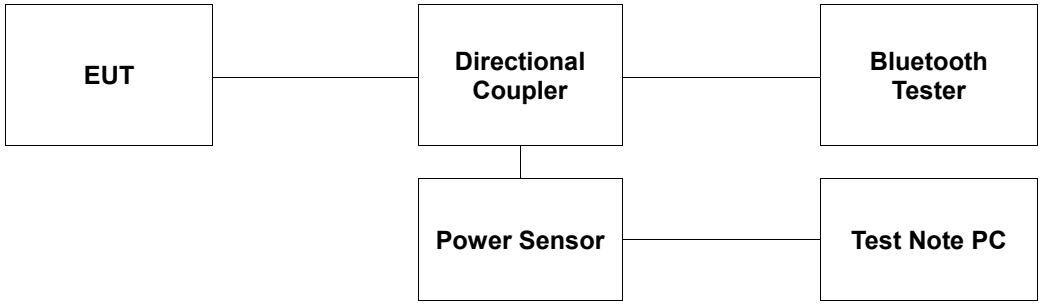
4. Maximum Peak Output Power Measurement

4.1. Test Setup



4.2. Limit

The maximum peak output power of the intentional radiator shall not exceed the following :

1. §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 ㎑ or the 20 ㏈ bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 ㎽.
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 ㎒ employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 – 5 805 ㎒ band: 1 Watt.

4.3. Test Procedure

All data rates and modes were investigated for this test. The test follows DA000705. 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 & average power each channel.

4.4. Test Results

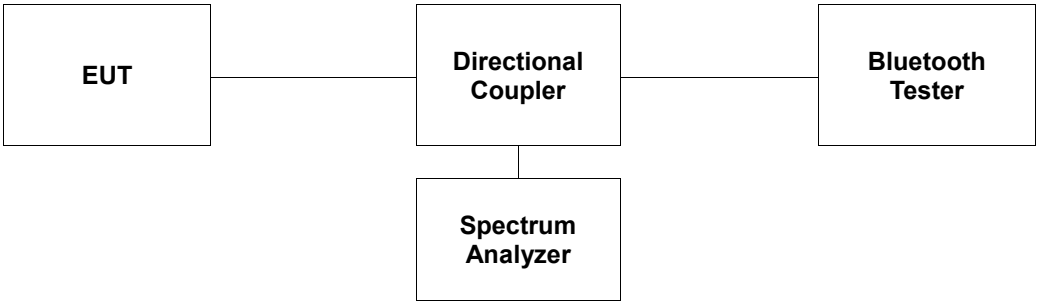
Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Operation Mode	Data Rate	Channel	Channel Frequency (㎒)	Directional coupler + Cable offset (dB)	Average Power Result (dB m)	Peak Power Result (dB m)	Peak Power Limit (dB m)
GFSK	1 Mbps	Low	2 402	15.92	5.73	6.11	30.00
		Middle	2 441	15.95	5.49	5.93	30.00
		High	2 480	15.96	5.47	5.89	30.00
π/4DQPSK	2 Mbps	Low	2 402	15.92	5.96	8.49	20.97
		Middle	2 441	15.95	5.72	8.30	20.97
		High	2 480	15.96	5.66	8.25	20.97
8DPSK	3 Mbps	Low	2 402	15.92	5.95	8.92	20.97
		Middle	2 441	15.95	5.70	8.66	20.97
		High	2 480	15.96	5.66	8.61	20.97

Remark:
In the case of AFH, the limit for peak power is 0.125 W

5. Hopping Channel Separation

5.1. Test Setup



5.2. Limit

§15.247(a)(1) Frequency hopping system operating in 2 400 – 2 483.5 ㎒. Band may have hopping channel carrier frequencies that are separated by 25 ㎑ or two-third of 20 ㏈ bandwidth of the hopping channel, whichever is is greater, provided the systems operate with an output power no greater than 125 ㎽.

5.3. 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 DA000705.

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:

Span = wide enough to capture the peaks of two adjacent channels.
RBW ≥ 1 % of the span.
VBW ≥ RBW
Sweep = auto
Detector = peak
Trace = max hold.

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

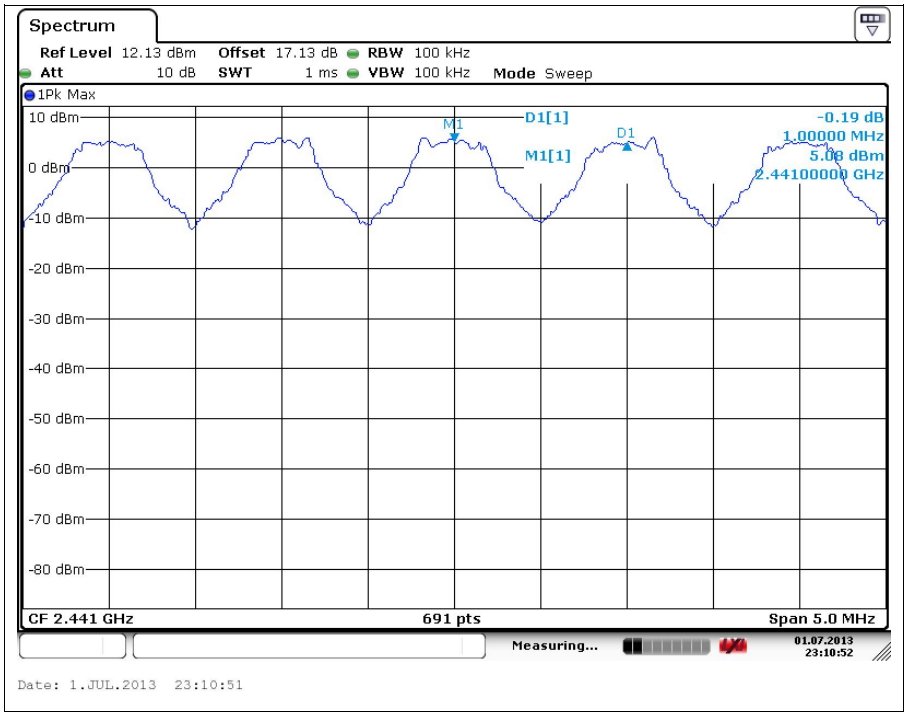
5.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

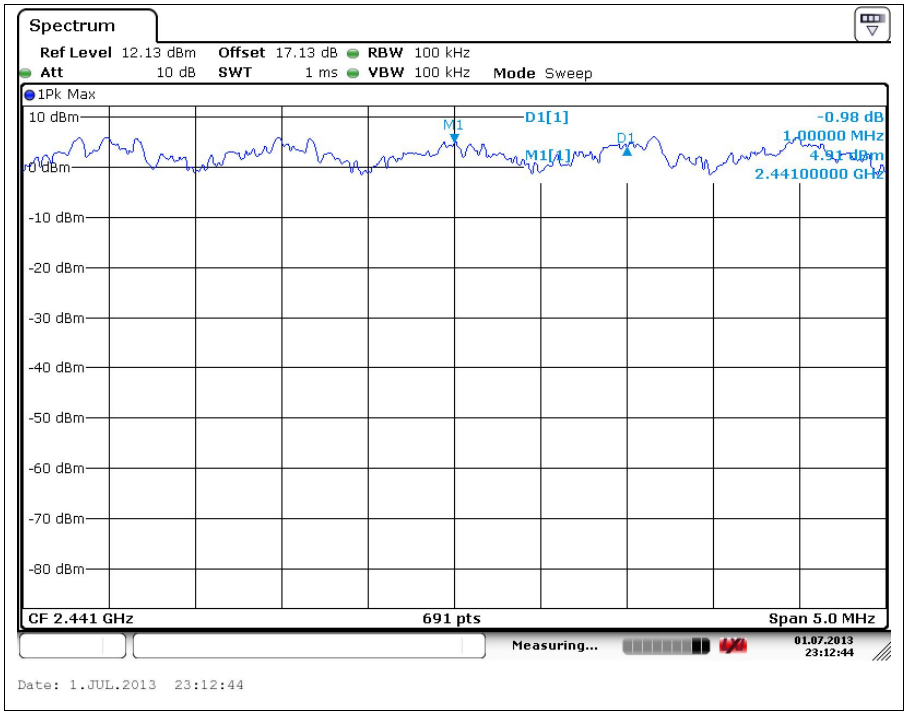
Operation Mode	Channel (Middle)	Adjacent Hopping Channel Separation (㎑)	Two-third of 20 dB Bandwidth (㎑)	Minimum Bandwidth (㎑)
GFSK	2 441 ㎒	1 000	628	25
8DPSK	2 441 ㎒	1 000	859	25

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

Operating Mode: GFSK

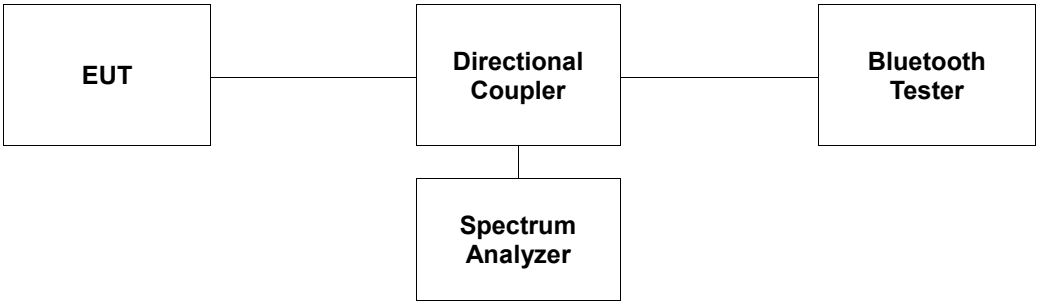


Operating Mode: 8DPSK



6. Number of Hopping Frequency

6.1. Test Setup



6.2. Limit

§15.247(a)(1)(iii), Frequency hopping systems in the 2 400–2 483.5 ㎒ 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

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 DA000705.

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

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

1. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna the port to the Spectrum analyzer
2. Set spectrum analyzer Start = 2 400 ㎒, Stop = 2 441.5 ㎒, Sweep=sweep and Start = 2 441.5 ㎒, Stop = 2 483.5 ㎒, Sweep = sweep. Detector = peak.
3. Set the spectrum analyzer as RBW, VBW = 500 ㎑.
4. Max hold, allow the trace to stabilize and count how many channel in the band.

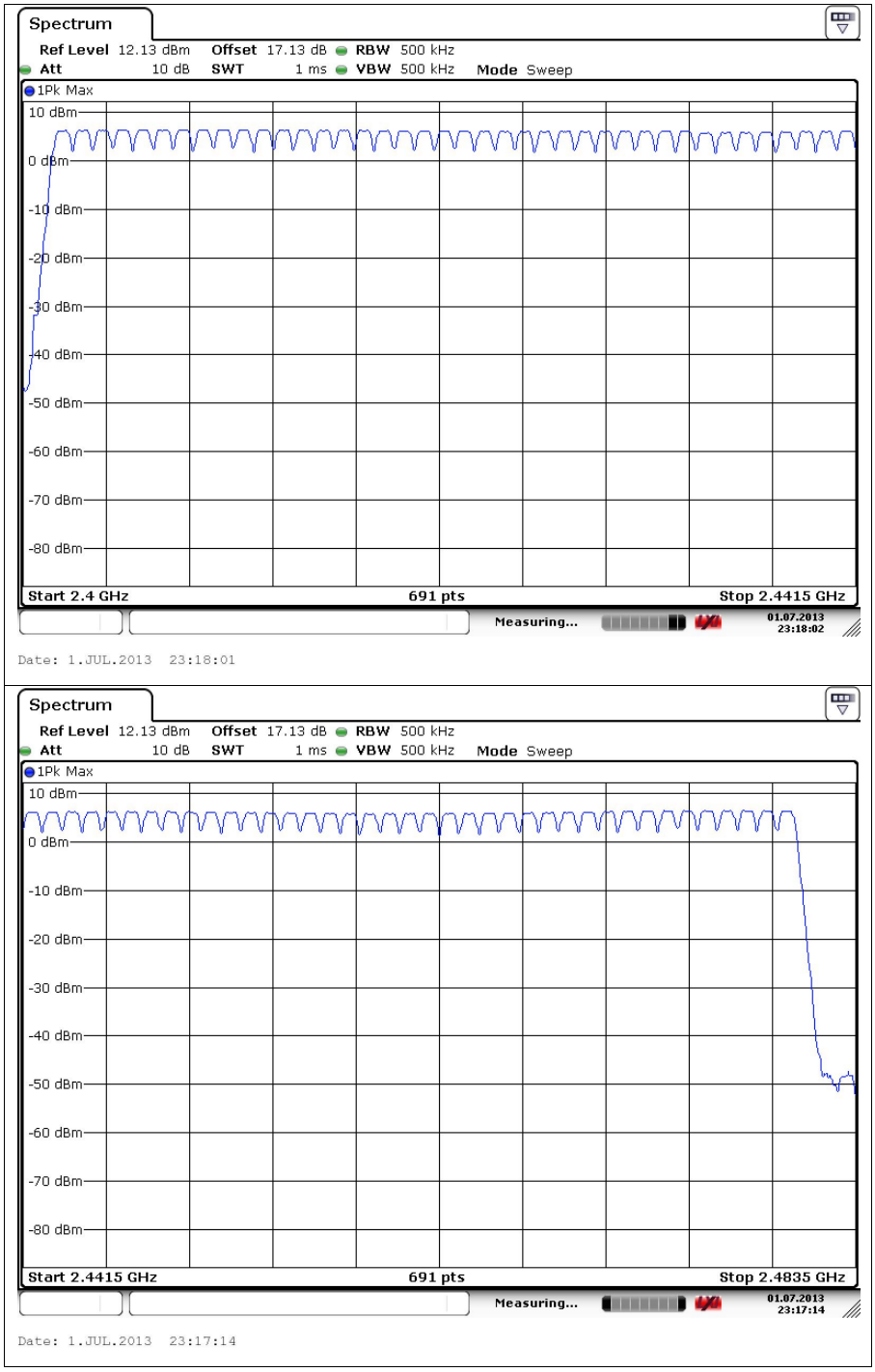
6.4. Test Results

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

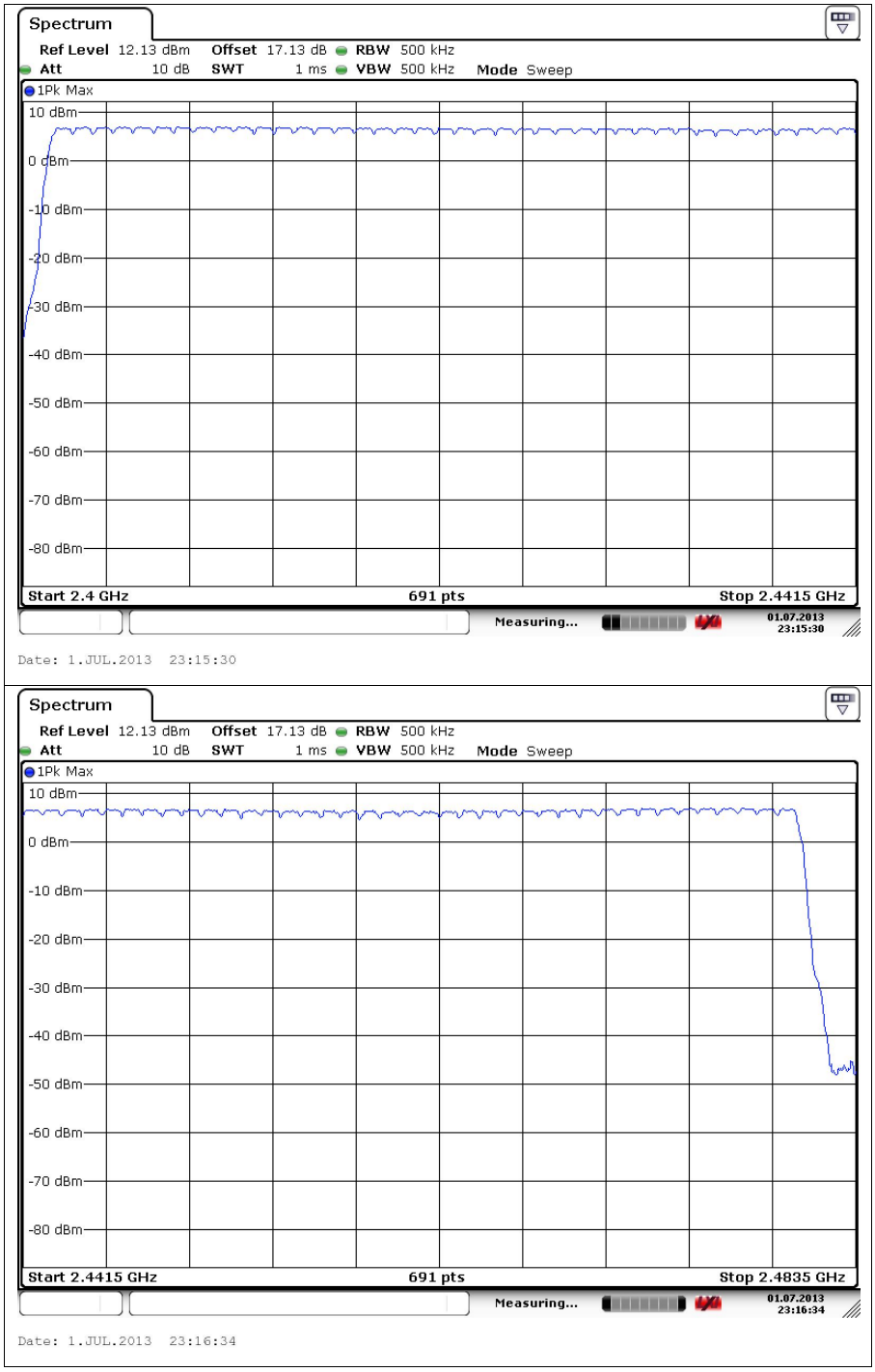
Operation Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ 15
8DPSK	79	≥ 15

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

Operating Mode: GFSK

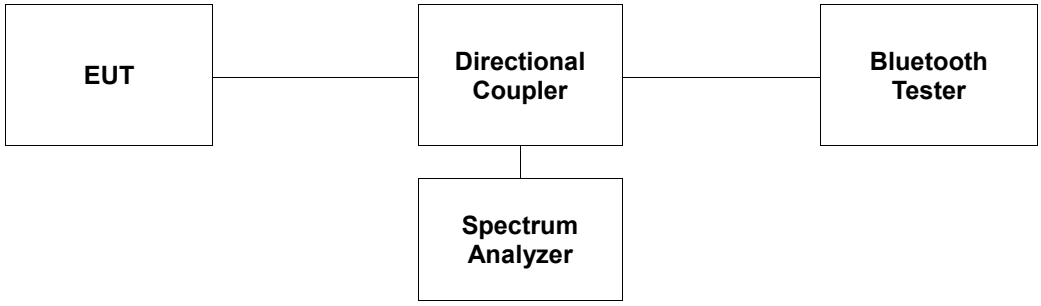


Operating Mode : 8DPSK



7. Time of Occupancy (Dwell Time)

7.1. Test Set up



7.2. Limit

§15.247(a)(1)(iii) For frequency hopping system operating in the 2 400 – 2 483.5 ㎒ 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)

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 DA000705.

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 3-DH1, 3-DH3, 3-DH5.The hopping rate is insisted of 1 600 per second.

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

Span = zero span, centered on a hopping channel
RBW = 1 ㎒
VBW = RBW
Sweep = as necessary to capture the entire dwell time per hopping channel
Detector = peak
Trace = max hold
Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation repeat this test for each variation.

7.4. Test Results

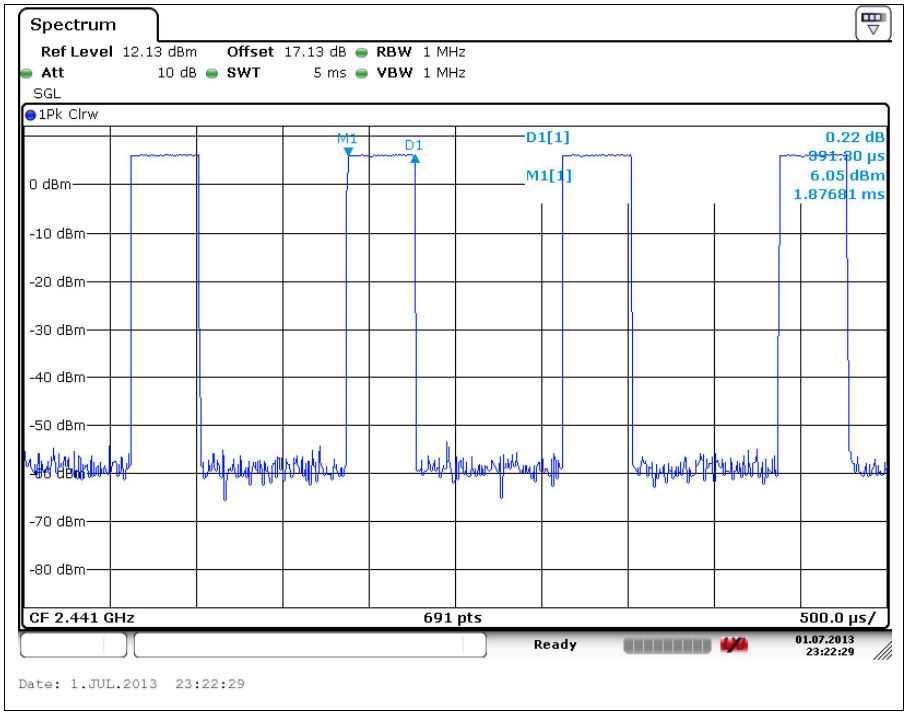
Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

7.4.1. Packet Type: DH1, 3-DH1

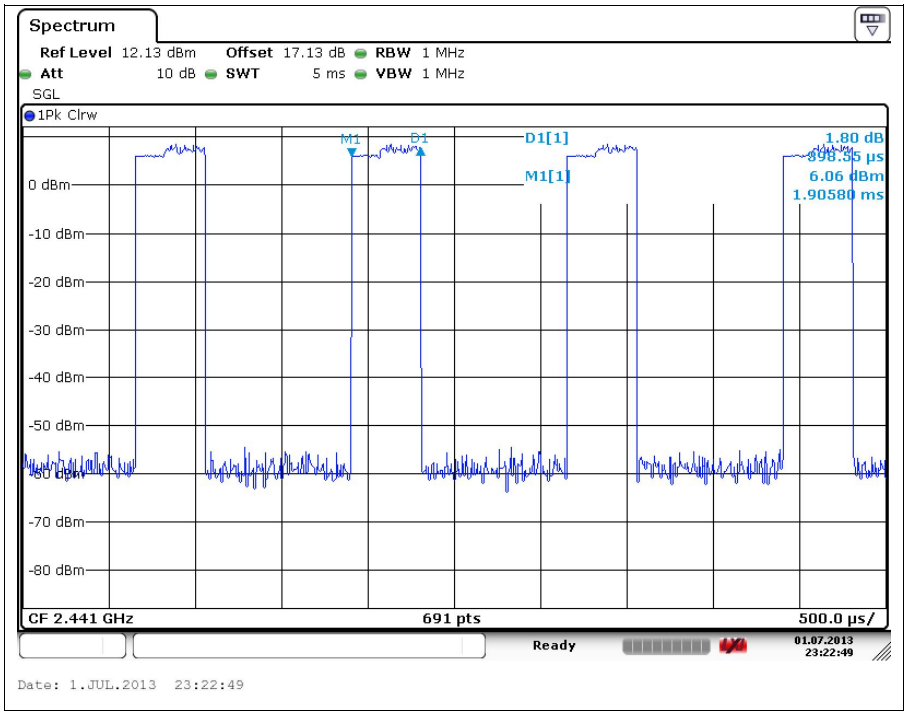
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	0.39	124.80	400
8DPSK	2 441 ㎒	0.40	128.00	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK, 0.39 × {(1600 ÷ 2) / 79} × 31.6 = 124.80 ㎳
In case of 8DPSK, 0.40 × {(1600 ÷ 2) / 79} × 31.6 = 128.00 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

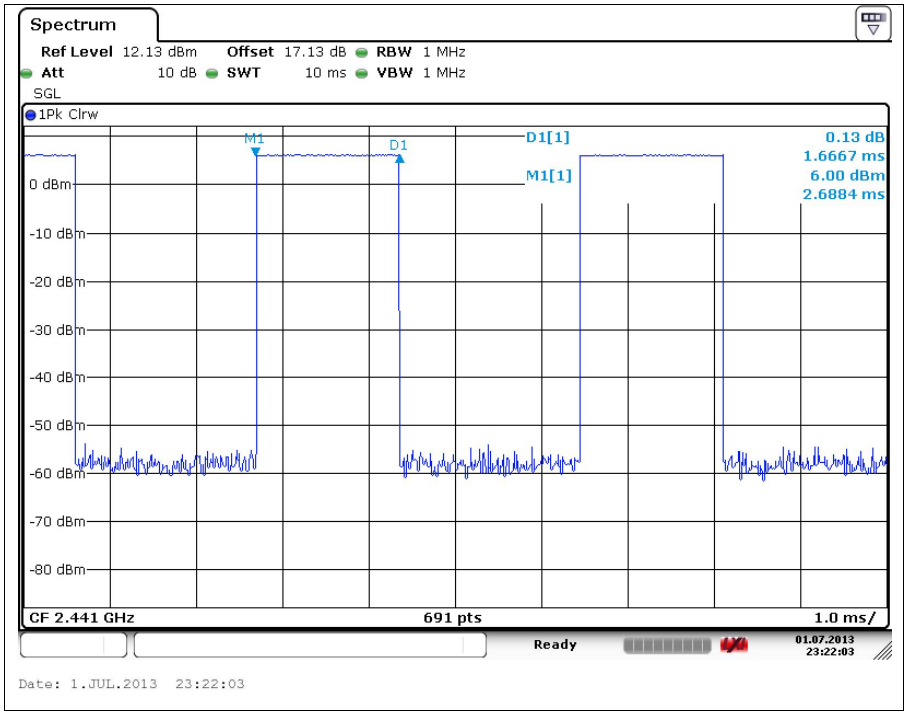


7.4.2. Packet Type: DH3, 3-DH3

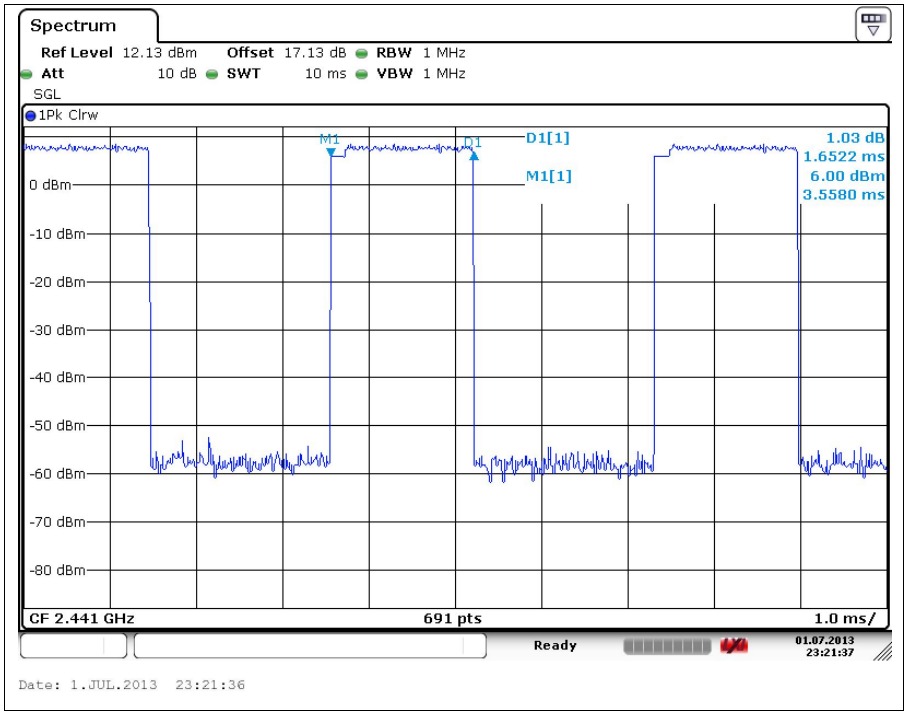
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	1.67	267.20	400
8DPSK	2 441 ㎒	1.65	264.00	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK, 1.67 × {(1600 ÷ 4) / 79} × 31.6 = 267.20 ㎳
In case of 8DPSK, 1.65 × {(1600 ÷ 4) / 79} × 31.6 = 264.00 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

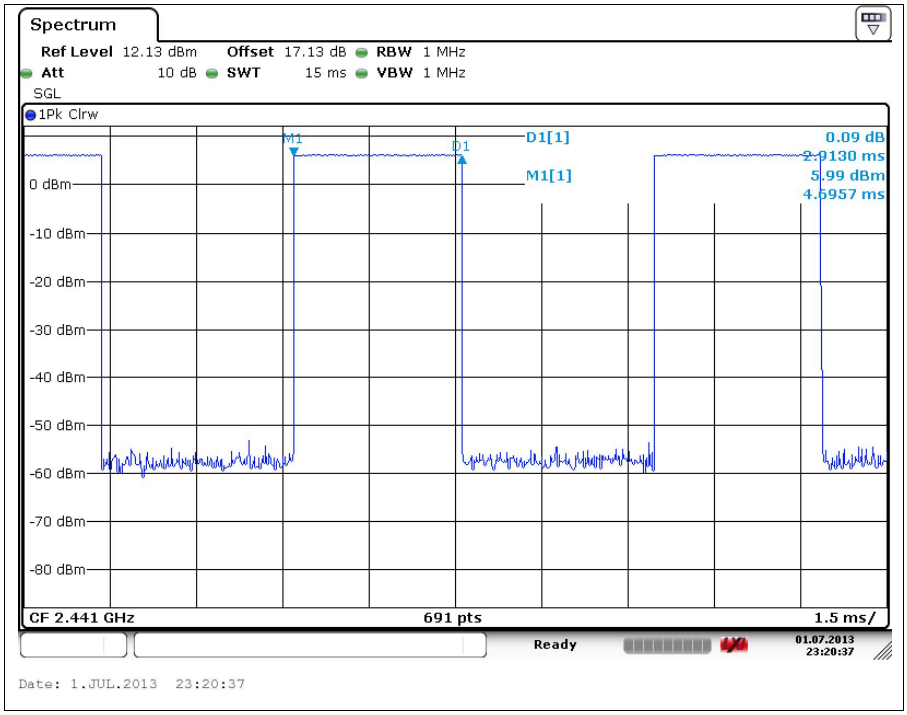


7.4.3. Packet Type: DH5, 3-DH5

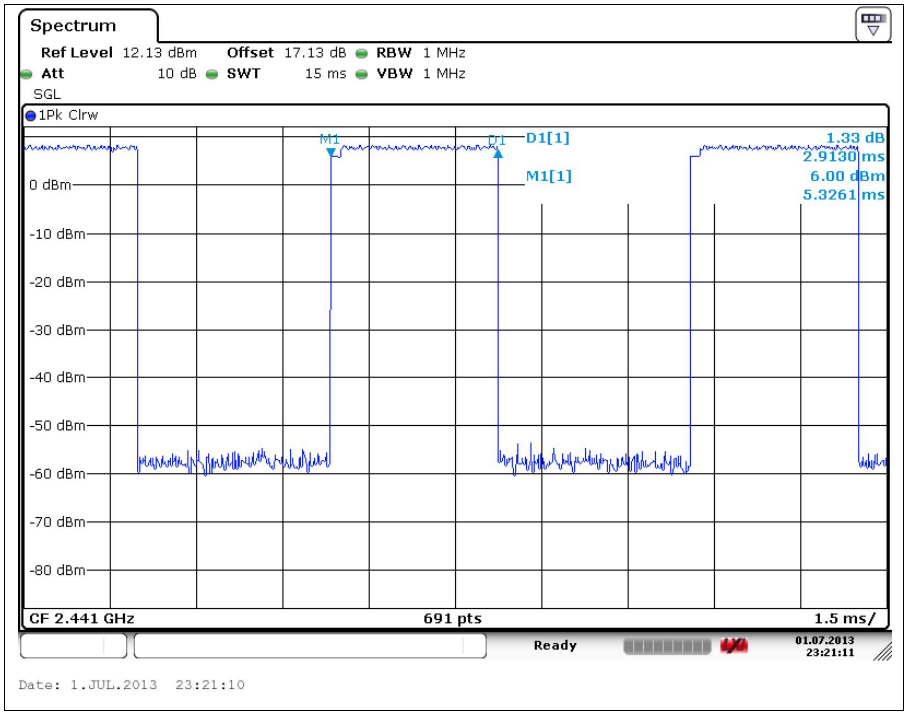
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 31.6 sec (㎳)	Limit for time of occupancy on the Tx Channel in 31.6 sec (㎳)
GFSK	2 441 ㎒	2.91	310.40	400
8DPSK	2 441 ㎒	2.91	310.40	400

Note:
Time of occupancy on the TX channel in 31.6 sec
In case of GFSK and 8DPSK, 2.91 × {(1600 ÷ 6) / 79} × 31.6 = 310.40 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

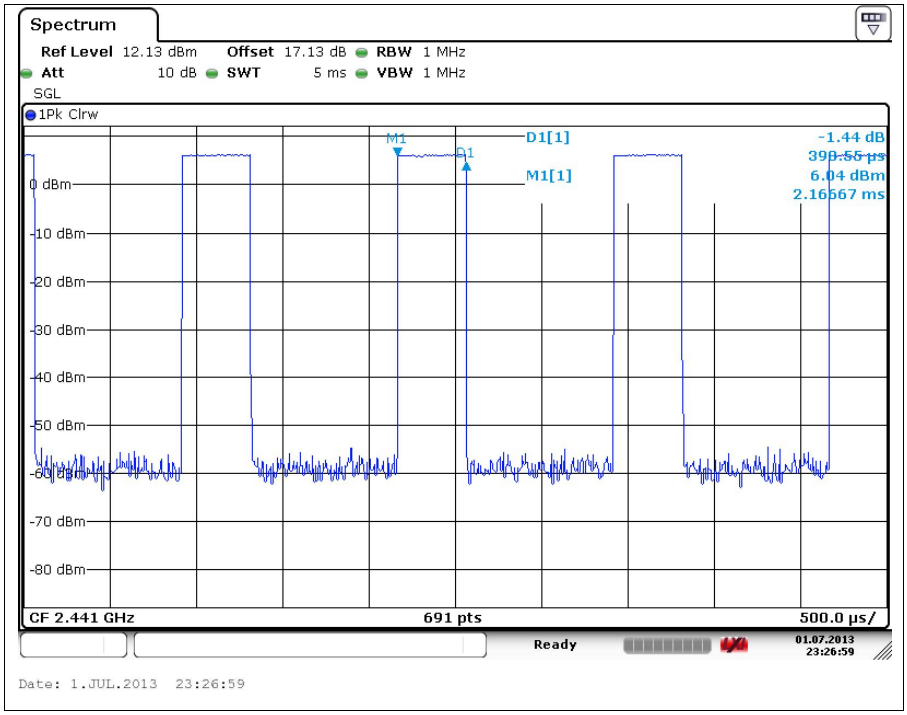


7.4.4. Packet Type: DH1, 3-DH1 (Adaptive Frequency Hopping)

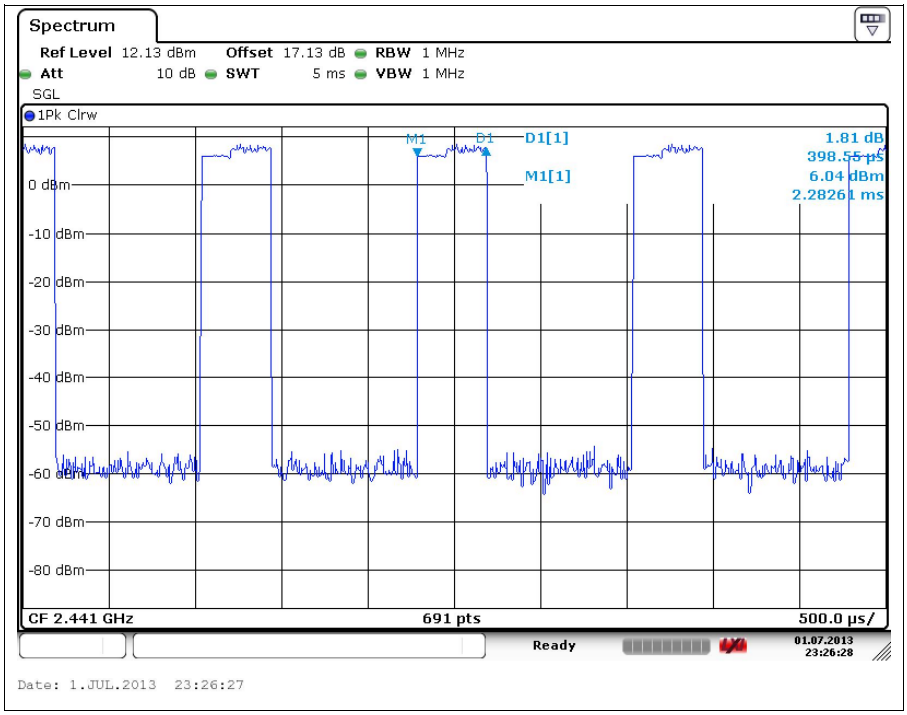
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	0.40	64.00	400
8DPSK	2 441 ㎒	0.40	64.00	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK and 8DPSK, 0.40 × {(800 ÷ 2) / 20} × 8 = 64.00 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

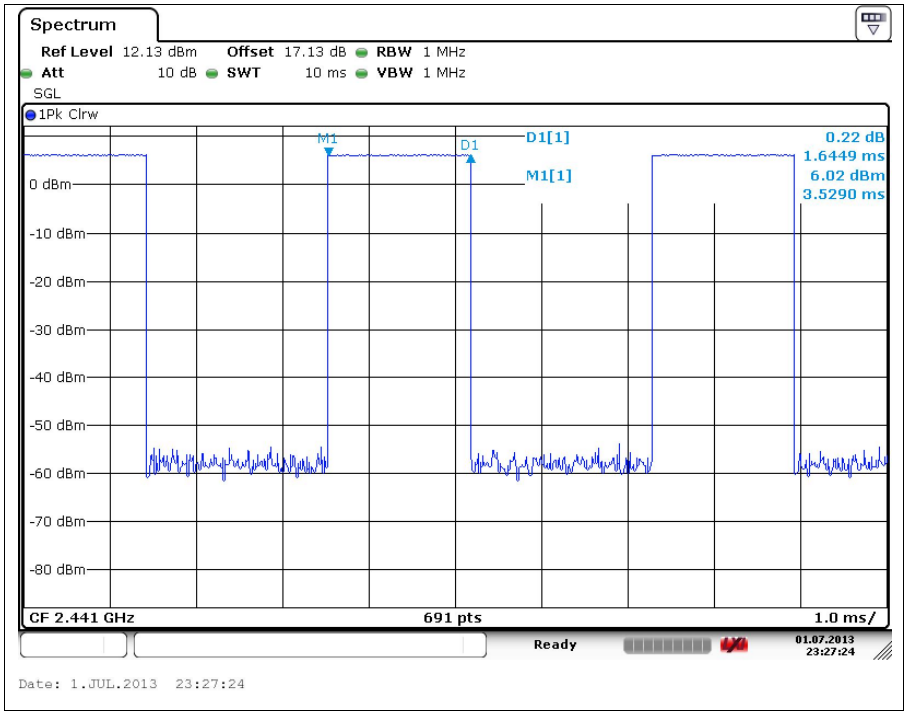


7.4.5. Packet Type: DH3, 3-DH3 (Adaptive Frequency Hopping)

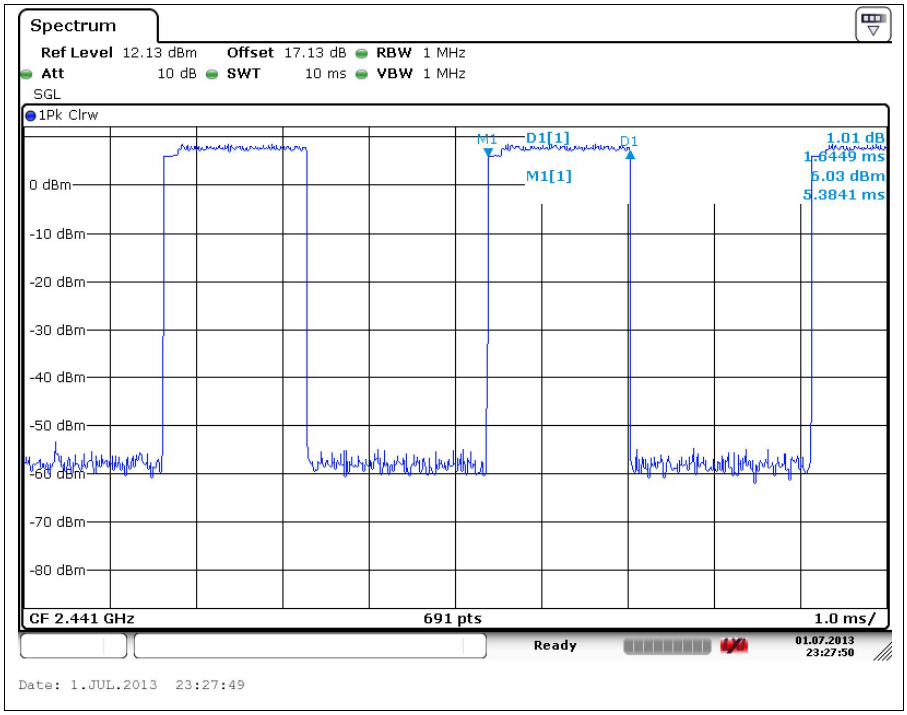
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	1.64	131.20	400
8DPSK	2 441 ㎒	1.64	131.20	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK and 8DPSK, 1.64 × {(800 ÷ 4) / 20} × 8 = 131.20 ㎳

Operating Mode: GFSK



Operating Mode: 8DPSK

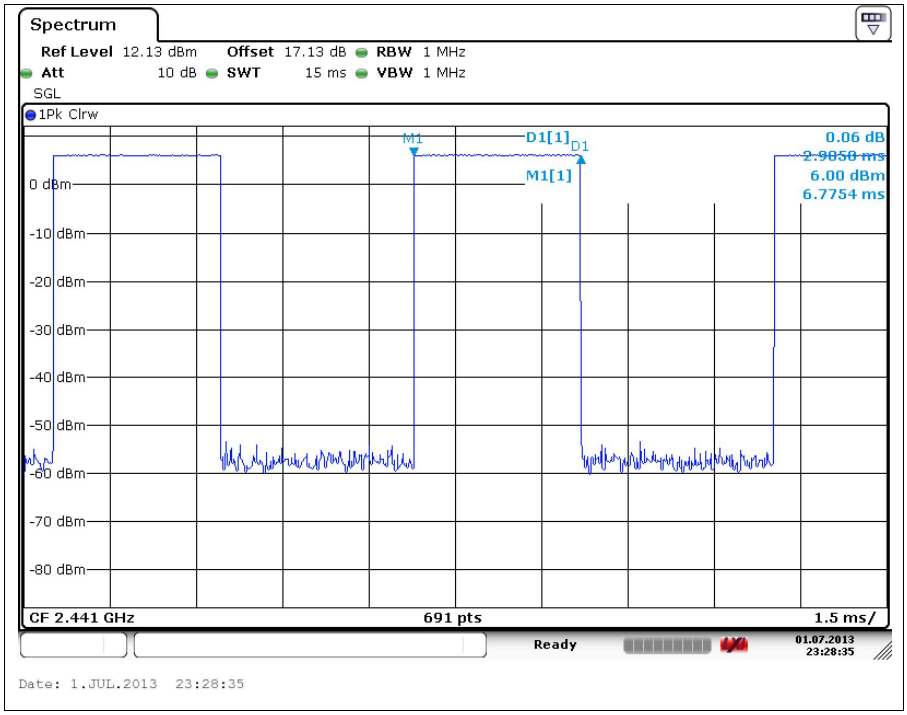


7.4.6. Packet Type: DH5, 3-DH5 (Adaptive Frequency Hopping)

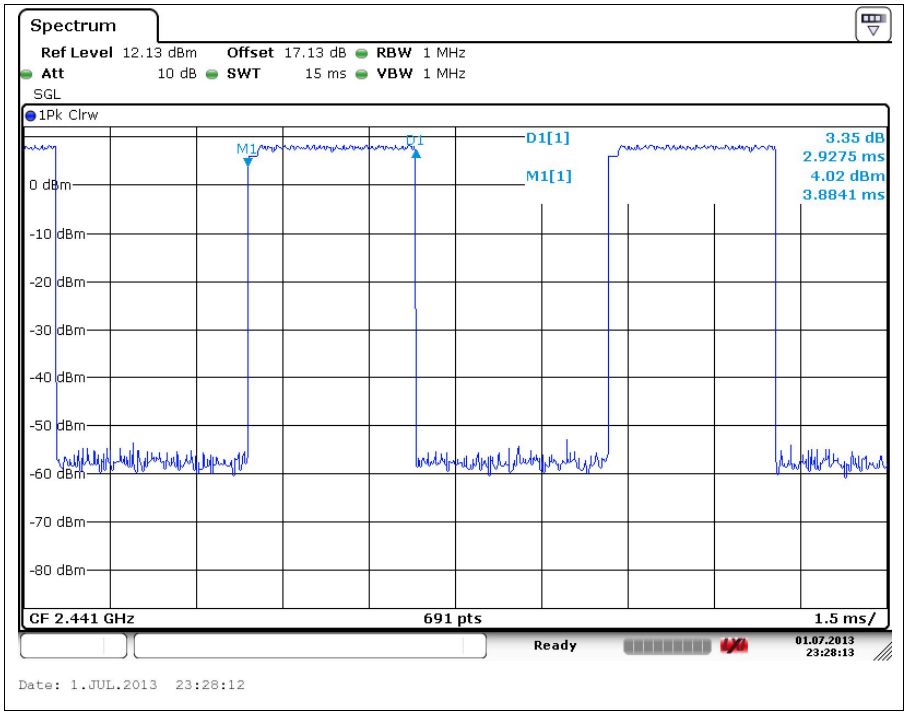
Operation Mode	Frequency	Dwell Time (㎳)	Time of occupancy on the Tx Channel in 8 sec (㎳)	Limit for time of occupancy on the Tx Channel in 8 sec (㎳)
GFSK	2 441 ㎒	2.91	155.20	400
8DPSK	2 441 ㎒	2.93	156.27	400

Note:
Time of occupancy on the TX channel in 8 sec
In case of GFSK, 2.91 × {(800 ÷ 6) / 20} × 8 = 155.20 ㎳
In case of 8DPSK, 2.93 × {(800 ÷ 6) / 20} × 8 = 156.27 ㎳

Operating Mode: GFSK

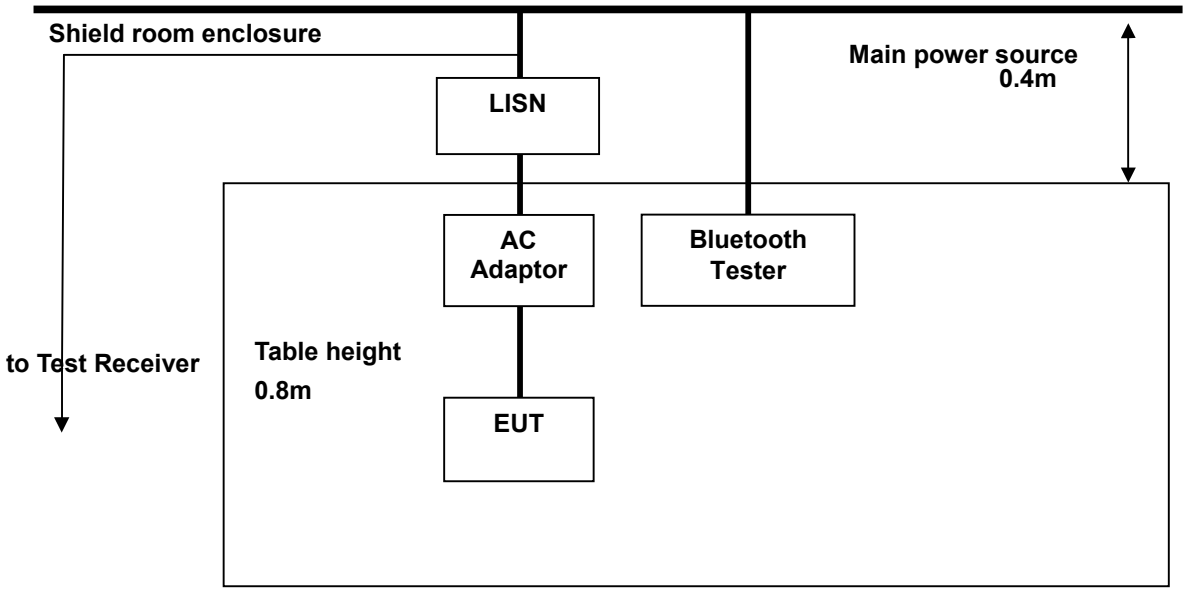


Operating Mode: 8DPSK



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 ㎑ to 30 ㎒, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network(LISN).
Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency of Emission (㎒)	Conducted limit (㏈ μV)	
	Quasi-peak	Average
0.15 – 0.50	66 - 56*	56 - 46*
0.50 – 5.00	56	46
5.00 – 30.0	60	50

* Decreases with the logarithm of the frequency.

8.3. Test Procedures

AC power line conducted emissions from the EUT were measured according to the dictates of ANSI C63.4:2003

All data rates and modes were investigated for this test. The full data for the worst case data rate are reported in this section.

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

8.4. Test Results (Worst case configuration_GFSK mode, 1 Mbps, Middle channel)

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

Ambient temperature : (23 ± 2) ℃
Relative humidity : 47 % R.H.

Frequency range : 0.15 ㎒ – 30 ㎒
Measured Bandwidth : 9 ㎑

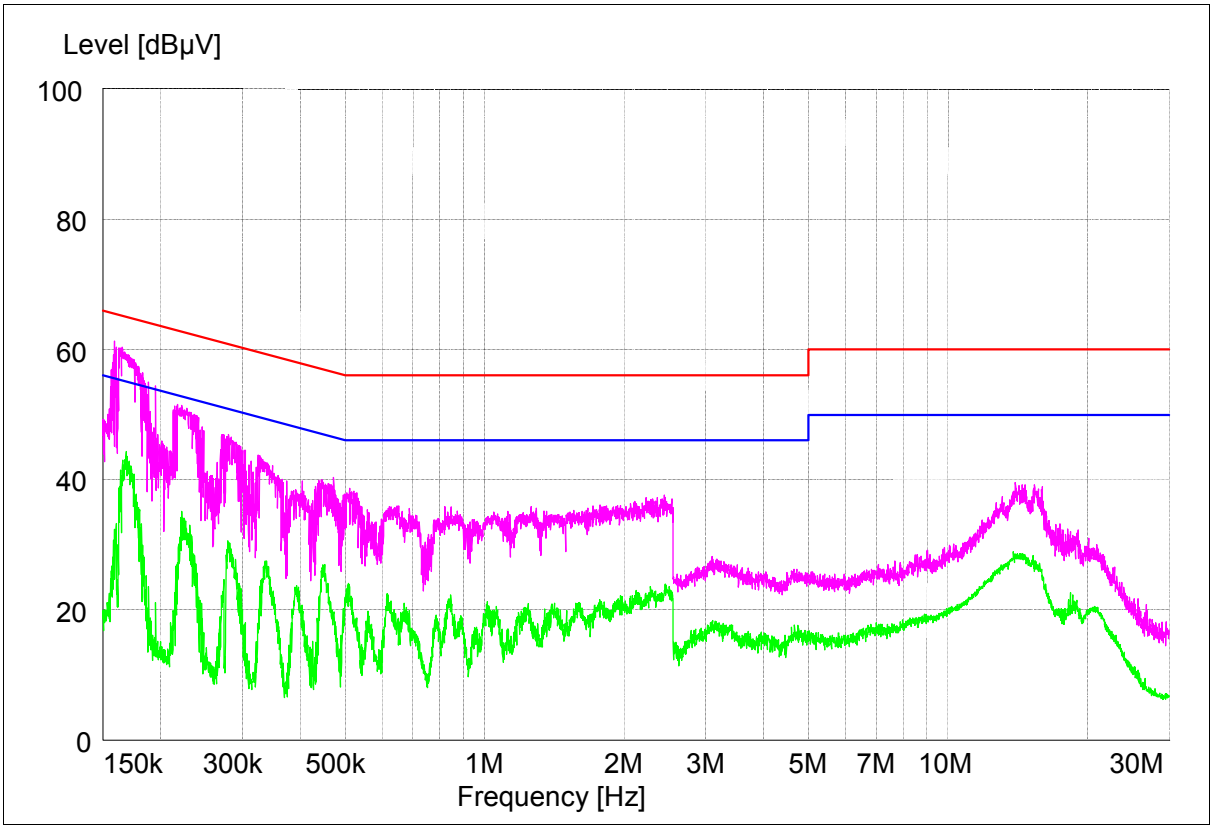
FREQ.	LEVEL(dB㎶)		LINE	LIMIT(dB㎶)		MARGIN(dB)	
(㎒)	Q-Peak	Average		Q-Peak	Average	Q-Peak	Average
0.16	46.38	31.08	N	65.53	55.53	19.15	24.45
0.22	38.78	23.78	N	62.94	52.94	24.16	29.16
0.28	31.28	16.88	N	60.82	50.82	29.54	33.94
0.47	23.59	14.69	N	56.49	46.49	32.90	31.80
2.44	22.52	17.12	N	56.00	46.00	33.48	28.88
13.95	33.00	28.50	N	60.00	50.00	27.00	21.50
0.39	36.61	29.51	H	58.15	48.15	21.54	18.64
0.48	22.71	12.11	H	56.39	46.39	33.68	34.28
0.67	23.81	17.11	H	56.00	46.00	32.19	28.89
2.30	26.05	20.85	H	56.00	46.00	29.95	25.15
15.17	35.14	29.24	H	60.00	50.00	24.86	20.76
16.34	34.25	27.85	H	60.00	50.00	25.75	22.15

Note ;

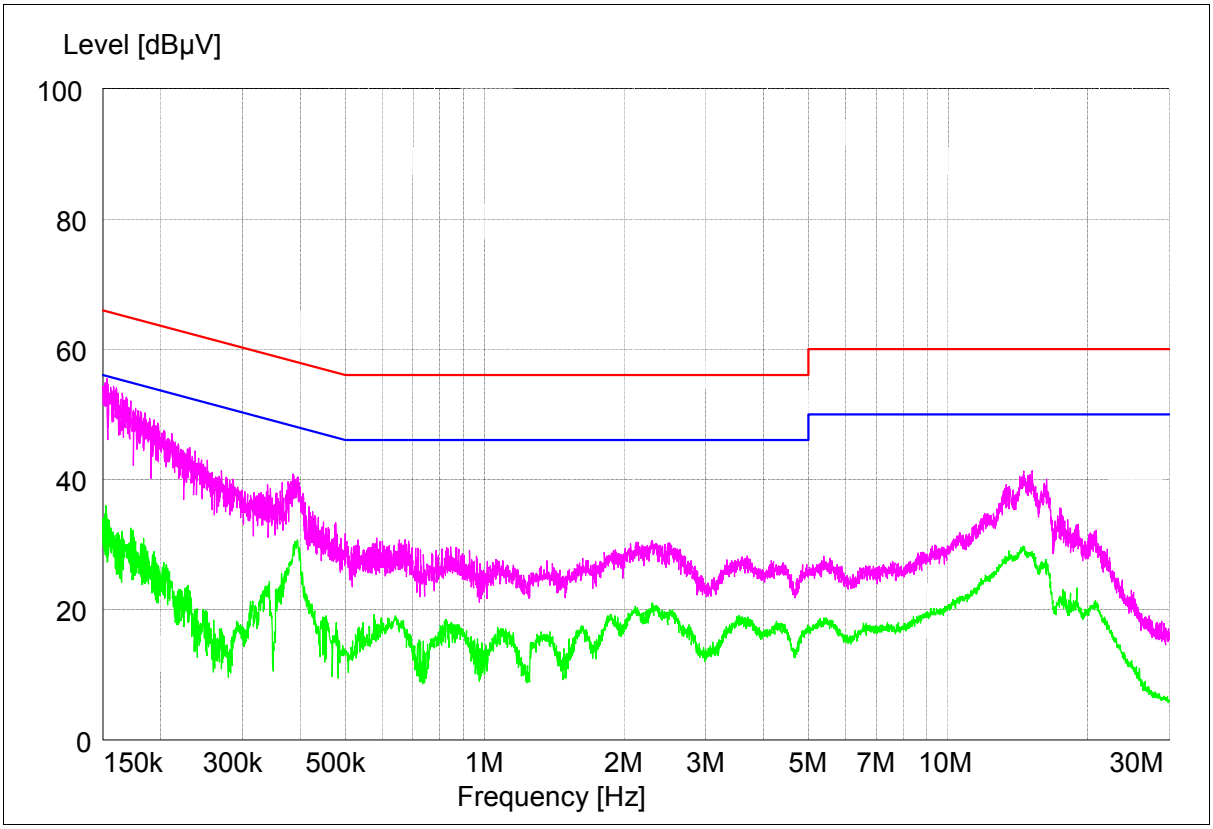
1. Line (H): Hot, Line (N): Neutral
2. All modes of operation were investigated and the worst-case emissions are reported using GFSK_1Mbps
3. The limit for Class B device(s) from 150 ㎑ to 30 ㎒ are specified in Section of the Title 47 CFR.
4. Traces shown in plot mad using a peak detector and average detector
5. Deviations to the Specifications: None.

Plot of Conducted Power line

Test mode: (Neutral)



Test mode: (Hot)



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 Internal type with gain of -3.78 dBi.