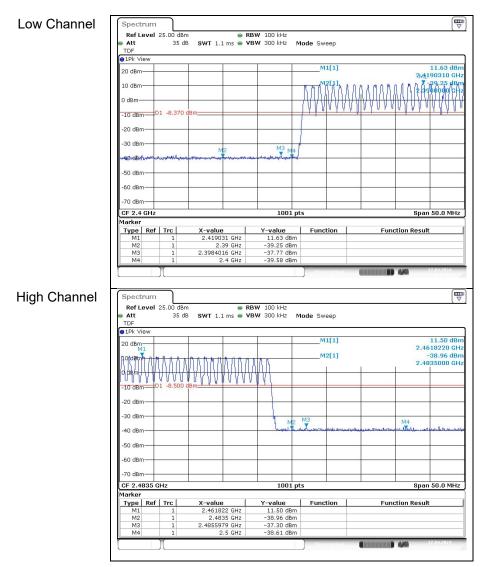


Report Number: F690501-RF-RTL004993

### Mode: GFSK\_hopping function turned on

### Band edge compliance





## Report Number: F690501-RF-RTL004993

## Mode: 8DPSK\_hopping function turned off

Low channel

TDF 1Pk View				
20 dBm			11[1]	7.63 dB 2.4018480 G
10 dBm		MI	12[1]	-40.45 dB 2.3900000 G
0 dBm		+	<u> </u>	2.090000 0
-10 dBm D1 -12.370	dBm	++++		
-20 dBm				
-30 dBm	M2 M3	1		
well-dependent with the second		with May hours	www.morenary.art.thethe	allal more water water
-50 dBm				
-60 dBm				
-70 dBm				
CF 2.4 GHz Marker		1001 pts		Span 50.0 MH
Type Ref Trc	X-value	Y-value Fund	tion	Function Result
M1 1 M2 1	2.401848 GHz 2.39 GHz	7.63 dBm -40.45 dBm		
M3 1 M4 1	2.3934066 GHz 2.4 GHz	-39.22 dBm -40.90 dBm		
		i Ne	swring 💷 💷	17.04.2024
				G
Ref Level 20.00 dBn		RBW 1 MHz		(
Att 30 di			еер	
TDF 1Pk View				
10 dBm	M1	M	11[1]	9.75 dE 2.402279 G
		M	2[1]	-24.71 dB 3.121002 G
0 dBm				
-10 dBm D1 -12.370	dBm			
-20 dBm	M2			
-30 dBm		and a state of the second	A musicipality of a star	And the second starts second starts
-40 com				
-50 dBm				
-60 dBm				
-70 dBm				
Start 9.0 kHz Marker		32001 pts		Stop 10.0 GH
Type Ref Trc M1 1	X-value 2.402279 GHz	Y-value Fund 9.75 dBm	tion	Function Result
M1 1 M2 1	3.121002 GHz	-24.71 dBm		
		nie-	aswing	
- Cin a atmum				ſ
Ref Level 13.00 dBn	n 🖷 RE	W 1 MHz		(
Att 25 dt TDF	3 SWT 45 ms 👄 VE	W 3 MHz Mode Swee	p	
●1Pk View	1		11[1]	-25.70 dB
10 dBm				24.372130 G
0 dBm				
-10 dBm D1 -12.370	dBm	+ +		
-20 dBm				M1
-30 dBm		All of the state o	and and property light and a profession	teres and the standing sales in the
-40-80	and the second			
-50 dBm				
-60 dBm				
-70 dBm				
-70 dBm				
		32001 pts		Stop 25.0 GH



# Report Number: F690501-RF-RTL004993

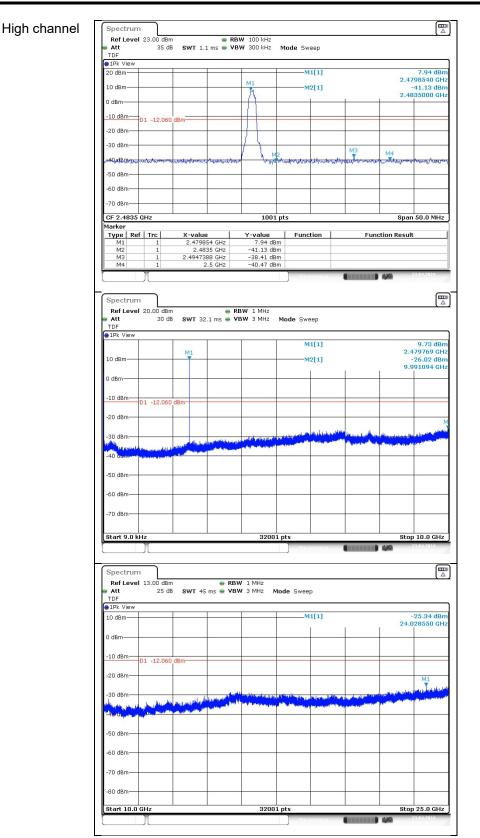


	● R SWT 1.1 ms ● V	3W 100 kHz 3W 300 kHz Mode	Sweep	
TDF 1Pk View				
20 dBm			_M1[1]	8.85 dB 2.4410000 GI
10 dBm		M1		
0 dBm		<u> </u>	_	
-10.dBm-D1 -11.150	dBm			
-20 dBm-				
-30 dBm				
100 TO 100		June 11		
por and a state of the second second	by and the particular of the second	a a a	when the second states and	and the second
-50 dBm				
-60 dBm				
-70 dBm				
CF 2.441 GHz Marker		1001 pts		Span 50.0 MH
Type Ref Trc	X-value		unction	Function Result
M1 1	2.441 GHz	8.85 dBm	Neasuring	17.04.2024
			-	
Spectrum				Ē
Ref Level 20.00 dBm Att 30 dB	●   SWT 32.1 ms ● 1	RBW 1 MHz /BW 3 MHz Mode	Sween	
TDF	3W1 32.1 IIS	ion sinitz mode	3weeb	
• 1Pk View	M1		M1[1]	11.78 dB
10 dBm			M2[1]	2.441029 GI -25.83 dB
0 dBm				9.849224 G
-10.dBm-01 -11.150	dBm			
-20 dBm				
-30 dBm	lt al ma		a standard and a state	and the second s
-40 comments and a sub-				
-50 dBm				
-60 dBm				
-70 dBm				
Start 9.0 kHz		32001 pts		Stop 10.0 GH
Marker Type   Ref   Trc	X-value	Y-value F	unction	Function Result
M1 1 M2 1	2.441029 GHz 9.849224 GHz	11.78 dBm -25.83 dBm		
			Measuring	17.04.2024
Spectrum				
		W 1 MHz W 3 MHz Mode S	veep	
TDF 1Pk View				
10 dBm			_M1[1]	-25.92 dB 24.140100 G
0 dBm				
-10 dBm-D1 -11.150	dBm			
-20 dBm	ubin			
				M1
-30 dBm	The second s	Party Service and Services		
- Personal and a second s	and the set of the set			
-50 dBm				
-60 dBm			_	
-70 dBm				
-80 dBm				
		00771		
Start 10.0 GHz Marker Type   Ref   Trc		32001 pts		Stop 25.0 GH



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Page:	33	of	58
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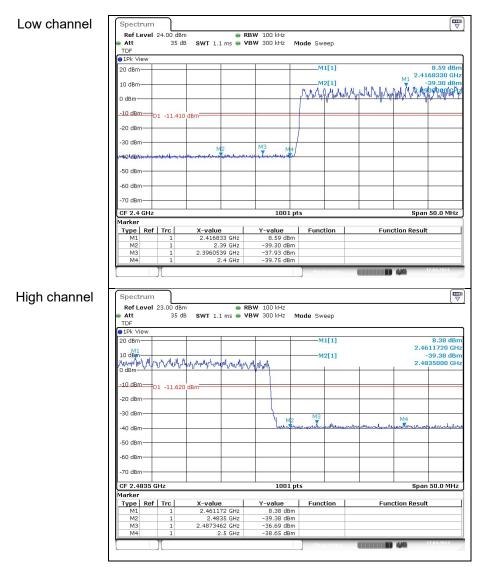




Report Number: F690501-RF-RTL004993

### Mode: 8DPSK\_hopping function turned on

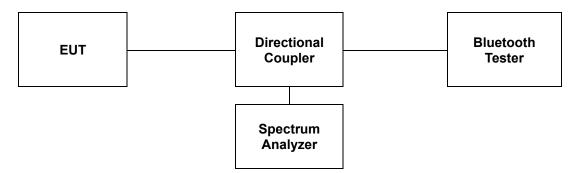
### Band edge compliance





# 3. 20 dB Bandwidth and 99 % Bandwidth

# 3.1. Test Setup



# 3.2. Limit

Limit: Not Applicable

# 3.3. Test Procedure

## **3.3.1. 20** dB **Bandwidth**

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  $\ge$  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.



## 3.3.2. 99 % Bandwidth

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1 % to 5 % of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99 % emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5 % of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99 % emission bandwidth).



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# 3.4. Test Results

Ambient temperature:  $(23 \pm 1)$  °CRelative humidity: 47 % R.H.

Mode	Data Rate (Mbps)	Channel	Frequency (₩z)	20 dB Bandwidth (M৳)	99 % Bandwidth (∰2)
		Low	2 402	0.878	0.854
GFSK	1	Middle	2 441	1.034	0.878
		High	2 480	1.034	0.878
		Low	2 402	1.337	1.172
π/4DQPSK	2	Middle	2 441	1.340	1.172
		High	2 480	1.334	1.172
		Low	2 402	1.286	1.160
8DPSK	3	Middle	2 441	1.268	1.163
		High	2 480	1.301	1.175

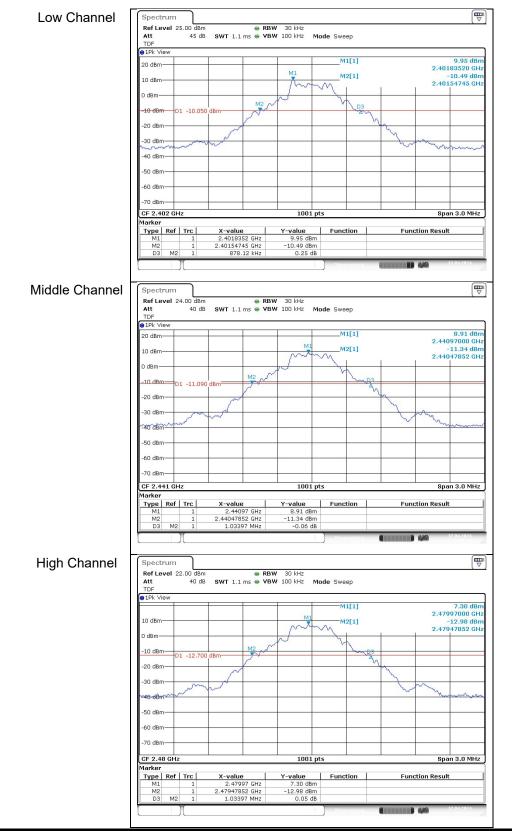


## Report Number: F690501-RF-RTL004993

### - Test plots

### $\textbf{20} \hspace{0.1 cm} dB \hspace{0.1 cm} \textbf{Bandwidth}$

### Mode: GFSK

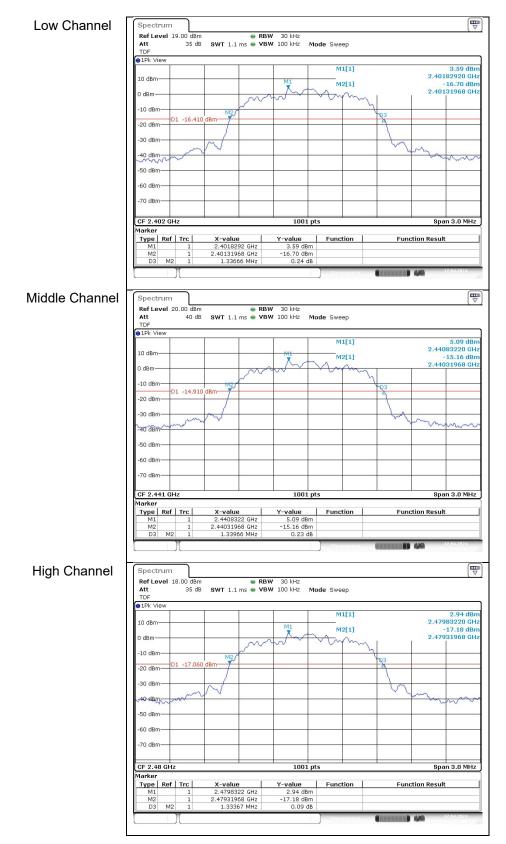




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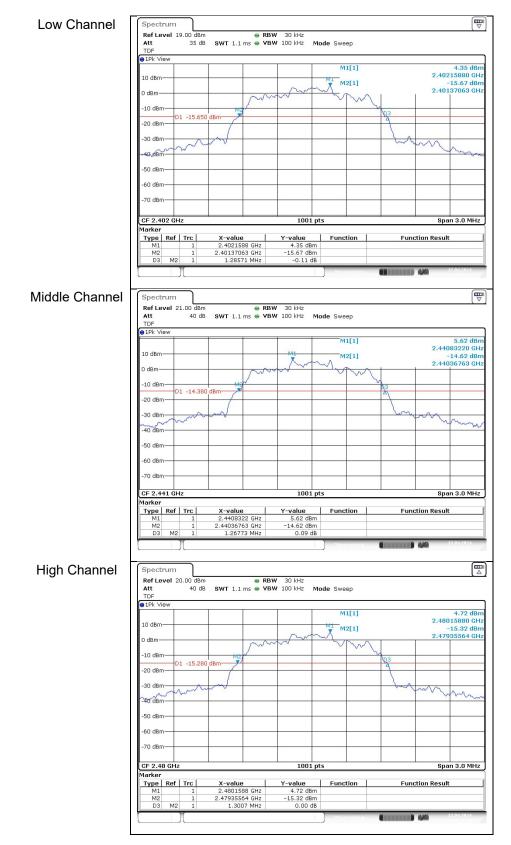
### Mode: π/4DQPSK





## Report Number: F690501-RF-RTL004993

### Mode: 8DPSK

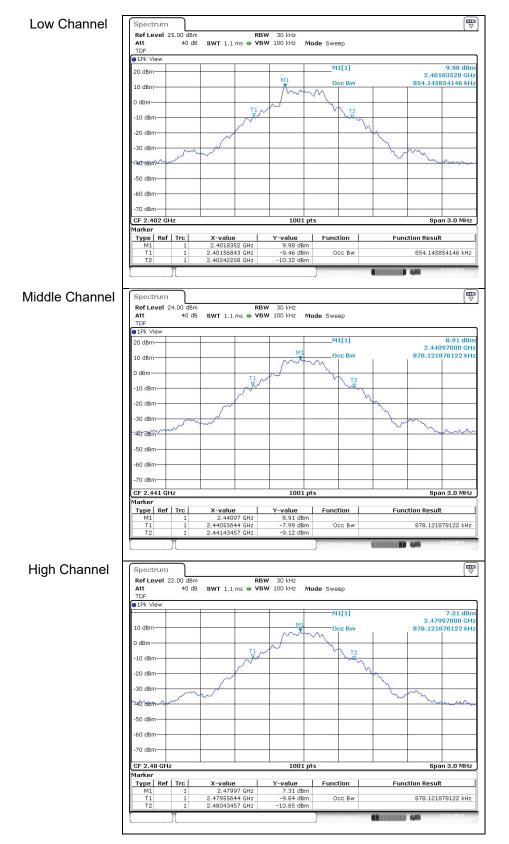




Report Number: F690501-RF-RTL004993

### 99 % Bandwidth

### Mode: GFSK

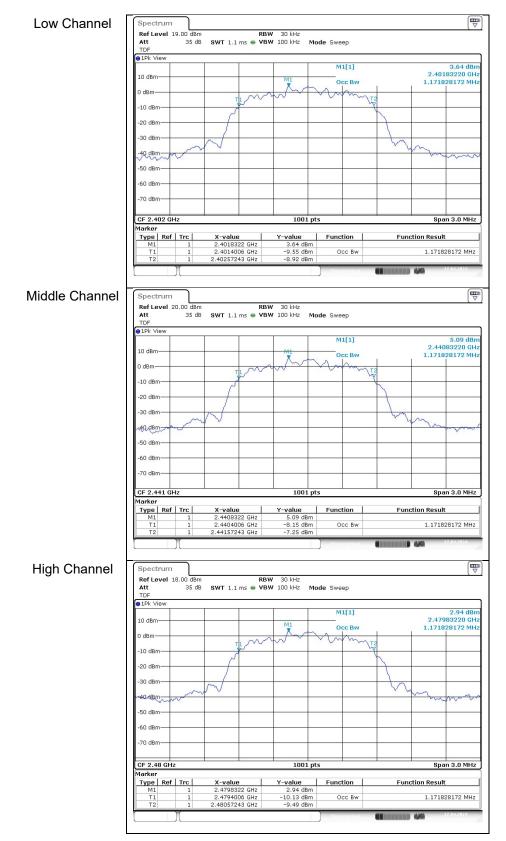




## Report Number: F690501-RF-RTL004993

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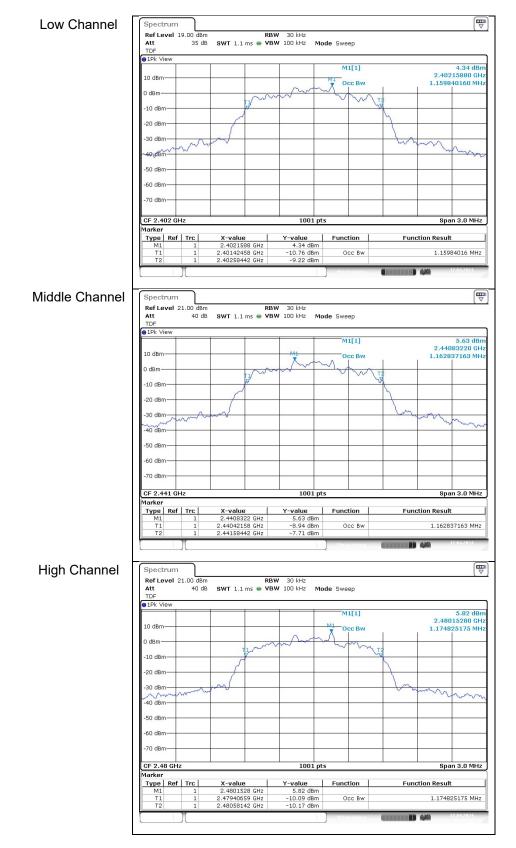
## Mode: π/4DQPSK





## Report Number: F690501-RF-RTL004993

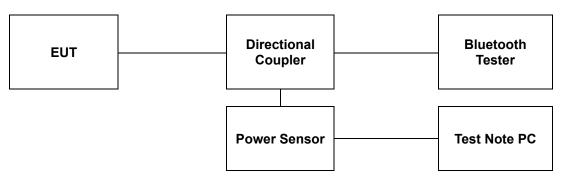
### Mode: 8DPSK





# 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 Mb band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725-5 850 Mb band: 1 watt. For all other frequency hopping systems in the 2 400-2 483.5 Mb band: 0.125 watts.

## 4.2.2. IC

- 1. According to RSS-247 Issue 3, 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 3, 5.4(b), for FHSs operating in the band 2 400-2 483.5 Mb, 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 each channel.



Report Number: F690501-RF-RTL004993

# 4.4. Test Results

Ambient temperature:  $(23 \pm 1)$  °CRelative humidity: 47 % R.H.

Mode	Data Rate (Mbps)	Channel	Frequency (Mb)	Average Power Result (dB m)	Peak Power Result (ⓓB m)	Limit (dB m)
		Low	2 402	<u>12.07</u>	<u>12.51</u>	
GFSK	1	Middle	2 441	11.96	12.39	
		High	2 480	12.00	12.43	
		Low	2 402	<u>9.00</u>	<u>11.86</u>	
π/4DQPSK	2	Middle	2 441	8.91	11.75	20.97
		High	2 480	8.85	11.75	
		Low	2 402	<u>8.95</u>	<u>12.33</u>	
8DPSK	3	Middle	2 441	8.77	12.30	
		High	2 480	8.79	12.30	

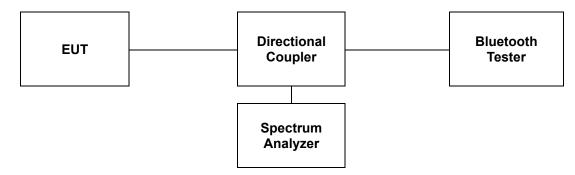
### Remark;

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



# 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 3, 5.1(b), FHSs shall have hopping channel carrier frequencies separated by a minimum of 25  $kl_{2}$  or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2 400-2 483.5  $Ml_{2}$  may have hopping channel carrier frequencies that are separated by 25  $kl_{2}$  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 section 7.8.2 Carrier frequency separation of 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 ≥ RBW
- 4. Sweep: Auto
- 5. Detector function: 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 :	<b>± 1)</b> ℃
Relative humidity	:	47	% R.H.

Mode	Frequency (쌘)	Adjacent Hopping Channel Separation (啦)	Two-third of 20 dB Bandwidth (虚)
GFSK	2 441	1 000	0.689
8DPSK	2 441	1 000	0.845

### 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.

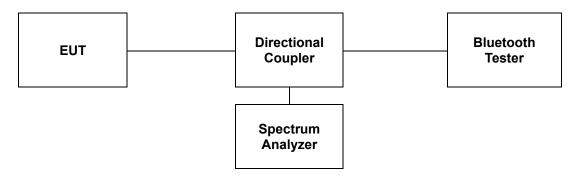
## - Test plots

GFSK	8DPSK
Spectrum Ref Level 27.00 dBm RBW 300 kHz   Att 45 dB SWT 1 ms VBW 300 kHz   TDF JPk View 12,2,441000   20 dBm 0 dBm 2,441000   10 dBm 1,000 1,000   -20 dBm -10 dBm -10 dBm   -30 dBm -40 dBm -10 dBm	Image: Spectrum Image: Sp
-50 dBm	
Marker Type Ref Trc X-value Y-value Function Function Result   M1 1 2:441 GHz 12:17 dbm 1000 GHz	Marker Yvgl Ref Trc X-value Y-value Function Function Result   M1 1 2.441 GHz 9.05 dBm



# 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 Mb 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 3, 5.1(d), FHSs operating in the band 2 400-2 483.5 Mb 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 section 7.8.3 Number of hopping frequencies of 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 ≥ 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

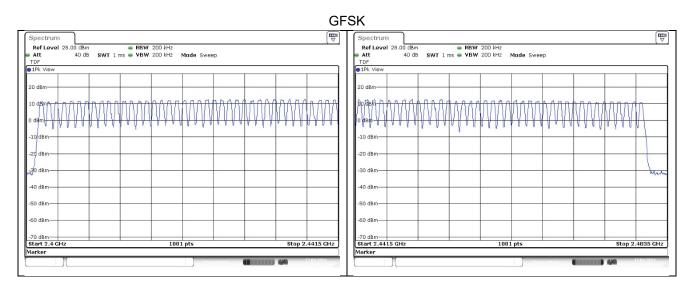
Ambient temperature	:	(23	± 1) ℃
Relative humidity	:	47	% R.H.

Mode	Number of Hopping Frequency	Limit
GFSK	79	≥ <b>15</b>
8DPSK	79	≥ 15

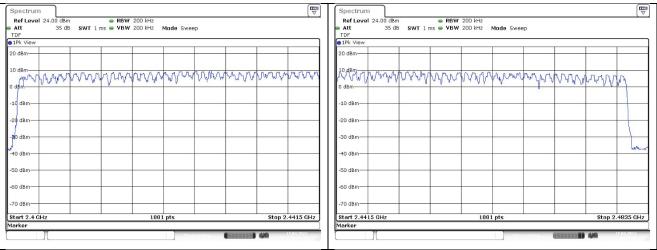
### Remark;

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



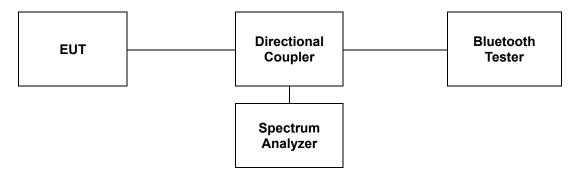
8DPSK





# 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 Mb 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 3, 5.1(d), FHSs operating in the band 2 400-2 483.5 Mb 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)



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## 7.3. Test Procedure

The test follows section 7.8.4 Time of occupancy of 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 shall be ≤ channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel.
- 3. Sweep = As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot.
- 4. Detector function: Peak
- 5. Trace: Max hold

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