7.3. Test Procedures

7.3.1. Test Procedures for Radiated Spurious Emissions

1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m.
   The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
3. For measurements above 1GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 GHz, the absorbers are removed.
4. The antenna is a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
5. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
6. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
7. If the emission level of the EUT in peak mode was 10 dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

Note: The radiated spurious emission was tested with below settings.
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) at frequency below 1 GHz.
2. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection at frequency above 1GHz.
3. The resolution bandwidth of test receiver/spectrum analyzer is 1 MHz and video bandwidth is [1/(minimum transmitter on time)] for Average detection (AV) at frequency above 1GHz.

7.3.2. Test Procedures for Conducted Spurious Emissions

1. The transmitter output was connected to the spectrum analyzer.
2. The **reference level** of the fundamental frequency was measured with the spectrum analyzer using RBW = 100 kHz, VBW = 300 kHz.
3. The conducted spurious emission was tested each ranges were set as below.

Frequency range : 9 kHz ~ 30 MHz
RBW = 100 kHz, VBW = 300 kHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40001

Frequency range : 30 MHz ~ 10 GHz, 10 GHz ~ 25 GHz
RBW = 1 MHz, VBW = 3 MHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40001

LIMIT LINE = 20 dB below of the reference level of above measurement procedure Step 2. (RBW = 100 kHz, VBW = 300 kHz)

If the emission level with above setting was close to the limit (ie, less than 3 dB margin) then zoom scan is required using RBW = 100 kHz, VBW = 300 kHz, SPAN = 100 MHz and BINS = 2001 to get accurate emission level within 100 kHz BW.

Also the path loss for conducted measurement setup was used as described on the Appendix I of this test report.

7.4. Test Results

7.4.1. Radiated Emissions

9 kHz ~ 25 GHz Data (Modulation : *GFSK*)

▪ Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2388.99	V	X	PK	45.38	1.70	N/A	N/A	47.08	74.00	26.92
2388.77	V	X	AV	34.37	1.70	N/A	N/A	36.07	54.00	17.93
4803.83	H	X	PK	45.75	5.45	N/A	N/A	51.20	74.00	22.80
4803.93	H	X	AV	37.33	5.45	N/A	N/A	42.78	54.00	11.22

▪ Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4881.76	H	X	PK	45.76	5.64	N/A	N/A	51.40	74.00	22.60
4881.89	H	X	AV	36.26	5.64	N/A	N/A	41.90	54.00	12.10

▪ Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2493.10	V	X	PK	45.09	1.86	N/A	N/A	46.95	74.00	27.05
2492.95	V	X	AV	35.37	1.85	N/A	N/A	37.22	54.00	16.78
4960.24	H	X	PK	45.05	5.76	N/A	N/A	50.81	74.00	23.19
4960.02	H	X	AV	35.42	5.76	N/A	N/A	41.18	54.00	12.82

▪ **Note.**

1. The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
   For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.
   - Calculation of distance factor = 20 log(applied distance / required distance) = **20 log(1 m / 3 m)** = **-9.54 dB**
   When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
   Margin = Limit – Result / Result = Reading + T.F + D.C.F / T.F = AF + CL – AG
   Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.

9 kHz ~ 25 GHz Data (Modulation : π/4DQPSK)

▪ Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2389.01	V	X	PK	45.21	1.70	N/A	N/A	46.91	74.00	27.09
2388.98	V	X	AV	33.90	1.70	N/A	N/A	35.60	54.00	18.40
4803.69	H	X	PK	45.82	5.45	N/A	N/A	51.27	74.00	22.73
4803.84	H	X	AV	34.79	5.45	N/A	N/A	40.24	54.00	13.76

▪ Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4881.65	H	X	PK	45.89	5.64	N/A	N/A	51.53	74.00	22.47
4881.84	H	X	AV	34.46	5.64	N/A	N/A	40.10	54.00	13.90

▪ Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2484.05	V	X	PK	46.90	1.80	N/A	N/A	48.70	74.00	25.30
2483.50	V	X	AV	34.43	1.79	N/A	N/A	36.22	54.00	17.78
4959.61	H	X	PK	44.29	5.76	N/A	N/A	50.05	74.00	23.95
4959.91	H	X	AV	33.62	5.76	N/A	N/A	39.38	54.00	14.62

▪ **Note.**

1. The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
   For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.
   - Calculation of distance factor = 20 log(applied distance / required distance) = **20 log(1 m / 3 m)** = **-9.54 dB**
   When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
   Margin = Limit – Result / Result = Reading + T.F + D.C.F / T.F = AF + CL – AG
   Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.

9 kHz ~ 25 GHz Data (Modulation : *8DPSK*)

▪ Lowest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2389.03	V	X	PK	44.97	1.70	N/A	N/A	46.67	74.00	27.33
2389.03	V	X	AV	34.07	1.70	N/A	N/A	35.77	54.00	18.23
4803.58	H	X	PK	45.17	5.45	N/A	N/A	50.62	74.00	23.38
4803.75	H	X	AV	34.56	5.45	N/A	N/A	40.01	54.00	13.99

▪ Middle Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4882.22	H	X	PK	46.29	5.64	N/A	N/A	51.93	74.00	22.07
4881.92	H	X	AV	35.25	5.64	N/A	N/A	40.89	54.00	13.11

▪ Highest Channel

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	D.C.F (dB)	Distance Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.66	V	X	PK	48.15	1.79	N/A	N/A	49.94	74.00	24.06
2483.65	V	X	AV	34.47	1.79	N/A	N/A	36.26	54.00	17.74
4959.56	H	X	PK	44.53	5.76	N/A	N/A	50.29	74.00	23.71
4959.87	H	X	AV	33.60	5.76	N/A	N/A	39.36	54.00	14.64

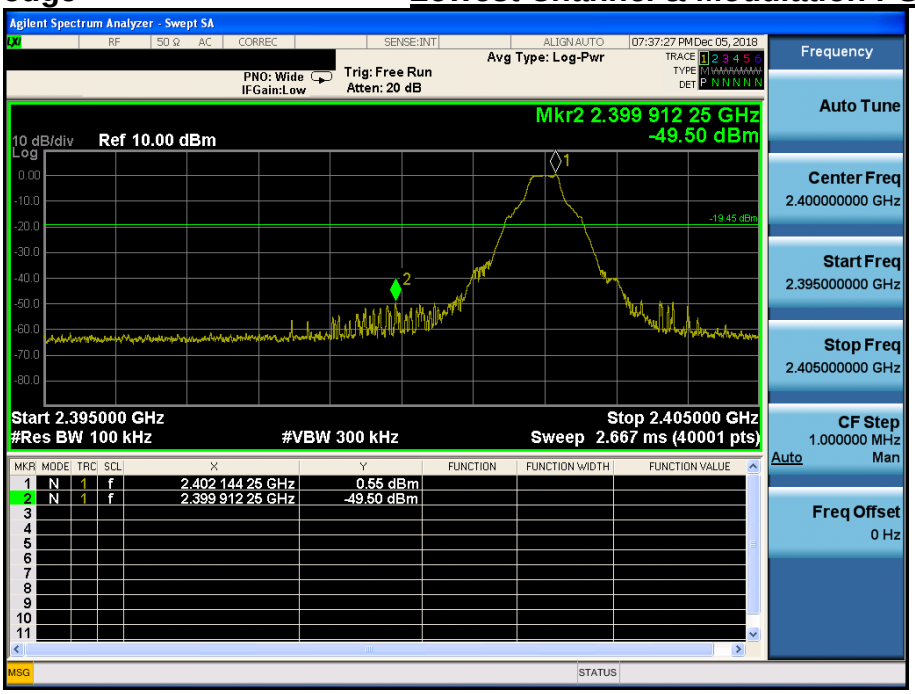
▪ **Note.**

1. The radiated emissions were investigated 9 kHz to 25 GHz. And no other spurious and harmonic emissions were found above listed frequencies.
2. Information of Distance Factor
   For finding emissions, the test distance might be reduced from 3m to 1m. In this case, the distance factor(-9.54dB) is applied to the result.
   - Calculation of distance factor = 20 log(applied distance / required distance) = **20 log(1 m / 3 m)** = **-9.54 dB**

   When distance factor is “N/A”, the distance is 3 m and distance factor is not applied.
3. Sample Calculation.
   Margin = Limit – Result / Result = Reading + T.F + D.C.F / T.F = AF + CL – AG
   Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain.

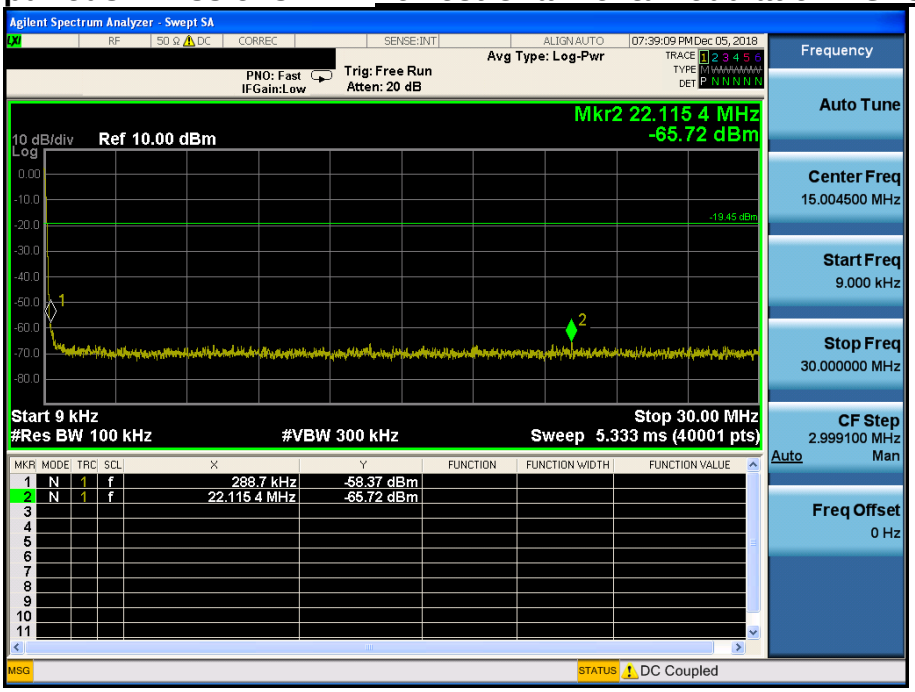
7.4.2. Conducted Spurious Emissions

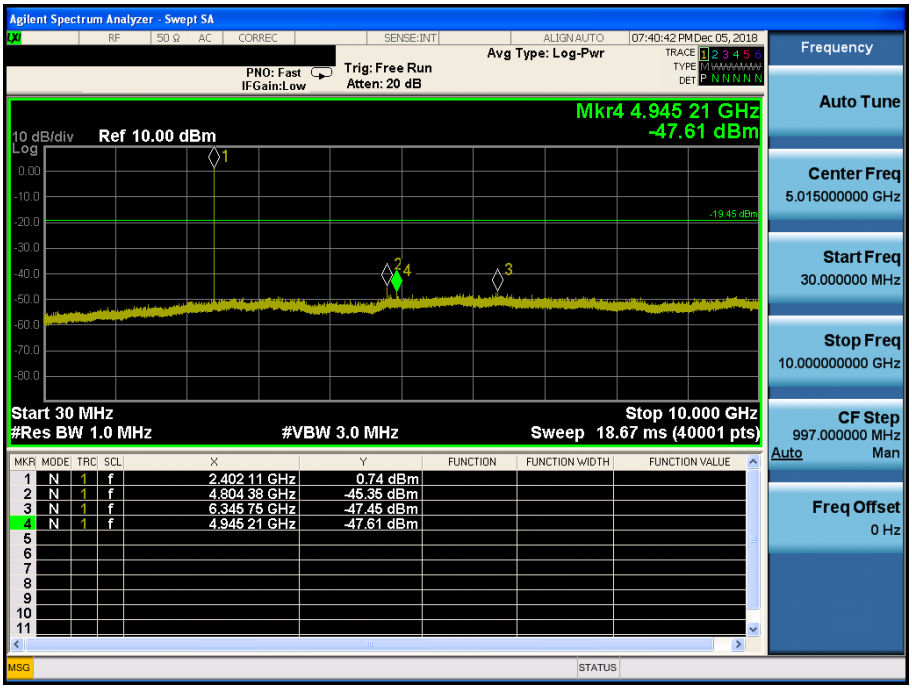
Low Band-edge ***Lowest Channel & Modulation : GFSK***



Low Band-edge ***Hopping mode & Modulation : GFSK***

Conducted Spurious Emissions *Lowest Channel & Modulation : GFSK*

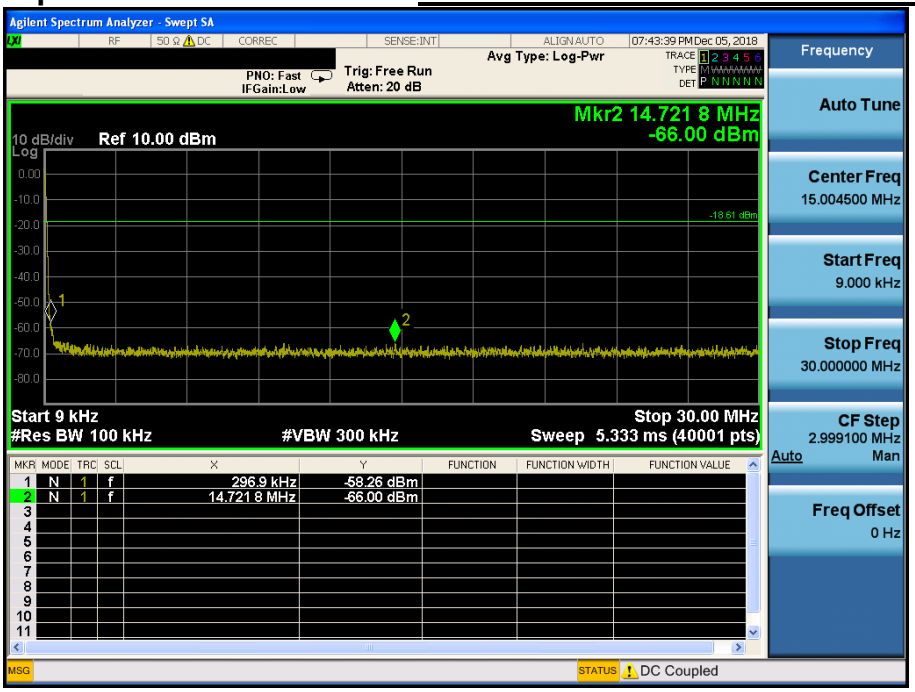




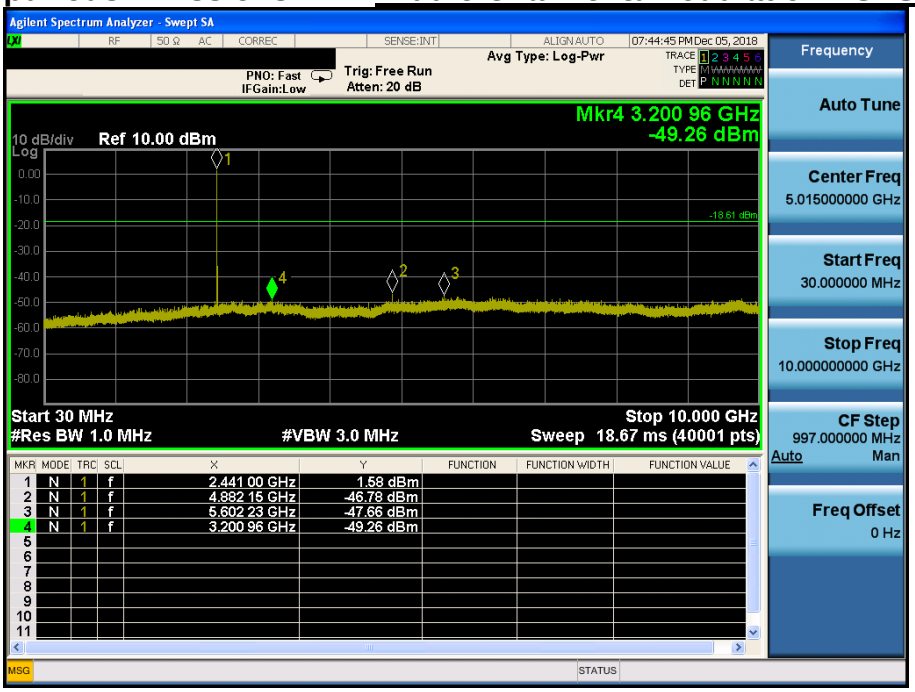
Conducted Spurious Emissions ***Lowest Channel & Modulation : GFSK***

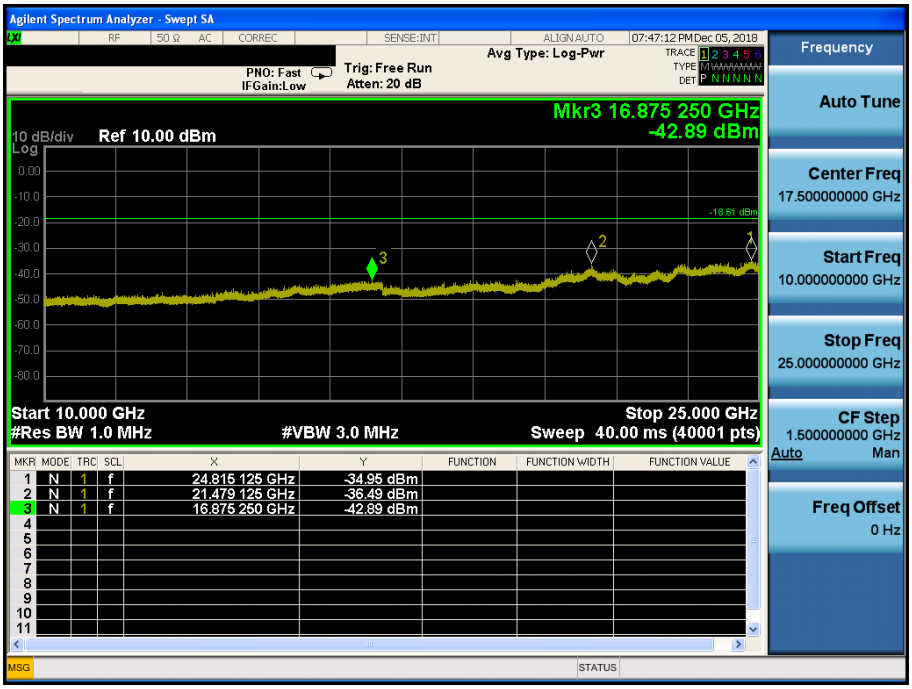
Reference for limit ***Middle Channel & Modulation : GFSK***

Conducted Spurious Emissions ***Middle Channel & Modulation : GFSK***

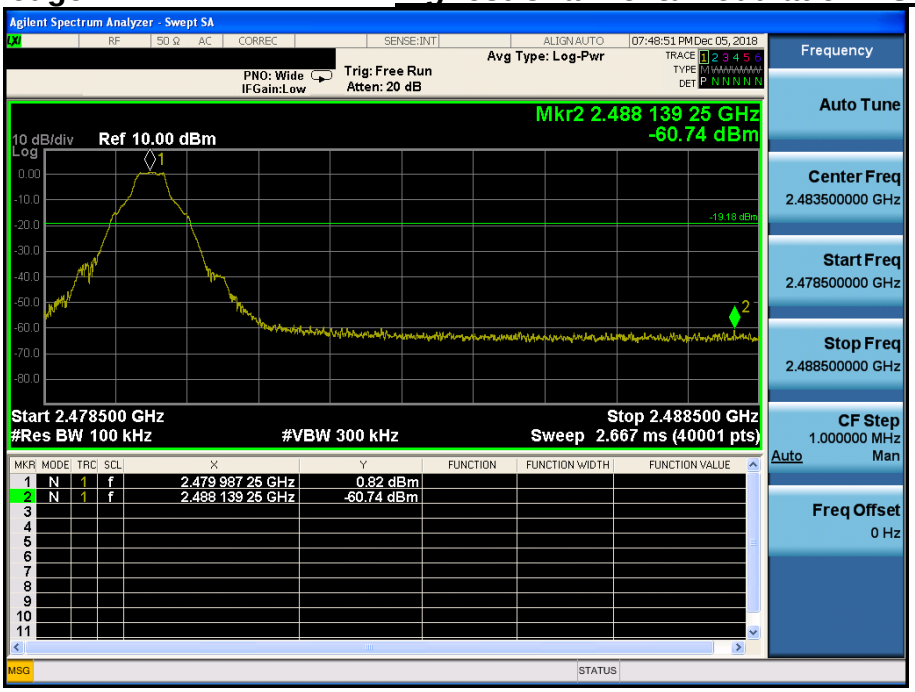


Conducted Spurious Emissions *Middle Channel & Modulation : GFSK*

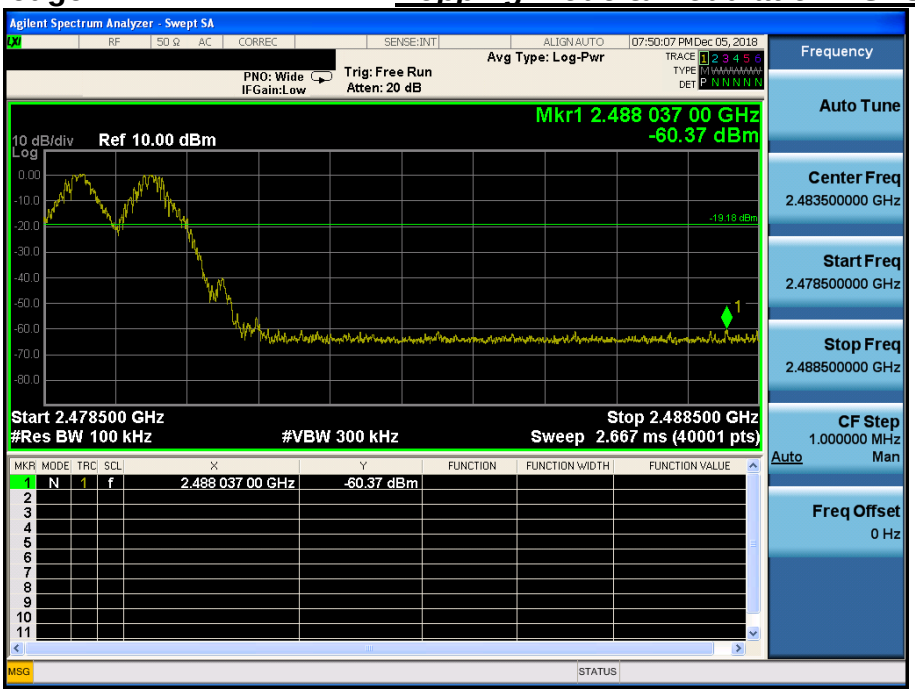




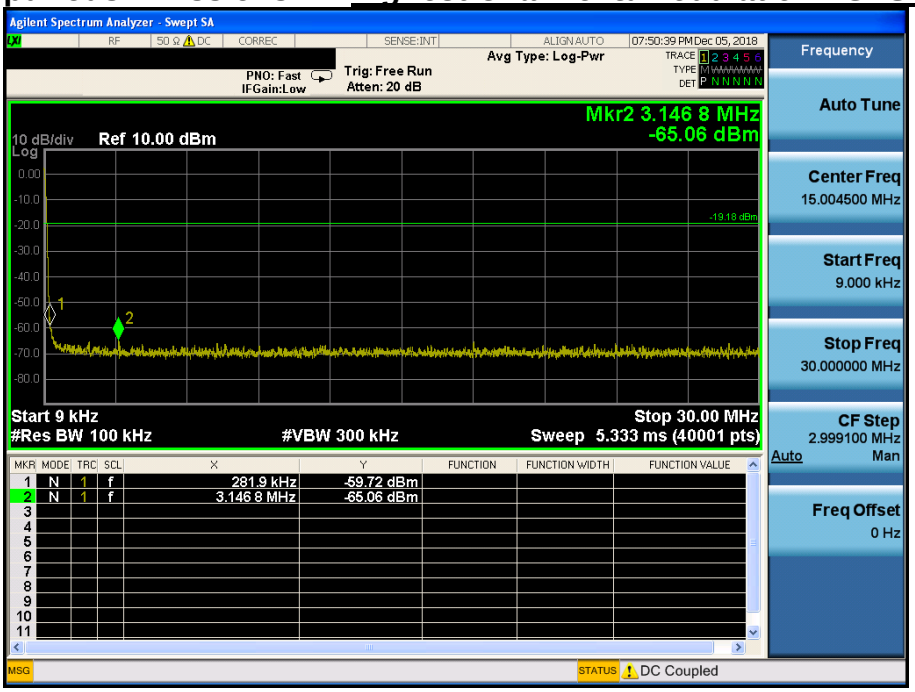
High Band-edge ***Highest Channel & Modulation : GFSK***

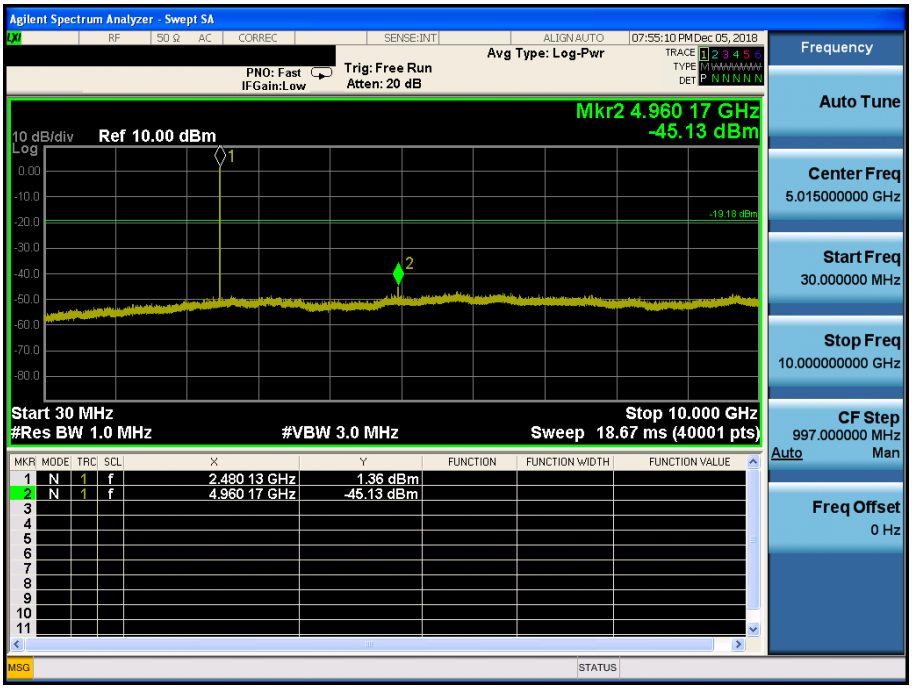


High Band-edge ***Hopping mode & Modulation : GFSK***



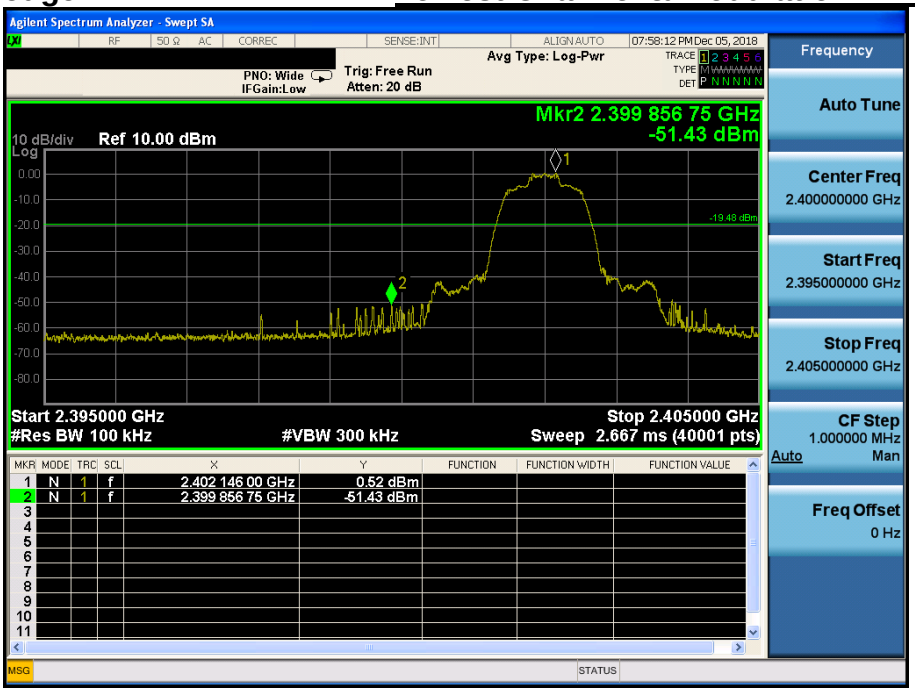
Conducted Spurious Emissions ***Highest Channel & Modulation : GFSK***





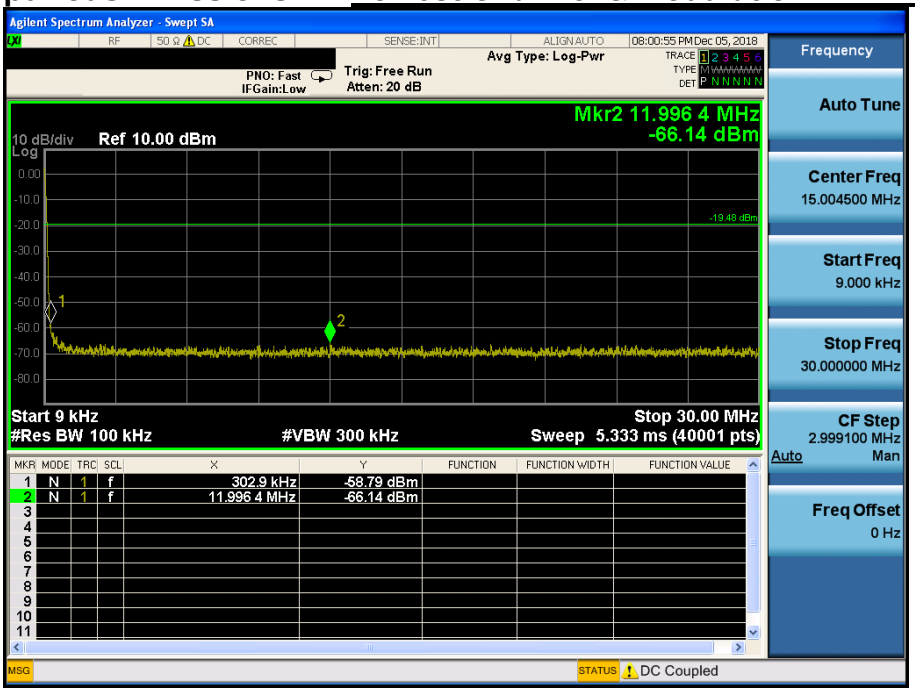
Conducted Spurious Emissions ***Highest Channel & Modulation : GFSK***

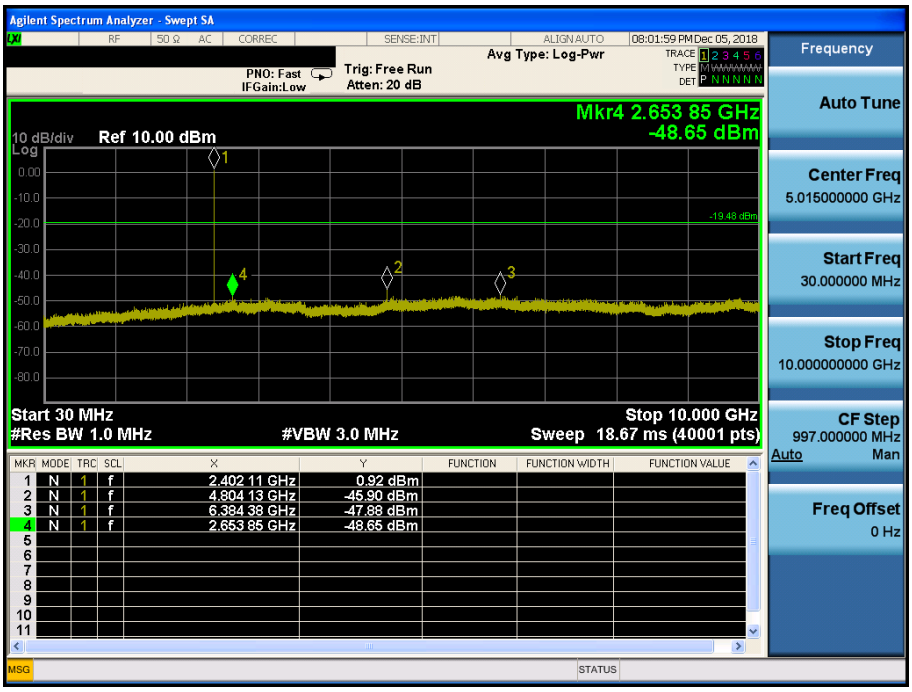
Low Band-edge ***Lowest Channel & Modulation : π/4DQPSK***



Low Band-edge ***Hopping mode & Modulation : π/4DQPSK***

Conducted Spurious Emissions ***Lowest Channel & Modulation : π/4DQPSK***

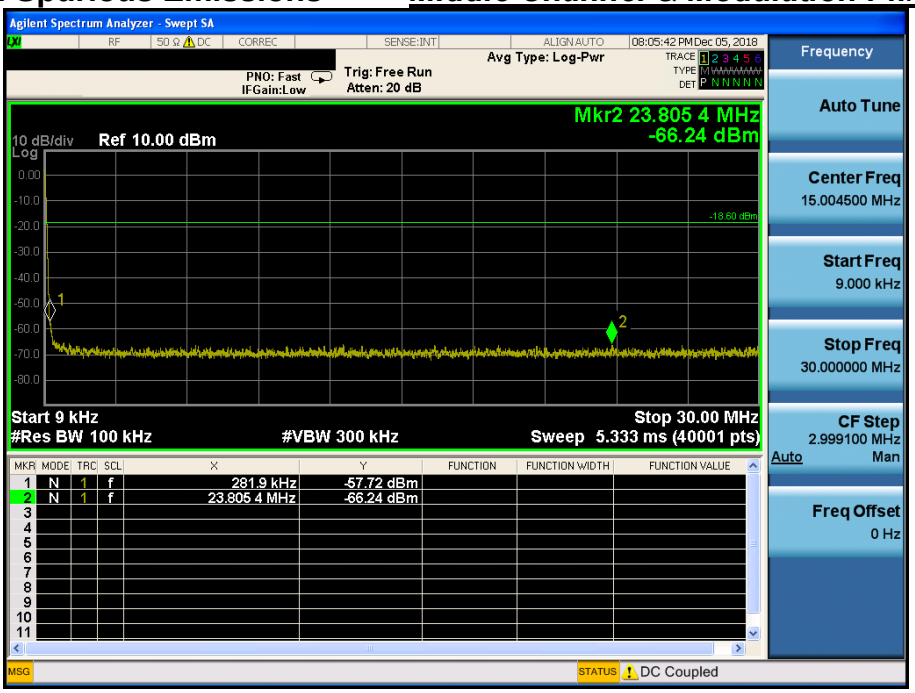




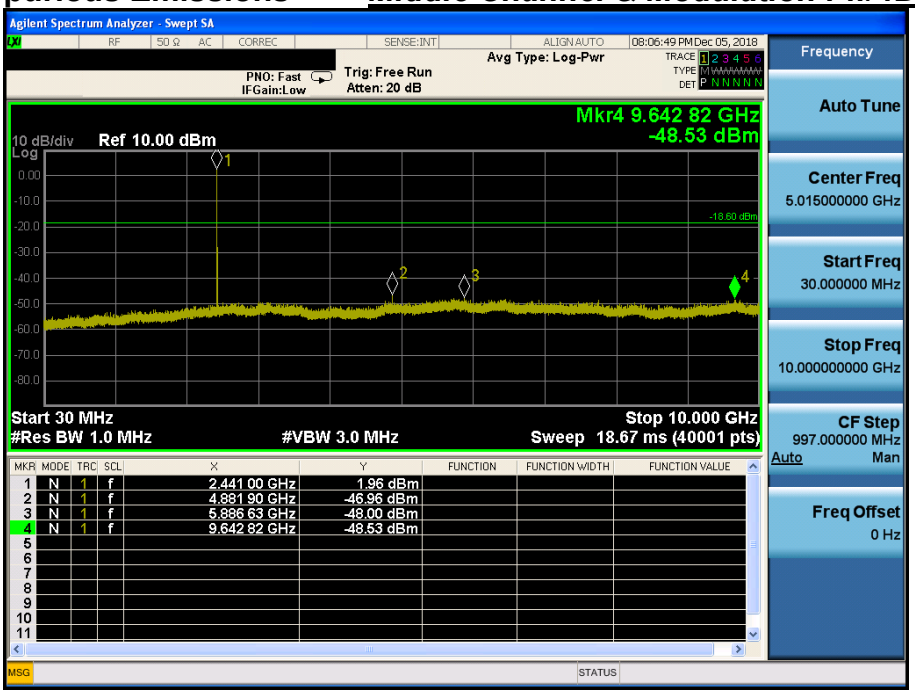
Conducted Spurious Emissions ***Lowest Channel & Modulation : π/4DQPSK***

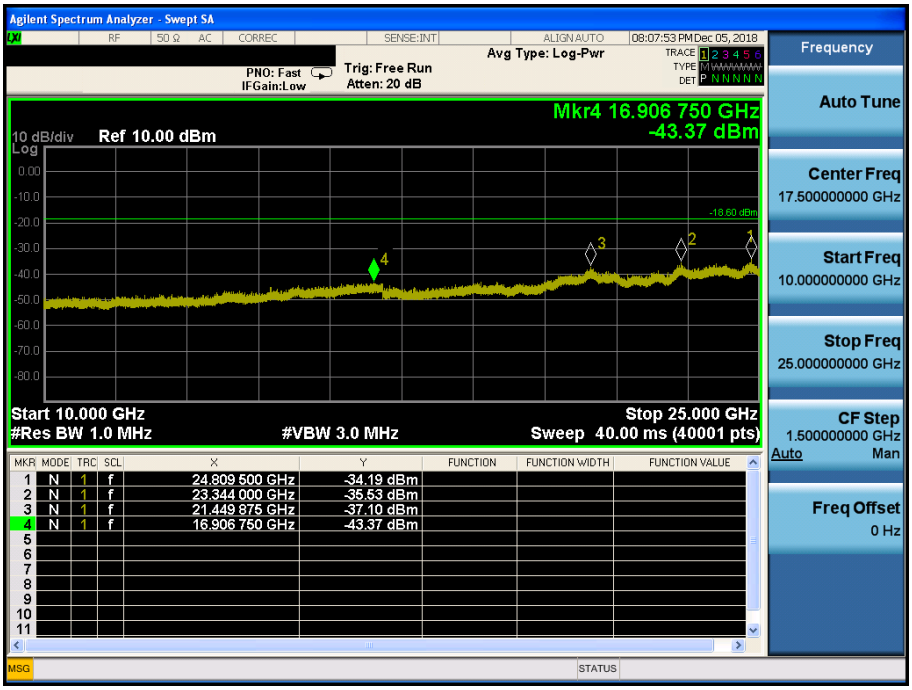
Reference for limit ***Middle Channel & Modulation : π/4DQPSK***

Conducted Spurious Emissions ***Middle Channel & Modulation : π/4DQPSK***

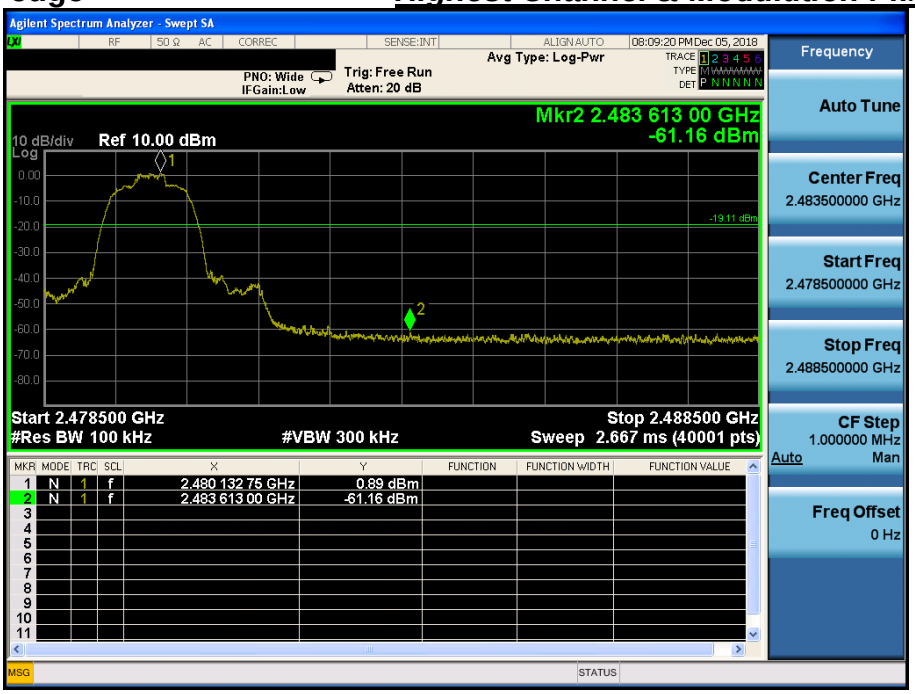


Conducted Spurious Emissions ***Middle Channel & Modulation : π/4DQPSK***

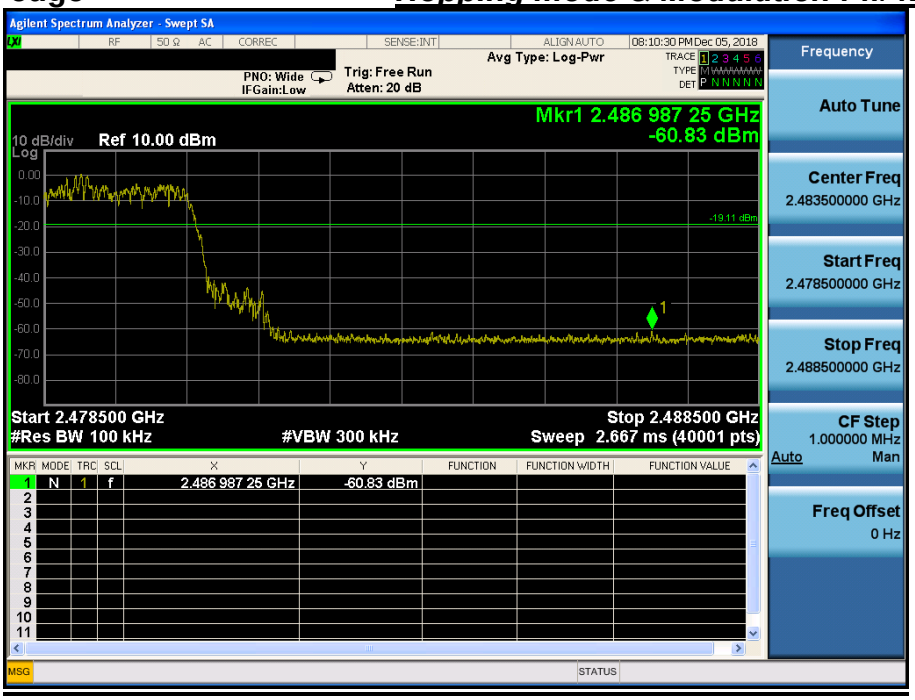




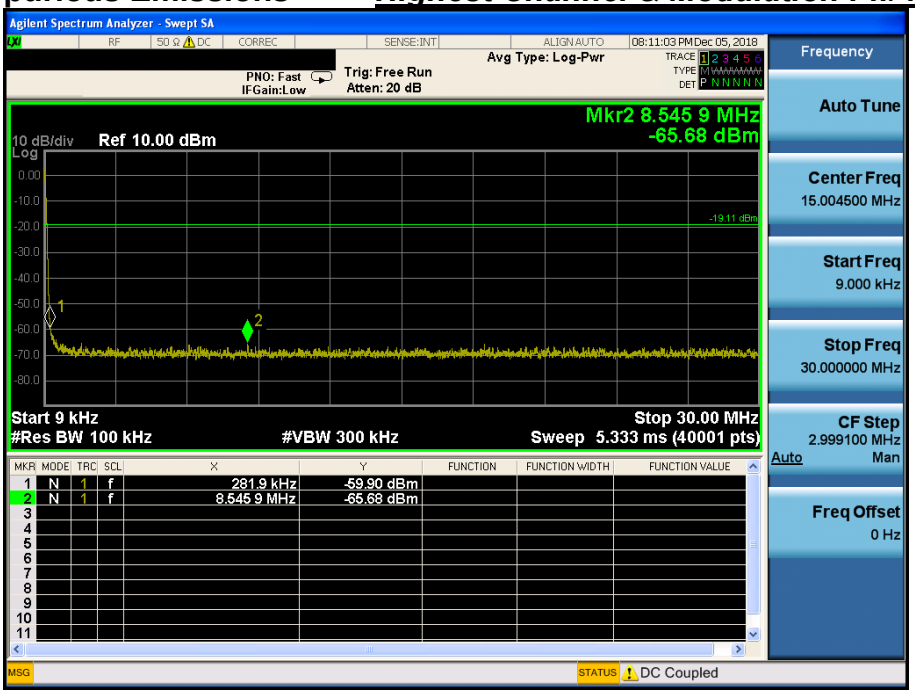
High Band-edge ***Highest Channel & Modulation : π/4DQPSK***

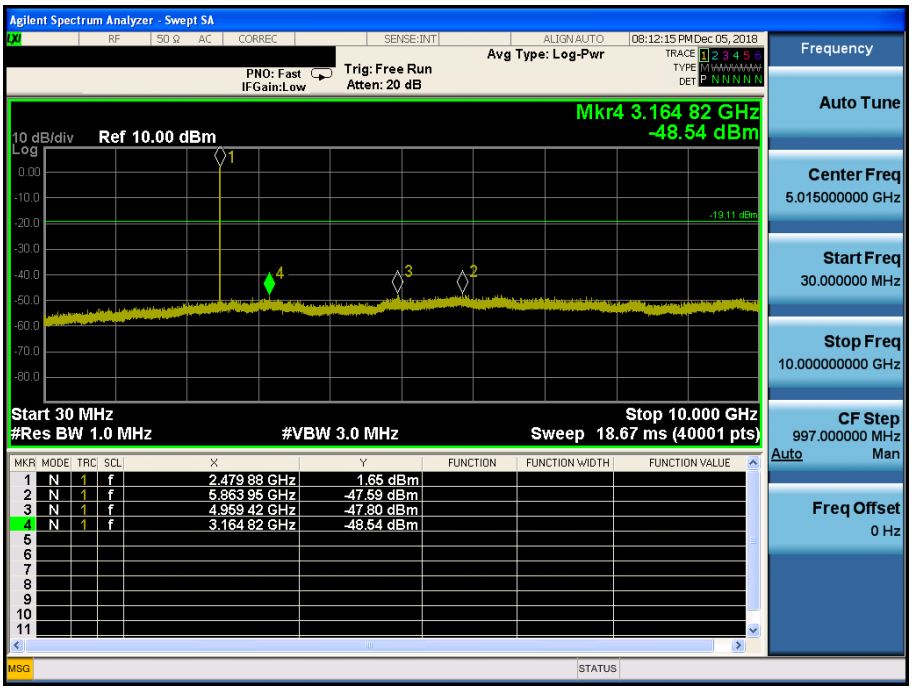


High Band-edge ***Hopping mode & Modulation : π/4DQPSK***



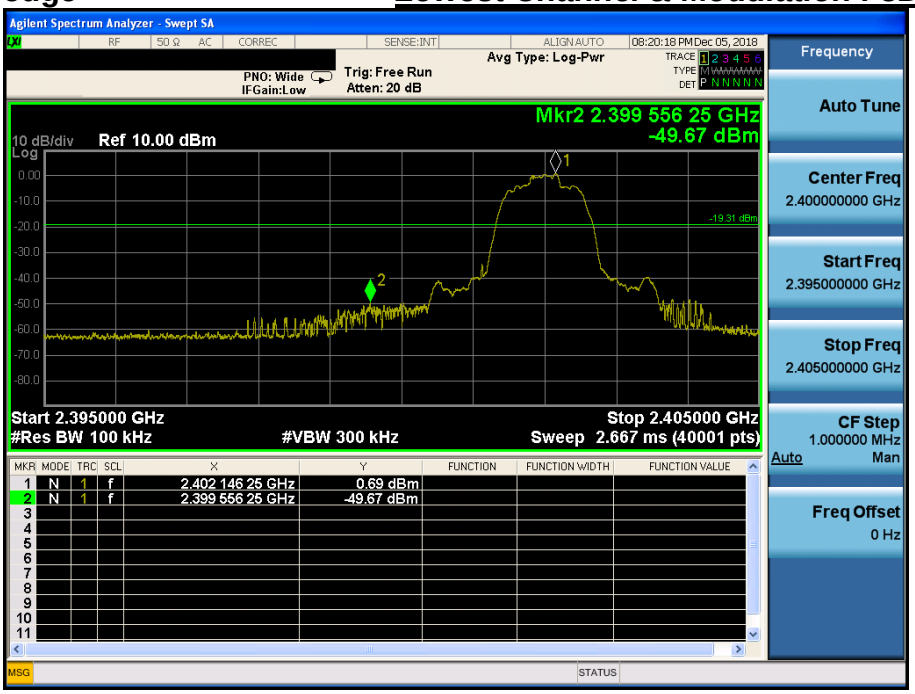
Conducted Spurious Emissions ***Highest Channel & Modulation : π/4DQPSK***



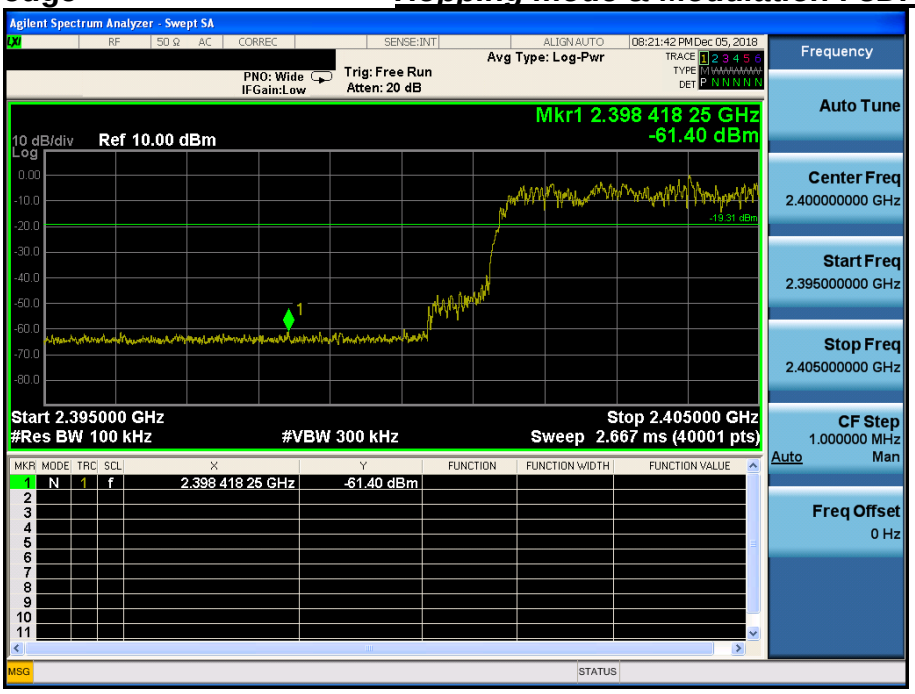


Conducted Spurious Emissions ***Highest Channel & Modulation : π/4DQPSK***

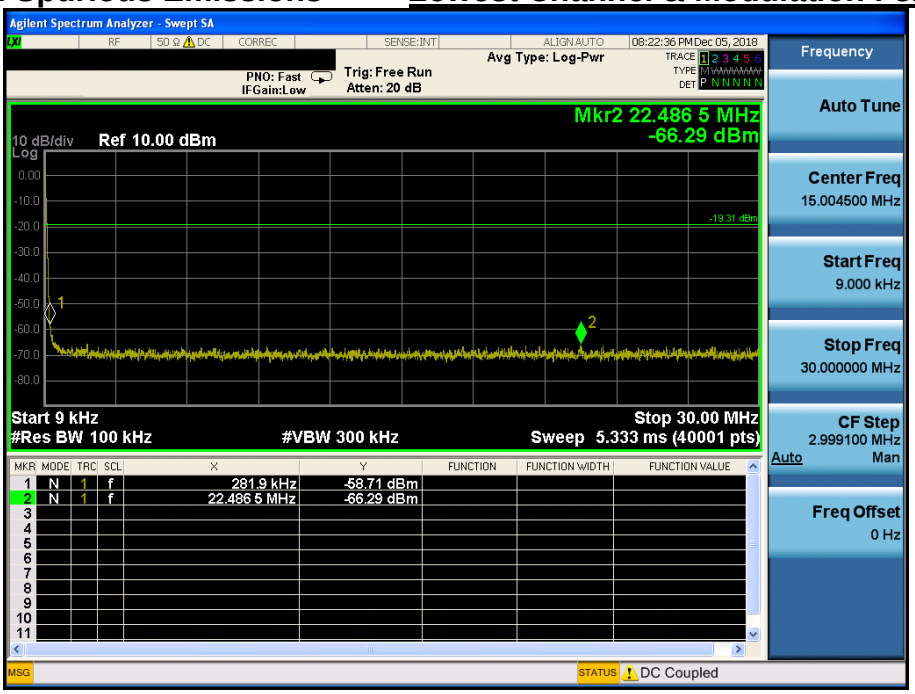
Low Band-edge ***Lowest Channel & Modulation : 8DPSK***



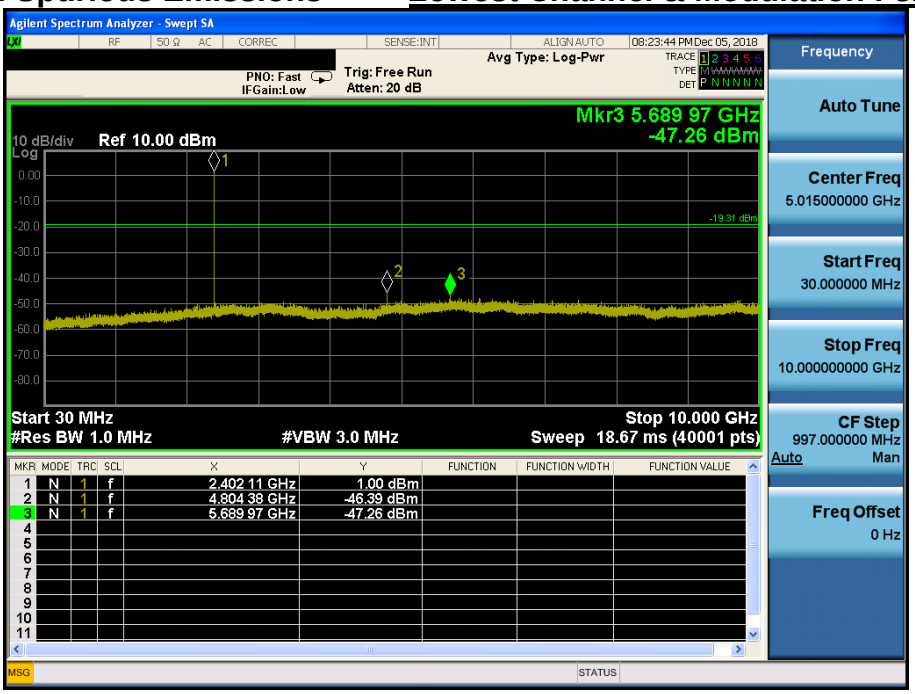
Low Band-edge ***Hopping mode & Modulation : 8DPSK***



Conducted Spurious Emissions ***Lowest Channel & Modulation : 8DPSK***

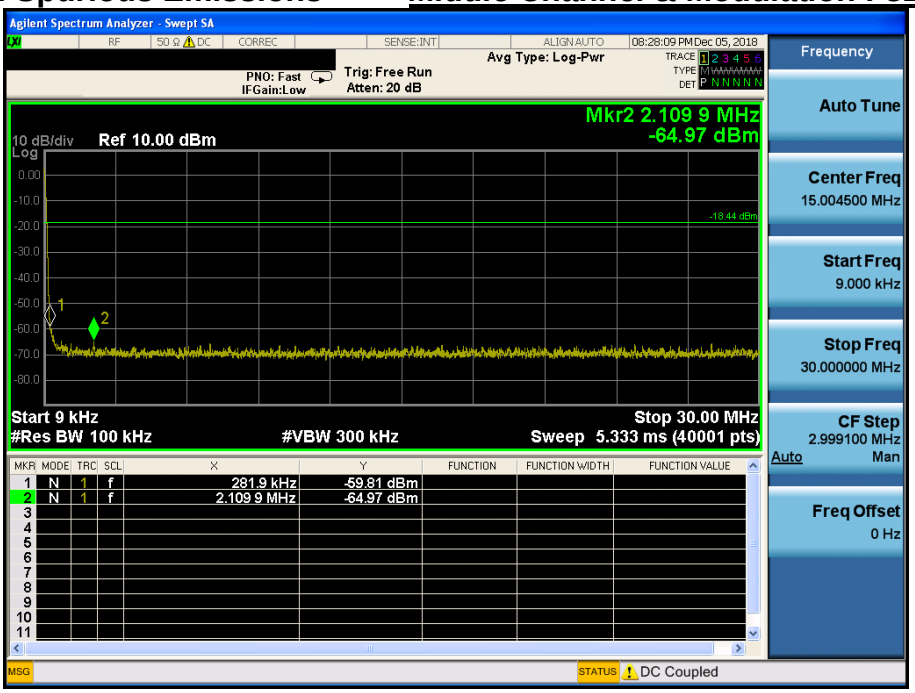


Conducted Spurious Emissions ***Lowest Channel & Modulation : 8DPSK***

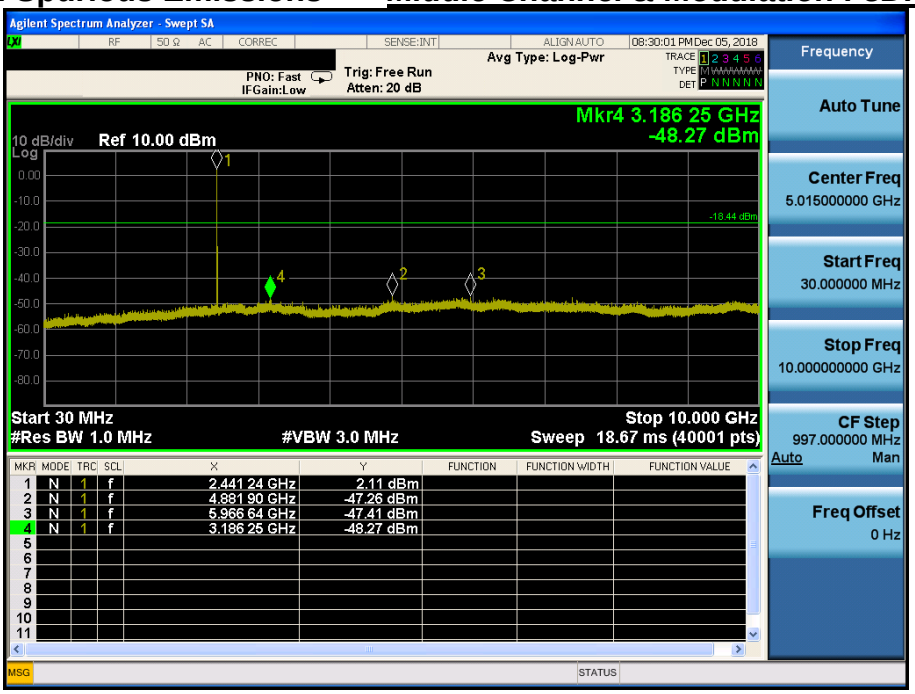


Reference for limit ***Middle Channel & Modulation : 8DPSK***

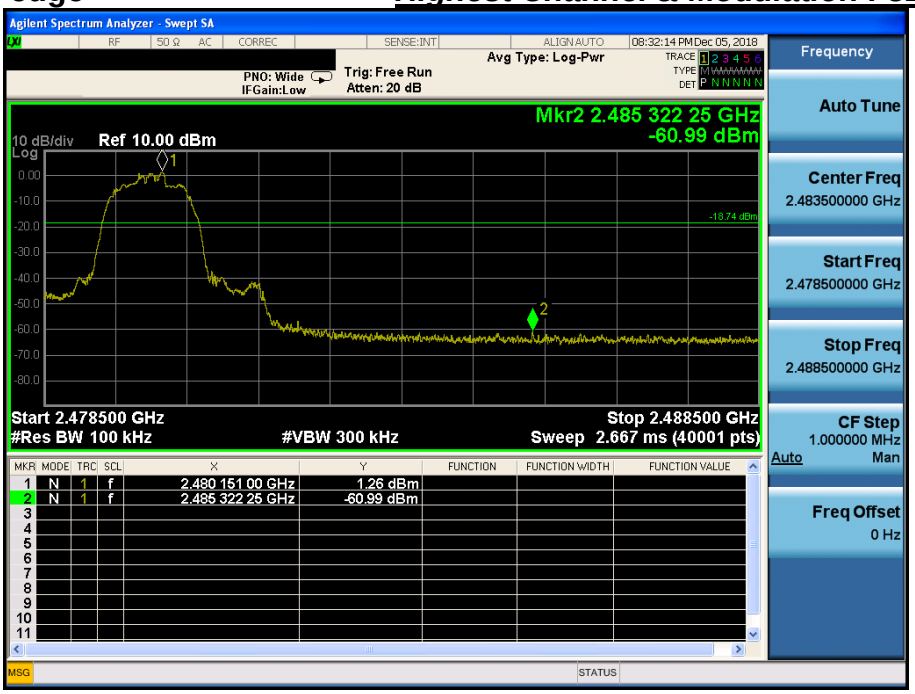
Conducted Spurious Emissions ***Middle Channel & Modulation : 8DPSK***



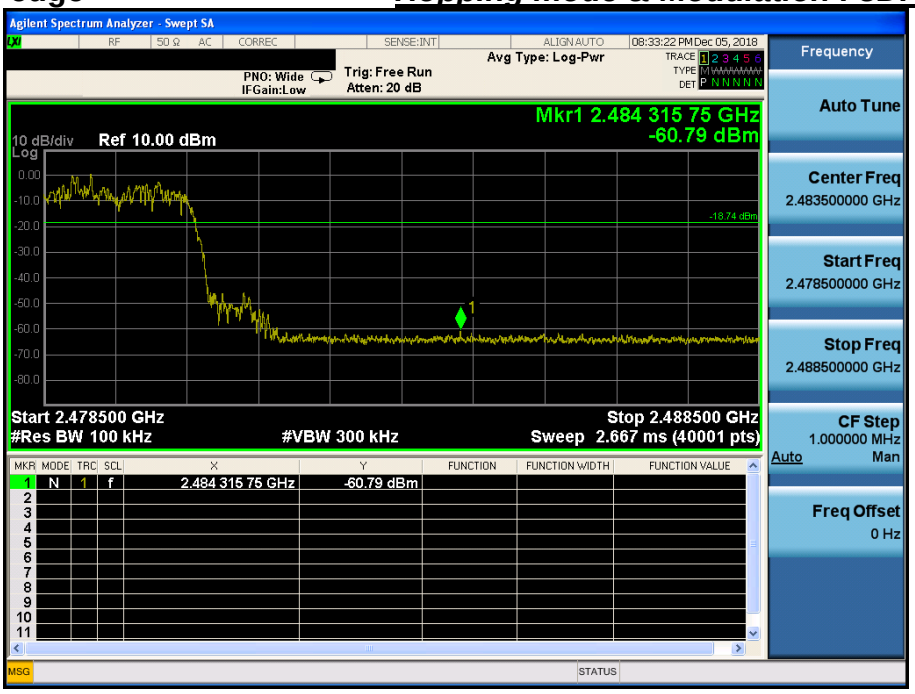
Conducted Spurious Emissions ***Middle Channel & Modulation : 8DPSK***



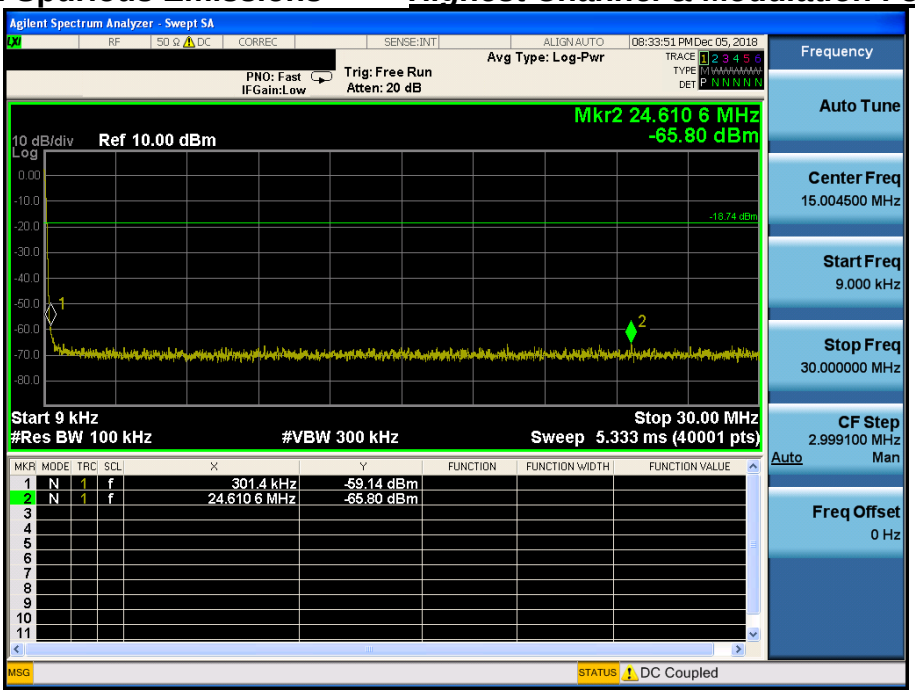
High Band-edge ***Highest Channel & Modulation : 8DPSK***

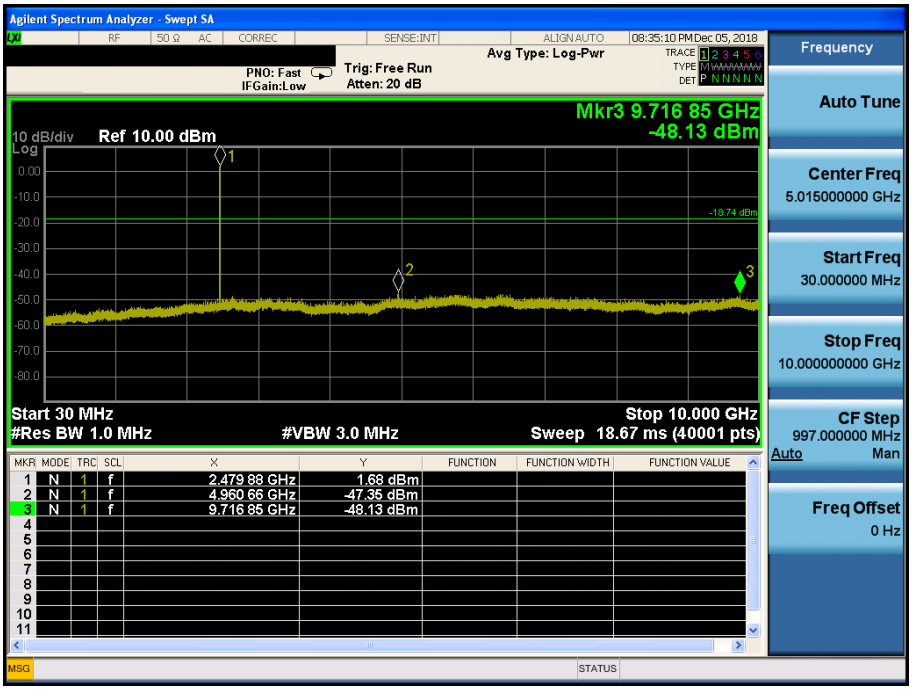


High Band-edge ***Hopping mode & Modulation : 8DPSK***



Conducted Spurious Emissions ***Highest Channel & Modulation : 8DPSK***





Conducted Spurious Emissions ***Highest Channel & Modulation : 8DPSK***

8. Transmitter AC Power Line Conducted Emission

8.1 Test Setup

NA

8.2 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 uH/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 frequency ranges.

Frequency Range (MHz)	Conducted Limit (dBuV)	
	Quasi-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

8.3 Test Procedures

Conducted emissions from the EUT were measured according to the ANSI C63.10.

1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

8.4 Test Results

NA

9. Antenna Requirement

Describe how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT.

Conclusion: Comply

The antenna is permanently attached. (Refer to Internal Photo file.)
Therefore this EUT complies with the requirement of §15.203.

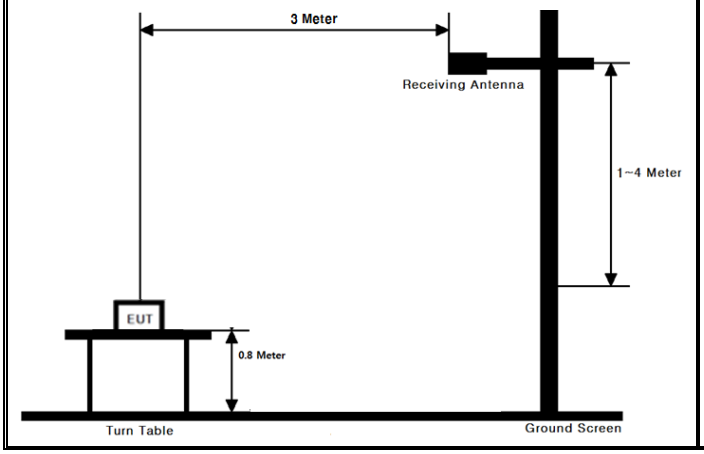
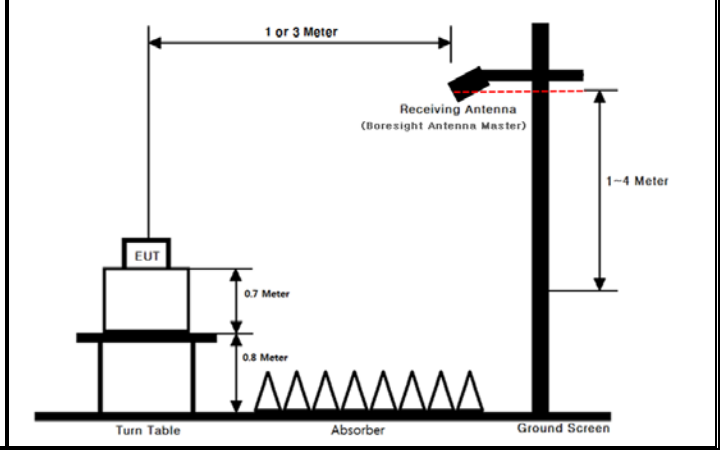
- **Minimum Standard :**

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.

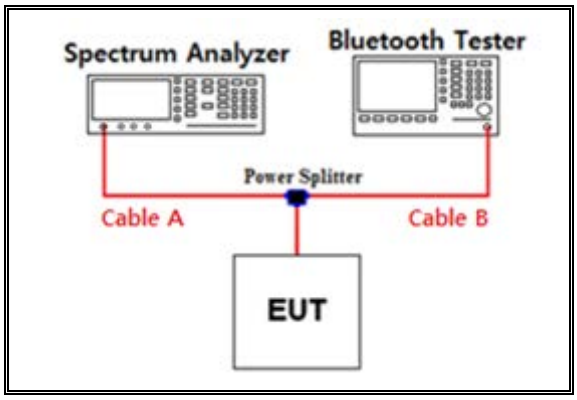
APPENDIX I

Test set up diagrams

▪ Radiated Measurement

Below 1GHz	Above 1GHz
	

▪ Conducted Measurement



Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	6.32	15	10.07
1	6.92	20	10.26
2.402 & 2.441 & 2.480	7.47	25	11.46
5	8.11	-	-
10	9.73	-	-

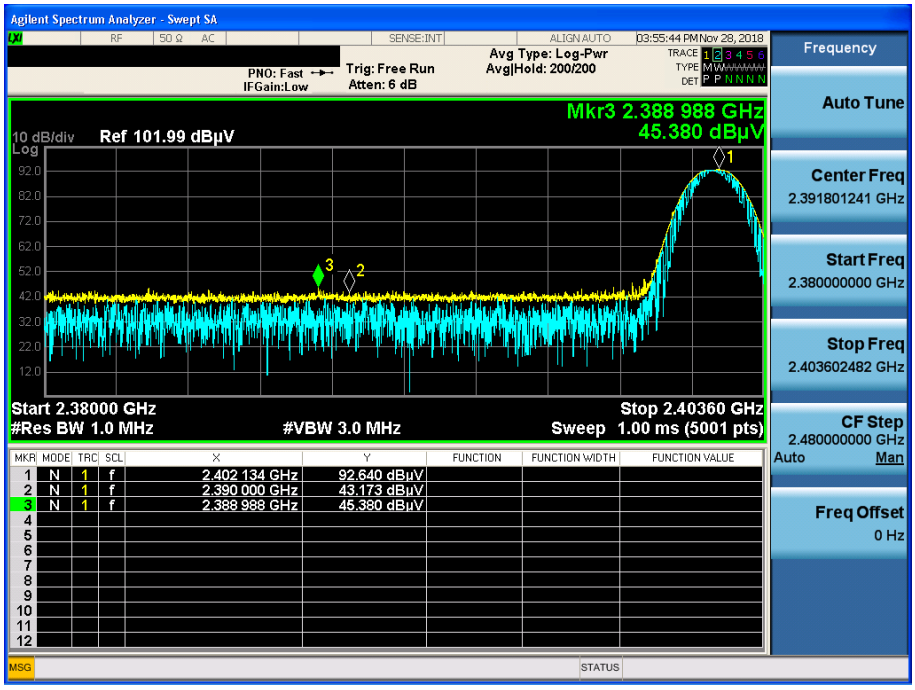
Note 1 : The path loss from EUT to Spectrum analyzer were measured and used for test.

Path loss (S/A's Correction factor) = Cable A+ Power splitter

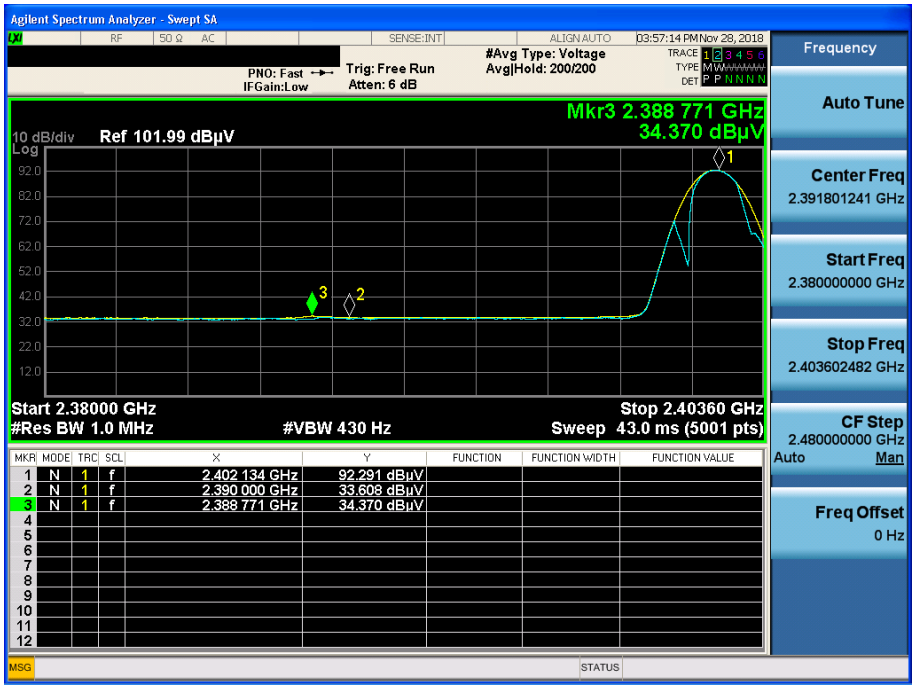
APPENDIX II

Unwanted Emissions (Radiated) Test Plot

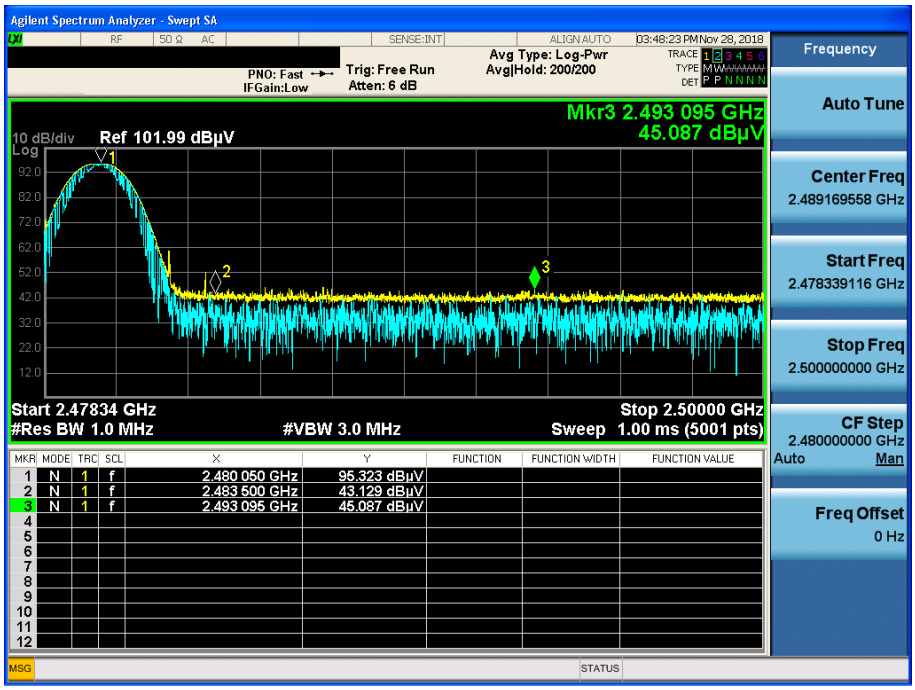
GFSK & Lowest & X & Ver — Detector Mode : PK



GFSK & Lowest & X & Ver — Detector Mode : AV

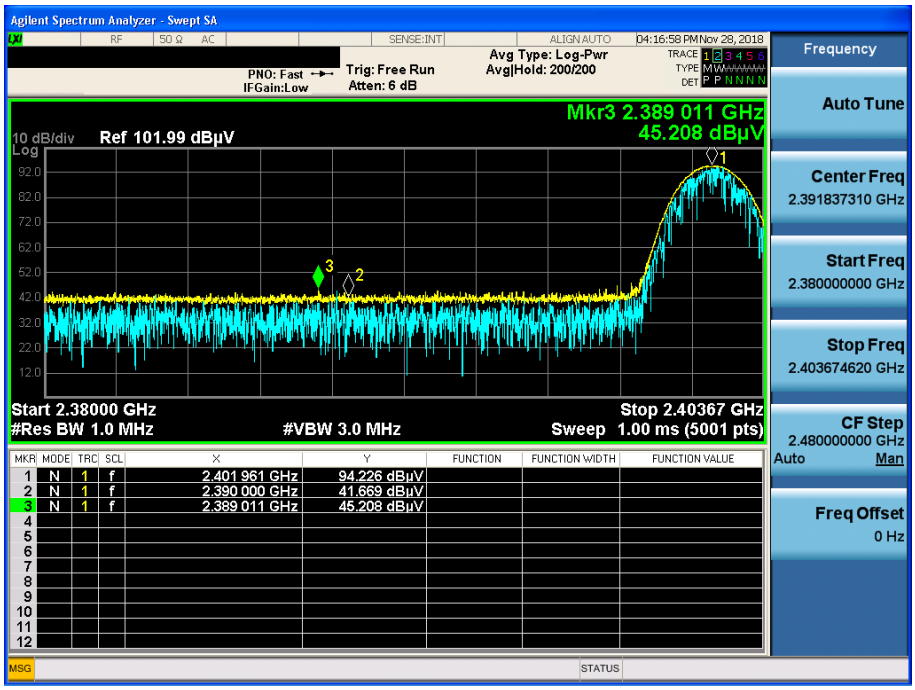


GFSK & Highest & X & Ver — Detector Mode : PK



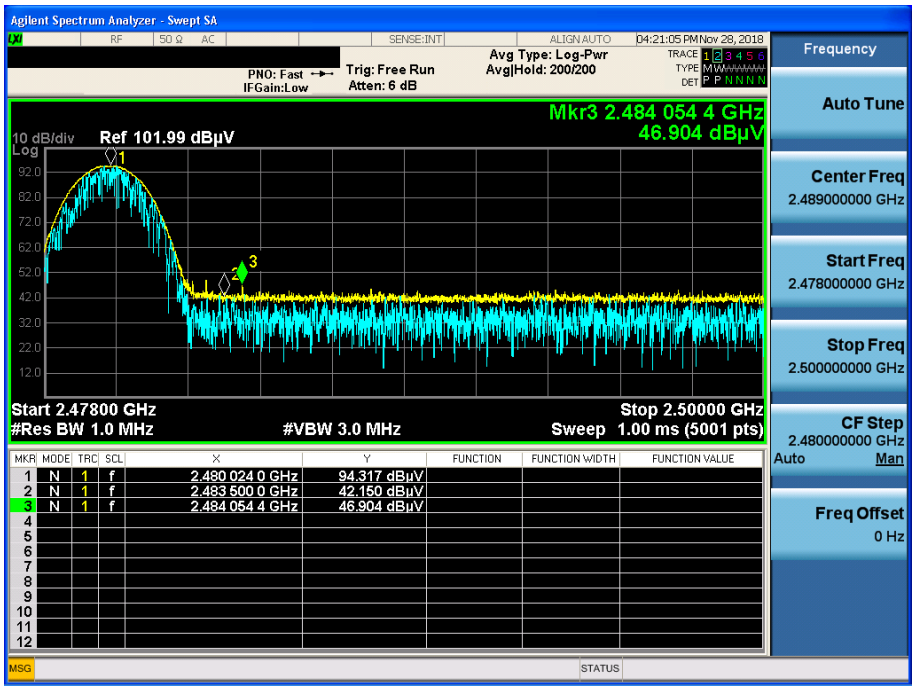
GFSK & Highest & X & Ver — Detector Mode : AV

π/4DQPSK & Lowest & X & Ver **Detector Mode : PK**

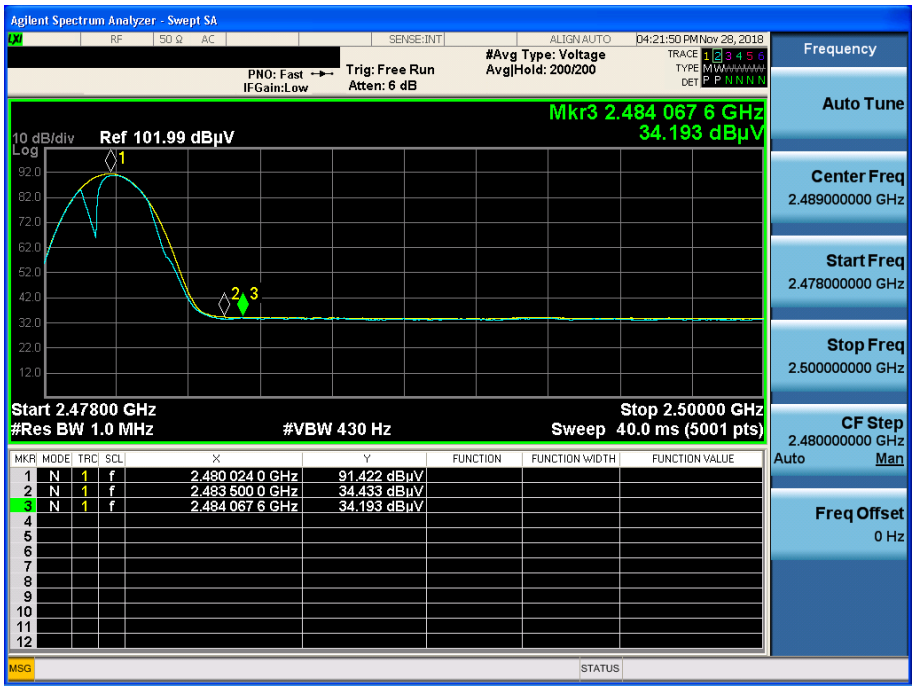


π/4DQPSK & Lowest & X & Hor **Detector Mode : AV**

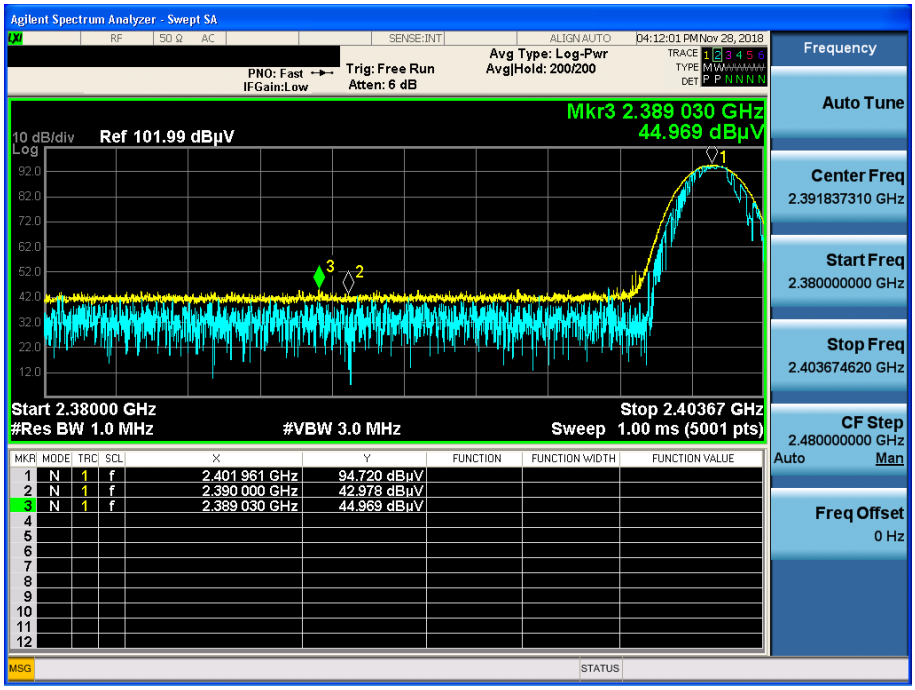
π/4DQPSK & Highest & X & Ver **Detector Mode : PK**



π/4DQPSK & Highest & X & Ver **Detector Mode : AV**

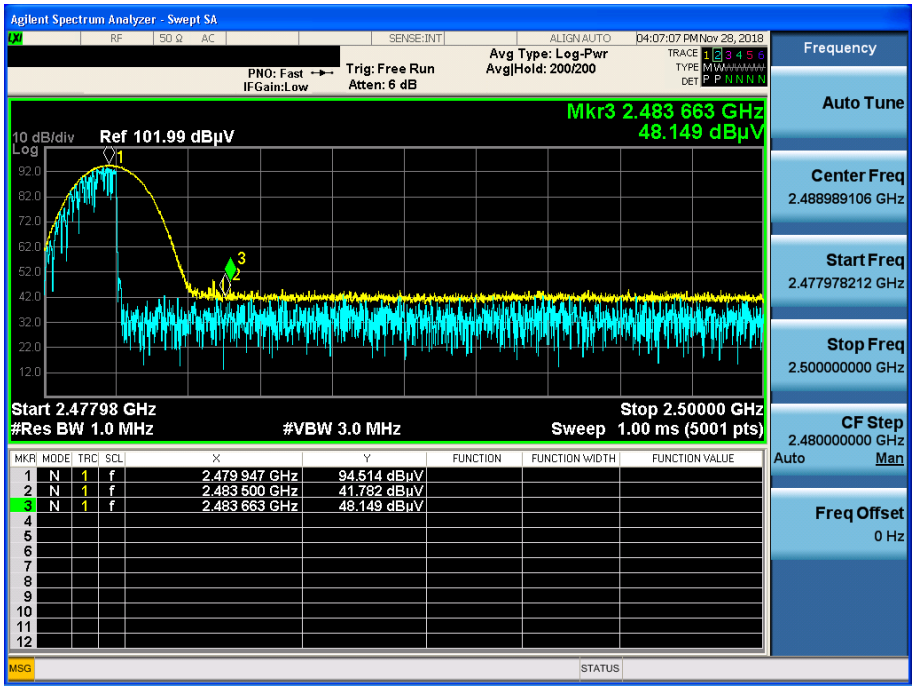


8DPSK & Lowest & X & Ver **Detector Mode : PK**

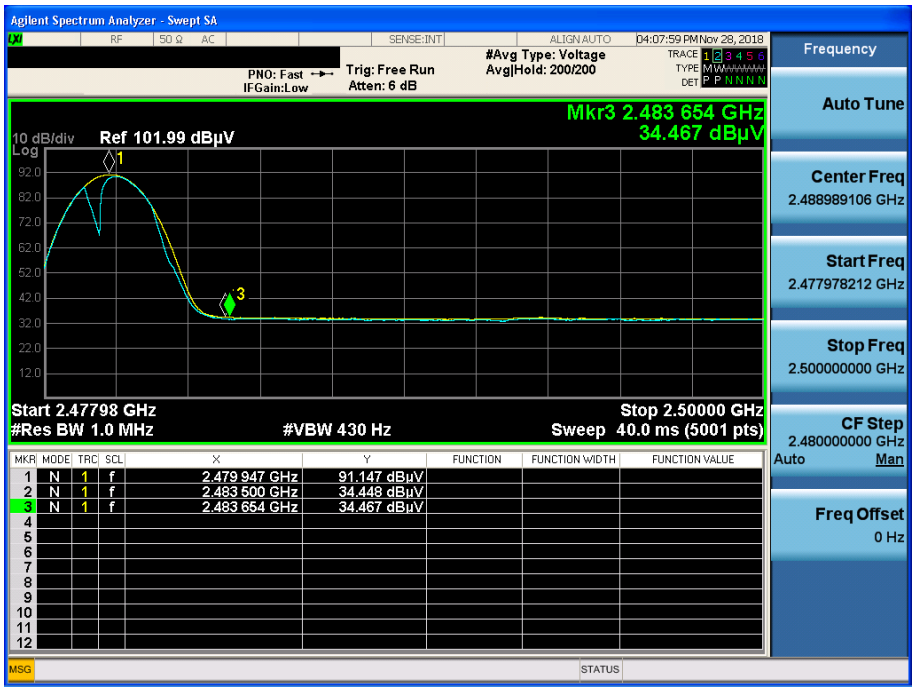


8DPSK & Lowest & X & Ver **Detector Mode : AV**

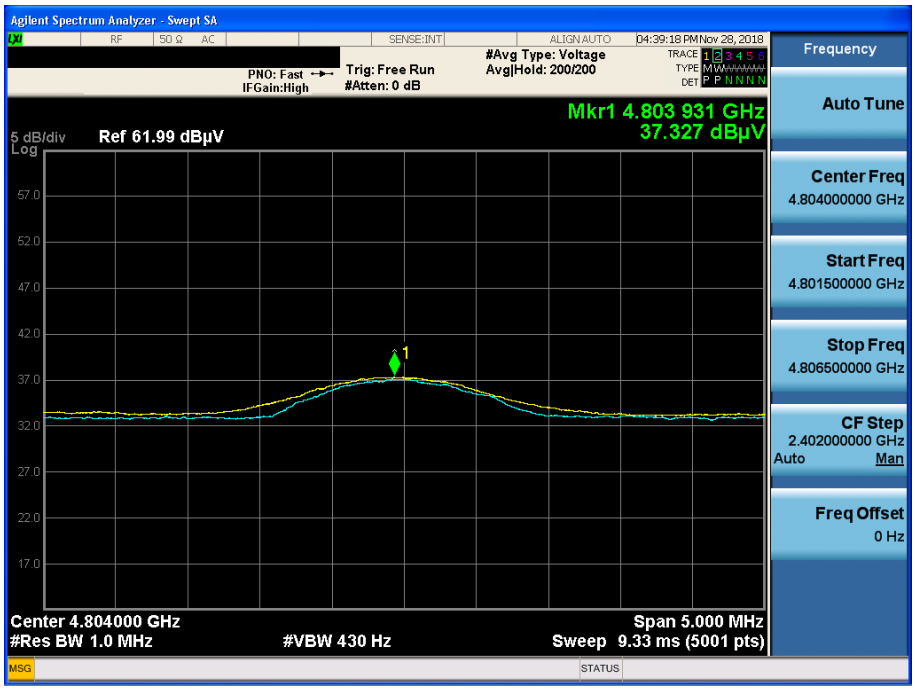
8DPSK & Highest & X & Ver **Detector Mode : PK**



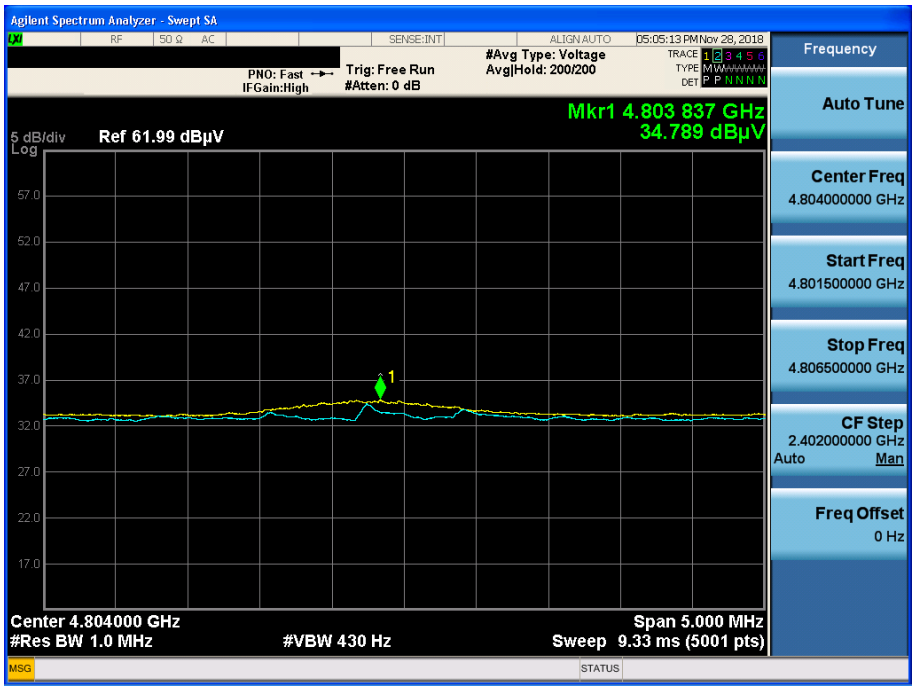
8DPSK & Highest & X & Ver **Detector Mode : AV**



GFSK & Lowest & X & Hor **Detector Mode : AV**



π/4DQPSK & Lowest & X & Hor **Detector Mode : AV**



8DPSK & Middle & X & Hor **Detector Mode : AV**