



TEST REPORT

<p>Eurofins KCTL Co.,Ltd. 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea TEL: 82-31-285-0894 FAX: 82-505-299-8311 www.kctl.co.kr</p>	<p>Report No.: KR22-SRF0192 Page (1) of (45)</p>	 
<p>1. Client</p> <ul style="list-style-type: none"> ◦ Name : Humax Co., Ltd. ◦ Address : HUMAX BLDG., 2, Yeongmun-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, South Korea ◦ Date of Receipt : 2022-06-17 <p>2. Use of Report : Certification</p> <p>3. Name of Product / Model : 4K Satellite Receiver Set-Top Box / H26K-500</p> <p>4. Manufacturer / Country of Origin : Humax Co., Ltd. / Korea</p> <p>5. FCC ID : O6ZH26K</p> <p>6. Date of Test : 2022-06-24 to 2022-11-08</p> <p>7. Location of Test : <input checked="" type="checkbox"/> Permanent Testing Lab <input type="checkbox"/> On Site Testing (Address:65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea)</p> <p>8. Test method used : FCC Part 15 Subpart C, 15.247</p> <p>9. Test Result : Refer to the test result in the test report</p>		
<p>Affirmation</p>	<p>Tested by</p> <p>Name : Taeyoung Kim (Signature)</p>	<p>Technical Manager</p> <p>Name : Hyeonsu Jang (Signature)</p>
<p style="text-align: right;">2022-11-08</p> <p style="text-align: center;">Eurofins KCTL Co.,Ltd.</p> <p>As a test result of the sample which was submitted from the client, this report does not guarantee the whole product quality. This test report should not be used and copied without a written agreement by Eurofins KCTL Co.,Ltd.</p>		

REPORT REVISION HISTORY

Date	Revision	Page No
2022-11-08	Originally issued	-

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General remarks for test reports

Statement concerning the uncertainty of the measurement systems used for the tests

(may be required by the product standard or client)

Internal procedure used for type testing through which traceability of the measuring uncertainty has been established:

Procedure number, issue date and title:

Calculations leading to the reported values are on file with the testing laboratory that conducted the testing.

Statement not required by the standard or client used for type testing

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1. General information

Client : Humax Co., Ltd.
 Address : HUMAX BLDG., 2, Yeongmun-ro, Cheoin-gu, Yongin-si,
 Gyeonggi-do, South Korea
 Manufacturer : Humax Co., Ltd.
 Address : HUMAX BLDG., 2, Yeongmun-ro, Cheoin-gu, Yongin-si,
 Gyeonggi-do, South Korea
 Laboratory : Eurofins KCTL Co.,Ltd.
 Address : 65, Sinwon-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Korea
 Accreditations : FCC Site Designation No: KR0040, FCC Site Registration No: 687132
 VCCI Registration No. : R-20080, G-20078, C-20059, T-20056
 CAB Identifier: KR0040, ISED Number: 8035A
 KOLAS No.: KT231

2. Device information

Equipment under test : 4K Satellite Receiver Set-Top Box
 Model : H26K-500
 Modulation technique : Bluetooth(BDR/EDR)_GFSK, $\pi/4$ DQPSK, 8DPSK
 Bluetooth(BLE)_GFSK
 Zigbee RF4CE_DSSS
 Number of channels : Bluetooth(BDR/EDR)_79 ch
 Bluetooth(BLE)_40 ch
 Zigbee RF4CE_3 ch
 Power source : DC 12 V
 Antenna specification : PCB printed Antenna
 Antenna gain : Zigbee Ant 1_2.70 dBi
 Zigbee Ant 2_3.80 dBi
 Bluetooth_3.90 dBi
 Frequency range : 2 402 MHz ~ 2 480 MHz(Bluetooth(BDR/EDR/BLE))
 2 425 MHz ~ 2 475 MHz(Zigbee RF4CE)
 Software version : Bolt1.64, BIST11
 Hardware version : HW2.1
 Operation temperature : -20 °C ~ 50 °C

2.1. Accessory information

Equipment	Manufacturer	Model	Serial No.	Power source
AC Adapter	-	EPS10R4-15	CL10D1643A0633	Input: 120 V ~ 0.5 A Output: 12 V / 1.5 A

2.2. Frequency/channel operations


This device contains the following capabilities:
 Bluetooth (BDR/EDR/BLE), Zigbee RF4CE

Ch.	Frequency (MHz)
00	2 402
⋮	⋮
39	2 441
⋮	⋮
78	2 480

Table 2.2.1. Bluetooth(BDR/EDR) mode

15.247 Requirements for Bluetooth transmitter:

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:
 - 1) This system is hopping pseudo-randomly.
 - 2) Each frequency is used equally on the average by each transmitter.
 - 3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
 - 4) The receiver shifts frequencies in synchronization with the transmitted signals.
- 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.
- 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

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3. Antenna requirement

Requirement of FCC part section 15.203:

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

Requirement of RSS-Gen Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

- The transmitter has permanently attached PCB printed Antenna (Internal antenna) on board.
- The E.U.T Complies with the requirement of §15.203, §15.247.

4. Summary of tests

FCC Part section(s)	Parameter	Test Condition	Test results
15.247(b)(1), (4)	Maximum peak output power	Conducted	Pass
15.247(a)(1)	Carrier frequency separation		Pass
15.247(a)(1)	20dB channel bandwidth		Pass
15.247(a)(iii) 15.247(b)(1)	Number of hopping channel		Pass
15.247(a)(iii)	Time of occupancy(dwel time)		Pass
15.207(a)	AC Conducted Emissions		Pass
15.247(d)	Conducted Spurious Emissions		Pass
15.205(a), 15.209(a)	Spurious emission	Radiated	Pass
	Band-edge, restricted band		Pass

Notes:

- All modes of operation and data rates were investigated. The test results shown in the following sections represent the worst case emissions.
- According to exploratory test no any obvious emission were detected from 9 kHz to 30 MHz. Although these tests were performed other than open field site, adequate comparison measurements were confirmed against 30 m open field site. Therefore sufficient tests were made to demonstrate that the alternative site produces results that correlate with the ones of tests made in an open field based on KDB 414788.
- The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z. It was determined that **X** orientation was worst-case orientation. Therefore, all final radiated testing was performed with the EUT in **X** orientation.
- The worst-case data rate were: BDR Packet type DH-1
EDR Packet type 3DH-1
- The test procedure(s) in this report were performed in accordance as following.
 - ANSI C63.10-2013
 - KDB 558074 D01 v05r02

5. Measurement uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of $k=2$ to indicated a 95 % level of confidence. The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and thus, can be compared directly to specified limits to determine compliance.

Parameter	Expanded uncertainty (\pm)	
Conducted RF power	0.9 dB	
Conducted spurious emissions	1.1 dB	
Radiated spurious emissions	9 kHz ~ 30 MHz:	2.4 dB
	30 MHz ~ 1 000 MHz	2.3 dB
	1 000 MHz ~ 18 000 MHz	5.6 dB
	Above 18 000 MHz	5.7 dB
Conducted emissions	9 kHz ~ 150 kHz	1.6 dB
	150 kHz ~ 30 MHz	1.7 dB

6. Measurement results explanation example

The offset level is set in the spectrum analyzer to compensate the RF cable loss factor between EUT conducted output port and spectrum analyzer.

With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Frequency (MHz)	Factor(dB)	Frequency (MHz)	Factor(dB)
30	13.09	10 000	20.48
100	13.32	11 000	20.62
200	13.52	12 000	20.76
300	13.52	13 000	21.07
400	13.79	14 000	21.56
500	14.05	15 000	21.86
600	14.21	16 000	21.70
700	14.44	17 000	21.58
800	14.55	18 000	22.09
900	14.94	19 000	22.06
1000	15.16	20 000	22.07
2 000	16.74	21 000	22.00
3 000	17.80	22 000	21.96
4 000	18.59	23 000	22.29
5 000	19.11	24 000	22.89
6 000	19.41	25 000	22.99
7 000	19.73	26 000	22.21
8 000	20.33	26 500	21.99
9 000	20.62		

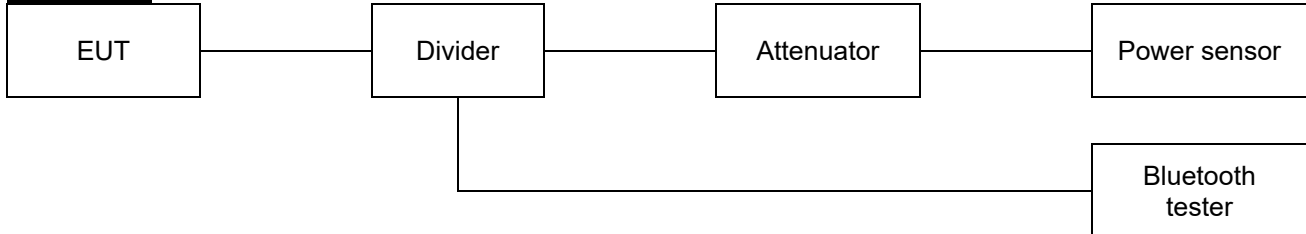
Note.

Offset(dB) = RF cable loss(dB) + Power Divider(dB)

7 Test results

7.1. Maximum peak output power

Test setup



Limit

According to §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 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.

According to §15.247(b)(1), for frequency hopping systems operating in the 2 400-2 483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725-5 850 MHz band: 1 watt. For all other frequency hopping systems in the 2 400-2 483.5 MHz band: 0.125 watts.

According to §15.247(b)(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Test procedure

ANSI C63.10-2013 - Section 7.8.5

Test settings

The test follows ANSI C63.10-2013 – Section 7.8.5. Using the power sensor instead of a spectrum analyzer.

Notes:

A peak responding power sensor is used, where the power sensor system video bandwidth is greater than the occupied bandwidth of the EUT.

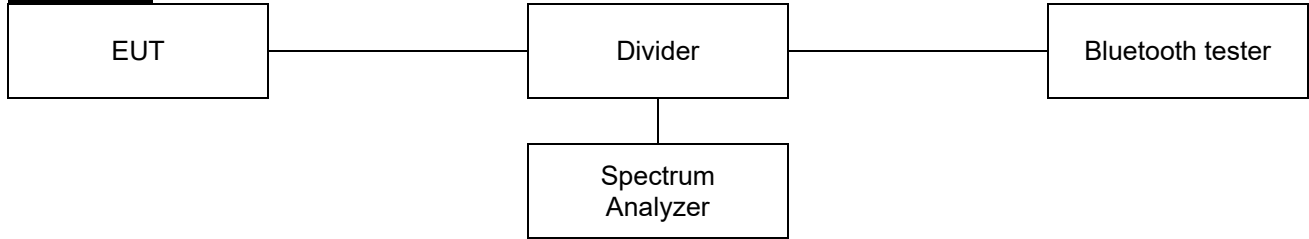
Test results

Frequency(MHz)	Data rate(Mbps)	Measured output power(dBm)		Limit(dBm)
		Peak	Average	
2 402	1	9.50	9.25	30.00
2 441	1	11.24	11.06	
2 480	1	10.48	10.26	
2 402	2	9.31	6.55	
2 441	2	10.85	8.15	
2 480	2	10.39	7.74	
2 402	3	9.55	6.57	
2 441	3	11.14	8.25	
2 480	3	10.51	7.66	



7.2. Carrier frequency separation

Test setup



Limit

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Test procedure

ANSI C63.10-2013 - Section 7.8.2

Test settings

- Span: Wide enough to capture the peaks of two adjacent channels.
- 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.
- Video (or average) bandwidth (VBW) \geq RBW.
- Sweep: Auto.
- Detector function: Peak.
- Trace: Max hold.
- Allow the trace to stabilize.

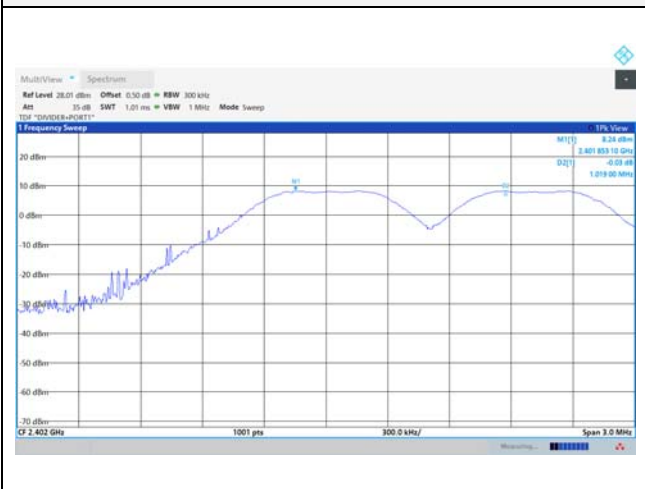
Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

Test results

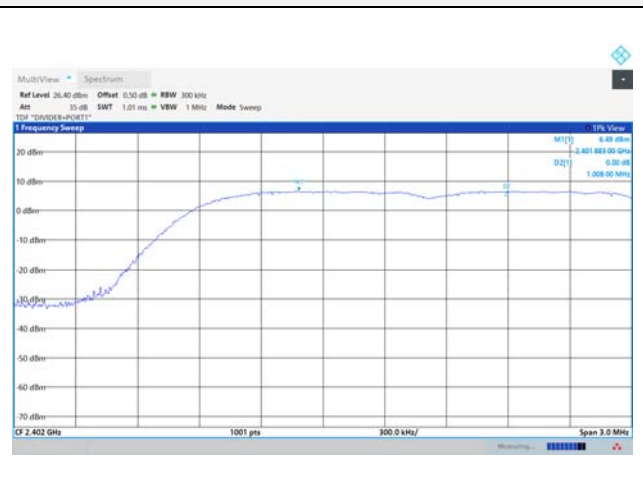
Frequency(MHz)	Data rate(Mbps)	Carrier frequency separation(MHz)	Limit(MHz)
2 402	1	1.019	0.706
2 441	1	0.984	0.706
2 480	1	1.007	0.706
2 402	3	1.000	0.886
2 441	3	1.000	0.886
2 480	3	1.000	0.886



GFSK / Low ch.



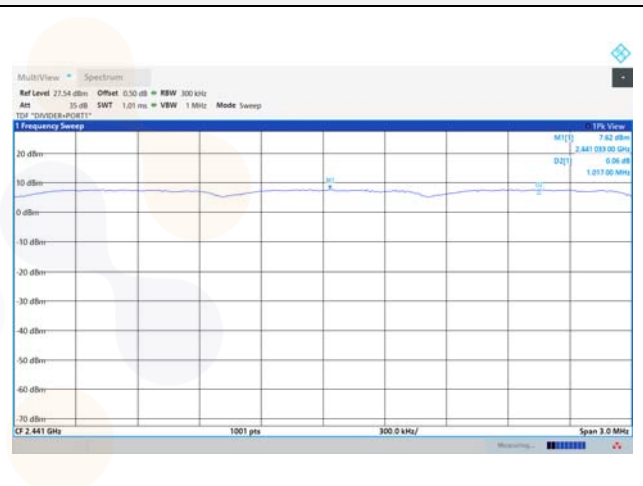
8DPSK / Low ch.



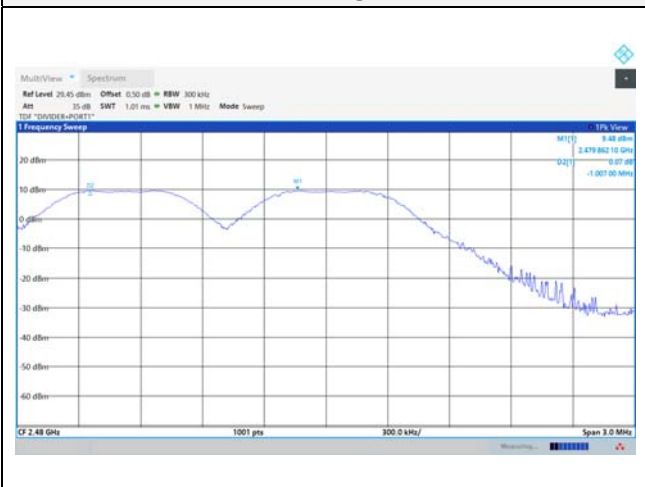
GFSK / Mid ch.



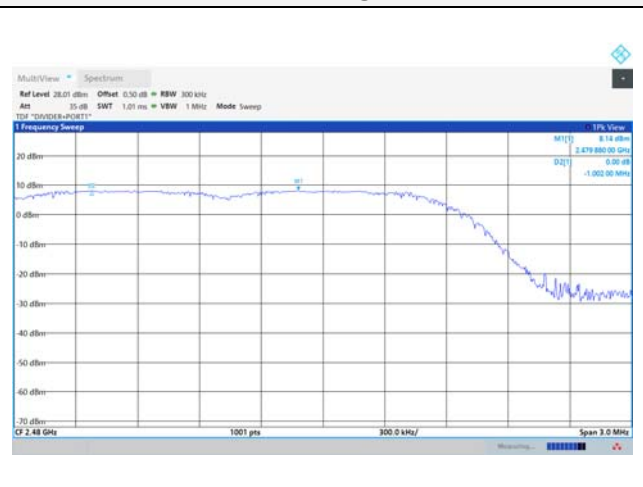
8DPSK / Mid ch.



GFSK / High ch.

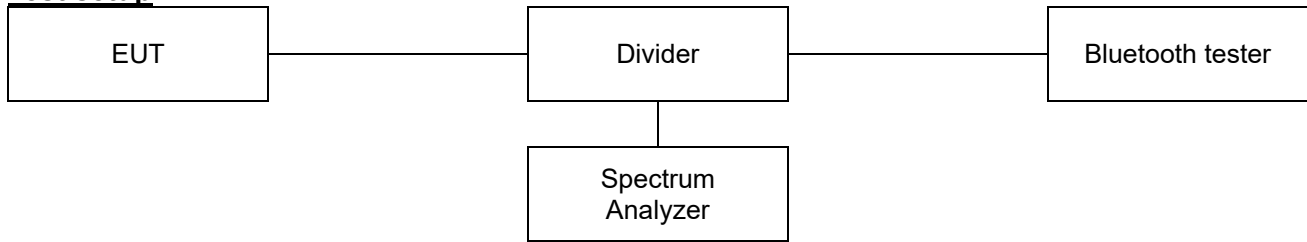


8DPSK / High ch.



7.3. 20dB channel bandwidth

Test setup



Limit

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Test procedure

ANSI C63.10-2013 - Section 6.9.2

Test settings

20dB channel bandwidth and Occupied bandwidth

The occupied bandwidth is measured as the width of the spectral envelope of the modulated signal, at an amplitude level reduced from a reference value by a specified ratio (or in decibels, a specified number of dB down from the reference value). Typical ratios, expressed in dB, are -6 dB, -20 dB, and -26 dB, corresponding to 6 dB BW, 20 dB BW, and 26 dB BW, respectively. In this subclause, the ratio is designated by “-xx dB.” The reference value is either the level of the unmodulated carrier or the highest level of the spectral envelope of the modulated signal, as stated by the applicable requirement. Some requirements might specify a specific maximum or minimum value for the “-xx dB” bandwidth; other requirements might specify that the “-xx dB” bandwidth be entirely contained within the authorized or designated frequency band.

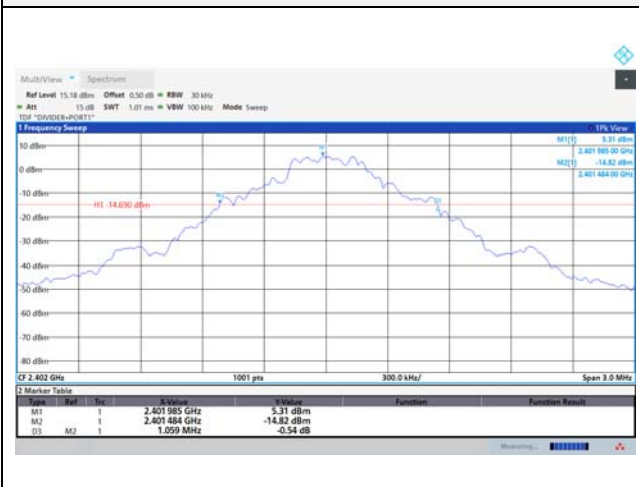
- a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency.
- b) Span: Two times and five times the OBW.
- c) RBW = 1 % to 5 % of the OBW and VBW $\geq 3 \times$ RBW
- d) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target “-xx dB down” requirement; that is, if the requirement calls for measuring the -20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.
- f) Detector: peak
- g) Trace mode: max hold.
- h) Allow the trace to stabilize.
- i) Determine the “-xx dB down amplitude” using ((reference value) - xx). Alternatively, this calculation may be made by using the marker-delta function of the instrument.
- j) If the reference value is determined by an unmodulated carrier, then turn the EUT modulation ON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
- k) Place two markers, one at the lowest frequency and the other at the highest frequency of the

envelope of the spectral display, such that each marker is at or slightly below the “-xx dB down amplitude” determined in step h). If a marker is below this “-xx dB down amplitude” value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the “-xx dB down amplitude” determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

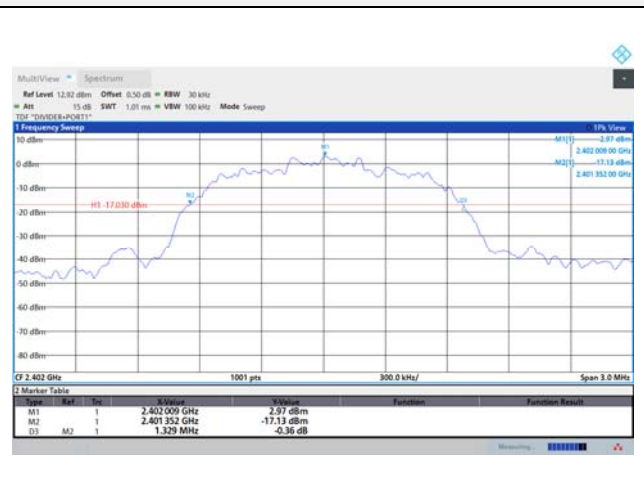
Test results

Frequency(MHz)	Data rate (Mbps)	20 dB Bandwidth (MHz)
2 402	1	1.059
2 441	1	1.059
2 480	1	1.059
2 402	3	1.329
2 441	3	1.329
2 480	3	1.329

GFSK / Low ch.



8DPSK / Low ch.



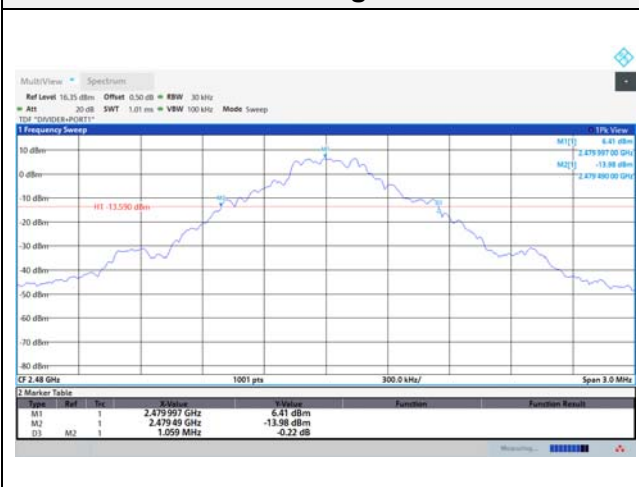
GFSK / Mid ch.



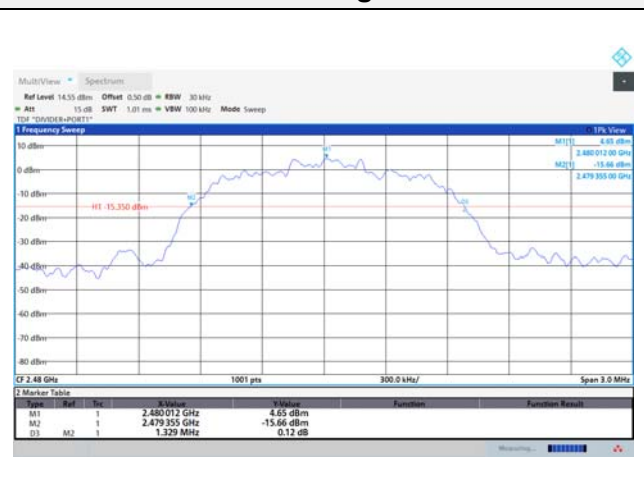
8DPSK / Mid ch.



GFSK / High ch.

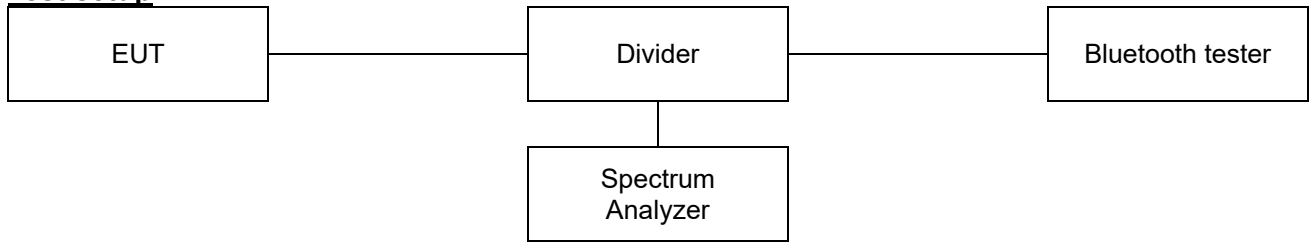


8DPSK / High ch.



7.4. Number of hopping channels

Test setup



Limit

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400-2 483.5 MHz band shall use at least 15 channels.

Test procedure

ANSI C63.10-2013 - Section 7.8.3

Test settings

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW: To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW \geq RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

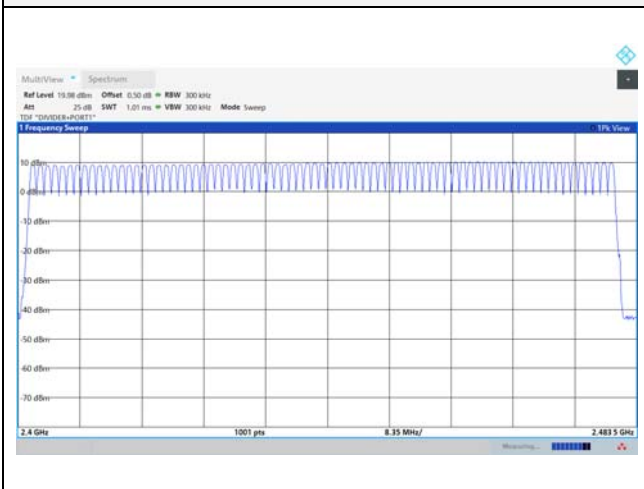
Test results

Mode	Number of hopping channel	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

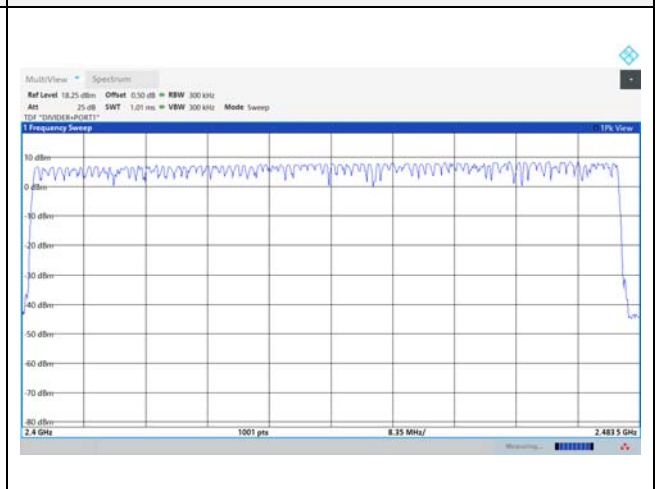
Notes:

In case of AFH mode, minimum number of hopping channels is 20.

GFSK

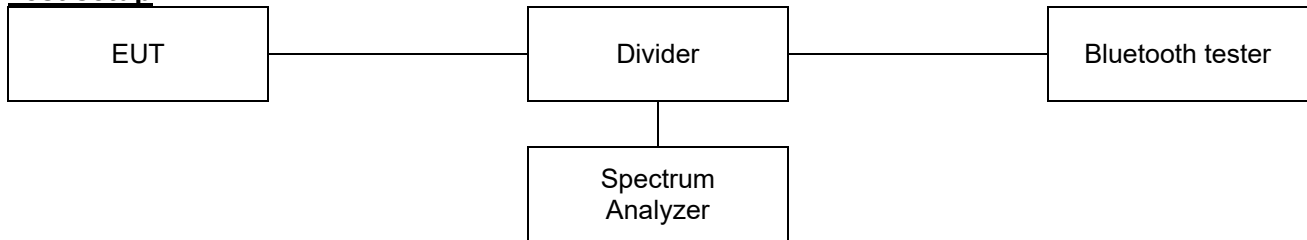


8DPSK



7.5. Time of occupancy(Dwell time)

Test setup



Limit

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400-2 483.5 MHz band shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test procedure

ANSI C63.10-2013 - Section 7.8.4

Test settings

- Span: Zero span, centered on a hopping channel.
- RBW \leq channel spacing and $\gg 1 / T$, where T is the expected dwell time per channel.
- 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. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- Detector function: Peak.
- Trace: Max hold.
- Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Test results

- Non-AFH

Modulation	Frequency (MHz)	Pulse Width (ms)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.383	800.000	79	0.123	0.400
DH3		1.640	400.000		0.262	
DH5		2.888	266.667		0.308	
3-DH1		0.389	800.000		0.124	
3-DH3		1.640	400.000		0.262	
3-DH5		2.891	266.667		0.308	

- AFH

Modulation	Frequency (MHz)	Pulse Width (ms)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.383	400.000	20	0.061	0.400
DH3		1.630	200.000		0.130	
DH5		2.888	133.333		0.154	
3-DH1		0.389	400.000		0.062	
3-DH3		1.640	200.000		0.131	
3-DH5		2.891	133.333		0.154	

Notes:

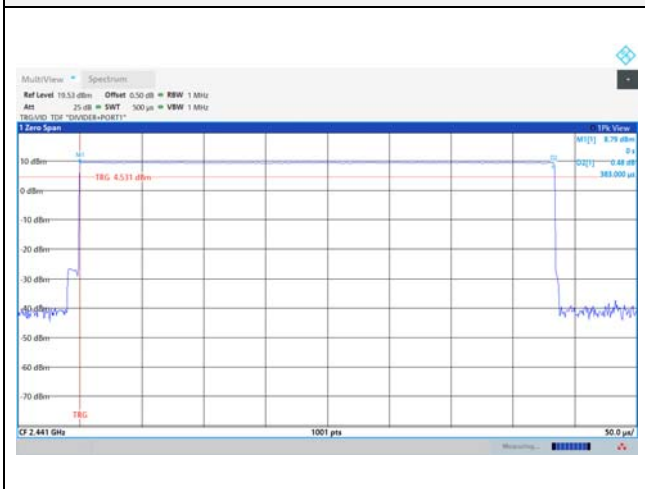
1. Non-AFH

- Period Time: 0.4 sec x 79 channels = 31.6 sec
- Result (s)= (Hopping rate (hop/s/slot) / 79 channels) x 31.6 sec x Pulse width (ms)

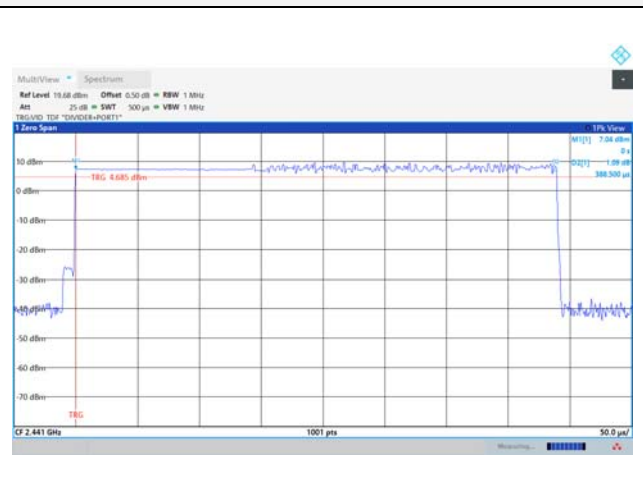
2. AFH

- Period Time: 0.4 sec x 20 channels = 8 sec
- Result (s)= (Hopping rate (hop/s/slot) / 20 channels) x 8 sec x Pulse width (ms)

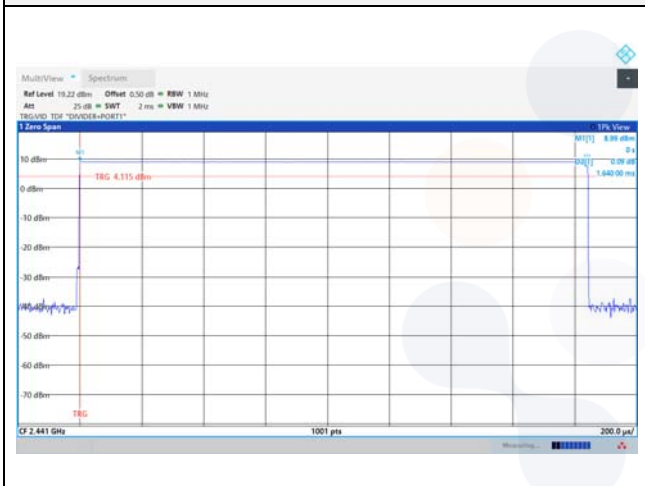
GFSK / DH1



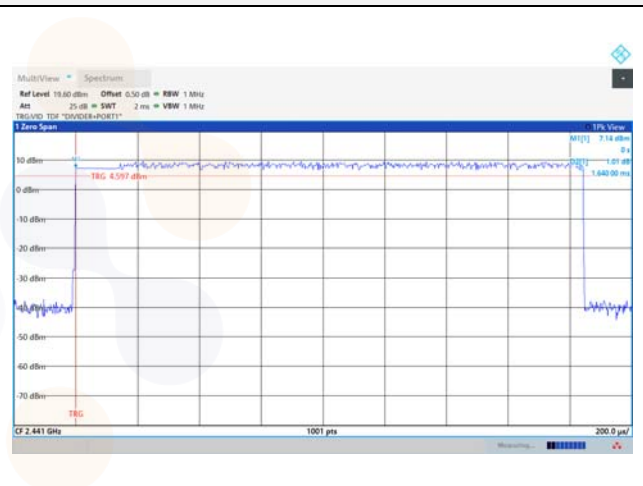
8DPSK / 3-DH1



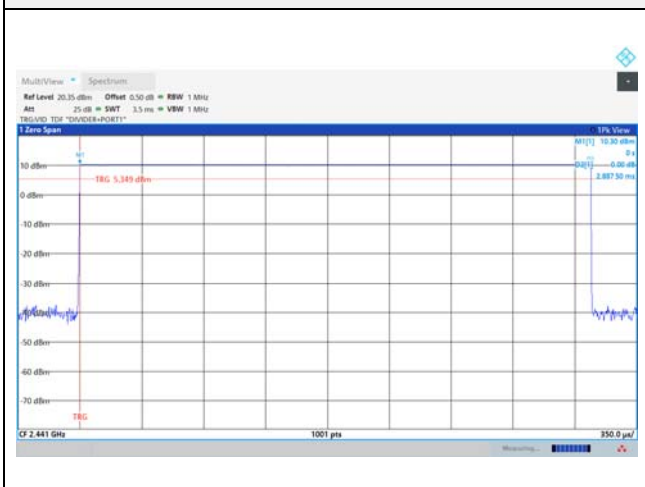
GFSK / DH3



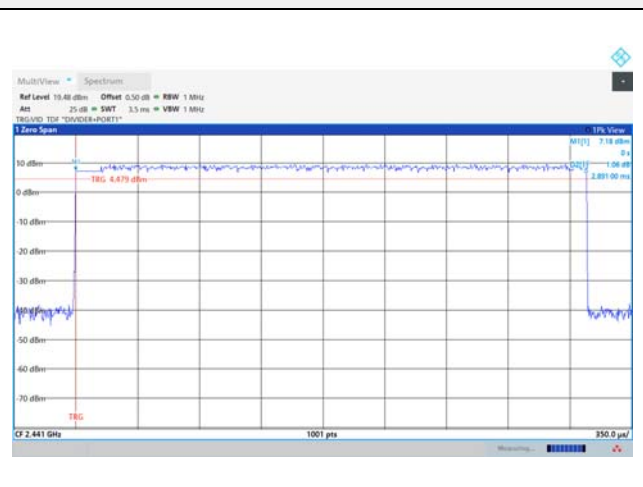
8DPSK / 3-DH3



GFSK / DH5



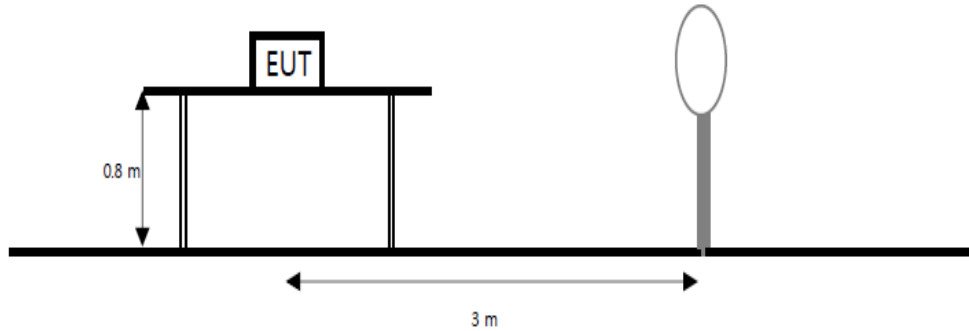
8DPSK / 3-DH5



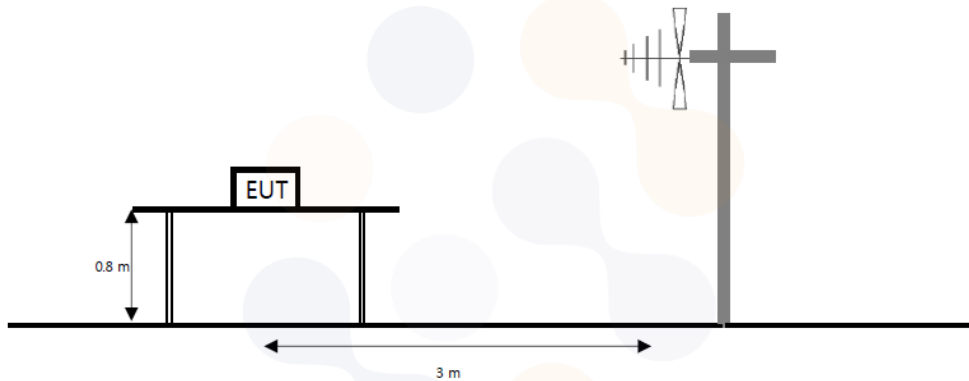
7.6. Radiated spurious emissions & band edge

Test setup

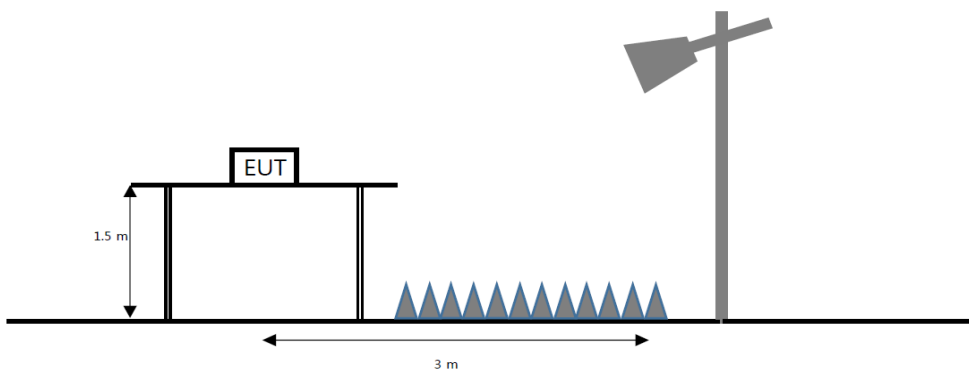
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions



The diagram below shows the test setup that is utilized to make the measurements for emission from 30 MHz to 1 GHz emissions.



The diagram below shows the test setup that is utilized to make the measurements for emission from 1 GHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz emissions, whichever is lower.



Limit

According to section 15.209(a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength ($\mu\text{V}/\text{m}$)	Measurement distance (m)
0.009 - 0.490	2 400/F(kHz)	300
0.490 - 1.705	24 000/F(kHz)	30
1.705 - 30	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., Section 15.231 and 15.241.

According to section 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.009 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
0.495 - 0.505	16.694 75 - 16.695 25	608 - 614	5.35 - 5.46
2.173 5 - 2.190 5	16.804 25 - 16.804 75	960 - 1 240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1 300 - 1 427	8.025 - 8.5
4.177 25 - 4.177 75	37.5 - 38.25	1 435 - 1 626.5	9.0 - 9.2
4.207 25 - 4.207 75	73 - 74.6	1 645.5 - 1 646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1 660 - 1 710	10.6 - 12.7
6.267 75 - 6.268 25	108 - 121.94	1 718.8 - 1 722.2	13.25 - 13.4
6.311 75 - 6.312 25	123 - 138	2 200 - 2 300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2 310 - 2 390	15.35 - 16.2
8.362 - 8.366	156.524 75 - 156.525	2 483.5 - 2 500	17.7 - 21.4
8.376 25 - 8.386 75	25	2 690 - 2 900	22.01 - 23.12
8.414 25 - 8.414 75	156.7 - 156.9	3 260 - 3 267	23.6 - 24.0
12.29 - 12.293	162.012 5 - 167.17	3 332 - 3 339	31.2 - 31.8
12.519 75 - 12.520 25	167.72 - 173.2	3 345.8 - 3 358	36.43 - 36.5
12.576 75 - 12.577 25	240 - 285	3 600 - 4 400	Above 38.6
13.36 - 13.41	322 - 335.4		

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in section 15.209. At frequencies equal to or less than 1 000 MHz, compliance with the limits in section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1 000 MHz, compliance with the emission limits in section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in section 15.35 apply to these measurements.

Test procedure

ANSI C63.10-2013

Test settings

Peak field strength measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = as specified in table
3. VBW \geq (3 \times RBW)
4. Detector = peak
5. Sweep time = auto
6. Trace mode = max hold
7. Allow sweeps to continue until the trace stabilizes

Table. RBW as a function of frequency

Frequency	RBW
9 kHz to 150 kHz	200 Hz to 300 Hz
0.15 MHz to 30 MHz	9 kHz to 10 kHz
30 MHz to 1 000 MHz	100 kHz to 120 kHz
> 1 000 MHz	1 MHz

Average field strength measurements

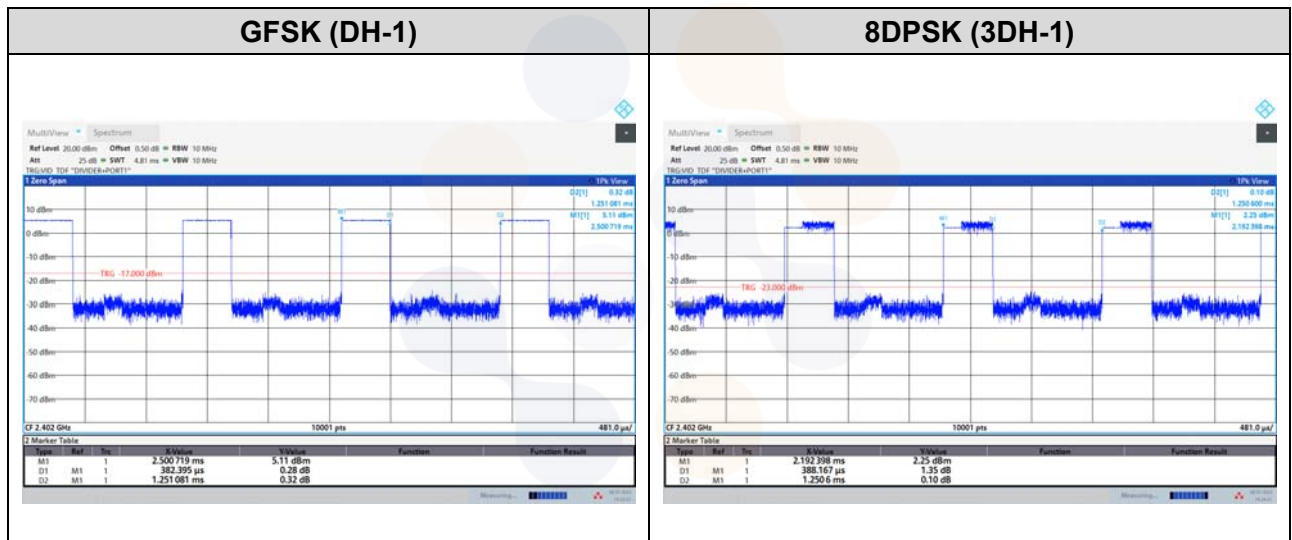
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1 MHz
3. VBW = 1/T \geq 1 Hz
4. Averaging type was set to RMS to ensure that video filtering was applied in the power domain
5. Detector = peak
6. Sweep time = auto
7. Trace mode = max hold
8. Trace was allowed to run for at least 50 times(1/duty cycle) traces

Notes:

- The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and the video bandwidth is 3 kHz($\geq 1/T$) for Average detection (AV) at frequency above 1 GHz.

According to ANSI C63.10-2013, for average measurement during radiation test, Reduced VBW shall be greater than $[1/(\text{minimum transmitter on time})]$ and no less than 1 Hz.

Test mode	Period (ms)	On time (ms)	Reduced VBW (Hz)
GFSK	1.251 1	0.382 4	2 615.062 8
8DPSK	1.250 6	0.388 2	2 575.991 8



- $f < 30$ MHz, extrapolation factor of 40 dB/decade of distance. $F_d = 40 \log(D_m/D_s)$
 $f \geq 30$ MHz, extrapolation factor of 20 dB/decade of distance. $F_d = 20 \log(D_m/D_s)$

Where:

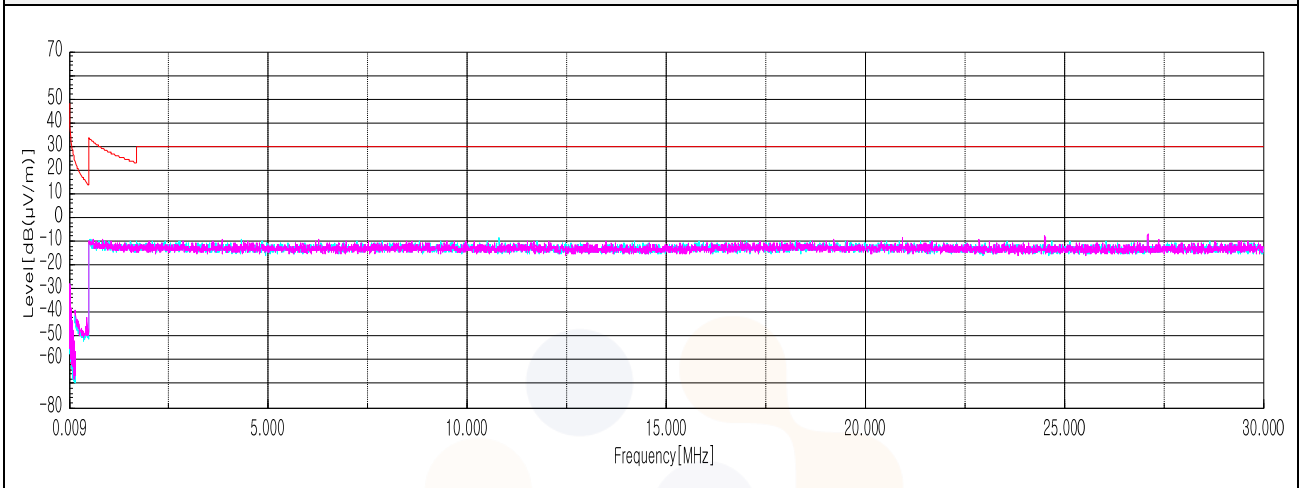
- F_d = Distance factor in dB
- D_m = Measurement distance in meters
- D_s = Specification distance in meters

- Factors(dB) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
- The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
- Average test would be performed if the peak result were greater than the average limit.
- 1) means restricted band.

Test results (Below 30 MHz) – Worst case: GFSK 2 441 MHz

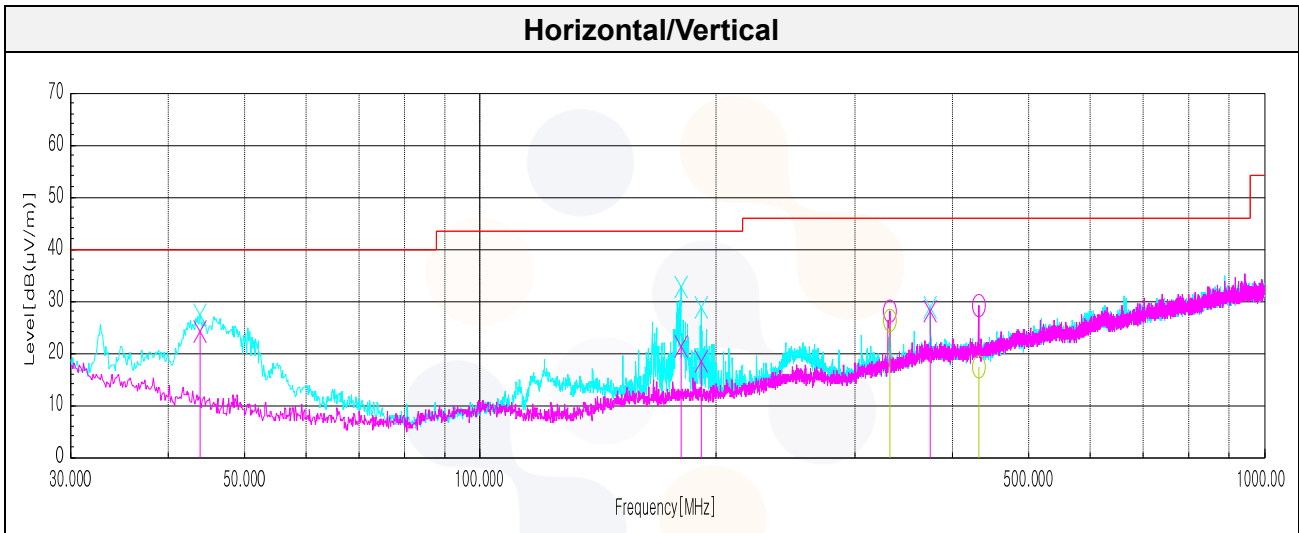
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Distance Factor	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
No spurious emissions were detected within 20 dB of the limit.								

Horizontal/Vertical



Test results (Below 1 000 MHz) – Worst case: GFSK 2 441 MHz

Frequency (MHz)	Pol. (V/H)	Reading (dB(μ V))	Ant. Factor (dB)	Amp. + Cable (dB)	Result (dB(μ V/m))	Limit (dB(μ V/m))	Margin (dB)
Quasi peak data							
43.94	V	38.20	16.02	-30.07	24.15	40.00	15.85
180.23	V	32.30	16.28	-27.31	21.27	43.50	22.23
191.51	V	29.20	16.50	-27.16	18.54	43.50	24.96
332.76 ¹⁾	H	30.90	20.60	-25.38	26.12	46.00	19.88
375.08	V	30.30	22.70	-24.80	28.20	46.00	17.80
431.70	H	18.90	22.70	-24.29	17.31	46.00	28.69

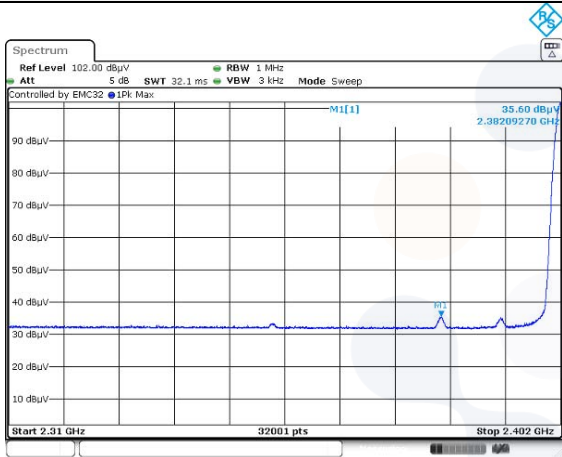


Test results (Above 1 000 MHz)

GFSK Low Channel

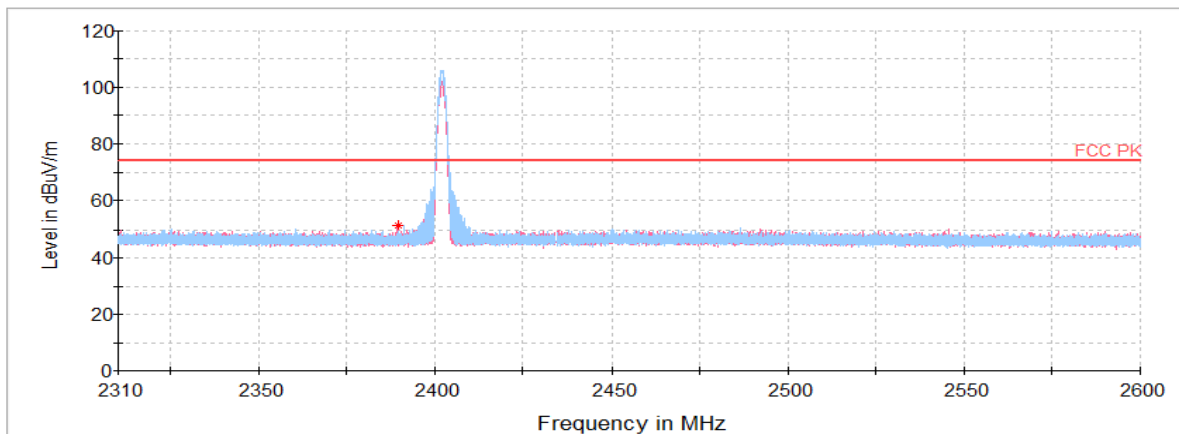
Frequency (MHz)	Pol. (V/H)	Reading (dB(μV))	Ant. Factor (dB)	Amp. + Cable (dB)	Result (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
Peak data							
2 382.09 ¹⁾	H	46.17	31.94	-26.76	51.35	74.00	22.65
4 804.09 ¹⁾	H	65.00	33.64	-53.47	45.17	74.00	28.83
7 205.66	V	65.43	35.42	-51.51	49.34	74.00	24.66
Average Data							
2 382.09 ¹⁾	H	35.60	31.94	-26.76	40.78	54.00	13.22

cAverage data

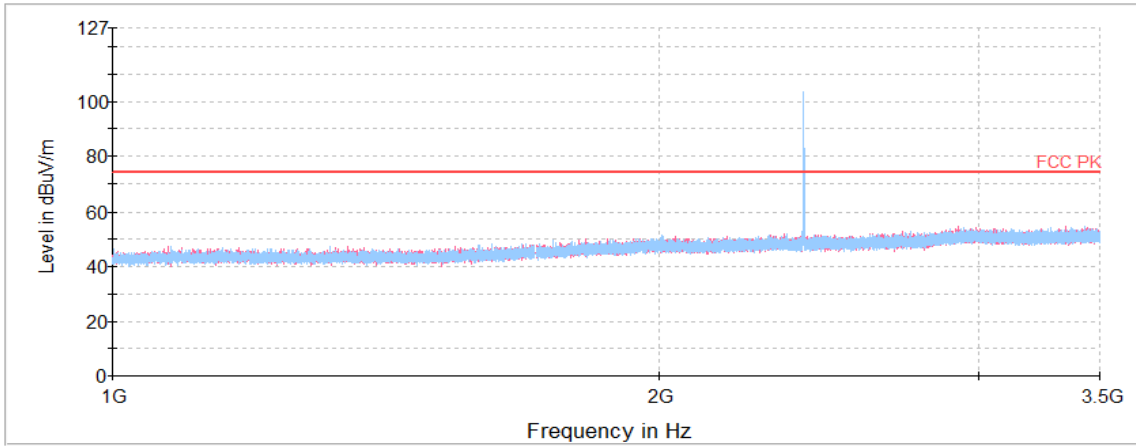


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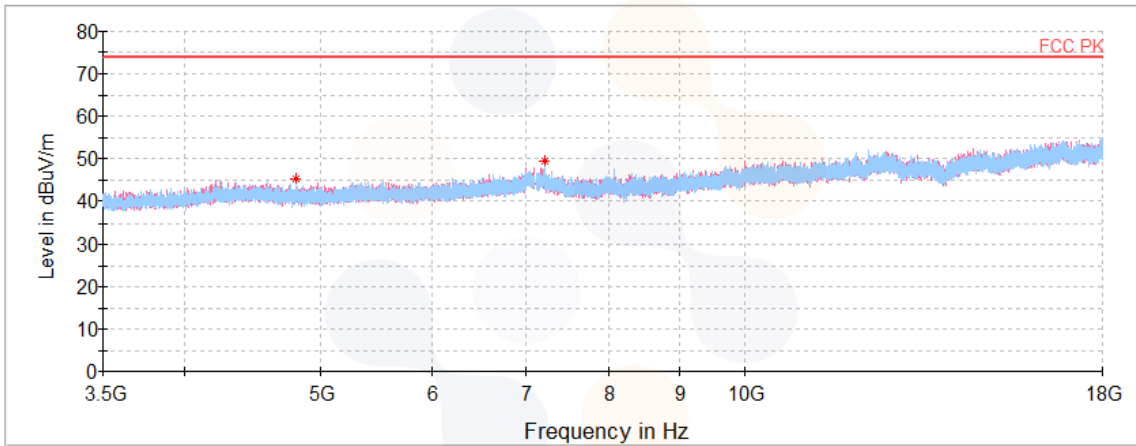
Horizontal/Vertical for Band-edge



Horizontal/Vertical for 1 GHz ~ 3.5 GHz



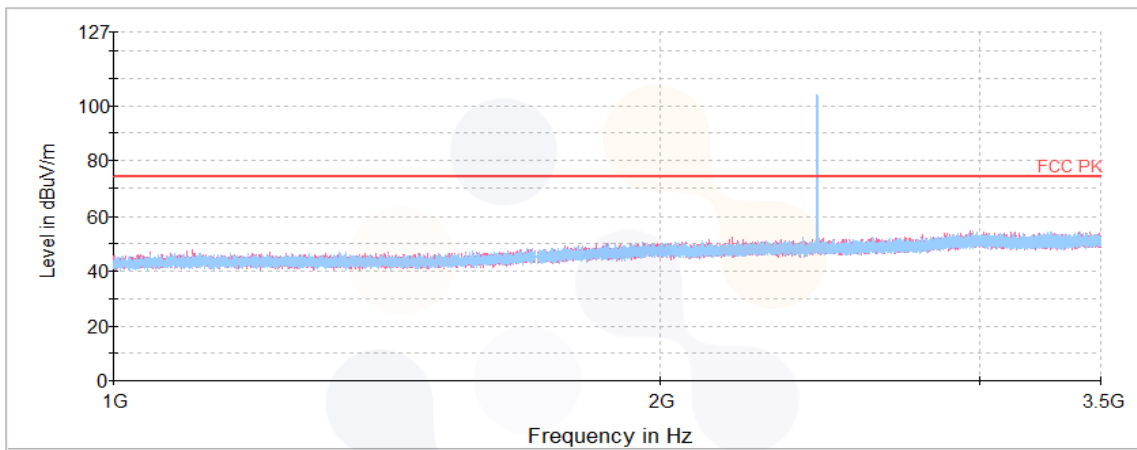
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



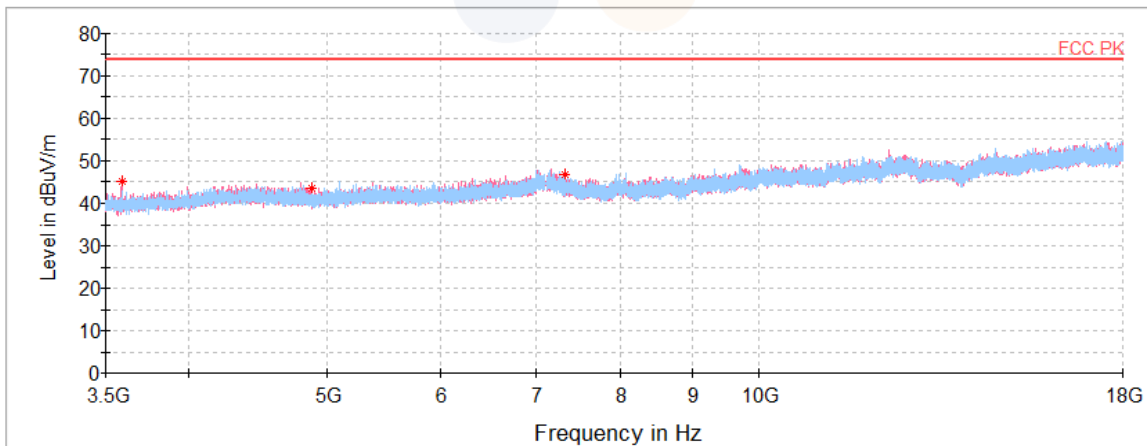
GFSK_Mid Channel

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data							
3 596.06	V	66.75	33.16	-54.77	45.14	74.00	28.86
4 882.48 ¹⁾	H	63.17	33.62	-53.49	43.30	74.00	30.70
7 322.56 ¹⁾	V	63.11	35.37	-51.98	46.50	74.00	27.50
Average Data							
No spurious emissions were detected within 20 dB of the limit.							

Horizontal/Vertical for 1 GHz ~ 3.5 GHz



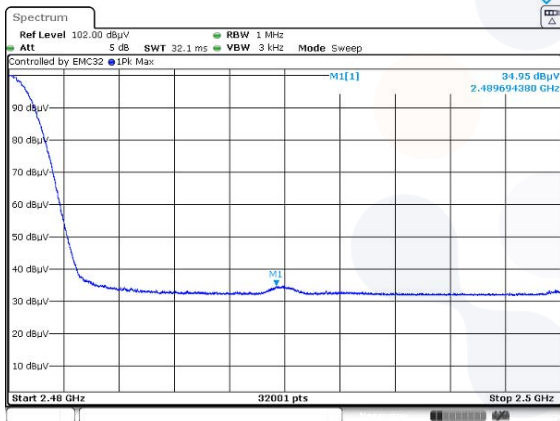
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



GFSK_High Channel

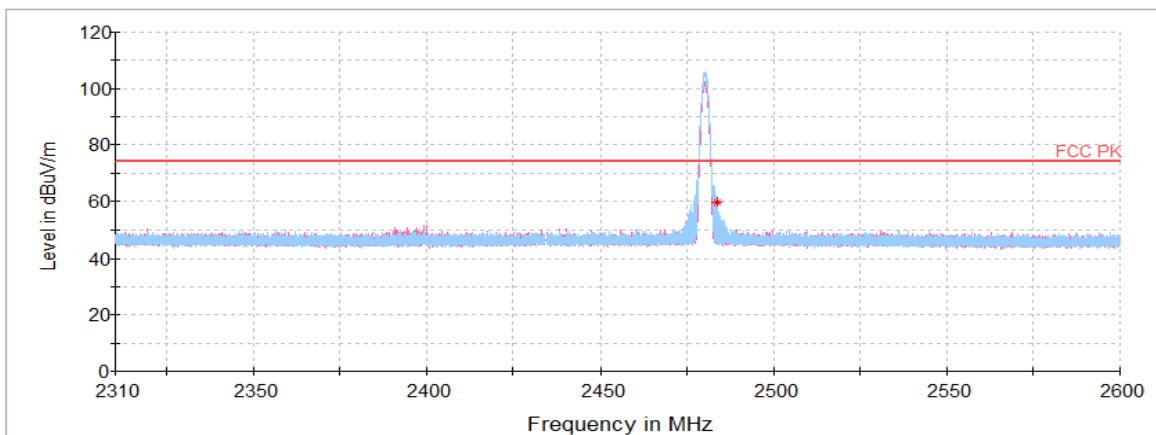
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data							
2 489.69 ¹⁾	H	54.08	32.18	-26.87	59.39	74.00	14.61
3 587.91	H	66.10	33.15	-54.78	44.47	74.00	29.53
4 791.41 ¹⁾	V	66.29	33.64	-53.46	46.47	74.00	27.53
4 962.69 ¹⁾	H	62.85	33.61	-53.34	43.12	74.00	30.88
5 307.97	V	64.18	34.22	-52.40	46.00	74.00	28.00
7 424.52 ¹⁾	V	62.41	35.33	-52.39	45.35	74.00	28.65
Average Data							
2 489.69 ¹⁾	H	34.95	32.18	-26.87	40.26	54.00	13.74

Average data

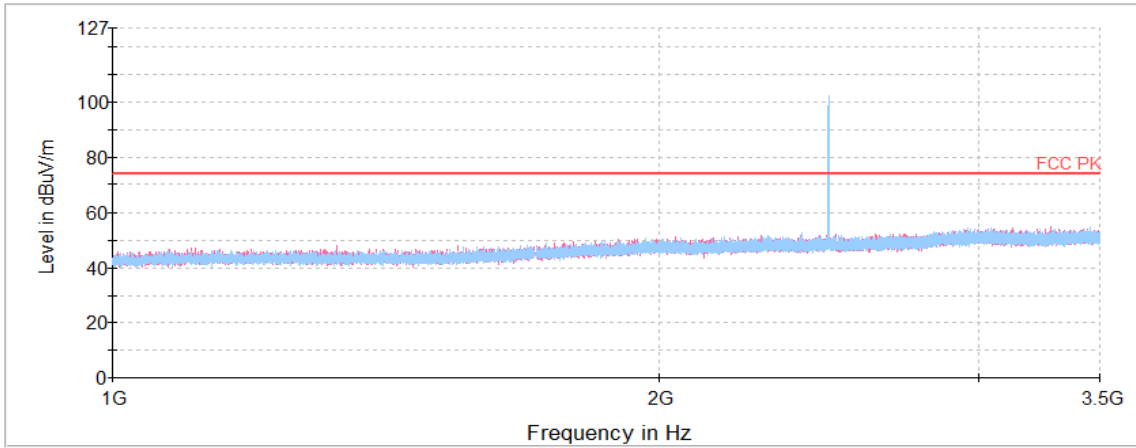


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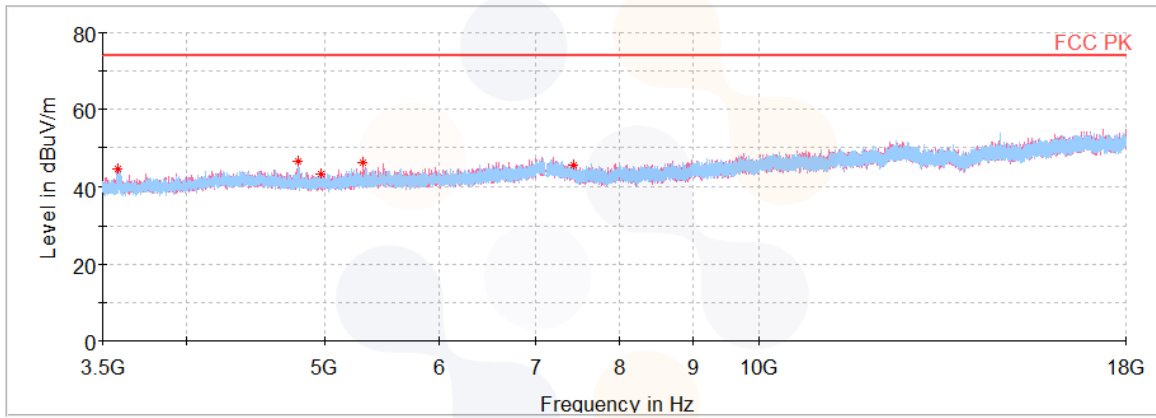
Horizontal/Vertical for Band-edge



Horizontal/Vertical for 1 GHz ~ 3.5 GHz



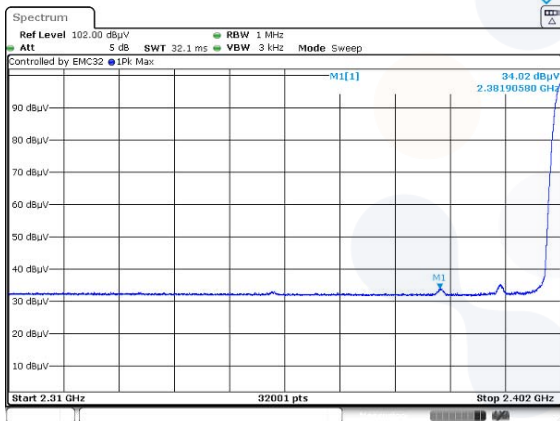
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



8DPSK Low Channel

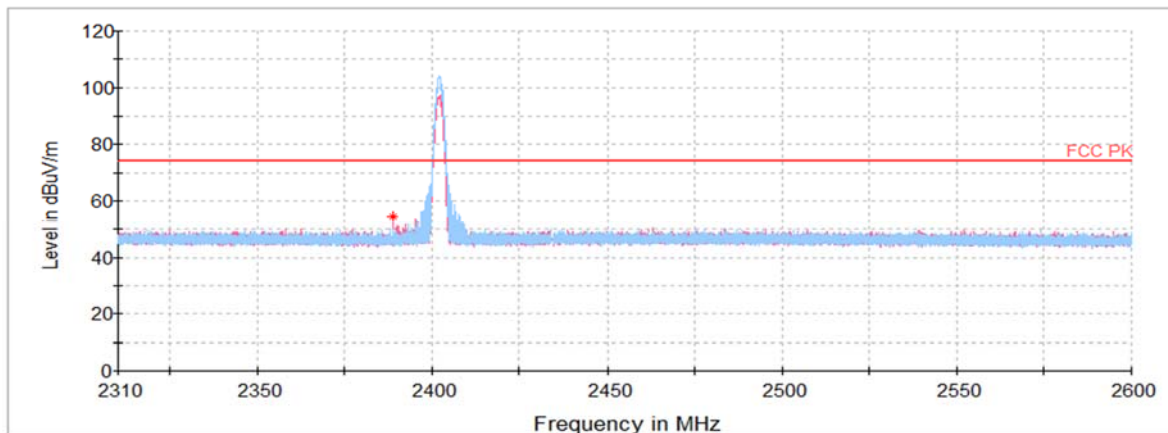
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data							
1 332.34 ¹⁾	V	68.60	27.73	-47.96	48.37	74.00	25.63
2 381.91 ¹⁾	H	49.55	31.94	-26.76	54.73	74.00	19.27
3 592.44	V	67.16	33.16	-54.77	45.55	74.00	28.45
4 804.09 ¹⁾	H	64.30	33.64	-53.47	44.47	74.00	29.53
6 663.72	V	64.18	35.37	-51.43	48.12	74.00	25.88
7 081.95	V	65.66	35.47	-51.01	50.12	74.00	23.88
Average Data							
2 381.91 ¹⁾	H	34.02	31.94	-26.76	39.20	54.00	14.80

Average data

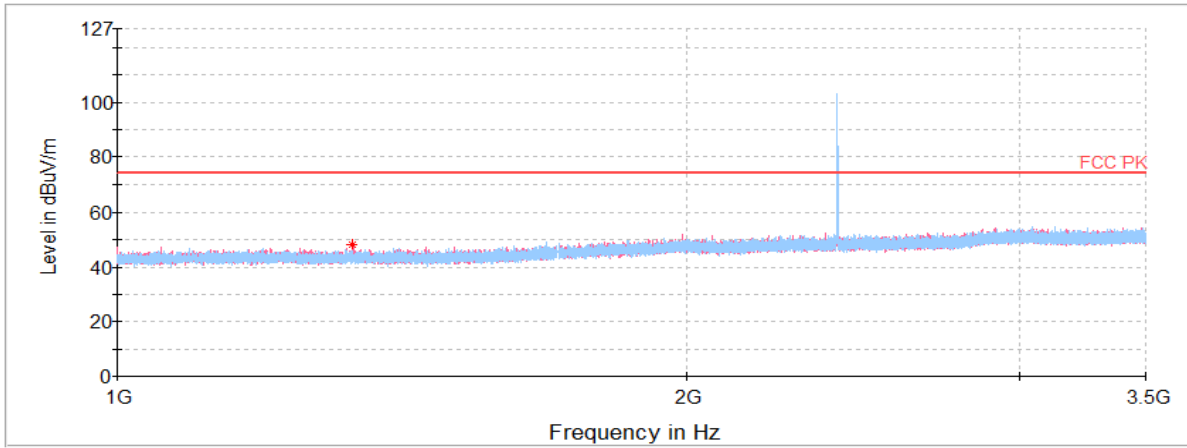


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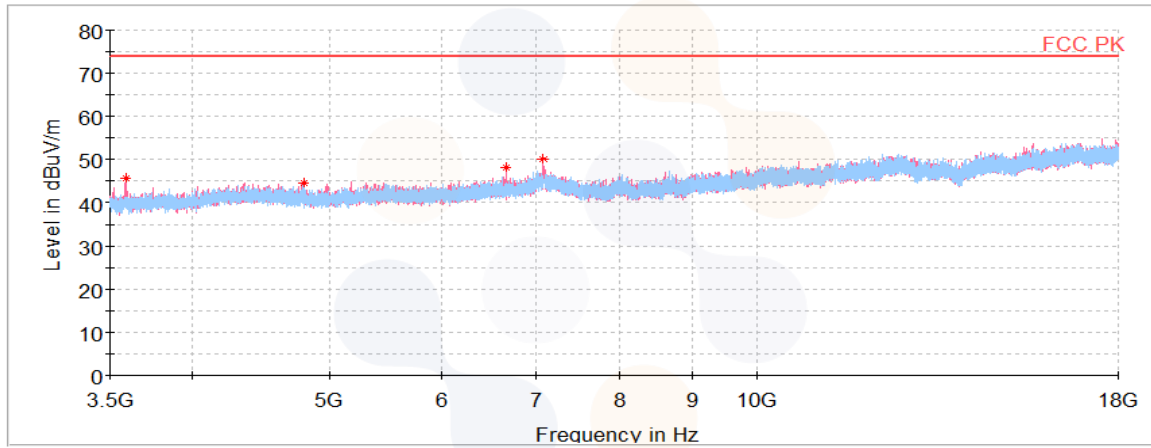
Horizontal/Vertical for Band-edge



Horizontal/Vertical for 1 GHz ~ 3.5 GHz



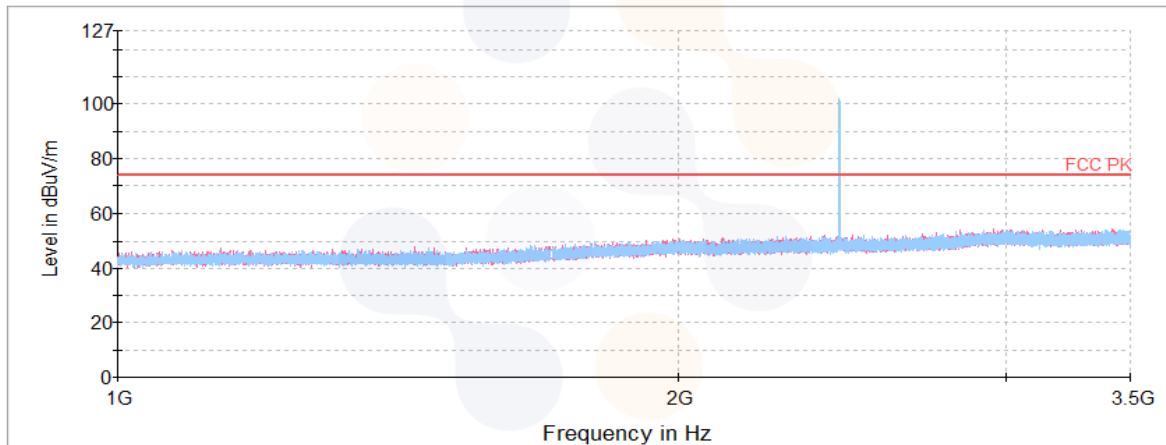
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



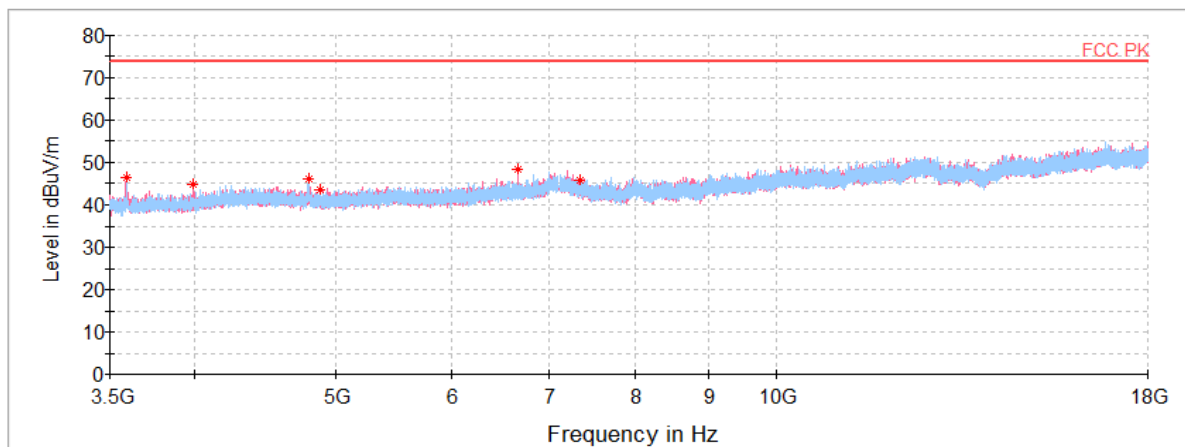
8DPSK_Mid Channel

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/m))	(dB)
Peak data							
3 594.70	V	67.86	33.16	-54.77	46.25	74.00	27.75
3 993.00 ¹⁾	V	65.20	33.40	-53.94	44.66	74.00	29.34
4 792.77 ¹⁾	V	65.72	33.64	-53.46	45.90	74.00	28.10
4 882.03 ¹⁾	V	63.36	33.62	-53.49	43.49	74.00	30.51
6 665.53	V	64.19	35.37	-51.43	48.13	74.00	25.87
7 333.89 ¹⁾	H	62.22	35.37	-52.03	45.56	74.00	28.44
Average Data							
No spurious emissions were detected within 20 dB of the limit.							

Horizontal/Vertical for 1 GHz ~ 3.5 GHz



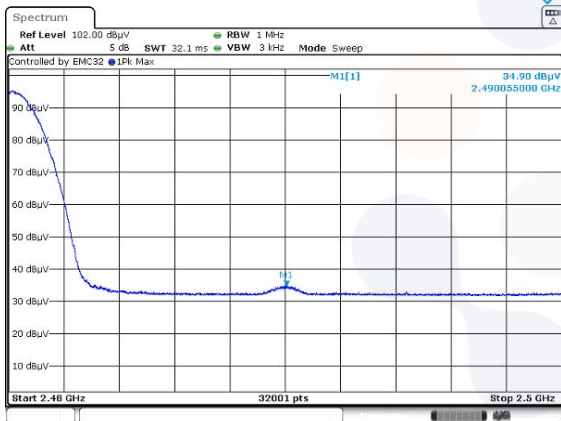
Horizontal/Vertical for 3.5 GHz ~ 18 GHz



8DPSK_High Channel

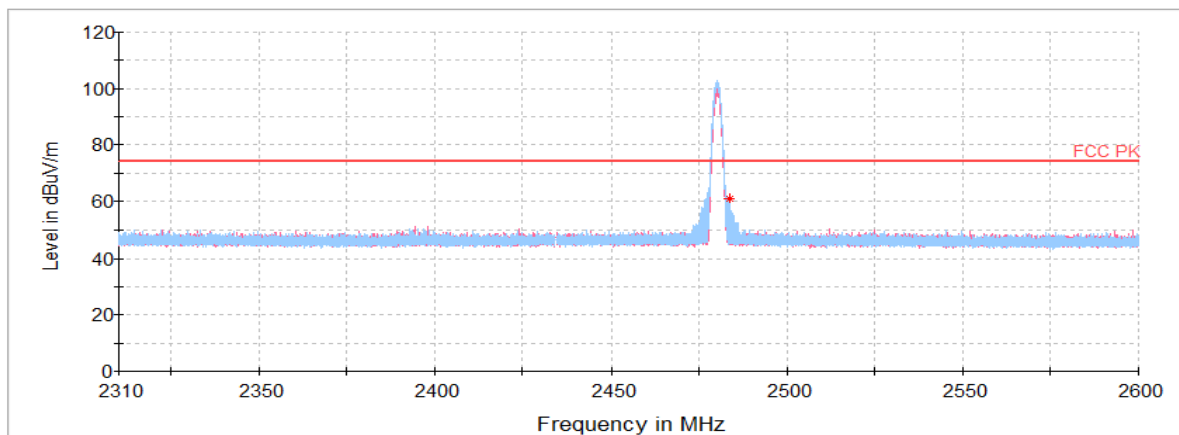
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data							
1 332.03 ¹⁾	V	70.26	27.73	-47.96	50.03	74.00	23.97
2 490.06 ¹⁾	H	55.39	32.18	-26.87	60.70	74.00	13.30
3 584.73	V	68.87	33.15	-54.78	47.24	74.00	26.76
4 787.33 ¹⁾	V	64.66	33.64	-53.46	44.84	74.00	29.16
4 961.33 ¹⁾	V	62.67	33.61	-53.34	42.94	74.00	31.06
7 377.84 ¹⁾	H	63.14	35.35	-52.20	46.29	74.00	27.71
Average Data							
2 490.06 ¹⁾	H	34.90	32.18	-26.87	40.21	54.00	13.79

Average data

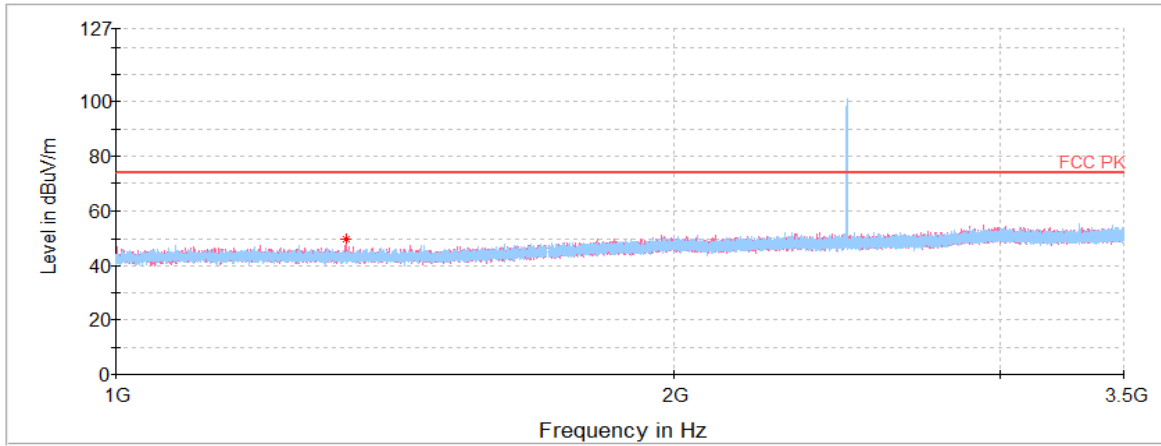


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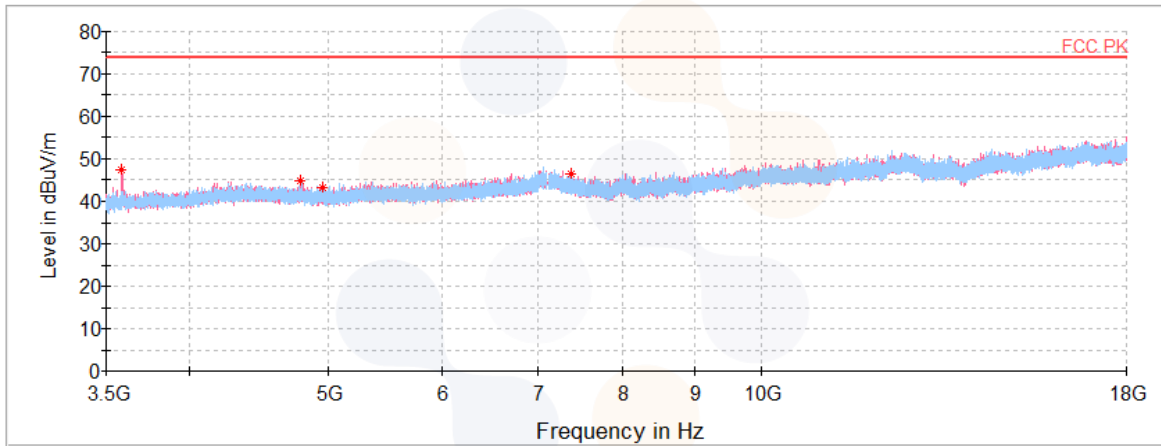
Horizontal/Vertical for Band-edge



Horizontal/Vertical for 1 GHz ~ 3.5 GHz

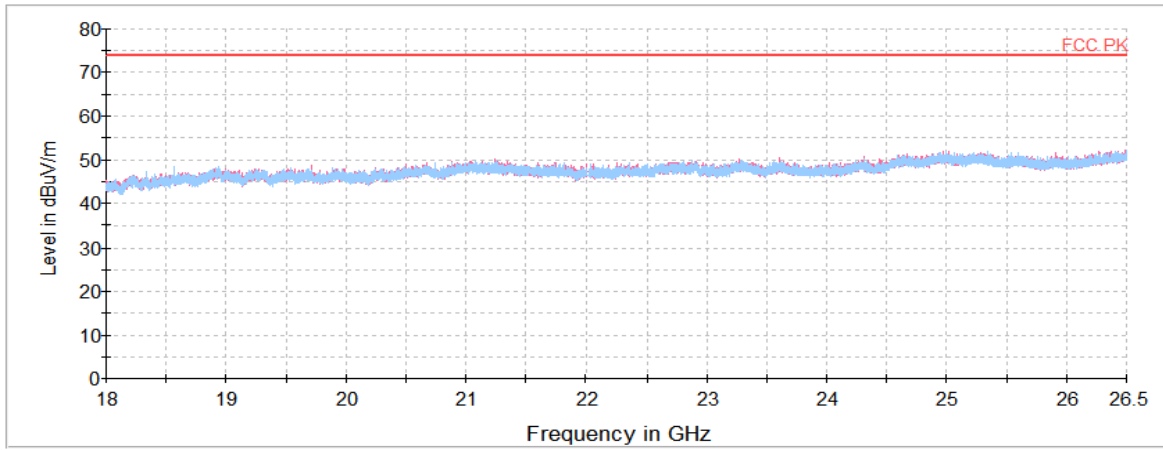


Horizontal/Vertical for 3.5 GHz ~ 18 GHz



Test results (Above 18 GHz) – Worst case: 8DPSK 2 480 MHz

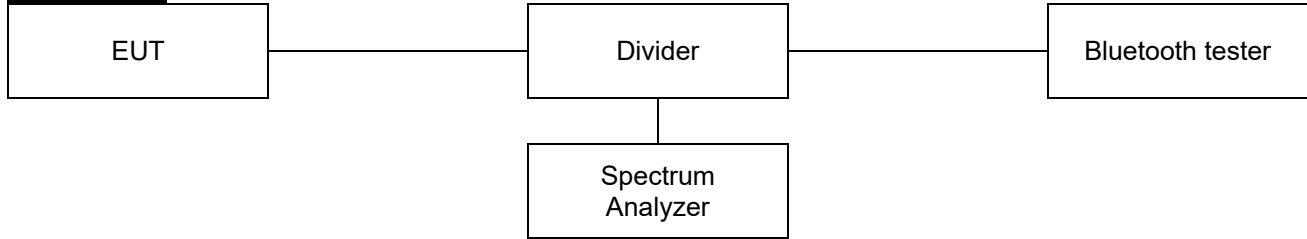
Horizontal/Vertical for 18 GHz ~ 26.5 GHz



Note: The Worst case was based on the lowest margin condition considering Harmonic and Spurious Emission

7.7. Conducted Spurious Emission

Test setup



Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operation, 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation specified in §15.209(a) is not required. In addition, radiated emission limits specified in §15.209(a) (see §15.205(c)).

Limit : 20 dBc

Test procedure

ANSI C63.10-2013 - Section 6.10.4, 7.8.8

Test settings

▪ Band-edge

- 1) Span : Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
- 2) Reference level : As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log(\text{OBW}/\text{RBW})]$ below the reference level.
- 3) Attenuation: Auto (at least 10 dB preferred)
- 4) Sweep time = Coupled
- 5) RBW : 100 kHz
- 6) VBW : 300 kHz
- 7) Detector : Peak
- 8) Trace : Max hold

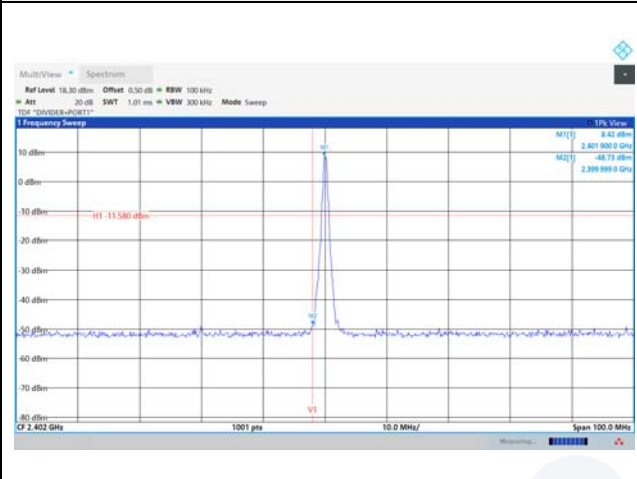
▪ Spurious emissions

- 1) Span : 30 MHz to 10 times the operating frequency in GHz
- 2) RBW : 100 kHz
- 3) VBW : 300 kHz
- 4) Sweep time : Coupled
- 5) Detector : Peak

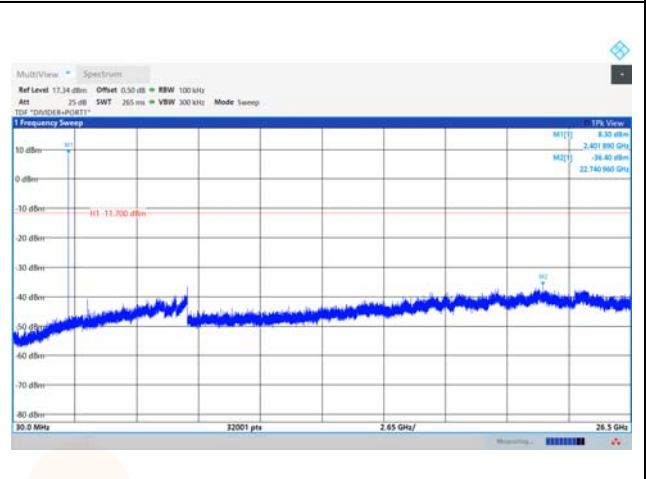
Test results

GFSK

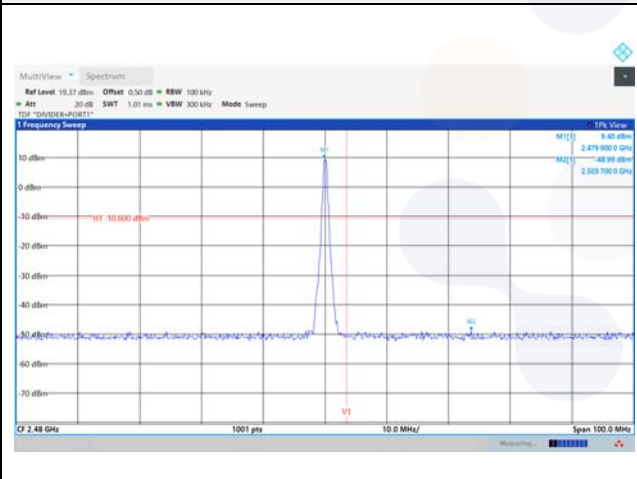
Conducted band-edge / Low ch.



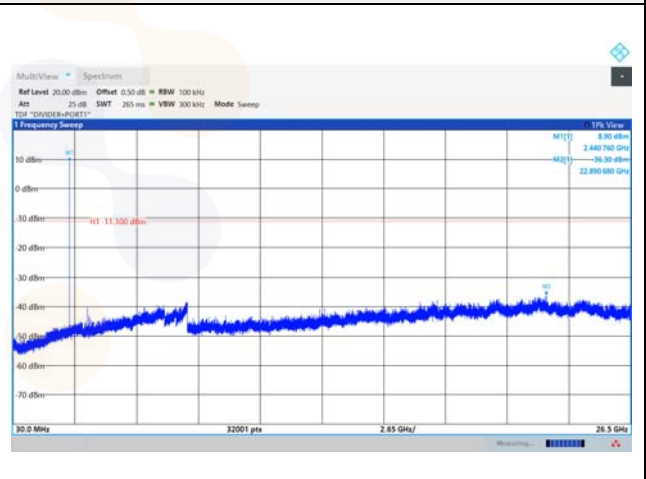
Conducted spurious / Low ch.



Conducted band-edge / High ch.



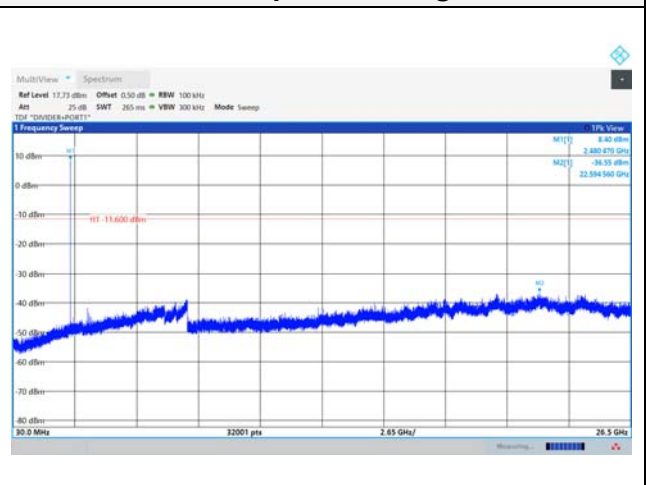
Conducted spurious / Mid ch.



Conducted band-edge / Hopping ch.

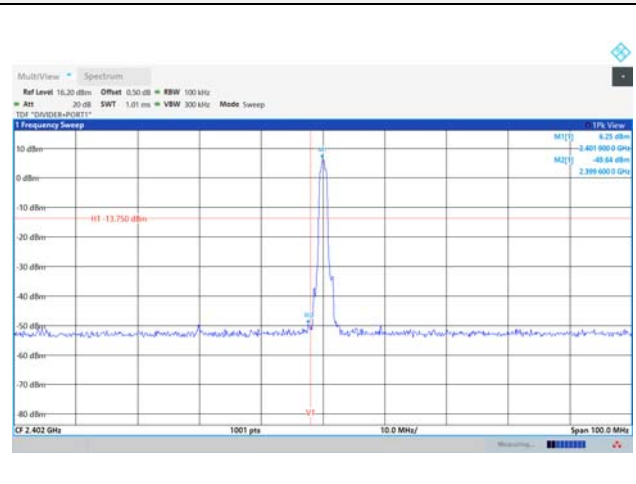


Conducted spurious / High ch.

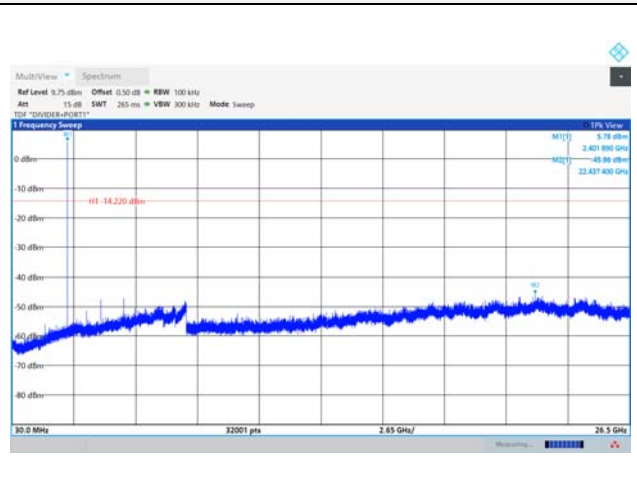


8DPSK

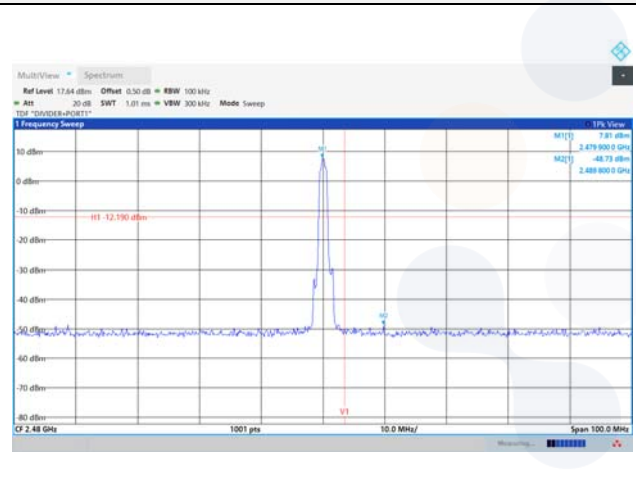
Conducted band-edge / Low ch.



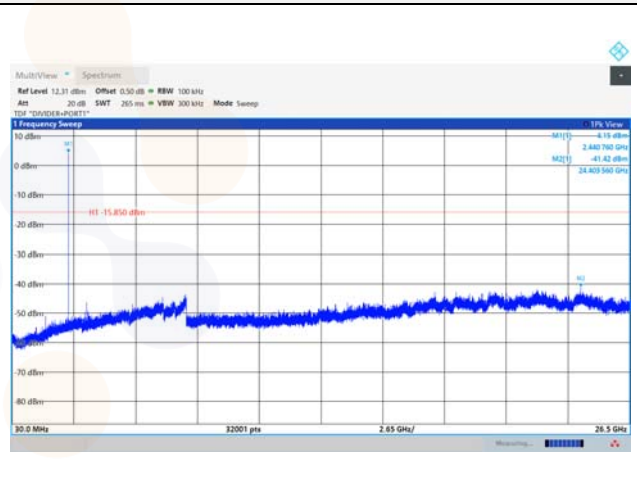
Conducted spurious / Low ch.



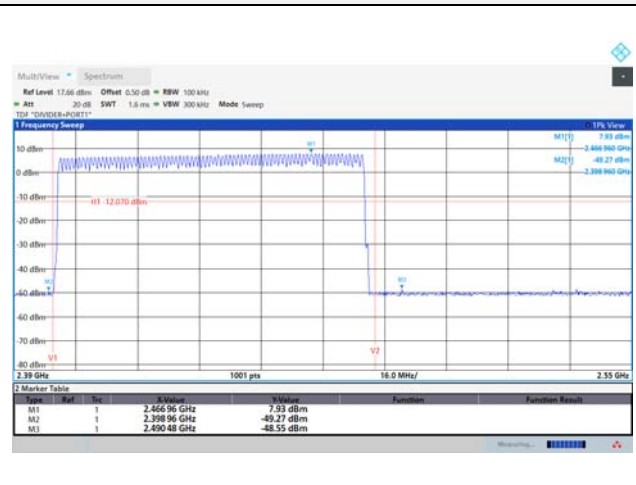
Conducted band-edge / High ch.



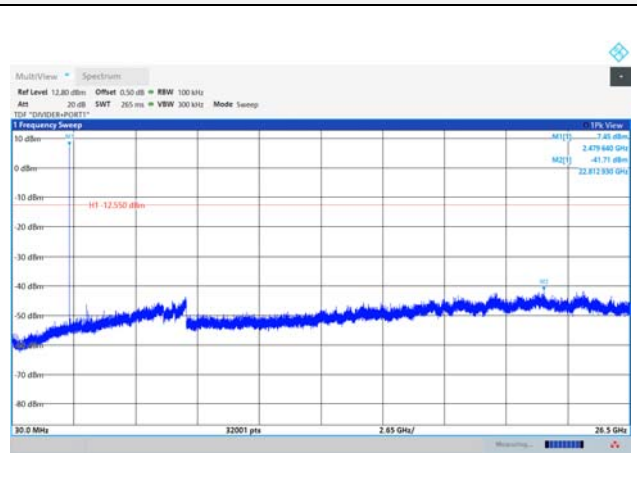
Conducted spurious / Mid ch.



Conducted band-edge / Hopping ch.

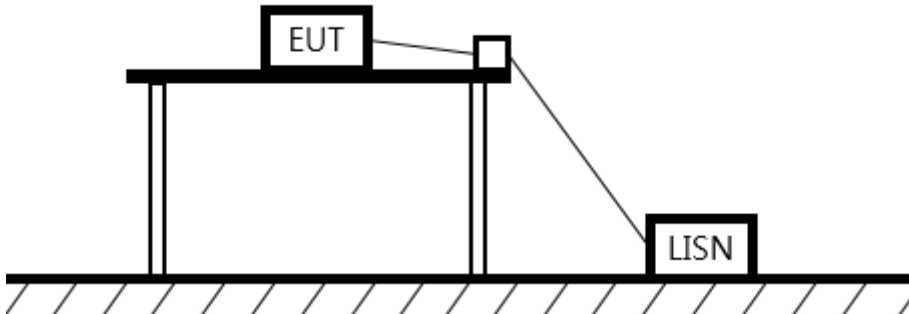


Conducted spurious / High ch.



7.8. AC Conducted emission

Test setup



Limit

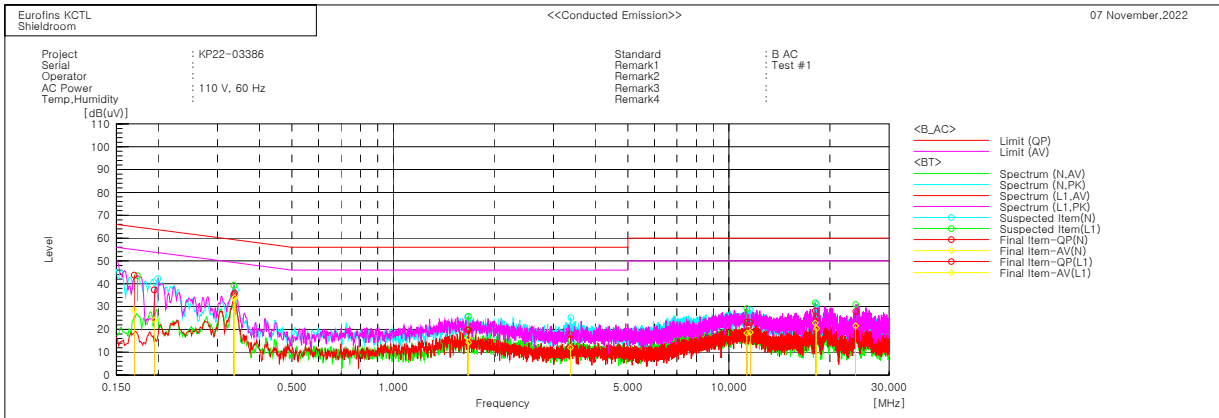
According to 15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohm line impedance stabilization network (LISN). Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted limit (dB μ V/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

Measurement procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50 Ω /50 μ H LISN, which is an input transducer to a spectrum analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to peak amplitude within a bandwidth of 10 kHz or to quasi-peak and average within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

Test results-Worst case: GFSK 2 441 MHz



Final Result

--- N Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.19441	27.4	14.2	9.9	37.3	24.1	63.8	53.8	26.5	29.7
2	0.33559	25.6	23.6	9.7	35.3	33.3	59.3	49.3	24.0	16.0
3	1.6688	10.1	6.6	9.7	19.8	16.3	56.0	46.0	36.2	29.7
4	3.37792	8.0	2.4	9.7	17.7	12.1	56.0	46.0	38.3	33.9
5	11.57372	13.1	8.8	9.9	23.0	18.7	60.0	50.0	37.0	31.3
6	18.25001	15.2	10.4	9.9	25.1	20.3	60.0	50.0	34.9	29.7

--- L1 Phase ---

No.	Frequency [MHz]	Reading QP [dB(uV)]	Reading CAV [dB(uV)]	c.f [dB]	Result QP [dB(uV)]	Result CAV [dB(uV)]	Limit QP [dB(uV)]	Limit AV [dB(uV)]	Margin QP [dB]	Margin CAV [dB]
1	0.16936	33.7	18.6	10.1	43.8	28.7	65.0	55.0	21.2	26.3
2	0.33708	26.2	24.2	9.7	35.9	33.9	59.3	49.3	23.4	15.4
3	1.67896	10.0	4.6	9.7	19.7	14.3	56.0	46.0	36.3	31.7
4	11.31421	13.3	8.6	9.8	23.1	18.4	60.0	50.0	36.9	31.6
5	18.08097	18.1	12.8	10.0	28.1	22.8	60.0	50.0	31.9	27.2
6	23.85984	17.8	11.5	10.0	27.8	21.5	60.0	50.0	32.2	28.5

8. Measurement equipment

Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
Spectrum Analyzer	R&S	FSV3030	1330.5000K30-101711-nf	23.10.14
Attenuator	R&S	DNF Dämpfungsglied 10 dB in N-50 Ohm	0004	23.05.02
Bluetooth Tester	TESCOM	TC-3000B	3000B640056	23.01.19
Power Sensor	R&S	NRP-Z81	1137.9009.02-106223-bB	23.05.03
Attenuator	Weinschel ENGINEERING	56-10	51395	23.01.21
AC/DC Power Supply	KIKUSUI	PCR2000W	GB001619	23.07.11
Vector Signal Generator	R&S	SMBV100A	257566	23.07.04
Signal Generator	R&S	SMB100A	176206	23.01.19
Spectrum Analyzer	R&S	FSV40	100989	23.10.14
EMI TEST RECEIVER	R&S	ESC17	100732	23.01.19
Bi-Log Antenna	TESEQ	CBL 6112D	62438	24.08.24
Amplifier	SONOMA INSTRUMENT	310N	284608	23.08.18
ATTENUATOR	KEYSIGHT	8491B-6dB	MY39271060	24.04.27
ISOLATION TRANSFORMER	ONETECH CO., LTD	OT-IT500VA	OTR1-16026	23.03.28
Horn antenna	ETS.lindgren	3117	155787	23.09.29
Horn antenna	ETS.lindgren	3116	00086635	23.05.04
Attenuator	API Inmet	40AH2W-10	12	23.05.03
AMPLIFIER	B&Z Technologies	BZRT-00504000-481055-382525	26299-27735	23.09.19
AMPLIFIER	B&Z Technologies	BZR-0050400-551028-252525	27736	23.09.19
LOOP Antenna	R&S	HFH2-Z2	100355	24.08.10
Antenna Mast	Innco Systems	MA4640-XP-ET	-	-
Turn Table	Innco Systems	CO3000	1175/45850319/P	-
Antenna Mast	Innco Systems	MA4000-EP	303	-
Turn Table	Innco Systems	CO3000	1175/45850319/P	-
Highpass Filter	WT	WT-A1698-HS	WT160411001	23.05.03
TWO-LINE V - NETWORK	R&S	ENV216	101358	23.09.29
EMI TEST RECEIVER	R&S	ESC13	100001	23.08.18

End of test report