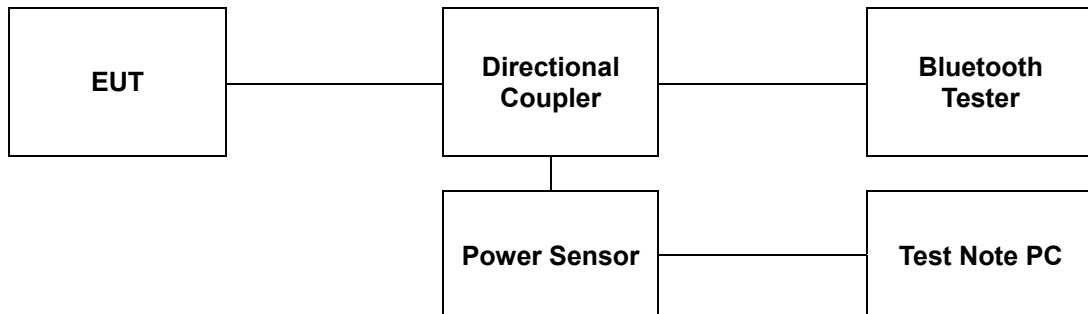


4. Maximum Peak Conducted Output Power

4.1. Test Setup



4.2. Limit

4.2.1. FCC

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.

4.2.2. IC

1. According to RSS-247 Issue 2, 5.1(b), FHSs 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, FHSs operating in the band 2 400-2 483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.
2. According to RSS-247 Issue 2, 5.4(b), for FHSs operating in the band 2 400-2 483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

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.

4.4. Test Results

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

Test voltage: DC 12 V

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	2.58	3.13	30
		Middle	2 441	3.00	3.45	
		High	2 480	<u>3.50</u>	<u>4.00</u>	
π/4DQPSK	2	Low	2 402	2.37	5.14	20.97
		Middle	2 441	3.00	5.65	
		High	2 480	<u>3.38</u>	<u>6.22</u>	
8DPSK	3	Low	2 402	2.48	5.82	
		Middle	2 441	3.13	6.50	
		High	2 480	<u>3.53</u>	<u>6.88</u>	

Test voltage: DC 24 V

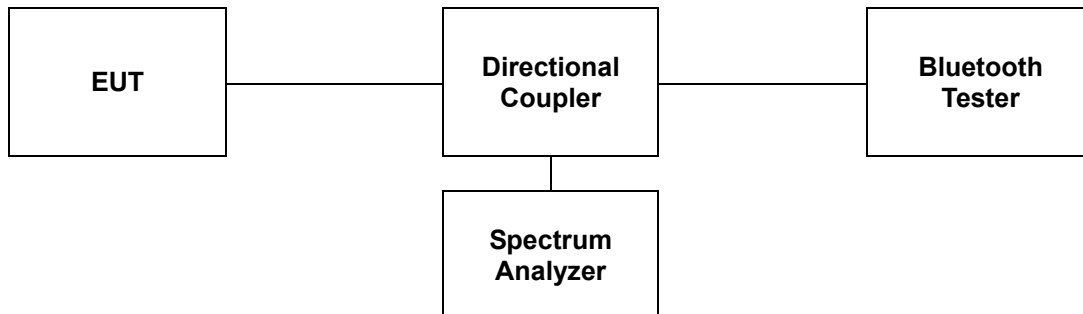
Operation Mode	Data Rate (Mbps)	Channel	Frequency (MHz)	Average Power Result (dB m)	Peak Power Result (dB m)	Limit (dB m)
GFSK	1	Low	2 402	2.54	3.03	30
		Middle	2 441	3.01	3.50	
		High	2 480	<u>3.50</u>	<u>4.00</u>	
$\pi/4$ DQPSK	2	Low	2 402	2.48	5.19	20.97
		Middle	2 441	2.88	5.70	
		High	2 480	<u>3.41</u>	<u>6.22</u>	
8DPSK	3	Low	2 402	2.38	5.73	
		Middle	2 441	3.05	6.40	
		High	2 480	<u>3.45</u>	<u>6.95</u>	

Remark;

In the case of AFH, the limit for peak power is 0.125 W.
Directional coupler and cable offset compensate for test program (R&S Power Viewer) before measuring.

5. Carrier Frequency Separation

5.1. Test Setup



5.2. Limit

5.2.1. FCC

§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.

5.2.2. IC

According to RSS-247 Issue 2, 5.1(b), FHSs 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, FHSs operating in the band 2 400-2 483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.

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.

5.4. Test Results

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

Test voltage: DC 12 V

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
GFSK	2 441	1 000	944	25

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	Two-third of 20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
8DPSK	2 441	1 000	851	25

Test voltage: DC 24 V

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
GFSK	2 441	1 000	944	25

Operation Mode	Frequency (MHz)	Adjacent Hopping Channel Separation (kHz)	Two-third of 20 dB Bandwidth (kHz)	Minimum Bandwidth (kHz)
8DPSK	2 441	1 000	841	25

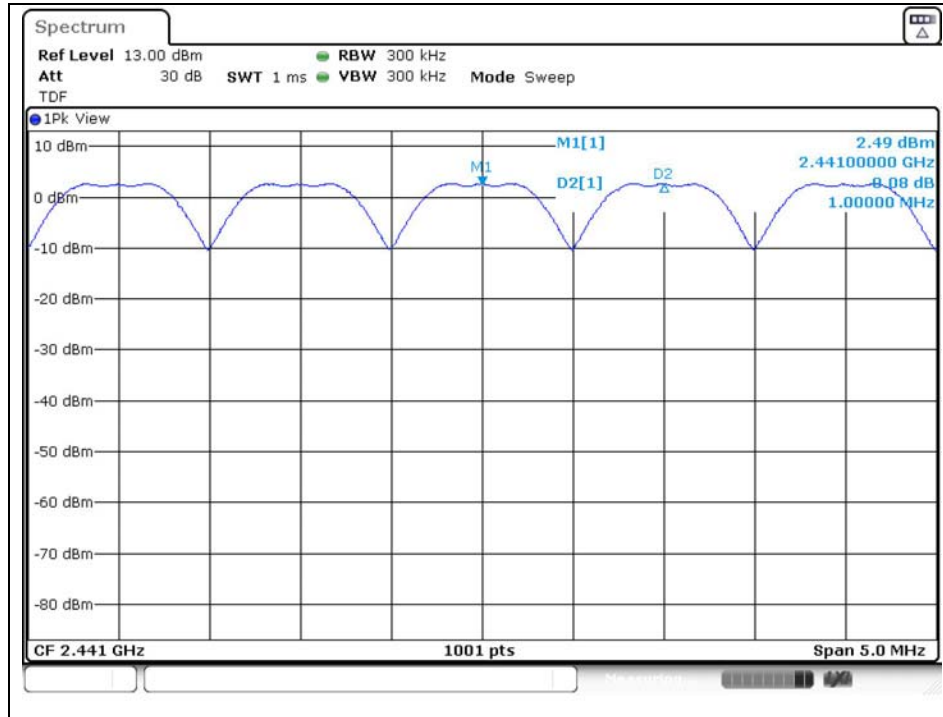
Remark;

Measurement is made with EUT operating in hopping mode between 79 channels providing a worst case scenario as compared to AFH mode hopping between 20 channels.

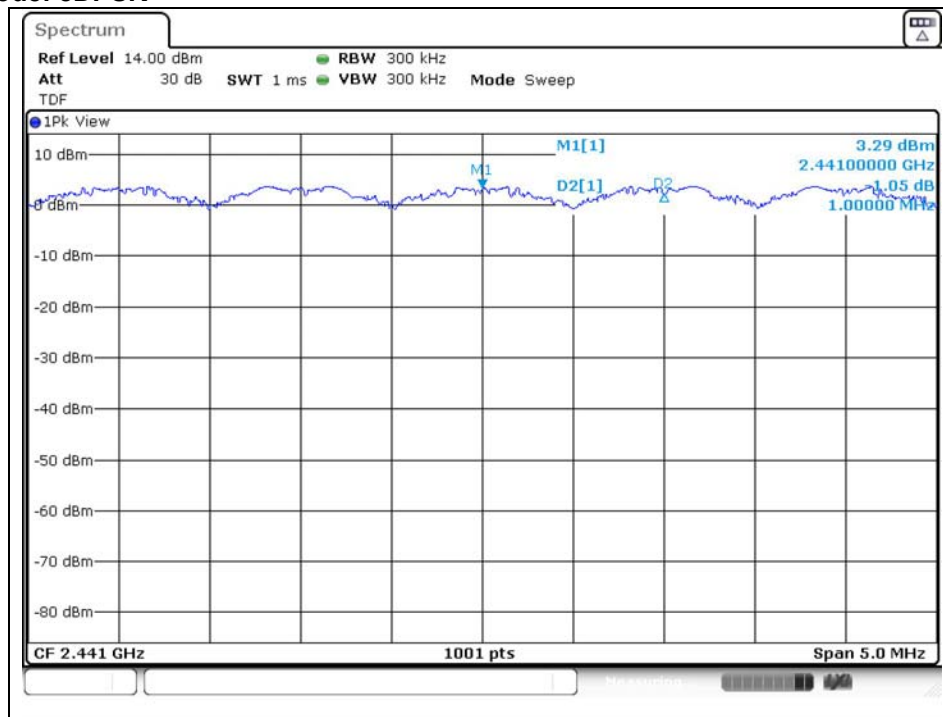
- Test plots

Test voltage: DC 12 V

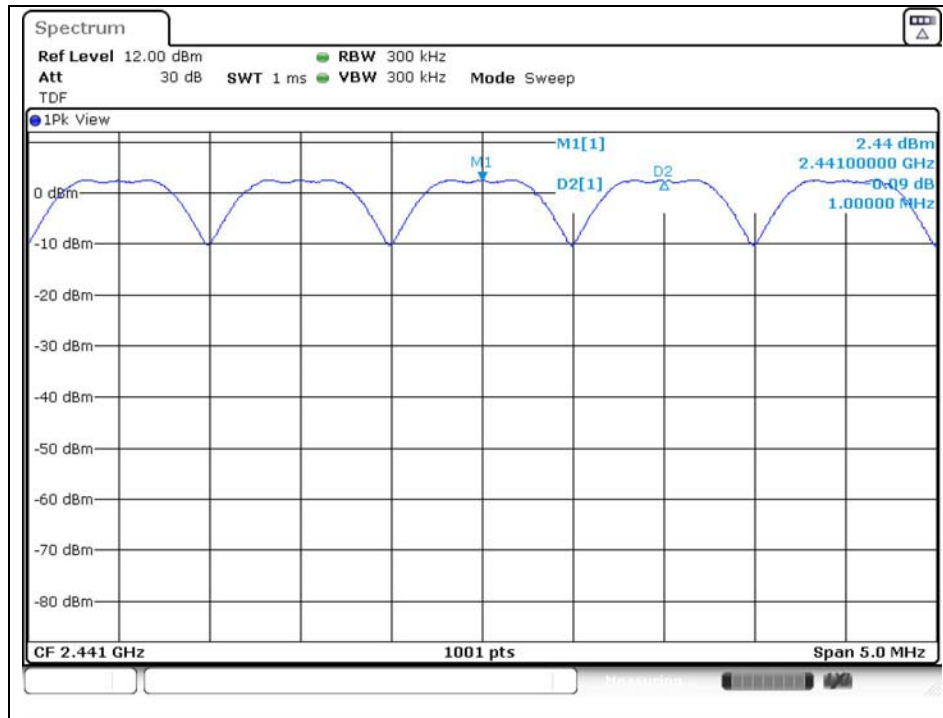
Operating Mode: GFSK



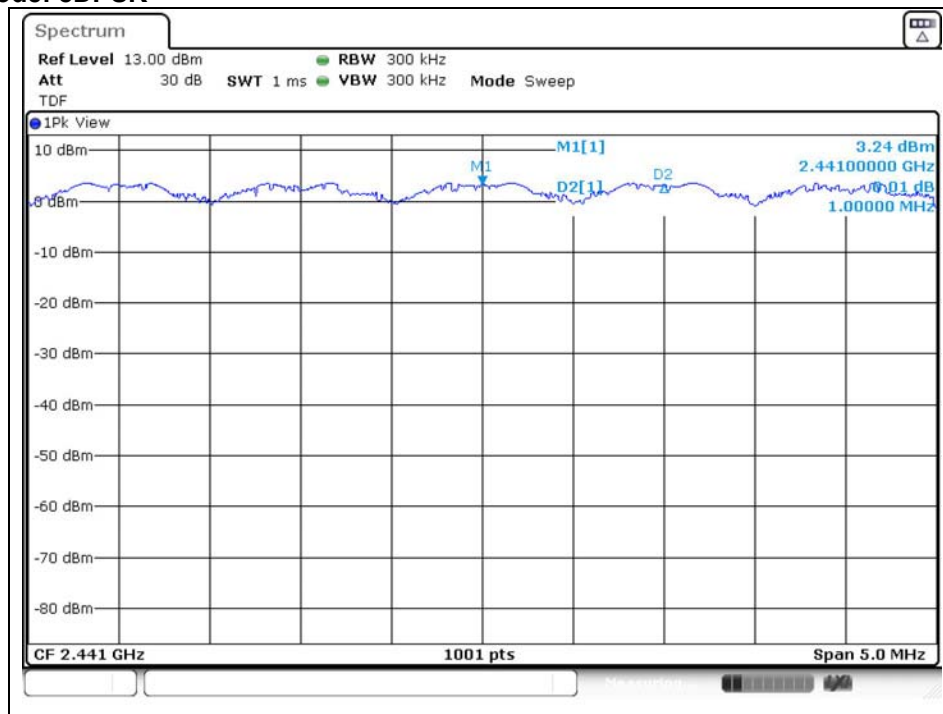
Operating Mode: 8DPSK



Test voltage: DC 24 V
Operating Mode: GFSK

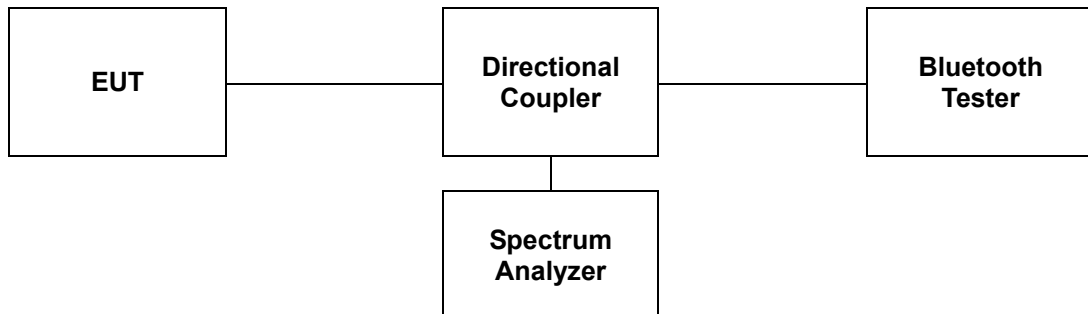


Operating Mode: 8DPSK



6. Number of Hopping Frequencies

6.1. Test Setup



6.2. Limit

6.2.1. FCC

§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.

6.2.2. IC

According to RSS-247 Issue 2, 5.1(d), FHSs operating in the band 2 400-2 483.5 MHz shall use at least 15 hopping 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping 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.

6.4. Test Results

Ambient temperature : $(23 \pm 1) ^\circ\text{C}$
 Relative humidity : 47 % R.H.

Test voltage: DC 12 V

Operation Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

Test voltage: DC 24 V

Operation Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

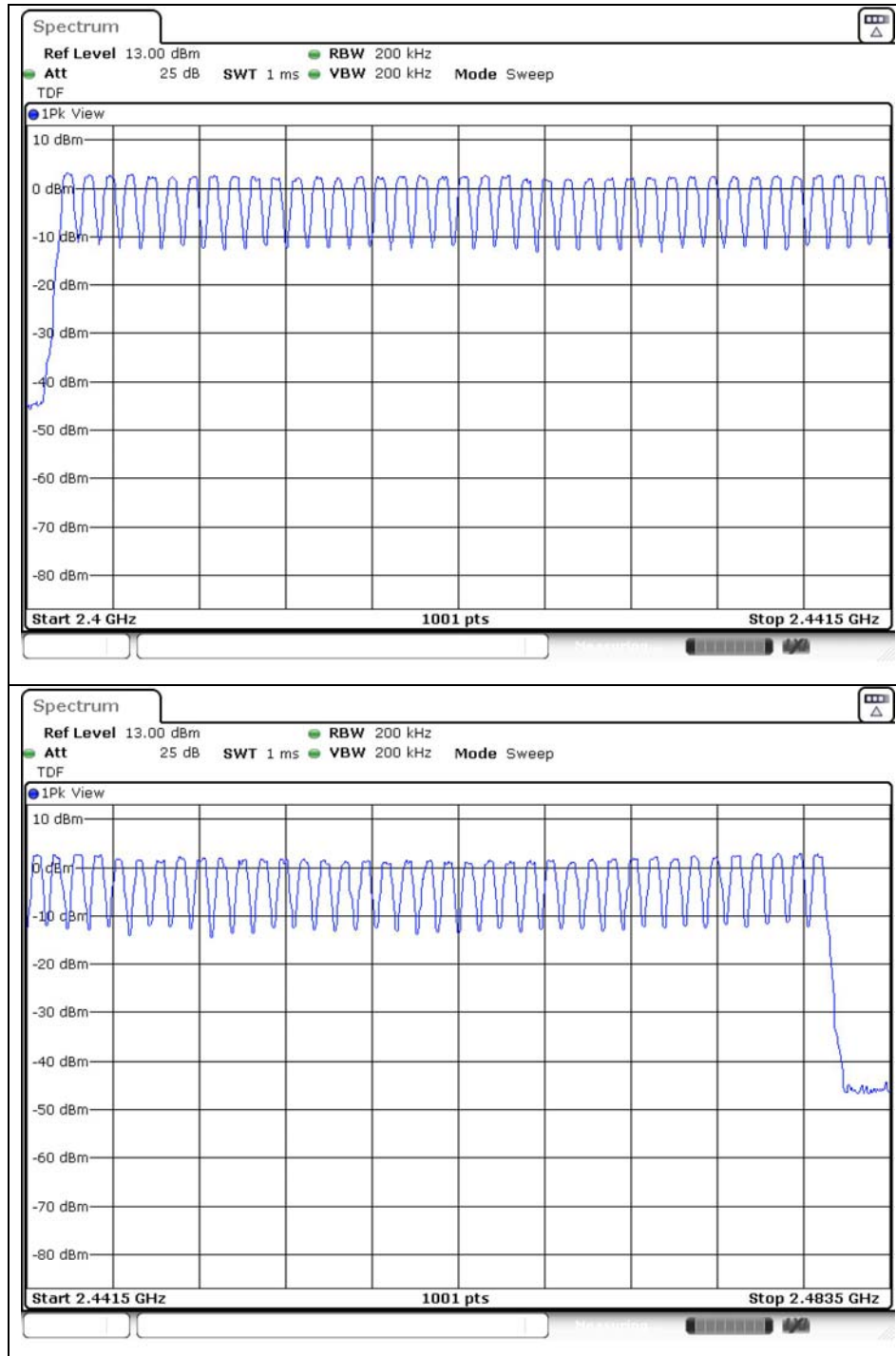
Remark;

Measurement is made with EUT operating in hopping mode between 79 channels providing a worst case scenario as compared to AFH mode hopping between 20 channels.

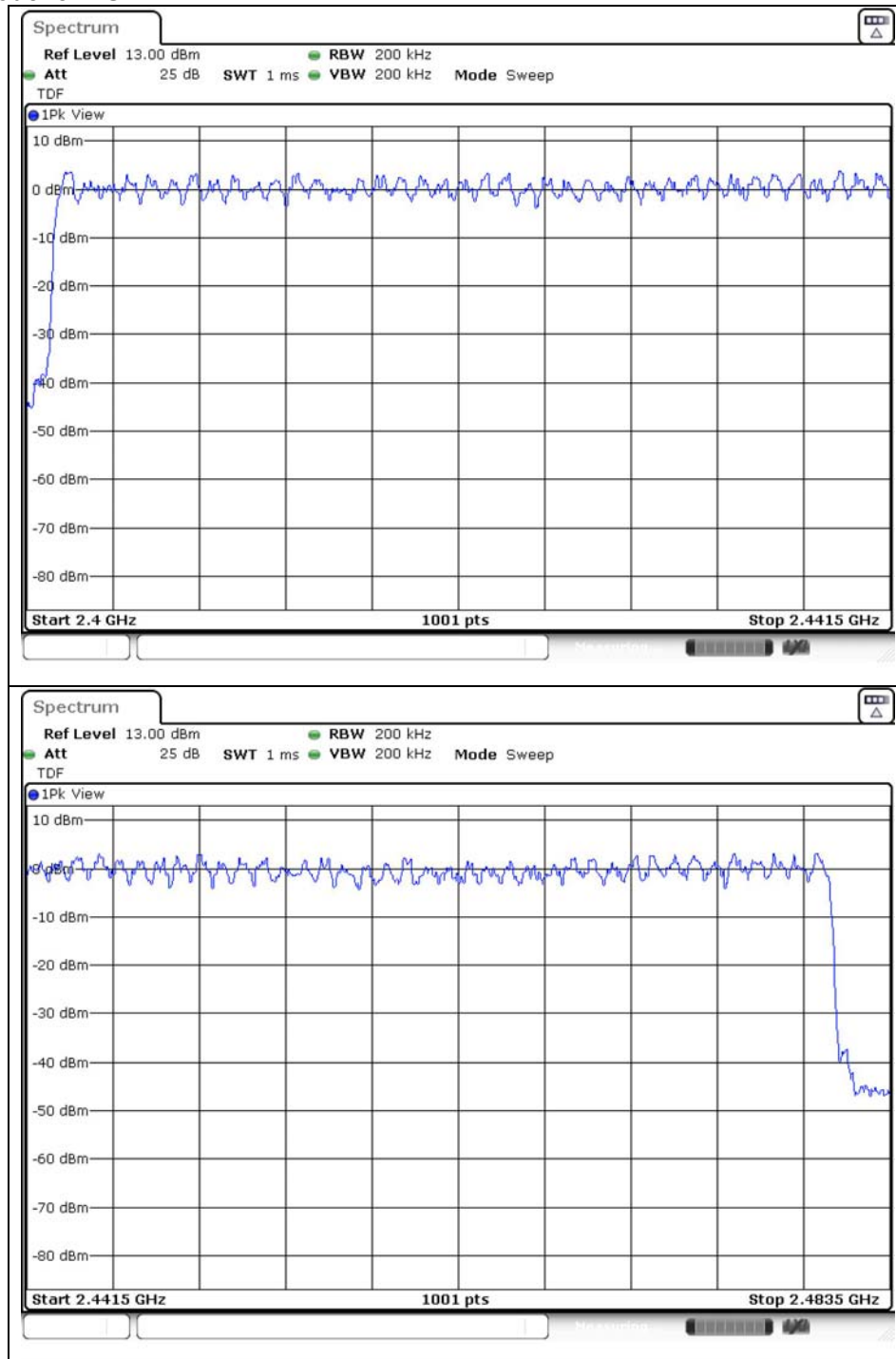
- Test plots

Test voltage: DC 12 V

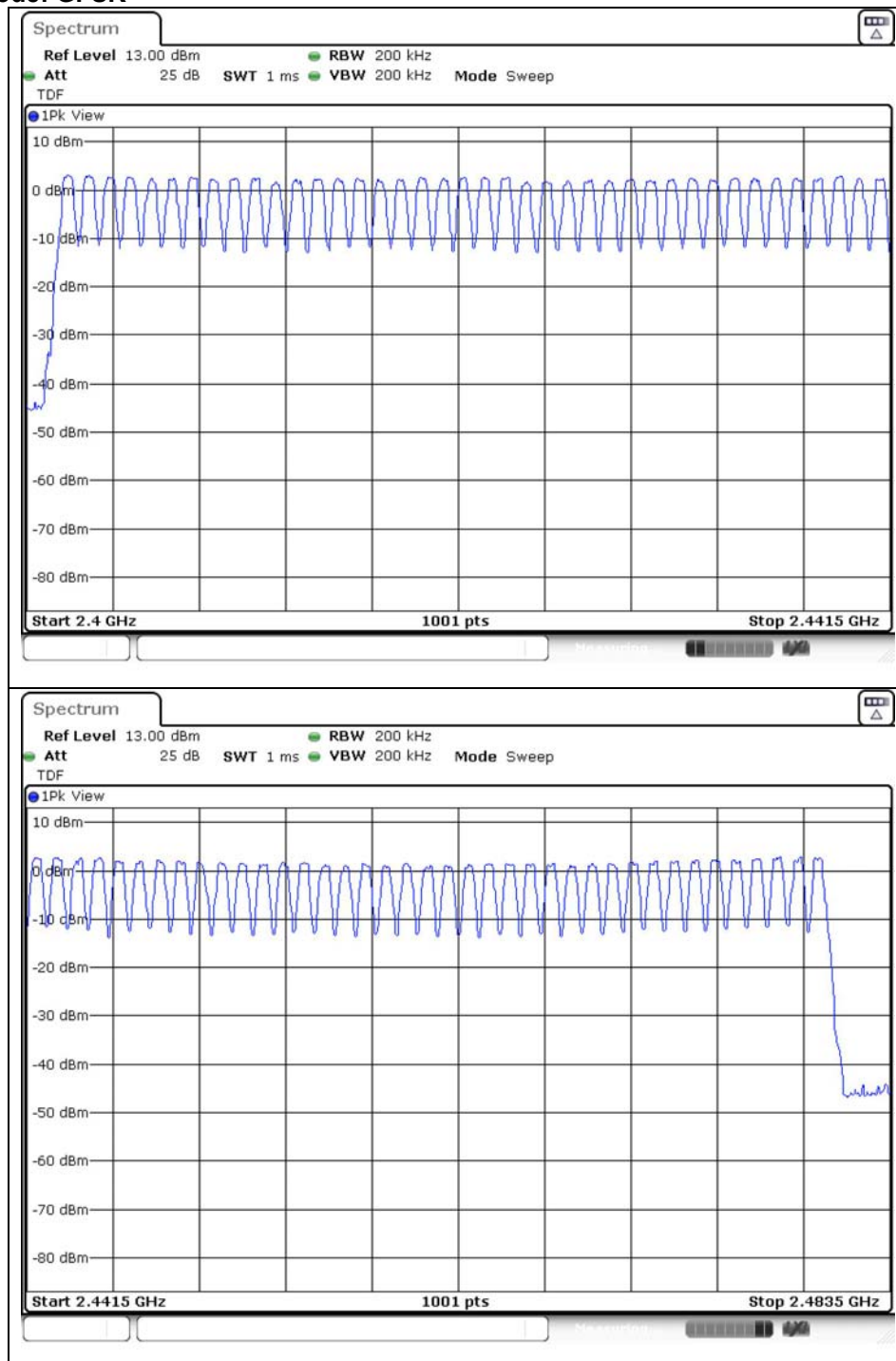
Operating Mode: GFSK



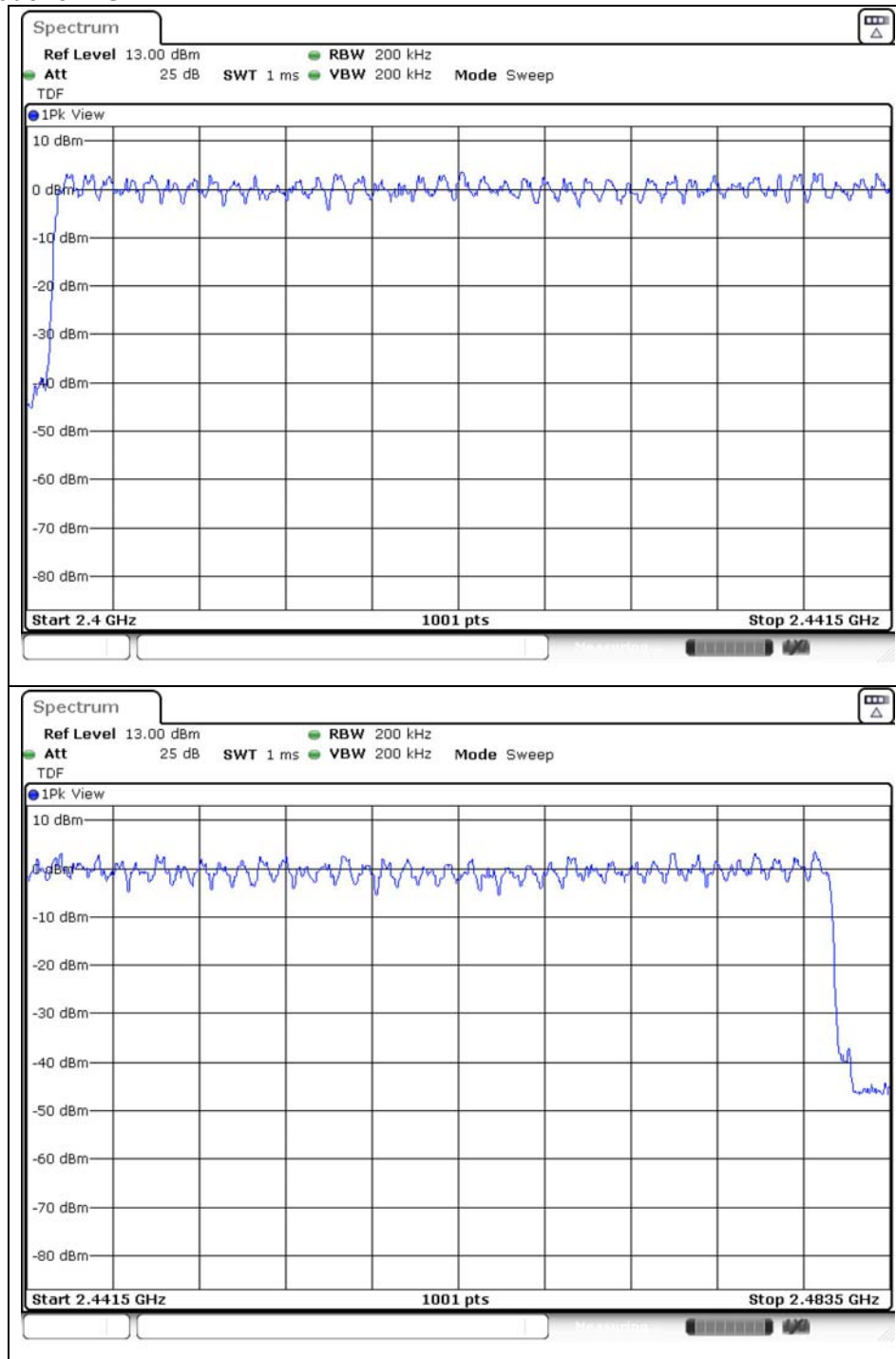
Operating Mode: 8DPSK



Test voltage: DC 24 V
Operating Mode: GFSK

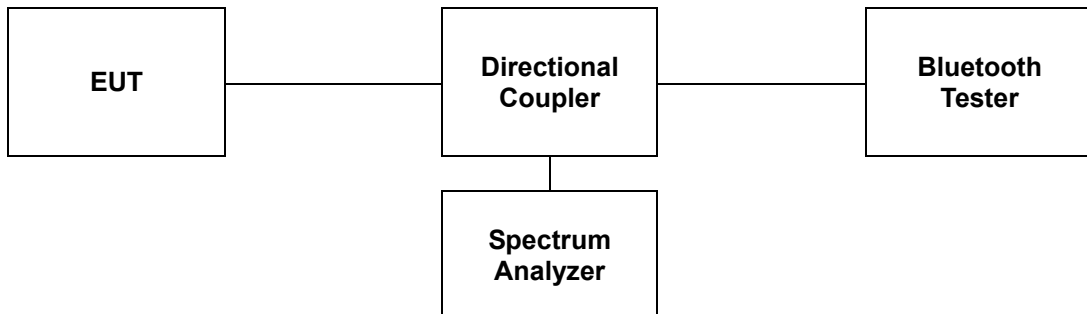


Operating Mode: 8DPSK



7. Time of Occupancy (Dwell Time)

7.1. Test Set up



7.2. Limit

7.2.1. FCC

§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.

7.2.2. IC

According to RSS-247 Issue 2, 5.1(d), FHSs operating in the band 2 400-2 483.5 MHz shall use at least 15 hopping 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

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

*Adaptive Frequency Hopping

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

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 3DH1, 3DH3, 3DH5. 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.

7.4. Test Results

Ambient temperature : $(23 \pm 1) ^\circ\text{C}$
 Relative humidity : 47 % R.H.

7.4.1. Test voltage: DC 12 V

7.4.1.1. Packet Type: DH1, 3DH1

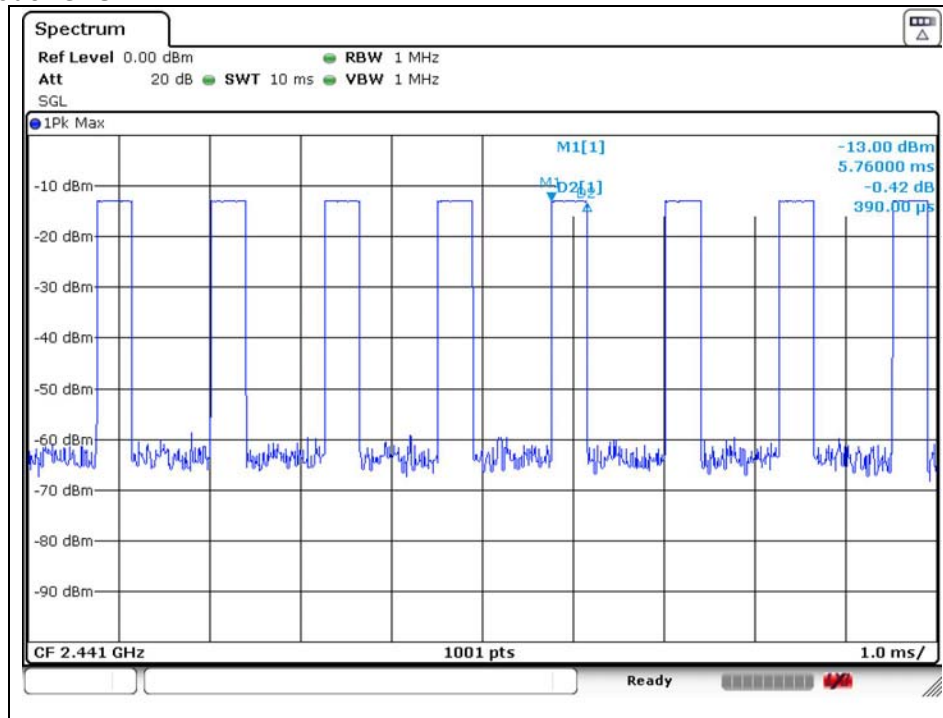
Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	0.39	124.80	400
8DPSK	2 441	0.39	124.80	400

Remark;

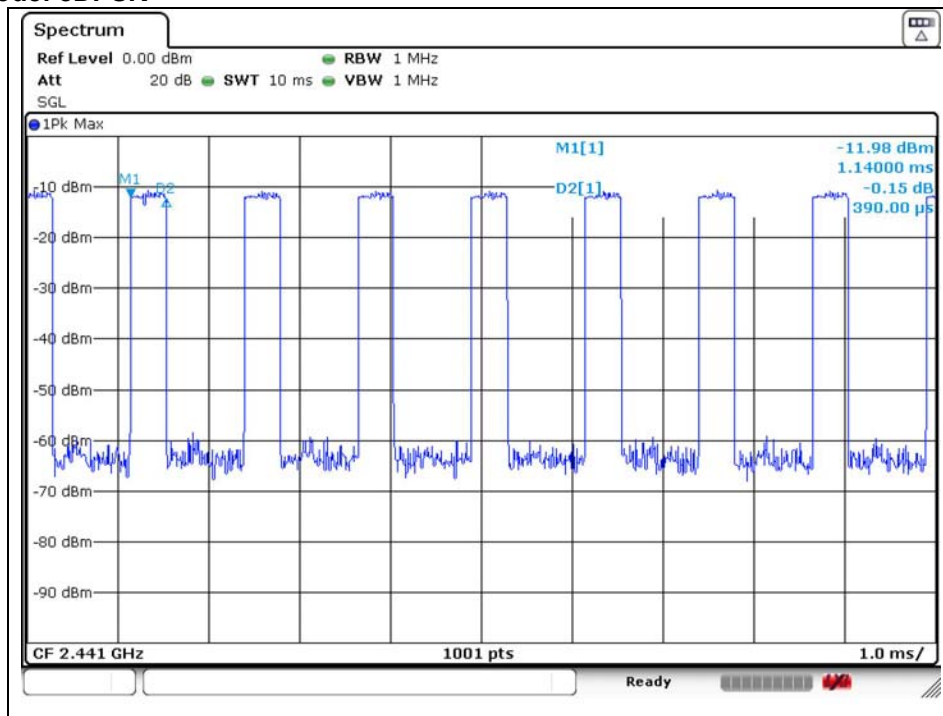
Time of occupancy on the TX channel in 31.6 sec

In case of GFSK and 8DPSK: $0.39 \times \{(1\ 600 \div 2) / 79\} \times 31.6 = 124.80 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.1.2. Packet Type: DH3, 3DH3

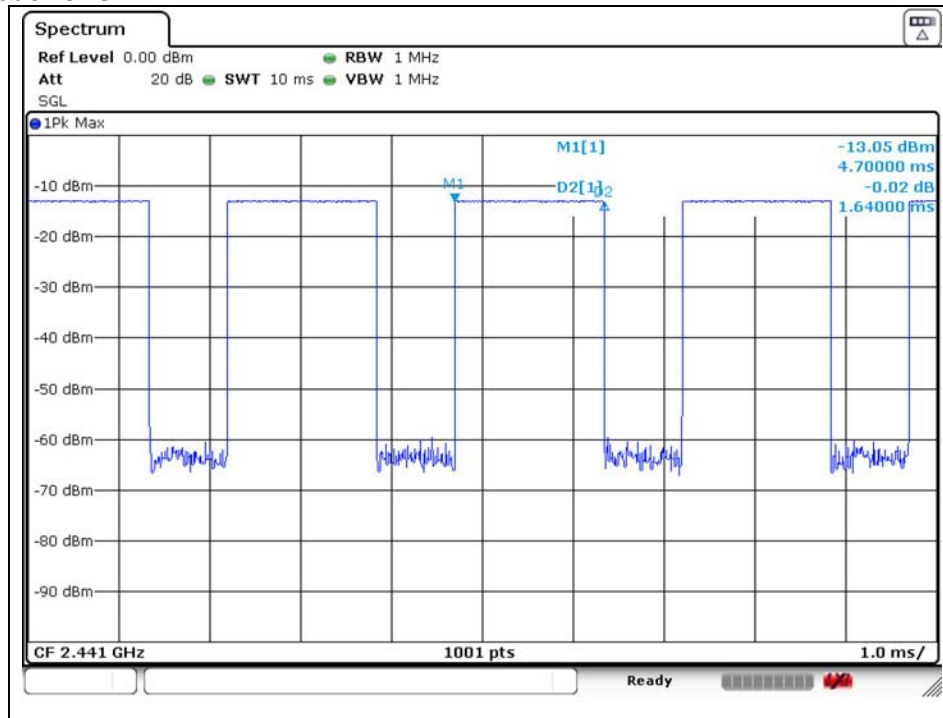
Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	1.64	262.40	400
8DPSK	2 441	1.64	262.40	400

Remark;

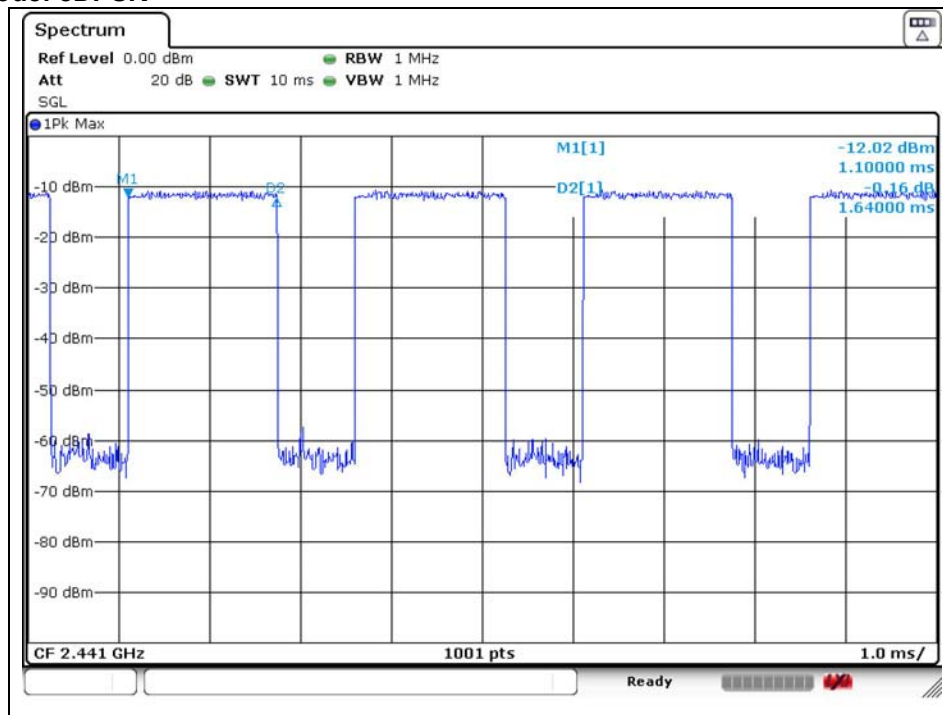
Time of occupancy on the TX channel in 31.6 sec

In case of GFSK and 8DPSK: $1.64 \times \{(1\ 600 \div 4) / 79\} \times 31.6 = 262.40\ \text{ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.1.3. Packet Type: DH5, 3DH5

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	2.89	308.27	400
8DPSK	2 441	2.90	309.33	400

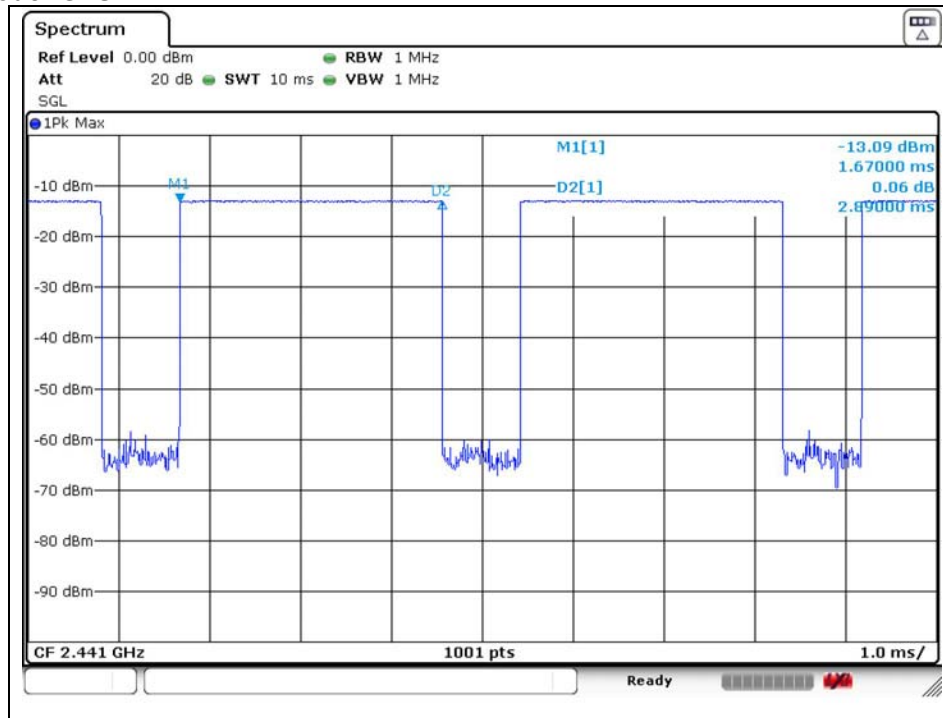
Remark;

Time of occupancy on the TX channel in 31.6 sec

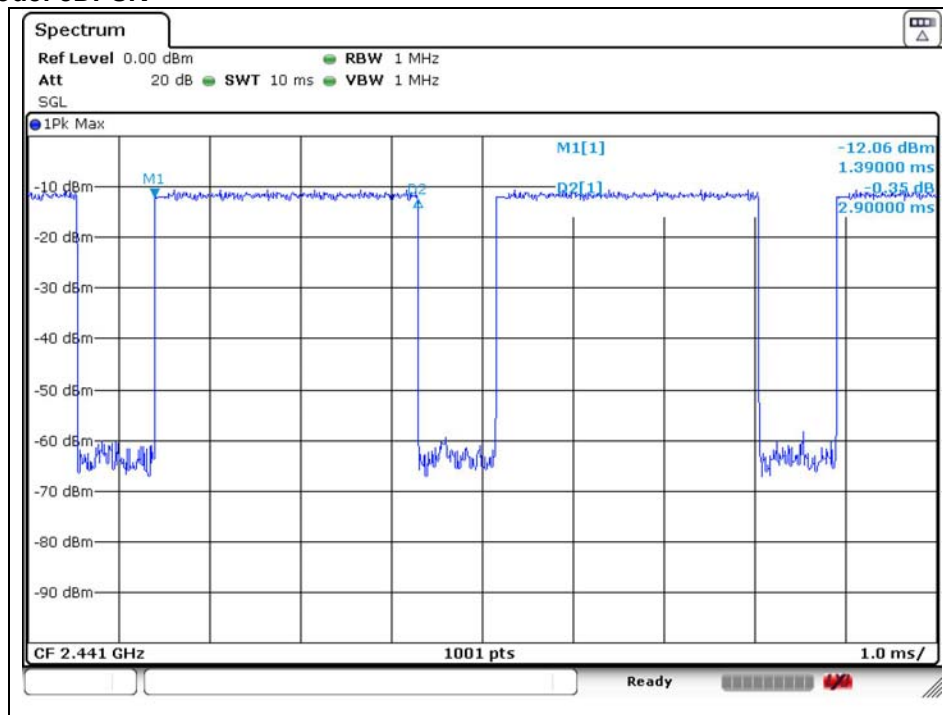
In case of GFSK: $2.89 \times \{(1\,600 \div 6) / 79\} \times 31.6 = 308.27 \text{ ms}$

In case of 8DPSK: $2.90 \times \{(1\,600 \div 6) / 79\} \times 31.6 = 309.33 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.1.4. Packet Type: DH1, 3DH1 (Adaptive Frequency Hopping)

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	0.38	60.80	400
8DPSK	2 441	0.39	62.40	400

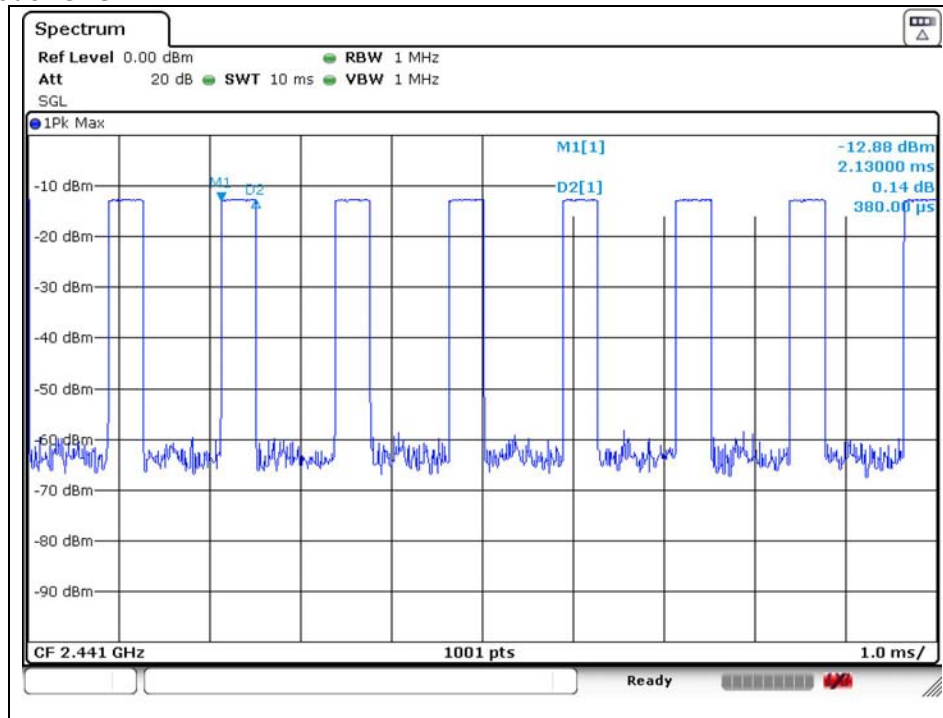
Remark;

Time of occupancy on the TX channel in 8 sec

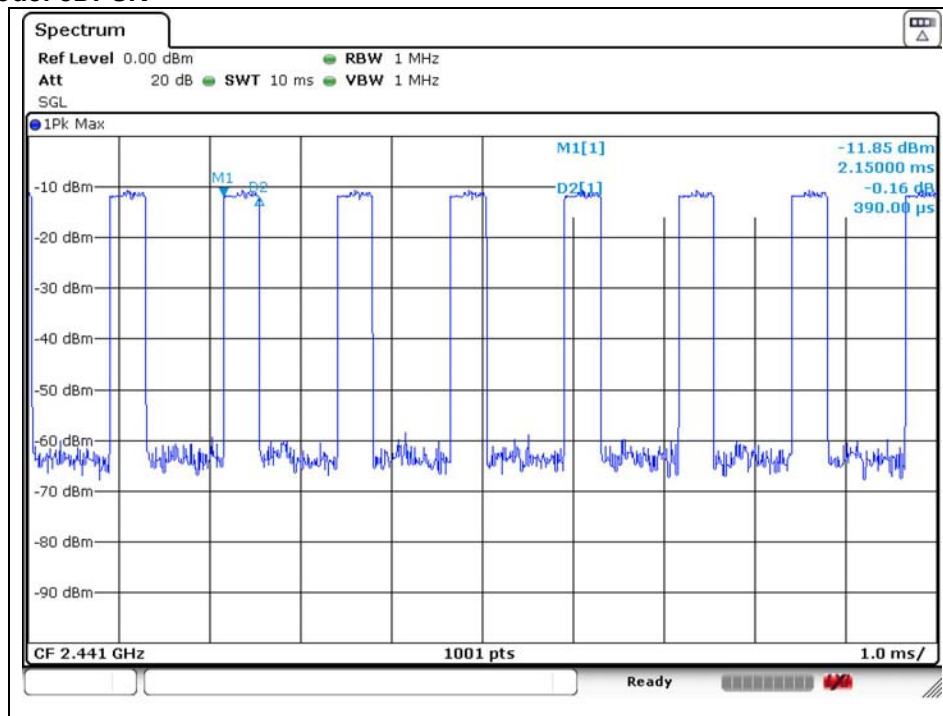
In case of GFSK: $0.38 \times \{(800 \div 2) / 20\} \times 8 = 60.80 \text{ ms}$

In case of 8DPSK: $0.39 \times \{(800 \div 2) / 20\} \times 8 = 62.40 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.1.5. Packet Type: DH3, 3DH3 (Adaptive Frequency Hopping)

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	1.64	131.20	400
8DPSK	2 441	1.65	132.00	400

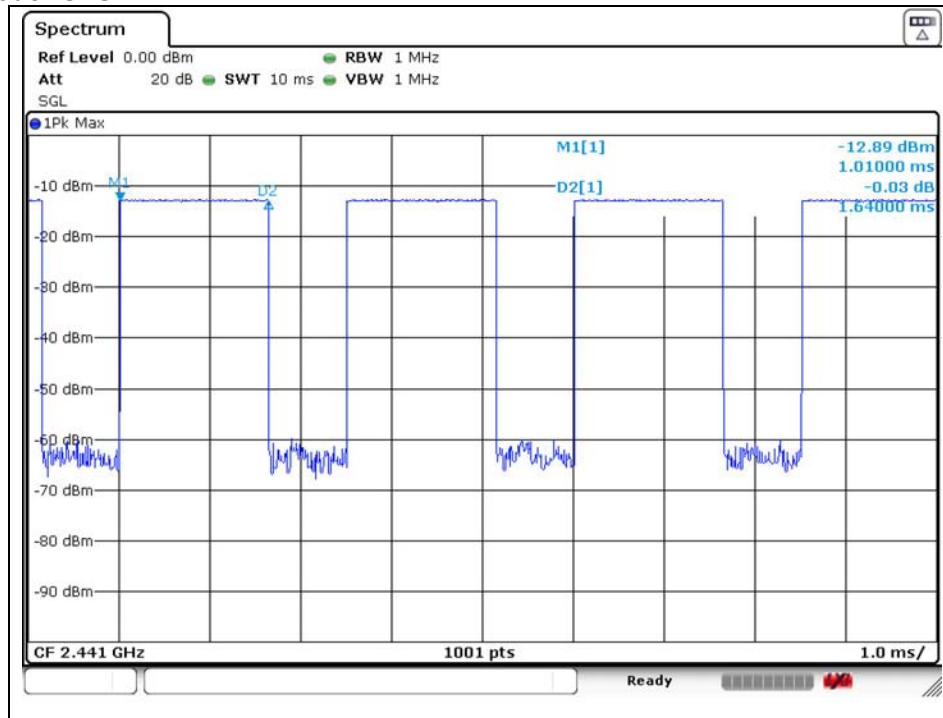
Remark;

Time of occupancy on the TX channel in 8 sec

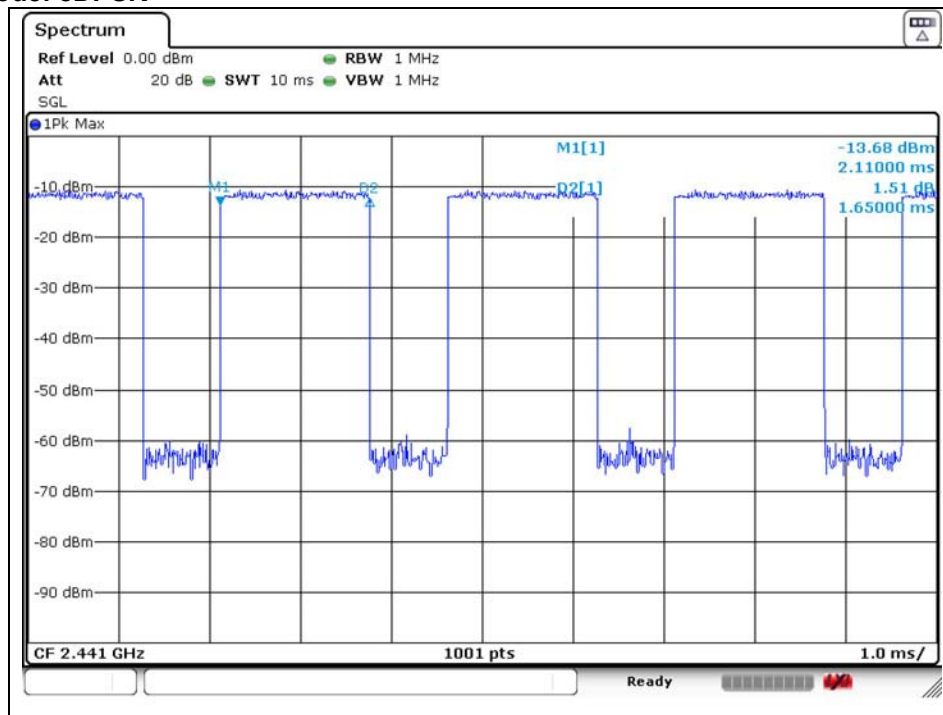
In case of GFSK: $1.64 \times \{(800 \div 4) / 20\} \times 8 = 131.20 \text{ ms}$

In case of 8DPSK: $1.65 \times \{(800 \div 4) / 20\} \times 8 = 132.00 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.1.6. Packet Type: DH5, 3DH5 (Adaptive Frequency Hopping)

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	2.89	154.13	400
8DPSK	2 441	2.90	154.67	400

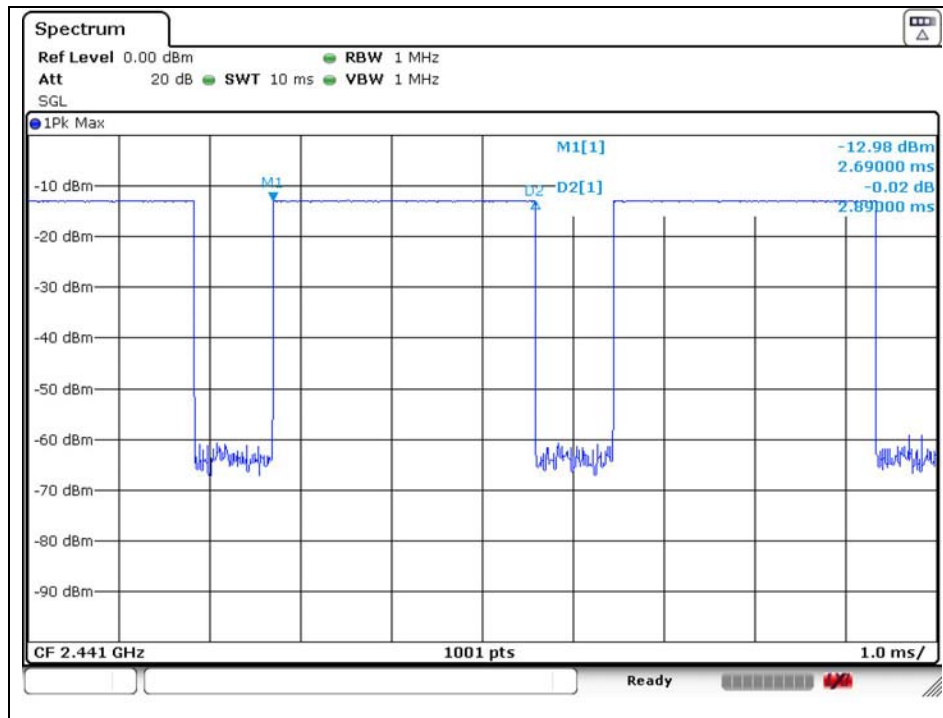
Remark;

Time of occupancy on the TX channel in 8 sec

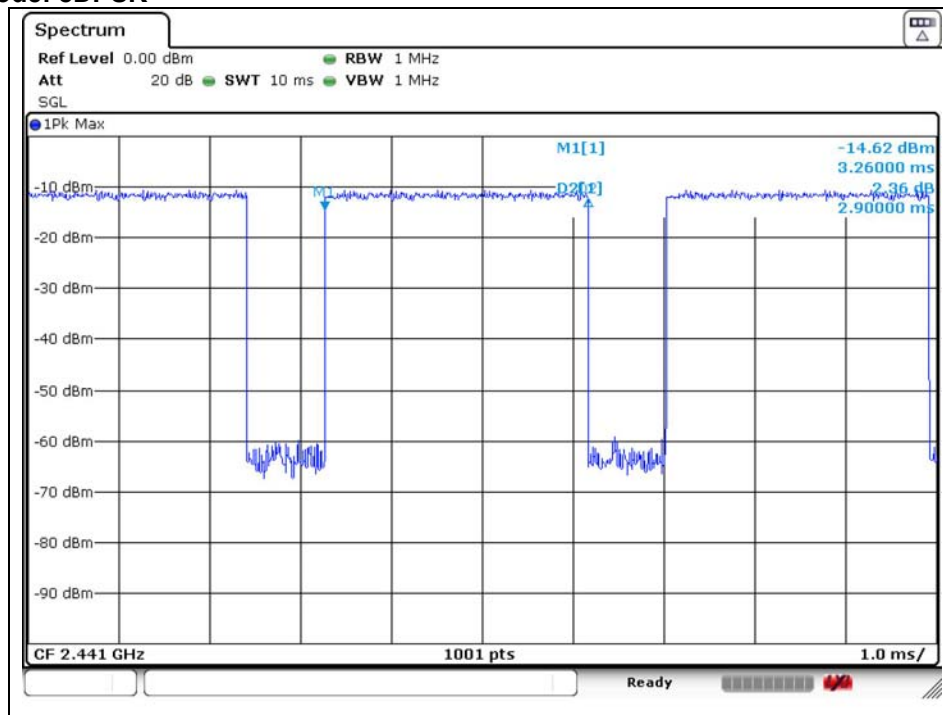
In case of GFSK: $2.89 \times \{(800 \div 6) / 20\} \times 8 = 154.13 \text{ ms}$

In case of 8DPSK: $2.90 \times \{(800 \div 6) / 20\} \times 8 = 154.67 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2. Test voltage: DC 24 V

7.4.2.1. Packet Type: DH1, 3DH1

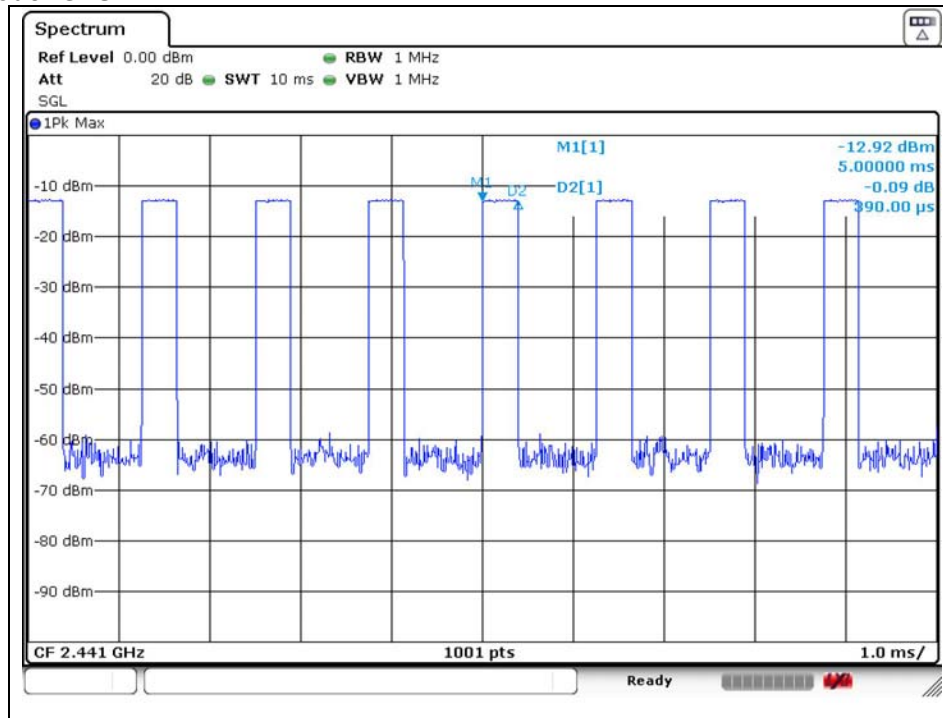
Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	0.39	124.80	400
8DPSK	2 441	0.39	124.80	400

Remark;

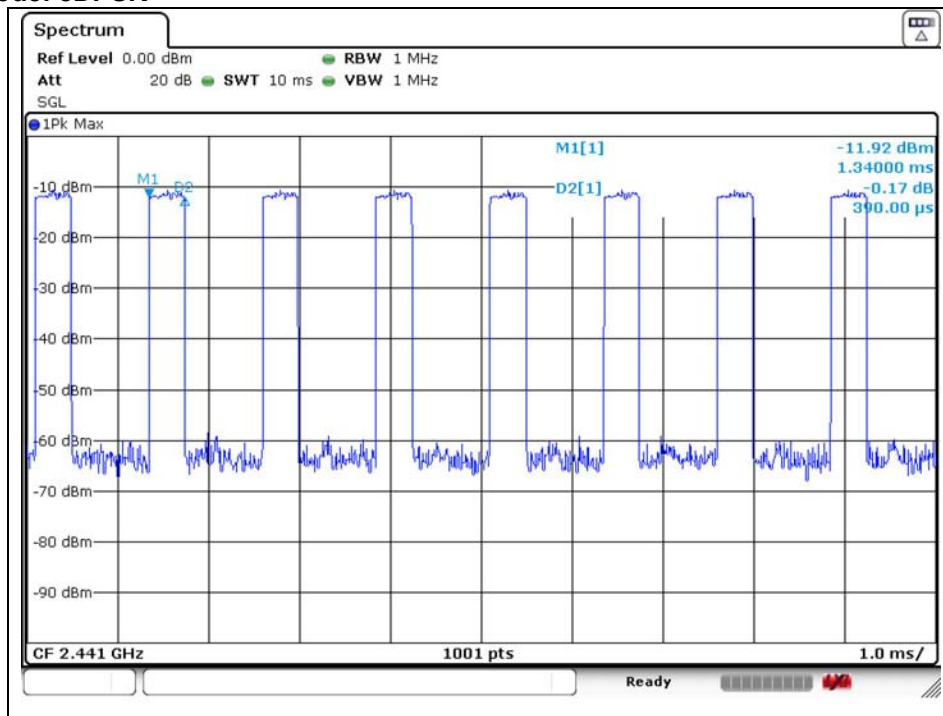
Time of occupancy on the TX channel in 31.6 sec

In case of GFSK and 8DPSK: $0.39 \times \{(1\ 600 \div 2) / 79\} \times 31.6 = 124.80\ \text{ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2.2. Packet Type: DH3, 3DH3

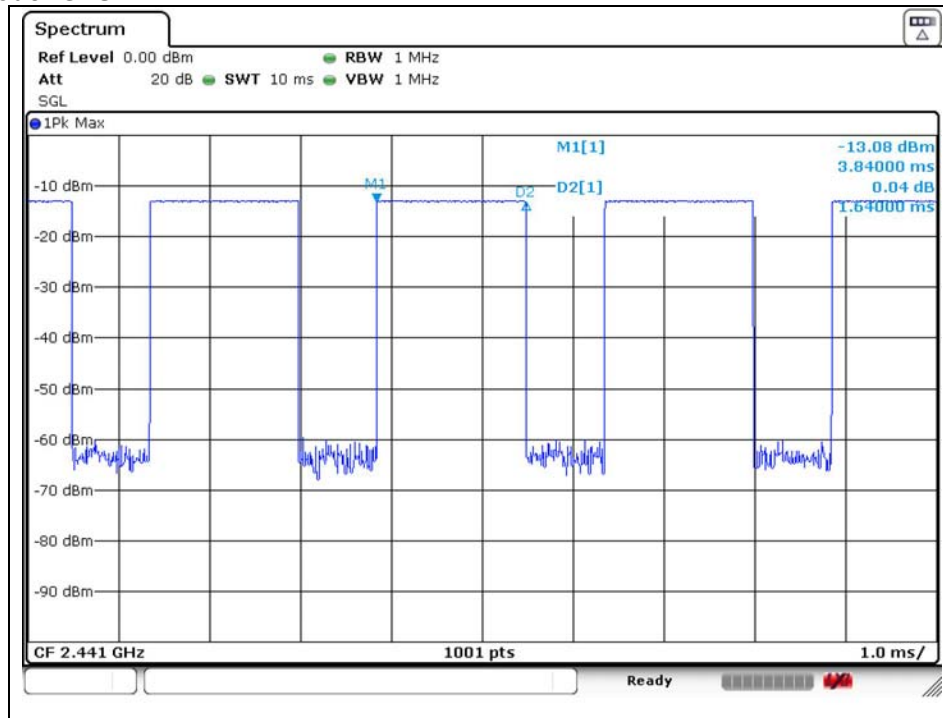
Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 31.6 sec (ms)	Limit for time of occupancy on the Tx Channel in 31.6 sec (ms)
GFSK	2 441	1.64	262.40	400
8DPSK	2 441	1.64	262.40	400

Remark;

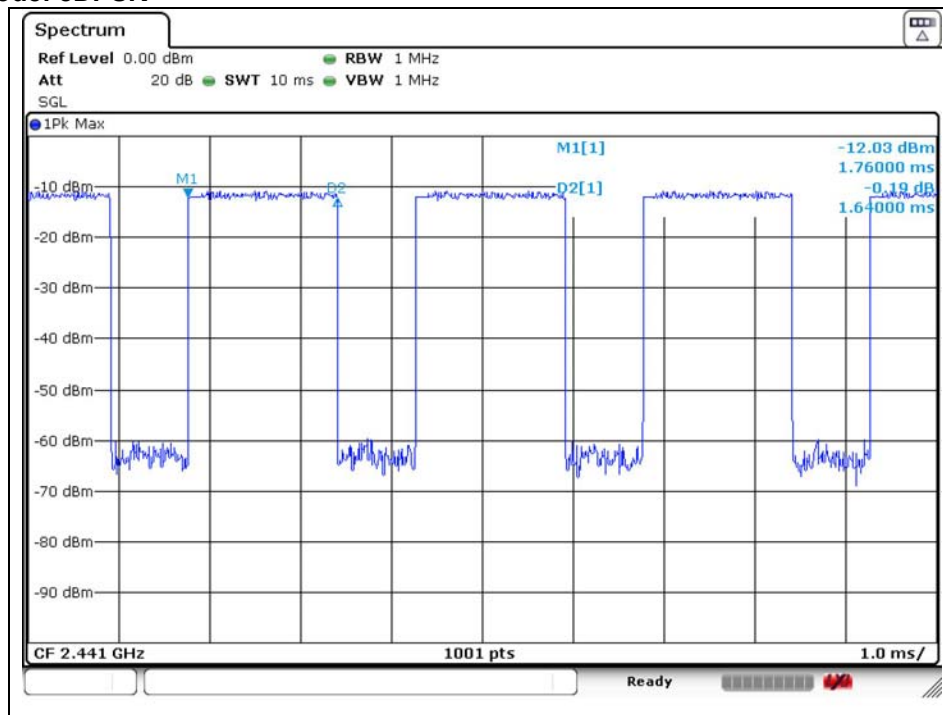
Time of occupancy on the TX channel in 31.6 sec

In case of GFSK and 8DPSK: $1.64 \times \{(1\ 600 \div 4) / 79\} \times 31.6 = 262.40\ \text{ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2.3. Packet Type: DH5, 3DH5

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	2.89	308.27	400
8DPSK	2 441	2.90	309.33	400

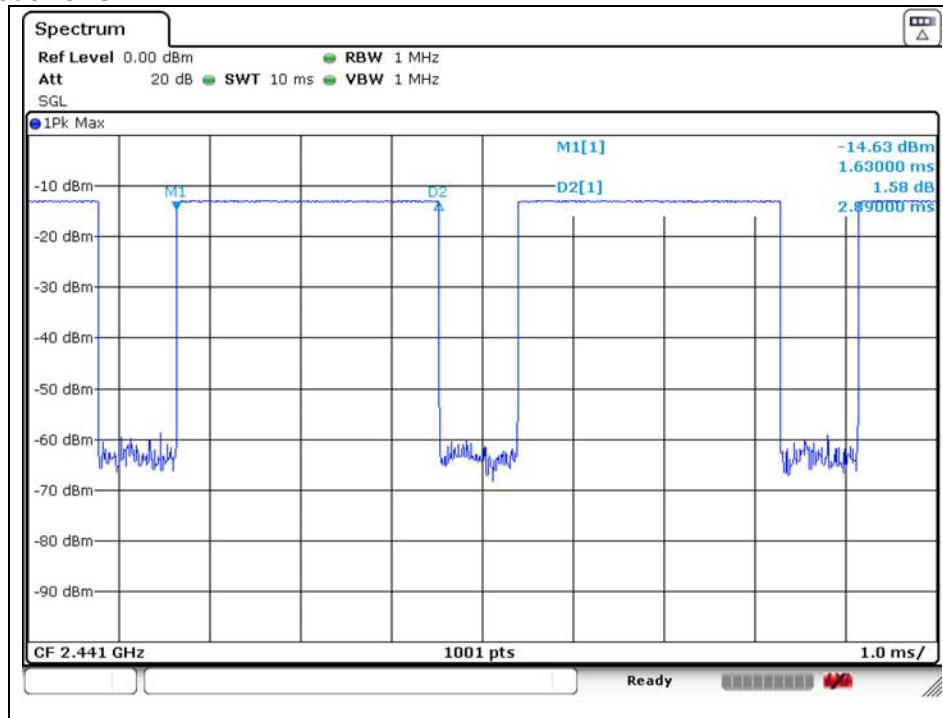
Remark;

Time of occupancy on the TX channel in 31.6 sec

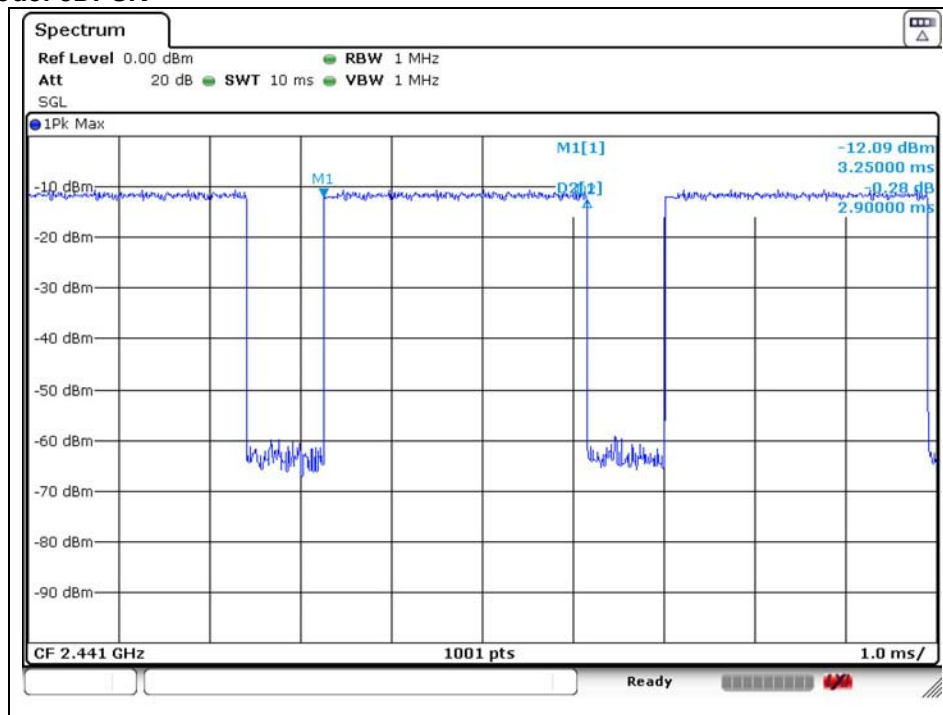
In case of GFSK: $2.89 \times \{(1\ 600 \div 6) / 79\} \times 31.6 = 308.27 \text{ ms}$

In case of 8DPSK: $2.90 \times \{(1\ 600 \div 6) / 79\} \times 31.6 = 309.33 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2.4. Packet Type: DH1, 3DH1 (Adaptive Frequency Hopping)

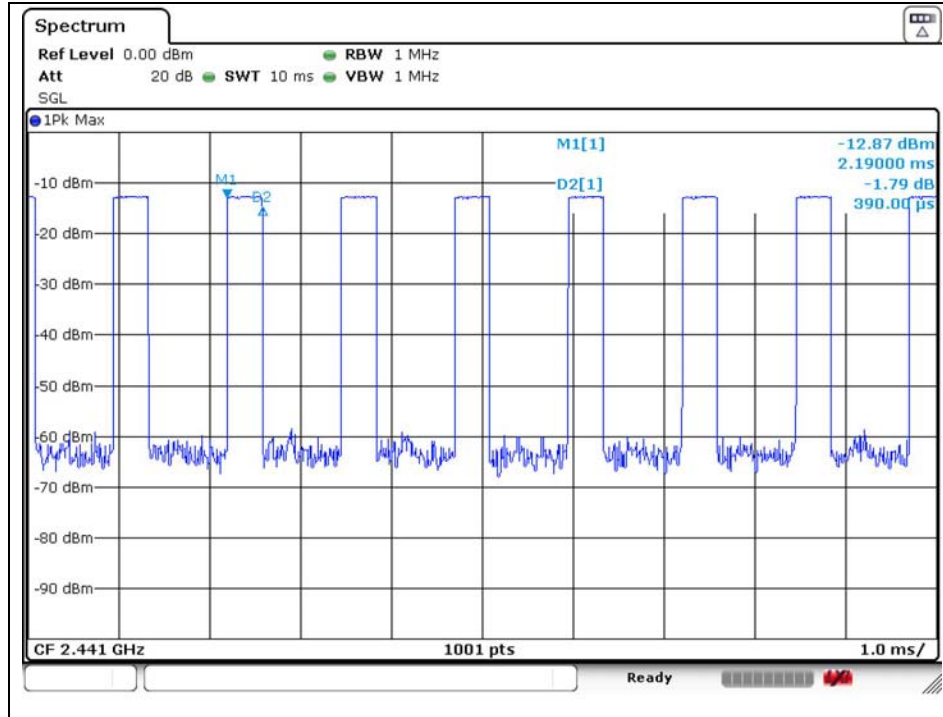
Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	0.39	62.40	400
8DPSK	2 441	0.39	62.40	400

Remark;

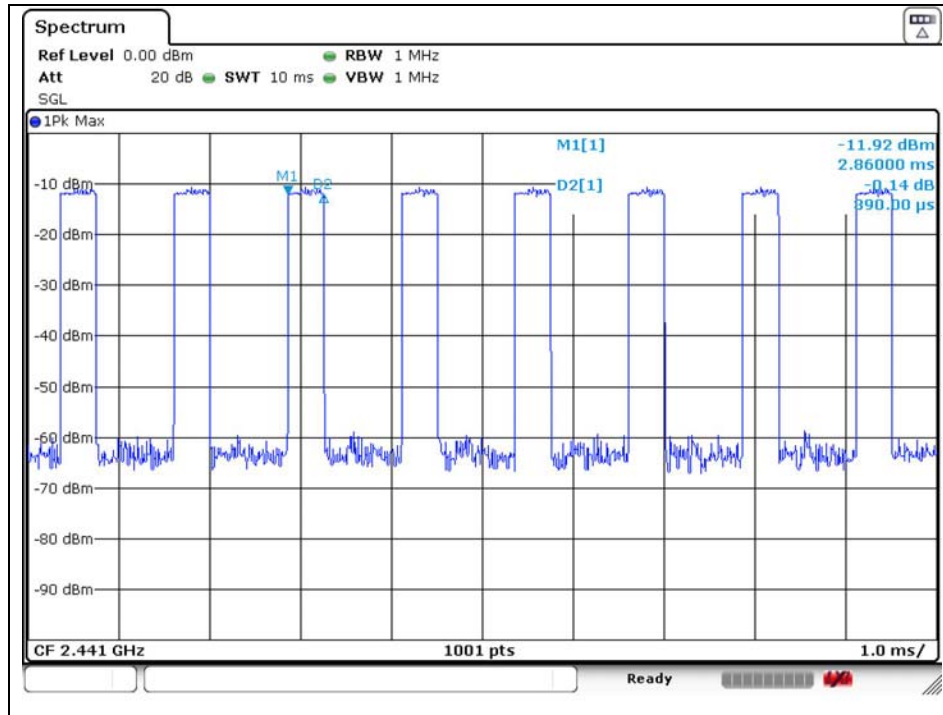
Time of occupancy on the TX channel in 8 sec

In case of GFSK and 8DPSK: $0.39 \times \{(800 \div 2) / 20\} \times 8 = 62.40 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2.5. Packet Type: DH3, 3DH3 (Adaptive Frequency Hopping)

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	1.64	131.20	400
8DPSK	2 441	1.65	132.00	400

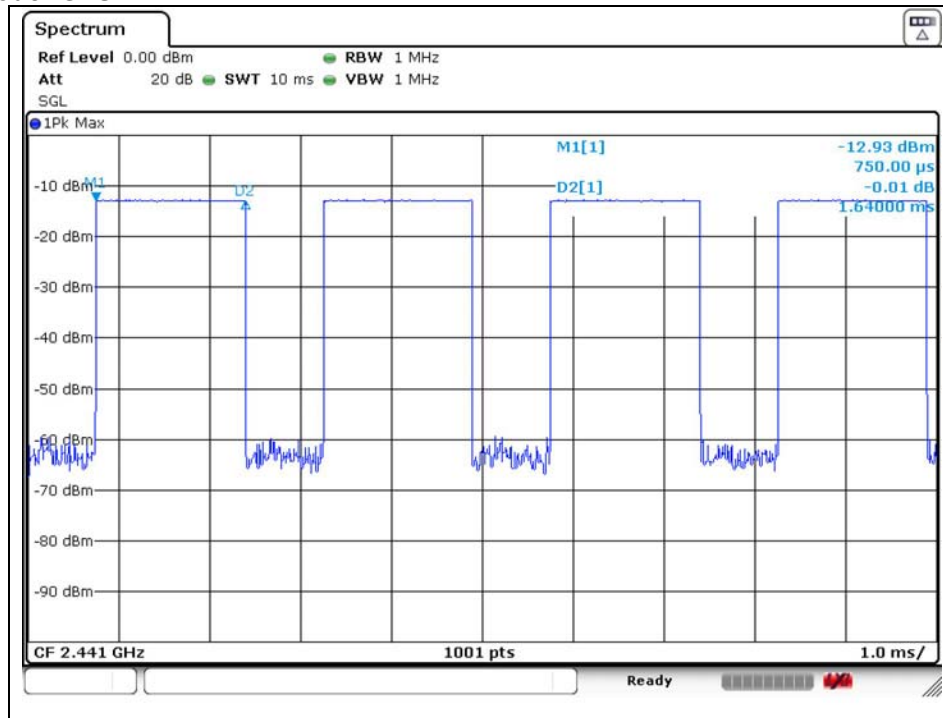
Remark;

Time of occupancy on the TX channel in 8 sec

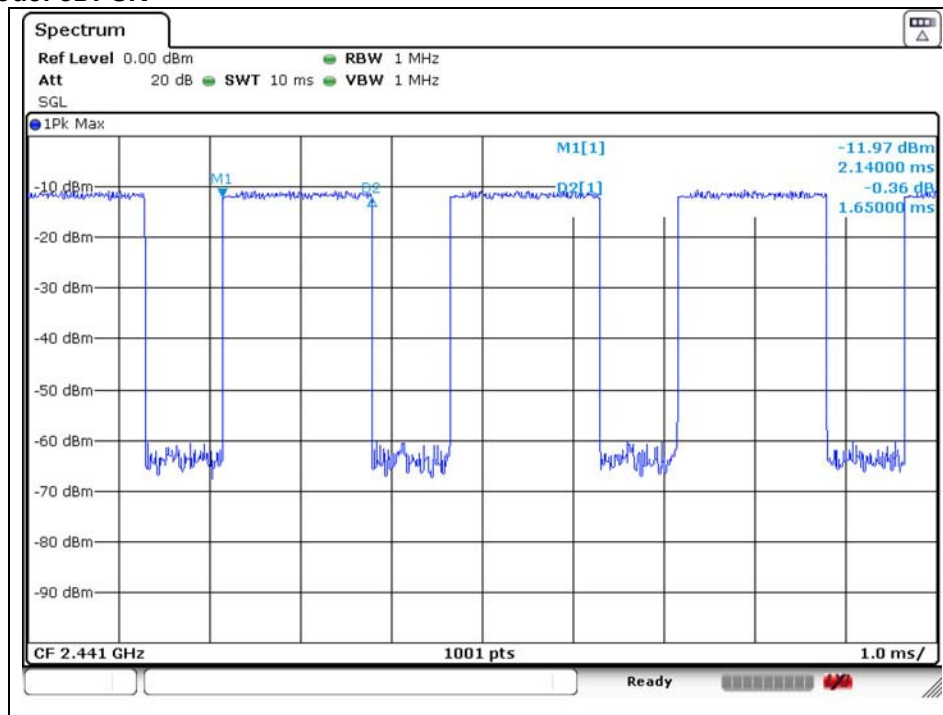
In case of GFSK: $1.64 \times \{(800 \div 4) / 20\} \times 8 = 131.20 \text{ ms}$

In case of 8DPSK: $1.65 \times \{(800 \div 4) / 20\} \times 8 = 132.00 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



7.4.2.6. Packet Type: DH5, 3DH5 (Adaptive Frequency Hopping)

Operation Mode	Frequency (MHz)	Dwell Time (ms)	Time of occupancy on the Tx Channel in 8 sec (ms)	Limit for time of occupancy on the Tx Channel in 8 sec (ms)
GFSK	2 441	2.89	154.13	400
8DPSK	2 441	2.90	154.67	400

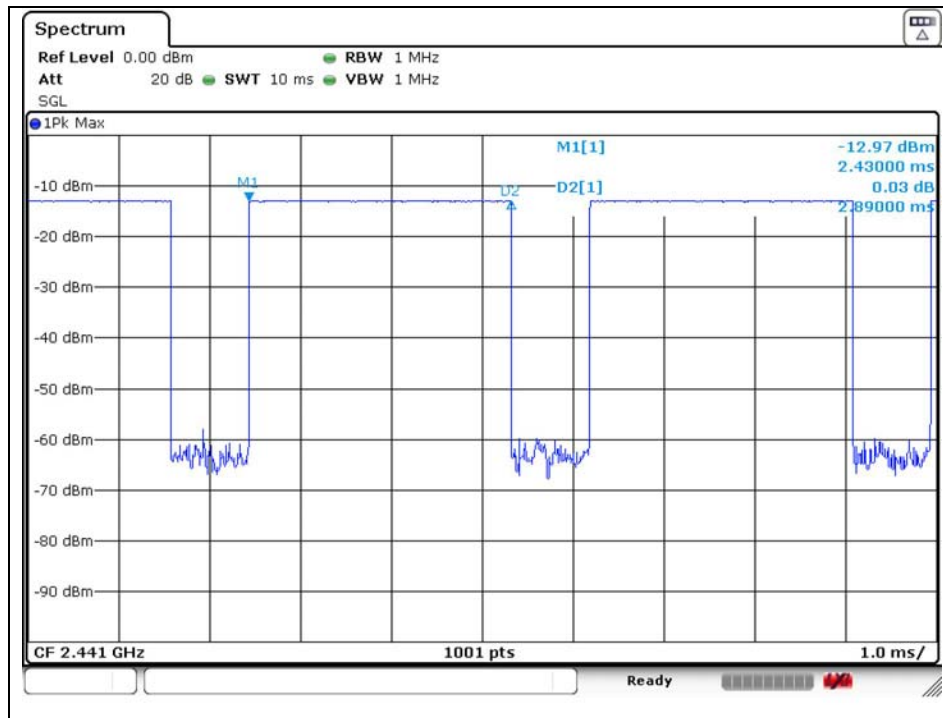
Remark;

Time of occupancy on the TX channel in 8 sec

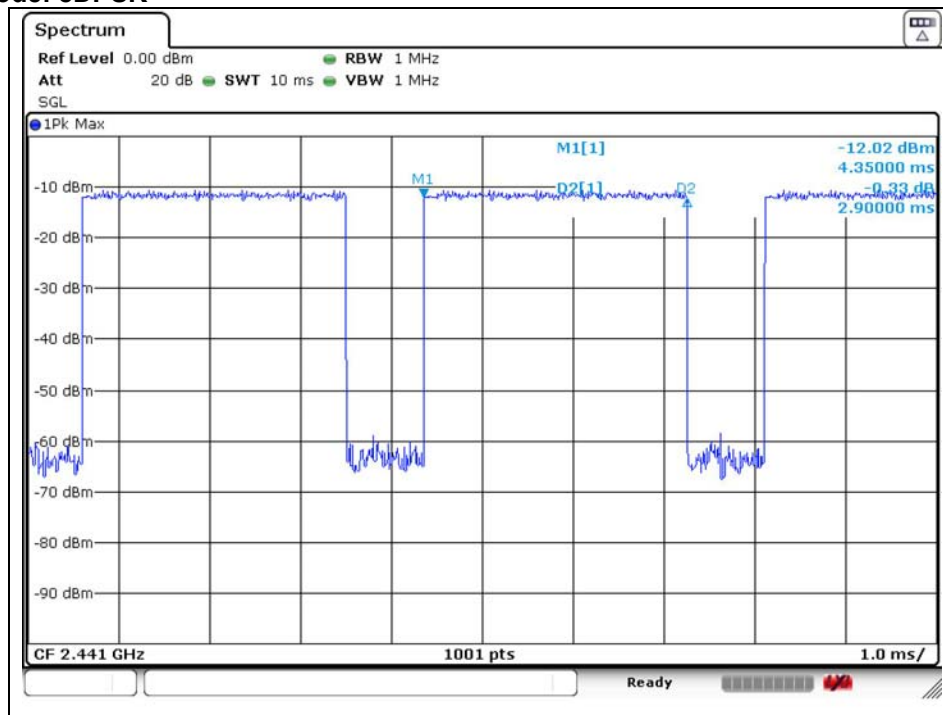
In case of GFSK: $2.89 \times \{(800 \div 6) / 20\} \times 8 = 154.13 \text{ ms}$

In case of 8DPSK: $2.90 \times \{(800 \div 6) / 20\} \times 8 = 154.67 \text{ ms}$

Operating Mode: GFSK



Operating Mode: 8DPSK



8. Antenna Requirement

8.1. 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.

8.2. Antenna Connected Construction

Antenna used in this product is Dielectric chip antenna with gain of 1.99 dBi.

- End of the Test Report -