7.6. Band Edges Measurement

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

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

Description
The 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.

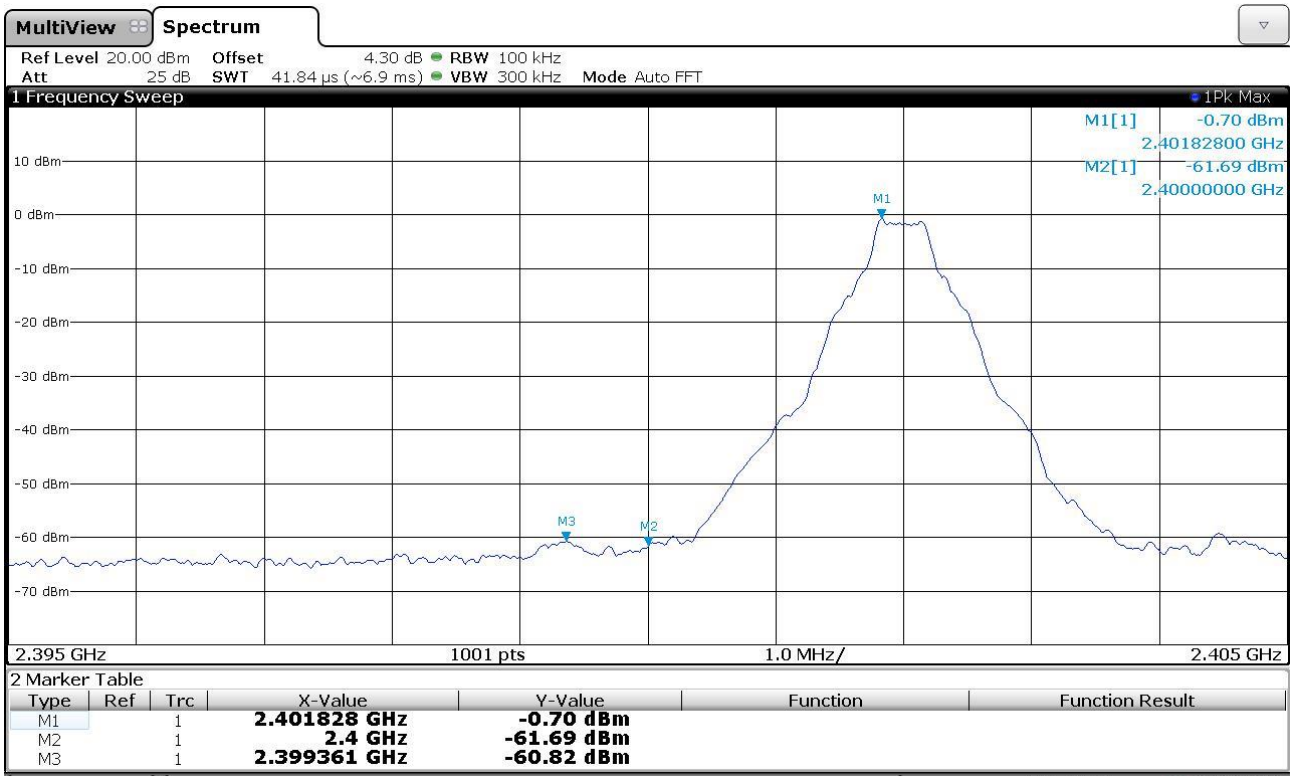
Detector function selection and bandwidth
For the measurement, an EMI test receiver that have CISPR peak and avearge detector was used.

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

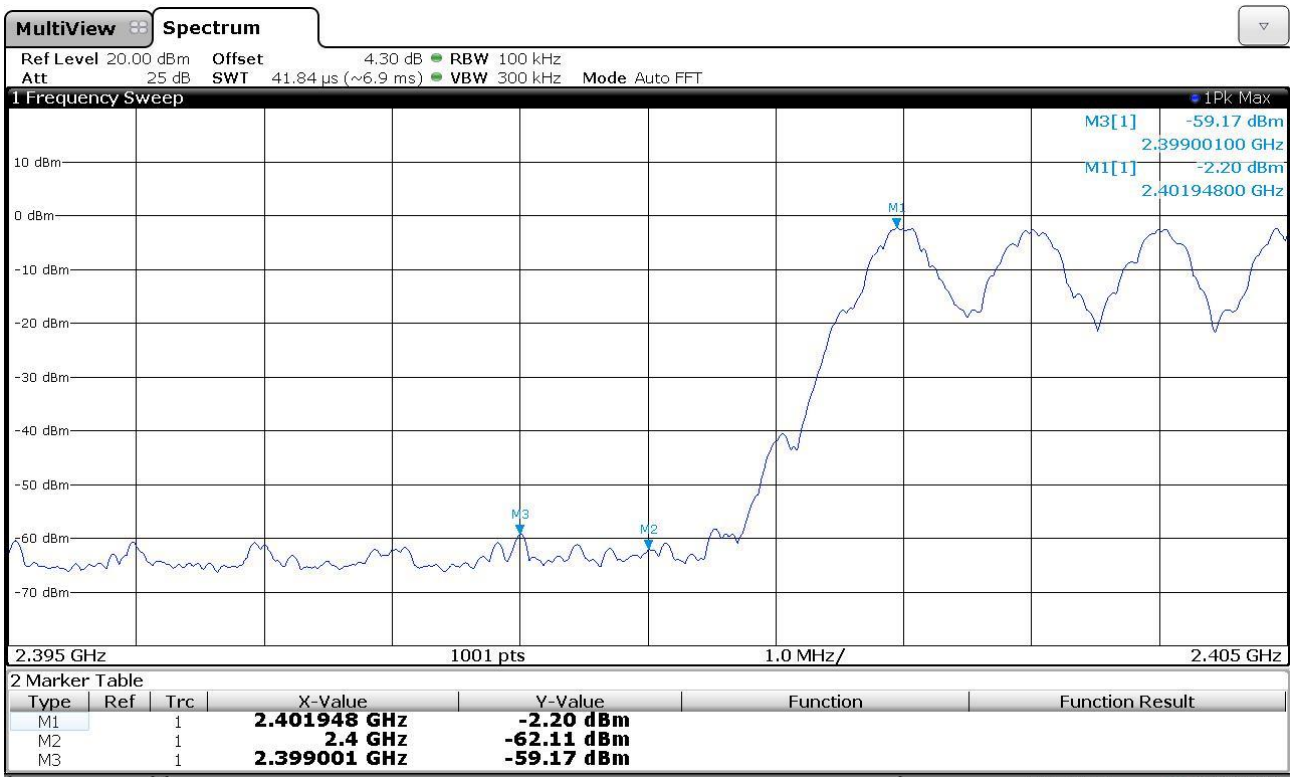
Limit:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. Emissions which fall in the restricted bands, as defined in §15.205 Restricted Bands of operation, must also comply with the radiated emission limits specified in §15.209 Radiated emission limits; general requirements.

Mesurement:

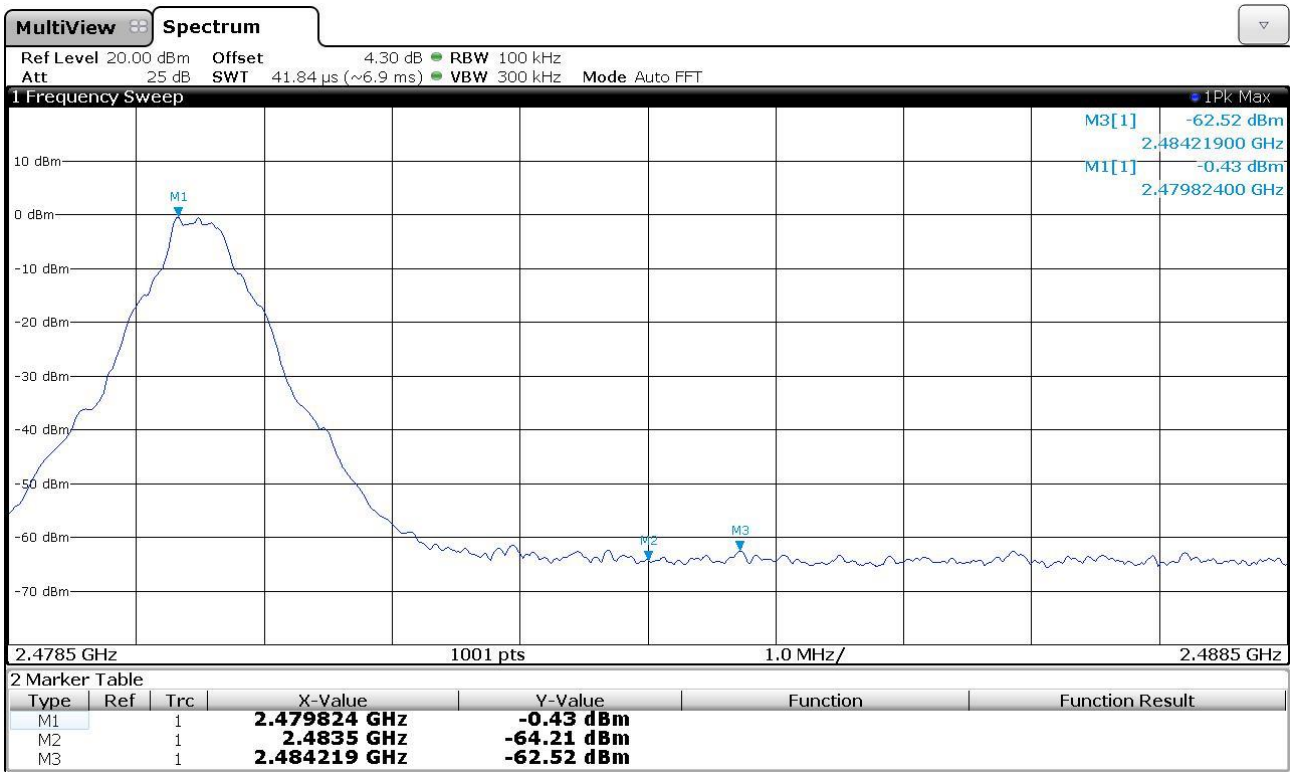
Band-edge Compliance of RF Emissions, GFSK (Hopping Off) – Lower Band Edge



Band-edge Compliance of RF Emissions, GFSK (Hopping On) – Lower Band Edge



Band-edge Compliance of RF Emissions, GFSK (Hopping Off) – Upper Band Edge



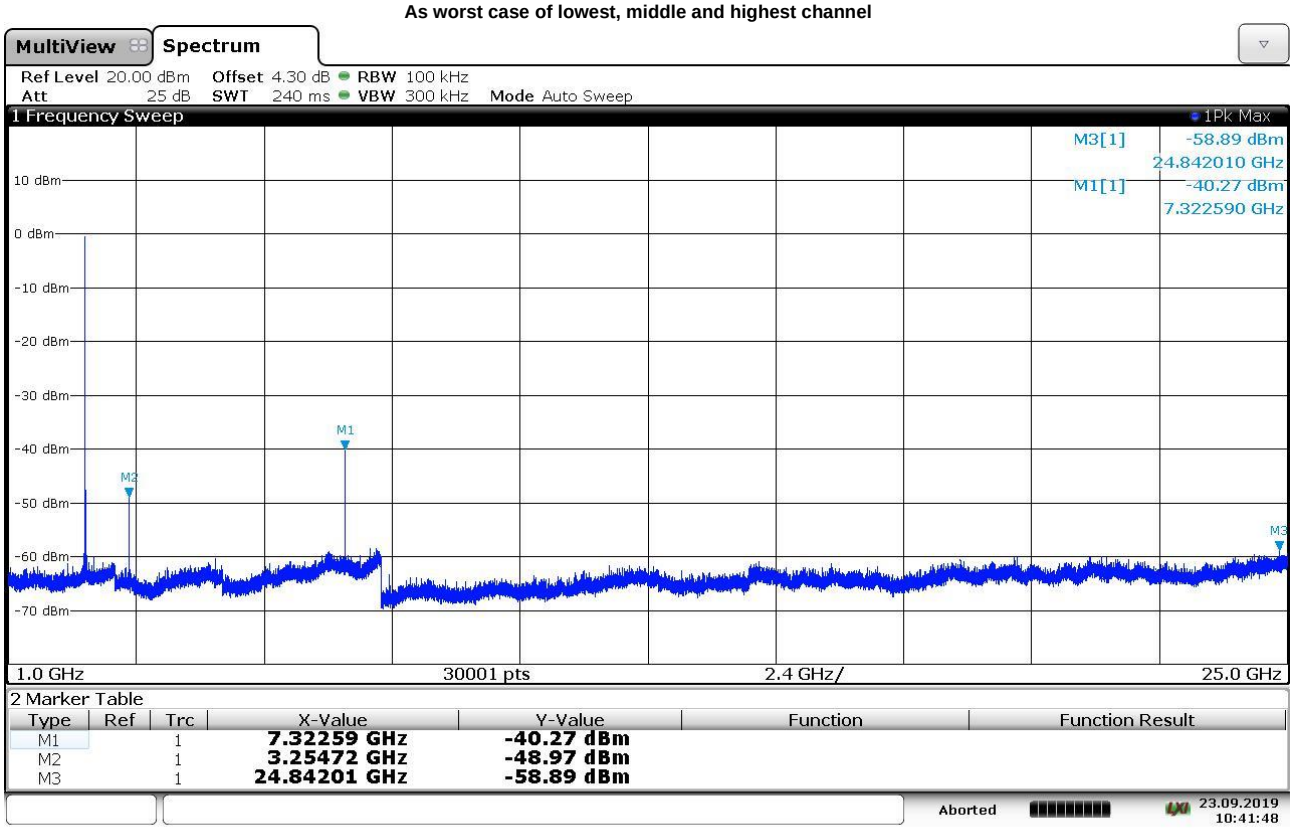
Band-edge Compliance of RF Emissions, GFSK (Hopping On) – Upper Band Edge

Summery result for GFSK mode

Frequency	Hopping on /off	Radiated Emission Attenuated below the Fundamental [dB]	Limit [dB]	Result
2402	OFF	60.99	> 20	pass
2402	ON	59.91	> 20	pass
2480	OFF	63.78	> 20	pass
2480	ON	62.7	> 20	pass

Out of Band Emissions Measurement - GFSK (2441 MHz):

As worst case of lowest, middle and highest channel

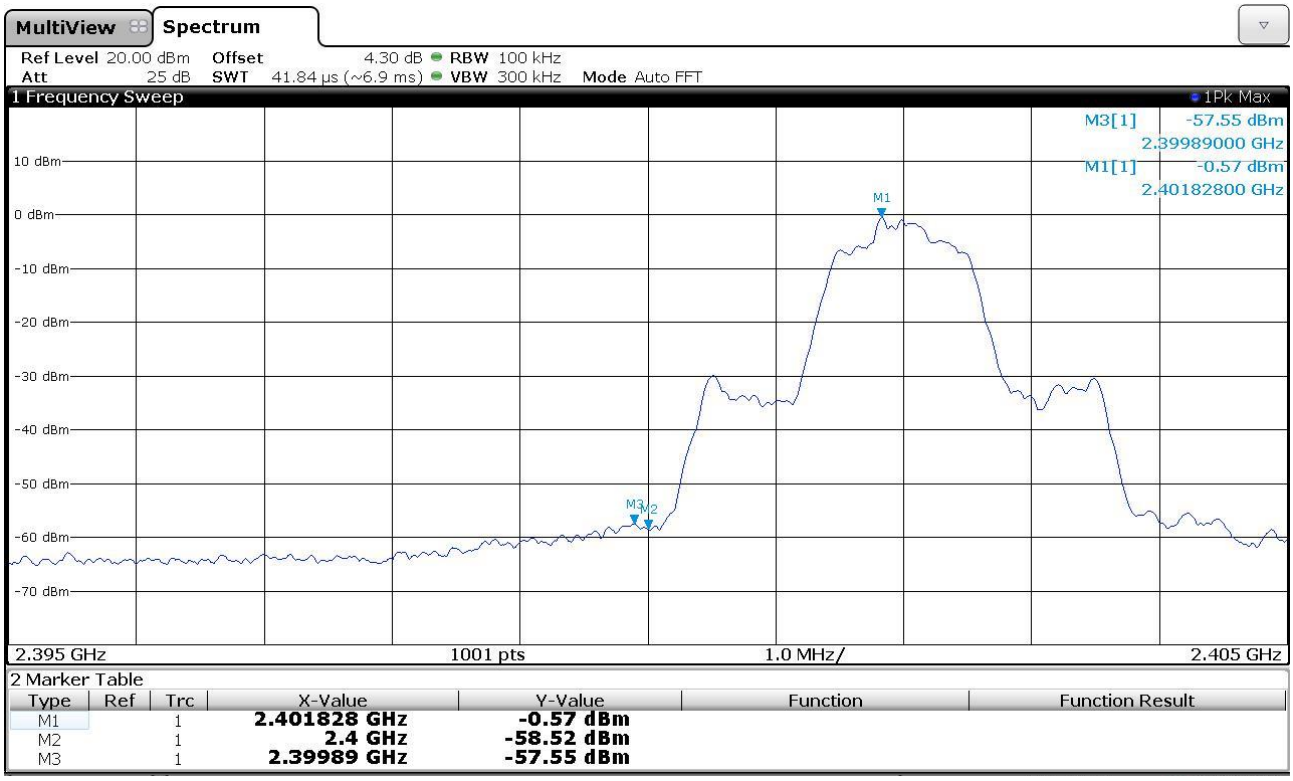


10:41:49 23.09.2019

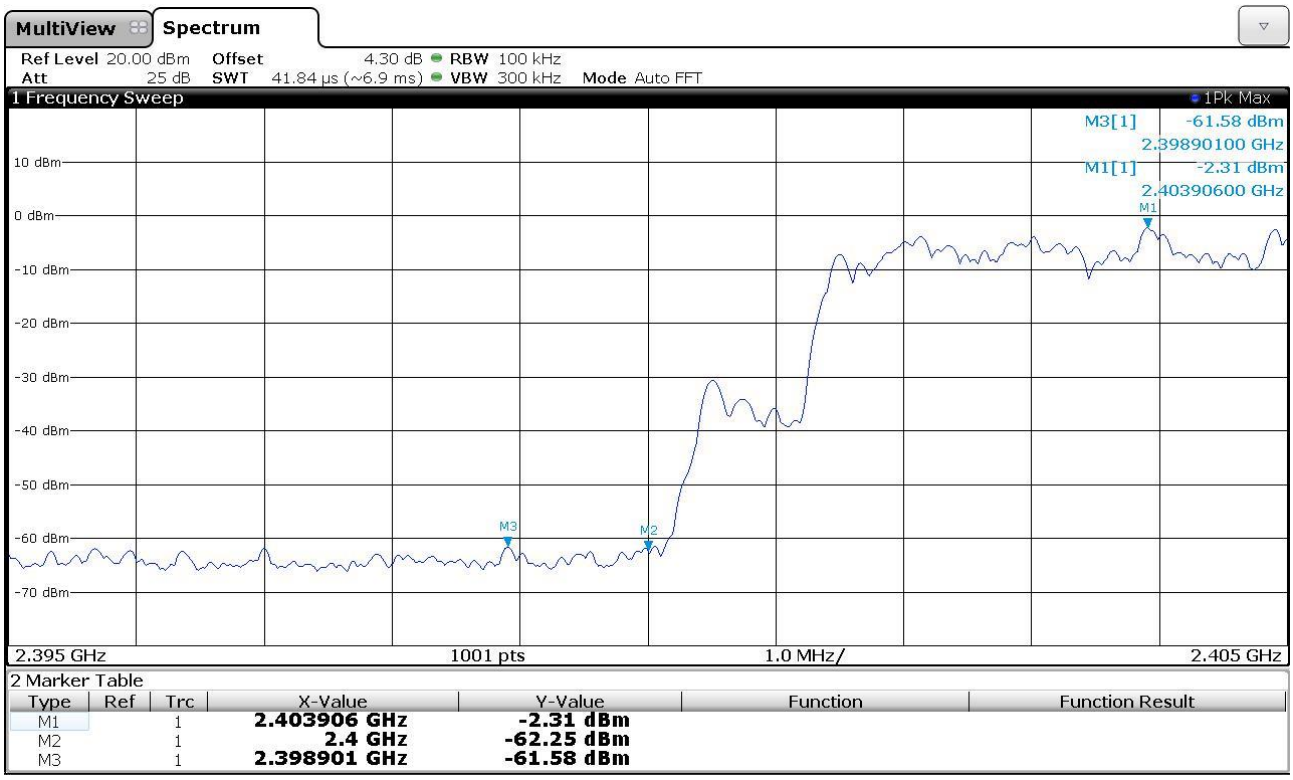
Frequency [GHz] (1)	Reading of test receiver [dBm] (2)	Antenna assembly gain [dB] (3)	Emission [dBm] (4)	Limit acc. §15.209 convert in [dBm] (5)	Limit acc. to §15.247 (d) [dBm] (6)	Result (7)
7.3225	-40.27	-7.16	-47.43	No Resticted Band	-21.73	**PASS**
3.2547	-48.97	-7.16	-56.13	-41.25	-/-	**PASS**
24.842	-58.89	-7.16	-66.05	No Resticted Band	-21.73	**PASS**

(3) Antenna assembly gain (dBi) = Max EIRP (dBm) – Conducted RMS Power (dBm)

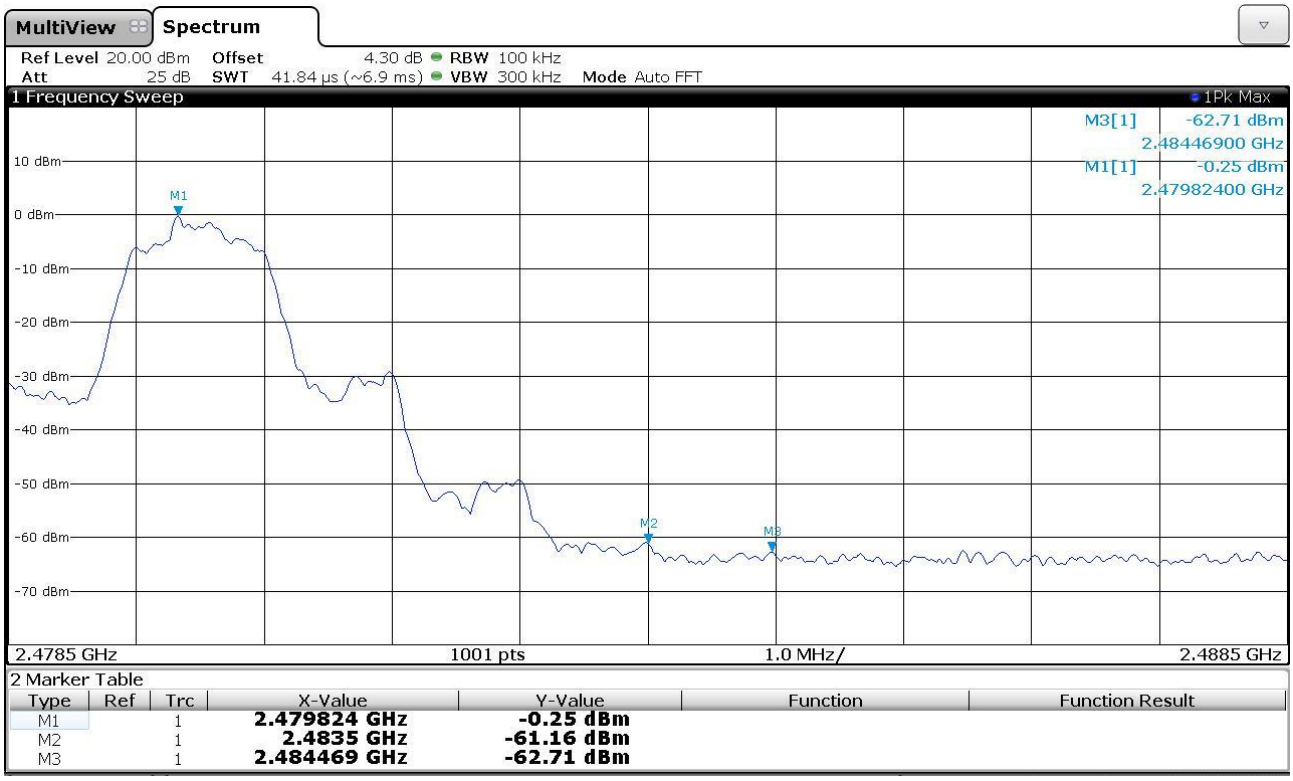
Band-edge Compliance of RF Emissions, π/4-DQPSK (Hopping Off) – Lower Band Edge



Band-edge Compliance of RF Emissions, π/4-DQPSK (Hopping ON) – Lower Band Edge



Band-edge Compliance of RF Emissions, π/4-DQPSK (Hopping Off) – Upper Band Edge

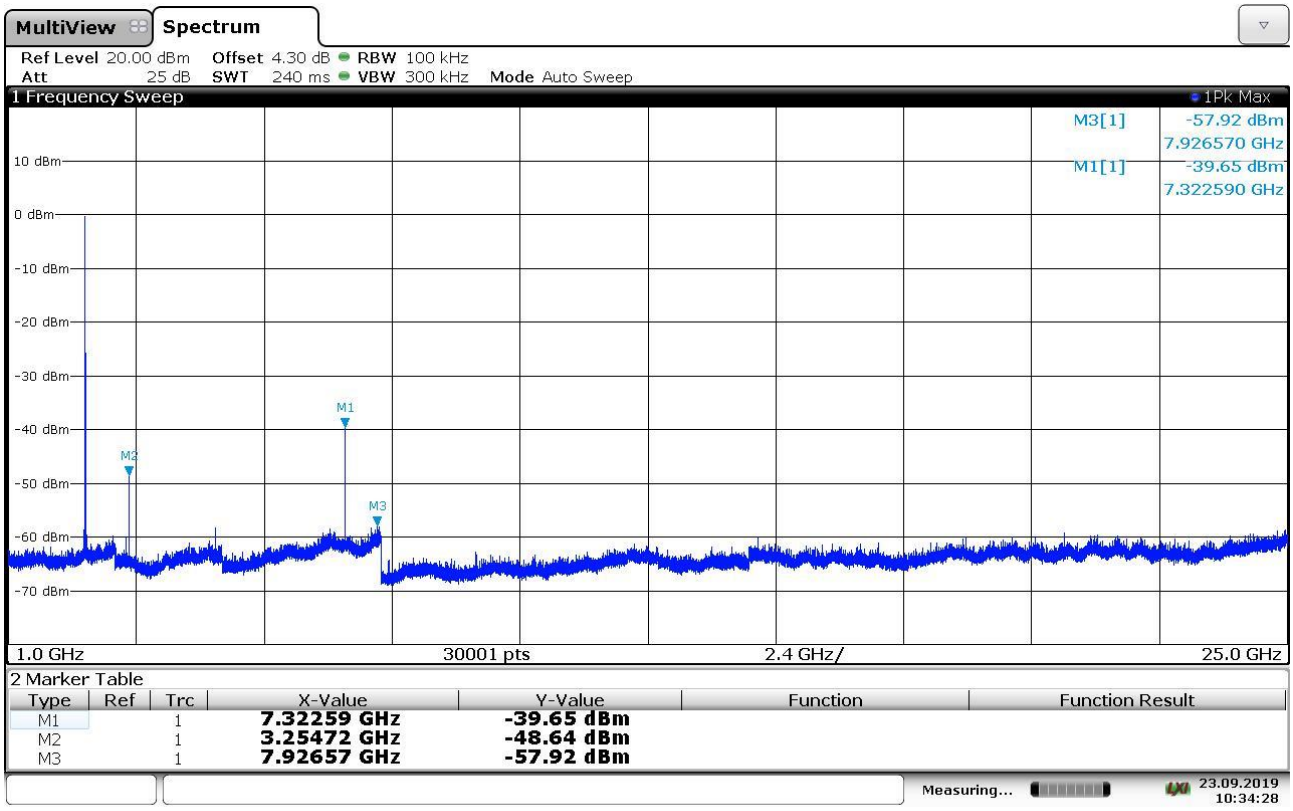


Band-edge Compliance of RF Emissions, π/4-DQPSK (Hopping On) – Upper Band Edge

Summery result for π/4-DQPSK mode

Frequency	Hopping on /off	Radiated Emission Attenuated below the Fundamental [dB]	Limit [dB]	Result
2402	OFF	56,98	> 20	pass
2402	ON	59,27	> 20	pass
2480	OFF	62,46	> 20	pass
2480	ON	57,04	> 20	pass

Out of Band Emissions Measurement - π/4-DQPSK (2441 MHz):
As worst case of lowest, middle and highest channel

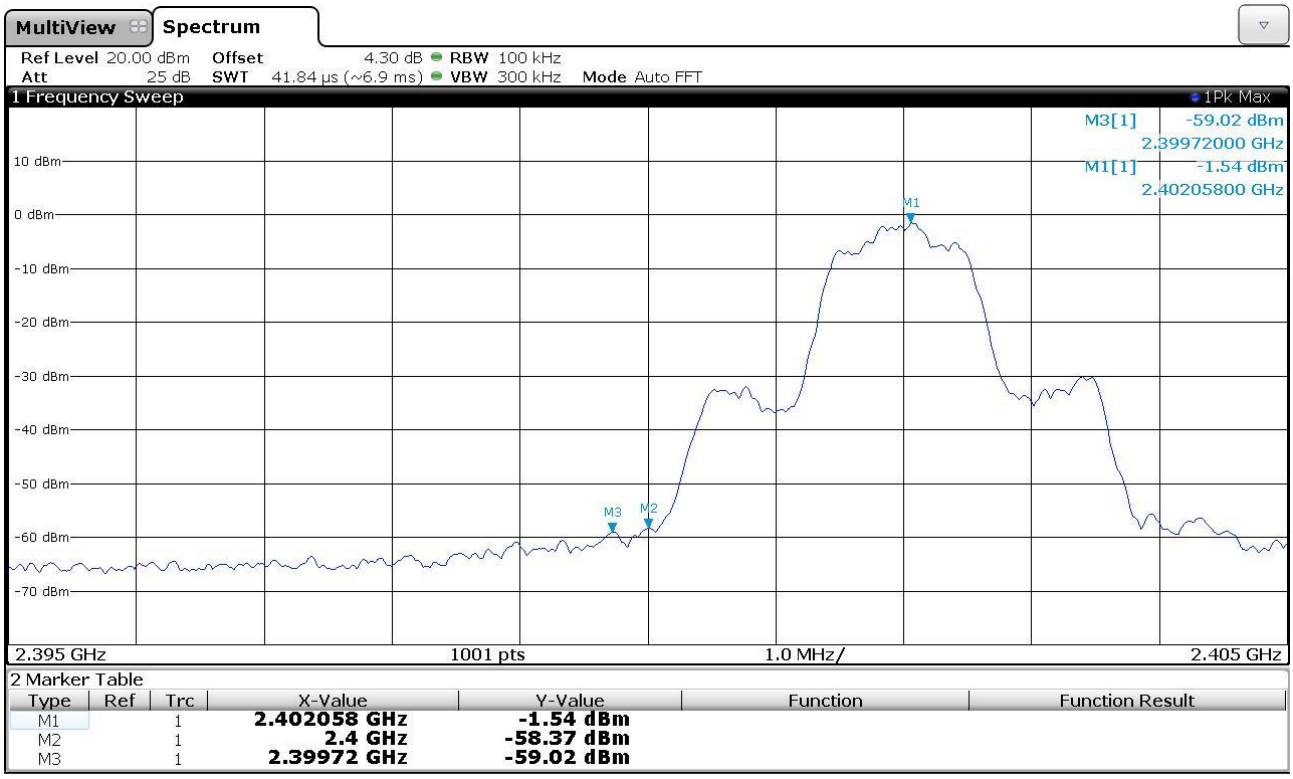


10:34:28 23.09.2019

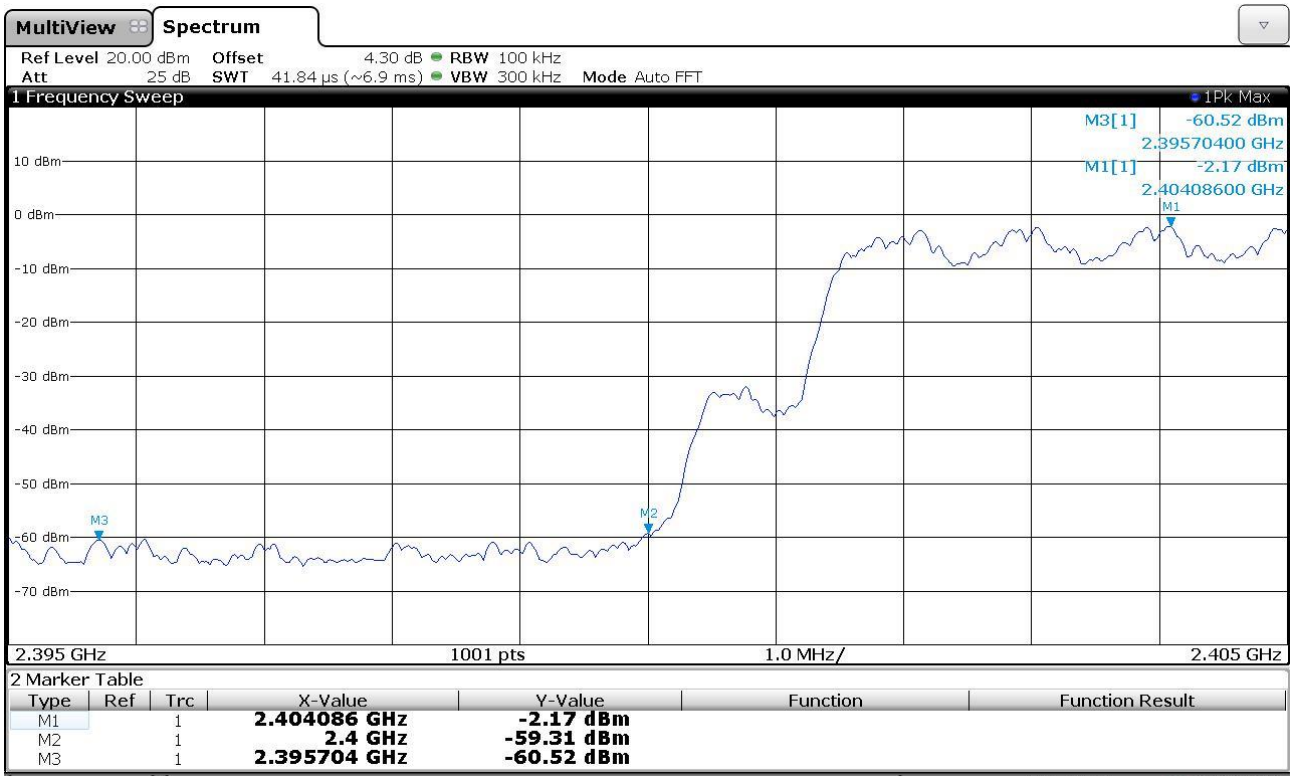
Frequency [GHz] (1)	Reading of test receiver [dBm] (2)	Antenna assembly gain [dB] (3)	Emission [dBm] (4)	Limit acc. §15.209 convert in [dBm] (5)	Limit acc. to §15.247 (d) [dBm] (6)	Result (7)
7.3226	-39.65	-7.16	-46.81	-41.25	-/-	**PASS**
3.2547	-48.64	-7.16	-55.80	No Resticted Band	-21.73	**PASS**
7.9266	-57.92	-7.16	-65.08	-41.25	-/-	**PASS**

(3) Antenna assembly gain (dBi) = Max EIRP (dBm) – Conducted RMS Power (dBm)

Band-edge Compliance of RF Emissions, 8-DPSK (Hopping Off) – Lower Band Edge

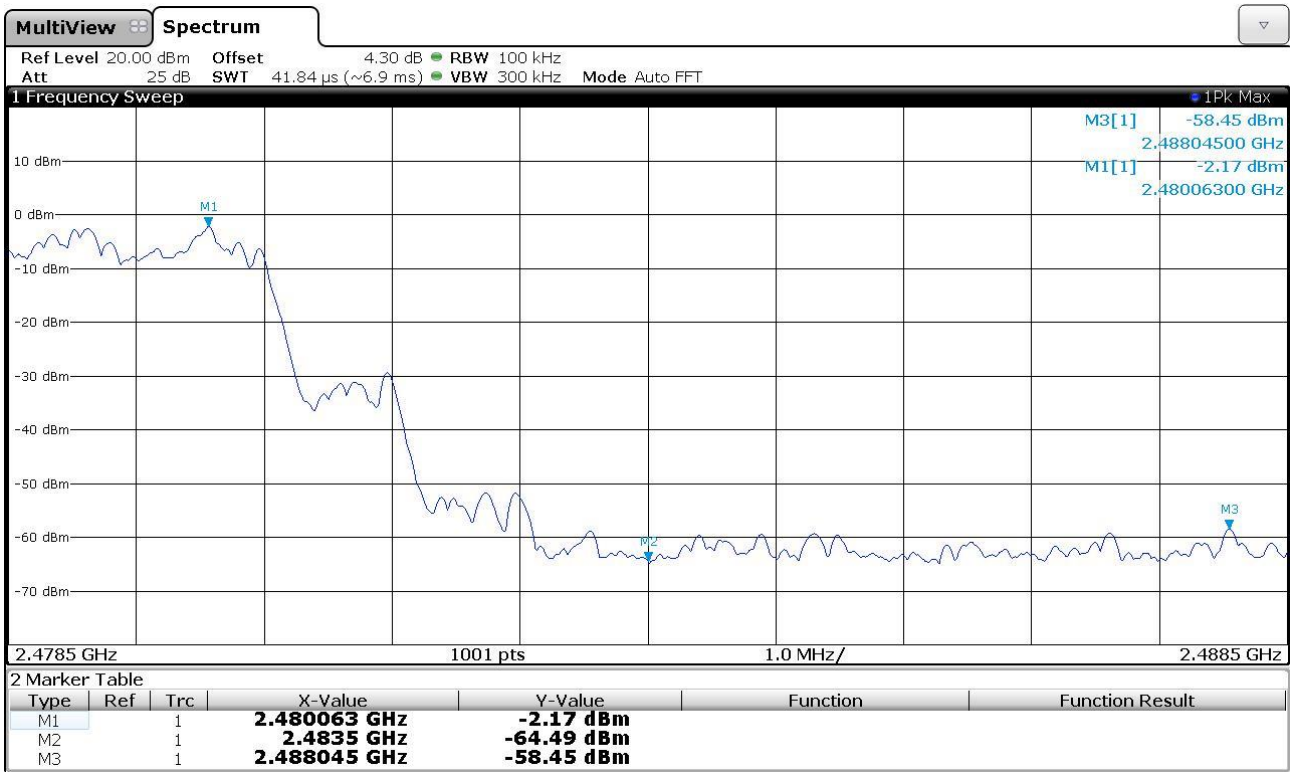


Band-edge Compliance of RF Emissions, 8-DPSK (Hopping ON) – Lower Band Edge



Band-edge Compliance of RF Emissions, 8-DPSK (Hopping Off) – Upper Band Edge

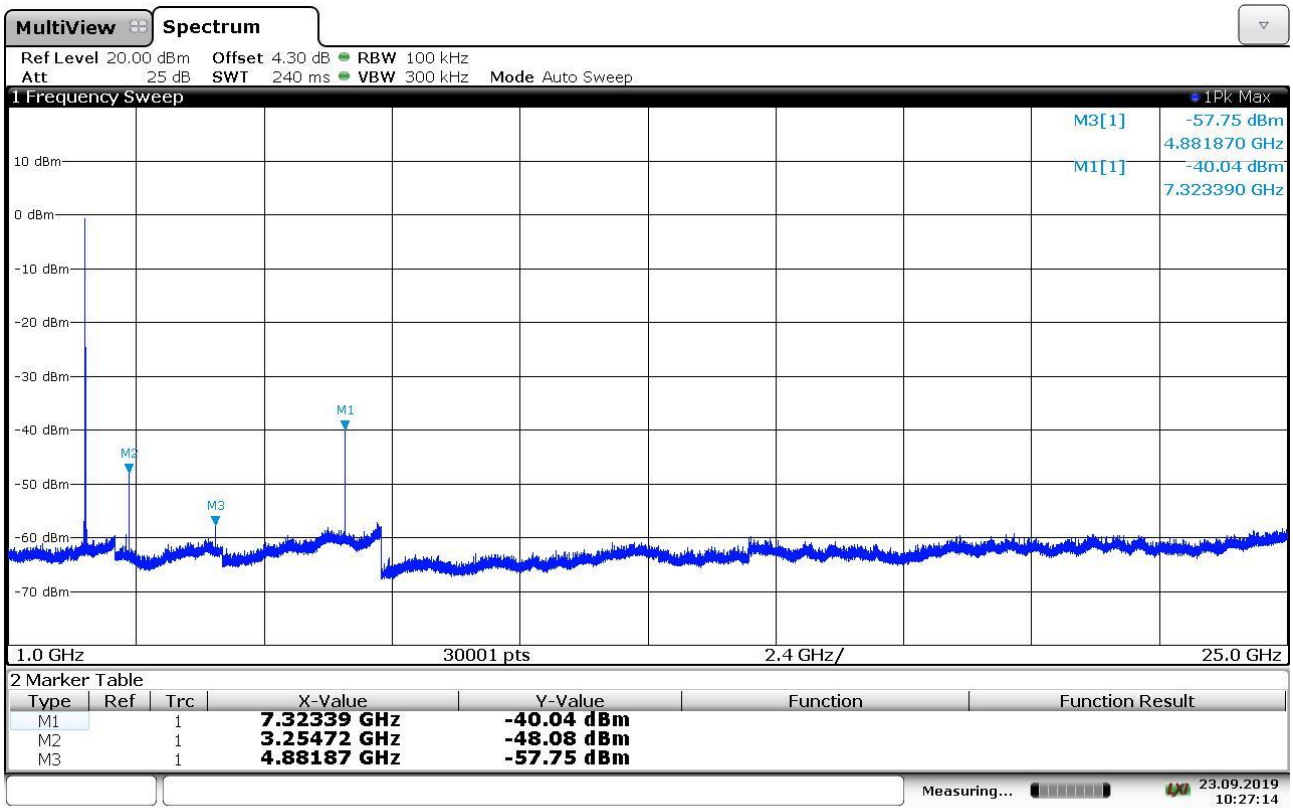
Band-edge Compliance of RF Emissions, 8-DPSK (Hopping On) – Upper Band Edge



Summery result for 8-DPSK mode

Frequency	Hopping on /off	Radiated Emission Attenuated below the Fundamental [dB]	Limit [dB]	Result
2402	OFF	57.48	> 20	pass
2402	ON	58,35	> 20	pass
2480	OFF	60.41	> 20	pass
2480	ON	56,28	> 20	pass

Out of Band Emissions Measurement - 8-DPSK (2441 MHz):
As worst case of lowest, middle and highest channel



10:27:14 23.09.2019

Frequency [GHz] (1)	Reading of test receiver [dBm] (2)	Antenna assembly gain [dB] (3)	Emission [dBm] (4)	Limit acc. §15.209 convert in [dBm] (5)	Limit acc. to §15.247 (d) [dBm] (6)	Result (7)
7.3234	-40.04	-7.16	-47.20	-41.25	-/-	**PASS**
3.2547	-48.08	-7.16	-55.24	No Resticted Band	-21.73	**PASS**
4.8819	-57.75	-7.16	-64.91	-41.25	-/-	**PASS**

(3) Antenna assembly gain (dBi) = Max EIRP (dBm) – Conducted RMS Power (dBm)

7.7. Time of Occupancy

Test Requirements:

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

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:

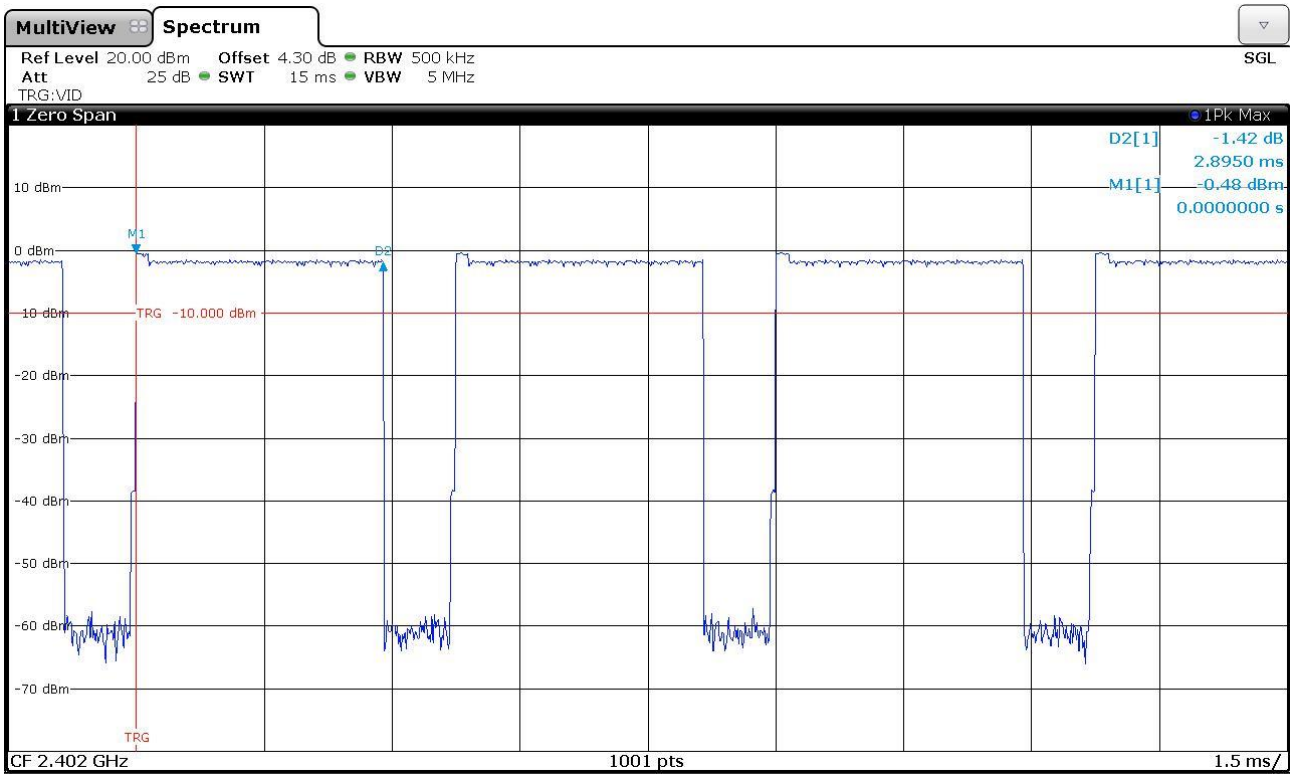
[Test time period] = [Limit] x [Channels] = 0.4 x 79 = 31.6 s

Mesurement:

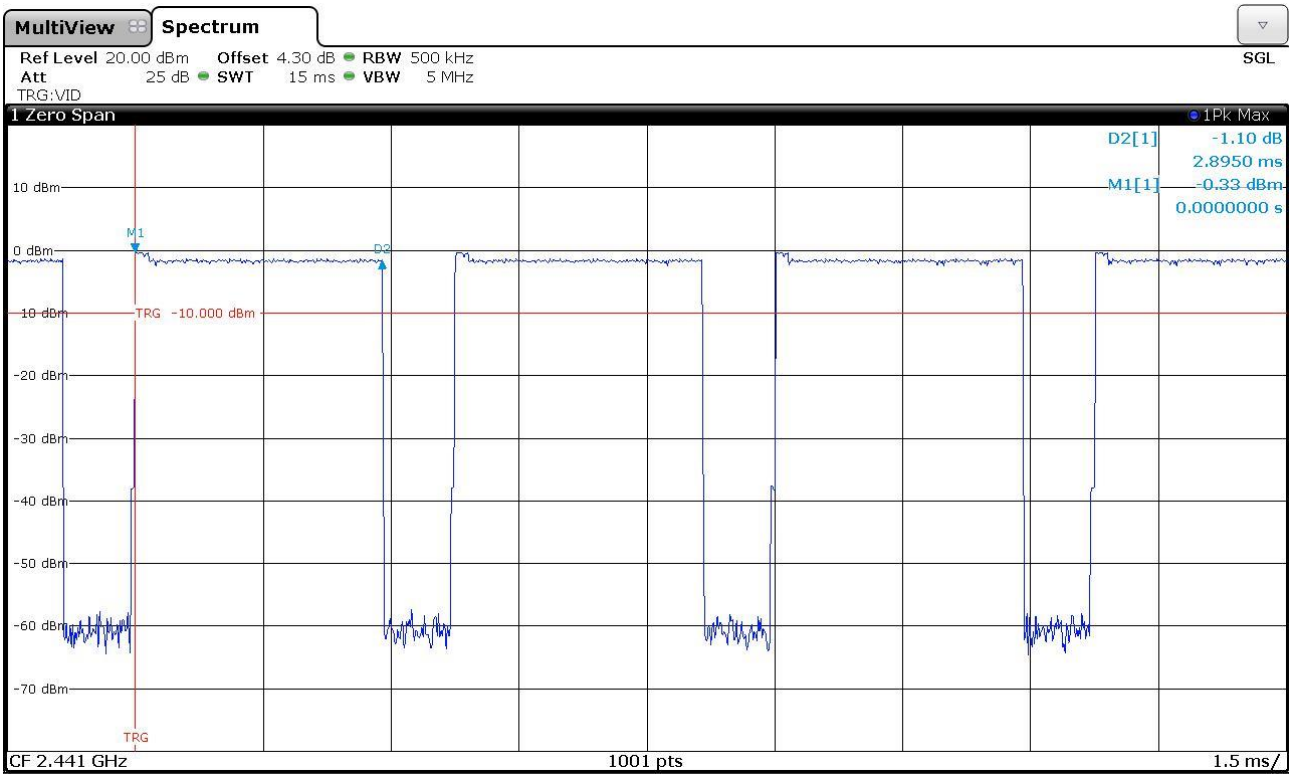
DH5 / 3-DH5 Packet:

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

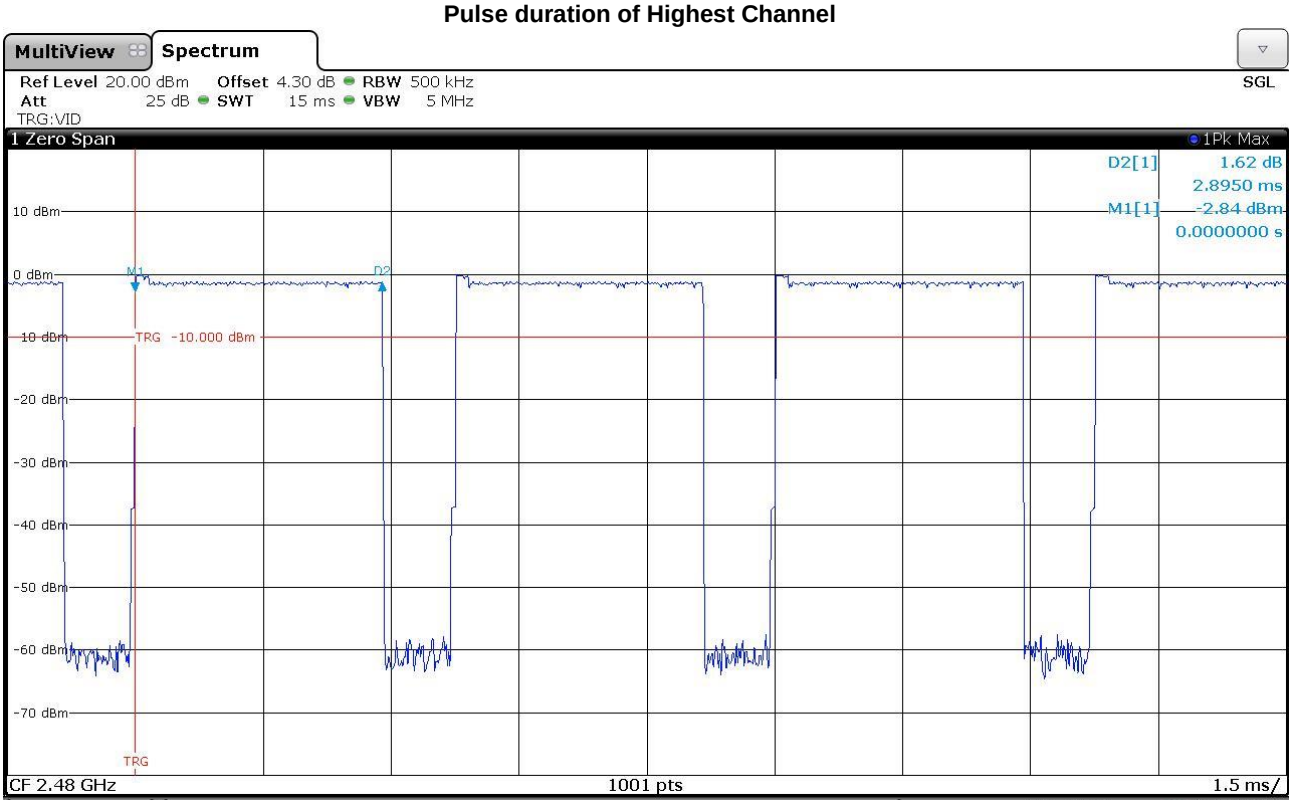
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



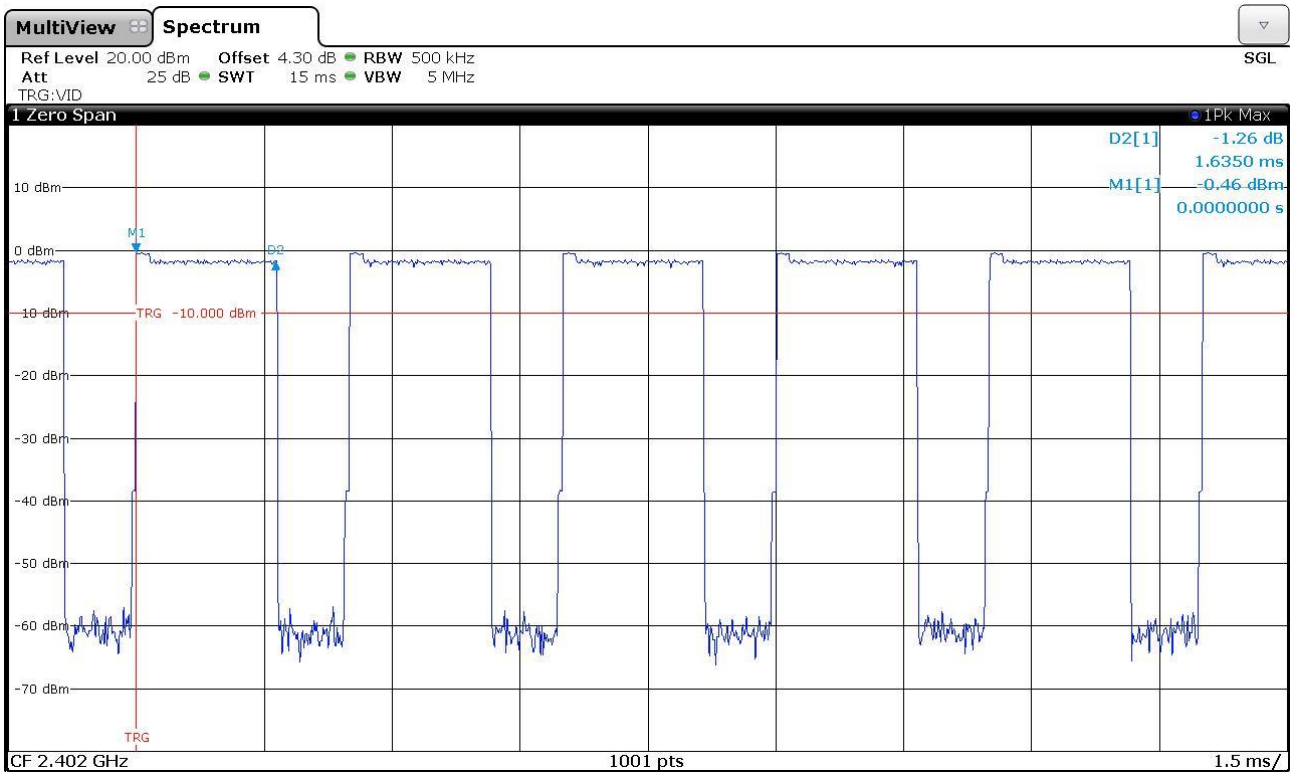
Pulse duration of Highest Channel



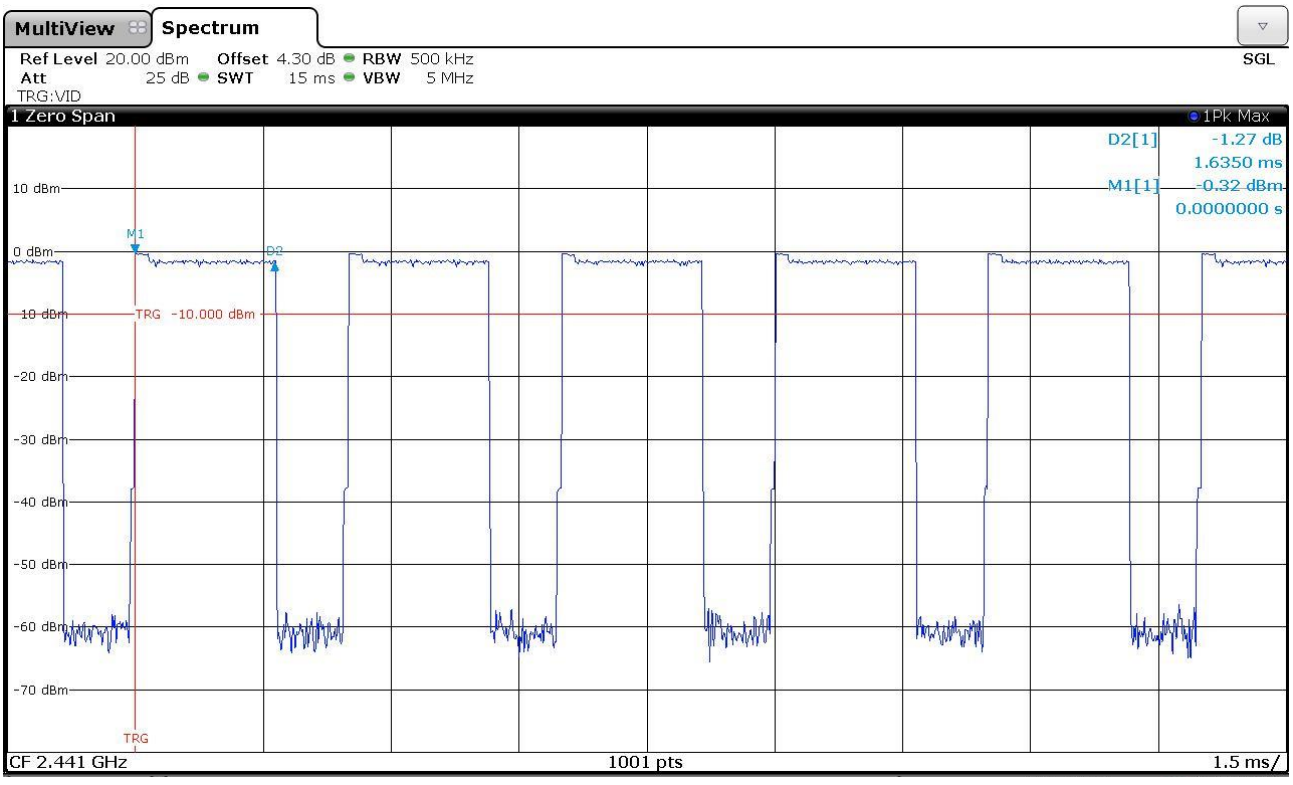
DH3 / 3-DH3 Packet:

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

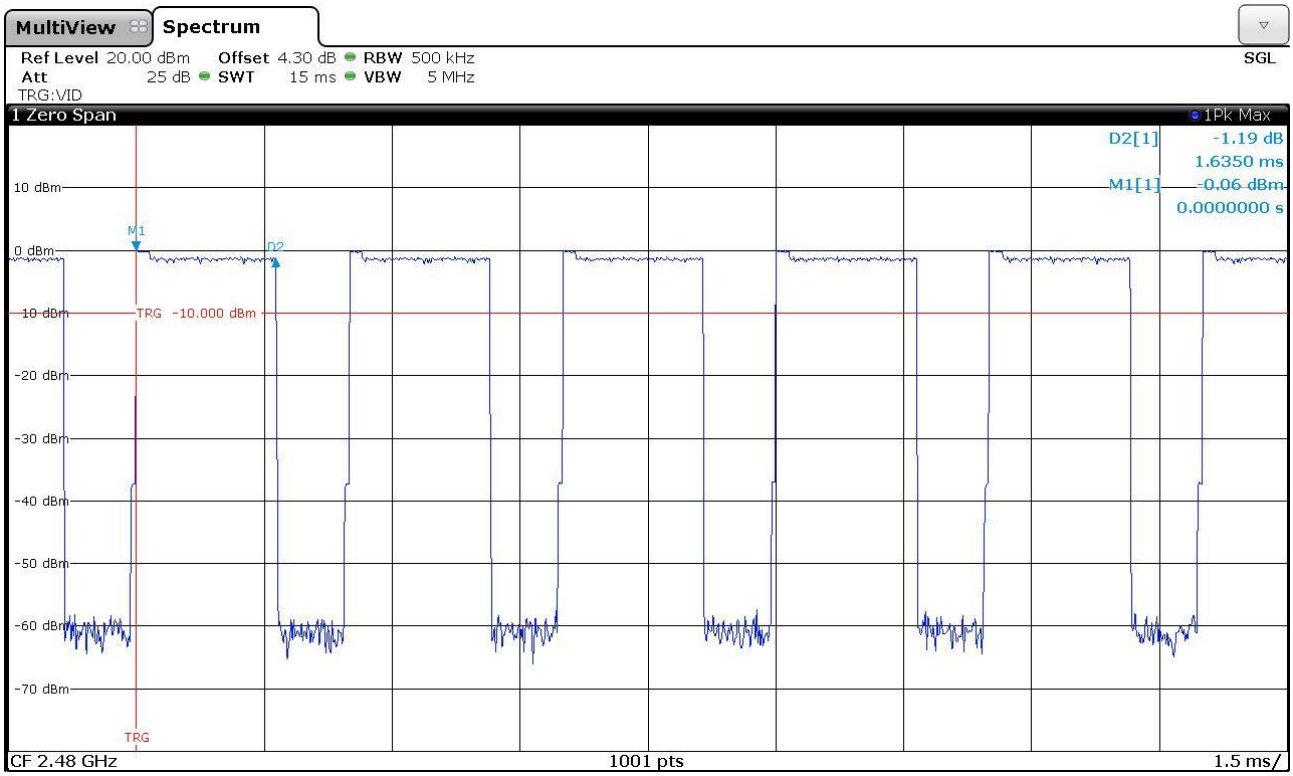
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



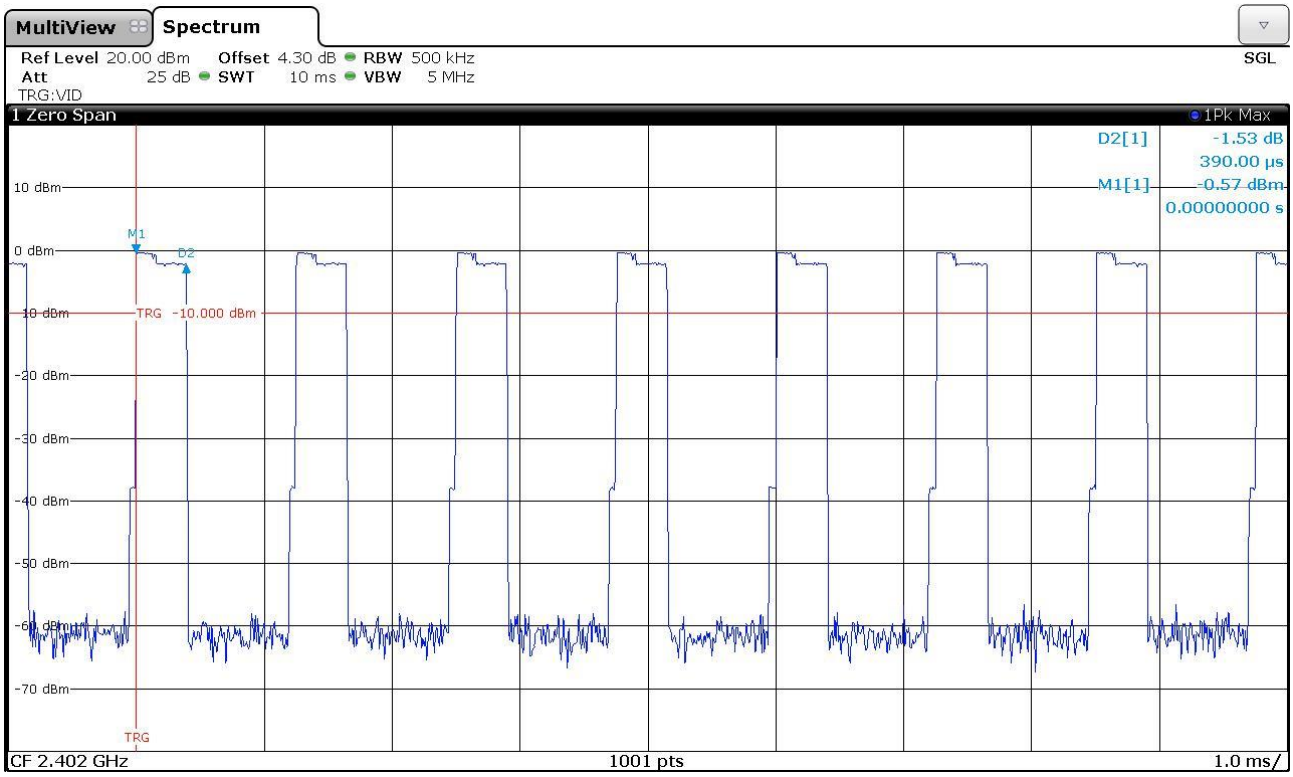
Pulse duration of Highest Channel



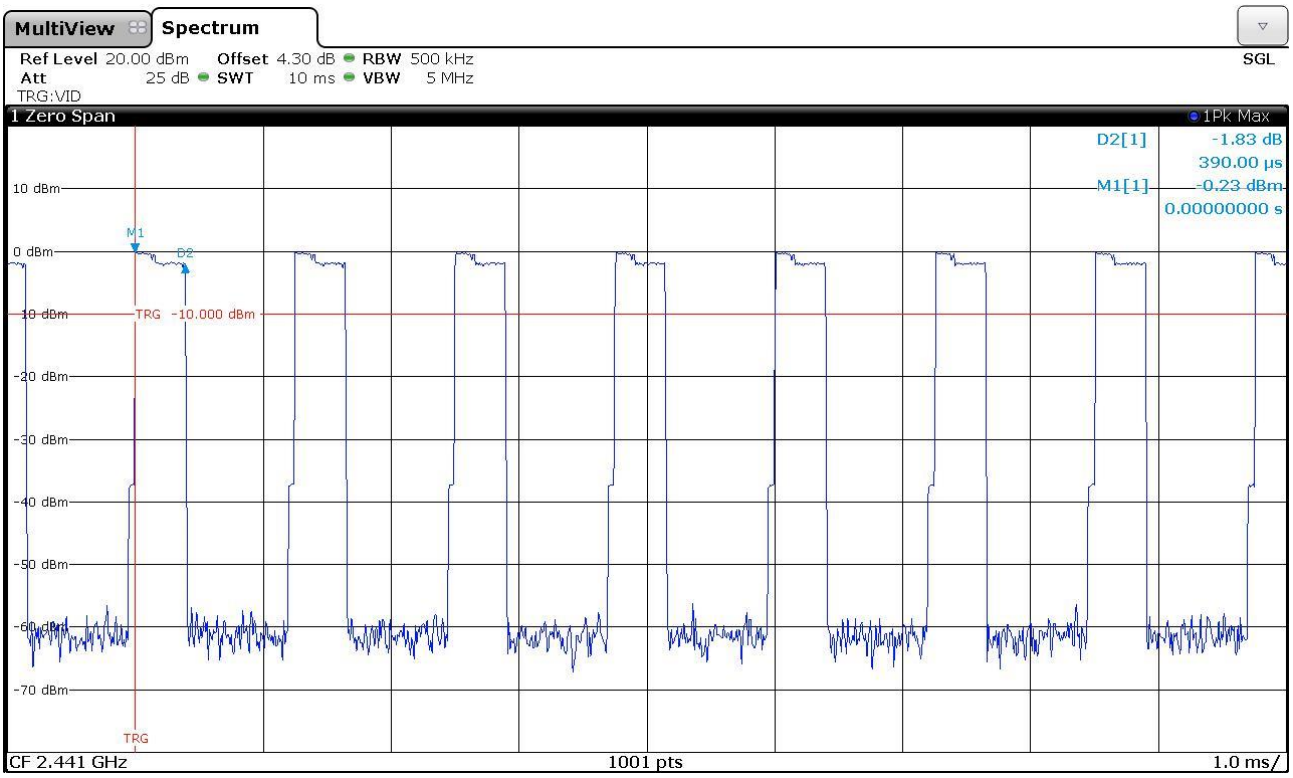
DH1 /2-DH1 Packet:

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

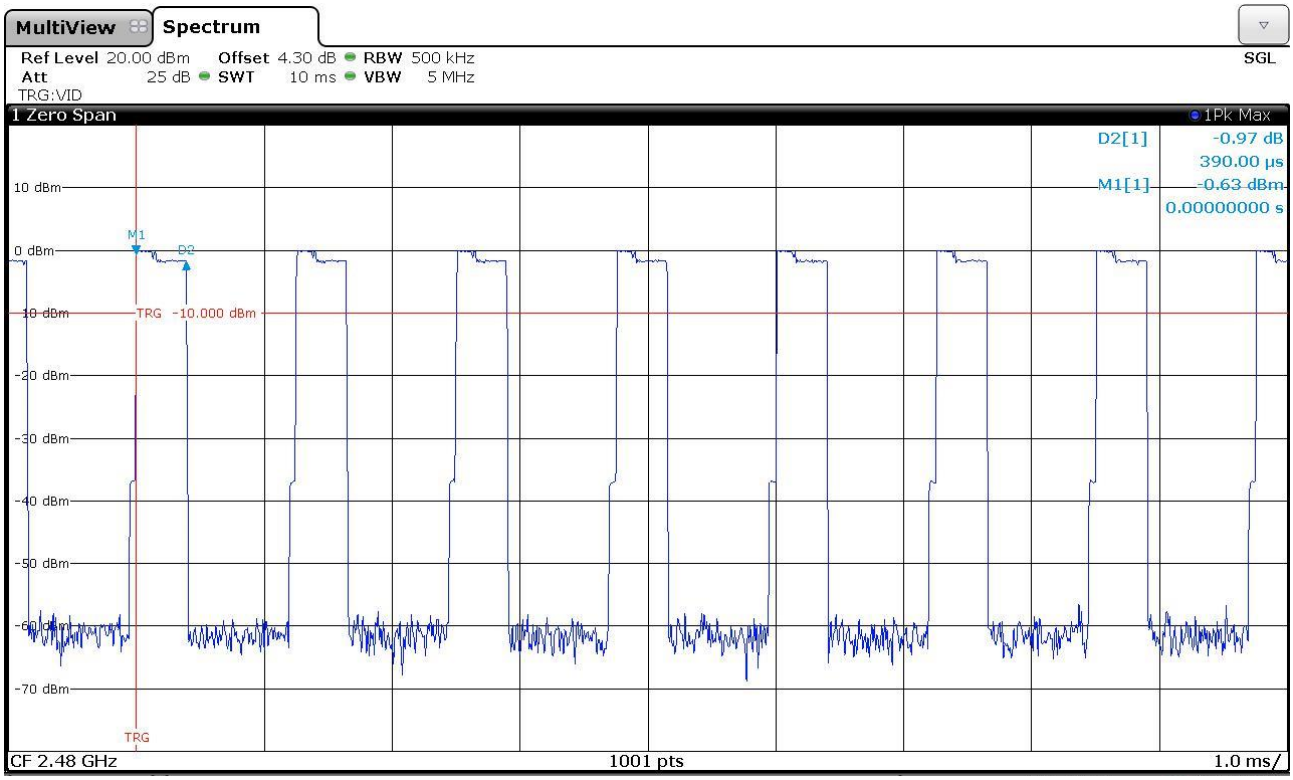
Pulse duration of Lowest Channel



Pulse duration of Middle Channel



Pulse duration of Highest Channel



Time of occupancy (Dwell Time):

Data Packet	Frequency (MHz)	Pulse Duration (ms)	Dwell Time (s)	Limits (s)	Test Results
DH5/3-DH5	2402	2.895	0.309	0.400	Complies
DH5/3-DH5	2441	2.895	0.309	0.400	Complies
DH5/3-DH5	2480	2.895	0.309	0.400	Complies
DH3/3-DH3	2402	1.635	0.262	0.400	Complies
DH3/3-DH3	2441	1.635	0.262	0.400	Complies
DH3/3-DH3	2480	1.635	0.262	0.400	Complies
DH1/2-DH1	2402	0.390	0.125	0.400	Complies
DH1/2-DH1	2441	0.390	0.125	0.400	Complies
DH1/2-DH1	2480	0.390	0.125	0.400	Complies

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

Results

From the measurement data obtained, the tested samples were considered to have COMPLIED with the requirements for the operation within the band 2400-2483.5 MHz according to §15.247.

8. RF Exposure

Applied Standard
e-CFR Title 47 Chapter I Subchapter A §1.1310 (d) June 2013

Types of Evaluation
-§ 1.1310 (d) RF Exposure Evaluation

RF Exposure Evaluation

Evaluated against exposure limits:
General Public Use ☒
Controlled Use ☐

RF power value: 0.2153 mW (at frequency = 2480 MHz) [1]
☒ Measured with Measurement distance of 3 m
☐ Computed
☐ Calculated

Note 1 The Maximum E.I.R.P. find in clause 8.2 of this report

Requirements:

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	$*900/f^2$	6
30-300	61.4	0.163	1.0	6
300-1,500	-/-	-/-	f/300	6
1,500-100,000	-/-	-/-	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	$*180/f^2$	30
30-300	27.5	0.073	0.2	30
300-1,500	-/-	-/-	f/1500	30
1,500-100,000	-/-	-/-	1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

RF Function	Unit	**Bluetooth**	**-/-**	**-/-**	**Combinated (TX at the same time)**
Max. RF output power (P)	dBm	-6.67	-/-	-/-	-/-
Measurement uncertainty	dB	4.8	-/-	-/-	-/-
Max. Duty cycle	%	100	-/-	-/-	-/-
Average total radiated power (P')	mW	**0.65**	**-/-**	**-/-**	**-/-**
Power density in 20 cm distance	mW/cm^2	**0.123×10^{-3}**	-/-	-/-	-/-
Min. distance for compliance with Power density Limit	cm	0.23	-/-	-/-	-/-
Limit Power density	mW/cm^2	1.0	-/-	-/-	-/-
Result		**Pass**	**-/-**	**-/-**	**-/-**

Description:

Max. RF output power (P): max. Radiated RF power

Average total radiated Power (P'): max. RF output power taking into account the measurement uncertainty and transmission time

Calculation of Power density $P_{density} = P' / (4 \times \pi \times d^2)$

$P_{density}$ = Power density [mW/cm^2]
P' = Average total radiated power [mW]
d = distance to radiation source [cm]

It is deemed that the EUT complies with the provisions of the e-CFR Title 47 Chapter I Subchapter A Part 1, § 1.1310, since Average total radiated power at 20 cm separation distance compliance with the RF-Exposure limit

Results
From the measurement data obtained, the tested samples were considered to have COMPLIED with the requirements of e-CFR Title 47 Chapter I Subchapter A Part 1, § 1.1310.

9. Test equipment

Test equipment used for radiated Measurements:

Kind of equipment	Manufacturer	Type	PKM-ident no.	Serial no.	Calibrated on (y-m-d)	Calibration interval
Signal Spectrum Analyzer 2Hz - 26,5 GHz	Rohde & Schwarz	FSW 26 Instrument FW 2.60	11571	102047	2019-Jan.	3 year
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
Antenna 9 kHz – 30 MHz	EMCO	6502	10546	2018	2017-Nov.	3 years
Antenna 30 MHz – 1 GHz	Chase	CBL6111C	10022	1064	2017-Jan.	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	2017-Jan.	3 years
Broadband-Preamplifier 1-18 GHz	Schwarzbeck	BBV9718	11231	9718-002	2017-Okt.	3 year
Preamplifier 18 - 40 GHz	CERNEX	CBM18403523	11679	29711	2019 - July	3 year
Cable	el-spec GmbH	FlexCore-SMA11-SMA11-8000-ARM	11625	-/-	2017-Dec.	3 years
Band Reject Filter	Telemeter	BRF-2450-150-7-N (0441)	11243	-/-	-/-	-/-
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	PKM-ident no.	Serial no.	Calibrated on (y-m-d)	Calibration interval
Signal Spectrum Analyzer 2Hz - 26,5 GHz	Rohde & Schwarz	FSW 26 Instrument FW 2.60	11571	102047	2019 - Jan.	3 year
EMI-Test-Receiver	Rohde & Schwarz	ESR7 Instrument FW 3.36	11505	101103	2017 - Nov.	3 year
Automatisation unit RF switch and power meter	Rohde & Schwarz	OSP120 and OSP B157	11573	101282	2017 - Dec.	3 year
Cable	el-spec GmbH	FlexCore-SMA11-SMA11-8000-ARM	11625	-/-	2017 - Dec.	3 years
Band Reject Filter	Telemeter	BRF-2450-150-7-N (0441)	11243	-/-	-/-	-/-
Shielded room/Chamber	Frankonia	SAC3 "SEMI-ANECHOIC-CHAMBER"	11609	004/16	2019-March	3 years

Test equipment used for Conducted Mains emissions:

Kind of equipment	Manufacturer	Type	PKM-ident no.	Serial no.	Calibrated on	Calibration interval
EMI-Test-Receiver	Rohde & Schwarz	ESR7 Instrument FW 3.36	11676	101694	2018 – Mar.	3 year
Software	PKM	PKM U5/6	-/-	V1.01.03	-/-	-/-
Line impedance stabilisation network (LISN)	Rohde & Schwarz	ESH2-Z5	10139	879675/028	2019 – Jan.	3 year
Shielded room	Siemens	(6,2 x 4,7 x 3,3) m (l x w x h) DC – 10 GHz	10113	1	-/-	-/-

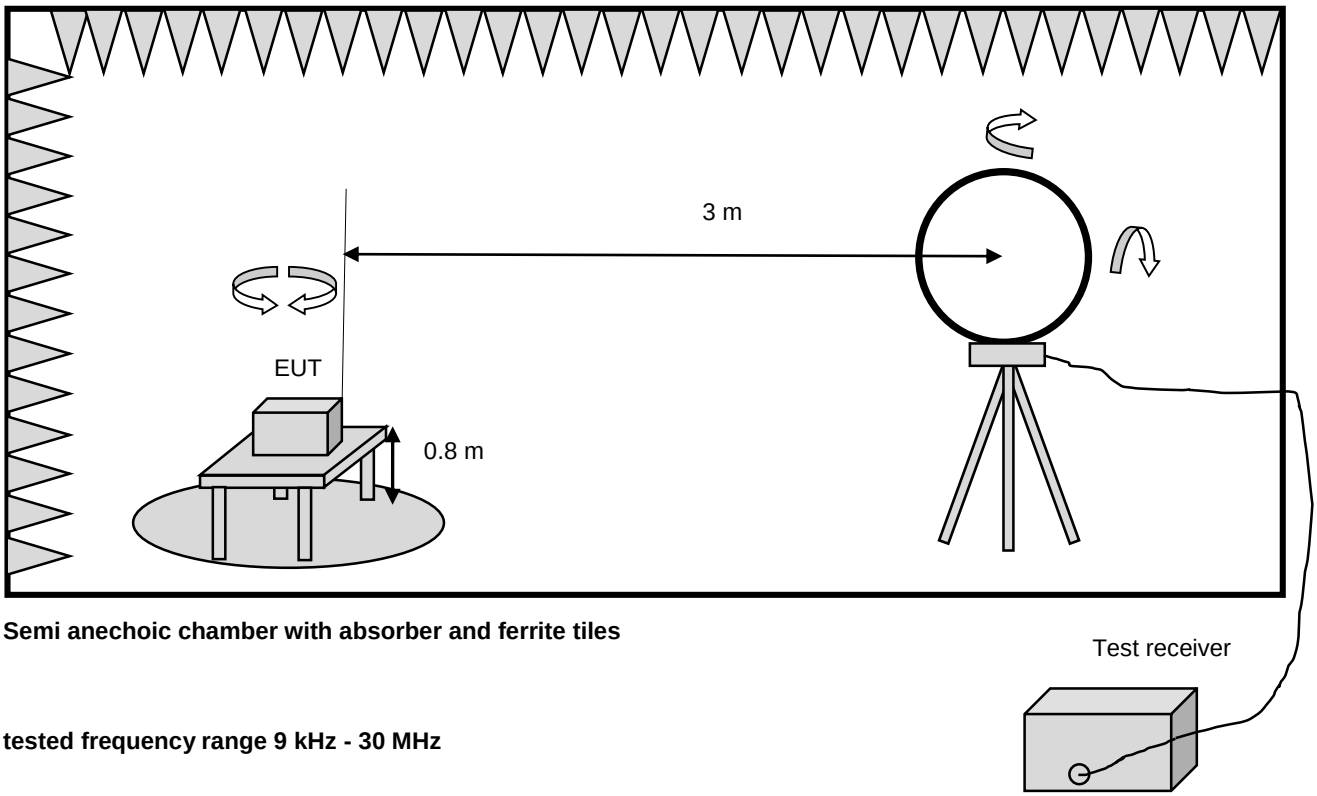
All measurements were made with measuring instruments, including any accessories that may affect test results, calibrated according to the requests of ISO/IEC 17025 according to which the test site is accredited from DAkkS. Measurement of conducted emissions was made with instruments conforming to American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

Test equipment to support EUT functions:

Kind of equipment	Manufacturer	Type	PKM-ident no.
Laptop	Fujitsu	Lifebook	11702
Host PC with monitor	Terra	Win 10 Desktop PC	11687
USB-Stick	Intenso	16 GB USB 3.0	-/-
DVD-Player / Blu-ray player	Sony	UBP-X800	-/-
Bluetooth speaker	Peaq	PPA20BT-GR	-/-

10. Test Setups

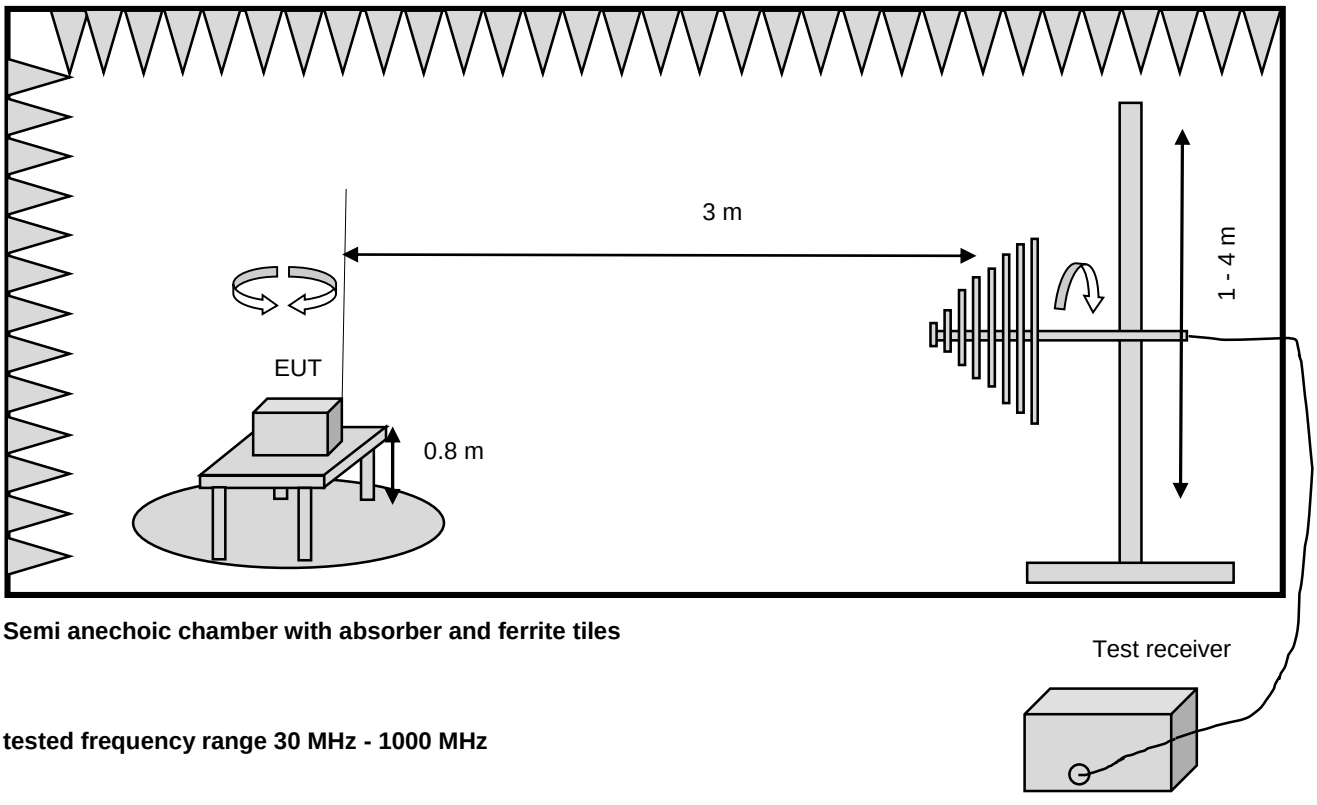
Block diagram Radiated emissions



Semi anechoic chamber with absorber and ferrite tiles

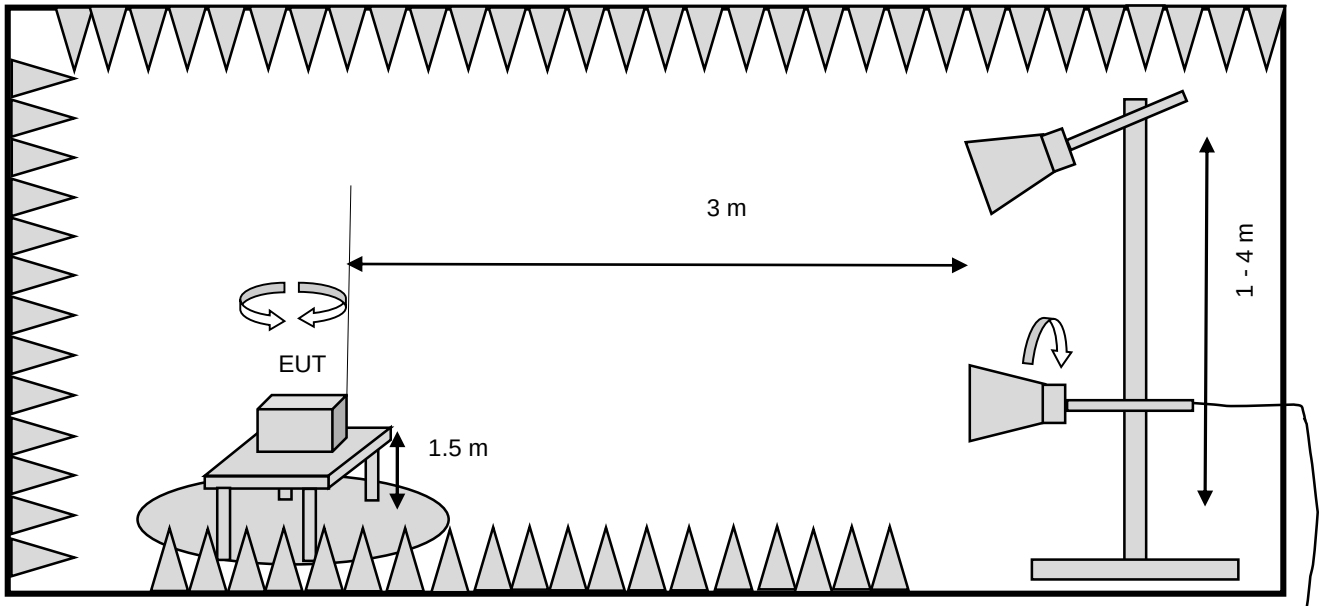
tested frequency range 9 kHz - 30 MHz

Block diagram Radiated emissions

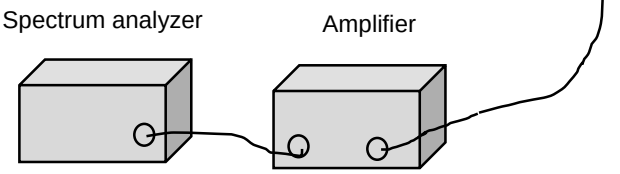


Semi anechoic chamber with absorber and ferrite tiles

tested frequency range 30 MHz - 1000 MHz

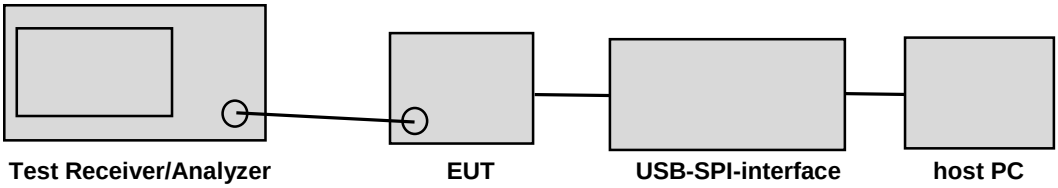


Semi anechoic chamber with absorber and ferrite tiles

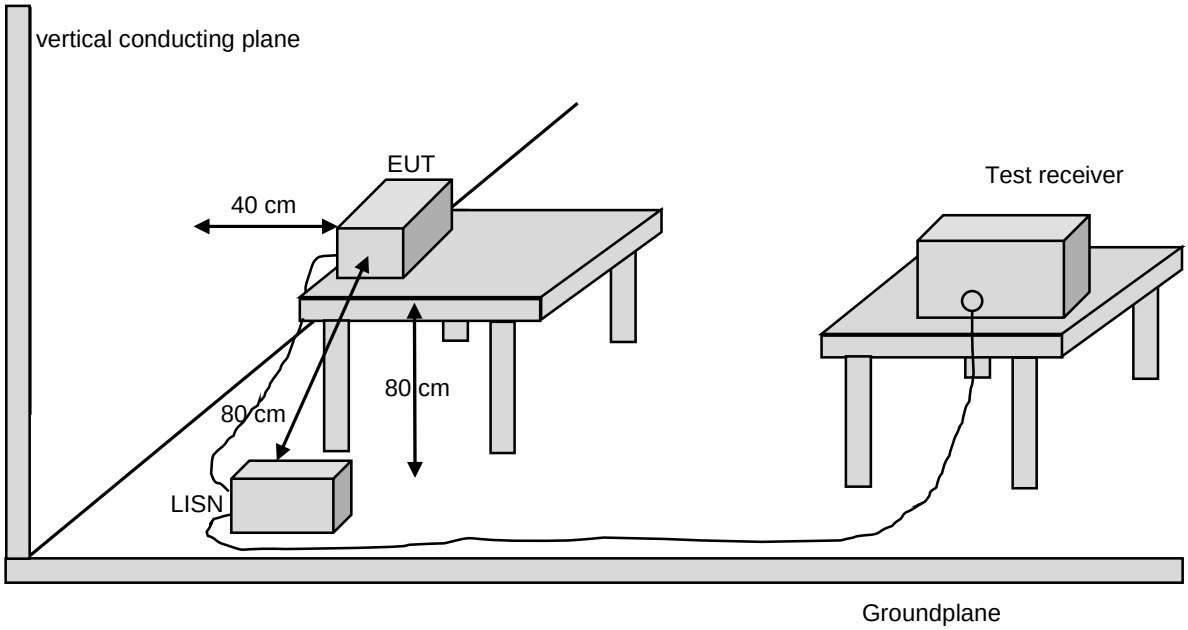


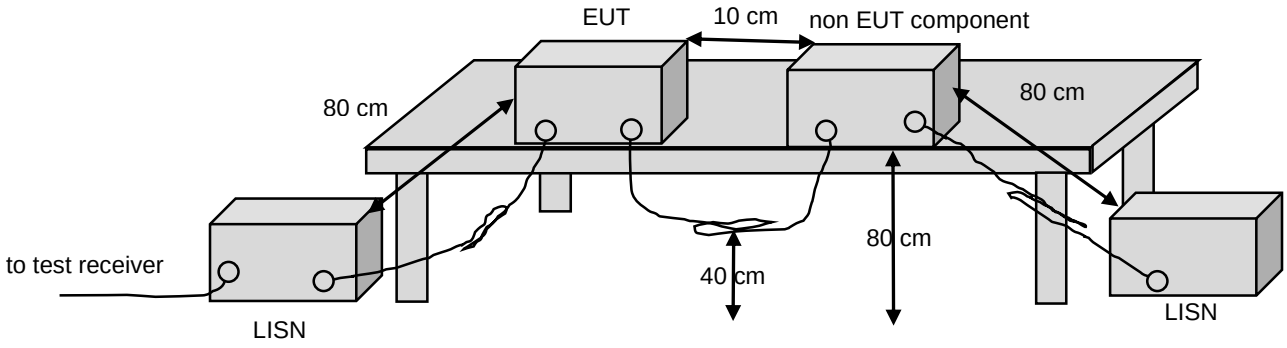
tested frequency range > 1000 MHz

Block diagram for conducted measurements



Block diagram Conducted Mains emissions





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	-/-
		Maximum measurement uncertainty according to EN300328:V2.1.1, table 17
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 “Photos_setup_19-09-0020.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 and §1.1310 Radiofrequency radiation exposure limits.

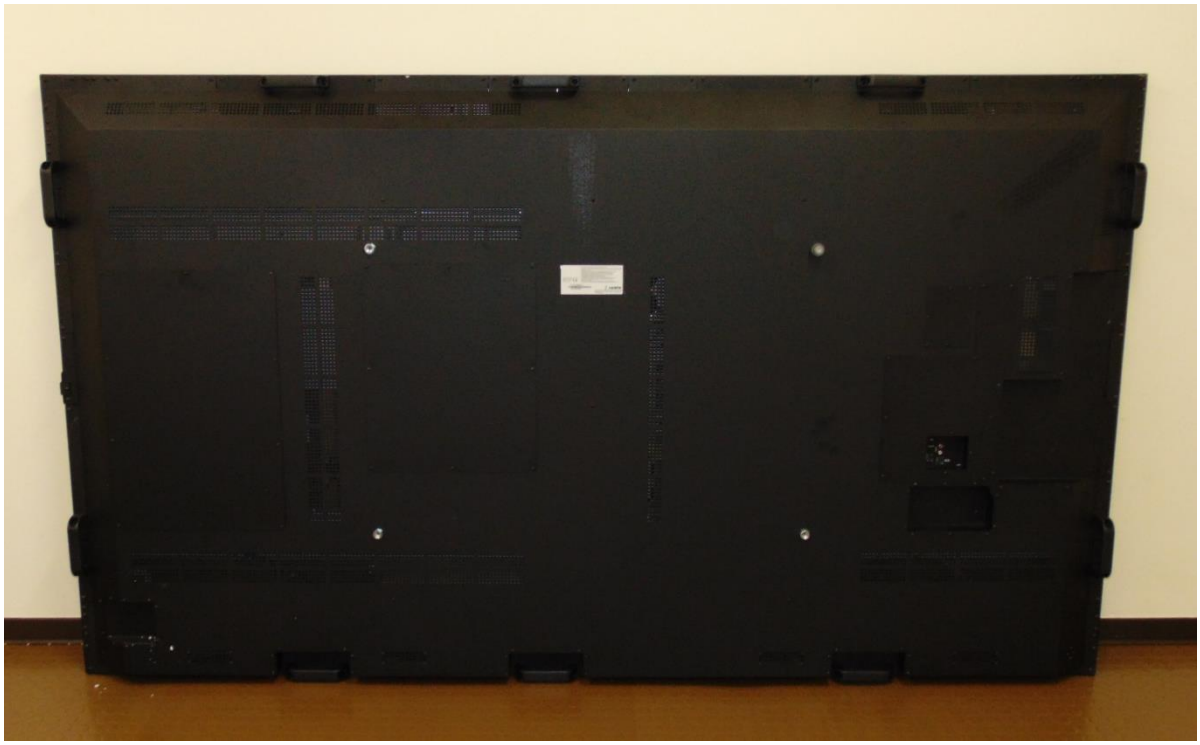
Following specific modifications and/or special attributes are necessary to pass the above mentioned requirements:

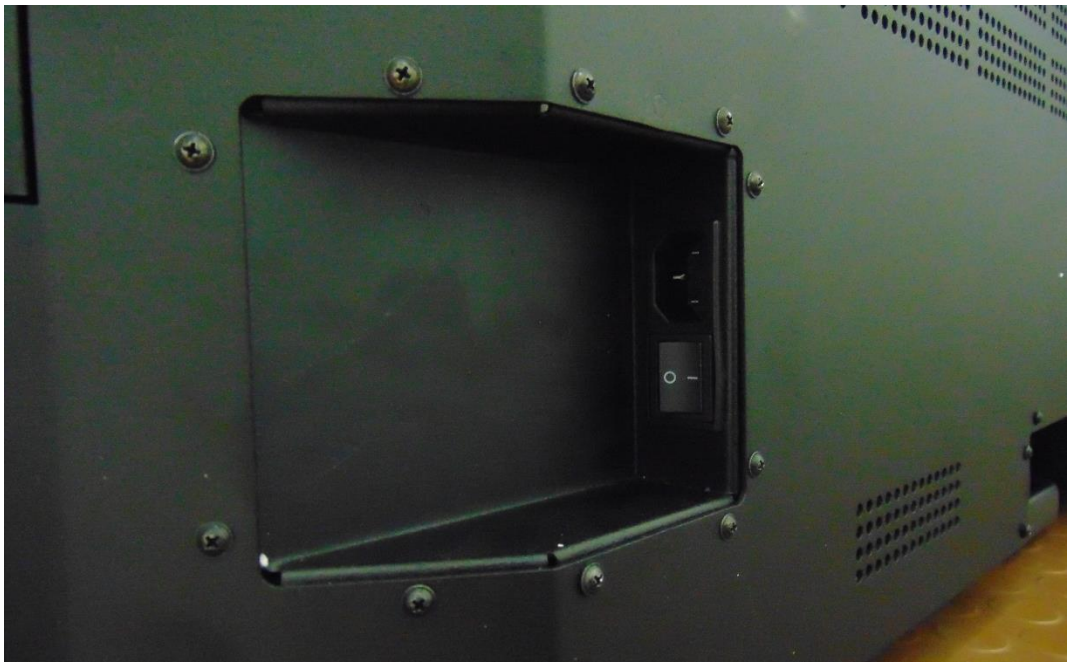
none

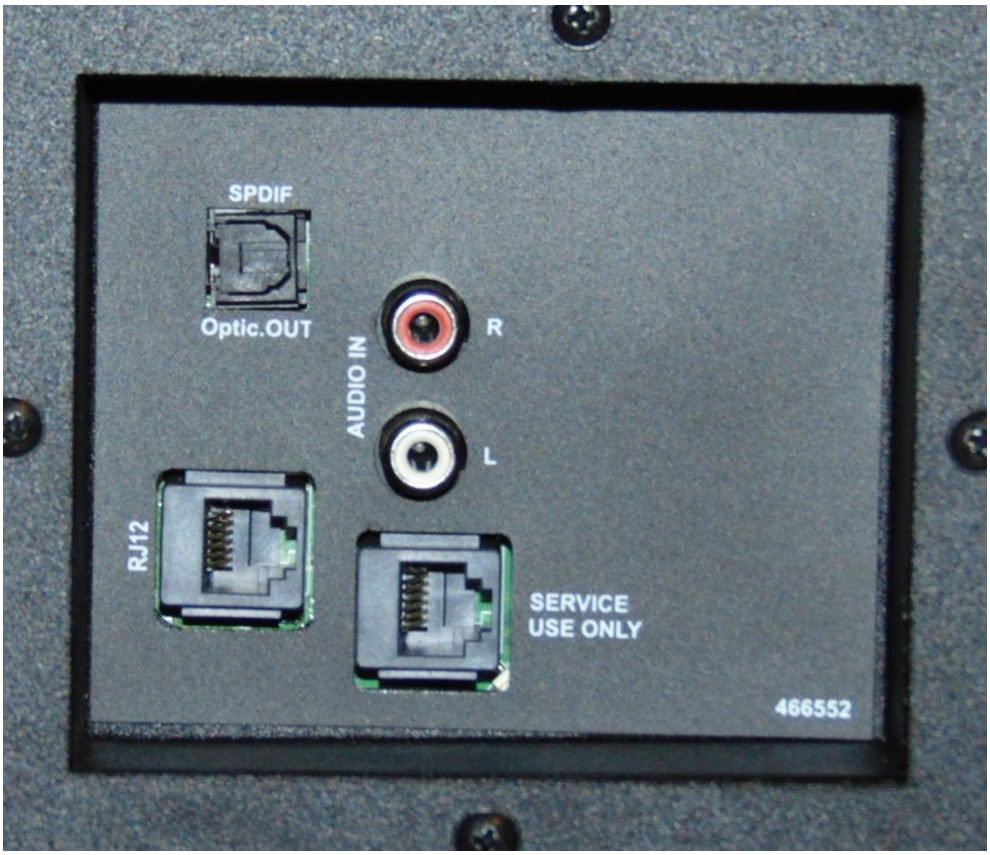
electronic GmbH
a member of the STC

04.11.2019	A. Tropmann, Test Engineer	
Erstellt am/*prepared on*	**(Name/***name* / **Stellung/***position***)**	**(Unterschrift/***signature***)**
04.11.2019	K. Simon, Deputy Head of Laboratory	
Freigabe am/released *on*	**(Name/***name* / **Stellung/***position***)**	**(Unterschrift/***signature***)**

14. Photos of tested sample






SPDIF
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AUDIO IN
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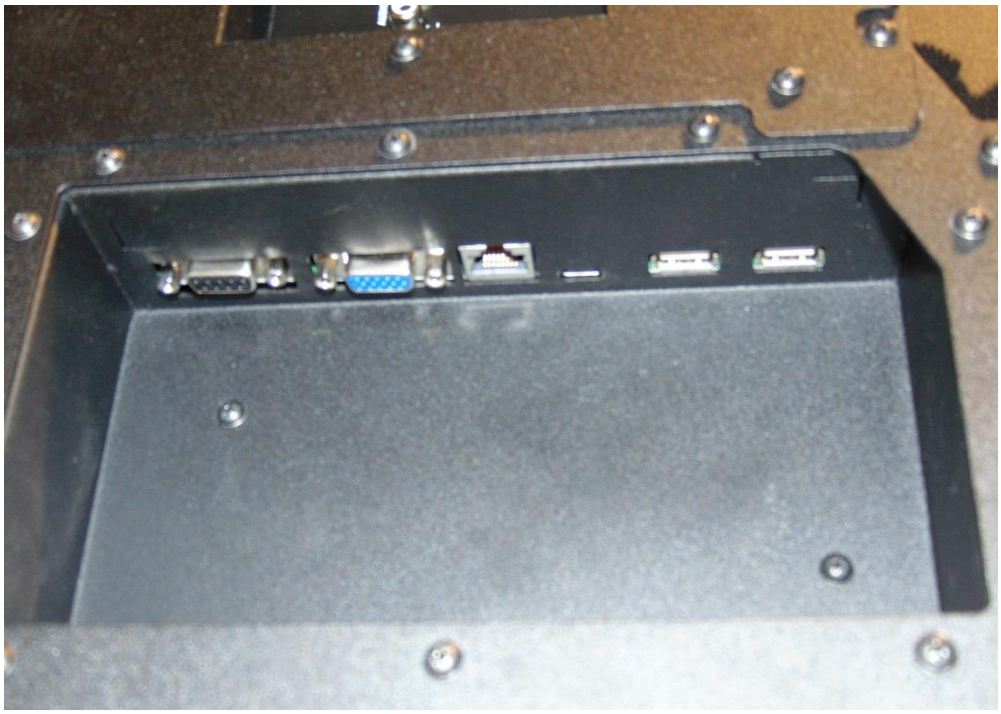
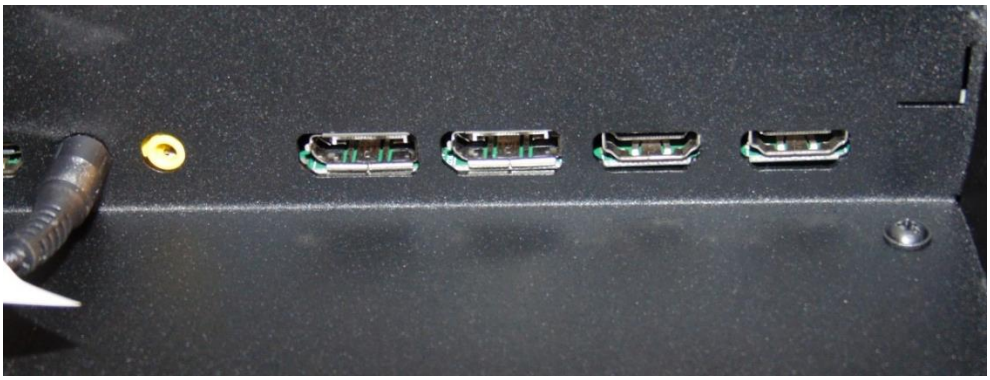
USE ONLY
466552






CHRISTIE
EXIT
OK
BACK
MENU
CMS
Q.MENU
P
R
G
Y
B

End of test report