

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 $\geq (3 \times \text{RBW})$
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 0.5 kHz ($\geq 1/T$) for Average detection (AV) at frequency above 1 GHz. (refer to Section 2.4 Duty Cycle)
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⁾ mean is restricted band.

7. According to part 15.31(f)(2), an extrapolation factor of 40 dB/decade is applied because measured distance of radiated emission is 3 m.

Duty cycle correction factor calculation:

According to 7.5 Procedure for determining the average value of pulsed emissions

Duty Cycle Correction Factor Calculation

- Worst case : AFH mode
- Channel hop rate = 800 hops/second
- Hopping rate for DH5 mode = 800 hops/second / 5 (6 slots for DH5) = 133.33 hops/second
- Time per channel hop = $1 / 133.33 \text{ hops/second} = 7.50 \text{ ms}$
- Time to cycle through all channels = $7.50 \times 20 \text{ channels(AFH mode)} = 150 \text{ ms}$
- Number of times transmitter hits on one channel = $100 \text{ ms} / \text{Time to cycle through all channels (ms)}$
 $= 100 \text{ ms} / 150 \text{ ms} = 1 \text{ time}$
- Worst case Dwell time = 7.5 ms
- Duty Cycle Correction Factor = $20\log(7.5 \text{ ms}/100 \text{ ms}) = -22.5 \text{ dB}$

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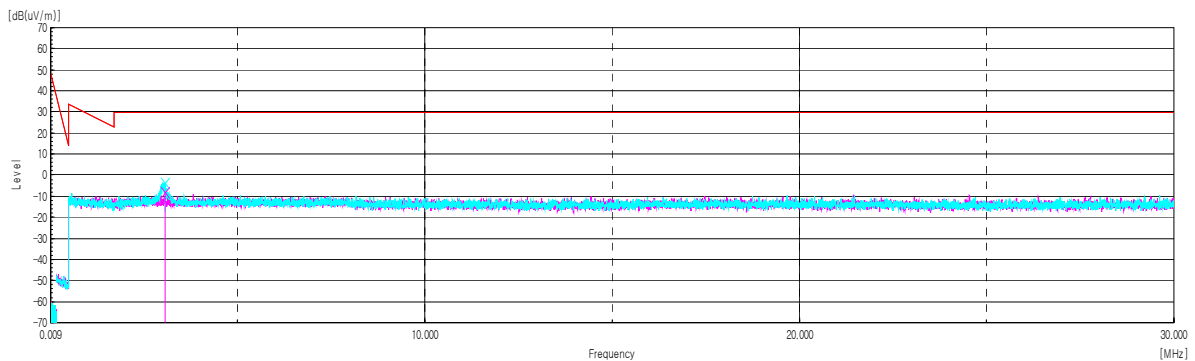
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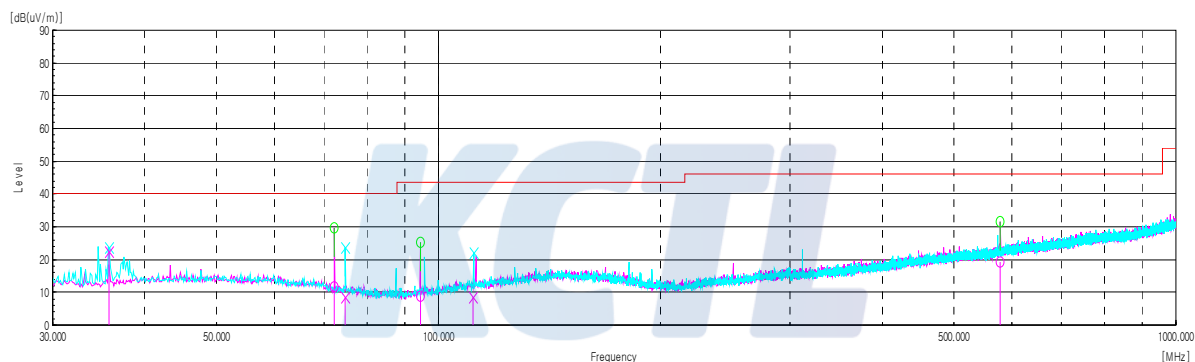
KCTL**Test results (Below 30 MHz) – Worst case: 8DPSK Lowest frequency**

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

Horizontal/Vertical**KCTL**

Test results (Below 1 000 MHz) – Worst case: 8DPSK Lowest frequency

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								
35.82	V	35.50	17.56	-30.53	-	22.53	40.00	17.47
72.32	H	25.60	15.94	-29.88	-	11.66	40.00	28.34
74.86	V	22.80	15.43	-29.82	-	8.41	40.00	31.59
94.51	H	23.90	14.24	-29.43	-	8.71	43.50	34.79
111.60	V	21.20	16.53	-29.21	-	8.52	43.50	34.98
578.29	H	20.30	25.23	-26.08	-	19.45	46.00	26.55

Horizontal/Vertical

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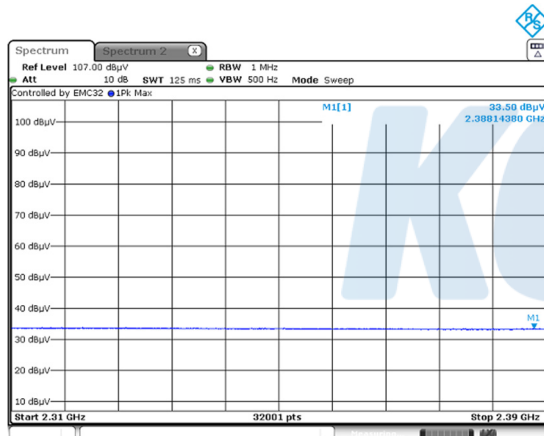
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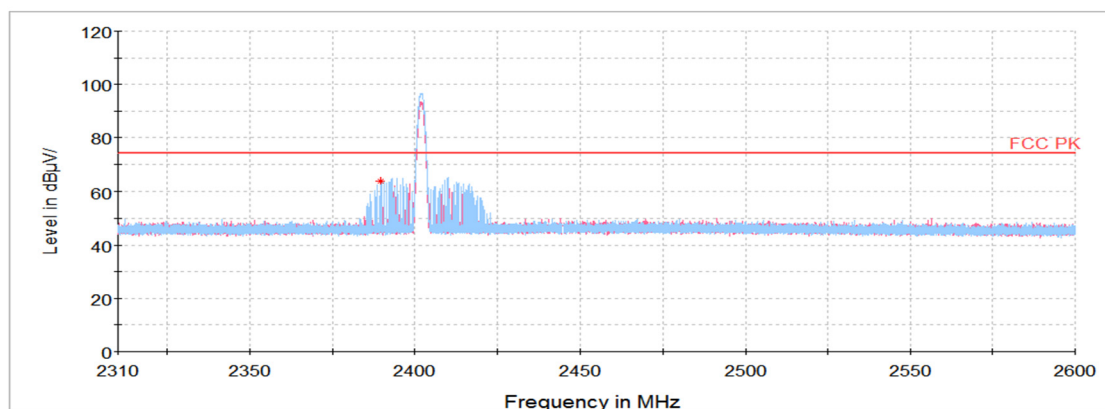
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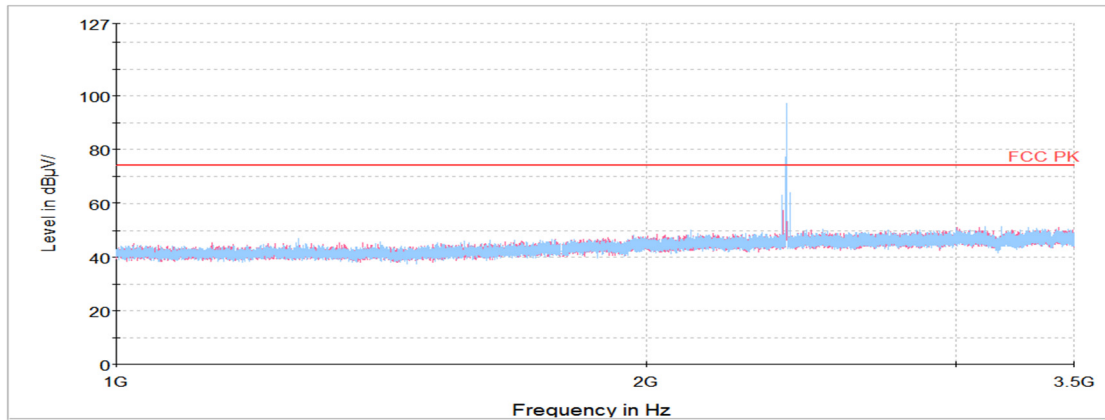
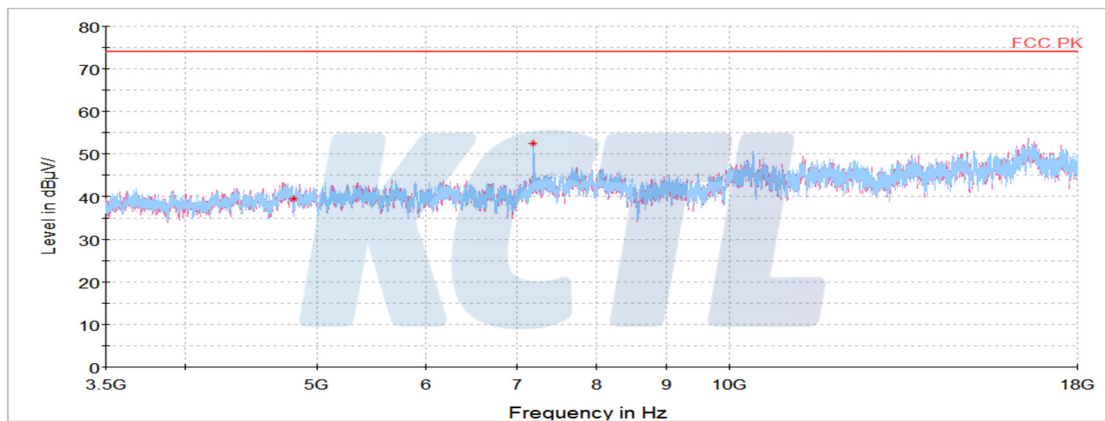
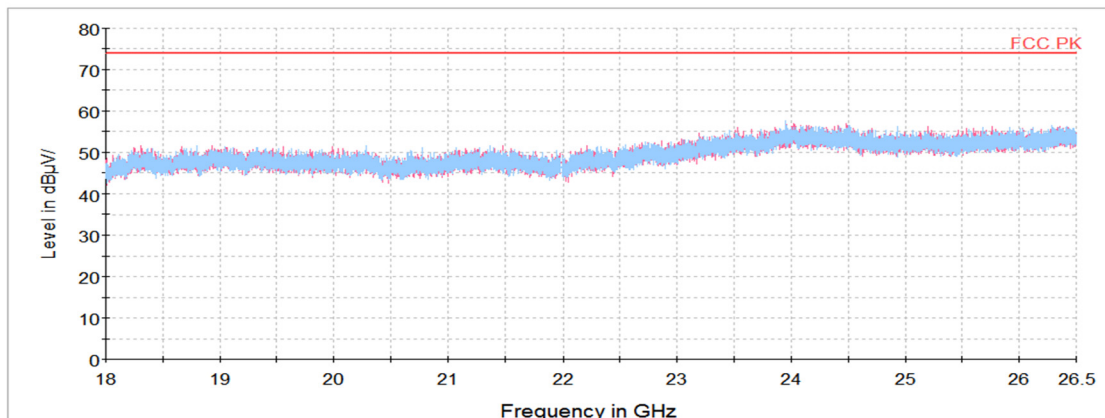
**Test results (Above 1 000 MHz)****GFSK****Low Channel**

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								
2 388.14 ¹⁾	H	60.73	31.88	-29.05	-	63.56	74.00	10.44
4 804.55 ¹⁾	H	58.71	33.92	-53.14	-	39.49	74.00	34.51
7 206.11	H	70.14	35.40	-53.12	-	52.42	74.00	21.58
Average Data								
2 388.14 ¹⁾	H	33.50	31.88	-29.05	-	36.33	54.00	17.67

Average data

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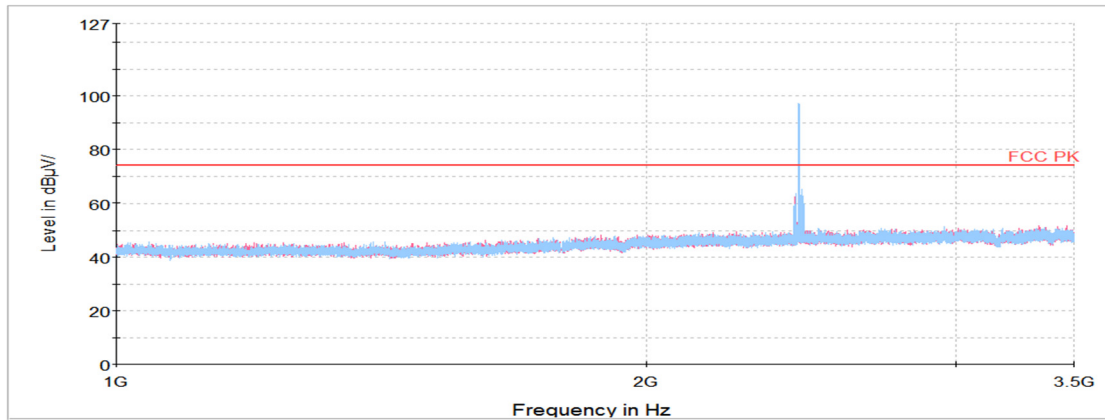
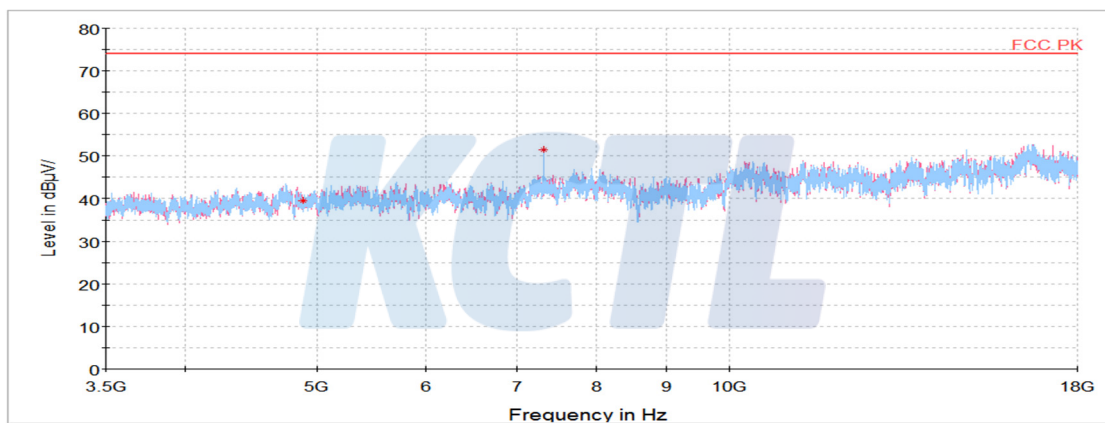
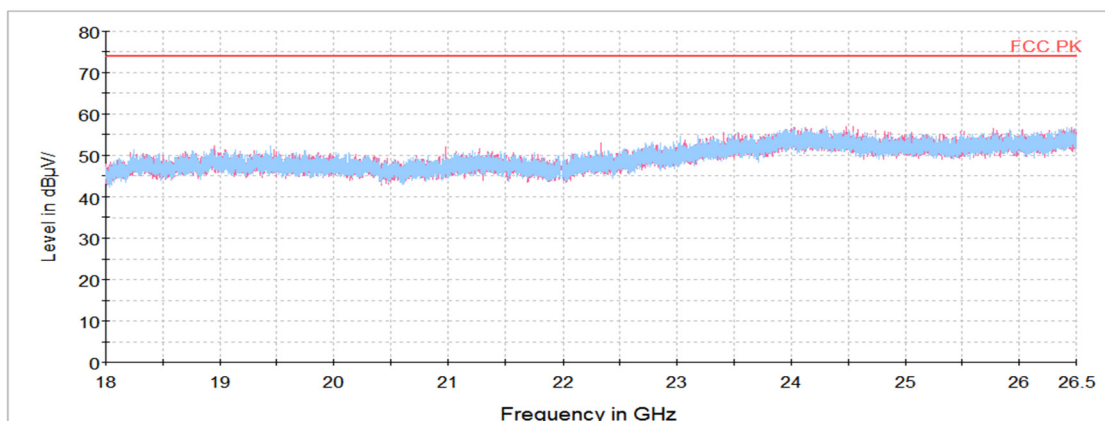
Horizontal/Vertical for Band-edge

Horizontal/Vertical for 1 GHz ~ 3.5 GHz**Horizontal/Vertical for 3.5 GHz ~ 18 GHz****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

Middle 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								
4 882.03 ¹⁾	H	60.03	33.95	-54.60	-	39.38	74.00	34.62
7 323.20 ¹⁾	H	68.45	35.40	-52.50	-	51.35	74.00	22.65
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****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

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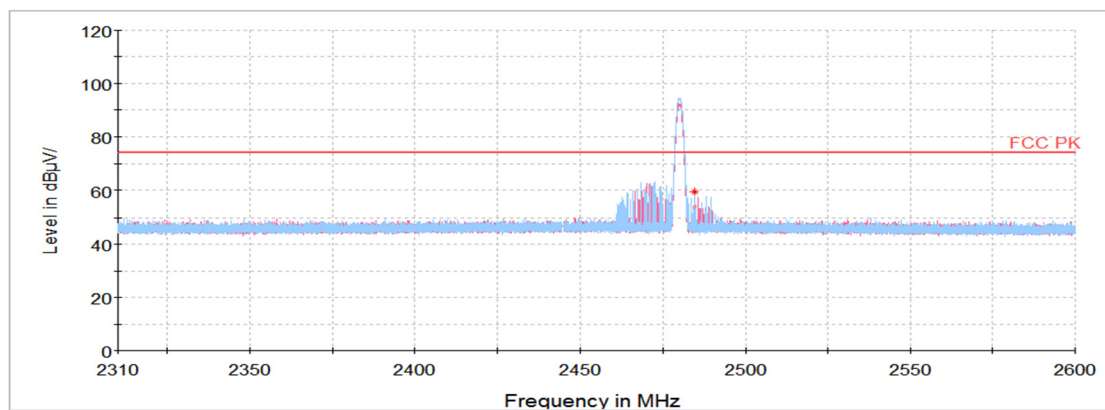
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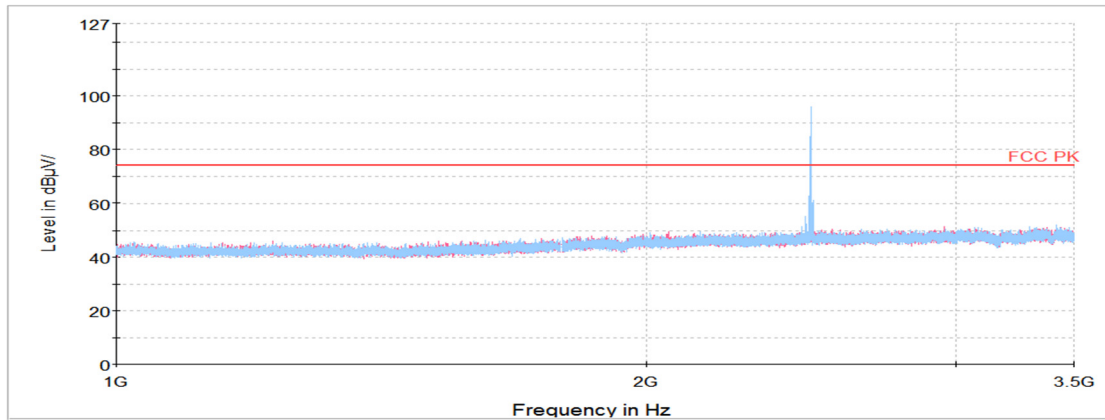
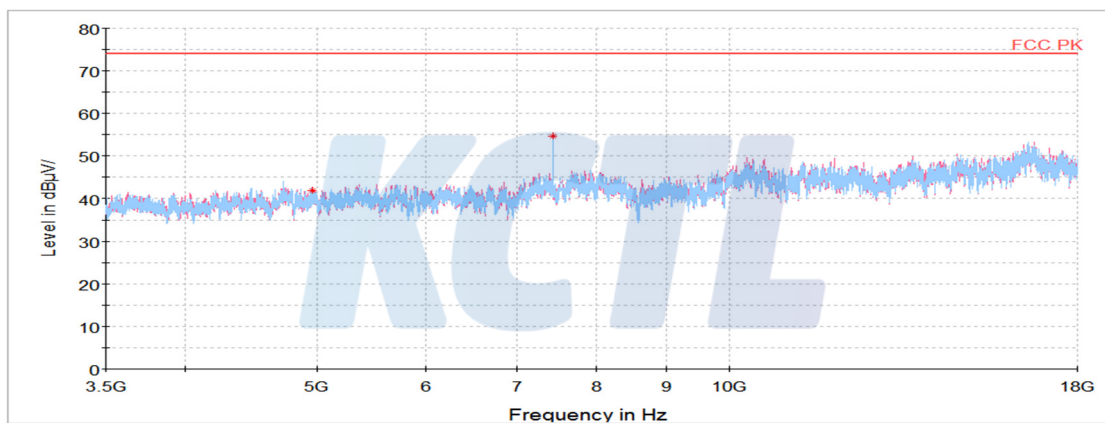
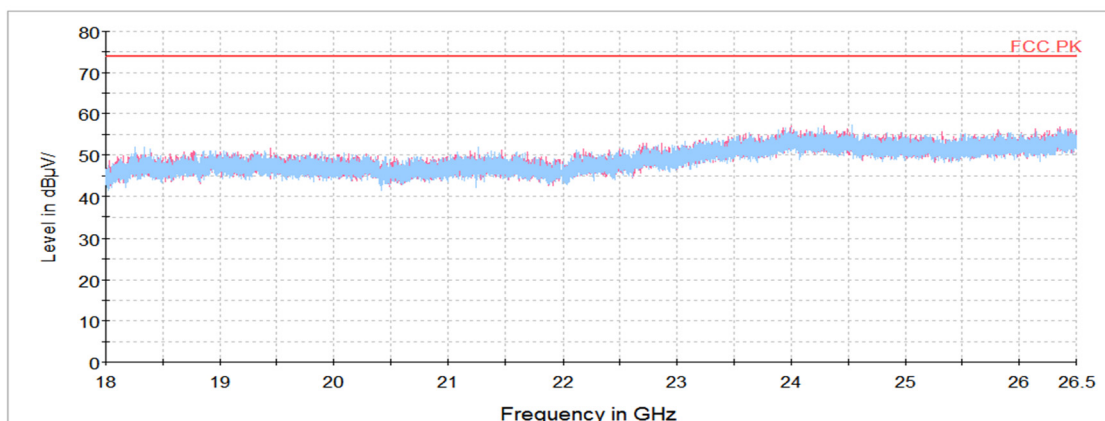
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KCTL**High Channel**

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								
2 483.70 ¹⁾	H	56.28	32.07	-29.21	-	59.14	74.00	14.86
4 960.88 ¹⁾	H	62.49	33.98	-54.59	-	41.88	74.00	32.12
7 440.01 ¹⁾	H	71.13	35.40	-51.89	-	54.64	74.00	19.36
Average Data								
2 483.70 ¹⁾	H	33.72	32.07	-29.21	-	36.58	54.00	17.42
7 440.01 ¹⁾	H	66.36	35.40	-51.89	-	49.87	54.00	4.13

Average data (2 483.70 MHz)**Average data (7 440.01 MHz)****Horizontal/Vertical for Band-edge**

Horizontal/Vertical for 1 GHz ~ 3.5 GHz**Horizontal/Vertical for 3.5 GHz ~ 18 GHz****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

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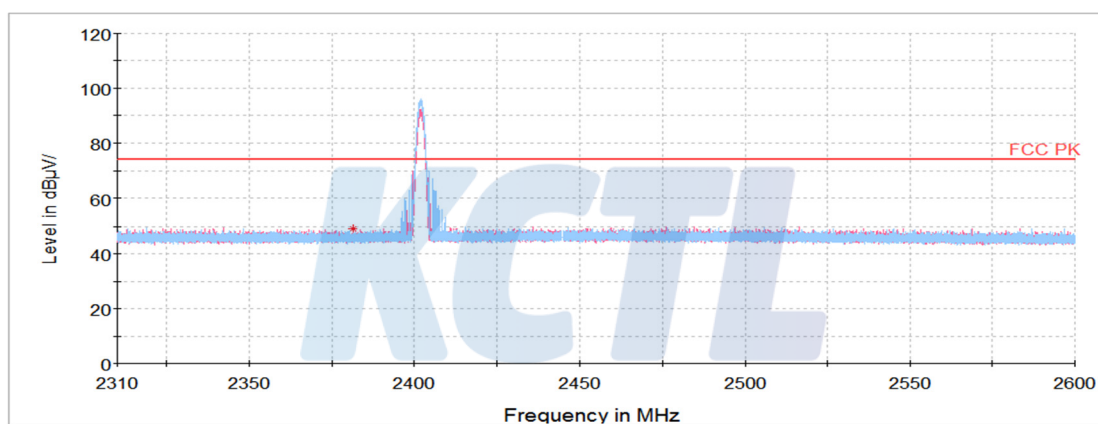
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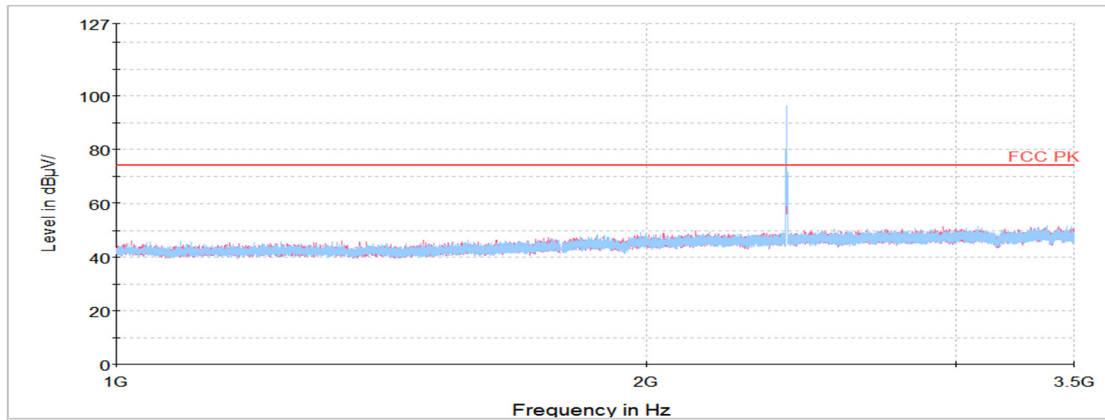
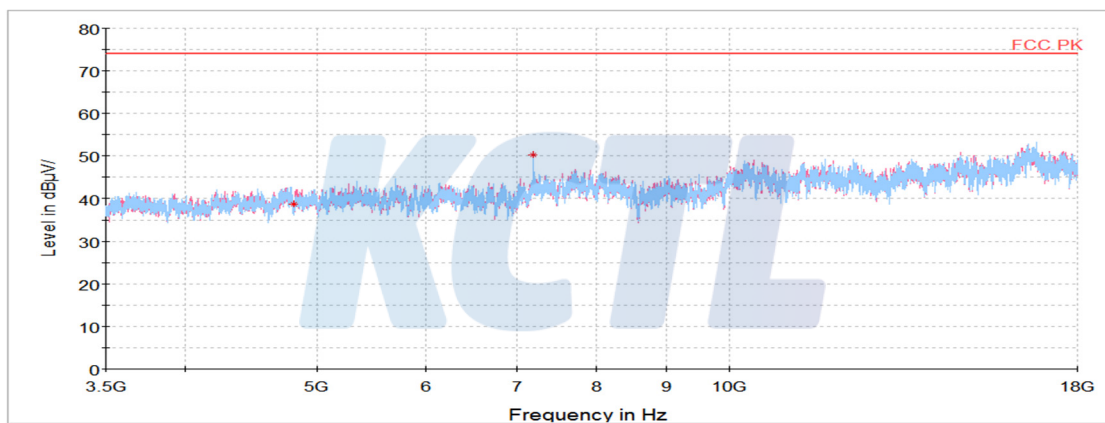
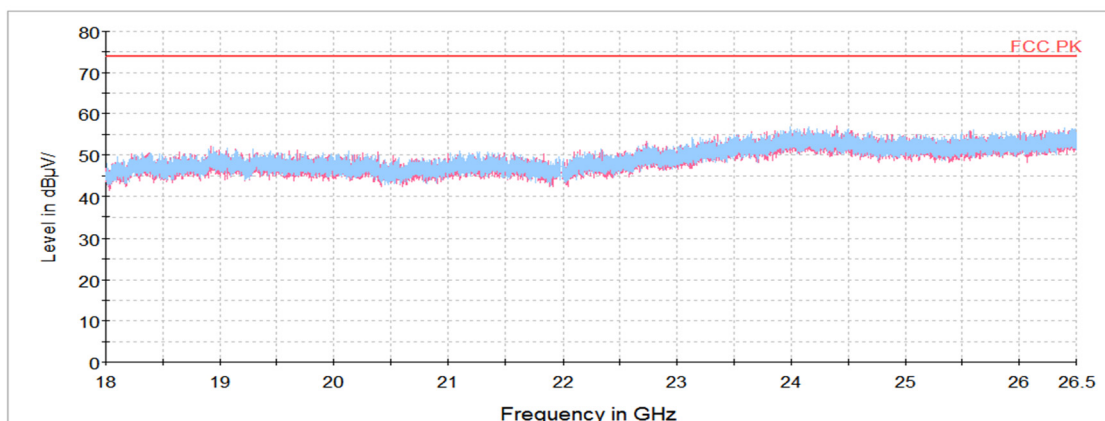
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KCTL**8DPSK****Low Channel**

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								
2 381.55 ¹⁾	V	46.46	31.86	-29.08	-	49.24	74.00	24.76
4 804.55 ¹⁾	V	57.86	33.92	-53.14	-	38.64	74.00	35.36
7 206.11 ¹⁾	H	67.83	35.40	-53.12	-	50.11	74.00	23.89
Average Data								
No spurious emissions were detected within 20 dB of the limit.								

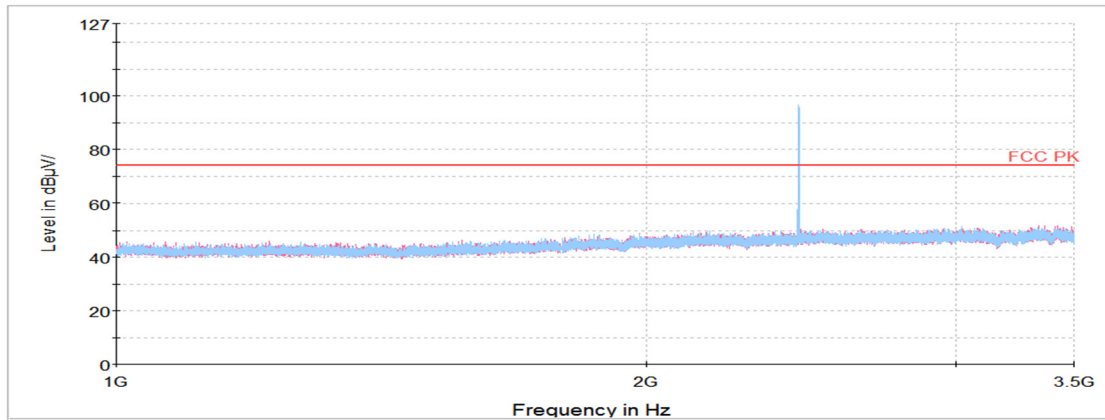
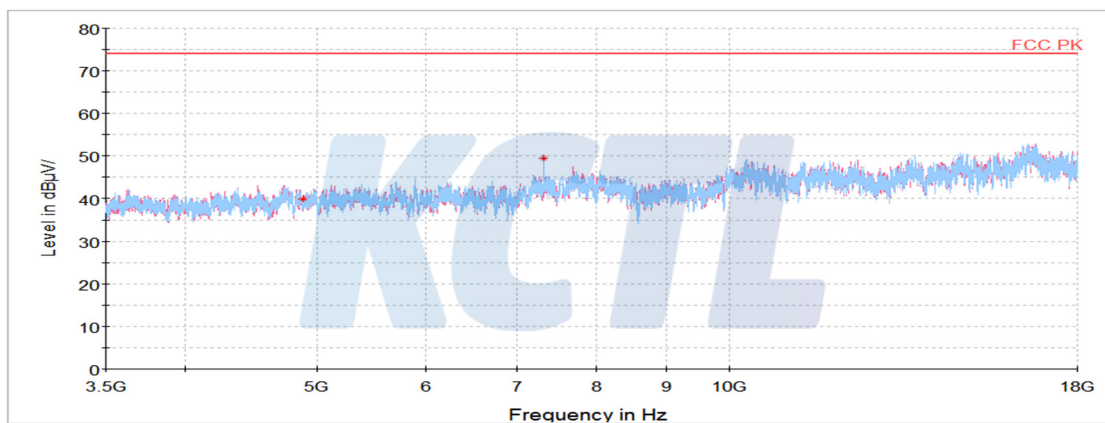
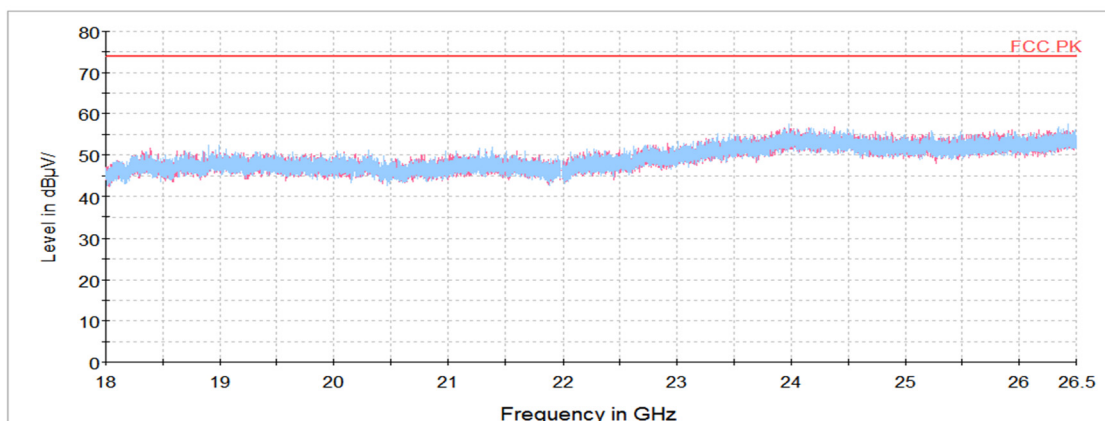
Horizontal/Vertical for Band-edge

Horizontal/Vertical for 1 GHz ~ 3.5 GHz**Horizontal/Vertical for 3.5 GHz ~ 18 GHz****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

Middle Channel

Frequency	Pol.	Reading	Ant. Factor	Amp. + Cable	DCCF	Result	Limit	Margin
(MHz)	(V/H)	(dB(μV))	(dB)	(dB)	(dB)	(dB($\mu V/m$))	(dB($\mu V/m$))	(dB)
Peak data								
4 881.58 ¹⁾	H	60.46	33.95	-54.59	-	39.82	74.00	34.18
7 322.56 ¹⁾	H	66.58	35.40	-52.51	-	49.47	74.00	24.53
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****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

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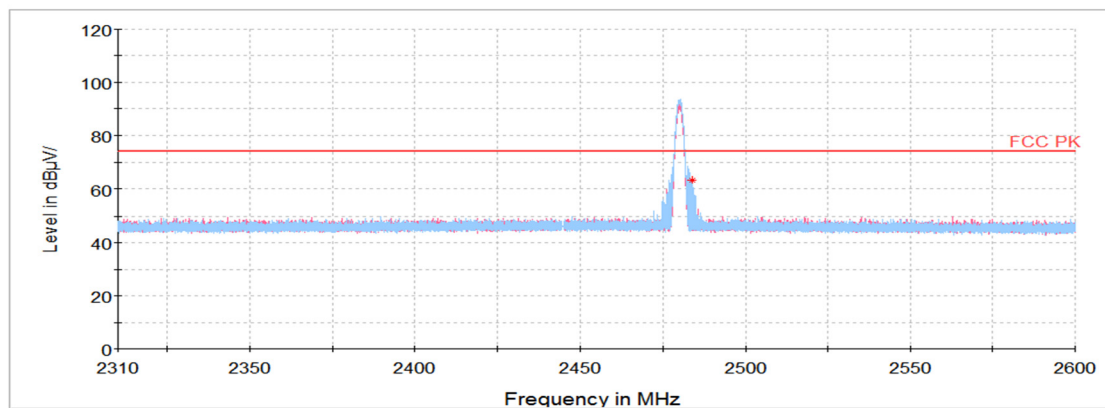
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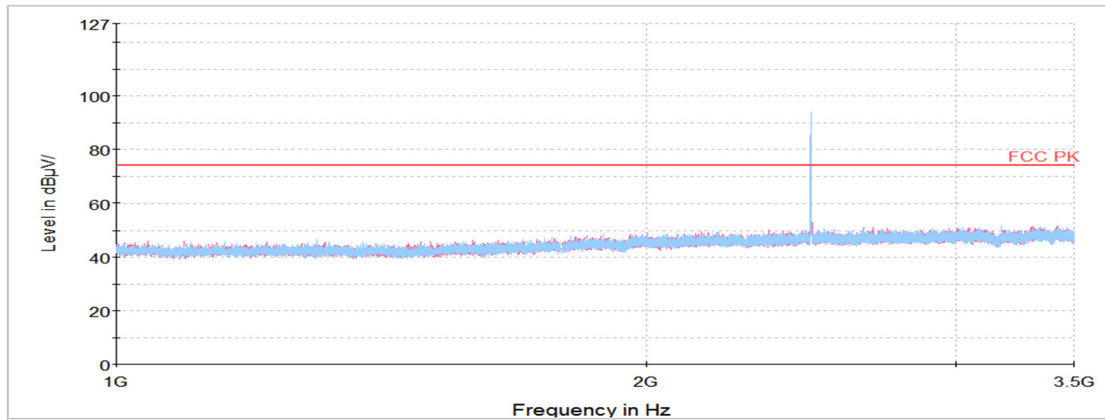
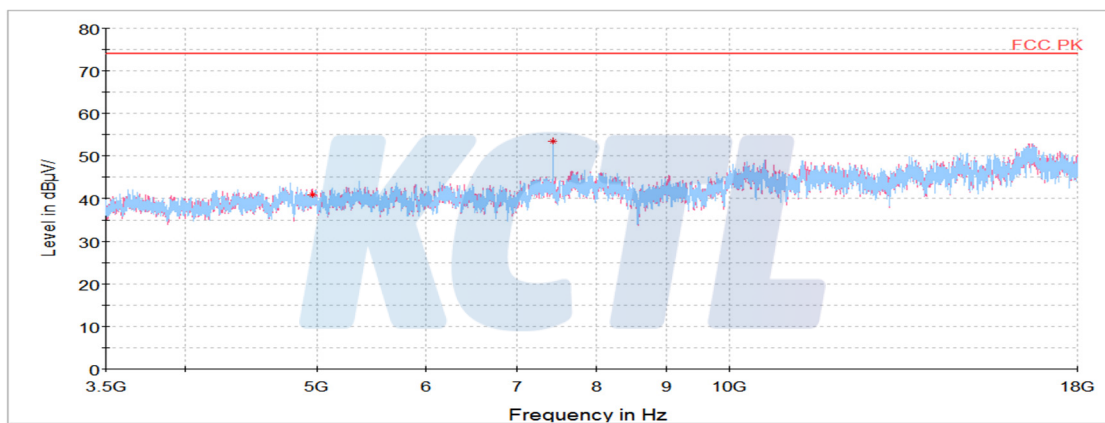
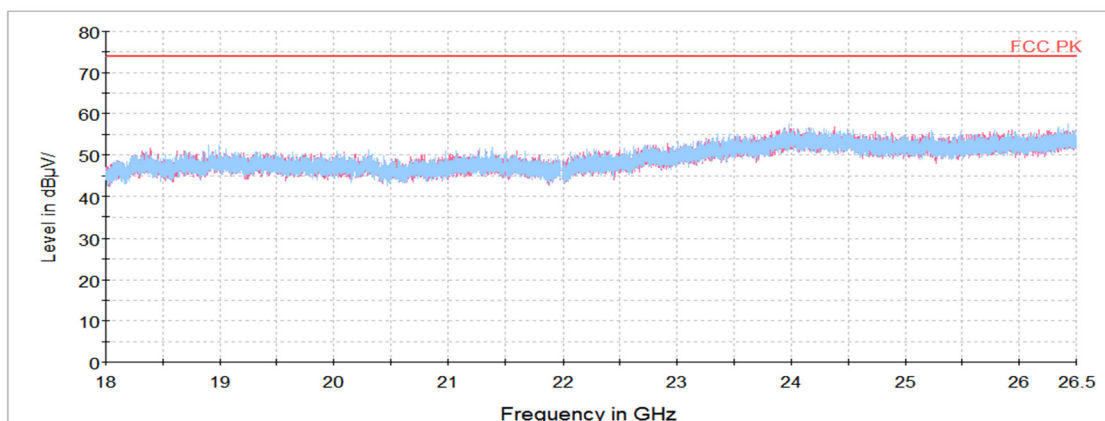
KCTL**High Channel**

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								
2 484.03 ¹⁾	H	60.48	32.07	-29.22	-	63.33	74.00	10.67
4 960.88 ¹⁾	V	61.38	33.98	-54.59	-	40.77	74.00	33.23
7 440.20 ¹⁾	V	69.94	35.40	-51.89	-	53.45	74.00	20.55
Average Data								
2 484.03 ¹⁾	H	33.64	32.07	-29.22	-	36.49	54.00	17.51

Average data

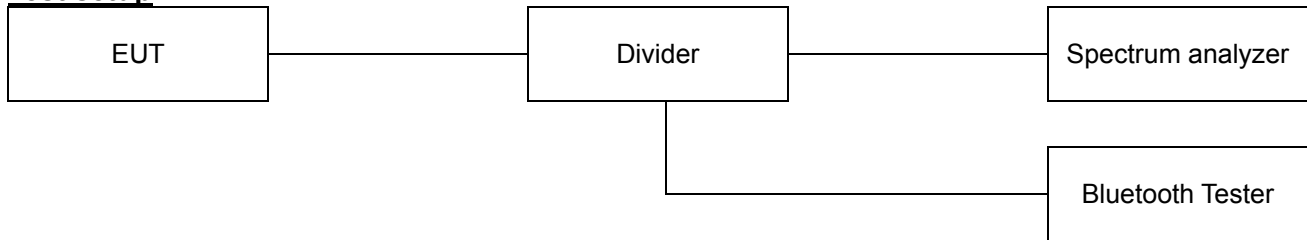
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Horizontal/Vertical for Band-edge

Horizontal/Vertical for 1 GHz ~ 3.5 GHz**Horizontal/Vertical for 3.5 GHz ~ 18 GHz****Horizontal/Vertical for 18 GHz ~ 26.5 GHz**

7.7. Conducted Spurious Emission

Test setup



Limit

According to §15.247(d), RSS-247(5.5), 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 11.11.3, 14.3.3

KDB 558074 D01 v05 - Section 8.5

KDB 662911 D01 v02r01 – section (E)(3)(b)

Test settings

Establish an emission level by using the following procedure:

- 1) Set the center frequency and span to encompass frequency range to be measured.
- 2) Set the RBW = 100 kHz
- 3) Set the VBW $\geq [3 \times \text{RBW}]$
- 4) Detector = peak
- 5) Sweep time = auto couple
- 6) Trace mode = max hold
- 7) Allow trace to fully stabilize.
- 8) Use the peak marker function to determine the maximum amplitude level.

Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in 11.11. Report the three highest emissions relative to the limit.

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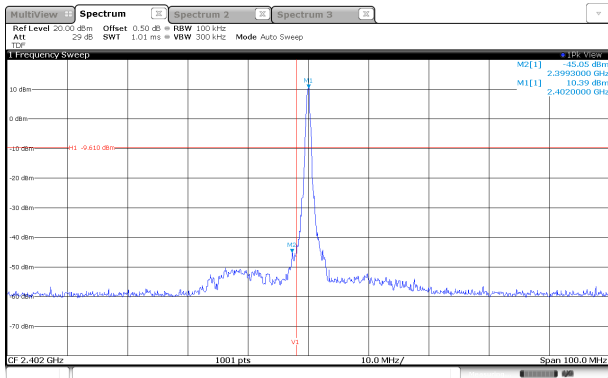
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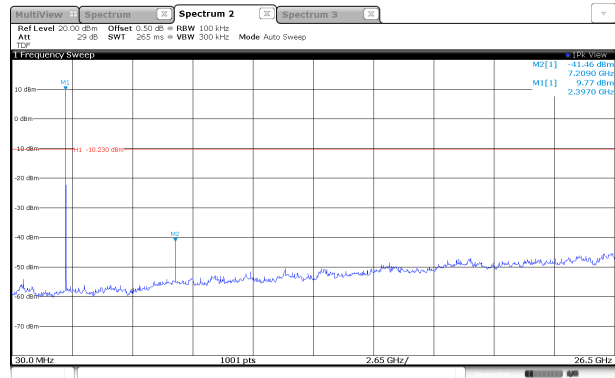
Test results

GFSK

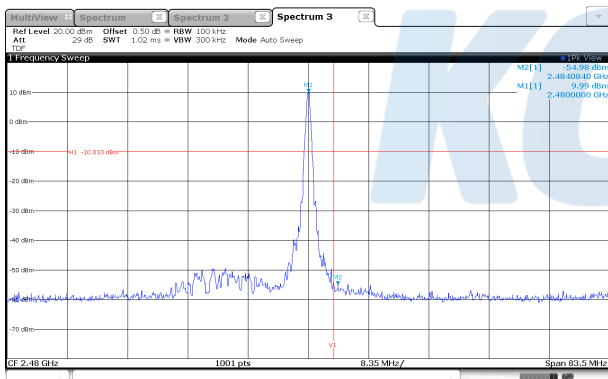
Conducted band-edge / Low ch.



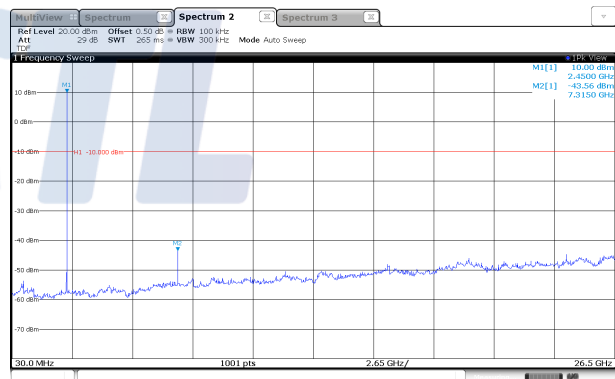
Conducted spurious / Low ch.



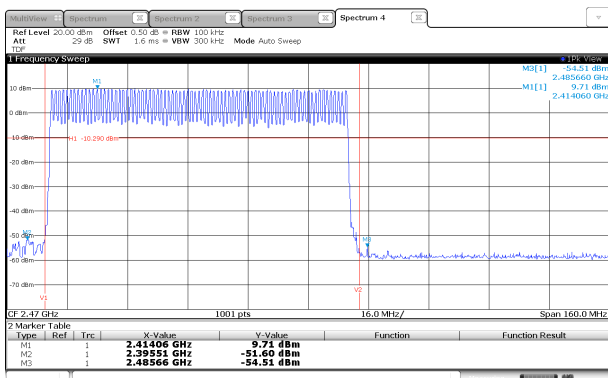
Conducted band-edge / High ch.



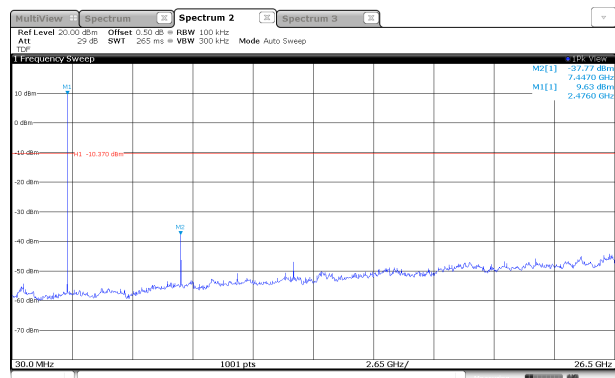
Conducted spurious / Mid ch.



Conducted band-edge / Hopping ch.



Conducted spurious / High ch.



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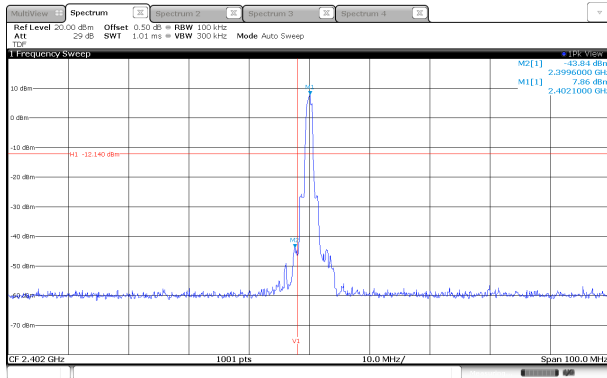
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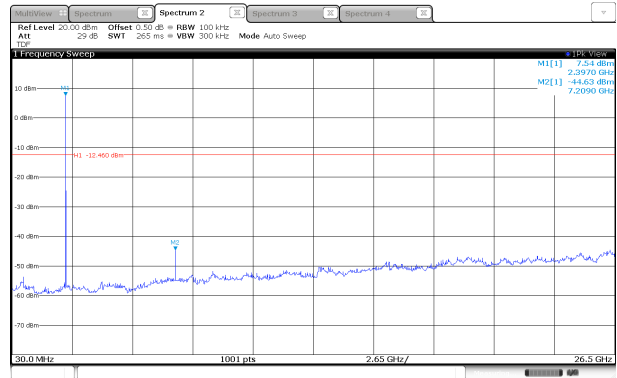
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8DPSK

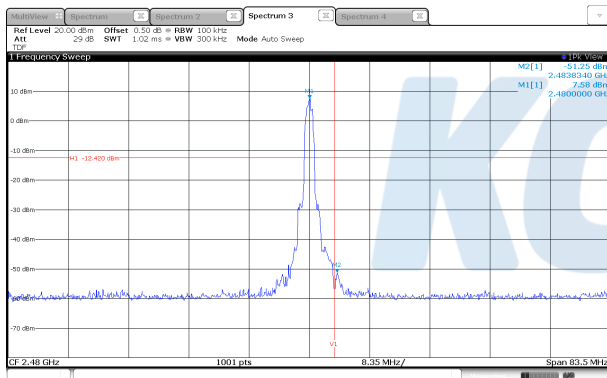
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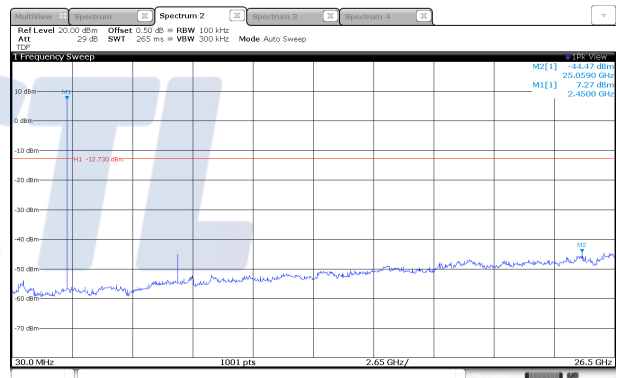
Conducted spurious / Low ch.



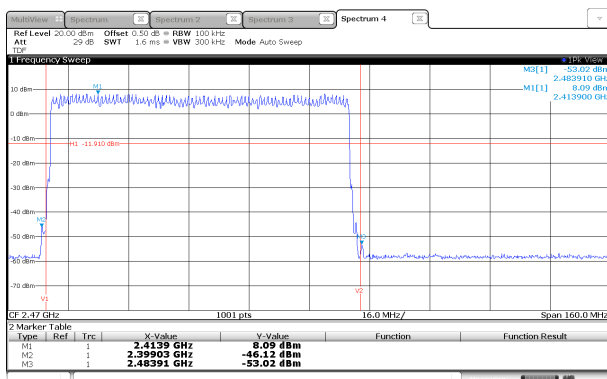
Conducted band-edge / High ch.



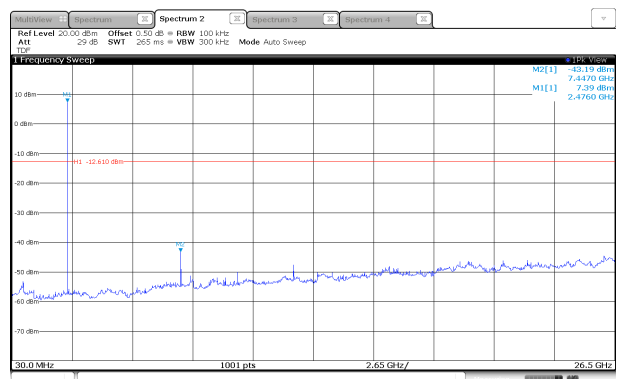
Conducted spurious / Mid ch.



Conducted band-edge / Hopping ch.

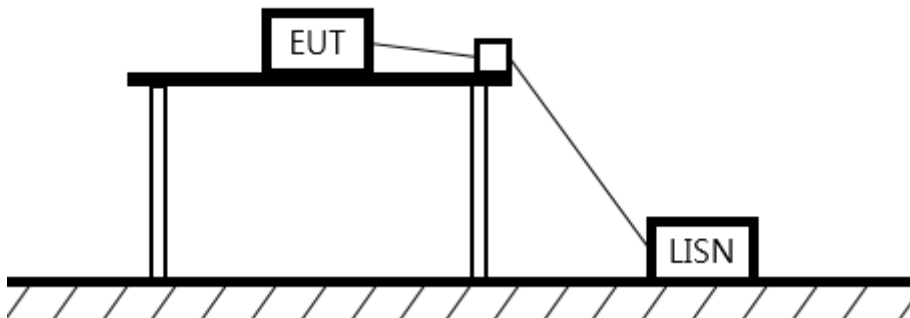


Conducted spurious / High ch.



7.7. 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 be 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.

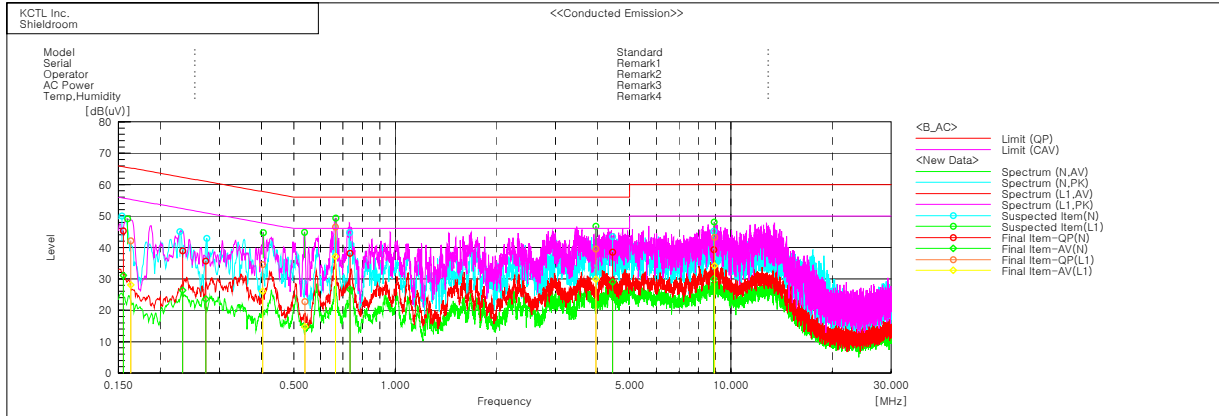
Frequency of Emission (MHz)	Conducted limit (dB μ V/m)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

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 in 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: 8DPSK Lowest frequency



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	0.15512	35.4	21.2	9.9	45.3	31.1	65.7	55.7	20.4	24.6
2	0.23295	29.2	16.7	9.7	38.9	26.4	62.3	52.3	23.4	25.9
3	0.27339	26.0	13.8	9.7	35.7	23.5	61.0	51.0	25.3	27.5
4	0.73356	28.4	16.7	9.8	38.2	26.5	56.0	46.0	17.8	19.5
5	4.44558	28.9	19.3	9.6	38.5	28.9	56.0	46.0	17.5	17.1
6	8.89484	29.4	20.1	9.8	39.2	29.9	60.0	50.0	20.8	20.1

--- 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	0.16345	32.0	18.0	10.1	42.1	28.1	65.3	55.3	23.2	27.2
2	0.40345	24.7	16.3	9.8	34.5	26.1	57.8	47.8	23.3	21.7
3	0.53929	12.8	4.8	9.9	22.7	14.7	56.0	46.0	33.3	31.3
4	0.66508	36.7	27.3	9.8	46.5	37.1	56.0	46.0	9.5	8.9
5	3.95952	29.9	20.3	9.6	39.5	29.9	56.0	46.0	16.5	16.1
6	8.93206	33.4	24.3	9.8	43.2	34.1	60.0	50.0	16.8	15.9

8. Measurement equipment

Equipment Name	Manufacturer	Model No.	Serial No.	Next Cal. Date
Spectrum Analyzer	R&S	FSW50	101013	20.05.13
Spectrum Analyzer	R&S	FSV40	100988	20.01.04
Bluetooth Tester	TESCOM	TC-3000B	3000B640056	20.01.25
Power Divider	Aeroflex/ Weinschel, Inc	1580-1	SC571	20.08.01
Wideband Power Sensor	R&S	NRP-Z81	102398	20.01.25
ATTENUATOR	R&S	DNF Dämpfungsglied 10 dB in N-50 Ohm	31212	20.05.13
EMI TEST RECEIVER	R&S	ESC17	100732	20.08.22
Bi-Log Antenna	SCHWARZBECK	VULB 9168	583	20.05.04
Amplifier	SONOMA INSTRUMENT	310N	284608	20.08.22
COAXIAL FIXED ATTENUATOR	Agilent	8491B-003	2708A18758	20.05.04
Horn antenna	ETS.lindgren	3116	00086632	20.02.15
Horn antenna	ETS.lindgren	3117	155787	20.10.24
Attenuator	API Inmet	40AH2W-10	12	20.05.15
Broadband PreAmplifier	SCHWARZBECK	BBV9718	216	20.07.30
AMPLIFIER	L-3 Narda-MITEQ	AMF-7D-01001800 -22-10P	2031196	20.02.21
AMPLIFIER	L-3 Narda-MITEQ	JS44-18004000-33 -8P	2000997	20.08.01
LOOP Antenna	R&S	HFH2-Z2	100355	20.08.24
Antenna Mast	Innco Systems	MA4640-XP-ET	-	-
Turn Table	Innco Systems	DT2000	79	-
Antenna Mast	Innco Systems	MA4000-EP	303	-
Turn Table	Innco Systems	DT2000	79	-
Highpass Filter	WT	WT-A1698-HS	WT160411001	20.05.14
TWO-LINE V - NETWORK	R&S	ENV216	101358	20.04.05
EMI TEST RECEIVER	R&S	ESCI	100001	20.08.22
Vector Signal Generator	R&S	SMBV100A	257566	20.01.04
Signal Generator	R&S	SMR40	100007	20.05.13
Cable Assembly	RadiAll	2301761768000PJ	1724.659	-
Cable Assembly	Gigalane	RG-400	-	-
Cable Assembly	HUER+SUHNER	SUCOFLEX 104	MY4342/4	-

End of test report