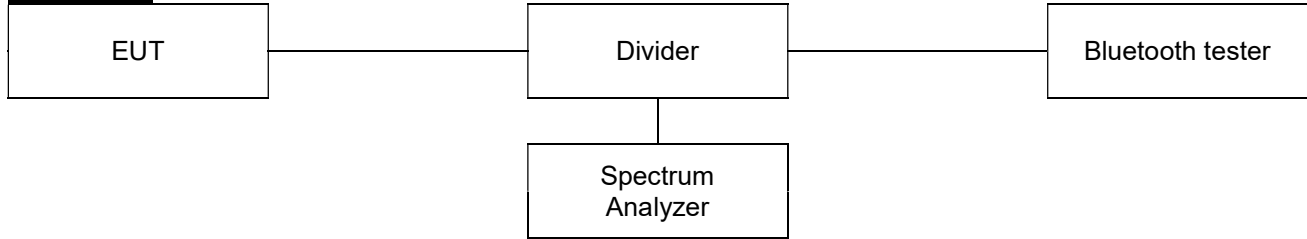


7.4. Number of hopping channels

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

- 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.
- 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.
- VBW \geq RBW.
- Sweep: Auto.
- Detector function: Peak.
- Trace: Max hold.
- 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
$\pi/4$ DQPSK	79	≥ 15
8DPSK	79	≥ 15

Notes:

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

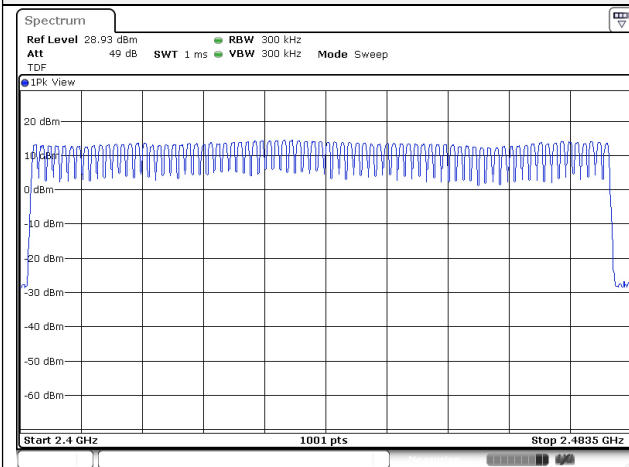
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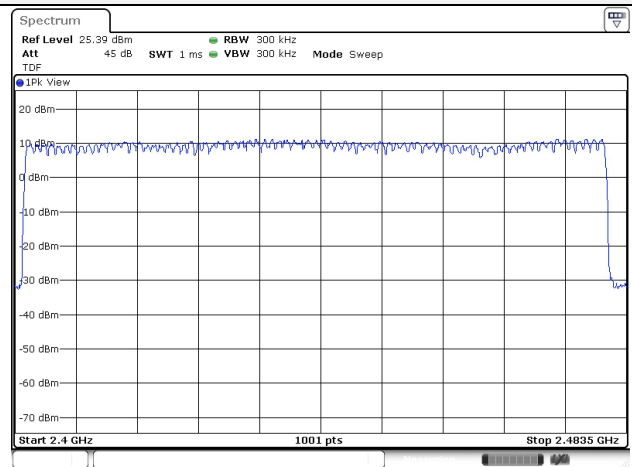
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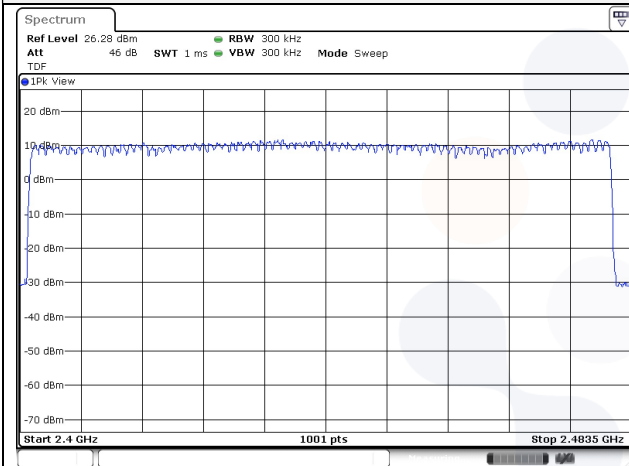
GFSK



$\pi/4$ QPSK



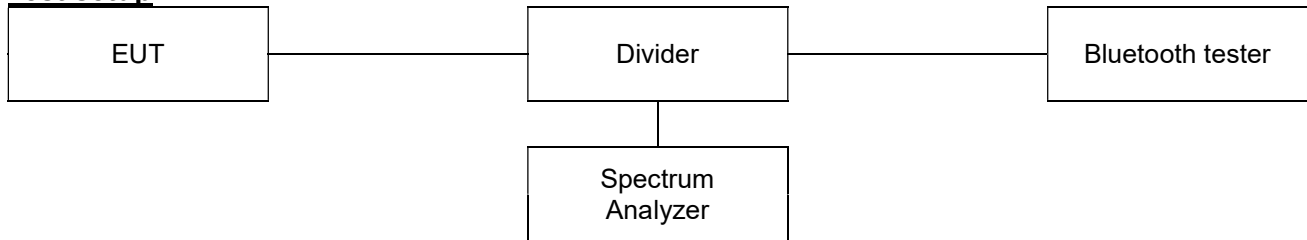
8DPSK



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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.

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**Test results****- Non-AFH**

Modulation	Frequency (MHz)	Pulse Width (ms)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.376	800.000	79	0.120	0.400
DH3		1.630	400.000		0.261	
DH5		2.877	266.667		0.307	
2-DH1		0.389	800.000		0.124	
2-DH3		1.640	400.000		0.262	
2-DH5		2.888	266.667		0.308	
3-DH1		0.252	800.000		0.081	
3-DH3		1.502	400.000		0.240	
3-DH5		2.755	266.667		0.294	

- AFH

Modulation	Frequency (MHz)	Pulse Width (ms)	Hopping rate (hop/s)	Number of Channels	Result (s)	Limit (s)
DH1	2 441	0.376	400.000	20	0.060	0.400
DH3		1.630	200.000		0.130	
DH5		2.877	133.333		0.153	
2-DH1		0.389	400.000		0.062	
2-DH3		1.640	200.000		0.131	
2-DH5		2.888	133.333		0.154	
3-DH1		0.252	400.000		0.040	
3-DH3		1.502	200.000		0.120	
3-DH5		2.755	133.333		0.147	

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)

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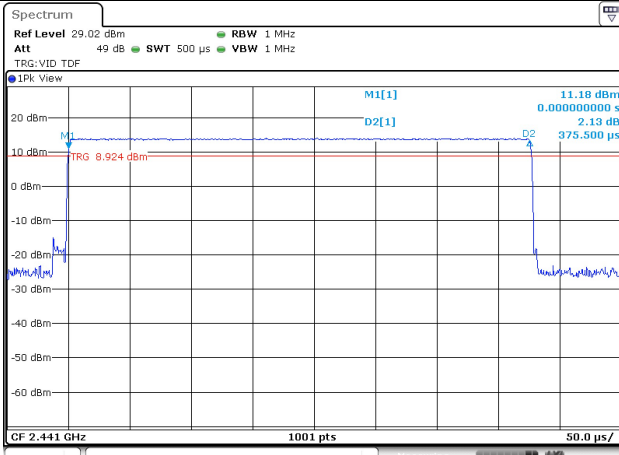
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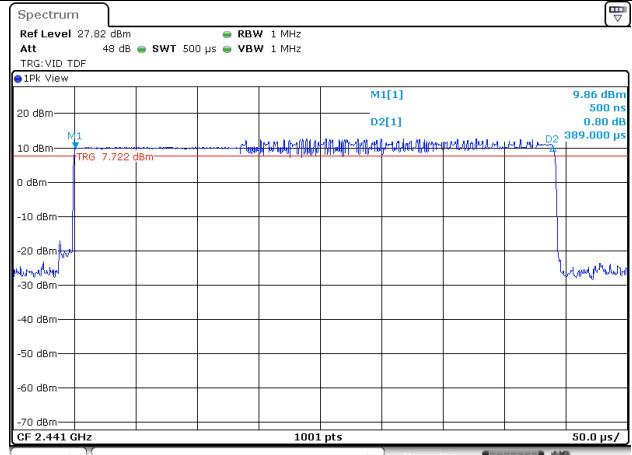


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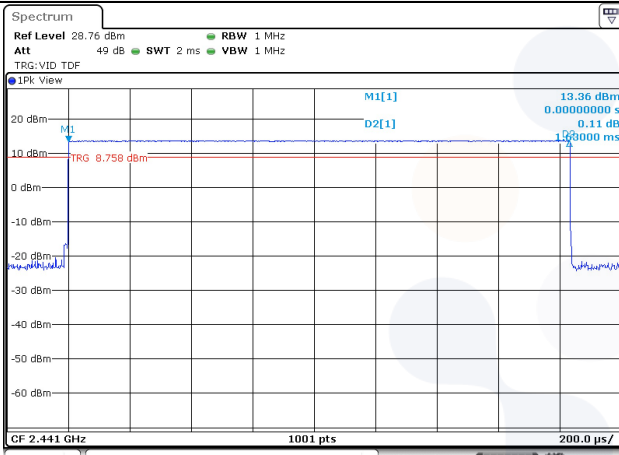
GFSK / DH1



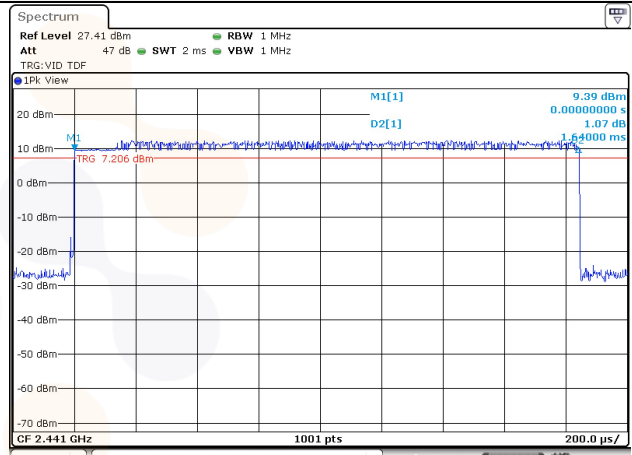
$\pi/4$ DQPSK / 2-DH1



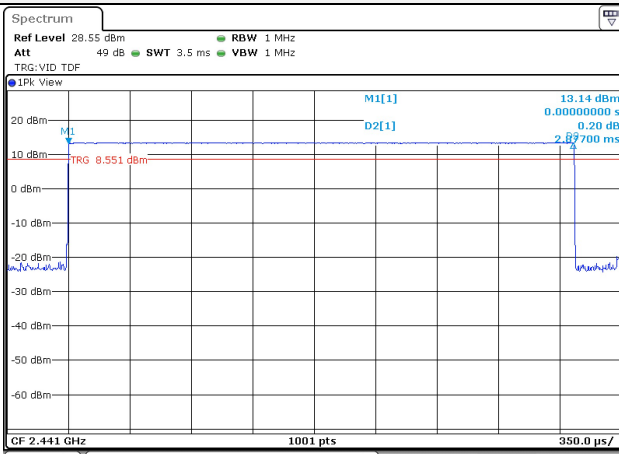
GFSK / DH3



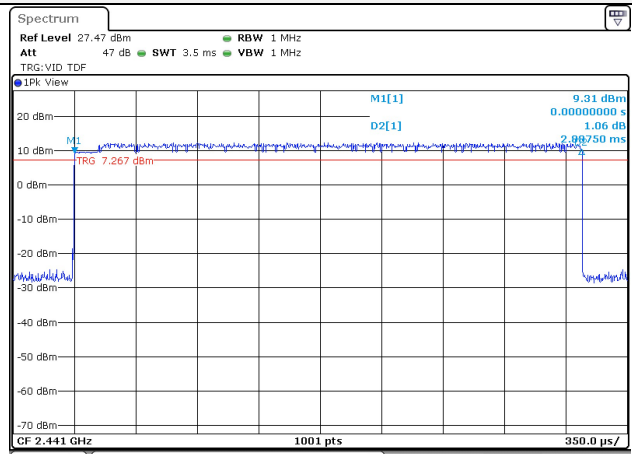
$\pi/4$ DQPSK / 2-DH3



GFSK / DH5



$\pi/4$ DQPSK / 2-DH5



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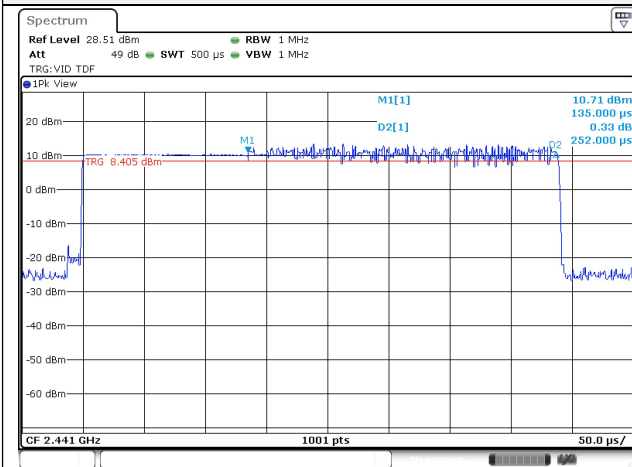
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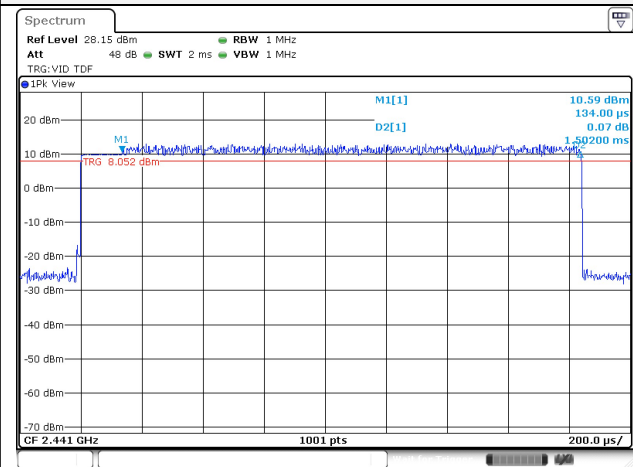


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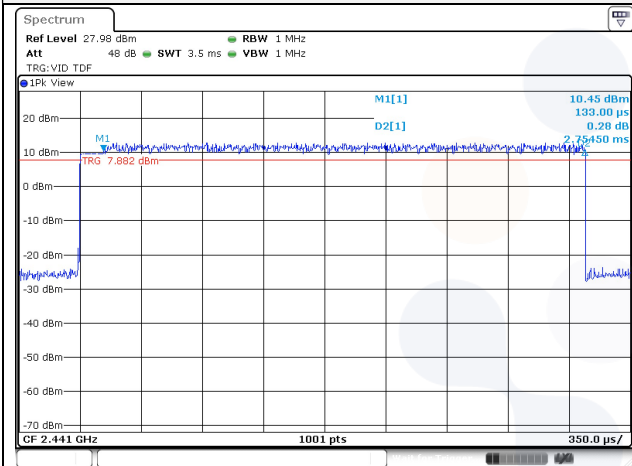
8DPSK / 3-DH1



8DPSK / 3-DH3



8DPSK / 3-DH5

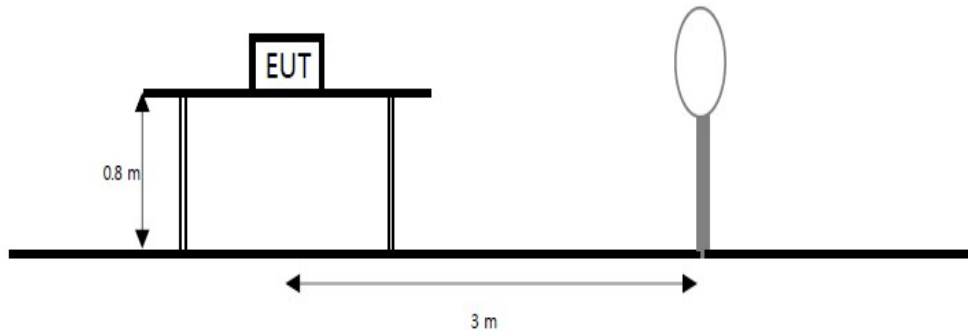


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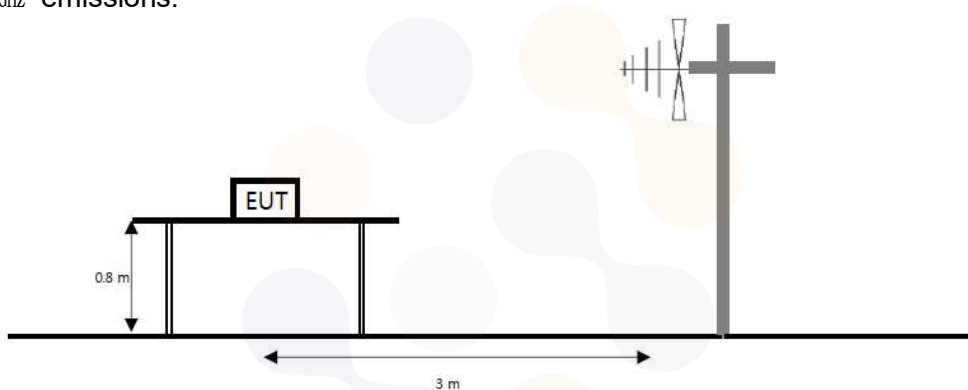
7.6. Radiated spurious emissions & band edge

Test setup

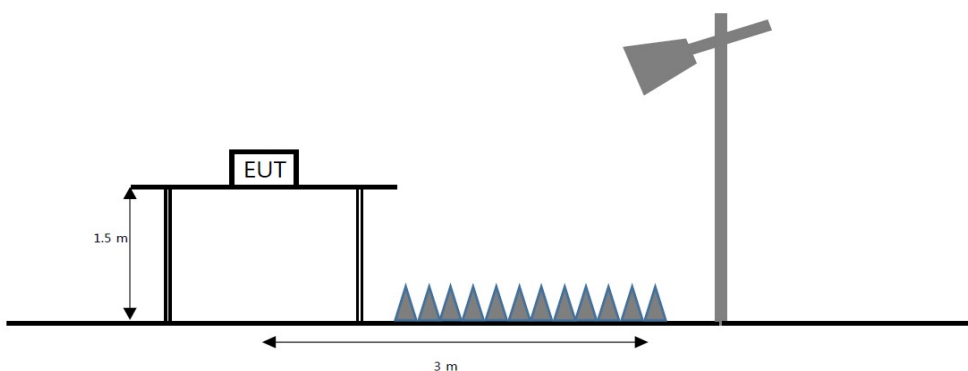
The diagram below shows the test setup that is utilized to make the measurements for emission from 9 kHz to 30 MHz Emissions



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.



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**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:

1. 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.
2. $f < 30$ 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
3. Factors(dB) = Antenna factor(dB/m) + Cable loss(dB) + or Amp. gain(dB) + or F_d (dB)
4. The worst-case emissions are reported however emissions whose levels were not within 20 dB of respective limits were not reported.
5. Average test would be performed if the peak result were greater than the average limit.
6. ¹⁾ means restricted band.

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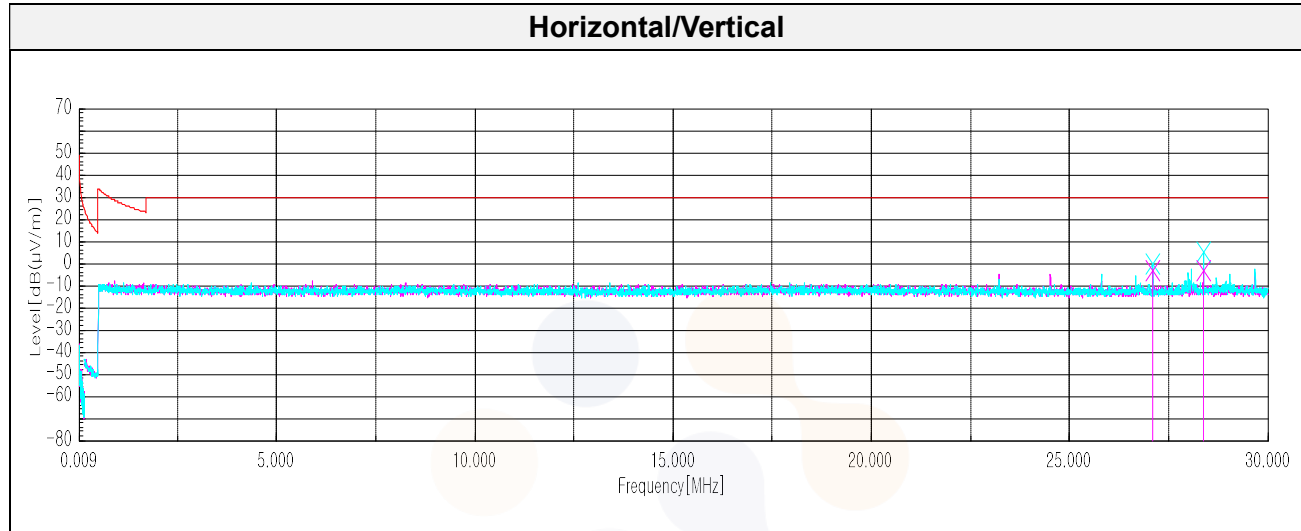
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Test results (Below 30 MHz) – Worst case: GFSK 2 441 MHz

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/m))	(dB)
Quasi peak data								
27.101	V	46.40	20.51	-30.51	40.00	-3.60	29.50	33.10
28.392	V	46.70	20.33	-30.44	40.00	-3.41	29.50	32.91

Horizontal/Vertical



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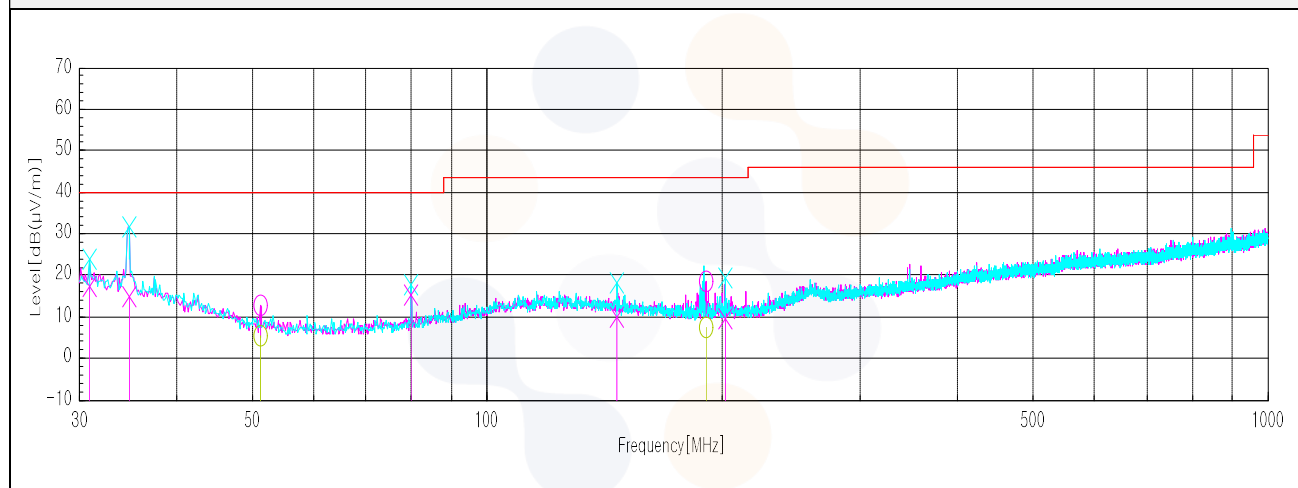
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Test results (Below 1 000 MHz) – Worst case: GFSK 2 441 MHz

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/m))	(dB)
Quasi peak data								
30.97	V	22.90	24.61	-30.35	-	17.16	40.00	22.84
34.85	V	23.30	21.82	-30.32	-	14.80	40.00	25.20
51.22	H	21.60	13.53	-29.87	-	5.26	40.00	34.74
79.96	V	31.40	13.00	-29.14	-	15.26	40.00	24.74
146.76	V	20.80	16.72	-27.93	-	9.59	43.50	33.91
190.90	H	19.60	14.80	-27.28	-	7.12	43.50	36.38
201.81	V	21.00	15.24	-27.14	-	9.10	43.50	34.40

Horizontal/Vertical



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Test results (Above 1 000 MHz)

GFSK Low Channel

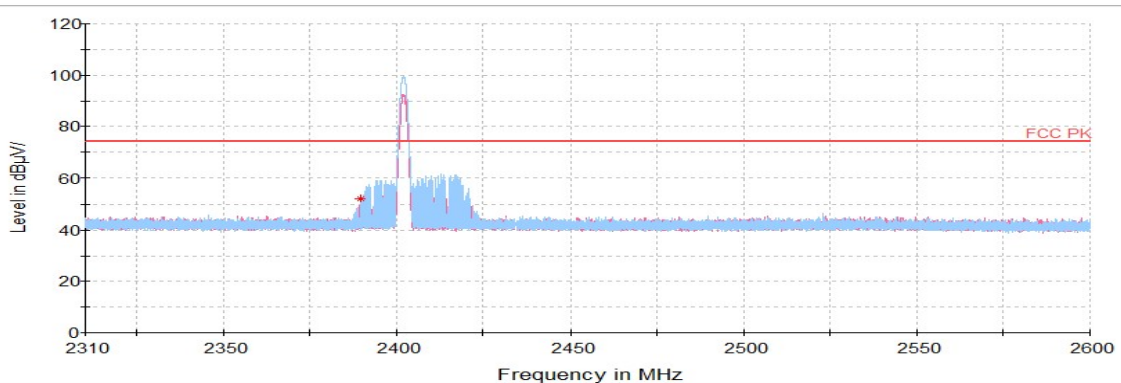
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data								
2 385.88 ¹⁾	H	47.32	31.95	-26.96	-	52.31	74.00	21.69
2 416.41	H	74.68	32.02	-45.58	-	61.12	74.00	12.88
2 659.38	V	67.81	32.46	-45.13	-	55.14	74.00	18.86
3 996.17 ¹⁾	V	63.32	33.40	-52.88	-	43.84	74.00	30.16
4 795.94 ¹⁾	V	62.78	33.64	-51.57	-	44.85	74.00	29.15
7 211.55	V	59.45	35.42	-49.78	-	45.09	74.00	28.91
Average Data								
2 385.88 ¹⁾	H	36.53	31.95	-26.96	-	41.52	54.00	12.48

Average data



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Horizontal/Vertical for Band-edge



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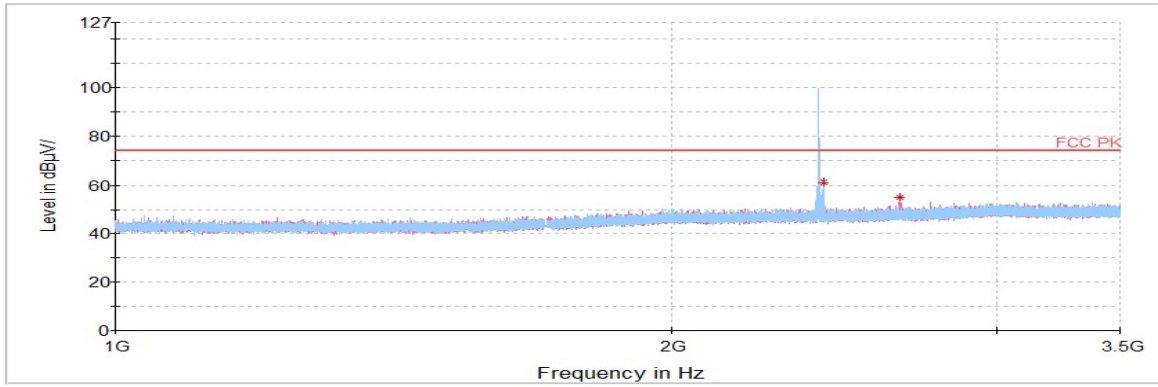
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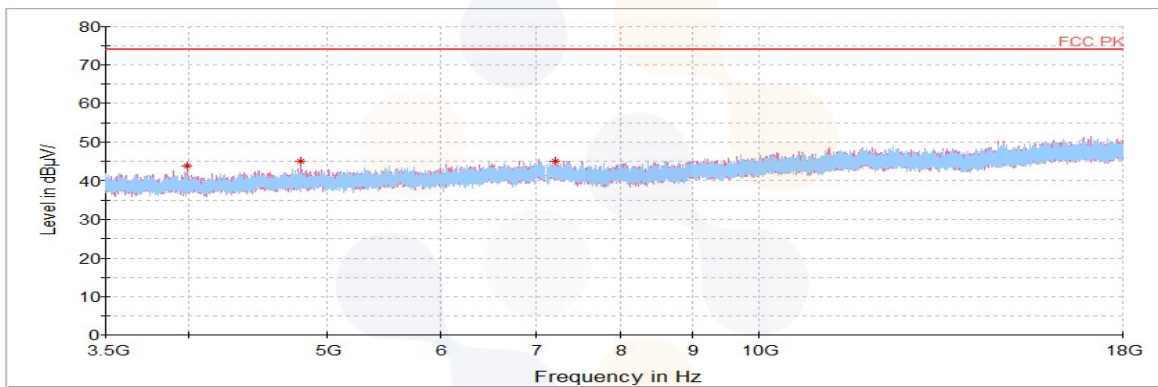


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Horizontal/Vertical for 1 GHz ~ 3.5 GHz



Horizontal/Vertical for 3.5 GHz ~ 18 GHz



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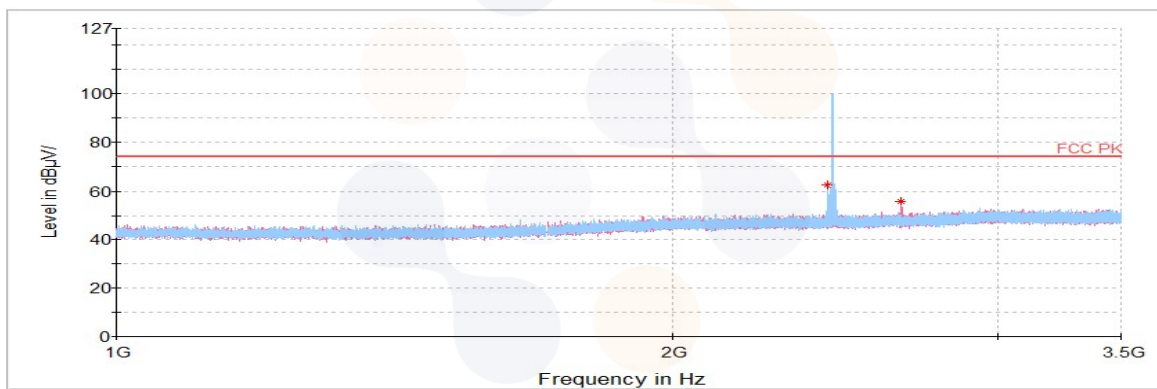
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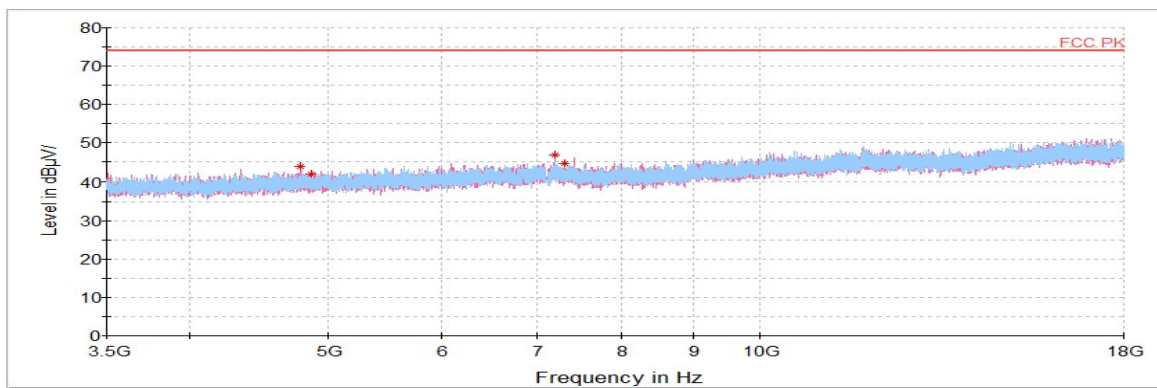
GFSK_Mid Channel

Frequency (MHz)	Pol. (V/H)	Reading (dB(μV))	Ant. Factor (dB)	Amp. + Cable (dB)	DCCF (dB)	Result (dB(μV/m))	Limit (dB(μV/m))	Margin (dB)
Peak data								
2 427.03	H	75.69	32.04	-45.55	-	62.18	74.00	11.82
2 660.00	V	68.64	32.46	-45.13	-	55.97	74.00	18.03
4 778.27 ¹⁾	V	61.73	33.64	-51.57	-	43.80	74.00	30.20
4 874.33 ¹⁾	H	59.73	33.63	-51.54	-	41.82	74.00	32.18
7 187.08	V	61.19	35.43	-49.78	-	46.84	74.00	27.16
7 308.06 ¹⁾	V	59.12	35.38	-49.78	-	44.72	74.00	29.28
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



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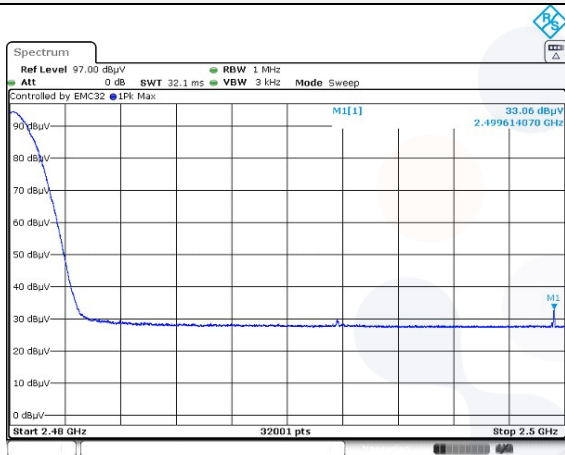
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GFSK_High Channel

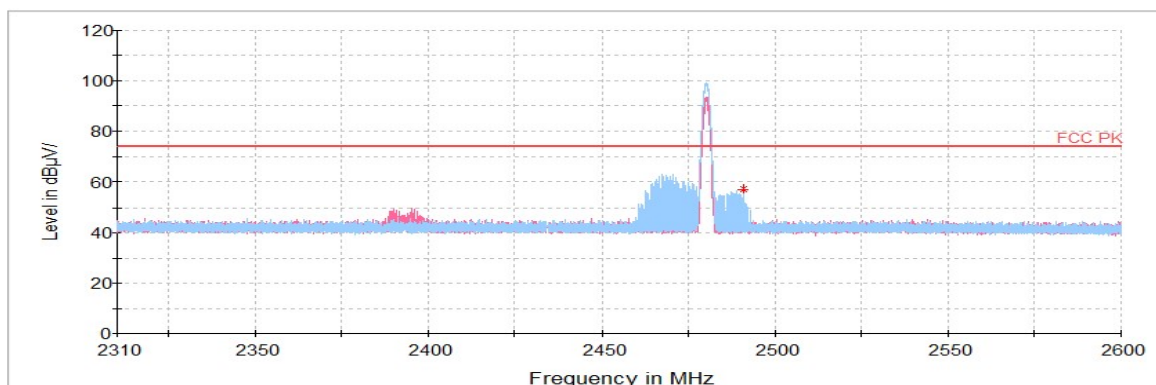
Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB)	(dB(μV/m))	(dB(μV/m))	(dB)
Peak data								
2 470.86	H	74.85	32.14	-45.43	-	61.56	74.00	12.44
2 499.61 ¹⁾	H	52.03	32.20	-27.25	-	56.98	74.00	17.02
4 777.36 ¹⁾	V	64.65	33.64	-51.57	-	46.72	74.00	27.28
4 951.81 ¹⁾	H	60.04	33.61	-51.66	-	41.99	74.00	32.01
7 434.03 ¹⁾	H	58.42	35.33	-49.78	-	43.97	74.00	30.03
Average Data								
2 499.61 ¹⁾	H	33.06	32.20	-27.25	-	38.01	54.00	15.99

Average data



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Horizontal/Vertical for Band-edge



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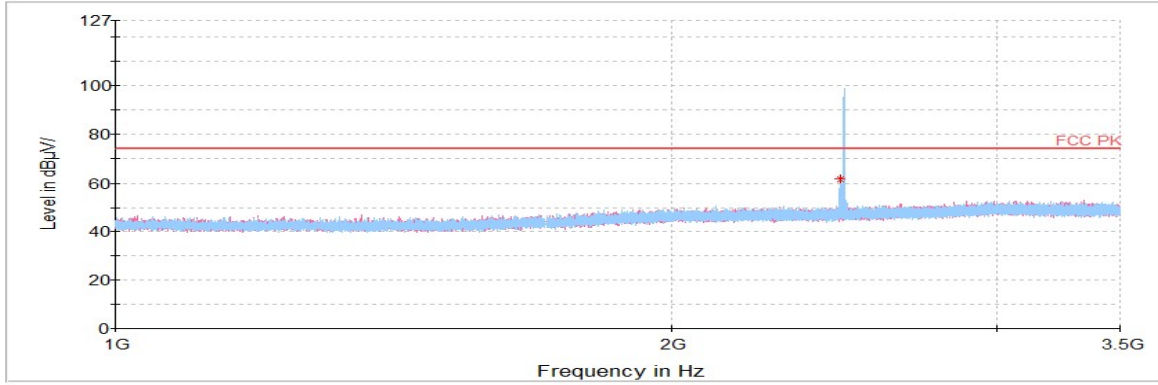
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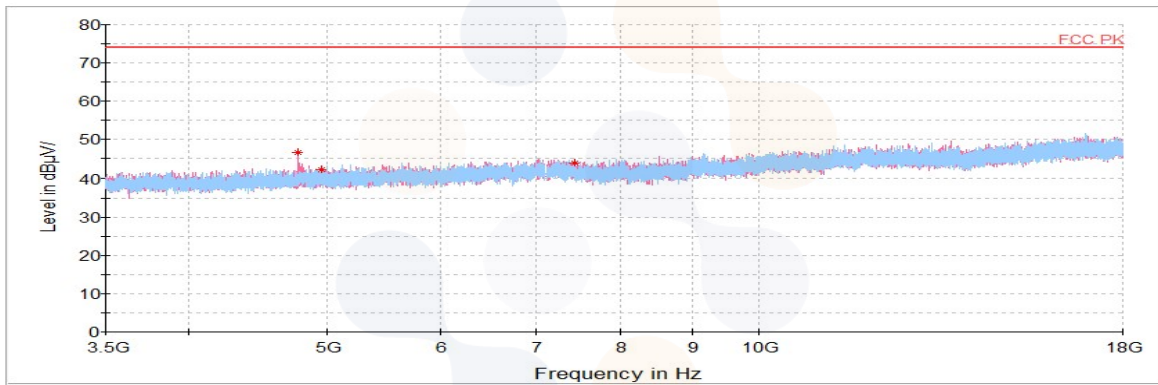


KCTL

Horizontal/Vertical for 1 GHz ~ 3.5 GHz



Horizontal/Vertical for 3.5 GHz ~ 18 GHz



KCTL Inc.

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

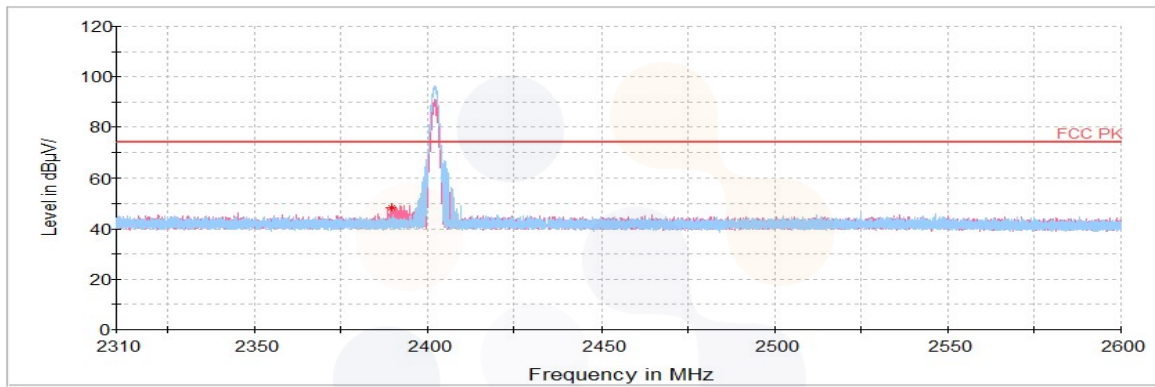
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8DPSK Low Channel

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μ V))	(dB)	(dB)	(dB)	(dB(μ V/m))	(dB(μ V/m))	(dB)
Peak data								
2 389.50 ¹⁾	V	43.55	31.96	-26.97	-	48.54	74.00	25.46
4 787.33 ¹⁾	V	62.58	33.64	-51.57	-	44.65	74.00	29.35
7 247.80	H	59.08	35.40	-49.78	-	44.70	74.00	29.30
Average Data								
No spurious emissions were detected within 20 dB of the limit.								

Horizontal/Vertical for Band-edge



KCTL Inc.

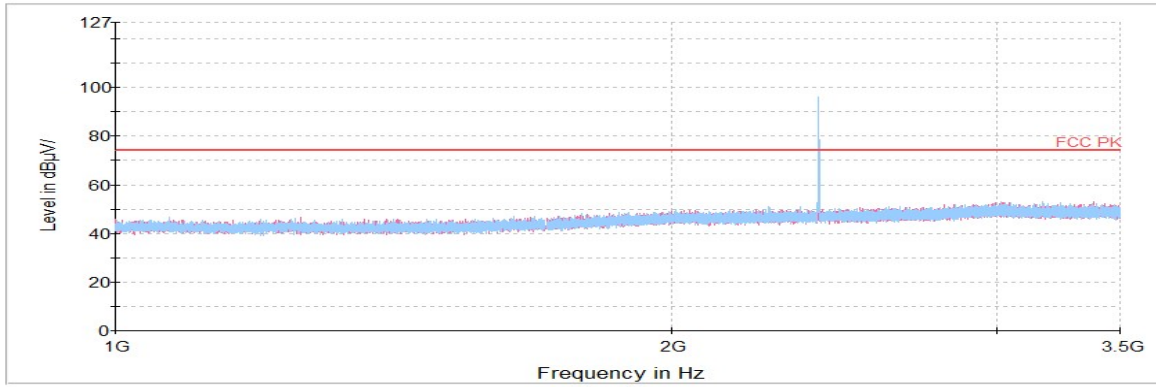
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