FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

According to FCC §15.247(a) (1) (iii):

Frequency hopping systems in the 2400-2483.5 MHz 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.

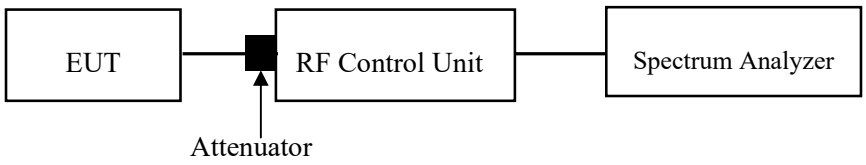
According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSs) operating in the band 2400-2483.5 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.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses



Note 1: A period time=0.4*79=31.6(S), Result=BurstWidth*Totalhops
Note 2: Totalhops=Hopping Number in 3.16s*10
Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s(Second high signals were other channel)

Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	51 %
ATM Pressure:	101 kPa

The testing was performed by Tom Tan on 2024-08-26 and 2024-08-27.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(b) (1) & RSS-247§ 5.1(b) &§ 5.4(b) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to FCC §15.247(b) (1):

For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

According to RSS-247§ 5.1(b) &§ 5.4(b):

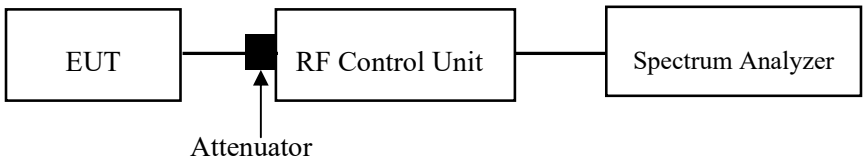
For frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (see Section 5.4(e) for exceptions).

Frequency hopping systems (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 2400-2483.5 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.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	24 ℃
Relative Humidity:	51 %
ATM Pressure:	101 kPa

The testing was performed by Tom Tan on 2024-08-26.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(d) & RSS-247 § 5.5 - BAND EDGES TESTING

Applicable Standard

According to FCC §15.247(d).

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)).

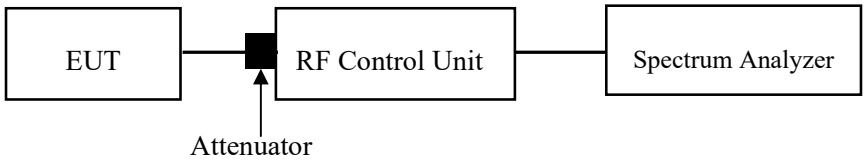
According to RSS-247 § 5.5.

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(e), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.6 & Clause 6.10

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 RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
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.



Test Data

Environmental Conditions

Temperature:	24 °C
Relative Humidity:	51 %
ATM Pressure:	101 kPa

The testing was performed by Tom Tan on 2024-08-26 and 2024-08-27.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

EUT PHOTOGRAPHS

Please refer to the attachment 2401V67572E-RF External photo and 2401V67572E-RF Internal photo.

TEST SETUP PHOTOGRAPHS

Please refer to the attachment 2401V67572E-RFA Test Setup photo.

APPENDIX

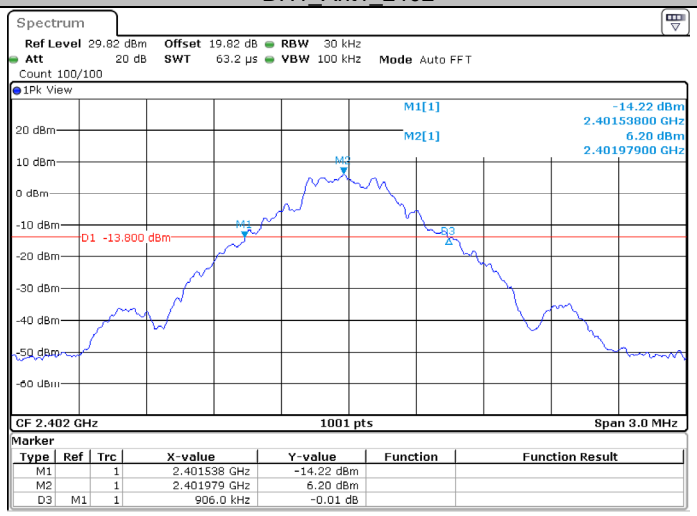
Appendix A: 20dB Emission Bandwidth

Test Result

Test Mode	Antenna	Channel	20dB EBW[MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.906	---	---
		2441	0.906	---	---
		2480	0.927	---	---
2DH1	Ant1	2402	1.260	---	---
		2441	1.260	---	---
		2480	1.269	---	---
3DH1	Ant1	2402	1.233	---	---
		2441	1.230	---	---
		2480	1.233	---	---

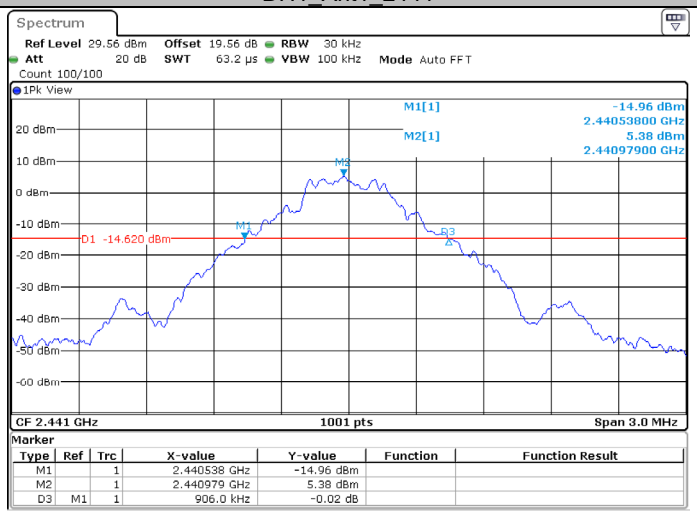
Test Graphs

DH1_Ant1_2402



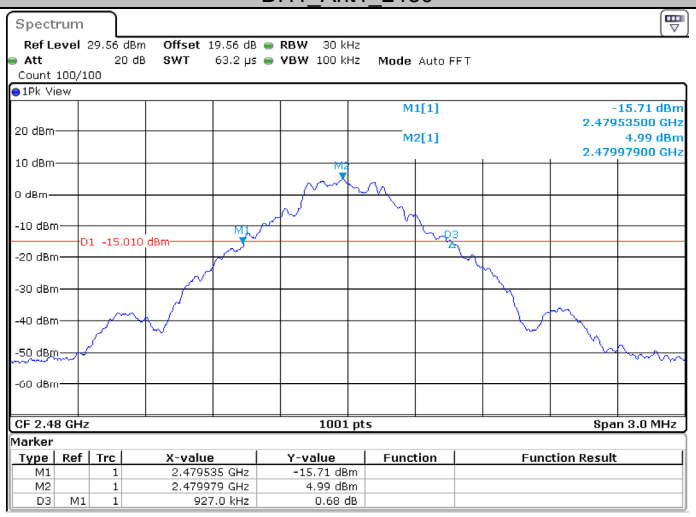
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:27:17

DH1_Ant1_2441



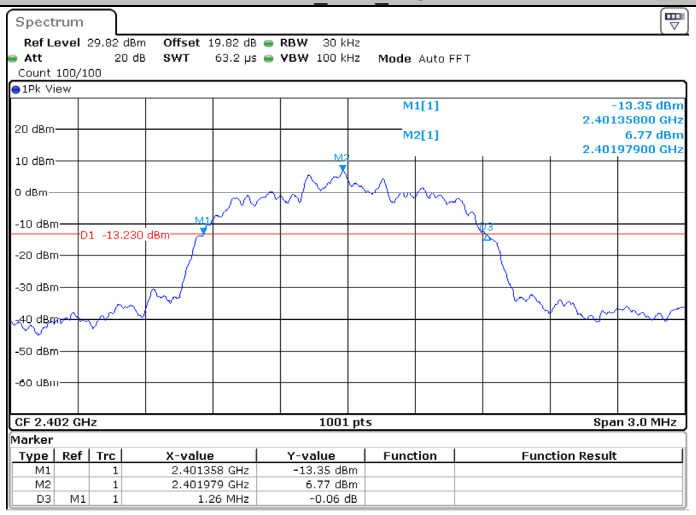
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:28:23

DH1_Ant1_2480



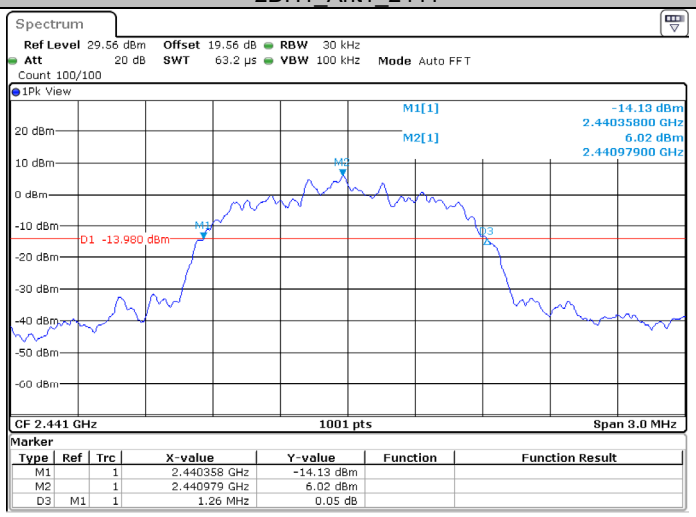
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:30:47

2DH1_Ant1_2402



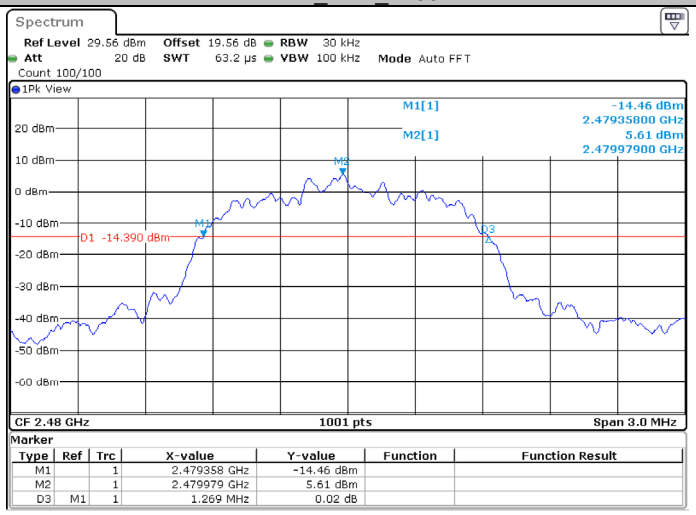
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:31:52

2DH1_Ant1_2441



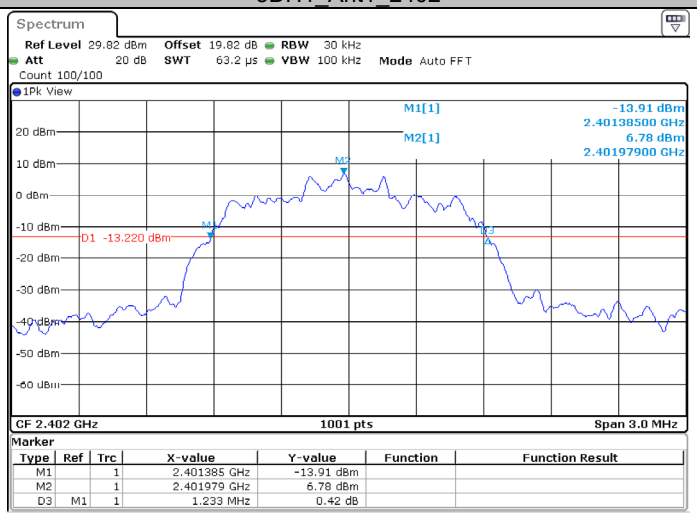
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:33:22

2DH1_Ant1_2480



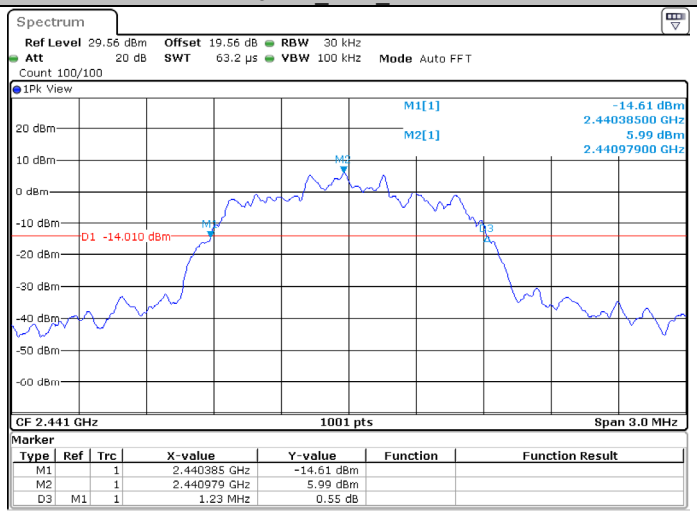
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:34:32

3DH1_Ant1_2402



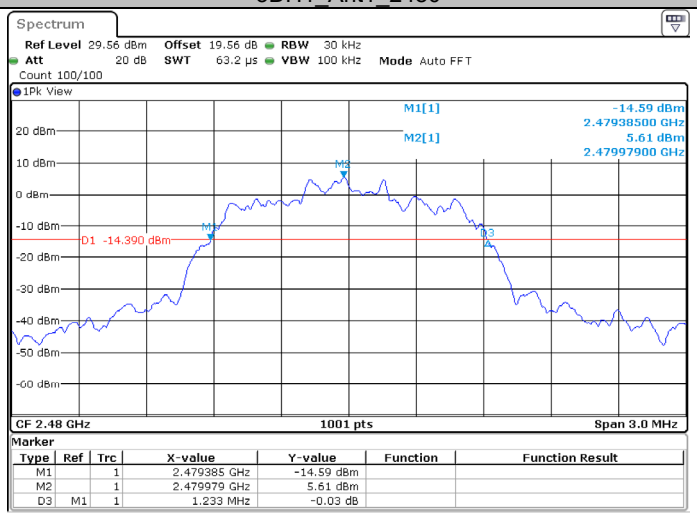
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:35:56

3DH1_Ant1_2441



ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:37:26

3DH1_Ant1_2480



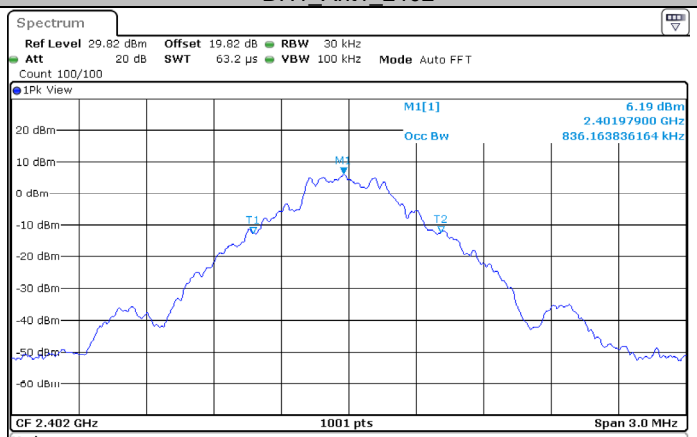
Appendix B: Occupied Channel Bandwidth

Test Result

Test Mode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.836	---	---
		2441	0.839	---	---
		2480	0.836	---	---
2DH1	Ant1	2402	1.157	---	---
		2441	1.157	---	---
		2480	1.160	---	---
3DH1	Ant1	2402	1.139	---	---
		2441	1.139	---	---
		2480	1.145	---	---

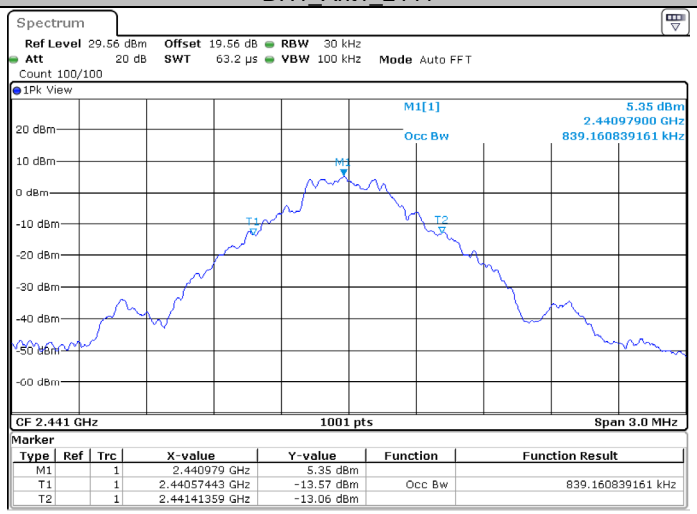
Test Graphs

DH1_Ant1_2402



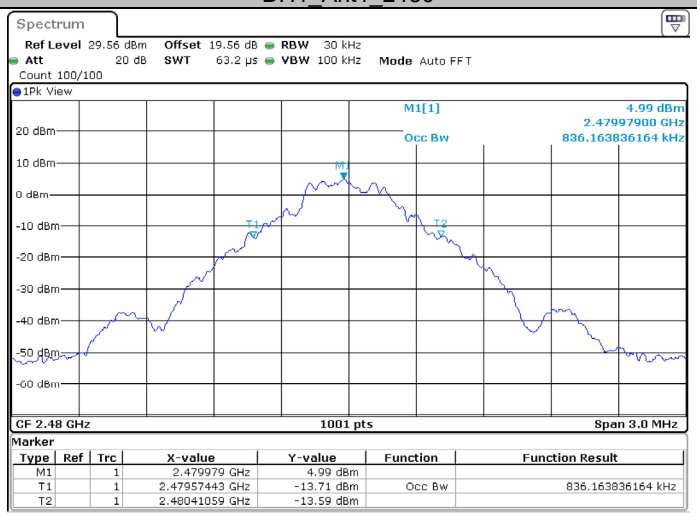
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:27:23

DH1_Ant1_2441



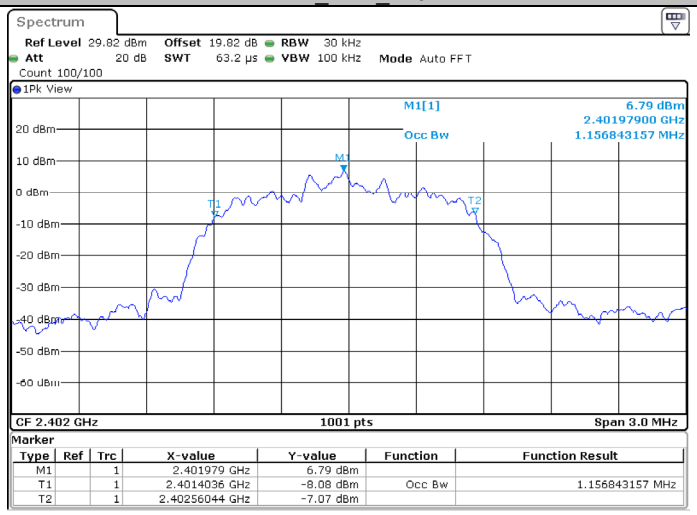
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:28:29

DH1_Ant1_2480



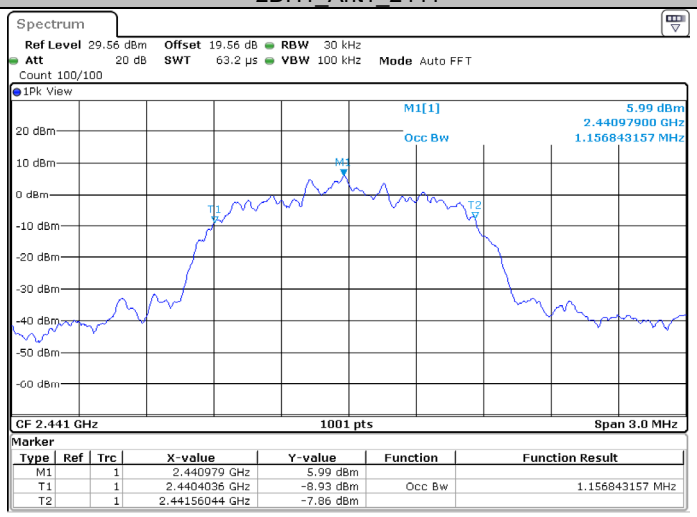
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:29:42

2DH1_Ant1_2402



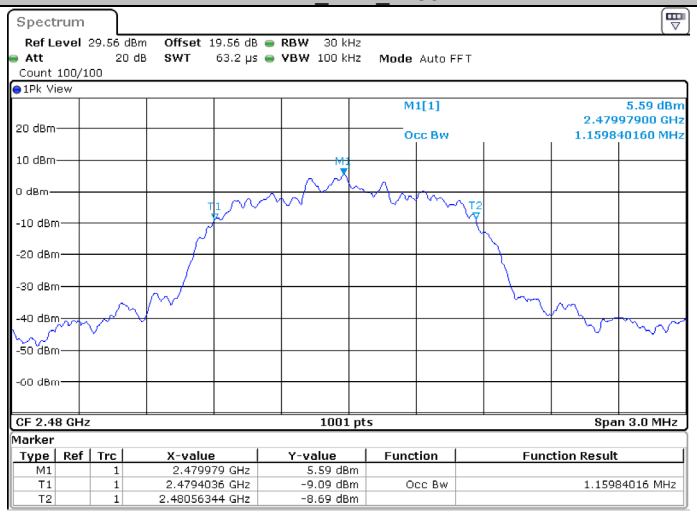
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:31:58

2DH1_Ant1_2441



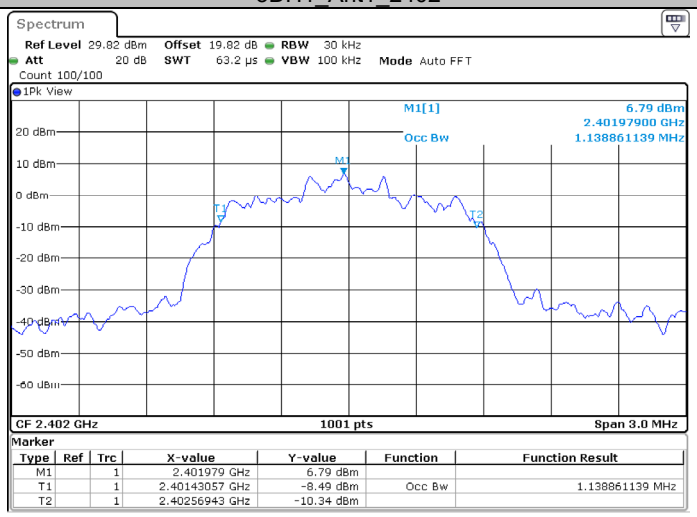
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:33:27

2DH1_Ant1_2480



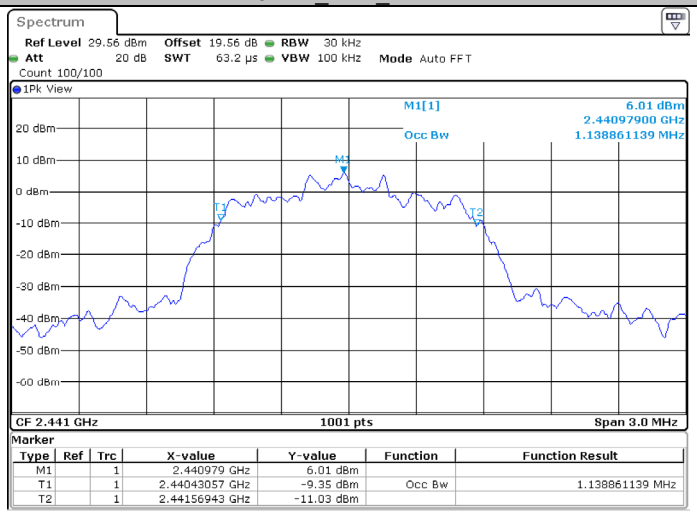
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:34:37

3DH1_Ant1_2402



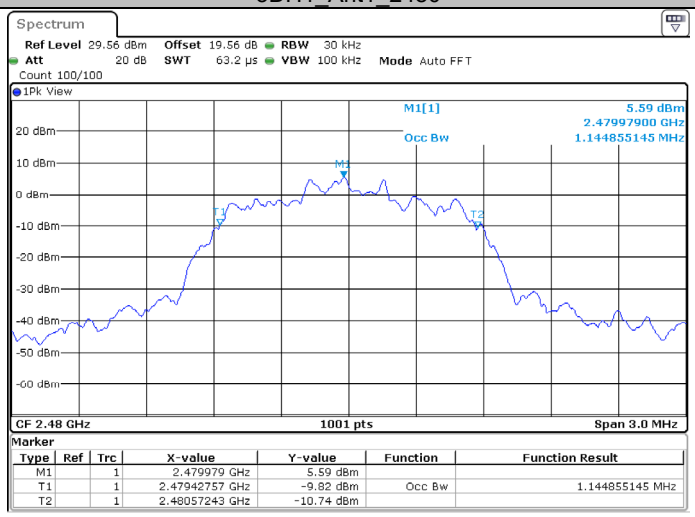
ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:36:02

3DH1_Ant1_2441



ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:37:32

3DH1_Ant1_2480



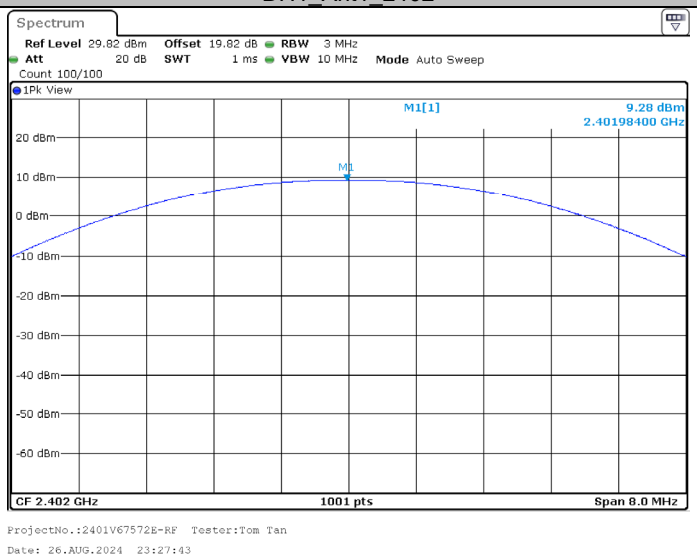
Appendix C: Maximum Conducted Peak Output Power

Test Result

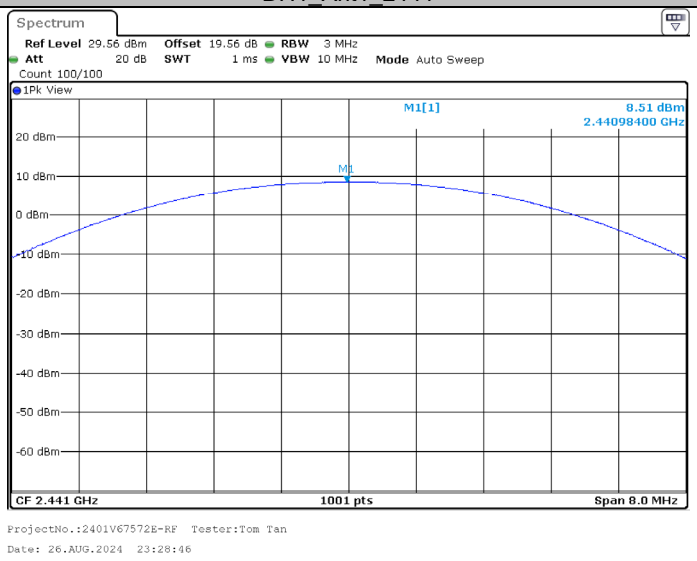
Test Mode	Antenna	Frequency [MHz]	Conducted Peak Power [dBm]	Conducted Limit [dBm]	EIRP[dBm]	EIRP Limit [dBm]	Verdict
DH1	Ant1	2402	9.28	≤20.97	9.49	≤36	PASS
		2441	8.51	≤20.97	8.72	≤36	PASS
		2480	8.09	≤20.97	8.30	≤36	PASS
2DH1	Ant1	2402	11.07	≤20.97	11.28	≤36	PASS
		2441	10.31	≤20.97	10.52	≤36	PASS
		2480	9.90	≤20.97	10.11	≤36	PASS
3DH1	Ant1	2402	11.91	≤20.97	12.12	≤36	PASS
		2441	11.19	≤20.97	11.40	≤36	PASS
		2480	10.80	≤20.97	11.01	≤36	PASS

Test Graphs

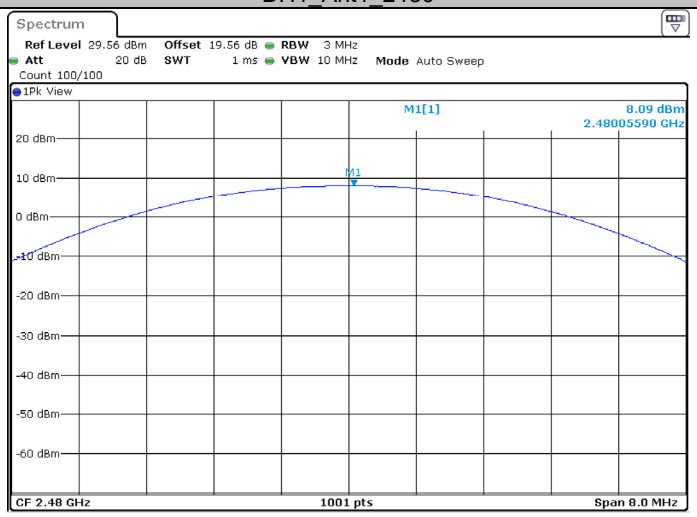
DH1_Ant1_2402



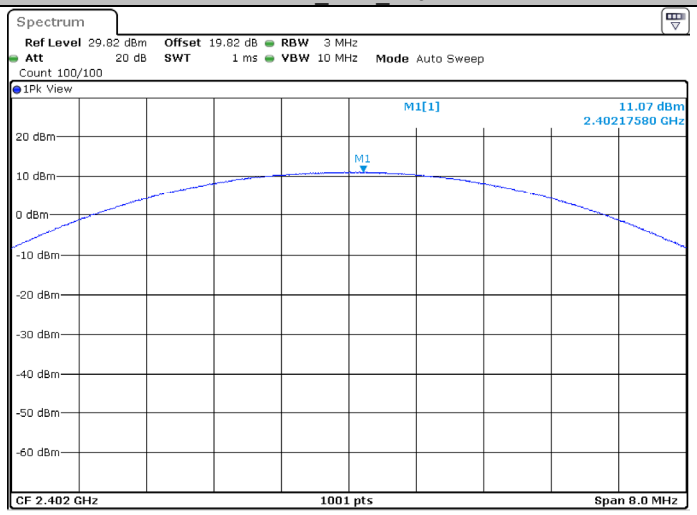
DH1_Ant1_2441



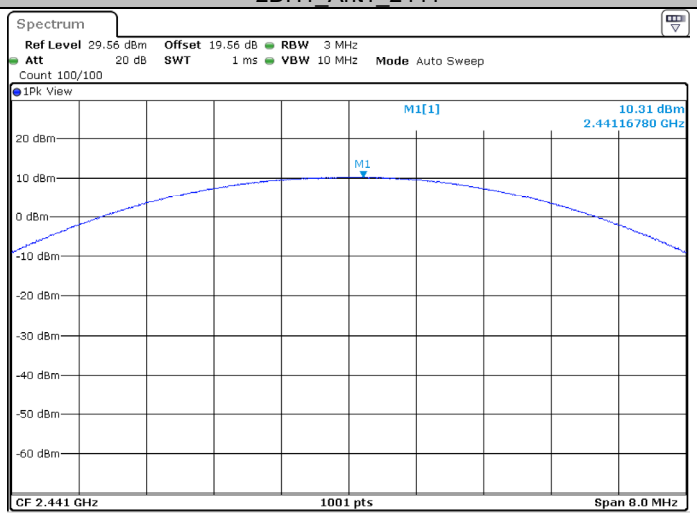
DH1_Ant1_2480



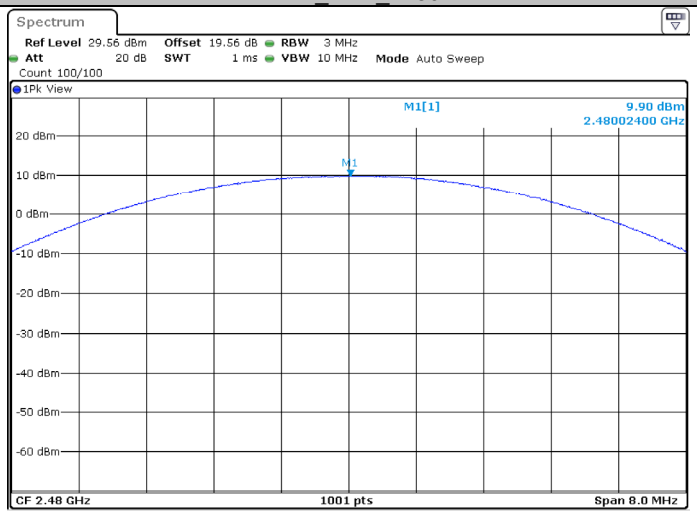
2DH1_Ant1_2402



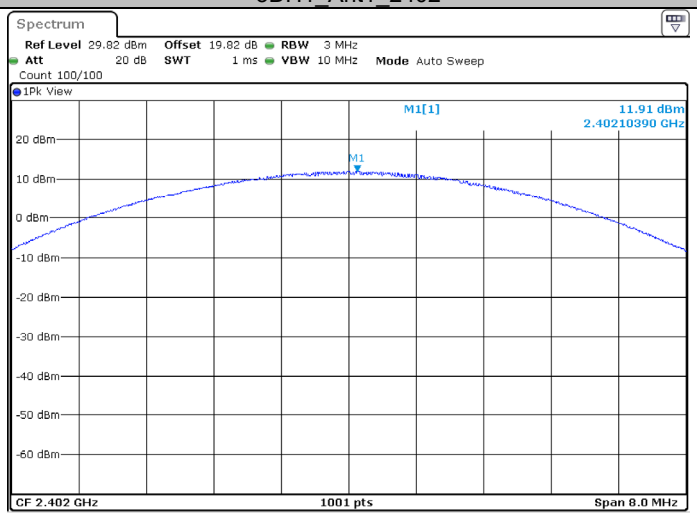
2DH1_Ant1_2441



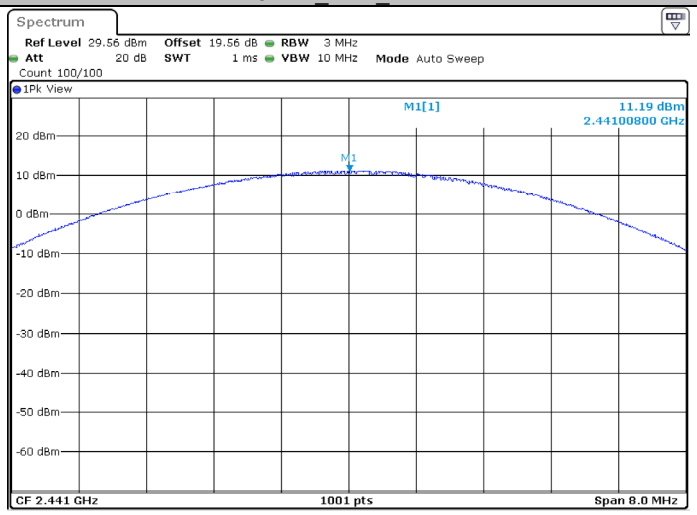
2DH1_Ant1_2480



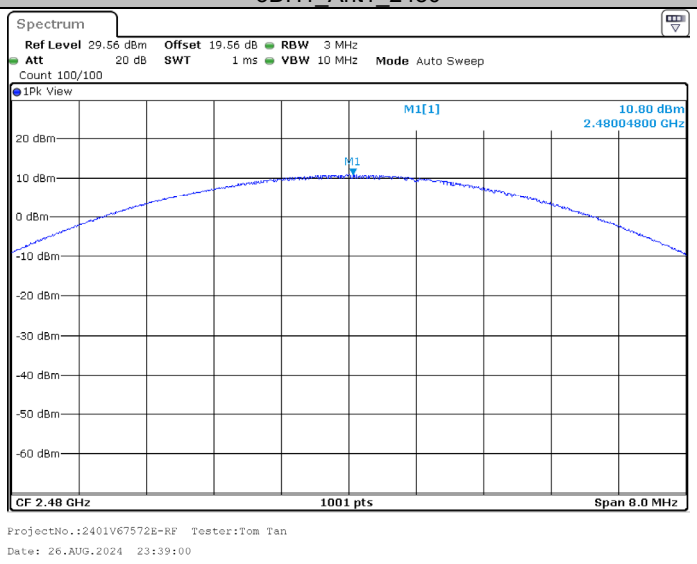
3DH1_Ant1_2402



3DH1_Ant1_2441



3DH1_Ant1_2480



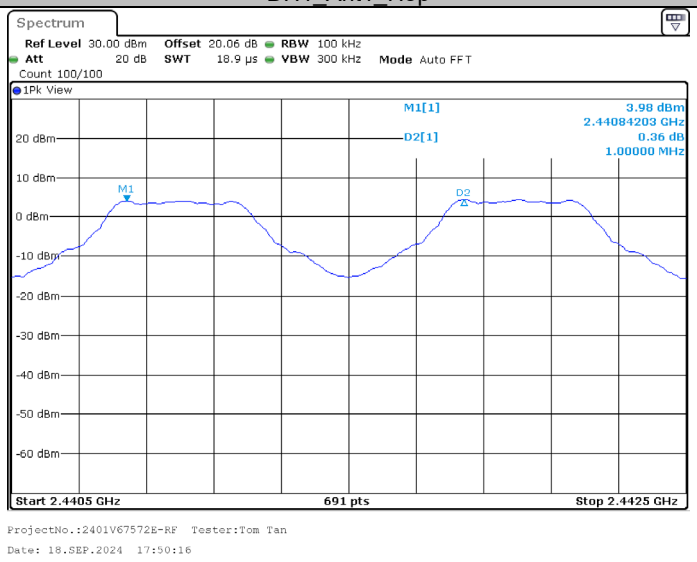
Appendix D: Carrier Frequency Separation

Test Result

Test Mode	Antenna	Channel	Result[MHz]	Limit[MHz]	Verdict
DH1	Ant1	Hop	1.000	≥0.846	PASS
Note: Only the BDR (GFSK) mode result is reported since EDR (π/4-DQPSK) and EDR (8DPSK) modes have the exact same channel plan, and the limit is the maximum 20dB bandwidth *2/3					

Test Graphs

DH1_Ant1_Hop



Appendix E: Time of Occupancy

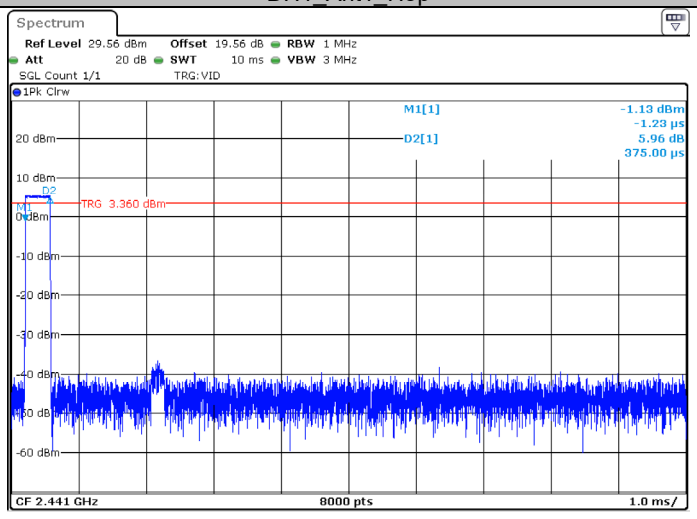
Test Result

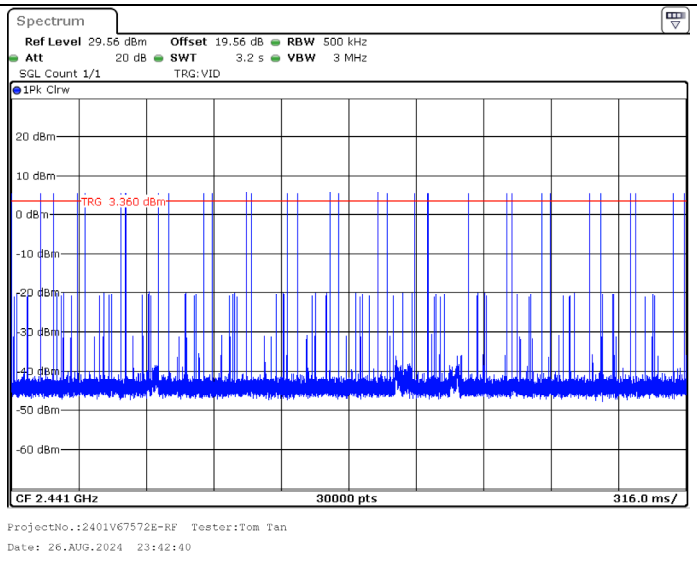
Test Mode	Antenna	Channel	BurstWidth [ms]	TotalHops [Num]	Result[s]	Limit[s]	Verdict
DH1	Ant1	Hop	0.375	320	0.120	≤0.4	PASS
DH3	Ant1	Hop	1.623	160	0.260	≤0.4	PASS
DH5	Ant1	Hop	2.863	130	0.372	≤0.4	PASS
2DH1	Ant1	Hop	0.385	310	0.119	≤0.4	PASS
2DH3	Ant1	Hop	1.629	150	0.244	≤0.4	PASS
2DH5	Ant1	Hop	2.870	130	0.373	≤0.4	PASS
3DH1	Ant1	Hop	0.385	310	0.119	≤0.4	PASS
3DH3	Ant1	Hop	1.626	150	0.244	≤0.4	PASS
3DH5	Ant1	Hop	2.870	130	0.373	≤0.4	PASS

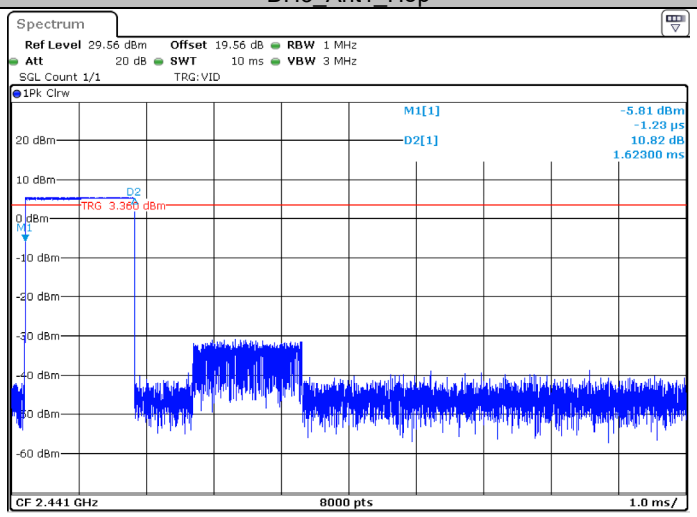
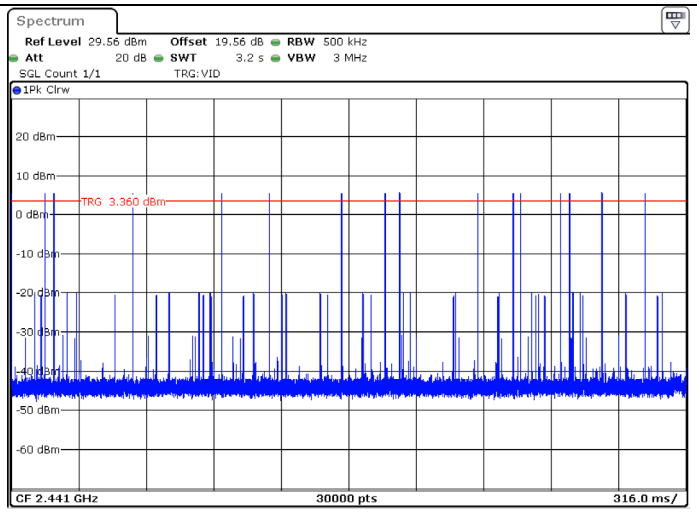
Note 1: A period time=0.4*79=31.6(S), Result=BurstWidth*Totalhops
Note 2: Totalhops=Hopping Number in 3.16s*10
Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s(Second high signals were other channel)

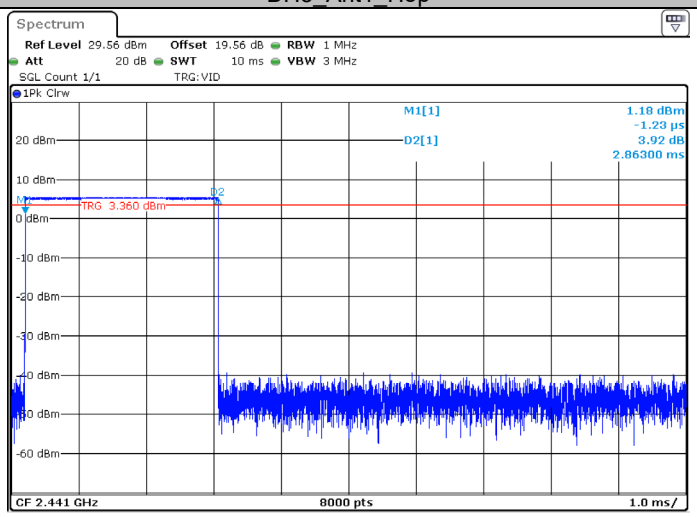
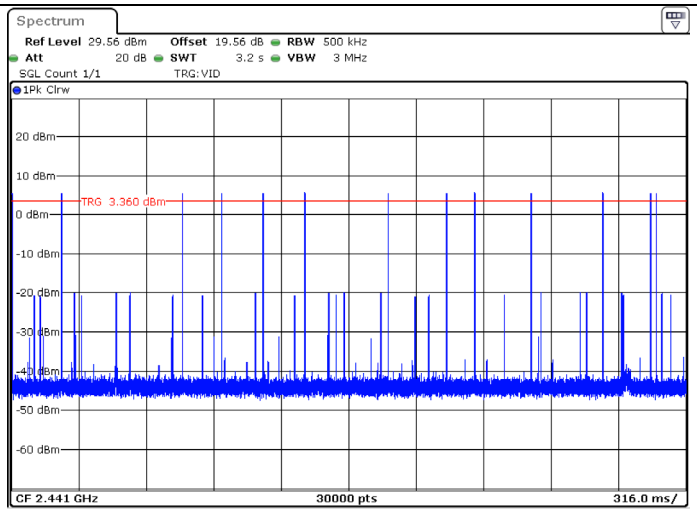
Test Graphs

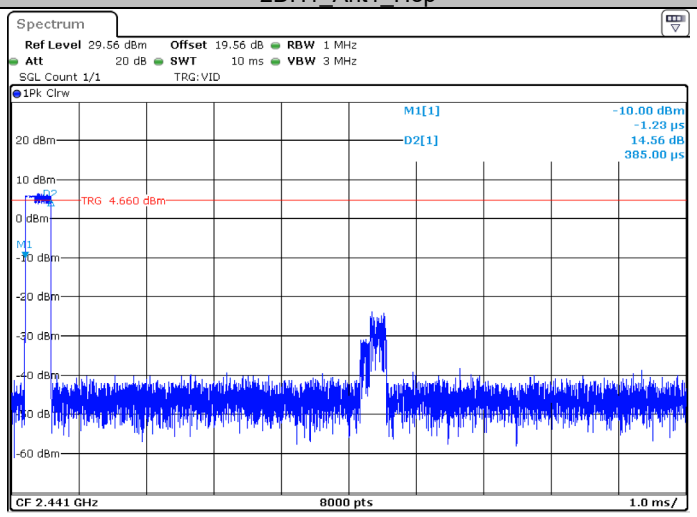
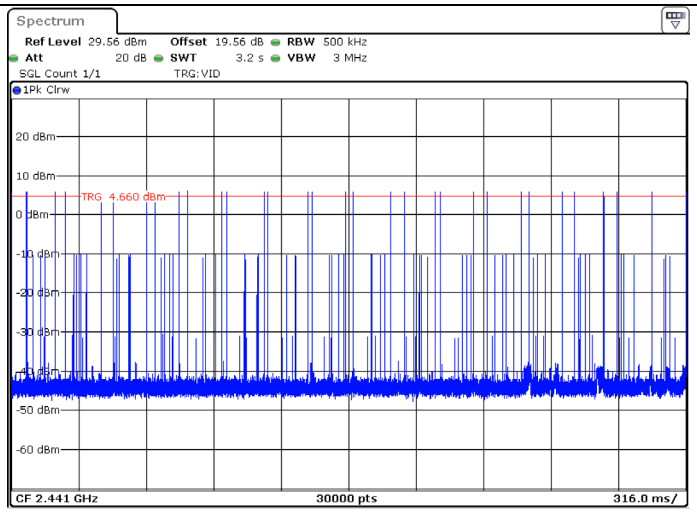
DH1_Ant1_Hop

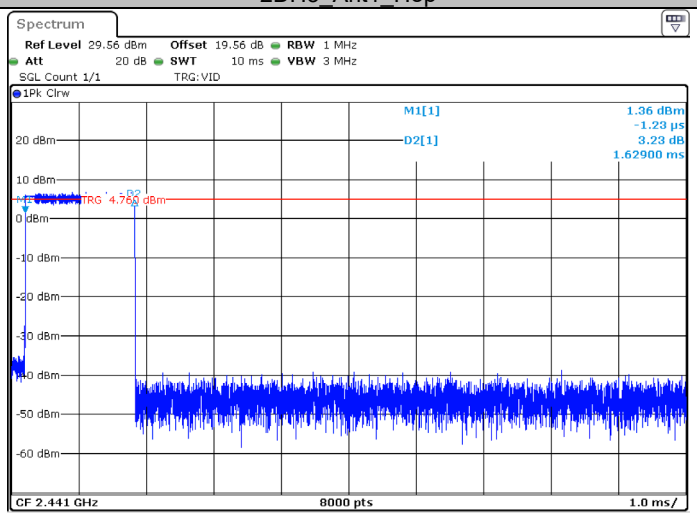
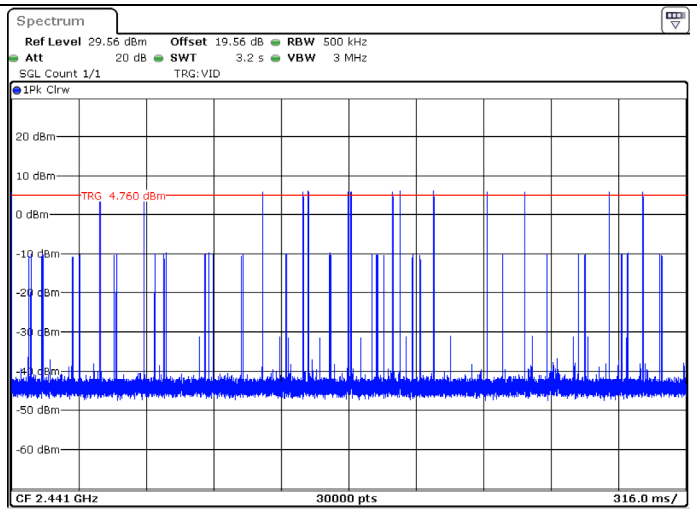


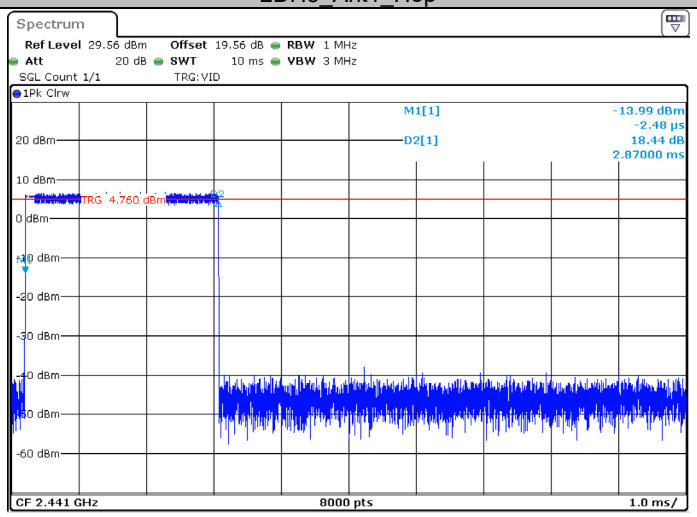
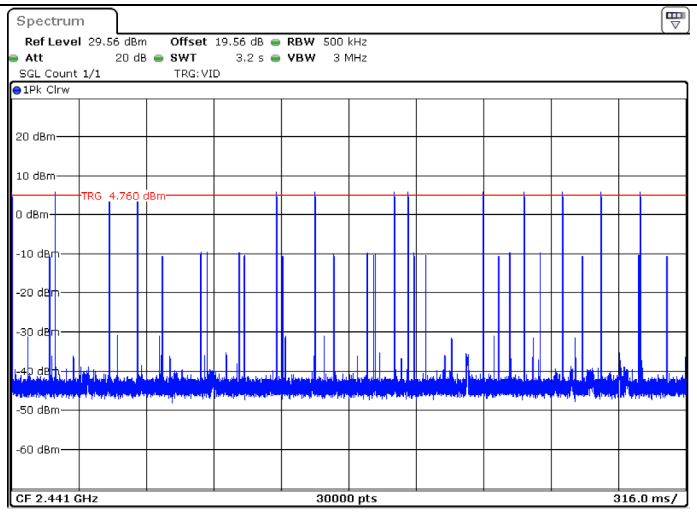


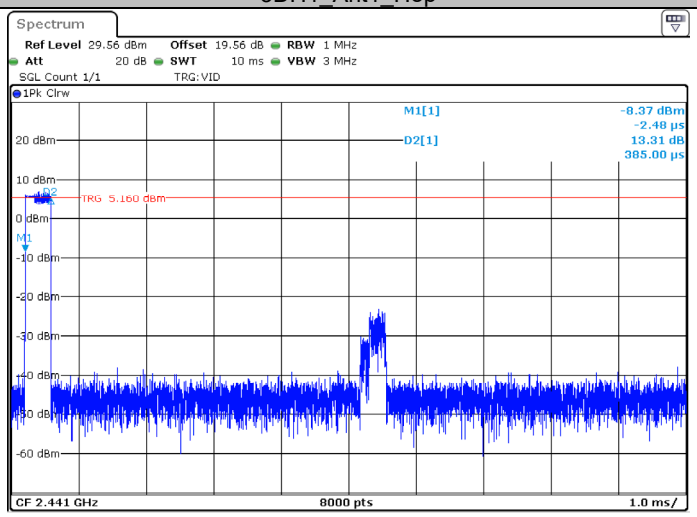
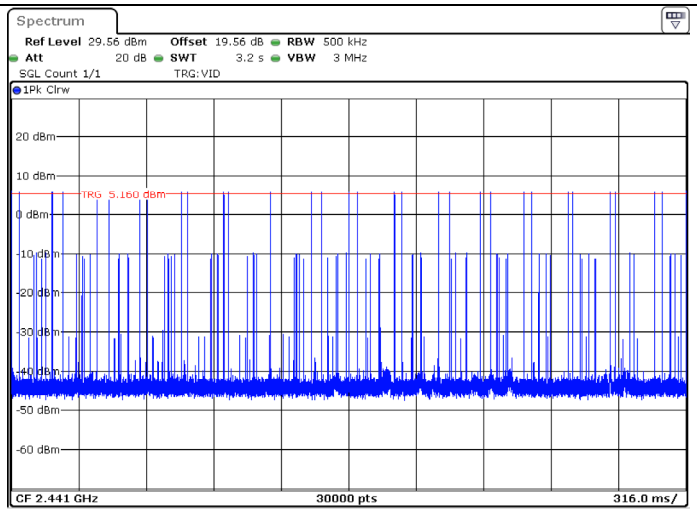
DH3_Ant1_Hop
 Spectrum Ref Level 29.56 dBm Offset 19.56 dB RBW 1 MHz Att 20 dB SWT 10 ms VBW 3 MHz SGL Count 1/1 TRG:VID 1Pk Clrw M1[1] -5.81 dBm -1.23 µs D2[1] 10.82 dB 1.62300 ms 20 dBm 10 dBm D2 TRG 3.360 dBm 0 dBm M1 -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm CF 2.441 GHz 8000 pts 1.0 ms/ ProjectNo.:2401V67572E-RF Tester:Tom Tan Date: 26.AUG.2024 23:46:39
 Spectrum Ref Level 29.56 dBm Offset 19.56 dB RBW 500 kHz Att 20 dB SWT 3.2 s VBW 3 MHz SGL Count 1/1 TRG:VID 1Pk Clrw 20 dBm 10 dBm TRG 3.360 dBm 0 dBm -10 dBm -20 dBm -30 dBm -40 dBm -50 dBm -60 dBm CF 2.441 GHz 30000 pts 316.0 ms/ ProjectNo.:2401V67572E-RF Tester:Tom Tan Date: 26.AUG.2024 23:46:44

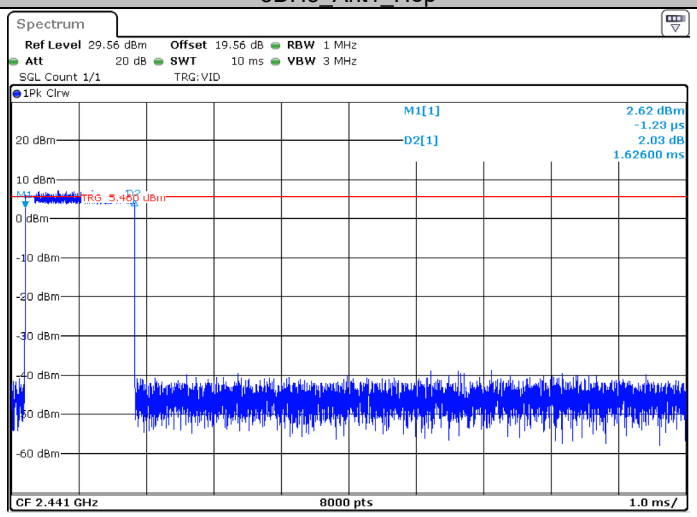
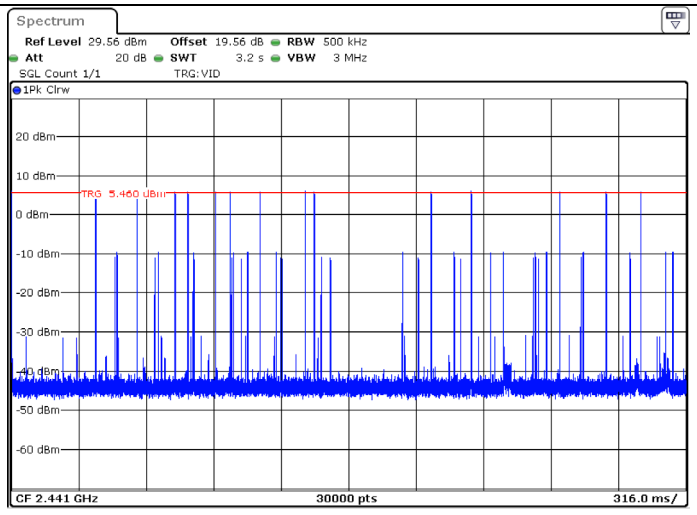
DH5_Ant1_Hop
 Spectrum Ref Level 29.56 dBm Offset 19.56 dB RBW 1 MHz Att 20 dB SWT 10 ms VBW 3 MHz SGL Count 1/1 TRG:VID 1Pk Clrw M1[1] 1.18 dBm -1.23 µs D2[1] 3.92 dB 2.86300 ms TRG 3.360 dBm CF 2.441 GHz 8000 pts 1.0 ms/ ProjectNo.:2401V67572E-RF Tester:Tom Tan Date: 26.AUG.2024 23:49:32
 Spectrum Ref Level 29.56 dBm Offset 19.56 dB RBW 500 kHz Att 20 dB SWT 3.2 s VBW 3 MHz SGL Count 1/1 TRG:VID 1Pk Clrw TRG 3.360 dBm CF 2.441 GHz 30000 pts 316.0 ms/ ProjectNo.:2401V67572E-RF Tester:Tom Tan Date: 26.AUG.2024 23:49:37

2DH1_Ant1_Hop



2DH3_Ant1_Hop



2DH5_Ant1_Hop



3DH1_Ant1_Hop



3DH3_Ant1_Hop



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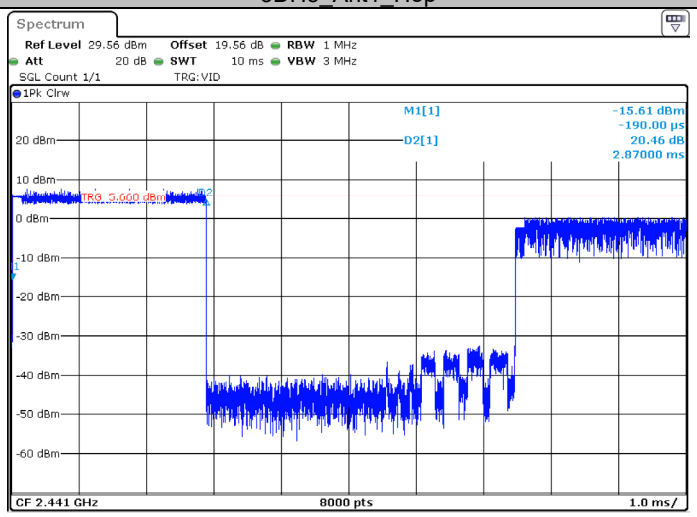
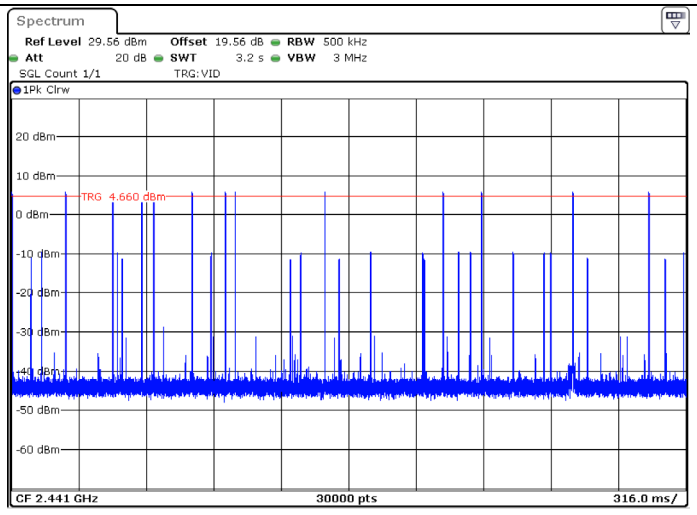



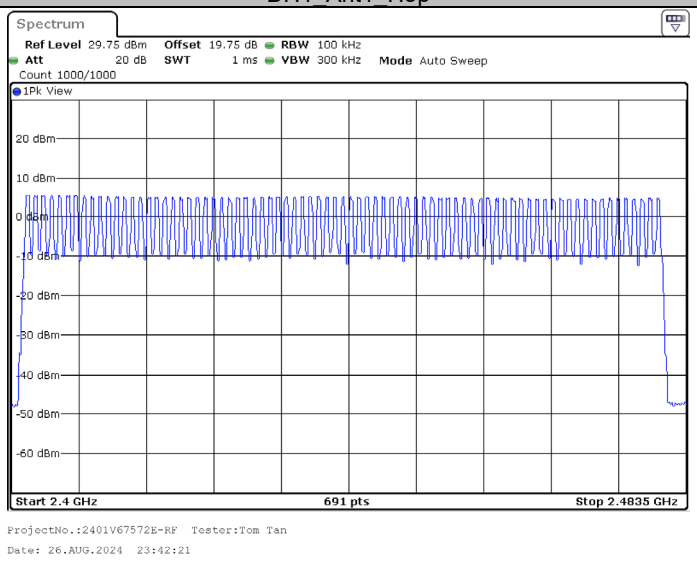
Appendix F: Number of Hopping Channels

Test Result

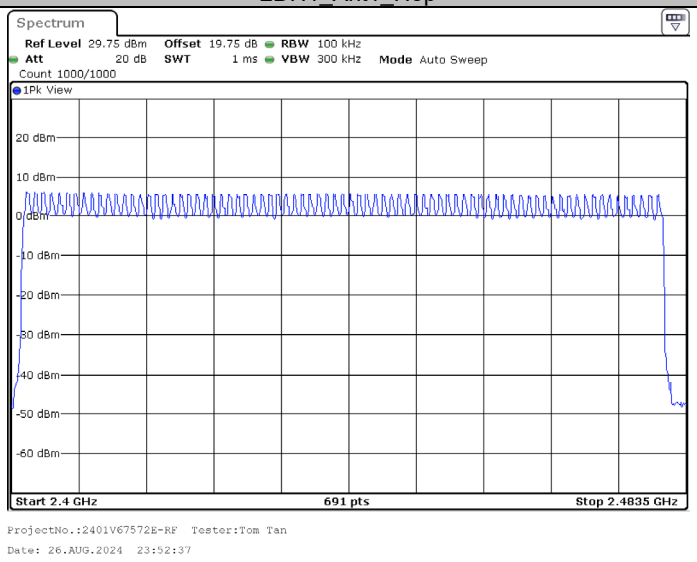
Test Mode	Antenna	Channel	Result[Num]	Limit[Num]	Verdict
DH1	Ant1	Hop	79	≥15	PASS
2DH1	Ant1	Hop	79	≥15	PASS
3DH1	Ant1	Hop	79	≥15	PASS

Test Graphs

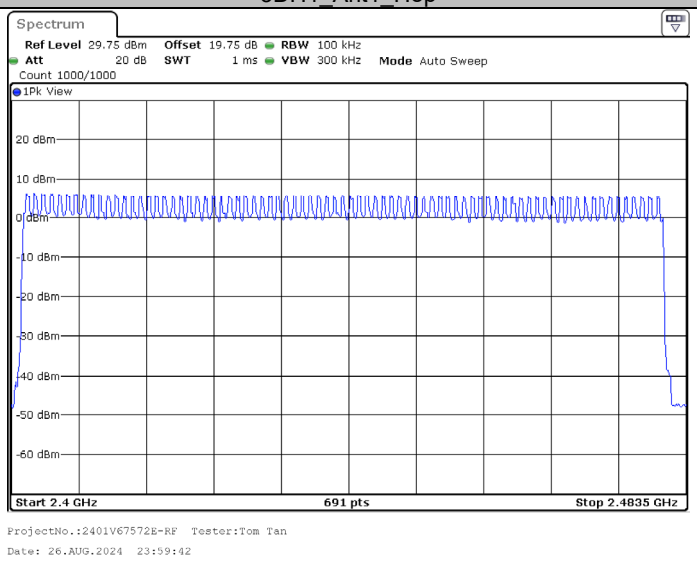
DH1_Ant1_Hop



2DH1_Ant1_Hop



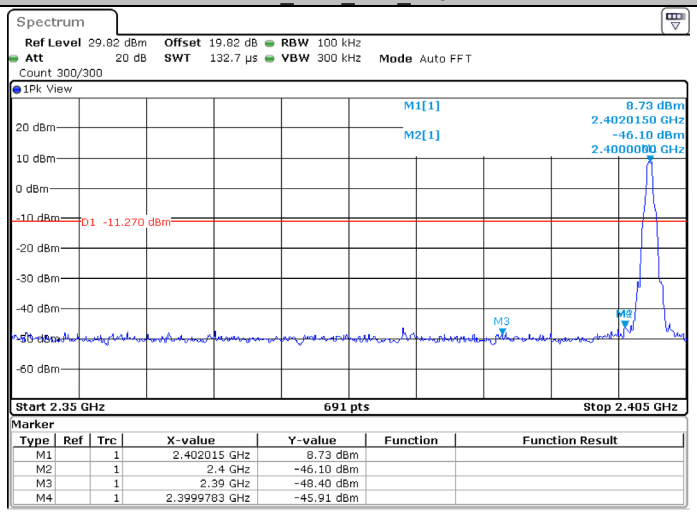
3DH1_Ant1_Hop



Appendix G: Band Edge Measurements

Test Graphs

DH1_Ant1_Low_2402



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.402015 GHz	8.73 dBm		
M2		1	2.4 GHz	-46.10 dBm		
M3		1	2.39 GHz	-48.40 dBm		
M4		1	2.3999783 GHz	-45.91 dBm		

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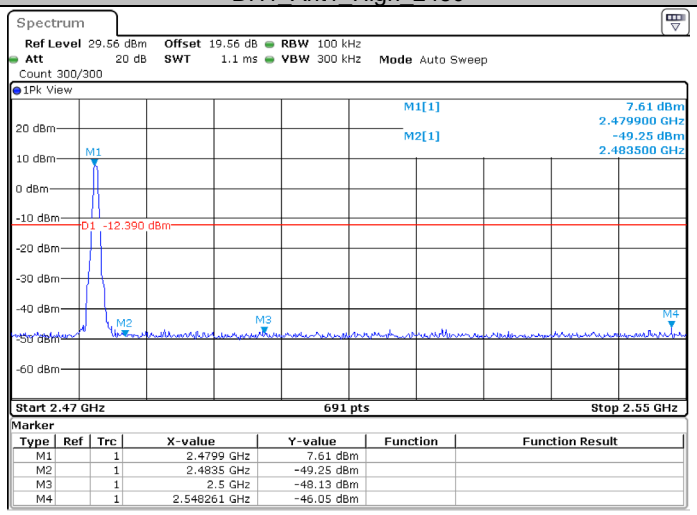
DH1_Ant1_High_2480

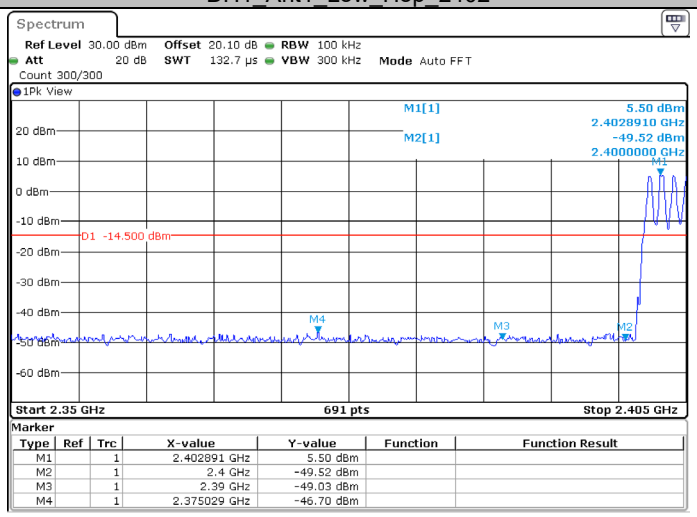


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4799 GHz	7.61 dBm		
M2		1	2.4835 GHz	-49.25 dBm		
M3		1	2.5 GHz	-48.13 dBm		
M4		1	2.548261 GHz	-46.05 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:29:50

DH1_Ant1_Low_Hop_2402

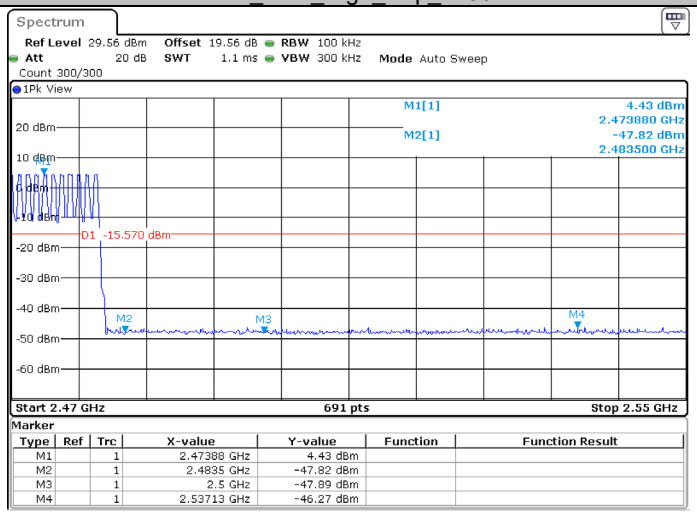


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.402891 GHz	5.50 dBm		
M2		1	2.4 GHz	-49.52 dBm		
M3		1	2.39 GHz	-49.03 dBm		
M4		1	2.375029 GHz	-46.70 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:40:03

DH1_Ant1_High_Hop_2480

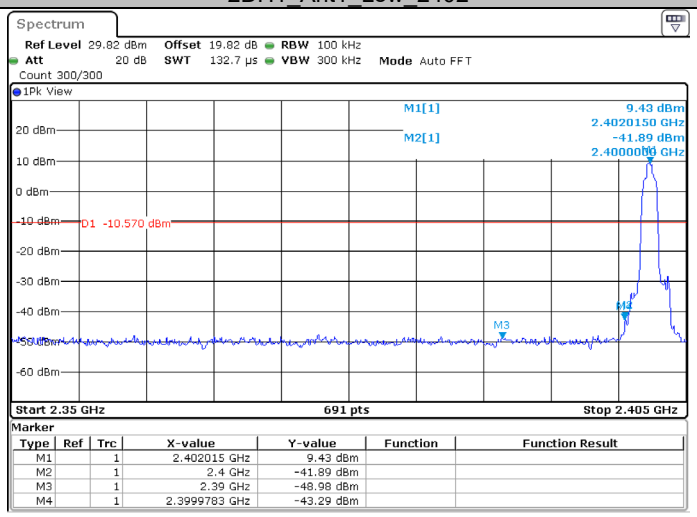


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.47388 GHz	4.43 dBm		
M2		1	2.4835 GHz	-47.82 dBm		
M3		1	2.5 GHz	-47.89 dBm		
M4		1	2.53713 GHz	-46.27 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:45:43

2DH1_Ant1_Low_2402

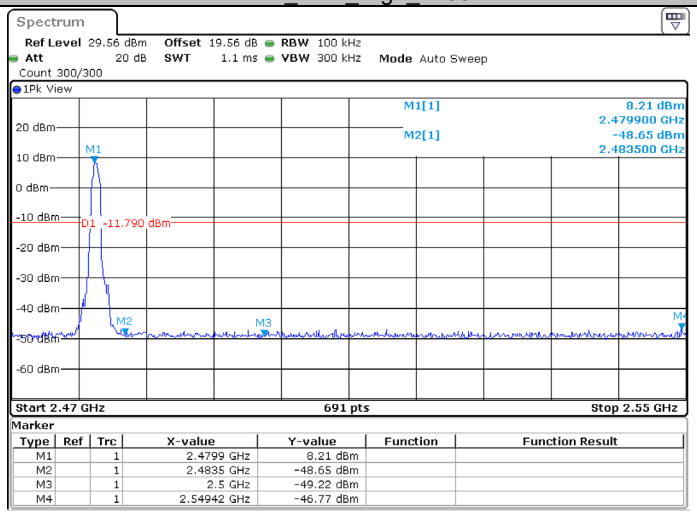


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.402015 GHz	9.43 dBm		
M2		1	2.4 GHz	-41.89 dBm		
M3		1	2.39 GHz	-48.98 dBm		
M4		1	2.3999783 GHz	-43.29 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:32:06

2DH1_Ant1_High_2480

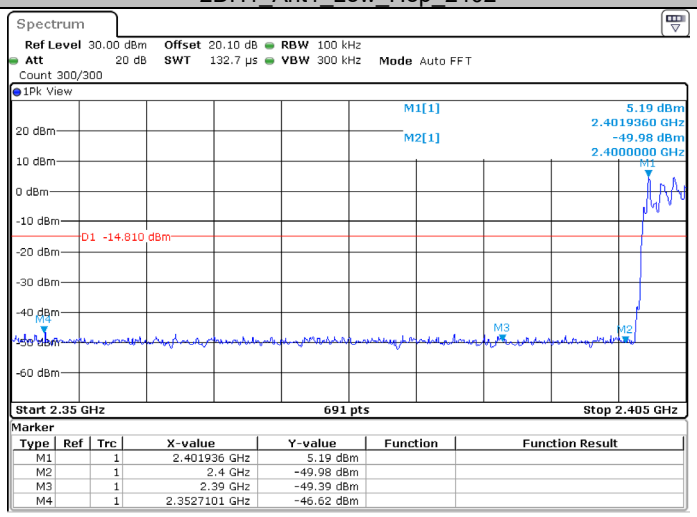


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4799 GHz	8.21 dBm		
M2		1	2.4835 GHz	-48.65 dBm		
M3		1	2.5 GHz	-49.22 dBm		
M4		1	2.54942 GHz	-46.77 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:34:46

2DH1_Ant1_Low_Hop_2402

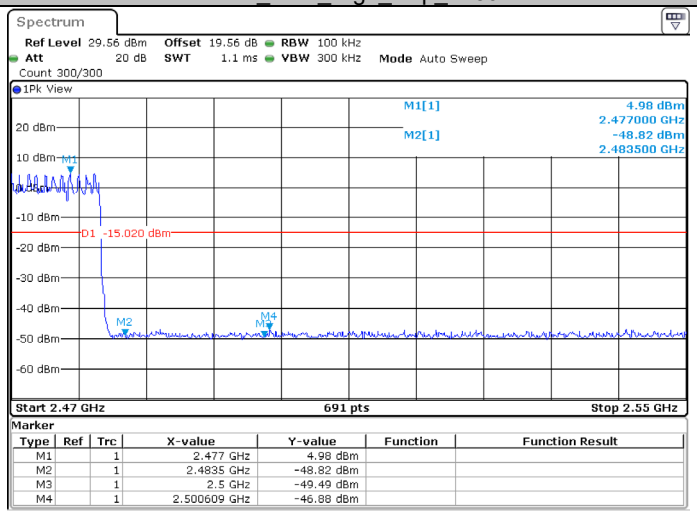


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.401936 GHz	5.19 dBm		
M2		1	2.4 GHz	-49.98 dBm		
M3		1	2.39 GHz	-49.39 dBm		
M4		1	2.3527101 GHz	-46.62 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:50:23

2DH1_Ant1_High_Hop_2480

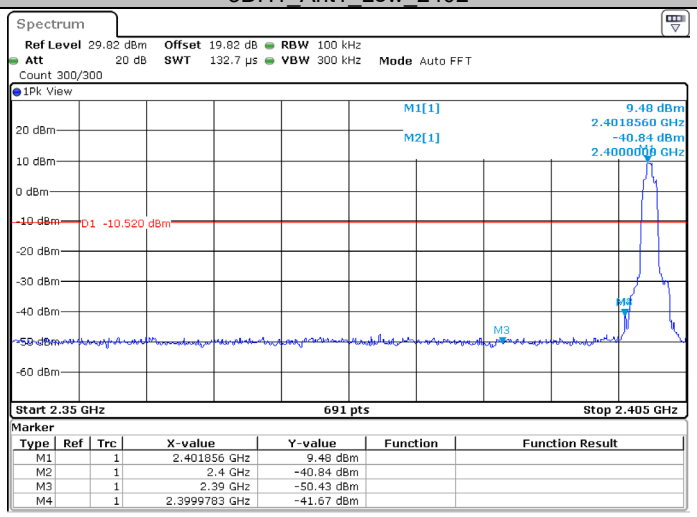


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.477 GHz	4.98 dBm		
M2		1	2.4835 GHz	-48.82 dBm		
M3		1	2.5 GHz	-49.49 dBm		
M4		1	2.500609 GHz	-46.88 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:55:15

3DH1_Ant1_Low_2402

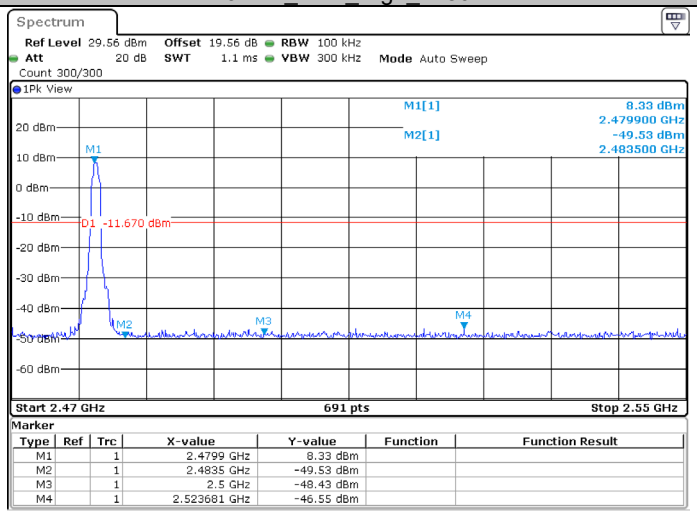


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.401856 GHz	9.48 dBm		
M2		1	2.4 GHz	-40.84 dBm		
M3		1	2.39 GHz	-50.43 dBm		
M4		1	2.3999783 GHz	-41.67 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:36:11

3DH1_Ant1_High_2480

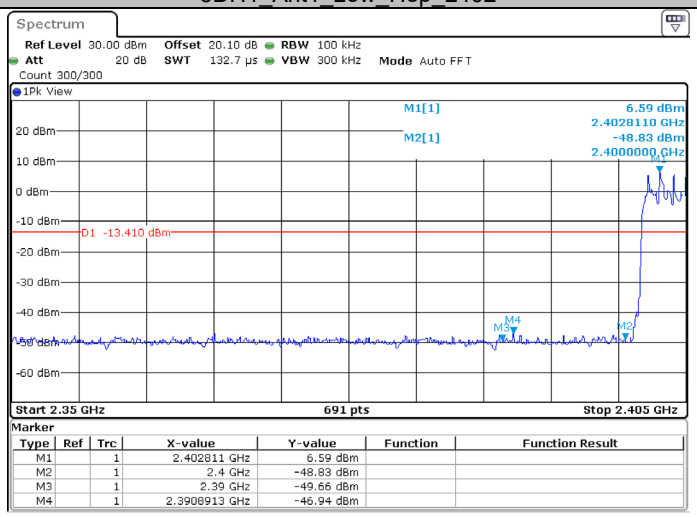


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4799 GHz	8.33 dBm		
M2		1	2.4835 GHz	-49.53 dBm		
M3		1	2.5 GHz	-48.43 dBm		
M4		1	2.523681 GHz	-46.55 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:38:43

3DH1_Ant1_Low_Hop_2402

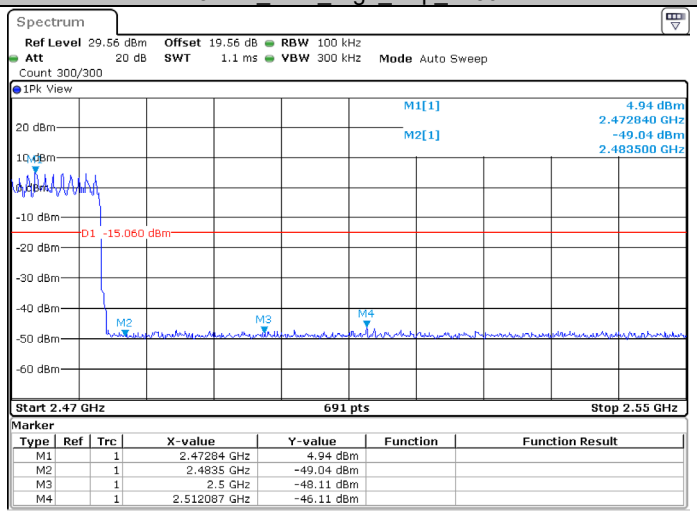


Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.402811 GHz	6.59 dBm		
M2		1	2.4 GHz	-48.83 dBm		
M3		1	2.39 GHz	-49.66 dBm		
M4		1	2.3908913 GHz	-46.94 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 26.AUG.2024 23:57:16

3DH1_Ant1_High_Hop_2480



Marker

Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.47284 GHz	4.94 dBm		
M2		1	2.4835 GHz	-49.04 dBm		
M3		1	2.5 GHz	-48.11 dBm		
M4		1	2.512087 GHz	-46.11 dBm		

ProjectNo.:2401V67572E-RF Tester:Tom Tan
Date: 27.AUG.2024 00:02:07

******* END OF REPORT *******