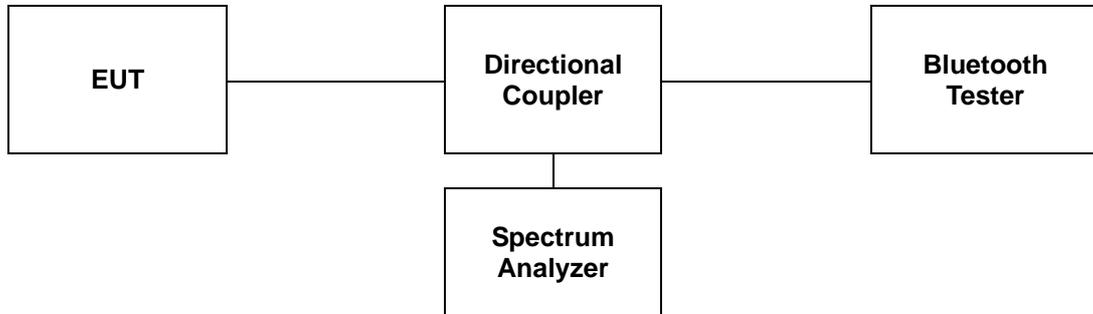


3. 20 dB Bandwidth

3.1. Test Setup



3.2. Limit

Limit: Not Applicable

3.3. Test Procedure

The test follows ANSI C63.10-2013.

The 20 dB bandwidth was measured with a spectrum analyzer connected to RF antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency.

Use the following spectrum analyzer setting:

1. Span = approximately 2 to 5 times the 20 dB bandwidth.
2. RBW \geq 1 % to 5 % of the 20 dB bandwidth.
3. VBW \geq 3 x RBW
4. Sweep = auto
5. Detector = peak
6. Trace = max hold

The marker-to-peak function to set the mark to the peak of the emission. Use the marker-delta function to measure 20 dB down one side of the emission. Reset the function, and move the marker to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is 20 dB bandwidth of the emission.

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3.4. Test Results

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Operation Mode	Data Rate (Mbps)	Channel	Frequency (MHz)	20 dB Bandwidth (MHz)
GFSK	1	Low	2 402	0.866
		Middle	2 441	0.866
		High	2 480	0.863
π/4DQPSK	2	Low	2 402	1.241
		Middle	2 441	1.238
		High	2 480	1.235

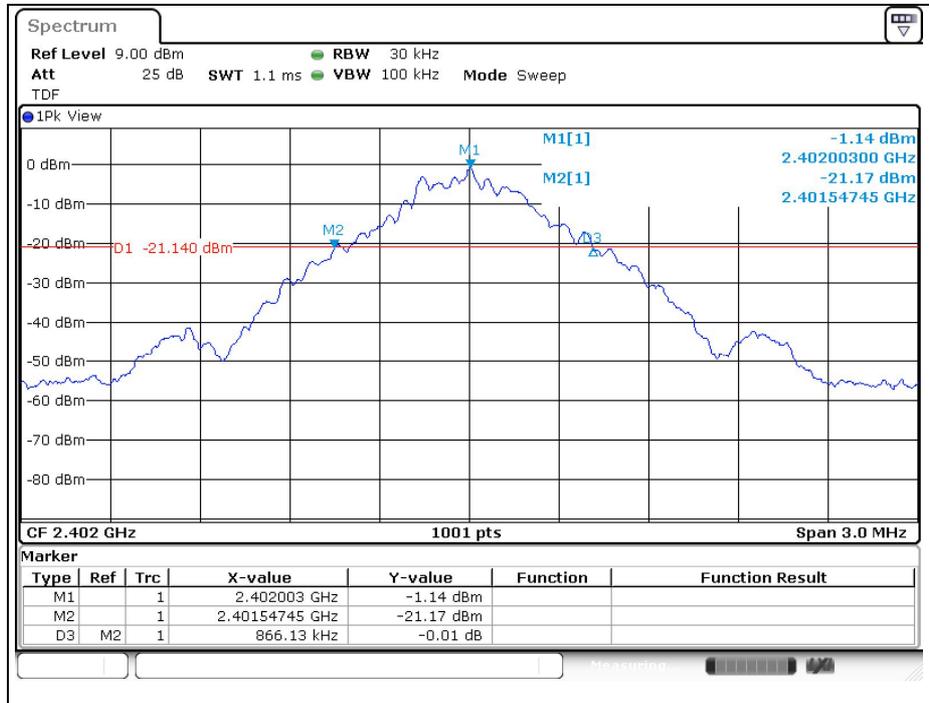
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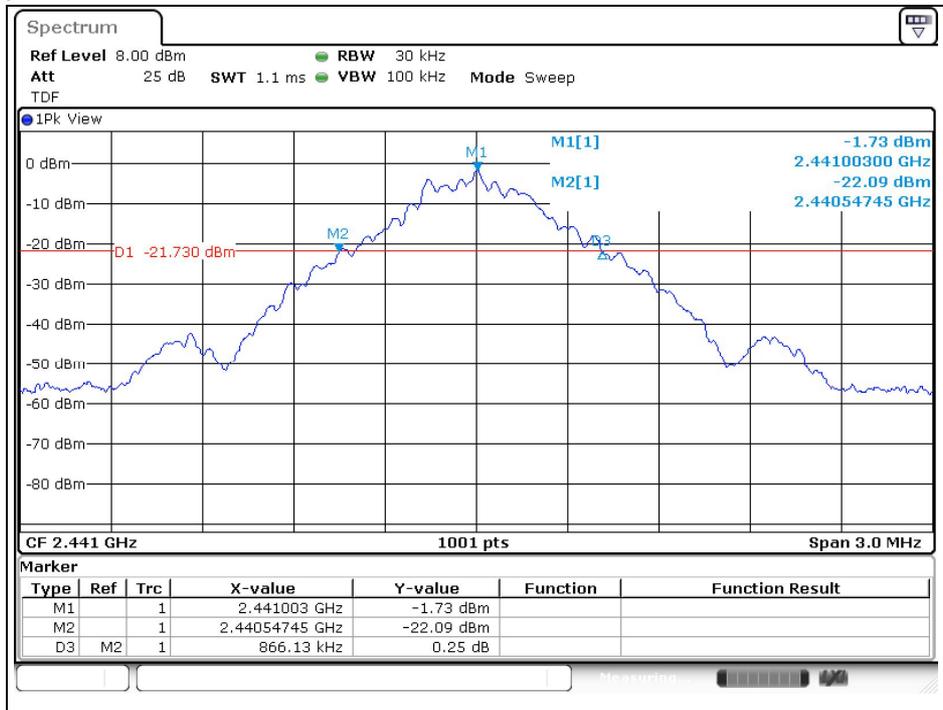
- Test plots

Operating Mode: GFSK

Low Channel

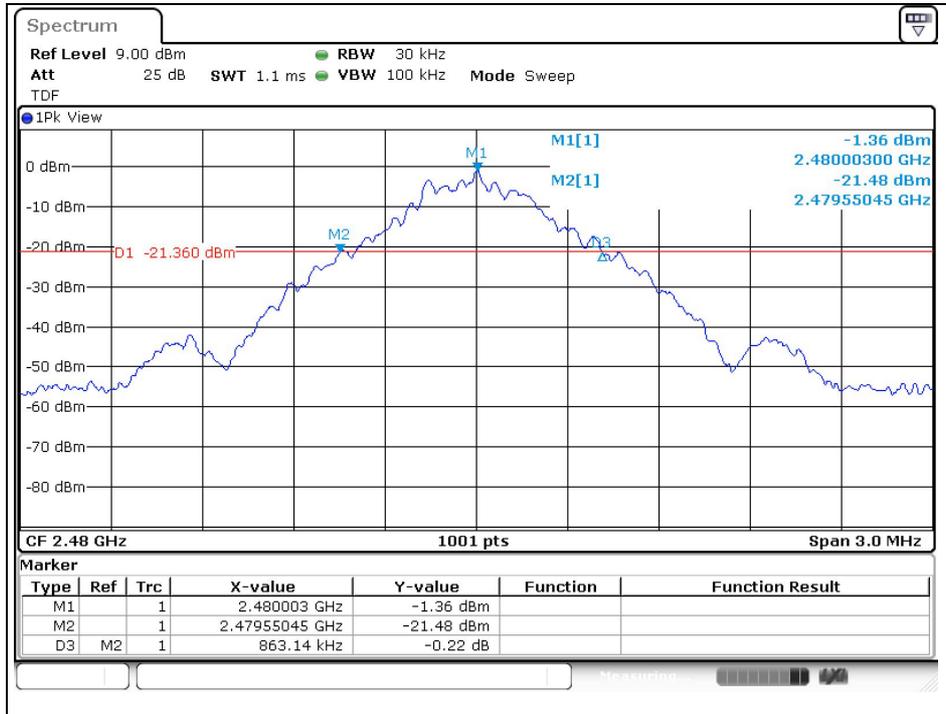


Middle Channel



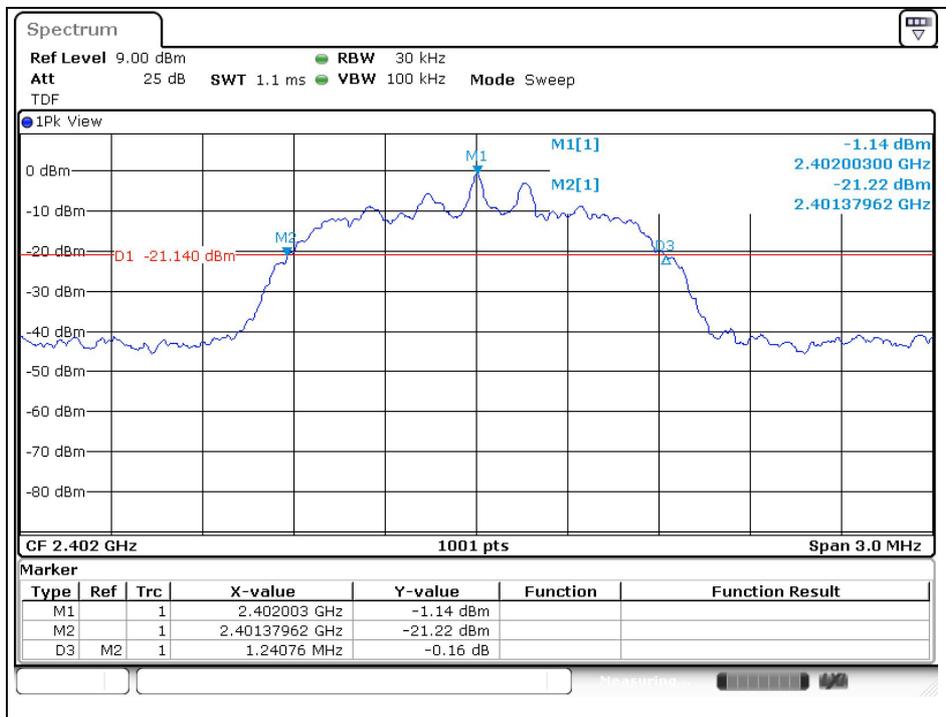
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High Channel



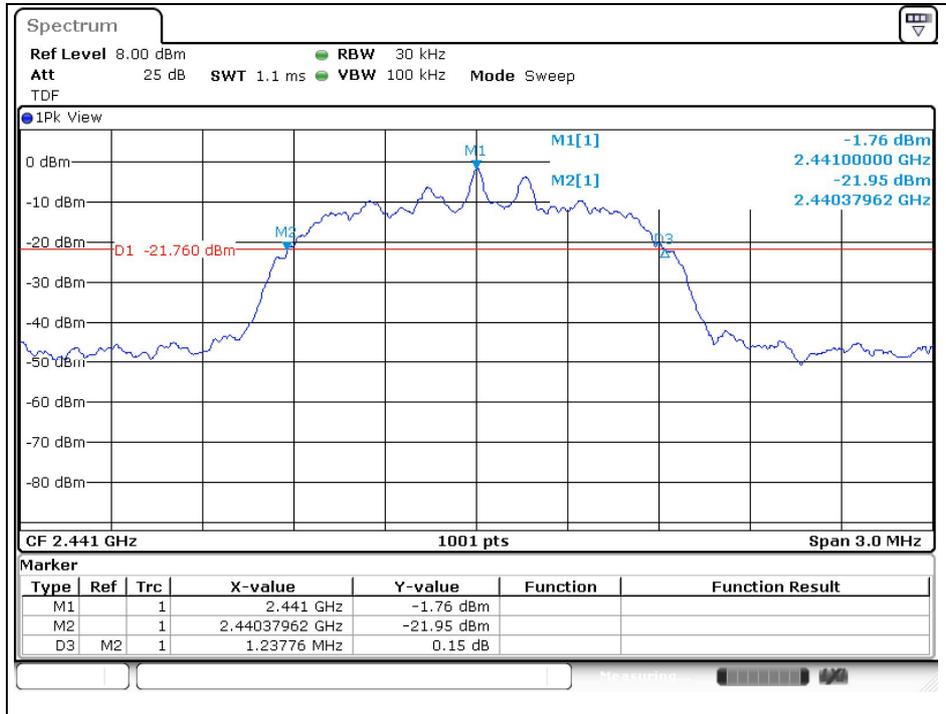
Operating Mode: $\pi/4$ DQPSK

Low Channel

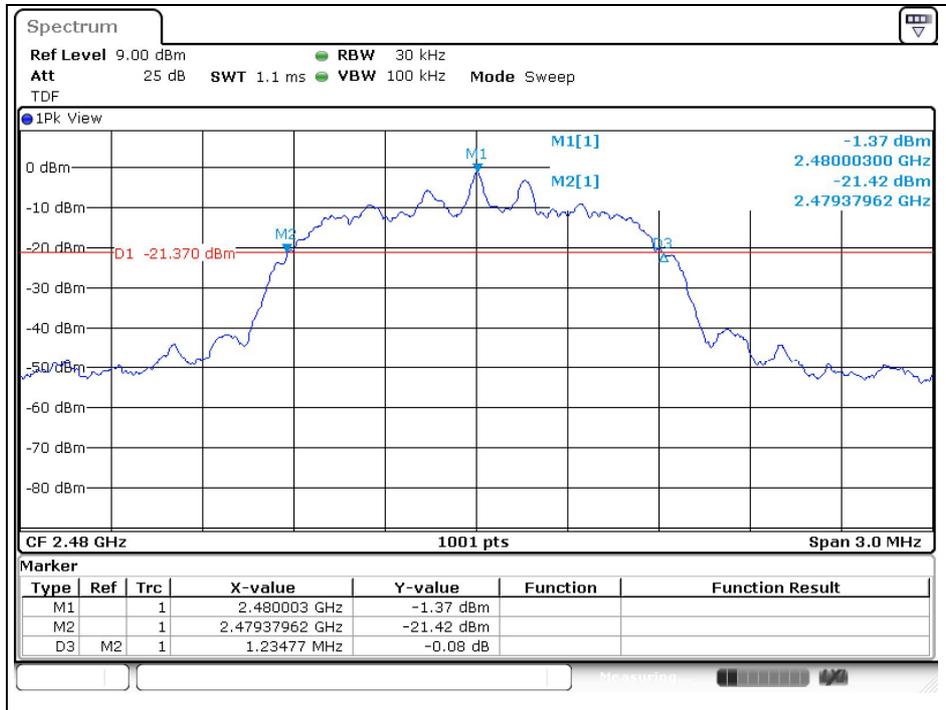


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Middle Channel



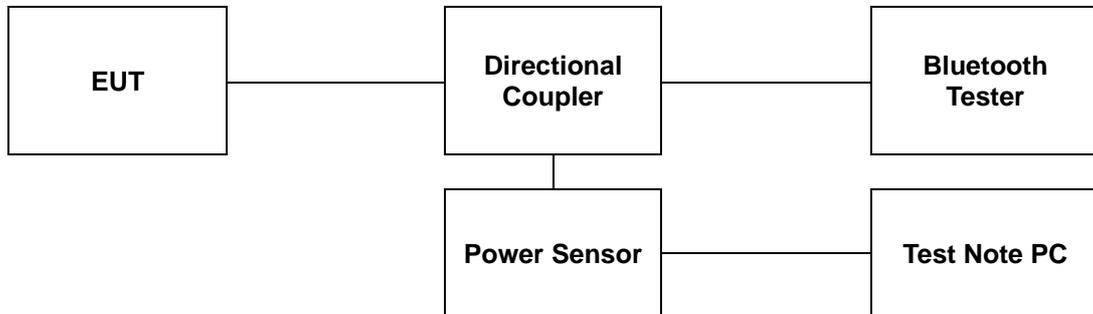
High Channel



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4. Maximum Peak Conducted Output Power

4.1. Test Setup



4.2. Limit

1. §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 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.
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400-2 483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725-5 850 MHz band: 1 watt. For all other frequency hopping systems in the 2 400-2 483.5 MHz band: 0.125 watts.

4.3. Test Procedure

The test follows ANSI C63.10-2013. Using the power sensor instead of a spectrum analyzer.

1. Place the EUT on the table and set it in the transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the Power sensor.
3. Test program: (S/W name: R&S Power Viewer, Version: 3.2.0)
4. Measure peak power each channel.

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4.4. Test Results

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Operation Mode	Data Rate (Mbps)	Channel	Frequency (MHz)	Average Power Result (dB m)	Peak Power Result (dB m)	Limit (dB m)
GFSK	1	Low	2 402	<u>-0.67</u>	<u>-0.07</u>	30
		Middle	2 441	-1.47	-0.87	
		High	2 480	-1.39	-0.71	
π/4DQPSK	2	Low	2 402	<u>-1.84</u>	<u>0.38</u>	20.97
		Middle	2 441	-2.69	-0.19	
		High	2 480	-2.70	0.13	

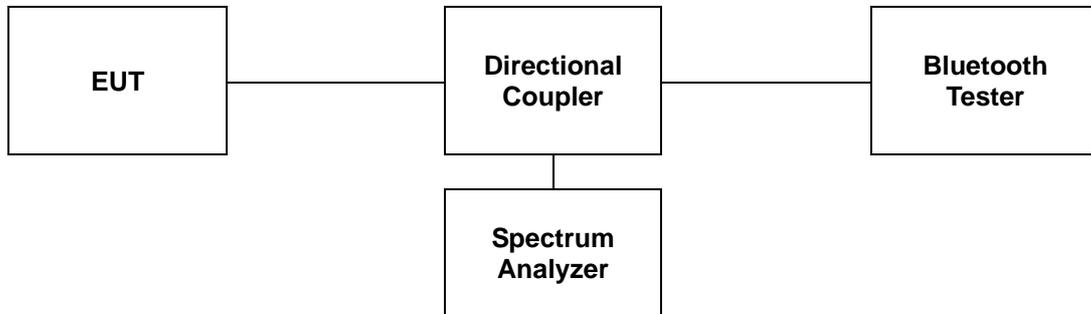
Remark;

Directional coupler and cable offset compensate for test program (R&S Power Viewer) before measuring.

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5. Carrier Frequency Separation

5.1. Test Setup



5.2. Limit

§15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400-2 483.5 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.

5.3. Test Procedure

The test follows ANSI C63.10-2013.

The device is operating in hopping mode between 79 channels and also supporting Adaptive Frequency Hopping with hopping between 20 channels. As compared with each operating mode, 79 channels are chosen as a representative for test.

Use the following spectrum analyzer settings:

1. Span: Wide enough to capture the peaks of two adjacent channels
2. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
3. VBW \geq RBW
4. Sweep: Auto
5. Detector: Peak
6. Trace: Max hold
7. Allow the trace to stabilize.

Use the marker-delta function to determine the between the peaks of the adjacent channels.

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5.4. Test Results

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
GFSK	2 441	1 000	866	25

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	Two-third of 20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
$\pi/4$ DQPSK	2 441	1 000	825	25

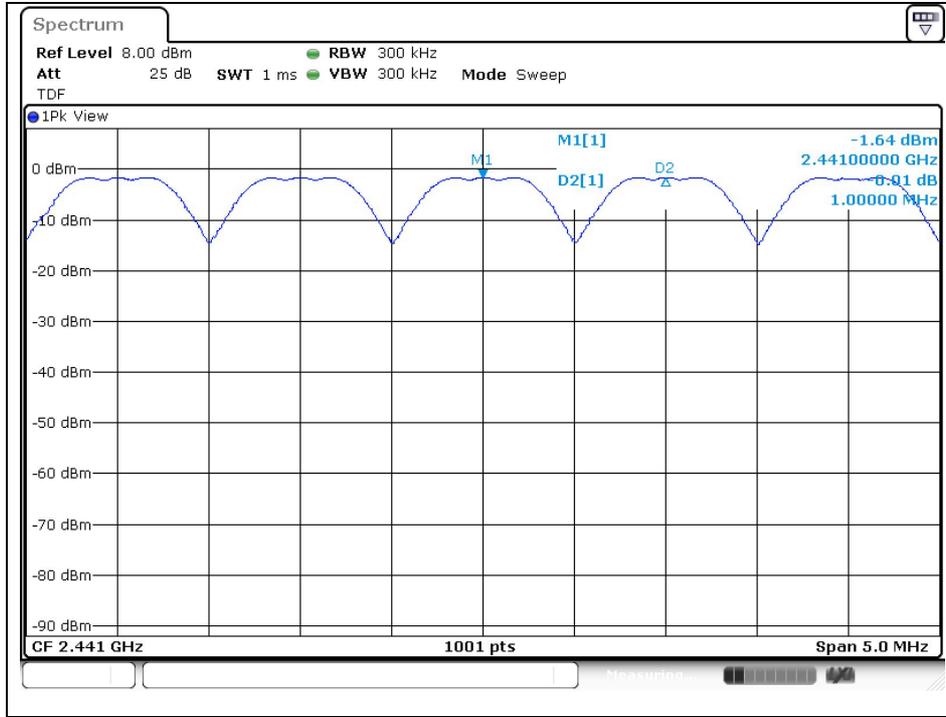
Remark;

Measurement is made with EUT operating in hopping mode between 79 channels.

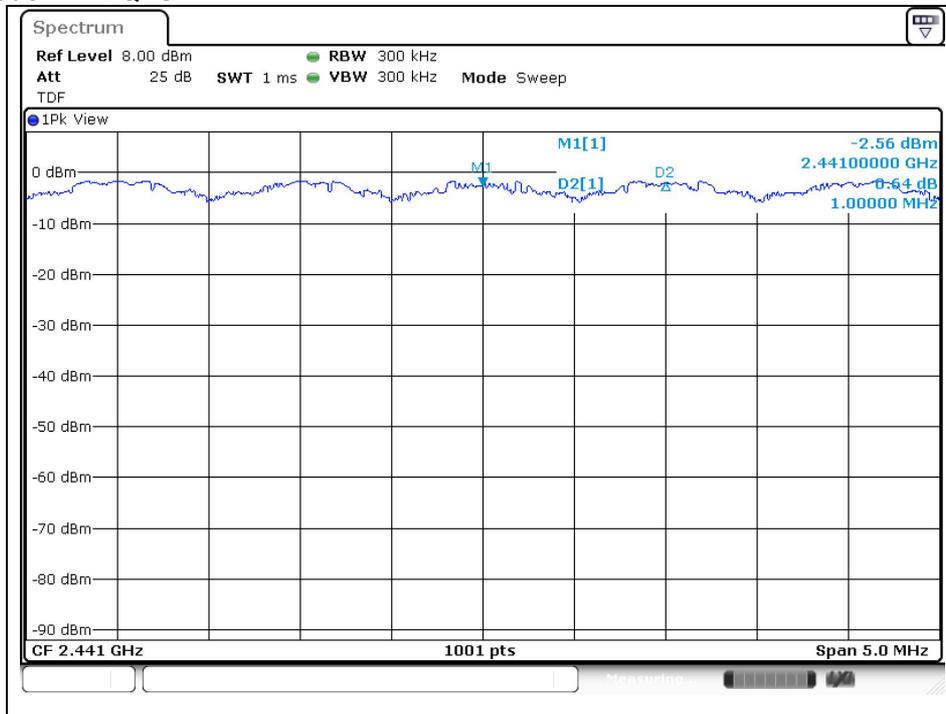
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- Test plots

Operating Mode: GFSK



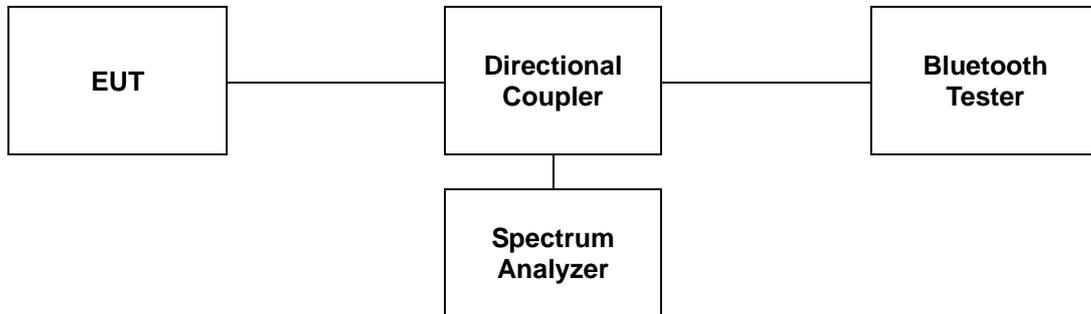
Operating Mode: $\pi/4$ DQPSK



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6. Number of Hopping Frequencies

6.1. Test Setup



6.2. Limit

§15.247(a)(1)(iii), Frequency hopping systems in the 2 400-2 483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

6.3. Test Procedure

The test follows ANSI C63.10-2013.

The device supports Adaptive Frequency Hopping and will use a minimum of 20 channels of the 79 available channels.

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

1. Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
2. RBW: To identify clearly the individual channels, set the RBW to less than 30 % of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3. VBW \geq RBW
4. Sweep: Auto
5. Detector function: Peak
6. Trace: Max hold
7. Allow the trace to stabilize.

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6.4. Test Results

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

Operation Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
π/4DQPSK	79	≥ 15

Remark;

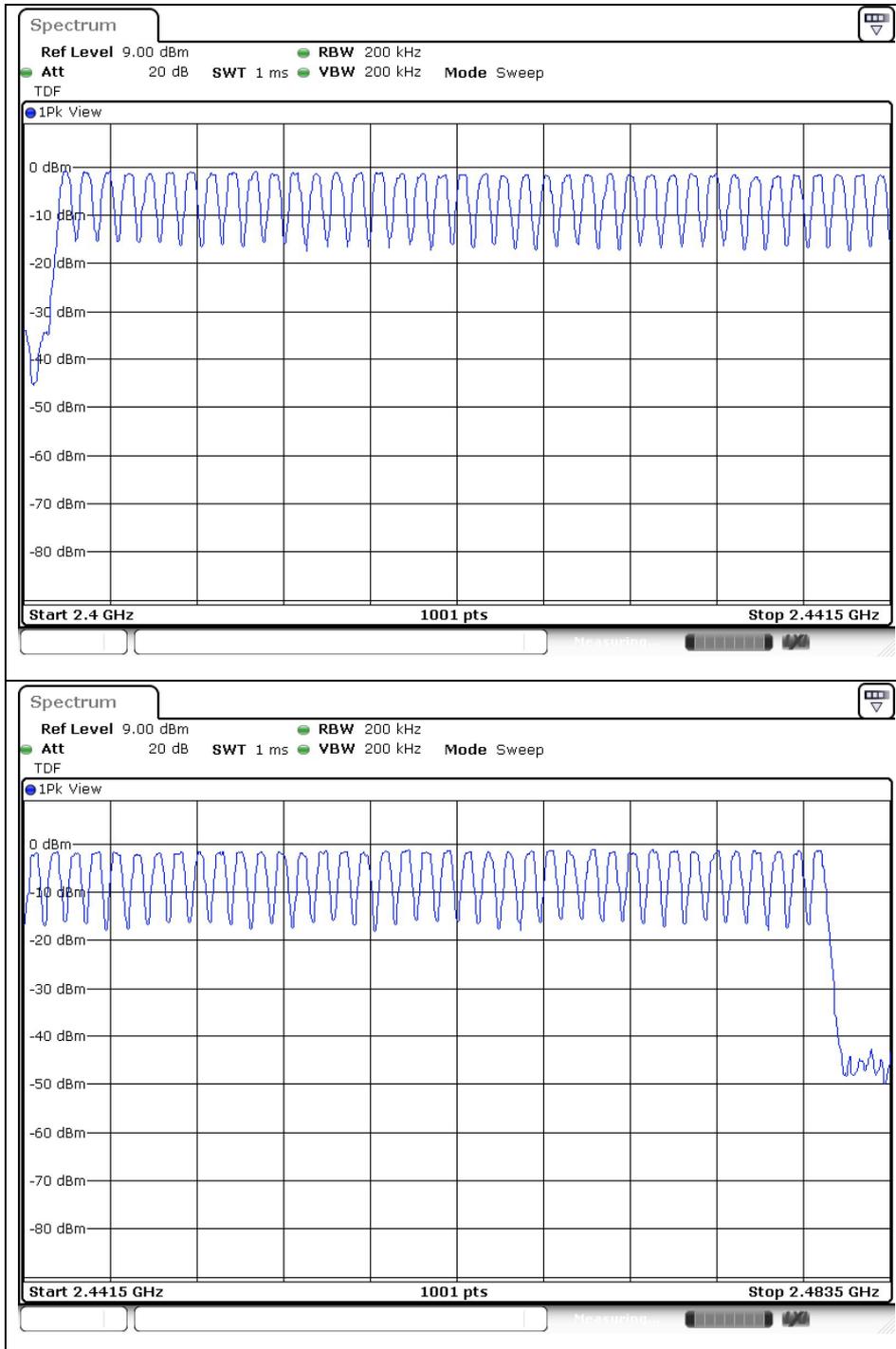
Measurement is made with EUT operating in hopping mode between 79 channels.

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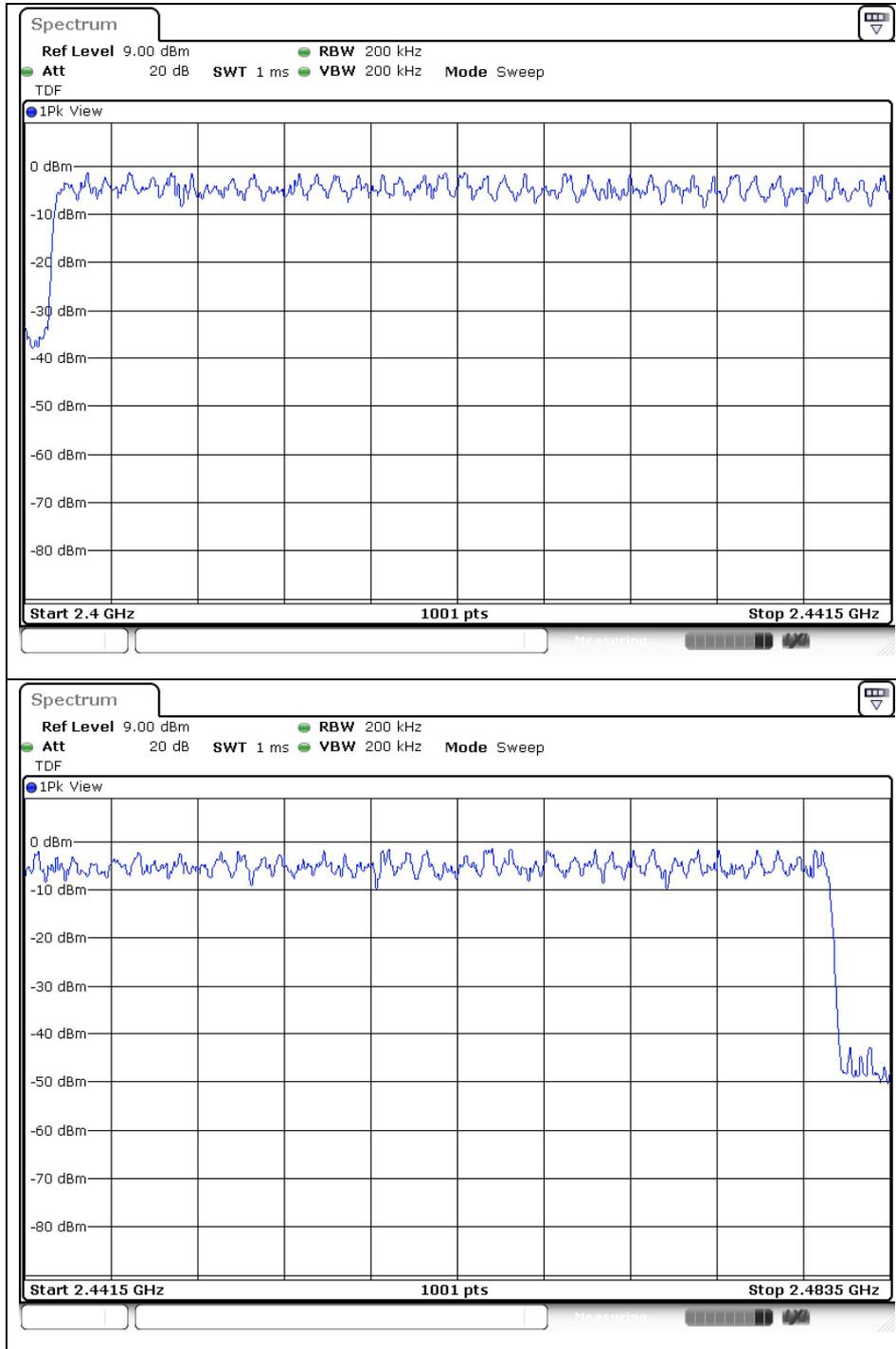
- Test plots

Operating Mode: GFSK



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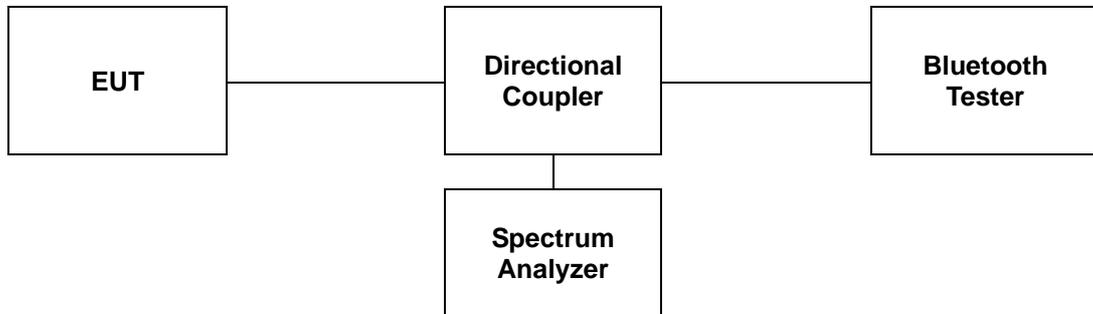
Operating Mode: $\pi/4$ DQPSK



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7. Time of Occupancy (Dwell Time)

7.1. Test Set up



7.2. Limit

§15.247(a)(1)(iii), Frequency hopping systems in the 2 400-2 483.5 MHz band, the average time of occupancy on any frequency shall not be greater than 0.4 second within a 31.6 second period.

A period time = 0.4 (s) * 79 = 31.6 (s)

*Adaptive Frequency Hopping

A period time = 0.4 (s) * 20 = 8 (s)

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7.3. Test Procedure

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section. The test follows ANSI C63.10-2013.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT as shown in test setup without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable.
3. Measure the time duration of one transmission on the measured frequency. And then plot the result with time difference of this time duration.
4. The Bluetooth has 3 type of payload, DH1, DH3, DH5 and 2DH1, 2DH3, 2DH5. The hopping rate is insisted of 1 600 per second.

The EUT must have its hopping function enabled. Use the following spectrum analyzer setting:

1. Span = Zero span, centered on a hopping channel.
2. RBW = 1 MHz.
3. VBW \geq RBW.
4. Sweep = As necessary to capture the entire dwell time per hopping channel.
5. Detector = Peak.
6. Trace = Max hold.

Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation, then repeat this test for each variation.

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7.4. Test Results

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.

7.4.1. Packet Type: DH1, 2DH1

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	0.41	131.20	400
$\pi/4$ DQPSK	2 441	0.42	134.40	400

Remark;

Time of occupancy on the TX channel in 31.6 sec

In case of GFSK: $0.41 \times \{(1\ 600 \div 2) / 79\} \times 31.6 = 131.20$ ms

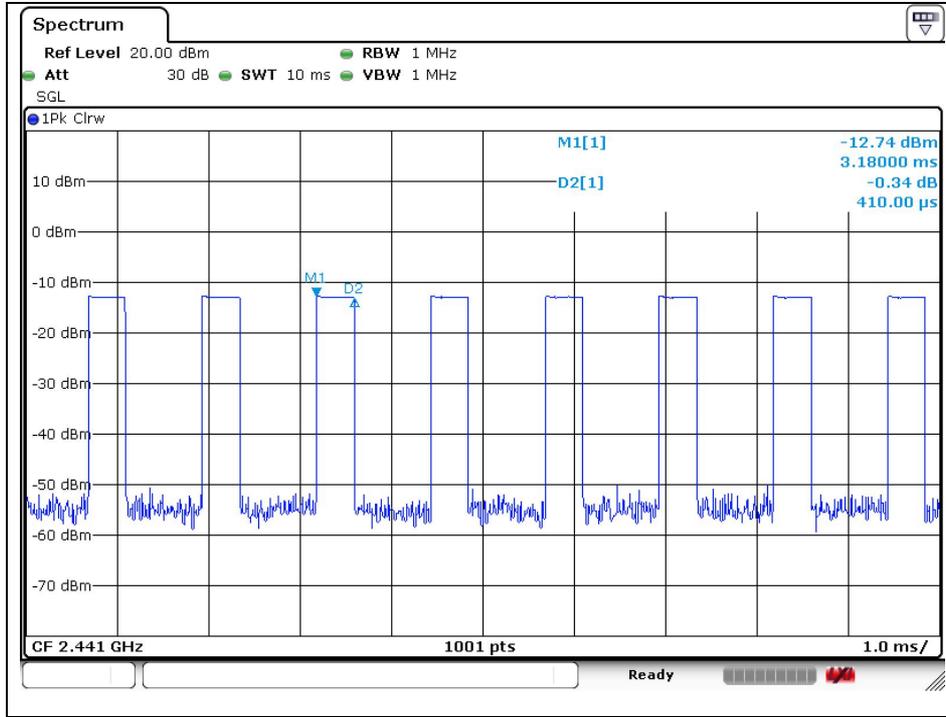
In case of $\pi/4$ DQPSK: $0.42 \times \{(1\ 600 \div 2) / 79\} \times 31.6 = 134.40$ ms

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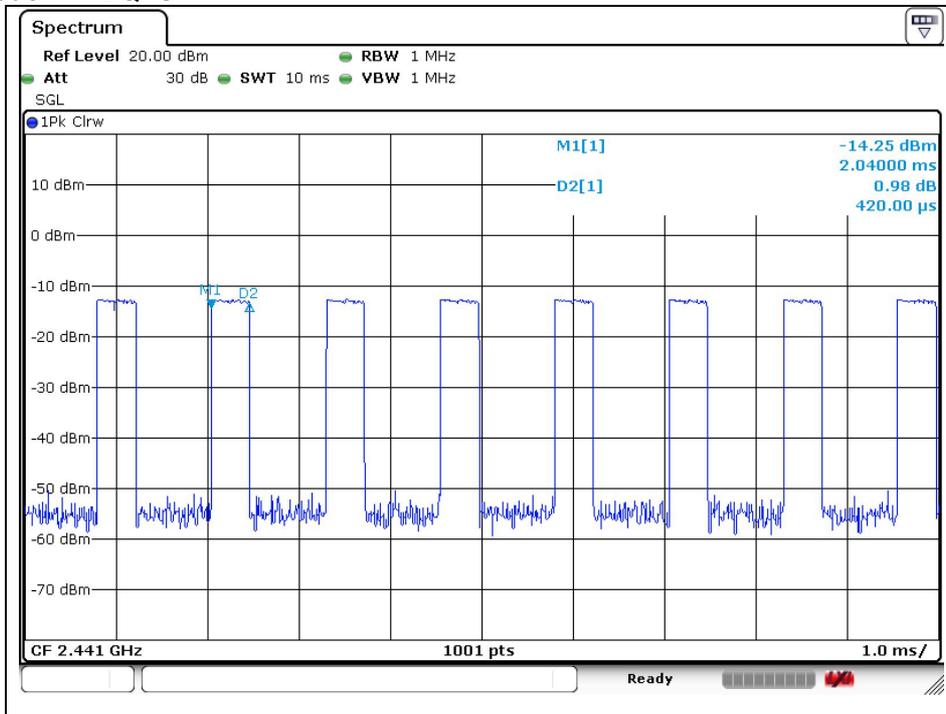
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- Test plots

Operating Mode: GFSK



Operating Mode: $\pi/4$ DQPSK



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7.4.2. Packet Type: DH3, 2DH3

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	1.66	265.60	400
$\pi/4$ DQPSK	2 441	1.67	267.20	400

Remark;

Time of occupancy on the TX channel in 31.6 sec

In case of GFSK: $1.66 \times \{(1\ 600 \div 4) / 79\} \times 31.6 = 265.60$ ms

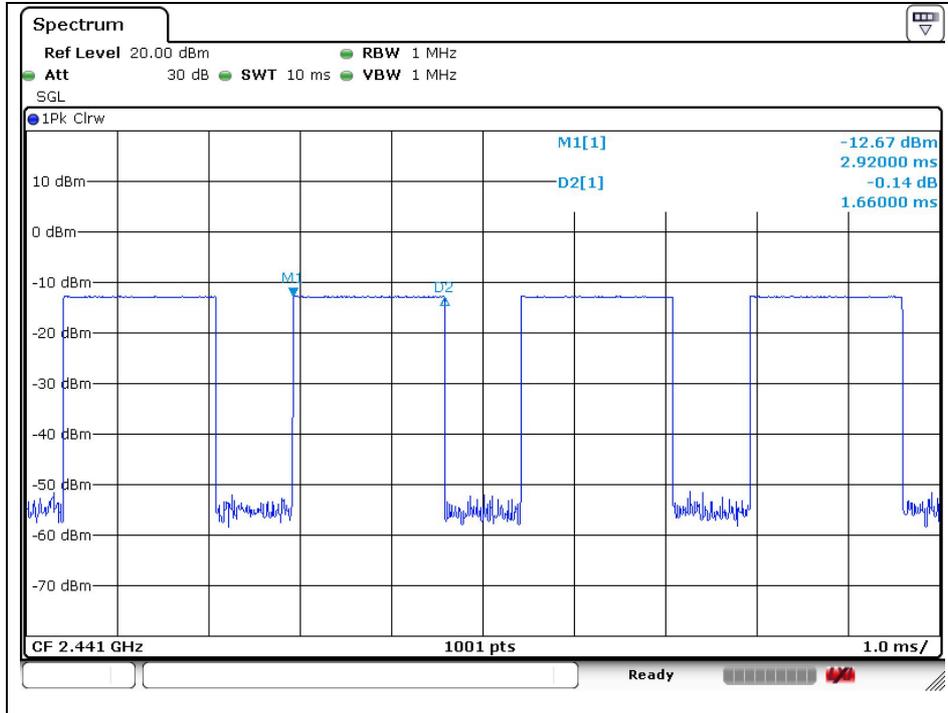
In case of $\pi/4$ DQPSK: $1.67 \times \{(1\ 600 \div 4) / 79\} \times 31.6 = 267.20$ ms

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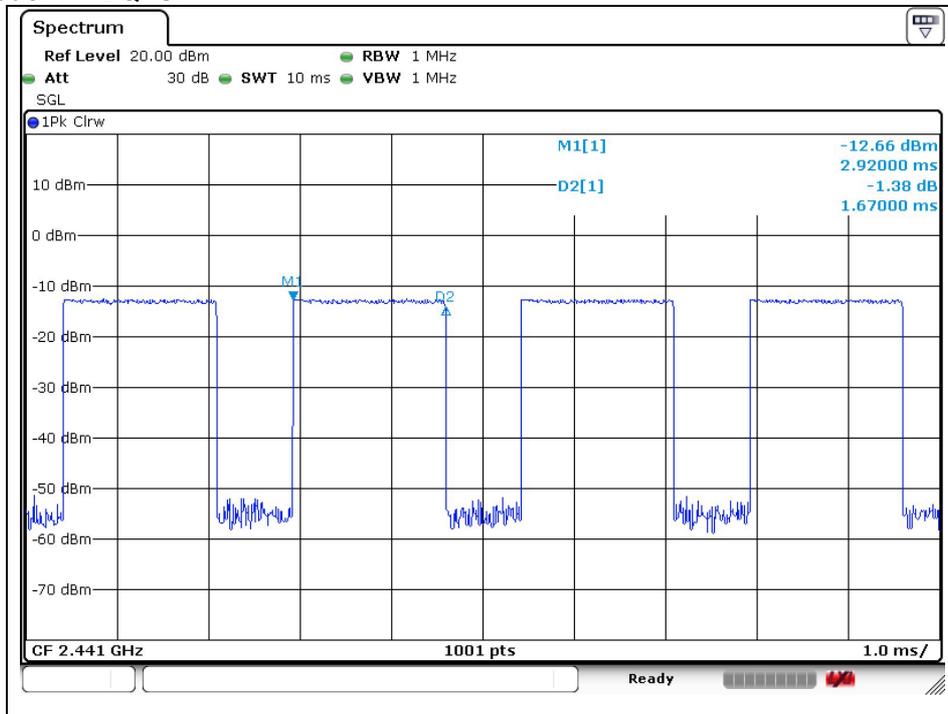
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- Test plots

Operating Mode: GFSK



Operating Mode: $\pi/4$ DQPSK



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7.4.3. Packet Type: DH5, 2DH5

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	2.92	311.47	400
$\pi/4$ DQPSK	2 441	2.92	311.47	400

Remark;

Time of occupancy on the TX channel in 31.6 sec

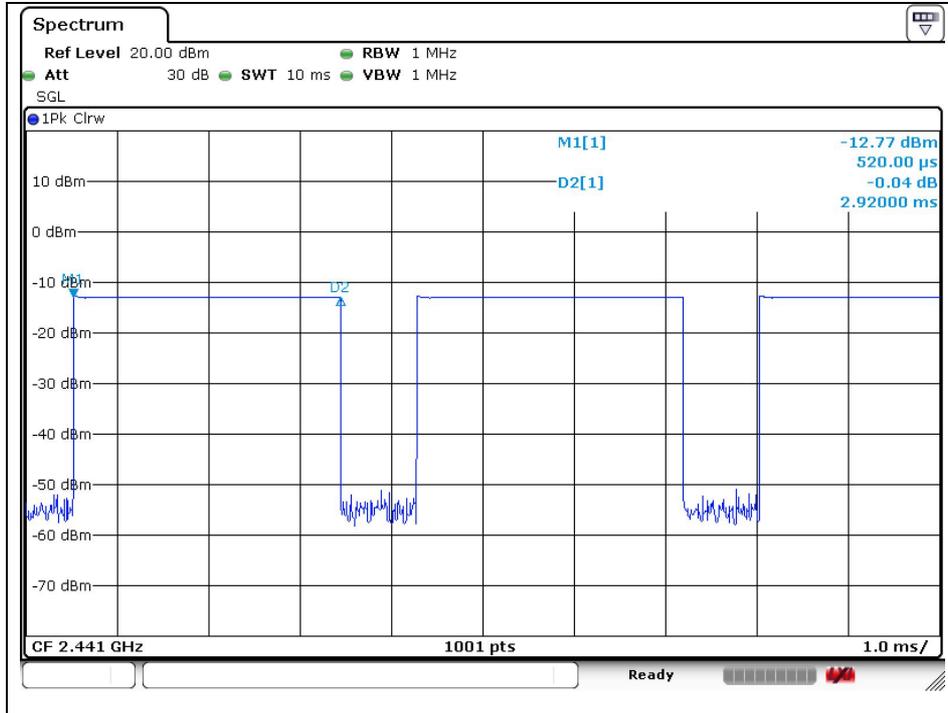
In case of GFSK and $\pi/4$ DQPSK: $2.92 \times \{(1\ 600 \div 6) / 79\} \times 31.6 = 311.47$ ms

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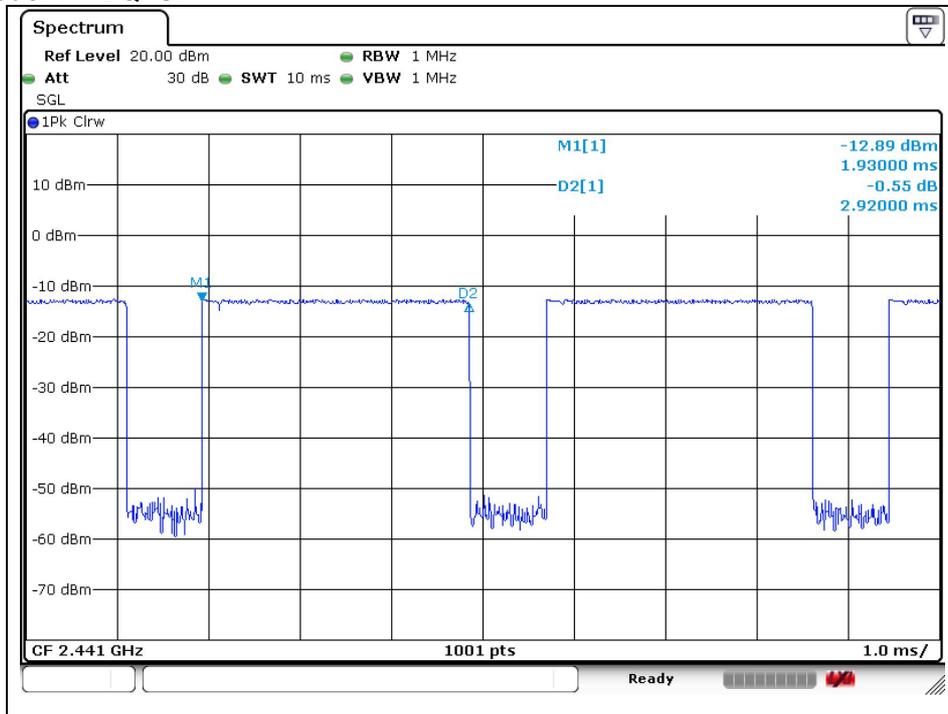
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- Test plots

Operating Mode: GFSK



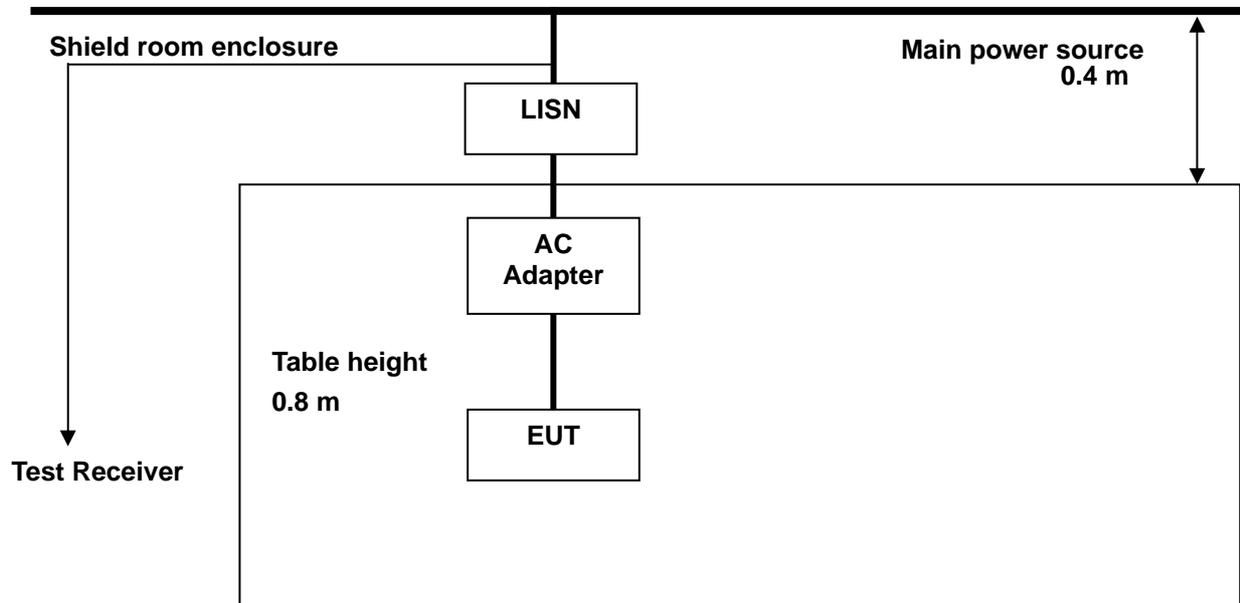
Operating Mode: $\pi/4$ DQPSK



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8. Transmitter AC Power Line Conducted Emission

8.1. Test Setup



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 μ H / 50 ohms line impedance stabilization network (LISN).

Compliance with the provision 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 (dB μ V)	
	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.

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8.3. Test Procedures

AC conducted emissions from the EUT were measured according to the dictates of ANSI C63.10:2013

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.

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8.4. Test Results

The following table shows the highest levels of conducted emissions on both phase of Hot and Neutral line.

Ambient temperature : (23 ± 1) °C
 Relative humidity : 47 % R.H.
 Frequency range : 0.15 MHz - 30 MHz
 Measured Bandwidth : 9 kHz

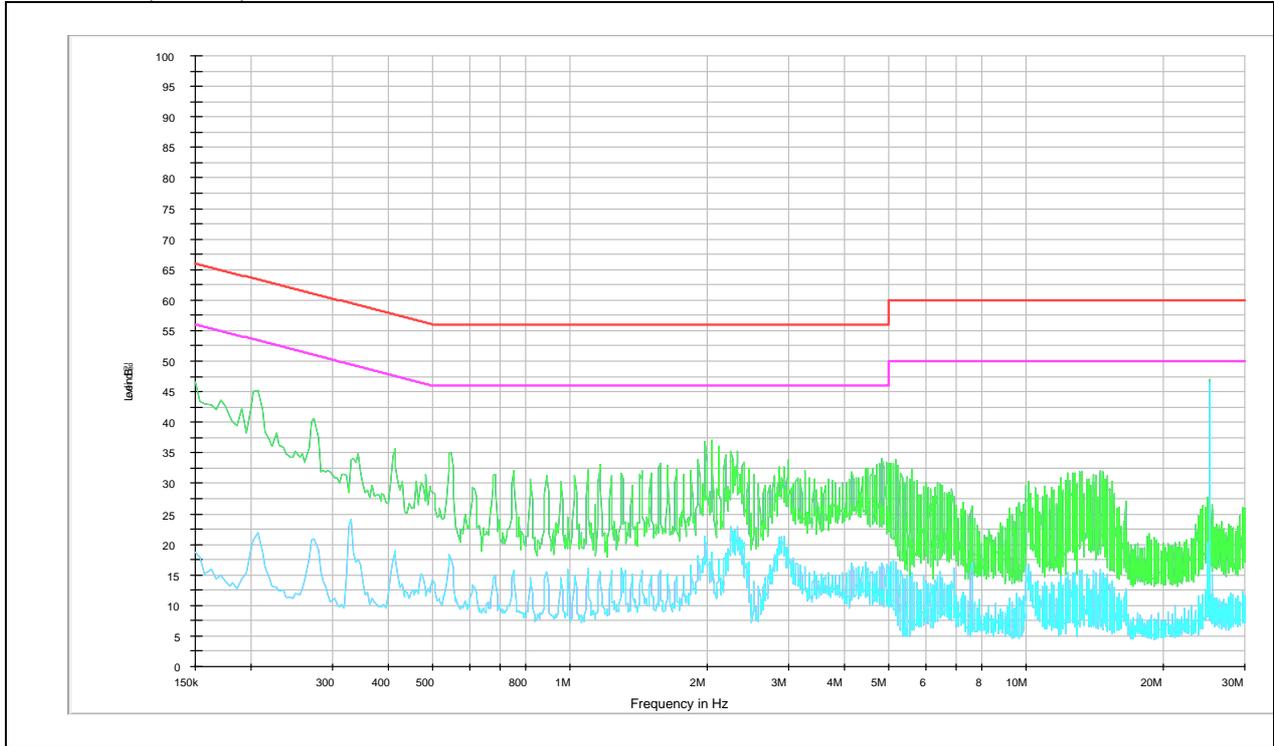
FREQ. (MHz)	LEVEL (dB μ V)		LINE	LIMIT (dB μ V)		MARGIN (dB)	
	Q-Peak	Average		Q-Peak	Average	Q-Peak	Average
0.20	38.70	21.50	N	38.70	21.50	24.91	32.11
0.54	31.20	18.40	N	31.20	18.40	24.80	27.60
2.04	31.10	18.60	N	31.10	18.60	24.90	27.40
5.17	30.20	17.00	N	30.20	17.00	29.80	33.00
14.54	29.30	16.20	N	29.30	16.20	30.70	33.80
25.23	26.70	14.00	N	26.70	14.00	33.30	36.00
0.20	35.90	15.40	H	35.90	15.40	27.71	38.21
0.54	29.90	13.10	H	29.90	13.10	26.10	32.90
2.31	27.60	20.70	H	27.60	20.70	28.40	25.30
4.76	28.80	11.90	H	28.80	11.90	27.20	34.10
14.41	28.30	10.90	H	28.30	10.90	31.70	39.10
25.11	26.00	14.70	H	26.00	14.70	34.00	35.30

Remark;

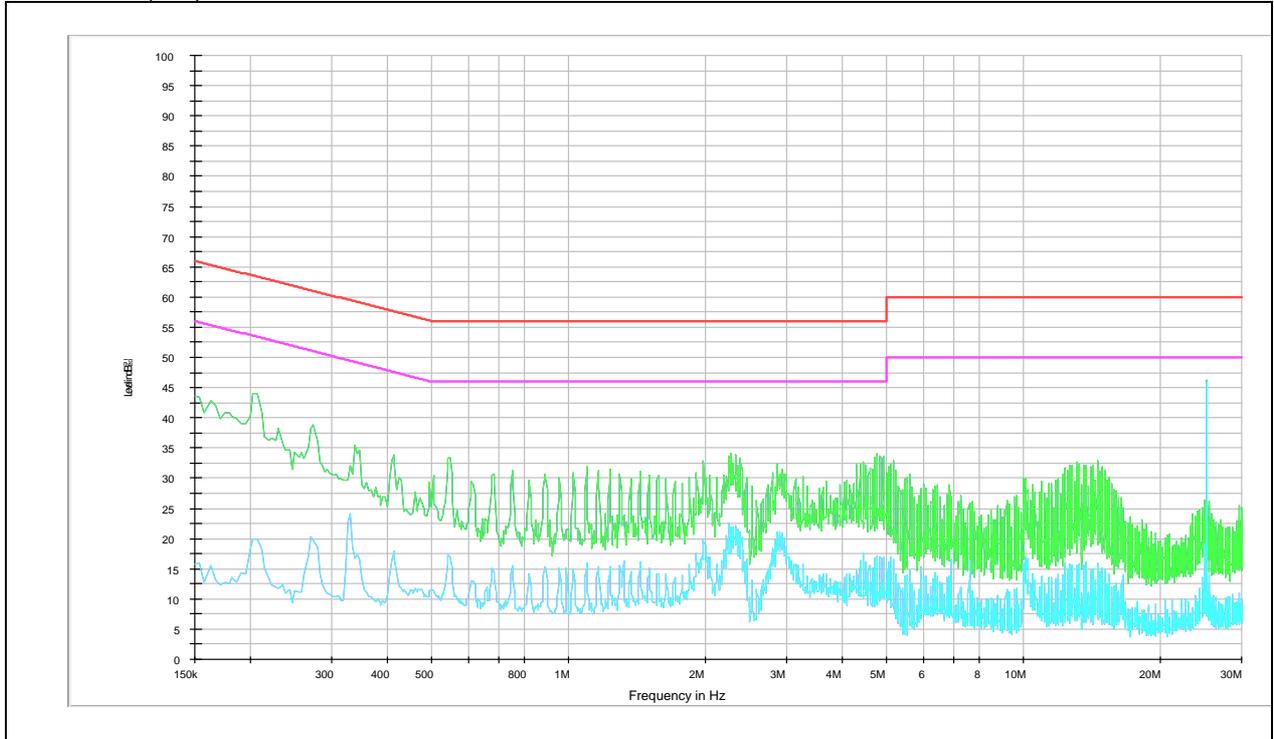
- Line (H): Hot, Line (N): Neutral.
- All modes of operation were investigated and the worst-case emissions were reported using **EDR / 2DH5 / Low channel**.
- The limit for Class B device(s) from 150 kHz to 30 MHz are specified in Section of the Title 47 CFR.
- Traces shown in plot were made by using a peak detector and average detector.
- Deviations to the Specifications: None.

The results of this test report are effective only to the items tested. The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received. This test report cannot be reproduced, except in full, without prior written permission of the Company. This test report does not assure KOLAS accreditation.

Test mode: (Neutral)



Test mode: (Hot)



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9. Antenna Requirement

9.1. Standard Applicable

For intentional device, according to FCC 47 CFR Section §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. And according to FCC 47 CFR Section §15.247 (b) if transmitting antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the amount in dB that the gain of the antenna exceeds 6 dBi.

9.2. Antenna Connected Construction

Antenna used in this product is Inverted F antenna with gain of -0.68 dBi

- End of the Test Report -

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