Test report

according to ISO/IEC 17025:2017

FCC
(Federal Communications Commission)
Test Firm Registration Number: 768032
Designation Number DE0022

ISED
(Inovation, Science and Economic Development)
CAB identifier: DE0012
ISED#: 6155A

Electromagnetic compatibility

Intentional Radiators

ilac-MRA

DAkkS Deutsche Akkreditierungsstelle
D-PL-17379-01-00
D-PL-17379-01-02
D-PL-17379-01-03

Bundesnetzagentur
BNetzA-CAB-18/21-19

TESTED IN GERMANY

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Test report no.: **20/01-0031**

Table of contents

Location of test facility:

STC Germany GmbH
Ohmstrasse 1
84160 Frontenhausen
Germany

1. Client information

Name:	**Vestel Elektronik Sanayi ve Ticaret A.Ş.**
Address:	**Organize Sanayi Bolgesi 45030, Yunusemre/MANISA/Turkey**
Name of contact:	Mr. Andac Pamuk
Telephone:	+90 236 2332582
Fax:	+90 236 2332584
E-mail:	Andac.pamuk@vestel.com.tr

2. Equipment under test (EUT)

2.1 Identification of the EUT

Equipment:	WIFI+BT Combo Module
Model:	17WFM25
Brand name:	-/-
Serial no.:	-/-
Manufacturer:	Vestel Elektronik San ve Tic. A.S., Organize Sanayi Bölgesi, Vestel City, High-End, 45030 MANISA, TURKEY
Country of origin:	TURKEY
Power rating:	4.75 V – 5.25 V nominal 5 V ⎓ via USB
Highest frequency generated or used in the device or on which the device operates or tunes (MHz):	5.825
Date Sample Received:	16.01.2020
Tests were performed:	03.03.2020 – 18.06.2020

2.2 Additional information about the EUT:

The EUT can also operate simultaneously as 2.4 GHz or 5 GHz Wifi module.
The 2.4 GHz / 5 GHz is not documented in this Report.

3. Description of the Equipment under test and test conditions

FCC-ID:	2AVQS-17WFM25		
IC:	25888-17WFM25		
HVIN:	080419R4		
Firmware version:	V0.5.0.0, Wi-Fi Component: V1.1.0		
Software to control EUT:	Media Tek BT Tool (Version: W1746)		
Power:	4.75 V – 5.25 V nominal 5 V ⎓ via USB		
Cables:	USB cable 100 cm Cable to test adaptor 30 cm		
Approx. Size (l x w x h):	(70 x 25 x 4.5) mm		
Test conditions:	The "WIFI+BT Combo Module – 17WFM25" (= equipment under test – EUT) had been tested, where applicable with test software Media Tek BT Tool and with maximal RF-output in the following modes: (1) Bluetooth 5.0: Tx mode GFSK 2402.0 MHz (2) Bluetooth 5.0: Tx mode GFSK 2441.0 MHz (3) Bluetooth 5.0: Tx mode GFSK 2480.0 MHz (4) Bluetooth 5.0: Tx mode π/4-DQPSK 2402.0 MHz (5) Bluetooth 5.0: Tx mode π/4-DQPSK 2441.0 MHz (6) Bluetooth 5.0: Tx mode π/4-DQPSK 2480.0 MHz (7) Bluetooth 5.0: Tx mode 8DPSK 2402.0 MHz (8) Bluetooth 5.0: Tx mode 8DPSK 2441.0 MHz (9) Bluetooth 5.0: Tx mode 8DPSK 2480.0 MHz (10) Bluetooth 5.0: Tx mode 8DPSK Hopping Mode The tested configuration represents (based on the product specification) with the tested operation modes the worst case.		
RF Module Model Number:	17WFM25		
Frequency range:	2.400 GHz – 2.483,5 GHz		
Operating frequencies:	2.402 GHz – 2.480 GHz		
Module Tranmission Type:	Bluetooth 5.0 (FHSS)		
Modulation:	GFSK	π/4-DQPSK	8DPSK
Data Rates:	1 MBit/s	2 MBit/s	3 MBit/s
Channel separation:	1 MHz	1 MHz	1 MHz
Number of channels:	79	79	79
Spurious Emissions: radiated lowest margin to limit	50.68 dBµV/m @ 3 m	50.68 dBµV/m @ 3 m	50.68 dBµV/m @ 3 m
Environmental conditions during tests:	Ambient temperature: 20 °C Relative humitity 40 % Atmospheric pressure 965 mbar		
Antenna specification:	Model: Printed PCB Antenna Gain: max. 0.29 dBi Type: ☐ External (with accessible antenna socket) ☒ Internal (integrated, PCB antenna)		
Test standard:	- e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz - RSS-247 issue 02 February 2017 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices		

Channel List

Bluetooth 5.0

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	42	2444
1	2403	43	2445
2	2404	44	2446
3	2405	45	2447
4	2406	46	2448
5	2407	47	2449
6	2408	48	2450
7	2409	…	…
8	2410	70	2472
9	2411	71	2473
…	…	72	2474
36	2438	73	2475
37	2439	74	2476
38	2440	75	2477
39	2441	76	2478
40	2442	77	2479
41	2443	78	2480

4. Performed measurements and results

The complete list of measurements required in e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 is given below.

Standard:	**Standard:**	**Test Method:**		**Test requirements:**			
				applicable:		**fulfilled:**	
				yes	**no**	**yes**	**no**
§ 15.207	RSS-Gen issue 5	ANSI 63.10 Section 6.2	AC Mains Conducted Emissions	☒	☐	☒	☐
§ 15.209	RSS-Gen issue 5	ANSI 63.10 Section 6.3 - 6.6	Radiated Emissions	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.7	20 dB Bandwidth	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.5	Output Power of Fundamental Emissions	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.3	Number of Operating Channel	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.2	Carrier Frequency Separation	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.6	Band Edges Measurement	☒	☐	☒	☐
§15.247	RSS-247 issue 2	ANSI 63.10 Section 7.8.4	Occupancy Time (Dwell time)	☒	☐	☒	☐
	RSS-Gen issue 5	ANSI 63.10 Section 6.9.3	99% Power Bandwidth	☒	☐	☒	☐

All required / applicable tests according to the following standards were performed under Ref-No. 20/01-0031.

- e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C §15.247 with test Method according to ANSI C63.10-2013

-RSS-247 issue 02 February 2017 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

- e-CFR data is current as of June 23, 2020

Remark: -/-

5. Antenna requirement

Applied standards
-e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart B, § 15.203 Conducted limits

Test conditions and configuration of EUT
The EUT was configured and operated with conditions as mentioned under “Test conditions” in clause 3 above.
Module has on board printed antennas with the given gain values below.

Onboard PCB Antennas Ant 0 + Ant 1

Oboard Antennas:

Antenna	Type	Gain (2.4 GHz) (dBi)
PCB Onboard	Ant 0	3.4
PCB Onboard	Ant 1	2.12

Requirements:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

Usage with PCB antennas There is no external antenna, the antenna gain max =3.4dBi
User is unable to remove or change the Antenna

6. AC Mains conducted emissions

Applied standards
-e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C, § 15.207 Conducted limits
-RSS-Gen issue 05 section 8.8

Test site
Measurements of conducted emission from EUT was made in the shielded chamber (DC - 10GHz) located in the test facility.

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

Detector function selection and bandwidth
In conducted emissions measurement CISPR quasi-peak- and average-detector were used.
The bandwidth of the detector of instrument is 10 kHz over the frequency range of 150 kHz to 30 MHz.

Frequency range to be scanned
For conducted emission measurements, the spectrum in the range of 150 kHz to 30 MHz was investigated.

Test conditions and configuration of EUT
The EUT was configured and operated with conditions as mentioned und “Test conditions” in clause 3 of this report.

All modes are investigated by operating the EUT in a range of typical modes of operation, with typical cable positions, and with a typical system equipment configuration and arrangement. For each mode of operation and for each ac power current-carrying conductor, cable manipulation are performed within the range of likely configurations. The highest values measured are shown in the table below. The corresponding configuration is shown in the “Photo(s) of test setup”.
The EUT was placed on a 80 cm high non metallic table. Measurements were performed on the AC terminals of the Host AC-Adaptor (Laptop), on neutral (N)- and live (L1)-wire had been performed.

Requirements

Frequency Range [MHz]	Quasi-Peak Limits [dBµV]	Average Limits [dBµV]
0.15 - 0.5	66 to 56 Note 1	56 to 46 Note 1
0.5 - 5.0	56	46
5.0 - 30.0	60	50
Note 1: The level decreases linearly with the logarithm of the frequency		

Measurement

Measruement performed on 17.03.2020

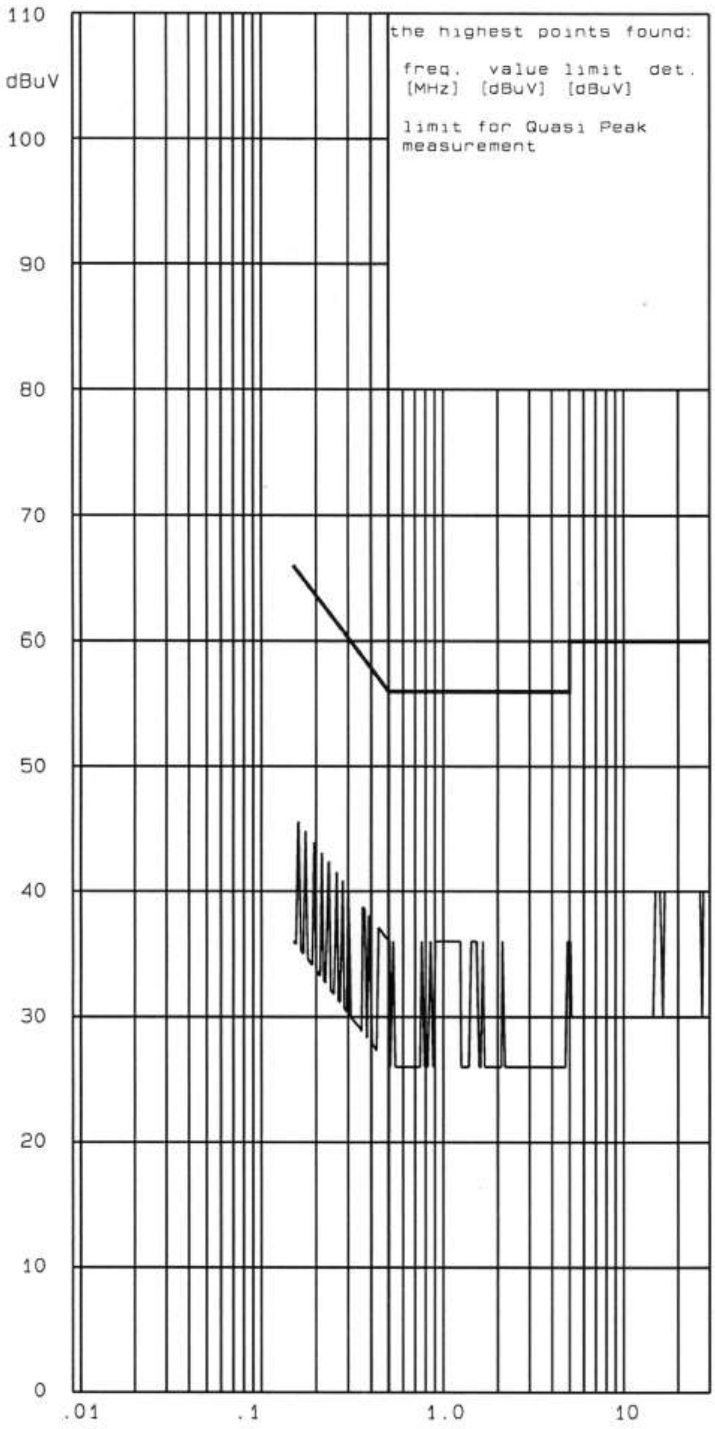
As worst cases the mode No.: 10 with Transmitting 8DPSK in hopping mode was found and documented in this report.

I T 1 / 2

Interference Voltage 150 KHz - 30 MHz

acc. FCC Part 15.207 / RSS-Gen

Cabin 1



Ref.-No.: 20/01-0031

Product: Trans.-/Rec.-System

Sample: 02

Date: 17 Mar 2020

Operator: bl

Test equipment:

Rohde & Schwarz ESHS 30

Rohde & Schwarz ESH 2-Z5

Connected sets:

Host PC (stc)

Operating mode:

Tx BT
8DPSK
Hopping Mode
Tested on L1

RFI suppression parts:

* two dB safety margin for type approval recommended

Result: pass [X] fail [ ]

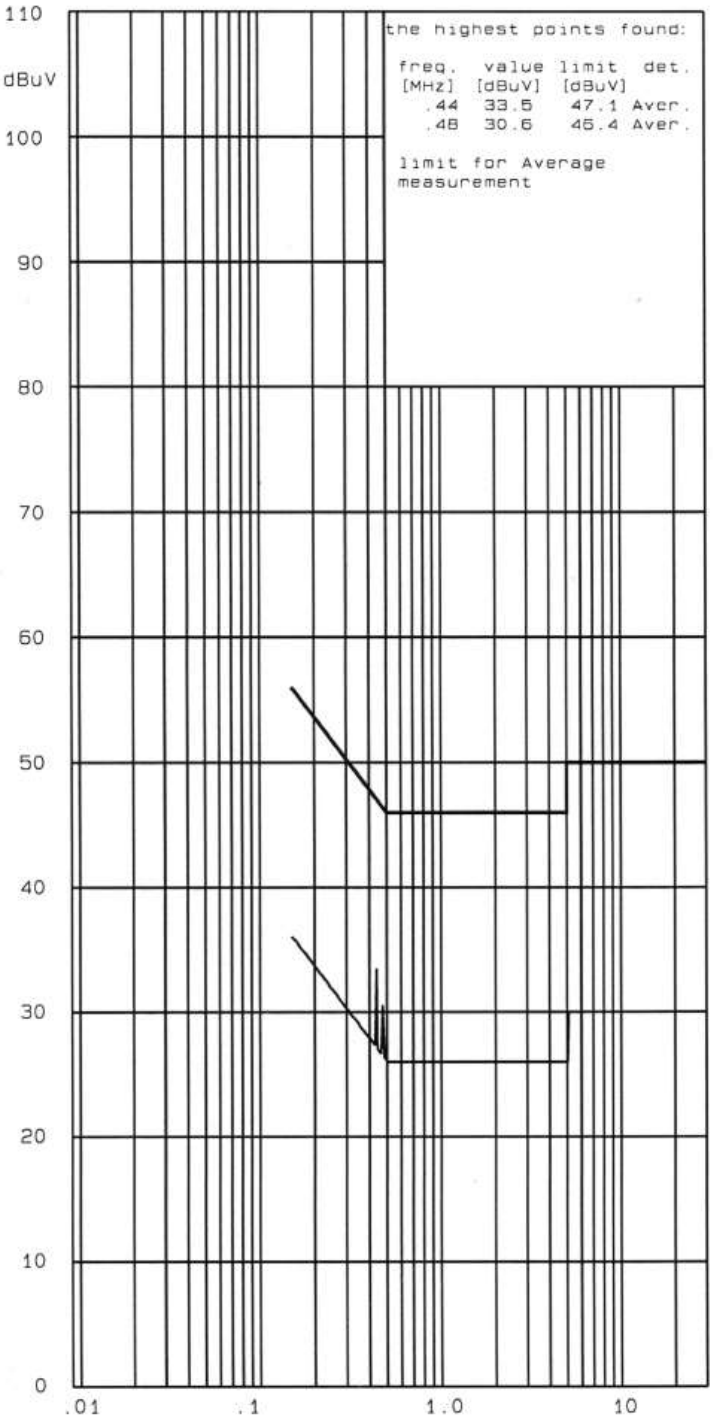
STC Germany GmbH

I T 1 / 2

Interference Voltage 150 KHz - 30 MHz

acc. FCC Part 15.207 / RSS-Gen

Cabin 1



Ref.-No.: 20/01-0031

Product: Trans.-/Rec.-System

Sample: 02

Date: 17 Mar 2020

Operator: bl

Test equipment:

Rohde & Schwarz ESHS 30

Rohde & Schwarz ESH 2-Z5

Connected sets:

Host PC (stc)

Operating mode:

Tx BT
8DPSK
Hopping Mode
Tested on L1

RFI suppression parts:

* two dB safety margin for type approval recommended

Result: pass [X] fail [ ]

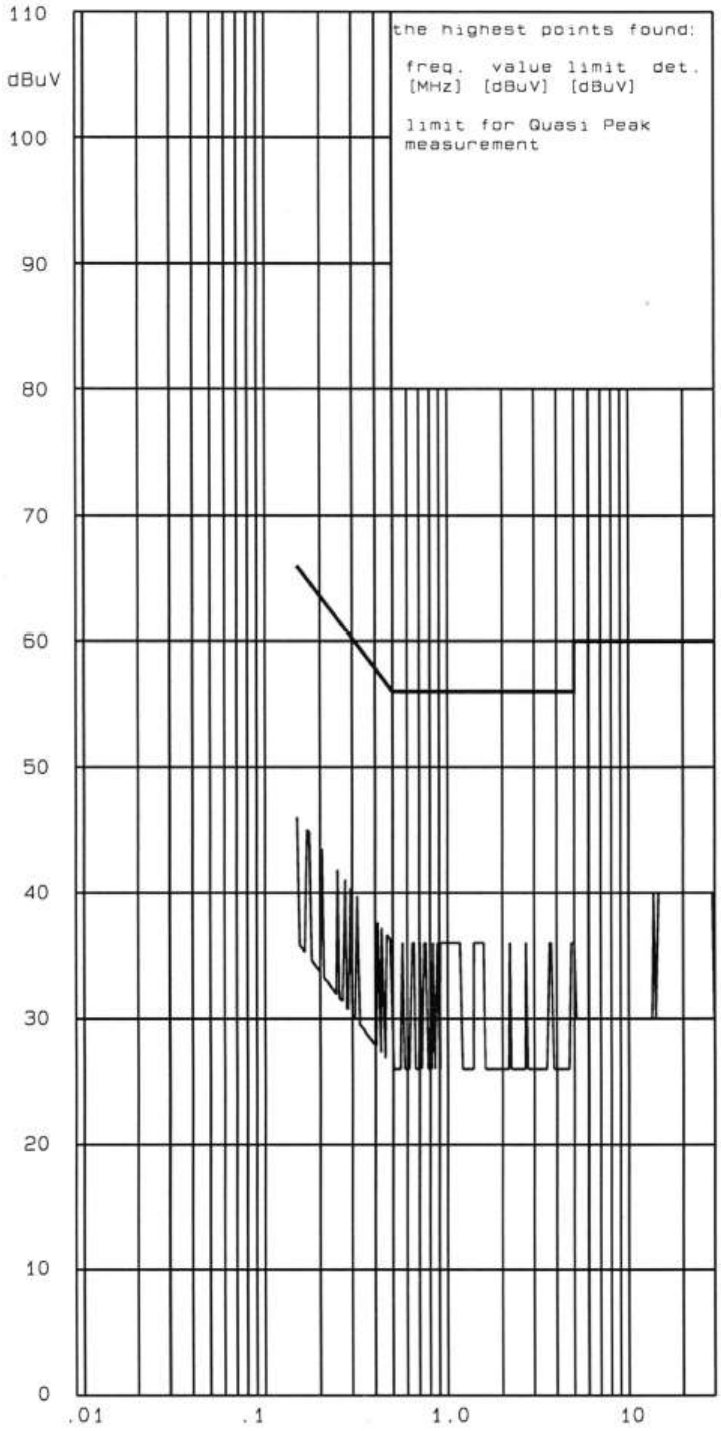
STC Germany GmbH

I T 1 / 2

Interference Voltage 150 KHz - 30 MHz

acc. FCC Part 15.207 / RSS-Gen

Cabin 1



Ref.-No.: 20/01-0031

Product: Trans.-/Rec.-System

Sample: 02

Date: 17 Mar 2020

Operator: bl

Test equipment:

Rohde & Schwarz ESHS 30

Rohde & Schwarz ESH 2-Z5

Connected sets:

Host PC (stc)

Operating mode:

Tx BT
8DPSK
Hopping Mode
Tested on N

RFI suppression parts:

* two dB safety margin for type approval recommended

Result: pass [X] fail [ ]

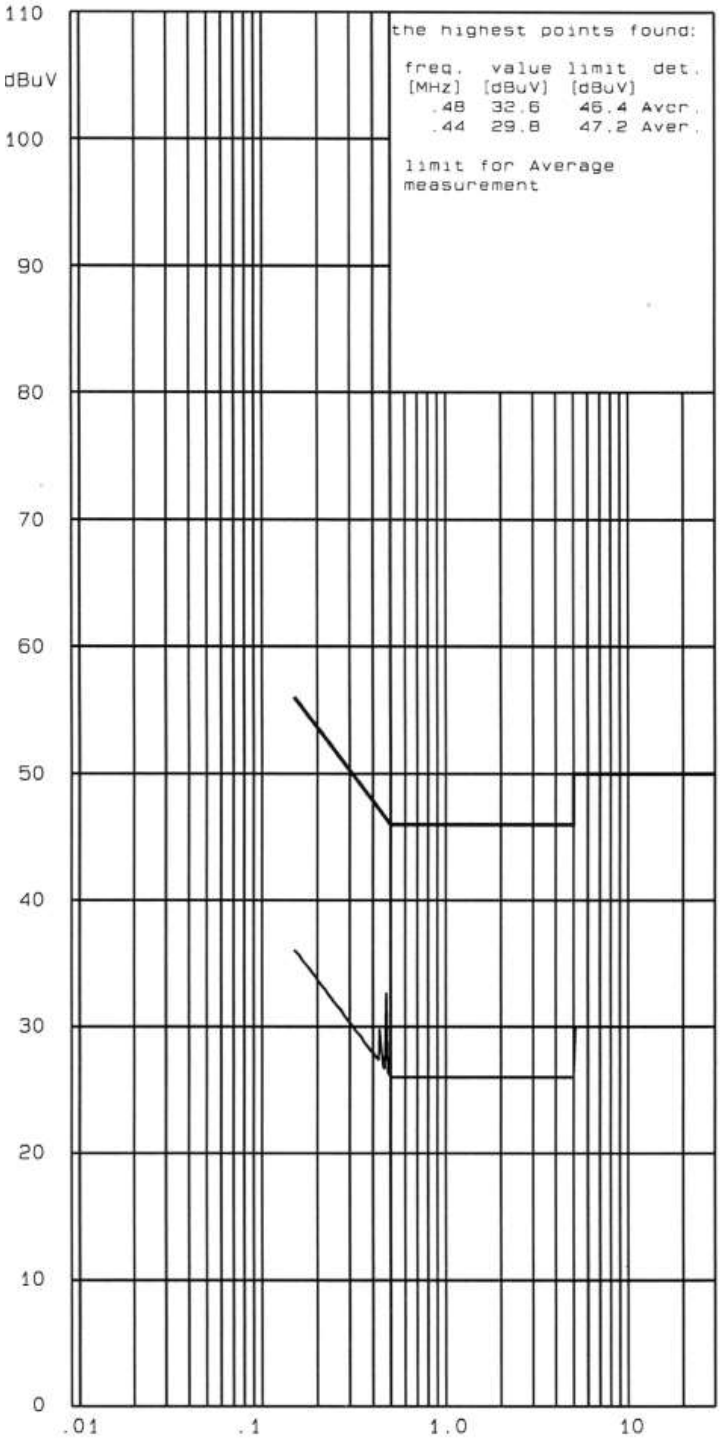
STC Germany GmbH

I T 1 / 2

Interference Voltage 150 KHz - 30 MHz

acc. FCC Part 15.207 / RSS-Gen

Cabin 1



Ref.-No.: 20/01-0031

Product: Trans.-/Rec.-System

Sample: 02

Date: 17 Mar 2020

Operator: bl

Test equipment:

Rohde & Schwarz ESHS 30

Rohde & Schwarz ESH 2-Z5

Connected sets:

Host PC (stc)

Operating mode:

Tx BT
8DPSK
Hopping Mode
Tested on N

RFI suppression parts:

* two dB safety margin for type approval recommended

Result: pass [X] fail [ ]

STC Germany GmbH

Remarks:
Composition of the measurement value:

$$\mathbf{M_{Value} = M_{Rec} + C_{Loss} + LISN_{cor}}$$

M_{Value} = Measurement Value
M_{Rec} = Reading value of test receiver
C_{Loss} = Cable loss between Receiver and LISN
$LISN_{cor}$ = LISN correction factor.

Sample calculation:

40.8 dBµV = 40.1 dBµV + 0.3 dB + 0.4 dB

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **Conducted Emission**.

7. Radiated emission measurements

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

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

Detector function selection and bandwidth
In radiated emissions measurement, an EMI test receiver that have CISPR detectors was used.

Frequency range	Resolution Bandwidth
9KHz – 150kHz (Quasi Peak & Average* Detector)	200Hz
150KHz – 30MHz (Quasi Peak & Average* Detector)	9kHz
30MHz – 1GHz (Quasi Peak Detector)	120kHz
Above 1GHz (Peak & Average Detector)	1MHz

*Average Detector only in specify frequency range.

Antennas
Measurements were made using a calibrated loop antenna in the range 9 kHz – 30 MHz, as well as a calibrated bilog antenna in the range of 30 to 1000 MHz to determine the emission characteristics of the EUT. Measurements were also made for both horizontal and vertical polarization.
The horizontal distance between the receiving antenna and the EUT was 3 meters.
In the range of 1 GHz to 40 GHz measurements were made using a calibrated horn antenna to determine the emission characteristics of the EUT. Measurements were also made for both horizontal and vertical polarization. The horizontal distance between the receiving antenna and the EUT was 3 meters.

Frequency range to be scanned
For radiated emissions measurements, the spectrum in the range of 9 kHz to 40 GHz was investigated as the highest frequency generated in the EUT is 5.825 GHz.

Test conditions and configuration of EUT

The EUT was configured and operated with conditions as mentioned under “Test conditions” in clause 3 above.

During test the EUT was operated as specified in the user manual of the EUT. For frequencies below 1000 MHz the EUT was placed on a 80 cm and for frequencies above 1000 MHz the RF Transmitter modul was placed on a 150 cm high non metallic table placed on the turntable. The EUT was rotated and the antenna height was varied between 1 m to 4 m to find the maximum RF energy generated from EUT. The procedure according to ANSI C63.10:2013 is used and all modes are investigated by operating the EUT in a range of typical modes of operation, with typical cable positions, and with a typical system equipment configuration and arrangement. For each mode of operation, cable manipulation are performed within the range of likely configurations. The highest values measured are shown in the table below.

As worst cases the mode No.: 10 Transmitting 8DPSK in hopping mode was found and documented in this report.

Remarks:
-Correction factor included antenna factor and cable attenuation.
-In the frequency range 1 GHz – 7 GHz the Band Reject Filter 2,4 GHz (ID11243) was used to attenuate the fundamental emission.

Applied standards
-e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C, § 15.209 Radiated emission limits
-RSS-Gen issue 05 section 8.9

Requirements

acc. e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C, § 15.209 Radiated emission limits

Frequency MHz	Limits [µV/m] Quasi-peak	Limits [dBµV/m] Quasi-peak	Limits [µV/m] Average	Limits [dBµV/m] Average	Test distance [m]
0.009 – 0.090	-/-	-/-	2400/F (kHz)	48.5 – 28.5	300
0.090 - 0.110	2400/F (kHz)	28.5 – 26.8	-/-	-/-	300
0.110 – 0.490	-/-	-/-	2400/F (kHz)	26.8 – 13.8	300
0.490 - 1.705	24000/F (kHz)	33.8 – 23.0	-/-	-/-	30
1.705 - 30.0	30	29.5	-/-	-/-	30

acc. RSS-Gen issue 05 section 8.9

Frequency MHz	Limits [µA/m] Quasi-peak	Limits [dBµA/m] Quasi-peak	Limits [µA/m] Average	Limits [dBµA/m] Average	Test distance [m]
0.009 – 0.090	-/-	-/-	6.37/F (kHz)	-3 – -23.0	300
0.090 - 0.110	6.37/F (kHz)	-23.0 – -24.7	-/-	-/-	300
0.110 – 0.490	-/-	-/-	6.37/F (kHz)	-24.7 – -37.7	300
0.490 - 1.705	63.7/F (kHz)	-17.7 – -28.5	-/-	-/-	30
1.705 - 30.0	0.08	-22	-/-	-/-	30

acc. e-CFR Title 47 Chapter I Subchapter A Part 15 Subpart C, § 15.209 Radiated emission limits and RSS-Gen issue 05 section 8.9

Frequency MHz	Limits [µV/m] Quasi-peak	Limits [dBµV/m] Quasi-peak	Limits [µV/m] Average	Limits [dBµV/m] Average	Test distance [m]
30 - 88	100	40	-/-	-/-	3
88 - 216	150	43.5	-/-	-/-	3
216 - 960	200	46	-/-	-/-	3
960 - 1000	500	54	-/-	-/-	3
Above 1000	-/-	-/-	500	54	3

Measurements

The Measurement was performed on: 12.03.2020 and 16.06.2020

Result 9 kHz – 30 MHz

In the frequency range 9 kHz – 30 MHz the EUT had been scanned in a distance of 3 m and
the Limit were corrected to the test distance of 3 m using a factor with 40 dB/decade acc. to § 15.31 (f)(2).

Only the worst case of the X,Y and Z axis measurement is documented in this report.

Result 9 kHz – 30 MHz

Operation Mode No.: 10. Transmitting 8DPSK in Hopping Mode

TESTED IN GERMANY

IT 3/4

Interference radiation (9kHz – 30MHz)

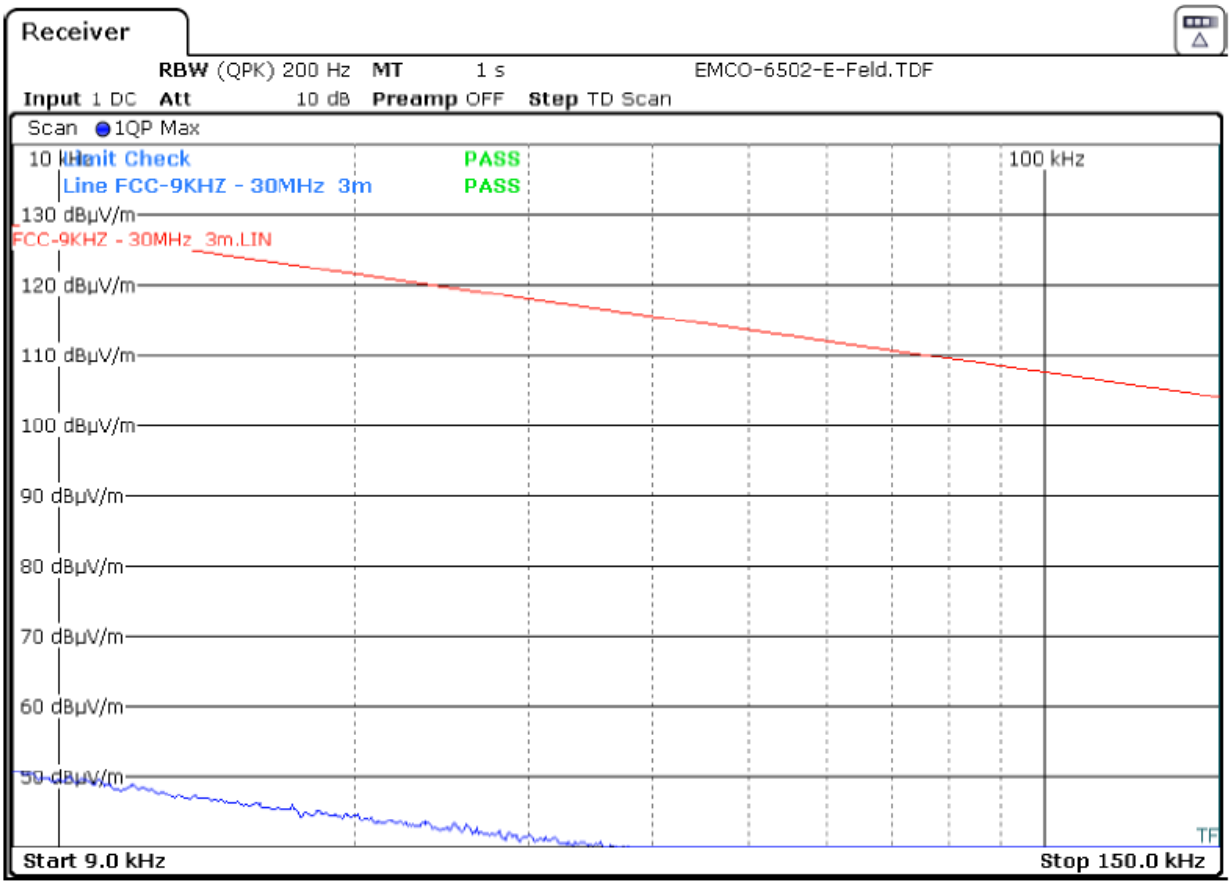
acc.FCC Subpart C § 15.209

STC

Ref.-No.: 20/01-0031

Operation mode: Tx BT; 8DPSK; Hopping Mode

Position X (9kHz - 150kHz)



Position: X									
Detector QP									
Frequ. [MHz]	**Level [dBµV/m]**	**Margin to Limit [dB]**	**Limit [dBµV/m]**	**Result**					
9kHz - 150kHz	-/-	>20	-/-	**pass**					

TESTED IN GERMANY

IT 3/4

Interference radiation (9kHz – 30MHz)

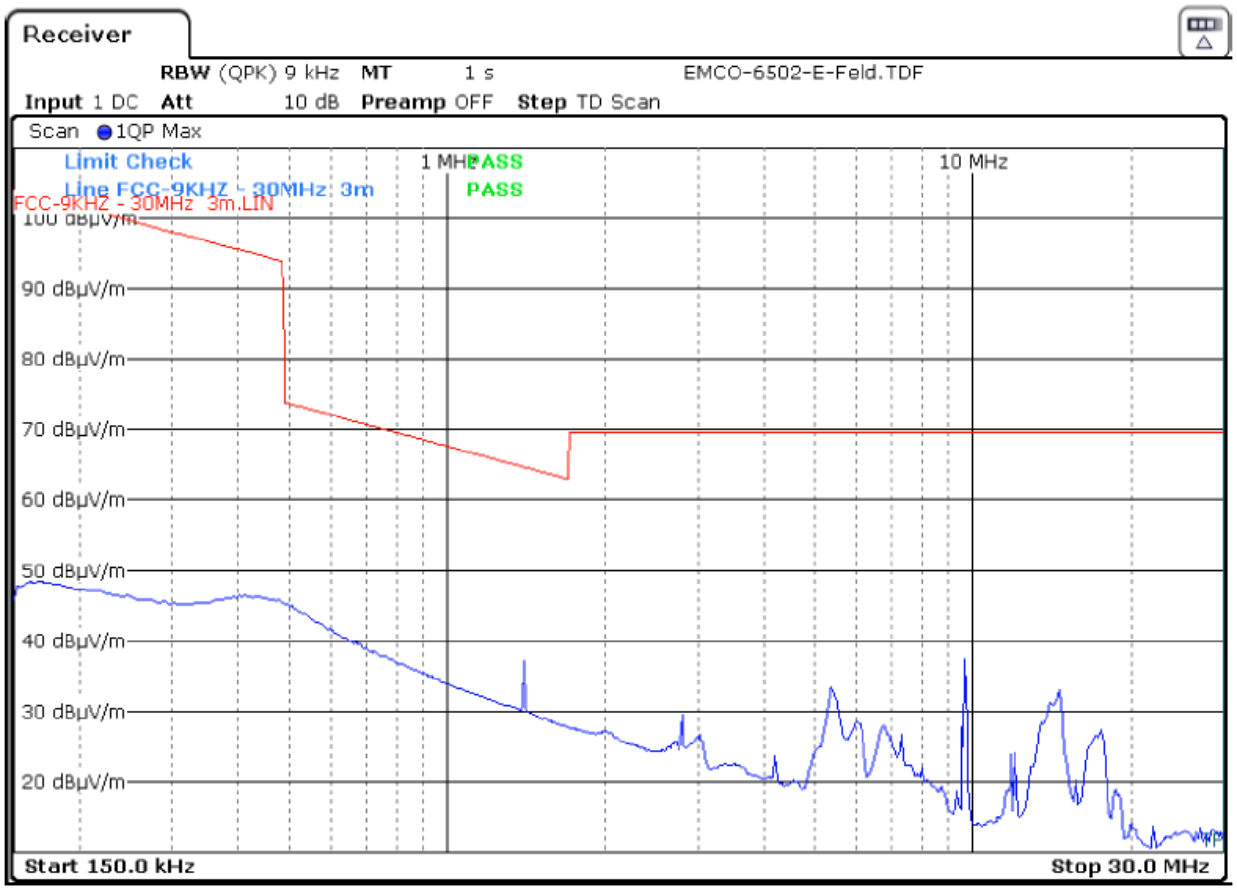
acc.FCC Subpart C § 15.209

STC

Ref.-No.: 20/01-0031

Operation mode: Tx BT; 8DPSK; Hopping Mode

Position X (150kHz – 30MHz)



Position: X									
		Detector QP							
Frequ. [MHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]	Result					
150kHz-30MHz	-/-	>20	-/-	pass					

Summery result for frequency range 9 kHz - 30 MHz to show combliance with RSS-Gen limits:

Function	Freq.	Measured Value @ 3m	Conversion to magnetic field[Note 1]		Limit @ 3m		Margin	Result
	[MHz]	[dBµV/m]	[dBµA/m]	[µA/m]	[dBµA/m]	[µA/m]	[dB]	
Transmitting	0.009 – 0.490	< 50.0	<- 1.5	-/-	77 - 42.3	-/-	>20	Pass
	0.490 – 1.705	< 47.0	< -4.5	-/-	22.3 - 11.5	-/-	>20	Pass
	1.705 - 30	< 38.0	< -13.5	-/-	18	-/-	>20	Pass

Note 1: Converstion E-field to H-Field:
x [dBµV/m] – 51.5 = y [dBµA/m]

Converstion [dBµA/m] in [µA/m]
10 ^ (y [dBµA/m] / 20) = z [µA/m]

Remarks:
Composition of the measurement value (Freq.-range < 30 MHz):

$$\mathbf{M_{Value} = M_{Rec} + C_{Loss} + AF_{Rec}}$$

M_{Value} = Measurement Value
M_{Rec} = Reading value of test receiver
C_{Loss} = Cable loss between Receiver and Antenna
AF_{Rec} = Antenna factor.

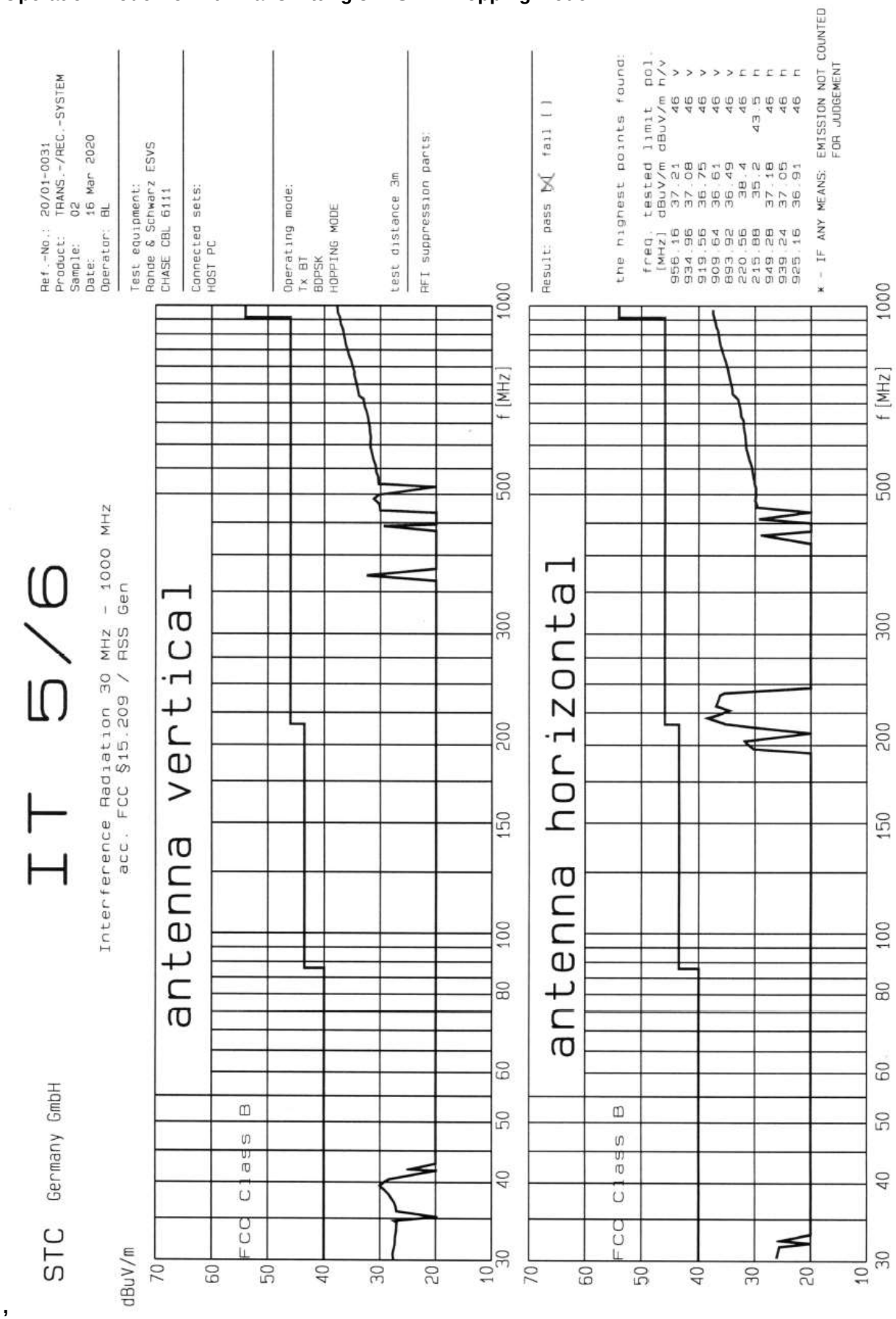
Sample calculation:

38.2 dBµV = 18.3 dBµV + 0.1 dB + 19.8 dB

All emissions in the frequency range 9 kHz – 30 MHz are at least 20 dB below the relevant limit.

Result 30 MHz – 1000 MHz

Operation Mode No.: 10. Transmitting 8DPSK in Hopping Mode



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Remarks:
Composition of the measurement value (Freq.-range 30 MHz – 1000 MHz):

$$\mathbf{M_{Value} = M_{Rec} + C_{Loss} + AF_{Rec}}$$

M_{Value} = Measurement Value
M_{Rec} = Reading value of test receiver
C_{Loss} = Cable loss between Receiver and Antenna
AF_{Rec} = Antenna factor.

Sample calculation:

38.7 dBµV = 18.3 dBµV + 0.6 dB + 19.8 dB

Result 1 GHz – 7 GHz

Operation Mode No.: 10. Transmitting 8DPSK in Hopping Mode

TESTED IN GERMANY

IT 5/6
Interference radiation
acc. to FCC § 15.209 / RSS-Gen

STC

Ref.-No.: 20/01-0031

Product: Transmitting/Receiving System

Sample: 02

Date: 12.03.2020

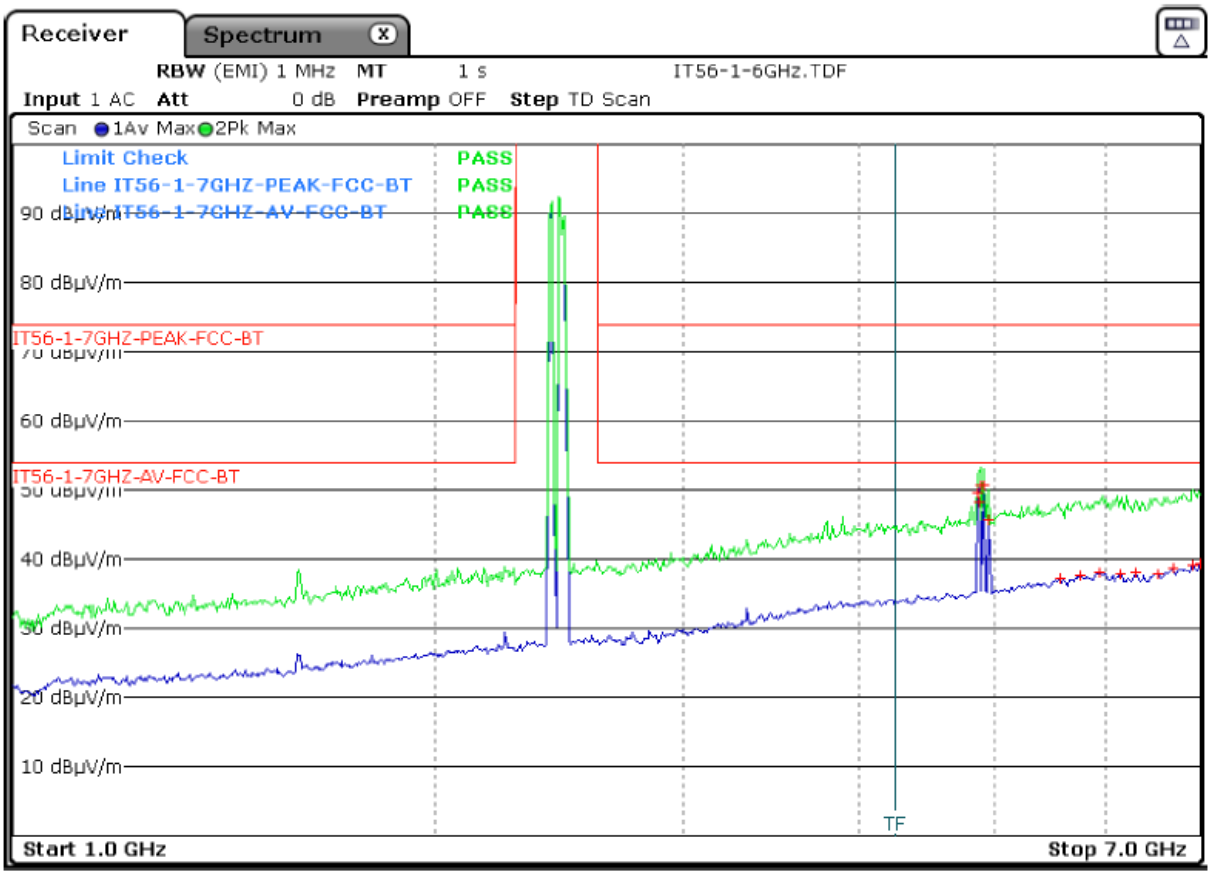
Operator: BI

Remarks:

pass ☒ fail ☐

Result:

Operation mode: Tx BT / 8DPSK / Hopping Mode



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
4,8800	50,68	-3,32	54,00	pass	1 - 7	-/-	>20	74	pass
4,9060	50,66	-3,34	54,00	pass					
4,8600	49,46	-4,54	54,00	pass					
4,8680	48,21	-5,79	54,00	pass					
4,9500	45,63	-8,37	54,00	pass					
6,9988	39,40	-14,60	54,00	pass					

TESTED IN GERMANY

IT 5/6

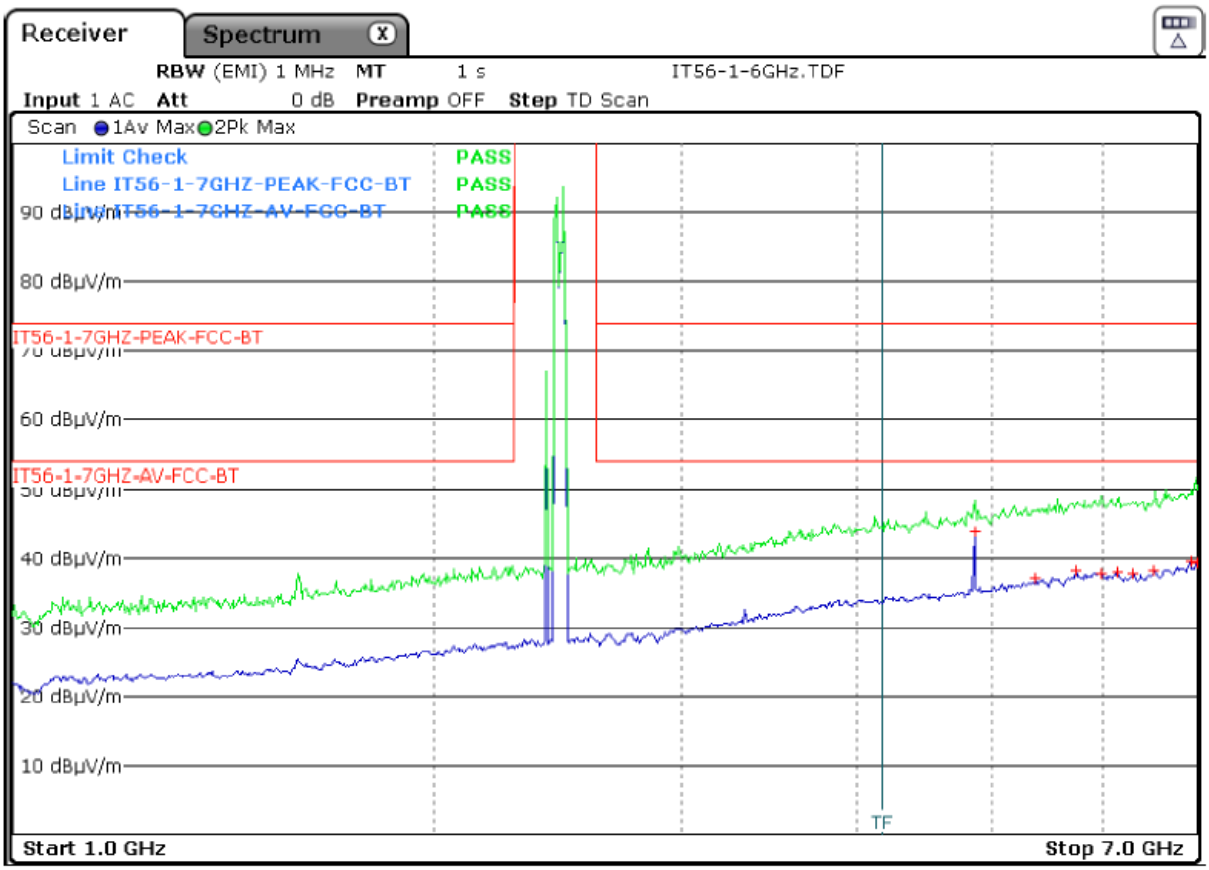
Interference radiation

acc. to FCC § 15.209 / RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: Tx BT / 8DPSK / Hopping Mode



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
4,8560	43,90	-10,10	54,00	pass	1 - 7	-/-	>20	74	pass
6,9238	39,52	-14,48	54,00	pass					
6,9923	39,44	-14,56	54,00	pass					
5,7373	38,22	-15,78	54,00	pass					
6,5233	38,22	-15,78	54,00	pass					
6,1430	38,08	-15,92	54,00	pass					

No further significant emission found above 7GHz

Remarks:
Composition of the measurement value (Freq.-range 1 GHz – 7 GHz):

$$\mathbf{M_{Value} = M_{Rec} + C_{Loss} + AF_{Rec} - G_{Amp}}$$

M_{Value} = Measurement Value
M_{Rec} = Reading value of test receiver
C_{Loss} = Cable loss between Receiver and Antenna
AF_{Rec} = Antenna factor.
G_{Amp} = Gain Amplifier

Sample calculation:

39.7 dBµV = 53.01 dBµV + 0.9 dB + 24.19 dB -38.4 dB

Result 7GHz – 40GHz

All emissions in the frequency range 7 GHz – 40 GHz are at least 20 dB below the relevant limit

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **Radiated Emissions**.

8. 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
-RSS-247 issue 2

8.1. 20 dB Spectrum Bandwidth Measurement

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

Limit
The minimum 20 dB bandwidth shall be at least 25 kHz.

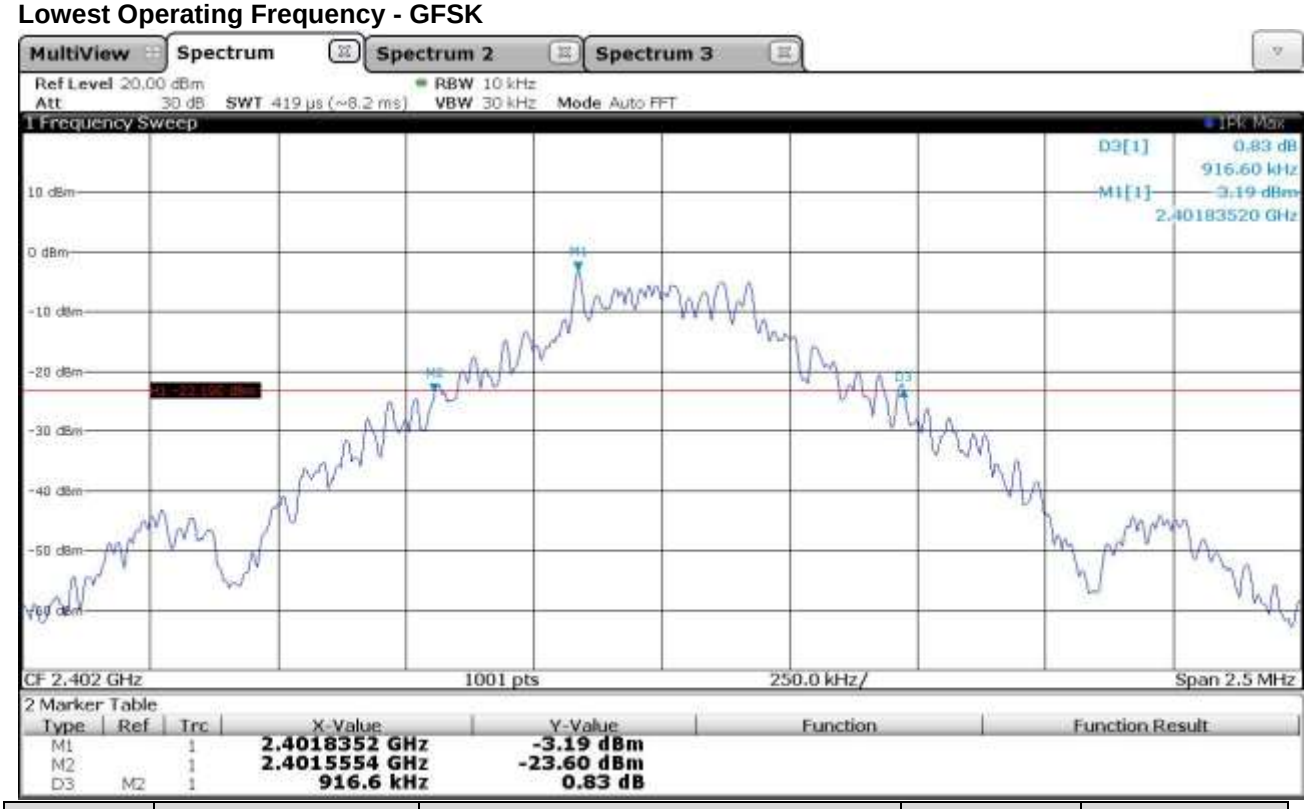
Test equipment and test set up
Test equipment used for conducted measurements as given in clause Test equipment of this report.
Test setup used for conducted measurements as given in clause Test setups of this report.

Description
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.

Measurement

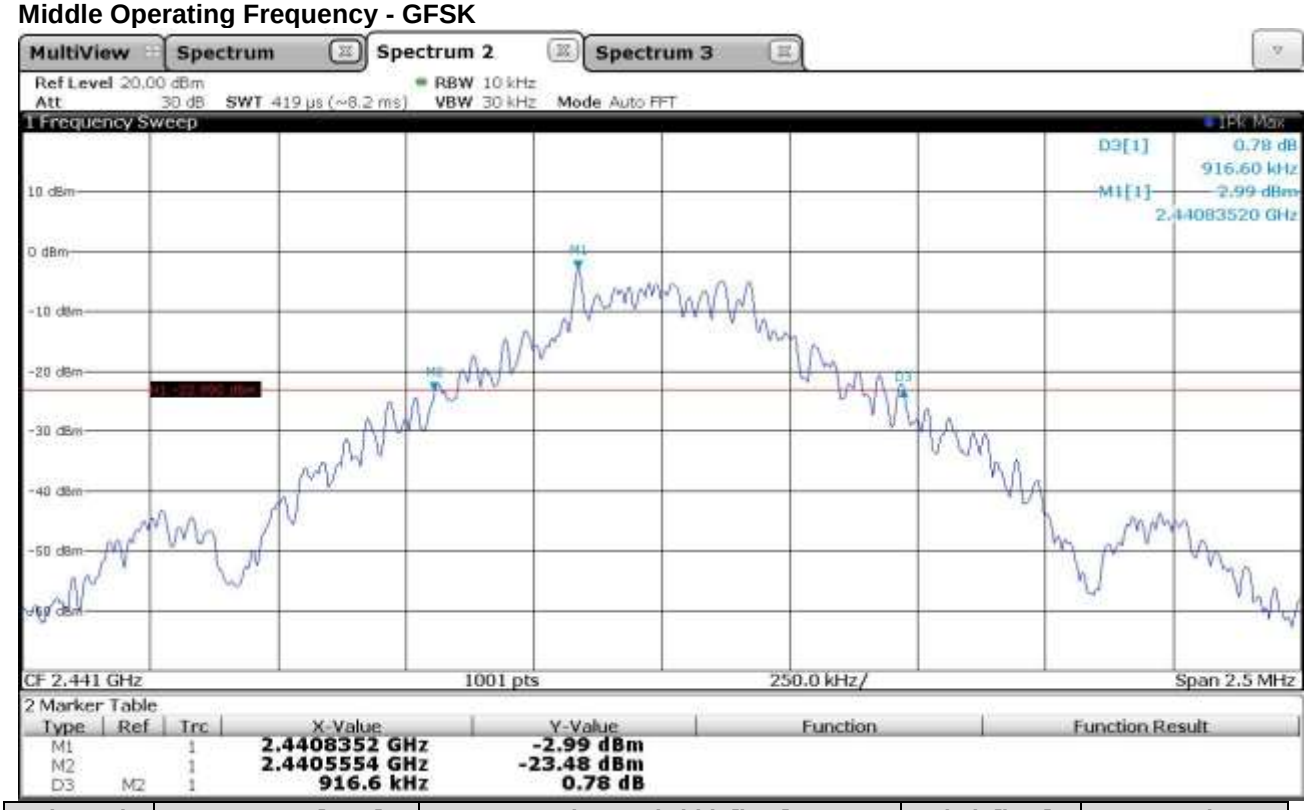
The Measurement was performed on: 03.03.2020

Lowest Operating Frequency - GFSK



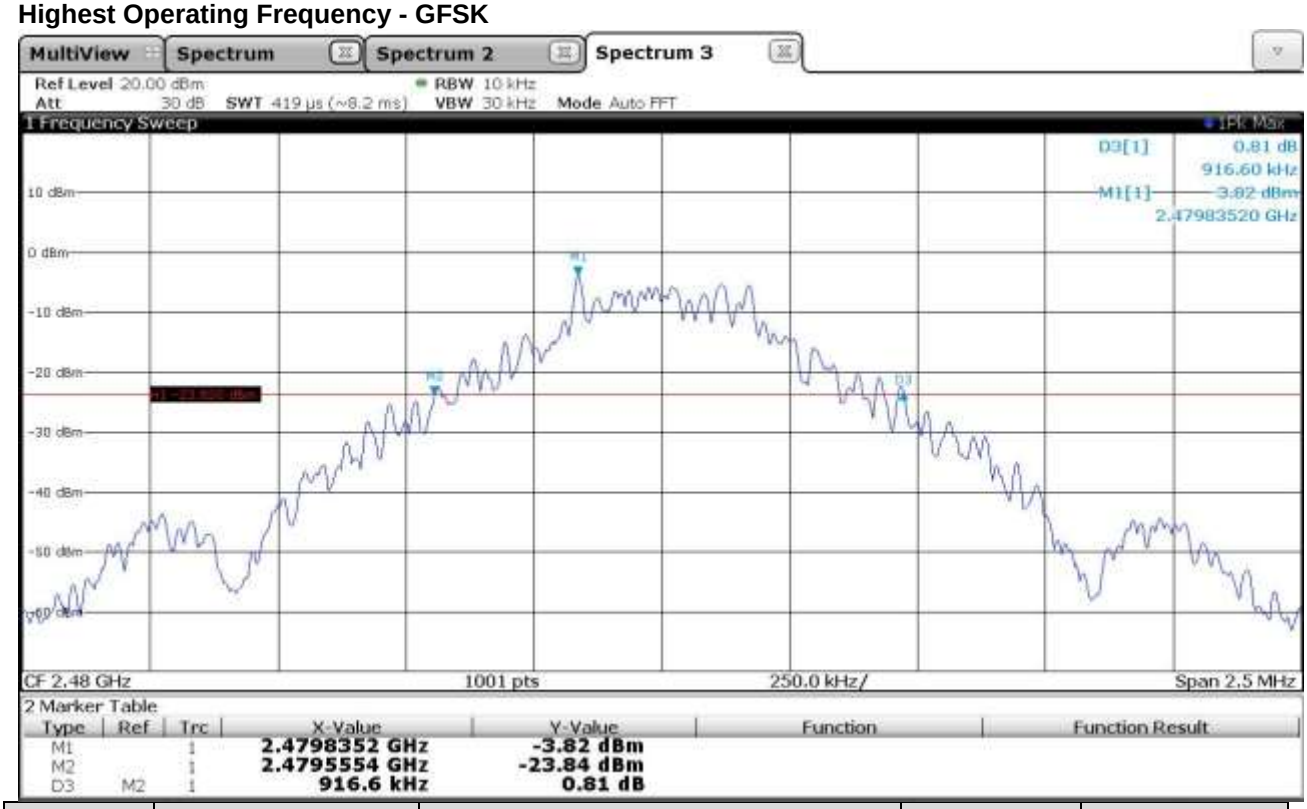
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
0	2402	916.6	25	Pass

Middle Operating Frequency - GFSK



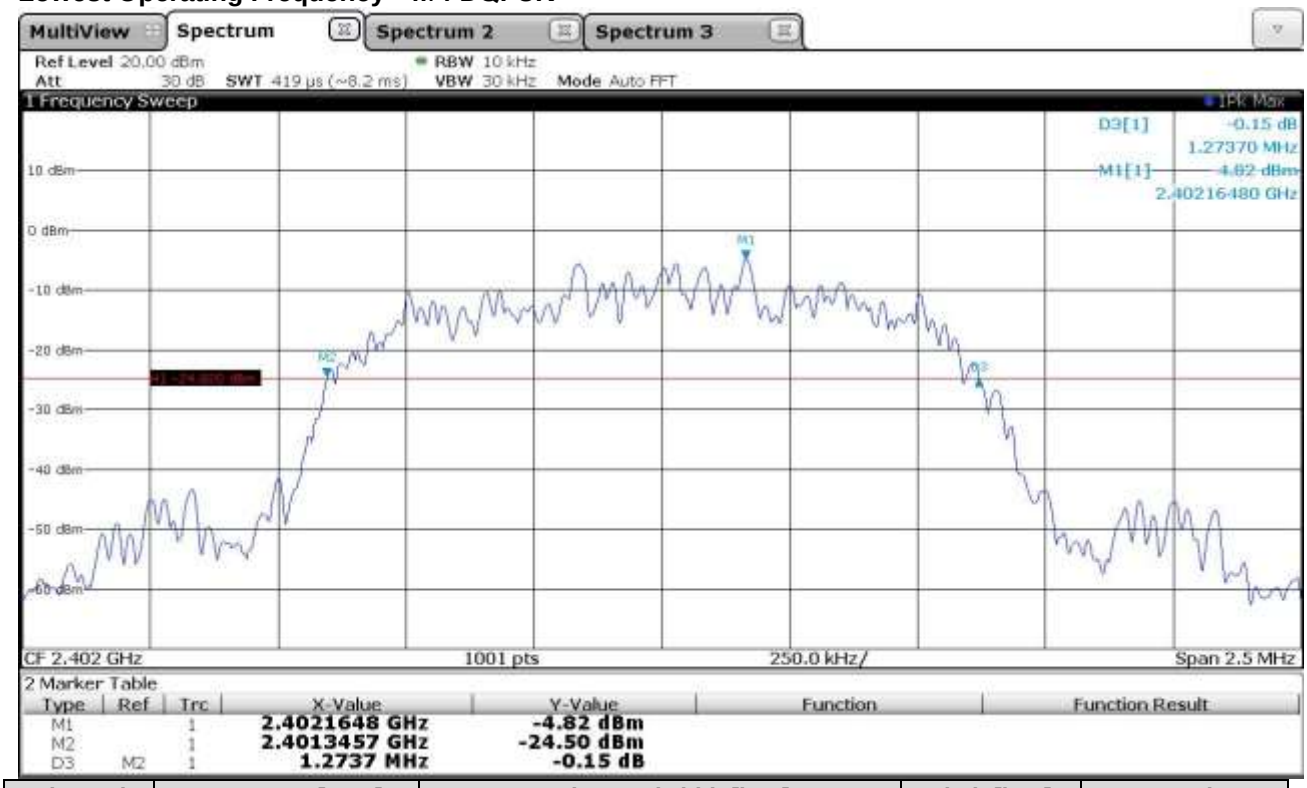
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
39	2441	916.6	25	Pass

Highest Operating Frequency - GFSK



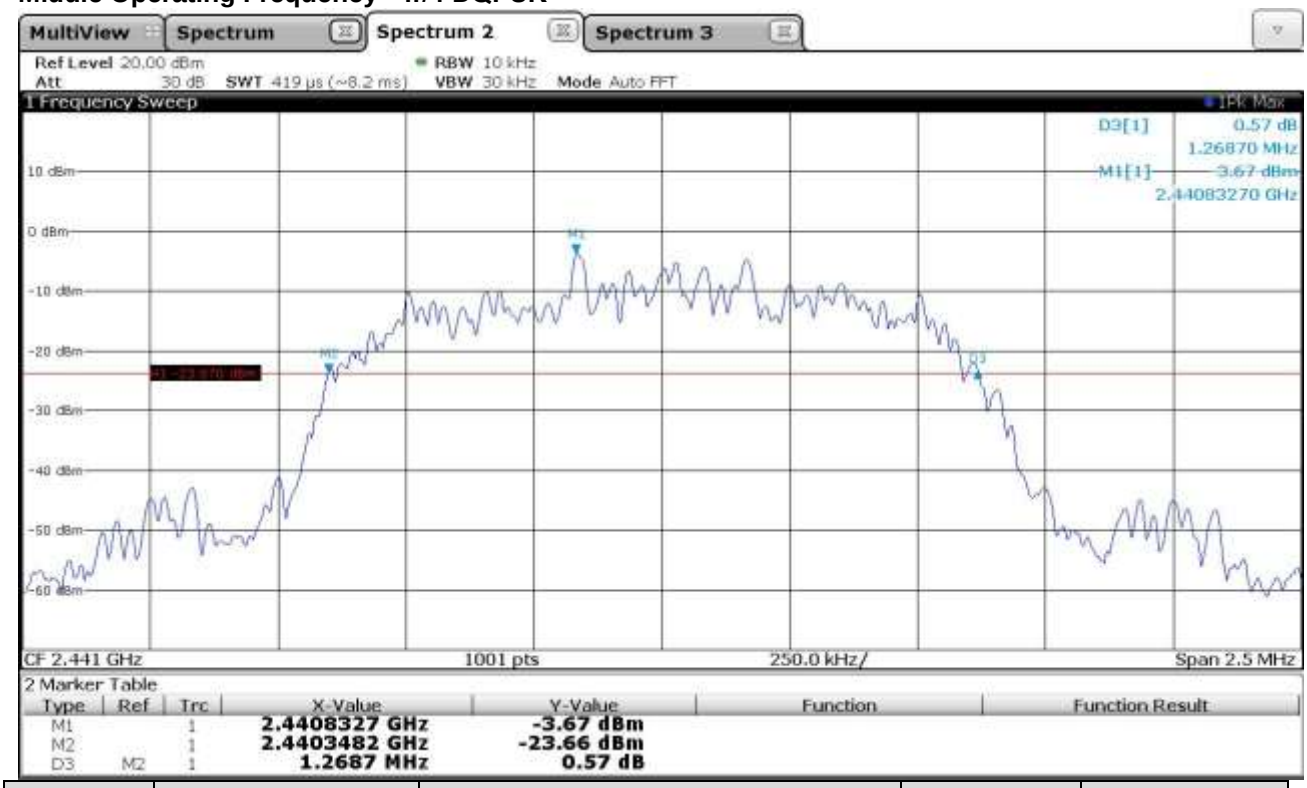
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
79	2480	916.6	25	Pass

Lowest Operating Frequency - π/4 DQPSK



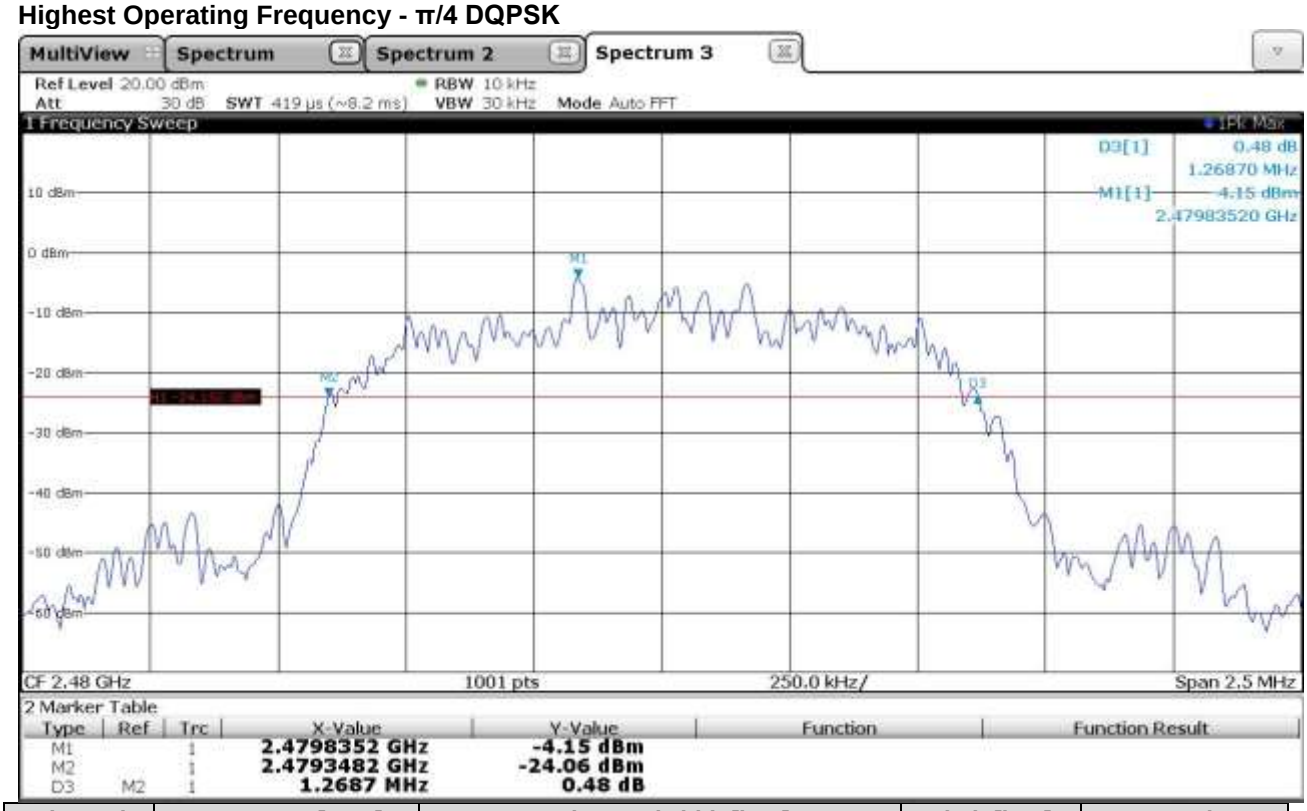
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
0	2402	1273.7	25	Pass

Middle Operating Frequency - π/4 DQPSK



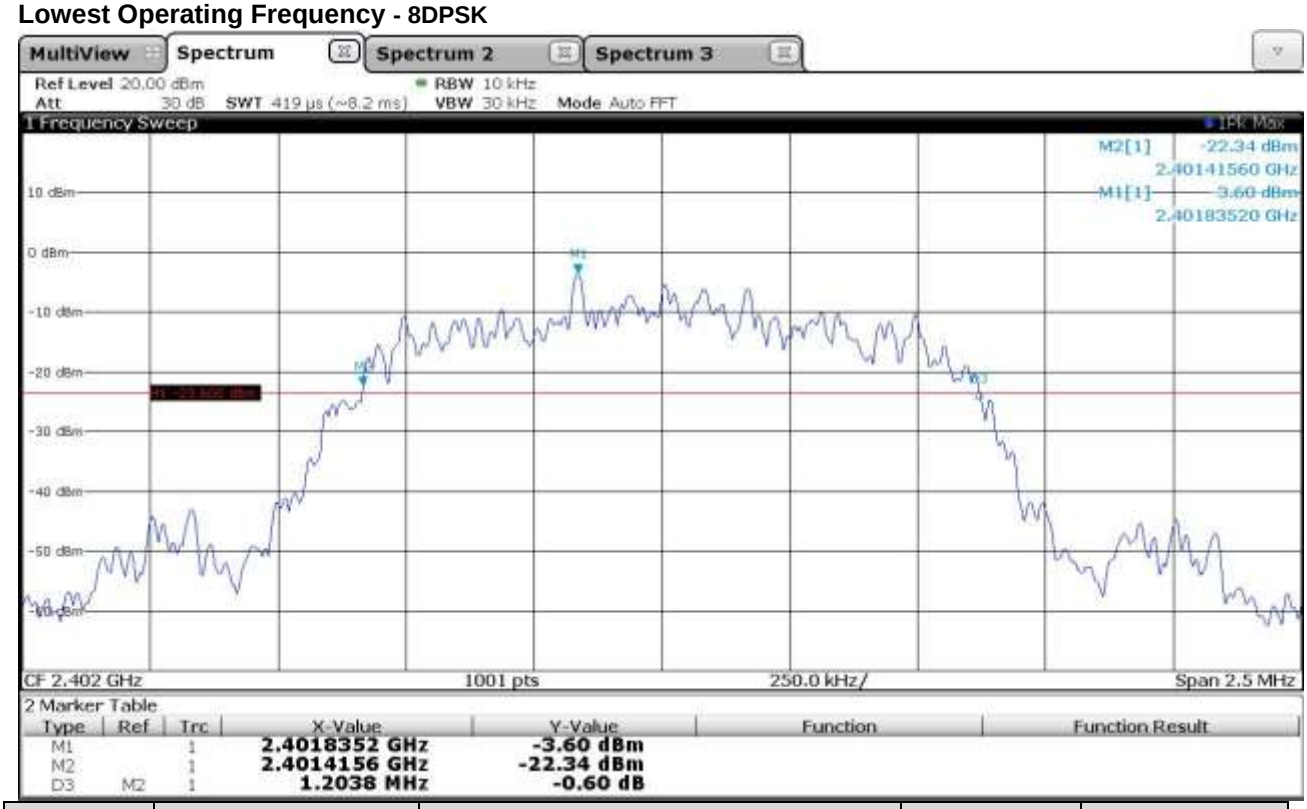
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
39	2441	1268.7	25	Pass

Highest Operating Frequency - π/4 DQPSK



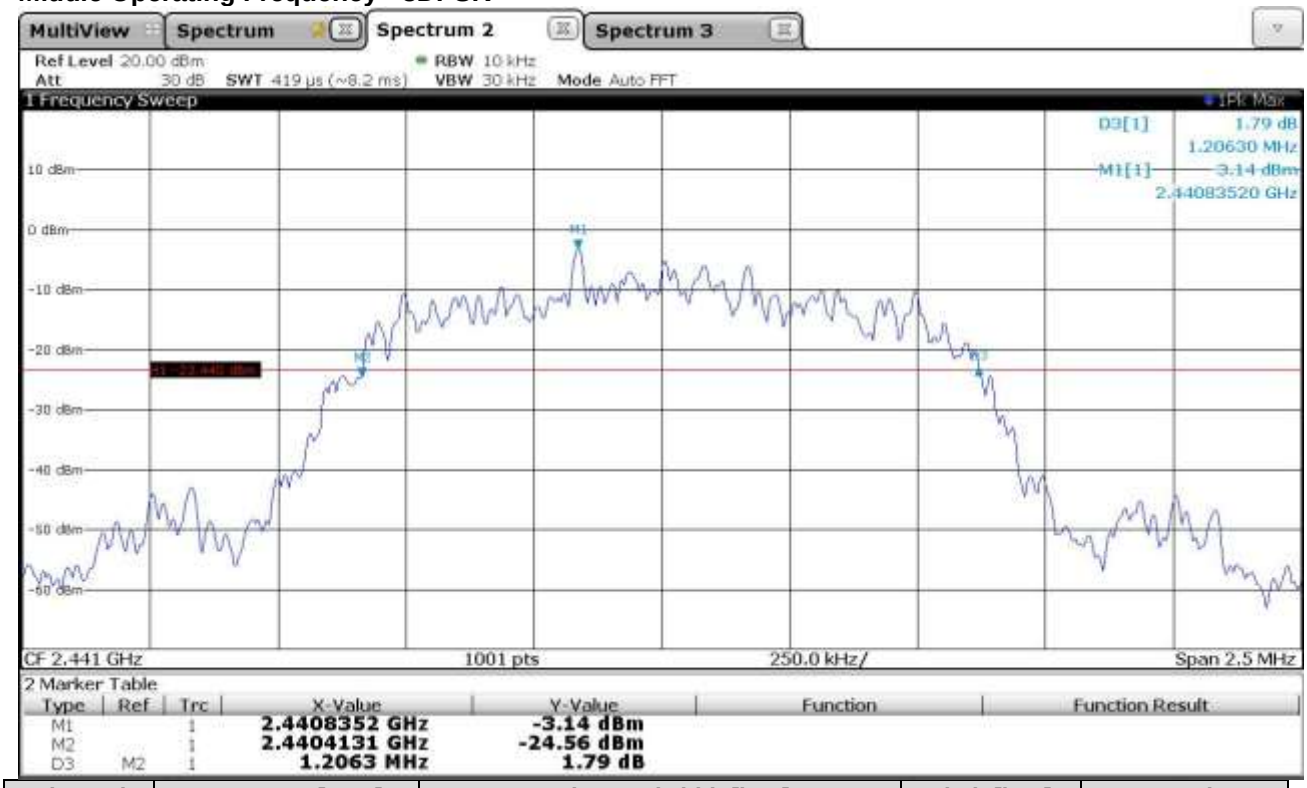
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
79	2480	1268.7	25	Pass

Lowest Operating Frequency - 8DPSK



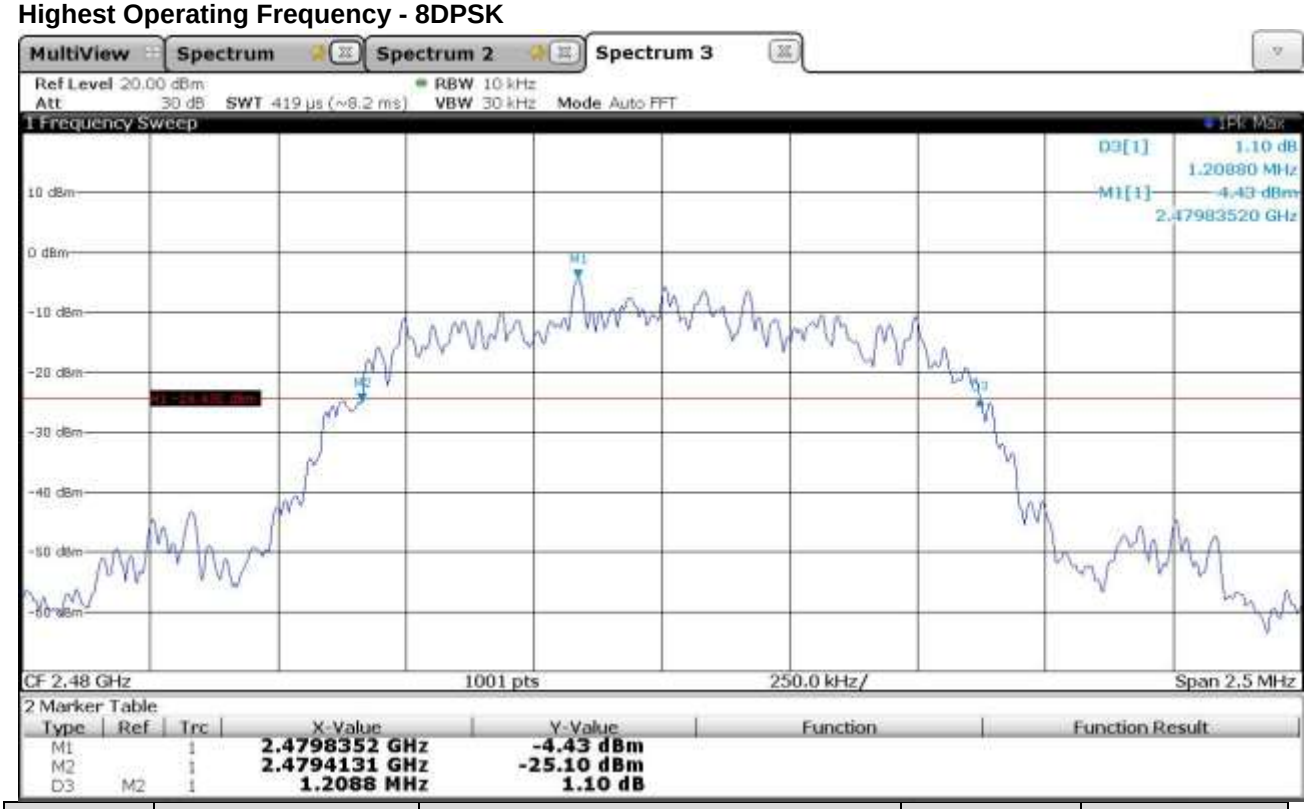
Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
0	2402	1203.8	25	Pass

Middle Operating Frequency - 8DPSK



Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
39	2441	1206.3	25	Pass

Highest Operating Frequency - 8DPSK



Channel	Frequency [MHz]	20 dB Bandwidth [kHz]	Limit [kHz]	Result
79	2480	1208.8	25	Pass

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **20 dB Bandwidth**.

8.2. 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 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.

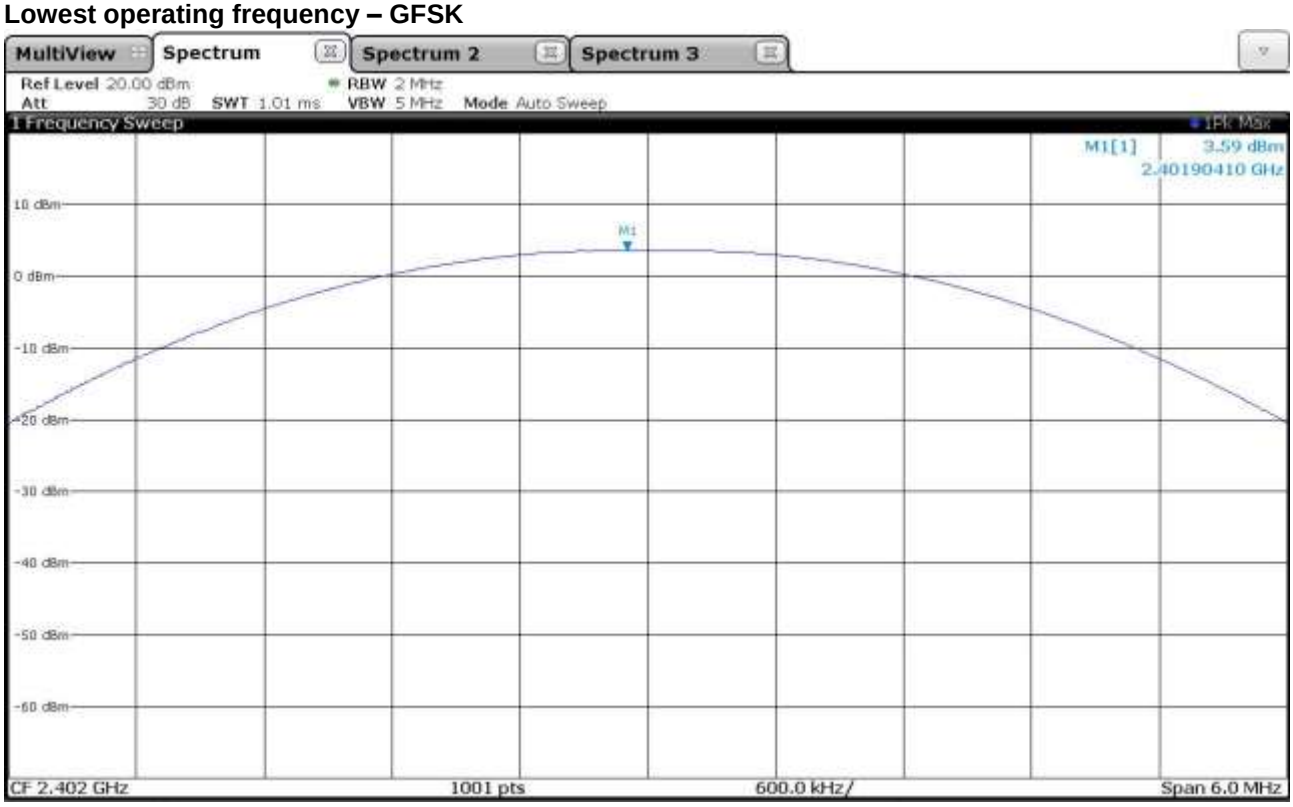
Test equipment and test set up
Test equipment used for conducted measurements as given in clause Test equipment of this report.
Test setup used for conducted measurements as given in clause Test setups of this report.

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.

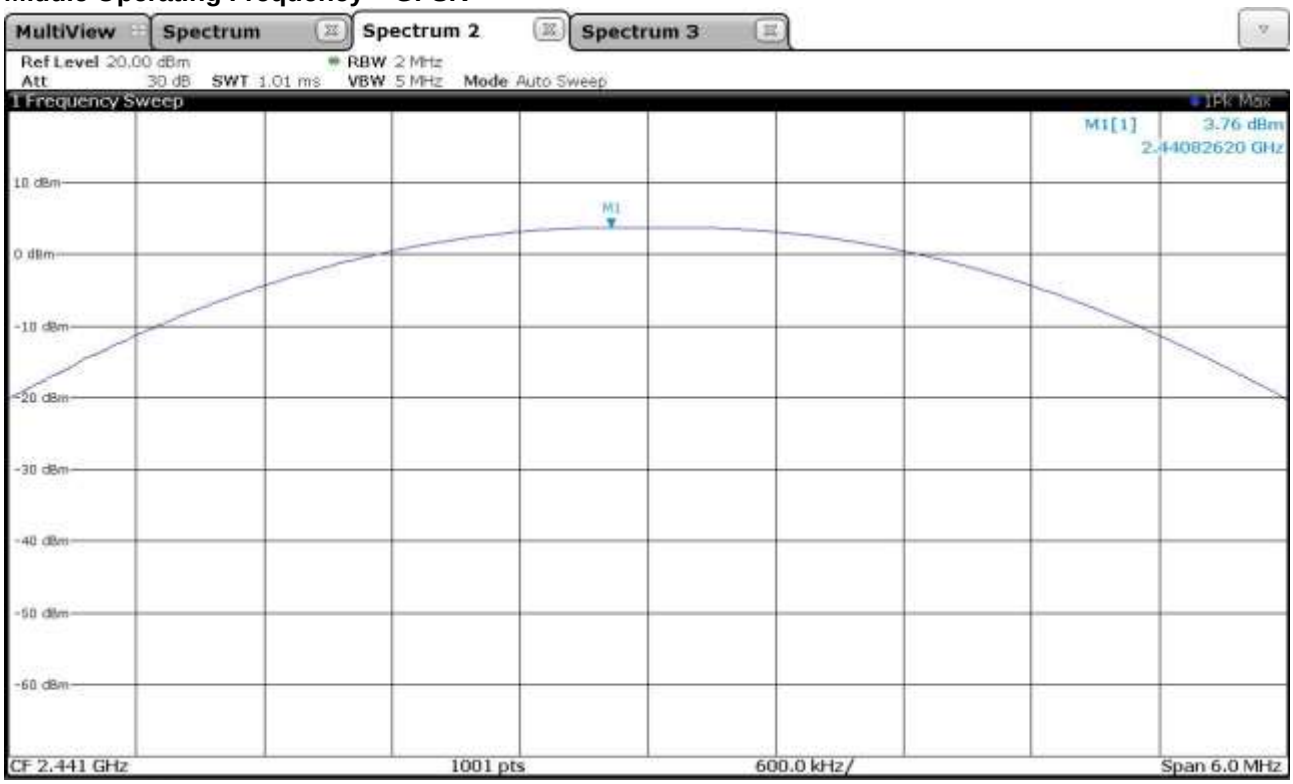
Measurement

The Measurement was performed on: 03.03.2020

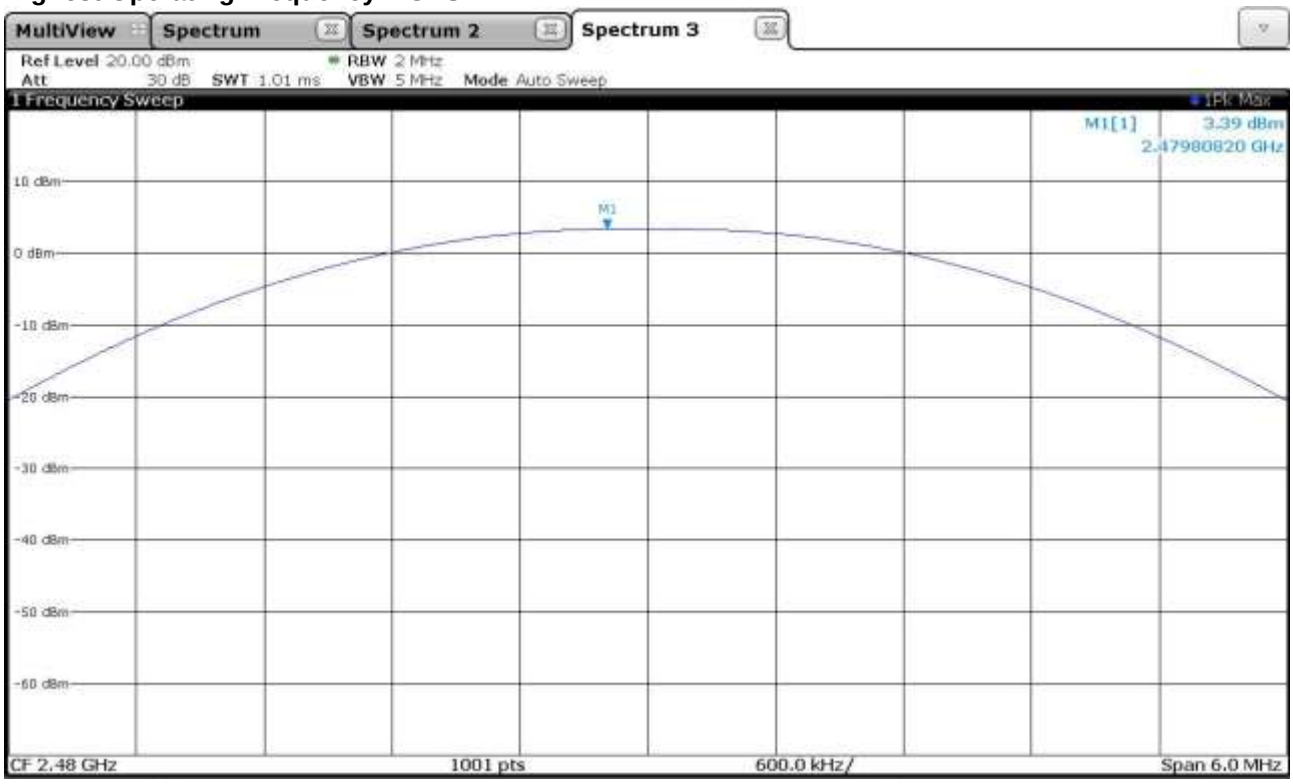
Lowest operating frequency – GFSK



Middle Operating Frequency – GFSK

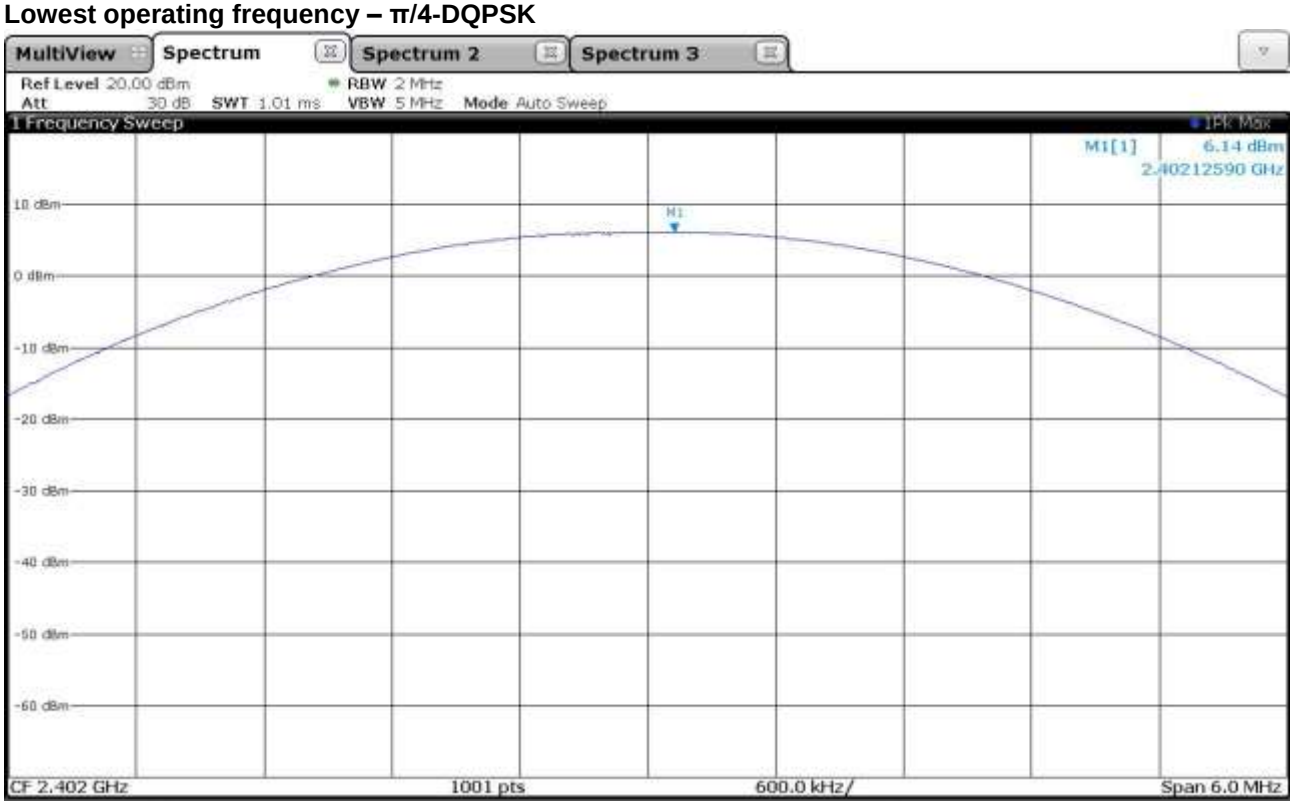


Highest Operating Frequency – GFSK

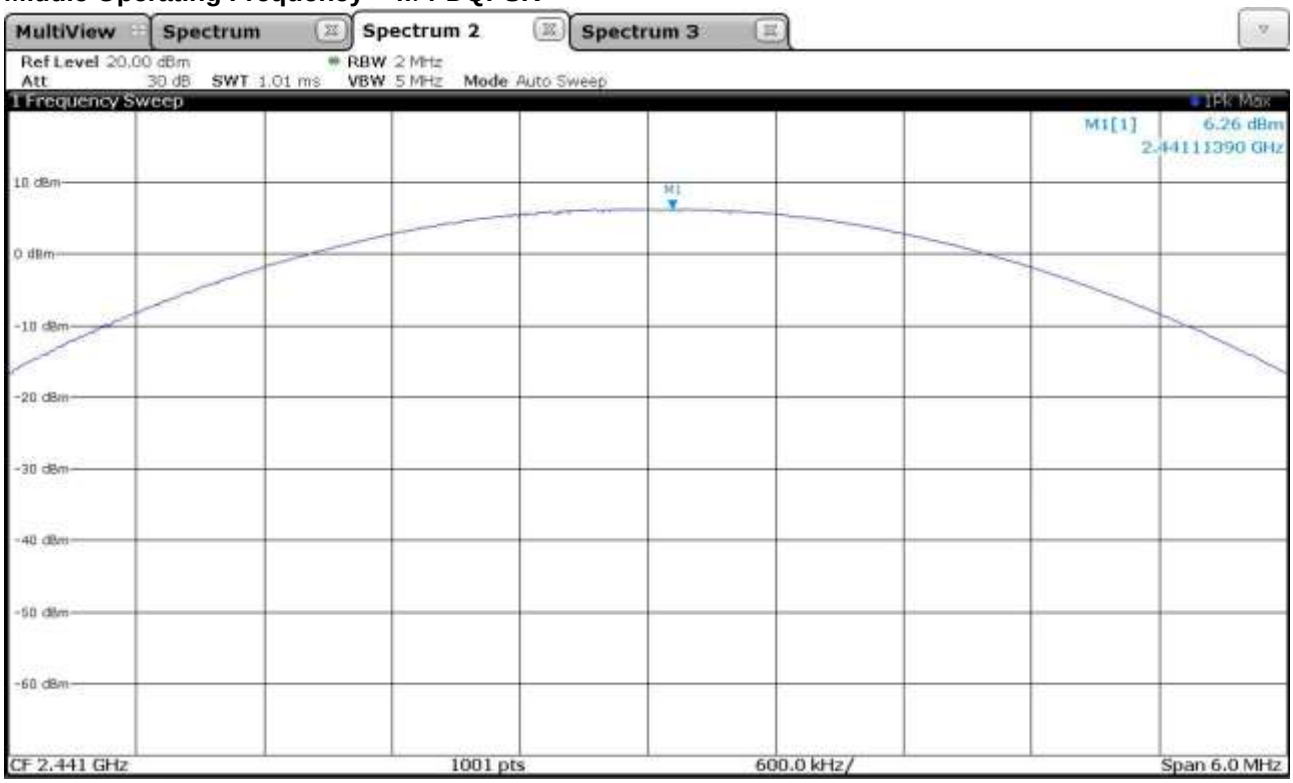


Maximum output power conducted measurement - GFSK								
Channel	Frequency [MHz]	Reading of Analyzer [dBm]	Cable Loss [dB]	Output Power		Limit		Result
				[dBm]	[mW]	[dBm]	[mW]	
0	2402	3.59	1.2	4.79	3.01	21	125	Pass
39	2441	3.76	1.2	4.96	3.13	21	125	Pass
78	2480	3.39	1.2	4.59	2.88	21	125	Pass

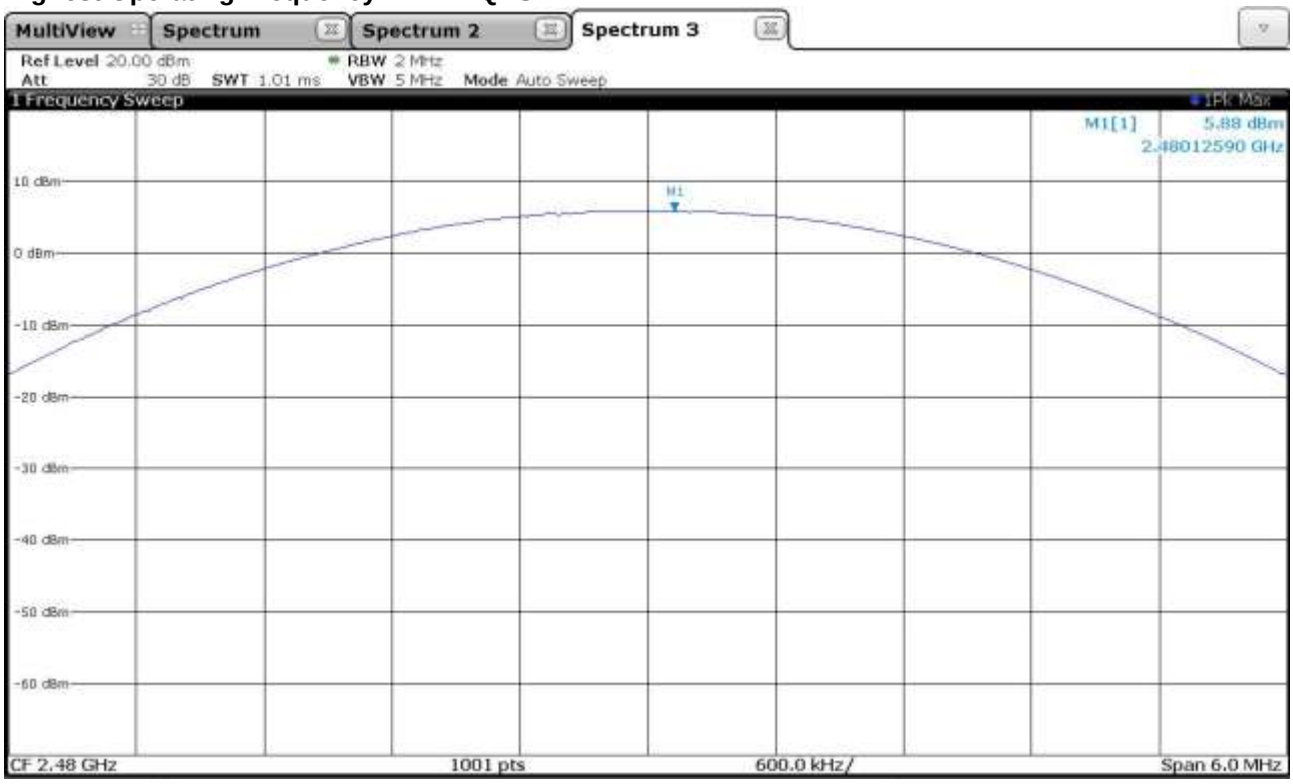
Lowest operating frequency – π/4-DQPSK



Middle Operating Frequency – π/4-DQPSK

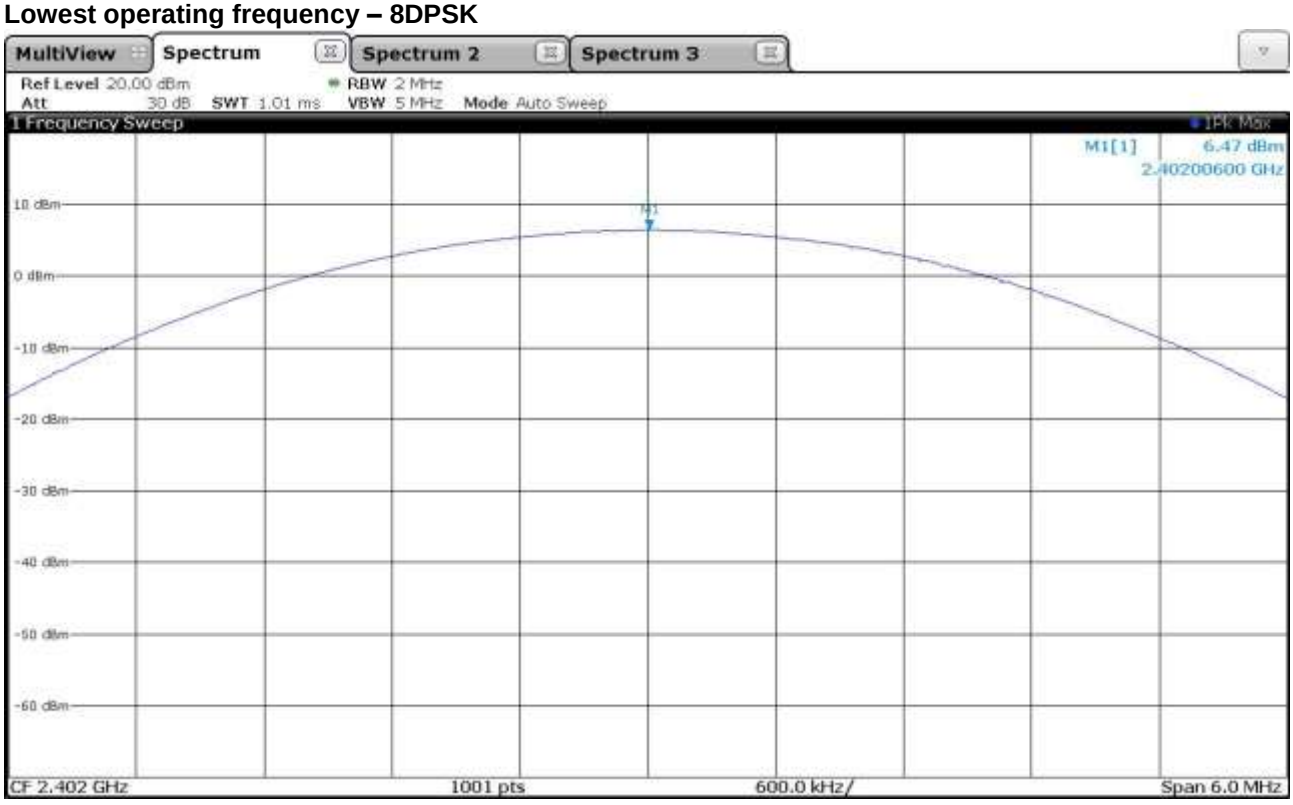


Highest Operating Frequency – π/4-DQPSK

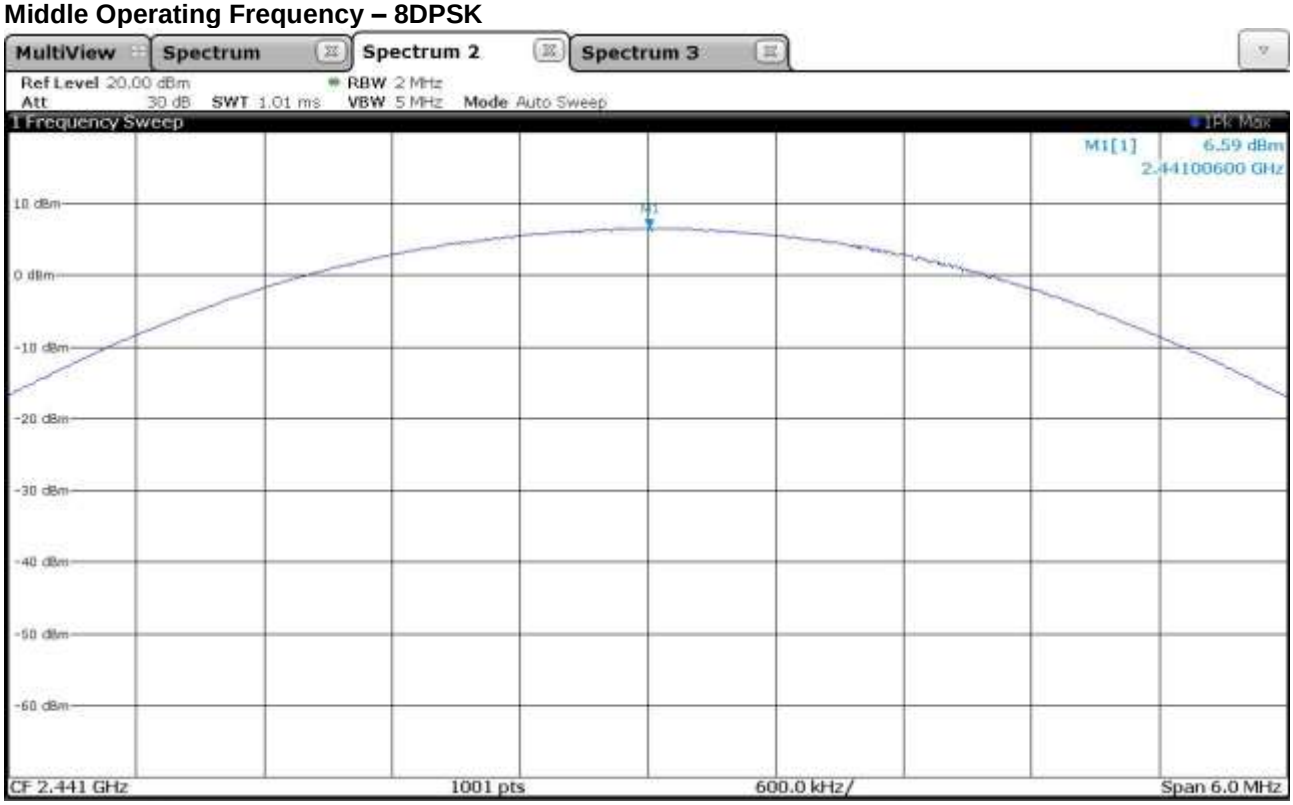


Maximum output power conducted measurement - π/4-DQPSK								
Channel	Frequency [MHz]	Reading of Analyzer [dBm]	Cable Loss [dB]	Output Power		Limit		Result
				[dBm]	[mW]	[dBm]	[mW]	
0	2402	6.14	1.2	7.34	5.42	21	125	Pass
39	2441	6.26	1.2	7.46	5.57	21	125	Pass
78	2480	5.88	1.2	7.08	5.11	21	125	Pass

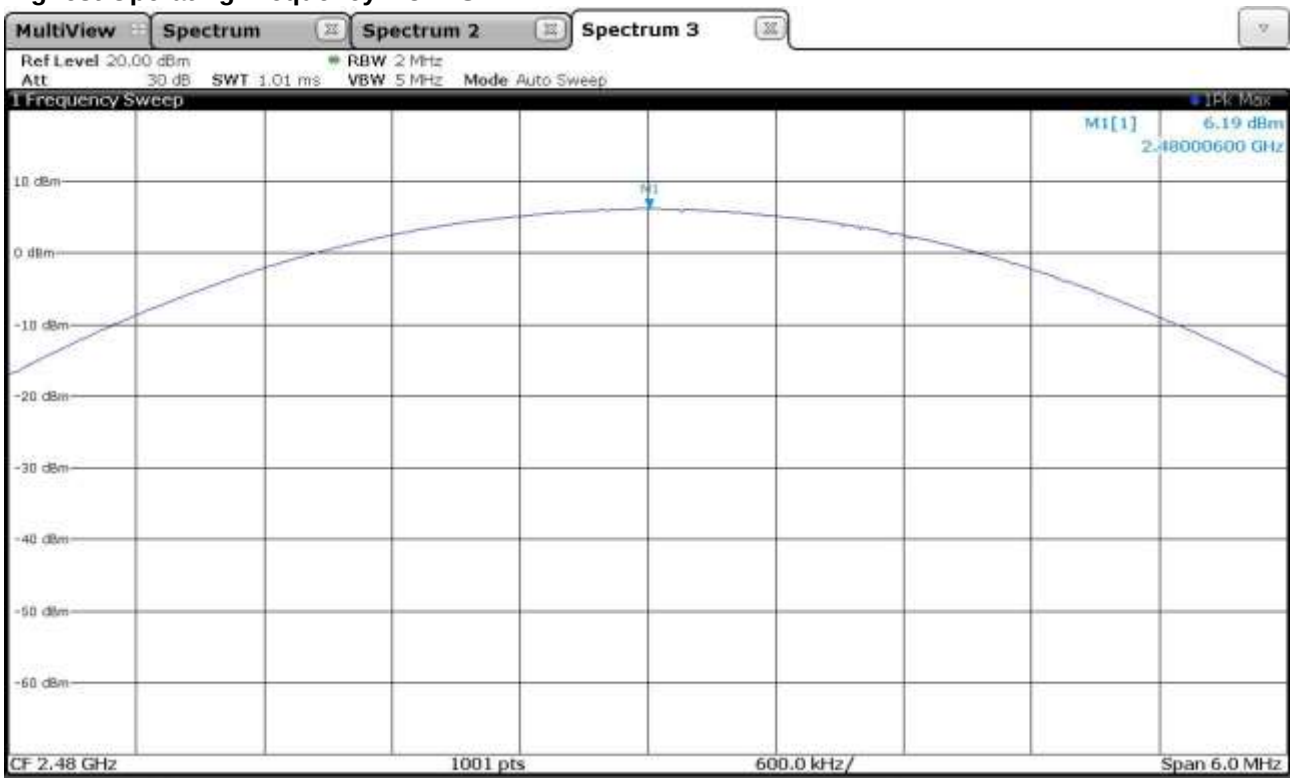
Lowest operating frequency – 8DPSK



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	6.47	1.2	7.67	5.85	21	125	Pass
39	2441	6.59	1.2	7.79	6.01	21	125	Pass
78	2480	6.19	1.2	7.39	5.48	21	125	Pass

Calculated EIRP:					
Channel	Frequency [MHz]	Output conducted		Output Power EIRP	
		[dBm]	[mW]	[dBm]	[mW]
0	2402	7.67	5.85	7.96	6.25
39	2441	7.79	6.01	8.08	6.42
78	2480	7.39	5.48	7.68	5.86
Formula: [Conducted RF power] + [Antenna gain] = [EIRP] Antenna Gain: max. 0.29 dBi					

Results

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

8.3. 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.

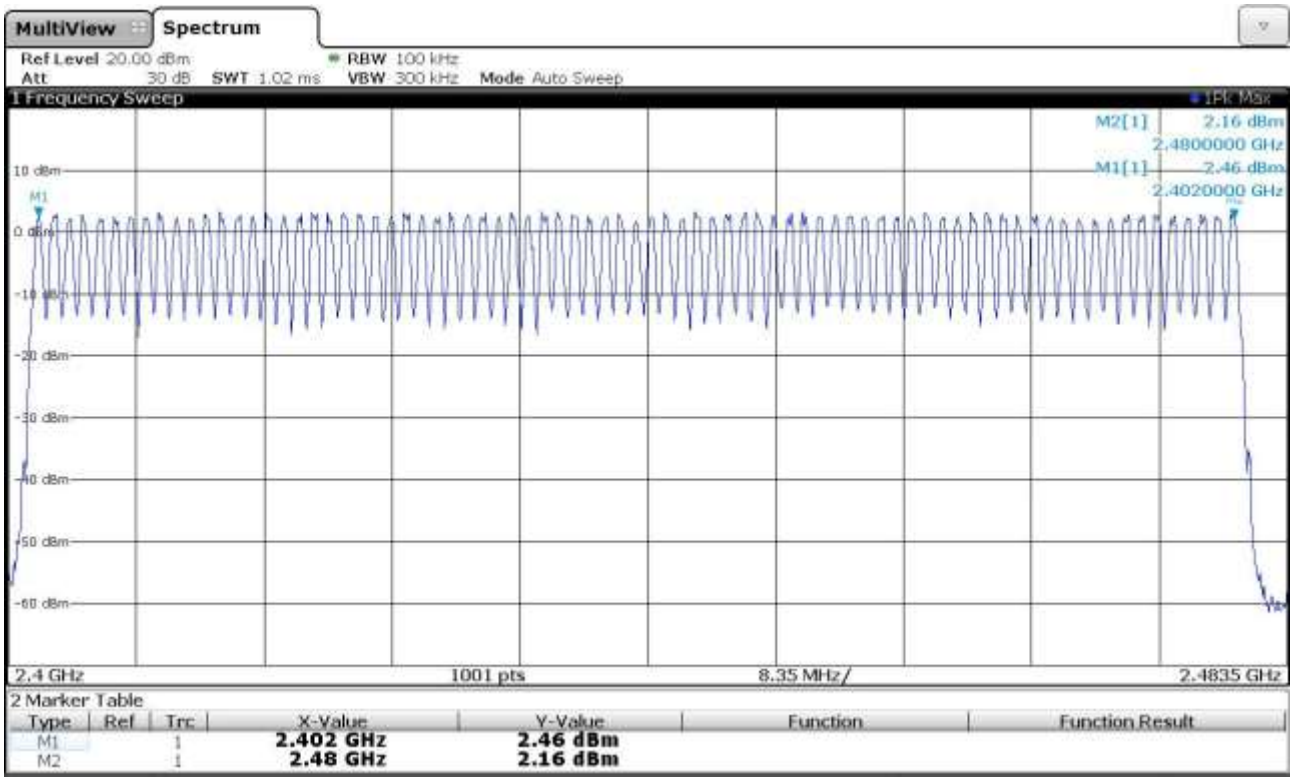
Description

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

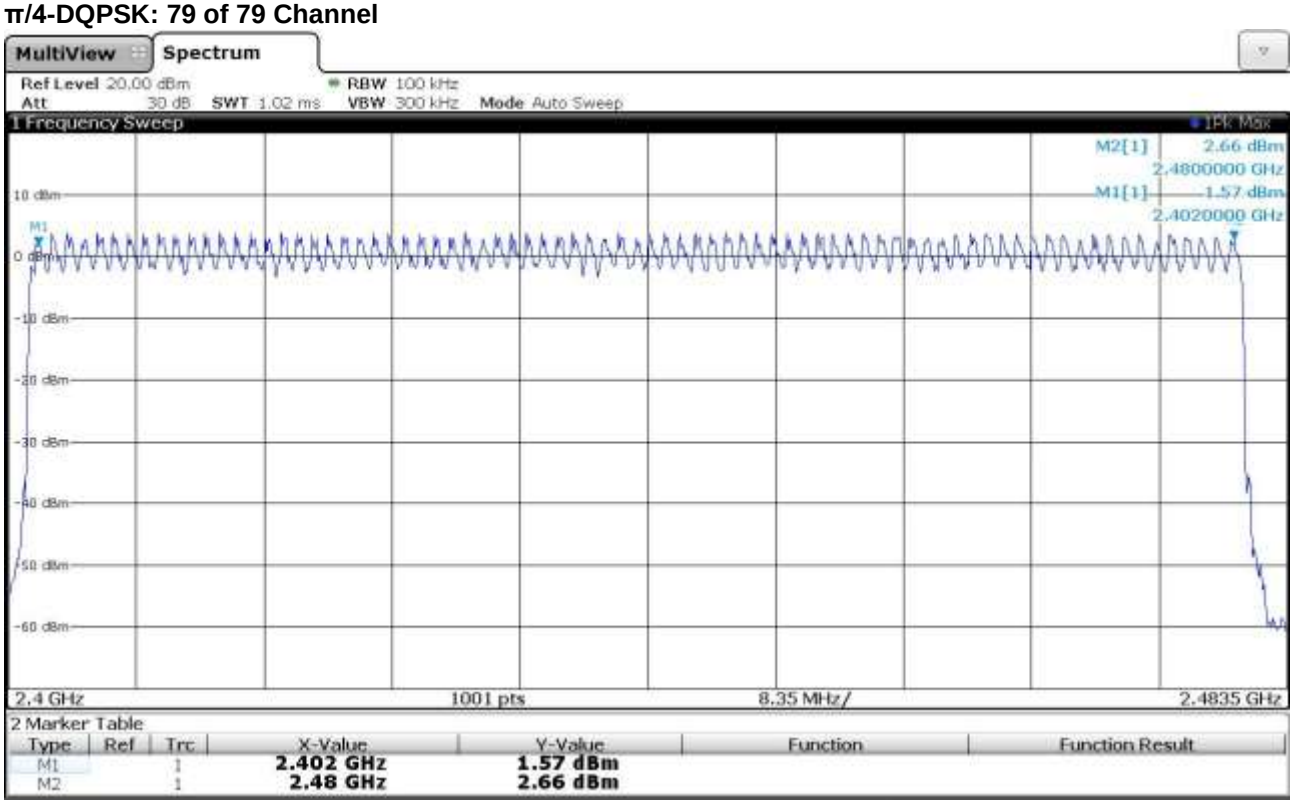
Measurement

The Measurement was performed on: 03.03.2020

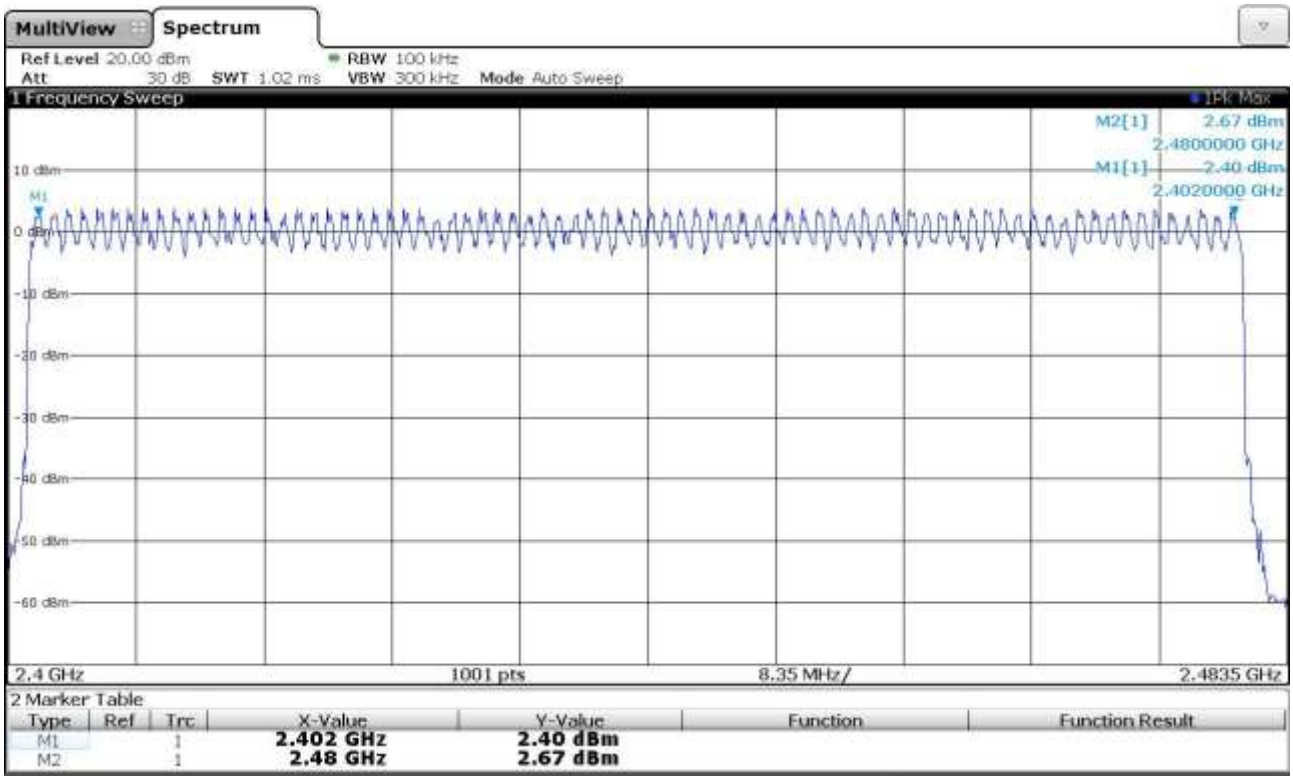
GFSK: 79 of 79 Channel



π/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.**

8.4. 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 3.5 MHz 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)

8.5. 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.

Description
Frequency range wide enough to capture the peaks of two adjacent channels.
(Peak Detector)

Limits

GFSK:
The measured maximum bandwidth* 2/3 = 916.6 kHz * 2/3 = 611.1 kHz

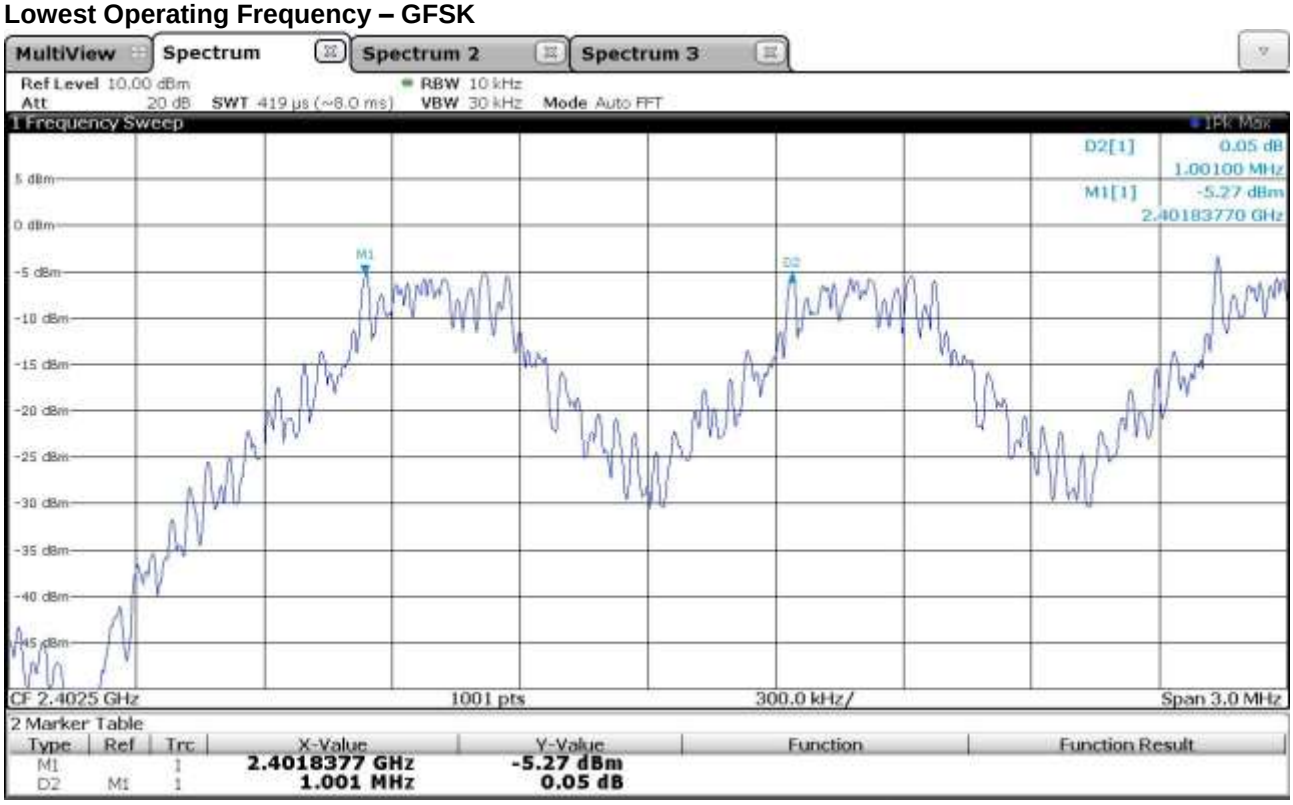
π/4 DQPSK:
The measured maximum bandwidth * 2/3 =1273.7 kHz * 2/3 = 849.1 kHz

8DPSK:
The measured maximum bandwidth * 2/3 =1208.8 kHz * 2/3 = 805.9 kHz

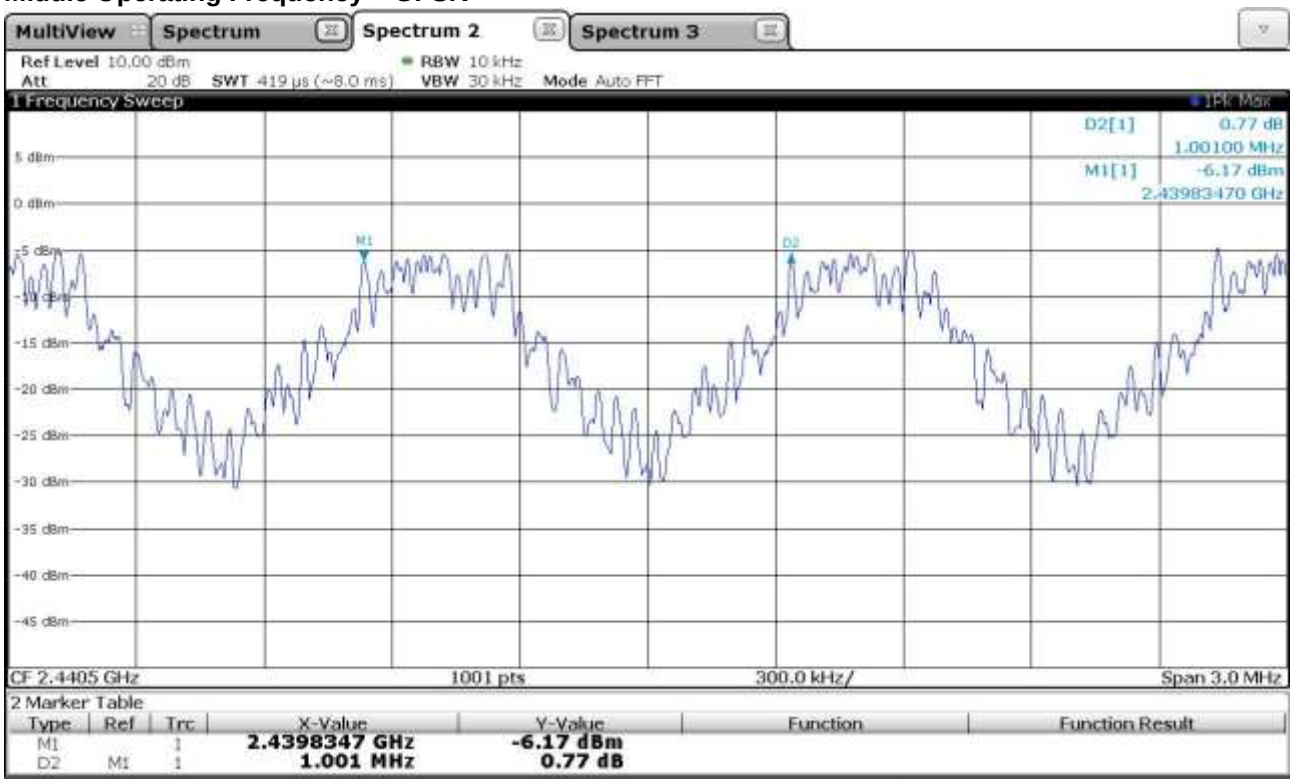
Measurement

The Measurement was performed on: 03.03.2020

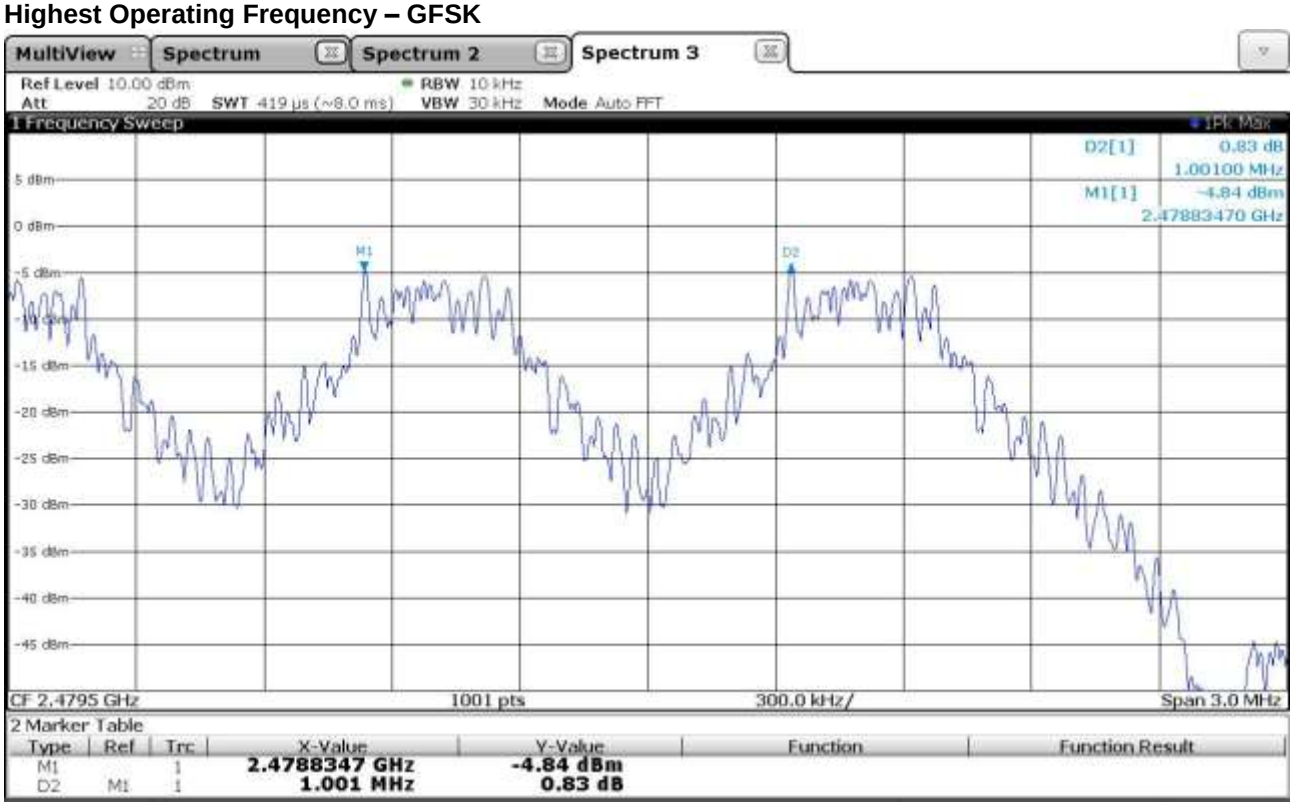
Lowest Operating Frequency – GFSK



Middle Operating Frequency – GFSK

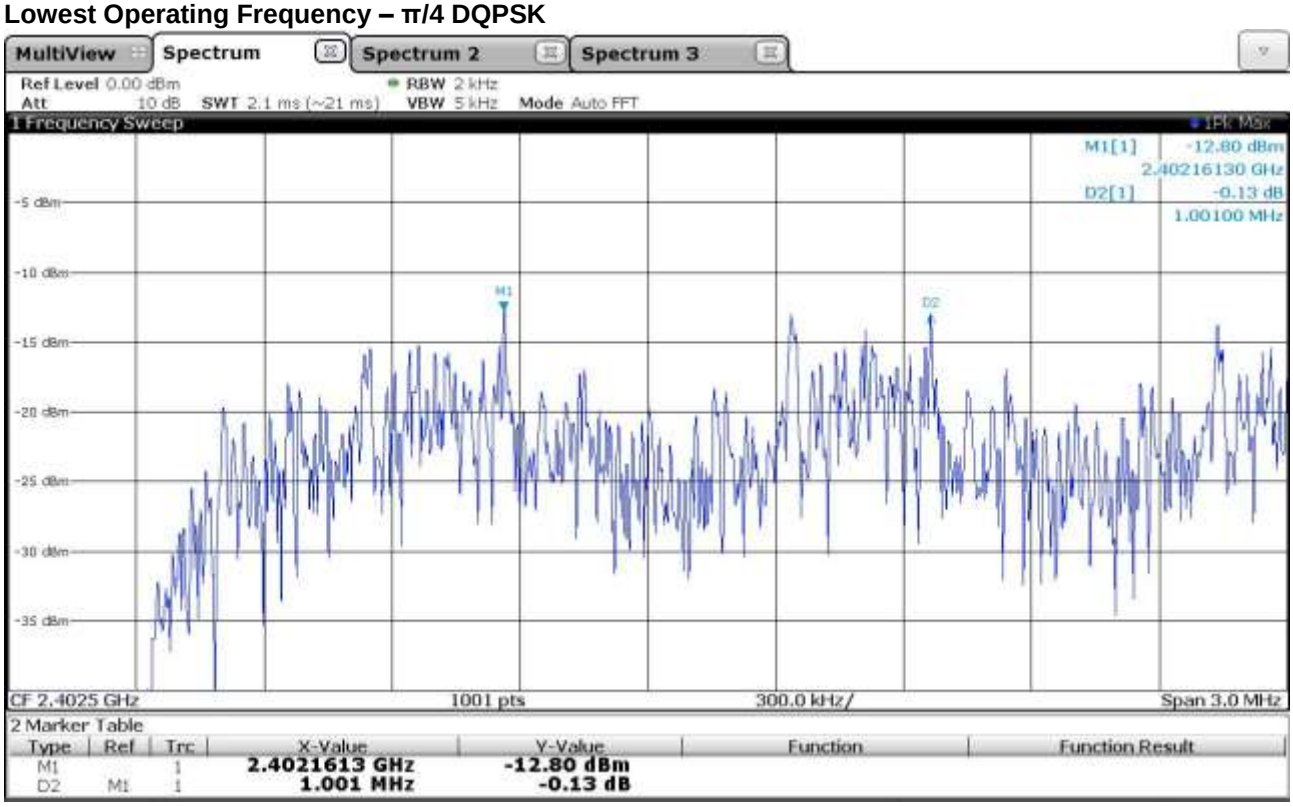


Highest Operating Frequency – GFSK

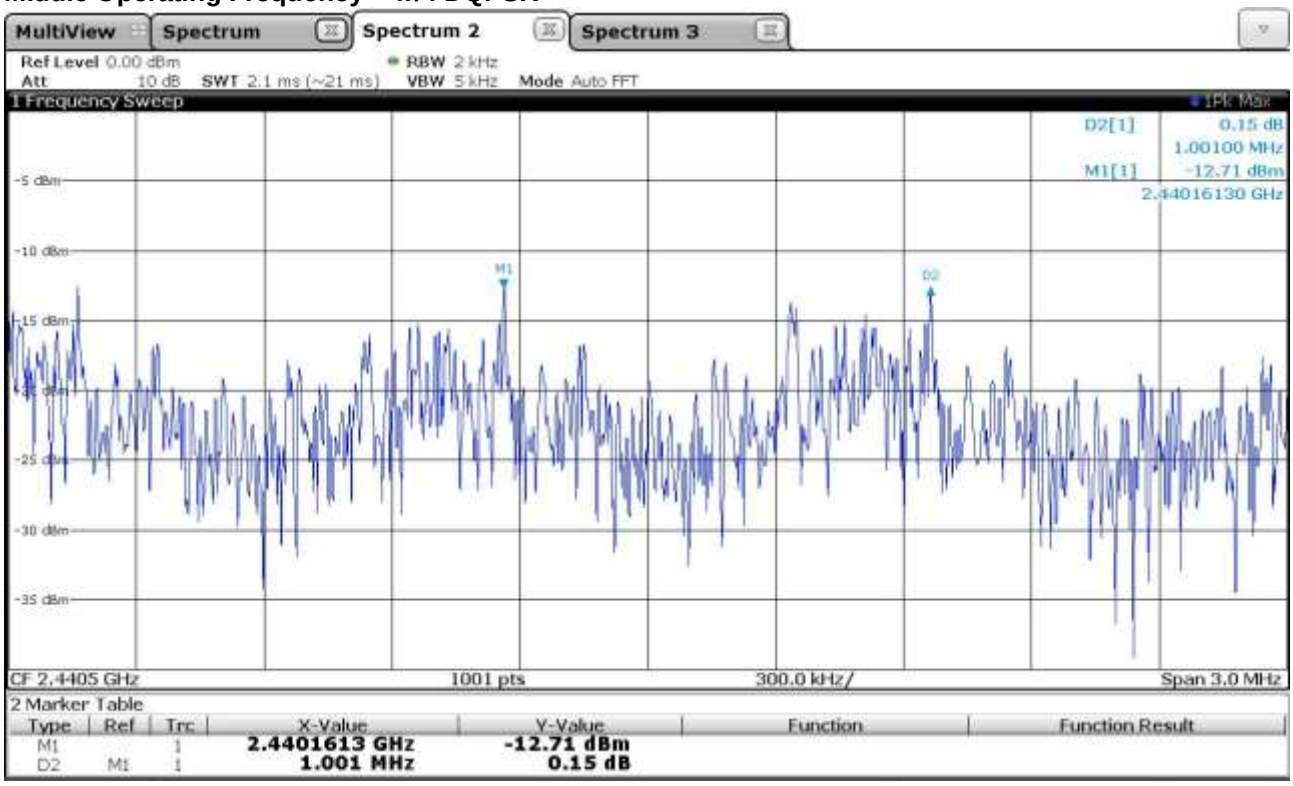


Summary of Channel seperation measurements – GFSK			
Tested Channel	**Channel seperation [kHz]**	**Limit = 2/3 BW [kHz]**	**Result**
Lowest	**1001**	**> 611.1**	**Pass**
Middle	**1001**	**> 611.1**	**Pass**
Highest	**1001**	**> 611.1**	**Pass**

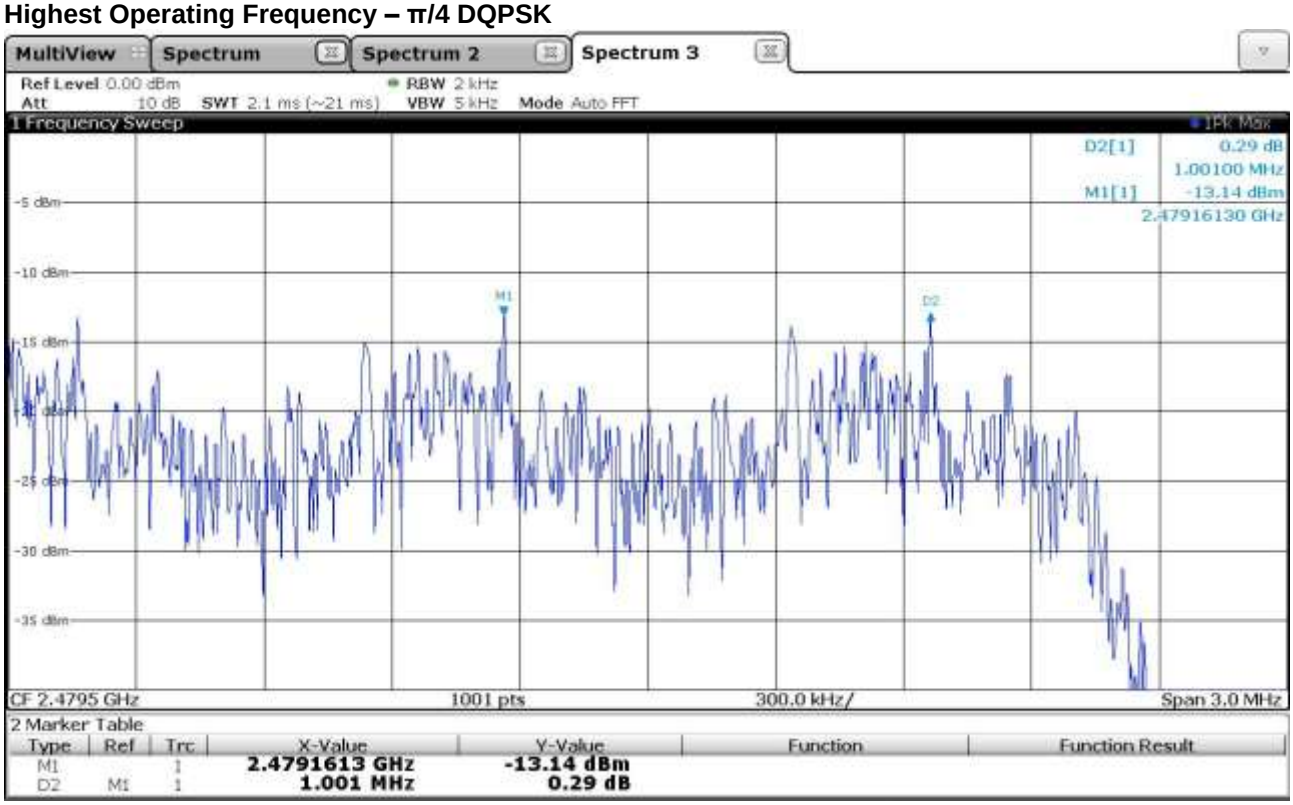
Lowest Operating Frequency – π/4 DQPSK



Middle Operating Frequency – π/4 DQPSK

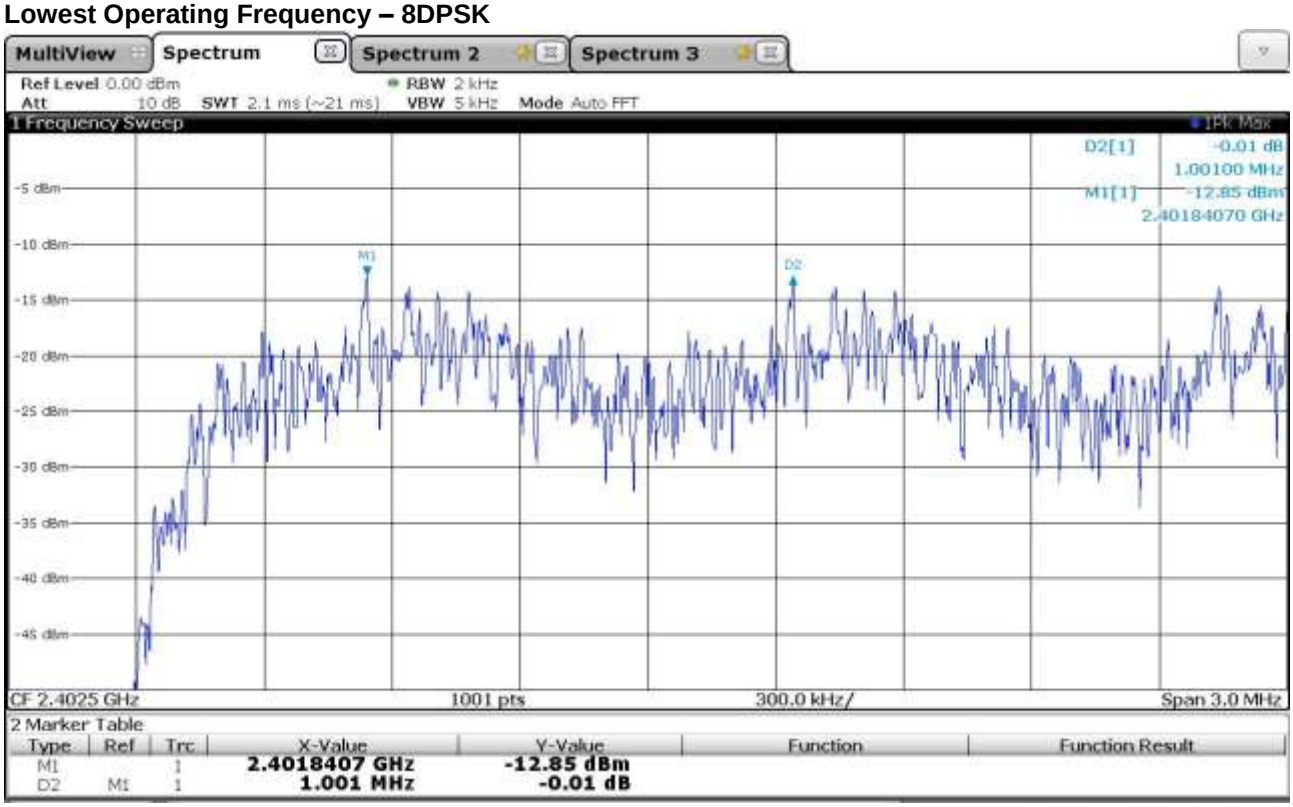


Highest Operating Frequency – π/4 DQPSK

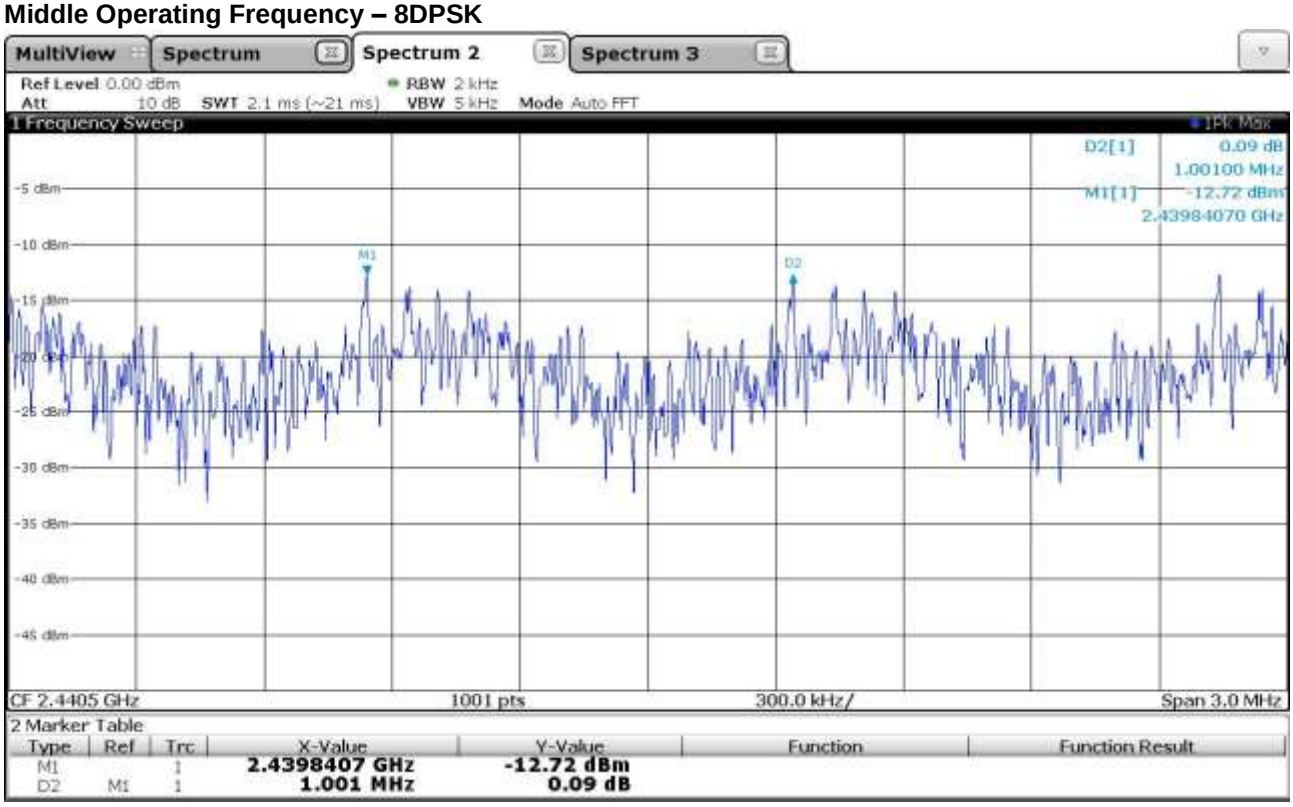


Summary of Channel seperation measurements – π/4 DQPSK			
Tested Channel	**Channel seperation [kHz]**	**Limit = 2/3 BW [kHz]**	**Result**
Lowest	**1001**	**> 849.1**	**Pass**
Middle	**1001**	**> 849.1**	**Pass**
Highest	**1001**	**> 849.1**	**Pass**

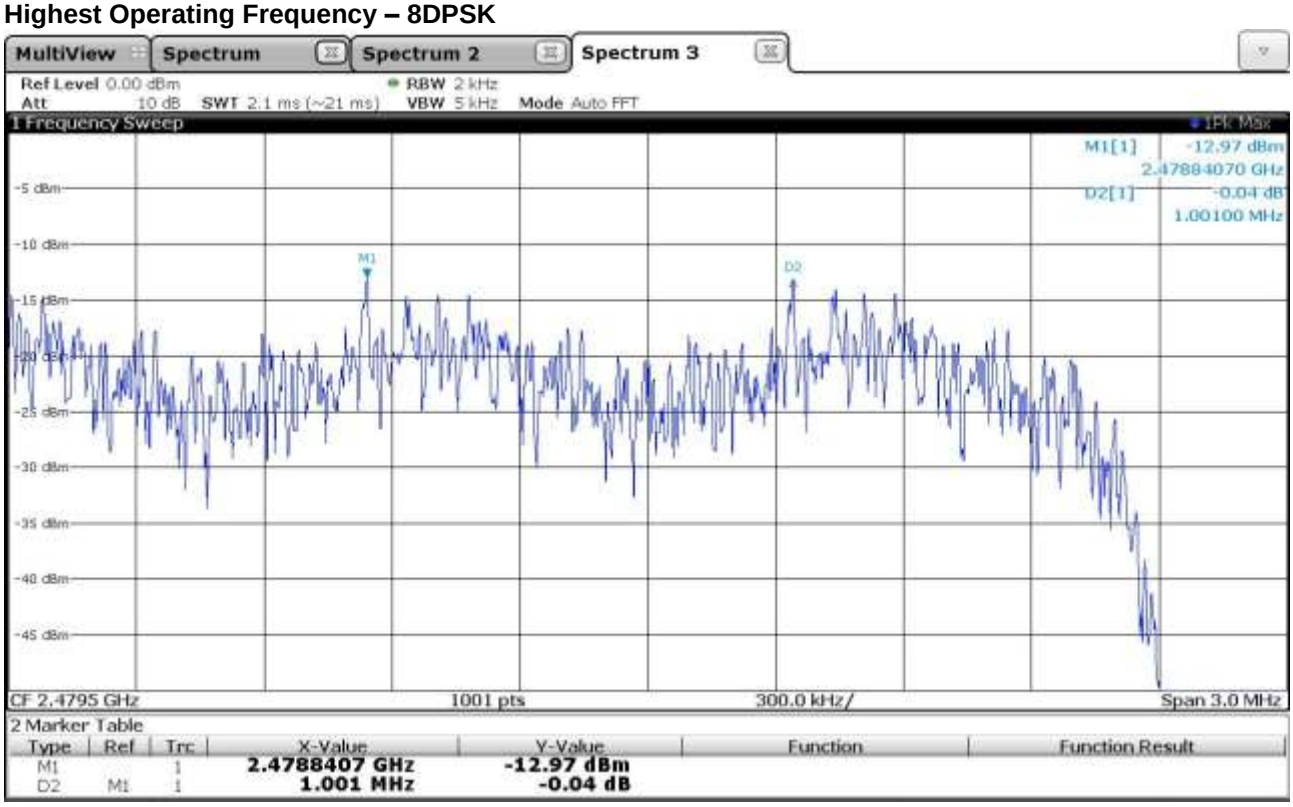
Lowest Operating Frequency – 8DPSK



Middle Operating Frequency – 8DPSK



Highest Operating Frequency – 8DPSK



Summary of Channel seperation measurements – 8DPSK			
Tested Channel	**Channel seperation [kHz]**	**Limit = 2/3 BW [kHz]**	**Result**
Lowest	**1001**	**> 805.9**	**Pass**
Middle	**1001**	**> 805.9**	**Pass**
Highest	**1001**	**> 805.9**	**Pass**

8.6. Band-Edges Measurement / Out of Band Emissions

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 requirments 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 requirments 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 restriced Band

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

Band Edge for non resticted Band

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

Measurement

The Measurement was performed on: 18.06.2020

TESTED IN GERMANY

FCC 3

Band edge emission

according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Product: Transmitting/Receiving System

Sample: 02

Date: 18.06.2020

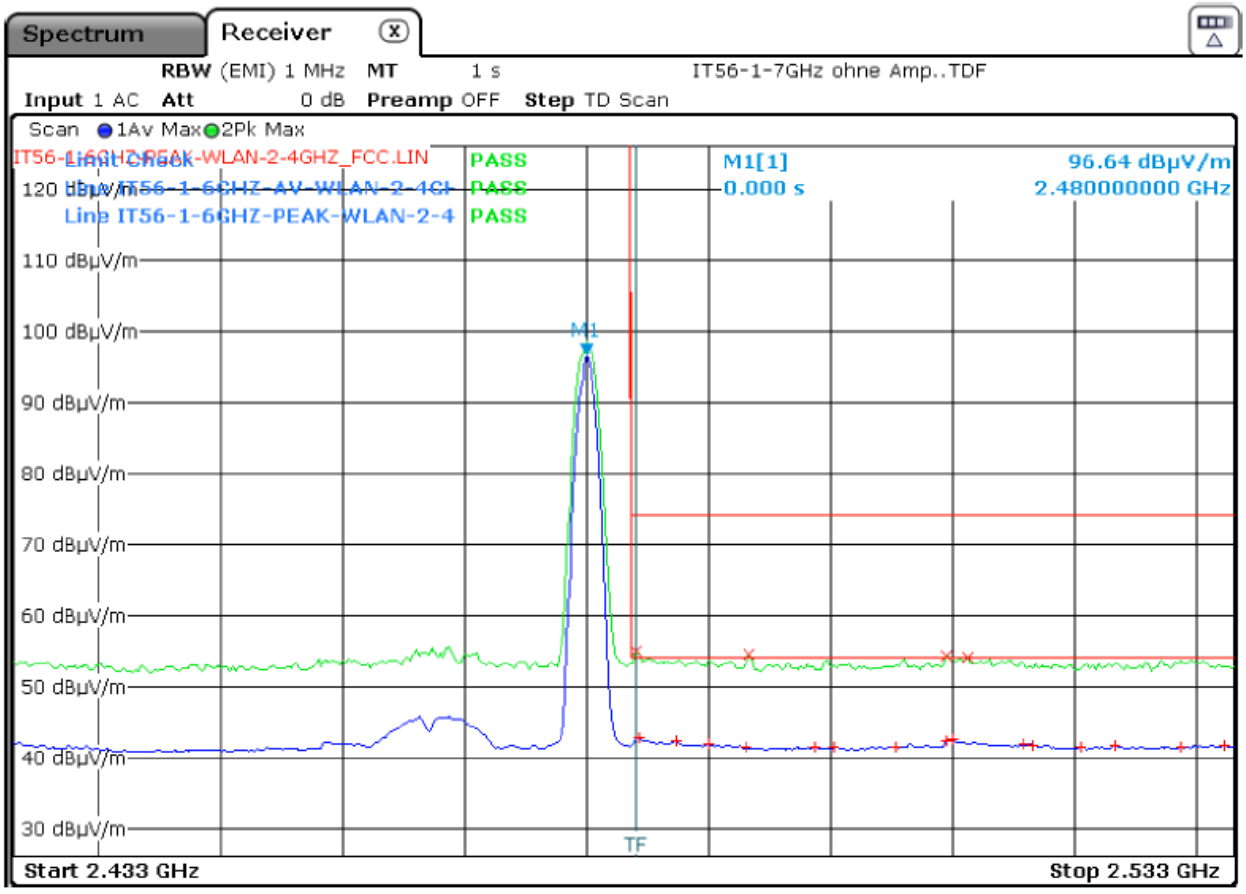
Operator: BI

Remarks:

pass fail

Result: ☒ ☐

Operation mode: BT CH.78; 8DPSK; 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
2,4843	42,80	-11,20	54,00	pass	2,4840	54,94	-19,06	74,00	pass
2,5100	42,43	-11,57	54,00	pass	2,4933	54,45	-19,55	74,00	pass
2,5095	42,40	-11,60	54,00	pass	2,5095	54,23	-19,77	74,00	pass
2,4873	42,36	-11,64	54,00	pass	2,5113	54,01	-19,99	74,00	pass
2,4900	41,90	-12,10	54,00	pass					
2,5158	41,81	-12,19	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

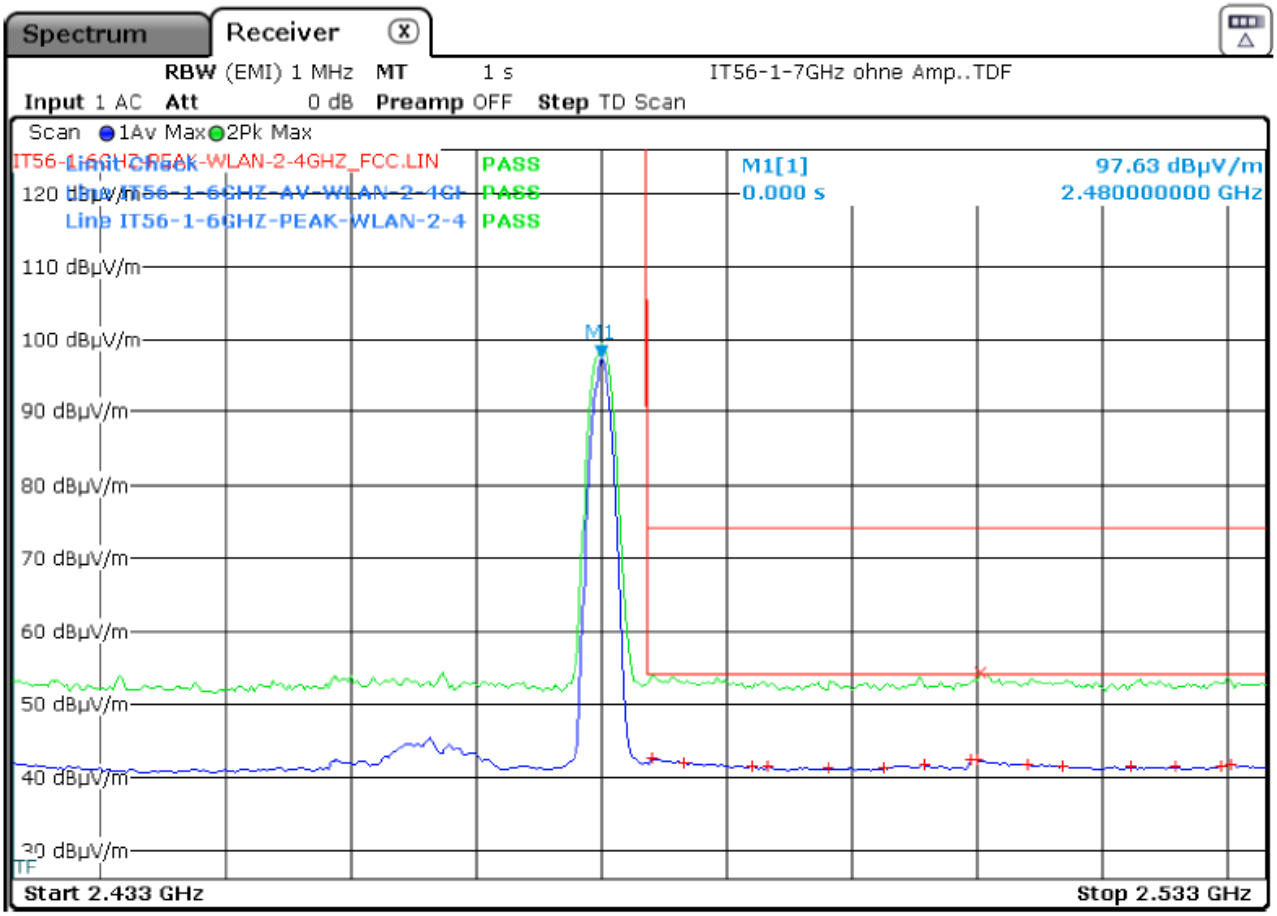
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.78; 8DPSK; High Edge



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
2,4840	42,45	-11,55	54,00	pass	2,5103	54,20	-19,80	74,00	pass
2,5100	42,24	-11,76	54,00	pass					
2,5095	42,22	-11,78	54,00	pass					
2,4865	41,89	-12,11	54,00	pass					
2,5058	41,70	-12,30	54,00	pass					
2,5140	41,68	-12,32	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

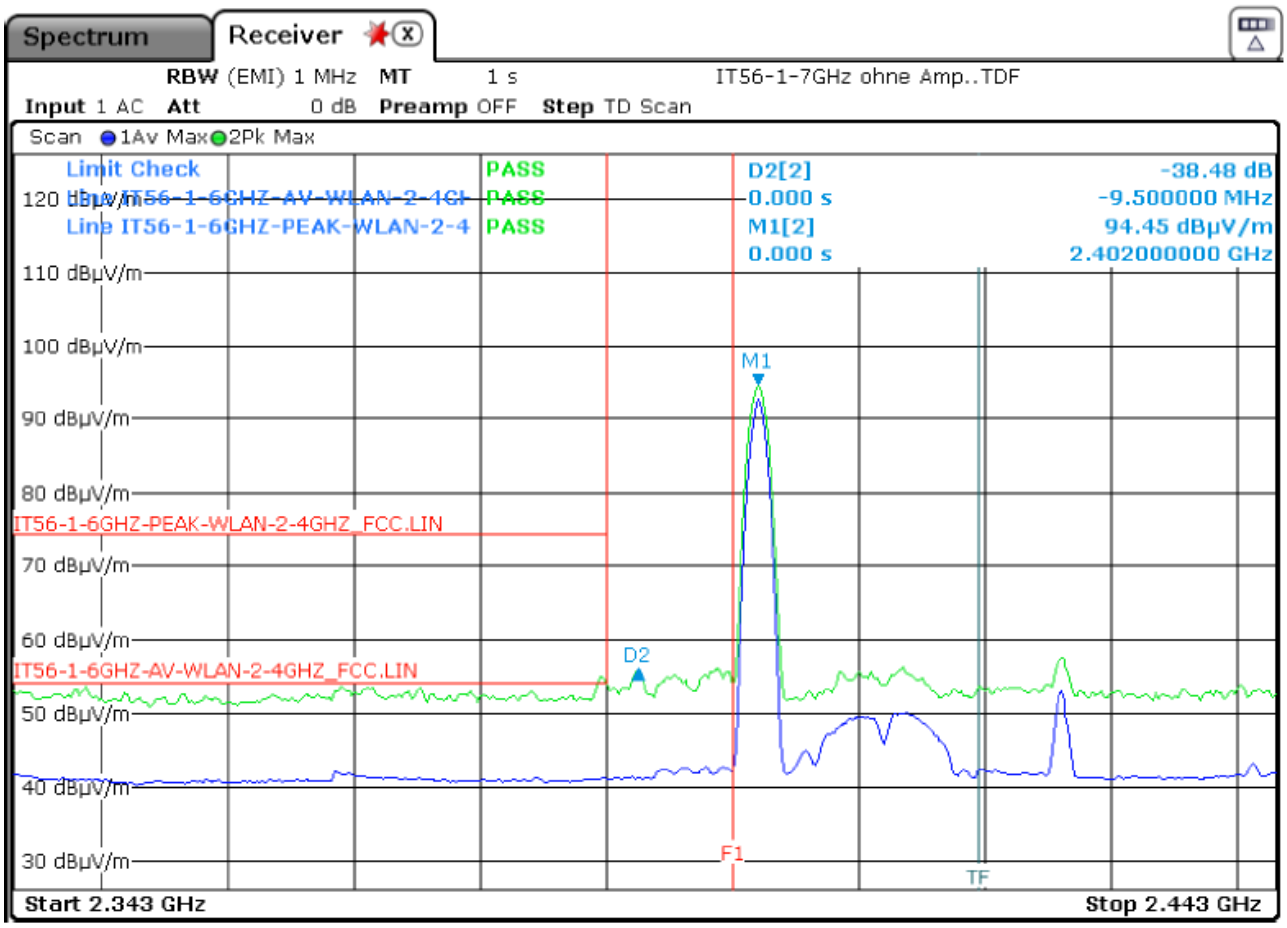
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.0; 8DPSK; Low 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

TESTED IN GERMANY

FCC 3

Band edge emission

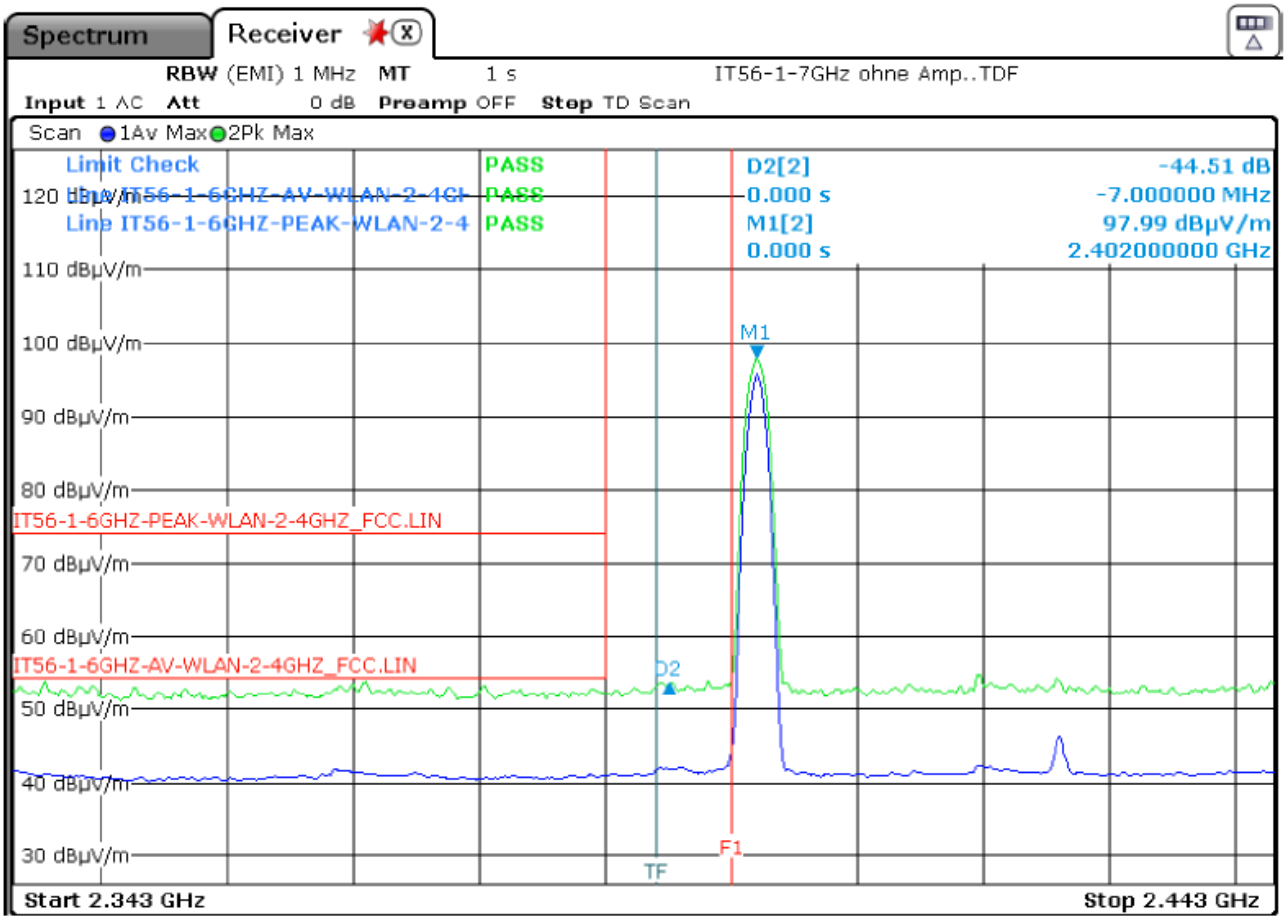
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.0; 8DPSK; Low Edge



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

TESTED IN GERMANY

FCC 3

Band edge emission

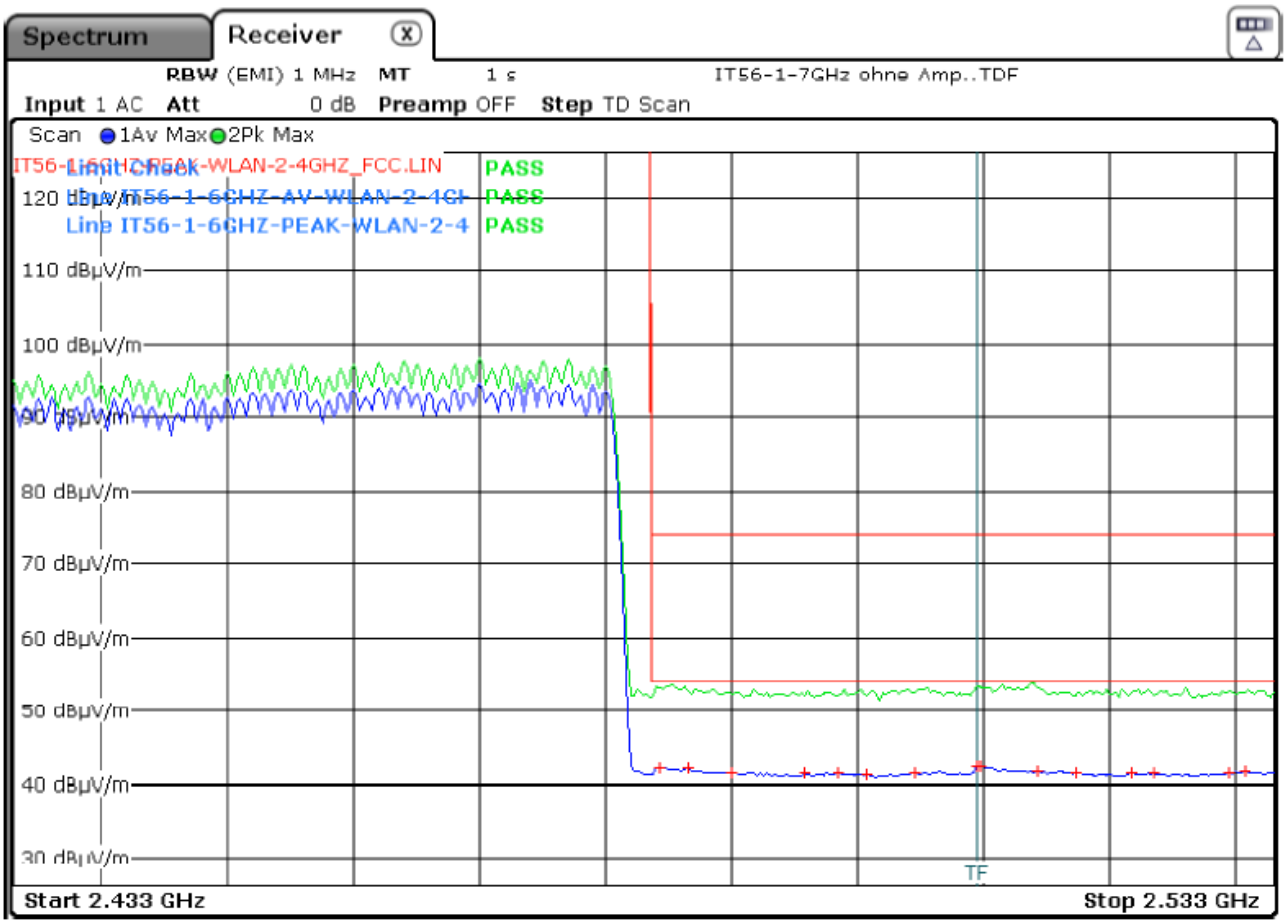
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping 8DPSK; 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
2,5098	42,34	-11,66	54,00	pass	all emissions are 10dB below limit				pass
2,5095	42,23	-11,77	54,00	pass					
2,4843	42,18	-11,82	54,00	pass					
2,4865	42,11	-11,89	54,00	pass					
2,5143	41,69	-12,31	54,00	pass					
2,5308	41,61	-12,39	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

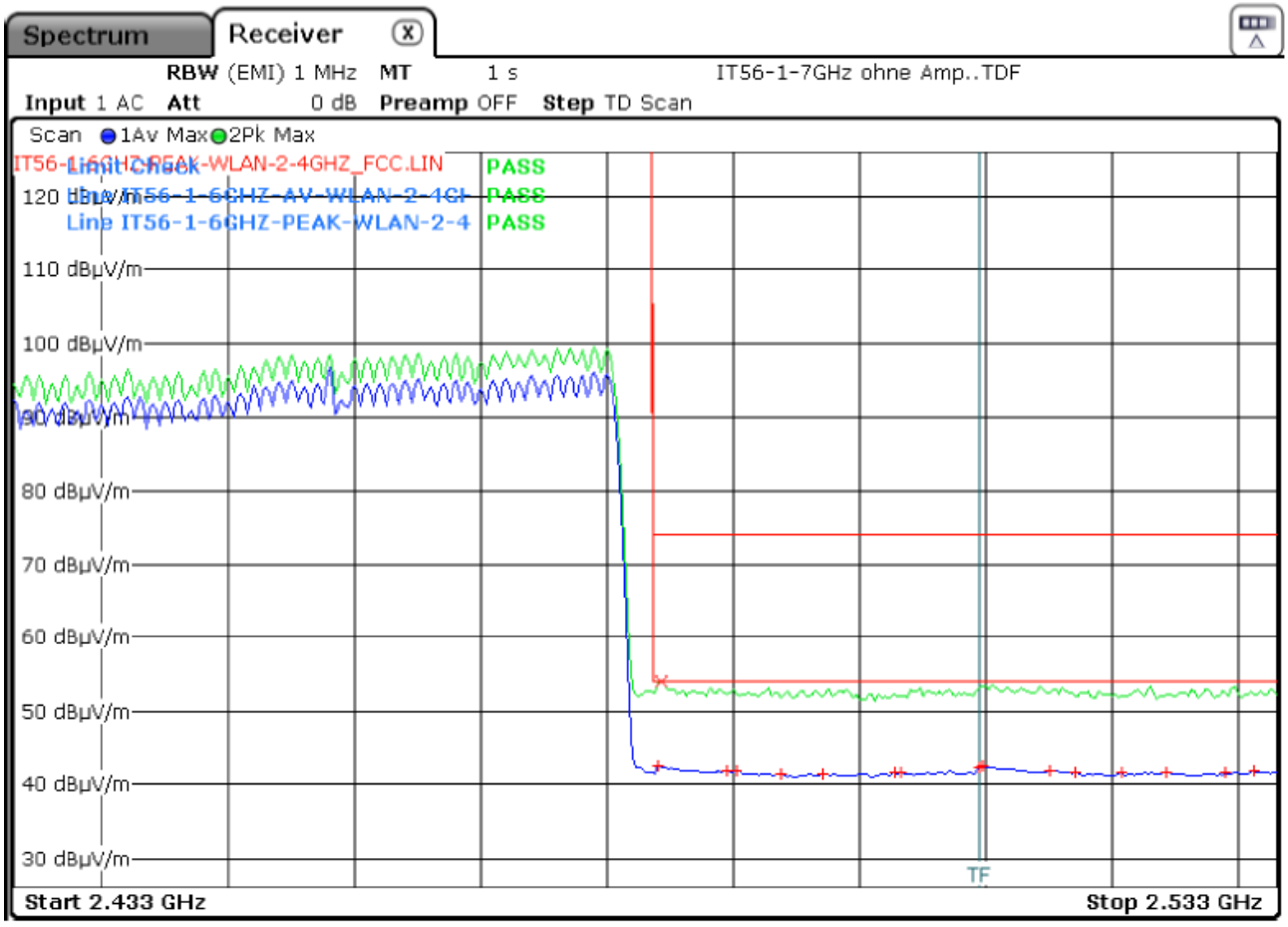
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping 8DPSK; High Edge



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
2,4840	42,38	-11,62	54,00	pass	2,4843	54,11	-19,89	74,00	pass
2,5098	42,25	-11,75	54,00	pass					
2,5095	42,17	-11,83	54,00	pass					
2,4903	41,69	-12,31	54,00	pass					
2,4895	41,66	-12,34	54,00	pass					
2,5150	41,65	-12,35	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

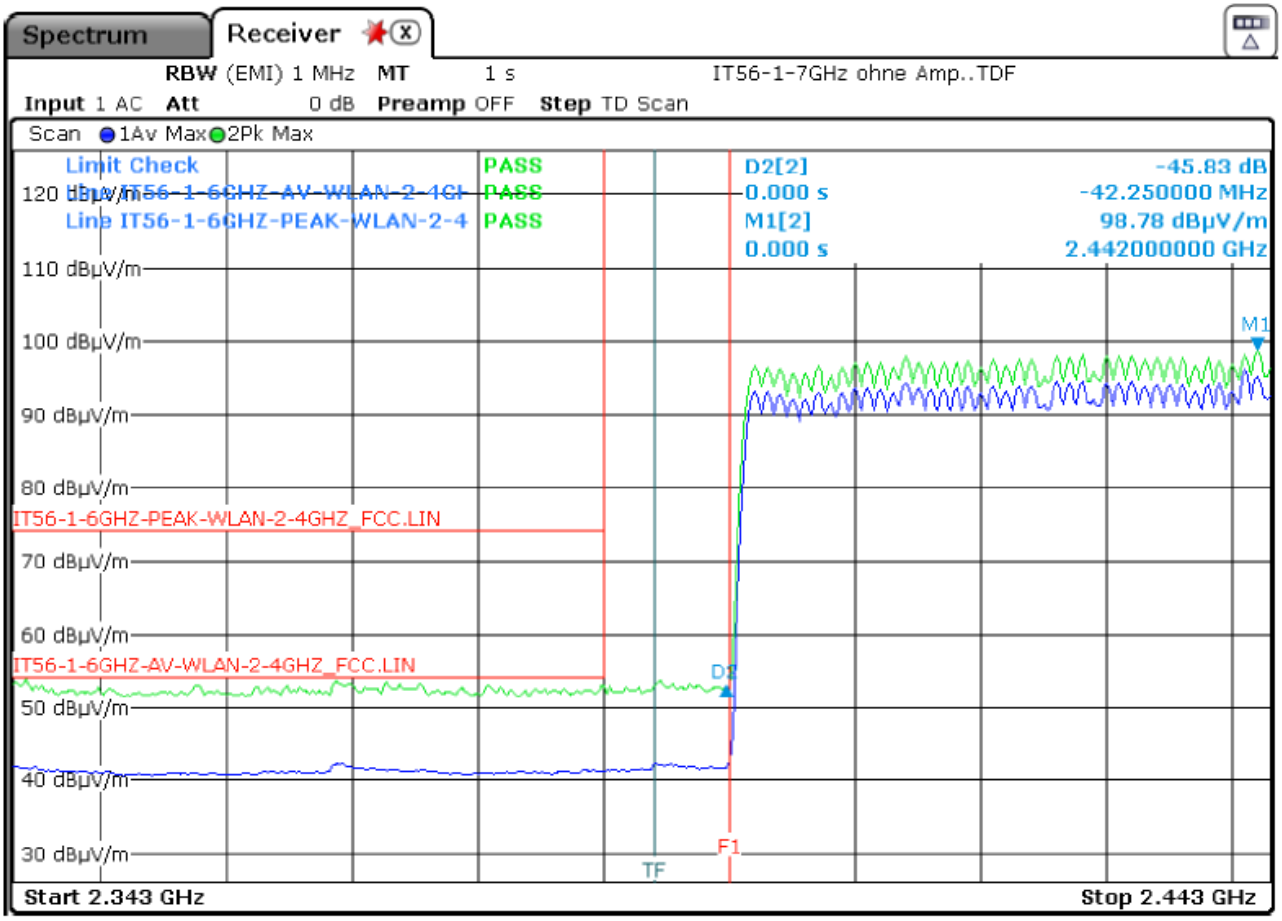
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping 8DPSK; Low 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

TESTED IN GERMANY

FCC 3

Band edge emission

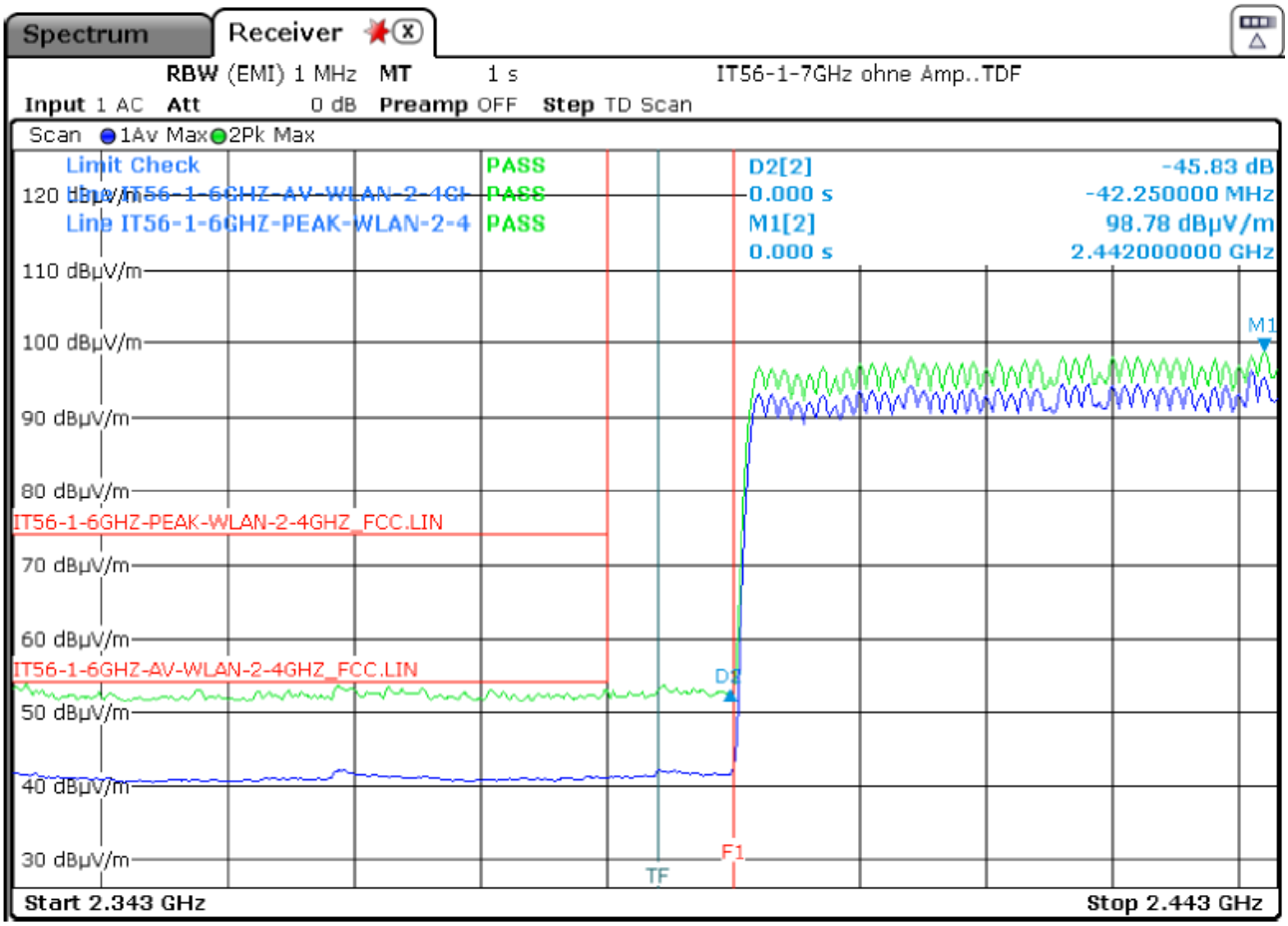
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping 8DPSK; Low Edge



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

TESTED IN GERMANY

FCC 3

Band edge emission

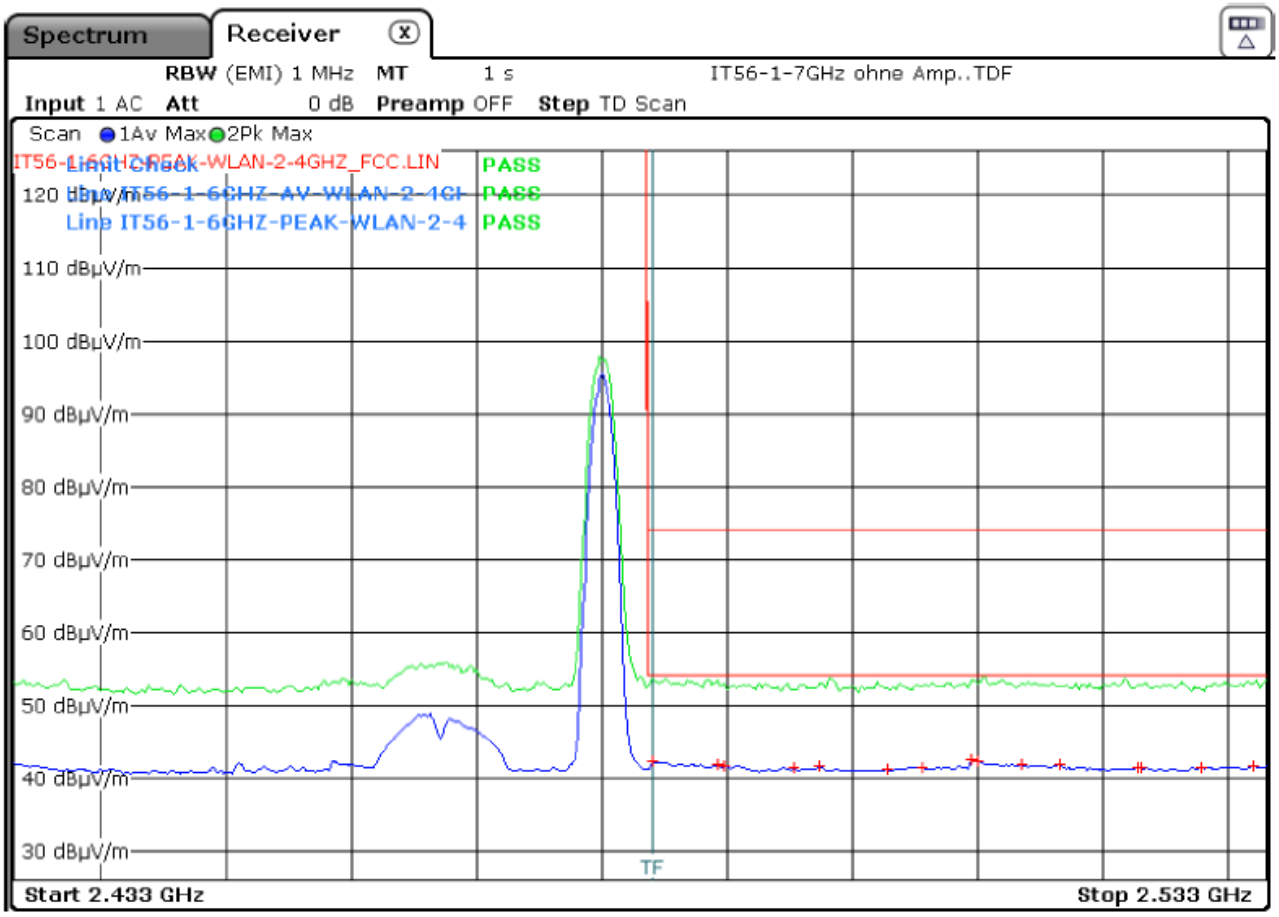
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.78; $\pi/4$ DQPSK; 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
2,5095	42,57	-11,43	54,00	pass	all emissions are 10dB below limit				pass
2,5100	42,39	-11,61	54,00	pass					
2,4840	42,24	-11,76	54,00	pass					
2,5165	41,86	-12,14	54,00	pass					
2,5135	41,86	-12,14	54,00	pass					
2,4893	41,81	-12,19	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

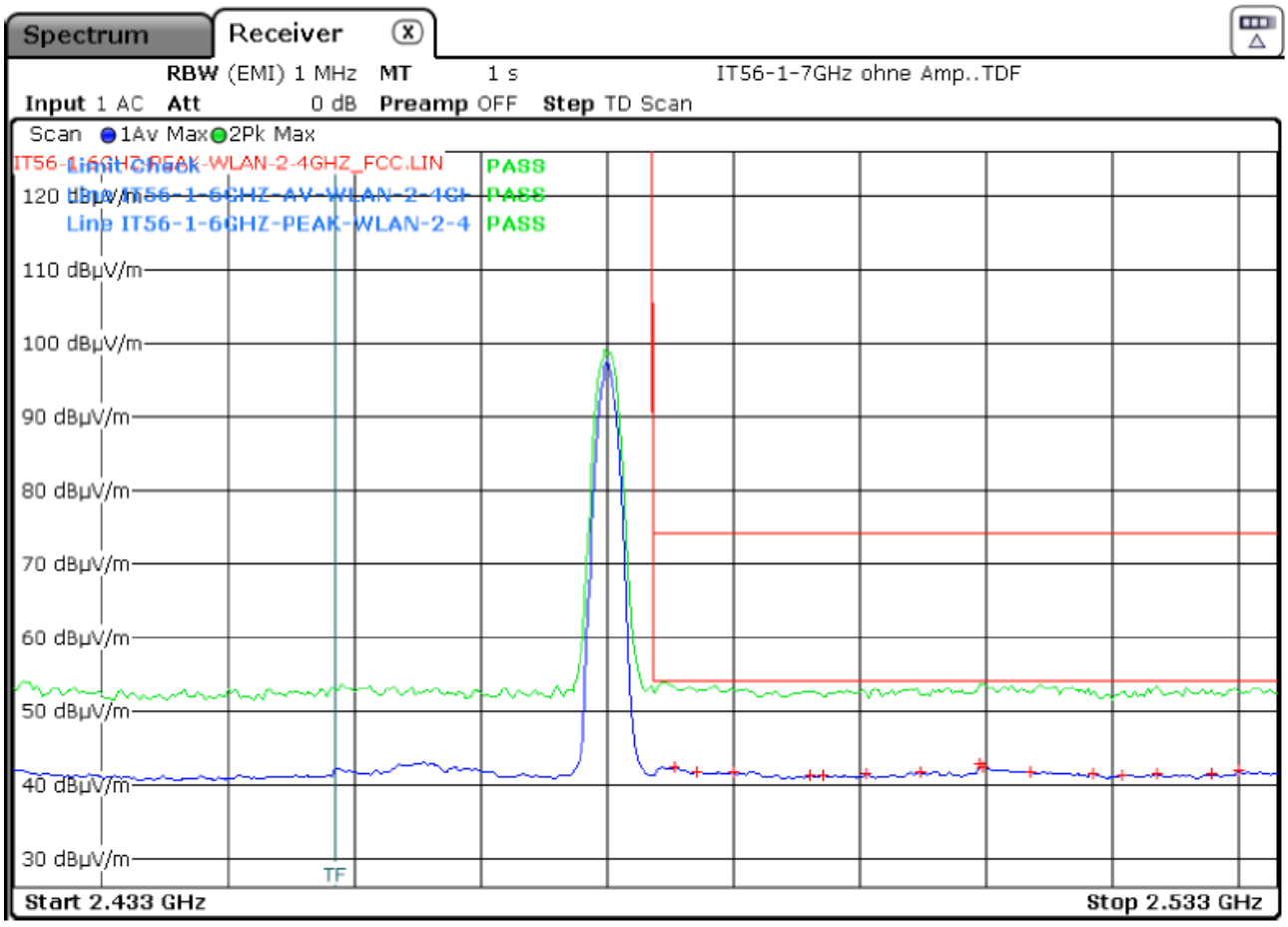
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.78; $\pi/4$ DQPSK; High Edge



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
2,5095	42,68	-11,32	54,00	pass	all emissions are 10dB below limit				pass
2,5098	42,40	-11,60	54,00	pass					
2,4853	42,23	-11,77	54,00	pass					
2,5300	41,84	-12,16	54,00	pass					
2,4870	41,75	-12,25	54,00	pass					
2,5048	41,69	-12,31	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

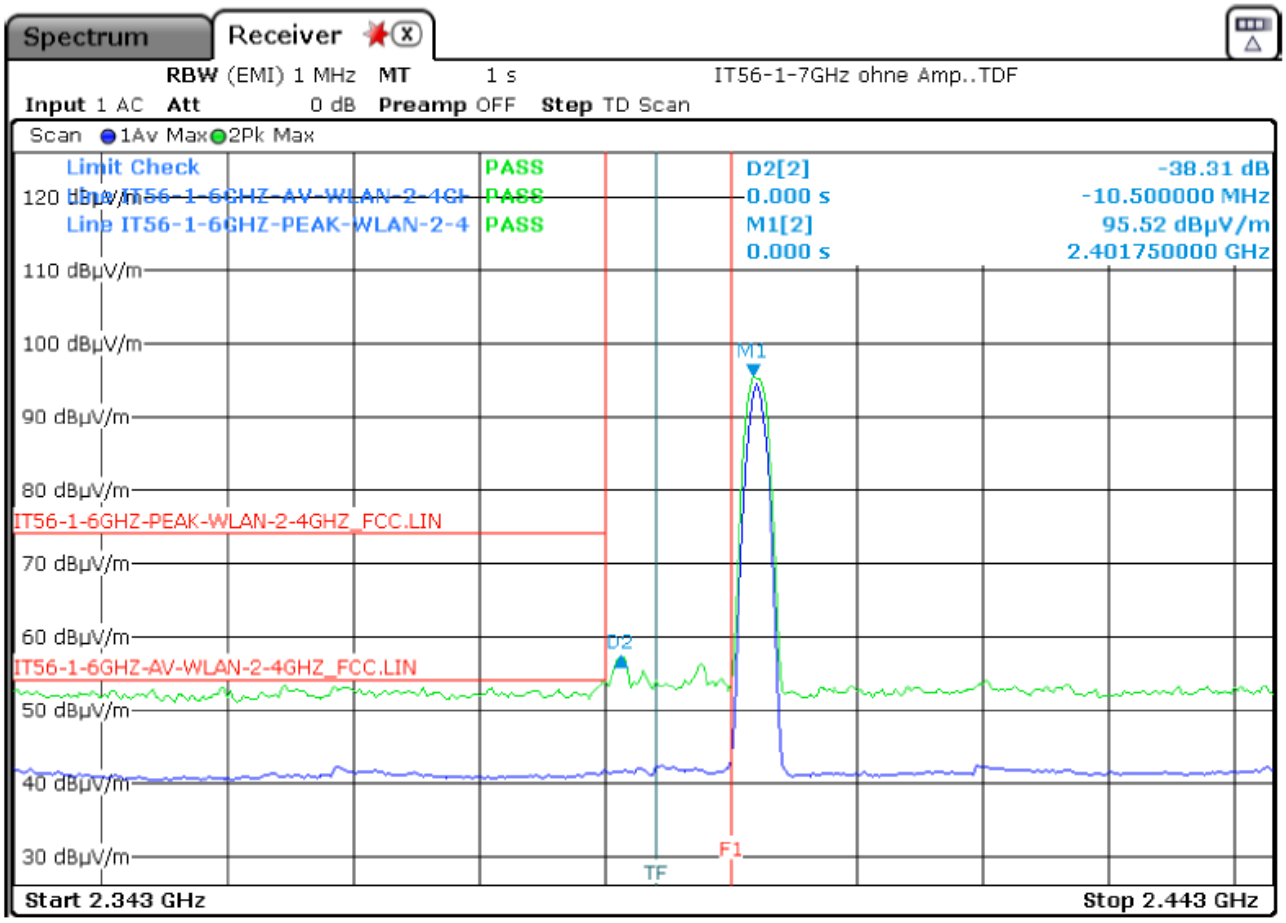
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

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

TESTED IN GERMANY

FCC 3

Band edge emission

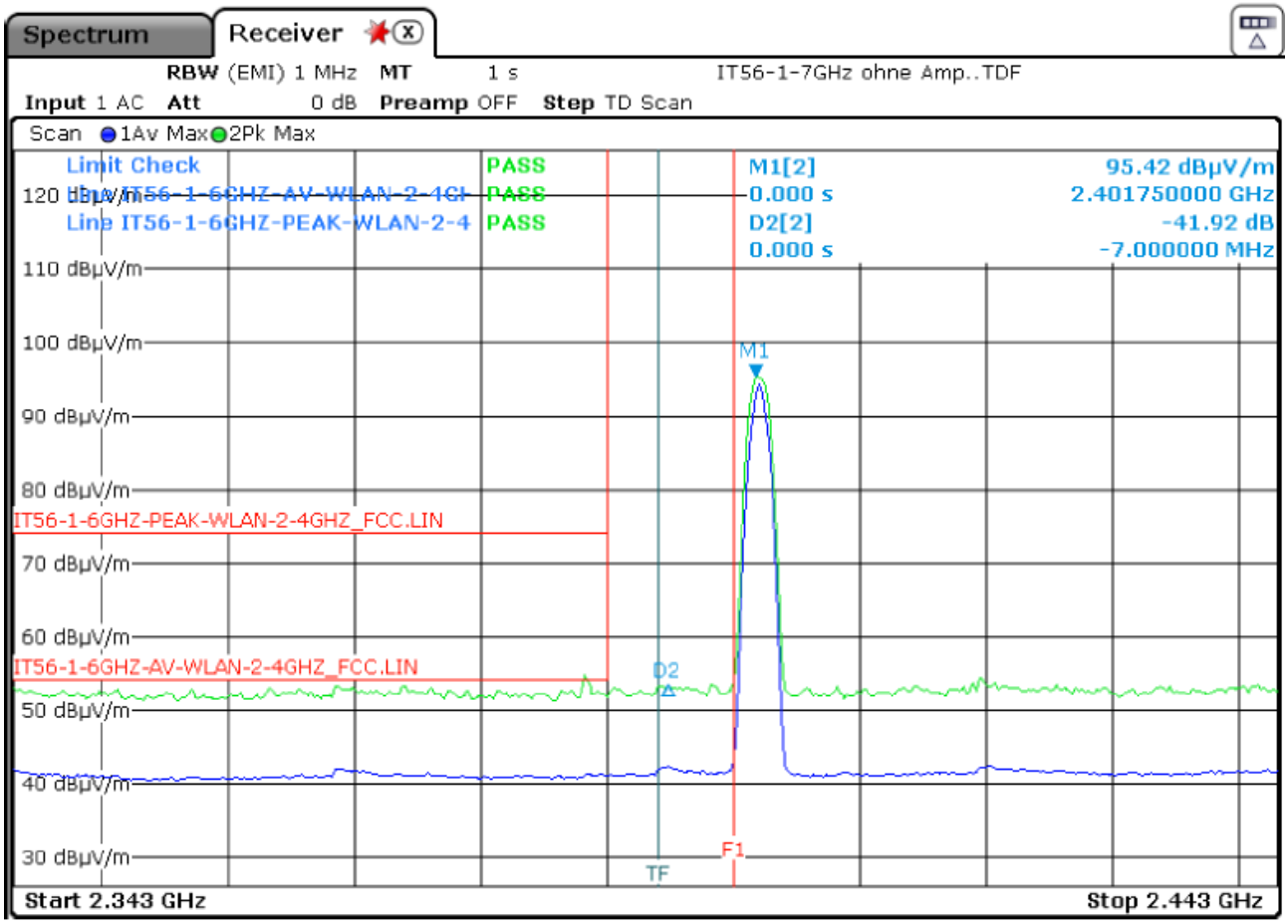
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.0; $\pi/4$ DQPSK; Low Edge



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

TESTED IN GERMANY

FCC 3

Band edge emission

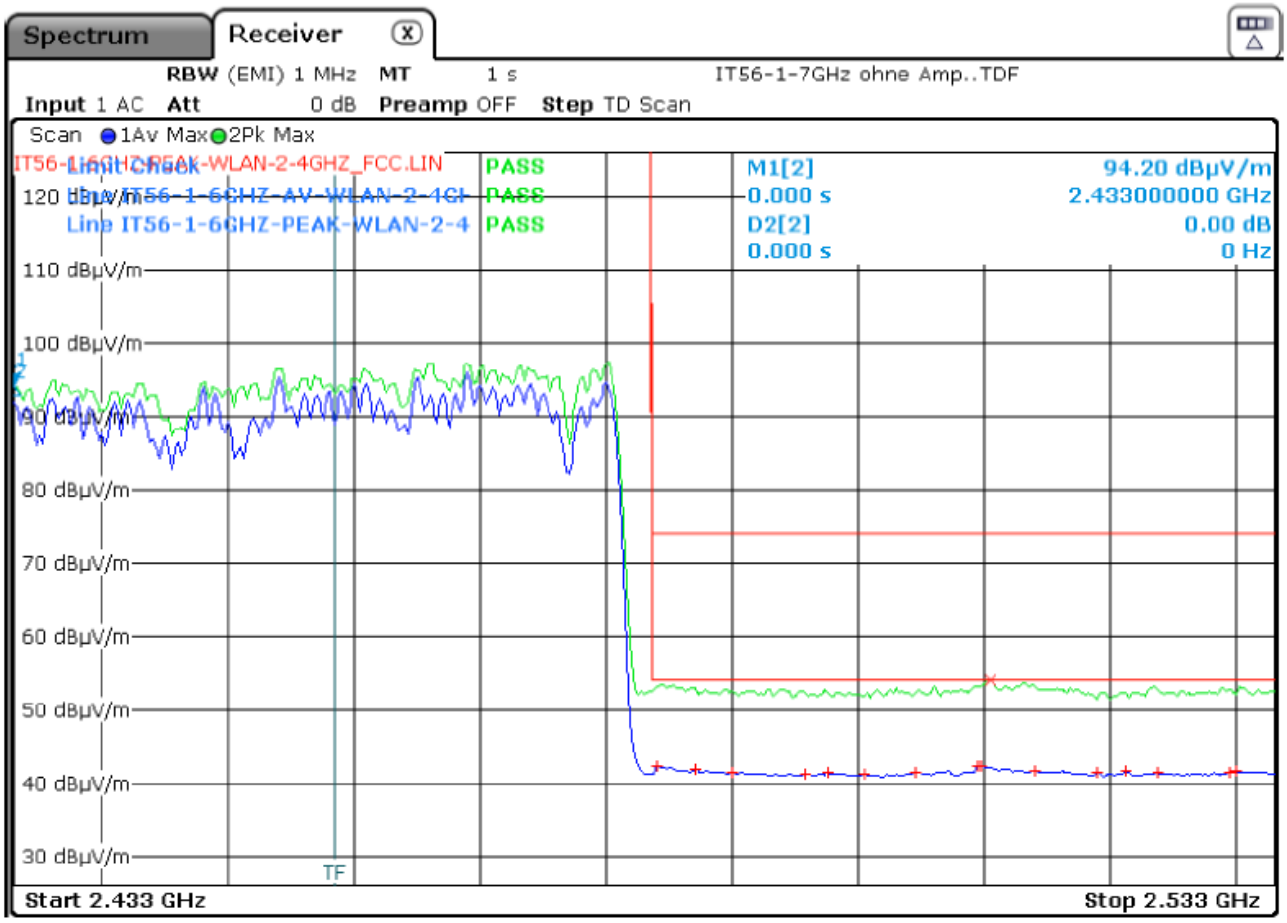
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT ; Hopping $\pi/4$ DQPSK; 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
2,4840	42,35	-11,65	54,00	pass	2,5105	54,15	-19,85	74,00	pass
2,5098	42,34	-11,66	54,00	pass					
2,5095	42,27	-11,73	54,00	pass					
2,4870	41,88	-12,12	54,00	pass					
2,5140	41,68	-12,32	54,00	pass					
2,5213	41,59	-12,41	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

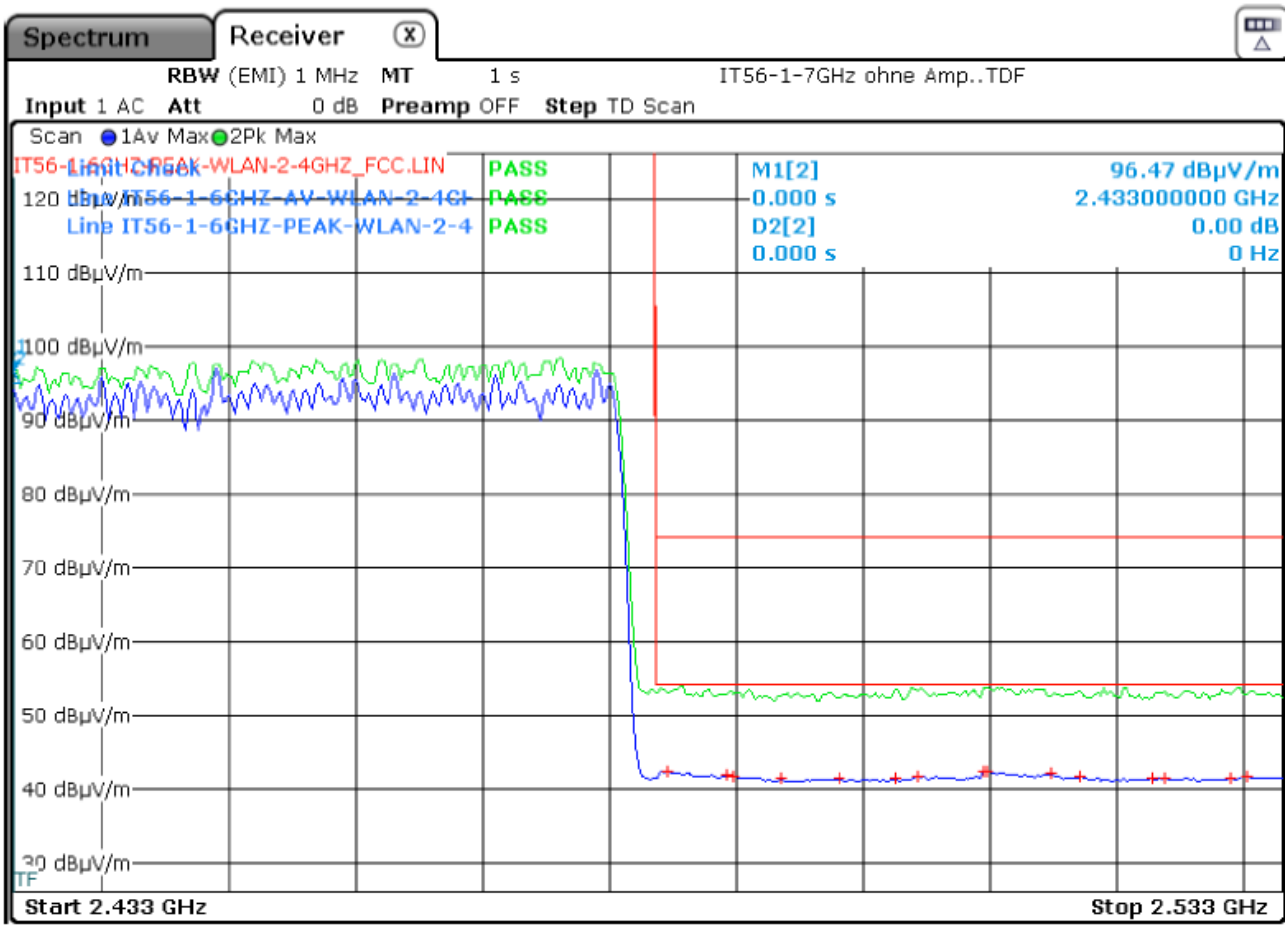
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT ; Hopping $\pi/4$ DQPSK; High Edge



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
2,5098	42,41	-11,59	54,00	pass	all emissions are 10dB below limit				pass
2,4845	42,38	-11,62	54,00	pass					
2,5095	42,22	-11,78	54,00	pass					
2,5148	42,02	-11,98	54,00	pass					
2,4893	41,82	-12,18	54,00	pass					
2,5043	41,71	-12,29	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

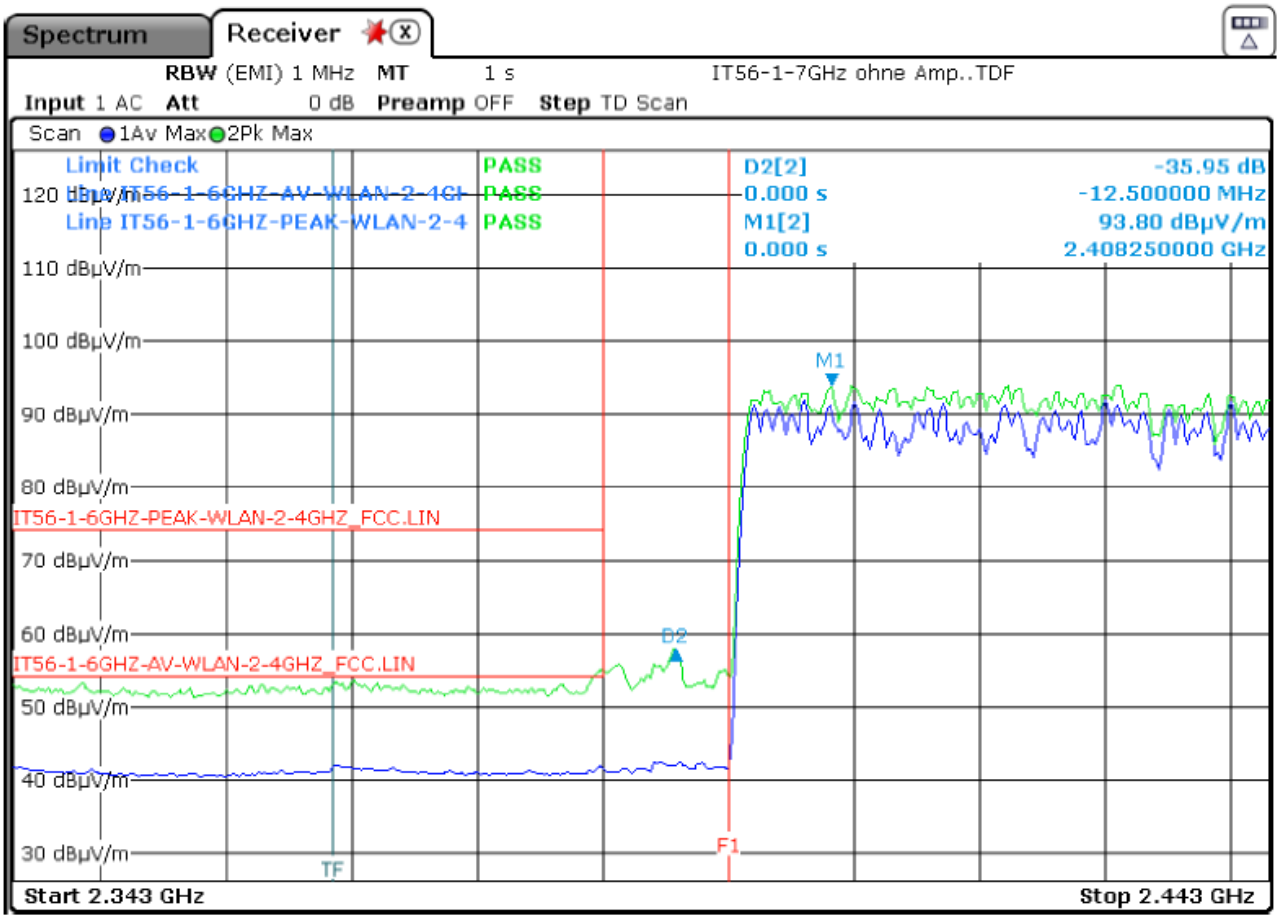
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT ; Hopping $\pi/4$ DQPSK; Low 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

TESTED IN GERMANY

FCC 3

Band edge emission

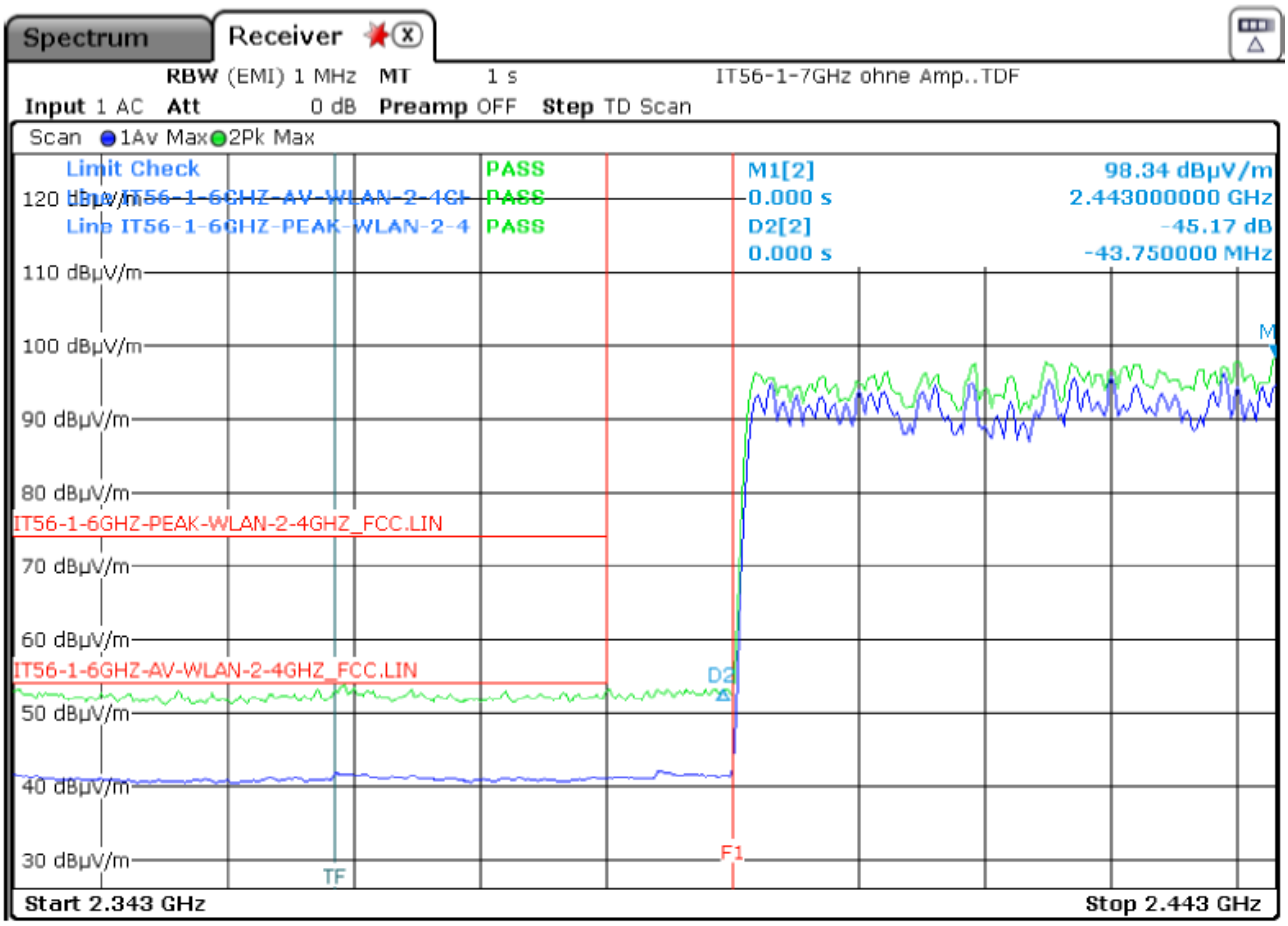
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT ; Hopping $\pi/4$ DQPSK; Low Edge



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

TESTED IN GERMANY

FCC 3

Band edge emission

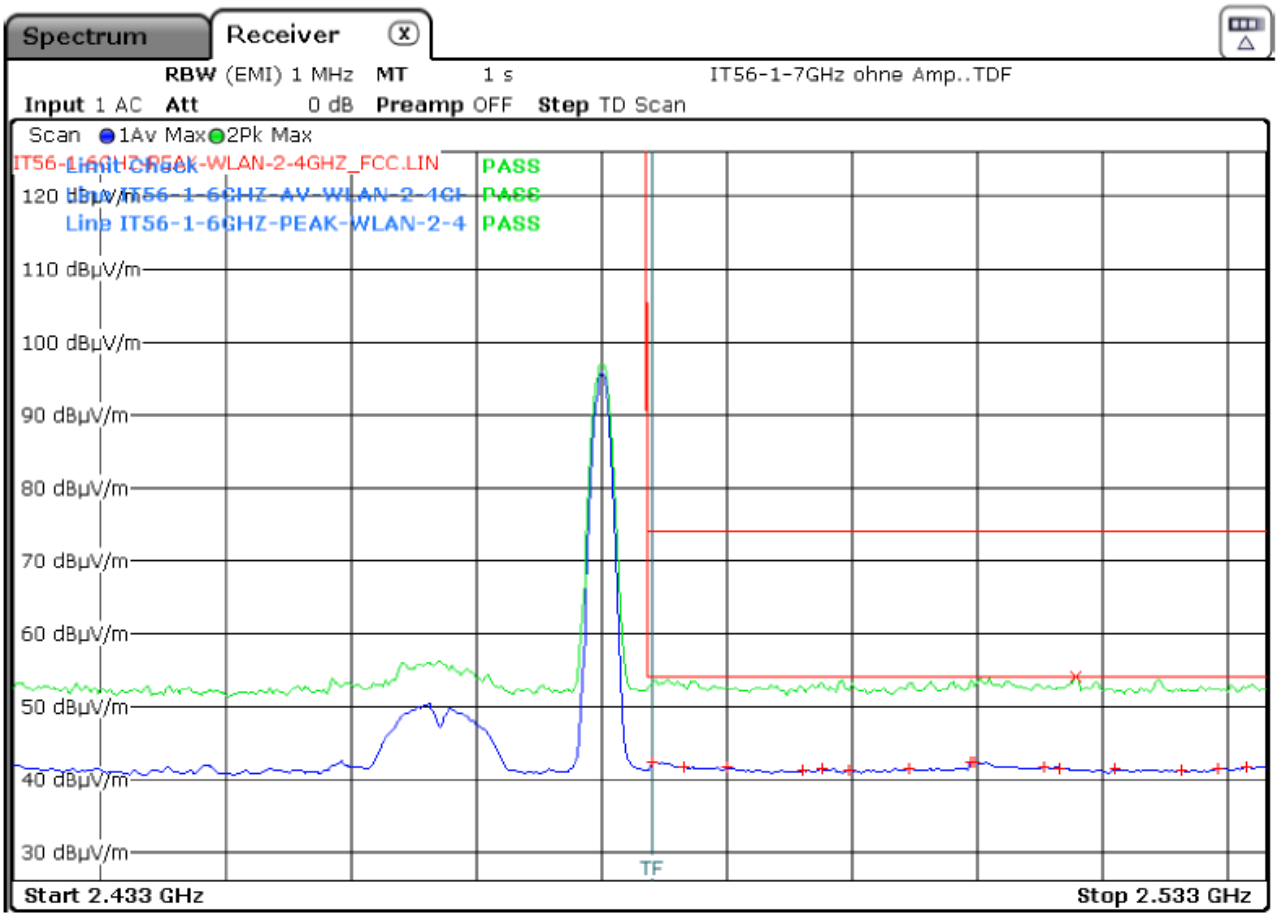
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.78; GFSK; 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
2,5098	42,34	-11,66	54,00	pass	2,5178	54,02	-19,98	74,00	pass
2,5095	42,29	-11,71	54,00	pass					
2,4840	42,24	-11,76	54,00	pass					
2,4865	41,72	-12,28	54,00	pass					
2,5153	41,70	-12,30	54,00	pass					
2,5315	41,66	-12,34	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

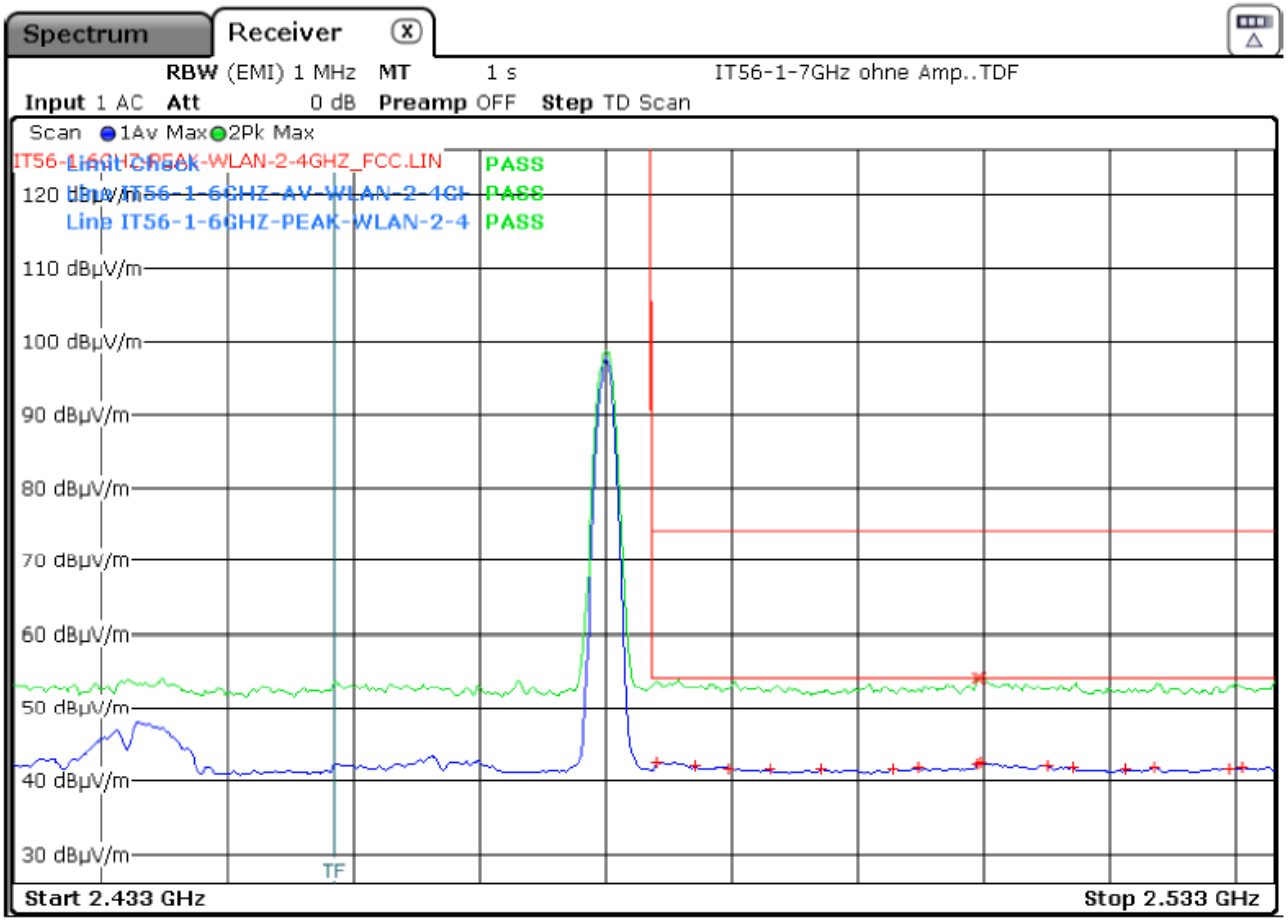
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.78; GFSK; High Edge



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
2,4840	42,32	-11,68	54,00	pass	2,5095	54,15	-19,85	74,00	pass
2,5098	42,22	-11,78	54,00	pass	2,5098	54,04	-19,96	74,00	pass
2,5095	42,05	-11,95	54,00	pass					
2,5150	41,86	-12,14	54,00	pass					
2,4870	41,80	-12,20	54,00	pass					
2,5235	41,69	-12,31	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

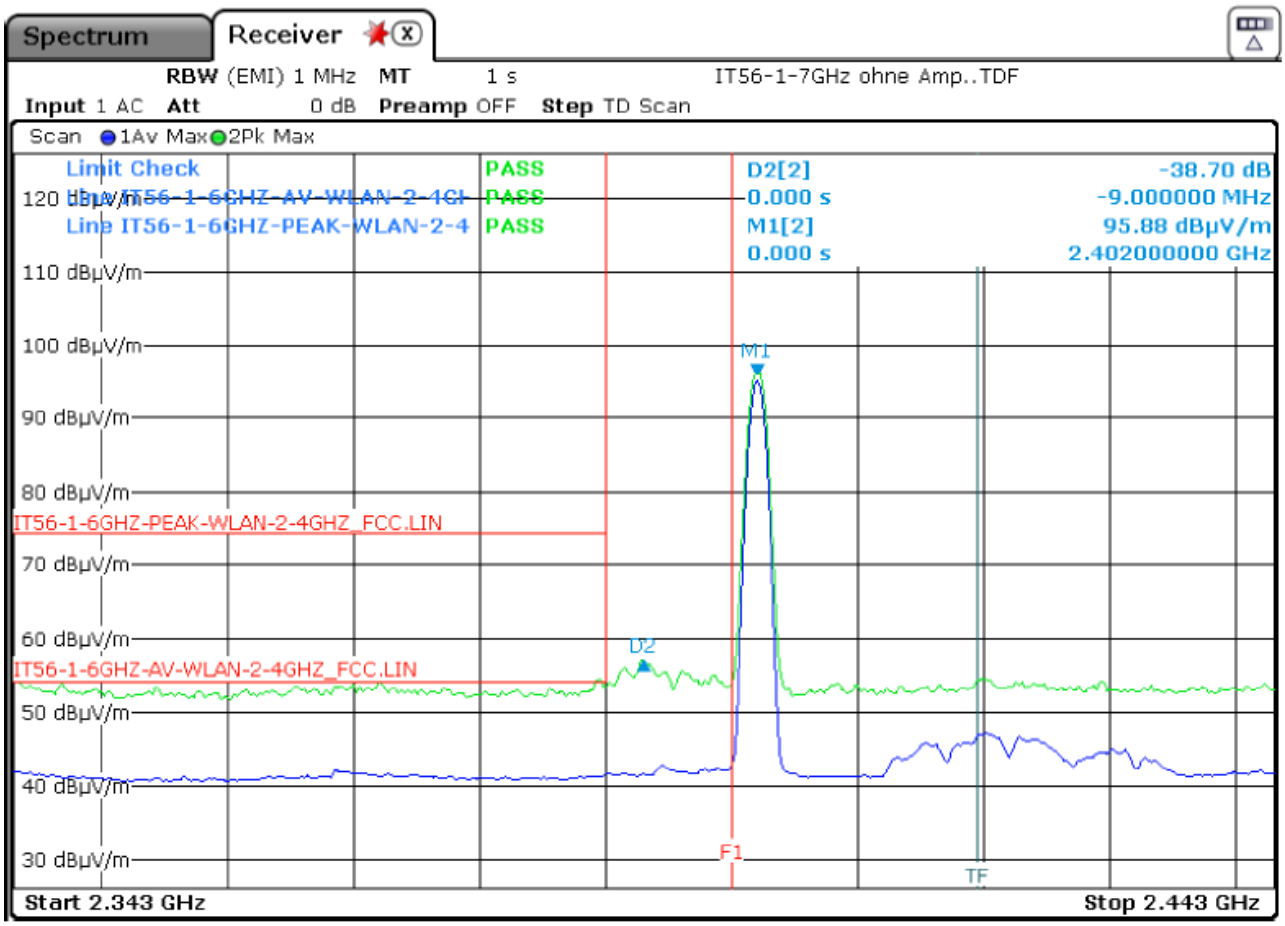
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.0; GFSK; Low 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

TESTED IN GERMANY

FCC 3

Band edge emission

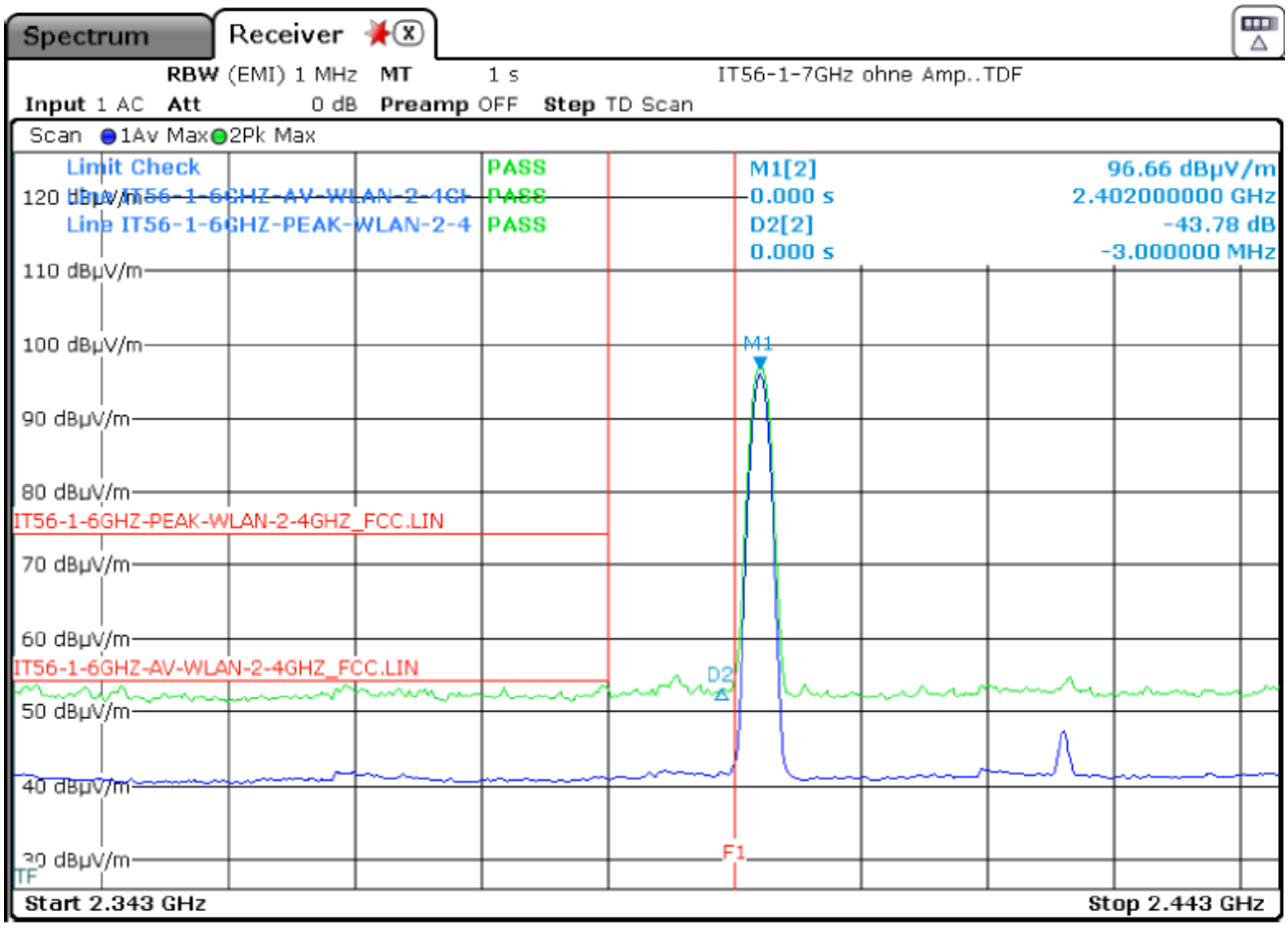
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT CH.0; GFSK; Low Edge



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

TESTED IN GERMANY

FCC 3

Band edge emission

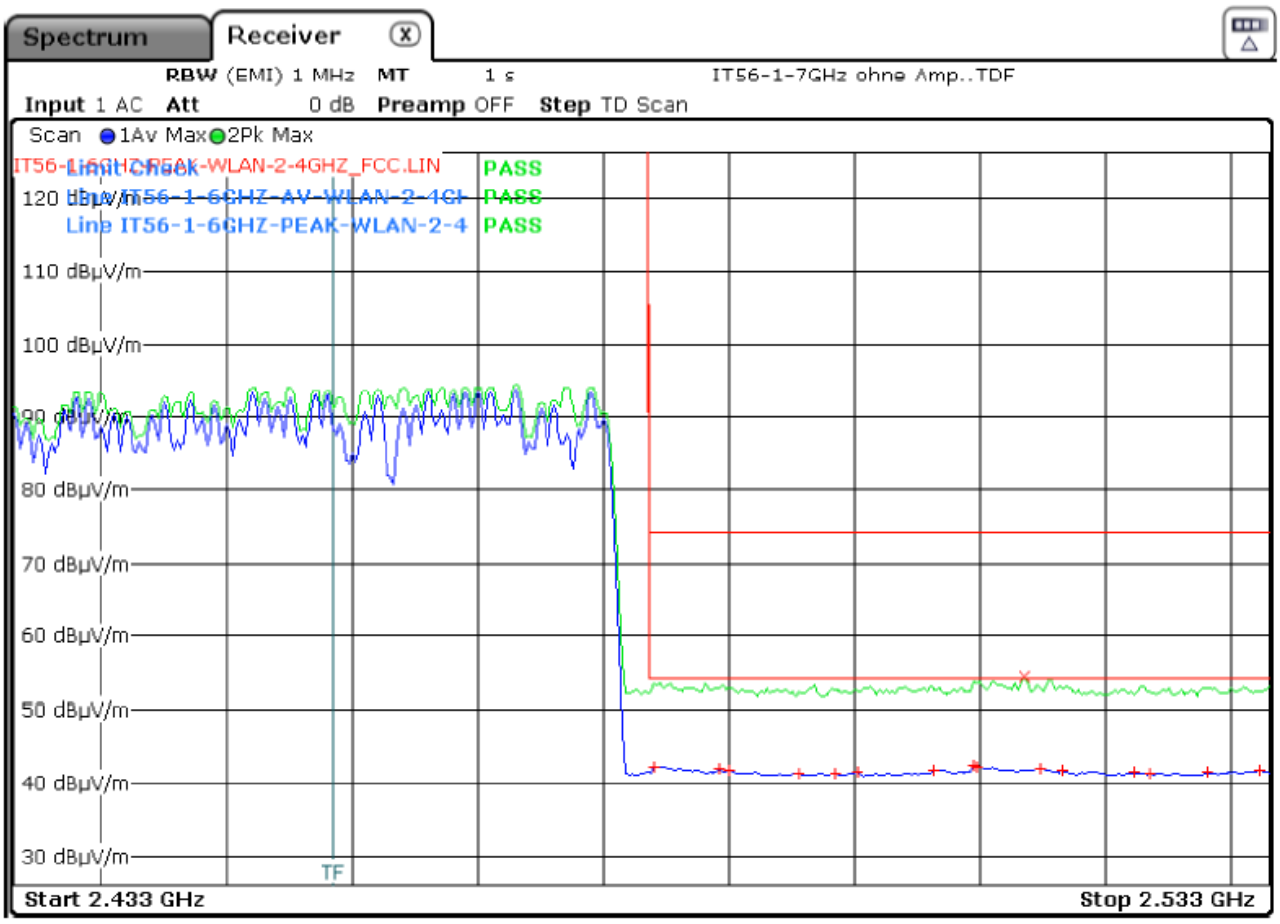
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping GFSK; 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
2,5095	42,22	-11,78	54,00	pass	2,5135	54,26	-19,74	74,00	pass
2,5098	42,11	-11,89	54,00	pass					
2,4840	42,09	-11,91	54,00	pass					
2,5148	41,92	-12,08	54,00	pass					
2,4893	41,79	-12,21	54,00	pass					
2,4900	41,71	-12,29	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

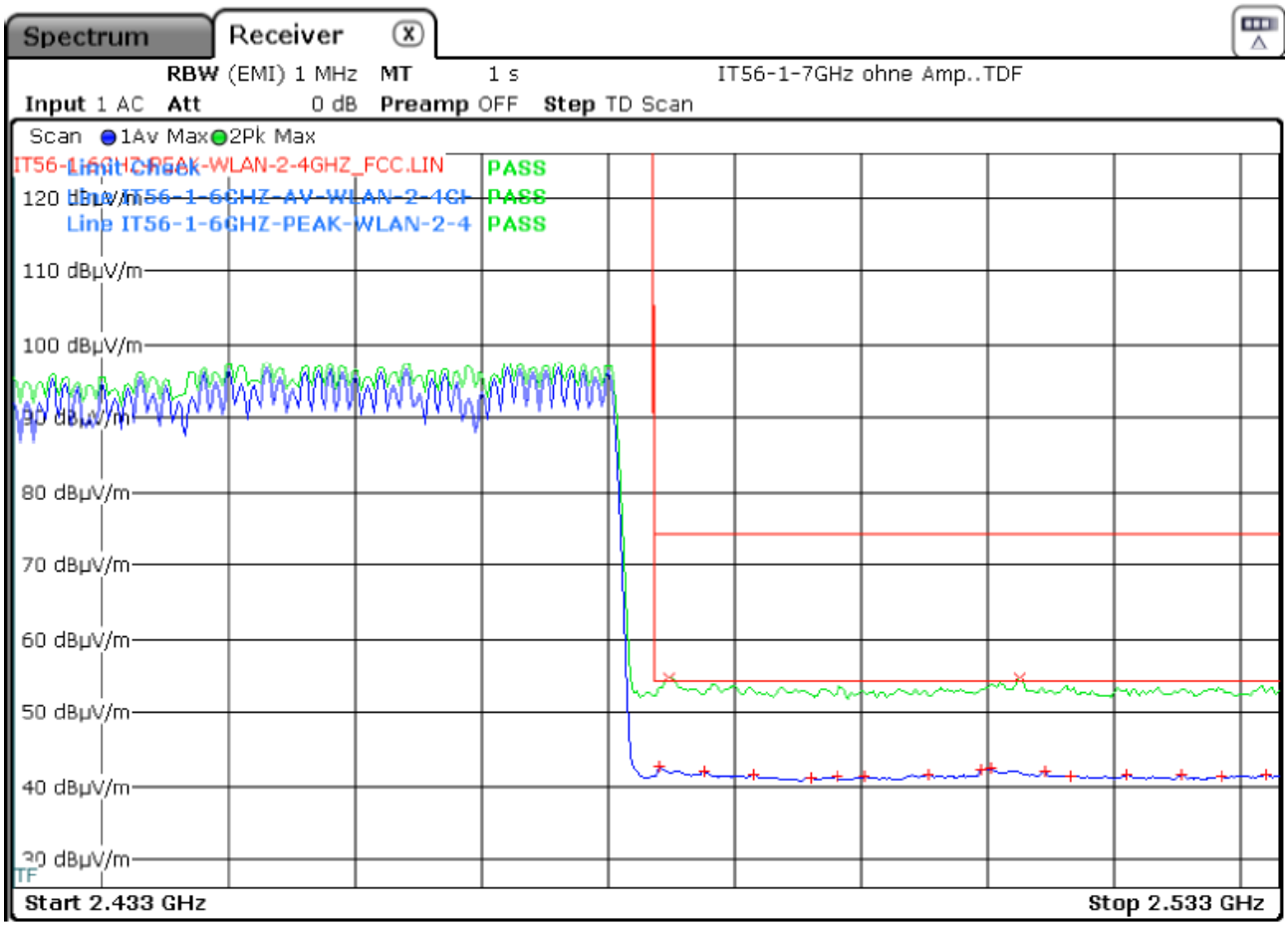
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping GFSK; High Edge



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
2,4840	42,69	-11,31	54,00	pass	2,4848	54,71	-19,29	74,00	pass
2,5103	42,44	-11,56	54,00	pass	2,5125	54,68	-19,32	74,00	pass
2,5095	42,21	-11,79	54,00	pass					
2,5145	42,08	-11,92	54,00	pass					
2,4875	42,00	-12,00	54,00	pass					
2,4915	41,72	-12,28	54,00	pass					

TESTED IN GERMANY

FCC 3

Band edge emission

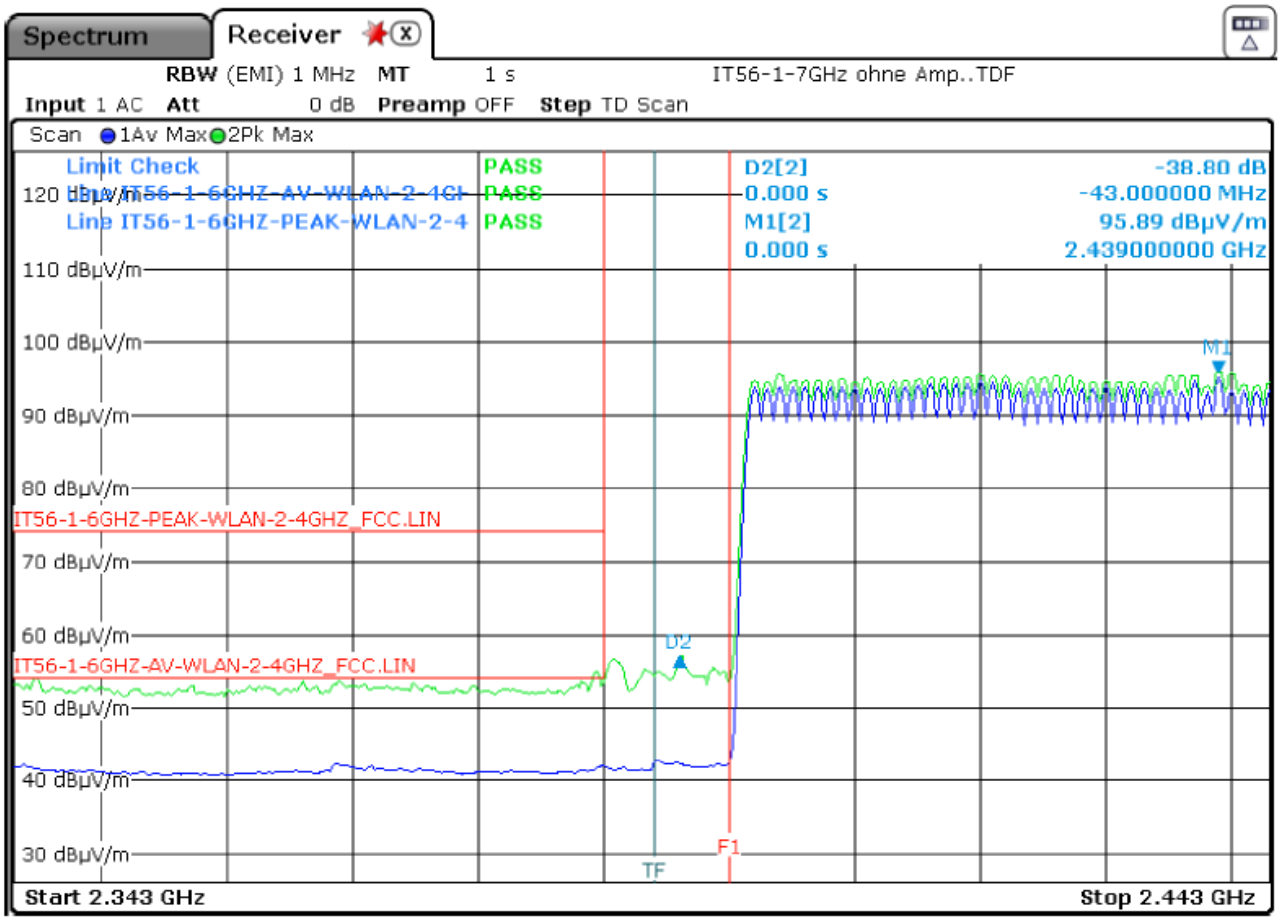
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping GFSK; Low 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

TESTED IN GERMANY

FCC 3

Band edge emission

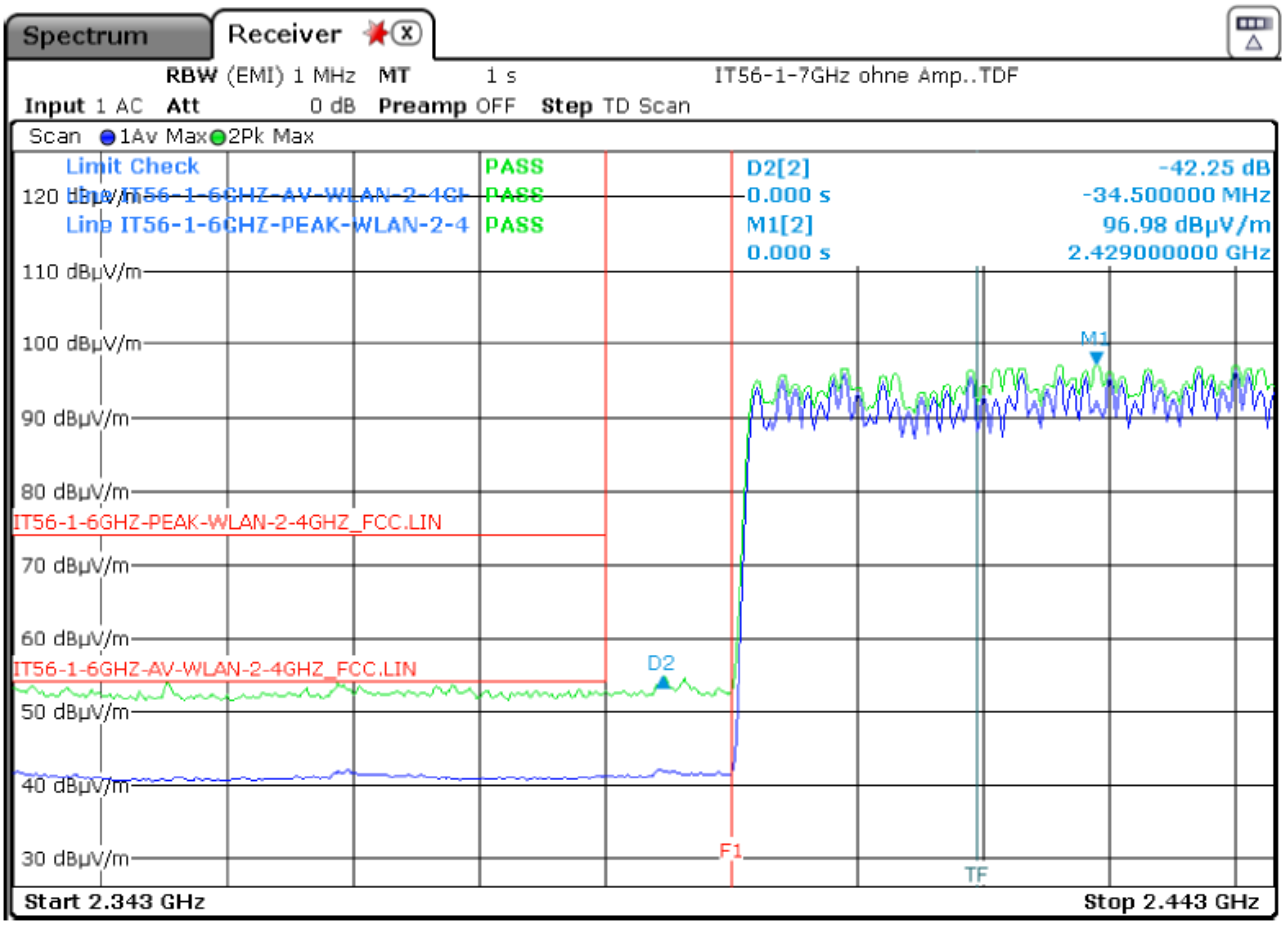
according to

FCC §15.247, RSS-247, FCC §15.209 RSS-Gen

STC

Ref.-No.: 20/01-0031

Operation mode: BT; Hopping GFSK; Low Edge



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

8.7. Occupancy Time

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)

Test 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 channel employed.
No requirements for Digital Transmission System.

Discription

[Test time period] = [Limit] x [Channels] = 0.4 s x 79 = 31.6 s

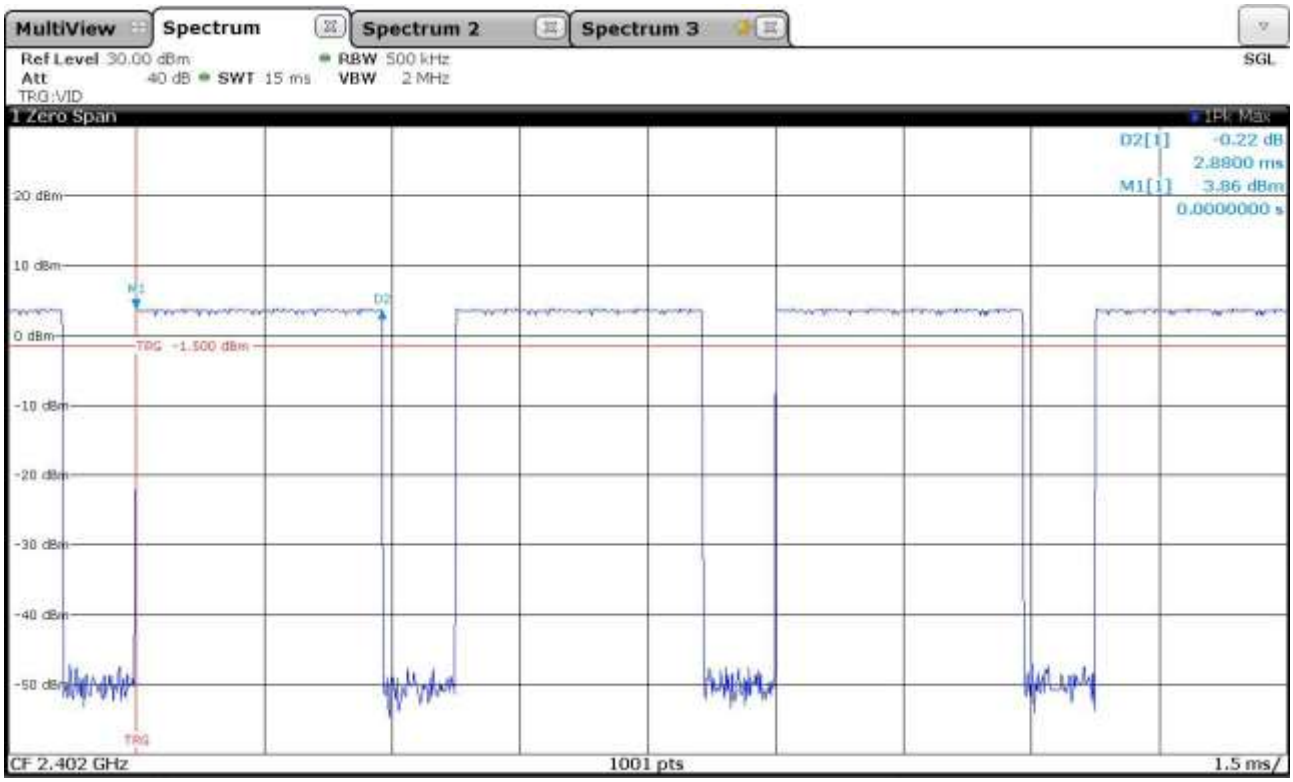
Measurement

The Measurement was performed on: 03.03.2020

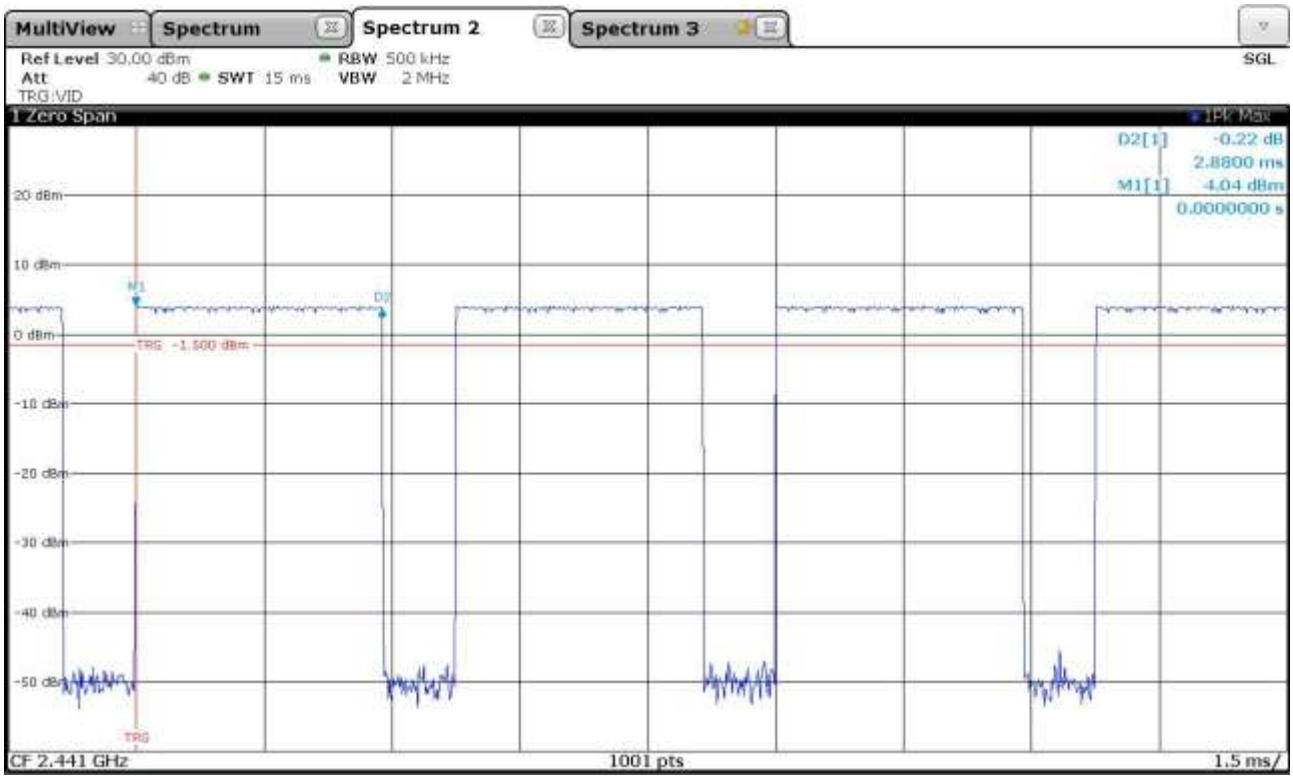
DH5 / 3-DH5 Packet

DH5 Packet permit maximum 1600/79/6 = 3.37 hops per second in each channel (5 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 3.37 hops/sec. x 31.6 sec. = 106.6 hops within 31.6 seconds

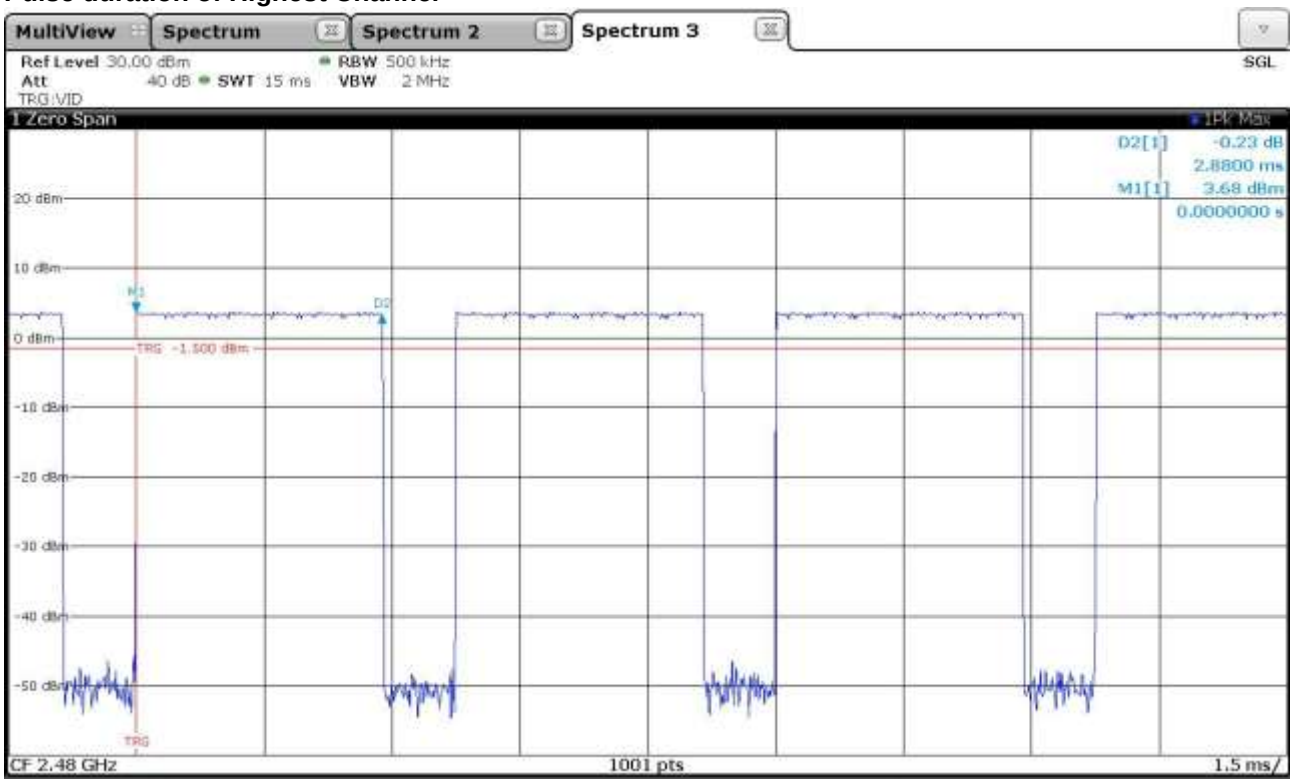
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



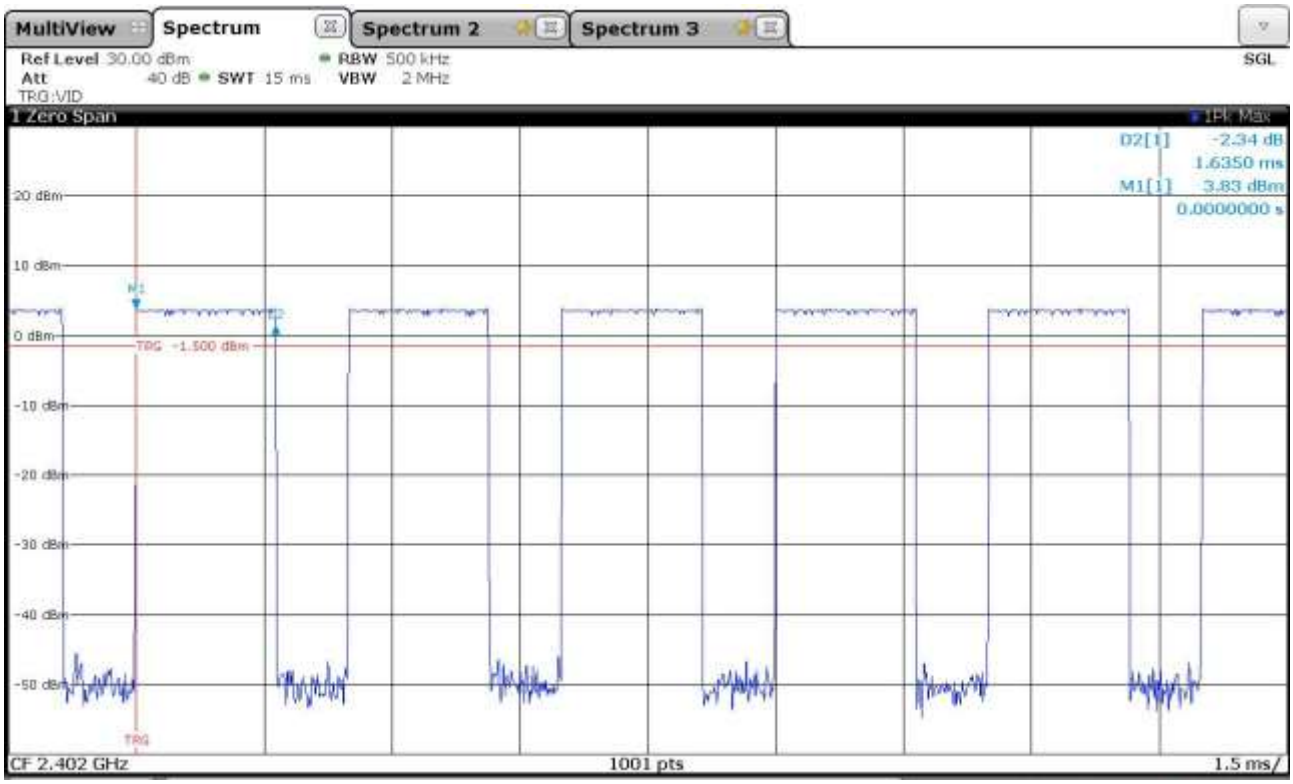
Pulse duration of Highest Channel



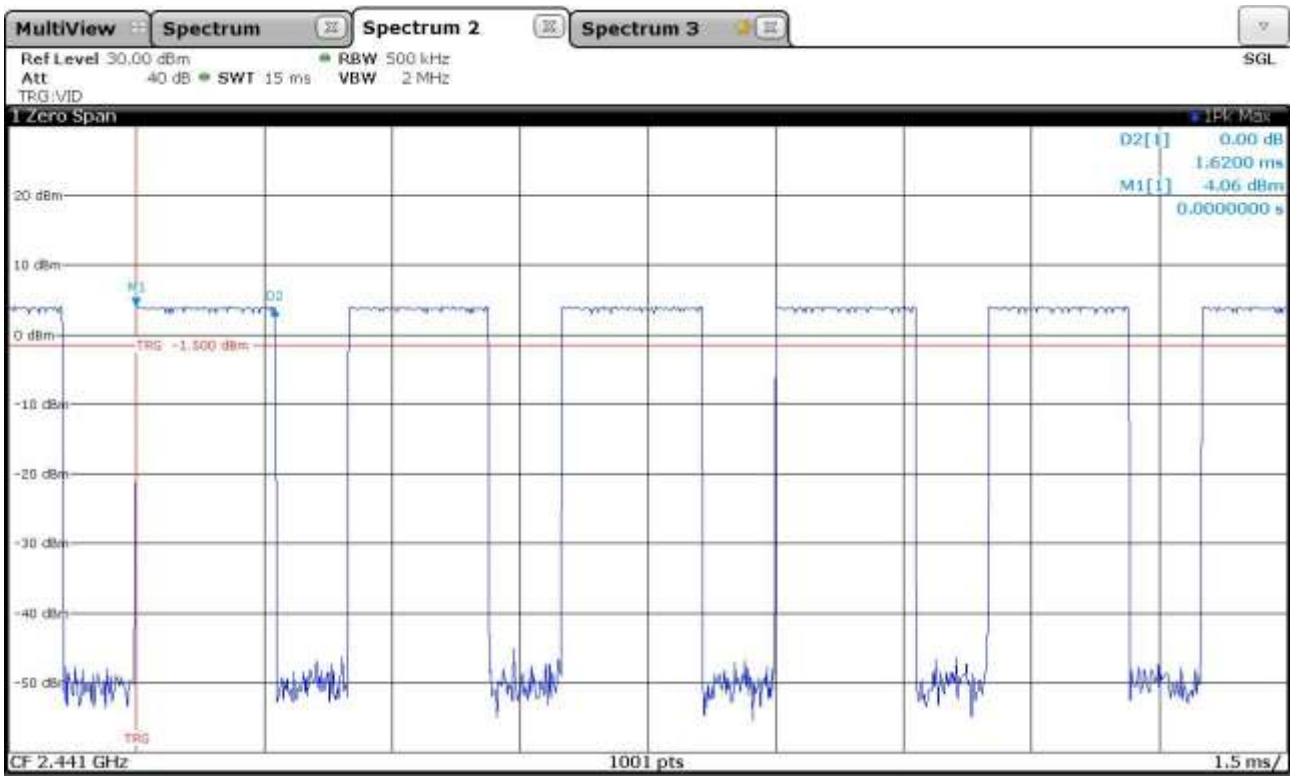
DH3 / 3-DH3 Packet:

DH3 Packet permit maximum 1600/79/4 = 5.06 hops per second in each channel (3 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 5.06 hops/sec. x 31.6 sec. = 160 hops within 31.6 seconds

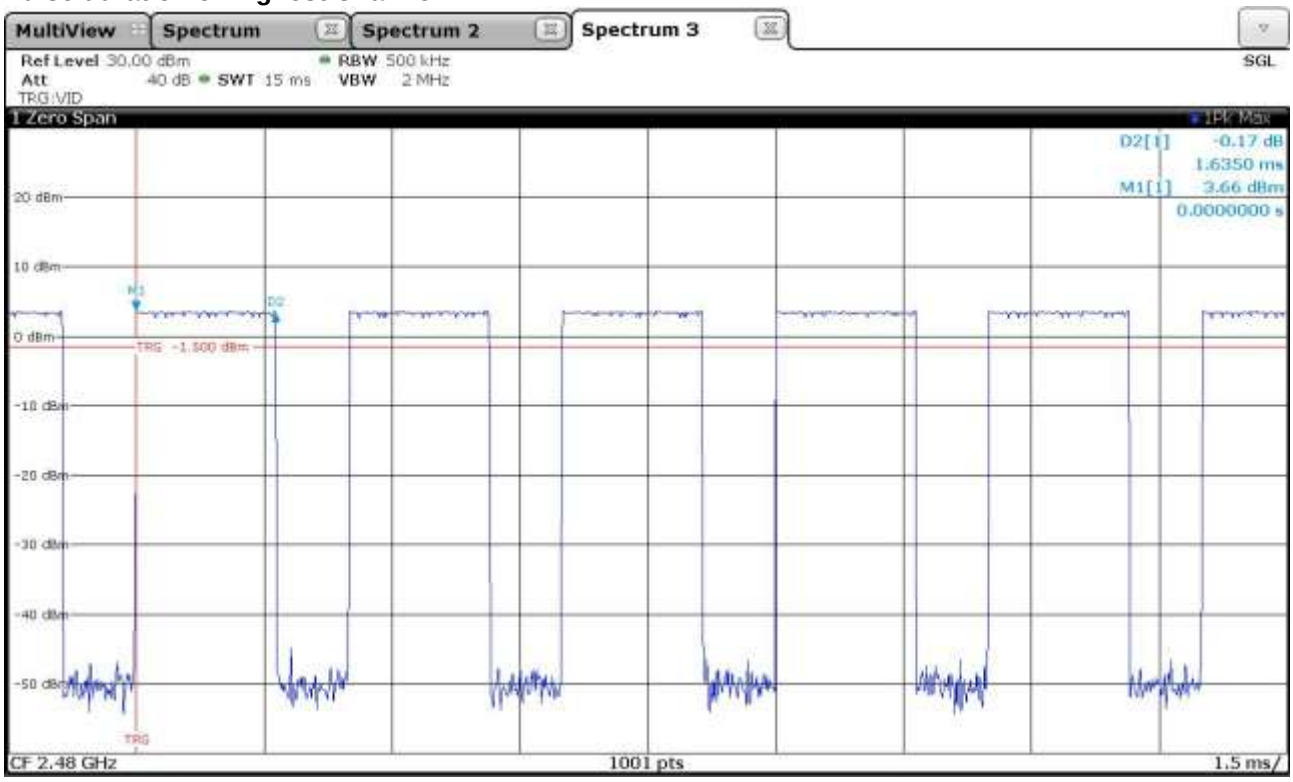
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



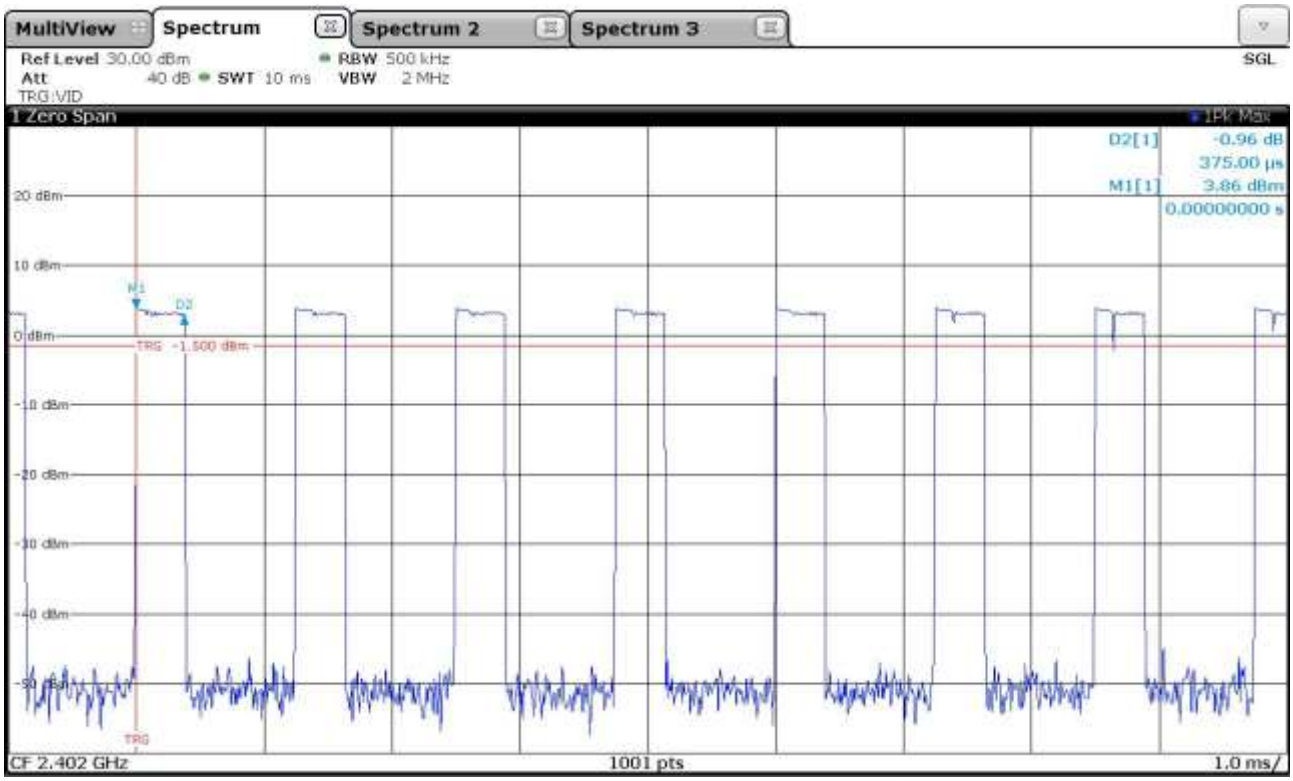
Pulse duration of Highest Channel



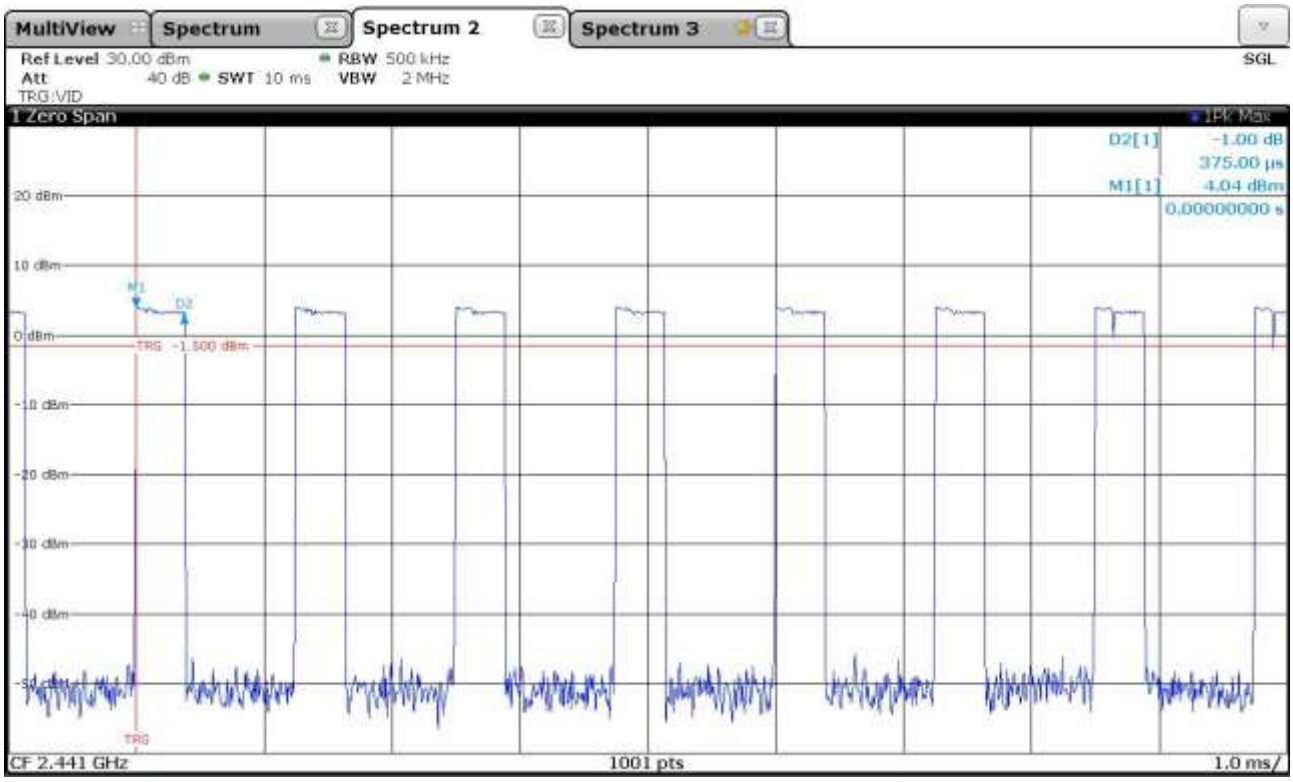
DH1 / 2-DH1 Packet:

DH1 Packet permit maximum 1600/79/2 = 10.12 hops per second in each channel (1 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 10.12 hops/sec. x 31.6 sec. = 320 hops within 31.6 seconds

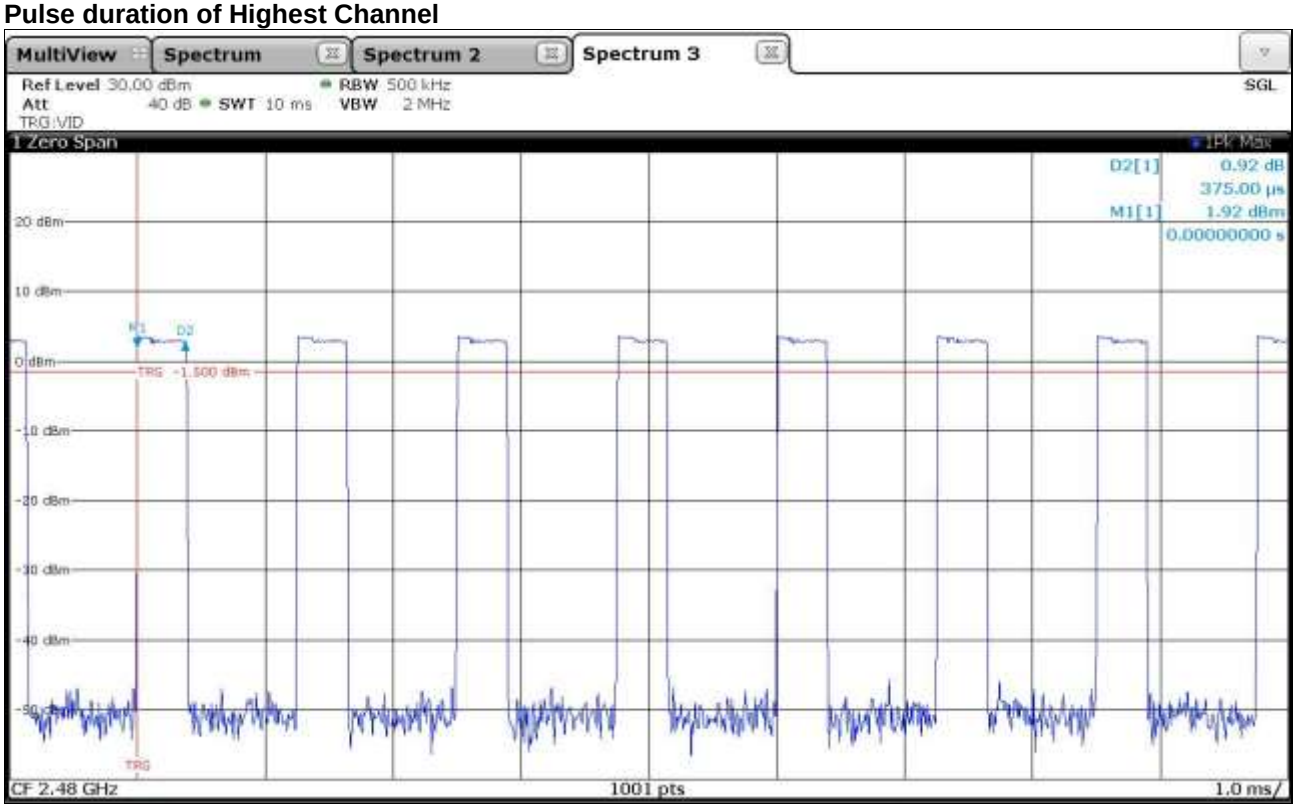
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



Pulse duration of Highest Channel



Time of occupancy (Dwell Time):						
Data Packet	**Frequency [MHz]**	**Hops in Test time period**	**Pulse Duration [ms]**	**Dwell Time [s]**	**Limit [s]**	**Result**
DH5/3-DH5	**2402**	**106.6**	**2.88**	**0.307**	**0.400**	**PASS**
DH5/3-DH5	**2441**	**106.6**	**2.88**	**0.307**	**0.400**	**PASS**
DH5/3-DH5	**2480**	**106.6**	**2.88**	**0.307**	**0.400**	**PASS**
DH3/3-DH3	**2402**	**160**	**1.635**	**0.262**	**0.400**	**PASS**
DH3/3-DH3	**2441**	**160**	**1.620**	**0.259**	**0.400**	**PASS**
DH3/3-DH3	**2480**	**160**	**1.635**	**0.262**	**0.400**	**PASS**
DH1/2-DH1	**2402**	**320**	**0.375**	**0.120**	**0.400**	**PASS**
DH1/2-DH1	**2441**	**320**	**0.375**	**0.120**	**0.400**	**PASS**
DH1/2-DH1	**2480**	**320**	**0.375**	**0.120**	**0.400**	**PASS**

Formula: [Dwell time] = [Hops in Test time period.] x [Pulse Duration]

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **Time of occupancy (dwell time).**

8.8. 99% Power Bandwidth

Applied standards
-RSS-Gen issue 5 Section 6.7

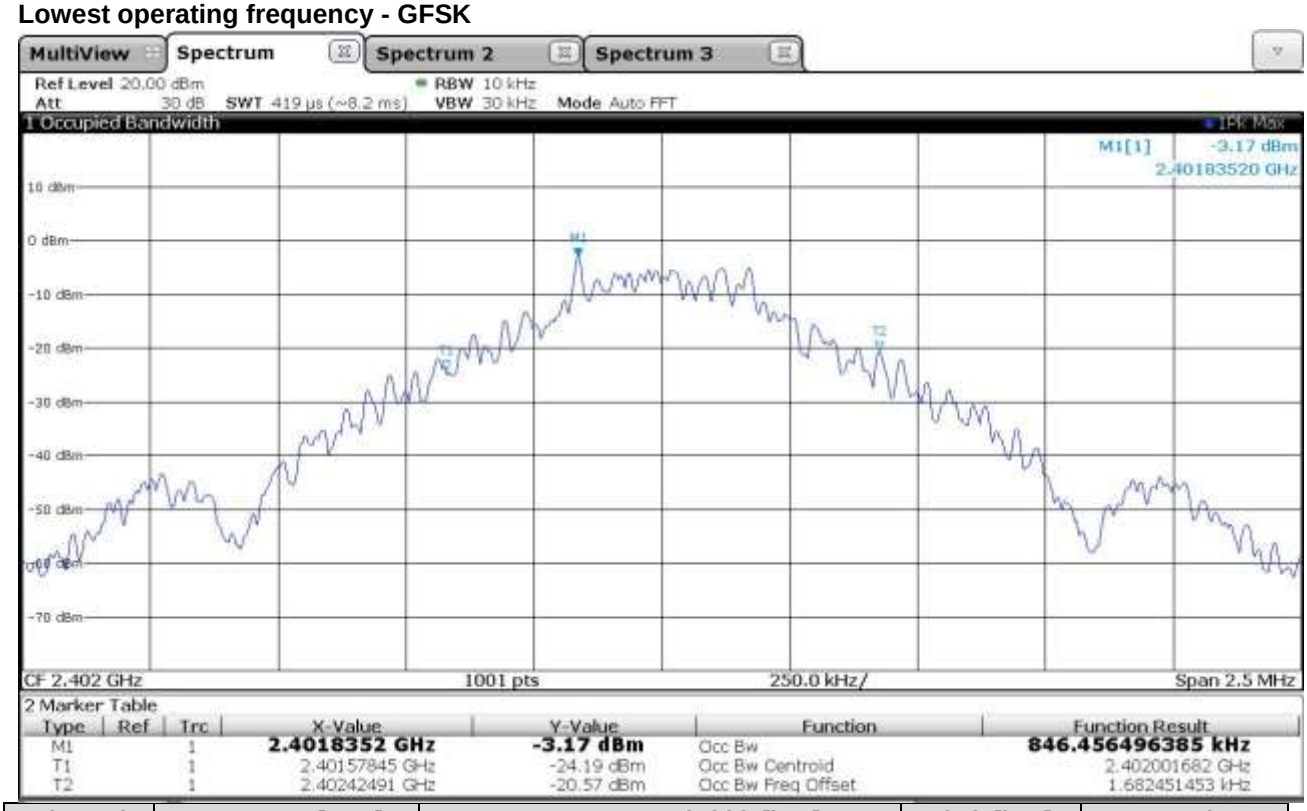
Test equipment and test set up
Test equipment used for conducted measurements as given in clause Test equipment of this report.
Test setup used for conducted measurements as given in clause Test setups of this report.

Description
The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.
The 99% power bandwidth function of the instrument was used for the measurement.

Measurement

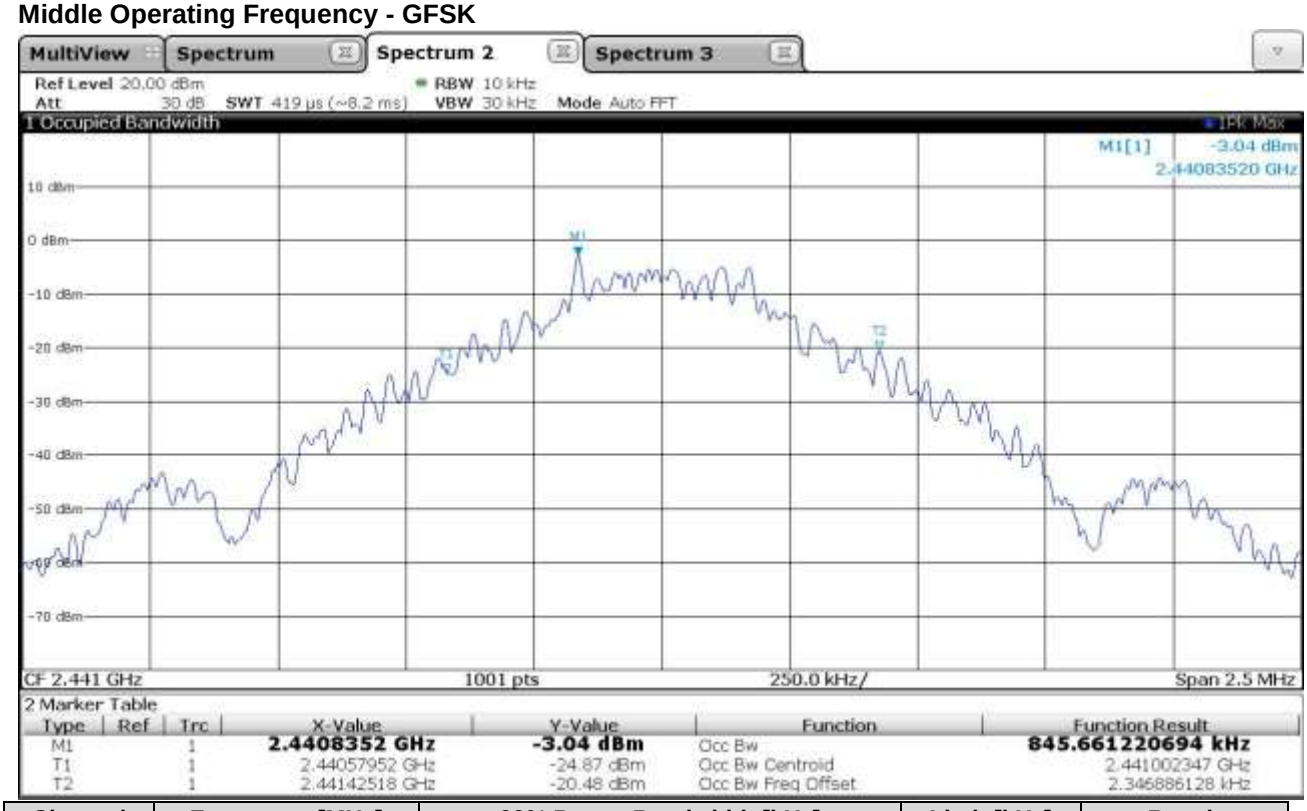
The Measurement was performed on: 03.03.2020

Lowest operating frequency - GFSK



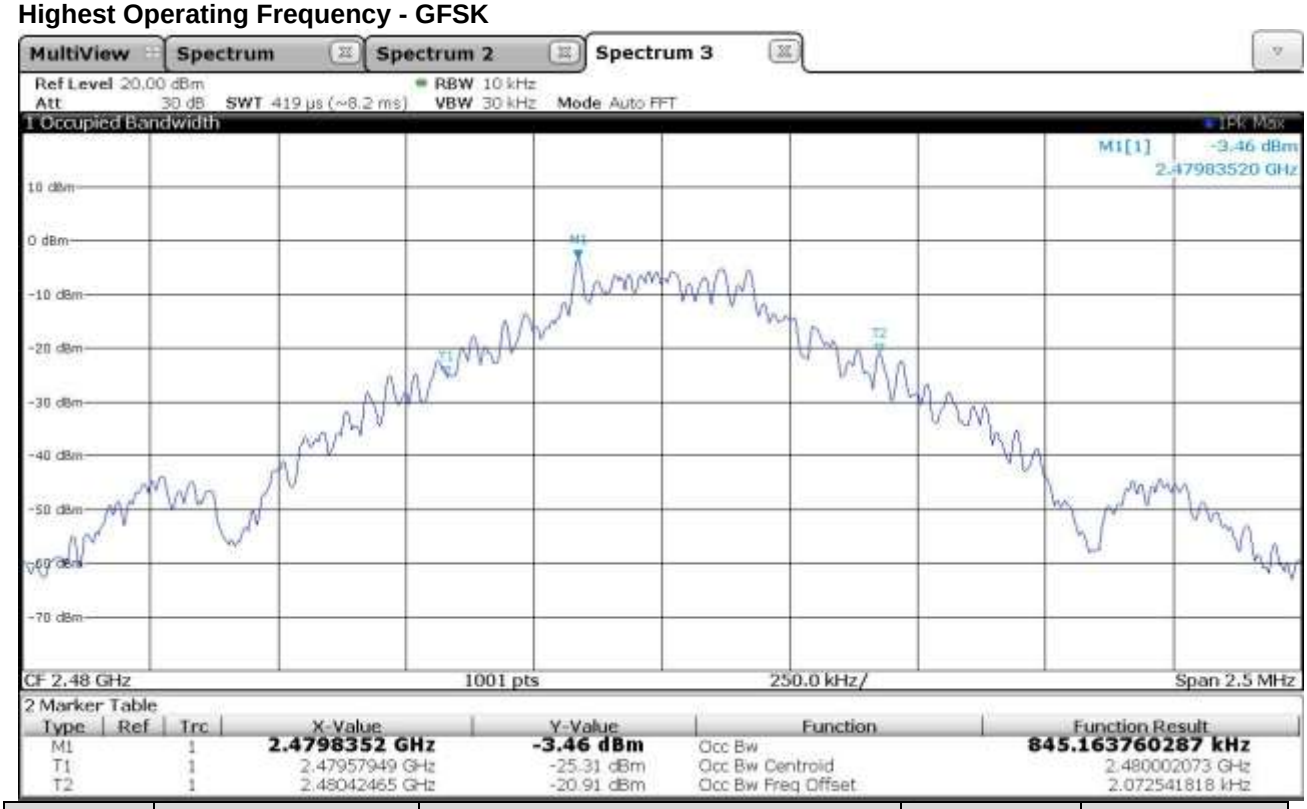
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
0	2402	846.456	-/-	Pass

Middle Operating Frequency - GFSK



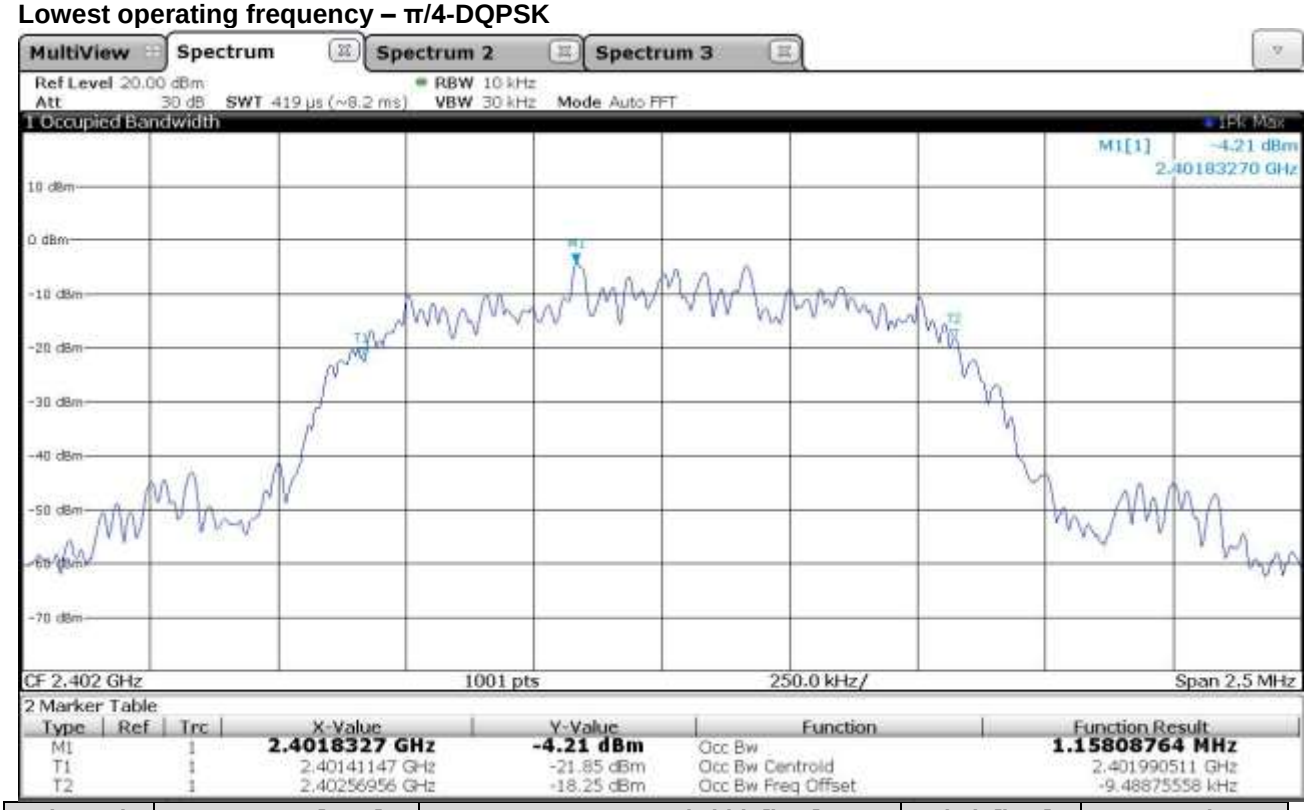
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
39	2441	845.661	-/-	Pass

Highest Operating Frequency - GFSK



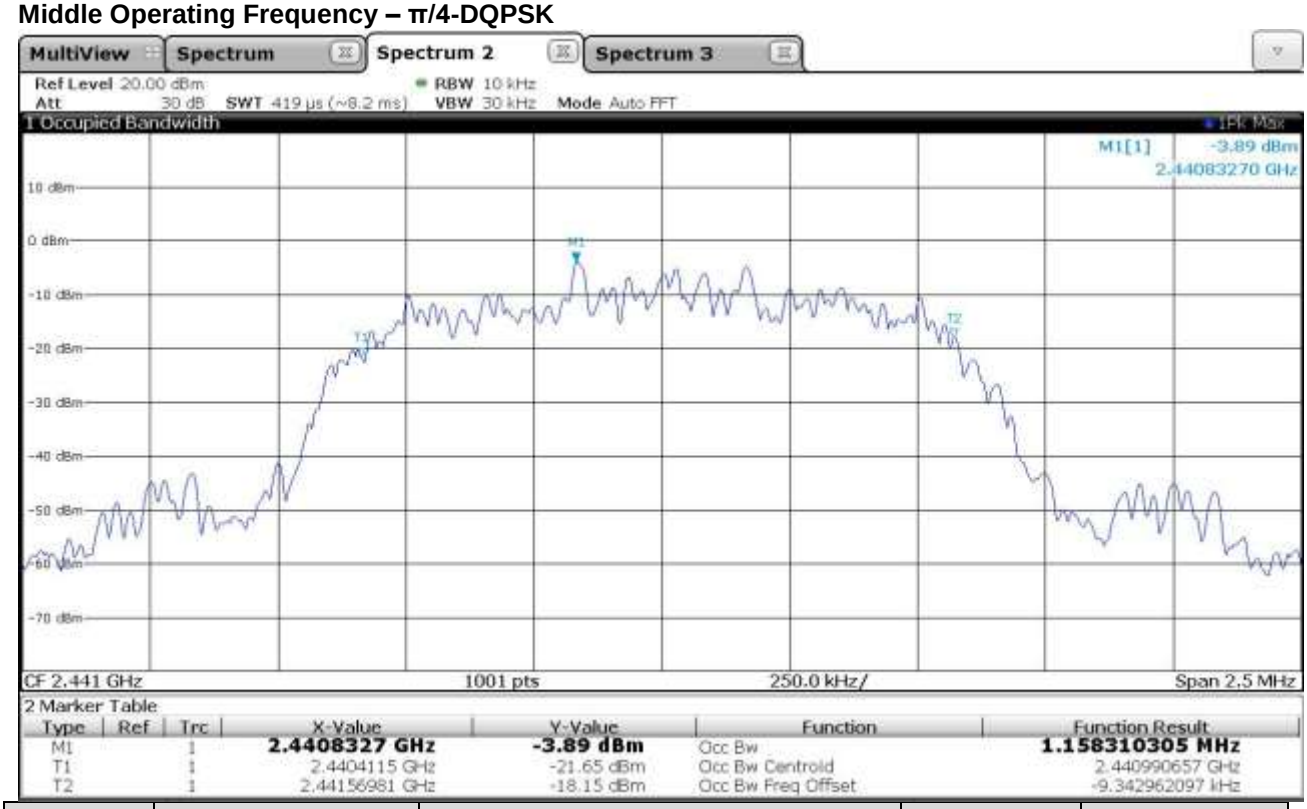
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
79	2480	845.164	-/-	Pass

Lowest operating frequency – π/4-DQPSK



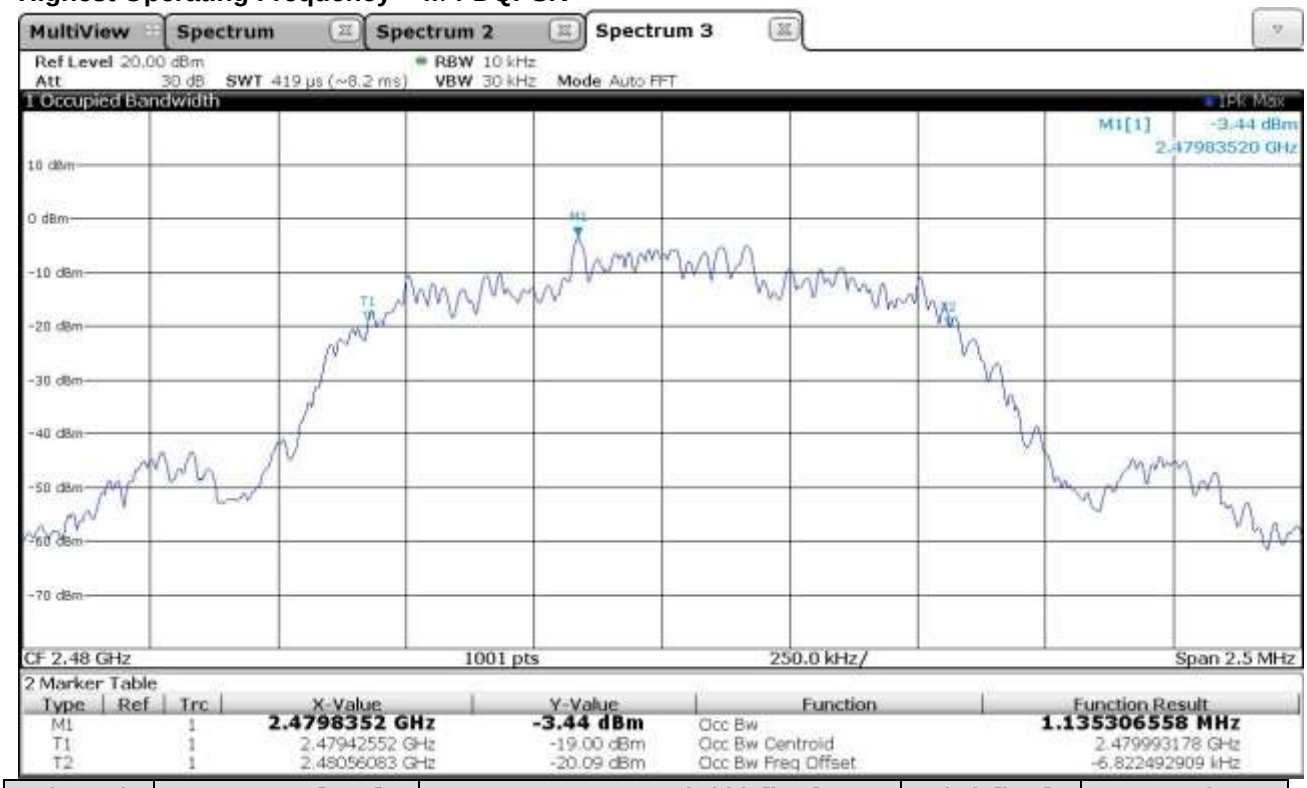
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
0	2402	1158.087	-/-	Pass

Middle Operating Frequency – π/4-DQPSK



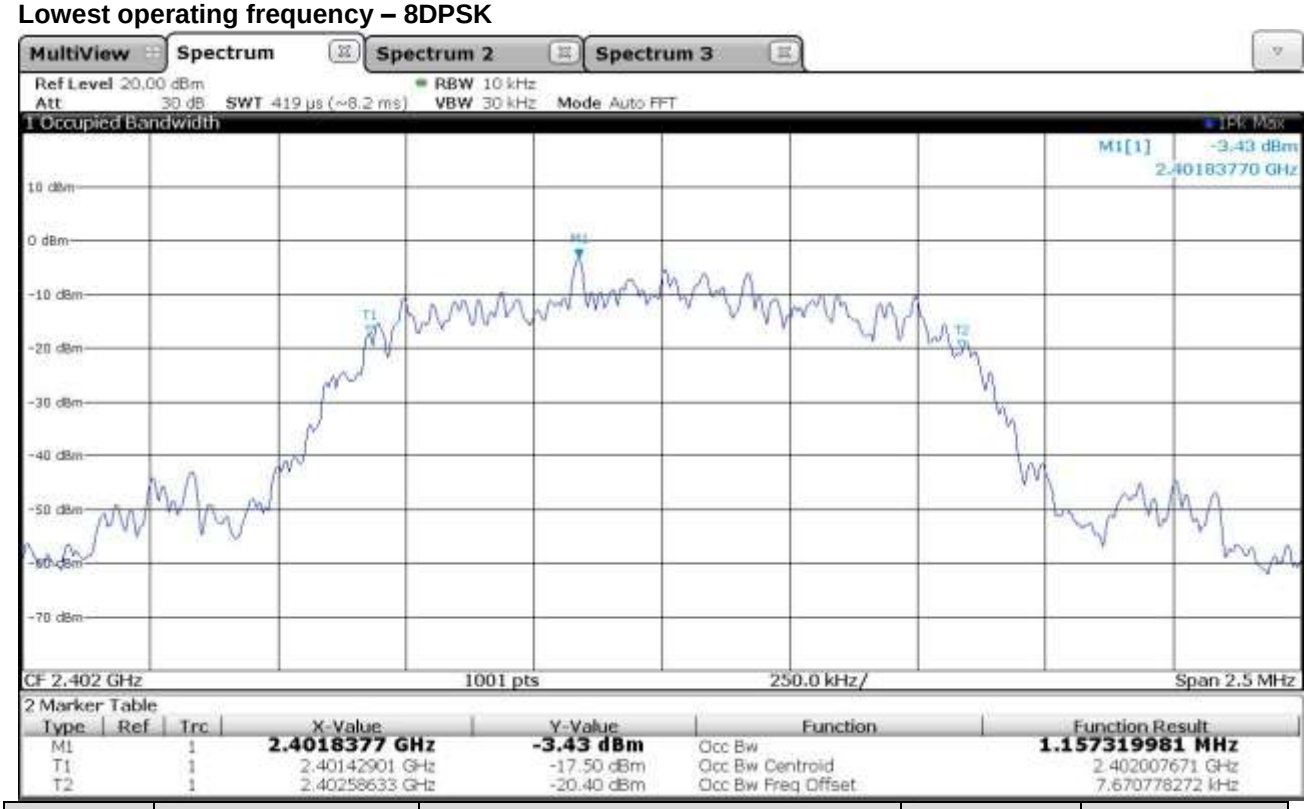
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
39	2441	1158.310	-/-	Pass

Highest Operating Frequency – π/4-DQPSK



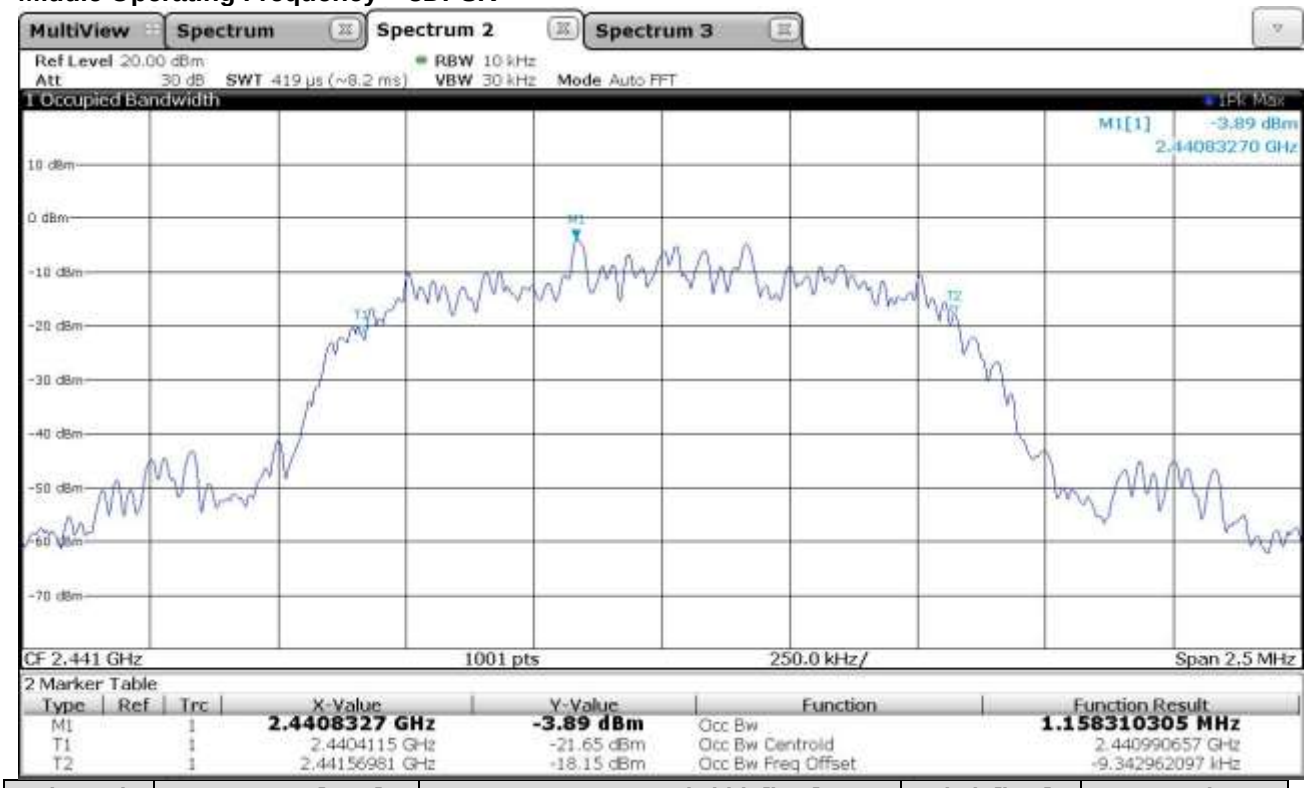
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
79	2480	1135.307	-/-	Pass

Lowest operating frequency – 8DPSK



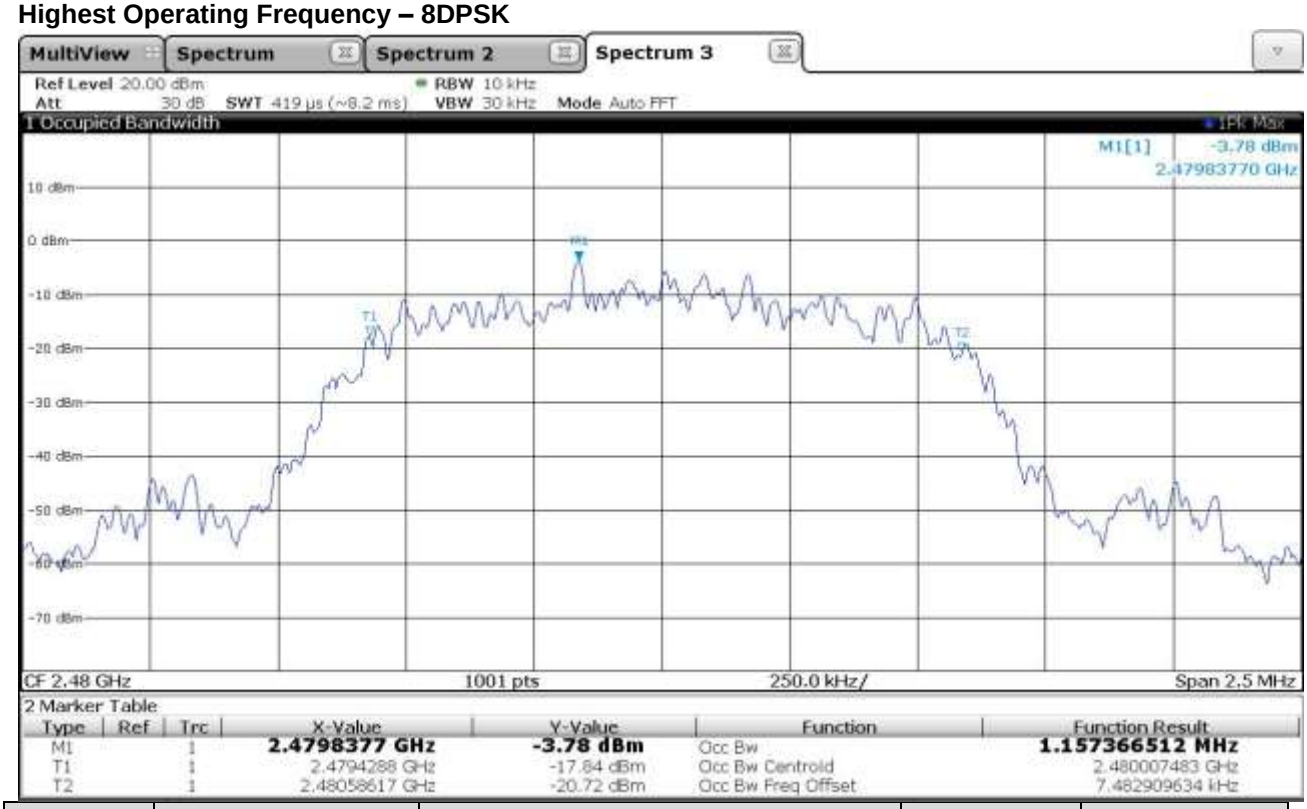
Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
0	2402	1157.320	-/-	Pass

Middle Operating Frequency – 8DPSK



Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
39	2441	1158.310	-/-	Pass

Highest Operating Frequency – 8DPSK



Channel	Frequency [MHz]	99% Power Bandwidth [kHz]	Limit [kHz]	Result
79	2480	1157.367	-/-	Pass

Results

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the **99% Power Bandwidth**.

9. Test equipment

Test equipment used for Conducted Mains emissions:

Kind of equipment	Manufacturer	Type	Ident no.	Serial no.	Calibrated on (y-m)	Calibration interval
Test-Receiver	Rohde & Schwarz	ESHS30	10571	842053/008	2019 – Mar.	3 years
Software	PKM	PKM U5/6	-/-	V1.01.03	-/-	-/-
Line impedance stabilisation network (LISN)	Rohde & Schwarz	ESH2-Z5	10139	879675/028	2019 – Jan.	3 years
Shielded room	Siemens	(6,2 x 4,7 x 3,3) m (l x w x h) DC – 10 GHz	10113	1	-/-	-/-

Test equipment used for radiated Measurements:

Kind of equipment	Manufacturer	Type	Ident no.	Serial no.	Calibrated on (y-m)	Calibration interval
Signal Spectrum Analyzer 2Hz – 26.5 GHz	Rohde & Schwarz	FSW 26 Instrument FW 2.60	11571	102047	2019-Jan.	3 years
ESR7 EMI Testreceiver 7GHz	Rohde & Schwarz	ESR7	11676	101694	2018-March	3 years
Test-Receiver	Rohde & Schwarz	ESVS30	10572	833825/010	2017-March	3 years
					2020-April	3 years
Antenna 9 kHz – 30 MHz	EMCO	6502	10546	2018	2017-Nov.	3 years
Antenna 30 MHz – 1 GHz	Chase	CBL6111C	10022	1064	2019-Dec.	3 years
Antenna 1GHz – 18 GHz	Electro Metric	RGA50/60	10273	2753	2017-Nov.	3 years
Broadband-Hornantenne 15 - 26,5 (40) GHz	Schwarzbeck	BBHA 9170	11580	BBHA9170621	2019-Dec.	3 years
Broadband-Preamplifier 1 - 18 GHz	Schwarzbeck	BBV9718	11231	9718-002	2017-Okt.	3 years
Preamplifier 18 - 40 GHz	CERNEX	CBM18403523	11679	29711	2019 - July	3 years
Cable	el-spec GmbH	FlexCore-SMA11-SMA11-8000-ARM	11625	-/-	2017-Dec.	3 years
Shielded room/Chamber	Frankonia	SAC3 "SEMI-ANECHOIC-CHAMBER"	11609	004/16	2019-March	3 years
Band Reject Filter	Telemeter	BRF-2450-150-7-N (0441)	11243	-/-	-/-	-/-

Test equipment used for Band Edge Measurements:

Kind of equipment	Manufacturer	Type	Ident no.	Serial no.	Calibrated on (y-m)	Calibration interval
ESR7 EMI Testreceiver 7GHz	Rohde & Schwarz	ESR7	11676	101694	2018-March	3 years
Antenna 1GHz – 18 GHz	Electro Metric	RGA50/60	10273	2753	2017-Nov.	3 years
Cable	el-spec GmbH	FlexCore-SMA11-SMA11-8000-ARM	11625	-/-	2017-Dec.	3 years
Shielded room/Chamber	Frankonia	SAC3 "SEMI-ANECHOIC-CHAMBER"	11609	004/16	2019-March	3 years

Test equipment used for conducted measurements:

Kind of equipment	Manufacturer	Type	Ident no.	Serial no.	Calibrated on (y-m)	Calibration interval
Signal Spectrum Analyzer 2Hz – 26.5 GHz	Rohde & Schwarz	FSW 26 Instrument FW 2.60	11571	102047	2019 - Jan.	3 years
EMI-Test-Receiver	Rohde & Schwarz	ESR7 Instrument FW 3.36	11505	101103	2017 - Nov.	3 years
Automatisation unit RF switch and power meter	Rohde & Schwarz	OSP120 and OSP B157	11573	101282	2017 - Dec.	3 years
Cable	el-spec GmbH	FlexCore-SMA11-SMA11-8000-ARM	11625	-/-	2017 - Dec.	3 years

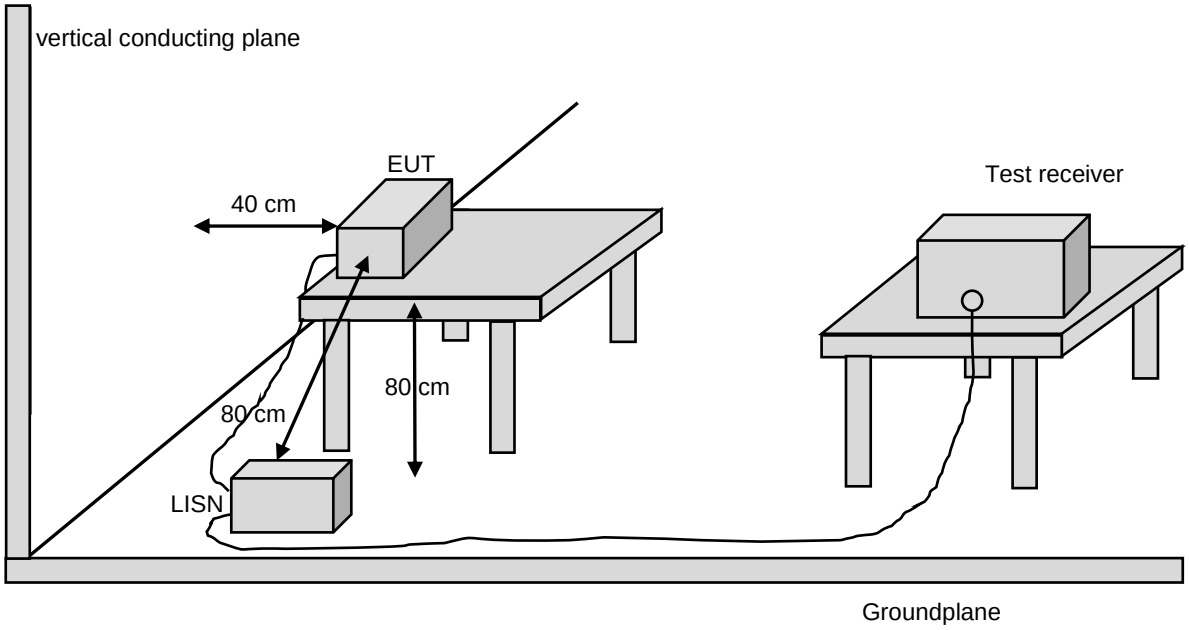
All measurements were made with measuring instruments, including any accessories that may affect test results, calibrated according to the requests of ISO/IEC 17025 according to which the test site is accredited from DAkkS. Measurement of conducted mains emissions was made with instruments conforming to American National Standard Specification, ANSI C63.10-2013.

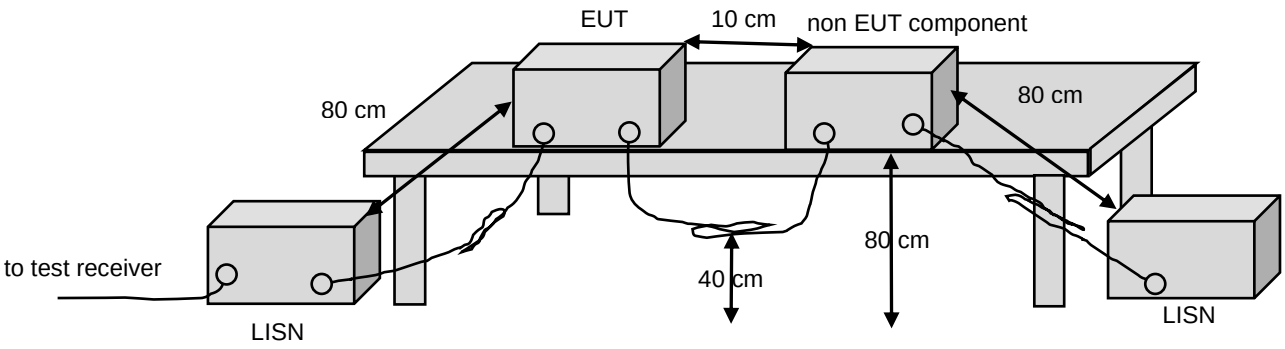
Test equipment to support EUT functions:

Kind of equipment	Manufacturer	Type	Ident no.
Laptop	DELL	Inspiron	11488
AC-Adaptor [Laptop/EUT]	DELL	DA130PE1-00	Part of 11488
Test Adaptor Board	Vestel (Client)	17TEST02	Client
Software	Provided by Vestel (Client)	Media Tek BT Tool	-/-

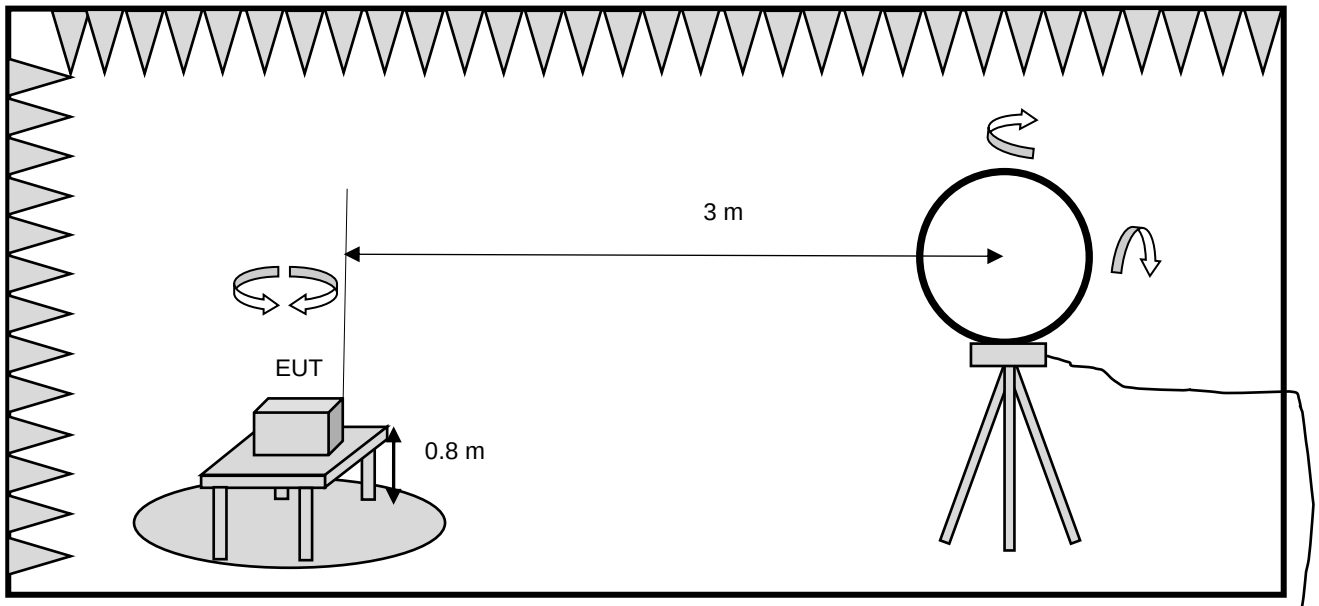
10. Test Setups

Block diagram Conducted Mains emissions





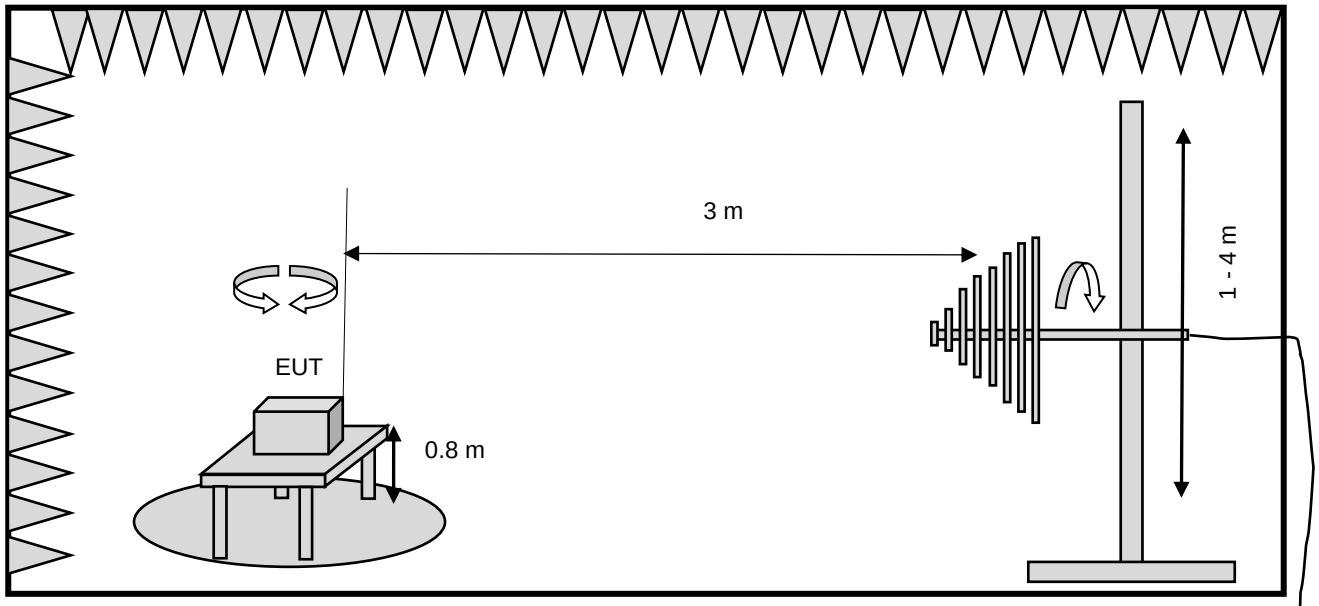
Block diagram Radiated emissions



Semi anechoic chamber with absorber and ferrite tiles

Test receiver

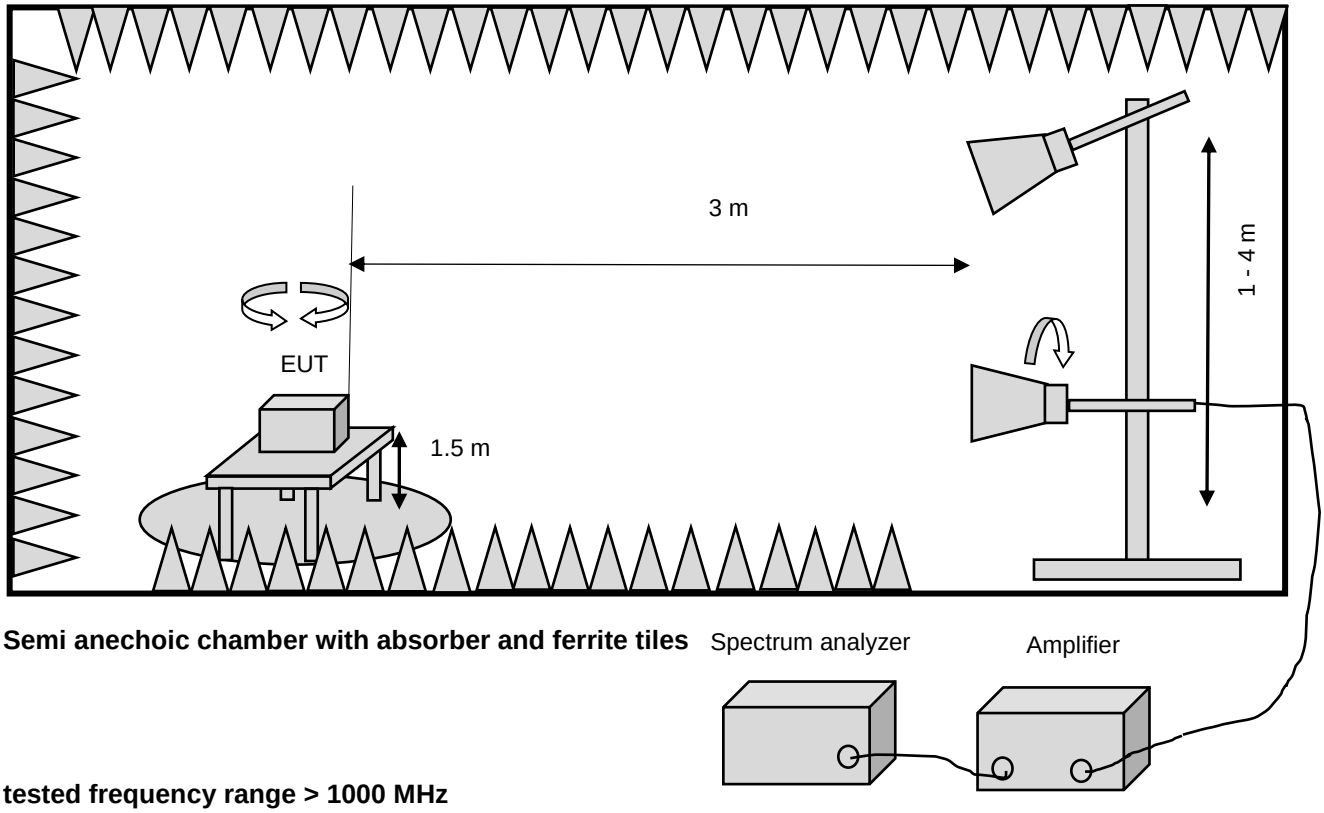
tested frequency range 9 kHz - 30 MHz



Semi anechoic chamber with absorber and ferrite tiles

Test receiver

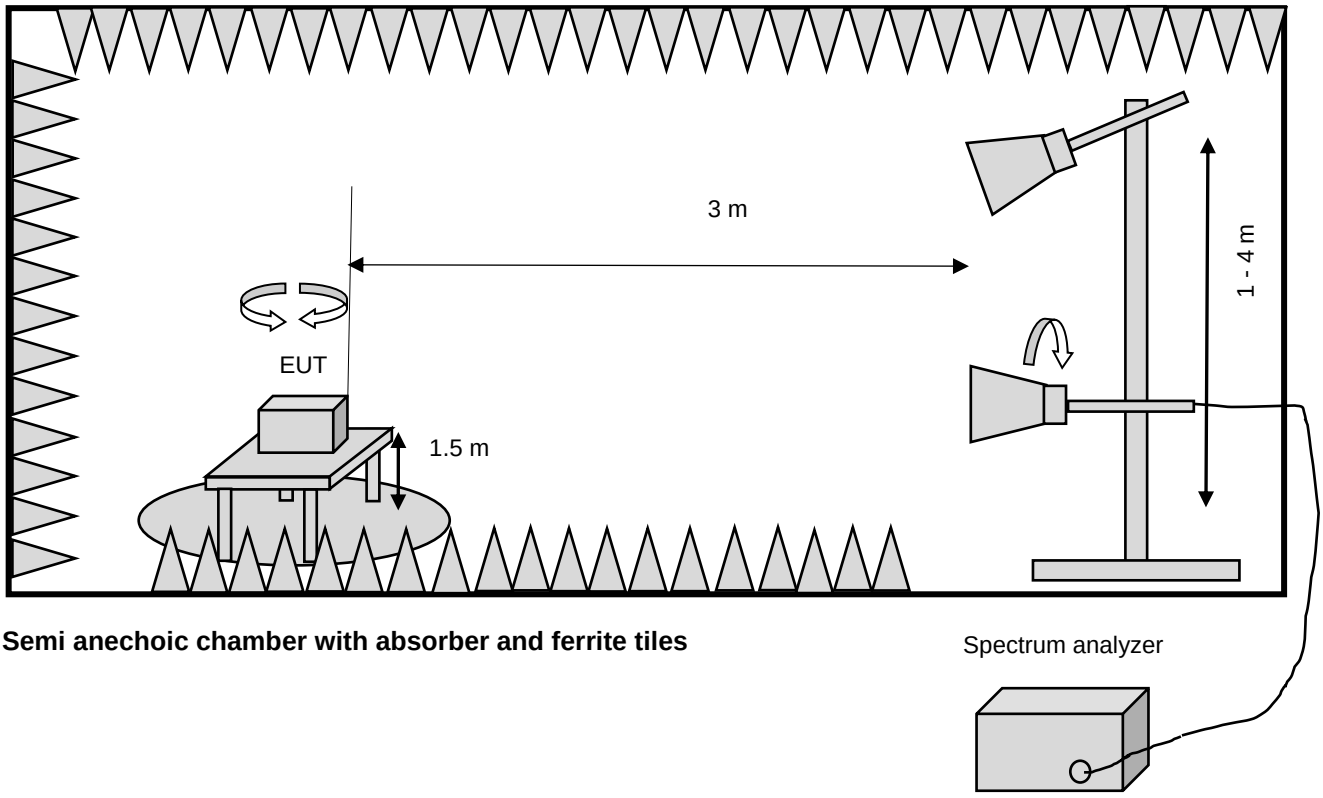
tested frequency range 30 MHz - 1000 MHz



Semi anechoic chamber with absorber and ferrite tiles

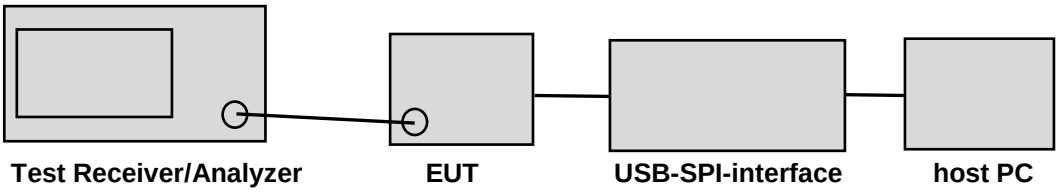
tested frequency range > 1000 MHz

Block diagram Band Edge emisions



Semi anechoic chamber with absorber and ferrite tiles

Block diagram for conducted measurements



11. Measurement uncertainty

according to *CISPR 16-4-2 Edition 2.0 2011-06*

Measurement	**calculated uncertainty U_{lab}**	**Specified CISPR uncertainty according CISPR 16-4-2 Edition 2.0 2011-06, table 1 U_{CISPR}**
Conducted disturbance at mains port using AMN 9 kHz – 150 kHz	3.6 dB	3.8 dB
Conducted disturbance at mains port using AMN 150 kHz – 30 MHz	3.2 dB	3.4 dB
Magn. fieldstrength 9kHz - 30MHz	3.4 dB	-/-
Radiated disturbance (electric field strength in the SAC) 30 MHz to 1 000 MHz	4.7 dB	6.3 dB
Radiated disturbance (electric field strength in the SAC) 1 GHz to 26.5 GHz	4.1 dB	-/-

Measurement	**calculated uncertainty U_{lab}**	**Maximum measurement uncertainty**
Channel Bandwidth	±1.17 %	±5 %
RF output power, conducted	±1.36 dB	±1.5 dB
Power Spectral Density, conducted	±1.99 dB	±3 dB
Unwanted Emissions, conducted	±1.71 dB	±3 dB
All emissions, radiated	±4.8 dB	±6 dB
Temperature	±0.72 °C	±3 °C
Supply voltages	±0.76 % (DC up to 40V) ±1.74 % (AC 50Hz up to 400V)	±3 %
Time	±0.012 %	±5 %

The measurement uncertainty describes the overall uncertainty of the given measured value during the operation of the EUT in the above mentioned way.

The measurements uncertainty was calculated in accordance with CISPR 16-4-2 Edition 2.0 2011-06.

The measurement uncertainty was given with a confidence of 95 % (k = 2).

12. Photos setup

Refer to “0031-fcc-ised-photos test setup.pdf” file

13. Conclusions

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the relevant §15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

From the measurement data obtained, the tested sample was considered to have **COMPLIED** with the requirements for the relevant RSS-247 issue 02 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.

Following specific modifications and/or special attributes are necessary to pass the above mentioned requirements:

none

15.12.2020	M. Beindl, Laboratory Engineer	
Erstellt am/*prepared on*	**(Name/***name* / **Stellung/***position***)**	**(Unterschrift/***signature***)**

15.12.2020	K. Simon, Deputy Head of Laboratory	
Freigabe am/released *on*	**(Name/***name* / **Stellung/***position***)**	**(Unterschrift/***signature***)**

14. Photos of tested sample

Refer to “0031-fcc-ised-ext-photos.pdf” file

End of test report