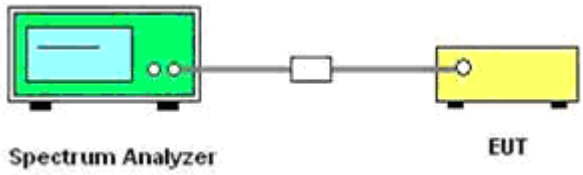
6.5 Conducted Spurious Emissions and Band Edges Test

6.5.1 Limit

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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in§15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see§15.205(c)).

6.5.2 Block Diagram of Test Setup



6.5.3 Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 100 KHz. The video bandwidth is set to 300 KHz.

Measurements are made over the 30 MHz to 25GHz range with the transmitter set to the lowest, middle, and highest channels

6.5.4 Test Results of Conducted Spurious Emissions

No non-compliance noted. Only record the worst test result in this report. The test data refer to the following page.

Test Mode	Channel	Frequency (MHz)	Spurious RF Conducted Emission (dBc)	Limits (dBc)	Verdict
GFSK	0	2402	<-20	-20	PASS
	39	2441	<-20		
	78	2480	<-20		
π/4-DQPSK	0	2402	<-20	-20	PASS
	39	2441	<-20		
	78	2480	<-20		
8-DPSK	0	2402	<-20	-20	PASS
	39	2441	<-20		
	78	2480	<-20		

Remark:

1. *Test results including cable loss;*
2. *Please refer to following plots;*
3. *Measured at difference Packet Type for each mode and recorded worst case for each mode.*
4. *Worst case data at DH5 for GFSK, 2DH5 for π/4-DQPSK, 3DH5 for 8DPSK modulation type;*

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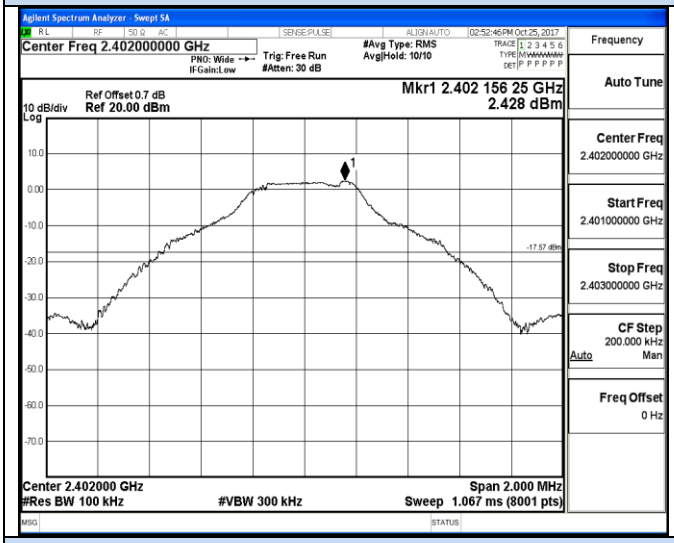
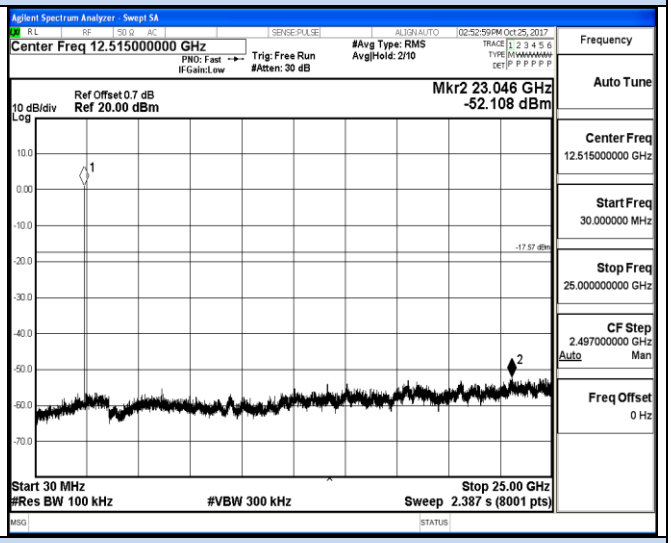
RF Conducted Spurious Emissions

GFSK / Channel 0 / 2402 MHz

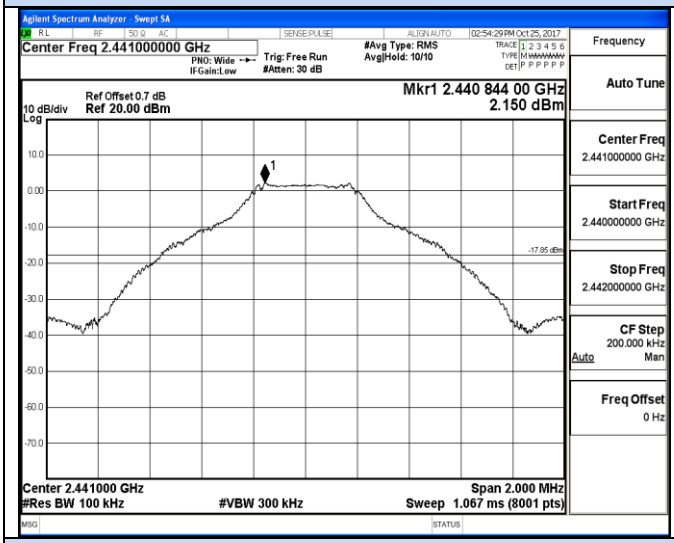


2402 MHz

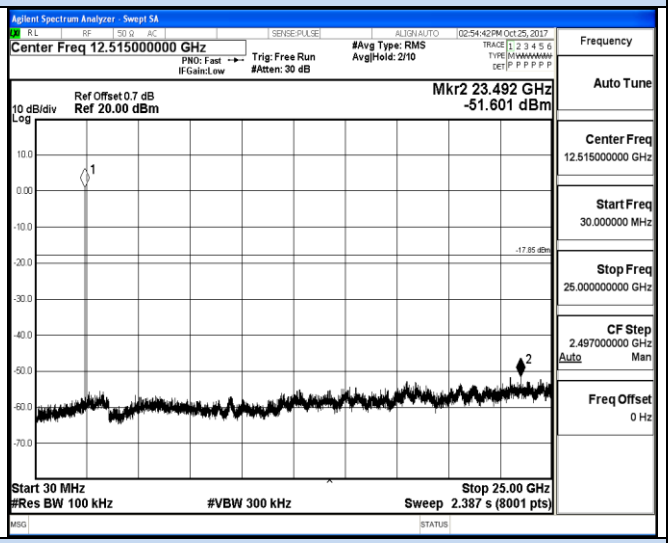


30 MHz – 25 GHz

GFSK / Channel 39 / 2441 MHz

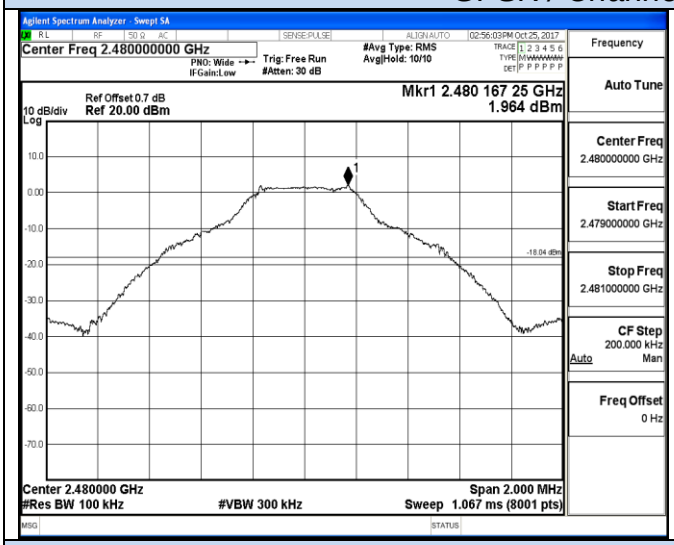


2441MHz

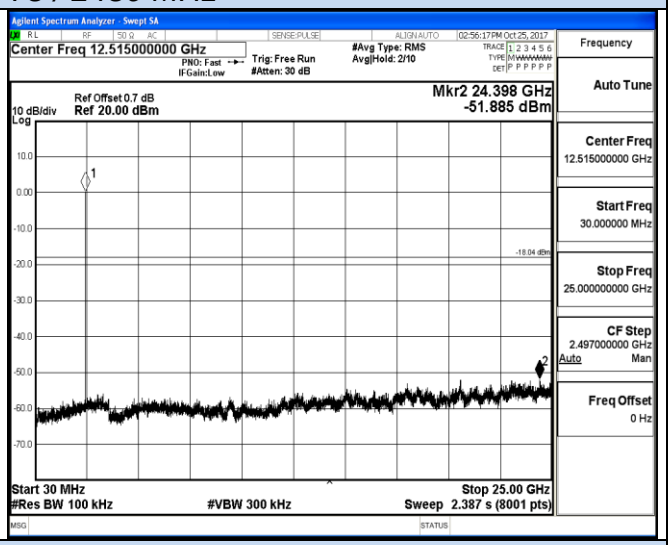


30 MHz – 25 GHz

GFSK / Channel 78 / 2480 MHz

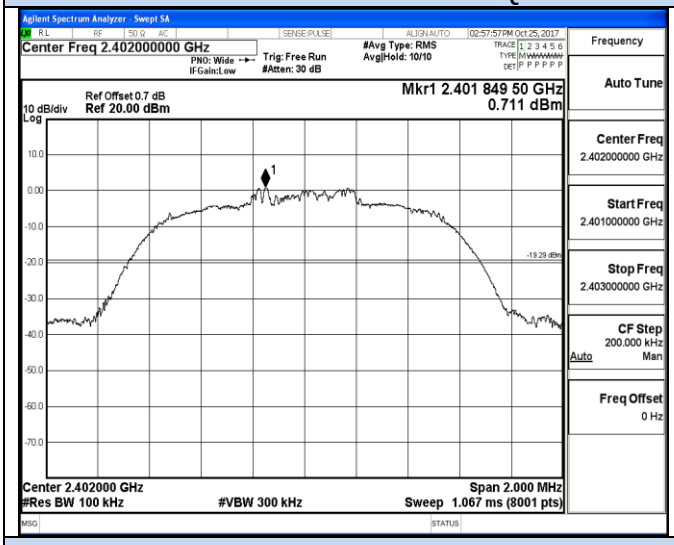


2480 MHz

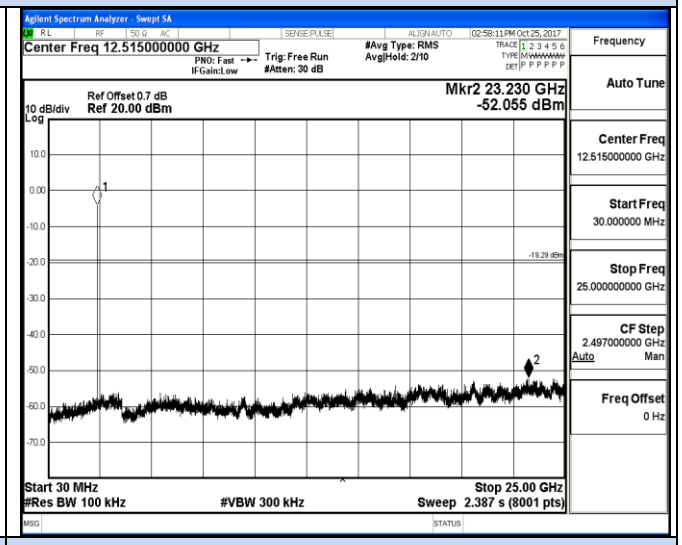


30 MHz – 25 GHz

π/4-DQPSK / Channel 0 / 2402 MHz

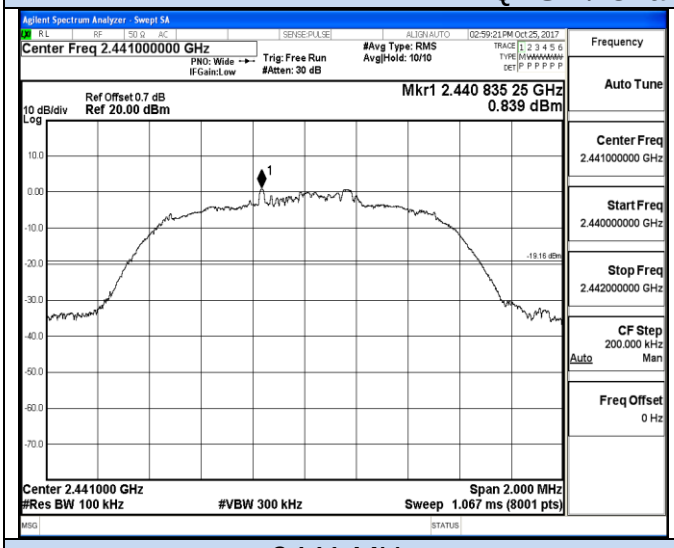


2402 MHz

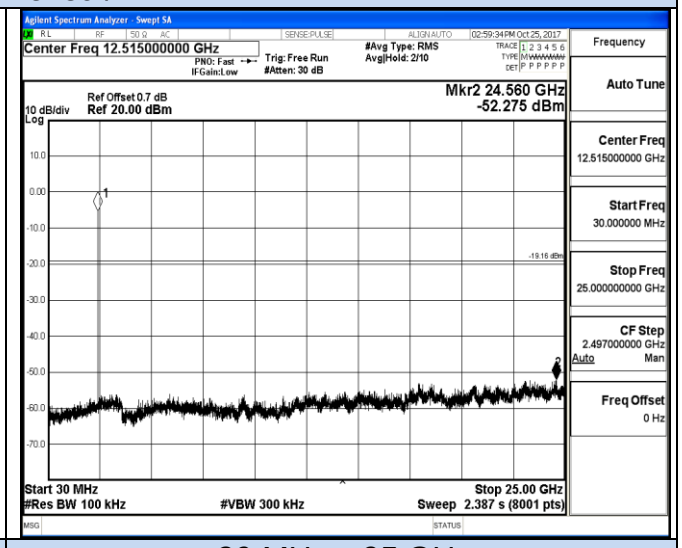


30 MHz – 25 GHz

π/4-DQPSK / Channel 39 / 2441 MHz

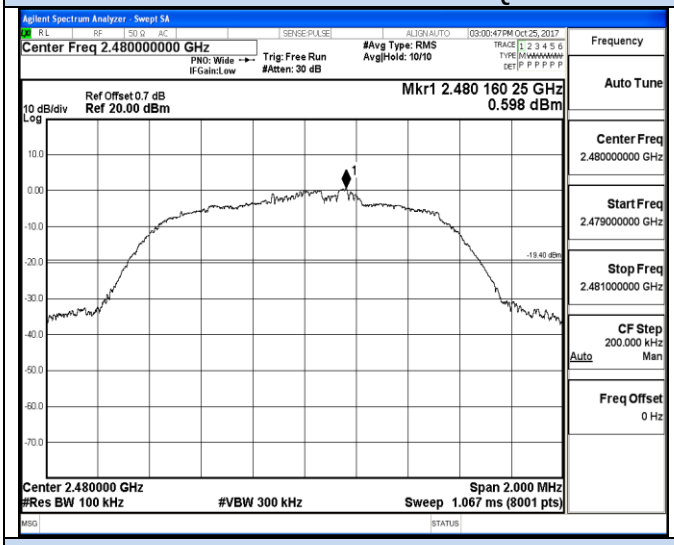


2441 MHz

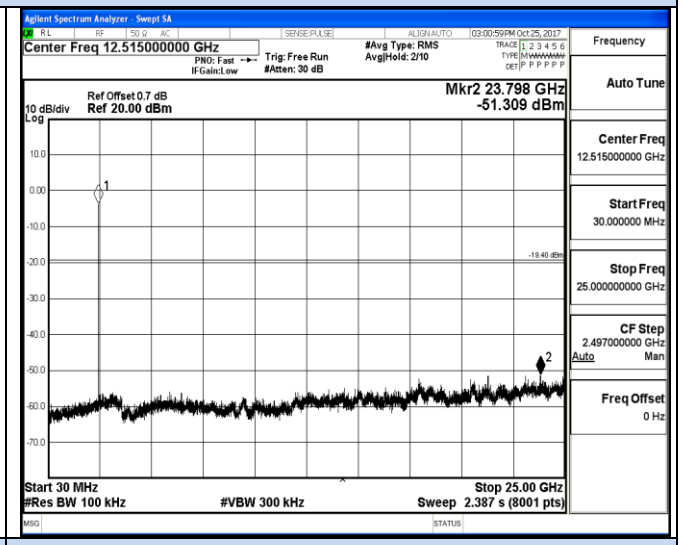


30 MHz – 25 GHz

π/4-DQPSK / Channel 78 / 2480 MHz

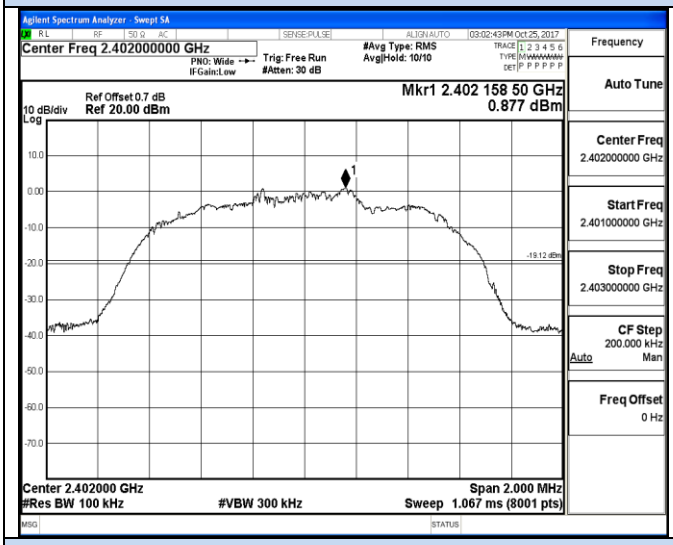


2480 MHz

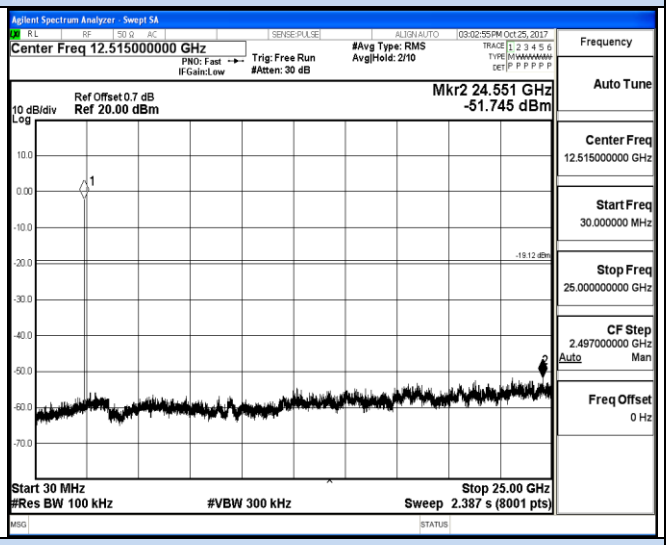


30 MHz – 25 GHz

8-DPSK / Channel 0 / 2402 MHz

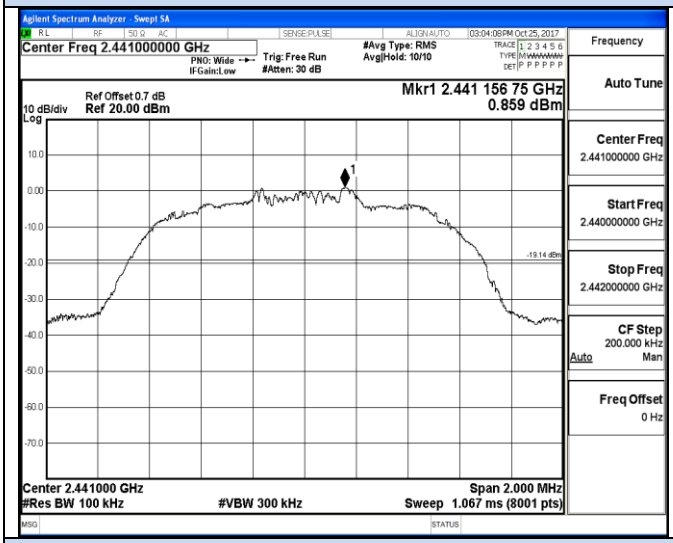


2402 MHz

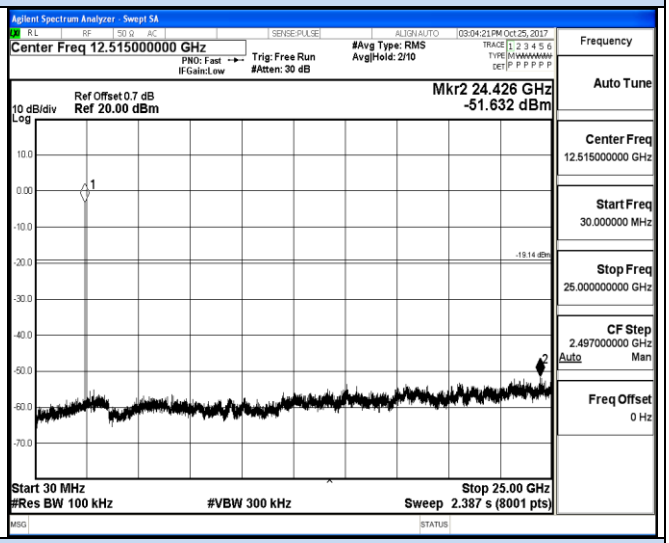


30 MHz – 25 GHz

8-DPSK / Channel 39 / 2441 MHz

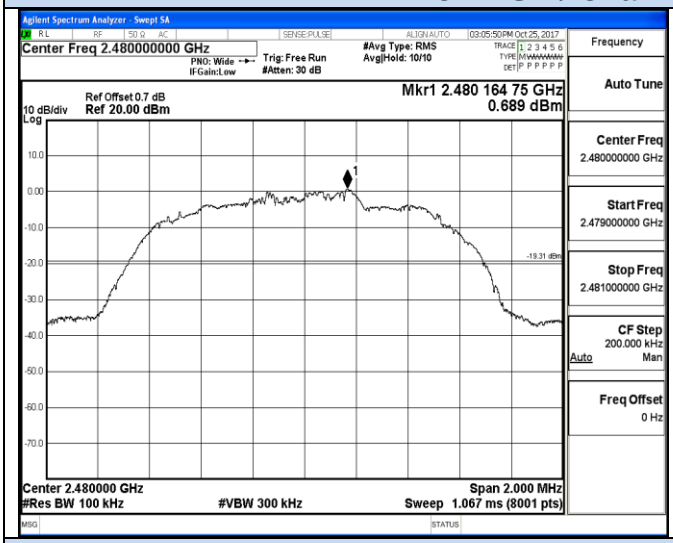


2441 MHz

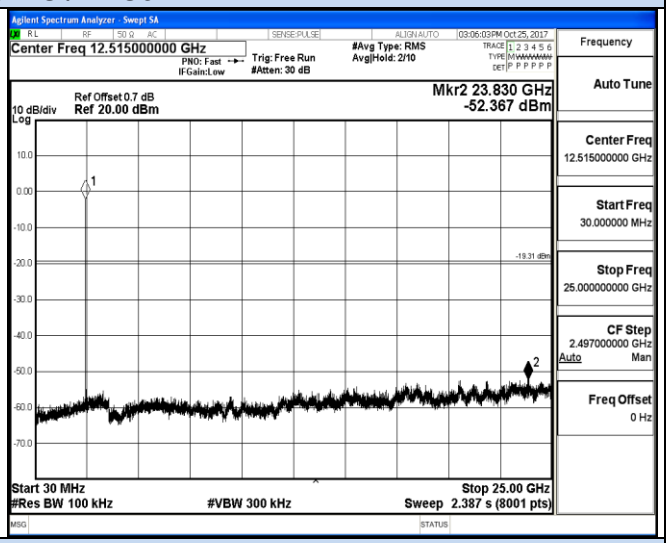


30 MHz – 25 GHz

8-DPSK / Channel 78 / 2480 MHz

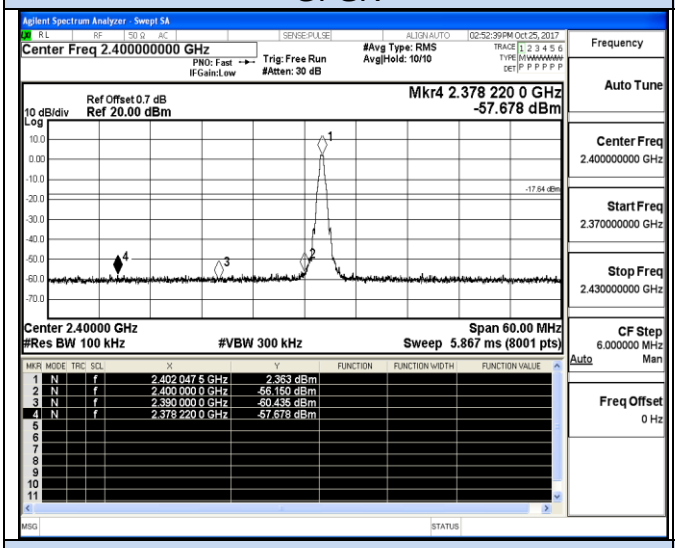
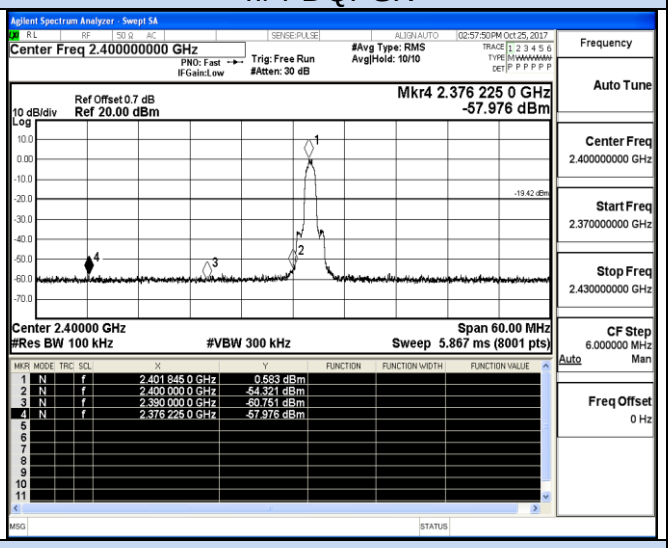
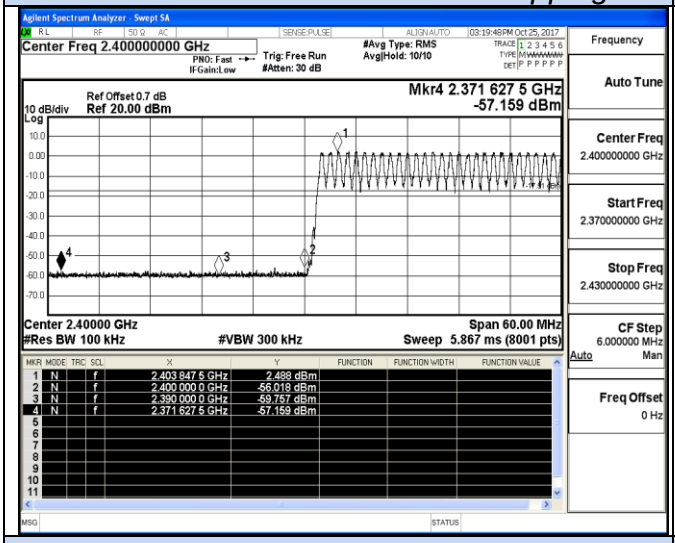
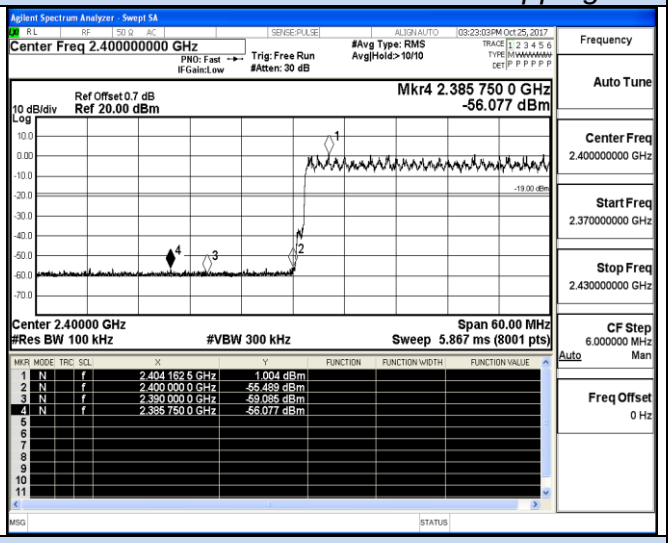
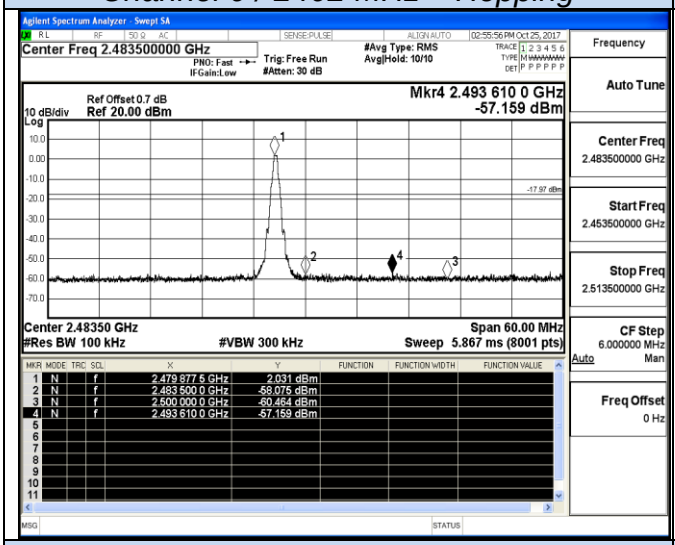
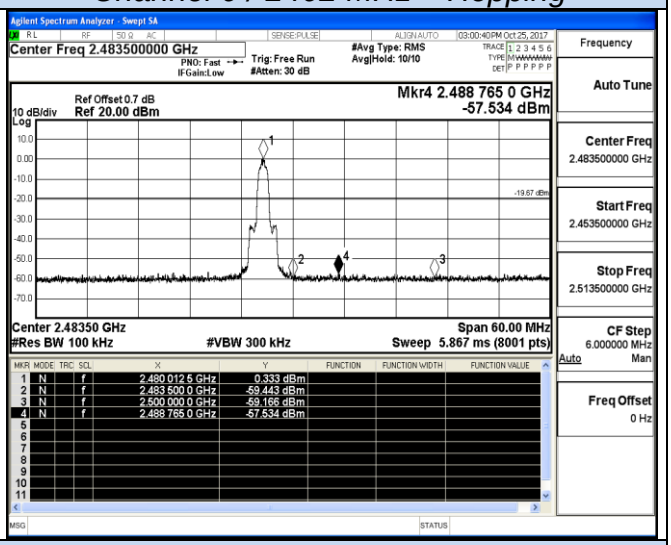


2480 MHz



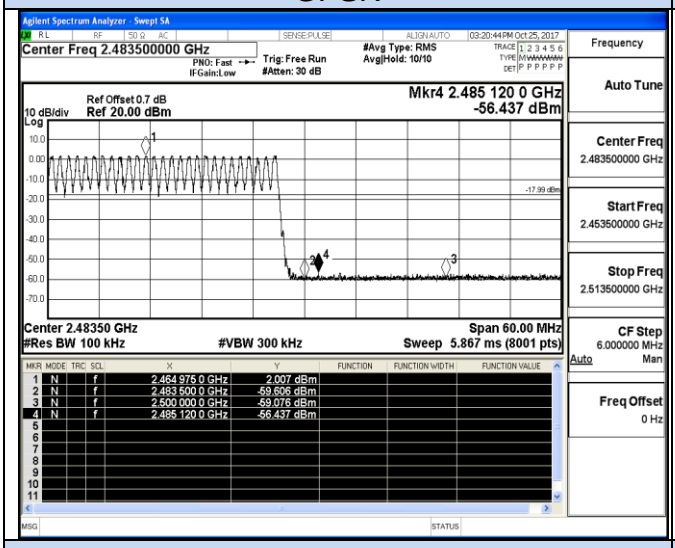
30 MHz – 25 GHz

Band-edge for RF conducted emissions

GFSK	π/4-DQPSK
	
Channel 0 / 2402 MHz – Non-Hopping	Channel 0 / 2402 MHz – Non-Hopping
	
Channel 0 / 2402 MHz – Hopping	Channel 0 / 2402 MHz – Hopping
	
Channel 78 / 2480 MHz – Non-Hopping	Channel 78 / 2480 MHz – Non-Hopping

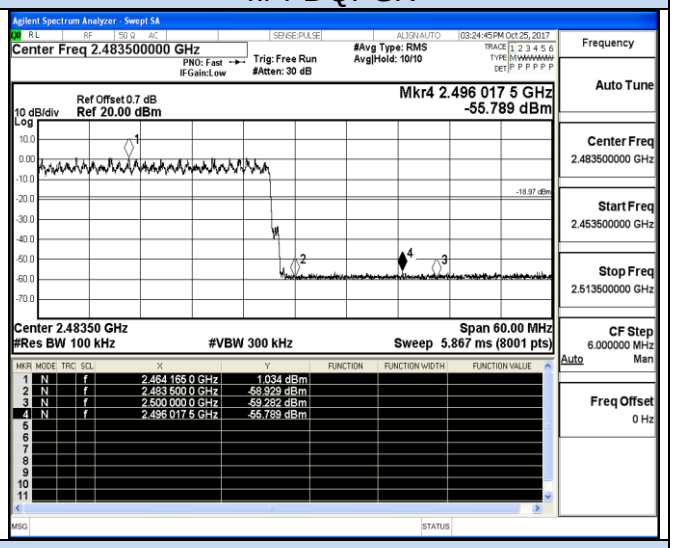
Band-edge for RF conducted emissions

GFSK



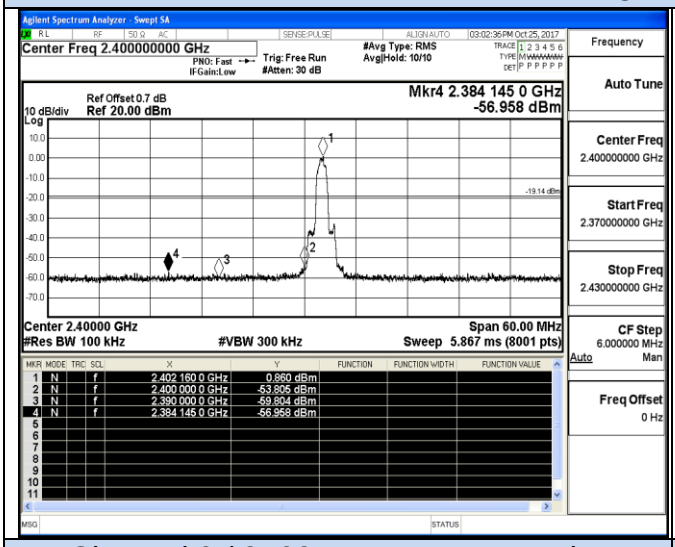
Channel 78 / 2480 MHz – Hopping

π/4-DQPSK

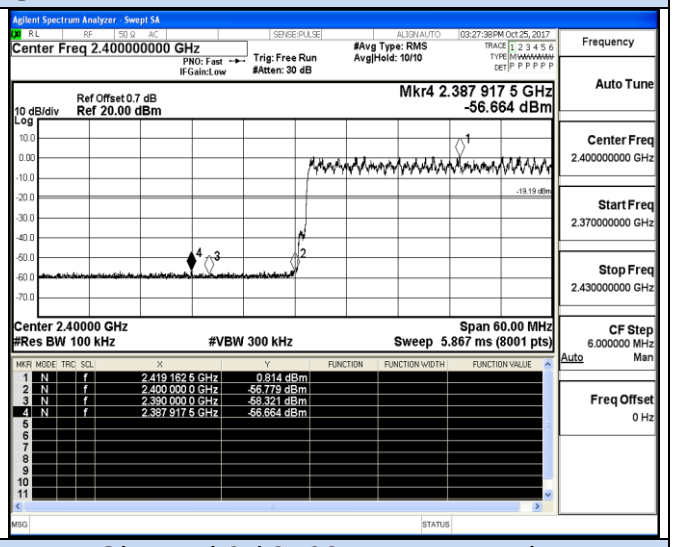


Channel 78 / 2480 MHz – Hopping

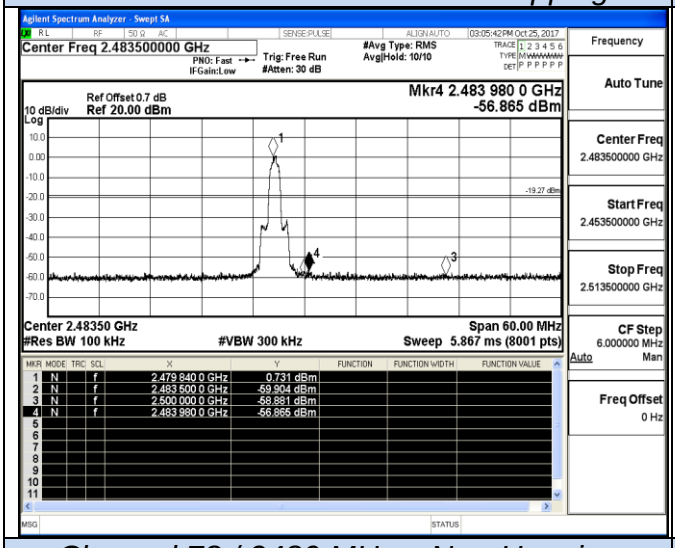
8-DPSK



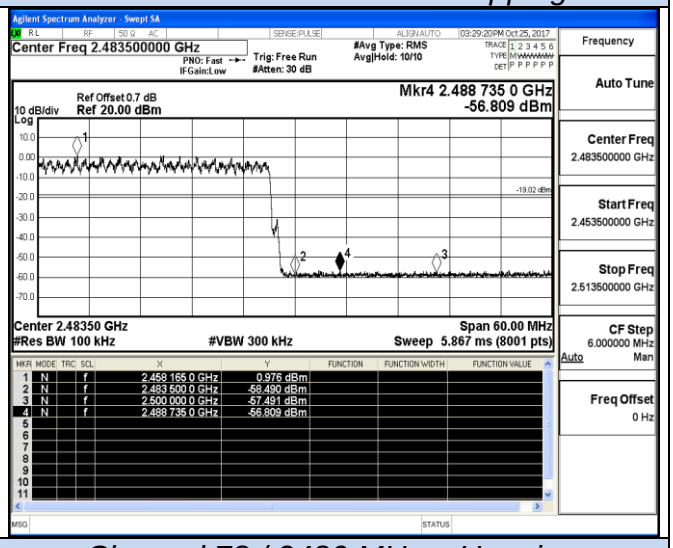
Channel 0 / 2402 MHz – Non-Hopping



Channel 0 / 2402 MHz – Hopping



Channel 78 / 2480 MHz – Non-Hopping



Channel 78 / 2480 MHz – Hopping

6.6 Restricted Band Emission Limit

6.6.1. Standard Applicable

15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
\1\ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293.	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(\2\)
13.36-13.41			

\1\ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz

\2\ Above 38.6

According to §15.247 (d): 20dBc in any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/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

6.6.2. Measuring Instruments and Setting

The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Attenuation	Auto
Start Frequency	1000 MHz
Stop Frequency	10th carrier harmonic
RB / VB (Emission in restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average

Receiver Parameter	Setting

Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB/VB 200Hz/1KHz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB/VB 9kHz/30KHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB/VB 120kHz/1MHz for QP

6.6.3. Test Procedures

1) Sequence of testing 9 kHz to 30 MHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna height is 0.8 meter.

--- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

--- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).

--- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

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2) Sequence of testing 30 MHz to 1 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height changes from 1 to 3 meter.

--- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter.

--- The final measurement will be done with QP detector with an EMI receiver.

--- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

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3) Sequence of testing 1 GHz to 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height scan range is 1 meter to 2.5 meter.

--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.

--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

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4) Sequence of testing above 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 1 meter.

--- The EUT was set into operation.

Premeasurement:

--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

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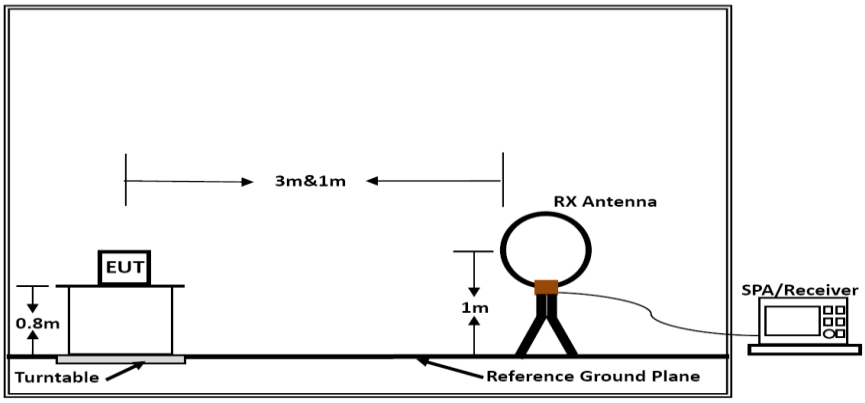
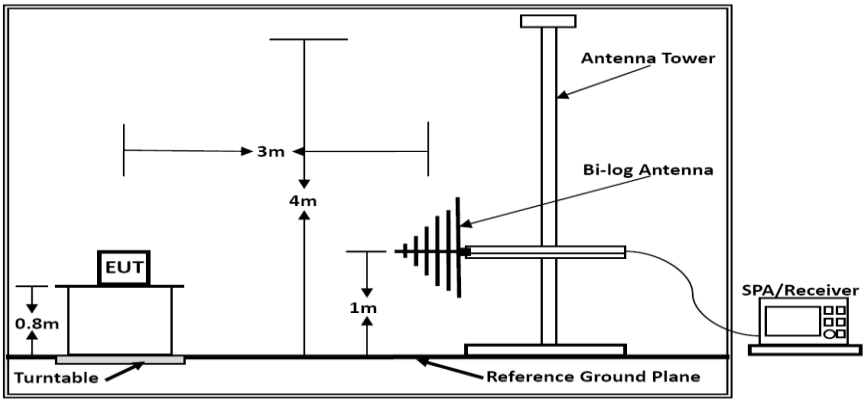
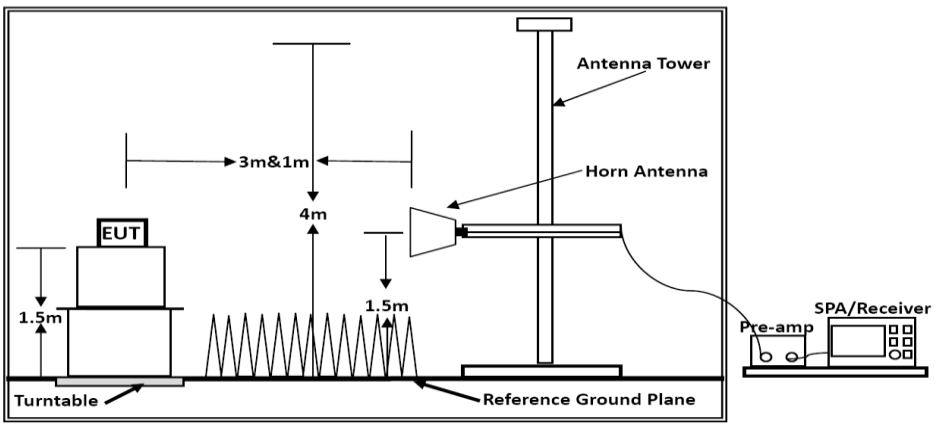
6.6.4. Test Setup Layout



Below 30MHz



Below 1GHz



Above 1GHz

Above 18 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m.

Distance extrapolation factor = 20 log (specific distanc [3m] / test distance [1m]) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].

6.6.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

6.6.6. Results of Radiated Emissions (9 KHz~30MHz)

Temperature	24℃	Humidity	54%
Test Engineer	Wilson Hong	Configurations	BT

Freq. (MHz)	Level (dBuV)	Over Limit (dB)	Over Limit (dBuV)	Remark
-	-	-	-	See Note

Note:

The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = 40 log (specific distance / test distance) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor.

PASS.

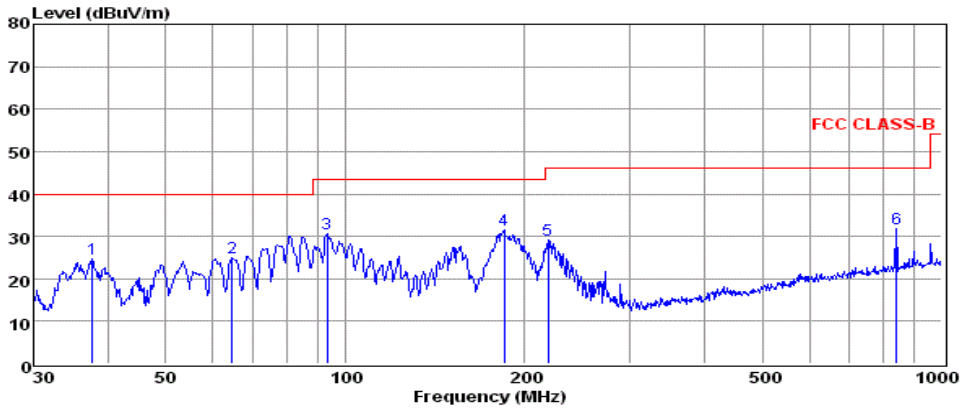
Only record the worst test result in this report.

The test data please refer to following page.

6.6.6. Results of Radiated Emissions (30 MHz~1000 MHz)

Below 1GHz

Vertical

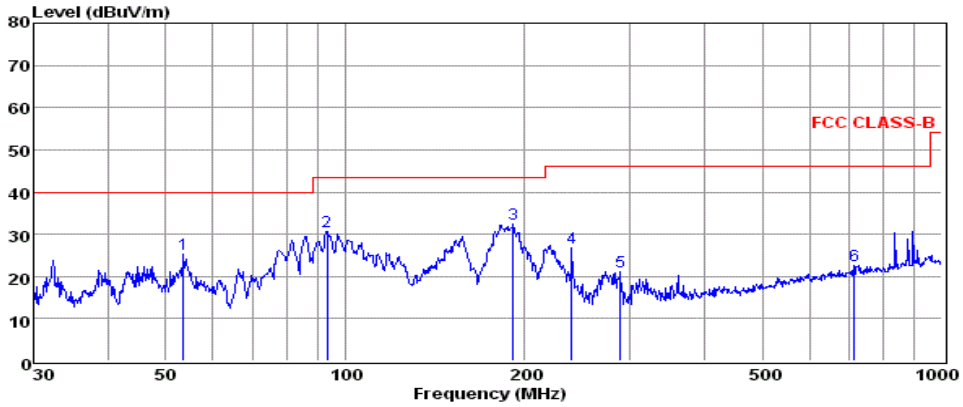


pol: VERTICAL

	Freq MHz	Reading dBuV	CabLos dB	Antfac dB/m	Measured dBuV/m	Limit dBuV/m	Over dB	Remark
1	37.68	11.21	0.38	12.99	24.58	40.00	-15.42	QP
2	64.66	13.62	0.52	10.84	24.98	40.00	-15.02	QP
3	93.11	17.56	0.56	12.49	30.61	43.50	-12.89	QP
4	184.49	20.69	0.70	10.08	31.47	43.50	-12.03	QP
5	219.08	16.88	0.95	11.17	29.00	46.00	-17.00	QP
6	839.18	9.54	1.70	20.46	31.70	46.00	-14.30	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that ate 20db blow the offficial limit are not reported

Horizontal



pol: HORIZONTAL

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	53.51	11.86	0.46	13.09	25.41	40.00	-14.59	QP
2	93.11	17.73	0.56	12.49	30.78	43.50	-12.72	QP
3	191.07	20.91	0.86	10.56	32.33	43.50	-11.17	QP
4	239.99	13.67	1.01	12.09	26.77	46.00	-19.23	QP
5	289.00	7.30	1.05	12.85	21.20	46.00	-24.80	QP
6	714.17	2.04	1.63	18.99	22.66	46.00	-23.34	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that ate 20db blow the offficial limit are not reported

****Note:*
Pre-scan all modes and recorded the worst case results in this report (TX (1Mbps)).
Emission level (dBuV/m) = 20 log Emission level (uV/m).
Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level.

Above 1GHz

The worst test result for GFSK, Channel 0 / 2402 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4804.00	54.63	33.06	35.04	3.94	56.59	74.00	-17.41	Peak	Horizontal
4804.00	40.84	33.06	35.04	3.94	42.80	54.00	-11.20	Average	Horizontal
12010.00	53.82	33.16	35.06	3.96	55.88	74.00	-18.12	Peak	Horizontal
12010.00	44.19	33.16	35.06	3.96	46.25	54.00	-7.75	Average	Horizontal
4804.00	51.95	33.06	35.04	3.94	53.91	74.00	-20.09	Peak	Vertical
4804.00	41.08	33.06	35.04	3.94	43.04	54.00	-10.96	Average	Vertical
12010.00	52.11	33.16	35.06	3.96	54.17	74.00	-19.83	Peak	Vertical
12010.00	39.05	33.16	35.06	3.96	41.11	54.00	-12.89	Average	Vertical

The worst test result for GFSK, Channel 39 / 2441 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4882.00	56.29	33.16	35.15	3.96	58.26	74.00	-15.74	Peak	Horizontal
4882.00	41.14	33.16	35.15	3.96	43.11	54.00	-10.89	Average	Horizontal
12205.00	52.44	33.26	35.17	3.98	54.51	74.00	-19.49	Peak	Horizontal
12205.00	39.18	33.26	35.17	3.98	41.25	54.00	-12.75	Average	Horizontal
4882.00	56.26	33.16	35.15	3.96	58.23	74.00	-15.77	Peak	Vertical
4882.00	39.55	33.16	35.15	3.96	41.52	54.00	-12.48	Average	Vertical
12205.00	52.79	33.26	35.17	3.98	54.86	74.00	-19.14	Peak	Vertical
12205.00	41.29	33.26	35.17	3.98	43.36	54.00	-10.64	Average	Vertical

The worst test result for GFSK, Channel 78 / 2480 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4960.00	53.97	33.26	35.14	3.98	56.07	74.00	-17.93	Peak	Horizontal
4960.00	43.50	33.26	35.14	3.98	45.60	54.00	-8.40	Average	Horizontal
12400.00	53.59	33.36	35.16	4.00	55.79	74.00	-18.21	Peak	Horizontal
12400.00	40.37	33.36	35.16	4.00	42.57	54.00	-11.43	Average	Horizontal
4960.00	49.81	33.26	35.14	3.98	51.91	74.00	-22.09	Peak	Vertical
4960.00	35.75	33.26	35.14	3.98	37.85	54.00	-16.15	Average	Vertical
12400.00	51.28	33.36	35.16	4.00	53.48	74.00	-20.52	Peak	Vertical
12400.00	38.20	33.36	35.16	4.00	40.40	54.00	-13.60	Average	Vertical

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The worst test result for π/4-DQPSK, Channel 0 / 2402 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4804.00	55.03	33.06	35.04	3.94	56.99	74.00	-17.01	Peak	Horizontal
4804.00	40.72	33.06	35.04	3.94	42.68	54.00	-11.32	Average	Horizontal
12010.00	50.93	33.16	35.06	3.96	52.99	74.00	-21.01	Peak	Horizontal
12010.00	41.64	33.16	35.06	3.96	43.70	54.00	-10.30	Average	Horizontal
4804.00	53.20	33.06	35.04	3.94	55.16	74.00	-18.84	Peak	Vertical
4804.00	42.78	33.06	35.04	3.94	44.74	54.00	-9.26	Average	Vertical
12010.00	53.25	33.16	35.06	3.96	55.31	74.00	-18.69	Peak	Vertical
12010.00	39.68	33.16	35.06	3.96	41.74	54.00	-12.26	Average	Vertical

The worst test result for π/4-DQPSK, Channel 39 / 2441 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4882.00	53.16	33.16	35.15	3.96	55.13	74.00	-18.87	Peak	Horizontal
4882.00	43.12	33.16	35.15	3.96	45.09	54.00	-8.91	Average	Horizontal
12205.00	53.56	33.26	35.17	3.98	55.63	74.00	-18.37	Peak	Horizontal
12205.00	40.35	33.26	35.17	3.98	42.42	54.00	-11.58	Average	Horizontal
4882.00	53.50	33.16	35.15	3.96	55.47	74.00	-18.53	Peak	Vertical
4882.00	37.82	33.16	35.15	3.96	39.79	54.00	-14.21	Average	Vertical
12205.00	53.62	33.26	35.17	3.98	55.69	74.00	-18.31	Peak	Vertical
12205.00	42.70	33.26	35.17	3.98	44.77	54.00	-9.23	Average	Vertical

The worst test result for π/4-DQPSK, Channel 78 / 2480 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4960.00	55.86	33.26	35.14	3.98	57.96	74.00	-16.04	Peak	Horizontal
4960.00	43.29	33.26	35.14	3.98	45.39	54.00	-8.61	Average	Horizontal
12400.00	50.21	33.36	35.16	4.00	52.41	74.00	-21.59	Peak	Horizontal
12400.00	40.27	33.36	35.16	4.00	42.47	54.00	-11.53	Average	Horizontal
4960.00	51.46	33.26	35.14	3.98	53.56	74.00	-20.44	Peak	Vertical
4960.00	40.27	33.26	35.14	3.98	42.37	54.00	-11.63	Average	Vertical
12400.00	53.03	33.36	35.16	4.00	55.23	74.00	-18.77	Peak	Vertical
12400.00	37.13	33.36	35.16	4.00	39.33	54.00	-14.67	Average	Vertical

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The worst test result for 8DPSK, Channel 0 / 2402 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4804.00	56.95	33.06	35.04	3.94	58.91	74.00	-15.09	Peak	Horizontal
4804.00	41.58	33.06	35.04	3.94	43.54	54.00	-10.46	Average	Horizontal
12010.00	52.34	33.16	35.06	3.96	54.40	74.00	-19.60	Peak	Horizontal
12010.00	43.73	33.16	35.06	3.96	45.79	54.00	-8.21	Average	Horizontal
4804.00	51.16	33.06	35.04	3.94	53.12	74.00	-20.88	Peak	Vertical
4804.00	42.71	33.06	35.04	3.94	44.67	54.00	-9.33	Average	Vertical
12010.00	52.40	33.16	35.06	3.96	54.46	74.00	-19.54	Peak	Vertical
12010.00	40.00	33.16	35.06	3.96	42.06	54.00	-11.94	Average	Vertical

The worst test result for 8DPSK, Channel 39 / 2441 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4882.00	56.83	33.16	35.15	3.96	58.80	74.00	-15.20	Peak	Horizontal
4882.00	41.37	33.16	35.15	3.96	43.34	54.00	-10.66	Average	Horizontal
12205.00	50.75	33.26	35.17	3.98	52.82	74.00	-21.18	Peak	Horizontal
12205.00	37.91	33.26	35.17	3.98	39.98	54.00	-14.02	Average	Horizontal
4882.00	56.09	33.16	35.15	3.96	58.06	74.00	-15.94	Peak	Vertical
4882.00	37.56	33.16	35.15	3.96	39.53	54.00	-14.47	Average	Vertical
12205.00	52.75	33.26	35.17	3.98	54.82	74.00	-19.18	Peak	Vertical
12205.00	42.65	33.26	35.17	3.98	44.72	54.00	-9.28	Average	Vertical

The worst test result for 8DPSK, Channel 78 / 2480 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4960.00	54.88	33.26	35.14	3.98	56.98	74.00	-17.02	Peak	Horizontal
4960.00	42.53	33.26	35.14	3.98	44.63	54.00	-9.37	Average	Horizontal
12400.00	50.91	33.36	35.16	4.00	53.11	74.00	-20.89	Peak	Horizontal
12400.00	42.03	33.36	35.16	4.00	44.23	54.00	-9.77	Average	Horizontal
4960.00	53.62	33.26	35.14	3.98	55.72	74.00	-18.28	Peak	Vertical
4960.00	39.86	33.26	35.14	3.98	41.96	54.00	-12.04	Average	Vertical
12400.00	54.66	33.36	35.16	4.00	56.86	74.00	-17.14	Peak	Vertical
12400.00	36.69	33.36	35.16	4.00	38.89	54.00	-15.11	Average	Vertical

Notes:

1). Measuring frequencies from 9 KHz - 10th harmonic (ex. 26GHz), No emission found between lowest internal used/generated frequency to 30 MHz.

2). Radiated emissions measured in frequency range from 9 KHz - 10th harmonic (ex. 26GHz) were made with an instrument using Peak detector mode.

3). 18~25GHz at least have 20dB margin. No recording in the test report.

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6.7. AC Power line conducted emissions

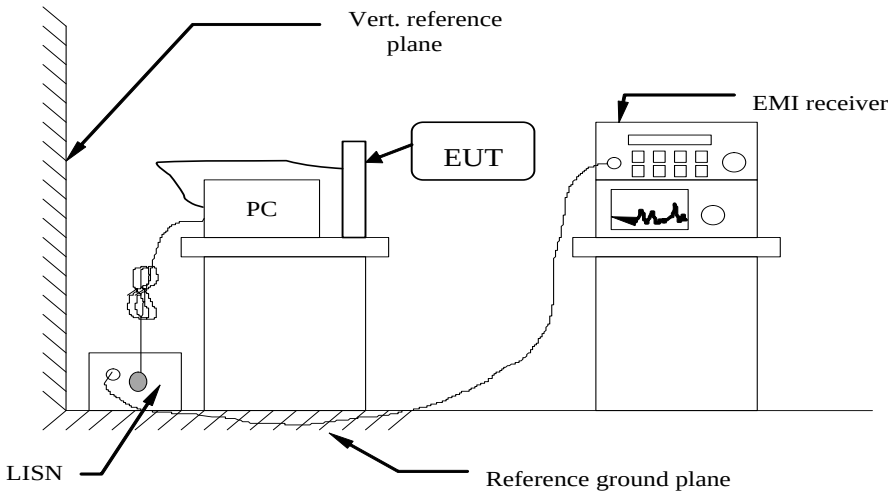
6.7.1 Standard Applicable

According to §15.207 (a): For an intentional radiator which 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 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range are listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency

6.7.2 Block Diagram of Test Setup



6.7.3 Test Results

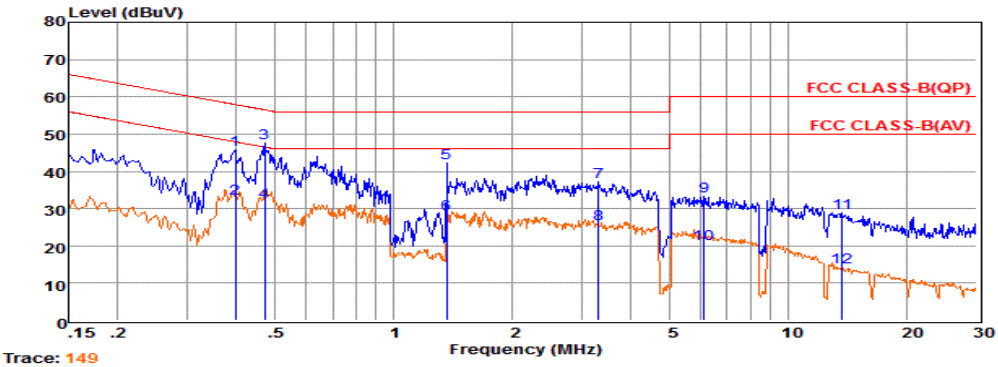
PASS.

The test data please refer to following page.

Temperature	24℃	Humidity	53.8%
Test Engineer	Wilson Hong	Configurations	BT

AC Conducted Emission of charge from AC mains mode @ AC 120V/60Hz @ GFSK (worst case)

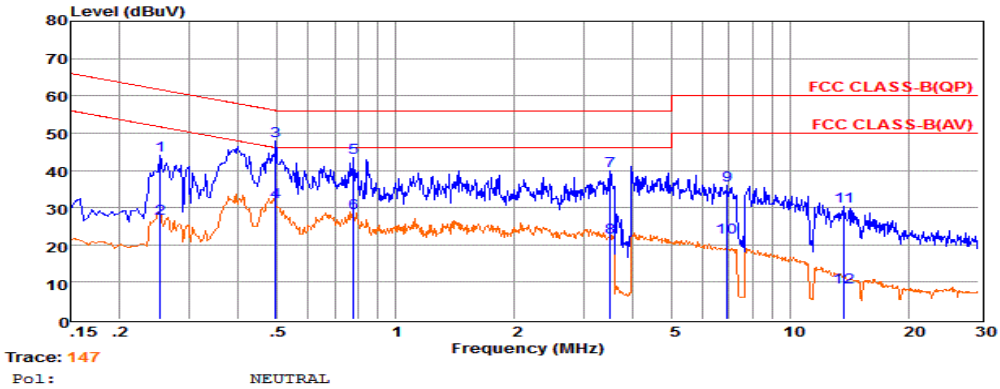
Line



	Freq MHz	Reading dBuV	LISNFac dB	CabLos dB	Aux2Fac dB	Measured dB	Limit dBuV	Over dBuV	Remark dB
1	0.40	26.12	9.62	0.04	10.00	45.78	57.90	-12.12	QP
2	0.40	12.94	9.62	0.04	10.00	32.60	57.90	-25.30	Average
3	0.47	27.97	9.62	0.04	10.00	47.63	56.49	-8.86	QP
4	0.47	12.05	9.62	0.04	10.00	31.71	56.49	-24.78	Average
5	1.36	22.68	9.63	0.05	10.00	42.36	56.00	-13.64	QP
6	1.36	8.78	9.63	0.05	10.00	28.46	56.00	-27.54	Average
7	3.31	17.35	9.65	0.06	10.00	37.06	56.00	-18.94	QP
8	3.31	6.15	9.65	0.06	10.00	25.86	56.00	-30.14	Average
9	6.12	13.65	9.67	0.07	10.00	33.39	60.00	-26.61	QP
10	6.12	0.83	9.67	0.07	10.00	20.57	60.00	-39.43	Average
11	13.70	9.11	9.71	0.10	10.00	28.92	60.00	-31.08	QP
12	13.70	-5.50	9.71	0.10	10.00	14.31	60.00	-45.69	Average

Remarks: 1. Measured = Reading + LISNFac + Cable Loss + Aux2 Fac.
2. The emission levels that are 20dB below the official limit are not reported.

Neutral



	Freq MHz	Reading dBuV	LISNFac dB	CabLos dB	Aux2Fac dB	Measured dB	Limit dBuV	Over dBuV	Remark dB
1	0.25	24.27	9.60	0.03	10.00	43.90	61.64	-17.74	QP
2	0.25	7.57	9.60	0.03	10.00	27.20	61.64	-34.44	Average
3	0.50	28.23	9.62	0.04	10.00	47.89	56.05	-8.16	QP
4	0.50	12.00	9.62	0.04	10.00	31.66	56.05	-24.39	Average
5	0.78	23.75	9.63	0.04	10.00	43.42	56.00	-12.58	QP
6	0.78	8.77	9.63	0.04	10.00	28.44	56.00	-27.56	Average
7	3.49	20.12	9.65	0.06	10.00	39.83	56.00	-16.17	QP
8	3.49	2.28	9.65	0.06	10.00	21.99	56.00	-34.01	Average
9	6.91	16.26	9.69	0.07	10.00	36.02	60.00	-23.98	QP
10	6.92	2.38	9.69	0.07	10.00	22.14	60.00	-37.86	Average
11	13.70	10.42	9.74	0.10	10.00	30.26	60.00	-29.74	QP
12	13.70	-11.34	9.74	0.10	10.00	8.50	60.00	-51.50	Average

Remarks: 1. Measured = Reading + LISNFac + Cable Loss + Aux2 Fac.
2. The emission levels that are 20dB below the official limit are not reported.

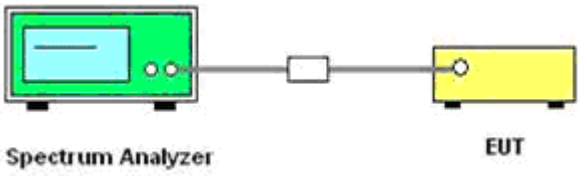
****Note: Pre-scan all modes and recorded the worst case results in this report (GFSK)*

6.8. Band-edge measurements for radiated emissions

6.8.1 Standard Applicable

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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

6.8.2. Test Setup Layout



6.8.3. Measuring Instruments and Setting

Please refer to equipment list in this report. The following table is the setting of Spectrum Analyzer.

6.8.4. Test Procedures

According to KDB 412172 section 1.1 Field Strength Approach (linear terms):

$eirp = p_t \times g_t = (E \times d)^2/30$

Where:

p_t = transmitter output power in watts,

g_t = numeric gain of the transmitting antenna (unit less),

E = electric field strength in V/m,

d = measurement distance in meters (m).

$erp = eirp/1.64 = (E \times d)^2/(30 \times 1.64)$

Where all terms are as previously defined.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=1/B for Peak detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
7. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)

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8. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
9. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
10. Compare the resultant electric field strength level to the applicable regulatory limit.
11. Perform radiated spurious emission test duress until all measured frequencies were complete.

6.8.5. Test Results

GFSK – Non-Hopping							
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Verdict
2310.000	-50.619	2.000	0.000	46.581	Peak	54.00	PASS
2390.000	-51.539	2.000	0.000	45.661	Peak	54.00	PASS
2483.500	-50.595	2.000	0.000	46.605	Peak	54.00	PASS
2500.000	-51.636	2.000	0.000	45.564	Peak	54.00	PASS

π/4-DQPSK – Non-Hopping							
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Verdict
2310.000	-49.032	2.000	0.000	48.168	Peak	54.00	PASS
2390.000	-51.228	2.000	0.000	45.972	Peak	54.00	PASS
2483.500	-48.679	2.000	0.000	48.521	Peak	54.00	PASS
2500.000	-51.253	2.000	0.000	45.947	Peak	54.00	PASS

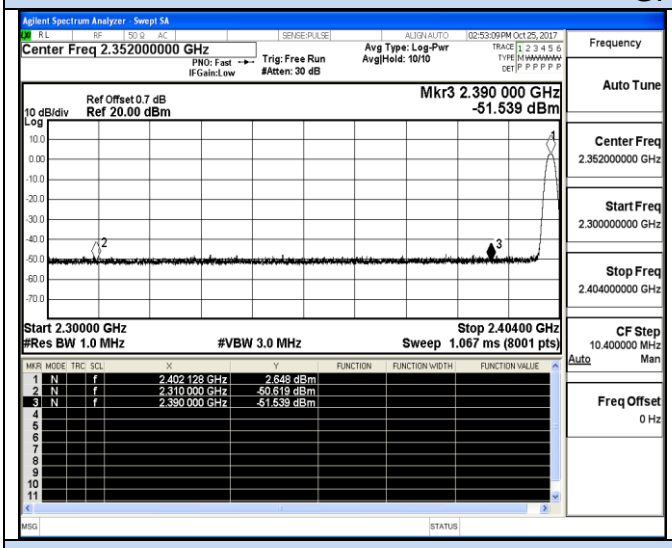
8-DPSK – Non-Hopping							
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Verdict
2310.000	-50.286	2.000	0.000	46.914	Peak	54.00	PASS
2390.000	-50.324	2.000	0.000	46.876	Peak	54.00	PASS
2483.500	-49.013	2.000	0.000	48.187	Peak	54.00	PASS
2500.000	-51.120	2.000	0.000	46.080	Peak	54.00	PASS

Remark:

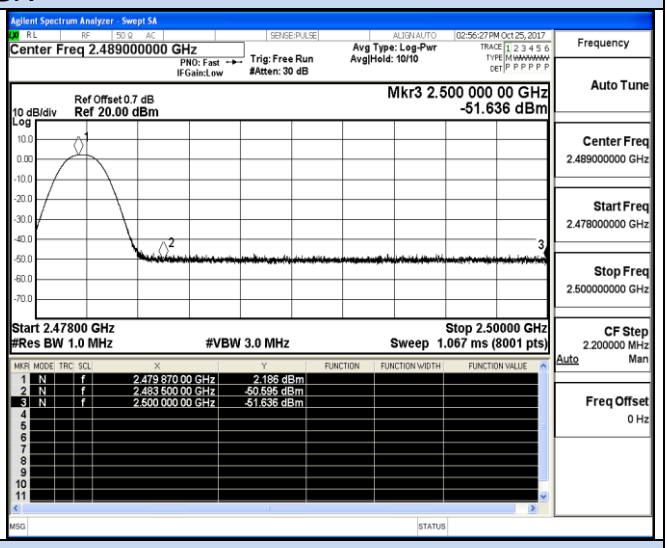
1. *Measured at difference Packet Type for each mode and recorded worst case for each mode.*
2. *Worst case data at DH5 for GFSK, 2DH5 for π/4DQPSK, 3DH5 for 8DPSK modulation type;*
3. *Measured at Hopping and Non-Hopping mode, recorded worst at Non-Hopping mode.*
4. *The other emission levels were very low against the limit.*
5. *The average measurement was not performed when the peak measured data under the limit of average detection.*
6. *Detector AV is setting spectrum/receiver. RBW=1MHz/VBW=330KHz/Sweep time=Auto/Detector=Peak;*
7. *Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no case shall a value less than 2 dBi be used.*
8. *Please refer to following test plots;*

Band-edge measurements for radiated emissions

GFSK

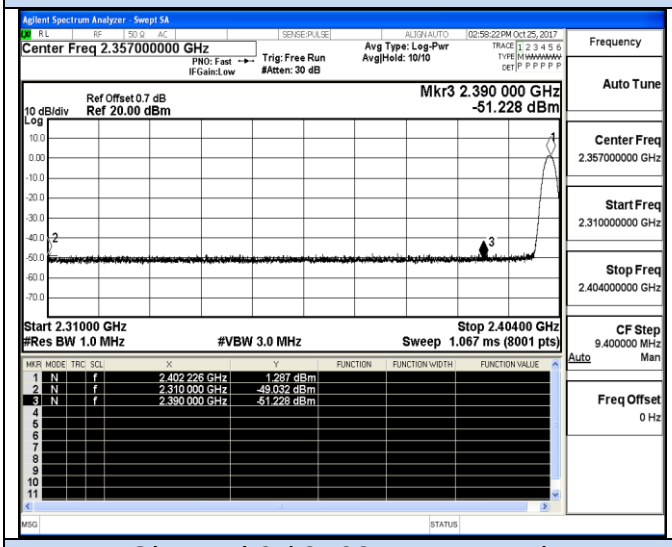


Channel 0 / 2402 MHz – Peak

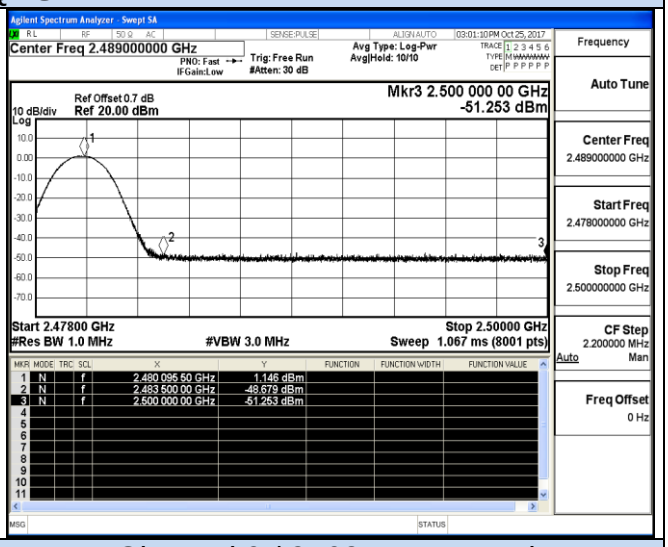


Channel 78 / 2480 MHz –Peak

π/4-DQPSK

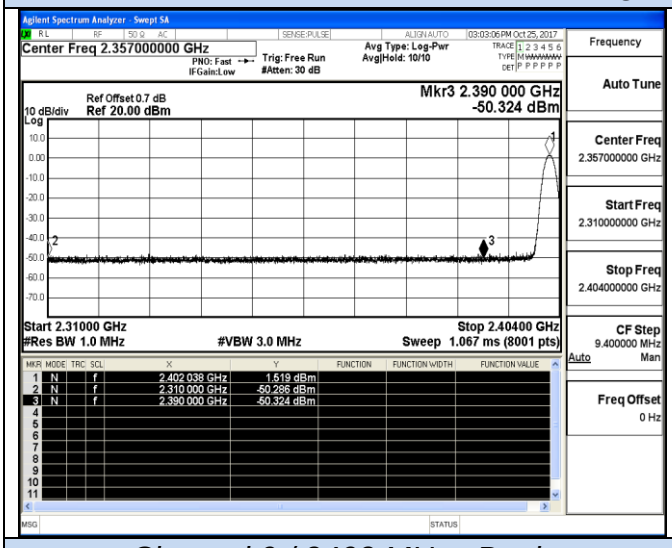


Channel 0 / 2402 MHz – Peak

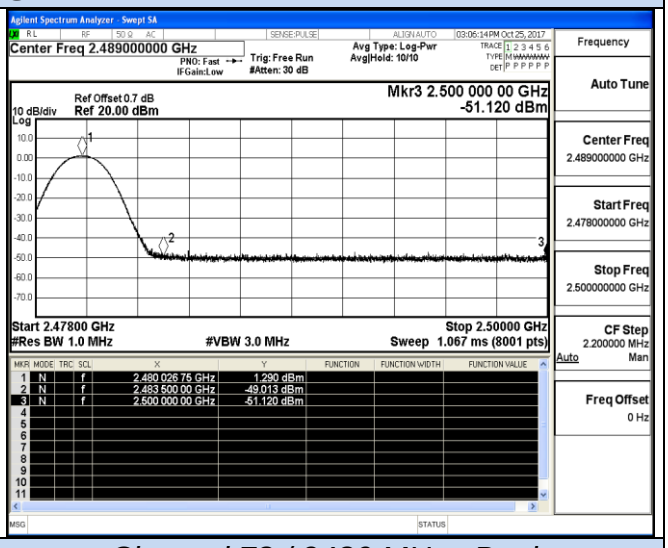


Channel 0 / 2402 MHz – Peak

8-DPSK



Channel 0 / 2402 MHz –Peak



Channel 78 / 2480 MHz –Peak

6.9. Pseudorandom frequency hopping sequence

6.9.1 Standard Applicable

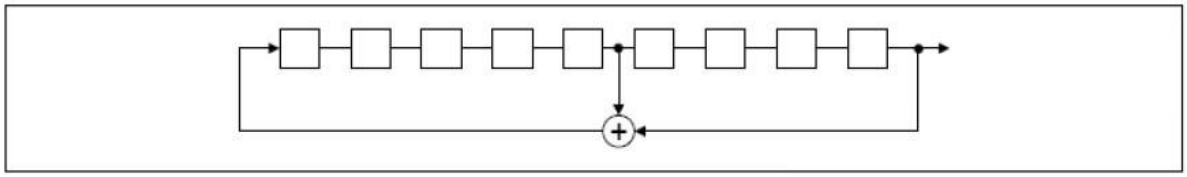
For 47 CFR Part 15C sections 15.247 (a) (1) requirement:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hop-ping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hop-ping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

6.9.2 EUT Pseudorandom Frequency Hopping Sequence Requirement

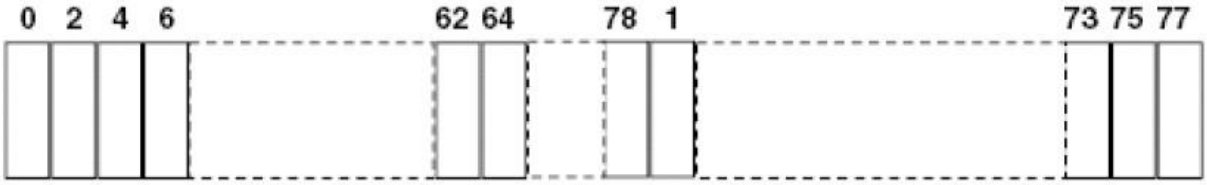
The pseudorandom frequency hopping sequence may be generated in a nice-stage shift register whose 5th first stage. The sequence begins with the first one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence:29-1=511 bits
- Longest sequence of zeros:8(non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of pseudorandom frequency hopping sequence as follows:



Each frequency used equally one the average by each transmitter.
The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.

6.10. ANTENNA REQUIREMENT

6.10.1 Standard Applicable

According to antenna requirement of §15.203.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

6.10.2 Antenna Connected Construction

6.10.2.1. Standard Applicable

According to § 15.203 & RSS-Gen, 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.

6.10.2.2. Antenna Connector Construction

The directional gains of antenna used for transmitting is 2dBi, and the antenna is an internal antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.

6.10.2.3. Results: Compliance.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For normal BT devices, the GFSK mode is used.

Conducted power refer ANSI C63.10:2013 Section 7.8.5 Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices

Radiated power refers to ANSI C63.10:2013 Section 6.6.4 Radiated emissions tests.

Measurement parameters

Measurement parameter	
Detector:	Peak
Sweep Time:	Auto
Resolution bandwidth:	1MHz
Video bandwidth:	3MHz
Trace-Mode:	Max hold

Limits

FCC	ISED
Antenna Gain	
6 dBi	

Note: The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For BT V4.0 devices, the GFSK mode is used;

T_{nom}	V_{nom}	Lowest Channel 2402 MHz	Middle Channel 2441 MHz	Highest Channel 2480 MHz
Conducted power [dBm] Measured with GFSK modulation		2.036	2.074	1.986
Radiated power [dBm] Measured with GFSK modulation		3.287	3.282	3.338
Gain [dBi] Calculated		1.251	1.208	1.352
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

7. TEST SETUP Photographs of EUT

Please refer to separated files for Test Setup Photos of the EUT.

8. Exterior Photographs of the EUT

Please refer to separated files for External Photos of the EUT.

9. INTERIOR Photographs of the EUT

Please refer to separated files for Internal Photos of the EUT.

----------THE END OF REPORT----------

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