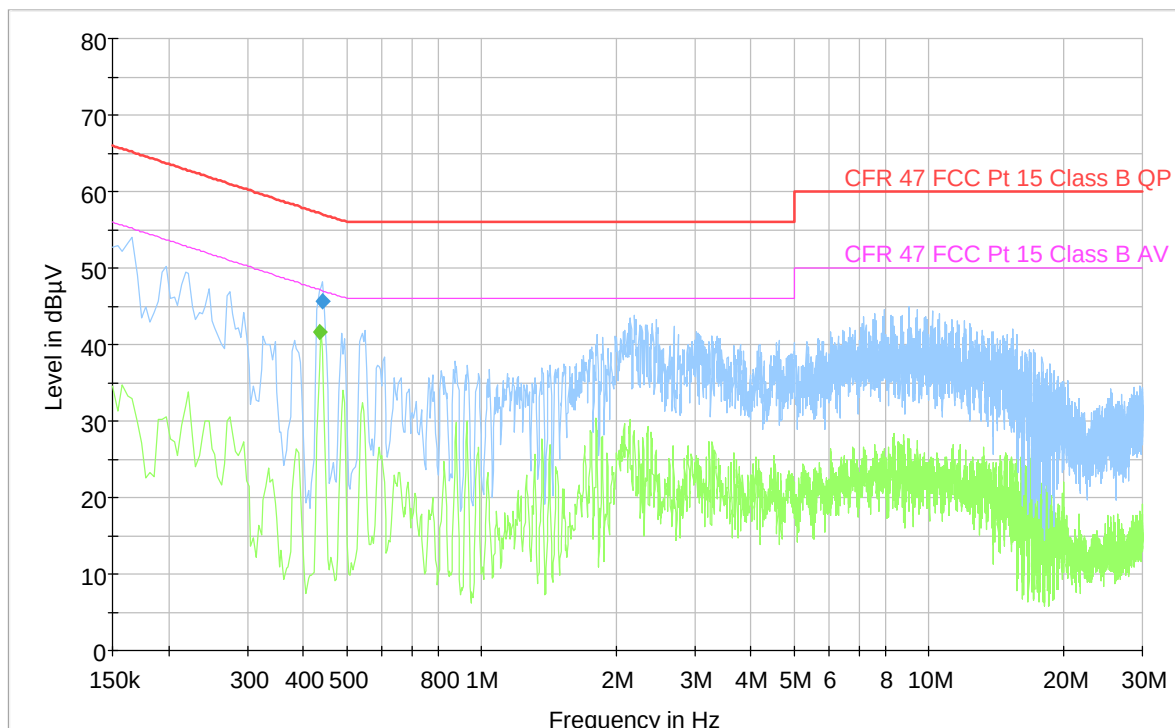
Test Results: Complies

Measurement Data: See attached plots

Highest measured value (L1 and N): 120Vac, 60Hz with USB AC/DC adapter , model no: SSW 2374

| Frequency (MHz) | QuasiPeak (dB $\mu$ V) | Average (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Filter |
|-----------------|------------------------|----------------------|--------------------|-------------|-----------------|-----------------|------|--------|
| 0.436           | ---                    | 41.58                | 47.14              | 5.56        | 1000            | 9               | L1   | OFF    |
| 0.440           | 45.65                  | ---                  | 57.06              | 11.42       | 1000            | 9               | L1   | OFF    |

Full Spectrum



### 3.3 Channel Separation

Para. No.: 15.247 (a)(1)

ISED RSS-247 Issue 2, Clause 5.1 (b)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.2

Test Results: Complies

#### Measurement Data:

|                                      |          |
|--------------------------------------|----------|
| Channel Separation:                  | 1 MHz    |
| Nominal value for Channel Separation | 0.88 MHz |

See attached plots

#### Requirement:

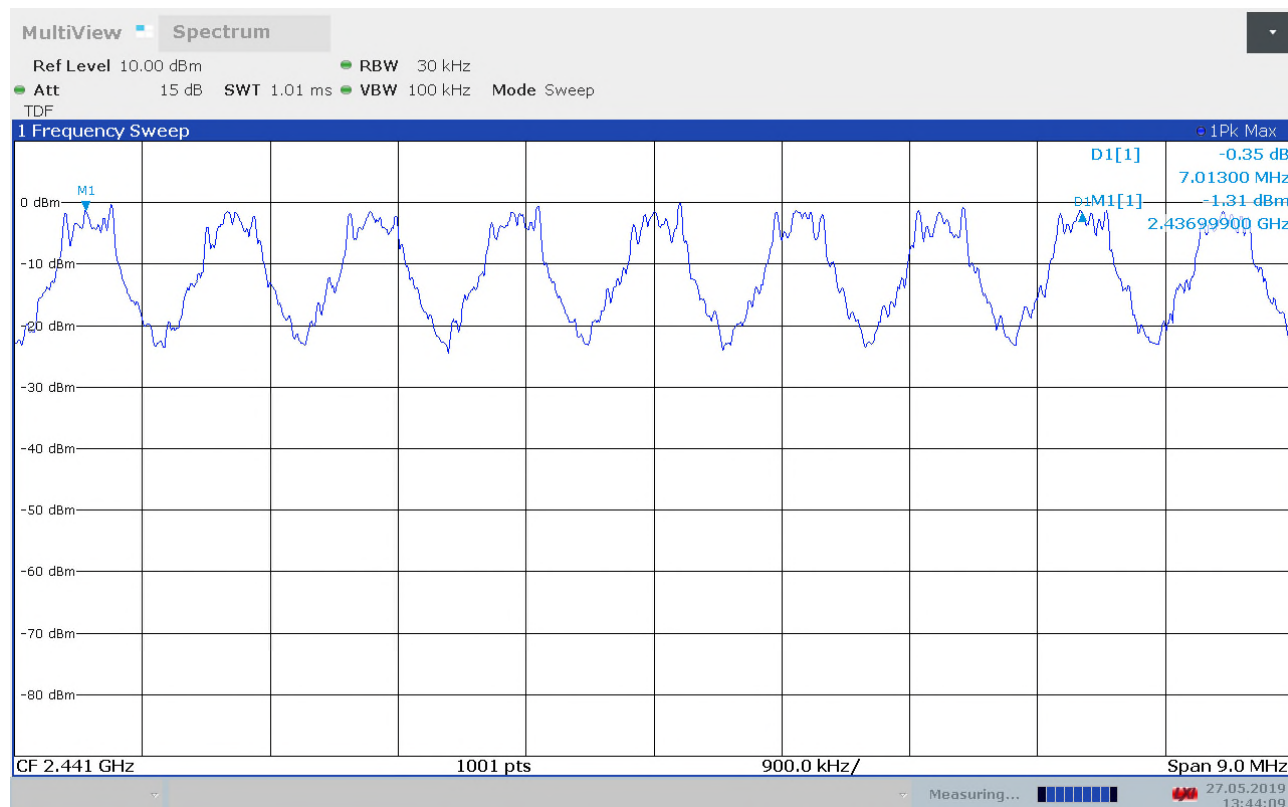
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

or:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the system operates with an output power no greater than 125 mW.

No requirements for Digital Transmission Systems.

## Channel Separation



### 3.4 Pseudorandom Hopping Algorithm

Para. No.: 15.247 (a)(1)

ISED Canada RSS-247 Issue 2, Clause 5.1

**Test Results: Complies**

**Measurement Data:** /

The hopping sequence follows the Bluetooth standard.

**Requirements:**

The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies. Each frequency must be used equally by the transmitter.

No requirements for Digital Transmission Systems.

### 3.5 Occupancy Time

Para. No.: 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 2, Clause 5.1 (c)

Measurement procedure: ANSI C63.10-2013 Clause 7.8.4

Test Results: Complies

#### Measurement Data:

|                                                      | DH1   | DH3    | DH5    |
|------------------------------------------------------|-------|--------|--------|
| Number of RF Channels:                               | 79    | 79     | 79     |
| Maximum Length of RF Burst pr. Channel, ms           | 0.292 | 1.19   | 2.22   |
| Minimum Time between RF Burst on same RF Channel, ms | 62.34 | 394.79 | 397.43 |
| Time of Occupancy, S                                 | 0.148 | 0.095  | 0.177  |

BT, 79 Ch Mode:

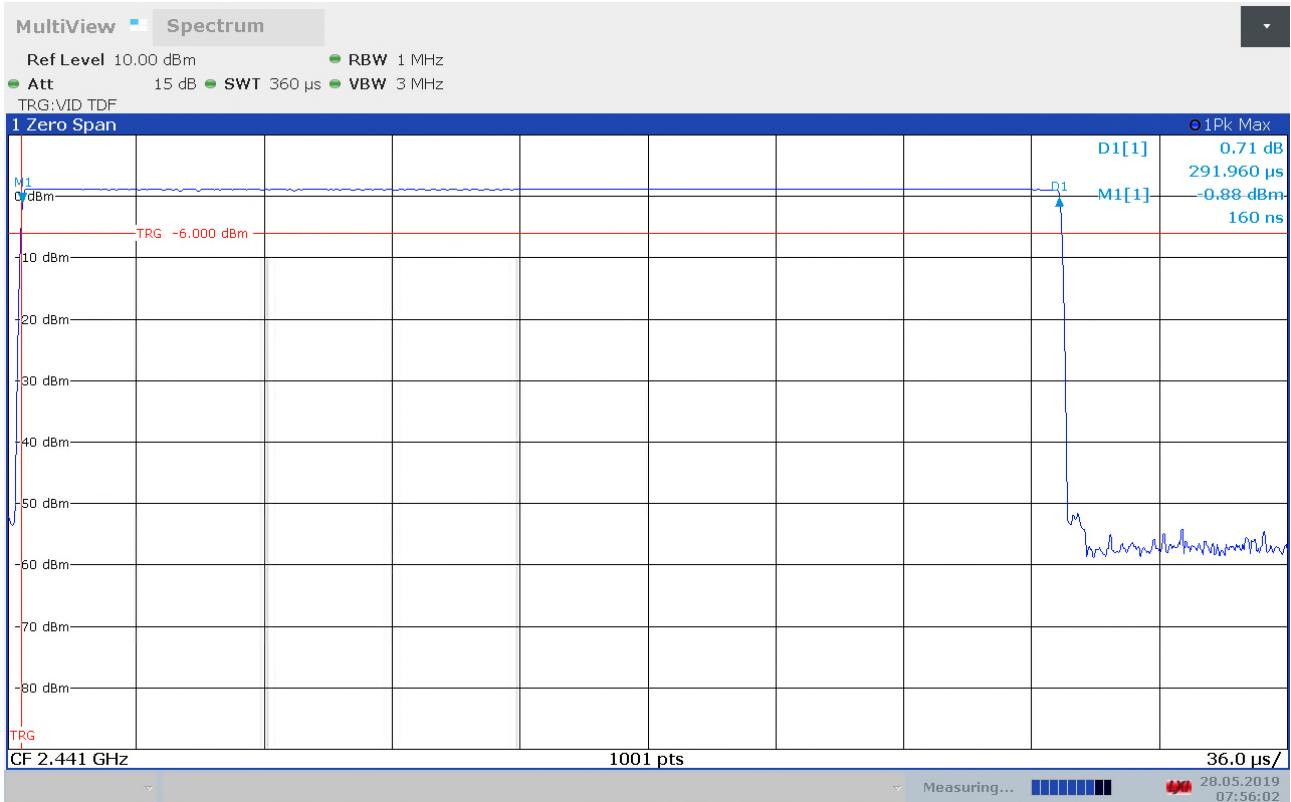
Time of occupancy:  $(0.292 \times 400 \times 79) / 62.34 = 148\text{ms}$

See attached graph.

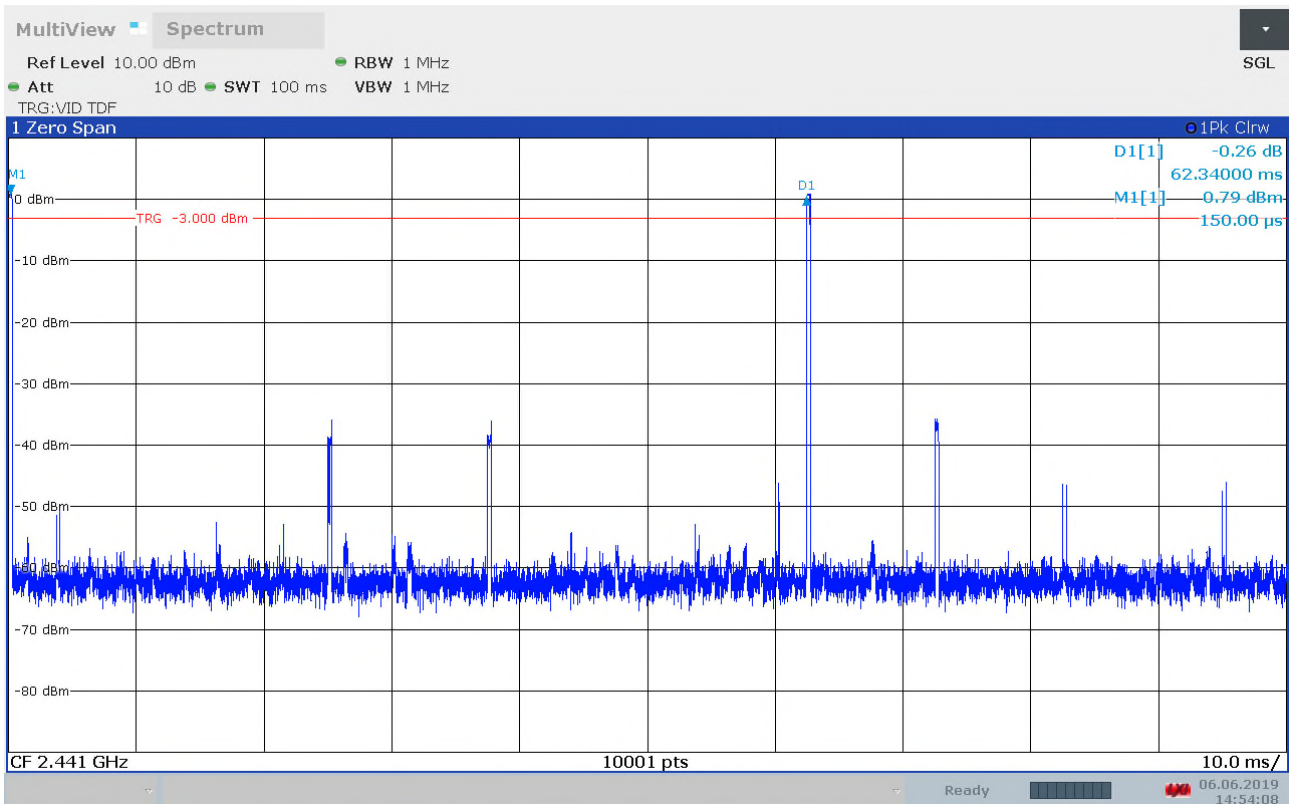
#### Requirements:

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.

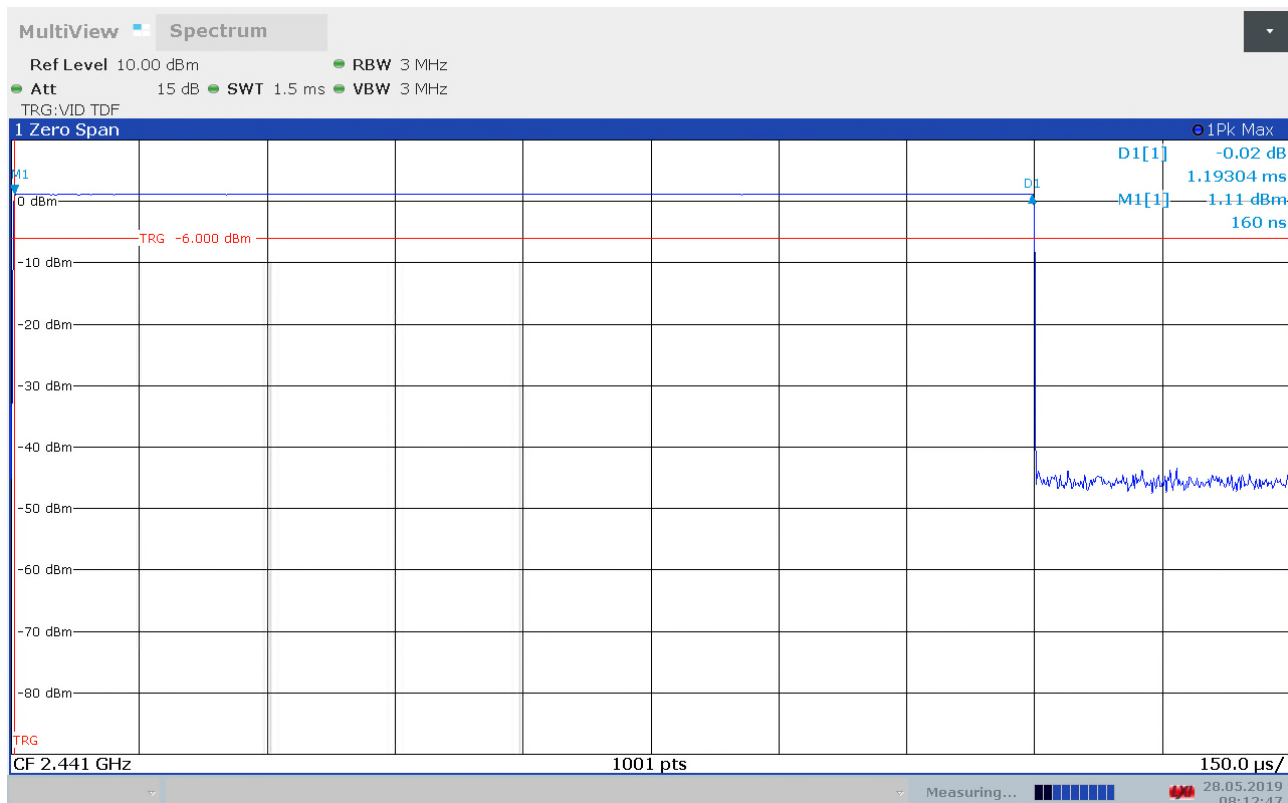
No requirements for Digital Transmission Systems.



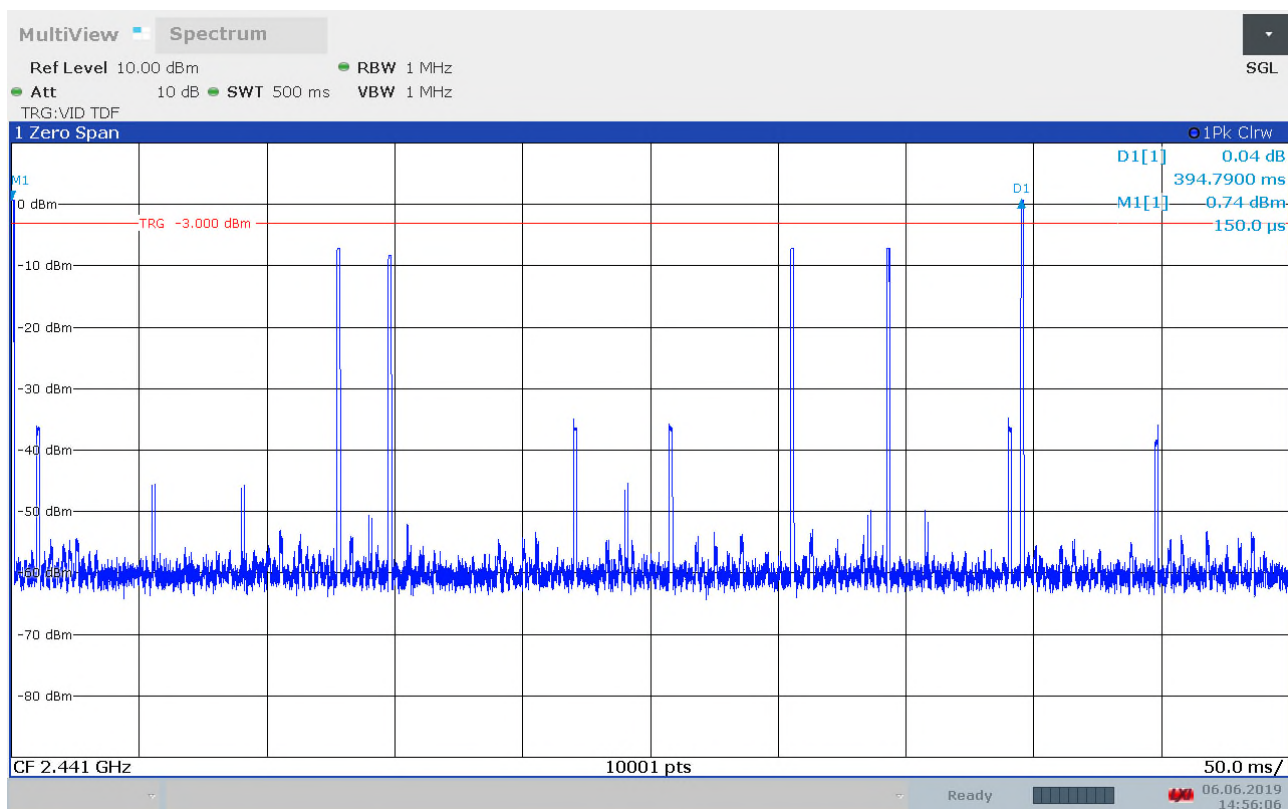
## Burst Length – DH1



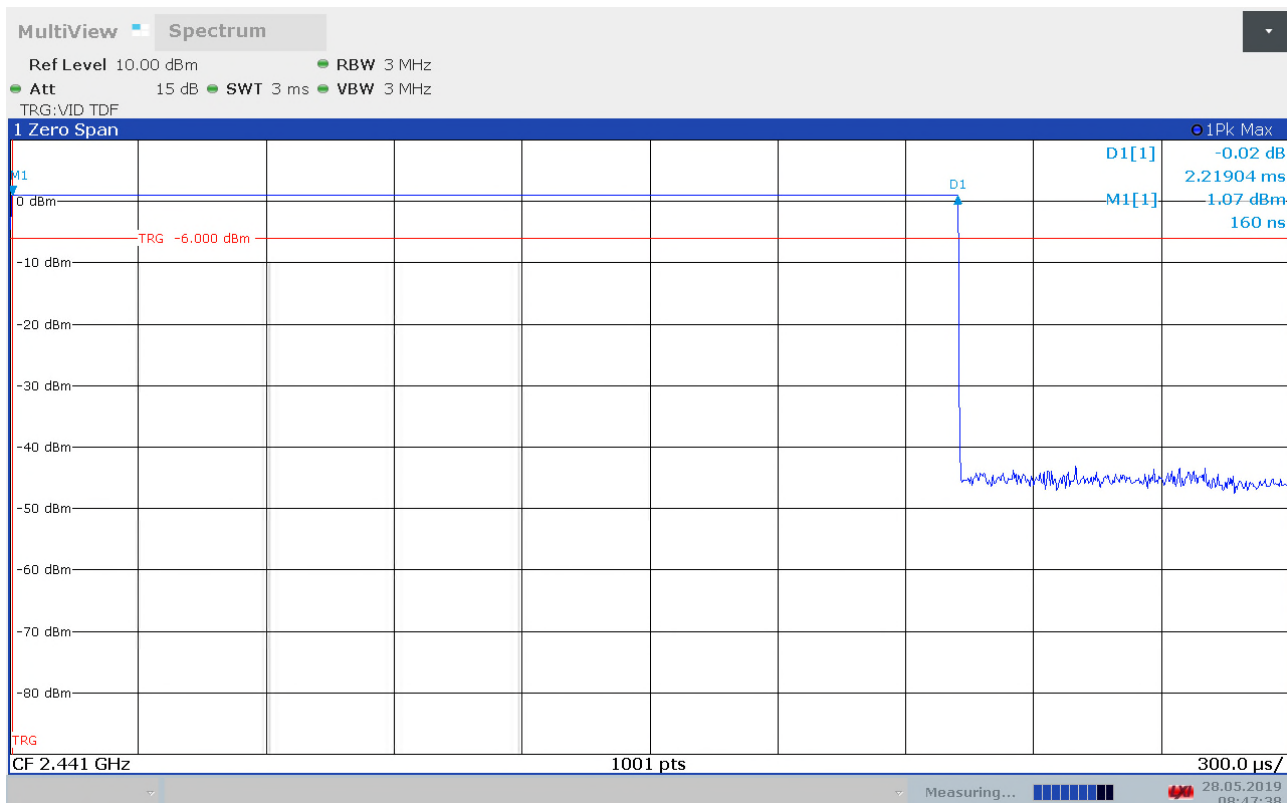
## Dwell Time – DH1



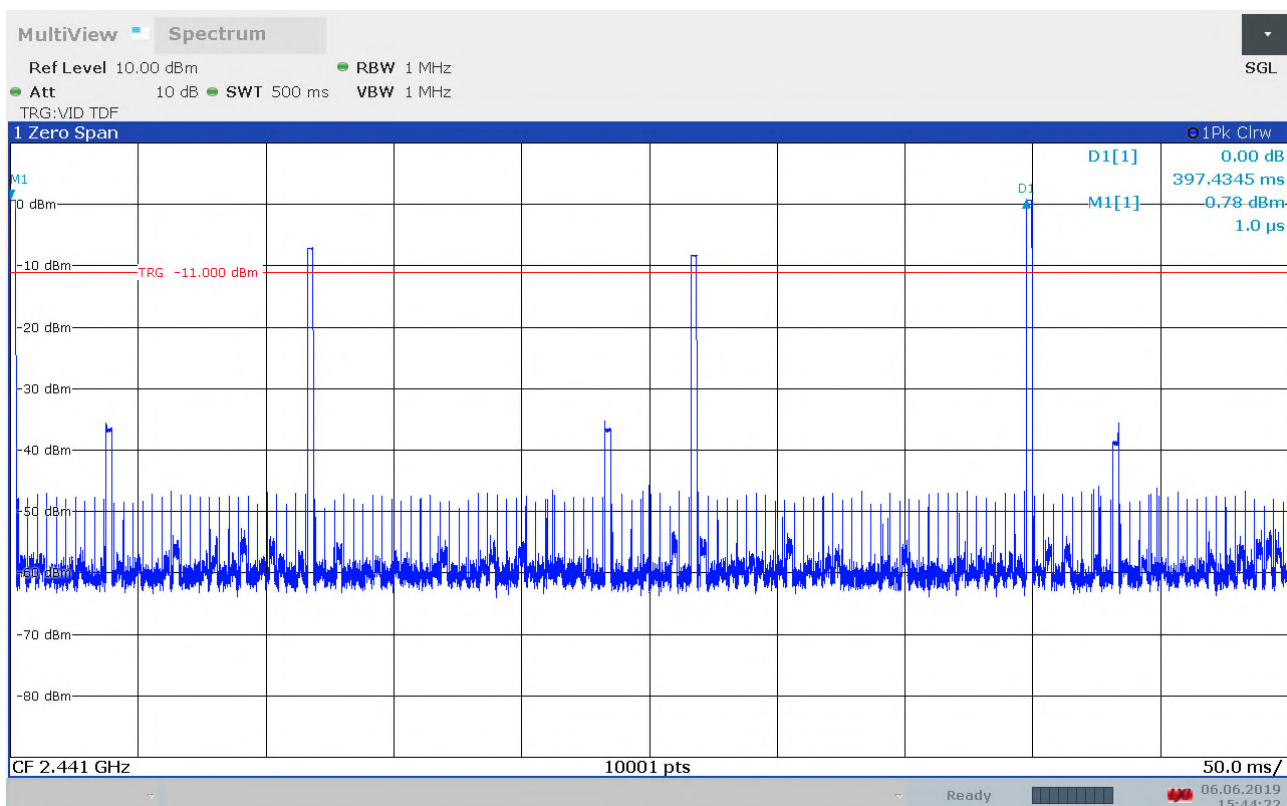
### Burst Length – DH3



### Dwell Time – DH3



## Burst Length – DH5



## Dwell Time – DH5

### 3.6 Occupied Bandwidth

Para. No.: 15.247 (a)(1)(iii)

ISED Canada RSS-247 Issue 2, Clause 5.1

ISED Canada RSS-GEN Issue 5, Clause 6.7

Measurement procedure: ANSI C63.10-2013 Clause 6.9.2 / 7.8.3

**Test Results: Complies**

#### Measurement Data:

|                               |                  |                  |                  |
|-------------------------------|------------------|------------------|------------------|
| Number of RF Channels in use: | 79               | 79               | 79               |
| Channel Centre Frequencies:   | 2402 to 2480 MHz | 2402 to 2480 MHz | 2402 to 2480 MHz |
| Modulation                    | GFSK             | 8DPSK            | 4 $\pi$ DPSK     |
| 99% BW, MHz                   | 0.874            | 1.22             | 1.22             |
| 20 dB BW, MHz                 | 1.11             | 1.46             | 1.45             |

RF channel has no influence on 20 dB bandwidth.

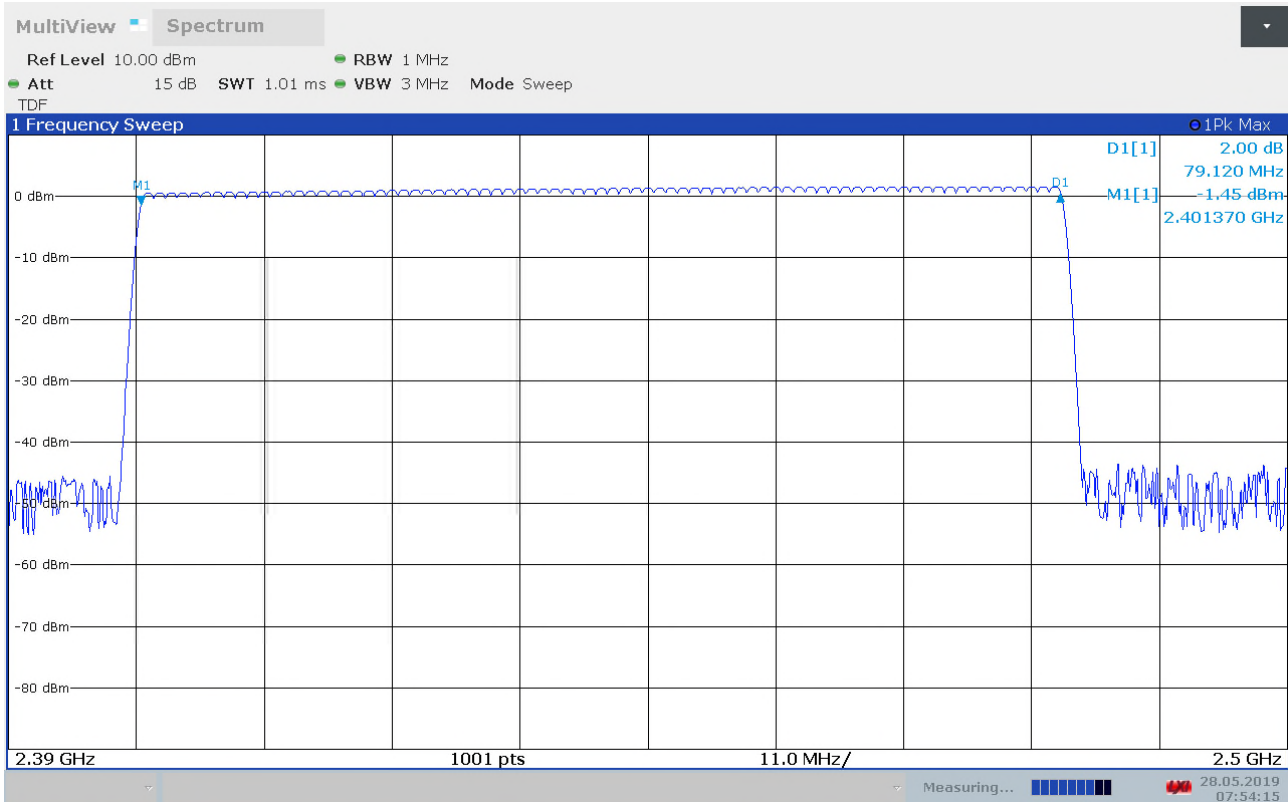
See attached plots.

#### Requirements:

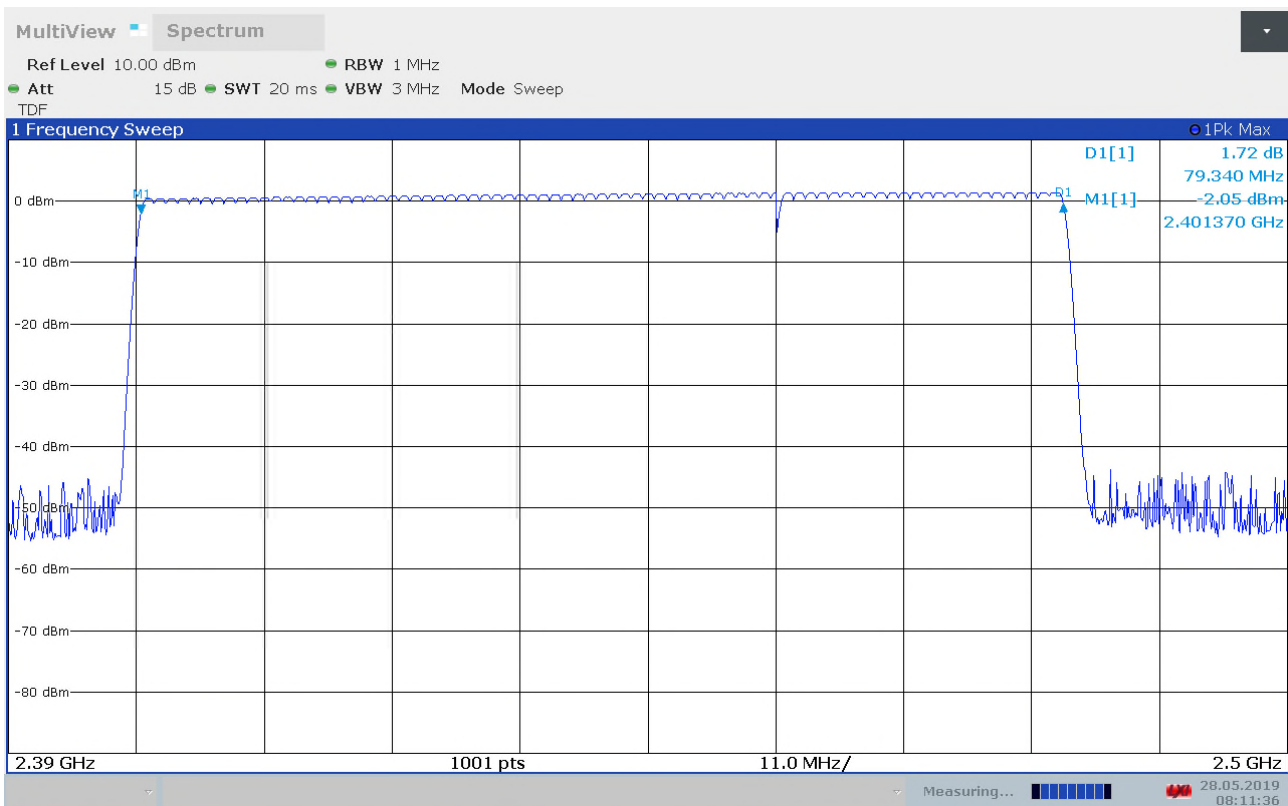
Frequency hopping systems in the 2400 - 2483.5 MHz band shall use at least 15 non-overlapping channels.  
No requirements for bandwidth for this frequency band.

No requirements for Digital Transmission Systems.

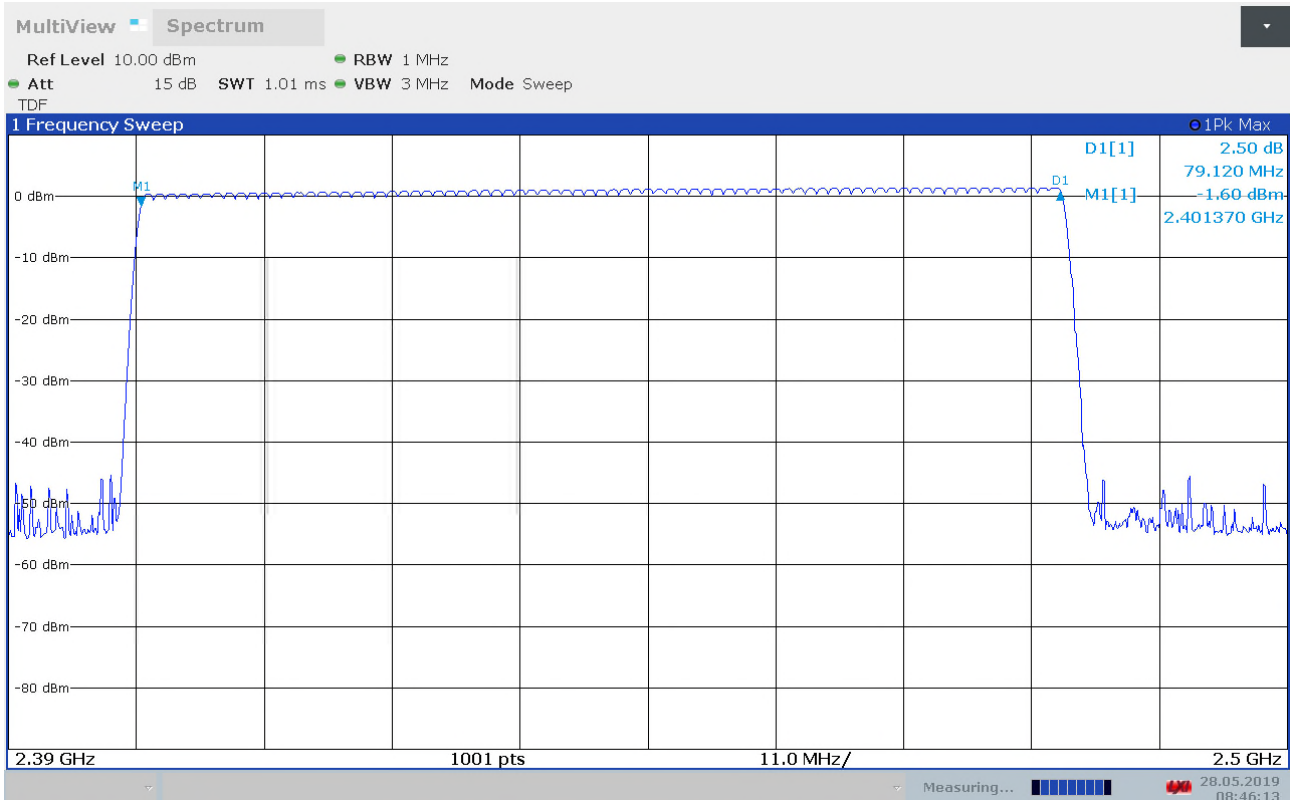
No requirement for 99% BW, reported for information only.



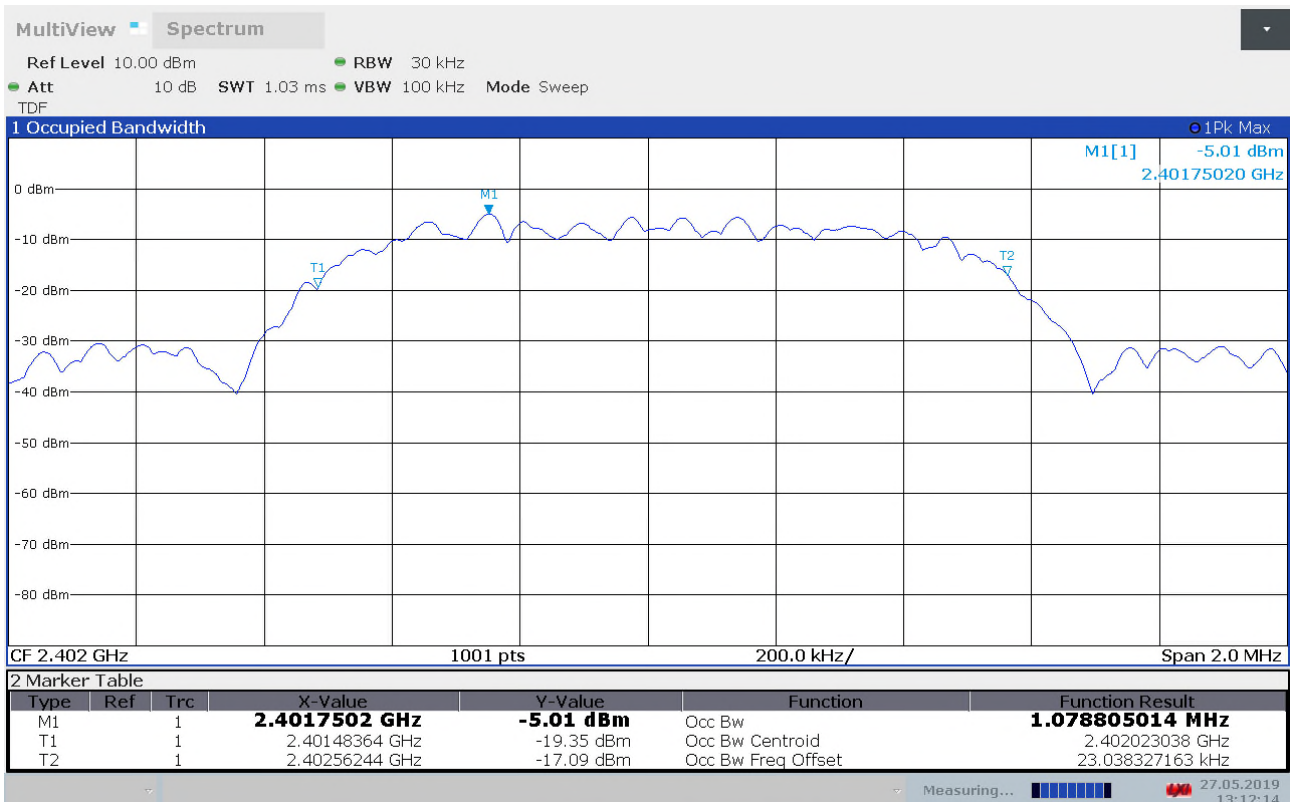
RF Channels in Use – DH1



RF Channels in Use – DH3



RF Channels in Use – DH5



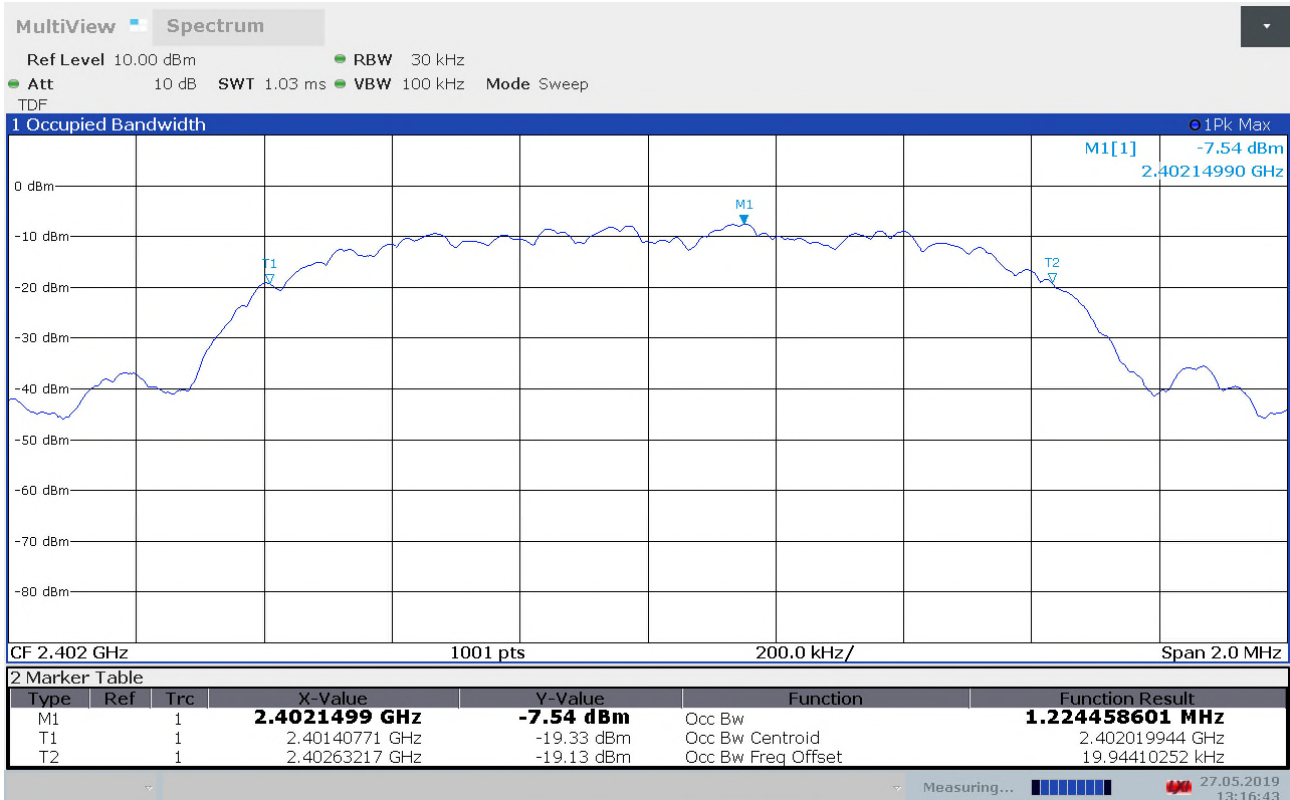
99% Bandwidth – GFSK, ch2402MHz



### 99% Bandwidth – GFSK, ch2441MHz



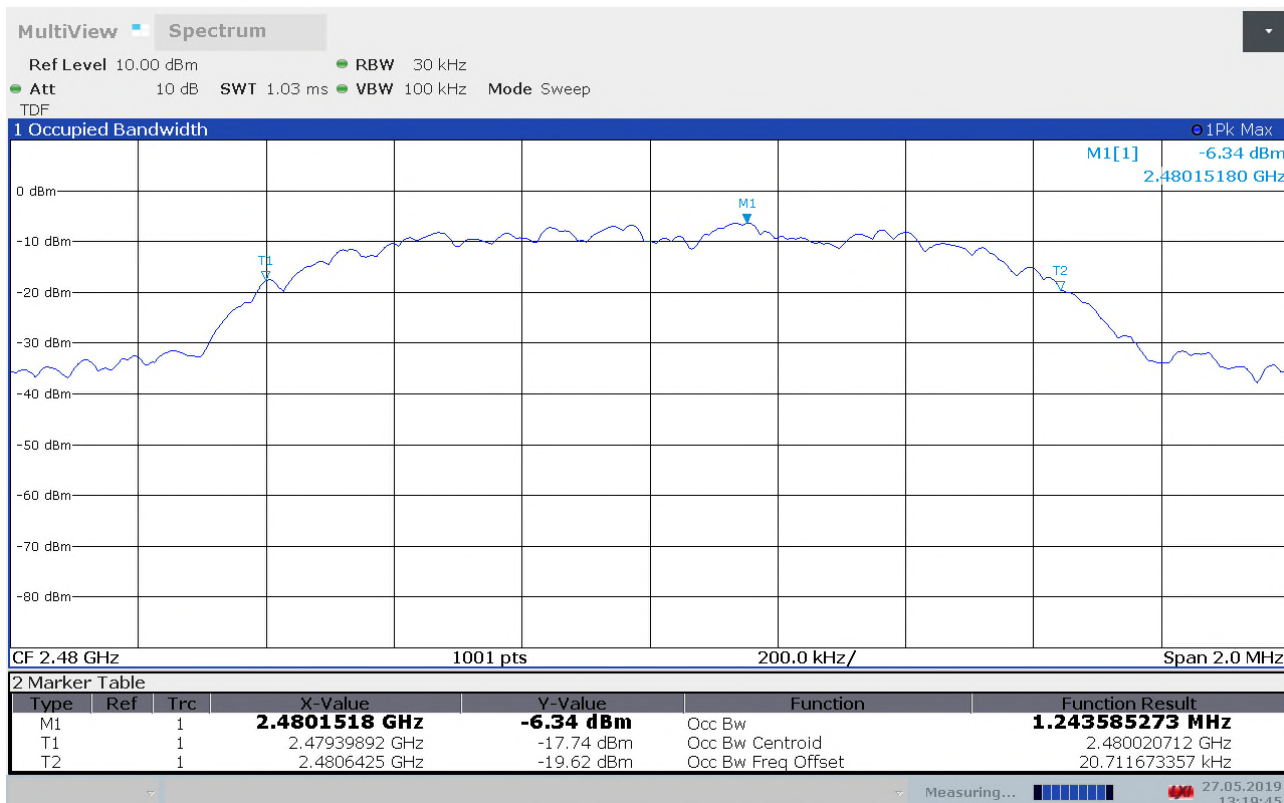
### 99% Bandwidth – GFSK, ch2480MHz



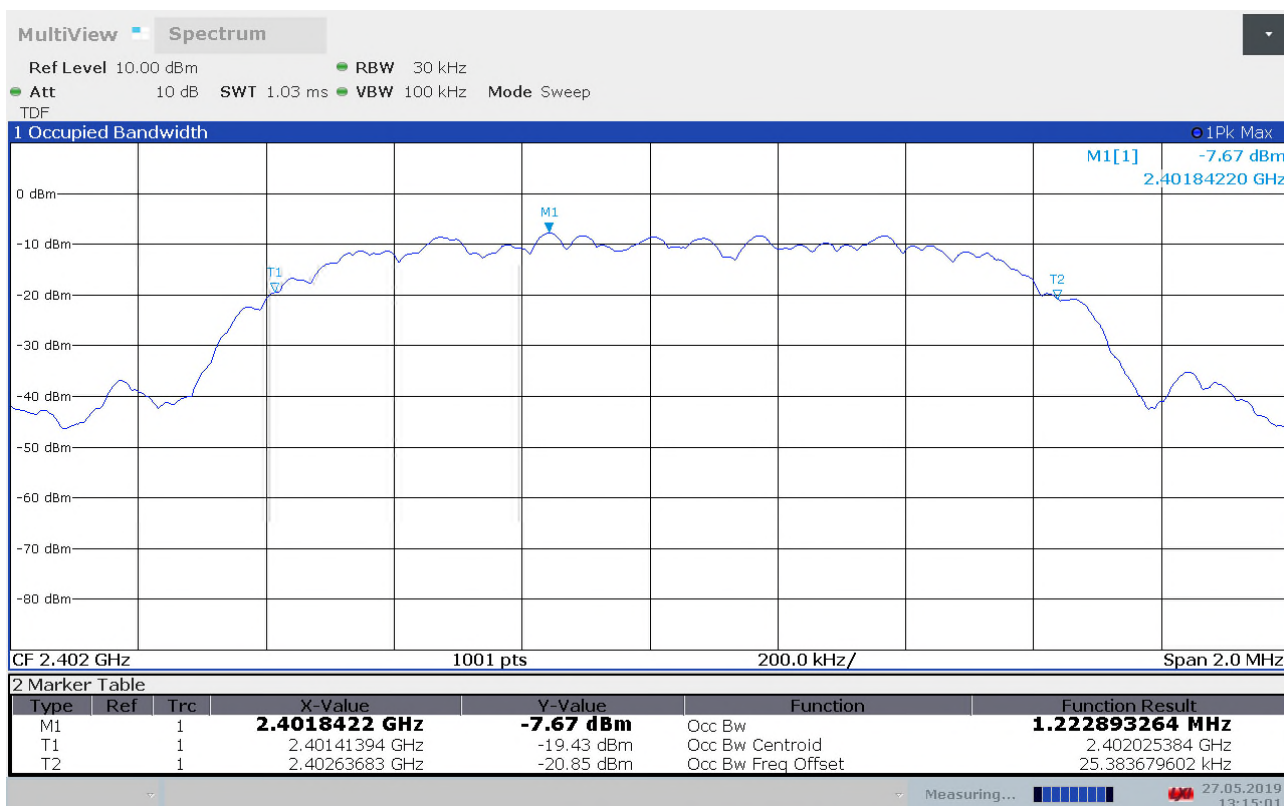
### 99% Bandwidth – 8DPSK, ch2402MHz



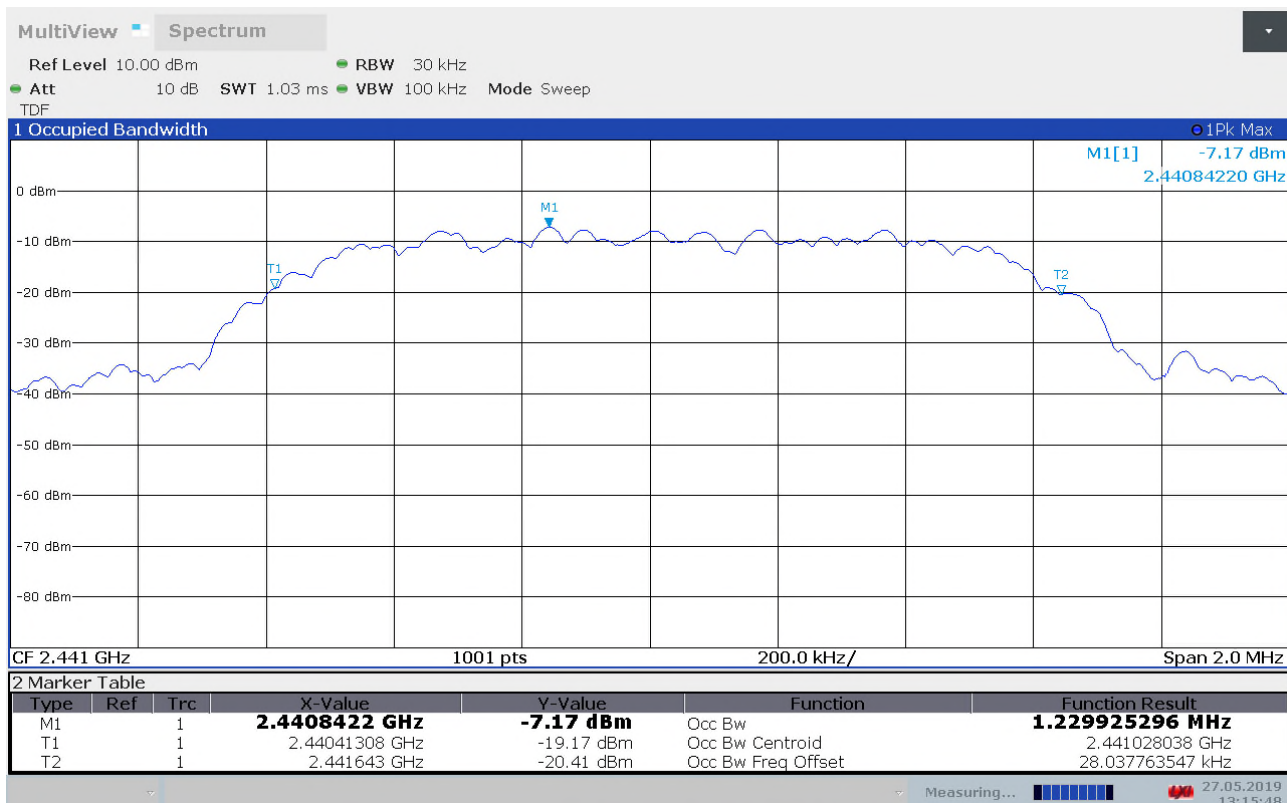
### 99% Bandwidth – 8DPSK, ch2441MHz



### 99% Bandwidth – 8DPSK, ch2480MHz



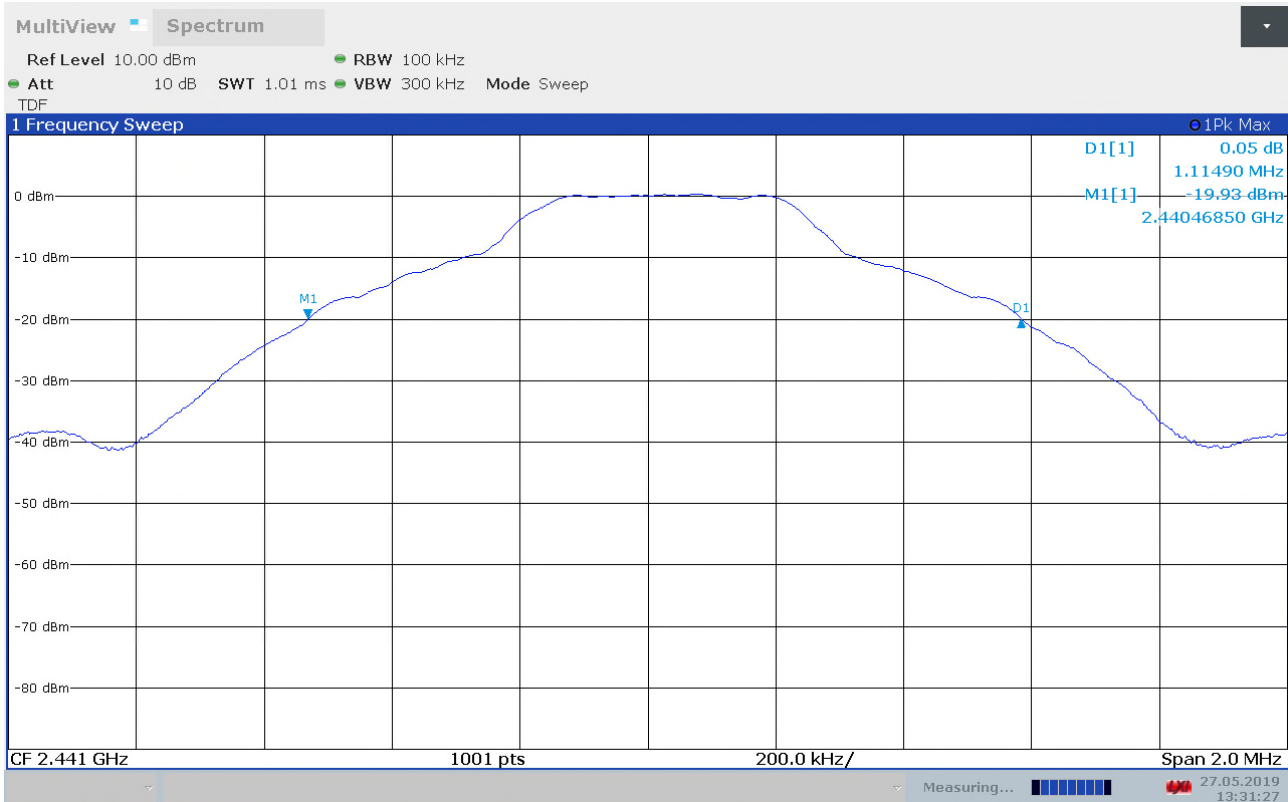
### 99% Bandwidth – 4πDPSK, ch2402MHz



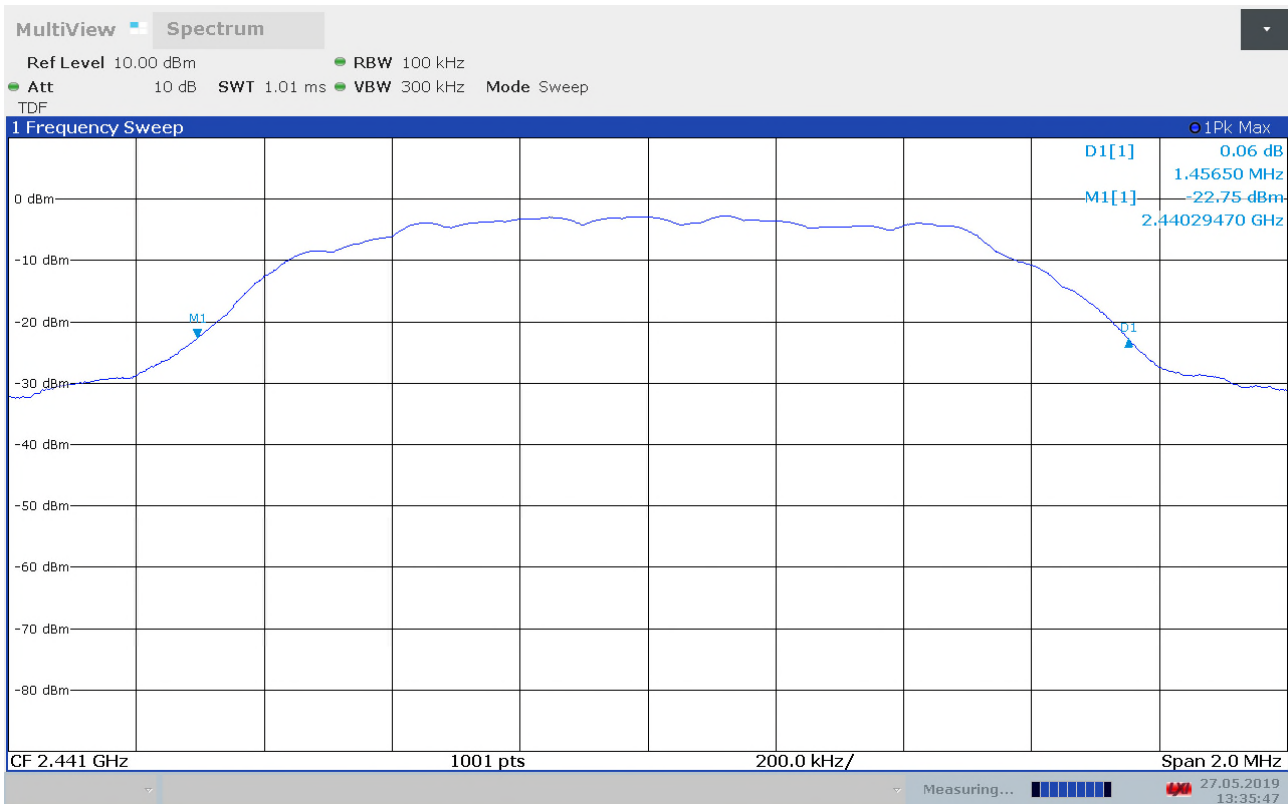
### 99% Bandwidth – 4πDPSK, ch2441MHz



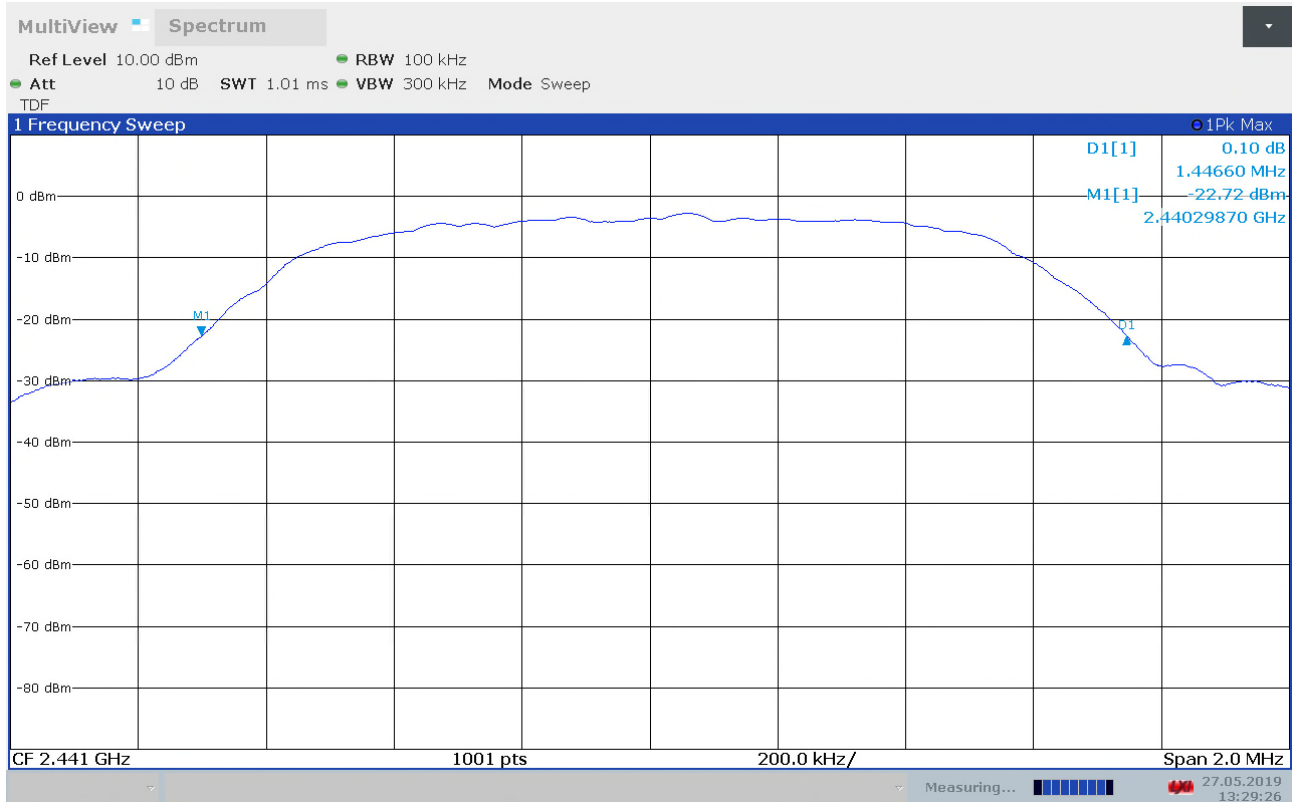
### 99% Bandwidth – 4πDPSK, ch2480MHz



20 dB BW – GFSK, ch 2441MHz



20 dB BW – 8DPSK, ch 2441MHz



20 dB BW – 4 $\pi$ DPSK, ch 2441MHz

### 3.7 Peak Power Output

FCC part 15.247 (b)

ISED Canada RSS-247 Issue 2, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

#### Measurement Data:

| Mode    |                            | 2402 MHz | 2441 MHz | 2480 MHz |
|---------|----------------------------|----------|----------|----------|
| GFSK    | Conducted Power (dBm)      | 0.22     | 0.93     | 1.21     |
|         | Conducted Power (mW)       | 1.05     | 1.24     | 1.32     |
|         | Field Strength (dBμV/m),VP | 96.47    | 97.41    | 97.13    |
|         | EIRP, Calculated (mW)      | 1.33     | 1.65     | 1.55     |
|         | Antenna gain (dBi)         | 1.0      | 1.3      | 0.7      |
| 8-DPSK  | Conducted Power (dBm)      | 1.54     | 1.96     | 1.99     |
|         | Conducted Power (mW)       | 1.43     | 1.57     | 1.58     |
|         | Field Strength (dBμV/m),VP | 100.17   | 100.62   | 99.87    |
|         | EIRP, Calculated (mW)      | 3.12     | 3.46     | 2.91     |
|         | Antenna gain (dBi)         | 3.4      | 3.4      | 2.7      |
| 4π-DPSK | Conducted Power (dBm)      | 0.9      | 1.44     | 1.61     |
|         | Conducted Power (mW)       | 1.23     | 1.39     | 1.45     |
|         | Field Strength (dBμV/m),VP | 96.90    | 96.45    | 99.51    |
|         | EIRP, Calculated (mW)      | 1.47     | 1.32     | 2.68     |
|         | Antenna gain (dBi)         | 0.8      | -0.2     | 2.7      |

Maximum field strength is obtained in VP

Antenna gain =  $10 \cdot \log(\text{EIRP} / \text{Conducted power})$  dBi

EIRP is calculated from measured field strength by the formulas in KDB 412172 D01.

See attached plots.

#### Requirements:

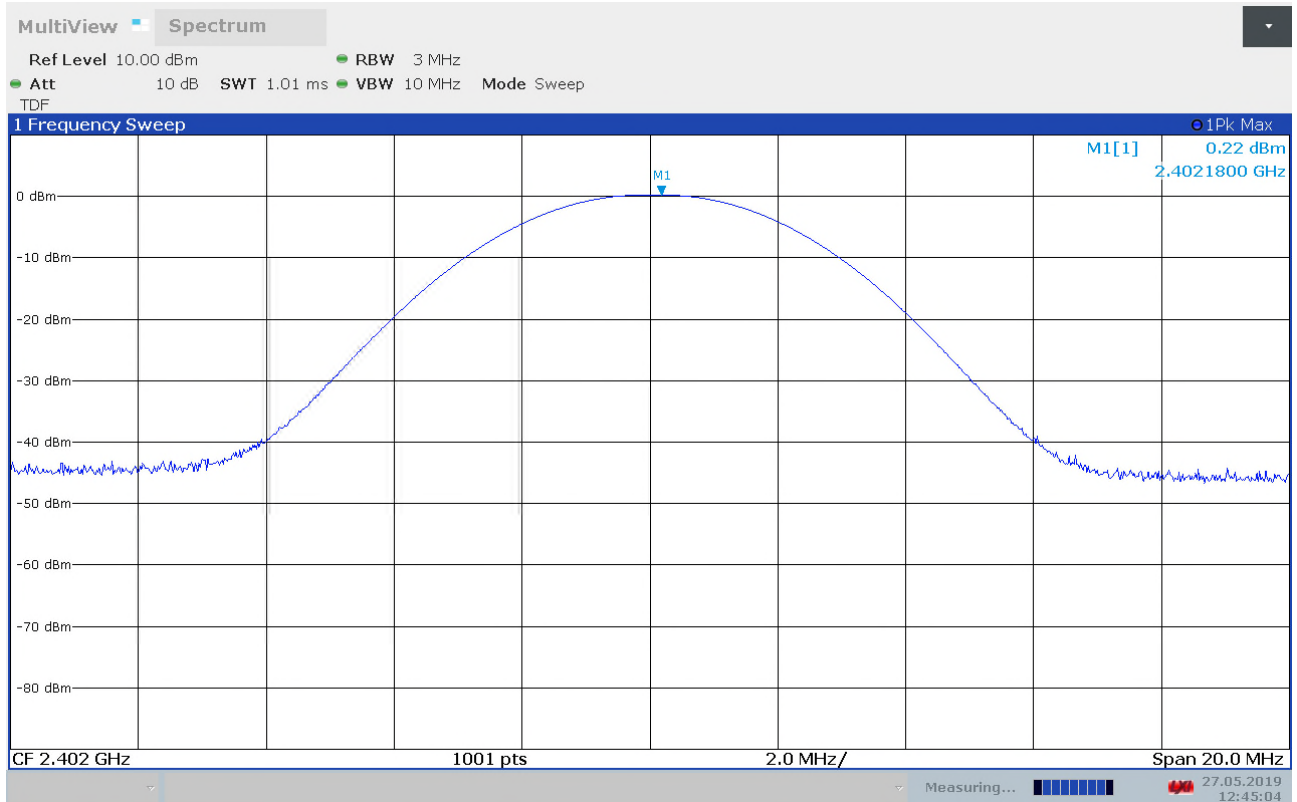
The maximum peak output power shall not exceed the following limits:

For frequency hopping systems employing at least 75 hopping channels: 1 Watt

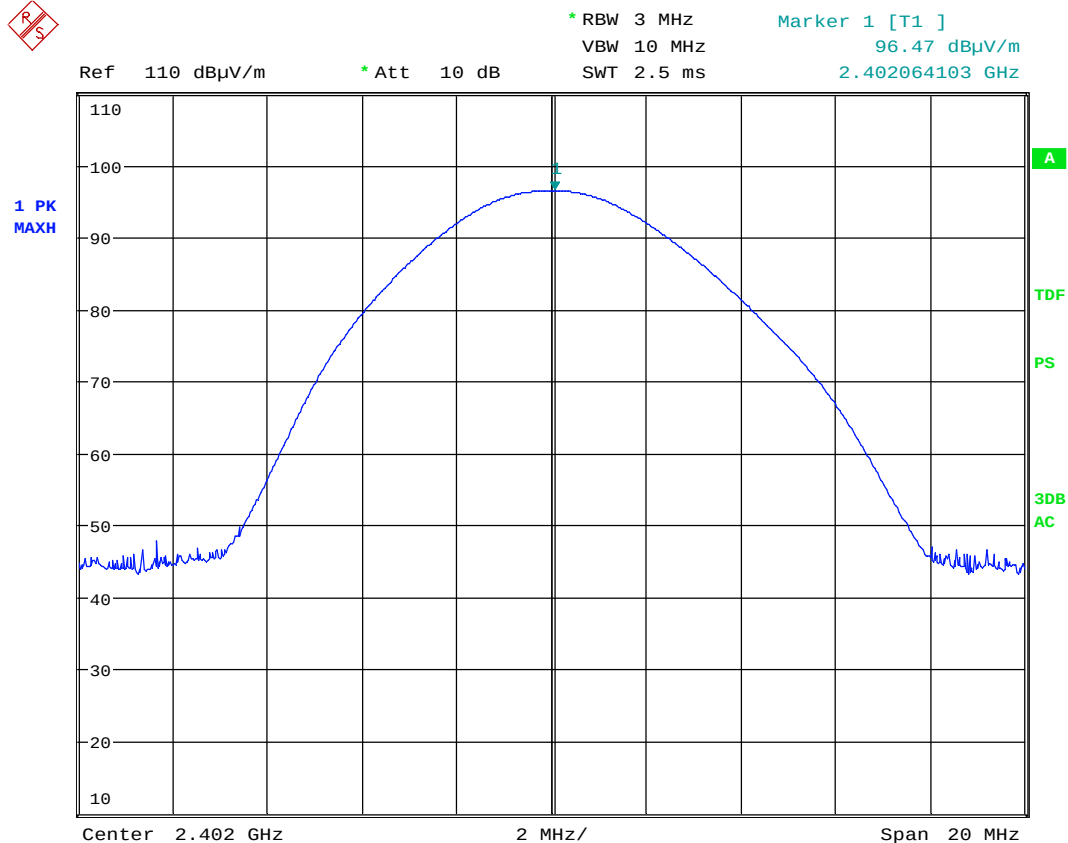
For all other frequency hopping systems in the 2400 - 2483.5 MHz band: 0.125 Watts

For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

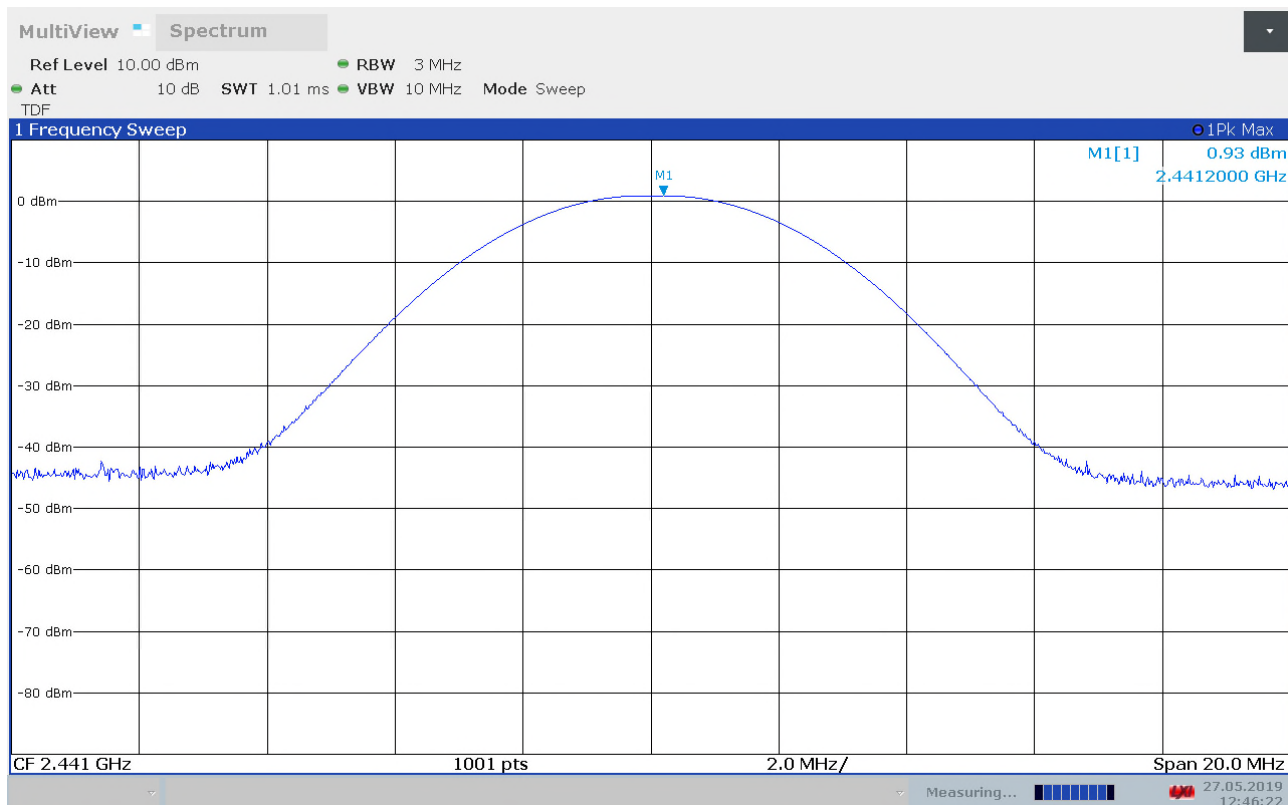


Conducted output Power, ch2402MHz , GFSK

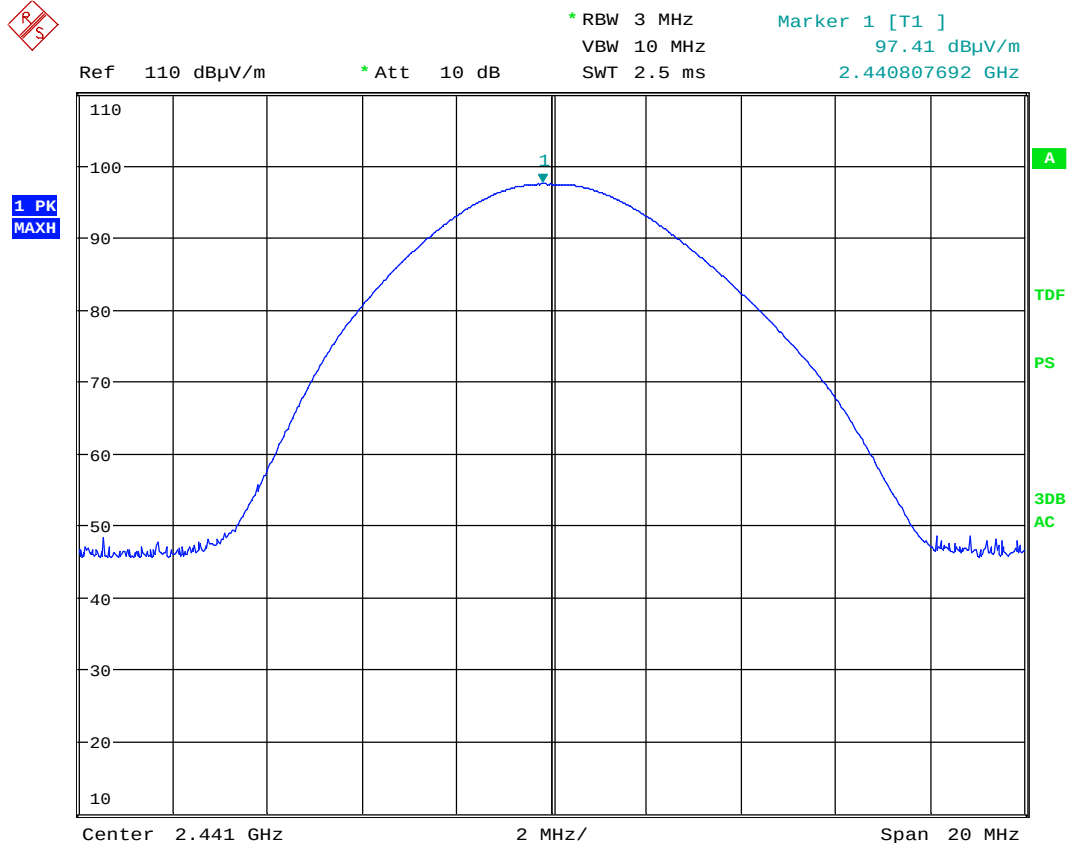


Date: 4.JUN.2019 10:21:12

**Radiated field strength-VP, ch2402MHz , GFSK**

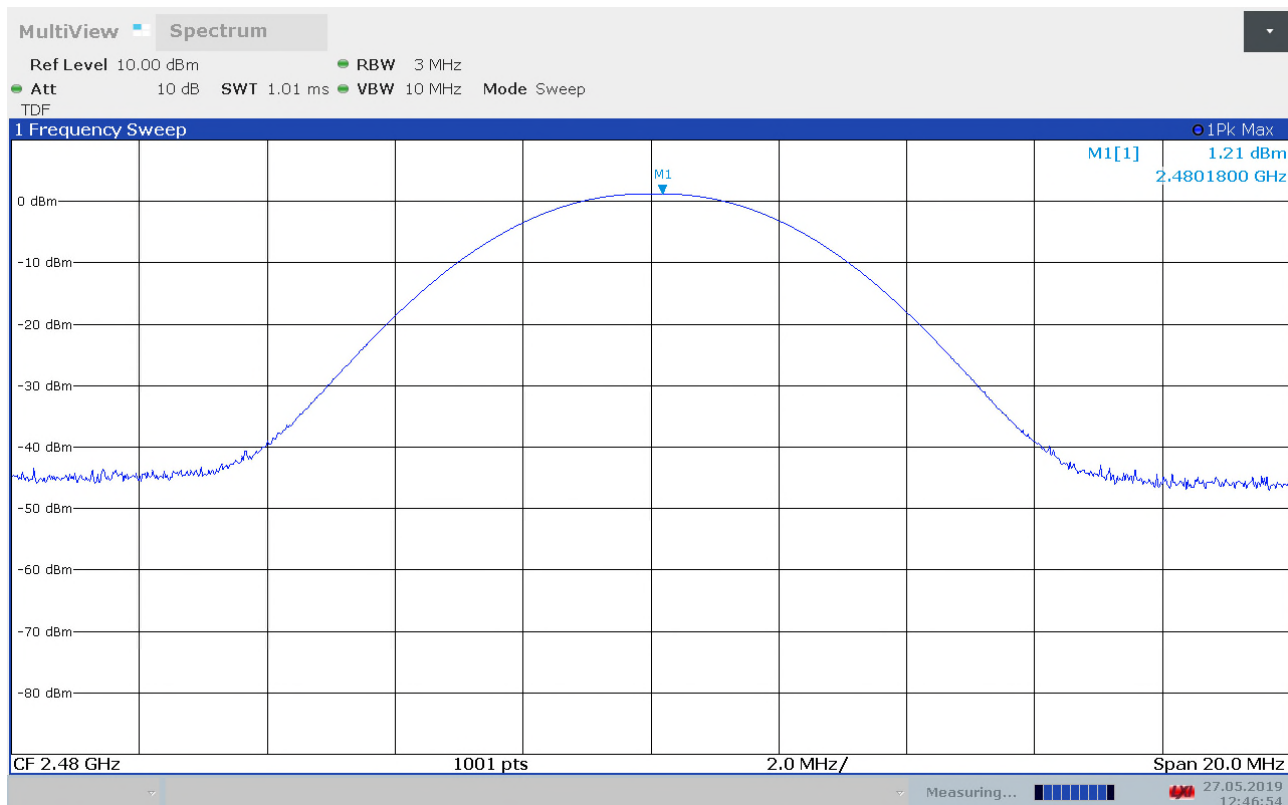


Conducted output Power, ch2441MHz , GFSK

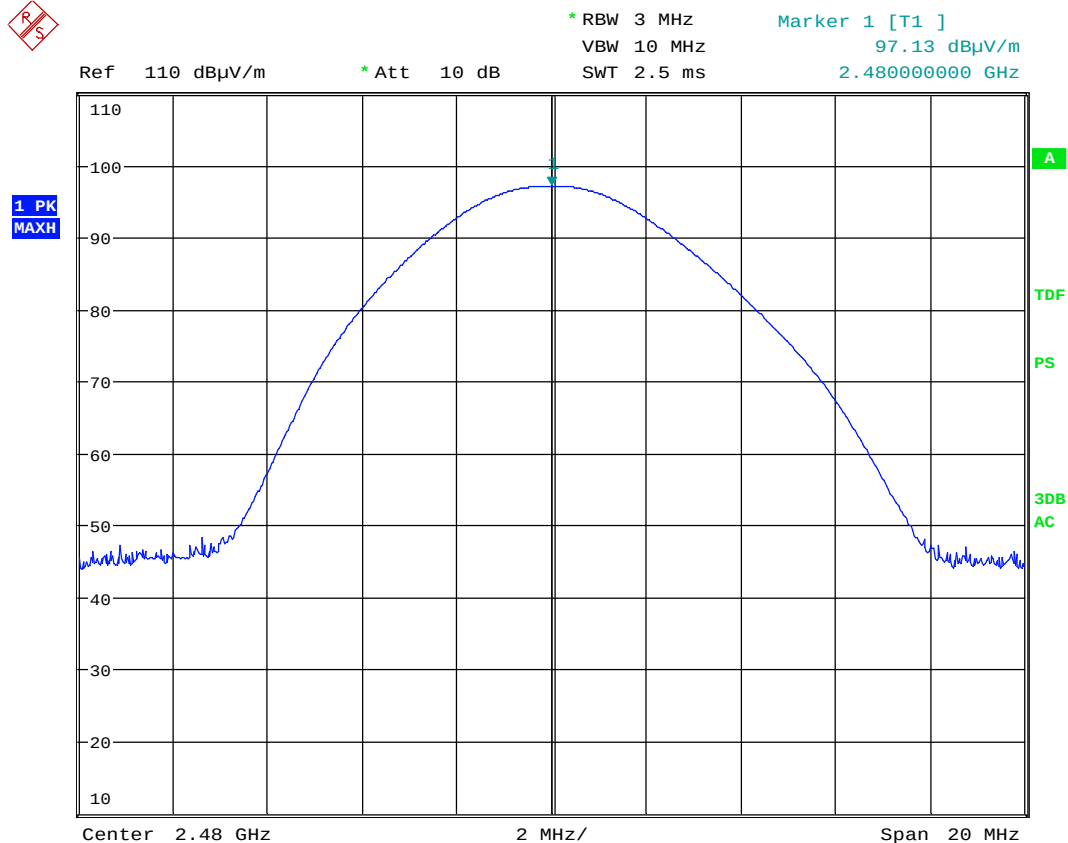


Date: 4.JUN.2019 10:27:58

**Radiated field strength-VP, ch2441MHz , GFSK**

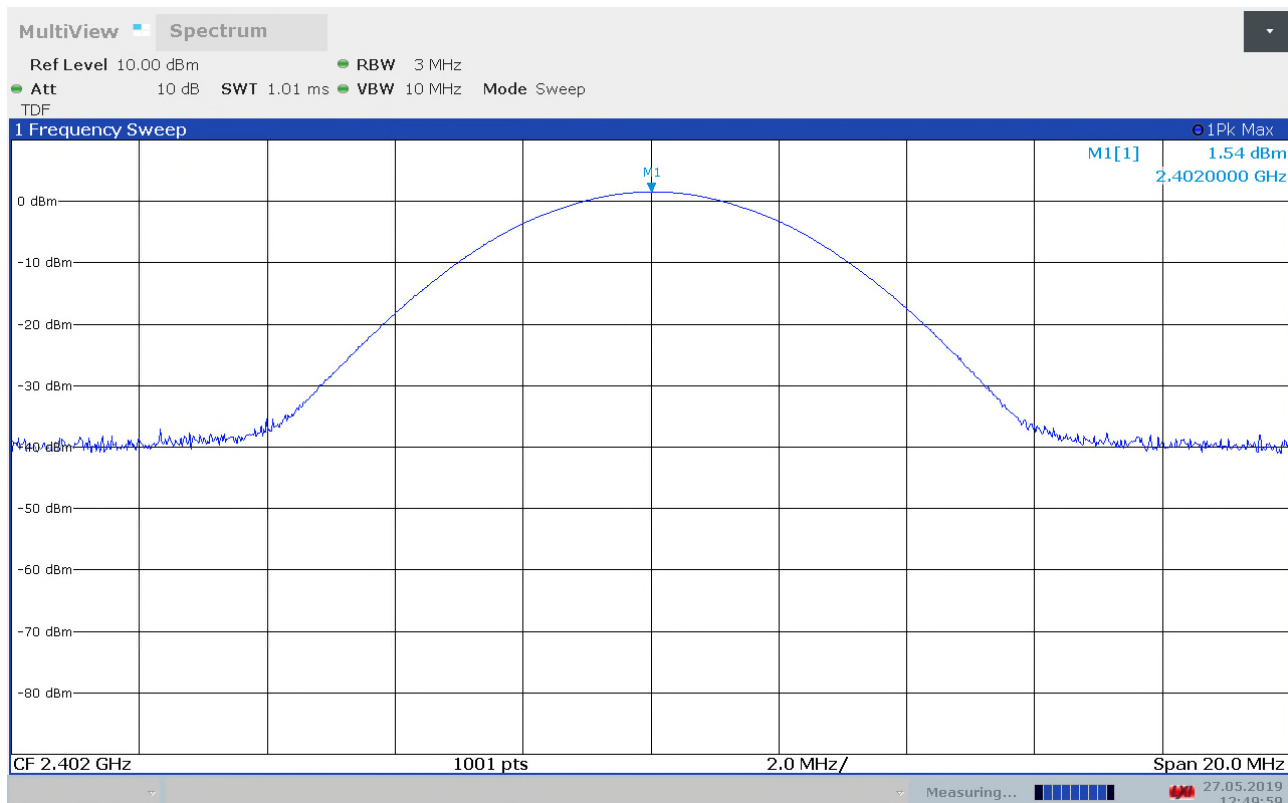


Conducted output Power, ch2480MHz , GFSK

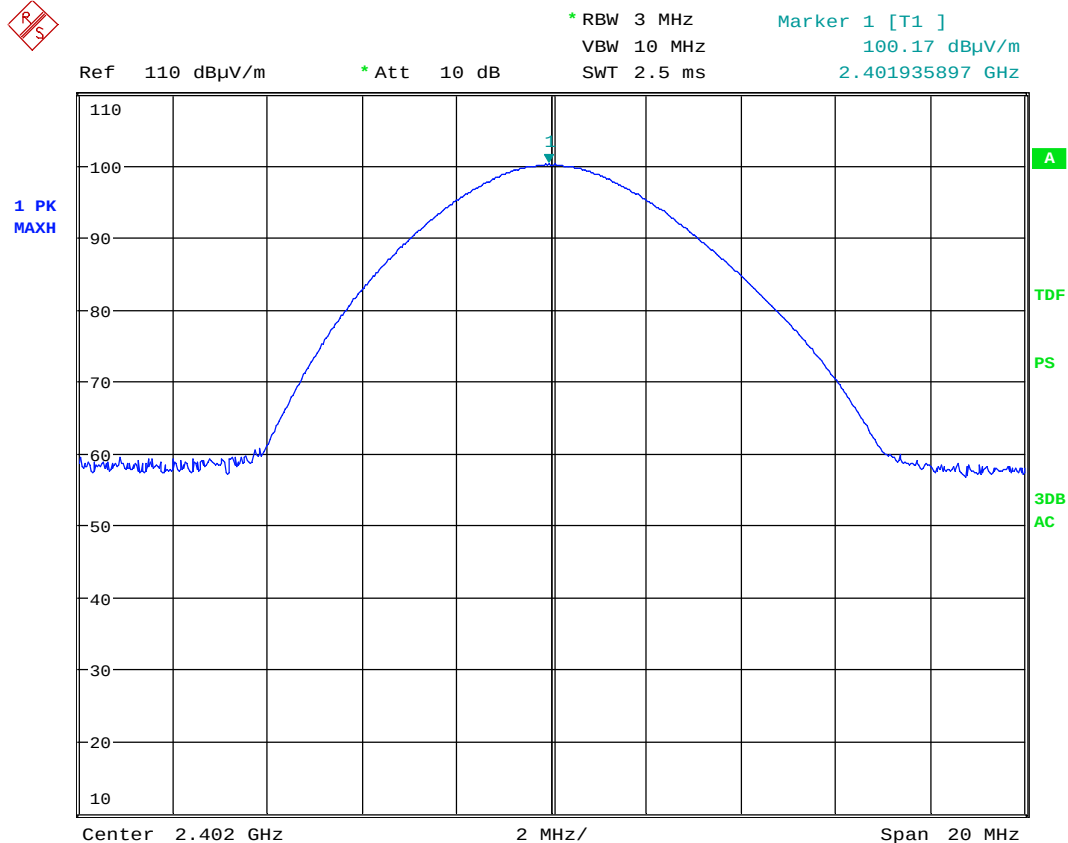


Date: 4.JUN.2019 10:31:24

**Radiated field strength-VP, ch2480MHz , GFSK**

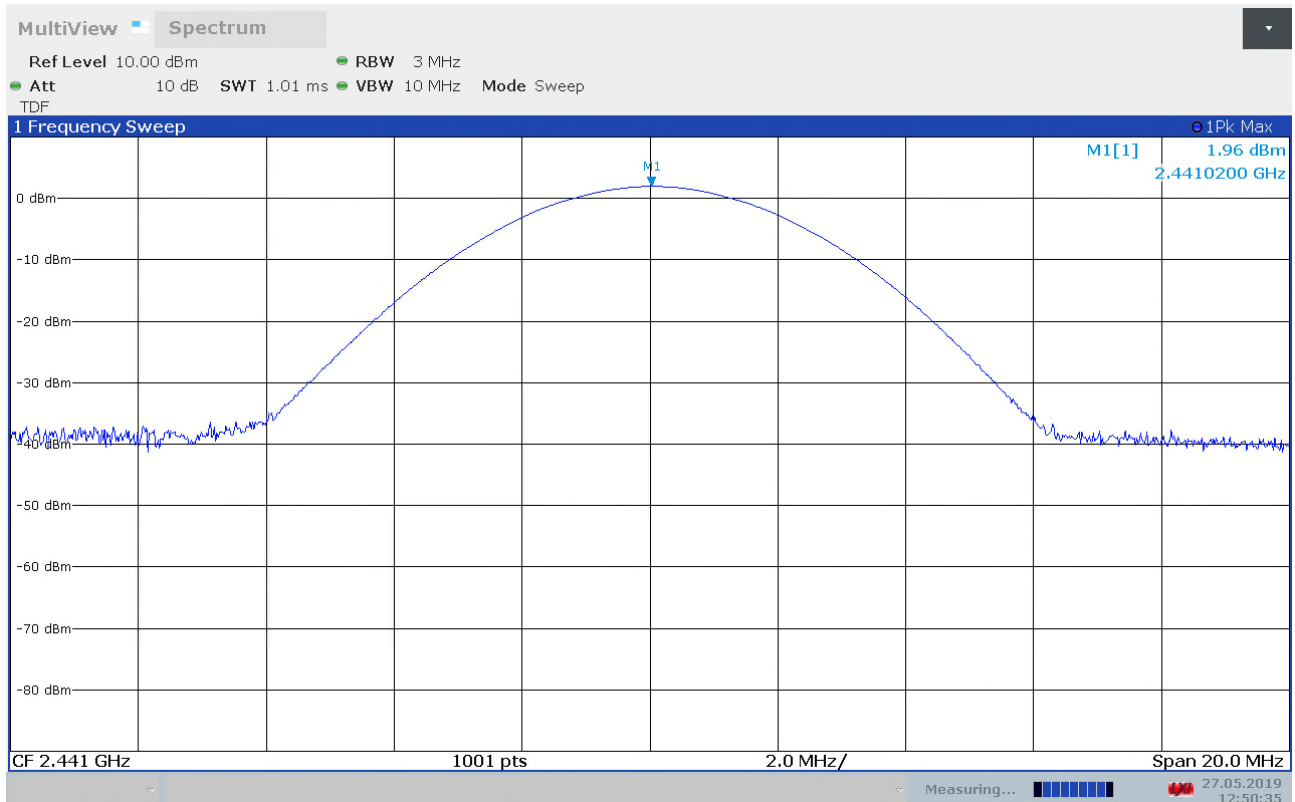


Conducted output Power, ch2402MHz , 8DPSK

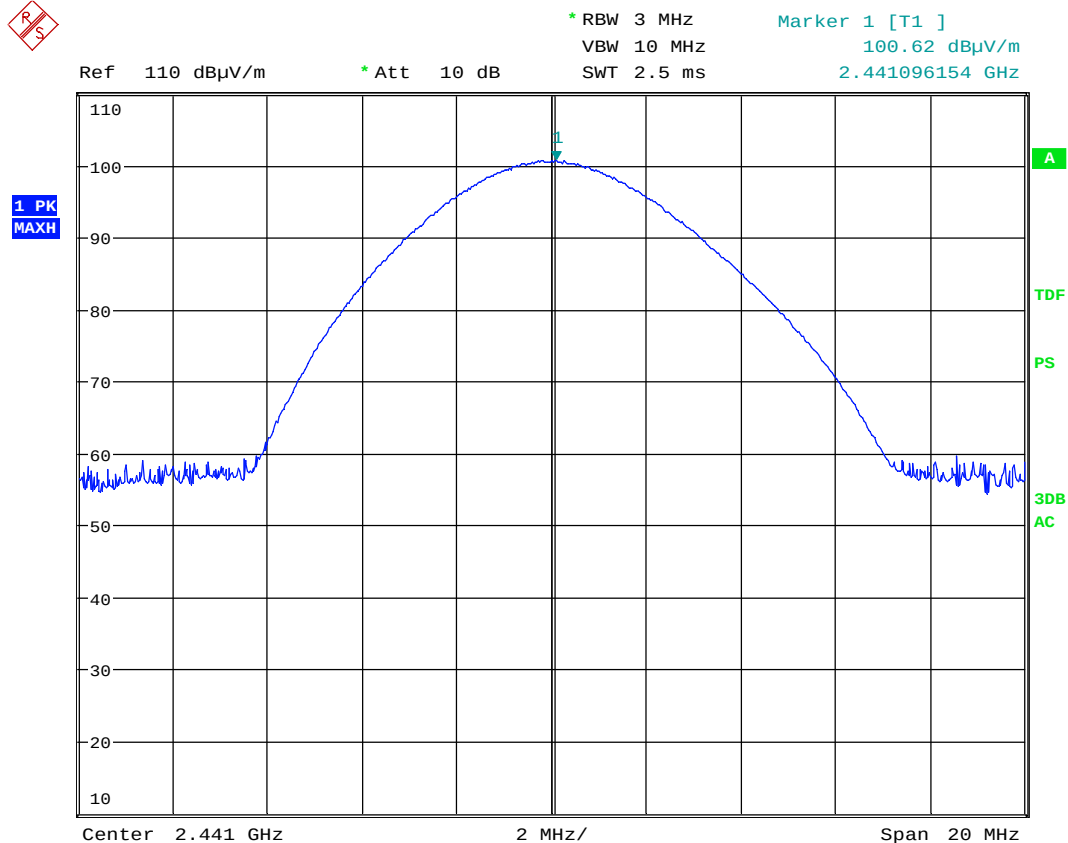


Date: 4.JUN.2019 09:12:56

**Radiated field strength-VP, ch2402MHz , 8DPSK**

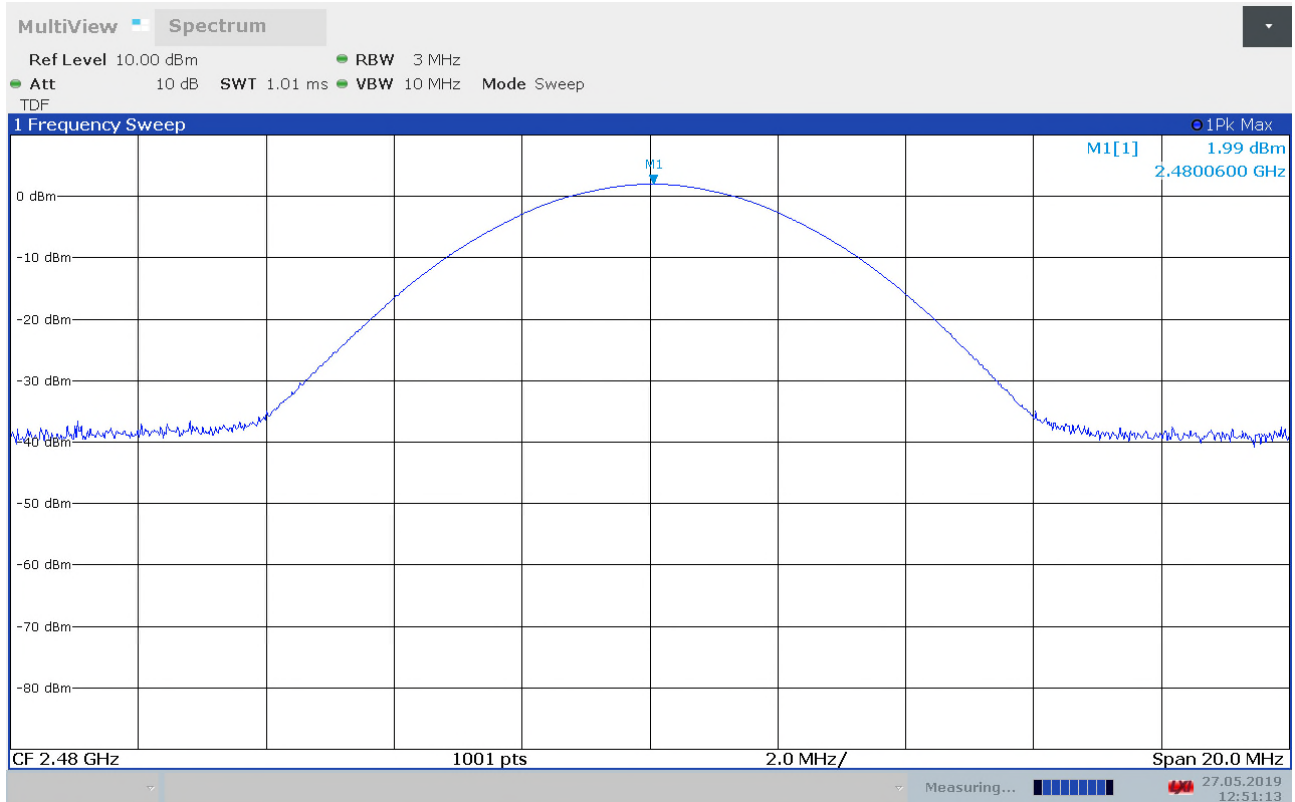


Conducted output Power, ch2441MHz , 8DPSK

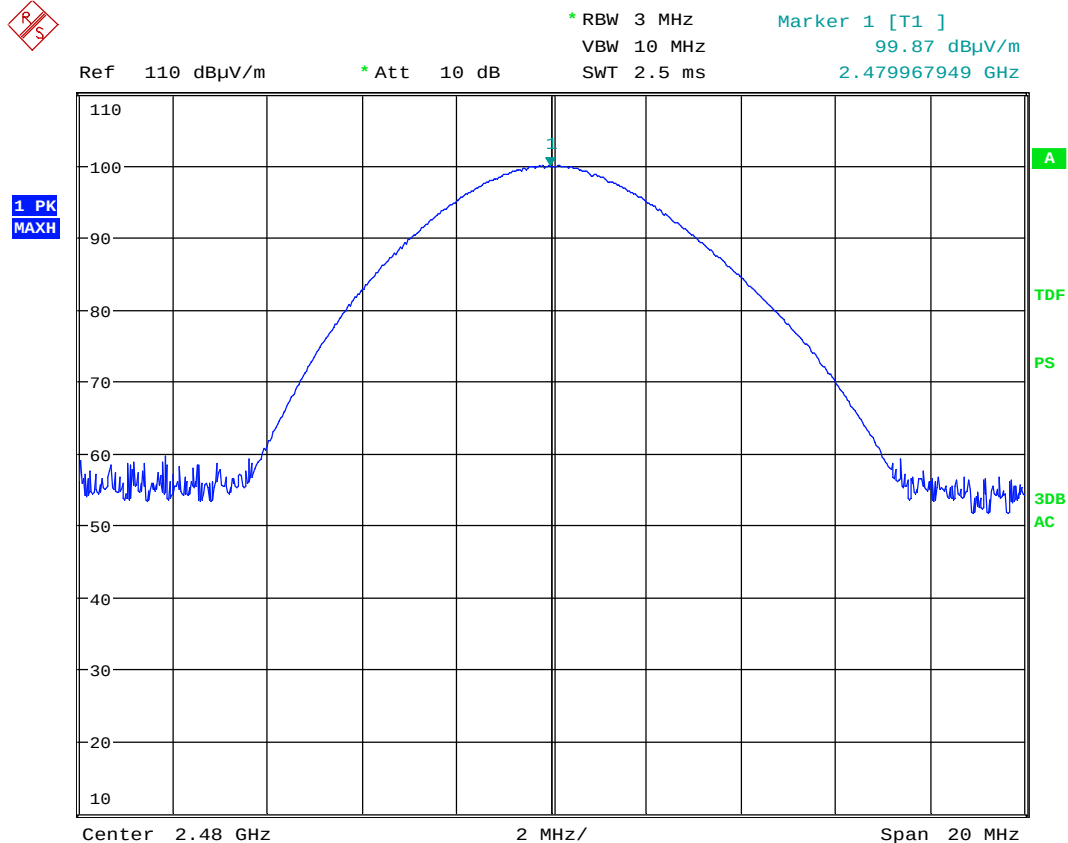


Date: 4.JUN.2019 09:21:45

**Radiated field strength-VP, ch2441MHz , 8DPSK**

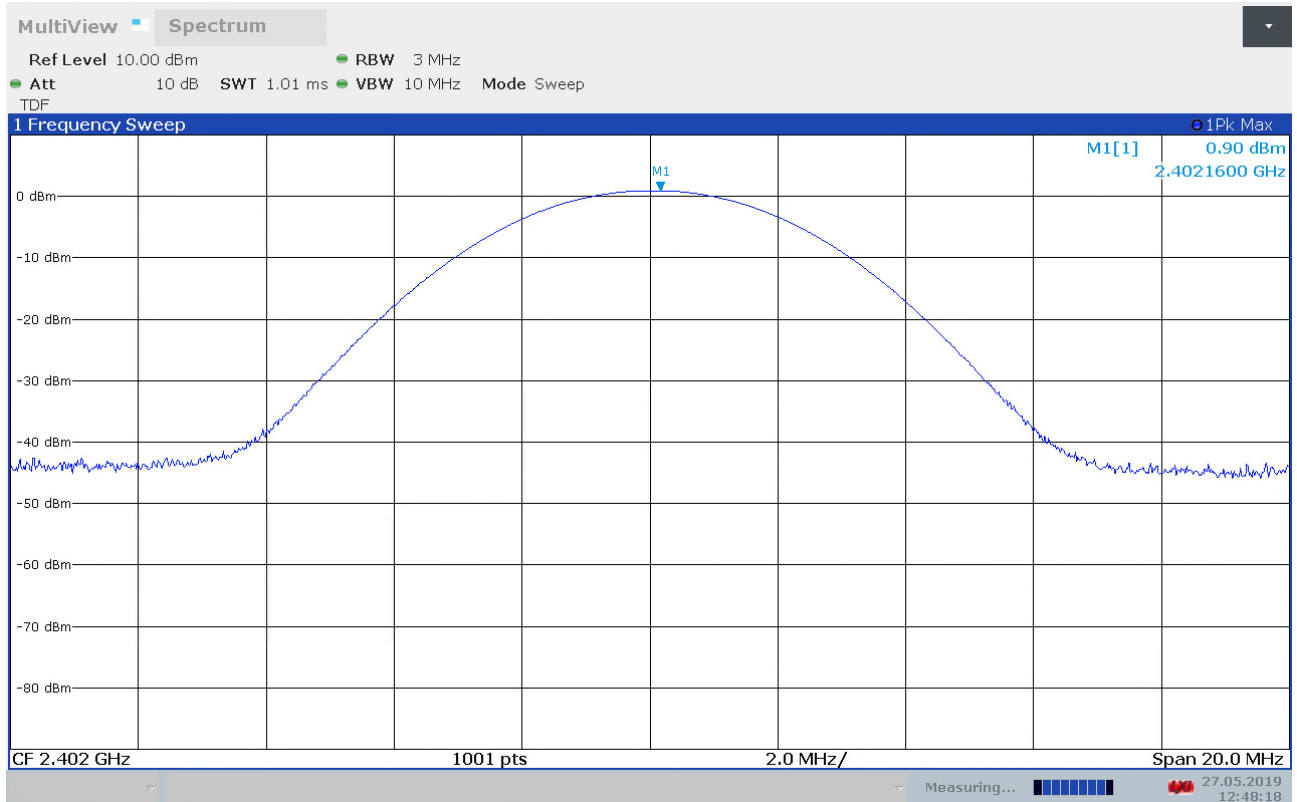


Conducted output Power, ch2480MHz , 8DPSK

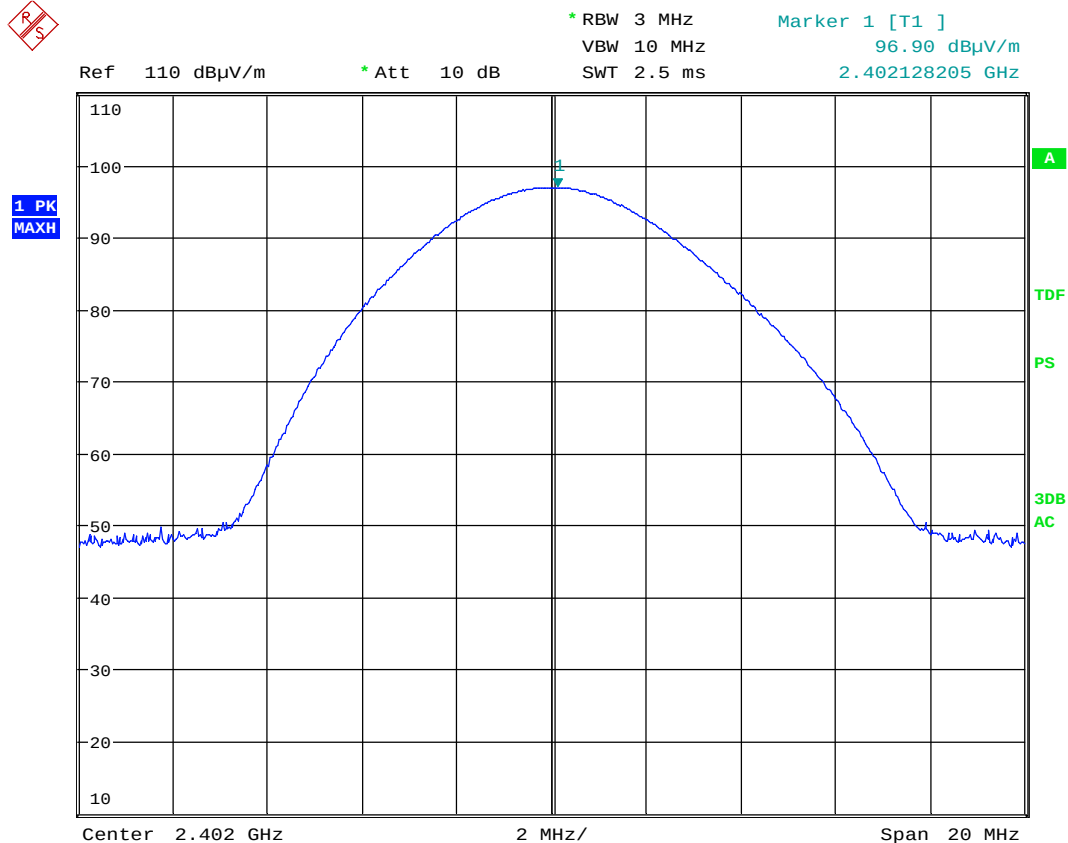


Date: 4.JUN.2019 09:36:43

**Radiated field strength-VP, ch2480MHz , 8DPSK**

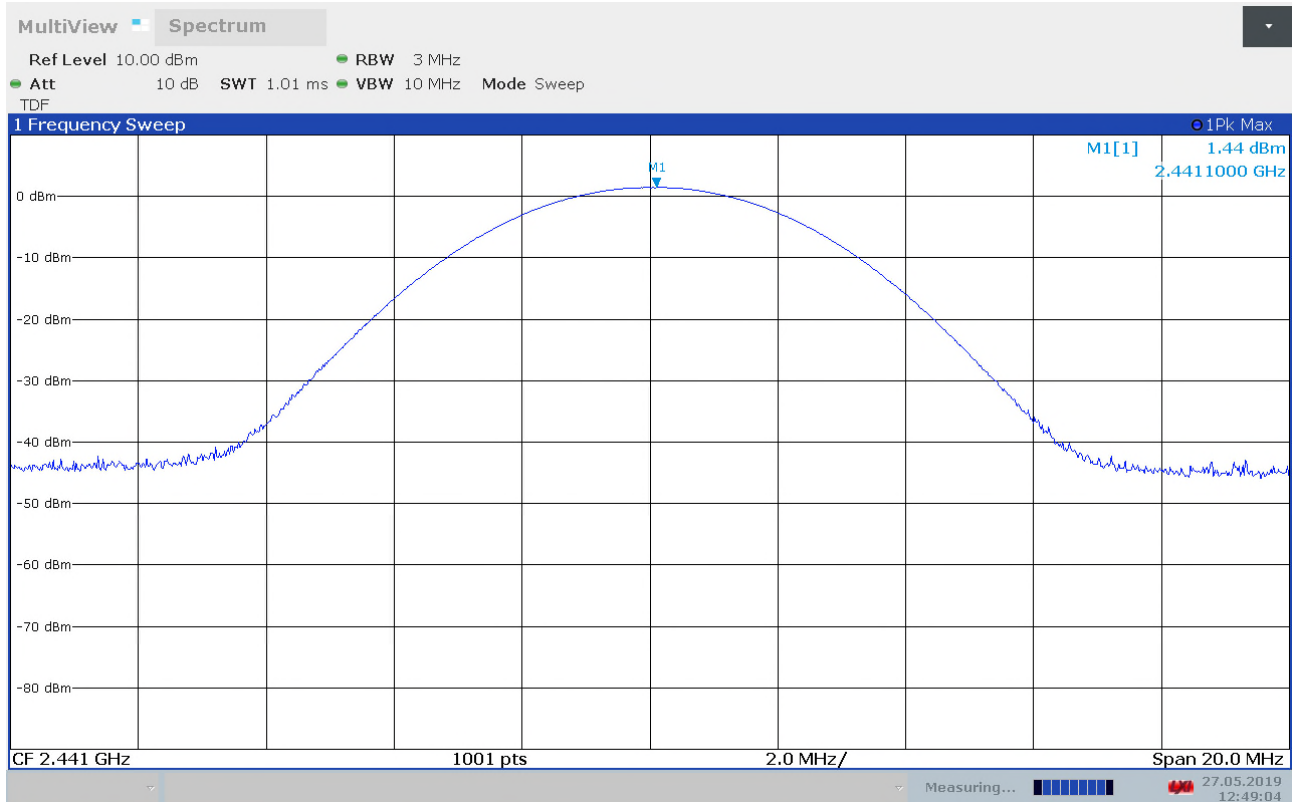


Conducted output Power, ch2402MHz , 4πDPSK

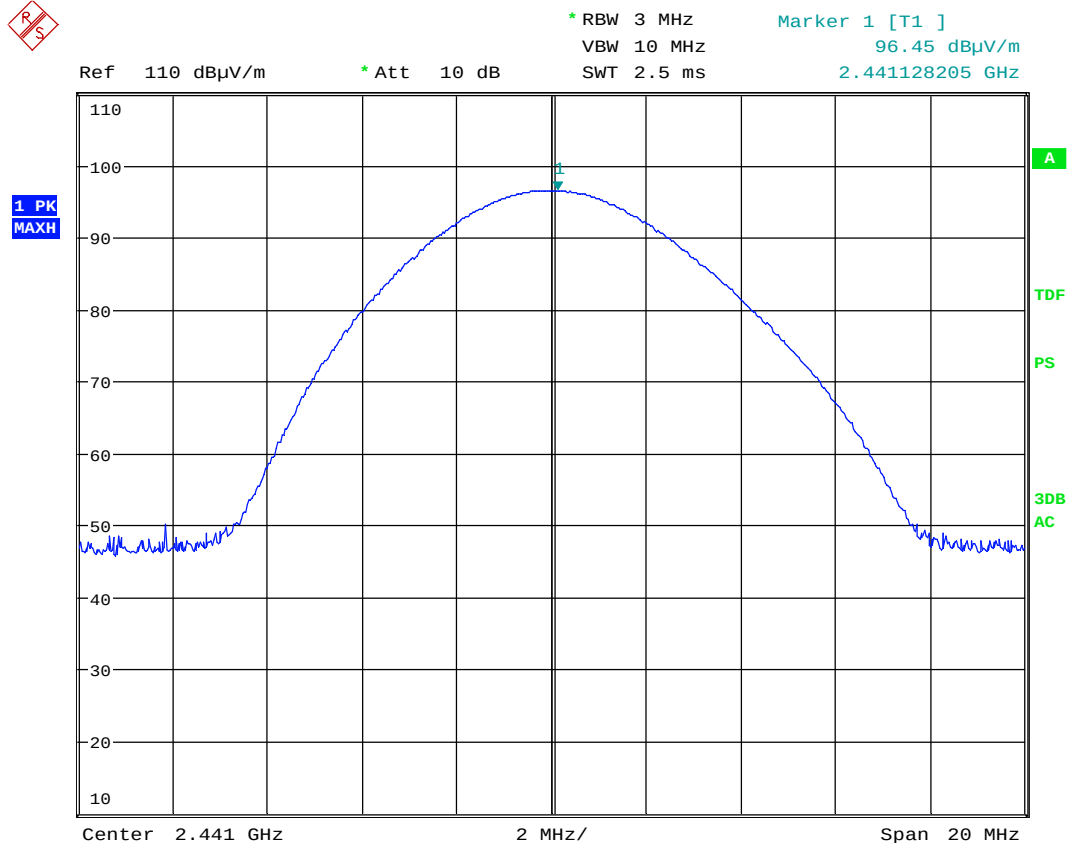


Date: 4.JUN.2019 10:37:32

**Radiated field strength-HP, ch2402MHz , 4πDPSK**

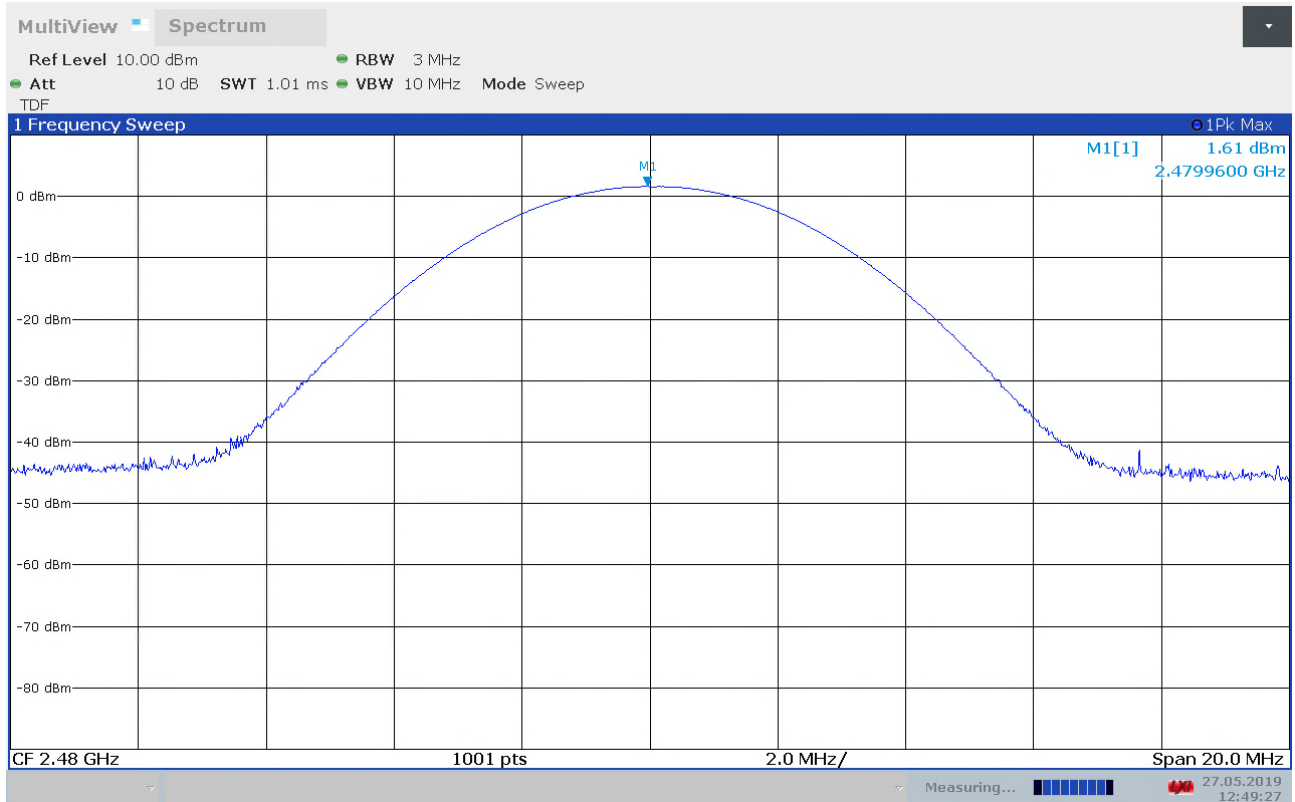


Conducted output Power, ch2441MHz , 4πDPSK

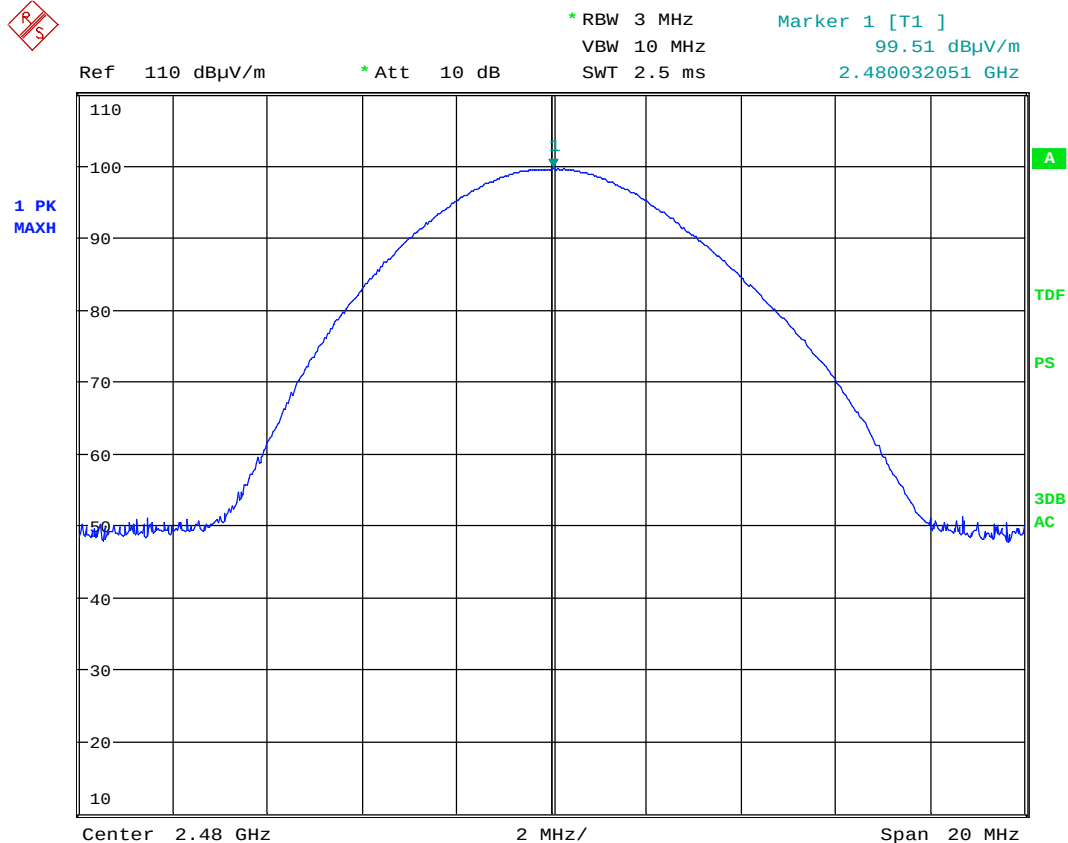


Date: 4.JUN.2019 10:42:25

**Radiated field strength-VP, ch2441MHz , 4πDPSK**



Conducted output Power, ch2480MHz , 4πDPSK



Date: 4.JUN.2019 08:49:39

**Radiated field strength-VP, ch2480MHz , 4πDPSK**

### 3.8 Conducted Emissions at Antenna Connector

Para. No.: 15.247 (d)

ISED Canada RSS-247 Issue 2, Clause 5.5

Measurement procedure: ANSI C63.10-2013 Clause 11.11

Test Results: Complies

**RF conducted power** to 25 GHz see attached plots.

Maximum RF level outside operating band:

RF in, GFSK: >54 dB/C, margin >20 dB

RF in, 8DPSK: >56 dB/C, margin >20 dB

RF in, 4π8DPSK: >44 dB/C, margin >20 dB

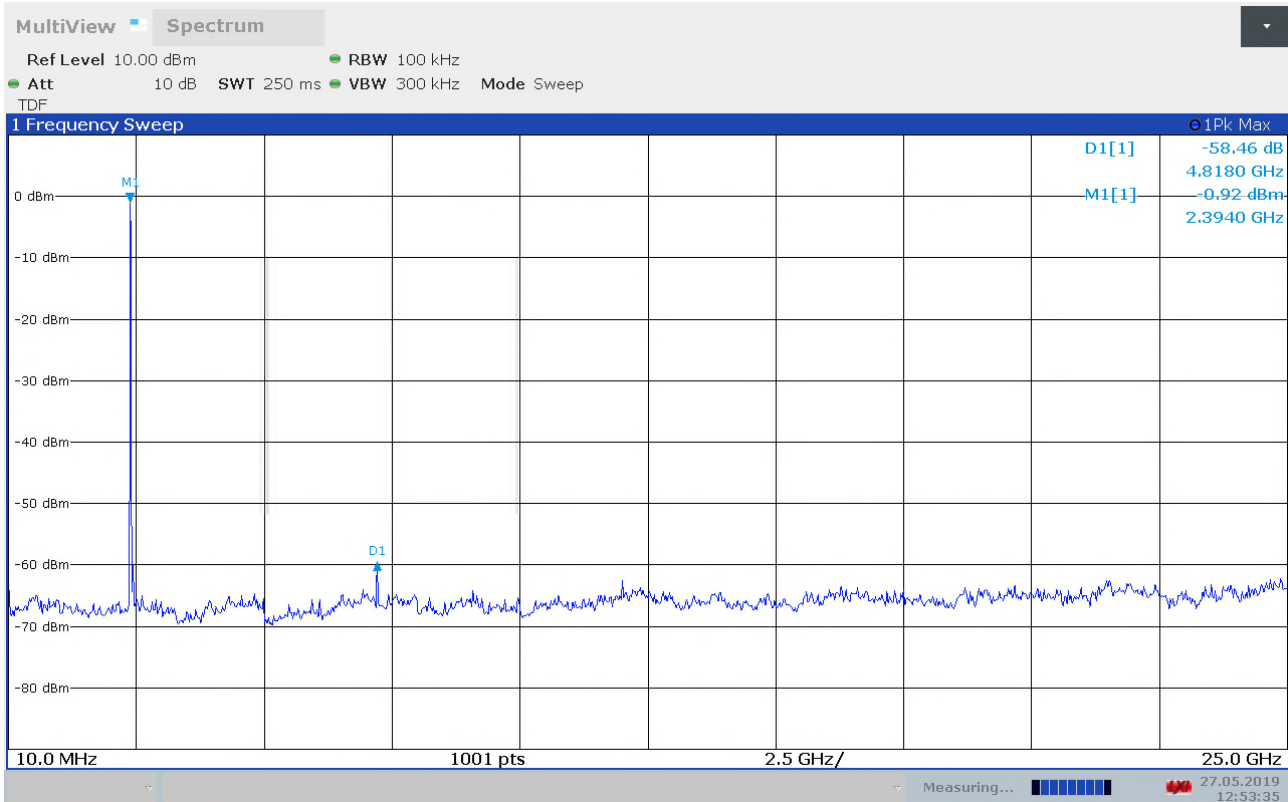
RF in hopping mode , DH1: >50 dB/C, margin >20 dB

#### Limit

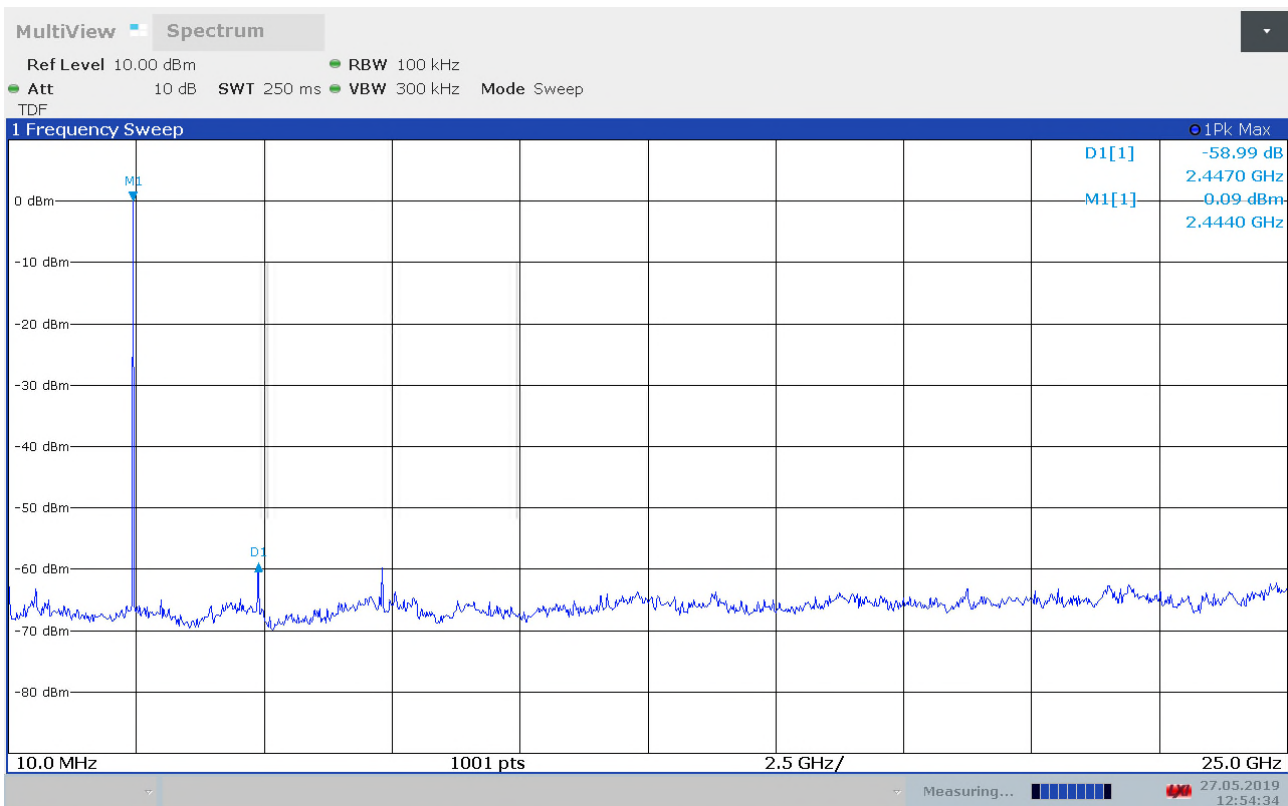
| Peak measurement                    | RMS averaging                       |
|-------------------------------------|-------------------------------------|
| 20 dBc or more in 100 kHz bandwidth | 30 dBc or more in 100 kHz bandwidth |

Detector type shall be the same as used for measuring Output Power.

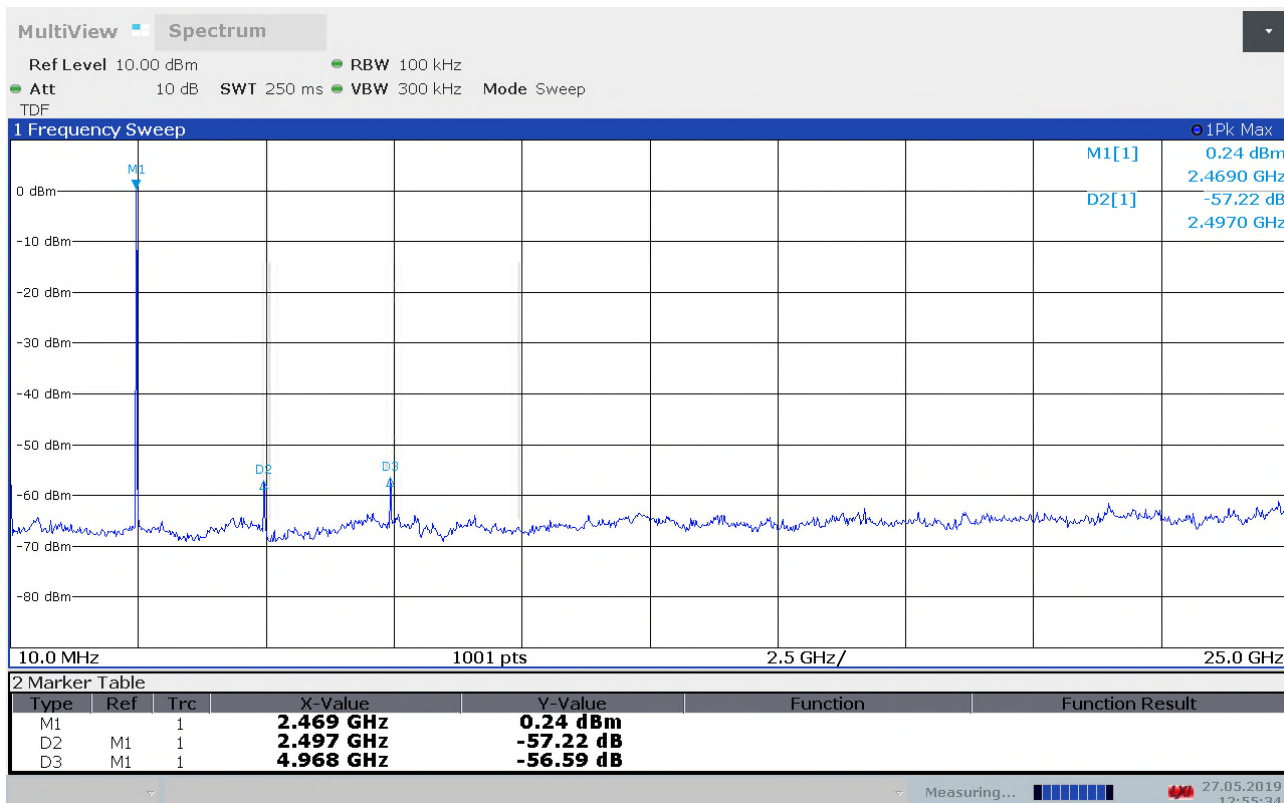
Attenuation below the general limits specified in part 15.209(a) is not required.



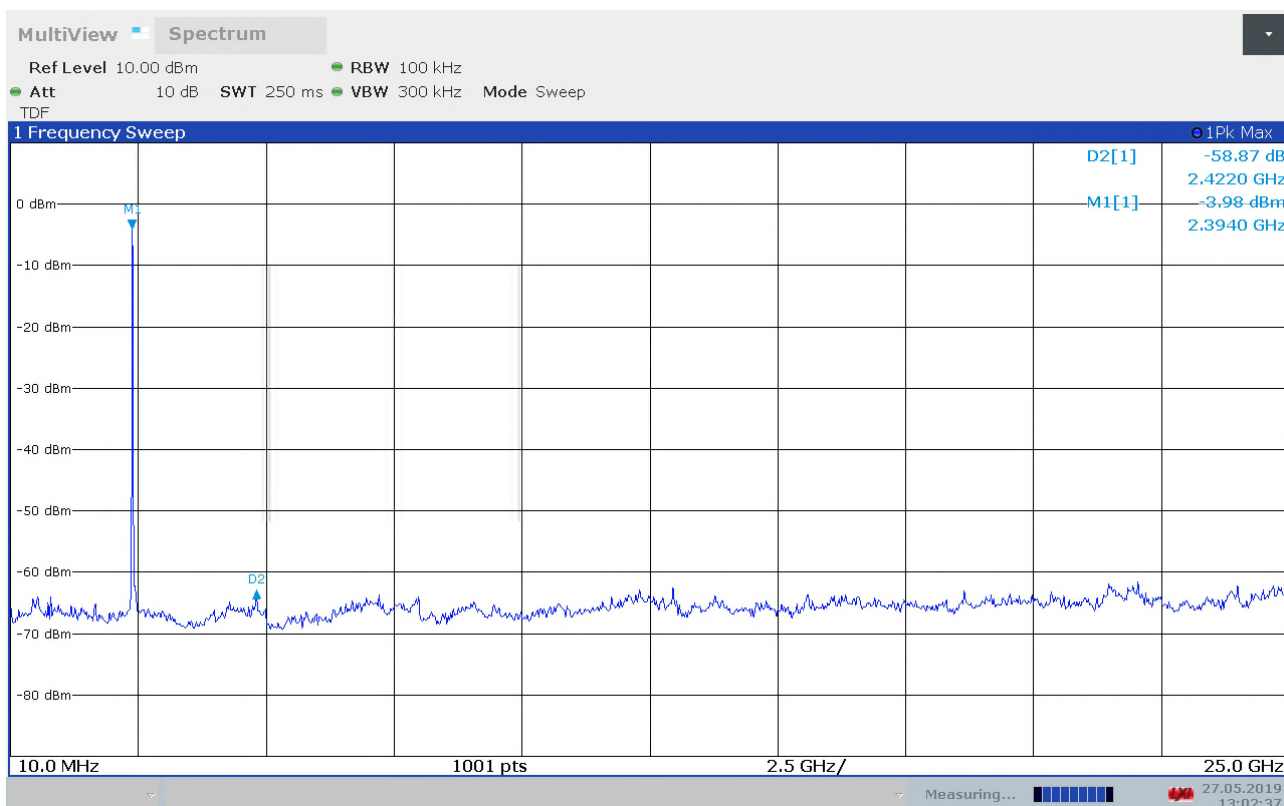
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, GFSK



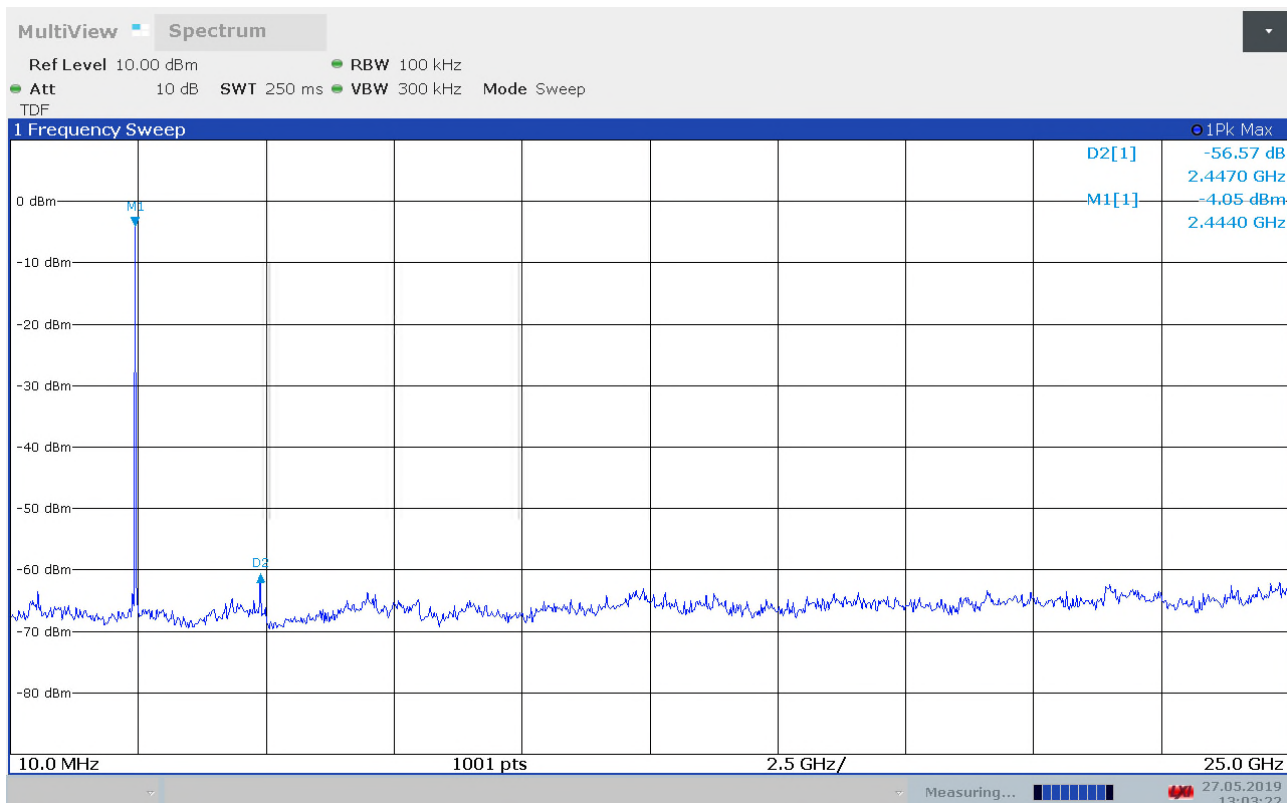
Conducted spurious emissions 10MHz – 25GHz, ch2441MHz, GFSK



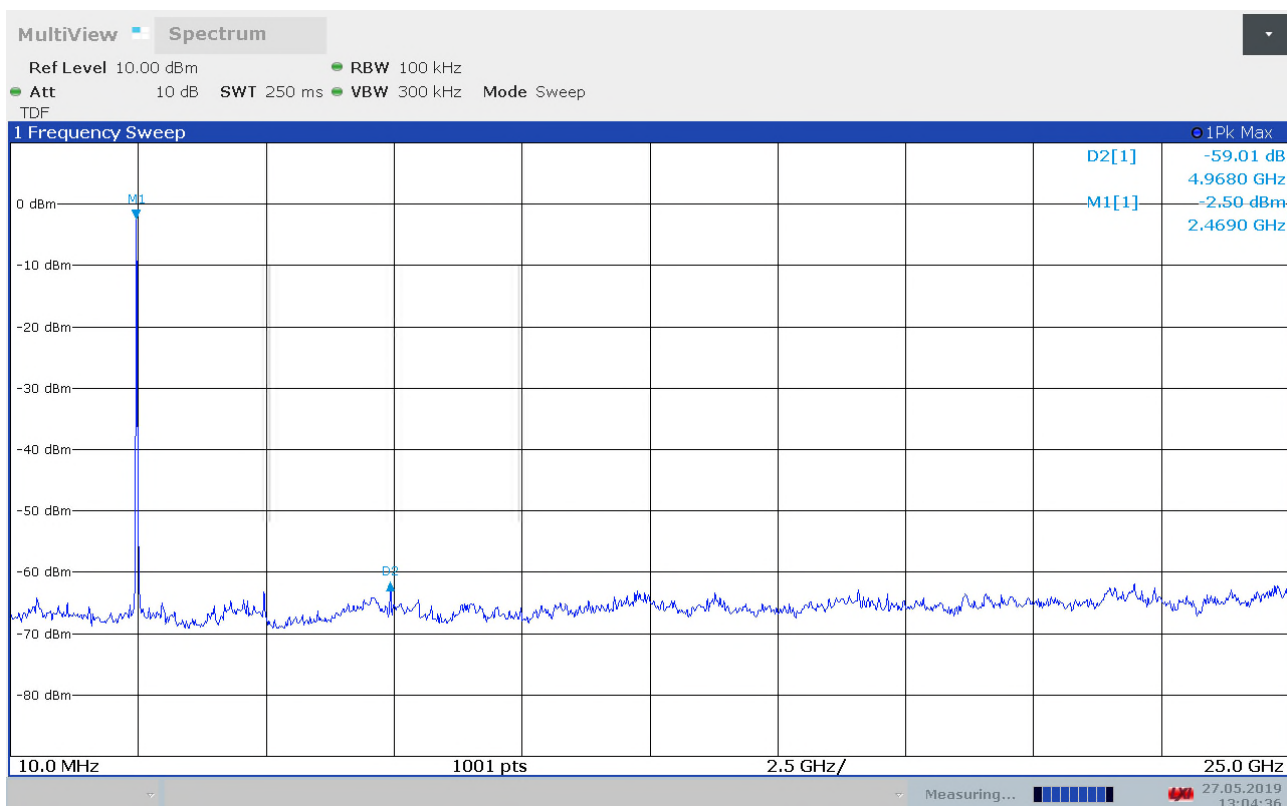
Conducted spurious emissions 10MHz – 25GHz, ch2480MHz, GFSK



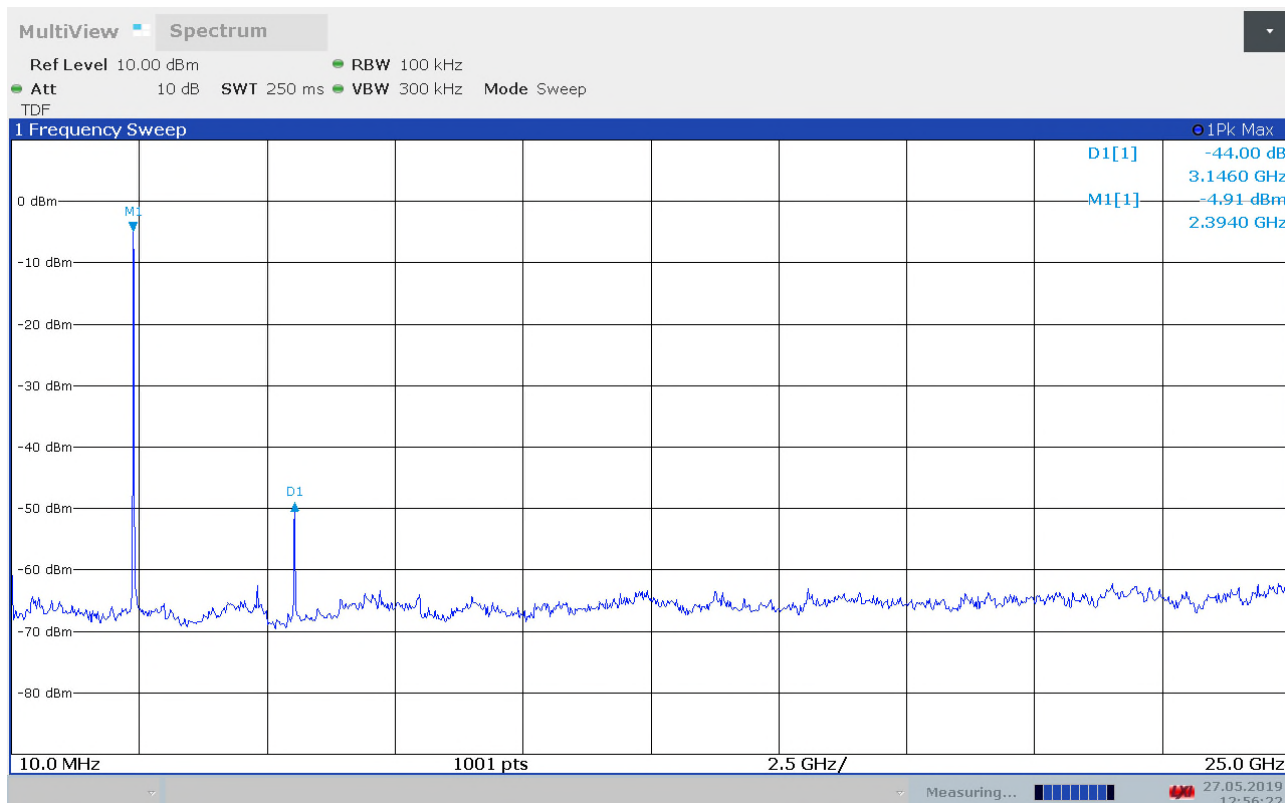
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, 8DPSK



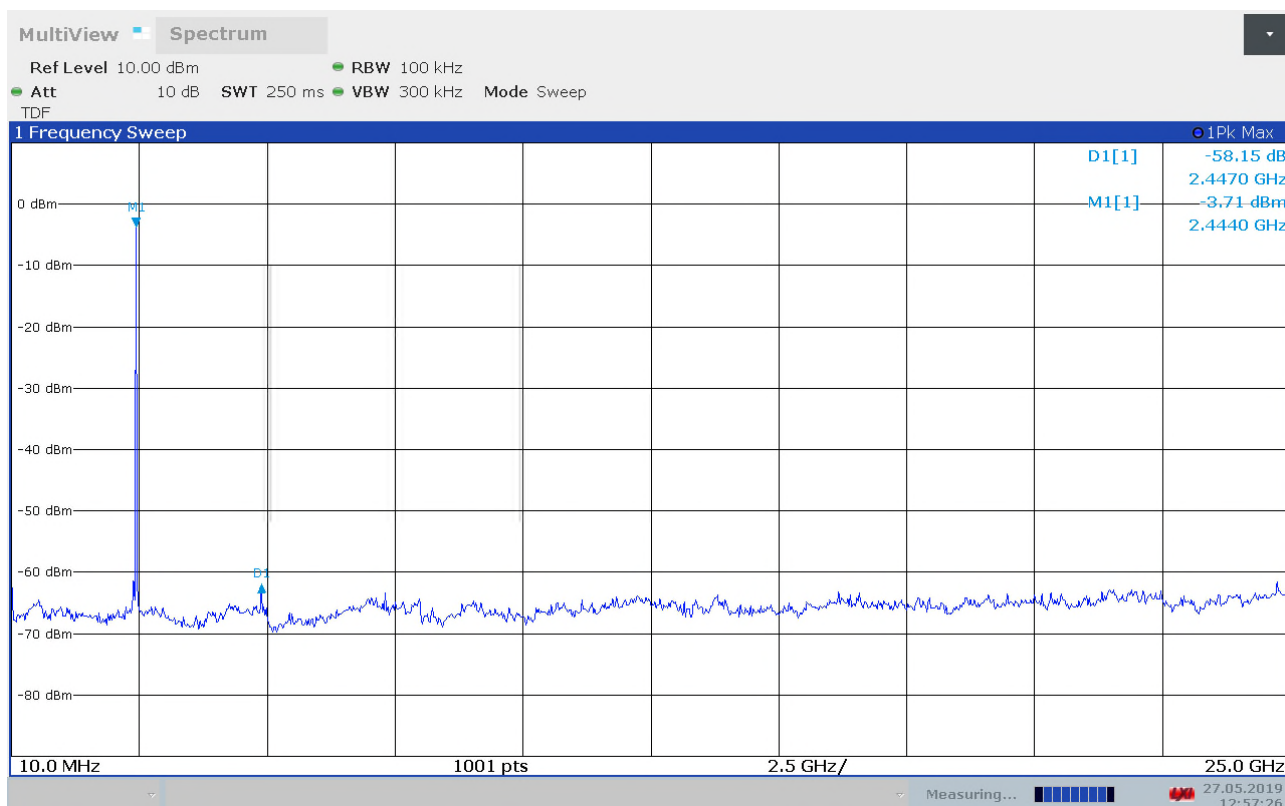
Conducted spurious emissions 10MHz – 25GHz, ch2441MHz, 8DPSK



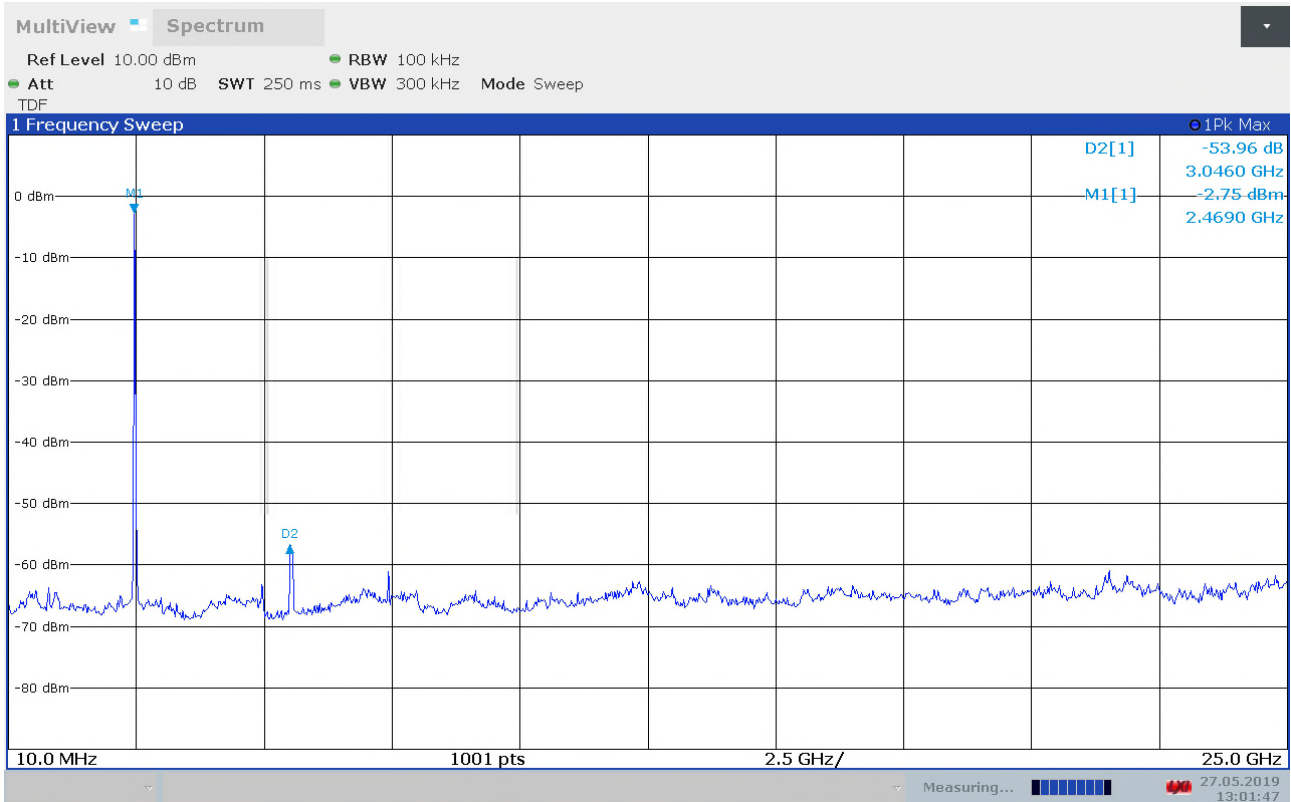
Conducted spurious emissions 10MHz – 25GHz, ch2480MHz, 8DPSK



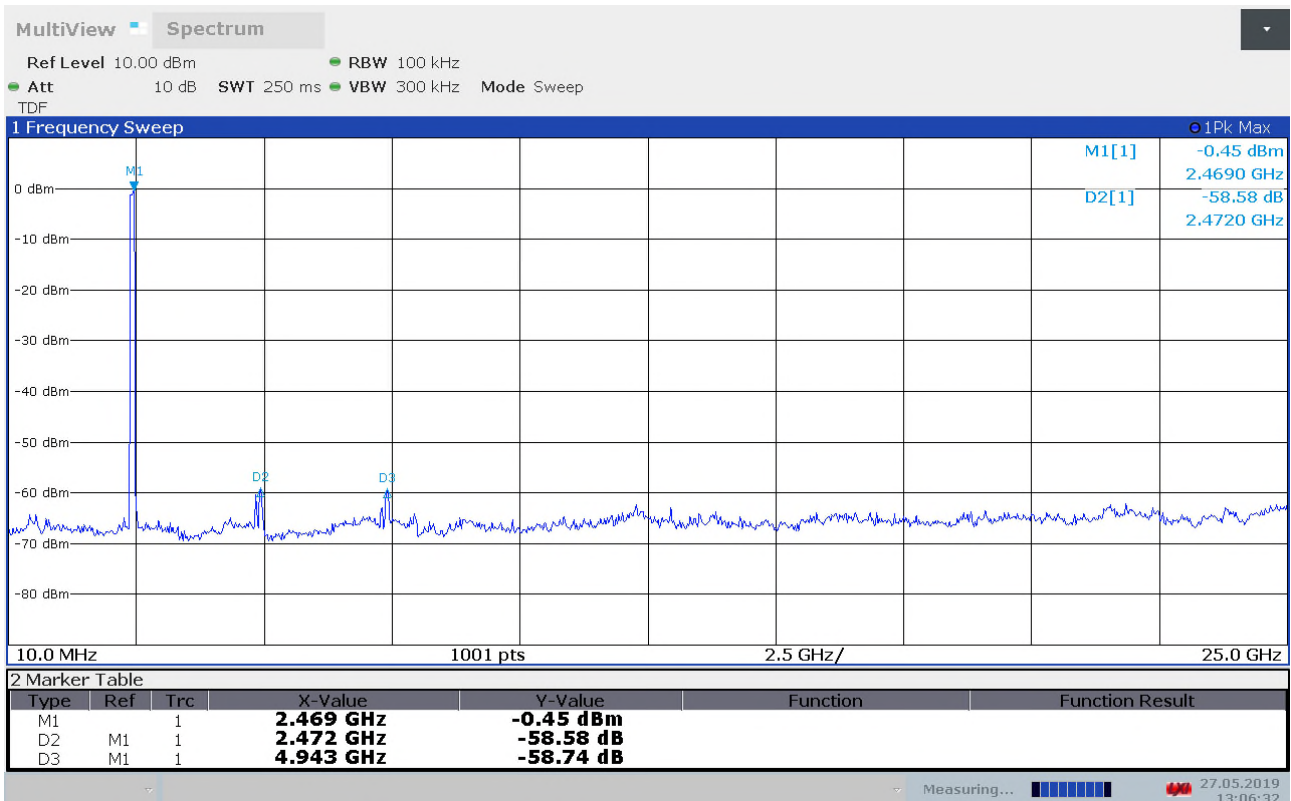
Conducted spurious emissions 10MHz – 25GHz , ch2402MHz, 4πDPSK



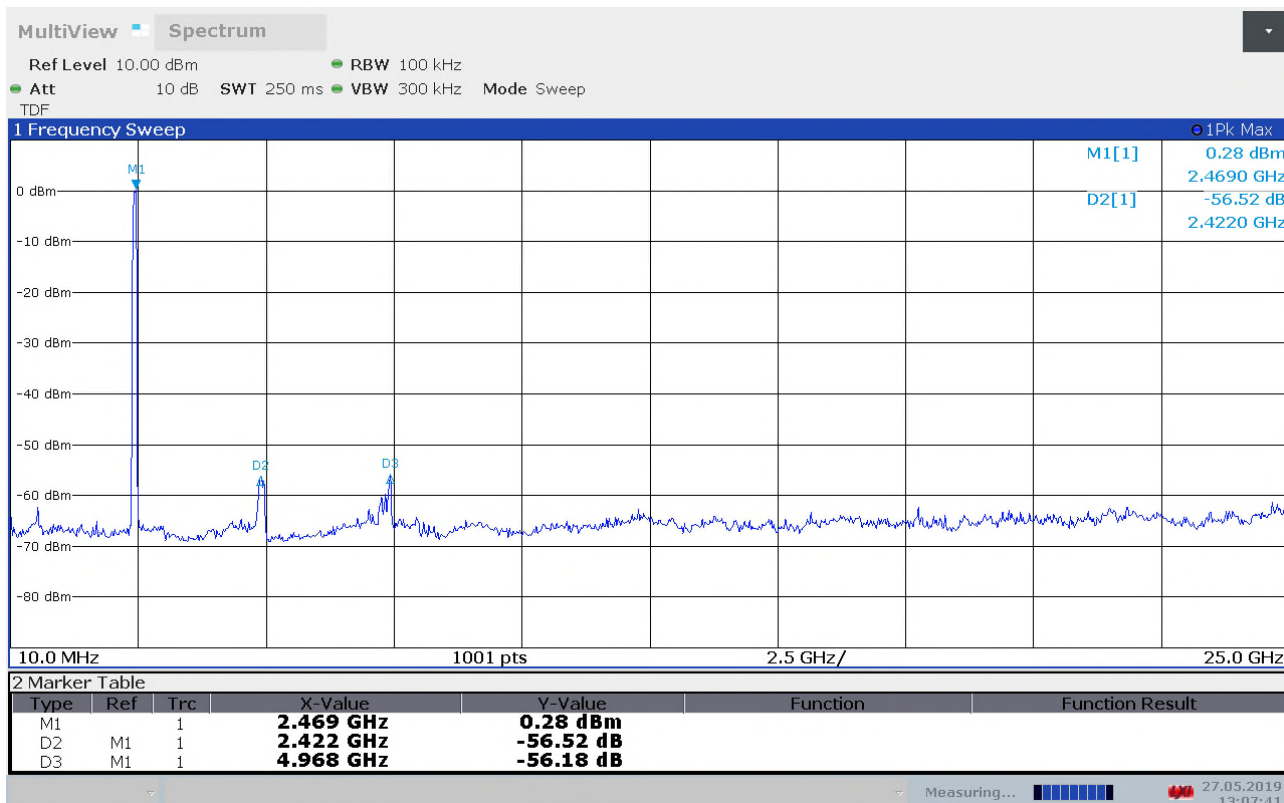
Conducted spurious emissions 10MHz – 25GHz, ch2441MHz, 4πDPSK



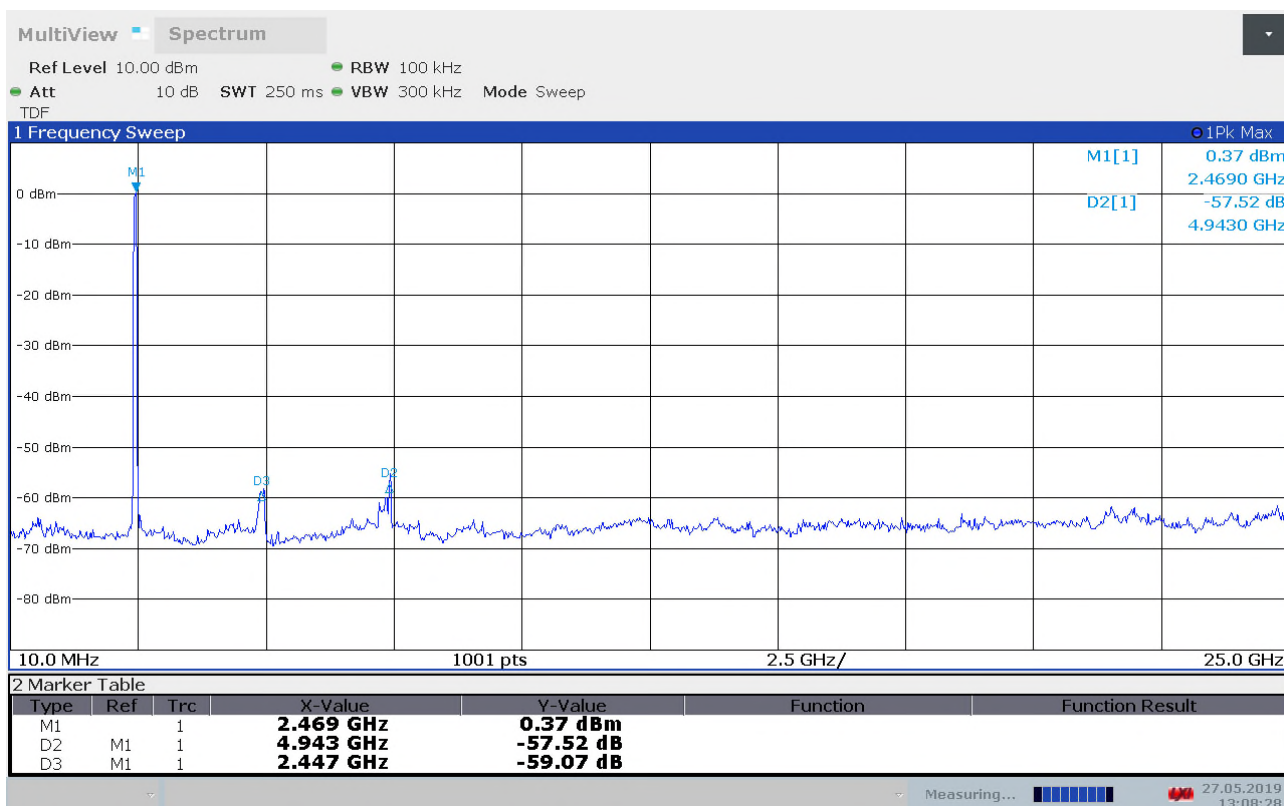
Conducted spurious emissions 10MHz – 25GHz, ch2480MHz, 4πDPSK



Conducted spurious emissions 10MHz – 25GHz , hopping mode, DH1



Conducted spurious emissions 10MHz – 25GHz, hopping mode, DH3



Conducted spurious emissions 10MHz – 25GHz, hopping mode, DH5

### 3.9 Spurious Emissions (Radiated)

FCC Part 15.247

ISED Canada RSS-GEN Issue 5, Clause 7.3 / 8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Band-edge radiated:

| Modulation Scheme | Detector         | Measured field strength (dBμV/m) |            | Limit  | Margin |       |
|-------------------|------------------|----------------------------------|------------|--------|--------|-------|
|                   |                  | 2390 MHz                         | 2483.5 MHz | dBμV/m | dB     |       |
| GFSK              | Peak Detector    | 39.74                            | 54.19      | 74     | 34.26  | 19.81 |
|                   | Average Detector | /                                | 34.19      | 54     | /      | 19.81 |
| 8DPSK             | Peak Detector    | 46.98                            | 58.26      | 74     | 27.02  | 15.74 |
|                   | Average Detector | /                                | 38.26      | 54     | /      | 15.74 |
| 4πDPSK            | Peak Detector    | 40.80                            | 58.14      | 74     | 33.20  | 15.86 |
|                   | Average Detector | /                                | 38.14      | 54     | /      | 15.86 |
| DH1, Hopping mode | Peak Detector    | 49.61                            | 56.63      | 74     | 24.39  | 17.07 |
|                   | Average Detector | /                                | 36.63      | 54     | /      | 17.07 |
| DH3, Hopping mode | Peak Detector    | 50.69                            | 57.90      | 74     | 23.31  | 16.1  |
|                   | Average Detector | /                                | 37.90      | 54     | /      | 16.1  |
| DH5, Hopping mode | Peak Detector    | 49.76                            | 57.70      | 74     | 24.24  | 16.3  |
|                   | Average Detector | /                                | 37.70      | 54     | /      | 16.3  |

Average Detector values are measured with Peak Detector and corrected for Duty Cycle.

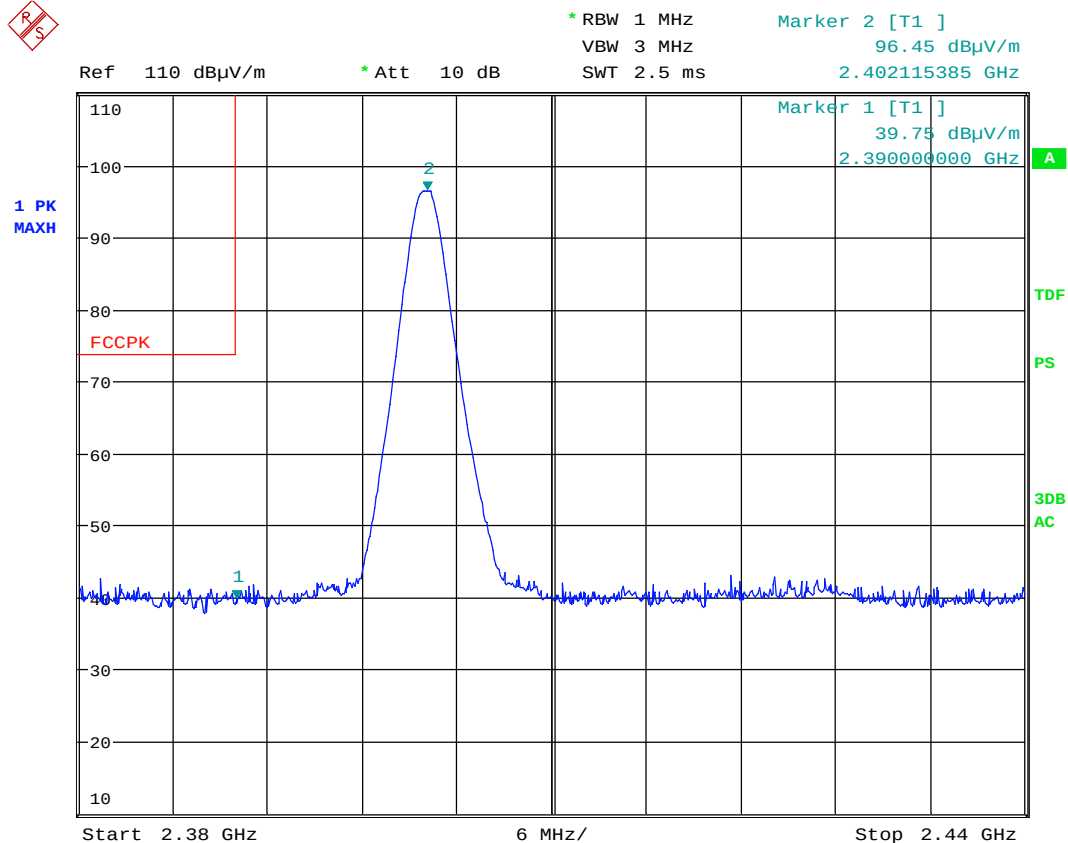
See attached plots.

#### Duty Cycle Correction Factor Calculation:

Duty Cycle = slot length / (frame length x hopping channels) = 0.626ms / (216ms x 79) = 2.9

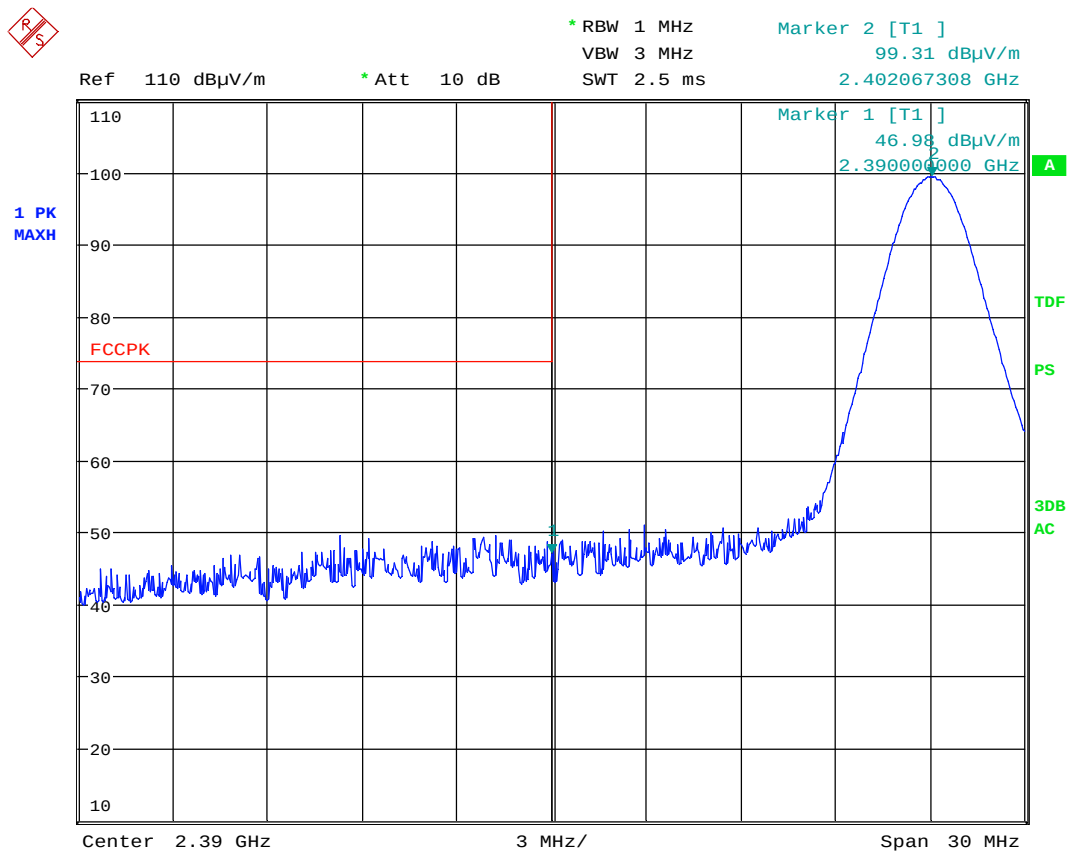
Duty Cycle Correction factor = -20 x log (Duty Cycle) = -30.7 dB

**Maximum Duty Cycle Correction Factor according to Para 15.35 (b): 20 dB**



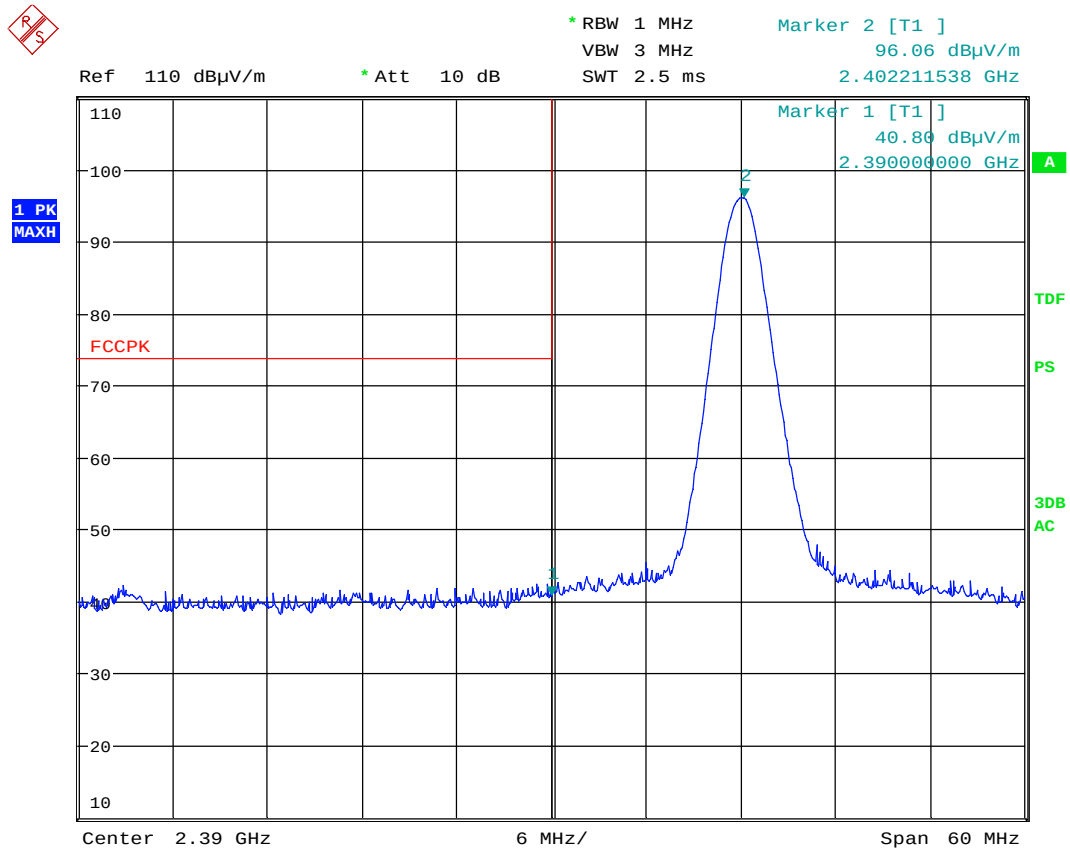
Date: 4.JUN.2019 10:23:02

Lower Band Edge, ch2402MHz , GFSK, Peak Det



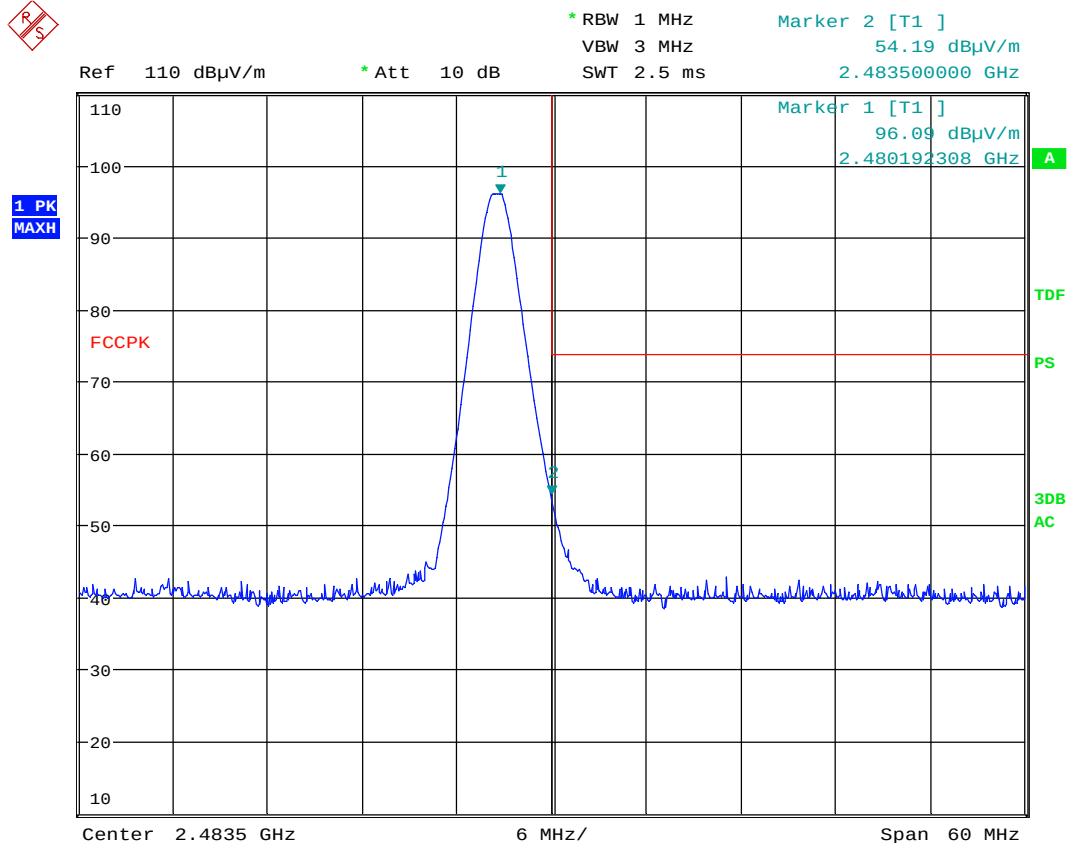
Date: 4.JUN.2019 09:15:23

### Lower Band Edge, ch2402MHz , 8DPSK, Peak Det



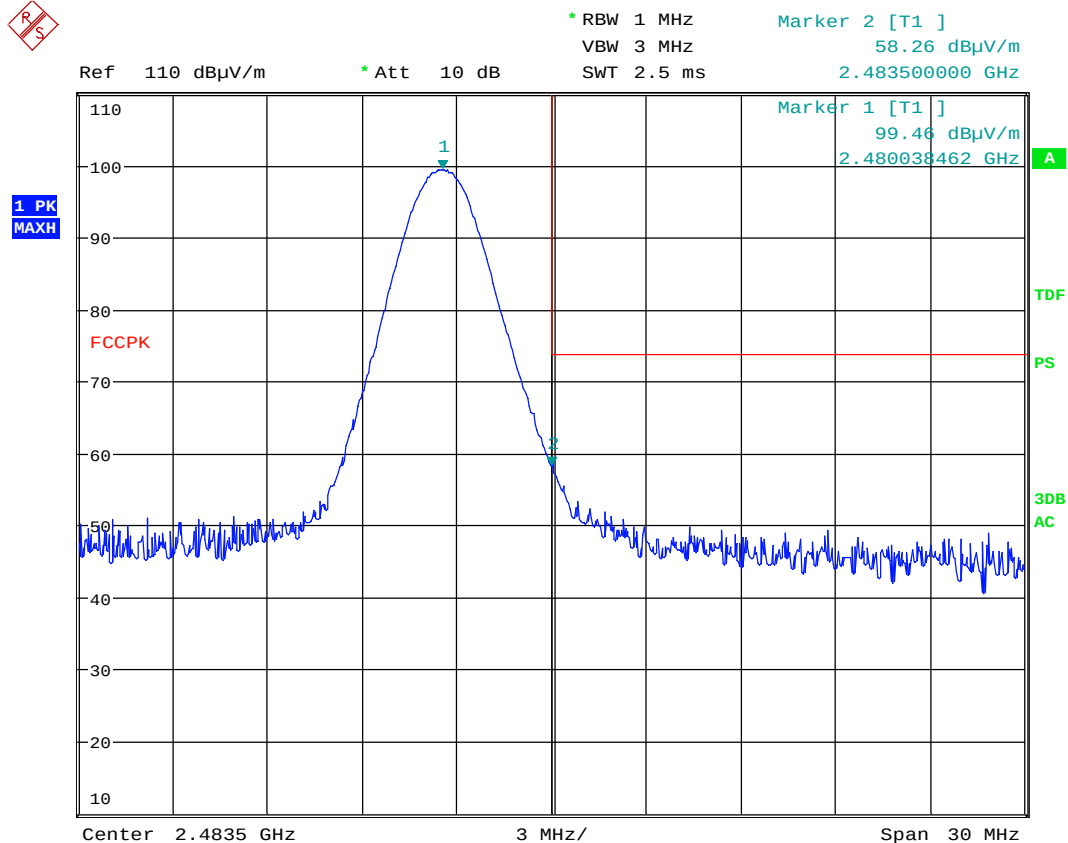
Date: 4.JUN.2019 10:40:12

Lower Band Edge, ch2402MHz, 4πDPSK, Peak Det



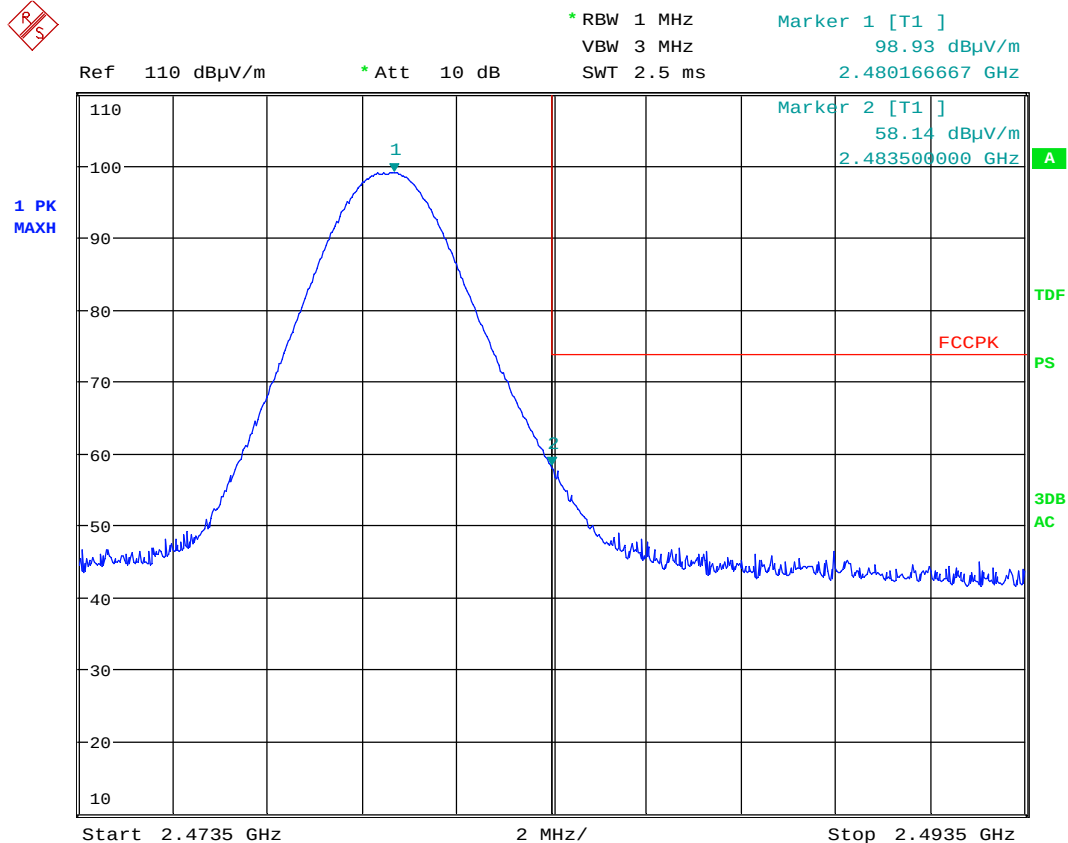
Date: 4.JUN.2019 10:30:44

Upper Band Edge, ch2480MHz , GFSK, Peak Det



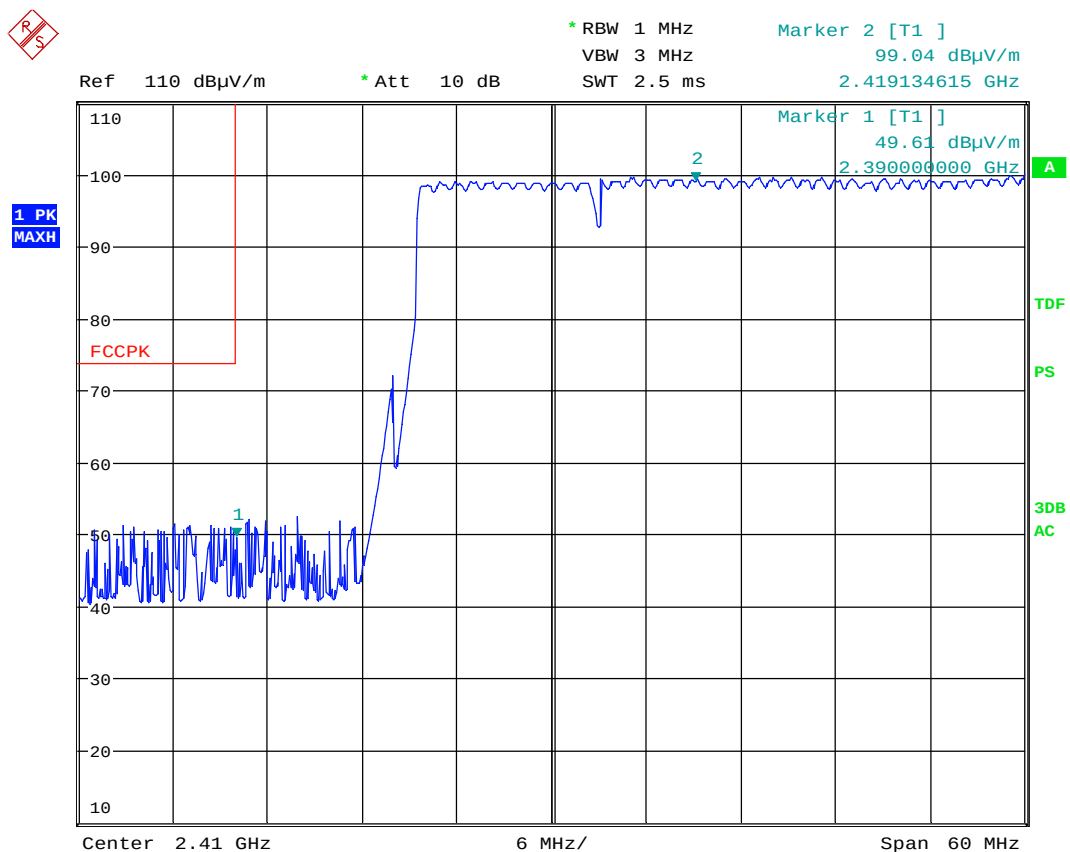
Date: 4.JUN.2019 09:35:14

Upper Band Edge, ch2480MHz , 8DPSK, Peak Det



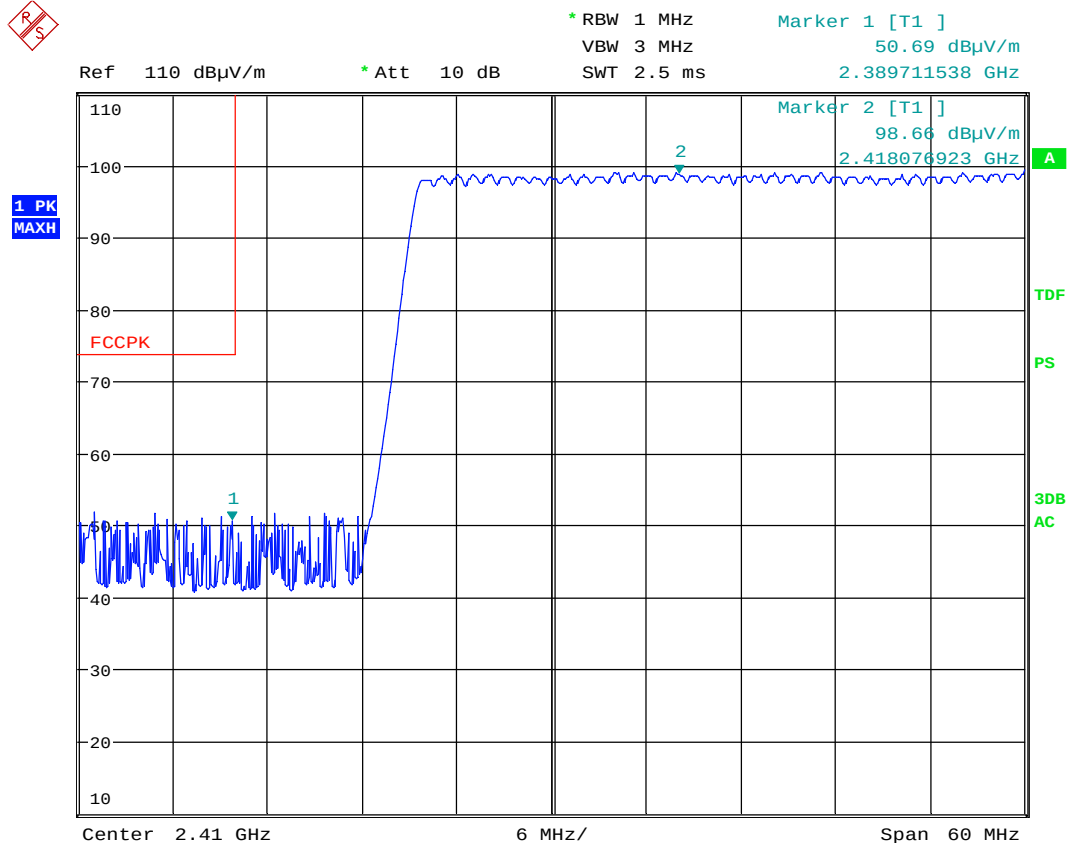
Date: 4.JUN.2019 08:38:00

Upper Band Edge, ch2480MHz, 4πDPSK, Peak Det



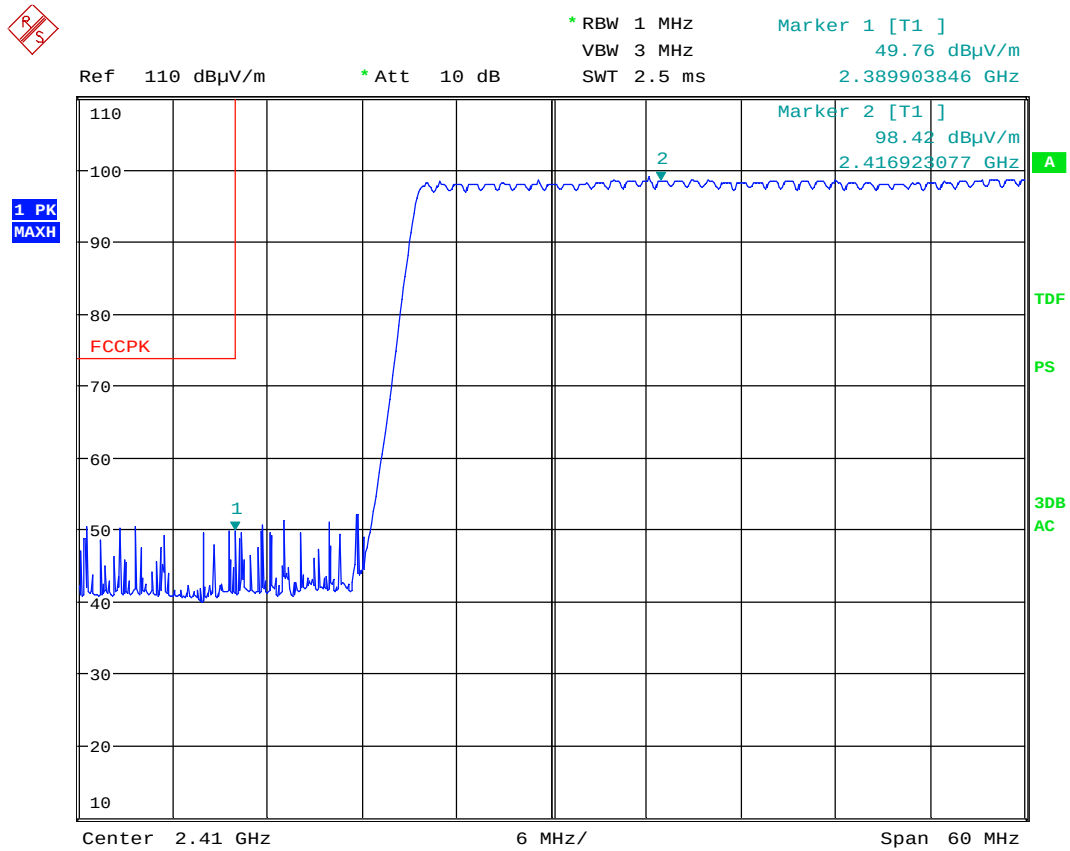
Date: 4.JUN.2019 09:49:12

Lower Band Edge, Hopping mode , DH1, Peak Det



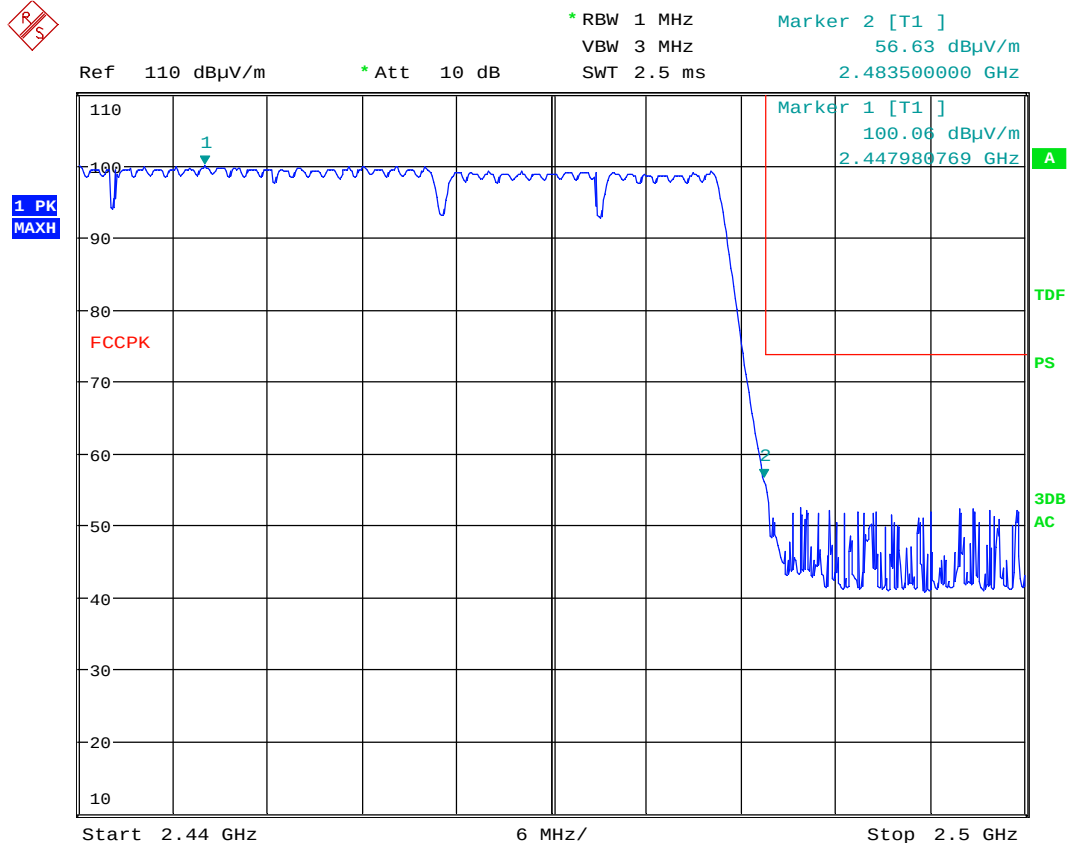
Date: 4.JUN.2019 09:58:04

Lower Band Edge, Hopping mode , DH3, Peak Det



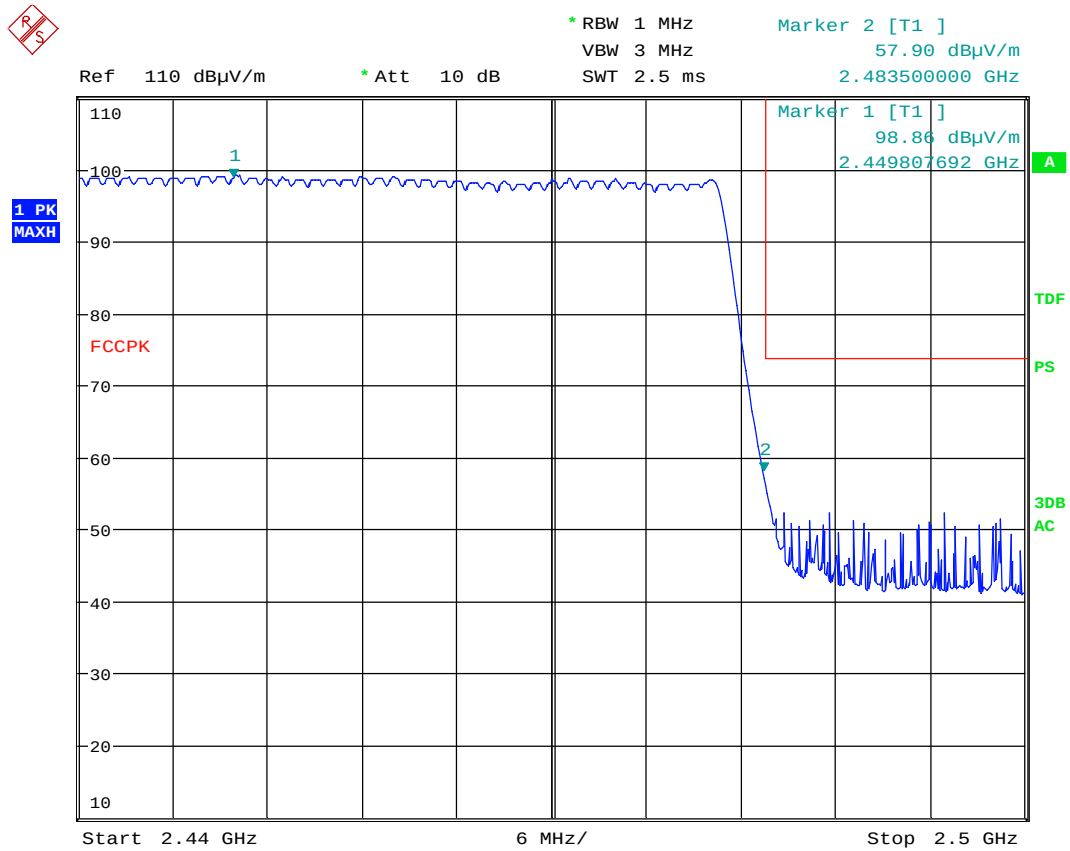
Date: 4.JUN.2019 10:15:55

Lower Band Edge, Hopping mode , DH5, Peak Det



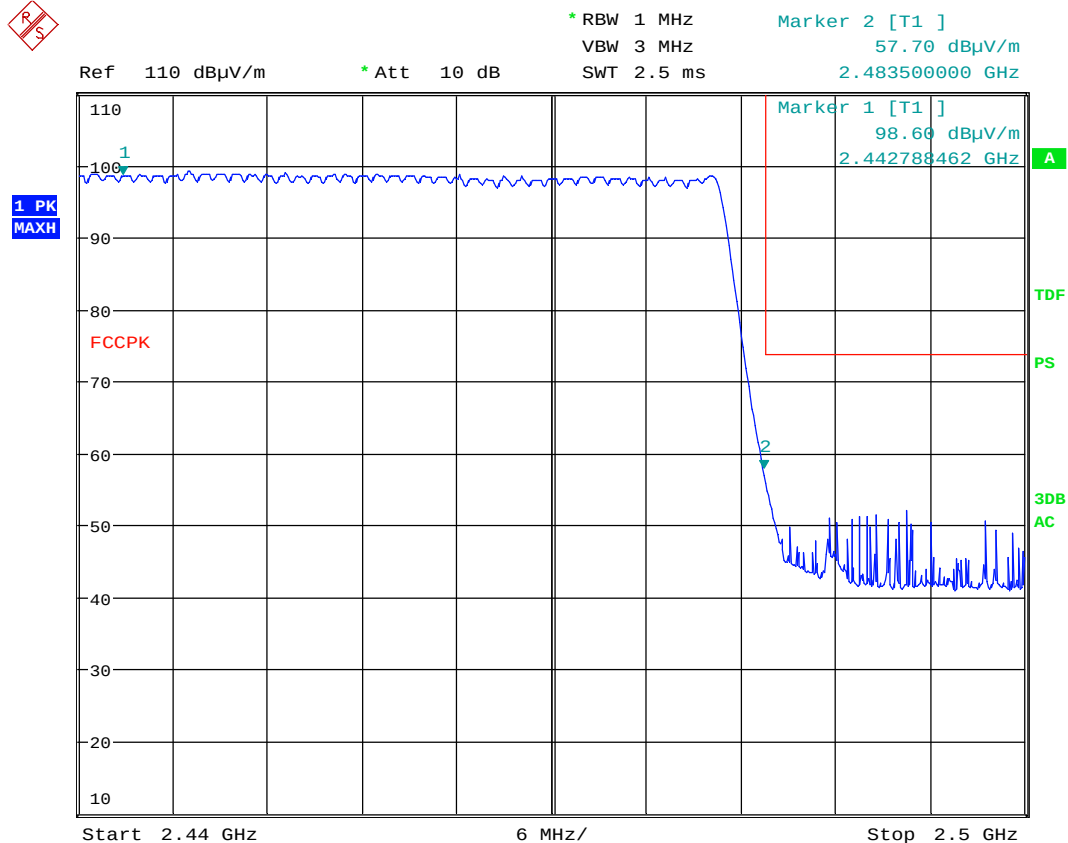
Date: 4.JUN.2019 09:50:29

Upper Band Edge, Hopping mode , DH1, Peak Det



Date: 4.JUN.2019 09:59:20

Upper Band Edge, Hopping mode , DH3, Peak Det



Date: 4.JUN.2019 10:16:58

Upper Band Edge, Hopping mode , DH5, Peak Det

# **Radiated emission 30 – 1000 MHz.**

ISED Canada RSS-GEN Issue 5, Clause 7.3 / 8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Measuring distance 3 m according to ANSI.

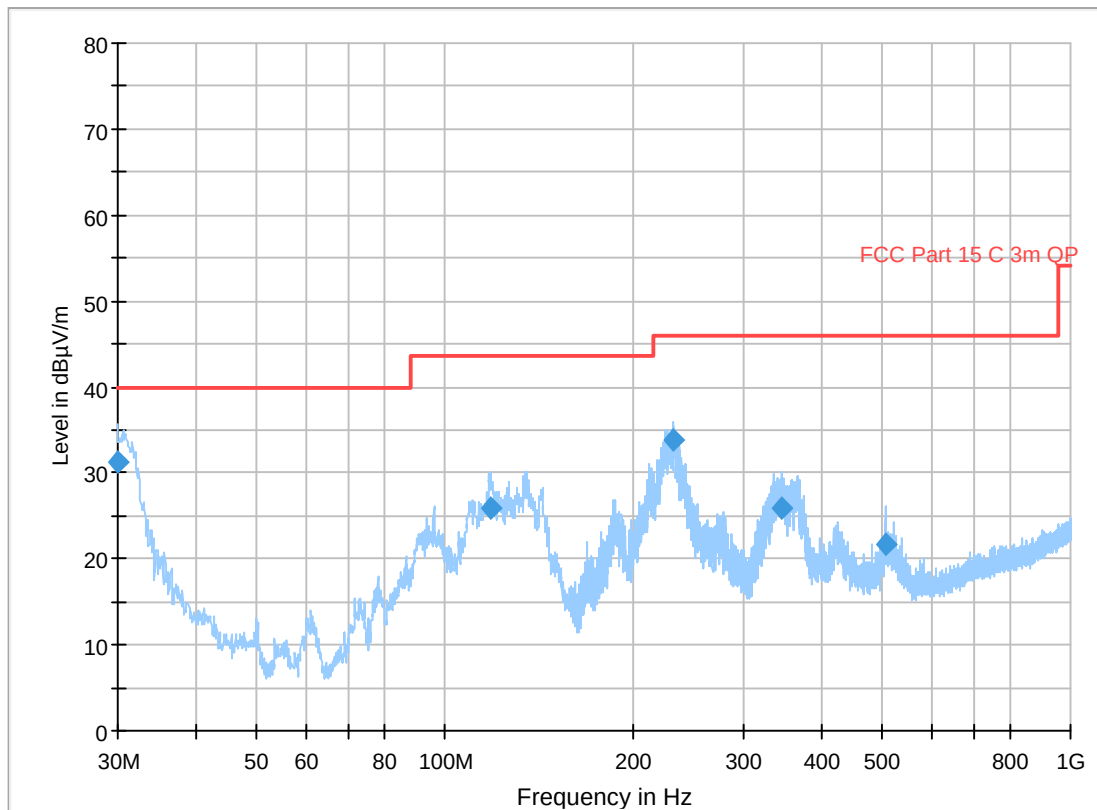
| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 30.023325       | 31.22              | 40.00          | 8.78        | 1000.0          | 120.000         | 106.0       | V   | 1.0           |
| 118.447400      | 25.96              | 43.50          | 17.54       | 1000.0          | 120.000         | 100.0       | V   | 224.0         |
| 232.584000      | 33.88              | 46.00          | 12.12       | 1000.0          | 120.000         | 123.0       | H   | 227.0         |
| 345.334800      | 25.87              | 46.00          | 20.13       | 1000.0          | 120.000         | 100.0       | H   | 233.0         |
| 507.849100      | 21.61              | 46.00          | 24.39       | 1000.0          | 120.000         | 194.0       | H   | 200.0         |

See attached graphs.

## **Requirements/Limit**

|                 |                                                                  |                     |
|-----------------|------------------------------------------------------------------|---------------------|
| FCC             | Part 15.209 @ frequencies defined in §15.205                     |                     |
| ISED            | RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10 |                     |
|                 | Radiated emission limit @3 meters                                |                     |
| Frequency (MHz) | Quasi Peak (µV/m)                                                | Quasi Peak (dBµV/m) |
| 30 – 88         | 100                                                              | 40.0                |
| 88 – 216        | 150                                                              | 43.5                |
| 216 – 960       | 200                                                              | 46.0                |
| Above 960       | 500                                                              | 54.0                |

### Full Spectrum



30MHz - 1000MHz - In hopping mode

**IN GFSK MODE:**

**Radiated Emissions, 1-25 GHz;** Measuring distance: 3m (1 – 8 GHz), 1m (8 – 18 GHz); A pre-scan was performed above 18 GHz and no spurious emissions were detected.

**Peak Detector:**

| Modulation scheme | Frequency | Polarization | Dist. corr. factor | Field strength, Peak Detector, 3m | Duty cycle corr. factor | Limit        | Margin |
|-------------------|-----------|--------------|--------------------|-----------------------------------|-------------------------|--------------|--------|
|                   | GHz       |              | dB                 | dB $\mu$ V/m                      | dB                      | dB $\mu$ V/m | dB     |
| GFSK              | 4.804     | HP           | 0                  | /                                 | /                       | 74           | /      |
|                   | 4.882     | HP           | 0                  | /                                 | /                       | 74           | /      |
|                   | 4.960     | HP           | 0                  | /                                 | /                       | 74           | /      |
| GFSK              | 7.206     | HP           | 0                  | 60.53                             | /                       | 74           | 13.47  |
|                   | 7.323     | HP           | 0                  | 61.96                             | /                       | 74           | 12.04  |
|                   | 7.440     | HP           | 0                  | 60.72                             | /                       | 74           | 13.28  |
| GFSK              | 9.608     | HP           | *                  | 46.35                             | /                       | 74           | 27.65  |
|                   | 9.760     | HP           | *                  | 44.31                             | /                       | 74           | 29.69  |
|                   | 9.920     | HP           | *                  | 45.40                             | /                       | 74           | 28.60  |
| GFSK              | 12.01     | HP           | *                  | 52.79                             | /                       | 74           | 21.21  |
|                   | 12.205    | HP           | *                  | 47.82                             | /                       | 74           | 26.18  |
|                   | 12.400    | HP           | *                  | 52.25                             | /                       | 74           | 21.75  |
| Other freqs       | L,M,H     | VP/HP        | /                  | None detected                     | /                       | 74           | >20    |

\*distance correction is included in the plot

**Average:**

| Modulation scheme | Frequency | Polarization | Dist. corr. factor | Field strength, Peak Detector, 3m | Duty cycle corr. factor | Limit        | Margin |
|-------------------|-----------|--------------|--------------------|-----------------------------------|-------------------------|--------------|--------|
|                   | MHz       |              | dB                 | dB $\mu$ V/m                      | dB                      | dB $\mu$ V/m | dB     |
| GFSK              | 4.804     | HP           | 0                  | /                                 | 20                      | 54           | /      |
|                   | 4.882     | HP           | 0                  | /                                 | 20                      | 54           | /      |
|                   | 4.960     | HP           | 0                  | /                                 | 20                      | 54           | /      |
| GFSK              | 7.206     | HP           | 0                  | 40.53                             | 20                      | 54           | 13.47  |
|                   | 7.323     | HP           | 0                  | 41.96                             | 20                      | 54           | 12.04  |
|                   | 7.440     | HP           | 0                  | 40.72                             | 20                      | 54           | 13.28  |
| GFSK              | 9.608     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 9.760     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 9.920     | HP           | *                  | /                                 | 20                      | 54           | /      |
| GFSK              | 12.01     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 12.205    | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 12.400    | HP           | *                  | /                                 | 20                      | 54           | /      |
| Other freqs       | L,M,H     | VP/HP        | /                  | None detected                     | 20                      | 54           | >20    |

Distance correction for 1m is included in the spectrum analyser.

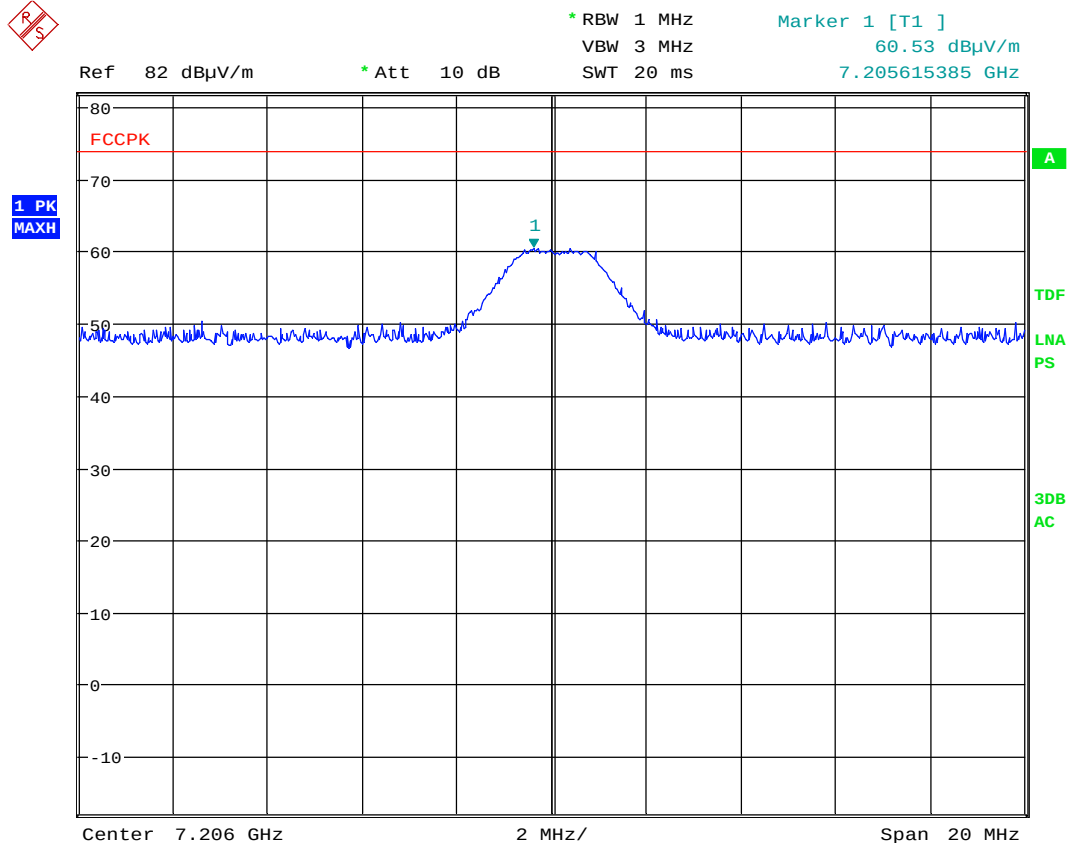
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor".

See plots.

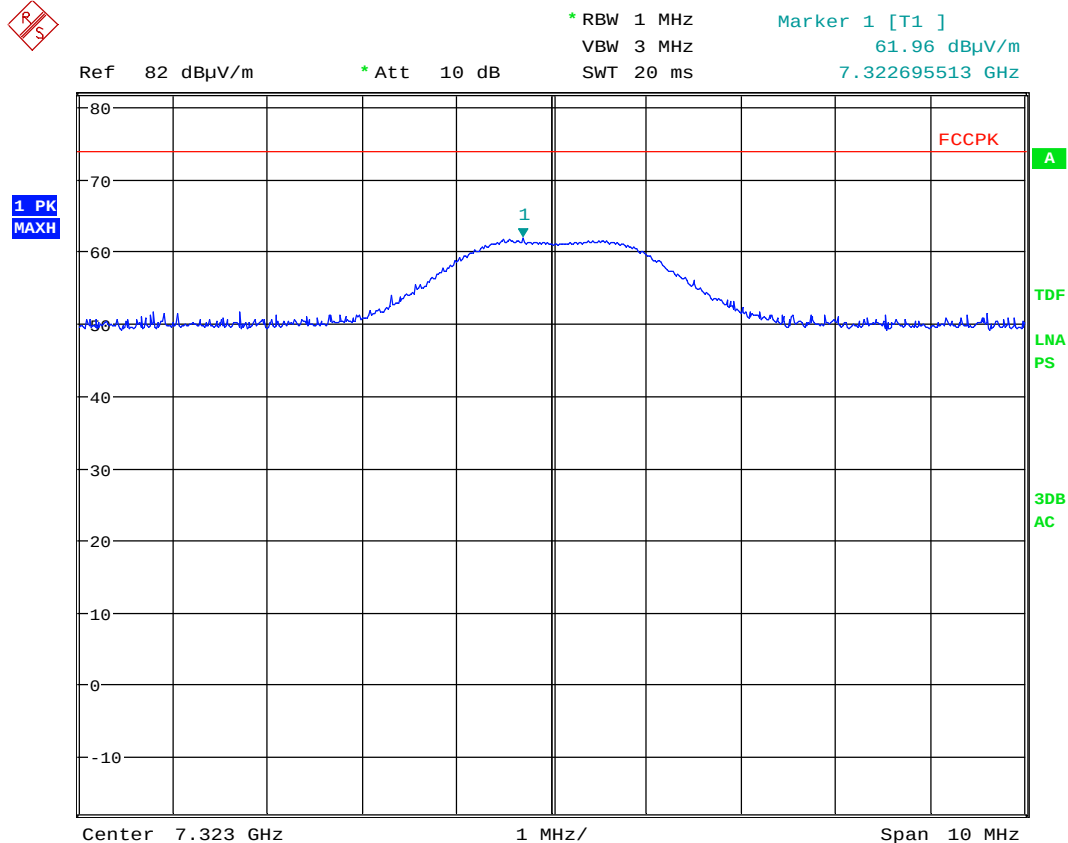
**Requirements/Limit**

|                        |                                                                  |                                     |
|------------------------|------------------------------------------------------------------|-------------------------------------|
| <b>FCC</b>             | Part 15.209 @ frequencies defined in §15.205                     |                                     |
| <b>ISED</b>            | RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10 |                                     |
|                        | <b>Radiated emission limit @3 meters</b>                         |                                     |
| <b>Frequency (MHz)</b> | <b>AV (dB<math>\mu</math>V/m)</b>                                | <b>Peak (dB<math>\mu</math>V/m)</b> |
| <b>Above 1 GHz</b>     | 54.0                                                             | 74.0                                |



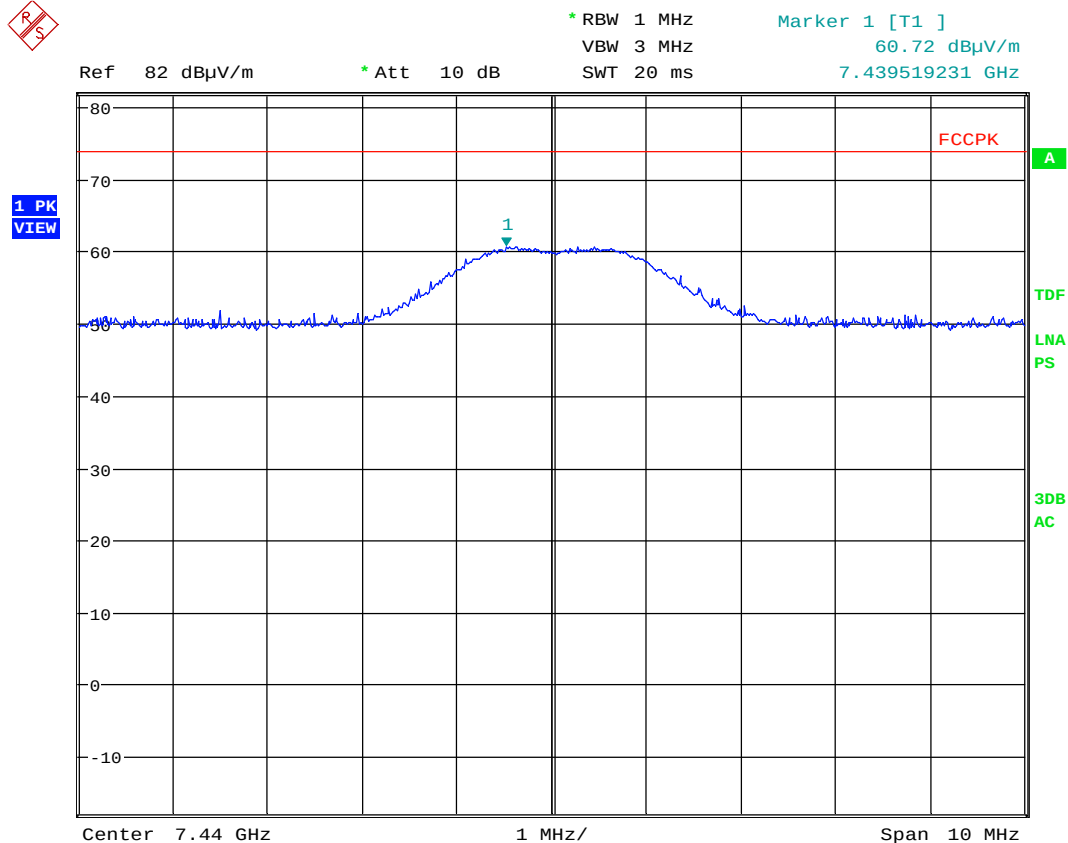
Date: 4.JUN.2019 12:28:44

3rd har, PK, ch2402MHz, GFSK – HP



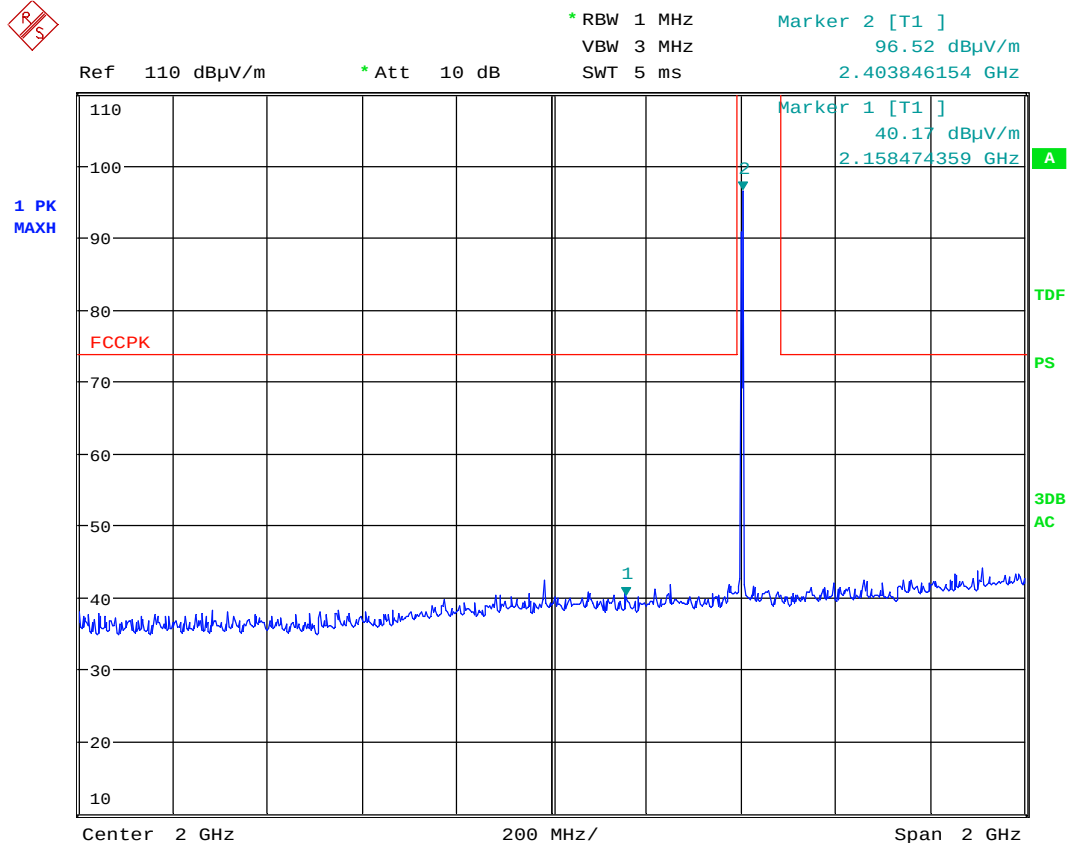
Date: 5.JUN.2019 17:03:24

3rd har, PK, ch2441MHz, GFSK – HP



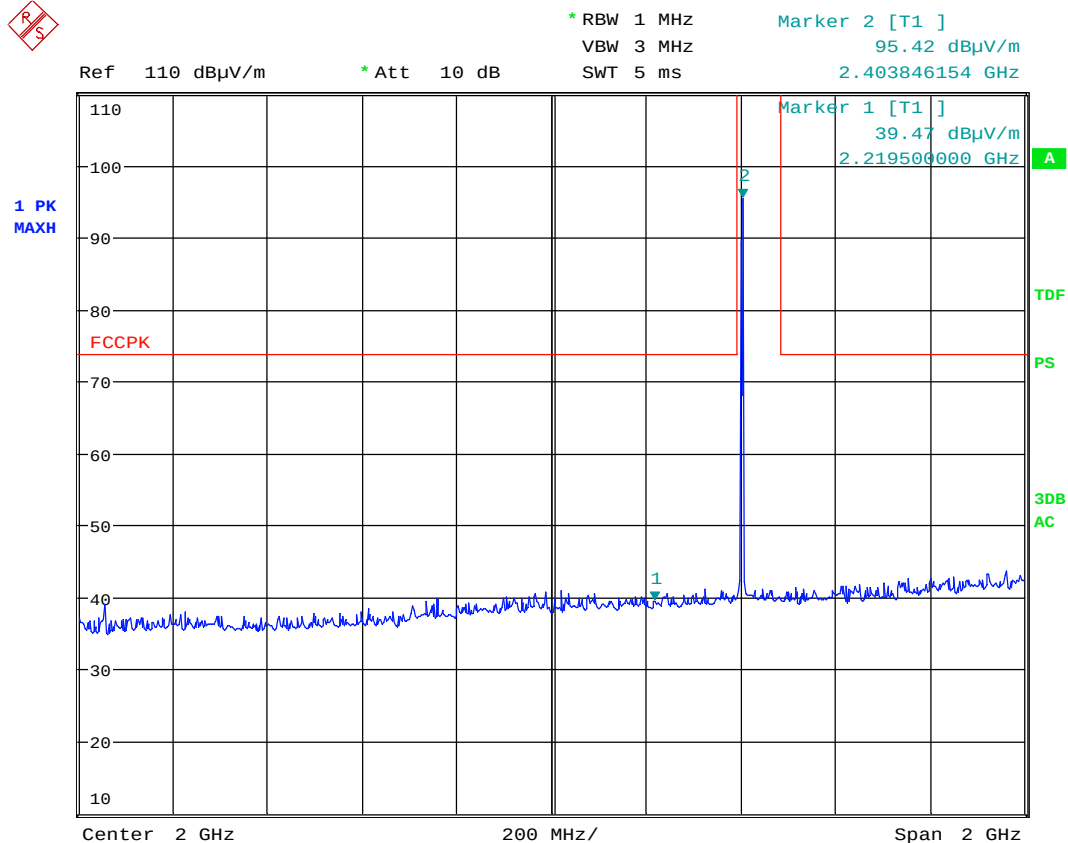
Date: 5.JUN.2019 17:08:02

3rd har, PK, ch2480MHz, GFSK – HP



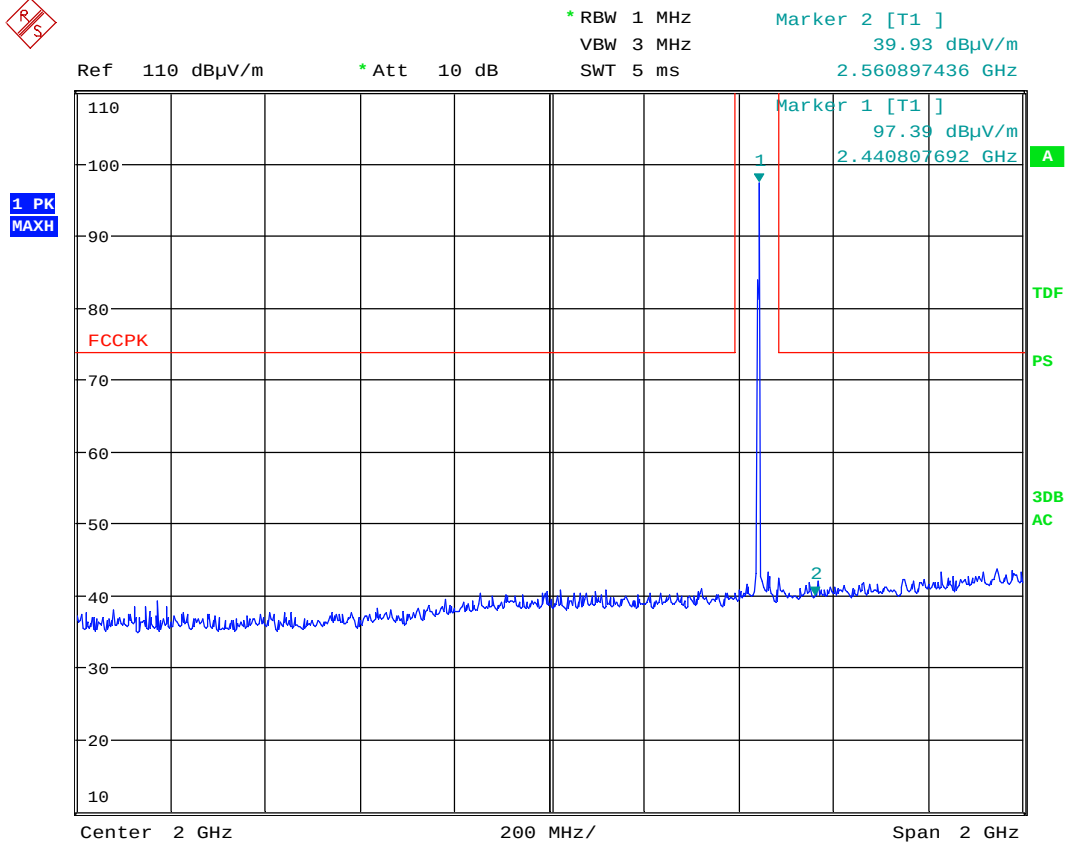
Date: 4.JUN.2019 10:22:03

VP, 1 - 3GHz , GFSK, ch2402MHz, PK scan



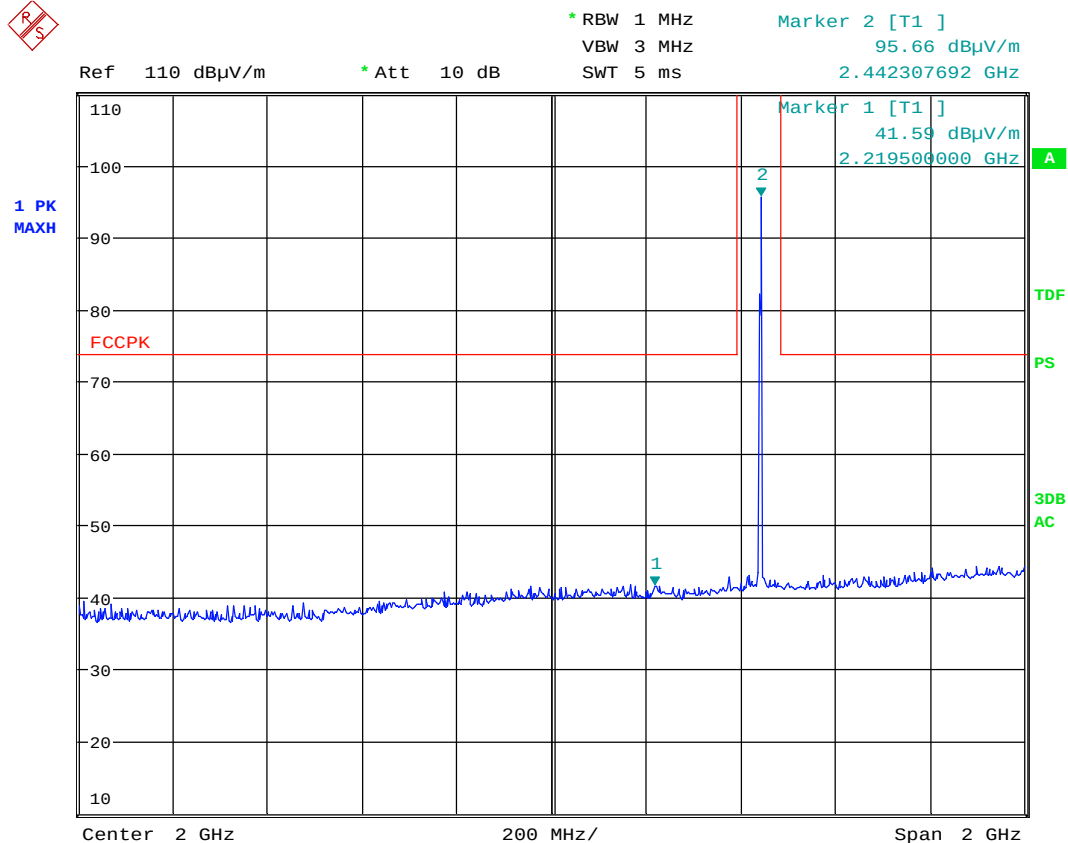
Date: 4.JUN.2019 10:24:44

HP, 1 - 3GHz , GFSK, Ch2402MHz, PK scan



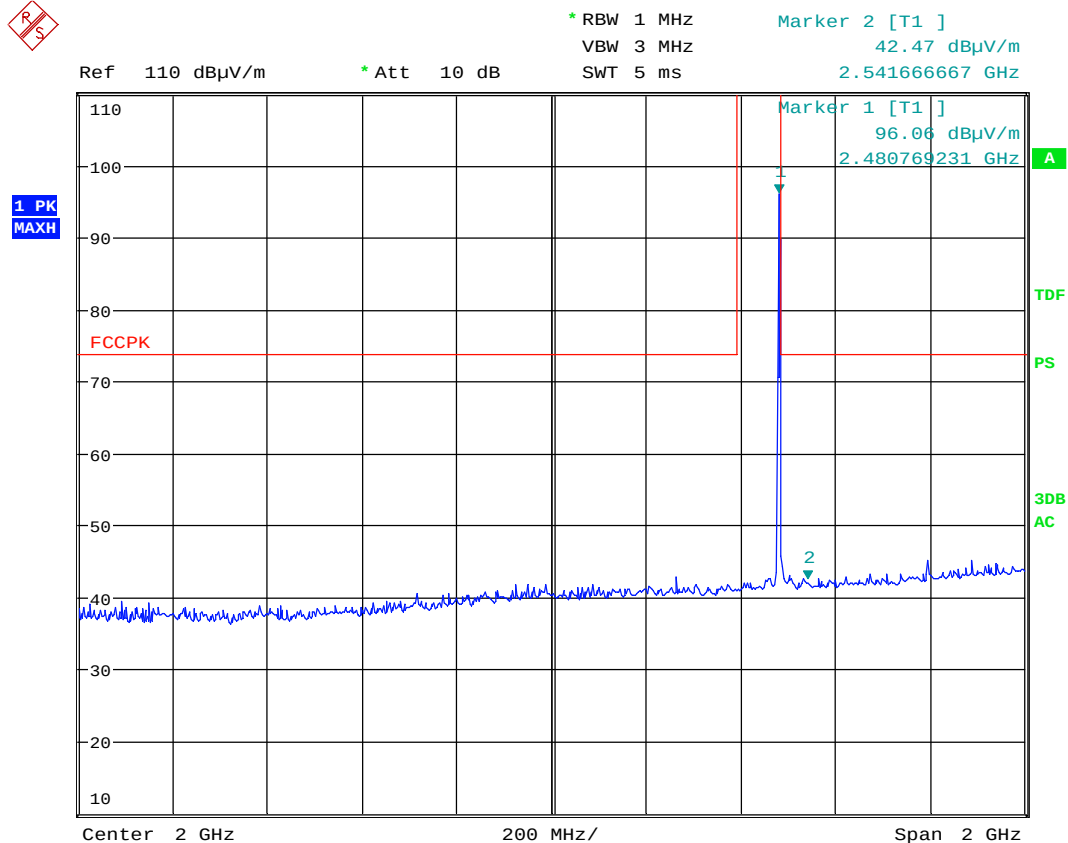
Date: 4.JUN.2019 10:28:33

VP, 1 - 3GHz , GFSK, ch2441MHz, PK scan



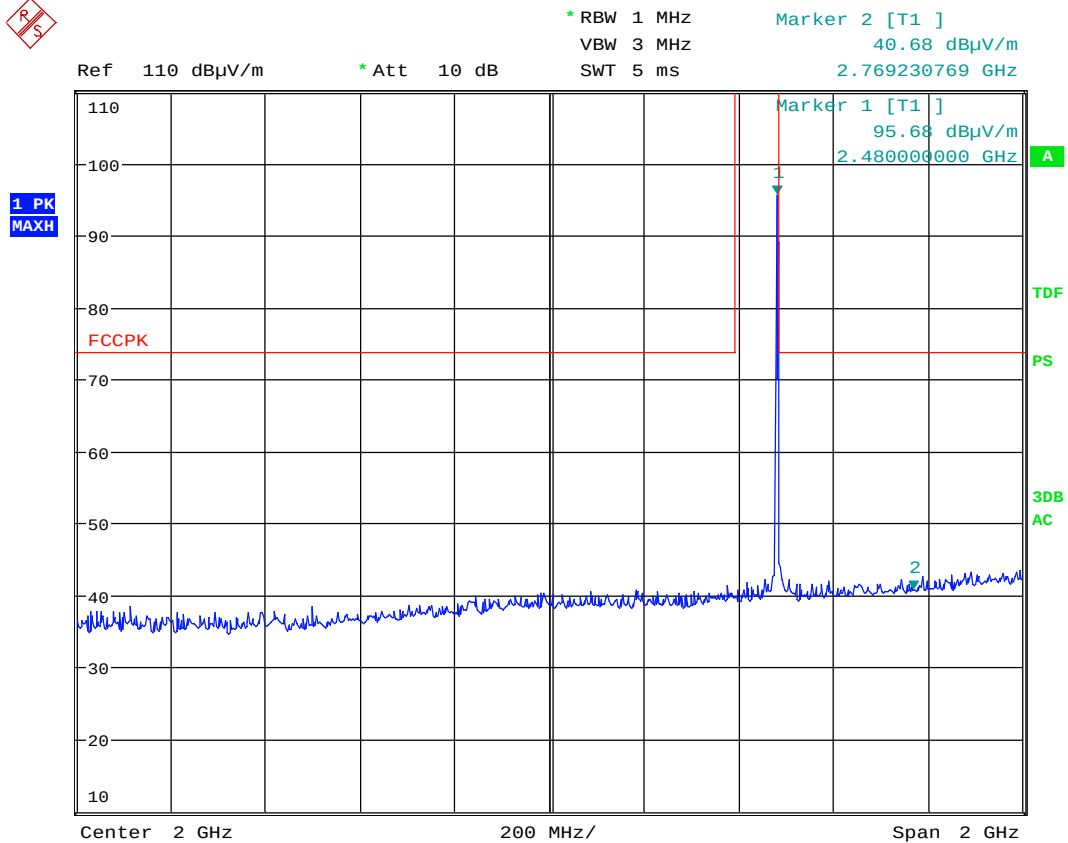
Date: 4.JUN.2019 10:26:12

HP, 1 - 3GHz , GFSK, Ch2441MHz, PK scan



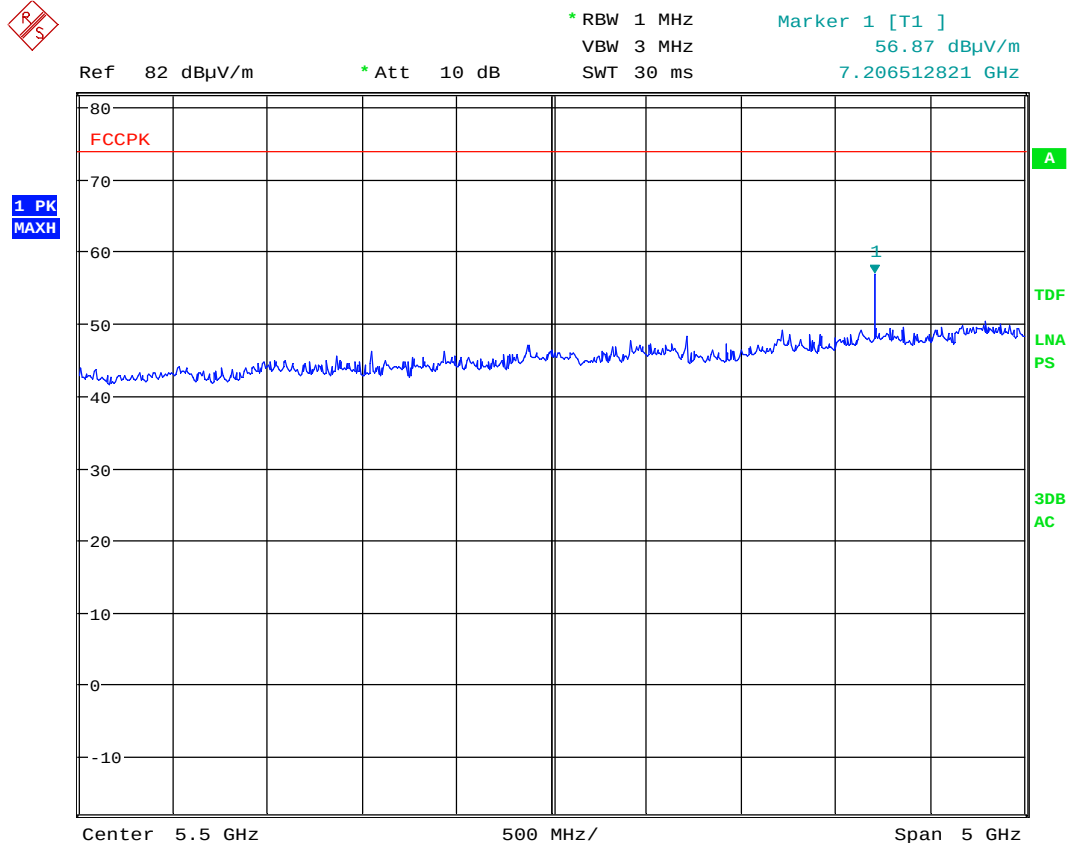
Date: 4.JUN.2019 10:29:38

VP, 1 - 3GHz , GFSK, ch2480MHz, PK scan



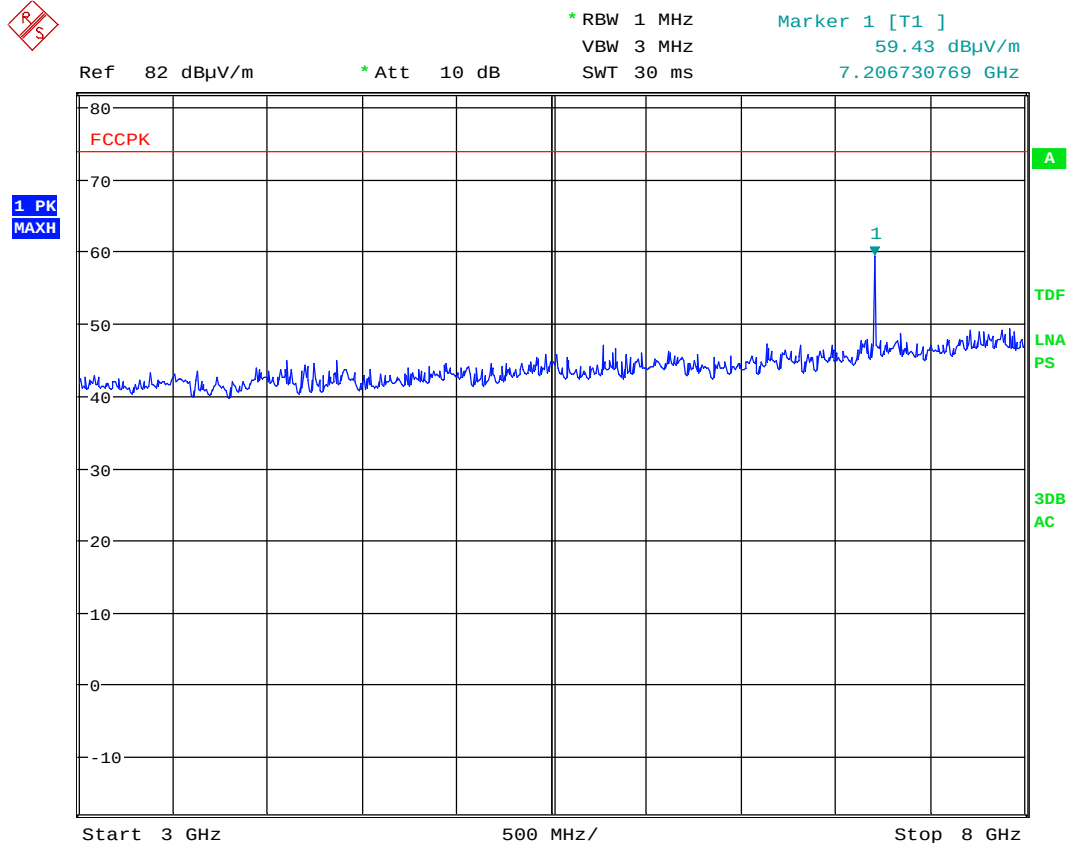
Date: 4.JUN.2019 10:33:15

HP, 1 - 3GHz , GFSK, Ch2480MHz, PK scan



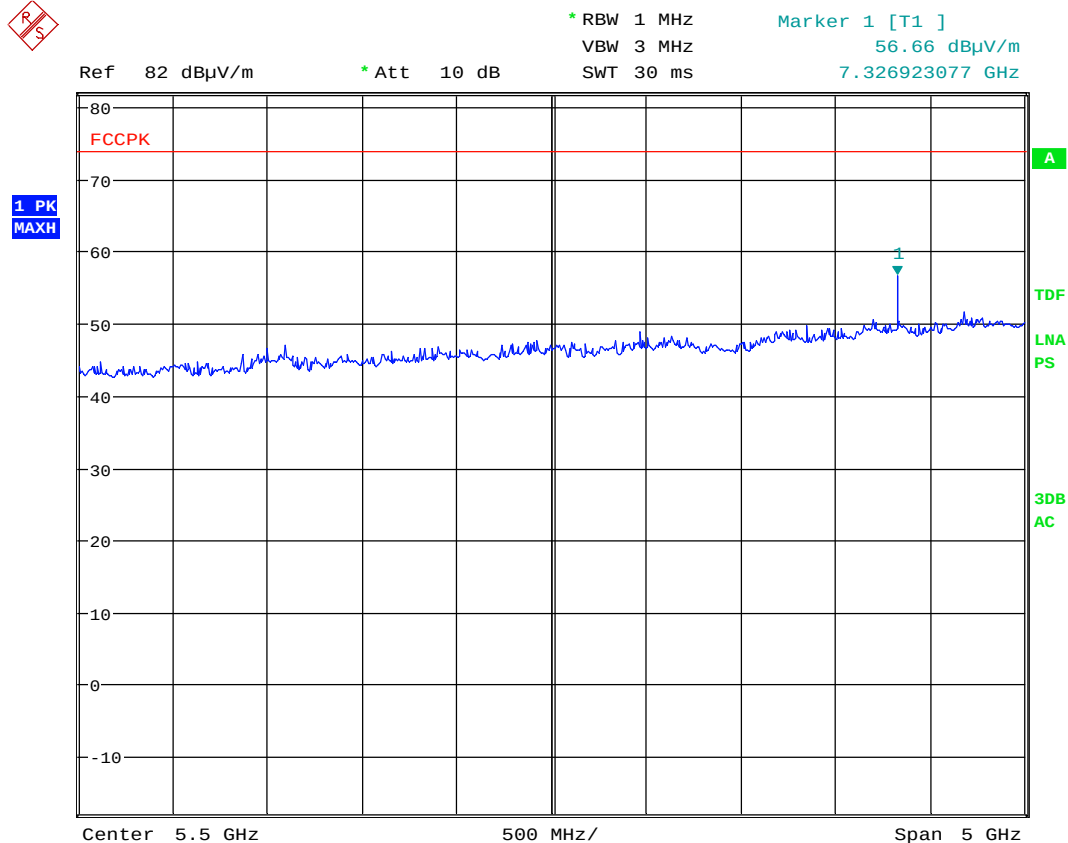
Date: 4.JUN.2019 12:31:15

VP, 3 - 8GHz , GFSK, ch2402MHz, PK scan



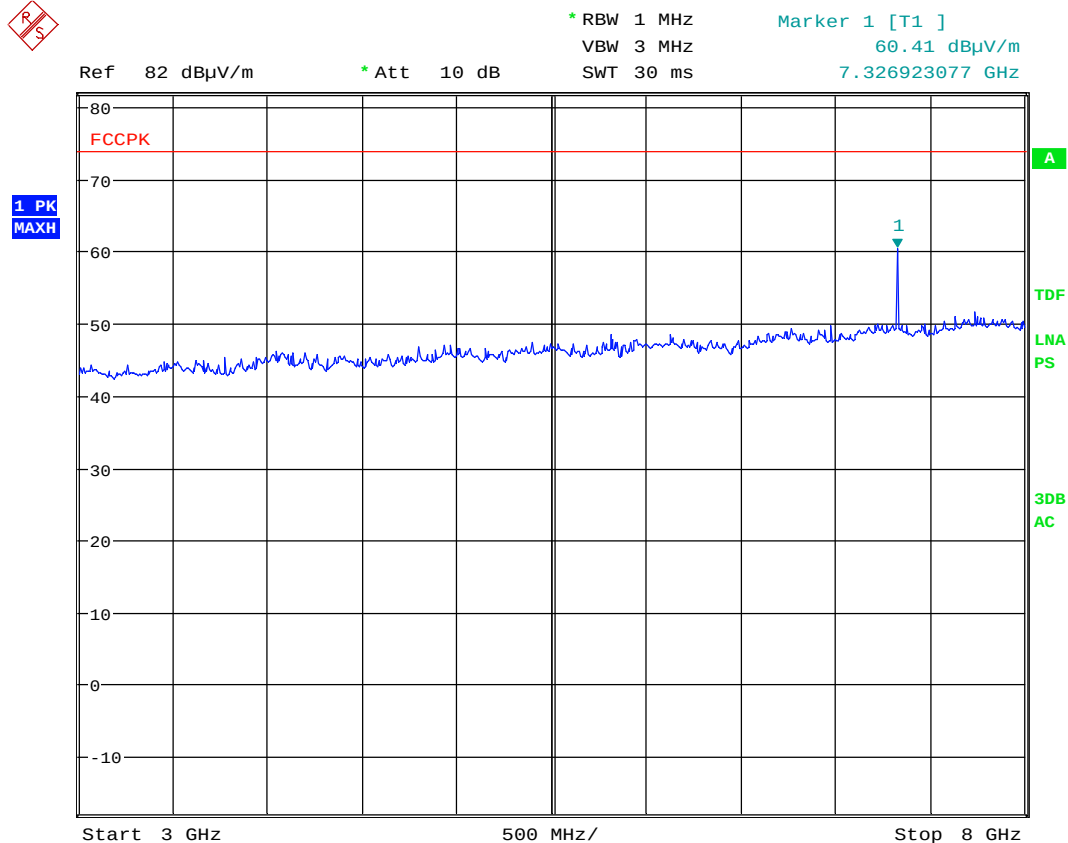
Date: 4.JUN.2019 12:27:44

HP, 3 - 8GHz , GFSK,ch2402MHz, PK scan



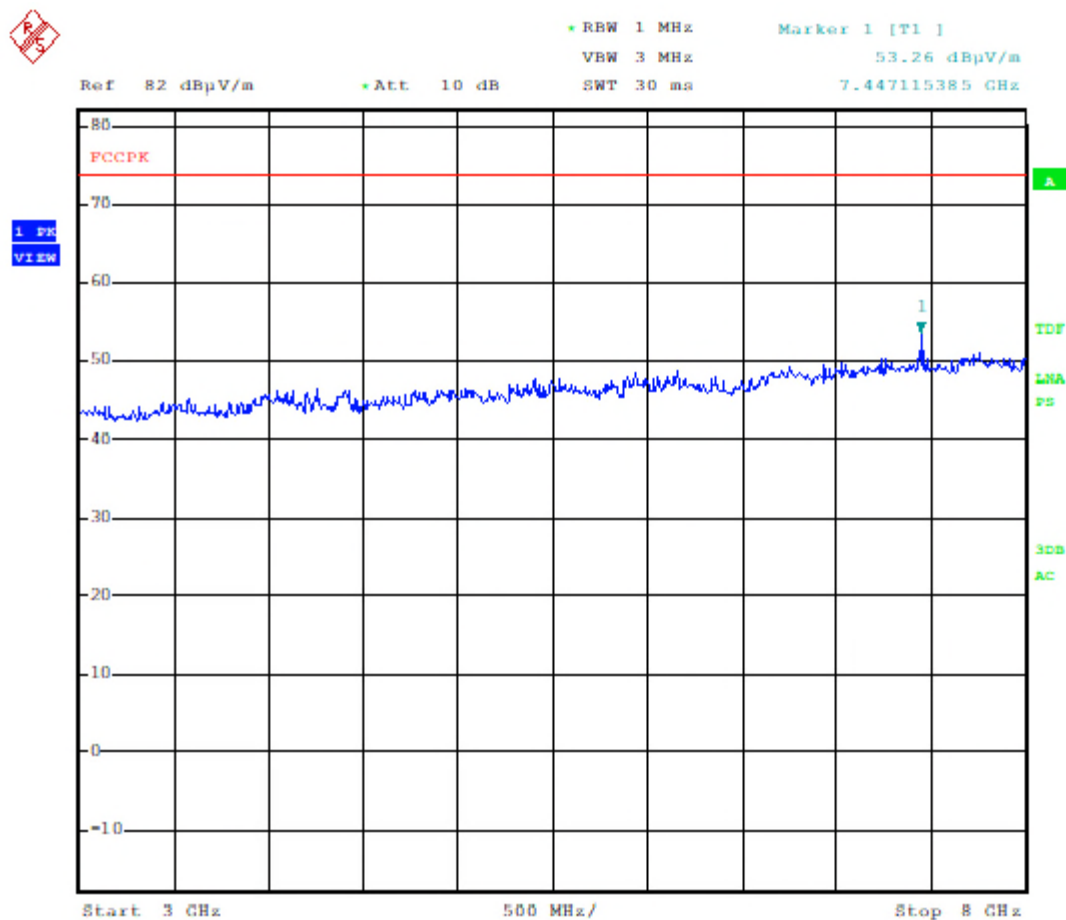
Date: 5.JUN.2019 16:58:39

VP, 3 - 8GHz , GFSK, ch2441MHz, PK scan

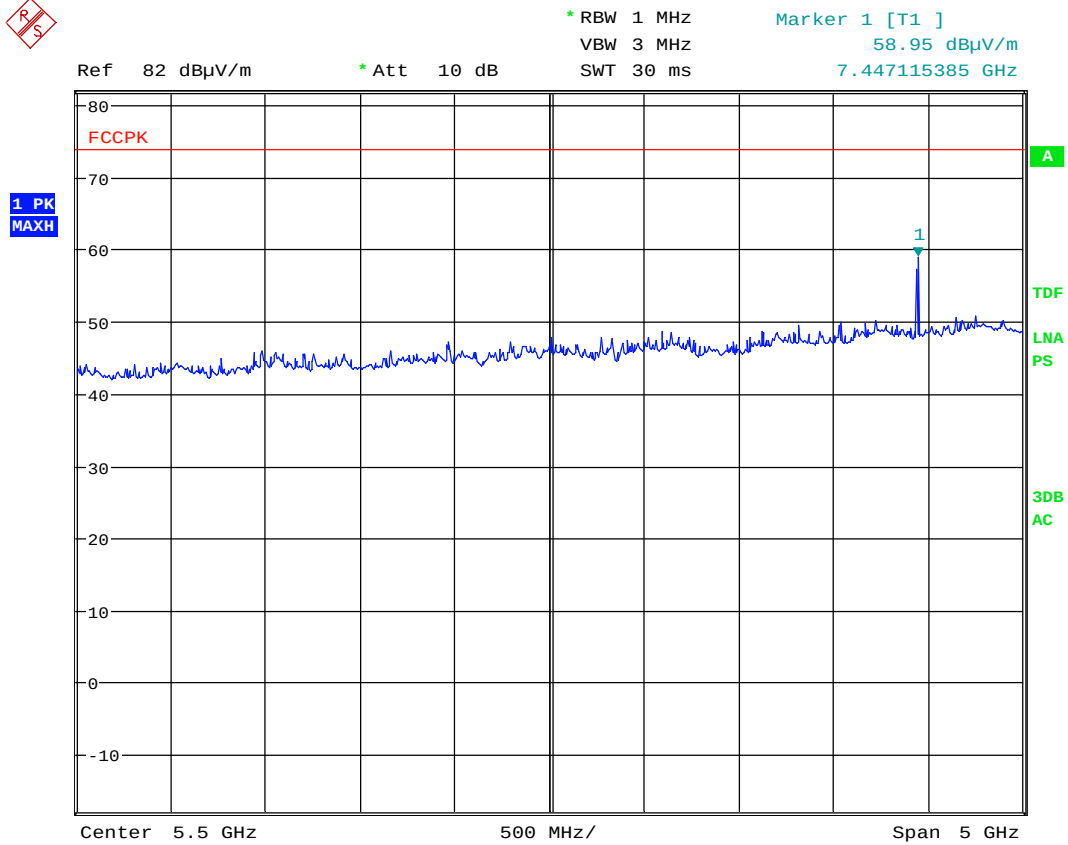


Date: 5.JUN.2019 17:00:54

HP, 3 - 8GHz , GFSK,ch2441MHz, PK scan

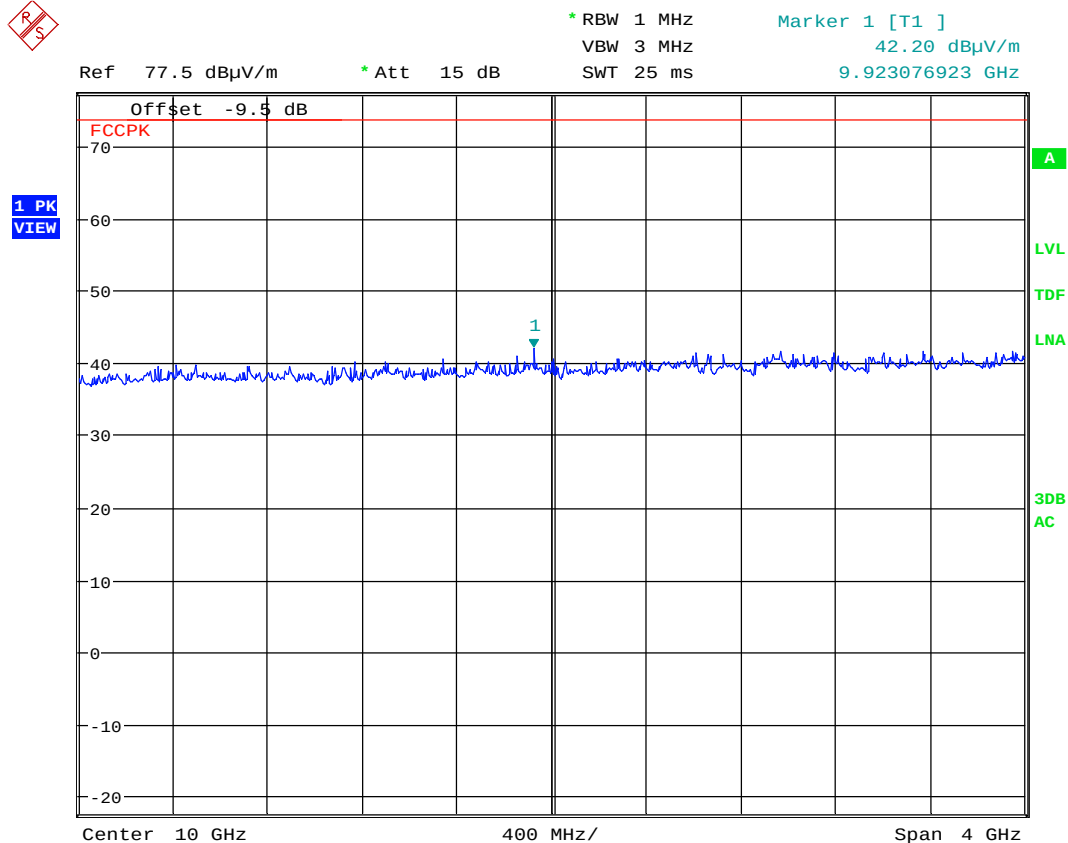


VP, 3 - 8GHz , GFSK, ch2480MHz, PK scan



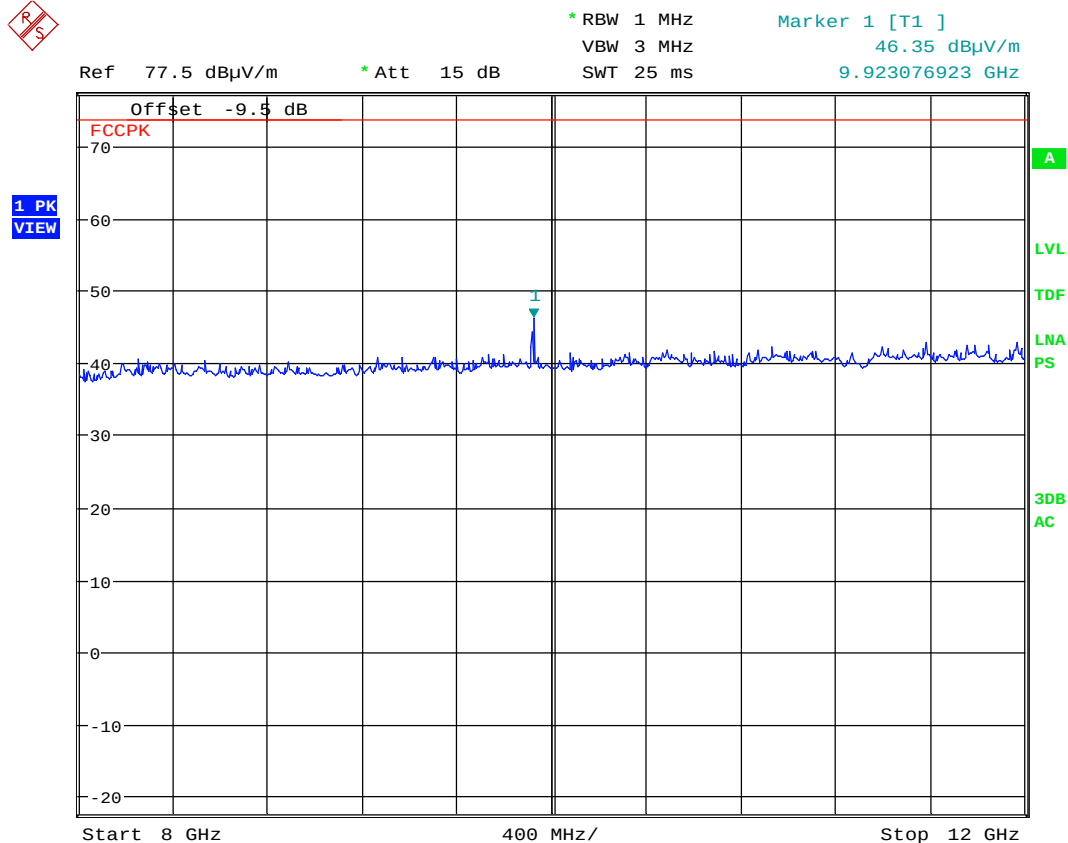
Date: 5.JUN.2019 17:07:11

HP, 3 - 8GHz , GFSK,ch2480MHz, PK scan



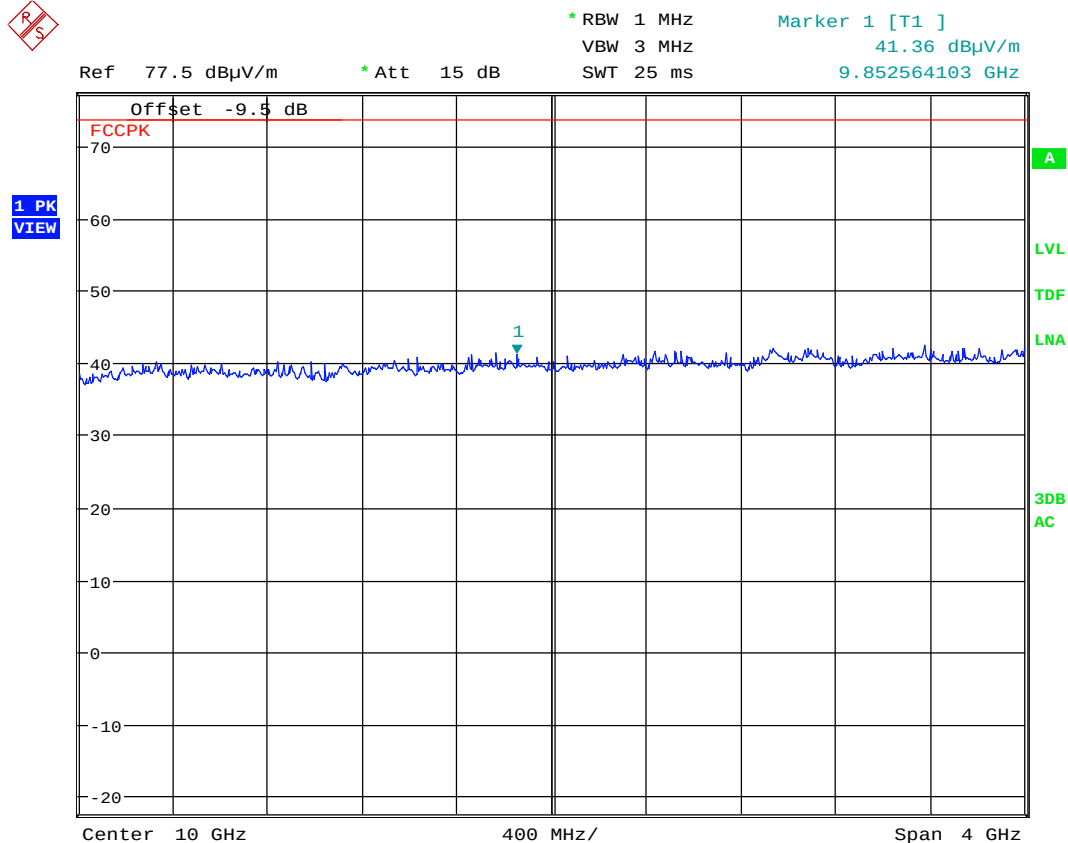
Date: 5.JUN.2019 19:03:10

VP, 8 - 12GHz , GFSK,ch2402MHz, PK scan,@ 1m distance



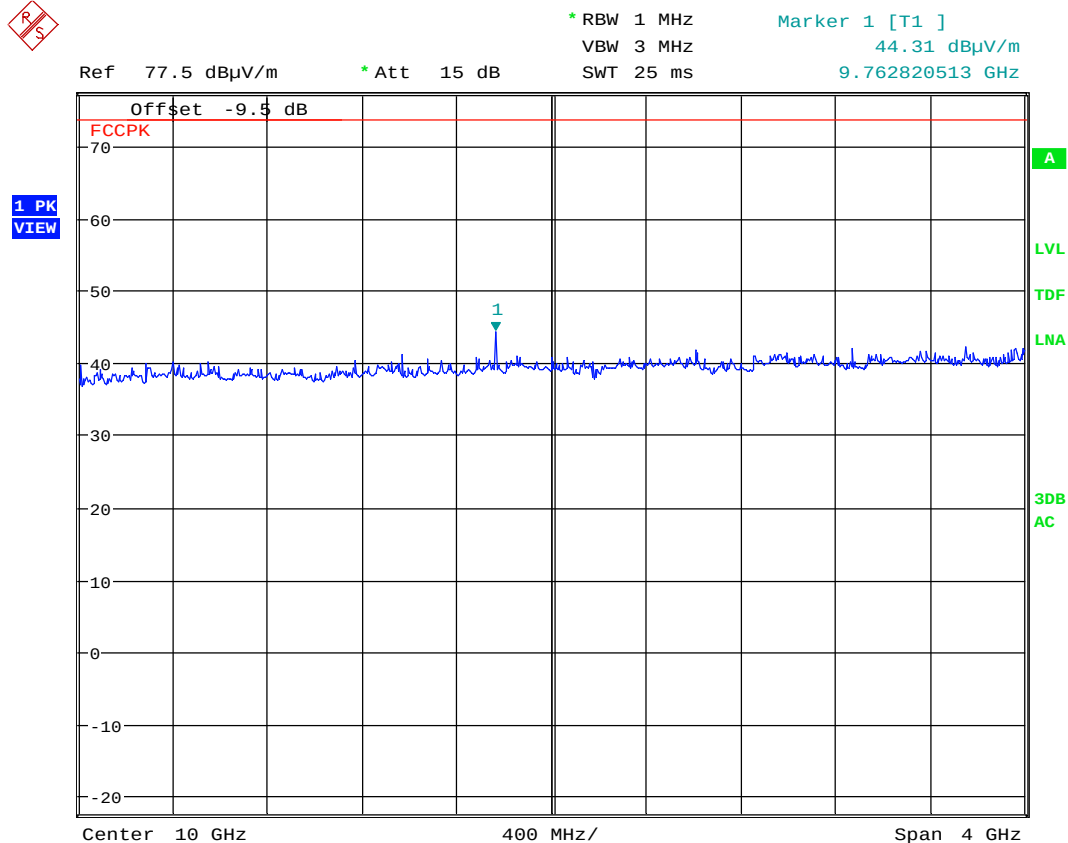
Date: 5.JUN.2019 19:01:57

HP, 8 - 12GHz , GFSK,ch2402MHz, PK scan, @ 1m distance



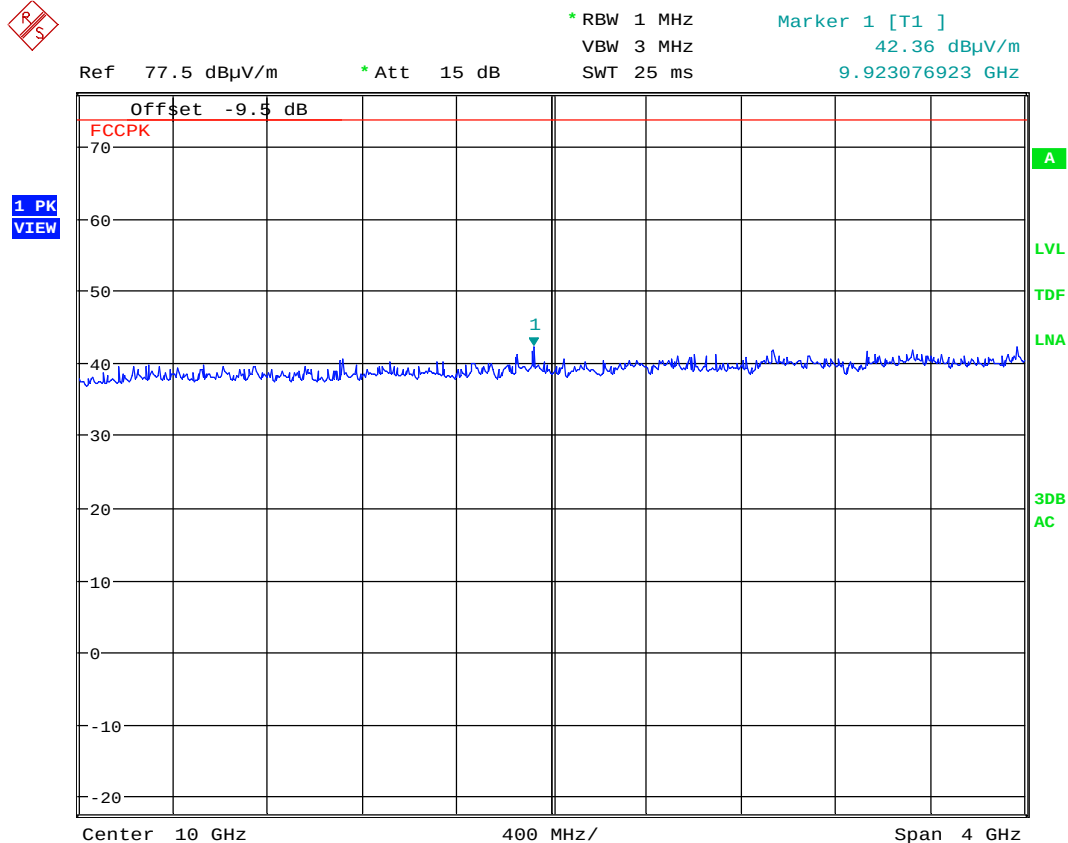
Date: 5.JUN.2019 19:13:27

VP, 8 - 12GHz , GFSK,ch2441MHz, PK scan,@ 1m distance



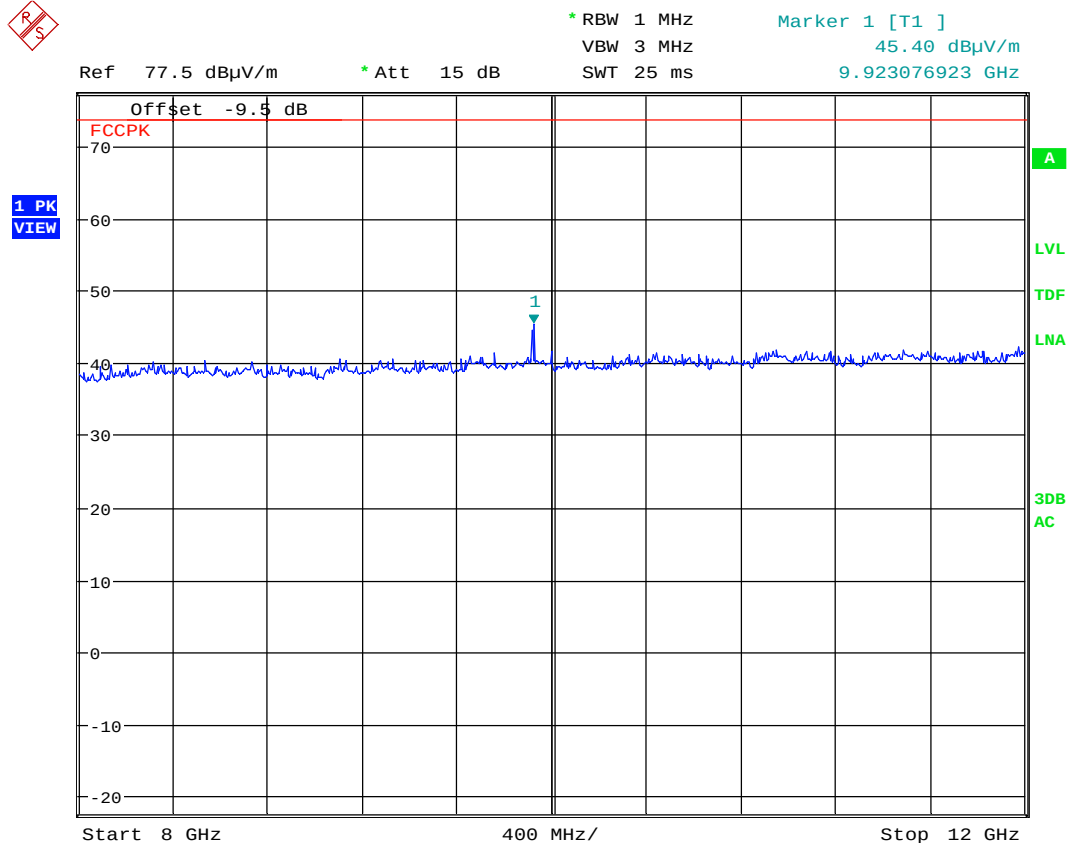
Date: 5.JUN.2019 19:14:09

HP, 8 - 12GHz , GFSK,ch2441MHz, PK scan, @ 1m distance



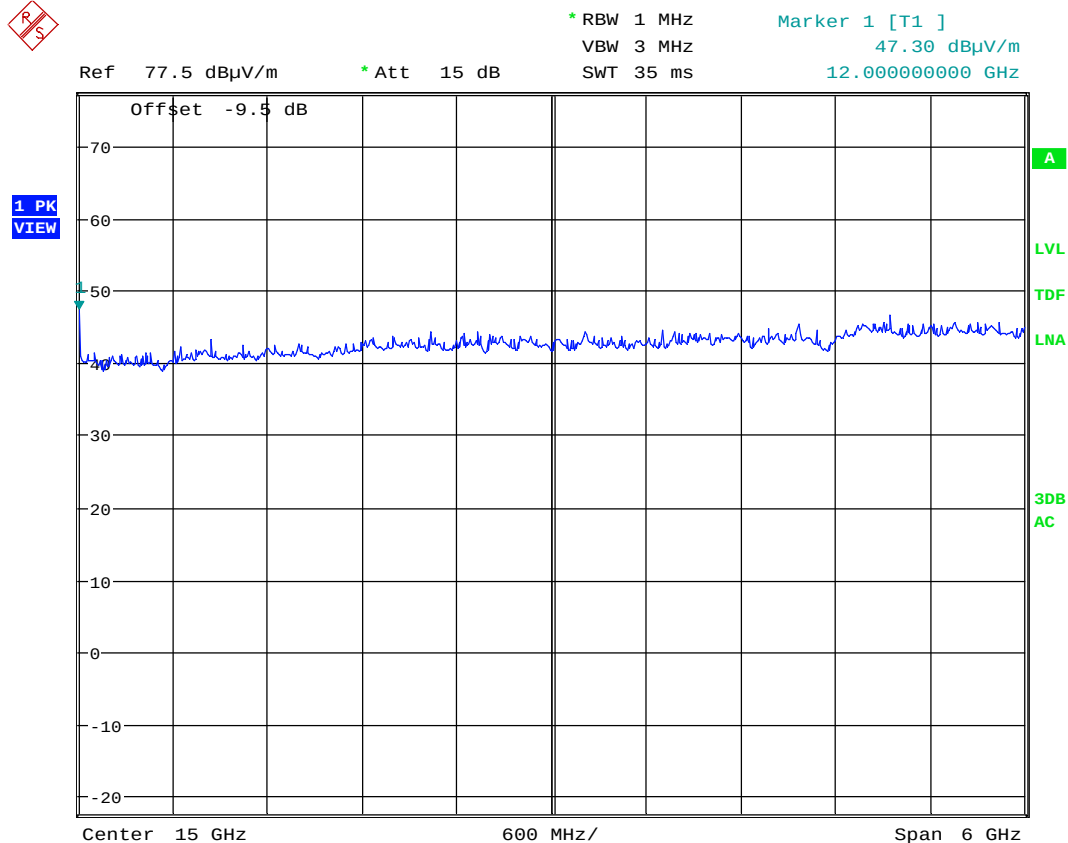
Date: 5.JUN.2019 19:11:20

VP, 8 - 12GHz , GFSK,ch2480MHz, PK scan,@ 1m distance



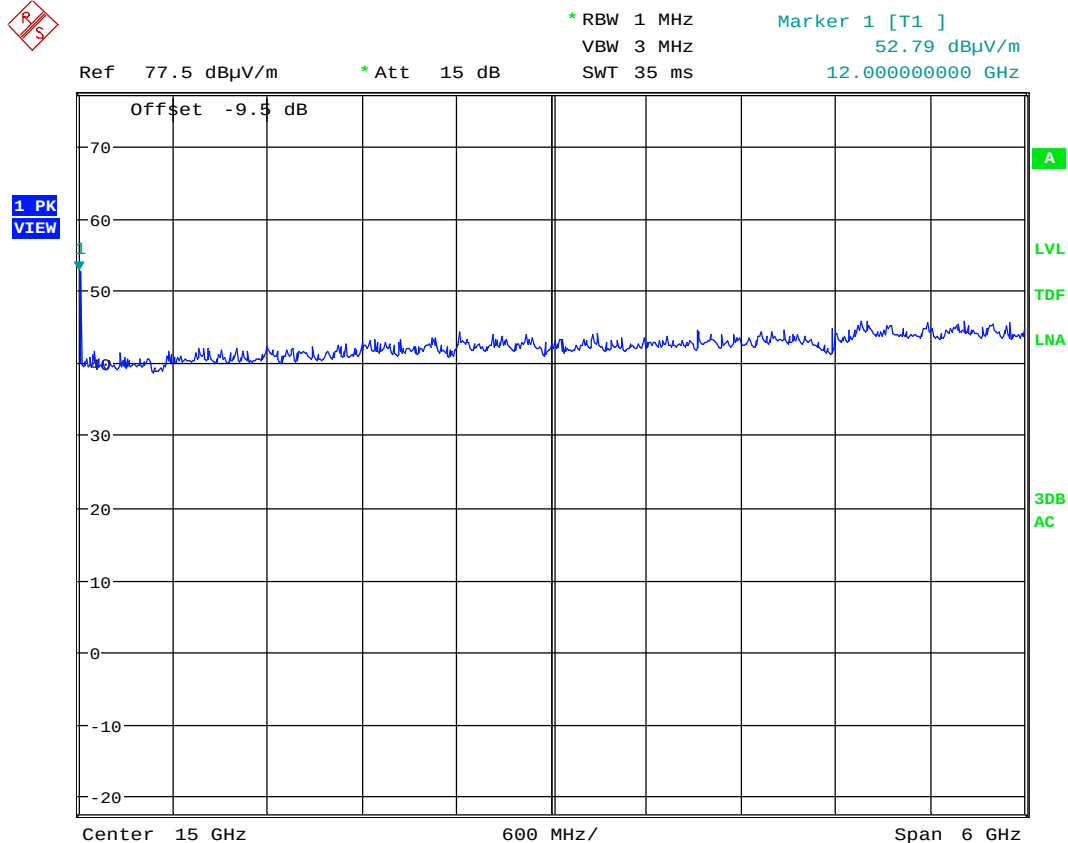
Date: 5.JUN.2019 19:10:44

HP, 8 - 12GHz , GFSK,ch2480MHz, PK scan, @ 1m distance



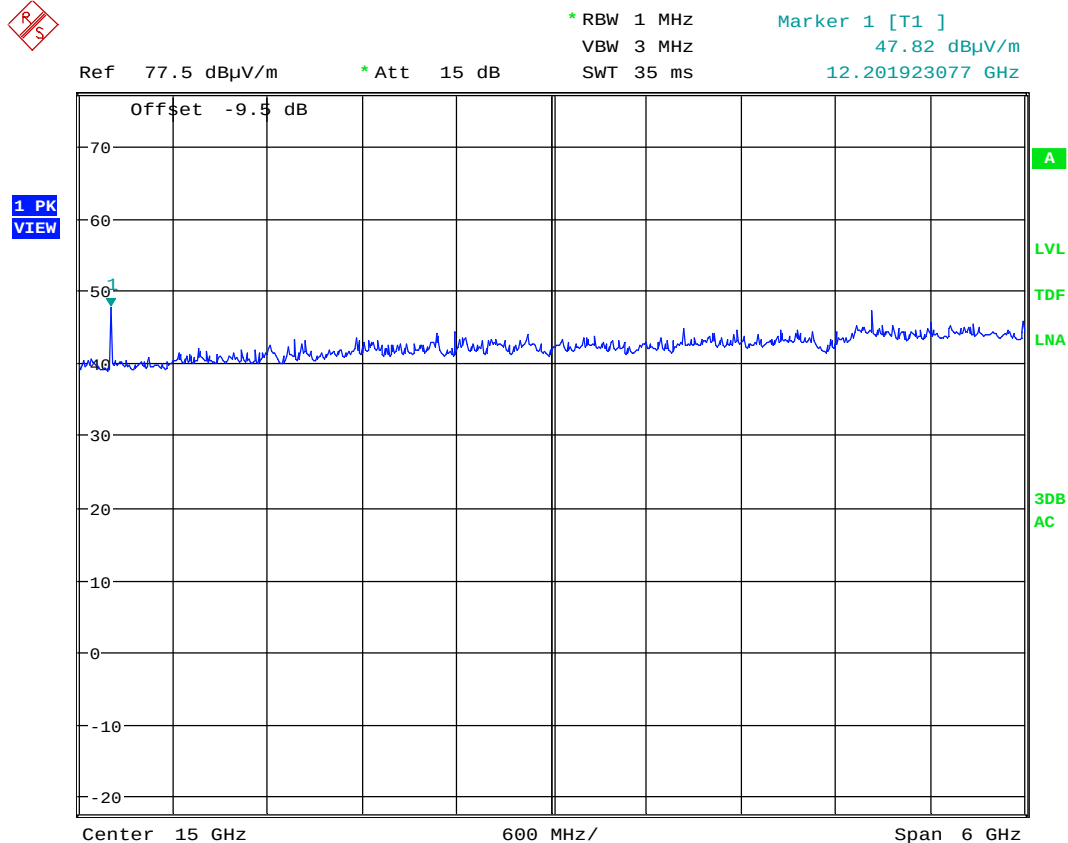
Date: 5.JUN.2019 20:30:47

VP, 12 - 18GHz , GFSK,ch2402MHz, PK scan, @ 1m distance



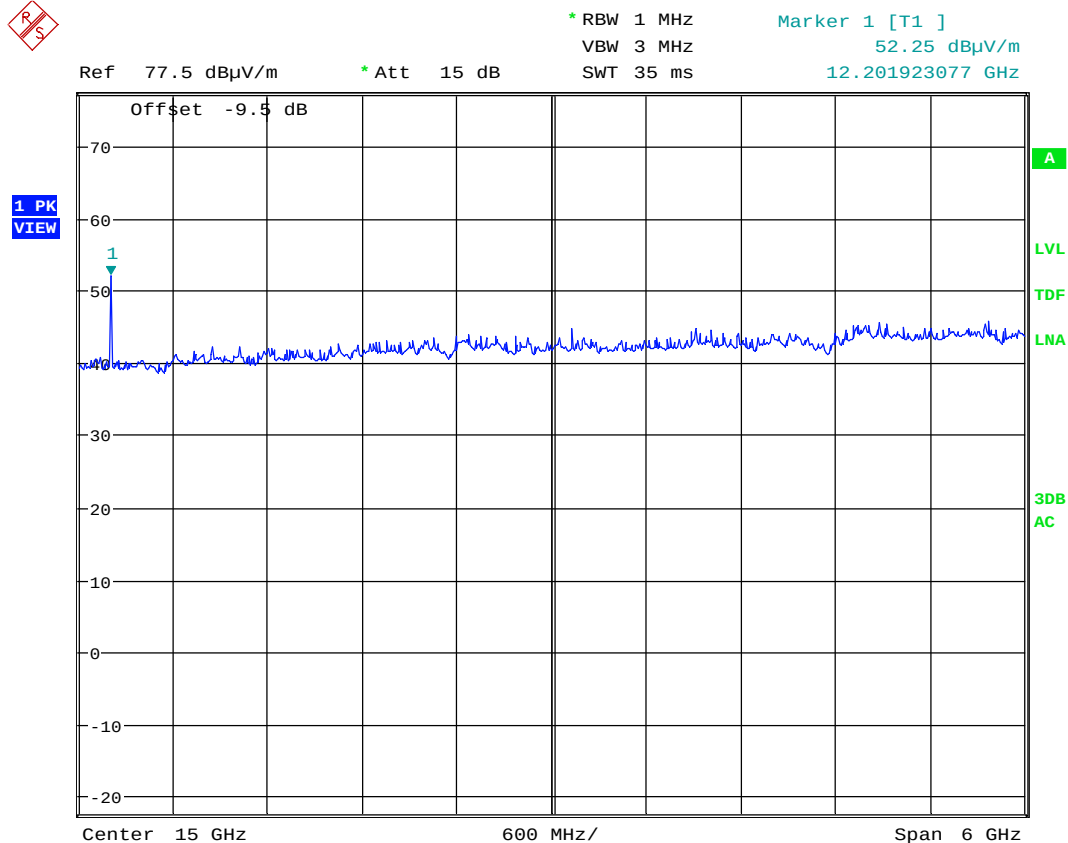
Date: 5.JUN.2019 20:31:16

HP, 12 - 18GHz , GFSK,ch2402MHz PK scan, @ 1m distance



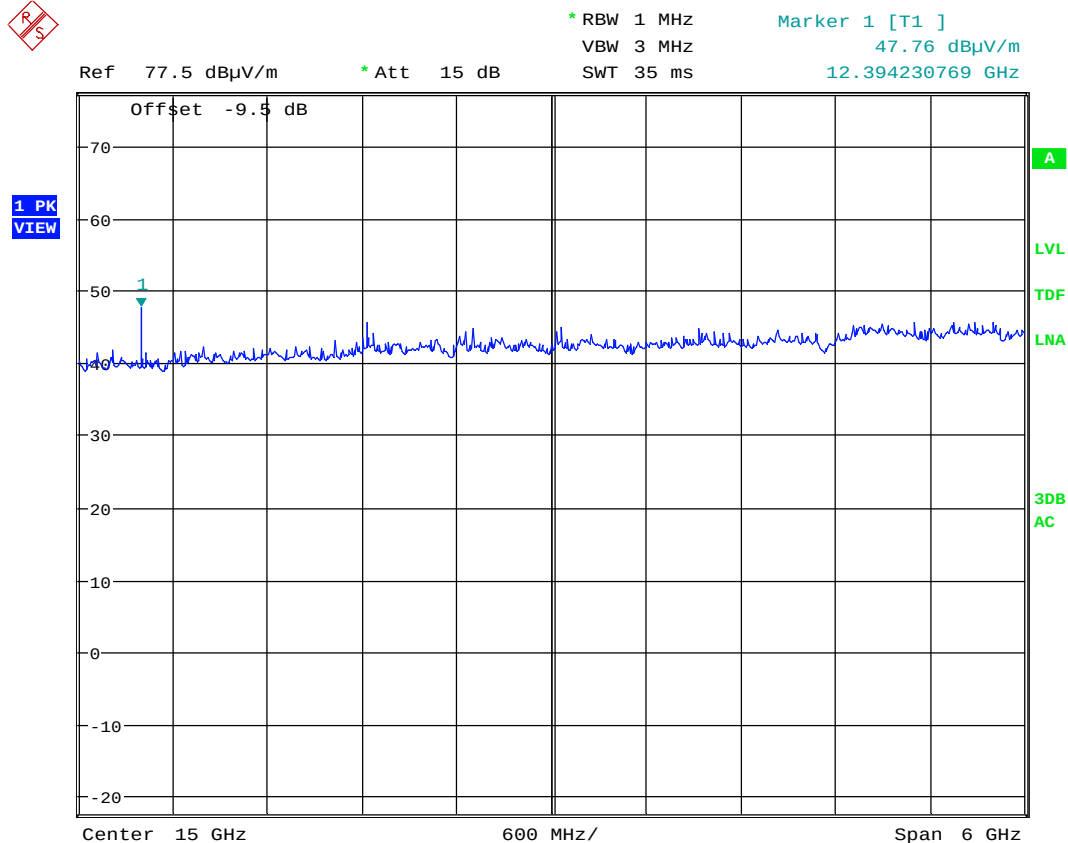
Date: 5.JUN.2019 20:32:37

VP, 12 - 18GHz , GFSK,ch2441MHz, PK scan, @ 1m distance



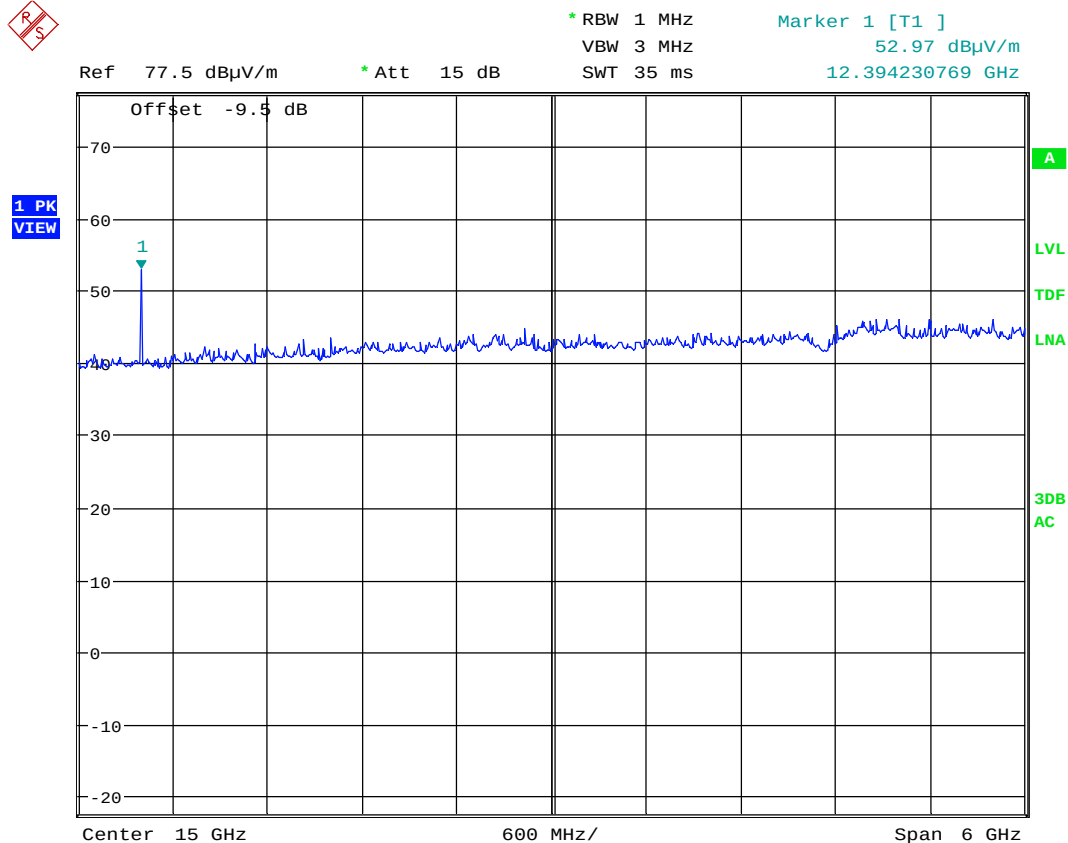
Date: 5.JUN.2019 20:32:12

HP, 12 - 18GHz , GFSK,ch2441MHz PK scan, @ 1m distance



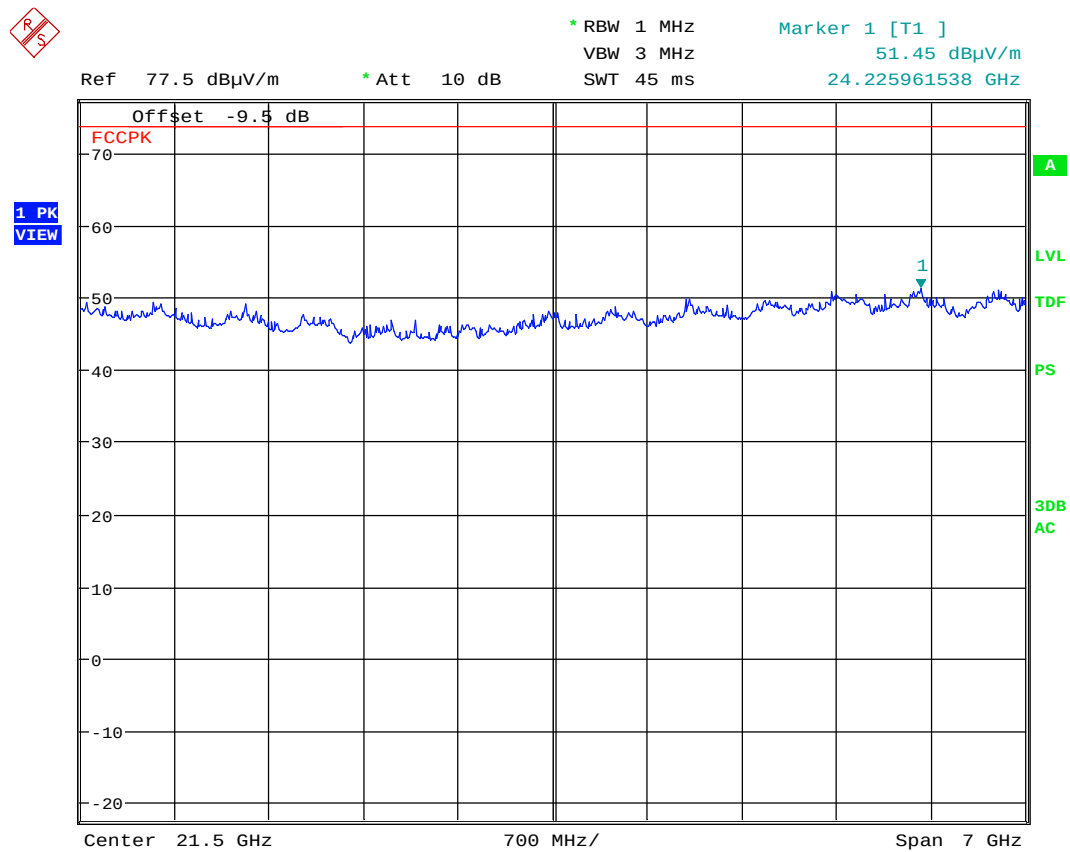
Date: 5.JUN.2019 20:33:42

VP, 12 - 18GHz , GFSK,ch2480MHz, PK scan, @ 1m distance



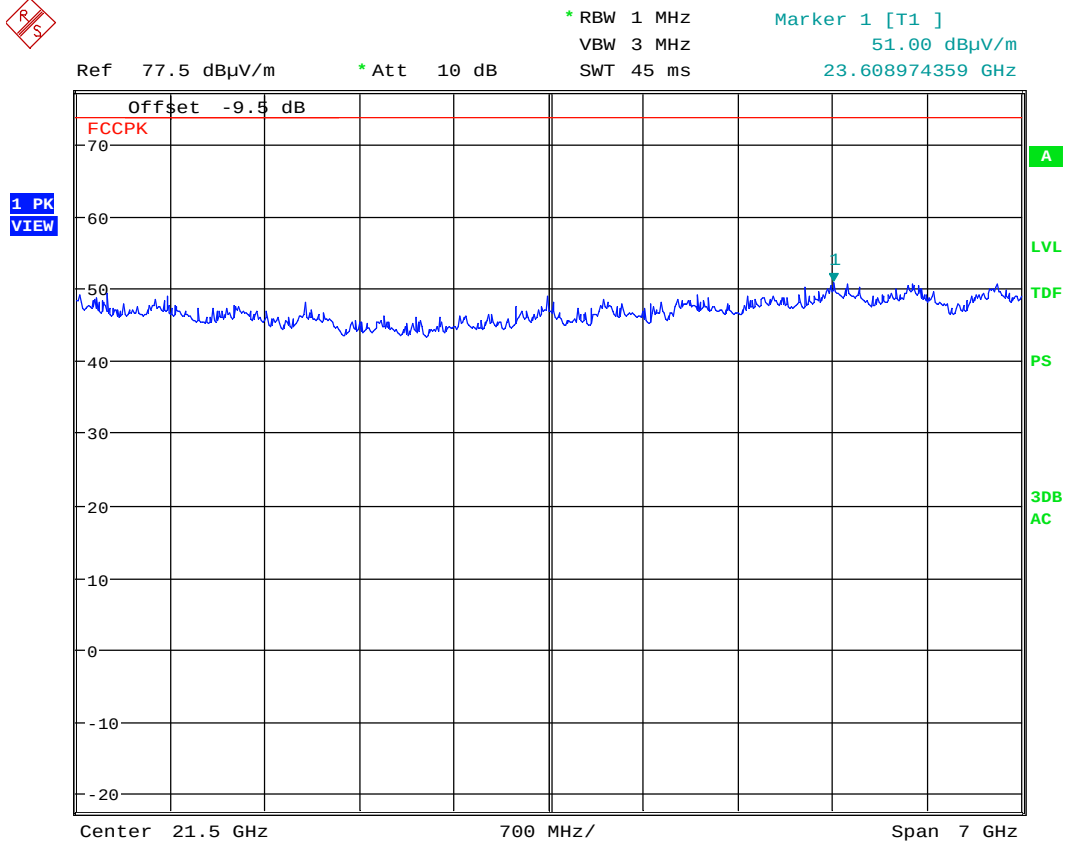
Date: 5.JUN.2019 20:34:16

HP, 12 - 18GHz , GFSK,ch2480MHz PK scan, @ 1m distance



Date: 5.JUN.2019 20:53:16

**Pre-scan VP, 18 - 25GHz , GFSK @ 1m distance**



Date: 5.JUN.2019 20:53:53

Pre-scn HP, 18 - 25GHz , GFSK @ 1m distance

# IN 8DPSK MODE:

**Radiated Emissions, 1-25 GHz;** Measuring distance:3m (1 – 8 GHz), 1m (8 – 18 GHz); A pre-scan was performed above 18 GHz and no spurious emissions were detected.

## Peak Detector:

| Modulation scheme | Frequency | Polarization | Dist. corr. factor | Field strength, Peak Detector, 3m | Duty cycle corr. factor | Limit        | Margin |
|-------------------|-----------|--------------|--------------------|-----------------------------------|-------------------------|--------------|--------|
|                   | GHz       |              | dB                 | dB $\mu$ V/m                      | dB                      | dB $\mu$ V/m | dB     |
| 8DPSK             | 4.804     | HP           | 0                  | /                                 | /                       | 74           | /      |
|                   | 4.882     | HP           | 0                  | /                                 | /                       | 74           | /      |
|                   | 4.960     | HP           | 0                  | /                                 | /                       | 74           | /      |
| 8DPSK             | 7.206     | HP           | 0                  | 61.57                             | /                       | 74           | 12.43  |
|                   | 7.323     | HP           | 0                  | 61.45                             | /                       | 74           | 12.55  |
|                   | 7.440     | HP           | 0                  | 60.79                             | /                       | 74           | 13.21  |
| 8DPSK             | 9.608     | HP           | *                  | 45.95                             | /                       | 74           | 28.05  |
|                   | 9.760     | HP           | *                  | 45.16                             | /                       | 74           | 28.84  |
|                   | 9.920     | HP           | *                  | 44.23                             | /                       | 74           | 29.77  |
| 8DPSK             | 12.01     | HP           | *                  | 49.30                             | /                       | 74           | 24.70  |
|                   | 12.205    | HP           | *                  | 51.29                             | /                       | 74           | 22.71  |
|                   | 12.400    | HP           | *                  | 49.80                             | /                       | 74           | 24.20  |
| Other freqs       | L,M,H     | VP/HP        | /                  | None detected                     | /                       | 74           | >20    |

\*distance correction is included in the plot

**Average:**

| Modulation scheme | Frequency | Polarization | Dist. corr. factor | Field strength, Peak Detector, 3m | Duty cycle corr. factor | Limit        | Margin |
|-------------------|-----------|--------------|--------------------|-----------------------------------|-------------------------|--------------|--------|
|                   | MHz       |              | dB                 | dB $\mu$ V/m                      | dB                      | dB $\mu$ V/m | dB     |
| 8DPSK             | 4.804     | HP           | 0                  | /                                 | 20                      | 54           | /      |
|                   | 4.882     | HP           | 0                  | /                                 | 20                      | 54           | /      |
|                   | 4.960     | HP           | 0                  | /                                 | 20                      | 54           | /      |
| 8DPSK             | 7.206     | HP           | 0                  | 41.57                             | 20                      | 54           | 12.43  |
|                   | 7.323     | HP           | 0                  | 41.45                             | 20                      | 54           | 12.55  |
|                   | 7.440     | HP           | 0                  | 40.79                             | 20                      | 54           | 13.21  |
| 8DPSK             | 9.608     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 9.760     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 9.920     | HP           | *                  | /                                 | 20                      | 54           | /      |
| 8DPSK             | 12.01     | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 12.205    | HP           | *                  | /                                 | 20                      | 54           | /      |
|                   | 12.400    | HP           | *                  | /                                 | 20                      | 54           | /      |
| Other freqs       | L,M,H     | VP/HP        | /                  | None detected                     | 20                      | 54           | >20    |

\*distance correction is included in the plot

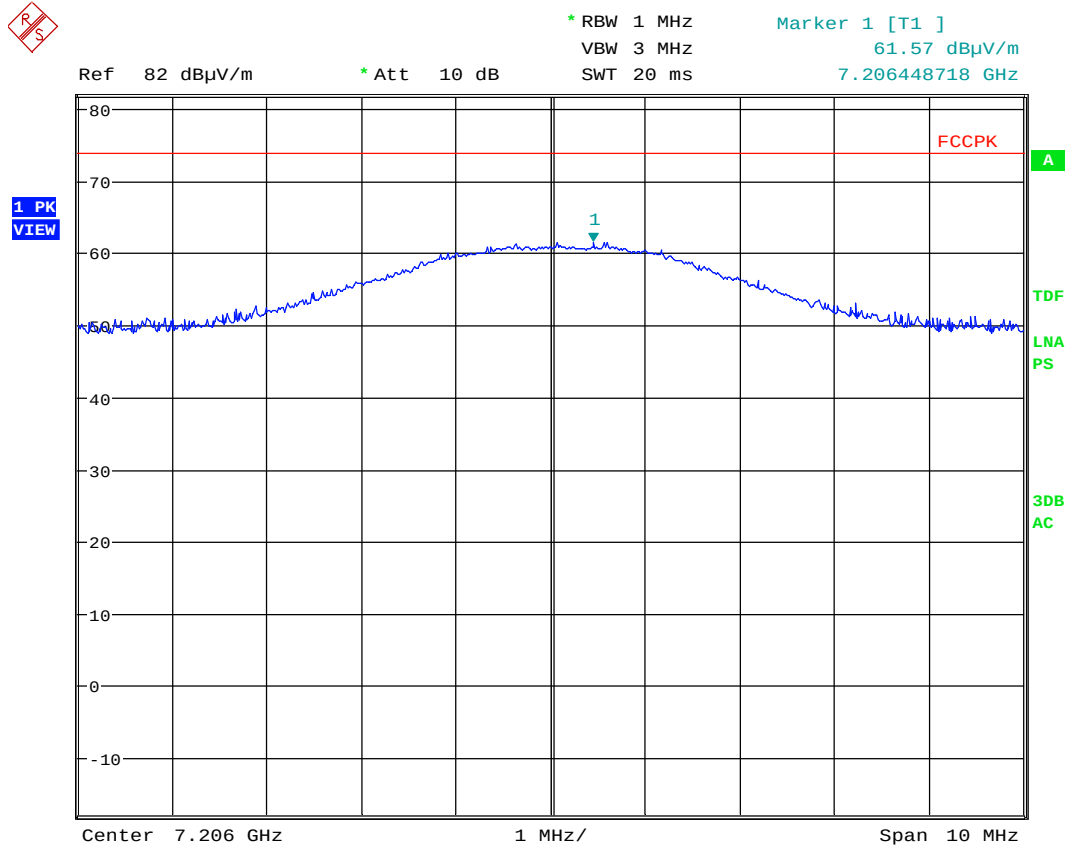
Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

Antenna factor, amplifier gain and cable loss are included in spectrum analyzer "Transducer factor".

See attached plots.

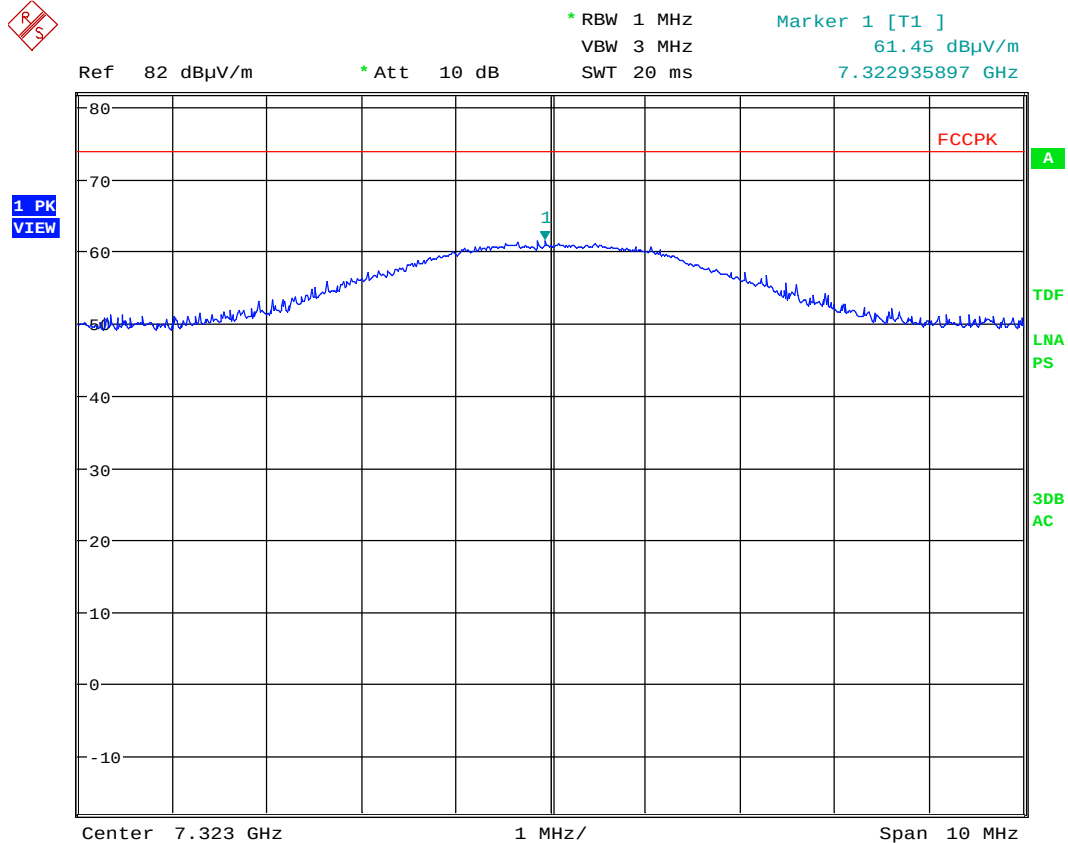
**Requirements/Limit**

|                        |                                                                  |                                     |
|------------------------|------------------------------------------------------------------|-------------------------------------|
| <b>FCC</b>             | Part 15.209 @ frequencies defined in §15.205                     |                                     |
| <b>ISED</b>            | RSS-GEN Issue 4, Clause 8.9 @ frequencies defined in clause 8.10 |                                     |
|                        | <b>Radiated emission limit @3 meters</b>                         |                                     |
| <b>Frequency (MHz)</b> | <b>AV (dB<math>\mu</math>V/m)</b>                                | <b>Peak (dB<math>\mu</math>V/m)</b> |
| <b>Above 1 GHz</b>     | 54.0                                                             | 74.0                                |



Date: 5.JUN.2019 17:47:39

3rd har, PK, ch2402MHz, 8DPSK – HP



Date: 5.JUN.2019 17:52:28

3rd har, PK, ch2441MHz, 8DPSK – HP