

7.2. Output Power of Fundamental Emissions

Maximum Peak Output Power

Applied standards

- e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (b) (1)
- RSS-247 Issue 2 section 5.4 (b)

Limits for Peak Output Power of Fundamental (EIRP)

For FHSS in the 2400 – 2483.5 MHz Band the maximum peak output power shall not exceed the following limits:

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

For frequency hopping systems employing less than 75 hopping channels: 0.125 Watt

The e.i.r.p shall not exceed 4 Watt.

Test equipment and test set up

Test equipment used for conducted measurements as given in clause Test equipment of this report.

Test setup used for conducted measurements as given in clause Test setups of this report.

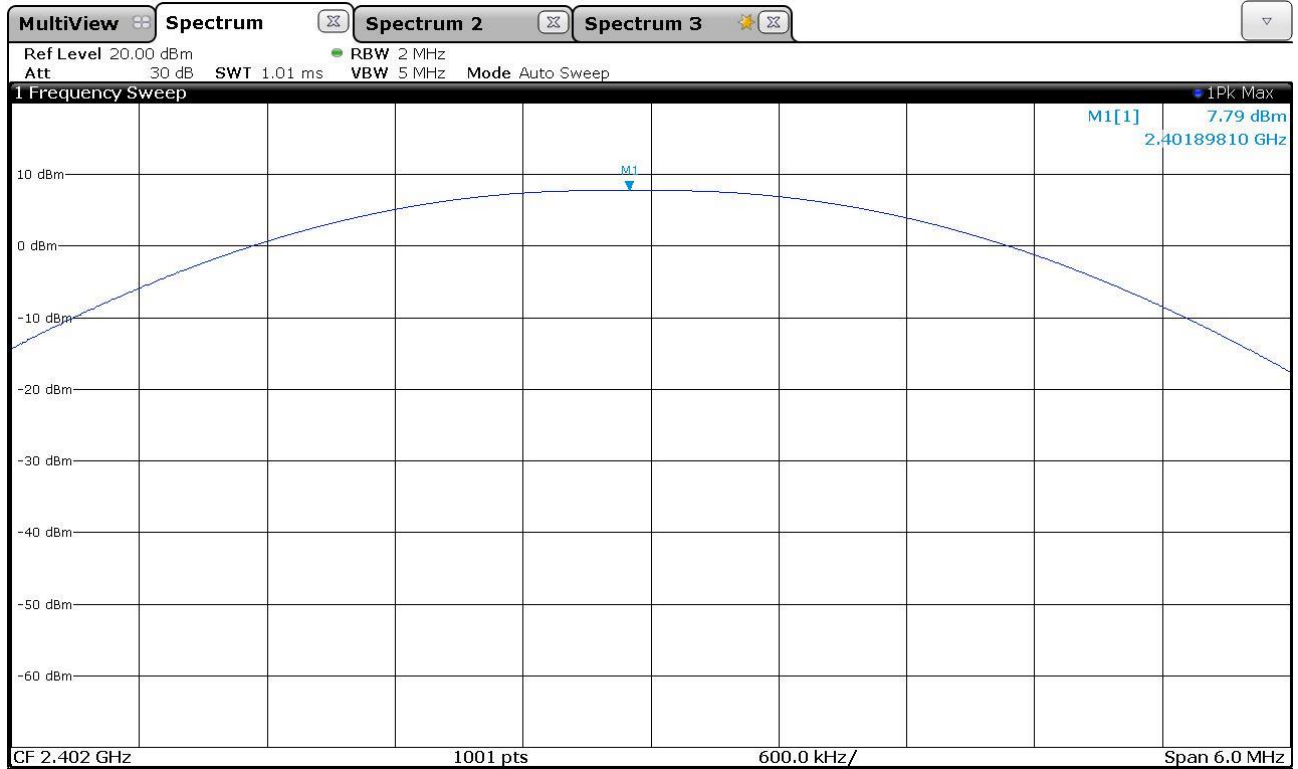
Description

For the conducted measurement, the RF output of the EUT was connected to the Analyzer. All the attenuation or cable loss will be added to the measured maximum output power.

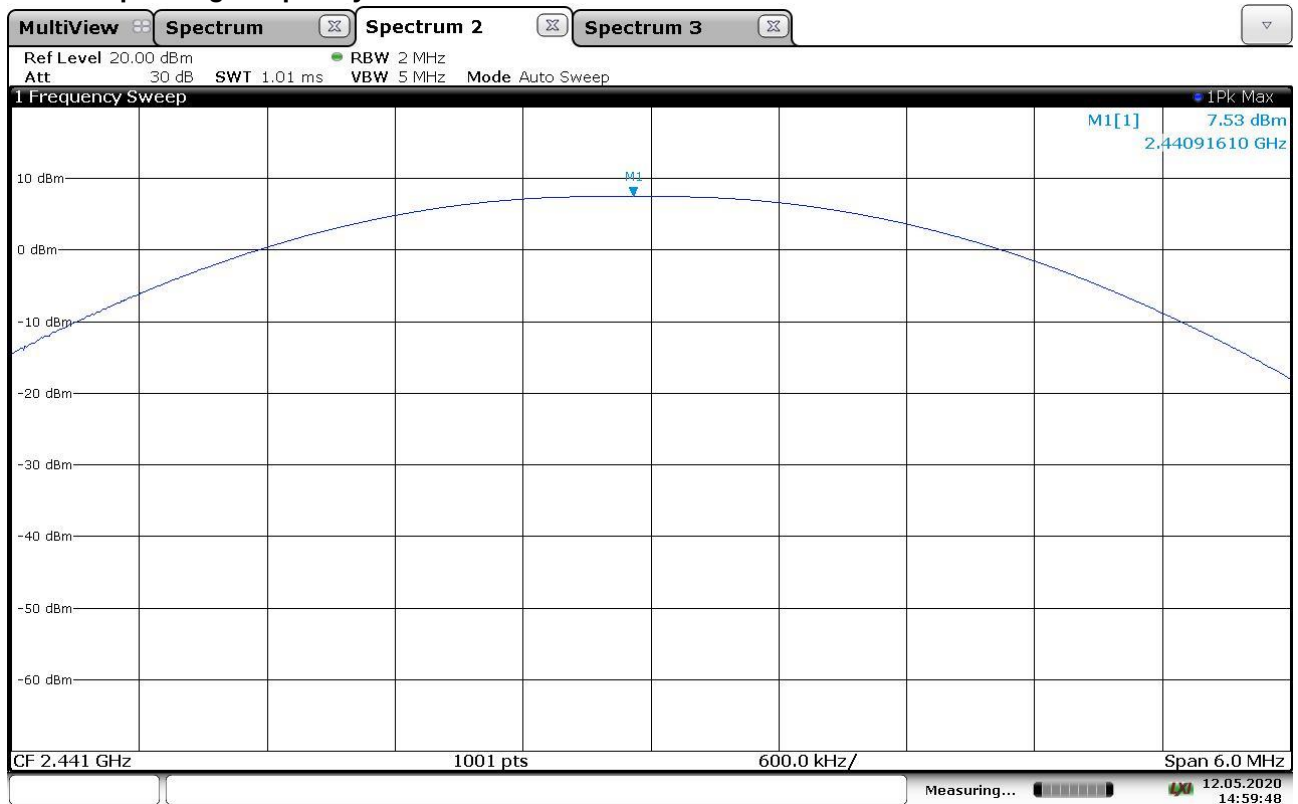
The results are recorded in Watt.

The Measurement was performed on: 12.05.2020 and 13.05.2020

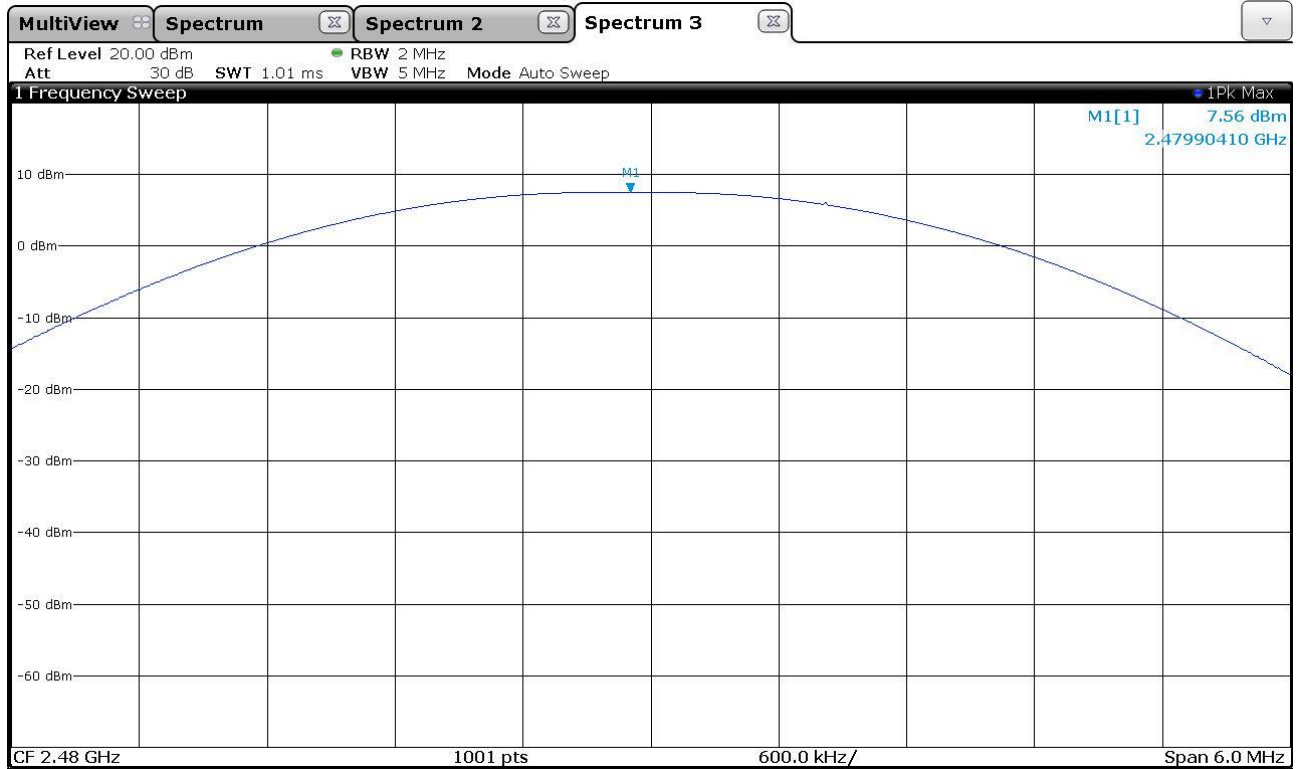
Lowest operating frequency – GFSK



Middle Operating Frequency – GFSK



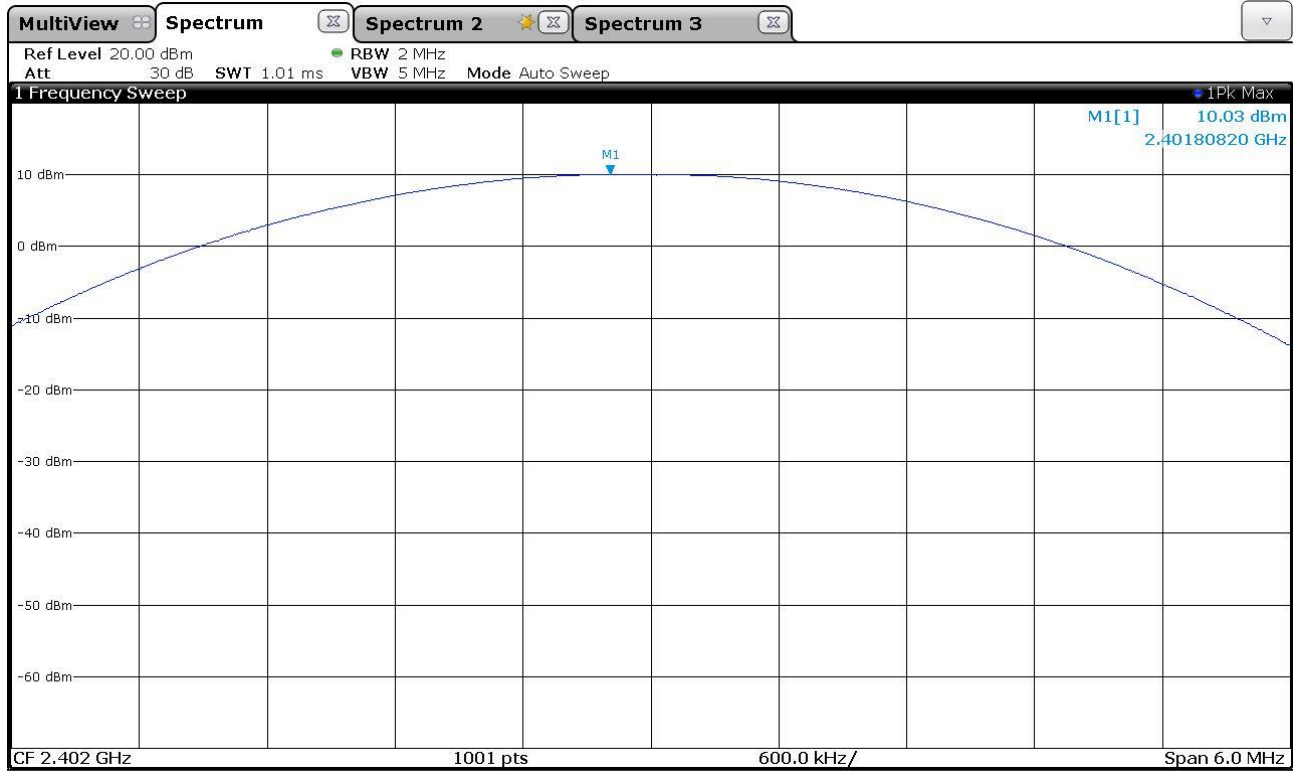
Highest Operating Frequency – GFSK



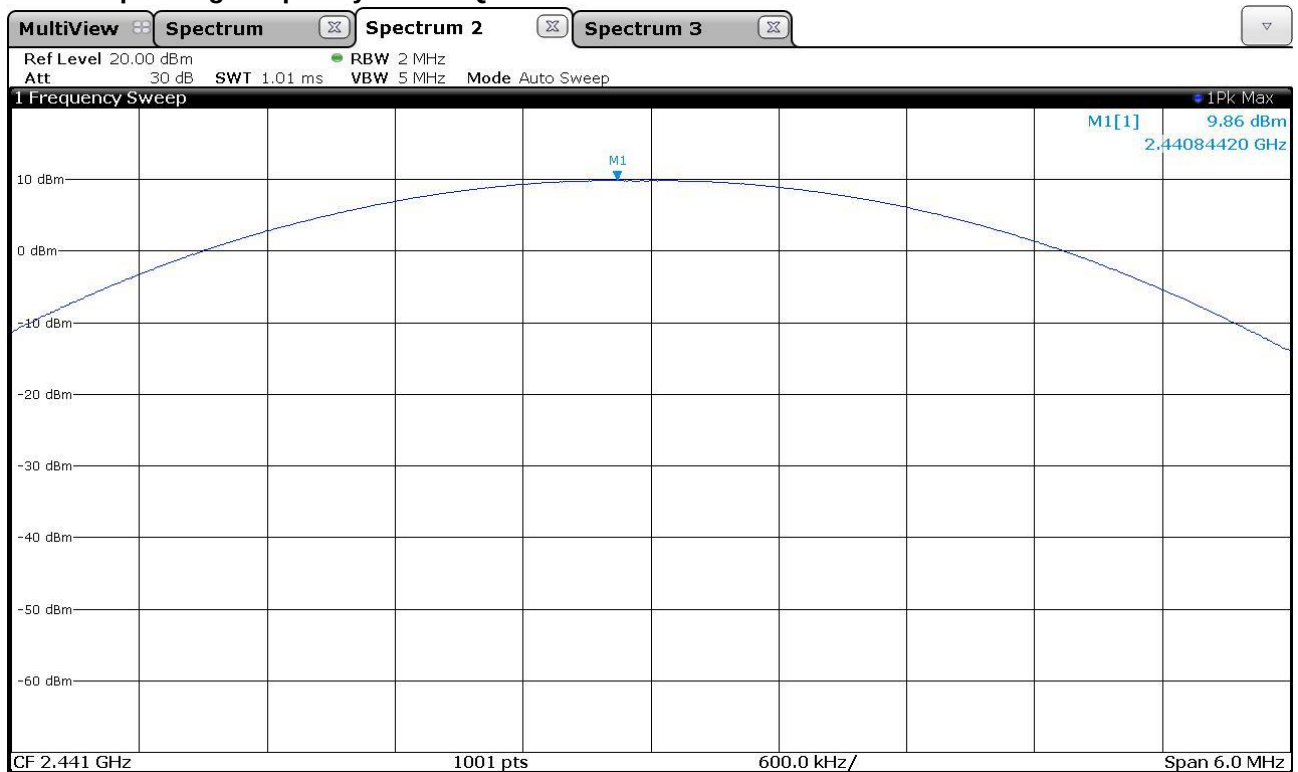
Maximum output power conducted measurement - GFSK

Channel	Frequency [MHz]	Reading of Analyzer [dBm]	Cable Loss [dB]	Output Power		Limit		Result
				[dBm]	[mW]	[dBm]	[mW]	
0	2402	7.79	0.5	8.29	6.75	30	1000	Pass
39	2441	7.53	0.5	8.03	6.35	30	1000	Pass
78	2480	7.56	0.5	8.06	6.40	30	1000	Pass

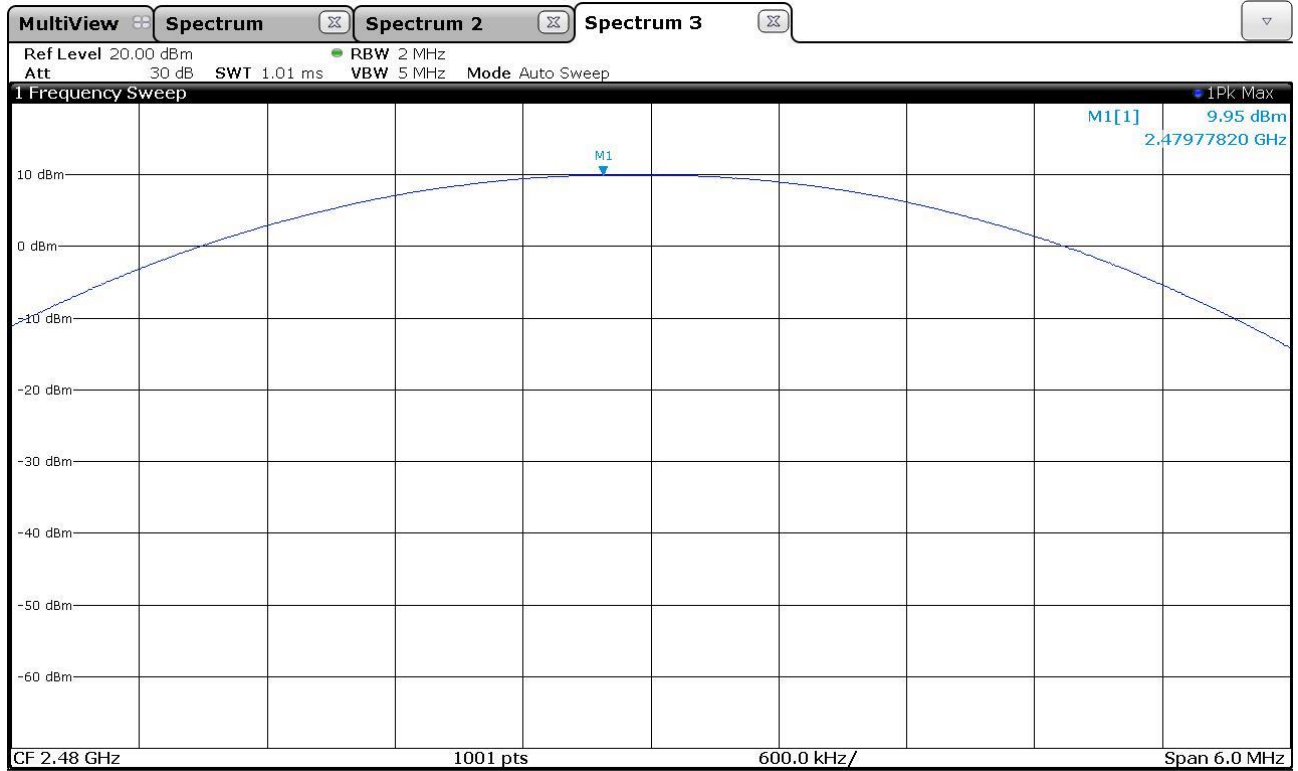
Lowest operating frequency – $\pi/4$ -DQPSK



Middle Operating Frequency – $\pi/4$ -DQPSK



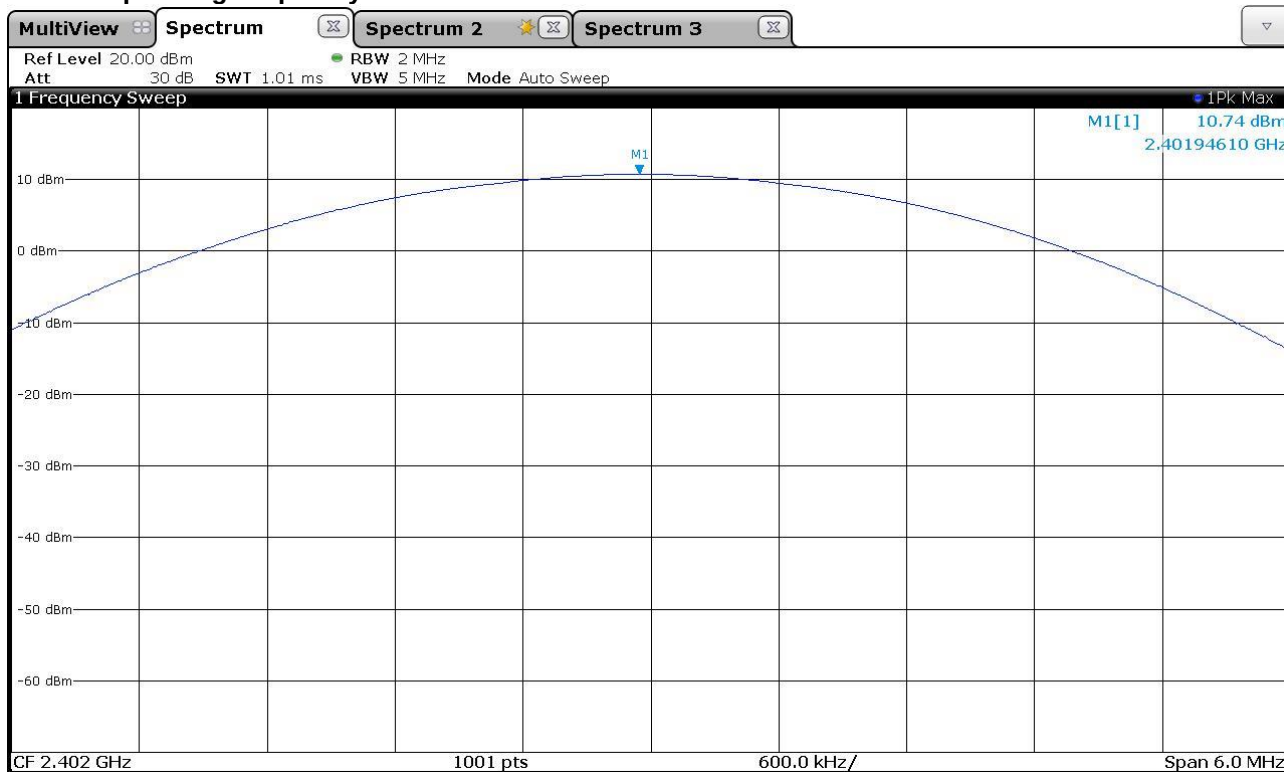
Highest Operating Frequency – $\pi/4$ -DQPSK



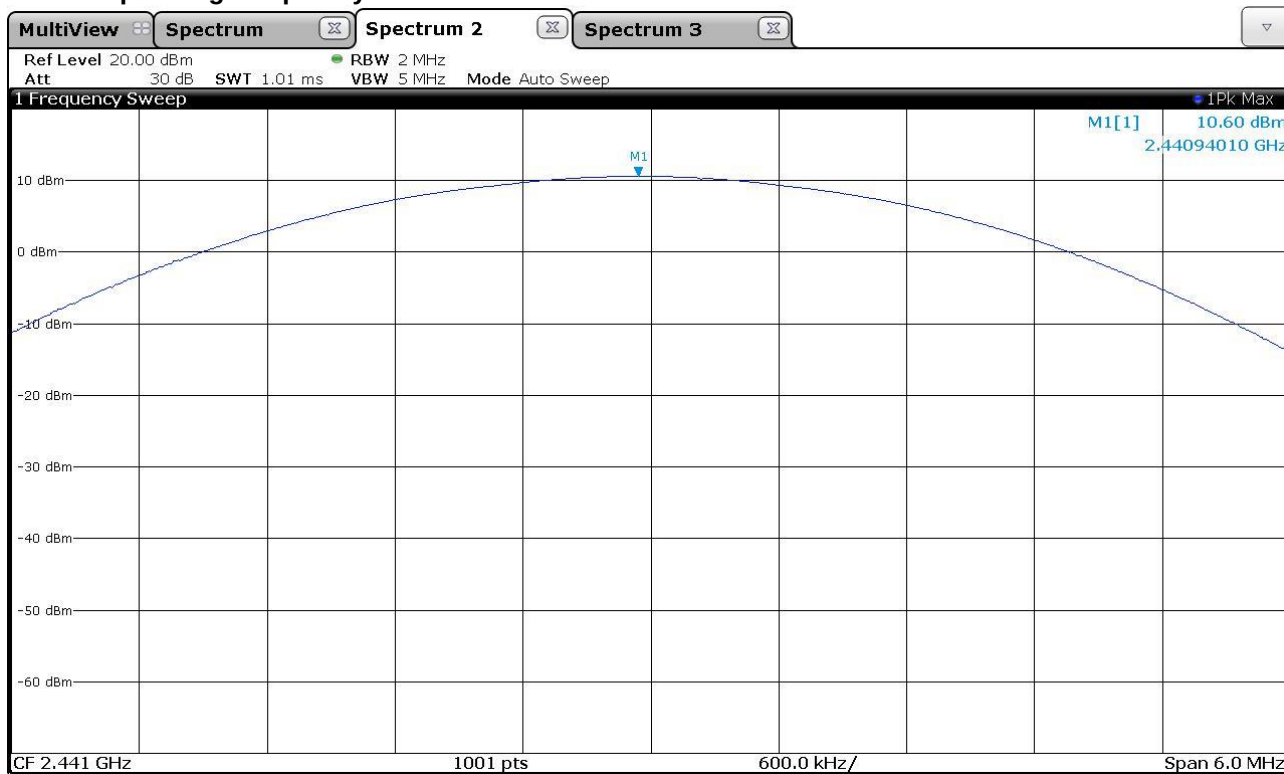
Maximum output power conducted measurement - $\pi/4$ -DQPSK

Channel	Frequency [MHz]	Reading of Analyzer [dBm]	Cable Loss [dB]	Output Power		Limit		Result
				[dBm]	[mW]	[dBm]	[mW]	
0	2402	10.03	0.5	10.53	11.30	30	1000	Pass
39	2441	9.86	0.5	10.36	10.86	30	1000	Pass
78	2480	9.95	0.5	10.45	11.09	30	1000	Pass

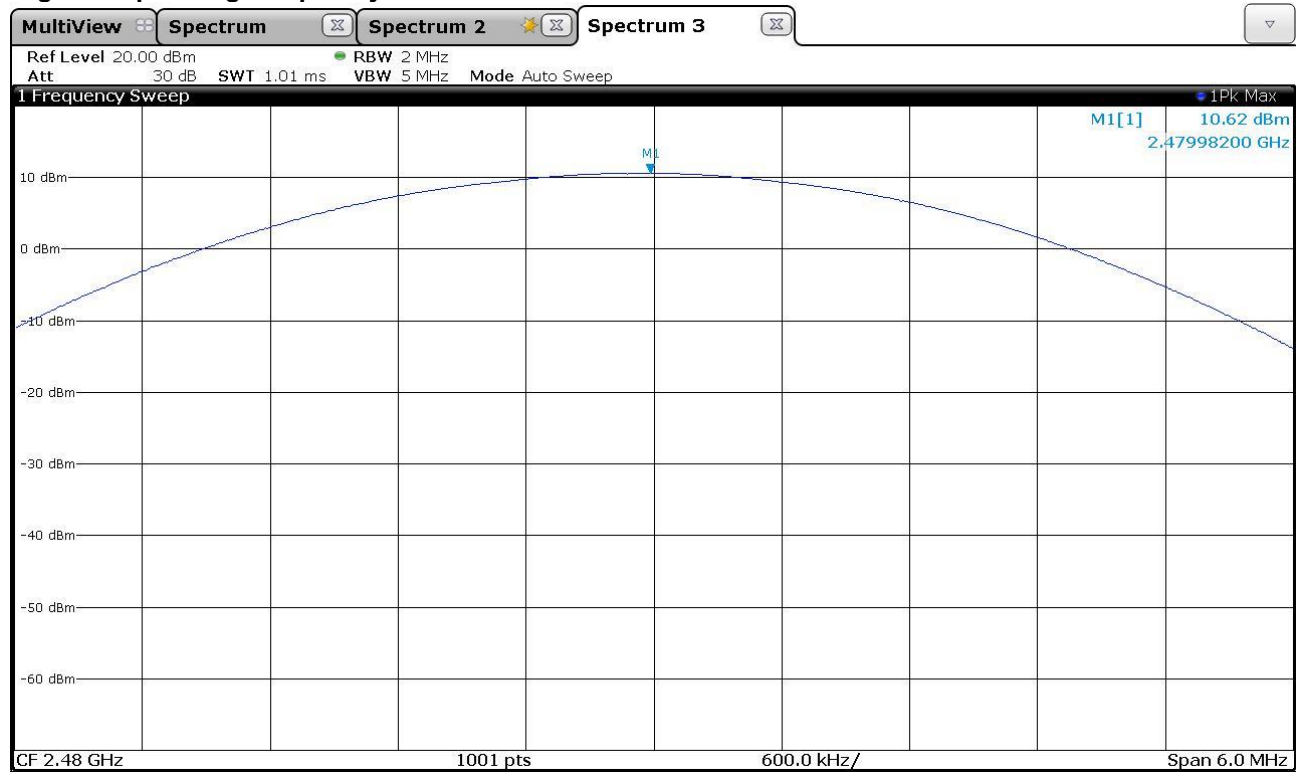
Lowest operating frequency – 8DPSK



Middle Operating Frequency – 8DPSK



Highest Operating Frequency – 8DPSK



Maximum output power conducted measurement - 8DPSK

Channel	Frequency [MHz]	Reading of Analyzer [dBm]	Cable Loss [dB]	Output Power		Limit		Result
				[dBm]	[mW]	[dBm]	[mW]	
0	2402	10.74	0.5	11.24	13.30	30	1000	Pass
39	2441	10.60	0.5	11.10	12.88	30	1000	Pass
78	2480	10.62	0.5	11.12	12.94	30	1000	Pass

Results

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

7.3. Number of Operating Channel

Applied standards

- e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (a) (1) (iii)
- RSS-247 issue 2 Section 5.1 (d)

Limit

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

Test equipment and test set up

Test equipment used for conducted measurements as given in clause Test equipment of this report.

Test setup used for conducted measurements as given in clause Test setups of this report.

Description

Frequency range

2.4 GHz – 2.4835 GHz (Peak Detector)

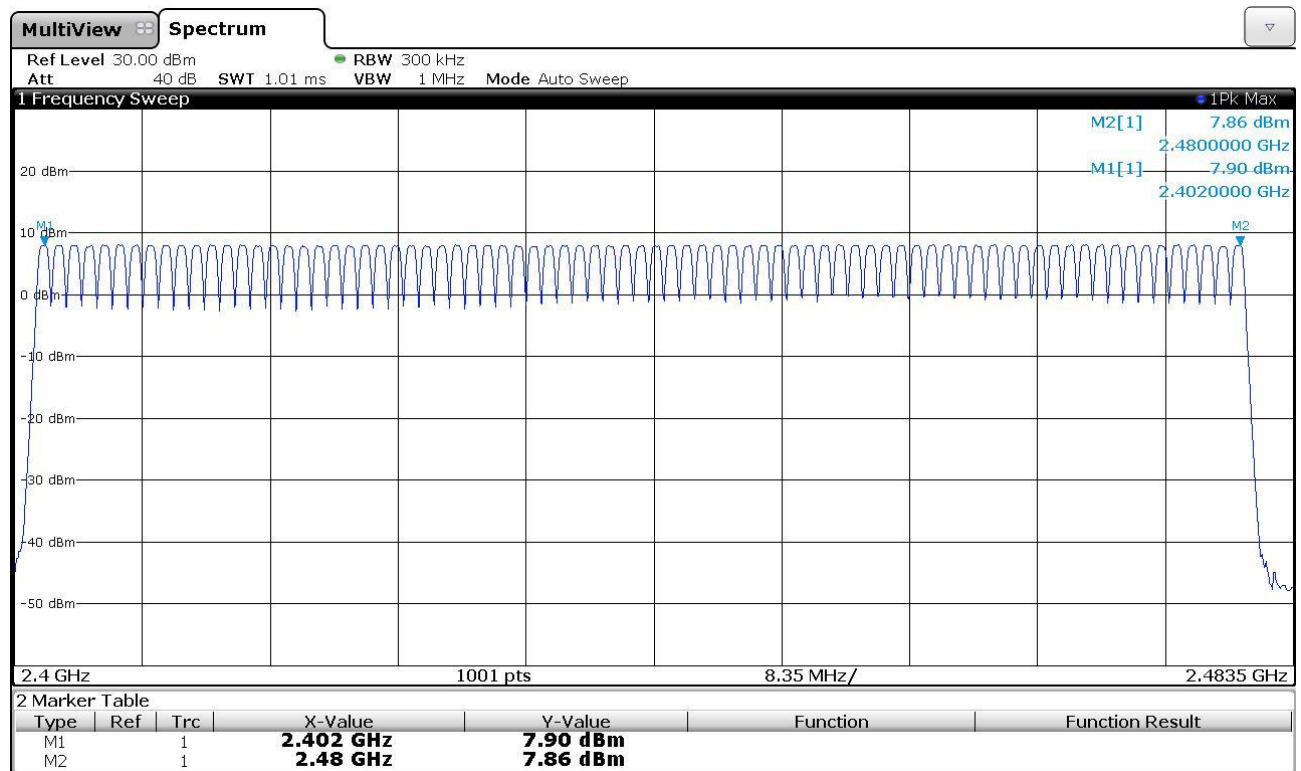
Bandwidth

RBW: 100 kHz

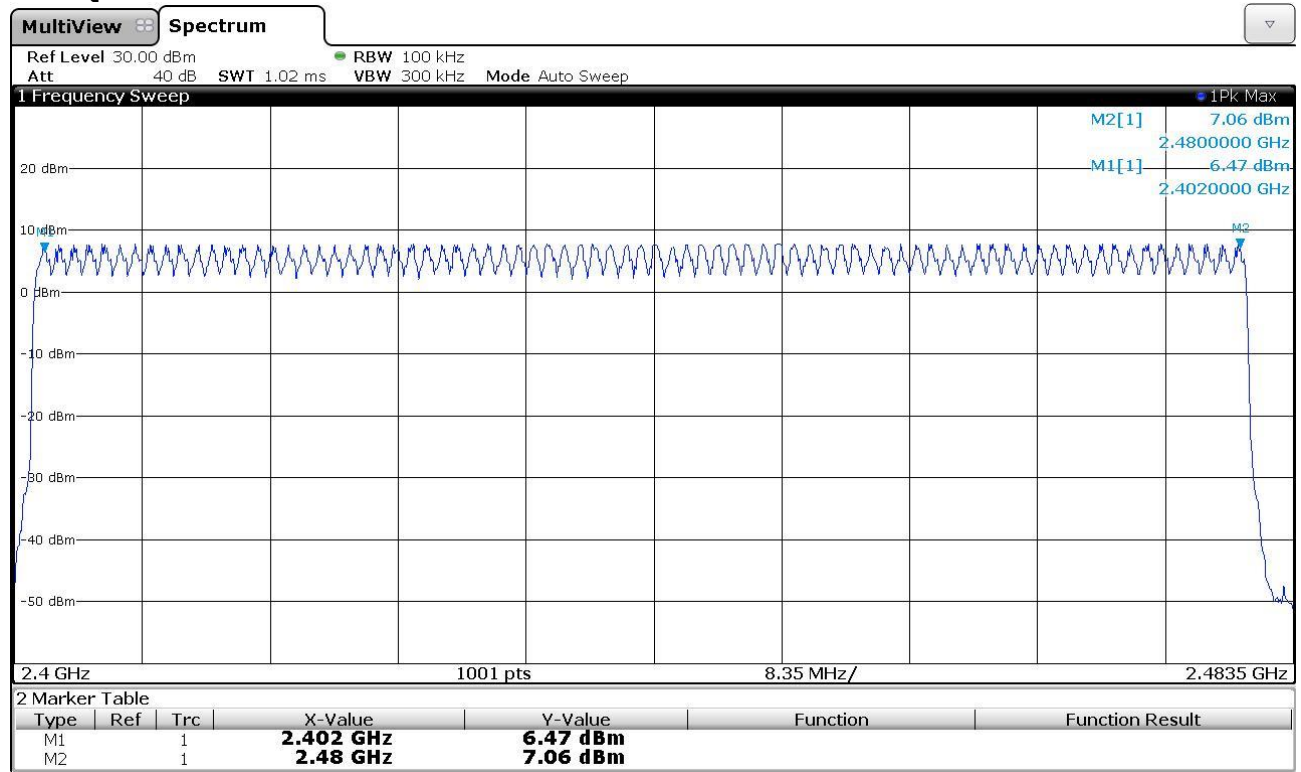
VBW: ≥ RBW

The Measurement was performed on: 12.05.2020 and 13.05.2020

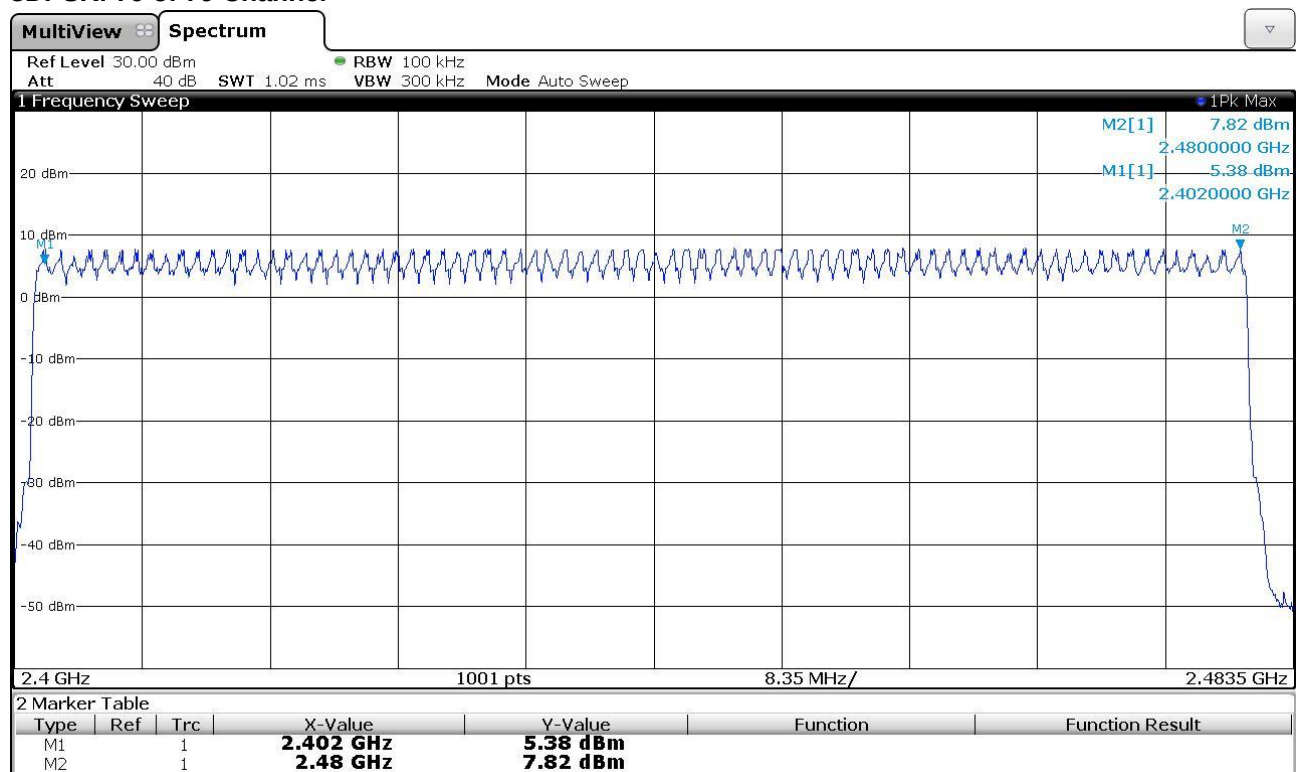
GFSK: 79 of 79 Channel



$\pi/4$ -DQPSK: 79 of 79 Channel



8DPSK: 79 of 79 Channel



Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **Number of Hopping Frequencies**.

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, $k = 0, \dots, 78$ (Channel separation = 1MHz)

7.5. Carrier Frequency Separation

Test Requirements

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

-RSS-247 issue 2 Section 5.1 (b)

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 Test equipment of this report.

Test setup used for conducted measurements as given in clause Test setups of this report.

Detector function selection and bandwidth

For the measurement, an EMI test receiver that have CISPR peak detector was used.

Description

Frequency range wide enough to capture the peaks of two adjacent channels.

(Peak Detector)

Limits

GFSK:

The measured maximum bandwidth * $2/3$ = $939.1 \text{ kHz} * 2/3 = 626.07 \text{ kHz}$

$\pi/4$ DQPSK:

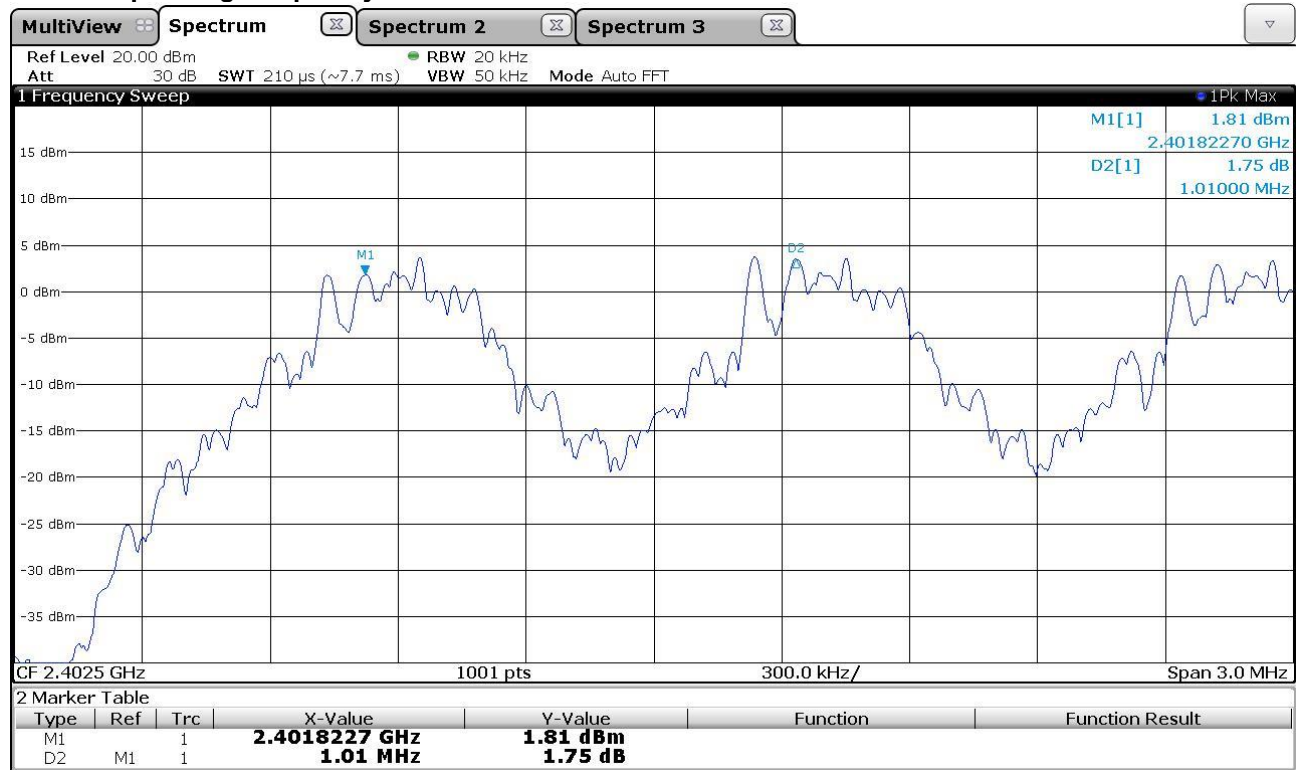
The measured maximum bandwidth * $2/3$ = $1313.7 \text{ kHz} * 2/3 = 875.8 \text{ kHz}$

8DPSK:

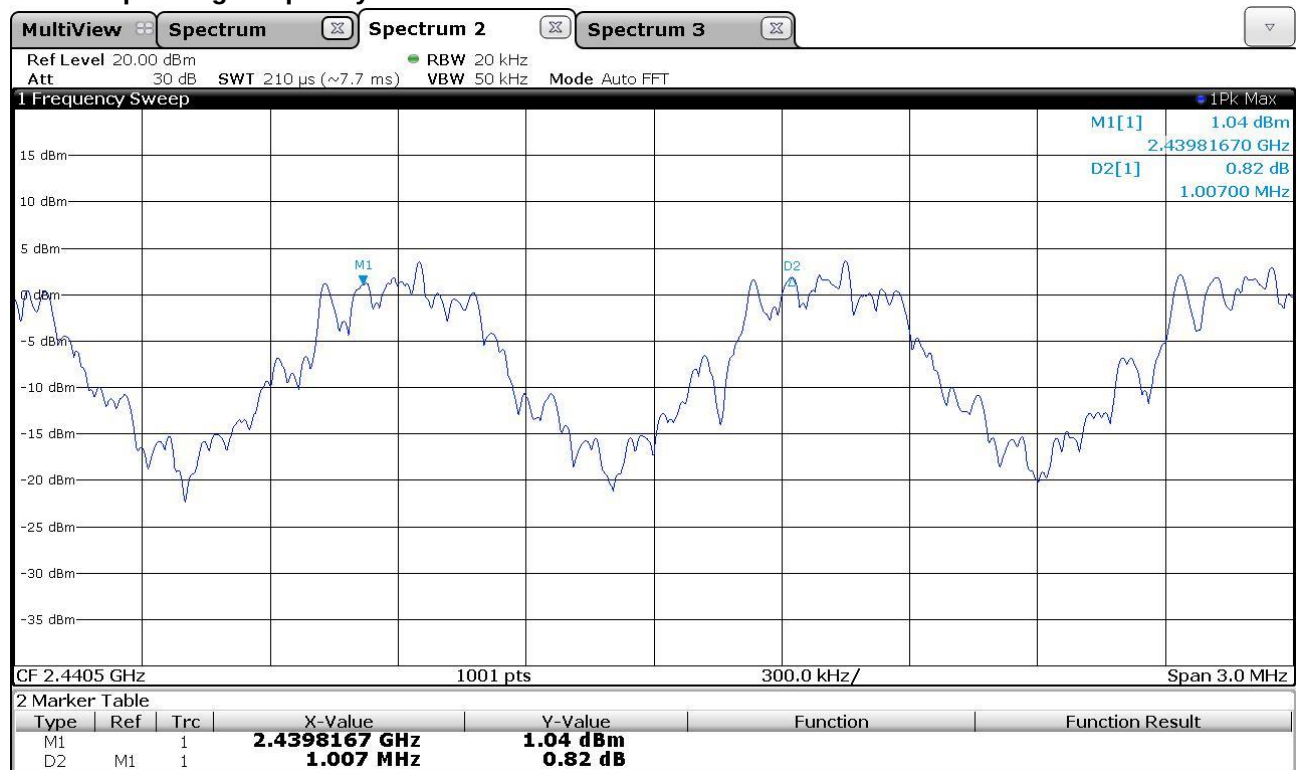
The measured maximum bandwidth * $2/3$ = $1291.2 \text{ kHz} * 2/3 = 860.8 \text{ kHz}$

The Measurement was performed on: 12.05.2020 and 13.05.2020

Lowest Operating Frequency – GFSK



Middle Operating Frequency – GFSK



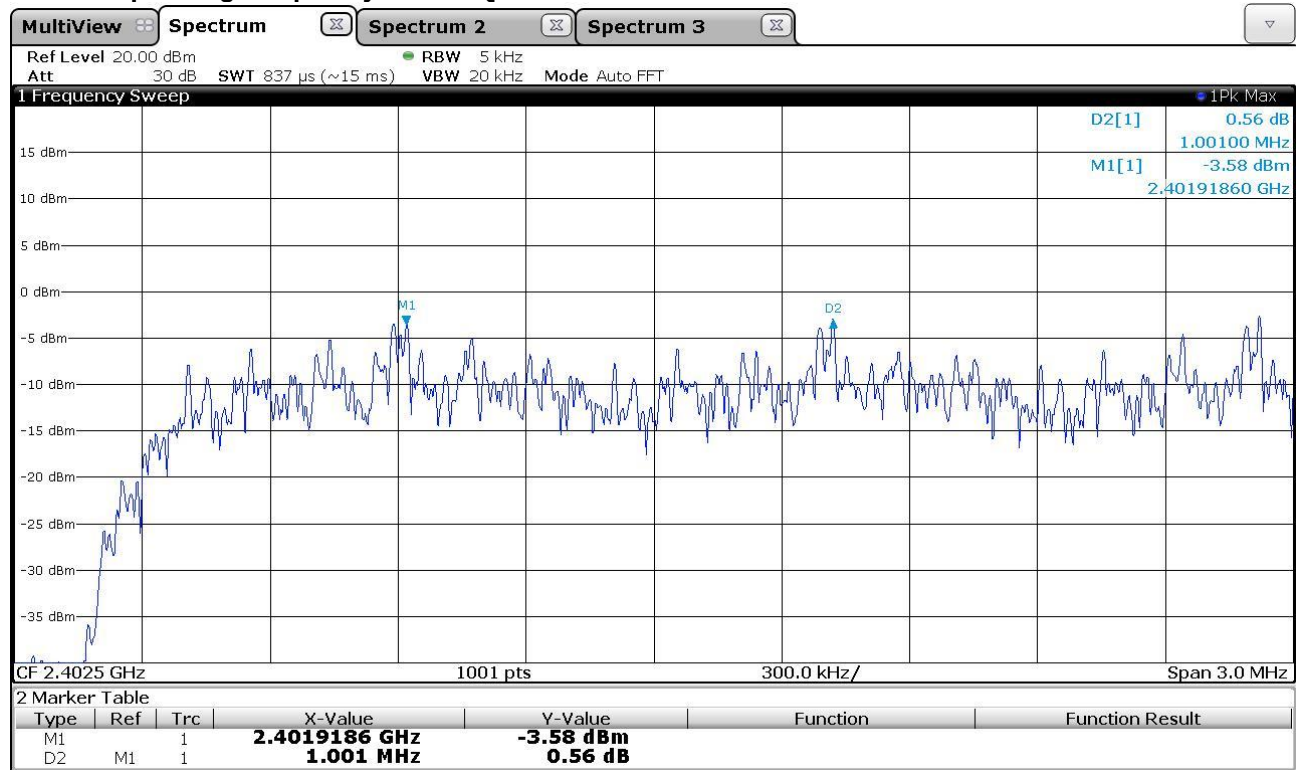
Highest Operating Frequency – GFSK



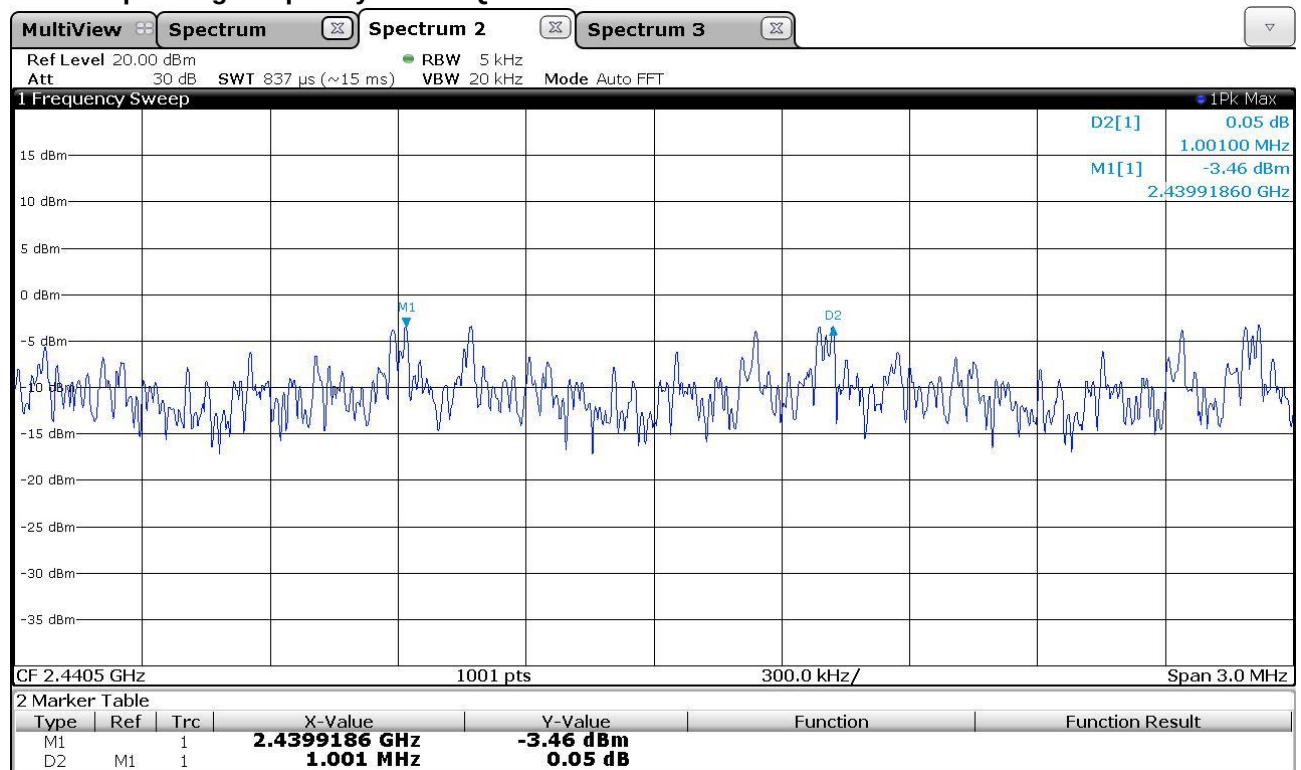
Summary of Channel separation measurements – GFSK

Tested Channel	Channel separation [kHz]	Limit = 2/3 BW [kHz]	Result
Lowest	1010	> 626.07	Pass
Middle	1007	> 626.07	Pass
Highest	1001	> 626.07	Pass

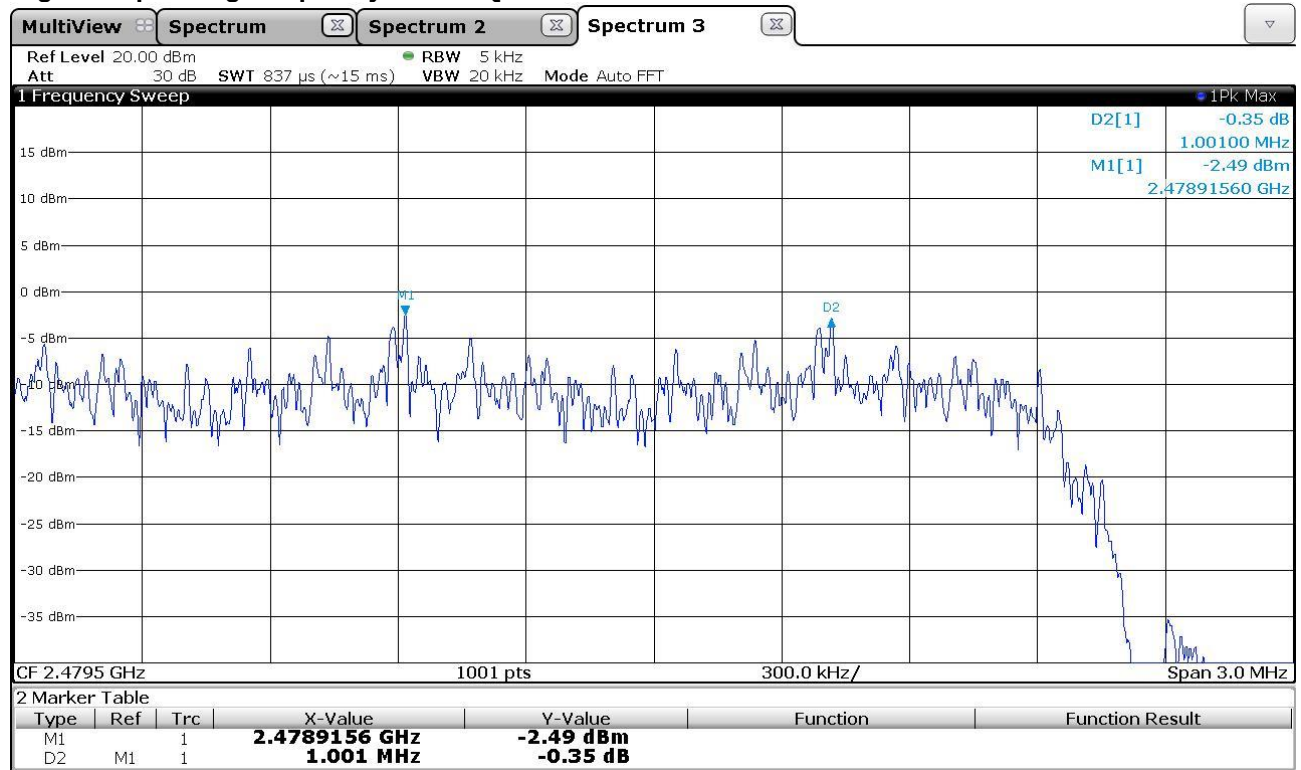
Lowest Operating Frequency – $\pi/4$ DQPSK



Middle Operating Frequency – $\pi/4$ DQPSK



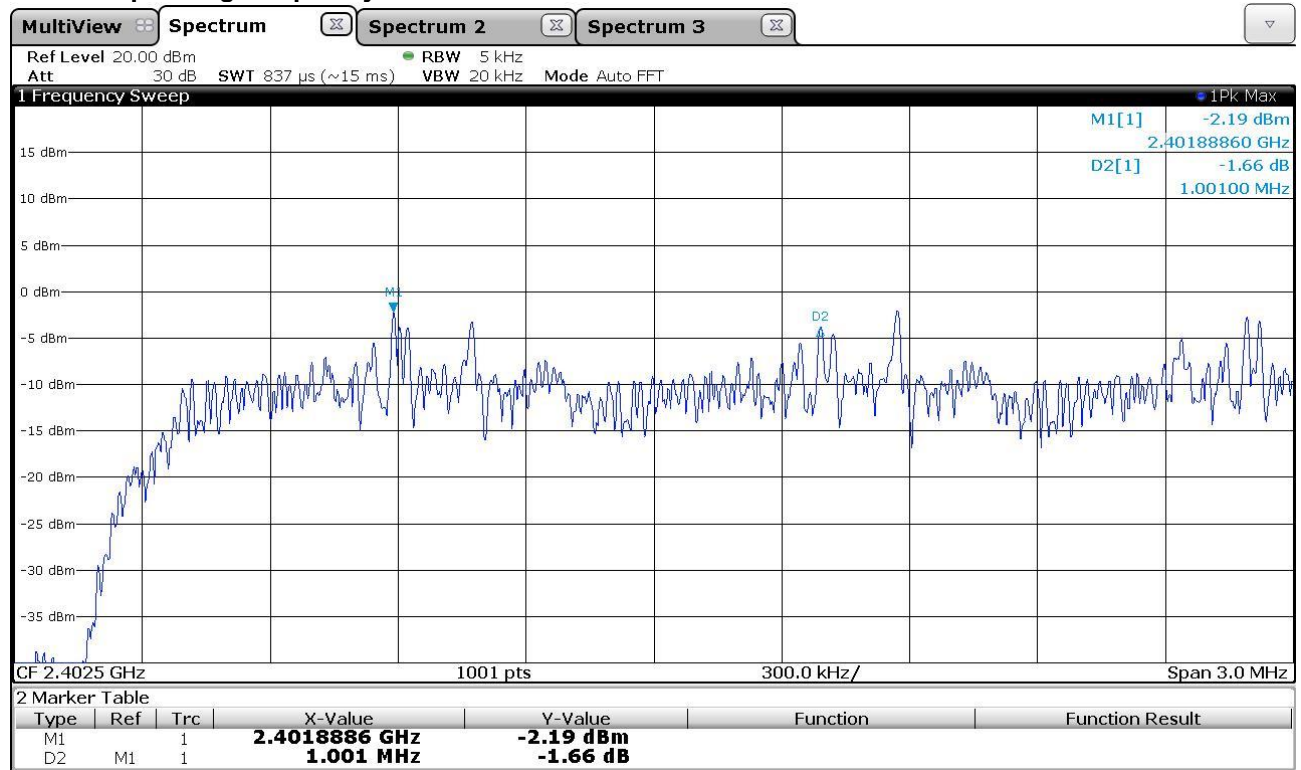
Highest Operating Frequency – $\pi/4$ DQPSK



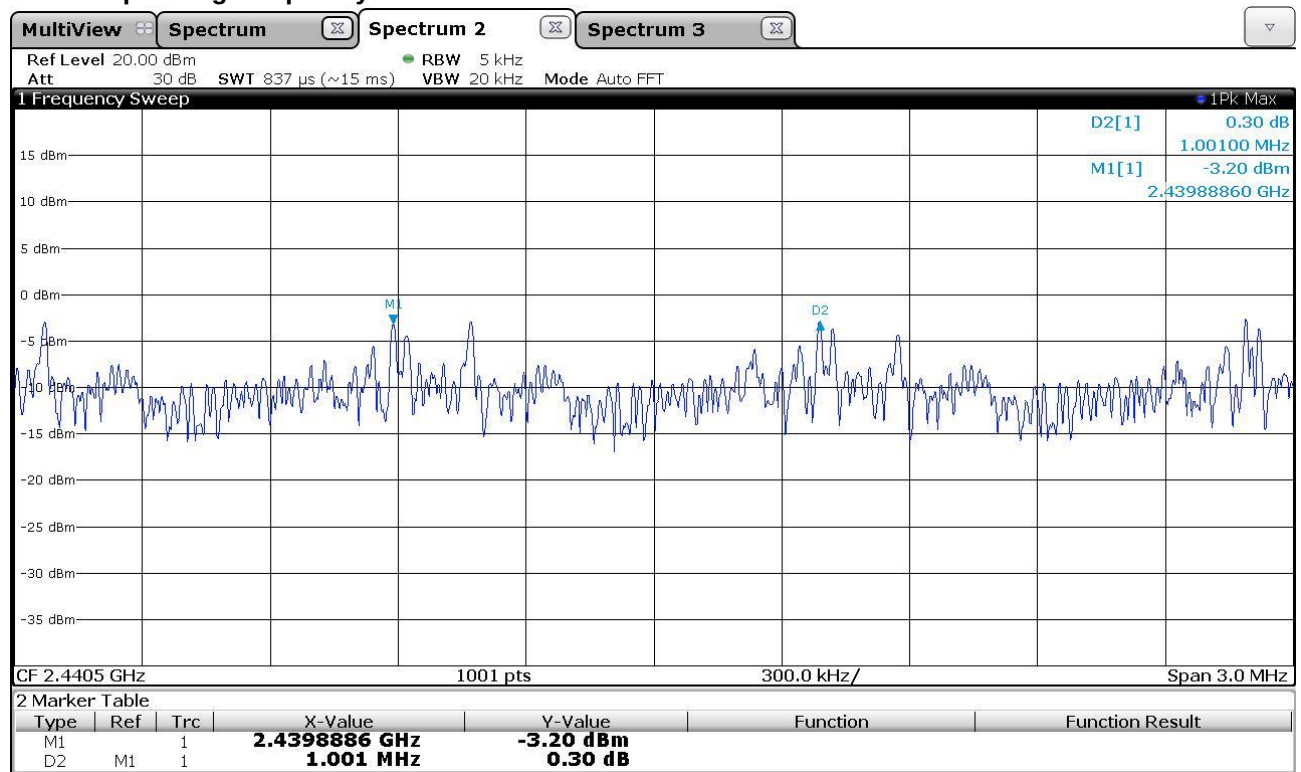
Summary of Channel separation measurements – $\pi/4$ DQPSK

Tested Channel	Channel separation [kHz]	Limit = 2/3 BW [kHz]	Result
Lowest	1001	> 875.8	Pass
Middle	1001	> 875.8	Pass
Highest	1001	> 875.8	Pass

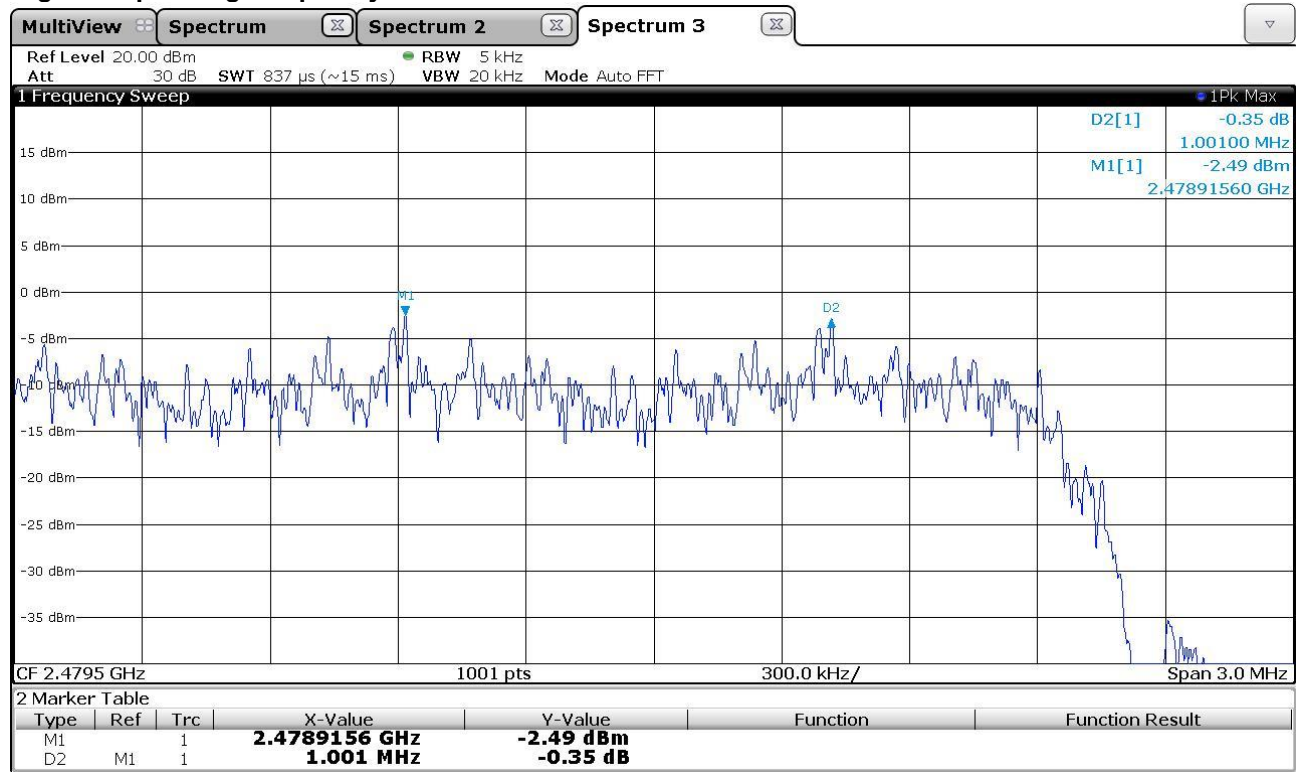
Lowest Operating Frequency – 8DPSK



Middle Operating Frequency – 8DPSK



Highest Operating Frequency – 8DPSK



Summary of Channel separation measurements – 8DPSK

Tested Channel	Channel separation [kHz]	Limit = 2/3 BW [kHz]	Result
Lowest	1001	> 860.8	Pass
Middle	1001	> 860.8	Pass
Highest	1001	> 860.8	Pass

7.6. Band-Edges Measurement

Applied standards

-e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 (d)
 -RSS-247 issue 2 Section 5.5

Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 30 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. Emissions which fall in the restricted bands, as defined in §15.205 Restricted Bands of operation as well as in restricted bands of the RSS-Gen Issue 5 (see Section 8.10 Restricted Frequency Bands) and must also comply with the radiated emission limits specified in §15.209 Radiated emission limits as well as the limits specified in RSS-Gen Table 5.

Test equipment and test set up

Test equipment used for Band Edge measurements as given in clause Test equipment of this report.
 Test setup used for Band Edge measurements as given in clause Test setups of this report.

Description

For restricted Bands:

The Emission must comply with the radiated emission limits. Measured with Average and Peak detector.

For non restricted Bands:

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

The measurements are initially carried out according to the requirements for restricted bands, as these requirements are more stringent. If the limit value is exceeded in a non-restricted band according to the restricted band specifications, the measurement is repeated again with requirements for non restricted bands in order to prove the conformity.

Note: It was not necessary to carry out a re-test for non restricted band requirements for the tested EUT.

Detector function selection and bandwidth

For the measurement, an EMI test receiver that have CISPR peak detector as well as average detector were used.

Band Edge for restricted Band

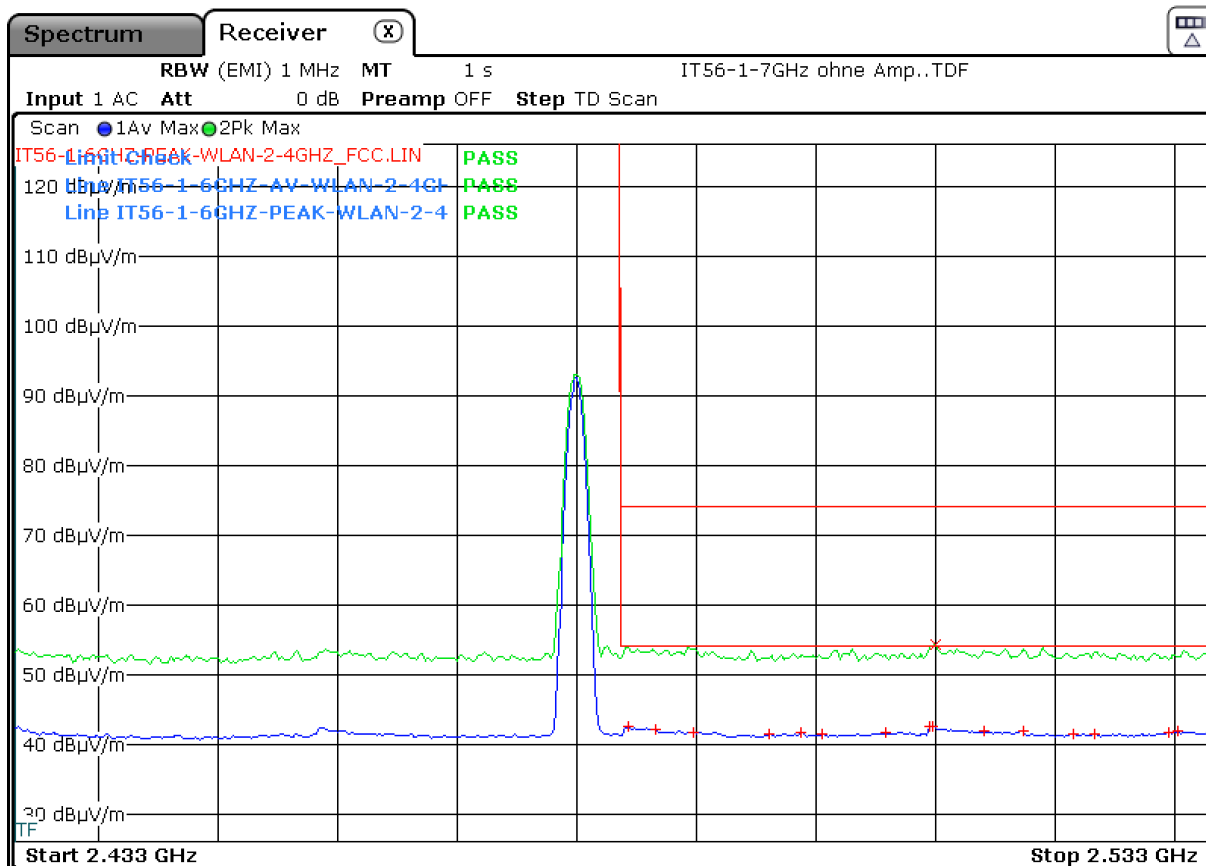
Frequency range:	Bandwidth	
See measurement graph	RBW:	1 MHz
	VBW:	3 MHz

Band Edge for non restricted Band

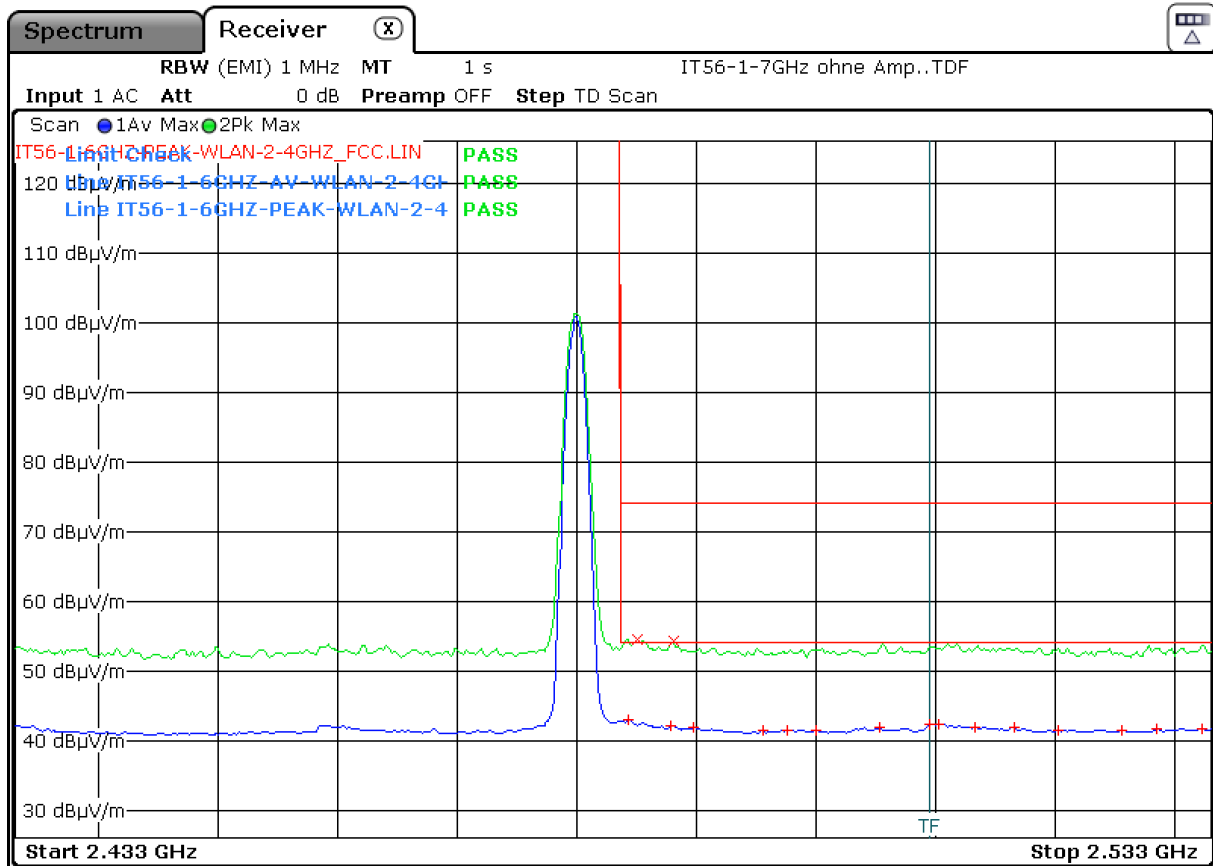
Frequency range:	Bandwidth	
See measurement graph	RBW:	100 kHz
	VBW:	300 kHz

The Measurement was performed on: 12.05.2020, 13.05.2020 and 19.05.2020

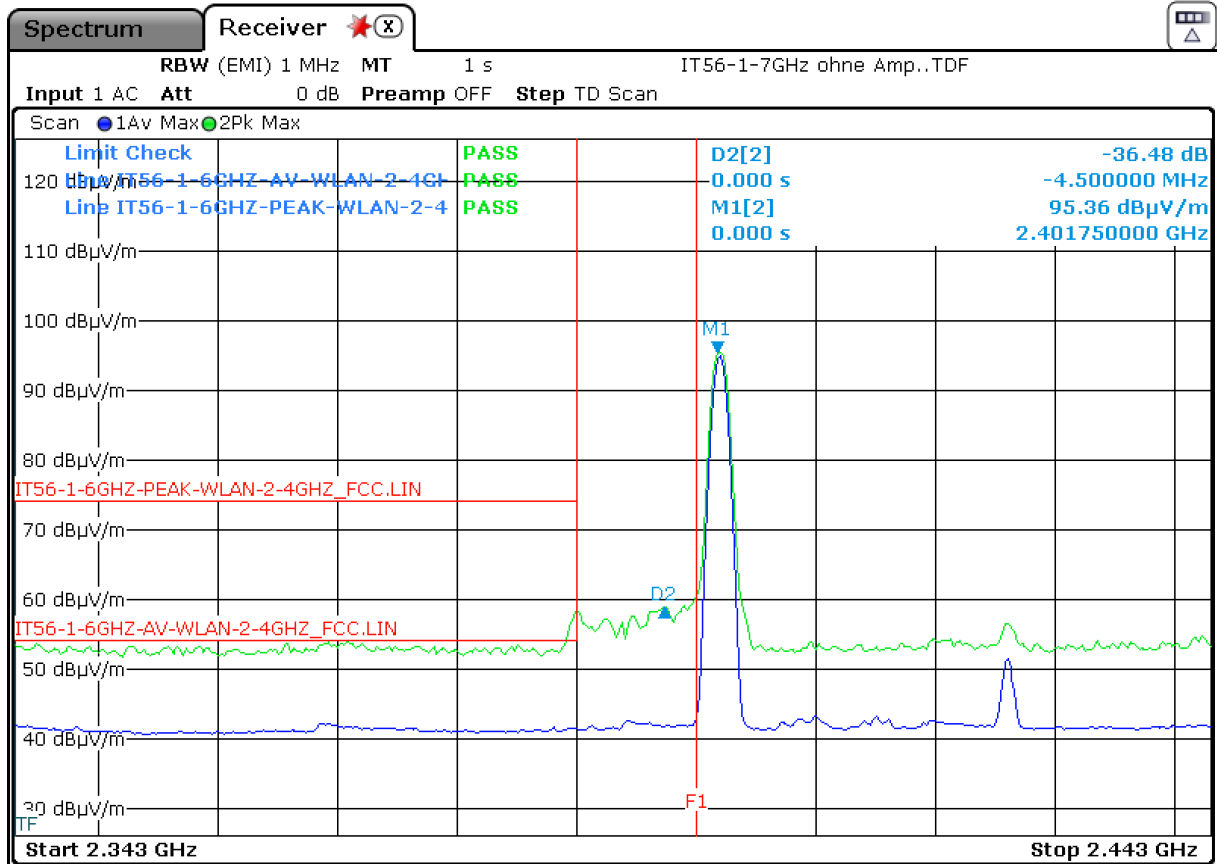
Operation mode: BT; GFSK; CH.78; Power max.; High edge

[illegible]

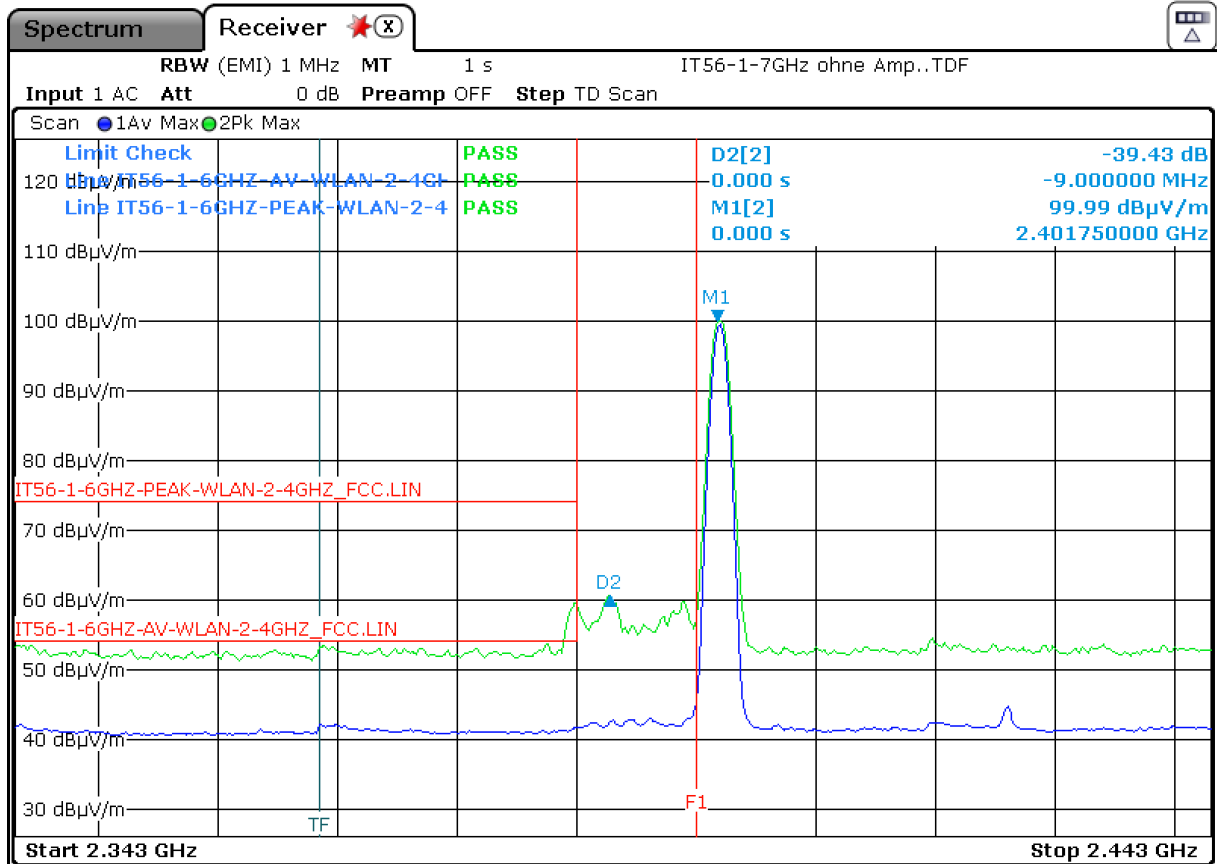
Operation mode: BT; GFSK; CH.78; Power max.; High edge

[illegible]

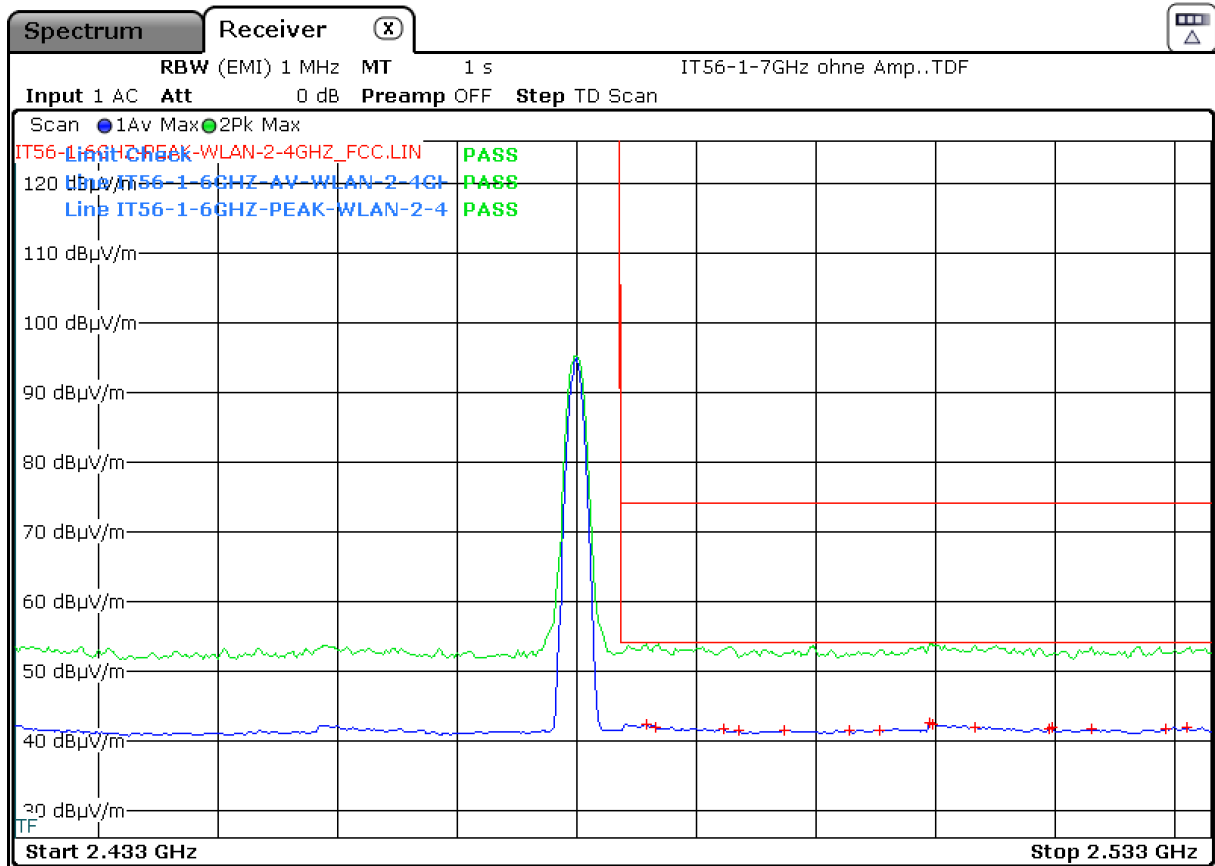
Operation mode: BT; GFSK; CH.0; Power max.; Low edge

[illegible]

Operation mode: BT; GFSK; CH.0; Power max.; Low edge

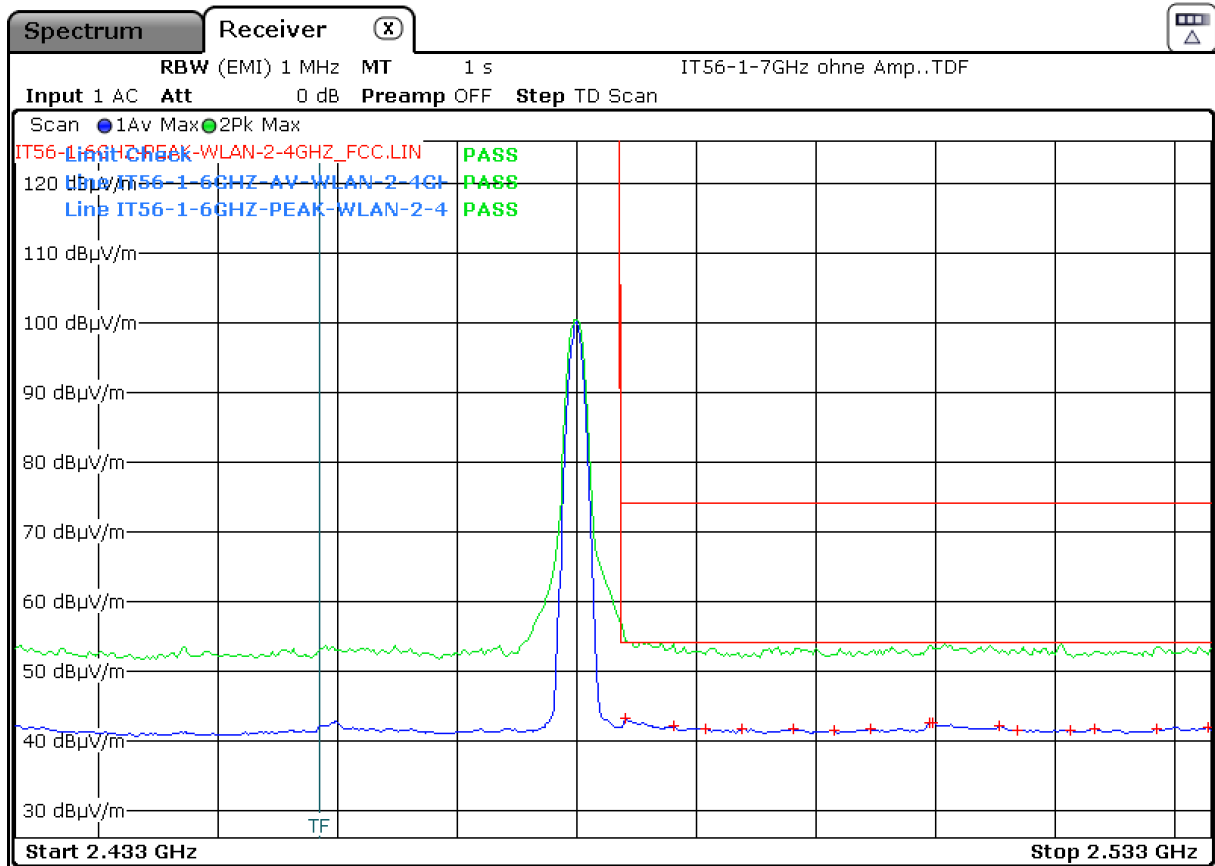
[illegible]

Operation mode: BT; $\pi/4$ DQPSK; CH.78; Power max.; High edge

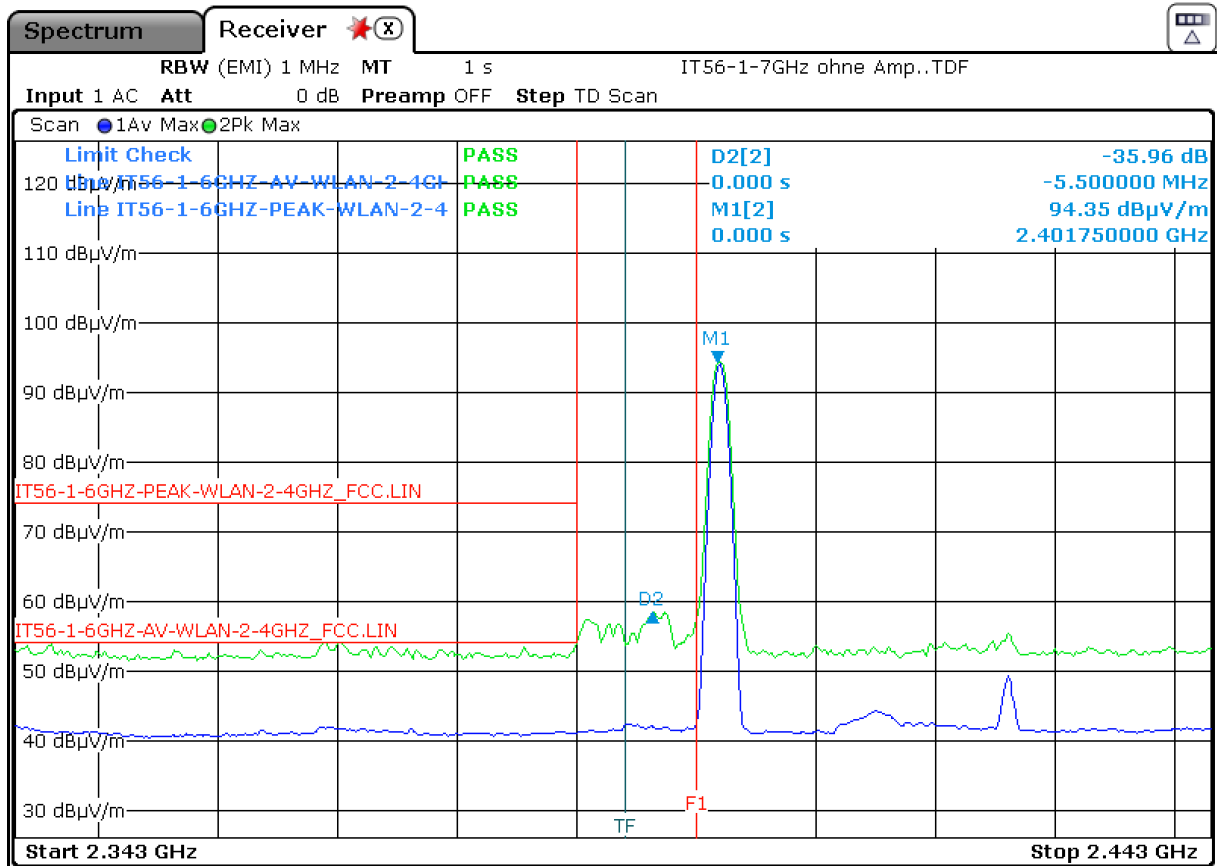


Polarisation: V									
Detector Average					Detector Peak				
Frequ. [GHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]	Result	Frequ. [GHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]	Result
all emissions are 10dB below limit				pass	all emissions are 10dB below limit				pass

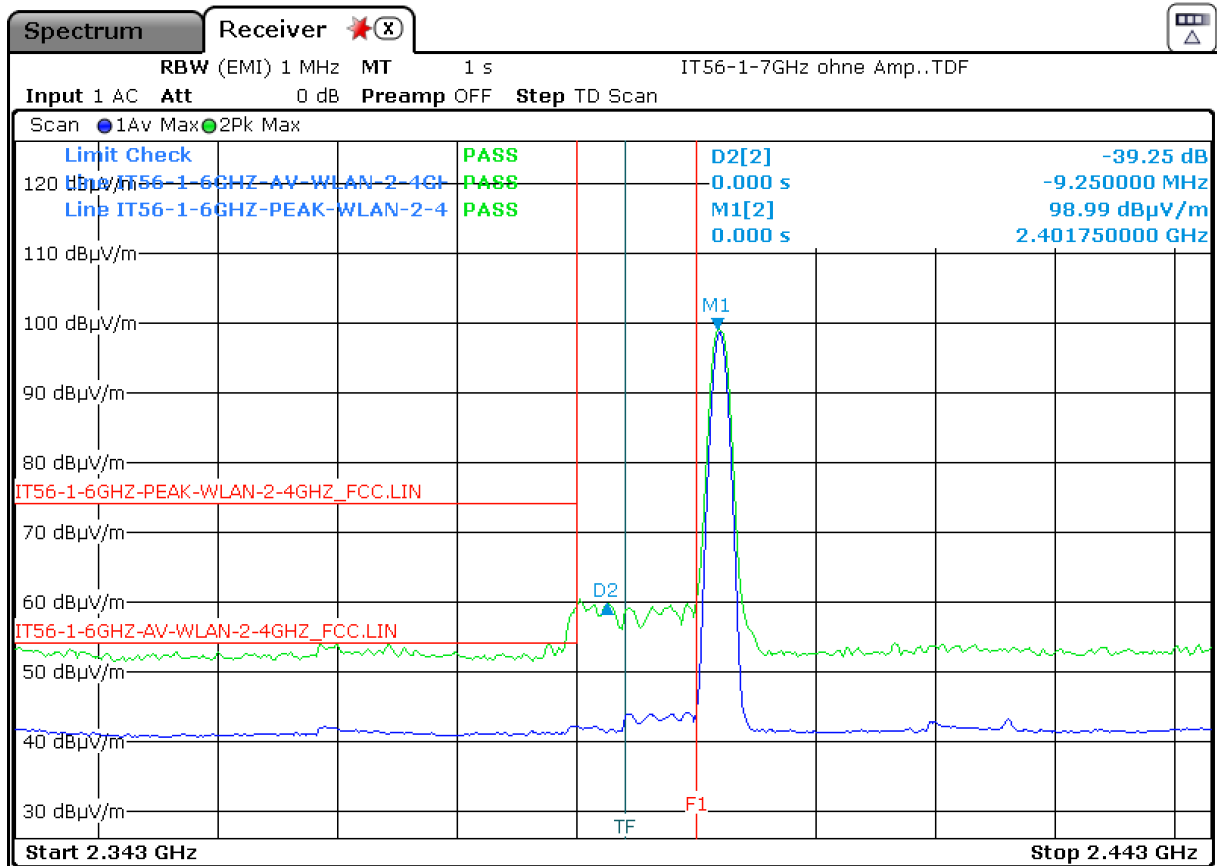
Operation mode: BT; $\pi/4$ DQPSK; CH.78; Power max.; High edge

[illegible]

Operation mode: BT; $\pi/4$ DQPSK; CH.0; Power max.; Low edge

[illegible]

Operation mode: BT; $\pi/4$ DQPSK; CH.0; Power max.; Low edge

[illegible]

Spectrum **Receiver** **RBW (EMI) 1 MHz** **MT 1 s** **IT56-1-7GHz ohne Amp..TDF**

Input 1 AC **Att 0 dB** **Preampl OFF** **Step TD Scan**

Scan **1Av Max** **2Pk Max**

Line Check

IT56-1-6GHZ-PEAK-WLAN-2-4GHZ **PASS**

IT56-1-6GHZ-AV-WLAN-2-4GHZ **PASS**

Line IT56-1-6GHZ-PEAK-WLAN-2-4 **PASS**

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

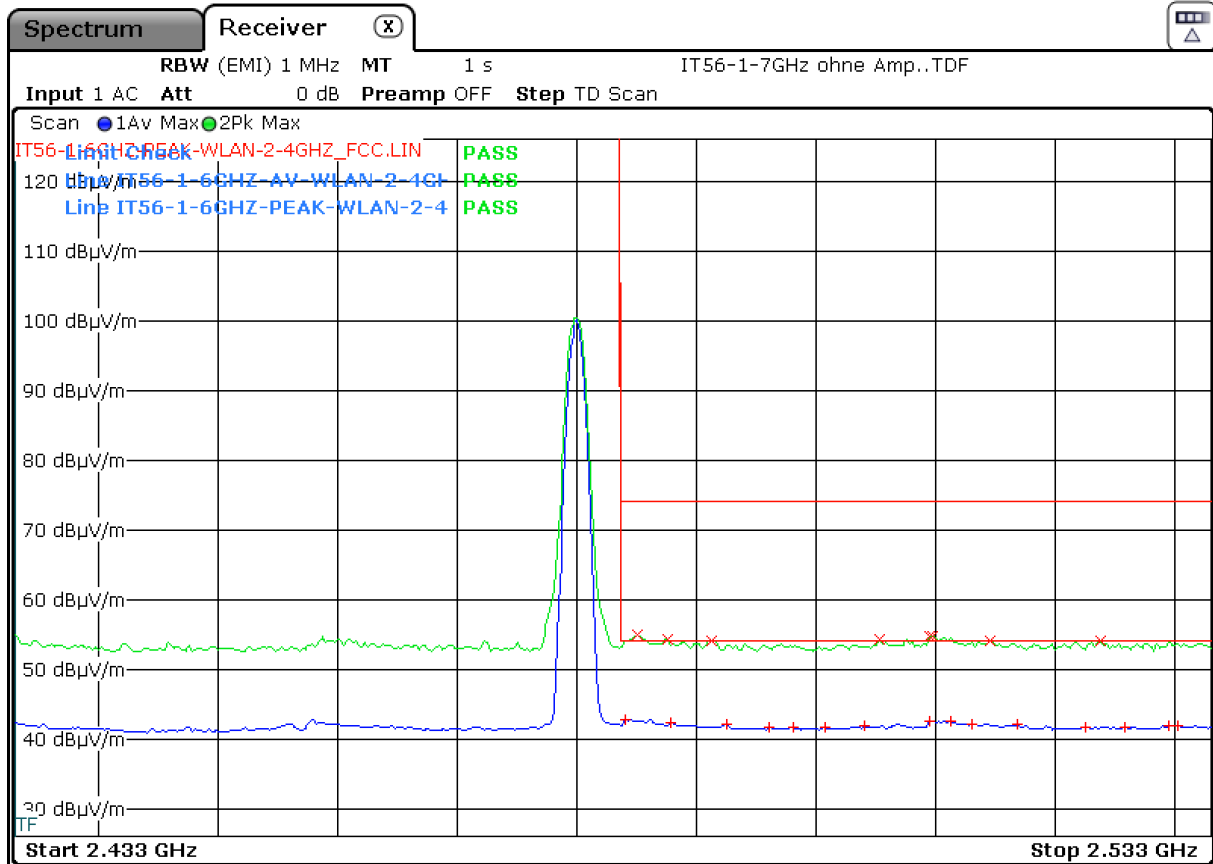
30 dBμV/m

Start 2.433 GHz **Stop 2.533 GHz**

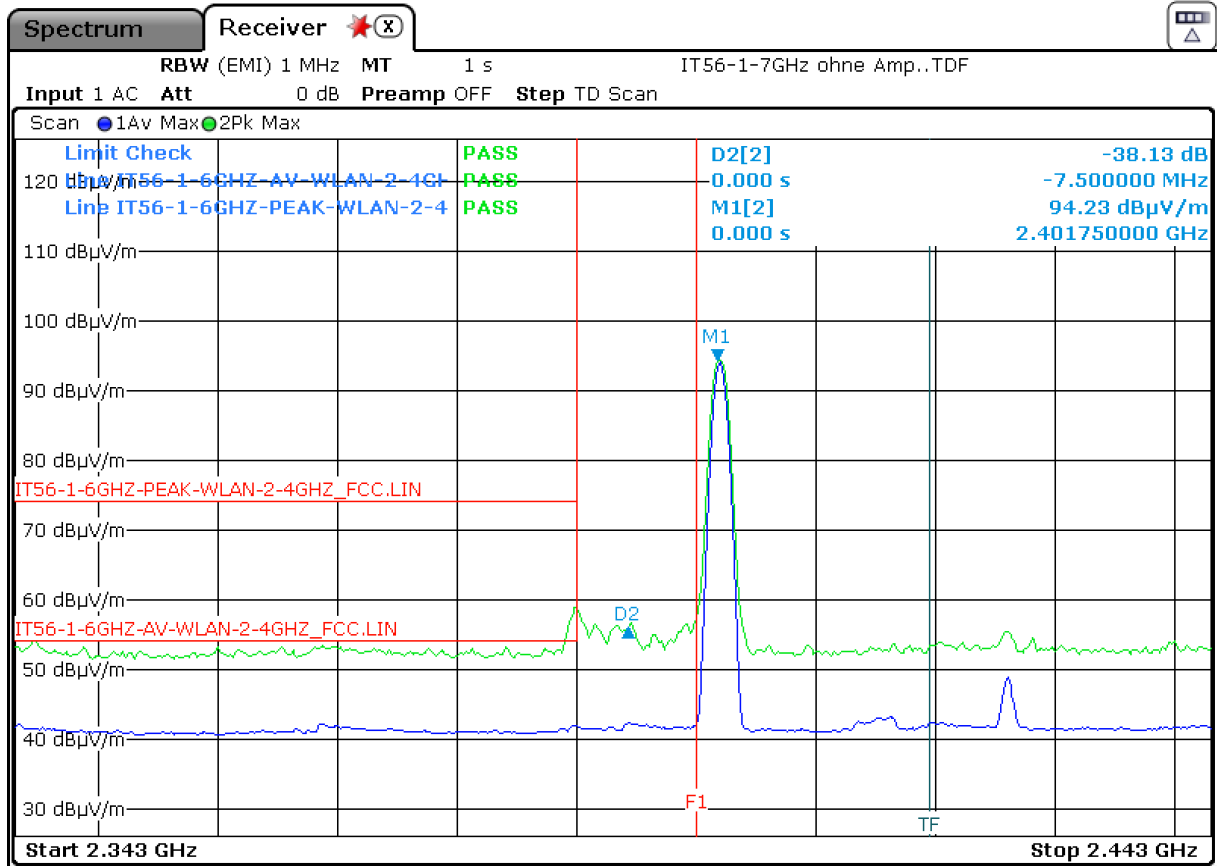
TF

[illegible]

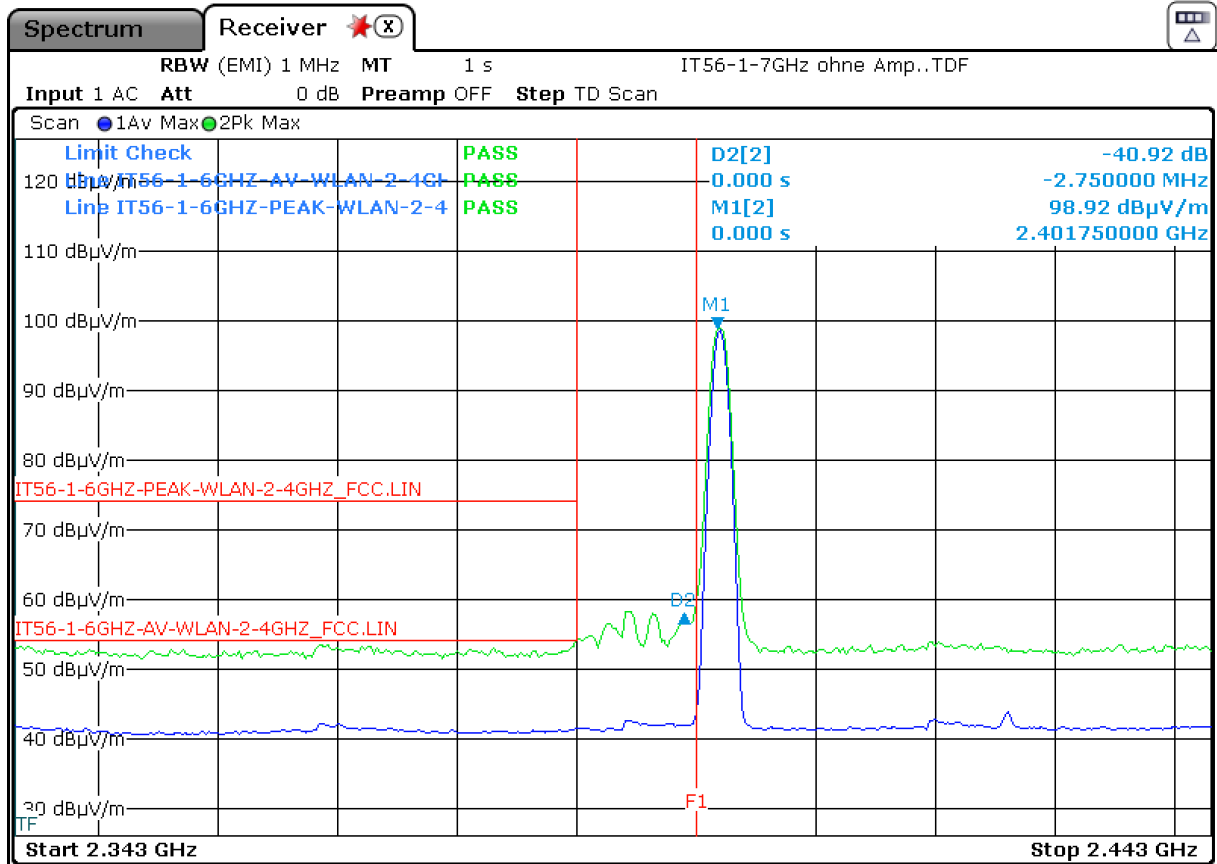
Operation mode: BT; 8DPSK; CH.78; Power max.; High edge

[illegible]

Operation mode: BT; 8DPSK; CH.0; Power max.; Low edge

[illegible]

Operation mode: BT; 8DPSK; CH.0; Power max.; Low edge

[illegible]

Spectrum **Receiver** (X)

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan 1Av Max 2Pk Max

Line IT56-1-6GHZ-PEAK-WLAN-2-4GHz.LIN PASS

Line IT56-1-6GHZ-AV-WLAN-2-4GHz PASS

Line IT56-1-6GHZ-PEAK-WLAN-2-4GHz PASS

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

30 dBμV/m

TF

Start 2.433 GHz Stop 2.533 GHz

[illegible]

Spectrum **Receiver** **X**

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan 1Av Max 2Pk Max

Line Check

IT56-1-6GHZ-PEAK-WLAN-2-4GHZ.LIN PASS

IT56-1-6GHZ-AV-WLAN-2-4GHZ PASS

Line IT56-1-6GHZ-PEAK-WLAN-2-4GHZ PASS

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

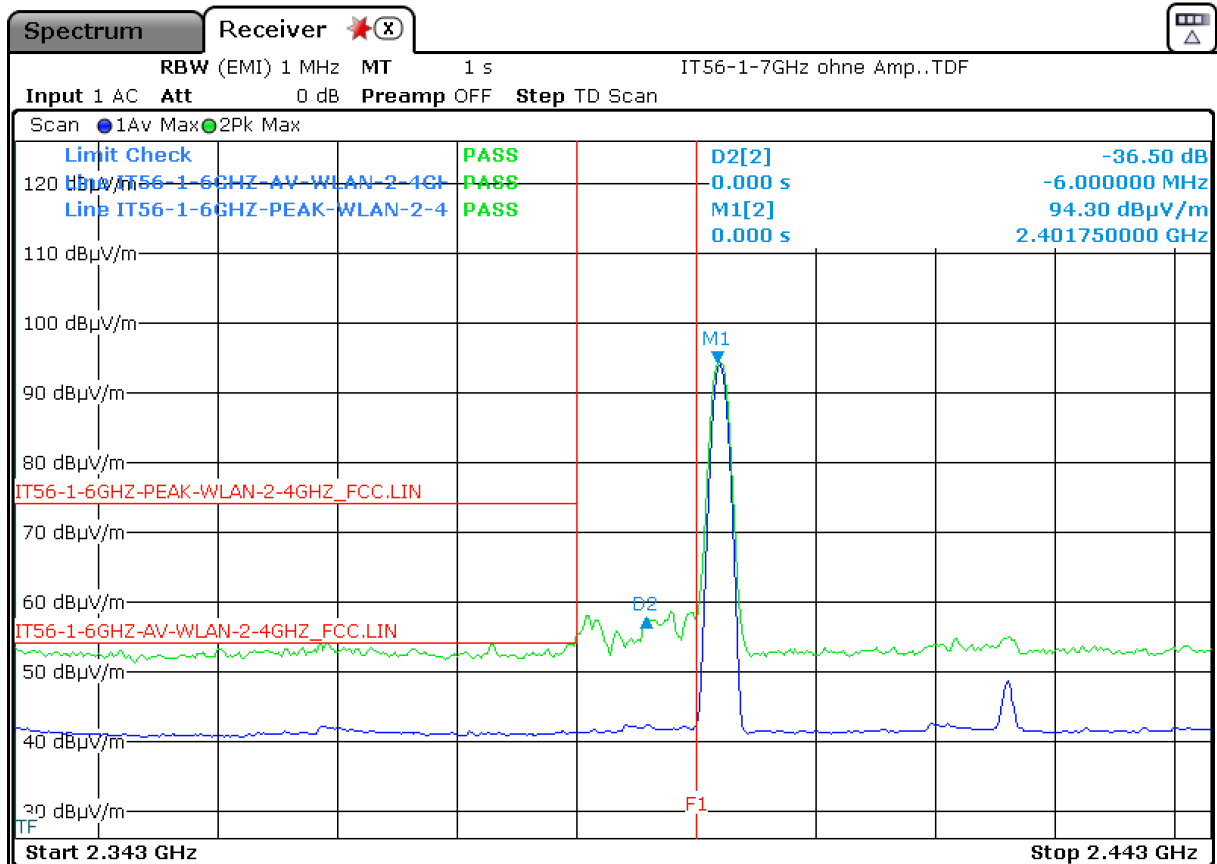
30 dBμV/m

Start 2.433 GHz Stop 2.533 GHz

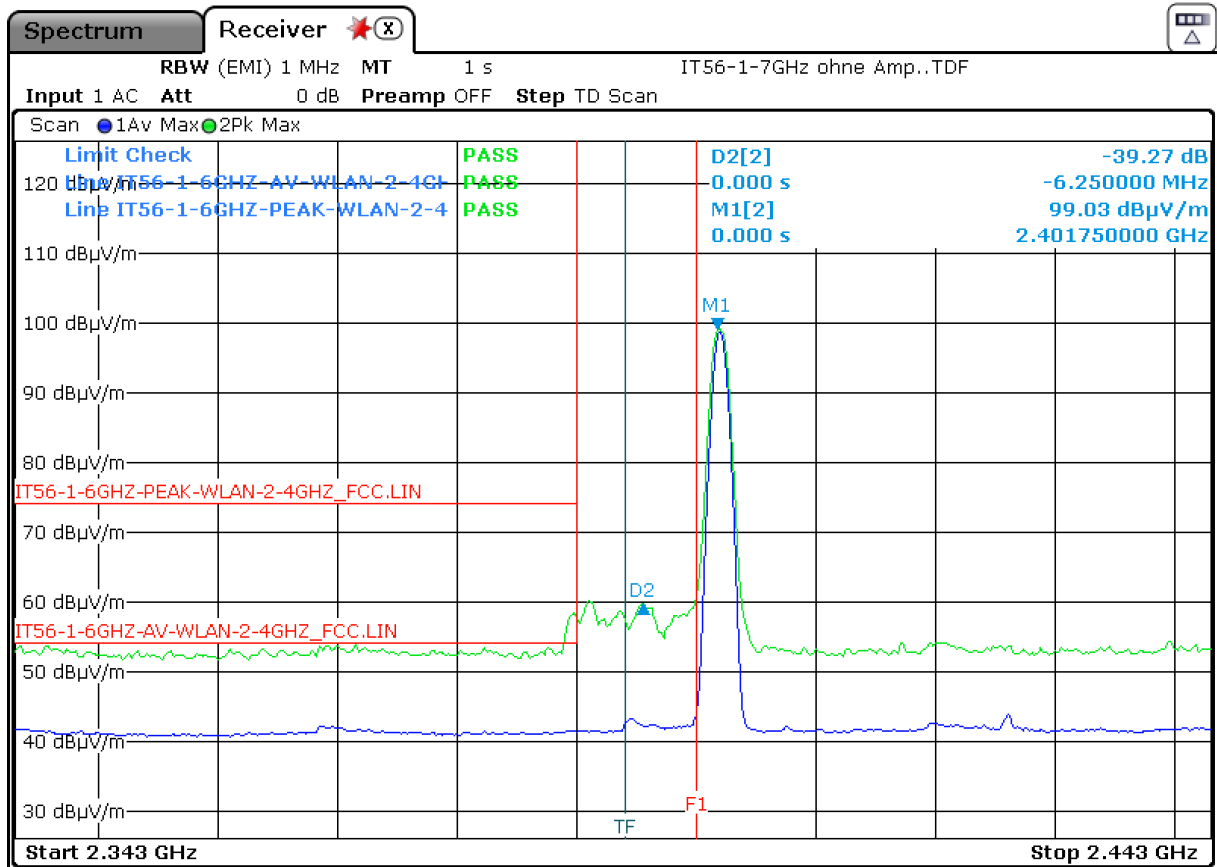
TF

[illegible]

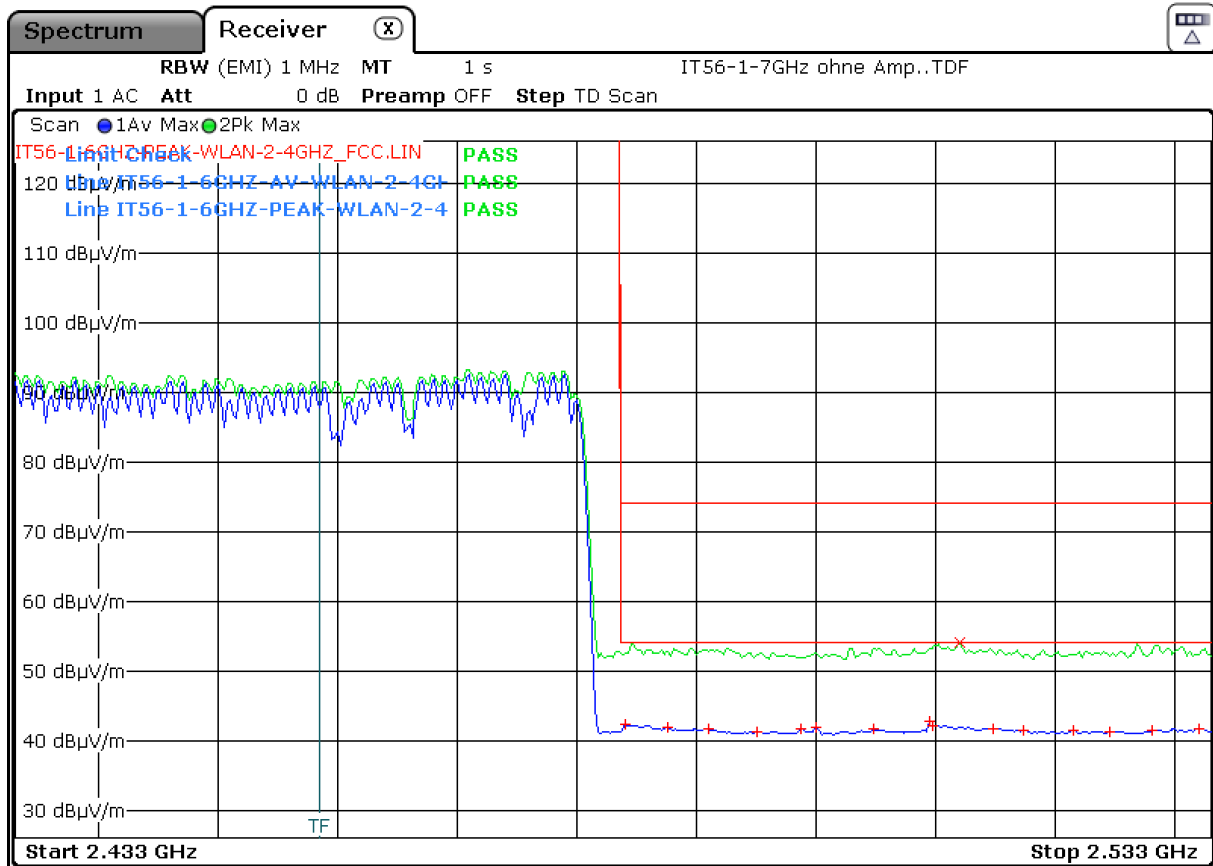
Operation mode: BT 8DPSK; CH.0; Power max.; Low edge
Simultaneous Transmission with 5GHz con.to Active Speaker

[illegible]

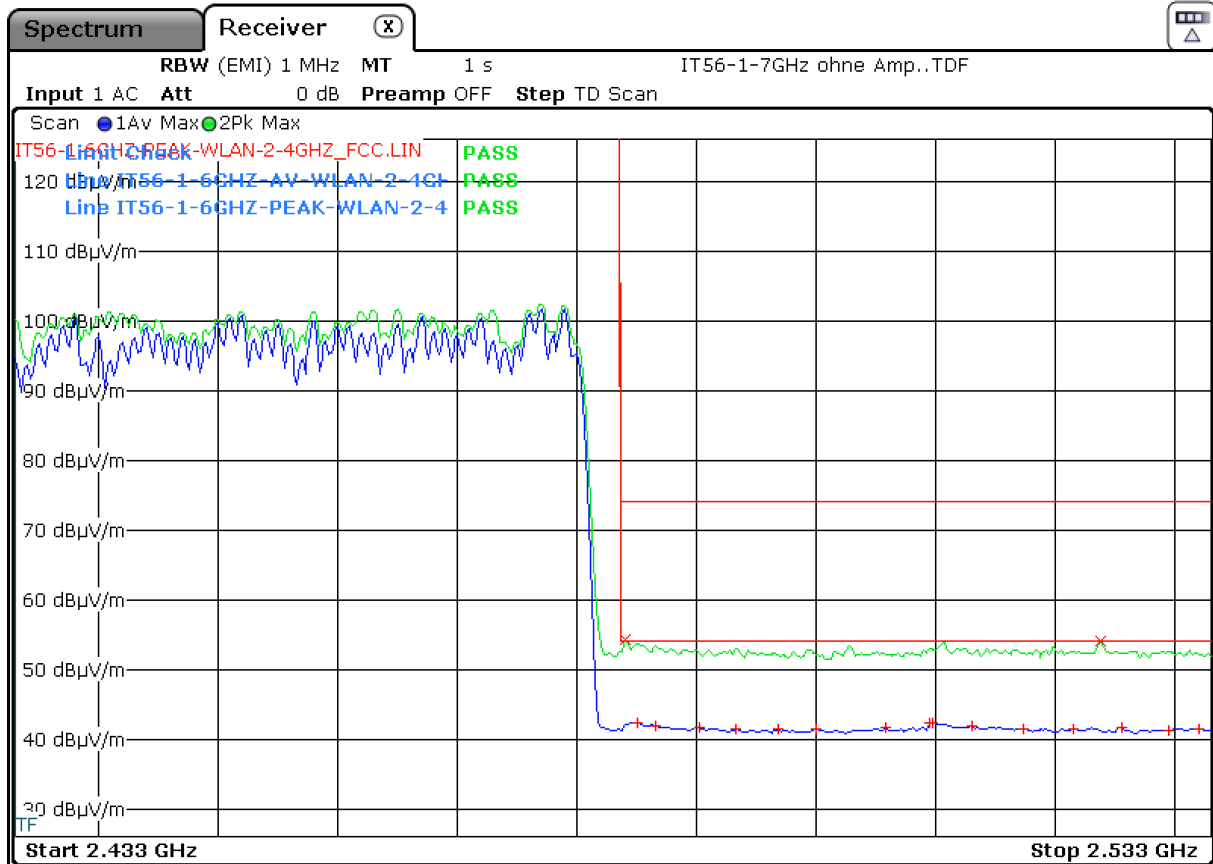
Operation mode: BT 8DPSK; CH.0; Power max.; Low edge
Simultaneous Transmission with 5GHz con.to Active Speaker

[illegible]

Operation mode: BT; GFSK Hopping; Power max.; High edge

[illegible]

Operation mode: BT; GFSK Hopping; Power max.; High edge

[illegible]

Spectrum **Receiver**  

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

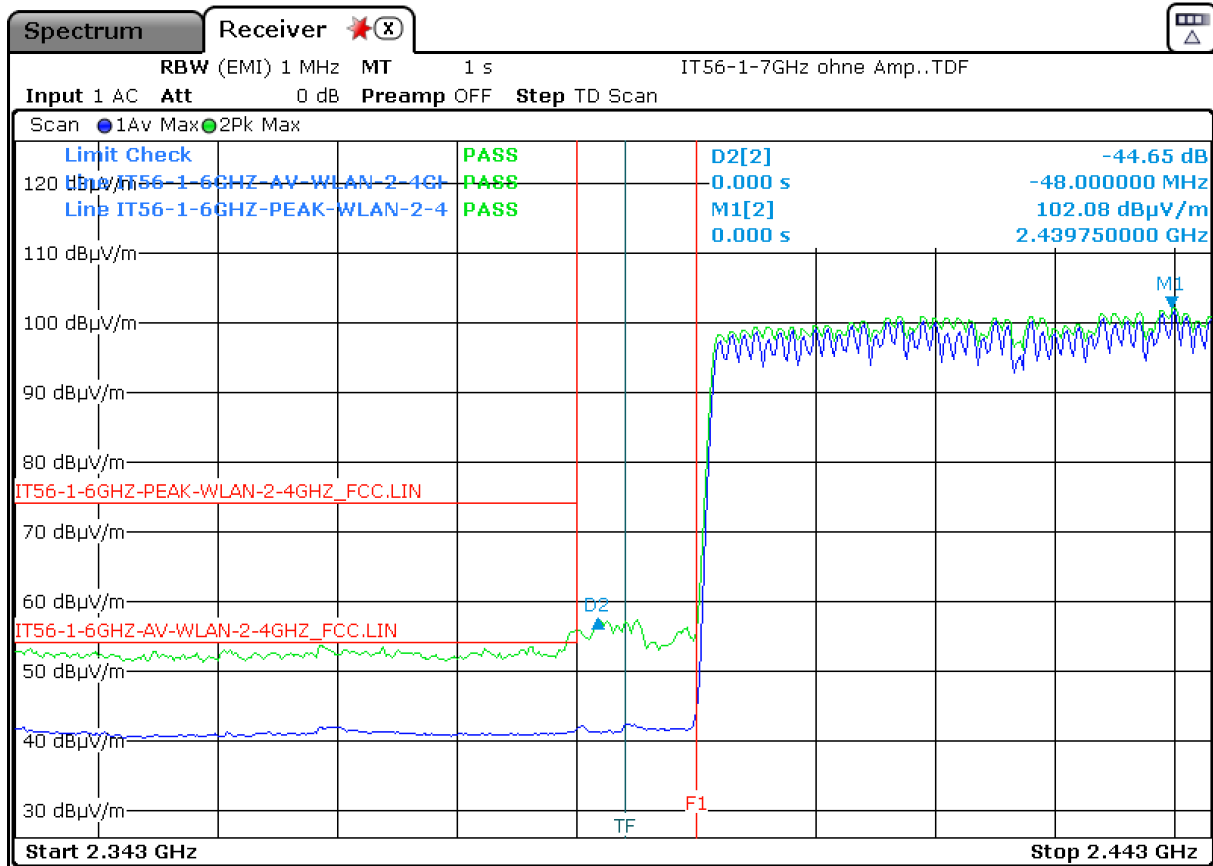
Scan  1Av Max  2Pk Max

Limit Check	Result	M1[2]	Value
120 dBµV/m IT56-1-6GHZ-AV-WLAN-2-4G	PASS	0.000 s	94.96 dBµV/m
Line IT56-1-6GHZ-PEAK-WLAN-2-4	PASS	D2[2]	2.428750000 GHz
		0.000 s	-37.19 dB
			-33.750000 MHz

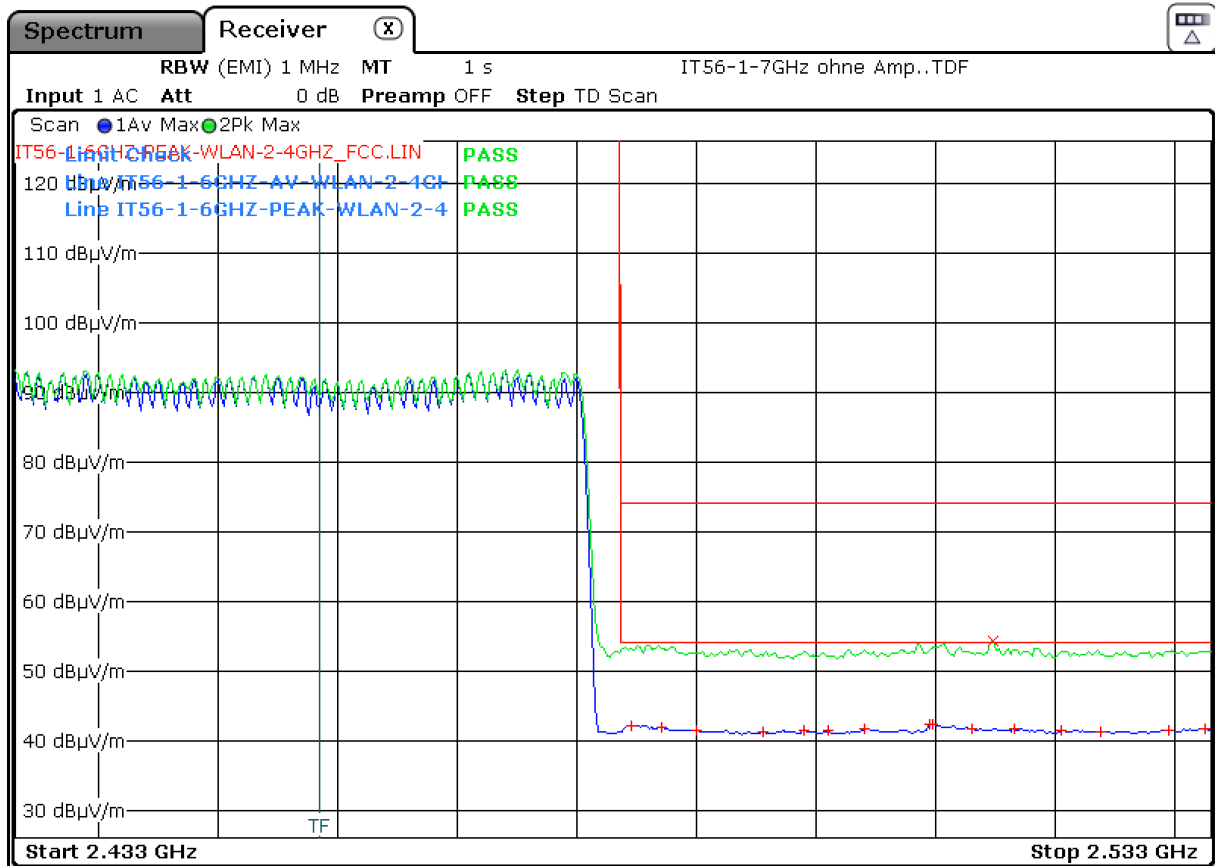
Start 2.343 GHz Stop 2.443 GHz

[illegible]

Operation mode: BT; GFSK Hopping; Power max.; Low edge

[illegible]

Operation mode: BT; $\pi/4$ DQPSK Hopping; Power max.; High edge

[illegible]

Spectrum **Receiver** (X) 🔋

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp.,TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan ● 1Av Max ● 2Pk Max

IT56-1-6GHZ-PEAK-WLAN-2-4GHZ_FCC.LIN PASS

120 dBμV/m IT56-1-6GHZ-AV-WLAN-2-4GHz PASS

Line IT56-1-6GHZ-PEAK-WLAN-2-4 PASS

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

30 dBμV/m

TF

Start 2.433 GHz Stop 2.533 GHz

[illegible]

Spectrum **Receiver**  

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan  1Av Max  2Pk Max

Limit Check

120 dBµV/m IT56-1-6GHZ-AV-WLAN-2-4G PASS

Line IT56-1-6GHZ-PEAK-WLAN-2-4 PASS

110 dBµV/m

100 dBµV/m

90 dBµV/m

80 dBµV/m

70 dBµV/m IT56-1-6GHZ-PEAK-WLAN-2-4GHZ_FCC.LIN

60 dBµV/m

50 dBµV/m IT56-1-6GHZ-AV-WLAN-2-4GHZ_FCC.LIN

40 dBµV/m

30 dBµV/m

D2

TF

F1

D2[2] -34.87 dB
0.000 s

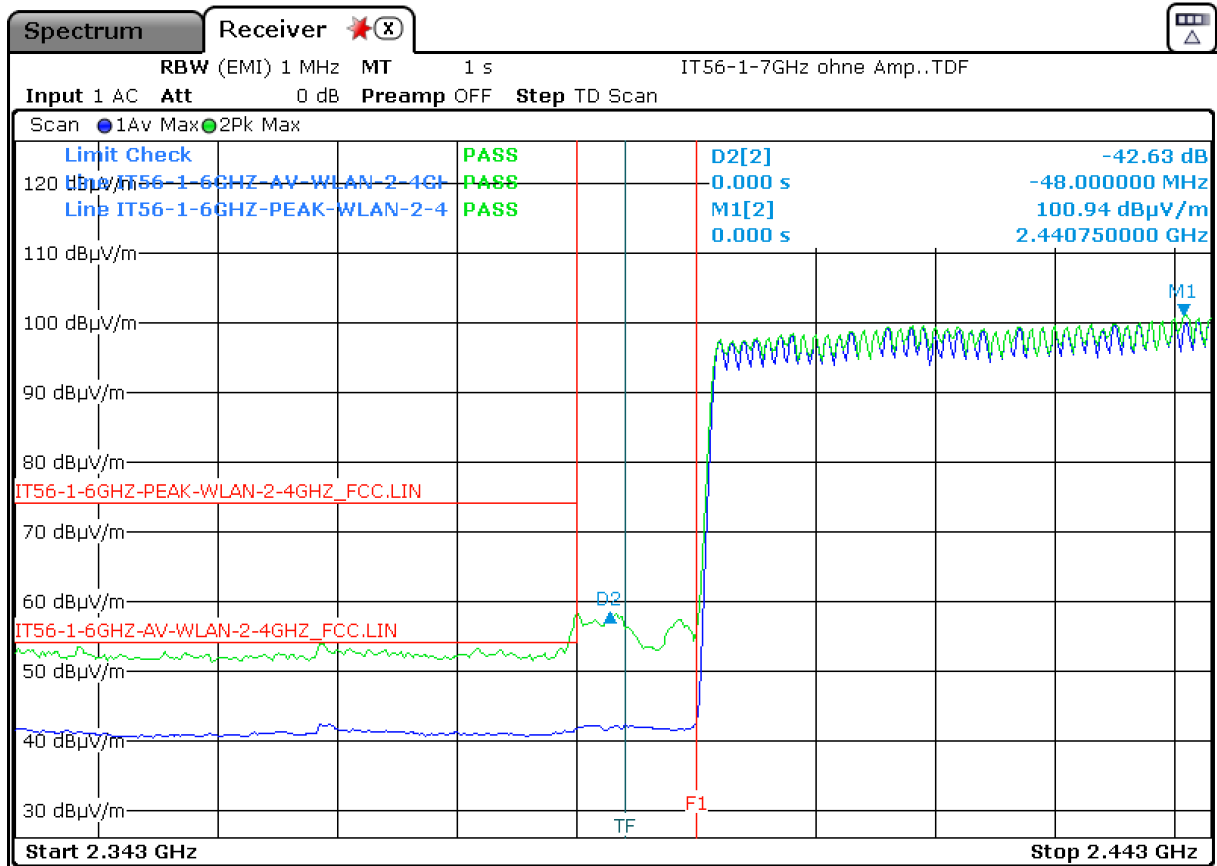
M1[2] -49.500000 MHz
93.81 dBµV/m
0.000 s
2.441000000 GHz

M1

Start 2.343 GHz Stop 2.443 GHz

[illegible]

Operation mode: BT; $\pi/4$ QPSK Hopping; Power max.; Low edge

[illegible]

Spectrum **Receiver** (X) 🔋

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp.,TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan ● 1Av Max ● 2Pk Max

Line Check

IT56-1-6GHz-PEAK-WLAN-2-4GHz_FCC.LIN PASS

120 dBμV/m IT56-1-6GHz-AV-WLAN-2-4GHz_FCC.LIN PASS

Line IT56-1-6GHz-PEAK-WLAN-2-4GHz_FCC.LIN PASS

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

30 dBμV/m

TF

Start 2.433 GHz Stop 2.533 GHz

[illegible]

The screenshot displays the Spectrum Analyzer interface with the following details:

- Top Bar:**
 - Spectrum** (selected) and **Receiver** tabs.
 - Buttons: **RBW** (EMI) 1 MHz, **MT** 1 s, **IT56-1-7GHz ohne Amp.,TDF**.
- Input Section:**
 - Input 1 AC**, **Att** 0 dB, **Preamp** OFF, **Step** TD Scan.
- Scan Settings:**
 - Scan** 1A V Max (blue dot), 2Pk Max (green dot).
- Measurement Results:**
 - Line IT56-1-6GHZ-PEAK-WLAN-2-4GHz_FCC.LIN** (red text) **PASS** (green text).
 - Line IT56-1-6GHZ-AV-WLAN-2-4GHz_FCC.LIN** (blue text) **PASS** (green text).
 - Line IT56-1-6GHZ-PEAK-WLAN-2-4GHz_FCC.LIN** (blue text) **PASS** (green text).
- Spectral Plot:**
 - Y-axis: Power spectral density in dBμV/m, ranging from 20 to 110.
 - X-axis: Frequency in GHz, ranging from 2.433 to 2.533.
 - Blue Trace:** Shows a noisy baseline around 100 dBμV/m, dropping sharply to approximately 42 dBμV/m at 2.45 GHz.
 - Green Trace:** Shows a noisy baseline around 100 dBμV/m, dropping sharply to approximately 52 dBμV/m at 2.45 GHz.
 - Red Vertical Line:** A reference line at approximately 2.45 GHz.
 - Red Horizontal Lines:** Two lines indicating power levels: one at approximately 75 dBμV/m and another at approximately 55 dBμV/m.
 - Red 'X' Markers:** Two markers on the red horizontal lines at approximately 2.45 GHz and 2.50 GHz.
 - Blue '+' Markers:** Multiple markers along the blue trace at various frequencies.
- Bottom Bar:**
 - Start 2.433 GHz** and **Stop 2.533 GHz**.

[illegible]

Spectrum **Receiver** ✖

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan ● 1Av Max ● 2Pk Max

Limit Check

120 dBμV/m IT56-1-6GHZ-AV-WLAN-2-4GHz FCC.LIN PASS M1[2] 0.000 s 93.76 dBμV/m

Line IT56-1-6GHZ-PEAK-WLAN-2-4GHz FCC.LIN PASS D2[2] 0.000 s 2.429000000 GHz

110 dBμV/m

100 dBμV/m

90 dBμV/m M1

80 dBμV/m

IT56-1-6GHZ-PEAK-WLAN-2-4GHz_FCC.LIN

70 dBμV/m

60 dBμV/m D2

IT56-1-6GHZ-AV-WLAN-2-4GHz_FCC.LIN

50 dBμV/m

40 dBμV/m

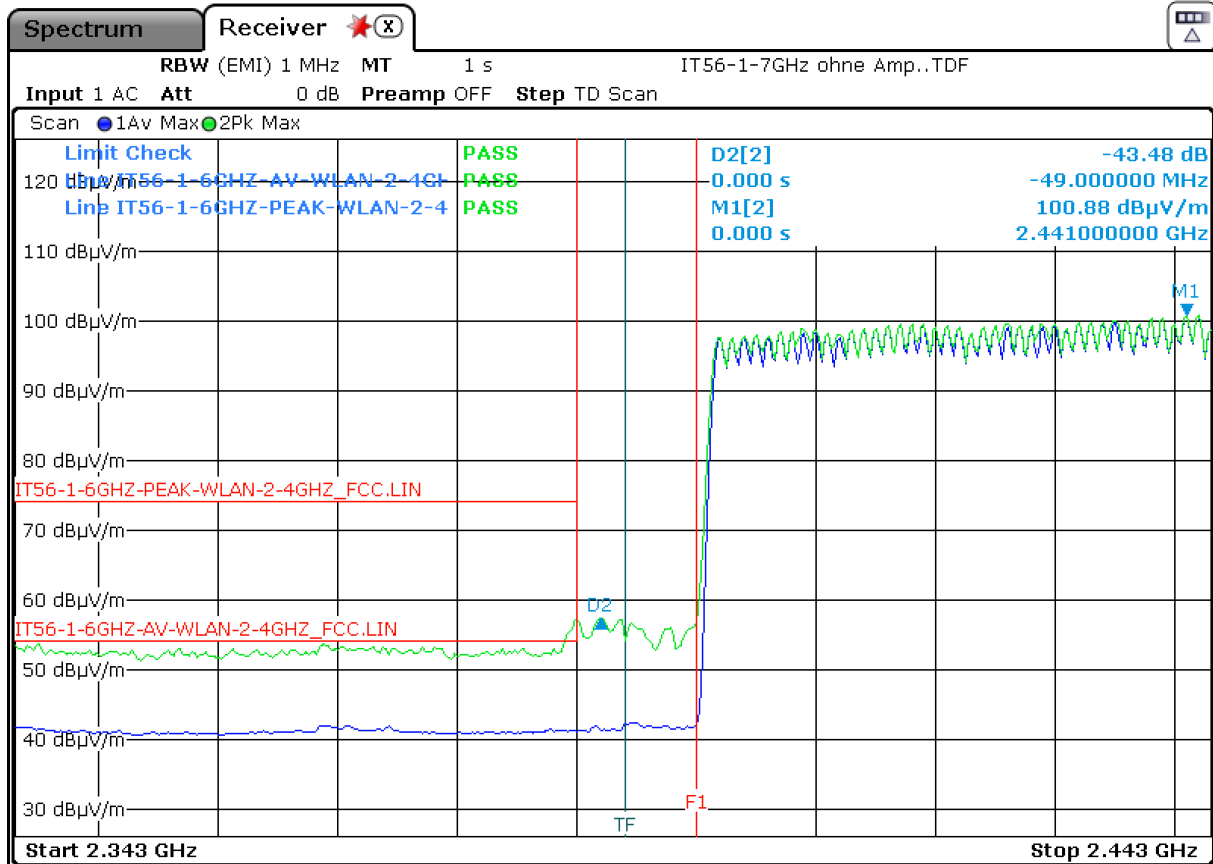
30 dBμV/m

TF F1

Start 2.343 GHz Stop 2.443 GHz

[illegible]

Operation mode: BT; 8DPSK Hopping; Power max.; Low edge

[illegible]

Spectrum **Receiver** (X) ⋮ ⏴

RBW (EMI) 1 MHz MT 1 s IT56-1-7GHz ohne Amp..TDF

Input 1 AC Att 0 dB Preamp OFF Step TD Scan

Scan ● 1Av Max ● 2Pk Max

Line IT56-1-6GHZ-PEAK-WLAN-2-4GHZ_FCC.LIN PASS

Line IT56-1-6GHZ-AV-WLAN-2-4GHZ PASS

Line IT56-1-6GHZ-PEAK-WLAN-2-4 PASS

120 dBμV/m

110 dBμV/m

100 dBμV/m

90 dBμV/m

80 dBμV/m

70 dBμV/m

60 dBμV/m

50 dBμV/m

40 dBμV/m

30 dBμV/m

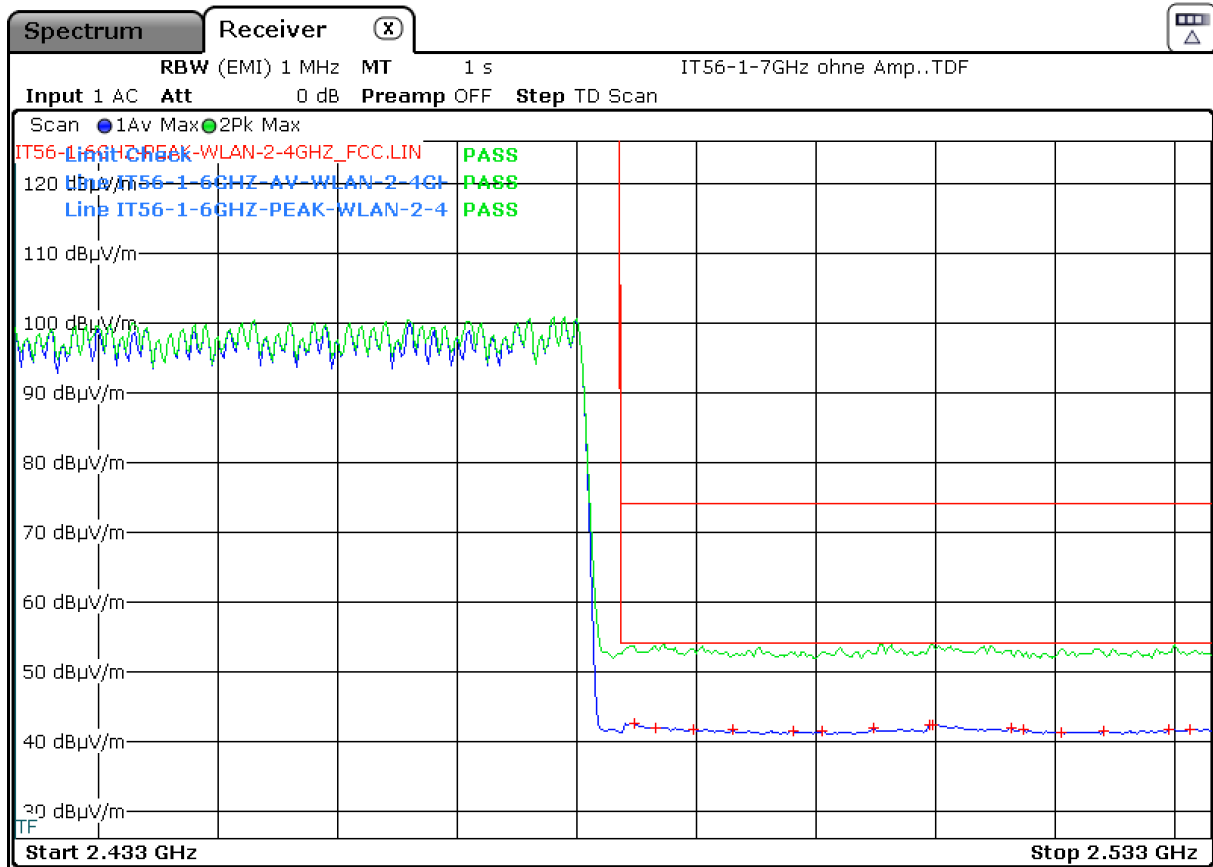
TF

Start 2.433 GHz Stop 2.533 GHz

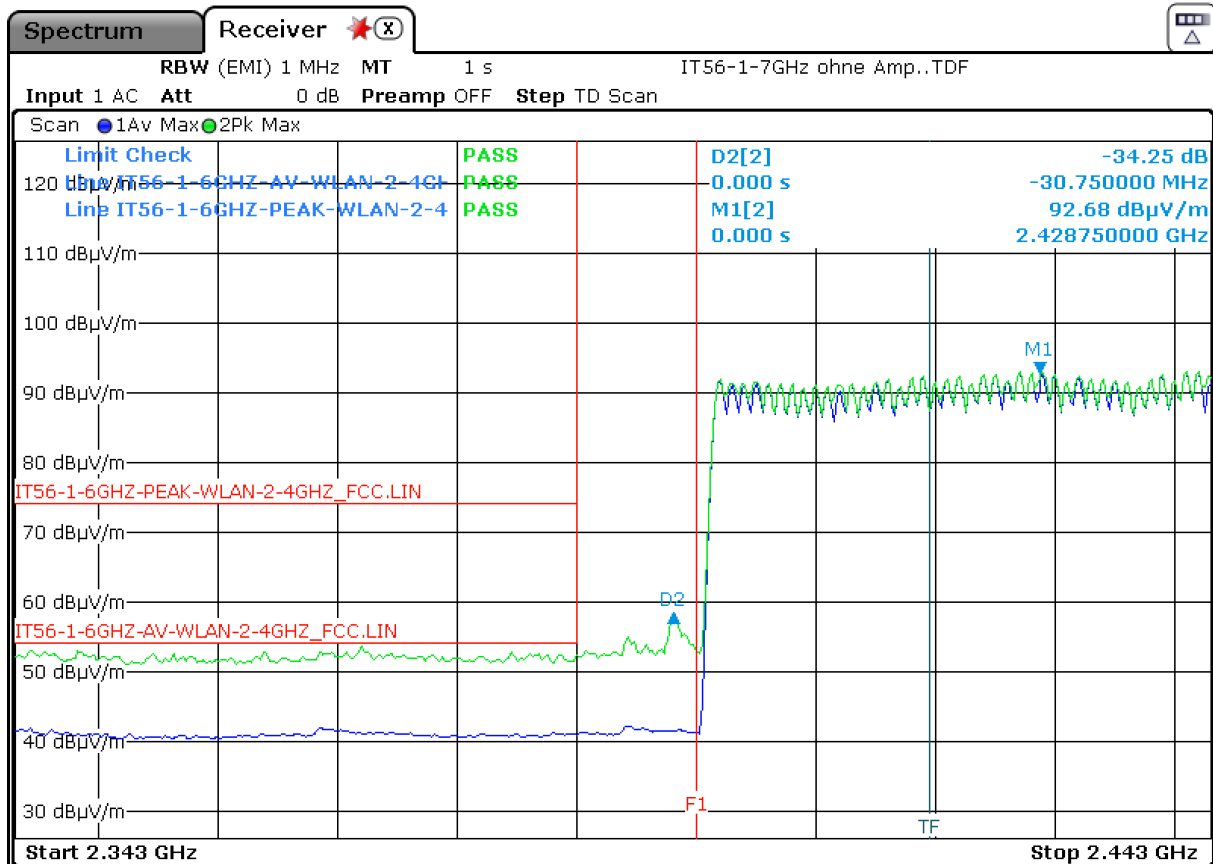
Frequency (GHz)	Green Trace (dBμV/m)	Blue Trace (dBμV/m)	Red Limit (dBμV/m)
2.433	~85	~85	~75
2.457	~85	~40	~55
2.533	~85	~40	~55

[illegible]

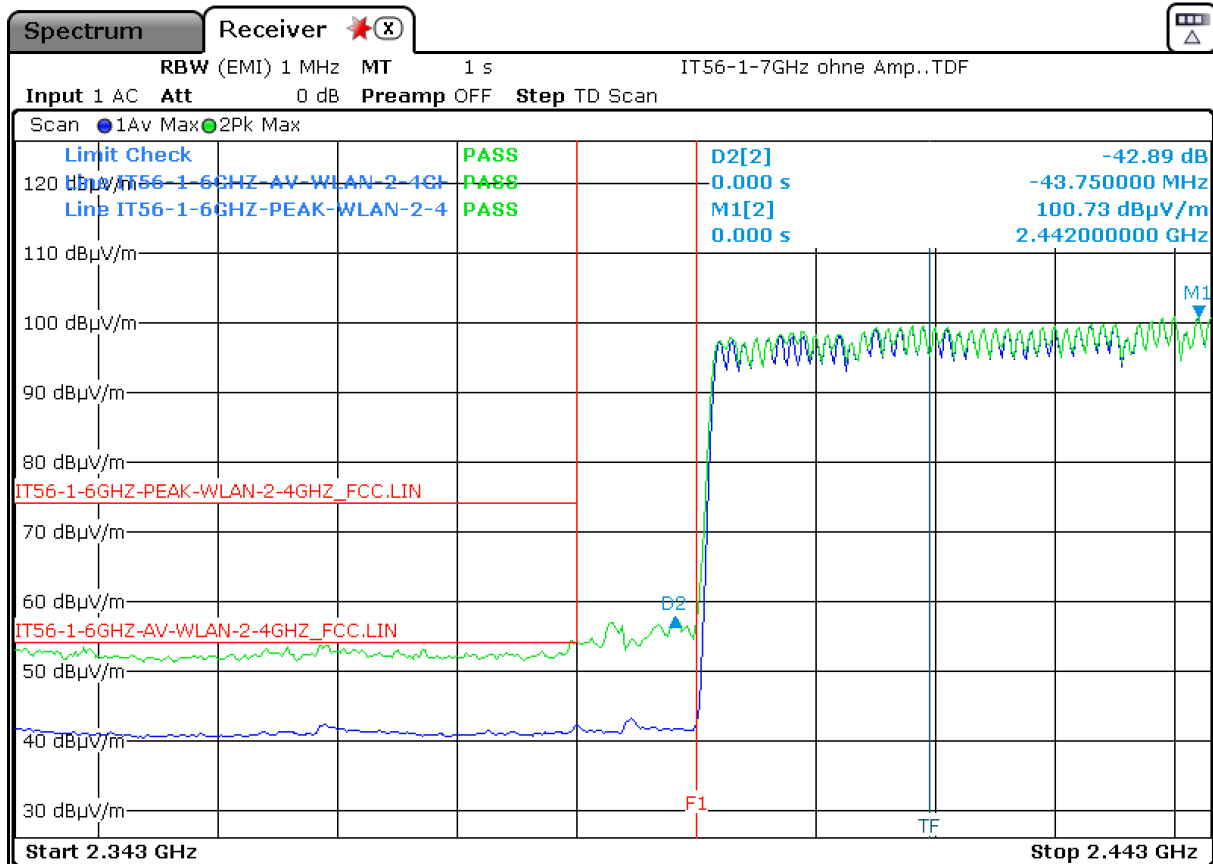
Operation mode: BT 8DPSK Hopping; Power max.; High edge
Simultaneous Transmission with 5GHz con.to Active Speaker

[illegible]

Operation mode: BT 8DPSK Hopping; Power max.; Low edge
Simultaneous Transmission with 5GHz con.to Active Speaker

[illegible]

Operation mode: BT 8DPSK Hopping; Power max.; Low edge
Simultaneous Transmission with 5GHz con.to Active Speaker



Polarisation: H									
Detector Average					Detector Peak				
Frequ. [GHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]	Result	Frequ. [GHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]	Result
all emissions are 10dB below limit				pass	all emissions are 10dB below limit				pass

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **Band Edges / Out of Band Emission**.