Test report

Customer:

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RF test report

180811-AU01+W01

HBC-radiomatic GmbH

RF module with 2.4 GHz frequency hopping

TC241-TC20, TC241-TC38, TC240-TC20, TC240-TC38

EMV TESTHAUS

ilac-MRA

DAkkS Deutsche Akkreditierungsstelle D-PL-12155-01-00

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CAB identifier: DE0011
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Location of Testing:

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The technical accuracy is guaranteed through the quality management of the EMV **TESTHAUS** GmbH.

Table of contents

List of figures

List of tables

1 Summary of test results

System type: Frequency hopping system (DSS)

47 CFR part and section	*Test*	*Equivalent to IC radio standard(s)*	*Page*	*Result*	*Note(s)*
15.207	AC power line conducted emissions 150 kHz to 30 MHz	RSS-Gen, section 8.8	34	Passed	1
15.247(a)(1) ANSI C63.10	20 dB bandwidth	RSS-247, section 5.1(a)	38	Passed	---
2.202(a) ANSI C63.10	Occupied bandwidth (99 %)	RSS-Gen, section 6.7	47	For reference only	---
15.247(b)(1) ANSI C63.10	Conducted output power	RSS-Gen, section 6.12 RSS-247, section 5.4(b)	55	Passed	---
15.247(a)(1) ANSI C63.10	Carrier frequency separation	RSS-247, section 5.1(b)	63	Passed	---
15.247(a)(1) ANSI C63.10	Number of hopping frequencies	RSS-247, section 5.1(d)	66	Passed	---
15.247(a)(1) ANSI C63.10	Time of occupancy (dwell time)	RSS-247, section 5.1(d)	70	Passed	
15.247(d) ANSI C63.10	Spurious RF conducted emissions	RSS-247, section 5.5	---	Not applicable	2
15.247(d) ANSI C63.10	Band-edge compliance	RSS-247, section 5.5	65	Passed	---
15.247(d) ANSI C63.10	Emissions outside the operating frequency band(s) specified 9 kHz to 10th harmonic	RSS-Gen, section 6.13 RSS-247, section 5.5			
	9 kHz to 30 MHz		96	Passed	---
	30 MHz to 1 GHz		99	Passed	---
	1 GHz to 10th harmonic		102	Passed	---
2.109	RF radiation exposure evaluation for portable devices	RSS-Gen, section 3.4 (exempted from SAR and RF evaluation)	104	Passed	---

Notes (for information about EUT see clause 3):

1 Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

2 If antenna port conducted tests cannot be performed (e.g. for portable or handheld devices with integral antenna), then radiated tests are performed for demonstrating compliance to the conducted emission requirements (see "Spurious radiated emissions 9 kHz to 10th harmonic").

Straubing, August 19, 2019

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2 Referenced publications

Publication	*Title*
CFR 47 Part 2 March 2019	Code of Federal Regulations, Title 47 (Telecommunication), Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)
CFR 47 Part 15 March 2019	Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)
KDB Publication no. 412172 August 7, 2015	Guidelines for determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF transmitting system
KDB Publication no. 447498 October 23, 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
KDB Publication no. 558074 April 02, 2019	Guidance for Performing Compliance Measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section15.247 of the FCC Rules
KDB Publication no. 662911 October 31, 2013	Emissions Testing of Transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc)
ANSI C63.10 June 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5 March 2019	Spectrum Management and Telecommunications - Radio Standards Specification - General Requirements for Compliance of Radio Apparatus
RSS-102, Issue 5 March 2015	Spectrum Management and Telecommunications - Radio Standards Specification - Radio Frequency Exposure Compliance of Radiocommunications Apperatus
RSS-247, Issue 2 February 2017	Spectrum Management and Telecommunications - Radio Standards Specification - Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

3 Equipment under test (EUT)

All Information in this clause is declared by customer.

3.1 General information

Product type:	RF module with 2.4 GHz frequency hopping		
Model name:	TC241-TC20, TC241-TC38, TC240-TC20, TC240-TC38		
Variants:	The EUT is available in four variants: Module with host interface TC20 with antenna connector Module with host interface TC38 with antenna connector Module with host interface TC20 with onboard antenna Module with host interface TC38 with onboard antenna		
Serial number(s):	07/000181 (Interface TC20 with antenna connector) (RF module 1) 07/00017B (Interface TC38 with antenna connector) (RF module 2)		
Applicant:	HBC-radiomatic GmbH		
Manufacturer:	HBC-radiomatic GmbH		
Version:	Hardware:	TC241261 (Interface TC20 with antenna connector) TC241382 (Interface TC38 with antenna connector)	
	Software:	07	
Additional modifications:	None		
FCC ID:	NO9TC241B		
IC registration number:	2977A-TC241B		
Power supply:	DC supply		
	Nominal voltage:	3.3 V	
Device type:	☒ Portable	☒ Mobile	☒ Fixed

3.2 Radio specifications

System type[1]: Frequency hopping system (DSS)

Application frequency band: 2400.0 MHz - 2483.5 MHz

Operating frequencies: 2402 MHz – 2480 MHz

Short description: The EUT is a RF module for control systems for cranes which is working in the 2.4 GHz band.

Antennas:

Model / No.	Manufacturer	Antenna Type	Gain
012-05-00228	HBC-radiomatic GmbH	λ/4 wire antenna (if used, then soldered on module instead of coax connector)	2,14 dBi
AB157010	HBC-radiomatic GmbH	dipole	2,15 dBi
AB144010	HBC-radiomatic GmbH	dipole	2,15 dBi
AA080016	HBC-radiomatic GmbH	wire antenna	2,14 dBi
AA080018	HBC-radiomatic GmbH	Sleeve antenna (Sperrtopf)	6 dBi
AA080019	HBC-radiomatic GmbH	Dipole	6 dBi
AA080020	HBC-radiomatic GmbH	Wire antenna	6 dBi
AA080021	HBC-radiomatic GmbH	collinear antenna	6 dBi
AA080022	HBC-radiomatic GmbH	λ/4 panel antenna	6 dBi
MU 2404-MMS	Procom A/S	collinear antenna	2 dB (compared to a λ/4 whip)
CXL 2400-1	Procom A/S	Dipol	2 dBi
C80950 / 60603030	Celphone	λ/4 panel antenna	2,15 dBi
Z47242-0005	WiMo	λ/4 panel antenna	2,15 dBi
MU 2404-LX	Procom	collinear antenna	2 dB (compared to a λ/4 whip)
MYP24010PTNF	PCTEL	Yagi	10 dBi
012-01-00052	ELRO	Sleeve antenna (Sperrtopf)	3 dBi
CTA2458/2/DB/SM/S1	Compotek	Sleeve antenna (Sperrtopf)	2 dBi
EXE2400TRNM-001	Liard	dipole	2,15 dBi
146153	Molex	Dipole	3,27 dBi
146175	Molex	SMT MID Chip Antenne	3 dBi
47948	Molex	SMT MID Chip Antenne	3,3 dBi
203006	Molex	SMT Keramik Antenne	2,3 dBi

Table 1: Antennas of EUT

[1] "DTS" is the equipment class for digital transmission systems, "DSS" for all other Part 15 spread spectrum transmitters as used for equipment authorization system form 731.

Frequency range used:	2402 MHz to 2480 MHz
Number of RF channels:	79
Channel spacing:	1 MHz
Modulation:	GFSK, Pi/4 DQPSK, 8DPSK

Channel	*Frequency [MHz]*
Low	2402
Middle	2440
High	2480

Table 2: Radio specifications of EUT

Note: Only the three channels being tested are listed above.

Mode	*Packet*	*Packet type*	*Packet size*
GFSK	DH1	4	27
	DH3	11	183
	DH5	15	339
Pi/4 DQPSK	2-DH1	20	54
	2-DH3	26	367
	2-DH5	30	679
8-DPSK	3-DH1	24	83
	3-DH3	27	552
	3-DH5	31	1021

Table 3: Modulation types and packets

3.3 Photo documentation

For external photos of the EUT see annex B, for internal ones see annex C.
Photos taken during testing including EUT positions can be found in annex A.

4 Test configuration and mode of operation

4.1 Test configuration

Device	*Type designation*	*Serial or inventory no.*	*Manufacturer*
		EUT	
RF module 1[1]	TC241261	07/000181	HBC-radiomatic GmbH
RF module 2[2]	TC241382	07/00017B	HBC-radiomatic GmbH
Remote control	FSE 516	516 – 19 07378	HBC-radiomatic GmbH
		Support equipment	
RS232 to USB connector	RS232 to USB adapter	---	HBC-radiomatic GmbH
Laptop	Lifebook U772	O00632	FUJITSU
Power supply for laptop	AC adapter	O00632	FUJITSU
Remote control	Micron 5	---	HBC-radiomatic GmbH

Table 4: Devices used for testing

Notes:
1 Host interface TC20 and antenna connector.
2 Host interface TC38 and antenna connector.

Port	*Classification (see note 1)*	*Cable type*	*Fixed*	*Cable length*		*Note*
				used	*maximum*	
Antenna ports (SMA)	Signal/control	Unshielded	☐	0.30 m	---	
Power supply port	DC power	Unshielded	☐	1.90 m	---	
6-pin connector	Signal/control	Unshielded	☐	0.80 m	---	

Table 5: Ports of EUT and appropriate cables[2]

Notes:
3 Ports of EUT are classified as “AC power”, “DC power”, “DC power connected to dedicated AC/DC power supply”, “Signal/control” or “Wired network”.

[2] As specified by manufacturer.

4.2 Mode of operation

4.2.1 Declaration of the manufacturer

In the “Sena Statement for BCD100B” the following FHSS characteristics are listed:

- The hopping sequence is pseudorandom.
- All channels are used equally on average.
- The receiver input bandwidth equals the transmit bandwidth.
- The receiver hops in sequence with the transmit signal.

4.2.2 Protocol limited duty cycle

As declared by the manufacturer in clause 4.2.1 the D.C.F. (Duty Cycle Correction Factor) is calculated as following:

- Time to cycle through all channels = Δt = T[ms] x 20 minimum hopping channels, where T = pulse width = 2.88 ms
- 100 ms / Δt [ms] = H → Round up to next highest integer, to account for worst case, H’ = 100 / (2.88 x 20) = 1.74 = 2
- The Worst Case Dwell Time = T [ms] x H’ = 2.88 ms x 2 = 5.76 ms
- **D.C.F**. = 20 Log (The Worst Case Dwell Time / 100 ms) dB = 20 log (5.76/100) = **-24.76 dB**

The D.C.F. is used in clause 6.8 and 6.9.3 to determine the average-value from the measured peak-values.

4.2.3 Test software used for all tests

For all tests the test software “BlueTest3” is used. After selecting the appropriate USB-port, the following window opens:

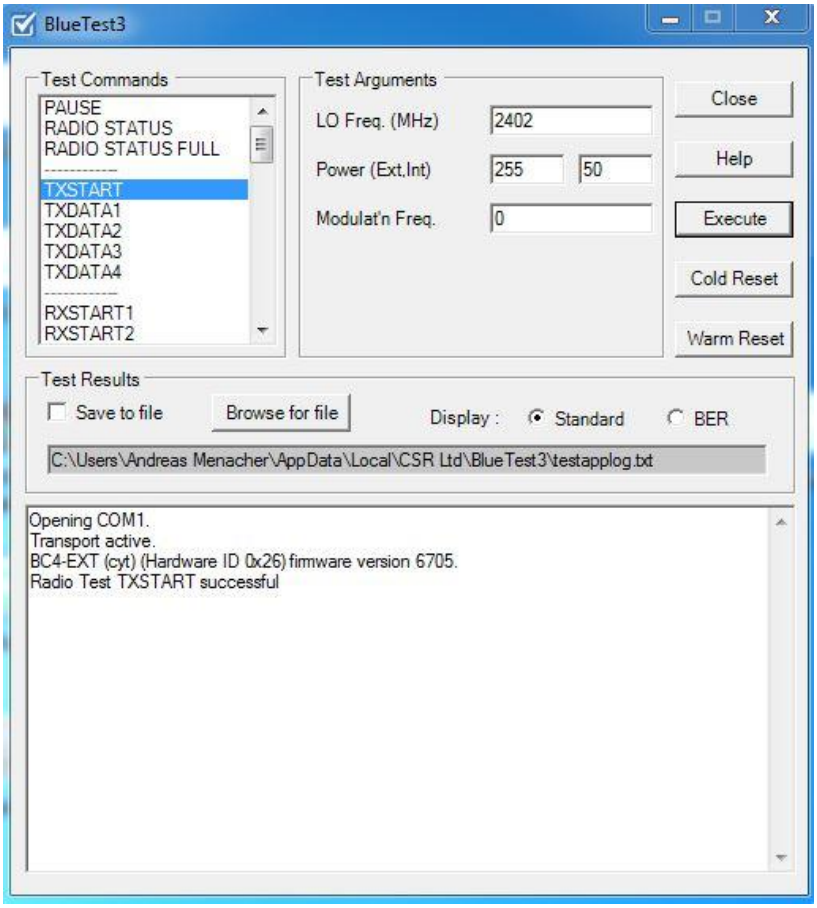


Figure 1: Test software for all measurements

For transmitting on a single channel, the test command “TXDATA1” is selected and the required channel can be chosen. After that, the button “Execute” is pressed for starting the transmitting. Before selecting the test mode, the required packet type and size can be chosen in CFG PKT, as specified in Table 3.

For frequency hopping in the whole operating band, the test command “TXDATA2” is selected.

4.2.4 Test modes applied

For the measurements the testing mode “TXDATA1” for modulated TX carrier is used with the carrier frequency set to the appropriate channel. For measurements in the hopping mode the testing mode “TXDATA2” is used. For further details see clause 4.2.3.

5 Test procedures

5.1 General specifications

5.1.1 Test setups

Tabletop devices are placed on a non-conductive table with a height of 0.8 m. In case of AC power-line conducted emissions test, the rear of the EUT is located 40 cm to the vertical wall of the RF-shielded (screened) room which is used as vertical conducting plane. For radiated emission measurements above 1 GHz, tabletop devices are placed at a height of 1.5 m above the floor using a support made of styrene placed on top of the non-conductive table.

All other surfaces of tabletop or floor-standing EUTs are at least 80 cm from any other grounded conducting surface. This includes the case or cases of one or more LISNs when performing an AC power-line conducted emissions test.

Radiated emission measurements of equipment that can be used in multiple orientations (e.g. portable or handheld devices) are performed with the EUT in each of three orthogonal axis positions.

5.1.2 Conversion to conducted test results

If test procedures described herein are based on the use of an antenna-port conducted test configuration, but the EUT cannot provide such a configuration (e.g., portable or handheld devices with integral antenna), radiated tests are performed for demonstrating compliance to the conducted requirements.

If a radiated test configuration has to be used, then the measured power or field strength levels are converted to equivalent conducted power levels for comparison to the applicable limit. For this purpose, at first the radiated field strength or power levels are converted to EIRP as described in annex G of ANSI C63.10 and KDB Publication 412172, document D01. The equivalent conducted power is then determined by subtracting the EUT transmit antenna gain from the EIRP (assuming logarithmic representation).

For devices utilizing multiple antenna technologies, KDB Publication 662911 applies.

5.2 Antenna-port conducted measurements

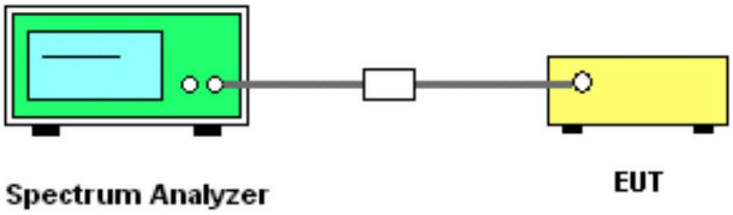


Figure 2: Setup for antenna-port conducted measurements

The RF signal of the EUT is measured conducted at the antenna port. In case of no permanent antenna connector available, a temporary antenna connector should be supplied by the manufacturer. The specific insertion loss of the signal path, which is matched to 50 Ohm, is determined. The test receiver is set to analyzer mode with pre-selector activated. The measurement readings on the test receiver are corrected by the signal path loss.

For frequency hopping systems (FHSS) and digital transmission systems (DTS) the settings as specified by KDB Publication 558074, document D01, are used.

If a radiated test configuration has to be used, conversion to conducted test results is performed according to clause 5.1.2.

5.3 AC powerline conducted emissions

AC powerline conducted emissions from 150 kHz to 30 MHz are measured according to clause 6.2 of ANSI C63.10.

The test is carried out in a shielded room using a line impedance stabilization network (LISN) 50 µH/50 Ohm and an EMI test receiver which is connected to the LISN and set to a measurement bandwidth of 9 kHz in the frequency range from 150 kHz to 30 MHz.

The EUT is placed on a table and connected to the LISN. To accelerate the measurement the detector of the EMI test receiver is set to peak and the whole frequency range from 150 kHz to 30 MHz is scanned. All peak values with less than 10 dB to quasi-peak limit or exceeding the limit are marked and re-measured with quasi-peak detector.

If the values are under the average limit no additional measurement is necessary. In case there are still values between quasi-peak and average limit these values are re-measured with average detector.

5.4 Radiated emissions below 30 MHz

Radiated emissions below 30 MHz are measured according to clause 6.4 of ANSI C63.10 using an inductive shielded loop antenna. As this antenna measures the magnetic field only, its antenna factors are converted to electric field strength values assuming a free space impedance of 377 Ω as described in clause 4.3.1 of ANSI C63.10. This results in an additional correction of 51.53 dB.

According to clause 6.4.3 of ANSI C63.10, at frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the requirements. In this case, the results are extrapolated to the specified distance by using a recalculation factor determined according to one of the methods described in clause 6.4.4 of ANSI C63.10, provided that the maximum dimension of the device is equal to or less than 0.625 times the wavelength at the frequency being measured. As the minimum wavelength is 10 meters corresponding to the maximum frequency of 30 MHz, this requirement is fulfilled if the maximum dimension of the device is equal to or less than 6.25 meters.

Unless otherwise stated, the recalculation factor is determined according to clause 6.4.4.2 "Extrapolation from the measurement of a single point" of ANSI C63.10:

$d_{near\ field}$ = 47.77 / f_{MHz}, or
f_{MHz} = 47.77 / $d_{near\ field}$

The frequency f_{MHz} at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula to determine the recalculation factor:

f_{MHz}(300 m) ≈ 0.159 MHz
f_{MHz}(30 m) ≈ 1.592 MHz
f_{MHz}(3 m) ≈ 15.923 MHz

Based on the test distances for the general radiated emission limits as specified in §15.209 of 47 CFR Part 15, the following formulas are used to determine the recalculation factor:

Frequency (f)	d_{limit}	$d_{measure}$	*Formula for recalculation factor*
9 kHz ≤ f ≤ 159 kHz 490 kHz < f ≤ 1.592 MHz	300 m 30 m	3 m	-40 log(d_{limit} / $d_{measure}$)
159 kHz < f ≤ 490 kHz 1.592 MHz < f ≤ 15.923 MHz	300 m 30 m	3 m	-40 log($d_{near\ field}$ / $d_{measure}$) - 20 log(d_{limit} / $d_{near\ field}$)
f > 15.923 MHz	30 m	3 m	-20 log(d_{limit} / $d_{measure}$)

Table 6: Recalculation factors for extrapolation

Prescans for radiated measurements below 30 MHz are performed in a fully anechoic room (called "CDC"). The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 7.

Frequency (f)	*Measurement receiver bandwidth*	*Step size*	*Detector type*		
			Prescan	*Prescan with FFT*	*Final scan*
9 kHz ≤ f < 150 kHz	200 Hz	≤ 100 Hz	Peak, Average	Peak Quasi-peak, Average	Peak Quasi-peak, Average
150 kHz ≤ f < 30 MHz	9 kHz	≤ 4.5 kHz	Peak, Average	Peak Quasi-peak, Average	Peak Quasi-peak, Average

Table 7: Bandwidth and detector type for radiated emissions test below 30 MHz

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dBµV/m)
10	20.00	19.59	0.33	19.92	39.92

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 20 dBµV + 19.92 dB = 39.92 dBµV/m

Prescans are performed with all detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans. If no limit is specified for certain detectors, final scan measurement with these detectors may be omitted.

The radiated emissions test below 30 MHz is performed in the following steps:

a) The loop antenna is positioned with its plane perpendicular to the ground with the lowest height of the antenna 1 m above the ground.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the loop antenna and set-up according to the specifications of the test (see table 7).
d) The EUT is turned to a position likely to get the maximum and the test antenna is rotated to detect the maximum of the fundamental in this EUT position.
e) Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position.
f) After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
g) With the test receiver set to the first frequency of the list, the EUT is rotated by ±45° around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
h) Step g) is repeated for all other frequencies in the list.
i) Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to i) are repeated in two other orthogonal positions. If the EUT may be used in one position only, steps a) to i) are repeated in one orthogonal position.

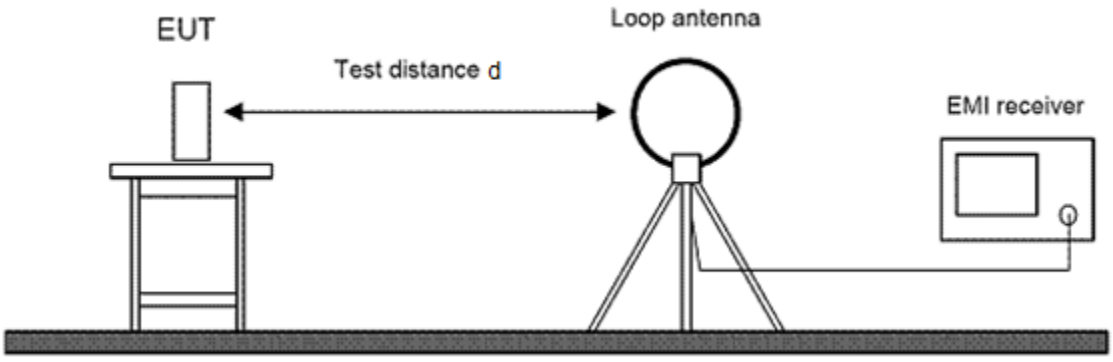


Figure 3: Setup for radiated emissions test below 30 MHz

5.5 Radiated emissions from 30 MHz to 1 GHz

Radiated emissions in the frequency range 30 MHz to 1 GHz are measured according to clause 6.5 of ANSI C63.10 using a semi-anechoic chamber (SAC) with a ground plane on the floor. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 8.

Frequency (f)	*Measurement receiver bandwidth*	*Step size*	*Detector type*		
			Prescan	*Prescan with FFT*	*Final scan*
30 MHz ≤ f ≤ 1 GHz	120 kHz	≤ 60 kHz	Peak	Quasi-peak	Quasi-peak

Table 8: Bandwidth and detector type for radiated emissions test from 30 MHz to 1 GHz

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dBµV/m)
100	30.00	11.71	1.06	12.77	42.77

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 30 dBµV + 12.77 dB = 42.77 dBµV/m

The measurement antenna is a combination of a biconical antenna and a logarithmic-periodic dipole array antenna. It is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and in a height between 1 m and 4 m above the ground plane.

If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The radiated emissions test from 30 MHz to 1 GHz is performed in the following steps:

a) The measurement antenna is oriented initially for vertical polarization.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 8).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
g) The antenna height is increased to 4 m in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step f) is repeated.

j) The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±60° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

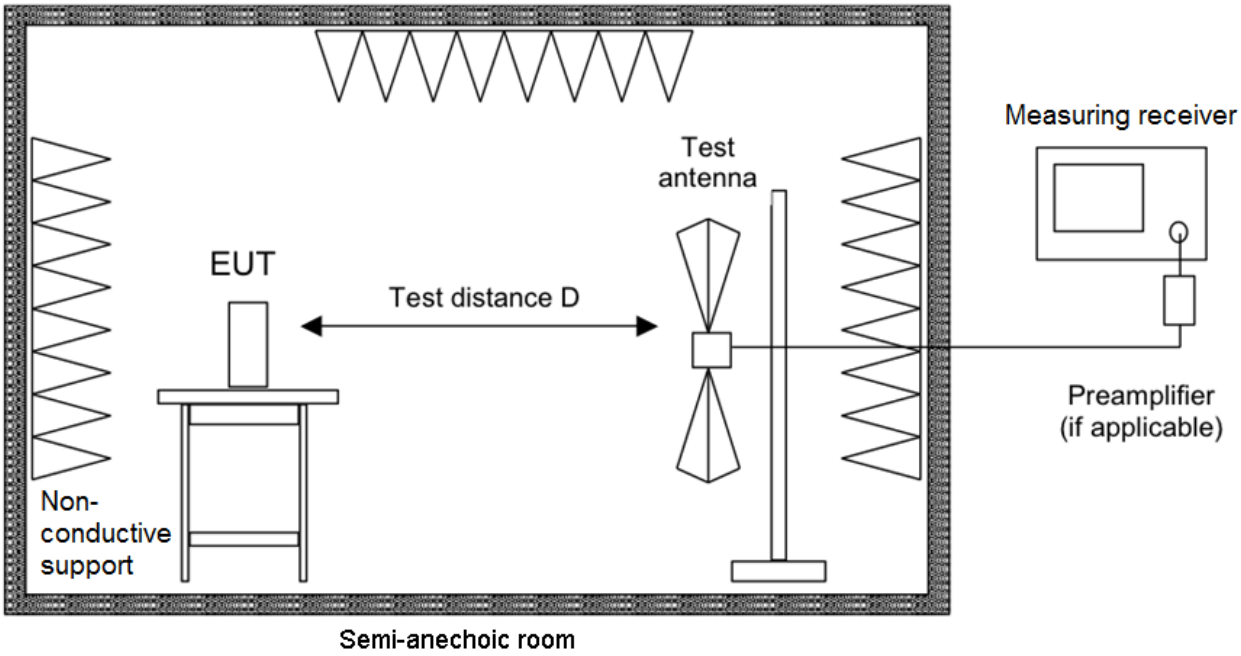


Figure 4: Setup for radiated emissions test from 30 MHz to 1 GHz

5.6 Radiated emissions above 1 GHz

Radiated emissions above 1 GHz are measured according to clause 6.6 of ANSI C63.10 by conducting exploratory and final radiated emission tests. According to clause 6.6.4.1 of ANSI C63.10, measurements may be performed at a distance closer than that specified in the

requirements. However, an attempt shall be made to avoid making final measurements in the near field of both the measurement antenna and the EUT.

For measurement of radiated emissions above 1 GHz, horn antennas are used.

Sample calculation:

Frequency (MHz)	Reading value (dBµV)	Antenna correction (dB/m)	Correction pre-amplifier (dB)	Cable attenuation (dB)	Correction factor (Corr.) (dB)	Level (dBµV/m)
2400	50.00	27.76	-34.57	3.51	-3.30	46.70

Correction factor = Antenna correction + Correction pre-amplifier + Cable attenuation

Level = Reading value + Correction factor = 50.00 dBµV – 3.30 dB = 46.70 dBµV/m

5.6.1 Exploratory radiated emissions measurements

Exploratory radiated emissions above 1 GHz are measured in a semi-anechoic chamber with RF absorbing material on the floor or a fully anechoic room. They are performed by moving the receiving antenna over all sides of the EUT at a closer distance (e.g. 0.5 or 1 m) while observing the display of the test receiver to find the emissions to be re-tested during final radiated emission measurements.

According to clause 5.3.3 of ANSI C63.10, when performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade of distance (inverse of linear distance for field-strength measurements). To simplify testing and documentation, the limits are increased accordingly instead of decreasing the results.

The emissions of the EUT are displayed and recorded with an EMI test receiver operating in the spectrum analyzer mode using the settings as described in table 9.

Frequency (f)	*Resolution bandwidth*	*Video bandwidth*	Sweep time	*Trace detector(s)*	*Trace mode(s)*	*Test*
f ≥ 1 GHz	1 MHz	3 MHz	AUTO	Max Peak, Average	Clear Write	Searching
					Max Hold	Recording

Table 9: Bandwidth and trace settings for exploratory radiated emissions test above 1 GHz

If during exploratory radiated emissions measurements no levels to be re-tested are found, the final radiated emissions measurement may be omitted. In this case, the chart of the exploratory radiated emissions measurements has to be reported.

5.6.2 Final radiated emissions measurements

Final radiated emissions above 1 GHz are measured in a semi-anechoic chamber (SAC) with RF absorbing material on the floor between measurement antenna and EUT. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 10.

Frequency (f)	*Measurement receiver bandwidth*	*Step size*	*Detector type*	
			Prescan	*Final scan*
f ≥ 1 GHz	1 MHz	≤ 500 kHz	Peak, Average	Peak, Average

Table 10: Bandwidth and detector type for final radiated emissions test above 1 GHz

Prescans are performed with both detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The horn antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and to be moved in a scan height range between 1 m and the scan height upper range defined in clause 6.6.3.3 of ANSI C63.10. When the EUT is manipulated through three different orientations, the scan height upper range for the measurement antenna is limited to 2.5 m above the ground plane.or 0.5 m above the top of the EUT, whichever is higher. Otherwise, the scan height upper range is 4 m above the ground plane.
To keep the emission signal within the illumination area of the 3 dB beamwidth of the measurement antenna, the automatic tilt function of the antenna support device is used to point the antenna at an angle toward the source of the emission.

The final radiated emissions test above 1 GHz is performed in the following steps:

a) The measurement antenna is oriented initially for vertical polarization.
b) The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
c) The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 10).
d) The table position is set to 0°.
e) The antenna height is set to 1 m.
f) The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
   g) The antenna height is increased to the scan height upper range in steps of 50 cm. At each height, step f) is repeated.
h) The polarization of the measurement antenna is changed to horizontal.
i) The antenna height is decreased from the scan height upper range to 1 m in steps of 50 cm. At each height, step f) is repeated.
j) The EUT is rotated in a horizontal plane through 360° in steps of 30°. At each table position, steps e) to i) are repeated.
k) After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.

l) With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
m) The antenna is moved by ±50 cm around this height and the EUT is rotated by ±30° around this table position while measuring the emission level continuously.
n) For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
o) Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

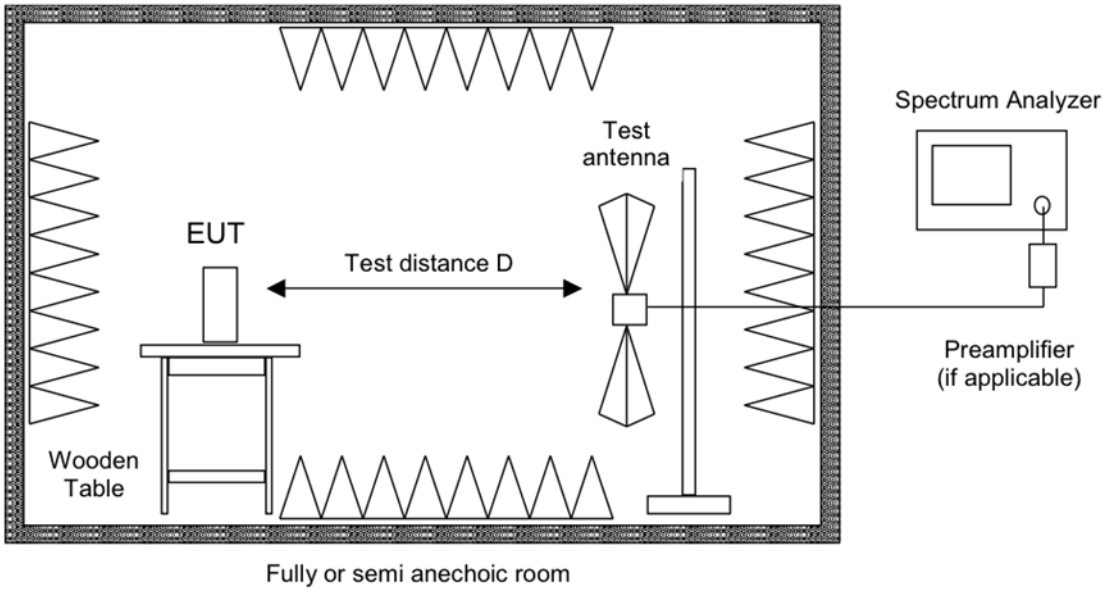


Figure 5: Setup for radiated emissions test above 1 GHz

5.7 Bandwidth measurements

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

5.7.1 20 dB bandwidth of the emission

The 20 dB bandwidth of the emission is measured according to clause 6.9.2 of ANSI C63.10 as the width of the spectral envelope of the modulated signal, at an amplitude level reduced by a ratio of 20 dB down from the reference value.

The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer is between two times and five times the 20 dB bandwidth. The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1 % to 5 % of the 20 dB bandwidth and the video bandwidth (VBW) shall be approximately three times RBW.

The reference level of the instrument is set as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (20 dB bandwidth/RBW)] below the reference level.

The 20 dB bandwidth of the emission is not required for digital transmission systems (DTS). For these systems, the 6 dB bandwidth applies.

5.7.2 6 dB bandwidth (DTS bandwidth)

The 6 dB bandwidth or DTS bandwidth is measured according to clause 8.0 of KDB Publication 558074, document D01, using the following settings:

a) Resolution bandwidth RBW = 100 kHz
b) Video bandwidth (VBW) ≥ 3 x RBW
c) Detector = Peak
d) Trace mode = max hold
e) Sweep = auto couple

After the trace is stabilized, the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

If using the automatic bandwidth measurement capability of the test instrument (6 dB down function), care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB. In addition, it has to be checked that this function delivers the two outermost amplitude points.

The 6 dB bandwidth is not required for frequency hopping systems (FHSS). For these systems the 20 dB bandwidth applies.

5.7.3 99 % occupied bandwidth

According to section 6.7 of RSS-Gen, the occupied bandwidth (OBW) is defined as the 99 % emission bandwidth.

The span of the spectrum analyzer is set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
The resolution bandwidth is in the range of 1 % to 5 % of the occupied bandwidth and the video bandwidth is not smaller than three times the resolution bandwidth. Video averaging is not permitted.
If possible, the detector of the spectrum analyzer is set to “Sample”. However, if the device is not transmitting continuously, a peak, or peak hold is used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement).

To measure the 99 % emission bandwidth, the OBW function of the test receiver is used with the power bandwidth set to 99 %. This function indicates the lowest frequency (starting from the left side of the span) and the highest frequency (starting from the right side of the span) where 0.5% of the total sum is reached. The difference between the two frequencies is the 99 % occupied bandwidth.

5.8 Maximum peak conducted output power

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

5.8.1 Frequency hopping systems

The maximum conducted output power test method for frequency hopping systems refers to section 7.8.5 of ANSI C63.10.

The spectrum analyzer settings are as follows:

a) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel
b) RBW > 20 dB bandwidth of the emission being measured
c) VBW ≥ RBW
d) Sweep: Auto
e) Detector function = peak
f) Trace mode = max hold
g)

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the maximum peak conducted output power.

5.9 Carrier frequency separation

The carrier frequency separation test method for frequency hopping systems refers to section 7.8.2 of ANSI C63.10.

The EUT shall have its hopping function enabled.

The spectrum analyzer settings are as follows:

a) Span: Wide enough to capture the peaks of two adjacent channels
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel
c) VBW ≥ RBW
d) Sweep time = auto coupled
e) Detector function = peak
f) Trace mode = max hold

After the trace is stabilized, the marker-delta function is used to determine the separation between the peaks of the adjacent channels.

5.10 Number of hopping frequencies

The number of hopping frequencies test method for frequency hopping systems refers to section 7.8.3 of ANSI C63.10.

The EUT shall have its hopping function enabled.

The spectrum analyzer settings are as follows:

a) Span: The frequency band of operation
b) RBW: less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller
c) VBW ≥ RBW
d) Sweep time = auto coupled
e) Detector function = peak
f) Trace mode = max hold
g) Allow the trace to stabilize.

5.11 Time of occupancy (dwell time)

The EUT shall have its hopping function enabled.

The spectrum analyzer settings are as follows:

a) Span: Zero span, centered on a hopping channel
b) RBW ≤ channel spacing and, where possible, the RBW should be set to >> 1/T where T is the expected dwell time per channel
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot
d) Detector function = peak
e) Trace mode = max hold

Use the marker-delta function to determine the transmit time per hop. Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the specified period.

(Number of hops in the period specified in the requirements) = (number of hops on spectrum analyzer) x (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the specified period.

6 Test results

This clause gives details about the test results as collected in the summary of test results on page 9.

The climatic conditions are recorded during the tests. It is ensured that the climatic conditions are within the following ranges:

Ambient temperature	*Ambient humidity*	*Ambient pressure*
15°C to 35°C	30 % to 75 %	86 kPa to 106 kPa

6.1 AC powerline conducted emissions

Section(s) in 47 CFR Part 15:	Requirement(s):	15.207(a)
	Reference(s)	ANSI C63.10, clause 6.2
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 8.8
	Reference(s):	ANSI C63.10, clause 6.2

Result[3]: ☒ Test passed ☐ Test not passed

6.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☒	Shielded room	ESCS30	Siemens – Matsushita	E00107
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☒	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Artificial mains network (AMN)	ESH2-Z5	Rohde & Schwarz	E00004
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☒	Cable set shielded room	RF cable(s)	Huber + Suhner	E00741 E00804
☒	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[3] For information about measurement uncertainties see page 97.

6.1.2 Limits

For intentional radiators that are designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 11.

Frequency of emission (MHz)	*Conducted limit (dBµV)*	
	Quasi-peak	*Average*
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

Table 11: Limits for AC powerline conducted emissions

*Decreases with the logarithm of the frequency

6.1.3 Test procedure

The AC powerline conducted emissions are measured using the test procedure as described in clause 5.3 and referring to the

☒ test method for conducted measurements as described in clause 5.3.
☐ test method for radiated measurements as described in clause 5.6.

6.1.4 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	October 24, 2019

Note: The test was performed at 115 V and 60 Hz.

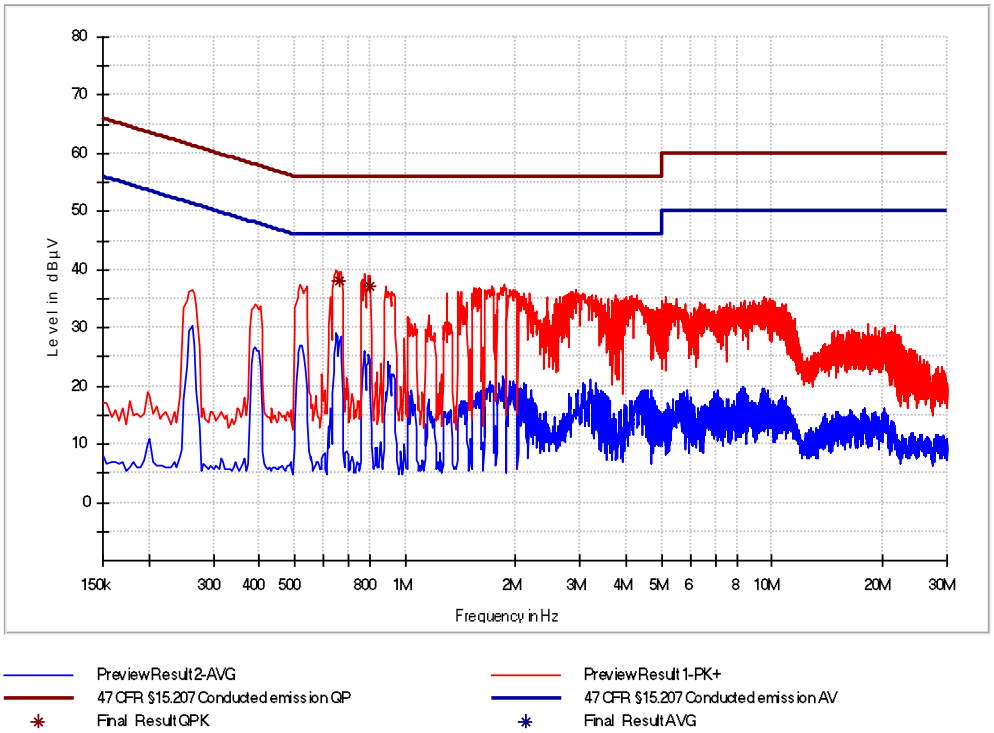


Figure 6: Chart of AC powerline conducted emissions on L1

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Line*	*PE*	*Corr. (dB)*
0.661000	38.00	---	56.00	18.00	1000.0	9.000	L1	GND	10.2
0.805000	37.04	---	56.00	18.96	1000.0	9.000	L1	GND	10.2

Table 12: Results of AC powerline conducted emissions on L1

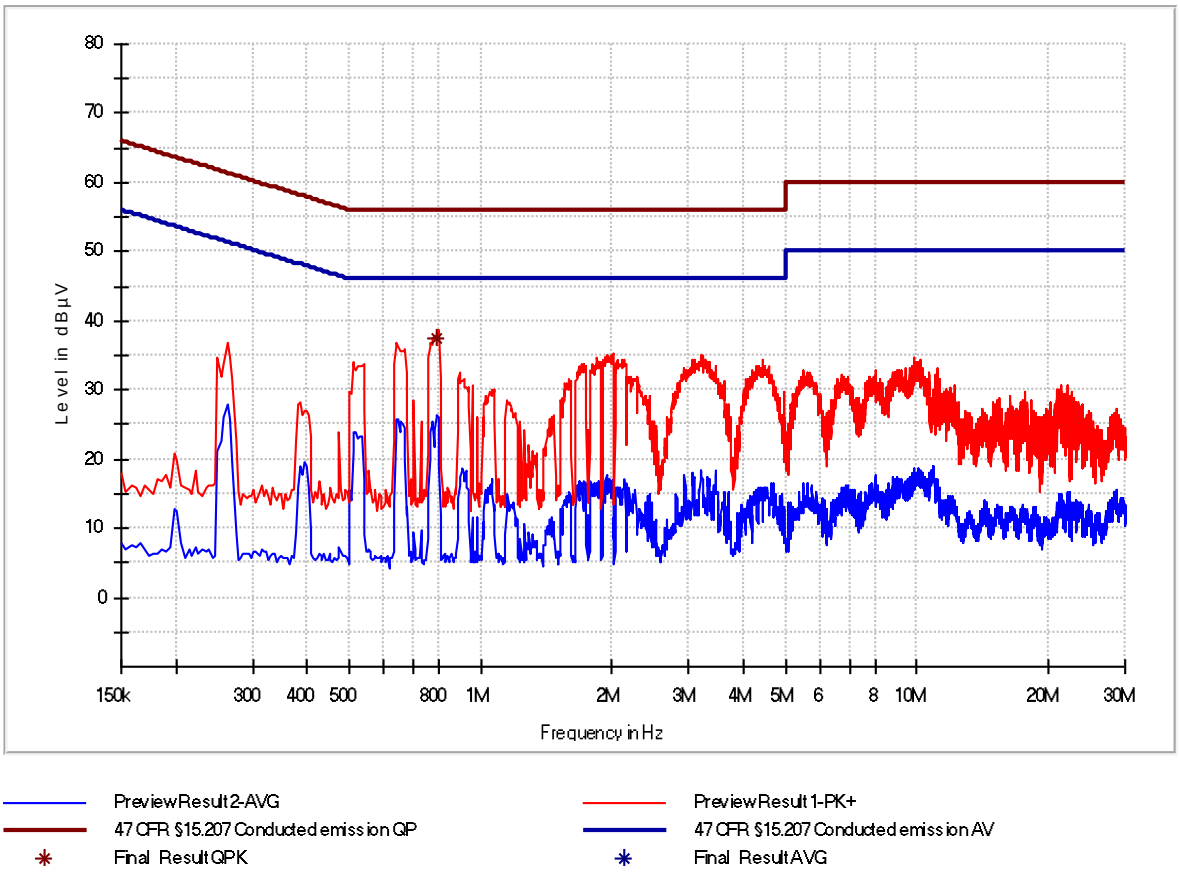


Figure 7: Chart of AC powerline conducted emissions on N

Frequency (MHz)	*QuasiPeak (dBµV)*	*Average (dBµV)*	*Limit (dBµV)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Line*	*PE*	*Corr. (dB)*
0.789000	37.52	---	56.00	18.48	1000.0	9.000	N	GND	10.2

Table 13: Results of AC powerline conducted emissions on N

6.2 20 dB bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s):	15.215(c), 15.247(a)(1)
	Reference(s):	ANSI C63.10, clause 6.9
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.1(a)
	Reference(s):	ANSI C63.10, clause 6.9

Result[4]: ☒ Test passed ☐ Test not passed

6.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[4] For information about measurement uncertainties see page 85.

6.2.1 Limits

According to §15.215(c), intentional radiators operating under the alternative provisions to the general emission limits must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

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.

The specific rule section under which the equipment operates is §15.247. According to §15.247(a)(2), for systems using digital modulation techniques (DTS), the 6 dB bandwidth (DTS bandwidth) is specified as the bandwidth of the emission. In this case, measuring the 20 dB bandwidth is not required.

6.2.2 Test procedure

The 20 dB bandwidth is measured using the test procedure as described in clause 5.7.1 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.2.3 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	May 23, 2019

Note: Each packet type and size in the three modulation types are tested but only the worst case pro modulation type is shown in this test report.

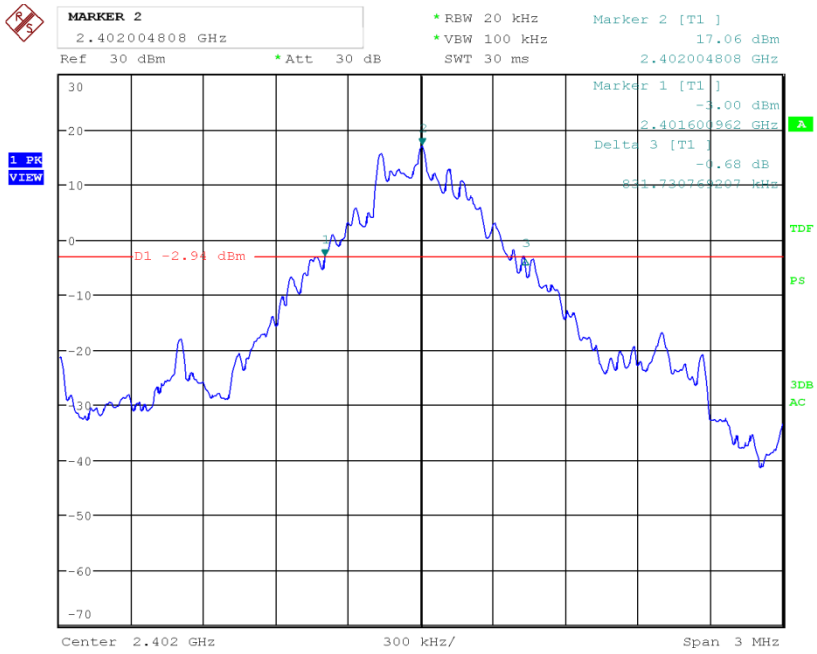


Figure 8: Chart of 20 dB bandwidth on channel low (GFSK, DH1)

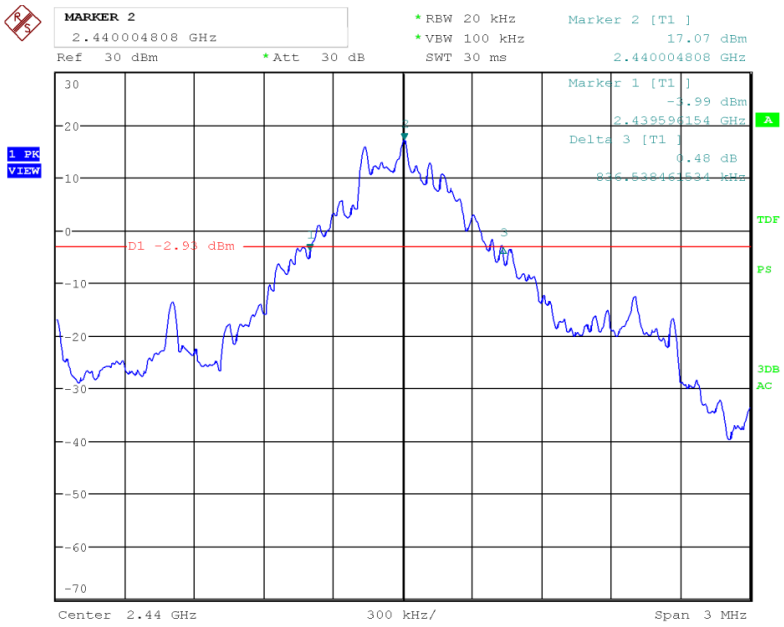


Figure 9: Chart of 20 dB bandwidth test on channel middle (GFSK, DH1)

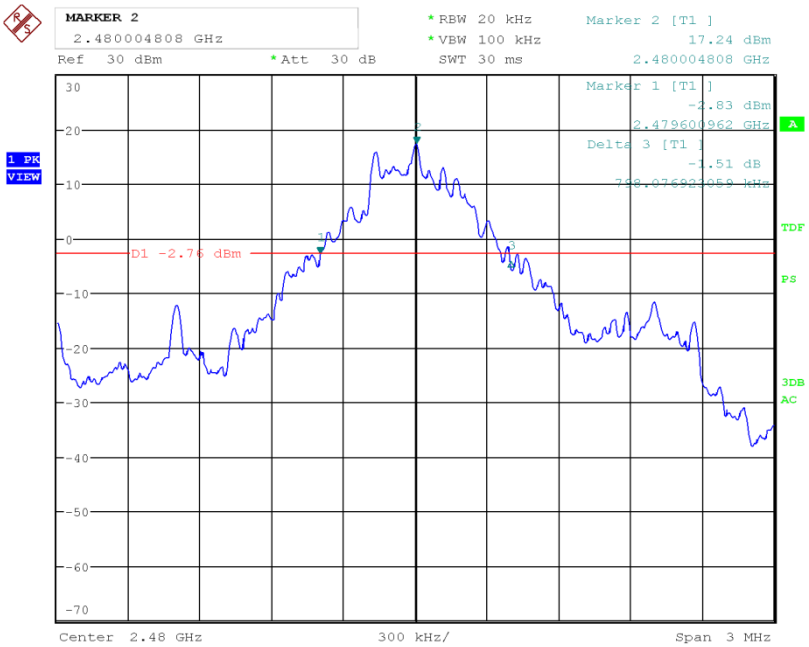


Figure 10: Chart of 20 dB bandwidth test on channel high (GFSK, DH1)

Channel	*20 dB bandwidth*	*Band edge left*		*Band edge right*		*Result*[5]
	[kHz]	*Frequency [MHz]*	*Limit [MHz]*	*Frequency [MHz]*	*Limit [MHz]*	
low	831.731	2401.60096	2400.0	2402.43269	2483.5	Passed
middle	836.538	2439.59615	2400.0	2440.43269	2483.5	Passed
high	798.077	2479.60096	2400.0	2480.39904	2483.5	Passed

Table 14: Results of 20 dB bandwidth tests (GFSK, DH1)

[5] For systems using digital modulation techniques (DTS), the 20 dB bandwidth is recorded for information only.

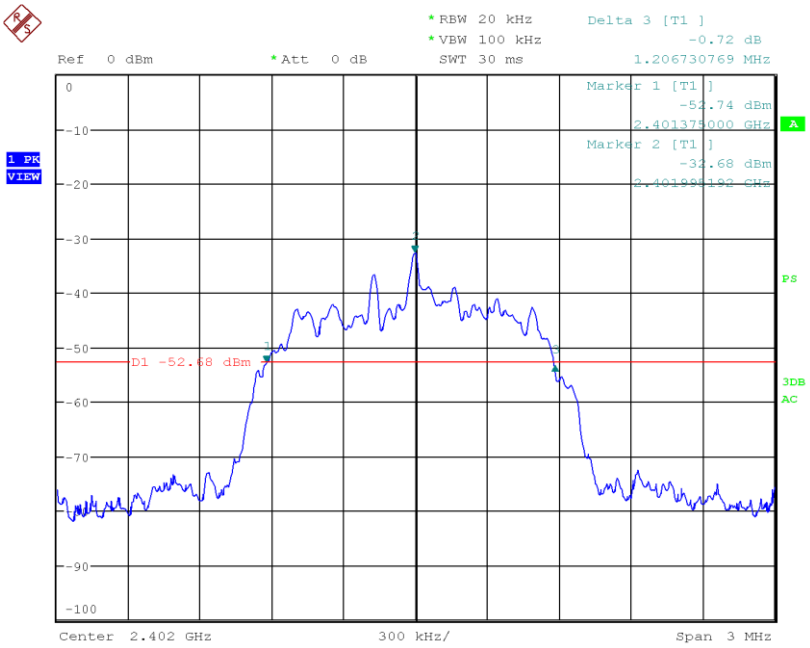


Figure 11: Chart of 20 dB bandwidth on channel low (π/4-DQPSK, 2-DH1)

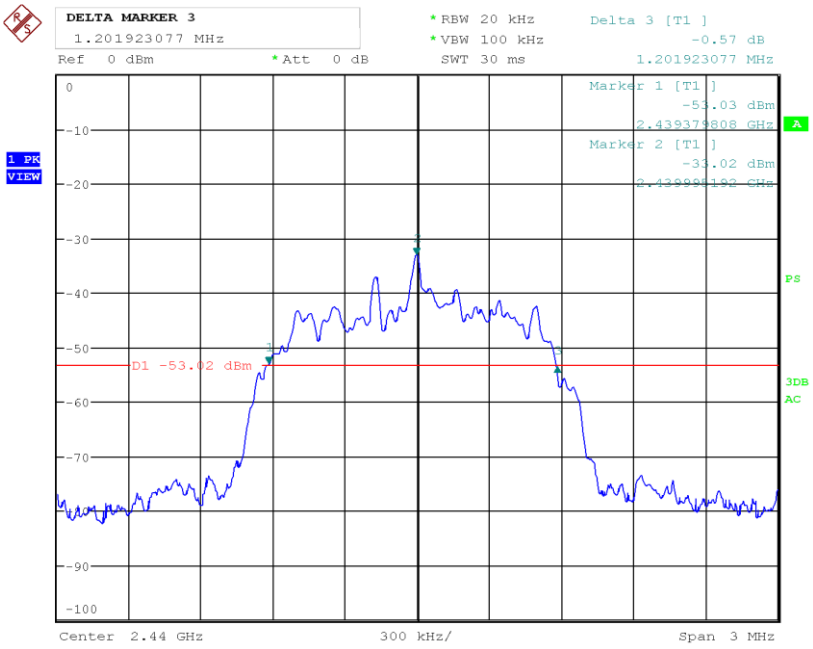


Figure 12: Chart of 20 dB bandwidth on channel middle (π/4-DQPSK, 2-DH1)

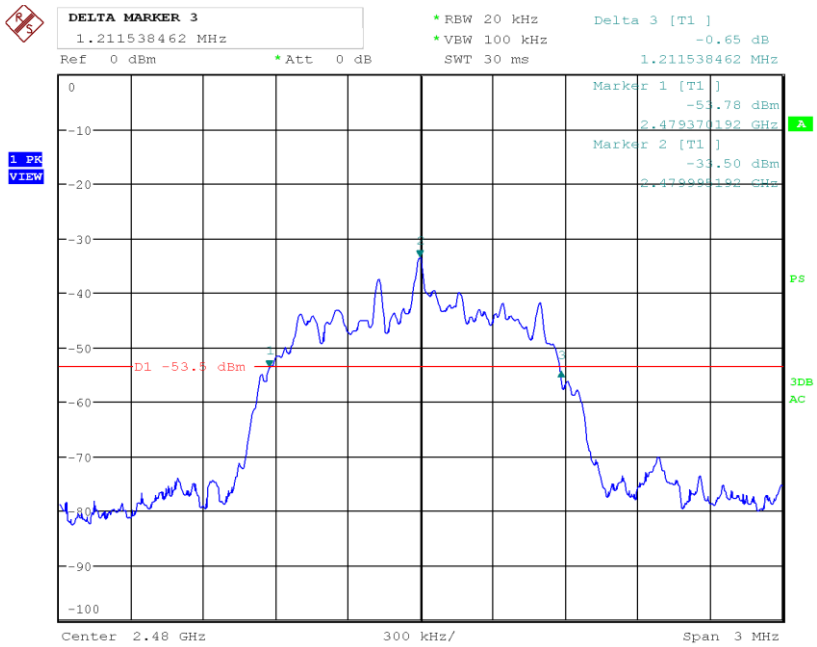


Figure 13: Chart of 20 dB bandwidth test on channel high (π/4-DQPSK, 2-DH1)

Channel	*20 dB bandwidth*	*Band edge left*		*Band edge right*		*Result*[6]
		Frequency	*Limit*	*Frequency*	*Limit*	
	[kHz]	*[MHz]*	*[MHz]*	*[MHz]*	*[MHz]*	
low	1206.731	2401.37500	2400.0	2402.58173	2483.5	Passed
middle	1201.923	2439.37981	2400.0	2440.58173	2483.5	Passed
high	1211.538	2479.37019	2400.0	2480.58173	2483.5	Passed

Table 15: Results of 20 dB bandwidth tests (π/4-DQPSK, 2-DH1)

[6] For systems using digital modulation techniques (DTS), the 20 dB bandwidth is recorded for information only.

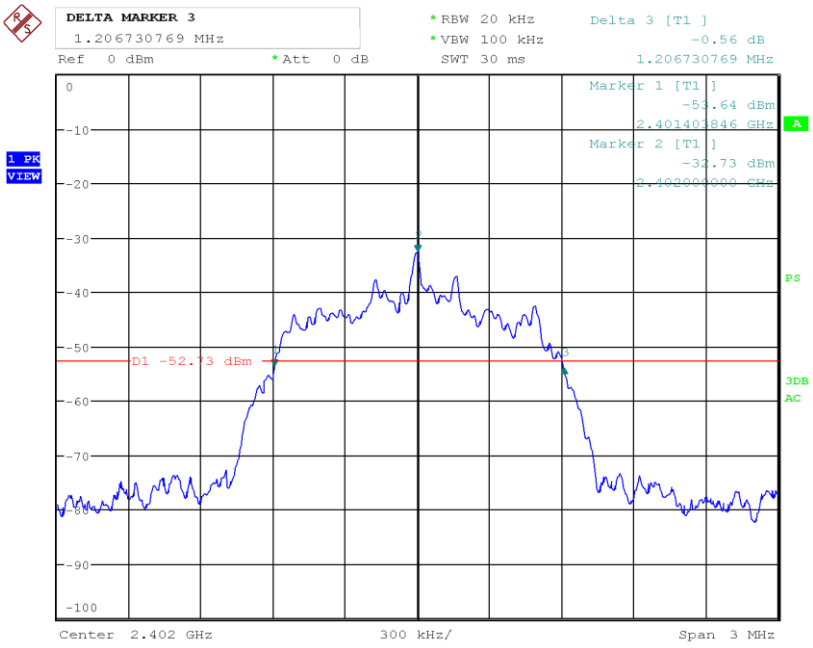


Figure 14: Chart of 20 dB bandwidth on channel low (8-DPSK, 3-DH1)

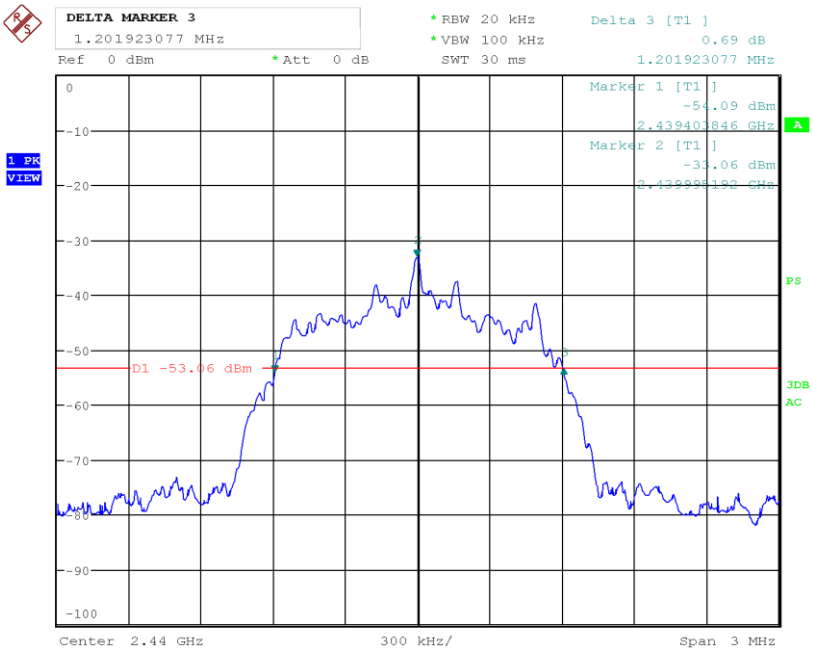


Figure 15: Chart of 20 dB bandwidth on channel middle (8-DPSK, 3-DH1)

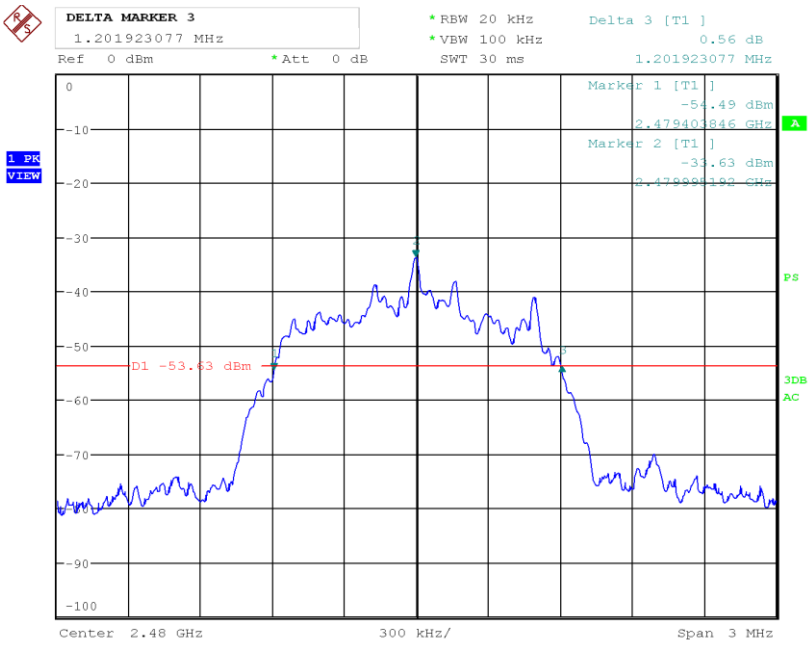


Figure 16: Chart of 20 dB bandwidth test on channel high (8-DPSK, 3-DH1)

Channel	*20 dB bandwidth*	*Band edge left*		*Band edge right*		*Result*[7]
		Frequency	*Limit*	*Frequency*	*Limit*	
	[kHz]	*[MHz]*	*[MHz]*	*[MHz]*	*[MHz]*	
low	1206.731	2401.40385	2400.0	2402.61058	2483.5	Passed
middle	1201.923	2439.40385	2400.0	2440.60577	2483.5	Passed
high	1201.923	2479.40385	2400.0	2480.60577	2483.5	Passed

Table 16: Results of 20 dB bandwidth tests (8-DPSK, 3-DH1)

[7] For systems using digital modulation techniques (DTS), the 20 dB bandwidth is recorded for information only.

6.3 Occupied bandwidth

Section(s) in 47 CFR Part 15:	Requirement(s): Reference(s):	2.202(a), KDB 558074 D01, section 5.2 ANSI C63.10, clause 6.9
Section(s) in RSS:	Requirement(s): Reference(s):	RSS-Gen, section 6.7 ANSI C63.10, clause 6.9

Result[8]: ☒ Test passed ☐ Test not passed

6.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[8] For information about measurement uncertainties see page 85.

6.3.2 Limits

According to section 5.2 of KDB Publication 558074, document D01, the 99 % occupied bandwidth is necessary for setting the proper reference level and input attenuation.

According to RSS-Gen, section 6.7, the occupied bandwidth or the “99% emission bandwidth” has to be reported for all equipment in addition to the specified bandwidth required in RSS-247.

Although there is no limit specified, the occupied bandwidth has to be recorded and reported.

6.3.3 Test procedure

The occupied bandwidth is measured using the test procedure as described in clause 5.7.3 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.3.4 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	May 23, 2019

Note: Each packet type and size in the three modulation types are tested but only the worst case pro modulation type is shown in this test report.

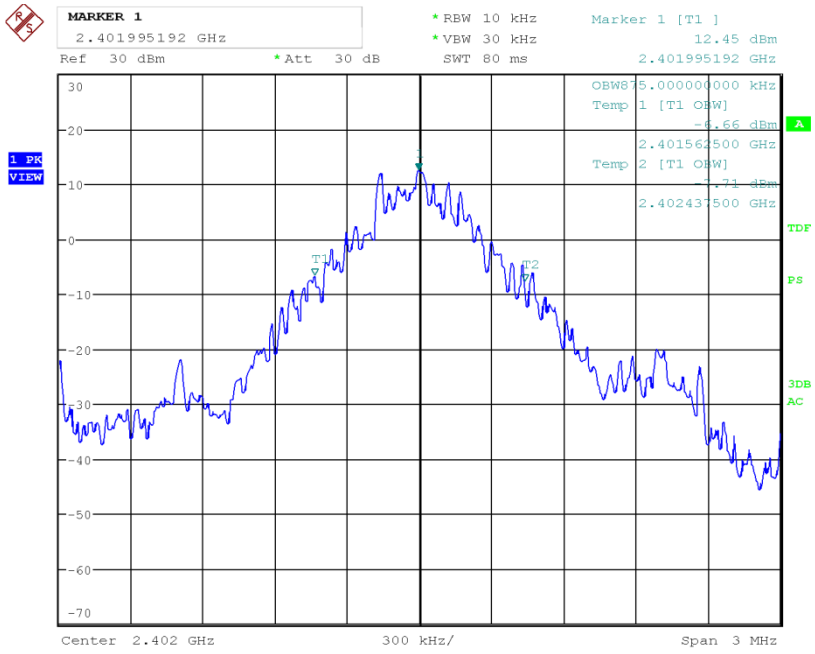


Figure 17: Chart of occupied bandwidth test on channel low (GFSK, DH1)

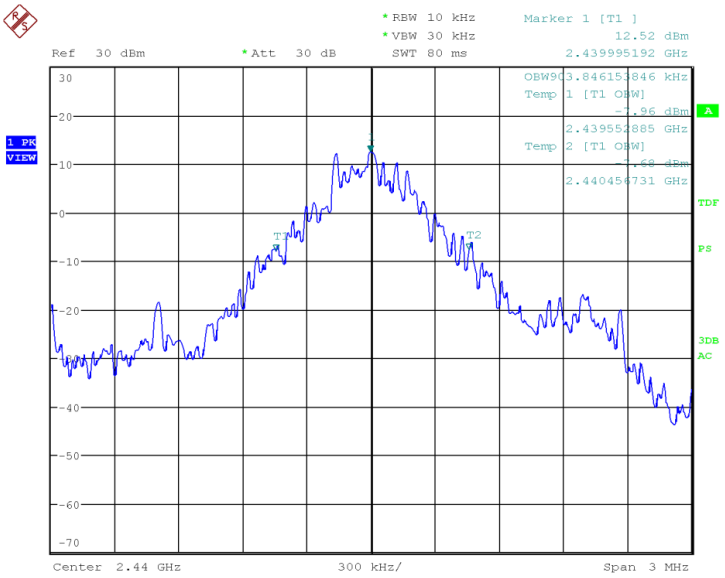


Figure 18: Chart of occupied bandwidth test on channel middle (GFSK, DH1)

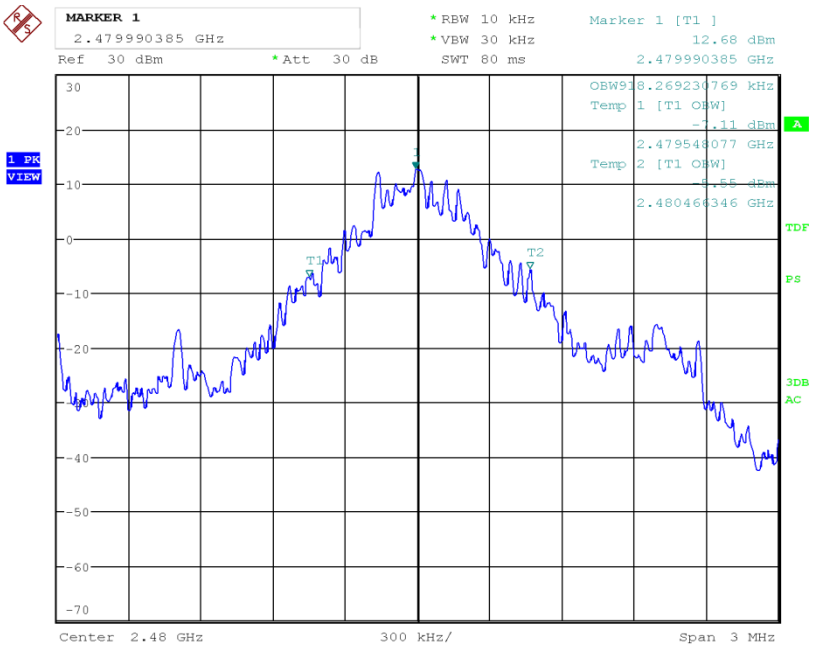


Figure 19: Chart of occupied bandwidth test on channel high (GFSK, DH1)

Channel	*99 % occupied bandwidth [kHz]*	*Result*
low	875.000	Recorded
middle	903.846	Recorded
high	918.269	Recorded

Table 17: Results of occupied bandwidth test (GFSK, DH1)

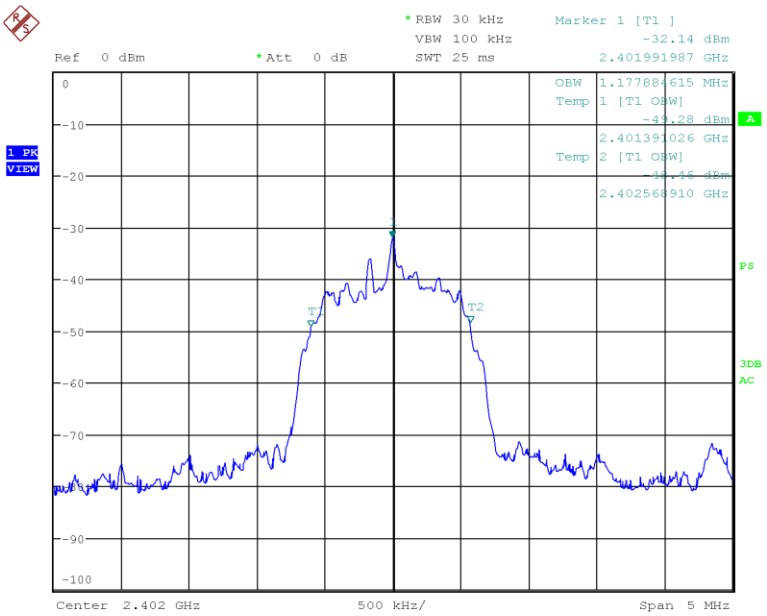


Figure 20: Chart of occupied bandwidth test on channel low (π/4-DQPSK, 2-DH1)

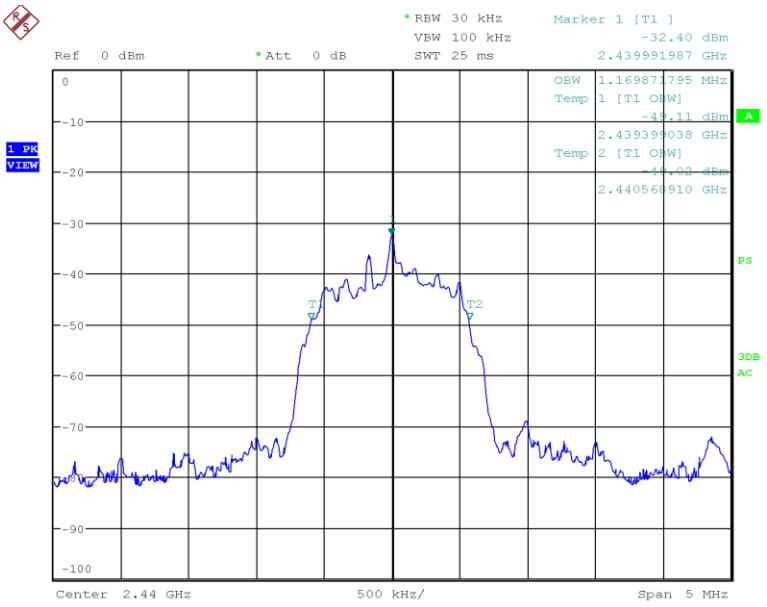


Figure 21: Chart of occupied bandwidth test on channel middle (π/4-DQPSK, 2-DH1)

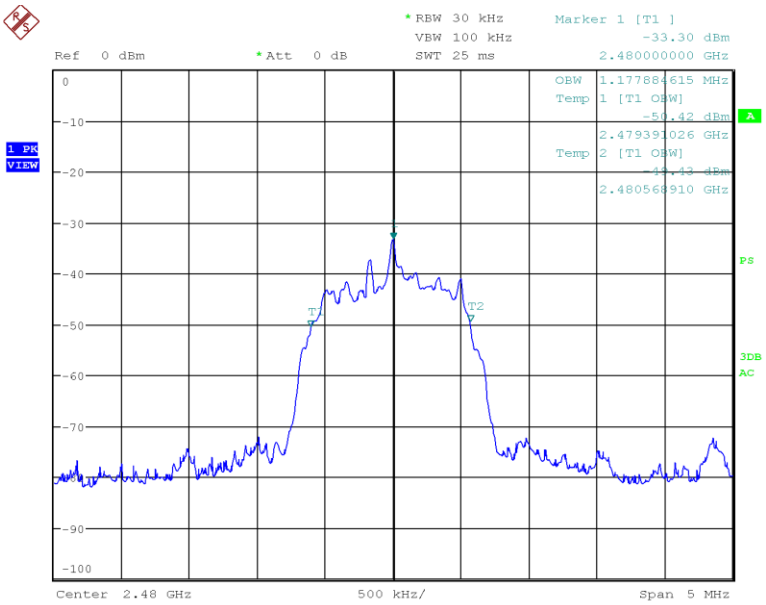


Figure 22: Chart of occupied bandwidth test on channel high (π/4-DQPSK, 2-DH1)

Channel	*99 % occupied bandwidth [kHz]*	*Result*
low	1177.885	Recorded
middle	1169.872	Recorded
high	1177.885	Recorded

Table 18: Results of occupied bandwidth test (π/4-DQPSK, 2-DH1)

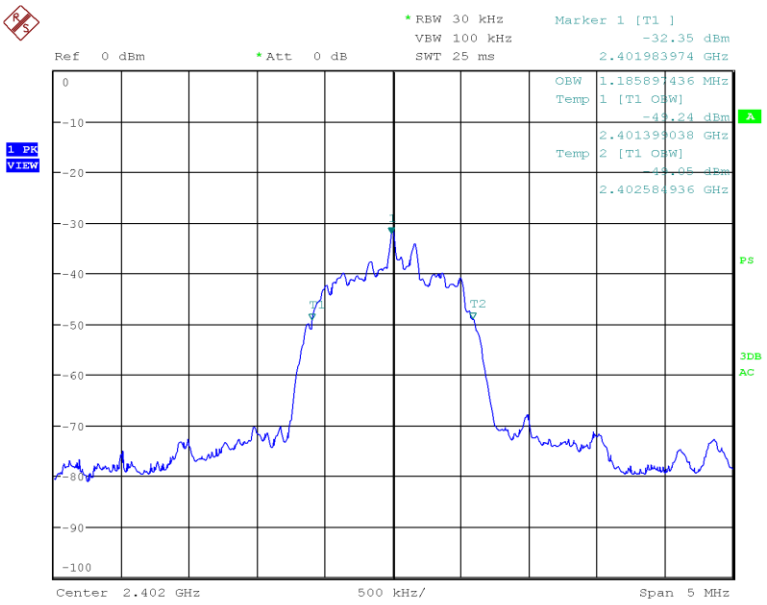


Figure 23: Chart of occupied bandwidth test on channel low (8-DPSK, 3-DH3)

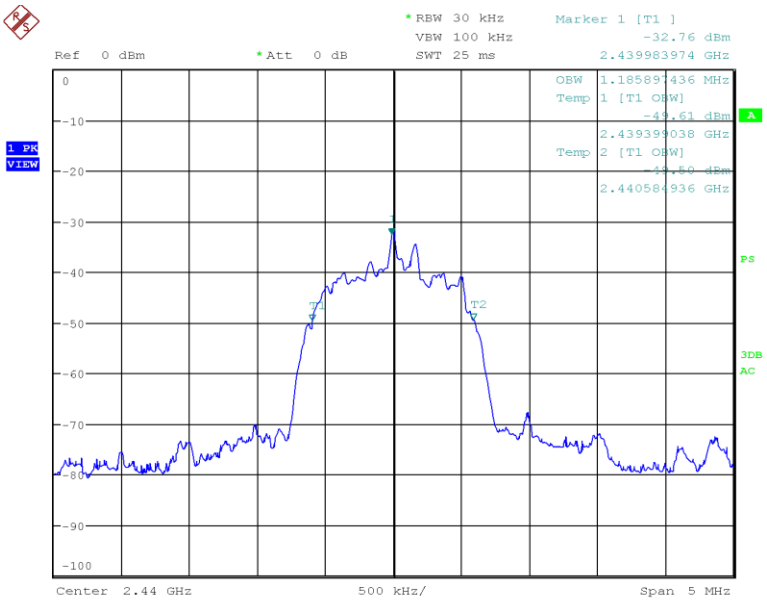


Figure 24: Chart of occupied bandwidth test on channel middle (8-DPSK, 3-DH3)

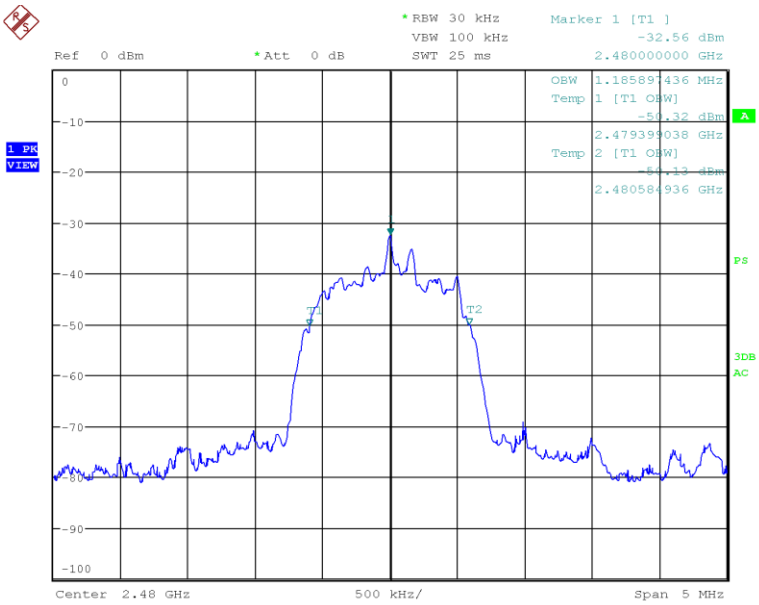


Figure 25: Chart of occupied bandwidth test on channel high (8-DPSK, 3-DH3)

Channel	*99 % occupied bandwidth [kHz]*	*Result*
low	1185.897	Recorded
middle	1185.897	Recorded
high	1185.897	Recorded

Table 19: Results of occupied bandwidth test (8-DPSK, 3-DH3)

6.4 Conducted output power

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(b)
	Reference(s):	ANSI C63.10, clause 7.8
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.4(b)
	Reference(s):	ANSI C63.10, clause 7.8

Result[9]: ☒ Test passed ☐ Test not passed

6.4.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[9] For information about measurement uncertainties see page 85.

6.4.2 Limits

As specified in section 15.247(b)(1) of 47 CFR Part 15, for frequency hopping systems employing at least 75 non-overlapping hopping channels the maximum peak conducted output power is 1 watt.
This limit is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

6.4.3 Test procedure

The maximum peak conducted output power is measured using the test procedure as described in clause 5.8 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.4.4 Testresults

Performed by:	Jennifer Ebner	Date(s) of test:	May 23, 2019

Note: Each packet type and size in the three modulation types are tested but only the worst case pro modulation type is shown in this test report.

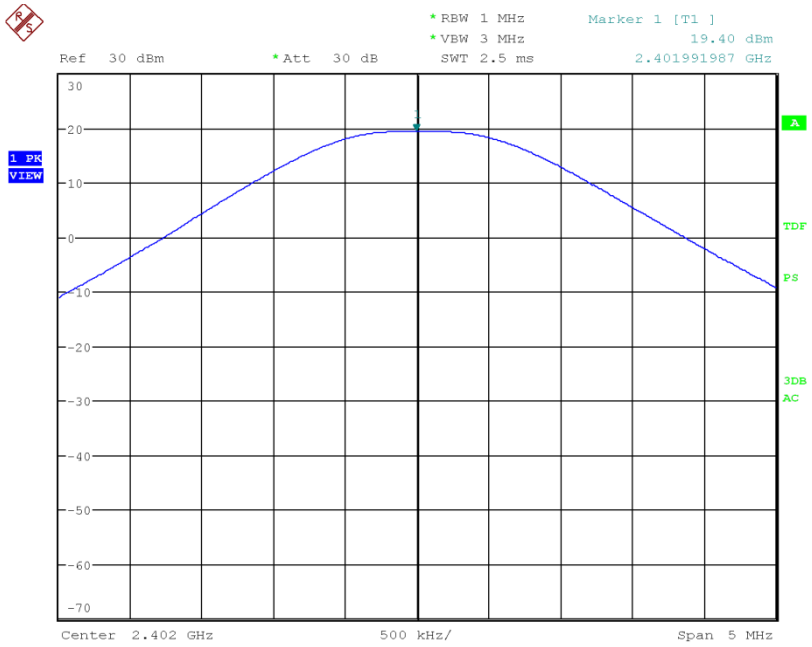


Figure 26: Chart of conducted output power on channel low (GFSK, DH1)

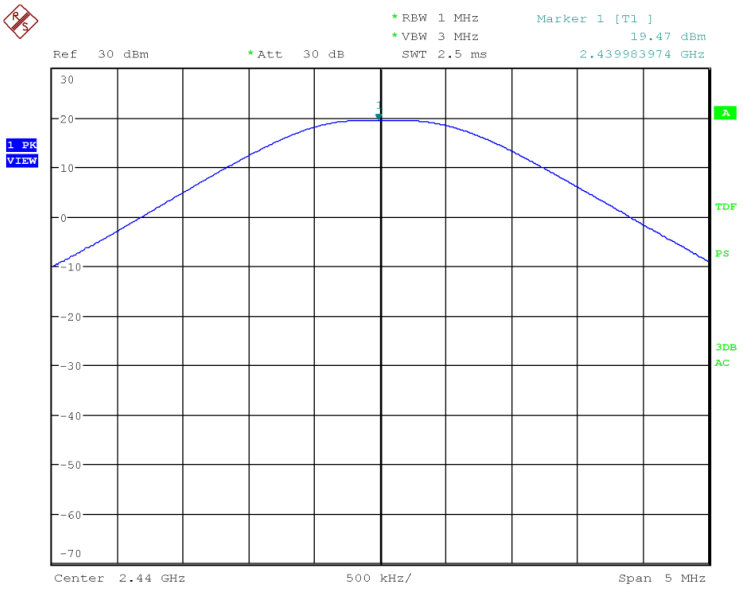


Figure 27: Chart of conducted output power on channel middle (GFSK, DH1)

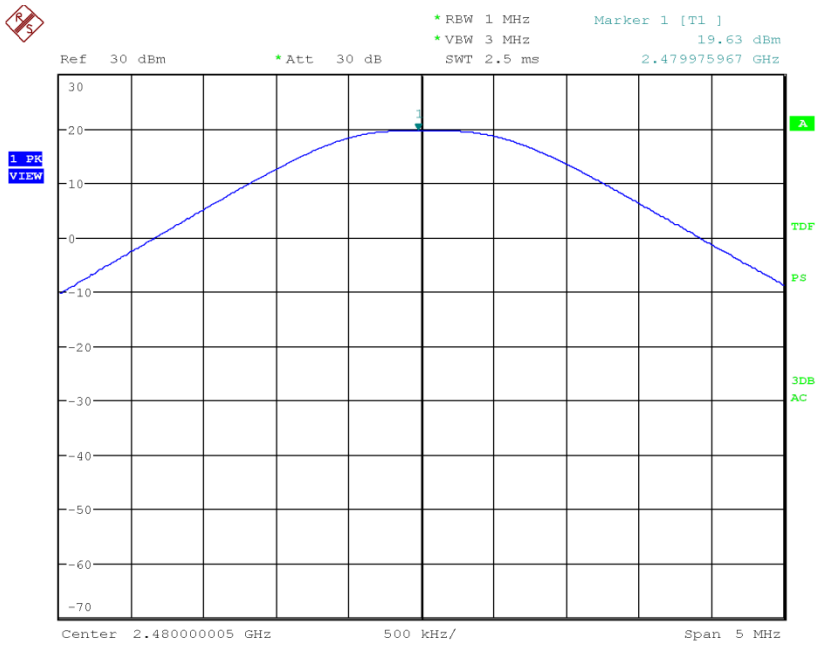


Figure 28: Chart of conducted output power on channel high (GFSK, DH1)

Channel	*Frequency [MHz]*	*Conducted output power [dBm]*	*Limit [dB]*[1]	*Margin*
low	2401.992	19.40	28.00	8.60 dB
middle	2439.984	19.47	28.00	8.53 dB
high	2479.976	19.63	28.00	8.37 dB

Table 20: Results of conducted output power (GFSK, DH1)

Note 1: The limit is the worst case limit for an antenna gain of 10 dBi. According to section c(2)(iv) and c(1)(i) the maximum conducted output power is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. So the limit is reduced by 2 dB.

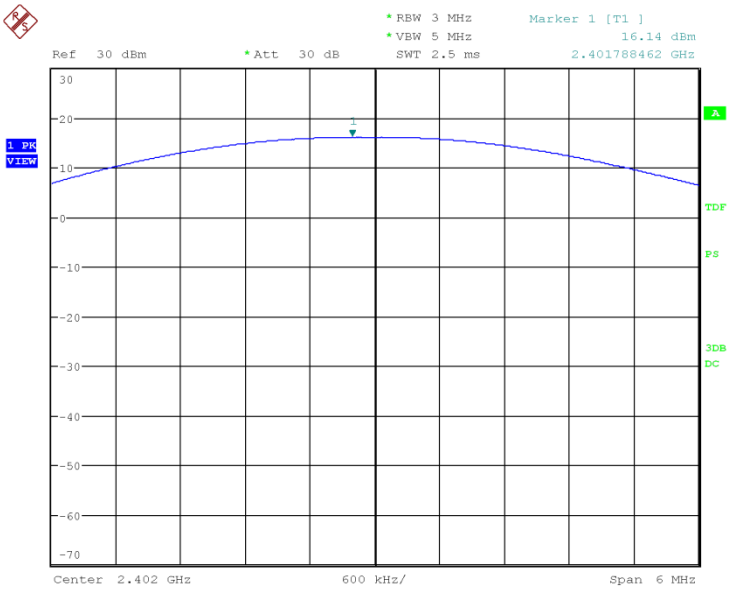


Figure 29: Chart of conducted output power on channel low (π/4-DQPSK, 2-DH1)

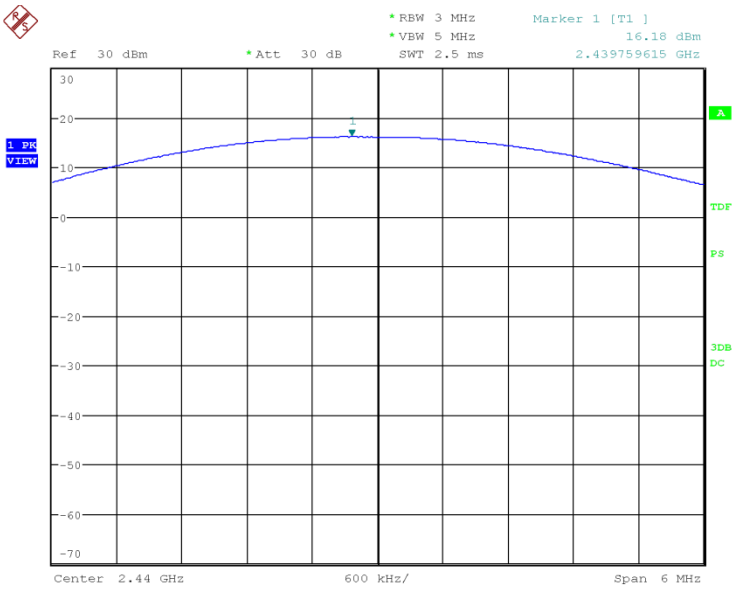


Figure 30: Chart of conducted output power on channel middle (π/4-DQPSK, 2-DH1)

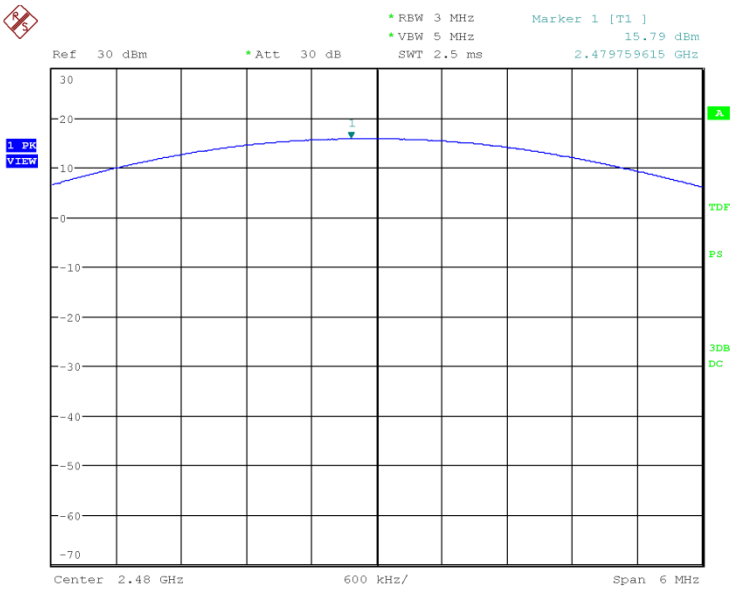


Figure 31: Chart of conducted output power on channel high (π/4-DQPSK, 2-DH1)

Channel	*Frequency [MHz]*	*Conducted output power [dBm]*	*Limit [dB]*[1]	*Margin*
low	2401.788	16.14	28.00	11.86 dB
middle	2439.760	16.18	28.00	11.82 dB
high	2479.780	15.79	28.00	12.21 dB

Table 21: Results of conducted output power (π/4-DQPSK, 2-DH1)

Note 1: The limit is the worst case limit for an antenna gain of 10 dBi. According to section c(2)(iv) and c(1)(i) the maximum conducted output power is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. So the limit is reduced by 2 dB.

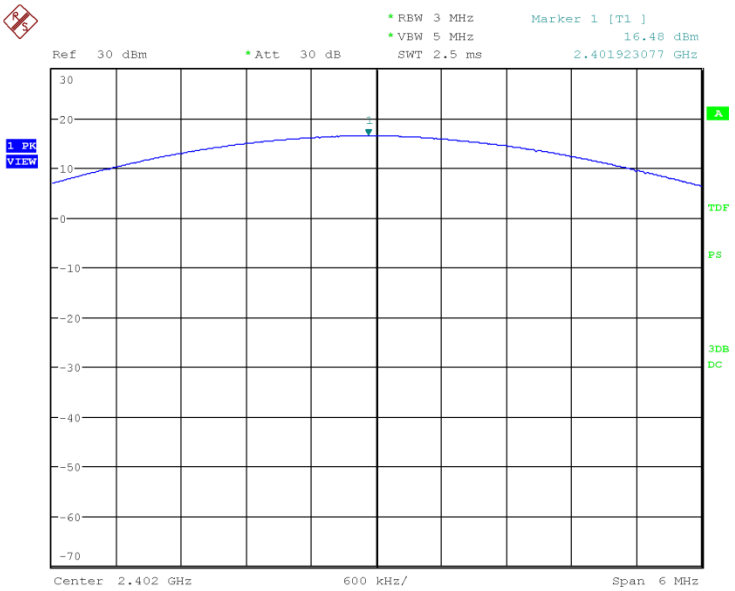


Figure 32: Chart of conducted output power on channel low (8-DPSK, 3-DH1)

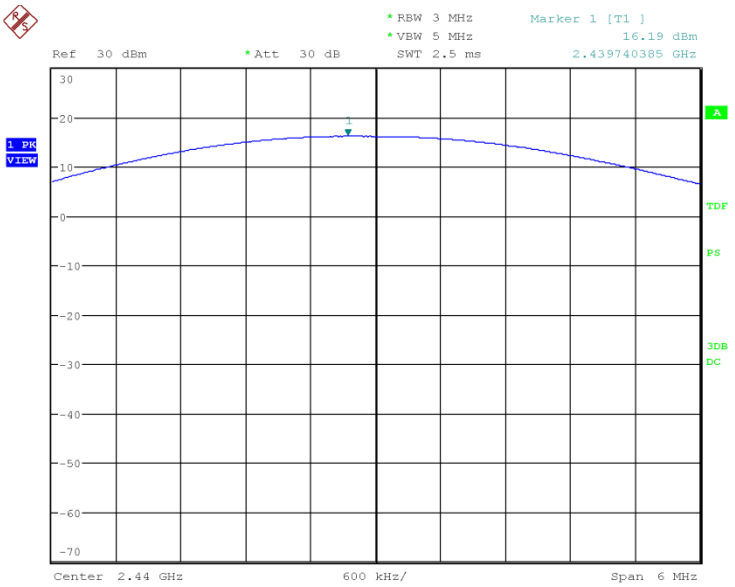


Figure 33: Chart of conducted output power on channel middle (8-DPSK, 3-DH1)

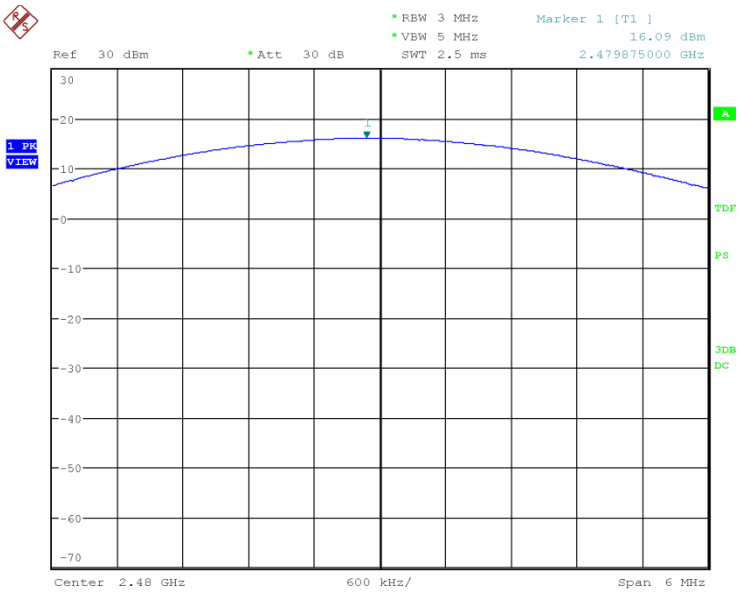


Figure 34: Chart of conducted output power on channel high (8-DPSK, 3-DH1)

Channel	*Frequency [MHz]*	*Conducted output power [dBm]*	*Limit [dB]*[1]	*Margin*
low	2401.923	16.48	28.00	11.52 dB
middle	2439.740	16.19	28.00	11.81 dB
high	2479.875	16.09	28.00	11.91 dB

Table 22: Results of conducted output power (8-DPSK, 3-DH1)

Note 1: The limit is the worst case limit for an antenna gain of 10 dBi. According to section c(2)(iv) and c(1)(i) the maximum conducted output power is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. So the limit is reduced by 2 dB.

6.5 Carrier frequency separation

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(a)
	Reference(s):	ANSI C63.10, clause 7.8
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.1(b)
	Reference(s):	ANSI C63.10, clause 7.8

Result[10]: ☒ Test passed ☐ Test not passed

6.5.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[10] For information about measurement uncertainties see page 85.

6.5.2 Limits

As specified in section 15.247(a) of 47 CFR Part 15, for frequency hopping systems the carrier frequency separation shall not be less than 25 KHz or 20 dB bandwidth of the hopping channel, whichever is greater. For frequency hopping systems operating in the 2400-2483.5 MHz band the carrier frequency separation shall be 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.

6.5.3 Test procedure

The carrier frequency separation is measured using the test procedure as described in clause 5.9 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.5.4 Testresults

Performed by:	Jennifer Ebner	Date(s) of test:	May 23, 2019

Note: The carrier frequency separation is tested on both module types and all three modulation types, but only the results of module 1 in 8-DPSK is shown in this test report.

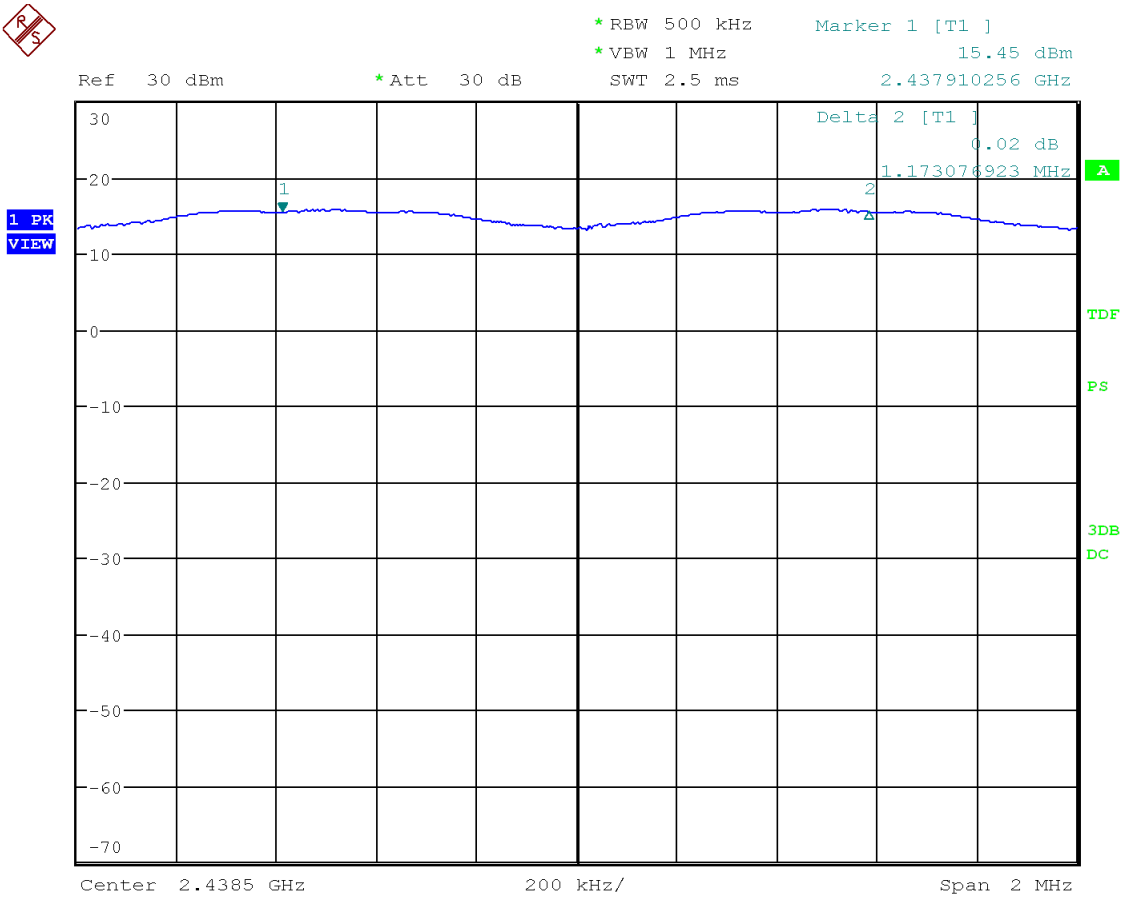


Figure 35: Chart of carrier frequency separation

Frequency left [MHz]	*Frequency right [MHz]*	*Carrier frequency separation [MHz]*	*Minimum level [MHz]*	*Result*
2437.910	2439.083	1.173	801.282	Passed

Table 23: Results of carrier frequency separation

6.6 Number of hopping frequencies

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(a)
	Reference(s):	ANSI C63.10, clause 7.8
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.1(d)
	Reference(s):	ANSI C63.10, clause 7.8

Result[11]: ☒ Test passed ☐ Test not passed

6.6.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[11] For information about measurement uncertainties see page 85.

6.6.2 Limits

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

6.6.3 Test procedure

The number of hopping frequencies is measured using the test procedure as described in clause 5.10 and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.6.4 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	May 23, 2019

Note: The number of hopping frequencies is tested on both modules but only the results of module 1 are shown in this test report.

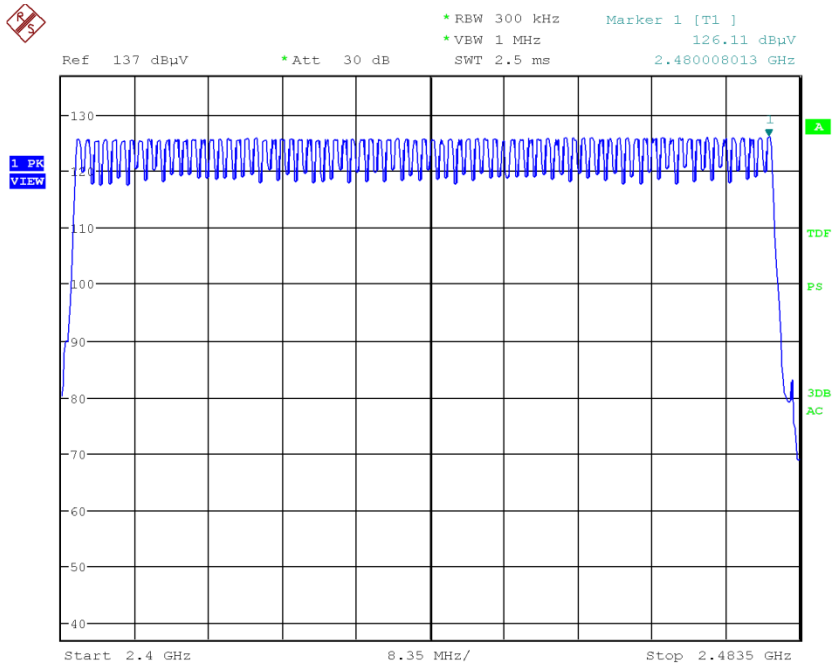


Figure 36: Chart of number of hopping frequencies – whole band

To identify the number of channels the whole band is separated in two bands.

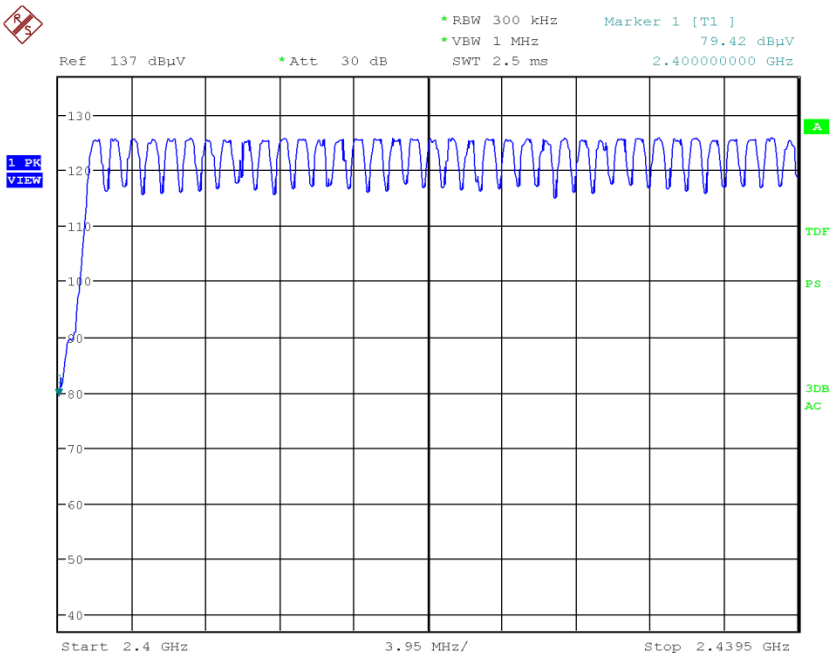


Figure 37: Chart of number of hopping frequencies – band 1

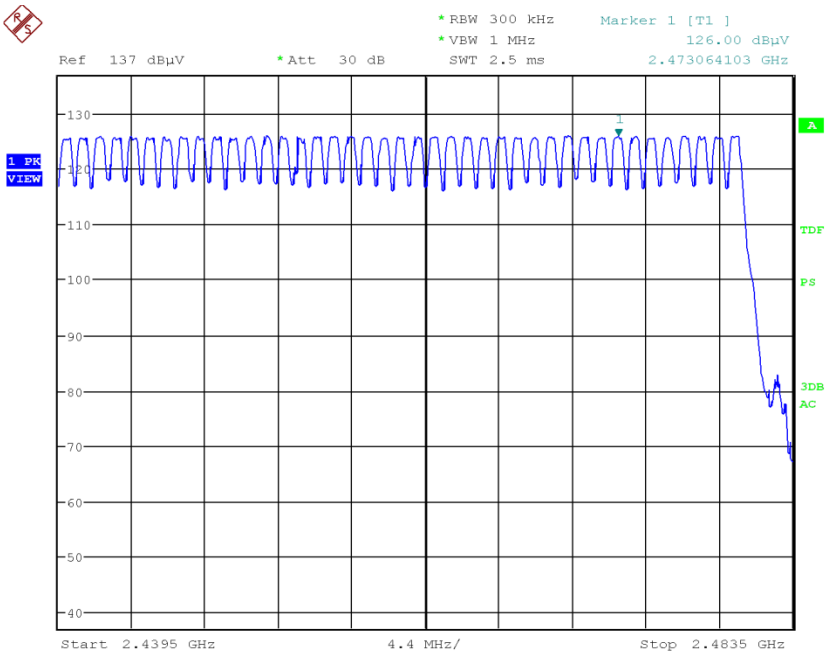


Figure 38: Chart of number of hopping frequencies – band 2

Number of frequencies
79

Table 24: Results of number of hopping frequencies

6.7 Time of occupancy (dwell time)

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(a)
	Reference(s):	ANSI C63.10, clause 7.8
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.1(d)
	Reference(s):	ANSI C63.10, clause 7.8

Result[12]: ☒ Test passed ☐ Test not passed

6.7.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[12] For information about measurement uncertainties see page 85.

6.7.2 Limits

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 channels employed.

6.7.3 Test procedure

The time of occupancy is measured using the test procedure as described in clause 5.11and referring to the

☒ test method for conducted measurements as described in clause 5.2.
☐ test method for radiated measurements as described in clause 5.6.

6.7.4 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	May 23, 2019

Note 1: The dwell time is tested on both modules but only the results of module 1 are shown in this test report.

Note 2: The dwell time is tested in all packet types and sizes pro modulation type but only the worst-case is shown in this test report.

As declared in §15.247(a)(iii) the observation period should 0.4 s multiplied by the number of hopping channels. So in this case the observation period is

$$t = 0.4s * 79 = 31.6s$$

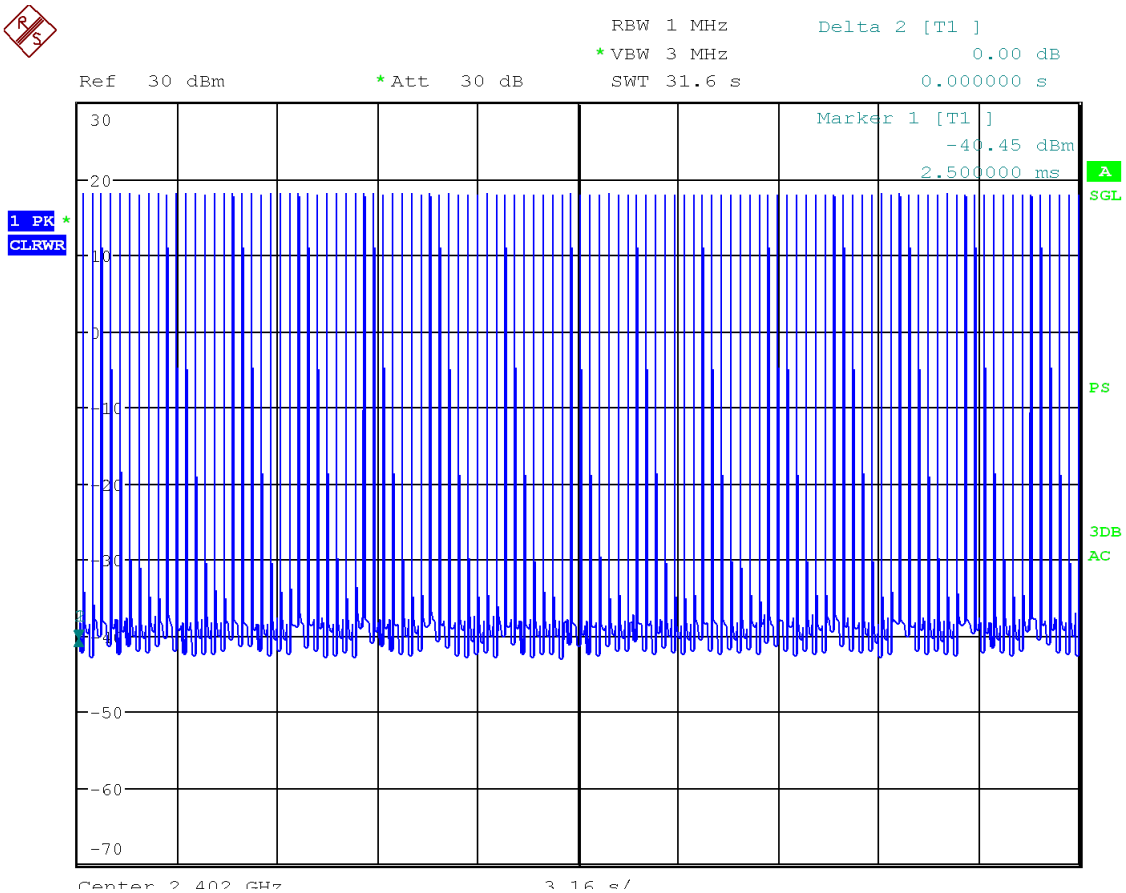


Figure 39: Chart of number of bursts in 31.6 s (GFSK, DH5)

To identify the number of bursts, the sweep time was reduced to 5 s.

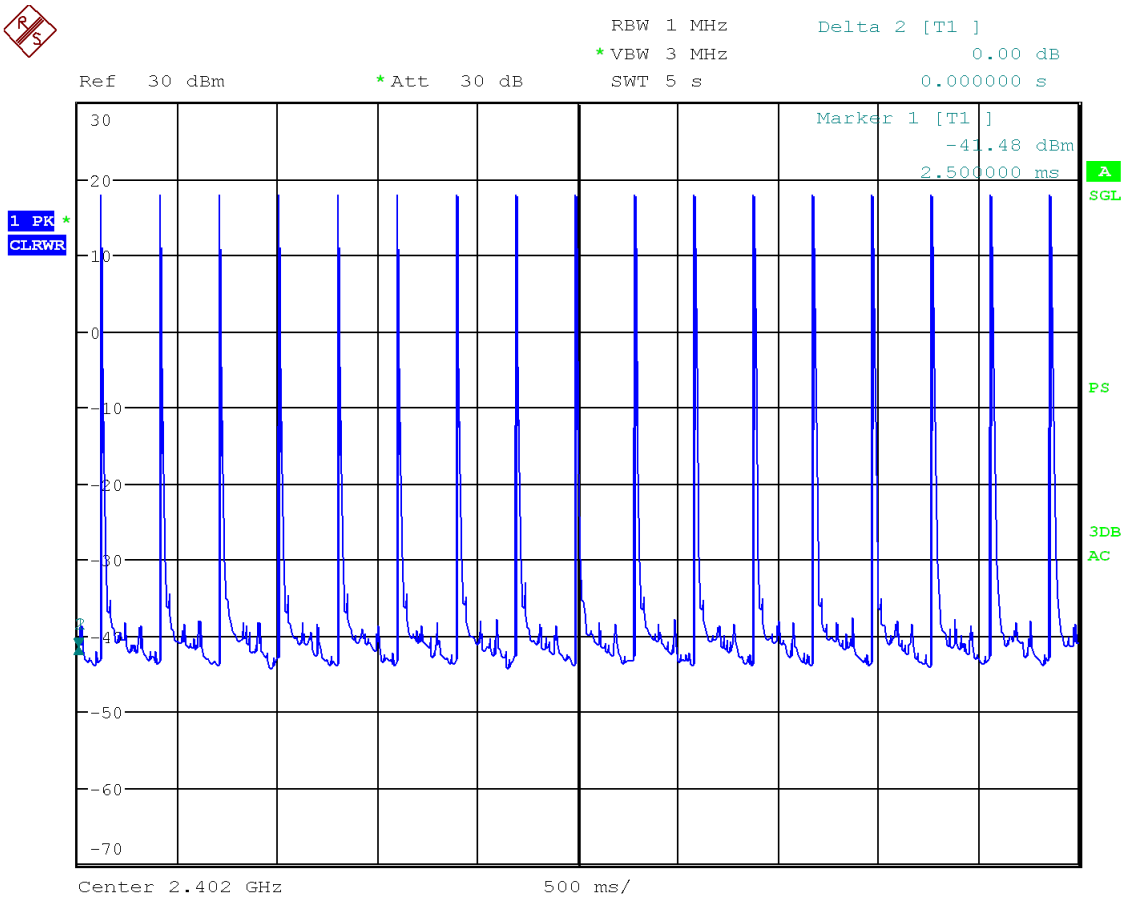


Figure 40: Chart of number of bursts in 5 s (GFSK, DH5)

Number of hops in 5 s: 17

Number of hops in 31.6 s: 107

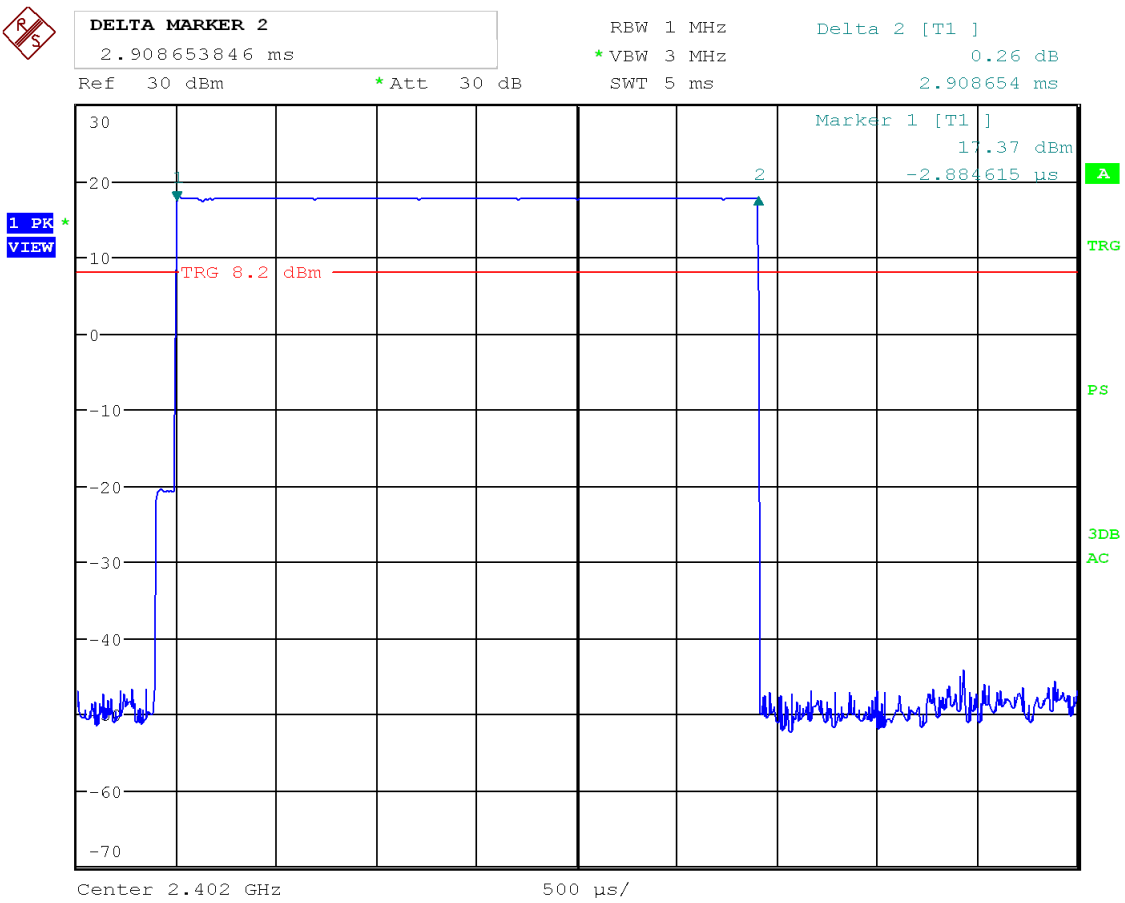


Figure 41: Chart of burst length in 5 ms (trigger offset -0.5 ms) (GFSK, DH5)

Number of hops in 31.6 s: 107

Burst length in 5 ms: 2.909 ms

Time of occupancy = (Number of hops) x (Burst length)

= 107 x 2.909 ms = 311.263 ms = 0.311 s

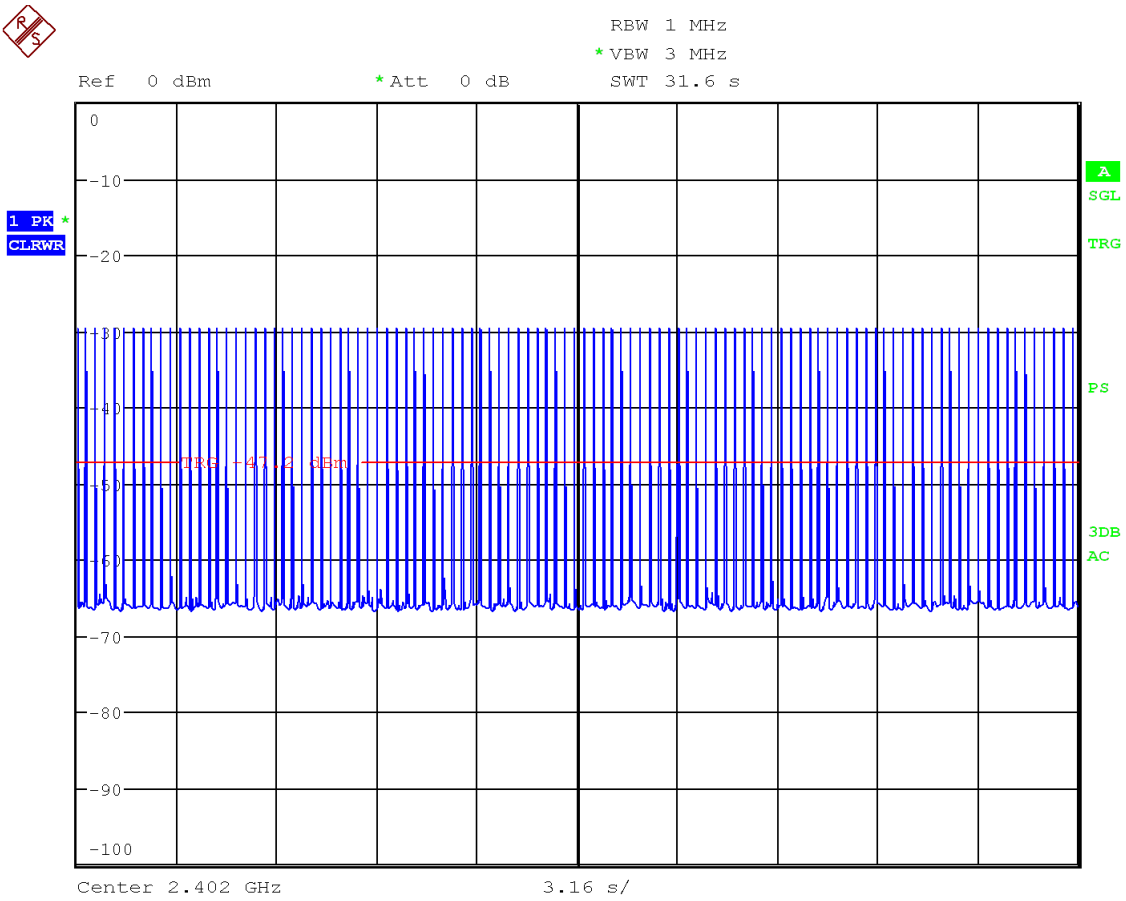


Figure 42: Chart of number of bursts in 31.6 s (π/4-DQPSK, 2-DH5)

To identify the number of bursts, the sweep time was reduced to 5 s.

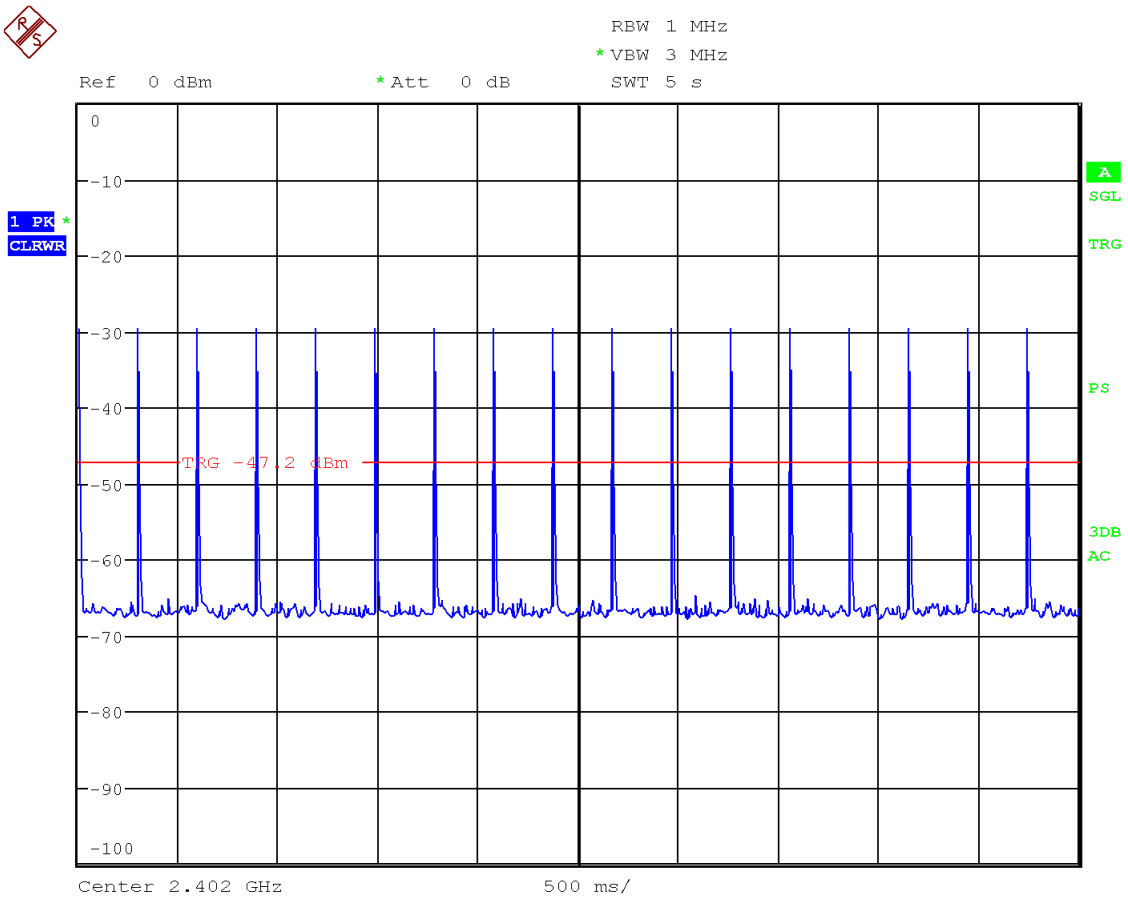


Figure 43: Chart of number of bursts in 5 s (π/4-DQPSK, 2-DH5)

Number of hops in 5 s:	17
Number of hops in 31.6 s:	107

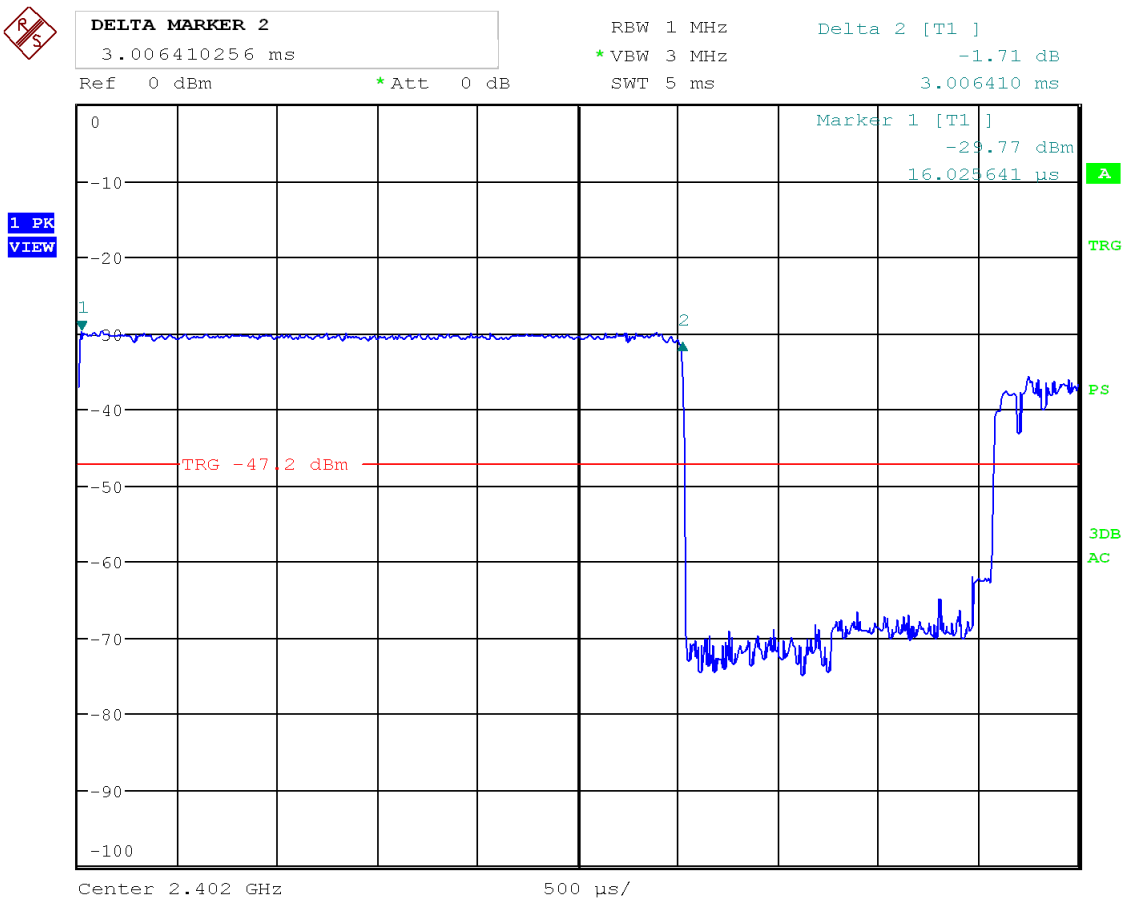


Figure 44: Chart of burst length in 5 ms (trigger offset -0.5 ms) (π/4-DQPSK, 2-DH5)

Number of hops in 31.6 s: 107

Burst length in 5 ms: 3.006 ms

Time of occupancy = (Number of hops) x (Burst length)

= 107 x 3.006 ms = 321.642 ms = 0.322 s

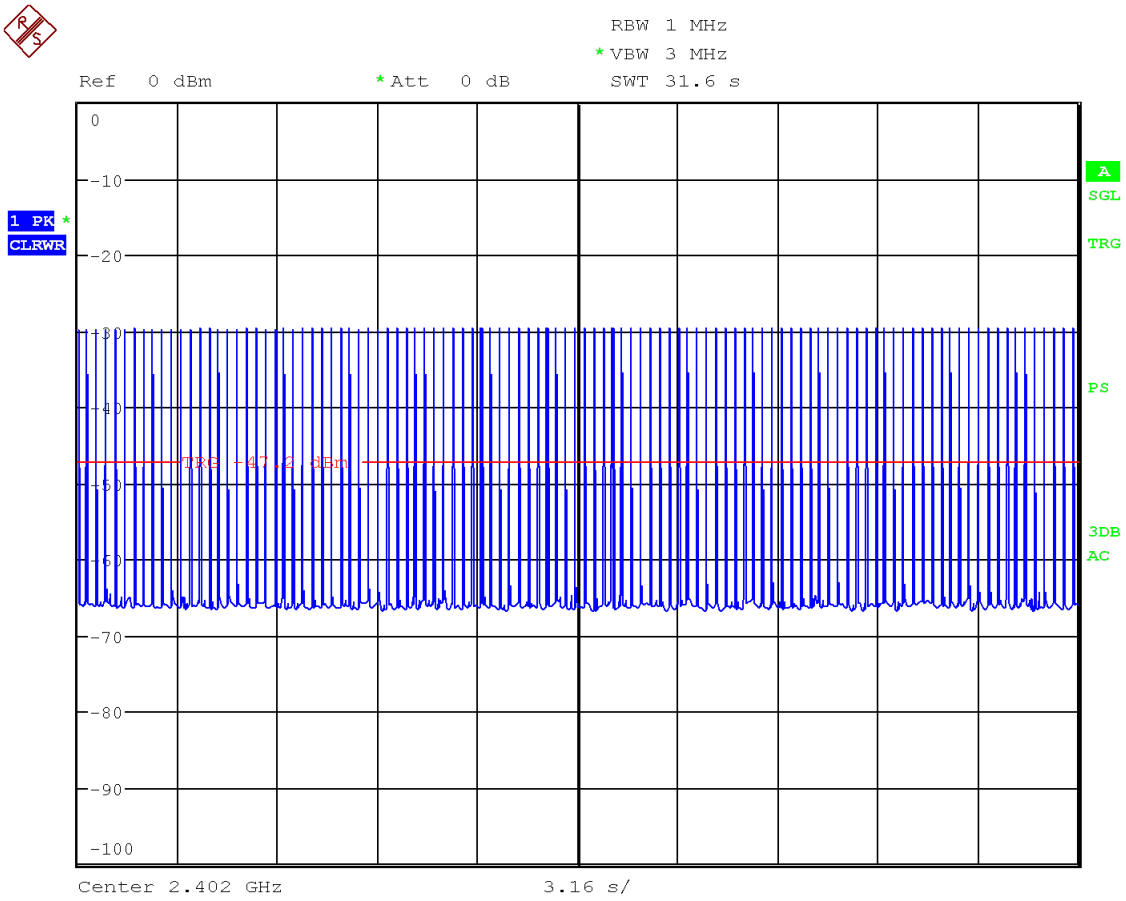


Figure 45: Chart of number of bursts in 31.6 s (8-DPSK, 3-DH5)

To identify the number of bursts, the sweep time was reduced to 5 s.

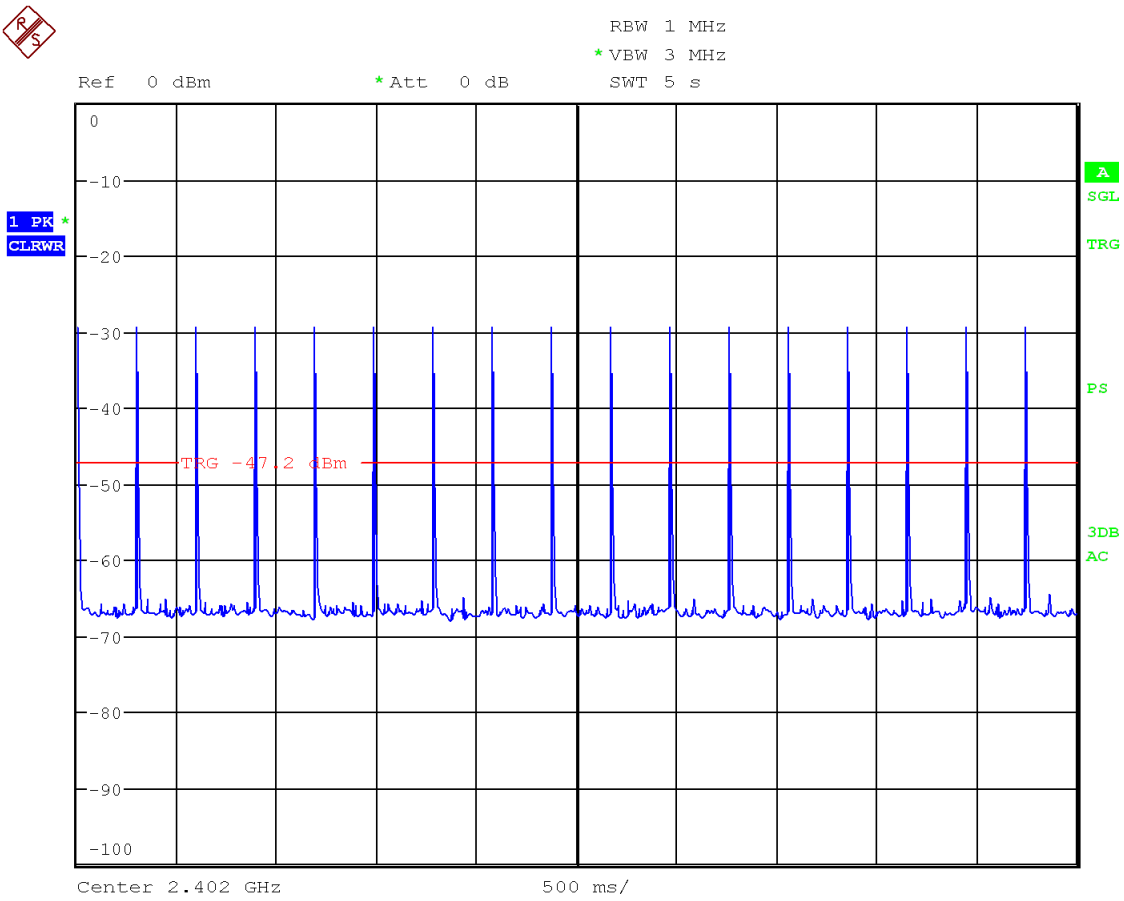


Figure 46: Chart of number of bursts in 5 s (8-DPSK, 3-DH5)

Number of hops in 5 s: 17

Number of hops in 31.6 s: 107

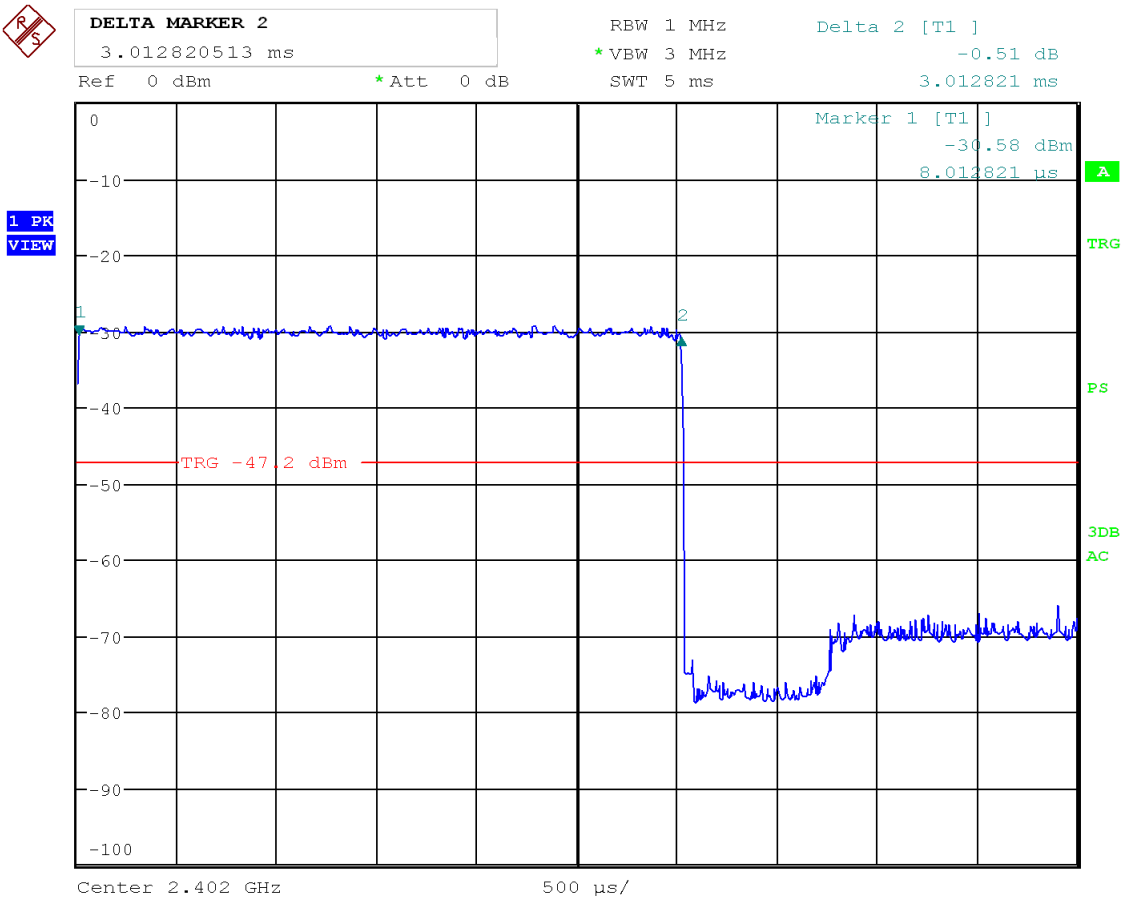


Figure 47: Chart of burst length in 5 ms (trigger offset -0.5 ms) (8-DPSK, 3-DH5)

Number of hops in 31.6 s: 107

Burst length in 5 ms: 3.013 ms

Time of occupancy = (Number of hops) x (Burst length)

= 107 x 3.013 ms = 322.391 ms = 0.322 s

6.8 Band-edge measurements

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(d)
	Reference(s):	ANSI C63.10, clause 6.10
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.5
	Reference(s):	ANSI C63.10, clause 6.10

Result[13]: ☒ Test passed ☐ Test not passed

6.8.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[13] For information about measurement uncertainties see page 85.

6.8.2 Limits

Only spurious emissions are permitted in any of the frequency bands listed below:

MHz	*MHz*	*MHz*	*GHz*
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	above 38.6
13.36-13.41			

Table 25: Restricted bands of operation according to §15.205

According to §15.247(d), in any 100 kHz bandwidth outside of 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. In addition, radiated emissions which fall in the restricted bands (see table 25) must also comply with the radiated emission limits specified in §15.209(a)

6.8.3 Test procedure

The band-edge measurements are performed using the

☒ test procedure for conducted measurements as described in clause 5.2.
☐ test procedure for radiated measurements as described in clause 5.6.

6.8.4 Testresults

Performed by:	Jennifer Riedel	Date(s) of test:	March 21, 2019

Note 1: The band-edge is tested on both modules but only the results of module 1 are shown in this test report.
Note 2: Each packet type and size in the three modulation types is tested but only the worst case of every modulation type is shown in this test report.

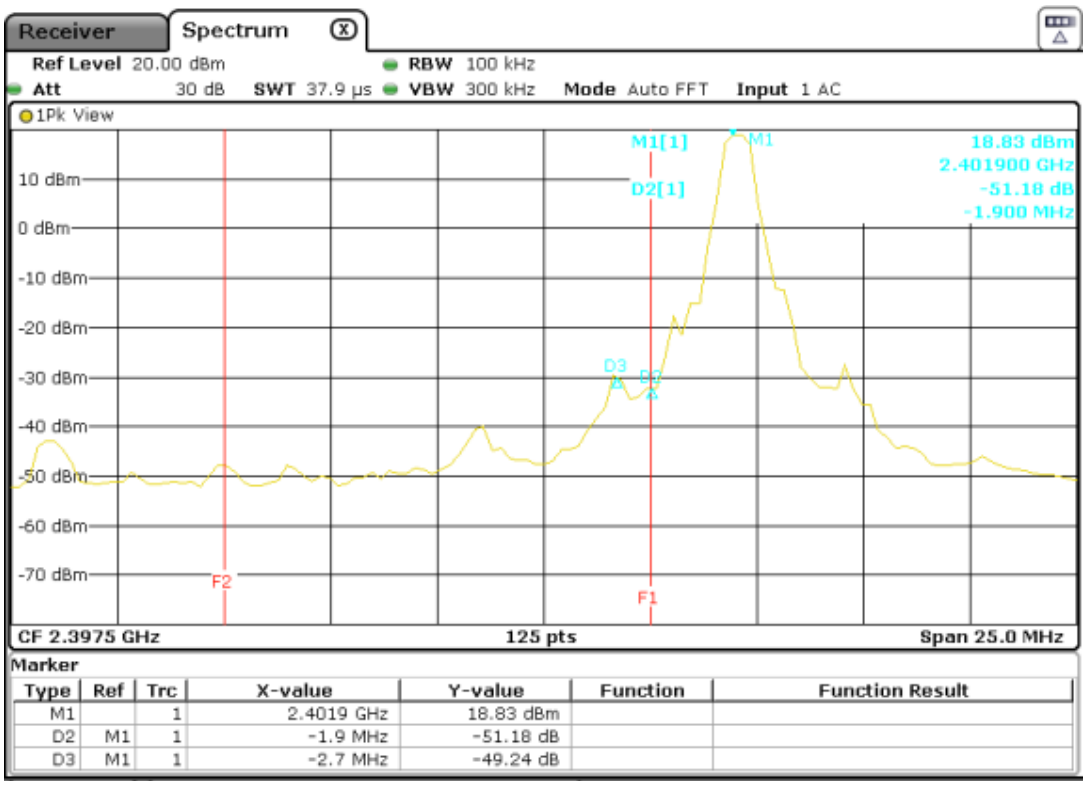


Figure 48: Chart of band-edge measurement on single channel low (GFSK, DH1)

Carrier frequency:	2401.90 MHz
Power of carrier frequency:	18.83 dBm
Band-edge:	2400 MHz
Power of band-edge:	-32.35 dBm
Frequency outside the operating band:	2399.20 MHz
Power of frequency:	-30.41 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier.

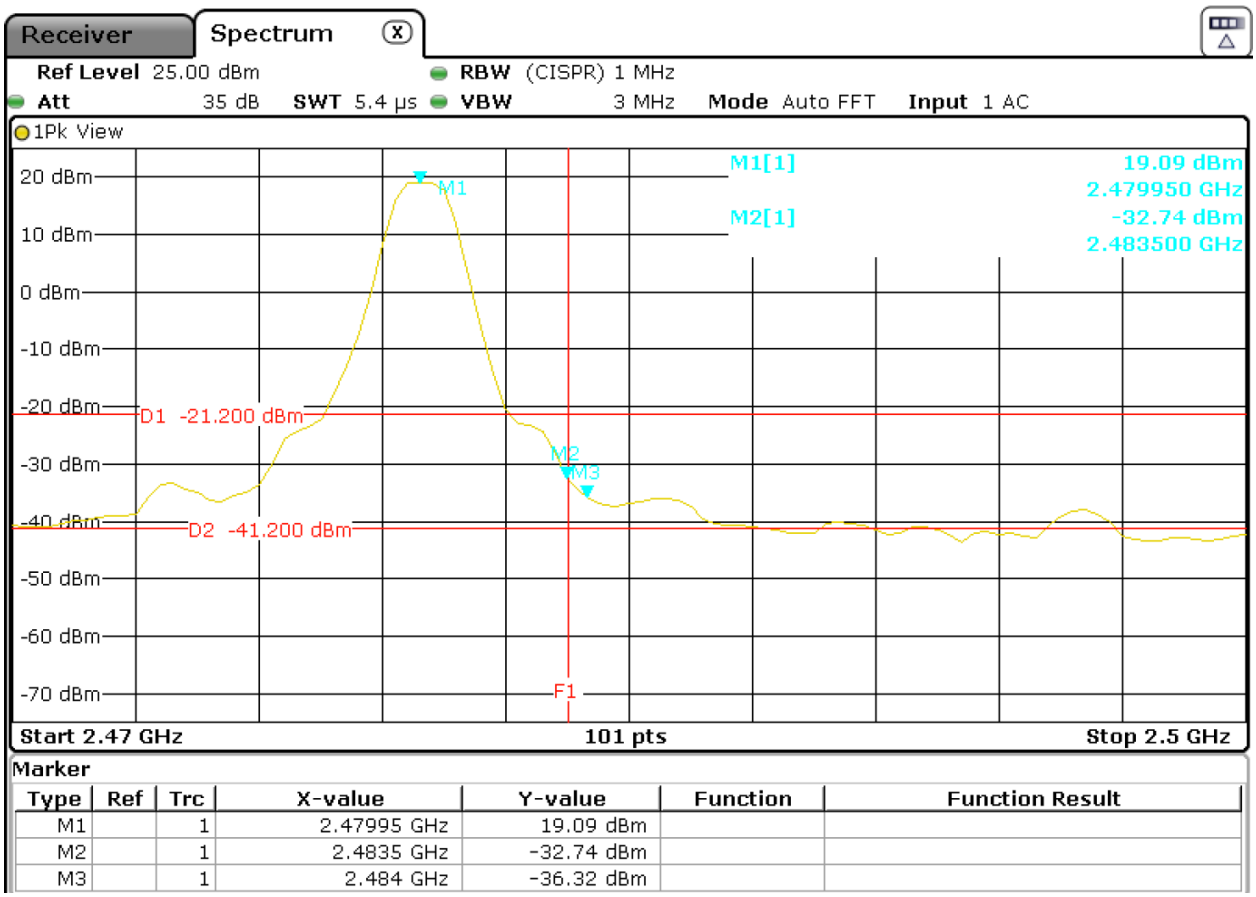


Figure 49: Chart of band-edge measurement on single channel high (GFSK, DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2479.950	19.09	---	---	---	---	
2483.500	-32.74	-31.20	-24.76	-57.50	-51.20	Passed

Table 26: Results of band-edge measurement on single channel high (GFSK, DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

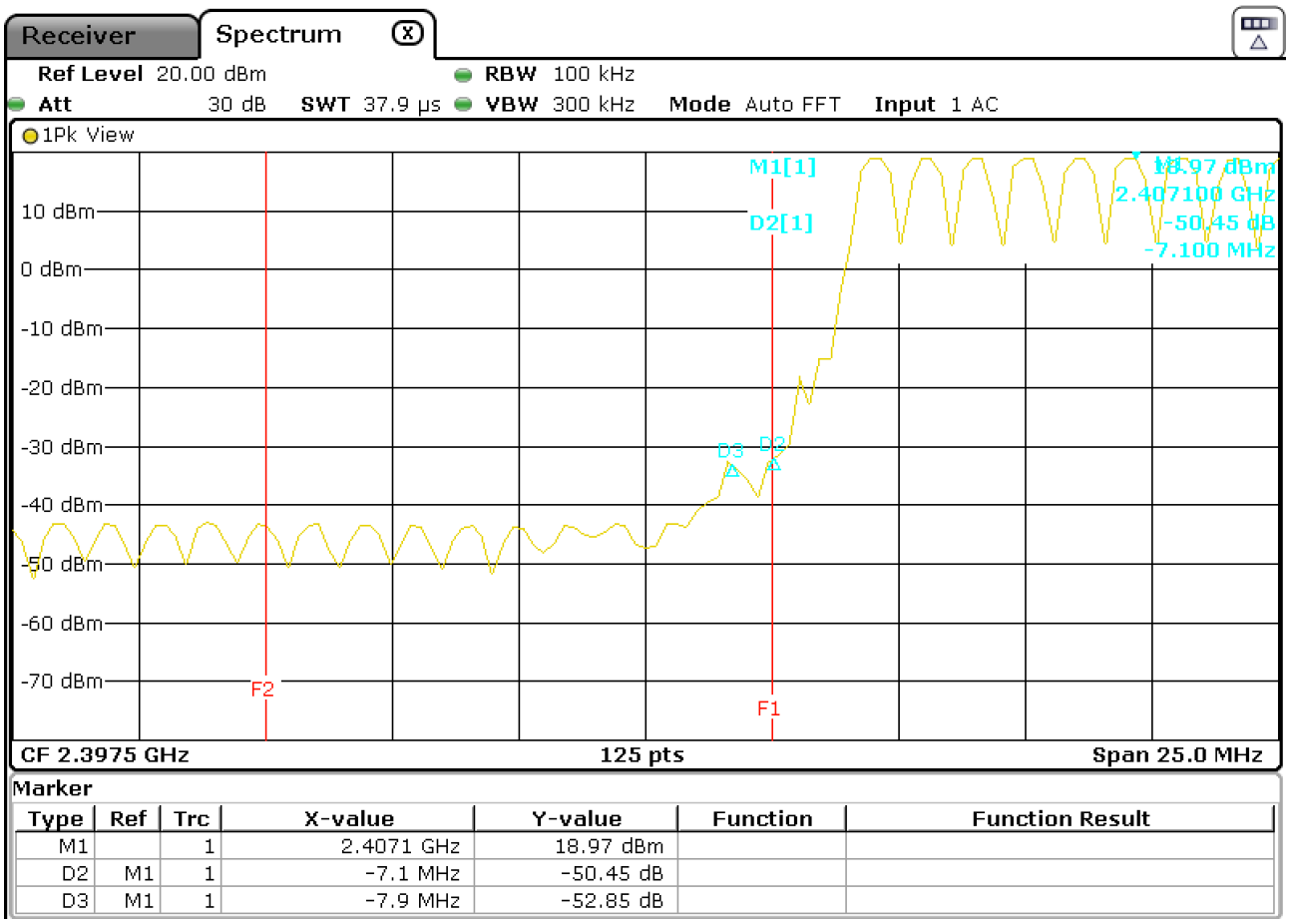


Figure 50: Chart of band-edge measurement in hopping mode in the lower band (GFSK, DH1)

Carrier frequency:	2407.10 MHz
Power of carrier frequency:	18.97 dBm
Band-edge:	2400 MHz
Power of band-edge:	-31.48 dBm
Frequency outside the operating band:	2399.20 MHz
Power of frequency outside the operating band:	-33.88 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier in hopping mode.

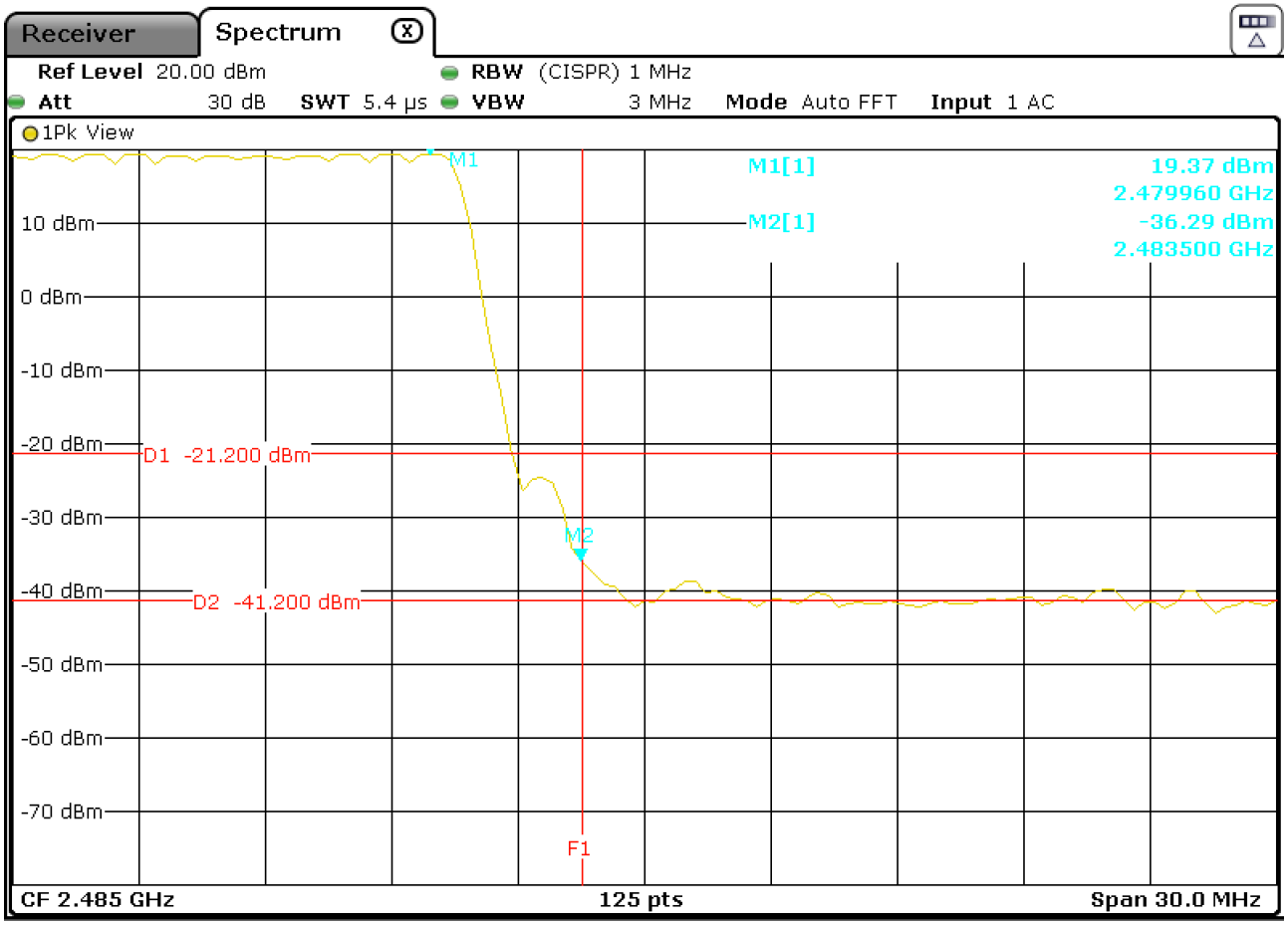


Figure 51: Chart of band-edge measurement in hopping mode in the higher band (GFSK, DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2479.960	19.37	---	---	---	---	
2483.500	-36.29	-31.20	-24.76	-55.96	-51.20	Passed

Table 27: Results of band-edge measurement in hopping mode (GFSK, DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

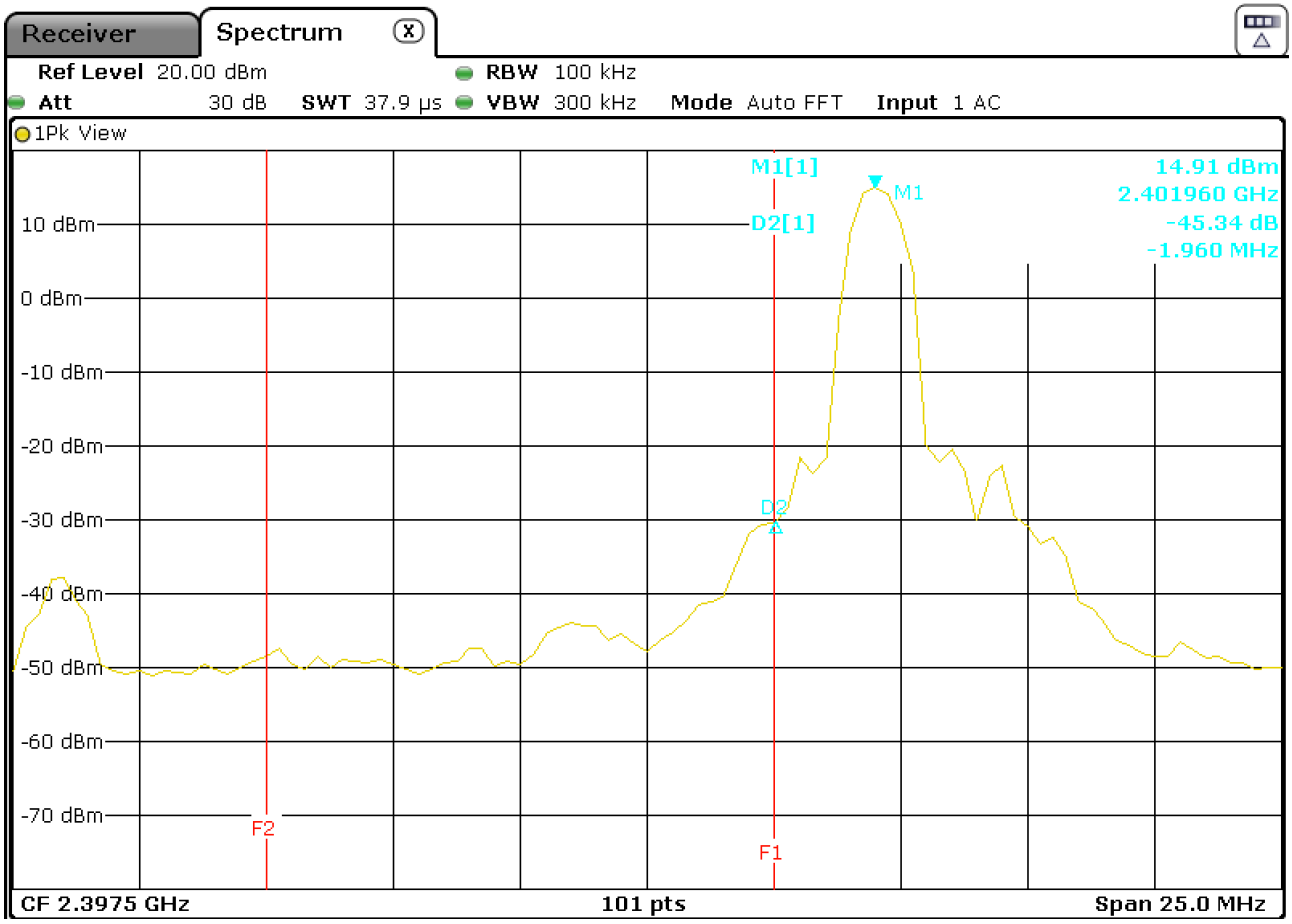


Figure 52: Chart of band-edge measurement on single channel low (π/4-DQPSK, 2-DH1)

Carrier frequency:	2401.96 MHz
Power of carrier frequency:	14.91 dBm
Band-edge:	2400 MHz
Power of band-edge:	-30.43 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier.

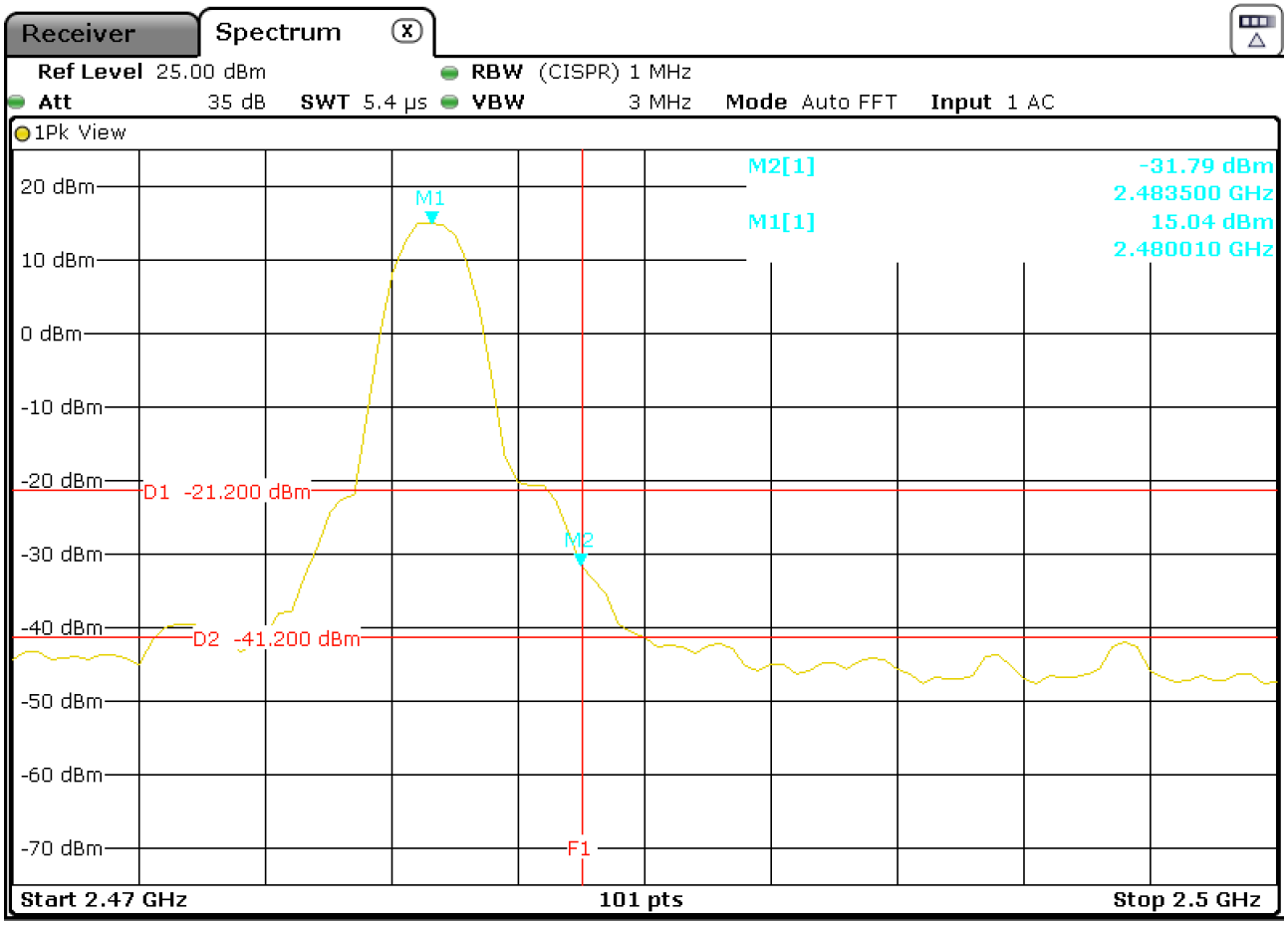


Figure 53: Chart of band-edge measurement on single channel high (π/4-DQPSK, 2-DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2480.010	15.04	---	---	---	---	
2483.500	-31.79	-31.20	-24.76	-56.55	-51.20	Passed

Table 28: Results of band-edge measurement on single channel high (π/4-DQPSK, 2-DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

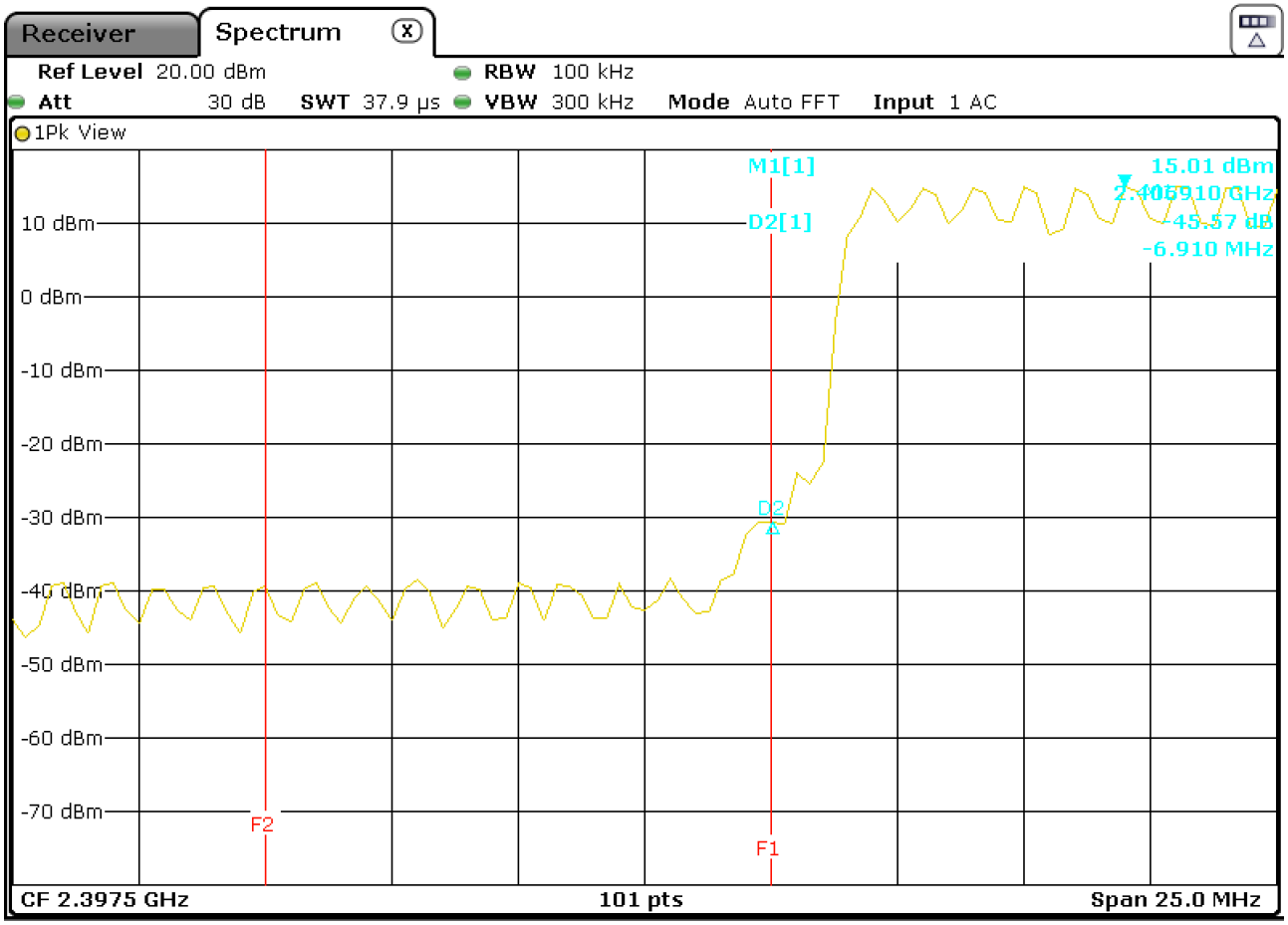


Figure 54: Chart of band-edge measurement in hopping mode in the lower band (π/4-DQPSK, 2-DH1)

Carrier frequency:	2406.91 MHz
Power of carrier frequency:	15.01 dBm
Band-edge:	2400 MHz
Power of band-edge:	-30.56 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier in hopping mode.

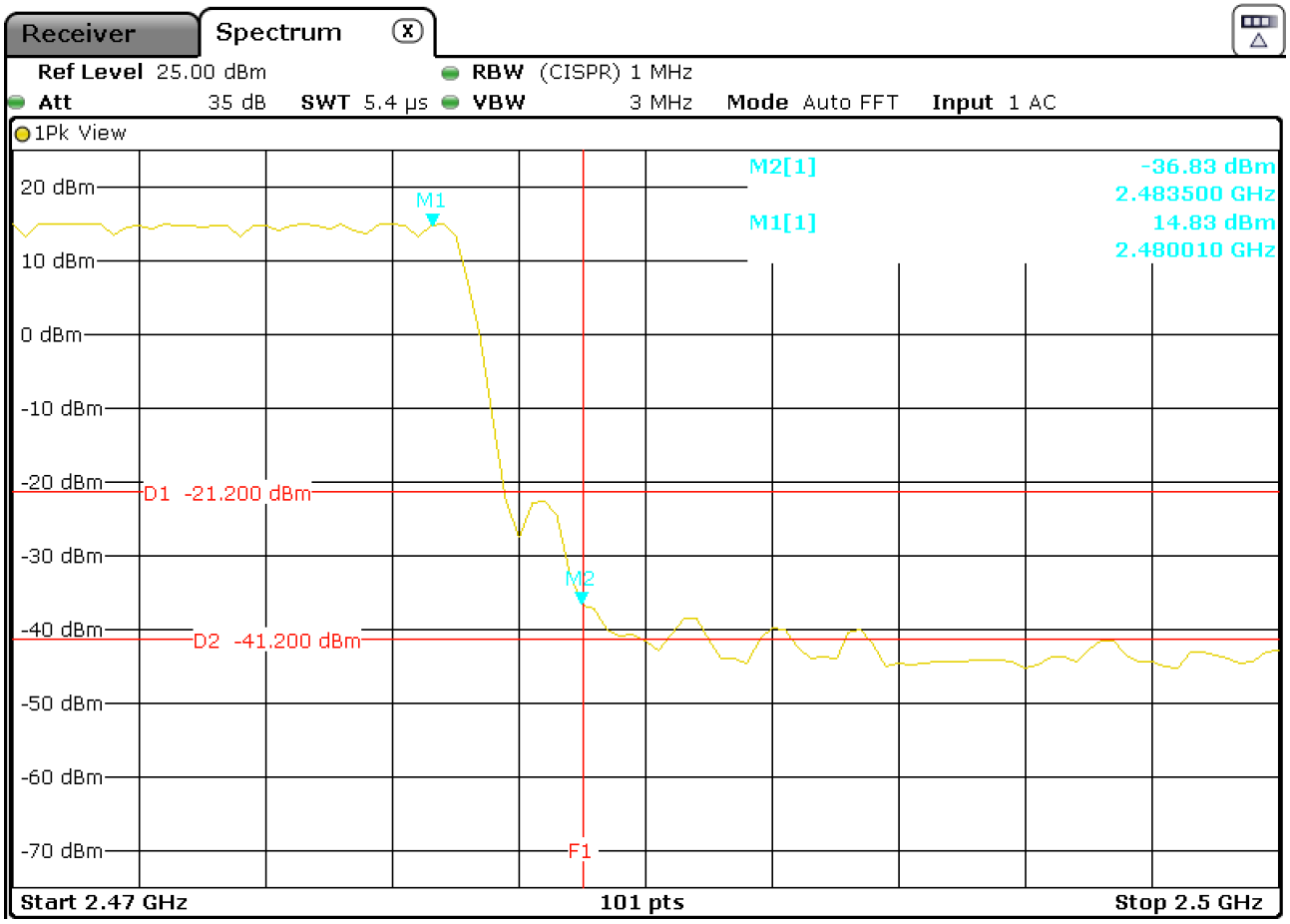


Figure 55: Chart of band-edge measurement in hopping mode in the higher band (π/4-DQPSK, 2-DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2480.010	14.83	---	---	---	---	
2483.500	-36.83	-31.20	-24.76	-61.59	-51.20	Passed

Table 29: Results of band-edge measurement in hopping mode (π/4-DQPSK, 2-DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

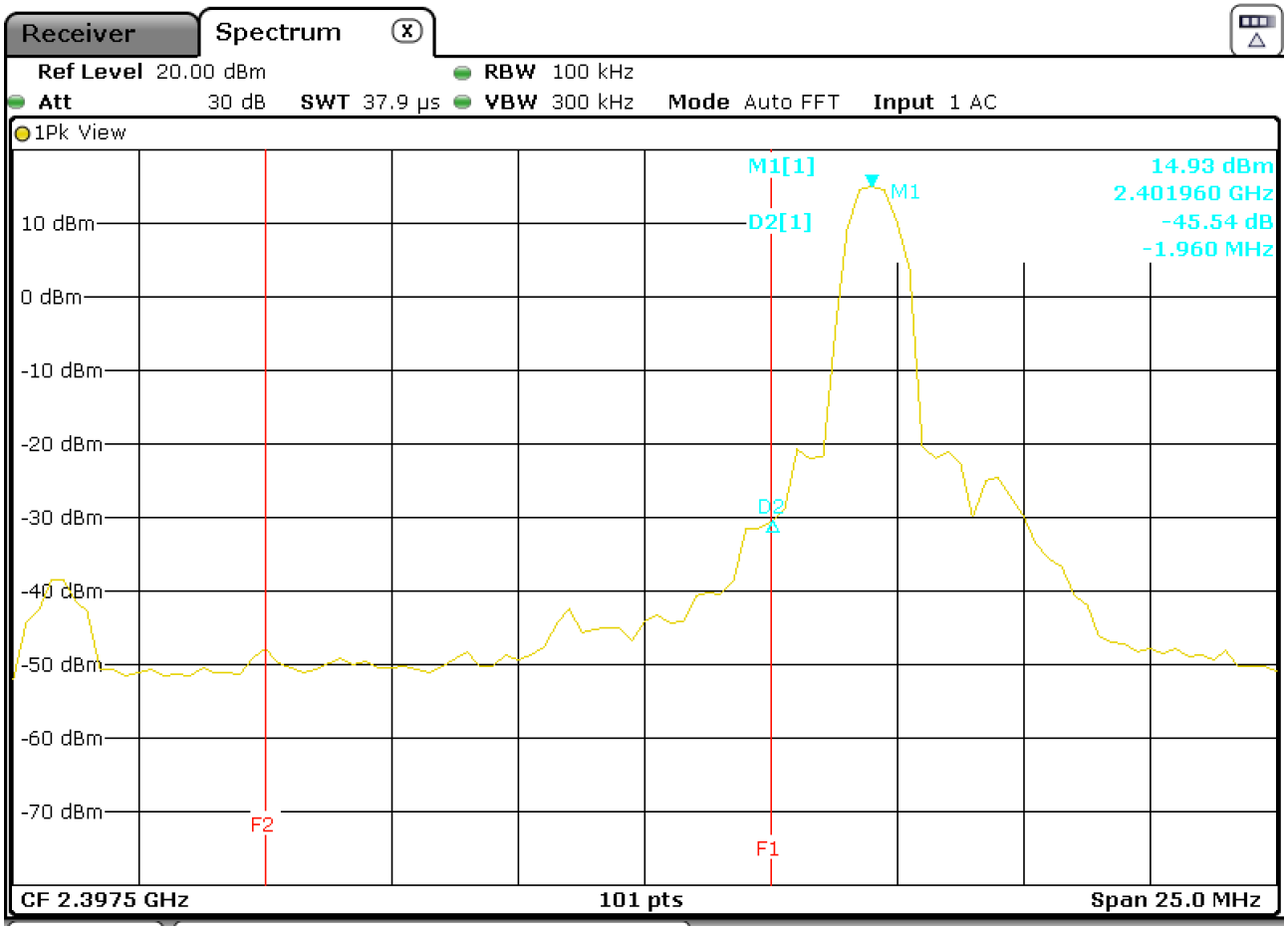


Figure 56: Chart of band-edge measurement on single channel low (8-DPSK, 3-DH1)

Carrier frequency:	2401.96 MHz
Power of carrier frequency:	14.93 dBm
Band-edge:	2400 MHz
Power of band-edge:	-30.61 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier.

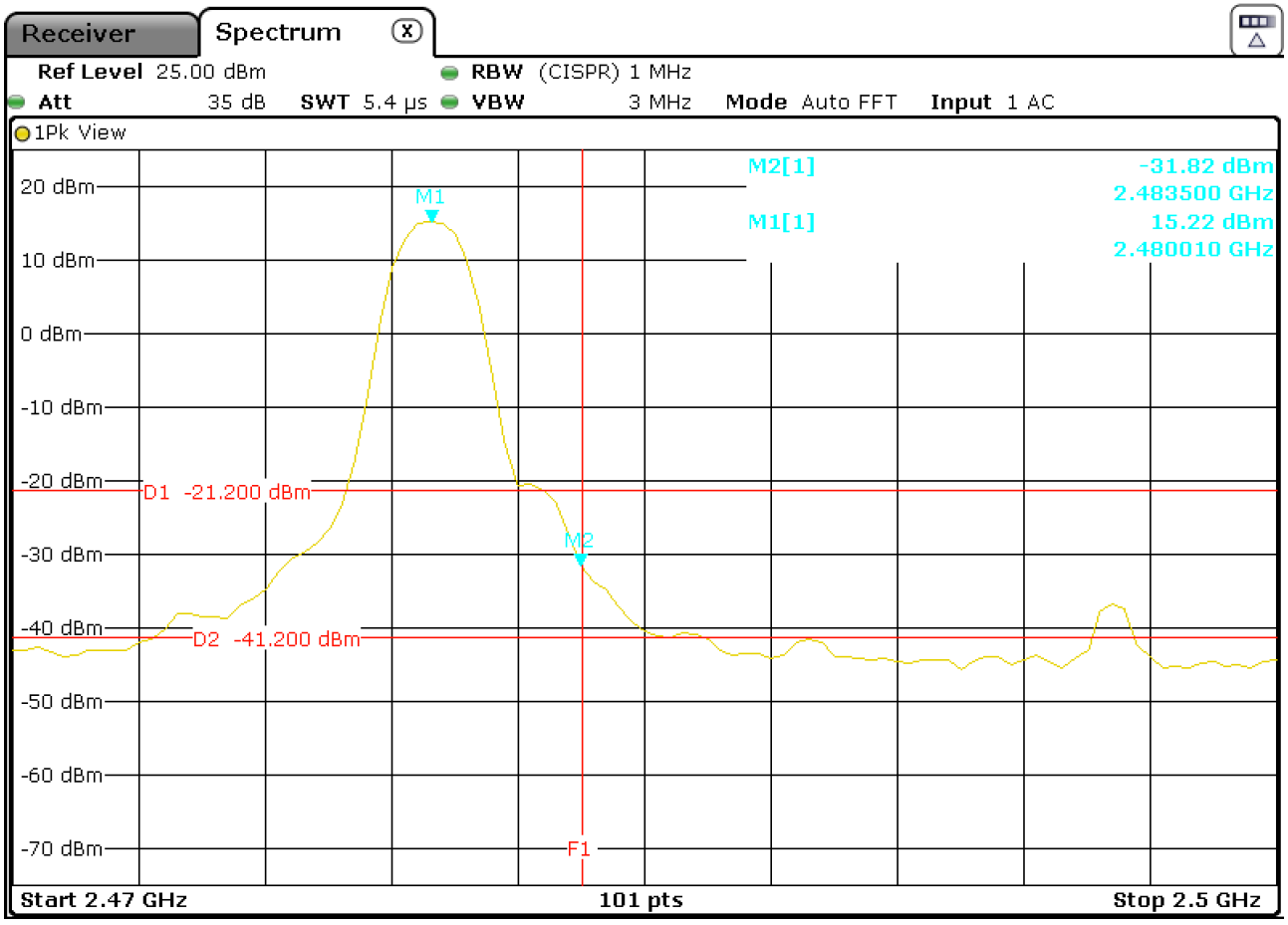


Figure 57: Chart of band-edge measurement on single channel high (8-DPSK, 3-DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2480.010	15.22	---	---	---	---	
2483.500	-31.82	-31.20	-24.76	-56.58	-51.20	Passed

Table 30: Results of band-edge measurement on single channel high (8-DPSK, 3-DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

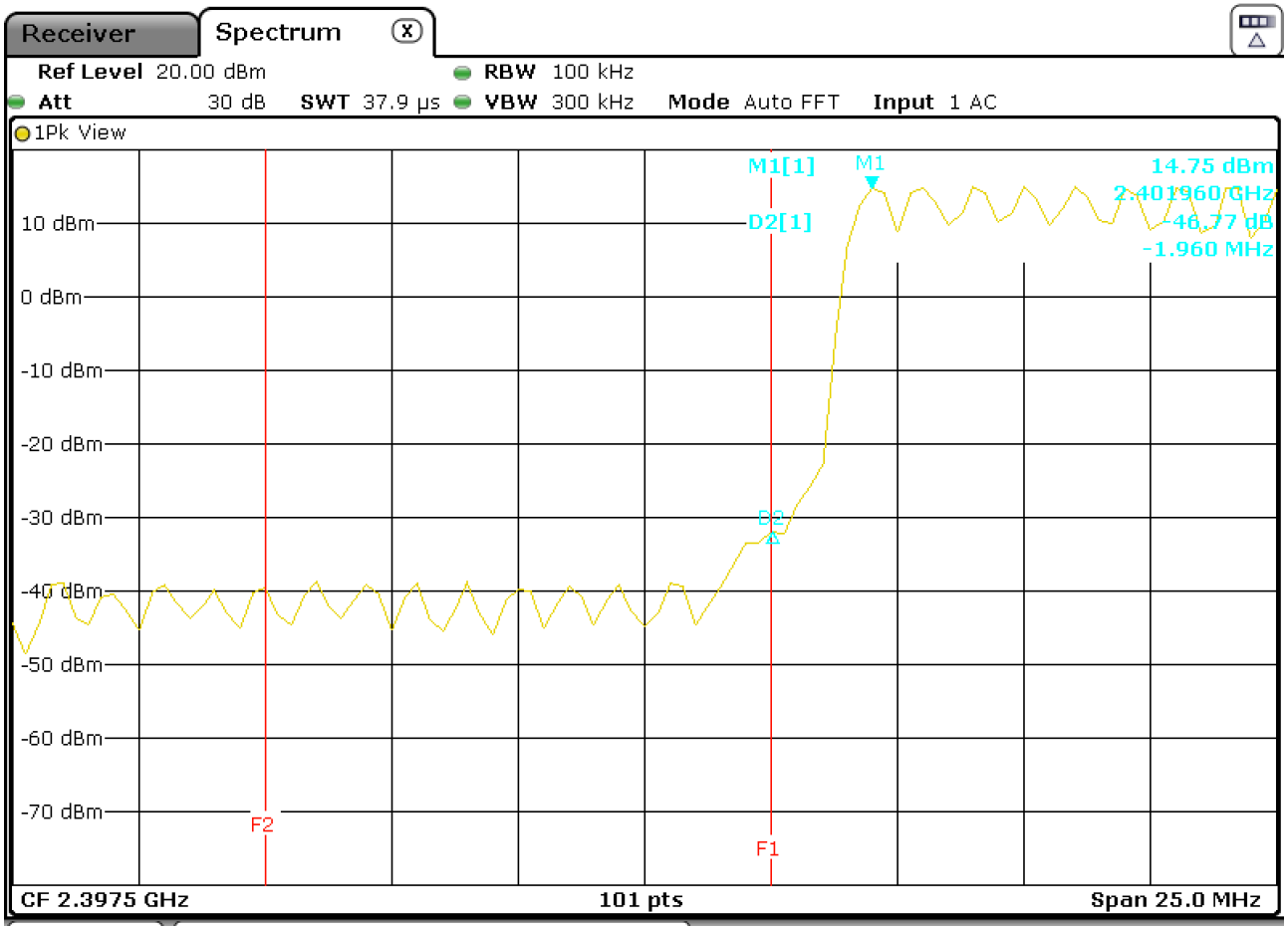


Figure 58: Chart of band-edge measurement in hopping mode in the lower band (8-DPSK, 3-DH1)

Carrier frequency:	2406.91 MHz
Power of carrier frequency:	14.75 dBm
Band-edge:	2400 MHz
Power of band-edge:	-32.02 dBm

The power of the band-edge and the emission outside the operating band are more than 20 dB lower than the power of the carrier in hopping mode.

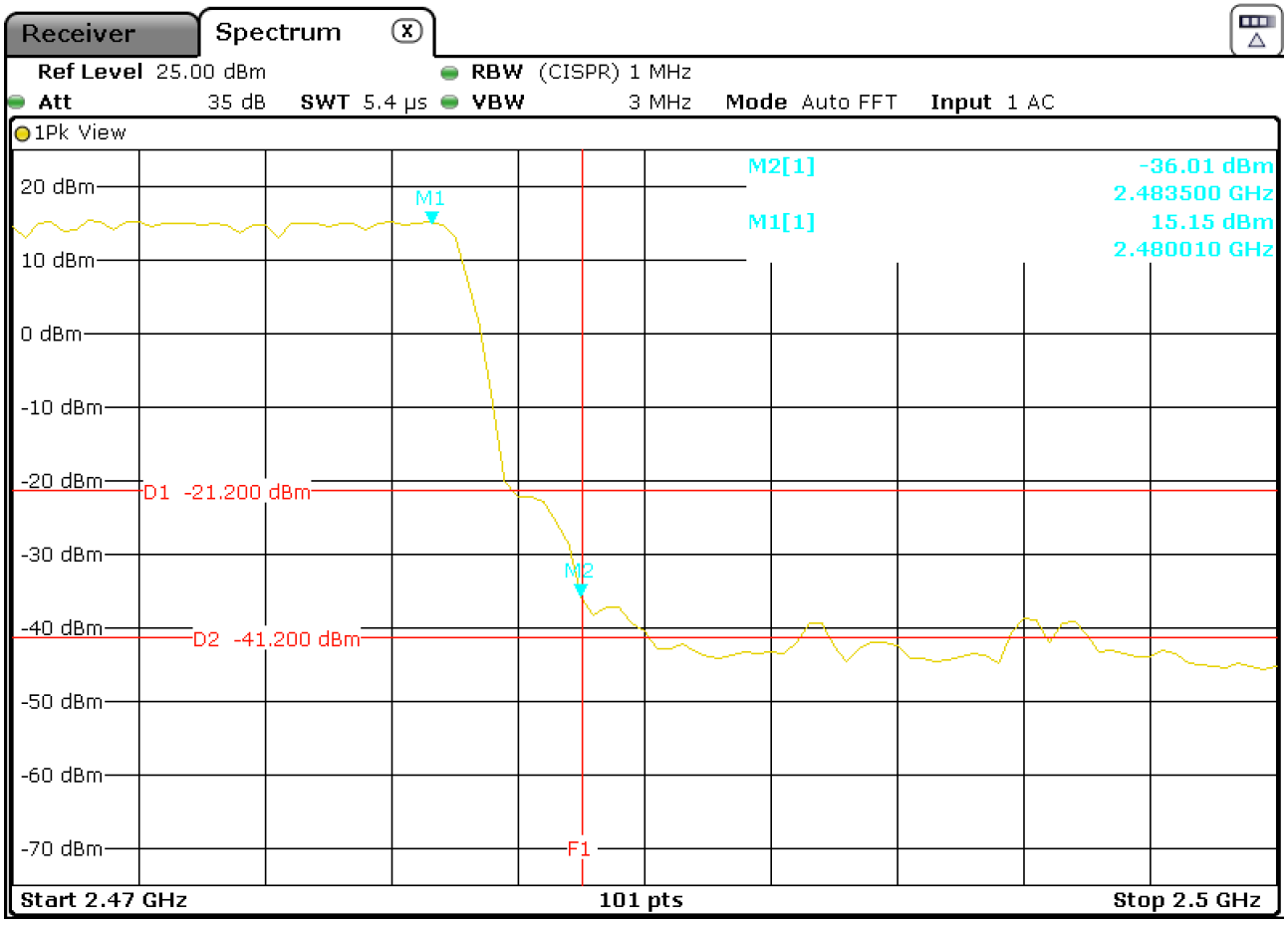


Figure 59: Chart of band-edge measurement in hopping mode in the higher band (8-DPSK, 3-DH1)

Frequency [MHz]	*Peak [dBm]*	*Limit PK [dBm]*[1]	*Correction factor [dB]*	*Average [dBm]*[2]	*Limit AV [dBm]*[1]	*Result*
2480.010	15.15	---	---	---	---	
2483.500	-36.01	-31.20	-24.76	-67.21	-51.20	Passed

Table 31: Results of band-edge measurement in hopping mode (8-DPSK, 3-DH1)

Note 1: The power limit lines in Figure 49 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

6.9 Emissions outside the operating frequency band(s) specified

6.9.1 Emissions below 30 MHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(d)
	Reference(s):	ANSI C63.10, clause 6.4
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.5 RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.4

Result[14]: ☒ Test passed ☐ Test not passed

6.9.1.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Compact Diagnostic Chamber (CDC)	VK041.0174	Albatross Projects	E00026
☐	Open area test site (OATS)	---	EMV **TESTHAUS**	E00354
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Field probe	RF-R 400-1	Langer EMV-Technik	E00270
☒	Loop antenna	HFH2-Z2	Rohde & Schwarz	E00060
☐	Cable set CDC	RF cable(s)	Huber + Suhner AME HF-Technik AME HF-Technik Stabo	E00446 E00920 E00921 E01215
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☒	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[14] For information about measurement uncertainties see page 85.

6.9.1.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of 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. In addition, radiated emissions which fall in the restricted bands (see table 25) must also comply with the radiated emission limits specified in §15.209(a). For the frequency range 9 kHz to 30 MHz, these limits are shown in table 32.

Frequency	*Field strength*		*Measurement distance*
[MHz]	*[µV/m]*	*[dBµV/m]*	*[m]*
0.009 – 0.490	2400/F(kHz) (266.67 – 4.90)	48.52 – 13.80	300
0.490 – 1.705	24000/F(kHz) (48.98 – 14.08)	33.80 – 22.97	30
1.705 – 30	30	29.54	30

Table 32: General radiated emission limits up to 30 MHz according to §15.209

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed in table 32 using the recalculation factor as described in clause 5.3.

6.9.1.3 Test procedure

The emissions below 30 MHz are measured using the

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.3.

6.9.1.4 Test results

Performed by:	Jennifer Riedel	Date(s) of test:	May 14, 2019
Test distance:	☒ 3 m	☐ 10 m	☐ ….. m
Antenna alignment:	☒ in parallel	☒ in line	☐ angle ….. °
EUT position[15]:	☒ Position X	☒ Position Y	☒ Position Z

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
9 kHz – 150 kHz	70.5 Hz	200 Hz	PK	PK,	2 s	1 s	Off
150 kHz – 30 MHz	7.462 kHz	9 kHz	PK	PK	2 s	1 s	Off

Note 1: Premeasurements have shown that there are no differences between the two types of modules, so only the worst case of module 1 is shown in this clause. There are also no differences between the three channels, so only channel low is shown in this clause.
Note 2: Each packet type and size in the three modulation types is tested but only the worst case of every modulation type is shown in this test report.

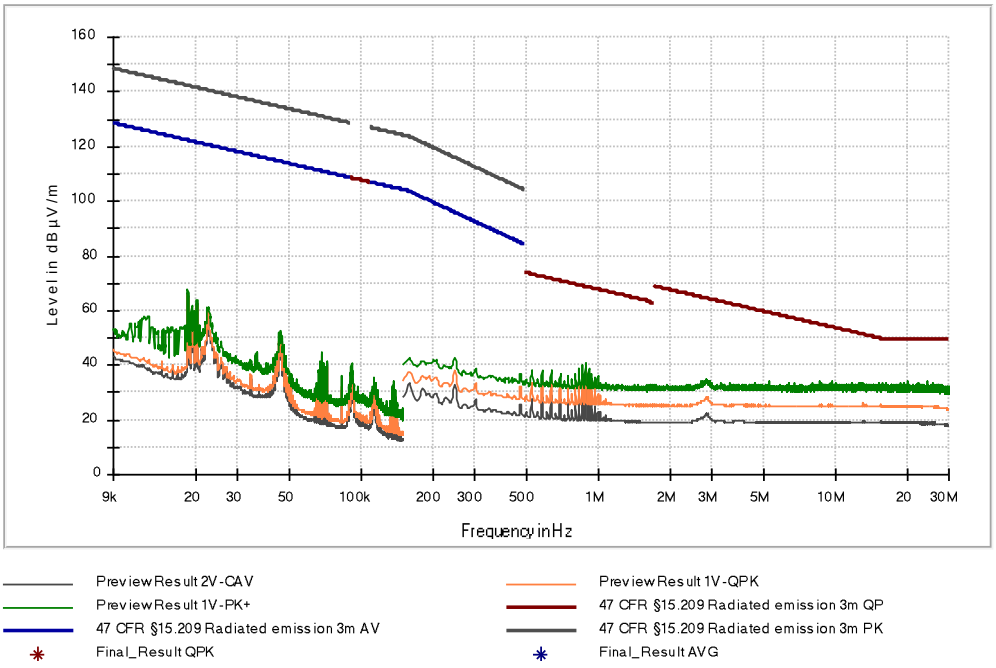


Figure 60: Chart of emissions test below 30 MHz on channel low (GFSK, DH1) in position Z with measurement antenna in line

Note: No assessable emissions were detected.

[15] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

6.9.2 Emissions from 30 MHz to 1 GHz

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(d)
	Reference(s):	ANSI C63.10, clause 6.5
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.5 RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.5

Result[16]: ☒ Test passed ☐ Test not passed

6.9.2.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☒	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☐	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☒	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☐	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☐	Preamplifier (1 GHz - 18 GHz)	ALS05749	Aldetec	W01007
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☒	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☐	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☐	Horn antenna	BBHA 9170	Schwarzbeck	W00054
☒	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☐	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☒	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[16] For information about measurement uncertainties see page 85.

6.9.2.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of 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. In addition, radiated emissions which fall in the restricted bands (see table 25) must also comply with the radiated emission limits specified in §15.209(a). For frequencies equal to and above 30 MHz, these limits are shown in table 33.

Frequency	*Field strength*		*Measurement distance*
[MHz]	*[µV/m]*	*[dBµV/m]*	*[m]*
30 – 88	100	40.00	3
88 – 216	150	43.52	3
216 - 960	200	46.02	3
Above 960	500	53.98	3

Table 33: General radiated emission limits ≥ 30 MHz according to §15.209

6.9.2.3 Test procedure

The emissions from 30 MHz to 1 GHz are measured using the

☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.5.

6.9.2.4 Test results

Performed by:	Jennifer Riedel	Date(s) of test:	May 23, 2019
Test distance:	☒ 3 m	☐ 10 m	☐ ….. m
EUT position[17]:	☒ Position X	☒ Position Y	☒ Position Z

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Preamplifier*
			Prescan	*Final scan*	*Prescan*	*Final scan*	
30 MHz – 1 GHz	30 kHz	120 kHz	QP	QP	1 s	1 s	20 dB

Note 1: Premeasurements have shown there are no differences between the channels low, middle and high in the range of 30 MHz to 1 GHz, so the final measurement was only performed on channel low. Also there are no differences between the two types of modules, so only module 1 is shown in this clause.
Note 2: Each packet type and size in the three modulation types is tested but only the worst case of every modulation type is shown in this test report.

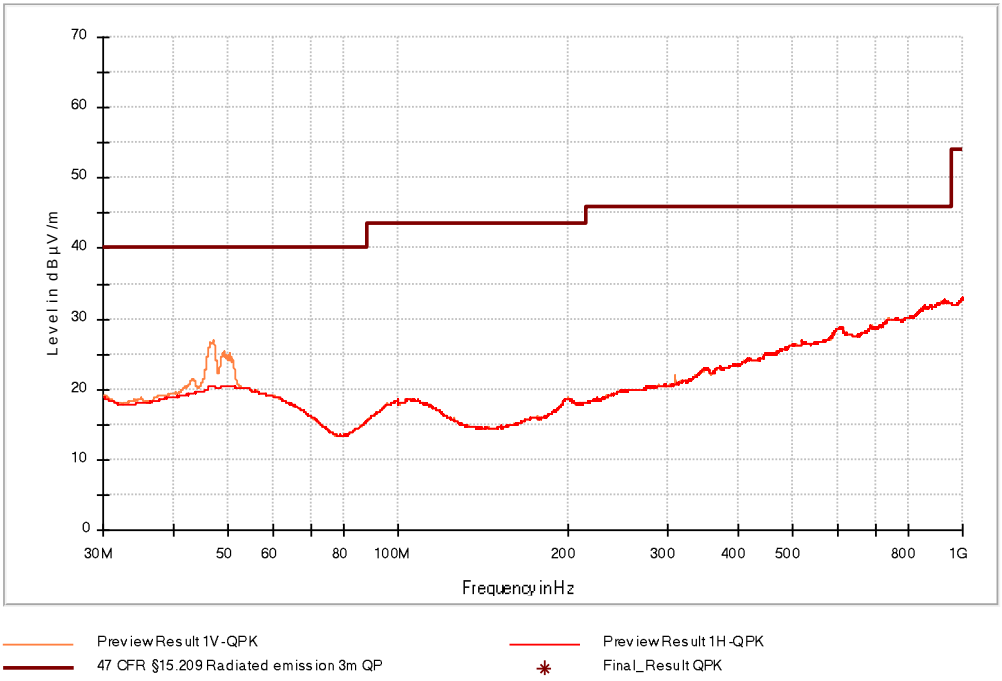


Figure 61: Chart of emissions test from 30 MHz to 1 GHz on channel low (GFSK, DH1) in position Y

Note: No assessable emissions were detected.

[17] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.

6.9.3 Emissions from 1 GHz to 25 GHz (10th harmonic)

Section(s) in 47 CFR Part 15:	Requirement(s):	15.247(d)
	Reference(s):	ANSI C63.10, clause 6.6
Section(s) in RSS:	Requirement(s):	RSS-247, section 5.5 RSS-Gen, section 6.13
	Reference(s):	ANSI C63.10, clause 6.6

Result[18]: ☒ Test passed ☐ Test not passed

6.9.3.1 Test equipment

	Type	*Designation*	*Manufacturer*	*Inventory no.*
☐	Semi-anechoic chamber (SAC)	SAC3	Albatross Projects	E00716
☒	Free space semi-anechoic chamber (FS-SAC)	FS-SAC	EMV **TESTHAUS**	E00100
☐	EMI test receiver (CDC)	ESCI 3	Rohde & Schwarz	E00552
☐	EMI test receiver (OATS)	ESCI 3	Rohde & Schwarz	E00001
☐	EMI test receiver	ESR 7	Rohde & Schwarz	E00739
☒	EMI test receiver	ESU 26	Rohde & Schwarz	W00002
☐	EMI test receiver	ESW 44	Rohde & Schwarz	E00895
☒	Preamplifier (0.5 GHz - 18 GHz)	BBV 9718 B	Schwarzbeck	W01325
☐	TRILOG broadband antenna (CDC)	VULB 9160	Schwarzbeck	E00011
☐	TRILOG broadband antenna (OATS)	VULB 9163	Schwarzbeck	E00013
☐	TRILOG broadband antenna (SAC)	VULB 9162	Schwarzbeck	E00643
☒	Horn antenna	BBHA 9120D	Schwarzbeck	W00052
☒	Horn antenna	BBHA 9170	Schwarzbeck	W01350
☒	Preamplifier (18 GHz – 40 GHz)	BBV 9721	Schwarzbeck	W01350
☐	Cable set SAC	RF cable(s)	Huber + Suhner	E00755 E01033 E01034
☒	Cable set FS-SAC	RF cable(s)	Teledyne Reynolds Huber + Suhner Teledyne Reynolds	E00435 E00307 E00433
☐	Test software	EMC32-EB (V10.35)	Rohde & Schwarz	E00777
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E00778
☐	Test software	EMC32-MEB (V10.35)	Rohde & Schwarz	E01073

[18] For information about measurement uncertainties see page 85.

6.9.3.2 Limits

According to §15.247(d), in any 100 kHz bandwidth outside of 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. In addition, radiated emissions which fall in the restricted bands (see table 25) must also comply with the radiated emission limits specified in §15.209(a). For frequencies above 960 MHz, these limits are shown in table 34.

Frequency	*Field strength*		*Measurement distance*
[MHz]	*[µV/m]*	*[dBµV/m]*	*[m]*
Above 960	500	53.98	3

Table 34: General radiated emission limits above 960 MHz according to §15.209

6.9.3.3 Test procedure

The emissions from 30 MHz to 1 GHz are measured using the

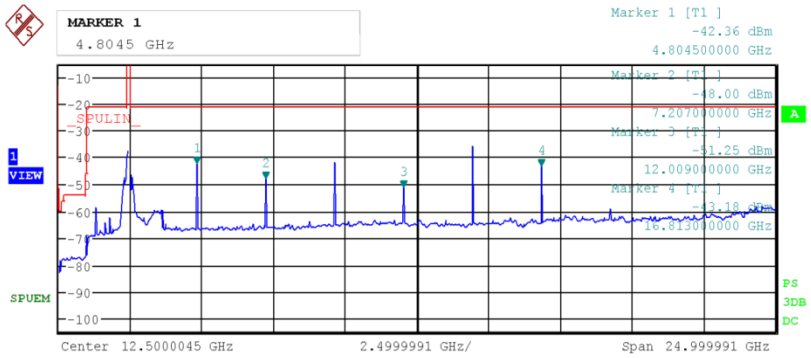
☐ test procedure for conducted measurements as described in clause 5.2.
☒ test procedure for radiated measurements as described in clause 5.6.

6.9.3.4 Test results

6.9.3.4.1 Conducted

Performed by:	Jennifer Riedel	Date(s) of test:	May 13, 2019

Note: Each packet type and size in the three modulation types is tested but only the worst case of every modulation type is shown in this test report.



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
9.000 k	150.000 k	200.00	147.462000 k	-100.08	-63.34
150.000 k	490.000 k	10.00 k	490.000000 k	-86.24	-38.79
490.000 k	1.705 M	10.00 k	1.688800 M	-89.09	-30.95
1.705 M	30.000 M	10.00 k	3.055218 M	-88.41	-36.71
30.000 M	88.000 M	100.00 k	69.053333 M	-78.31	-18.41
88.000 M	216.000 M	100.00 k	177.600000 M	-77.91	-21.51
216.000 M	960.000 M	100.00 k	912.086400 M	-77.19	-23.29
960.000 M	1.000 G	1.00 M	988.571429 M	-68.95	-23.05
1.000 G	2.390 G	1.00 M	2.386525 G	-37.74	-16.54
2.500 G	4.000 G	1.00 M	2.530000 G	-46.78	-25.58
4.000 G	10.000 G	1.00 M	9.607500 G	-41.87	-20.67
10.000 G	25.000 G	1.00 M	14.411500 G	-35.89	-14.69

Figure 62: Chart of emissions test from 1 GHz to 25 GHz on channel low (GFSK, DH1) (PK-detector)

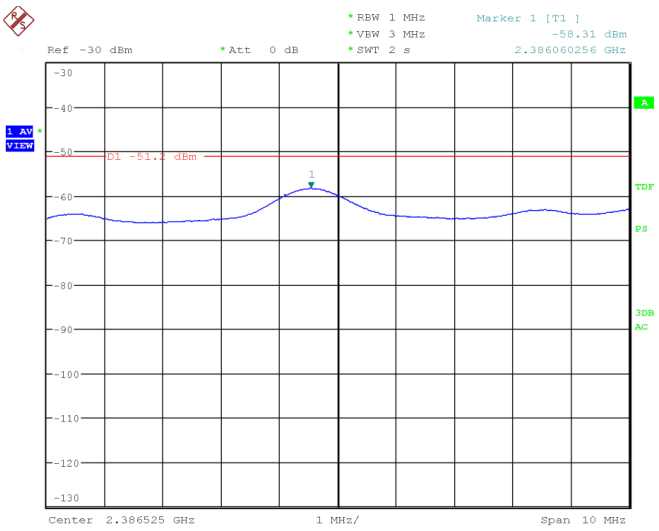


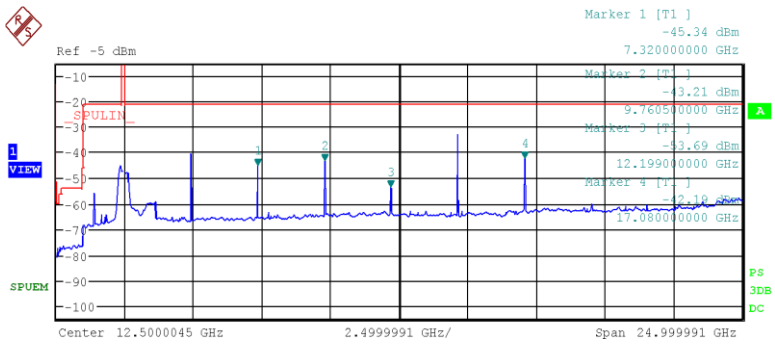
Figure 63: Chart of 2386.06 MHz on channel low (GFSK, DH1) (AV-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
69.053	-78.31	PK	-68.31	26.89	40.00	13.11	Passed
2386.525	-37.74	PK	-27.74	67.46	74.00	6.54	Passed
2386.060	-58.31	AV	-48.31	46.89	54.00	7.11	Passed
4804.500	-42.36	PK	-32.36	62.84	74.00	11.16	Passed
4804.500	-67.12[2]	AV	-57.12	38.08	54.00	15.92	Passed
7207.000	-48.00	PK	-38.00	57.20	74.00	16.80	Passed
7207.000	-72.76[2]	AV	-62.76	32.44	54.00	21.56	Passed
9607.500	-41.87	PK	-31.87	63.33	74.00	10.67	Passed
9607.500	-66.63[2]	AV	-56.63	38.57	54.00	15.43	Passed
12009.000	-51.25	PK	-41.25	53.95	74.00	20.05	Passed
12009.000	-76.01[2]	AV	-66.01	29.19	54.00	24.81	Passed
14411.500	-35.89	PK	-25.89	69.31	74.00	4.69	Passed
14411.500	-60.65[2]	AV	-50.65	44.55	54.00	9.45	Passed
16813.000	-43.18	PK	-33.18	62.02	74.00	11.98	Passed
16813.000	-67.94[2]	AV	-57.94	37.26	54.00	16.74	Passed

Table 35: Results of conducted emissions test from 1 GHz to 25 GHz on channel low (GFSK, DH1)

Note 1: The power limit lines in Figure 62 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



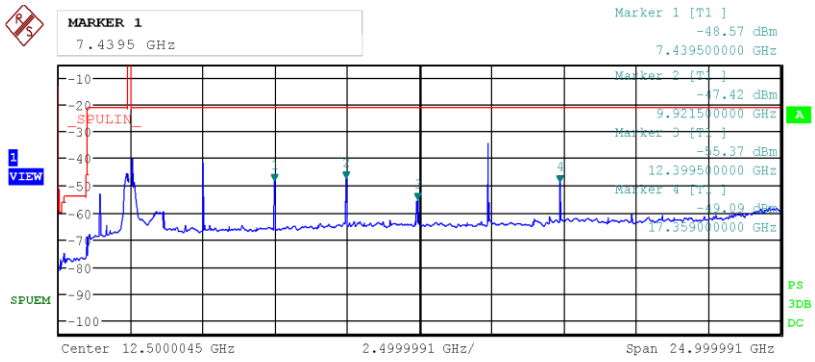
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
9.000 k	150.000 k	200.00	148.214000 k	-99.25	-62.38
150.000 k	490.000 k	10.00 k	434.805195 k	-85.11	-39.33
490.000 k	1.705 M	10.00 k	1.660450 M	-88.30	-30.41
1.705 M	30.000 M	10.00 k	3.740254 M	-88.27	-36.57
30.000 M	88.000 M	100.00 k	85.680000 M	-77.44	-17.54
88.000 M	216.000 M	100.00 k	112.073846 M	-76.99	-20.59
216.000 M	960.000 M	100.00 k	784.862400 M	-76.33	-22.43
960.000 M	1.000 G	1.00 M	975.584416 M	-68.53	-22.63
1.000 G	2.390 G	1.00 M	2.312557 G	-45.27	-24.07
2.500 G	4.000 G	1.00 M	2.504000 G	-47.74	-26.54
4.000 G	10.000 G	1.00 M	4.880000 G	-40.24	-19.04
10.000 G	25.000 G	1.00 M	14.639500 G	-32.85	-11.65

Figure 64: Chart of emissions test from 1 GHz to 25 GHz on channel middle (GFSK, DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
85.680	-77.44	PK	-67.44	27.76	40.00	12.24	Passed
4880.000	-40.24	PK	-30.24	64.96	74.00	9.04	Passed
4880.000	-65.00[2]	AV	-55.00	40.20	54.00	13.80	Passed
7320.000	-45.34	PK	-35.34	59.86	74.00	14.14	Passed
7320.000	-70.10[2]	AV	-60.10	35.1	54.00	18.9	Passed
9760.500	-43.21	PK	-33.21	61.99	74.00	12.01	Passed
9760.500	-67.97[2]	AV	-57.97	37.23	54.00	16.77	Passed
12199.000	-53.69	PK	-43.69	51.51	74.00	22.49	Passed
12199.000	-78.45[2]	AV	-68.45	26.75	54.00	27.25	Passed
14639.500	-32.85	PK	-22.85	72.35	74.00	1.65	Passed
14639.500	-57.61[2]	AV	-47.61	47.59	54.00	6.41	Passed
17080.000	-42.19	PK	-32.19	63.01	74.00	10.99	Passed
17080.000	-66.95[2]	AV	-56.95	38.25	54.00	15.75	Passed

Table 36: Results of conducted emissions test from 1 GHz to 25 GHz on channel middle (GFSK, DH1)

Note 1: The power limit lines in Figure 64 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.
Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
9.000 k	150.000 k	200.00	149.718000 k	-99.25	-62.12
150.000 k	490.000 k	10.00 k	439.220779 k	-84.54	-38.63
490.000 k	1.705 M	10.00 k	1.696900 M	-89.06	-30.84
1.705 M	30.000 M	10.00 k	2.057446 M	-89.61	-37.91
30.000 M	88.000 M	100.00 k	74.128333 M	-77.54	-17.64
88.000 M	216.000 M	100.00 k	165.636923 M	-75.17	-18.77
216.000 M	960.000 M	100.00 k	959.404800 M	-76.61	-22.71
960.000 M	1.000 G	1.00 M	989.090909 M	-68.99	-23.09
1.000 G	2.390 G	1.00 M	2.320004 G	-45.40	-24.20
2.500 G	4.000 G	1.00 M	2.506000 G	-40.11	-18.91
4.000 G	10.000 G	1.00 M	4.960000 G	-41.36	-20.16
10.000 G	25.000 G	1.00 M	14.879500 G	-34.26	-13.06

Figure 65: Chart of emissions test from 1 GHz to 25 GHz on channel high (GFSK, DH1) (PK-detector)

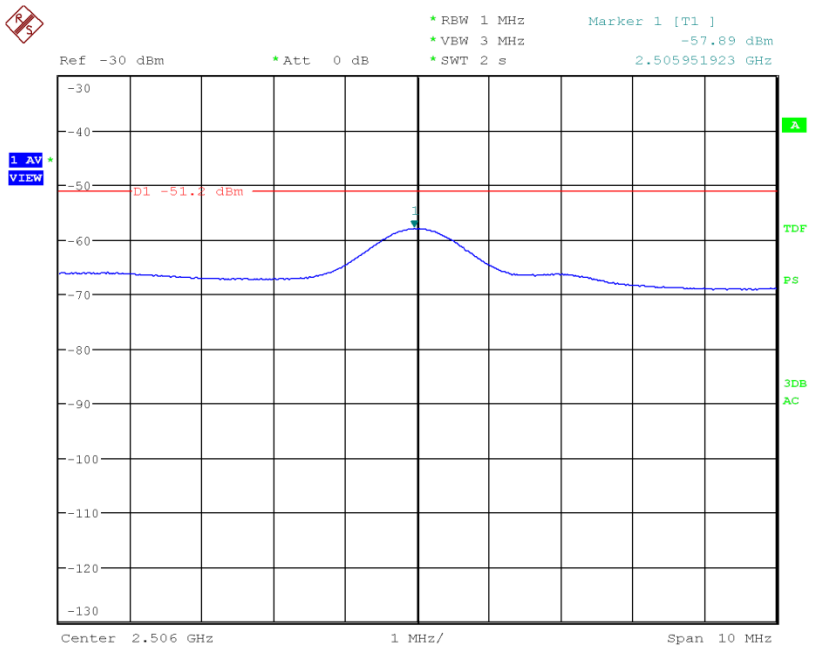


Figure 66: Chart of 2506.00 MHz on channel high (GFSK, DH1) (AV-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
74.128	-77.54	PK	-67.54	27.66	40.00	12.34	Passed
165.637	-75.17	PK	-65.17	30.03	74.00	43.97	Passed
2506.000	-40.11	PK	-30.11	65.09	74.00	8.91	Passed
2506.000	-57.89	AV	-47.89	47.31	54.00	6.69	Passed
4960.000	-41.36	PK	-31.36	63.84	74.00	10.16	Passed
4960.000	-66.12[2]	AV	-56.12	39.08	54.00	14.92	Passed
7439.500	-48.57	PK	-38.57	56.63	74.00	17.37	Passed
7439.500	-73.33[2]	AV	-63.33	31.87	54.00	22.13	Passed
9921.500	-47.42	PK	-37.42	57.78	74.00	16.22	Passed
9921.500	-72.18[2]	AV	-62.18	33.02	54.00	20.98	Passed
12399.500	-55.37	PK	-45.37	49.83	74.00	24.17	Passed
12399.500	-80.13[2]	AV	-70.13	25.07	54.00	28.93	Passed
14879.500	-34.26	PK	-24.26	70.94	74.00	3.06	Passed
14879.500	-59.02[2]	AV	-49.02	46.18	54.00	7.82	Passed
17359.000	-49.09	PK	-39.09	56.11	74.00	17.89	Passed
17359.000	-73.85[2]	AV	-63.85	31.35	54.00	22.65	Passed

Table 37: Results of conducted emissions test from 1 GHz to 25 GHz on channel high (GFSK, DH1)

Note 1: The power limit lines in Figure 65 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

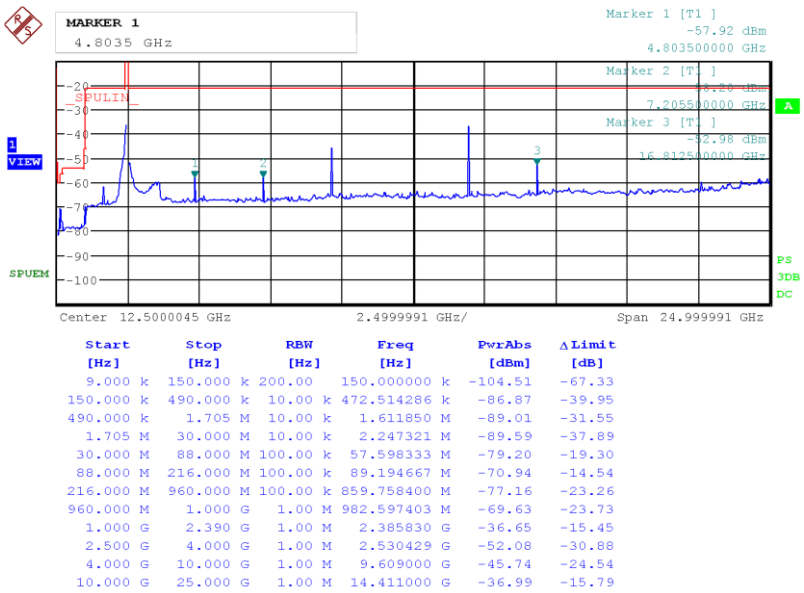


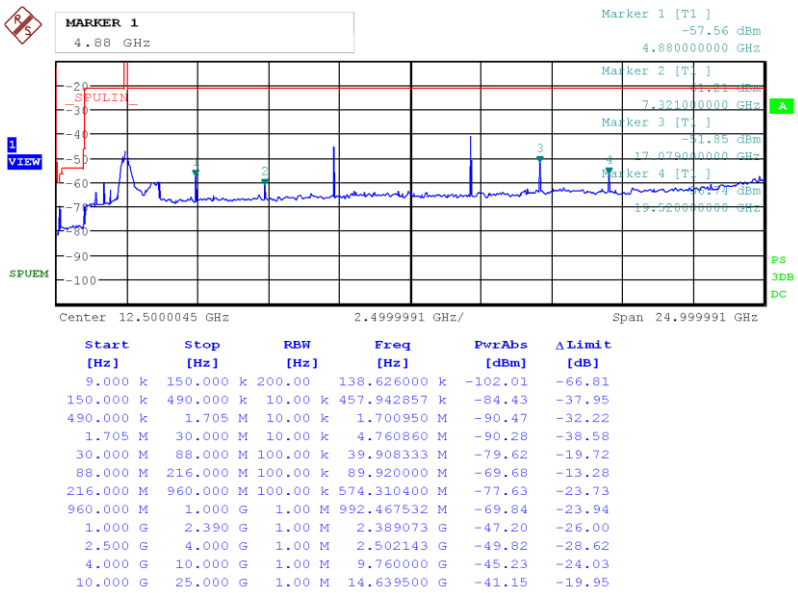
Figure 67: Chart of emissions test from 1 GHz to 25 GHz on channel low (π/4-DQPSK, 2-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
89.195	-70.94	PK	-60.94	34.26	43.52	9.26	Passed
2385.830	-36.65	PK	-26.65	68.55	74.00	5.45	Passed
2385.830	-61.41[2]	AV	-51.41	43.79	54.00	10.21	Passed
4803.500	-57.92	PK	-47.92	47.28	74.00	26.72	Passed
4803.500	-82.68[2]	AV	-72.68	22.52	54.00	31.48	Passed
7205.500	-58.2	PK	-48.20	47.00	74.00	27.00	Passed
7205.500	-82.96[2]	AV	-72.96	22.24	54.00	31.76	Passed
9609.000	-45.74	PK	-35.74	59.46	74.00	14.54	Passed
9609.000	-70.50[2]	AV	-60.50	34.70	54.00	19.30	Passed
14411.000	-36.99	PK	-26.99	68.21	74.00	5.79	Passed
14411.000	-61.75[2]	AV	-51.75	43.45	54.00	10.55	Passed
16812.500	-52.98	PK	-42.98	52.22	74.00	21.78	Passed
16812.500	-77.74[2]	AV	-67.74	27.46	54.00	26.54	Passed

Table 38: Results of conducted emissions test from 1 GHz to 25 GHz on channel low (π/4-DQPSK, 2-DH1)

Note 1: The power limit lines in Figure 67 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
9.000 k	150.000 k	200.00	138.626000 k	-102.01	-66.81
150.000 k	490.000 k	10.00 k	457.942857 k	-84.43	-37.95
490.000 k	1.705 M	10.00 k	1.700950 M	-90.47	-32.22
1.705 M	30.000 M	10.00 k	4.760860 M	-90.28	-38.58
30.000 M	88.000 M	100.00 k	39.908333 M	-79.62	-19.72
88.000 M	216.000 M	100.00 k	89.920000 M	-69.68	-13.28
216.000 M	960.000 M	100.00 k	574.310400 M	-77.63	-23.73
960.000 M	1.000 G	1.00 M	992.467532 M	-69.84	-23.94
1.000 G	2.390 G	1.00 M	2.389073 G	-47.20	-26.00
2.500 G	4.000 G	1.00 M	2.502143 G	-49.82	-28.62
4.000 G	10.000 G	1.00 M	9.760000 G	-45.23	-24.03
10.000 G	25.000 G	1.00 M	14.639500 G	-41.15	-19.95

Figure 68: Chart of emissions test from 1 GHz to 25 GHz on channel middle (π/4-DQPSK, 2-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
89.920	-69.68	PK	-59.68	35.52	43.52	8.00	Passed
4880.000	-57.56	PK	-47.56	47.64	74.00	26.36	Passed
4880.000	-82.32[2]	AV	-72.32	22.88	54.00	31.12	Passed
7321.000	-61.21	PK	-51.21	43.99	74.00	30.01	Passed
7321.000	-85.97[2]	AV	-75.97	19.23	54.00	34.77	Passed
9760.000	-45.23	PK	-35.23	59.97	74.00	14.03	Passed
9760.000	-69.99[2]	AV	-59.99	35.21	54.00	18.79	Passed
14639.500	-41.15	PK	-31.15	64.05	74.00	9.95	Passed
14639.500	-65.91[2]	AV	-55.91	39.29	54.00	14.71	Passed
17079.000	-51.85	PK	-41.85	53.35	74.00	20.65	Passed
17079.000	-76.61[2]	AV	-66.61	28.59	54.00	25.41	Passed
19520.000	-56.74	PK	-46.74	48.46	74.00	25.54	Passed
19520.000	-81.50[2]	AV	-71.50	23.70	54.00	30.30	Passed

Table 39: Results of conducted emissions test from 1 GHz to 25 GHz on channel middle (π/4-DQPSK, 2-DH1)

Note 1: The power limit lines in Figure 68 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

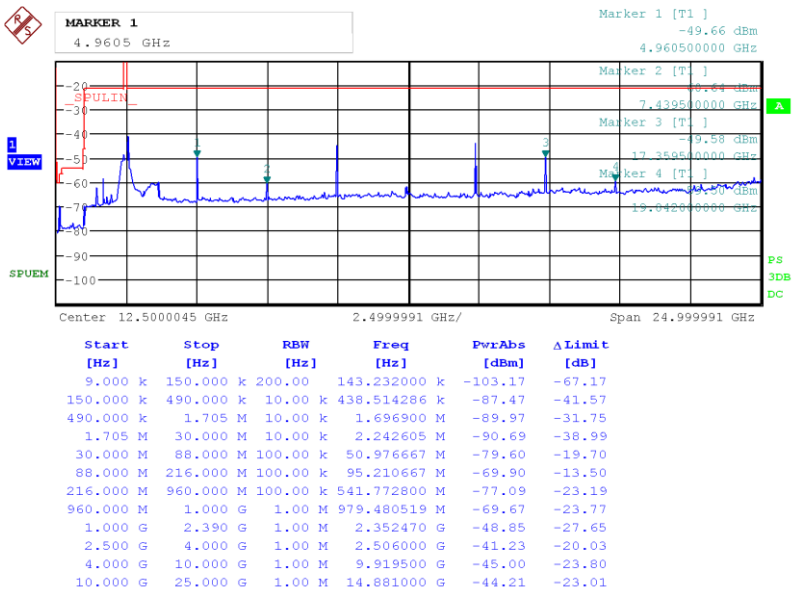


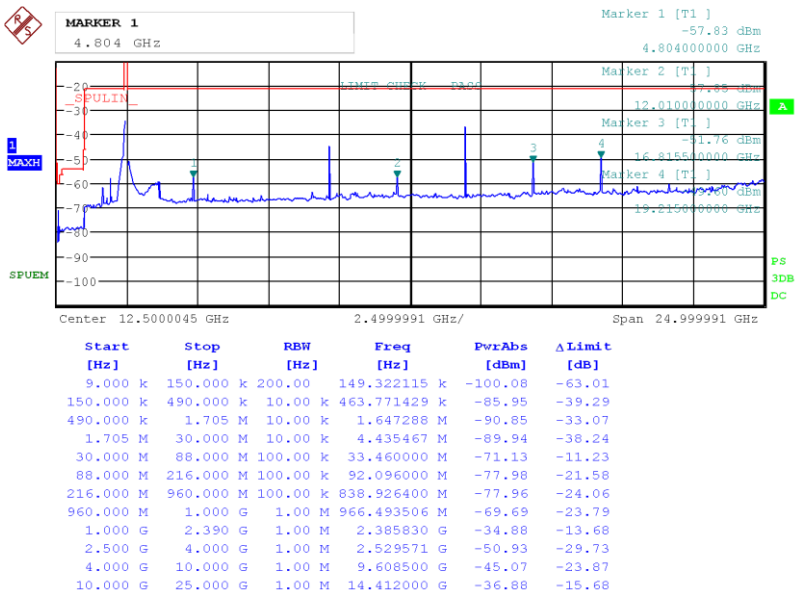
Figure 69: Chart of emissions test from 1 GHz to 25 GHz on channel high (π/4-DQPSK, 2-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
95.211	-69.90	PK	-59.90	35.30	43.52	8.22	Passed
4960.500	-49.66	PK	-39.66	55.54	74.00	18.46	Passed
4960.500	-74.42[2]	AV	-64.42	30.78	54.00	23.22	Passed
7439.500	-60.64	PK	-50.64	44.56	74.00	29.44	Passed
7439.500	-85.40[2]	AV	-75.40	19.80	54.00	34.20	Passed
9919.500	-45.00	PK	-35.00	60.20	74.00	13.80	Passed
9919.500	-69.76[2]	AV	-59.76	35.44	54.00	18.56	Passed
14881.000	-44.21	PK	-34.21	60.99	74.00	13.01	Passed
14881.000	-68.97[2]	AV	-58.97	36.23	54.00	17.77	Passed
17359.500	-49.58	PK	-39.58	55.62	74.00	18.38	Passed
17359.500	-74.34[2]	AV	-64.34	30.86	54.00	23.14	Passed
19042.000	-59.50	PK	-49.50	45.70	74.00	28.30	Passed
19042.000	-84.26[2]	AV	-74.26	20.94	54.00	33.06	Passed

Table 40: Results of conducted emissions test from 1 GHz to 25 GHz on channel high (π/4-DQPSK, 2-DH1)

Note 1: The power limit lines in Figure 69 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	ΔLimit [dB]
9.000 k	150.000 k	200.00	149.322115 k	-100.08	-63.01
150.000 k	490.000 k	10.00 k	463.771429 k	-85.95	-39.29
490.000 k	1.705 M	10.00 k	1.647288 M	-90.85	-33.07
1.705 M	30.000 M	10.00 k	4.435467 M	-89.94	-38.24
30.000 M	88.000 M	100.00 k	33.460000 M	-71.13	-11.23
88.000 M	216.000 M	100.00 k	92.096000 M	-77.98	-21.58
216.000 M	960.000 M	100.00 k	838.926400 M	-77.96	-24.06
960.000 M	1.000 G	1.00 M	966.493506 M	-69.69	-23.79
1.000 G	2.390 G	1.00 M	2.385830 G	-34.88	-13.68
2.500 G	4.000 G	1.00 M	2.529571 G	-50.93	-29.73
4.000 G	10.000 G	1.00 M	9.608500 G	-45.07	-23.87
10.000 G	25.000 G	1.00 M	14.412000 G	-36.88	-15.68

Figure 70: Chart of emissions test from 1 GHz to 25 GHz on channel low (8-DPSK, 3-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
33.460	-71.13	PK	-61.13	34.07	40.00	5.93	Passed
2385.525	-34.88	PK	-24.88	70.32	74.00	3.68	Passed
2385.525	-59.64[2]	AV	-49.64	45.56	54.00	8.44	Passed
4804.000	-57.83	PK	-47.83	47.37	74.00	26.63	Passed
4804.000	-82.59[2]	AV	-72.59	22.61	54.00	31.39	Passed
9608.500	-45.07	PK	-35.07	60.13	74.00	13.87	Passed
9608.500	-69.83[2]	AV	-59.83	35.37	54.00	18.63	Passed
12010.000	-57.85	PK	-47.85	47.35	74.00	26.65	Passed
12010.000	-82.61[2]	AV	-72.61	22.59	54.00	31.41	Passed
14412.000	-36.88	PK	-26.88	68.32	74.00	5.68	Passed
14412.000	-61.64[2]	AV	-51.64	43.56	54.00	10.44	Passed
16815.500	-51.76	PK	-41.76	53.44	74.00	20.56	Passed
16815.500	-76.52[2]	AV	-66.52	28.68	54.00	25.32	Passed

Table 41: Results of conducted emissions test from 1 GHz to 25 GHz on channel low (8-DPSK, 3-DH1)

Note 1: The power limit lines in Figure 70 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

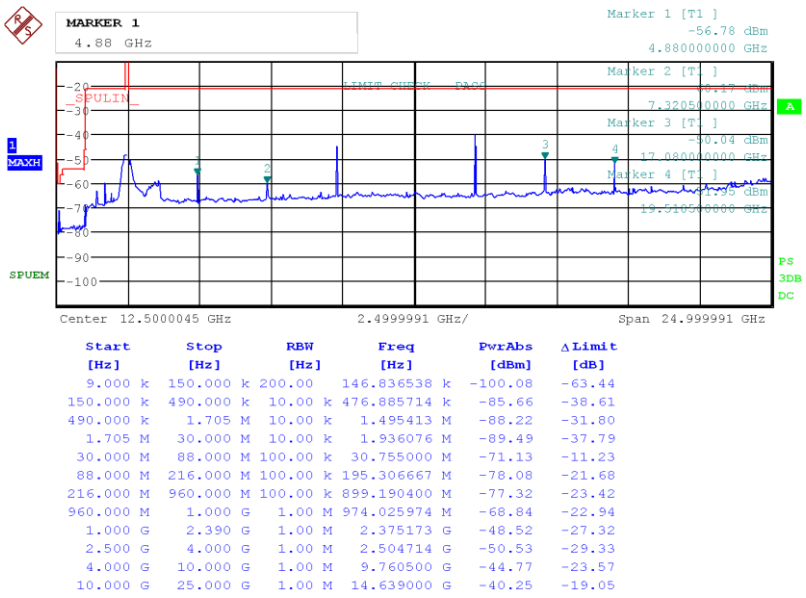


Figure 71: Chart of emissions test from 1 GHz to 25 GHz on channel middle (8-DPSK, 3-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
30.755	-71.13	PK	-61.13	34.07	40.00	5.93	Passed
4880.000	-56.78	PK	-46.78	48.42	74.00	25.58	Passed
4880.000	-81.54[2]	AV	-71.54	23.66	54.00	30.34	Passed
7320.500	-60.17	PK	-50.17	45.03	74.00	28.97	Passed
7320.500	-84.93[2]	AV	-74.93	20.27	54.00	33.73	Passed
9760.500	-44.77	PK	-34.77	60.43	74.00	13.57	Passed
9760.500	-69.53[2]	AV	-59.53	35.67	54.00	18.33	Passed
14639.000	-40.25	PK	-30.25	64.95	74.00	9.05	Passed
14639.000	-65.01[2]	AV	-55.01	40.19	54.00	13.81	Passed
17080.000	-50.04	PK	-40.04	55.16	74.00	18.84	Passed
17080.000	-74.80[2]	AV	-64.80	30.40	54.00	23.60	Passed
19518.500	-51.95	PK	-41.95	53.25	74.00	20.75	Passed
19518.500	-76.71[2]	AV	-66.71	28.49	54.00	25.51	Passed

Table 42: Results of conducted emissions test from 1 GHz to 25 GHz on channel middle (8-DPSK, 3-DH1)

Note 1: The power limit lines in Figure 71 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

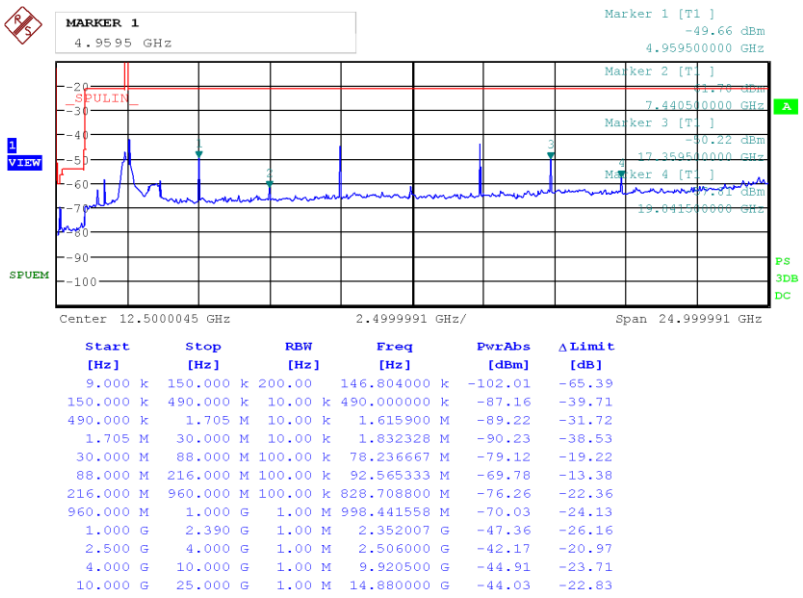


Figure 72: Chart of emissions test from 1 GHz to 25 GHz on channel high (8-DPSK, 3-DH1) (PK-detector)

Frequency (MHz)	*Level (dBm)*	*Detector*	*EIRP (dBm)*	*Field strength (dBµV/m) at 3 m*	*Limit (dBµV/m) at 3 m*	*Margin*	*Result*
92.565	-69.78	PK	-59.78	35.42	40.00	4.58	Passed
4959.500	-49.66	PK	-39.66	55.54	74.00	18.46	Passed
4959.500	-74.42[2]	AV	-64.42	30.78	54.00	23.22	Passed
7440.500	-61.70	PK	-51.70	43.50	74.00	30.50	Passed
7440.500	-86.46[2]	AV	-76.46	18.74	54.00	35.26	Passed
9920.500	-44.91	PK	-34.91	60.29	74.00	13.71	Passed
9920.500	-69.67[2]	AV	-59.67	35.53	54.00	18.47	Passed
14880.000	-44.03	PK	-34.03	61.17	74.00	12.83	Passed
14880.000	-68.79[2]	AV	-58.79	36.41	54.00	17.59	Passed
17359.500	-50.22	PK	-40.22	54.98	74.00	19.02	Passed
17359.500	-74.98[2]	AV	-64.98	30.22	54.00	23.78	Passed
19041.500	-57.81	PK	-47.81	47.39	74.00	26.61	Passed
19041.500	-82.57[2]	AV	-72.57	22.63	54.00	31.37	Passed

Table 43: Results of conducted emissions test from 1 GHz to 25 GHz on channel high (8-DPSK, 3-DH1)

Note 1: The power limit lines in Figure 72 are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 10 dBi, so the peak limit is -31.20 dBm and the average limit is -51.20 dBm.

Note 2: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

6.9.3.4.2 Radiated

Performed by:	Jennifer Riedel	Date(s) of test:	June 25, 2019
Test distance:	Exploratory tests: Final tests:	☐ 1 m ☐ 3 m	☐ 0.5 m ☒ 1.5 m
EUT position[19]:	☒ Position X	☒ Position Y	☒ Position Z

Frequency range	*Step size*	*IF Bandwidth*	*Detector*		*Measurement Time*		*Pre-amplifier*	*Distance*
			Prescan	*Final scan*	*Prescan*	*Final scan*		
1 GHz – 25 GHz	250 kHz	1 MHz	PK + AV	PK + AV	1.5 s	0.1 s	External	3 m

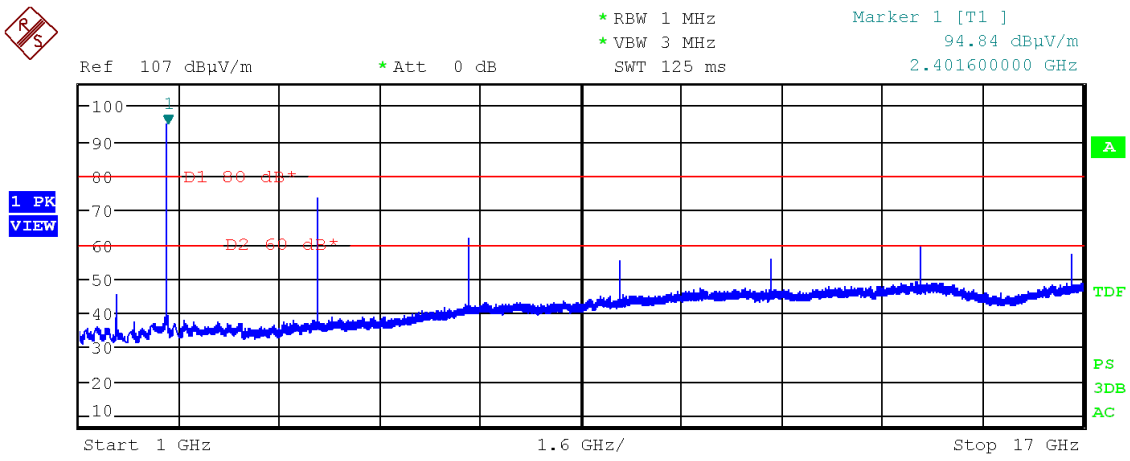
Note 1: The measurements from 1 GHz to 25 GHz are made at a measurement distance of 1.5 m. The limit lines for these tests are converted and calculated from the limit lines at a measurement distance of 3 m. However, the table results are converted and calculated at a measurement distance of 3 m.

Note 2: Premeasurements are performed in all three positions and antenna polarizations. However, the figures within this test report show only the worst case position and antenna polarization. The table results are the final measurements of the emissions detected in the premeasurements which are shown in this test report.

Note 3: Premeasurements have shown that there are no differences between the module 1 and module 2, so only the final measurements of module 1 are in this test report.

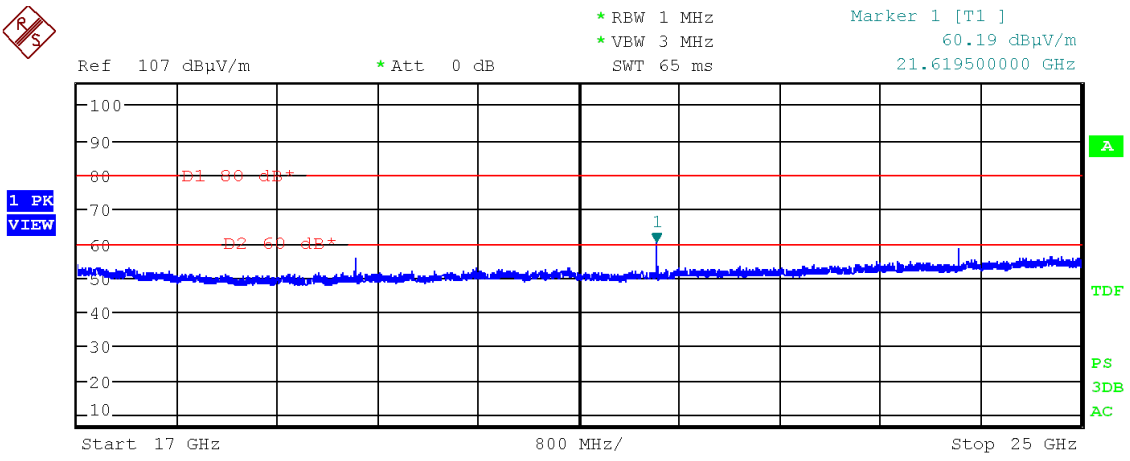
Note 4: Based on the conducted spurious emissions and the conducted output power the modulation type GFSK DH1 is selected for radiated testing.

[19] Exploratory measurements are performed in all positions as indicated. However, the figures and result tables within this test report show the worst case position, only.



#	Frequency	Level
1	1.601067 GHz	45.15 dBµV
2	2.401600 GHz	94.84 dBµV
3	4.803733 GHz	73.51 dBµV
4	7.205867 GHz	61.84 dBµV
5	9.607467 GHz	54.93 dBµV
6	12.011200 GHz	55.39 dBµV
7	14.412800 GHz	59.28 dBµV
8	16.813333 GHz	57.01 dBµV

Figure 73: Chart of emissions test from 1 GHz to 17 GHz on channel low (GFSK, DH1)



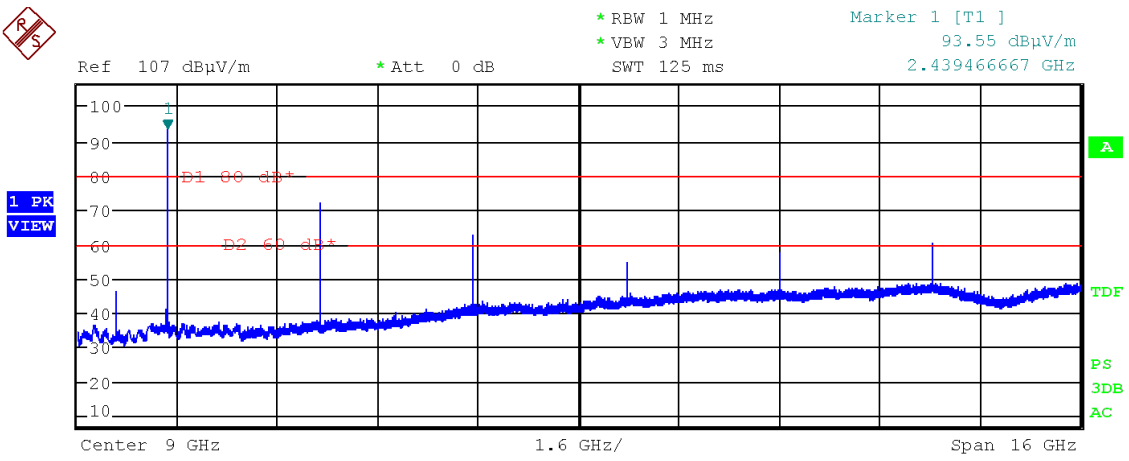
#	Frequency	Level
1	17.000000 GHz	53.78 dBµV
2	19.217500 GHz	55.71 dBµV
3	21.619500 GHz	60.19 dBµV
4	24.019000 GHz	58.21 dBµV

Figure 74: Chart of emissions test from 17 GHz to 25 GHz on channel low (GFSK, DH1)

Frequency (MHz)	*EUT Pos.*	*Level (dBµV/m)*	*Detec-tor*	*Limit (dBµV/m)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Pol.*	*Corr. (dB/m)*
4803.733	Y	67.51	PK	74.00	6.49	125.0	1000.000	V	-2.8
4803.733	---	42.74[1]	AV	54.00	11.25	---	---	---	---
7205.867	Y	55.84	PK	74.00	18.16	125.0	1000.000	V	1.1
7205.867	---	31.08[1]	AV	54.00	22.92	---	---	---	---
9607.467	Y	48.93	PK	74.00	25.07	125.0	1000.000	V	11.6
12011.200	Y	49.39	PK	74.00	24.61	125.0	1000.000	V	15.4
14412.800	Y	53.28	PK	74.00	20.72	125.0	1000.000	V	18.3
19217.500	Z	49.71	PK	74.00	24.29	65.0	1000.000	V	12.9
21619.500	Z	54.19	PK	74.00	19.81	65.0	1000.000	V	14.7
21619.500	---	29.43[1]	AV	54.00	24.57	---	---	---	---
24019.000	Z	52.21	PK	74.00	21.79	65.0	1000.000	V	17.2

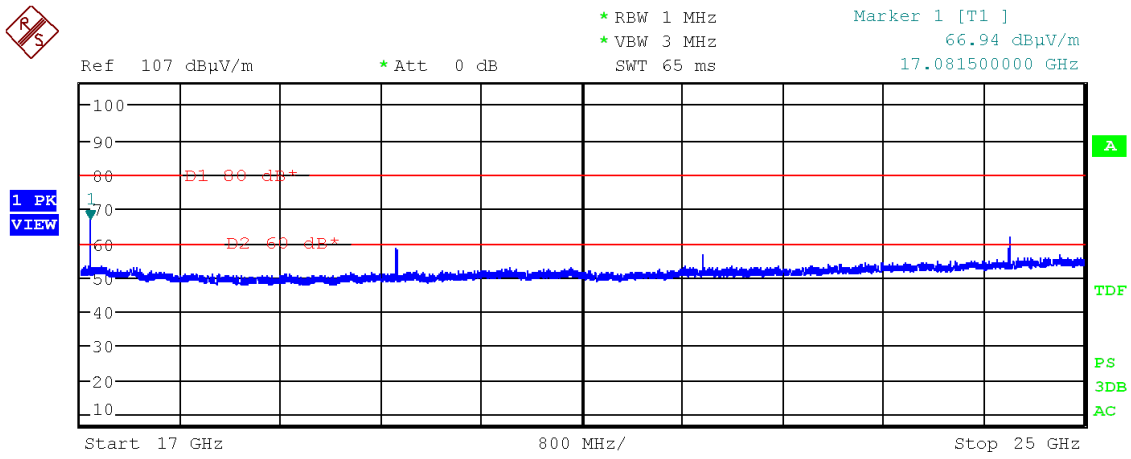
Table 44: Results of emissions test from 1 GHz to 25 GHz on channel low (GFSK DH1)

Note 1: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



#	Frequency	Level
1	1.626667 GHz	46.31 dBµV
2	2.439467 GHz	93.55 dBµV
3	4.880000 GHz	71.84 dBµV
4	7.320533 GHz	62.67 dBµV
5	9.761067 GHz	54.63 dBµV
6	12.201067 GHz	57.32 dBµV
7	14.640533 GHz	60.11 dBµV
8	16.763200 GHz	48.70 dBµV

Figure 75: Chart of emissions test from 1 GHz to 17 GHz on channel middle (GFSK, DH1)



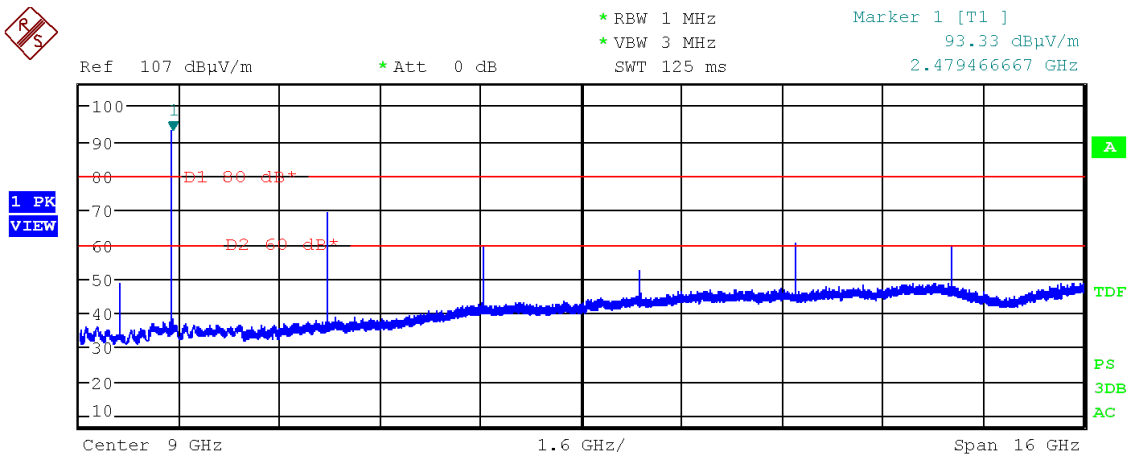
#	Frequency	Level
1	17.081500 GHz	66.94 dBµV
2	19.519000 GHz	58.55 dBµV
3	21.959000 GHz	56.72 dBµV
4	24.402500 GHz	61.59 dBµV

Figure 76: Chart of emissions test from 17 GHz to 25 GHz on channel middle (GFSK, DH1)

Frequency (MHz)	EUT Pos.	Level (dBµV/m)	Detec-tor	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol.	Corr. (dB/m)
4880.000	Y	65.48	PK	74.00	8.16	125.0	1000.000	V	-2.8
4880.000	---	41.08[1]	AV	54.00	12.92	---	---	---	---
7320.533	Y	56.67	PK	74.00	17.33	125.0	1000.000	V	1.1
7320.533	---	31.91[1]	AV	54.00	22.09	---	---	---	---
9761.067	Y	48.63	PK	74.00	25.37	125.0	1000.000	V	11.6
12201.067	Y	51.32	PK	74.00	22.68	125.0	1000.000	V	15.4
14640.533	Y	54.11	PK	74.00	19.89	125.0	1000.000	V	18.3
14640.533	---	29.35[1]	AV	54.00	24.65	---	---	---	---
17081.500	Z	60.94	PK	74.00	13.06	65.0	1000.000	V	17.0
17081.500	---	36.18[1]	AV	54.00	17.82	---	---	---	---
19519.000	Z	52.55	PK	74.00	21.45	65.0	1000.000	V	13.2
21959.000	Z	50.72	PK	74.00	23.28	65.0	1000.000	V	15.4
24402.500	Z	55.59	PK	74.00	18.41	65.0	1000.000	V	17.6
24402.500	---	30.83[1]	AV	54.00	23.17	---	---	---	---

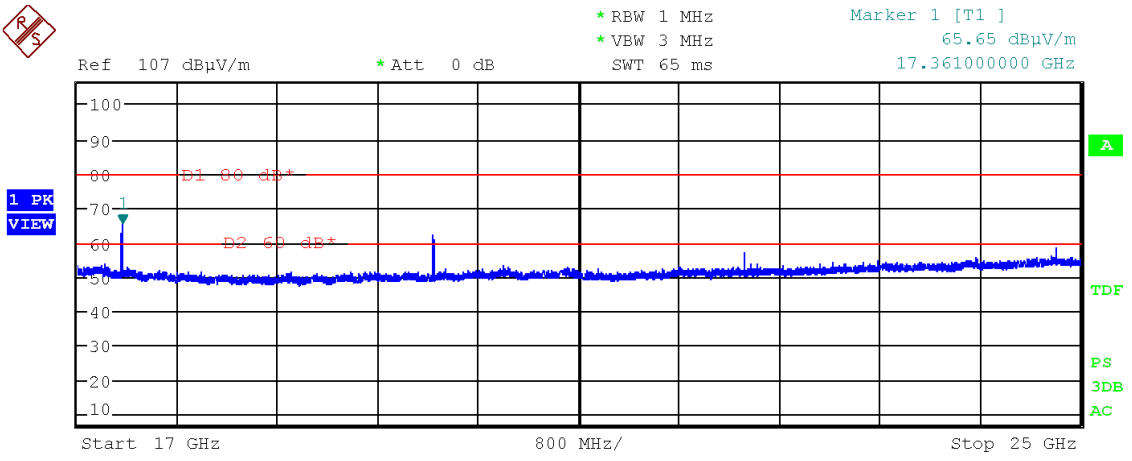
Table 45: Results of emissions test from 1 GHz to 25 GHz on channel middle (GFSK, DH1)

Note 1: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.



#	Frequency	Level
1	1.653333 GHz	48.53 dBµV
2	2.479467 GHz	93.33 dBµV
3	4.960000 GHz	69.03 dBµV
4	7.439467 GHz	59.24 dBµV
5	9.921067 GHz	52.17 dBµV
6	12.400533 GHz	60.41 dBµV
7	14.881067 GHz	59.18 dBµV
8	16.641600 GHz	48.78 dBµV

Figure 77: Chart of emissions test from 1 GHz to 17 GHz on channel high (GFSK, DH1)



#	Frequency	Level
1	17.361000 GHz	65.65 dBµV
2	19.841500 GHz	62.13 dBµV
3	22.319000 GHz	56.88 dBµV
4	24.802500 GHz	58.51 dBµV

Figure 78: Chart of exploratory emissions test from 17 GHz to 25 GHz on channel high (GFSK, DH1)

Frequency (MHz)	*EUT Pos.*	*Level (dBµV/m)*	*Detec-tor*	*Limit (dBµV/m)*	*Margin (dB)*	*Meas. Time (ms)*	*Bandwidth (kHz)*	*Pol.*	*Corr. (dB/m)*
4960.000	Y	63.03	PK	74.00	10.97	125.0	1000.000	V	-2.8
4960.000	---	38.27[1]	AV	54.00	15.73	---	---	---	---
7439.467	Y	53.24	PK	74.00	20.76	125.0	1000.000	V	1.1
9921.067	Y	46.17	PK	74.00	27.83	125.0	1000.000	V	11.6
12400.533	Y	54.41	PK	74.00	19.59	125.0	1000.000	V	15.4
12400.533	---	29.65[1]	AV	54.00	24.35	---	---	---	---
14881.067	Y	53.18	PK	74.00	20.82	125.0	1000.000	V	18.3
17361.000	Z	59.65	PK	74.00	14.35	65.0	1000.000	V	15.2
17361.000	---	34.89[1]	AV	54.00	19.11	---	---	---	---
19841.500	Z	56.13	PK	74.00	17.87	65.0	1000.000	V	13.6
19841.500	---	31.37[1]	AV	54.00	22.63	---	---	---	---
22319.000	Z	50.88	PK	74.00	23.12	65.0	1000.000	V	15.8
24802.500	Z	52.51	PK	74.00	21.49	65.0	1000.000	V	18.2

Table 46: Results of emissions test from 1 GHz to 25 GHz on channel high

Note 1: The average value is calculated as the difference between the peak value and the duty cycle correction factor which is determined as described in clause 4.2.2.

6.10 Radio frequency radiation exposure evaluation for portable devices

Section(s) in 47 CFR Chapter I:	Requirement(s):	1.1310, 2.1093, 15.247(i)
	Reference(s):	KDB 447498 D01, section 7
Section(s) in RSS:	Requirement(s):	RSS-Gen, section 3.4
	Reference(s):	RSS-102, section 2.5.2

Result: ☒ Test passed ☐ Test not passed

7 Equipment calibration status

Description	*Modell number*	*Serial number*	*Inventory number(s)*	*Last calibration*	*Next calibration*
EMI test receiver	ESW44	101538	E00895	2018-04	2019-07
EMI test receiver	ESR7	101059	E00739	2018-05	2019-11
EMI test receiver	ESU26	100026	W00002	2018-06	2019-12
EMI test receiver	ESCI3	100013	E00001	2018-05	2020-05
Preamplifier (0.5 GHz – 18 GHz)	BBV 9718 B	00032	W01325	2018-09	2019-09
Preamplifier (18 GHz – 40 GHz)	BBV 9721	9721-043	W01350	2018-11	2019-11
Loop antenna	HFH2-Z2	871398/0050	E00060	2018-10	2020-10
TRILOG broadband antenna (SAC3)	VULB 9162	9162-041	E00643	2018-03	2021-03
Horn antenna	BBHA 9120D	9120D-592	W00052	2017-04	2020-04
Horn antenna	BBHA 9170	9170-332	W00054	2017-04	2020-04
Horn antenna	BBHA 9170	9170-332	W01350	2018-11	2019-11
Artificial mains network (AMN)	ESH2-Z5	881362/037	E00004	2018-10	2020-10
Shielded room	P92007	B 83117 C 1109 T 211	E00107	N/A	
Compact diagnostic chamber (CDC)	VK041.0174	D62128-A502-A69-2-0006	E00026	N/A	
Semi-anechoic chamber (SAC) with floor absorbers	FS-SAC	---	E00100	2018-03	2021-03
Semi-anechoic chamber (SAC)	SAC3	C62128-A520-A643-x-0006	E00716	2018-03	2021-03
Cable set shielded room	RG 223/U	---	E00741	2019-09	2020-09
	RG 223/U	---	E00804	2019-09	2020-09
Cable set CDC	RG214/U	---	E00446	2019-04	2020-04
	LCF12-50J	---	E01215	2019-04	2020-04
	LMR400	1718020006	E00920	2019-01	2020-01
	RG214 Hiflex	171802007	E00921	2019-01	2020-01
Cable set anechoic chamber	262-0942-1500	005	E00435	2018-10	2019-10
	SF104EA/2x11PC35-42/5m	11144/4EA	E00307	2018-12	2019-12
	262-0942-1500	003	E00433	2018-10	2019-10
Cable set of semi-anechoic chamber SAC3	SF104EA/11PC35/11PC35/10000MM	501347/4EA	E00755	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507410/4E	E01033	2018-12	2019-12
	SF104E/11PC35/11PC35/2000MM	507411/4E	E01034	2018-09	2019-09

8 Measurement uncertainties

Description	*Uncertainty*	*k=*
AC power line conducted emission	± 4.1 dB	2
Carrier frequency separation Number of hopping frequencies Time of occupancy (dwell time)	± 5.0 %	2
Bandwidth tests	± 2.0 %	
Maximum conducted output power (conducted)	± 1.5 dB	
Power spectral density (conducted)	± 2.9 dB	
Conducted spurious emissions	± 2.9 dB	
Radiated emissions in semi-anechoic chamber		
9 kHz to 30 MHz	± 4.8 dB	2
30 MHz to 300 MHz	± 5.4 dB	2
300MHz to 1 GHz	± 4.7 dB	2
Radiated emissions in semi-anechoic chamber with RF absorbing material on the floor or fully anechoic room		
1 GHz to 25 GHz	± 4.5 dB	2

Comment: The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.

Test related measurement uncertainties have to be taken into consideration when evaluating the test results. All used test instrument as well as the test accessories are calibrated at regular intervals.

9 Revision history

Revision	*Date*	*Issued by*	*Description of modifications*
0	2019-08-19	Jennifer Riedel	First edition