

7.6. 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. Attenuation below the general limits specified in § 15.209 and RSS-Gen Table 5 is not required. 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

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.

Detector function selection and bandwidth

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

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

Measurement

The Measurement was performed on: 25.06.2020

Higher Band Edge - GFSK CH. 78 – radiated



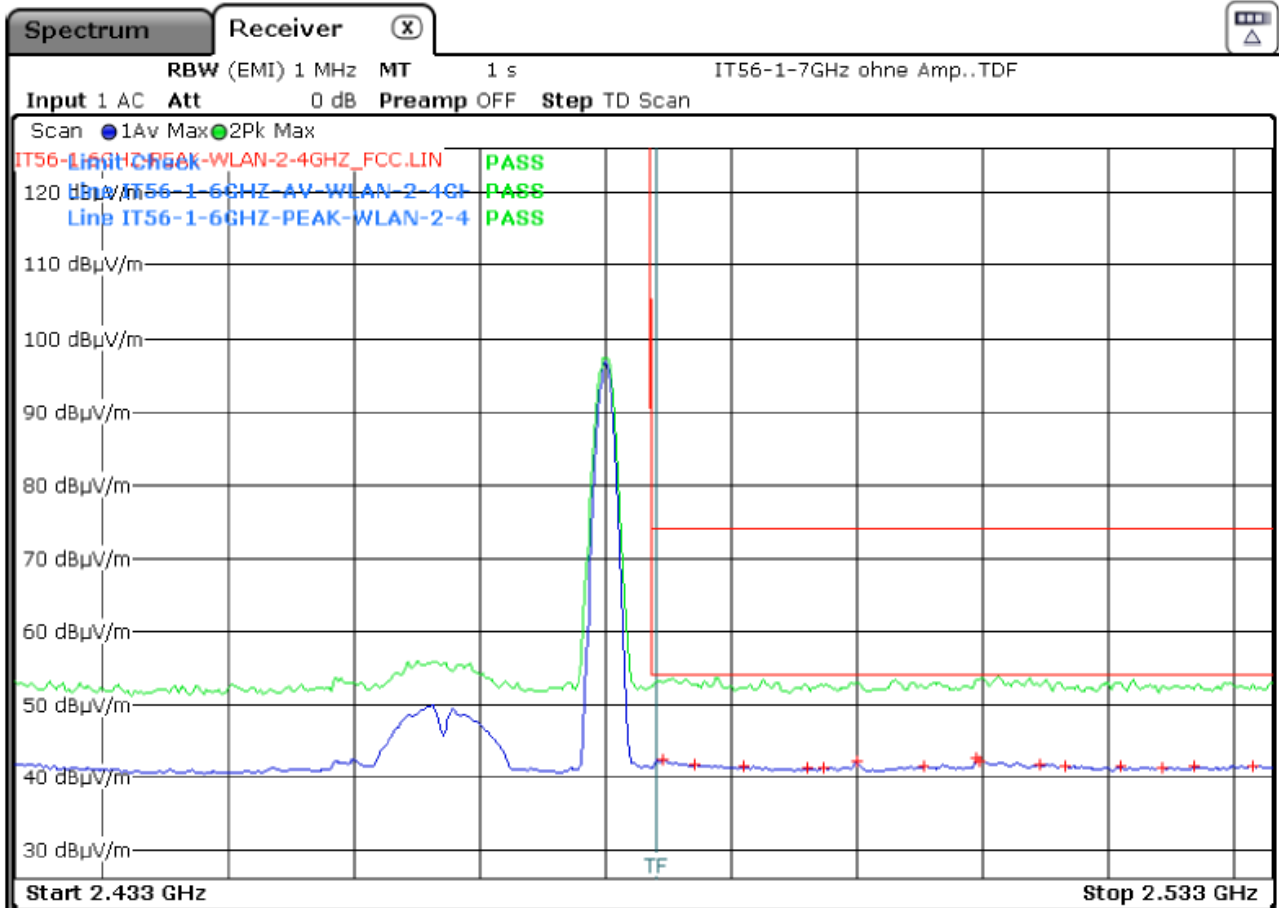
FCC 3
Band edge emission
according to



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

Ref.-No.: 20/01-0029

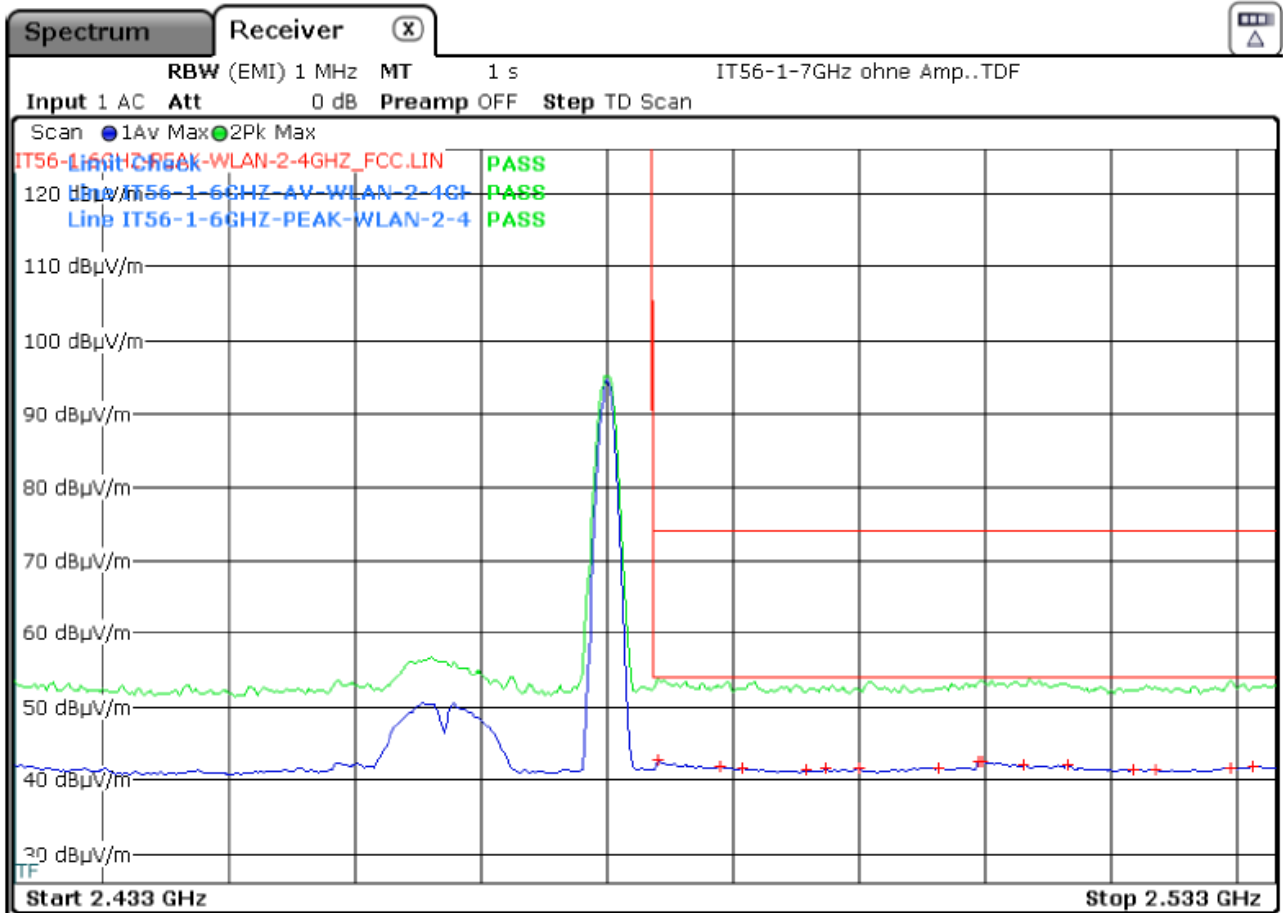
Operation mode: BT CH.78; GFSK; High Edge



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
2,4845	42,41	-11,59	54,00	pass	all emissions are 20dB below limit				pass
2,4870	41,55	-12,45	54,00	pass					
2,4910	41,39	-12,61	54,00	pass					
2,4960	41,11	-12,89	54,00	pass					
2,4973	41,26	-12,74	54,00	pass					
2,5000	42,01	-11,99	54,00	pass					

Ref.-No.: 20/01-0029

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



Polarisation: H									
Frequ. [GHz]	Level [dBµV/m]	Detector Average			Result	Detector Peak			
		Margin to Limit [dB]	Limit [dBµV/m]	Result		Frequ. [GHz]	Level [dBµV/m]	Margin to Limit [dB]	Limit [dBµV/m]
2,4840	42,47	-11,53	54,00	pass	all emissions are 20dB below limit				pass
2,4890	41,63	-12,37	54,00	pass					
2,4908	41,46	-12,54	54,00	pass					
2,4958	41,12	-12,88	54,00	pass					
2,4973	41,39	-12,61	54,00	pass					
2,5000	41,47	-12,53	54,00	pass					

Higher Band Edge - $\pi/4$ -DQPSK CH. 78 – radiated



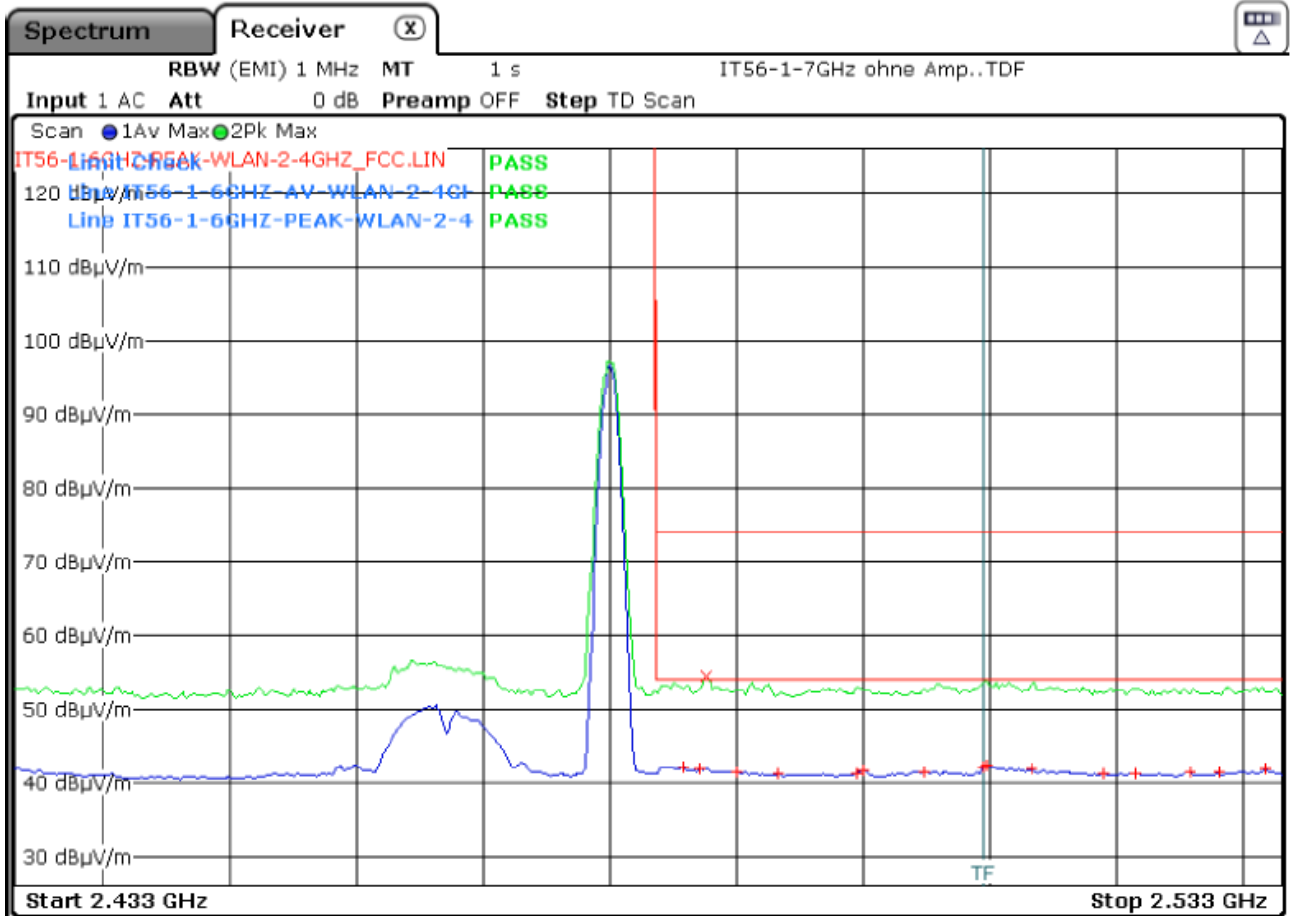
FCC 3
Band edge emission
according to



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

Ref.-No.: 20/01-0029

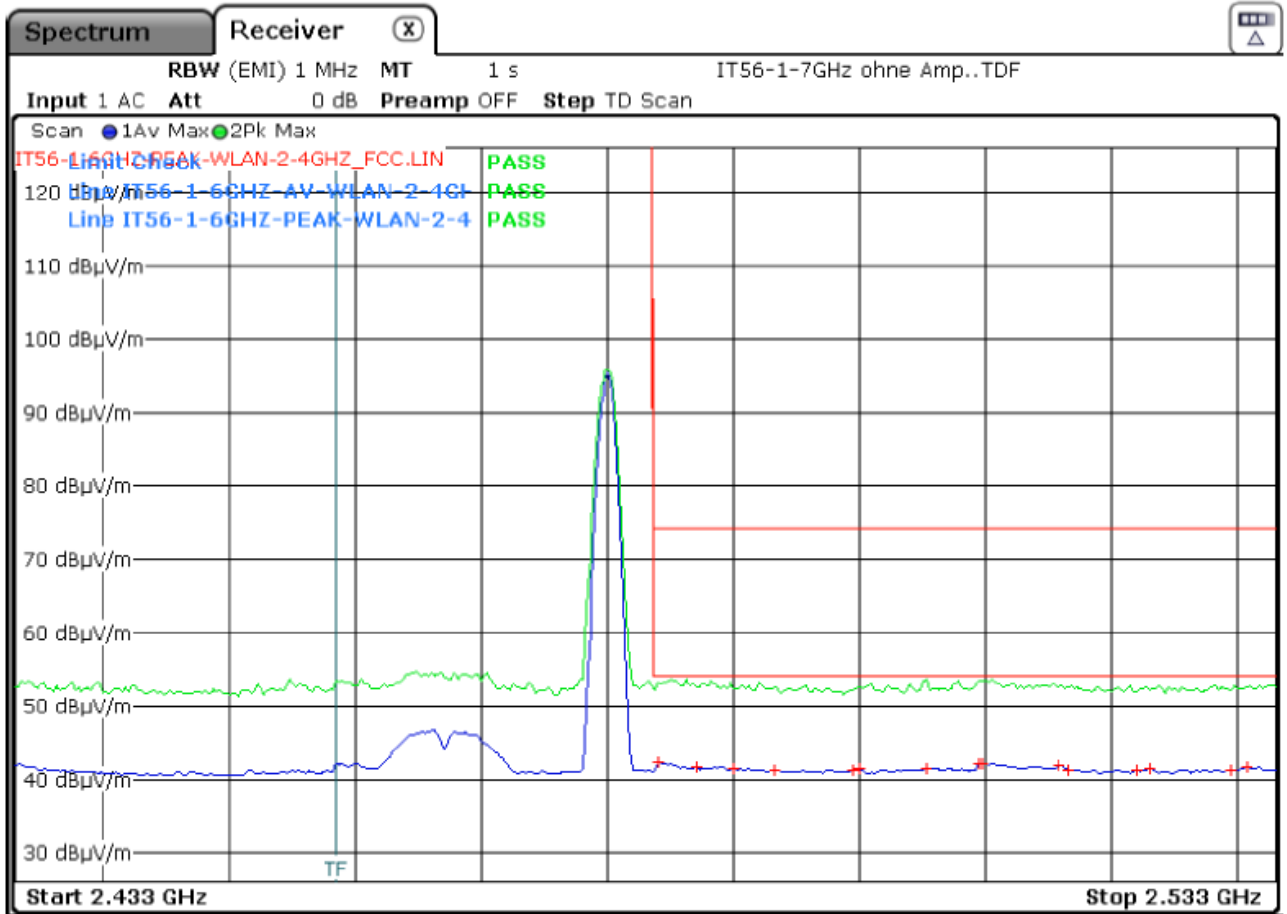
Operation mode: BT CH.78; $\pi/4$ DQPSK; High Edge



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
2,4858	42,13	-11,87	54,00	pass	2,4875	54,42	-19,58	74,00	pass
2,4870	41,89	-12,11	54,00	pass					
2,4900	41,50	-12,50	54,00	pass					
2,4933	41,16	-12,84	54,00	pass					
2,4995	41,30	-12,70	54,00	pass					
2,5000	41,70	-12,30	54,00	pass					

Ref.-No.: 20/01-0029

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
2,4840	42,24	-11,76	54,00	pass	all emissions are 20dB below limit				pass
2,4870	41,68	-12,32	54,00	pass					
2,4900	41,44	-12,56	54,00	pass					
2,4933	41,20	-12,80	54,00	pass					
2,4995	41,31	-12,69	54,00	pass					
2,5000	41,46	-12,54	54,00	pass					

Higher Band Edge - 8DPSK CH. 78 – radiated



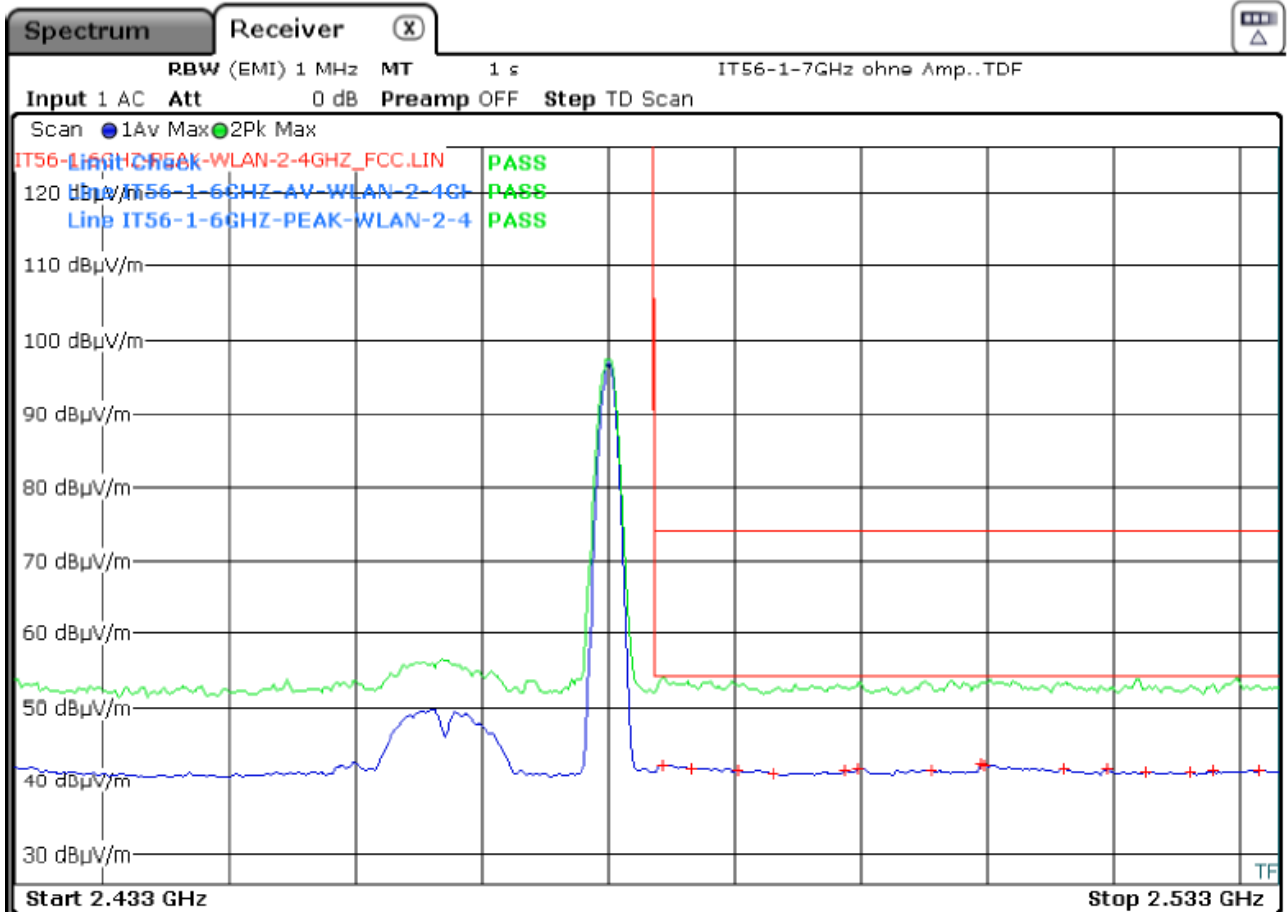
FCC 3
Band edge emission
according to



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

Ref.-No.: 20/01-0029

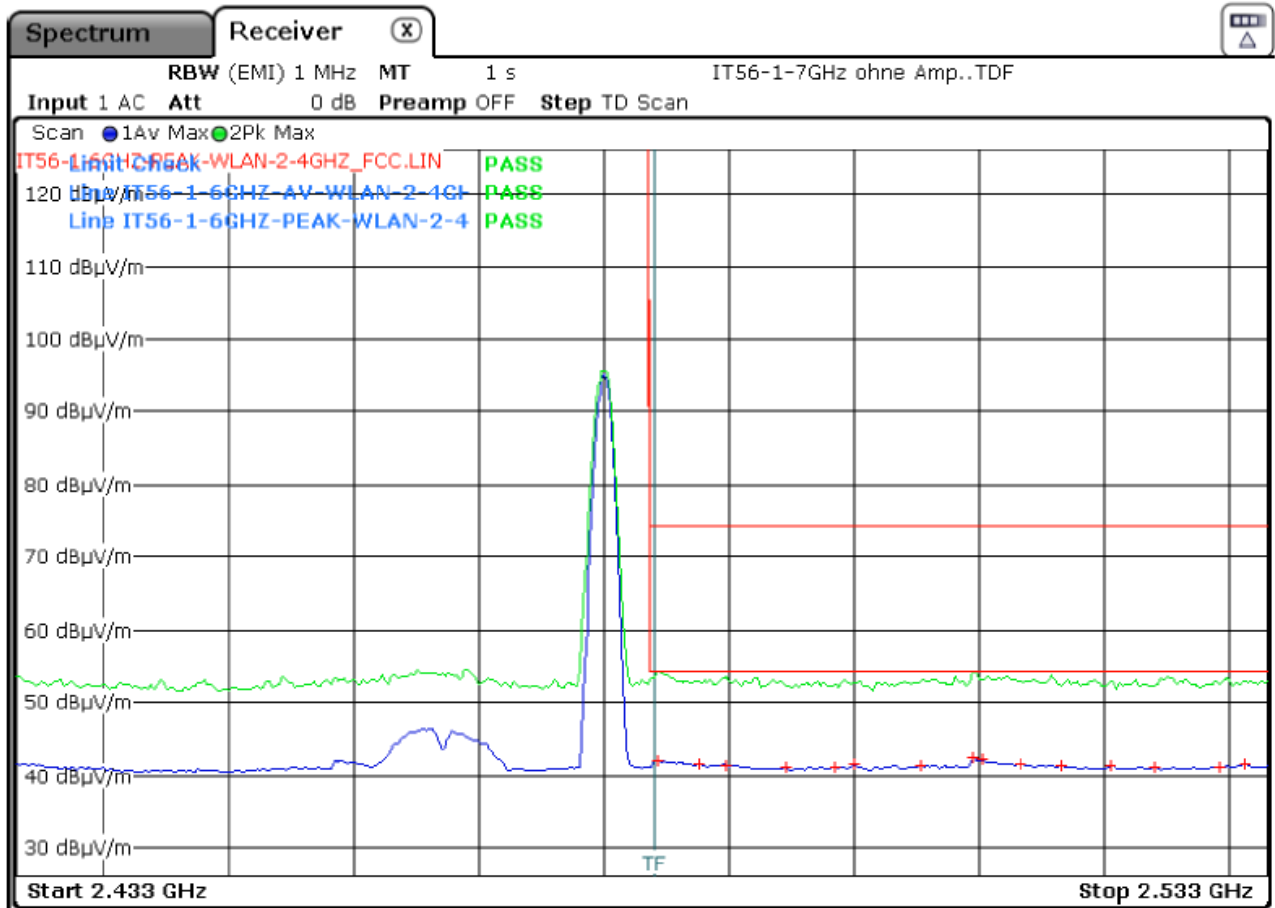
Operation mode: BT CH.78; 8DPSK; High Edge



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	42,19	-11,81	54,00	pass	all emissions are 10dB below limit				pass
2,4865	41,74	-12,26	54,00	pass					
2,4903	41,46	-12,54	54,00	pass					
2,4930	41,05	-12,95	54,00	pass					
2,4988	41,35	-12,65	54,00	pass					
2,4998	41,74	-12,26	54,00	pass					

Ref.-No.: 20/01-0029

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
2,4843	42,05	-11,95	54,00	pass	all emissions are 20dB below limit				pass
2,4875	41,59	-12,41	54,00	pass					
2,4898	41,51	-12,49	54,00	pass					
2,4945	41,16	-12,84	54,00	pass					
2,4985	41,29	-12,71	54,00	pass					
2,5000	41,57	-12,43	54,00	pass					

Hopping mode

Band Edge Measurement were also performed in Hopping mode.
For hopping mode the 8DPSK mode was found as worst case and documented in this report.



FCC 3
Band edge emission
according to



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

Ref.-No.: 20/01-0029

Product: Transmitting/Receiving System

Sample: 01

Date: 25.06.2020

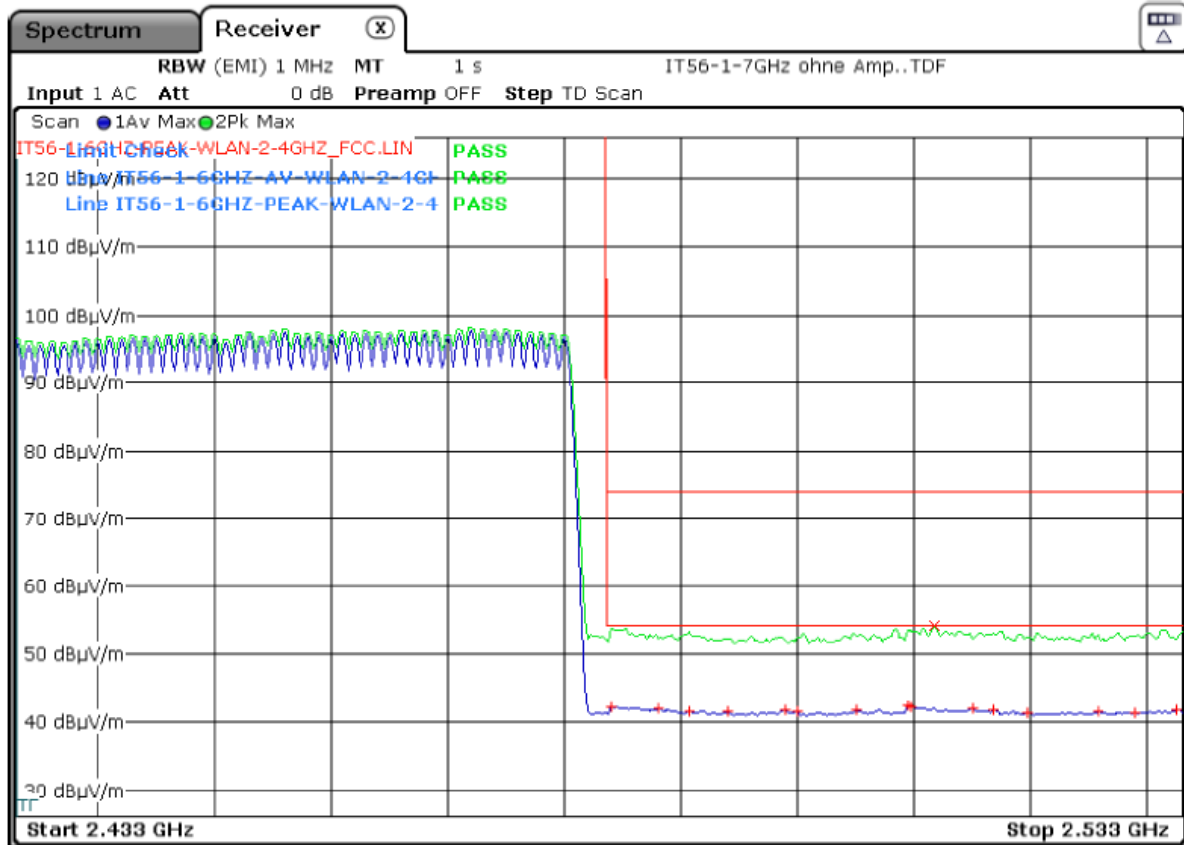
Operator: TM

Remarks:

pass fail

Result:

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
2,4840	42,13	-11,87	54,00	pass	2,5118	54,04	-19,96	74,00	pass
2,4880	41,91	-12,09	54,00	pass					
2,4908	41,46	-12,54	54,00	pass					
2,4940	41,37	-12,63	54,00	pass					
2,4990	41,72	-12,28	54,00	pass					
2,5000	41,36	-12,64	54,00	pass					



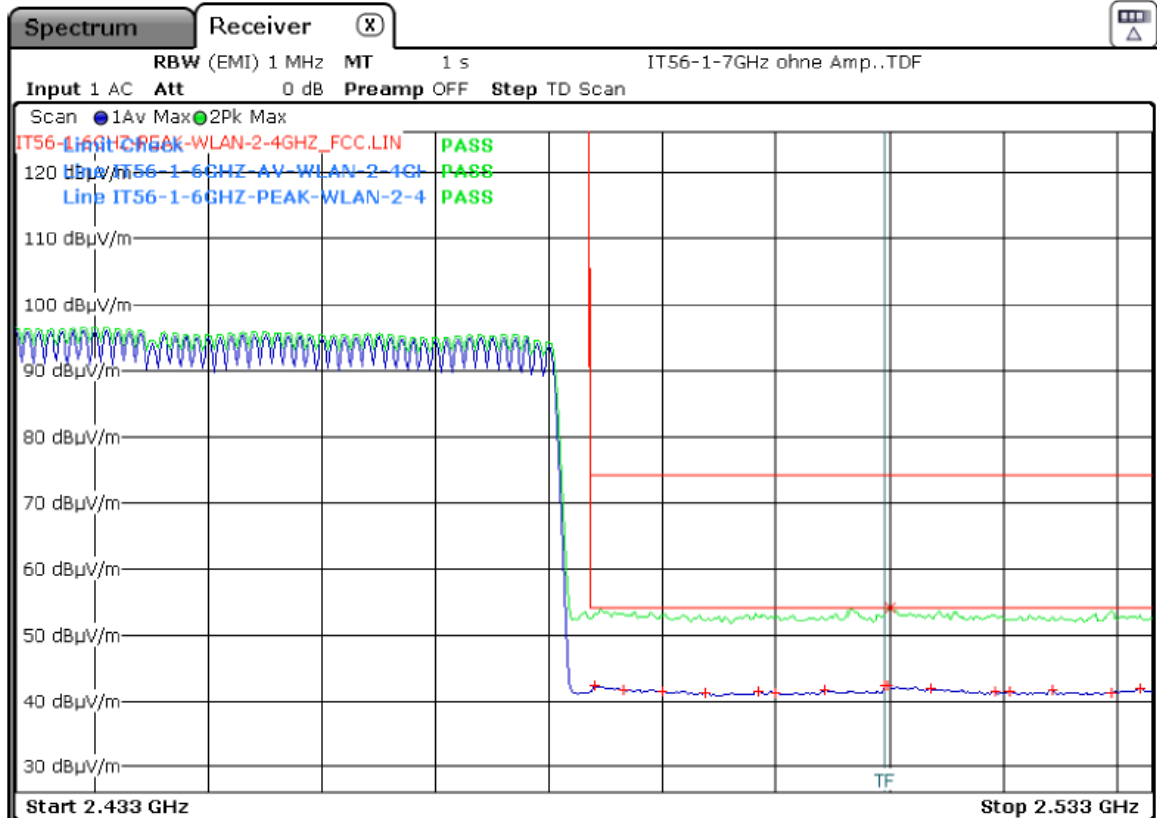
FCC 3
Band edge emission
according to



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

Ref.-No.: 20/01-0029

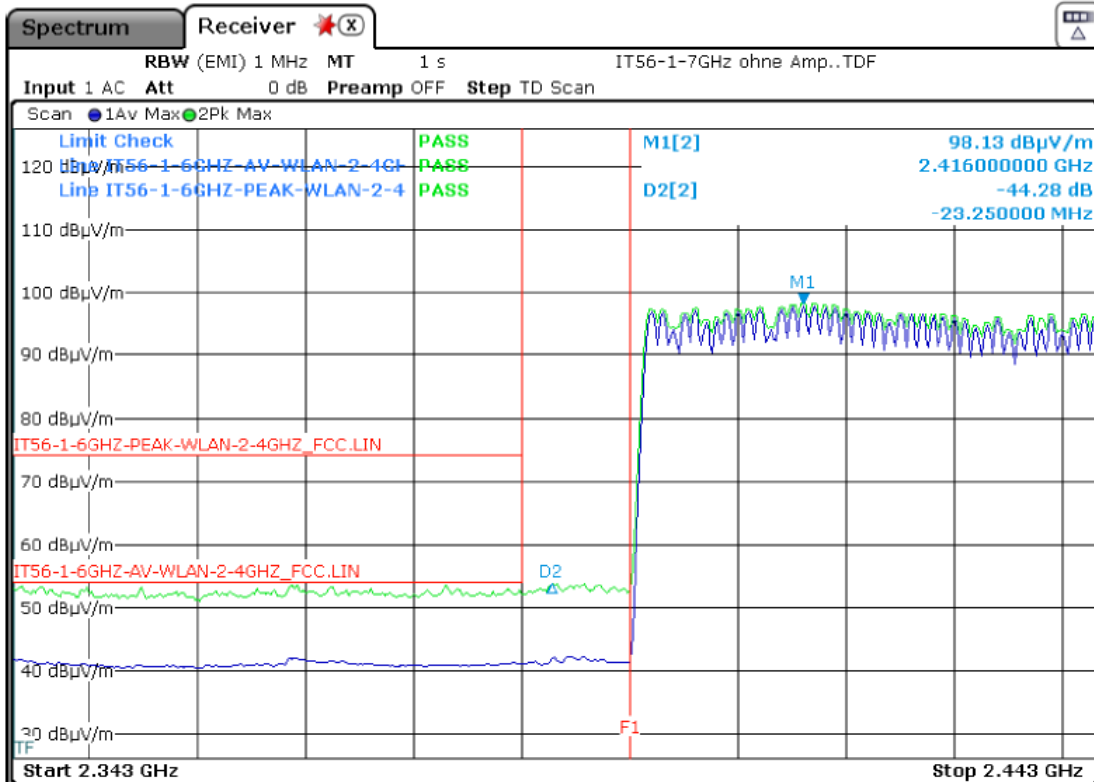
Operation mode: BT; Hopping 8DPSK; High Edge



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	42,22	-11,78	54,00	pass	2,5100	54,08	-19,92	74,00	pass
2,4865	41,72	-12,28	54,00	pass					
2,4900	41,47	-12,53	54,00	pass					
2,4938	41,26	-12,74	54,00	pass					
2,4985	41,41	-12,59	54,00	pass					
2,5000	41,26	-12,74	54,00	pass					

Ref.-No.: 20/01-0029

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

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**.

7.7. 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

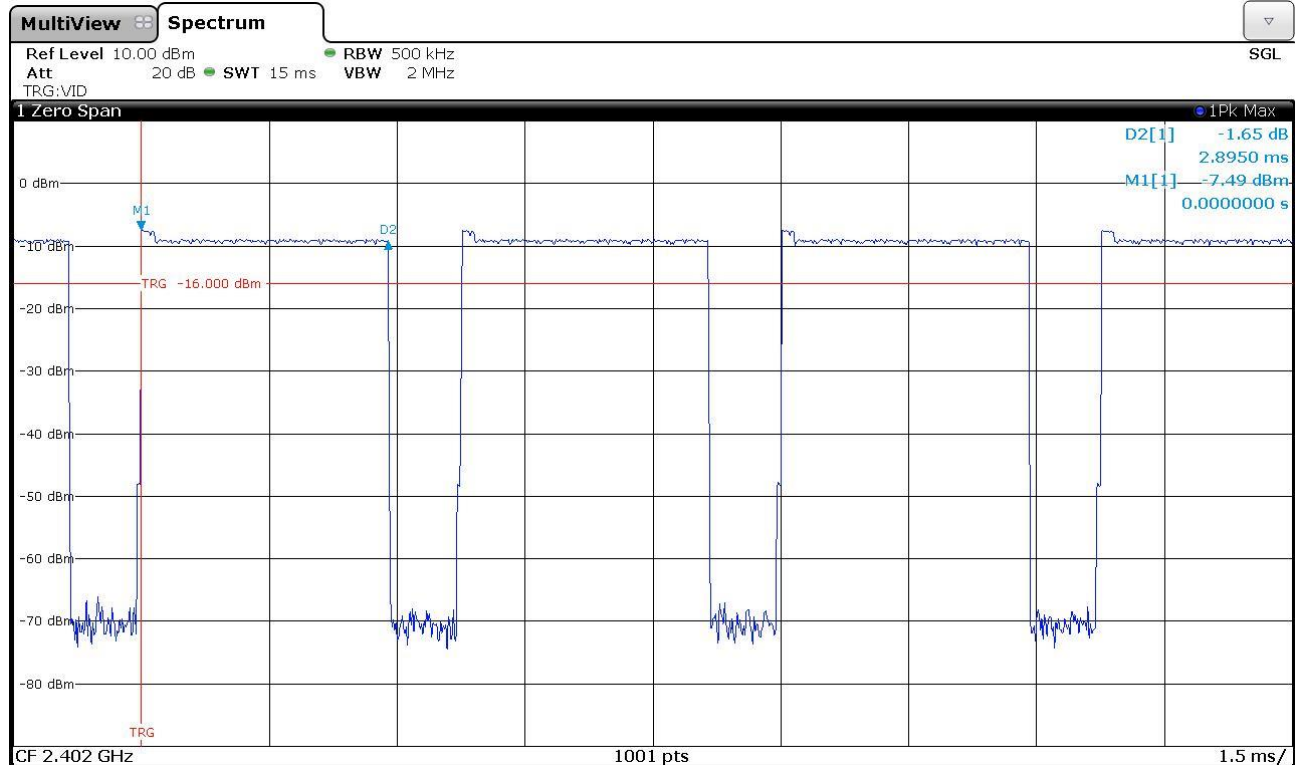
Measurement

The Measurement was performed on: 18.02.2020

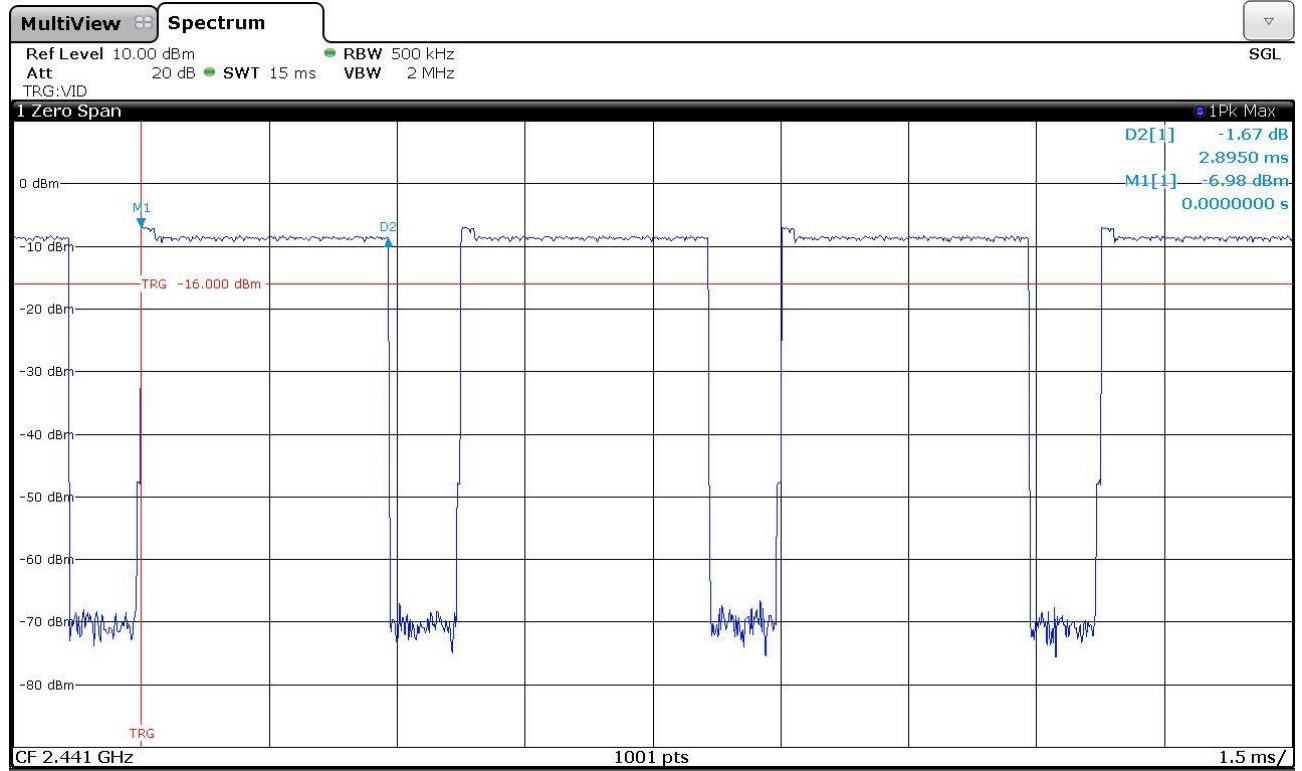
DH5 / 3-DH5 Packet

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 $3.37 \text{ hops/sec.} \times 31.6 \text{ sec.} = 106.6$ hops within 31.6 seconds

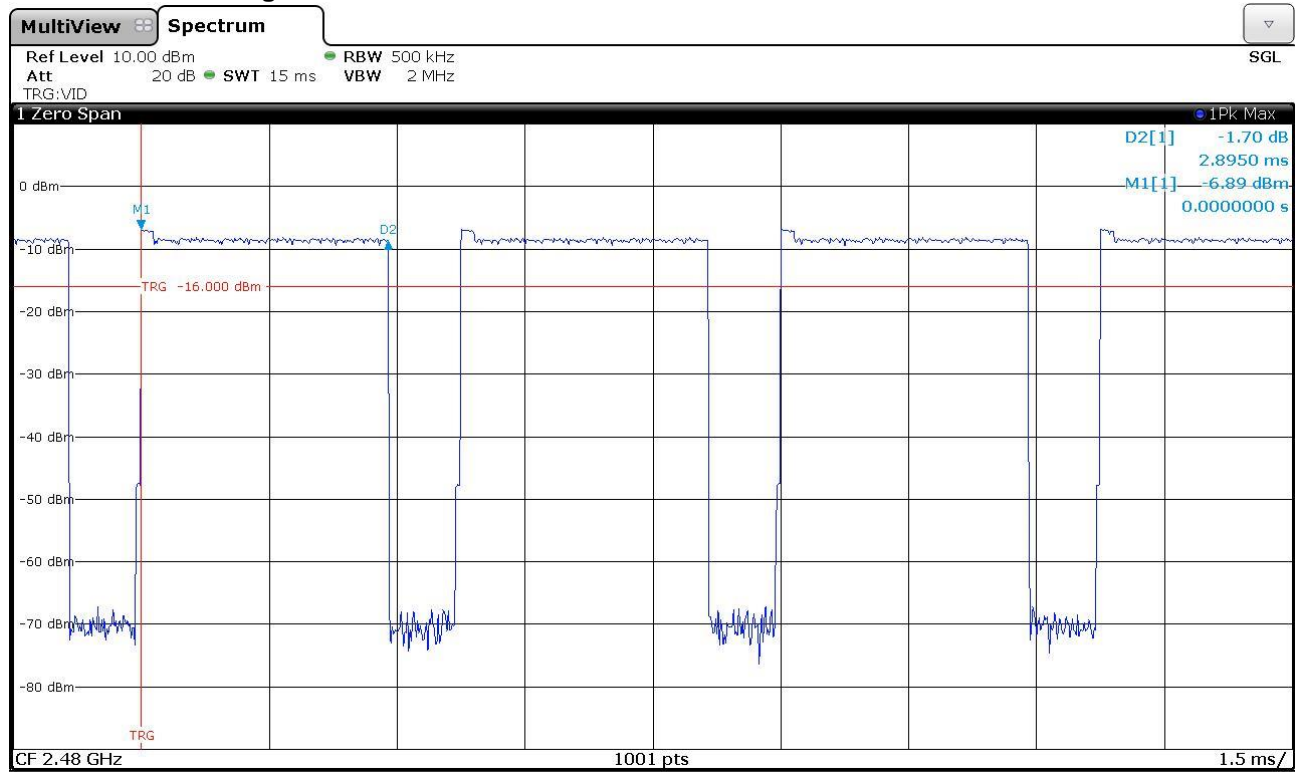
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



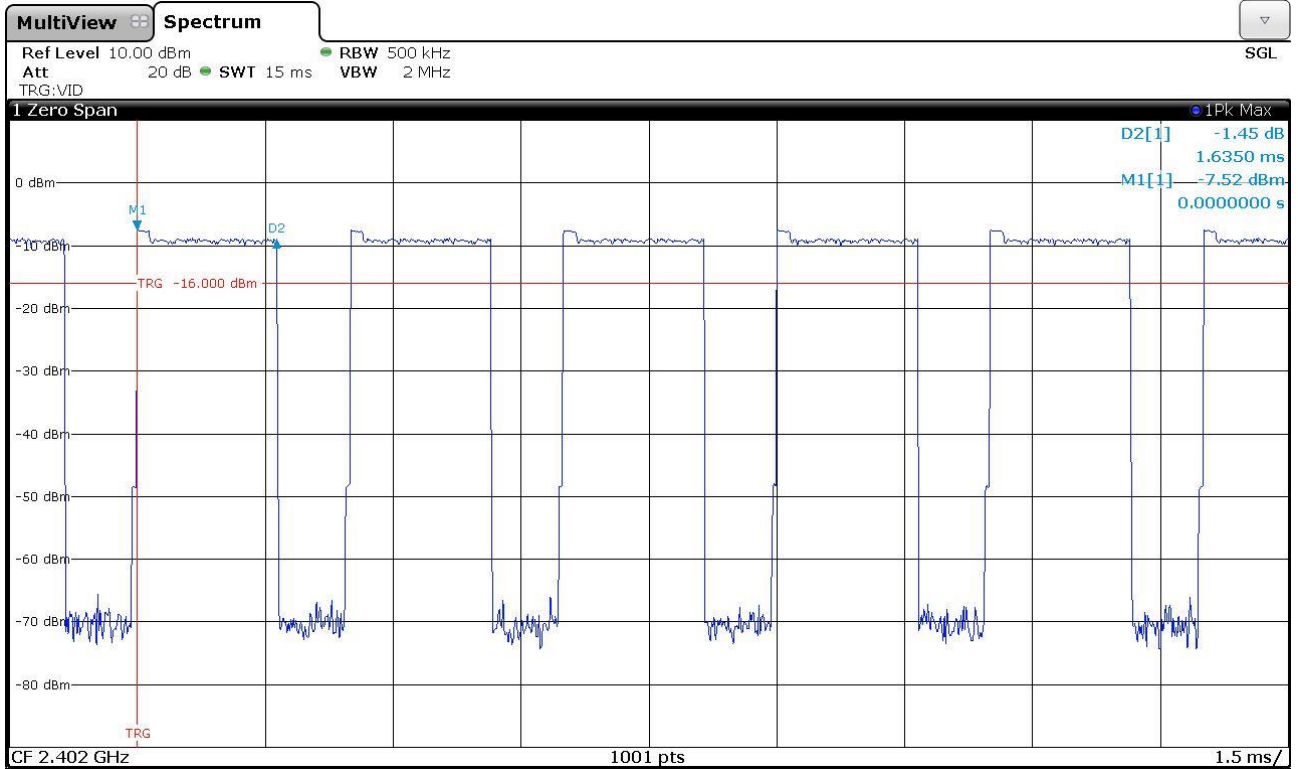
Pulse duration of Highest Channel



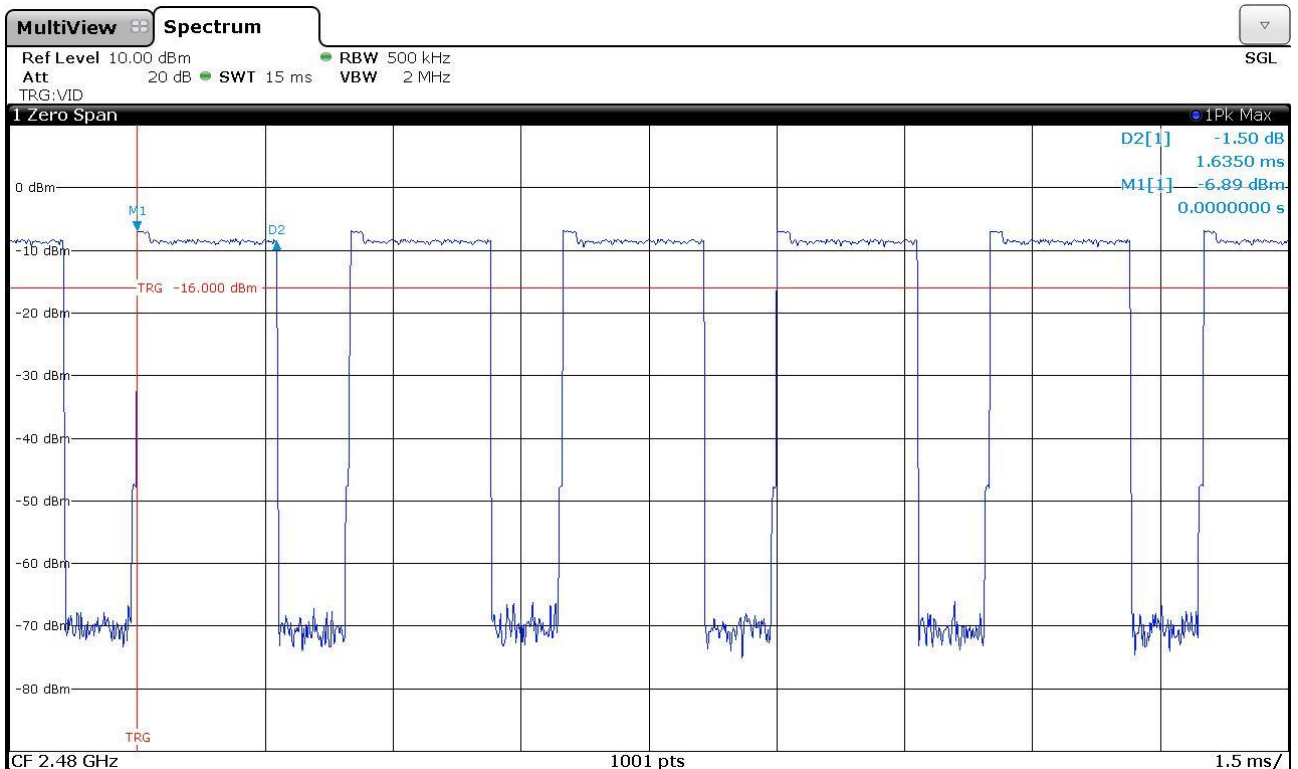
DH3 / 3-DH3 Packet:

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 $5.06 \text{ hops/sec.} \times 31.6 \text{ sec.} = 160$ hops within 31.6 seconds

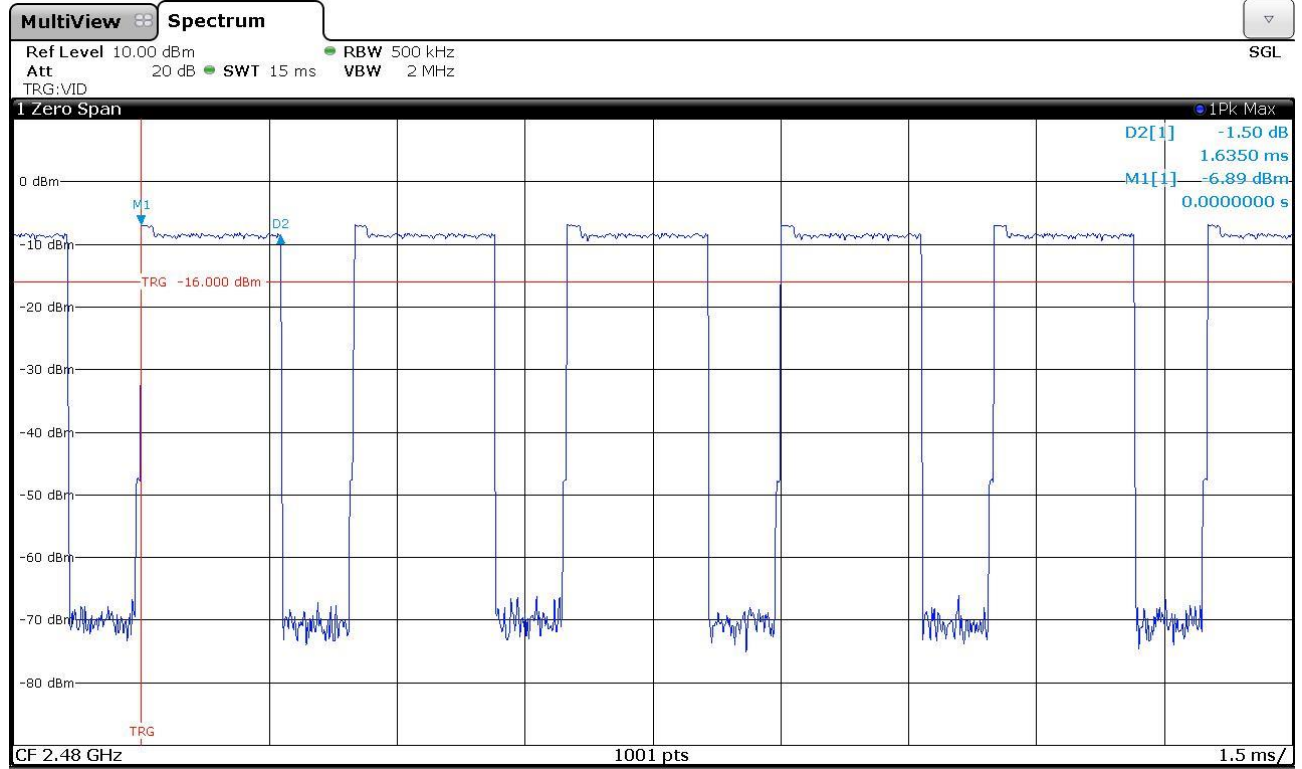
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



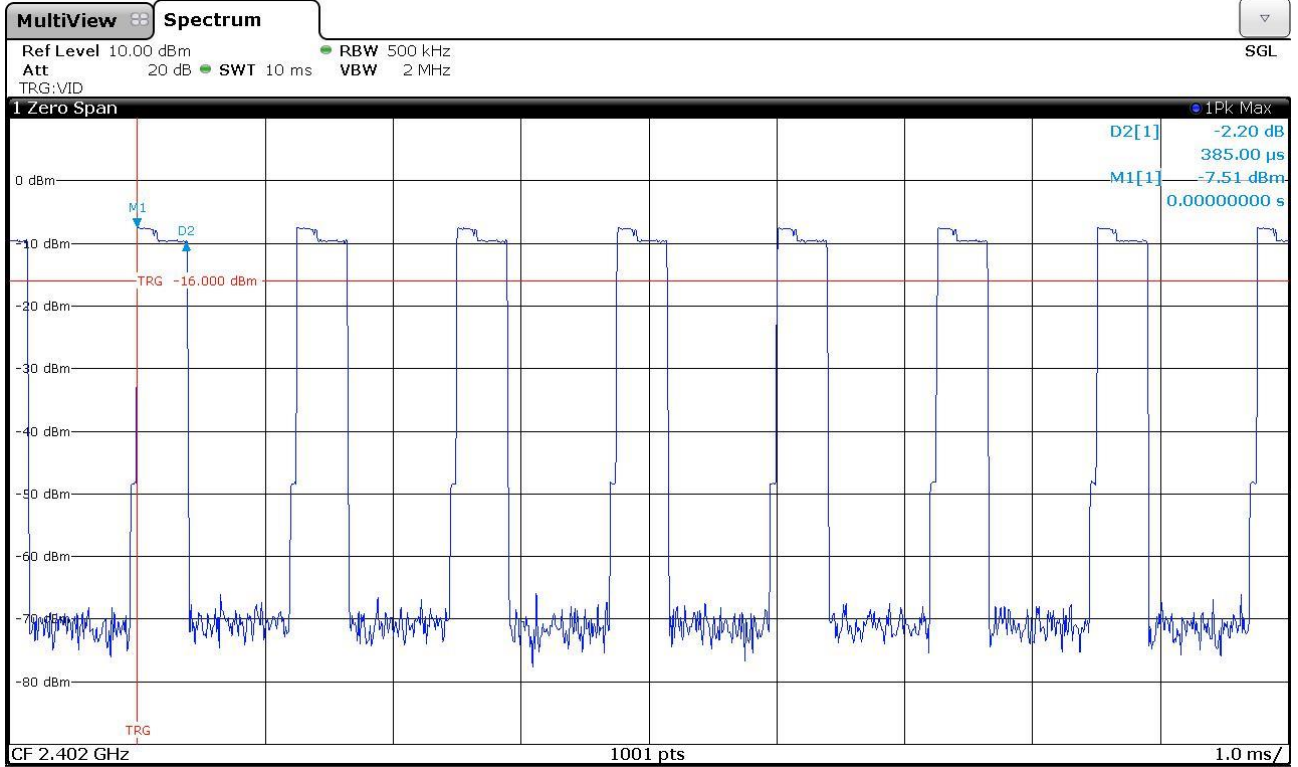
Pulse duration of Highest Channel



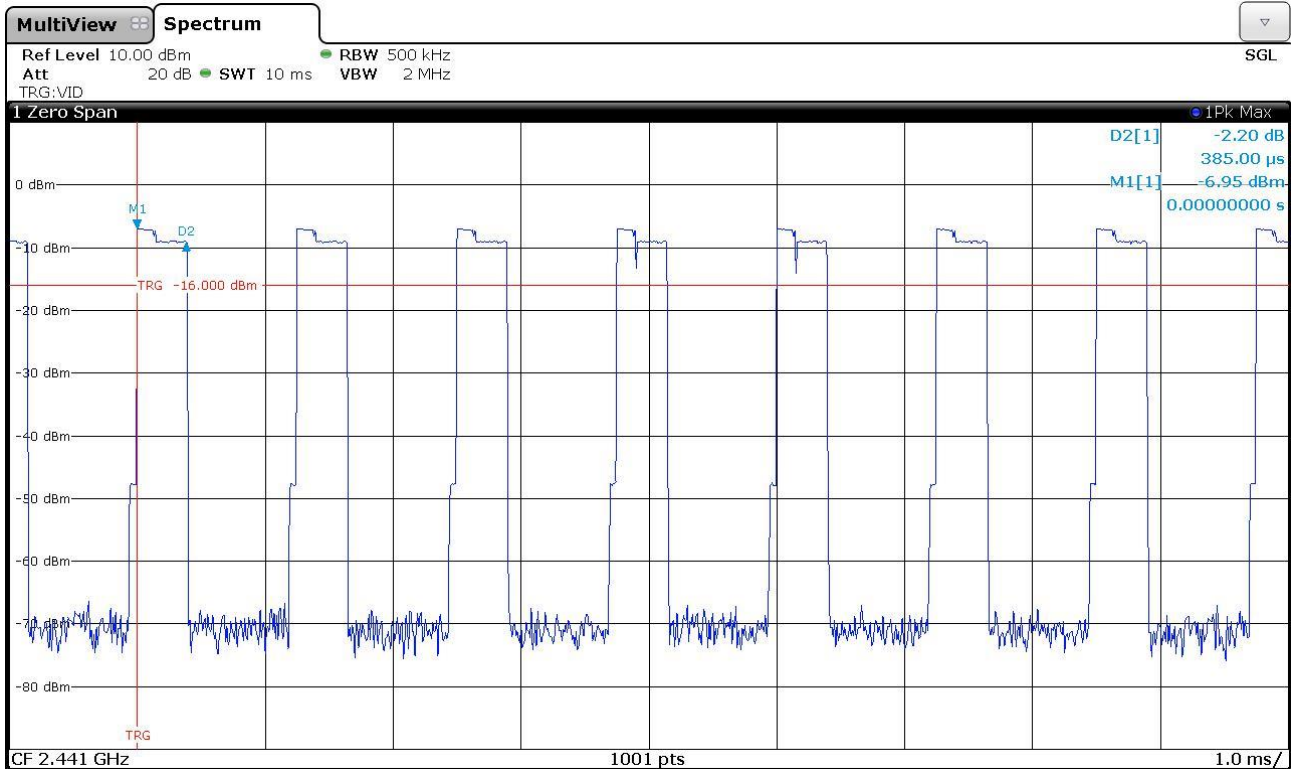
DH1 /2-DH1 Packet:

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 $10.12 \text{ hops/sec.} \times 31.6 \text{ sec.} = 320$ hops within 31.6 seconds

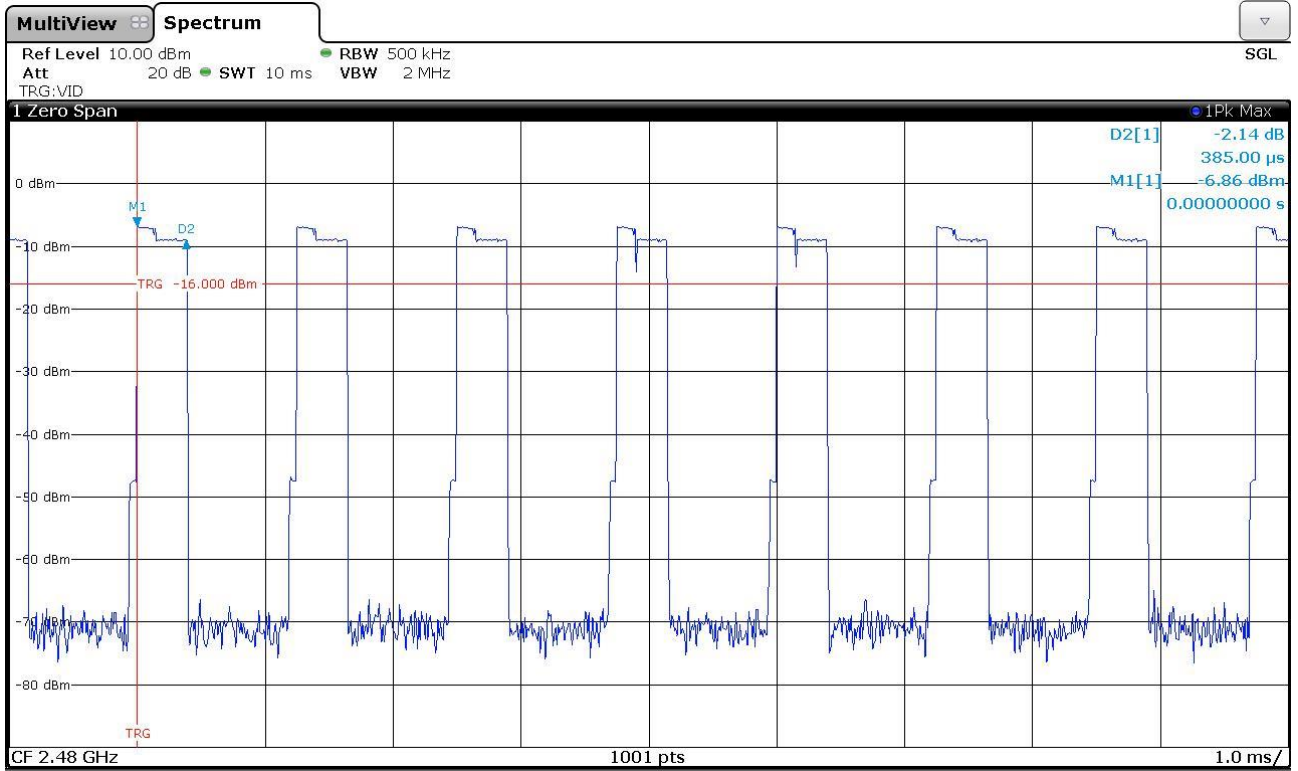
Pulse duration of Lowest Channel



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	2.895	0.309	0.400	PASS
DH5/3-DH5	2441	106.6	2.895	0.309	0.400	PASS
DH5/3-DH5	2480	106.6	2.895	0.309	0.400	PASS
DH3/3-DH3	2402	160	1.635	0.262	0.400	PASS
DH3/3-DH3	2441	160	1.635	0.262	0.400	PASS
DH3/3-DH3	2480	160	1.635	0.262	0.400	PASS
DH1/2-DH1	2402	320	0.385	0.123	0.400	PASS
DH1/2-DH1	2441	320	0.385	0.123	0.400	PASS
DH1/2-DH1	2480	320	0.385	0.123	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)**.

7.8. 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.

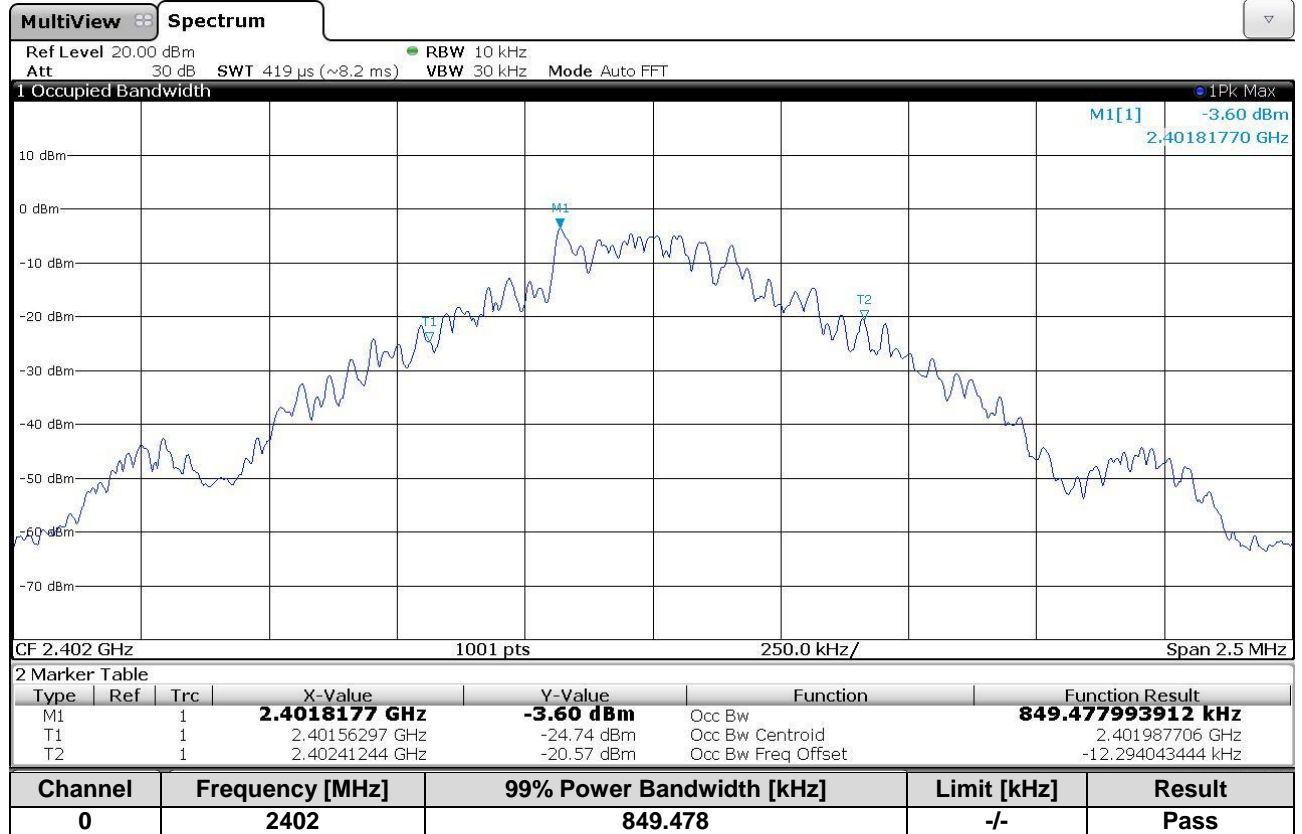
Description

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.

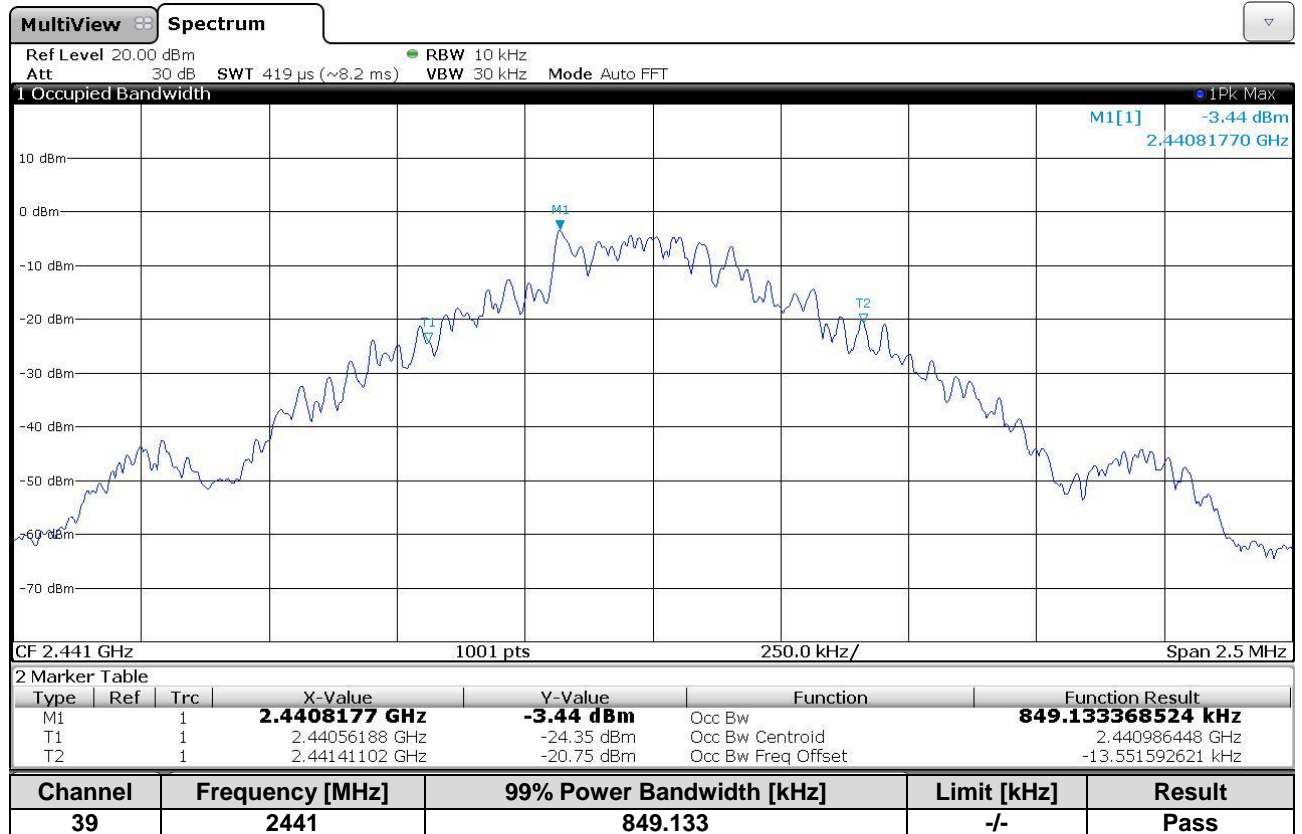
Measurement

The Measurement was performed on: 18.02.2020

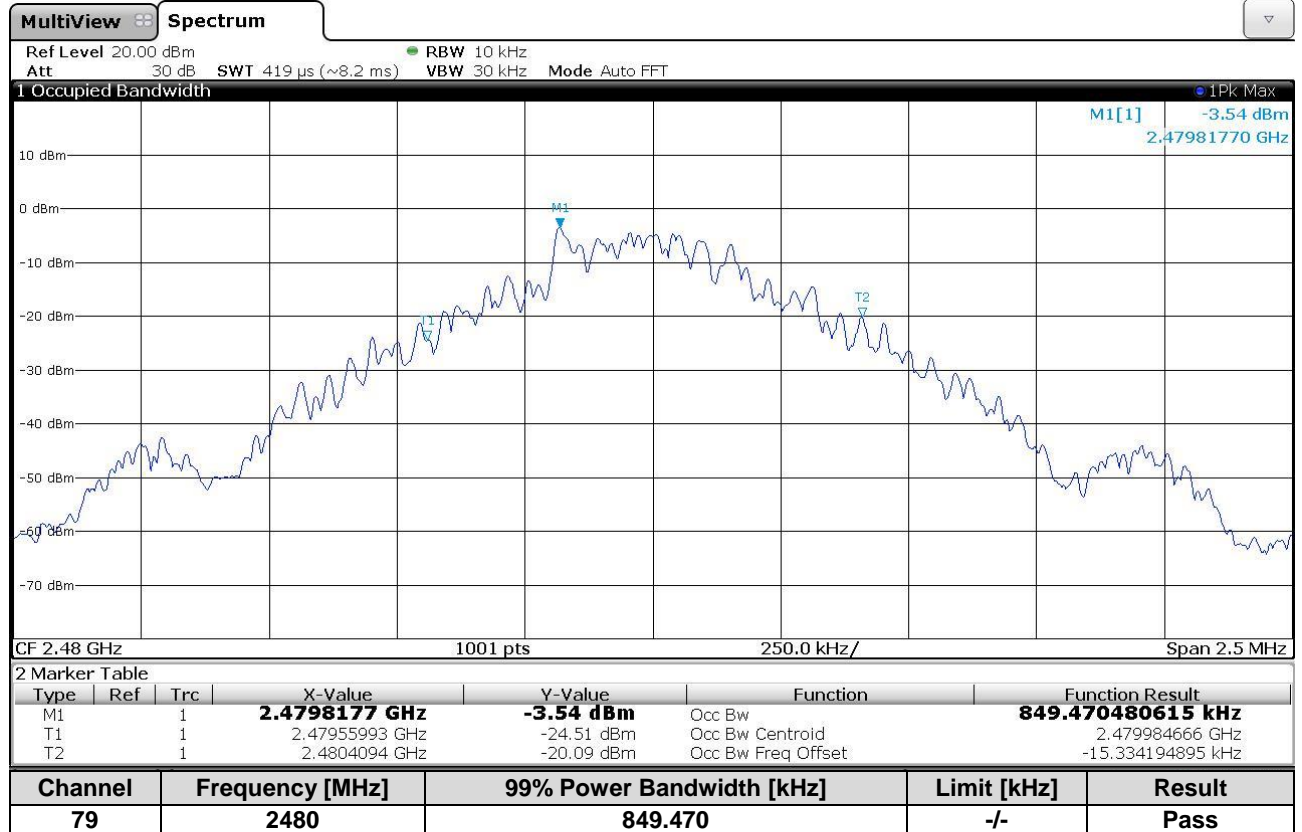
Lowest operating frequency - GFSK



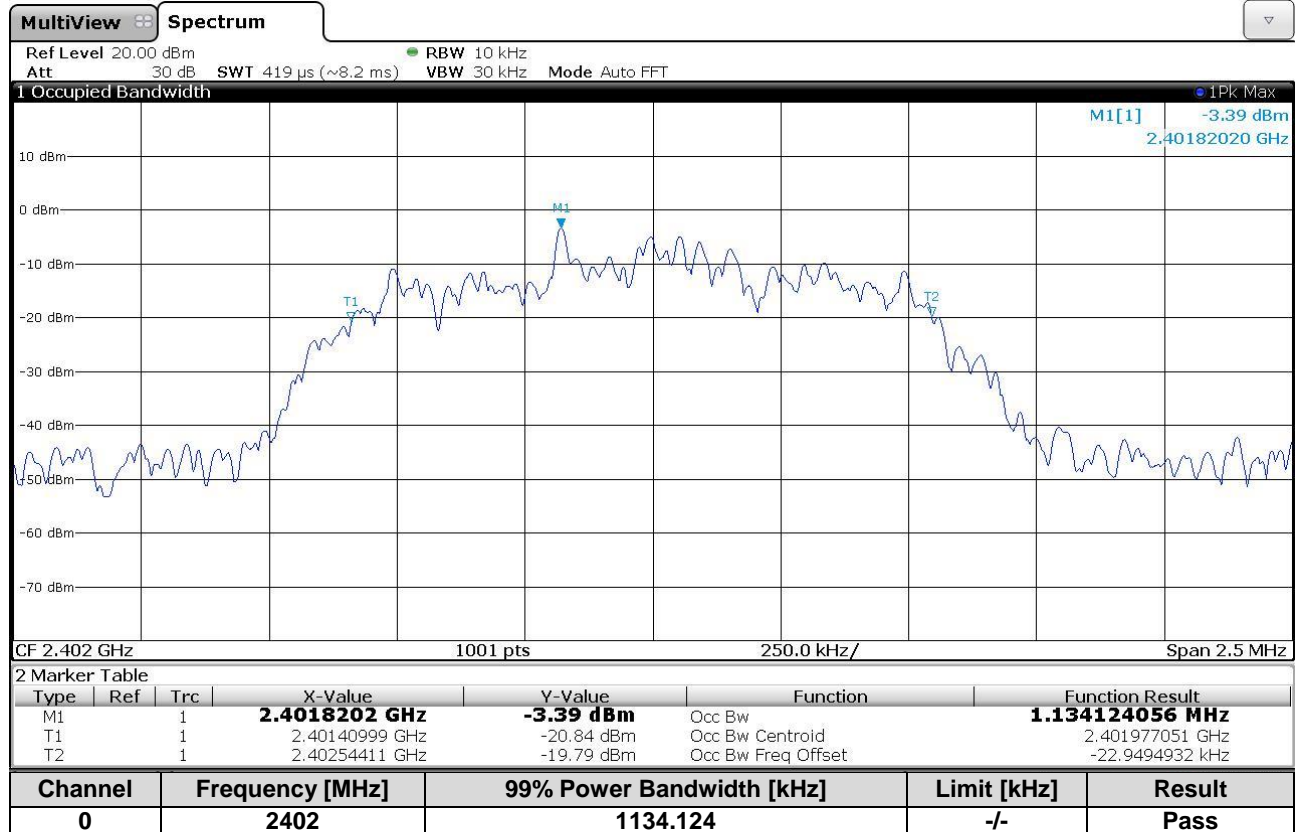
Middle Operating Frequency - GFSK



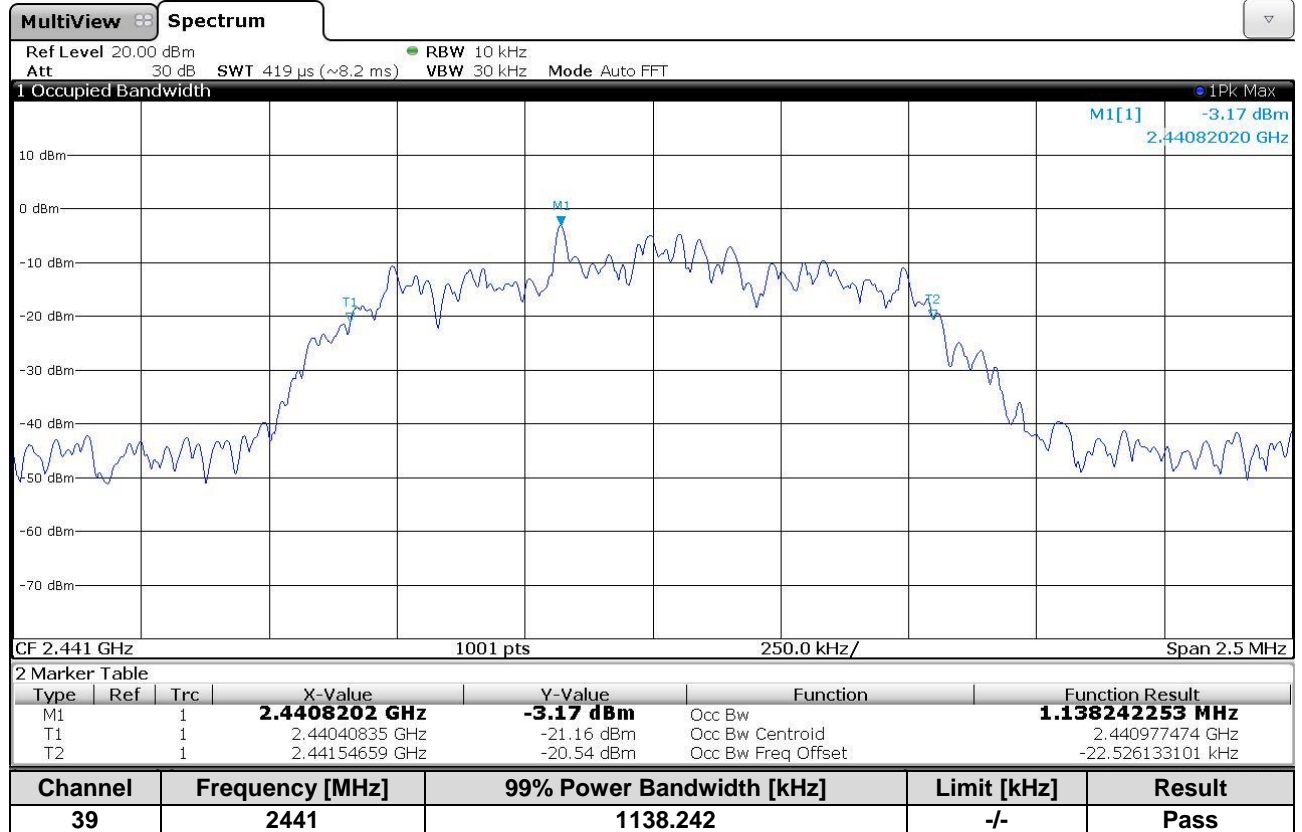
Highest Operating Frequency - GFSK



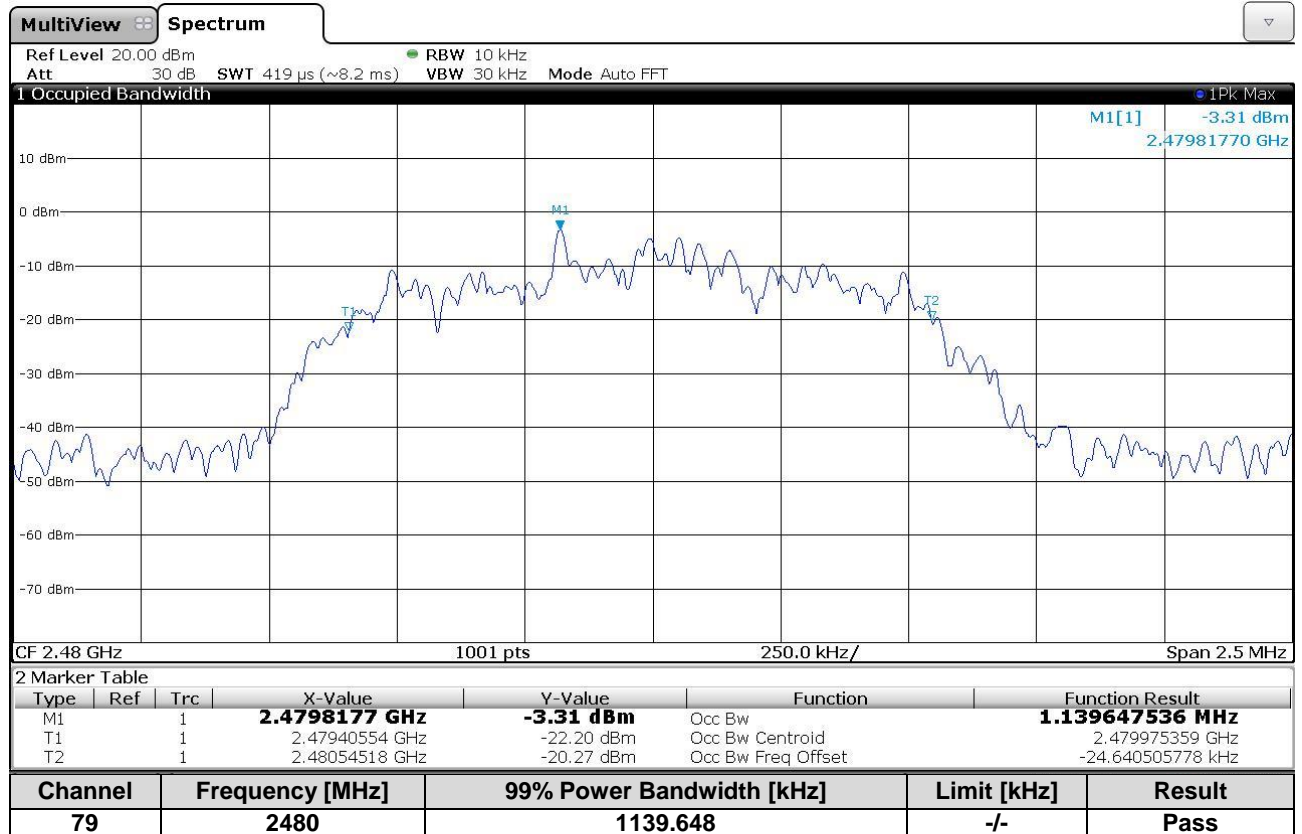
Lowest operating frequency – $\pi/4$ -DQPSK



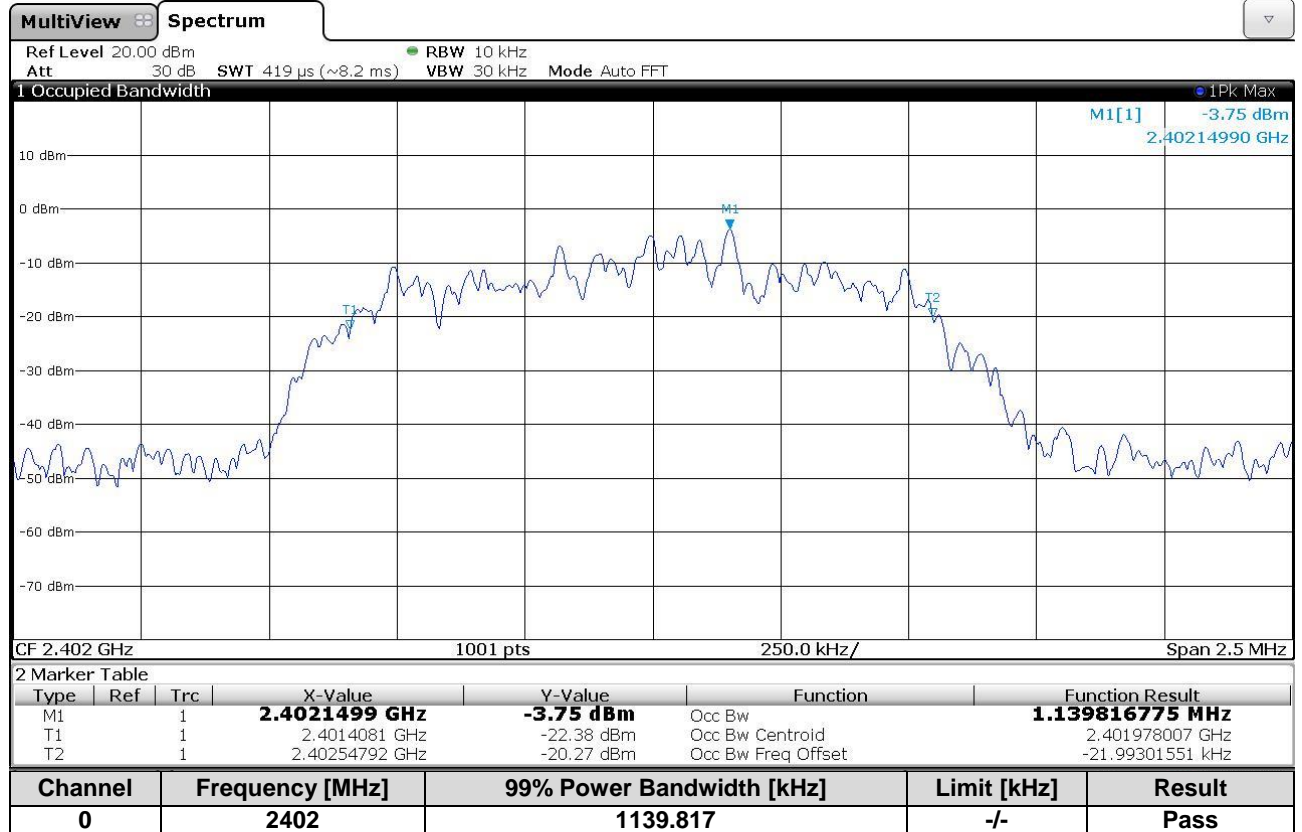
Middle Operating Frequency – $\pi/4$ -DQPSK



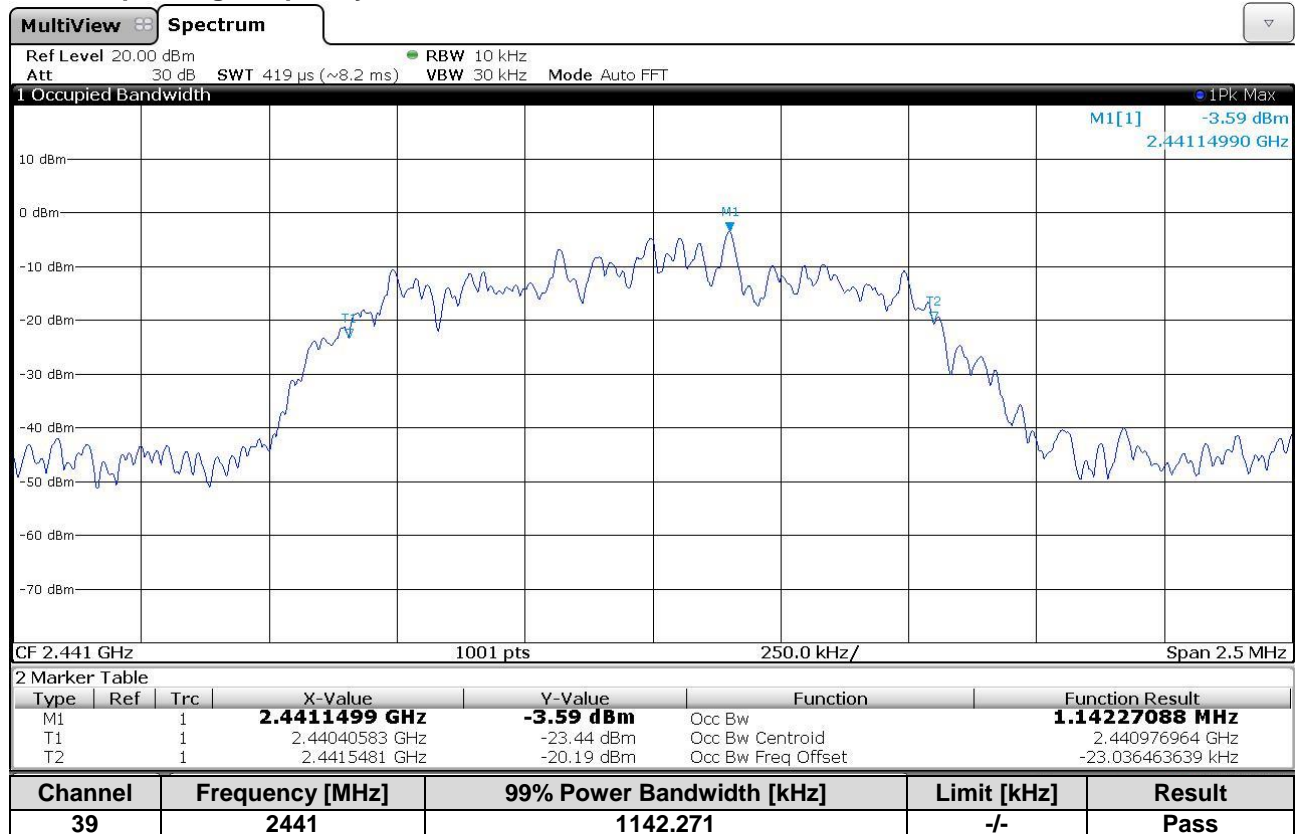
Highest Operating Frequency – $\pi/4$ -DQPSK



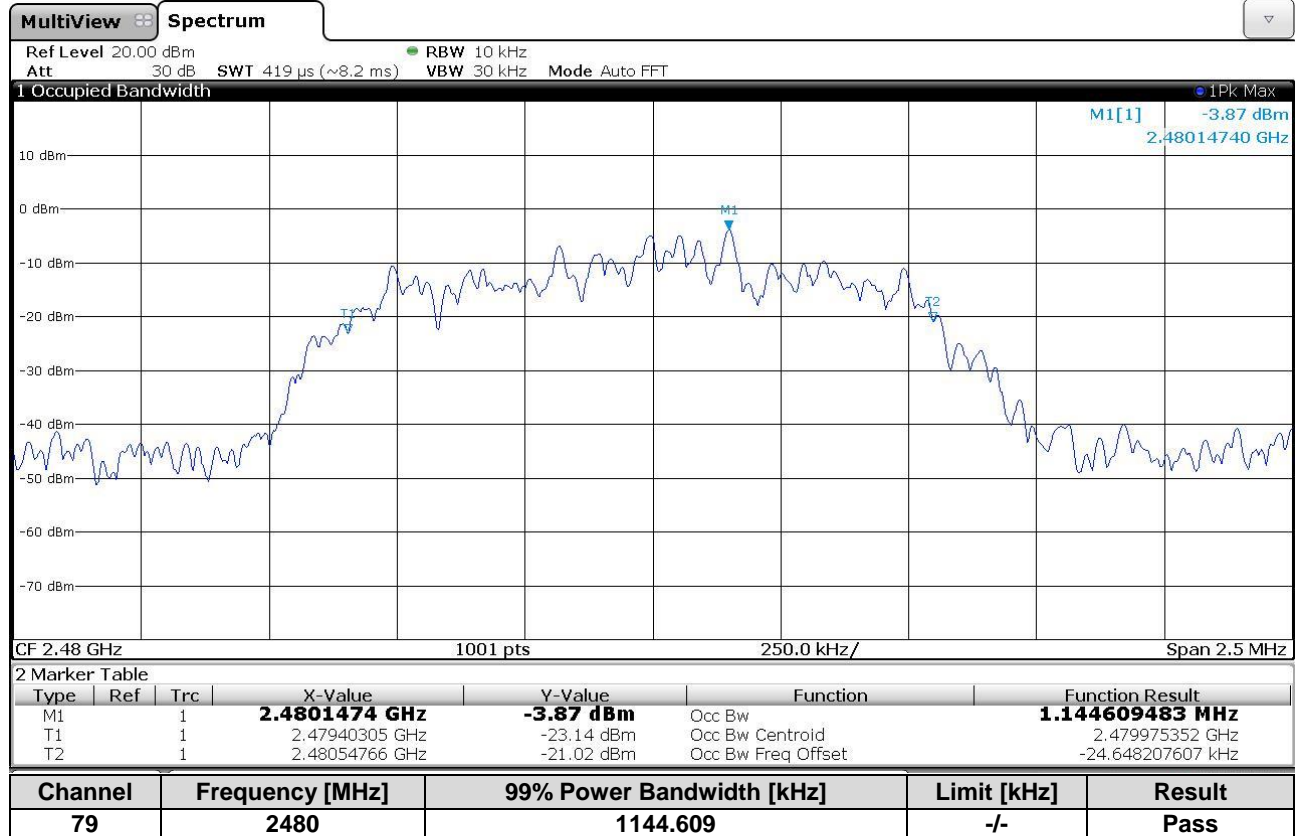
Lowest operating frequency – 8DPSK



Middle Operating Frequency – 8DPSK



Highest Operating Frequency – 8DPSK



Results

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

8. 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 2020-April	3 years 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	BBHA91706 21	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

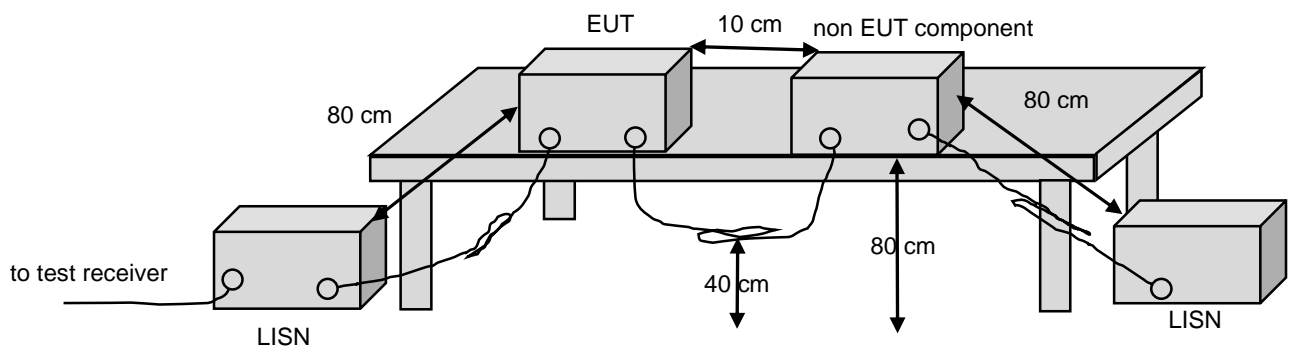
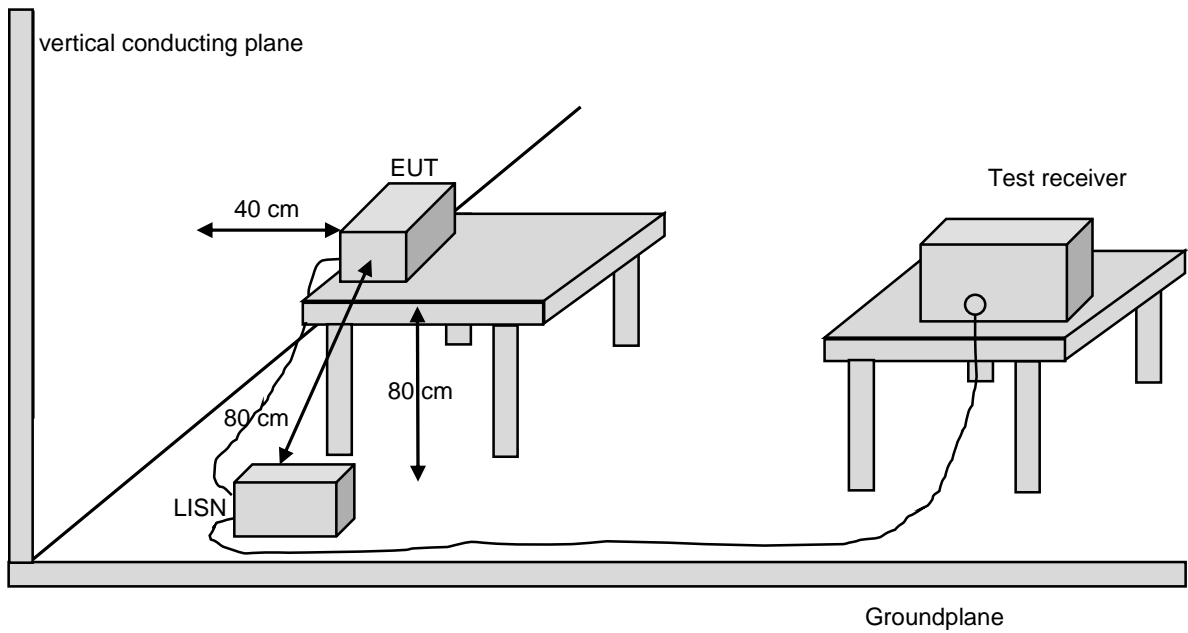
All measurements were made with measuring instruments, including any accessories that may affect test results, calibrated according to the requests of ISO/IEC 17025 according to which the test site is accredited from DAkkS. Measurement of conducted mains emissions was made with instruments conforming to American National Standard Specification, ANSI C63.4-2014.

Test equipment to support EUT functions:

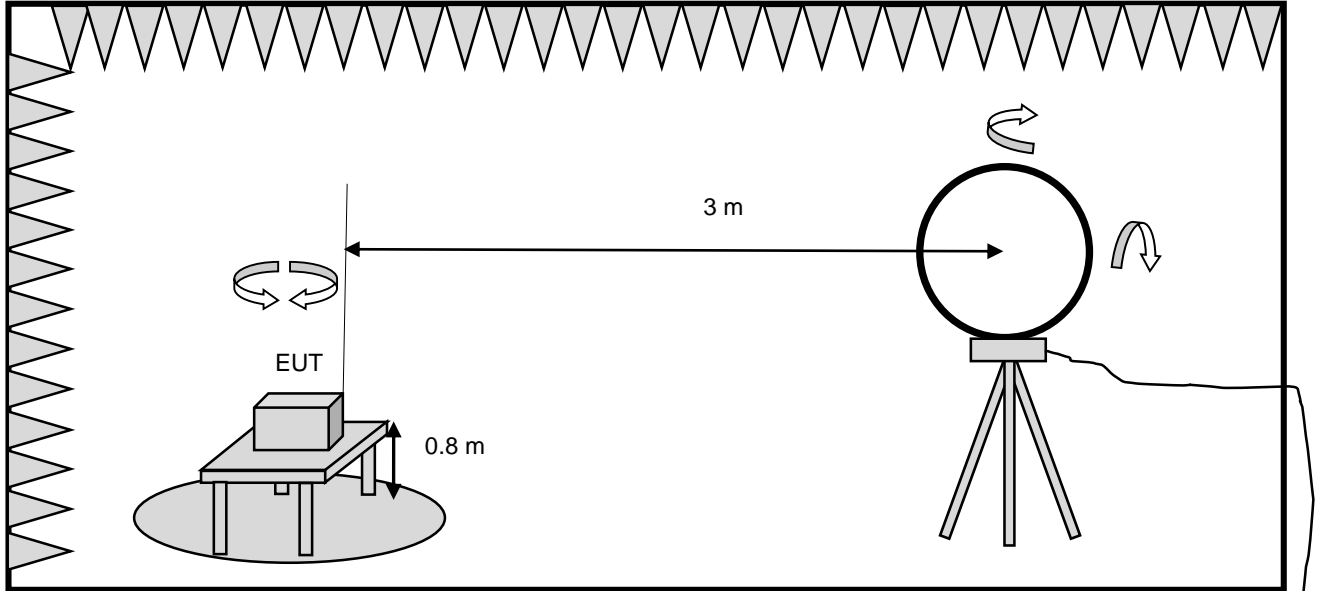
Kind of equipment	Manufacturer	Type	Ident no.
Laptop	DELL	Inspiron	11488
AC-Adaptor [Laptop/EUT]	DELL	DA130PE1-00	Part of 11488
Test Adaptor Board	Vestel (Client)	17TEST02	Client
Software	Provided by Vestel (Client)	CyBluetool	-/-

9. Test Setups

Block diagram Conducted Mains emissions

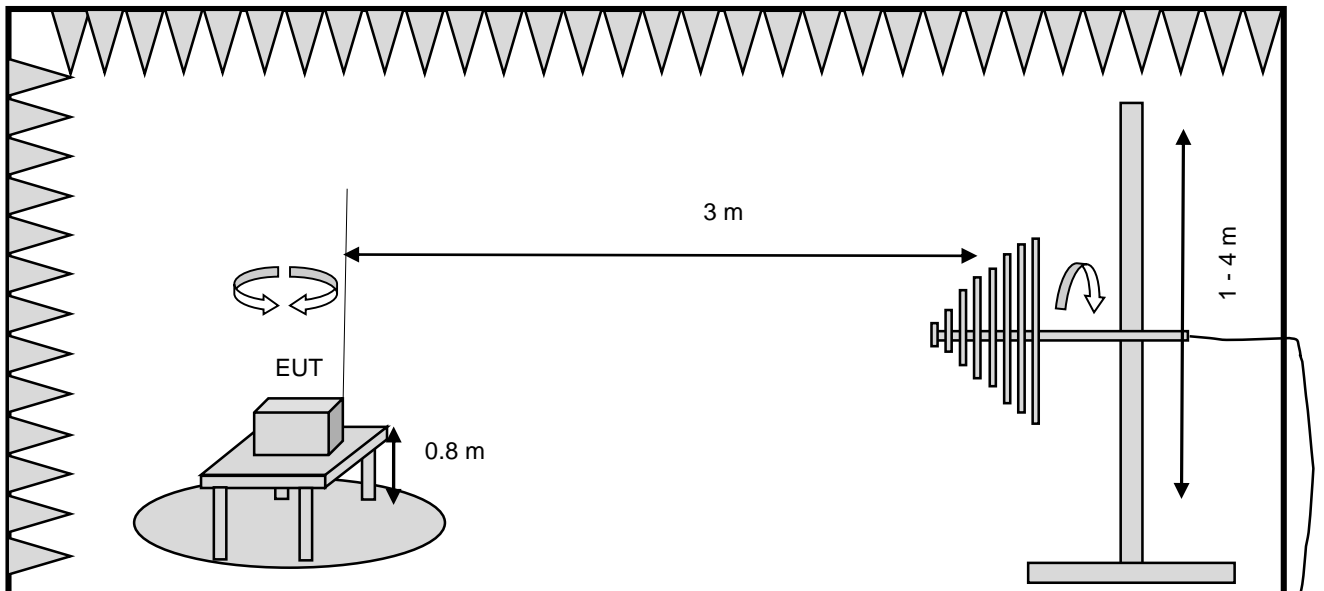
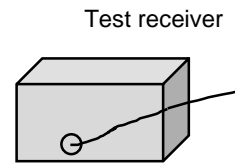


Block diagram Radiated emissions



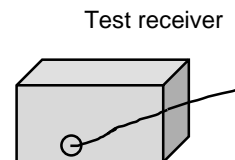
Semi anechoic chamber with absorber and ferrite tiles

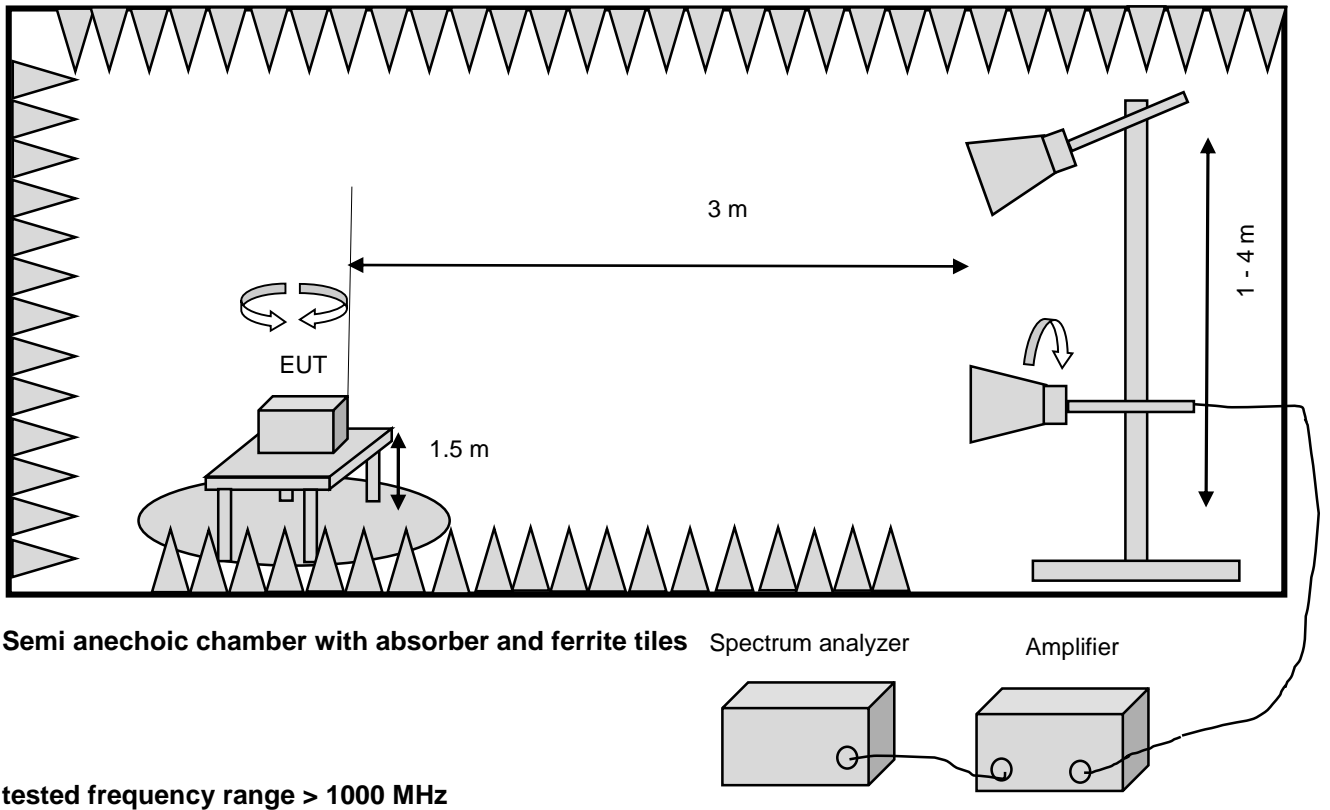
tested frequency range 9 kHz - 30 MHz



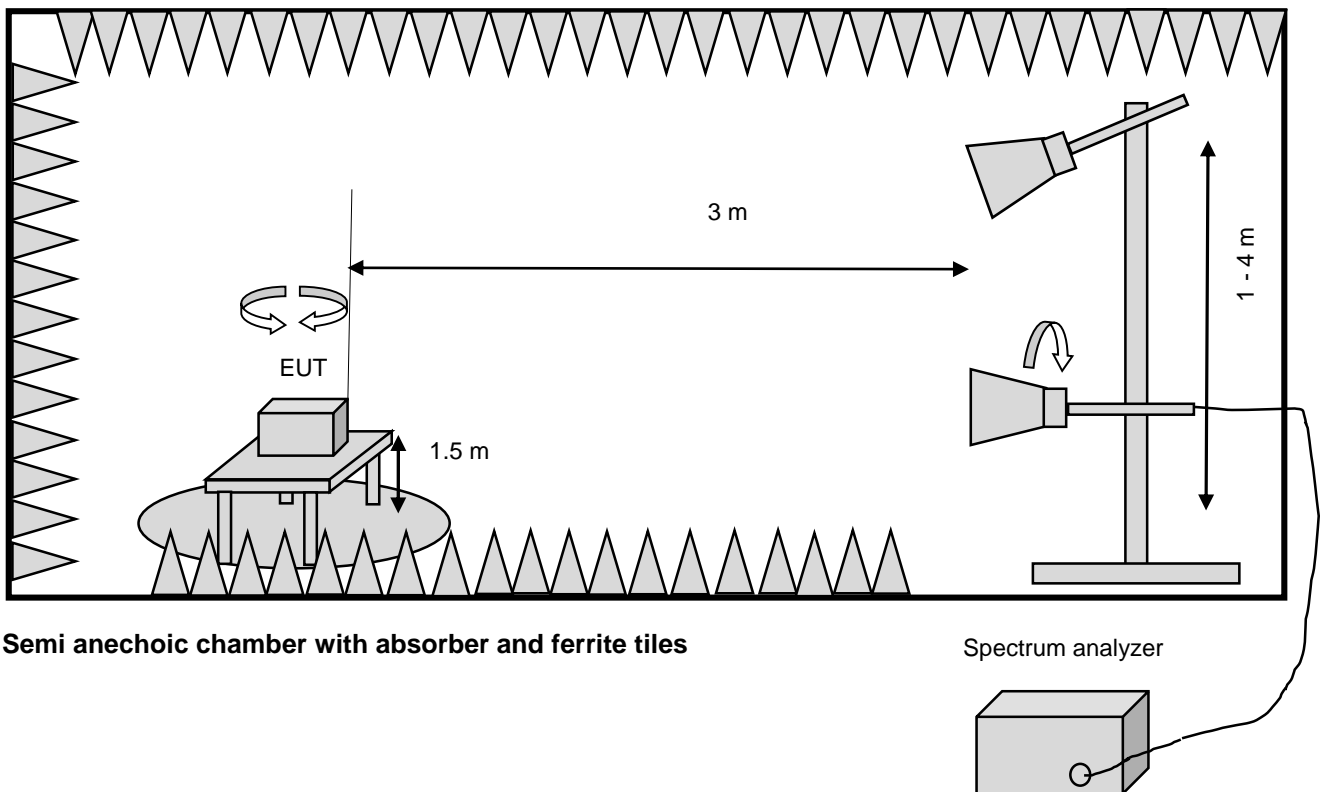
Semi anechoic chamber with absorber and ferrite tiles

tested frequency range 30 MHz - 1000 MHz

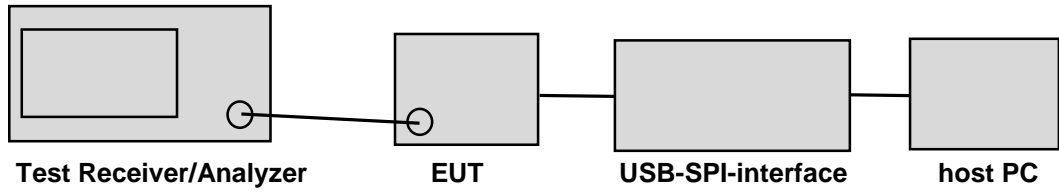




Block diagram Band Edge emissions



Block diagram for conducted measurements



10. 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	$\pm 1.17 \%$	$\pm 5 \%$
RF output power, conducted	$\pm 1.36 \text{ dB}$	$\pm 1.5 \text{ dB}$
Power Spectral Density, conducted	$\pm 1.99 \text{ dB}$	$\pm 3 \text{ dB}$
Unwanted Emissions, conducted	$\pm 1.71 \text{ dB}$	$\pm 3 \text{ dB}$
All emissions, radiated	$\pm 4.8 \text{ dB}$	$\pm 6 \text{ dB}$
Temperature	$\pm 0.72 \text{ }^\circ\text{C}$	$\pm 3 \text{ }^\circ\text{C}$
Supply voltages	$\pm 0.76 \%$ (DC up to 40V) $\pm 1.74 \%$ (AC 50Hz up to 400V)	$\pm 3 \%$
Time	$\pm 0.012 \%$	$\pm 5 \%$

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 % ($k = 2$).

11. Photos setup

Refer to "0029-fcc-ised-photos test setup.pdf" file

12. 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

28.09.2020

Erstellt am/prepared on

M. Beindl, Laboratory Engineer

(Name/name / Stellung/position)



(Unterschrift/signature)

28.09.2020

Freigabe am/released on

A. Tropmann, Head of Laboratory

(Name/name / Stellung/position)



(Unterschrift/signature)

13. Photos of tested sample

Refer to "0029-fcc-ised-ext-photos.pdf" file

End of test report