7. Operation within the band 902-928 MHz, 2400-2483,5 MHz and 5725-5850 MHz

Applied standards
e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247

The Measurement was performed on: 19.09.2019 – 04.11.2019

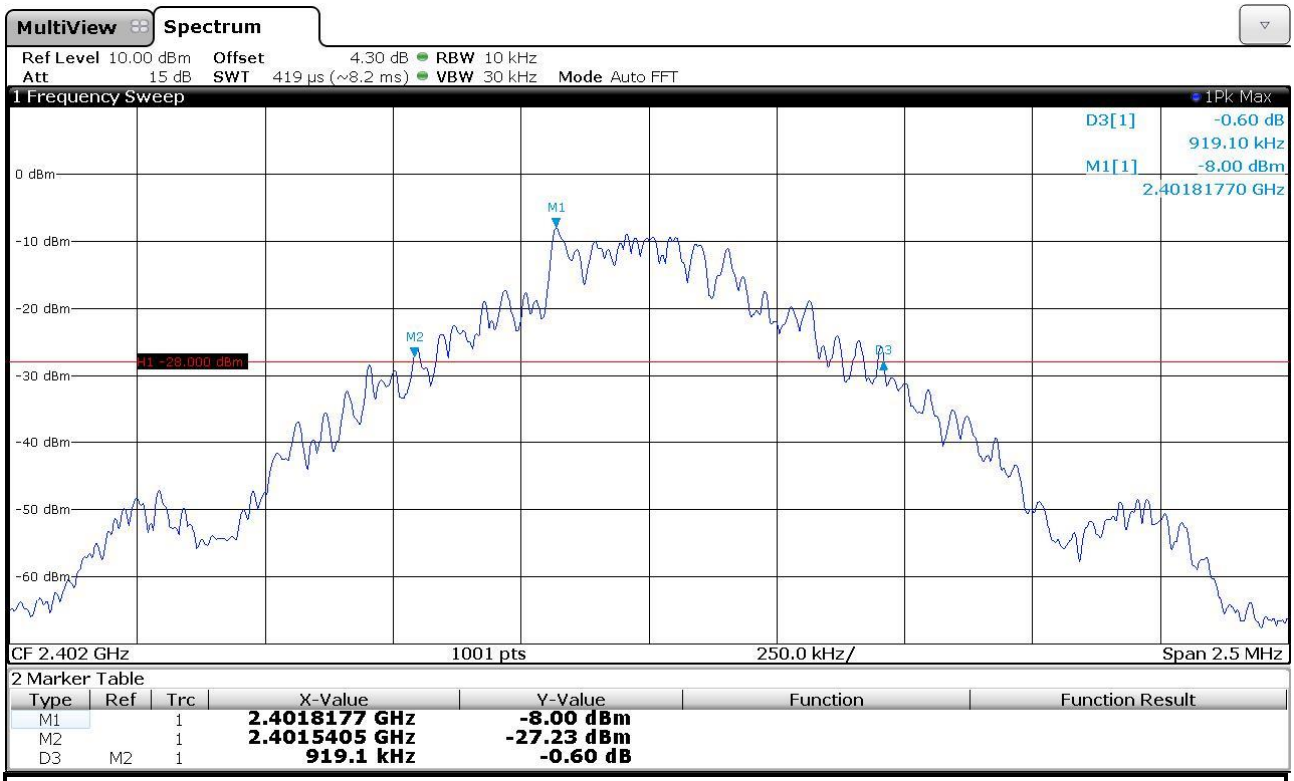
7.1. 20 dB Spectrum Bandwidth Measurement

Test Requirement
e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (a)

Test equipment and test set up:
Test equipment used for conducted measurements as given in clause 10 Test equipment of this report.
Test setup used for conducted measurements as given in clause 11 Test setups of this report.

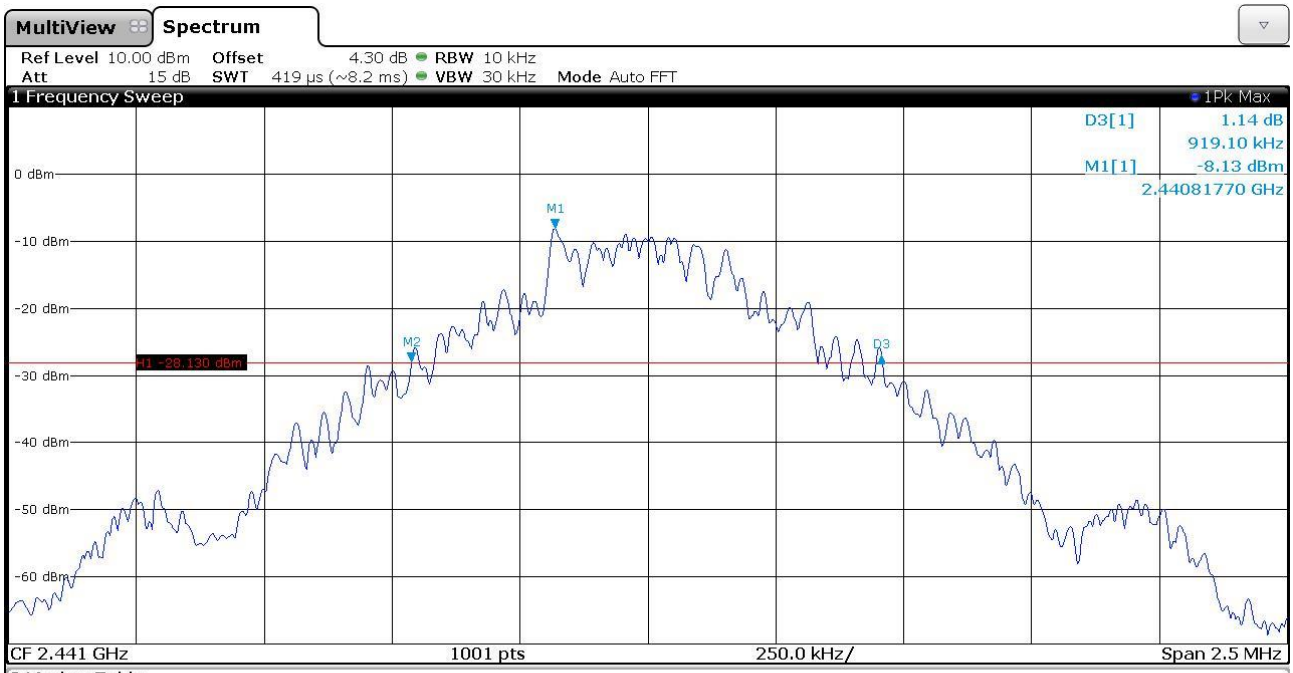
Description
The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency. Once the reference level is established, the equipment is conditioned with typical modulating signal to produce the worst-case (i.e. the widest) bandwidth.

Lowest Operating Frequency - GFSK



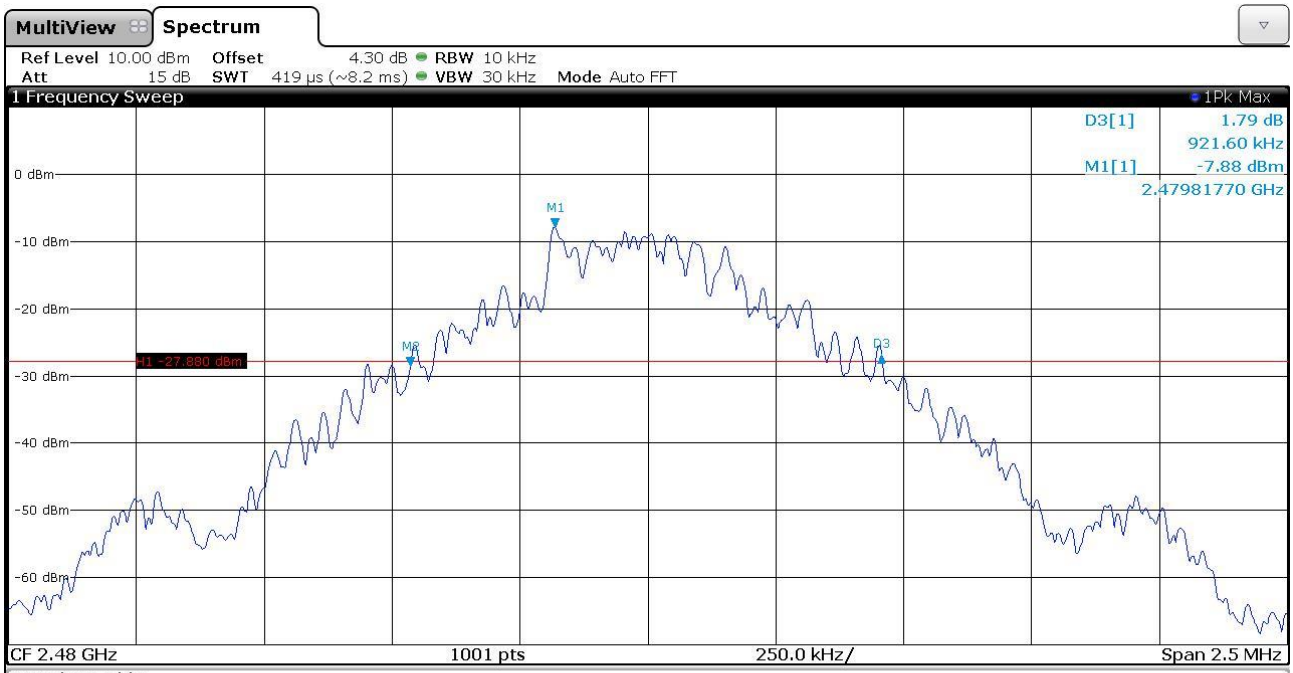
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2402	919.1

Middle Operating Frequency - GFSK



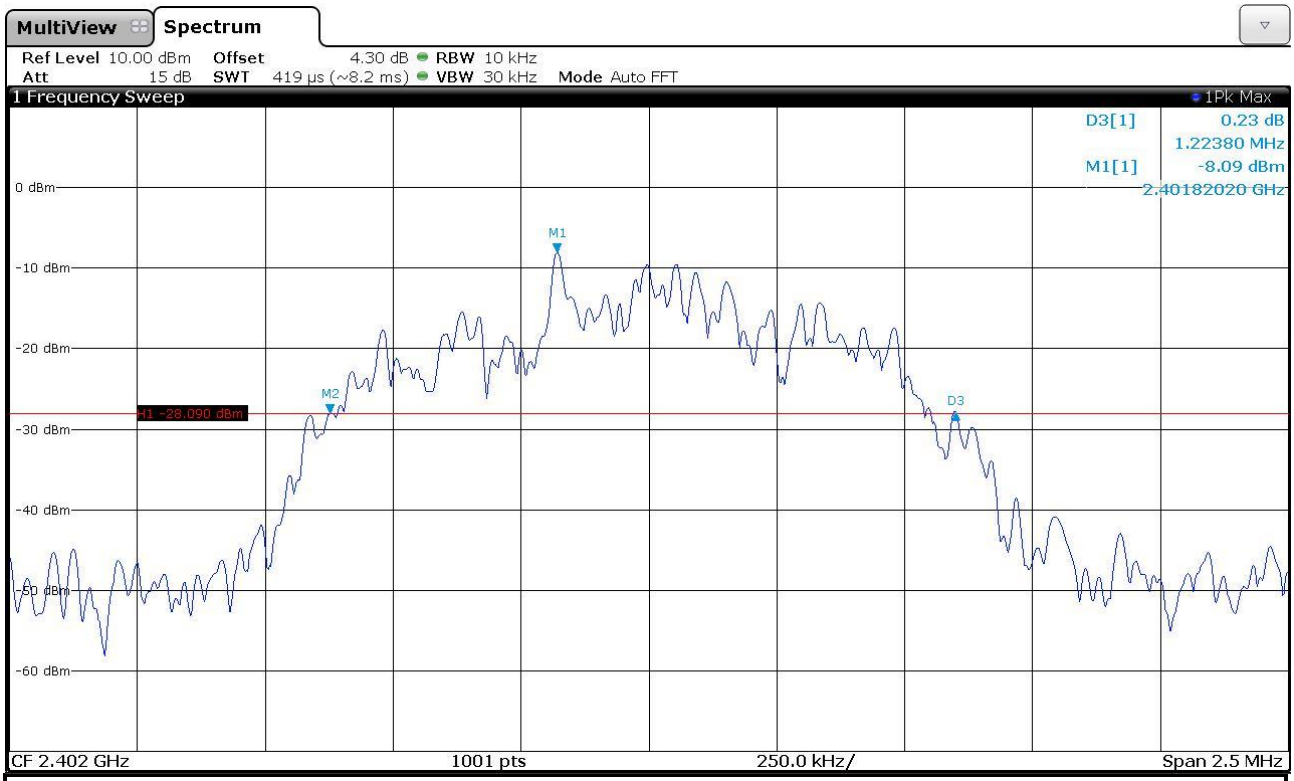
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2441	919.1

Highest Operating Frequency - GFSK



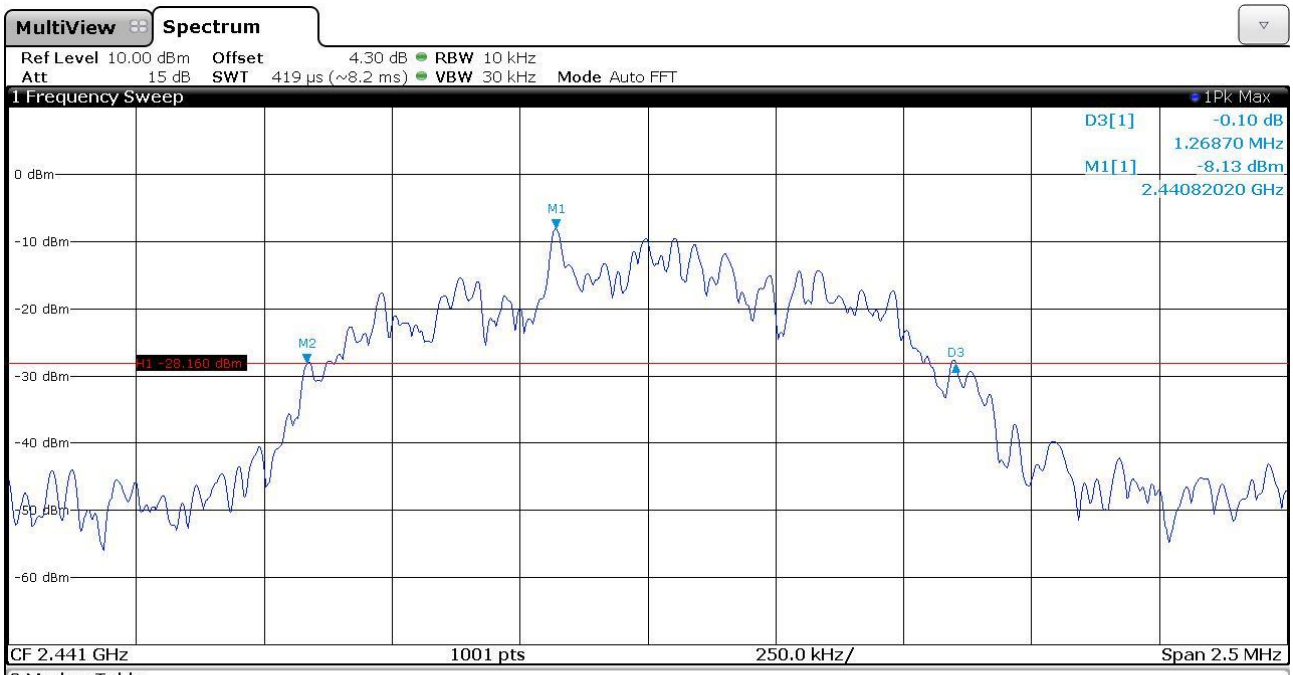
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2480	921.6

Lowest Operating Frequency - π/4 DQPSK



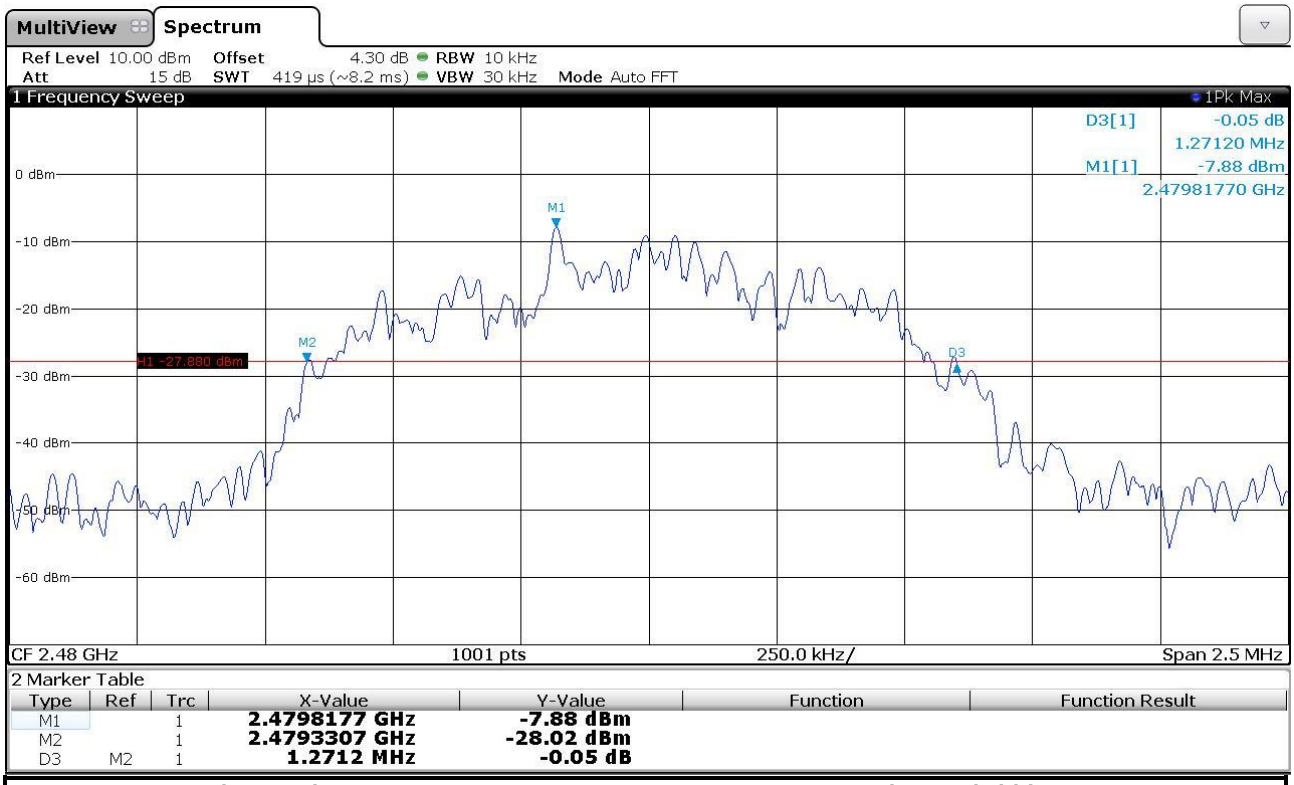
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2402	1223.8

Middle Operating Frequency - π/4 DQPSK



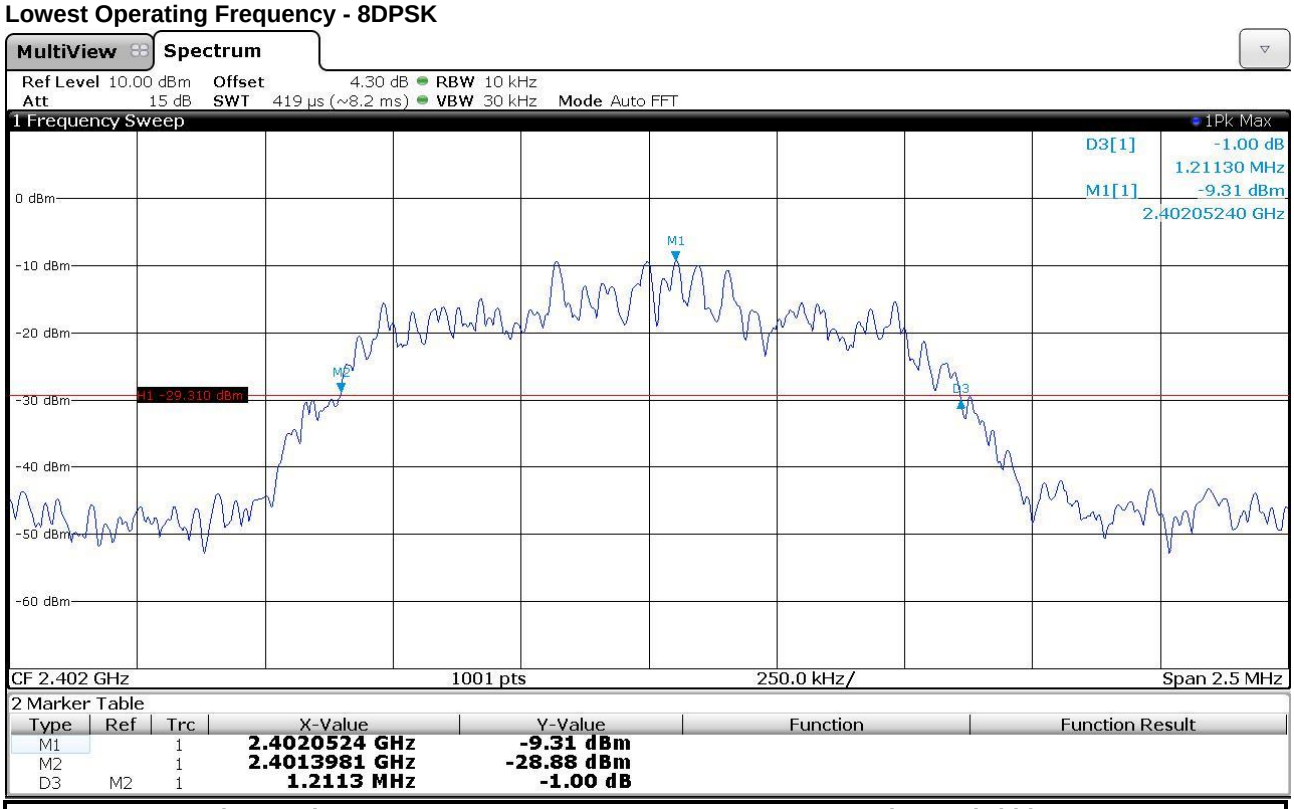
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2402	1268.7

Highest Operating Frequency - π/4 DQPSK



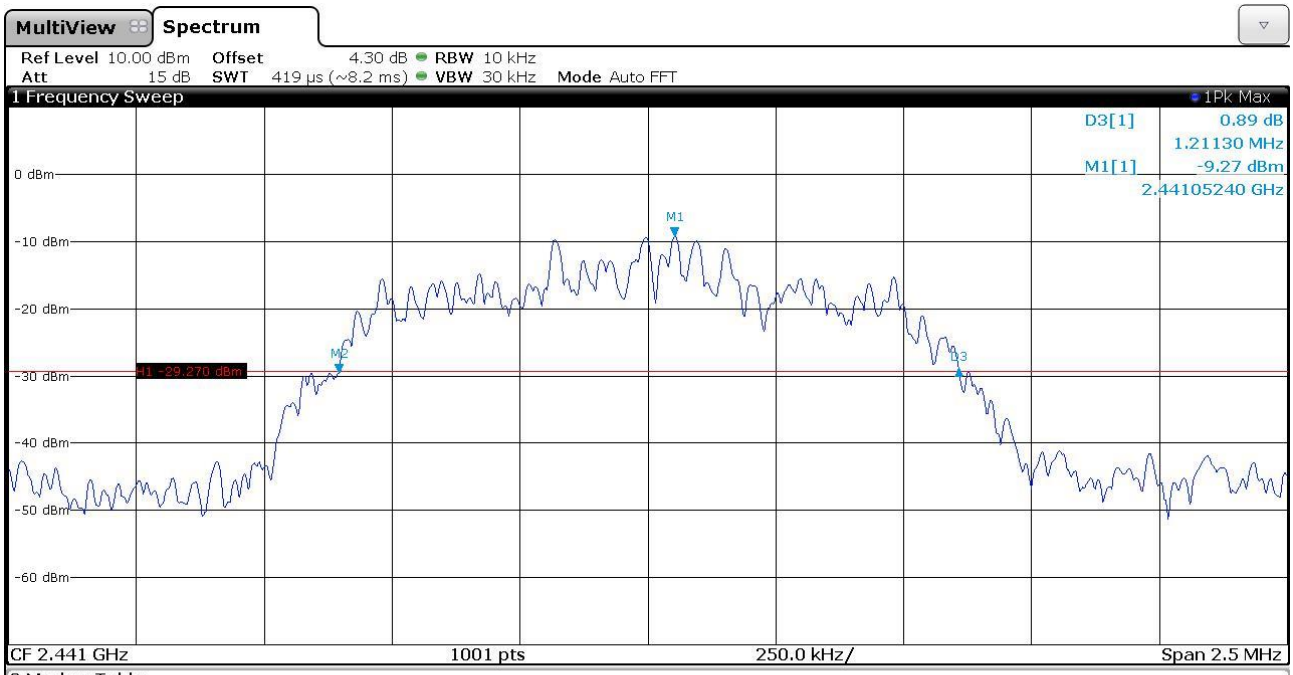
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2402	1271.2

Lowest Operating Frequency - 8DPSK



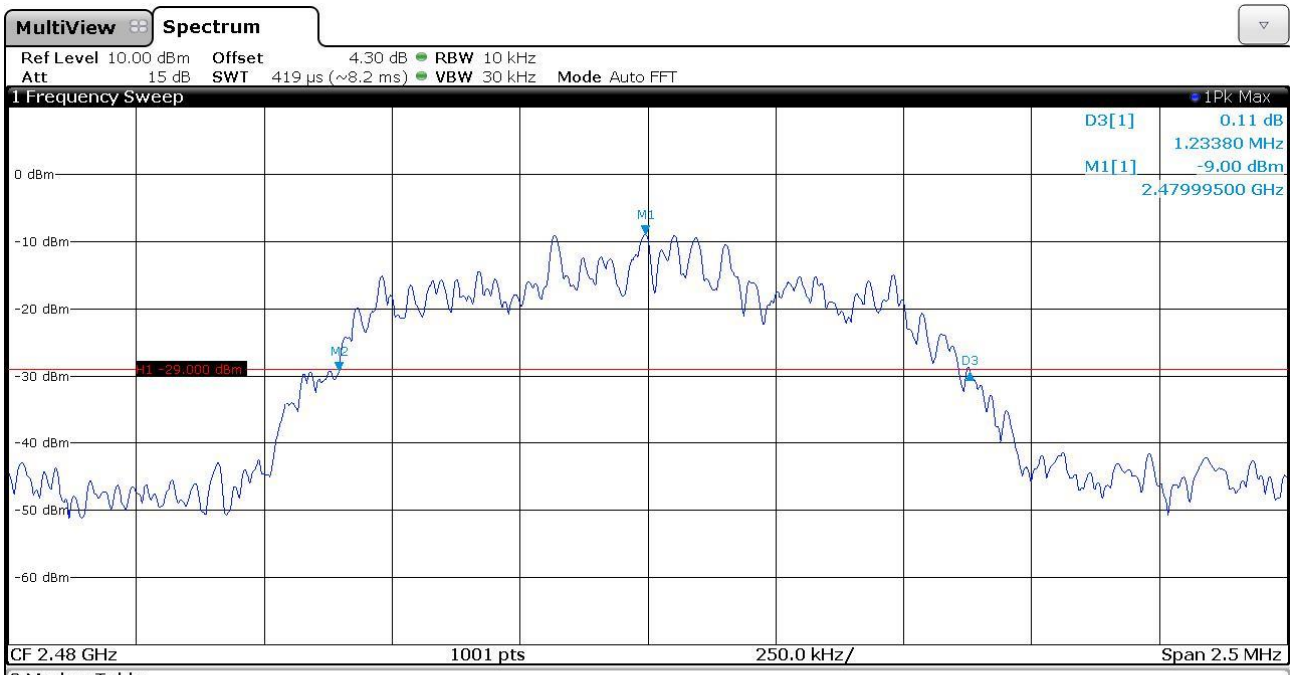
Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2402	1211.3

Middle Operating Frequency - 8DPSK



Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2441	1211.3

Highest Operating Frequency - 8DPSK



Fundamental Frequency [MHz]	20dB Bandwidth [kHz]
2480	1233.8

7.2. Output Power of Fundamental Emissions
Maximum Peak Output Power

Test site
Measurement of radiated emissions from EUT was made in the semi-anechoic chamber SAC3 from DC to 40 GHz located in the test facility.

For Maximum Peak Output Power measurements above 1 GHz, the sample was placed 1.5m above the ground plane of semi-anechoic Chamber.
Measurements in both horizontal and vertical polarities were performed.
During the test, each Output Power Level was maximized by: having the EUT continuously working.
The measured field strength would be calculated as EIRP.

For the contacted measurement, the RF output of the EUT was connected to the Power Sensor. All the attenuation or cable loss will be added to the measured maximum output power. The results are recorded in Watt.

Test equipment and test set up:
Test equipment used for conducted/ radiated measurements as given in clause 10 Test equipment of this report.
Test setup used for conducted / radiated measurements as given in clause 11 Test setups of this report.

The Measurement was performed on: 20.09.2019

Applied standards
e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (b)

Limits for Peak Output Power of Fundamental (EIRP)

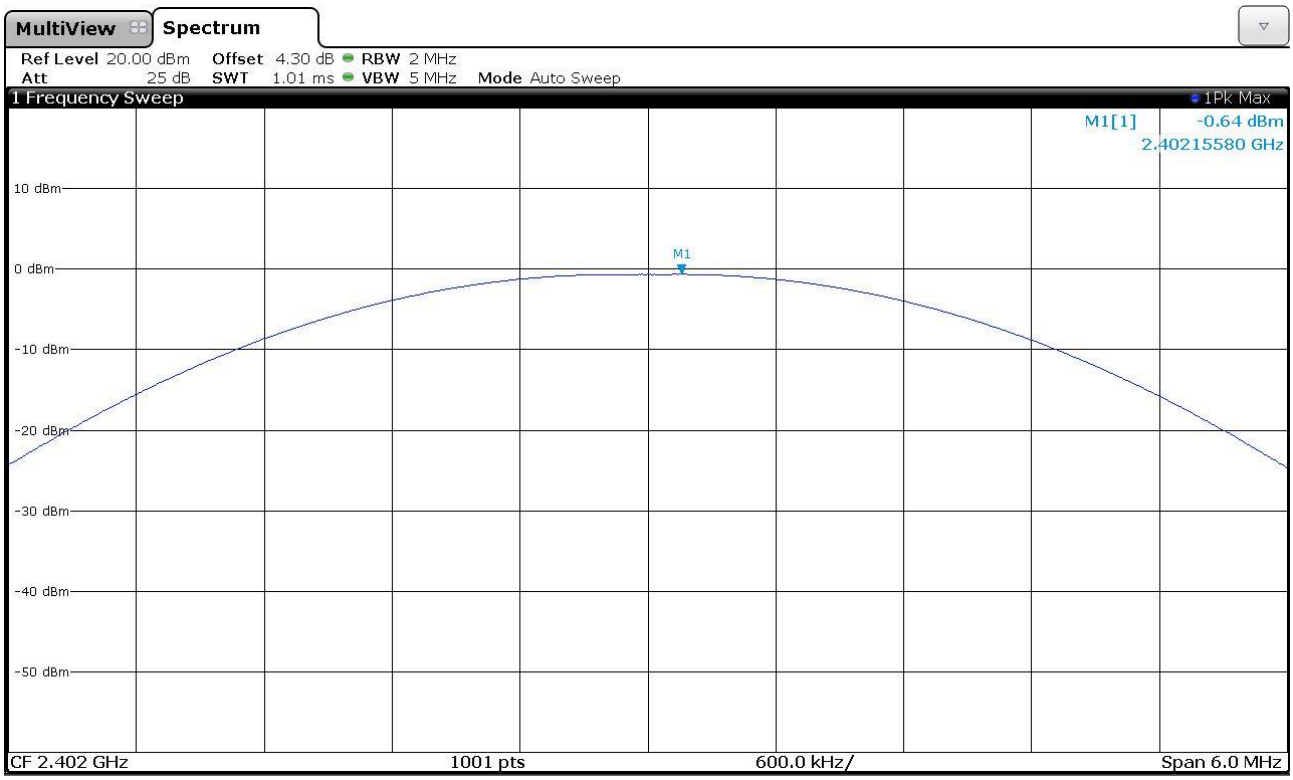
According to e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (b)
For FHSS in the 2400 – 2483,5 MHz Band the maximum peak output power shall not exceeded the following limits:
For frequency hopping systems employing at least 75 hopping channels: 1 Watt
For frequency hopping systems employing less then 75 hopping channels: 0.125 Watt
The e.i.r.p shall not exceed 4 Watt

Mesurement and Result Maximum Peak Output Power

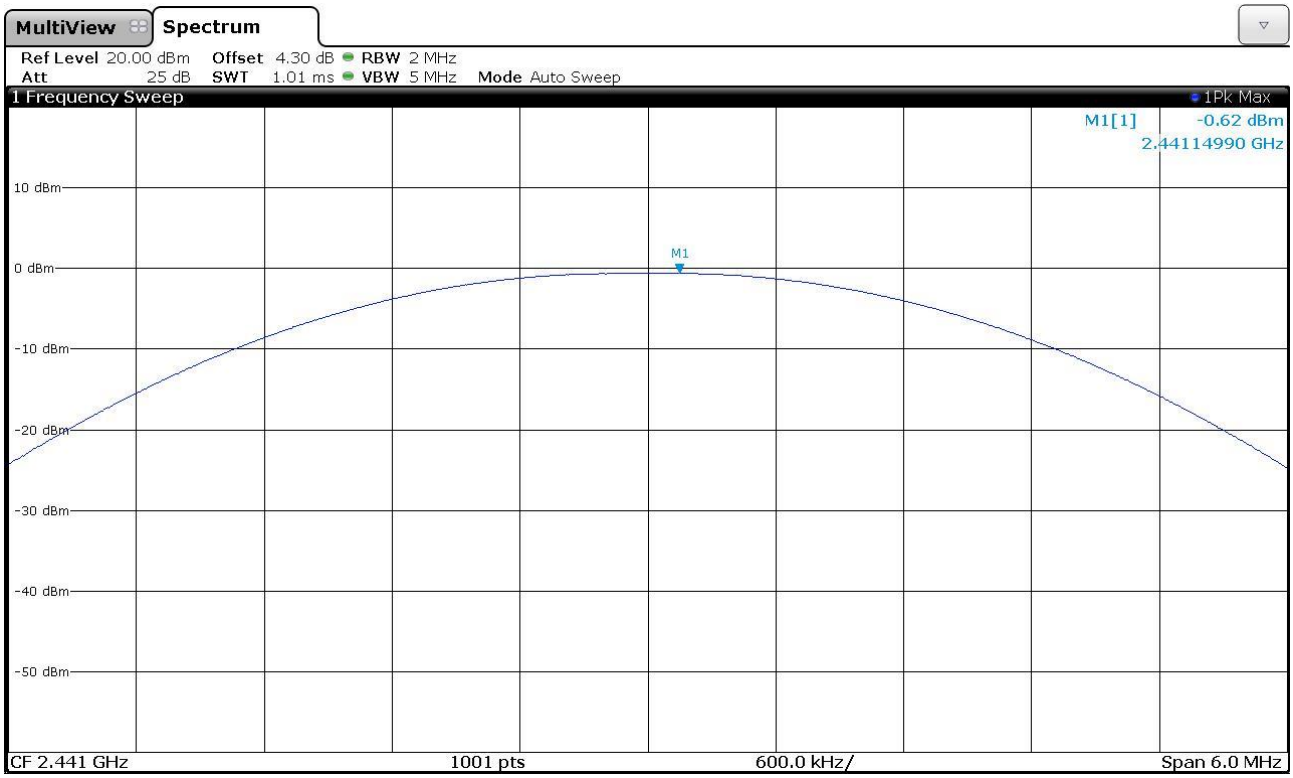
Measurement was performed on 19.09.2019

Conducted measurement data:

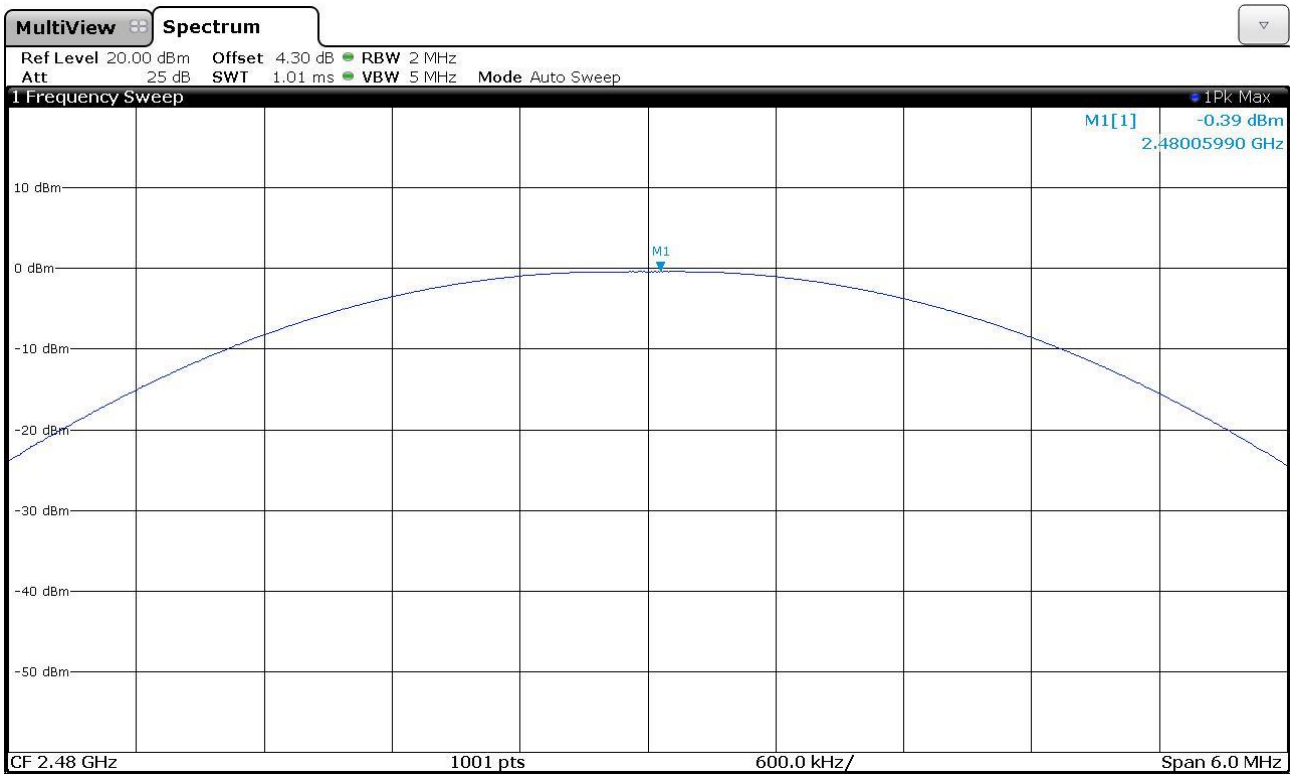
Lowest Operating Frequency – GFSK



Middle Operating Frequency - GFSK



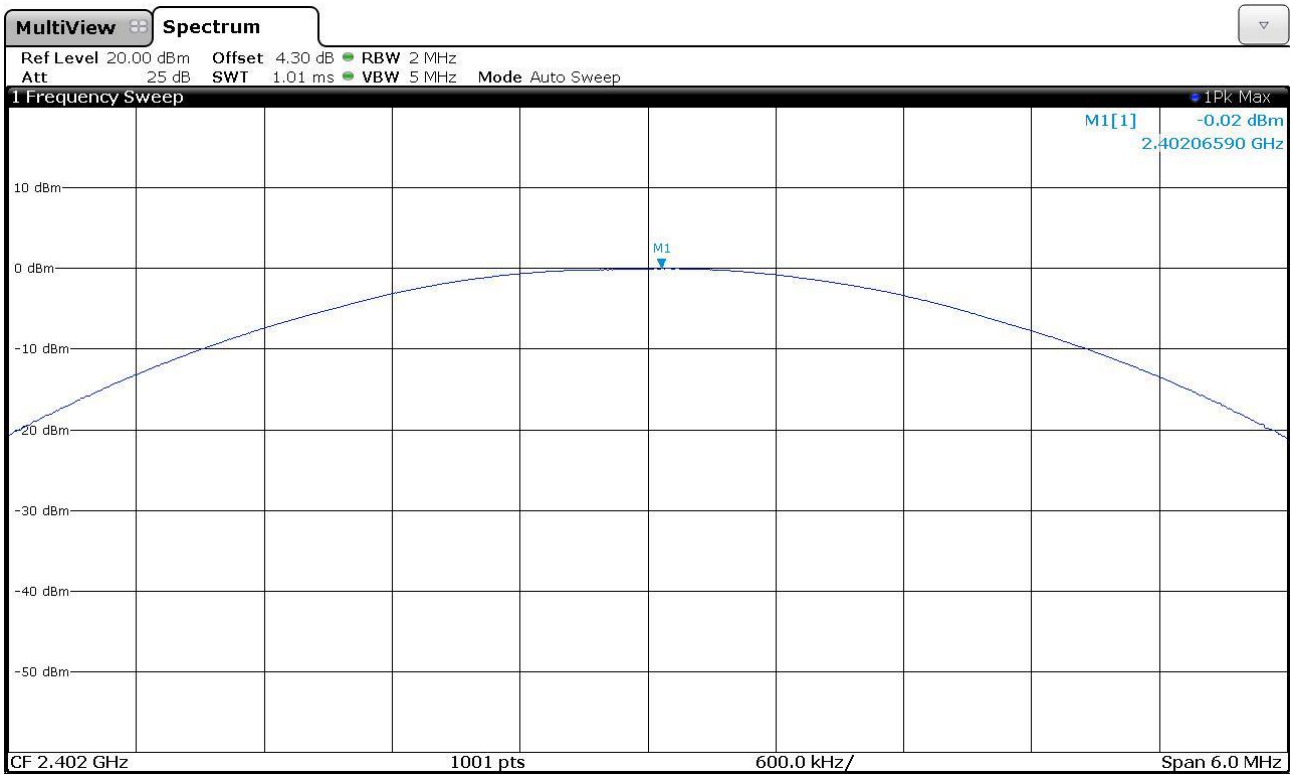
Highest Operating Frequency - GFSK



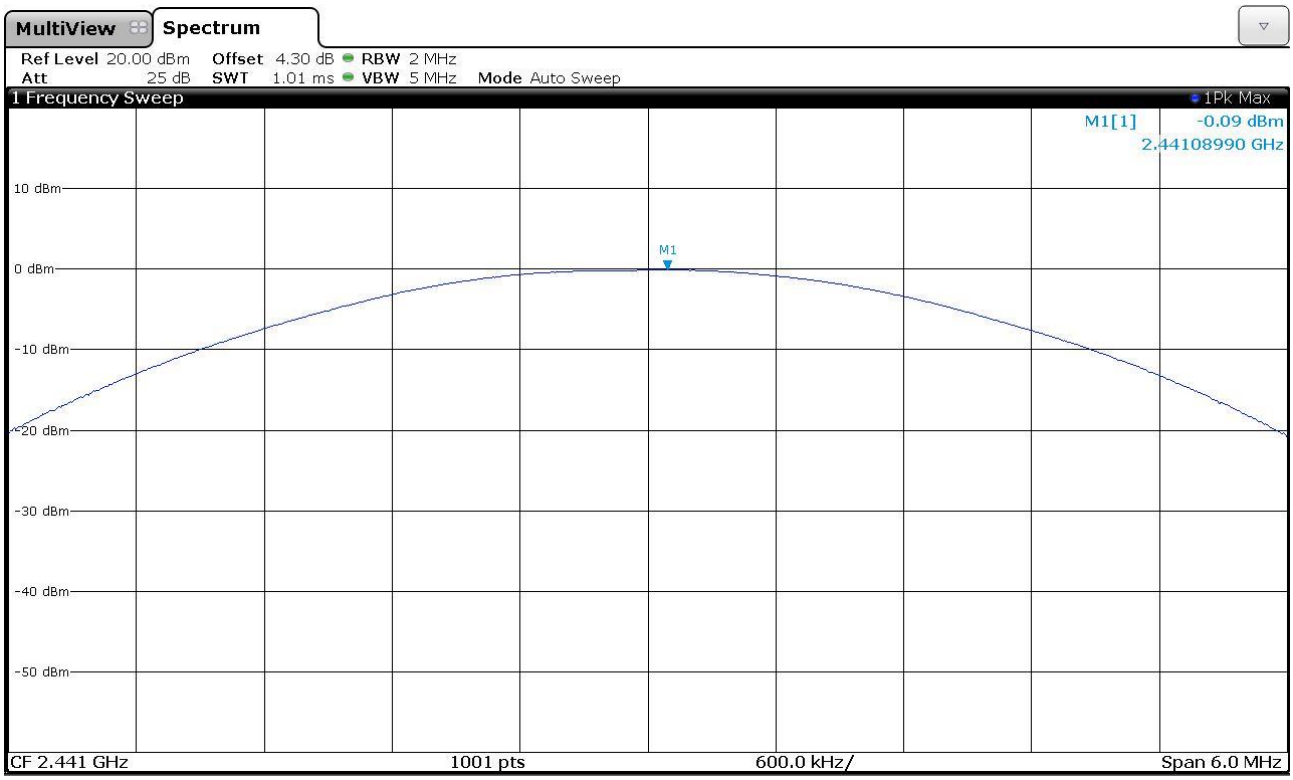
Results of Bluetooth Communication mode (GFSK) (Fundamental Power):
Maximum output power conducted Measurement setup

Channel	Frequency(MHz)	Output Power		Result
		(dBm)	(mW)	
0	2402	-0,64	0,862	**Pass**
39	2441	-0,62	0,867	**Pass**
78	2480	-0,39	0,914	**Pass**

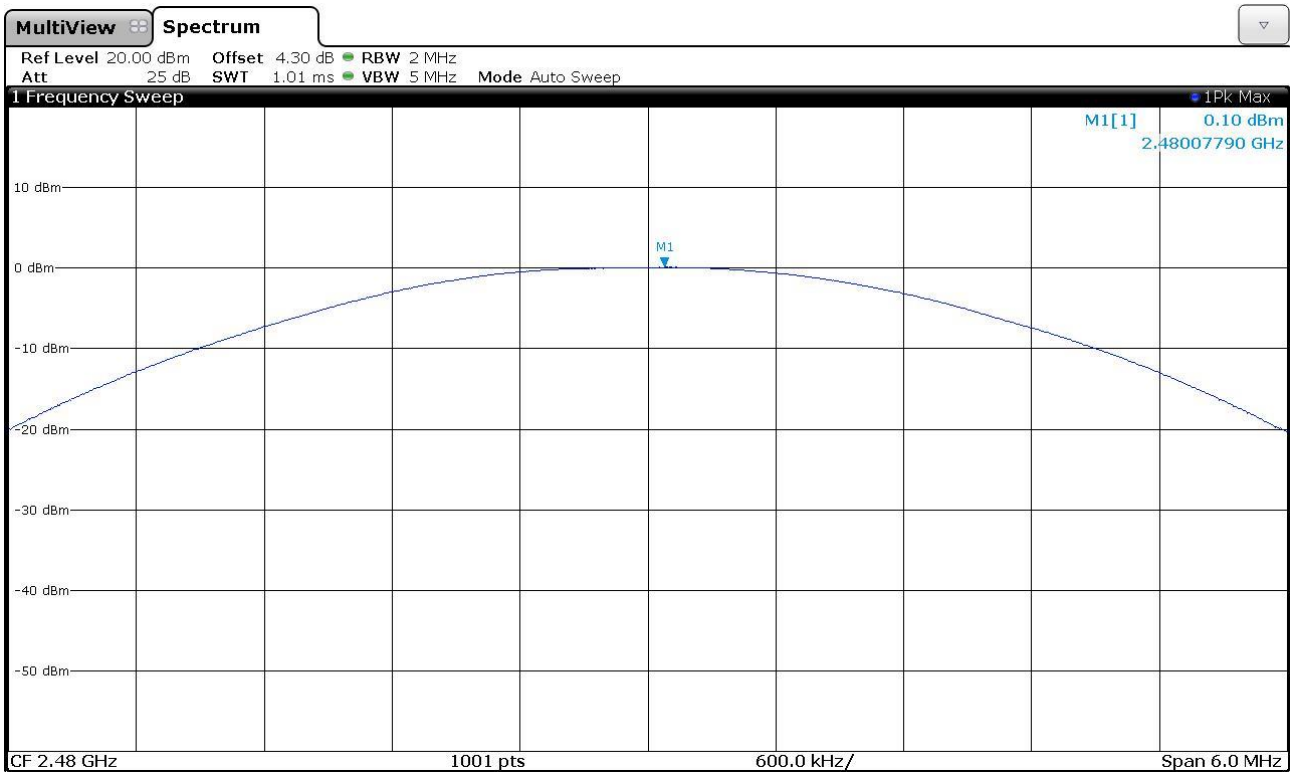
Lowest Operating Frequency – π/4-DQPSK



Middle Operating Frequency - π/4-DQPSK



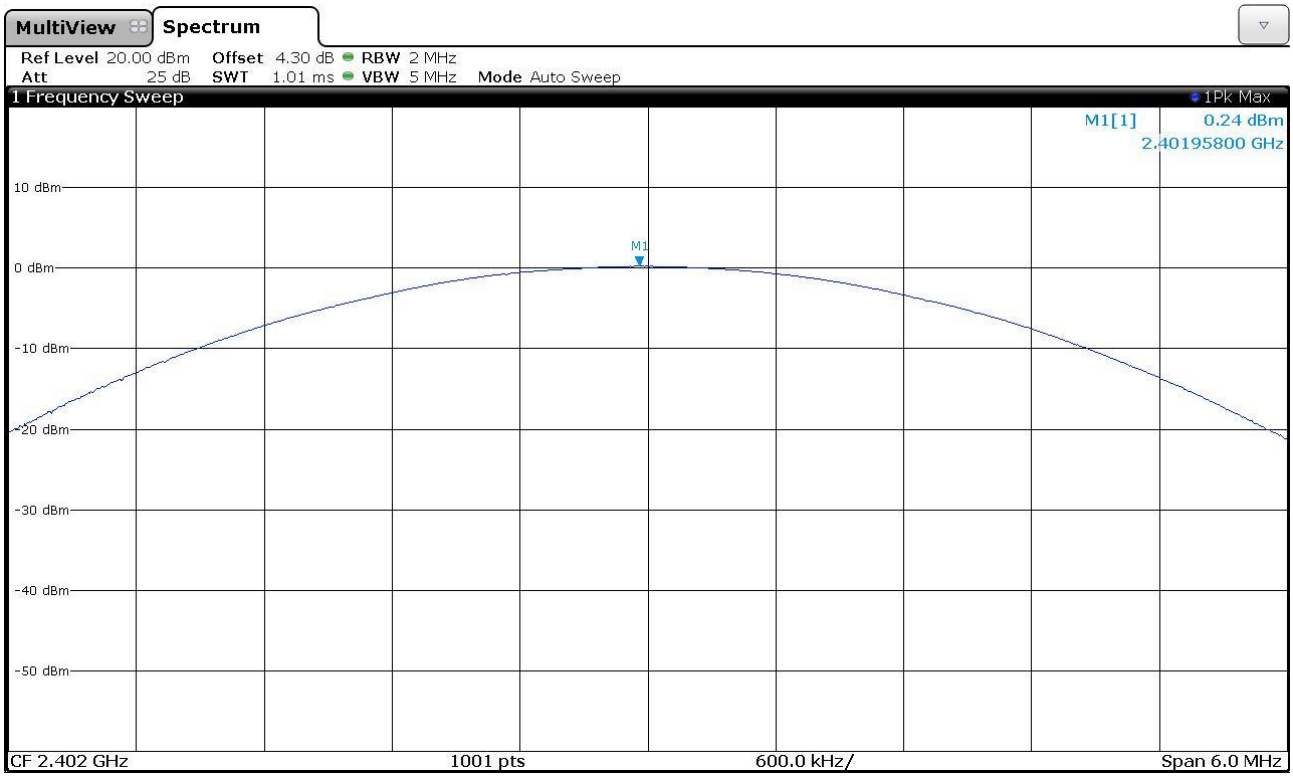
Highest Operating Frequency - π/4-DQPSK



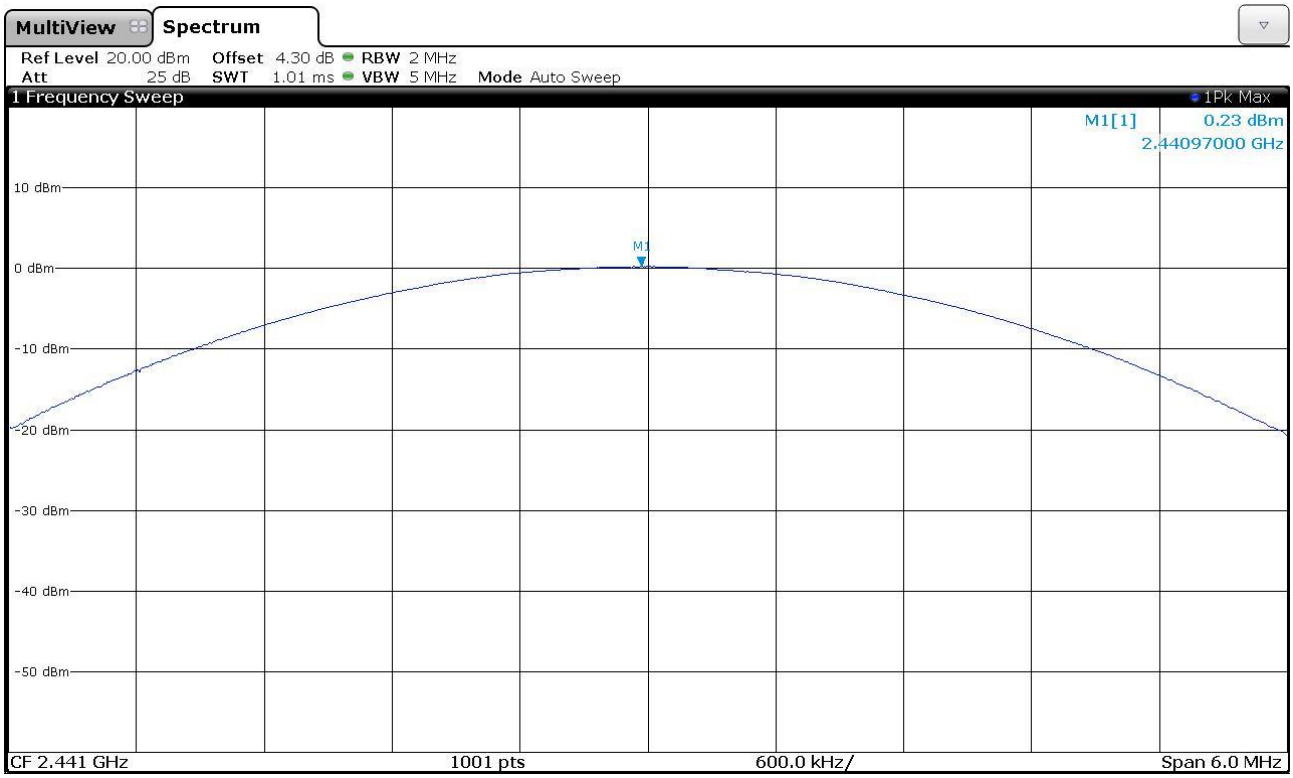
Results of Bluetooth Communication mode (π/4-DQPSK) (Fundamental Power):
Maximum output power conducted Measurement setup

Channel	Frequency(MHz)	Output Power		Result
		(dBm)	(mW)	
0	2402	-0,02	0,995	**Pass**
39	2441	-0,09	0,979	**Pass**
78	2480	0,10	1,023	**Pass**

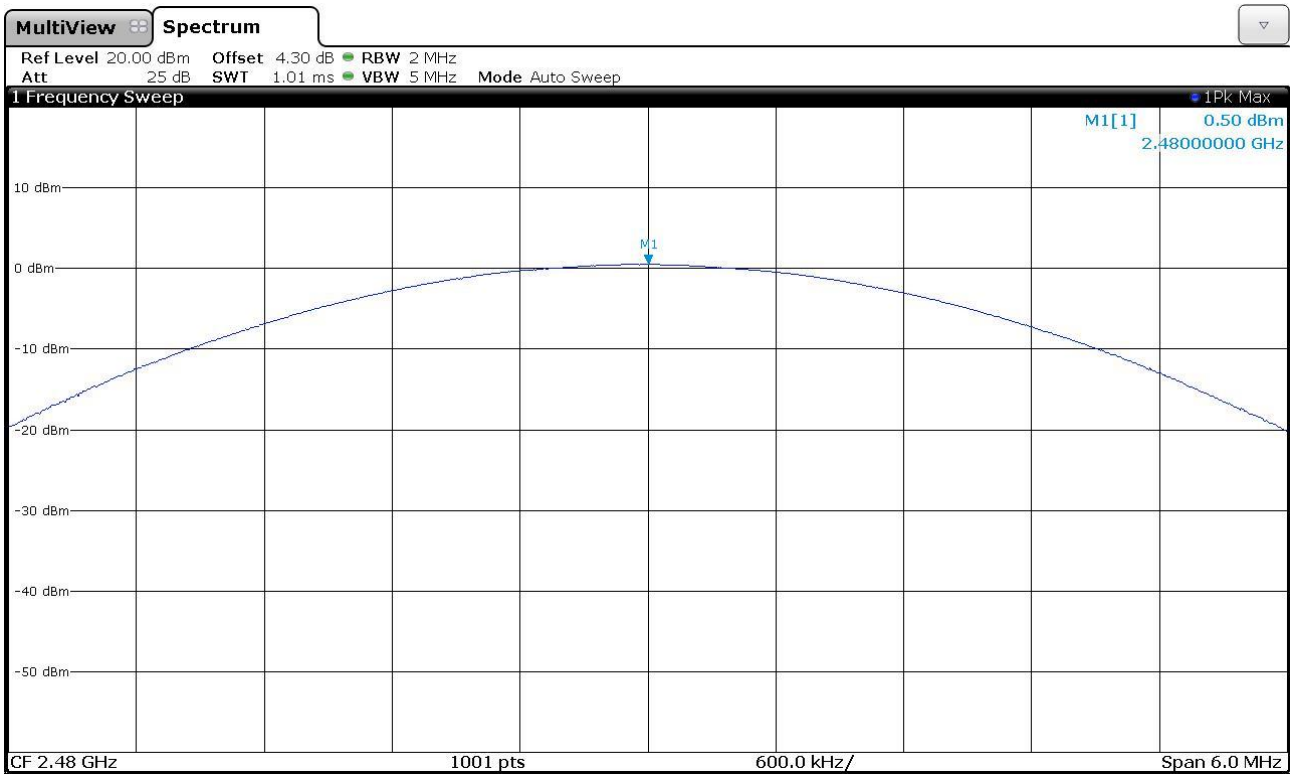
Lowest Operating Frequency – 8DPSK



Middle Operating Frequency - 8DPSK



Highest Operating Frequency - 8DPSK



Results of Bluetooth Communication mode (8DPSK) (Fundamental Power):
Maximum output power conducted Measurement setup

Channel	Frequency(MHz)	Output Power		Result
		(dBm)	(mW)	
0	2402	0,24	1,057	**Pass**
39	2441	0,23	1,054	**Pass**
78	2480	0,50	1,122	**Pass**

Radiated measurement data:

Mode: **Bluetooth Communication mode 8DPSK Channal 78**
as the mode with the highest conducted measured Output power.

Field strength @ 3 m distance (E) [dBµV/m]	EIRP		Conducted RF Output Power [dBm]	Antenna Gain [dBi]
	[dBm]	[mW]		
88,59	-6,66	0,215	0,5	-7,16
Used formulas: EIRP (dBm) = E (dBµV/m) + 20 x log(3) – 104,8 [Formula acc. KDB 971168 section 5.8.3, d] Antenna Gain (dBi) = EIRP (dBm) – Conducted RF Output Power (dBm)				

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the Output Power of Fundamental Emissions measurements.

7.3. Number of Operating Channel

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels

Test Requirement
e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (a) (1) (iii)

Description
The RF output of the EUT was connected to the spectrum analyzer by a low loss cable.

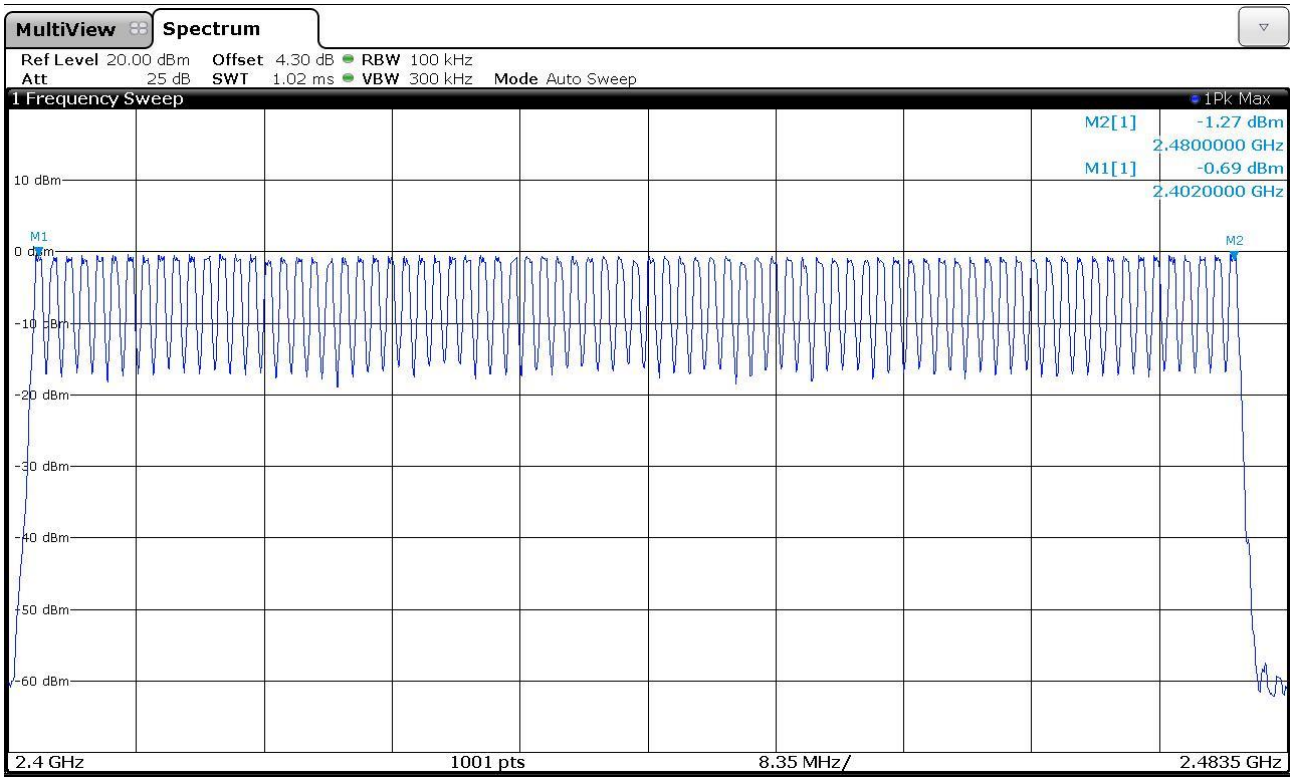
Test equipment and test set up:
Test equipment used for conducted measurements as given in clause 10 Test equipment of this report.
Test setup used for conducted measurements as given in clause 11 Test setups of this report.

Detector function selection and bandwidth
For the measurement, an EMI test receiver that have CISPR peak detector was used.

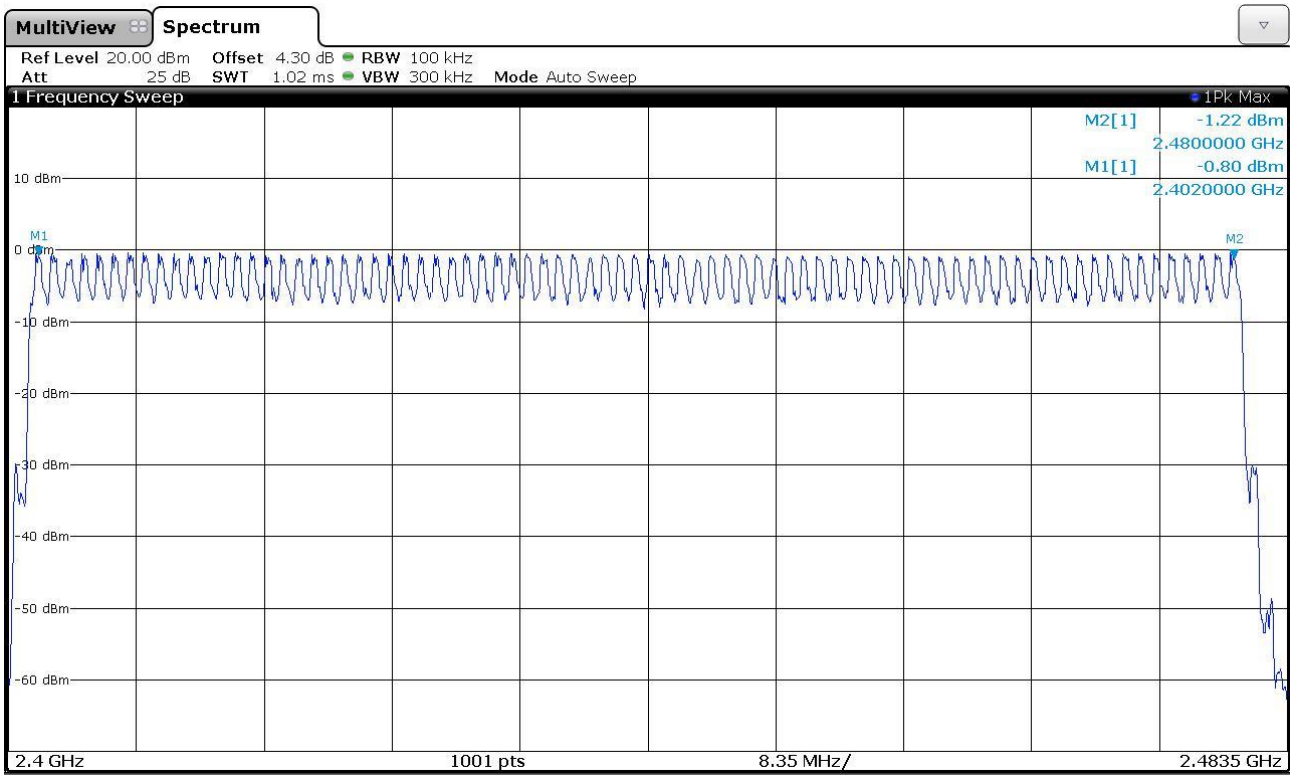
Frequency range:	**Bandwidth**
2.4 GHz – 2.4835 GHz (Peak Detector)	RBW: 100 kHz VBW: ≥ RBW

Measurement Data:

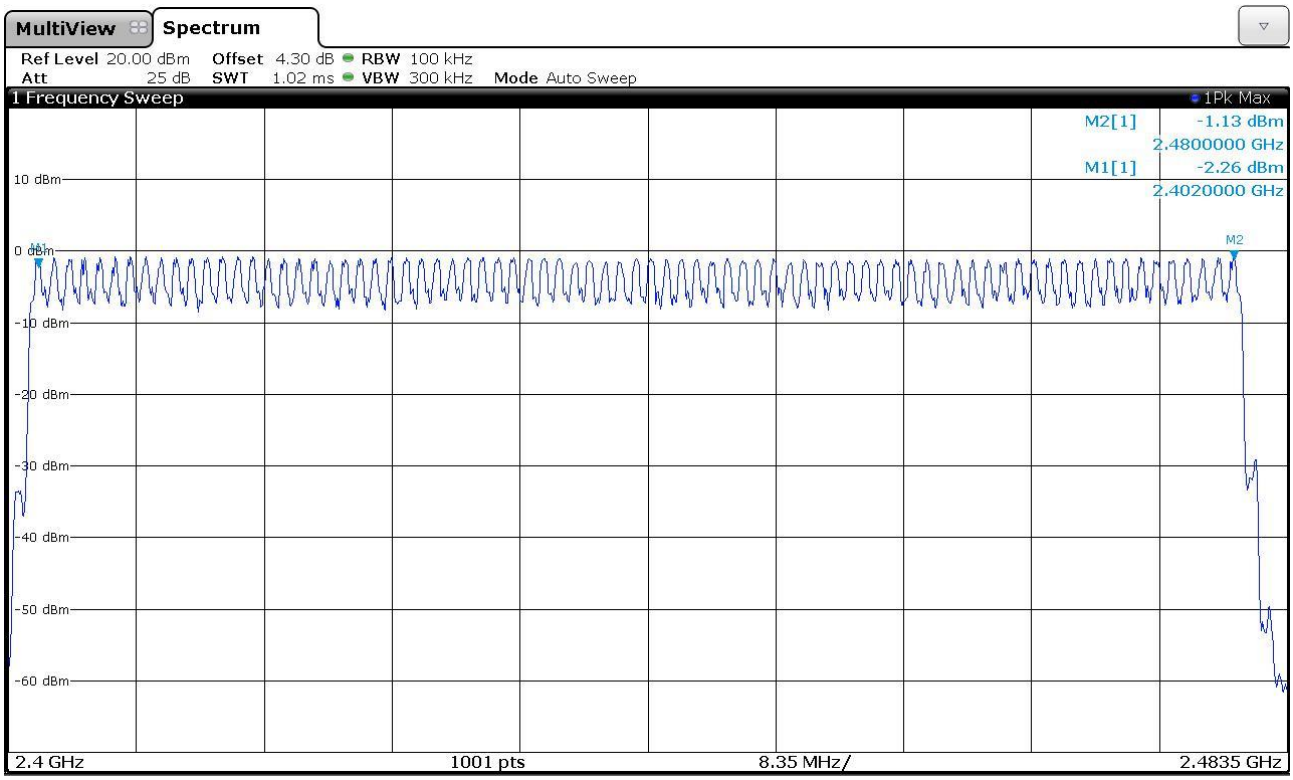
GFSK: 79 of 79 Channel



π/4-DQPSK: 79 of 79 Channel



8DPSK: 79 of 79 Channel



7.4. Channel Center Frequency

Test Requirements:
Frequency hopping system in the 2400-2483.5MHz band shall use at least 79 (Channel 0 to 78) non-overlapping channels.

The EUT operates in according with the Bluetooth system specification within the 2400 - 2483.5 MHz frequency band. RF channels for Bluetooth systems are spaced 1 MHz and are ordered in channel number k. In order to comply with out-of-band regulations, a lower frequency guard band of 2.0 MHz and a higher frequency guard band of 3.5MHz is used.

The operating frequencies of each channel are as follows:

First RF channel start from 2400MHz + 2MHz guard band = 2402MHz
Frequency of RF Channel = 2402+(k+1) MHz, k = 0,…,78 (Channel separation = 1MHz)

7.5. Hopping Channel Separation

Test Requirements:
e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (a) (1)

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

Test equipment and test set up:
Test equipment used for conducted measurements as given in clause 10 Test equipment of this report.
Test setup used for conducted measurements as given in clause 11 Test setups of this report.

Detector function selection and bandwidth
For the measurement, an EMI test receiver that have CISPR peak detector was used.

Frequency range:		**Bandwidth**
Wide enough to captur the peaks of two adjacent channels	RBW:	100kHz
	VBW:	≥ RBW

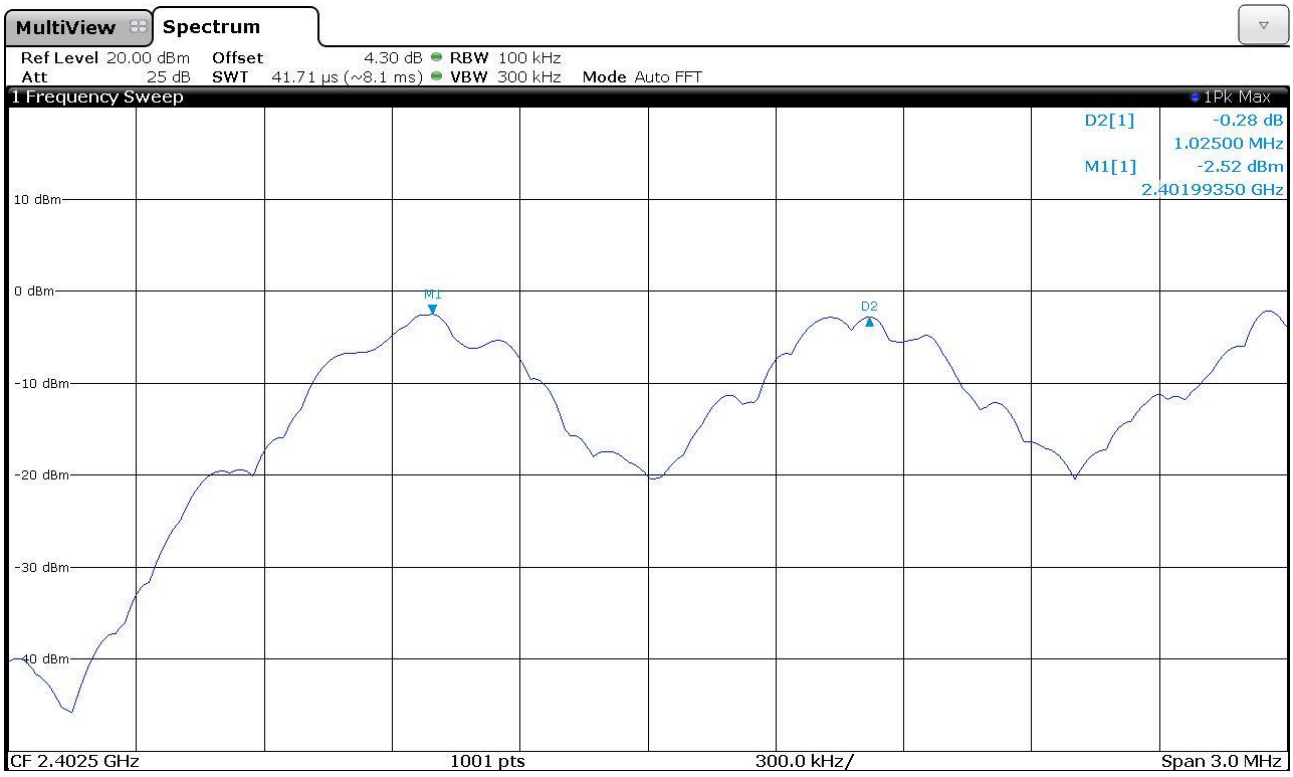
Limit:

GFSK:
The measured maximum bandwidth* 2/3 =921.6 kHz * 2/3 = 614.4 kHz

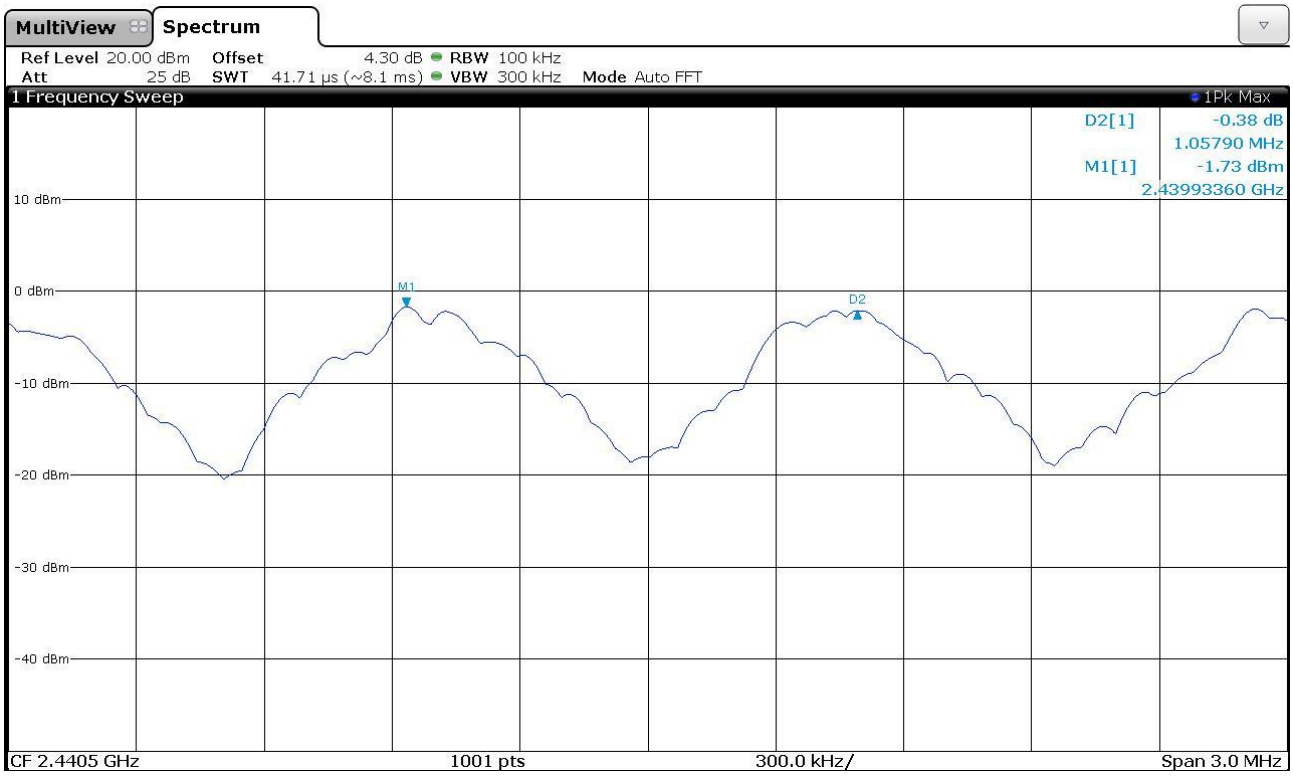
π/4 DQPSK:
The measured maximum bandwidth * 2/3 =1271.2 kHz * 2/3 = 847.5 kHz

8DPSK:
The measured maximum bandwidth * 2/3 =1233.8 kHz * 2/3 = 822.5 kHz

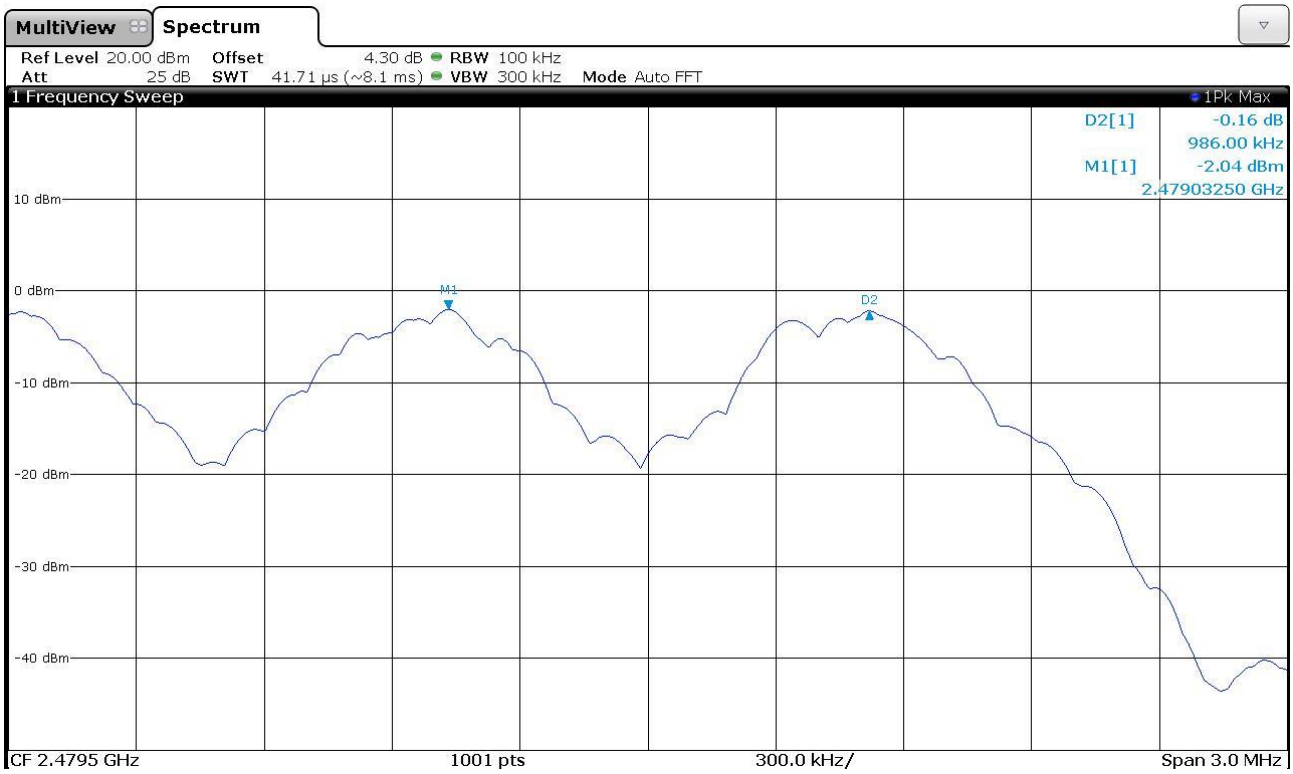
Lowest Operating Frequency - GFSK



Middle Operating Frequency - GFSK



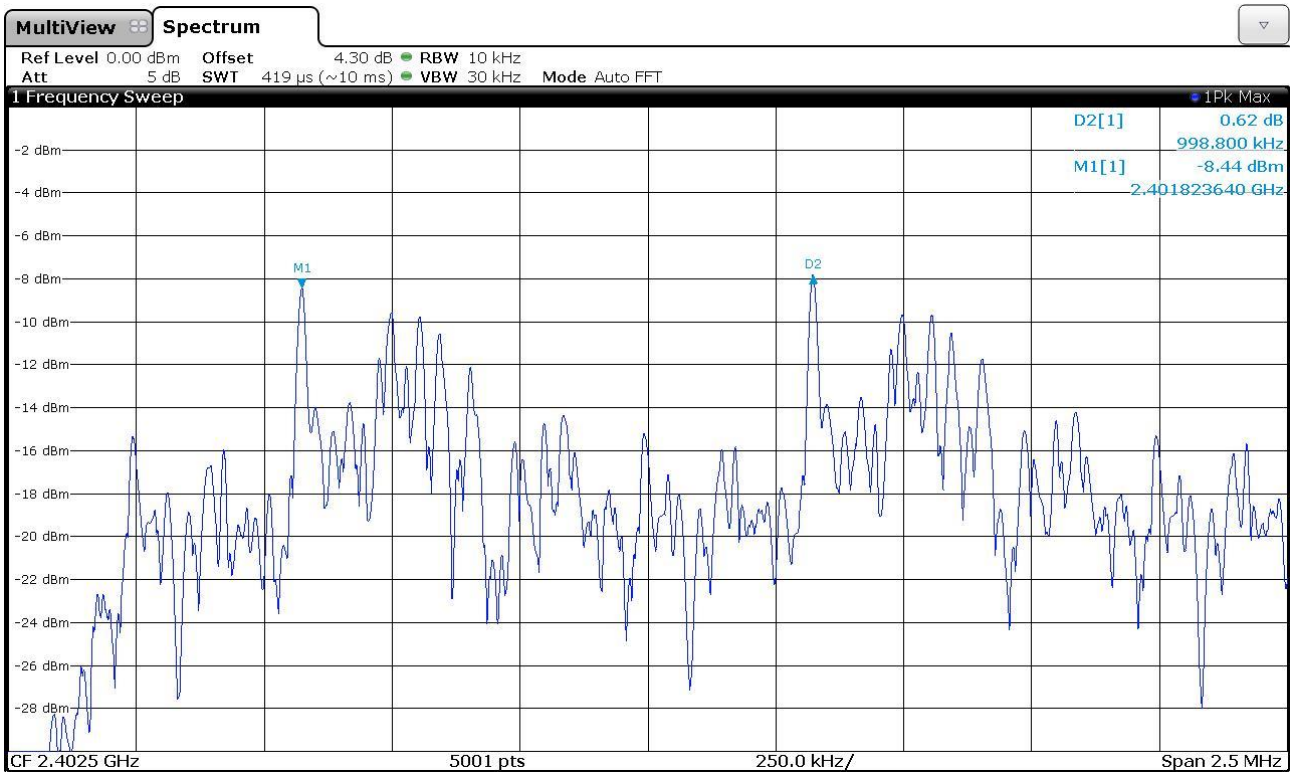
Highest Operating Frequency - GFSK



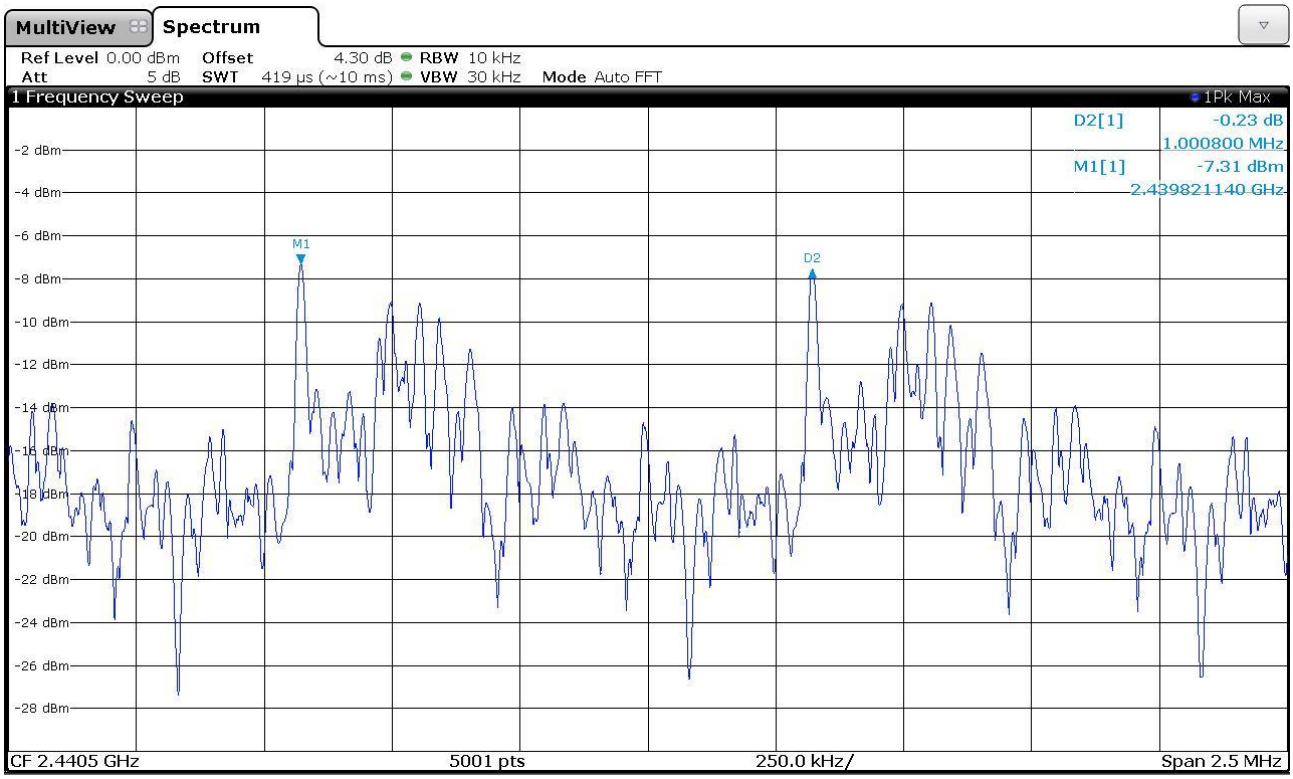
Summary of Channel seperation measurements - GFSK

Tested Channel	Channal seperation [kHz]	Limit = 2/3 BW [kHz]	Result
Lowest	1205	> 614.4	pass
Middle	1058	> 614.4	pass
Highest	986	> 614.4	pass

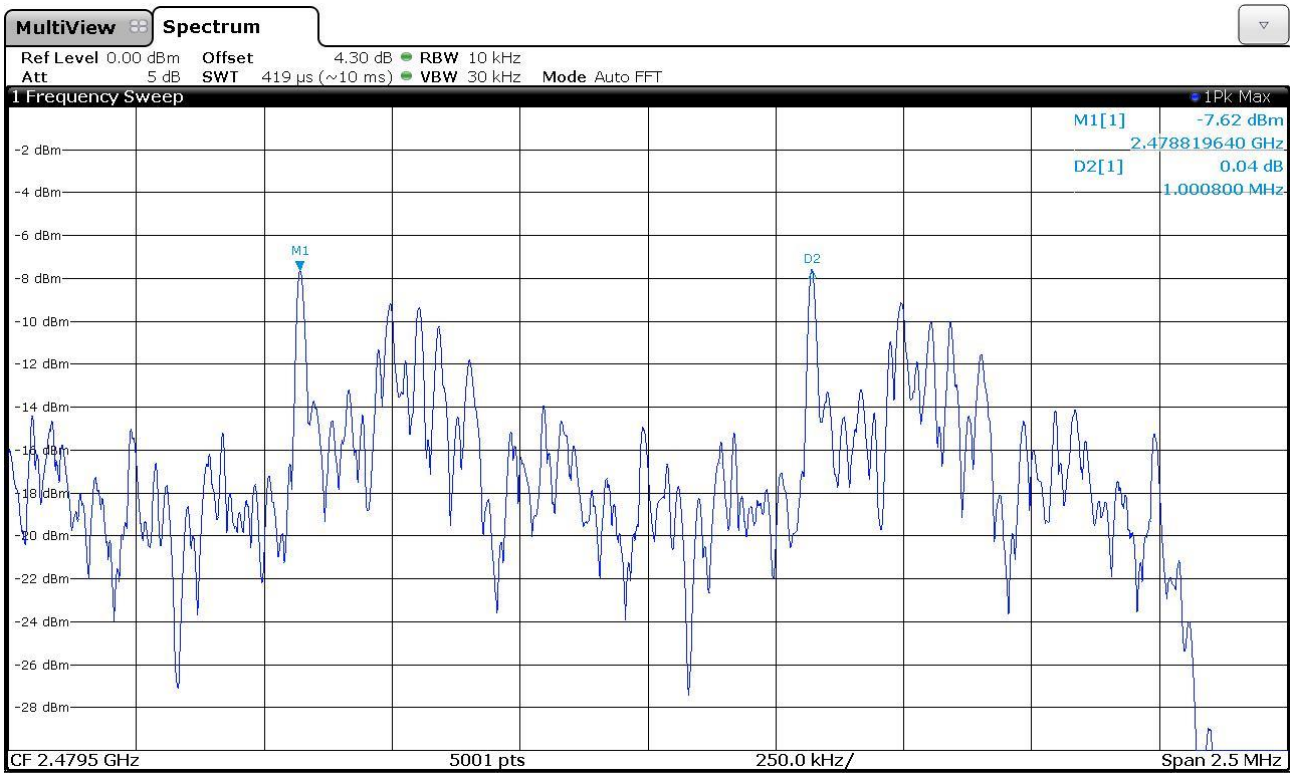
Lowest Operating Frequency – π/4 DQPSK



Middle Operating Frequency – π/4 DQPSK



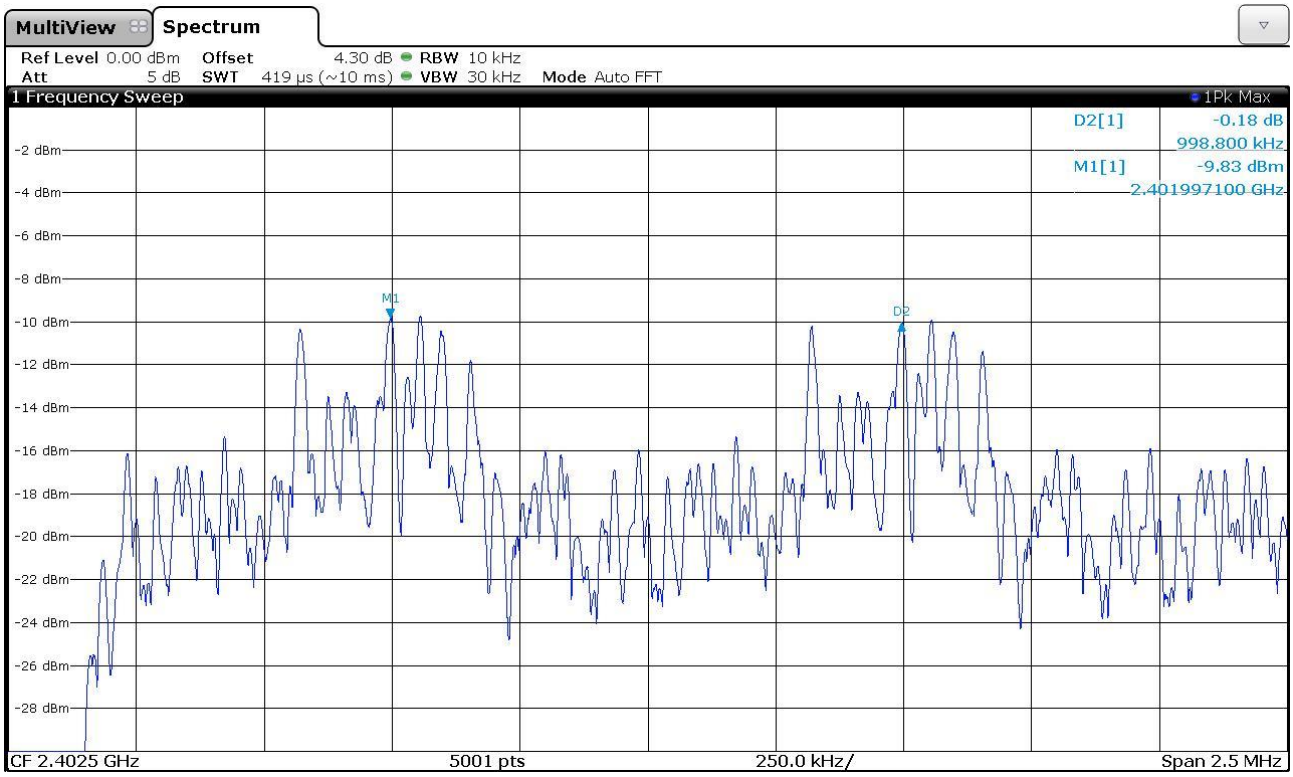
Highest Operating Frequency – π/4 DQPSK



Summary of Channel seperation measurements - π/4 DQPSK

Tested Channel	Channal seperation [kHz]	Limit = 2/3 BW [kHz]	Result
Lowest	998.8	> 847.5	pass
Middle	1001.8	> 847.5	pass
Highest	1001.8	> 847.5	pass

Lowest Operating Frequency – 8DPSK



Middle Operating Frequency – 8DPSK