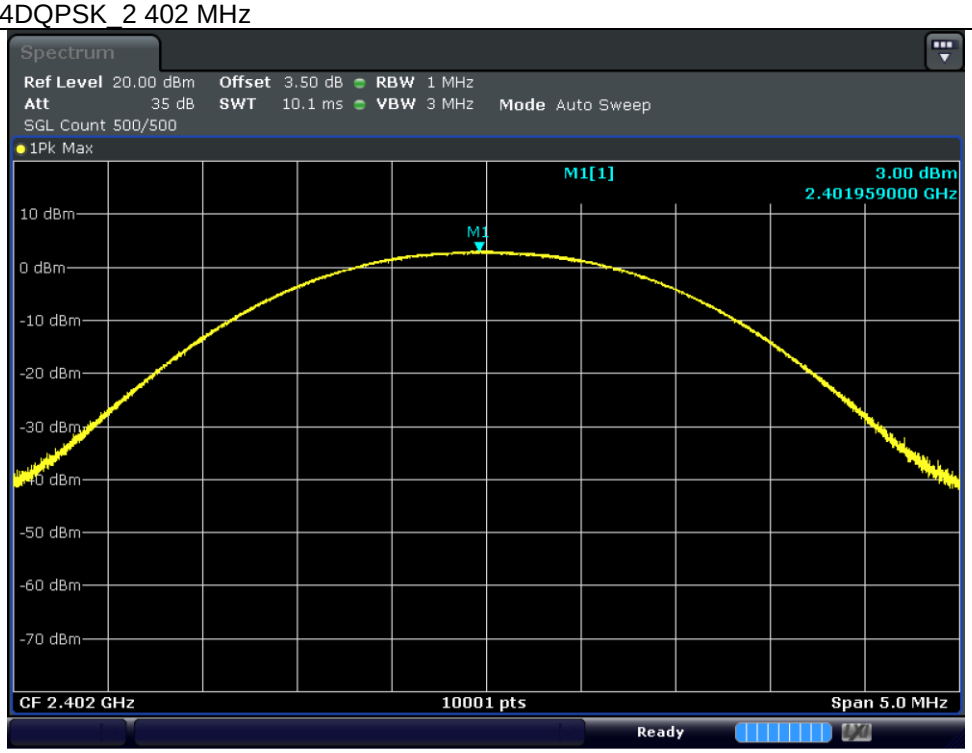
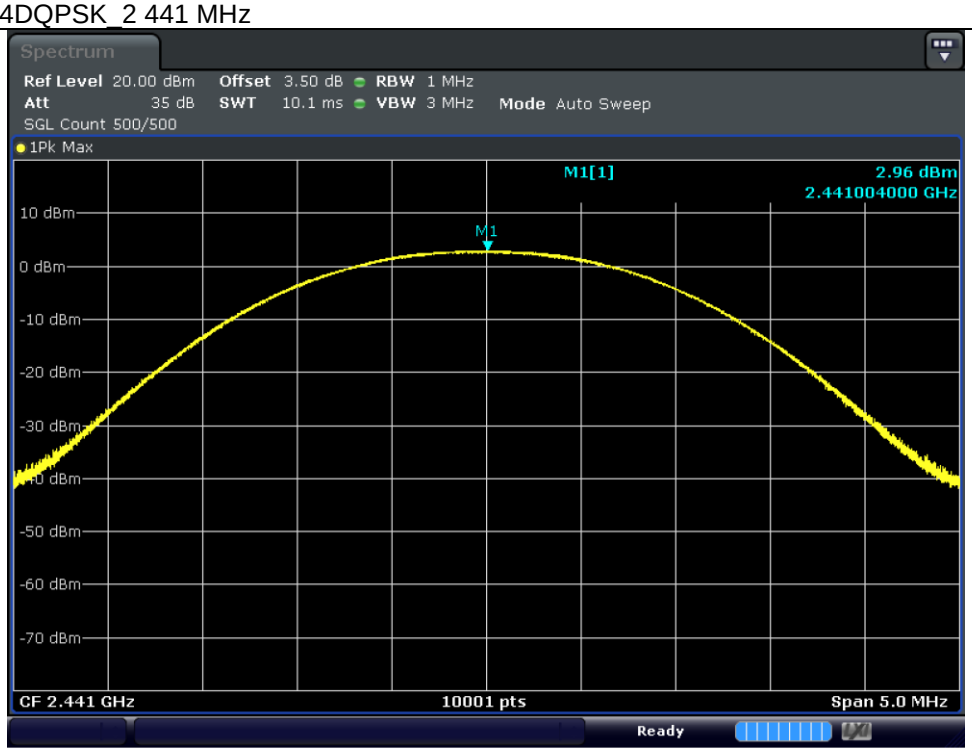
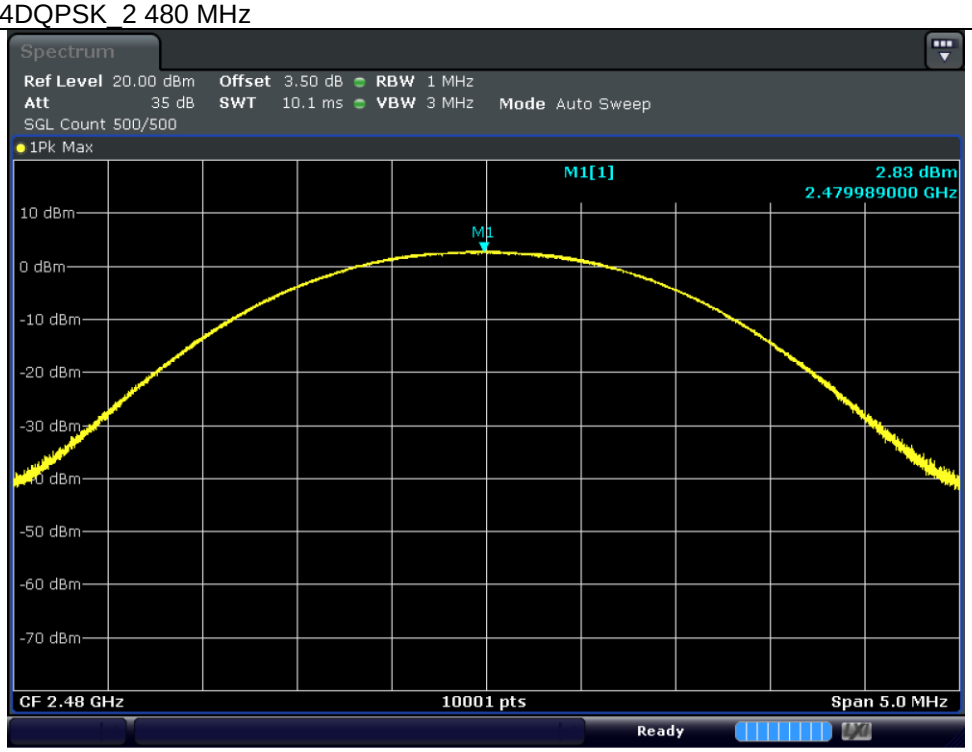
pi/4DQPSK_2 402 MHz



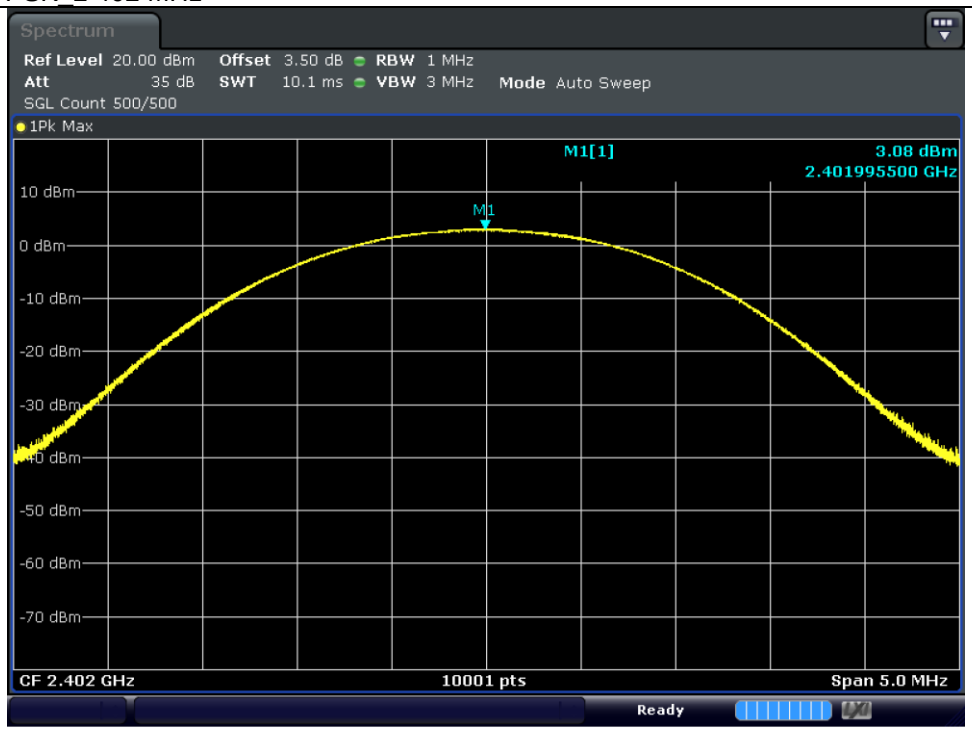
pi/4DQPSK_2 441 MHz



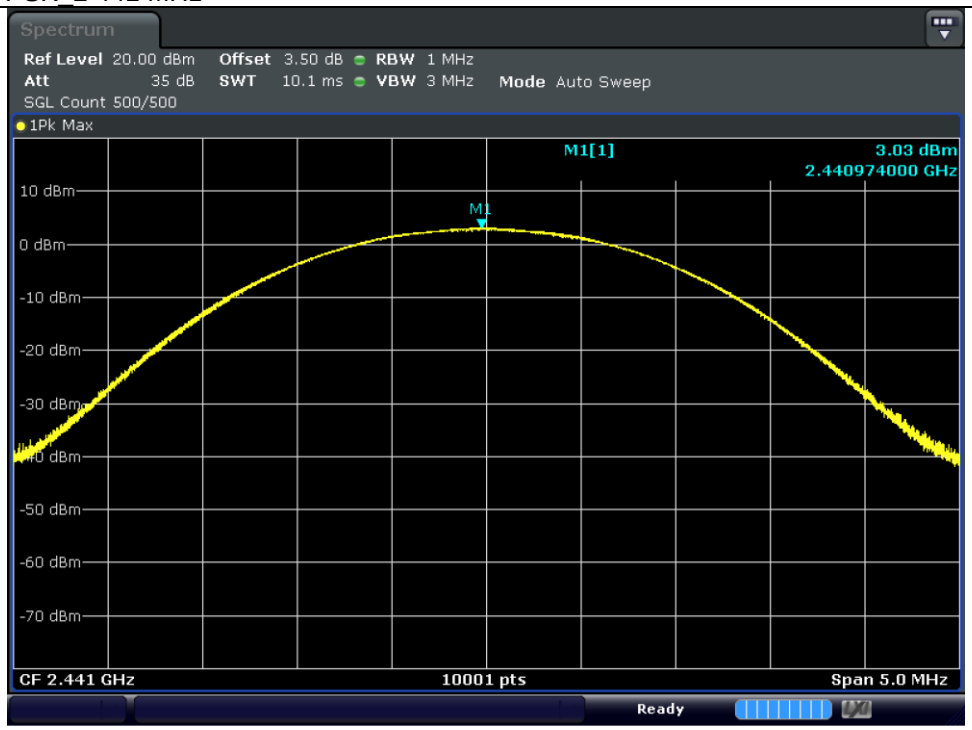
pi/4DQPSK_2 480 MHz



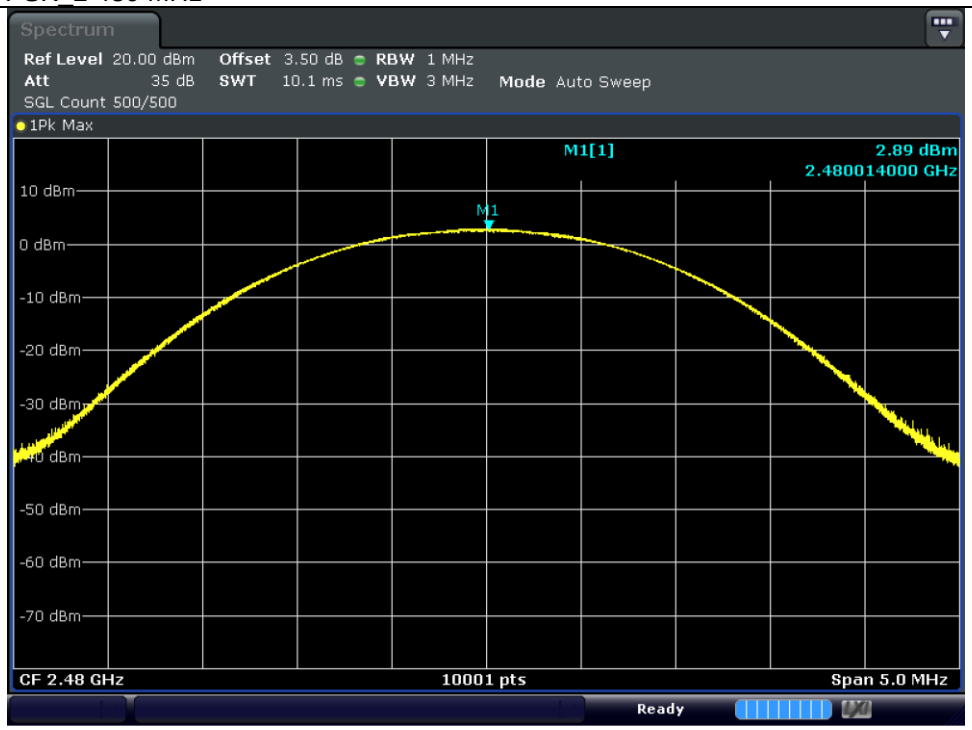
8DPSK_2 402 MHz



8DPSK_2 441 MHz



8DPSK_2 480 MHz



4.3.7 Spurious Emission, Band Edge, and Restricted bands

4.3.7.1 Regulation

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 operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

According to §15.209(a) and RSS-GEN §8.9 Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall notexceed the field strength levels specified in the following table:

Frequency(MHz)	Field strength(microvolts/meter)	Measurement distance(meters)
0.009 - 0.490	2 400/F(kHz)	300
0.490 - 1.705	24 000/F(kHz)	30
1.705 - 30.0	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 shallnot 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., §§15.231 and 15.241.

According to §15.205(a),(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 25	2 483.5 – 2 500	17.7 - 21.4
8.376 25 - 8.386 75	156.7 - 156.9	2 690 – 2 900	22.01 - 23.12
8.414 25 - 8.414 75	162.012 5 - 167.17	3 260 – 3 267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3 332 – 3 339	31.2 - 31.8
12.519 75 - 12.520 25	240 - 285	3 345.8 – 3 358	36.43 - 36.5
12.576 75 - 12.577 25	322 - 335.4	3 600 – 4 400	Above 38.6
13.36 - 13.41			

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurement

4.3.7.2 Measurement Procedure

ANSI C63.10 § 6.10.4 Authorized band-edge relative method (lower bandedge)
ANSI C63.10 § 6.10.6 Marker Delta Method (upper restricted bandedge)
ANSI C63.10 § 11.11.1 General Information
ANSI C63.10 § 11.11.3 Emission level measurement

4.3.7.2.1 Band-edge Compliance of RF Conducted Emissions

Span : wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation
RBW : ≥ 1% of the span
VBW : ≥ RBW
Sweep : Auto
Detector : Peak
Trace : Max hold

Allow the trace to stabilize. Set the marker on the emission at the bandedge, or on the highest modulation product outside of the band, if this level is greater than that at the bandedge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission. The marker-delta value now displayed must comply with the limit specified in this Section. Submit this plot.

Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit. Submit this plot.

4.3.7.2.2 Conducted Spurious Emissions

Span : wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation
RBW : ≥ 1% of the span
VBW : ≥ RBW
Sweep : Auto
Detector : Peak
Trace : Max hold

Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this Section. Submit these plots.

4.3.7.2.3 Radiated Spurious Emissions

1) The preliminary and final rdiated measurements were performed to determine the frequency producing the maximum emissions in at a 10m anechoic chamber. The EUT was tested at a distance 3 m(Below 1 GHz) and 1 m(Above 1 GHz).
2) The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360°.
3) The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, and from 30 to 1 000 MHz using the BILOG broadband antenna, and from 1 000 MHz to 10 000 MHz using the horn antenna.
4) Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

Span : wide enough to fully capture the emission being measured
RBW : ≥ 1 MHz for f ≥1 GHz, 100 kHz for f < 1 GHz
VBW : ≥ RBW
Sweep : Auto
Detector : Peak
Trace : Max hold

Follow the guidelines in ANSI C63.4 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization, etc. A pre-amp and a high pass filter are required for this test, in order to provide the measuring system with sufficient sensitivity. Allow the trace to stabilize. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, which must comply with the limit specified in Section 15.35(b). Submit this data.

set the VBW to 10 Hz, while maintaining all of the other instrument settings. This peak level, once corrected, must comply with the limit specified in Section 15.209. If the dwell time per channel of the hopping signal is less than 100 ms, then the reading obtained with the 10 Hz VBW may be further adjusted by a “duty cycle correction factor”, derived from 20log(dwell time/100 ms), in an effort to demonstrate compliance with the 15.209 limit. Submit this data.

NOTE1 : The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequency below 1 GHz.
NOTE2 : The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
NOTE3 : The 0.8 m height is for below 1 GHz testing, and 1.5 m is for above 1 GHz testing

4.3.7.3 Result

Comply (measurement data : refer to the next page)

4.3.7.4 Measurement data_Radiated Spurious Emissions

Test mode : Below 1 GHz (Worst case : 8DPSK_2 480 MHz)

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Ant Factor (dB)	Loss (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
77.17	QP	V	37.20	15.60	-28.40	24.40	40.00	15.60
149.55	QP	H	50.40	19.70	-27.60	42.50	43.50	1.00
326.09	QP	H	46.60	20.40	-26.60	40.40	46.00	5.60
419.93	QP	H	41.90	22.30	-26.50	37.70	46.00	8.30

Note 1 : Loss : Cable loss - Amp gain
Note 2 : Result : Reading + Ant Factor + Loss

Test mode : Above 1 GHz_GFSK_2 402

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2540.66	PK	V	59.40	-4.50	-	54.86	74.00	19.14
	AV	V	27.00	-4.50	-24.77	-2.31	54.00	56.31
Above 3 GHz	Not Detected	-	-	-	-	-	-	-

Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

Test mode : Above 1 GHz_GFSK_2 441

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
			Not Detected					

Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

Test mode : Above 1 GHz_GFSK_2 480

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
			Not Detected					

Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

Test mode : Above 1 GHz_8DPSK_2 402

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2568.26	PK	V	59.60	-4.30	-	55.26	74.00	18.74
	AV	V	27.30	-4.30	-24.76	-1.80	54.00	55.80
Above 3 GHz	Not Detected	-	-	-	-	-	-	-

Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

Test mode : Above 1 GHz_8DPSK_2 441

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
			Not Detected					

Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

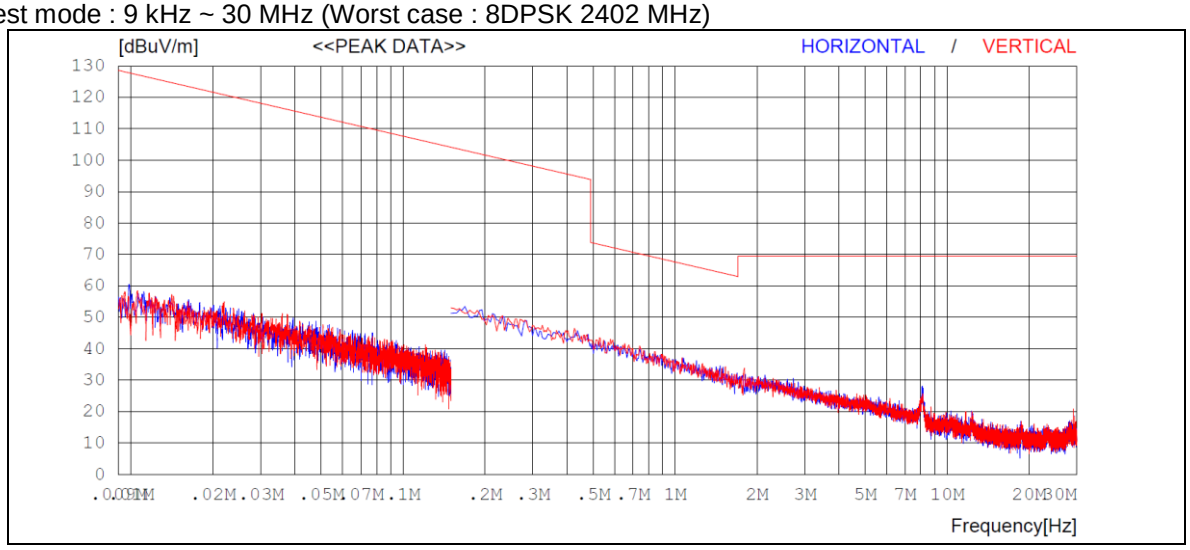
Test mode : Above 1 GHz_8DPSK_2 480

Frequency (MHz)	Detector	Pol. (V/H)	Reading (dBµV)	Factor (dB)	DCCF (dB)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)
			Not Detected					

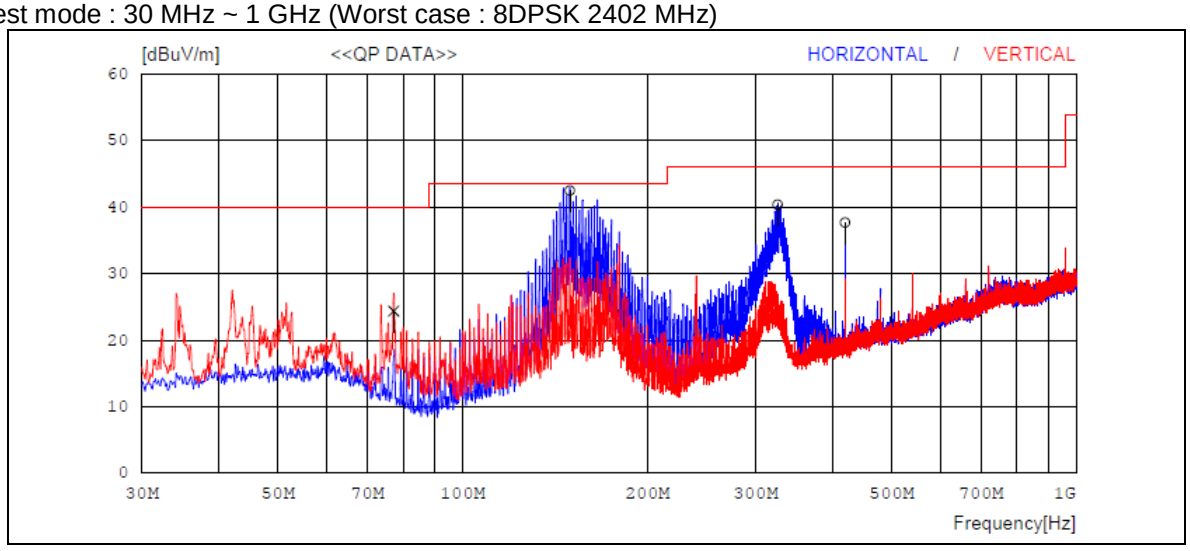
Note 1 : Factor : Ant Factor + Cable loss - Amp gain + Distance Factor
Note 2 : Peak Result : Reading + Factor
Note 3 : DCCF(Duty Cyle Correction Factor) : 20 x Log(worst case dwell time / 100 ms) dB, refer to 4.4.7.7
Average Reasult : Average Reading + Factor + DCCF
Note 4 : Above 1 GHz Measured distance : 1 m
Above 1 GHz Distance Factor = 20log(1 / 3) = -9.54
Note 5 : Not Detected means that peak data does not exceed the average limit.

4.3.7.5 Measurement Plot_Radiated Spurious Emissions

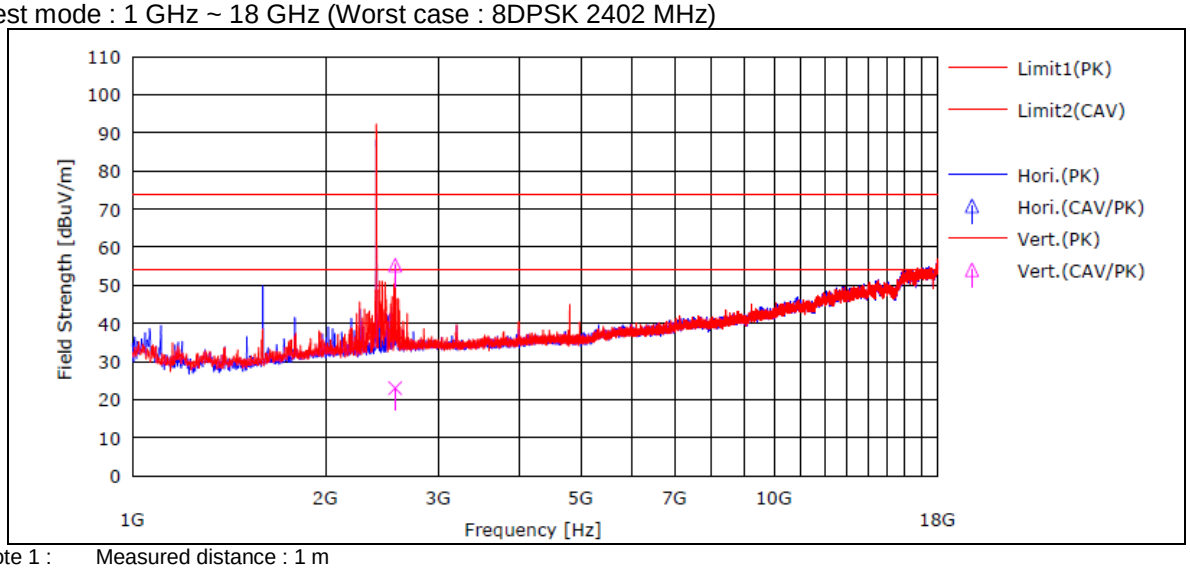
Test mode : 9 kHz ~ 30 MHz (Worst case : 8DPSK 2402 MHz)



Test mode : 30 MHz ~ 1 GHz (Worst case : 8DPSK 2402 MHz)

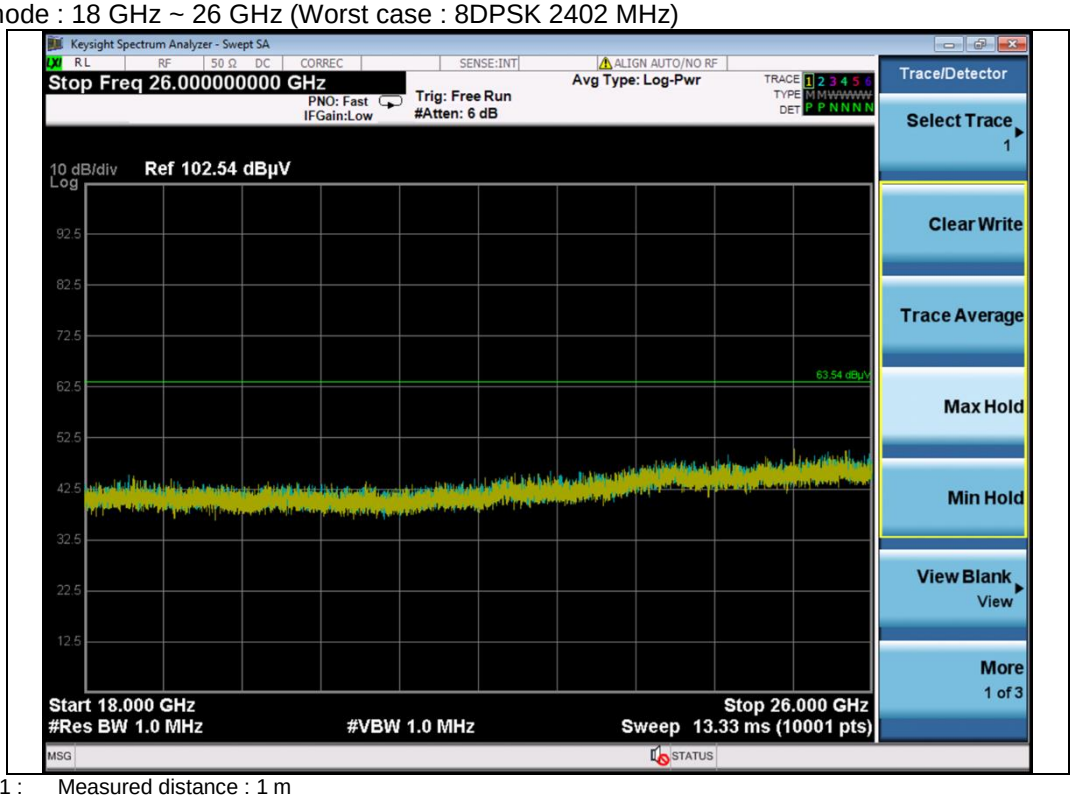


Test mode : 1 GHz ~ 18 GHz (Worst case : 8DPSK 2402 MHz)



Note 1 : Measured distance : 1 m
Note 2 : Limit : Peak : 74 dBµV/m, Average : 54 dBµV/m

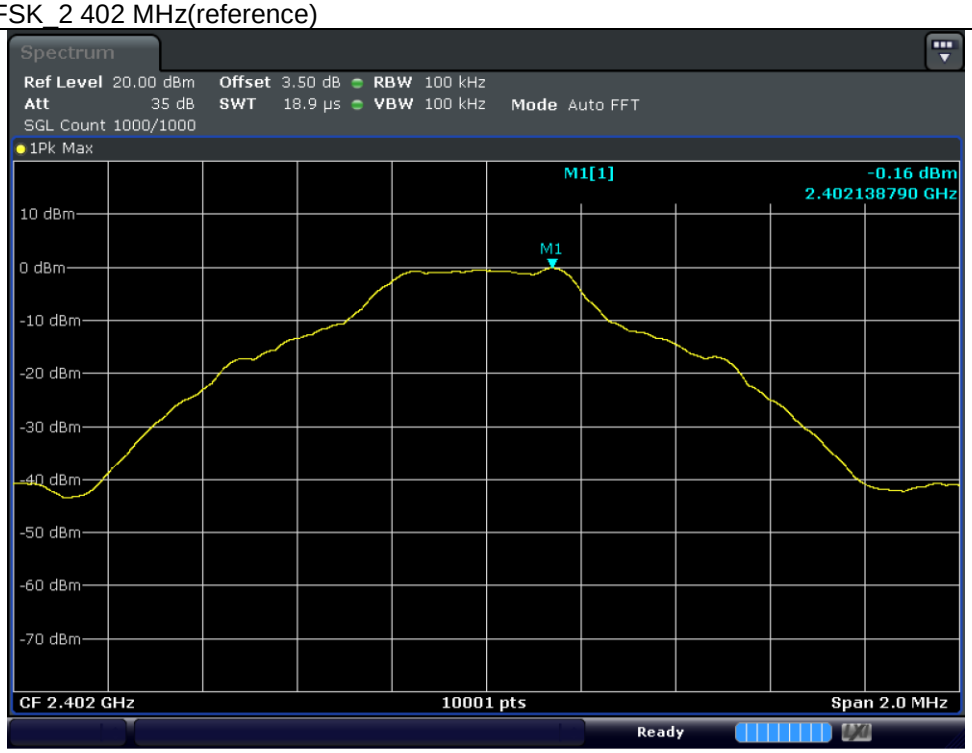
Test mode : 18 GHz ~ 26 GHz (Worst case : 8DPSK 2402 MHz)



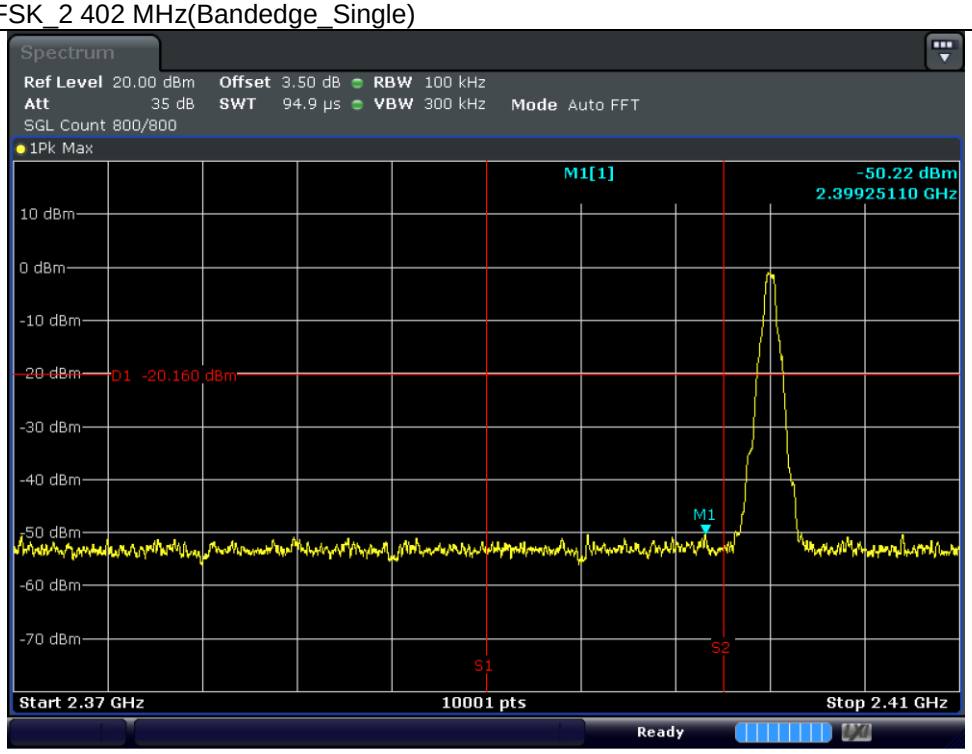
NOTE 1 : Measured distance : 1 m
NOTE 2 : Limit : Peak : 83.54 dBµV/m, Average : 63.54 dBµV/m

4.3.7.6 Measurement data_Conducted Spurious Emissions

GFSK_2 402 MHz(reference)

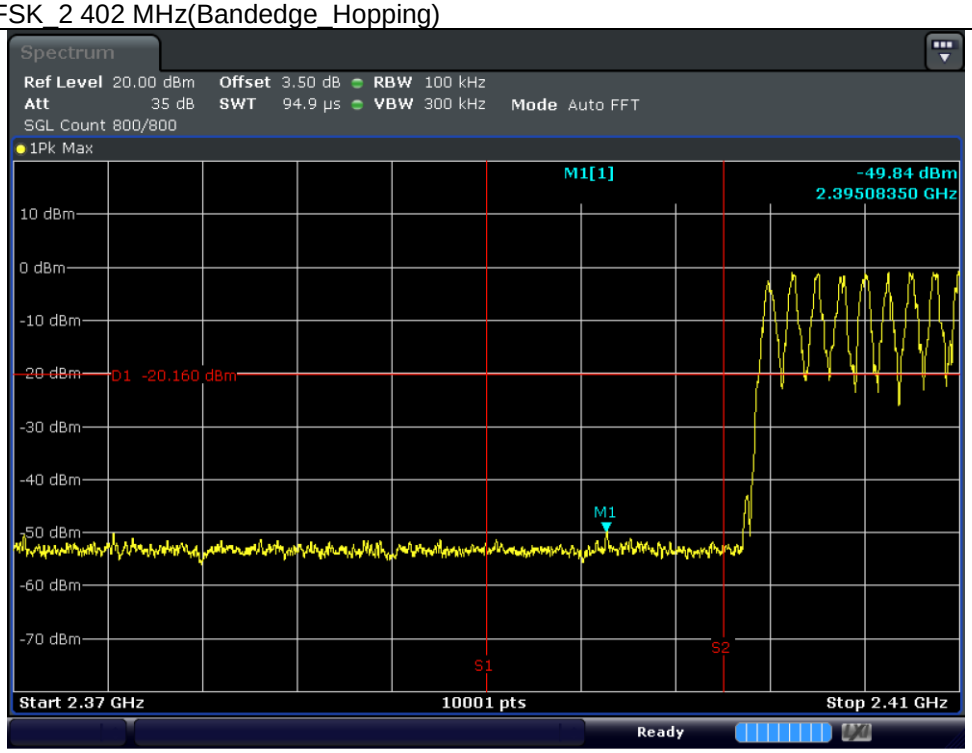


GFSK_2 402 MHz(Bandedge_Single)



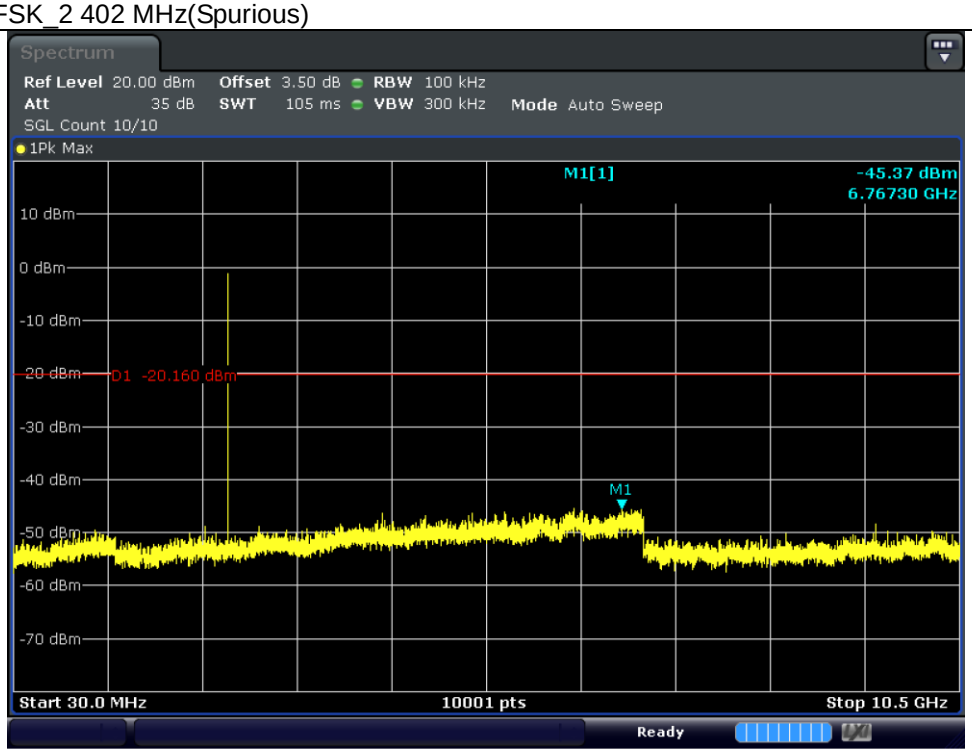
NOTE: F1 : 2 390 MHz, F2 : 2 400 MHz

GFSK_2 402 MHz(Bandedge_Hopping)

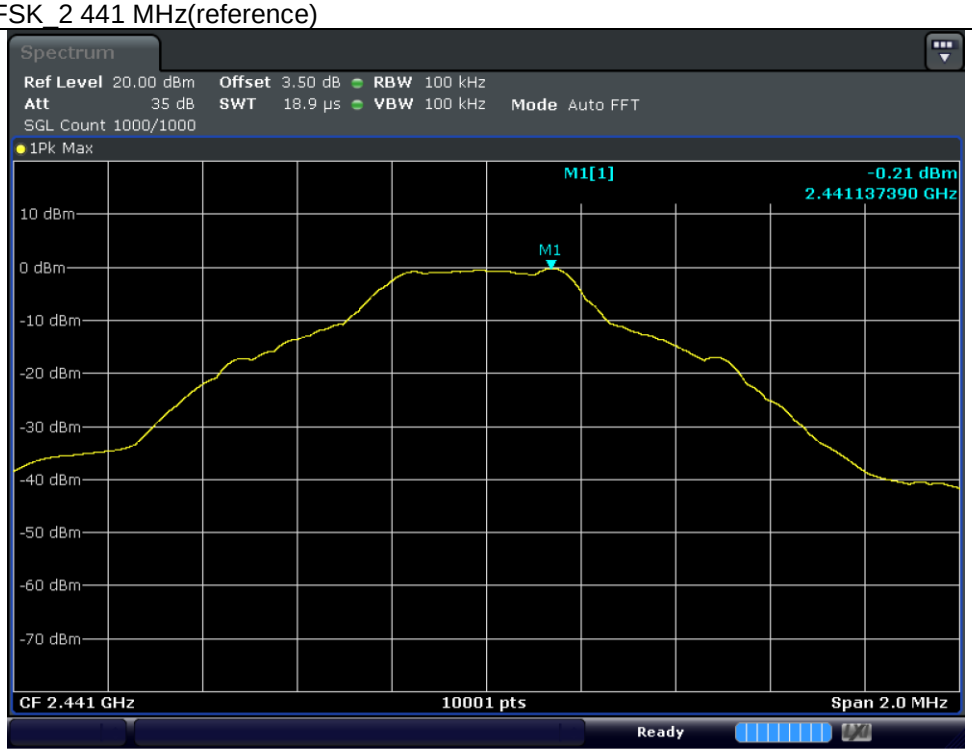


NOTE: F1 : 2 390 MHz, F2 : 2 400 MHz

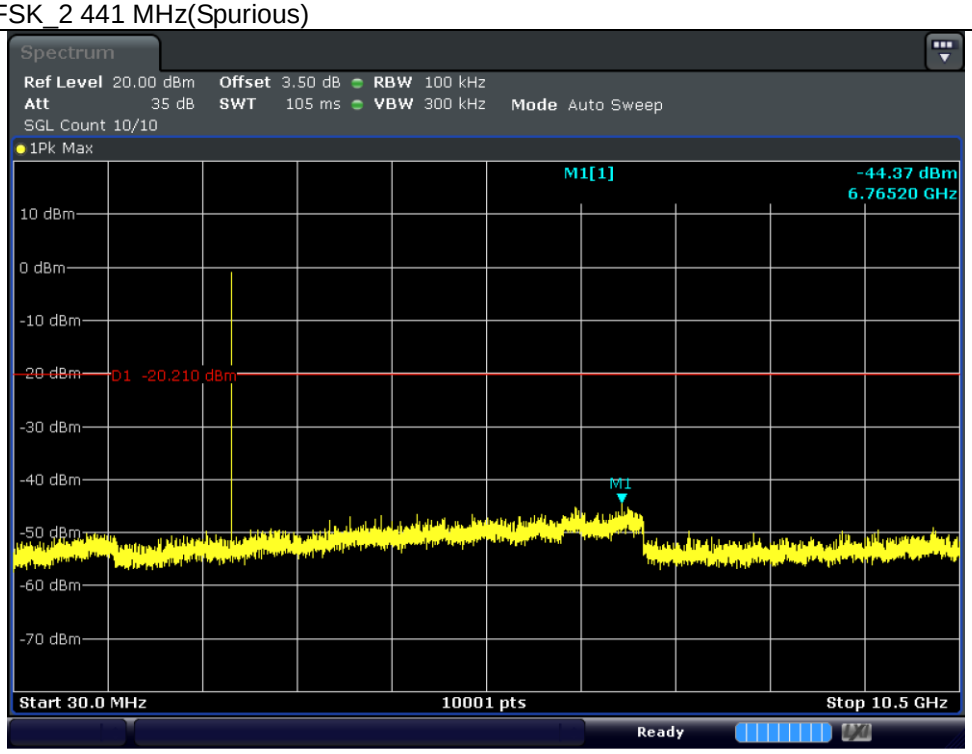
GFSK_2 402 MHz(Spurious)



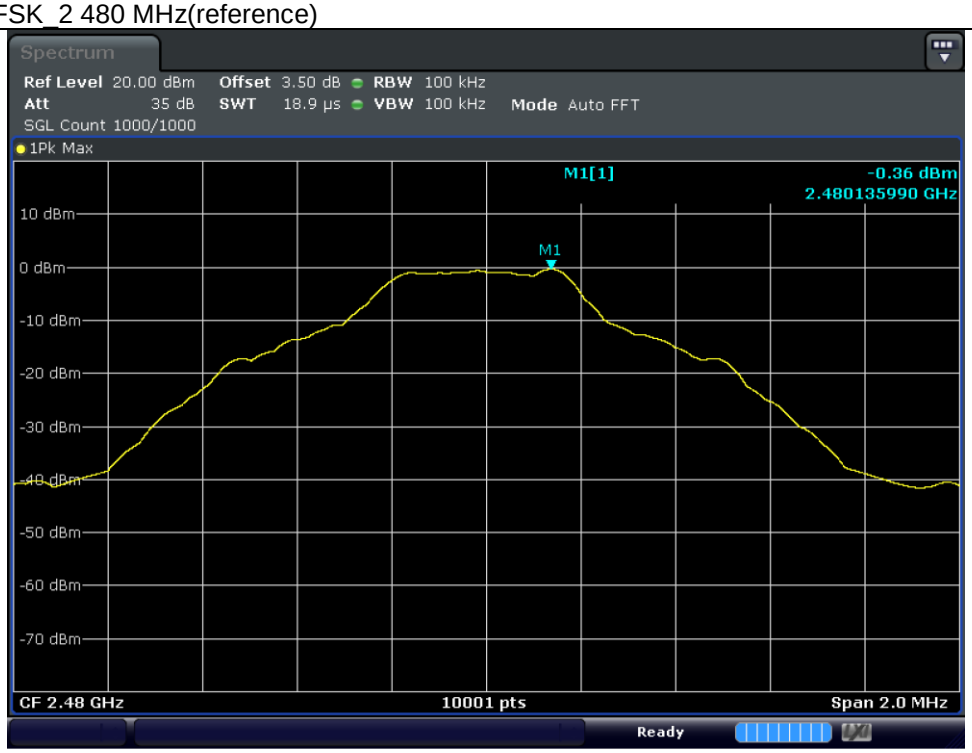
GFSK_2 441 MHz(reference)



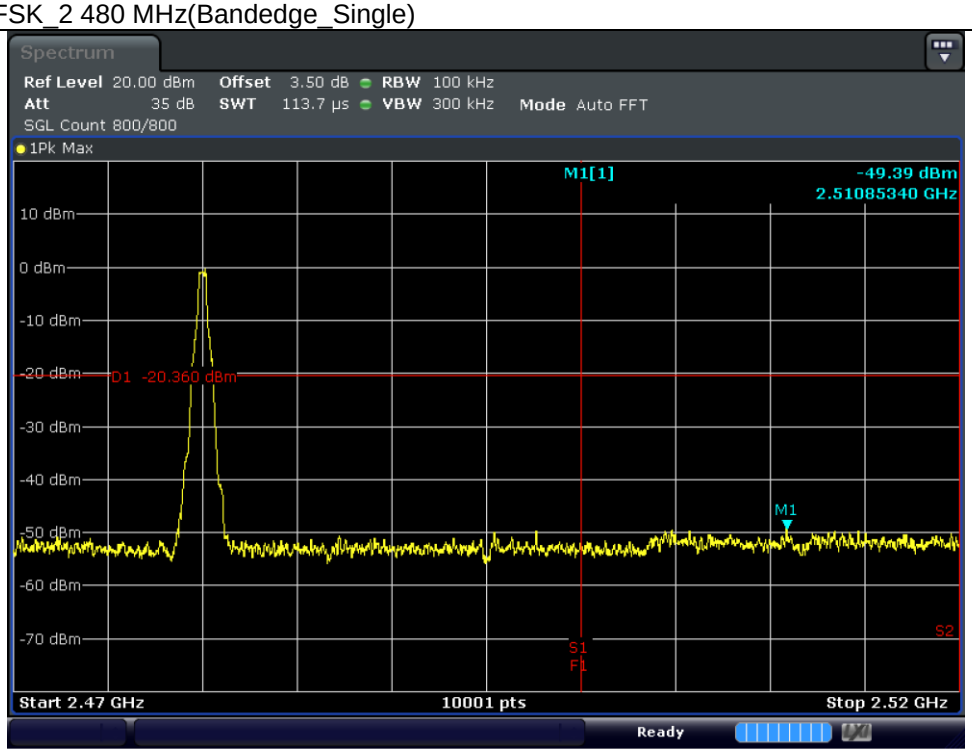
GFSK_2 441 MHz(Spurious)



GFSK_2 480 MHz(reference)

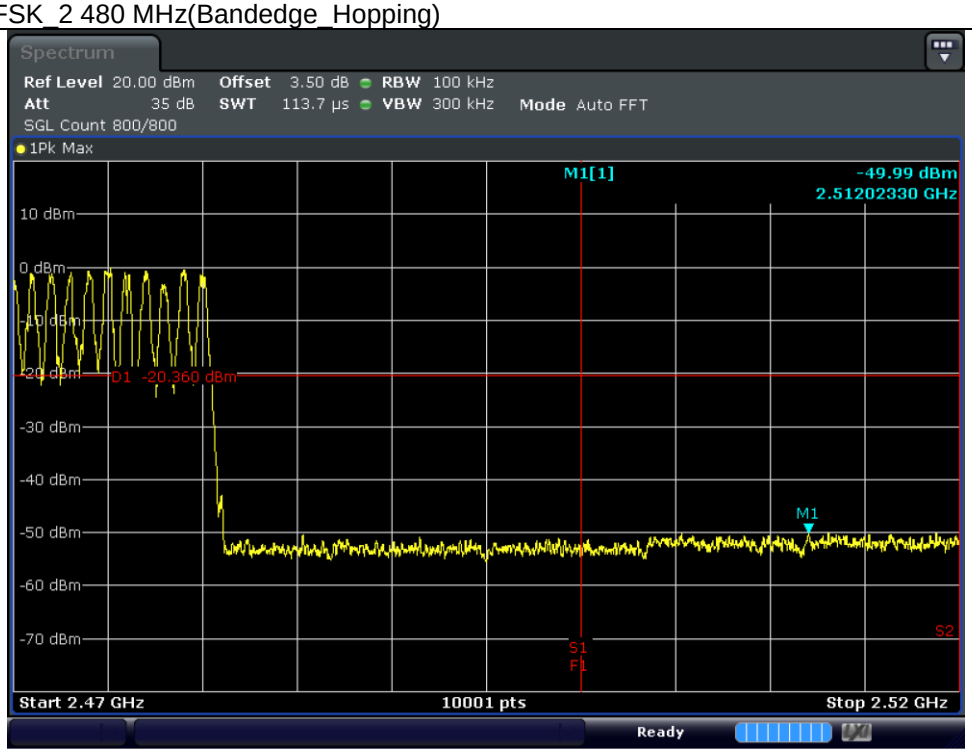


GFSK_2 480 MHz(Bandedge_Single)



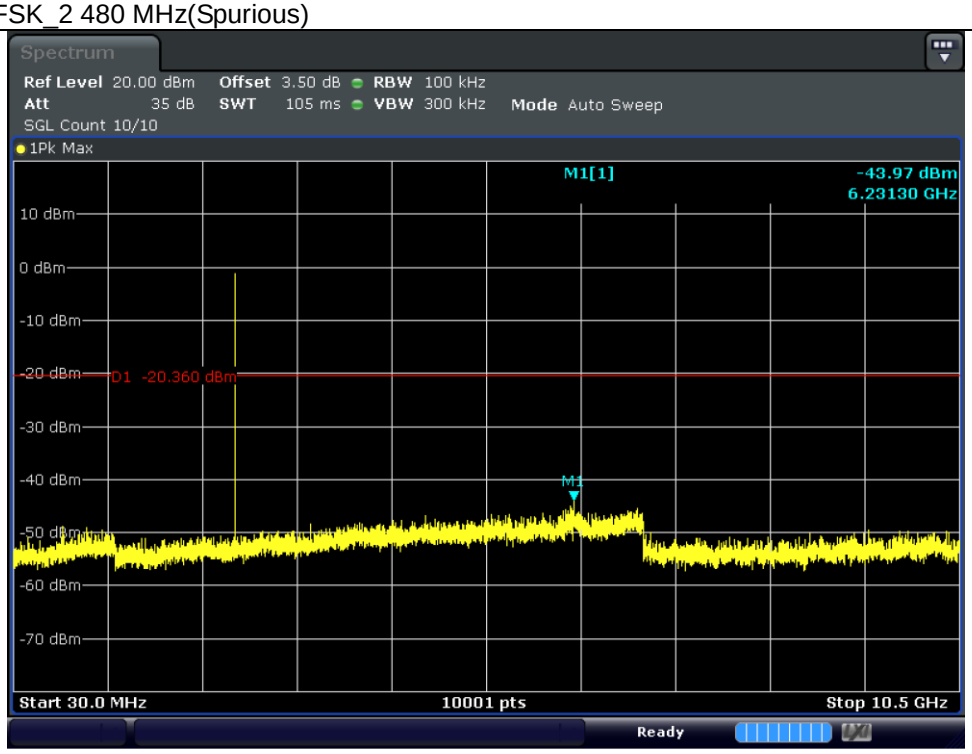
NOTE: F1 : 2 500 MHz

GFSK_2 480 MHz(Bandedge_Hopping)

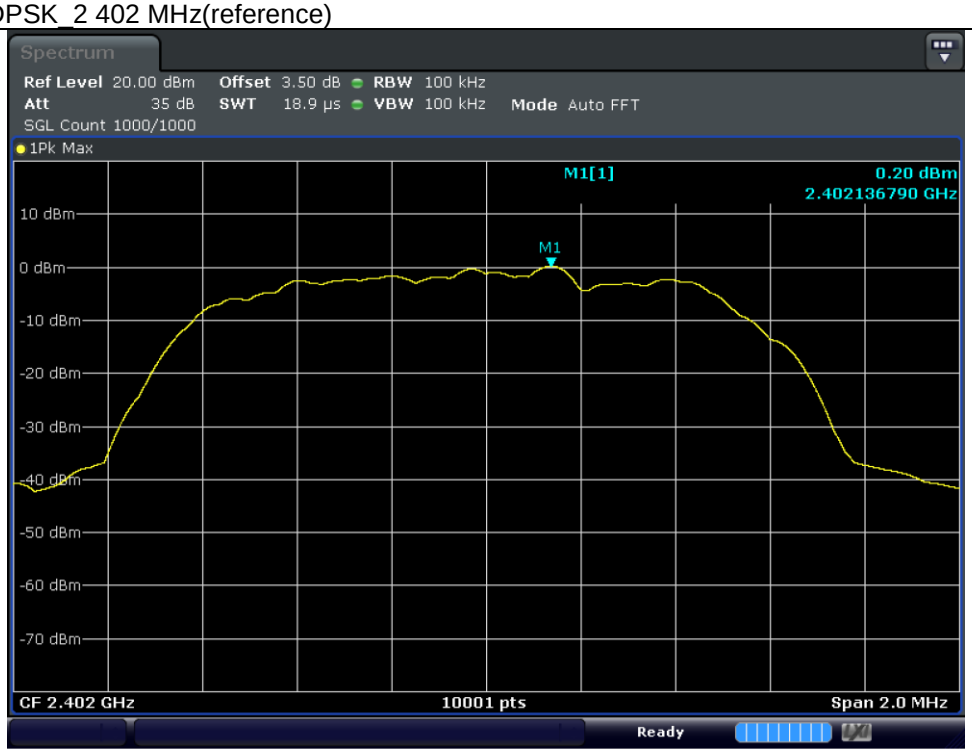


NOTE: F1 : 2 500 MHz

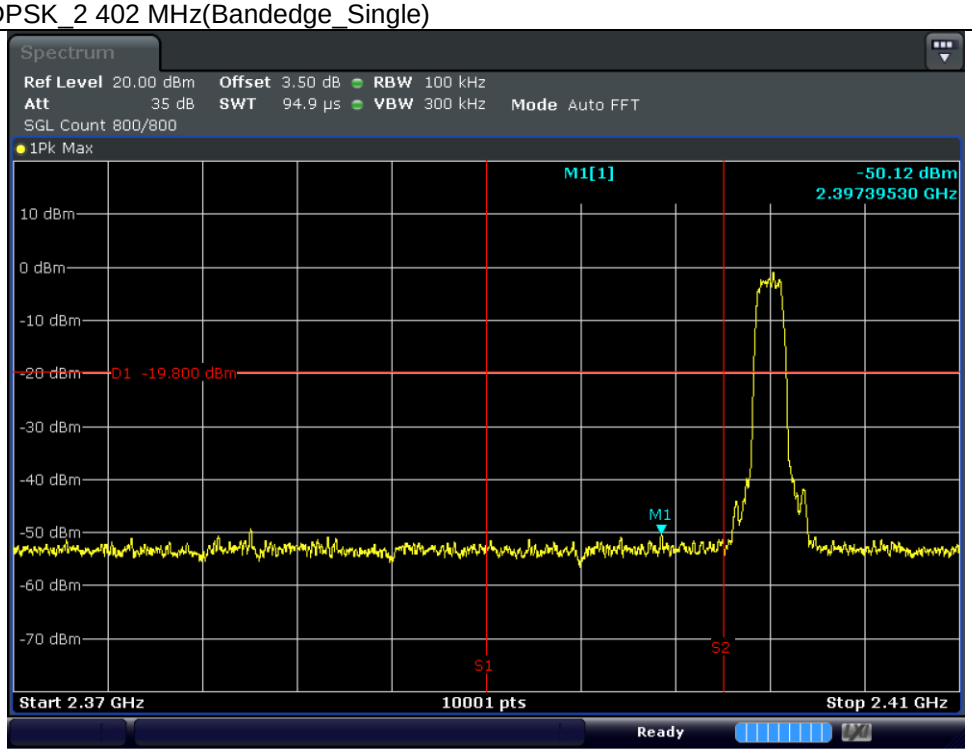
GFSK_2 480 MHz(Spurious)



8DPSK_2 402 MHz(reference)

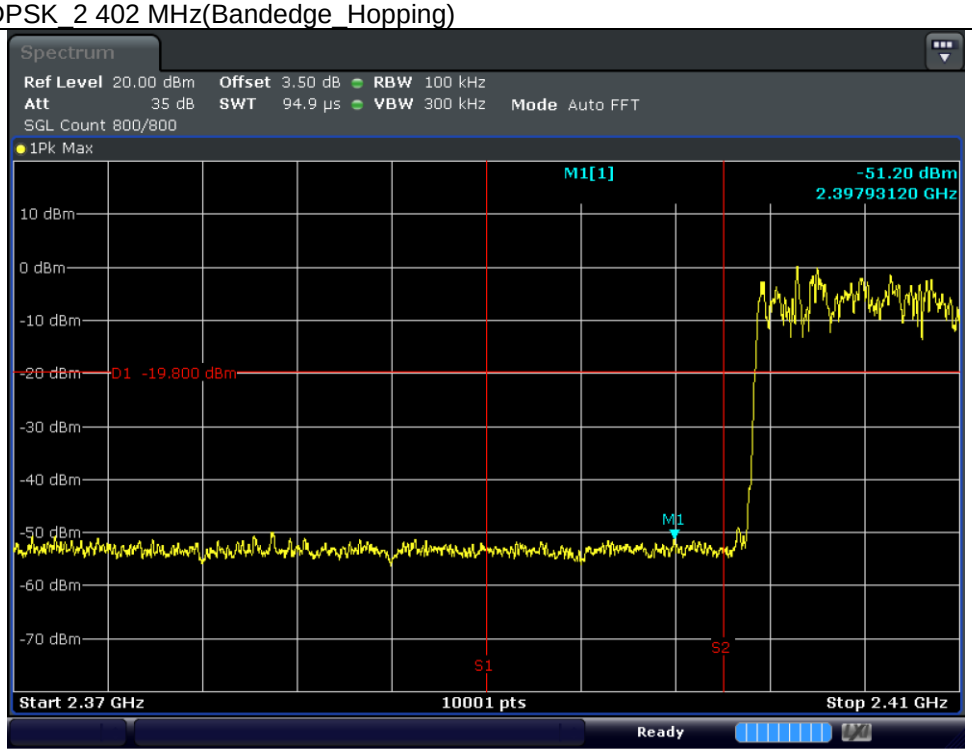


8DPSK_2 402 MHz(Bandedge_Single)



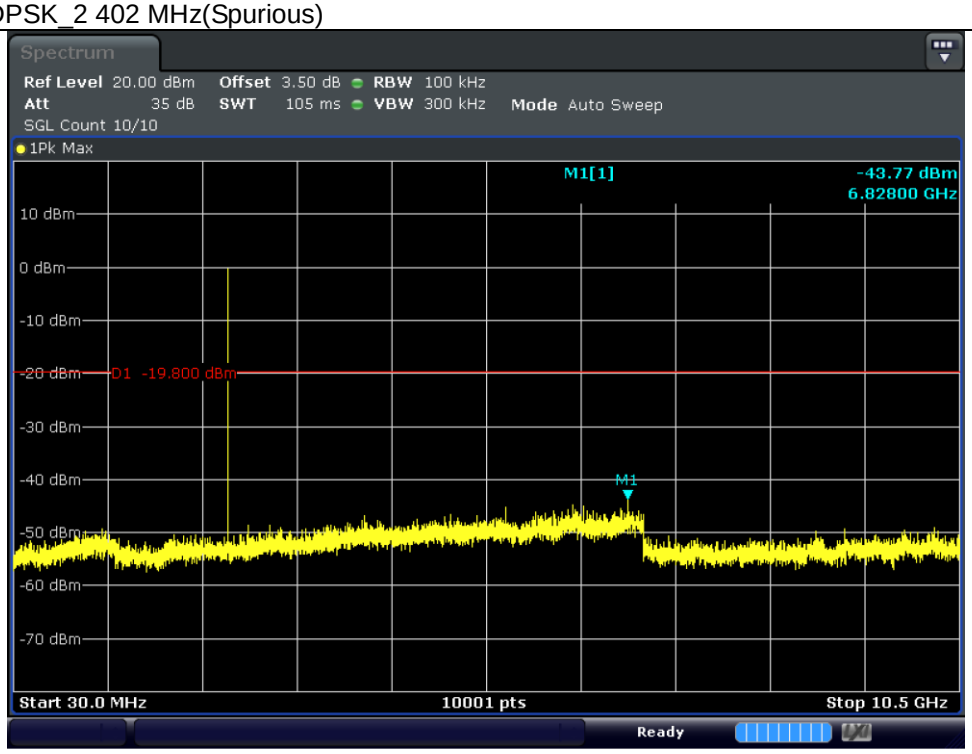
NOTE: F1 : 2 390 MHz, F2 : 2 400 MHz

8DPSK_2 402 MHz(Bandedge_Hopping)

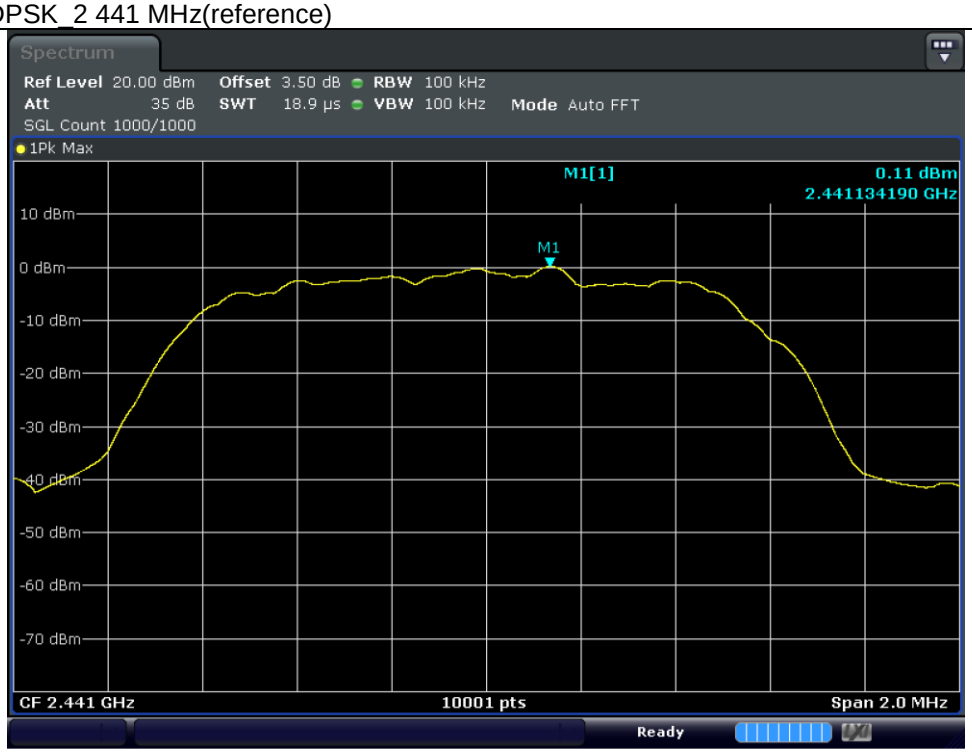


NOTE: F1 : 2 390 MHz, F2 : 2 400 MHz

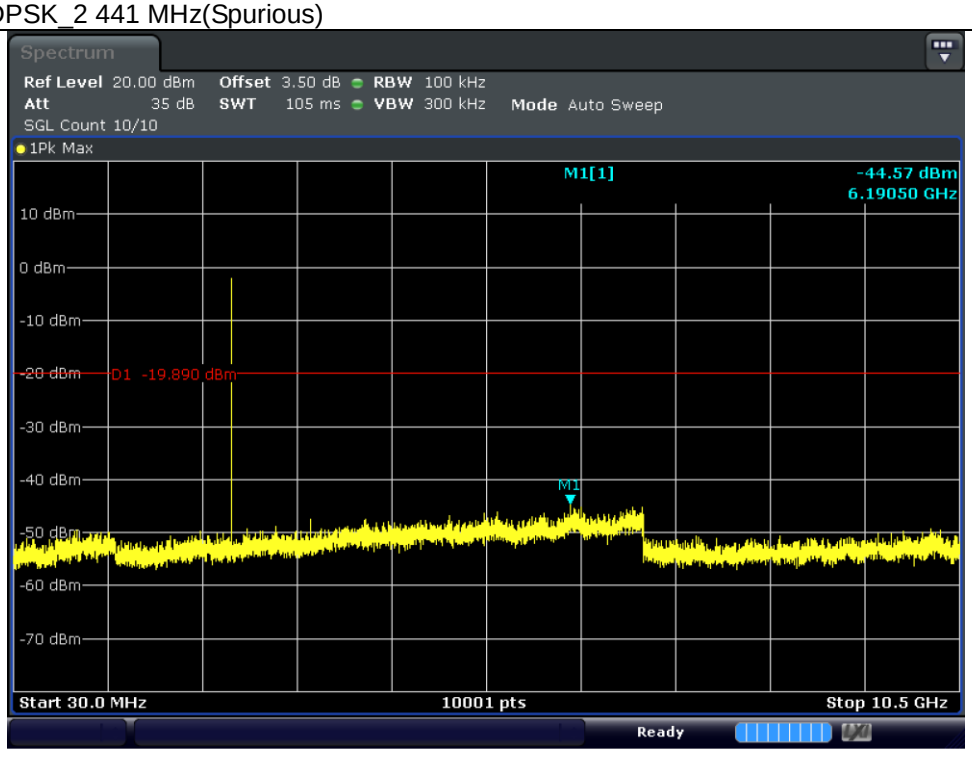
8DPSK_2 402 MHz(Spurious)



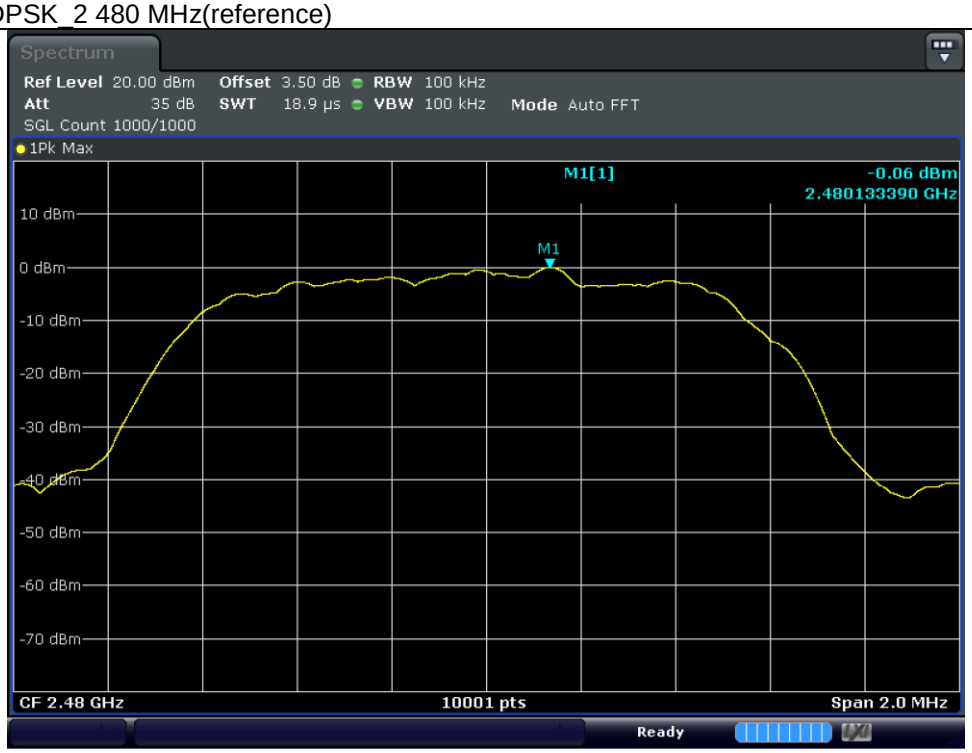
8DPSK_2 441 MHz(reference)



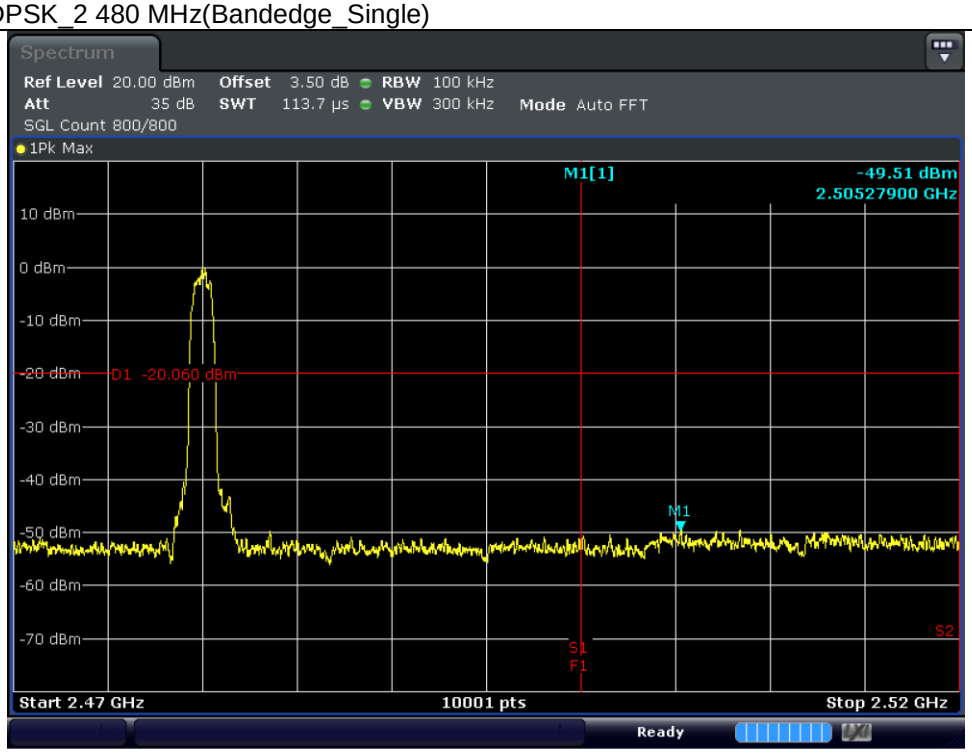
8DPSK_2 441 MHz(Spurious)



8DPSK_2 480 MHz(reference)

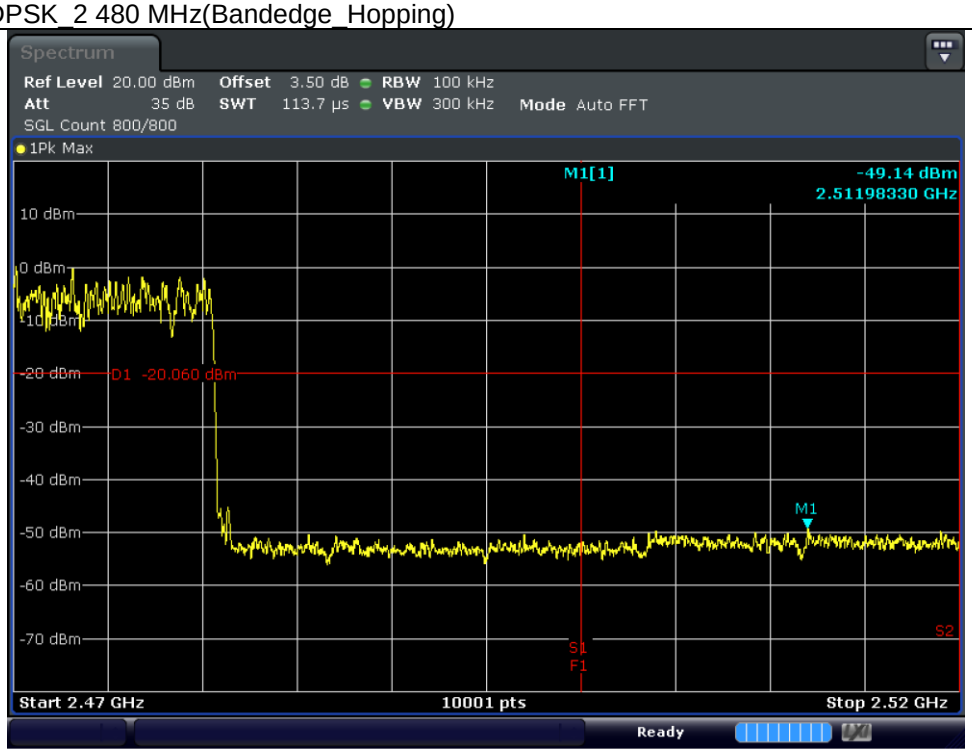


8DPSK_2 480 MHz(Bandedge_Single)



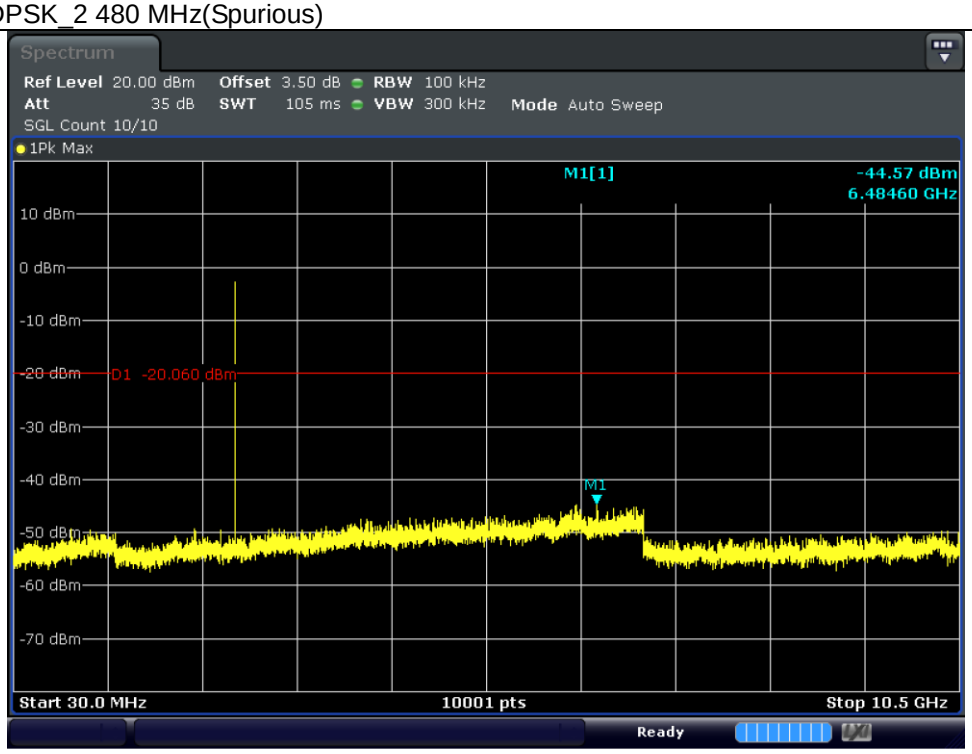
NOTE: F1 : 2 500 MHz

8DPSK_2 480 MHz(Bandedge_Hopping)



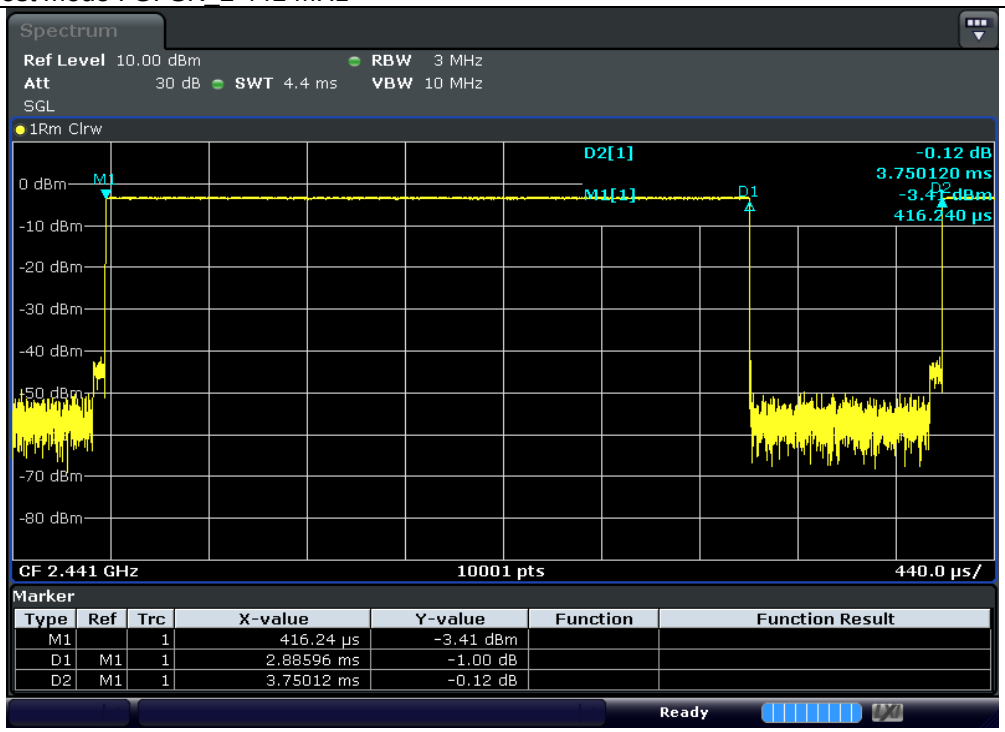
NOTE: F1 : 2 500 MHz

8DPSK_2 480 MHz(Spurious)



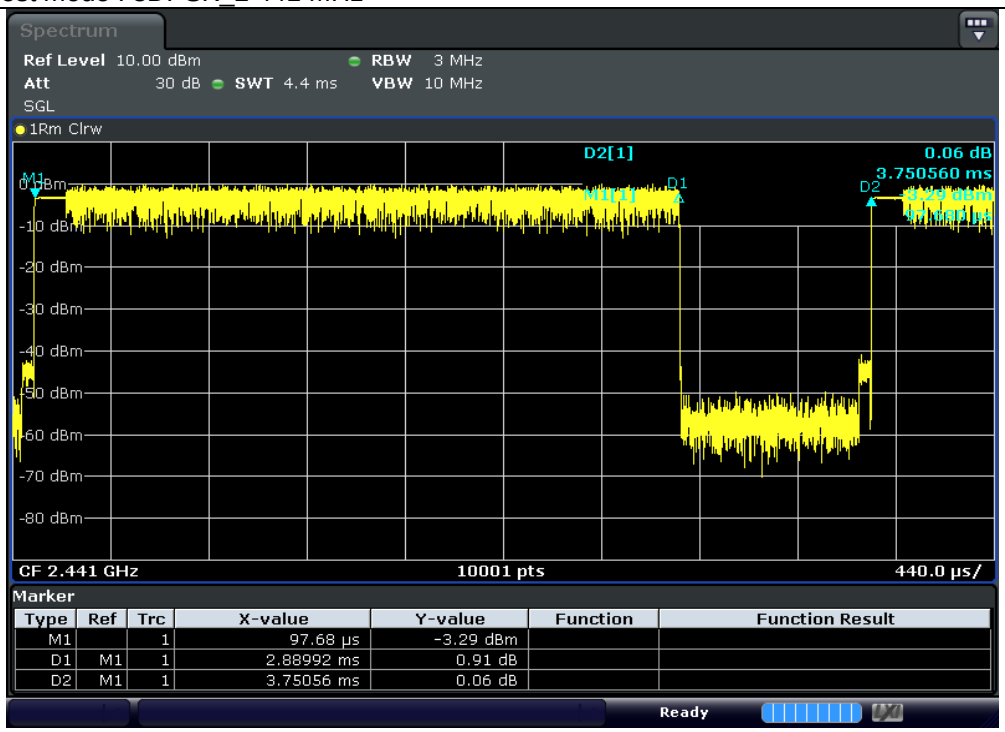
4.3.7.7 Measurement Plot_Dutycycle

Test mode : GFSK_2 441 MHz



NOTE: Dwell time: on time*No. of hop
Dutycycle Factor : 20log(dwell time/100) = 20log((2.886*2)/100) = -24.77

Test mode : 8DPSK_2 441 MHz



NOTE: Dwell time: on time*No. of hop
Dutycycle Factor : 20log(dwell time/100) = 20log((2.890*2)/100) = -24.76

4.3.8 Conducted Emission

4.3.8.1 Regulation

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 μH/50 Ω line impedance stabilization network (LISN).
Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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

* Decreases with the logarithm of the frequency.

According to §15.107(a), for unintentional device, except for Class A digital devices, line conducted emission limits are the same as the above table.

4.3.8.2 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 1.5 m 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 μH 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 QUASIPEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

4.3.8.3 Result

Not Applicable (This device gets power supply from vehicle battery. (DC 12 V)
Therefore this test item was not performed)

APPENDIX I

TEST EQUIPMENT USED FOR TESTS

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment.

Equipment	Manufacturer	Model	Serial No.	Cal. Date (yy.mm.dd)	Next Cal.Date (yy.mm.dd)
FSV Signal Analyzer	ROHDE&SCHWARZ	FSV40	101010	2021-04-20	2022-04-20
Power Sensor	KEYSIGHT	U2022XA	MY55320008	2020-08-21	2021-08-21
DC Power Supply	AGILENT	E3632A	MY51160055	2021-04-21	2022-04-21
Digital MultiMeter	HP	34401A	US36025428	2021-01-13	2022-01-13
ATTENUATOR	INMET	26A-3	TR006	2020-10-12	2021-10-12
Signal Generator	ROHDE&SCHWARZ	SMB100A	178384	2020-10-13	2021-10-13
EMI Test Receiver	ROHDE&SCHWARZ	ESU40	100445	2020-09-21	2021-09-21
BiLog Antenna	Schwarzbeck	VULB9168	00821	2021-03-31	2023-03-31
Attenuator	JFW	50F-006	6 dB-3	2021-04-22	2022-04-22
Preamplifier	TSJ	MLA-10k01-b01-27	1870367	2020-09-21	2021-09-21
Antenna Mast(10 m)	TOKIN	5977	-	-	-
Antenna Mast(10 m)	Innco	MA4640-XPET-0800	578	-	-
Controller(10 m)	TOKIN	5909L	141909L-1	-	-
Controller(10 m)	Innco	CO3000	40040217	-	-
Turn Table(10 m)	TOKIN	5983-1.5	-	-	-
10 m Semi-Anechoic Chamber	SY CORPORATION	-	-	-	-
Active Loop H-Field	ETS	6502	00150598	2021-05-25	2023-05-25
Double Ridege Horn Antenna	ETS	3117	00168719	2020-08-28	2021-08-28
Double Ridege Horn Antenna	A.H Systems, Inc	SAS-574	465	2021-04-26	2023-04-26
PREAMPLIFIER	Agilent	8449B	3008A02110	2021-01-11	2022-01-11
PREAMPLIFIER	A.H Systems, Inc	PAM-1840VH	166	2021-01-11	2022-01-11